Biologically Derived Magnetic Nanoparticles: Processing for Application in Magnetic Storage Media.

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The use of size-monodisperse, high-anisotropy nanoparticles in magnetic recording media is emerging as a likely route to extend recording densities beyond 100 Gbit/in2. The L10 (fct) phase of both CoPt and FePt have been considered as they exhibit outstanding magnetic characteristics, with *Ku* equalling 5x107 and 6.6x107 ergs/cm3 respectively (1,2).

In this study the biological macro-molecule Ferritin (an iron storage protein) was used as a precursor to create an empty, spherical shell template with core diameter ~8nm. This template was used as a reaction vessel for the synthesis of CoPt nanoparticles. Under specific controlled conditions it was possible to grow stable nanoparticles with Co:Pt = 1:1 stoichiometry in aqueous dispersion (Fig.1 a, b).

To be useful in magnetic storage applications the protein-encapsulated nanoparticles are heat treated in order to:

1. Anneal and transform the metal alloy core (Co:Pt or Fe:Pt) to the magnetically highly anisotropic L10 (*fct*) phase (Fig.2a, b);
2. Carbonise the protein shell by controlled pyrolysis.

A similar treatment is required for magnetic nanoparticles produced by the well known reverse micelle technique where the particles are encapsulated within organic surfactants. However, under the high temperature required (600 C-700 C), the surfactant around each nanoparticle decomposes / evaporates and the particles sinter (e.g. 3), leading to undesirable grain size growth. As a consequence, magnetic exchange coupling is induced which compromises the magnetic performance of the media.

A significant possible advantage of using ferritin-encapsulated nanoparticles is their relatively high carbon content. By controlled pyrolysis the protein shell can be transformed into stable amorphous carbon, or even into a graphitic (fullerenic) capsule around the nanoparticle (5). In this study we investigate the specific annealing conditions required to optimise the two processes above and so allow crystallographic transformation of non-sintered nanograins.

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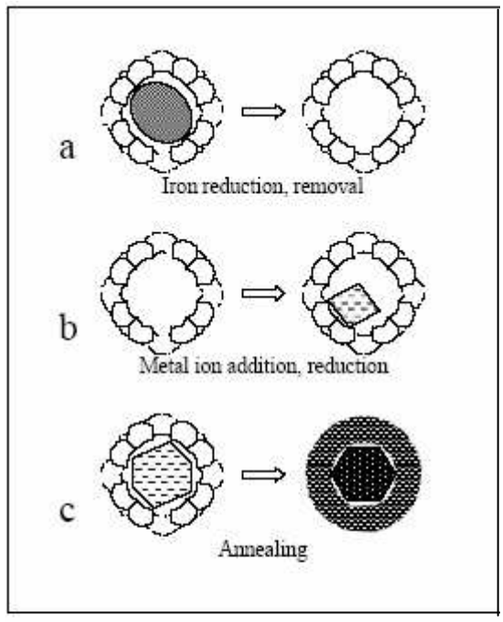

Fig. 1 Schematic for the production of biologically-derived magnetic nanoparticles. Amorphous ferrihydrite is reduced and removed from ferritin proteins to form apoferritin (a), which is then reconstituted with ions of Co and Pt, and chemically reduced to form a full metal alloy core (b) that is ultimately annealed to form the $L1_0$ phase encased in a carbonized matrix (c).

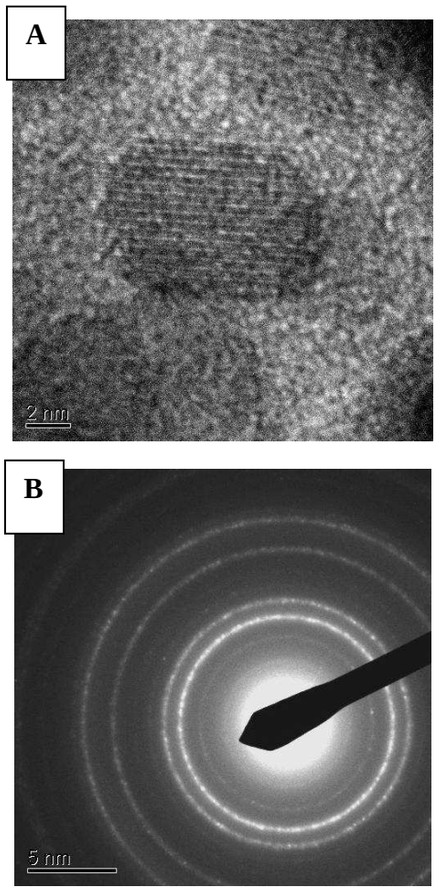

Fig. 2 (A) A high-resolution TEM micrograph, showing a lattice image of post-annealed nanoparticles of Co50:Pt50 at. % (scale bar – 2nm);
(B) TEM diffraction pattern , taken on those particles, showing L10 structure formation.