

Synthesis of Novel Iron- Oxide-Based Superparamagnetic Nanoparticles for MRI Contrasting Agent

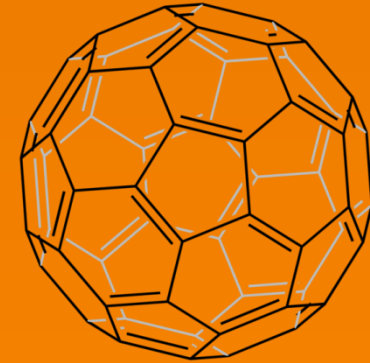
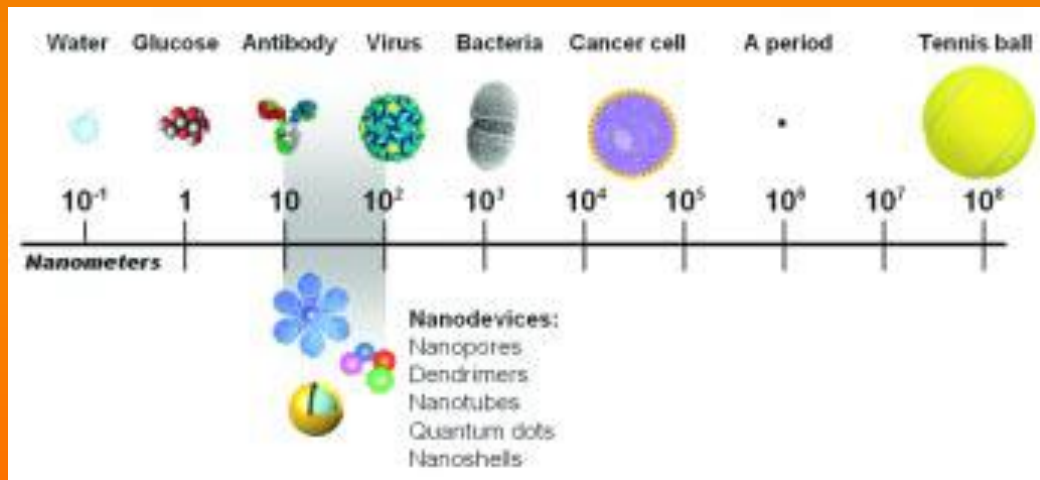
Kevin Kerim Willis, Pavel Kucheryavy, Denis Nilov, Galina Goloverda, and Vladimir Kolesnichenko

Xavier University of Louisiana

New Orleans, Louisiana

Nanoparticles: The Properties

- Properties depend on the size and the properties of their surface
- Color
 - Size dependent
 - Composition independent



1.1 nm




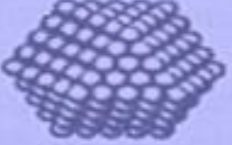
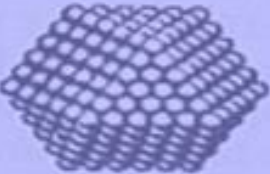
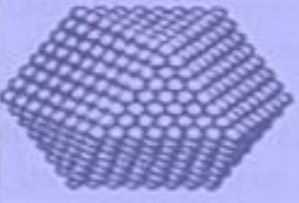
Semiconductor Quantum Dots



360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740

Wavelength of visible light, nanometers

Nanoparticles: The Properties (cont.)

Total no of atoms		Surface Atoms (%)
13		92
55		76
147		63
309		52
561		45
1415		35



Fluorescence of CdS colloids coated with variable amount of HgS, increasing from left to right.

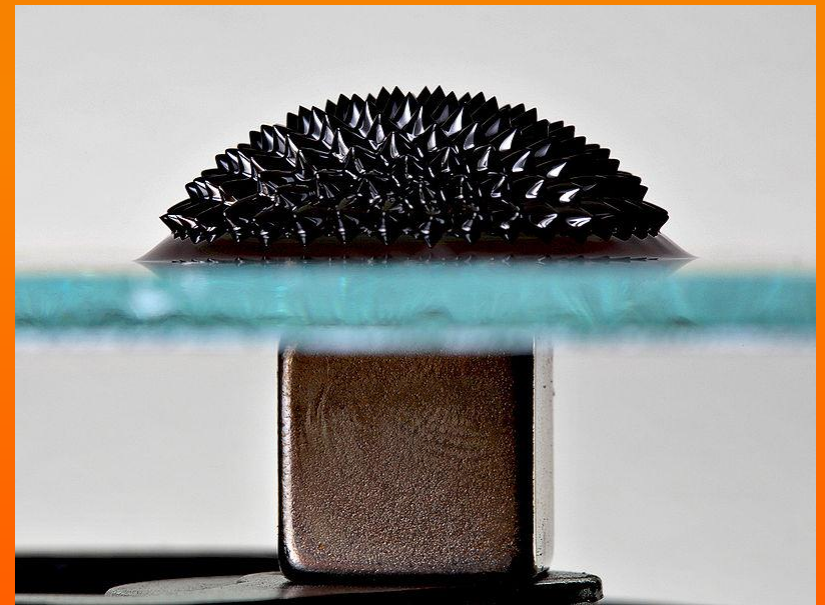
Nanoparticles: Magnetism

- Includes

- Elements (C, Si, Ge, Sb, Bi, Fe, Co, Ni, Cu, Ag, Au, Pt, Pd, etc.)
- Some alloys
- Metal oxides (Fe_2O_3 , Fe_3O_4 , CoFe_2O_4)
- Metal chalcogenides (CdS, CdTe) - semiconductor quantum dots
- Metal pnictides (GaAs, InP) - semiconductor quantum dots

- These lead to

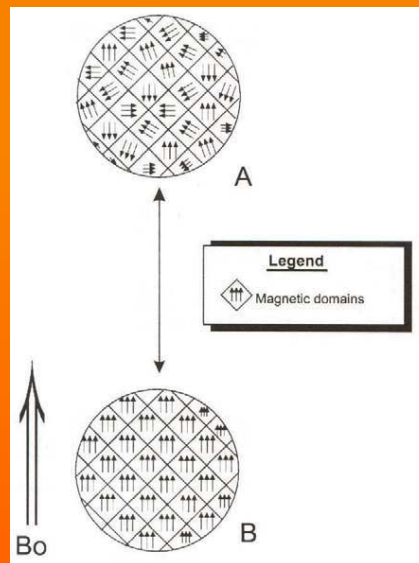
- Ferromagnetics
- Superparamagnetics
- Ferrofluids



Nanoparticles: Superparamagnetism

- Magnetic domains

- Crystal-containing regions of unpaired spins
- Each domain is magnetized in a different direction
- Domains' magnetism align when magnetic field is applied
 - Much greater than the sum of magnetic moment of unpaired electrons
 - No magnetization of the particle when the field is removed



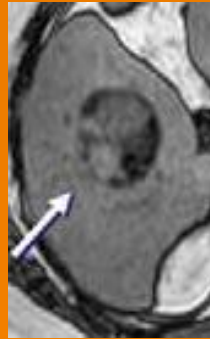
MRI Contrasting Agents

- MRI contrasting agents
 - work by altering the relaxation rates of water protons that are trying to realign
 - Used under
 - Magnetic field and
 - radiofrequency (RF) pulses
- 2 types
 - T1
 - Longitudinal relaxation
 - 'positive contrast'
 - T2
 - Transverse relaxation
 - 'negative contrast' (aka dark spots)
- Currently the gadolinium agents are used

Example



MRI image with T1 where protons in-phase shows a hyperintense mass in the liver.



