Nucleation and Growth of FePt Nanoparticles by Organometallic Route

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Motivation

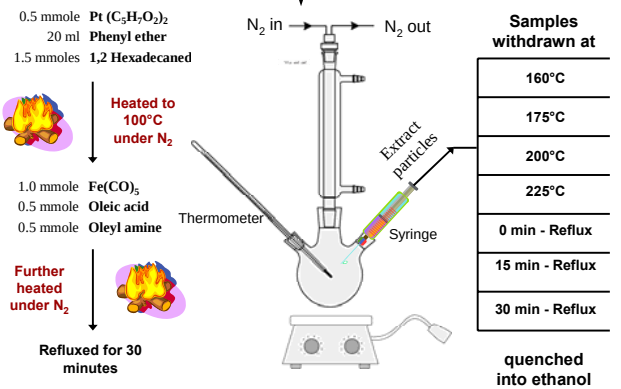
Yu *et al.* Appl. Phys. Lett., Vol. 85, No. 25, 20 December 2004

TABLE III. Atomic composition of six selected Fe_xPt_{100-x} nanoparticles demonstrating the atomic composition variation issue among individual nanoparticles. EDS measurement was carried out on each individual nanoparticle.

Nanoparticle	Fe (at.%)	Pt (at.%)
1	66.89	33.11
2	65.82	34.18
3	54.07	45.93
4	46.52	53.48
5	33.24	66.76
6	21.92	78.08

Wide variation in composition between individual FePt nanoparticles!!!

Experiment

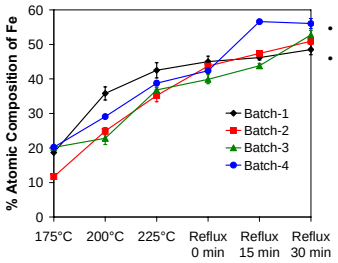


Sun S et al. *Science* 2000, 287, 1989

Analysis

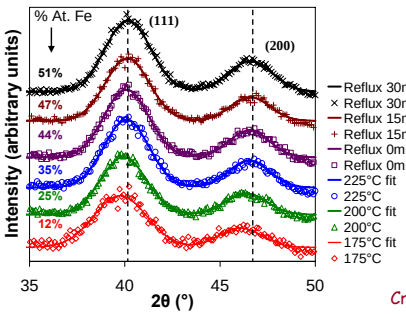
Particles from different stages analyzed for composition, crystal structure and size

Composition by SEM-EDS



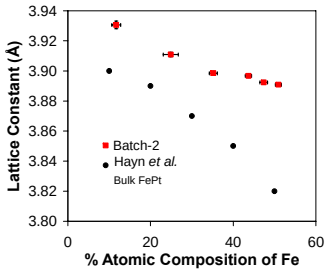
- Pt-rich particles formed at early stages
- Fe composition increases with progress in synthesis to the target composition of $Fe_{50}Pt_{50}$

Crystal Structure by XRD



- Particles have the expected fcc structure
- With increase in iron composition both (111) and (200) peak positions shift to higher angles suggesting formation of alloy

Lattice constants from XRD

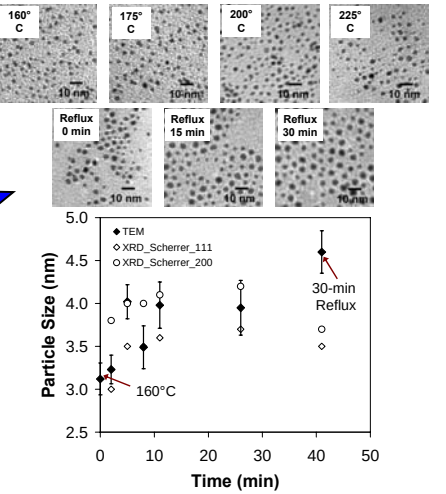


- Comparison of lattice constants of particles from different stages to that of bulk FePt
- Bulk and nanoparticle lattice constants match well up to ~30% Fe
- Significant deviation beyond 30% Fe probably due to heterogeneous arrangement of atoms within the nanoparticle (Hwang et al., 2005)

Hayn et al., *Physical Review B, 58*, 4341-4344; Hwang et al., *J. Am. Chem. Soc., 127*, 11140

Particle Size by TEM

- TEM indicates an increase in size from 3.1 nm to 4.6 nm with progress in synthesis
- XRD Scherrer analysis also indicates a similar increase in size with progress in synthesis, except for the 30-min reflux sample that decreases in size (particle dissolution due to decreased monomer concentration??)



Individual particle composition by TEM-EDS

Batch-1 sample	Average Pt composition SEM-EDS (% at)	TEM-EDS	
		Average Pt Composition (% at)	No. of Particles
160°C	-	96 ± 2	12
200°C	64 ± 2	63 ± 12	13
30min-Reflux	51 ± 1	52 ± 8	14

- Individual particle compositions of above three samples measured by TEM-EDS matched well with SEM-EDS measurements
- Particles withdrawn at 160°C found to almost completely platinum
- Particles withdrawn at both 200°C and 30-min Reflux showed wide variation in composition suggesting that variation in composition between individual nanoparticle starts early in the synthesis

Conclusions and Future work

- Analysis by SEM-EDS, XRD, TEM and TEM-EDS suggests that initially Pt nuclei are formed and with progress in synthesis the composition of iron increases until $Fe_{50}Pt_{50}$
- TEM-EDS suggests that variation in composition between individual particles starts early in the synthesis
- Decrease in XRD scherrer size of the final nanoparticle sample needs further study

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