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Organocatalysis

Donor-Acceptor Aminocyclobutane Monoesters: Synthesis and Silylium-Catalyzed (4+2) Annulation with Indoles

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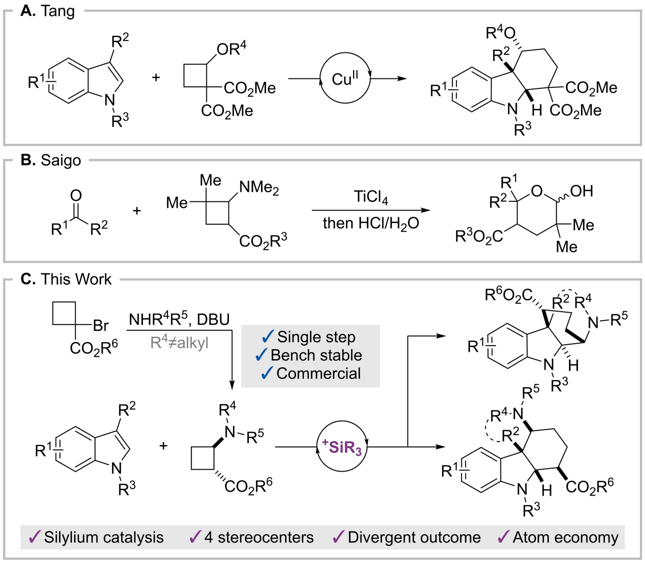
Abstract: A convenient one-step synthesis of β-aminocyclobutane monoesters starting from commercially available reagents is reported. The obtained strained rings undergo (4+2) dearomative annulation with indole partners using silylium catalysis. This organocatalyzed annulation provided tricyclic indolines with four new stereocenters in up to quantitative yield and >95:5 diastereoselectivity and can proceed both intra- and intermolecularly. When performed intramolecularly, the tetracyclic structure of either *akuamma* or *malagasy* alkaloids was obtained selectively depending on the temperature of the reaction. This divergent outcome could be rationalized based on DFT calculations.

Introduction

Donor-acceptor (DA) cyclopropanes are one of the most studied strained ring motifs. Their versatile chemistry has been extensively investigated over the past decades.[1] Nitrogen substituted carbocyclic structures are omnipresent in natural products and bioactive compounds. By taking advantage of the unique reactivity profile of donor-acceptor aminocyclopropanes, complex nitrogen substituted molecules can be built efficiently.[2] In most reports, donor-acceptors bearing a malonyl diester group activated by a chelating Lewis acid are used. In contrast, mono carbonyl acceptor systems have been much less studied despite their synthetic relevance. Indeed, an extra stereocenter is generated and no additional decarboxylation step is required after product formation.[3] Only rare examples of annulation reactions using a single acceptor group have been reported and are neither selective nor catalytic.[1f,h,4] In 2021, our group reported the first catalytic annulation involving aminocyclopropane monoesters.[5] Activation of these less reactive systems was accomplished by an in situ generated silyl bistriflimide[6] organocatalyst, leading to (3+2) annulation products with high yield and selectivity, further demonstrating the potential of silylium catalysis.[7]

In contrast to cyclopropanes, the corresponding donor-acceptor cyclobutanes have been less studied despite their similar ring strain energy.[8] Progress in this area is highly desirable, as cyclobutanes stand out as advantageous precursors in the construction of saturated ring systems. Indeed, annulation reactions provide an alternative to the classical bond-disconnection strategies, such as the Diels–Alder reaction, to build partially unsaturated systems.[9] In particular, (4+2) annulations between cyclobutanes and indoles have proved to be very effective to rapidly form complex alkaloid skeletons containing a 6-membered ring.[10] For example, Tang and co-workers reported a (4+2) annulation between alkoxy cyclobutane diesters and indoles catalyzed by Cu^{II} (Scheme 1A).[11] In this case, extra steps were necessary to access the nitrogen and monoester



Scheme 1. A) Synthesis of alkaloid skeletons via (4+2) annulation between indoles and alkoxycyclobutane diesters. B) First annulation with aminocyclobutane monoesters. C) One-step synthesis of aminocyclobutane monoesters and silylium catalyzed (4+2) annulations with indoles.

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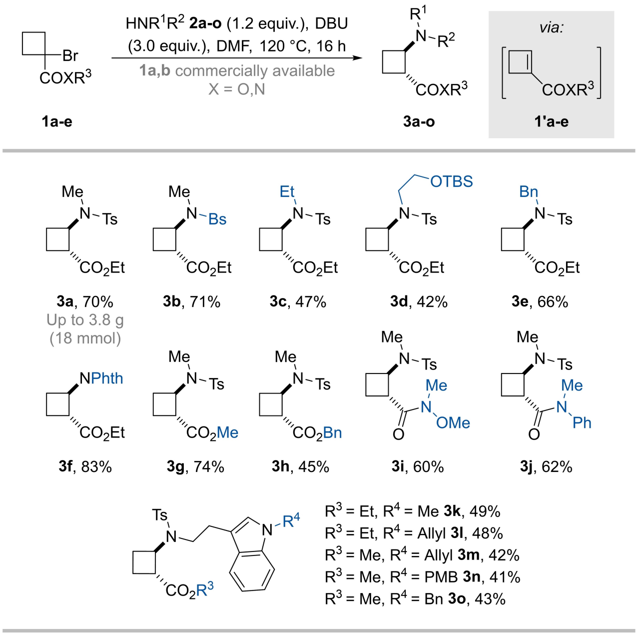
substituted 6-membered ring required for the synthesis of natural alkaloids. In that regard, the use of aminocyclobutanes would enable a more efficient synthesis of alkaloid building blocks. However, only a few methods for the synthesis and annulation of nitrogen substituted DA cyclobutanes have been reported so far. In 2013, our group disclosed the synthesis of donor-acceptor aminocyclobutane diesters via a (2+2) cycloaddition[12] and applied them in catalytic (4+2) annulations with enol ethers and carbonyls.[13,14] Since then, Pagenkopf and co-workers reported in 2020 a single example of (4+2) annulation between DA aminocyclobutanes and *cis*-diazenes catalyzed by $GaCl_3$.[15]

Driven by the pursuit of efficiency and atom economy, we considered the development of an annulation process with a single ester as an acceptor. However, there are only a few reports on the synthesis and use of these less activated substrates. The first synthesis of such cyclobutanes was achieved by Brannock in 1961 via a thermal (2+2) cycloaddition.[16] Only nitrogen bearing alkyl substituents could be used in this process.[17] Other multi-steps syntheses have also been reported by Aitken.[18] The first example of annulation involving an aminocyclobutane was reported by Saigo and co-workers in 1991 (Scheme 1B).[19] The Lewis acid mediated annulation between aminocyclobutane monoesters and aldehydes provided *N*,*O*-acetals, which were directly hydrolyzed under the reaction conditions, resulting in the loss of the valuable nitrogen functionality. To the best of our knowledge, the use of aminocyclobutane monoesters in annulation reactions conserving the nitrogen functionality has not been reported so far.

Herein, we describe the first synthesis of bench stable donor-acceptor aminocyclobutane monoesters in one single step from commercially available building blocks (Scheme 1, C). We then disclose the first catalytic annulation reaction involving aminocyclobutane monoesters. Using silylium catalysis to activate the strained ring, aminocyclobutane monoesters were able to perform (4+2) annulation with indoles providing valuable alkaloid scaffolds. This reaction allowed the construction of four new stereocenters in one single step with high diastereoselectivity. When performed intramolecularly, the tetracyclic structure of either *akuamma* or *malagasy* alkaloids was obtained selectively depending on the temperature of the reaction.

Results and Discussion

To prepare β-aminocyclobutane monoesters, we envisioned a bromo elimination-Michael addition sequence starting from the commercially available bromo-cyclobutane ethyl ester building block **1a** ($COXR^3 = CO_2Et$, Scheme 2). Following the work of Grygorenko on the synthesis of cyclobutene esters,[20] DBU was selected as a non-nucleophilic base to perform the dehydrobromination. Due to its volatility and to avoid possible polymerization of the generated cyclobutene **1′a**, we decided not to isolate this intermediate and to introduce the nitrogen nucleophile directly at the beginning of the reaction. When using *N*-methyl tosyl amide as a nucleophile, fine tuning of the reaction conditions allowed us to access aminocyclobutane **3a** in 70 % yield in a single step from commercially available reagents (see Supporting Information for optimization details). This reaction provides exclusively the *trans*- diastereoisomer, where the interactions between the two adjacent groups are minimized. In addition, the reaction was successfully scaled-up to 18 mmol scale (3.8 g) with a similar yield.

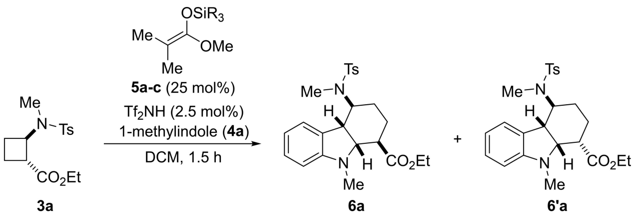


Scheme 2. Scope of β-aminocyclobutane monoesters. Reaction conditions: 0.30 mmol (1.0 equiv) bromo-cyclobutane **1a–e**, 0.36 mmol (1.2 equiv) amine **2a–o**, 0.90 mmol (3.0 equiv) DBU, DMF (0.2 M), 120 °C, 16 h.

Other donor-acceptor aminocyclobutanes were synthesized using this method. A *para*-bromophenylsulfonyl (Bs) group was well tolerated (**3b**, 71 % yield). An ethyl (**3c**), an alkyloxy (**3d**) and a benzyl (**3e**) group were introduced in lower yields (42 to 66 %). Phthalimide can be used for the reaction giving **3f** in 83 % yield. Carbamate protected amines could not be transferred on the cyclobutane ring. The use of the commercial methyl ester bromocyclobutane **1b** gave **3g** in 74 % yield. The presence of a benzyl ester decreased the yield (**3h**, 45 % yield). Weinreb amide derivative **1d** could also be used as a precursor, giving **3i** in 60 % yield. More hindered amide can also be synthetized like **3j** in 62 % yield. Alkyl-indole substituted sulfonamide could also perform the reaction offering **3k–o** in 41 to 49 % yield. Alternatively, benzyl ester and phenyl ketone substituted aminocyclobutanes can be easily synthetized via saponification of **3a** followed by further functionalization, giving higher overall yields (see Supporting Information for details).

With these novel donor-acceptor cyclobutanes in hand, we started to explore the catalyzed (4+2) annulation reaction with 1-methylindole (**4a**) (Table 1). In analogy to our previous work on cyclopropanes,[5] tosyl protected aminocyclobutane ethyl ester **3a** was selected as model

Table 1: Optimization of the (4+2) annulation with indole **4a**.



Entry	SiR$_3$ group	T [°C]	Yield [%][a]	dr[b]
1	TMS	−78	8	62:38
2	TMS	−50	45	66:34
3	TMS	−10	98	68:32
4	TMS	0	99	72:28
5	TMS	20	93	90:10
6	**TMS**	**40**	**96[c]**	**94:6**
7	TTMSS	40	74[c]	92:8
8	TIPS	40	93[c]	81:19

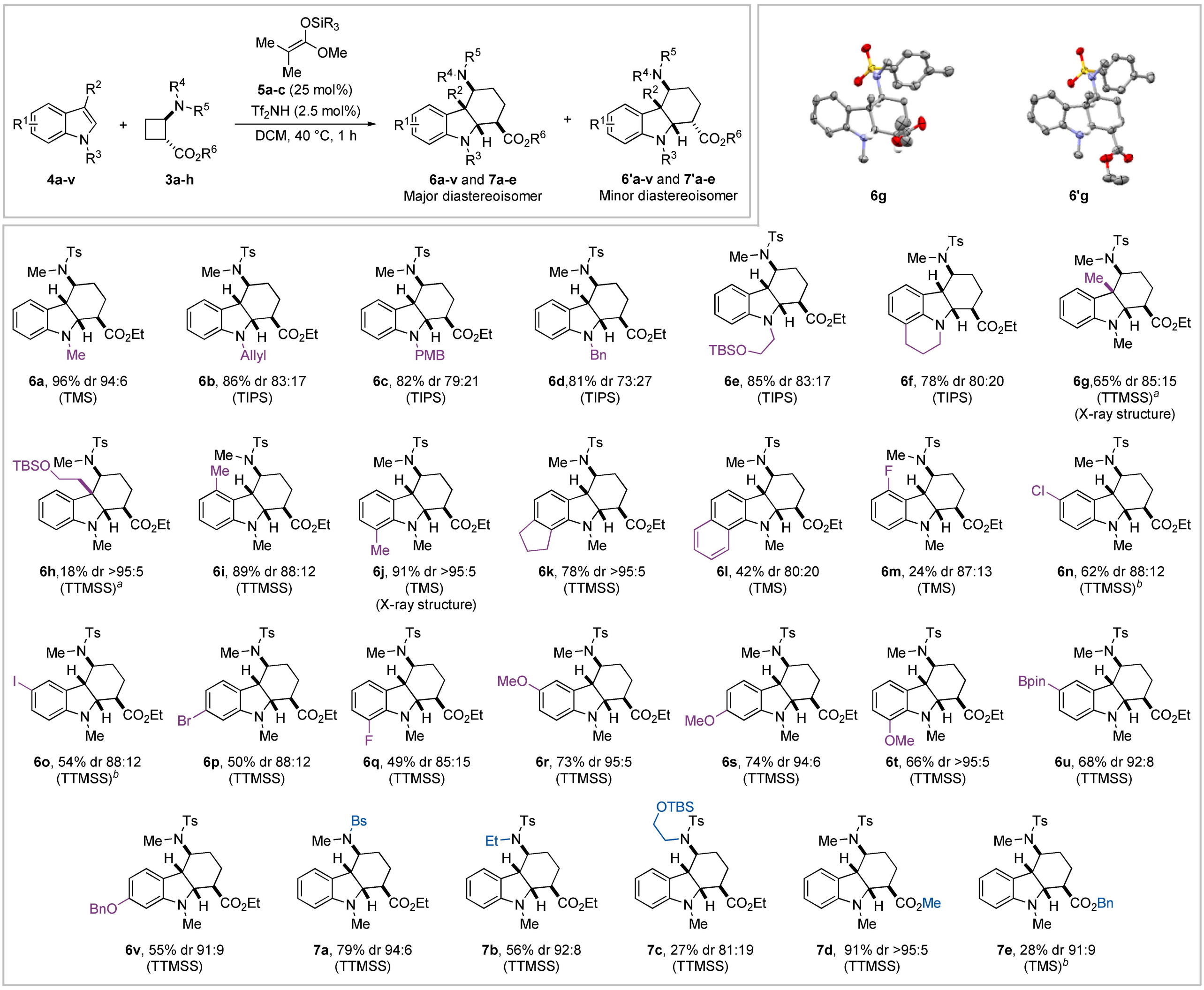
Reaction conditions: 0.2 mmol (1.0 equiv) aminocyclobutane (**3a**), 0.21 mmol (1.05 equiv) 1-methylindole (**4a**), 25 mol% silyl ketene acetals (**5a–c**), 2.5 mol% Tf$_2$NH, DCM (0.1 M), 1.5 h. [a] GC yield. [b] dr was measured from the GC chromatograph of the crude mixture. [c] Isolated yield on 0.3 mmol scale.

substrate for the (4+2) annulation. Silyl bistriflimides generated in situ from silyl ketene acetals and bistriflimide acid were used as a catalyst.[6b] The reactions were conducted with **3a**, *N*-methyl-indole (**4a**), different silyl ketene acetals **5** (25 mol%) and bistriflimide (2.5 mol%) in DCM (0.1 M) at −78 °C. Adapting the reaction time from our previous work[5] (1.5 h instead of 30 minutes) gave 8% yield and 62:38 dr with TMS as a silylium source (Table 1, entry 1). Increasing the temperature led to a significant increase of yield and dr (entries 2–5). Moreover, performing the reaction at 40 °C allowed us to obtain a higher and more reproducible dr compared to lower temperature (entries 1–5) (see Supporting Information for details). At this temperature, TMS gave 96% yield and 94:6 dr (entry 6). Other silyl ketene acetals were examined (see Supporting Information for details), but led to lower yield and dr: tris(trimethylsilyl)silyl (TTMSS) gave 74% yield and 92:8 dr (entry 7) and TIPS gave 93% yield and 81:19 dr (entry 8). Closer monitoring of the reaction revealed that the reaction time can be shortened to 1 hour. We then focused on the scope of indoles in the (4+2) annulation with **3a** (Scheme 3). Different larger *N*-protecting groups were tolerated with trimethylsilyl ketene acetal as a catalyst precursor, but the dr decreased (between 60:40 to 70:30). In contrast to the model substrate, we were pleased to observe that the use of TTMSS as a silylium source improved the dr (82:18–90:10), but at the cost of the yield (26–28%) (see Supporting Information for details). Finally, using triisopropylsilyl (TIPS) ketene acetal (**5c**) allowed us to obtain alkaloids protected with an allyl group (**6b**, 86% yield dr 83:17), a 4-methoxybenzyl (PMB) group (**6c**, 82% yield, dr 79:21), and a benzyl (Bn) group (**6d**, 81%, dr 73:27) with a better compromise between yield and dr. *N*-alkyl substituents gave compounds **6e** (85% yield, dr 83:17) and **6f** (78% yield, dr 80:20). No reaction was observed with a free indole. Indoles with substituents in C-2 did not react. 3-Methylindole and protected tryptophol gave cycloadducts **6g** (65% yield, dr 85:15) and **6h** (18% yield, dr >95:5) with a quaternary carbon center. The X-ray crystal structure analysis of **6g** and **6′g** confirmed the relative configuration of the cycloadducts for both diastereoisomers.[21] A broad range of arene-substituted indoles was tolerated in the reaction (**6i–v**). Alkyl substituents were well tolerated and gave products **6i** (89% yield, dr 88:12), **6j** (91% yield, dr >95:5) and **6k** (78% yield, dr >95:5 respectively). An additional benzene ring on the indole gave **6l** with lower yield and selectivity (42% yield, dr 80:20). Halogen atoms on the 4- to 7-positions gave **6m–q** with moderate yields and selectivity. Methoxy substituents, often present in natural alkaloids, were tolerated in positions 5 to 7 and **6r–t** were obtained with good yield and selectivity (73% yield, dr 95:5, 74% yield, dr 94:6 and 66% yield, dr >95:5 respectively). Pinacol borane (**6u**) and benzyloxy (**6v**) substituted indoline were obtained with moderate yield and good selectivity (68% yield, dr 92:8 and 55% yield, dr 91:9 respectively).

The scope of aminocyclobutanes was then examined. A *para*-bromophenylsulfonyl group on the sulfonamide was tolerated and gave **7a** with 79% yield and 94:6 dr. Longer alkyl substituents on the nitrogen like ethyl or ethylsilyloxy gave **7b** and **7c** respectively with lower yield and selectivity, probably due to steric hinderance. Methyl ester substituted cyclobutane **3g** gave **7d** with excellent selectivity (dr >95:5). A more hindered benzyl ester cyclobutane offered **7e** with significantly lower yield but good selectivity (28% yield, dr 91:9).[22]

Intramolecular annulation reactions were then investigated (Scheme 4). In this case, a complete switch of reaction outcome was observed by changing the reaction temperature. At −50 °C the core structure **8** observed in *akuamma* alkaloids, such as akuammiline (**10**), was obtained as the major isomer, whereas at 40 °C the core structure **9** observed in *malagasy* alkaloids, such as myrtoidine (**11**), was obtained as the major isomer. Starting from methyl protected indole-cyclobutane **3k**, a mixture of **8a** and **9a** was obtained at −50 °C with 31% yield and 92:8 selectivity. At 40 °C, the products are obtained in 87% yield and reversed 36:64 selectivity. An allyl protecting group was tolerated, both with ethyl and methyl ester giving **8b**/**9b** and **8c**/**9c** with good selectivity and improved yield at low temperature. A PMB and Bn group were introduced giving **8d**/**9d** and **8e**/**9e** respectively.[23] The X-ray crystal structure analysis of **8c** and **9a** confirmed the structure of the two different isomers obtained.

To highlight the efficiency of the reaction, we further performed a scale-up experiment with one gram (3.2 mmol) of cyclobutane **3a**. Similar yield and an unchanged dr were obtained for **6a** (Scheme 5A). We then explored the functionalization of **6a–c**. The ester group of **6a** can be reduced using DIBAL-H, giving **12** in 94% yield. Reductive naphthalene/lithium conditions were then applied on **12**, and amino alcohol **13** was obtained in quantitative yield. A PDC oxidation of **6a** led to the corresponding indole **14** with 93% yield. The free indoline adduct **15** could be obtained either from **6b** using palladium and 1,3-dimethylbarbituric acid in



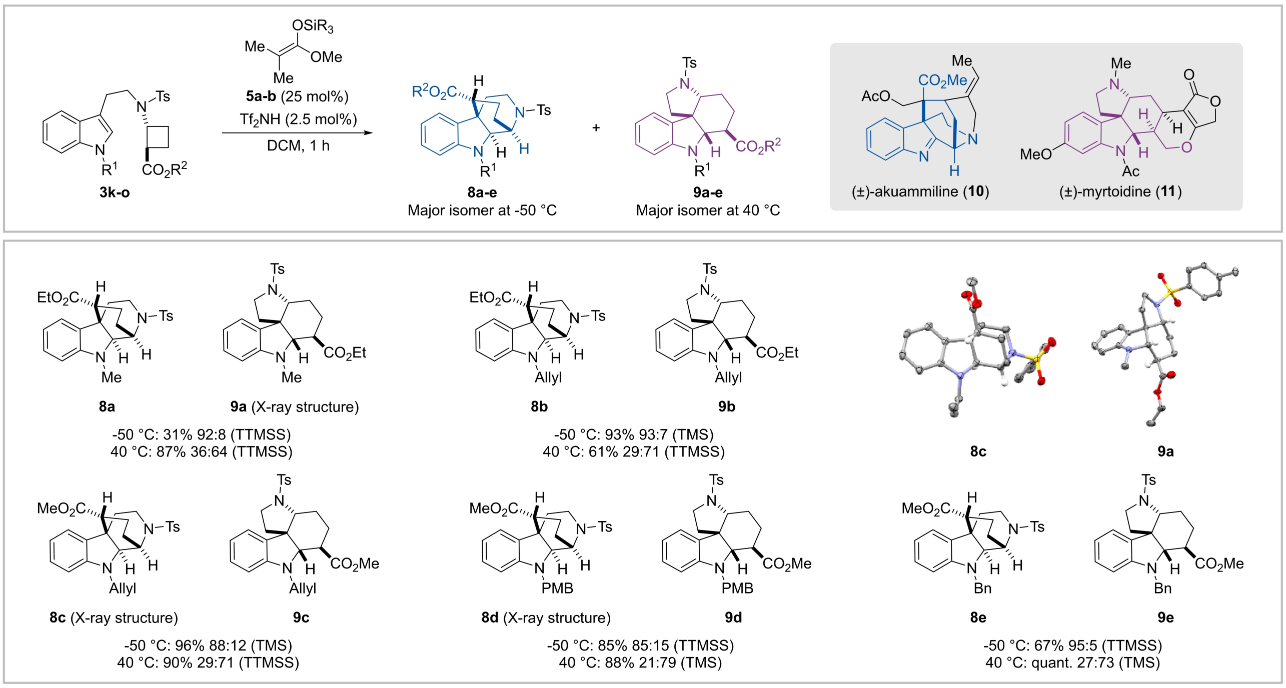
Scheme 3. Scope of the intermolecular (4+2) annulation. For the X-ray structures of **6g** and **6′g** the H atoms not involved in stereocenters are omitted for clarity; thermal ellipsoids given at 50% probability. General conditions: 0.30 mmol (1.0 equiv) cyclobutane **3**, 0.32 mmol (1.05 equiv) indole **4**, 25 mol% silyl ketene acetal **5**, 2.5 mol% Tf_2NH, DCM (0.1 M), 40 °C, 1 h. [a] Overnight reaction. [b] Product obtained as an inseparable mixture with **3a–h** (9 to 30 mol%).

ethanol at 80 °C (95 % yield) or from **6c** using thiophenol in TFA at 60 °C (74 % yield). The allyl group of the tetracycle **8c** was removed using the same condition than for **6b** and **16** was obtained in 98 % yield. In all cases, the relative configuration remained unchanged.

The use of our developed methodologies allowed us to shorten the total synthesis of 11-demethoxy-*epi*-myrtoidine (**17**) previously described by the group of Tang (Scheme 5B).[24] Starting from the same intermediate **2o**, the indole-cyclobutane **3o** was obtained in 43 % yield. Intermediate **9d**, obtained after the silylium catalyzed annulation in quantitative yield and 73:27 isomer ratio, has been converted into the *malagasy* alkaloid **17** in 12 steps by Tang's and co-worker procedure.[24] Overall, our approach allowed us to access intermediate **9d** in two steps instead of four.

Gas chromatography monitoring of the intermolecular annulation reaction between **4a** and **3a** at 40 °C revealed that full conversion is achieved after 15 minutes of reaction, whereas the dr continued to increase and reached a plateau after 1 hour of reaction, indicating a thermodynamic control of the diastereoisomeric ratio (see Supporting Information for details). We then subjected the minor diastereoisomer **6′a** to the reaction conditions and a 91:9 mixture of **6a**:**6′a** was obtained after 1 hour (Scheme 6A). This confirmed that epimerization of the product was possible under the reaction conditions, probably via silylium promoted epimerization of the stereocenter in the α position to the ester group.

Concerning the mechanism of the reaction, a similar proposal as in our previous work[5] could be made. After in situ proto-desilylation of the silyl ketene acetal,[6b,25] ring opening of the cyclobutane **3a** and silylation of the ester would lead to iminium **A** (Scheme 6B). The indole **4a** would then attack the iminium with its most nucleophilic C-3 position giving iminium **B**. The 6-membered ring would be closed through a Mannich reaction, leading to a mixture of



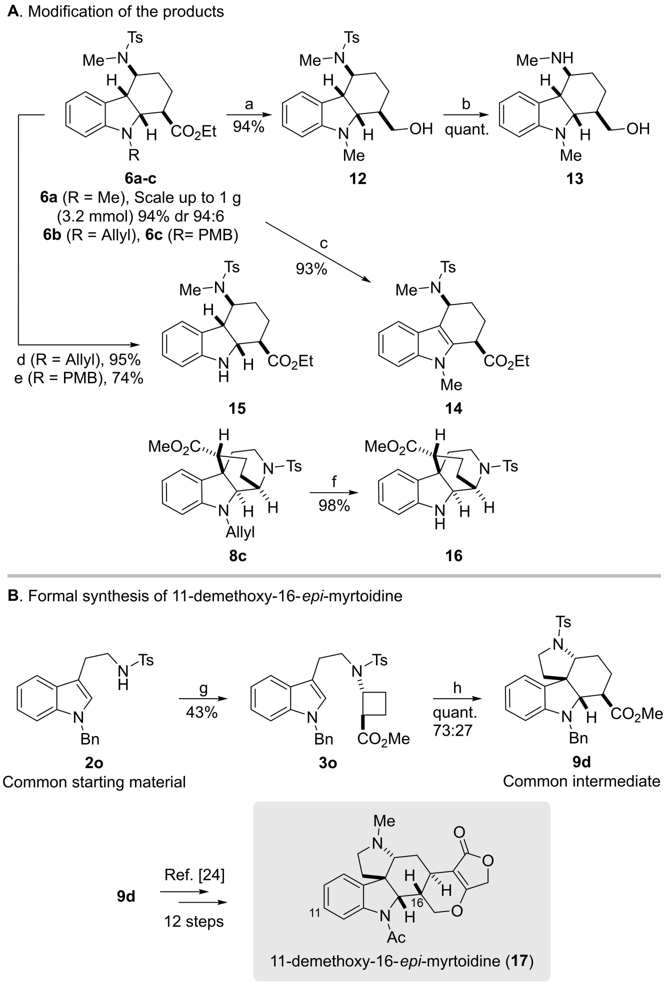
Scheme 4. Scope of the intramolecular (4+2) annulation. For the X-ray structures of **8c** and **9a** the H atoms not involved in stereocenters are omitted for clarity; thermal ellipsoids given at 50% probability. General conditions: 0.30 mmol (1.0 equiv) indole-cyclobutane **3**, 25 mol% silyl ketene acetal **5**, 2.5 mol% Tf_2NH, DCM (0.1 M), 1 h.

6a and **6′a**. Finally, thermodynamic equilibrium between **6a** and **6′a** would establish the dr.

For the intramolecular case, when the major isomer obtained at −50 °C (**8a**) was submitted to the reaction conditions at 40 °C for one hour, no conversion into **9a** was observed, suggesting that no thermodynamic equilibrium takes place in this case between the two final products. In order to better understand the selectivity switch observed with the variation of temperature, we turned to computational chemistry. To achieve a more accurate energetic picture of the reaction mechanism, we employed a computational pipeline[26] that leverages the graph-based based Molassembler library[27] in which multiple conformers of each intermediate and transition state were computed at the M06-2X[28]/def2-TZVP[29]//M06-2X/def2-SVP level and the final free energies of each intermediate/TS Boltzmann weighted (see Supporting Information for additional details). This computational protocol was performed for the reaction of **3k** with TMS as a silylium source starting with intermediate **A** obtained after opening of the cyclobutane (Scheme 7). The *Z* silyl enol ether of **A** was found to be more stable by computation and was therefore used as a starting point. An irreversible exothermic iminium formation followed by C-3 attack from the indole moiety onto the existing iminium leading to intermediate **B** was located with a barrier of 18.0 kcal mol^{-1} (path a). Surprisingly, direct C-2 attack of the indole onto the iminium leading to intermediate **C**, was found to have an even lower barrier of 15.4 kcal mol^{-1} (path b). This contrasts with the higher reactivity of the C-3 position in intermolecular transformations. However, as expected, intermediate **B** is more stable than intermediate **C** ($\Delta\Delta G = 7.2$ kcal mol^{-1}). Interestingly, we were unable to locate the frequently proposed 1,2-shift of the Ciamician-Plancher rearrangement[30] from **B** to **C** in our case. Intermediate **B** undergoes Mannich reaction to close the ring system irreversibly with a barrier of 12.6 kcal mol^{-1}, leading to **9a** as the thermodynamic product ($\Delta G = -37.1$ kcal mol^{-1}). Finally, intermediate **C** can cyclize irreversibly with a barrier of 11.4 kcal mol^{-1} giving **8a** as the kinetic product ($\Delta G = -31.1$ kcal mol^{-1}). Overall, the computed energy profiles qualitatively reproduce the observed experimental results: at low temperature, high selectivity for the kinetic product **8a** is observed due to the faster C-2 attack leading to **C** and the low energy barrier for cyclization. At higher temperature, the pathway leading to more stable intermediate **B** become accessible, leading to product **9a**. Selectivity is lower in this case, probably due to the low energy barrier for both cyclization steps, leading still to formation of the kinetic product **8a** via intermediate **C**.

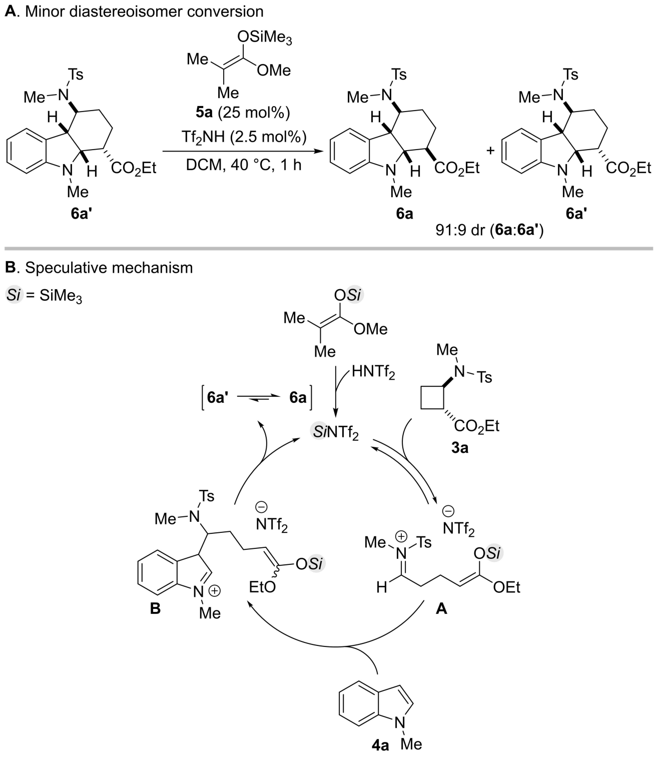
Conclusion

In summary, we have developed a new one-step synthesis to access donor-acceptor aminocyclobutane monoesters. Starting from commercially available bromo cyclobutanes, the desired compounds were obtained after dehydrobromination and Michael addition of a nitrogen nucleophile. Extension of this approach to more complex substituted cyclobutanes is currently ongoing in our laboratory. With these novel donor-acceptor strained rings, a catalytic and diastereoselective (4+2) annulation between donor-acceptor



Scheme 5. A) Reagents and conditions: a) DIBAL–H, THF, 94 %; b) Naphthalene/lithium, THF, quant.; c) PDC, silica gel, DCM, 93 %; d) Pd(PPh$_3$)$_4$, 1,3-dimethylbarbituric acid, EtOH, 80 °C, 95 % e) Thiophenol, TFA, 60 °C, 74 %; f) Pd(PPh$_3$)$_4$, 1,3-dimethylbarbituric acid, EtOH, 80 °C, 98 %. B) Reagents and conditions: g) **1 b**, DBU, DMF, 120 °C, 43 % h) **5 a**, Tf$_2$NH, quant. (73 : 27 isomer ratio).

tosyl protected aminocyclobutane monoesters and indole derivatives was developed. The reaction allowed access to highly functionalized indoline cycloadducts with good yields and selectivity. When applied intramolecularly, the main polycyclic structure of either *akuamma* or *malagasy* alkaloids was accessed selectively depending on the reaction temperature. This surprising outcome could be attributed to a kinetically favored intramolecular C2 attack at low temperature, as supported by computational studies. Therefore, this annulation approach has a high potential for the divergent synthesis of diverse alkaloids starting from simple and commercially available starting materials.[31]



Scheme 6. A) Conversion of the minor diastereoisomer **6′a** into **6 a**. B) Speculative mechanism for the intermolecular (4+2) annulation reaction.

Acknowledgements

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available in the Supporting Information of this article.

Keywords: Alkaloids · Cycloadditions · Cyclobutanes · Donor-Acceptor Systems · Silylium Catalysis

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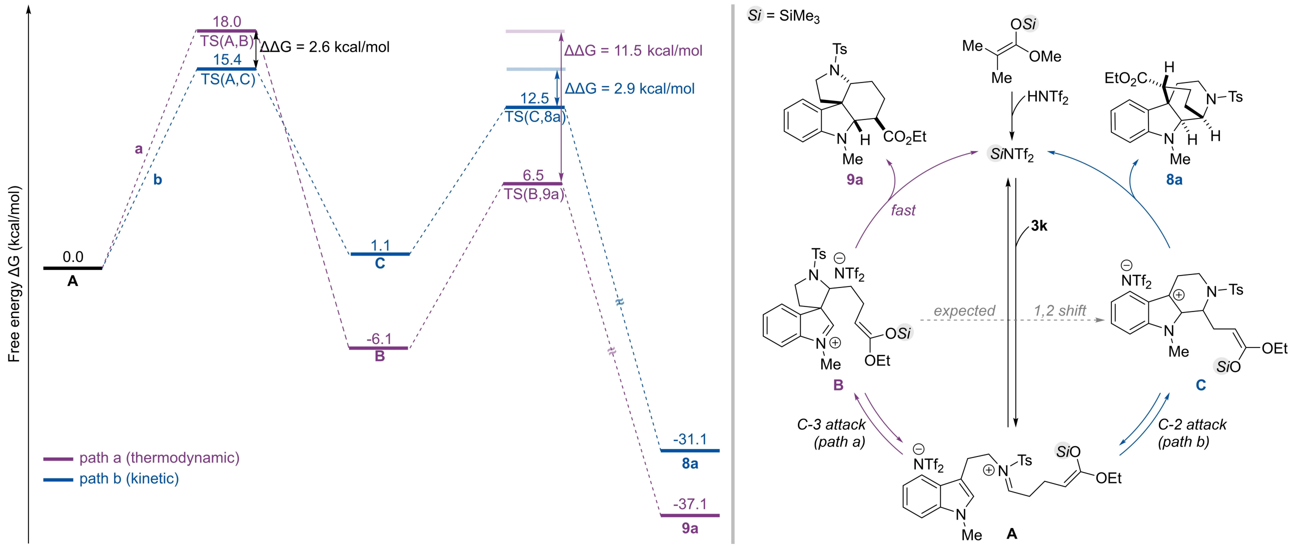

Scheme 7. Reaction free energy profile (313.15 K) at the M06-2X/def2-TZVP//M06-2X/def2-SVP level for the intramolecular (4+2) annulation of **3k** and proposed reaction mechanism.

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[21] Deposition Numbers 2193381 (for **6g**), 2196011 (for **6′g**), 2194477 (for **6j**), 2216802 (for **8c**), 2202396 (for **8d**), and 2201959 (for **9a**) contain the supplementary crystallographic data for this paper. These data are provided free of charge by the joint Cambridge Crystallographic Data Centre and Fachinformationszentrum Karlsruhe Access Structures service.

[22] Except for the model substrate **6a**, the use of the TMS substituted catalyst gave higher yield and the TTMSS substituted catalyst higher diastereoselectivity. Hinderance around the reactive sites (1- and 4- position of the indole, *N*- and ester substitution of the cyclobutane) significantly impacted the yield and decreased the diastereoselectivity. For substitution at the 1- to 4- positions, several conditions were tested and only the best result is reported here. For substitution at the 5- to 7-position, we identified that TTMSS gave a good compromise between yield and selectivity, and it was in some case the only catalyst tested. The scope with the complete set of conditions is available in the Supporting Information. Cyclobutanes **3e**, **3f**, **3i** and **3j** were to able to undergo the (4+2) annulation reaction.

[23] For the intramolecular reactions, both TMS and TTMSS catalysts were tested in every case at −50 °C and 40 °C, the best compromised between yield and selectivity is displayed here for each temperature. The complete set of conditions is available in the Supporting Information.

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Contents

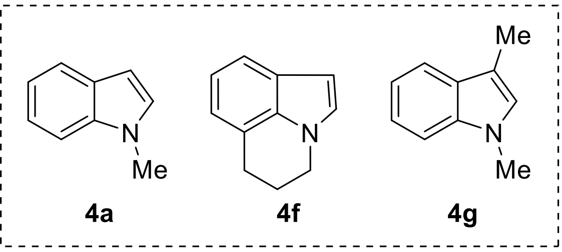
1. Experimental part

All reactions were carried out in oven dried glassware under an atmosphere of nitrogen, unless stated otherwise. For flash chromatography, distilled technical grade solvents were used. CH_2Cl_2 was dried by passage over activated alumina under nitrogen atmosphere (H_2O content < 10 ppm, Karl-Fischer titration). All chemicals were purchased from Acros, Aldrich, Fluka, VWR, TCI, Merck or Bachem and used as such unless stated otherwise. Chromatographic purification was performed as flash chromatography using Macherey-Nagel silica 40-63, 60 Å, using the solvents indicated as eluent with 0.1-0.5 bar pressure. TLC was performed on Merck silica gel 60 F254 TLC aluminum or glass plates and visualized with UV light and para-anysaldehyde stain. ^{1}H-NMR spectra were recorded on a Brucker DPX-400 400 MHz spectrometer in chloroform-*d* or methanol-d_4, all signals are reported in ppm with the internal chloroform signal at 7.26 ppm or the internal methanol signal at 3.31 ppm as standard. The data is being reported as (s = singlet, d = doublet, t= triplet, q = quadruplet, qi = quintet, m = multiplet or unresolved, br = broad signal, app = apparent, coupling constant(s) in Hz, integration, interpretation).^{13}C-NMR spectra were recorded with ^{1}H-decoupling on a Brucker DPX-400 100 MHz spectrometer in chloroform-*d* or methanol-d_4 all signals are reported in ppm with the internal chloroform signal at 77.0 ppm or the internal methanol signal at 49.0 ppm as standard. Melting points were measured on a Büchi B-540 melting point apparatus using open glass capillaries and are uncorrected. Infrared spectra were recorded on a JASCO FT-IR B4100 spectrophotometer with an ATR PRO410-S and a ZnSe prisma and are reported as cm^{-1} (w = weak, m = medium, s = strong, br = broad). High resolution mass spectrometric measurements were performed by the mass spectrometry service of ISIC at the EPFL on a MICROMASS (ESI) Q-TOF Ultima API. A standard data acquisition and instrument control system was utilized (Thermo Scientific) whereas the ion source was controlled by Chipsoft 8.3.1 software (Advion BioScience). Samples were loaded onto a 96-well plate (Eppendorf, Hamburg, Germany) within an injection volume of 5µl. The experimental condition for the ionization voltage was +1.4kV and the gas pressure was set at 0.30 psi. The temperature of ion transfer capillary was 275 °C, tube voltages. FTMS spectra were obtained in the 80-1000 m/z range in the reduce profile mode with a resolution set to 120,000. In all spectra one microscan was acquired with a maximum injection time value of 1000ms. Typical CID experiments were carried out using Normalized collision energy values of 26-28 and 5 Da of isolation width. Gas chromatographic measurements were performed on an Agilent 9000 gas chromatographer using an Agilent 19091J-413-INT (HP-5) column (length: 30 m, diameter: 0.32 mm) and Helium as carrier gas.

1.1. Synthesis of indoles derivatives

Figure 1 discloses the commercially available indoles **4a**, **4f** and **4g**, and the protected indoles already prepared by our group. The data of **4c**, **4d**, **4e**, **4h**, **4j**, **4m**, **4n**, **4m**, **4o**, **4p**, **4r**, **4s** and **4v** are disclosed below and were taken from our original publication.[1,2]

Commercially available



Data see (1) Waser, *Chem. Eur. J.* **2018**, *24* (40), 10049–10053.
(2) Waser, *Chem. Sci.* **2021**, *12* (25), 8706–8712.

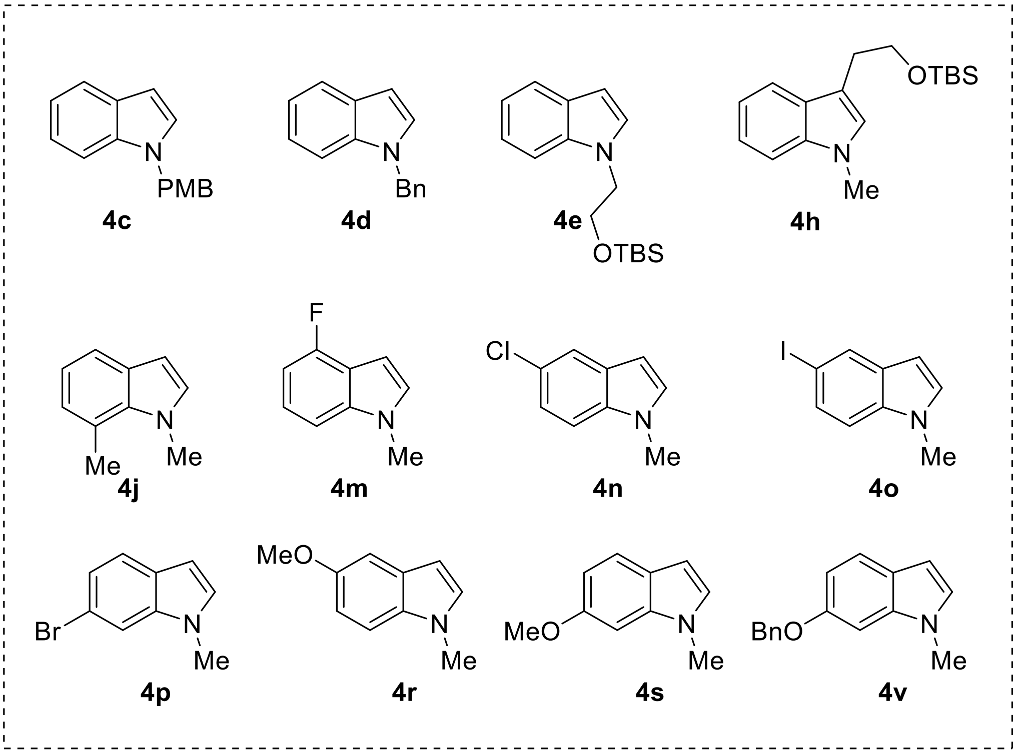


Figure 1: Indole derivatives described by our group.

General procedure (A) for the methylation of indoles

A solution of indole (1.0 equiv.) in anhydrous DMF was added dropwise to a stirred suspension of NaH (60% dispersion in mineral oil, 1.1 to 3.5 equiv.) in DMF at 0 ºC. The mixture was allowed to slowly warm up to rt over 15 min, and iodomethane, allyl bromide, 4-methoxybenzyl bromide or benzyl bromide (1.00 to 1.5 equiv.) was added dropwise at 0 °C. The resulting mixture was then allowed to reach rt and stirred for 1 h. The reaction was then quenched at 0 °C with water and extracted Et_2O. The combined organic layers were washed with water and

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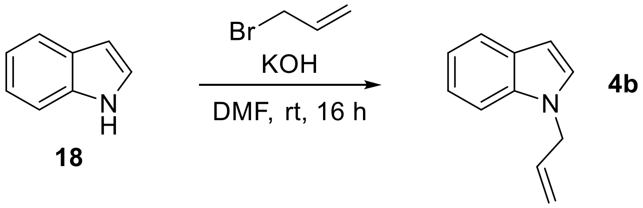
[2] Pirenne, V.; Robert, E. G. L.; Waser, J. Catalytic (3 + 2) Annulation of Donor–Acceptor Aminocyclopropane Monoesters and Indoles. *Chem. Sci.* **2021**, *12* (25), 8706–8712.

LiCl (5%w), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude indole was then purified by flash chromatography.

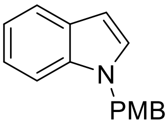
1-Allylindole (4b)



Prepared according to a reported procedure,[3] indole (1.50 g, 12.6 mmol, 1.00 equiv.) was diluted with dry DMF (15.0 mL) and KOH (847 mg, 15.1 mmol, 1.20 equiv.) was added followed by allyl bromide (1.98 g, 16.4 mmol, 1.30 equiv.). The reaction was stirred 16 h at rt. The mixture was diluted with Et_2O (30 mL) and washed with brine (2 x 25mL). The organic layer was dried over $MgSO_4$, filtered, and and concentrated under reduced pressure. The crude indole was then purified by flash chromatography using pent/Et_2O 99:1 to afford **4b** as a yellow oil (1.84 g, 11.7 mmol, 93% yield).

Rf (pent/Et_2O 98:2): 0.74.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.66 (d, *J* = 7.9 Hz, 1H, Ar*H*), 7.35 (d, *J* = 7.8 Hz, 1H, Ar*H*), 7.25 – 7.19 (m, 1H, Ar*H*), 7.17 – 7.09 (m, 2H, Ar*H*), 6.56 – 6.51 (m, 1H, Ar*H*), 6.02 (ddt, *J* = 17.0, 10.6, 5.4 Hz, 1H, $NCH_2C\mathit{H}CH_2$), 5.22 (dd, *J* = 10.3, 1.3 Hz, 1H, $NCH_2CHC\mathit{H_2}$), 5.11 (dq, *J* = 17.1, 1.7 Hz, 1H, $NCH_2CHC\mathit{H_2}$), 4.75 (dt, *J* = 5.4, 1.6 Hz, 2H, $NC\mathit{H_2}CHCH_2$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 136.2, 133.6, 128.8, 127.9, 121.6, 121.1, 119.5, 117.4, 109.7, 101.5, 49.0.
NMR spectra are in agreement with the reported data.[3]

1-(4-Methoxybenzyl)-1H-indole (4c)



Prepared according to the general procedure A from indole (0.13 g, 1.1 mmol, 1.0 equiv.), NaH (52 mg, 1.3 mmol, 1.2 equiv.) and 4-methoxybenzyl bromide (0.19 mL, 1.3 mmol, 1.2 equiv.) in DMF (5.4 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4c** as a colorless oil (195 mg, 822 µmol, 75%).

Rf (pent/Et_2O 9:1): 0.90.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.69 – 7.66 (m, 1H, Ar*H*), 7.33 (d, *J* = 8.2 Hz, 1H, Ar*H*), 7.23 – 7.07 (m, 5H, Ar*H*), 6.88 – 6.82 (m, 2H, Ar*H*), 6.58 – 6.55 (m, 1H, Ar*H*), 5.27 (s, 2H, $C\mathit{H_2}$), 3.79 (s, 3H, $C\mathit{H_3}$).
^{13}C NMR (101 MHz, chloroform-*d*): δ 159.2, 136.3, 129.6, 128.9, 128.3, 128.2, 121.7, 121.1, 119.6, 114.2, 109.8, 101.6, 55.4, 49.7.
NMR spectra are in agreement with the reported data.[2]

1-Benzylindole (4d)

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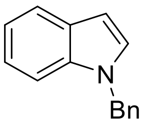
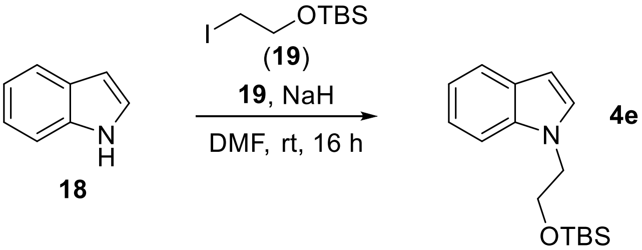


Prepared according to the general procedure A from indole (2.0 g, 17 mmol, 1.0 equiv.), NaH (1.0 g, 26 mmol, 1.5 equiv.) and benzyl bromide (2.5 mL, 20 mmol, 1.2 equiv.) in DMF (34 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 97:3 to afford **4d** as a beige solid (3.2 g, 15 mmol, 89%).

Rf (pent/Et_2O 9:1): 0.91.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.68 – 7.63 (m, 1H, Ar*H*), 7.40 – 7.22 (m, 4H, Ar*H*), 7.21 – 7.08 (m, 5H, Ar*H*), 6.56 (d, *J* = 3.1 Hz, 1H, Ar*H*), 5.34 (s, 2H, CH_2).
^{13}C NMR (101 MHz, chloroform-*d*) δ 137.7, 136.4, 128.9, 128.4, 127.7, 126.9, 121.8, 121.1, 119.7, 109.8, 101.8, 50.2.
NMR spectra are in agreement with the reported data.[2]

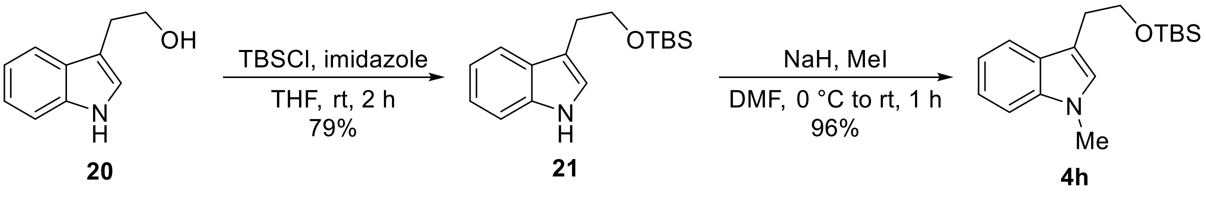
1-(2-((tert-Butyldimethylsilyl)oxy)ethyl)-indole (4e)



Prepared according to the general procedure A from indole (0.20 g, 1.7 mmol, 1.0 equiv.), NaH (60% dispersion in mineral oil) (75 mg, 1.9 mmol, 1.1 equiv.) and iodide **19** (0.54 g, 1.9 mmol, 1.1 equiv.) in DMF (5.7 mL) for 16 h. The crude was purified by flash chromatography using pent/Et_2O 97:3 to afford **4e** as a colorless oil (396 mg, 1.44 mmol, 84%).

Rf (pent/Et_2O 9:1): 0.79.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.66 – 7.63 (m, 1H, Ar*H*), 7.37 (d, *J* = 8.2 Hz, 1H, Ar*H*), 7.22 (ddd, *J* = 8.2, 7.0, 1.2 Hz, 1H, Ar*H*), 7.16 (d, *J* = 3.0 Hz, 1H, Ar*H*), 7.12 (ddd, *J* = 7.9, 7.0, 1.0 Hz, 1H, Ar*H*), 6.51 (d, *J* = 2.9 Hz, 1H, Ar*H*), 4.25 (t, *J* = 5.7 Hz, 2H, CH_2), 3.94 (t, *J* = 5.7 Hz, 2H, CH_2), 0.86 (s, 9H, SiC(CH_3)$_3$), -0.10 (s, 6H, Si(CH_3)$_2$).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully resolved): δ 136.2, 128.8 (2C), 121.4, 121.0, 119.3, 109.4, 101.1, 62.5, 48.8, 26.0, 18.4, -5.5.
NMR spectra are in agreement with the reported data.[2]

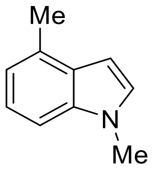
3-(2-((tert-Butyldimethylsilyl)oxy)ethyl)-1-methylindole (4h)



Tryptophol (0.50 g, 3.1 mmol, 1.0 equiv.) was dissolved in dry THF (10 mL). Imidazole (232 mg, 3.41 mmol, 1.10 equiv.) and *tert*-butylchlorodimethylsilane (514 mg, 3.41 mmol, 1.10 equiv.) were added in one portion at rt. The reaction mixture was stirred at rt for 2 h and was diluted with EtOAc. The organic layer was washed with water and brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The yellow oil was purified by flash chromatography using pent/Et_2O 90:10 to afford **21** as a colorless oil which was used directly in the next step. According to the general procedure **A** from **21** (672 mg, 2.44 mmol, 1.00 equiv.), NaH (107 mg, 2.68 mmol, 1.10 equiv.) and iodomethane (167 µL, 2.68 mmol, 1.10 equiv.) in DMF (8 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 98:2 to afford **4h** as a colorless oil (675 mg, 2.33 mmol, 75% for two steps).

Rf (pent/Et_2O 9:1): 0.79.
^1H NMR (400 MHz, chloroform-*d*): δ 7.59 (*d*, *J* = 7.9 Hz, 1H, Ar*H*), 7.28 (*d*, *J* = 8.3 Hz, 1H, Ar*H*), 7.21 (t, *J* = 7.6 Hz, 1H, Ar*H*), 7.10 (t, *J* = 7.4 Hz, 1H, Ar*H*), 6.89 (s, 1H, Ar*H*), 3.86 (t, *J* = 7.5 Hz, 2H, OCH_2), 3.74 (s, 3H, NCH_3), 2.98 (t, *J* = 7.5 Hz, 2H, OCH_2CH_2), 0.91 (s, 9H, $SiC(CH_3)_3$), 0.04 (s, 6H, $Si(CH_3)_2$).
^1H NMR spectrum is in agreement with the reported data.[2]

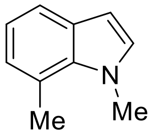
1,4-Dimethylindole (4i)



Prepared according to the general procedure A from 4-methylindole (400 mg, 3.05 mmol, 1.00 equiv.), NaH (146 mg, 3.66 mmol, 1.20 equiv.) and iodomethane (199 µL, 3.20 mmol, 1.05 equiv.) in DMF (8 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4i** as a brown oil (432 mg, 2.98 mmol, 98% yield).

Rf (pent/Et_2O 9:1): 0.79.
^1H NMR (400 MHz, chloroform-*d*) δ 7.22 – 7.12 (m, 2H, Ar*H*), 7.06 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.95 – 6.90 (m, 1H, Ar*H*), 6.51 (dd, *J* = 3.1, 0.8 Hz, 1H, Ar*H*), 3.80 (s, 3H, NCH_3), 2.57 (s, 3H, CCH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 136.5, 130.5, 128.5, 128.3, 121.8, 119.6, 106.9, 99.5, 33.1, 18.9.
NMR spectra are in agreement with the reported data.[4]

1,7-Dimethyl-1H-indole (4j)



Prepared according to the general procedure A from 7-methylindole (400 mg, 3.05 mmol, 1.00 equiv.), NaH (146 mg, 3.66 mmol, 1.20 equiv.) and iodomethane (199 µL, 3.20 mmol, 1.05 equiv.) in DMF (8 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4j** as a colorless oil (440 mg, 3.03 mmol, quant.).

Rf (pent/Et_2O 9:1): 0.79.
^1H NMR (400 MHz, chloroform-*d*): δ 7.50 – 7.43 (m, 1H, Ar*H*), 7.02 – 6.89 (m, 3H, Ar*H*), 6.47 – 6.41 (m, 1H, Ar*H*), 4.07 (s, 3H, NCH_3), 2.78 (s, 3H, CCH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 135.5, 130.5, 129.7, 124.3, 121.3, 119.7, 119.2, 101.0, 36.9, 19.8.
NMR spectra are in agreement with the reported data.[2]

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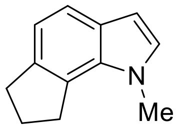
[4] Kim, J.; Kim, H.; Chang, S. Copper-Mediated Selective Cyanation of Indoles and 2-Phenylpyridines with Ammonium Iodide and DMF. *Org. Lett.* **2012**, *14* (15), 3924–3927.

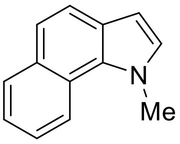
1-Methyl-1,6,7,8-tetrahydrocyclopenta[g]indole (4k)



Prepared according to the general procedure A from 7-methylindole (400 mg, 2.54 mmol, 1.00 equiv.), NaH (122 mg, 3.05 mmol, 1.20 equiv.) and iodomethane (166 µL, 2.67 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4k** as a brownish solid (383 mg, 2.24 mmol, 88% yield).

Rf (pent/Et_2O 98:2): 0.42.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.41 (d, *J* = 8.0 Hz, 1H, Ar*H*), 7.00 (d, *J* = 8.0 Hz, 1H, Ar*H*), 6.91 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.43 (d, *J* = 3.1 Hz, 1H, Ar*H*), 3.96 (s, 3H, NCH_3), 3.39 (t, *J* = 7.4 Hz, 2H, CH_2), 3.01 (t, *J* = 7.3 Hz, 2H, CH_2), 2.19 (p, *J* = 7.4 Hz, 2H, CH_2).
^{13}C NMR (101 MHz, chloroform-*d*) δ 138.6, 134.2, 128.8, 127.9, 125.2, 119.2, 116.7, 101.4, 35.2, 32.9, 31.5, 25.6.
NMR spectra are in agreement with the reported data.[5]

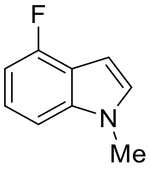
1-Methylbenz[g]indole (4l)



Prepared according to the general procedure A from 1H-benz[g]indole (400 mg, 2.54 mmol, 1.00 equiv.), NaH (122 mg, 3.05 mmol, 1.20 equiv.) and iodomethane (166 µL, 2.67 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4l** as a brown solid (425 mg, 2.35 mmol, 98% yield).

Rf (pent/Et_2O 98:2): 0.45.
^{1}H NMR (400 MHz, chloroform-*d*) δ 8.49 (dd, *J* = 8.5, 1.1 Hz, 1H, Ar*H*), 7.98 – 7.91 (m, 1H, Ar*H*), 7.70 (d, *J* = 8.6 Hz, 1H, Ar*H*), 7.57 – 7.48 (m, 2H, Ar*H*), 7.43 (ddd, *J* = 8.1, 6.9, 1.2 Hz, 1H, Ar*H*), 7.07 (d, *J* = 3.0 Hz, 1H, Ar*H*), 6.61 (d, *J* = 2.9 Hz, 1H, Ar*H*), 4.31 (s, 3H, NCH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 131.5, 130.1, 129.3, 129.2, 125.9, 125.3, 123.5, 123.4, 121.2, 121.0, 120.7, 102.2, 38.7.
NMR spectra are in agreement with the reported data.[6]

4-Fluoro-1-methylindole (4m)



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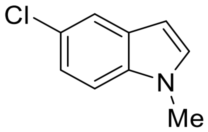
[5] Zhang, C.; Santiago, C. B.; Crawford, J. M.; Sigman, M. S. Enantioselective Dehydrogenative Heck Arylations of Trisubstituted Alkenes with Indoles to Construct Quaternary Stereocenters. *J. Am. Chem. Soc.* **2015**, *137* (50), 15668–15671.

[6] Zhou, B.; Chen, Z.; Yang, Y.; Ai, W.; Tang, H.; Wu, Y.; Zhu, W.; Li, Y. Redox-Neutral Rhodium-Catalyzed C-H Functionalization of Arylamine N-Oxides with Diazo Compounds: Primary C(Sp3)-H/C(Sp2)-H Activation and Oxygen-Atom Transfer. *Angew. Chem.* **2015**, *127* (41), 12289–12294.

Prepared according to the general procedure A from 4-fluoroindole (303 mg, 2.24 mmol, 1.00 equiv.), NaH (108 mg, 2.69 mmol, 1.20 equiv.) and iodomethane (147 µL, 2.35 mmol, 1.05 equiv.) in DMF (5.6 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 97:3 to afford **4m** as a colorless oil (291 mg, 1.95 mmol, 87%).

Rf (pent/Et_2O 9:1): 0.79.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.21 – 7.11 (m, 2H, Ar*H*), 7.04 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.83 (ddd, *J* = 10.4, 7.5, 1.1 Hz, 1H, Ar*H*), 6.62 (dd, *J* = 3.1, 0.8 Hz, 1H, Ar*H*), 3.80 (s, 3H, NCH_3).
^{13}C NMR (101 MHz, chloroform-*d*): δ 156.5 (d, *J* = 246.8 Hz), 139.5 (d, *J* = 11.7 Hz), 128.8, 122.1 (d, *J* = 7.8 Hz), 117.5 (d, *J* = 22.6 Hz), 105.5 (d, *J* = 3.6 Hz), 104.2 (d, *J* = 19.1 Hz), 97.1, 33.2.
^{19}F NMR (376 MHz, chloroform-*d*) δ -122.2 – -122.3 (m).
NMR spectra are in agreement with the reported data.[2]

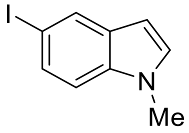
5-Chloro-1-methyl-1H-indole (4n)



Prepared according to the general procedure A from 5-chloroindole (445 mg, 2.94 mmol, 1.00 equiv.), NaH (141 mg, 3.52 mmol, 1.20 equiv.) and iodomethane (192 µL, 3.08 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4n** as a colorless oil (432 mg, 2.61 mmol, 89%).

Rf (pent/Et_2O 9:1): 0.67.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.58 (d, *J* = 2.0 Hz, 1H, Ar*H*), 7.23 (d, *J* = 8.7 Hz, 1H, Ar*H*), 7.17 (dd, *J* = 8.7, 2.0 Hz, 1H, Ar*H*), 7.07 (d, *J* = 3.0 Hz, 1H, Ar*H*), 6.42 (d, *J* = 3.0 Hz, 1H, Ar*H*), 3.78 (s, 3H, CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 135.2, 130.2, 129.5, 125.2, 121.9, 120.3, 110.3, 100.7, 33.1.
NMR spectra are in agreement with the reported data.[2]

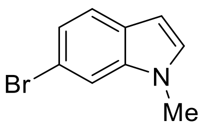
5-iodo-1-methylindole (4o)



Prepared according to the general procedure A from 5-iodo-1H-indole (400 mg, 1.65 mmol, 1.00 equiv.), NaH (79.0 mg, 1.97 mmol, 1.20 equiv.) and iodomethane (108 µL, 1.73 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 98:2 to afford **4o** as an orange liquid (419 mg, 1.63 mmol, 99% yield).

Rf (pent/Et_2O 9:1): 0.70.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.96 (d, *J* = 1.7 Hz, 1H, Ar*H*), 7.46 (dd, *J* = 8.6, 1.7 Hz, 1H, Ar*H*), 7.10 (d, *J* = 8.6 Hz, 1H, Ar*H*), 7.01 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.41 (dd, *J* = 3.1, 0.9 Hz, 1H, Ar*H*), 3.77 (s, 3H, NCH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 135.9, 131.1, 129.9, 129.8, 129.7, 111.4, 100.4, 83.0, 33.1.
NMR spectra are in agreement with the reported data.[1]

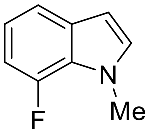
6-Bromo-1-methyl-1H-indole (4p)



Prepared according to the general procedure A from 6-bromo-1H-indole (266 mg, 1.36 mmol, 1.00 equiv.), NaH (65 mg, 1.6 mmol, 1.2 equiv.) and iodomethane (88 µL, 1.42 mmol, 1.05 equiv.) in DMF (3 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4p** as a colorless oil (246 mg, 1.17 mmol, 84%).

Rf (pent/Et_2O 9:1): 0.71.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.53 – 7.46 (m, 2H, Ar*H*), 7.26 – 7.19 (m, 1H, Ar*H*), 7.03 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.47 (d, *J* = 3.0 Hz, 1H, Ar*H*), 3.75 (s, 3H, C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*): δ 137.6, 129.6, 127.4, 122.6, 122.2, 115.2, 112.4, 101.3, 33.0.
NMR spectra are in agreement with the reported data.[2]

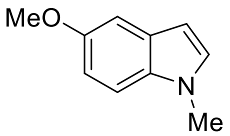
7-fluoro-1-methylindole (4q)



Prepared according to the general procedure A from 5-iodo-1H-indole (400 mg, 2.96 mmol, 1.00 equiv.), NaH (79.0 mg, 1.97 mmol, 1.20 equiv.) and iodomethane (108 µL, 1.73 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 98:2 to afford **4q** as brown oil (427 mg, 2.86 mmol, 97% yield).

Rf (pent/Et_2O 9:1): 0.79.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.35 (d, *J* = 7.9 Hz, 1H, Ar*H*), 7.06 – 6.91 (m, 2H, Ar*H*), 6.85 (dd, *J* = 12.7, 7.8 Hz, 1H, Ar*H*), 6.47 (t, *J* = 2.8 Hz, 1H, Ar*H*), 4.00 (d, *J* = 1.8 Hz, 3H, NC*H*$_3$).
^{13}C NMR (101 MHz, CDCl3) δ 150.6 (d, *J* = 243.3 Hz), 132.8 (d, *J* = 5.5 Hz), 130.5, 124.8 (d, *J* = 9.9 Hz), 119.7 (d, *J* = 6.6 Hz), 116.8 (d, *J* = 3.3 Hz), 107.1 (d, *J* = 17.6 Hz), 101.8 (d, J = 1.7 Hz), 35.8 (d, *J* = 5.1 Hz).
^{19}F NMR (376 MHz, chloroform-*d*) δ -137.0 (d, *J* = 12.6 Hz).
NMR spectra are in agreement with the reported data.[7]

5-Methoxy-1-methyl-1H-indole (4r)



Prepared according to the general procedure A from 6-methoxyindole (400 mg, 2.72 mmol, 1.00 equiv.), NaH (130 mg, 3.26 mmol, 1.20 equiv.) and iodomethane (178 µL, 2.85 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4r** as a yellow solid (362 mg, 2.25 mmol, 83% yield).

Rf (pent/Et_2O 98:2): 0.40.

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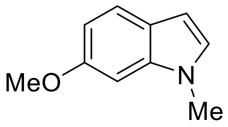
[7] Cheng, H.-G.; Pu, M.; Kundu, G.; Schoenebeck, F. Selective Methylation of Amides, N-Heterocycles, Thiols, and Alcohols with Tetramethylammonium Fluoride. *Org. Lett.* **2020**, *22* (1), 331–334.

^{1}H NMR (400 MHz, chloroform-*d*) δ 7.22 (d, *J* = 8.8 Hz, 1H, Ar*H*), 7.10 (d, *J* = 2.5 Hz, 1H, Ar*H*), 7.03 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.90 (dd, *J* = 8.8, 2.5 Hz, 1H, Ar*H*), 6.41 (dd, *J* = 3.0, 0.9 Hz, 1H, Ar*H*), 3.86 (s, 3H, OC*H₃*), 3.77 (s, 3H, NC*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 154.1, 132.3, 129.4, 128.9, 112.0, 110.0, 102.6, 100.5, 56.0, 33.1.
NMR spectra are in agreement with the reported data.[1]

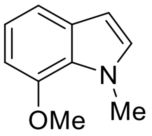
6-Methoxy-1-methyl-1H-indole (4s)



Prepared according to the general procedure A from 6-methoxyindole (400 mg, 2.72 mmol, 1.00 equiv.), NaH (130 mg, 3.26 mmol, 1.20 equiv.) and iodomethane (178 µL, 2.85 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4s** as a colorless oil (356 mg, 2.21 mmol, 81%).

Rf (pent/Et_2O 9:1): 0.45.
^{1}H NMR (400 MHz, chloroform-*d*): δ 7.51 – 7.47 (m, 1H, Ar*H*), 6.95 (s, 1H, Ar*H*), 6.81 – 6.77 (m, 2H, Ar*H*), 6.41 (brs, 1H, Ar*H*), 3.89 (s, 3H, OC*H₃*), 3.74 (s, 3H, NC*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 156.4, 137.5, 127.9, 122.9, 121.6, 109.4, 100.9, 92.9, 55.9, 33.0.
NMR spectra are in agreement with the reported data.[2]

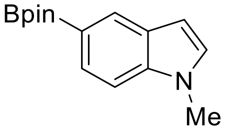
6-Methoxy-1-methyl-1H-indole (4t)



Prepared according to the general procedure A from 7-methoxyindole (400 mg, 2.72 mmol, 1.00 equiv.), NaH (130 mg, 3.26 mmol, 1.20 equiv.) and iodomethane (178 µL, 2.85 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **4t** as a brown solid (429 mg, 2.66 mmol, 98% yield).

Rf (pent/Et_2O 9:1): 0.45.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.20 (dd, *J* = 8.0, 0.9 Hz, 1H, Ar*H*), 6.97 (t, *J* = 7.8 Hz, 1H, Ar*H*), 6.92 (d, *J* = 3.0 Hz, 1H, Ar*H*), 6.61 (d, *J* = 7.7 Hz, 1H, Ar*H*), 6.41 (d, *J* = 3.0 Hz, 1H, Ar*H*), 4.06 (s, 3H, OC*H₃*), 3.93 (s, 3H, NC*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 148.0, 131.0, 129.9, 126.6, 119.9, 113.9, 102.3, 101.1, 55.5, 36.7.
NMR spectra are in agreement with the reported data.[8]

1-Methyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)indole (4u)



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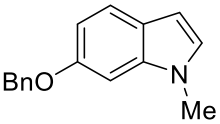
[8] Gray, V. J.; Wilden, J. D. A Selective, Tin-Free Radical Mediated Synthesis of Indoles Based on a Sulfonate Template. *Tetrahedron Lett.* **2012**, *53* (1), 41–44.

Prepared according to the general procedure A from 5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-1H-indole (400 mg, 1.65 mmol, 1.00 equiv.), NaH (79.0 mg, 1.97 mmol, 1.20 equiv.) and iodomethane (108 µL, 1.73 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 98:2 to afford **4u** as brown solid (395 mg, 1.54 mmol, 93% yield).

m.p.: 108-110 °C.
Rf (pent/Et_2O 9:1): 0.79.
^{1}H NMR (400 MHz, chloroform-*d*) δ 8.16 (d, *J* = 1.0 Hz, 1H, Ar*H*), 7.67 (dd, *J* = 8.3, 1.1 Hz, 1H, Ar*H*), 7.32 (dd, *J* = 8.3, 0.9 Hz, 1H, Ar*H*), 7.04 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.51 (dd, *J* = 3.1, 0.9 Hz, 1H, Ar*H*), 3.79 (s, 3H, NC*H₃*), 1.37 (s, 12H, CC*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully resolved) δ 138.8, 129.0, 128.9 (2C), 128.3, 127.8, 108.7, 101.8, 83.5, 33.0, 25.1.
IR (v_{max}, cm^{-1}) 2977 (m), 2925 (m), 1609 (m), 1516 (m), 1439 (m), 1367 (s), 1349 (s), 1301 (m), 1142 (s), 1106 (m), 1069 (m), 964 (m), 857 (s), 756 (m).
HRMS (ESI/QTOF) m/z: $[M + H]^+$ Calcd for $C_{15}H_{21}BNO_2^+$ 258.1660; Found 258.1653.

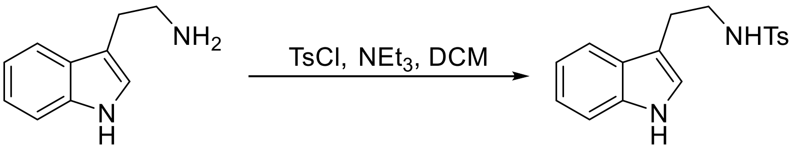
6-Benzoxy-1-methyl-indole (4v)



Prepared according to the general procedure A from 6-benzoxy-1H-indole (400 mg, 1.79 mmol, 1.00 equiv.), NaH (86.0 mg, 2.15 mmol, 1.20 equiv.) and iodomethane (117 µL, 1.88 mmol, 1.05 equiv.) in DMF (7 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 98:2 to afford **4v** as orange solid (393 mg, 1.66 mmol, 92% yield).

Rf (pent/Et_2O 9:1): 0.84.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.54 – 7.45 (m, 3H, Ar*H*), 7.45 – 7.37 (m, 2H, Ar*H*), 7.37 – 7.29 (m, 1H, Ar*H*), 6.95 (d, *J* = 3.1 Hz, 1H, Ar*H*), 6.90 – 6.83 (m, 2H, Ar*H*), 6.42 (dd, *J* = 3.1, 0.8 Hz, 1H, Ar*H*), 5.14 (s, 2H, OC*H₂*), 3.73 (s, 3H, NC*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 155.6, 137.7, 137.5, 128.7, 128.0, 128.0, 127.7, 123.1, 121.6, 110.0, 100.9, 94.5, 70.9, 33.0.
NMR spectra are in agreement with the reported data.[1]

N-[2-(1H-Indol-3-yl)ethyl]-4-methylbenzenesulfonamide (23)



22 **23**

Prepared according to a reported procedure,[9] 2-(1H-indol-3-yl)ethanamine (2.00 g, 12.5 mmol, 1.00 equiv.) was diluted in dry dichloromethane (25.0 mL) and tosyl chloride (2.38 g, 12.5 mmol, 1.00 equiv.) was added at 0 °C followed by N,N-diethylethanamine (1.39 g, 1.91 mL, 13.7 mmol, 1.10 equiv.). The reaction mixture was then stirred at rt for 30 min and quenched with a saturated NH_4Cl. The aqueous layer was exctracted with DCM and the combined

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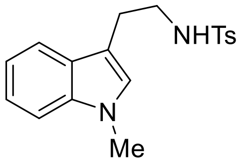
[9] Zhu, J.; Cheng, Y.-J.; Kuang, X.-K.; Wang, L.; Zheng, Z.-B.; Tang, Y. Highly Efficient Formal [2+2+2] Strategy for the Rapid Construction of Polycyclic Spiroindolines: A Concise Synthesis of 11-Demethoxy-16-Epi-Myrtoidine. *Angew. Chem.* **2016**, *128* (32), 9370–9374.

organic layers were washed with water and brine, dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford **23** as a beige solid (3.89 g, 12.4 mmol, 99% yield) which was pure enough without further purification.

^{1}H NMR (400 MHz, chloroform-*d*) δ 8.07 (s, 1H, ${}_{ind}$N*H*), 7.70 – 7.58 (m, 2H, Ar*H*), 7.41 (dq, *J* = 7.9, 0.9 Hz, 1H, Ar*H*), 7.35 (dt, *J* = 8.1, 0.9 Hz, 1H, Ar*H*), 7.24 – 7.16 (m, 3H, Ar*H*), 7.06 (ddd, *J* = 8.0, 7.0, 1.0 Hz, 1H, Ar*H*), 6.97 (d, *J* = 2.4 Hz, 1H, Ar*H*), 4.45 (t, *J* = 6.2 Hz, 1H, N*H*Ts), 3.27 (q, *J* = 6.5 Hz, 2H, $\mathrm{CCH_2C}\mathit{H_2}\mathrm{NHTs}$), 2.93 (td, *J* = 6.7, 0.8 Hz, 2H, $\mathrm{C}\mathit{CH_2}\mathrm{CH_2NHTs}$), 2.40 (s, 3H, $\mathrm{C}\mathit{CH_3}$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 143.4, 136.9, 136.5, 129.8, 127.1, 127.0, 122.7, 122.4, 119.7, 118.6, 111.7, 111.4, 43.2, 25.6, 21.6.
NMR spectra are in agreement with the reported data.[9]

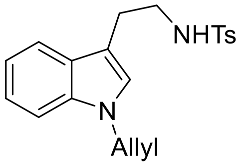
4-Methyl-N-[2-(1-methyl-3-indolyl)ethyl]benzenesulfonamide (2k)



Prepared according to the general procedure A from **23** (3.92 g, 12.5 mmol, 1.00 equiv.), NaH (1.50 g, 37.4 mmol, 3.00 equiv.) and iodomethane (777 µL, 12.5 mmol, 1.00 equiv.) in DMF (40 mL) for 16 h. The crude was purified by flash chromatography using pent/EtOAc 70:30 to afford **2k** as a white solid (393 mg, 1.66 mmol, 92% yield).

Rf (pent/EtOAc 7:3): 0.48.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.66 – 7.61 (m, 2H, Ar*H*), 7.40 (dt, *J* = 7.9, 0.9 Hz, 1H, Ar*H*), 7.30 – 7.27 (m, 1H, Ar*H*), 7.25 – 7.19 (m, 3H, Ar*H*), 7.05 (ddd, *J* = 8.0, 6.9, 1.1 Hz, 1H, Ar*H*), 6.82 (s, 1H, Ar*H*), 4.41 (t, *J* = 6.2 Hz, 1H, N*H*), 3.73 (s, 3H, $\mathrm{N}\mathit{CH_3}$), 3.26 (q, *J* = 6.5 Hz, 2H, $\mathrm{TsNC}\mathit{H_2}\mathrm{CH_2}$), 2.92 (t, *J* = 6.6 Hz, 2H, $\mathrm{TsNCH_2C}\mathit{H_2}$), 2.41 (s, 3H, $\mathrm{C}\mathit{CH_3}$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 143.4, 137.3, 137.0, 129.7, 127.5, 127.4, 127.2, 122.0, 119.2, 118.7, 110.1, 109.5, 43.3, 32.8, 25.5, 21.7.
NMR spectra are in agreement with the reported data.[9]

N-(2-(1-allyl-1H-indol-3-yl)ethyl)-4-methylbenzenesulfonamide (2l)

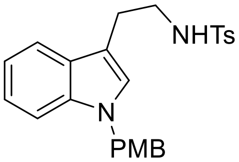


Prepared according to the general procedure A from **23** (5.00 g, 15.9 mmol, 1.00 equiv.), NaH (2.23 g, 55.7 mmol, 3.50 equiv.) and allylbromide (1.37 mL, 15.9 mmol, 1.00 equiv.) in DMF (50 mL) for 16 h. The crude was purified by flash chromatography using pent/EtOAc 90:10 to afford **2l** as an oil (4.17 g, 11.8 mmol, 74% yield).

Rf (pent/EtOAc 7:3): 0.34.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.64 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.40 (d, *J* = 7.9 Hz, 1H, Ar*H*), 7.29 (d, *J* = 8.3 Hz, 1H, Ar*H*), 7.25 – 7.16 (m, 3H, Ar*H*), 7.09 – 7.00 (m, 1H, Ar*H*), 6.86 (s, 1H, Ar*H*), 6.06 – 5.83 (m, 1H, $_{\mathrm{ind}}\mathrm{NCH_2C}\mathit{H}\mathrm{CH_2}$), 5.21 (dq, *J* = 10.2, 1.4 Hz, 1H, $_{\mathrm{ind}}\mathrm{NCH_2CHC}\mathit{H_2}$), 5.10 (dq, *J* = 17.0, 1.6 Hz, 1H, $_{\mathrm{ind}}\mathrm{NCH_2CHC}\mathit{H_2}$), 4.66 (dt, *J* = 5.5, 1.6 Hz, 2H $_{\mathrm{ind}}\mathrm{NC}\mathit{H_2}\mathrm{CHCH_2}$), 4.40 (t, *J* = 5.9 Hz, 1H, TsN*H*), 3.27 (q, *J* = 6.5 Hz, 2H, $\mathrm{TsNHC}\mathit{H_2}$), 2.92 (t, *J* = 6.6 Hz, 2H $\mathrm{TsNHCH_2C}\mathit{H_2}$), 2.40 (s, 3H, $\mathrm{C}\mathit{CH_3}$).

^{13}C NMR (101 MHz, chloroform-*d*) δ 143.4, 137.0, 136.7, 133.5, 129.8, 127.7, 127.2, 126.3, 122.0, 119.3, 118.8, 117.6, 110.6, 109.9, 48.9, 43.3, 25.6, 21.7.
NMR spectra are in agreement with the reported data.[10]

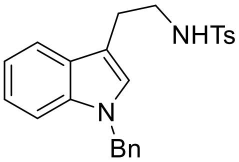
4-Methyl-N-[2-(1-p-anisylindol-3-yl)ethyl]benzenesulfonamide (2n)



Prepared according to the general procedure A from **23** (1.50 g, 4.77 mmol, 1.00 equiv.), NaH (668 mg, 16.7 mmol, 3.50 equiv.) and 4-methoxybenzyl bromide (688 µL, 4.77 mmol, 1.00 equiv.) in DMF (15 mL) for 1 h. The crude was purified by flash chromatography using pent/Et_2O 95:5 to afford **2n** as a colorless oil (1.70 g, 3.91 mmol, 82% yield).

Rf (pent/EtOAc 8:2): 0.29.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.63 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.41 (dt, *J* = 7.9, 1.0 Hz, 1H, Ar*H*), 7.28 (dd, *J* = 8.3, 0.9 Hz, 1H, Ar*H*), 7.22 – 7.14 (m, 3H, Ar*H*), 7.11 – 7.01 (m, 3H, Ar*H*), 6.87 – 6.79 (m, 3H, Ar*H*), 5.17 (s, 2H, NCH_2), 4.42 (t, *J* = 6.1 Hz, 1H, N*H*), 3.78 (s, 3H, OCH_3), 3.27 (q, *J* = 6.5 Hz, 2H, CH_2), 2.98 – 2.82 (m, 2H, CH_2), 2.39 (s, 3H, CCH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 159.3, 143.4, 137.0, 136.9, 129.7, 129.4, 128.4, 127.7, 127.1, 126.5, 122.1, 119.4, 118.9, 114.3, 110.7, 110.0, 55.4, 49.6, 43.3, 25.6, 21.6.
NMR spectra are in agreement with the reported data.[11]

4-Methyl-N-[2-[1-(phenylmethyl)indol-3-yl]ethyl]benzenesulfonamide (2o)



Prepared according to the general procedure A from **23** (4.00 g, 12.7 mmol, 1.00 equiv.), NaH (1.78 g, 44.5 mmol, 3.50 equiv.) and benzyl bromide (2.18 g, 12.7 mmol, 1.00 equiv.) in DMF (40 mL) for 16 h. The crude was purified by flash chromatography using pent/EtOAc 80:20 to afford **2o** as an oil (4.21 g, 10.4 mmol, 82% yield).

Rf (pent/EtOAc 7:3): 0.38.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.63 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.42 (d, *J* = 7.9 Hz, 1H, Ar*H*), 7.34 – 7.24 (m, 4H, Ar*H*), 7.22 – 7.15 (m, 3H, Ar*H*), 7.13 – 7.08 (m, 2H, Ar*H*), 7.08 – 7.02 (m, 1H, Ar*H*), 6.86 (s, 1H, Ar*H*), 5.25 (s, 2H, $_{ind}$NCH_2), 4.40 (t, *J* = 6.0 Hz, 1H, TsN*H*), 3.28 (q, *J* = 6.5 Hz, 2H, TsNCH_2), 2.93 (t, *J* = 6.7 Hz, 2H, TsNCH_2CH_2), 2.39 (s, 3H, CCH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 143.4, 137.5, 137.0, 136.9 129.7, 128.9, 127.8, 127.7, 127.2, 127.0, 126.7, 122.2, 119.4, 118.9, 110.9, 110.0, 50.1, 43.3, 25.6, 21.6.
NMR spectra are in agreement with the reported data.[12]

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[10] Chen, S.-K.; Yang, J.-S.; Dai, K.-L.; Zhang, F.-M.; Zhang, X.-M.; Tu, Y.-Q. Exploration of a KI-Catalyzed Oxidation System for Direct Construction of Bispyrrolidino[2,3-b]Indolines and the Total Synthesis of (+)-WIN 64821. *Chem. Commun.* **2019**, *56* (1), 121–124.

[11] Zheng, N.; Chang, Y.-Y.; Zhang, L.-J.; Gong, J.-X.; Yang, Z. Gold-Catalyzed Intramolecular Tandem Cyclization of Indole-Ynamides: Diastereoselective Synthesis of Spirocyclic Pyrrolidinoindolines. *Chem. Asian J.* **2016**, *11* (3), 371–375.

[12] Wang, H.; Liu, D.; Chen, H.; Li, J.; Wang, D. Z. CuCl2/TBHP-Mediated Direct Chlorooxidation of Indoles. *Tetrahedron* **2015**, *71* (38), 7073–7076.

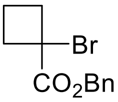
1.2. Synthesis of aminocyclobutane monoesters

The starting materials 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**), 1-bromocyclobutanecarboxylic acid methyl ester (**1b**) and 1-bromocyclobutane-1-carboxylic acid (**24**) were commercially available.

General procedure (B) for the synthesis of bromocyclobutane monoesters

A solution of 1-bromocyclobutane-1-carboxylic acid **24** (1.00 equiv.), benzylalcohol, Weinreb amine or N-methylaniline (1.20 equiv.), EDC·HCl (1.20 equiv.) and DMAP (0.10 equiv.) in DCM was stirred 16 h at rt. The mixture was then washed with water (1 x 50 mL), and the organic layer was dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude bromocyclobutane was purified by flash chromatography.

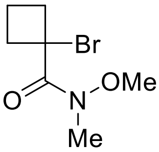
1-Bromocyclobutanecarboxylic acid benzyl ester (1c)



Prepared according to the general procedure B from 1-bromocyclobutane-1-carboxylic acid (150 mg, 838 µmol, 1.00 equiv.), benzylalcohol (109 mg, 1.01 mmol, 1.20 equiv.), EDC·HCl (193 mg, 1.01 mmol, 1.20 equiv.), DMAP (10.2 mg, 83.8 µmol, 0.100 equiv.), and DCM (4.0 mL). The crude product was purified by flash chromatography using pent/EtOAc 98:2 to afford **1c** as an oil (239 mg, 886 µmol, 79% yield).

Rf (pent/EtOAc 96:4): 0.71.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.50 – 7.30 (m, 5H, Ar*H*), 5.24 (s, 2H, OC*H*$_2$Ph), 3.05 – 2.84 (m, 2H, CC*H*$_2$), 2.72 – 2.52 (m, 2H, CC*H*$_2$), 2.33 – 2.10 (m, 1H, CCH$_2$C*H*$_2$), 2.00 – 1.78 (m, 1H, CCH$_2$C*H*$_2$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 171.5, 135.6, 128.7, 128.5, 128.1, 67.7, 54.3, 37.4, 16.9.
IR (ν_{max}, cm^{-1}) 3653 (w), 3454 (w), 2957 (w), 1732 (s), 1289 (s), 1247 (m), 1195 (s), 1122 (s), 1076 (m), 752 (s).
HRMS (Sicrit plasma/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{12}H_{14}{}^{79}BrO_2^+$ 269.0172; Found 269.0172.

1-Bromanyl-N-methoxy-N-methyl-cyclobutane-1-carboxamide (1d)

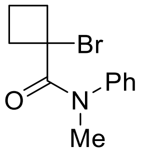


Prepared according to the general procedure B from 1-bromocyclobutane-1-carboxylic acid (300 mg, 1.68 mmol, 1.00 equiv.), methoxy(methyl)amine;hydrochloride (196 mg, 2.01 mmol, 1.20 equiv.), EDC·HCl (386 mg, 2.01 mmol, 1.20 equiv.), DMAP (20.5 mg, 168 µmol, 0.100 equiv.), and DCM (8.0 mL). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **1d** as an oil (267 mg, 1.20 mmol, 72% yield).

Rf (pent/EtOAc 9:1): 0.40.
^{1}H NMR (400 MHz, chloroform-*d*) δ 3.77 (s, 3H, OC*H*$_3$), 3.23 (s, 3H, NC*H*$_3$), 2.96 – 2.85 (m, 2H, CC*H*$_2$), 2.57 – 2.45 (m, 2H, CC*H*$_2$), 2.43 – 2.28 (m, 1H, CCH$_2$C*H*$_2$), 1.86 – 1.69 (m, 1H, CCH$_2$C*H*$_2$).
13C NMR (101 MHz, chloroform-*d*) δ 174.7, 60.6, 57.0, 37.3, 33.3, 16.2.

IR (ν_{max}, cm^{-1}) 3559 (w), 2990 (w), 2939 (m), 1732 (m), 1656 (s), 1418 (m), 1381 (m), 1195 (m), 1094 (m), 988 (s).
HRMS (ESI/QTOF) m/z: $[M + H]^+$ Calcd for $C_7H_{13}{}^{79}BrNO_2^+$ 222.0124; Found 222.0126.

1-Bromo-N-methyl-N-phenylcyclobutane-1-carboxamide (1e)



Prepared according to the general procedure B from 1-bromocyclobutane-1-carboxylic acid (400 mg, 2.23 mmol, 1.00 equiv.), N-methylaniline (263 mg, 2.46 mmol, 1.10 equiv.), EDC·HCl (514 mg, 2.68 mmol, 1.20 equiv.), DMAP (27.3 mg, 223 µmol, 0.100 equiv.), and DCM (11.2 mL). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **1e** as a light-yellow liquid (216 mg, 806 µmol, 72% yield).

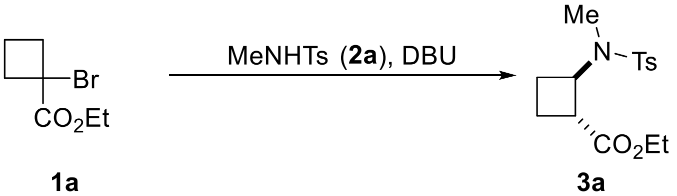
Rf (pent/EtOAc 9:1): 0.20.
^1H NMR (400 MHz, chloroform-*d*) δ 7.54 – 7.29 (m, 5H, Ar*H*), 3.30 (s, 3H, C*H₃*), 2.75 – 2.44 (m, 2H, CC*H₂*), 2.17 (br d, *J* = 10.5 Hz, 1H, CCH_2CH_2), 1.84 (br d, *J* = 12.8 Hz, 2H, CC*H₂*), 1.52 (br d, *J* = 9.6 Hz, 1H, CCH_2CH_2).
^{13}C NMR (101 MHz, chloroform-*d*) δ 170.7, 142.8, 129.3, 128.5, 128.3, 60.7, 39.6, 38.2, 15.7.
IR (ν_{max}, cm^{-1}) 2995 (w), 2954 (w), 1650 (s), 1596 (m), 1497 (m), 1378 (m), 1106 (m), 840 (m), 769 (m), 700 (s).
HRMS (ESI/QTOF) m/z: $[M + H]^+$ Calcd for $C_{12}H_{15}{}^{79}BrNO^+$ 268.0332; Found 268.0340.

1.2.1 Optimization of the reaction

General procedure for reaction optimization

In a sealed vial, 1-bromocyclobutane (**1a**) (1.00 equiv.) was diluted in dry solvent (0.67 mL). N,4-dimethylbenzenesulfonamide (**2a**) and DBU were added at rt. The reaction mixture was then stirred at the indicated temperature and time, cooled to rt, and quenched with 1:1 (v/v) of saturated NH_4Cl and $Na_2S_2O_3$ (10%w) (5 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (3 x 10 mL). The combined organic layers were washed with saturated NH_4Cl (10 mL), LiCl (5%w) (10 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The resulting mixture was analyzed by ^1H NMR (400 MHz, chloroform-*d*) using CH_2Br_2 as an internal standard by integration of the TsNCHC*H* proton.

Optimization Table



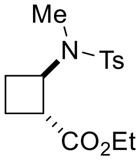
Entry[a]	2a (equiv.)	DBU (equiv.)	Solvent	T °C	Time (h)	NMR Yield[b] (%)
1	4	4	Toluene	110	16	47
2	**1.2**	4	Toluene	110	16	51
3	1.2	**3**	Toluene	110	16	52
4	1.2	3	**DMF**	110	16	83
5	1.2	3	DMF	**120**	16	85 (70)[c]
6	1.2	**1.2**	DMF	120	16	52
7	1.2	3	DMF	120	**6**	76

[a]Reaction conditions: 0.1 mmol (1.0 equiv.) bromocyclobutane (**1a**), 0.15 M. [b]^{1}H NMR of the crude mixture with CH_2Br_2 as an internal standard. [c]Isolated yield.

General procedure (C) for the synthesis of aminocyclobutane monoesters

In sealed vial, 1-bromocyclobutane **1a-e** (1.00 equiv.) was diluted in dry DMF (0.15 M, 2 mL). Amine **2a-o** (1.20 equiv.) and DBU (137 mg, 900 µmol, 3.00 equiv.) were added at rt. The reaction mixture was then stirred at 120 °C for 16 h, cooled to rt, and quenched with 1:1 (v/v) of saturated NH_4Cl and $Na_2S_2O_3$ (10%w) (10 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (3 x 15 mL). The combined organic layers were washed with saturated NH_4Cl (15 mL), LiCl (5%w) (15 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude aminocyclobutane was then purified by flash chromatography.

Ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (3a)



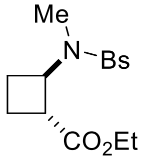
Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 µmol, 1.00 equiv.) and N,4-dimethylbenzenesulfonamide (**2a**) (66.7 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford **3a** as a white solid (65.0 mg, 209 µmol, 70% yield).

A 18 mmol scale up experiment with 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (3.84 g, 18.5 mmol, 1.00 equiv.) was also accomplished using the same procedure and led to **3a** (3.92 g, 12.6 mmol, 68% yield) with similar yield.

m.p.: 67-69 °C.
Rf (pent/EtOAc 9:1): 0.18.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.68 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.30 (d, *J* = 7.8 Hz, 2H, Ar*H*), 4.16 (td, *J* = 8.7, 7.5 Hz, 1H, TsNC*H*), 4.09 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$), 3.23 – 3.14 (m, 1H,

TsNCHC*H*), 2.67 (s, 3H, NC*H₃*), 2.42 (s, 3H, ArC*H₃*), 2.15 – 1.93 (m, 3H, TsNCHC*H₂*C*H₂*CH), 1.87 – 1.76 (m, 1H, TsNCHCH$_2$C*H₂*CH), 1.23 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.0, 143.6, 134.5, 129.7, 127.8, 60.8, 54.8, 44.6, 31.5, 24.8, 21.7, 19.2, 14.3.
IR (ν_{max}, cm^{-1}) 2978 (m), 2957 (m), 1728 (s), 1690 (m), 1598 (m), 1464 (m), 1344 (s), 1250 (m), 1185 (s), 1165 (s), 1090 (m), 1042 (m), 971 (m), 857 (m), 818 (m), 772 (s), 660 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{15}H_{21}NNaO_4S^+$ 334.1084; Found 334.1085.

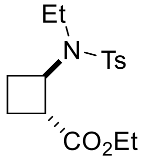
Ethyl 2-((4-bromo-N-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (3b)



Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 μmol, 1.00 equiv.) and 4-bromanyl-N-methyl-benzenesulfonamide (**2b**) (90.0 mg, 360 μmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3b** as an oil (80.0 mg, 213 μmol, 71% yield).

Rf (pent/EtOAc 8:2): 0.45.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 – 7.59 (m, 4H, Ar*H*), 4.18 (td, *J* = 8.9, 7.6 Hz, 1H, BsNC*H*), 4.09 (tdd, *J* = 8.0, 6.7, 0.9 Hz, 2H, OC*H₂*), 3.19 (td, *J* = 9.5, 7.2 Hz, 1H, BsNCHC*H*), 2.69 (s, 3H, BsNC*H₃*), 2.14 – 1.95 (m, 3H, BsNCHC*H₂*C*H₂*CHC(O)), 1.88 – 1.75 (m, 1H, BsNCHCH$_2$C*H₂*CHC(O)), 1.23 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.9, 136.6, 132.4, 129.3, 127.9, 60.9, 54.6, 44.5, 31.4, 24.8, 19.2, 14.3.
IR (ν_{max}, cm^{-1}) 3088 (w), 2986 (w), 2946 (w), 1728 (s), 1574 (m), 1469 (m), 1386 (m), 1346 (s), 1188 (m), 1166 (s), 1145 (m), 1087 (m), 1069 (s), 1040 (m), 1010 (m), 965 (m), 857 (m), 824 (m), 772 (s), 737 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{14}H_{18}{}^{79}BrNNaO_4S^+$ 398.0032; Found 398.0037.

Ethyl 2-((N-ethyl-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (3c)

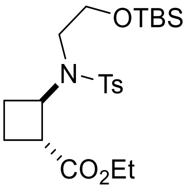


Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 μmol, 1.00 equiv.) and N-ethyl-4-methylbenzenesulfonamide (**2c**) (71.7 mg, 360 μmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3c** as a white solid (46.1 mg, 142 μmol, 47% yield).

m.p.: 52-54°C.
Rf (pent/EtOAc 9:1): 0.26.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.27 (d, *J* = 8.5 Hz, 2H, Ar*H*), 4.29 (q, *J* = 8.9 Hz, 1H, TsNC*H*), 4.08 (q, *J* = 7.1 Hz, 2H, TsNC*H₂*), 3.30 – 3.17 (m, 3H, OC*H₂* + TsNCHC*H*), 2.41 (s, 3H, CC*H₃*), 2.19 – 1.91 (m, 3H, TsNCHC*H₂*C*H₂*CHC(O)), 1.88 – 1.73 (m, 1H, TsNCHCH$_2$C*H₂*CHC(O)), 1.22 (td, *J* = 7.1, 0.7 Hz, 3H, NCH$_2$C*H₃*), 1.15 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.9, 143.2, 137.6, 129.7, 127.4, 60.8, 54.5, 45.8, 40.7, 26.1, 21.6, 19.2, 16.1, 14.3.

IR (ν_{max}, cm^{-1}) 3033 (w), 2919 (w), 2852 (w), 1602 (w), 1496 (w), 1447 (w), 1404 (w), 1321 (s), 1206 (m), 1159 (m), 1139 (m), 1024 (m), 936 (m), 752 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{16}H_{23}NNaO_4S^+$ 348.1240; Found 348.1235.

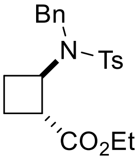
Ethyl 2-((N-(2-((tert-butyldimethylsilyl)oxy)ethyl)-4- methylphenyl) sulfonamido) cyclobutane-1-carboxylate (3d)



Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 µmol, 1.00 equiv.) and N-[2-[tert-butyl(dimethyl)silyl]oxyethyl]-4-methylbenzenesulfonamide (**2d**) (119 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/Et_2O 80:20 to afford **3d** as an oil (57.0 mg, 125 µmol, 42% yield).

Rf (pent/EtOAc 8:2):0.56.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.74 – 7.67 (m, 2H, Ar*H*), 7.30 – 7.26 (m, 2H, Ar*H*), 4.40 – 4.25 (m, 1H, TsNC*H*), 4.07 (q, *J* = 7.1 Hz, 2H, OC*H₂*CH₃), 3.84 – 3.68 (m, 2H, OTBSC*H₂*), 3.38 – 3.06 (m, 3H, OTBSCH₂C*H₂* + TsNCHC*H*C(O)), 2.41 (s, 3H, CC*H₃*), 2.21 – 2.06 (m, 1H, TsNCHC*H₂*CH₂CHC(O)), 2.06 – 1.90 (m, 2H, TsNCHC*H₂*C*H₂*CHC(O)), 1.79 (tdd, *J* = 10.8, 9.8, 8.3 Hz, 1H, TsNCHCH₂C*H₂*CHC(O)), 1.22 (t, *J* = 7.2 Hz, 3H, OCH₂C*H₃*), 0.90 (s, 9H, SiC(C*H₃*)₃), 0.07 (s, 6H, Si(C*H₃*)₂).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.0, 143.4, 136.8, 129.7, 127.5, 63.2, 60.7, 54.9, 47.3, 45.6, 26.1, 25.9, 21.6, 19.0, 18.5, 14.3, -5.2.
IR (ν_{max}, cm^{-1}) 3624 (w), 2957 (m), 2859 (m), 1728 (m), 1471 (w), 1346 (m), 1252 (m), 1195 (m), 1159 (s), 1094 (m), 1090 (s), 836 (s), 813 (s), 773 (s), 759 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{22}H_{37}NNaO_5SSi^+$ 478.2054; Found 478.2066.

2-((N-Benzyl-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (3e)

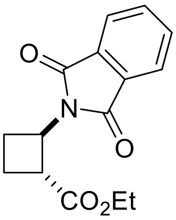


Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 µmol, 1.00 equiv.) and N-benzyl-4-methylbenzenesulfonamide (**2e**) (94.1 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford **3e** as a white solid (77.1 mg, 199 µmol, 66% yield).

m.p.: 77-79 °C
Rf (pent/EtOAc 9:1): 0.31.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.37 – 7.23 (m, 7H, Ar*H*), 4.49 – 4.28 (m, 3H, TsNC*H*Ph + TsNC*H*CHC(O)), 4.01 (q, *J* = 7.1 Hz, 2H, OC*H₂*), 3.11 (q, *J* = 9.3 Hz, 1H, TsNCHC*H*C(O)), 2.43 (s, 3H, CC*H₃*), 2.05 – 1.78 (m, 3H, TsNCHC*H₂*C*H₂*CHC(O)), 1.71 (td, *J* = 10.5, 8.2 Hz, 1H, TsNCHCH₂C*H₂*CHC(O)), 1.18 (t, *J* = 7.1 Hz, 3H, OCH₂C*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.8, 143.5, 138.1, 137.0, 129.8, 128.7, 127.5, 127.4, 127.4, 60.7, 55.1, 49.7, 45.3, 25.9, 21.7, 19.4, 14.2.

IR (ν_{max}, cm^{-1}) 2979 (m), 1728 (s), 1343 (s), 1250 (m), 1189 (s), 1161 (s), 1091 (m), 1040 (m), 662 (s).
HRMS (ESI/QTOF) m/z: $[M + H]^+$ Calcd for $C_{21}H_{26}NO_4S^+$ 388.1577; Found 388.1581.

Ethyl 2-(1,3-dioxoisoindolin-2-yl)cyclobutane-1-carboxylate (3f)

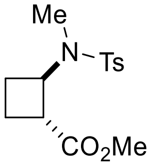


Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 µmol, 1.00 equiv.) and phthalimide (**2f**) (53.0 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3f** as an oil (67.8 mg, 248 µmol, 83% yield).

A 1.2 mmol scale up experiment with 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (256 mg, 1.24 mmol, 1.00 equiv.) was also accomplished using the same procedure and led to **3f** with higher yield (321 mg, 1.17 mmol, 95% yield).

m.p.: 88-90 °C.
Rf (pent/EtOAc 8:2):0.75.
^1H NMR (400 MHz, chloroform-*d*) δ 7.83 (dd, *J* = 5.5, 3.1 Hz, 2H, Ar*H*), 7.71 (dd, *J* = 5.5, 3.0 Hz, 2H, Ar*H*), 4.99 – 4.84 (m, 1H, PhthNC*H*), 4.21 – 3.99 (m, 3H, OCH_2 + PhthNCHC*H*C(O)), 2.82 (p, *J* = 10.5 Hz, 1H, $PhthNCHCH_2CH_2CHC(O)$), 2.34 – 2.13 (m, 2H, $PhthNCHCH_2CH_2CHC(O)$), 2.11 – 1.96 (m, 1H, $PhthNCHCH_2CH_2CHC(O)$), 1.21 (t, *J* = 7.1 Hz, 3H, OCH_2CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.1, 168.3, 134.2, 132.0, 123.4, 60.7, 46.6, 43.1, 24.0, 19.1, 14.3.
IR (ν_{max}, cm^{-1}) 2982 (w), 1775 (m), 1709 (s), 1469 (w), 1375 (s), 1253 (m), 1198 (m), 1181 (m), 1037 (m), 876 (m), 719 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: $[M + H]^+$ Calcd for $C_{15}H_{16}NO_4^+$ 274.1074; Found 274.1064.

Methyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (3g)

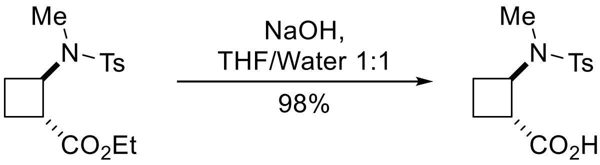


Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid methyl ester (**1b**) (57.9 mg, 300 µmol, 1.00 equiv.) and N,4-dimethylbenzenesulfonamide (**2a**) (66.7 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3g** as a white solid (66.2 mg, 223 µmol, 74% yield).

mp: 94-95 °C.
Rf (pent/EtOAc 8:2):0.33.
^1H NMR (400 MHz, chloroform-*d*) δ 7.67 (d, *J* = 7.9 Hz, 2H, Ar*H*), 7.31 (d, *J* = 7.9 Hz, 2H, Ar*H*), 4.17 (q, *J* = 8.5 Hz, 1H, TsNC*H*), 3.63 (d, *J* = 1.0 Hz, 3H, OCH_3), 3.20 (q, *J* = 9.1 Hz, 1H, TsNCHC*H*C(O)), 2.68 (s, 3H, $TsNCH_3$), 2.42 (s, 3H, CCH_3), 2.14 – 1.94 (m, 3H, $TsNCHCH_2CH_2CHC(O)$), 1.89 – 1.77 (m, 1H, $TsNCHCH_2CH_2CHC(O)$).

^{13}C NMR (101 MHz, chloroform-*d*) δ 173.4, 143.6, 134.5, 129.7, 127.8, 54.8, 51.9, 44.4, 31.4, 24.8, 21.7, 19.2.
IR (ν_{max}, cm^{-1}) 2996 (w), 2955 (w), 2878 (w), 1730 (m), 1599 (w), 1523 (m), 1494 (m), 1341 (m), 1214 (m), 1163 (s), 1146 (s), 1088 (m), 997 (m), 770 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{14}H_{19}NNaO_4S^+$ 320.0927; Found 320.0927.

2-((N,4-Dimethylphenyl)sulfonamido)cyclobutane-1-carboxylic acid (25)

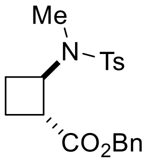


3a **25**

To a solution **3a** (769 mg, 2.47 mmol, 1.00 equiv.) in THF (5 mL) and water (5 mL) was added sodium hydroxide (296 mg, 7.41 mmol, 3.00 equiv.). The reaction was stirred 4 h at rt. The mixture was extracted with EtOAc (3 x 20 mL). The pH value of the aqueous layer was adjusted to 1 using HCl (1 M). The mixture was extracted with ethyl acetate (3 x 20 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. **25** (689 mg, 2.43 mmol, 98% yield) was obtained as a white solid and was pure enough without further purification.

m.p.: 119-120°C.
^{1}H NMR (400 MHz, methanol-*d*$_4$) δ 7.75 – 7.65 (m, 2H, Ar*H*), 7.38 (d, *J* = 8.0 Hz, 2H, Ar*H*), 4.23 (ddd, *J* = 9.8, 8.4, 7.3 Hz, 1H, TsNC*H*), 3.26 – 3.13 (m, 1H, TsNCHC*H*C(O)), 2.70 (s, 3H, TsNC*H*$_3$), 2.43 (s, 3H, C*CH*$_3$), 2.20 – 2.03 (m, 1H, TsNCHC*H*$_2$), 2.01 – 1.86 (m, 2H, TsNCHC*H*$_2$C*H*$_2$), 1.86 – 1.70 (m, 1H, TsNCHCH$_2$C*H*$_2$).
^{13}C NMR (101 MHz, methanol-*d*$_4$) δ 176.3, 145.2, 135.8, 130.8, 128.8, 56.1, 45.4, 31.4, 25.1, 21.5, 19.9.
IR (ν_{max}, cm^{-1}) 2953 (m), 2914 (m), 1725 (w), 1465 (w), 1335 (w), 1216 (m), 1159 (m), 759 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{13}H_{17}NNaO_4S^+$ 306.0770; Found 306.0774.

Benzyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (3h)

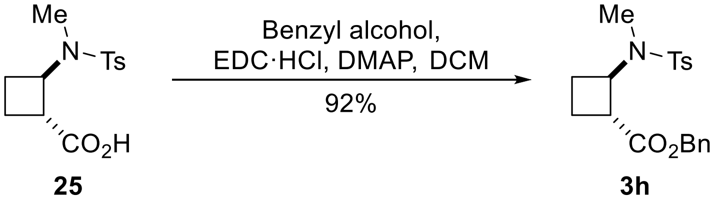


Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid benzyl ester (**1c**) (80.7 mg, 300 µmol, 1.00 equiv.) and N,4-dimethylbenzenesulfonamide (**2a**) (66.7 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3h** as a white solid (50.5 mg, 135 µmol, 45% yield).

m.p.: 88-89°C.
Rf (pent/EtOAc 9:1): 0.17.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.73 – 7.61 (m, 2H, Ar*H*), 7.39 – 7.31 (m, 5H, Ar*H*), 7.28 – 7.24 (m, 2H, Ar*H*), 5.18 – 5.00 (m, 2H, OC*H*$_2$), 4.20 (td, *J* = 8.8, 7.5 Hz, 1H, TsNC*H*), 3.33 – 3.21 (m, 1H, TsNCHC*H*), 2.66 (s, 3H, NC*H*$_3$), 2.40 (s, 3H, CC*H*$_3$), 2.14 – 1.94 (m, 3H, TsNCHC*H*$_2$C*H*$_2$CHC(O)), 1.91 – 1.79 (m, 1H, TsNCHC*H*$_2$C*H*$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.7, 143.6, 135.9, 134.4, 129.7, 128.7, 128.3, 128.2, 127.8, 66.6, 54.8, 44.5, 31.5, 24.8, 21.7, 19.2.
IR (ν_{max}, cm^{-1}) 3031 (m), 2954 (m), 1730 (s), 1456 (m), 1339 (s), 1246 (m), 1213 (m), 1159 (s), 1089 (m), 992 (m), 816 (m), 752 (s).

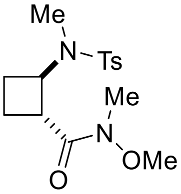
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{20}H_{23}NNaO_4S^+$ 396.1240; Found 396.1244.

The product can also be prepared following the method bellow:



A solution of **25** (300 mg, 1.06 mmol, 1.00 equiv.), benzylalcohol (137 mg, 132 µL, 1.27 mmol, 1.20 equiv.), EDC·HCl (244 mg, 1.27 mmol, 1.20 equiv.) and DMAP (12.9 mg, 106 µmol, 0.100 equiv.) in dichloromethane (8 mL) was stirred 16 h at rt. The mixture was then washed with water (1 x 10 mL), and the organic layer was dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3h** as a white solid (363 mg, 973 µmol, 92% yield).

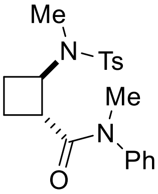
2-((N,4-Dimethylphenyl)sulfonamido)-N-methoxy-N-methylcyclobutane-1-carboxamide (3i)



Prepared according to the general procedure C from 1-bromanyl-N-methoxy-N-methyl-cyclobutane-1-carboxamide (**1d**) (66.6 mg, 300 µmol, 1.00 equiv.) and N,4-dimethylbenzenesulfonamide (**2a**) (66.7 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford **3i** as an oil (59.0 mg, 181 µmol, 60% yield).

Rf (pent/EtOAc 7:3): 0.43.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.72 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.31 (d, *J* = 8.0 Hz, 2H, Ar*H*), 4.09 (q, *J* = 8.4 Hz, 1H, Ts NCHC*H*C(O)), 3.78 – 3.70 (m, 1H, TsNC*H*CHC(O)), 3.68 (s, 3H, OC*H₃*) 3.17 (s, 3H, C(O)NC*H₃*), 2.61 (s, 3H, TsNC*H₃*), 2.41 (s, 3H, CC*H₃*), 2.16 – 1.91 (m, 3H, TsNCHC*H₂*C*H₂*CHC(O)), 1.89 – 1.73 (m, 1H, TsNCHC*H₂*CH₂CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.2, 143.5, 133.8, 129.7, 128.2, 61.7, 54.3, 41.8, 32.3, 32.1, 24.8, 21.7, 19.4.
IR (v_{max}, cm^{-1}) 3620 (w), 2961 (w), 2884 (w), 1653 (s), 1443 (m), 1338 (s), 1166 (s), 1150 (s), 1089 (m), 964 (s), 871 (m), 817 (m), 745 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{15}H_{22}N_2NaO_4S^+$ 349.1192; Found 349.1189.

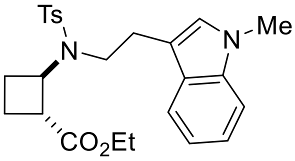
2-((N,4-Dimethylphenyl)sulfonamido)-N-methyl-N-phenylcyclobutane-1-carboxamide (3j)



Prepared according to the general procedure C from 1-bromo-N-methyl-N-phenylcyclobutane-1-carboxamide (**1e**) (80.4 mg, 300 µmol, 1.00 equiv.) and N,4-dimethylbenzenesulfonamide (**2a**) (66.7 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford **3j** as a white solid (69.3 mg, 186 µmol, 62% yield).

m.p.: 103-106 °C.
Rf (pent/EtOAc 7:3): 0.28.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.80 – 7.69 (m, 2H, Ar*H*), 7.44 – 7.30 (m, 5H, Ar*H*), 7.12 – 7.07 (m, 2H, Ar*H*), 4.17 (q, *J* = 7.9 Hz, 1H, NC*H*), 3.24 (s, 3H, C(O)NC*H₃*), 3.10 (q, *J* = 8.8 Hz, 1H, C(O)C*H*), 2.42 (s, 3H, ArC*H₃*), 2.37 (s, 3H, SNC*H₃*), 1.93 – 1.77 (m, 3H, TsNCHC*H₂*CH₂ + TsNCHCH₂C*H₂*), 1.69 – 1.61 (m, 1H, TsNCHCH₂C*H₂*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.1, 143.7, 143.5, 134.1, 129.8, 129.7, 128.2, 128.0, 127.6, 54.5, 43.5, 37.5, 31.5, 24.4, 21.7, 20.1.
IR (ν_{max}, cm^{-1}) 2951 (m), 2922 (w), 1651 (s), 1595 (m), 1496 (s), 1395 (m), 1342 (s), 1167 (s), 1151 (s), 964 (m), 738 (s), 671 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{20}H_{25}N_2O_3S^+$ 373.1580; Found 373.1587.

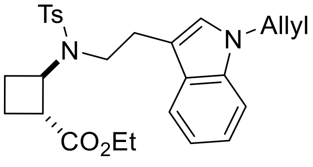
Ethyl 2-((4-methyl-N-(2-(1-methyl-1H-indol-3-yl)ethyl)phenyl)sulfonamido)cyclobutane-1-carboxylate (3k)



Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 µmol, 1.00 equiv.) and 4-methyl-N-[2-(1-methyl-3-indolyl)ethyl]benzenesulfonamide (**2k**) (118 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford **3k** as an oil (67.1 mg, 148 µmol, 49% yield).

Rf (pent/EtOAc 8:2): 0.38.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.79 – 7.70 (m, 2H, Ar*H*), 7.63 (dt, *J* = 7.9, 1.0 Hz, 1H, Ar*H*), 7.34 – 7.20 (m, 4H, Ar*H*), 7.13 (ddd, *J* = 8.0, 6.9, 1.1 Hz, 1H, Ar*H*), 6.89 (s, 1H, Ar*H*), 4.37 (td, *J* = 9.1, 7.8 Hz, 1H, TsNC*H*CHC(O)), 4.09 (qd, *J* = 7.1, 1.4 Hz, 2H, OC*H₂*), 3.75 (s, 3H, $_{ind}$NC*H₃*), 3.46 – 3.29 (m, 2H, TsNC*H₂*CH₂), 3.22 (q, *J* = 9.3 Hz, 1H, NCHC*H*C(O)), 3.13 – 2.99 (m, 2H, TsNCH₂C*H₂*), 2.40 (s, 3H, CC*H₃*), 2.13 – 2.01 (m, 2H, NCHC*H₂*), 2.01 – 1.89 (m, 1H, TsNCHCH₂C*H₂*), 1.88 – 1.76 (m, 1H, TsNCHCH₂C*H₂*), 1.23 (t, *J* = 7.1 Hz, 3H, OCH₂C*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.9, 143.3, 137.3, 137.1, 129.7, 127.8, 127.4, 127.0, 121.8, 119.1, 119.0, 111.4, 109.4, 60.8, 54.8, 46.9, 45.9, 32.6, 27.3, 26.0, 21.6, 19.1, 14.3.
IR (ν_{max}, cm^{-1}) 3022 (w), 2926 (w), 1727 (w), 1472 (w), 1376 (w), 1328 (w), 1217 (w), 1162 (m), 757 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{31}N_2O_4S^+$ 455.1999; Found 455.2003.

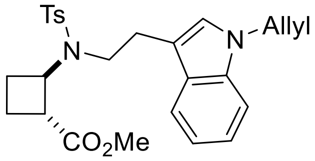
Ethyl 2-((N-(2-(1-allyl-1H-indol-3-yl)ethyl)-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (3l)



Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid ethyl ester (**1a**) (62.1 mg, 300 µmol, 1.00 equiv.) and N-(2-(1-allyl-1H-indol-3-yl)ethyl)-4-methylbenzenesulfonamide (**2l**) (128 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford **3l** as an oil (69.0 mg, 144 µmol, 48% yield).

Rf (pent/Et$_2$O 5:5): 0.68.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.74 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.63 (d, *J* = 7.8 Hz, 1H, Ar*H*), 7.33 – 7.24 (m, 3H, Ar*H*), 7.24 – 7.15 (m, 1H, Ar*H*), 7.15 – 7.10 (m, 1H, Ar*H*), 6.93 (s, 1H, Ar*H*), 5.98 (ddt, *J* = 16.9, 10.6, 5.5 Hz, 1H, $_{ind}$NCH$_2$C*H*CH$_2$), 5.20 (dd, *J* = 10.2, 1.3 Hz, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 5.11 (dd, *J* = 17.1, 1.3 Hz, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 4.74 – 4.60 (m, 2H, $_{ind}$NC*H*$_2$), 4.36 (q, *J* = 8.9 Hz, 1H, TsNC*H*), 4.08 (qd, *J* = 7.1, 1.4 Hz, 2H, OC*H*$_2$), 3.47 – 3.29 (m, 2H, TsNC*H*$_2$C*H*$_2$), 3.27 – 3.16 (m, 1H, TsNCHC*H*C(O)), 3.14 – 3.02 (m, 2H, TsNC*H*$_2$C*H*$_2$), 2.40 (s, 3H, CC*H*$_3$), 2.14 – 2.01 (m, 2H, TsNCHC*H*$_2$CH$_2$CHC(O)), 2.01 – 1.90 (m, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.88 – 1.74 (m, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.22 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.9, 143.3, 137.3, 136.5, 133.6, 129.7, 128.0, 127.4, 125.9, 121.9, 119.3, 119.1, 117.5, 111.8, 109.8, 60.8, 54.8, 48.8, 46.9, 45.9, 27.3, 26.0, 21.6, 19.1, 14.3.
IR (ν_{max}, cm^{-1}) 2982 (w), 1725 (s), 1467 (m), 1335 (m), 1246 (w), 1186 (m), 1156 (s), 1091 (m), 1044 (m), 917 (m), 815 (m), 736 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{27}H_{32}N_2NaO_4S^+$ 503.1975; Found 503.1984.

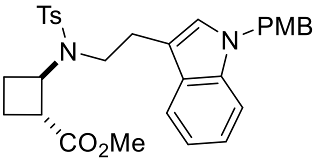
Methyl 2-((N-(2-(1-allyl-1H-indol-3-yl)ethyl)-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (3m)



Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid methyl ester (**1b**) (57.9 mg, 300 µmol, 1.00 equiv.) and N-(2-(1-allyl-1H-indol-3-yl)ethyl)-4-methylbenzenesulfonamide (**2l**) (128 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford **3m** as an oil (58.8 mg, 126 µmol, 42% yield).

Rf (pent/Et$_2$O 5:5): 0.52.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.73 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.63 (d, *J* = 7.8 Hz, 1H, Ar*H*), 7.34 – 7.25 (m, 3H, Ar*H*), 7.26 – 7.17 (m, 1H, Ar*H*), 7.16 – 7.08 (m, 1H, Ar*H*), 6.93 (s, 1H, Ar*H*), 6.13 – 5.85 (m, 1H, $_{ind}$NCH$_2$C*H*CH$_2$), 5.20 (dd, *J* = 10.2, 1.3 Hz, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 5.11 (dd, *J* = 17.1, 1.3 Hz, 1H, $_{ind}$NCH$_2$C*H*CH$_2$), 4.76 – 4.58 (m, 2H, $_{ind}$NC*H*$_2$CHCH$_2$), 4.36 (q, *J* = 8.9 Hz, 1H, TsNC*H*CHC(O)), 3.62 (s, 3H, OC*H*$_3$), 3.47 – 3.32 (m, 2H, TsNC*H*$_2$), 3.22 (q, *J* = 9.2 Hz, 1H, TsNCHC*H*C(O)), 3.14 – 3.01 (m, 2H, TsNCH$_2$C*H*$_2$), 2.40 (s, 3H, CC*H*$_3$), 2.17 – 2.02 (m, 2H, TsNCHC*H*$_2$CH$_2$CHC(O)), 2.02 – 1.90 (m, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.86 – 1.74 (m, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.4, 143.4, 137.2, 136.5, 133.6, 129.8, 128.0, 127.4, 125.9, 121.9, 119.3, 119.1, 117.5, 111.8, 109.8, 54.8, 51.9, 48.8, 46.9, 45.7, 27.3, 26.0, 21.6, 19.2.
IR (ν_{max}, cm^{-1}) 3022 (w), 2950 (w), 2866 (w), 1731 (m), 1458 (w), 1333 (m), 1184 (m), 1158 (s), 1091 (m), 1044 (w), 990 (w), 932 (w), 817 (m), 759 (m), 741 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{26}H_{30}N_2NaO_4S^+$ 489.1818; Found 489.1822.

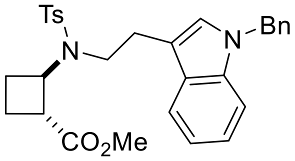
Methyl 2-((N-(2-(1-(4-methoxybenzyl)-1H-indol-3-yl)ethyl)-4-methylphenyl)sulfonamido) cyclobutane-1-carboxylate (3n)



Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid methyl ester (**1b**) (57.9 mg, 300 µmol, 1.00 equiv.) and 4-methyl-N-[2-(1-p-anisylindol-3-yl)ethyl]benzenesulfonamide (**2n**) (156 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/Et_2O 80:20 to afford **3n** as an amorphous solid (67.0 mg, 123 µmol, 41% yield).

Rf (pent/Et_2O 8:2): 0.30.
^1H NMR (400 MHz, chloroform-*d*) δ 7.76 – 7.70 (m, 2H, Ar*H*), 7.64 (dd, *J* = 7.7, 1.2 Hz, 1H, Ar*H*), 7.31 – 7.23 (m, 3H, Ar*H*), 7.19 (ddd, *J* = 8.2, 7.0, 1.3 Hz, 1H, Ar*H*), 7.15 – 7.05 (m, 3H, Ar*H*), 6.92 (s, 1H, Ar*H*), 6.87 – 6.80 (m, 2H, Ar*H*), 5.20 (s, 2H, $_{ind}NCH_2$), 4.34 (q, *J* = 8.9 Hz, 1H, TsNC*H*), 3.78 (s, 3H, $ArOCH_3$), 3.61 (s, 3H, OCH_3), 3.42 – 3.33 (m, 2H, $TsNCH_2CH_2$), 3.21 (q, *J* = 9.2 Hz, 1H, TsNCHC*H*C(O)), 3.12 – 2.98 (m, 2H, $TsNCH_2CH_2$), 2.40 (s, 3H, CCH_3), 2.12 – 1.99 (m, 2H, $TsNCHCH_2CH_2CHC(O)$), 1.98 – 1.90 (m, 1H, $TsNCHCH_2CH_2CHC(O)$), 1.87 – 1.73 (m, 1H, $TsNCHCH_2CH_2CHC(O)$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.4, 159.2, 143.3, 137.2, 136.7, 129.7, 129.6, 128.5, 128.1, 127.5, 126.1, 122.0, 119.4, 119.1, 114.3, 112.0, 109.9, 55.4, 54.8, 51.9, 49.6, 46.8, 45.7, 27.3, 26.0, 21.6, 19.2.
IR (ν_{max}, cm^{-1}) 3007 (w), 2941 (w), 1730 (m), 1617 (w), 1513 (m), 1466 (m), 1332 (m), 1246 (s), 1152 (s), 1037 (m), 907 (m), 817 (m), 730 (s).
HRMS (ESI/QTOF) m/z: $[M + Na]^+$ Calcd for $C_{31}H_{34}N_2NaO_5S^+$ 569.2081; Found 569.2093.

Methyl 2-((N-(2-(1-benzyl-1H-indol-3-yl)ethyl)-4-methylphenyl)sulfonamido) cyclobutane-1-carboxylate (3o)

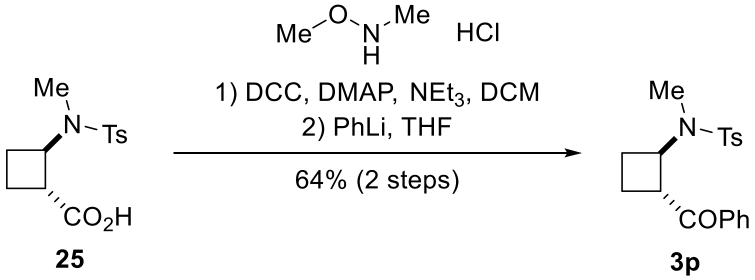


Prepared according to the general procedure C from 1-bromocyclobutanecarboxylic acid methyl ester (**1b**) (57.9 mg, 300 µmol, 1.00 equiv.) and 4-methyl-N-[2-[1-(phenylmethyl)indol-3-yl]ethyl]benzenesulfonamide (**2o**) (146 mg, 360 µmol, 1.20 equiv.). The crude product was purified by flash chromatography using pent/Et_2O 50:50 to afford **3o** as an oil (66.0 mg, 128 µmol, 43% yield).

Rf (pent/Et_2O 5:5): 0.46.
^1H NMR (400 MHz, chloroform-*d*) δ 7.73 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.65 (d, *J* = 7.7 Hz, 1H, Ar*H*), 7.32 – 7.23 (m, 6H, Ar*H*), 7.21 – 7.08 (m, 4H, Ar*H*), 6.95 (s, 1H, Ar*H*), 5.27 (s, 2H, $_{ind}NCH_2Ph$), 4.34 (q, *J* = 8.9 Hz, 1H, TsNC*H*CHC(O)), 3.61 (s, 3H, OCH_3), 3.41 – 3.32 (m, 2H, $TsNCH_2$), 3.21 (q, *J* = 9.2 Hz, 1HTsNCHC*H*C(O)), 3.12 – 3.01 (m, 2H, $TsNCH_2CH_2$), 2.40 (s, 3H, CCH_3), 2.11 – 1.99 (m, 2H, $TsNCHCH_2CH_2CHC(O)$), 2.00 – 1.90 (m, 1H, $TsNCHCH_2CH_2CHC(O)$), 1.87 – 1.70 (m, 1H, $TsNCHCH_2CH_2CHC(O)$).

^{13}C NMR (101 MHz, chloroform-*d*) δ 173.4, 143.4, 137.7, 137.2, 136.8, 129.8, 128.9, 128.1, 127.8, 127.5, 127.0, 126.3, 122.1, 119.4, 119.2, 112.1, 109.9, 54.8, 51.9, 50.1, 46.8, 45.7, 27.3, 26.0, 21.6, 19.2.
IR (ν_{max}, cm^{-1}) 3359 (w), 3028 (w), 2946 (w), 2855 (w), 1725 (m), 1602 (w), 1461 (m), 1335 (m), 1260 (w), 1162 (s), 1091 (m), 911 (s), 730 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{30}H_{32}N_2NaO_4S^+$ 539.1975; Found 539.1972.

N-(2-benzoylcyclobutyl)-N,4-dimethylbenzenesulfonamide (3p)



To a solution of **20** (247 mg, 871 μmol, 1.00 equiv.), DCC (270 mg, 1.31 mmol, 1.50 equiv.), DMAP (10.7 mg, 87.2 μmol, 0.100 equiv.), and *N,O*-dimethylhydroxylamine hydrochloride (128 mg, 1.31 mmol, 1.50 equiv.) in dry DCM (4 mL) was added triethylamine (132 mg, 1.31 mmol, 1.5 equiv.). The reaction mixture was stirred 16 h at rt. After evaporation of the solvent, the crude was purified by flash chromatography using pent/EtOAc 60:40 to afford 2-((N,4-dimethylphenyl)sulfonamido)-N-methoxy-N-methylcyclobutane-1-carboxamide which was used directly in the next step.

To a solution 2-((N,4-dimethylphenyl)sulfonamido)-N-methoxy-N-methylcyclobutane-1-carboxamide (240 mg, 735 μmol, 1.00 equiv.) in dry THF (7 mL) was added dropwise at -78 °C, PhLi (426 μL, 809 μmol, 1.90 M in dibutyl ether, 1.10 equiv.). The reaction mixture was stirred at -78 °C for 0.5 h and the reaction mixture was quenched with saturated $NaHCO_3$ (10 mL) and extracted with Et_2O (3x10 mL). The combined organic layers were washed with brine (10 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash chromatography using pent/EtOAc 85:15 to afford **3p** as an oil (188 mg, 547 μmol, 64% yield, 2 steps).

