Analytical and Bioanalytical Chemistry

Electronic Supplementary Material

Bubble cell for magnetic bead trapping in capillary electrophoresis

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Finite-element formulation of the magnetic field

The integral formulation is based on the local form given by Eq (1) using the scalar potential ϕ:

$$div\boldsymbol{B} = \nabla \bullet \left(-\mu\nabla\phi + \boldsymbol{B_0}\right) = 0 \qquad \text{(S1)}$$

Equation (S1) is derived in the global form (S2), using the Galerkin formulation frequently used in the finite element method (multiplication by a projective function α and integration on the domain of study).

$$\iint \left[\alpha \nabla \bullet \left(-\mu\nabla\phi + \boldsymbol{B_0}\right)\right] d\omega = 0 \qquad \text{(S2)}$$

By decomposing the product between α and the divergence in (S2), the second order derivative of the unknown ϕ (divergence of $\nabla\phi$) becomes:

$$\alpha \nabla \bullet (-\mu\nabla\phi + \boldsymbol{B_0}) = \nabla \bullet \left[\alpha\left(-\mu\nabla\phi + \boldsymbol{B_0}\right)\right] - \nabla\alpha \bullet \left(-\mu\nabla\phi + \boldsymbol{B_0}\right) \qquad \text{(S3)}$$

Equation (S3) is applied in (S2) and the Ostrogradsky theorem is used to reject the divergence term $\nabla \bullet \left[\alpha\left(-\mu\nabla\phi + \boldsymbol{B_0}\right)\right]$ at the boundary in (S4) where it equals to zero (no magnetic field at the external boundaries of the domain due to the use of a large "air box").

$$\iint \left[\nabla\alpha \bullet \left(\mu\nabla\phi - \boldsymbol{B_0}\right)\right] d\omega + \int \alpha\, \boldsymbol{B} \bullet n \, d\omega = 0 \qquad \text{(S4)}$$

The unknown vector ϕ is interpolated with a function β, of the same type as the projective function α as the Galerkin method is used. It leads to the final form (S5) where the first term corresponds to the matrix to invert, the second term being the source term (discretization non described).

$$\iint \mu\nabla\alpha \bullet \nabla\beta\, \phi \, d\omega = \iint \nabla\alpha \bullet \boldsymbol{B_0} \, d\omega \qquad \text{(S5)}$$

Plexiglas holder and ring magnets

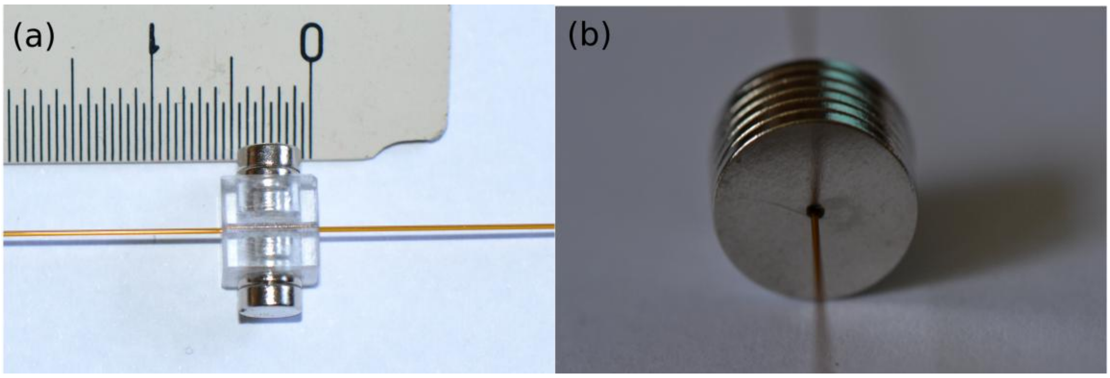

Figure S1: (a) Plexiglas holder (cube 6 mm side) machined on each side to insert magnets 4 mm in diameter with 1 mm spacing between them. A channel is drilled between the magnets to allow the insertion of a capillary. (b) ring magnets piled up to form a larger magnet with the capillary slid through