Synthesizing iron oxide nanostructures: the polyethylenenemine (PEI) role

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Iron oxide nanoparticles (NPs) are a well-known and very attractive class of materials, whose aplications covers very different fields going from catalysis and magnetic energy storage to biomedical applications.[1] Consequently, diverse synthetic approaches, including thermal decomposition, coprecipitation, sol-gel and hydrothermal-solvothermal have been developed to synthesize NPs with different morphologies,[2] always striving towards the common goal of obtaining monodisperse NPs, easily and finely tuning their size and shape in a most reproducible way.

The design and preparation of anisotropic iron oxide NPs is a challenge in the field of nanomaterial research because the punctual control over particle size and shape in such anisotropic systems could be the key factor in tailoring their magnetic properties over a wide range of values. In the last years, diverses approaches have been proposed to prepare one monodimensional (1D) systems, such as nanorods, nanotubes and nanowires,[3] probing that their synthesis is non-trivial. Among them, a process involving the dehydration and/or reduction of premade elongated β-FeOOH with a channel-type nanoporous structure (akaganeite) seems particularly promising.

In particular, following up a previous work showcasing the synthesis of magnetite nanorods (NRs) using a two-step approach that made use of polyethylenenemine (PEI) as a capping ligand to synthesize intermediate β-FeOOH NRs,[4] we studied the effect and influence of the capping ligand on the formation of β-FeOOH NRs. By comparing the results reported in the literature with those we obtained from syntheses performed (1) in the absence of PEI; (2) by addition of a low weight-average molecular weight PEI (800 g/mol); or (3) a PEI of high weight-average molecular weight (25,000 g/mol), we showed how the choice of different PEIs determines the aspect ratio and the structural stability of the β-FeOOH NRs and how this affects the final iron oxide nanostructures, which are obtained by a heating treatment of β-FeOOH NRs in presence of OLA, and cannot retain the shape and size of the starting nanorods (Fig. 1). For this purpose, a multi-technique study of XRD, HRTEM, and direct current superconducting quantum interference device (DC SQUID) magnetometry was used to identify the phases formed in the final products and study their morphostructural features and related magnetic behavior.

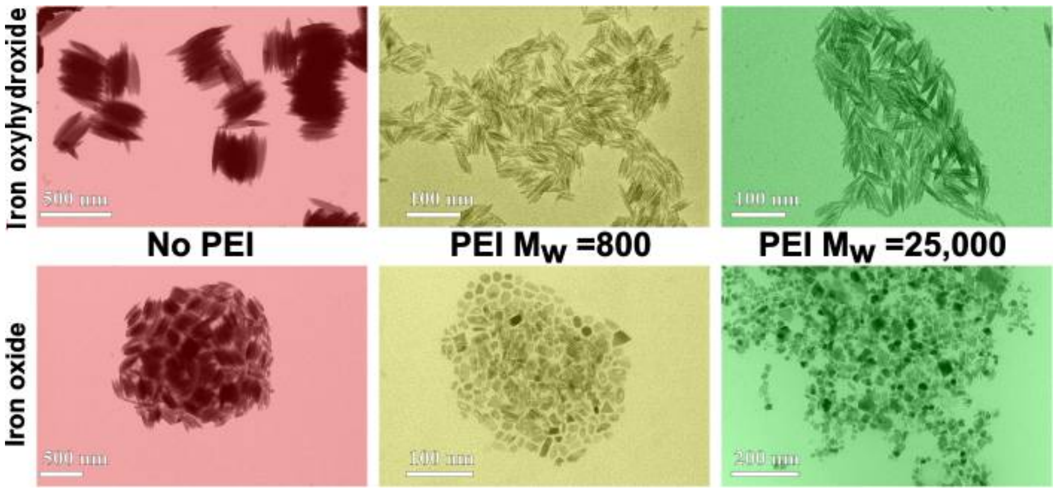

Fig. 1. Conventional TEM images of the samples iron oxyhydroxide and iron oxide prepared with no PEI or different PEIs.

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