Optical manipulation of nanoparticles in a tapered glass capillary

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Light can provide an efficient and contactless way to detect and separate micro- and nano-objects in liquid colloidal solution with different optical properties. Depending for instance on its wavelength and polarization, light can be used to apply object-dependent optical forces based on radiation pressure. This effect can be used to achieve optical sorting of nanoparticles [1-4]. However, optical manipulation based on radiation pressure usually requires a large light intensity, especially for handling nanoparticles.

In this work, we investigate the use of tapered glass capillaries as an original optofluidic system for optical chromatography. Tapered glass capillaries with micrometer- or nanometer-scale inner and outer diameters can be fabricated using a standard optical fiber pulling device. Once filled with a small amount of colloidal solution (low-concentration suspension of nanoparticles in water), a tapered glass capillary suspended in the air acts as a partially-liquid-core waveguide capable of highly focusing the laser beam on a few-millimeter-long distance. Finite-Element Method numerical simulations (COMSOL) have been conducted in order to evaluate the optical properties of such a system. The modal dispersion of the waveguide is discussed as a function of the laser wavelength and the dimensions of the tapered capillary. We also evaluate the optical forces acting on a nanoparticle located inside the capillary as a function of its size, refractive index and absorption properties. Since the large overlap between the laser beam and the colloidal solution inside the tapered capillary allows for a large enhancement of light-matter interactions, the use of tapered glass capillaries could lead to the practical optical sorting of sub-100nm-sized nanoparticles depending on their optical properties.

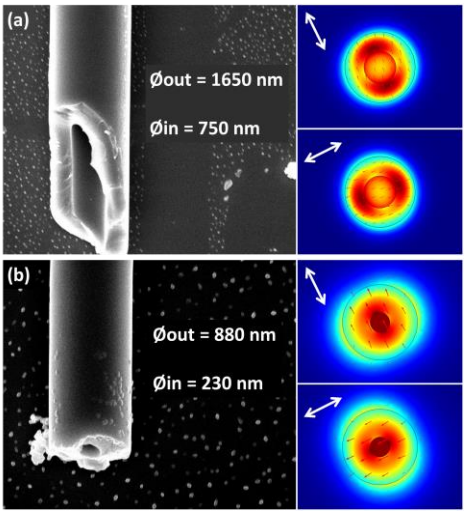

Figure 1: (a,b) SEM images of tapered glass capillaries with different size and numerical calculations of the fundamental mode intensity profile (two orthogonal polarizations) for corresponding water-filled capillaries.

REFERENCES:

[1] Imasaka T., Kawabata Y., Kaneta T., Ishidzu Y., *Analytical Chemistry* **67**, 1763-1765 (1995).

[2] Shi Y. *et al.*, *Science Advances* **4**, eaao0773 (2018).

[3] Tkachenko G., Brasselet E., *Nature Communications*, **5**, 3577 (2014).

[4] Rukhlenko I. D. *et al.*, *Scientific Reports* **6**, 36884 (2016).