Rf (pent/EtOAc 8:2): 0.61.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.91 – 7.86 (m, 2H, Ar*H*), 7.65 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.55 (t, *J* = 7.4 Hz, 1H, Ar*H*), 7.44 (t, *J* = 7.6 Hz, 2H, Ar*H*), 7.26 (d, *J* = 8.0 Hz, 2H, Ar*H*), 4.32 – 4.15 (m, 2H, TsNC*H*C*H*C(O)), 2.67 (s, 3H, TsNC*H₃*), 2.38 (s, 3H, CC*H₃*), 2.30 – 2.20 (m, 1H, TsNCHCH₂C*H₂*CHC(O)), 2.20 – 2.05 (m, 2H, TsNCHC*H₂*C*H₂*CHC(O)), 1.90 – 1.79 (m, 1H, TsNCHC*H₂*CH₂CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 198.9, 143.6, 136.1, 133.8, 133.3, 129.7, 128.8, 128.5, 128.0, 53.7, 47.5, 32.3, 24.7, 21.6, 21.1.
IR (ν_{max}, cm^{-1}) 3050 (m), 2946 (m), 1727 (m), 1674 (m), 1598 (m), 1512 (m), 1339 (s), 1250 (m), 1159 (s), 1089 (m), 999 (m), 915 (m), 815 (m), 738 (s).
H RMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{19}H_{21}NNaO_3S^+$ 366.1134; Found 366.1141.

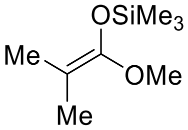
1.3. Synthesis of silyl ketone acetals

The silyl ketene acetals **5a-d** were prepared according to a reported procedure.[13]

General procedure D for the preparation of silyl ketone acetals

To a solution of *i*-Pr_2NH (1.03 equiv.) in dry THF (0.4 M) cooled to 0 °C, *n*-BuLi (2.5 M solution in hexanes, 1.04 equiv.) was added dropwise, and the reaction mixture was stirred at rt for 10 min. The reaction was subsequently cooled to 0 ºC and neat methyl isobutyrate (1.00 equiv.) was added dropwise. The reaction mixture was stirred for 30 min at 0 ºC, followed by the addition of 1,3-dimethyl-3,4,5,6,-tetrahydro-2(1H)-pyrimidinone (DMPU, 2.00 equiv.) and the corresponding silyl chloride (1.20 equiv.). The reaction was allowed to warm up to room temperature and stirred for 3 h. The reaction mixture was then concentrated under reduced pressure. Pentane (75 mL) and saturated $NaHCO_3$ (50 mL) were added to the residue. The aqueous layer was extracted with pentane. The organic layers were further washed with water, saturated $CuSO_4$ (3 x 50 mL), water (50 mL), and brine (50 mL). The crude product was dried over $MgSO_4$, filtered, concentrated under reduced pressure, and then purified by distillation under reduced pressure to afford the silyl ketene acetals **5a-e** as colorless liquids.

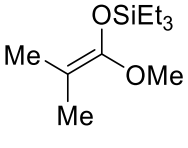
((1-Methoxy-2-methylprop-1-en-1-yl)oxy)trimethylsilane (5a)



Prepared according to the general procedure D from diisopropylamine (2.5 mL, 18 mmol, 1.03 equiv.), *n*-BuLi (2.5 M, 7.3 mL, 18 mmol, 1.04 equiv.), methyl isobutyrate (2.0 mL, 17 mmol, 1.0 equiv.), DMPU (4.2 mL, 35 mmol, 2.0 equiv.) and chlorotrimethylsilane (2.3 mL, 18 mmol, 1.04 equiv.) in THF (35 mL). The crude oil was purified by distillation (10 mbar, 65 °C) to afford a colorless liquid **5a** (1.1 g, 6.3 mmol, 37%).

^1H NMR (400 MHz, chloroform-*d*): δ 3.50 (s, 3H, OCH_3), 1.57 (s, 3H, CCH_3), 1.52 (s, 3H, CCH_3), 0.20 (s, 9H, $Si(CH_3)_3$).
^{13}C NMR (101 MHz, chloroform-*d*): δ 149.5, 91.0, 56.6, 17.0, 16.2, 0.1.
NMR spectra are in agreement with the reported data.[13]

Triethyl((1-methoxy-2-methylprop-1-en-1-yl)oxy)silane (5b)



Prepared according to the general procedure D from diisopropylamine (2.5 mL, 18 mmol, 1.03 equiv.), *n*-BuLi (2.5M, 7.3 mL, 18 mmol, 1.04 equiv.), methyl isobutyrate (2.0 mL, 17 mmol, 1.0 equiv.), DMPU (4.2 mL, 35 mmol, 2.0 equiv.) and chlorotriethylsilane (3.1 mL, 18 mmol, 1.04 equiv.) in THF (35 mL). The crude oil was purified by distillation (1 mbar, 70 – 72 °C) to afford a colorless liquid **5b** (2.6 g, 12 mmol, 68%).

^1H NMR (400 MHz, chloroform-*d*): δ 3.52 (s, 3H, OCH_3), 1.56 (s, 3H, CCH_3), 1.54 (s, 3H, CCH_3), 0.99 (t, *J* = 7.9 Hz, 9H, $Si(CH_2CH_3)_3$), 0.69 (q, *J* = 7.9 Hz, 6H, $Si(CH_2CH_3)_3$).

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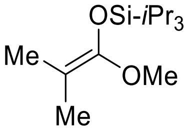
[13] Gatzenmeier, T.; Kaib, P. S. J.; Lingnau, J. B.; Goddard, R.; List, B. The Catalytic Asymmetric Mukaiyama–Michael Reaction of Silyl Ketene Acetals with α,β-Unsaturated Methyl Esters. *Angew. Chem. Int. Ed* **2018**, *57* (9), 2464–2468.

^{13}C NMR (101 MHz, chloroform-*d*): δ 150.0, 91.1, 57.2, 17.0, 16.3, 6.7, 5.1.
NMR spectra are in agreement with the reported data.[13]

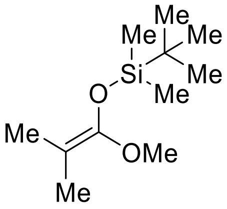
Triisopropyl((1-methoxy-2-methylprop-1-en-1-yl)oxy)silane (5c)



Prepared according to the general procedure D from diisopropylamine (2.5 mL, 18 mmol, 1.03 equiv.), *n*-BuLi (2.5 M, 7.3 mL, 18 mmol, 1.04 equiv.), methyl isobutyrate (2.0 mL, 17 mmol, 1.0 equiv.), DMPU (4.2 mL, 35 mmol, 2.0 equiv.) and chlorotriisopropylsilane (3.9 mL, 18 mmol, 1.04 equiv.) in THF (35 mL). The crude oil was purified by distillation (1 mbar, 100 – 115 °C) to afford a colorless liquid **5c** (2.8 g, 10 mmol, 62%).

^{1}H NMR (400 MHz, chloroform-*d*): δ 3.56 (s, 3H, OC*H*$_3$), 1.57 (s, 6H, CC*H*$_3$), 1.22 – 1.04 (m, 21H, Si(C*H*(C*H*$_3$)$_2$)$_3$).
^{13}C NMR (101 MHz, chloroform-*d*): δ 150.9, 91.2, 58.3, 18.0, 17.2, 16.5, 12.9.
NMR spectra are in agreement with the reported data.[13]

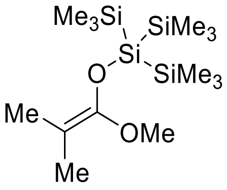
***tert*-Butyl((1-methoxy-2-methylprop-1-en-1-yl)oxy)dimethylsilane (5d)**



Prepared according to the general procedure D from diisopropylamine (2.5 mL, 18 mmol, 1.03 equiv.), *n*-BuLi (2.5 M, 7.3 mL, 18 mmol, 1.04 equiv.), methyl isobutyrate (2.0 mL, 17 mmol, 1.0 equiv.), DMPU (4.2 mL, 35 mmol, 2.0 equiv.) and *tert*-butylchlorodimethylsilane (2.7 g, 18 mmol, 1.04 equiv.) in THF (35 mL). The crude oil was purified by distillation (1 mbar, 75 – 80 °C) to afford a colorless liquid **5d** (1.9 g, 8.7 mmol, 50%).

^{1}H NMR (400 MHz, chloroform-*d*): δ 3.51 (s, 3H, OC*H*$_3$), 1.57 (s, 3H, CC*H*$_3$), 1.53 (s, 3H, CC*H*$_3$), 0.96 (s, 9H, SiC(C*H*$_3$)$_3$), 0.14 (s, 6H, Si(C*H*$_3$)$_2$).
^{13}C NMR (101 MHz, chloroform-*d*): δ 149.9, 91.5, 57.1, 25.9, 18.2, 17.0, 16.4, -4.5.
NMR spectra are in agreement with the reported data.[13]

2-((1-Methoxy-2-methylprop-1-en-1-yl)oxy)-1,1,1,3,3,3-hexamethyl-2-(trimethylsilyl)trisilane (5e)



Prepared according to the general procedure D from diisopropylamine (1.04 g, 1.46 mL, 10.3 mmol, 1.03 equiv.), *n*-BuLi (2.5 M, 4.16 mL, 10.4 mmol, 1.04 equiv.), methyl isobutyrate (1.15 mL, 10.0 mmol, 1.00 equiv.), DMPU (2.41 mL, 20.0 mmol, 2.00 equiv.) and 2-chloro-1,1,1,3,3,3-hexamethyl-2-(trimethylsilyl)trisilane (3.09 g, 10.4 mmol, 1.04 equiv.) in THF (20 mL). The crude oil was purified by distillation (0.6 mbar, 130 – 132 °C) to afford a colorless liquid **5e** (1.72 g, 4.93 mmol, 49% yield).

^{1}H NMR (400 MHz, chloroform-*d*) δ 3.49 (s, CH_3), 1.53 (s, 6H, CCH_3), 0.21 (s, 27H, $Si(Si(CH_3)_3)_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 152.6, 91.6, 58.1, 17.4, 16.4, 0.3.
IR (v_{max}, cm^{-1}) 2949 (m), 2897 (w), 1699 (m), 1244 (m), 1168 (m), 1138 (m), 908 (m), 835 (s), 805 (m), 733 (s), 688 (m).
HRMS (Sicrit plasma/LTQ-Orbitrap) m/z: $[M + H]^+$ Calcd for $C_{14}H_{37}O_2Si_4^+$ 349.1865; Found 349.1862.

1.4. Optimization of the (4+2) annulation reaction

General procedure for reaction optimization

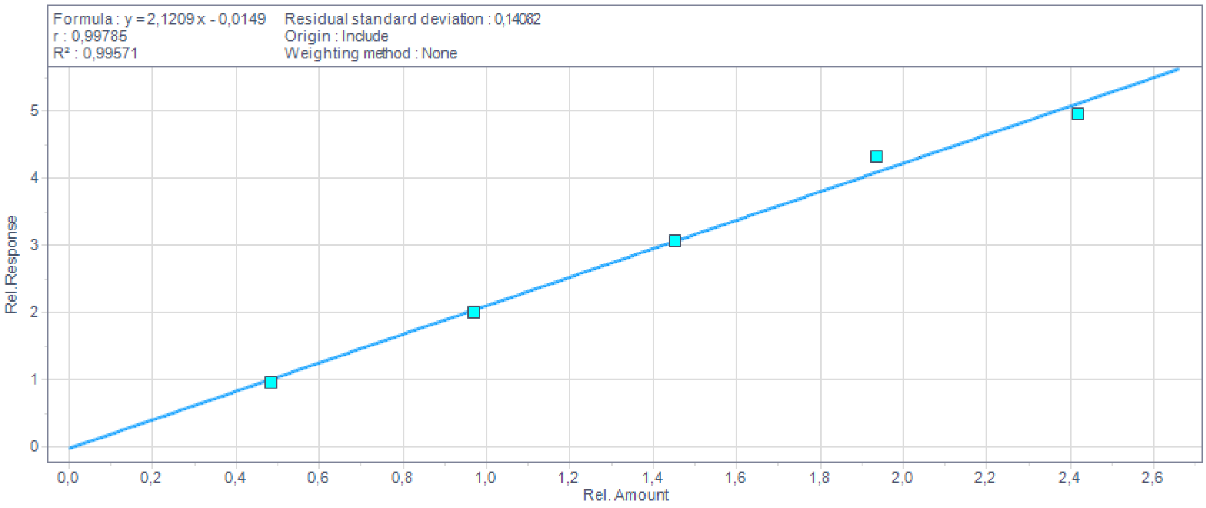
In an oven dried sealed vial, a freshly prepared DCM solution of bis(trifluoromethanesulfonyl)imide was added to silyl ketene acetal **5** diluted in 0.2 mL of dry DCM and the mixture was stirred for 10 min at rt. The mixture was then diluted with 0.8 mL of DCM. Aminocyclobutane **3a** and 1-methylindole **4a** were diluted together in 1.0 mL of DCM and added dropwise to the preformed catalyst. The reaction mixture was stirred for the indicated time. The reaction was quenched by addition of 10 µL of Et_3N. Decane (20.0 µL, 103 µmol, 0.517 equiv.) was added to the mixture. The resulting solution was injected into GC and the oven program was followed: Initial temperature: 100° C, hold 3 min, Ramp: 40.0 °C/min to 330 °C, hold 8 min at 330 °C.

GC Quantification

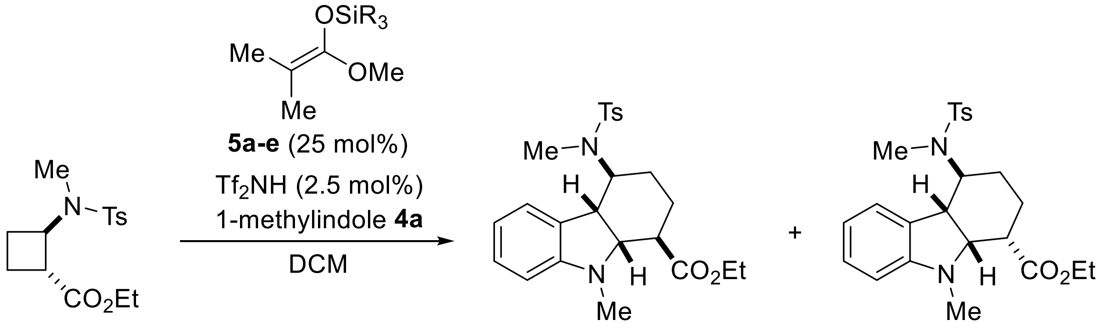
Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (**6a**) (5.4 mg, 0.012 mmol) was dissolved in DCM (ca. 500 µL) (solution P). Decane (20.0 µL, 0.103 mmol) was dissolved in DCM (ca. 2 mL) (solution S).

- 10.2 µL of solution P and 10 µL of solution S were diluting by adding 979.8 µL of DCM to obtain solution A.
- 20.4 µL of solution P and 10 µL of solution S were diluting by adding 969.6 µL of DCM to obtain solution B.
- 30.7 µL of solution P and 10 µL of solution S were diluting by adding 959.3 µL of DCM to obtain solution C.
- 40.9 µL of solution P and 10 µL of solution S were diluting by adding 949.1 µL of DCM to obtain solution D.
- 51.2 µL of solution P and 10 µL of solution S were diluting by adding 938.8 µL of DCM to obtain solution E.

GC chromatograms were acquired for solutions A, B, C, D and E. For each of them the ratio between the integrals of the signals corresponding to the compound **6a** (retention time: 11.79 min) and to the internal standard (retention time: 3.19 min) was calculated. These observed ratios by integration of the chromatogram peaks and the ratios (mmol **6a**/mmol decane) were used as the axis of the calibration graph.



Optimization Table

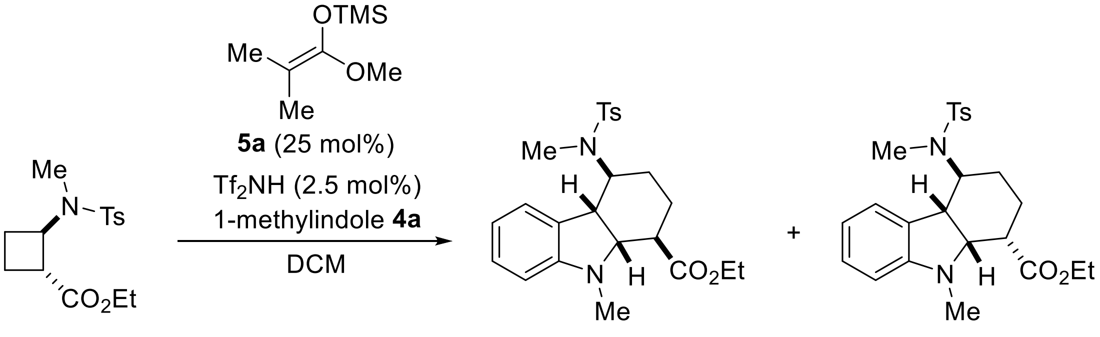


3a **6a** **6a'**

Entry[a]	4a (eq.)	Tf$_2$NH (mol %)	SiR$_3$	(mol %)	Time (h)	T °C	GC Yield[b] (%)	dr[c]
1[e]	1.05	2.5	TTMSS	25	1.5	0	85 (77)[d]	94:6
2[e]	1.05	2.5	TTMSS	25	**3**	0	88	94:6
3[e]	**1.20**	2.5	TTMSS	25	1.5	0	91	94:6
4[e]	1.05	**5.0**	TTMSS	25	1.5	0	85	94:6
5[e]	1.05	**10**	TTMSS	25	1.5	0	89	94:6
6[e]	1.05	2.5	TTMSS	25	1.5	**20**	82	93:7
7[e]	1.05	**5.0**	TTMSS	25	1.5	**20**	85	93:7
8[e]	**1.50**	**5.0**	TTMSS	25	1.5	**20**	84	93:7
9[e]	1.05	**5.0**	TTMSS	**50**	1.5	0	92	94:6
10[e]	1.05	**5.0**	TTMSS	**50**	1.5	**20**	80	93:7
24	1.05	2.5	TTMSS	25	1.5	**40**	74	92:8
11	1.05	2.5	**TMS**	25	1.5	**20**	93	90:10
12	1.05	2.5	**TES**	25	1.5	**20**	94	88:12
13	1.05	2.5	**TIPS**	25	1.5	**20**	93	89:11
14	1.05	2.5	**TBS**	25	1.5	**20**	93	88:12
15	1.05	**5.0**	**TMS**	25	1.5	0	91	79:21
16	1.05	2.5	**TMS**	25	1.5	0	99	72:28
17	1.05	2.5	**TMS**	25	1.5	**40**	95	94:6
18	1.05	2.5	**TMS**	25	**3**	**40**	96	94:6
19	1.05	2.5	**TMS**	25	1.5	0	99	72:28
20	1.05	2.5	**TMS**	25	1.5	**-5**	95	76:24
21	1.05	2.5	**TMS**	25	1.5	**-10**	98	68:32
22	1.05	2.5	**TMS**	25	1.5	**-40**	45	66:34
23	1.05	2.5	**TMS**	25	1.5	**-78**	8	62:38
25	1.05	2.5	**TMS**	25	**5 min**	**40**	95	78:22
26	1.05	2.5	**TMS**	25	**10 min**	**40**	95	83:17
27	1.05	2.5	**TMS**	25	**15 min**	**40**	95	87:13
28	1.05	2.5	**TMS**	25	**0.5**	**40**	95	91:9
29	1.05	2.5	**TMS**	25	**0.75**	**40**	95	93:7

[a]Reaction conditions: 0.2 mmol (1.00 equiv.) aminocyclobutane (**3a**), 0.1 M. [b]GC yield. [c]dr was measured from the GC chromatograph of the crude mixture. [d]Isolated yield. [e]Reaction yields were poorly reproducible. The reactions were repeated 3 to 5 times and an average yield is given.

Control experiments



3a **6a** **6a'**

Entry[a]	Deviation from standard conditions	GC Yield[b]	dr[c]
1	None	95 %	94:6
2	No silyl ketene acetal	0 %	-
3	No bistriflimide	0 %	-
4	No preformation of the active catalyst	88 %	91:9
5	Reaction in DCE	79 %	93:7
6	Reaction in THF	0 %	-

[a]Reaction conditions: 0.1 mmol (1.00 equiv.) aminocyclobutane (**3a**), 1.05 mmol (1.05 equiv.) 1-methylindole (**4a**), 25 mol% of silyl ketene acetals (**5a**), 2.5 mol% of Tf_2NH, unless otherwise stated, 0.1 M. [b]GC yield. [c]dr was measured from the GC chromatograph of the crude mixture.

Closer monitoring of the reaction at 40 °C revealed that the final yield is reached after 15 min of reaction (Figure 2). The dr kept increasing and reached a plateau after 1 hour of reaction.

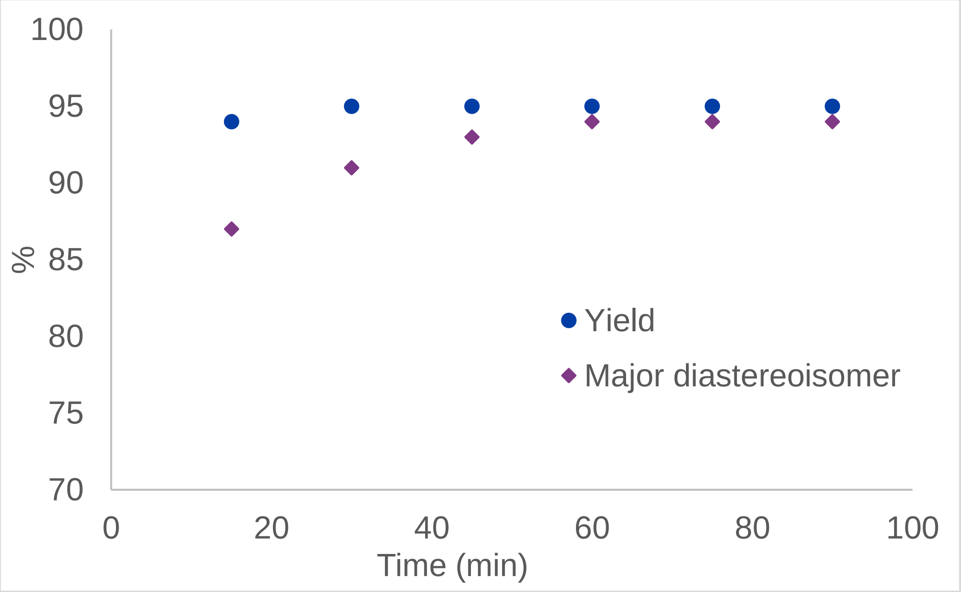
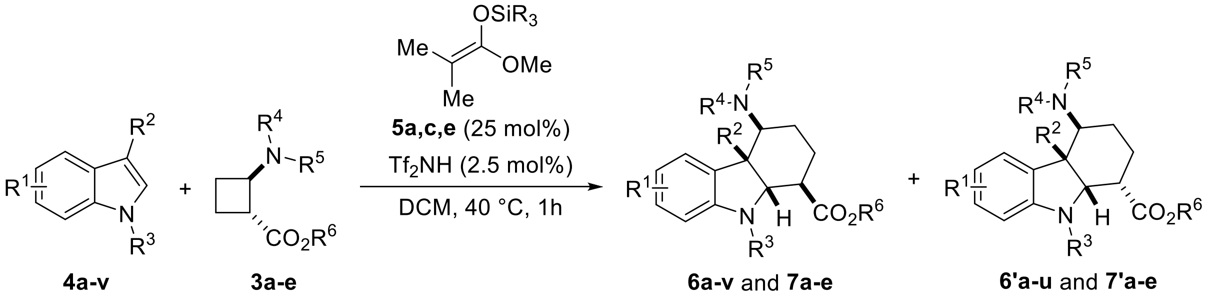


Figure 2: Reaction monitoring of major diastereoisomer proportion and yield.

1.5. (4+2) Annulation of donor-acceptor aminocyclobutanes with indoles

General procedure for the (4+2) annulation of aminocyclobutanes



Procedure E: with SiR_3=TMS

In an oven dried sealed vial, a freshly prepared DCM solution of bis(trifluoromethanesulfonyl)imide (37.5 µL, 7.50 µmol, 0.20 M, 0.0250 equiv.) was added to silyl ketene acetal **5a** (13.1 mg, 75.0 µmol, 0.250 equiv.) diluted in 0.3 mL of dry DCM and the mixture was stirred for 10 min at rt. The mixture was then diluted with 1.2 mL of DCM. Aminocyclobutane derivative **3a-e** (1.00 equiv.) and the indole derivative **4a-v** (1.05 equiv.) were diluted together in 1.5 mL of DCM and added dropwise to the preformed catalyst. The reaction mixture was stirred at 40 °C for 1 h, unless otherwise stated. The reaction was quenched by addition of 10 µL of Et_3N and was concentrated under reduced pressure. The crude product was then purified by flash chromatography. The dr was measured from the GC chromatograph of the crude mixture and/or the crude NMR spectra. The crude solution was injected into GC and the oven program was followed: Initial temperature: 100° C, hold 3 min, Ramp: 40.0 °C/min to 330 °C, hold 8 min at 330 °C.

Procedure F: with SiR_3=TTMSS

In an oven dried sealed vial, a freshly prepared DCM solution of bis(trifluoromethanesulfonyl)imide (2.11 mg, 37.5 µL, 7.50 µmol, 0.20 M, 0.0250 equiv.) was added to silyl ketene acetal **5e** (26.2 mg, 75.0 µmol, 0.250 equiv.) diluted in 0.3 mL of dry DCM and the mixture was stirred for 10 min at rt. The mixture was then diluted with 1.2 mL of DCM. Aminocyclobutane derivative **3a-e** (1.00 equiv.) and the indole derivative **4a-v** (1.05 equiv.) were diluted together in 1.5 mL of DCM and added dropwise to the preformed catalyst. The reaction mixture was stirred at 40 °C for 1 h, unless indicated otherwise. The reaction was quenched by addition of 10 µL of Et_3N and was concentrated under reduced pressure. The crude product was then purified by flash chromatography. The dr was measured from the GC chromatograph of the crude mixture and/or the crude NMR spectra. The crude solution was injected into GC and the oven program was followed: Initial temperature: 100° C, hold 3 min, Ramp: 40.0 °C/min to 330 °C, hold 8 min at 330 °C.

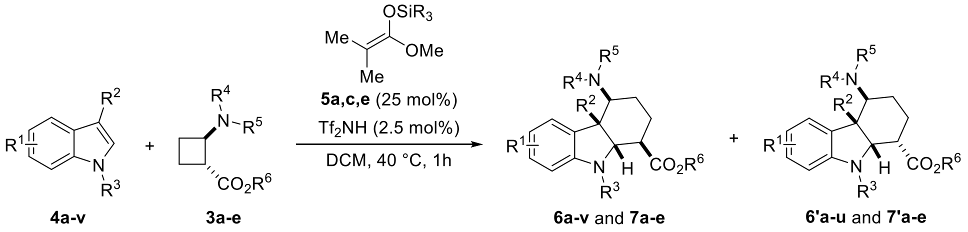
Procedure G: with SiR_3=TIPS

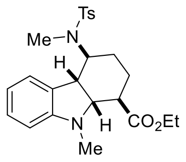
In an oven dried sealed vial, a freshly prepared DCM solution of bis(trifluoromethanesulfonyl)imide (2.11 mg, 37.5 µL, 7.50 µmol, 0.20 M, 0.0250 equiv.) was added to silyl ketene acetal **5c** (19.4 mg, 75.0 µmol, 0.250 equiv.) diluted in 0.3 mL of dry DCM and the mixture was stirred for 10 min at rt. The mixture was then diluted with 1.2 mL of DCM. Aminocyclobutane derivative **3a-e** (1.00 equiv.) and the indole derivative **4a-v** (1.05 equiv.) were diluted together in 1.5 mL of DCM and added dropwise to the preformed catalyst. The reaction mixture was stirred at 40 °C for 1 h, unless indicated otherwise. The reaction was quenched by addition of 10 µL of Et_3N and was concentrated under reduced pressure. The crude product was then purified by flash chromatography. The dr was measured from the GC chromatograph of the crude mixture and/or the crude NMR spectra. The crude solution was injected into GC and the oven program was followed: Initial temperature: 100° C, hold 3 min, Ramp: 40.0 °C/min to 330 °C, hold 8 min at 330 °C.

Notice on the handling of bis(trifluoromethanesulfonyl)imide

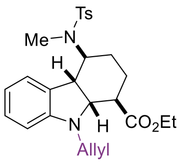
Bis(trifluoromethanesulfonyl)imide was purchased from Sigma-Aldrich and was stored in a glovebox. The solution in DCM (ca. 0.2 M, 2-3 mL) was prepared by diluting the acid (previously weighted in a glovebox) with dry DCM in oven-dried and nitrogen-purged vial. The solution was used directly to set up a reaction by taking off the required amount and renewed every day.

Complete scope of the reaction

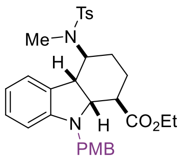




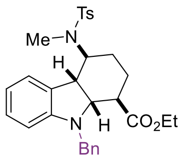
6a, 96% dr 94:6 (TMS)
74% dr 92:8 (TTMSS)
93% dr 81:19 (TIPS)



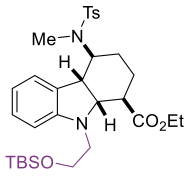
6b, 95% dr 60:40 (TMS)
56% dr 89:11 (TTMSS)
86% dr 83:17 (TIPS)



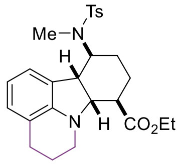
6c, 98% dr 68:32 (TMS)
<5% (TTMSS)
82% dr 79:21 (TIPS)



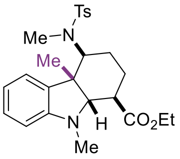
6d, 89% dr 62:38 (TMS)
28% dr 90:10 (TTMSS)
81% dr 73:27 (TIPS)



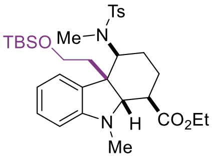
6e, 89% dr 70:30 (TMS)
<5% (TTMSS)
85% dr 83:17 (TIPS)



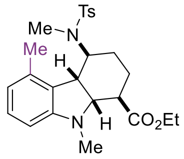
6f, 81% dr 60:40 (TMS)
26% dr 82:18 (TTMSS)
78% dr 80:20 (TIPS)



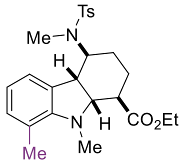
6g, 65% dr 85:15 (TTMSS)[a]
(X-ray structure)



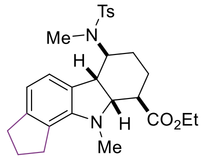
6h,18% dr >95:5 (TTMSS)[a]



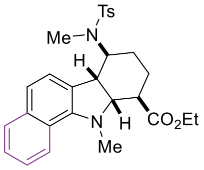
6i, 74% dr 64:36 (TMS)
89% dr 88:12 (TTMSS)



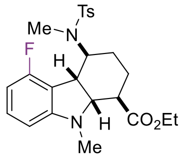
6j, 91% dr >95:5 (TMS)
(X-ray structure)



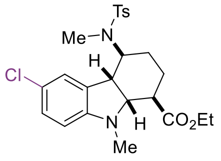
6k, 78% dr >95:5 (TTMSS)



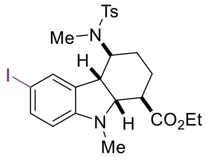
6l, 42% dr 80:20 (TMS)



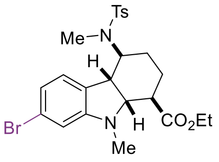
6m, 24% dr 87:13 (TMS)
<10% 90:10 (TTMSS)



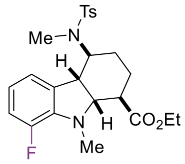
6n,[b] 85% dr 64:36 (TMS)
62% dr 88:12 (TTMSS)



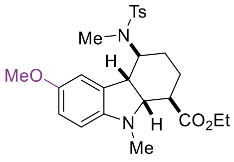
6o,[b] 54% dr 88:12 (TTMSS)



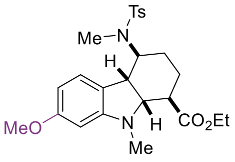
6p, 50% dr 88:12 (TTMSS)



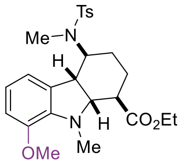
6q, 82% dr 57:43 (TMS)
49% dr 85:15 (TTMSS)



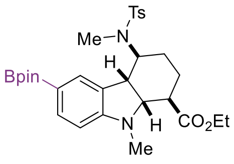
6r, 73% dr 95:5 (TTMSS)



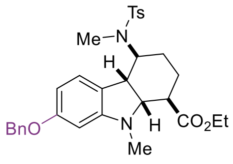
6s, 89 % dr 70:30 (TMS)
74% dr 94:6 (TTMSS)



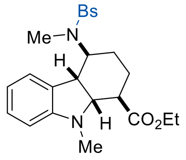
6t, 66% dr >95:5 (TTMSS)



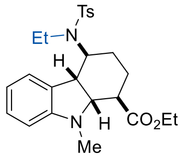
6u, 68% dr 92:8 (TTMSS)



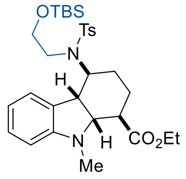
6v, 55% dr 91:9 (TTMSS)



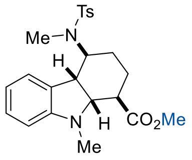
7a, 91% dr 86:14 (TMS)
79% dr 94:6 (TTMSS)



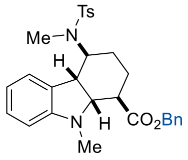
7b, 70% dr 64:36 (TMS)
56% dr 92:8 (TTMSS)



7c, 48% dr 53:47 (TMS)
27% dr 81:19 (TTMSS)

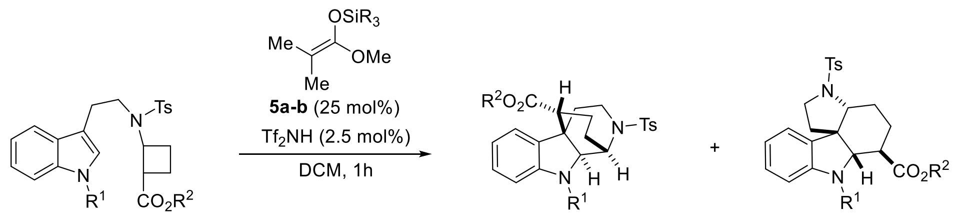


7d, 94% dr >95:5 (TMS)
91% dr >95:5 (TTMSS)



7e,[b] 28% dr 91:9 (TMS)
5% dr >95:5 (TTMSS)

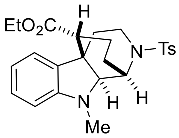
[a] Overnight reaction. [b] Product obtained in an inseparable mixture with **3a-e** (9 to 30 mol%).



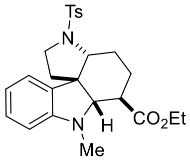
3k-o

8a-e
Major isomer at -50 °C

9a-e
Major isomer at 40 °C

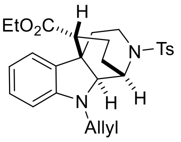


8a

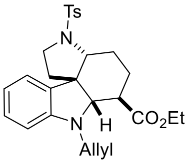


9a (X-ray structure)

31% 92:8 (TTMSS -50 °C)
35% 87:13 (TMS -50 °C)
100% 46:54 (TMS 40 °C)
87% 36:64 (TTMSS 40°C)

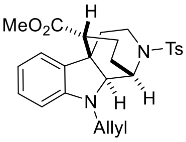


8b

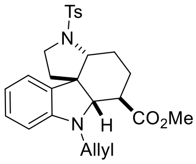


9b

38% 96:4 (TTMSS -50 °C)
93% 93:7 (TMS -50 °C)
87% 43:57 (TMS 40 °C)
61% 29:71 (TTMSS 40°C)

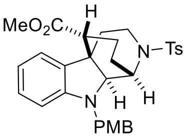


8c (X-ray structure)

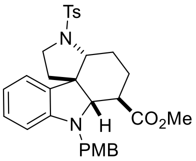


9c

100% 85:15 (TTMSS -50 °C)
96% 88:12 (TMS -50 °C)
90% 27:73 (TMS 40 °C)
90% 29:71 (TTMSS 40°C)

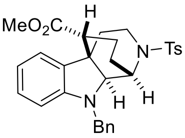


8d (X-ray structure)

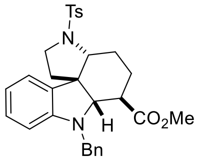


9d

85% 85:15 (TTMSS -50 °C)
96% 83:17 (TMS -50 °C)
88% 21:79 (TMS 40 °C)
100% 27:73 (TTMSS 40 °C)



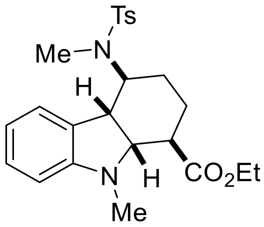
8e



9e

67% 95:5 (TTMSS -50 °C)
87% 86:14 (TMS -50 °C)
100% 27:73 (TMS 40 °C)
77% 37:63 (TTMSS 40 °C)

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6a)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (43.0 mg, 42.2 µL, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6a** as a colorless oil (128 mg, 289 µmol, 96% yield, dr 94:6).

A gram scale experiment with **3a** (1.00 g, 3.21 mmol, 1.00 equiv.) was also accomplished using the same procedure and led to **6a** (1.34 g, 3.02 mmol, 94% yield, dr 94:6) with a similar yield and identical dr.

Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (43.0 mg, 42.2 µL, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6a** as a colorless oil (98.3 mg, 222 µmol, 74% yield, dr 92:8).

Prepared according to the general procedure G from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (43.0 mg, 42.2 µL, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6a** as a colorless oil (123 mg, 278 µmol, 93% yield, dr 81:19).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

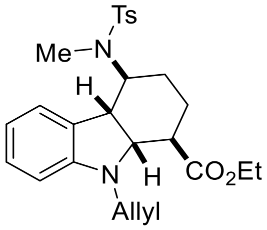
Rf (pent/EtOAc 8:2): 0.35.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.53 – 7.48 (m, 2H, Ar*H*), 7.21 – 7.10 (m, 3H, Ar*H*), 6.99 – 6.93 (m, 1H, Ar*H*), 6.67 – 6.58 (m, 2H, Ar*H*), 4.22 – 4.12 (m, 2H, OC*H*$_2$), 3.66 (ddd, *J* = 12.4, 10.8, 4.2 Hz, 1H, TsNC*H*), 3.50 (dt, *J* = 6.7, 1.6 Hz, 1H, $_{ind}$NC*H*), 3.18 (dd, *J* = 10.8, 6.6 Hz, 1H, TsNCHC*H*), 3.01 (dt, *J* = 4.7, 2.4 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.85 (s, 3H, TsNC*H*$_3$), 2.67 (s, 3H, $_{ind}$NC*H*$_3$), 2.39 (s, 3H, CC*H*$_3$), 2.06 – 1.86 (m, 2H, TsNCHC*H*$_2$C*H*$_2$CHC(O)), 1.48 (qd, *J* = 12.6, 3.6 Hz, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.35 – 1.22 (m, 4H, OCH$_2$C*H*$_3$ + TsNCHC*H*$_2$CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 152.3, 142.9, 137.4, 131.5, 129.6, 127.9, 127.2, 125.2, 119.3, 109.2, 68.5, 60.9, 58.8, 41.2, 39.0, 34.6, 29.0, 23.6, 23.3, 21.6, 14.4.
IR (v_{max}, cm^{-1}) 2975 (m), 2869 (m), 2811 (m), 1725 (s), 1609 (m), 1481 (s), 1342 (s), 1191 (s), 1164 (s), 986 (s), 944 (m), 911 (m), 735 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{24}H_{30}N_2NaO_4S^+$ 465.1818; Found 465.1826.

Data for minor diastereoisomer:

Rf (pent /EtOAc 9:1): 0.21.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.51 (d, *J* = 8.4 Hz, 2H, Ar*H*), 7.21 – 7.16 (m, 2H, Ar*H*), 7.14 (td, *J* = 7.7, 1.3 Hz, 1H, Ar*H*), 6.99 (dd, *J* = 7.3, 1.3 Hz, 1H, Ar*H*), 6.65 (td, *J* = 7.4, 1.0 Hz,

1H, Ar*H*), 6.59 (d, *J* = 7.9 Hz, 1H, Ar*H*), 4.19 (qt, *J* = 7.2, 3.6 Hz, 2H, OC*H*$_2$), 3.81 (dd, *J* = 5.9, 3.2 Hz, 1H, $_{\text{ind}}$NC*H*), 3.64 (ddd, *J* = 12.4, 10.5, 4.2 Hz, 1H, TsNC*H*), 2.93 (dd, *J* = 10.5, 5.9 Hz, 1H, TsCHC*H*), 2.82 (s, 3H, TsNC*H*$_3$), 2.61 – 2.50 (m, 4H, $_{\text{ind}}$NC*H*$_3$ + $_{\text{ind}}$NCHC*H*C(O)), 2.39 (s, 3H, CC*H*$_3$), 1.99 – 1.84 (m, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.58 – 1.48 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.48 – 1.37 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.28 (t, *J* = 7.2 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.0, 152.7, 142.9, 137.3, 131.0, 129.6, 128.0, 127.2, 124.8, 119.0, 109.0, 69.3, 60.8, 58.9, 44.6, 44.0, 34.8, 29.7, 27.5, 21.6, 14.2.
IR (ν_{max}, cm^{-1}) 3032 (w), 2943 (w), 2869 (w), 2814 (w), 1728 (m), 1609 (w), 1481 (m), 1339 (m), 1208 (s), 1159 (s), 1143 (s), 1089 (m), 1038 (m), 958 (m), 905 (m), 816 (m), 757 (s), 680 (s), 653 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{24}H_{30}N_2NaO_4S^+$ 465.1818; Found 465.1830.

Ethyl 9-allyl-4-((N,4-dimethylphenyl)sulfonamido)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6b)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-allylindole (**4b**) (49.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6b** as a colorless oil (134 mg, 285 µmol, 95% yield, dr 60:40).

Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-allylindole (**4b**) (49.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6b** as a colorless oil (79.0 mg, 169 µmol, 56% yield, dr 89:11).

Prepared according to the general procedure G from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-allylindole (**4b**) (49.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6b** as a colorless oil (121 mg, 258 µmol, 86% yield, dr 83:17).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

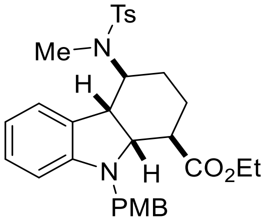
Rf (pent/EtOAc 7:3): 0.73.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.51 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.18 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.10 (td, *J* = 7.7, 1.2 Hz, 1H, Ar*H*), 6.95 (d, *J* = 6.8 Hz, 1H, Ar*H*), 6.61 (t, *J* = 7.2 Hz, 2H, Ar*H*), 5.93 – 5.78 (m, 1H, $_{\text{ind}}$NCH$_2$C*H*CH$_2$), 5.29 (dd, *J* = 17.2, 1.6 Hz, 1H, $_{\text{ind}}$NCH$_2$CHC*H*$_2$), 5.18 (dd, *J* = 10.3, 1.5 Hz, 1H, $_{\text{ind}}$NCH$_2$CHC*H*$_2$), 4.16 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$), 3.91 – 3.78 (m, 2H, $_{\text{ind}}$NC*H*$_2$CHCH$_2$ + $_{\text{ind}}$NC*H*), 3.67 (td, *J* = 12.2, 4.2 Hz, 1H, TsNC*H*), 3.58 (dd, *J* = 16.7, 6.6 Hz, 1H, $_{\text{ind}}$NC*H*$_2$CHCH$_2$), 3.17 (dd, *J* = 10.7, 6.8 Hz, 1H, TsNCHC*H*), 2.99 (s, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.84 (s, 3H, TsNHC*H*$_3$), 2.39 (s, 3H, CC*H*$_3$), 2.03 – 1.86 (m, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.48

(qd, *J* = 12.6, 3.7 Hz, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.35 – 1.29 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.26 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 151.1, 142.9, 137.3, 133.8, 131.3, 129.6, 127.9, 127.3, 125.3, 119.0, 117.5, 109.1, 65.5, 60.9, 58.9, 49.8, 41.1, 38.9, 29.0, 23.5, 23.3, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2927 (m), 2867 (w), 1724 (s), 1607 (m), 1478 (m), 1342 (m), 1191 (s), 1159 (s), 1089 (m), 1026 (m), 986 (s), 941 (m), 752 (s), 739 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{26}H_{33}N_2O_4S^+$ 469.2156; Found 469.2152.

Data for minor diastereoisomer:

Rf (pent/EtOAc 7:3): 0.59.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.51 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.19 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.10 (t, *J* = 7.7 Hz, 1H, Ar*H*), 6.98 (d, *J* = 7.2 Hz, 1H, Ar*H*), 6.63 (t, *J* = 7.4 Hz, 1H, Ar*H*), 6.55 (d, *J* = 7.9 Hz, 1H, Ar*H*), 5.79 (ddt, *J* = 16.1, 10.5, 5.4 Hz, 1H, $_{\text{ind}}$NCH$_2$C*H*CH$_2$), 5.30 – 5.09 (m, 2H, $_{\text{ind}}$NCH$_2$CHC*H*$_2$), 4.29 – 4.14 (m, 2H, OC*H*$_2$ + $_{\text{ind}}$NC*H*), 4.14 – 3.99 (m, 1H, OC*H*$_2$), 3.77 (dd, *J* = 17.4, 5.2 Hz, 1H, $_{\text{ind}}$NC*H*$_2$CHCH$_2$), 3.71 – 3.57 (m, 1H, TsNC*H*), 3.48 (dd, *J* = 17.3, 5.3 Hz, 1H, $_{\text{ind}}$NC*H*$_2$CHCH$_2$), 2.96 (dd, *J* = 10.4, 6.1 Hz, 1H, TsNCHC*H*), 2.81 (s, 3H, TsNC*H*$_3$), 2.66 – 2.53 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.40 (s, 3H, CC*H*$_3$), 1.93 (dd, *J* = 12.9, 9.8 Hz, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.63 – 1.51 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.44 (td, *J* = 12.4, 4.1 Hz, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.26 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 151.6, 143.0, 137.3, 133.3, 130.8, 129.6, 128.0, 127.3, 124.7, 118.8, 117.2, 109.7, 65.8, 61.0, 59.3, 49.2, 44.7, 44.4, 29.8, 27.5, 21.8, 21.6, 14.1.
IR (ν_{max}, cm^{-1}) 2975 (w), 2860 (w), 1721 (m), 1606 (w), 1480 (m), 1339 (m), 1209 (m), 1156 (s), 1037 (m), 957 (m), 813 (m), 755 (s), 738 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{26}H_{33}N_2O_4S^+$ 469.2156; Found 469.2162.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-(4-methoxybenzyl)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6c)



Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 1-[(4-methoxyphenyl)methyl]indole (**4c**) (74.7 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6c** as a colorless oil (162 mg, 295 μmol, 98% yield, dr 68:32).

Prepared according to the general procedure G from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 1-[(4-methoxyphenyl)methyl]indole (**4c**) (74.7 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6c** as a colorless oil (135 mg, 246 μmol, 82% yield, dr 79:21).

The dr was measured on the crude GC chromatogram and on the crude ^{1}H NMR spectrum by integrating the Ar*H* protons of each diastereomers.

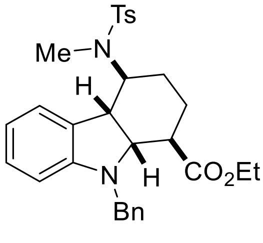
Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.37.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.56 – 7.49 (m, 2H, Ar*H*), 7.27 – 7.22 (m, 2H, Ar*H*), 7.21 – 7.17 (m, 2H, Ar*H*), 7.06 (td, *J* = 7.7, 1.4 Hz, 1H, Ar*H*), 6.96 (dd, *J* = 7.3, 1.3 Hz, 1H, Ar*H*), 6.89 – 6.86 (m, 2H, Ar*H*), 6.63 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 6.53 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.27 (d, *J* = 16.1 Hz, 1H, NCH_2), 4.17 – 4.06 (m, 3H, OCH_2 + NCH_2), 3.84 – 3.79 (m, 4H, OCH_3 + $_{\text{ind}}$NC*H*), 3.73 (ddd, *J* = 12.3, 10.7, 4.3 Hz, 1H, TsNC*H*), 3.23 – 3.17 (m, 1H, TsNCHC*H*), 2.99 – 2.94 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.85 (s, 3H, TsNCH_3), 2.39 (s, 3H, CCH_3), 2.00 – 1.83 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.50 (qd, *J* = 12.4, 4.4 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.37 (dt, *J* = 12.7, 3.9 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.24 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 158.8, 151.9, 142.9, 137.2, 131.2, 130.7, 129.6, 128.4, 128.0, 127.4, 125.2, 119.1, 114.1, 109.2, 66.7, 60.9, 59.1, 55.4, 51.8, 41.1, 39.2, 28.9, 23.6, 23.5, 21.6, 14.3.
IR (ν_{max}, cm^{-1}) 3154 (w), 2984 (w), 2838 (w), 2253 (w), 1718 (m), 1615 (w), 1512 (m), 1246 (m), 1179 (m), 903 (s), 723 (s), 648 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{31}H_{37}N_2O_5S^+$ 549.2418; Found 549.2433.

Data for minor diastereoisomer:

Rf (pent/EtOAc 8:2): 0.23.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.57 – 7.49 (m, 2H, Ar*H*), 7.21 – 7.16 (m, 4H, Ar*H*), 7.04 – 6.95 (m, 2H, Ar*H*), 6.88 – 6.82 (m, 2H, Ar*H*), 6.62 (td, *J* = 7.4, 0.9 Hz, 1H, Ar*H*), 6.37 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.27 (dd, *J* = 6.4, 3.2 Hz, 1H, $_{\text{ind}}$NC*H*), 4.22 (d, *J* = 16.8 Hz, 1H, NCH_2), 3.99 – 3.83 (m, 3H, NCH_2 + OCH_2), 3.80 (s, 3H, OCH_3), 3.78 – 3.67 (m, 1H, TsNC*H*), 3.04 (dd, *J* = 10.5, 6.1 Hz, 1H, TsNCHC*H*), 2.84 (s, 3H, TsNCH_3), 2.70 – 2.57 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.39 (s, 3H, CCH_3), 2.04 – 1.88 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.65 (dq, *J* = 11.8, 3.6 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.48 (qd, *J* = 12.6, 3.7 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.01 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 158.5, 152.7, 143.0, 137.2, 130.8, 130.5, 129.6, 128.2, 127.9, 127.4, 124.6, 118.9, 114.0, 109.4, 67.1, 61.0, 59.5, 55.4, 51.4, 44.8, 44.6, 29.7, 27.6, 22.0, 21.6, 13.9.
IR (ν_{max}, cm^{-1}) 3024 (w), 2948 (w), 2842 (w), 1729 (m), 1612 (w), 1511 (m), 1480 (m), 1246 (m), 1215 (m), 1161 (m), 1037 (m), 958 (m), 908 (m), 754 (s), 657 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{31}H_{37}N_2O_5S^+$ 549.2418; Found 549.2427.

Ethyl 9-benzyl-4-((N,4-dimethylphenyl)sulfonamido)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6d)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 1-benzylindole (**4d**) (65.3 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6d** as a colorless oil (139 mg, 268 μmol, 89% yield, dr 62:38).

Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 1-benzylindole (**4d**) (65.3 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6d** as a colorless oil (43.3 mg, 83.5 µmol, 28% yield, dr 90:10).

Prepared according to the general procedure G from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-benzylindole (**4d**) (65.3 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6d** as a colorless oil (126 mg, 243 µmol, 81% yield, dr 73:27).

The dr was measured on the crude GC chromatogram and on the crude ^{1}H NMR spectrum by integrating the Ar*H* protons of each diastereomers.

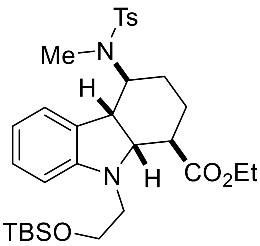
Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.31.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.53 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.39 – 7.27 (m, 5H, Ar*H*), 7.21 – 7.15 (m, 2H, Ar*H*), 7.05 (td, *J* = 7.7, 1.4 Hz, 1H, Ar*H*), 6.99 – 6.94 (m, 1H, Ar*H*), 6.63 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 6.49 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.31 (d, *J* = 16.4 Hz, 1H, NCH_2), 4.21 – 4.08 (m, 3H, OCH_2 + NCH_2), 3.84 (s, 1H, $_{ind}$NC*H*), 3.74 (td, *J* = 11.6, 4.2 Hz, 1H, TsNC*H*), 3.23 (dd, *J* = 10.8, 6.8 Hz, 1H, TsNCHC*H*), 2.95 (s, 1H, $_{ind}$NCHC*H*C(O)), 2.86 (s, 3H, TsNCH_3), 2.39 (s, 3H, CCH_3), 2.01 – 1.88 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.49 (td, *J* = 11.9, 5.2 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.43 – 1.35 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.23 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully resolved) δ 173.8, 152.0, 143.0, 139.0, 137.2, 131.2, 129.6, 128.8, 128.0 (2C), 127.4, 127.2, 125.3, 119.2, 109.2, 67.1, 60.9, 59.1, 52.7, 41.2, 39.4, 29.0, 23.6, 23.5, 21.6, 14.3.
IR (ν_{max}, cm^{-1}) 3026 (w), 2937 (w), 1727 (s), 1606 (w), 1479 (m), 1341 (m), 1255 (m), 1186 (s), 1164 (s), 1091 (m), 1026 (m), 989 (m), 765 (s), 755 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{30}H_{35}N_2O_4S^+$ 519.2312; Found 519.2329.

Data for minor diastereoisomer:

Rf (pent/EtOAc 8:2): 0.17.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.57 – 7.50 (m, 2H, Ar*H*), 7.35 – 7.29 (m, 2H, Ar*H*), 7.29 – 7.17 (m, 5H, Ar*H*), 7.05 – 6.98 (m, 2H, Ar*H*), 6.63 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 6.38 – 6.33 (m, 1H, Ar*H*), 4.35 – 4.25 (m, 2H, NCH_2 + $_{ind}$NC*H*), 4.05 (d, *J* = 17.2 Hz, 1H, NCH_2), 3.95 – 3.67 (m, 3H, OCH_2 + TsNC*H*), 3.05 (dd, *J* = 10.5, 6.1 Hz, 1H, TsNCHC*H*), 2.85 (s, 3H, TsNCH_3), 2.63 (dt, *J* = 12.3, 3.5 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.39 (s, 3H, CCH_3), 2.09 – 1.86 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.66 (dq, *J* = 12.6, 3.6 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.48 (qd, *J* = 12.6, 3.7 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 0.96 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully resolved) δ 173.7, 152.6, 143.0, 138.8, 137.1, 130.5, 129.6, 128.5, 128.2 (2C), 127.4, 126.7, 124.6, 118.9, 109.3, 67.0, 61.0, 59.4, 51.8, 44.8, 44.6, 29.9, 27.5, 22.0, 21.6, 13.7.
IR (ν_{max}, cm^{-1}) 3030 (m), 2952 (m), 2868 (w), 1727 (m), 1606 (m), 1480 (s), 1452 (m), 1343 (s), 1313 (m), 1213 (s), 1161 (s), 1089 (m), 1030 (m), 959 (m), 816 (m), 759 (s), 733 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{30}H_{35}N_2O_4S^+$ 519.2312; Found 519.2330.

Ethyl 9-(2-((tert-butyldimethylsilyl)oxy)ethyl)-4-((N,4-dimethylphenyl)sulfonamido)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6e)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and tert-butyl-(2-indol-1-ylethoxy)-dimethylsilane (**4e**) (86.8 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford cycloadduct **6e** as a colorless oil (156 mg, 266 µmol, 89% yield, dr 70:30).

Prepared according to the general procedure G from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and tert-butyl-(2-indol-1-ylethoxy)-dimethylsilane (**4e**) (86.8 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford cycloadduct **6e** as a colorless oil (150 mg, 255 µmol, 85% yield, dr 83:17).

The dr was measured on the crude GC chromatogram and on the crude ^{1}H NMR spectrum by integrating the Ar*H* protons of each diastereomers.

Data for major diastereoisomer:

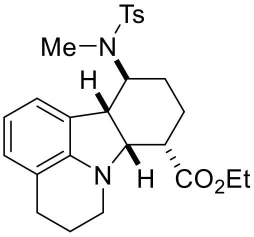
Rf (pent/EtOAc 8:2): 0.55.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.53 – 7.47 (m, 2H, Ar*H*), 7.18 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.10 (td, *J* = 7.7, 1.3 Hz, 1H, Ar*H*), 6.94 (dd, *J* = 7.3, 1.3 Hz, 1H, Ar*H*), 6.63 – 6.53 (m, 2H, Ar*H*), 4.15 (q, *J* = 7.1 Hz, 2H, OCH_2CH$_3$), 3.87 (d, *J* = 6.8 Hz, 1H, $_{ind}$NC*H*), 3.81 (dt, *J* = 10.3, 6.0 Hz, 1H, NCH$_2$CH_2OTBS), 3.72 (dt, *J* = 10.3, 5.9 Hz, 1H, NCH$_2$CH_2OTBS), 3.63 (ddd, *J* = 12.4, 10.7, 4.2 Hz, 1H, TsNC*H*), 3.26 – 3.10 (m, 4H, TsNCHC*H* + $_{ind}$NCHC*H*C(O) + NCH_2CH$_2$OTBS), 2.84 (s, 3H, NCH_3), 2.39 (s, 3H, CCH_3), 2.00 – 1.89 (m, 2H, TsNCHCH_2CH$_2$CHC(O)), 1.51 – 1.37 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.34 – 1.20 (m, 4H, OCH$_2$CH_3 + TsNCHCH$_2$CH_2CHC(O)), 0.89 (s, 9H, SiC(CH_3)$_3$), 0.06 (d, *J* = 4.5 Hz, 6H, Si(CH_3)$_2$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.0, 151.5, 142.9, 137.4, 131.2, 129.6, 127.9, 127.3, 125.3, 118.6, 108.2, 66.6, 61.7, 60.8, 58.9, 50.1, 41.1, 39.2, 29.0, 26.1, 23.5, 23.3, 21.6, 18.5, 14.4, -5.2.
IR (ν_{max}, cm^{-1}) 2953 (m), 2858 (m), 1727 (m), 1608 (w), 1478 (m), 1343 (m), 1256 (m), 1190 (m), 1163 (m), 1089 (m), 986 (m), 836 (m), 775 (s), 741 (s).
HRMS (ESI/QTOF) m/z: [M + H]+ Calcd for $C_{31}H_{47}N_2O_5SSi^+$ 587.2969; Found 587.2973.

Data for minor diastereoisomer:

Rf (pent/EtOAc 8:2): 0.38.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 – 7.46 (m, 2H, Ar*H*), 7.19 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.12 (td, *J* = 7.7, 1.4 Hz, 1H, Ar*H*), 6.95 (dd, *J* = 7.3, 1.3 Hz, 1H, Ar*H*), 6.68 – 6.57 (m, 2H, Ar*H*), 4.25 – 4.07 (m, 3H, OCH_2CH$_3$ + $_{ind}$NC*H*), 3.75 – 3.64 (m, 2H, NCH$_2$CH_2OTBS), 3.59 (ddd, *J* = 12.4, 10.4, 4.2 Hz, 1H, TsNC*H*), 3.04 (ddd, *J* = 9.7, 6.5, 3.2 Hz, 2H, NCH_2CH$_2$OTBS), 2.94 (dd, *J* = 10.5, 6.1 Hz, 1H, TsNCHC*H*), 2.80 (s, 3H, NCH_3), 2.64 – 2.54 (m, 1H, $_{ind}$NCHC*H*C(O)), 2.40 (s, 3H, CCH_3), 1.93 – 1.87 (m, 2H, TsNCHCH_2CH$_2$CHC(O)), 1.55 – 1.48 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.42 (td, *J* = 12.3, 4.7 Hz, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.33 – 1.24 (m, 3H, OCH$_2$CH_3), 0.89 (s, 9H, SiC(CH_3)$_3$), 0.06 (d, *J* = 4.8 Hz, 6H, Si(CH_3)$_2$).

^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 152.4, 142.9, 137.4, 130.3, 129.6, 128.1, 127.3, 124.6, 118.6, 109.0, 67.1, 61.1, 60.6, 59.3, 50.1, 44.8, 44.5, 29.8, 29.7, 27.5, 26.1, 21.8, 21.6, 18.4, 14.1, -5.1, -5.2.
IR (ν_{max}, cm^{-1}) 2949 (m), 2929 (m), 2857 (w), 1732 (m), 1610 (w), 1480 (m), 1343 (m), 1255 (m), 1215 (m), 1160 (m), 1123 (m), 961 (m), 836 (m), 758 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{31}H_{47}N_2O_5SSi^+$ 587.2969; Found 587.2980.

Ethyl 11-((N,4-dimethylphenyl)sulfonamido)-5,6,7a,8,9,10,11,11a-octahydro-4H-pyrido[3,2,1-jk]carbazole-8-carboxylate (6f)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-azatricyclo[6.3.1.04,12]dodeca-2,4(12),5,7-tetraene (**4f**) (49.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford cycloadduct **6f** as a colorless oil (114 mg, 243 µmol, 81% yield, dr 60:40).

Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**36a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-azatricyclo[6.3.1.04,12]dodeca-2,4(12),5,7-tetraene (**44f**) (49.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford cycloadduct **45f** as a colorless oil (36.8 mg, 78.5 µmol, 26% yield, dr 82:18).

Prepared according to the general procedure G from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-azatricyclo[6.3.1.04,12]dodeca-2,4(12),5,7-tetraene (**4f**) (49.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 90:10 to afford cycloadduct **6f** as a colorless oil (109 mg, 233 µmol, 78% yield, dr 80:20).

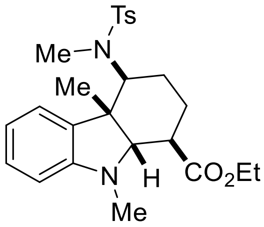
The dr was measured on the crude GC chromatogram and on the crude ^{1}H NMR spectrum by integrating the Ar*H* protons of each diastereomers.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.35.
^{1}H NMR (400 MHz, chloroform-*d*, 70:30 mixture of rotamers (major/minor)) δ 7.55 – 7.50 (m, 2H, Ar*H* (major+minor)), 7.21 – 7.15 (m, 2H, Ar*H* (major+minor)), 6.86 (ddd, *J* = 7.7, 2.2, 1.1 Hz, 1H, Ar*H* (major+minor)), 6.82 – 6.75 (m, 1H, Ar*H* (major+minor)), 6.60 – 6.52 (m, 1H, Ar*H* (major+minor)), 4.21 – 4.10 (m, 2H, OCH_2 (major+minor)), 3.78 (ddd, *J* = 12.3, 10.4, 4.3 Hz, 1.3H, TsNC*H* (major+minor) + $_{\mathrm{ind}}$NC*H* (minor)), 3.54 – 3.49 (m, 0.7H, $_{\mathrm{ind}}$NC*H* (major)), 3.24 (dt, *J* = 10.0, 3.6 Hz, 0.7H, NCH_2 (major)), 3.13 (dd, *J* = 10.8, 6.6 Hz, 0.7H, TsNCHC*H* (major)), 3.03 (dt, *J* = 9.5, 3.3 Hz, 0.3H, NCH_2 (minor)), 2.99 – 2.92 (m, 0.7H, $_{\mathrm{ind}}$NCHC*H*C(O) (major)), 2.90 (dd, *J* = 10.6, 6.0 Hz, 0.3H, TsNCHC*H* (minor)), 2.84 (s, 2.1H, TsNCH_3 (major)), 2.82 (s, 0.9H, TsNCH_3 (minor)), 2.75 – 2.63 (m, 2H, NCH$_2$CH$_2$CH_2 (major+minor)), 2.54 (dt, *J* = 11.8, 3.8 Hz, 0.3H, $_{\mathrm{ind}}$NCHC*H*C(O) (minor)), 2.50 – 2.41 (m, 1H, NCH_2 (major+minor)), 2.39 (s, 3H, CCH_3 (major+minor)), 2.22 – 2.04 (m, 2H, NCH$_2$CH_2 (major+minor)), 2.04 – 1.85 (m, 2.3H, TsNCHCH$_2$CH_2CHC(O) (major+minor), TsNCHCH_2CH$_2$CHC(O) (minor)), 1.52 – 1.37 (m, 1H,

TsNCHC*H*$_2$CH$_2$CHC(O) (minor)), 1.36 – 1.29 (m, 0.7H, TsNCHC*H*$_2$CH$_2$CHC(O) (minor)), 1.29 – 1.23 (m, 3H, OCH$_2$C*H*$_3$ (major+minor)).
^{13}C NMR (101 MHz, chloroform-*d*, mixture of rotamers, signals not fully resolved) δ 173.9, 149.1, 148.8, 142.7, 137.3, 137.2, 130.2, 129.8, 129.4, 127.2, 127.0, 126.8, 122.5, 122.2, 120.9, 120.5, 119.3, 119.2, 69.0, 68.0, 60.7, 58.5, 46.1, 45.4, 44.7, 43.7, 41.4, 38.7, 28.9, 27.5, 24.1, 23.9, 23.7, 23.3, 23.2, 23.0, 21.6, 21.5, 14.3, 14.1.
IR (ν_{max}, cm^{-1}) 3019 (m), 2929 (m), 2858 (m), 1727 (s), 1600 (m), 1455 (m), 1342 (s), 1209 (s), 1161 (s), 1090 (m), 1029 (m), 969 (m), 754 (s), 679 (m), 654 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{26}H_{33}N_2O_4S^+$ 469.2156; Found 469.2174.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-4a,9-dimethyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6g)



Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1,3-dimethylindole (**4g**) (47.6 mg, 315 µmol, 1.05 equiv.). The reaction mixture was stirred 16 h at 40 °C. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6g** as a grey solid (89.7 mg, 196 µmol, 65% yield, 85:15 dr).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

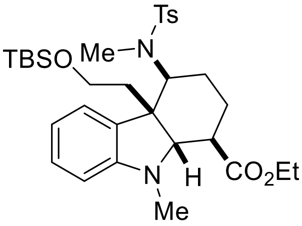
m.p.: 146-147 °C.
Rf (pent/EtOAc 8:2): 0.38.
^{1}H NMR (400 MHz, chloroform-*d*, signals for major diastereomer) δ 7.53 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.23 (tt, *J* = 7.7, 2.5 Hz, 4H, Ar*H*), 6.88 (ddd, *J* = 8.4, 6.8, 1.0 Hz, 1H, Ar*H*), 6.68 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.25 – 4.08 (m, 2H, OC*H*$_2$), 3.91 (d, *J* = 9.6 Hz, 1H,TsNC*H*), 3.46 (t, *J* = 1.7 Hz, 1H, $_{\text{ind}}$NC*H*), 2.93 (d, *J* = 3.5 Hz, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.74 (s, 3H, TsNC*H*$_3$), 2.73 (s, 3H, $_{\text{ind}}$NC*H*$_3$), 2.39 (s, 3H, ArC*H*$_3$), 2.10 (d, *J* = 9.4 Hz, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.93 – 1.75 (m, 2H, TsNCHC*H*$_2$C*H*$_2$CHC(O)), 1.34 (s, 3H, TsNCHCC*H*$_3$), 1.30 – 1.21 (m, 3H, OCH$_2$C*H*$_3$), 0.92 – 0.82 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully resolved) δ 173.8, 151.2, 143.0, 135.8 (2C), 129.6, 128.2, 127.5, 124.2, 119.4, 109.2, 77.4, 60.9, 59.7, 48.3, 38.1, 34.5, 32.6, 23.2, 21.6, 21.2, 18.1, 14.3.
IR (ν_{max}, cm^{-1}) 3027 (m), 2974 (m), 2875 (m), 2811 (w), 1727 (s), 1608 (m), 1482 (m), 1465 (m), 1345 (s), 1305 (m), 1196 (m), 1163 (s), 1089 (m), 1030 (m), 974 (m), 908 (m), 756 (s), 744 (s), 667 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_4S^+$ 457.2156; Found 457.2160.

Data for minor diastereoisomer:

m.p.: 148-150 °C.
Rf (pent/EtOAc 8:2): 0.31.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.53 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.30 – 7.19 (m, 4H, Ar*H*), 6.88 (t, *J* = 7.4 Hz, 1H, Ar*H*), 6.66 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.19 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$), 3.89 (d, *J* = 12.3 Hz, 1H, TsNC*H*), 3.44 (d, *J* = 3.1 Hz, 1H, $_{\text{ind}}$NC*H*), 2.73 (s, 3H, TsNC*H*$_3$), 2.67

– 2.53 (m, 4H, $_{ind}$NC*H$_3$* + $_{ind}$NCHC*H*C(O)), 2.39 (s, 3H, ArC*H$_3$)*, 2.01 – 1.85 (m, 2H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.55 – 1.39 (m, 4H, TsNCHCC*H$_3$* + TsNCHC*H$_2$*CH$_2$CHC(O)), 1.28 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H$_3$*), 1.03 (d, *J* = 11.8 Hz, 1H, TsNCHC*H$_2$*CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.4, 151.6, 143.1, 135.7, 135.2, 129.6, 128.2, 127.5, 124.0, 119.3, 108.9, 77.3, 60.9, 59.3, 49.0, 41.5, 34.7, 32.7, 24.2, 22.6, 21.6, 16.8, 14.2.
IR (ν_{max}, cm^{-1}) 3029 (w), 2960 (w), 2871 (w), 2813 (w), 1728 (m), 1609 (w), 1480 (m), 1339 (m), 1310 (w), 1213 (m), 1158 (s), 1089 (m), 1037 (m), 986 (m), 940 (m), 908 (m), 813 (m), 748 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_4S^+$ 457.2156; Found 457.2159.

Ethyl 4a-(2-((tert-butyldimethylsilyl)oxy)ethyl)-4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6h)



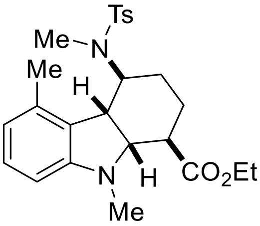
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and *tert*-butyl-dimethyl-[2-(1-methyl-3-indolyl)ethoxy]silane (**4h**) (95.0 mg, 315 µmol, 1.05 equiv.). The reaction mixture was stirred 16 h at 40 °C. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6h** as an oil (32.0 mg, 53.3 µmol, 18% yield, >95:5 dr).

The dr was measured on the crude ^{1}H NMR spectrum by integrating the Ar*H* protons of each diastereomers.

<u>*Data for major diastereoisomer:*</u>

Rf (pent/EtOAc 8:2): 0.41.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.32 – 7.08 (m, 4H, Ar*H*), 6.89 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 6.67 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.30 – 4.08 (m, 2H, C(O)OC*H$_2$*), 3.91 (d, *J* = 9.9 Hz, 1H, TsNC*H*), 3.76 – 3.57 (m, 1H, TBSOC*H$_2$*), 3.55 – 3.41 (m, 2H, $_{ind}$NC*H* + TBSOC*H$_2$*), 2.93 (d, *J* = 3.5 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.78 – 2.64 (m, 6H, $_{ind}$NC*H$_3$* + TsNC*H$_3$*), 2.38 (s, 3H, CC*H$_3$*), 2.17 (td, *J* = 12.2, 4.8 Hz, 1H, TBSOCH$_2$C*H$_2$*), 2.09 (d, *J* = 9.1 Hz, 1H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.90 (ddd, *J* = 13.3, 10.8, 5.5 Hz, 1H, TBSOCH$_2$C*H$_2$*), 1.86 – 1.70 (m, 2H, TsNCHC*H$_2$*C*H$_2$*CHC(O)), 1.40 – 1.18 (m, 4H, C(O)OCH$_2$C*H$_3$* + TsNCHC*H$_2$*CH$_2$CHC(O)), 0.85 (s, 9H, SiC(CH$_3$)$_3$), -0.01 (d, *J* = 10.1 Hz, 6H, Si(C*H$_3$*)$_2$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.6, 151.2, 143.1, 135.5, 132.9, 129.6, 128.1, 127.6, 124.7, 119.4, 109.1, 71.3, 61.2, 60.5, 60.2, 50.9, 38.3, 34.4, 33.1, 30.9, 26.0, 23.0, 21.6, 21.0, 18.3, 14.2, -5.0, -5.1.
IR (ν_{max}, cm^{-1}) 3020 (w), 2957 (m), 2925 (m), 2853 (w), 1721 (m), 1482 (w), 1348 (w), 1216 (s), 1163 (w), 1088 (s), 977 (w), 838 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{32}H_{49}N_2O_5SSi^+$ 601.3126; Found 601.3139.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-5,9-dimethyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6i)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1,4-dimethylindole (**4i**) (45.7 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6i** as a colorless oil (102 mg, 223 µmol, 74% yield, dr 64:36).

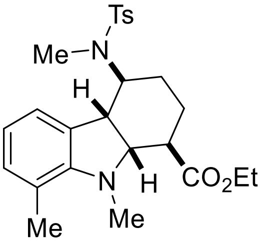
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1,4-dimethylindole (**4i**) (45.7 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6i** as a colorless oil (122 mg, 268 µmol, 89% yield, dr 88:12).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 7:3): 0.52.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.55 – 7.44 (m, 2H, Ar*H*), 7.21 – 7.13 (m, 2H, Ar*H*), 7.07 (t, *J* = 7.7 Hz, 1H, Ar*H*), 6.56 (d, *J* = 7.6 Hz, 1H, Ar*H*), 6.48 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.16 (qd, *J* = 7.1, 0.9 Hz, 2H, OCH_2), 3.80 – 3.69 (m, 1H, TsNC*H*), 3.39 (d, *J* = 5.9 Hz, 1H, $_{\text{ind}}$NC*H*), 3.24 (dd, *J* = 10.5, 5.9 Hz, 1H, TsNCHC*H*), 3.03 – 2.96 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.82 (s, 3H, TsNCH_3), 2.64 (s, 3H $_{\text{ind}}$NCH_3), 2.38 (s, 3H, TsCCH_3), 2.19 (s, 3H, $_{\text{ind}}$CCH_3), 1.99 – 1.85 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.42 (dd, *J* = 12.8, 4.5 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.27 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3), 1.08 (ddd, *J* = 14.5, 6.7, 3.0 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 152.6, 142.9, 137.0, 134.9, 131.1, 129.6, 127.7, 127.2, 121.6, 106.9, 69.2, 60.9, 58.7, 40.5, 38.8, 34.6, 29.1, 23.5, 23.1, 21.6, 19.4, 14.4.
IR (ν_{max}, cm^{-1}) 3015 (m), 1725 (s), 1599 (m), 1451 (m), 1341 (m), 1215 (s), 1163 (s), 986 (w).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_4S^+$ 457.2156; Found 457.2159.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-8,9-dimethyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6j)



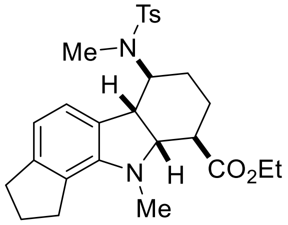
Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1,7-dimethylindole (**4j**) (45.7 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6j** as a colorless oil (124 mg, 272 µmol, 91% yield, dr >95:5).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.14.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.58 – 7.46 (m, 2H, Ar*H*), 7.22 – 7.13 (m, 2H, Ar*H*), 6.95 – 6.88 (m, 1H, Ar*H*), 6.86 (d, *J* = 7.2 Hz, 1H, Ar*H*), 6.62 (t, *J* = 7.4 Hz, 1H, Ar*H*), 4.17 (qd, *J* = 7.2, 0.8 Hz, 2H, OCH_2), 3.57 (ddd, *J* = 12.4, 10.6, 4.2 Hz, 1H, TsNC*H*), 3.46 (dt, *J* = 7.1, 1.5 Hz, 1H, $_{\text{ind}}$NC*H*), 3.22 (dd, *J* = 10.6, 7.1 Hz, 1H, TsNCHC*H*), 3.06 – 2.95 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.83 (s, 3H, $_{\text{ind}}$NCH_3), 2.82 (s, 3H, TsNCH_3) 2.39 (s, 6H, CCH_3), 2.01 – 1.84 (m, 2H, TsNCHCH_2CH_2CHC(O)), 1.46 (qd, *J* = 12.4, 4.3 Hz, 1H, TsNCHCH_2CH_2CHC(O)), 1.33 – 1.20 (m, 4H, OCH_2CH_3 + TsNCHCH_2CH_2CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.2, 150.6, 142.9, 137.3, 132.2, 131.7, 129.5, 127.4, 123.2, 121.2, 120.1, 69.0, 60.9, 59.2, 41.2, 39.2, 38.2, 28.9, 23.5, 23.3, 21.6, 20.3, 14.4.
IR (ν_{max}, cm^{-1}) 3022 (m), 2959 (m), 2870 (m), 1726 (s), 1597 (m), 1461 (m), 1340 (s), 1234 (m), 1188 (s), 1162 (s), 988 (s), 955 (m), 781 (s), 753 (s), 688 (m), 654 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_4S^+$ 457.2156; Found 457.2162.

Ethyl 6-((N,4-dimethylphenyl)sulfonamido)-10-methyl-1,2,3,5b,6,7,8,9,9a,10-decahydrocyclopenta[a]carbazole-9-carboxylate (6k)



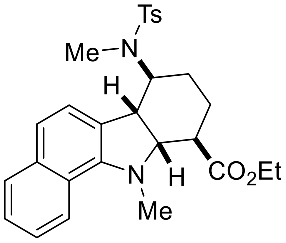
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 1-methyl-1,6,7,8-tetrahydrocyclopenta[g]indole (**4k**) (56.2 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **6k** as a colorless oil (112 mg, 233 μmol, 78% yield, dr >95:5).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.37.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.50 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.20 – 7.12 (m, 2H, Ar*H*), 6.76 (d, *J* = 7.3 Hz, 1H, Ar*H*), 6.56 – 6.48 (m, 1H, Ar*H*), 4.17 (td, *J* = 7.2, 6.6 Hz, 2H, OCH_2), 3.63 – 3.55 (m, 1H, TsNC*H*), 3.46 (dt, *J* = 6.9, 1.6 Hz, 1H, $_{\text{ind}}$NC*H*), 3.17 (dd, *J* = 10.8, 7.0 Hz, 1H, TsNCHC*H*), 3.13 – 3.05 (m, 1H, cyclopentylCH_2), 3.05 – 3.00 (m, 1H, cyclopentylCH_2), 3.00 – 2.95 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.90 – 2.76 (m, 7H, NCH_3 + cyclopentylCH_2), 2.39 (s, 3H, CCH_3), 2.27 – 1.86 (m, 5H, cyclopentylCH_2 + TsNCHCH_2CH_2CHC(O)), 1.47 (qd, *J* = 12.5, 4.0 Hz, 1H, TsNCHCH_2CH_2CHC(O)), 1.37 – 1.30 (m, 1H, TsNCHCH_2CH_2CHC(O)), 1.27 (t, *J* = 7.1 Hz, 3H, OCH_2CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.1, 148.5, 145.9, 142.8, 137.4, 129.5, 129.4, 127.3, 125.6, 123.3, 115.8, 69.0, 60.8, 59.2, 41.0, 39.0, 36.5, 32.7, 31.5, 28.9, 25.7, 23.6, 23.4, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2947 (m), 2866 (w), 1726 (s), 1598 (m), 1458 (m), 1342 (m), 1319 (m), 1187 (s), 1162 (s), 1089 (m), 974 (s), 910 (m), 815 (m), 732 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{27}H_{35}N_2O_4S^+$ 483.2312; Found 483.2322.

Ethyl 7-((N,4-dimethylphenyl)sulfonamido)-11-methyl-6b,8,9,10,10a,11-hexahydro-7H-benzo[a]carbazole-10-carboxylate (6l)



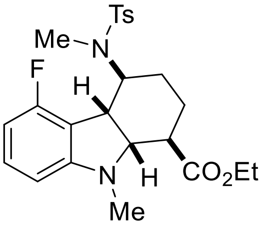
Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 1-methylbenzo[g]indole (**4l**) (59.5 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6l** as a colorless oil (62.0 mg, 126 µmol, 42% yield, dr 80:20).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.37.
^{1}H NMR (400 MHz, chloroform-*d*) δ 8.07 (ddd, *J* = 6.3, 2.2, 1.4 Hz, 1H, Ar*H*), 7.84 – 7.72 (m, 1H, Ar*H*), 7.47 – 7.32 (m, 4H, Ar*H*), 7.23 – 7.08 (m, 2H, Ar*H*), 7.08 – 6.95 (m, 2H, Ar*H*), 4.20 (qd, *J* = 7.1, 0.9 Hz, 2H, OCH_2), 3.64 (dd, *J* = 7.5, 2.5 Hz, 1H, $_{ind}$NC*H*), 3.61 – 3.54 (m, 1H, TsNC*H*), 3.43 (dd, *J* = 10.5, 7.4 Hz, 1H, TsNCHC*H*), 3.10 (s, 3H, $_{ind}$NCH_3), 3.07 (dt, *J* = 4.0, 2.2 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.90 (s, 3H, TsNCH_3), 2.32 (s, 3H, CCH_3), 2.03 (ddt, *J* = 7.5, 5.0, 2.8 Hz, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.54 – 1.47 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.44 – 1.33 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.30 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.4, 148.3, 142.9, 137.0, 135.2, 129.4, 129.2, 127.5, 127.2, 124.8, 124.1, 123.5, 123.0, 122.6, 120.7, 70.4, 60.9, 59.8, 41.6, 40.8, 39.7, 29.0, 23.6, 23.4, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 3023 (w), 1724 (m), 1451 (w), 1328 (w), 1286 (w), 1213 (m), 1187 (m), 1159 (m), 1087 (w), 1026 (w), 935 (w).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{28}H_{33}N_2O_4S^+$ 493.2156; Found 493.2162.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-5-fluoro-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6m)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 4-fluoro-1-methylindole (**4m**) (47.0 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6m** as a colorless oil (33.7 mg, 73.2 µmol, 24% yield, dr 87:13).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

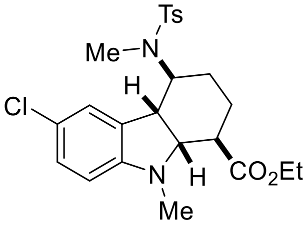
Rf (pent/EtOAc 7:3): 0.52.

^{1}H NMR (400 MHz, chloroform-*d*) δ 7.51 – 7.44 (m, 2H, Ar*H*), 7.18 – 7.10 (m, 2H, Ar*H*), 7.04 (td, *J* = 8.1, 5.6 Hz, 1H, Ar*H*), 6.38 (d, *J* = 7.9 Hz, 1H, Ar*H*), 6.28 (td, *J* = 8.5, 0.7 Hz, 1H, Ar*H*), 4.18 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$), 3.75 – 3.68 (m, 1H,TsNC*H*), 3.50 (dt, *J* = 6.5, 1.6 Hz, 1H, $_{\text{ind}}$NC*H*), 3.45 (dd, *J* = 10.6, 6.3 Hz, 1H, TsNCHC*H*), 3.00 (dt, *J* = 4.7, 2.3 Hz, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.88 (s, 3H, TsNC*H*$_3$), 2.66 (s, 3H, $_{\text{ind}}$NC*H*$_3$), 2.37 (s, 3H, CC*H*$_3$), 2.05 – 1.88 (m, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.52 (qd, *J* = 12.7, 3.4 Hz, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.41 – 1.33 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.28 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.6, 159.5 (d, *J* = 245.4 Hz), 155.1 (d, *J* = 8.8 Hz), 142.7, 137.6, 129.4, 129.3 (d, *J* = 8.8 Hz), 127.1, 117.6 (d, *J* = 21.6 Hz), 107.0 (d, *J* = 22.0 Hz), 105.2, 69.1, 61.0, 58.1, 39.2, 38.8, 34.4, 28.4, 24.0, 23.4, 21.6, 14.4.
^{19}F NMR (376 MHz, chloroform-*d*) δ -118.8 (dd, *J* = 8.8, 5.5 Hz).
IR (ν_{max}, cm^{-1}) 3026 (m), 1725 (s), 1628 (m), 1472 (m), 1332 (m), 1213 (s), 1161 (s), 1091 (w), 986 (m), 969 (m).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{24}H_{29}FN_2NaO_4S^+$ 483.1724; Found 483.1722.

Data for minor diastereoisomer:

Rf (pent/EtOAc 7:3): 0.40.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 – 7.45 (m, 2H, Ar*H*), 7.15 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.05 (td, *J* = 8.1, 5.7 Hz, 1H, Ar*H*), 6.42 – 6.25 (m, 2H, Ar*H*), 4.18 (qd, *J* = 7.1, 4.6 Hz, 2H, OC*H*$_2$), 3.83 (dd, *J* = 5.7, 3.2 Hz, 1H, $_{\text{ind}}$NC*H*), 3.79 – 3.72 (m, 1H, TsNC*H*), 3.16 (dd, *J* = 10.6, 5.6 Hz, 1H, TsNCHC*H*), 2.87 (s, 3H, TsNC*H*$_3$), 2.60 – 2.53 (m, 4H, $_{\text{ind}}$NC*H*$_3$ + $_{\text{ind}}$NCHC*H*C(O)), 2.38 (s, 3H, CC*H*$_3$), 2.00 – 1.82 (m, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.67 – 1.55 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.51 – 1.39 (m, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.28 (t, *J* = 7.2 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully resolved) δ 173.6, 159.2 (d, *J* = 245.0 Hz), 155.5 (d, *J* = 8.4 Hz), 142.8, 137.5, 129.5, 129.4 (d, *J* = 8.8 Hz), 127.1, 117.1 (d, *J* = 21.6 Hz), 106.8 (d, *J* = 21.6 Hz), 105.0, 69.7, 61.0, 57.8, 43.9, 42.3, 34.6, 28.5, 27.7, 21.6 (2C), 14.2.
^{19}F NMR (376 MHz, chloroform-*d*) δ -119.6 (dd, *J* = 8.6, 5.9 Hz).
IR (ν_{max}, cm^{-1}) 3029 (w), 2944 (w), 2863 (w), 2817 (w), 1725 (m), 1628 (w), 1473 (m), 1335 (m), 1213 (m), 1156 (m), 1091 (m), 966 (m), 814 (m), 755 (s), 728 (m).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{24}H_{30}FN_2O_4S^+$ 461.1905; Found 461.1894.

Ethyl 6-chloro-4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6n)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 5-chloro-1-methylindole (**4n**) (54.3 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6n** as a colorless oil (121 mg, 254 µmol, 85% yield, dr 64:36).

Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 5-chloro-1-methylindole (**4n**) (54.3 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6n** as a colorless oil (89.0 mg, 187 μmol, 62% yield, dr 88:12).

The dr was measured on the crude GC chromatogram.

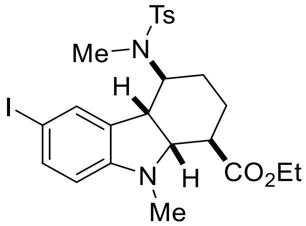
Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.30.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 – 7.45 (m, 2H, Ar*H*), 7.20 (d, *J* = 8.1 Hz, 2H, Ar*H*), 7.05 (dd, *J* = 8.3, 2.2 Hz, 1H, Ar*H*), 6.74 (d, *J* = 2.1 Hz, 1H, Ar*H*), 6.48 (d, *J* = 8.4 Hz, 1H, Ar*H*), 4.18 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$), 3.70 – 3.63 (m, 1H, TsNC*H*), 3.49 (d, *J* = 6.6 Hz, 1H, $_{\text{ind}}$NC*H*), 3.14 (dd, *J* = 11.0, 6.5 Hz, 1H, TsNCHC*H*), 3.03 – 2.98 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.82 (s, 3H, TsNC*H*$_3$), 2.64 (s, 3H, $_{\text{ind}}$NC*H*$_3$), 2.39 (s, 3H, CC*H*$_3$), 2.10 – 1.91 (m, 2H, TsNCHC*H*$_2$C*H*$_2$CHC(O)), 1.59 – 1.54 (m, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.31 – 1.24 (m, 4H, OCH$_2$C*H*$_3$ + TsNCHC*H*$_2$CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 151.2, 143.2, 136.8, 133.3, 129.7, 127.7, 127.2, 125.2, 123.7, 109.9, 68.7, 61.0, 58.1, 41.0, 38.9, 34.5, 28.7, 24.2, 23.4, 21.7, 14.4.
IR (ν_{max}, cm^{-1}) 2926 (w), 2850 (w), 1726 (s), 1654 (m), 1606 (m), 1478 (s), 1457 (s), 1343 (s), 1193 (s), 1162 (s), 1091 (s), 986 (s), 811 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{24}H_{29}{}^{35}ClN_2NaO_4S^+$ 499.1429; Found 499.1429.

Data for minor diastereoisomer:

Rf (pent/EtOAc 8:2): 0.24.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.55 – 7.42 (m, 2H, Ar*H*), 7.20 (d, *J* = 8.1 Hz, 2H, Ar*H*), 7.04 (dd, *J* = 8.4, 2.2 Hz, 1H, Ar*H*), 6.77 (d, *J* = 2.2 Hz, 1H, Ar*H*), 6.45 (d, *J* = 8.4 Hz, 1H, Ar*H*), 4.26 – 4.11 (m, 2H, OC*H*$_2$), 3.80 (dd, *J* = 5.9, 3.2 Hz, 1H, $_{\text{ind}}$NC*H*), 3.73 – 3.59 (m, 1H, TsNC*H*), 2.90 – 2.83 (m, 1H, TsNCHC*H*), 2.80 (s, 3H, TsNC*H*$_3$), 2.54 (s, 4H, $_{\text{ind}}$NC*H*$_3$ + $_{\text{ind}}$NCHC*H*C(O)), 2.39 (s, 3H, CC*H*$_3$), 2.00 – 1.90 (m, 2H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.75 (dq, *J* = 12.6, 3.6 Hz, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.49 (dddd, *J* = 16.1, 12.4, 7.9, 5.2 Hz, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.28 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.6, 151.5, 143.2, 136.8, 132.7, 129.7, 127.7, 127.2, 124.8, 123.5, 109.8, 69.5, 61.0, 58.2, 44.3, 43.9, 34.7, 29.3, 28.0, 21.7, 21.6, 14.2.
IR (ν_{max}, cm^{-1}) 2970 (w), 2869 (w), 1729 (s), 1599 (w), 1479 (s), 1333 (m), 1212 (s), 1160 (s), 1144 (s), 1089 (m), 1038 (m), 958 (m), 815 (m), 761 (s), 659 (s).
HRMS (ESI/QTOF) m/z: [M + H]+ Calcd for $C_{24}H_{30}{}^{35}ClN_2O_4S^+$ 477.1609; Found 477.1608.

Ethyl 6-iodo-4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6o)



Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 5-iodo-1-methylindole (**4o**) (84.4 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6o** as a colorless oil (92.6 mg, 163 μmol, 54% yield, dr 88:12).

The dr was measured on the crude ^{1}H NMR spectrum by integrating the TsNCH_3 protons of each diastereomers.

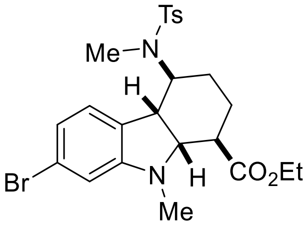
Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.36.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 – 7.48 (m, 2H, Ar*H*), 7.38 (dd, *J* = 8.3, 1.8 Hz, 1H, Ar*H*), 7.25 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.10 (d, *J* = 1.8 Hz, 1H, Ar*H*), 6.37 (d, *J* = 8.2 Hz, 1H, Ar*H*), 4.18 (q, *J* = 7.1 Hz, 2H, OCH_2), 3.68 (td, *J* = 10.4, 7.2 Hz, 1H, TsNC*H*), 3.50 (d, *J* = 6.7 Hz, 1H, $_{\text{ind}}$NC*H*), 3.15 (dd, *J* = 11.0, 6.6 Hz, 1H, TsNCHC*H*), 3.00 (dt, *J* = 4.8, 2.4 Hz, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.79 (s, 3H, TsNCH_3), 2.63 (s, 3H, $_{\text{ind}}$NCH_3), 2.41 (s, 3H, CCH_3), 2.08 – 1.86 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.61 – 1.52 (m, 2H, TsNCHCH_2CH$_2$CHC(O)), 1.28 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.7, 152.2, 143.2, 136.7, 136.6, 134.3, 133.4, 129.9, 127.4, 111.3, 80.5, 68.4, 61.0, 58.0, 40.9, 38.9, 34.2, 28.8, 24.0, 23.3, 21.8, 14.4.
IR (ν_{max}, cm^{-1}) 2950 (m), 2869 (m), 1724 (s), 1598 (m), 1475 (m), 1458 (m), 1340 (m), 1321 (m), 1191 (s), 1159 (s), 1144 (s), 1087 (s), 1019 (m), 985 (s), 939 (m), 863 (m), 806 (m), 759 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{24}H_{30}IN_2O_4S^+$ 569.0966; Found 569.0978.

Data for minor diastereoisomer:

Rf (pent/EtOAc 8:2): 0.25.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.50 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.38 (dd, *J* = 8.3, 1.8 Hz, 1H, Ar*H*), 7.25 (d, *J* = 7.4 Hz, 2H, Ar*H*), 7.10 (d, *J* = 1.7 Hz, 1H, Ar*H*), 6.34 (d, *J* = 8.3 Hz, 1H, Ar*H*), 4.27 – 4.10 (m, 2H, OCH_2), 3.81 (dd, *J* = 5.7, 3.2 Hz, 1H, $_{\text{ind}}$NC*H*), 3.67 (td, *J* = 12.4, 3.9 Hz, 1H, TsNC*H*), 2.88 (dd, *J* = 10.7, 5.8 Hz, 1H, TsNCHC*H*), 2.77 (s, 3H, TsNCH_3), 2.61 – 2.55 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.54 (s, 3H, $_{\text{ind}}$NCH_3), 2.41 (s, 3H, CCH_3), 2.02 – 1.88 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.84 – 1.72 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.54 – 1.42 (m, 1H TsNCHCH_2CH$_2$CHC(O)), 1.28 (t, *J* = 7.2 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.6, 152.7, 143.2, 136.8, 136.7, 133.8, 133.0, 129.9, 127.4, 111.2, 80.3, 69.3, 61.0, 58.2, 44.2, 43.9, 34.5, 29.4, 28.0, 21.8, 21.6, 14.2.
IR (ν_{max}, cm^{-1}) 2956 (w), 2863 (w), 1727 (m), 1599 (w), 1472 (m), 1340 (m), 1210 (m), 1158 (s), 1087 (m), 1037 (m), 957 (w), 814 (m), 748 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{24}H_{30}IN_2O_4S^+$ 569.0966; Found 569.0952.

Ethyl 7-bromo-4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6p)



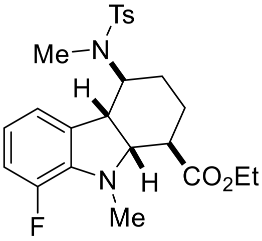
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 6-bromo-1-methylindole (**4p**) (68.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6p** as a colorless oil (79.0 mg, 151 µmol, 50% yield, dr 88:12).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.34.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.50 – 7.45 (m, 2H, Ar*H*), 7.18 (d, *J* = 8.1 Hz, 2H, Ar*H*), 6.73 – 6.67 (m, 2H, Ar*H*), 6.62 (dd, *J* = 7.7, 1.7 Hz, 1H, Ar*H*), 4.17 (q, *J* = 7.1 Hz, 2H, OCH_2), 3.63 – 3.54 (m, 1H, TsNC*H*), 3.52 (dd, *J* = 6.7, 1.8 Hz, 1H, $_{ind}$NC*H*), 3.13 (dd, *J* = 10.8, 6.6 Hz, 1H, TsNCHC*H*), 2.98 (dt, *J* = 4.9, 2.4 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.85 (s, 3H, TsNCH_3), 2.64 (s, 3H, $_{ind}$NCH_3), 2.42 (s, 3H, CCH_3), 2.01 (dd, *J* = 13.9, 3.8 Hz, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.97 – 1.83 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.47 (qd, *J* = 12.6, 3.4 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.37 (dq, *J* = 12.6, 4.0 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.27 (t, *J* = 7.2 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.7, 153.7, 143.1, 137.3, 130.4, 129.6, 127.0, 126.0, 121.9, 121.7, 112.2, 68.5, 61.0, 58.5, 40.7, 38.9, 34.1, 29.0, 23.6, 23.3, 21.7, 14.4.
IR (ν_{max}, cm^{-1}) 3030 (w), 2948 (m), 2869 (m), 2802 (w), 1725 (s), 1602 (m), 1479 (s), 1379 (m), 1339 (s), 1190 (s), 1163 (s), 1089 (m), 985 (s), 944 (m), 907 (m), 873 (s), 812 (m), 761 (s), 734 (s), 691 (m), 654 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{24}H_{30}{}^{79}BrN_2O_4S^+$ 521.1104; Found 521.1107.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-8-fluoro-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6q)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 7-fluoro-1-methylindole (**4q**) (47.0 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6q** as a colorless oil (113 mg, 246 µmol, 82% yield, dr 57:43).

Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 7-fluoro-1-methylindole (**4q**) (47.0 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6q** as a colorless oil (68.0 mg, 148 µmol, 49% yield, dr 85:15).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

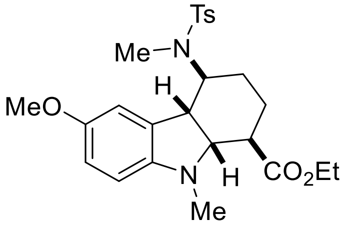
Rf (pent/EtOAc 7:3): 0.60.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.53 – 7.47 (m, 2H, Ar*H*), 7.19 (d, *J* = 8.0 Hz, 2H, Ar*H*), 6.92 – 6.77 (m, 2H, Ar*H*), 6.61 (ddd, *J* = 8.2, 7.3, 4.3 Hz, 1H, Ar*H*), 4.17 (q, *J* = 7.1 Hz, 2H, OCH_2), 3.60 (ddd, *J* = 12.4, 10.7, 4.2 Hz, 1H, TsNC*H*), 3.53 (dt, *J* = 6.9, 1.6 Hz, 1H, $_{ind}$NC*H*), 3.24 (dd, *J* = 10.8, 6.8 Hz, 1H, TsNCHC*H*), 3.07 – 2.96 (m, 1H, $_{ind}$NCHC*H*C(O)), 2.88 (s, 3H, $_{ind}$NCH_3), 2.82 (s, 3H, TsNCH_3), 2.39 (s, 3H, CCH_3), 2.10 – 1.83 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.41 (qd, *J* = 12.5, 3.6 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.33 – 1.13 (m, 4H, OCH$_2$CH_3 + TsNCHCH_2CH$_2$CHC(O)).

^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 150.1 (d, *J* = 241.7 Hz), 143.0, 138.6 (d, *J* = 7.7 Hz), 137.2, 135.0 (d, *J* = 4.4 Hz), 129.6, 127.2, 121.2, 120.3 (d, *J* = 6.2 Hz), 115.9 (d, *J* = 20.2 Hz), 69.2, 61.0, 58.8, 41.9, 38.5, 36.4 (d, *J* = 8.4 Hz), 29.0, 23.3, 23.2, 21.6, 14.4.
^{19}F NMR (376 MHz, chloroform-*d*) δ -134.6 (dd, *J* = 12.7, 4.3 Hz).
IR (ν_{max}, cm^{-1}) 3019 (m), 1723 (m), 1483 (w), 1340 (w), 1216 (s), 1162 (s), 1089 (m), 973 (m), 910 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{24}H_{30}FN_2O_4S^+$ 461.1905; Found 461.1908.

Data for minor diastereoisomer:

Rf (pent/EtOAc 7:3): 0.45.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.56 – 7.47 (m, 2H, Ar*H*), 7.20 (d, *J* = 8.0 Hz, 2H, Ar*H*), 6.95 – 6.77 (m, 2H, Ar*H*), 6.72 – 6.44 (m, 1H, Ar*H*), 4.31 – 4.03 (m, 2H, OCH_2), 3.86 (dd, *J* = 6.1, 3.2 Hz, 1H, $_{ind}$NC*H*), 3.58 (ddd, *J* = 12.4, 10.5, 4.4 Hz, 1H, TsNC*H*), 2.98 (dd, *J* = 10.6, 6.0 Hz, 1H, TsNCHC*H*), 2.80 (s, 3H, $_{ind}$NCH_3), 2.78 (s, 3H, TsNCH_3), 2.58 – 2.50 (m, 1H, $_{ind}$NCHC*H*C(O)), 2.39 (s, 3H, CCH_3), 1.95 – 1.85 (m, 2H, TsNCHCH_2CH_2CHC(O)), 1.52 – 1.34 (m, 2H, TsNCHCH_2CH$_2$CHC(O)), 1.28 (t, *J* = 7.2 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 149.9 (d, *J* = 241.7 Hz), 143.1, 138.9 (d, *J* = 7.0 Hz), 137.1, 134.5 (d, *J* = 4.4 Hz), 129.6, 127.2, 120.8 (d, *J* = 2.9 Hz), 120.0 (d, *J* = 6.6 Hz), 116.1 (d, *J* = 20.9 Hz), 70.1, 60.9, 58.9, 45.3, 43.8, 36.9 (d, *J* = 9.9 Hz), 29.7, 27.1, 21.6, 21.5, 14.1.
^{19}F NMR (376 MHz, chloroform-*d*) δ -134.5 (dd, *J* = 12.6, 4.2 Hz).
IR (ν_{max}, cm^{-1}) 3018 (w), 2935 (w), 2867 (w), 2815 (w), 1728 (m), 1599 (w), 1465 (m), 1335 (m), 1209 (m), 1162 (m), 1051 (m), 957 (m), 903 (w), 755 (s), 738 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{24}H_{30}FN_2O_4S^+$ 461.1905; Found 461.1891.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-6-methoxy-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6r)



Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 5-methoxy-1-methylindole (**4r**) (52.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6r** as a colorless oil (103 mg, 218 µmol, 73% yield, dr 95:5).

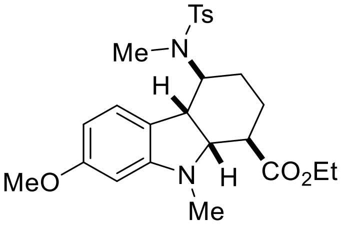
The dr was measured on the crude GC chromatogram.

Characterised as mixture of diastereomers

Rf (pent/EtOAc 8:2): 0.20.
^{1}H NMR (400 MHz, chloroform-*d*, signals for major diastereoisomer) δ 7.52 – 7.44 (m, 2H, Ar*H*), 7.17 (d, *J* = 8.0 Hz, 2H, Ar*H*), 6.69 (dd, *J* = 8.5, 2.6 Hz, 1H, Ar*H*), 6.60 – 6.50 (m, 2H, Ar*H*), 4.17 (q, *J* = 7.1 Hz, 2H, OCH_2), 3.75 – 3.64 (m, 4H, OCH_3 + TsNC*H*), 3.42 (d, *J* = 6.6 Hz, 1H, $_{ind}$NC*H*), 3.15 (dd, *J* = 10.8, 6.6 Hz, 1H, TsNCHC*H*), 2.99 (d, *J* = 4.3 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.83 (s, 3H, TsNCH_3), 2.62 (s, 3H, $_{ind}$NCH_3), 2.39 (s, 3H, CCH_3), 2.07 – 1.89

(m, 2H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.49 (td, *J* = 12.2, 4.4 Hz, 1H, TsNCHC*H$_2$*CH$_2$CHC(O)), 1.36 (dd, *J* = 12.8, 3.9 Hz, 1H, TsNCHC*H$_2$*CH$_2$CHC(O)), 1.27 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H$_3$*).
^{13}C NMR (101 MHz, chloroform-*d*, signals for major diastereoisomer) δ 174.0, 153.4, 146.5, 142.9, 137.3, 132.8, 129.6, 127.2, 113.2, 112.0, 109.7, 69.2, 60.9, 58.8, 55.9, 41.5, 39.1, 35.5, 28.9, 23.9, 23.4, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2946 (m), 2858 (w), 1725 (s), 1598 (w), 1490 (s), 1457 (m), 1341 (m), 1236 (s), 1189 (s), 1152 (s), 1089 (m), 1032 (m), 986 (s), 950 (m), 809 (m), 770 (m), 737 (s), 666 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_5S^+$ 473.2105; Found 473.2112.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-7-methoxy-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6s)



Prepared according to the general procedure E from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 6-methoxy-1-methylindole (**4s**) (52.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6s** as a colorless oil (126 mg, 267 µmol, 89% yield, dr 70:30).

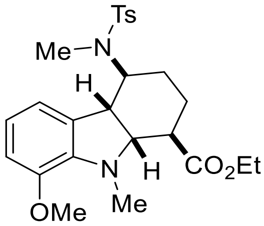
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 µmol, 1.00 equiv.) and 6-methoxy-1-methylindole (**4s**) (52.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6s** as a colorless oil (105 mg, 222 µmol, 74% yield, dr 94:6).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.21.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.23 – 7.15 (m, 2H, Ar*H*), 6.85 (d, *J* = 8.0 Hz, 1H, Ar*H*), 6.22 – 6.07 (m, 2H, Ar*H*), 4.16 (qd, *J* = 7.1, 0.8 Hz, 2H, OC*H$_2$*), 3.79 (s, 3H, OC*H$_3$*), 3.68 – 3.56 (m, 1H, TsNC*H*), 3.52 (dt, *J* = 6.6, 1.6 Hz, 1H, $_{ind}$NC*H*), 3.11 (dd, *J* = 10.7, 6.7 Hz, 1H, TsNCHC*H*), 2.99 (dt, *J* = 4.9, 2.4 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.84 (s, 3H, TsNC*H$_3$*), 2.65 (s, 3H, $_{ind}$NC*H$_3$*), 2.39 (s, 3H, CC*H$_3$*), 2.06 – 1.81 (m, 2H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.45 (qd, *J* = 12.6, 3.5 Hz, 1H, TsNCHC*H$_2$*CH$_2$CHC(O)), 1.34 – 1.19 (m, 3H, OCH$_2$C*H$_3$* + TsNCHC*H$_2$*CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 160.4, 153.7, 142.8, 137.4, 129.5, 127.2, 125.4, 124.0, 103.3, 96.7, 68.8, 60.9, 59.0, 55.4, 40.5, 39.2, 34.4, 29.0, 23.5, 23.3, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2954 (m), 2866 (w), 1725 (s), 1621 (m), 1597 (m), 1495 (s), 1465 (m), 1380 (m), 1340 (s), 1213 (s), 1190 (s), 1164 (s), 1089 (m), 1078 (s), 987 (s), 950 (m), 818 (m), 764 (s), 736 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_5S^+$ 473.2105; Found 473.2114.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-8-methoxy-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6t)



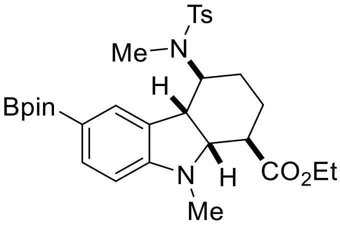
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 7-methoxy-1-methylindole (**4t**) (52.9 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6t** as a colorless oil (93.0 mg, 197 μmol, 66% yield, dr >95:5).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.33.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.50 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.18 (d, *J* = 8.0 Hz, 2H, Ar*H*), 6.81 – 6.72 (m, 1H, Ar*H*), 6.73 – 6.65 (m, 2H, Ar*H*), 4.22 – 4.11 (m, 2H, OCH_2), 3.83 (s, 3H, OCH_3), 3.57 (ddd, *J* = 12.4, 10.7, 4.2 Hz, 1H, TsNC*H*), 3.48 – 3.42 (m, 1H, $_{\text{ind}}$NC*H*), 3.24 (dd, *J* = 10.7, 7.0 Hz, 1H, TsNCHC*H*), 3.03 – 2.98 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.93 (s, 3H, TsNCH_3), 2.82 (s, 3H, indNCH_3), 2.39 (s, 3H, CCH_3), 2.00 – 1.91 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.48 – 1.38 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.30 – 1.23 (m, 4H, OCH$_2$CH_3 + TsNCHCH_2CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.2, 147.2, 142.8, 140.1, 137.4, 133.5, 129.6, 127.3, 120.7, 118.5, 111.8, 69.5, 60.9, 59.3, 55.7, 41.7, 38.7, 37.6, 29.0, 23.4, 23.3, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2957 (m), 2920 (m), 2842 (m), 1728 (s), 1595 (m), 1490 (m), 1456 (m), 1343 (s), 1238 (s), 1185 (s), 1163 (s), 1083 (m), 956 (m), 910 (s), 737 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for C$_{25}$H$_{33}$N$_2$O$_5$S$^+$ 473.2105; Found 473.2105.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6u)



Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 1-methyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)indole (**4u**) (84.4 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6u** as a white amorphous solid (115 mg, 203 μmol, 68% yield, dr 92:8).

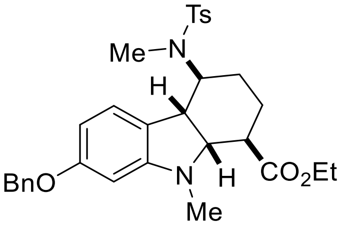
The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 7:3): 0.54.

^{1}H NMR (400 MHz, chloroform-*d*) δ 7.62 (dd, *J* = 7.9, 1.3 Hz, 1H, Ar*H*), 7.55 – 7.46 (m, 2H, Ar*H*), 7.37 (d, *J* = 1.3 Hz, 1H, Ar*H*), 7.13 (d, *J* = 8.0 Hz, 2H, Ar*H*), 6.56 (d, *J* = 7.9 Hz, 1H, Ar*H*), 4.18 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$), 3.69 (dt, *J* = 9.9, 7.5 Hz, 1H, TsNC*H*), 3.53 (d, *J* = 6.6 Hz, 1H, ${}_{ind}$NC*H*), 3.18 (dd, *J* = 10.8, 6.5 Hz, 1H, TsNCHC*H*), 3.05 – 2.96 (m, 1H, ${}_{ind}$NCHC*H*C(O)), 2.83 (s, 3H, TsNC*H*$_3$), 2.67 (s, 3H, ${}_{ind}$NC*H*$_3$), 2.36 (s, 3H, CC*H*$_3$), 2.11 – 1.89 (m, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.64 – 1.49 (m, 2H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.34 (s, 12H, BpinC*H*$_3$), 1.27 (t, *J* = 7.2 Hz, 3H, OCH$_2$C*H*$_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 155.2, 142.8, 136.7, 135.9, 131.2, 130.9, 129.5, 127.7, 127.6, 108.4, 83.3, 68.5, 61.0, 57.7, 40.9, 39.0, 33.9, 29.0, 25.1, 25.1, 23.9, 23.4, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2961 (m), 2921 (m), 1610 (m), 1438 (m), 1380 (m), 1353 (s), 1307 (m), 1145 (s), 1094 (m), 986 (m), 860 (m), 763 (s), 759 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{30}H_{42}BN_2O_6S^+$ 569.2851; Found 569.2863.

Ethyl 7-(benzyloxy)-4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (6v)



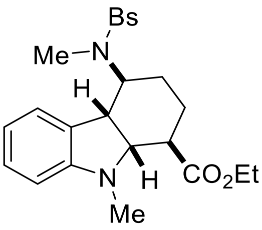
Prepared according to the general procedure F from ethyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3a**) (93.4 mg, 300 μmol, 1.00 equiv.) and 6-benzoxy-1-methyl-indole (**4v**) (77.9 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **6v** as an oil (90.3 mg, 165 μmol, 55% yield, dr 91:9).

The dr was measured on the crude ^{1}H NMR spectrum by integrating the TsNC*H*$_3$ protons of each diastereomers.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.32.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.52 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.46 (d, *J* = 7.2 Hz, 2H, Ar*H*), 7.39 (t, *J* = 7.4 Hz, 2H, Ar*H*), 7.33 (d, *J* = 7.1 Hz, 1H, Ar*H*), 7.16 (d, *J* = 8.0 Hz, 2H, Ar*H*), 6.85 (d, *J* = 8.0 Hz, 1H, Ar*H*), 6.29 (d, *J* = 2.2 Hz, 1H, Ar*H*), 6.24 (dd, *J* = 8.0, 2.2 Hz, 1H, Ar*H*), 5.15 – 4.94 (m, 2H, OC*H*$_2$Ph), 4.17 (q, *J* = 7.1 Hz, 2H, OC*H*$_2$CH$_3$), 3.65 (td, *J* = 11.7, 4.2 Hz, 1H, TsNC*H*), 3.53 (d, *J* = 6.7 Hz, 1H, ${}_{ind}$NC*H*), 3.12 (dd, *J* = 10.7, 6.7 Hz, 1H, TsNCHC*H*), 3.02 – 2.97 (m, 1H, ${}_{ind}$NCHC*H*C(O)), 2.83 (s, 3H, TsNC*H*$_3$), 2.64 (s, 3H, ${}_{ind}$NC*H*$_3$), 2.39 (s, 3H, CC*H*$_3$), 2.05 – 1.84 (m, 2H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.46 (qd, *J* = 12.6, 3.5 Hz, 1H, TsNCHC*H*$_2$CH$_2$CHC(O)), 1.38 – 1.21 (m, 4H, OCH$_2$C*H*$_3$ + TsNCHC*H*$_2$CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 159.7, 153.7, 142.9, 137.6, 137.4, 129.6, 128.7, 128.0, 127.8, 127.3, 125.4, 124.4, 104.1, 97.7, 70.2, 68.8, 60.9, 59.0, 40.5, 39.2, 34.4, 29.0, 23.5, 23.4, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 2959 (m), 2863 (m), 1725 (s), 1620 (m), 1595 (m), 1494 (s), 1455 (m), 1380 (m), 1339 (m), 1187 (s), 1163 (s), 1091 (m), 1025 (m), 986 (s), 914 (s), 732 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{31}H_{37}N_2O_5S^+$ 549.2418; Found 549.2427.

Ethyl 4-((4-bromo-N-methylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (7a)



Prepared according to the general procedure E from ethyl 2-((4-bromo-N-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3b**) (37.6 mg, 100 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **7a** as an oil (46.3 mg, 91.2 µmol, 91% yield, dr 86:14).

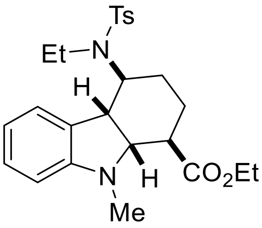
Prepared according to the general procedure F from ethyl 2-((4-bromo-N-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3b**) (37.6 mg, 100 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford cycloadduct **7a** as an oil (120 mg, 237 µmol, 79% yield, dr 94:6).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 7:3): 0.64.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.48 (d, *J* = 8.5 Hz, 2H, Ar*H*), 7.42 (d, *J* = 8.5 Hz, 2H, Ar*H*), 7.13 (t, *J* = 7.7 Hz, 1H, Ar*H*), 6.79 (d, *J* = 7.2 Hz, 1H, Ar*H*), 6.60 (d, *J* = 7.8 Hz, 1H, Ar*H*), 6.54 (t, *J* = 7.4 Hz, 1H, Ar*H*), 4.18 (q, *J* = 7.1 Hz, 2H, OCH_2), 3.63 (td, *J* = 11.6, 4.2 Hz, 1H, BsNC*H*), 3.48 (d, *J* = 6.6 Hz, 1H, $_{ind}$NC*H*), 3.18 (dd, *J* = 10.9, 6.6 Hz, 1H, BsNCHC*H*), 3.05 – 2.98 (m, 1H, $_{ind}$NCHC*H*C(O)), 2.90 (s, 3H, TsNCH_3), 2.67 (s, 3H, $_{ind}$NCH_3), 2.09 – 1.87 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.63 – 1.48 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.45 – 1.36 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.28 (t, *J* = 7.2 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 152.4, 139.5, 132.2, 131.3, 128.5, 128.0, 127.2, 124.8, 119.4, 109.2, 68.6, 61.0, 59.0, 41.1, 38.9, 34.5, 29.0, 24.2, 23.3, 14.4.
IR (v_{max}, cm^{-1}) 3674 (w), 3019 (w), 1722 (w), 1577 (w), 1472 (w), 1343 (w), 1213 (m), 1191 (w), 1166 (m), 1087 (w), 1069 (w), 986 (m), 943 (w), 747 (s), 734 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{23}H_{28}{}^{79}BrN_2O_4S^+$ 507.0948; Found 507.0954.

Ethyl 4-((N-ethyl-4-methylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (7b)



Prepared according to the general procedure E from ethyl 2-((N-ethyl-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3c**) (97.6 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7b** as an oil (95.9 mg, 210 µmol, 70% yield, dr 64:36).

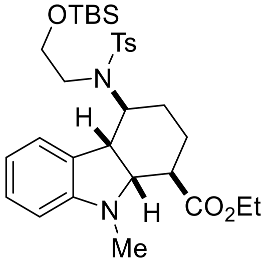
Prepared according to the general procedure F from ethyl 2-((N-ethyl-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3c**) (97.6 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7b** as an oil (76.3 mg, 167 µmol, 56% yield, dr 92:8).

The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.36.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.55 – 7.47 (m, 2H, Ar*H*), 7.18 – 7.11 (m, 2H, Ar*H*), 7.09 (td, *J* = 7.7, 1.3 Hz, 1H, Ar*H*), 6.98 (dd, *J* = 7.3, 1.3 Hz, 1H, Ar*H*), 6.59 (d, *J* = 7.8 Hz, 1H, Ar*H*), 6.53 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 4.20 (q, *J* = 7.1 Hz, 2H, OCH_2), 3.54 – 3.32 (m, 4H, TsNCH_2 + TsNC*H*C*H* + $_{\text{ind}}$NC*H*), 3.23 – 3.12 (m, 1H, TsNCH_2), 3.06 – 2.96 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.66 (s, 3H, $_{\text{ind}}$NCH_3), 2.38 (s, 3H, CCH_3), 2.09 – 1.98 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.92 (tdd, *J* = 13.6, 4.9, 3.3 Hz, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.74 – 1.46 (m, 2H, TsNCHCH_2CH$_2$CHC(O)), 1.36 – 1.21 (m, 6H, OCH$_2$CH_3 + NCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.9, 152.4, 142.7, 138.7, 131.6, 129.5, 127.7, 127.1, 125.3, 119.3, 109.1, 68.7, 61.0, 60.6, 42.0, 40.1, 39.1, 34.6, 25.6, 23.6, 21.6, 16.8, 14.4.
IR (ν_{max}, cm^{-1}) 2961 (w), 2860 (w), 1724 (m), 1606 (w), 1480 (m), 1325 (m), 1188 (m), 1152 (s), 1091 (m), 1022 (m), 996 (m), 950 (m), 867 (w), 814 (m), 752 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_4S^+$ 457.2156; Found 457.2162.

Ethyl 4-((N-(2-((tert-butyldimethylsilyl)oxy)ethyl)-4-methylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (7c)



Prepared according to the general procedure E from ethyl 2-((N-ethyl-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3d**) (137 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7c** as an oil (84.5 mg, 144 µmol, 48% yield, dr 53:47).

Prepared according to the general procedure F from ethyl ethyl 2-((N-ethyl-4-methylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3d**) (137 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7c** as an oil (47.5 mg, 80.9 µmol, 27% yield, dr 81:19).

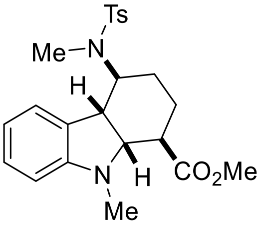
The dr was measured on the crude ^{1}H NMR spectrum by integrating the Ar*H* protons of each diastereomers.

Characterised as a mixture of diastereoisomers:

Rf (pent/EtOAc 7:3): 0.57.
^{1}H NMR (400 MHz, chloroform-*d*, 67:33 mixture of diastereoisomers (major/minor)) δ 7.57 (d, *J* = 8.1 Hz, 0.67H, Ar*H* (minor)), 7.52 (d, *J* = 8.2 Hz, 1.34H, Ar*H* (major)), 7.21 – 7.03 (m, 3.33H,

Ar*H* (major+minor)), 7.00 (d, *J* = 7.1 Hz, 0.67H, Ar*H* (major)), 6.64 – 6.51 (m, 2H, Ar*H* (major+minor)), 4.29 – 4.11 (m, 2H, C(O)OC*H*$_2$ (major+minor)), 3.91 – 3.82 (m, 0.67H, TBSOC*H*$_2$ (major)), 3.81 – 3.75 (m, 1H, TBSOC*H*$_2$ (major) + TsNC*H* (minor)), 3.70 (d, *J* = 11.7 Hz, 0.33H, TBSOC*H*$_2$ (minor)), 3.63 – 3.58 (m, 0.33H, TBSOC*H*$_2$ (minor)), 3.55 – 3.11 (m, 4.34H, TsNC*H* (major) + TsNCHC*H* (major+minor) + $_{\text{ind}}$NC*H* (major+minor) + TBSOCH$_2$C*H*$_2$ (major+minor)), 3.08 – 3.02 (m, 0.33H, TBSOCH$_2$C*H*$_2$ (minor)), 2.99 (br s, 0.67H, $_{\text{ind}}$NCHC*H*C(O) (major)), 2.65 (s, 2.01H, $_{\text{ind}}$NC*H*$_3$ (major)), 2.65 – 2.60 (m, 0.33H, $_{\text{ind}}$NCHC*H*C(O) (minor)), 2.55 (s, 0.99H, $_{\text{ind}}$NC*H*$_3$ (minor)), 2.39 (s, 0.99H, CC*H*$_3$ (minor)), 2.38 (s, 2.01H, CC*H*$_3$ (major)), 2.03 (d, *J* = 11.6 Hz, 1H, TsNCHCH2C*H*$_2$CHC(O) (major)), 1.98 – 1.81 (m, 1.33H, TsNCHCH$_2$C*H*$_2$CHC(O) (major+minor)), 1.70 (s, 0.66H, TsNCHC*H*$_2$CH$_2$CHC(O) (minor)), 1.58 (d, *J* = 12.0 Hz, 0.67H, TsNCHC*H*$_2$CH$_2$CHC(O) (major)), 1.48 – 1.37 (m, 0.67H, TsNCHC*H*$_2$CH$_2$CHC(O) (major)), 1.36 – 1.20 (m, 3H, C(O)OCH$_2$C*H*$_3$ (major+minor)), 0.88 (s, 6.03H, SiC(C*H*$_3$)$_3$ (major)), 0.85 (s, 2.97H, SiC(C*H*$_3$)$_3$ (major)), 0.07 (d, *J* = 3.2 Hz, 4.02H, Si(C*H*$_3$)$_2$ (major)), 0.01 (d, *J* = 3.9 Hz, 1.98H, Si(C*H*$_3$)$_2$ (minor)).
^{13}C NMR (101 MHz, chloroform-*d*, signals for both diastereoisomers) δ 174.1, 173.7, 152.9, 152.4, 143.1, 142.9, 138.2, 138.1, 131.6, 131.3, 129.7, 129.6, 127.9, 127.7, 127.3, 127.2, 125.4, 125.1, 119.2, 118.9, 109.1, 108.9, 69.6, 68.7, 63.0, 62.7, 61.4, 60.9, 60.9, 47.1, 45.6, 45.3, 44.0, 42.1, 39.1, 34.7, 34.5, 29.2, 26.1, 26.0, 25.3, 23.5, 21.9, 21.6, 18.5, 18.4, 14.4, 14.2, -5.2, -5.2.
IR (ν_{max}, cm^{-1}) 3054 (w), 2957 (m), 2929 (m), 2856 (m), 1725 (m), 1609 (w), 1480 (m), 1465 (m), 1343 (m), 1260 (m), 1188 (m), 1158 (s), 1088 (s), 993 (m), 914 (m), 836 (s), 777 (m), 734 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{31}H_{47}N_2O_5SSi^+$ 587.2969; Found 587.2979.

Methyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (7d)



Prepared according to the general procedure E from methyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3h**) (89.2 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7d** as an oil (121 mg, 282 µmol, 94% yield, dr >95:5).

Prepared according to the general procedure F from methyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3h**) (89.2 mg, 300 µmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 µmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7d** as an oil (117 mg, 273 µmol, 91% yield, dr >95:5).

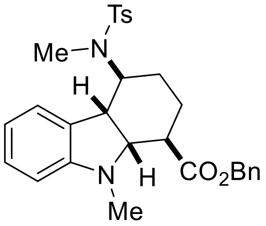
The dr was measured on the crude GC chromatogram.

Data for major diastereoisomer:

Rf (pent/EtOAc 8:2): 0.50.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.57 – 7.44 (m, 2H, Ar*H*), 7.19 – 7.05 (m, 3H, Ar*H*), 6.96 (dd, *J* = 7.2, 1.2 Hz, 1H, Ar*H*), 6.71 – 6.51 (m, 2H, Ar*H*), 3.71 (s, 3H, OC*H*$_3$), 3.70 – 3.59 (m,

1H, TsNC*H*), 3.50 (dt, *J* = 6.7, 1.6 Hz, 1H, $_{ind}$NC*H*), 3.18 (dd, *J* = 10.7, 6.7 Hz, 1H, TsNCHC*H*), 3.03 (dt, *J* = 3.7, 1.8 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.85 (s, 3H, TsNCH_3), 2.67 (s, 3H, $_{ind}$NCH_3), 2.39 (s, 3H, CCH_3), 2.08 – 1.83 (m, 2H, TsNCHCH_2CH_2CHC(O)), 1.46 (qd, *J* = 12.7, 3.7 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.29 (dq, *J* = 12.4, 3.9 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.4, 152.3, 142.9, 137.3, 131.4, 129.6, 127.9, 127.2, 125.2, 119.3, 109.2, 68.5, 58.8, 52.1, 41.1, 38.9, 34.6, 29.0, 23.6, 23.2, 21.6.
IR (ν_{max}, cm^{-1}) 3029 (w), 2863 (w), 2811 (w), 1727 (w), 1605 (w), 1523 (m), 1480 (m), 1314 (w), 1256 (m), 1216 (m), 1166 (m), 1080 (m), 994 (m), 979 (m), 941 (m), 752 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{23}H_{29}N_2O_4S^+$ 429.1843; Found 429.1840.

Benzyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (7e)



Prepared according to the general procedure E from benzyl 2-((N,4-dimethylphenyl)sulfonamido)cyclobutane-1-carboxylate (**3l**) (112 mg, 300 μmol, 1.00 equiv.) and 1-methylindole (**4a**) (77.9 mg, 315 μmol, 1.05 equiv.). The crude product was purified by flash chromatography using pent/EtOAc 70:30 to afford cycloadduct **7e** as an oil (42.4 mg, 84.0 μmol, 28% yield, dr 91:9).

The dr was measured on the crude ^{1}H NMR spectrum by integrating the TsNCH_3 protons of each diastereomers.

Data for major diastereoisomer:

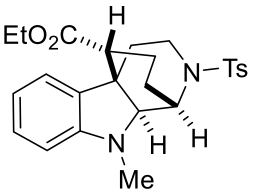
Rf (pent/EtOAc 9:1): 0.17.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.48 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.42 – 7.32 (m, 5H, Ar*H*), 7.20 – 7.09 (m, 3H, Ar*H*), 6.93 (d, *J* = 7.2 Hz, 1H, Ar*H*), 6.68 – 6.58 (m, 2H, Ar*H*), 5.25 – 5.09 (m, 2H, OCH_2), 3.69 – 3.58 (m, 1H, TsNC*H*), 3.53 (d, *J* = 6.5 Hz, 1H, $_{ind}$NC*H*), 3.12 (dd, *J* = 10.8, 6.7 Hz, 1H, TsNCHC*H*), 3.09 – 3.04 (m, 1H, $_{ind}$NCHC*H*C(O)), 2.75 (s, 3H, TsNCH_3), 2.66 (s, 3H, $_{ind}$NCH_3), 2.39 (s, 3H, CCH_3), 2.13 – 1.96 (m, 2H, TsNCHCH$_2$CH_2CHC(O)), 1.47 – 1.32 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.31 – 1.25 (m, 1H, TsNCHCH_2CH$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.7, 152.3, 142.9, 137.4, 135.8, 131.4, 129.6, 128.8, 128.6, 128.5, 128.0, 127.2, 125.2, 119.3, 109.2, 68.4, 66.8, 58.7, 41.1, 39.1, 34.6, 28.9, 23.6, 23.3, 21.6.
IR (ν_{max}, cm^{-1}) 3033 (w), 2928 (w), 2868 (w), 1728 (s), 1606 (w), 1481 (m), 1455 (m), 1339 (m), 1181 (m), 1159 (s), 1091 (m), 989 (m), 752 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{33}N_2O_4S^+$ 457.2156; Found 457.2162.

Data for minor diastereoisomer:

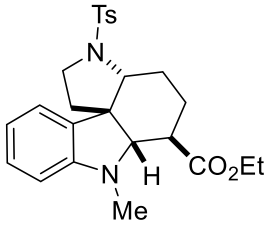
Rf (pent/EtOAc 9:1): 0.13.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.50 (d, *J* = 8.2 Hz, 2H, Ar*H*)), 7.41 – 7.30 (m, 5H, Ar*H*)), 7.19 (d, *J* = 8.0 Hz, 2H, Ar*H*)), 7.15 – 7.07 (m, 1H, Ar*H*)), 6.97 (dd, *J* = 7.2, 1.3 Hz, 1H, Ar*H*)), 6.69 – 6.61 (m, 1H, Ar*H*)), 6.56 (d, *J* = 7.9 Hz, 1H, Ar*H*)), 5.16 (s, 2H, OCH_2Ph), 3.82 (dd, *J* = 6.0, 3.2 Hz, 1H, $_{ind}$NC*H*), 3.63 (td, *J* = 11.4, 4.2 Hz, 1H, TsNC*H*), 2.92 (dd, *J* = 10.6, 6.0 Hz, 1H, TsNCHC*H*), 2.81 (s, 3H, TsNCH_3), 2.74 – 2.58 (m, 1H, $_{ind}$NCHC*H*C(O)), 2.47 (s, 3H,

$_{\text{ind}}\text{NC}H_3$), 2.39 (s, 3H, $\text{C}CH_3$), 1.94 (dd, *J* = 8.4, 3.4 Hz, 2H, $\text{TsNCHCH}_2\text{C}H_2\text{CHC(O)}$), 1.54 (dd, *J* = 12.7, 3.9 Hz, 1H, $\text{TsNCHC}H_2\text{CH}_2\text{CHC(O)}$), 1.48 – 1.40 (m, 1H, $\text{TsNCHC}H_2\text{CH}_2\text{CHC(O)}$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 173.8, 152.7, 142.9, 137.4, 135.3, 131.0, 129.6, 128.8, 128.7, 128.6, 128.1, 127.2, 124.8, 119.1, 109.0, 69.3, 66.8, 58.9, 44.6, 44.2, 34.8, 29.8, 27.5, 21.6, 21.6.
IR (ν_{max}, cm^{-1}) 3026 (w), 2925 (m), 2869 (w), 1730 (m), 1602 (w), 1481 (m), 1343 (m), 1199 (m), 1159 (s), 1091 (m), 815 (m), 755 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: $[M + H]^+$ Calcd for $C_{29}H_{33}N_2O_4S^+$ 505.2156; Found 505.2144.

