Arborescent Amphiphilic Copolymers as Templates for the Preparation of Gold Nanoparticles

29th Annual Institute for Polymer Research Symposium

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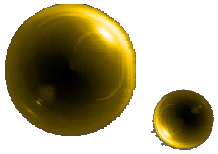


Outline

1. Focus of Research

2. The Template

3. Results

4. Conclusions & Future Work

Main Focus

To synthesize a branched polymer template with an inverse micelle morphology for metallic nanoparticle assembly.

Specifically, amphiphilic arborescent copolymers will serve as static scaffolding for metal loading.

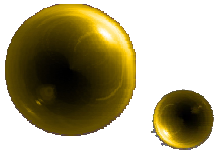
Nanoparticle Applications

Applicable to hydrogenation and various coupling reactions

Stable, high turnover, and easy isolation

Oligonucleotide functionalized nanoparticles exhibit size-dependant light scattering

Functionalized nanoparticles can target then destroy cells when subjected to laser pulses



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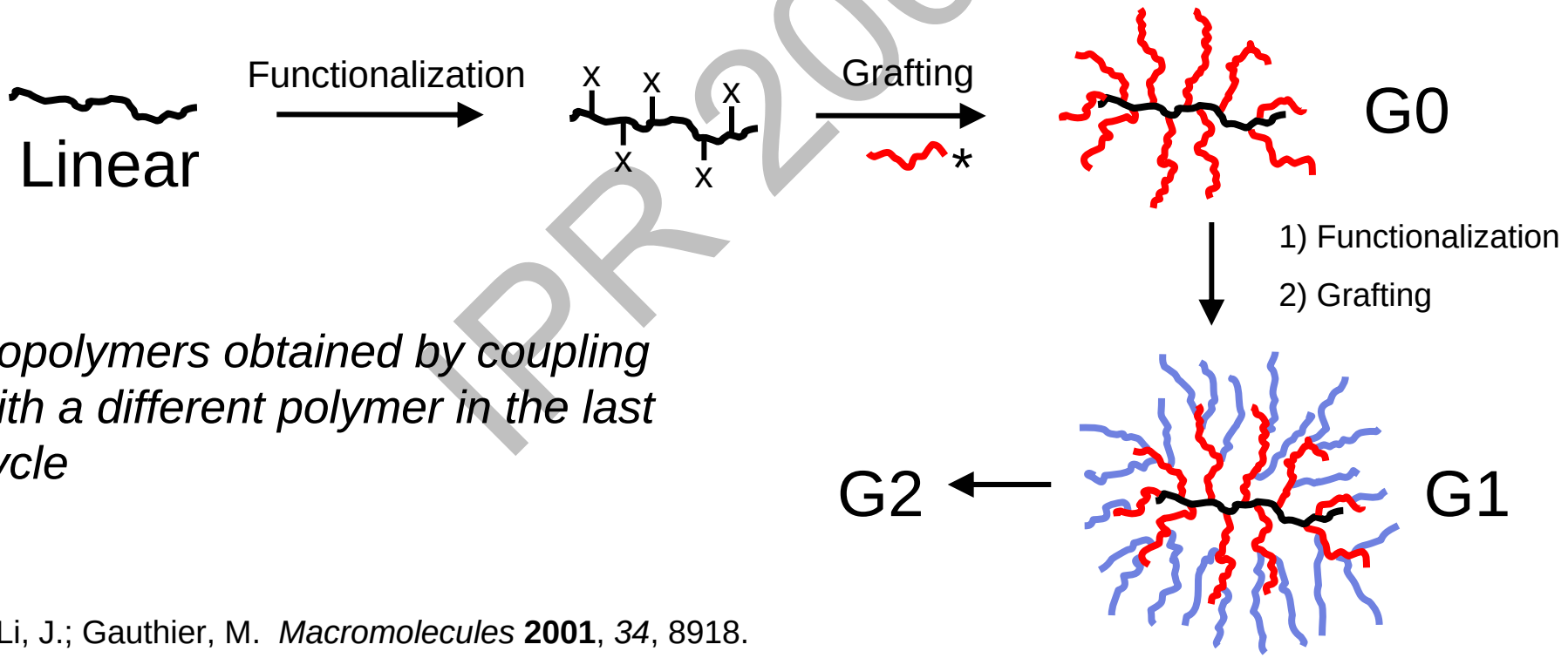
Arborescent Polymers

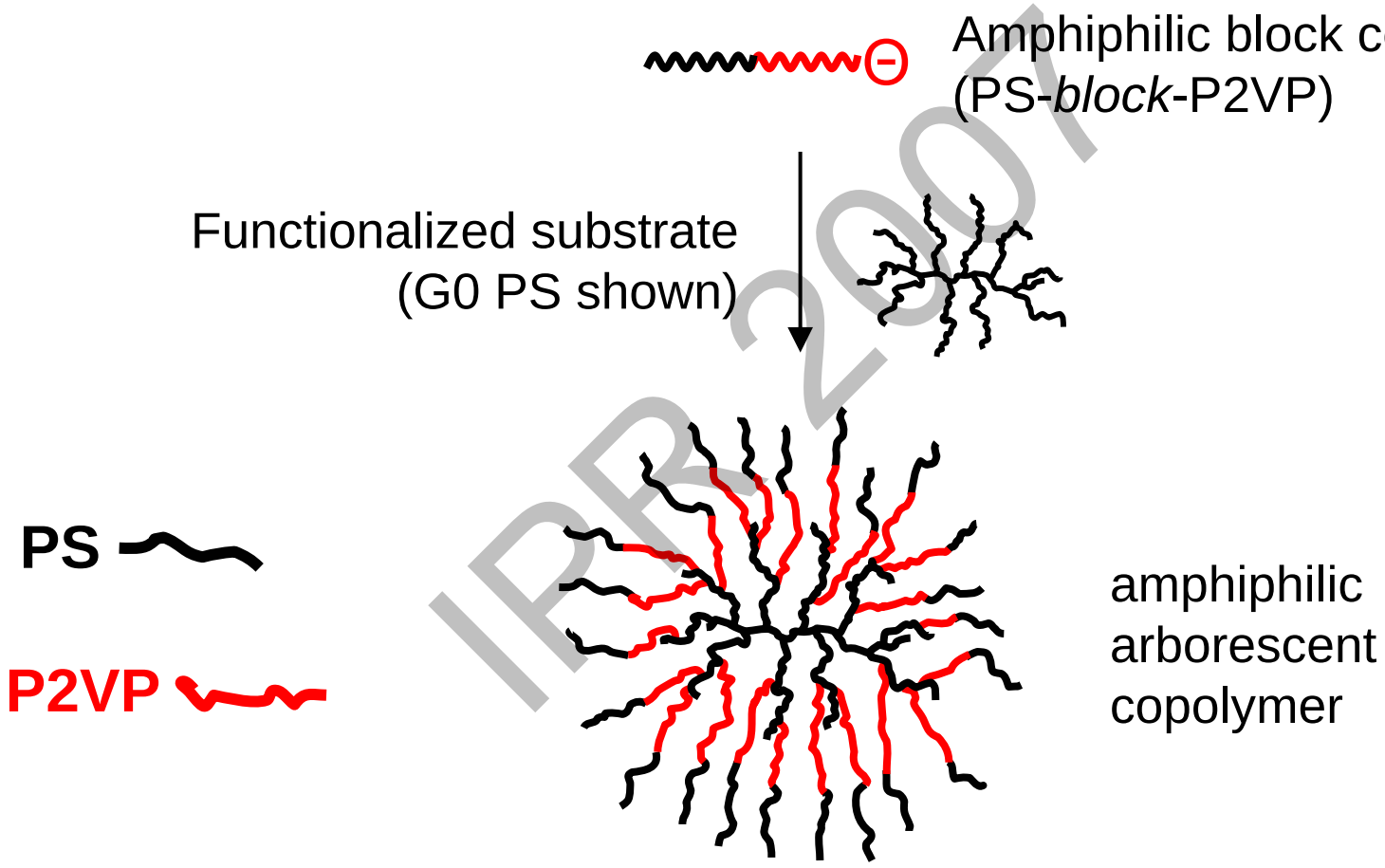
Branched structure obtained from successive grafting reactions



