Chemical synthesis of FeCo nanoparticles: size and shape control.

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Soft magnetic nanoparticles (NPs) and their synthesis have been extensively studied over the past decades due to their unique properties. Among them, FeCo alloy presents a very high saturation magnetization (Ms = 240 emu/gFeCo) with a low anisotropy constant (K $Fe_{50}Co_{50}$ = 1,5.10^4 J/m^3). These characteristics make FeCo NPs a very promising material for various applications such as hyperthermia[1] and nanoelectronics[2]. However, the chemical synthesis of FeCo NPs remains a challenge. Indeed, the obtained FeCo NPs are often not well crystallized or have a core-shell structure, resulting in low saturation magnetization (Ms). The desired bulk magnetic properties is generally achieved after an annealing process[3,4], but after such a treatment the NPs are aggregated and are no more dispersible. Another challenge is the fine tuning the size and the shape of the FeCo NPs, since these two parameters are controlling the magnetic properties and thus the specific absorption rate for hyperthermia treatments.

We managed to obtain homogeneous FeCo NPs through a new chemical synthesis based on co-decomposition of an iron and a cobalt metalloid amide ($\{X[N(SiMe_3)]_2\}_2$ (X = Fe or Co)) under 3 bars of H_2 at 150°C in presence of organic ligands. The size and shape of the nanoparticles can be controlled by adjusting the concentration of the ligands and their nature, while the FeCo atomic composition can be tuned by adjusting the precursors ratio. For example, cubes of 8 nm can be obtained by using 3 equivalents of palmitic acid while spheres of 11 nm can be obtained with 3 equivalents of hexadecylamonium chloride (Figure 1). The obtained NPs are well crystallized and exhibit magnetic properties close to the bulk ones (Figure 2). At the end we have access to a large panel of FeCo NPs that can be tested in hyperthermia measurements.

Figures

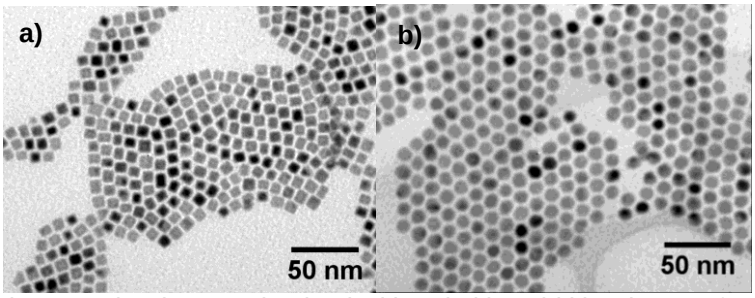

Figure 1: TEM images a) cubes synthesized with palmitic acid b) spheres of synthesized with hexadecylamonium chloride

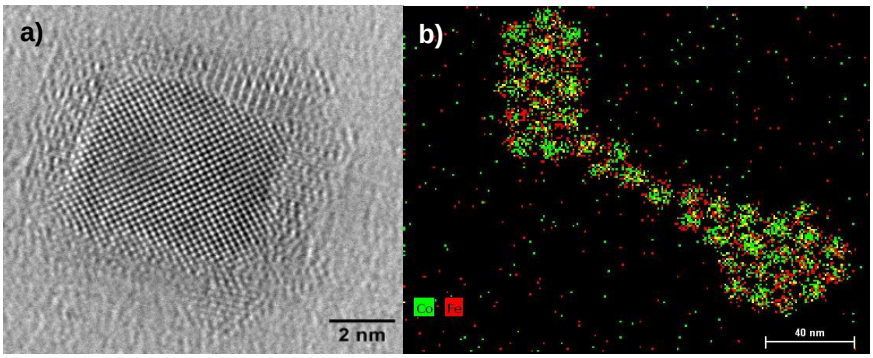

Figure 2: a) High resolution transmission electron microscopy image of an 8 nm cube, b) Energy dispersive X-ray mapping of 8 nm spheres, (green for cobalt and red for iron)

References

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