Ethyl 9-methyl-12-tosyl-1,2,3,4,9,9a-hexahydro-1,4a-(epiminoethano)carbazole-4-carboxylate (8a) and ethyl 7-methyl-3-tosyl-2,3,3a,4,5,6,6a,7-octahydro-1H-pyrrolo[2,3-d]carbazole-6-carboxylate (9a)



8a



9a

Prepared according to the general procedure F from **3k** (136 mg, 300 µmol, 1.00 equiv.) at -50 °C. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford a mixture of **8a**:**9a** (42.2 mg, 92.8 µmol, 31% yield, isomer ratio 92:8).

Prepared according to the general procedure E from **3k** (136 mg, 300 µmol, 1.00 equiv.) at -50 °C. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford a mixture of **8a**:**9a** (47.7 mg, 105 µmol, 35% yield, isomer ratio 87:13).

Prepared according to the general procedure E from **3k** (136 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford a mixture of **8a**:**9a** (136 mg, 299 µmol, 100% yield, isomer ratio 46:54).

Prepared according to the general procedure F from **3k** (136 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/EtOAc 80:20 to afford a mixture of **8a**:**9a** (118 mg, 260 µmol, 87% yield, isomer ratio 36:64).

The isomer ratio was measured on the crude GC chromatogram.

Data for isomer ***8a****:*

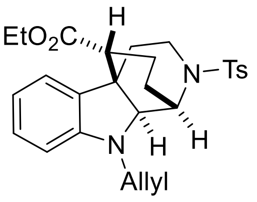
Rf (pent/EtOAc 7:3): 0.74.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.73 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.28 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.14 (td, *J* = 7.7, 1.3 Hz, 1H, Ar*H*), 7.00 (dd, *J* = 7.3, 1.4 Hz, 1H, Ar*H*), 6.75 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 6.65 (d, *J* = 7.9 Hz, 1H, Ar*H*), 4.50 (q, *J* = 3.1 Hz, 1H, $_{\text{ind}}\text{NCHC}H\text{NTs}$), 4.11 – 3.99 (m, 2H, $\text{OC}H_2$), 3.85 – 3.67 (m, 2H, $\text{TsNC}H_2$), 2.79 (ddd, *J* = 13.4, 5.4, 2.2 Hz, 1H, $\text{TsNCH}_2\text{C}H_2$), 2.65 (s, 3H, $_{\text{ind}}\text{NC}H_3$), 2.57 (dd, *J* = 12.3, 6.2 Hz, 1H, C(O)C*H*), 2.52 (d, *J* = 3.7 Hz, 1H, $_{\text{ind}}\text{NC}H$), 2.40 (s, 3H, $\text{C}CH_3$), 2.09 – 1.99 (m, 1H, $\text{TsNCHC}H_2\text{CH}_2\text{CHC(O)}$), 1.94 – 1.81 (m, 3H, $\text{TsNCHC}H_2\text{C}H_2\text{CHC(O)} + \text{TsNCH}_2\text{C}H_2$), 1.76 – 1.66 (m, 1H, $\text{TsNCHCH}_2\text{C}H_2\text{CHC(O)}$), 1.16 (t, *J* = 7.1 Hz, 3H, $\text{OCH}_2\text{C}H_3$).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.2, 152.2, 143.5, 137.4, 137.0, 129.9, 128.1, 127.0, 123.0, 119.3, 109.9, 74.4, 60.4, 50.4, 46.0, 43.2, 41.7, 34.3, 29.3, 25.1, 23.4, 21.7, 14.3.

IR (ν_{max}, cm^{-1}) 2950 (m), 2894 (m), 1721 (m), 1603 (m), 1476 (m), 1339 (m), 1162 (s), 1094 (m), 1049 (m), 1021 (m), 838 (s), 748 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{25}H_{31}N_2O_4S^+$ 455.1999; Found 455.2000.

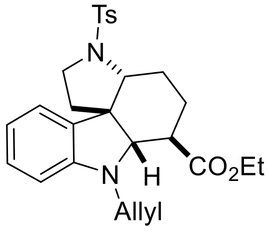
*Data for isomer **9a**:*

Rf (pent/EtOAc 7:3): 0.62.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.42 (dd, *J* = 7.3, 1.2 Hz, 1H, Ar*H*), 7.37 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.14 (td, *J* = 7.7, 1.3 Hz, 1H, Ar*H*), 6.73 (td, *J* = 7.5, 1.0 Hz, 1H, Ar*H*), 6.43 (d, *J* = 7.7 Hz, 1H, Ar*H*), 4.12 (qd, *J* = 7.1, 2.6 Hz, 2H, OCH_2), 3.75 (d, *J* = 7.9 Hz, 1H, $_{\text{ind}}$NC*H*), 3.54 (td, *J* = 10.8, 7.0 Hz, 1H, TsNCH_2), 3.42 – 3.31 (m, 1H, TsNCH_2), 2.84 (dd, *J* = 12.0, 3.4 Hz, 1H, TsNC*H*), 2.68 (s, 3H, $_{\text{ind}}$NCH_3), 2.56 – 2.49 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 2.48 (s, 3H, CCH_3), 2.28 – 2.14 (m, 1H, $_{\text{ind}}$NCHC*H*C(O)), 2.02 – 1.88 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.79 – 1.66 (m, 2H, TsNCHCH_2CH$_2$CHC(O) + TsNCH$_2$CH_2), 1.51 (q, *J* = 10.8 Hz, 1H, TsNCH$_2$CH_2), 1.41 – 1.31 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.22 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 176.1, 150.2, 143.9, 132.6, 131.3, 130.0, 128.5, 127.9, 124.8, 118.3, 107.9, 71.3, 63.0, 61.0, 54.6, 47.2, 43.1, 35.8, 31.9, 27.8, 25.5, 21.7, 14.2.
IR (ν_{max}, cm^{-1}) 2972 (w), 2943 (w), 2869 (w), 1725 (m), 1603 (m), 1475 (m), 1450 (m), 1353 (m), 1296 (m), 1162 (s), 1103 (m), 1021 (m), 752 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{25}H_{31}N_2O_4S^+$ 455.1999; Found 455.1986.

Ethyl 9-allyl-12-tosyl-1,2,3,4,9,9a-hexahydro-1,4a-(epiminoethano)carbazole-4-carboxylate (8b) and ethyl 7-allyl-3-tosyl-2,3,3a,4,5,6,6a,7-octahydro-1H-pyrrolo[2,3-d]carbazole-6-carboxylate (9b)



8b



9b

Prepared according to the general procedure F from **3l** (144 mg, 300 µmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8b**:**9b** (54.7 mg, 114 µmol, 38% yield, isomer ratio 96:4).

Prepared according to the general procedure E from **3l** (144 mg, 300 µmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8b**:**9b** (134 mg, 279 µmol, 93% yield, isomer ratio 93:7).

Prepared according to the general procedure E from **3l** (144 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8b**:**9b** (125 mg, 260 µmol, 87% yield, isomer ratio 43:57).

Prepared according to the general procedure F from **3l** (144 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8b**:**9b** (88.0 mg, 183 µmol, 61% yield, isomer ratio 29:71).

The isomer ratio was measured on the crude ^{1}H NMR spectrum by integrating the CCH_3 protons of each diastereomers.

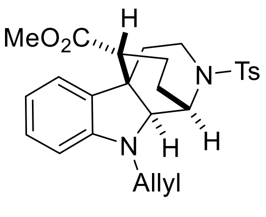
*Data for isomer **8b**:*

Rf (pent/Et$_2$O 5:5): 0.49.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.70 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.29 – 7.23 (m, 2H, Ar*H*), 7.11 (td, *J* = 7.8, 1.2 Hz, 1H, Ar*H*), 7.02 – 6.97 (m, 1H, Ar*H*), 6.77 – 6.70 (m, 1H, Ar*H*), 6.67 (d, *J* = 7.9 Hz, 1H, Ar*H*), 5.83 (dddd, *J* = 17.0, 10.3, 6.7, 5.2 Hz, 1H, $_{\mathrm{ind}}$NCH$_2$C*H*CH$_2$), 5.28 (dd, *J* = 17.2, 1.5 Hz, 1H, $_{\mathrm{ind}}$NCH$_2$CHC*H$_2$*), 5.17 (dd, *J* = 10.2, 1.3 Hz, 1H, $_{\mathrm{ind}}$NCH$_2$CHC*H$_2$*), 4.48 (br s, 1H, $_{\mathrm{ind}}$NCHC*H*NTs), 4.05 (qq, *J* = 7.4, 3.7 Hz, 2H, OC*H$_2$*CH$_3$), 3.86 – 3.69 (m, 3H, $_{\mathrm{ind}}$NC*H$_2$*CHCH$_2$ + TsNC*H$_2$*), 3.57 (dd, *J* = 16.0, 6.8 Hz, 1H, $_{\mathrm{ind}}$NC*H$_2$*CHCH$_2$), 2.87 – 2.74 (m, 2H, $_{\mathrm{ind}}$NC*H* + TsNCH$_2$C*H$_2$*), 2.66 – 2.55 (m, 1H, C(O)C*H*), 2.40 (s, 3H, CC*H$_3$*), 2.10 – 2.01 (m, 1H, TsNCHC*H$_2$*CH$_2$CHC(O)), 1.99 – 1.81 (m, 3H, TsNCH$_2$C*H$_2$* + TsNCHC*H$_2$*C*H$_2$*CHC(O)), 1.81 – 1.69 (m, 1H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.16 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H$_3$*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.2, 150.8, 143.4, 137.4, 136.8, 133.2, 129.9, 128.0, 127.0, 123.1, 119.1, 118.3, 110.2, 71.5, 60.4, 50.4, 49.8, 46.0, 43.1, 41.7, 29.2, 25.4, 23.4, 21.6, 14.3.
IR (ν_{max}, cm^{-1}) 3058 (w), 2942 (w), 2867 (w), 1774 (w), 1723 (m), 1605 (w), 1469 (m), 1335 (m), 1260 (w), 1162 (s), 1105 (m), 1029 (w), 921 (m), 741 (m).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{27}H_{33}N_2O_4S^+$ 481.2156; Found 481.2158.

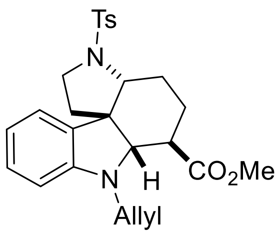
*Data for isomer **9b**:*

Rf (pent/Et$_2$O 5:5): 0.42.
1H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.1 Hz, 2H, Ar*H*), 7.51 – 7.36 (m, 3H, Ar*H*), 7.09 (t, *J* = 7.6 Hz, 1H, Ar*H*), 6.71 (t, *J* = 7.4 Hz, 1H, Ar*H*), 6.46 (d, *J* = 7.8 Hz, 1H, Ar*H*), 5.80 (ddt, *J* = 15.5, 10.2, 5.1 Hz, 1H, $_{\mathrm{ind}}$NCH$_2$C*H*CH$_2$), 5.19 (d, *J* = 17.2 Hz, 1H, $_{\mathrm{ind}}$NCH$_2$CHC*H$_2$*), 5.11 (d, *J* = 10.3 Hz, 1H, $_{\mathrm{ind}}$NCH$_2$CHC*H$_2$*), 4.11 (q, *J* = 7.1 Hz, 2H, OC*H$_2$*), 3.90 – 3.69 (m, 2H, $_{\mathrm{ind}}$NC*H* + $_{\mathrm{ind}}$NC*H$_2$*CHCH$_2$), 3.69 – 3.49 (m, 2H, $_{\mathrm{ind}}$NC*H$_2$*CHCH$_2$ + TsNC*H$_2$*), 3.37 (t, *J* = 10.3 Hz, 1H, TsNC*H$_2$*), 2.86 (dd, *J* = 11.8, 3.5 Hz, 1H, TsNC*H*), 2.64 – 2.44 (m, 4H, CC*H$_3$* + TsNCHC*H$_2$*CH$_2$CHC(O)), 2.30 (dd, *J* = 11.3, 5.2 Hz, 1H, $_{\mathrm{ind}}$NCHC*H*C(O)), 1.97 – 1.83 (m, 1H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.83 – 1.69 (m, 2H, TsNCHC*H$_2$*CH$_2$CHC(O) + TsNCH$_2$C*H$_2$*), 1.57 – 1.33 (m, 2H, TsNCHCH$_2$C*H$_2$*CHC(O) + TsNCH$_2$C*H$_2$*), 1.23 (t, *J* = 7.1 Hz, 3H, OCH$_2$C*H$_3$*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 175.9, 149.3, 143.9, 134.6, 132.6, 131.2, 130.0, 128.4, 127.9, 124.9, 118.1, 116.3, 108.2, 69.9, 62.5, 61.0, 54.7, 48.0, 47.1, 44.3, 36.1, 26.9, 25.2, 21.7, 14.2.
IR (ν_{max}, cm^{-1}) 3069 (w), 2979 (w), 2871 (w), 1721 (m), 1602 (m), 1475 (m), 1350 (m), 1296 (w), 1159 (s), 1102 (m), 1028 (w), 912 (m), 813 (w), 730 (s).
HRMS (Nanochip-based ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{27}H_{33}N_2O_4S^+$ 481.2156; Found 481.2155.

Methyl 9-allyl-12-tosyl-1,2,3,4,9,9a-hexahydro-1,4a-(epiminoethano)carbazole-4-carboxylate (8c) and methyl 7-allyl-3-tosyl-2,3,3a,4,5,6,6a,7-octahydro-1H-pyrrolo[2,3-d]carbazole-6-carboxylate (9c)



8c



9c

Prepared according to the general procedure F from **3m** (140 mg, 300 μmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8c**:**9c** (140 mg, 300 μmol, 100% yield, isomer ratio 85:15).

Prepared according to the general procedure E from **3m** (140 mg, 300 μmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8c**:**9c** (134 mg, 287 μmol, 96% yield, isomer ratio 88:12).

Prepared according to the general procedure E from **3m** (140 mg, 300 μmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8c**:**9c** (126 mg, 270 μmol, 90% yield, isomer ratio 27:73).

Prepared according to the general procedure F from **3m** (140 mg, 300 μmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8c**:**9c** (126 mg, 270 μmol, 90% yield, isomer ratio 29:71).

The isomer ratio was measured on the crude ^{1}H NMR spectrum by integrating the C*H*$_3$ protons of each diastereomers.

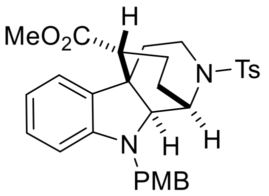
*Data for isomer **8c**:*

Rf (pent/Et$_2$O 6:4): 0.48.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.70 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.28 – 7.23 (m, 2H, Ar*H*), 7.11 (t, *J* = 7.7 Hz, 1H, Ar*H*), 6.99 (d, *J* = 7.3 Hz, 1H, Ar*H*), 6.74 (t, *J* = 7.4 Hz, 1H, Ar*H*), 6.67 (d, *J* = 7.9 Hz, 1H, Ar*H*), 5.82 (ddt, *J* = 17.0, 10.5, 6.0 Hz, 1H, $_{ind}$NCH$_2$C*H*CH$_2$), 5.28 (d, *J* = 17.1 Hz, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 5.17 (d, *J* = 10.3 Hz, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 4.48 (br s, 1H, $_{ind}$NCHC*H*NTs), 3.84 – 3.67 (m, 3H, $_{ind}$NC*H*$_2$CHCH$_2$ + TsNC*H*$_2$), 3.60 – 3.56 (m, 4H, OC*H*$_3$ + $_{ind}$NC*H*$_2$CHCH$_2$), 2.85 – 2.75 (m, 2H, $_{ind}$NC*H* + TsNCH$_2$C*H*$_2$), 2.68 – 2.59 (m, 1H, C(O)C*H*), 2.40 (s, 3H, CC*H*$_3$), 2.08 – 1.71 (m, 5H, TsNCH$_2$C*H*$_2$ + TsNCHC*H*$_2$C*H*$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.6, 150.7, 143.4, 137.4, 136.8, 133.1, 129.9, 128.1, 127.0, 122.9, 119.2, 118.3, 110.2, 71.4, 51.4, 50.4, 49.8, 46.0, 43.0, 41.7, 29.1, 25.4, 23.4, 21.6.
IR (ν_{max}, cm^{-1}) 3046 (w), 2937 (w), 2867 (w), 1725 (m), 1603 (w), 1471 (m), 1460 (m), 1435 (m), 1335 (m), 1256 (m), 1156 (s), 1108 (m), 1015 (w), 910 (m), 867 (m), 730 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{26}H_{31}N_2O_4S^+$ 467.1999; Found 467.2007.

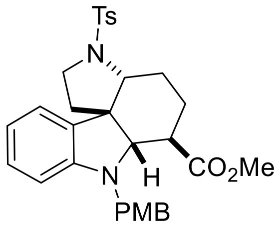
*Data for isomer **9c**:*

Rf (pent/Et$_2$O 6:4): 0.42.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.47 – 7.40 (m, 2H, Ar*H*), 7.09 (td, *J* = 7.7, 1.2 Hz, 1H, Ar*H*), 6.71 (td, *J* = 7.5, 0.8 Hz, 2H, Ar*H*), 6.46 (d, *J* = 7.8 Hz, 1H, Ar*H*), 5.80 (ddt, *J* = 17.1, 10.4, 5.2 Hz, 1H, $_{ind}$NCH$_2$C*H*CH$_2$), 5.23 – 5.16 (m, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 5.15 – 5.06 (m, 1H, $_{ind}$NCH$_2$CHC*H*$_2$), 3.80 (d, *J* = 7.1 Hz, 1H, $_{ind}$NC*H*), 3.78 – 3.71 (m, 1H, $_{ind}$NC*H*$_2$CHCH$_2$), 3.66 (s, 3H, OC*H*$_3$), 3.63 – 3.50 (m, 2H, $_{ind}$NC*H*$_2$CHCH$_2$ + TsNC*H*$_2$), 3.37 (t, *J* = 10.1 Hz, 1H, TsNC*H*$_2$), 2.86 (dd, *J* = 11.9, 3.8 Hz, 1H, TsNC*H*), 2.55 – 2.43 (m, 4H, CC*H*$_3$ + TsNCHC*H*$_2$CH$_2$CHC(O)), 2.31 (ddd, *J* = 11.7, 7.1, 5.1 Hz, 1H, $_{ind}$NCHC*H*C(O)), 1.93 – 1.82 (m, 1H, TsNCHCH$_2$C*H*$_2$CHC(O)), 1.80 – 1.71 (m, 3H, TsNCH$_2$C*H*$_2$ + TsNCHC*H*$_2$CH$_2$CHC(O)), 1.55 – 1.34 (m, 2H, TsNCH$_2$C*H*$_2$ + TsNCHCH$_2$C*H*$_2$CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 176.3, 149.2, 143.9, 134.5, 132.6, 131.1, 130.0, 128.4, 127.9, 125.0, 118.1, 116.4, 108.2, 69.9, 62.5, 54.8, 52.3, 47.9, 47.1, 44.1, 36.1, 26.8, 25.2, 21.7.
IR (ν_{max}, cm^{-1}) 3062 (w), 2943 (w), 2851 (w), 1728 (m), 1599 (m), 1476 (m), 1458 (w), 1339 (m), 1294 (m), 1162 (s), 1091 (m), 913 (m), 809 (w), 733 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{26}H_{31}N_2O_4S^+$ 467.1999; Found 467.2006.

Methyl 9-(4-methoxybenzyl)-12-tosyl-1,2,3,4,9,9a-hexahydro-1,4a-(epiminoethano)carbazole-4-carboxylate (8d) and methyl 7-(4-methoxybenzyl)-3-tosyl-2,3,3a,4,5,6,6a,7-octahydro-1H-pyrrolo[2,3-d]carbazole-6-carboxylate (9d)



8d



9d

Prepared according to the general procedure F from **3n** (164 mg, 300 µmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8d**:**9d** (139 mg, 254 µmol, 85% yield, isomer ratio 85:15).

Prepared according to the general procedure E from **3n** (164 mg, 300 µmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8d**:**9d** (157 mg, 288 µmol, 96% yield, isomer ratio 83:17).

Prepared according to the general procedure E from **3n** (164 mg, 300 µmol, 1.00 equiv.) at 40 °C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8d**:**9d** (144 mg, 263 µmol, 88% yield, isomer ratio 21:79).

Prepared according to the general procedure F from **3n** (164 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8d**:**9d** (164 mg, 300 µmol, 100% yield, isomer ratio 27:73).

The isomer ratio was measured on the crude ^{1}H NMR spectrum by integrating the C(O)OC*H*$_3$ protons of each diastereomers.

*Data for isomer **8d**:*

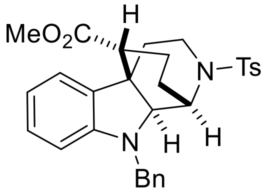
Rf (pent/EtOAc 9:1): 0.25.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.65 – 7.58 (m, 2H, Ar*H*), 7.26 – 7.21 (m, 4H, Ar*H*), 7.07 (td, *J* = 7.7, 1.4 Hz, 1H, Ar*H*), 6.99 (dd, *J* = 7.4, 1.3 Hz, 1H, Ar*H*), 6.87 (d, *J* = 8.6 Hz, 2H, Ar*H*), 6.74 (t, *J* = 7.4 Hz, 1H, Ar*H*), 6.60 (d, *J* = 7.9 Hz, 1H, Ar*H*), 4.50 – 4.39 (m, 1H, $_{ind}$NCHC*H*NTs), 4.23 (d, *J* = 15.3 Hz, 1H, $_{ind}$NC*H*$_2$Ar), 4.06 (d, *J* = 15.3 Hz, 1H, $_{ind}$NC*H*$_2$Ar), 3.82 (s, 3H, ArOC*H*$_3$), 3.77 – 3.67 (m, 2H, TsNC*H*$_2$), 3.58 (s, 3H, C(O)OC*H*$_3$), 2.84 (d, *J* = 3.6 Hz, 1H, $_{ind}$NC*H*), 2.82 – 2.78 (m, 1H, TsNCH$_2$C*H*$_2$), 2.75 – 2.65 (m, 1H, C(O)C*H*), 2.41 (s, 3H, CC*H*$_3$), 1.96 – 1.73 (m, 5H, TsNCHC*H*$_2$C*H*$_2$CHC(O) + TsNCH$_2$C*H*$_2$).
^{13}C NMR (101 MHz, chloroform-*d*, signals not fully reslved) δ 174.6, 159.0, 151.5, 143.4, 137.3, 136.8, 129.9, 129.8 129.0, 128.1, 127.0, 122.8, 119.3, 114.2, 110.5, 72.5, 55.4, 51.4 (2C), 50.5, 46.2, 42.9, 41.8, 29.2, 25.5, 23.5, 21.7.
IR (ν_{max}, cm^{-1}) 3019 (w), 2936 (w), 1725 (m), 1606 (w), 1512 (m), 1469 (m), 1339 (m), 1249 (m), 1159 (s), 1102 (w), 1022 (w), 820 (m), 753 (s).
HRMS (nanochip-ESI/LTQ-Orbitrap) m/z: [M + H]$^+$ Calcd for $C_{31}H_{35}N_2O_5S^+$ 547.2261; Found 547.2242.

*Data for isomer **9d**:*

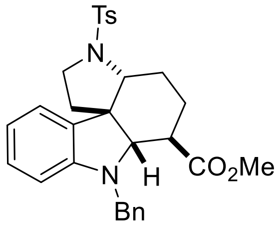
Rf (pent/EtOAc 9:1): 0.21.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.43 (dd, *J* = 7.3, 1.3 Hz, 1H, Ar*H*), 7.36 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.15 (d, *J* = 8.7 Hz, 2H, Ar*H*), 7.04 (td, *J* = 7.7, 1.3 Hz,

1H, Ar*H*), 6.81 (d, *J* = 8.6 Hz, 2H, Ar*H*), 6.71 (td, *J* = 7.4, 0.9 Hz, 1H, Ar*H*), 6.34 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.27 (d, *J* = 15.1 Hz, 1H, $_{\text{ind}}$NCH_2Ar), 4.08 (d, *J* = 15.2 Hz, 1H, $_{\text{ind}}$NCH_2Ar), 3.82 – 3.75 (m, 4H, $_{\text{ind}}$NC*H* + ArOCH_3), 3.64 (s, 3H, C(O)OCH_3), 3.56 (td, *J* = 10.8, 7.0 Hz, 1H, TsNCH_2), 3.37 (t, *J* = 10.3 Hz, 1H, TsNCH_2), 2.85 (dd, *J* = 11.9, 3.7 Hz, 1H, TsNC*H*), 2.52 (dt, *J* = 13.0, 4.1 Hz, 1H, TsNCHCH_2CH$_2$CHC(O)), 2.47 (s, 3H, CCH_3), 2.38 (ddd, *J* = 11.9, 7.3, 5.0 Hz, 1H, $_{\text{ind}}$NCHC*H*C(O)), 1.90 (dq, *J* = 13.6, 4.4 Hz, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.79 (dd, *J* = 11.6, 6.1 Hz, 2H, TsNCH$_2$CH_2 + TsNCHCH_2CH$_2$CHC(O)), 1.55 – 1.47 (m, 1H, TsNCH$_2$CH_2), 1.41 (dtd, *J* = 13.9, 11.2, 4.4 Hz, 1H, TsNCHCH$_2$CH_2CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 176.3, 158.9, 149.2, 144.0, 132.5, 131.2, 130.3, 130.0, 128.4, 128.3, 127.9, 125.0, 118.2, 114.0, 108.3, 69.8, 62.6, 55.4, 54.8, 52.3, 48.5, 47.1, 44.2, 36.0, 27.1, 25.3, 21.7.
IR (ν_{max}, cm^{-1}) 2939 (w), 2837 (w), 1723 (m), 1609 (w), 1511 (m), 1461 (w), 1338 (w), 1245 (w), 1158 (m), 1102 (w), 1037 (w), 905 (s), 816 (w), 723 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{31}H_{34}N_2NaO_5S^+$ 569.2081; Found 569.2084.

Methyl 9-benzyl-12-tosyl-1,2,3,4,9,9a-hexahydro-1,4a-(epiminoethano)carbazole-4-carboxylate (8e) and methyl 7-benzyl-3-tosyl-2,3,3a,4,5,6,6a,7-octahydro-1H-pyrrolo[2,3-d]carbazole-6-carboxylate (9e)



8e



9e

Prepared according to the general procedure F from **3o** (155 mg, 300 µmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8e**:**9e** (104 mg, 201 µmol, 67% yield, isomer ratio 95:5).

Prepared according to the general procedure E from **3o** (155 mg, 300 µmol, 1.00 equiv.) at -50°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8e**:**9e** (135 mg, 261 µmol, 87% yield, isomer ratio 86:14).

Prepared according to the general procedure E from **3o** (155 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8e**:**9e** (155 mg, 300 µmol, 100% yield, isomer ratio 27:73).

Prepared according to the general procedure F from **3o** (155 mg, 300 µmol, 1.00 equiv.) at 40°C. The crude product was purified by flash chromatography using pent/Et$_2$O 40:60 to afford a mixture of **8e**:**9e** (119 mg, 230 µmol, 77% yield, isomer ratio 37:63).

The isomer ratio was measured on the crude ^{1}H NMR spectrum by integrating the C(O)OCH_3 protons of each diastereomers.

*Data for isomer **8e**:*

Rf (pent/Et$_2$O 5:5): 0.46.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.63 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.38 – 7.27 (m, 5H, Ar*H*), 7.25 (d, *J* = 8.9 Hz, 2H, Ar*H*), 7.06 (td, *J* = 7.8, 1.2 Hz, 1H, Ar*H*), 7.01 – 6.98 (m, 1H, Ar*H*), 6.78 – 6.71 (m, 1H, Ar*H*), 6.55 (d, *J* = 7.9 Hz, 1H, Ar*H*), 4.44 (br s, 1H, $_{\text{ind}}$NCHC*H*NTs), 4.27 (d, *J* = 15.6 Hz, 1H, $_{\text{ind}}$NCH_2Ph), 4.11 (d, *J* = 15.6 Hz, 1H, $_{\text{ind}}$NCH_2Ph), 3.80 – 3.69 (m, 2H, TsNCH_2), 3.59 (s, 3H, OCH_3), 2.88 (d, *J* = 3.5 Hz, 1H, $_{\text{ind}}$NC*H*), 2.83 (ddd, *J* = 13.5, 5.1, 2.4

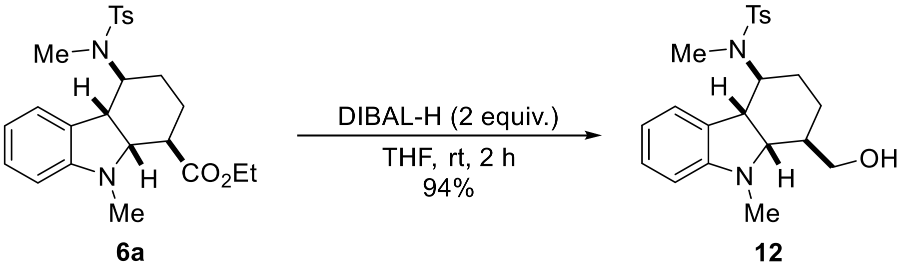
Hz, 1H, TsNCH$_2$C*H$_2$*), 2.77 – 2.70 (m, 1H, C(O)C*H*), 2.41 (s, 3H, CC*H$_3$*), 1.99 – 1.74 (m, 5H, TsNCH$_2$C*H$_2$* + TsNCHC*H$_2$*C*H$_2$*CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.6, 151.6, 143.4, 138.0, 137.3, 136.8, 129.9, 128.8, 128.1, 127.7, 127.5, 127.0, 122.8, 119.4, 110.6, 72.8, 52.3, 51.4, 50.5, 46.2, 42.9, 41.9, 29.2, 25.4, 23.5, 21.7.
IR (ν_{max}, cm^{-1}) 3059 (w), 2932 (w), 2852 (w), 1728 (m), 1595 (w), 1469 (w), 1353 (m), 1156 (s), 1102 (w), 911 (m), 817 (w), 727 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{30}H_{33}N_2O_4S^+$ 517.2156; Found 517.2156.

*Data for isomer **9e**:*

Rf (pent/Et$_2$O 5:5): 0.42.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.71 (d, *J* = 8.2 Hz, 2H, Ar*H*), 7.48 – 7.41 (m, 1H, Ar*H*), 7.37 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.31 – 7.17 (m, 5H, Ar*H*), 7.04 (td, *J* = 7.7, 1.2 Hz, 1H, Ar*H*), 6.77 – 6.68 (m, 1H, Ar*H*), 6.32 (d, *J* = 7.8 Hz, 1H, Ar*H*), 4.33 (d, *J* = 15.5 Hz, 1H, $_{ind}$NC*H$_2$*Ph), 4.16 (d, *J* = 15.5 Hz, 1H, $_{ind}$NC*H$_2$*Ph), 3.83 (d, *J* = 7.3 Hz, 1H, $_{ind}$NC*H*), 3.64 (s, 3H, OC*H$_3$*), 3.57 (td, *J* = 10.9, 7.0 Hz, 1H, TsNC*H$_2$*), 3.39 (t, *J* = 10.1 Hz, 1H, TsNC*H$_2$*), 2.86 (dd, *J* = 11.9, 3.7 Hz, 1H, TsNC*H*), 2.52 (dt, *J* = 12.6, 4.1 Hz, 1H, TsNCHC*H$_2$*CH$_2$CHC(O)), 2.47 (s, 3H, CC*H$_3$*), 2.40 (ddd, *J* = 12.1, 7.3, 5.1 Hz, 1H, $_{ind}$NCHC*H*C(O)), 1.91 (dt, *J* = 13.5, 4.5 Hz, 1H, TsNCHCH$_2$C*H$_2$*CHC(O)), 1.87 – 1.73 (m, 2H, TsNCH$_2$C*H$_2$* + TsNCHC*H$_2$*CH$_2$CHC(O)), 1.55 – 1.34 (m, 2H, TsNCH$_2$C*H$_2$* + TsNCHCH$_2$C*H$_2$*CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 176.3, 149.2, 144.0, 138.4, 132.5, 131.2, 130.0, 128.6, 128.5, 127.9, 127.3, 127.1, 125.0, 118.3, 108.3, 70.0, 62.6, 54.8, 52.3, 49.1, 47.1, 44.2, 36.0, 27.1, 25.3, 21.7.
IR (ν_{max}, cm^{-1}) 3040 (w), 2950 (m), 2867 (w), 1728 (m), 1602 (m), 1475 (m), 1447 (m), 1351 (m), 1162 (s), 1094 (m), 1049 (m), 907 (m), 820 (w), 730 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{30}H_{33}N_2O_4S^+$ 517.2156; Found 517.2165.
NMR spectra are in agreement with the reported data.[9]

1.6. Product modifications

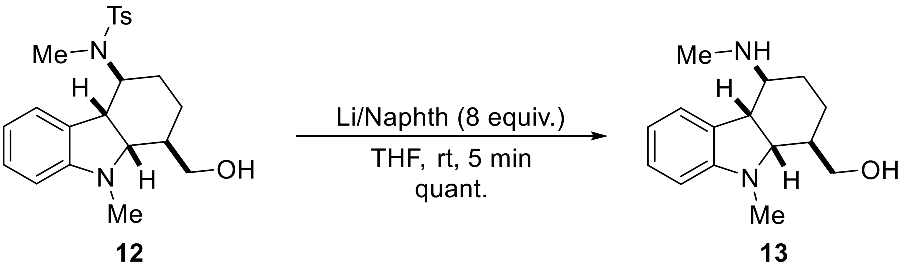
N-(1-(Hydroxymethyl)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazol-4-yl)-N,4-dimethylbenzenesulfonamide (12)



Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (**6a**) (133 mg, 300 µmol, 1.00 equiv.) was diluted in dry THF (5 mL) and the mixture was cooled to 0 °C. Diisobutylaluminium hydride (85.3 mg, 600 µL, 600 µmol, 1.00M solution in toluene, 2.00 equiv.) was added dropwise and the reaction mixture was stirred for 2 h. The reaction was diluted with ether and cooled to 0°C, 4 µL of water were added, followed by 4 µL of 15 % sodium hydroxide and 9 µL of water. The mixture was warmed to rt and stirred for 15 min. $MgSO_4$ was added and the mixture stirred for an additional 15 min. The mixture was filtered and concentrated under reduced pressure to afford **12** as an amorphous solid (113 mg, 282 µmol, 94% yield) which was pure enough without further purification.

Rf (pent/EtOAc 7:3): 0.17.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.54 – 7.48 (m, 2H, Ar*H*), 7.18 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.13 (td, *J* = 7.7, 1.3 Hz, 1H, Ar*H*), 6.96 (d, *J* = 7.3 Hz, 1H, Ar*H*), 6.65 – 6.57 (m, 2H, Ar*H*), 3.70 (dt, *J* = 7.7, 5.3 Hz, 2H, CH_2OH), 3.62 (td, *J* = 11.8, 3.9 Hz, 1H, TsNC*H*), 3.13 (d, *J* = 6.6 Hz, 1H, $_{ind}$NC*H*), 2.97 (dd, *J* = 10.8, 6.6 Hz, 1H, TsNCHC*H*), 2.82 (s, 3H, TsNCH_3), 2.68 (s, 3H, $_{ind}$NCH_3), 2.39 (s, 3H, CCH_3), 2.23 (s, 1H, $_{ind}$NCHC*H*C(O)), 1.87 – 1.73 (m, 2H, TsNCHCH_2CH_2CH), 1.58 – 1.51 (m, 1H, TsNCHCH_2CH_2CH), 1.41 (t, *J* = 5.2 Hz, 1H, O*H*), 1.31 – 1.22 (m, 1H, TsNCHCH_2CH_2CH).
^{13}C NMR (101 MHz, chloroform-*d*) δ 152.8, 142.9, 137.5, 131.6, 129.6, 128.0, 127.2, 125.2, 119.1, 109.1, 70.0, 64.4, 59.5, 41.2, 34.7, 34.5, 29.7, 22.6, 22.5, 21.6.
IR (ν_{max}, cm^{-1}) 3513 (w), 3029 (w), 2935 (m), 2865 (w), 2799 (w), 1606 (m), 1480 (m), 1324 (m), 1159 (s), 1145 (m), 1087 (m), 989 (m), 941 (m), 761 (s), 748 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{22}H_{29}N_2O_3S^+$ 401.1893; Found 401.1901.

(9-Methyl-4-(methylamino)-2,3,4,4a,9,9a-hexahydro-1H-carbazol-1-yl)methanol (13)

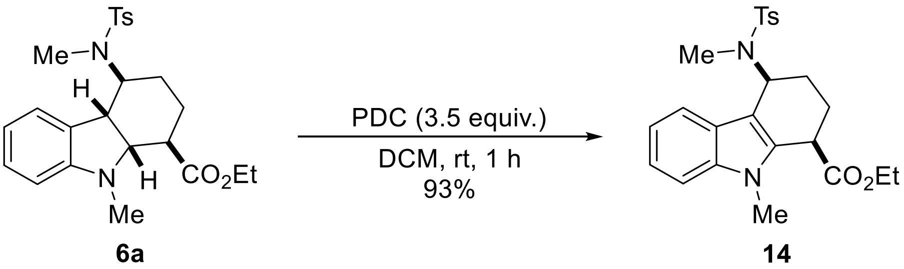


<u>Preparation of a 0.5M Li/naphthalene solution in THF</u>: Li sticks (41.6 mg, 6.00 mmol, 60.0 equiv.) were added to dry THF (12 mL), and naphthalene (769 mg, 6.00 mmol, 60.0 equiv.) was added. The heterogenous solution was sonicated for 30 min at rt. The color turned dark/green and is ready to be used.

To a solution of N-(1-(hydroxymethyl)-9-methyl-2,3,4,4a,9,9a-hexahydro-1H-carbazol-4-yl)-N,4-dimethylbenzenesulfonamide (**12**) (46.6 mg, 100 µmol, 1.00 equiv.) in dry THF (2.00 mL), the Li/naphthalene solution (103 mg, 1.60 mL, 800 µmol, 0.500M, 8.00 equiv.) was added at rt and full conversion was reached after 5 min. The reaction was quenched with a 1M HCl (5 mL). The aqueous layer was extracted with DCM (20 mL). The aqueous layer was then basified to pH>10 and extracted with DCM (3 x 20 mL). The combined organic layers were washed with brine (50 mL), dried over $MgSO_4$, filtered, and concentrated under reduced pressure to afford **13** as an amorphous solid (24.6 mg, 99.9 µmol, 100% yield) which was pure enough without further purification.

^{1}H NMR (400 MHz, chloroform-*d*) δ 7.21 – 7.09 (m, 2H, Ar*H*), 6.74 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 6.67 – 6.56 (m, 1H, Ar*H*), 3.77 – 3.65 (m, 2H, C*H₂*OH), 3.14 (dd, *J* = 6.9, 1.7 Hz, 1H, $_{ind}$NC*H*), 2.76 (dd, *J* = 8.9, 6.9 Hz, 1H, NHCHC*H*C(O)), 2.70 (s, 3H, $_{ind}$NC*H₃*), 2.34 (s, 3H, NHC*H₃*), 2.31 – 2.24 (m, 2H, NHC*H* + $_{ind}$NCHC*H*), 1.85 – 1.72 (m, 3H, NHCHC*H₂*C*H₂*), 1.27 – 1.15 (m, 1H, NHCHC*H₂*CH₂).
^{13}C NMR (101 MHz, chloroform-*d*) δ 153.4, 133.4, 128.1, 123.8, 118.7, 109.4, 69.7, 64.9, 59.9, 44.5, 35.1, 34.7, 33.5, 23.5, 21.6.
IR (ν_{max}, cm^{-1}) 3375 (w), 2932 (m), 2860 (m), 2802 (w), 1663 (w), 1605 (m), 1479 (s), 1456 (m), 1361 (m), 1281 (m), 1105 (w), 1051 (m), 910 (m), 764 (m), 734 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{15}H_{23}N_2O^+$ 247.1805; Found 247.1807.

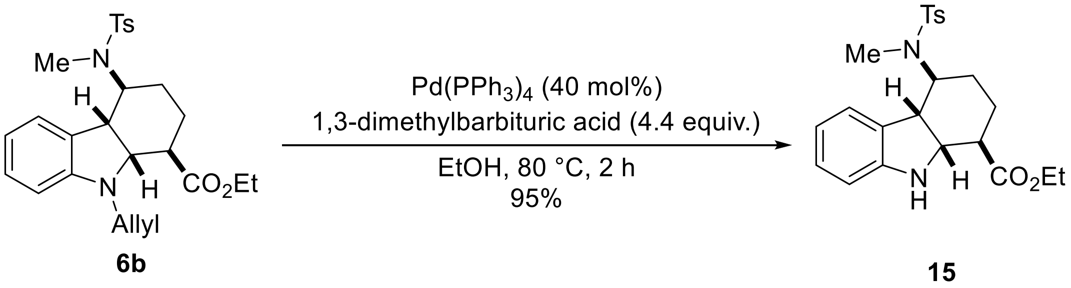
Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-methyl-2,3,4,9-tetrahydro-1H-carbazole-1-carboxylate (14)



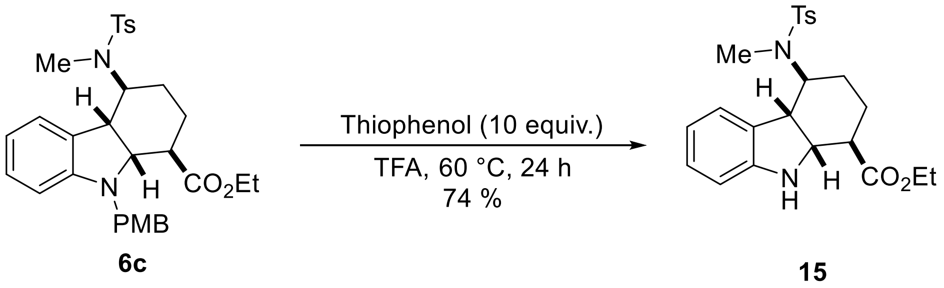
To a solution of **6a** (133 mg, 300 µmol, 1.00 equiv.) in DCM (30 mL), was added silica gel (800 mg) followed by PDC (395 mg, 1.05 mmol, 3.50 equiv.). The reaction was stirred at rt for 1 h, then filtered through a plug of silica gel, which was washed with EtOAc. The solution was concentrated under reduced pressure and purified by flash chromatography using pent/EtOAC 70:30 to afford **14** as a beige solid (123 mg, 279 µmol, 93% yield).

m.p.: 57-60 °C.
Rf (pent/EtOAC 7:3): 0.61.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.83 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.43 (d, *J* = 7.9 Hz, 1H, Ar*H*), 7.35 (d, *J* = 6.8 Hz, 2H, Ar*H*), 7.28 – 7.24 (m, 1H, Ar*H*), 7.22 – 7.17 (m, 1H, Ar*H*), 7.05 – 6.98 (m, 1H, Ar*H*), 5.47 (dd, *J* = 9.1, 6.4 Hz, 1H, TsNC*H*), 4.16 (qd, *J* = 7.1, 1.3 Hz, 2H, OC*H₂*), 3.76 (dd, *J* = 5.7, 2.0 Hz, 1H, $_{ind}$NCC*H*), 3.62 (s, 3H, $_{ind}$NC*H₃*), 2.59 (s, 3H, TsNC*H₃*), 2.47 (s, 3H, CC*H₃*), 2.30 (ddt, *J* = 13.6, 5.3, 2.9 Hz, 1H, TsNCHCH₂C*H₂*CHC(O)), 2.03 (tdd, *J* = 13.5, 5.8, 3.2 Hz, 1H, TsNCHCH₂C*H₂*CHC(O)), 1.92 – 1.71 (m, 2H, TsNCHC*H₂*CH₂CHC(O)), 1.22 (t, *J* = 7.1 Hz, 3H, OCH₂C*H₃*).
^{13}C NMR (101 MHz, chloroform-*d*) δ 172.4, 143.2, 137.9, 137.4, 135.0, 129.9, 127.3, 125.7, 122.1, 120.0, 119.8, 108.9, 108.8, 61.5, 53.4, 38.3, 29.8, 29.2, 26.2, 23.8, 21.7, 14.4.
IR (ν_{max}, cm^{-1}) 2932 (m), 1728 (s), 1471 (m), 1366 (m), 1328 (m), 1209 (m), 1161 (s), 1025 (m), 939 (w), 744 (s).
HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calcd for $C_{24}H_{28}N_2NaO_4S^+$ 463.1662; Found 463.1666.

Ethyl 4-((N,4-dimethylphenyl)sulfonamido)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (15)



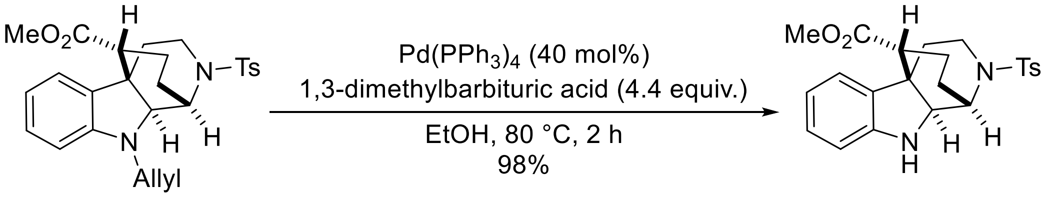
A solution of **6b** (46.9 mg, 100 µmol, 1.00 equiv.), 1,3-dimethylbarbituric acid (68.7 mg, 440 µmol, 2.20 equiv.), and Pd(PPH$_3$)$_4$ (46.2 mg, 40.0 µmol, 0.200 equiv.) in degassed EtOH (4.0 mL) was stirred at 80 °C for 2 h. The reaction was quenched with saturated NaHCO$_3$ (10 mL), and extracted with DCM (3 x 10 mL). The combined organic layers were dried over MgSO$_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash chromatography using DCM/MeOH 98:2 to afford **15** as an amorphous white solid (40.7 mg, 95.0 µmol, 95% yield).



A vial was charged with ethyl 4-((N,4-dimethylphenyl)sulfonamido)-9-(4-methoxybenzyl)-2,3,4,4a,9,9a-hexahydro-1H-carbazole-1-carboxylate (**6c**) (63.8 mg, 100 µmol, 1.00 equiv.), thiophenol (110 mg, 102 µL, 1.00 mmol, 10.0 equiv.), and trifluoroacetic acid (2 mL) and heated to 60 °C for 24 h. The solution was concentrated under reduced pressure. The crude mixture was purified by flash chromatography using DCM/MeOH/NEt$_3$ 98:1:1 to afford **15** as an amorphous white solid (25.0 mg, 58.3 µmol, 74% yield).

Rf (DCM/MeOH/NEt$_3$ 98:1:1): 0.26.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.58 – 7.50 (m, 2H, Ar*H*), 7.19 (d, *J* = 8.0 Hz, 2H, Ar*H*), 7.05 (td, *J* = 7.6, 1.3 Hz, 1H, Ar*H*), 6.99 (d, *J* = 7.3 Hz, 1H, Ar*H*), 6.68 (d, *J* = 7.7 Hz, 1H, Ar*H*), 6.63 (td, *J* = 7.4, 1.0 Hz, 1H, Ar*H*), 4.23 – 4.11 (m, 3H, OCH_2 + $_{ind}$NC*H*), 3.82 (td, *J* = 11.1, 4.4 Hz, 1H, TsNC*H*), 3.17 (dd, *J* = 10.4, 7.1 Hz, 1H, TsNCHC*H*), 2.86 (s, 3H, TsNCH_3), 2.79 (q, *J* = 4.5 Hz, 1H, $_{ind}$NCHC*H*C(O)), 2.39 (s, 3H, CCH_3), 2.10 – 1.99 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.98 – 1.87 (m, 1H, TsNCHCH$_2$CH_2CHC(O)), 1.54 – 1.43 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.39 – 1.31 (m, 1H, TsNCHCH_2CH$_2$CHC(O)), 1.27 (t, *J* = 7.1 Hz, 3H, OCH$_2$CH_3).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.0, 149.6, 143.0, 137.3, 131.1, 129.6, 127.9, 127.2, 125.6, 119.5, 110.0, 61.3, 60.9, 57.7, 42.1, 41.8, 29.2, 23.5, 23.1, 21.6, 14.4.
IR (ν_{max}, cm^{-1}) 3360 (w), 3031 (w), 2923 (m), 2870 (w), 1718 (m), 1612 (w), 1465 (m), 1335 (m), 1185 (m), 1159 (s), 1087 (m), 1018 (m), 989 (m), 752 (s).
HRMS (ESI/QTOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{29}N_2O_4S^+$ 429.1843; Found 429.1847.

Methyl 12-tosyl-1,2,3,4,9,9a-hexahydro-1,4a-(epiminoethano)carbazole-4-carboxylate (14)



8c **16**

A solution of **8b** (46.7 mg, 100 µmol, 1.00 equiv.), 1,3-dimethylbarbituric acid (68.7 mg, 440 µmol, 2.20 equiv.), and Pd(PPh$_3$)$_4$ (46.2 mg, 40.0 µmol, 0.200 equiv.) in degassed EtOH (4.0 mL) was stirred at 80 °C for 2 h. The reaction was quenched with saturated NaHCO$_3$ (10 mL) and extracted with DCM (3 x 10 mL). The combined organic layers were dried over MgSO$_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash chromatography using DCM/MeOH 98:2 to afford **16** as an amorphous solid (41.6 mg, 97.5 µmol, 98% yield).

Rf (DCM/MeOH 99:1): 0.53.
^{1}H NMR (400 MHz, chloroform-*d*) δ 7.72 (d, *J* = 8.3 Hz, 2H, Ar*H*), 7.28 (d, *J* = 8.1 Hz, 2H, Ar*H*), 7.07 (td, *J* = 7.7, 1.1 Hz, 1H, Ar*H*), 7.03 – 6.97 (m, 1H, Ar*H*), 6.80 – 6.72 (m, 2H, Ar*H*), 4.46 (d, *J* = 3.0 Hz, 1H, $_{\text{ind}}$NHCHC*H*), 3.96 (br s, 1H, $_{\text{ind}}$N*H*), 3.79 (ddd, *J* = 12.9, 7.8, 1.9 Hz, 1H, TsNCH_2), 3.69 (td, *J* = 12.3, 5.5 Hz, 1H, TsNCH_2), 3.57 (s, 3H, OCH_3), 3.27 (d, *J* = 3.7 Hz, 1H, $_{\text{ind}}$NHC*H*), 2.81 (ddd, *J* = 13.5, 5.4, 2.0 Hz, 1H, TsNCH$_2$CH_2), 2.65 (dd, *J* = 13.0, 6.0 Hz, 1H, C(O)C*H*), 2.41 (s, 3H, CCH_3), 2.08 – 1.77 (m, 5H, TsNCH$_2$CH_2 + TsNCHCH_2CH_2CHC(O)), 1.75 – 1.64 (m, 1H, TsNCHCH$_2$CH_2CHC(O)).
^{13}C NMR (101 MHz, chloroform-*d*) δ 174.7, 149.3, 143.4, 137.3, 136.8, 129.9, 128.0, 127.0, 123.2, 119.7, 111.6, 68.1, 51.8, 51.4, 45.3, 42.9, 42.2, 29.2, 24.8, 23.3, 21.6.
IR (ν_{max}, cm^{-1}) 3357 (m), 2922 (w), 1721 (m), 1613 (m), 1461 (m), 1325 (m), 1173 (m), 1159 (s), 1116 (s), 1089 (m), 998 (s), 910 (s), 852 (m), 770 (m), 734 (s), 724 (s).
HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calcd for $C_{23}H_{27}N_2O_4S^+$ 427.1686; Found 427.1690.

2. Computational Details

We began by creating a template structure for each of the intermediates and transition states of interest. From this template an ensemble of geometries was created [50 conformers each for IntB, IntC, Int8A, Int9A, TS(A,B), TS(A,C), TS(B,9A), TS(C,8A) and 20 conformers for IntA] using Molassembler[14] (also see the SI of these references for additional details). The geometries of all species were first optimized at the PM7[15] level using a set of user defined "extra loose" geometric convergence criteria [IOp(1/7=10000)] to quickly obtain a rough geometry in Gaussian16.[16] This was followed by further (gas phase) optimization at the M06-2X[17]/def2-SVP[18] level and single point energies (using the SMD solvation model[19] for dichloromethane) the M06-2X/def2-TZVP level also in Gaussian16. Species were characterized as either minima (zero imaginary frequencies) or transition states (one imaginary frequency) by examining vibrational frequencies on the optimized structures. Free energy corrections were determined using the quasi rigid-rotor harmonic oscillator model[20] and corrected for translational entropy in solution[21] using the approach proposed by Martin, Hay,

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and Pratt[22] (15.62 mol/L for dichloromethane) as implemented in Goodvibes.[23] Final free energies for each species/conformer were obtained by summing the M06-2X/def2-TZVP electronic energies and the enthalpy/entropy corrections from the M06-2X/def2-SVP frequency analysis. The free energies for all conformer of each species were then Boltzmann weighted at 313.15K and the free energy profiles assessed (see Scheme 7). For convenience, the outputs from Goodvibes (.dat) along with the Cartesian Coordinates of each of the energetically contributing structures (.xyz) can be found elsewhere in the SI (Indoles.zip).

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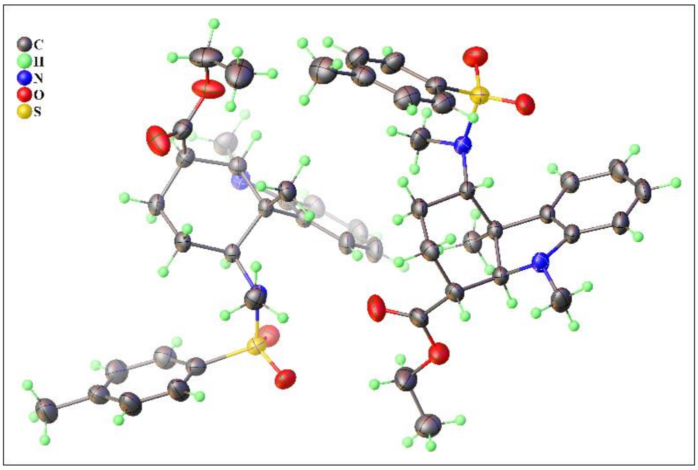
3. X-ray crystallographic data

3.1 Compound **6g** (ccdc number 2193381)

The crystal suitable for X-ray measurement for compound **6g** was obtained by evaporation of chloroform.



Experimental. Single colourless prism-shaped crystals of **6g** were used as supplied. A suitable crystal with dimensions 0.28 × 0.16 × 0.04 mm^3 was selected and mounted on a SuperNova, Dual, Cu at home/near, AtlasS2 diffractometer. During data collection, the crystal was kept at a steady T = 140.00(10) K. The structure was solved with the **ShelXT** 2018/2 (Sheldrick, 2015) solution program using dual methods and **Olex2** 1.5 (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full-matrix least-squares minimisation on $\boldsymbol{F^2}$.

Compound	**6g**
Formula	$C_{25}H_{32}N_2O_4S$
$D_{calc.}$/ g cm^{-3}	1.289
μ/mm^{-1}	1.496
Formula Weight	456.58
Colour	colourless
Shape	prism-shaped
Size/mm^3	0.28×0.16×0.04
T/K	140.00(10)
Crystal System	triclinic
Space Group	$P\bar{1}$
a/Å	9.8109(2)
b/Å	13.0488(4)
c/Å	18.8165(7)
α/°	102.335(3)
β/°	90.842(2)
γ/°	90.121(2)
V/Å^3	2353.00(12)
Z	4
Z'	2
Wavelength/Å	1.54184
Radiation type	Cu$K\alpha$
Θ_{min}/°	3.467
Θ_{max}/°	76.240
Measured Refl's.	10947
Indep't Refl's	10947
Refl's I≥2σ(I)	9006
R_{int}	.
Parameters	588
Restraints	0
Largest Peak/e Å^{-3}	0.356
Deepest Hole/e Å^{-3}	-0.324
GooF	0.973
wR_2 (all data)	0.1135
wR_2	0.1095
R_1 (all data)	0.0505
R_1	0.0425
CCDC number	2193381

Table 1: Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **6g.** U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	U_{eq}
S1	7701.0(5)	4758.6(5)	8531.6(3)	37.47(12)
O1	8575.6(16)	3978.0(15)	8126.7(10)	46.9(4)
O2	8076.0(17)	5286.3(17)	9255.5(9)	52.0(4)
O3	6385.9(16)	6850.2(14)	5309.1(10)	46.7(4)
O4	4631.8(16)	6707.2(15)	6014.6(12)	54.0(5)
N1	8462.6(16)	4342.9(13)	5858.8(9)	31.8(3)
N2	7476.1(15)	5678.8(13)	8061.3(8)	30.7(3)
C1	8116.5(16)	5835.6(14)	6804.8(10)	26.6(3)
C2	7160.3(16)	5302.2(14)	7279.0(10)	25.9(3)
C3	5649.9(17)	5366.4(16)	7078.8(11)	31.2(4)
C4	5422.0(17)	4801.2(16)	6286.2(12)	33.1(4)
C5	6267.8(18)	5302.2(17)	5774.6(11)	31.6(4)
C6	7790.6(17)	5374.9(15)	5989.4(10)	28.6(4)
C7	9657.5(18)	4505.5(16)	6295.6(11)	30.5(4)
C8	10841(2)	3902.7(18)	6236.1(13)	39.6(5)
C9	11853.4(19)	4196(2)	6769.8(14)	43.8(5)
C10	11719.1(19)	5053.1(19)	7334.2(14)	41.8(5)

Atom	**x**	**y**	**z**	U_{eq}
C11	10535.1(18)	5662.4(17)	7387.1(12)	34.6(4)
C12	9526.4(16)	5380.6(15)	6859.9(10)	27.2(4)
C13	8084.3(18)	7031.4(15)	6985.0(12)	33.5(4)
C14	6772(2)	6616.7(19)	8462.0(12)	42.7(5)
C15	6081(2)	4175.7(19)	8562.3(12)	38.3(4)
C16	5160(2)	4666(2)	9082.1(12)	44.0(5)
C17	3859(2)	4250(2)	9078.8(13)	47.2(5)
C18	3442(2)	3381(2)	8567.2(14)	43.6(5)
C19	4379(3)	2898.4(19)	8054.8(15)	48.6(5)
C20	5693(3)	3291.1(18)	8051.8(13)	44.3(5)
C21	2010(3)	2966(3)	8577.7(18)	59.3(7)
C22	5673.6(19)	6361.5(18)	5730.0(12)	34.8(4)
C23	5864(3)	7877(2)	5252.0(17)	58.2(7)
C24	6475(3)	8170(2)	4611.9(15)	53.8(6)
C25	8558(2)	3762(2)	5114.4(13)	48.5(6)
S2	2624.0(5)	9811.3(4)	6450.4(2)	33.20(11)
O5	2974.0(16)	9200.6(14)	5751.3(8)	44.0(4)
O6	3510.3(15)	10637.1(13)	6813.9(9)	41.5(3)
O7	-293.0(16)	8184.2(16)	9163.0(13)	57.7(5)
O8	1526(2)	8225.9(17)	9890.9(10)	56.6(5)
N3	3460.7(16)	10613.8(13)	9167.6(9)	30.6(3)
N4	2435.7(15)	8981.6(12)	6986.8(8)	28.4(3)
C26	3142.9(16)	9032.0(14)	8281.6(10)	25.7(3)
C27	2143.7(16)	9452.5(14)	7758.7(9)	25.1(3)
C28	639.6(17)	9362.4(16)	7955.5(11)	30.1(4)
C29	409.3(17)	10007.7(16)	8717.8(11)	31.7(4)
C30	1299.6(18)	9623.8(16)	9279.3(11)	31.7(4)
C31	2820.2(17)	9569.9(15)	9082.5(10)	28.4(4)
C32	4650.8(18)	10435.9(16)	8751.8(11)	30.8(4)
C33	5821(2)	11058.0(19)	8808.1(13)	39.8(5)
C34	6836.0(19)	10736(2)	8292.0(15)	45.6(5)
C35	6708.8(19)	9839(2)	7758.6(14)	45.1(5)
C36	5535.3(18)	9213.7(17)	7715.3(12)	36.1(4)
C37	4530.4(17)	9518.5(15)	8222.0(10)	28.5(4)
C38	3174.9(19)	7842.0(15)	8172.9(11)	32.8(4)
C39	1750(2)	7994.0(17)	6644.2(11)	36.4(4)
C40	1000(2)	10361.4(17)	6359.9(11)	35.2(4)
C41	35(3)	9812(2)	5877.0(13)	46.2(5)
C42	-1256(3)	10236(2)	5840.0(14)	51.8(6)
C43	-1598(2)	11196(2)	6281.9(12)	44.8(5)
C44	-626(3)	11735.0(19)	6754.7(14)	48.2(5)
C45	677(2)	11326.0(18)	6797.1(13)	42.3(5)
C46	-3013(3)	11630(3)	6221.7(16)	61.4(7)
C47	750(2)	8592.1(17)	9418.3(12)	36.3(4)
C48	1042(3)	7273(3)	10099.7(16)	61.6(7)
C49	1431(4)	6347(3)	9562(2)	77.4(10)
C50	3561(2)	11256(2)	9898.5(12)	43.1(5)

Table 2: Anisotropic Displacement Parameters (×10^4) for **6g.** The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2} \times U_{11}+ \ldots +2hka^* \times b^* \times U_{12}]$

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	34.2(2)	51.0(3)	30.0(2)	14.6(2)	1.99(17)	6.6(2)
O1	42.0(8)	55.0(10)	49.7(9)	23.9(8)	8.3(7)	19.3(7)
O2	44.6(8)	79.2(13)	33.6(8)	15.5(8)	-3.1(6)	-2.4(8)
O3	46.7(8)	47.7(9)	52.7(9)	25.9(8)	11.7(7)	13.3(7)
O4	36.7(7)	55.8(10)	78.8(13)	34.1(10)	13.9(8)	17.3(7)
N1	30.1(7)	32.6(8)	30.4(8)	1.6(7)	1.2(6)	6.2(6)
N2	30.1(7)	34.1(8)	26.9(7)	4.5(6)	2.4(6)	4.9(6)
C1	21.2(7)	27.6(8)	31.2(9)	6.4(7)	1.8(6)	1.5(6)
C2	22.1(7)	27.8(8)	27.9(8)	5.9(6)	2.5(6)	3.1(6)

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
C3	22.3(8)	34.4(10)	38.7(10)	11.2(8)	2.7(7)	1.4(7)
C4	23.9(8)	33.8(10)	42.8(11)	11.0(8)	-6.5(7)	-3.9(7)
C5	27.3(8)	36.8(10)	30.3(9)	6.4(8)	-5.0(7)	1.7(7)
C6	23.9(8)	32.6(9)	30.1(9)	8.3(7)	1.8(6)	3.7(6)
C7	23.8(8)	36.2(10)	32.8(9)	9.9(8)	4.5(7)	4.3(7)
C8	30.3(9)	43.9(12)	45.6(12)	10.9(9)	8.1(8)	11.0(8)
C9	24.1(8)	51.1(13)	60.4(14)	21.4(11)	3.9(8)	9.0(8)
C10	22.2(8)	50.4(13)	55.8(13)	18.7(10)	-5.9(8)	-1.2(8)
C11	25.5(8)	37.6(10)	41.4(11)	10.3(9)	-1.9(7)	-1.8(7)
C12	20.4(7)	30.6(9)	31.9(9)	9.3(7)	2.0(6)	1.4(6)
C13	28.8(8)	29.0(9)	42.8(10)	7.9(8)	0.4(7)	-0.4(7)
C14	45.5(11)	43.5(12)	34.5(10)	-2.3(9)	7.4(8)	10.6(9)
C15	41.0(10)	45.4(12)	31.3(10)	14.2(9)	2.6(8)	4.0(8)
C16	45.1(11)	53.3(14)	30.3(10)	1.2(9)	4.1(8)	-6.6(10)
C17	45.7(11)	56.0(14)	39.8(12)	9.5(10)	8.1(9)	-1.4(10)
C18	48.4(11)	40.5(12)	45.7(12)	17.7(10)	-1.5(9)	-5.2(9)
C19	64.8(14)	30.7(10)	50.1(13)	8.1(10)	4.0(11)	-4.4(10)
C20	58.9(13)	32.7(10)	42.8(12)	11.1(9)	9.3(10)	6.9(9)
C21	54.7(14)	58.2(16)	67.8(17)	20.4(13)	-0.5(12)	-17.5(12)
C22	27.9(8)	41.5(11)	37.2(10)	13.5(8)	-5.4(7)	2.0(8)
C23	59.1(14)	57.4(16)	69.2(17)	36.5(14)	18.9(13)	22.7(12)
C24	64.1(14)	47.2(14)	53.8(15)	18.6(12)	8.5(12)	3.9(11)
C25	45.4(11)	58.2(15)	34.4(11)	-7.1(10)	0.9(9)	13.9(10)
S2	33.9(2)	37.8(2)	29.0(2)	9.22(18)	3.77(17)	2.50(18)
O5	47.3(8)	54.7(10)	31.2(7)	11.1(7)	9.9(6)	12.1(7)
O6	40.2(7)	42.1(8)	44.7(8)	14.5(7)	2.7(6)	-6.6(6)
O7	33.3(8)	50.4(10)	98.2(16)	35.8(11)	-5.7(8)	-9.0(7)
O8	71.4(11)	60.5(12)	44.9(10)	28.3(9)	-16.3(8)	-23.7(9)
N3	29.1(7)	30.5(8)	29.8(8)	0.9(6)	-1.5(6)	-3.0(6)
N4	28.9(7)	28.3(7)	26.6(7)	3.0(6)	0.2(6)	0.1(6)
C26	20.3(7)	27.3(9)	28.8(8)	4.1(7)	1.2(6)	2.0(6)
C27	21.9(7)	25.2(8)	27.2(8)	3.6(6)	1.1(6)	1.6(6)
C28	21.0(7)	32.6(9)	36.2(10)	6.2(8)	-0.2(7)	0.1(6)
C29	24.0(7)	32.1(10)	38.6(10)	6.0(8)	6.2(7)	3.2(7)
C30	30.1(8)	34.4(10)	29.7(9)	4.1(8)	6.3(7)	-0.5(7)
C31	27.7(8)	28.7(9)	28.6(8)	5.4(7)	0.4(6)	0.4(6)
C32	25.3(8)	35.4(10)	31.7(9)	7.8(8)	-5.5(7)	-1.8(7)
C33	28.6(9)	42.0(12)	49.0(12)	11.1(10)	-10.5(8)	-7.3(8)
C34	23.0(8)	51.6(13)	66.2(15)	21.9(12)	-4.4(9)	-5.7(8)
C35	22.5(8)	55.2(14)	59.9(14)	17.1(11)	7.2(9)	3.8(8)
C36	24.2(8)	41.1(11)	42.5(11)	7.9(9)	3.7(7)	6.0(7)
C37	21.8(7)	32.2(9)	32.6(9)	9.2(7)	-1.8(7)	2.2(7)
C38	30.9(8)	28.7(9)	39.1(10)	7.9(8)	0.6(7)	4.6(7)
C39	38.8(9)	34.1(10)	32.5(9)	-1.1(8)	-1.4(8)	-3.8(8)
C40	40.9(10)	36.6(10)	29.4(9)	9.9(8)	2.9(7)	7.2(8)
C41	50.9(12)	48.9(13)	34.4(11)	-0.7(10)	-6.2(9)	15.2(10)
C42	50.9(13)	60.2(16)	40.0(12)	1.8(11)	-10.1(10)	15.4(11)
C43	51.1(12)	50.1(13)	35.7(11)	14.3(10)	2.6(9)	16.8(10)
C44	58.1(13)	36.8(11)	49.4(13)	8.3(10)	6.6(10)	14.0(10)
C45	48.3(11)	33.7(10)	44.1(12)	6.4(9)	-0.8(9)	3.6(9)
C46	58.6(15)	73.3(19)	53.3(15)	15.2(13)	1.3(12)	29.6(14)
C47	34.7(9)	38.8(11)	36.1(10)	9.1(8)	8.5(8)	0.2(8)
C48	79.4(18)	64.5(18)	49.2(14)	31.3(13)	-6.7(12)	-20.4(14)
C49	85(2)	61.8(19)	99(3)	44.2(19)	26.0(19)	14.2(16)
C50	45.8(11)	45.3(12)	32.7(10)	-3.9(9)	-1.3(8)	-5.7(9)

Table 3: Bond Lengths in Å for **6g**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
S1	O1	1.4302(16)	S1	N2	1.6501(17)
S1	O2	1.4312(18)	S1	C15	1.767(2)

Atom	Atom	Length/Å
O3	C22	1.324(3)
O3	C23	1.460(3)
O4	C22	1.204(3)
N1	C6	1.475(2)
N1	C7	1.411(3)
N1	C25	1.448(3)
N2	C2	1.477(2)
N2	C14	1.472(2)
C1	C2	1.565(2)
C1	C6	1.552(3)
C1	C12	1.517(2)
C1	C13	1.525(3)
C2	C3	1.530(2)
C3	C4	1.529(3)
C4	C5	1.527(3)
C5	C6	1.539(2)
C5	C22	1.520(3)
C7	C8	1.396(3)
C7	C12	1.391(3)
C8	C9	1.395(4)
C9	C10	1.376(4)
C10	C11	1.402(3)
C11	C12	1.383(3)
C15	C16	1.394(3)
C15	C20	1.383(3)
C16	C17	1.385(3)
C17	C18	1.378(4)
C18	C19	1.393(3)
C18	C21	1.508(3)
C19	C20	1.387(4)
C23	C24	1.474(3)
S2	O5	1.4317(16)
S2	O6	1.4313(18)
S2	N4	1.6422(16)
S2	C40	1.770(2)
O7	C47	1.198(3)
O8	C47	1.327(3)
O8	C48	1.462(3)
N3	C31	1.475(3)
N3	C32	1.407(2)
N3	C50	1.452(3)
N4	C27	1.484(2)
N4	C39	1.469(3)
C26	C27	1.560(2)
C26	C31	1.558(2)
C26	C37	1.516(2)
C26	C38	1.523(3)
C27	C28	1.537(2)
C28	C29	1.521(3)
C29	C30	1.527(3)
C30	C31	1.541(2)
C30	C47	1.524(3)
C32	C33	1.394(3)
C32	C37	1.388(3)
C33	C34	1.402(3)
C34	C35	1.374(4)
C35	C36	1.401(3)
C36	C37	1.381(2)
C40	C41	1.389(4)
C40	C45	1.389(3)
C41	C42	1.390(3)
C42	C43	1.392(4)
C43	C44	1.379(4)
C43	C46	1.512(3)
C44	C45	1.394(3)
C48	C49	1.456(5)

Table 4: Bond Angles in ° for **6g**.

Atom	Atom	Atom	Angle/°
O1	S1	O2	120.16(11)
O1	S1	N2	108.00(9)
O1	S1	C15	107.61(11)
O2	S1	N2	106.49(11)
O2	S1	C15	108.02(10)
N2	S1	C15	105.70(9)
C22	O3	C23	114.99(17)
C7	N1	C6	104.81(16)
C7	N1	C25	118.70(16)
C25	N1	C6	117.90(18)
C2	N2	S1	115.71(13)
C14	N2	S1	114.01(14)
C14	N2	C2	118.71(16)
C6	C1	C2	108.81(14)
C12	C1	C2	106.62(14)
C12	C1	C6	99.60(13)
C12	C1	C13	113.92(15)
C13	C1	C2	114.60(14)
C13	C1	C6	112.13(16)
N2	C2	C1	110.88(14)
N2	C2	C3	114.13(14)
C3	C2	C1	113.01(15)
C4	C3	C2	109.02(14)
C5	C4	C3	111.11(16)
C4	C5	C6	112.24(16)
C22	C5	C4	109.84(16)
C22	C5	C6	112.37(17)
N1	C6	C1	103.04(14)
N1	C6	C5	112.93(17)
C5	C6	C1	115.65(14)
C8	C7	N1	128.8(2)
C12	C7	N1	110.77(15)
C12	C7	C8	120.38(19)
C9	C8	C7	117.6(2)
C10	C9	C8	122.14(19)
C9	C10	C11	120.0(2)
C12	C11	C10	118.3(2)
C7	C12	C1	108.26(16)
C11	C12	C1	130.03(17)
C11	C12	C7	121.49(17)
C16	C15	S1	118.66(18)
C20	C15	S1	121.00(16)
C20	C15	C16	120.2(2)
C17	C16	C15	118.9(2)
C18	C17	C16	121.9(2)
C17	C18	C19	118.4(2)
C17	C18	C21	120.1(2)
C19	C18	C21	121.6(2)

Atom	Atom	Atom	Angle/˚
C20	C19	C18	120.9(2)
C15	C20	C19	119.7(2)
O3	C22	C5	112.77(17)
O4	C22	O3	122.8(2)
O4	C22	C5	124.31(19)
O3	C23	C24	108.4(2)
O5	S2	N4	106.53(9)
O5	S2	C40	107.35(10)
O6	S2	O5	120.07(10)
O6	S2	N4	107.83(9)
O6	S2	C40	107.78(10)
N4	S2	C40	106.57(9)
C47	O8	C48	116.4(2)
C32	N3	C31	104.77(15)
C32	N3	C50	118.42(16)
C50	N3	C31	117.25(17)
C27	N4	S2	115.92(12)
C39	N4	S2	114.60(14)
C39	N4	C27	118.48(15)
C31	C26	C27	109.15(13)
C37	C26	C27	107.50(14)
C37	C26	C31	99.11(14)
C37	C26	C38	113.51(14)
C38	C26	C27	114.61(15)
C38	C26	C31	111.78(15)
N4	C27	C26	111.11(13)
N4	C27	C28	113.55(15)
C28	C27	C26	112.95(14)
C29	C28	C27	109.23(15)
C28	C29	C30	111.29(15)
C29	C30	C31	112.68(15)
C47	C30	C29	110.58(17)
C47	C30	C31	112.91(16)
N3	C31	C26	103.15(14)
N3	C31	C30	113.01(15)
C30	C31	C26	115.64(15)
C33	C32	N3	128.46(19)
C37	C32	N3	110.66(16)
C37	C32	C33	120.87(18)
C32	C33	C34	117.1(2)
C35	C34	C33	122.1(2)
C34	C35	C36	120.09(19)
C37	C36	C35	118.4(2)
C32	C37	C26	108.82(15)
C36	C37	C26	129.67(18)
C36	C37	C32	121.34(18)
C41	C40	S2	120.22(16)
C45	C40	S2	119.53(18)
C45	C40	C41	120.2(2)
C40	C41	C42	119.3(2)
C41	C42	C43	121.1(3)
C42	C43	C46	119.3(3)
C44	C43	C42	118.9(2)
C44	C43	C46	121.7(2)
C43	C44	C45	120.9(2)
C40	C45	C44	119.7(2)
O7	C47	O8	123.7(2)
O7	C47	C30	124.4(2)
O8	C47	C30	111.85(19)
C49	C48	O8	110.5(2)

Table 5: Torsion Angles in ˚ for **6g.**

Atom	Atom	Atom	Atom	Angle/˚
S1	N2	C2	C1	-129.66(13)
S1	N2	C2	C3	101.35(16)
S1	C15	C16	C17	175.9(2)
S1	C15	C20	C19	-174.99(19)
O1	S1	N2	C2	46.13(15)
O1	S1	N2	C14	-170.92(16)
O1	S1	C15	C16	162.61(19)
O1	S1	C15	C20	-21.8(2)
O2	S1	N2	C2	176.46(12)
O2	S1	N2	C14	-40.59(17)
O2	S1	C15	C16	31.5(2)
O2	S1	C15	C20	-152.9(2)
N1	C7	C8	C9	-175.9(2)
N1	C7	C12	C1	0.9(2)
N1	C7	C12	C11	176.05(17)
N2	S1	C15	C16	-82.2(2)
N2	S1	C15	C20	93.5(2)
N2	C2	C3	C4	-171.21(15)
C1	C2	C3	C4	60.9(2)
C2	C1	C6	N1	-77.13(15)
C2	C1	C6	C5	46.6(2)
C2	C1	C12	C7	91.06(18)
C2	C1	C12	C11	-83.5(2)
C2	C3	C4	C5	-60.0(2)
C3	C4	C5	C6	53.9(2)
C3	C4	C5	C22	-71.9(2)
C4	C5	C6	N1	70.0(2)

Atom	Atom	Atom	Atom	Angle/˚
C4	C5	C6	C1	-48.4(2)
C4	C5	C22	O3	178.25(18)
C4	C5	C22	O4	-5.2(3)
C6	N1	C7	C8	-160.1(2)
C6	N1	C7	C12	22.2(2)
C6	C1	C2	N2	177.31(13)
C6	C1	C2	C3	-53.10(19)
C6	C1	C12	C7	-22.00(18)
C6	C1	C12	C11	163.4(2)
C6	C5	C22	O3	52.5(2)
C6	C5	C22	O4	-130.9(2)
C7	N1	C6	C1	-35.32(17)
C7	N1	C6	C5	-160.81(15)
C7	C8	C9	C10	-0.8(3)
C8	C7	C12	C1	-177.03(17)
C8	C7	C12	C11	-1.9(3)
C8	C9	C10	C11	0.1(4)
C9	C10	C11	C12	-0.3(3)
C10	C11	C12	C1	175.15(19)
C10	C11	C12	C7	1.2(3)
C12	C1	C2	N2	70.73(17)
C12	C1	C2	C3	-159.68(16)
C12	C1	C6	N1	34.22(16)
C12	C1	C6	C5	157.93(16)
C12	C7	C8	C9	1.6(3)
C13	C1	C2	N2	-56.3(2)
C13	C1	C2	C3	73.3(2)
C13	C1	C6	N1	155.06(14)
C13	C1	C6	C5	-81.23(19)
C13	C1	C12	C7	-141.53(17)
C13	C1	C12	C11	43.9(3)
C14	N2	C2	C1	89.21(19)
C14	N2	C2	C3	-39.8(2)
C15	S1	N2	C2	-68.81(14)
C15	S1	N2	C14	74.14(17)
C15	C16	C17	C18	-1.5(4)
C16	C15	C20	C19	0.6(4)
C16	C17	C18	C19	1.8(4)
C16	C17	C18	C21	-179.1(3)
C17	C18	C19	C20	-1.0(4)
C18	C19	C20	C15	-0.2(4)
C20	C15	C16	C17	0.2(4)
C21	C18	C19	C20	179.9(3)
C22	O3	C23	C24	-162.8(2)
C22	C5	C6	N1	-165.64(16)
C22	C5	C6	C1	76.0(2)
C23	O3	C22	O4	3.8(4)
C23	O3	C22	C5	-179.5(2)
C25	N1	C6	C1	-169.91(17)
C25	N1	C6	C5	64.6(2)
C25	N1	C7	C8	-25.9(3)
C25	N1	C7	C12	156.4(2)
S2	N4	C27	C26	-128.51(13)
S2	N4	C27	C28	102.86(16)
S2	C40	C41	C42	176.9(2)
S2	C40	C45	C44	-176.57(18)
O5	S2	N4	C27	176.67(13)
O5	S2	N4	C39	-39.67(15)
O5	S2	C40	C41	33.4(2)
O5	S2	C40	C45	-149.29(18)
O6	S2	N4	C27	46.55(15)
O6	S2	N4	C39	-169.79(13)
O6	S2	C40	C41	164.07(19)

Atom	Atom	Atom	Atom	Angle/˚
O6	S2	C40	C45	-18.6(2)
N3	C32	C33	C34	-175.8(2)
N3	C32	C37	C26	0.1(2)
N3	C32	C37	C36	175.74(19)
N4	S2	C40	C41	-80.4(2)
N4	S2	C40	C45	96.89(19)
N4	C27	C28	C29	-171.46(15)
C26	C27	C28	C29	60.9(2)
C27	C26	C31	N3	-78.38(16)
C27	C26	C31	C30	45.5(2)
C27	C26	C37	C32	92.25(18)
C27	C26	C37	C36	-83.0(2)
C27	C28	C29	C30	-59.9(2)
C28	C29	C30	C31	53.3(2)
C28	C29	C30	C47	-74.09(18)
C29	C30	C31	N3	71.5(2)
C29	C30	C31	C26	-47.1(2)
C29	C30	C47	O7	-5.2(3)
C29	C30	C47	O8	178.36(17)
C31	N3	C32	C33	-158.7(2)
C31	N3	C32	C37	22.9(2)
C31	C26	C27	N4	178.55(14)
C31	C26	C27	C28	-52.51(19)
C31	C26	C37	C32	-21.26(19)
C31	C26	C37	C36	163.5(2)
C31	C30	C47	O7	-132.5(2)
C31	C30	C47	O8	51.1(2)
C32	N3	C31	C26	-35.61(18)
C32	N3	C31	C30	-161.19(16)
C32	C33	C34	C35	-1.1(4)
C33	C32	C37	C26	-178.42(18)
C33	C32	C37	C36	-2.7(3)
C33	C34	C35	C36	0.3(4)
C34	C35	C36	C37	-0.6(3)
C35	C36	C37	C26	176.5(2)
C35	C36	C37	C32	1.8(3)
C37	C26	C27	N4	71.97(18)
C37	C26	C27	C28	-159.08(15)
C37	C26	C31	N3	33.84(17)
C37	C26	C31	C30	157.70(16)
C37	C32	C33	C34	2.3(3)
C38	C26	C27	N4	-55.22(18)
C38	C26	C27	C28	73.73(18)
C38	C26	C31	N3	153.77(14)
C38	C26	C31	C30	-82.4(2)
C38	C26	C37	C32	-139.92(18)
C38	C26	C37	C36	44.9(3)
C39	N4	C27	C26	89.30(19)
C39	N4	C27	C28	-39.3(2)
C40	S2	N4	C27	-68.95(15)
C40	S2	N4	C39	74.71(15)
C40	C41	C42	C43	-0.4(4)
C41	C40	C45	C44	0.7(4)
C41	C42	C43	C44	0.9(4)
C41	C42	C43	C46	179.8(3)
C42	C43	C44	C45	-0.6(4)
C43	C44	C45	C40	-0.2(4)
C45	C40	C41	C42	-0.4(4)
C46	C43	C44	C45	-179.4(2)
C47	O8	C48	C49	83.0(4)
C47	C30	C31	N3	-162.35(17)
C47	C30	C31	C26	79.1(2)
C48	O8	C47	O7	-0.3(4)

Atom	Atom	Atom	Atom	Angle/˚
C48	O8	C47	C30	176.2(2)
C50	N3	C31	C26	-169.20(16)
C50	N3	C31	C30	65.2(2)
C50	N3	C32	C33	-25.8(3)
C50	N3	C32	C37	155.88(19)

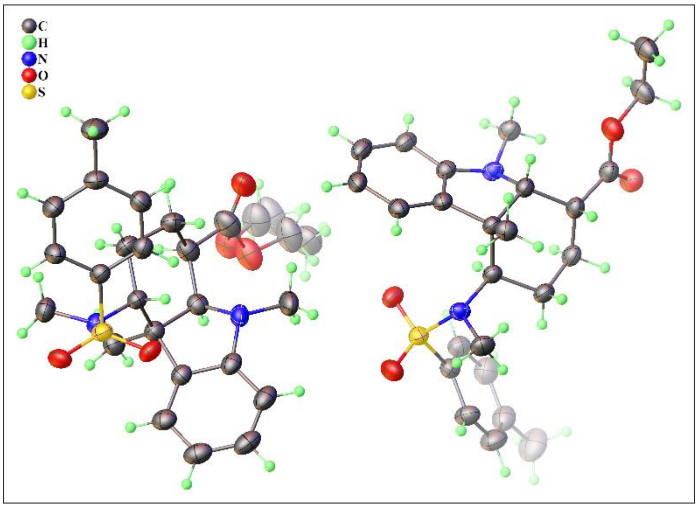
Table 6: Hydrogen Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **6g.** U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	x	y	z	U_{eq}
H2	7393.56	4539.51	7162.62	31
H3A	5088.2	5034.05	7400.87	37
H3B	5374.83	6109.73	7143.86	37
H4A	5677.21	4054.62	6228.01	40
H4B	4443.68	4830.23	6155.66	40
H5	6186.75	4839.44	5278.25	38
H6	8257.76	5818.65	5693.31	34
H8	10952.34	3313.82	5846.28	48
H9	12661.88	3791.27	6742.46	53
H10	12429.02	5231.93	7688.19	50
H11	10428.26	6254.08	7775.33	41
H13A	8620.54	7300.88	6628.61	50
H13B	8471.93	7292.86	7473.23	50
H13C	7139.59	7269.02	6968.84	50
H14A	5835.71	6430.28	8560.04	64
H14B	6756.11	7154.32	8169.37	64
H14C	7255.89	6889.68	8923.18	64
H16	5419.81	5275.16	9432.79	53
H17	3236.66	4572.62	9439.54	57
H19	4113.83	2292.09	7702.78	58
H20	6324.09	2953.96	7700.56	53
H21A	1436.37	3241.66	8231.64	89
H21B	1642.81	3187.3	9068	89
H21C	2018.21	2197.71	8440.37	89
H23A	6105.31	8405.05	5697.41	70
H23B	4858.6	7848.31	5197.77	70
H24A	6166.58	7677.27	4169.56	81
H24B	7470.8	8144.21	4652.79	81
H24C	6193.97	8881.72	4587.87	81
H25A	7639.86	3612.38	4905.34	73
H25B	9037.12	3100.89	5104.69	73
H25C	9062	4179.15	4829.13	73
H27	2341.95	10219.6	7826.4	30
H28A	48.15	9622.24	7601.9	36
H28B	402.49	8618.73	7935.01	36
H29A	-561.91	9959.1	8842.97	38
H29B	622.9	10753.28	8730.46	38
H30	1220.5	10154.62	9746.2	38
H31	3309.58	9180.53	9412.06	34
H33	5926.16	11673.3	9180.01	48
H34	7637.12	11152.31	8311.84	55
H35	7417.79	9641.69	7418.69	54
H36	5433.32	8594.96	7346.1	43
H38A	2247.51	7575.7	8203	49
H38B	3751.18	7646.16	8551.96	49
H38C	3546.56	7538.4	7693.76	49
H39A	838.33	8144.83	6473.9	55
H39B	1670.66	7548.02	6999.89	55
H39C	2282.95	7630.39	6230.32	55
H41	255.07	9153.98	5575.27	55
H42	-1916.3	9864.01	5507.71	62

Atom	**x**	**y**	**z**	***U*$_{eq}$**
H44	-846.37	12393.67	7055.43	58
H45	1340.55	11705.24	7123.29	51
H46A	-3355.58	11405.29	5720.43	92
H46B	-2978.52	12397.79	6354.11	92
H46C	-3622.71	11367.57	6551.44	92
H48A	1436.13	7233.86	10580.46	74
H48B	36.88	7295.16	10141.26	74
H49A	1017.04	6376.37	9089.37	116
H49B	1113.18	5715.9	9713.63	116
H49C	2425.84	6327.28	9520.14	116
H50A	2643.94	11408.37	10091.85	65
H50B	4031.03	11915.11	9885.65	65
H50C	4074.99	10878.63	10211.58	65

3.2 Compound **6g’** (ccdc number 2196011)

The crystal suitable for X-ray measurement for compound **6g’** was obtained by evaporation of chloroform.



Experimental. Single colourless plate-shaped crystals of **6g’** were used as supplied. A suitable crystal with dimensions 0.17 × 0.12 × 0.02 mm^3 was selected and mounted on an XtaLAB Synergy R, DW system, HyPix-Arc 150 diffractometer. The crystal was kept at a steady T = 139.99(10) K during data collection. The structure was solved with the **ShelXT** 2018/2 (Sheldrick, 2015) solution program using dual methods and by using **Olex2** 1.5 (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full-matrix least-squares minimisation on $\boldsymbol{F}^2$.

Compound	**6g'**
Formula	$C_{25}H_{32}N_2O_4S$
$D_{calc.}$/ g cm^{-3}	1.276
μ/mm^{-1}	1.481
Formula Weight	456.58
Colour	colourless
Shape	plate-shaped
Size/mm^3	0.17×0.12×0.02
T/K	139.99(10)
Crystal System	monoclinic
Flack Parameter	0.006(11)
Space Group	$P2_1$
a/Å	11.47555(18)
b/Å	12.97193(17)
c/Å	15.9925(2)
α/°	90
β/°	93.3345(13)
γ/°	90
V/Å^3	2376.62(6)
Z	4
Z'	2
Wavelength/Å	1.54184
Radiation type	Cu$K\alpha$
Θ_{min}/°	2.768
Θ_{max}/°	76.222
Measured Refl's.	10579
Indep't Refl's	10579
Refl's I≥2σ(I)	10096
R_{int}	n/a
Parameters	618
Restraints	89
Largest Peak/e Å^{-3}	0.619
Deepest Hole/e Å^{-3}	-0.316
GooF	1.048
wR_2 (all data)	0.1129
wR_2	0.1107
R_1 (all data)	0.0441
R_1	0.0419
CCDC number	2196011

Table 7: Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **6g'**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	U_{eq}
S1	7600.4(8)	7298.2(6)	6941.3(6)	34.57(19)
O1	5957(3)	7418(2)	2401.7(17)	46.4(6)
O2	4691(3)	6121(2)	2555.8(16)	42.9(6)
O3	8234(2)	6408(2)	6696.9(18)	41.1(6)
O4	7418(3)	7472(2)	7808.6(17)	43.1(6)
N1	6685(3)	5484(2)	4234.8(19)	33.1(6)
N2	6306(3)	7264(2)	6453.3(18)	32.7(6)
C1	5491(3)	6169(3)	5260(2)	30.3(7)
C2	5553(3)	6009(3)	4299(2)	30.7(7)
C3	6782(3)	4824(3)	4926(2)	32.1(7)
C4	7429(3)	3922(3)	5031(3)	36.9(8)
C5	7436(4)	3433(3)	5808(3)	42.4(9)
C6	6812(3)	3814(3)	6453(2)	38.4(8)
C7	6130(3)	4702(3)	6329(2)	36.5(8)
C8	6107(3)	5189(3)	5567(2)	31.8(7)
C9	6976(4)	5087(3)	3423(2)	38.5(8)
C10	6291(3)	7097(2)	5531(2)	30.3(7)
C11	6020(3)	8075(3)	5022(2)	35.3(8)

Atom	x	y	z	U_{eq}
C12	6202(3)	7866(3)	4104(2)	36.2(7)
C13	5382(3)	7006(3)	3789(2)	34.1(7)
C14	4234(3)	6249(3)	5520(2)	36.3(7)
C15	5399(4)	6881(3)	2848(2)	37.9(8)
C16	4713(4)	5927(4)	1657(2)	49.0(10)
C17	3799(4)	5142(4)	1433(3)	52.4(11)
C18	5457(3)	8004(3)	6772(3)	40.7(8)
C19	8338(3)	8382(3)	6557(2)	35.0(7)
C20	8136(4)	9360(3)	6880(3)	44.1(9)
C21	8678(4)	10208(3)	6552(3)	51.9(10)
C22	9416(4)	10111(3)	5901(3)	48.0(10)
C23	9605(4)	9121(4)	5585(3)	48.2(10)
C24	9080(3)	8267(3)	5914(2)	40.0(8)
C25	9994(5)	11037(4)	5542(4)	73.4(16)
S2	7322.8(8)	2840.8(6)	11990.6(6)	34.09(19)
O5	9026(3)	2638(3)	7524(2)	62.1(9)
O6A	10152(6)	4029(7)	7838(4)	61.5(15)
O6B	10567(8)	3637(8)	7890(6)	60.0(17)
O7	6690(2)	3715.7(19)	11660.3(18)	40.4(6)
O8	7562(3)	2733(2)	12875.7(16)	42.1(6)
N3	8301(3)	4619(2)	9304(2)	38.3(7)
N4	8589(3)	2813(2)	11561.4(18)	34.3(6)
C26	9434(3)	3878(3)	10434(2)	33.4(7)
C27	9395(3)	4029(3)	9466(2)	36.5(8)
C28	8245(3)	5284(3)	9990(3)	36.7(8)
C29	7653(4)	6217(3)	10043(3)	45.9(10)
C30	7675(4)	6706(3)	10816(3)	49.3(10)
C31	8284(4)	6301(3)	11512(3)	47.3(10)
C32	8915(4)	5385(3)	11448(3)	40.7(8)
C33	8894(3)	4882(3)	10686(2)	33.9(7)
C34	8055(4)	5054(3)	8471(3)	51.4(11)
C35	10685(3)	3736(3)	10794(3)	40.7(8)
C36	9489(3)	3026(3)	8979(2)	41.2(9)
C37	8602(4)	2221(3)	9214(2)	42.3(8)
C38	8762(4)	2003(3)	10145(3)	39.1(8)
C39	8581(3)	2988(3)	10646(2)	33.0(7)
C40	9556(5)	3144(4)	8040(3)	57.7(11)
C42A	10221(8)	4277(10)	6961(6)	67.5(19)
C42B	10974(13)	3701(11)	7053(8)	71(2)
C43A	11317(8)	3906(12)	6659(6)	82(3)
C43B	10560(16)	4671(11)	6627(9)	79(3)
C44	9399(4)	2029(3)	11929(3)	43.7(9)
C45	6541(3)	1733(3)	11639(2)	32.9(7)
C46	5816(3)	1782(3)	10918(2)	37.8(8)
C47	5255(3)	901(3)	10626(2)	39.7(8)
C48	5402(4)	-40(3)	11037(3)	40.6(8)
C49	6119(4)	-72(3)	11771(3)	43.9(9)
C50	6684(4)	808(3)	12072(2)	40.4(8)
C51	4780(4)	-990(4)	10703(3)	56.2(11)

Table 8: Anisotropic Displacement Parameters (×10⁴) for **6g'**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2} \times U_{11} + \ldots + 2hka^* \times b^* \times U_{12}]$

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	41.7(4)	28.5(4)	33.2(4)	-0.5(3)	-0.3(3)	-2.2(3)
O1	63.1(17)	40.9(14)	36.0(13)	3.9(12)	10.3(12)	-3.8(13)
O2	49.7(15)	49.7(15)	29.6(13)	4.0(11)	3.5(11)	-5.3(13)
O3	42.4(14)	30.5(13)	49.6(16)	-0.3(11)	-4.1(12)	3.4(10)
O4	58.2(16)	43.2(15)	27.6(12)	0.4(11)	1.7(12)	-9.0(12)
N1	38.9(15)	29.1(14)	31.9(15)	-2.4(12)	7.9(12)	1.8(12)
N2	37.1(14)	30.4(14)	30.9(14)	-4.9(12)	3.7(11)	0.9(12)

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
C1	35.1(17)	26.4(16)	29.6(16)	-0.3(13)	3.1(13)	1.4(13)
C2	32.3(16)	27.5(16)	32.2(17)	1.9(13)	1.3(13)	0.7(13)
C3	35.0(17)	27.4(16)	33.9(17)	-0.2(13)	2.0(14)	-2.8(13)
C4	36.0(18)	27.9(17)	47(2)	-1.5(15)	0.4(15)	1.2(14)
C5	42(2)	28.5(18)	55(2)	2.1(16)	-5.4(18)	-0.1(15)
C6	46(2)	29.6(17)	38.9(19)	6.0(15)	-7.1(16)	-5.9(15)
C7	42.3(19)	32.6(18)	34.2(18)	0.2(14)	-0.9(15)	-6.8(15)
C8	34.9(17)	25.7(15)	34.5(17)	-0.4(13)	-0.1(14)	-3.6(13)
C9	48(2)	35.4(18)	33.1(18)	-1.4(15)	10.2(15)	3.3(16)
C10	35.0(16)	26.9(16)	29.4(16)	-1.0(12)	4.9(13)	2.1(13)
C11	42.6(19)	26.5(17)	37.1(18)	-0.9(13)	4.3(15)	1.7(14)
C12	44.8(19)	28.6(16)	35.6(17)	5.7(15)	5.4(14)	2.0(16)
C13	40.9(18)	31.8(17)	30.0(16)	4.7(13)	4.3(14)	3.4(14)
C14	36.1(18)	38.1(18)	35.2(18)	-2.2(15)	5.9(14)	-1.3(15)
C15	46(2)	33.7(18)	33.8(19)	3.6(15)	3.1(16)	3.4(16)
C16	58(3)	61(3)	27.3(19)	3.4(17)	2.4(17)	-11(2)
C17	64(3)	60(3)	33.1(19)	7.7(19)	-0.8(19)	-16(2)
C18	42.4(19)	36.7(19)	44(2)	-7.8(16)	9.8(16)	4.4(15)
C19	37.6(18)	33.7(18)	33.3(17)	-0.8(14)	-1.9(14)	-1.3(14)
C20	57(2)	34.1(19)	42(2)	-4.7(16)	12.4(18)	-3.3(17)
C21	62(3)	33(2)	61(3)	-3.7(19)	5(2)	-7.4(18)
C22	45(2)	42(2)	57(3)	9.7(19)	2.0(19)	-9.3(18)
C23	41(2)	53(2)	52(2)	8.9(19)	9.3(18)	-2.6(18)
C24	39.3(19)	37.8(19)	43(2)	-3.4(16)	3.7(16)	0.8(15)
C25	73(3)	57(3)	91(4)	27(3)	12(3)	-16(3)
S2	43.0(4)	26.5(4)	33.2(4)	-1.5(3)	6.0(3)	-1.4(3)
O5	85(2)	61(2)	39.3(15)	-9.9(14)	-5.8(15)	15.6(17)
O6A	50(3)	94(4)	41(2)	11(3)	12(2)	-5(3)
O6B	64(4)	75(4)	43(3)	8(3)	21(3)	5(3)
O7	46.0(15)	26.0(12)	49.6(16)	1.0(11)	7.4(12)	5.0(10)
O8	60.7(16)	37.7(14)	28.1(12)	-4.9(11)	5.6(11)	-5.8(12)
N3	41.8(17)	34.8(16)	37.5(17)	7.2(13)	-4.9(13)	-1.2(13)
N4	37.8(15)	31.0(14)	34.0(15)	3.5(13)	0.7(12)	1.4(13)
C26	33.6(17)	32.8(17)	34.1(17)	0.9(14)	4.0(14)	-0.2(14)
C27	34.5(18)	39.4(19)	35.6(19)	0.5(15)	1.2(14)	-4.5(15)
C28	35.1(18)	29.2(17)	46(2)	6.0(15)	1.9(15)	-4.3(14)
C29	40(2)	31.6(19)	66(3)	7.7(18)	0.6(19)	-3.1(16)
C30	45(2)	30.2(19)	74(3)	0.4(19)	13(2)	-0.2(16)
C31	53(2)	35(2)	56(3)	-6.0(18)	19(2)	-8.5(17)
C32	46(2)	32.7(18)	44(2)	-0.6(15)	8.4(16)	-9.3(15)
C33	34.1(17)	30.4(17)	37.7(18)	3.5(14)	6.1(14)	-2.3(14)
C34	67(3)	42(2)	43(2)	12.2(18)	-12(2)	-6(2)
C35	38.5(19)	43(2)	41(2)	0.4(16)	0.6(16)	0.0(16)
C36	38.4(18)	52(2)	33.9(19)	-2.5(16)	4.9(14)	1.5(17)
C37	46(2)	38(2)	43(2)	-8.2(17)	3.9(16)	0.3(17)
C38	42(2)	29.6(17)	46(2)	-1.2(15)	7.6(16)	3.3(15)
C39	36.9(17)	27.2(16)	34.8(17)	-0.7(14)	1.4(14)	0.1(14)
C40	62(3)	75(3)	37(2)	-4(2)	7.6(18)	1(2)
C42A	58(4)	102(5)	44(3)	16(4)	14(3)	5(3)
C42B	73(4)	92(5)	50(4)	12(4)	20(4)	5(4)
C43A	58(5)	142(7)	47(5)	13(5)	12(4)	1(5)
C43B	104(7)	84(7)	50(6)	-2(6)	11(6)	2(6)
C44	45(2)	39(2)	47(2)	7.9(16)	-1.3(17)	5.3(16)
C45	39.2(18)	29.9(17)	30.2(16)	0.3(13)	7.0(14)	0.8(14)
C46	41.6(19)	35.5(18)	36.6(18)	3.4(15)	4.7(15)	4.4(15)
C47	40(2)	42(2)	37.0(19)	-2.5(15)	-0.5(16)	0.5(16)
C48	43(2)	33.9(19)	45(2)	-8.2(16)	3.4(16)	-4.6(15)
C49	55(2)	31.6(18)	45(2)	3.8(16)	0.2(18)	-3.0(16)
C50	49(2)	35.7(19)	35.8(19)	0.6(15)	-1.7(16)	-4.2(16)
C51	57(3)	44(2)	66(3)	-10(2)	-9(2)	-6(2)

Table 9: Bond Lengths in Å for **6g'**.

Atom	Atom	Length/Å
S1	O3	1.432(3)
S1	O4	1.433(3)
S1	N2	1.638(3)
S1	C19	1.770(4)
O1	C15	1.207(5)
O2	C15	1.344(5)
O2	C16	1.461(5)
N1	C2	1.476(4)
N1	C3	1.397(5)
N1	C9	1.453(4)
N2	C10	1.490(4)
N2	C18	1.479(4)
C1	C2	1.556(5)
C1	C8	1.521(5)
C1	C10	1.559(5)
C1	C14	1.528(5)
C2	C13	1.535(5)
C3	C4	1.392(5)
C3	C8	1.402(5)
C4	C5	1.394(6)
C5	C6	1.381(6)
C6	C7	1.401(5)
C7	C8	1.372(5)
C10	C11	1.531(5)
C11	C12	1.520(5)
C12	C13	1.525(5)
C13	C15	1.516(5)
C16	C17	1.490(6)
C19	C20	1.393(5)
C19	C24	1.381(5)
C20	C21	1.382(6)
C21	C22	1.386(7)
C22	C23	1.402(7)
C22	C25	1.503(6)
C23	C24	1.379(6)
S2	O7	1.432(3)
S2	O8	1.433(3)
S2	N4	1.643(3)
S2	C45	1.769(4)
O5	C40	1.193(6)
O6A	C40	1.385(8)
O6A	C42A	1.446(9)
O6B	C40	1.359(9)
O6B	C42B	1.445(11)
N3	C27	1.479(5)
N3	C28	1.400(5)
N3	C34	1.459(5)
N4	C39	1.482(4)
N4	C44	1.477(5)
C26	C27	1.558(5)
C26	C33	1.508(5)
C26	C35	1.527(5)
C26	C39	1.563(5)
C27	C36	1.523(5)
C28	C29	1.393(5)
C28	C33	1.404(5)
C29	C30	1.388(7)
C30	C31	1.383(7)
C31	C32	1.398(6)
C32	C33	1.381(5)
C36	C37	1.520(6)
C36	C40	1.515(6)
C37	C38	1.517(5)
C38	C39	1.529(5)
C42A	C43A	1.455(11)
C42B	C43B	1.495(12)
C45	C46	1.383(5)
C45	C50	1.391(5)
C46	C47	1.380(6)
C47	C48	1.392(6)
C48	C49	1.395(6)
C48	C51	1.506(6)
C49	C50	1.384(6)

Table 10: Bond Angles in ° for **6g'**.

Atom	Atom	Atom	Angle/°
O3	S1	O4	119.79(17)
O3	S1	N2	107.99(16)
O3	S1	C19	106.61(17)
O4	S1	N2	106.60(16)
O4	S1	C19	108.12(17)
N2	S1	C19	107.15(17)
C15	O2	C16	115.0(3)
C3	N1	C2	104.9(3)
C3	N1	C9	118.5(3)
C9	N1	C2	118.3(3)
C10	N2	S1	115.7(2)
C18	N2	S1	114.5(2)
C18	N2	C10	117.7(3)
C2	C1	C10	108.5(3)
C8	C1	C2	99.2(3)
C8	C1	C10	107.5(3)
C8	C1	C14	113.5(3)
C14	C1	C2	112.1(3)
C14	C1	C10	114.9(3)
N1	C2	C1	102.8(3)
N1	C2	C13	115.9(3)
C13	C2	C1	113.6(3)
N1	C3	C8	110.5(3)
C4	C3	N1	128.9(3)
C4	C3	C8	120.6(3)
C3	C4	C5	117.8(4)
C6	C5	C4	121.8(4)
C5	C6	C7	119.8(4)
C8	C7	C6	119.1(4)
C3	C8	C1	108.2(3)
C7	C8	C1	131.0(3)
C7	C8	C3	120.7(3)
N2	C10	C1	111.1(3)
N2	C10	C11	113.4(3)
C11	C10	C1	113.2(3)
C12	C11	C10	109.3(3)
C11	C12	C13	109.4(3)

Atom	Atom	Atom	Angle/°
C12	C13	C2	112.5(3)
C15	C13	C2	115.4(3)
C15	C13	C12	111.2(3)
O1	C15	O2	123.3(3)
O1	C15	C13	124.3(4)
O2	C15	C13	112.4(3)
O2	C16	C17	107.6(3)
C20	C19	S1	120.1(3)
C24	C19	S1	120.0(3)
C24	C19	C20	119.8(4)
C21	C20	C19	119.7(4)
C20	C21	C22	121.4(4)
C21	C22	C23	117.9(4)
C21	C22	C25	121.2(4)
C23	C22	C25	120.9(4)
C24	C23	C22	121.2(4)
C23	C24	C19	119.9(4)
O7	S2	O8	120.38(17)
O7	S2	N4	107.77(16)
O7	S2	C45	106.82(17)
O8	S2	N4	106.68(16)
O8	S2	C45	107.45(17)
N4	S2	C45	107.11(17)
C40	O6A	C42A	117.8(7)
C40	O6B	C42B	121.1(10)
C28	N3	C27	105.0(3)
C28	N3	C34	117.5(3)
C34	N3	C27	118.5(3)
C39	N4	S2	117.1(2)
C44	N4	S2	113.6(3)
C44	N4	C39	117.8(3)
C27	C26	C39	109.1(3)
C33	C26	C27	99.7(3)
C33	C26	C35	113.3(3)
C33	C26	C39	107.9(3)
C35	C26	C27	111.2(3)
C35	C26	C39	114.6(3)
N3	C27	C26	102.4(3)
N3	C27	C36	115.9(3)
C36	C27	C26	113.6(3)
N3	C28	C33	110.2(3)
C29	C28	N3	129.0(4)
C29	C28	C33	120.8(4)
C30	C29	C28	117.9(4)
C31	C30	C29	121.7(4)
C30	C31	C32	120.2(4)
C33	C32	C31	118.9(4)
C28	C33	C26	108.4(3)
C32	C33	C26	131.2(4)
C32	C33	C28	120.4(4)
C37	C36	C27	113.1(3)
C40	C36	C27	115.4(4)
C40	C36	C37	112.8(3)
C38	C37	C36	109.1(3)
C37	C38	C39	110.2(3)
N4	C39	C26	111.1(3)
N4	C39	C38	113.4(3)
C38	C39	C26	113.5(3)
O5	C40	O6A	122.2(5)
O5	C40	O6B	122.8(6)
O5	C40	C36	125.3(5)
O6A	C40	C36	111.6(5)
O6B	C40	C36	108.4(5)
O6A	C42A	C43A	110.2(9)
O6B	C42B	C43B	111.1(12)
C46	C45	S2	119.8(3)
C46	C45	C50	120.2(3)
C50	C45	S2	120.0(3)
C47	C46	C45	119.3(3)
C46	C47	C48	121.7(4)
C47	C48	C49	118.2(3)
C47	C48	C51	120.5(4)
C49	C48	C51	121.2(4)
C50	C49	C48	120.6(4)
C49	C50	C45	120.0(4)

Table 11: Torsion Angles in ° for **6g'**.

Atom	Atom	Atom	Atom	Angle/°
S1	N2	C10	C1	126.5(3)
S1	N2	C10	C11	-104.7(3)
S1	C19	C20	C21	-177.3(3)
S1	C19	C24	C23	176.6(3)
O3	S1	N2	C10	-50.5(3)
O3	S1	N2	C18	167.5(3)
O3	S1	C19	C20	-162.4(3)
O3	S1	C19	C24	20.1(4)
O4	S1	N2	C10	179.5(2)
O4	S1	N2	C18	37.6(3)
O4	S1	C19	C20	-32.3(4)
O4	S1	C19	C24	150.2(3)
N1	C2	C13	C12	-66.1(4)
N1	C2	C13	C15	63.0(4)
N1	C3	C4	C5	176.0(4)
N1	C3	C8	C1	1.3(4)
N1	C3	C8	C7	-175.6(3)
N2	S1	C19	C20	82.2(4)
N2	S1	C19	C24	-95.3(3)
N2	C10	C11	C12	171.6(3)

Atom	Atom	Atom	Atom	Angle/°
C1	C2	C13	C12	52.6(4)
C1	C2	C13	C15	-178.3(3)
C1	C10	C11	C12	-60.6(4)
C2	N1	C3	C4	155.5(4)
C2	N1	C3	C8	-24.8(4)
C2	C1	C8	C3	21.0(3)
C2	C1	C8	C7	-162.6(4)
C2	C1	C10	N2	-177.8(3)
C2	C1	C10	C11	53.3(4)
C2	C13	C15	O1	-132.3(4)
C2	C13	C15	O2	49.7(4)
C3	N1	C2	C1	37.2(3)
C3	N1	C2	C13	161.8(3)
C3	C4	C5	C6	1.0(6)
C4	C3	C8	C1	-179.0(3)
C4	C3	C8	C7	4.2(5)
C4	C5	C6	C7	1.3(6)
C5	C6	C7	C8	-0.9(5)
C6	C7	C8	C1	-177.8(3)
C6	C7	C8	C3	-1.8(5)
C8	C1	C2	N1	-34.6(3)
C8	C1	C2	C13	-160.6(3)
C8	C1	C10	N2	-71.4(3)
C8	C1	C10	C11	159.7(3)
C8	C3	C4	C5	-3.7(5)
C9	N1	C2	C1	172.1(3)
C9	N1	C2	C13	-63.4(4)
C9	N1	C3	C4	20.8(5)
C9	N1	C3	C8	-159.4(3)
C10	C1	C2	N1	77.5(3)
C10	C1	C2	C13	-48.6(4)
C10	C1	C8	C3	-91.9(3)
C10	C1	C8	C7	84.5(4)
C10	C11	C12	C13	60.5(4)
C11	C12	C13	C2	-57.4(4)
C11	C12	C13	C15	171.4(3)
C12	C13	C15	O1	-2.6(5)
C12	C13	C15	O2	179.4(3)
C14	C1	C2	N1	-154.6(3)
C14	C1	C2	C13	79.3(4)
C14	C1	C8	C3	140.0(3)
C14	C1	C8	C7	-43.6(5)
C14	C1	C10	N2	55.9(4)
C14	C1	C10	C11	-73.0(4)
C15	O2	C16	C17	-174.5(4)
C16	O2	C15	O1	4.9(6)
C16	O2	C15	C13	-177.1(3)
C18	N2	C10	C1	-92.9(3)
C18	N2	C10	C11	36.0(4)
C19	S1	N2	C10	64.0(3)
C19	S1	N2	C18	-78.0(3)
C19	C20	C21	C22	0.5(7)
C20	C19	C24	C23	-1.0(6)
C20	C21	C22	C23	-0.4(7)
C20	C21	C22	C25	179.4(5)
C21	C22	C23	C24	-0.4(7)
C22	C23	C24	C19	1.1(6)
C24	C19	C20	C21	0.2(6)
C25	C22	C23	C24	179.8(5)
S2	N4	C39	C26	126.2(3)
S2	N4	C39	C38	-104.6(3)
S2	C45	C46	C47	176.8(3)
S2	C45	C50	C49	-176.6(3)

Atom	Atom	Atom	Atom	Angle/˚
O7	S2	N4	C39	-45.1(3)
O7	S2	N4	C44	172.3(3)
O7	S2	C45	C46	24.6(3)
O7	S2	C45	C50	-157.5(3)
O8	S2	N4	C39	-175.7(2)
O8	S2	N4	C44	41.7(3)
O8	S2	C45	C46	155.0(3)
O8	S2	C45	C50	-27.1(4)
N3	C27	C36	C37	-65.3(4)
N3	C27	C36	C40	66.7(5)
N3	C28	C29	C30	176.1(4)
N3	C28	C33	C26	0.9(4)
N3	C28	C33	C32	-176.8(3)
N4	S2	C45	C46	-90.7(3)
N4	S2	C45	C50	87.2(3)
C26	C27	C36	C37	52.9(4)
C26	C27	C36	C40	-175.2(3)
C27	N3	C28	C29	156.1(4)
C27	N3	C28	C33	-24.3(4)
C27	C26	C33	C28	21.3(3)
C27	C26	C33	C32	-161.5(4)
C27	C26	C39	N4	179.9(3)
C27	C26	C39	C38	50.8(4)
C27	C36	C37	C38	-57.8(4)
C27	C36	C40	O5	-135.6(5)
C27	C36	C40	O6A	33.9(6)
C27	C36	C40	O6B	65.1(7)
C28	N3	C27	C26	36.8(3)
C28	N3	C27	C36	161.0(3)
C28	C29	C30	C31	1.5(6)
C29	C28	C33	C26	-179.6(3)
C29	C28	C33	C32	2.8(5)
C29	C30	C31	C32	1.0(6)
C30	C31	C32	C33	-1.6(6)
C31	C32	C33	C26	-177.2(4)
C31	C32	C33	C28	-0.2(5)
C33	C26	C27	N3	-34.5(3)
C33	C26	C27	C36	-160.2(3)
C33	C26	C39	N4	-72.7(4)
C33	C26	C39	C38	158.2(3)
C33	C28	C29	C30	-3.4(6)
C34	N3	C27	C26	170.3(3)
C34	N3	C27	C36	-65.4(4)
C34	N3	C28	C29	22.1(6)
C34	N3	C28	C33	-158.4(4)
C35	C26	C27	N3	-154.3(3)
C35	C26	C27	C36	80.0(4)
C35	C26	C33	C28	139.5(3)
C35	C26	C33	C32	-43.2(5)
C35	C26	C39	N4	54.5(4)
C35	C26	C39	C38	-74.6(4)
C36	C37	C38	C39	59.8(4)
C37	C36	C40	O5	-3.5(7)
C37	C36	C40	O6A	166.0(5)
C37	C36	C40	O6B	-162.7(6)
C37	C38	C39	N4	173.4(3)
C37	C38	C39	C26	-58.7(4)
C39	C26	C27	N3	78.4(3)
C39	C26	C27	C36	-47.3(4)
C39	C26	C33	C28	-92.5(3)
C39	C26	C33	C32	84.7(5)
C40	O6A	C42A	C43A	-96.2(11)
C40	O6B	C42B	C43B	92.8(15)

Atom	Atom	Atom	Atom	Angle/˚
C40	C36	C37	C38	168.9(4)
C42A	O6A	C40	O5	-6.3(11)
C42A	O6A	C40	C36	-176.2(7)
C42B	O6B	C40	O5	9.2(14)
C42B	O6B	C40	C36	169.1(9)
C44	N4	C39	C26	-92.8(4)
C44	N4	C39	C38	36.4(4)
C45	S2	N4	C39	69.5(3)
C45	S2	N4	C44	-73.1(3)
C45	C46	C47	C48	-0.2(6)
C46	C45	C50	C49	1.3(6)
C46	C47	C48	C49	1.3(6)
C46	C47	C48	C51	-179.9(4)
C47	C48	C49	C50	-1.1(6)
C48	C49	C50	C45	-0.2(7)
C50	C45	C46	C47	-1.1(6)
C51	C48	C49	C50	-179.9(4)

Table 12: Hydrogen Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **6g’**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	x	y	z	U_{eq}
H2	4921.28	5516.3	4110.17	37
H4	7851.56	3647.52	4588.8	44
H5	7883.03	2822.42	5895.82	51
H6	6845.47	3473.38	6979.86	46
H7	5688.77	4963.38	6766.35	44
H9A	6383.47	4586.11	3225.07	58
H9B	7741.28	4750.9	3475.2	58
H9C	6998.76	5657.31	3022.44	58
H10	7102.2	6890.76	5406.84	36
H11A	5202.18	8289	5088.82	42
H11B	6539.75	8641.33	5226.99	42
H12A	7021.42	7659.49	4036.11	43
H12B	6041.93	8499.16	3771.32	43
H13	4577.56	7251.52	3895.53	41
H14A	3892.37	6900.85	5314.87	55
H14B	4225.91	6226.98	6132.22	55
H14C	3776.56	5671.97	5279.75	55
H16A	5489.97	5668.81	1518.53	59
H16B	4550.12	6571.96	1339.76	59
H17A	3749.72	5037.2	824.72	79
H17B	3043.93	5383.41	1611.89	79
H17C	4003.7	4490.24	1713.63	79
H18A	5429.32	7924.85	7379.82	61
H18B	4681.99	7870.55	6504.34	61
H18C	5698.28	8708.66	6642.7	61
H20	7628.01	9442.39	7323.26	53
H21	8541.6	10871.26	6778.55	62
H23	10103.76	9036	5136.83	58
H24	9228.13	7600.35	5698.32	48
H25A	9593.78	11218.82	5003.88	110
H25B	10813.68	10877.6	5456.17	110
H25C	9952.57	11618.22	5930.09	110
H27	10063.5	4482.03	9329.8	44
H29	7247.84	6510.44	9565.7	55
H30	7260.8	7334.11	10868.28	59
H31	8273.22	6646.65	12035.48	57
H32	9350.87	5113.46	11921.2	49
H34A	8699.71	5505.36	8329.62	77
H34B	7329.97	5452.93	8464.21	77

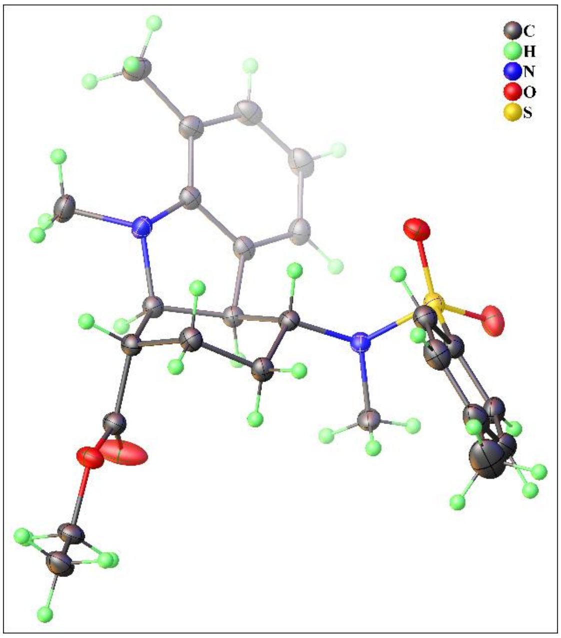
Atom	x	y	z	U_{eq}
H34C	7971.55	4494.89	8059.42	77
H35A	10990	3075.5	10603.88	61
H35B	10695.4	3741.27	11407.18	61
H35C	11172.52	4298.56	10602.35	61
H36	10262.31	2731.5	9175.08	49
H37A	7801.74	2476.88	9074.85	51
H37B	8715.7	1579.48	8892.9	51
H38A	9556.82	1730.76	10279.19	47
H38B	8192.69	1473.21	10302.65	47
H39	7779.57	3238.8	10471.87	40
H42A	10166.02	5033.17	6883.11	81
H42B	9558.95	3954.39	6633.62	81
H42C	10683.17	3098.86	6721.99	85
H42D	11837.44	3681.57	7080.86	85
H43A	11442.12	4217.97	6113.51	123
H43B	11285.79	3154.26	6601.33	123
H43C	11960.31	4095.83	7059.12	123
H43D	10934.39	4743.93	6094.95	118
H43E	10763.37	5262.68	6987.42	118
H43F	9711.11	4641.66	6519.91	118
H44A	9447.64	2097.07	12540.44	66
H44B	10174.87	2130.34	11716.84	66
H44C	9111.95	1339.67	11774.03	66
H46	5705.97	2416.06	10627.02	45
H47	4755.53	937.32	10132.23	48
H49	6221.55	-703.11	12067.74	53
H50	7169.22	778.96	12573.03	48
H51A	4064.28	-1092.18	10997.94	84
H51B	5290.23	-1590.76	10791.1	84
H51C	4582.03	-904.42	10102.71	84

Table 13: Atomic Occupancies for all atoms that are not fully occupied in **6g’**.

Atom	Occupancy
O6A	0.567(9)
O6B	0.433(9)
C42A	0.567(9)
H42A	0.567(9)
H42B	0.567(9)
C42B	0.433(9)
H42C	0.433(9)
H42D	0.433(9)
C43A	0.567(9)
H43A	0.567(9)
H43B	0.567(9)
H43C	0.567(9)
C43B	0.433(9)
H43D	0.433(9)
H43E	0.433(9)
H43F	0.433(9)

3.3 Compound **6j** (ccdc number 2194477)

The crystal suitable for X-ray measurement for compound **6j** was obtained by evaporation of chloroform.



Experimental. Single colourless prism-shaped crystals of **6j** were used as supplied. A suitable crystal with dimensions 0.47 × 0.30 × 0.24 mm^3 was selected and mounted on a SuperNova, Dual, Cu at home/near, Atlas diffractometer. During data collection, the crystal was kept at a steady T = 140.00(10) K. The structure was solved with the **ShelXT** 2018/2 (Sheldrick, 2015) solution program using dual methods and **Olex2** 1.5 (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full-matrix least-squares minimisation on $\boldsymbol{F^2}$.

Compound	**6j**
Formula	$C_{25}H_{32}N_2O_4S$
$D_{calc.}$/ g cm^{-3}	1.293
μ/mm^{-1}	1.500
Formula Weight	456.58
Colour	colourless
Shape	prism-shaped
Size/mm^3	0.47×0.30×0.24
T/K	140.00(10)
Crystal System	monoclinic
Flack Parameter	0.409(12)
Space Group	$P2_1$
a/Å	9.95357(12)
b/Å	10.70001(12)
c/Å	11.57591(16)
α/°	90
β/°	107.9165(14)
γ/°	90
V/Å^3	1173.09(3)
Z	2
Z'	1
Wavelength/Å	1.54184
Radiation type	Cu$K\alpha$
Θ_{min}/°	4.013
Θ_{max}/°	76.277
Measured Refl's.	13189
Indep't Refl's	4843
Refl's I≥2σ(I)	4815
R_{int}	0.0121
Parameters	295
Restraints	1
Largest Peak/e Å^{-3}	0.290
Deepest Hole/e Å^{-3}	-0.244
GooF	1.049
wR_2 (all data)	0.0641
wR_2	0.0640
R_1 (all data)	0.0243
R_1	0.0242
CCDC number	2194477

Table 14: Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **6j**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	$\boldsymbol{U_{eq}}$
S1	4919.5(4)	6095.4(4)	66.2(3)	17.49(10)
O1	5764.8(17)	6041.8(16)	5780.1(18)	49.0(5)
O2	4159.7(13)	4589.2(11)	5768.5(11)	23.3(3)
O3	5641.1(13)	4992.9(12)	-115.7(11)	23.2(3)
O4	5105.5(15)	7238.8(12)	-513.8(12)	26.2(3)
N1	8042.9(13)	3594.8(15)	4275.0(12)	18.5(3)
N2	5401.0(14)	6364.8(12)	1532.6(12)	16.4(3)
C1	7145.6(16)	4600.8(15)	4532.6(14)	17.5(3)
C2	5800.4(17)	4090.8(16)	4743.1(15)	17.6(3)
C3	4640.9(17)	3798.6(15)	3552.3(15)	19.5(3)
C4	4310.9(17)	4956.2(16)	2748.2(15)	19.8(3)
C5	5608.3(16)	5274.5(15)	2364.1(15)	16.0(3)
C6	6920.4(16)	5534.1(15)	3474.1(14)	16.4(3)
C7	8260.7(16)	5333.9(16)	3149.1(15)	18.4(3)
C8	8829.3(17)	6067.2(18)	2433.5(15)	21.7(3)
C9	10034.6(19)	5644.3(19)	2184.2(17)	26.4(4)
C10	10621.6(17)	4504.4(19)	2645.5(17)	25.7(4)

Atom	x	y	z	U_{eq}
C11	10070.5(17)	3734.3(18)	3368.9(15)	22.0(3)
C12	8856.0(16)	4184.8(16)	3618.6(15)	18.1(3)
C13	8777(2)	2891.7(18)	5372.7(17)	26.3(4)
C14	5270.4(18)	5028.7(16)	5484.4(15)	20.8(3)
C15	3569.9(19)	5406.4(18)	6496.8(17)	24.4(4)
C16	2189(2)	4835(2)	6489.6(17)	28.9(4)
C17	4777(2)	7493.1(15)	1887.7(16)	22.3(3)
C18	3085.7(18)	5784.0(16)	-380.6(14)	19.8(3)
C19	2618.0(18)	4558.0(17)	-382.7(15)	22.5(3)
C20	1177(2)	4329.8(19)	-660.0(17)	28.8(4)
C21	204(2)	5307(2)	-928.1(18)	32.3(4)
C22	700(2)	6521(2)	-917.5(18)	31.7(4)
C23	2135(2)	6775.4(18)	-659.1(16)	26.0(4)
C24	-1360(2)	5042(3)	-1212(2)	51.6(7)
C25	10792.4(19)	2511.7(18)	3814.8(18)	27.3(4)

Table 15: Anisotropic Displacement Parameters (×10⁴) for **6j**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2} \times U_{11} + ... + 2hka^* \times b^* \times U_{12}]$

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	20.67(17)	16.75(17)	15.13(17)	-1.60(14)	5.63(13)	-2.69(14)
O1	50.3(9)	33.2(8)	80.6(12)	-30.5(9)	45.3(9)	-18.7(8)
O2	27.5(6)	21.2(6)	26.2(6)	-2.5(5)	15.8(5)	-1.0(5)
O3	24.2(6)	24.5(6)	22.4(6)	-4.6(5)	9.6(5)	-0.5(5)
O4	35.7(7)	23.5(6)	19.7(6)	1.4(5)	8.8(5)	-7.7(5)
N1	16.7(6)	19.9(6)	18.6(6)	3.4(6)	4.9(5)	2.6(6)
N2	20.4(6)	13.2(6)	14.8(6)	-1.3(5)	4.3(5)	-0.2(5)
C1	17.4(7)	18.4(7)	16.2(7)	-0.4(6)	4.5(6)	-1.1(6)
C2	19.8(7)	16.5(7)	17.8(8)	1.4(6)	7.7(6)	-0.4(6)
C3	19.9(8)	19.0(8)	20.4(8)	0.3(6)	7.3(6)	-3.5(6)
C4	16.2(7)	23.4(8)	19.5(7)	0.8(6)	4.9(6)	-1.4(6)
C5	16.8(7)	13.7(7)	17.3(7)	0.2(6)	4.9(6)	-0.4(6)
C6	15.8(7)	16.3(7)	16.7(7)	-0.3(6)	4.7(6)	-1.2(6)
C7	15.0(7)	23.3(8)	16.0(7)	-0.9(6)	3.2(6)	-3.2(6)
C8	19.8(7)	23.3(7)	21.2(7)	3.5(7)	5.0(6)	-2.4(7)
C9	21.3(8)	36.3(10)	23.6(8)	0.9(7)	9.7(7)	-7.0(7)
C10	16.5(7)	36.3(10)	25.5(9)	-3.6(8)	8.0(7)	-2.2(7)
C11	15.0(7)	28.2(9)	20.6(8)	-3.1(7)	2.4(6)	-0.3(7)
C12	15.0(7)	21.4(8)	16.2(8)	-1.5(6)	2.4(6)	-2.2(6)
C13	23.3(9)	30.4(9)	24.2(9)	9.6(7)	5.7(7)	5.5(7)
C14	22.2(8)	20.2(8)	20.9(8)	0.0(7)	7.9(6)	0.4(6)
C15	27.1(8)	26.2(9)	22.2(8)	-5.4(7)	10.9(7)	2.6(7)
C16	26.4(9)	38.3(10)	25.2(9)	-2.5(8)	12.7(7)	1.6(8)
C17	31.5(9)	15.3(8)	19.7(8)	-1.1(6)	7.3(7)	3.3(7)
C18	20.0(7)	24.0(9)	13.9(7)	-1.6(6)	2.9(6)	-0.3(6)
C19	24.0(8)	23.0(8)	20.0(8)	-1.8(7)	6.0(7)	-1.8(7)
C20	28.2(9)	34.7(10)	23.9(9)	-2.3(7)	8.5(7)	-8.2(8)
C21	23.0(9)	51.9(12)	21.8(9)	-0.3(8)	6.4(7)	-0.2(9)
C22	26.0(9)	44.7(11)	21.8(9)	2.6(8)	3.5(7)	11.7(8)
C23	30.6(9)	26.6(9)	18.3(8)	1.5(7)	3.6(7)	4.5(7)
C24	23.5(10)	85(2)	44.7(13)	1.1(14)	8.1(9)	-3.4(11)
C25	19.1(8)	30.7(10)	30.8(9)	-1.6(8)	5.8(7)	5.0(7)

Table 16: Bond Lengths in Å for **6j**.

Atom	Atom	Length/Å
S1	O3	1.4300(13)
S1	O4	1.4347(13)
S1	N2	1.6413(13)
S1	C18	1.7689(17)

Atom	Atom	Length/Å
O1	C14	1.196(2)
O2	C14	1.332(2)
O2	C15	1.458(2)
N1	C1	1.486(2)
N1	C12	1.417(2)
N1	C13	1.464(2)
N2	C5	1.486(2)
N2	C17	1.473(2)
C1	C2	1.533(2)
C1	C6	1.543(2)
C2	C3	1.533(2)
C2	C14	1.517(2)
C3	C4	1.523(2)
C4	C5	1.528(2)
C5	C6	1.550(2)
C6	C7	1.509(2)
C7	C8	1.382(2)
C7	C12	1.400(2)
C8	C9	1.393(2)
C9	C10	1.386(3)
C10	C11	1.401(3)
C11	C12	1.411(2)
C11	C25	1.505(3)
C15	C16	1.502(3)
C18	C19	1.392(2)
C18	C23	1.392(2)
C19	C20	1.392(3)
C20	C21	1.394(3)
C21	C22	1.388(3)
C21	C24	1.515(3)
C22	C23	1.393(3)

Table 17: Bond Angles in ° for **6j**.