Copolymers obtained by coupling with a different polymer in the last cycle

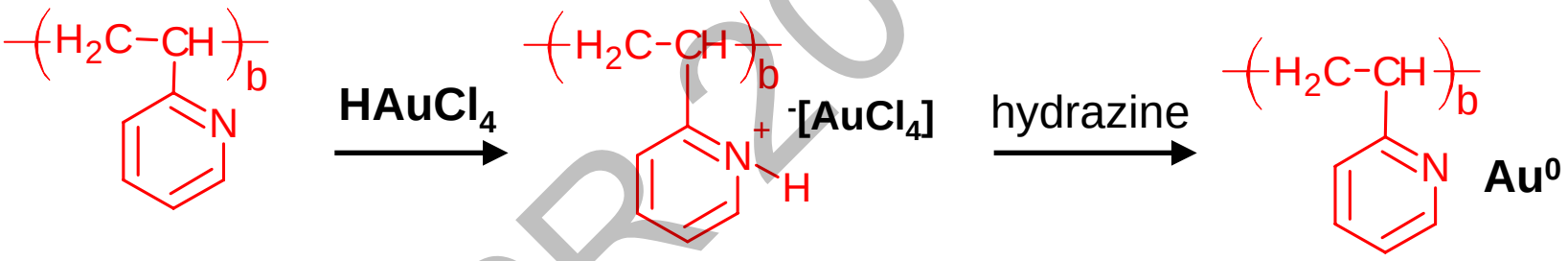
- Li, J.; Gauthier, M. *Macromolecules* **2001**, *34*, 8918.
- Kee, R.A.; Gauthier, M. *Macromolecules* **1999**, *32*, 6478.

