Optical Coherence Correlation Spectroscopy (OCCS)

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KEY WORDS: optical coherence microscopy, correlation spectroscopy, nanoparticles.

We present optical coherence correlation spectroscopy (OCCS), a novel method to study the motion dynamics of nanoparticles within many observation volumes simultaneously. For this purpose, OCCS combines the key features of dark-field optical coherence microscopy (dfOCM) and fluorescence correlation spectroscopy (FCS).

dfOCM is a Fourier domain optical coherence microscopy technique offering micrometer three-dimensional spatial resolution and microseconds temporal sampling [1]. The rapid temporal sampling is achieved by detecting the weakly back-scattered light by nanoparticles that is optically amplified upon interference with the strong reference light. For instance, our near-infrared dfOCM system is able to detect diffusing gold nanoparticles as small as 30 nm in diameter every 50 μs, which is sufficiently fast to observe the motion dynamics of these particles. On the other hand, FCS is a classical method to investigate the motion dynamics of diffusing fluorescent markers and their photo-physical and/or photo-chemical processes at the single-molecule level [2]. Whereas FCS suffers from photo-bleaching, triplet blinking and saturation of the fluorescence emission of the marker fluorophores, OCCS overcomes these limitations by detecting the back-scattered light from nanoparticles.

Using a mode-locked Ti:Sapphire laser (780 nm central wavelength), we performed experiments with nanoparticles ranging from 30 nm to 100 nm in diameter. We present these initial results and an associated theoretical fit model for the extraction of the particles' concentrations and diffusion parameters. The experimental determination of the diffusion time and concentration of gold nanoparticles based on this method is presented as a proof of principle and shows the potential of this technique. Moreover, the interferometric detection allows observing the back-scattered light from many sample volumes along the optical axis. This simultaneous detection enables assessing the axial flow of nanoparticles, which is similar to a lateral flow measurement in dual-focus FCS [3].

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