Atom	Atom	Atom	Angle/°
O3	S1	O4	119.45(7)
O3	S1	N2	107.28(7)
O3	S1	C18	108.75(8)
O4	S1	N2	107.19(7)
O4	S1	C18	107.09(8)
N2	S1	C18	106.39(7)
C14	O2	C15	116.32(13)
C12	N1	C1	105.21(13)
C12	N1	C13	118.64(13)
C13	N1	C1	111.61(13)
C5	N2	S1	118.05(10)
C17	N2	S1	114.75(11)
C17	N2	C5	116.70(13)
N1	C1	C2	112.46(13)
N1	C1	C6	105.00(12)
C2	C1	C6	115.85(13)
C1	C2	C3	112.48(13)
C14	C2	C1	109.09(13)
C14	C2	C3	110.30(13)
C4	C3	C2	110.17(13)
C3	C4	C5	108.45(13)
N2	C5	C4	113.71(13)
N2	C5	C6	108.06(12)
C4	C5	C6	111.77(13)
C1	C6	C5	114.96(13)
C7	C6	C1	100.52(12)
C7	C6	C5	110.62(13)
C8	C7	C6	128.71(16)
C8	C7	C12	121.92(15)
C12	C7	C6	109.21(14)
C7	C8	C9	118.51(17)
C10	C9	C8	119.59(16)
C9	C10	C11	123.46(16)
C10	C11	C12	116.04(16)
C10	C11	C25	118.85(16)
C12	C11	C25	125.11(16)
C7	C12	N1	110.85(14)
C7	C12	C11	120.48(16)
C11	C12	N1	128.60(16)
O1	C14	O2	123.28(16)
O1	C14	C2	125.28(16)
O2	C14	C2	111.44(14)
O2	C15	C16	106.45(14)
C19	C18	S1	119.51(13)
C23	C18	S1	119.39(13)
C23	C18	C19	121.00(16)
C20	C19	C18	119.09(17)
C19	C20	C21	121.08(19)
C20	C21	C24	120.3(2)
C22	C21	C20	118.58(17)
C22	C21	C24	121.1(2)
C21	C22	C23	121.59(18)
C18	C23	C22	118.65(18)

Table 18: Torsion Angles in ° for **6j**.

Atom	Atom	Atom	Atom	Angle/°
S1	N2	C5	C4	-94.87(14)
S1	N2	C5	C6	140.42(11)
S1	C18	C19	C20	175.91(13)
S1	C18	C23	C22	-175.07(14)
O3	S1	N2	C5	-37.56(13)
O3	S1	N2	C17	178.71(11)
O3	S1	C18	C19	23.93(16)
O3	S1	C18	C23	-159.63(13)
O4	S1	N2	C5	-167.00(11)

Atom	Atom	Atom	Atom	Angle/°
O4	S1	N2	C17	49.28(13)
O4	S1	C18	C19	154.29(14)
O4	S1	C18	C23	-29.28(16)
N1	C1	C2	C3	-80.46(17)
N1	C1	C2	C14	156.82(13)
N1	C1	C6	C5	89.98(15)
N1	C1	C6	C7	-28.80(15)
N2	S1	C18	C19	-91.33(14)
N2	S1	C18	C23	85.10(15)
N2	C5	C6	C1	170.15(12)
N2	C5	C6	C7	-76.88(16)
C1	N1	C12	C7	-17.46(17)
C1	N1	C12	C11	165.48(16)
C1	C2	C3	C4	-56.11(18)
C1	C2	C14	O1	5.0(3)
C1	C2	C14	O2	-175.43(14)
C1	C6	C7	C8	-165.58(17)
C1	C6	C7	C12	19.04(17)
C2	C1	C6	C5	-34.73(19)
C2	C1	C6	C7	-153.51(13)
C2	C3	C4	C5	65.96(17)
C3	C2	C14	O1	-119.0(2)
C3	C2	C14	O2	60.55(18)
C3	C4	C5	N2	177.78(13)
C3	C4	C5	C6	-59.54(17)
C4	C5	C6	C1	44.29(18)
C4	C5	C6	C7	157.26(13)
C5	C6	C7	C8	72.5(2)
C5	C6	C7	C12	-102.86(15)
C6	C1	C2	C3	40.31(19)
C6	C1	C2	C14	-82.41(17)
C6	C7	C8	C9	-175.24(16)
C6	C7	C12	N1	-1.70(18)
C6	C7	C12	C11	175.63(14)
C7	C8	C9	C10	0.6(3)
C8	C7	C12	N1	-177.46(15)
C8	C7	C12	C11	-0.1(2)
C8	C9	C10	C11	-0.3(3)
C9	C10	C11	C12	-0.2(3)
C9	C10	C11	C25	179.70(17)
C10	C11	C12	N1	177.21(16)
C10	C11	C12	C7	0.4(2)
C12	N1	C1	C2	155.90(13)
C12	N1	C1	C6	29.08(15)
C12	C7	C8	C9	-0.4(3)
C13	N1	C1	C2	-74.17(17)
C13	N1	C1	C6	159.02(14)
C13	N1	C12	C7	-143.14(16)
C13	N1	C12	C11	39.8(2)
C14	O2	C15	C16	169.10(15)
C14	C2	C3	C4	65.94(17)
C15	O2	C14	O1	-1.2(3)
C15	O2	C14	C2	179.20(14)
C17	N2	C5	C4	48.15(18)
C17	N2	C5	C6	-76.55(16)
C18	S1	N2	C5	78.69(13)
C18	S1	N2	C17	-65.04(13)
C18	C19	C20	C21	-0.3(3)
C19	C18	C23	C22	1.3(3)
C19	C20	C21	C22	0.2(3)
C19	C20	C21	C24	-179.21(18)
C20	C21	C22	C23	0.7(3)
C21	C22	C23	C18	-1.4(3)

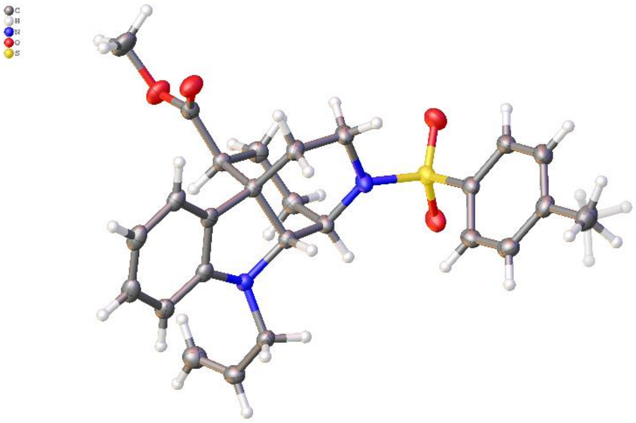
Atom	Atom	Atom	Atom	Angle/°
C23	C18	C19	C20	-0.5(3)
C24	C21	C22	C23	-179.93(19)
C25	C11	C12	N1	-2.7(3)
C25	C11	C12	C7	-179.47(16)

Table 19: Hydrogen Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **6j.** U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{IJ}.

Atom	x	y	z	U_{eq}
H1	7707.65	5034.07	5293.21	21
H2	6045.12	3299.94	5222.31	21
H3A	4956.53	3114.19	3121.55	23
H3B	3777.53	3518.45	3730.7	23
H4A	4074.59	5665.33	3199.8	24
H4B	3491.03	4793.49	2022.47	24
H5	5825.22	4532.82	1926.8	19
H6	6886.99	6407.65	3771.14	20
H8	8407.48	6842.11	2118.66	26
H9	10451.82	6133.89	1701.19	32
H10	11440.68	4231.01	2461.42	31
H13A	9463.48	3436.78	5938.33	39
H13B	9269.41	2178.82	5156.26	39
H13C	8089.66	2588.93	5758.46	39
H15A	3418.45	6256.65	6142.99	29
H15B	4217.88	5464.04	7337.18	29
H16A	1547.52	4812.43	5655.95	43
H16B	1767.11	5336.87	6996.2	43
H16C	2351.51	3982.27	6811.87	43
H17A	4885.34	8199.21	1384.34	33
H17B	5259.8	7681.53	2743.71	33
H17C	3771.88	7349.46	1771.27	33
H19	3273.46	3886.02	-197.38	27
H20	851.32	3494.5	-666.71	35
H22	46.13	7193.59	-1090.62	38
H23	2458.55	7609.08	-672.79	31
H24A	-1885.2	5499.7	-1945.12	77
H24B	-1675.91	5311.65	-528.99	77
H24C	-1529.36	4143.74	-1345.47	77
H25A	11253.74	2558.41	4693.39	41
H25B	11501.74	2342.98	3406.07	41
H25C	10091.88	1837.64	3635.22	41

3.4 Compound **8c** (ccdc number 2216802)

The crystal suitable for X-ray measurement for compound **8c** was obtained by evaporation of chloroform.



Experimental. Single clear pale colourless irregular-shaped crystals of **8c** were used as supplied. A suitable crystal with dimensions 0.36 × 0.28 × 0.19 mm^3 was selected and mounted on a XtaLAB Synergy R, DW system, HyPix-Arc 150 diffractometer. The crystal was kept at a steady T = 139.99(10) K during data collection. The structure was solved with the **ShelXT** (Sheldrick, 2015) solution program using dual methods and by using **Olex2** 1.5 (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full matrix least squares minimisation on F^2.

Compound	**8c**
Formula	$C_{26}H_{30}N_2O_4S$
$D_{calc.}$/ g cm^{-3}	1.354
μ/mm^{-1}	1.553
Formula Weight	466.58
Colour	clear pale colourless
Shape	irregular-shaped
Size/mm^3	0.36×0.28×0.19
T/K	139.99(10)
Crystal System	triclinic
Space Group	P-1
a/Å	8.67681(16)
b/Å	11.1974(2)
c/Å	12.8051(2)
α/°	91.3191(16)
β/°	98.5791(16)
γ/°	110.9859(18)
V/Å^3	1144.64(4)
Z	2
Z'	1
Wavelength/Å	1.54184
Radiation type	Cu K$_\alpha$
Θ_{min}/°	3.503
Θ_{max}/°	75.577
Measured Refl's.	18950
Indep't Refl's	4604
Refl's I≥2 σ(I)	4460
R_{int}	0.0134
Parameters	426
Restraints	0
Largest Peak	0.326
Deepest Hole	-0.364
GooF	1.036
wR_2 (all data)	0.0817
wR_2	0.0812
R_1 (all data)	0.0308
R_1	0.0301
CCDC	2216802

Table 20: Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **8c**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	U_{eq}
S1	7112.2(3)	3187.0(3)	5421.9(2)	24.16(10)
O1	5702.6(11)	2573.7(9)	5936.9(7)	32.3(2)
O2	8079.6(12)	4525.0(8)	5699.4(6)	30.1(2)
O3	1914.8(11)	923.5(8)	1205.8(8)	32.5(2)
O4	938.5(10)	2509.3(9)	1310.4(8)	33.3(2)
N1	6531.1(13)	2998.4(9)	4145.1(8)	26.1(2)
N2	7337.4(11)	4579.5(9)	1626.4(7)	20.6(2)
C1	6818.1(14)	4140.6(10)	3514.9(9)	22.1(2)
C2	6967.4(13)	3656.4(10)	2430.8(8)	20.2(2)
C3	6787.4(13)	3800.8(11)	658.1(9)	21.5(2)
C4	7254.9(15)	4127.1(12)	-318.7(9)	26.0(2)
C5	6609.3(15)	3173.4(13)	-1161.7(10)	29.6(3)
C6	5546.3(15)	1947.4(13)	-1028.6(10)	29.3(3)
C7	5039.2(14)	1637.5(12)	-48.9(9)	25.0(2)
C8	5662.3(13)	2571.1(11)	789.2(9)	21.0(2)
C9	5322.0(13)	2589.8(10)	1917.8(8)	19.8(2)
C10	5218.0(15)	1420.1(11)	2540.2(9)	23.6(2)
C11	5299.6(16)	1709.0(11)	3727.8(9)	26.7(2)

Atom	x	y	z	U_{eq}
C12	3829.2(13)	3070.4(11)	1898.4(9)	21.1(2)
C13	3731.8(15)	3716.5(12)	2953.2(10)	26.5(2)
C14	5439.1(16)	4693.1(11)	3450.5(9)	26.2(2)
C15	9044.0(14)	5532.0(11)	1793.7(9)	23.7(2)
C16	9164.2(15)	6824.1(12)	1447.1(10)	27.1(2)
C17	7890.9(18)	7170.4(13)	1110.3(11)	33.9(3)
C18	8463.7(14)	2328.1(11)	5663.2(9)	23.5(2)
C19	8077.5(16)	1304.5(12)	6292.6(10)	28.1(3)
C20	9204.1(16)	688.5(13)	6524.8(10)	31.7(3)
C21	10716.5(15)	1087.2(12)	6147.5(10)	29.6(3)
C22	11072.3(16)	2111.8(12)	5509.3(10)	30.1(3)
C23	9956.4(16)	2730.3(12)	5256.5(10)	27.5(2)
C24	11960.8(19)	447.1(16)	6440.0(13)	39.9(3)
C25	2163.9(14)	2033.4(11)	1438.8(9)	23.6(2)
C26	-693.4(16)	1605.3(16)	828.1(13)	39.2(3)

Table 21: Anisotropic Displacement Parameters (×10^4) for **8c**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2} \times U_{11}+ \ldots +2hka^{*} \times b^{*} \times U_{12}]$

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	29.15(16)	23.17(15)	18.17(15)	1.82(10)	3.80(11)	7.25(11)
O1	34.2(5)	37.3(5)	28.0(4)	7.7(4)	11.4(4)	13.3(4)
O2	41.8(5)	23.2(4)	21.6(4)	-1.1(3)	2.4(4)	8.9(4)
O3	24.7(4)	26.0(4)	43.1(5)	0.5(4)	-2.0(4)	7.8(3)
O4	21.1(4)	40.5(5)	40.0(5)	-4.7(4)	1.1(4)	15.5(4)
N1	32.9(5)	20.1(5)	19.4(5)	1.9(4)	-0.3(4)	4.5(4)
N2	19.4(4)	23.1(5)	18.1(4)	0.7(4)	2.8(3)	6.6(4)
C1	26.1(6)	18.9(5)	18.7(5)	1.6(4)	3.0(4)	5.5(4)
C2	20.4(5)	20.4(5)	20.3(5)	0.5(4)	2.3(4)	8.3(4)
C3	18.4(5)	27.0(6)	21.4(5)	-1.5(4)	1.5(4)	11.8(4)
C4	22.3(5)	33.8(6)	23.4(6)	1.5(5)	5.4(4)	11.6(5)
C5	26.2(6)	45.7(7)	20.6(6)	-2.2(5)	4.3(5)	17.8(5)
C6	26.2(6)	38.7(7)	24.9(6)	-9.7(5)	-0.9(5)	17.0(5)
C7	21.0(5)	28.1(6)	27.3(6)	-4.9(5)	-1.0(4)	13.1(5)
C8	17.8(5)	25.7(5)	22.2(5)	-0.8(4)	1.1(4)	12.3(4)
C9	19.4(5)	20.0(5)	20.5(5)	-0.8(4)	1.5(4)	8.8(4)
C10	24.8(6)	19.6(5)	25.0(6)	0.1(4)	-1.1(4)	8.5(4)
C11	29.9(6)	20.2(5)	24.7(6)	3.2(4)	0.2(5)	4.3(5)
C12	20.7(5)	22.4(5)	22.7(5)	2.0(4)	5.0(4)	10.4(4)
C13	27.6(6)	29.4(6)	26.1(6)	0.1(5)	8.6(5)	13.4(5)
C14	32.7(6)	24.5(6)	23.1(6)	-1.6(5)	6.8(5)	12.0(5)
C15	18.9(5)	26.7(6)	23.0(6)	1.4(4)	1.9(4)	6.2(4)
C16	26.1(6)	25.3(6)	27.0(6)	0.8(5)	5.4(5)	5.4(5)
C17	35.3(7)	29.0(6)	39.3(7)	5.0(5)	7.9(6)	13.1(5)
C18	25.5(6)	21.3(5)	18.8(5)	-0.3(4)	0.7(4)	4.0(4)
C19	26.3(6)	28.3(6)	24.9(6)	5.5(5)	3.3(5)	4.4(5)
C20	32.6(6)	28.7(6)	29.2(6)	8.5(5)	0.5(5)	7.0(5)
C21	27.7(6)	28.9(6)	27.0(6)	-2.3(5)	-3.7(5)	7.7(5)
C22	26.3(6)	29.9(6)	29.3(6)	-0.8(5)	4.7(5)	4.8(5)
C23	30.7(6)	23.1(6)	23.9(6)	2.3(5)	5.3(5)	3.7(5)
C24	33.8(7)	41.6(8)	42.3(8)	2.0(7)	-4.6(6)	15.9(6)
C25	21.1(5)	29.6(6)	22.3(5)	4.4(4)	5.9(4)	10.9(5)
C26	19.5(6)	51.6(9)	44.6(8)	-1.5(7)	1.2(5)	12.6(6)

Table 22: Bond Lengths in Å for **8c**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
S1	O1	1.4361(9)	S1	O2	1.4357(9)

Atom	Atom	Length/Å
S1	N1	1.6229(10)
S1	C18	1.7633(12)
O3	C25	1.2048(15)
O4	C25	1.3414(14)
O4	C26	1.4473(16)
N1	C1	1.4927(14)
N1	C11	1.4836(14)
N2	C2	1.4636(14)
N2	C3	1.4146(14)
N2	C15	1.4628(14)
C1	C2	1.5190(15)
C1	C14	1.5246(16)
C2	C9	1.5359(14)
C3	C4	1.3888(16)
C3	C8	1.4049(16)
C4	C5	1.3990(17)
C5	C6	1.3839(19)
C6	C7	1.4011(18)
C7	C8	1.3811(16)
C8	C9	1.5187(15)
C9	C10	1.5309(15)
C9	C12	1.5679(14)
C10	C11	1.5333(16)
C12	C13	1.5452(15)
C12	C25	1.5152(16)
C13	C14	1.5238(17)
C15	C16	1.4955(17)
C16	C17	1.3150(19)
C18	C19	1.3869(17)
C18	C23	1.3949(17)
C19	C20	1.3875(18)
C20	C21	1.3908(19)
C21	C22	1.3943(18)
C21	C24	1.5052(18)
C22	C23	1.3853(18)

Table 23: Bond Angles in ° for **8c**.

Atom	Atom	Atom	Angle/°
O1	S1	N1	110.19(5)
O1	S1	C18	107.05(5)
O2	S1	O1	118.80(5)
O2	S1	N1	107.40(5)
O2	S1	C18	108.20(5)
N1	S1	C18	104.24(5)
C25	O4	C26	115.10(10)
C1	N1	S1	120.18(7)
C11	N1	S1	115.01(8)
C11	N1	C1	122.29(9)
C3	N2	C2	103.82(9)
C3	N2	C15	116.82(9)
C15	N2	C2	115.56(9)
N1	C1	C2	103.94(9)
N1	C1	C14	114.01(10)
C2	C1	C14	111.91(9)
N2	C2	C1	117.66(9)
N2	C2	C9	104.19(8)
C1	C2	C9	110.67(9)
C4	C3	N2	127.62(11)
C4	C3	C8	121.33(11)
C8	C3	N2	111.04(10)
C3	C4	C5	117.61(12)
C6	C5	C4	121.32(11)
C5	C6	C7	120.69(11)
C8	C7	C6	118.57(12)
C3	C8	C9	107.10(9)
C7	C8	C3	120.41(11)
C7	C8	C9	132.43(11)
C2	C9	C12	109.89(8)
C8	C9	C2	98.62(8)
C8	C9	C10	118.54(9)
C8	C9	C12	106.71(8)
C10	C9	C2	105.39(9)
C10	C9	C12	116.07(9)
C9	C10	C11	111.95(9)
N1	C11	C10	113.10(10)
C13	C12	C9	115.99(9)
C25	C12	C9	111.97(9)
C25	C12	C13	111.13(9)
C14	C13	C12	110.90(9)
C13	C14	C1	112.34(9)
N2	C15	C16	114.12(9)
C17	C16	C15	125.68(12)
C19	C18	S1	120.06(9)
C19	C18	C23	120.71(11)
C23	C18	S1	119.16(9)
C18	C19	C20	119.21(12)
C19	C20	C21	121.23(12)
C20	C21	C22	118.55(12)
C20	C21	C24	120.83(12)
C22	C21	C24	120.60(12)
C23	C22	C21	121.18(12)
C22	C23	C18	119.09(11)
O3	C25	O4	122.53(11)
O3	C25	C12	126.66(10)
O4	C25	C12	110.81(10)

Table 24: Torsion Angles in ° for **8c**.

Atom	Atom	Atom	Atom	Angle/°
S1	N1	C1	C2	152.37(8)
S1	N1	C1	C14	-85.53(11)
S1	N1	C11	C10	-161.11(8)
S1	C18	C19	C20	-176.22(9)
S1	C18	C23	C22	175.45(9)

Atom	Atom	Atom	Atom	Angle/˚
O1	S1	N1	C1	122.15(9)
O1	S1	N1	C11	-40.26(10)
O1	S1	C18	C19	-2.47(11)
O1	S1	C18	C23	-179.41(9)
O2	S1	N1	C1	-8.64(11)
O2	S1	N1	C11	-171.04(9)
O2	S1	C18	C19	126.68(10)
O2	S1	C18	C23	-50.27(10)
N1	S1	C18	C19	-119.23(10)
N1	S1	C18	C23	63.83(10)
N1	C1	C2	N2	-177.20(9)
N1	C1	C2	C9	63.23(11)
N1	C1	C14	C13	-59.15(13)
N2	C2	C9	C8	37.74(10)
N2	C2	C9	C10	160.63(8)
N2	C2	C9	C12	-73.61(10)
N2	C3	C4	C5	176.82(10)
N2	C3	C8	C7	-176.69(9)
N2	C3	C8	C9	5.76(12)
N2	C15	C16	C17	6.26(18)
C1	N1	C11	C10	36.89(15)
C1	C2	C9	C8	165.13(9)
C1	C2	C9	C10	-71.98(11)
C1	C2	C9	C12	53.77(12)
C2	N2	C3	C4	-159.91(11)
C2	N2	C3	C8	19.12(11)
C2	N2	C15	C16	-145.05(10)
C2	C1	C14	C13	58.46(13)
C2	C9	C10	C11	57.00(12)
C2	C9	C12	C13	-48.73(13)
C2	C9	C12	C25	-177.71(9)
C3	N2	C2	C1	-158.85(9)
C3	N2	C2	C9	-35.92(10)
C3	N2	C15	C16	92.36(12)
C3	C4	C5	C6	-0.16(17)
C3	C8	C9	C2	-26.47(10)
C3	C8	C9	C10	-139.31(10)
C3	C8	C9	C12	87.40(10)
C4	C3	C8	C7	2.41(16)
C4	C3	C8	C9	-175.14(10)
C4	C5	C6	C7	2.19(18)
C5	C6	C7	C8	-1.89(17)
C6	C7	C8	C3	-0.36(16)
C6	C7	C8	C9	176.47(11)
C7	C8	C9	C2	156.39(11)
C7	C8	C9	C10	43.55(16)
C7	C8	C9	C12	-89.74(14)
C8	C3	C4	C5	-2.12(17)
C8	C9	C10	C11	166.07(10)
C8	C9	C12	C13	-154.69(10)
C8	C9	C12	C25	76.32(11)
C9	C10	C11	N1	-40.34(14)
C9	C12	C13	C14	46.67(14)
C9	C12	C25	O3	7.37(17)
C9	C12	C25	O4	-172.44(9)
C10	C9	C12	C13	70.69(12)
C10	C9	C12	C25	-58.29(12)
C11	N1	C1	C2	-46.54(14)
C11	N1	C1	C14	75.57(13)
C12	C9	C10	C11	-64.84(12)
C12	C13	C14	C1	-50.03(13)
C13	C12	C25	O3	-124.12(13)
C13	C12	C25	O4	56.07(12)

Atom	Atom	Atom	Atom	Angle/°
C14	C1	C2	N2	59.33(13)
C14	C1	C2	C9	-60.24(12)
C15	N2	C2	C1	71.90(12)
C15	N2	C2	C9	-165.18(9)
C15	N2	C3	C4	-31.42(16)
C15	N2	C3	C8	147.61(10)
C18	S1	N1	C1	-123.29(9)
C18	S1	N1	C11	74.30(10)
C18	C19	C20	C21	0.68(19)
C19	C18	C23	C22	-1.48(17)
C19	C20	C21	C22	-1.18(19)
C19	C20	C21	C24	177.51(12)
C20	C21	C22	C23	0.35(19)
C21	C22	C23	C18	0.96(18)
C23	C18	C19	C20	0.67(18)
C24	C21	C22	C23	-178.34(12)
C25	C12	C13	C14	176.06(10)
C26	O4	C25	O3	-2.59(17)
C26	O4	C25	C12	177.23(11)

Table 25: Hydrogen Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($Å^2 \times 10^3$) for **8c**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

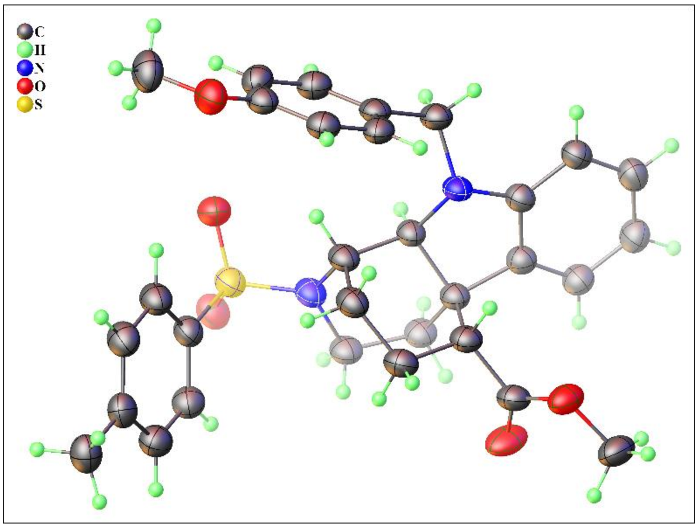
Atom	x	y	z	U_{eq}
H1	7898(18)	4798(13)	3853(11)	24(3)
H2	7850(18)	3266(13)	2551(11)	25(3)
H4	8010(19)	4982(15)	-407(12)	29(4)
H5	6910(19)	3374(15)	-1844(13)	34(4)
H6	5130(20)	1312(16)	-1629(13)	36(4)
H7	4245(18)	783(14)	40(11)	26(3)
H10A	4206(18)	670(14)	2283(11)	26(3)
H10B	6193(19)	1200(14)	2416(12)	30(4)
H11A	4172(19)	1612(14)	3884(11)	26(3)
H11B	5660(19)	1074(15)	4128(12)	32(4)
H24A	11540(50)	-470(40)	6150(30)	47
H24B	13120(50)	1010(40)	6260(30)	47
H24C	12190(50)	410(40)	7240(30)	47
H24D	12910(50)	1000(40)	6950(30)	47
H24E	12400(50)	210(40)	5810(30)	47
H24F	11380(50)	-410(40)	6720(30)	47
H12	3999(17)	3725(13)	1398(11)	21(3)
H13A	3283(18)	3058(15)	3436(12)	30(4)
H13B	2944(19)	4135(14)	2803(12)	31(4)
H14A	5767(19)	5441(15)	3017(12)	31(4)
H14B	5429(19)	5001(14)	4169(12)	32(4)
H15A	9493(18)	5611(14)	2556(12)	30(4)
H15B	9742(19)	5200(15)	1419(12)	34(4)
H16	10290(20)	7420(16)	1515(12)	37(4)
H17A	6760(20)	6581(16)	1044(13)	42(4)
H17B	8100(20)	8059(18)	925(14)	48(5)
H19	7060(20)	1046(15)	6573(13)	36(4)
H20	8950(20)	6(17)	6972(14)	42(4)
H22	12130(20)	2415(16)	5248(13)	40(4)
H23	10200(20)	3415(16)	4804(13)	35(4)
H26A	-650(20)	1126(17)	196(15)	45(5)
H26B	-1180(20)	980(20)	1317(16)	59(5)
H26C	-1380(30)	2090(20)	673(17)	68(6)

Table 26: Atomic Occupancies for all atoms that are not fully occupied in **8c.**

Atom	**Occupancy**
H24A	0.50(2)
H24B	0.50(2)
H24C	0.50(2)
H24D	0.50(2)
H24E	0.50(2)
H24F	0.50(2)

3.5 Compound **8d** (ccdc number 2202396)

The crystal suitable for X-ray measurement for compound **8d** was obtained by evaporation of chloroform.



Experimental. Single colourless prism-shaped crystals of **8d** were used as supplied. A suitable crystal with dimensions 0.13 × 0.10 × 0.05 mm^3 was selected and mounted on an XtaLAB Synergy R, DW system, HyPix-Arc 150 diffractometer. The crystal was kept at a steady T = 140.00(10) K during data collection. The structure was solved with the **ShelXT** 2018/2 (Sheldrick, 2015) solution program using dual methods and by using **Olex2** 1.5 (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full-matrix least-squares minimisation on ***F*²**.

Compound	**8d**
Formula	$C_{31}H_{34}N_2O_5S$
$D_{calc.}$/ g cm^{-3}	1.339
μ/mm^{-1}	1.422
Formula Weight	546.66
Colour	colourless
Shape	prism-shaped
Size/mm^3	0.13×0.10×0.05
T/K	140.00(10)
Crystal System	triclinic
Space Group	$P\bar{1}$
a/Å	11.0149(5)
b/Å	11.9527(6)
c/Å	12.3367(8)
α/°	62.471(6)
β/°	71.939(5)
γ/°	74.907(4)
V/Å^3	1356.09(15)
Z	2
Z'	1
Wavelength/Å	1.54184
Radiation type	Cu$K\alpha$
Θ_{min}/°	4.144
Θ_{max}/°	75.936
Measured Refl's.	26620
Indep't Refl's	5509
Refl's I≥2σ(I)	4562
R_{int}	0.0386
Parameters	355
Restraints	0
Largest Peak/e Å^{-3}	0.566
Deepest Hole/e Å^{-3}	-0.491
GooF	1.025
wR_2 (all data)	0.1663
wR_2	0.1590
R_1 (all data)	0.0680
R_1	0.0586
CCDC number	2202396

Table 27: Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **8d**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	U_{eq}
S1	7170.7(5)	2128.9(5)	8306.4(5)	42.65(18)
O1	8157.1(16)	1946.0(16)	8932.0(16)	48.5(4)
O2	6404.4(17)	1127.4(16)	8765.7(17)	51.6(4)
O3	10325.6(18)	5085.3(19)	2864.0(18)	62.1(5)
O4	9348.0(16)	5320.5(16)	1427.3(16)	49.3(4)
O5	1873.3(15)	1790.0(17)	7500.6(17)	50.6(4)
N1	7856.9(17)	2442.3(19)	6852.8(18)	41.3(4)
N2	7660.4(16)	1543.4(17)	4354.0(17)	36.7(4)
C1	9114.0(19)	2693(2)	4362(2)	36.2(4)
C2	9897(2)	2671(2)	5204(2)	40.5(5)
C3	9070(2)	3027(2)	6279(2)	42.5(5)
C4	7087(2)	2488(2)	6024(2)	39.2(5)
C5	8061.4(19)	1837(2)	5224(2)	35.6(4)
C6	8838(2)	1393(2)	3515(2)	36.8(5)
C7	9143(2)	738(2)	2757(2)	41.2(5)
C8	10374(2)	722(2)	2004(2)	45.3(5)
C9	11295(2)	1335(2)	1984(2)	45.1(5)

Atom	**x**	**y**	**z**	U_{eq}
C10	10977(2)	2009(2)	2735(2)	42.1(5)
C11	9765(2)	2021(2)	3499(2)	37.7(5)
C12	8467(2)	4027(2)	3530(2)	38.7(5)
C13	7439(2)	4714(2)	4267(2)	42.8(5)
C14	6472(2)	3819(2)	5255(2)	42.6(5)
C15	6092(2)	3501(2)	8356(2)	41.8(5)
C16	4767(2)	3506(3)	8639(2)	47.7(5)
C17	3952(2)	4593(3)	8677(2)	49.4(6)
C18	4425(2)	5677(2)	8437(2)	45.6(5)
C19	5765(2)	5637(2)	8150(2)	46.8(5)
C20	6590(2)	4570(2)	8106(2)	45.2(5)
C21	3536(3)	6851(3)	8499(2)	52.8(6)
C22	9476(2)	4853(2)	2600(2)	41.7(5)
C23	10357(3)	6030(3)	477(3)	56.7(7)
C24	6885(2)	493(2)	4931(2)	40.3(5)
C25	5559(2)	809(2)	5645(2)	37.7(5)
C26	4679(2)	1793(2)	5023(2)	39.8(5)
C27	3467(2)	2101(2)	5662(2)	41.1(5)
C28	3101(2)	1421(2)	6957(2)	41.7(5)
C29	3964(2)	437(2)	7597(2)	43.7(5)
C30	5175(2)	145(2)	6927(2)	42.8(5)
C31	1470(3)	1123(3)	8819(3)	60.2(7)

Table 28: Anisotropic Displacement Parameters (×10⁴) for **8d**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2} \times U_{11} + \ldots + 2hka^* \times b^* \times U_{12}]$

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	42.2(3)	45.7(3)	46.2(3)	-24.4(3)	-6.9(2)	-9.2(2)
O1	48.2(9)	54.9(10)	50.4(9)	-27.5(8)	-15.8(7)	-3.2(7)
O2	57.4(10)	47.3(9)	52.8(10)	-23.7(8)	-1.1(8)	-19.4(8)
O3	64.6(11)	70.3(12)	60.1(11)	-15.6(9)	-18.3(9)	-40.1(10)
O4	52.6(9)	51.4(9)	46.1(9)	-13.0(8)	-12.5(8)	-22.8(8)
O5	38.8(8)	57.4(10)	56.8(10)	-30.2(9)	-2.5(7)	-5.6(7)
N1	36.3(9)	49.3(10)	49.7(11)	-28.6(9)	-7.4(8)	-11.1(8)
N2	34.3(9)	38.8(9)	45.0(10)	-23.1(8)	-4.2(7)	-12.2(7)
C1	32.3(10)	38.7(10)	43.0(11)	-20.8(9)	-5.7(8)	-9.4(8)
C2	33.8(10)	45.7(12)	48.0(12)	-21.1(10)	-9.8(9)	-10.9(9)
C3	36.9(11)	48.7(12)	51.6(13)	-25.5(11)	-8.4(10)	-13.9(9)
C4	33.9(10)	44.3(11)	48.9(12)	-25.8(10)	-7.2(9)	-10.5(9)
C5	32.9(10)	40.0(11)	40.7(11)	-21.4(9)	-5.1(8)	-10.7(8)
C6	35.3(10)	37.5(10)	41.8(11)	-19.6(9)	-8.6(9)	-5.5(8)
C7	42.4(11)	41.2(11)	44.7(12)	-21.6(10)	-7.8(9)	-8.2(9)
C8	48.0(12)	45.2(12)	43.4(12)	-22.5(10)	-6.3(10)	-4.6(10)
C9	38.0(11)	51.1(13)	45.0(13)	-22.2(11)	-2.7(10)	-7.9(10)
C10	34.8(10)	46.4(12)	46.5(12)	-20.3(10)	-6.4(9)	-9.1(9)
C11	34.8(10)	38.2(11)	42.1(11)	-17.9(9)	-7.4(9)	-7.3(8)
C12	36.1(10)	39.6(11)	47.2(12)	-20.2(10)	-10.2(9)	-10.4(9)
C13	40.7(11)	38.7(11)	54.9(14)	-22.7(10)	-12.9(10)	-5.6(9)
C14	34.5(10)	48.7(12)	54.1(13)	-29.8(11)	-8.5(10)	-6.3(9)
C15	40.1(11)	48.6(12)	43.6(12)	-25.3(10)	-5.7(9)	-9.5(9)
C16	41.3(12)	57.1(14)	54.1(14)	-30.9(12)	-5.4(10)	-13.2(10)
C17	37.0(11)	61.8(15)	55.5(14)	-31.1(12)	-5.6(10)	-9.3(10)
C18	47.8(13)	50.7(13)	39.2(12)	-20.8(10)	-8.3(10)	-5.7(10)
C19	48.4(13)	48.3(13)	48.3(13)	-21.3(11)	-11.5(11)	-10.5(10)
C20	39.4(11)	52.2(13)	48.5(13)	-22.6(11)	-8.9(10)	-11.1(10)
C21	51.9(14)	56.5(15)	47.6(14)	-24.4(12)	-7.8(11)	-2.4(11)
C22	42.3(11)	37.2(11)	51.8(13)	-20.9(10)	-9.8(10)	-11.7(9)
C23	64.7(16)	55.4(15)	50.0(14)	-13.9(12)	-7.0(12)	-30.5(13)
C24	37.2(11)	38.0(11)	50.5(13)	-21.5(10)	-6.3(9)	-11.0(9)
C25	36.9(10)	36.6(10)	47.5(12)	-21.5(9)	-7.5(9)	-12.4(8)
C26	41.2(11)	41.7(11)	42.8(12)	-18.6(9)	-7.6(9)	-15.7(9)

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
C27	39.2(11)	38.9(11)	50.2(13)	-19.8(10)	-13.0(10)	-7.3(9)
C28	37.1(11)	43.7(12)	52.3(13)	-26.7(10)	-5.2(10)	-11.2(9)
C29	41.6(11)	48.8(12)	42.5(12)	-18.5(10)	-5.8(9)	-14.3(10)
C30	40.8(11)	38.8(11)	51.5(13)	-17.8(10)	-12.8(10)	-8.6(9)
C31	44.7(13)	84(2)	54.9(16)	-37.7(15)	0.3(12)	-10.7(13)

Table 29: Bond Lengths in Å for **8d**.

Atom	Atom	Length/Å
S1	O1	1.4368(17)
S1	O2	1.4385(17)
S1	N1	1.617(2)
S1	C15	1.771(2)
O3	C22	1.210(3)
O4	C22	1.328(3)
O4	C23	1.447(3)
O5	C28	1.369(3)
O5	C31	1.420(3)
N1	C3	1.490(3)
N1	C4	1.494(3)
N2	C5	1.482(3)
N2	C6	1.415(3)
N2	C24	1.473(3)
C1	C2	1.531(3)
C1	C5	1.539(3)
C1	C11	1.519(3)
C1	C12	1.567(3)
C2	C3	1.530(3)
C4	C5	1.532(3)
C4	C14	1.527(3)
C6	C7	1.395(3)
C6	C11	1.407(3)
C7	C8	1.387(3)
C8	C9	1.387(3)
C9	C10	1.403(3)
C10	C11	1.376(3)
C12	C13	1.532(3)
C12	C22	1.504(3)
C13	C14	1.532(3)
C15	C16	1.390(3)
C15	C20	1.388(3)
C16	C17	1.385(3)
C17	C18	1.393(3)
C18	C19	1.401(3)
C18	C21	1.507(3)
C19	C20	1.373(3)
C24	C25	1.508(3)
C25	C26	1.395(3)
C25	C30	1.382(3)
C26	C27	1.377(3)
C27	C28	1.396(3)
C28	C29	1.391(3)
C29	C30	1.388(3)

Table 30: Bond Angles in ° for **8d**.

Atom	Atom	Atom	Angle/°
O1	S1	O2	119.06(11)
O1	S1	N1	107.28(10)
O1	S1	C15	107.29(10)
O2	S1	N1	108.25(10)
O2	S1	C15	106.98(11)
N1	S1	C15	107.48(11)
C22	O4	C23	115.45(19)
C28	O5	C31	116.9(2)
C3	N1	S1	119.83(15)
C3	N1	C4	119.45(18)
C4	N1	S1	118.47(14)
C6	N2	C5	102.96(15)
C6	N2	C24	115.61(16)
C24	N2	C5	116.44(17)
C2	C1	C5	106.82(17)
C2	C1	C12	116.90(17)
C5	C1	C12	109.00(16)
C11	C1	C2	117.62(18)
C11	C1	C5	98.96(16)
C11	C1	C12	105.86(18)
C3	C2	C1	113.52(17)
N1	C3	C2	111.52(17)
N1	C4	C5	102.73(16)
N1	C4	C14	114.79(17)
C14	C4	C5	113.70(19)
N2	C5	C1	103.36(16)
N2	C5	C4	121.10(17)
C4	C5	C1	108.77(17)
C7	C6	N2	128.64(19)
C7	C6	C11	120.1(2)
C11	C6	N2	111.29(18)
C8	C7	C6	118.3(2)
C9	C8	C7	122.0(2)
C8	C9	C10	119.4(2)
C11	C10	C9	119.2(2)
C6	C11	C1	107.02(17)
C10	C11	C1	131.95(19)
C10	C11	C6	120.9(2)
C13	C12	C1	114.62(19)
C22	C12	C1	110.45(17)
C22	C12	C13	111.62(18)
C14	C13	C12	110.18(18)
C4	C14	C13	114.43(18)
C16	C15	S1	120.50(18)
C20	C15	S1	118.94(18)
C20	C15	C16	120.6(2)

Atom	Atom	Atom	Angle/°
C17	C16	C15	118.9(2)
C16	C17	C18	121.7(2)
C17	C18	C19	117.6(2)
C17	C18	C21	121.7(2)
C19	C18	C21	120.7(2)
C20	C19	C18	121.5(2)
C19	C20	C15	119.6(2)
O3	C22	O4	122.2(2)
O3	C22	C12	125.0(2)
O4	C22	C12	112.80(18)
N2	C24	C25	112.54(17)
C26	C25	C24	120.6(2)
C30	C25	C24	121.6(2)
C30	C25	C26	117.8(2)
C27	C26	C25	121.3(2)
C26	C27	C28	119.9(2)
O5	C28	C27	115.4(2)
O5	C28	C29	124.9(2)
C29	C28	C27	119.8(2)
C30	C29	C28	119.0(2)
C25	C30	C29	122.2(2)

Table 31: Torsion Angles in ° for **8d**.

Atom	Atom	Atom	Atom	Angle/°
S1	N1	C3	C2	152.30(17)
S1	N1	C4	C5	-139.96(16)
S1	N1	C4	C14	96.1(2)
S1	C15	C16	C17	179.63(19)
S1	C15	C20	C19	-179.51(19)
O1	S1	N1	C3	-26.0(2)
O1	S1	N1	C4	171.17(15)
O1	S1	C15	C16	-136.7(2)
O1	S1	C15	C20	43.4(2)
O2	S1	N1	C3	-155.63(17)
O2	S1	N1	C4	41.50(19)
O2	S1	C15	C16	-7.8(2)
O2	S1	C15	C20	172.21(19)
O5	C28	C29	C30	178.8(2)
N1	S1	C15	C16	108.2(2)
N1	S1	C15	C20	-71.7(2)
N1	C4	C5	N2	173.08(18)
N1	C4	C5	C1	-67.6(2)
N1	C4	C14	C13	66.0(3)
N2	C6	C7	C8	180.0(2)
N2	C6	C11	C1	-2.8(3)
N2	C6	C11	C10	-179.2(2)
N2	C24	C25	C26	63.9(3)
N2	C24	C25	C30	-115.8(2)
C1	C2	C3	N1	41.0(3)
C1	C12	C13	C14	-50.2(2)
C1	C12	C22	O3	-53.7(3)
C1	C12	C22	O4	126.4(2)
C2	C1	C5	N2	-161.01(16)
C2	C1	C5	C4	69.1(2)
C2	C1	C11	C6	139.8(2)
C2	C1	C11	C10	-44.3(3)
C2	C1	C12	C13	-63.7(2)
C2	C1	C12	C22	63.4(2)
C3	N1	C4	C5	57.1(2)
C3	N1	C4	C14	-66.8(2)
C4	N1	C3	C2	-45.0(3)
C5	N2	C6	C7	157.9(2)
C5	N2	C6	C11	-22.4(2)
C5	N2	C24	C25	68.1(2)
C5	C1	C2	C3	-53.7(2)
C5	C1	C11	C6	25.4(2)
C5	C1	C11	C10	-158.7(2)
C5	C1	C12	C13	57.5(2)
C5	C1	C12	C22	-175.36(17)
C5	C4	C14	C13	-51.9(2)
C6	N2	C5	C1	38.1(2)

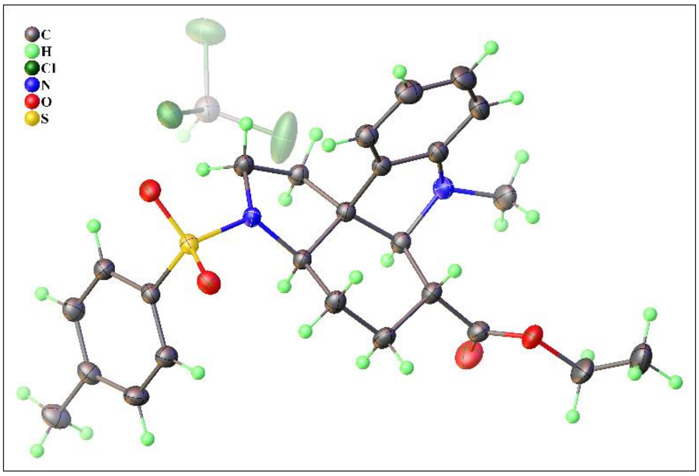
Atom	Atom	Atom	Atom	Angle/˚
C6	N2	C5	C4	160.10(19)
C6	N2	C24	C25	-170.84(19)
C6	C7	C8	C9	-0.1(4)
C7	C6	C11	C1	176.9(2)
C7	C6	C11	C10	0.5(3)
C7	C8	C9	C10	-0.8(4)
C8	C9	C10	C11	1.6(4)
C9	C10	C11	C1	-176.9(2)
C9	C10	C11	C6	-1.4(4)
C11	C1	C2	C3	-163.70(19)
C11	C1	C5	N2	-38.46(19)
C11	C1	C5	C4	-168.36(17)
C11	C1	C12	C13	163.14(17)
C11	C1	C12	C22	-69.8(2)
C11	C6	C7	C8	0.3(3)
C12	C1	C2	C3	68.6(2)
C12	C1	C5	N2	71.83(19)
C12	C1	C5	C4	-58.1(2)
C12	C1	C11	C6	-87.4(2)
C12	C1	C11	C10	88.5(3)
C12	C13	C14	C4	46.3(3)
C13	C12	C22	O3	75.1(3)
C13	C12	C22	O4	-104.9(2)
C14	C4	C5	N2	-62.3(3)
C14	C4	C5	C1	57.1(2)
C15	S1	N1	C3	89.15(19)
C15	S1	N1	C4	-73.72(18)
C15	C16	C17	C18	0.1(4)
C16	C15	C20	C19	0.5(4)
C16	C17	C18	C19	0.2(4)
C16	C17	C18	C21	-179.0(2)
C17	C18	C19	C20	-0.1(4)
C18	C19	C20	C15	-0.3(4)
C20	C15	C16	C17	-0.4(4)
C21	C18	C19	C20	179.1(2)
C22	C12	C13	C14	-176.72(19)
C23	O4	C22	O3	5.4(3)
C23	O4	C22	C12	-174.7(2)
C24	N2	C5	C1	165.71(17)
C24	N2	C5	C4	-72.3(3)
C24	N2	C6	C7	29.8(3)
C24	N2	C6	C11	-150.53(19)
C24	C25	C26	C27	-179.55(18)
C24	C25	C30	C29	179.2(2)
C25	C26	C27	C28	0.0(3)
C26	C25	C30	C29	-0.6(3)
C26	C27	C28	O5	-179.26(19)
C26	C27	C28	C29	0.1(3)
C27	C28	C29	C30	-0.4(3)
C28	C29	C30	C25	0.7(3)
C30	C25	C26	C27	0.2(3)
C31	O5	C28	C27	-179.7(2)
C31	O5	C28	C29	1.0(3)

Table 32: Hydrogen Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **8d**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	U_{eq}
H2A	10377.81	1807.15	5558.94	49
H2B	10535.62	3272.46	4685.97	49
H3A	9569.62	2735.95	6928.22	51
H3B	8855.21	3965.51	5959.38	51
H4	6386.36	1945.07	6557.45	47
H5	8482.73	1024.38	5804.4	43
H7	8524.12	314.13	2756.62	49
H8	10592.85	277.14	1485.28	54
H9	12134.71	1299.33	1467.51	54
H10	11590.77	2451.12	2715.59	50
H12	8016.68	3872.68	3031.06	46
H13A	7857.62	4998.83	4681.74	51
H13B	6981.27	5475.55	3684.94	51
H14A	5937.26	4210.78	5833.72	51
H14B	5891.78	3739.3	4829.7	51
H16	4426.66	2775.57	8804.86	57
H17	3045.8	4598.82	8871.19	59
H19	6111.74	6365.12	7981.85	56
H20	7496.37	4563.32	7905.78	54
H21A	2866.77	7061.13	8038.8	79
H21B	4031.05	7565.04	8123.06	79
H21C	3131.51	6690.61	9376.75	79
H23A	10100.97	6469.33	-329.48	85
H23B	11155.54	5442.76	406.45	85
H23C	10499.69	6657.06	711.81	85
H24A	7340.79	-274.85	5509.05	48
H24B	6799.02	291.46	4266.84	48
H26	4920.06	2261.37	4141.42	48
H27	2881.13	2774.26	5220.86	49
H29	3726.99	-27.97	8479.77	52
H30	5759.96	-533.21	7363.96	51
H31A	1570.51	209.67	9039.91	90
H31B	563	1429.73	9091.1	90
H31C	1999.48	1271.1	9237.2	90

3.6 Compound **9a** (ccdc number 2201959)

The crystal suitable for X-ray measurement for compound **9a** was obtained by evaporation of chloroform.



Experimental. Single colourless prism-shaped crystals of **9a** were used as supplied. A suitable crystal with dimensions 0.20 × 0.16 × 0.08 mm^3 was selected and mounted on an XtaLAB Synergy R, DW system, HyPix-Arc 150 diffractometer. The crystal was kept at a steady *T* = 140.00(10) K during data collection. The structure was solved with the **ShelXT** 2018/2 (Sheldrick, 2015) solution program using dual methods and by using **Olex2** 1.5 (Dolomanov et al., 2009) as the graphical interface. The model was refined with **ShelXL** 2018/3 (Sheldrick, 2015) using full-matrix least-squares minimisation on ***F*^{2}**.

Compound	**9a**
Formula	$C_{26}H_{31}Cl_3N_2O_4S$
$D_{calc.}$/ g cm^{-3}	1.397
μ/mm^{-1}	4.046
Formula Weight	573.94
Colour	colourless
Shape	prism-shaped
Size/mm^3	0.20×0.16×0.08
T/K	140.00(10)
Crystal System	triclinic
Space Group	$P\bar{1}$
a/Å	9.7931(2)
b/Å	10.17325(17)
c/Å	14.7114(4)
α/°	105.4959(18)
β/°	102.568(2)
γ/°	94.2455(16)
V/Å^3	1364.86(5)
Z	2
Z'	1
Wavelength/Å	1.54184
Radiation type	Cu$K\alpha$
Θ_{min}/°	3.217
Θ_{max}/°	76.216
Measured Refl's.	28968
Indep't Refl's	5552
Refl's I≥2σ(I)	5206
R_{int}	0.0149
Parameters	328
Restraints	0
Largest Peak/e Å^{-3}	1.002
Deepest Hole/e Å^{-3}	-0.877
GooF	1.057
wR_2 (all data)	0.0895
wR_2	0.0884
R_1 (all data)	0.0373
R_1	0.0354
CCDC number	2201959

Table 33: Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for **9a**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	**x**	**y**	**z**	U_{eq}
Cl1	5832.4(4)	1601.0(4)	859.5(3)	30.55(11)
Cl2	7573.4(6)	-521.9(6)	1089.2(5)	52.91(16)
Cl3	6869.3(9)	1264.4(6)	2764.3(4)	69.8(2)
C26	6292.7(19)	421.8(18)	1518.1(13)	29.8(4)
S1	4340.7(4)	6966.1(4)	1405.4(3)	19.22(9)
O1	5928.1(15)	6454.7(15)	6401.7(10)	39.4(3)
O2	7305.5(13)	8510.5(13)	7010.4(8)	29.3(3)
O3	4052.5(12)	8337.4(11)	1804.4(9)	24.8(2)
O4	4759.2(12)	6627.0(12)	503.9(8)	24.9(2)
N1	8575.5(15)	6148.8(15)	4955.9(10)	25.8(3)
N2	5618.7(13)	6679.1(13)	2206.7(9)	19.9(3)
C1	6903.8(16)	6352.7(15)	3624.4(11)	19.2(3)
C2	8298.4(16)	7246.8(16)	3760.5(11)	21.2(3)
C3	8741.9(18)	8083.6(17)	3251.0(12)	26.2(3)
C4	10156(2)	8697.4(19)	3528.0(14)	34.0(4)
C5	11093(2)	8443(2)	4288.9(15)	37.9(4)
C6	10665.3(19)	7597(2)	4810.2(14)	34.1(4)
C7	9254.6(18)	7012.3(17)	4543.2(12)	25.2(3)
C8	7051.8(17)	6244.7(16)	4661.0(11)	21.4(3)

Atom	x	y	z	U_{eq}
C9	6686.2(17)	7581.0(17)	5309.9(11)	22.7(3)
C10	5302.8(18)	8030.0(18)	4841.0(12)	26.6(3)
C11	5338.2(18)	8233.8(17)	3848.4(12)	24.8(3)
C12	5522.3(16)	6843.4(16)	3224.0(11)	19.4(3)
C13	6306.6(18)	5422.3(17)	1887.6(12)	24.3(3)
C14	6801.4(17)	4999.9(16)	2818.3(11)	21.9(3)
C15	9210(2)	6134(2)	5944.1(13)	34.9(4)
C16	6582.4(18)	7421.0(18)	6285.8(12)	26.0(3)
C17	7336(2)	8471(3)	7990.7(13)	41.2(5)
C18	8437(3)	9616(2)	8666.3(14)	46.6(5)
C19	2812.2(16)	5835.5(16)	1272.0(11)	20.3(3)
C20	1922.6(17)	6230.6(17)	1886.1(12)	25.7(3)
C21	717.1(18)	5342.4(18)	1783.2(13)	28.0(4)
C22	378.7(17)	4076.7(17)	1066.0(13)	26.1(3)
C23	1285.6(18)	3708.4(17)	460.2(13)	27.0(3)
C24	2509.3(17)	4569.3(17)	559.5(12)	24.0(3)
C25	-943.3(19)	3134.6(19)	955.4(16)	34.6(4)

Table 34: Anisotropic Displacement Parameters (×10^4) for **9a**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2} \times U_{11}+ ... +2hka^* \times b^* \times U_{12}]$

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
Cl1	28.7(2)	27.2(2)	36.7(2)	15.29(17)	4.30(17)	-0.57(15)
Cl2	45.8(3)	61.0(3)	75.3(4)	42.4(3)	29.2(3)	25.8(3)
Cl3	122.9(6)	38.8(3)	31.9(3)	9.4(2)	-9.8(3)	4.0(3)
C26	32.3(9)	25.8(8)	32.3(9)	12.2(7)	7.1(7)	-0.3(7)
S1	18.17(18)	20.36(18)	19.55(18)	7.84(14)	3.48(14)	1.19(13)
O1	45.5(8)	43.5(8)	31.7(7)	13.6(6)	14.9(6)	-4.7(6)
O2	33.0(6)	36.4(7)	17.5(6)	5.3(5)	6.8(5)	5.1(5)
O3	24.4(6)	20.6(5)	30.3(6)	10.0(5)	5.5(5)	3.3(4)
O4	24.4(6)	31.4(6)	21.1(6)	11.1(5)	6.6(5)	2.0(5)
N1	25.6(7)	32.7(8)	20.6(7)	10.2(6)	4.0(6)	10.0(6)
N2	19.8(6)	21.4(6)	17.0(6)	3.8(5)	3.1(5)	4.8(5)
C1	20.1(7)	18.6(7)	18.8(7)	5.3(6)	4.4(6)	3.7(6)
C2	20.3(7)	21.2(7)	19.6(7)	2.0(6)	4.6(6)	3.1(6)
C3	27.2(8)	24.8(8)	26.1(8)	6.2(7)	7.2(7)	3.1(7)
C4	31.7(9)	30.4(9)	38.5(10)	5.9(8)	13.3(8)	-3.1(7)
C5	22.4(9)	41.9(11)	40.5(11)	0.3(9)	6.9(8)	-5.1(8)
C6	23.1(9)	43.8(11)	28.2(9)	3.4(8)	0.0(7)	4.8(8)
C7	24.1(8)	27.5(8)	21.9(8)	3.6(6)	4.9(6)	6.0(6)
C8	24.0(8)	21.2(7)	19.6(7)	6.8(6)	4.8(6)	4.8(6)
C9	26.5(8)	22.8(8)	18.5(7)	4.8(6)	6.4(6)	3.5(6)
C10	30.5(9)	28.2(8)	22.0(8)	4.5(6)	9.2(7)	11.3(7)
C11	28.5(8)	23.3(8)	21.8(8)	4.6(6)	4.9(6)	9.6(6)
C12	19.9(7)	20.4(7)	17.2(7)	4.5(6)	4.1(6)	3.8(6)
C13	25.6(8)	24.9(8)	19.9(8)	2.7(6)	3.8(6)	8.7(6)
C14	24.3(8)	19.9(7)	20.8(7)	4.6(6)	5.3(6)	5.4(6)
C15	36.4(10)	46.7(11)	24.2(9)	13.7(8)	4.5(7)	18.8(8)
C16	26.0(8)	31.3(9)	22.6(8)	8.1(7)	8.4(7)	6.5(7)
C17	39.6(11)	65.9(14)	19.2(9)	12.0(9)	10.0(8)	9.0(10)
C18	53.0(13)	56.5(13)	22.8(9)	4.1(9)	-0.2(9)	18.0(11)
C19	17.8(7)	22.7(7)	20.1(7)	7.9(6)	2.7(6)	1.2(6)
C20	24.3(8)	24.4(8)	26.2(8)	3.3(7)	7.2(7)	1.7(6)
C21	22.5(8)	30.5(9)	32.6(9)	7.7(7)	11.8(7)	3.8(7)
C22	20.6(8)	24.6(8)	33.7(9)	11.4(7)	4.8(7)	2.1(6)
C23	26.5(8)	22.1(8)	28.5(9)	3.2(7)	4.8(7)	0.8(6)
C24	23.2(8)	26.0(8)	22.4(8)	5.8(6)	6.0(6)	3.4(6)
C25	25.3(9)	29.2(9)	48.5(11)	10.3(8)	10.6(8)	-1.9(7)

Table 35: Bond Lengths in Å for **9a**.

Atom	Atom	Length/Å
Cl1	C26	1.7585(18)
Cl2	C26	1.7584(19)
Cl3	C26	1.7472(19)
S1	O3	1.4364(12)
S1	O4	1.4349(12)
S1	N2	1.6239(13)
S1	C19	1.7603(16)
O1	C16	1.204(2)
O2	C16	1.338(2)
O2	C17	1.447(2)
N1	C7	1.399(2)
N1	C8	1.479(2)
N1	C15	1.456(2)
N2	C12	1.4856(19)
N2	C13	1.5011(19)
C1	C2	1.527(2)
C1	C8	1.534(2)
C1	C12	1.529(2)
C1	C14	1.538(2)
C2	C3	1.379(2)
C2	C7	1.404(2)
C3	C4	1.402(2)
C4	C5	1.380(3)
C5	C6	1.394(3)
C6	C7	1.391(2)
C8	C9	1.554(2)
C9	C10	1.541(2)
C9	C16	1.511(2)
C10	C11	1.536(2)
C11	C12	1.514(2)
C13	C14	1.533(2)
C17	C18	1.496(3)
C19	C20	1.392(2)
C19	C24	1.390(2)
C20	C21	1.387(2)
C21	C22	1.393(2)
C22	C23	1.392(2)
C22	C25	1.504(2)
C23	C24	1.387(2)

Table 36: Bond Angles in ° for **9a**.

Atom	Atom	Atom	Angle/°
Cl2	C26	Cl1	110.70(10)
Cl3	C26	Cl1	110.80(10)
Cl3	C26	Cl2	111.37(11)
O3	S1	N2	107.08(7)
O3	S1	C19	106.88(7)
O4	S1	O3	119.35(7)
O4	S1	N2	106.14(7)
O4	S1	C19	108.46(7)
N2	S1	C19	108.57(7)
C16	O2	C17	116.65(15)
C7	N1	C8	105.93(13)
C7	N1	C15	119.20(15)
C15	N1	C8	119.94(14)
C12	N2	S1	121.50(10)
C12	N2	C13	108.13(12)
C13	N2	S1	117.28(10)
C2	C1	C8	100.31(12)
C2	C1	C12	118.68(13)
C2	C1	C14	108.92(12)
C8	C1	C14	116.72(13)
C12	C1	C8	113.06(12)
C12	C1	C14	99.98(12)
C3	C2	C1	133.22(15)
C3	C2	C7	120.28(15)
C7	C2	C1	106.35(14)
C2	C3	C4	119.10(17)
C5	C4	C3	120.16(18)
C4	C5	C6	121.55(17)
C7	C6	C5	117.98(17)
N1	C7	C2	110.47(14)
C6	C7	N1	128.61(16)
C6	C7	C2	120.91(17)
N1	C8	C1	101.32(12)
N1	C8	C9	110.75(13)
C1	C8	C9	109.60(12)
C10	C9	C8	113.58(13)
C16	C9	C8	111.07(13)
C16	C9	C10	108.45(13)
C11	C10	C9	111.46(13)
C12	C11	C10	105.42(13)
N2	C12	C1	100.01(12)
N2	C12	C11	119.61(13)
C11	C12	C1	113.01(13)
N2	C13	C14	104.16(12)
C13	C14	C1	102.55(12)
O1	C16	O2	124.20(16)
O1	C16	C9	124.98(16)
O2	C16	C9	110.81(14)
O2	C17	C18	107.07(17)
C20	C19	S1	119.08(12)
C24	C19	S1	119.90(12)
C24	C19	C20	121.03(15)
C21	C20	C19	119.24(15)
C20	C21	C22	120.86(16)
C21	C22	C25	120.16(16)
C23	C22	C21	118.70(15)
C23	C22	C25	121.13(16)
C24	C23	C22	121.49(16)
C23	C24	C19	118.66(15)

Table 37: Torsion Angles in ° for **9a**.

Atom	Atom	Atom	Atom	Angle/˚
S1	N2	C12	C1	175.86(10)
S1	N2	C12	C11	-60.30(18)
S1	N2	C13	C14	-150.21(11)
S1	C19	C20	C21	180.00(13)
S1	C19	C24	C23	-178.95(13)
O3	S1	N2	C12	54.94(13)
O3	S1	N2	C13	-168.45(11)
O3	S1	C19	C20	-27.41(15)
O3	S1	C19	C24	152.52(13)
O4	S1	N2	C12	-176.54(11)
O4	S1	N2	C13	-39.94(13)
O4	S1	C19	C20	-157.29(13)
O4	S1	C19	C24	22.63(15)
N1	C8	C9	C10	158.93(13)
N1	C8	C9	C16	-78.50(16)
N2	S1	C19	C20	87.79(14)
N2	S1	C19	C24	-92.29(14)
N2	C13	C14	C1	-22.67(15)
C1	C2	C3	C4	-175.06(16)
C1	C2	C7	N1	-4.49(18)
C1	C2	C7	C6	175.08(15)
C1	C8	C9	C10	47.96(18)
C1	C8	C9	C16	170.54(13)
C2	C1	C8	N1	-37.41(14)
C2	C1	C8	C9	79.65(14)
C2	C1	C12	N2	69.38(16)
C2	C1	C12	C11	-58.94(18)
C2	C1	C14	C13	-80.77(15)
C2	C3	C4	C5	1.2(3)
C3	C2	C7	N1	179.42(14)
C3	C2	C7	C6	-1.0(2)
C3	C4	C5	C6	-1.1(3)
C4	C5	C6	C7	-0.1(3)
C5	C6	C7	N1	-179.34(17)
C5	C6	C7	C2	1.2(3)
C7	N1	C8	C1	36.69(15)
C7	N1	C8	C9	-79.52(15)
C7	C2	C3	C4	-0.2(2)
C8	N1	C7	C2	-20.81(18)
C8	N1	C7	C6	159.67(17)
C8	C1	C2	C3	-158.18(17)
C8	C1	C2	C7	26.44(15)
C8	C1	C12	N2	-173.58(12)
C8	C1	C12	C11	58.10(17)
C8	C1	C14	C13	166.62(13)
C8	C9	C10	C11	-56.78(18)
C8	C9	C16	O1	-48.0(2)
C8	C9	C16	O2	132.68(14)
C9	C10	C11	C12	60.70(17)
C10	C9	C16	O1	77.4(2)
C10	C9	C16	O2	-101.83(16)
C10	C11	C12	N2	-179.17(13)
C10	C11	C12	C1	-61.87(17)
C12	N2	C13	C14	-8.26(16)
C12	C1	C2	C3	-34.6(2)
C12	C1	C2	C7	150.04(14)
C12	C1	C8	N1	-164.83(12)
C12	C1	C8	C9	-47.77(17)
C12	C1	C14	C13	44.36(14)
C13	N2	C12	C1	35.85(15)
C13	N2	C12	C11	159.69(14)
C14	C1	C2	C3	78.8(2)
C14	C1	C2	C7	-96.62(15)

Atom	Atom	Atom	Atom	Angle/°
C14	C1	C8	N1	80.02(16)
C14	C1	C8	C9	-162.93(13)
C14	C1	C12	N2	-48.76(13)
C14	C1	C12	C11	-177.07(13)
C15	N1	C7	C2	-159.76(15)
C15	N1	C7	C6	20.7(3)
C15	N1	C8	C1	175.28(15)
C15	N1	C8	C9	59.06(19)
C16	O2	C17	C18	167.93(16)
C16	C9	C10	C11	179.21(14)
C17	O2	C16	O1	2.8(3)
C17	O2	C16	C9	-177.94(15)
C19	S1	N2	C12	-60.12(13)
C19	S1	N2	C13	76.48(13)
C19	C20	C21	C22	-1.0(3)
C20	C19	C24	C23	1.0(2)
C20	C21	C22	C23	0.9(3)
C20	C21	C22	C25	-179.14(17)
C21	C22	C23	C24	0.2(3)
C22	C23	C24	C19	-1.1(3)
C24	C19	C20	C21	0.1(3)
C25	C22	C23	C24	-179.78(16)

Table 38: Hydrogen Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($Å^2\times 10^3$) for **9a**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij}.

Atom	x	y	z	U_{eq}
H26	5427	-241.74	1411.76	36
H3	8097.63	8241.59	2719.68	31
H4	10470.45	9290.23	3191.24	41
H5	12051.96	8853.42	4461.3	46
H6	11317.59	7425.86	5332.08	41
H8	6455.08	5406.03	4665.17	26
H9	7472.49	8339.29	5428.56	27
H10A	4499.05	7321.09	4755.83	32
H10B	5154.35	8903.15	5279.61	32
H11A	4446.51	8527.98	3557.11	30
H11B	6136.06	8939.59	3917.17	30
H12	4724.32	6155.9	3205.32	23
H13A	7116.93	5639.54	1625.47	29
H13B	5623.12	4679.2	1382.56	29
H14A	7730.66	4667.1	2852.75	26
H14B	6107.11	4273.49	2859.87	26
H15A	9326.1	7066.21	6389.39	52
H15B	10135.44	5818.52	5971.72	52
H15C	8595.64	5509.04	6136.36	52
H17A	7574.95	7573.16	8071.58	49
H17B	6401.47	8596.43	8129.24	49
H18A	9358.87	9471.35	8528.71	70
H18B	8478.87	9631.7	9340.72	70
H18C	8195.78	10496.49	8572.01	70
H20	2138.49	7098.57	2370.21	31
H21	114.53	5600.89	2207.41	34
H23	1061.25	2848.21	-32.32	32
H24	3127.81	4299.04	148.93	29
H25A	-1039.92	2313.52	402.33	52
H25B	-1765.1	3617	841.16	52
H25C	-886.3	2859.6	1550.74	52

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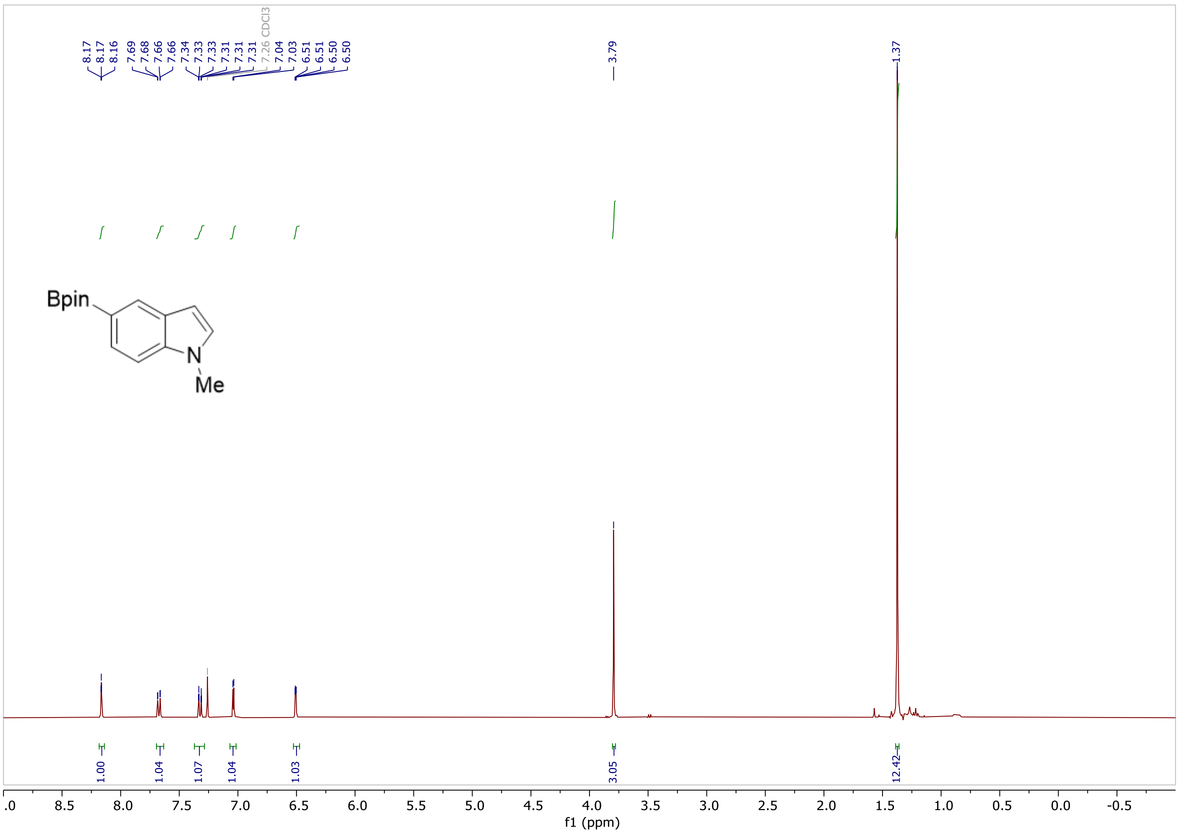
5. NMR Spectra

^{1}H-NMR (400 MHz, chloroform-*d*) (4u)



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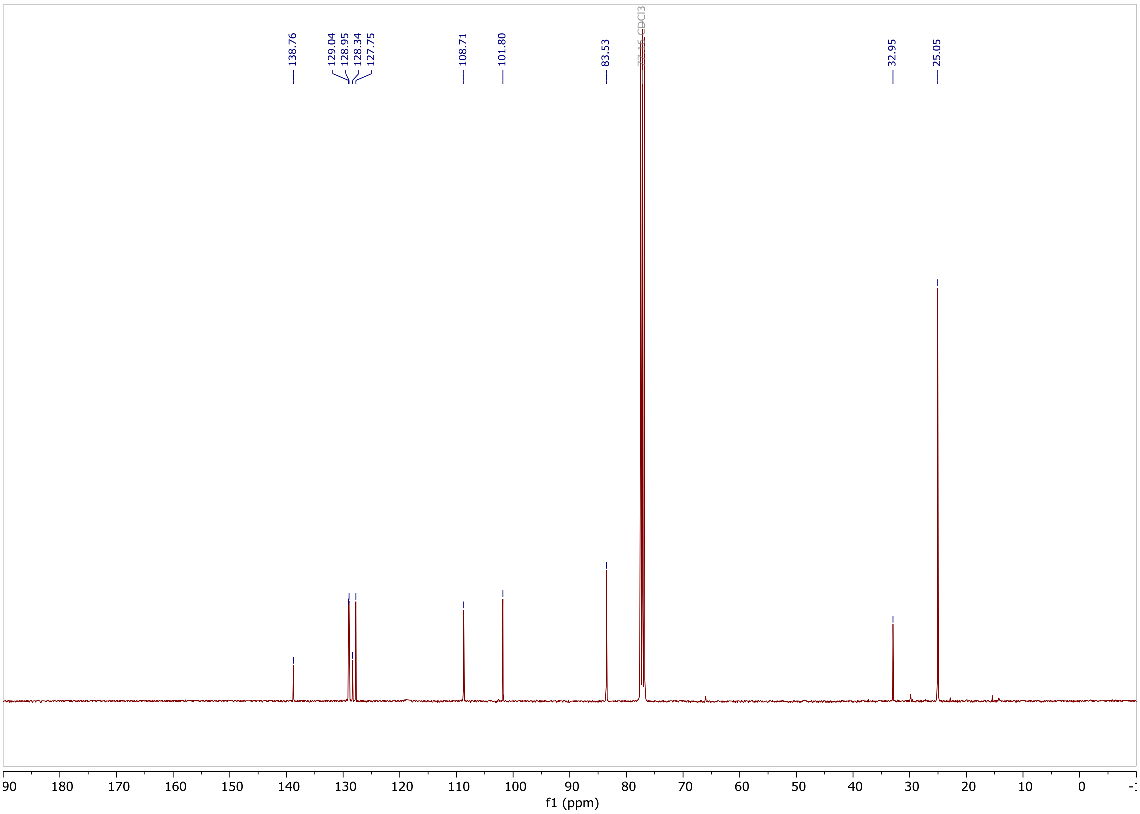

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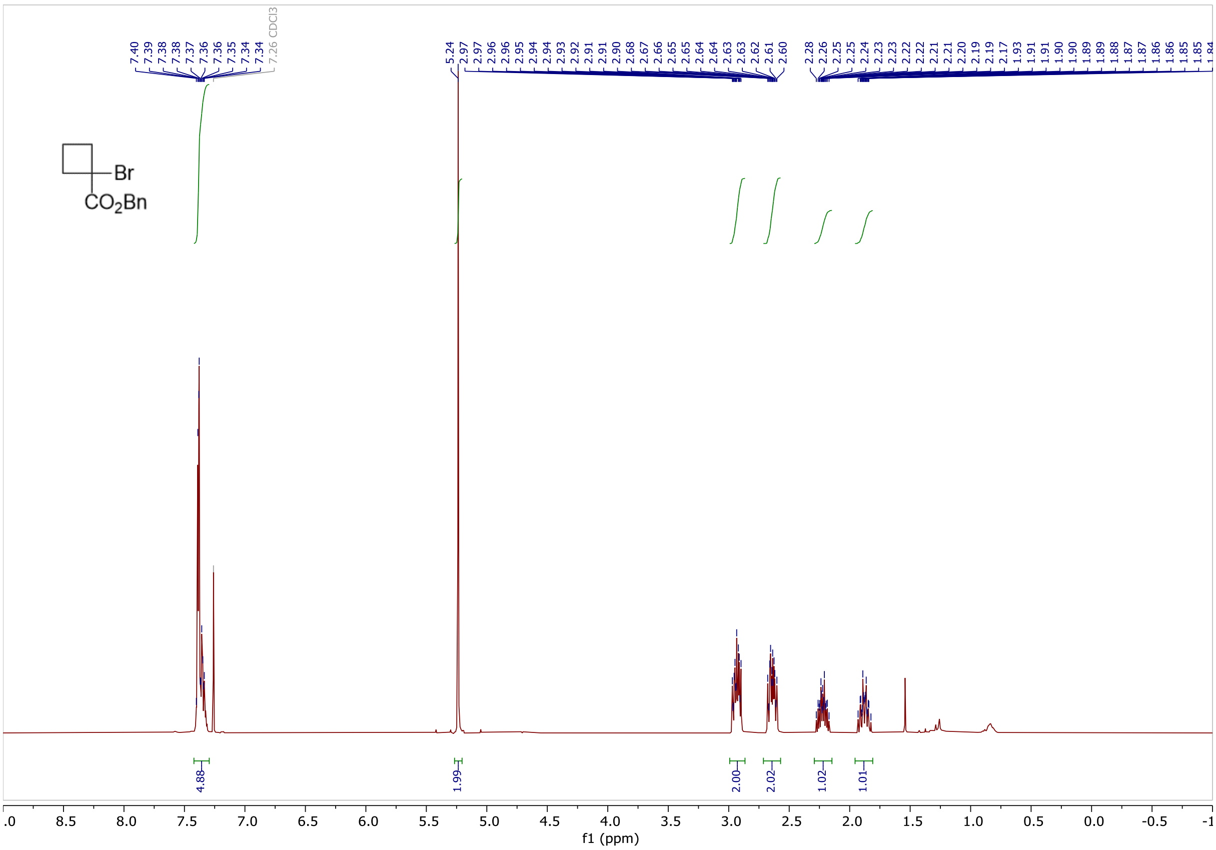

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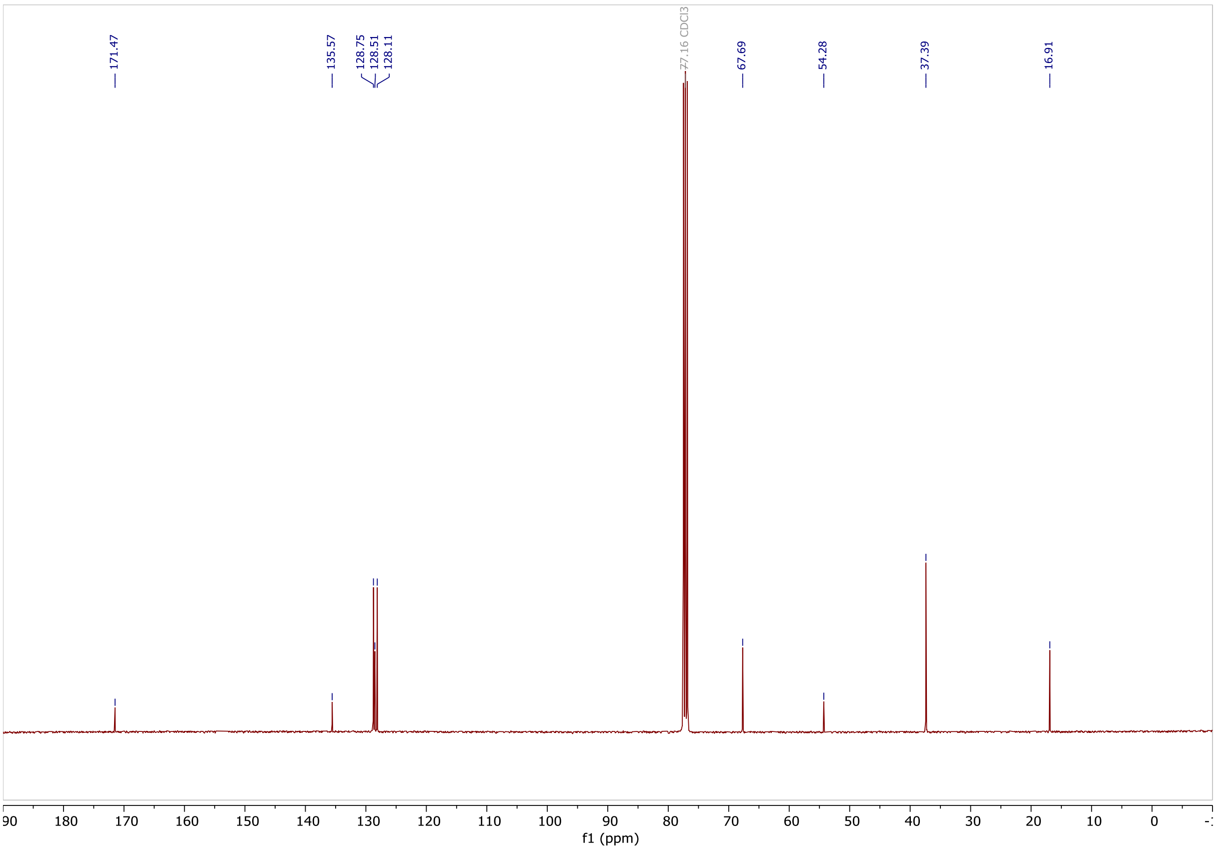

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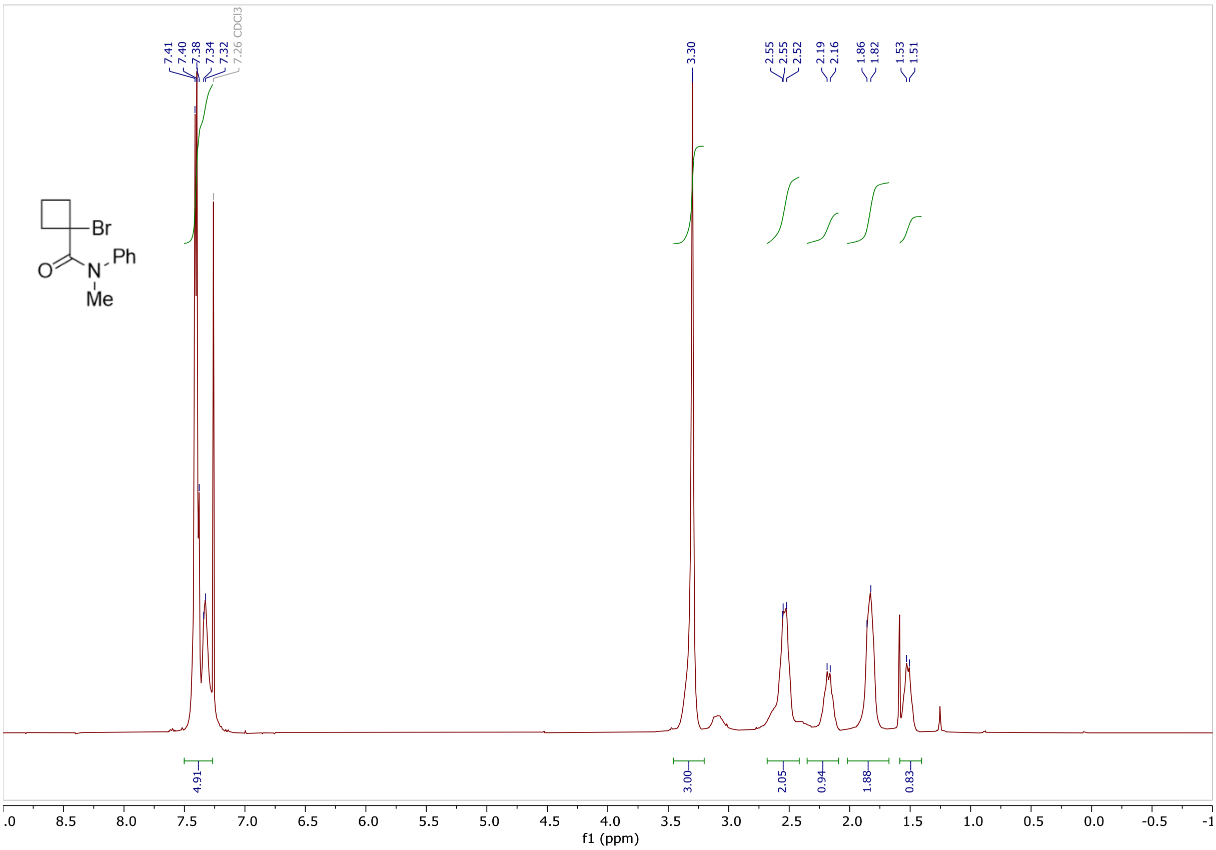

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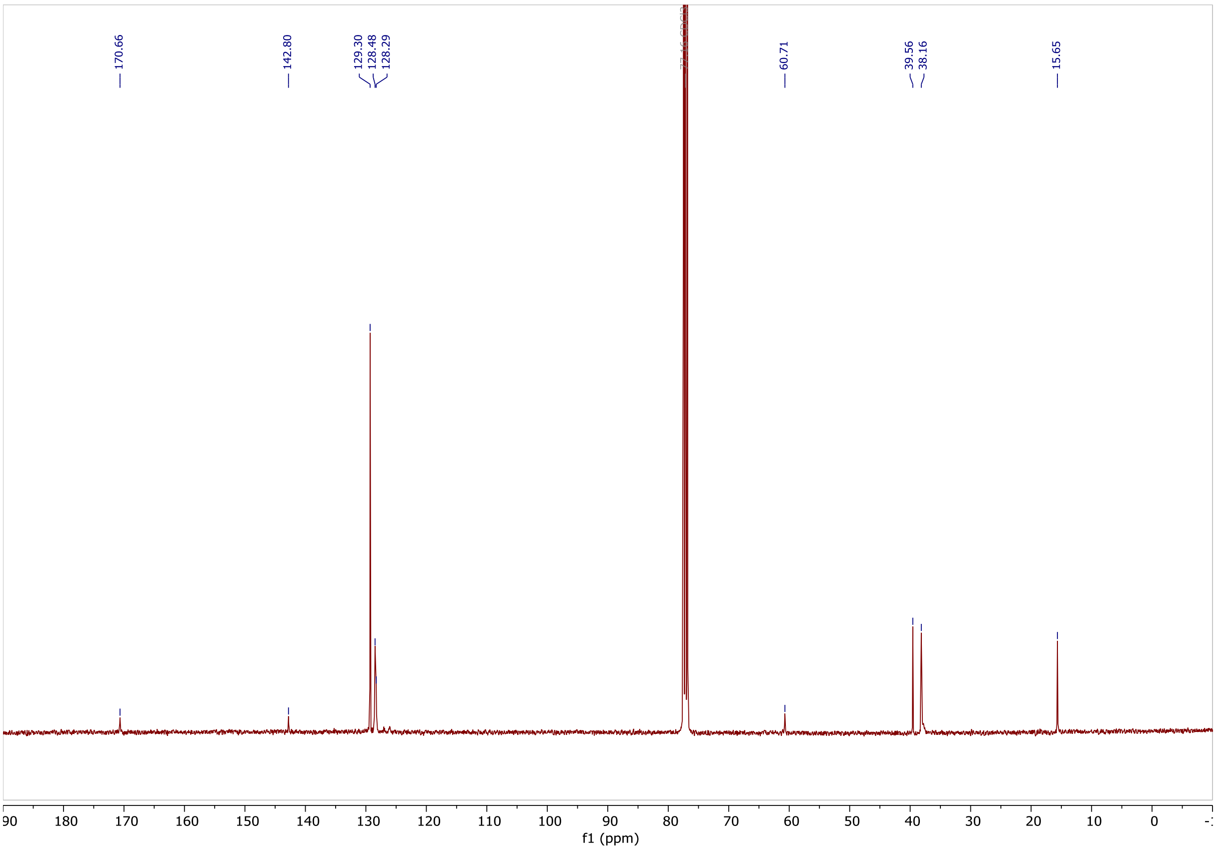

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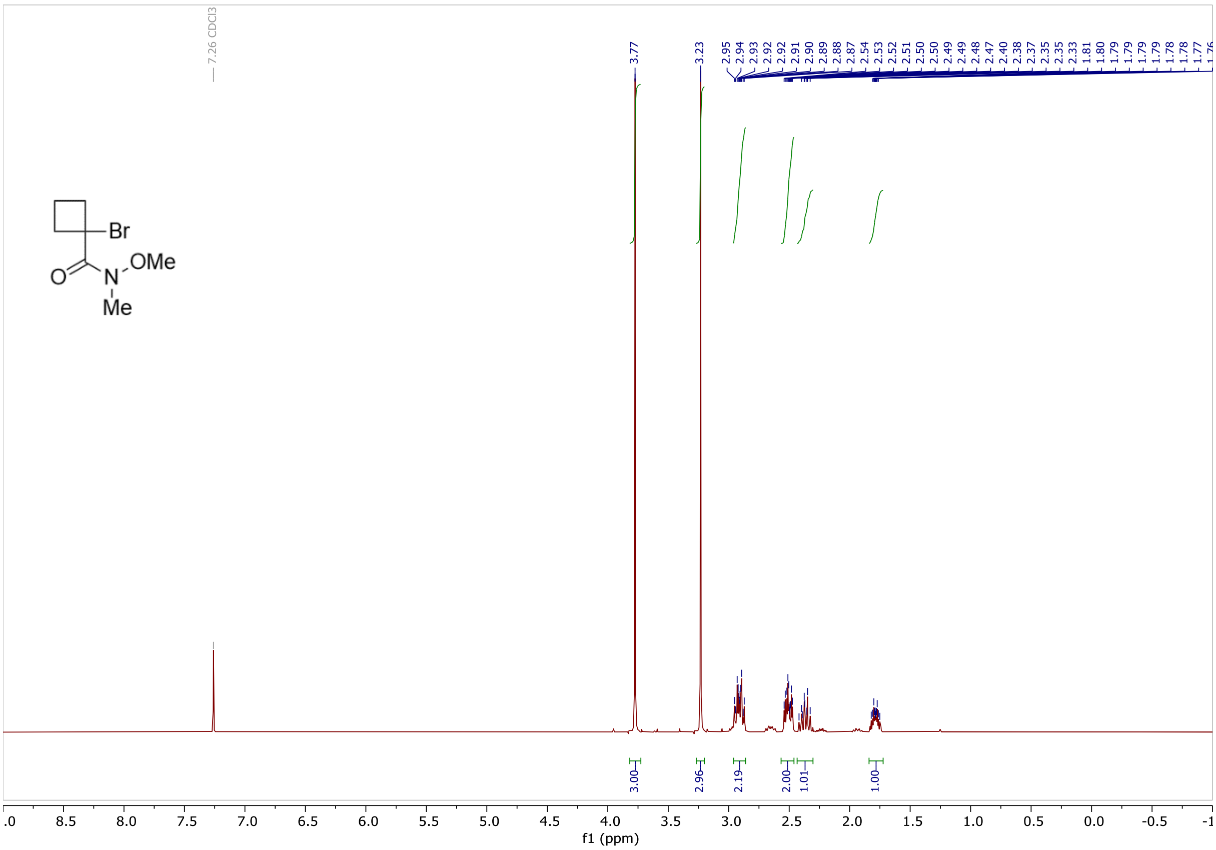

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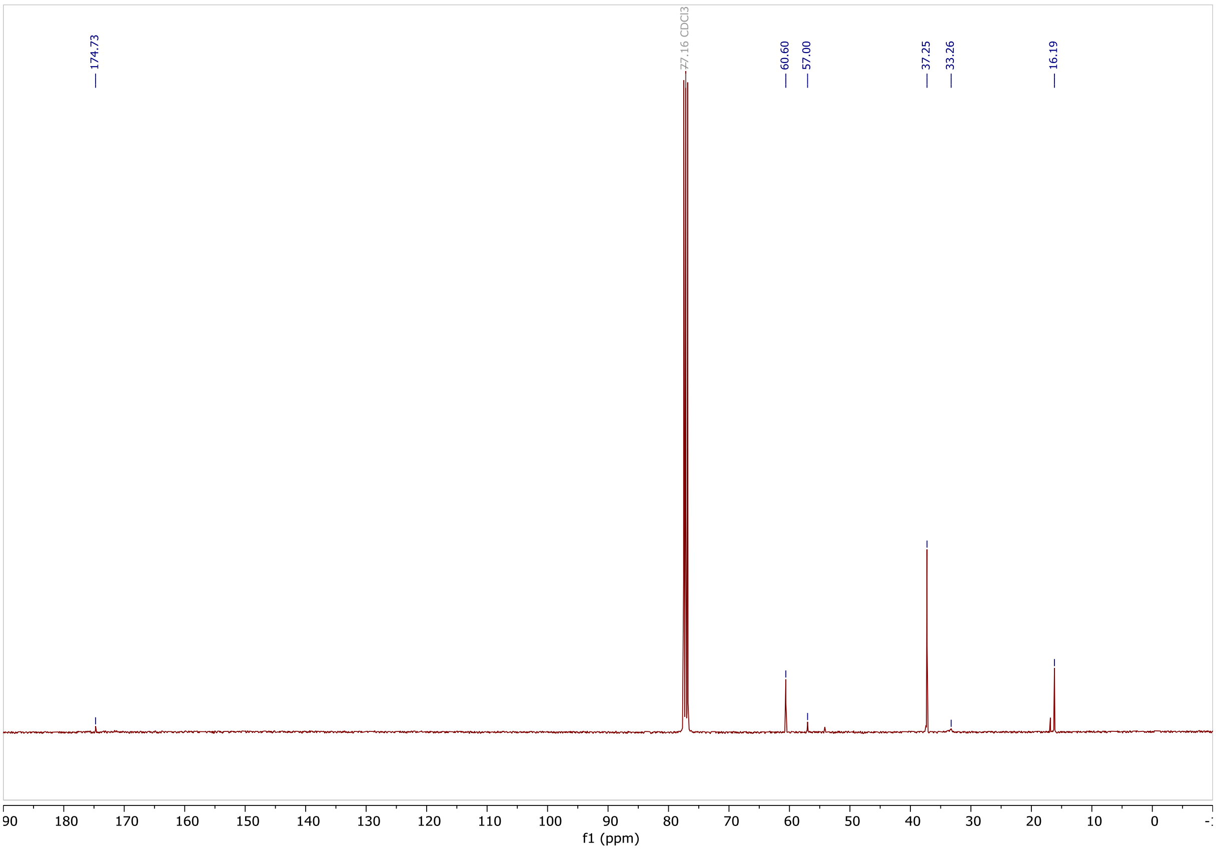

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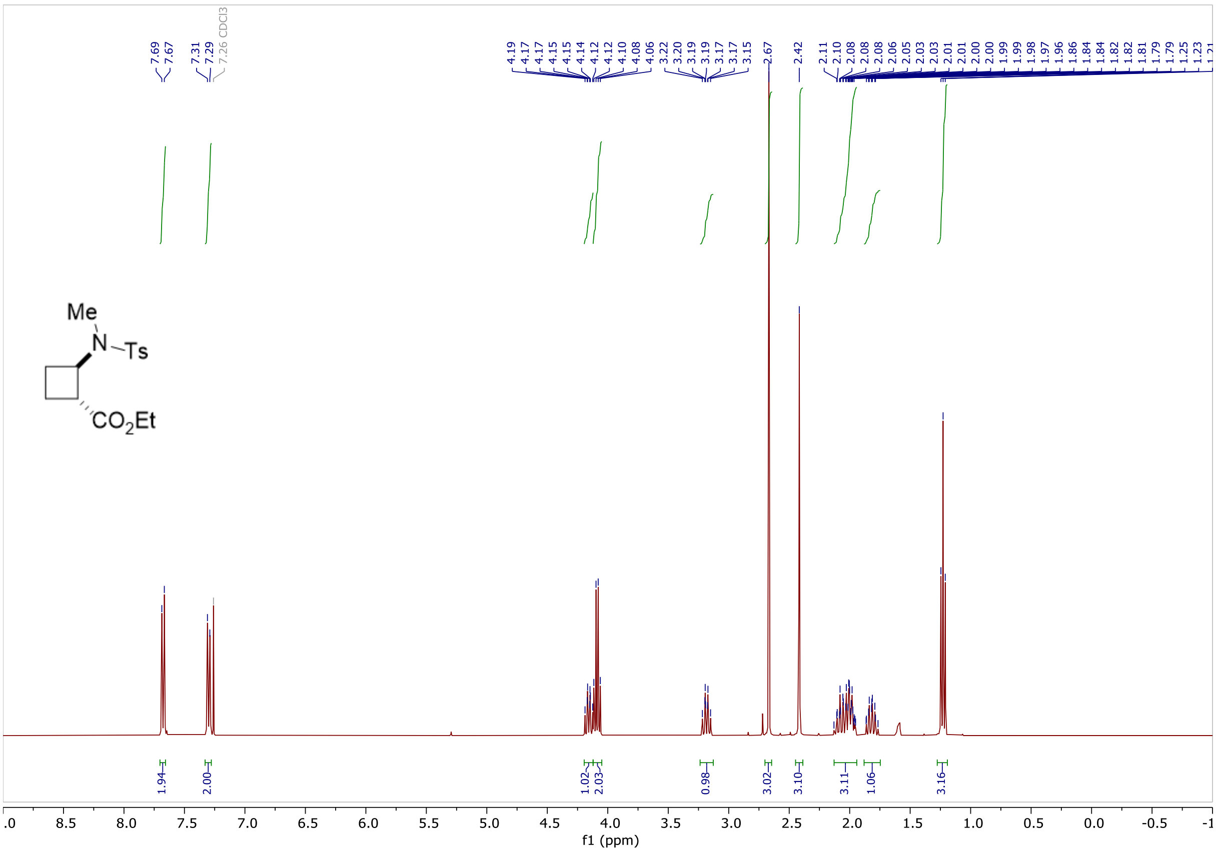

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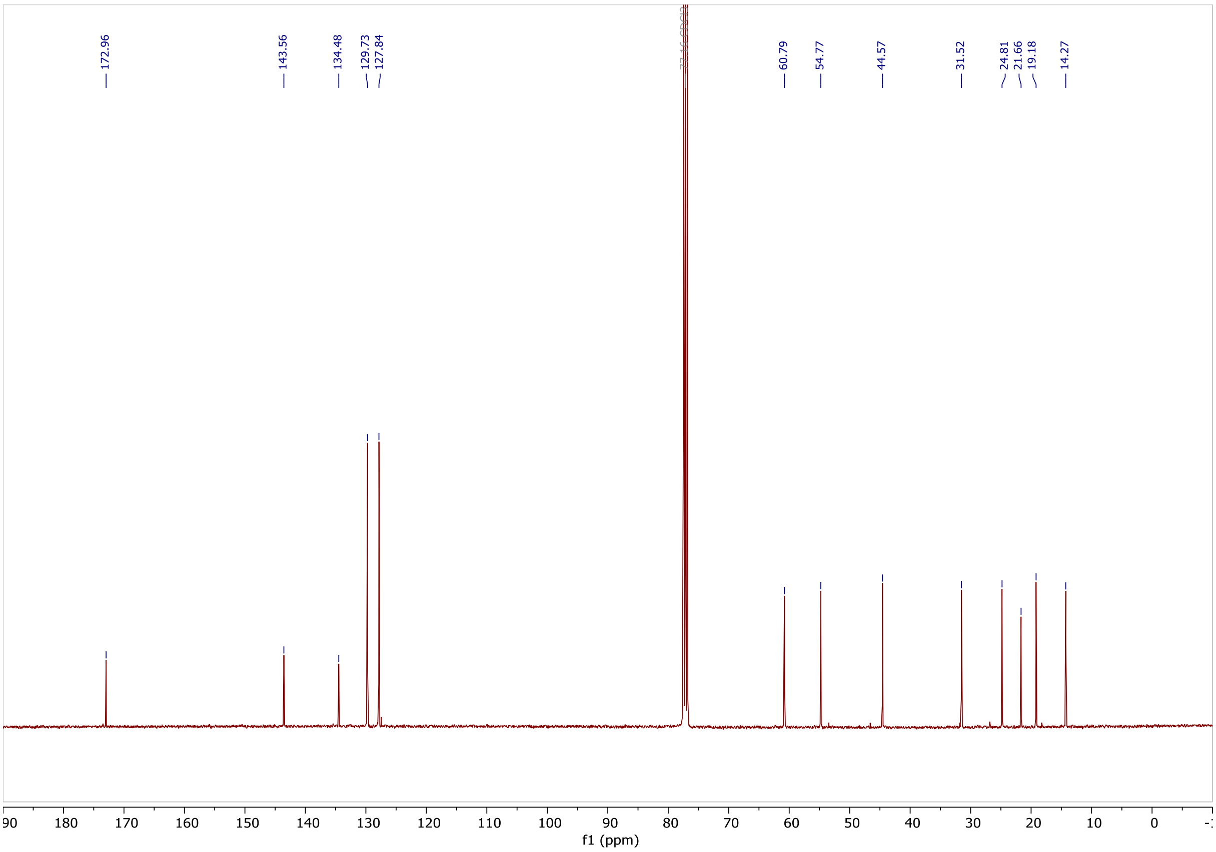
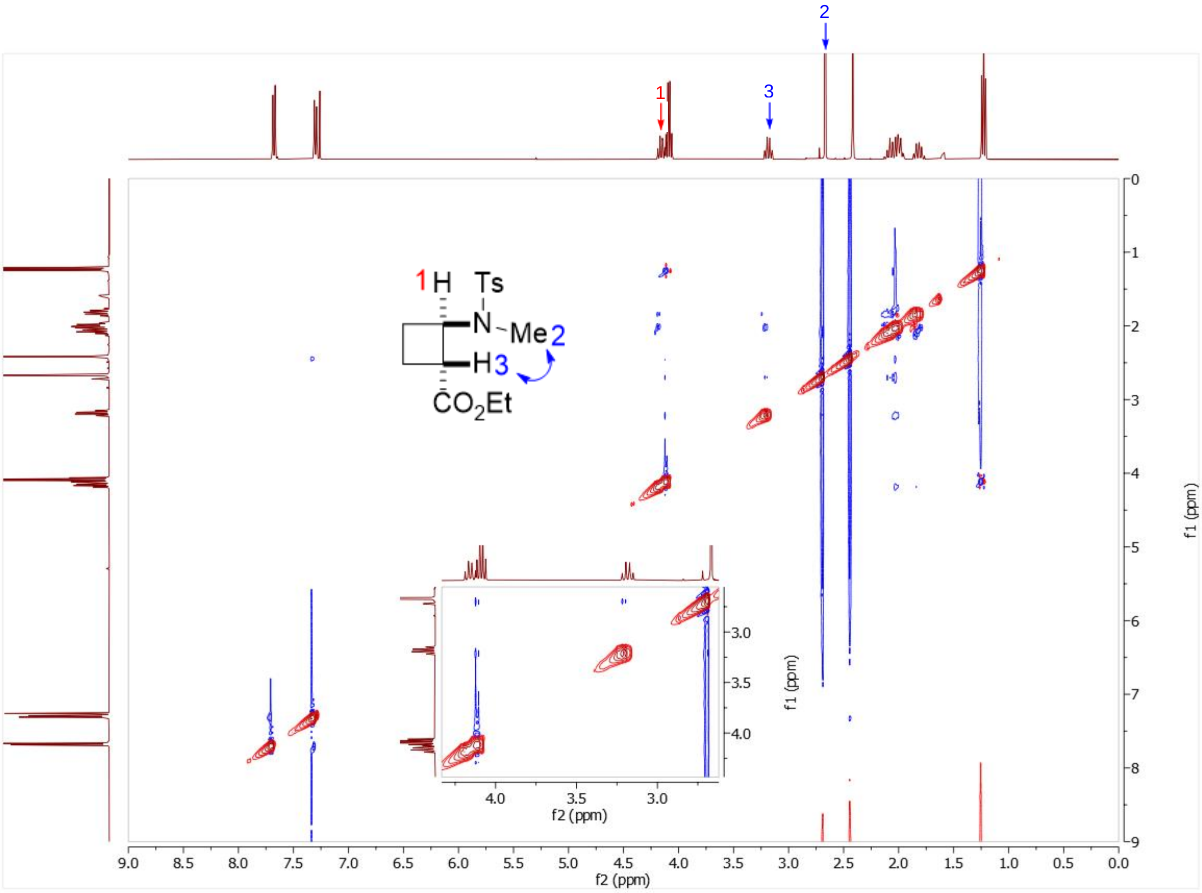


2D-NOESY (400 MHz, chloroform-*d*) (3a)



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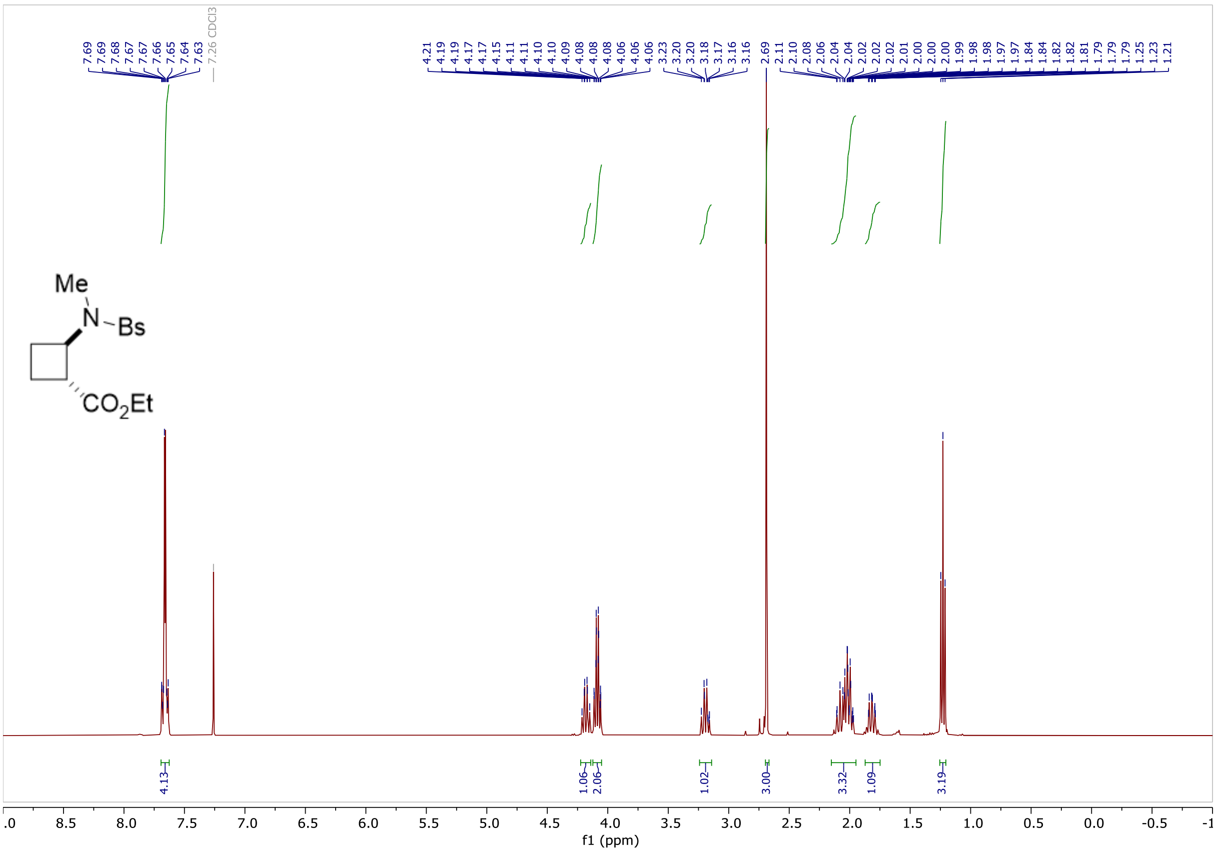

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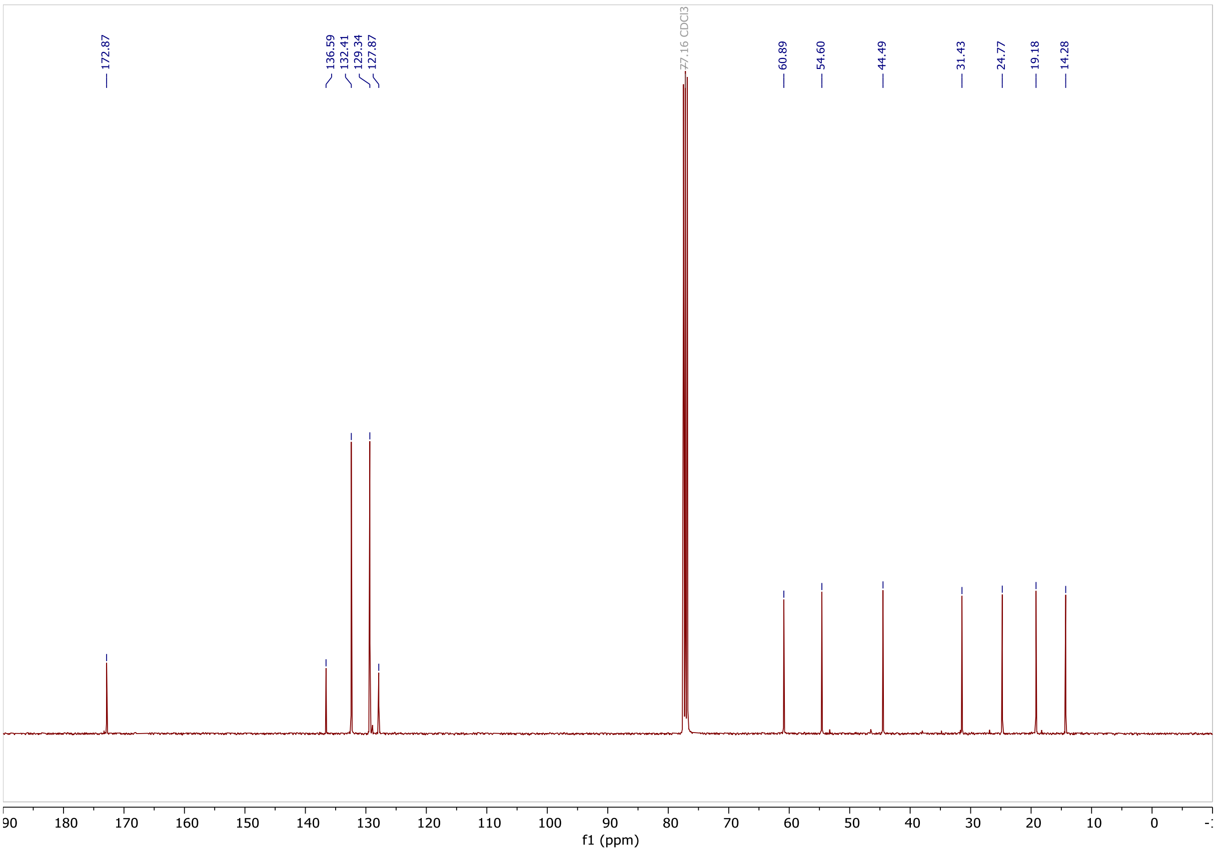

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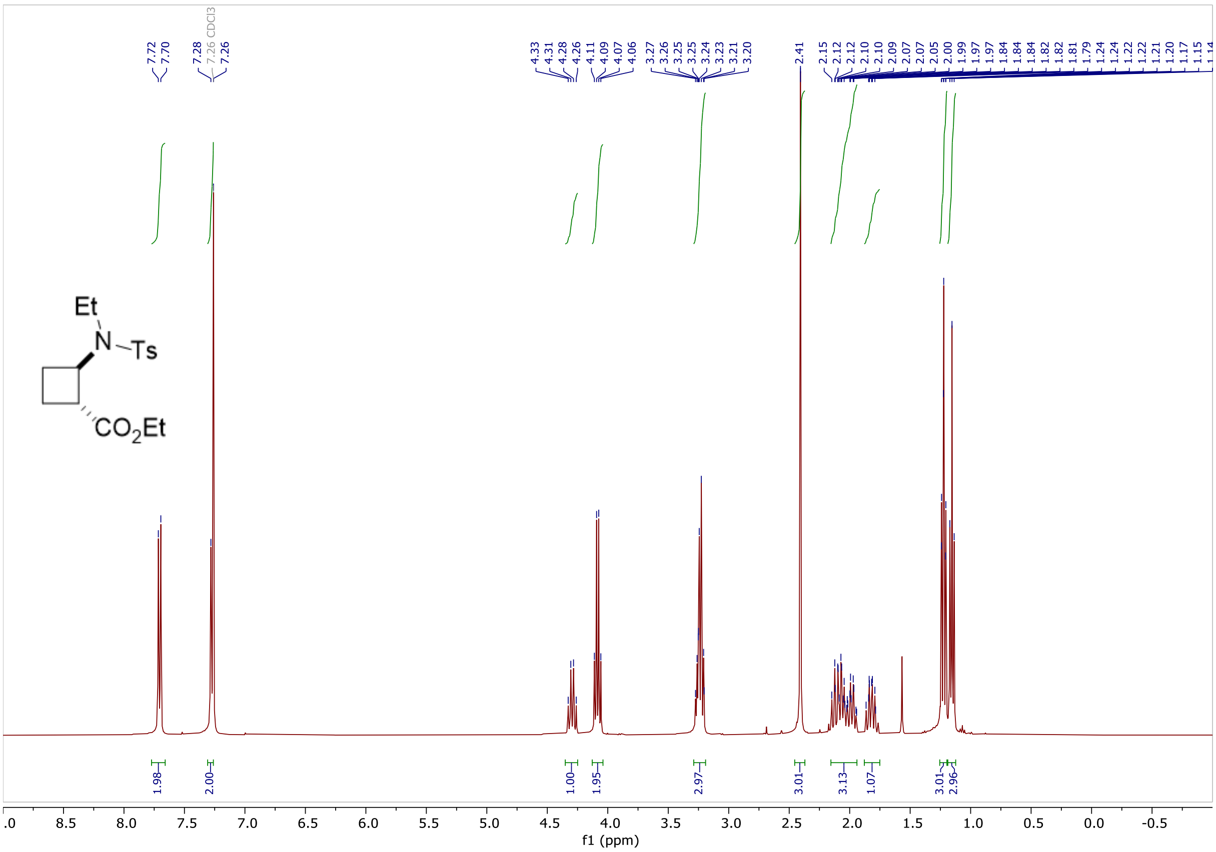

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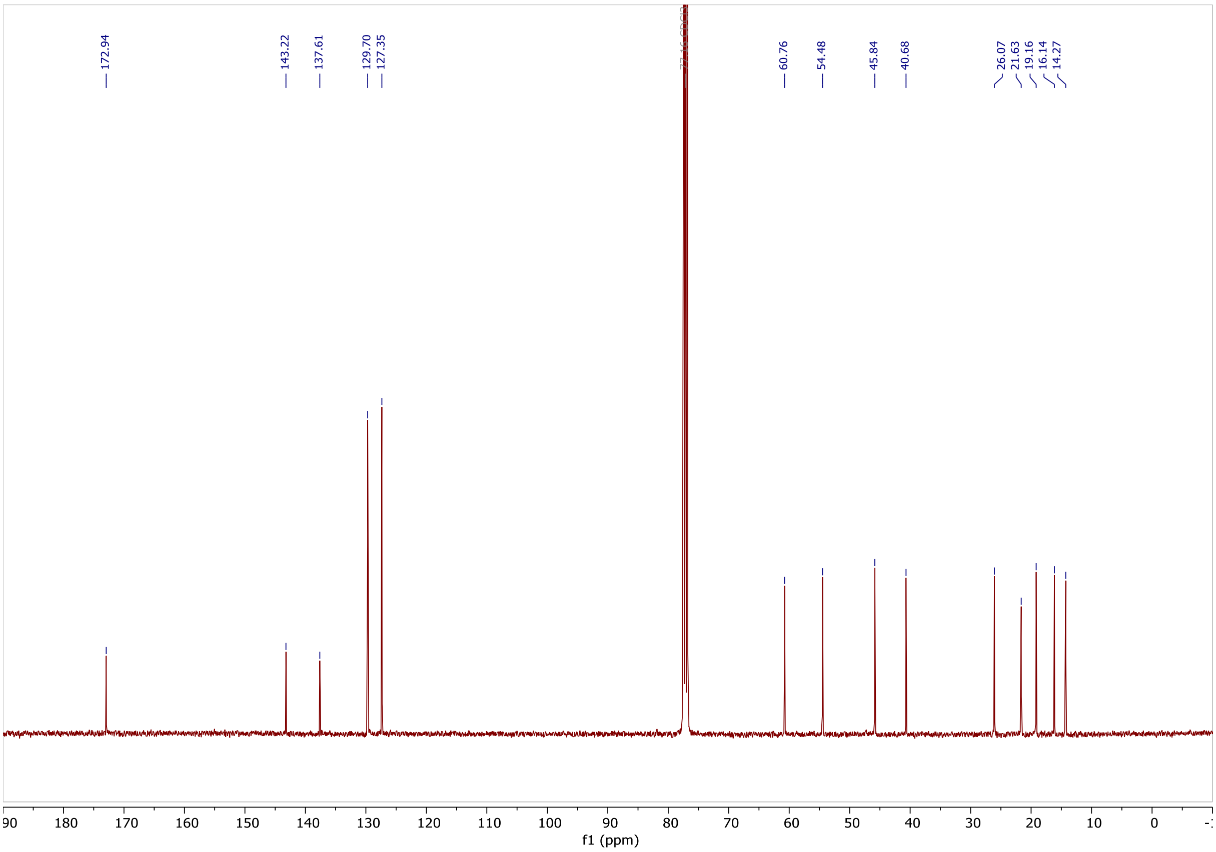

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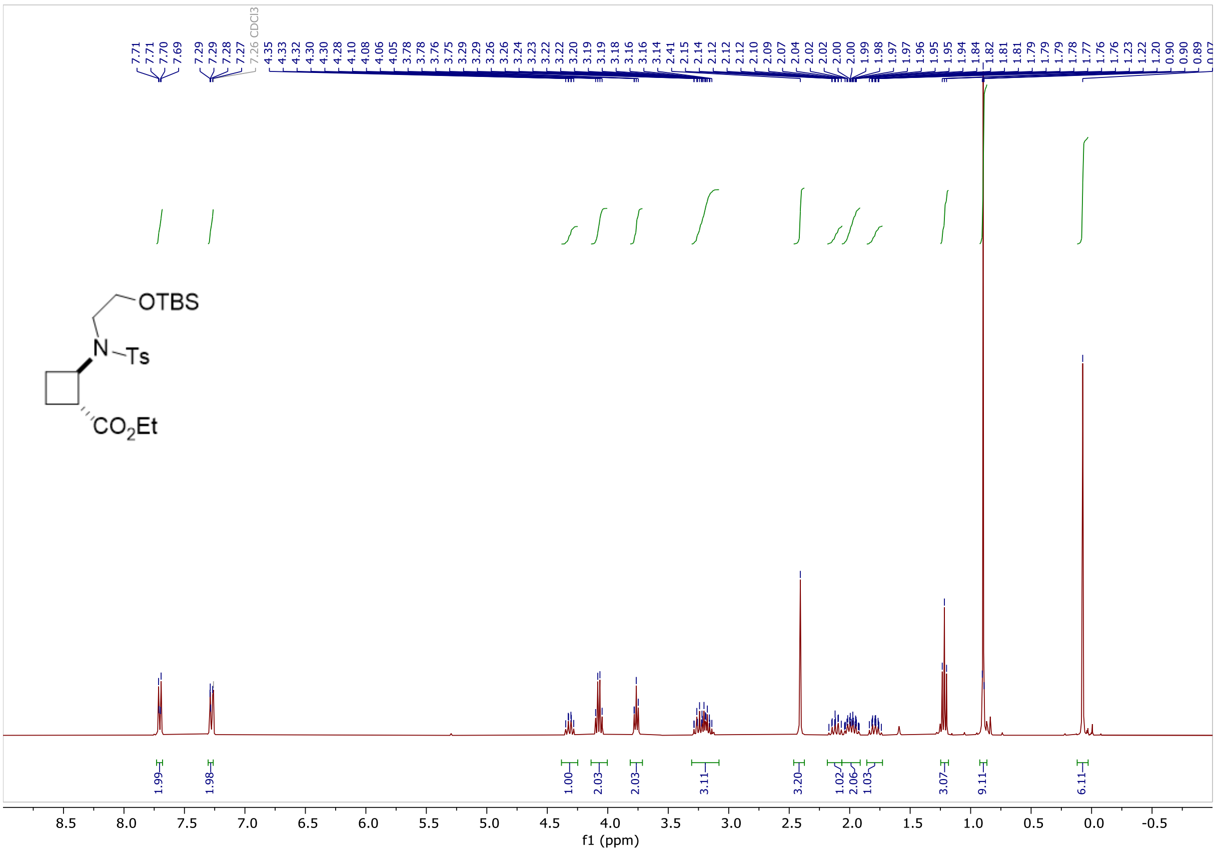

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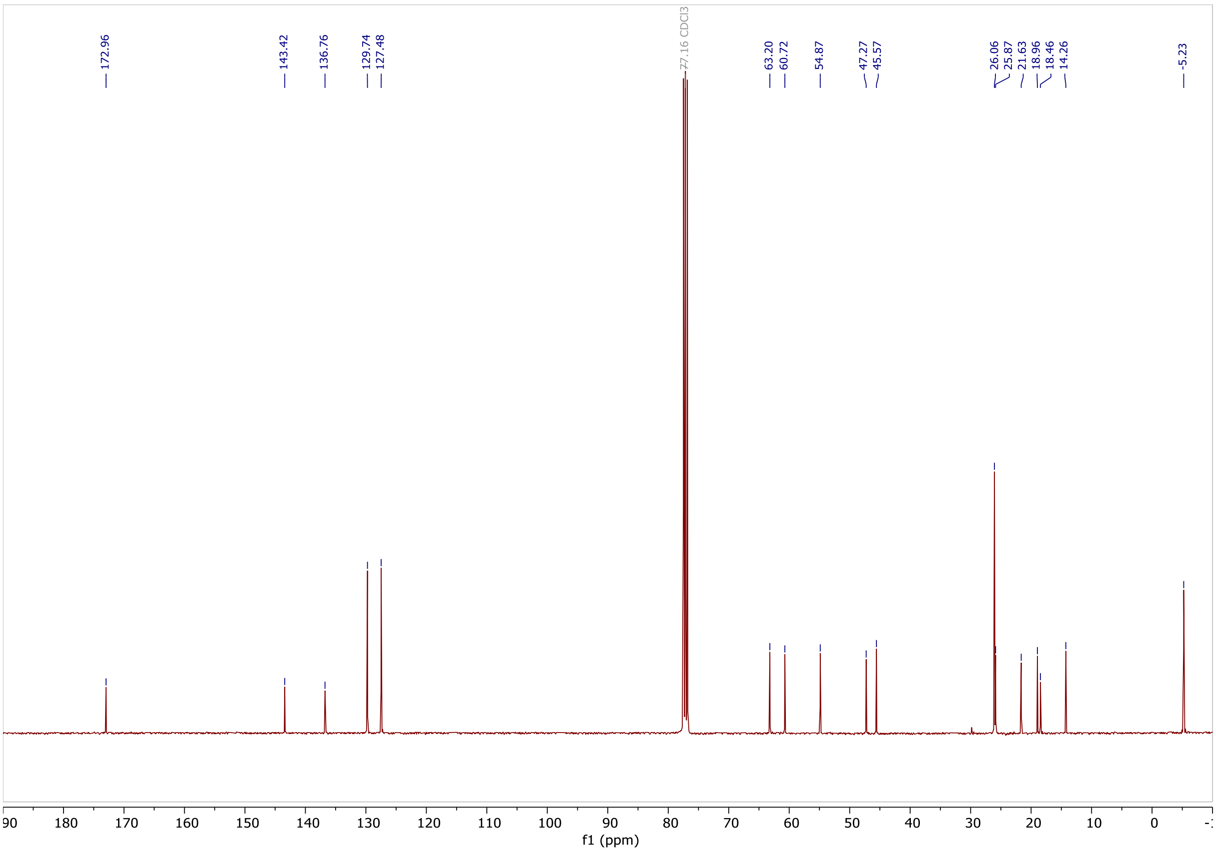

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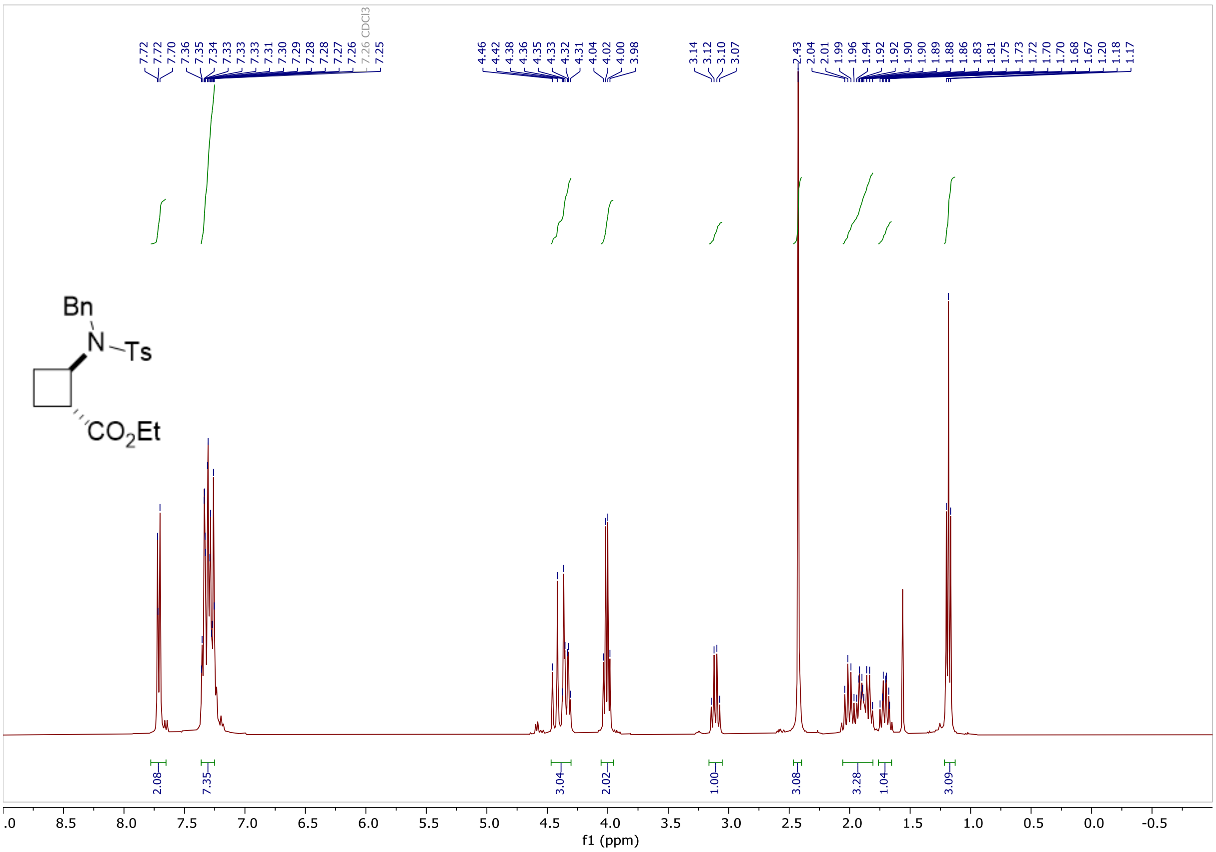

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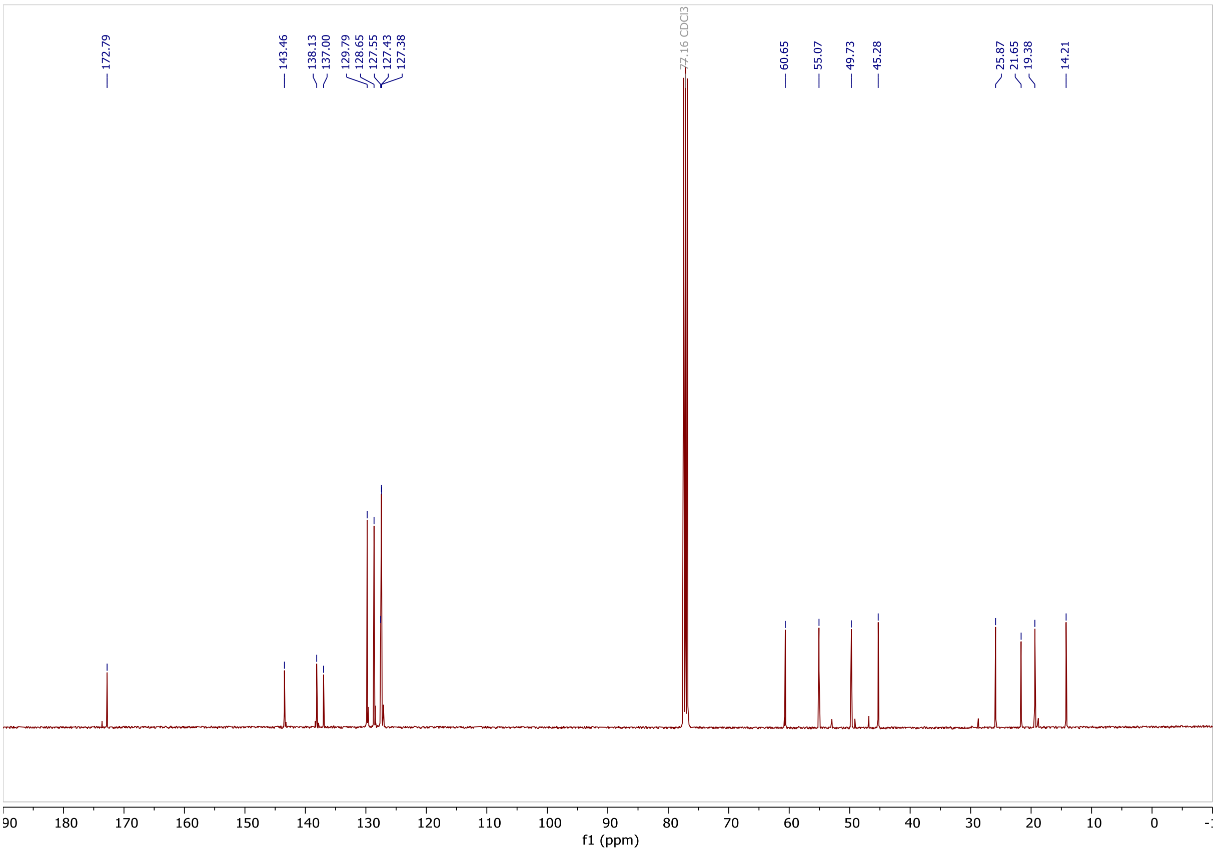