Synthesis



Selective Reactions

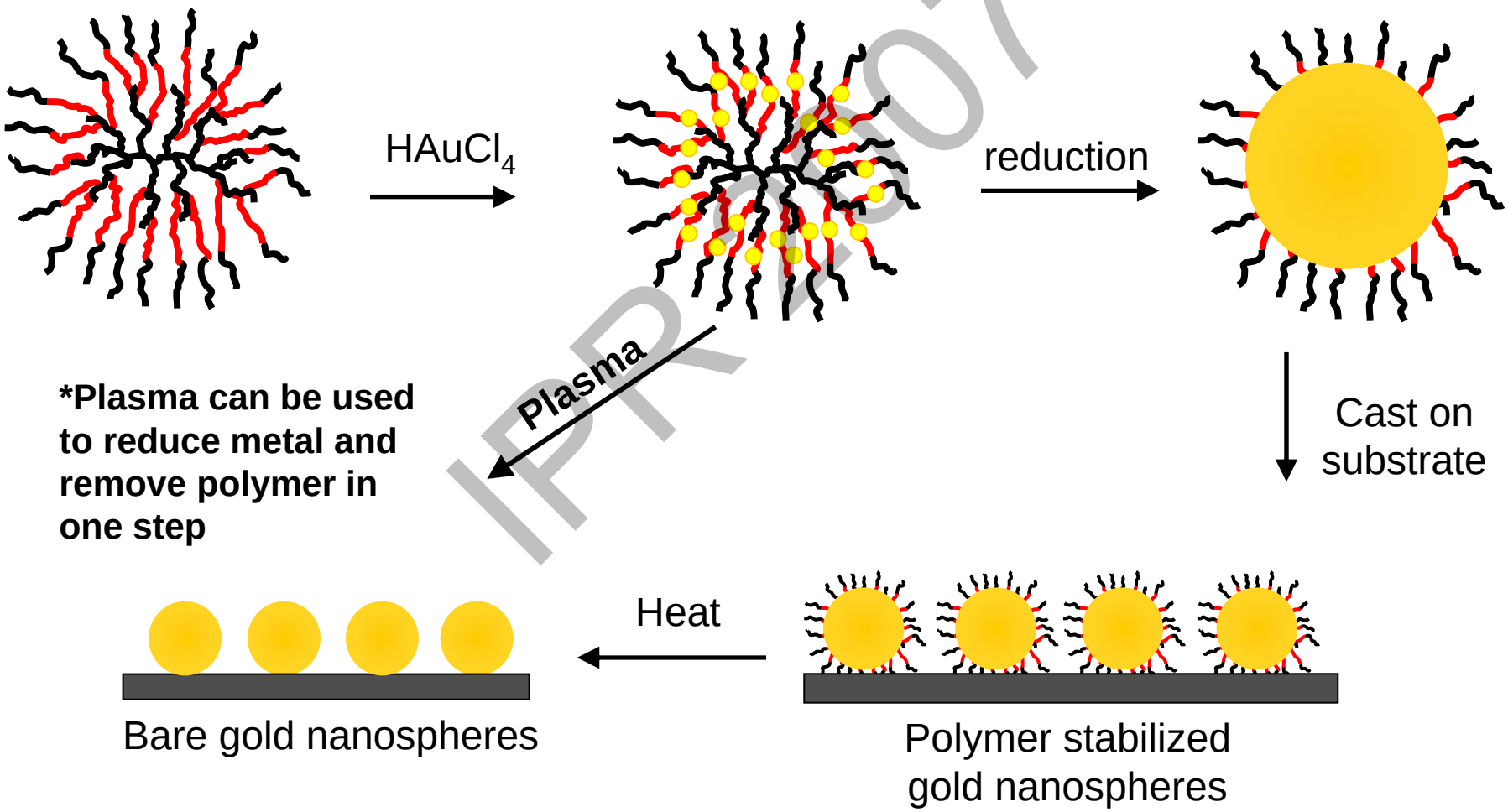
Polymer loading and reduction



Other loadable metal salts:

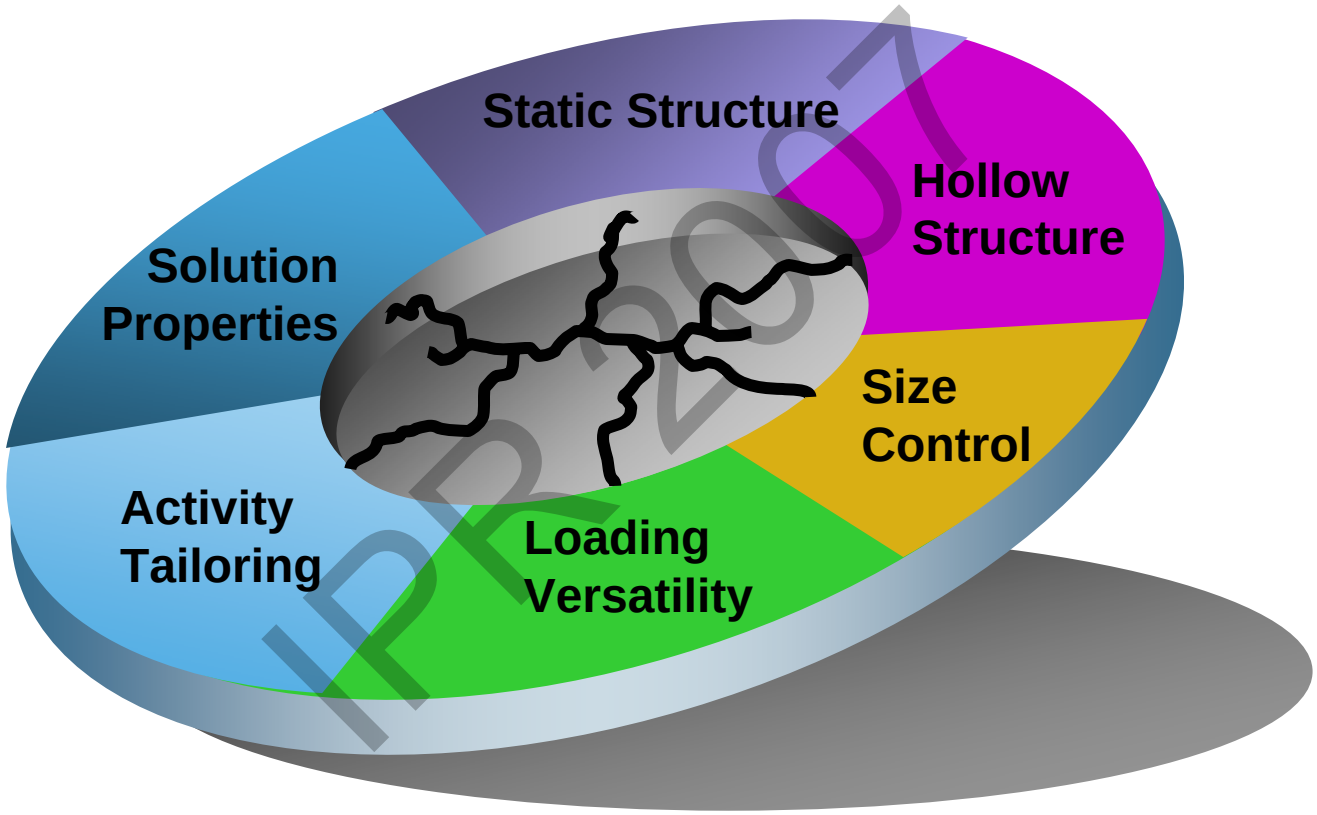
- Palladium: $Pd(OAC)_2$
- Platinum: $K(PtCl_3C_2H_4)$
- Rhodium: $[Rh(CO)_2Cl]_2$

