

MAGNETIC NANOCOMPOSITES

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Introduction

- Nanomaterials have particles size of a few nanometers.
- Nanomaterials and nanoscience is still an area of research and development.
- Constituents of nanocomposites are mixed at nanometer scale.
- Magnetic nanocomposites have one or more components made of magnetic particles in nanoscale.
- Materials dispersed in magnetic or non magnetic matrix.

Brief history

- Nanocomposite magnetic materials have their origins in amorphous alloys
 - These amorphous alloys were highly anisotropic.
 - Hence magnetic materials were added to reduce anisotropy.
- In **1988**, Yoshizawa developed the FINEMET alloy based on $\text{Fe}_{73.5}\text{Si}_{13.5}\text{B}_9\text{Nb}_3\text{Cu}_1$ which was extension of Fe-Si-B alloy.
- In **1990** Suzuki developed NANOPERM alloy composed of $\text{Fe}_{88}\text{Zr}_7\text{B}_4\text{Cu}_1$.
 - High magnetic saturation and coercivity achieved compared to FINEMET.
- In **1998**, Willard developed HITPERM alloy composed of $\text{Fe}_{44}\text{Co}_{44}\text{Zr}_7\text{B}_4\text{Cu}_1$
 - Magnetic saturation and coercivity further increased compared to FINEMET and NANOPERM.
- In **2003**, Pankhurst et al. developed magnetic particle/fluid hyperthermia treatment for cancerous tumors and the controlled and directed transport of pharmaceuticals and therapeutic genes.

Recent developments

Nanocomposite

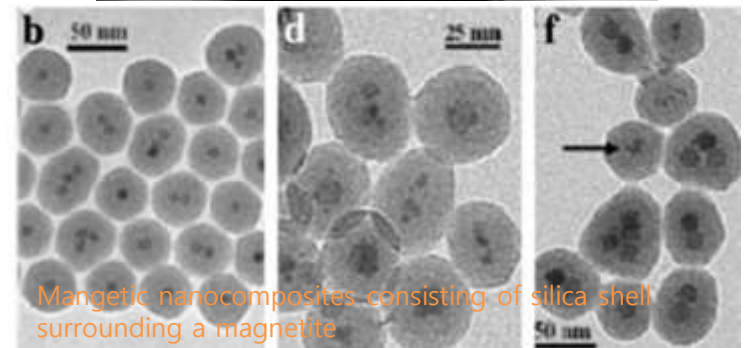
- **Colloidal magnetic fluid**

- The particles are coated with dispersing agent (surfactant) which prevents particle agglomeration even when a strong magnetic field gradient is applied to the magnetic fluid.



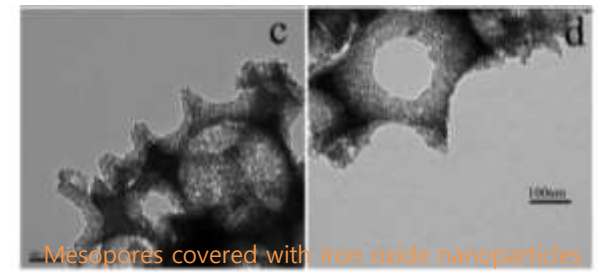
- **Core shell type NPs**

- The surface of iron oxide NPs could be modified by organic materials or inorganic materials, such as polymers, biomolecules, silica, metals, etc.



- **Porous magnetic material**

- Porous materials have excellent adsorption properties due to the high surface area.



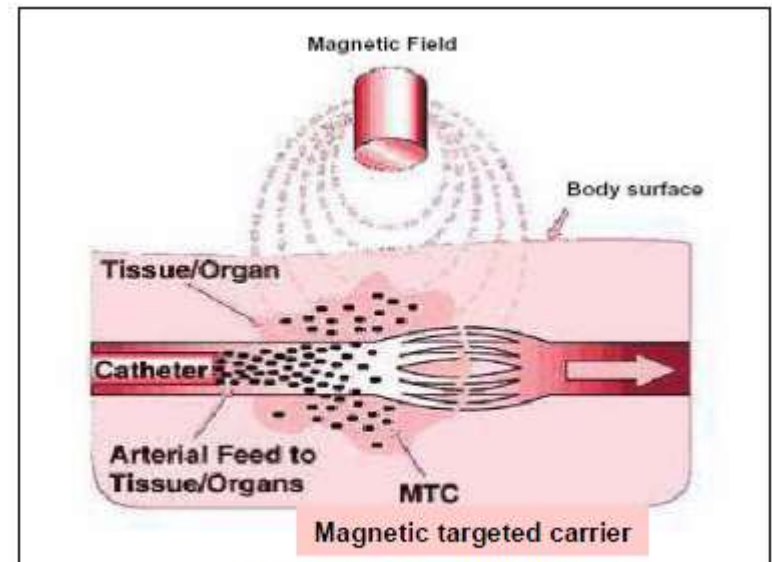
Applications

To destroy tumor cells causing cancer

The nanoparticles are put inside the target cell. A magnetic field is applied externally, hence all the particles orient along a single direction and apply force on the cell. When the concentration of the nanoparticles is high, the cell gets destroyed.