MRI image where the mass drops out with T1 agent and protons out-of-phase and indicates fat content



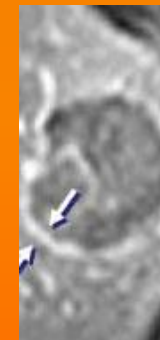
T2-weighted image with fat suppression reveals that the mass has subtle hyperintensity.



T1-weighted image with Gadolinium treatment reveals a hyperenhancing mass.



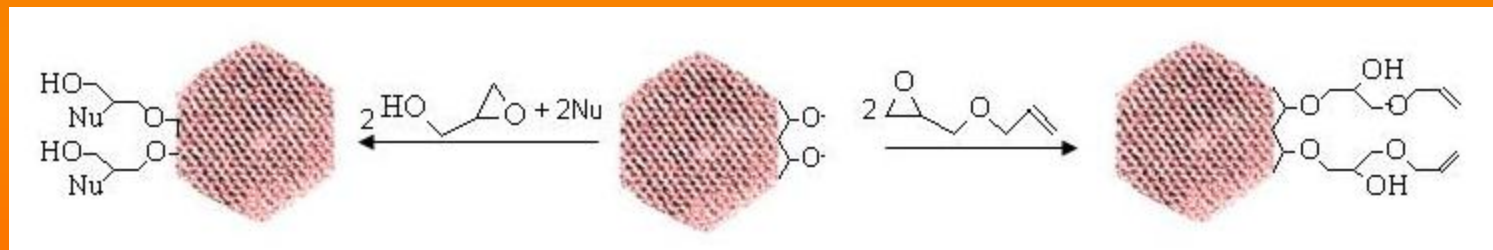
Further T1-weighted image with Gadolinium treatment reveals a subtle slightly hyperenhancing mass.



Final T1-weighted image with Gadolinium treatment shows that the mass has washed out but now demonstrates a thin capsule.

“Requirements” for a Nanoparticle to be a MRI Contrasting Agent

- Must be biocompatible and non-toxic.
- Must be comparable in size with the nanocore.
 - Covalently bound is preferred.
- Must be hydrophilic & stabilize aqueous colloids.
 - Must have appropriate terminal group.



Fe₃O₄ Nanoparticle: Synthesis

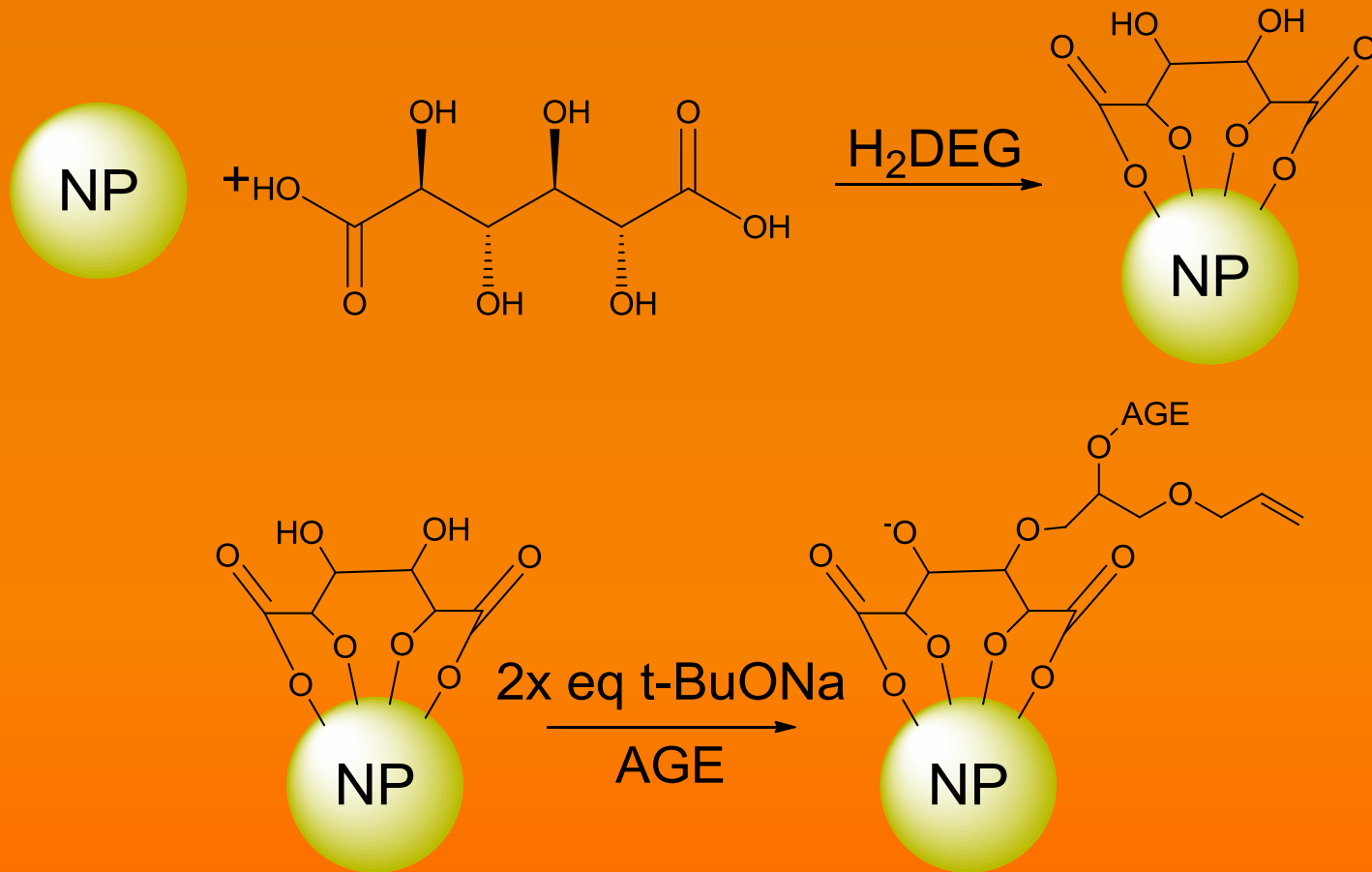
Synthesis of Superparamagnetic Iron Oxide Nanoparticle



