A synthesis to magnetic metal nanoparticles and dual-functional microspheres

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Functional silica-encapsulated nanomagnets, *e.g.*, have been studied for their biomedical and environmental application, because they reveal several benefits such as biocompatibility, functionality, stability against degradation, and a hydrophilic character. Various sol-gel based strategies have been used for generating silica-encapsulated iron oxide particles.[1] However, reports on silica-encapsulated magnetic metal particles like Co, Fe, or Ni are scarce, even though many advantages are expected (*e.g.*, large saturation magnetization, enhanced magnetophoretic mobility).

We take advantage of amino-functionalized siloxanes not only to directly control particle nucleation and growth by coordinating to the metal surface but also to provide reactive siloxane groups on the particle surface as a functional interface for further deposition of oxides, such as SiO_2 and TiO_2.[2] This procedure permits the synthesis of Co and Fe nanoparticles of various sizes by thermolysis of $Co_2(CO)_8$ or $Fe(CO)_5$ in solution, respectively, and the preparation of magnetic microspheres. After surface passivation with low doses of oxygen (*smooth oxidation*), the nanoparticles show a good resistance to oxidation. The reaction mechanism was investigated by UV-visible and FTIR spectrometry; the size, structure, and magnetic properties of the particles were characterized by TEM, EDX, XPS, Mössbauer spectroscopy, XRD, AES-ICP, and magnetic measurements.

The applied bifunctional siloxane compound not only controls particle formation by complexation of cobalt but also serves as a coupling agent for SiO_2 and TiO_2 deposition, resulting in functional magnetic microspheres (*e.g.*, catalytic/magnetic microspheres). Magnetic Co@SiO_2 microspheres are obtained by adding and heating TEOS in water/ethanol in the presence of the APTES-functionalized Co nanoparticles. These Co@SiO_2 microspheres can be further functionalized, e.g. by molecular Rh complexes to form magnetically recycable hydroformylation catalysts or by TiO_2 deposition to form photocatalytic systems for the treatment of biological or organic pollutants in water.

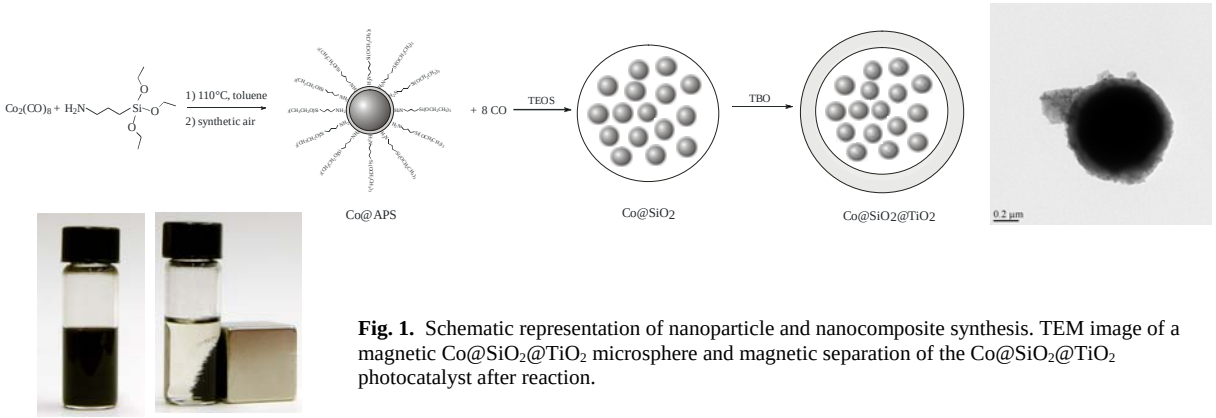

Fig. 1. Schematic representation of nanoparticle and nanocomposite synthesis. TEM image of a magnetic Co@SiO_2@TiO_2 microsphere and magnetic separation of the Co@SiO_2@TiO_2 photocatalyst after reaction.

References

[1] A.P. Philipse, M. P. van Bruggen, and C. Pathmammanoharan, *Langmuir*, 1994, **10**, 92.

[2] A. Gorschinski, G. Khelashvili, D. Schild, W. Habicht, R. Brand, M. Ghafari, H. Bönnemann, E. Dinjus, S. Behrens, *J. Mater. Chem.*, 2009, **19**, 8829.