Polymeric Nanoparticle Surface Coatings for Biomedical Applications

Xavi Loinaz, Xiaoting Guo, Jake Villanova, Hyewon Kim, and Vicki L. Colvin

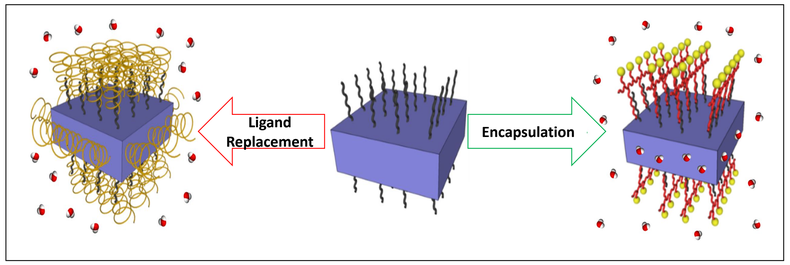
Project #1: Amphiphilic Polymer Coating for MRI Contrast Agent

1. Phase Transfer: approach

Organic → Aqueous

Ligand Replacement:
- Stronger binding affinity
- Binds to edges

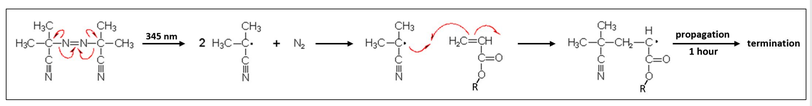
Encapsulation:
- Amphiphilic polymer
- Binds to original ligand



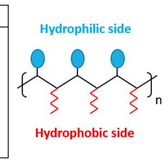
- For MRI contrast agent applications, Gd_2O_3 Nanoplates synthesized in hydrophobic solution must be transferred into water without blocking edges

PAMPS-LA Synthesis

UV-activated Radical Polymerization

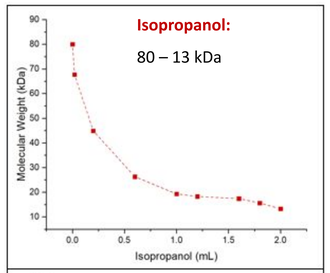


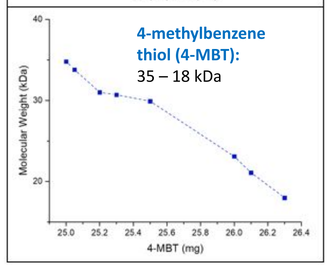
Hydrophilic moiety	Hydrophobic moiety	Photo-initiator
2-acrylamido-2-methylpropansulfonic acid (AMPS)	Lauryl acrylate (LA)	Azobisisobutyronitrile (AIBN)

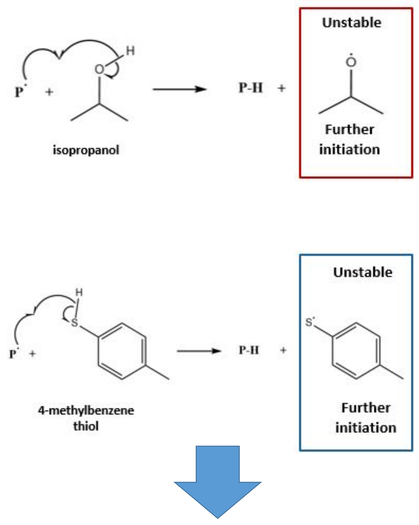


4. PAMPS-LA Size Reduction

❖ **Use of Chain Transfer Agents for Shorter Polymer**
- Takes radical → Starts new chains
- More chains = smaller polymers



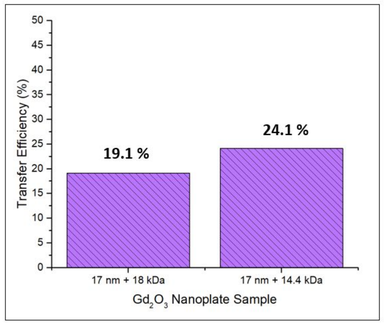




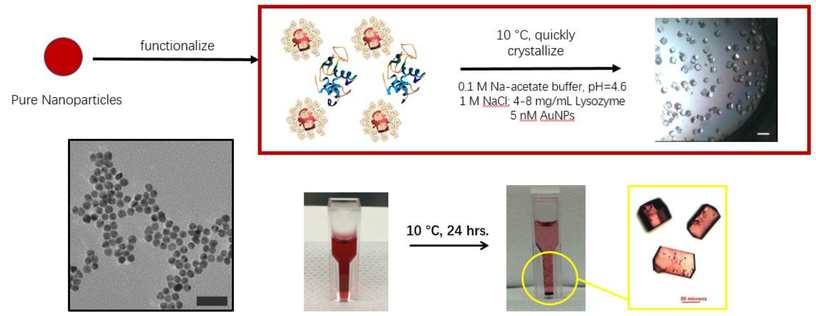
Procedure:
- Gd_2O_3 Nanoplates (17nm) in DEE
- PAMPS-LA (14.4 – 18 kDa) in DMF