Oxygenation of Superparamagnetic Iron Oxide Nanoparticle

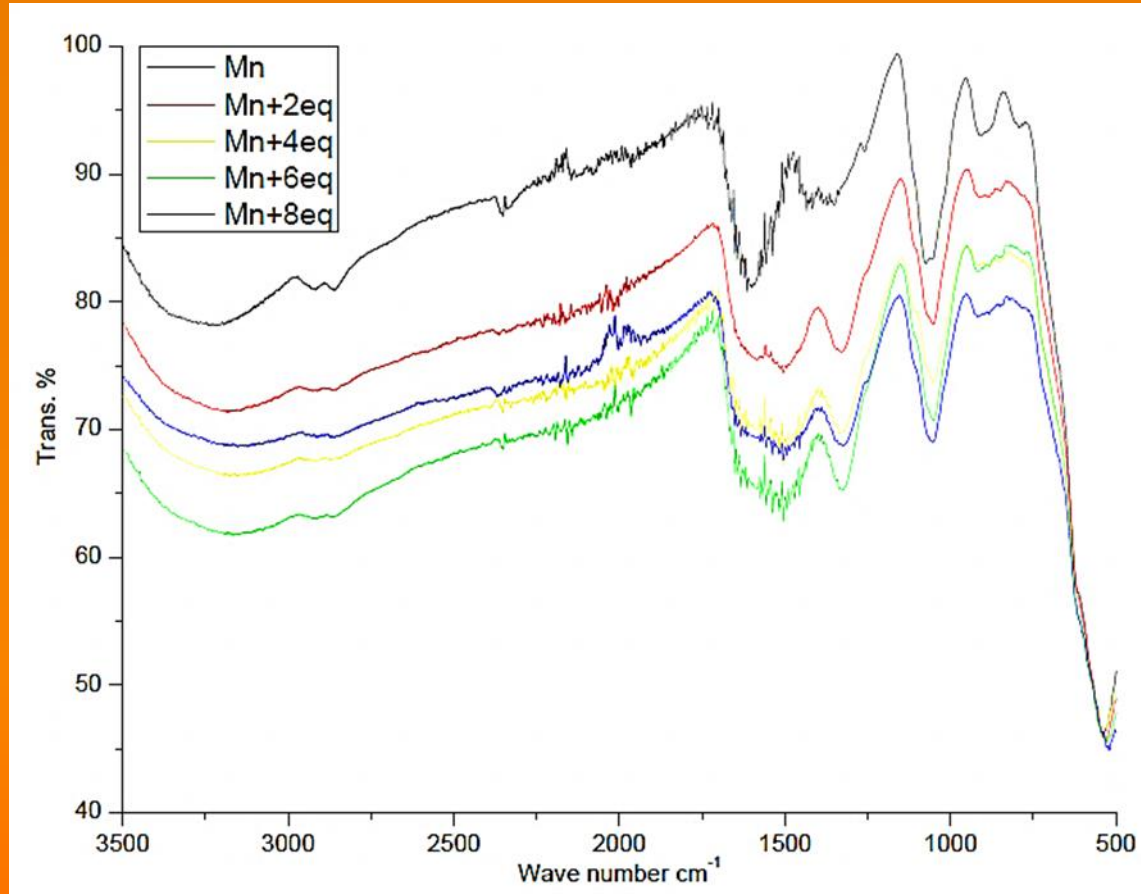


Synthesis of Fe₃O₄ Galactarate Nanoparticle



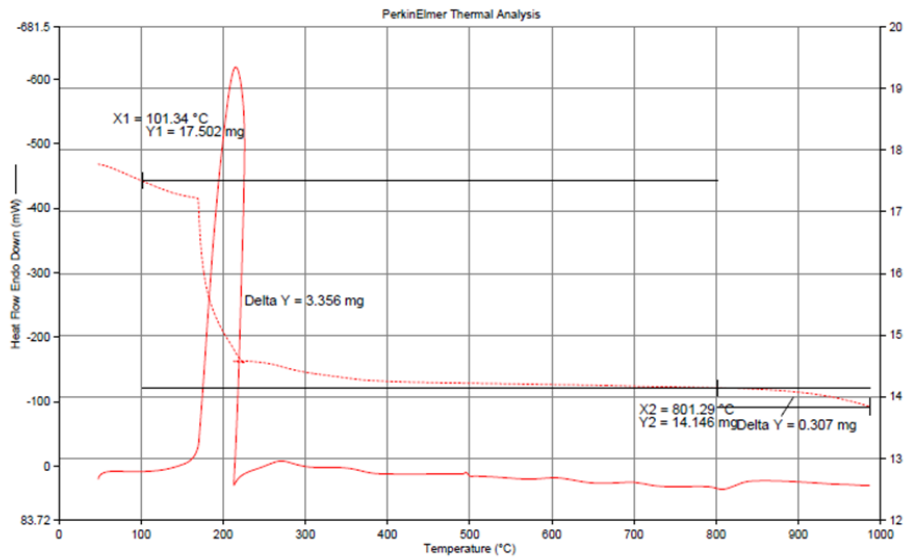
Fe₃O₄ Galactarate Nanoparticle: Results

Reaction	Size (nm)
Fe ₃ O ₄ +DEG	5.827
Fe ₃ O ₄ +DEG+ox	9.452
Fe ₃ O ₄ +DEG+ox+ Mu+250mmL AGE	8.401
Fe ₃ O ₄ +DEG+ox+ Mu+500mmL AGE	16.35
Fe ₃ O ₄ +DEG+Mu+ 750mmL AGE	11.57
Fe ₃ O ₄ +DEG+ox+ Mu+1mL AGE	8.533
Fe ₃ O ₄ +DEG+ox+ Mu+1mL AGE (final)	234.3



