diffusion-fundamentals.org

The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application

Suppressing rotational diffusion of Janus particles by surface modifications for directed thermophoretic motion

Katrin Günther[1*], **Andreas Bregulla**[2], **Martin Bönsch**[1], **Frank Cichos**[2], **Michael Mertig** [1,3]

[1]Physikalische Chemie, Mess- und Sensortechnik, Technische Universität Dresden, Dresden, Germany
[2]Molecular Nano-Photonics, Institute for Experimental Physics I, Universität Leipzig, Leipzig, Germany
[3]Kurt-Schwabe-Institut für Mess- und Sensortechnik e.V. Meinsberg, Waldheim, Germany
[*]katrin.guenther@tu-dresden.de

Control over translational motion on a microscopic scale is the basis for directed transport of cargo. Besides different forms of the external driven phoretic motion, self-propelled motion gains increasing interest.

Here, the influence of various surface modifications on self-propelled motion of laser-heated gold-capped Janus particles is investigated. Wide-field laser heating of the gold hemisphere induces an asymmetric temperature profile around the particles resulting in thermophoretic self-propulsion [1]. Besides the desired directed translational motion also rotational diffusion of the Janus particles has to be regarded [2]. Therefore, we modified the Janus particles with linear DNA strands to stabilize the self-driven thermophoretic motion against the rotational diffusion. In addition, by changing the surface properties of the confining microfluidic chambers, the orientation of Janus particle was also affected. Furthermore, linking polystyrene microspheres to Janus particles via linear double-stranded DNA was investigated as a model system for transport of microcargo.

The used Janus particles consist of polystyrene microspheres with one hemisphere covered with a 50 nm thick gold layer. The water-suspended Janus particles are contained in microchambers built of cover glasses and PDMS spacers. To prevent sticking of Janus particles, the glass surfaces were passivated. Heating is achieved by laser irradiation at a wavelength of 532 nm with laser power ranging from 0 to 50 mW. From the two-dimensional trajectories of Janus particles visualized by dark-field microscopy, the mean squared displacement, rotational diffusion time, particle velocity and correlation parameters were achieved.

Linear double-stranded DNA molecules at different lengths were specifically attached to the gold side of the Janus particles via gold-thiol bonds. To this end, single-stranded λ-DNA overhangs were filled in with thiolized nucleotides in an enzymatic reaction. For flexible linking of polystyrene microspheres to Janus particles, DNA was functionalized with two different labels at both ends: thiol for binding to the gold hemisphere of the Janus particle and biotin for binding to the streptavidin-coated polystyrene microspheres. The attachement of DNA to Janus particles and polystyrene particles was verified by transmission electron microscopy.

The electrochemical properties of the passivated microchamber surfaces were characterized by zeta potential measurements and their influence on particle orientation and mobility was examined. Here, the effects of an amino-terminated and a hydrophobic silane as well as a nonionic poloxamer were studied.

This work was supported by the DFG (FOR 877).

References

[1] H.-R. Jiang, N. Yoshinaga, M. Sano: *Active motion of a Janus particle by self-thermophoresis in a defocused laser beam*. Phys. Rev. Lett. **105**, 268302 (2010)

[2] B. Qian, D. Montiel, A. Bregulla, F. Cichos, H. Yang: *Harnessing thermal fluctuations for purposeful activities: The manipulation of single micro-swimmers by adaptive photon nudging*. Chem. Sci. **4**, 1420–1429 (2013)