Mix overnight

Conclusion:
- Smaller polymer → less aggregation
- More efficient encapsulation

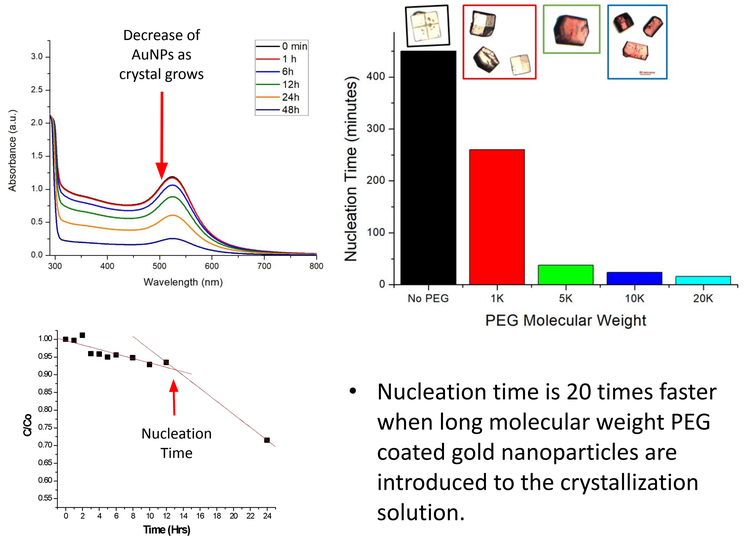


Gold Nanoparticle as Nucleant



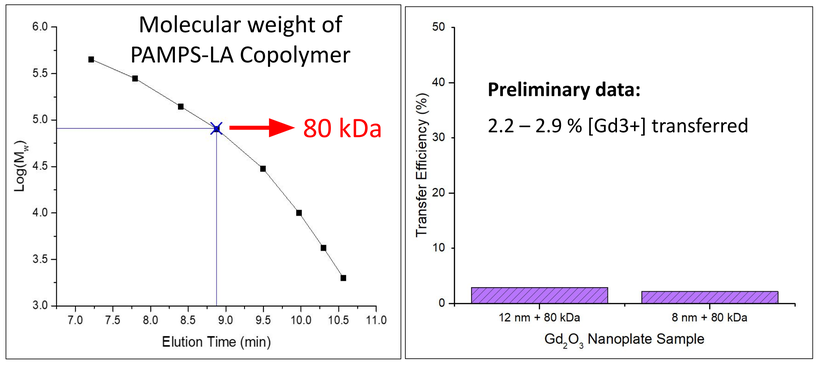
- PEGylated gold nanoparticles introduced to the crystallization solution, and the nucleation time is measured by UV-VIS spectroscopy.

Faster Nucleation Time with Longer PEG



- Nucleation time is 20 times faster when long molecular weight PEG coated gold nanoparticles are introduced to the crystallization solution.

Polymer Size Dependent Transfer Efficiency



- Low transfer efficiency is suspected due to large molecular weight and aggregation of polymer -> Need smaller polymer for better encapsulation

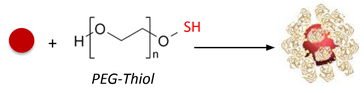
Project #2: Design Effective Nucleant for Protein Crystallization using PEGylated AuNPs

Protein Crystallization

- Protein crystals are important in order to solve protein structure
- Slow crystallization and difficult to find crystallization conditions
  - years to develop suitable crystals
- Faster crystallization can be achieved using effective nucleant

Challenge to use Nanoparticles as a Nucleant

- Crystallization condition requires high salt concentration and low pH
  - Aggregation of nanoparticles occurs without appropriate surface coating



Conclusions

- Hydrophilic polymer coating is required for nanoparticles in order to use them in biomedical application.
- It is important investigate a suitable molecular weight of polymers in order to fully encapsulate Gd nanocrystals.
- The shorter PAMPS-LA was synthesized using chain transfer agents.
- Smaller molecular weight of PAMPS-LA showed better encapsulation efficiency.
- Larger molecular weight PEG on the surface of AuNPs promotes nanoparticle-protein interaction.
- Nucleation time is 20 times faster when gold nanoparticles coated with larger molecular weight PEG was introduced in the lysozyme crystallization solution.