Nonionic Surfactant Monolayers for Aqueous Dispersion of Magnetite Nanoparticles

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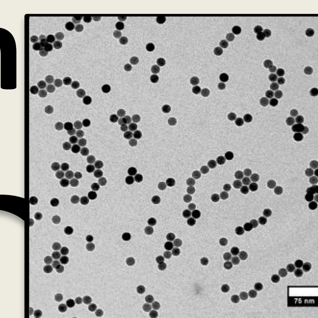
Motivation

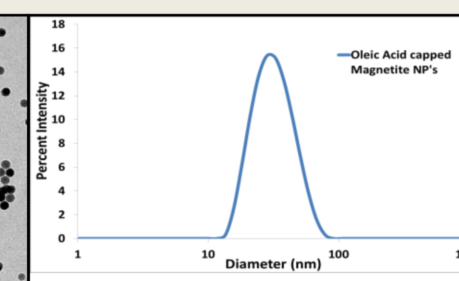
- Practical use of superparamagnetic iron oxide nanoparticles in biomedical applications requires that particles are modified with ligands that impart stability and functionality in physiological environments.
- This work demonstrates a method by which superparamagnetic magnetite nanoparticles stabilized with a lipophilic ligand can be encapsulated with surfactant molecules that confer aqueous stability.
- Further, we show that a custom poly(N-isopropylacrilamide)-18 carbon chain (pNIPAM-C18) surfactant provides thermal responsiveness that has implications for delivery of therapeutic molecules and compounds *in vivo.*

Introduction

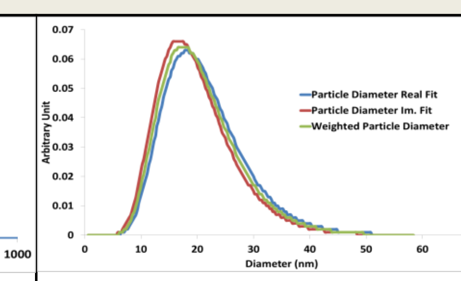
- Oleic acid coated particles, as synthesized, are not dispersible in an aqueous environment, limiting their use in biological settings .
- Functionalization using ligand exchange can cause agglomeration, etching, and other undesirable effects changing the characteristics and properties of the particles.
- Creation of a heterobilayer allows for a degradation free, facile way to both confer water solubility and functionality to the particles.



