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The preparation of ordered colloidal magnetic particles by magnetophoretic deposition

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Abstract. The preparation of ordered two-dimensional (2-D) magnetic nanoparticles using a magnetophoretic technique is reported. The quality of the ordering can be readily observed by electron microscope and the lattice constants determined by electron diffraction. Using image processing, it can be shown that the cobalt particles condense into hexagonal close packing and also that the crystallographic axes of the individual cobalt particles are randomly oriented. The equilibrium distance between the particles corresponds approximately to the size of the absorbed stabilisers and the strength of the magnetic field. The method is of general interest as a means of preparing monolayer films of nanosized magnetic particles such as cobalt or iron oxide.

1 Results and discussion

Cobalt nanoparticles were prepared by thermolysis of dicobaltoctacarbonyls in an organic carrier at 110 °C in presence of two different surfactants. The surfactants used were sodium-bis 2-(ethyl-hexyl) sulfosuccinate (Co I) and oleoylsarcosine (Co II). As a result ferrofluids (FF) of saturation magnetization of at least 20 mT were obtained. After the reaction non-stabilised particles were separated in an external magnetic field. After that, the stable ferrofluid was diluted with toluene in a ratio of 1:100. The composition of the particles (core and shell) was analysed by chemical and physical methods. The results corresponded to the magnetic properties of the core. Furthermore, magnetite particles were prepared by co-precipitation. The particles were modified by an inner surfactant layer of lauric acid and an outer layer of an ethoxylated alcohol. Aqueous base FF of a saturation magnetization by 100 mT were obtained. For observations all FF were highly diluted with the carrier.

Observation by high resolution transmission electron microscopy (HRTEM) (Fig. 1 and Fig. 2) showed Co particles well isolated and regularly dispersed in the surfactant with a narrow size distribution of about 8 nm ± 6% (Co I) and 12 nm ± 5% (Co II) in diameter. The sizes of the particles deduced from the analysis of the magnetic susceptibilities and magnetisation curves are consistent with those measured by HRTEM.

The distribution of the particle magnetic moments in ferrofluids reconstructed from the magnetization curves is in a good agreement with those computed from the particle sizes on HRTEM-images.

We have used the small nanoparticles for the creation of two dimensional arrays. The magnetic particles were ordered by drying a drop (5 μL) on a carbon-coated grid in the presence of an external magnetic field of ca. 0.8 T, which was created by placing the grid between two magnets.

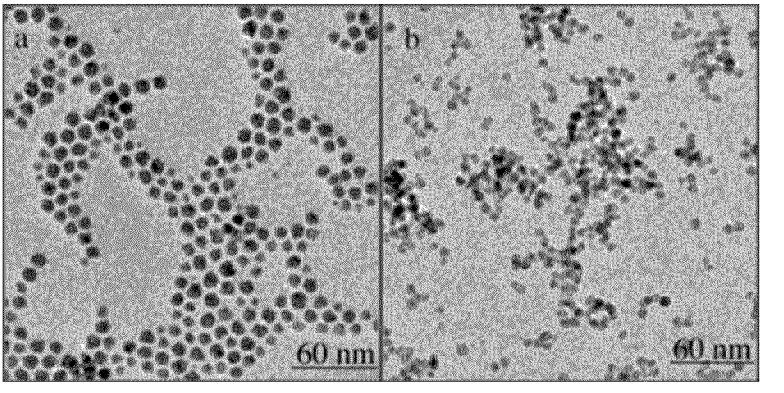

Fig. 1. Low magnification TEM micrograph of small Co particles in different solutions: (a) Co I; (b) Co II.

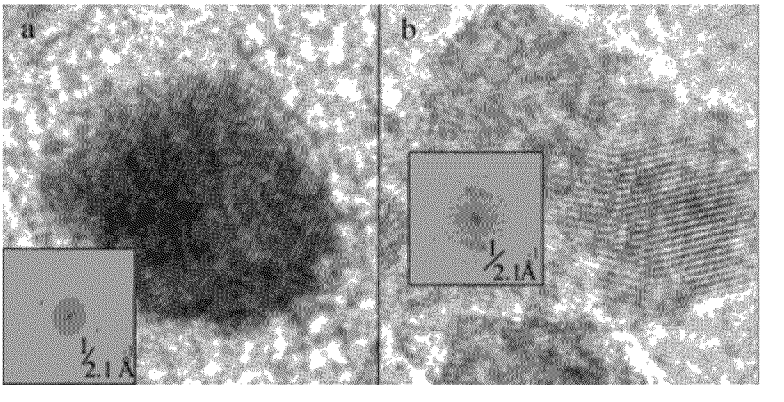

Fig. 2. HRTEM micrograph of two Co particles from the pictures Fig. 1 and Fig. 2 respectively.

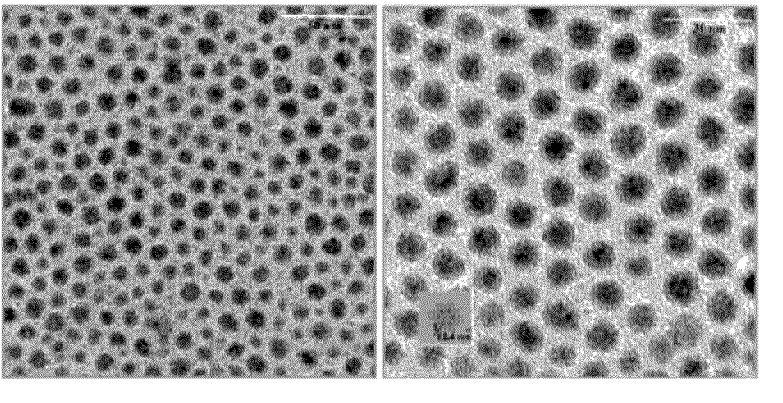

Fig. 3. TEM micrograph of 2-D ordering of Co nanoparticles by using an external magnetic field.

Figure 3 shows two TEM images of 2-D orderd Co particles at different magnetic field strengths.

References

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