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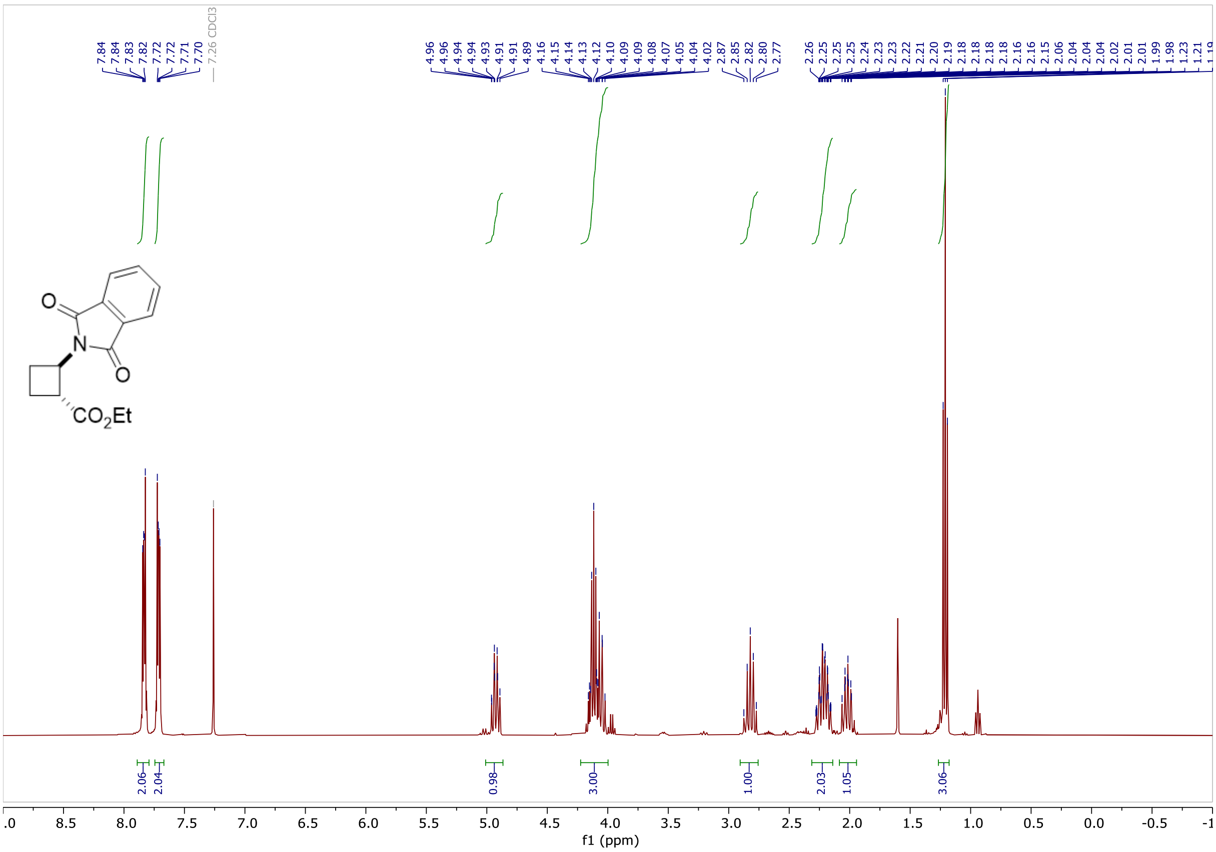

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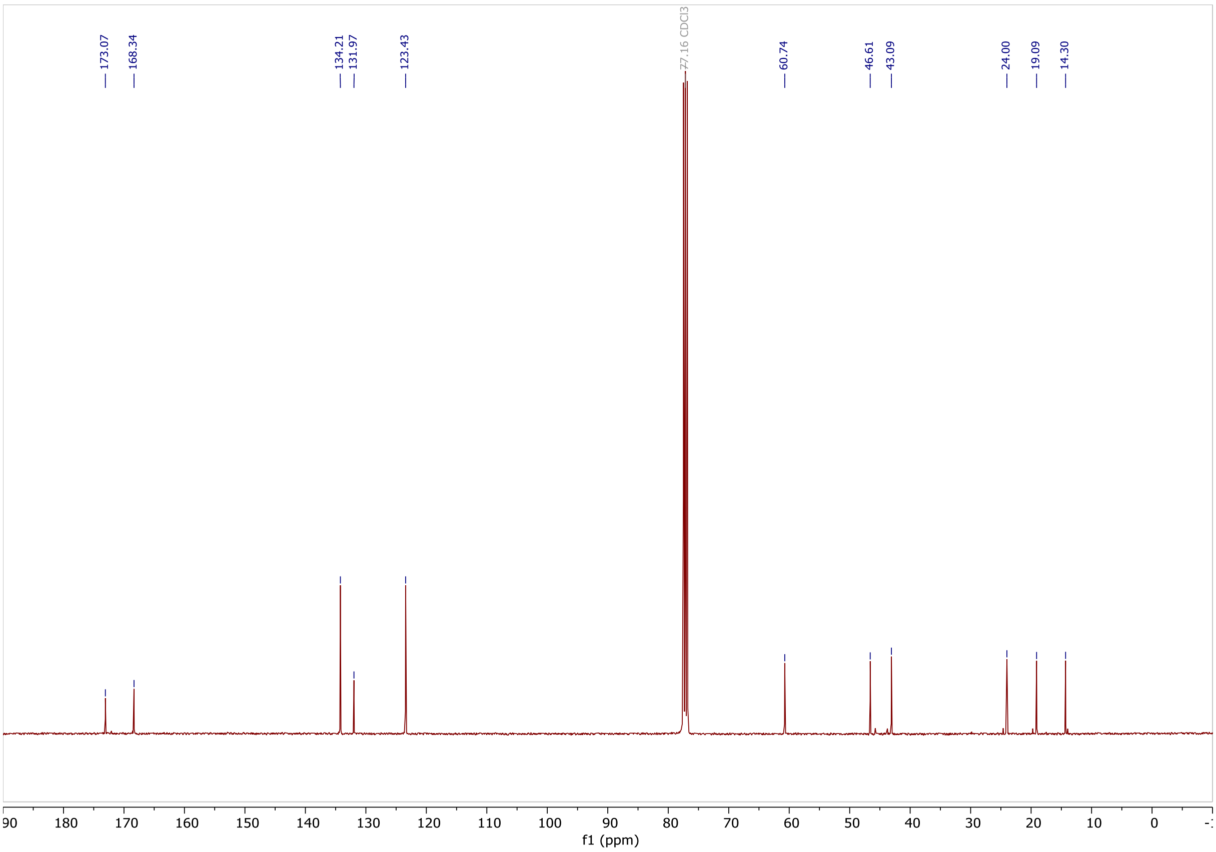

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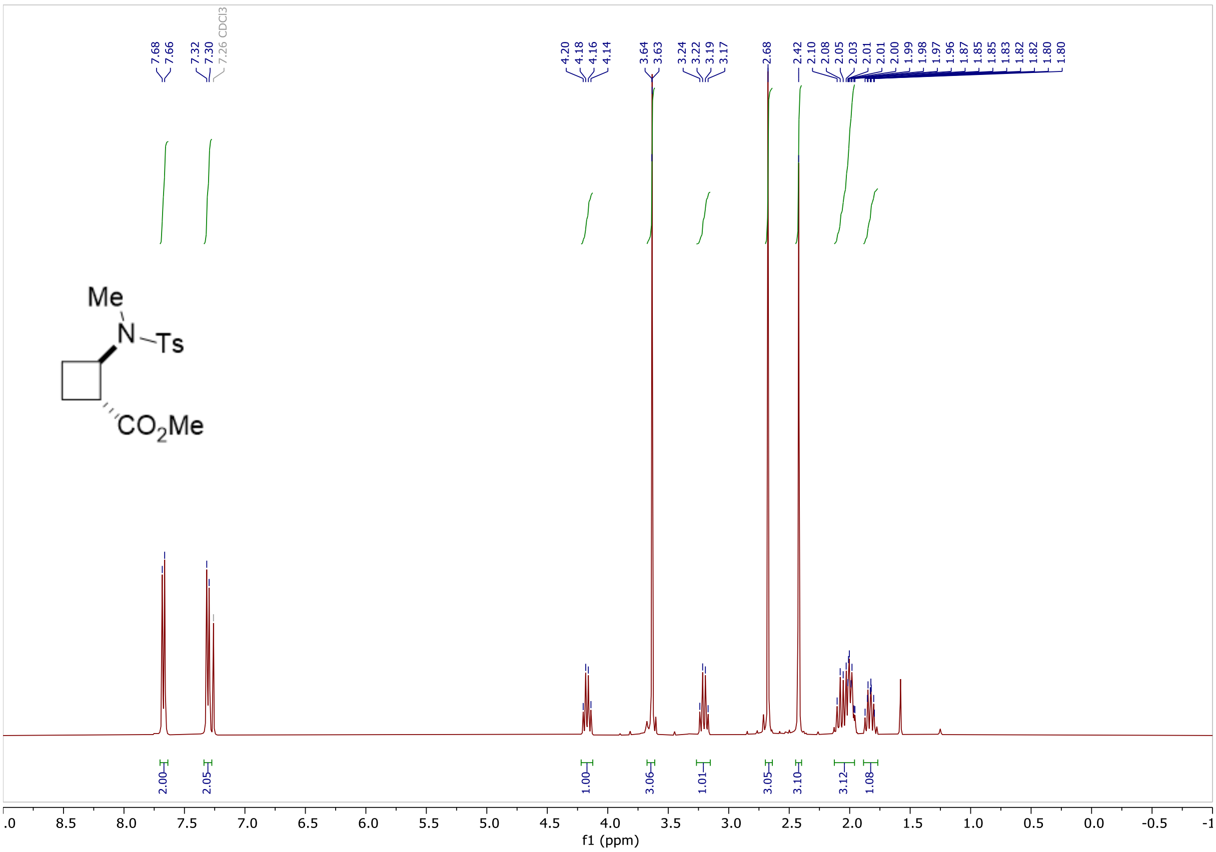

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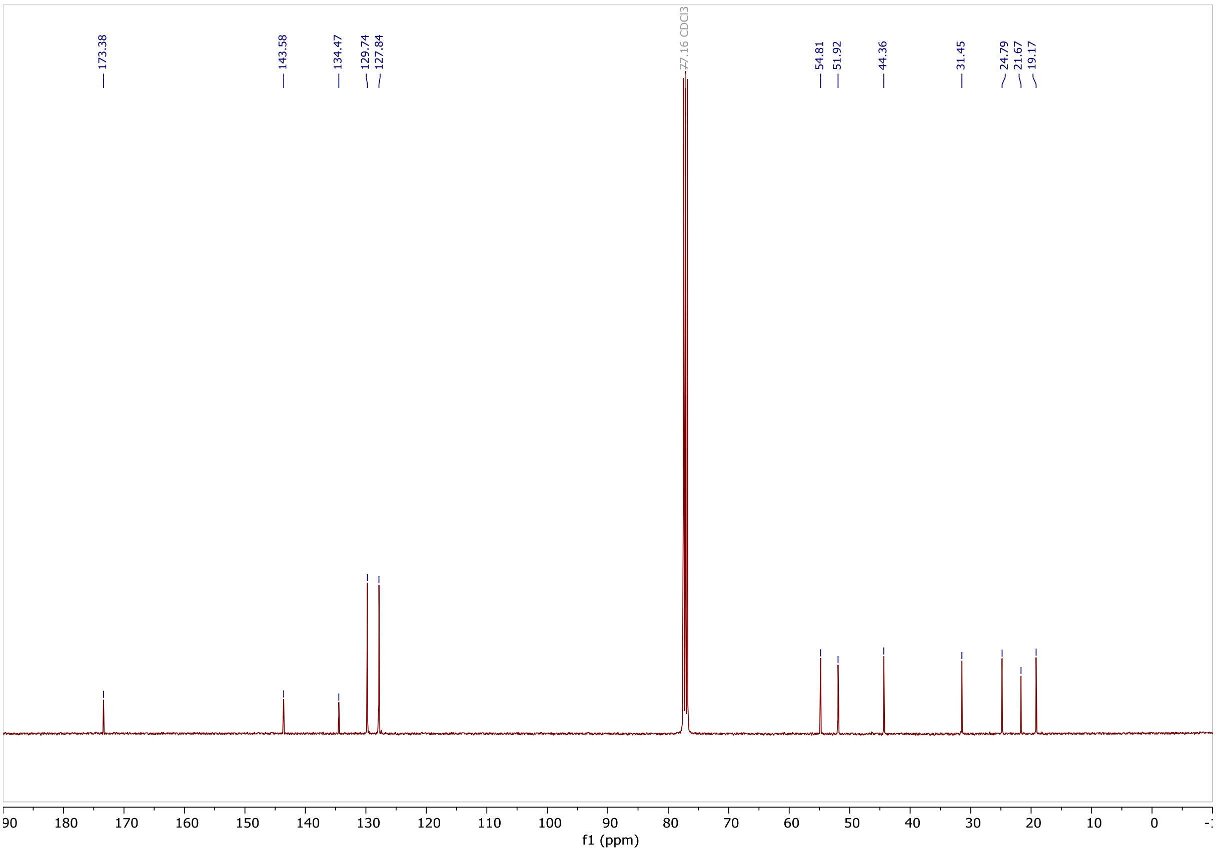

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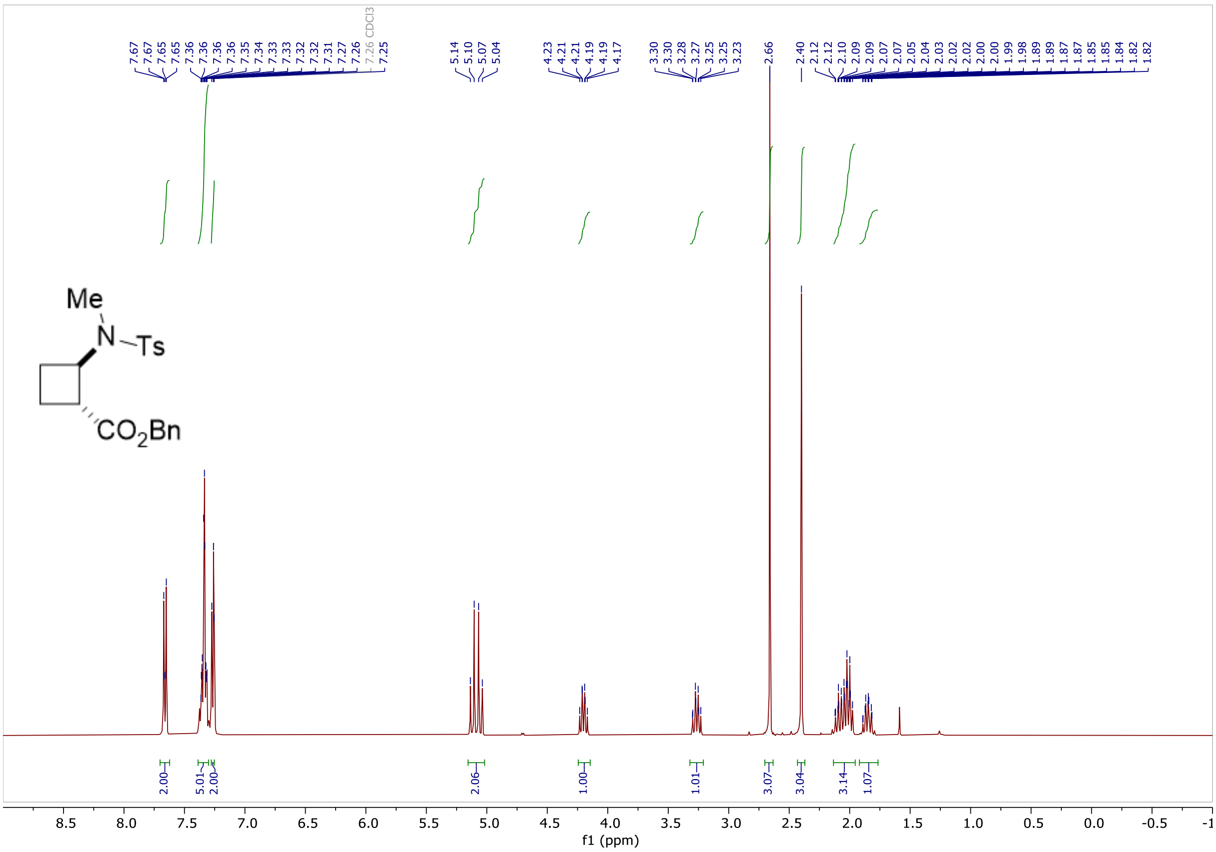

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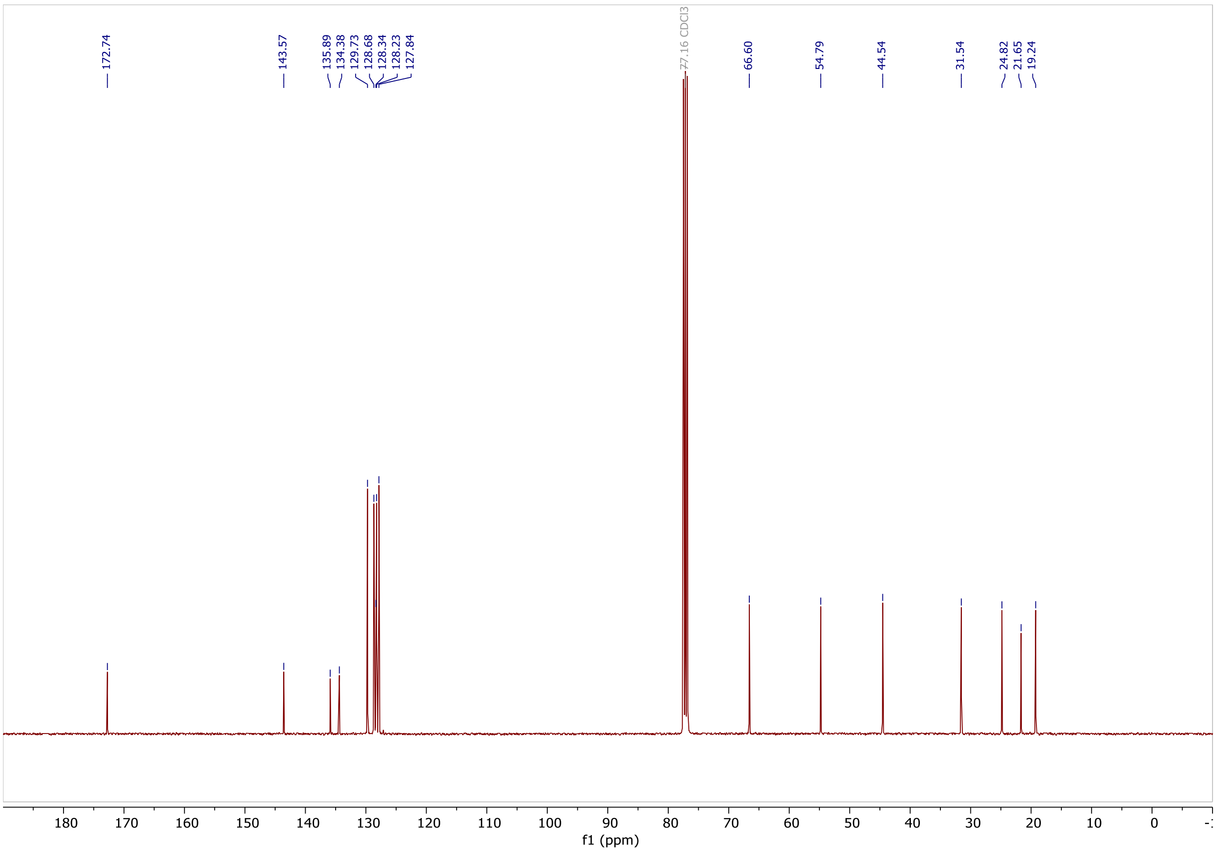

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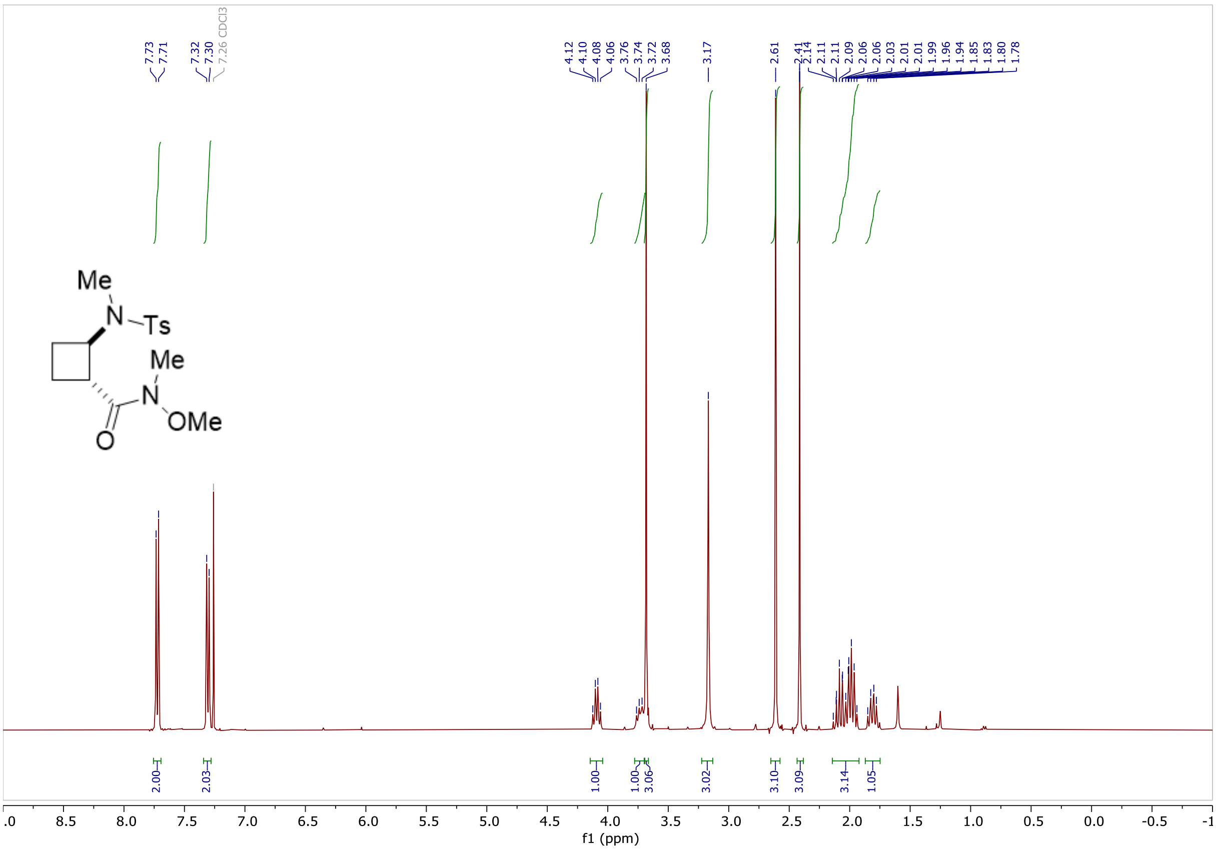

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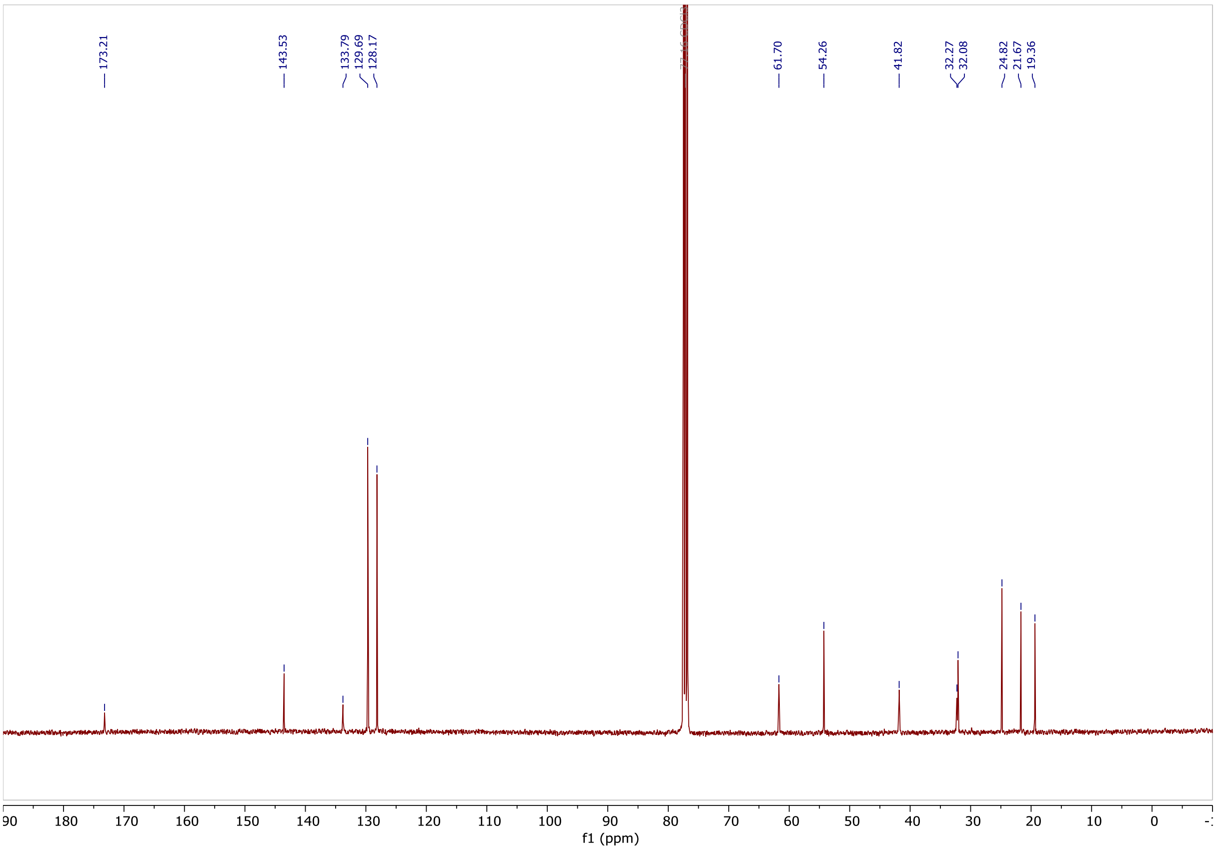

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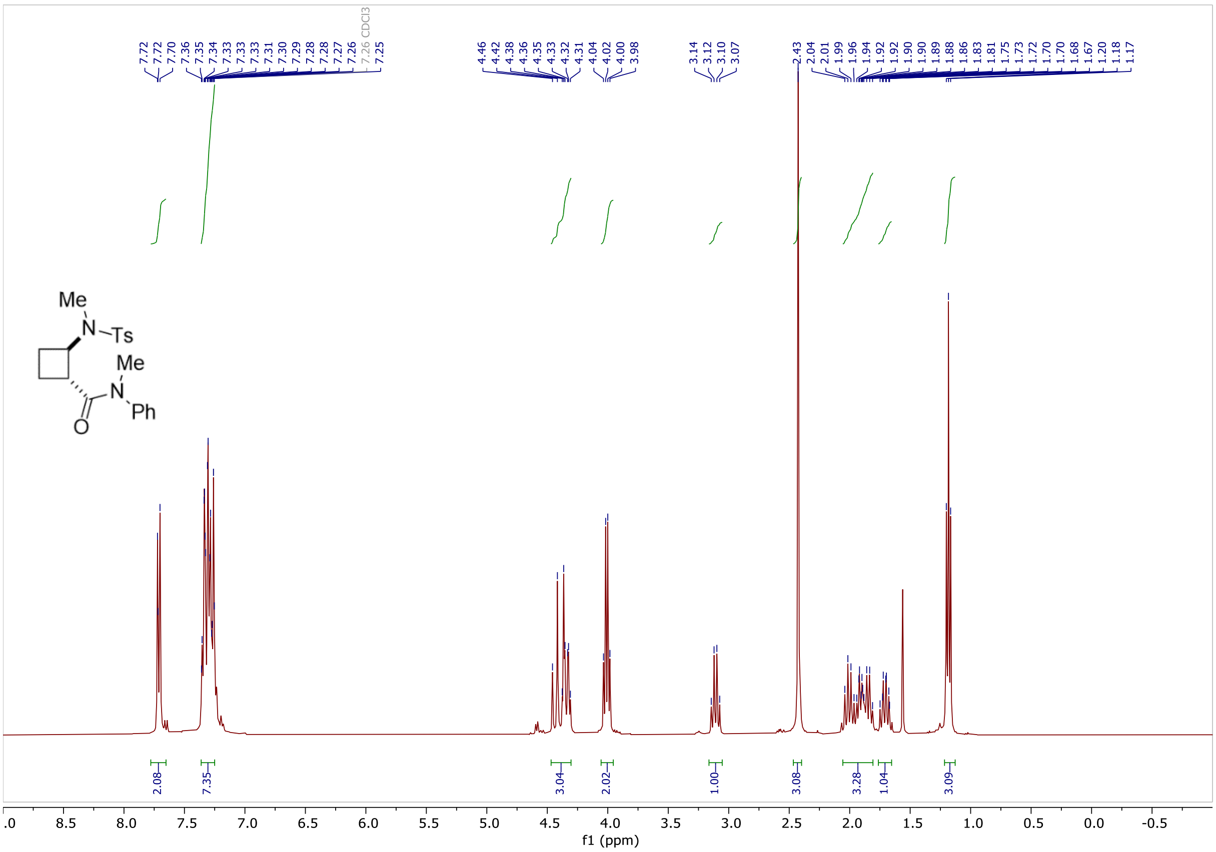

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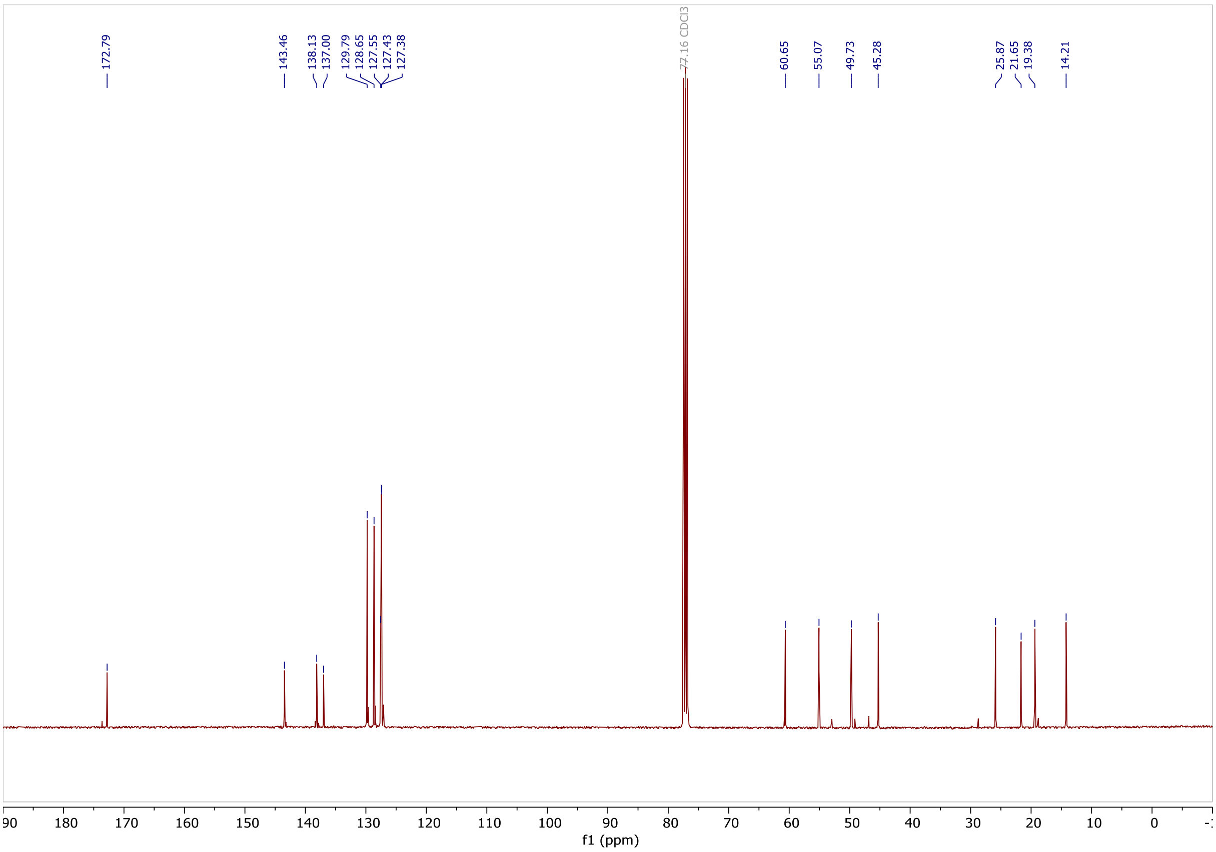

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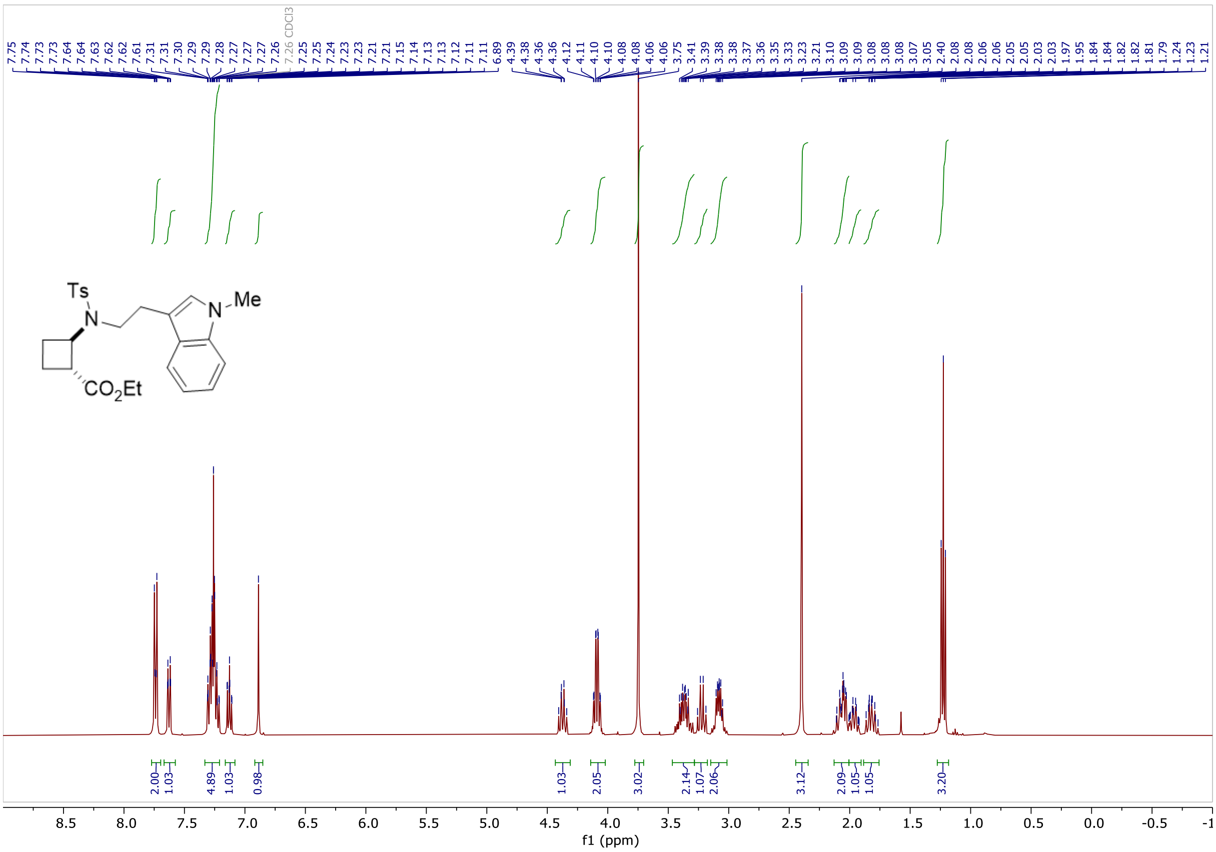

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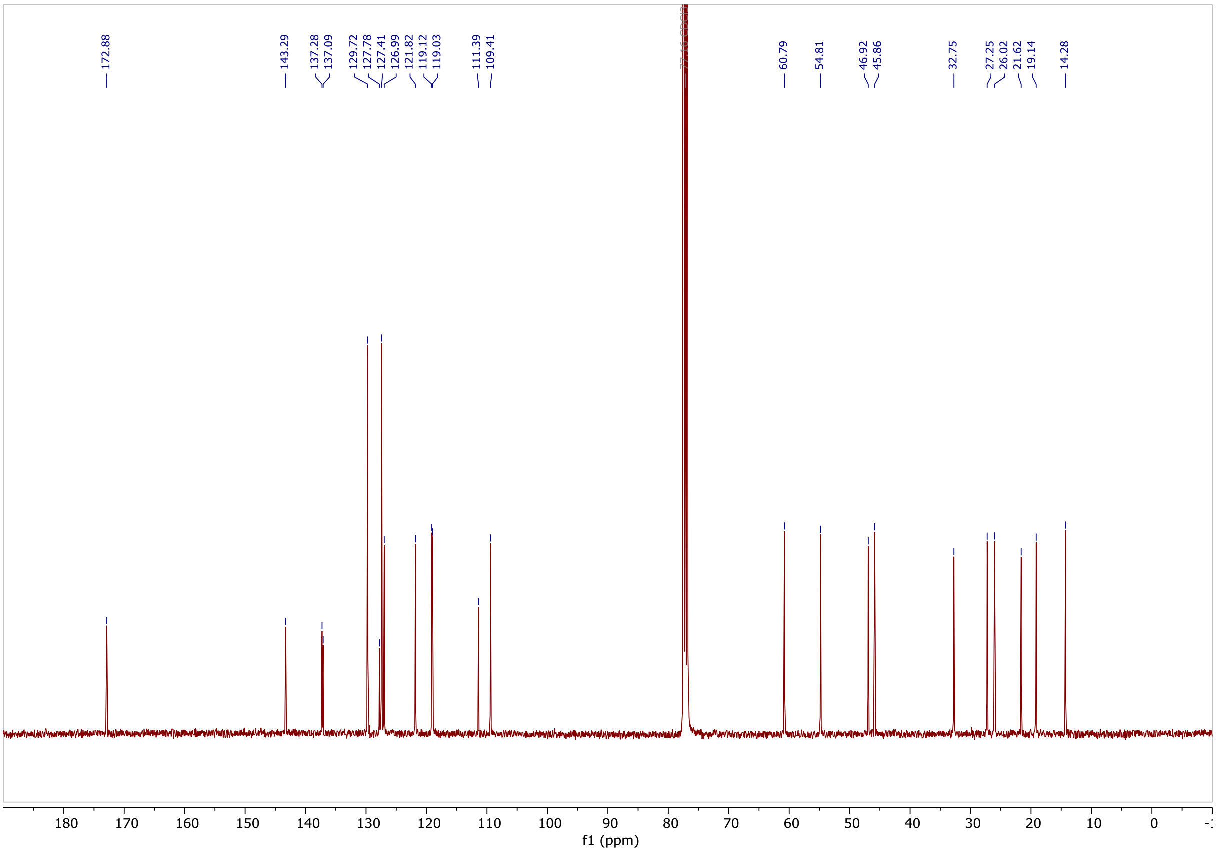

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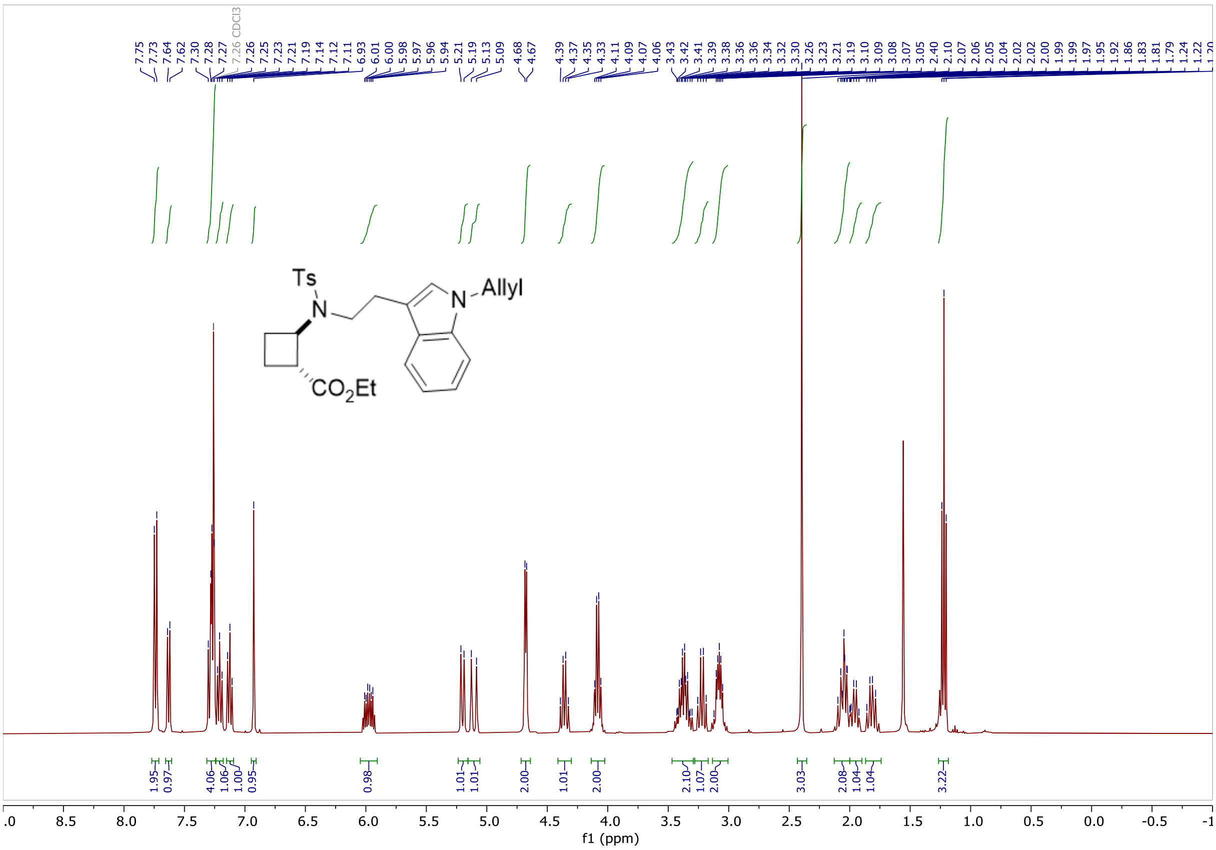

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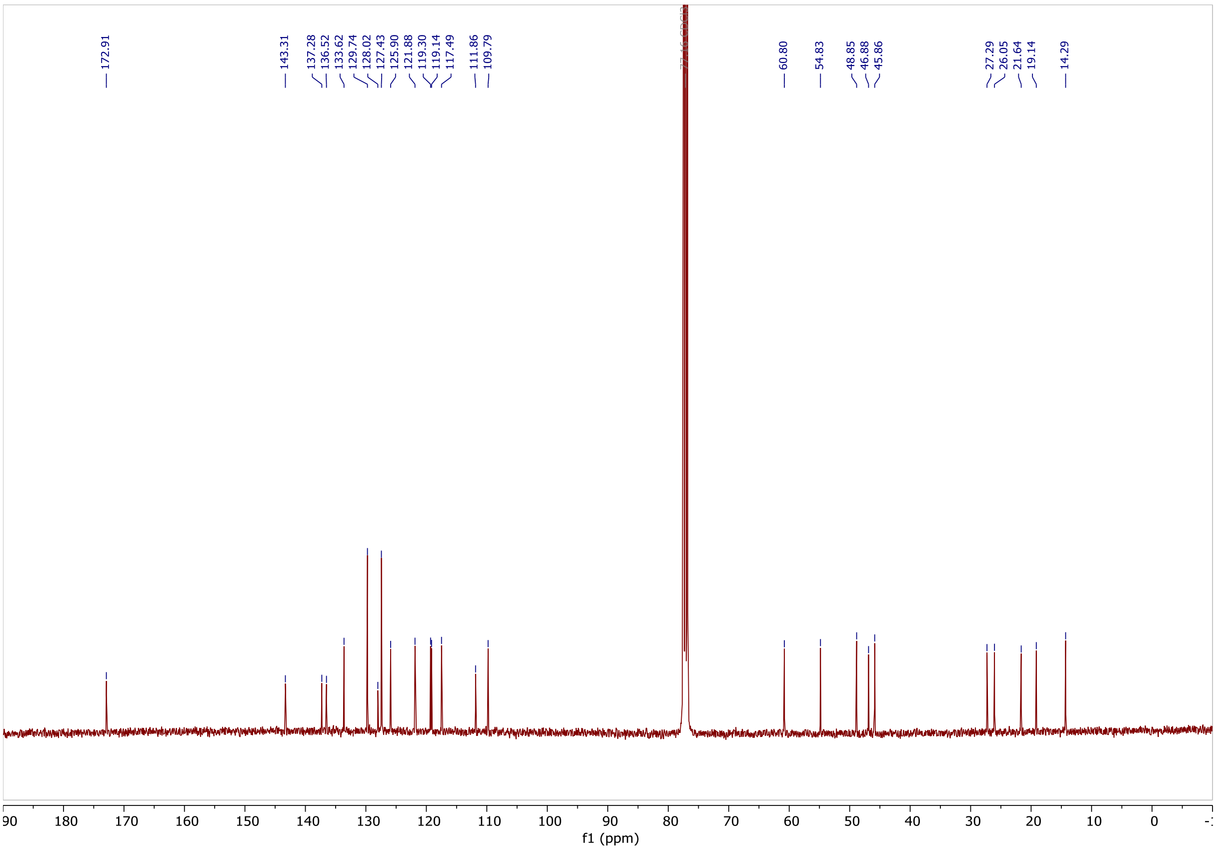

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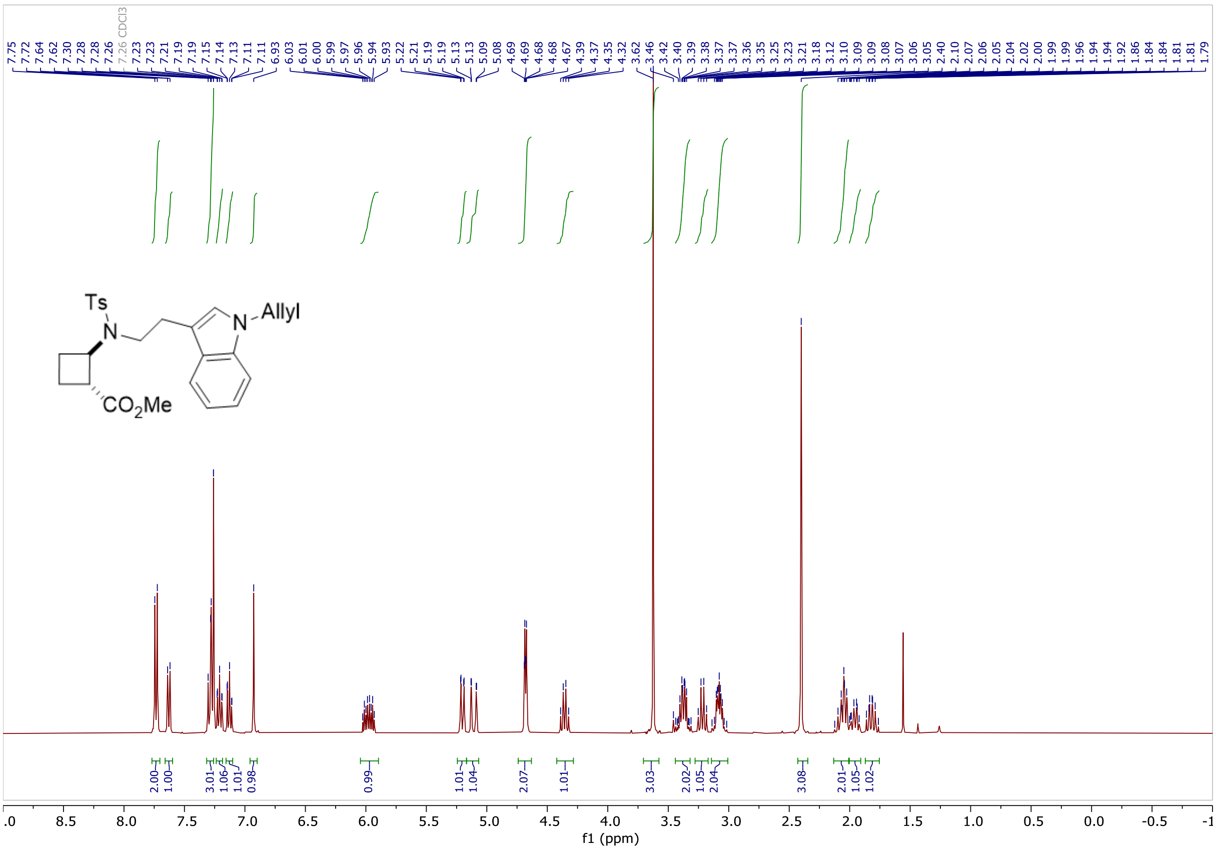

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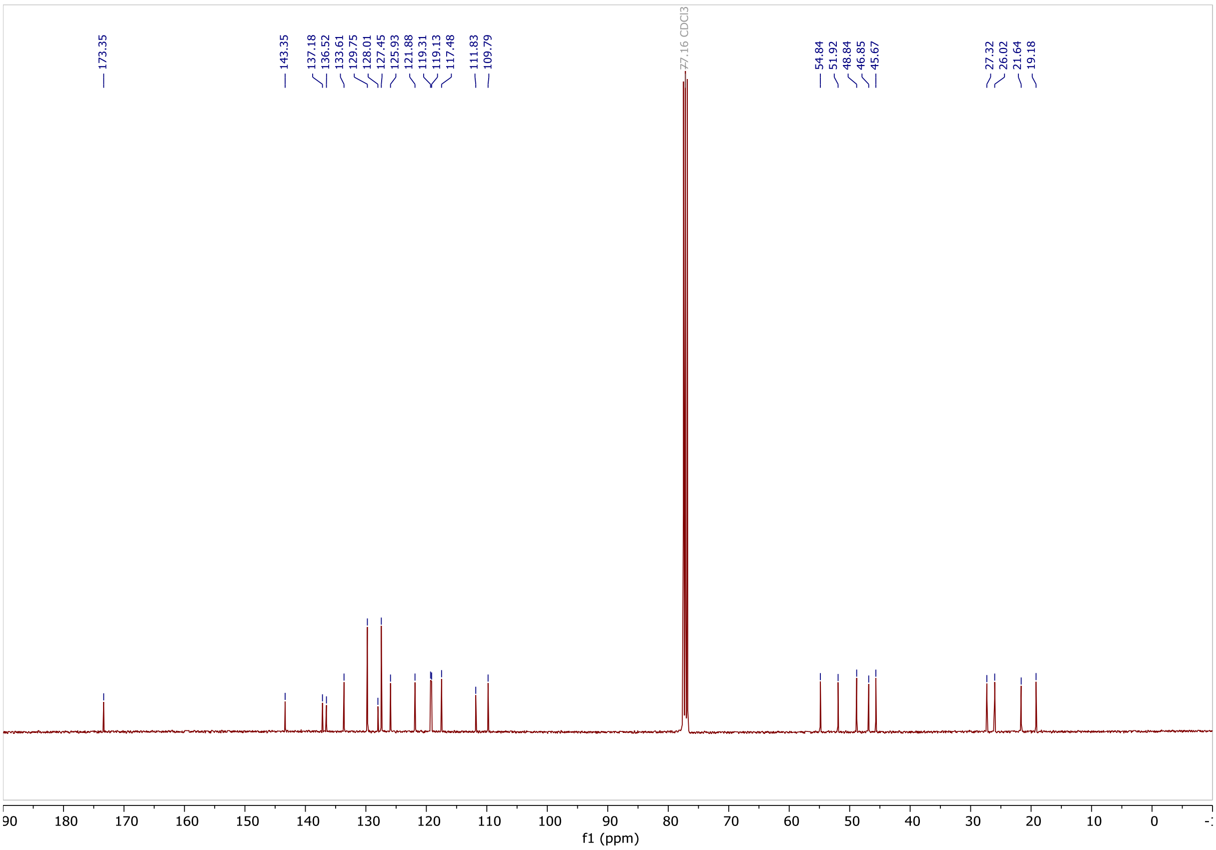

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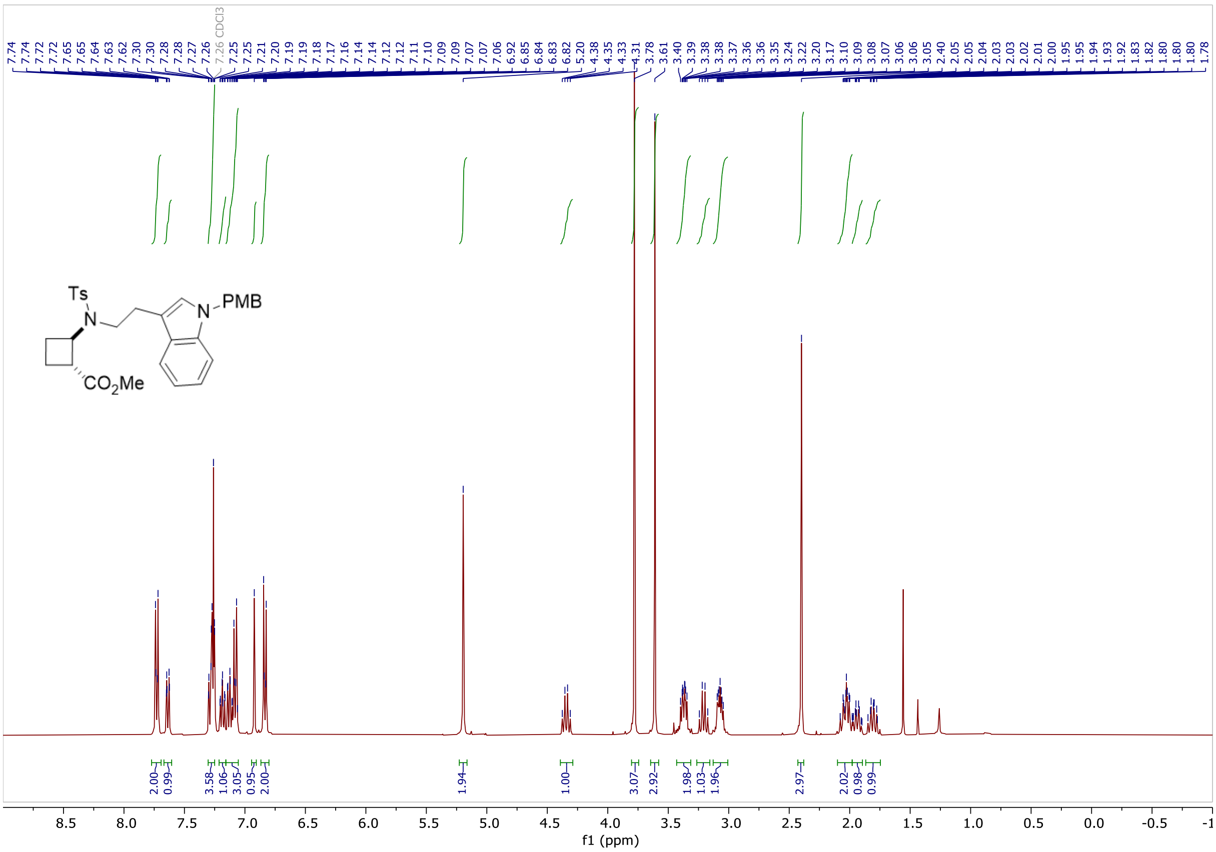

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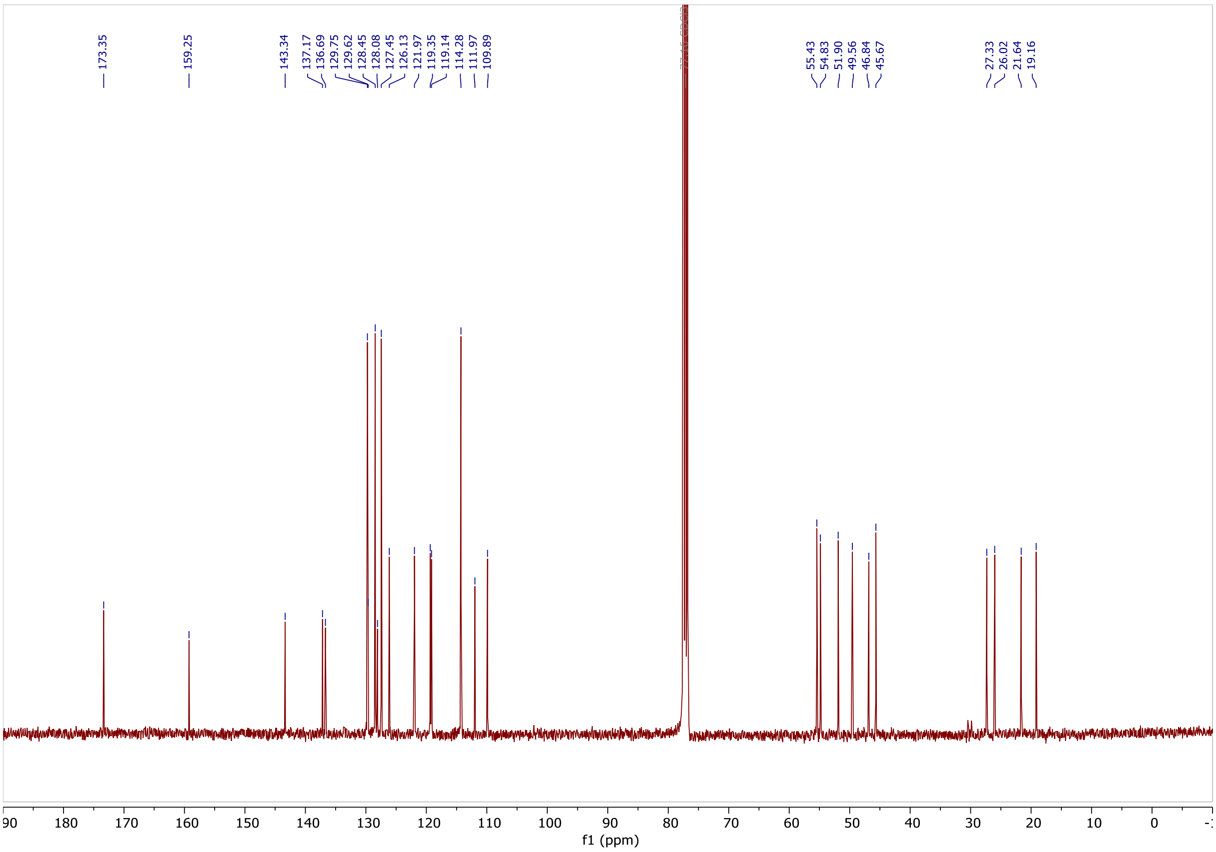

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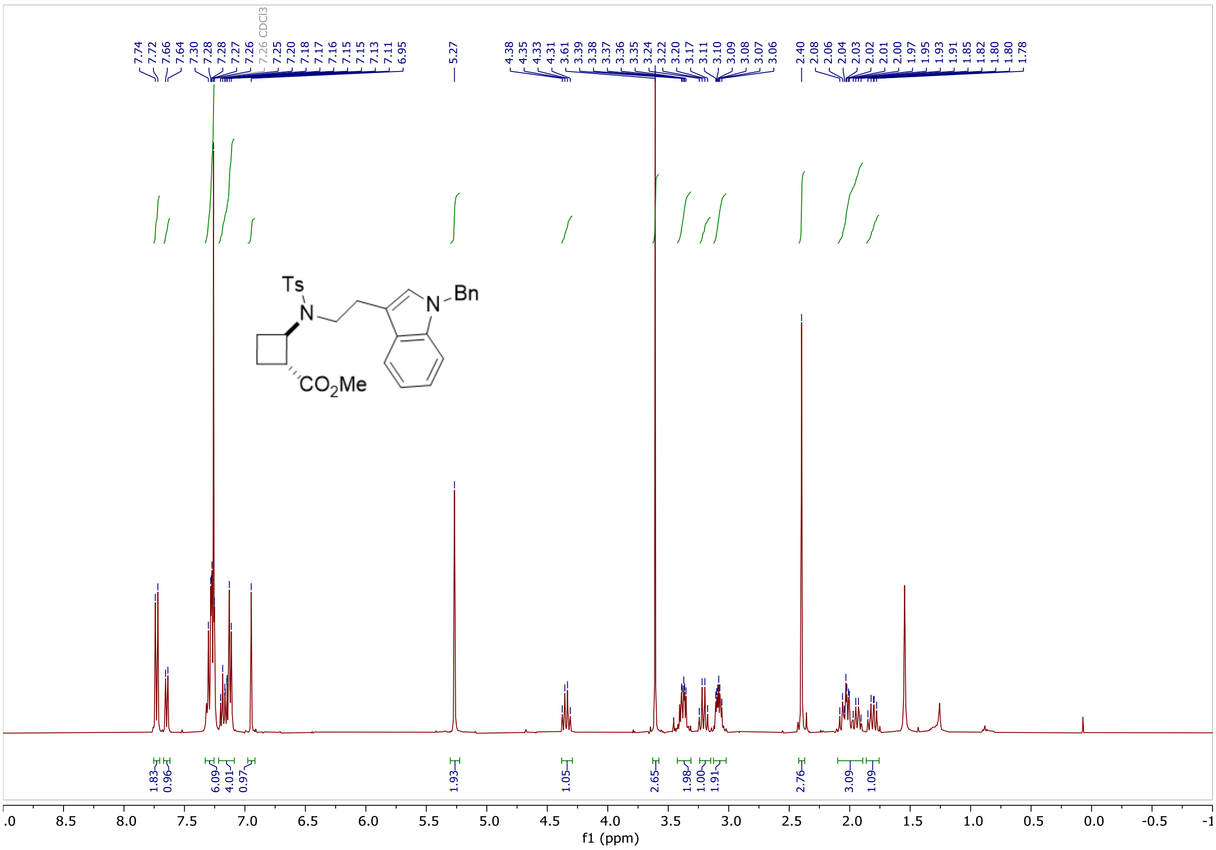

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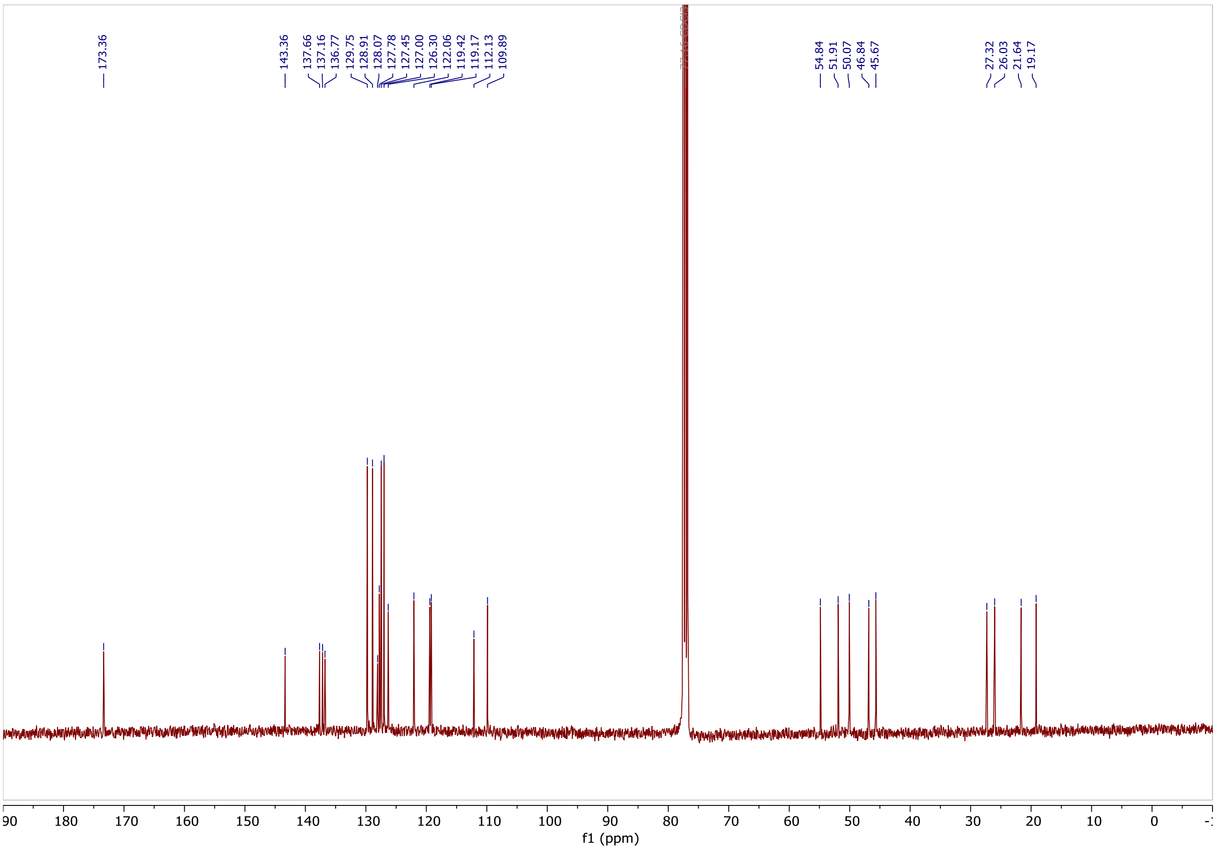

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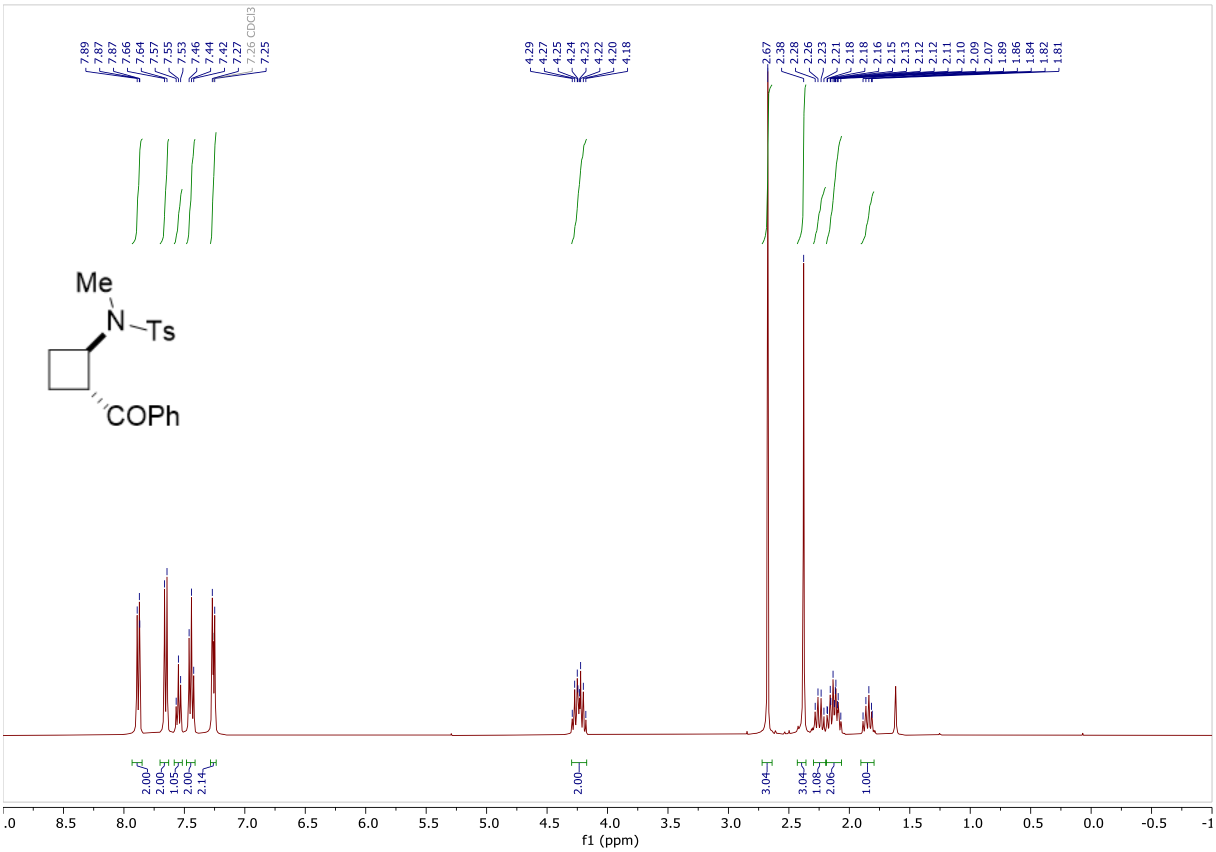

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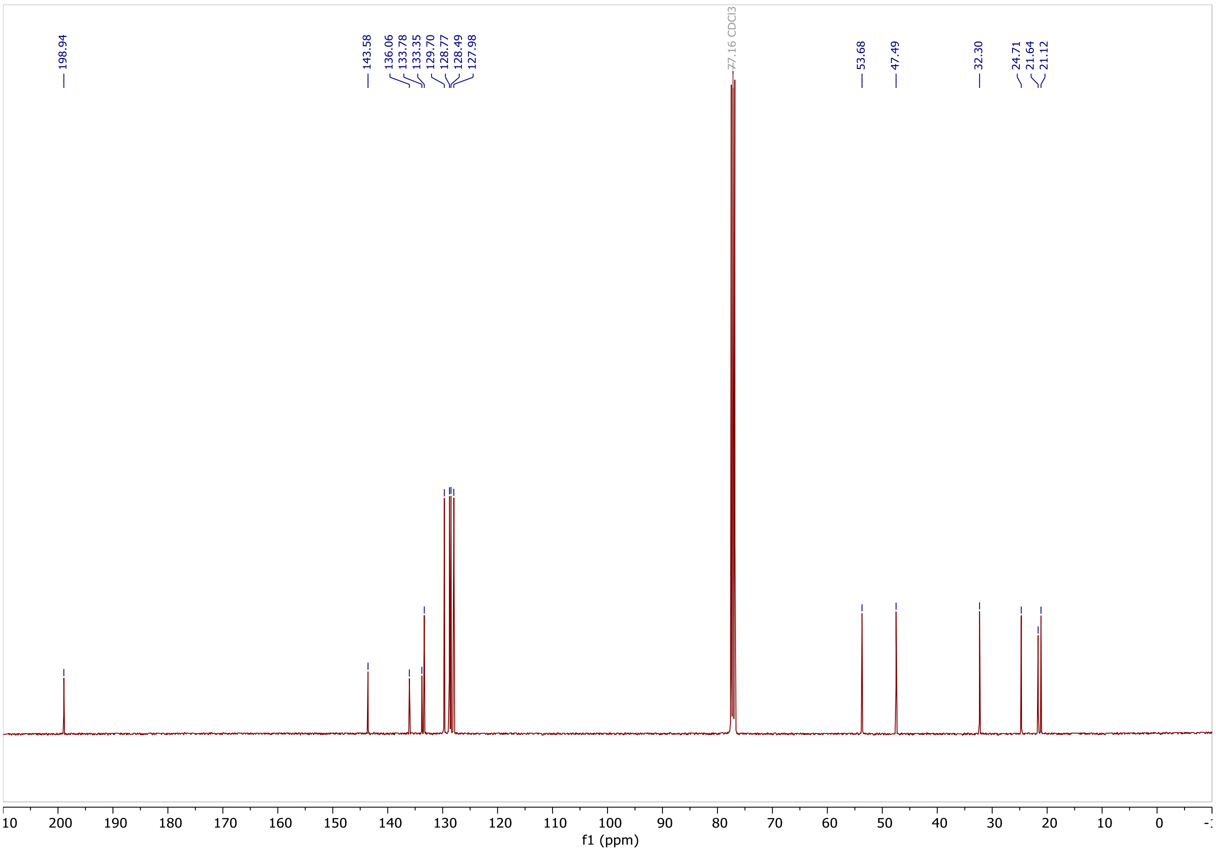

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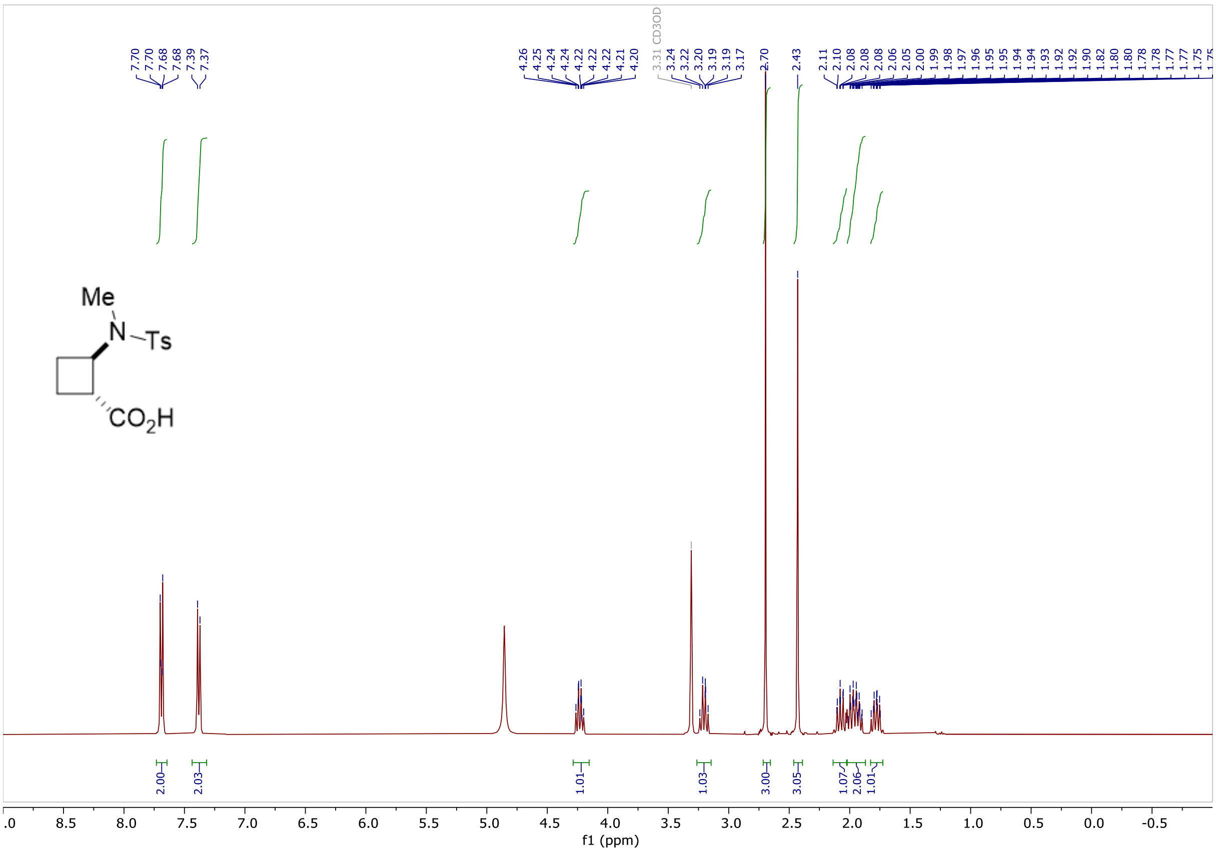

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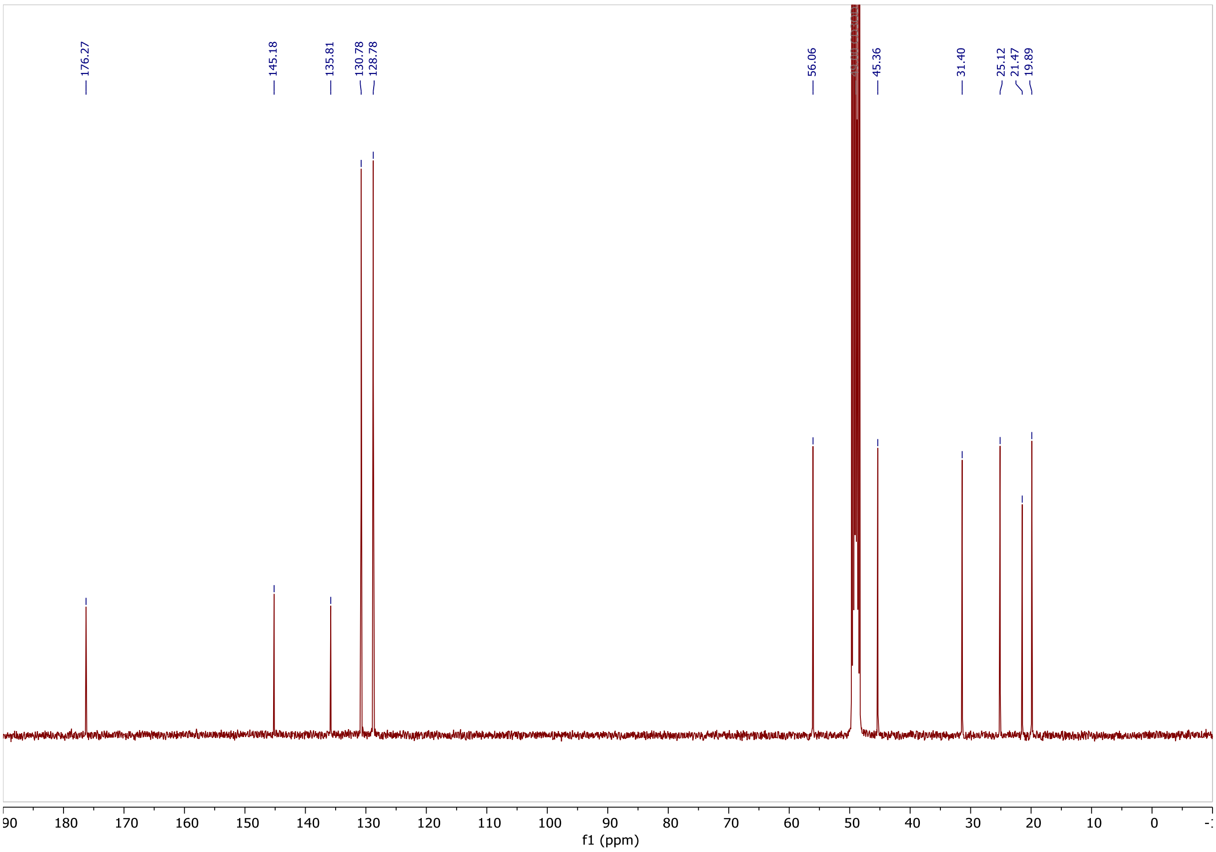

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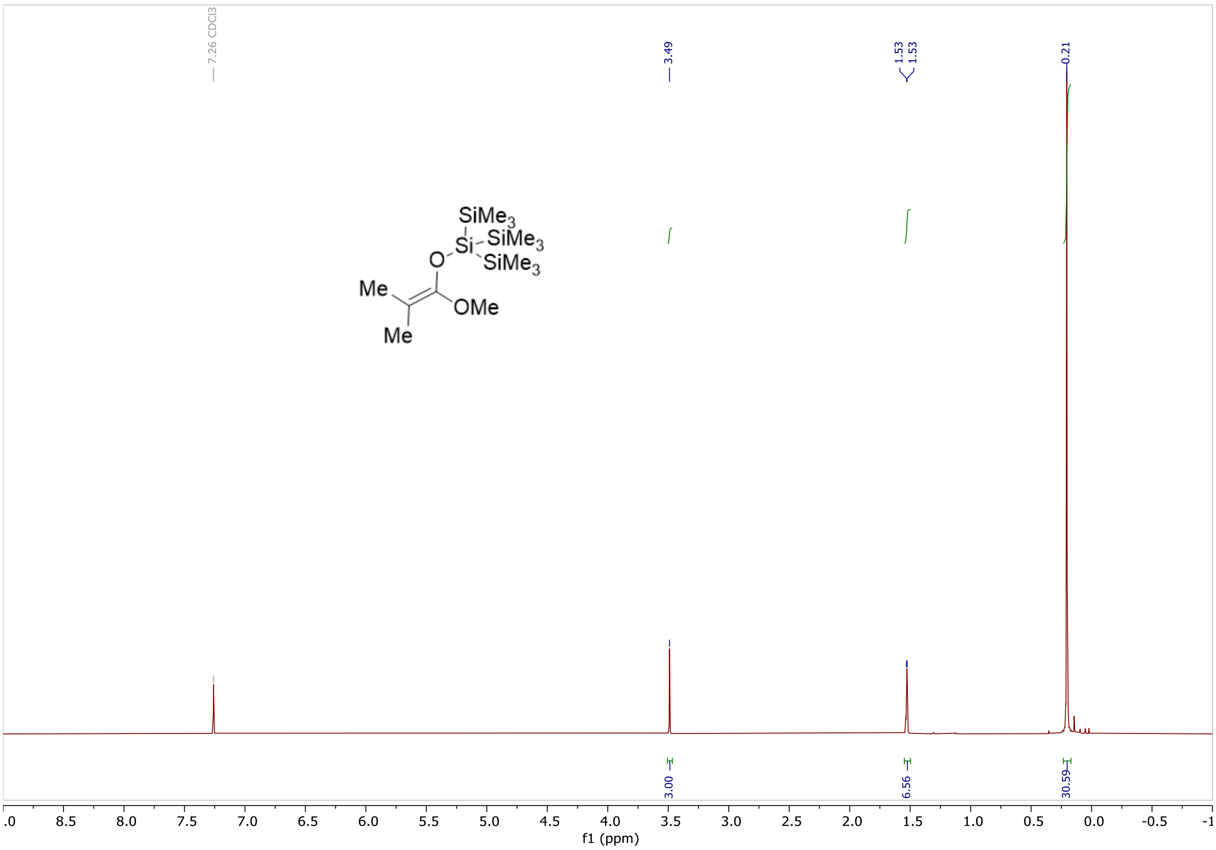

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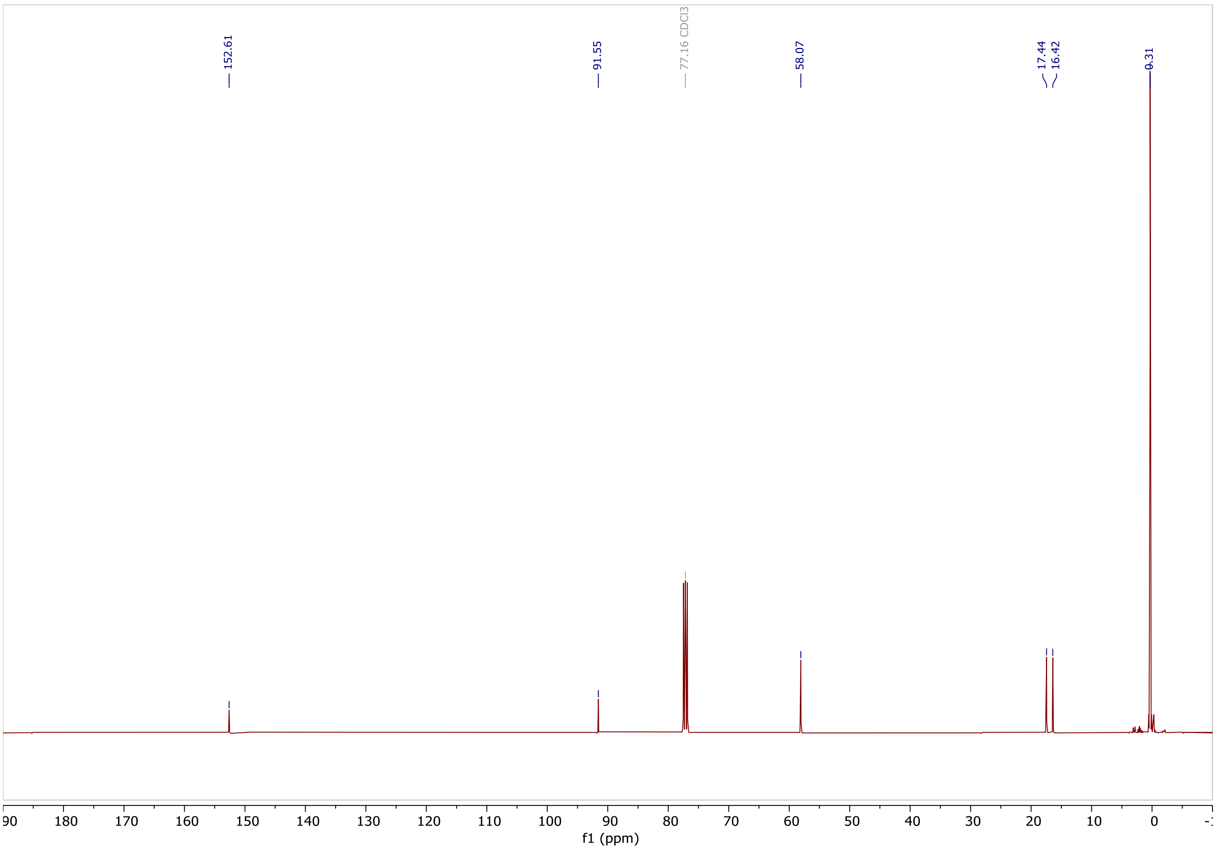

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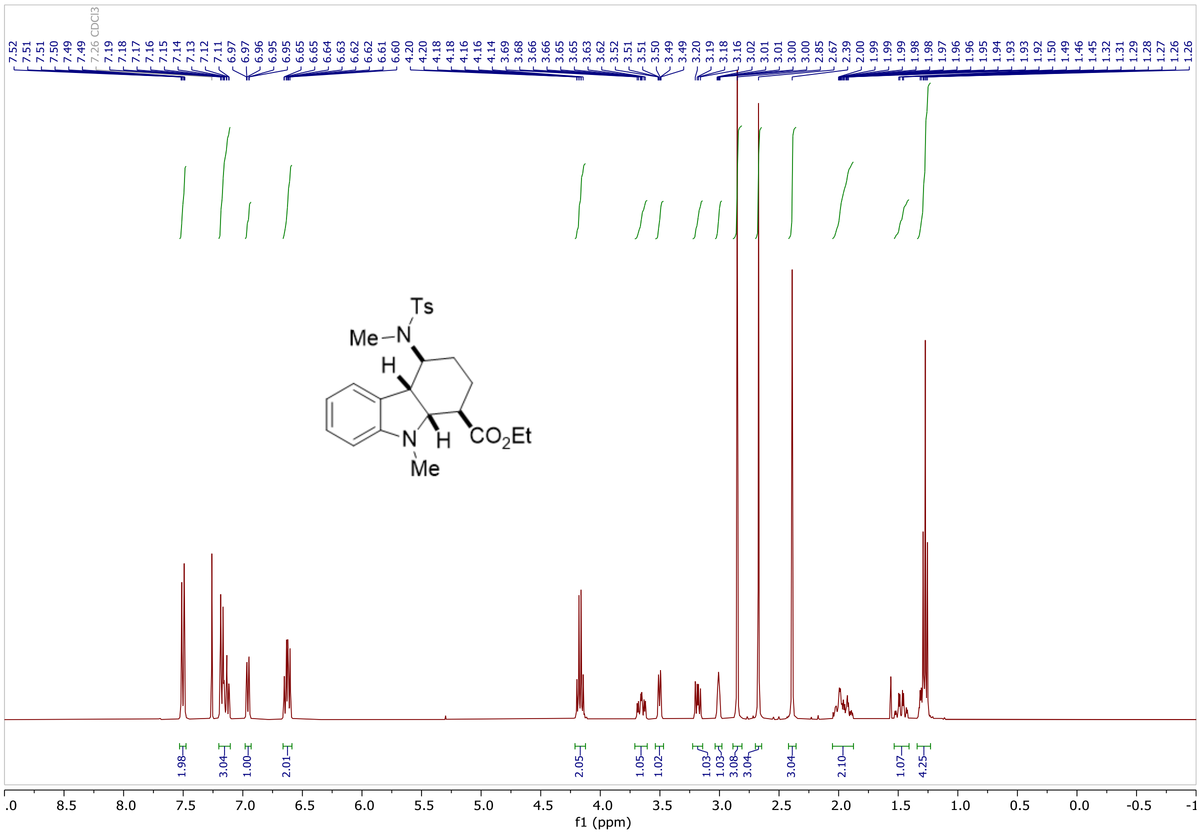

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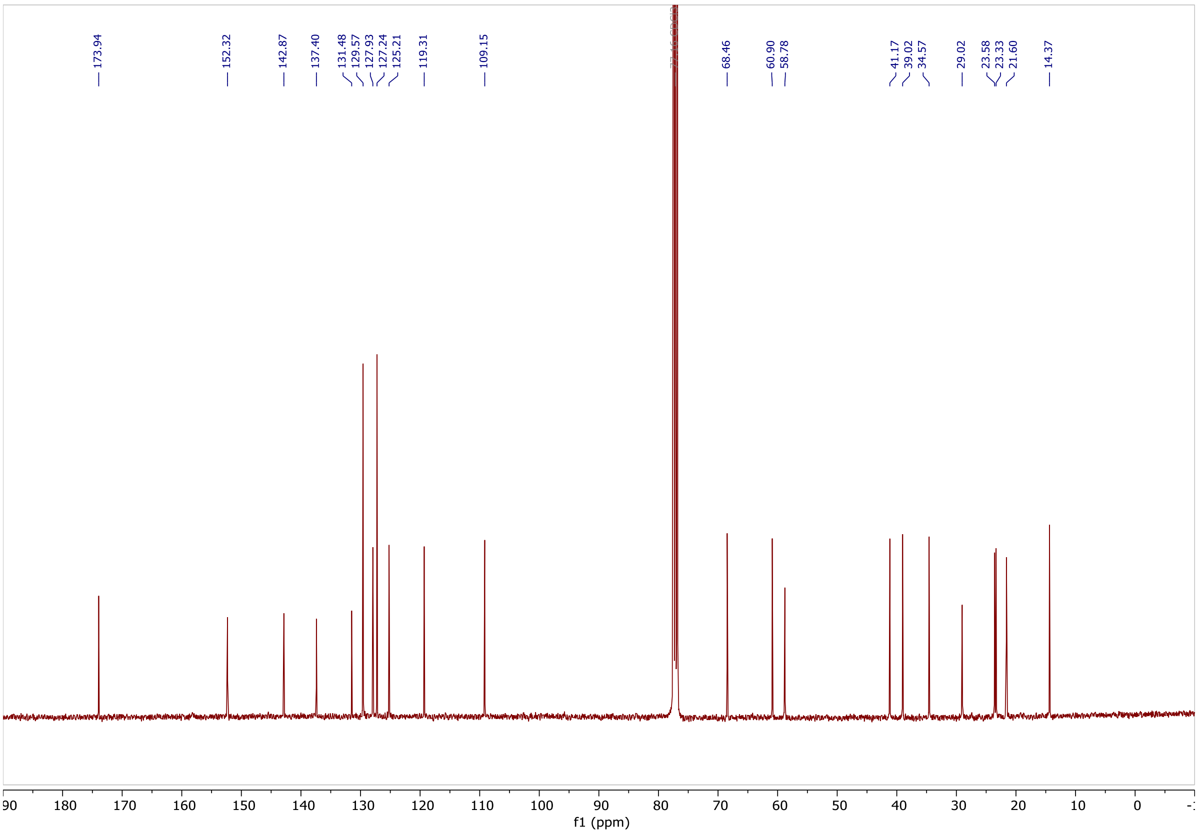
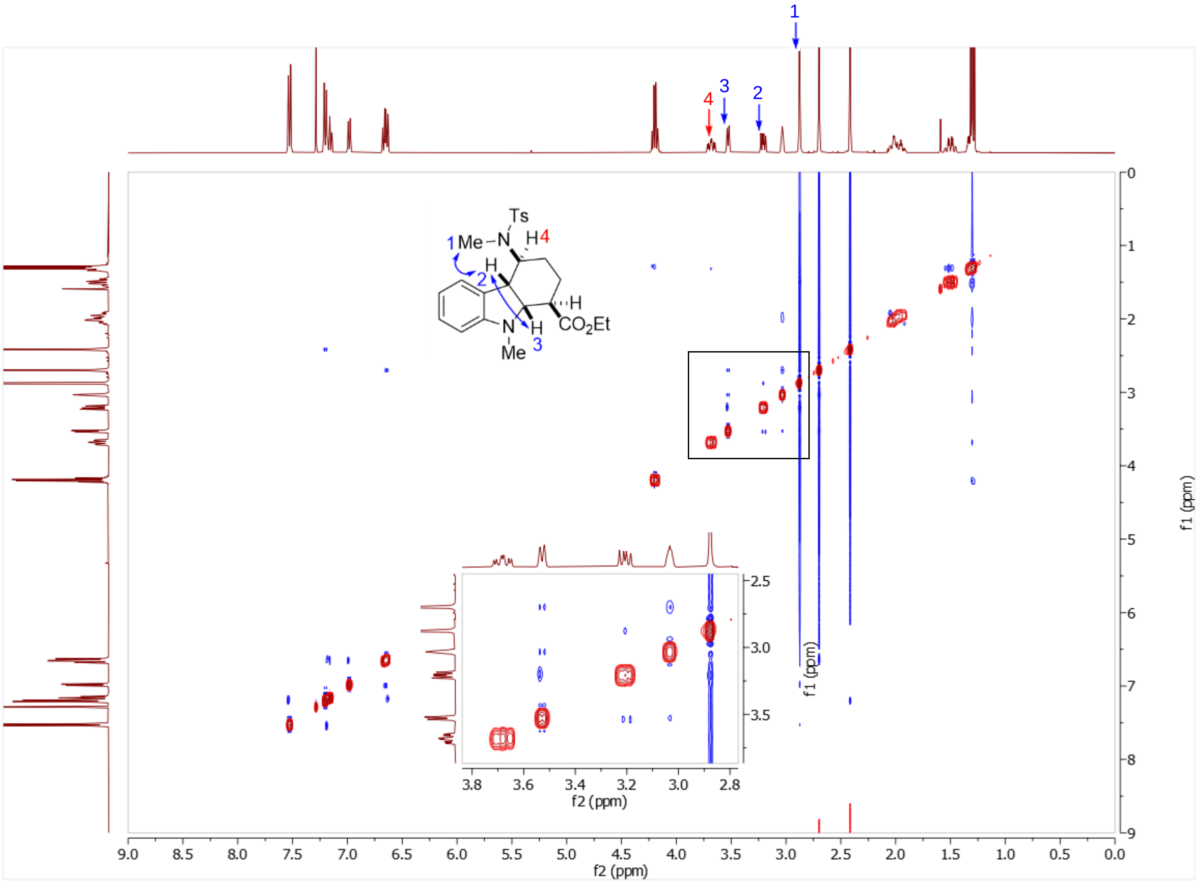
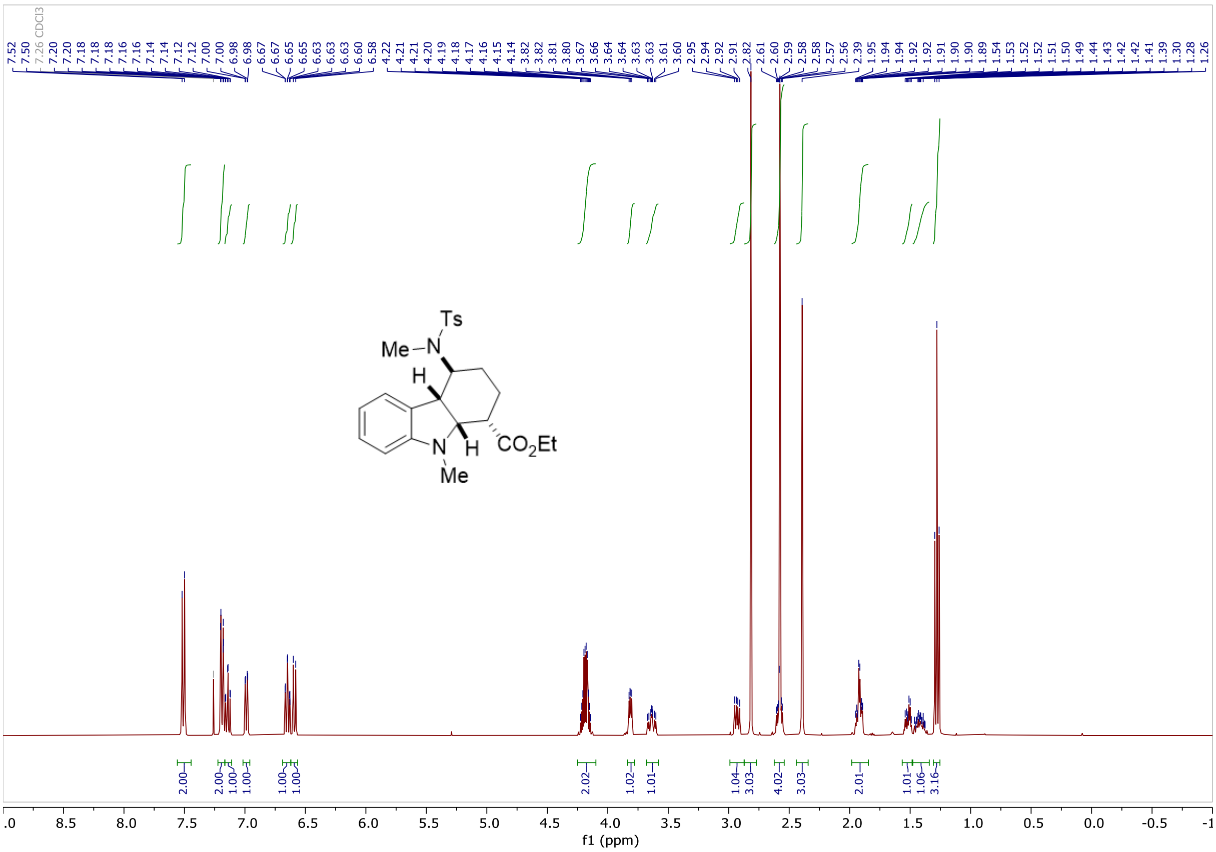


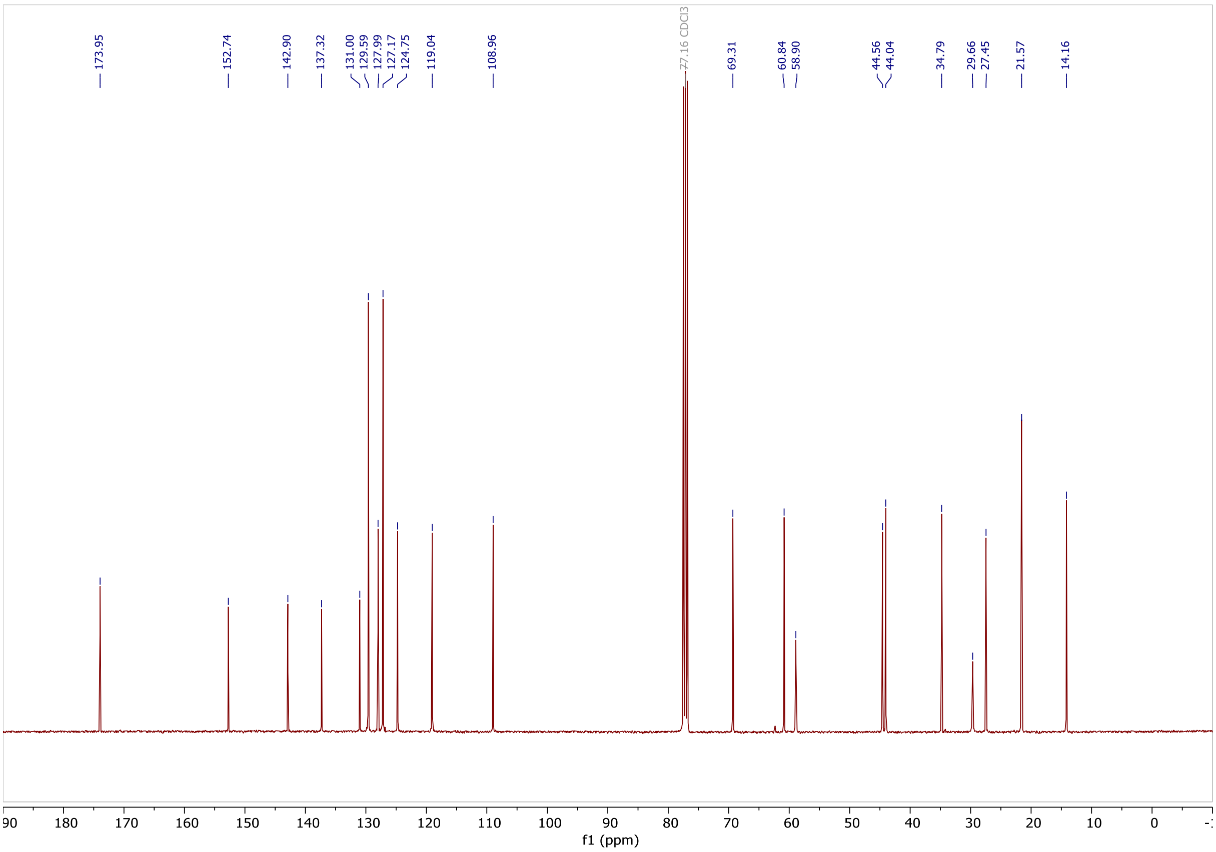
2D-NOESY (400 MHz, chloroform-*d*) (6a)



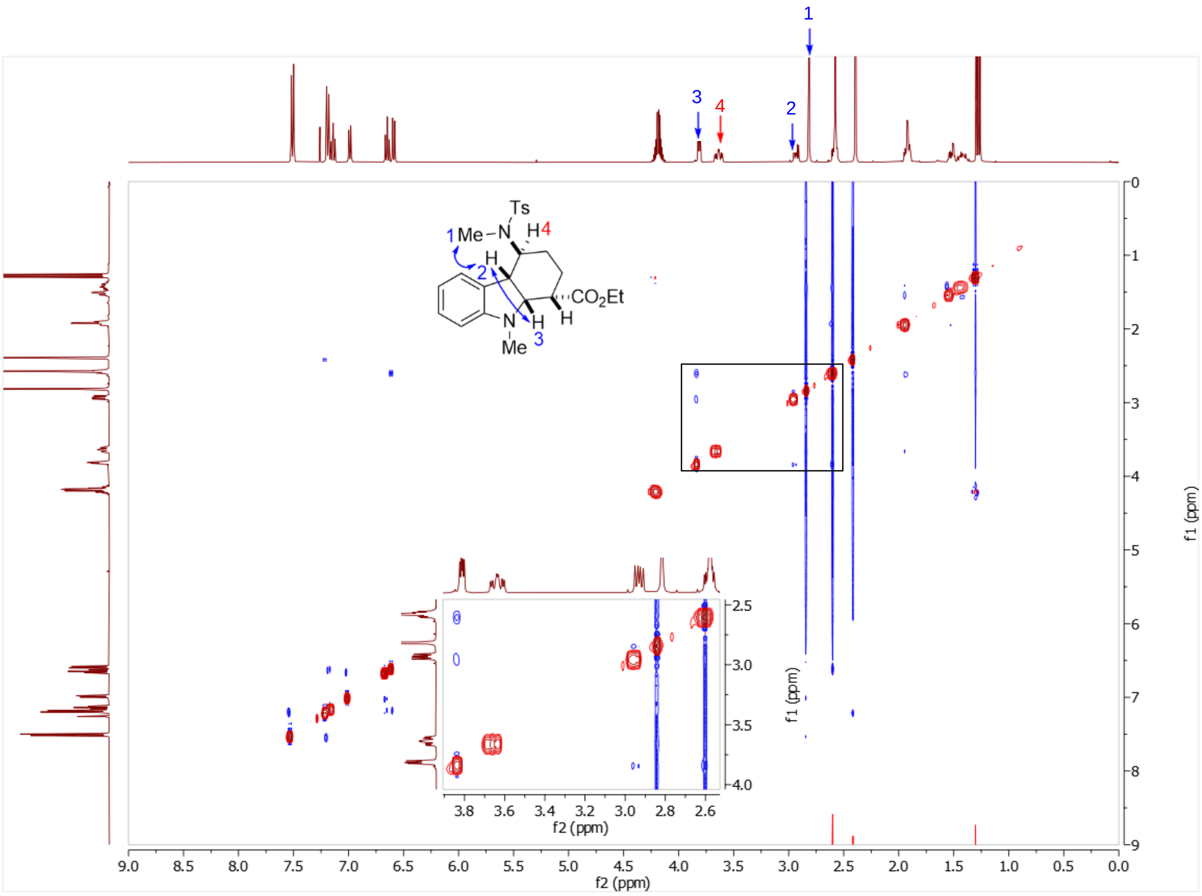
^{1}H-NMR (400 MHz, chloroform-*d*) (6’a)



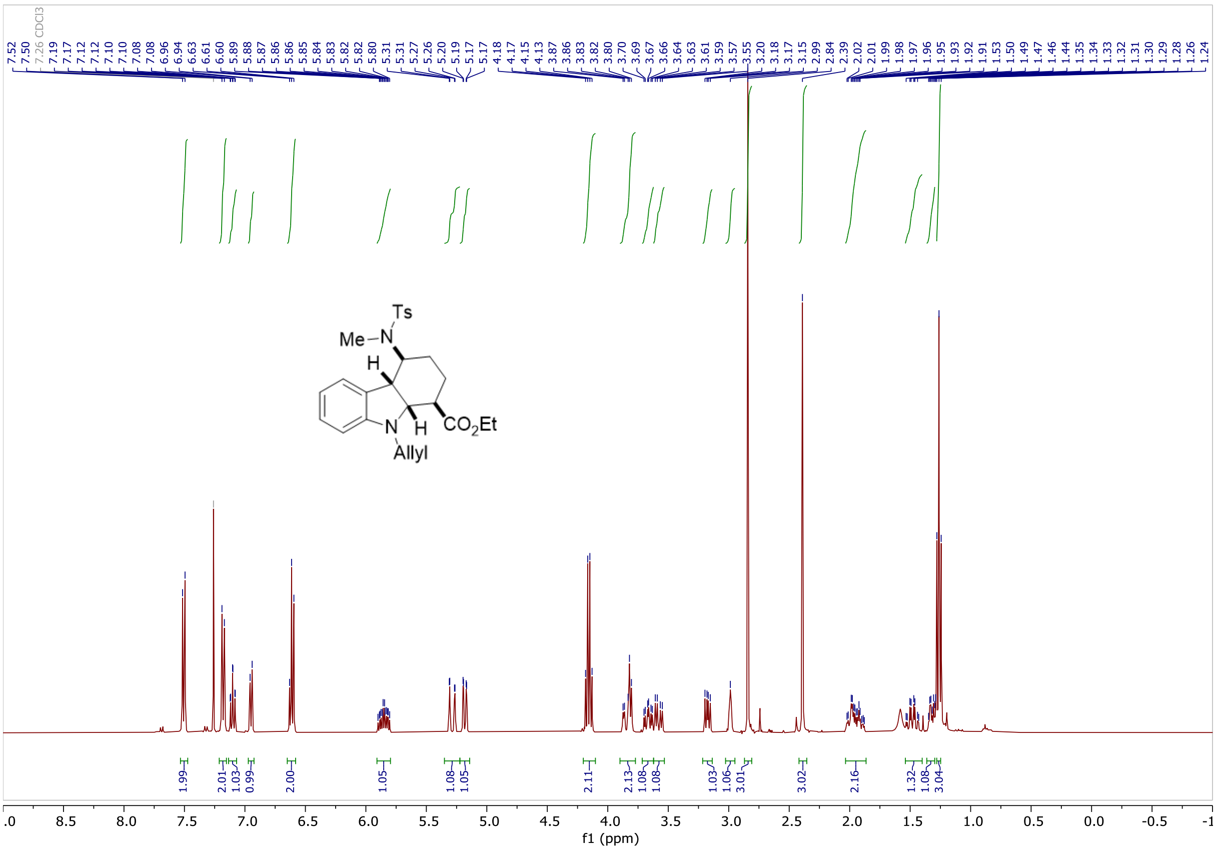
^{13}C-NMR (101 MHz, chloroform-*d*) (6’a)



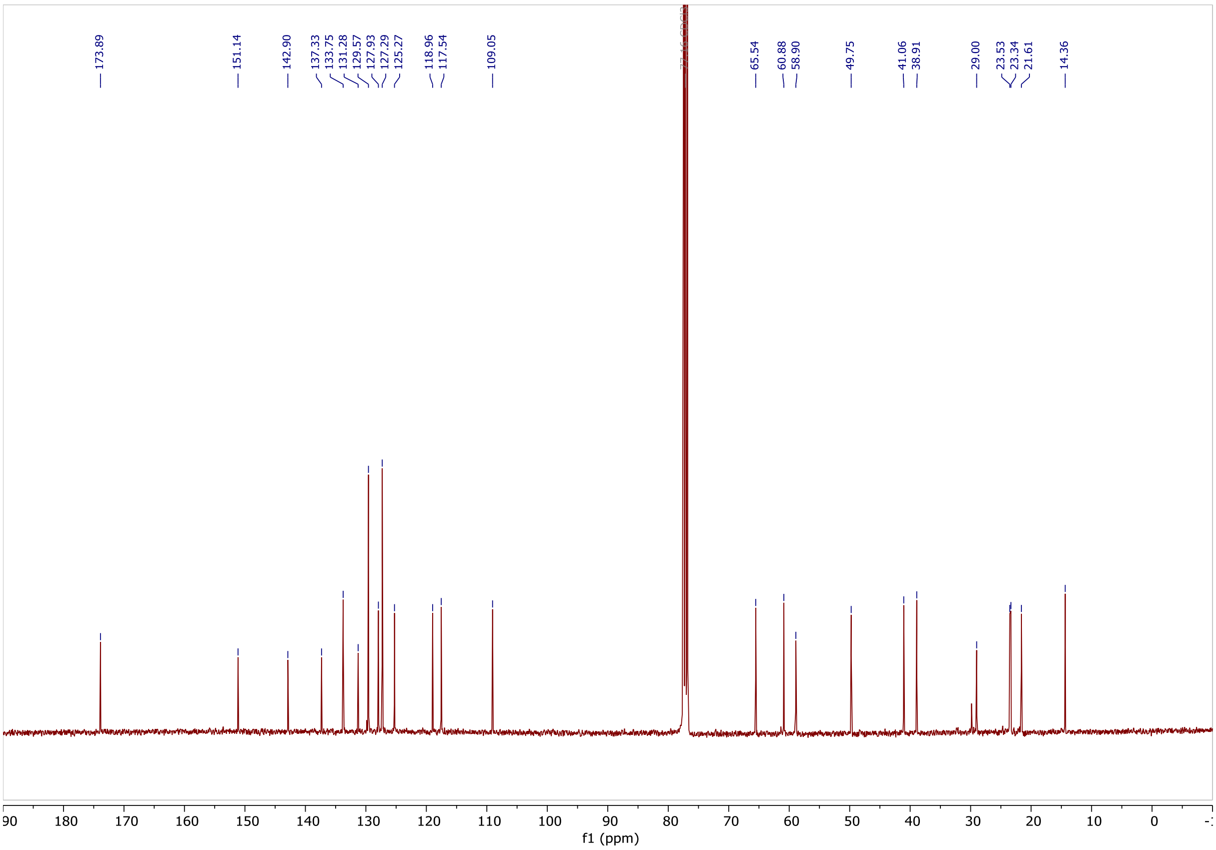
2D-NOESY (400 MHz, chloroform-*d*) (6’a)



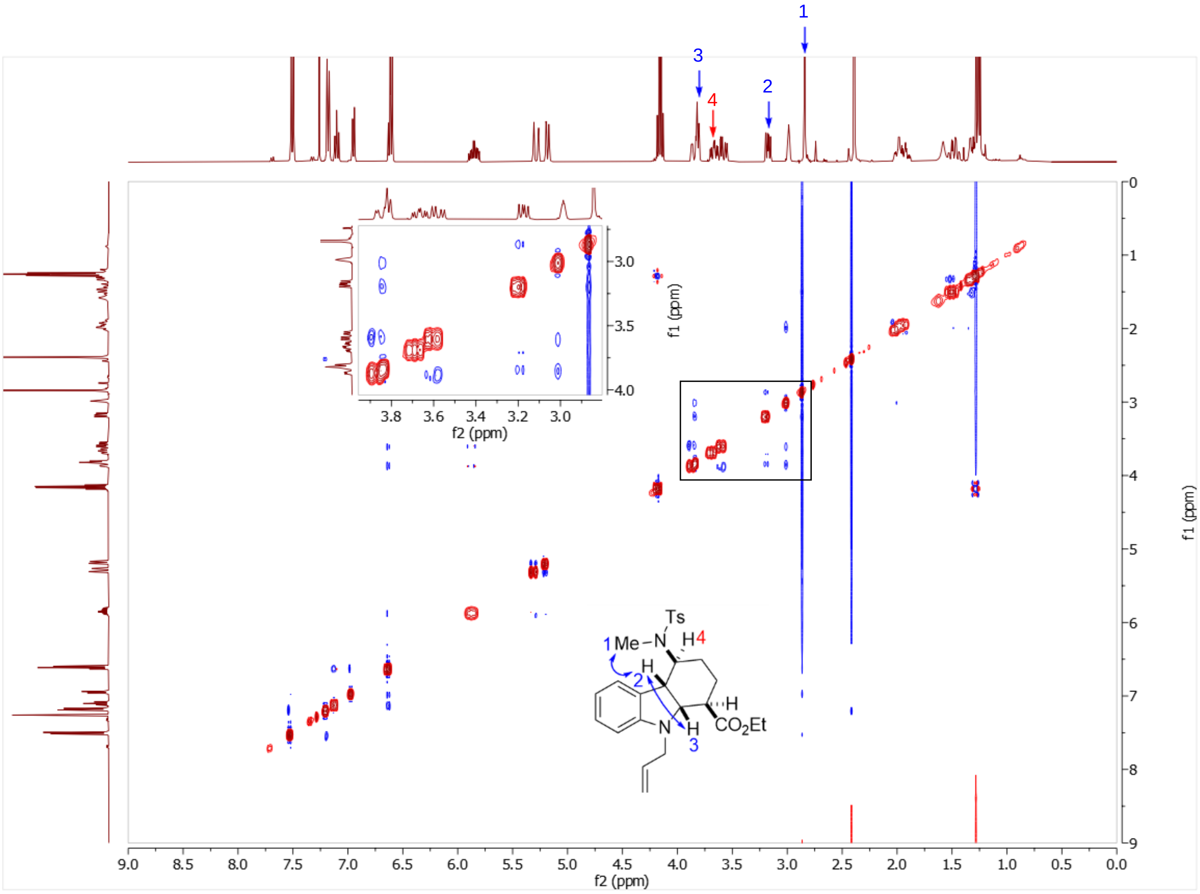
^{1}H-NMR (400 MHz, chloroform-*d*) (6b)



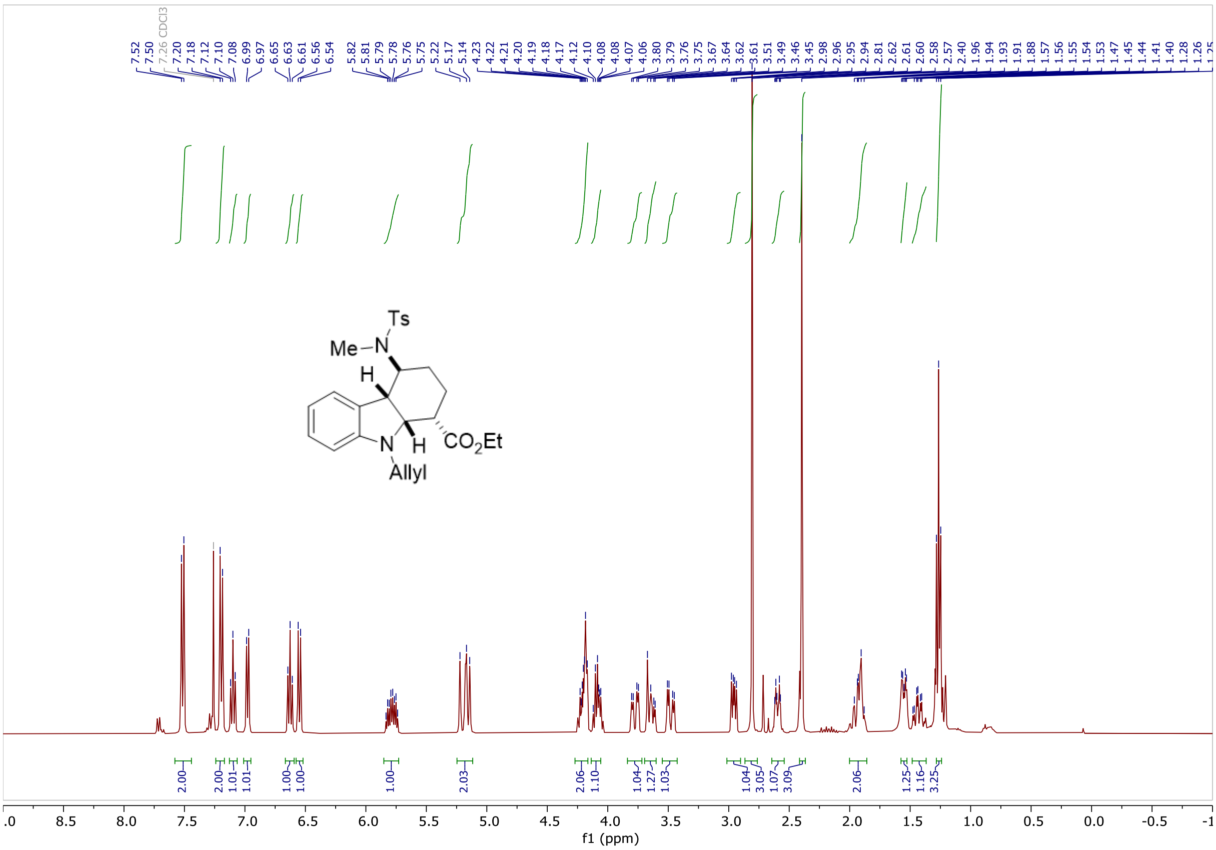
^{13}C-NMR (101 MHz, chloroform-*d*) (6b)



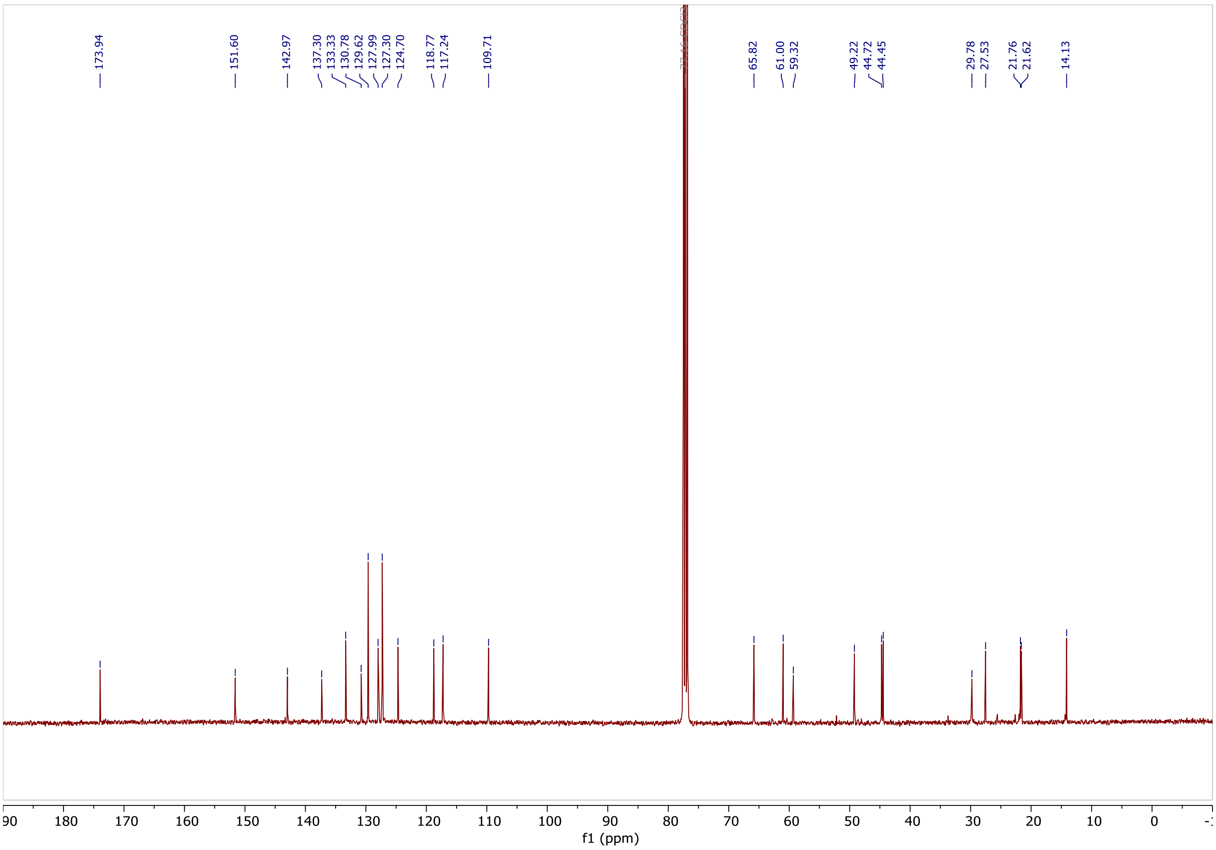
2D-NOESY (400 MHz, chloroform-*d*) (6b)



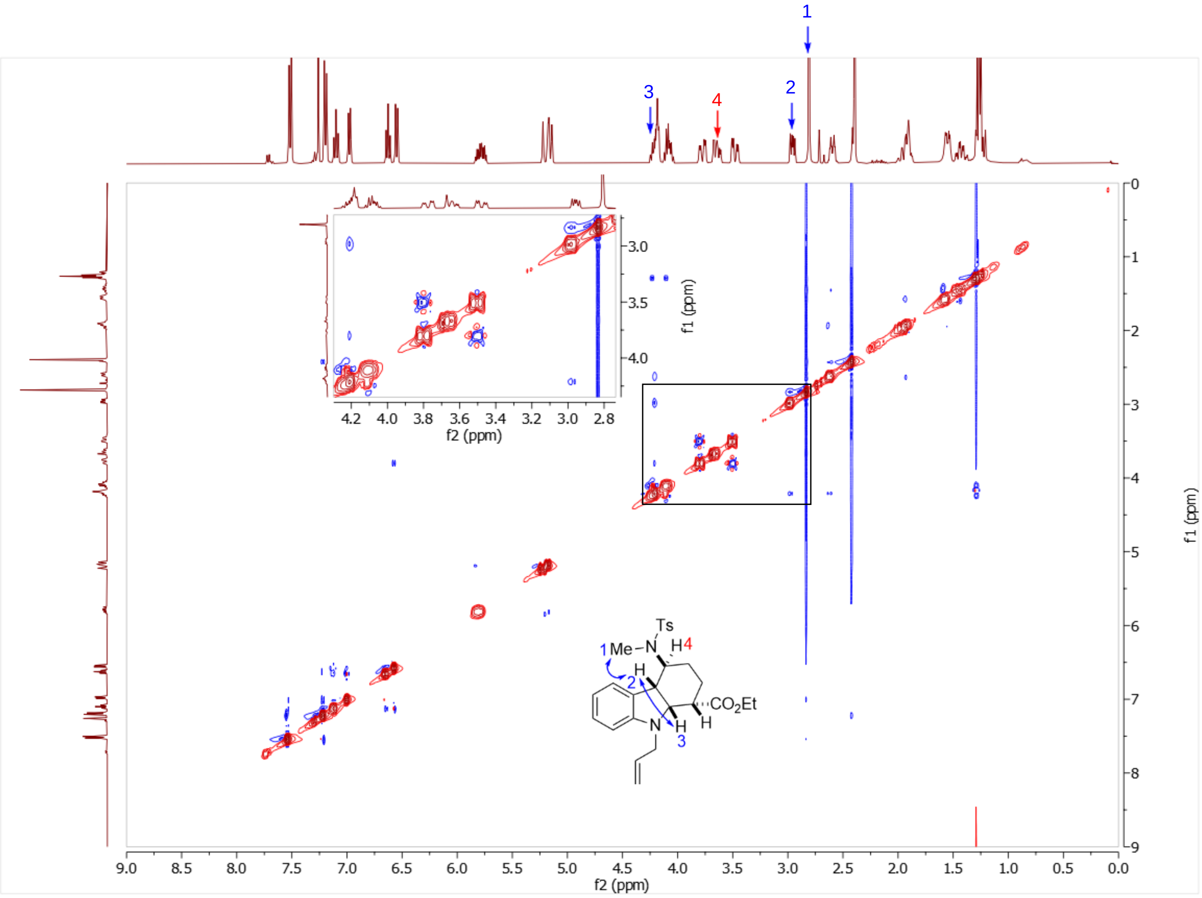
^{1}H-NMR (400 MHz, chloroform-*d*) (6’b) 93% purity, mixed with 6b



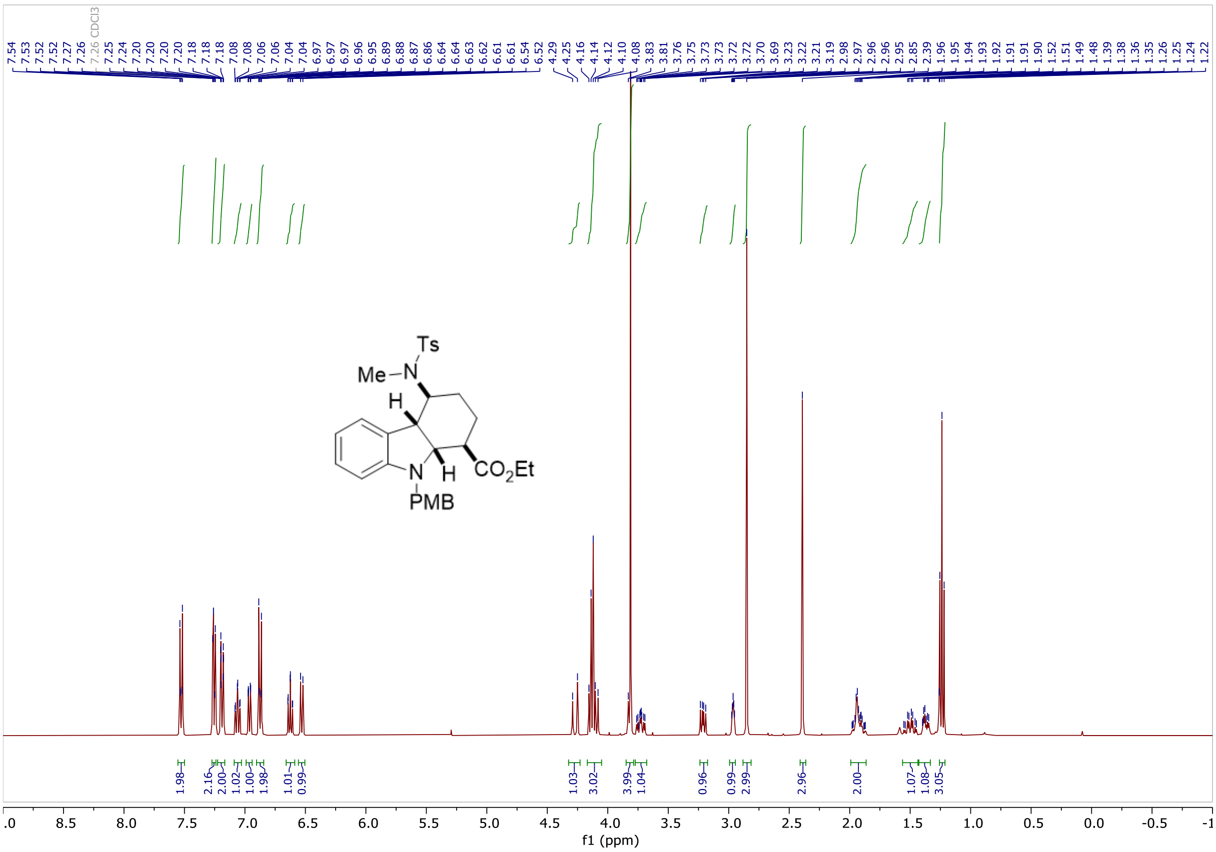
^{13}C-NMR (101 MHz, chloroform-*d*) (6’b) 93% purity, mixed with 6b



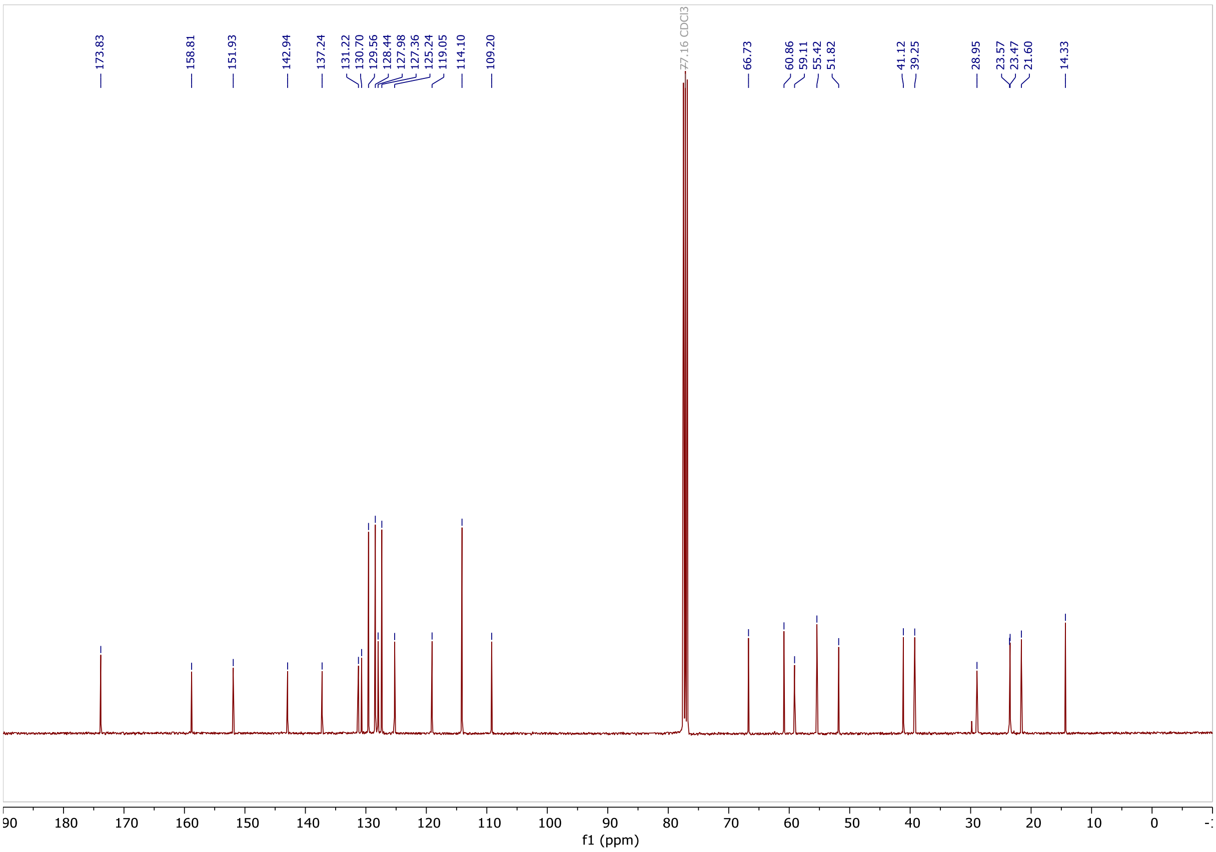
2D-NOESY (400 MHz, chloroform-*d*) (6’b)