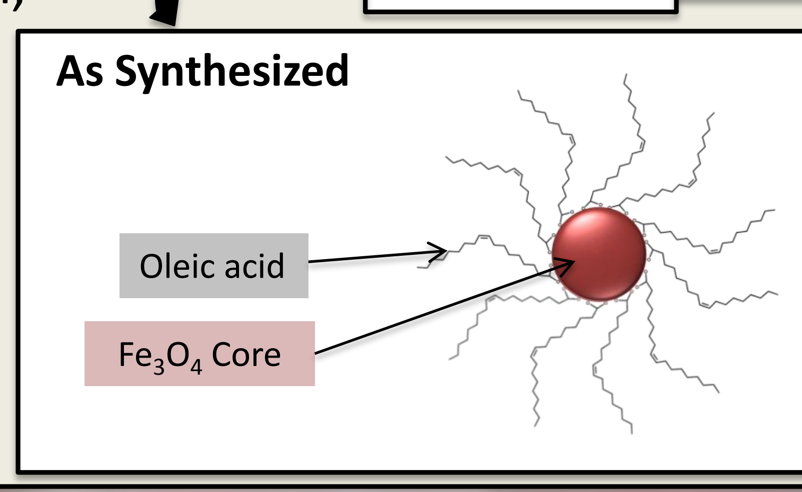
20nm Fe_3O_4 NPs

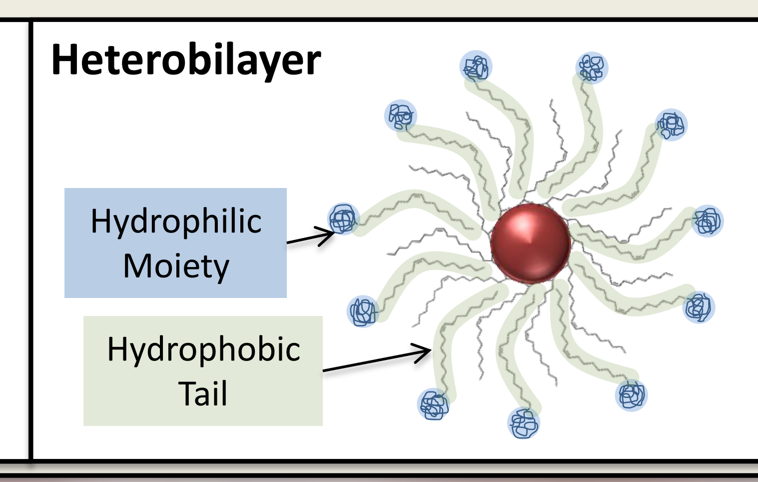


DLS of 20nm Fe_3O_4 NPs in Hexanes

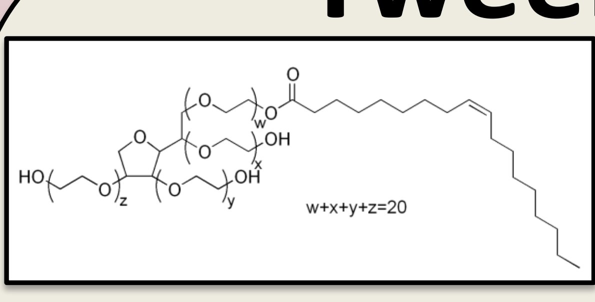


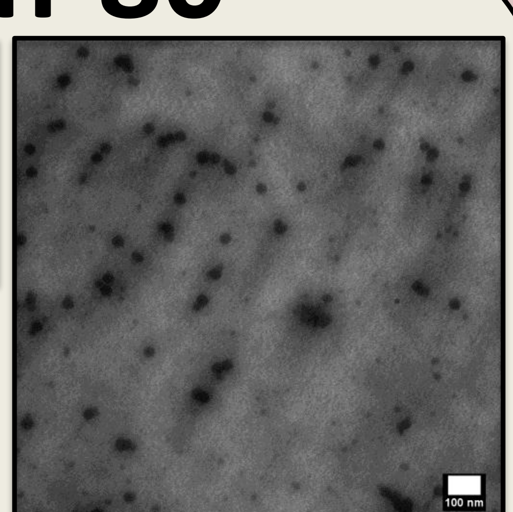
AC Magnetometry of 20nm Fe_3O_4 NPs in Hexanes