Drug delivery

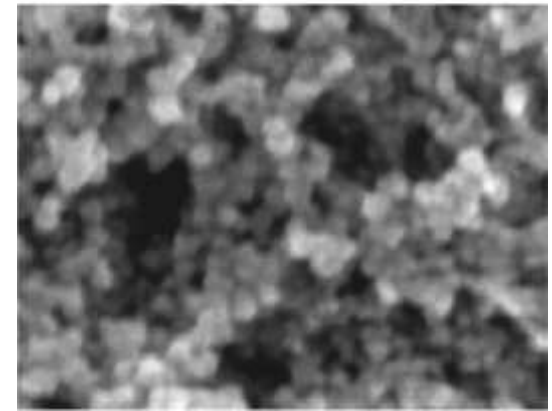
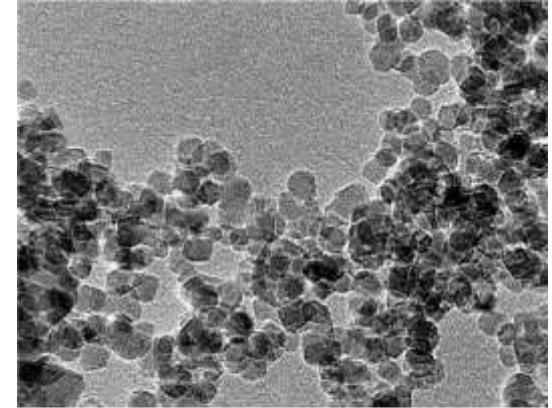
Magnetic drug carriers such as magnetic capsules and magnetic nanoparticles encapsulated with a smart polymer can be delivered to the required area through the use of an external magnetic field.

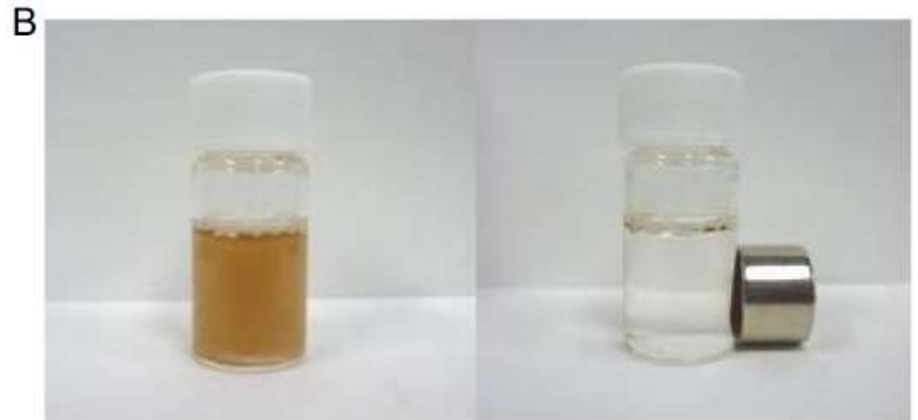
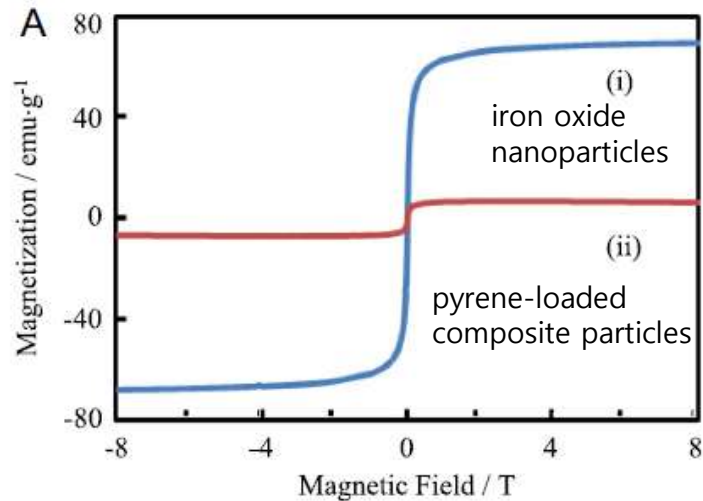