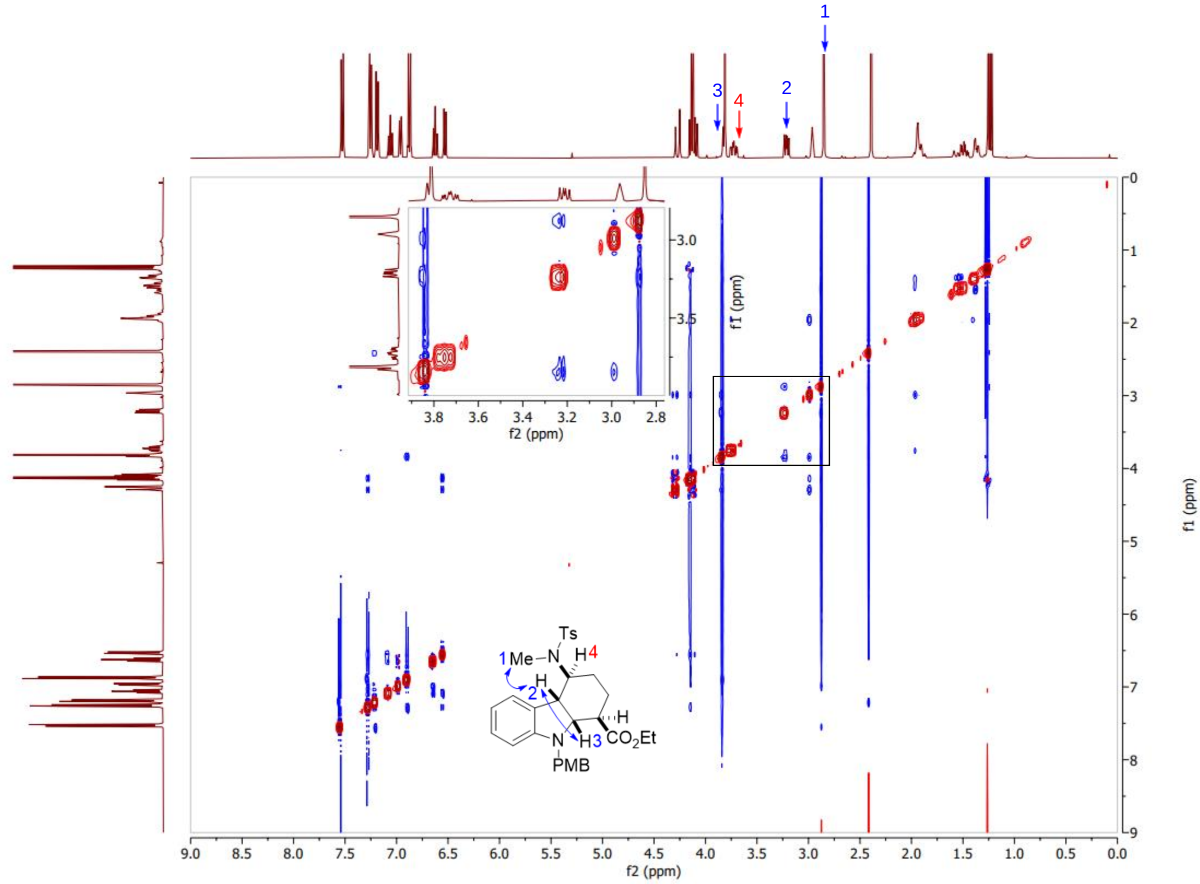
^{1}H-NMR (400 MHz, chloroform-*d*) (6c)



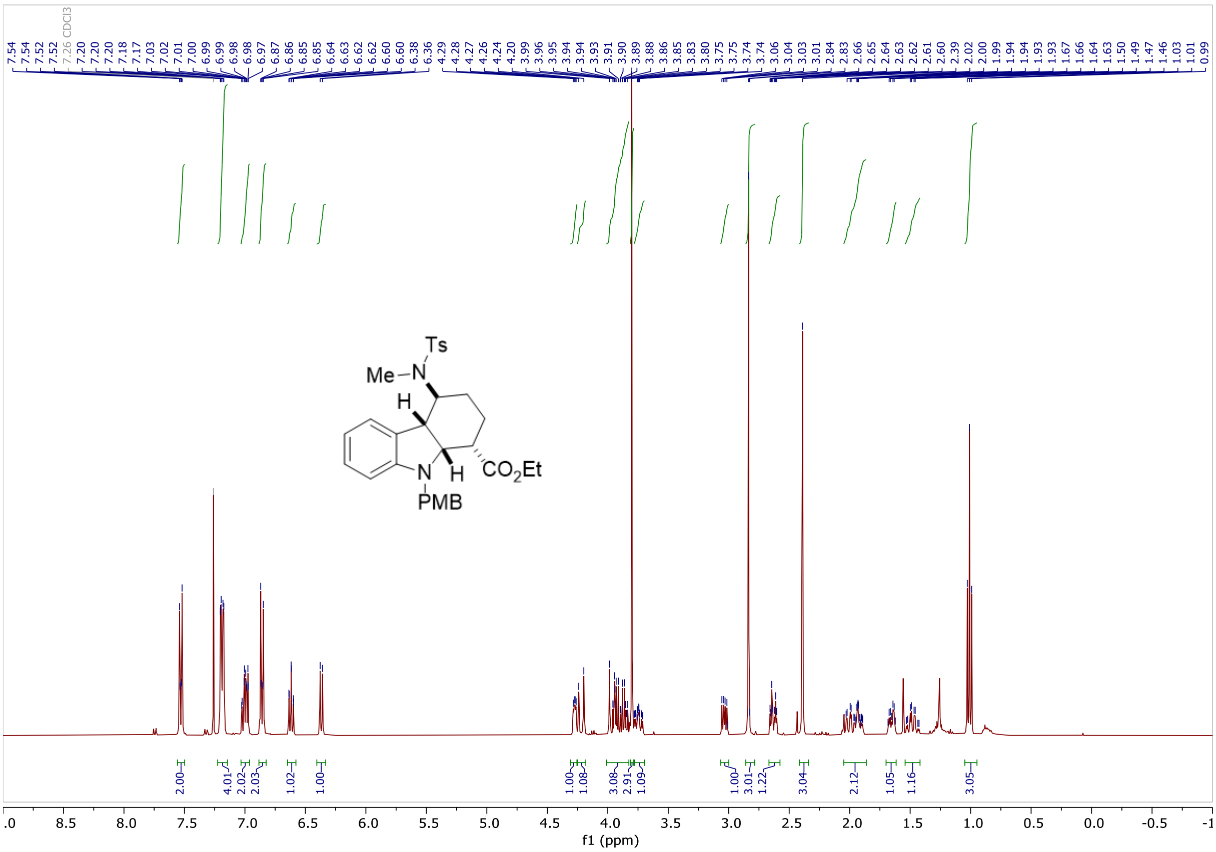
^{13}C-NMR (101 MHz, chloroform-*d*) (6c)



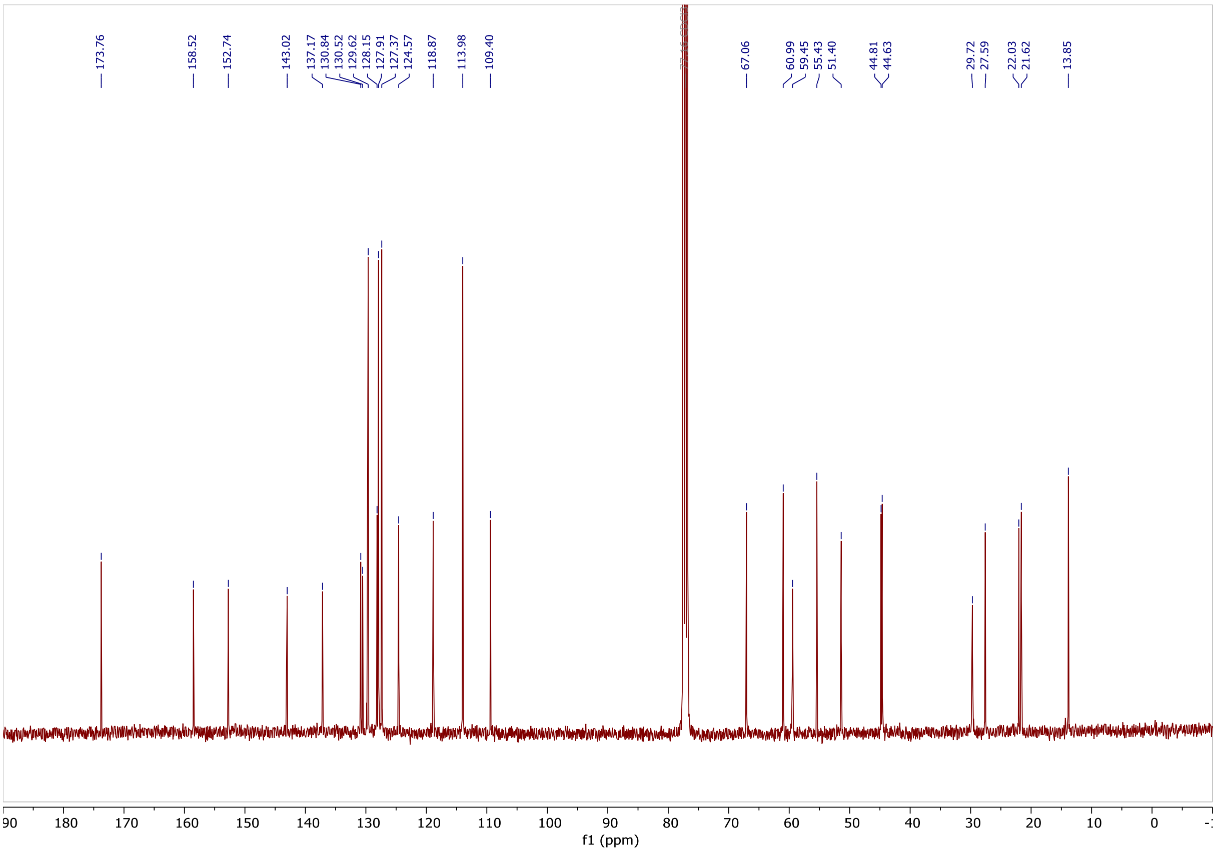
2D-NOESY (400 MHz, chloroform-*d*) (6c)



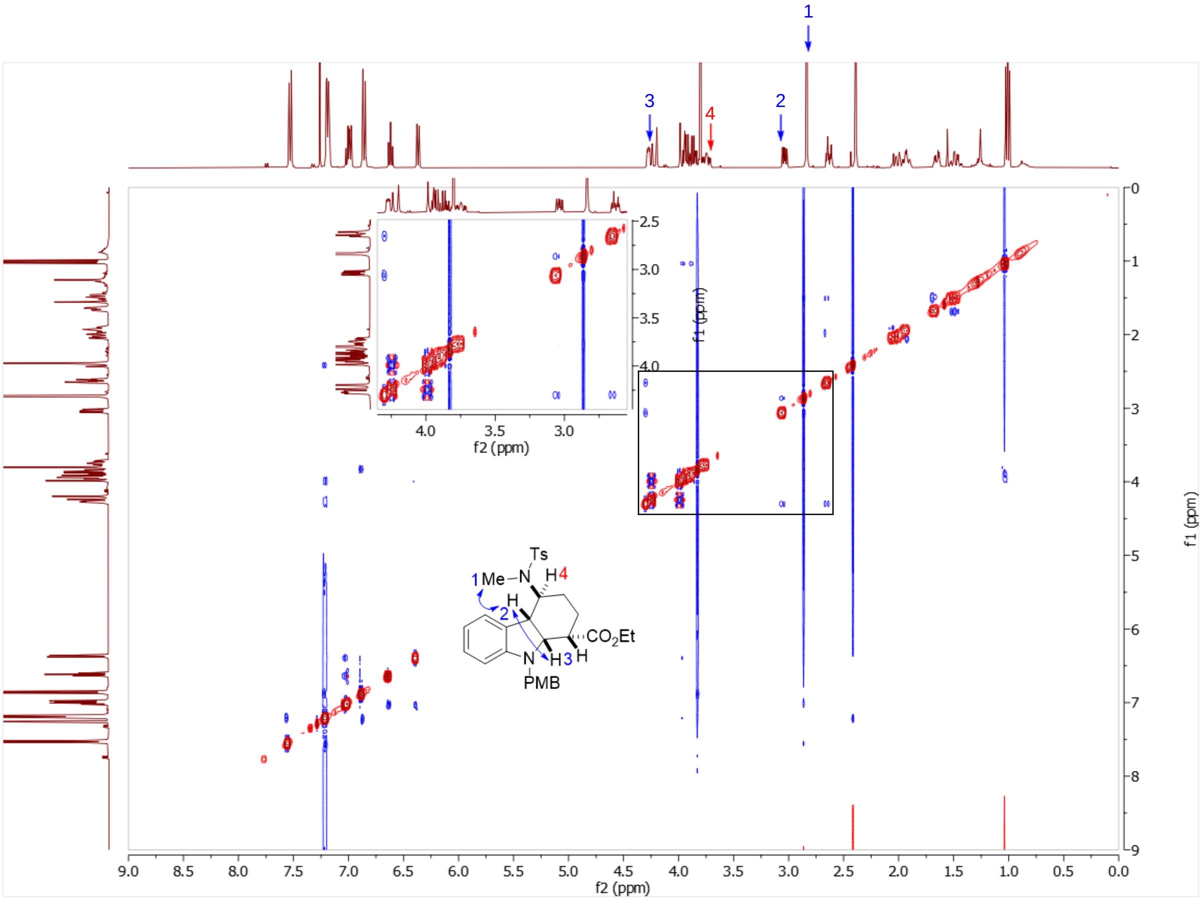
^{1}H-NMR (400 MHz, chloroform-*d*) (6’c)



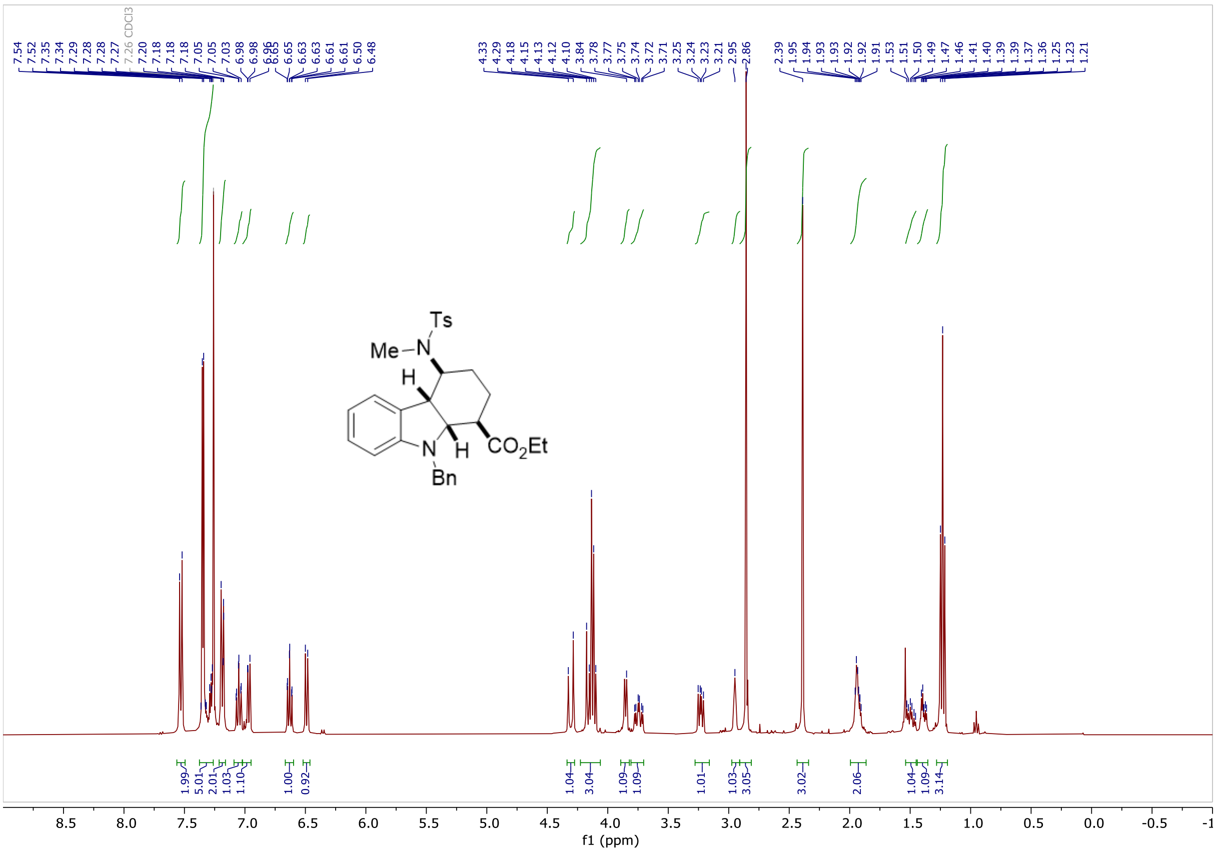
^{13}C-NMR (101 MHz, chloroform-*d*) (6’c)



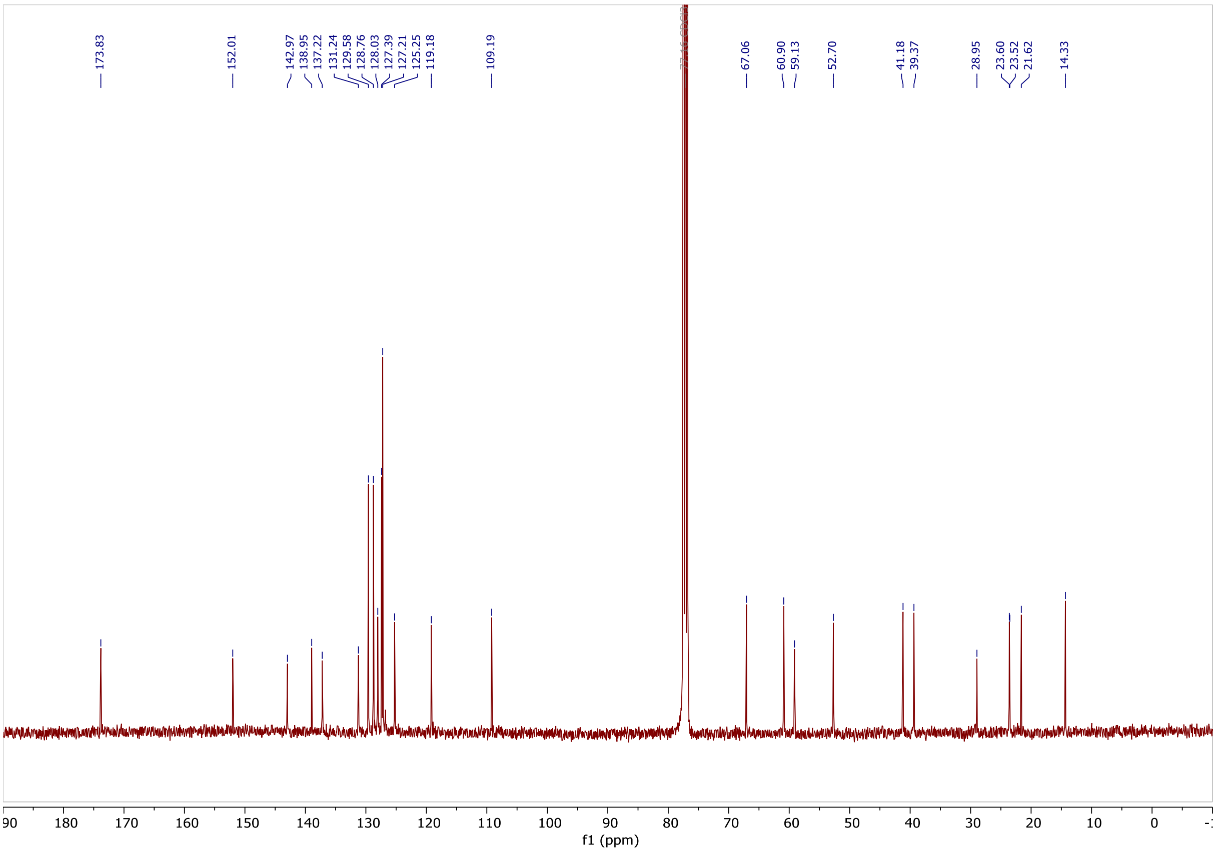
2D-NOESY (400 MHz, chloroform-*d*) (6’c)



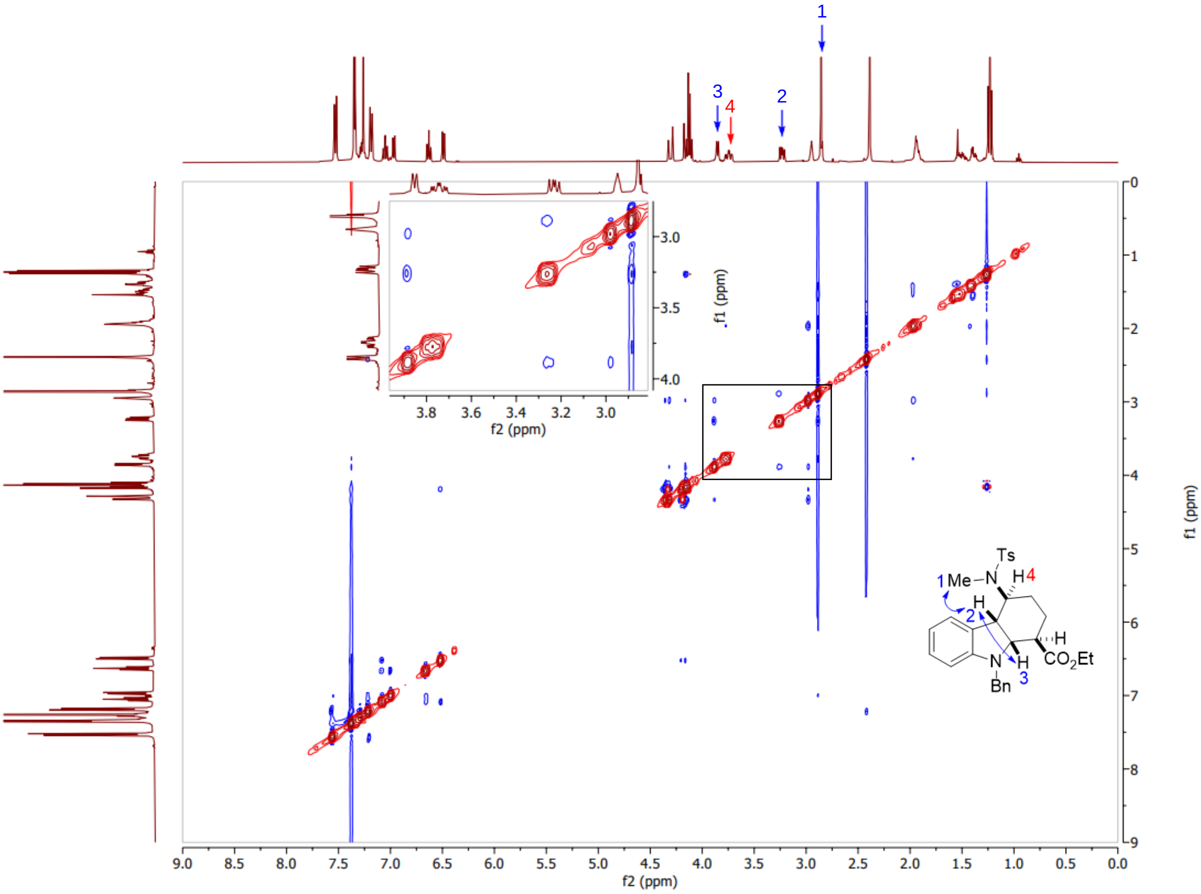
^{1}H-NMR (400 MHz, chloroform-*d*) (6d)



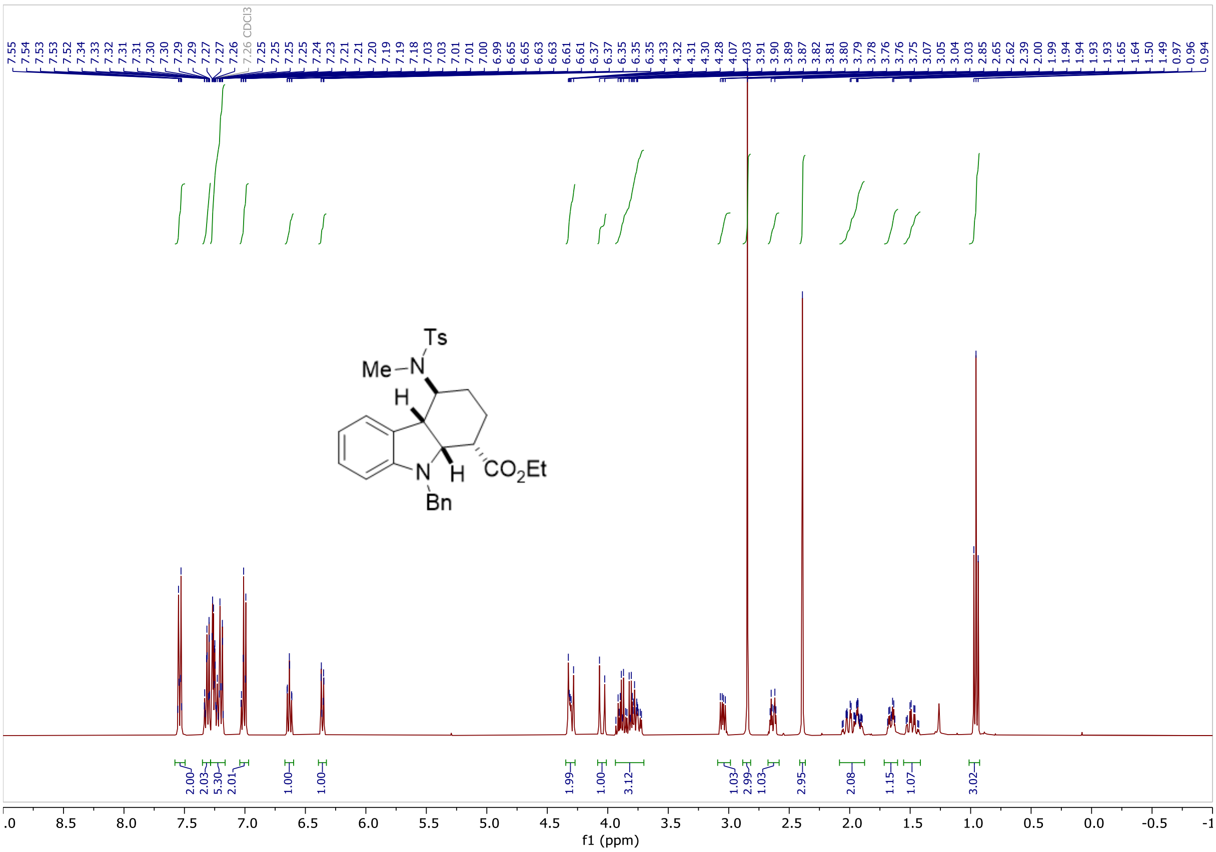
^{13}C-NMR (101 MHz, chloroform-*d*) (6d)



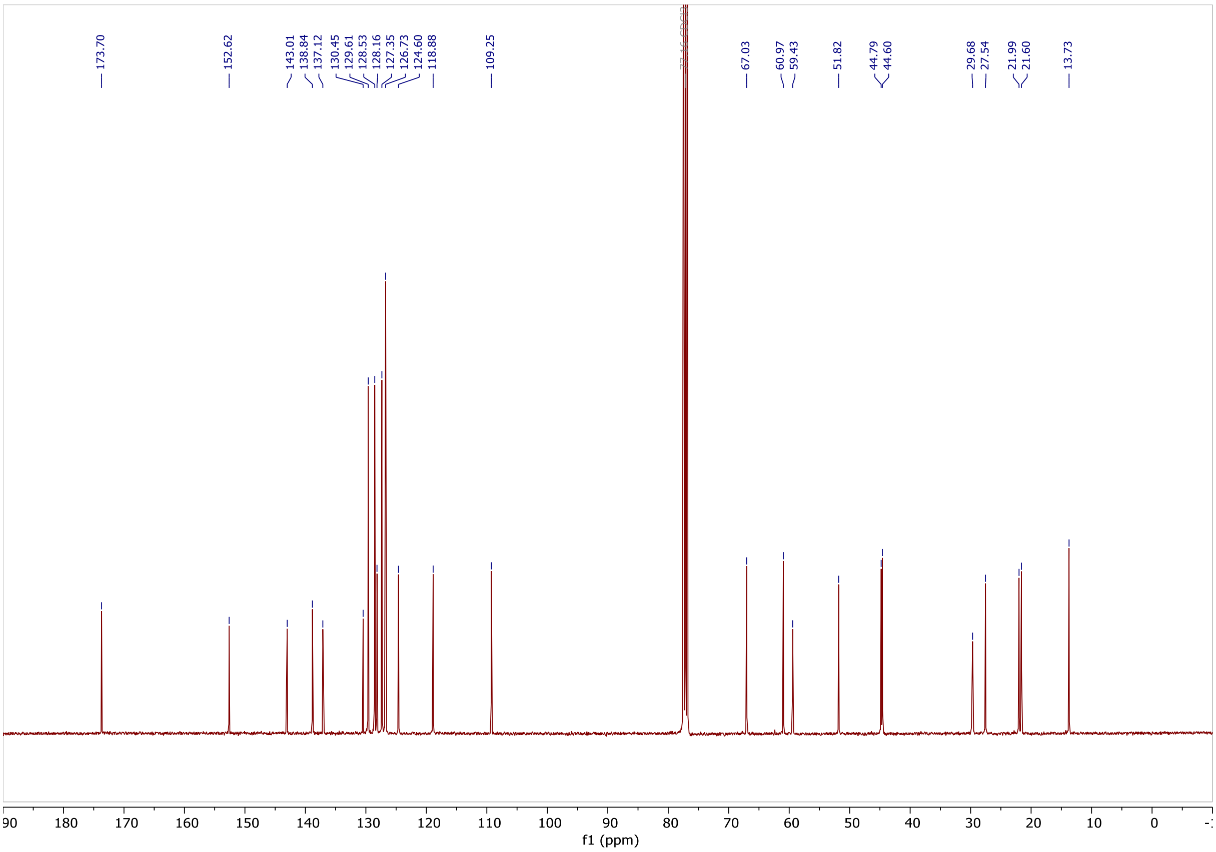
2D-NOESY (400 MHz, chloroform-*d*) (6d)



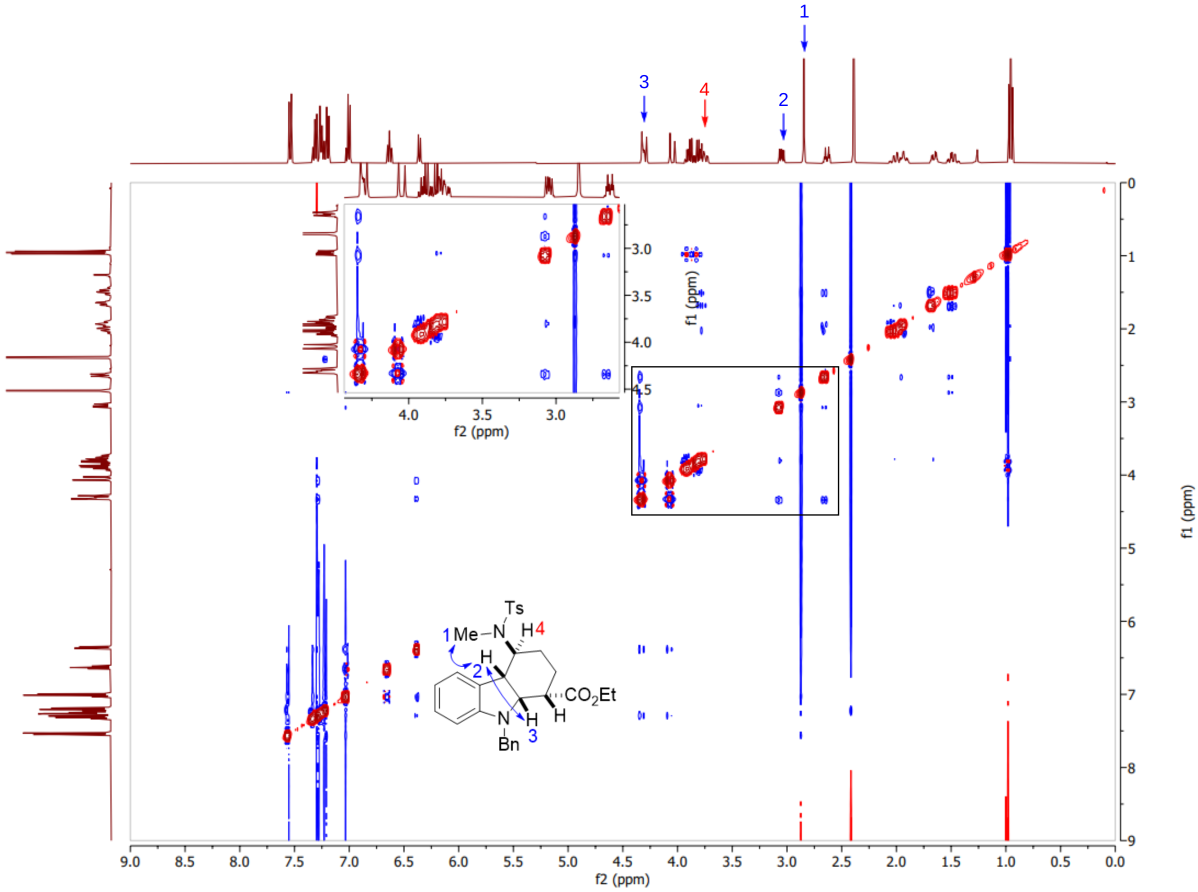
^{1}H-NMR (400 MHz, chloroform-*d*) (6’d)



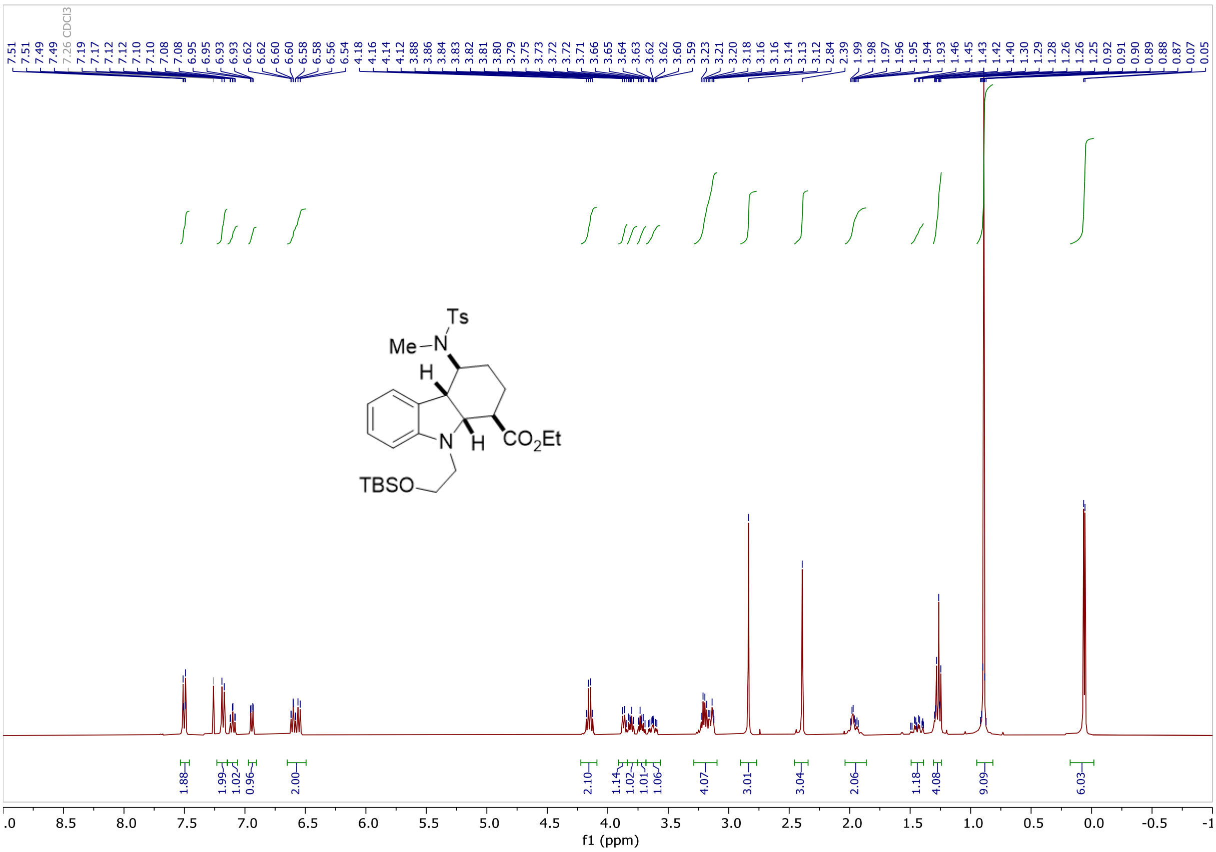
^{13}C-NMR (101 MHz, chloroform-*d*) (6’d)



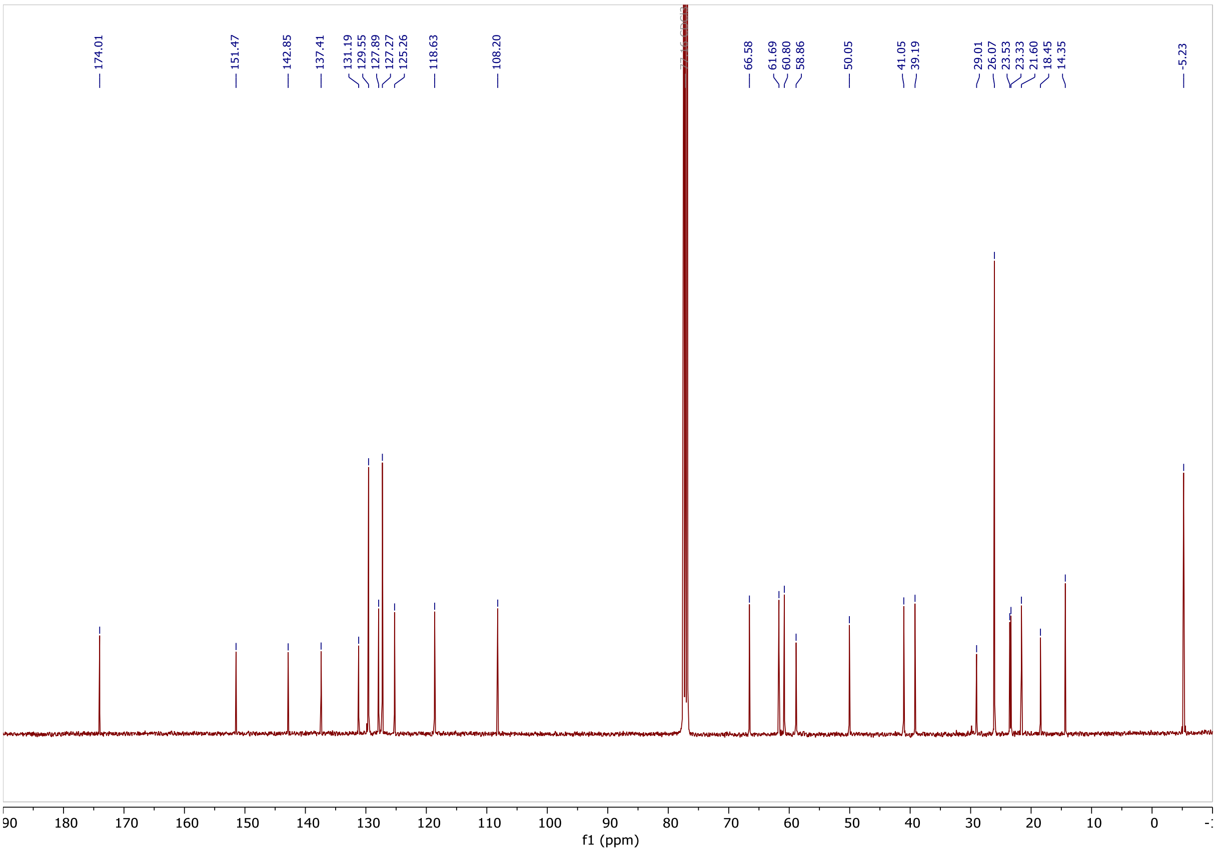
2D-NOESY (400 MHz, chloroform-*d*) (6’d)



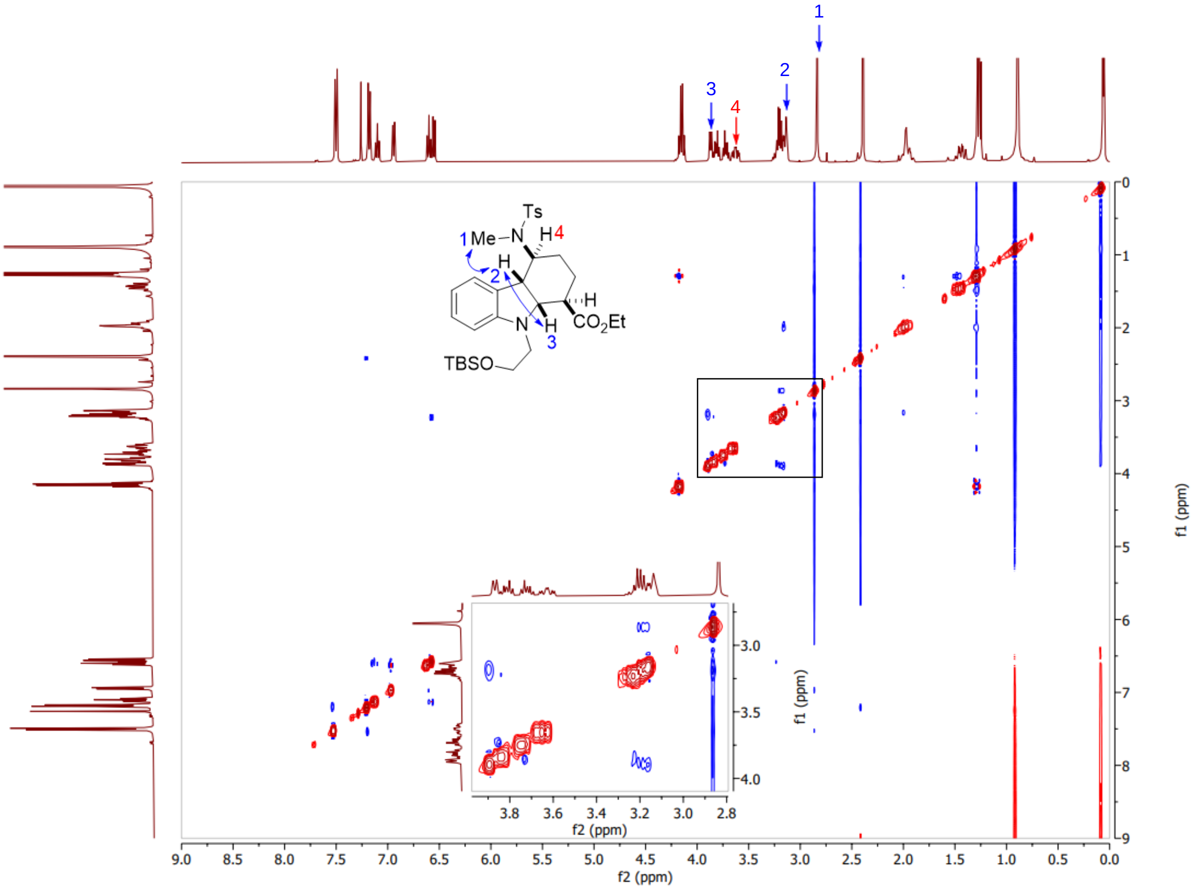
^{1}H-NMR (400 MHz, chloroform-*d*) (6e)



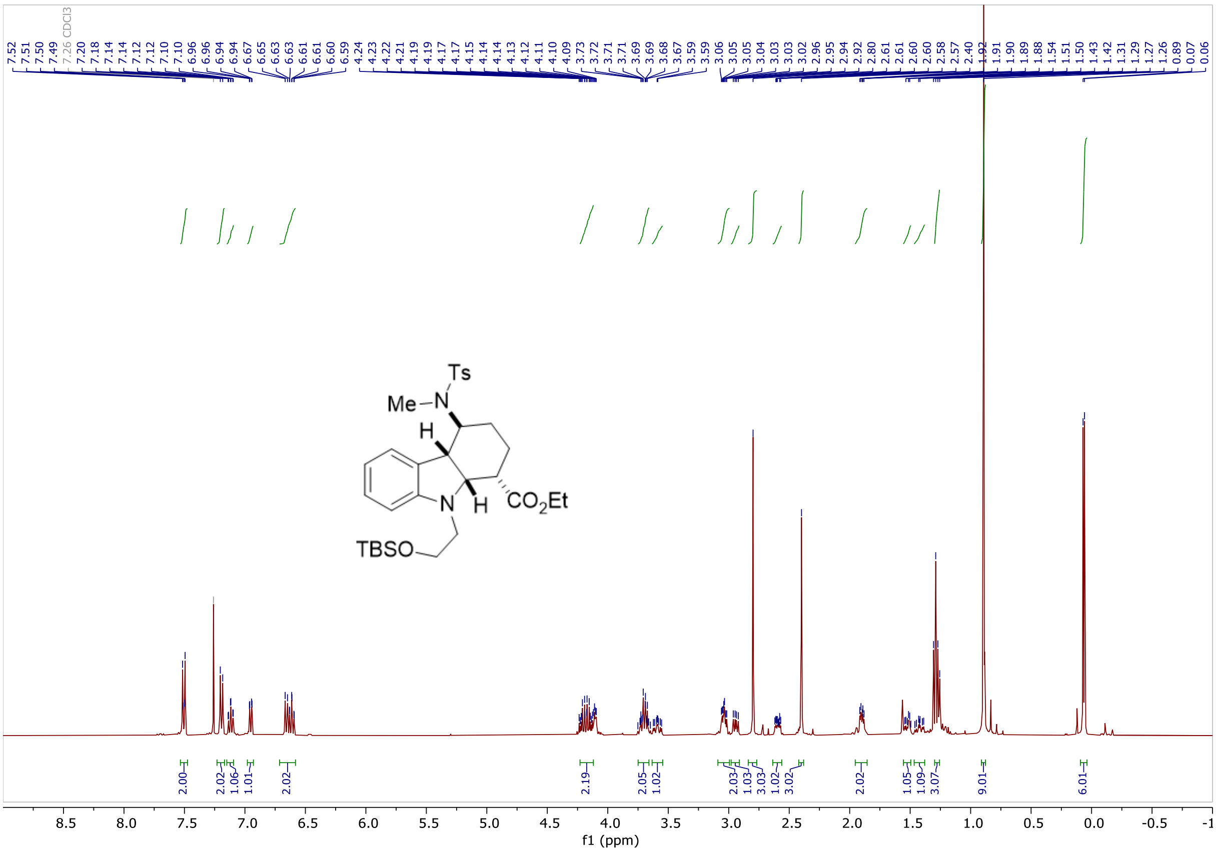
^{13}C-NMR (101 MHz, chloroform-*d*) (6e)



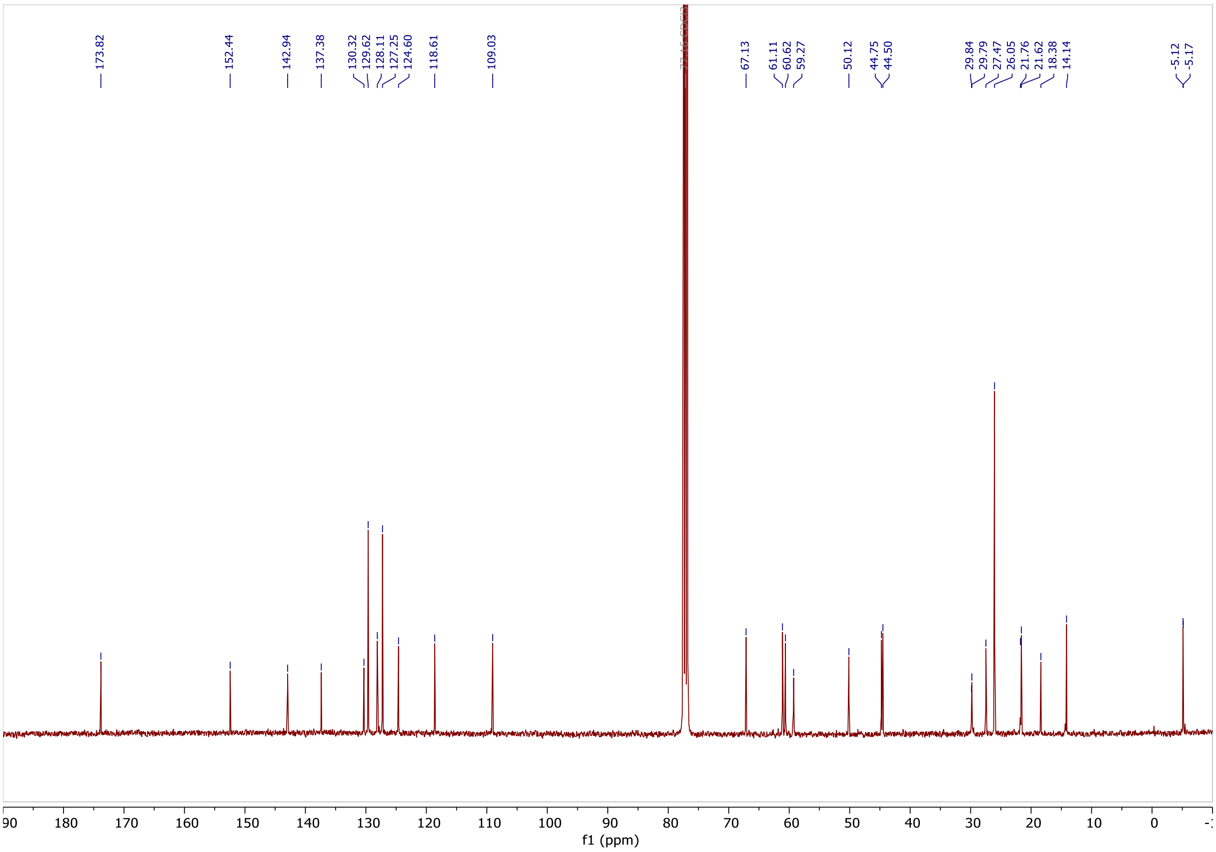
2D-NOESY (400 MHz, chloroform-*d*) (6e)



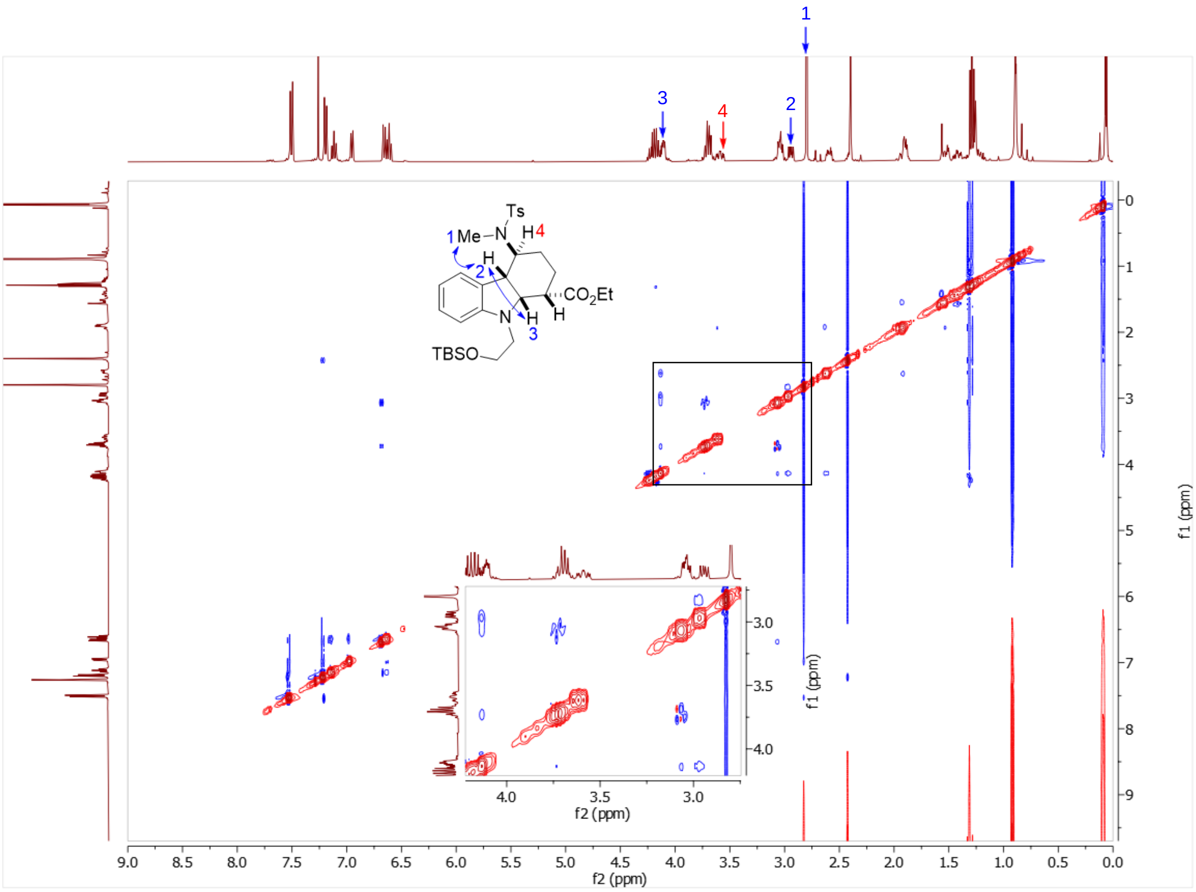
^{1}H-NMR (400 MHz, chloroform-*d*) (6’e)



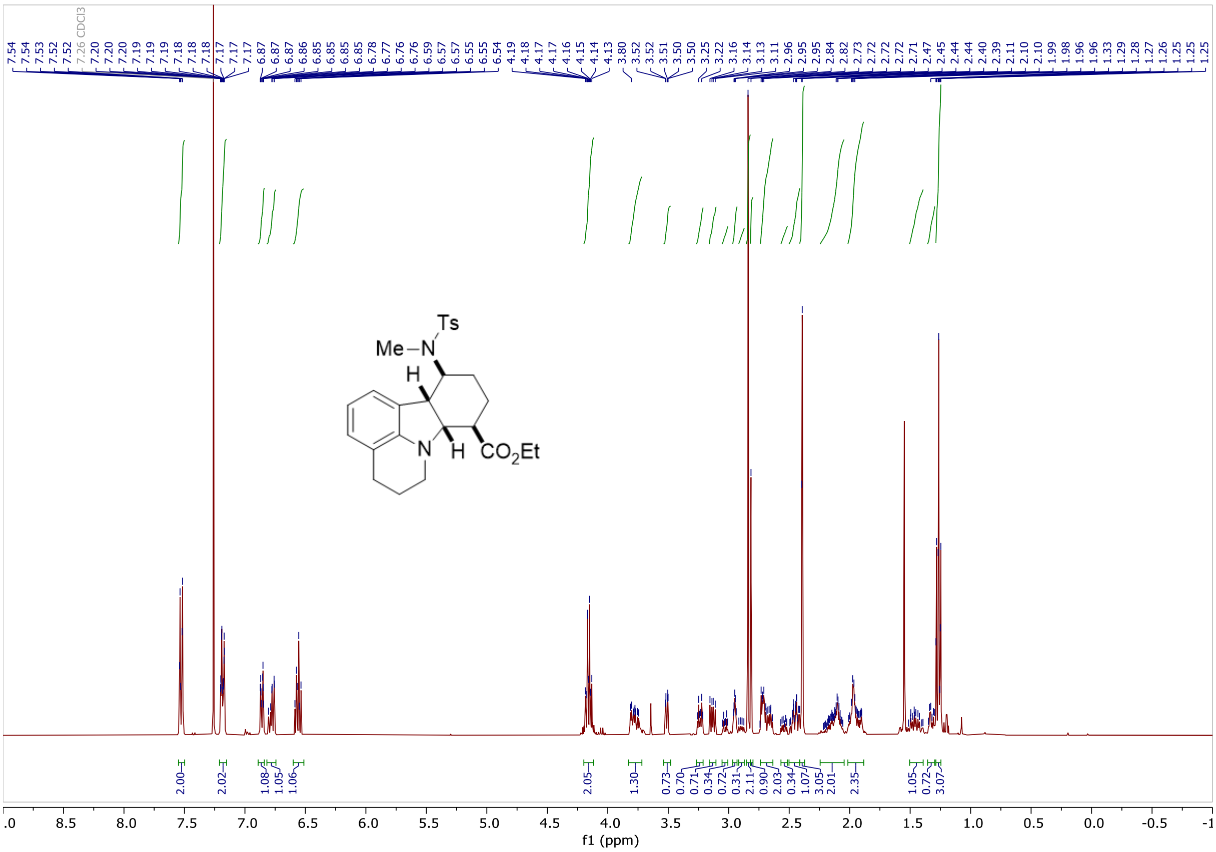
^{13}C-NMR (101 MHz, chloroform-*d*) (6’e)



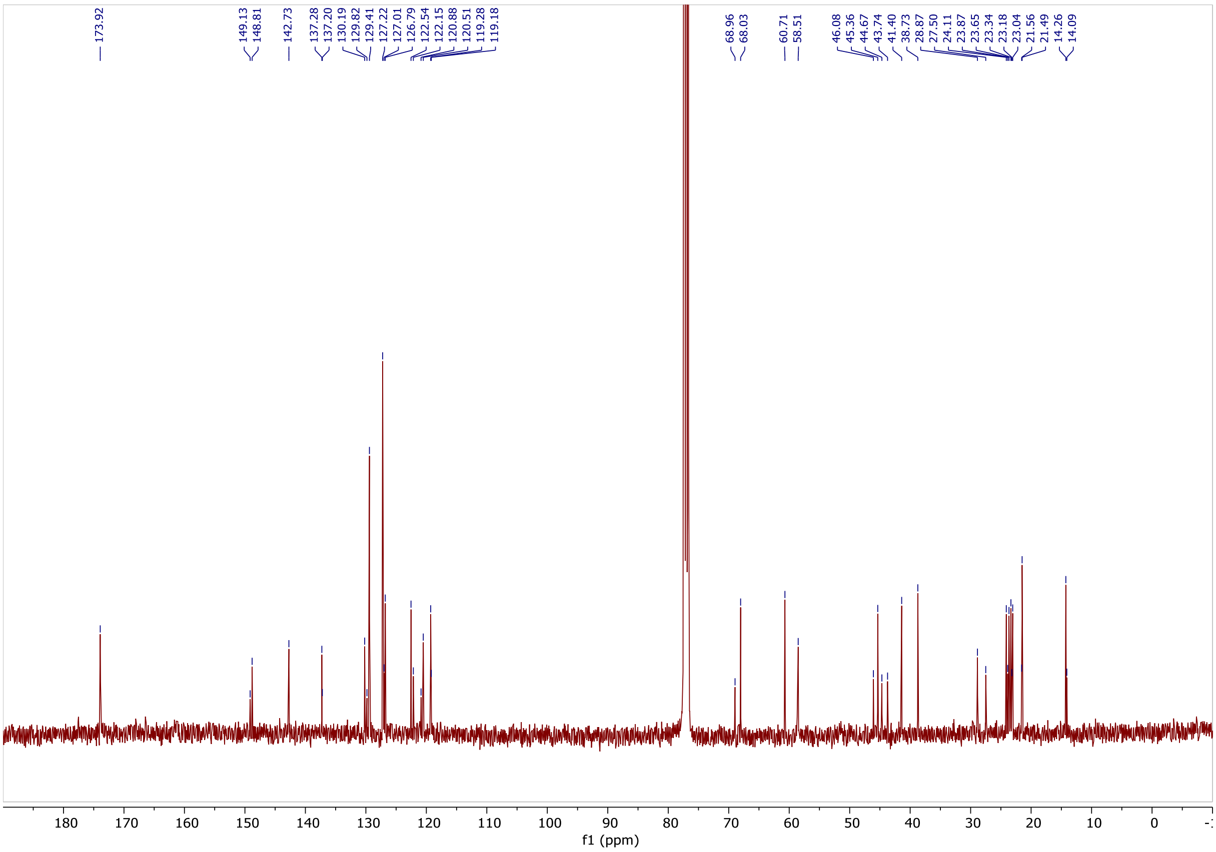
2D-NOESY (400 MHz, chloroform-*d*) (6’e)



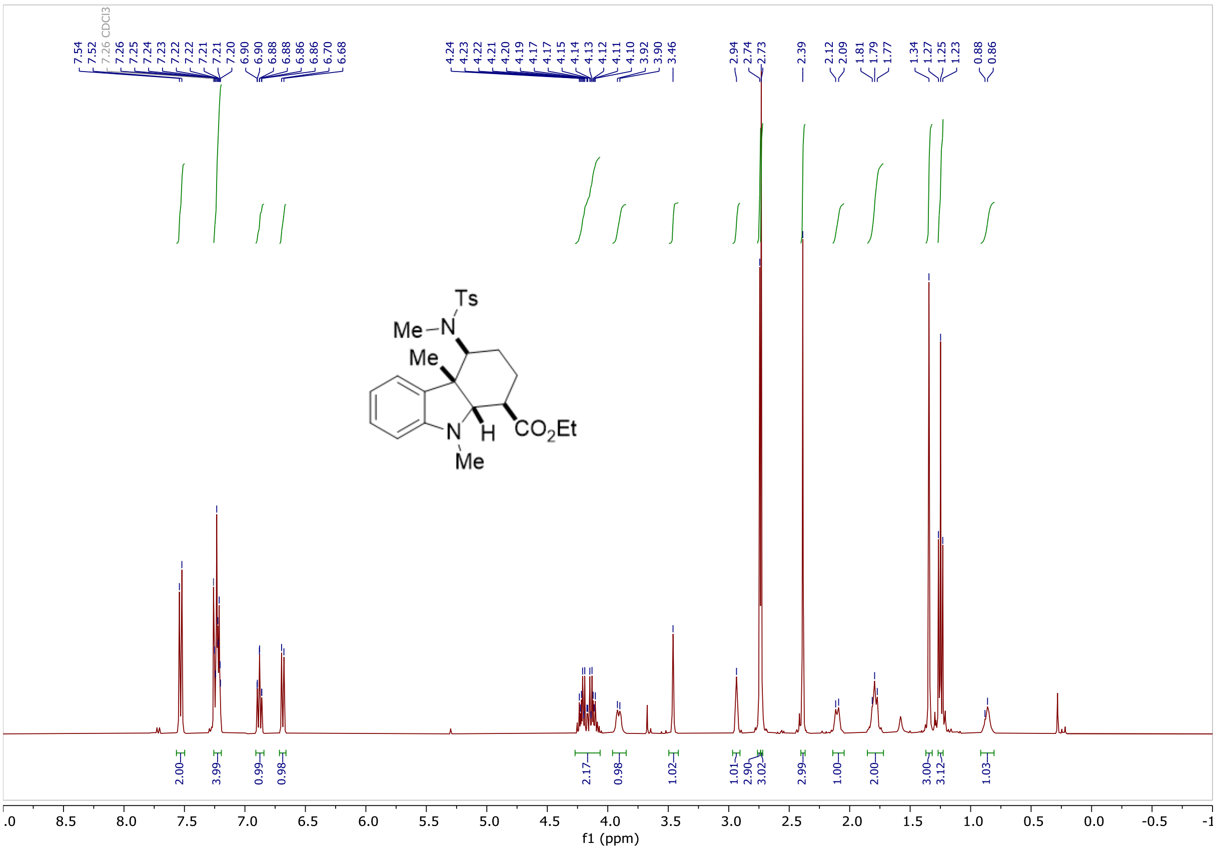
^{1}H-NMR (400 MHz, chloroform-*d*) (6f)



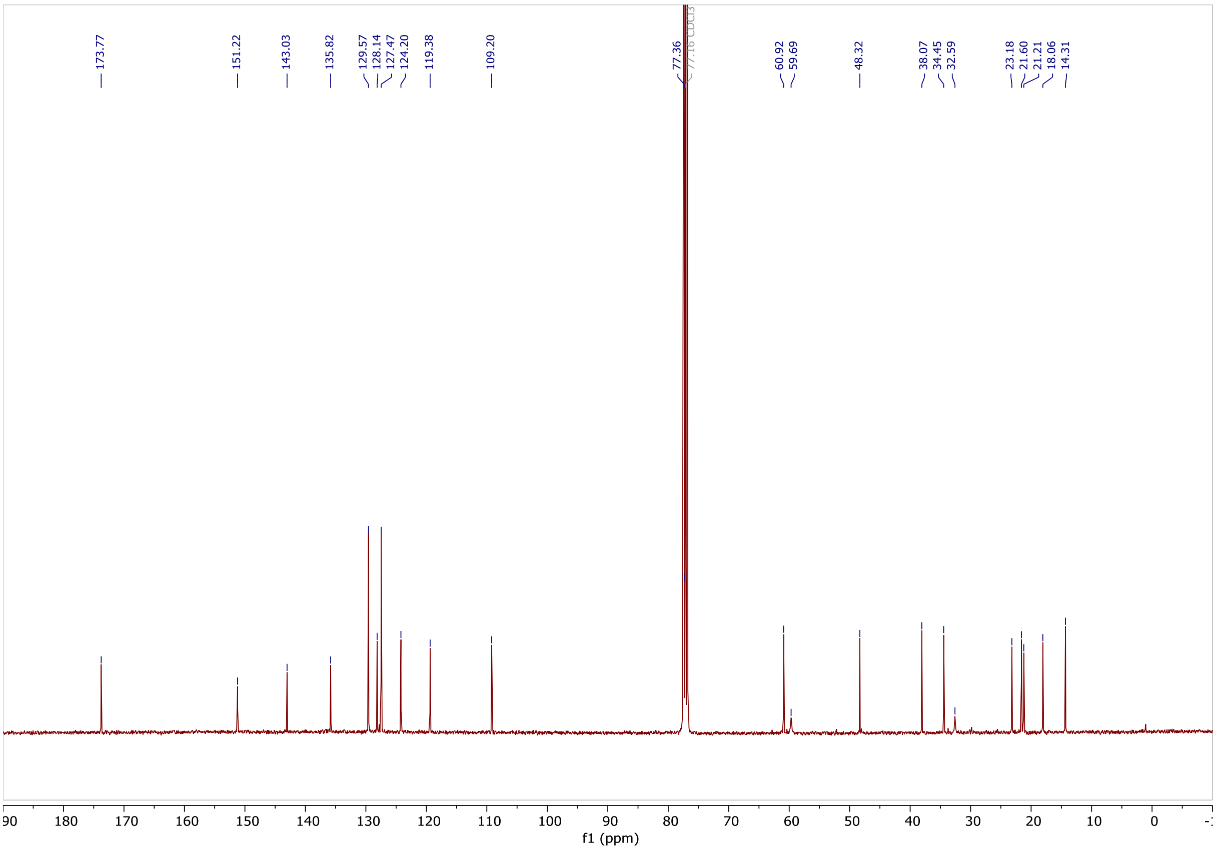
^{13}C-NMR (101 MHz, chloroform-*d*) (6f)



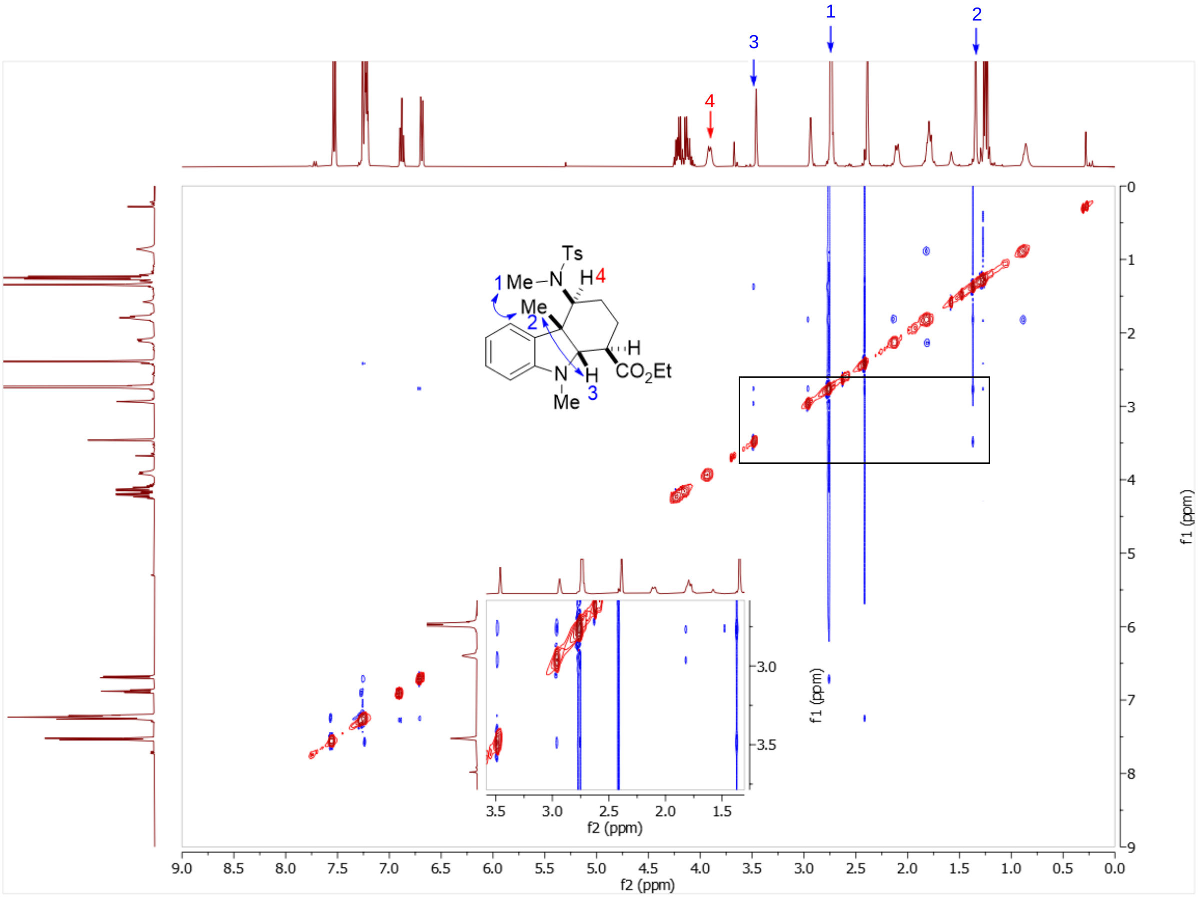
^{1}H-NMR (400 MHz, chloroform-*d*) (6g)



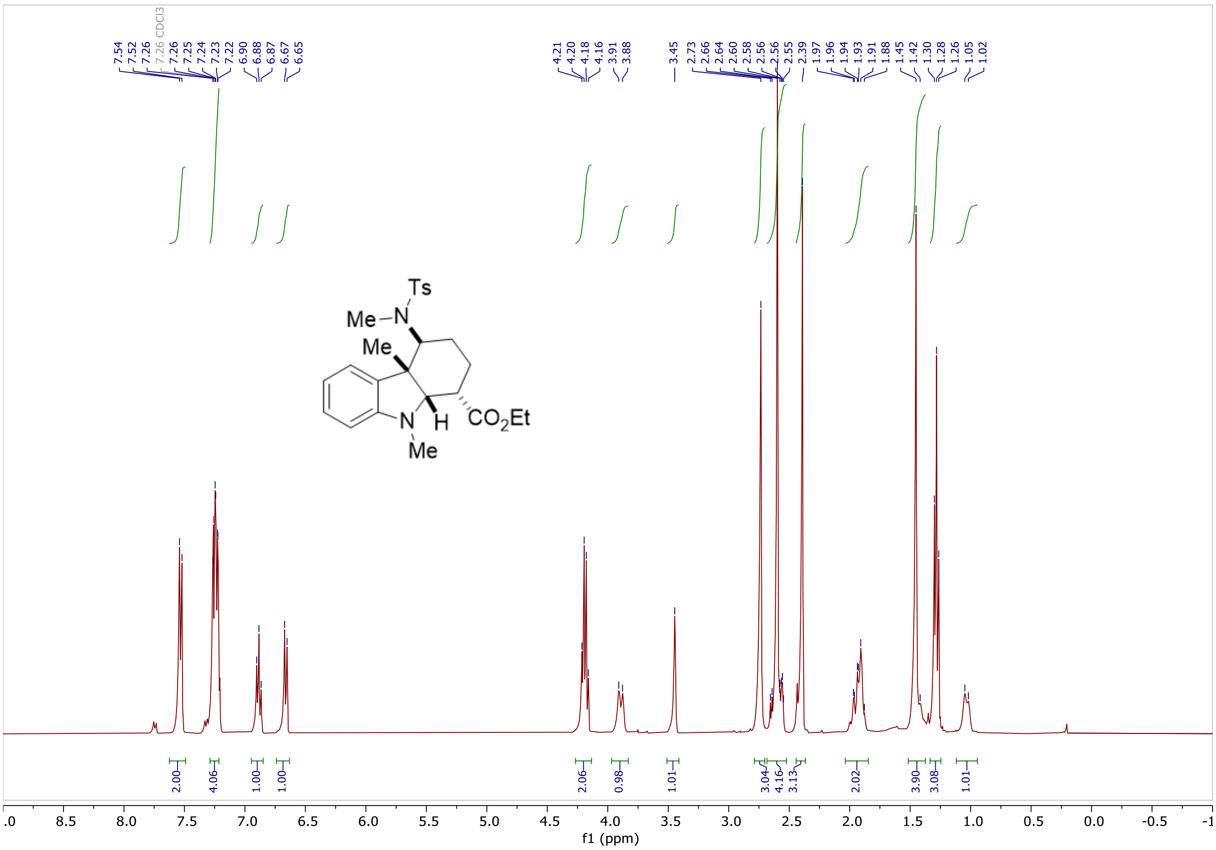
^{13}C-NMR (101 MHz, chloroform-*d*) (6g)



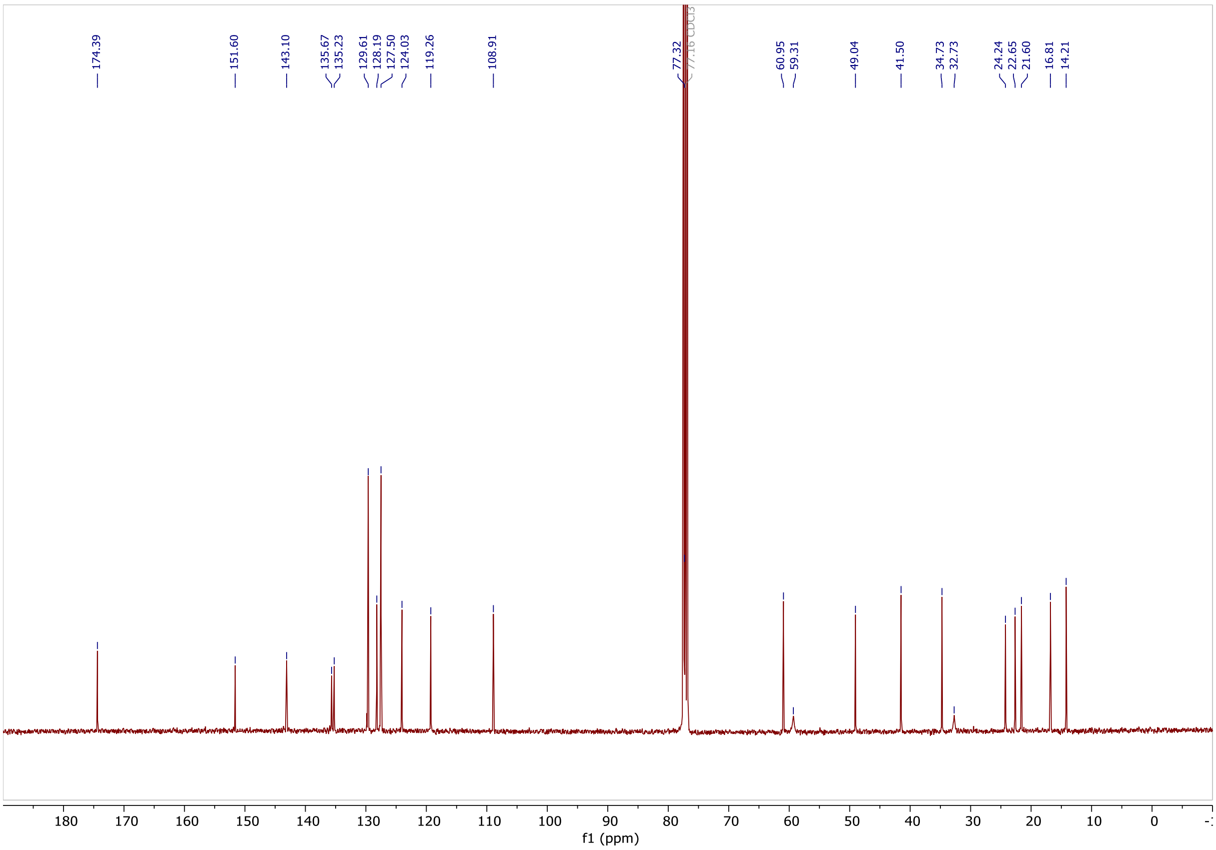
2D-NOESY (400 MHz, chloroform-*d*) (6g)



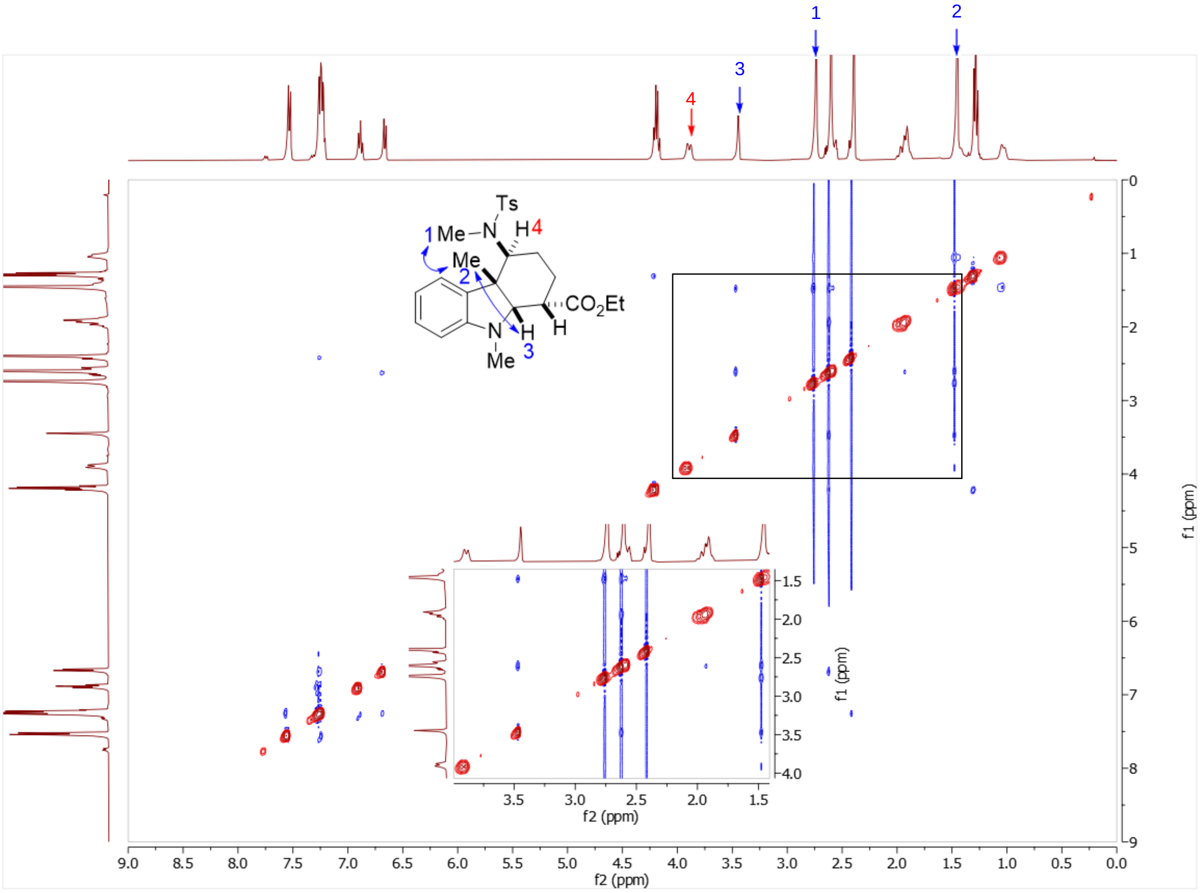
^{1}H-NMR (400 MHz, chloroform-*d*) (6’g)



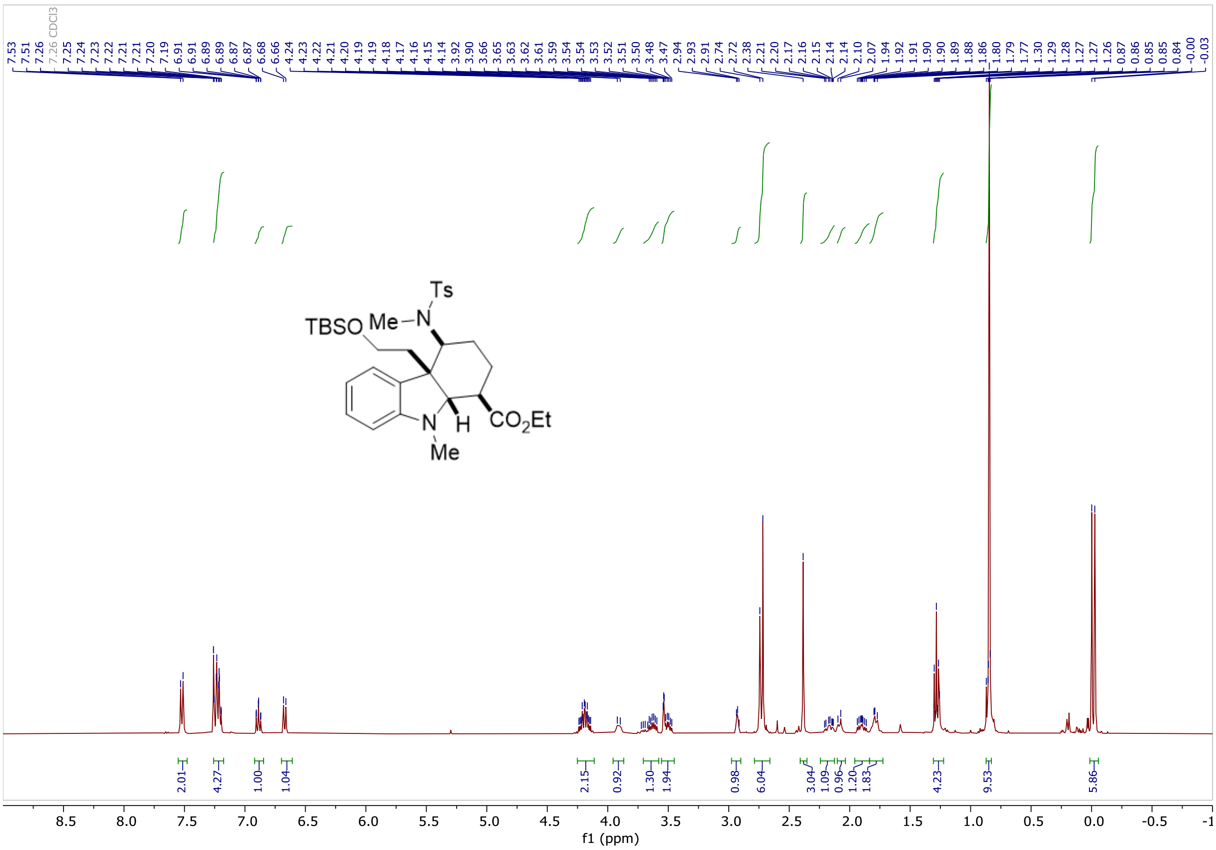
^{13}C-NMR (101 MHz, chloroform-*d*) (6’g)



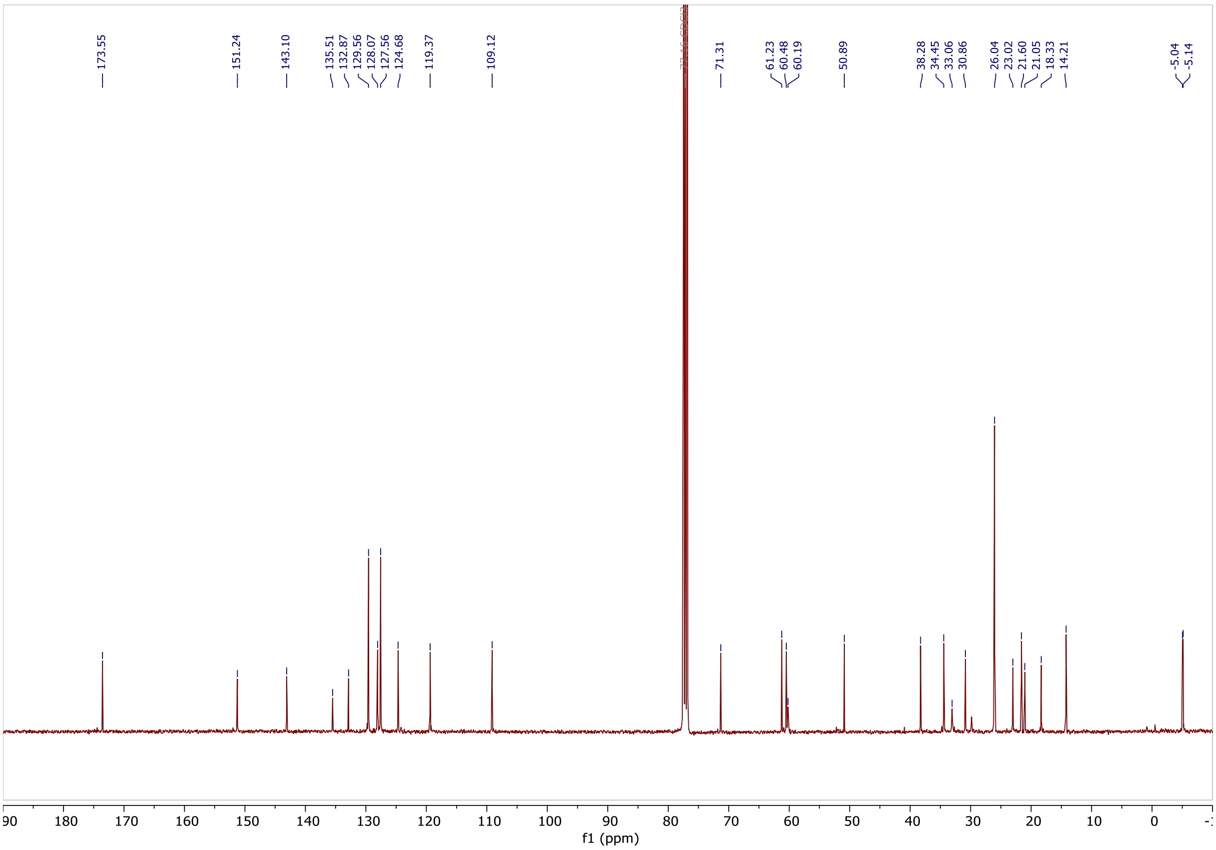
2D-NOESY (400 MHz, chloroform-*d*) (6’g)



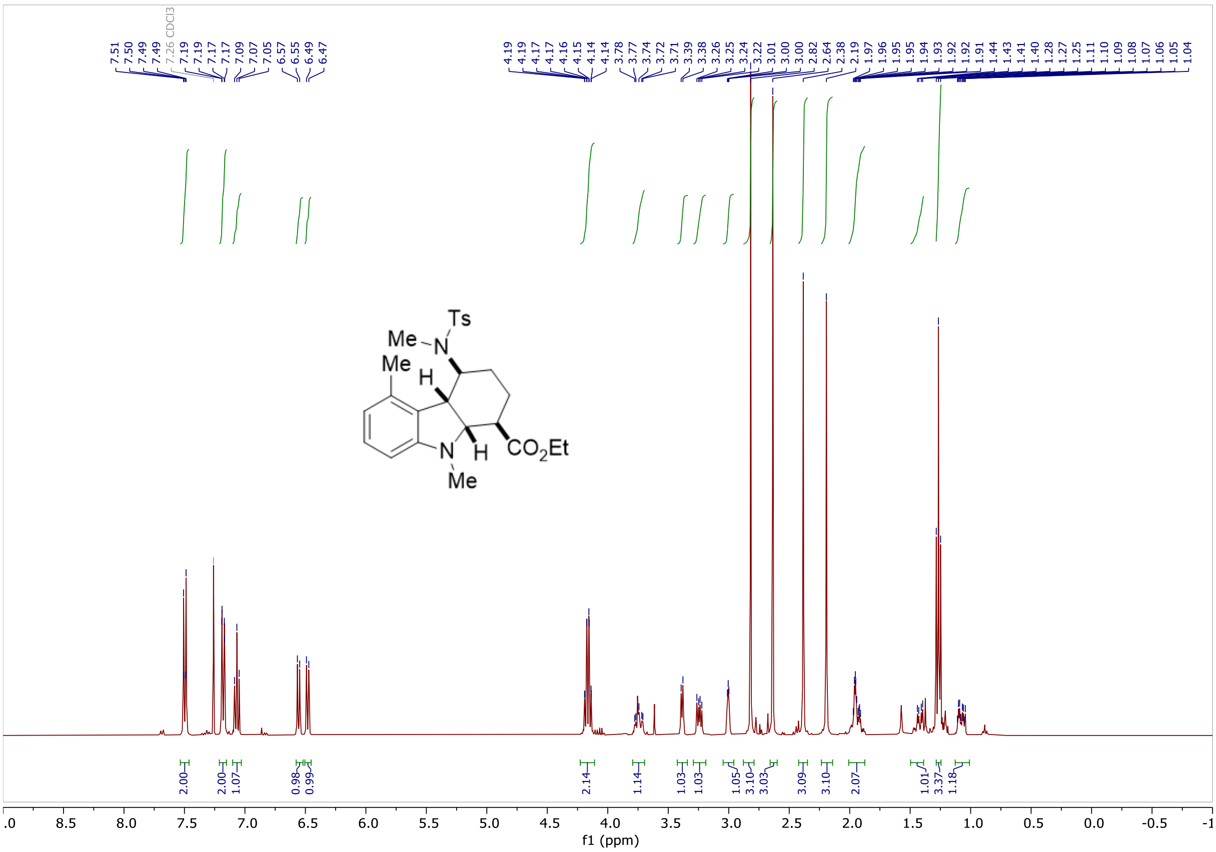
^{1}H-NMR (400 MHz, chloroform-*d*) (6h)



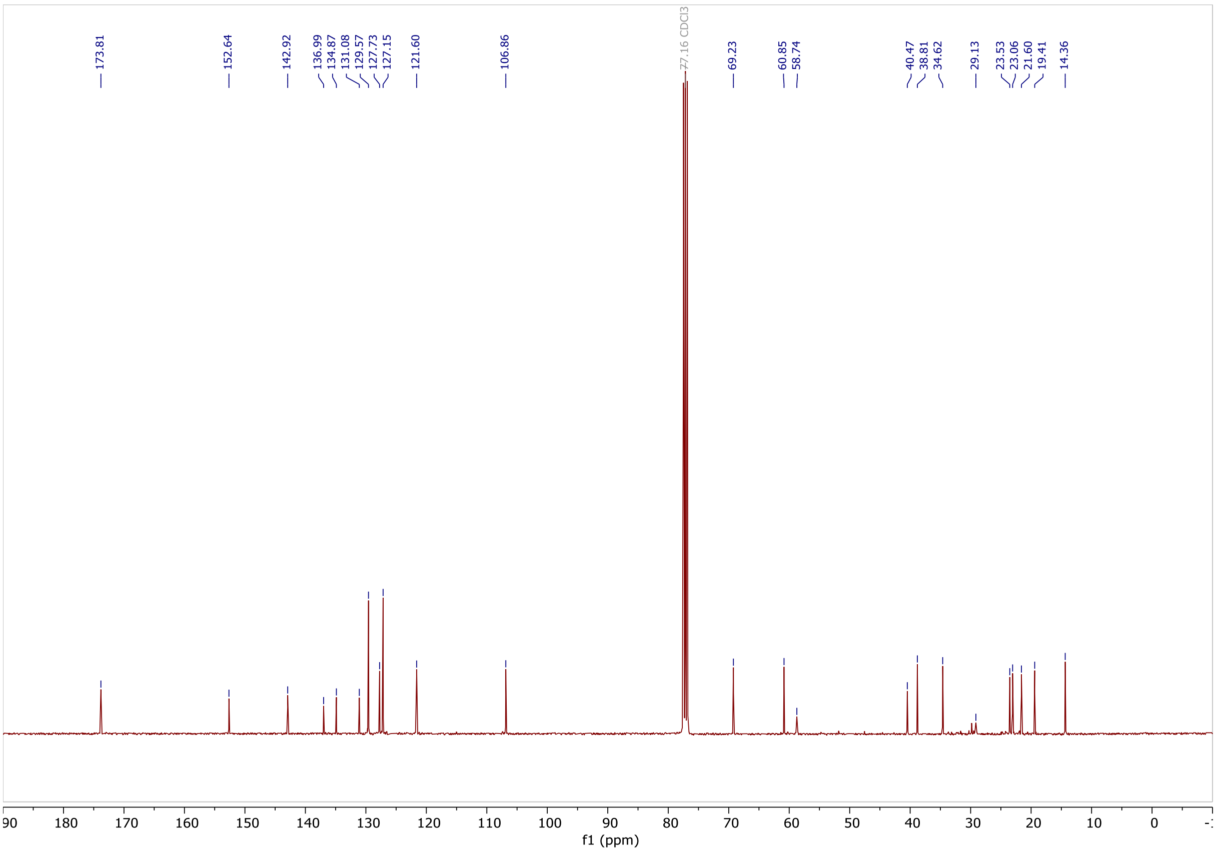
^{13}C-NMR (101 MHz, chloroform-*d*) (6h)



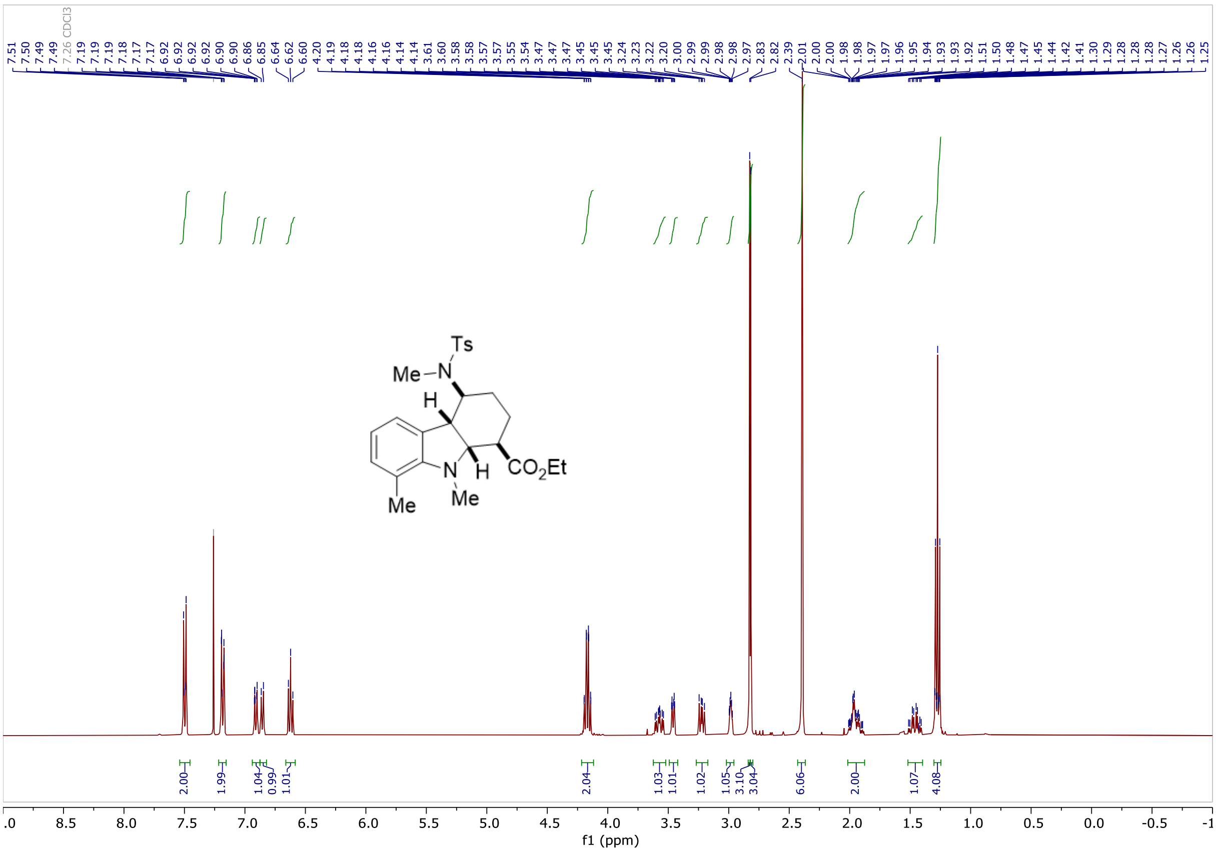
^{1}H-NMR (400 MHz, chloroform-*d*) (6i)



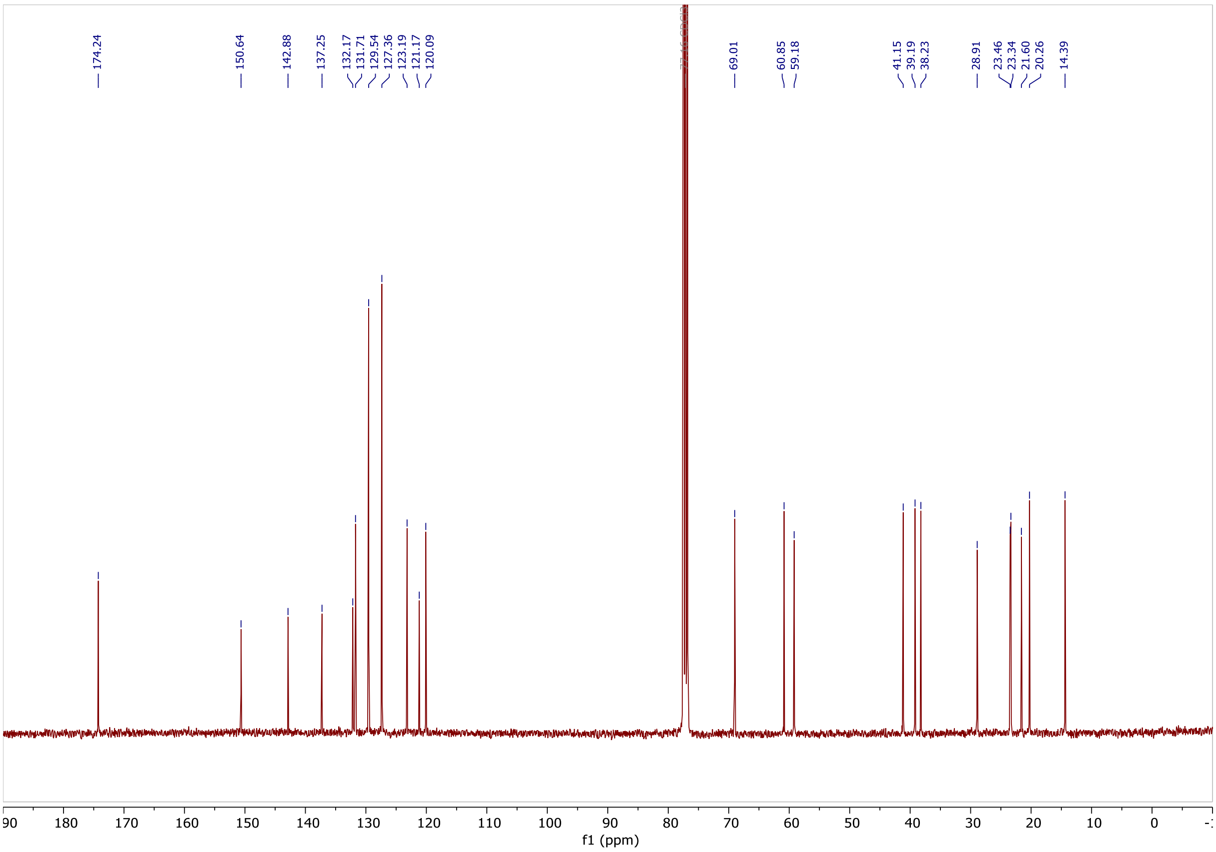
^{13}C-NMR (101 MHz, chloroform-*d*) (6i)



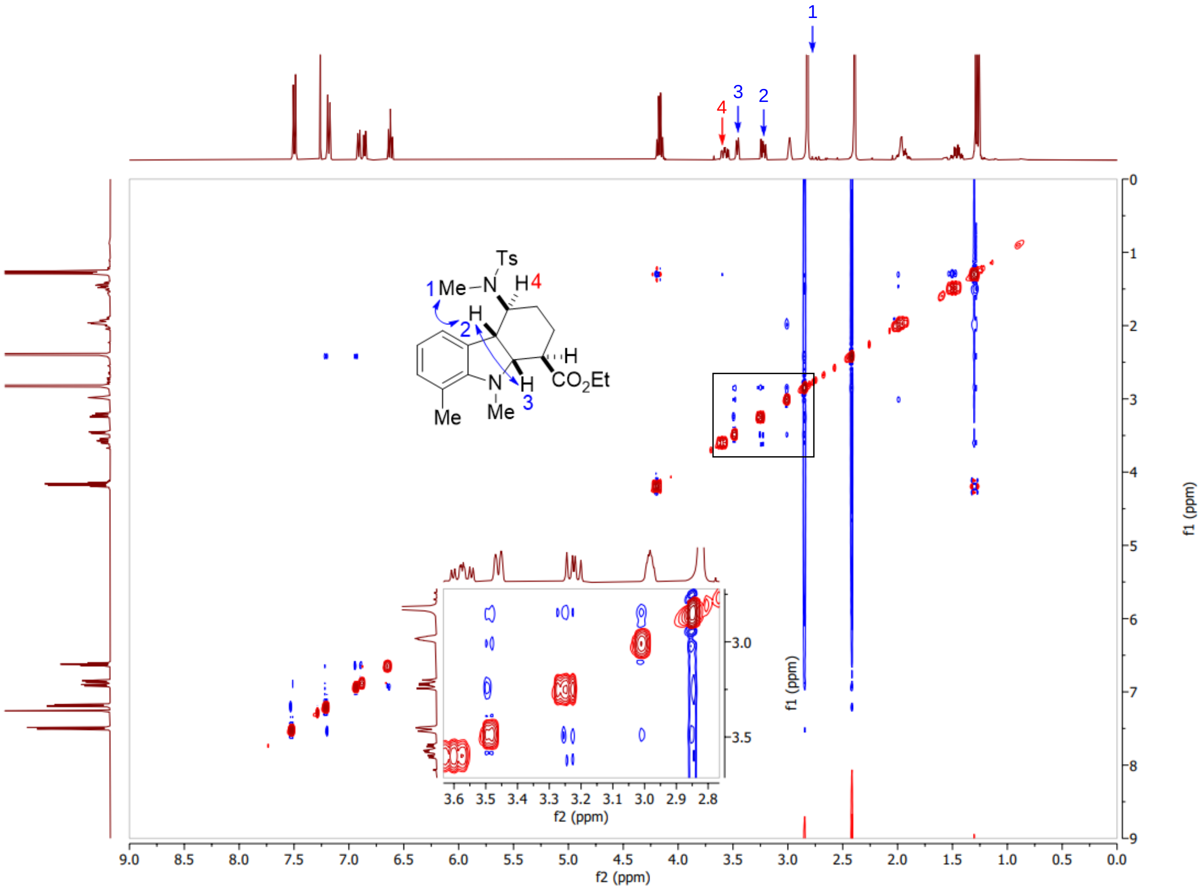
^{1}H-NMR (400 MHz, chloroform-*d*) (6j)



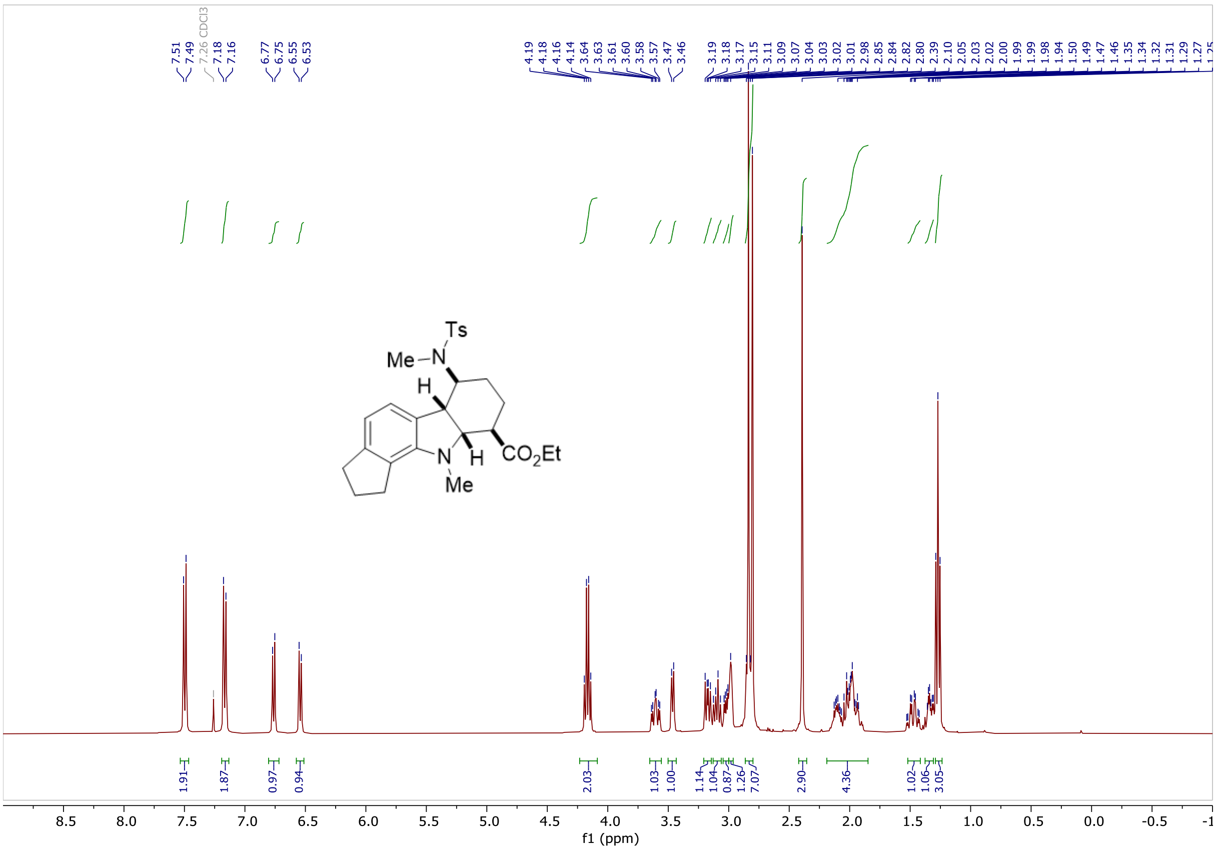
^{13}C-NMR (101 MHz, chloroform-*d*) (6j)



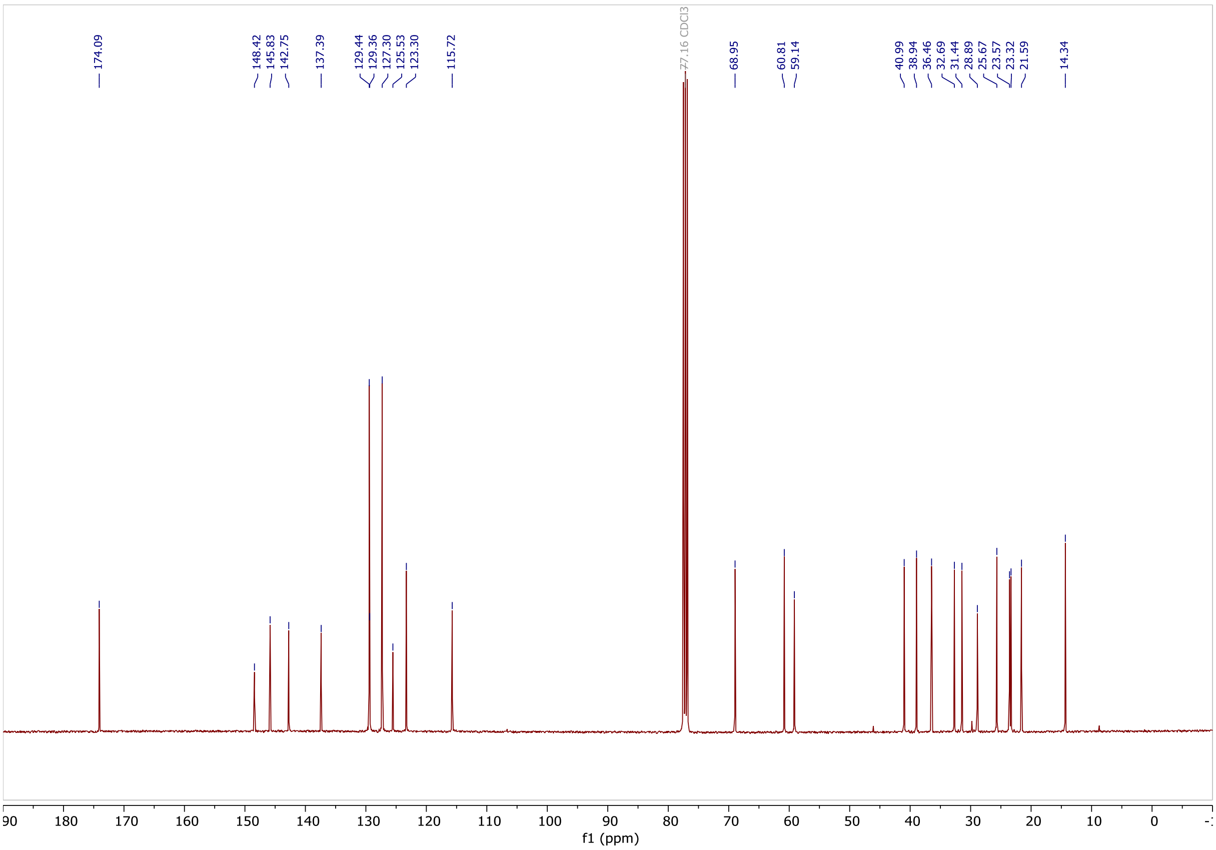
2D-NOESY (400 MHz, chloroform-*d*)



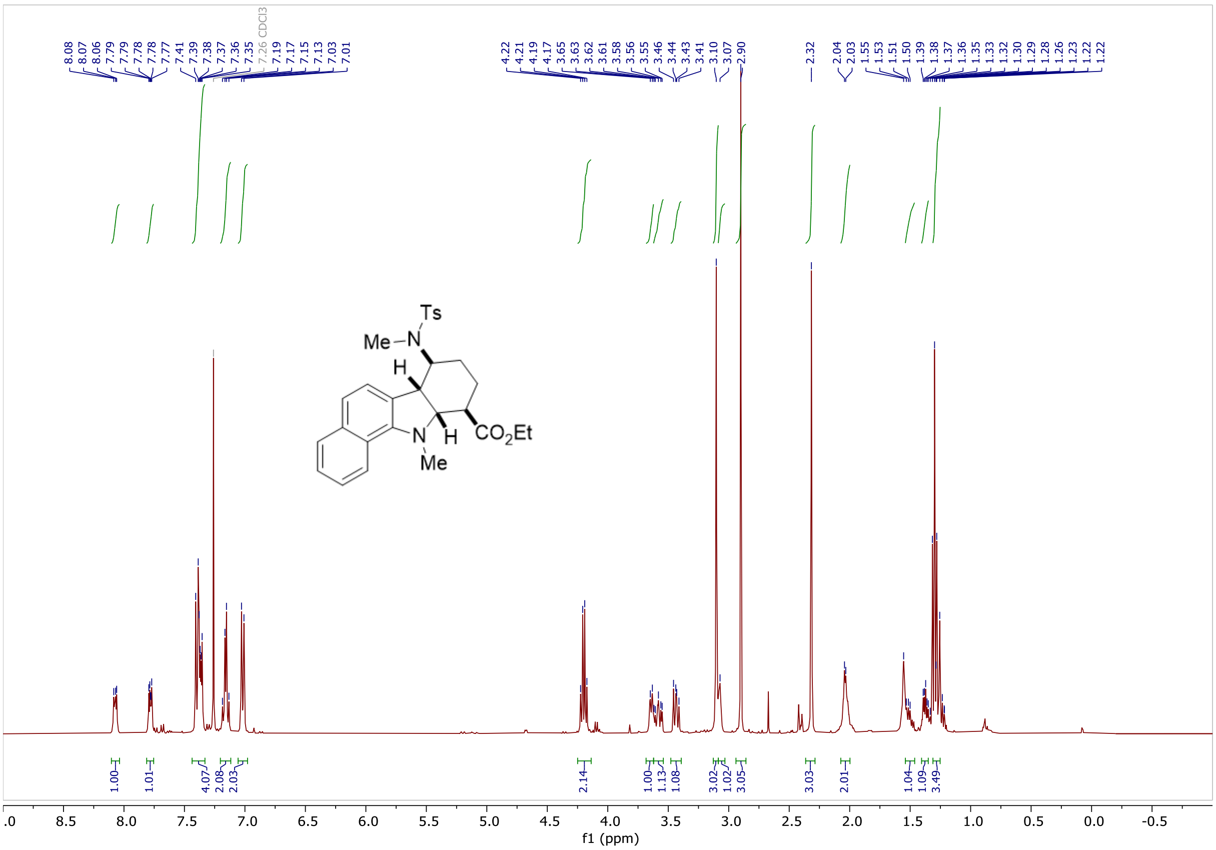
^{1}H-NMR (400 MHz, chloroform-*d*) (6k)



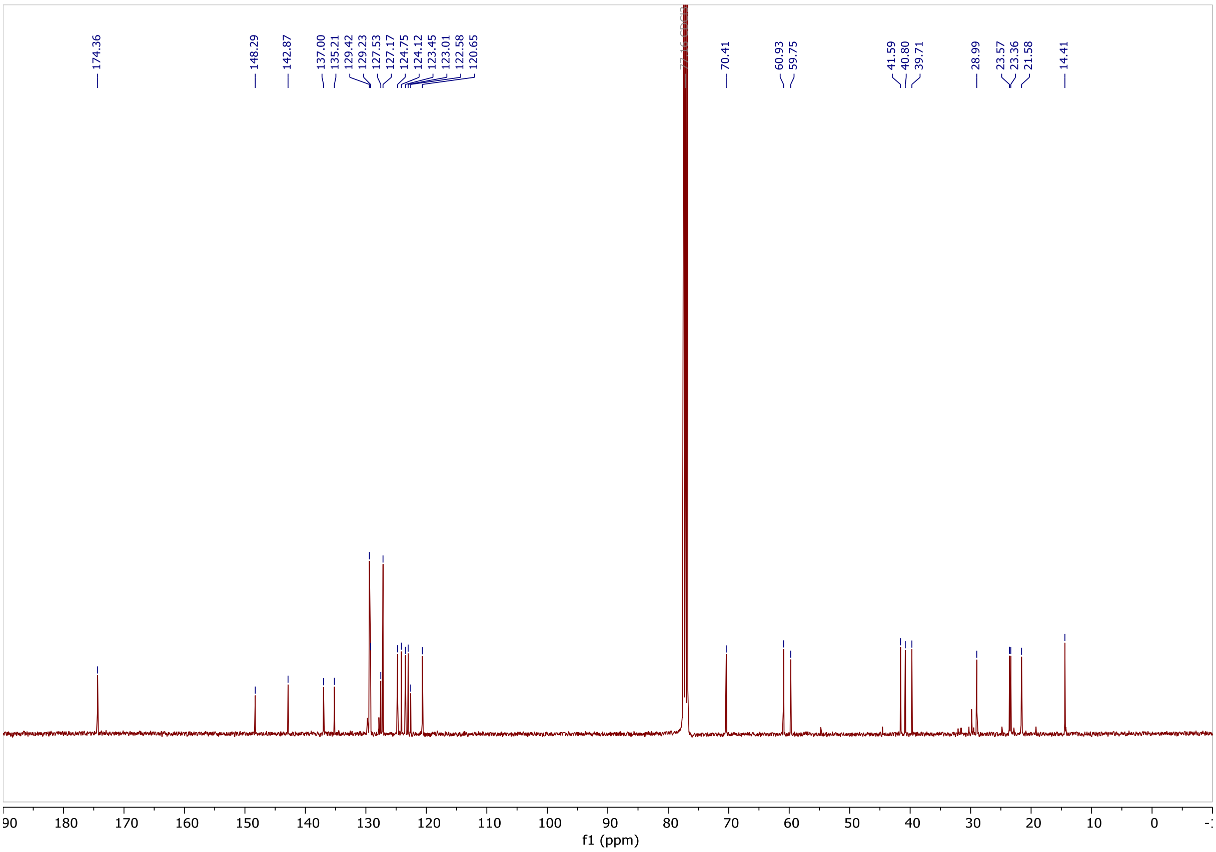
^{13}C-NMR (101 MHz, chloroform-*d*) (6k)



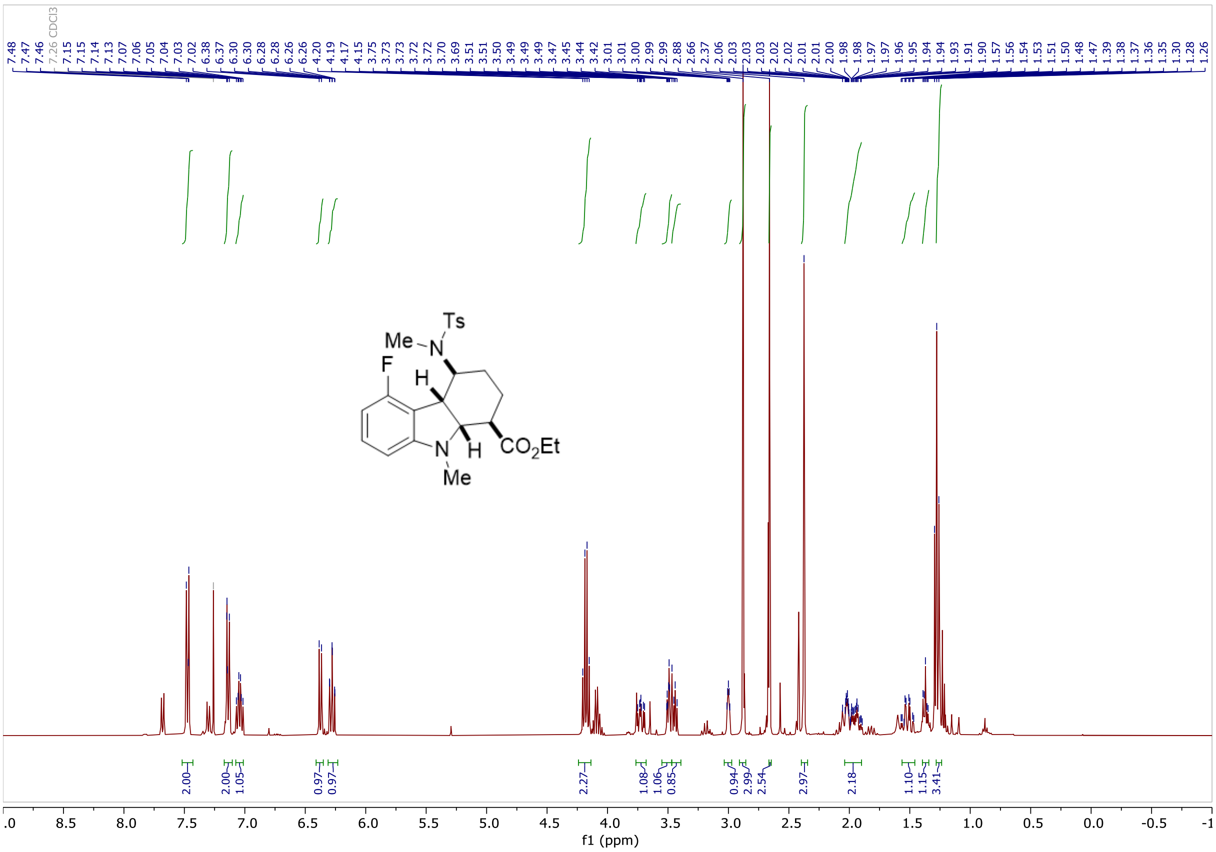
^{1}H-NMR (400 MHz, chloroform-*d*) (6l) 92% purity, mixed with 6'l



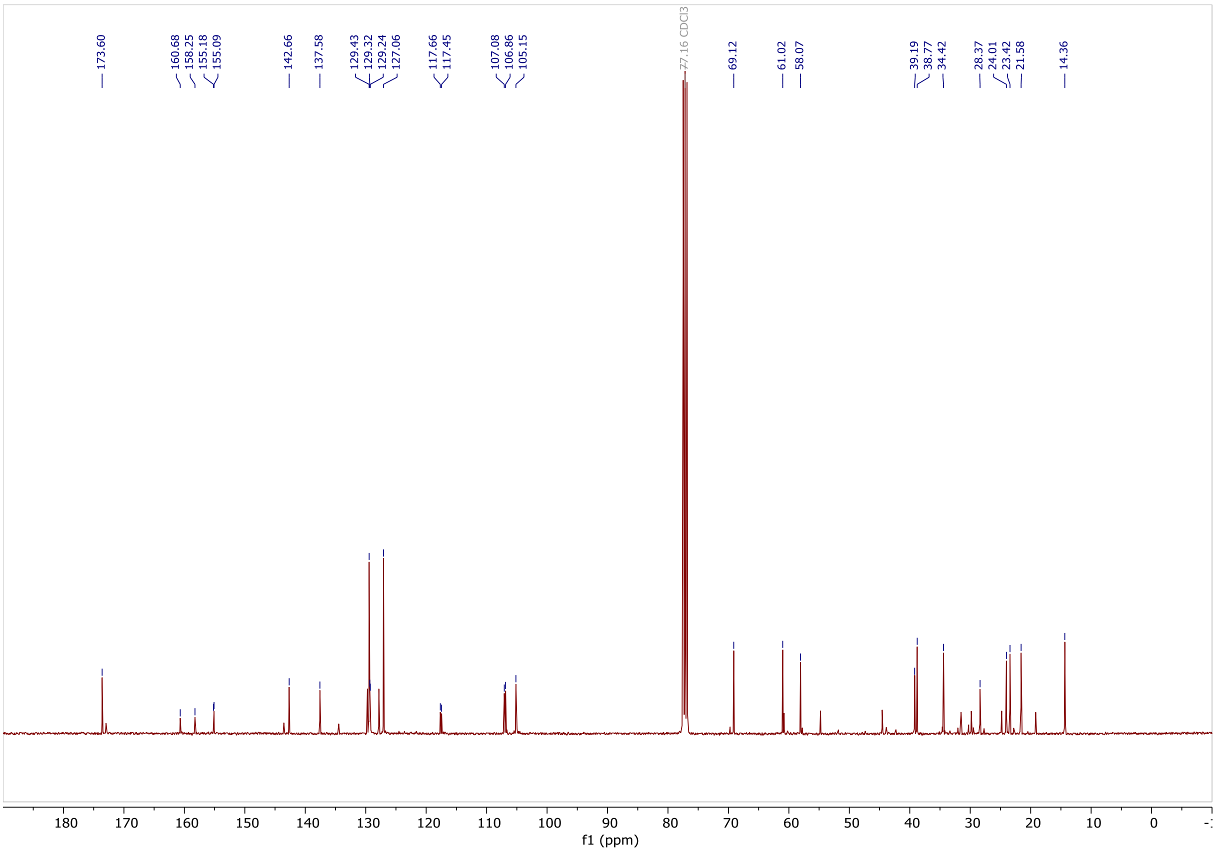
^{13}C-NMR (101 MHz, chloroform-*d*) (6l) 92% purity, mixed with 6'l



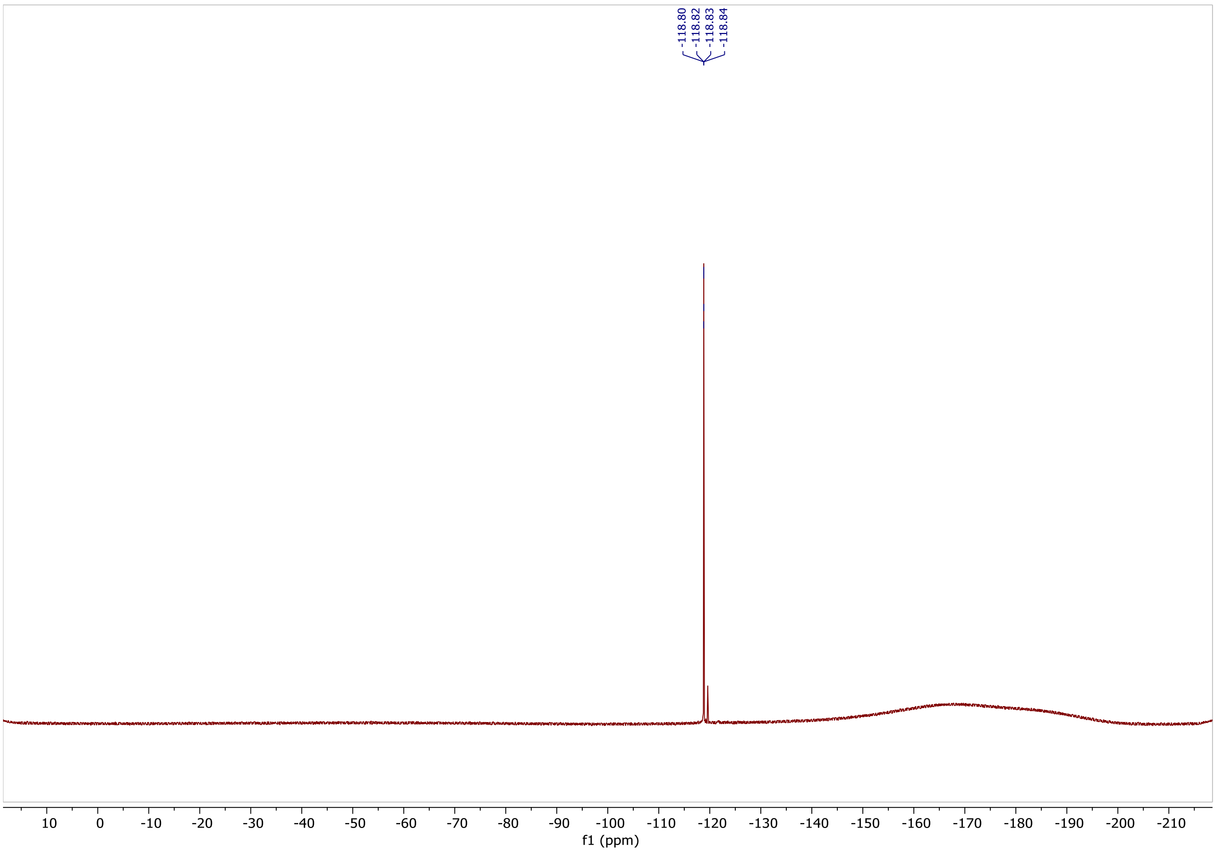
^{1}H-NMR (400 MHz, chloroform-*d*) (6m) 80% purity, mixed with 6’m



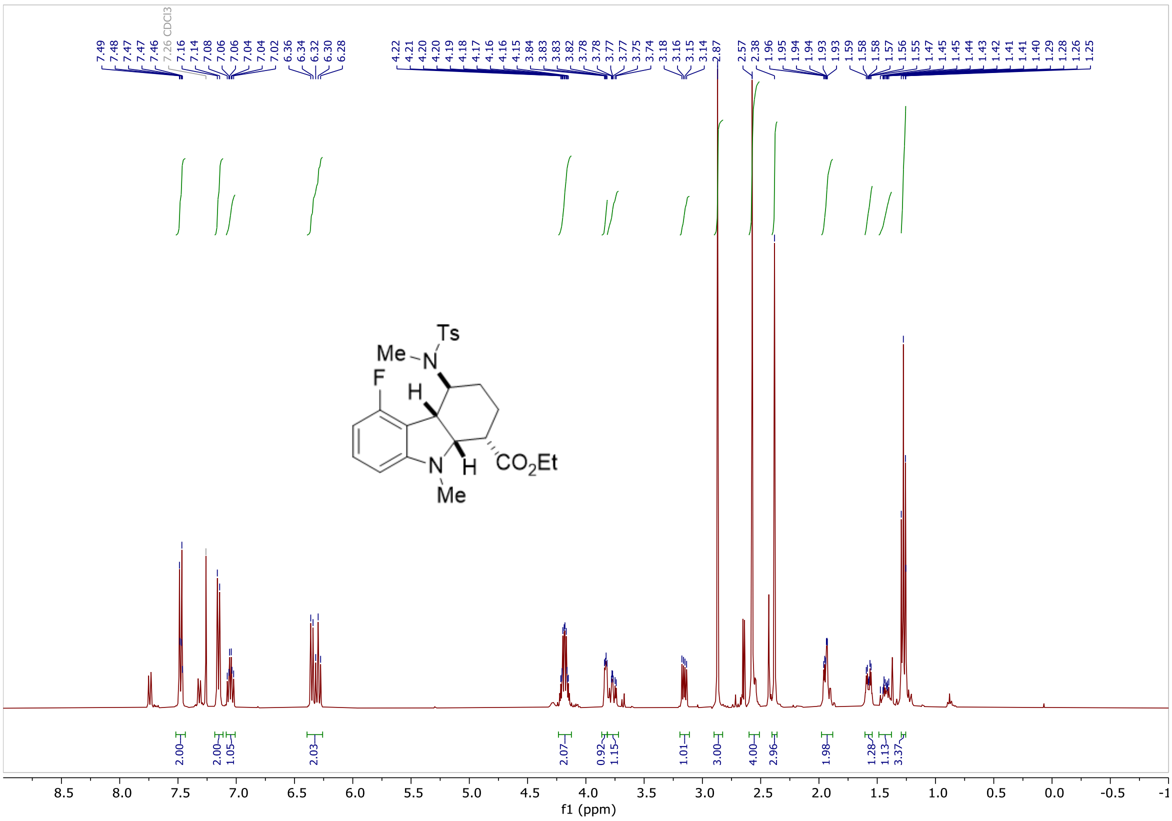
^{13}C-NMR (101 MHz, chloroform-*d*) (6m) 80% purity, mixed with 6’m