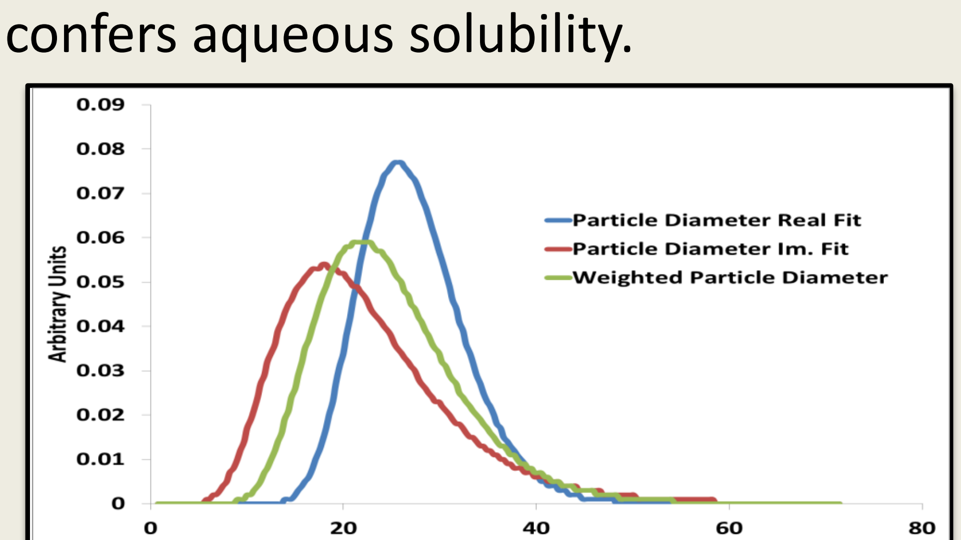
Tween-80



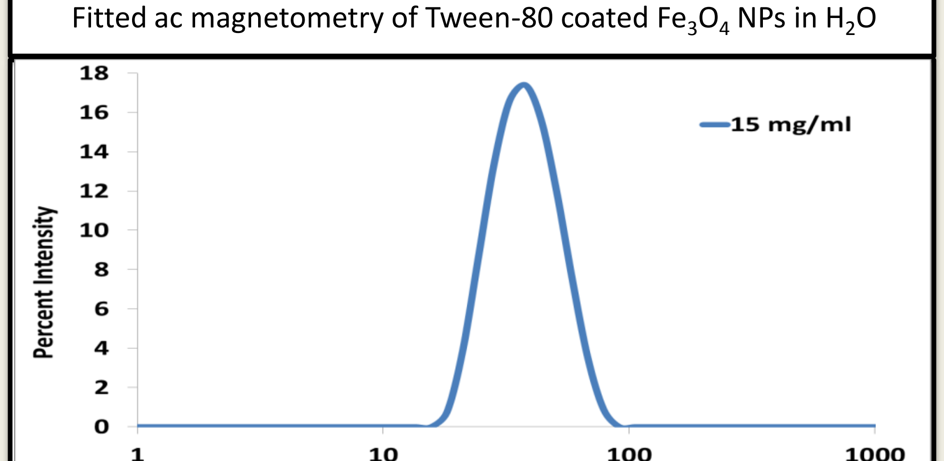


TEM of Tween-80 coated Fe_3O_4 NP's

- Tween-80 is a cheap commercially available nonionic surfactant.
- Done as control against pNIPAM–C18.
- Good single particle coating through sonic mixing.
- Heterobilayer creation with Tween-80 confers aqueous solubility.

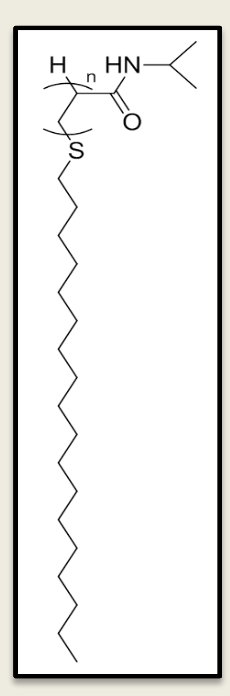


Fitted ac magnetometry of Tween-80 coated Fe_3O_4 NPs in H_2O

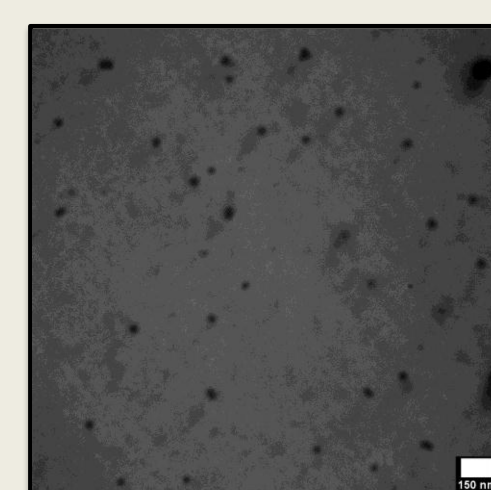


DLS of Tween-80 coated Fe_3O_4 NPs in H_2O

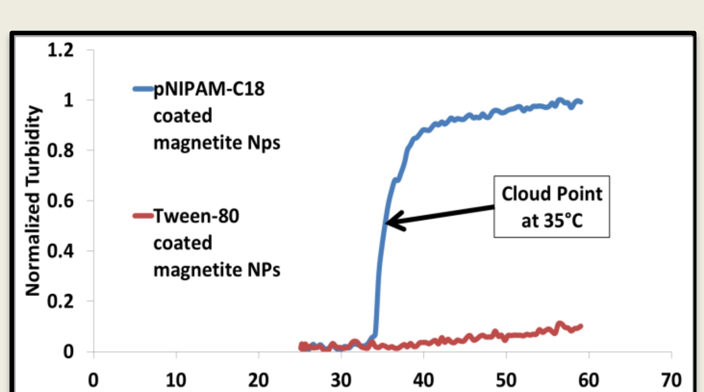
pNIPAM-C18



- pNIPAM is a thermally responsive polymer with a lower critical solution temperature (LCST) at 33-35°C.
- pNIPAM-C18 is a custom made surfactant composed of a hydrophilic pNIPAM polymer and a saturated 18 carbon chain.