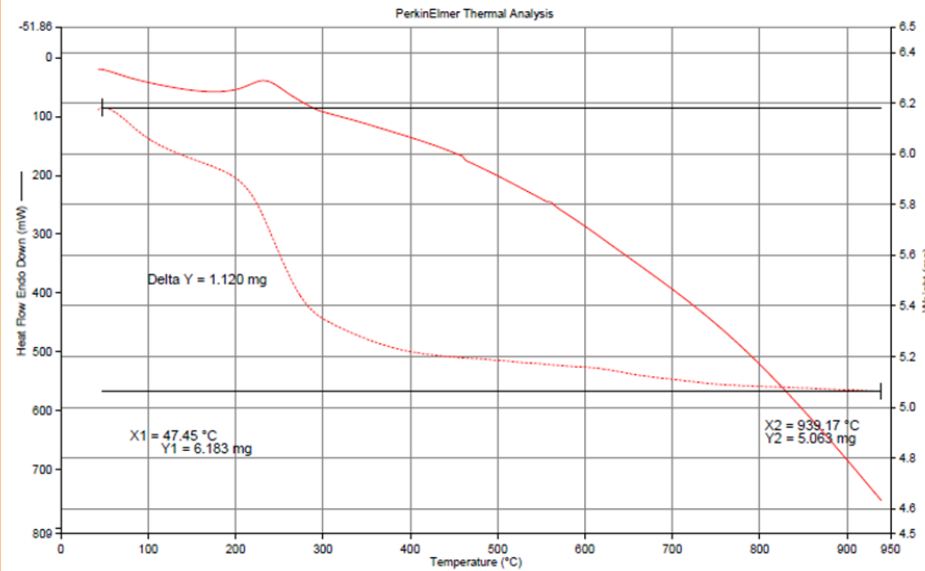
Fe₃O₄ Galactarate Nanoparticle: Results

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 Operator ID: Vladimir
 Sample ID: Fe3O4 mu
 Sample Weight: 17.788 mg
 Comment:



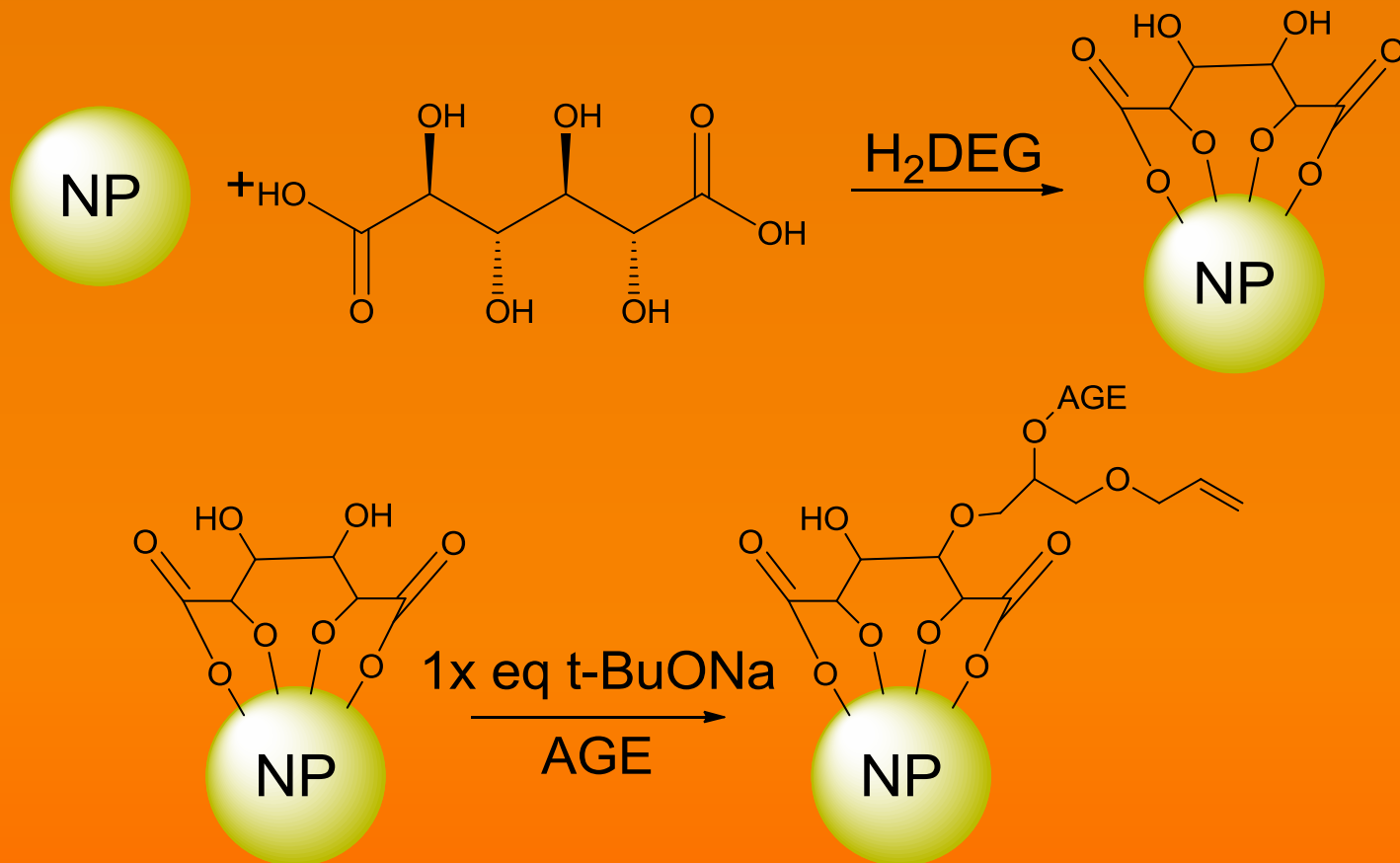
1) Heat from 50.00°C to 500.00°C at 20.00°C/min
 2) Heat from 500.00°C to 995.00°C at 40.00°C/min
 7/2/2012 6:53:23 PM

Filename: C:\Program Files\Pyrus\...\Fe3O4 mu age 4.stad
 Operator ID: Vladimir
 Sample ID: Fe3O4 mu age 4
 Sample Weight: 6.172 mg
 Comment:



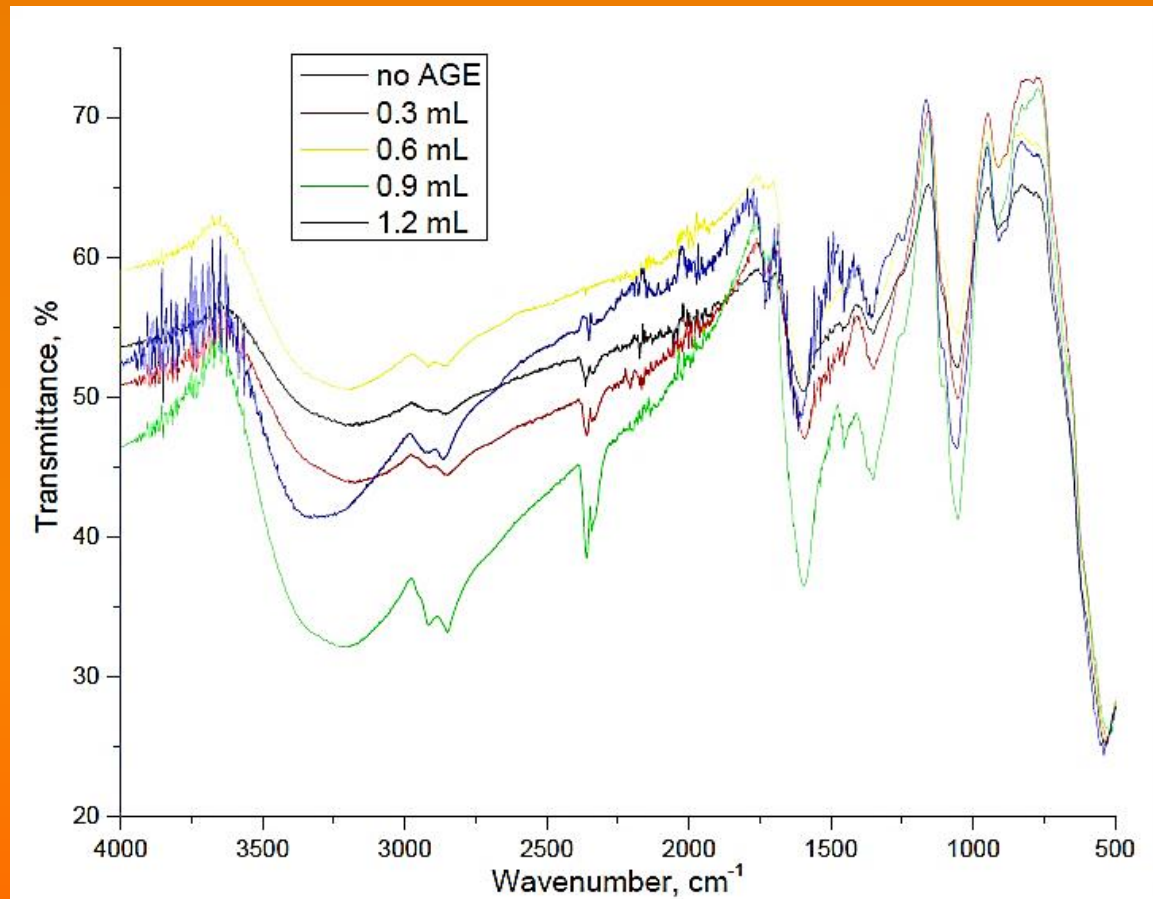
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 2) Heat from 500.00°C to 995.00°C at 40.00°C/min
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Modified Synthesis of Fe₃O₄ Galactarate Nanoparticle



Modified Synthesis of Fe_3O_4 Galactarate Nanoparticle: Results

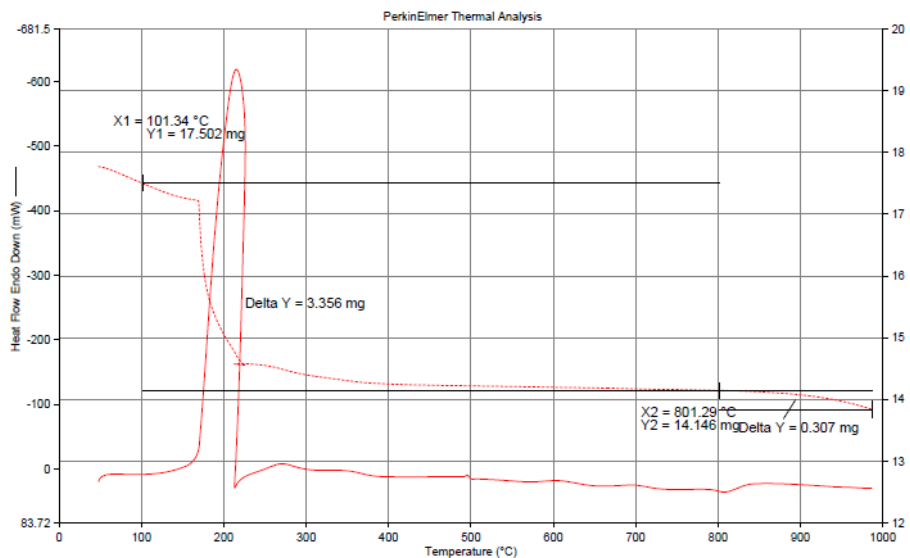
Reaction	Size (nm)
Fe_3O_4 +DEG	5.827
Fe_3O_4 +DEG+ox	9.452
Fe_3O_4 +DEG+ox+ Mu+300mmLAGE	9.798
Fe_3O_4 +DEG+ox+ Mu+600mmLAGE	7.608
Fe_3O_4 +DEG+Mu+ 900mmLAGE	8.272
Fe_3O_4 +DEG+ox+ Mu+1200mmLAGE	13.42
Fe_3O_4 +DEG+ox+ Mu+1200mmLAGE (final)	6.172



Modified Synthesis of Fe_3O_4 Galactarate Nanoparticle: Results

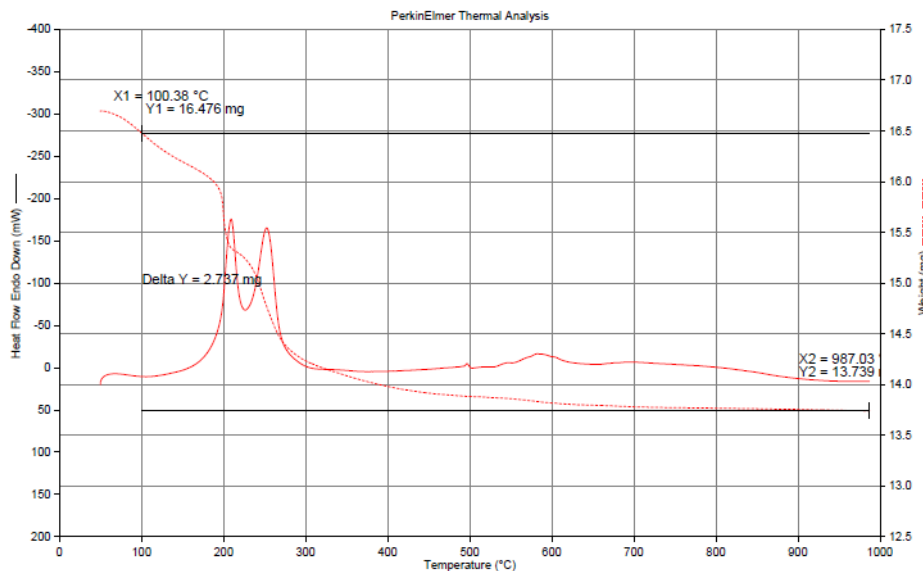


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 Operator ID: Vladimir
 Sample ID: Fe3O4 mu
 Sample Weight: 17.788 mg
 Comment:



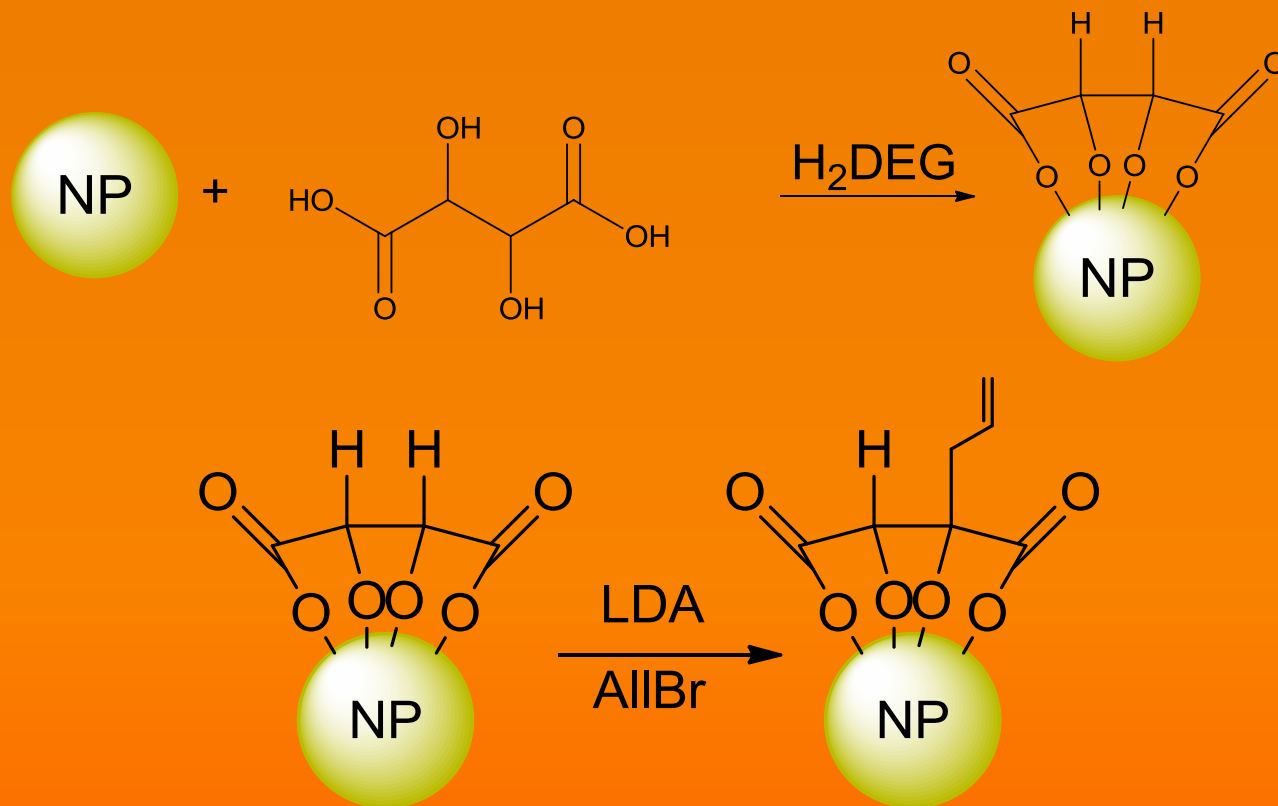
7/2/2012 6:53:23 PM
 1) Heat from 50.00°C to 500.00°C at 20.00°C/min
 2) Heat from 500.00°C to 995.00°C at 40.00°C/min

Filename: C:\Program Files\Pyr...Fe3O4 mu + AGE.stad
 Operator ID: Vladimir
 Sample ID: Fe3O4 mu + AGE
 Sample Weight: 16.697 mg
 Comment:



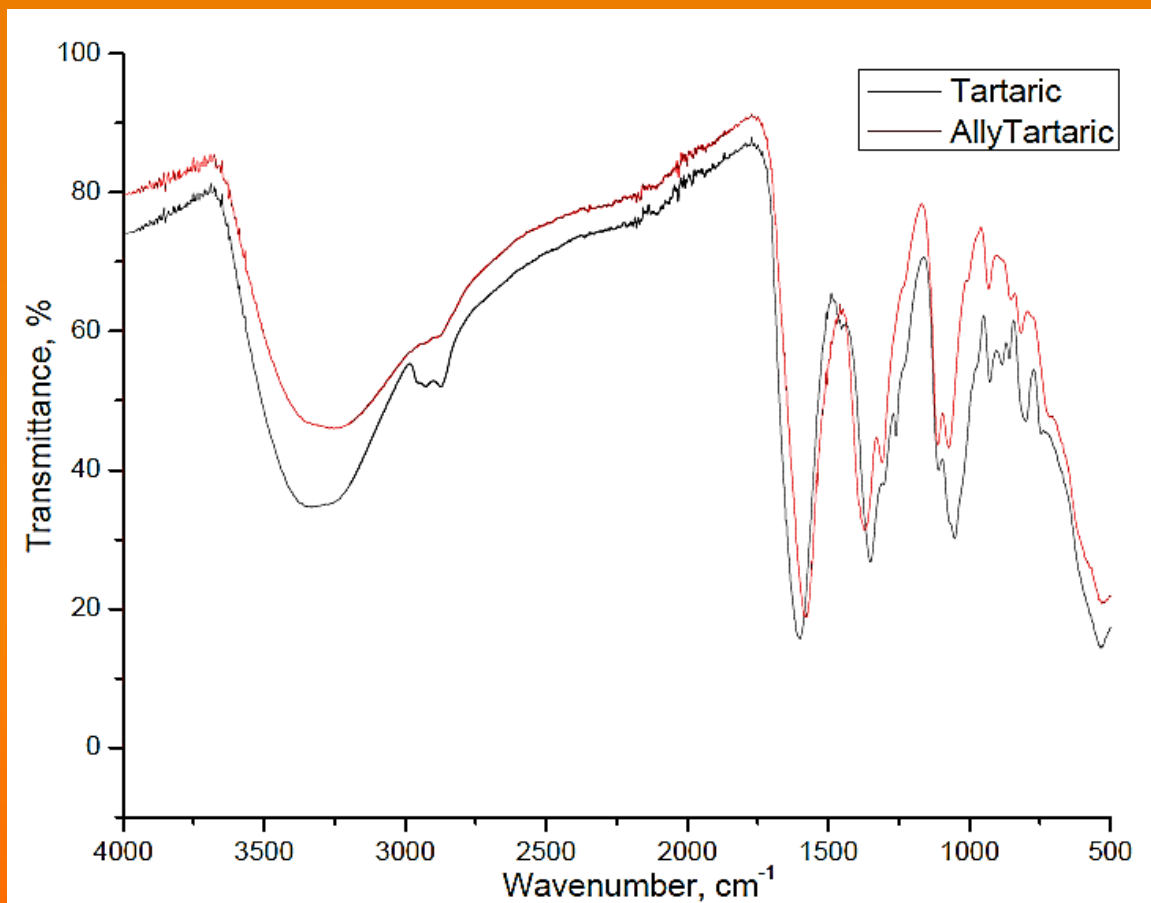
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 1) Heat from 50.00°C to 500.00°C at 20.00°C/min
 2) Heat from 500.00°C to 995.00°C at 40.00°C/min

