Bimagnetic Nanoparticles and Nanocomposite Magnets

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Abstract

Bimagnetic nanoparticles with core-shell and brick-like structure are synthesized from high-temperature solution phase coating of FePt core with tunable Fe_3O_4, $CoFe_2O_4$ or FeCo shells. Magnetic properties of the as-synthesized bimagnetic particles are dependent on shell materials and its thickness due to the exchange coupling between core and shell. Upon reductive annealing, an assembly of the core/shell nanoparticles is transformed into a hard magnetic nanocomposite with enhanced energy product which is 30% higher than the single FePt phase. With proper choice of materials and dimension tuning of both core and shell, these bimagnetic nanoparticles may be used as building blocks for novel functional nanomaterials for various magnetic applications..

Preparation

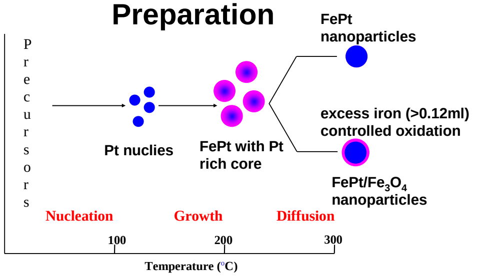

Fig. 1 Schematic of the mechanism of the formation FePt and $FePt/Fe_3O_4$ nanoparticles.

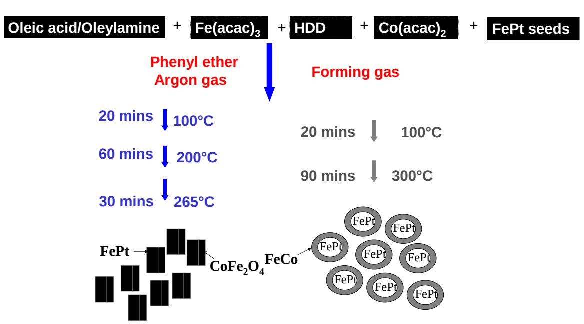

Fig. 2 Schematic of formation of $CoFe_2O_4$ attached (left) and FeCo coated (right) FePt bimagnetic nanoparticles.

$FePt/Fe_3O_4$

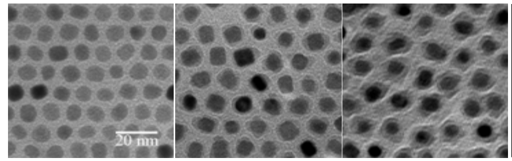

Fig 3 TEM image of (a) 7 nm FePt with (b) 1 nm and (c) 2 nm Fe_3O_4 shell

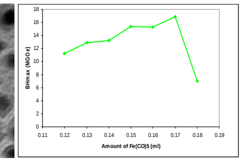

Fig 4 Variation of maximum energy product with increasing amount (ml) of Iron precursor

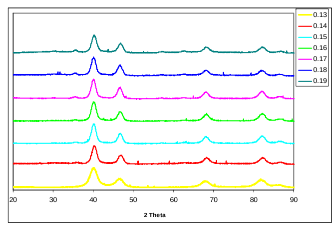

Fig 5 Increment of Fe3O4 shell thickness on FePt nanoparticles with increasing amount (ml) of Iron precursor

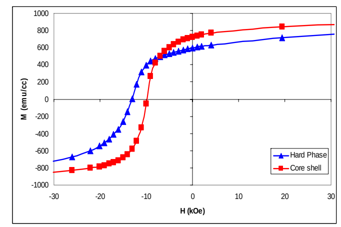

Fig 6 Hysteresis loop of FePt and $FePt/Fe_3O_4$ nanoparticles annealed at 650 °C for 1 hr

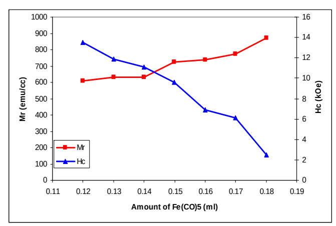

Fig 7 Variation of remenance and energy product with increasing amount (ml) of Iron precursor

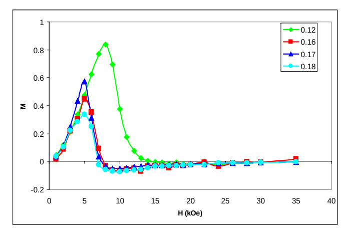

Fig 8 Delta M curves for FePt (0.12) and $FePt/Fe_3O_4$ (0.16 to 0.18) nanoparticles annealed at 650 °C for 1 hr

FePt/FeCo

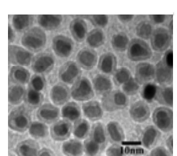

Fig 9 TEM image of FePt@FeCo nanoparticles

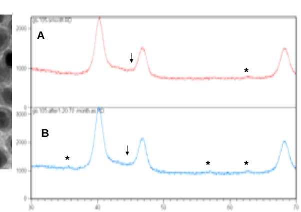

Fig 10 XRD of FePt@FeCo nanoparticles (A) arrow show peak for FeCo and star show peak arises from oxidation of FeCo. All other peaks are from fcc FePt (B) taken after 1 month of synthesis. Sample was kept in air atmosphere. Star show peaks arises from the oxidation of FeCo. All other peaks are from fcc FePt.

$FePt/CoFe_2O_4$

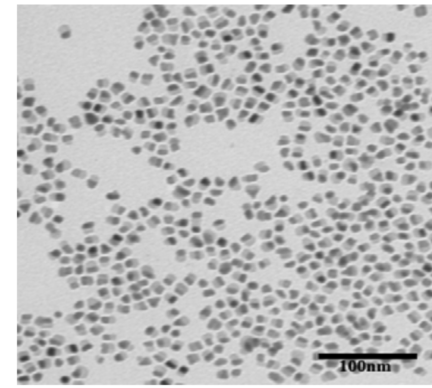

Fig 11 $CoFe_2O_4$ attached FePt nanoparticles forming shadow of one-another.

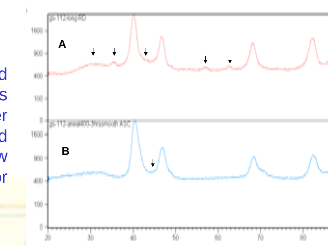

Fig 12 XRD of FePt attached $CoFe_2O_4$ nanoparticles (A) arrows show peaks for $CoFe_2O_4$. All other peaks are from fcc FePt (B) annealed at 400°C for 3 hrs in FG. Arrow show peak for FeCo. All other peaks are for fcc FePt.

Conclusions

Bimagnetic core-shell nanoparticles are excellent building blocks for exchange coupled nanocomposite magnets. We have coated FePt nanoparticles with Fe_3O_4 and observed enhanced energy products. The possibility of coating other soft phases with higher saturation magnetization has been explored and their magnetic properties studies are underway.

References

1. S. Sun, C.B. Murray, D. Weller, L.. Folks, A. Moser, *Science,* **287**, 2000, 1989.
2. H. Zeng, J. Li, J.P. Liu, Z.L. Wang, S.Sun, *Nature*, 420, 2002, 395.
3. H. Zeng, J. Li, J.P. Liu, Z.L. Wang, S.Sun, JACS, 4, 2004, 197.

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