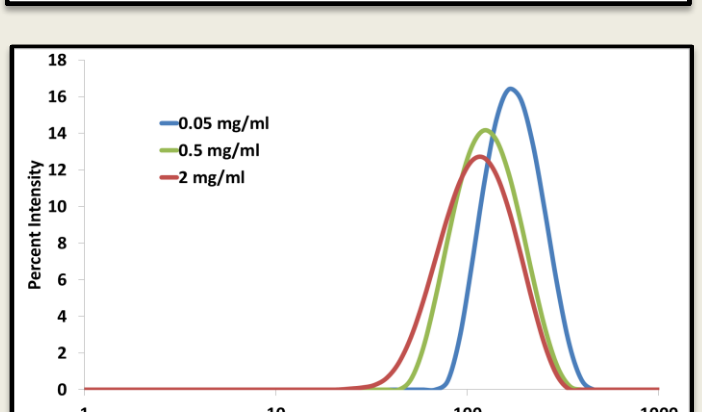


TEM of pNIPAM-C18 coated Fe_3O_4 NPs

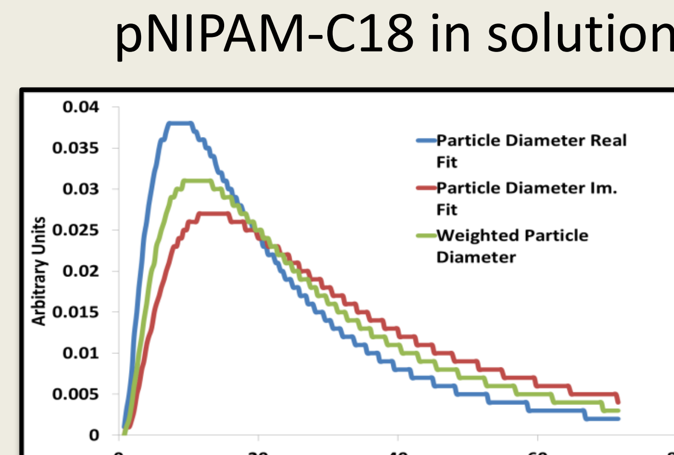


Normalized cloud point measurement of Tween-80 coated NPs compared to pNIPAM-C18 coated NPs

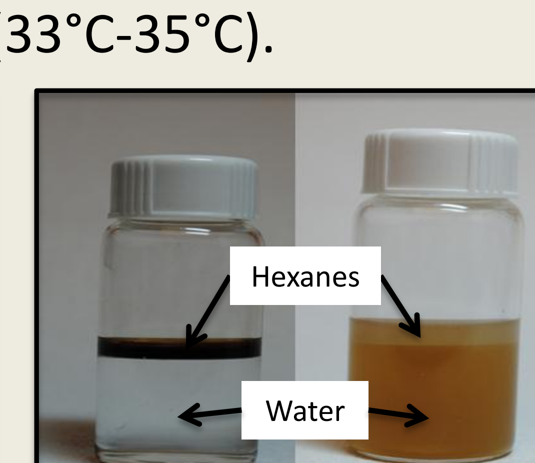
- Cloud point measurements were done using aqueous particle solutions void of excess surfactant.
- Tween-80 showed no cloud point and was used as a control.
- Cloud Point of pNIPAM-C18 coated NPs is within the range of cloud point measurements done with free pNIPAM-C18 in solution (33°C-35°C).



DLS peak vs. concentration of pNIPAM-C18 solution used



AC Magnetometry of pNIPAM-C18 coated Fe_3O_4 NPs in H_2O

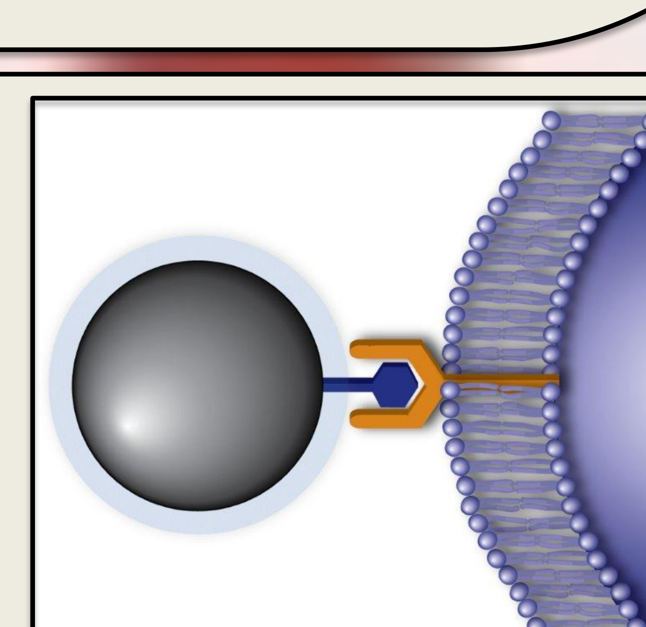


Left: before phase transfer, Right: after phase transfer

- Hydrodynamic size is not a strong function of concentration when using pNIPAM-C18 as a surfactant.
- There is no phase transfer of magnetite NP's from organic phase to aqueous phase at pNIPAM-C18 concentrations below 0.01 mg/ml.

Future Work

- Optimization of phase transfer to reduce aggregates and create an aqueous solution of single coated NPs.
- Construction of reversible macrostructure assemblies using pNIPAM-C18 coated magnetite nanoparticles.
- Exploration of other functional surfactants for encapsulation of magnetic nanoparticles.
- Further bio-functionalize pNIPAM-C18 coated nanoparticles to confer more precise specificity.



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NNSA National Nuclear Security Administration