Loading and Deposition



***Plasma can be used to reduce metal and remove polymer in one step**

Unique Characteristics



Arborescent Polymer Templates

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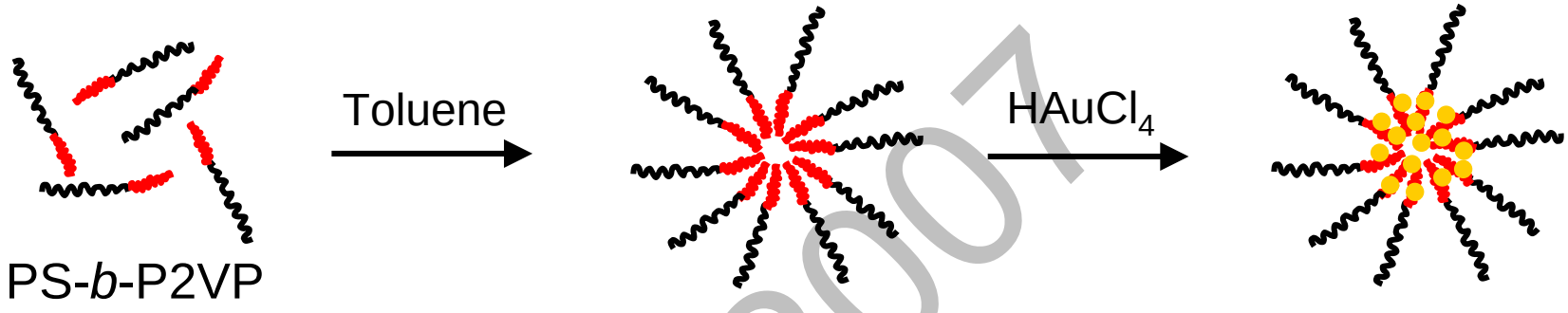
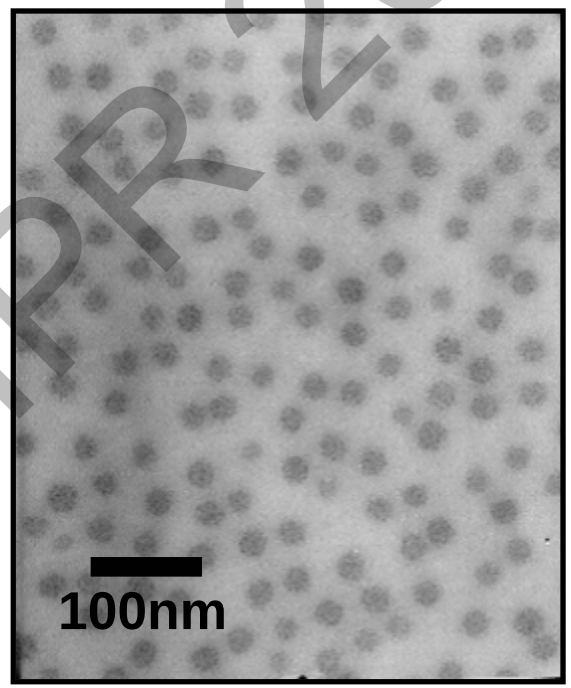
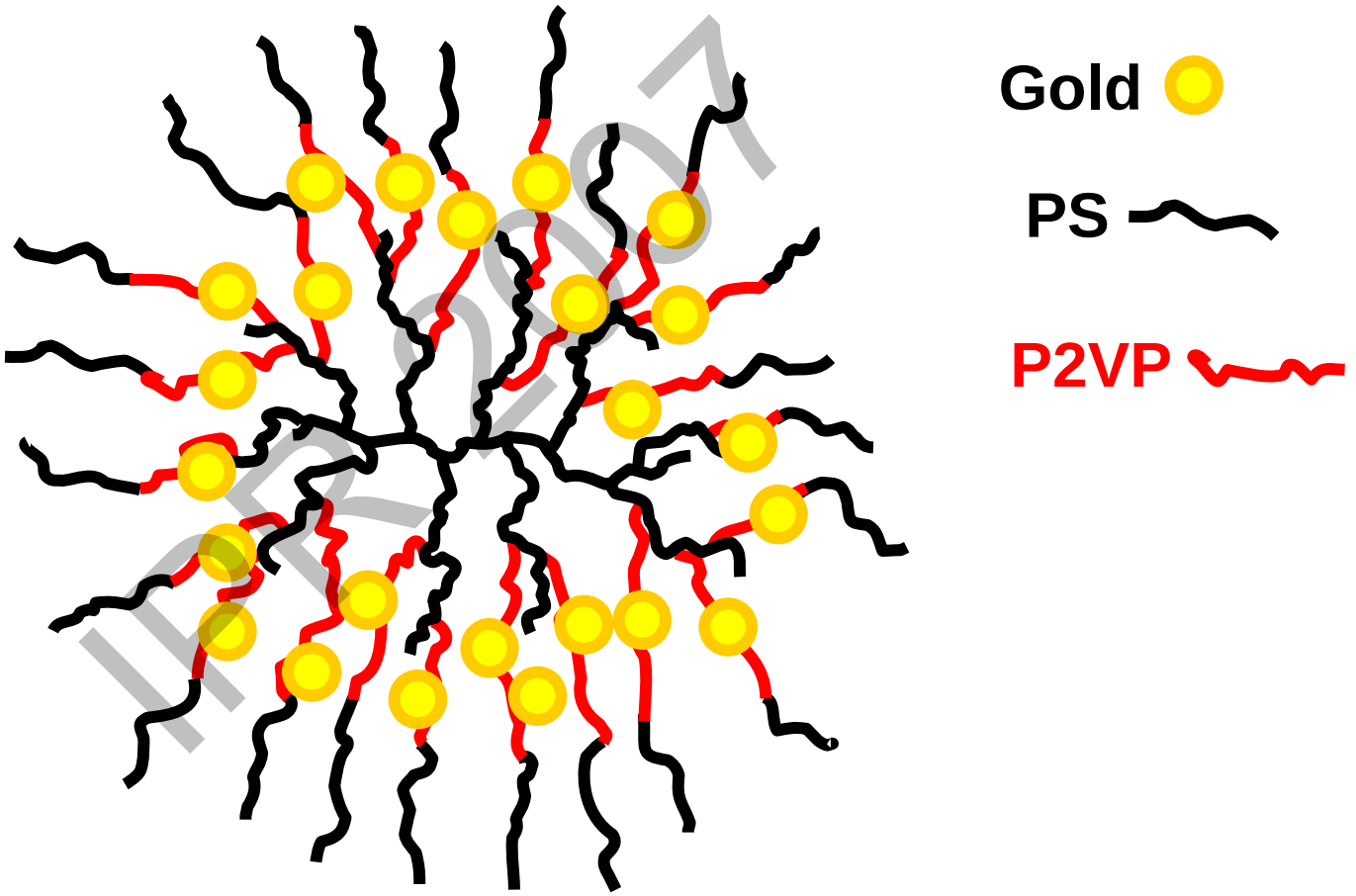
Preliminary tests



