Non-spherical magnetic nanoparticles for the design of asymmetric structures

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The combination of magnetic particles with soft matter, like polymers, surfactants and colloids is attractive with respect to the manipulation, investigation and exploitation of mechanical properties on the nanoscale range. By employing ferromagnetic, non-spherical particles, novel possibilities for materials with nanoscale anisotropy become accessible.

One of our goals is the creation of asymmetric, ferromagnetic nanoparticles with defined size that are of use for the implementation of well-defined organic-inorganic nanohybrid materials. For this purpose, cobalt ferrite ($CoFe_2O_4$) particles were chosen, accessible by the organic route of thermal decomposition of a mixed oleate complex precursor. This reaction undergoes the LaMer mechanism, hence, a variation of the reaction parameters can be used to result in particles with different size and shape[1]. Since the magnetic nature of the nanoparticles is also size-dependent, tailoring of the properties from superparamagnetic to ferromagnetic is possible.

We succeeded in the synthesis of $CoFe_2O_4$ nanoparticles between 5 nm and 25 nm with each a narrow size distribution.. The particle shape changes with the size from spherical to cubic.

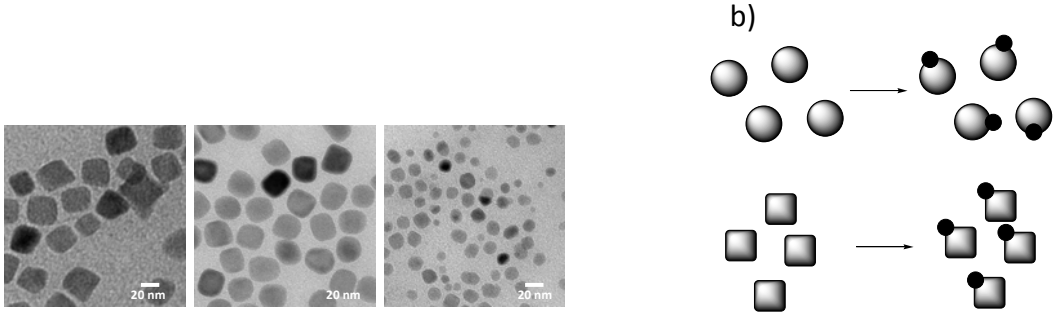

Figure 1: a) TEM images of $CoFe_2O_4$ nanoparticles from mixed oleate decomoposition b) Preparation of $CoFe_2O_4$dumbells modified with silver or gold

By means of VSM it was found that the particles show ferromagnetic behavior in the solid state, while employing quasi-superparamagnetic behavior (absence of hysteresis) when dispersed in organic solvents like toluene and hexane.

In order to produce nanoobjects with more amphiphilic character, different methods of postfunctionalization are employed. On the one hand, a Pickering emulsion-based method is employed, when the magnetic particles are on the interphase. To obtain asymmetric nanoparticles, growing or attaching of silver or gold nanoparticles to the surface of primary seed particles is proposed[2]. For this point, the non-spherical shape of the magnetic particles can be advantageous due to inequality of the surface positions for crystal nucleation, growth or attachment.

The proposed nanoobjects can be further modified with organic polymers, providing great opportunities for the design of materials and surfaces with structural, magnetic or optical anisotropy.

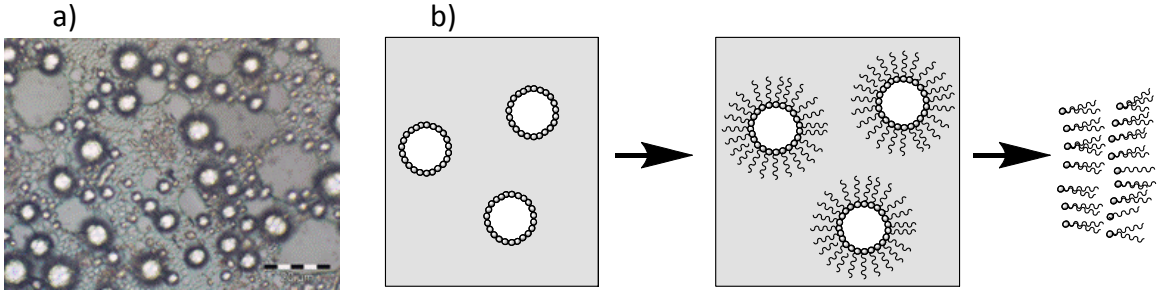

Figure 2: a) Light microscopy image of Pickering emulsion b) Magnetic Janus nanostructures from Pickering emulsions

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