ZM Saiyed et al., BioMagnetic Research and Technology, (2003)

Multicomponent magnetic NPs : core-shell type NPs

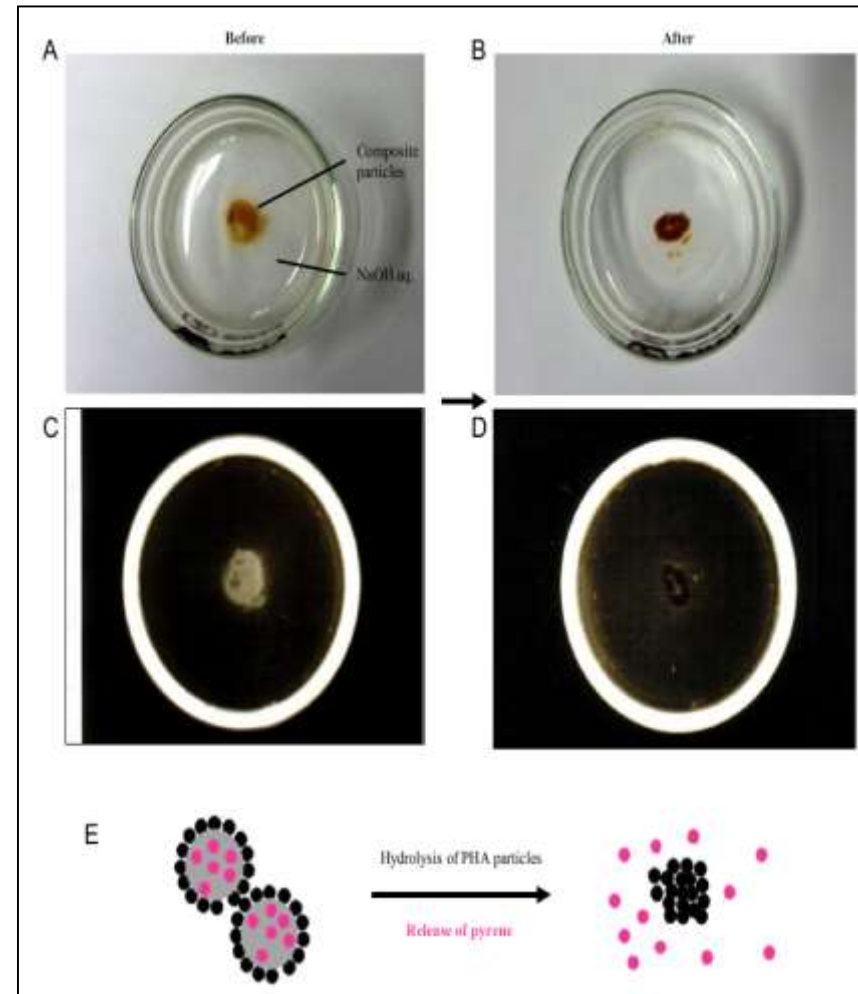
- In order to implement the practical application, the particles must have combined properties of high magnetic saturation, stability, biocompatibility, and interactive functions at the surface.
- ✓ Core-shell composite particles consisting of a core of PHA particles and a shell of assembled iron oxide nanoparticles (7~20nm).
- ✓ PHA particles have to serve as drug carriers that can release drugs inside the body.
- ✓ Iron oxide nanoparticles not only have high biocompatibility but are also biodegradable and they are not toxic to humans and are not retained in the human body.





- ✓ The magnetization of the loaded composite particles was found to be 7 emu/g at 8T, which is one tenth that of the pure iron oxide nanoparticles.
- ✓ Even so, the composite particles were strongly attracted to an NdFeB magnet.
- ✓ The color of the initial suspension was brown, but it became transparent when exposed to a magnet because the composites were all drawn to the side of the bottle.

- ✓ The white area at the center of the dish indicates that the pyrene was loaded in the composite particles collected at the center of the dish.
- ✓ Fig. A and B show that the color of the center area changed from light brown to dark brown after 3 days due to the Release of the pyrene from the loaded composite particles via the decomposition of PHA.
- ✓ → These results indicate that only the iron oxide nanoparticles would remain and the PHA would be completely decomposed.



Thank you

Q&A