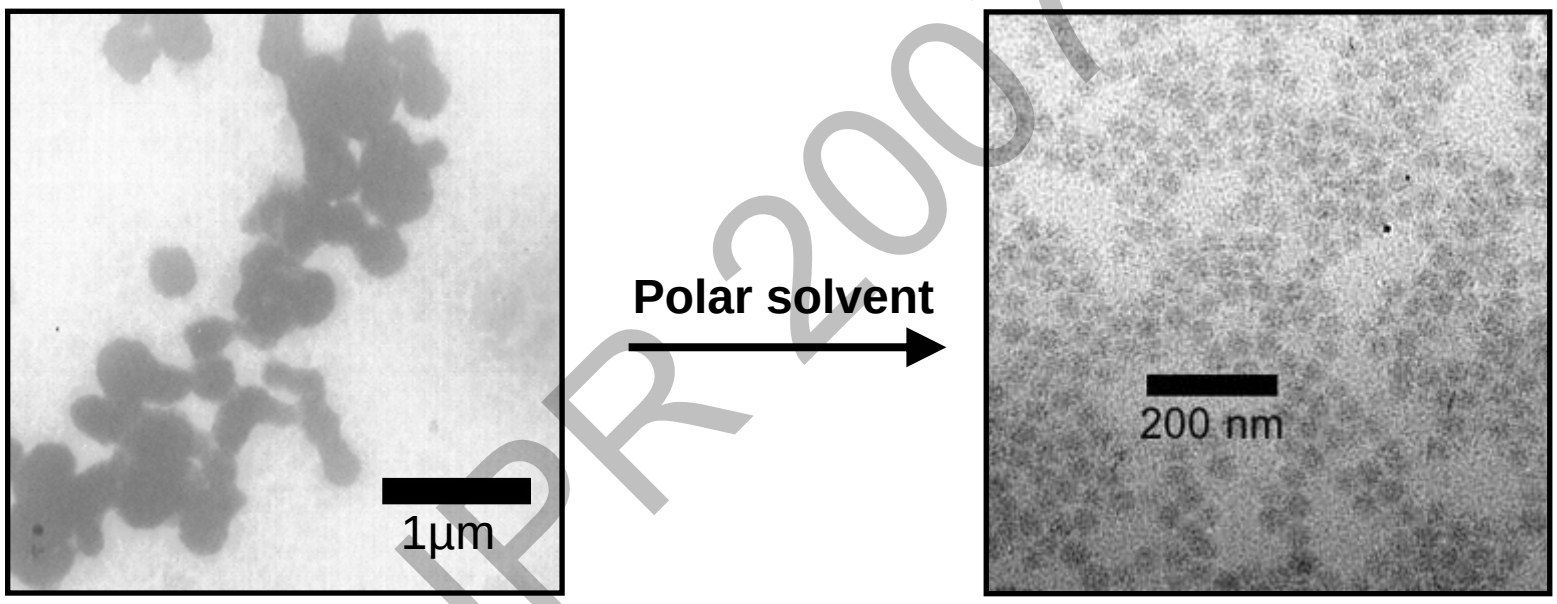


Arborescent Polymer Loading



G0PS-*g*-(P2VP-*b*-PS)

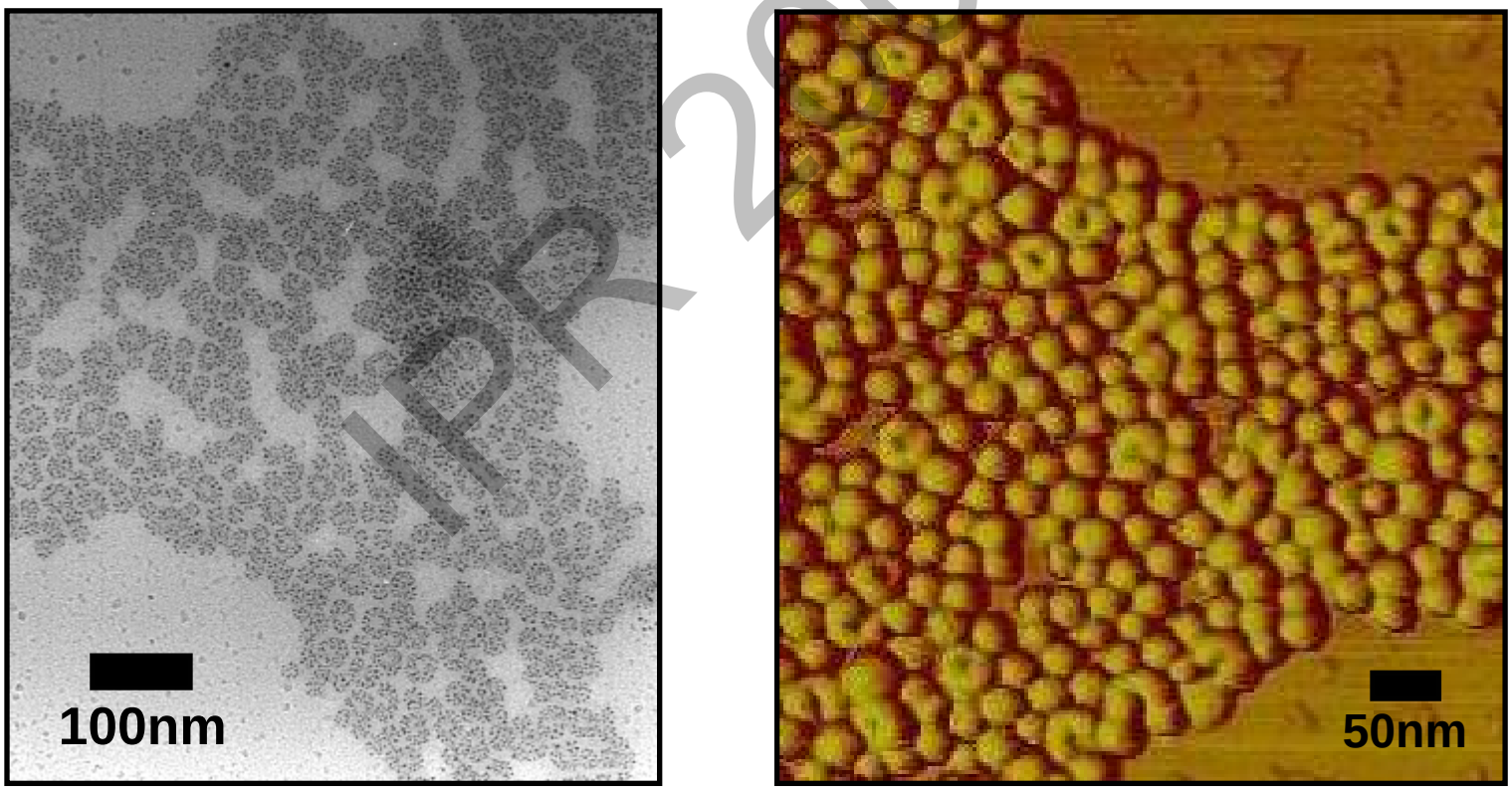
G1PS-*g*-(P2VP-*b*-PS)