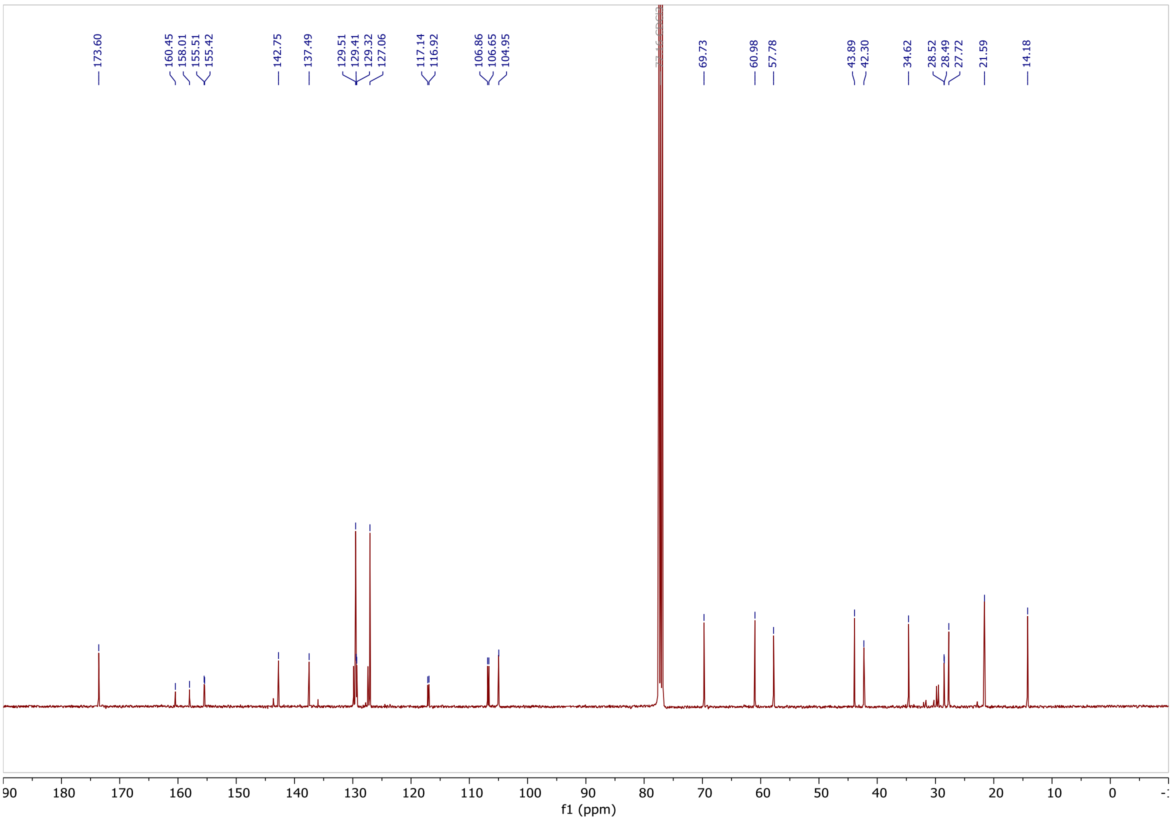
^{19}F NMR (376 MHz, chloroform-*d*) (6m) 80% purity, mixed with 6’m



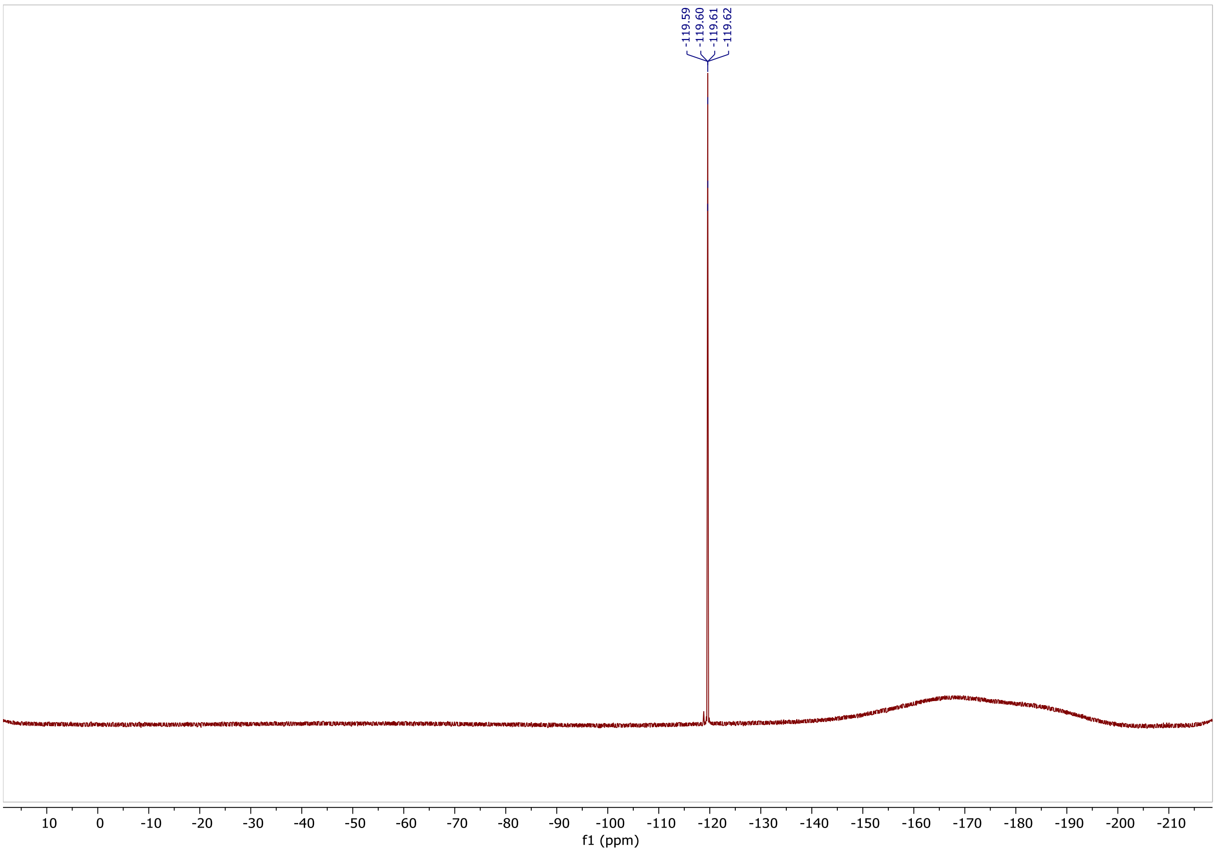
^{1}H-NMR (400 MHz, chloroform-*d*) (6'm) 80% purity, mixed with 6m



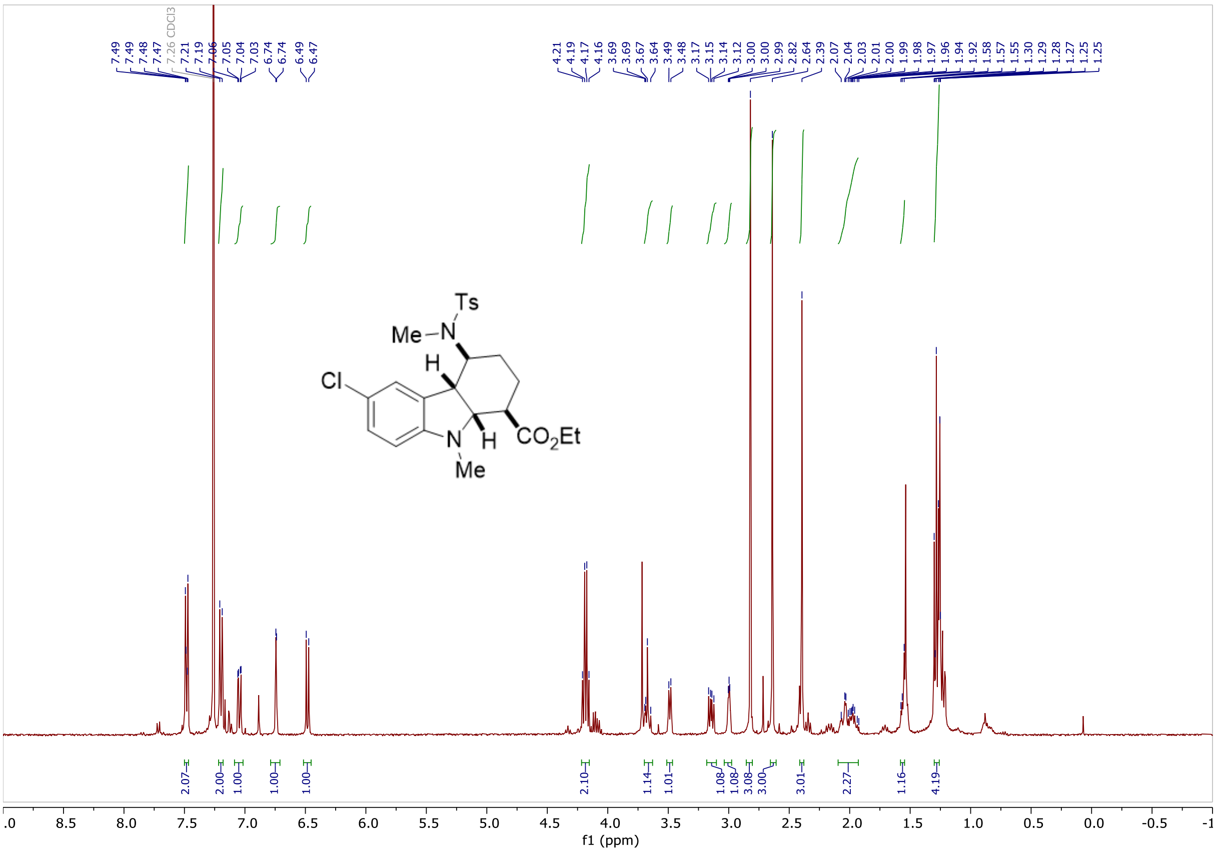
^{13}C-NMR (101 MHz, chloroform-*d*) (6'm) 80% purity, mixed with 6m



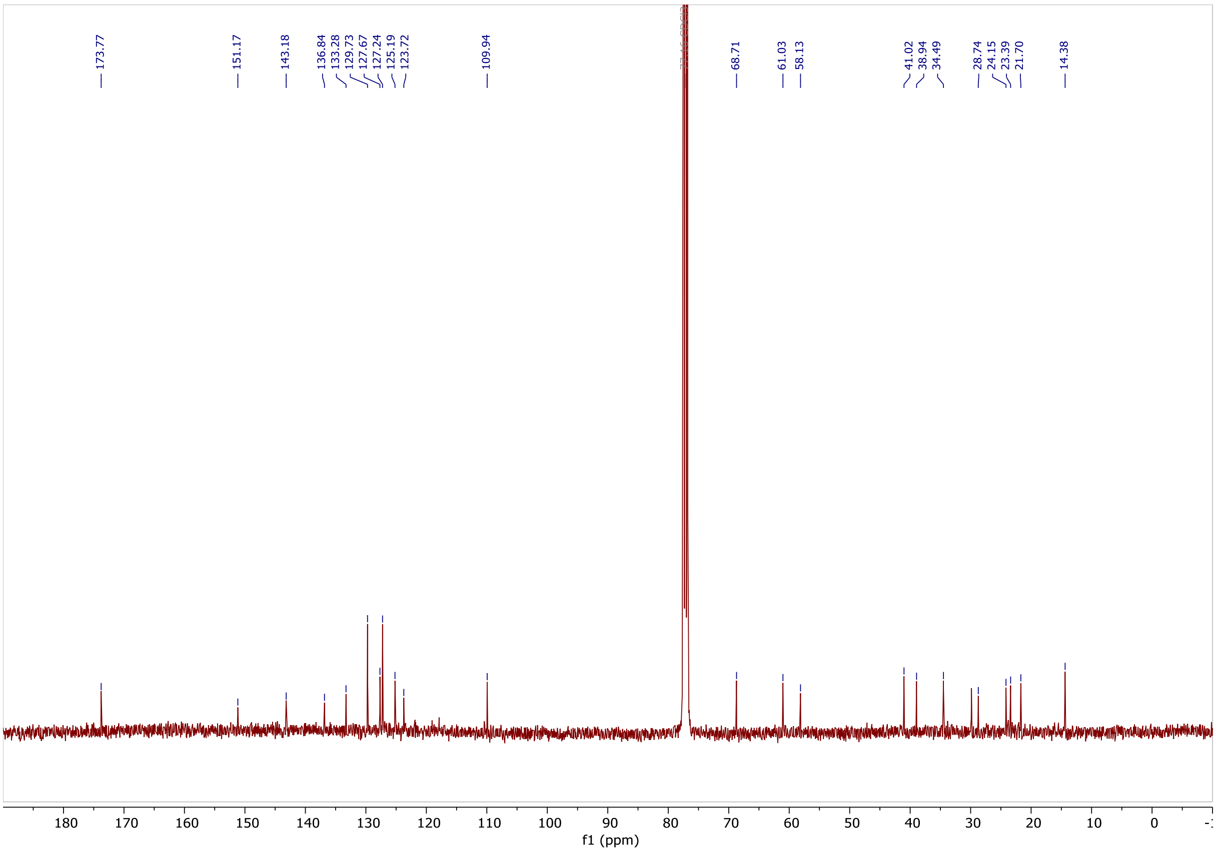
^{19}F NMR (376 MHz, chloroform-*d*) (6’m) 80% purity, mixed with 6m



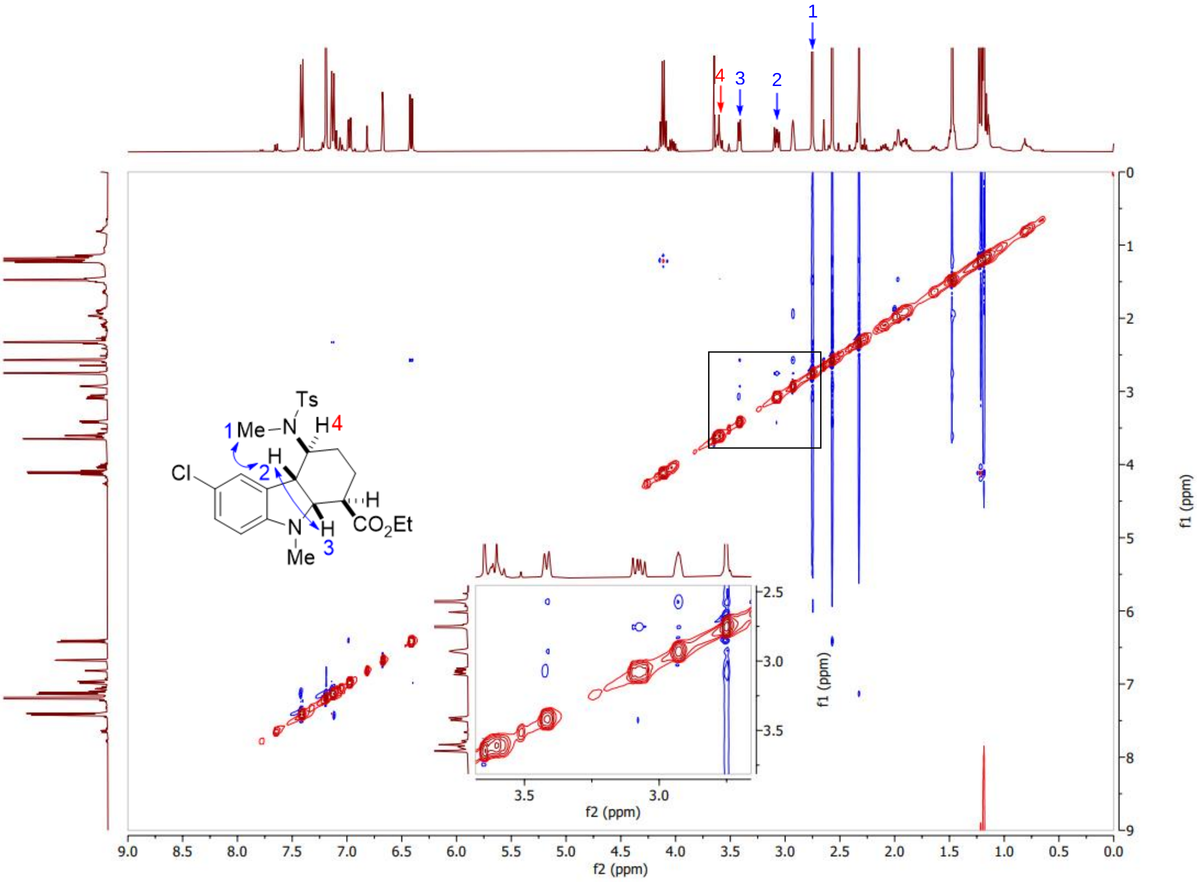
^{1}H-NMR (400 MHz, chloroform-*d*) (6n) 91% purity, mixed with 3a



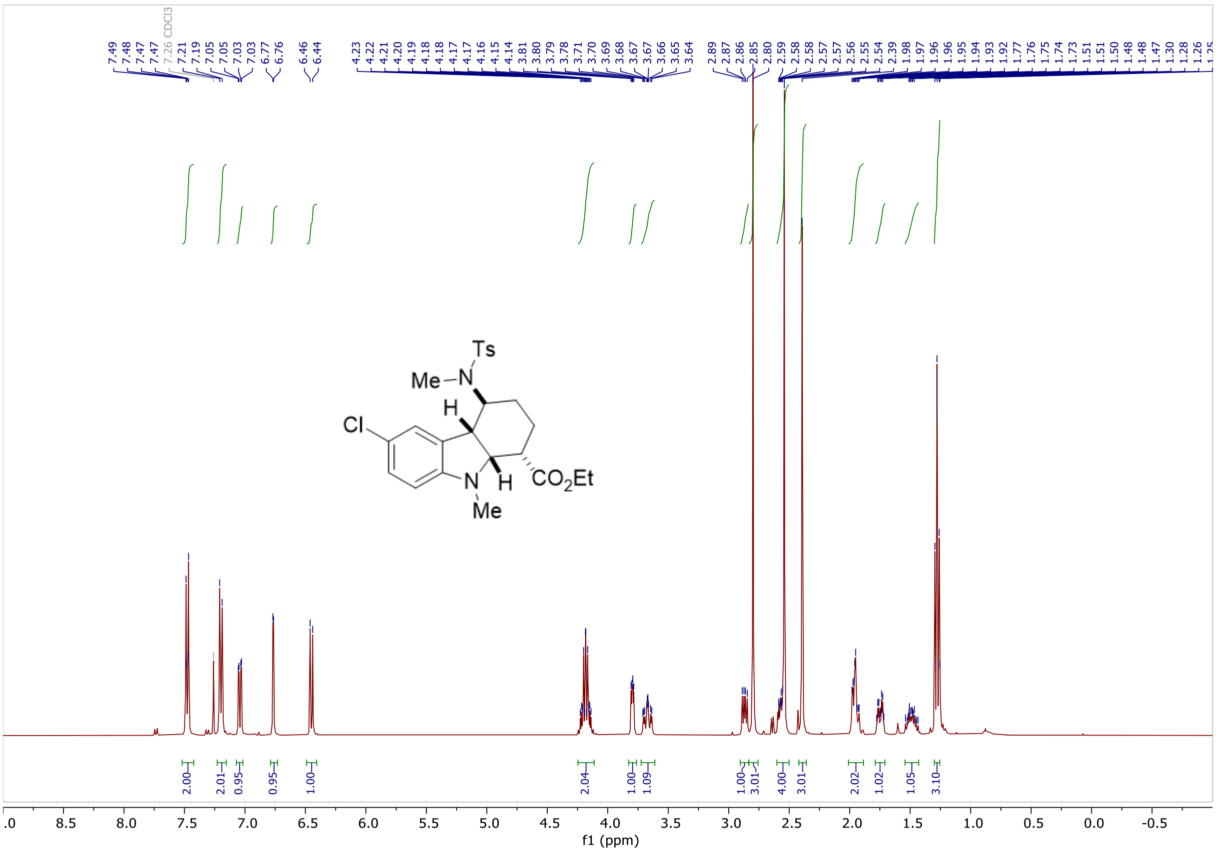
^{13}C-NMR (101 MHz, chloroform-*d*) (6n) 91% purity, mixed with 3a



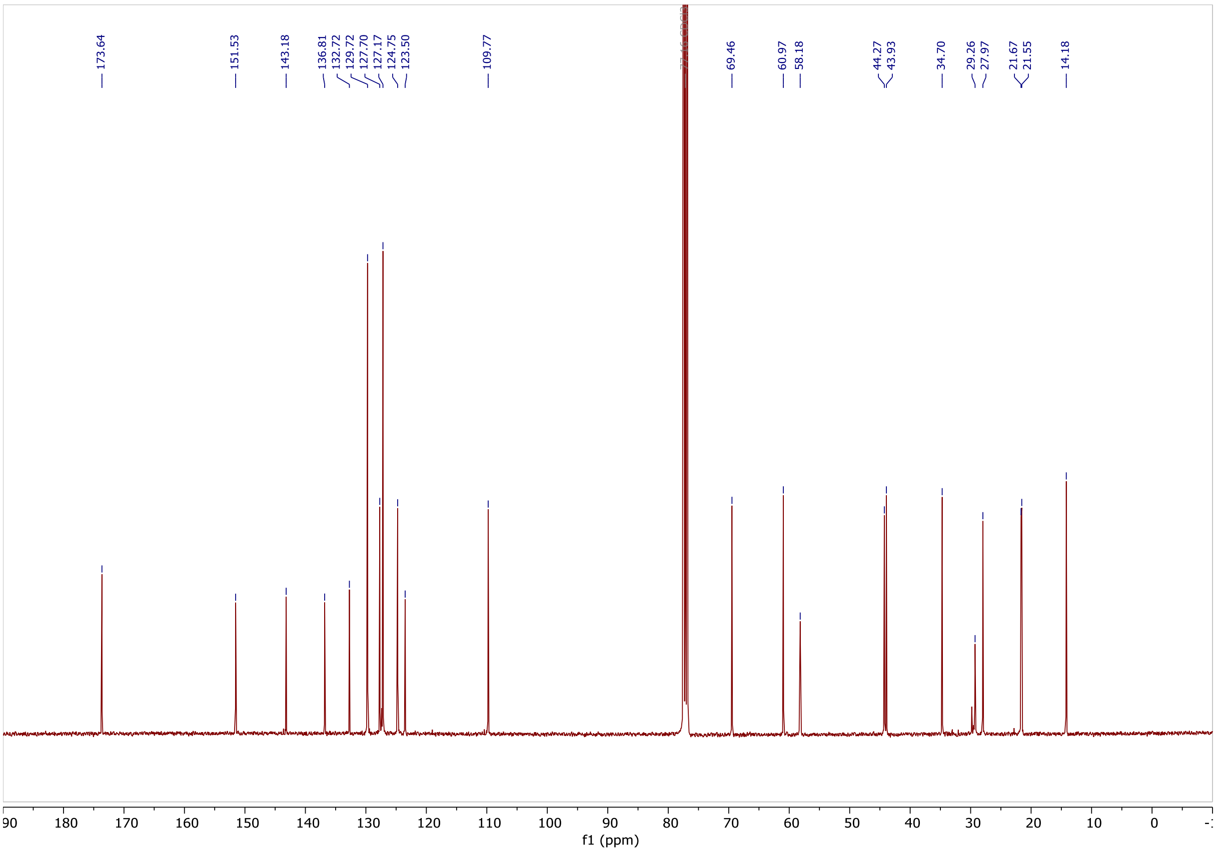
2D-NOESY (400 MHz, chloroform-*d*) (6n)



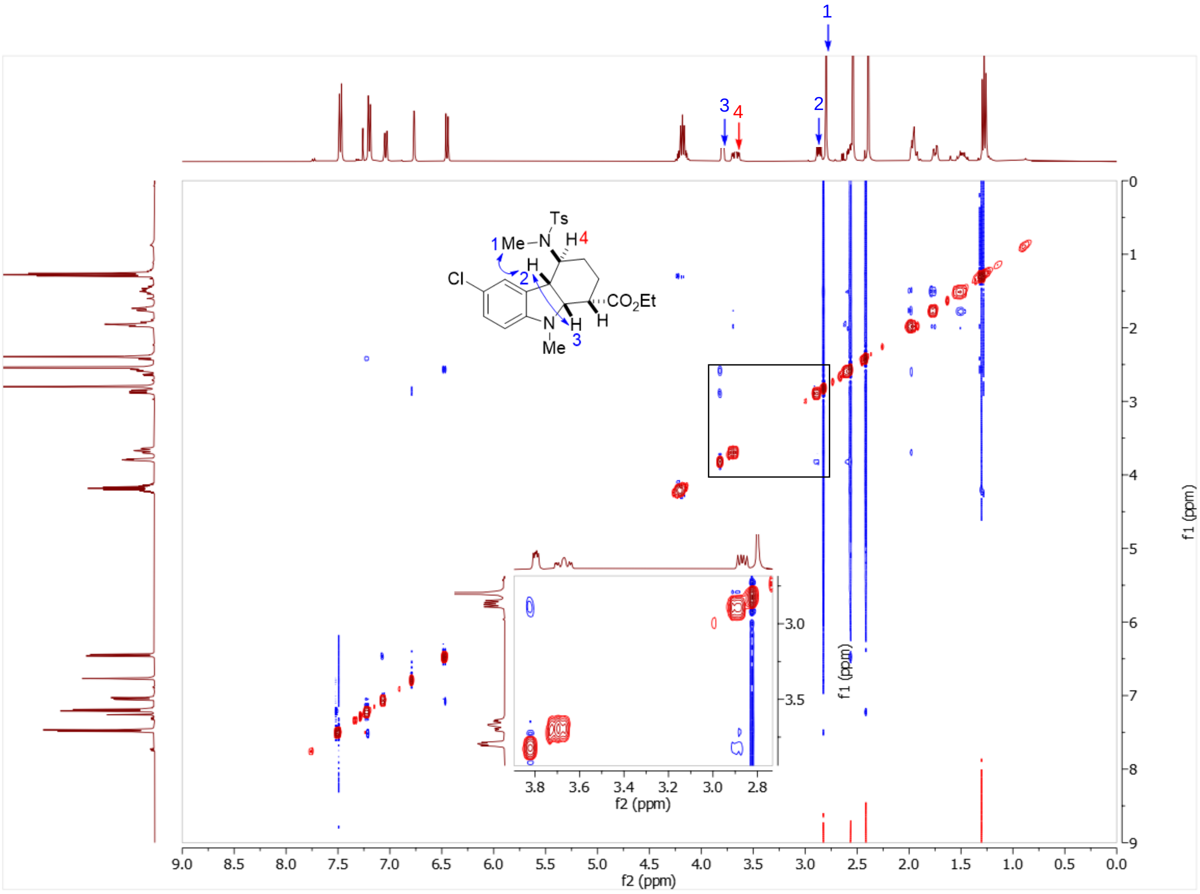
^{1}H-NMR (400 MHz, chloroform-*d*) (6’n)



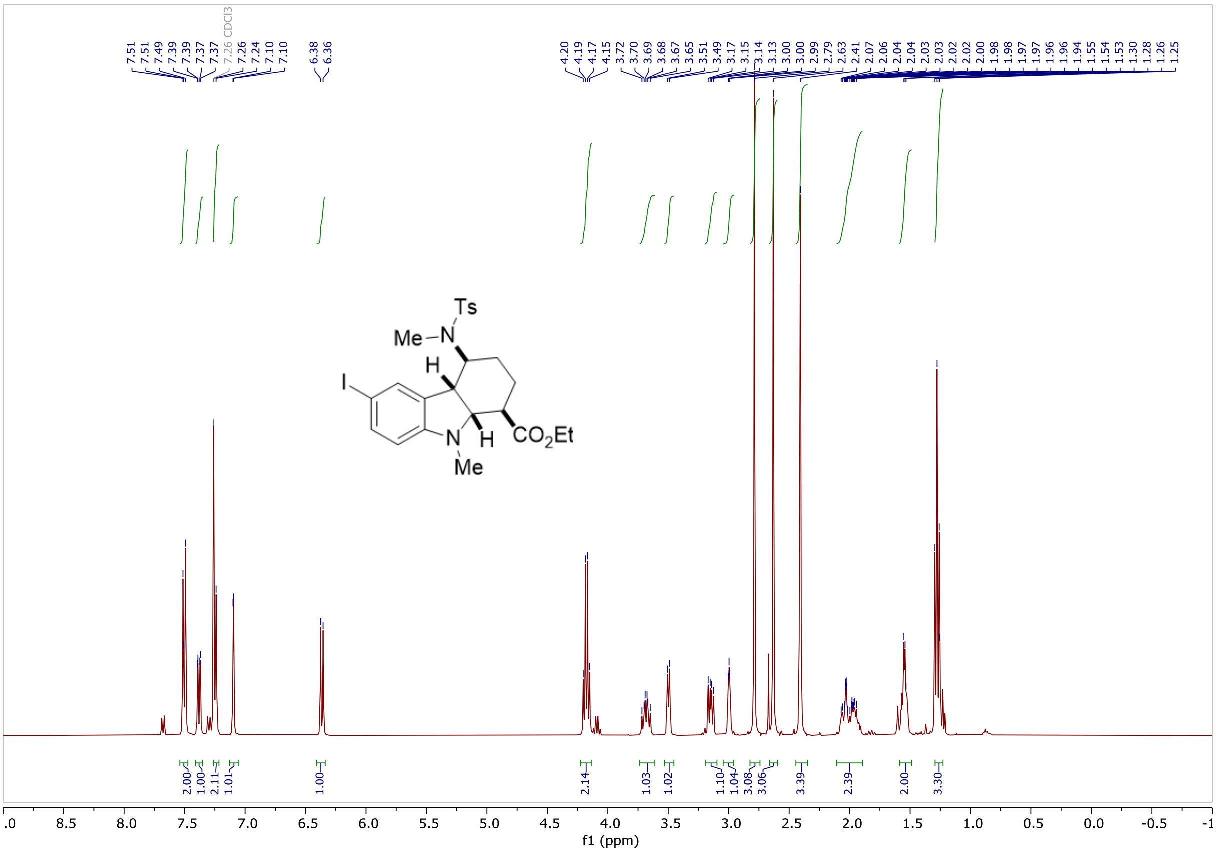
^{13}C-NMR (101 MHz, chloroform-*d*) (6’n)



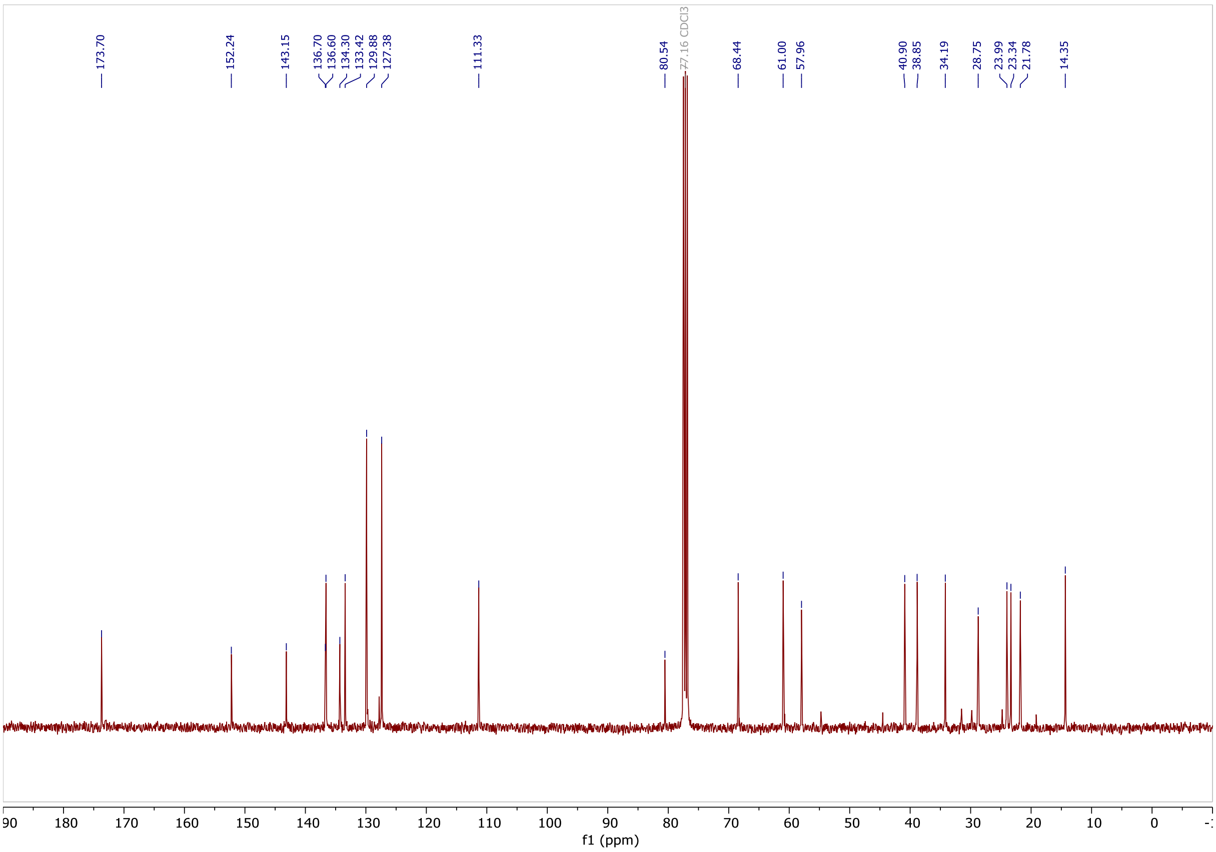
2D-NOESY (400 MHz, chloroform-*d*) (6’n)



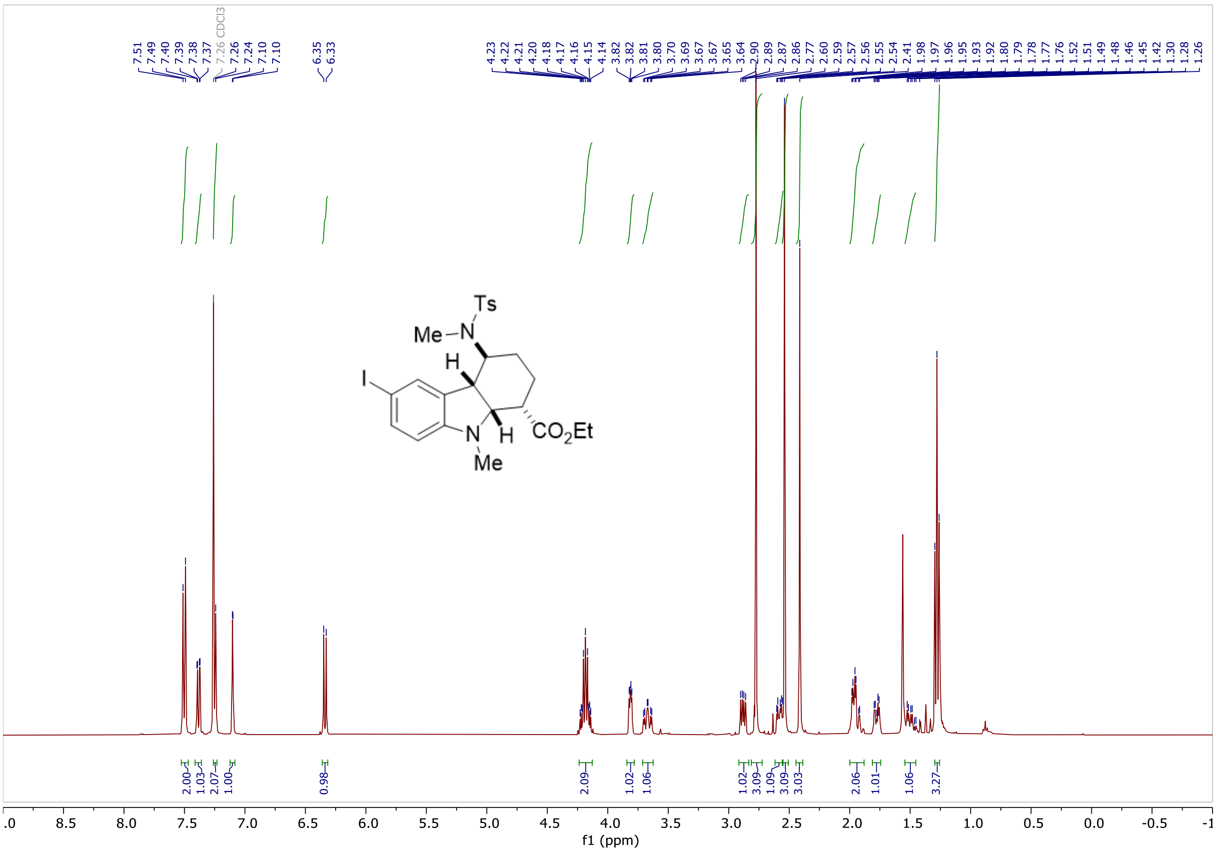
^{1}H-NMR (400 MHz, chloroform-*d*) (6o) 90% purity, mixed with 3a



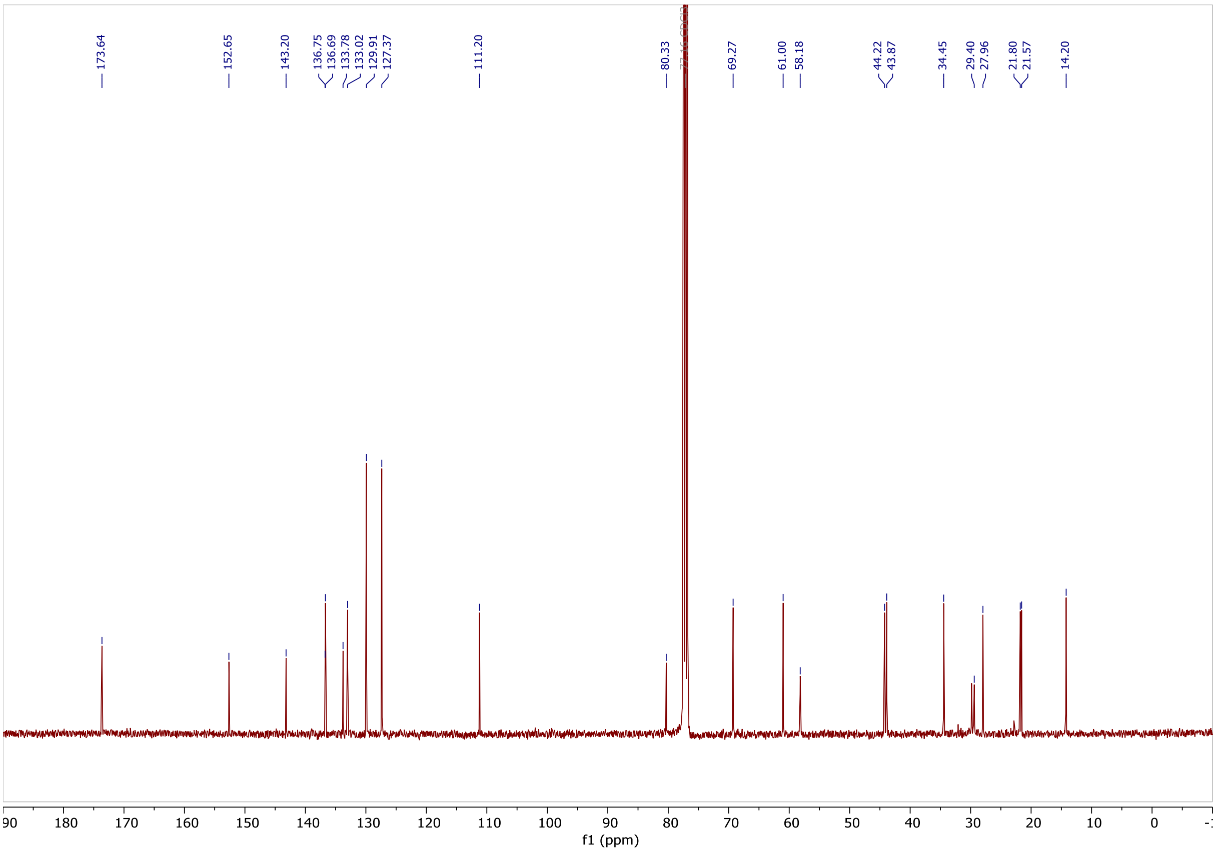
^{13}C-NMR (101 MHz, chloroform-*d*) (6o) 90% purity, mixed with 3a



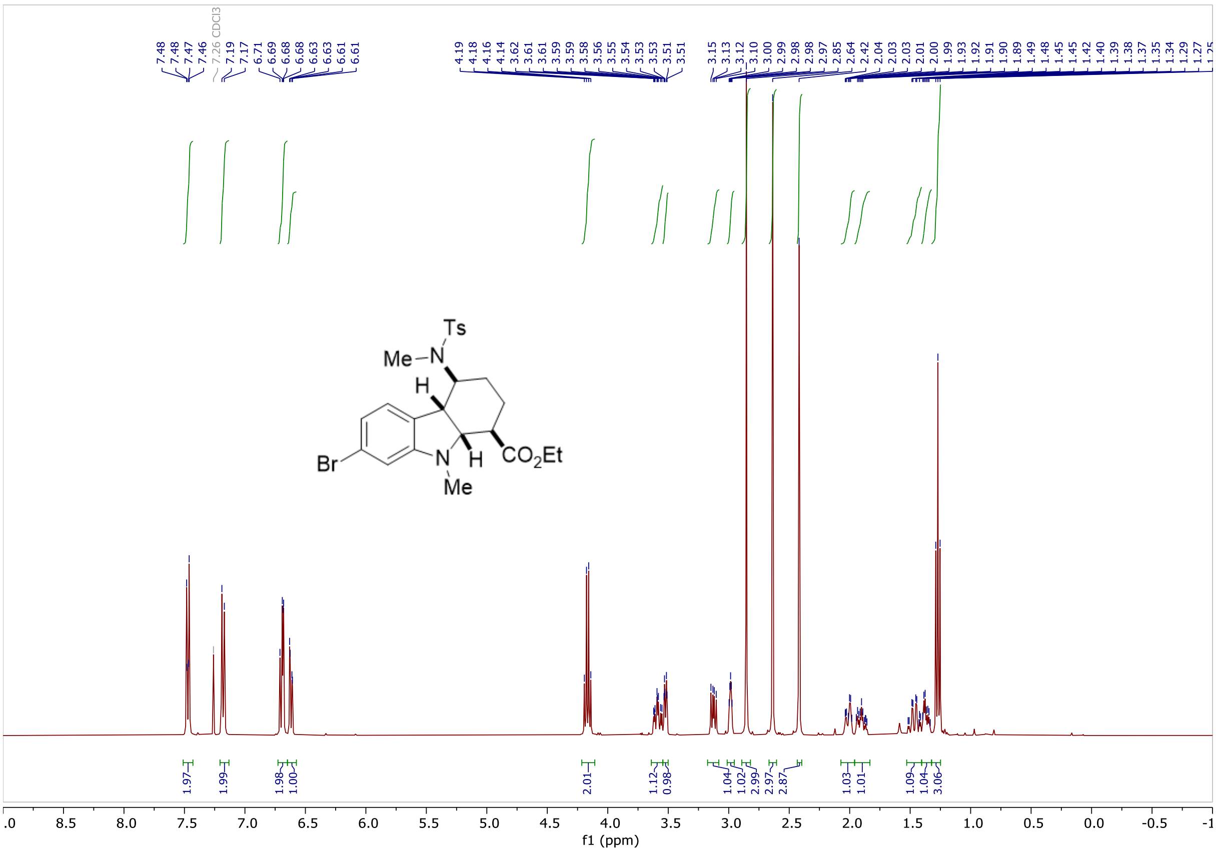
^{1}H-NMR (400 MHz, chloroform-*d*) (6’o)



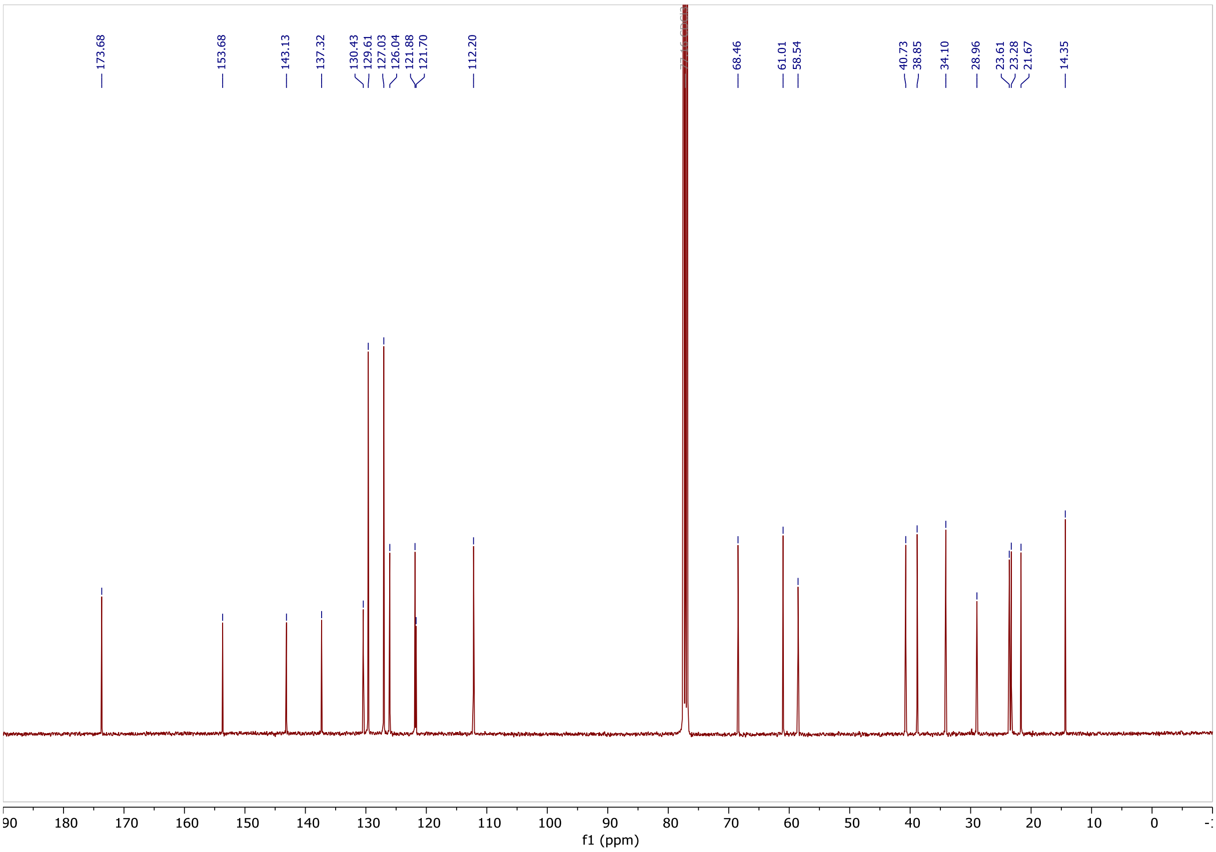
^{13}C-NMR (101 MHz, chloroform-*d*) (6’o)



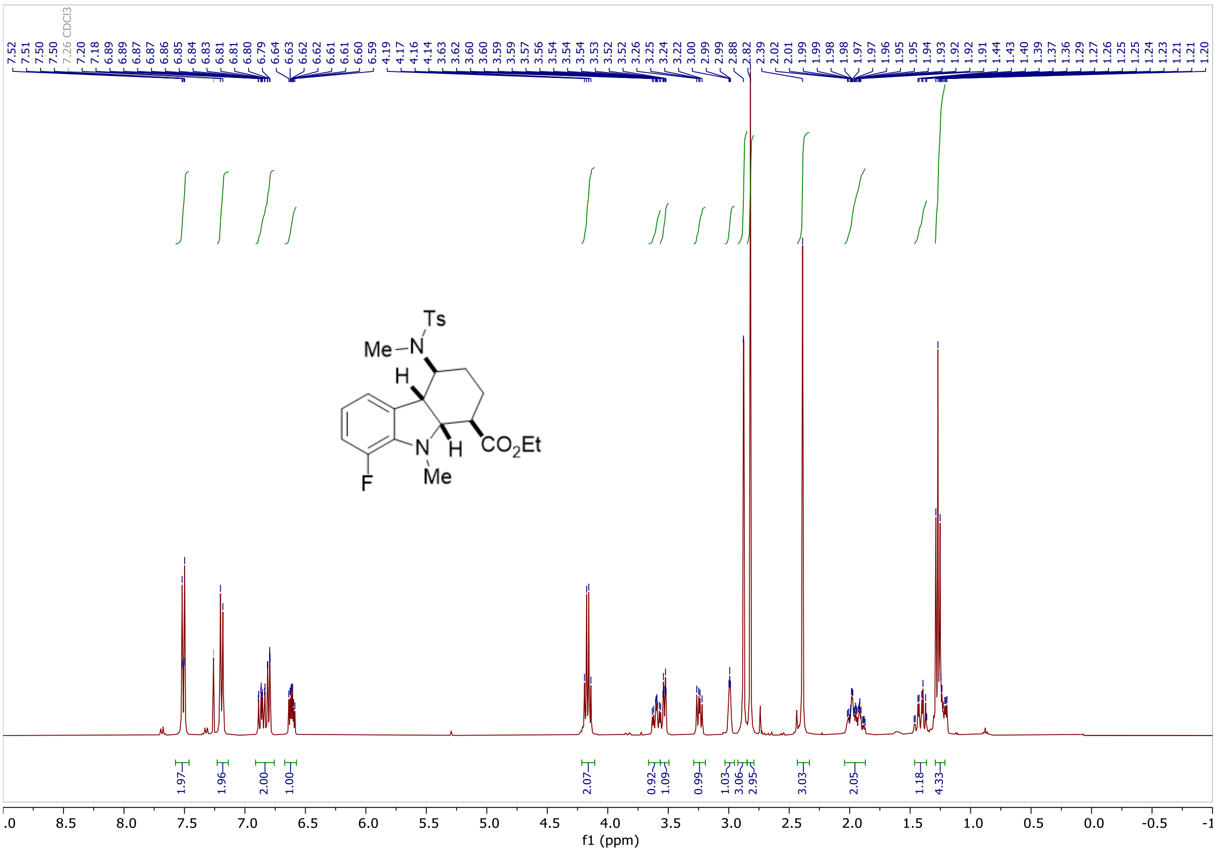
^{1}H-NMR (400 MHz, chloroform-*d*) (6p)



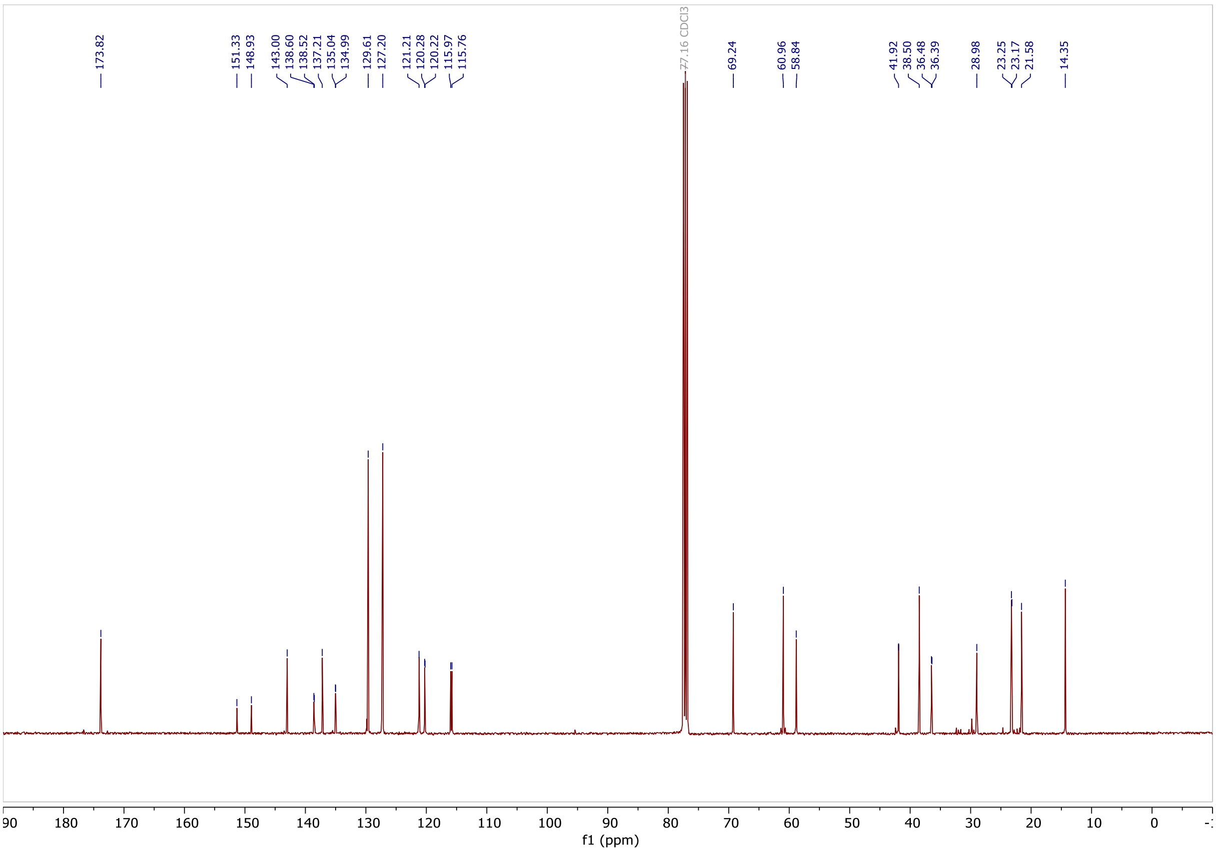
^{13}C-NMR (101 MHz, chloroform-*d*) (6p)



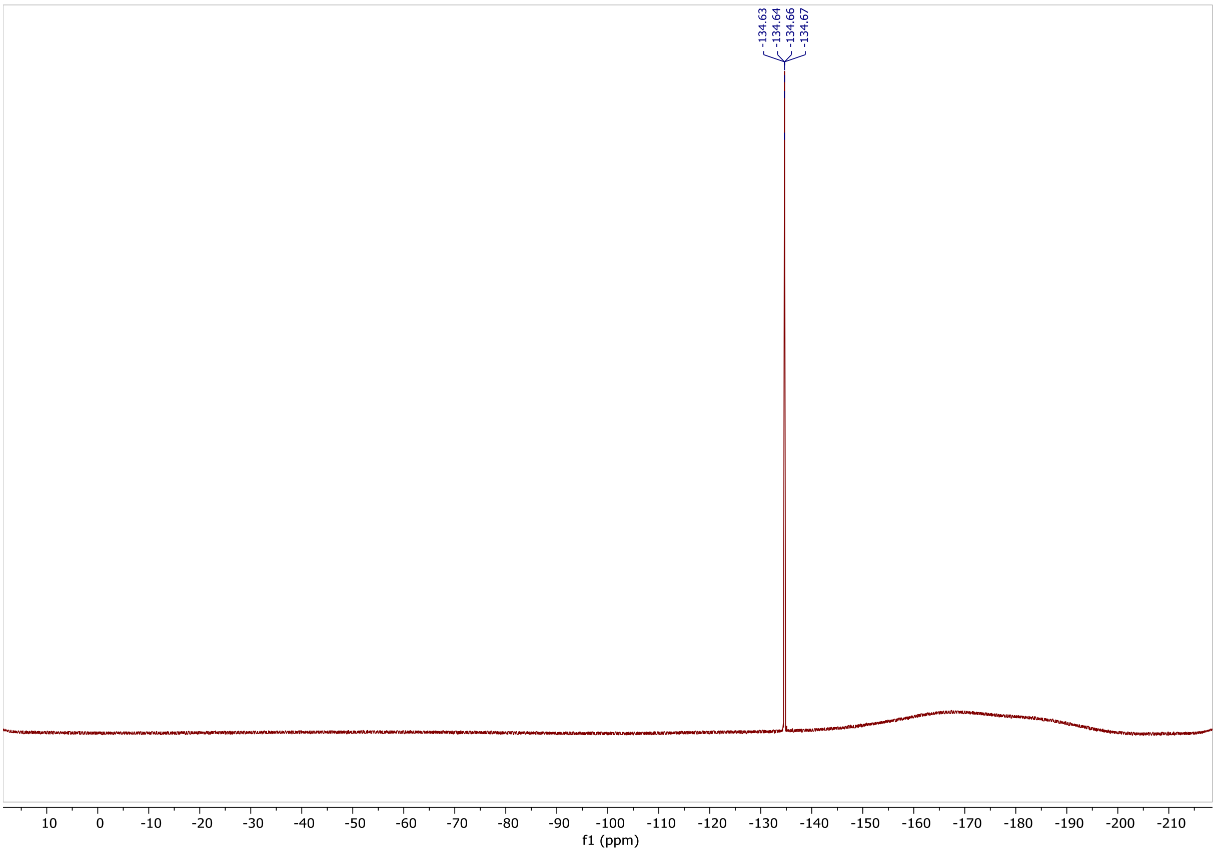
^{1}H-NMR (400 MHz, chloroform-*d*) (6q)



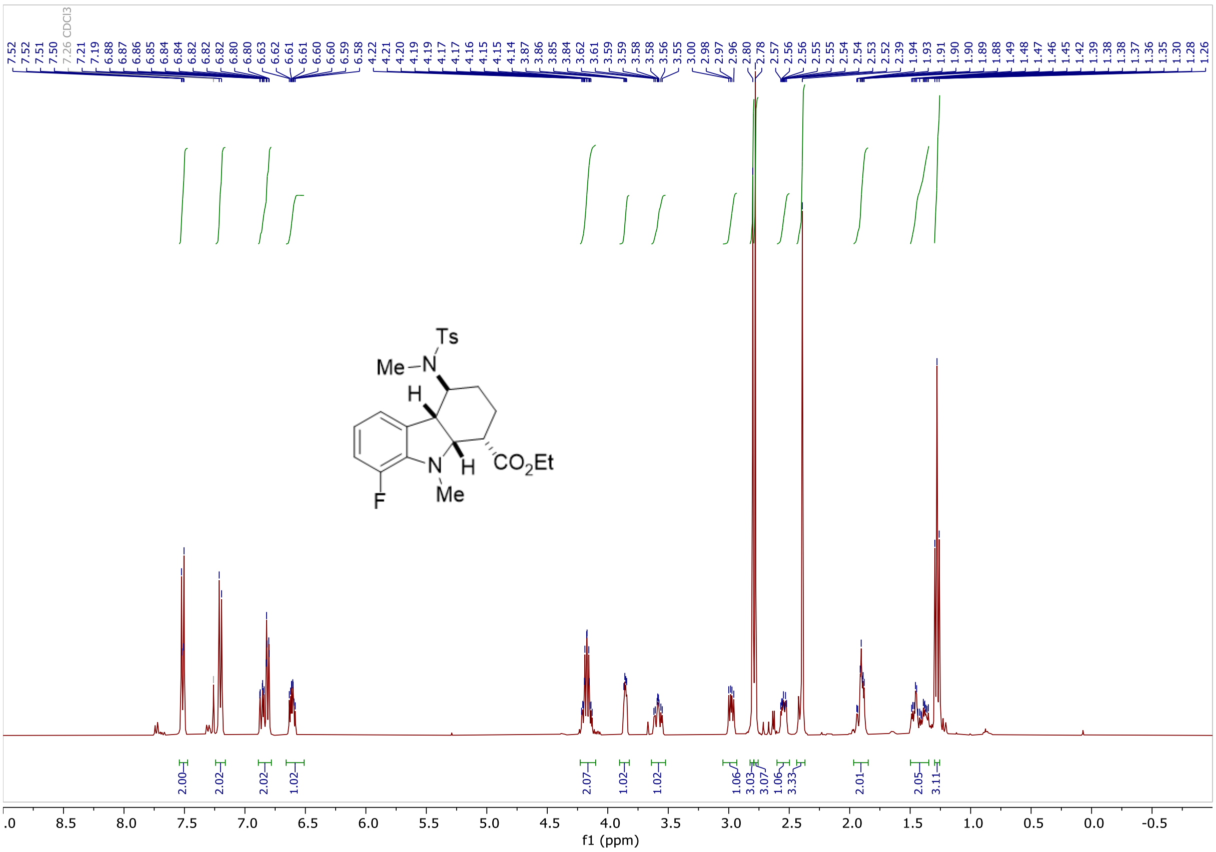
^{13}C-NMR (101 MHz, chloroform-*d*) (6q)



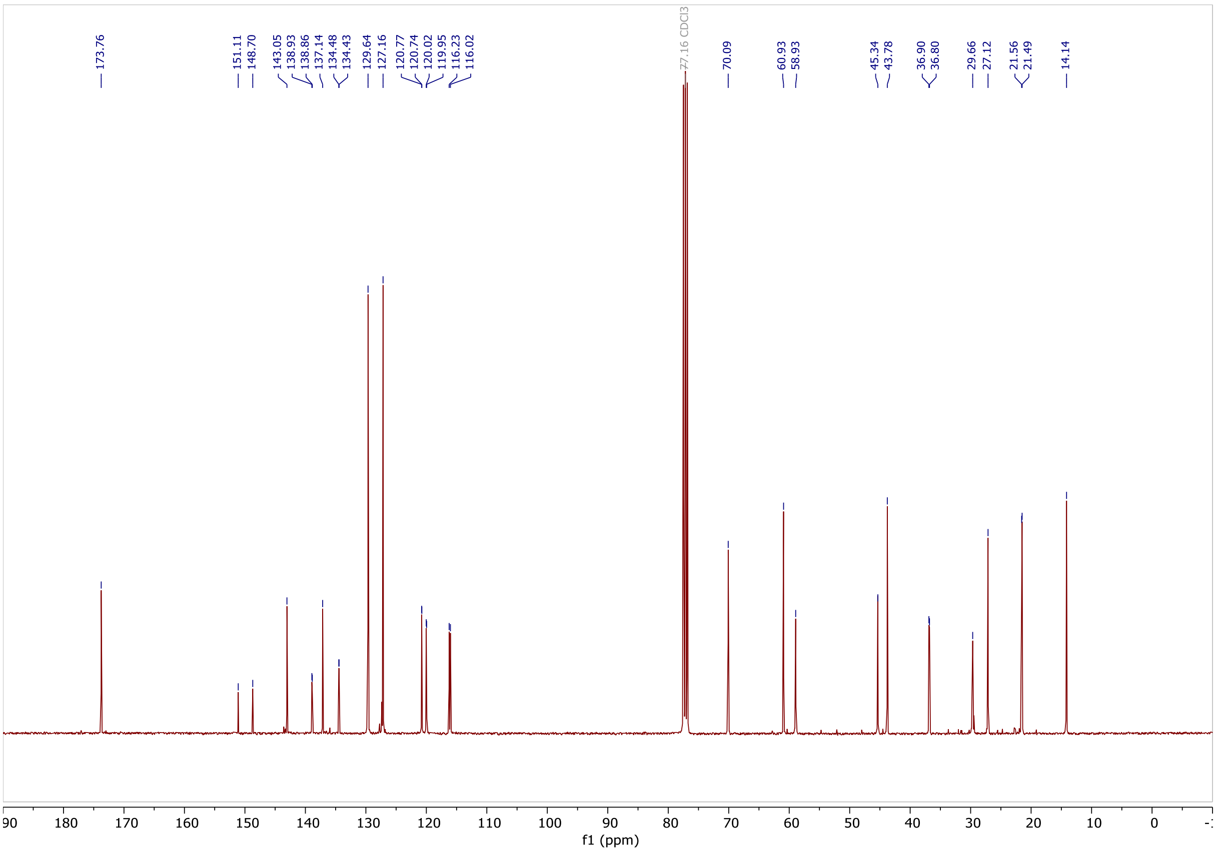
^{19}F NMR (376 MHz, chloroform-*d*) (6q)



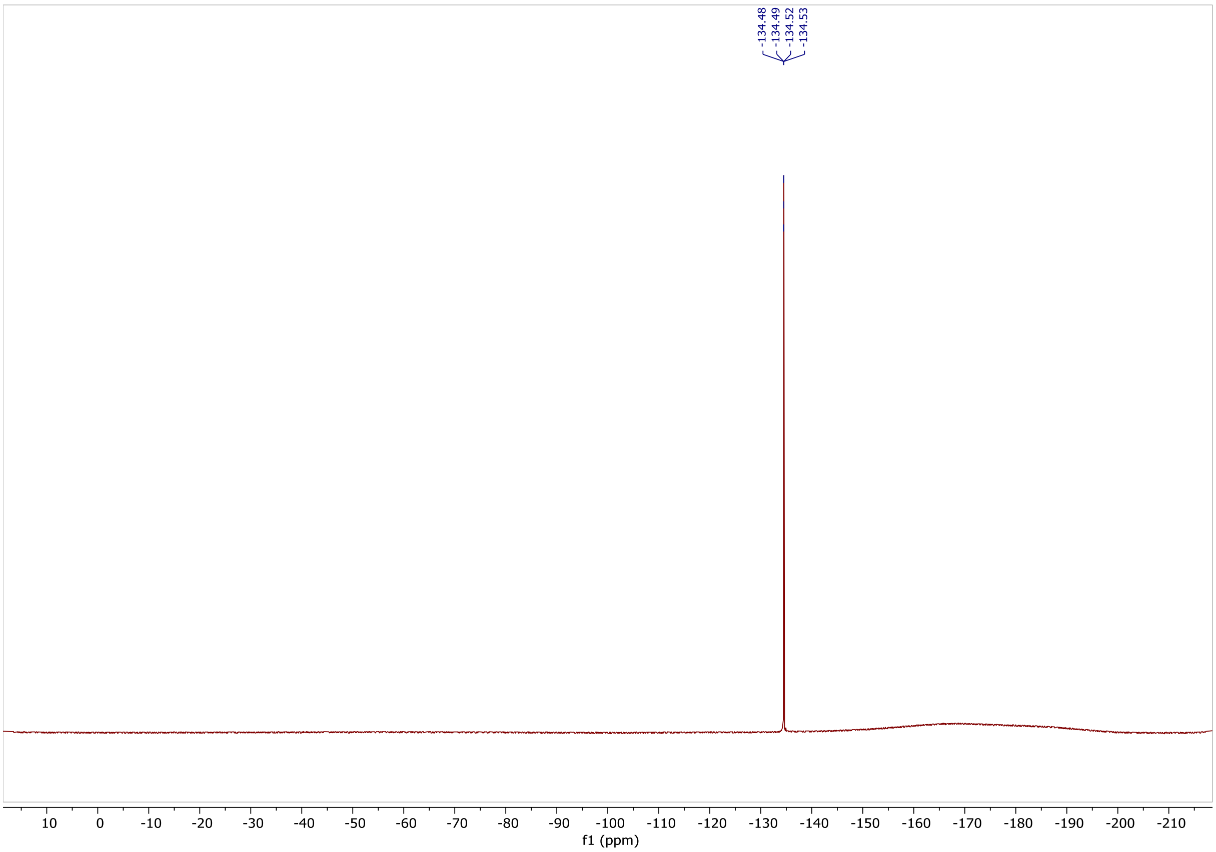
^{1}H-NMR (400 MHz, chloroform-*d*) (6’q)



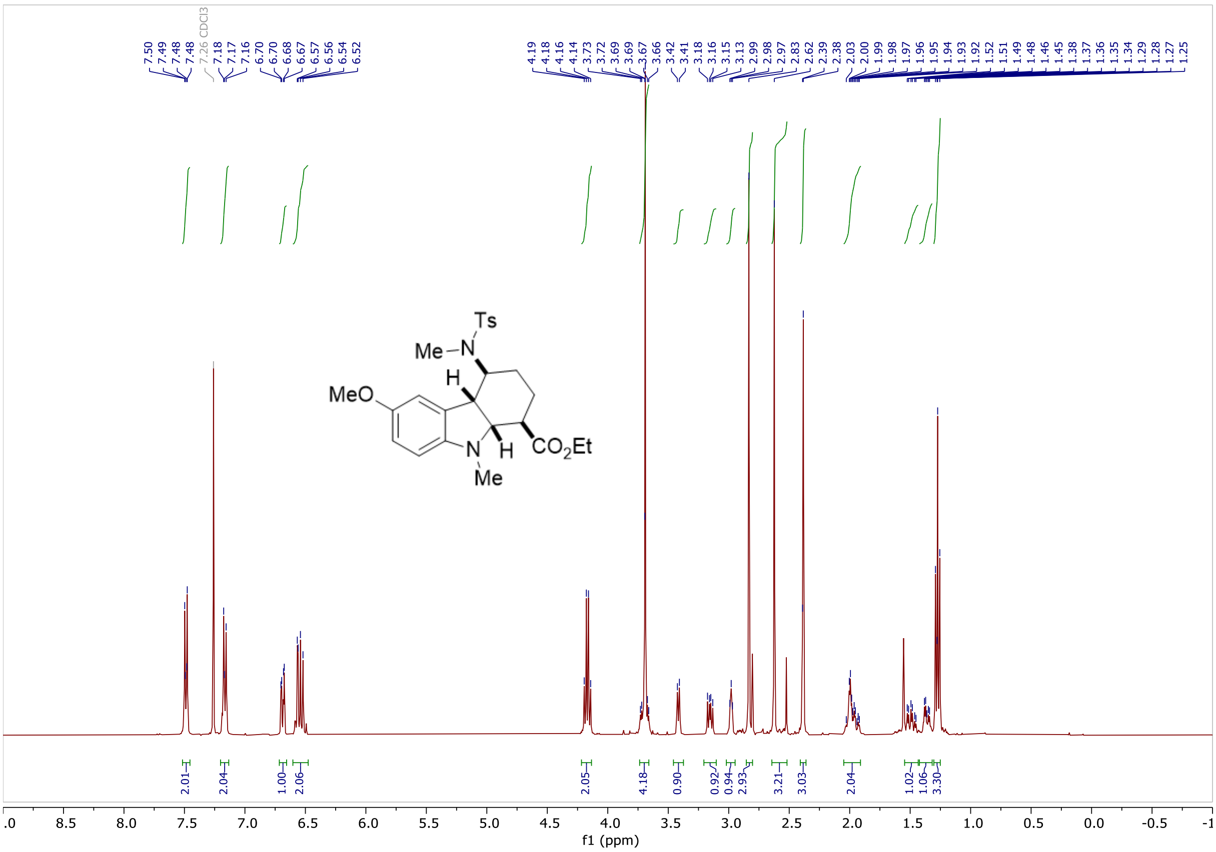
^{13}C-NMR (101 MHz, chloroform-*d*) (6’q)



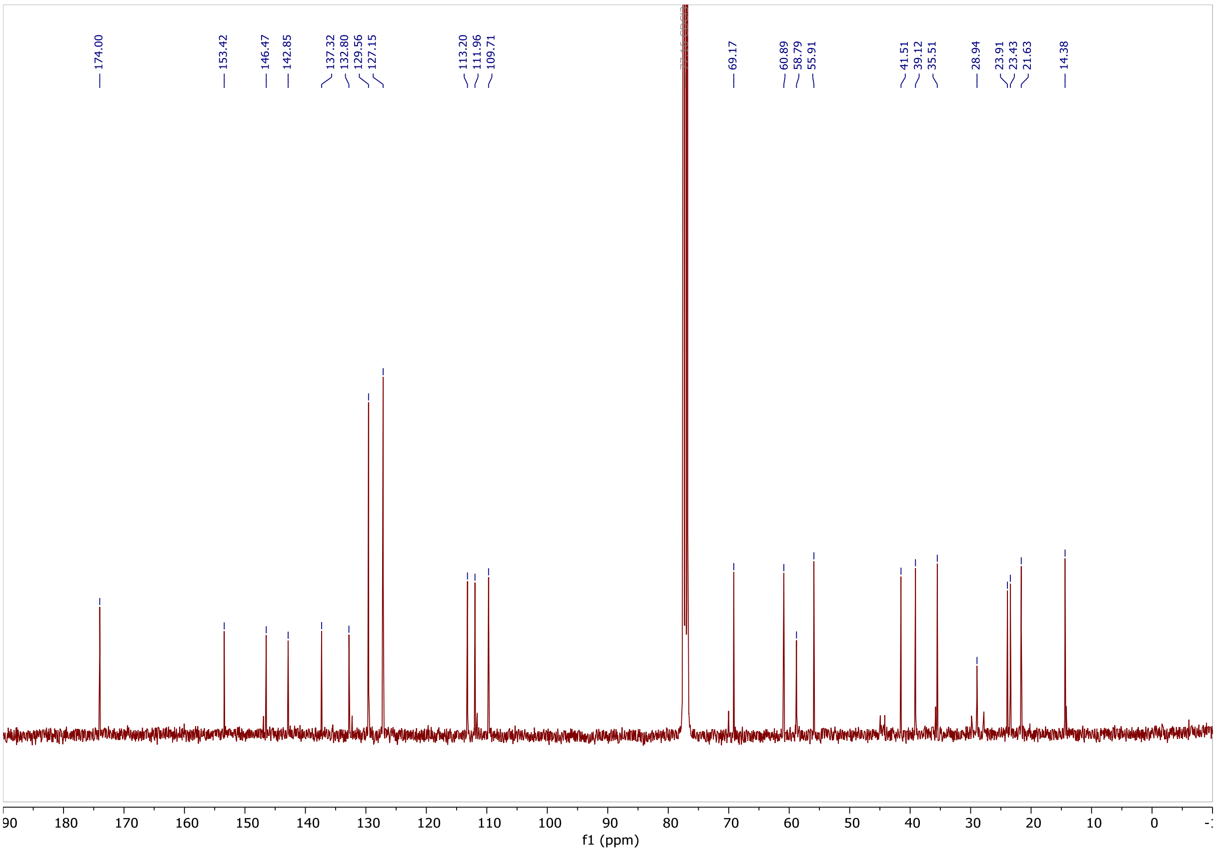
^{19}F NMR (376 MHz, chloroform-*d*) (6’q)



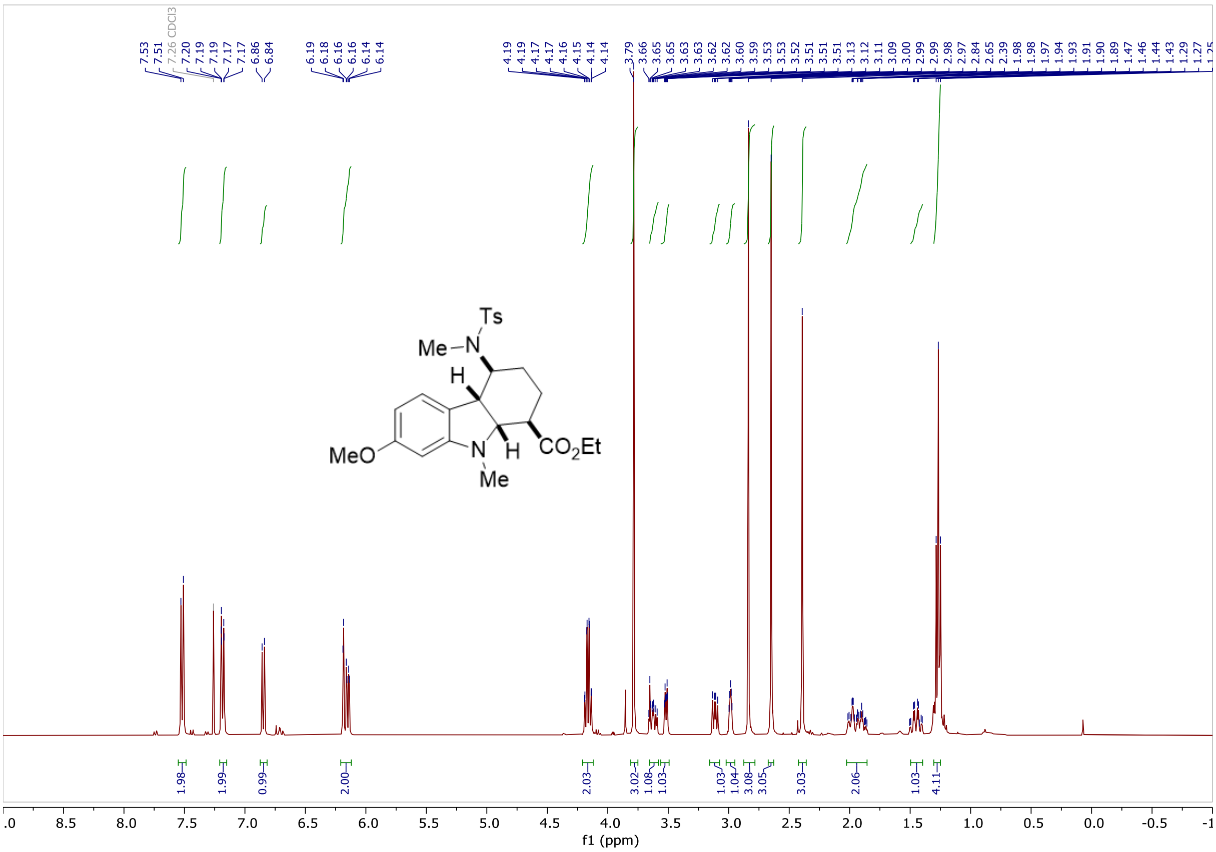
^{1}H-NMR (400 MHz, chloroform-*d*) (6r)



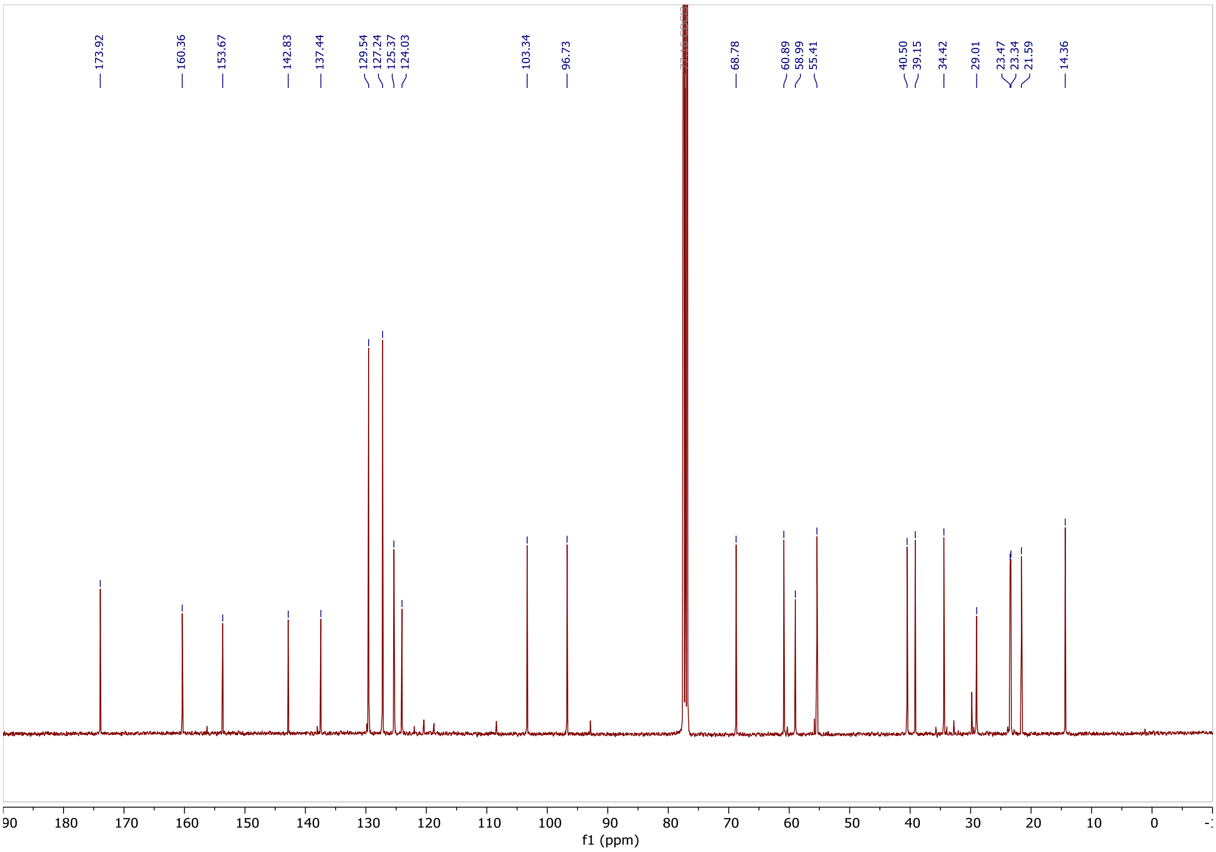
^{13}C-NMR (101 MHz, chloroform-*d*) (6r)



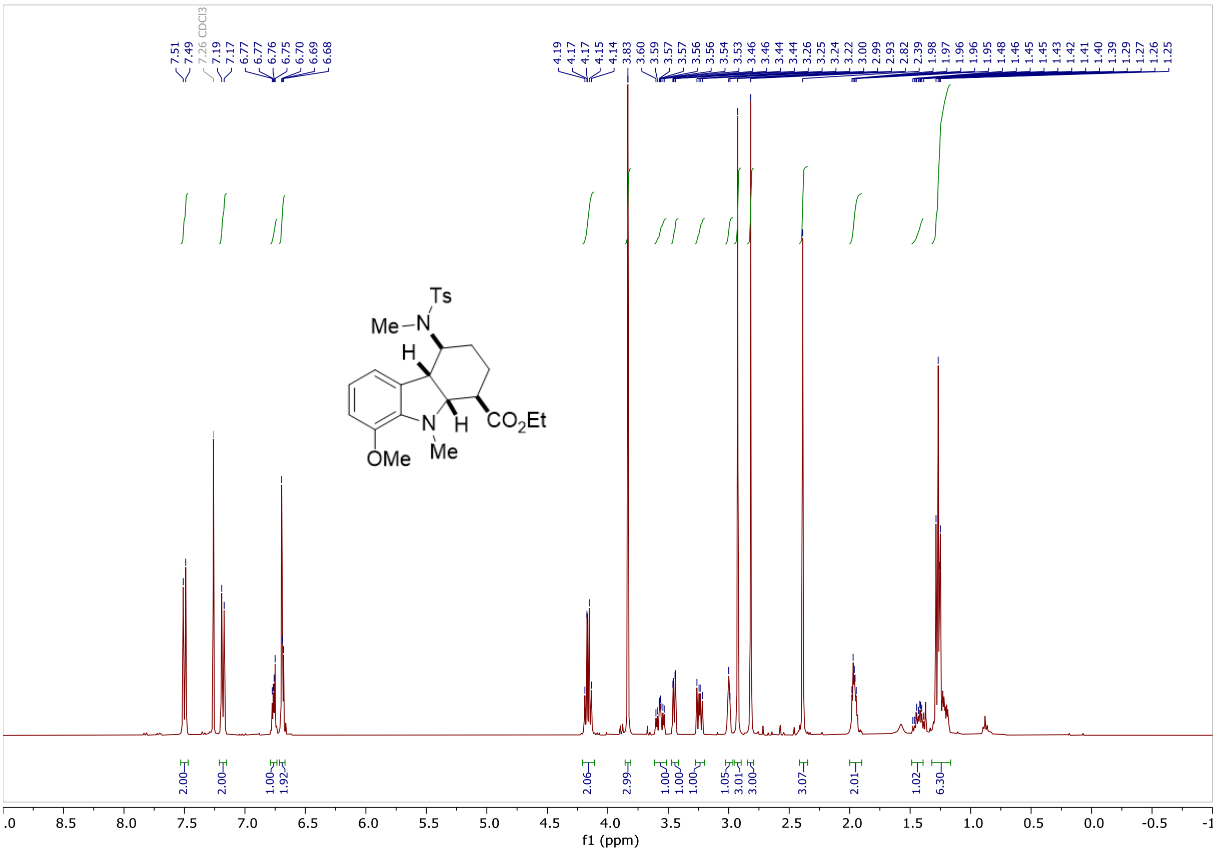
^{1}H-NMR (400 MHz, chloroform-*d*) (6s)



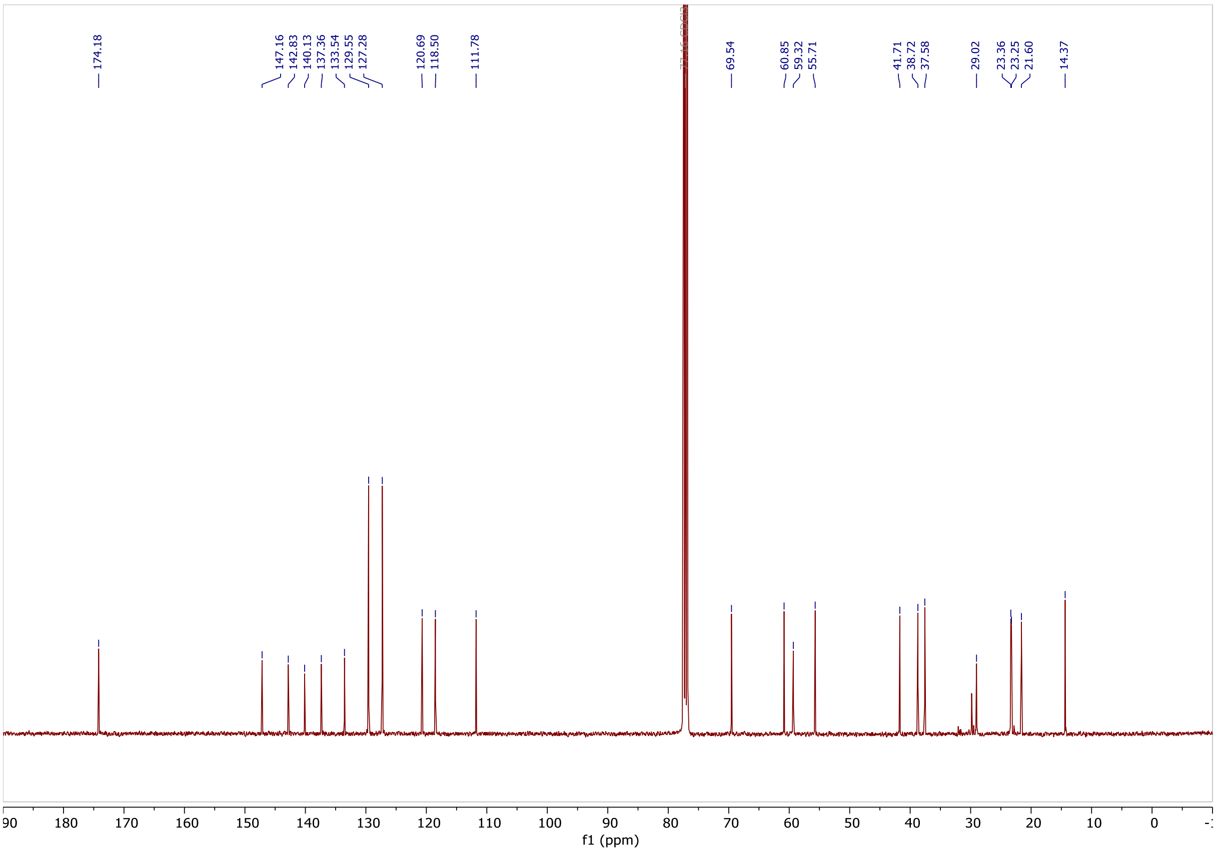
^{13}C-NMR (101 MHz, chloroform-*d*) (6s)



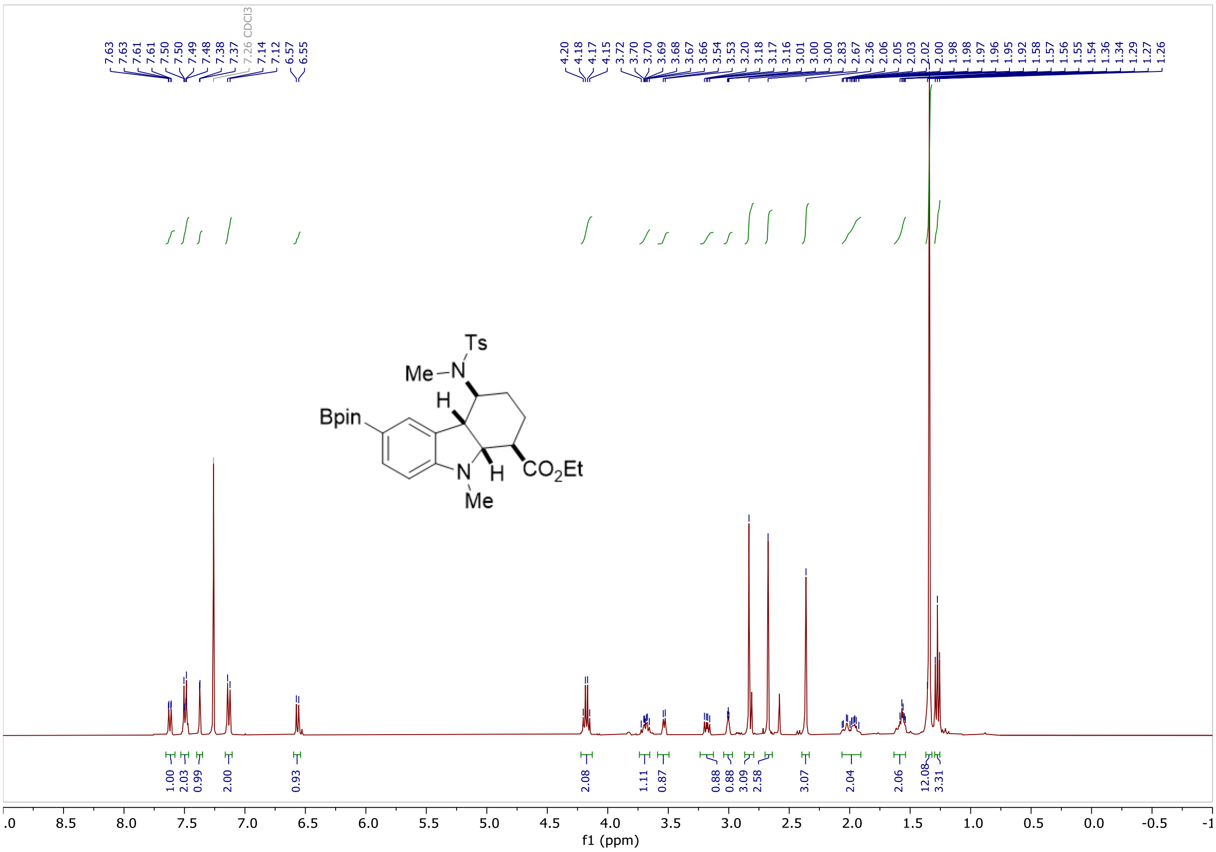
^{1}H-NMR (400 MHz, chloroform-*d*) (6t)



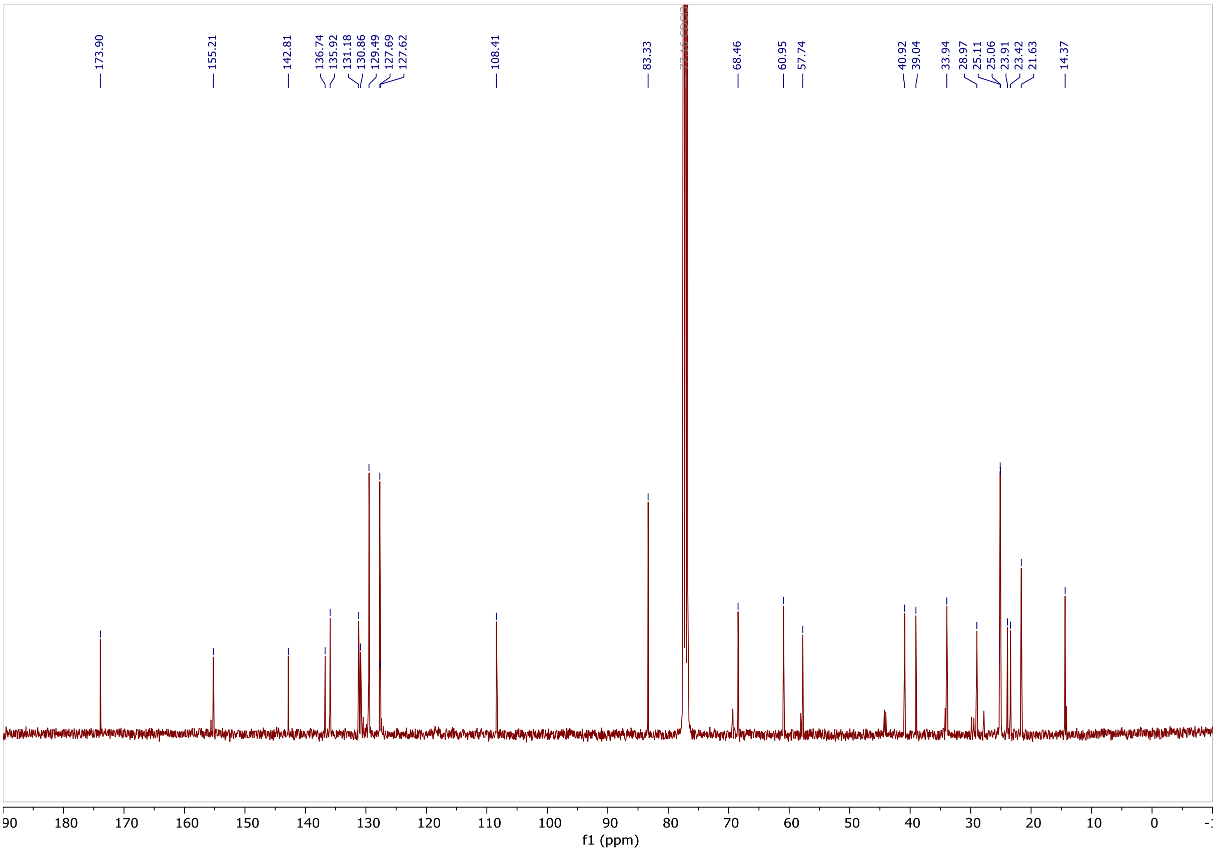
^{13}C-NMR (101 MHz, chloroform-*d*) (6t)



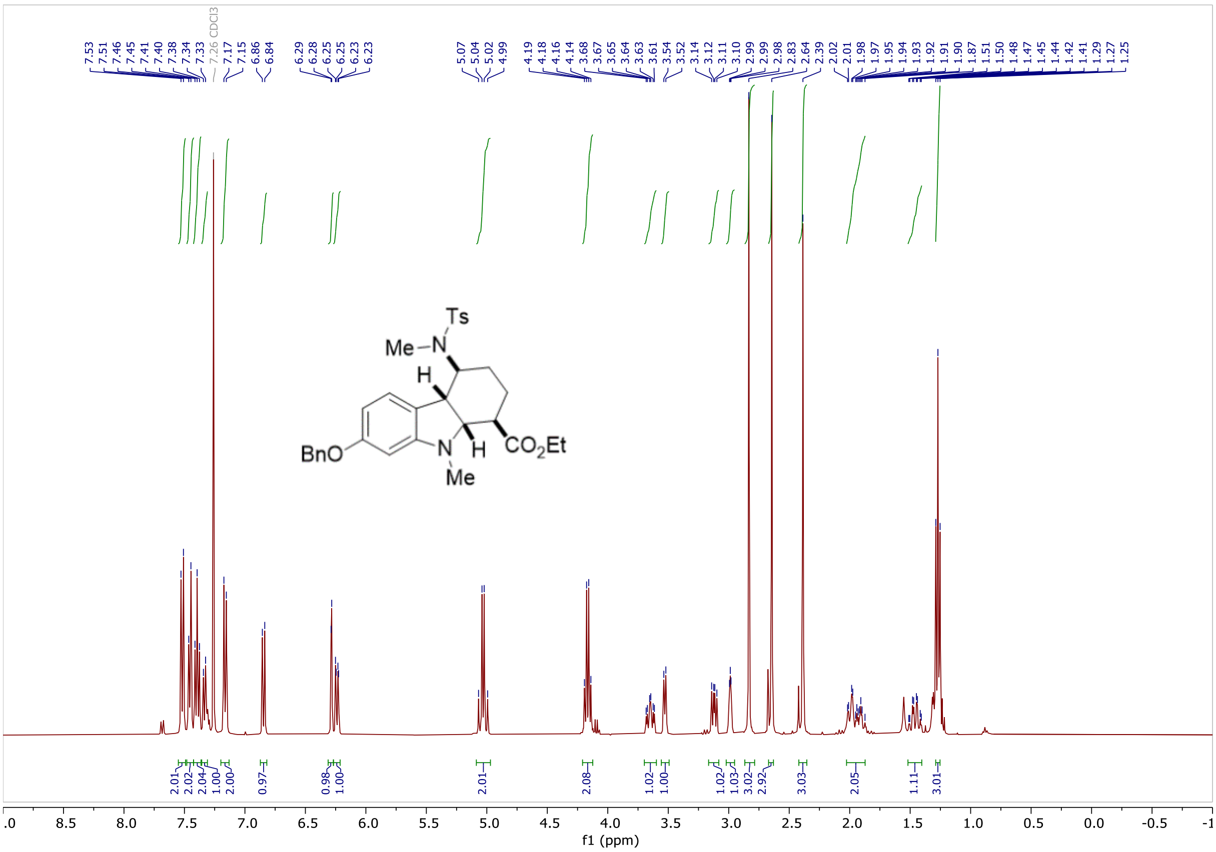
^{1}H-NMR (400 MHz, chloroform-*d*) (6u)



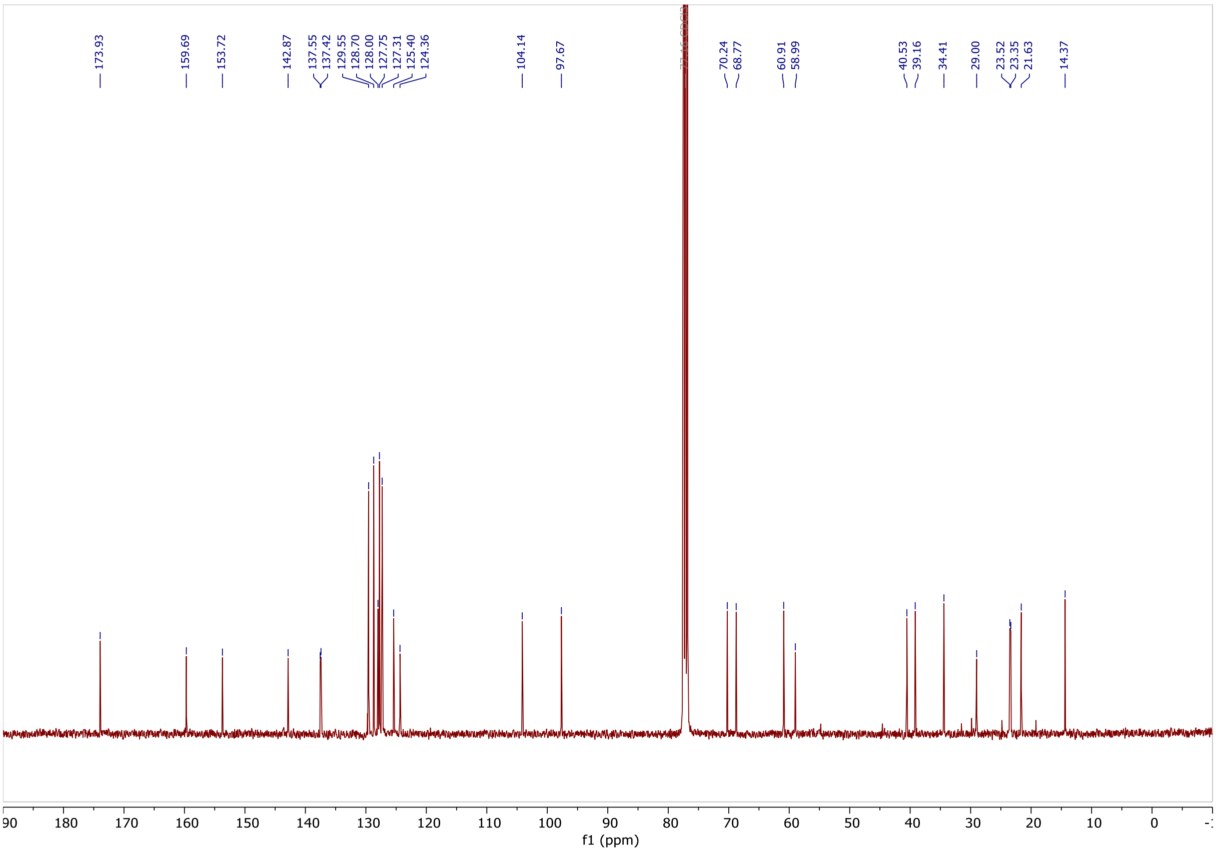
^{13}C-NMR (101 MHz, chloroform-*d*) (6u)



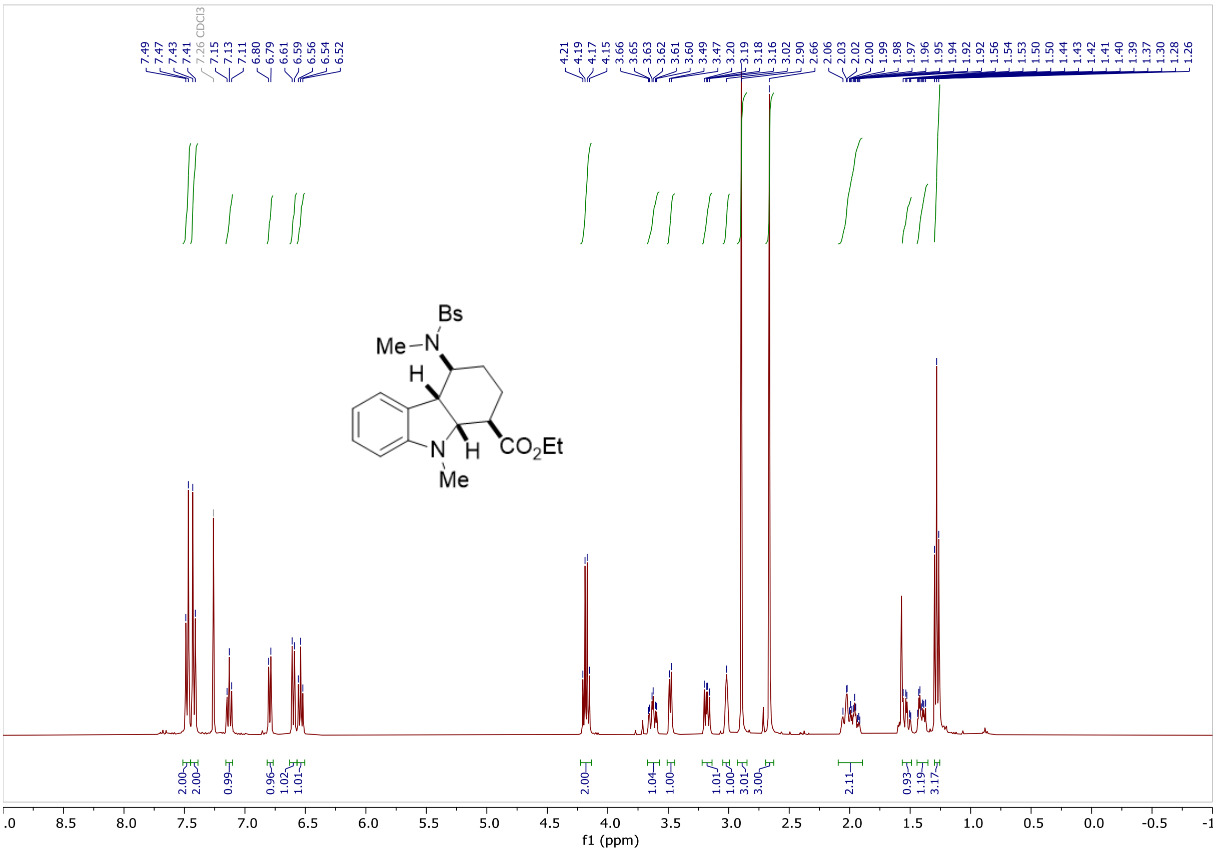
^{1}H-NMR (400 MHz, chloroform-*d*) (6v) 93% purity, mixed with 6’v



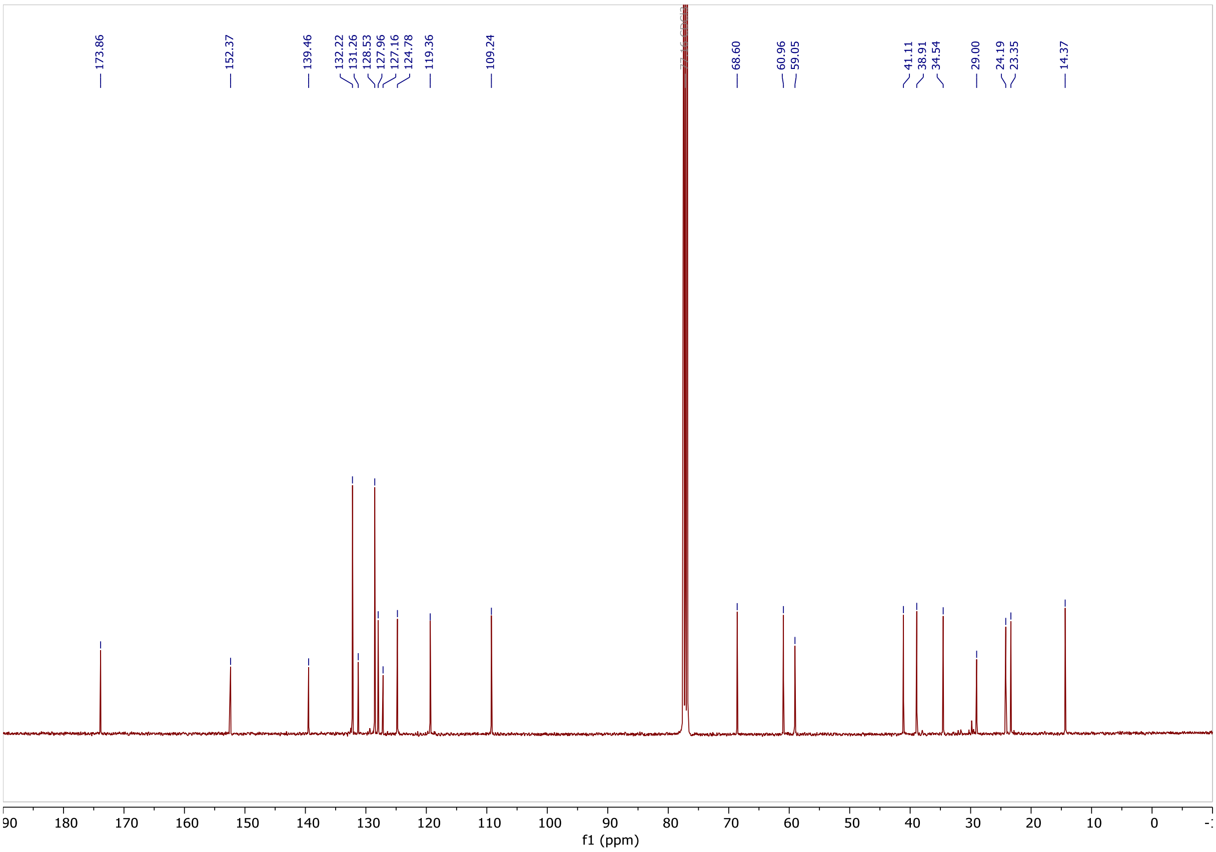
^{13}C-NMR (101 MHz, chloroform-*d*) (6v) 93% purity, mixed with 6’v



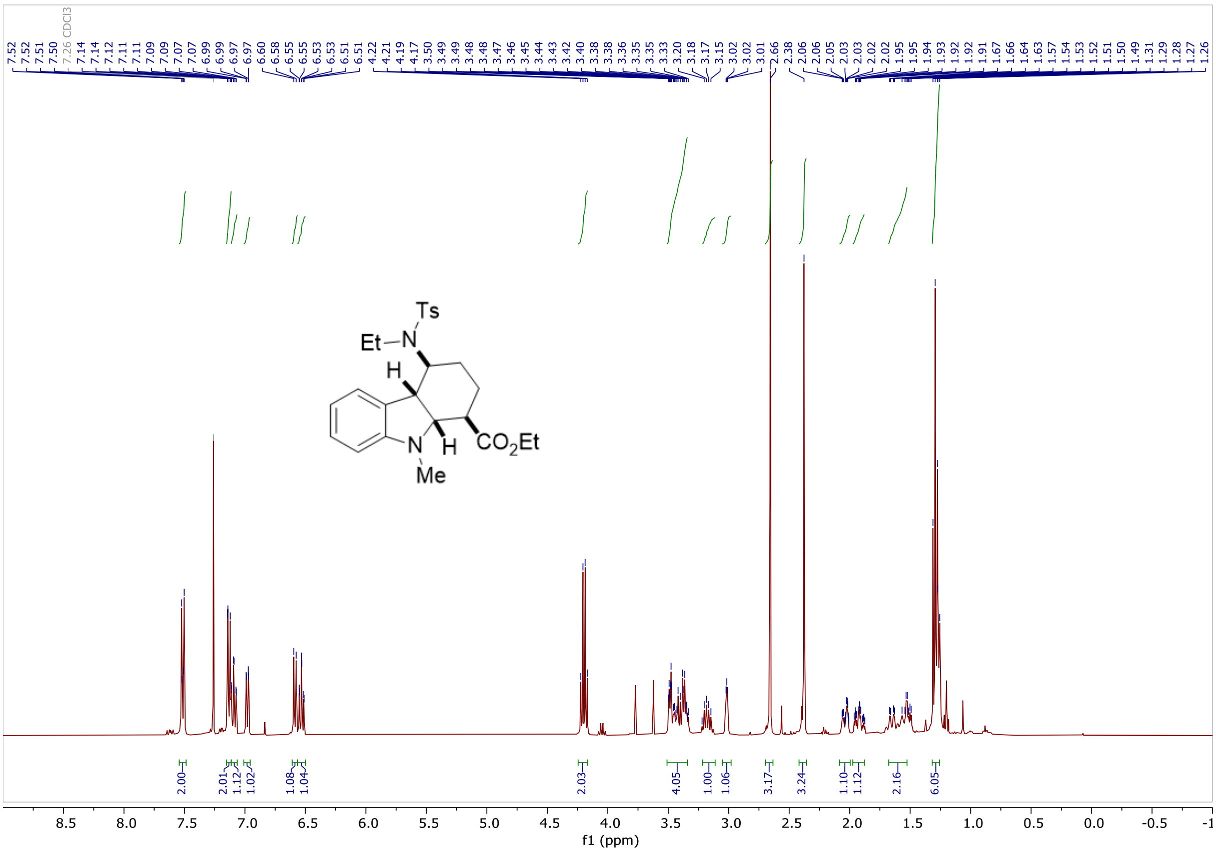
^{1}H-NMR (400 MHz, chloroform-*d*) (7a)



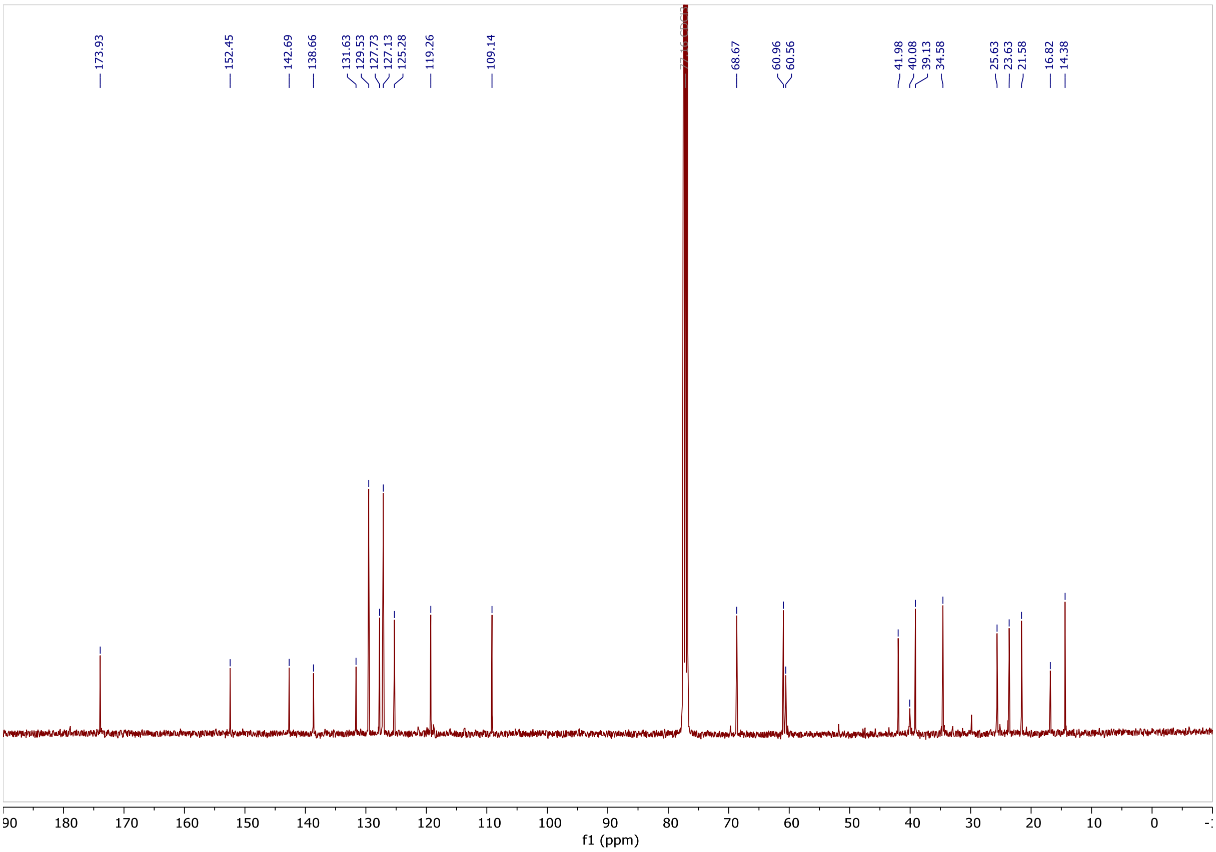
^{13}C-NMR (101 MHz, chloroform-*d*) (7a)



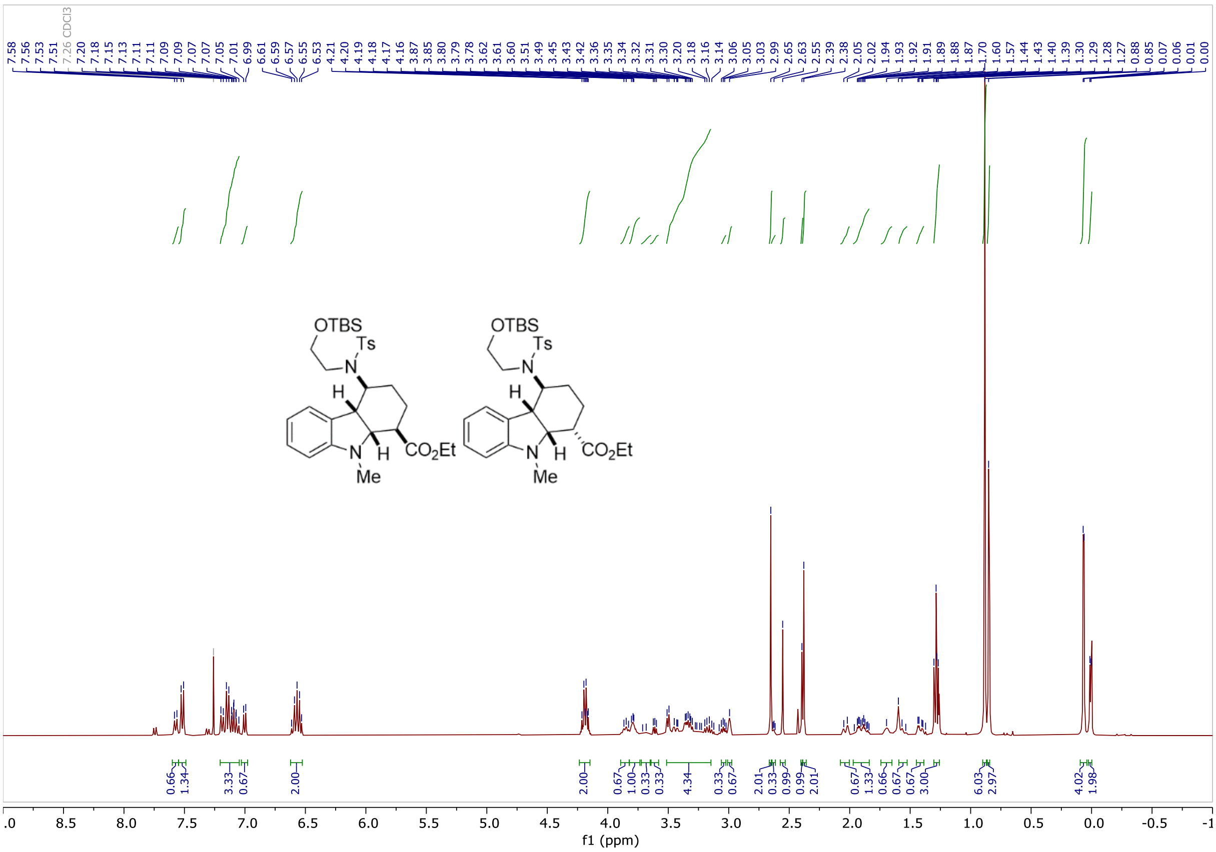
^{1}H-NMR (400 MHz, chloroform-*d*) (7b)



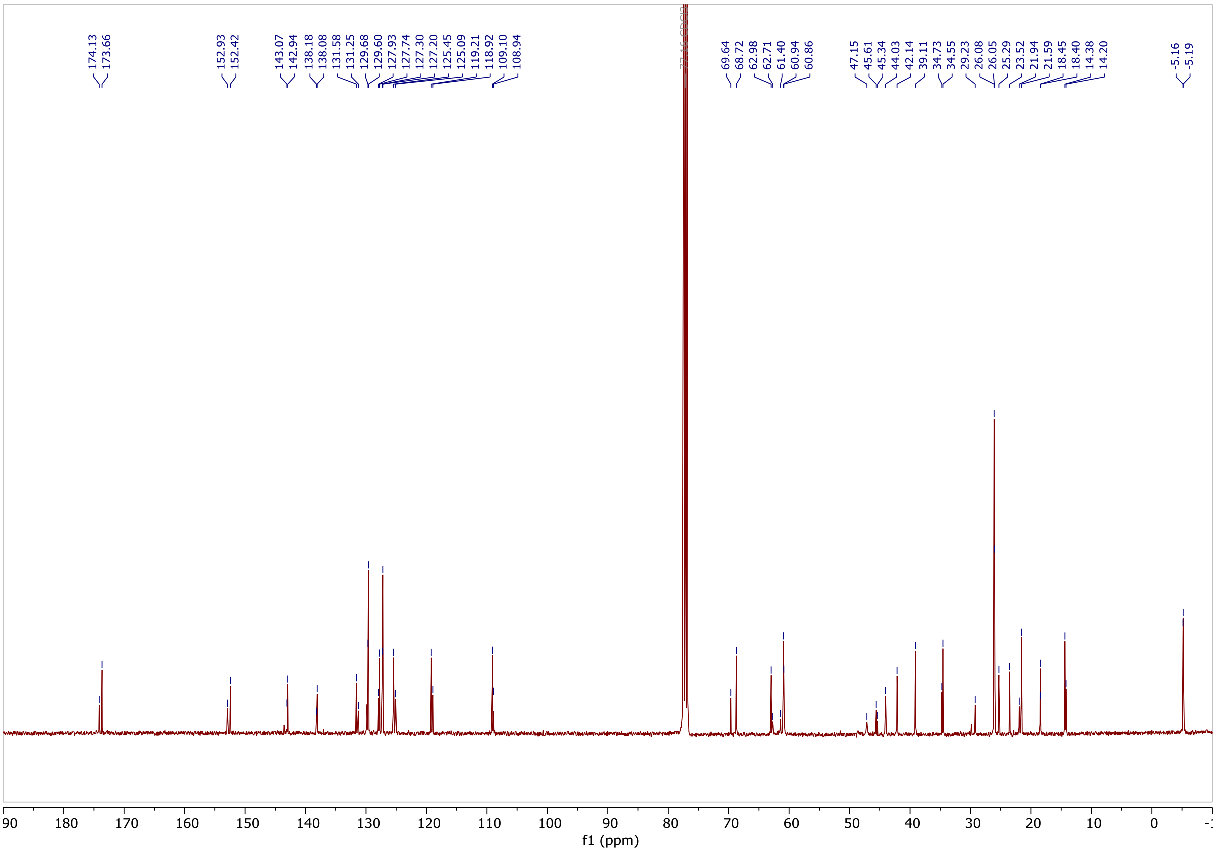
^{13}C-NMR (101 MHz, chloroform-*d*) (7b)



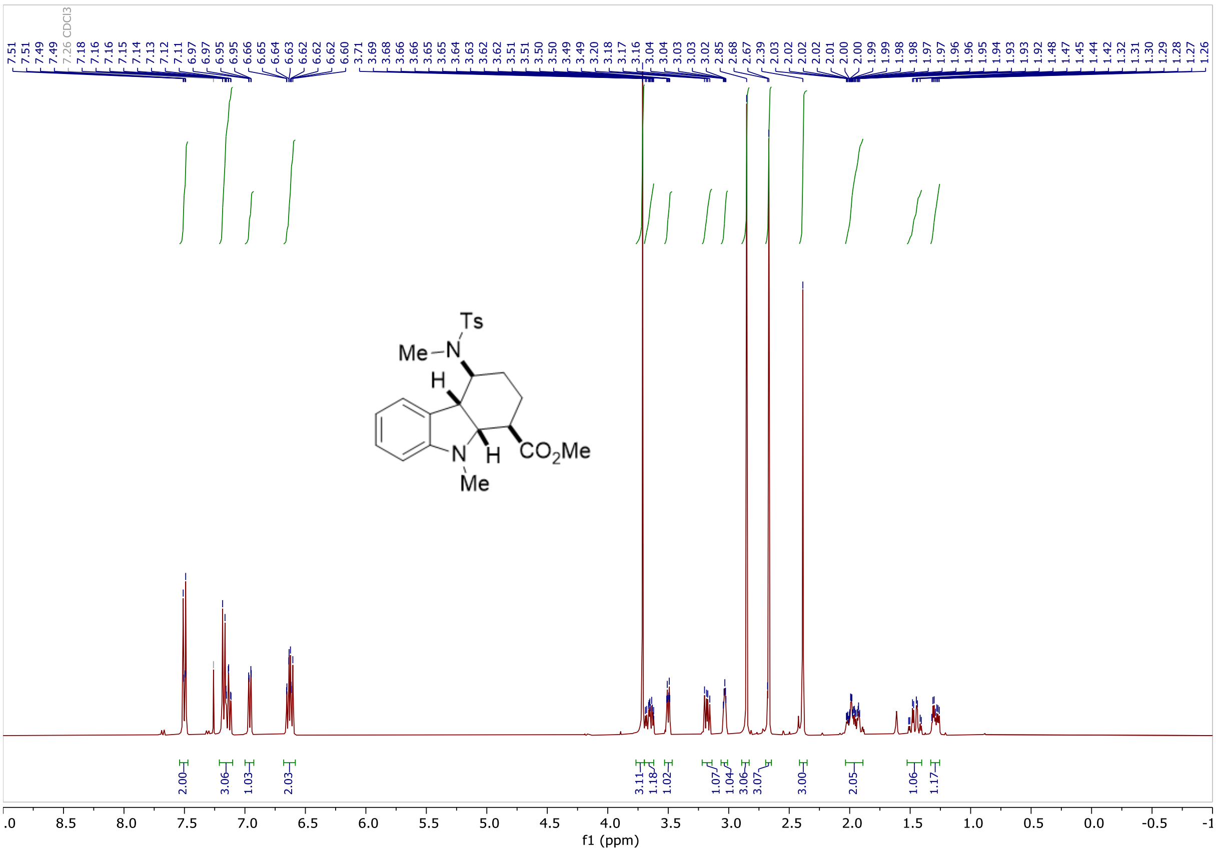
^{1}H-NMR (400 MHz, chloroform-*d*) (7c:7’c 67:33 mixture of diastereoisomers)



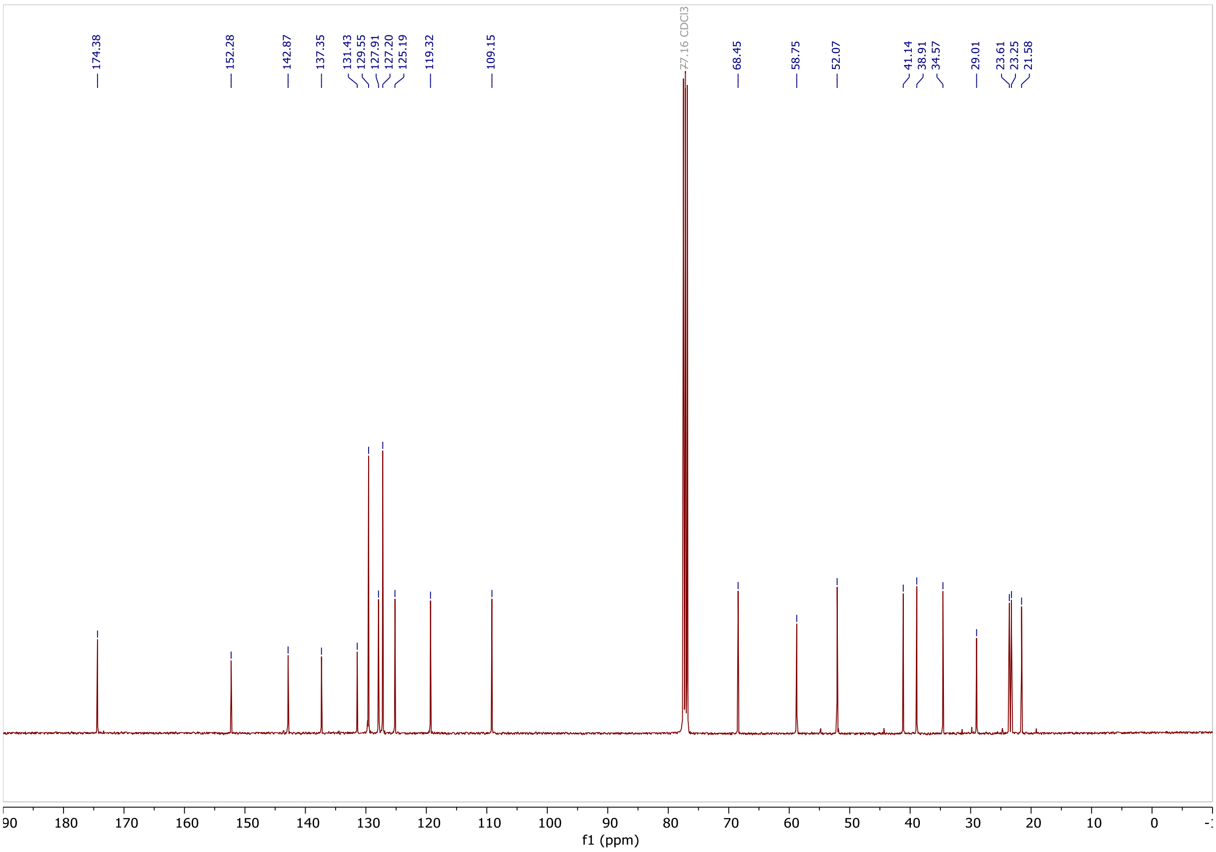
^{13}C-NMR (101 MHz, chloroform-*d*) (7c:7’c 67:33 mixture of diastereoisomers)



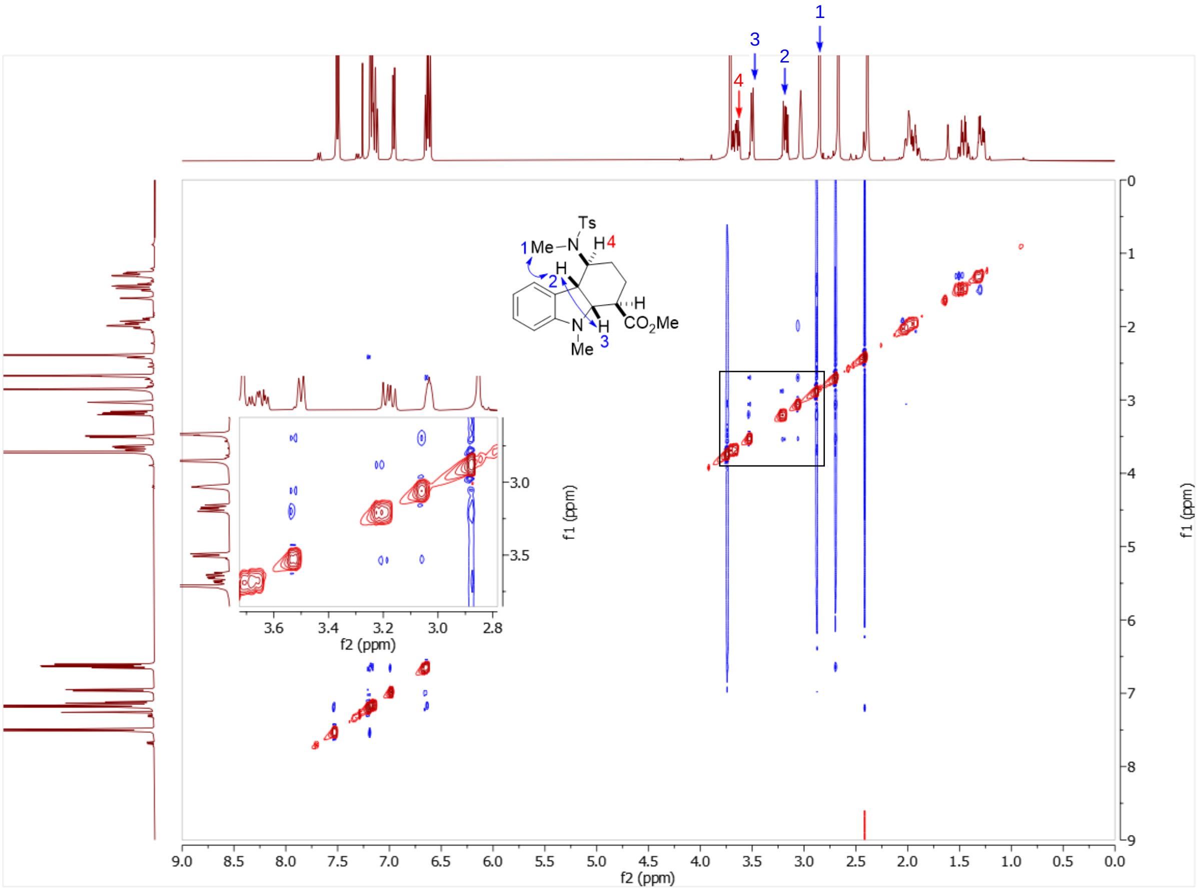
^{1}H-NMR (400 MHz, chloroform-*d*) (7d)



