Synthesis and Characterization of Silica/Metal Nanoparticle Spheres

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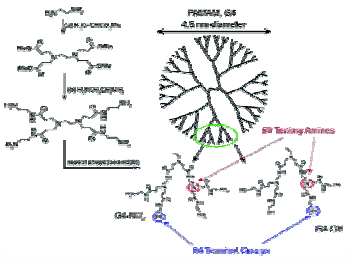
Introduction

Magnetic metal nanoparticles have potentially significant applications in high-density magnetic recording media, magnetic refrigeration system, ferrofluids, and biomedicine. Coating magnetic metal with silica can enhance the stability against oxidation by air and agglomeration by magnetic attraction. Moreover interparticle interaction can be controlled by the thickness of the shell. Dendrimers are globular, highly branched, monodisperse polymeric materials. They are roughly spherical, sterically crowded on the exterior, less so in the interior. Their interior cavities can be used to coordinate metal ions. These ions can be reduced chemically or by photo-reduction to get dendrimer-metal clusters. We use dendrimer synthesized CoPt nanoparticles and coat with silica shells to increase the stability and control interparticle interactions. Our results show that the thickness of silica shell and dispersion of CoPt nanoparticles influence the coercivity significantly.

PAMAM Dendrimers

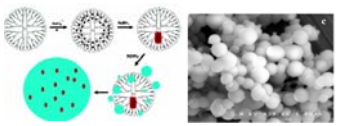
PAMAM dendrimers are branched amine-terminated molecules with well defined molecular weight and size. For G4, it has an EDA core with 4 repeat units and 64 NH2- endgroups. It is ideal monodisperse molecular-level reactor for nanoparticle syntheses.



Formation of Metal Nanoparticles in Dendrimers

The dendrimer monolayer can attract copper ions to its interior. The electrons supplied during electrodeposition could simply allow reduction of Cu^{2+} to Cu^0 (metal). (Zhao, M.; Crooks, R. M. *Adv. Mater.* **1999**, *11*, 217-220.)

Dendrimer-Mediated Multicomponent Nanospheres

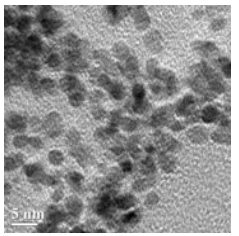


Silicic acid method

PAMAM dendrimers have been utilized successfully as both a host for Au^0 nanoparticle synthesis and an active agent for silica condensation. The resulting product yields mesoporous silica nanospheres of 80-nm diameter supporting randomly distributed gold nanoparticles.

Marc R. Knecht and David W. Wright, Chem. Mater. ***2004,*** *16, 4890-4895*

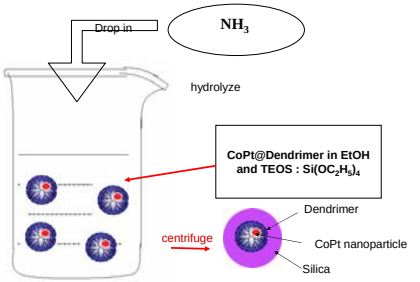
Formation of CoPt in Dendrimer



TEM image of CoPt made by H.Y. Wan.

CoPt alloy can be prepared with dendrimers by chemistry reduction or photo reduction. The average size of CoPt is 5 nm.

Experiment Design



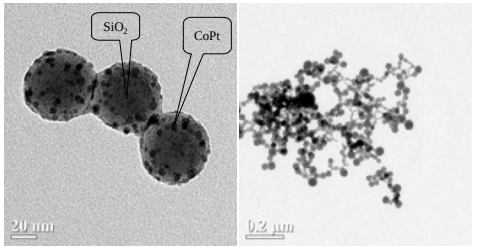
Stöber method was used to synthesize monodisperse silica microspheres:

3ml CoPt@dendrimer water solution +7ml ethanol+20µl TEOS, then 0.5ml concentrated ammonia were dropped in. The size of the silica microspheres is determined by concentration of ammonia and amount of TEOS

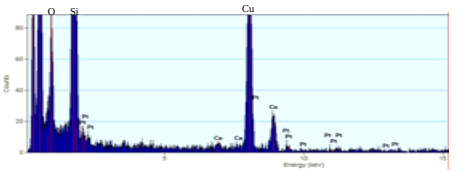
Hydrolysis: $Si(OC_2H_5)_4+4H_2O=Si(OH)_4+4C_2H_5OH$

Condensation: $Si(OH)_4 \longrightarrow SiO_2+4H_2O$

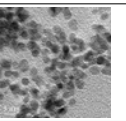
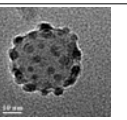
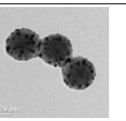
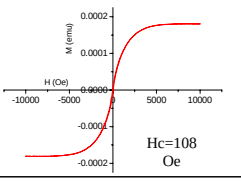
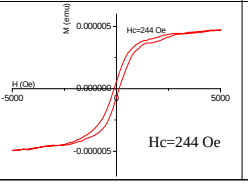
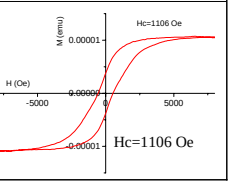
Experiment Results



TEM images of dendrimer mediated CoPt in silica



EDX of dendrimer mediated CoPt in silica

Reaction condition	CoPt as prepared	TEOS: 0.0045mol/L Ammonia: 0.1mol/L Size: 30 nm	TEOS: 0.009mol/L Ammonia: 0.8mol/L Size: 60 nm
TEM image			
AGM Test	 Hc=108 Oe	 Hc=244 Oe	 Hc=1106 Oe

TEM images show that CoPt is dispersed in silica spheres. By control the amount of TEOS and ammonia, silica spheres with different size can be synthesized . EDX show the present of CoPt and silica. From AGM test result, we can find that the thickness of silica shell and dispersion of CoPt nanoparticles influence coercivity significantly .

Future work:

1 Investigate how the thickness of silica shell and dispersion of magnetic particles influence the coercivity of sample.
2 Extend this method to other metals, and study how the coating influence the magnetic character of these metals
3 Synthesize monodispersed microspheres and make highly ordered nanostuctures with self-assembly of silica microspheres.

Acknowledgement:

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