Increase the size of PS chains in corona to shield charges

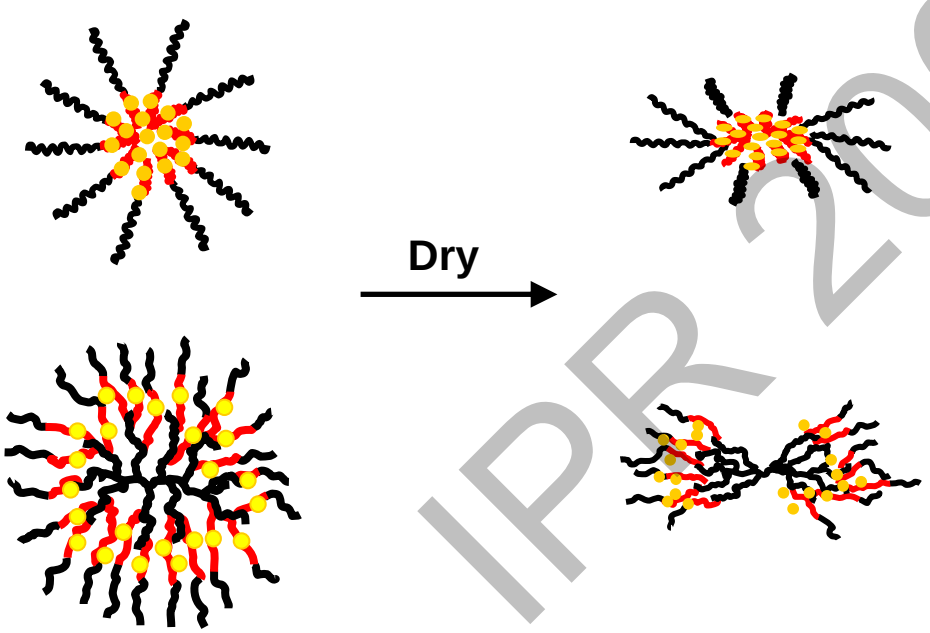
G1PS-*g*-(P2VP-*b*-PS)

