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Autonomous Propulsion at the Nanoscale

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Abstract: In molecular nanotechnology and supramolecular chemistry, control of dynamics, i.e. translational and rotational motion, is one of the most fundamental problems and challenging goals. Autonomous propulsion properties of microparticles depend strongly on the particle size, shape, anisotropy (isotropic NPs vs. Janus NPs) and the propulsion mechanism. But can we extrapolate the swimming behaviour of particles as we keep reducing the scale? Can isotropic nanoparticles be self-motile? What is the size limit for catalytic swimmers? To answer this questions we have prepared a series of nanoparticles of different sizes and shapes. We have chosen two different strategies to achieve propulsion by means of catalytic H2O2 decomposition: (1) grafting a manganese catalyst to the surface of silica nanoparticles and (2) growing a Pt half-shell on Au-silica Janus NPs. Since fluorescent swimmers facilitate direct motility studies, even at sizes smaller than the optical diffraction limit, some strategies for fluorophore-attachment will also be presented. Possible methods for studying autonomous propulsion at the nanoscale will be discussed.

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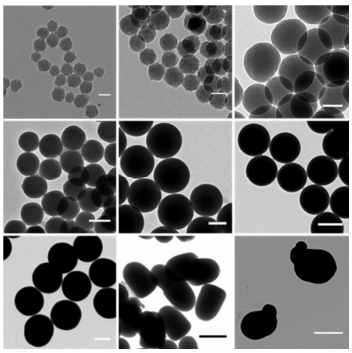
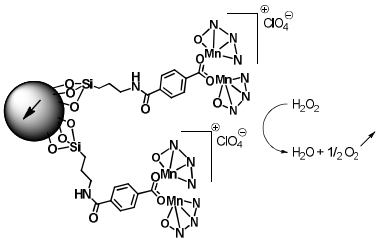
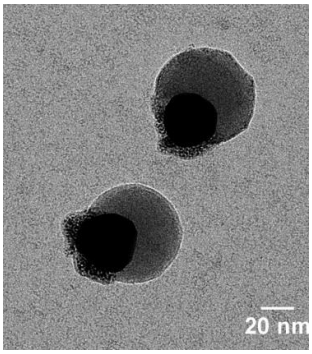


Spherical silica particles (a, b, c, d, e, f and g), rodlike particles with aspect ratio 3:2 (h) and functionally anisotropic Janus particles (i). Scale bars are: 30 nm (a); 50 nm (b); 70 nm (c); 200 nm (d, e); 500 nm (f, g, h); 1 µm (i).



Schematic representation of the manganese catalyst, attached to the surface of a silica nanoparticle to act as a propulsion unit.



SiO_2-Au-Pt Janus nanoparticles.

Dr. Krzysztof K. Krawczyk was born in Czństochowa, Poland. He received a MSc in Environmental Studies and a PhD in Chemical Sciences at the University of Warsaw, both under the supervision of prof. dr. Zbigniew Czarnocki (Laboratory of Natural Products Chemistry). In 2011 he was a guest researcher at the Centre National de Recherche Scientifique in Caen, France, working on chemically robust magnetic core-shell nanoparticles with prof. dr. Bernhard Witulski. In 2012 he received the ñKolumbòfellowship of the Foundation for Polish Science and is currently working at the University of Groningen, The Netherlands, in the group of prof. dr. Ben L. Feringa. His research interests include molecular switches & motors and the engineering of nanostructures.

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