BIG energy seminar series

Addressing the scale and complexity of the global energy challenge.

Local Energy Conversion in Catalytic Janus "Micro-motors"

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Abstract:

Synthetic micro-motors which can move cargo in a well controlled way through a liquid environment are of significant interest for applications such as renewable energy research, targeted drug delivery, biosensing, and shuttle-transport of living cells. One promising approach is to use catalytically active Janus colloidal particles as model micro-motors. This type of particles harvest "chemical" free energy from the surrounding liquid environment and then transform it into mechanical energy. Due to an asymmetric decoration of their surface with a catalyst, which promotes a specific chemical reaction in the surrounding liquid, concentration gradients of the reaction products develop along the surface of the particle. Depending on the systems, various self-propulsion mechanisms emerge, such as bubble propulsion, self-electrophoresis, or self-diffusiophoresis, which in some systems can be activated by light. In this talk only the last mechanism, i.e. self-propulsion due to self-generated electrically neutral solute gradients, shall be considered.

First, we discuss the self-difusiophoretic motion of a spheroidal particle, which is covered by a catalyst over a cap-like region centered at one of the poles of the particle [1]. We describe how the self-phoretic velocity depends on the aspect ratio of the polar and the equatorial diameters of the particle and on the fraction of the particle surface contributing to the chemical reaction. Next we show that such particles can be used as micro-carriers [2]. As a simple model for a carrier-cargo system we consider a catalytically active particle connected by a thin rigid rod to a catalytically inert cargo particle. We show that the velocity of the composite strongly depends on the relative orientation of the carrier-cargo link. Accordingly, there is an optimal configuration for the linkage. The subtlety of such carriers is underscored by the observation that a spherical particle completely covered by catalyst, which is motionless when isolated, acts as a carrier once attached to a cargo. Finally, some preliminary experimental results, demonstrating motion of different composites of carrier and cargo particles [3] are presented.

[1] M. N. Popescu, S. Dietrich, M. Tasinkevych, and J. Ralston, Eur. Phys. J. E 31, 351 (2010).
[2] M. N. Popescu, M. Tasinkevych, and S. Dietrich, EPL 95, 28004 (2011).
[3] L. Baraban, M. Tasinkevych, M. N. Popescu, S. Sanchez, S. Dietrich and O. G. Schmidt, Soft Matter 8, 48 (2012).

Bio:

Mykola Tasinkevych is a theoretical and computational physicist specializing in Soft Matter Physics. After his PhD work on the behavior of micro-emulsions in confined geometry (PhD program completed 1999) he spent three years as a postdoc in Lisbon. Mykola worked on several research projects with topics ranging from non-equilibrium pattern formation of dipolar particles to colloidal aggregation in nematic suspensions. Currently he is a staff member at the Max Planck Institute for Intelligent Systems in Stuttgart, Germany. Mykola's research activities cover wetting properties of nano-patterned substrates, local energy conversion in active systems, effective solvent mediated interactions between colloidal particles including nematic colloids, self-propulsion at low Reynolds number, and active colloids.

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