Nanoparticle size and texture are very important for drug delivery of poor water soluble drugs

Drug Delivery & Structure of Nanoparticles

Surgeons at work

Iron oxide nanoparticles (usually below 20nm) are being investigated for biomedical applications because of their biocompatibility and unique physical properties. This biocompatibility results from their capacity for metabolism, transportation and storage in human tissues. Magnetic iron oxide particles with diameters above 20nm are ferromagnetic, i.e. they have a reminiscent magnetic moment that generates unstable particulate suspensions, as the particles aggregate together into biologically toxic, micron-sized clusters.

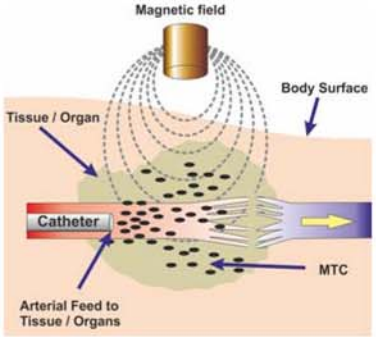
Small Fe_2O_3 below about 20 nm are superparamagnetic, which means thermal energy is sufficient to cause large fluctuations of their magnetic moment, so that in the absence of an magnetic field, the particles have no effective moment. This reduces inter-particle attraction and makes stable, biocompatible suspensions possible. These particles maintain a strong response to an external magnetic field, which make them ideal candidates for biomedical applications, e.g improve effectively the poor water solubility of hydrophobic drugs.

Colloidal systems, including nanoparticles and liposomes, have been extensively studied as potential drug carriers for targeted or controlled release. Monitoring of the nano-assembly will facilitate an indirect determination of the site at which the therapy is administered.

The challenge:	Identify orientation textufe of very small <5nm nanoparticles & distinguish between particles of same cells but different space groups
Solution:	ASTAR technique coupled with precession electron diffraction

The texture of nanoparticles is therefore the utmost importance to control undesired agglomeration effects for drug delivery applications. ASTAR has been used in order to reveal succesfully 1 nm scale details of very small nanoparticles (Pt of 5-10nm in size and magnetite Fe_3O_4 parttcles of 100nm in size (figure 1).

On the other hand, ASTAR has been used successfully to distinguish between a mixture of structurally closely related nanoparticle structures (e.g magnetite and maghemiite having essentially the same unit cell dimemsions but different space groups , see table).HR-TEM study is possible to use to distinguish between both phases,but is too time-consuming. Automatic ASTAR orientation / phase map analysis by comparing experimental PED patterns with both maghemite /magnetite templates , reveraled higher reliability for magnetite crystals (results confirmed independently by HREM techniques). Collection of quasi-kinematical PED was essential to distinguish between patterns that belong to different Space Groups and extinctions may become visibe with ZOLZ – HOLZ reflections.



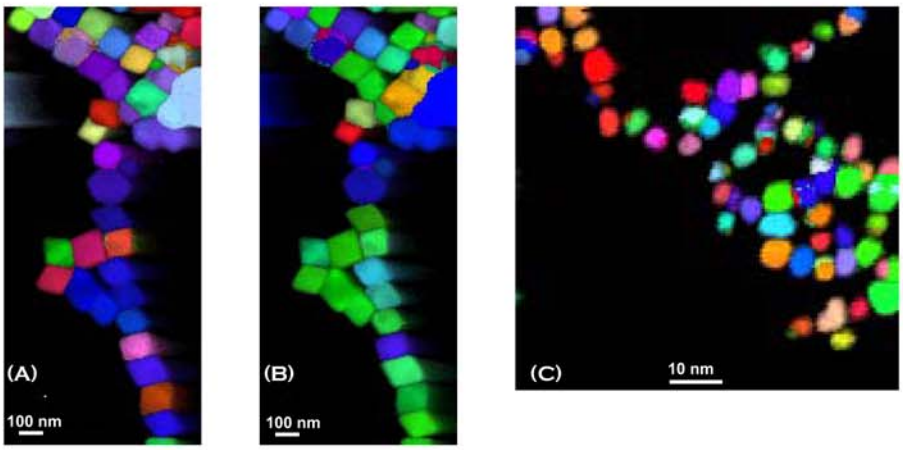


figure 1 (a) ASTAR orientation mapping of magnetite nanoparticles along z direction (b) along x direction (c) Pt nanoparticles along z direction

Crystal Structure

Magnetite Fe_3O_4: Cubic, Fd3m, a=8.32 Å
Maghemite γ-Fe_2O_3: Cubic $P4_132$, a=8.33 Å

Experimental Data

TEM type: Tecnai 20 & Jeol 2010F
Map resolution: 1 nm
Scanned area: 2 x 2 µm

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