Synthesis of Fe₃O₄ Tartarate Nanoparticle



Synthesis of Fe₃O₄ Tartarate Nanoparticle: Results

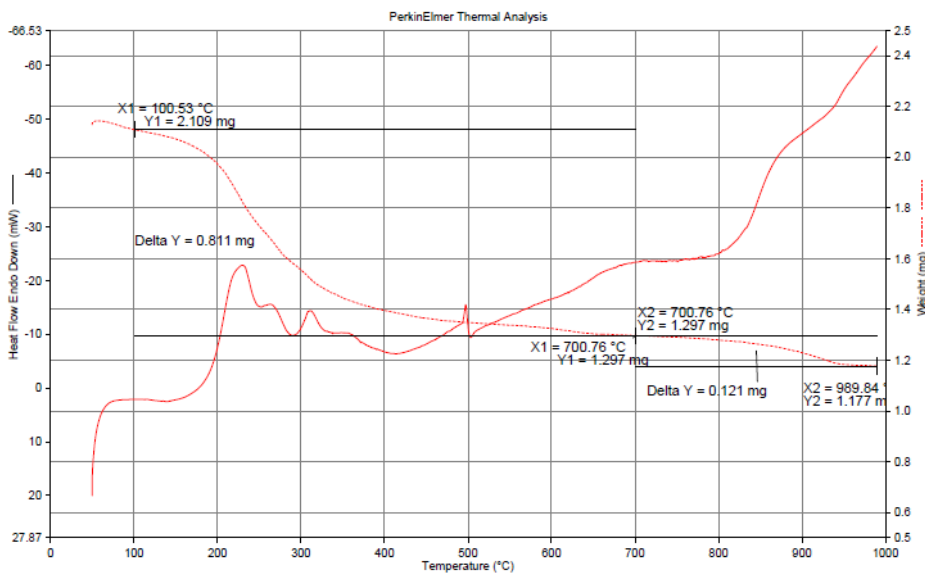
Reaction	Size (nm)
Fe ₃ O ₄ +Tar	8.845
Fe ₃ O ₄ +Tar+ LDA/AlIBr	8.409



Synthesis of Fe₃O₄ Tartarate Nanoparticle: Results



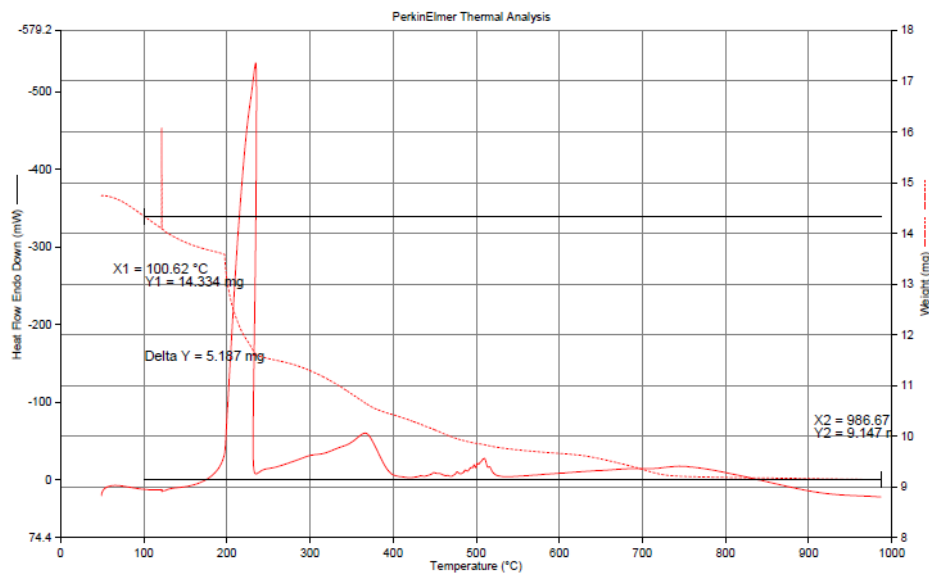
Filename: C:\Program Files\PyrisID...\Fe3O4 tart.stad
 Operator ID: Vladimir
 Sample ID: Fe3O4 tartrate before LDA and allylBr
 Sample Weight: 2.125 mg
 Comment:



1) Heat from 50.00°C to 500.00°C at 20.00°C/min
 2) Heat from 500.00°C to 995.00°C at 40.00°C/min