PS degree of polymerization increased from 65 to 150

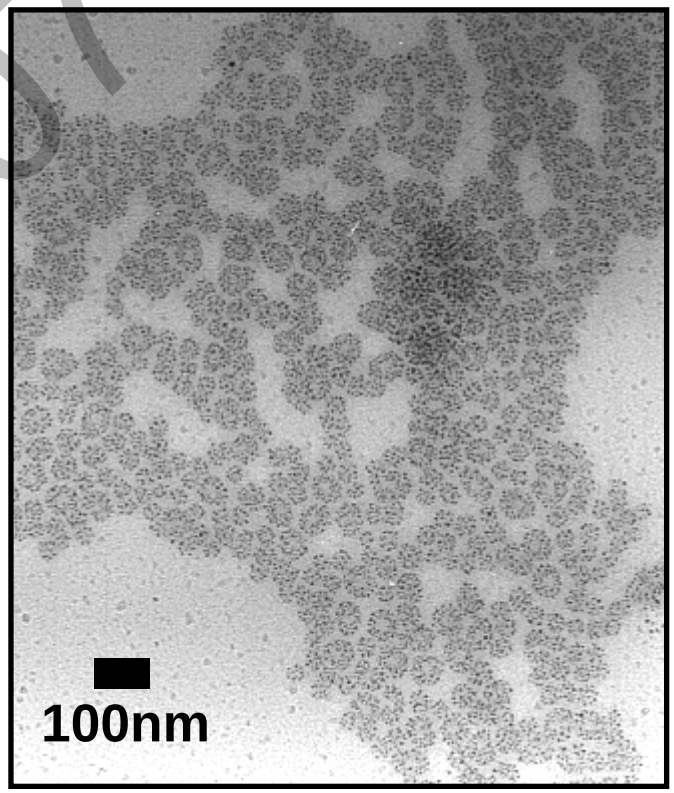


Structure Analysis

Solid Structures: Linear side-chain micelles

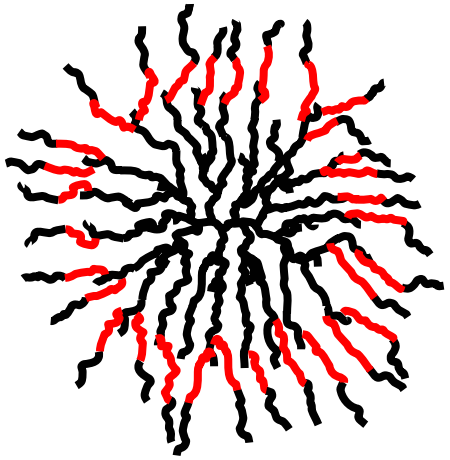


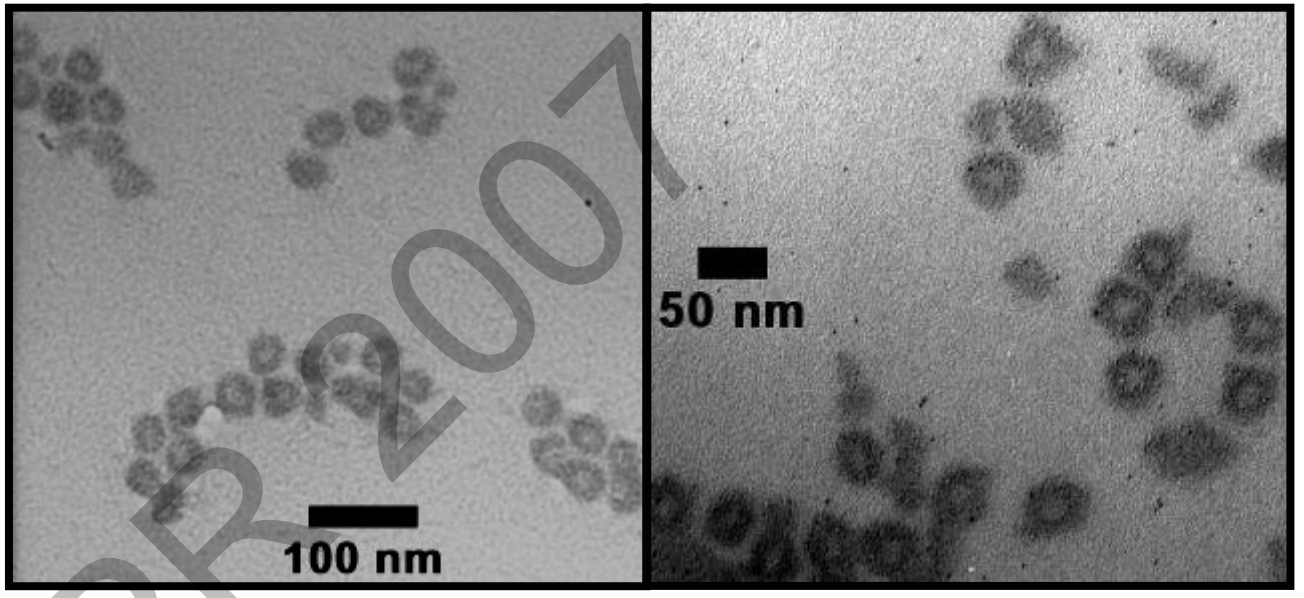
Ring Structures: Graft copolymer



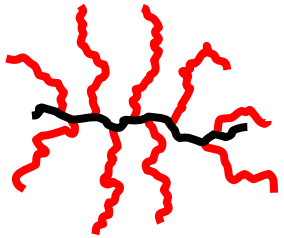
Structure Analysis

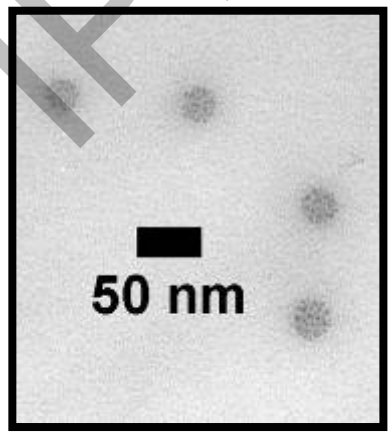
