Kinetically Controlled, Size Tunable Iron Oxide Nanoparticle Synthesis

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Erika C. Vreeland[1], Andrew D. Price[2], Ben D. Fellows[1], Gretchen B. Schober[1], Todd C. Monson[1], Bradley G. Hance[1], and Dale L. Huber[1]*

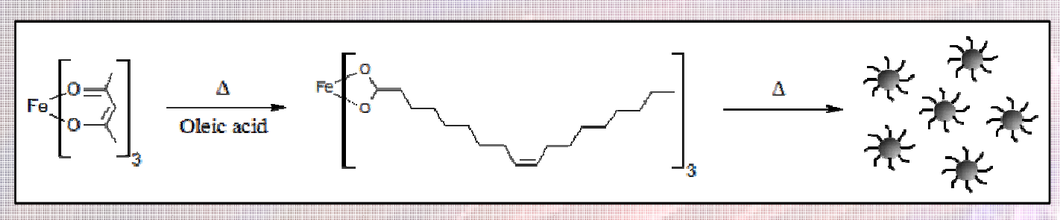
*[1]Center for Integrated Nanotechnologies, Sandia National Laboratories, PO Box 5800, Albuquerque, NM 87185 USA *Dale.Huber@sandia.gov*
[2]Senior Scientific LLC, 11109 Country Club NE, Albuquerque, NM 87111 USA

Introduction

We have developed a novel method for the synthesis of superparamagnetic iron oxide (Fe_3O_4) nanoparticles. This approach overcomes challenges that have previously limited synthetic reproducibility, including stoichiometric control of iron precursor, dependence on reaction duration and temperature, and coarsening effects during particle growth.

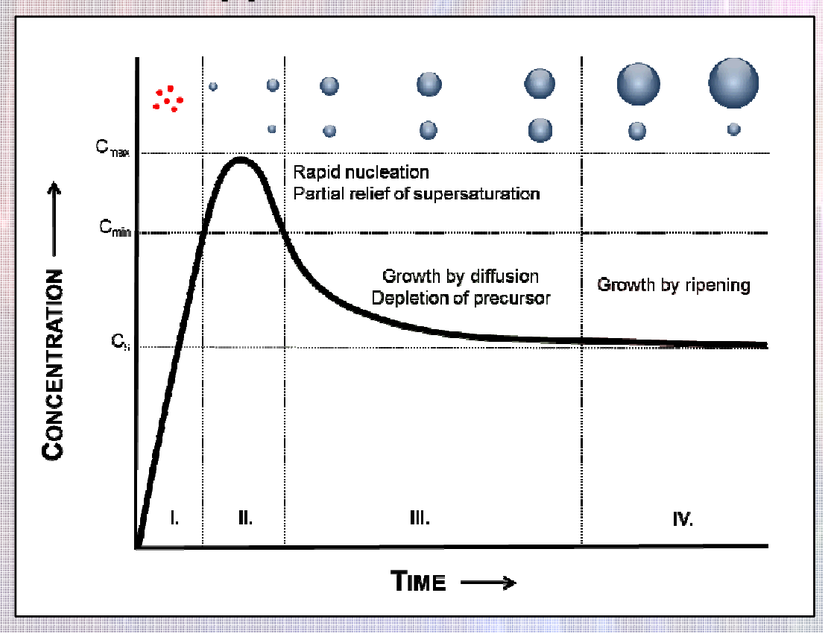
Approach

Reaction scheme:

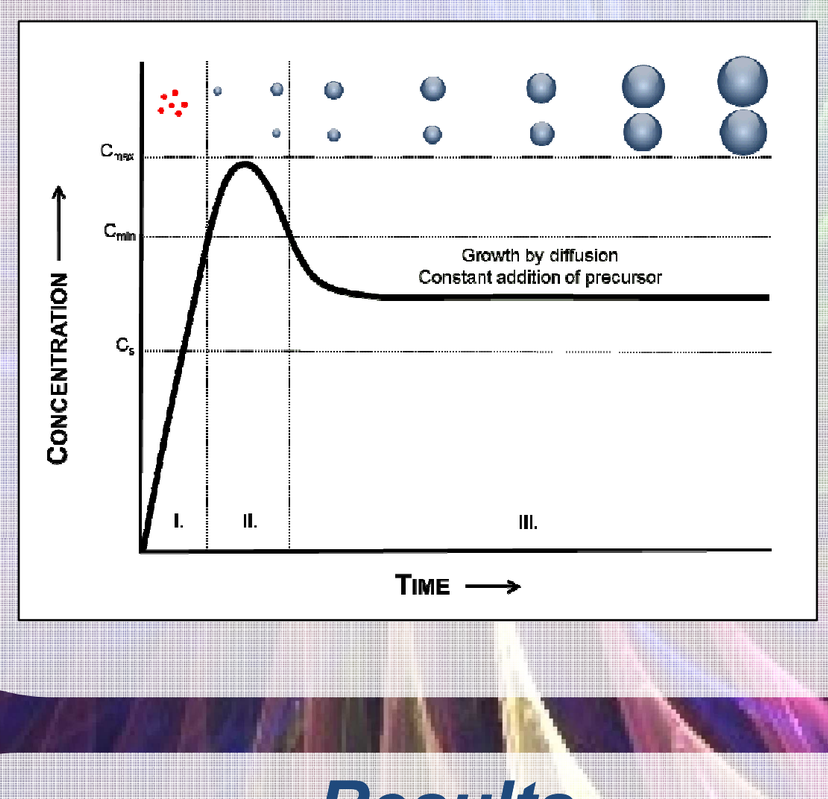


I. Thermal decomposition of $Fe(acac)_3$ in oleic acid.
II. Formation and thermal decomposition of iron oleate intermediate.
III. Oleic acid-stabilized iron oxide nanoparticles.