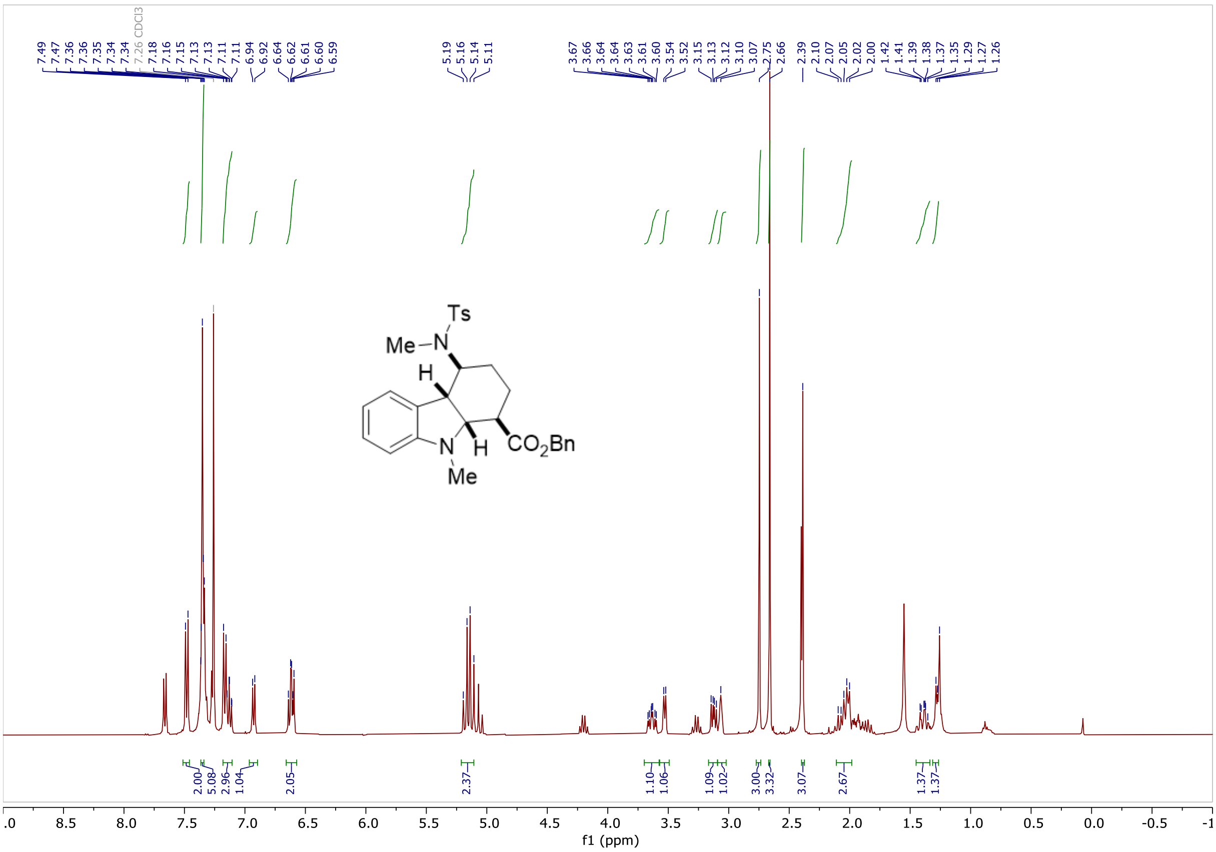
^{13}C-NMR (101 MHz, chloroform-*d*) (7d)



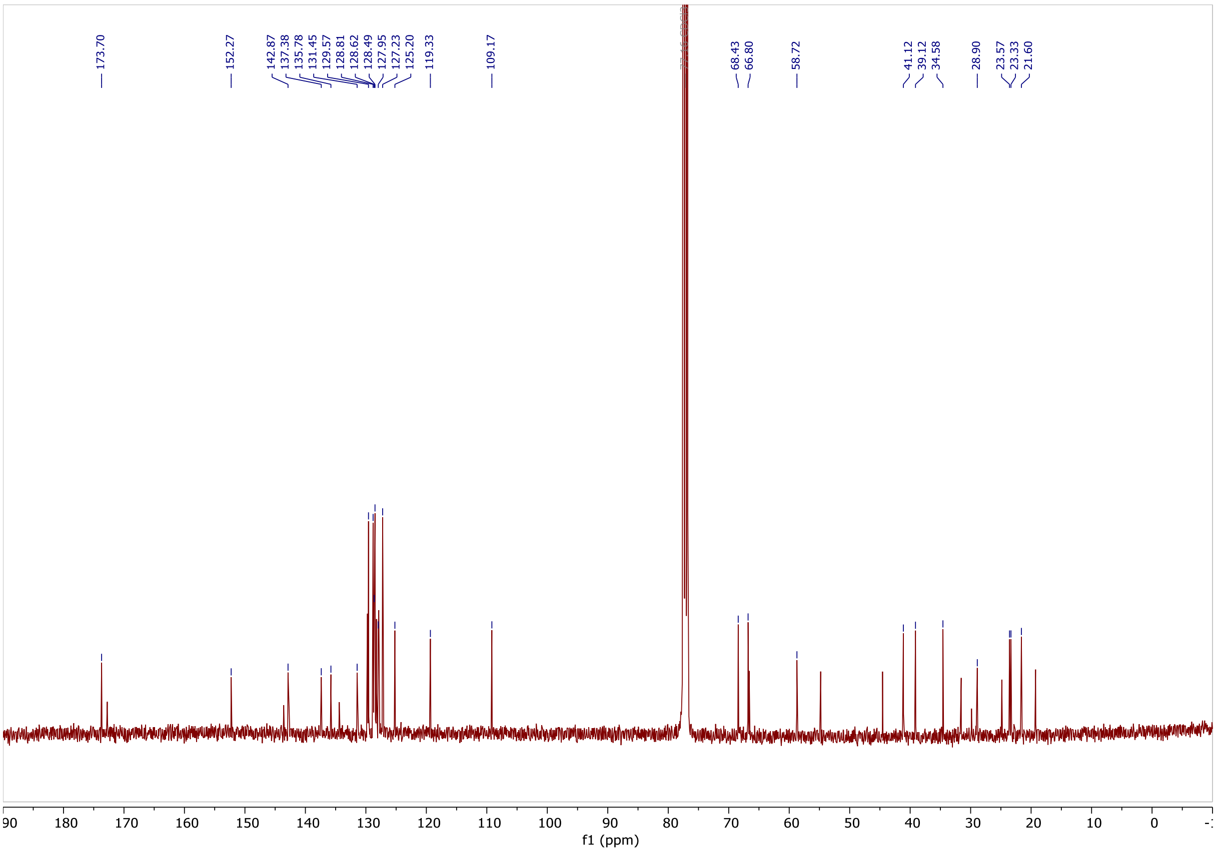
2D-NOESY (400 MHz, chloroform-*d*) (7d)



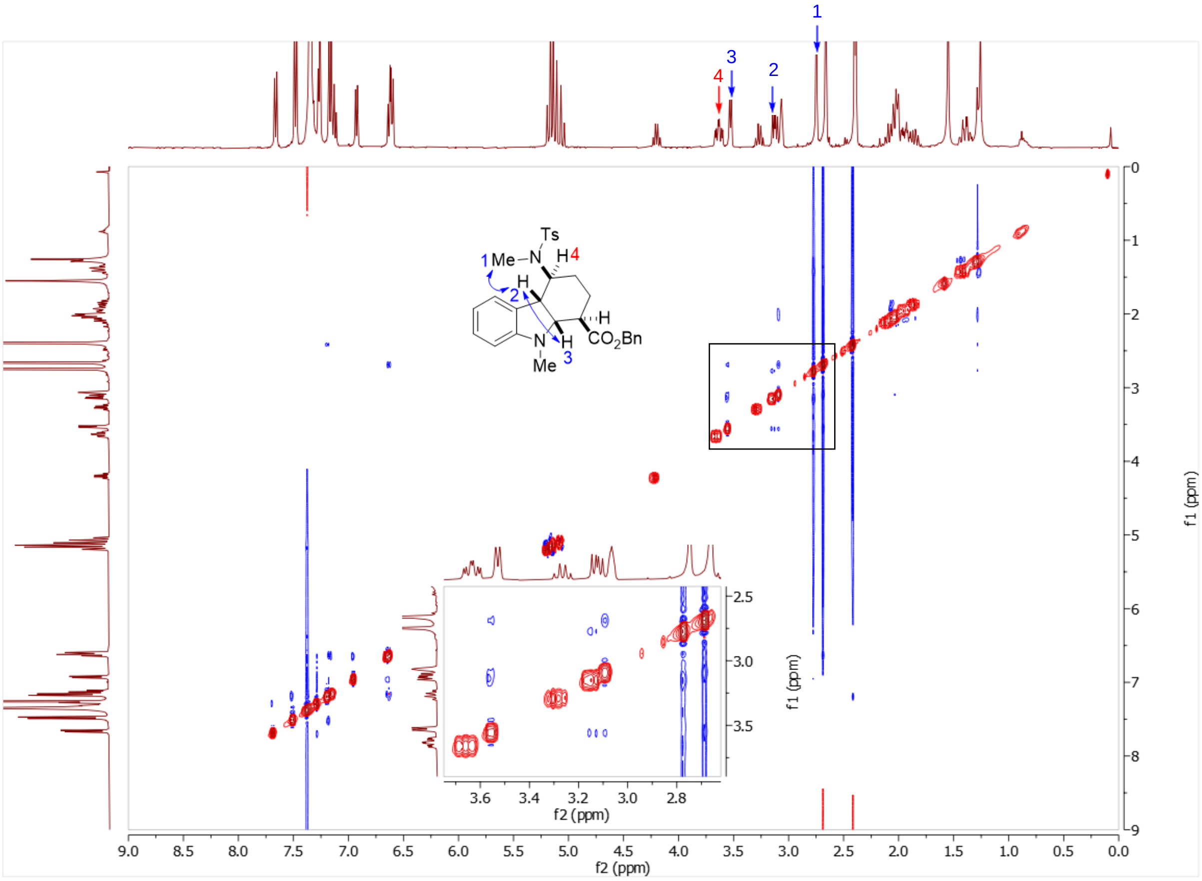
^{1}H-NMR (400 MHz, chloroform-*d*) (7e) 70% purity, mixed with 3h



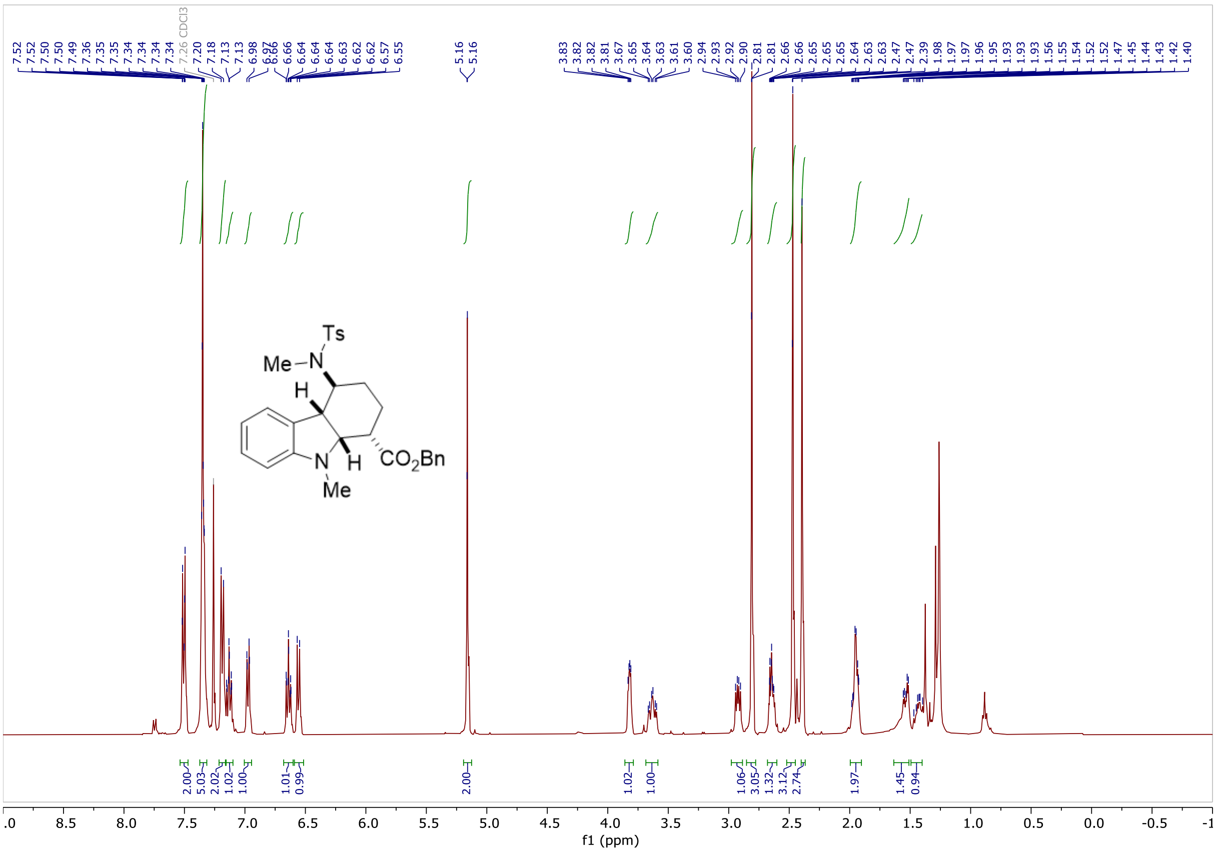
^{13}C-NMR (101 MHz, chloroform-*d*) (7e) 70% purity, mixed with 3h



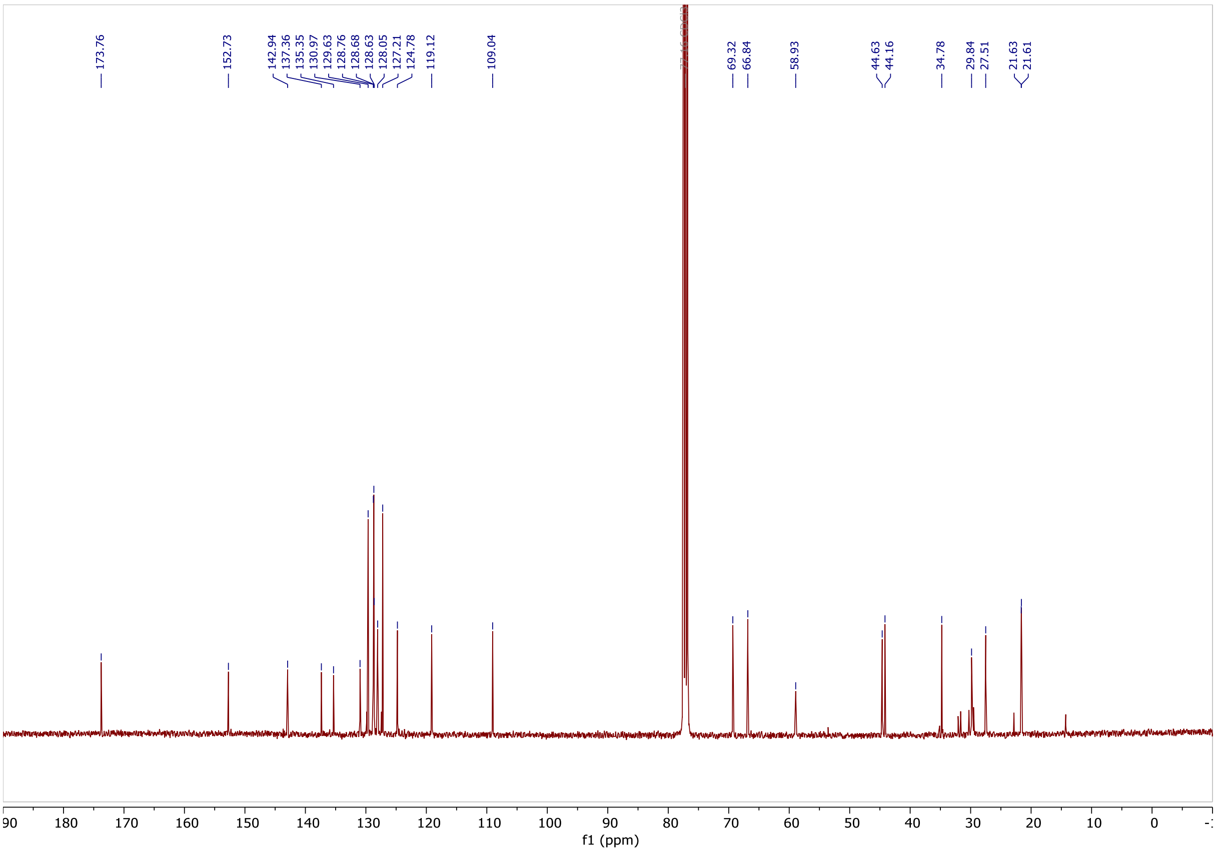
2D-NOESY (400 MHz, chloroform-*d*) (7e)



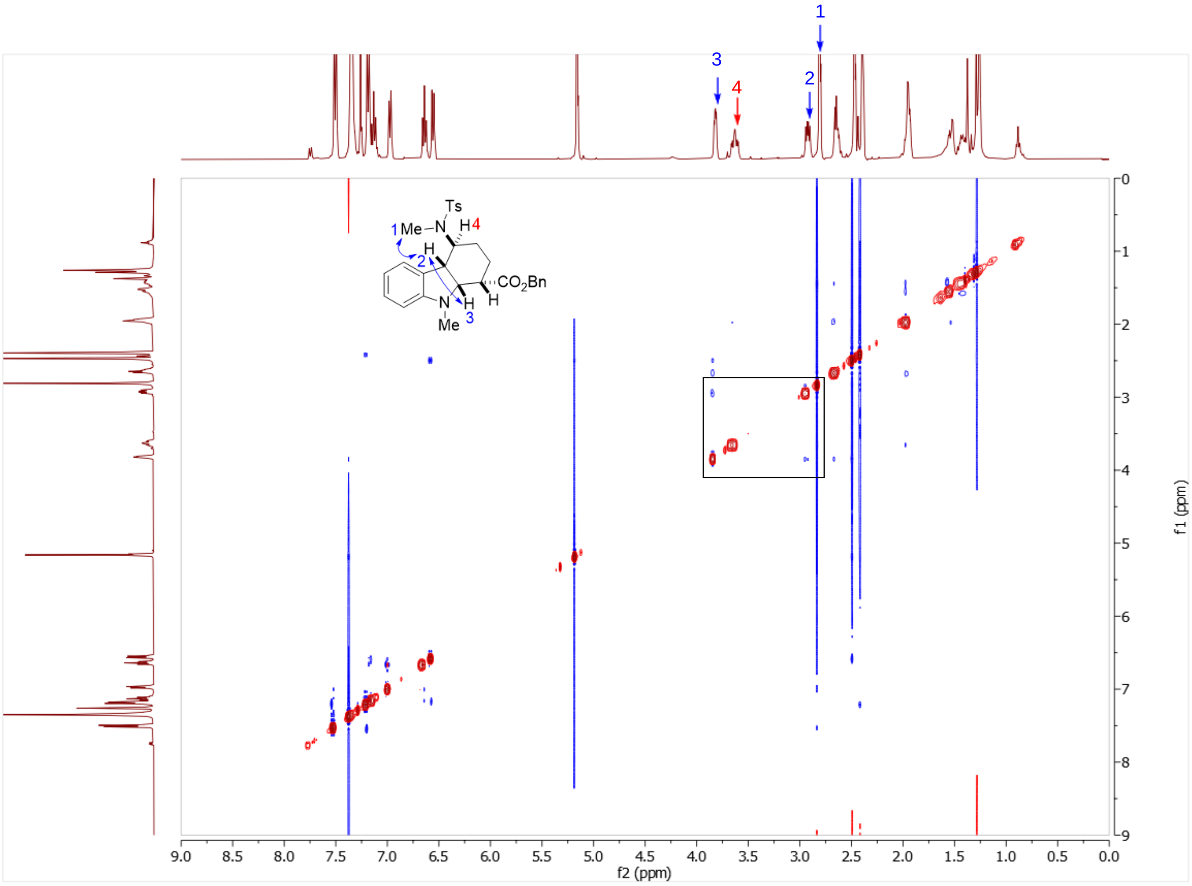
^{1}H-NMR (400 MHz, chloroform-*d*) (7'e)

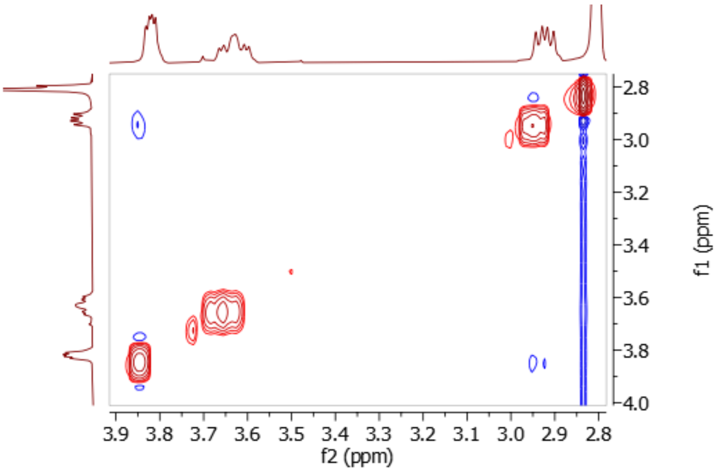


^{13}C-NMR (101 MHz, chloroform-*d*) (7'e)

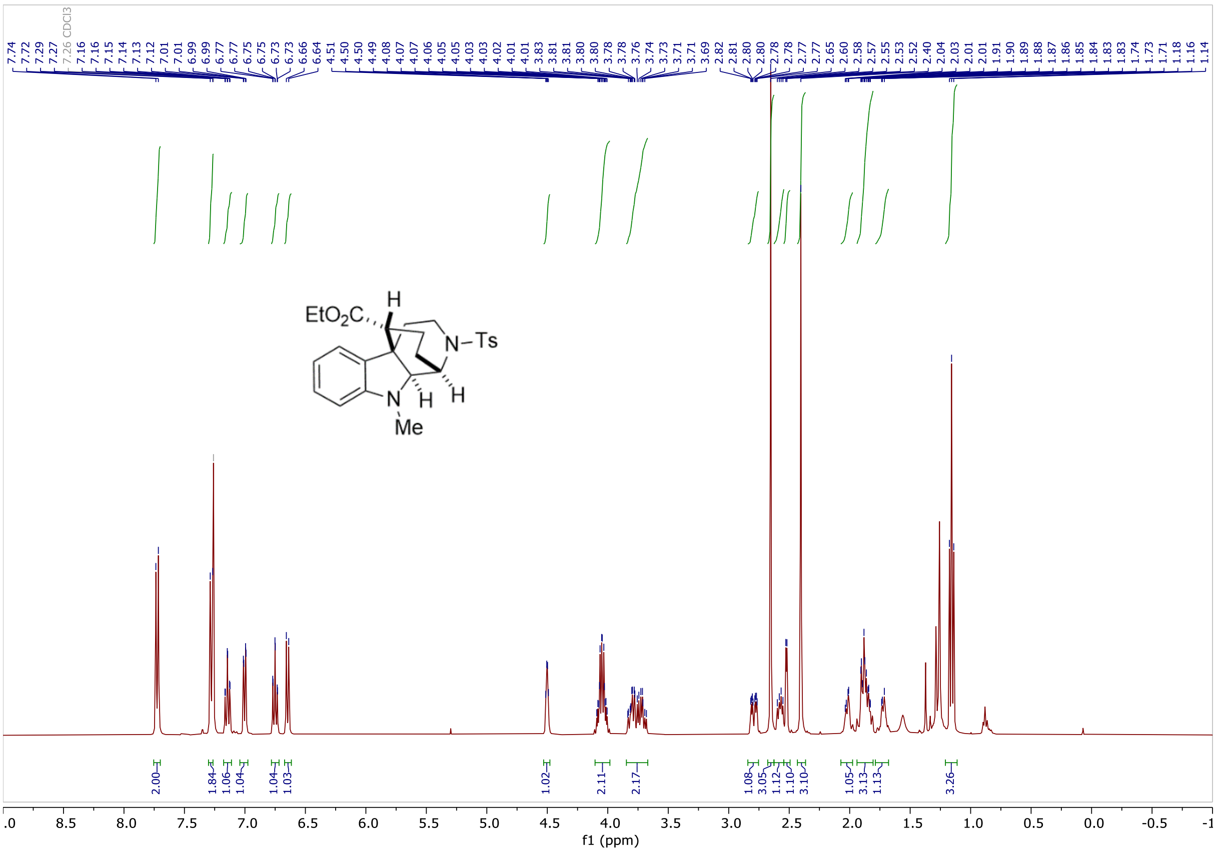


2D-NOESY (400 MHz, chloroform-*d*) (7’e)

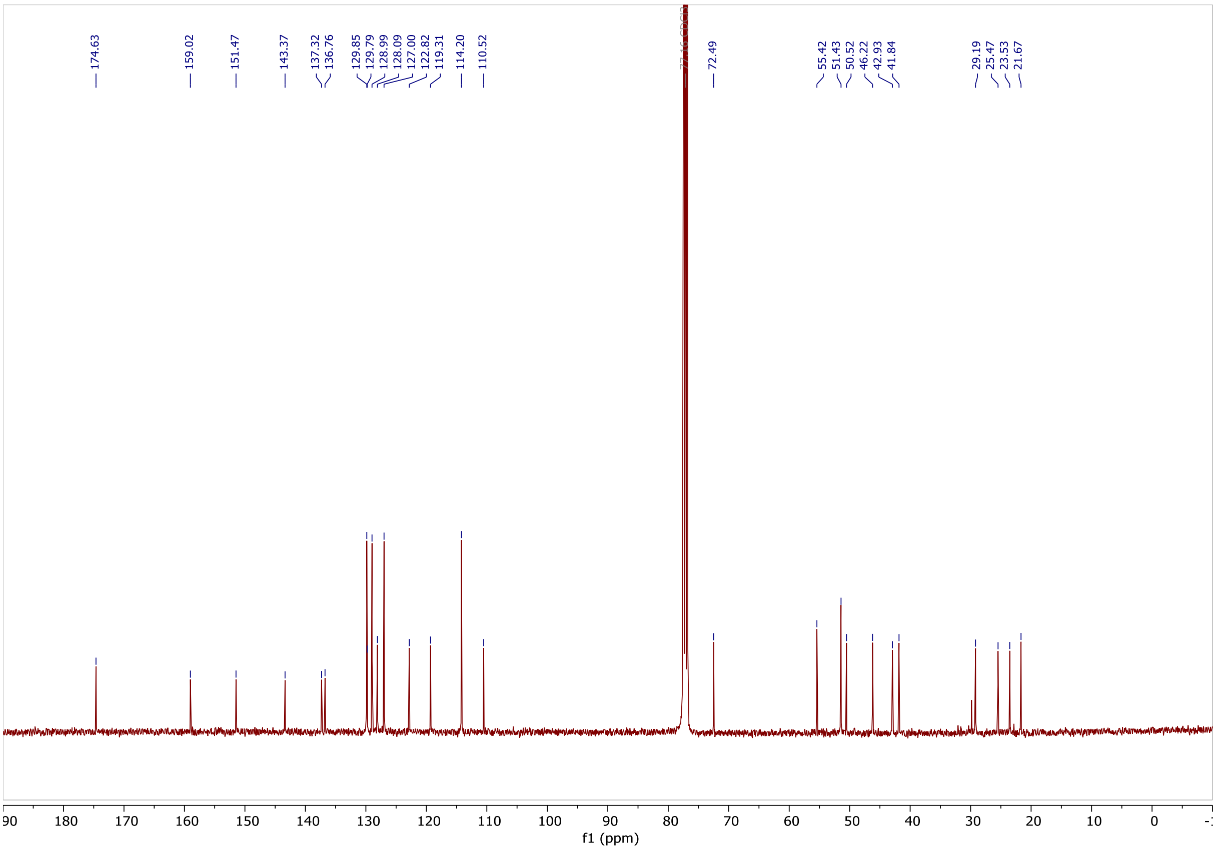




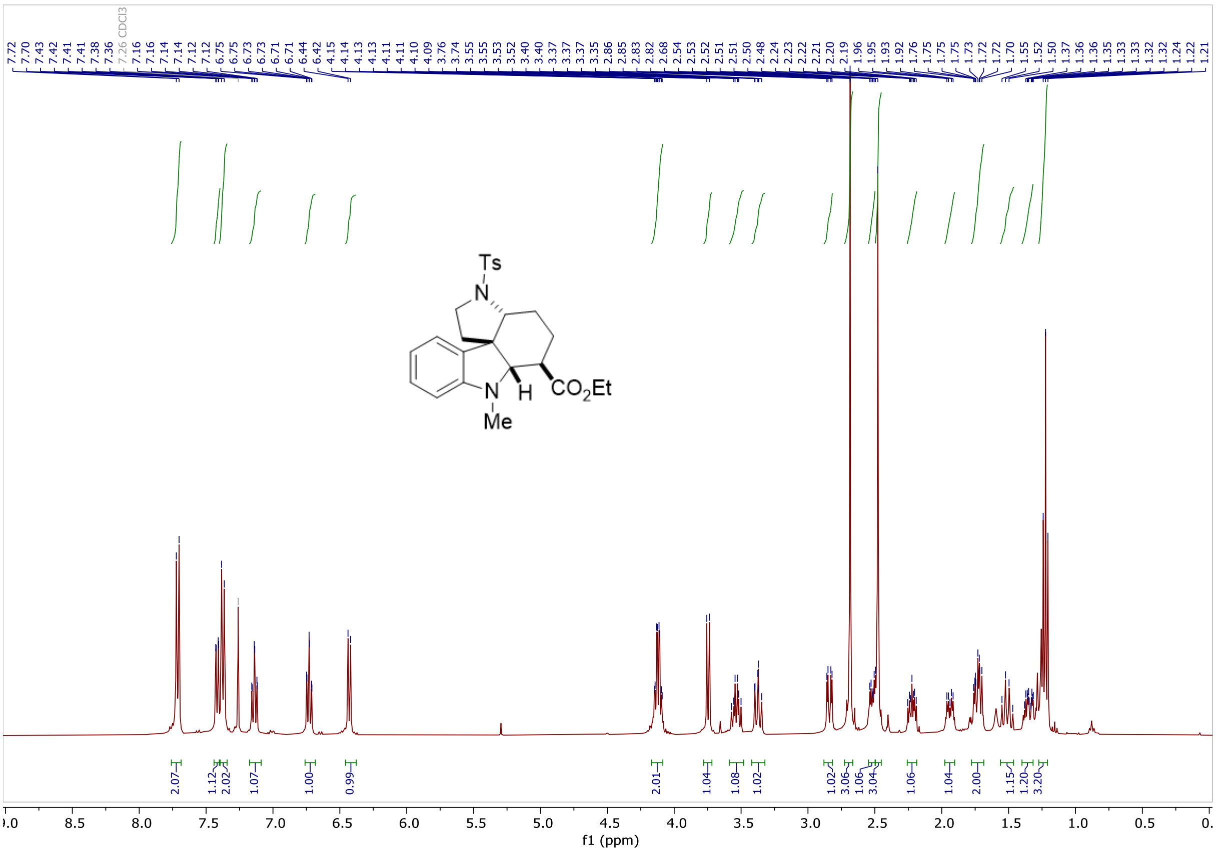
^{1}H-NMR (400 MHz, chloroform-*d*) (8a)



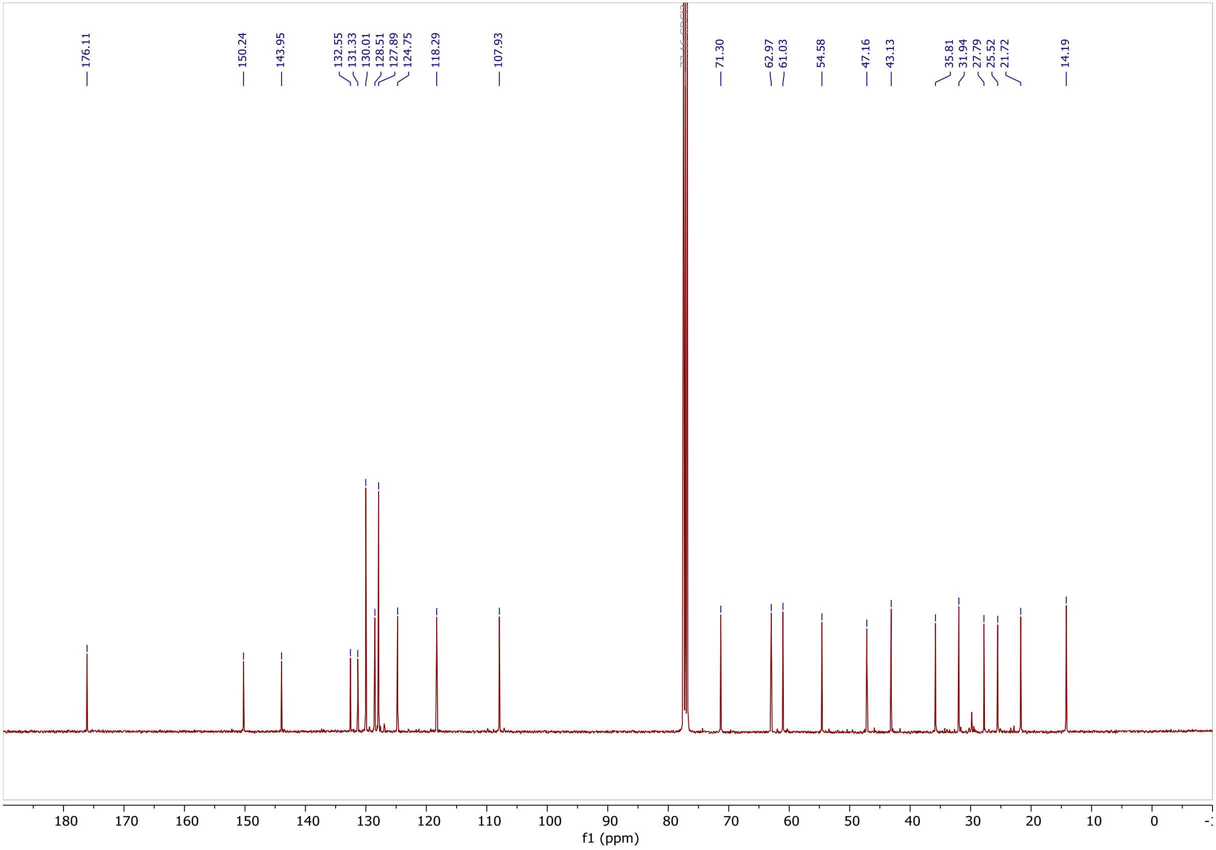
^{13}C-NMR (101 MHz, chloroform-*d*) (8a)



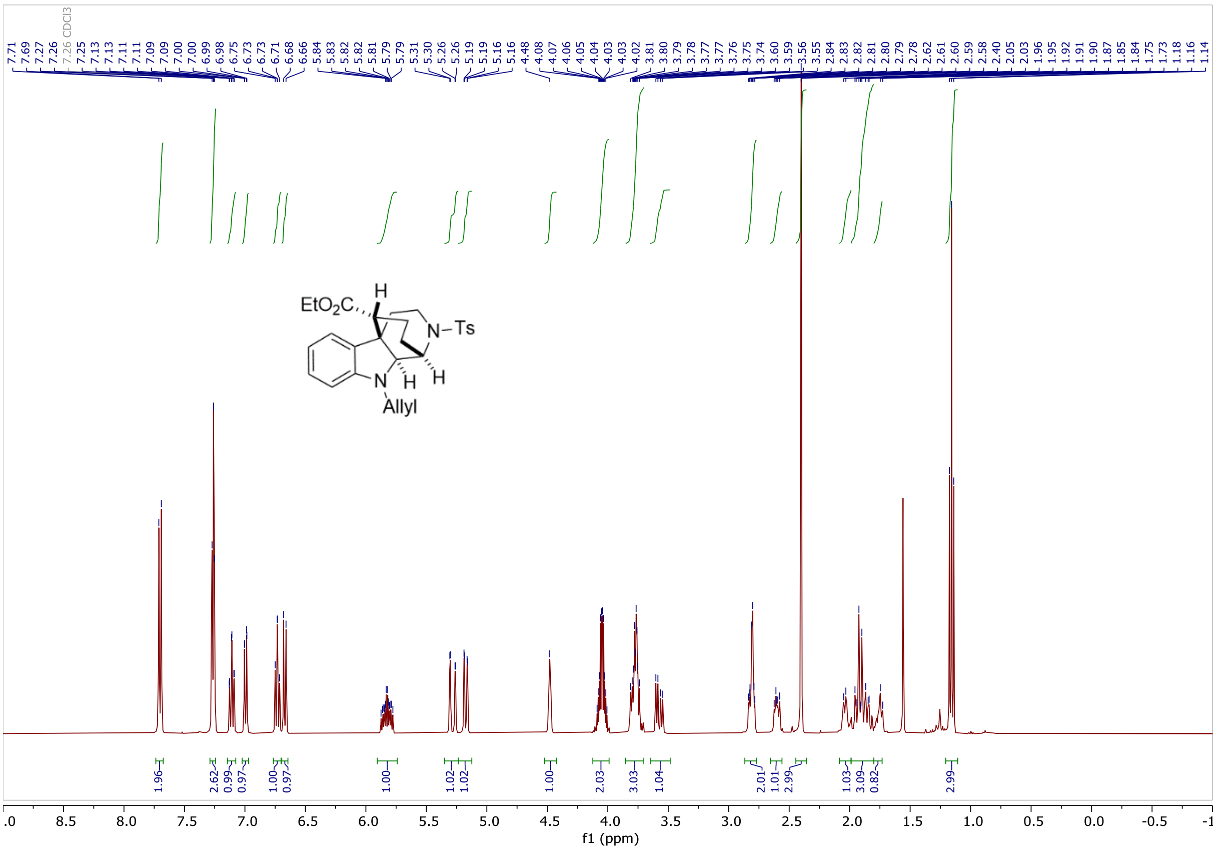
^{1}H-NMR (400 MHz, chloroform-*d*) (9a)



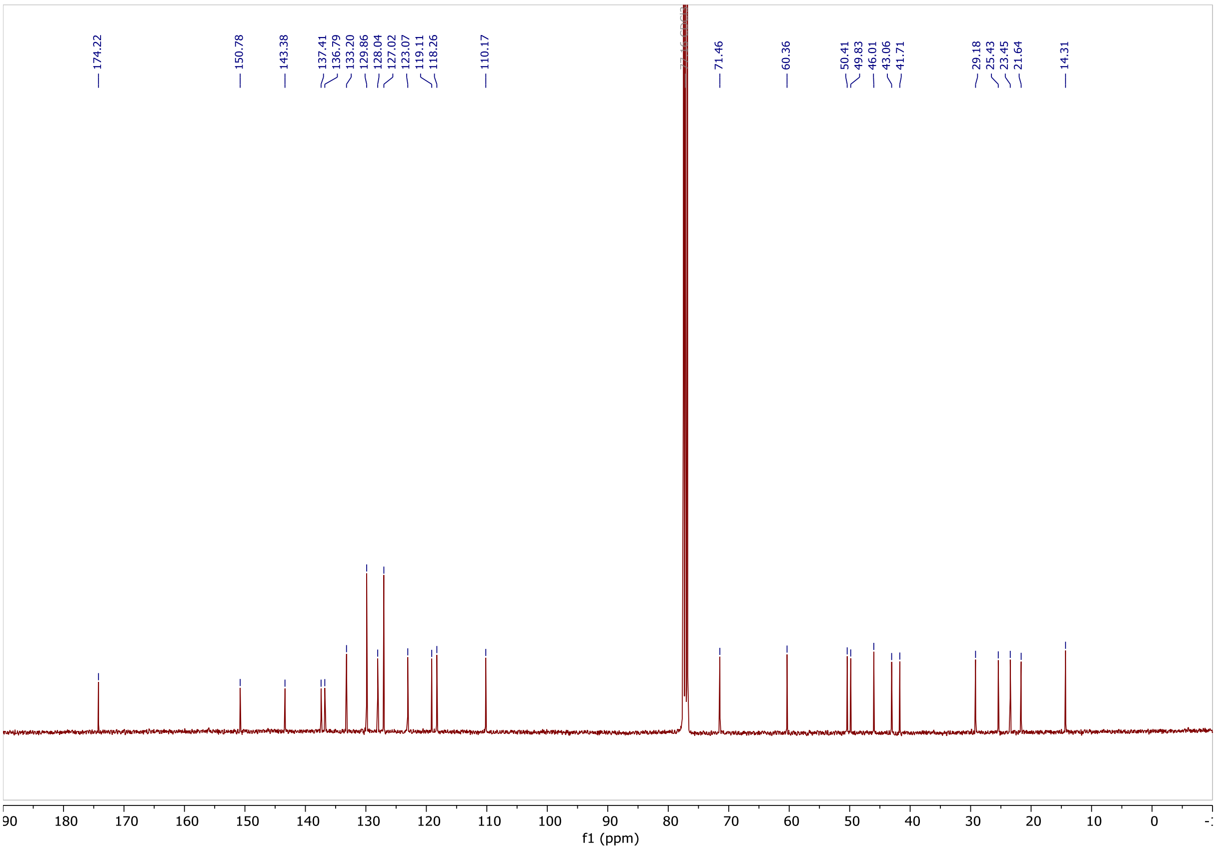
^{13}C-NMR (101 MHz, chloroform-*d*) (9a)



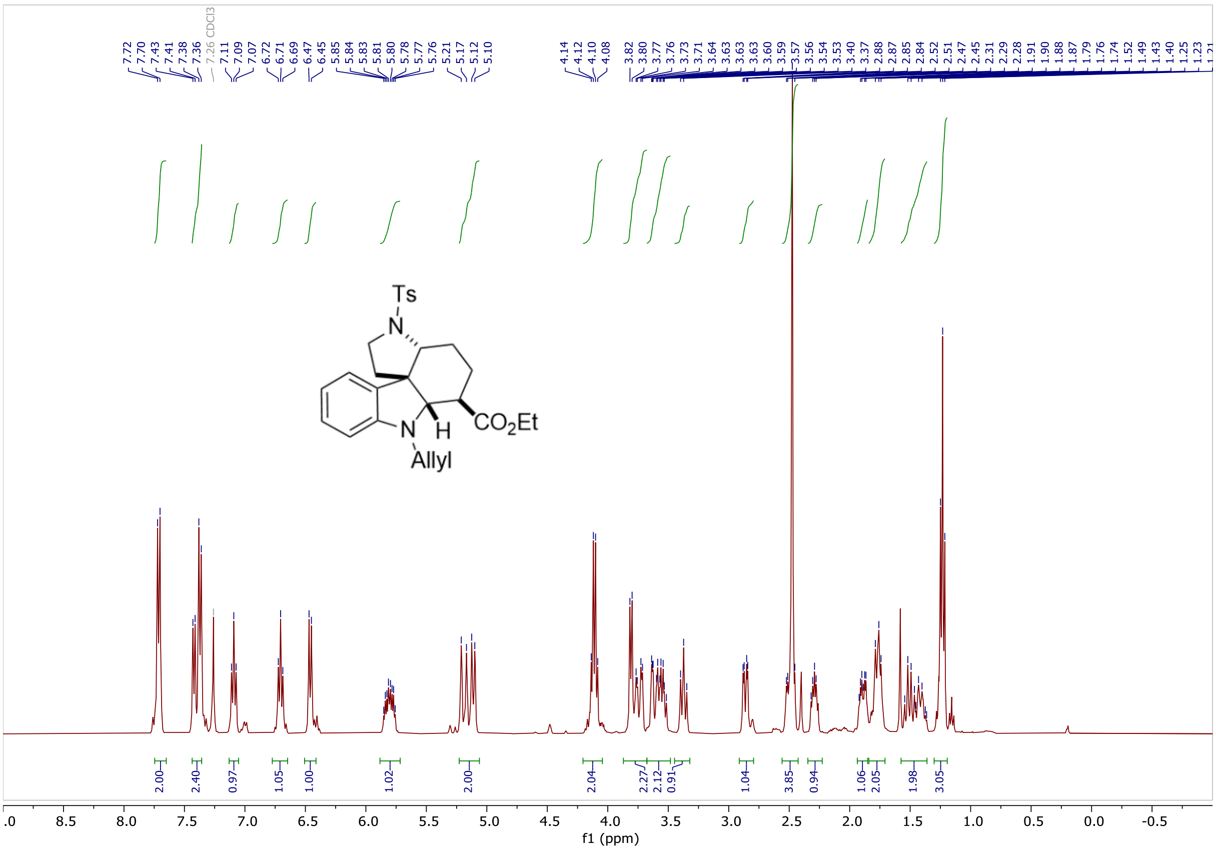
^{1}H-NMR (400 MHz, chloroform-*d*) (8b)



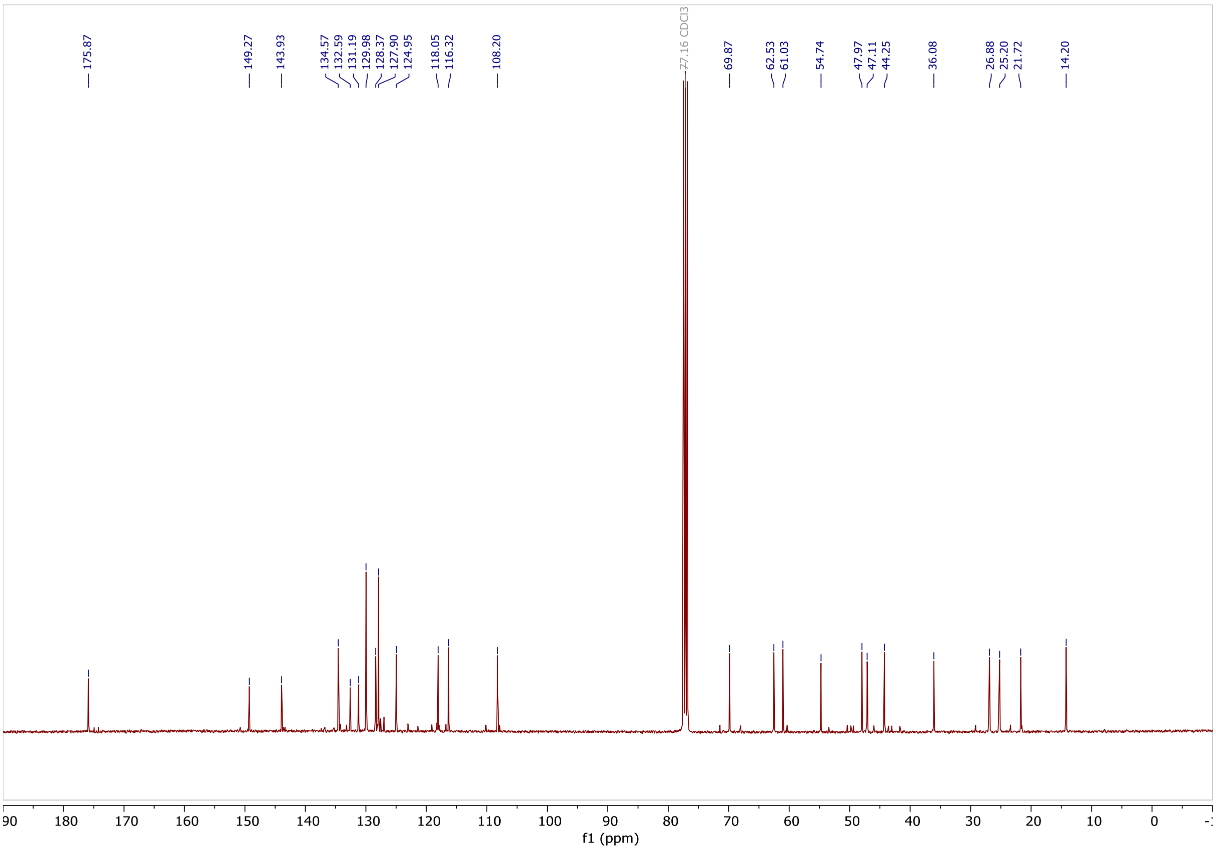
^{13}C-NMR (101 MHz, chloroform-*d*) (8b)



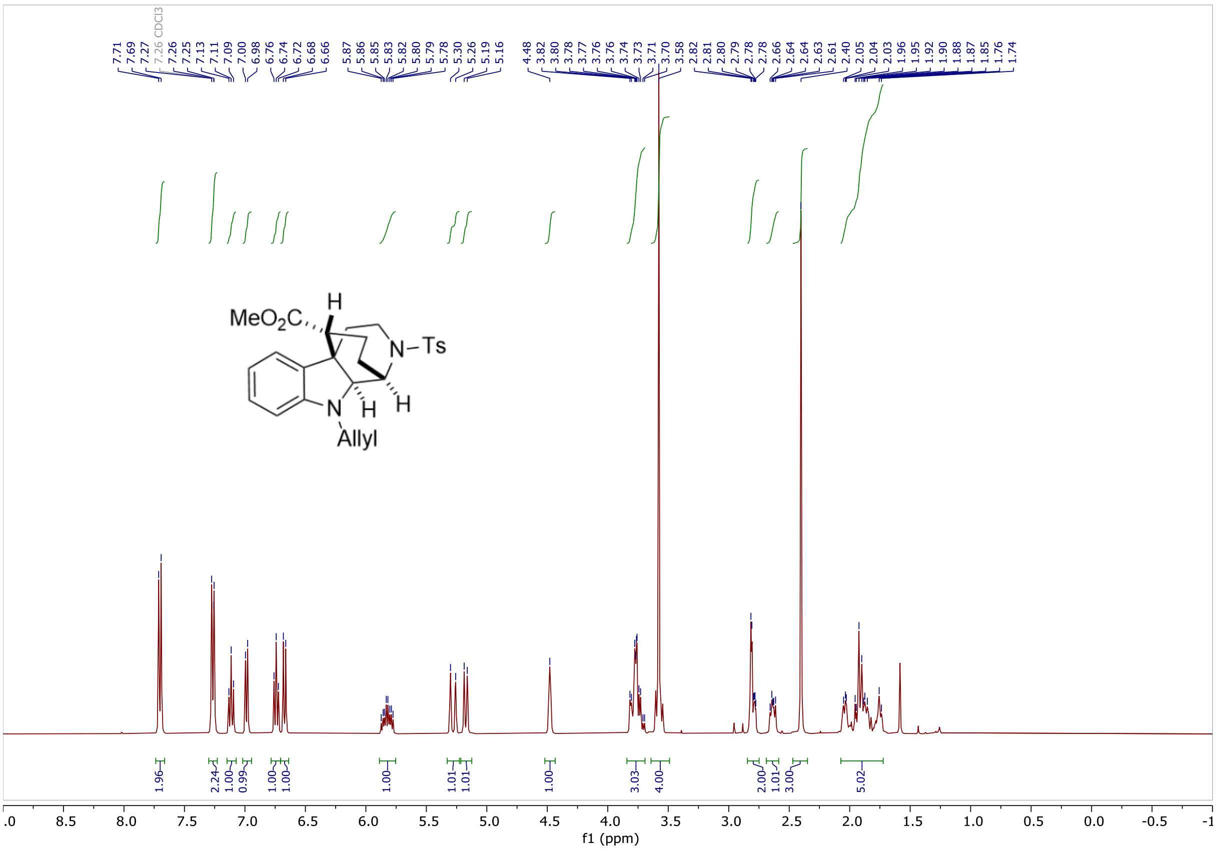
^{1}H-NMR (400 MHz, chloroform-*d*) (9b) 86% purity, mixed with 8b



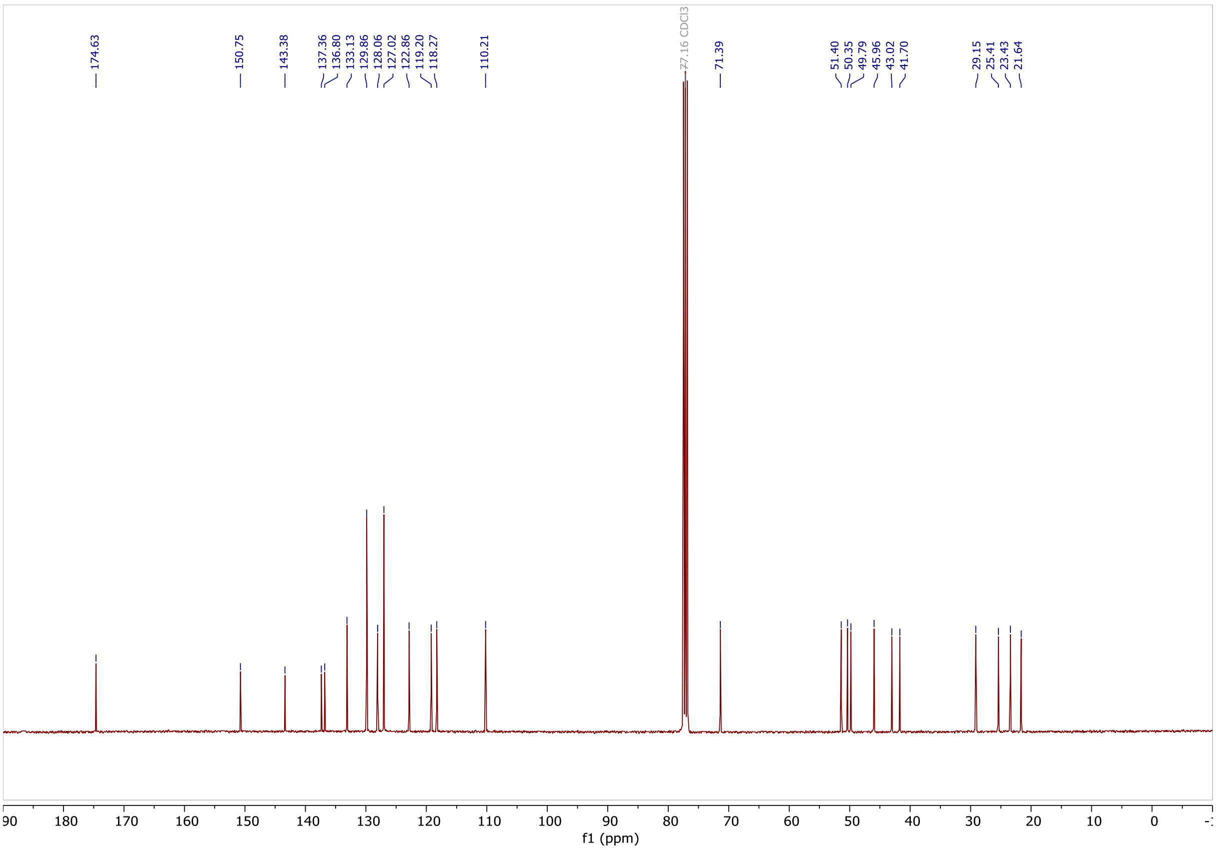
^{13}C-NMR (101 MHz, chloroform-*d*) (9b) 86% purity, mixed with 8b



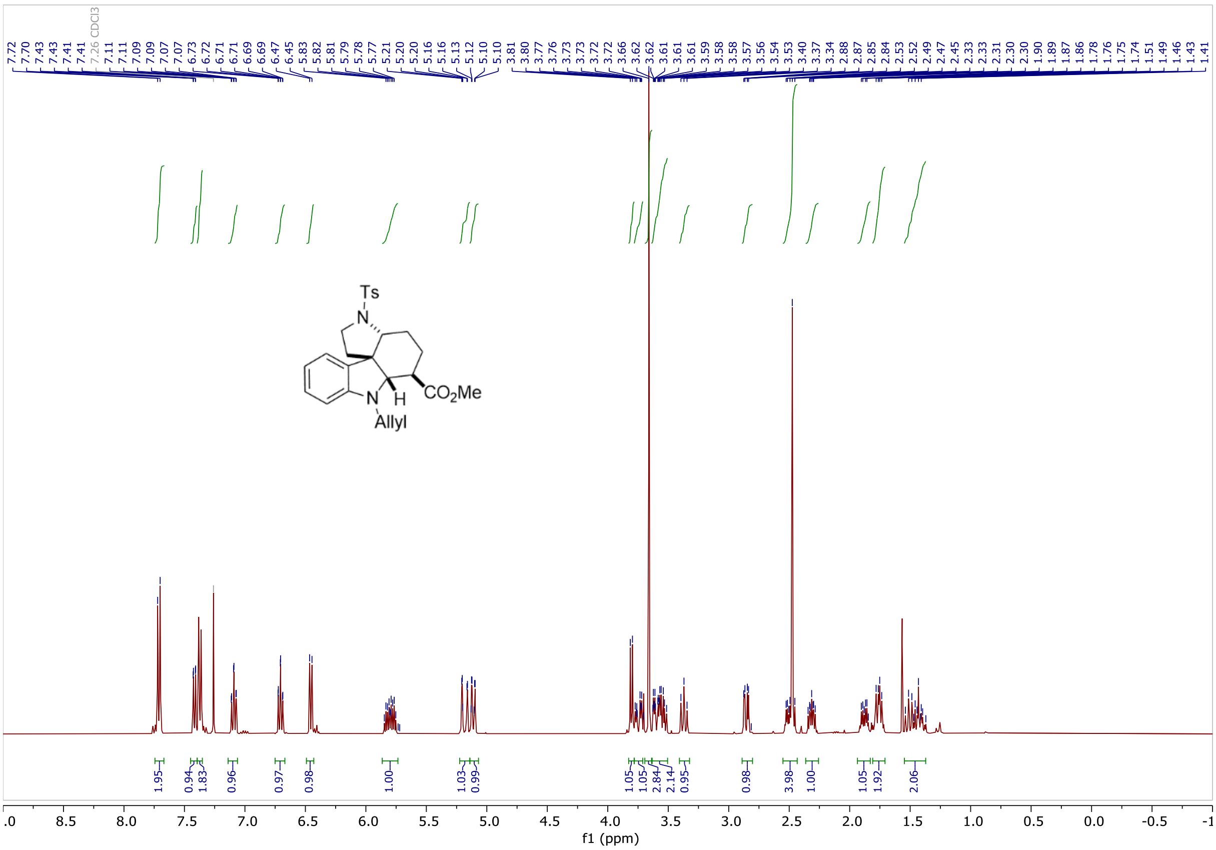
^{1}H-NMR (400 MHz, chloroform-*d*) (8c)



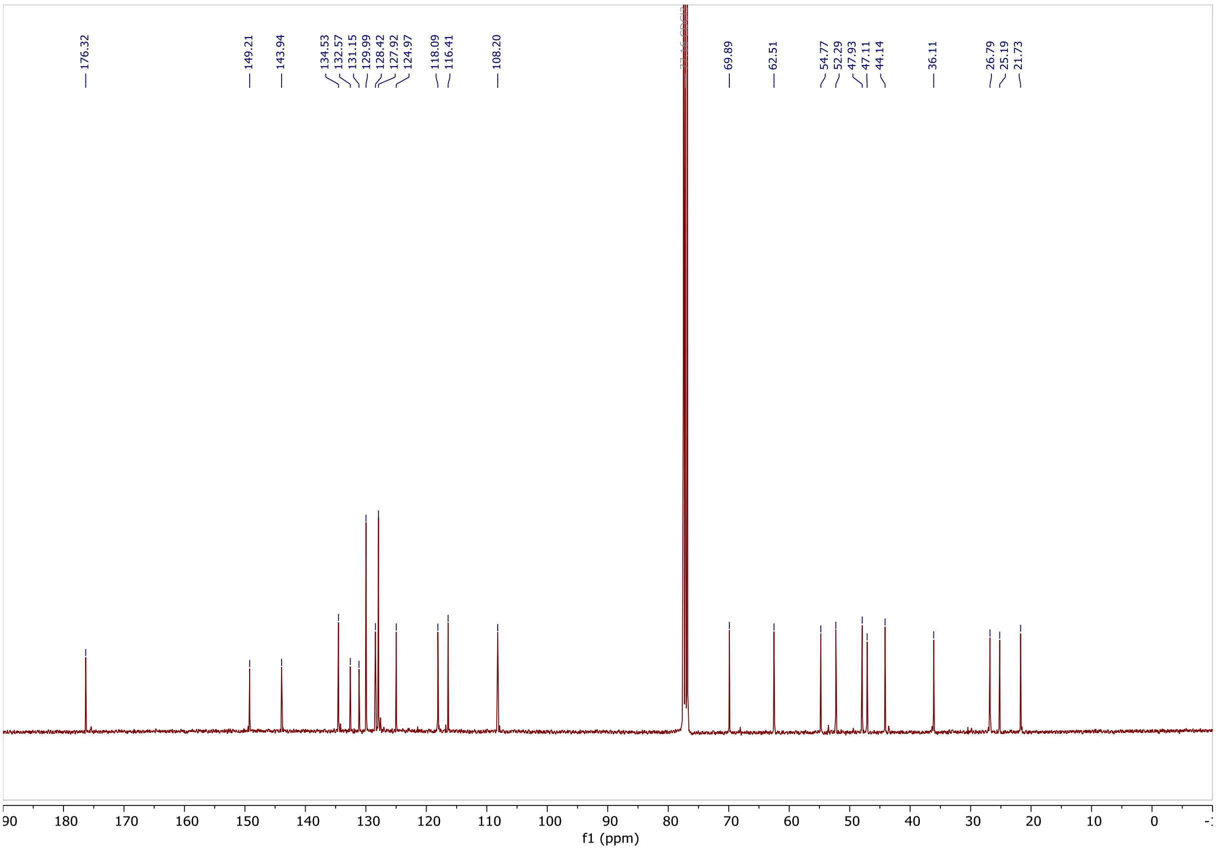
^{13}C-NMR (101 MHz, chloroform-*d*) (8c)



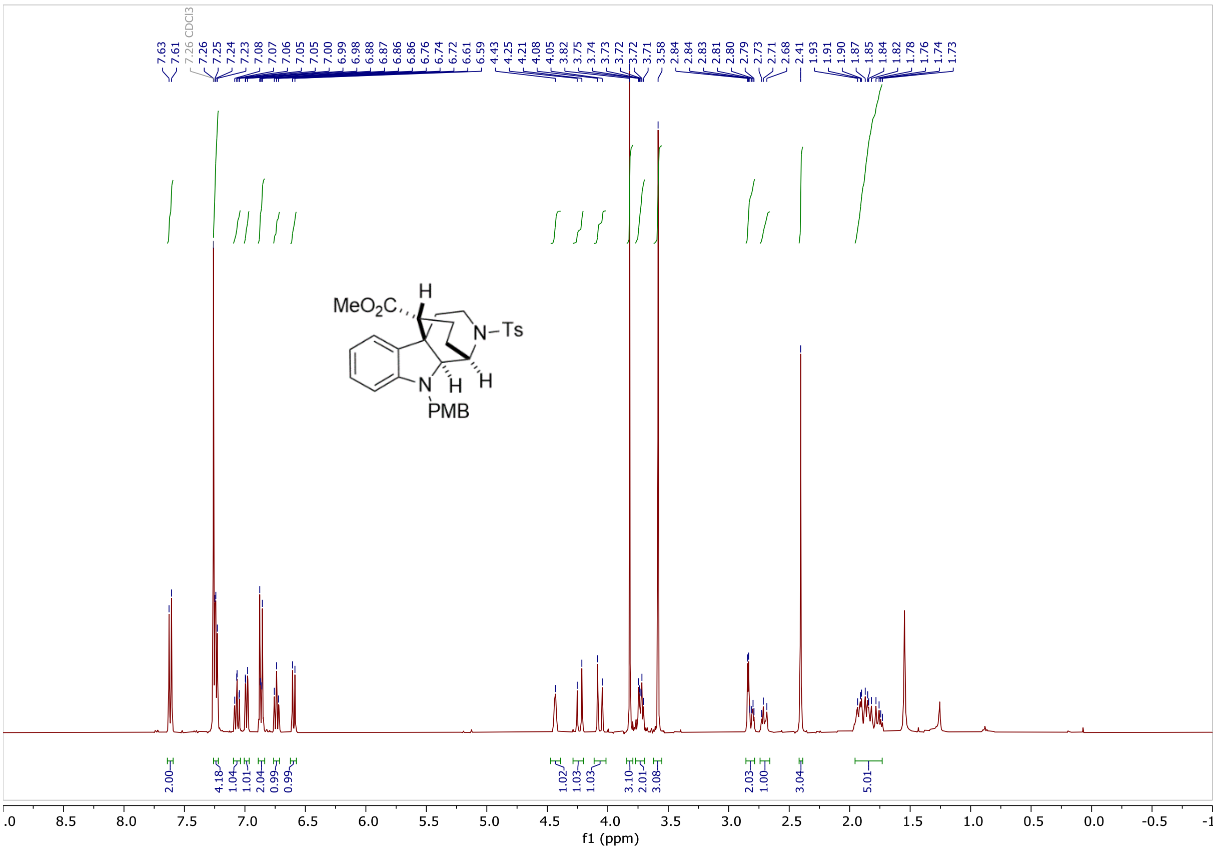
^{1}H-NMR (400 MHz, chloroform-*d*) (9c)



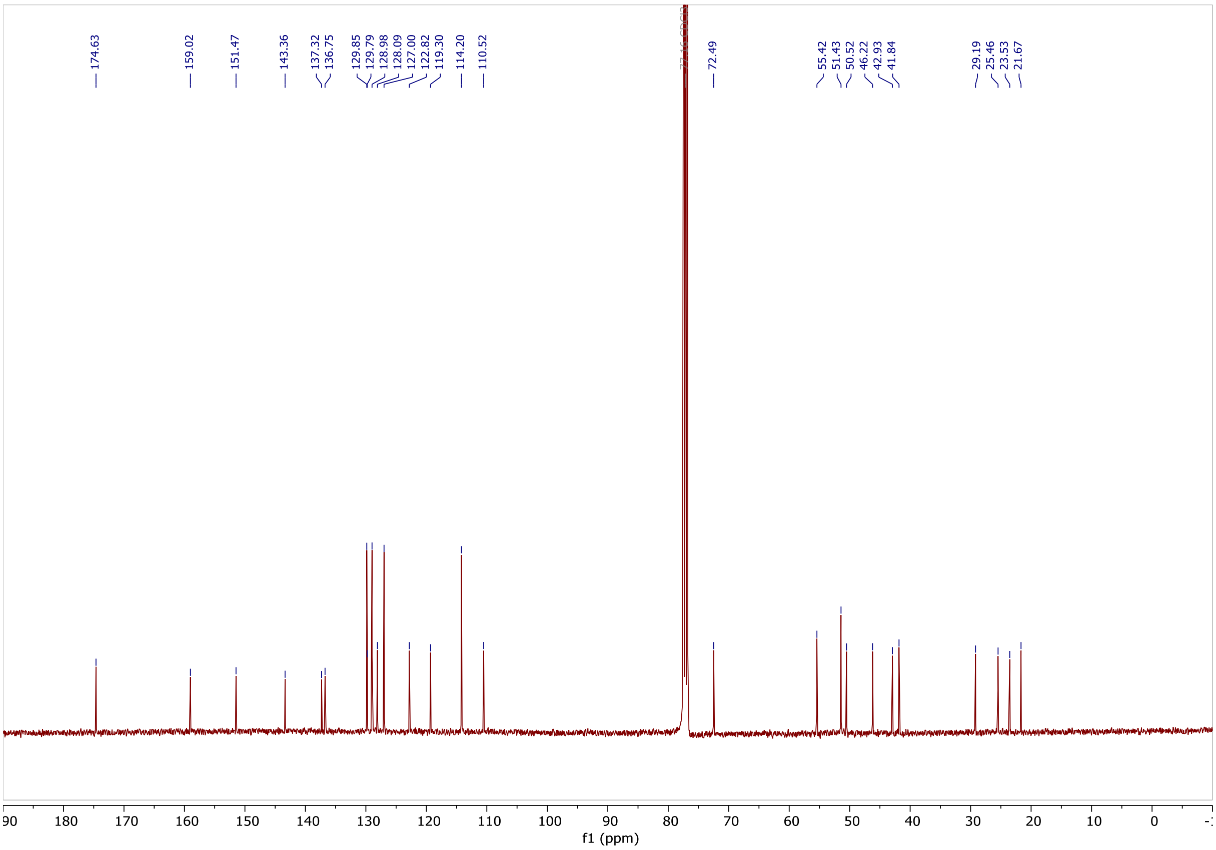
^{13}C-NMR (101 MHz, chloroform-*d*) (9c)



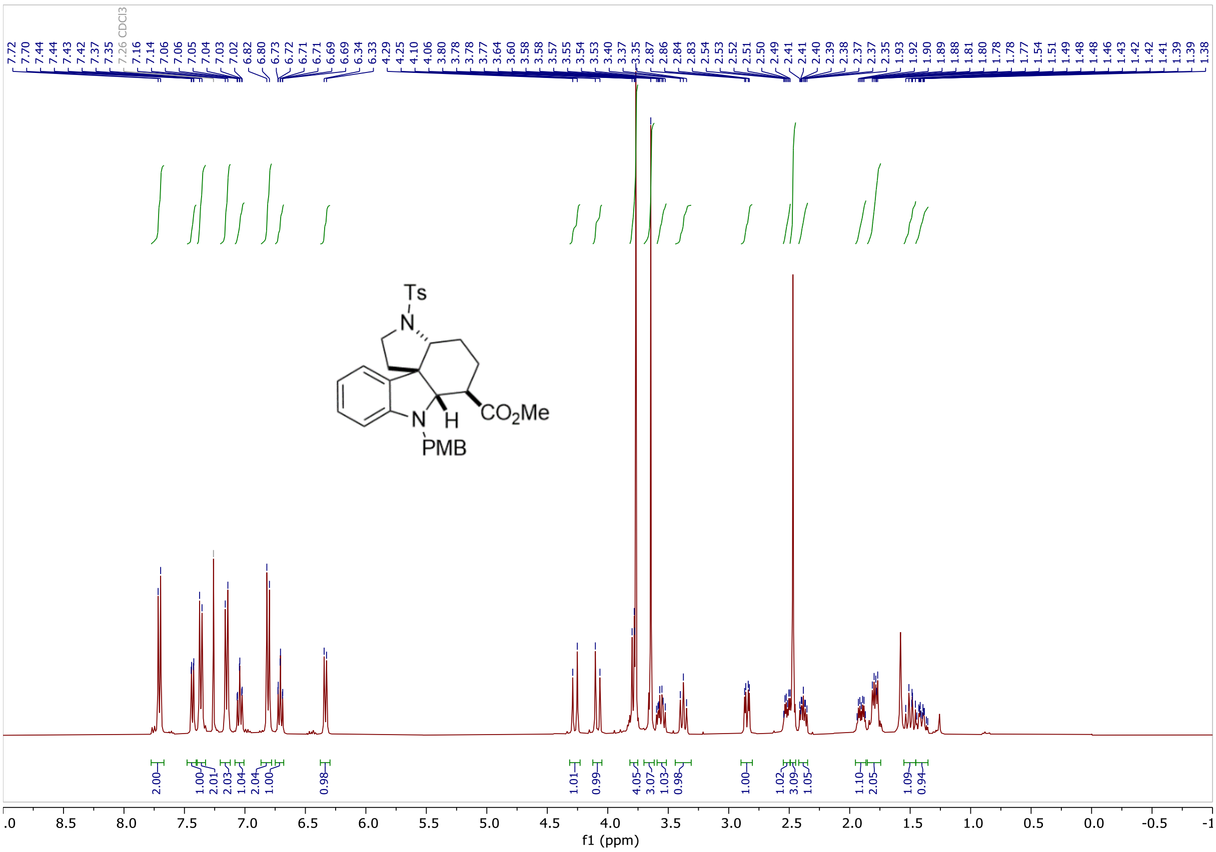
^{1}H-NMR (400 MHz, chloroform-*d*) (8d)



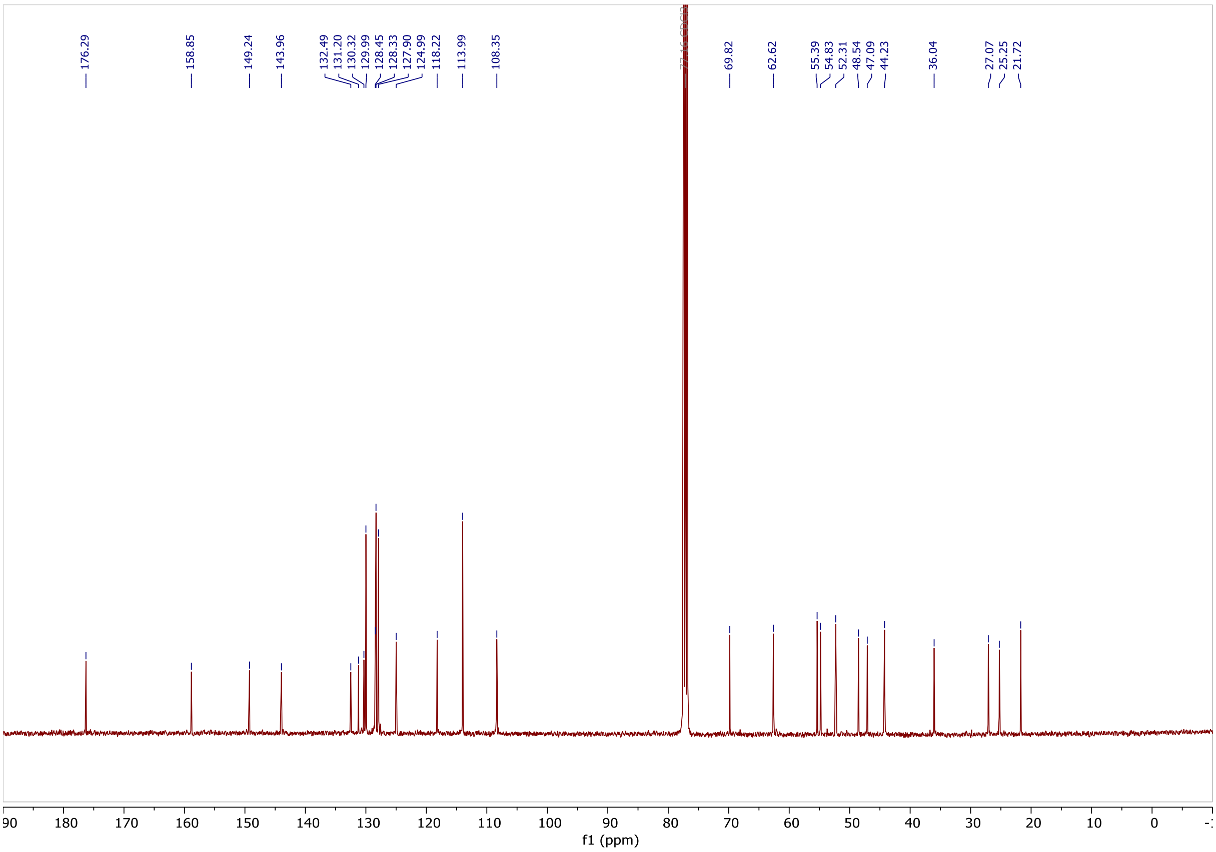
^{13}C-NMR (101 MHz, chloroform-*d*) (8d)



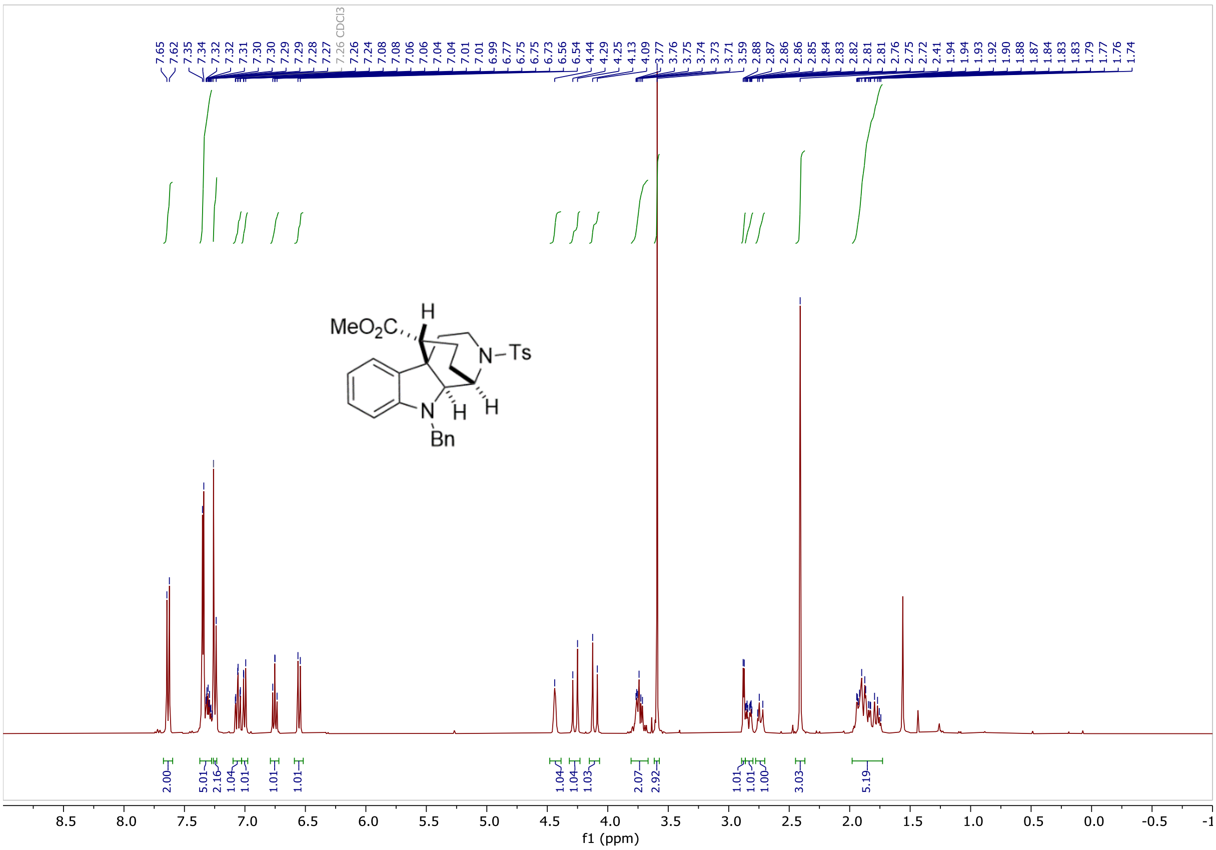
^{1}H-NMR (400 MHz, chloroform-*d*) (9d)



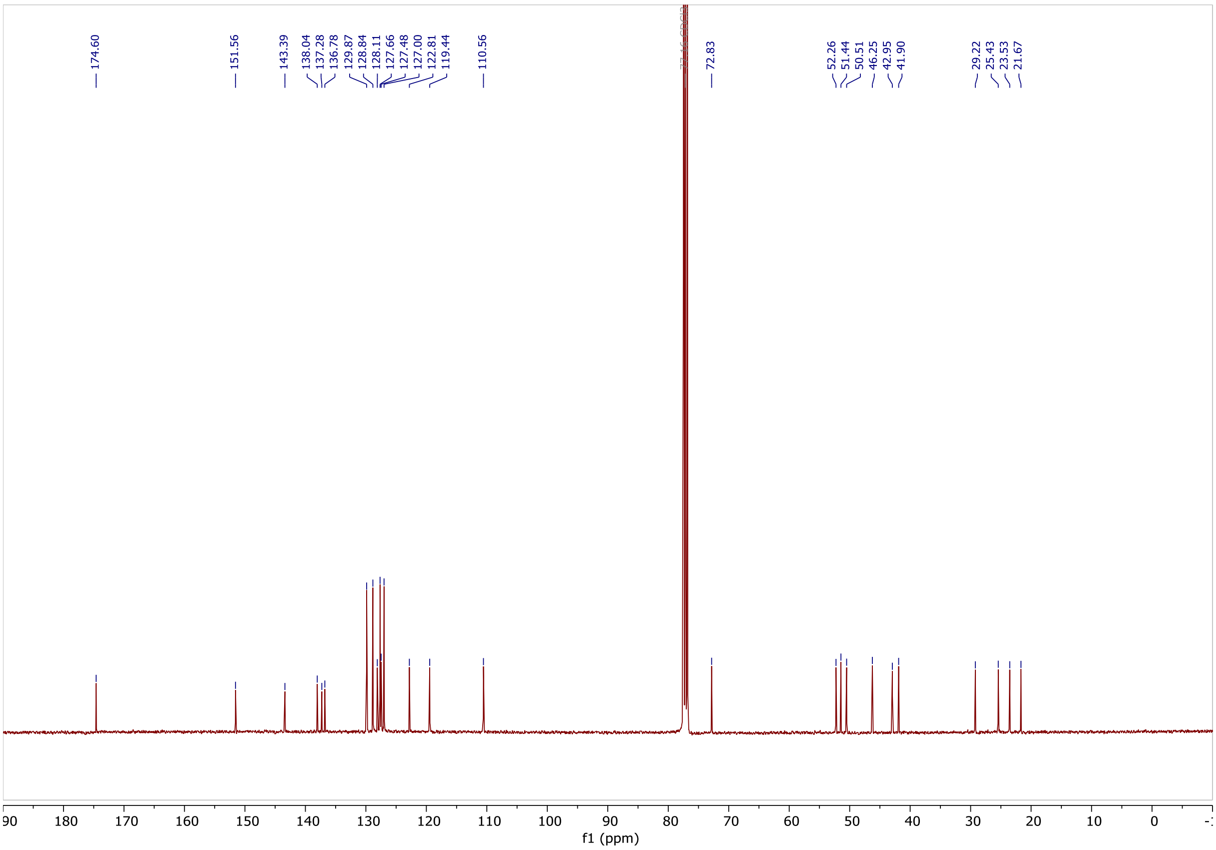
^{13}C-NMR (101 MHz, chloroform-*d*) (9d)



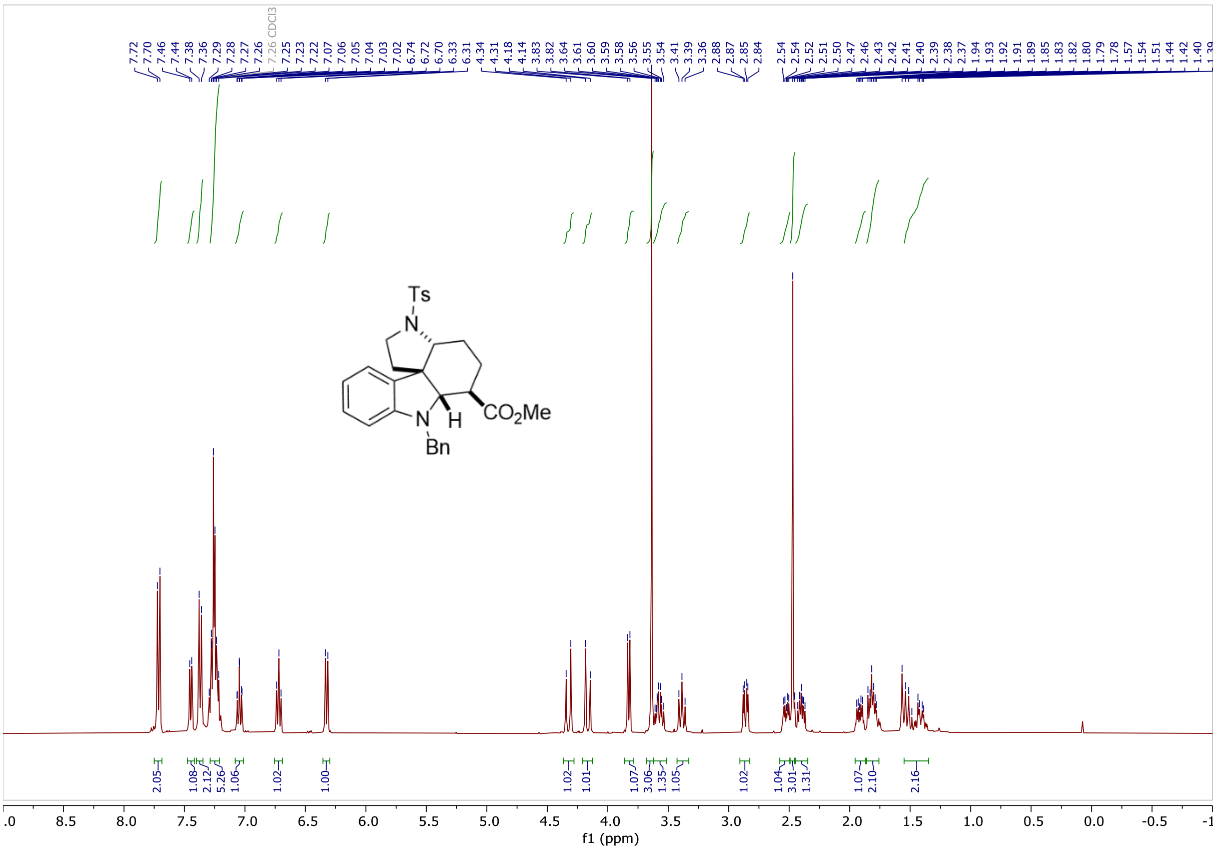
^{1}H-NMR (400 MHz, chloroform-*d*) (8e)



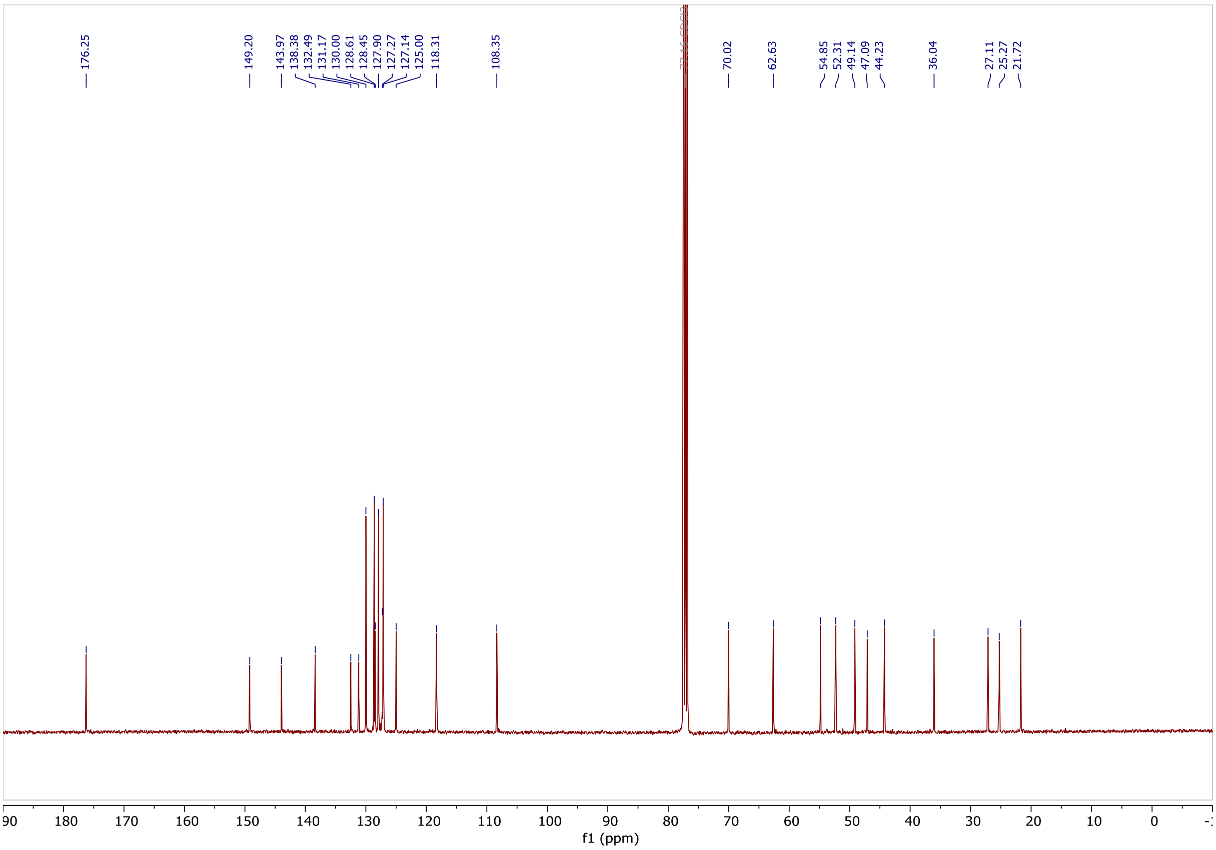
^{13}C-NMR (101 MHz, chloroform-*d*) (8e)



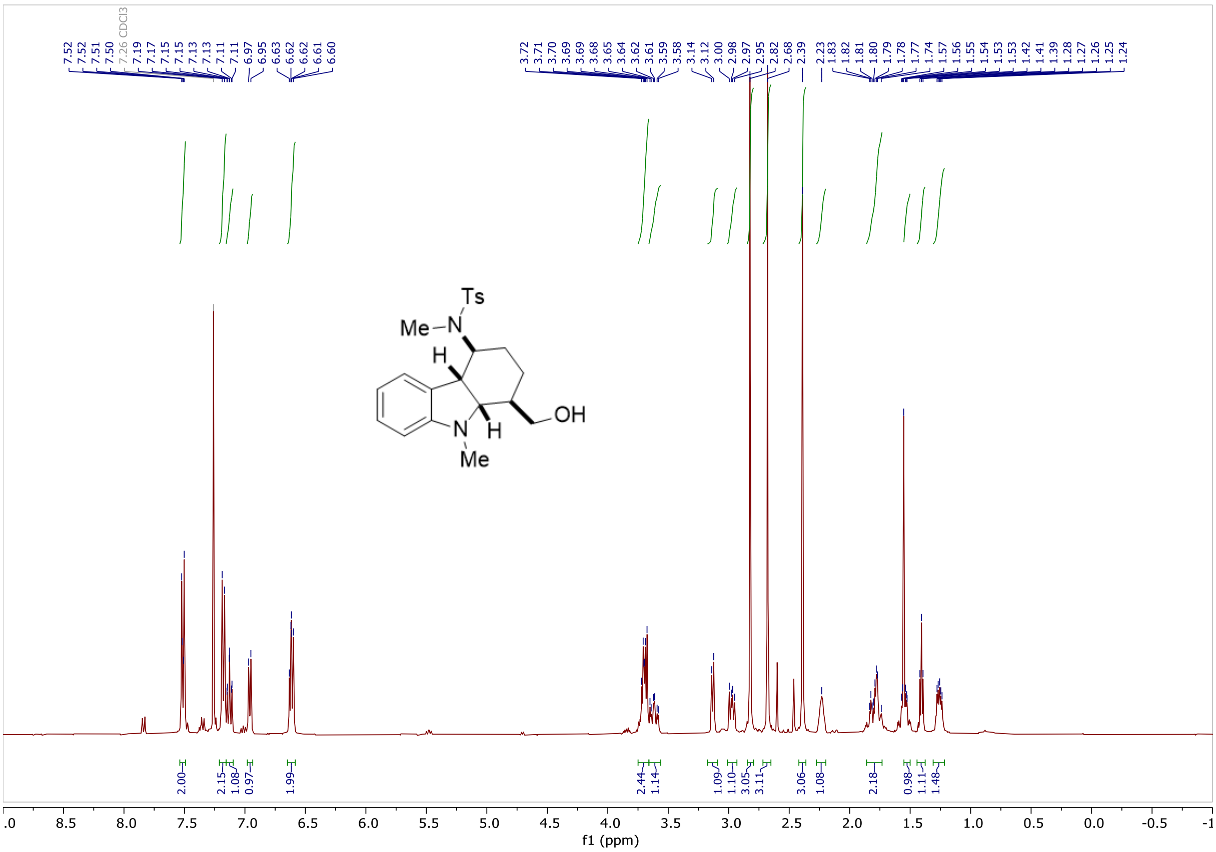
^{1}H-NMR (400 MHz, chloroform-*d*) (9e)



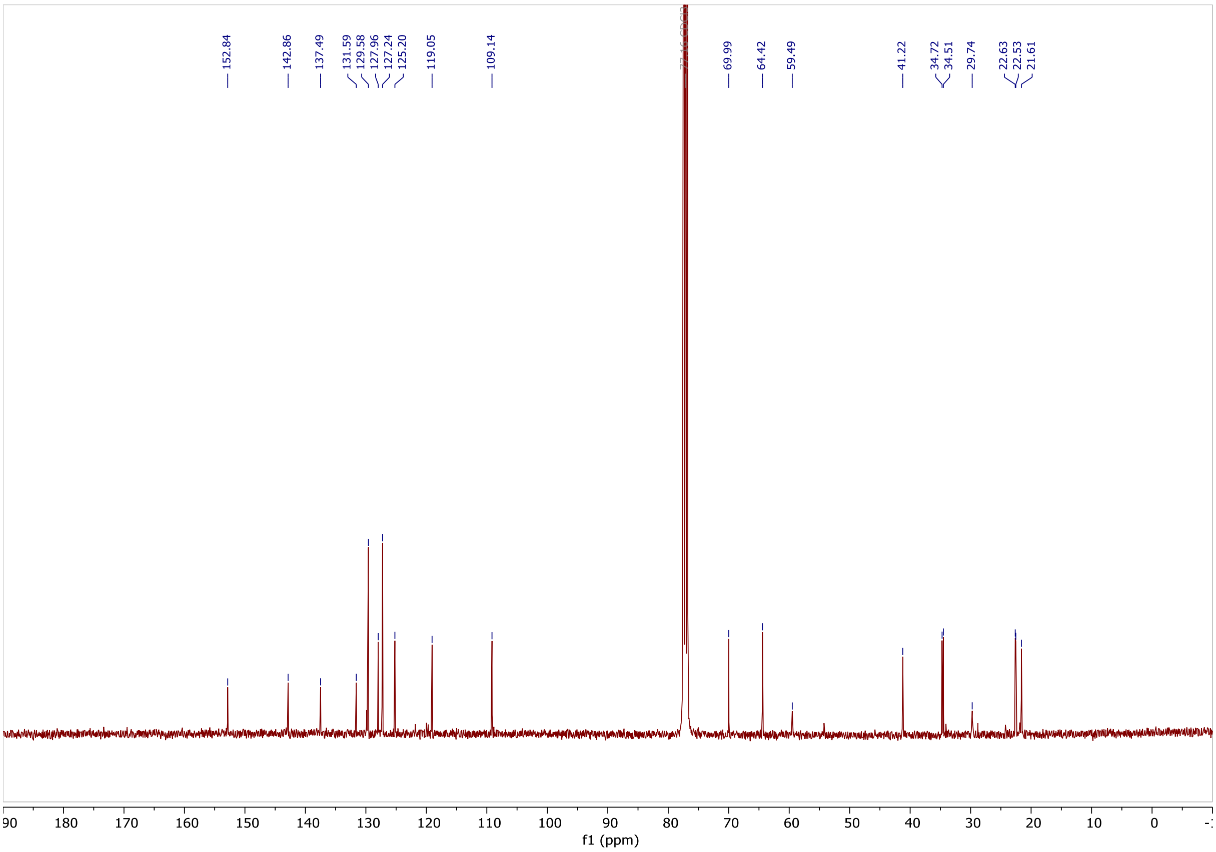
^{13}C-NMR (101 MHz, chloroform-*d*) (9e)



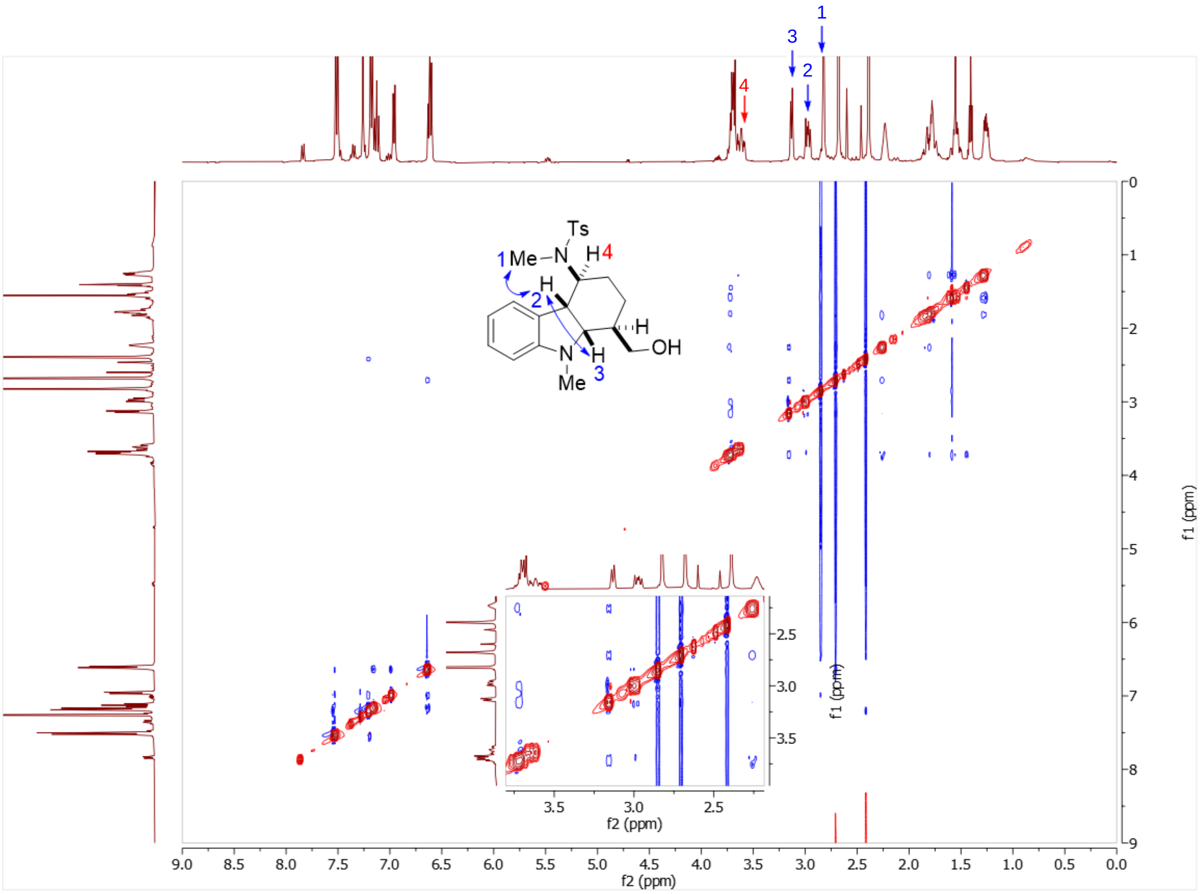
^{1}H-NMR (400 MHz, chloroform-*d*) (12)



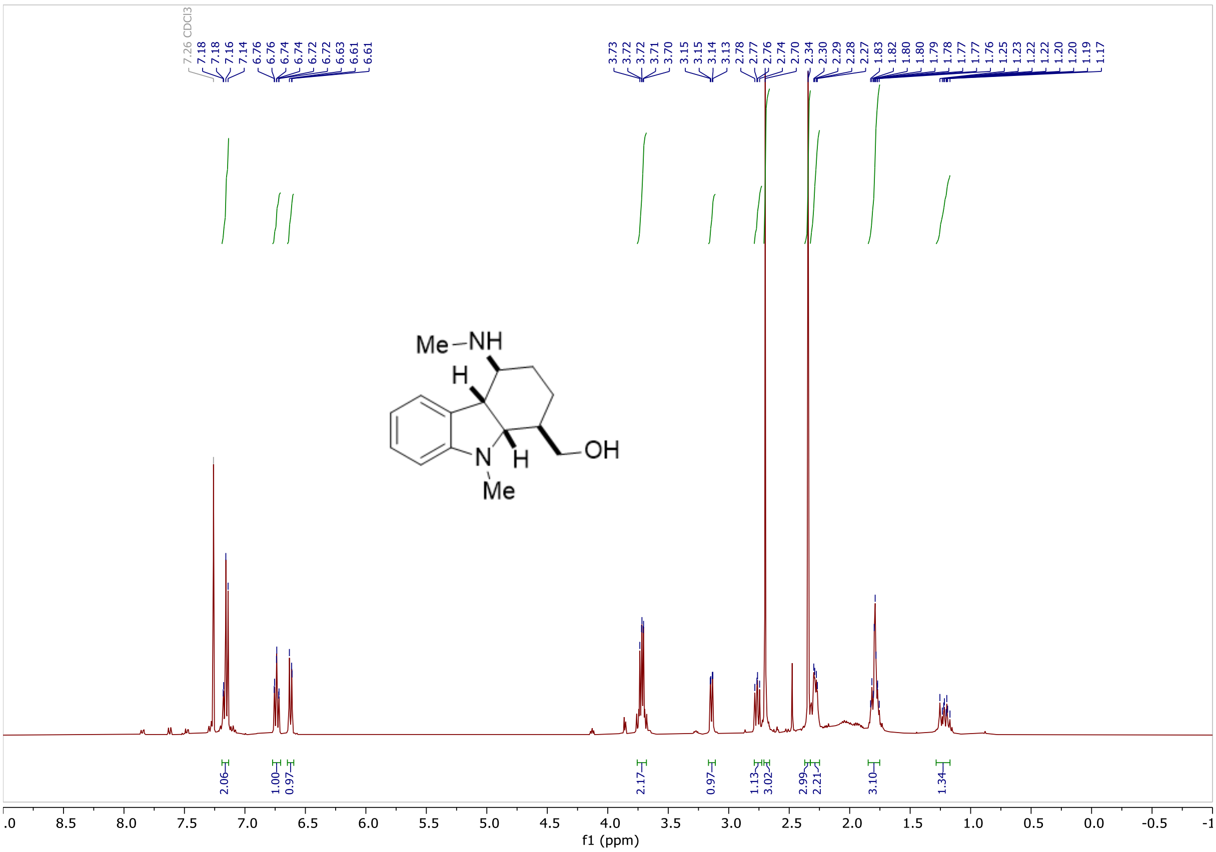
^{13}C-NMR (101 MHz, chloroform-*d*) (12)



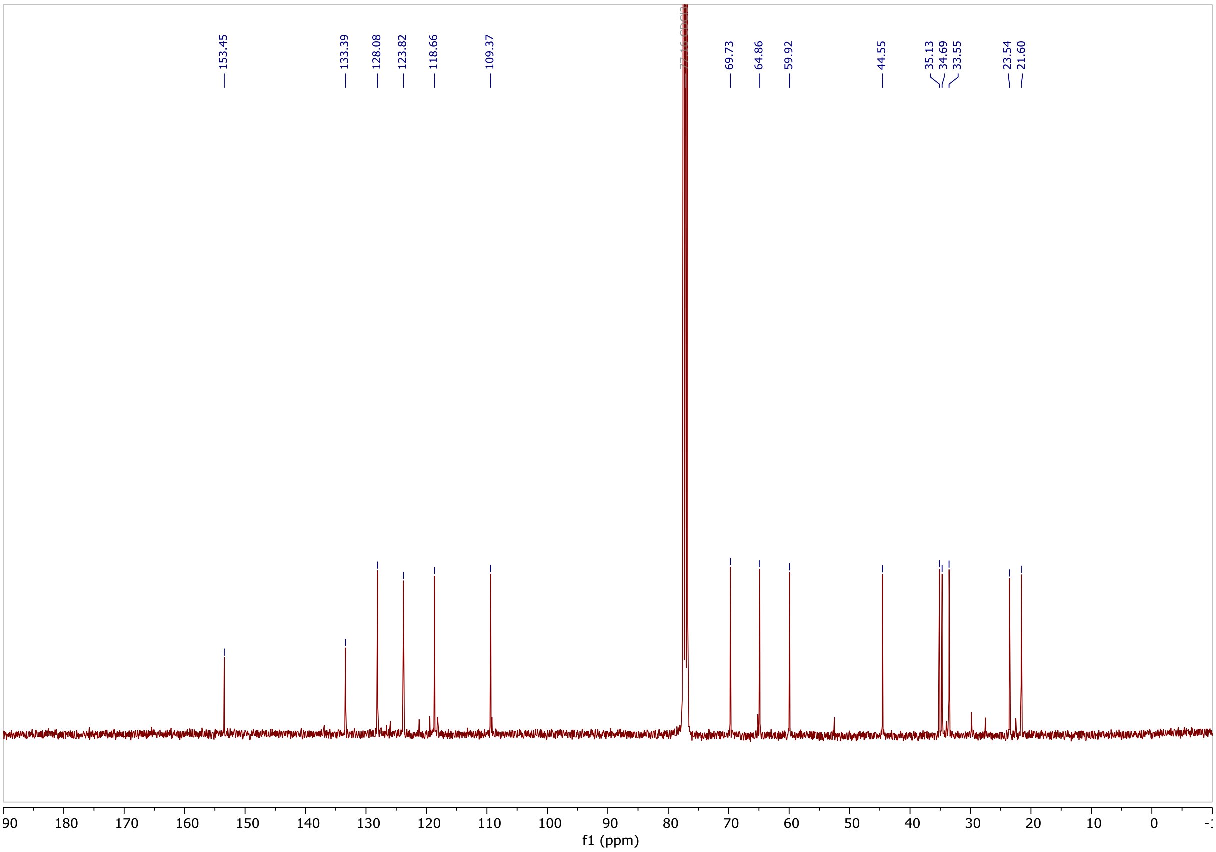
2D-NOESY (400 MHz, chloroform-*d*) (12)



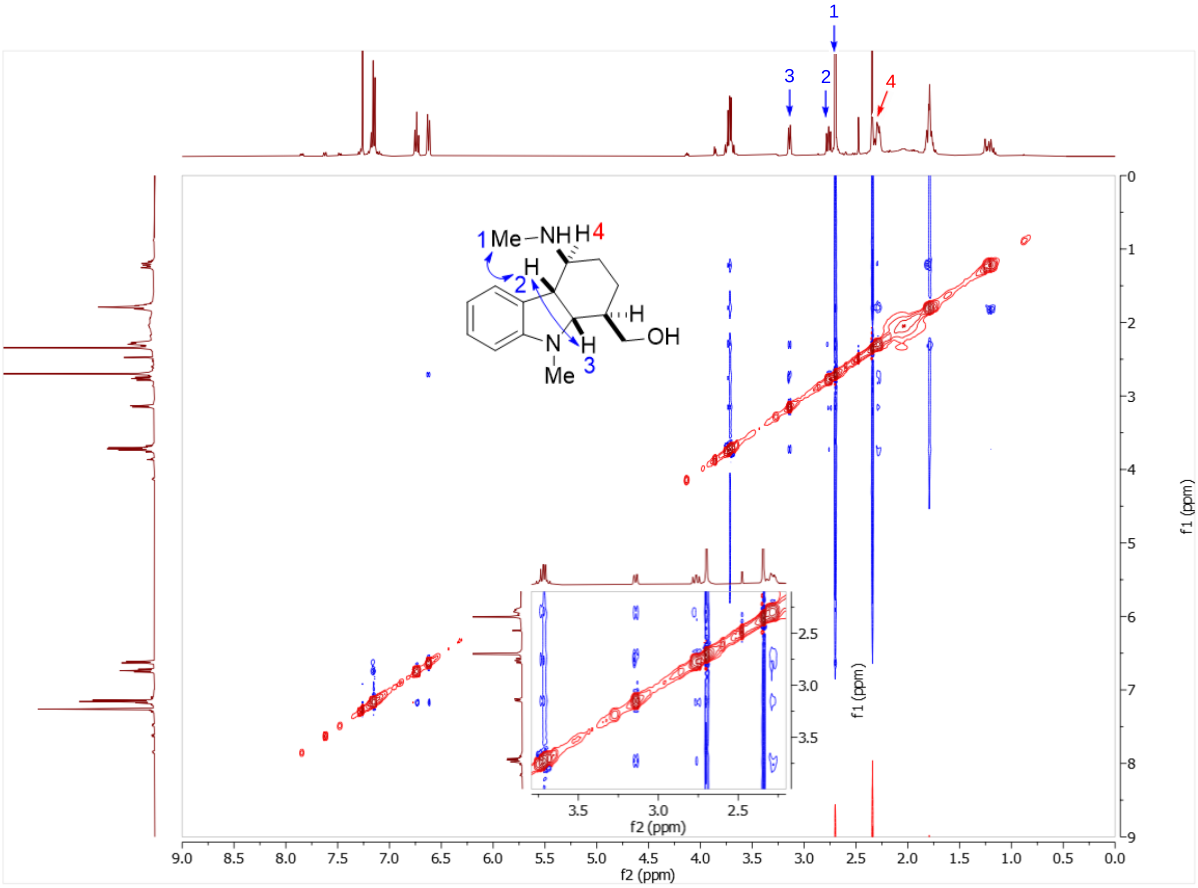
^{1}H-NMR (400 MHz, chloroform-*d*) (13)



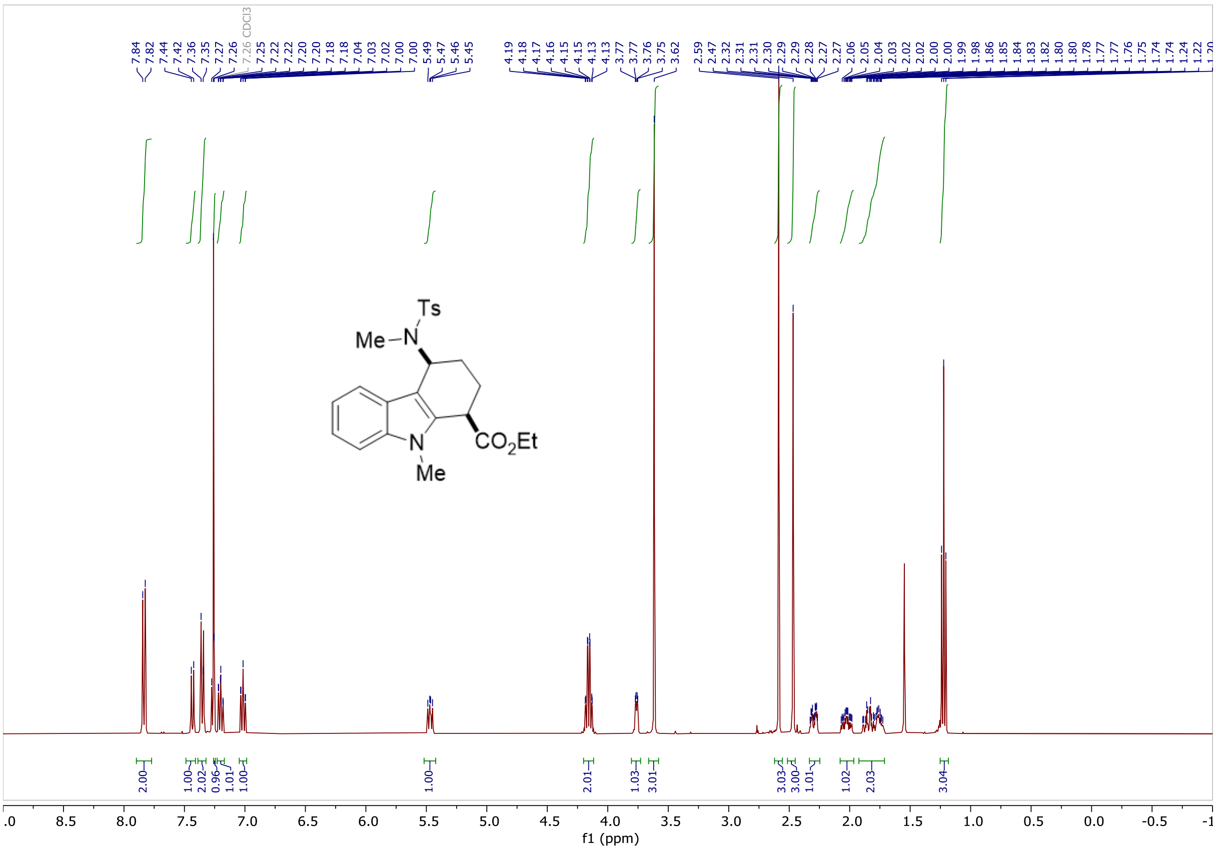
^{13}C-NMR (101 MHz, chloroform-*d*) (13)



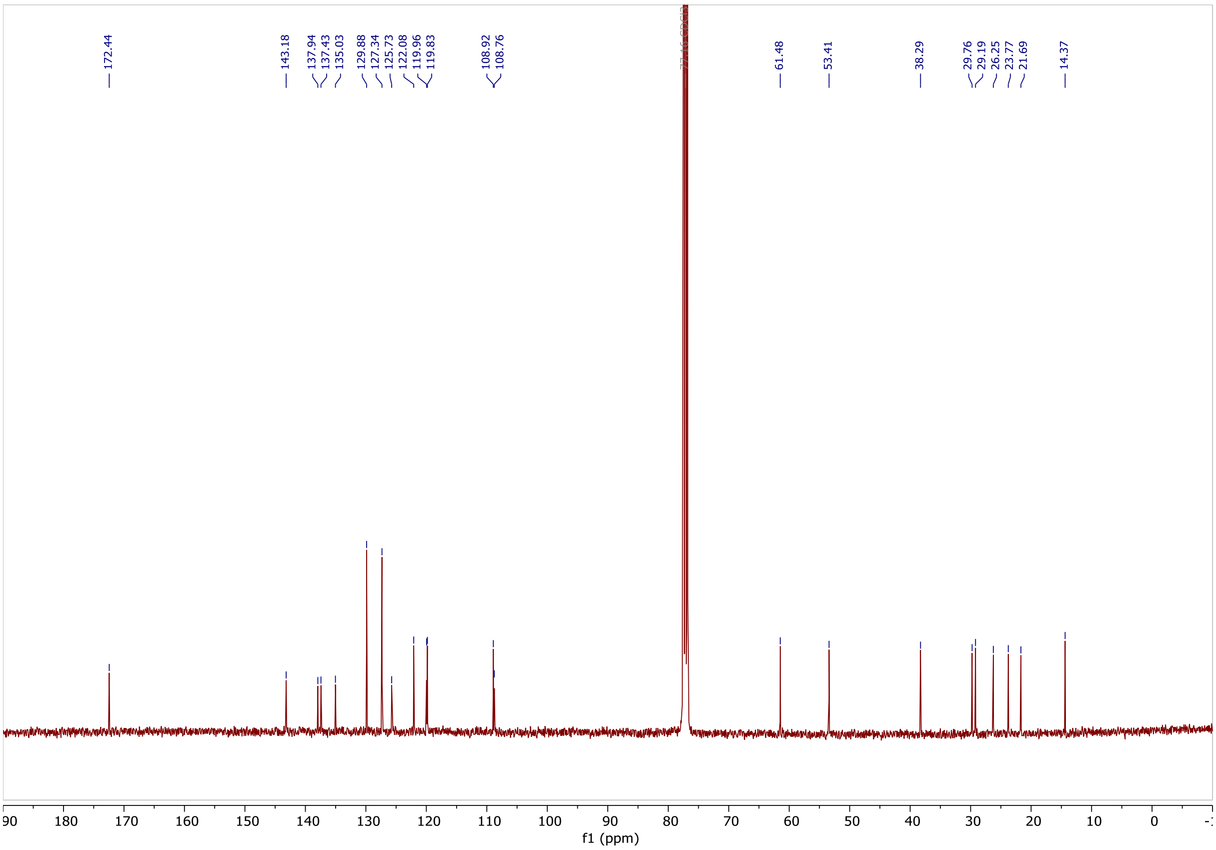
2D-NOESY (400 MHz, chloroform-*d*) (13)



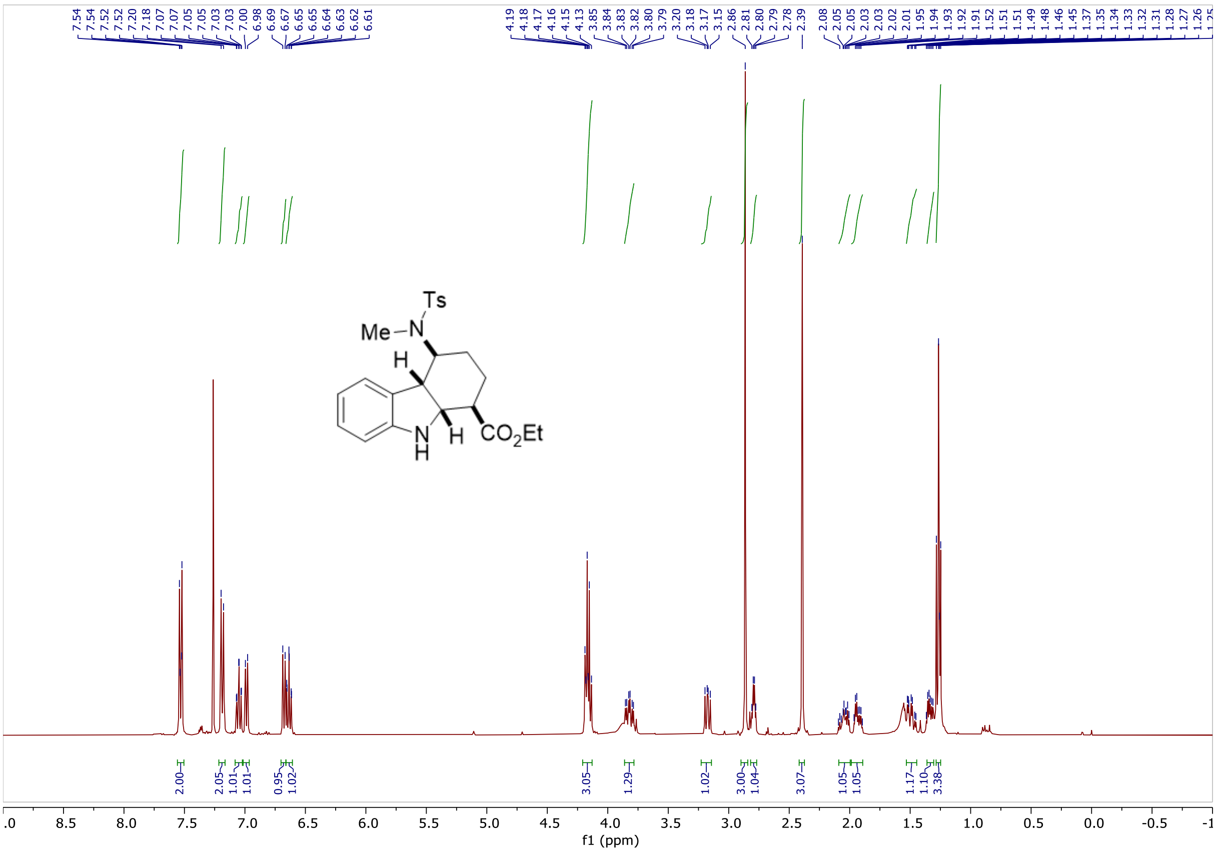
^{1}H-NMR (400 MHz, chloroform-*d*) (14)



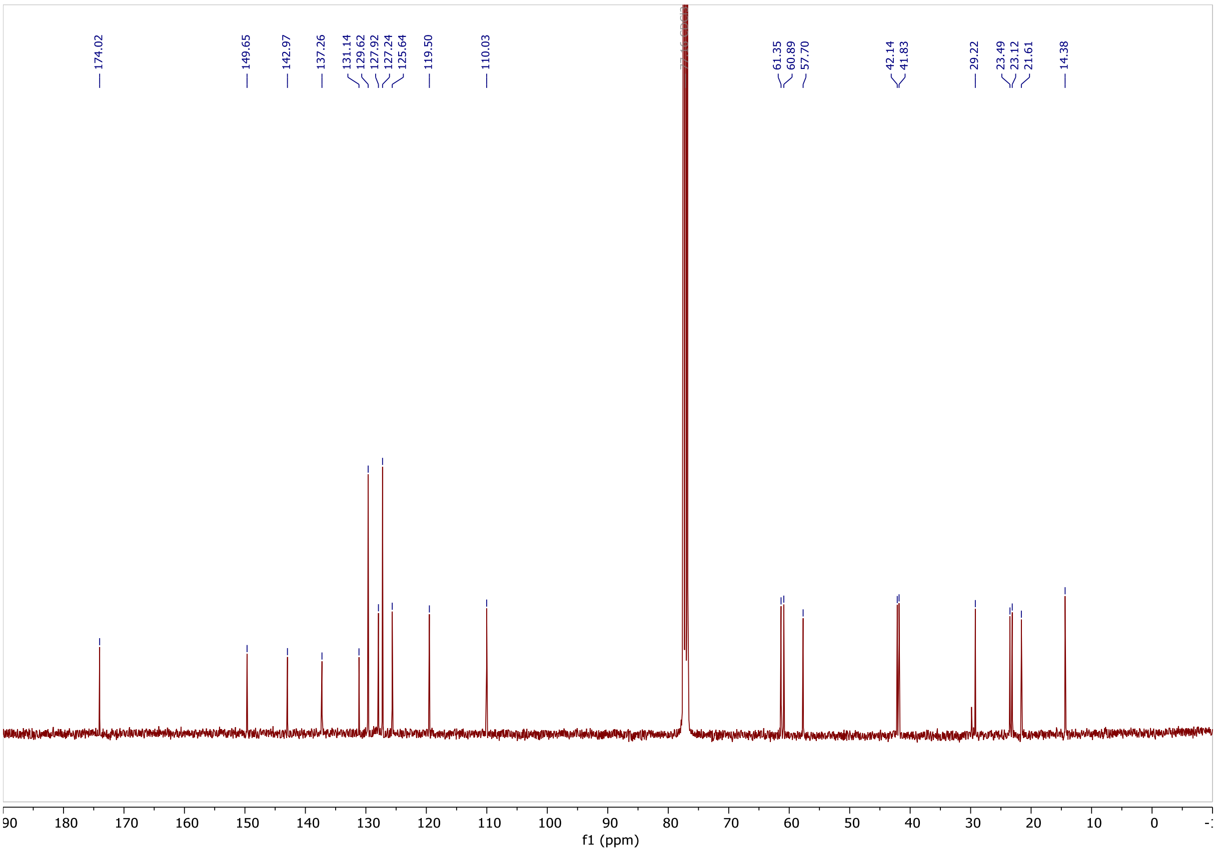
^{13}C-NMR (101 MHz, chloroform-*d*) (14)



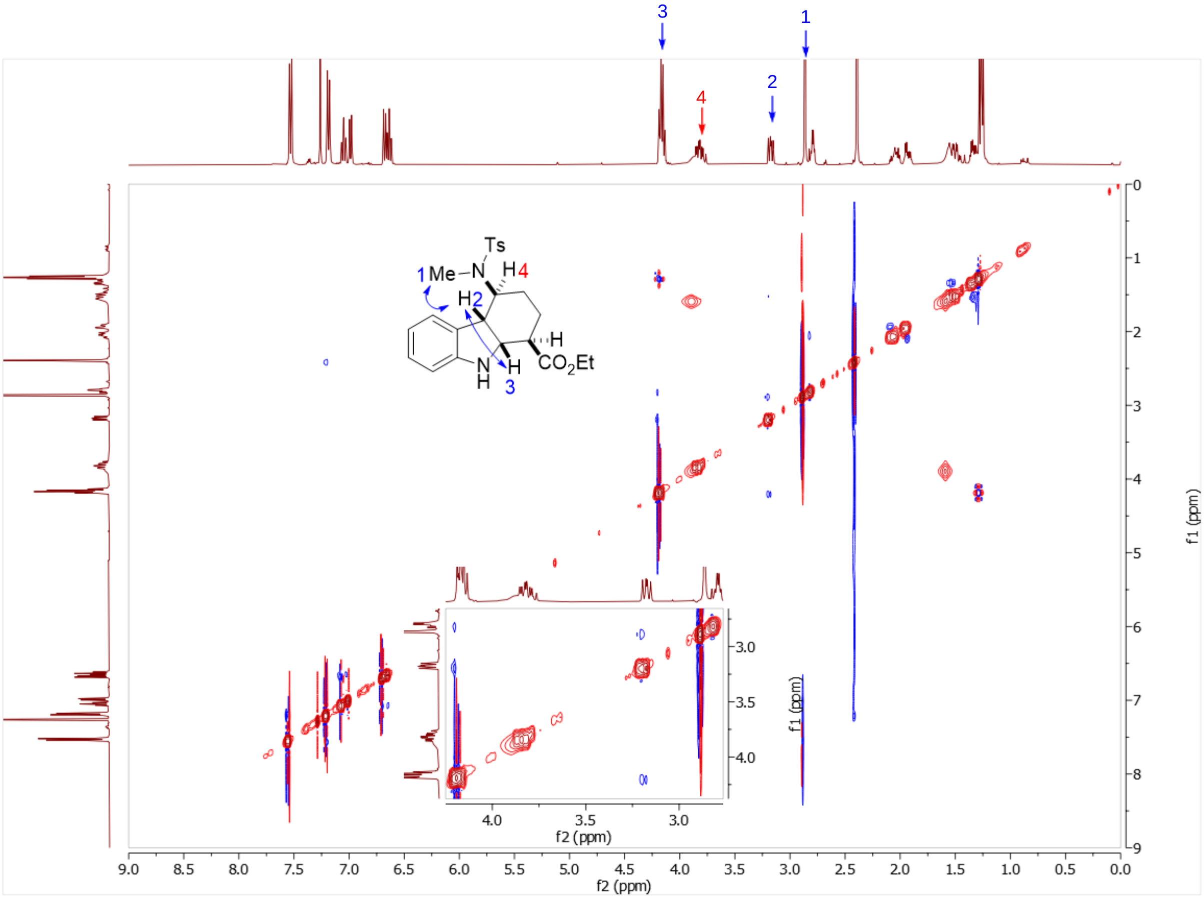
^{1}H-NMR (400 MHz, chloroform-*d*) (15)



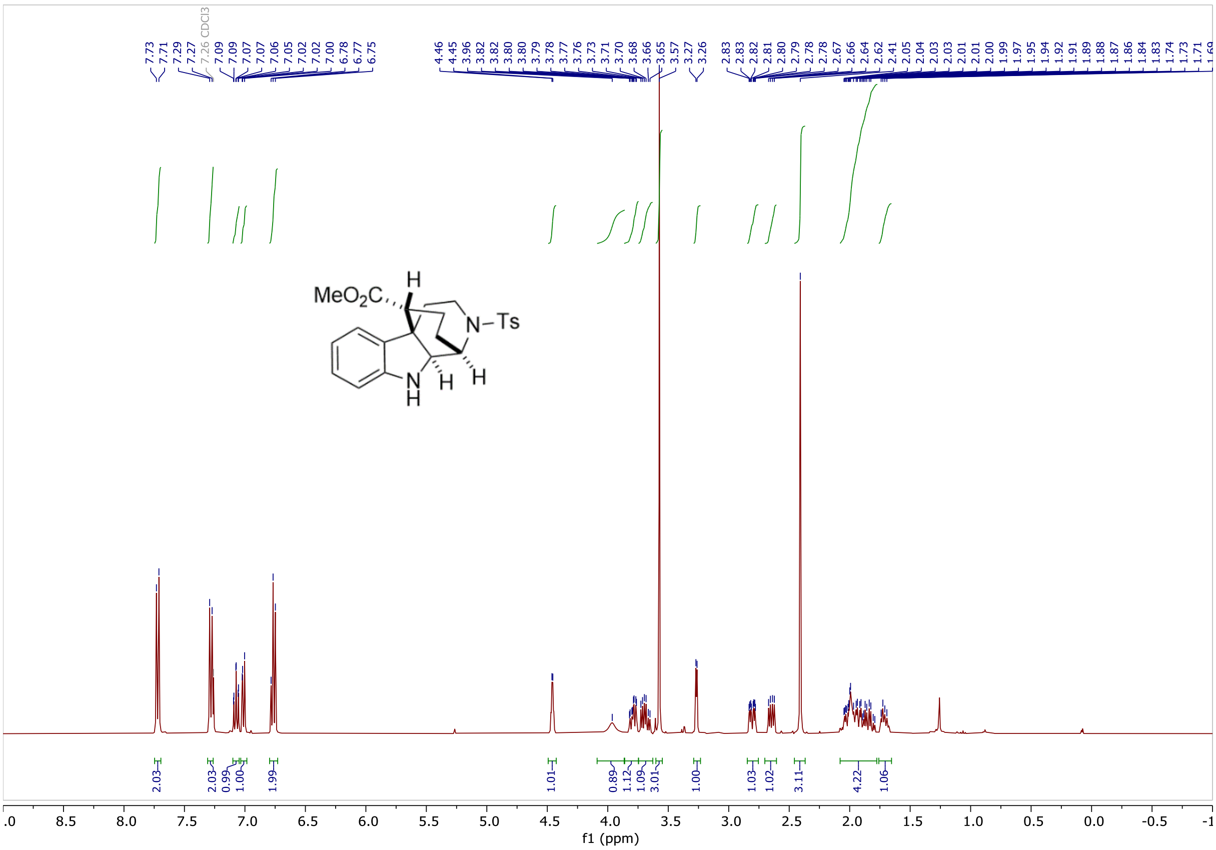
^{13}C-NMR (101 MHz, chloroform-*d*) (15)



2D-NOESY (400 MHz, chloroform-*d*) (15)



^{1}H-NMR (400 MHz, chloroform-*d*) (16)



^{13}C-NMR (101 MHz, chloroform-*d*) (16)