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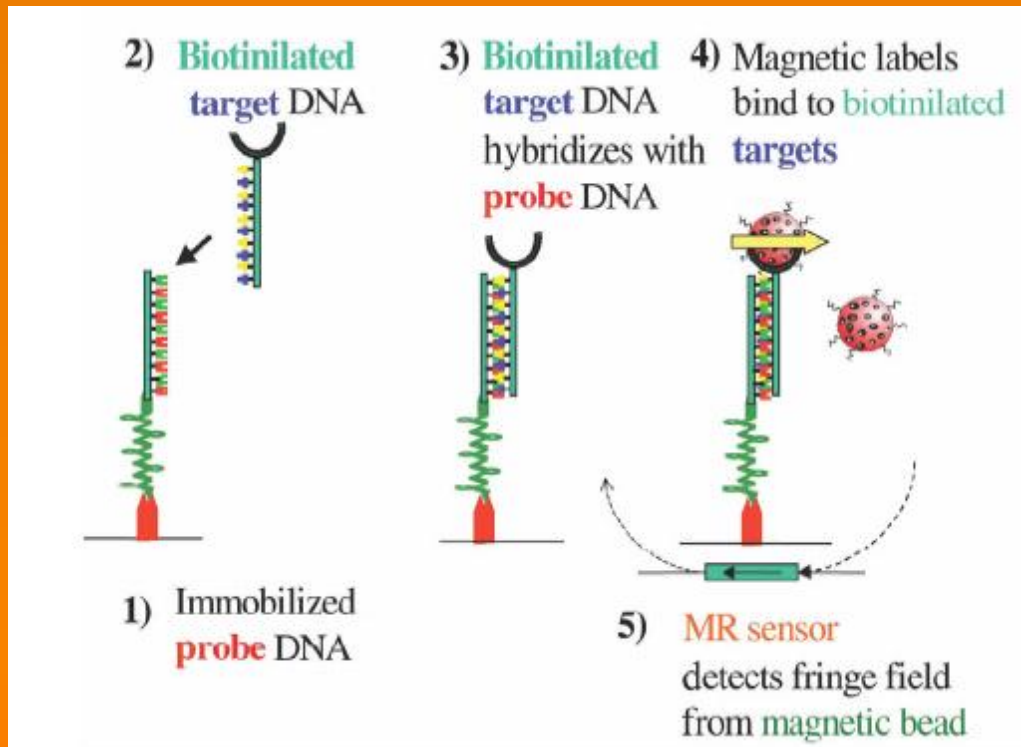
Filename: C:\Program Files\PyrisID...\Fe3O4 tart allyl.stad
 Operator ID: Vladimir
 Sample ID: Fe3O4 tartrate + LDA + allylBr
 Sample Weight: 14.740 mg
 Comment:



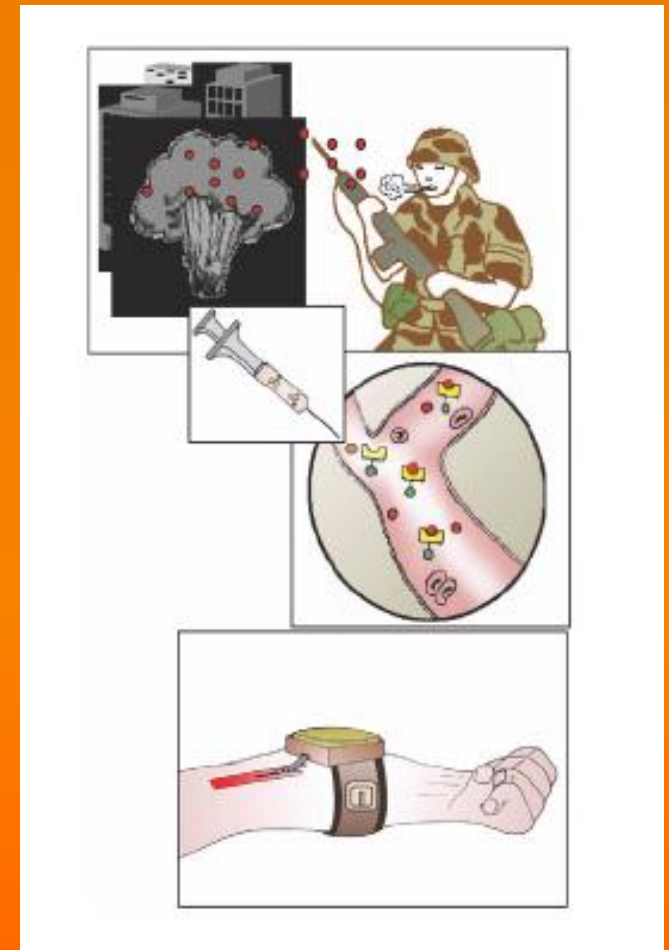
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Superparamagnetic Iron Oxide Applications



Detecting target DNA

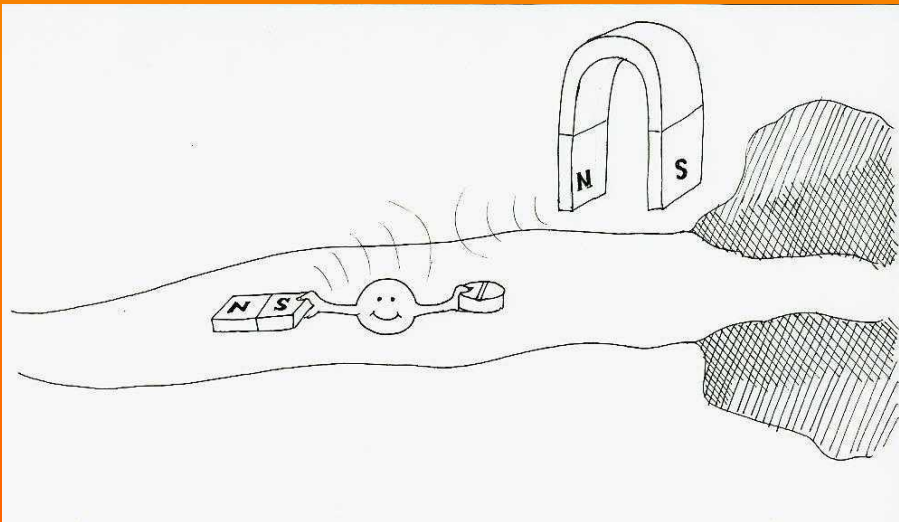


Magnetic filter

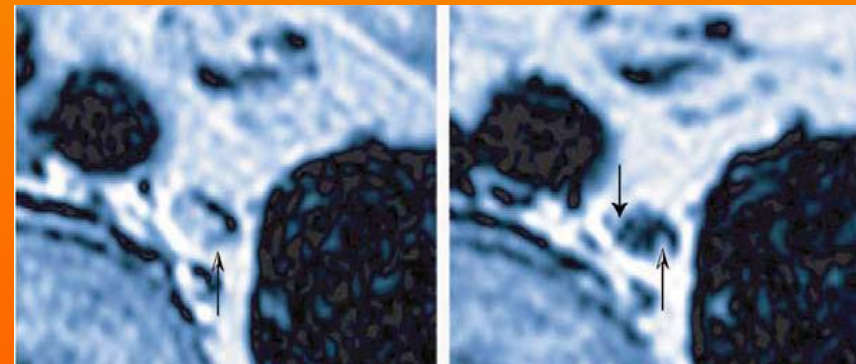
Superparamagnetic Iron Oxide Applications (cont.)



Cell Tracking: biodistribution of stem cells after implantation by monitoring their migration and trafficking, and determine the success of cell-transplantation therapy over six weeks



Drug Delivery and MRI Contrasting Agents



Future Work

- Basic media decomposition for further analysis
- Repeat the Galactarate reaction under optimized conditions

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