Traditional Approach – LaMer mechanism:

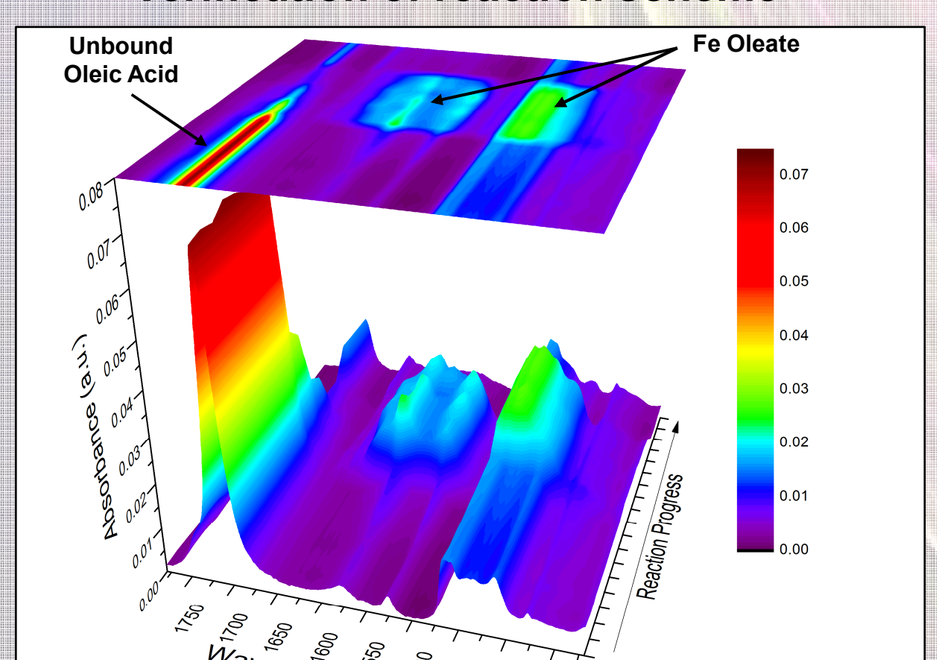


Novel approach – 'extended' LaMer mechanism:



Results

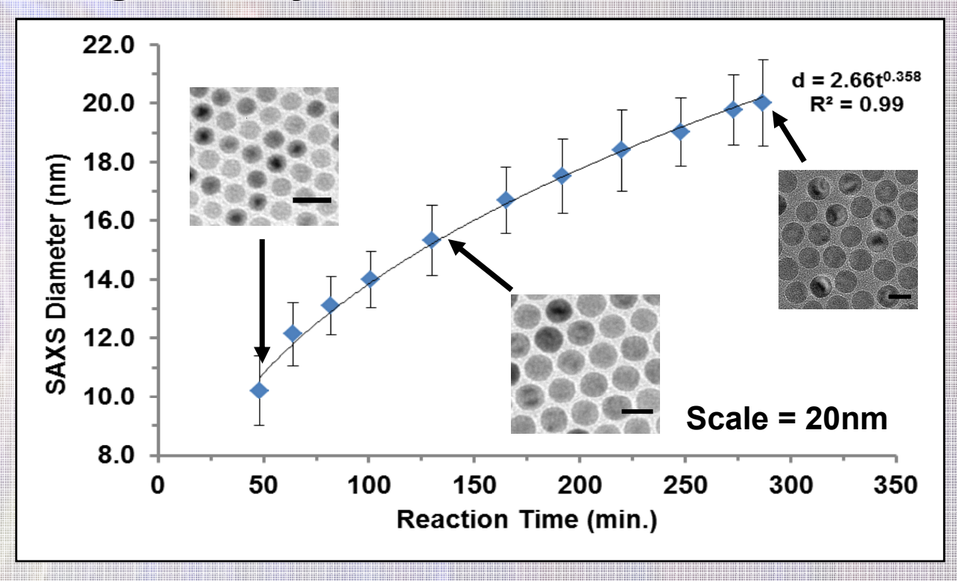
Verification of reaction scheme



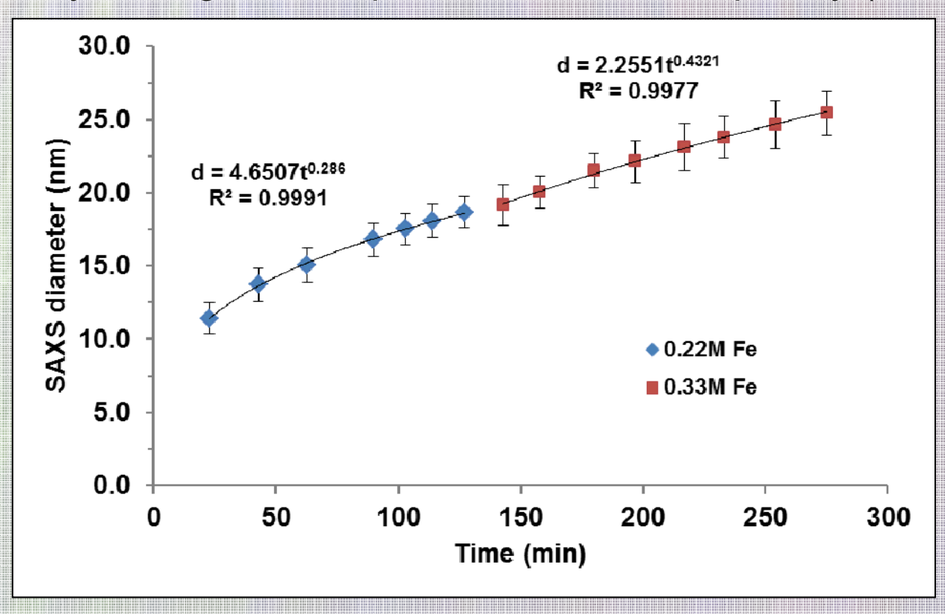
- FTIR confirms the formation of iron oleate *in situ*.

Results

Particle growth by continuous addition of iron oleate

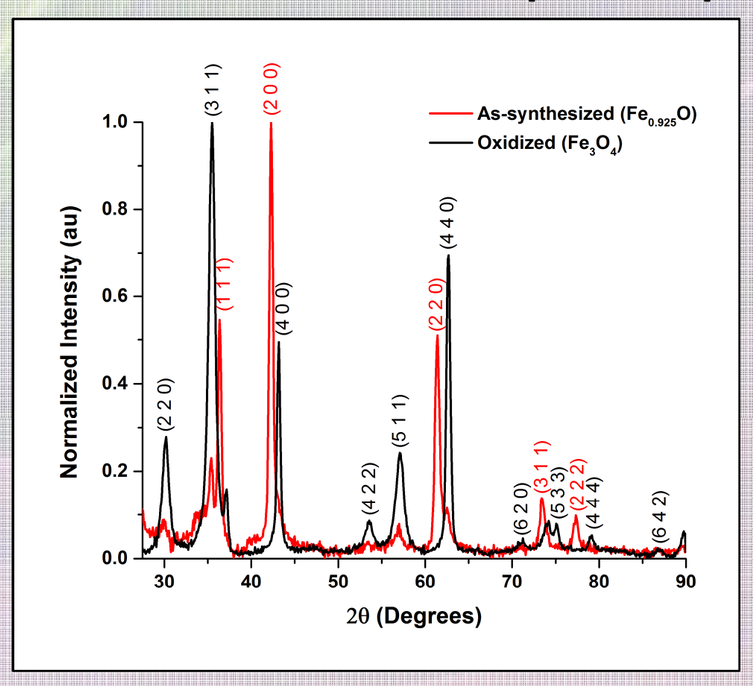


- Steady state growth of particles with low dispersity (<10%)



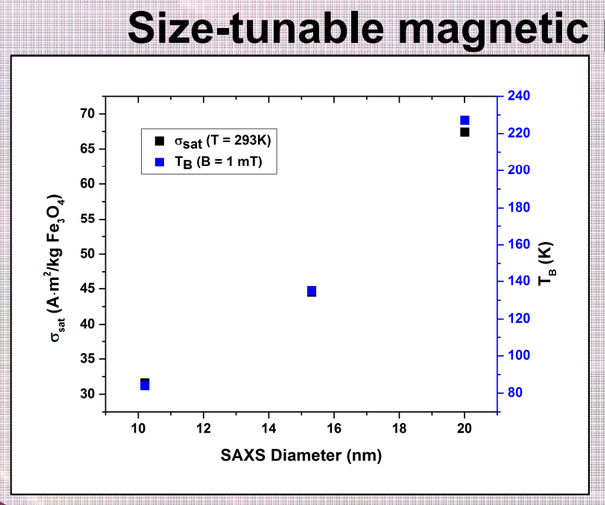
- Growth of arbitrarily large particles can be realized by increasing concentration of iron oleate solution added.

Control of product purity



- Some disagreement in the literature regarding phase of synthesized product.
- XRD confirms as-synthesized particles are FeO.
- Conversion to Fe_3O_4 by *in situ* oxidation.

Size-tunable magnetic properties



- Saturation magnetization (σ_{sat}) and blocking temperature (T_B) measured using SQUID magnetometry.

Conclusions and Future Work

- Demonstrated the ability to reproducibly synthesize superparamagnetic Fe_3O_4 nanoparticles with low dispersity.
- Size-tunable synthesis imparts broad applicability in a number of applications.
- Surface modification of synthesized particles will confer additional functionality in physiological environments.

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