G2

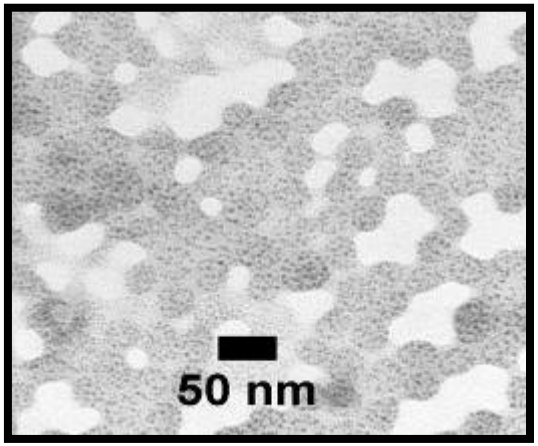




G0





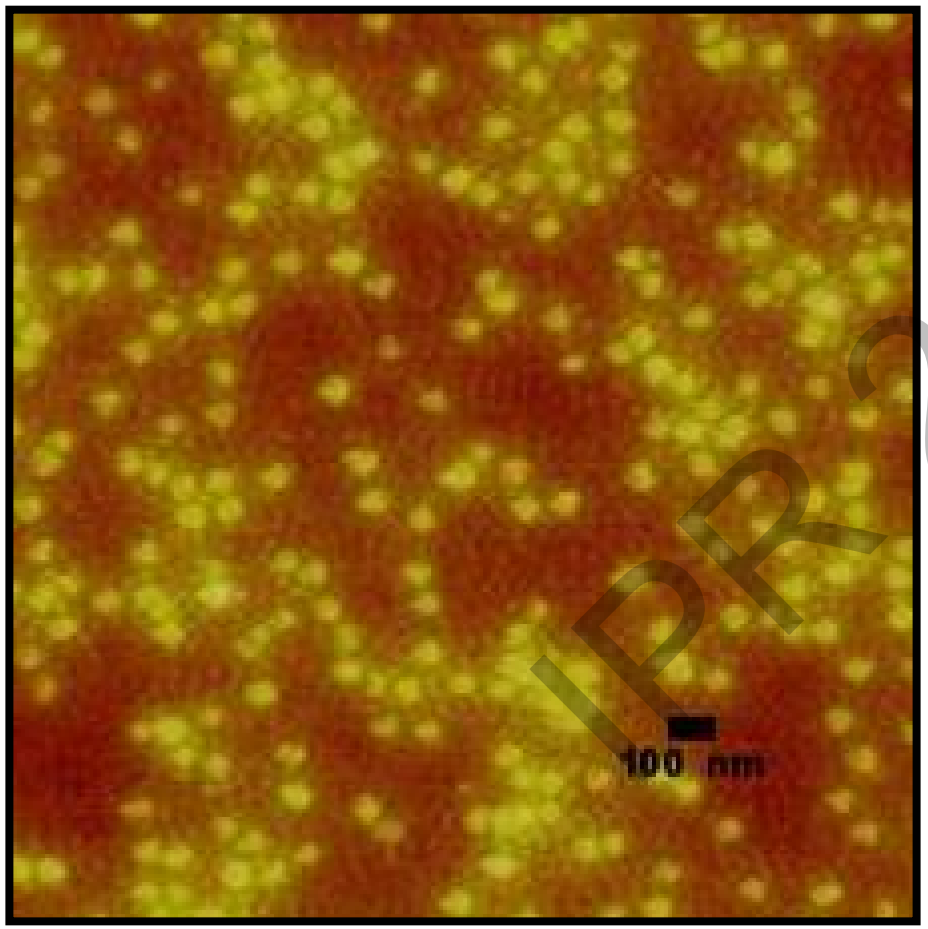


Purification

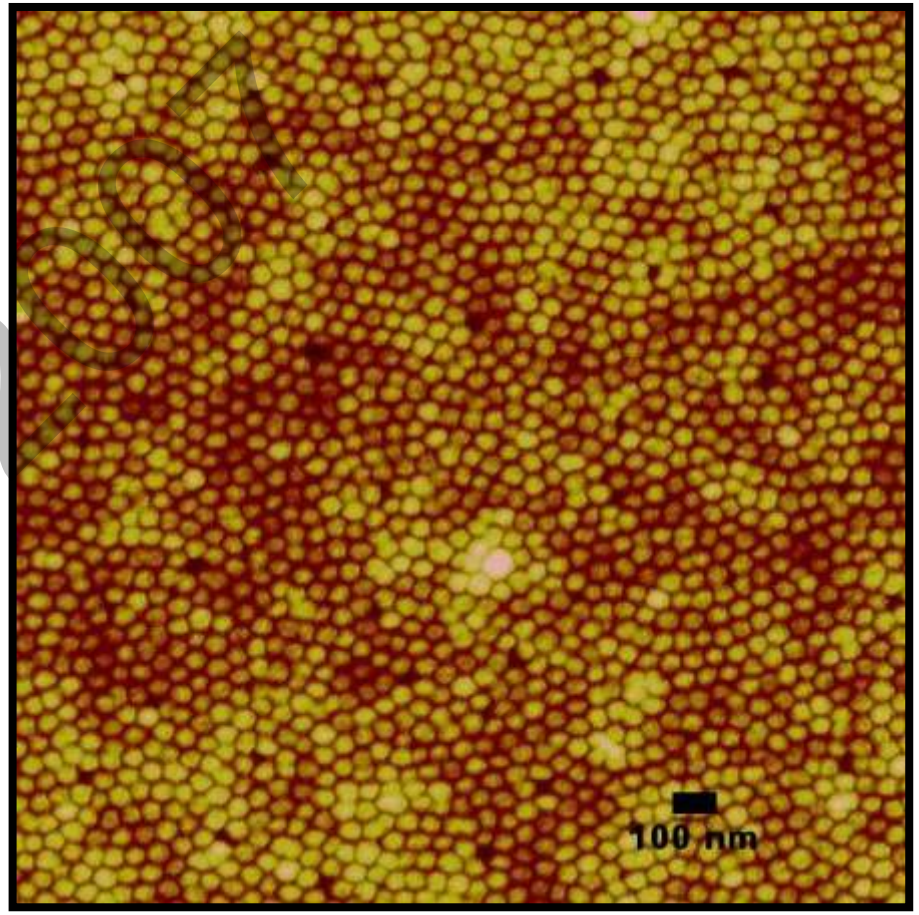
“Cloud-point centrifugation”

Addition of a non-solvent to reach cloud point, followed by centrifugation to isolate graft material.

Atomic Force Microscopy

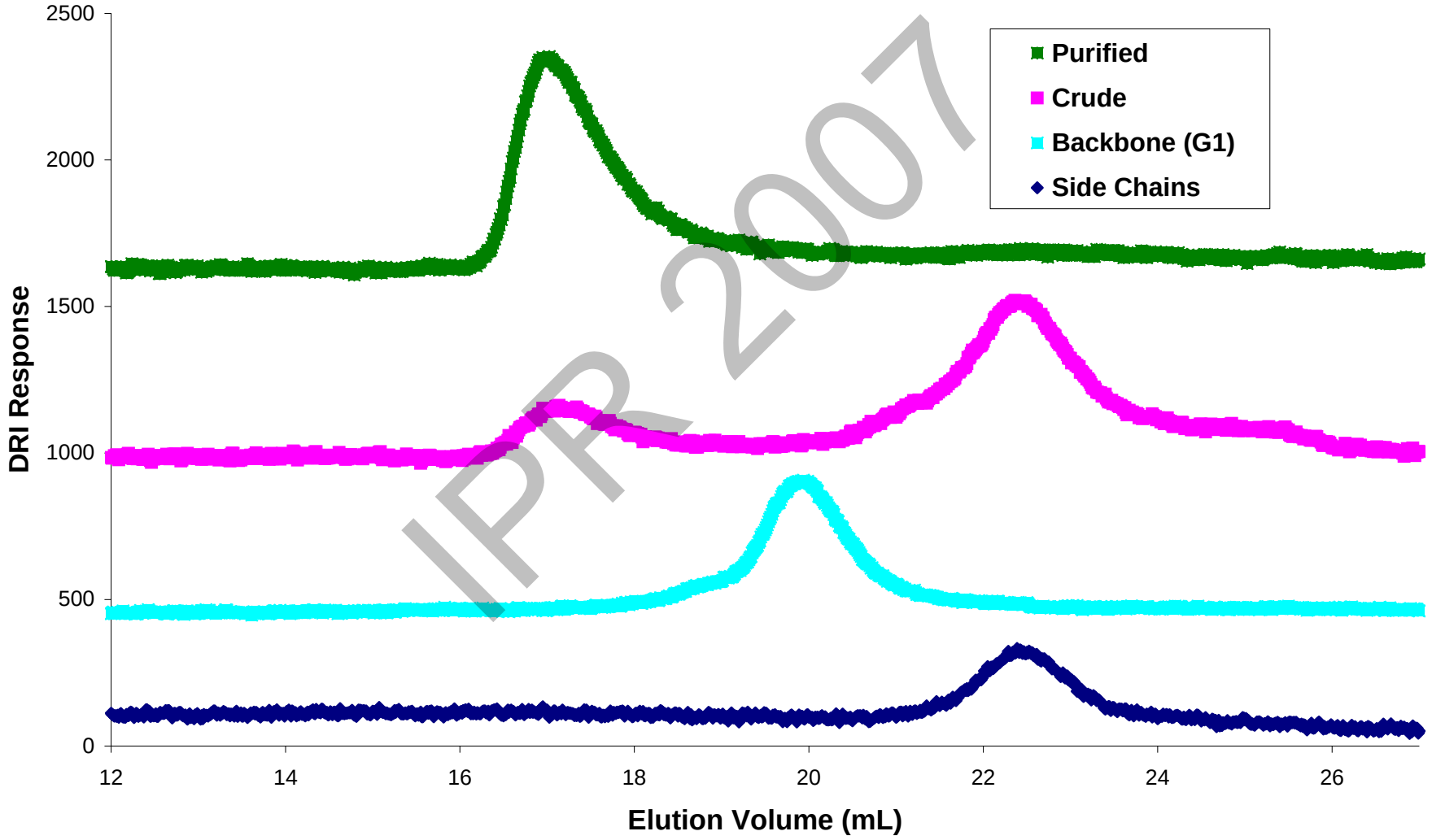


Crude

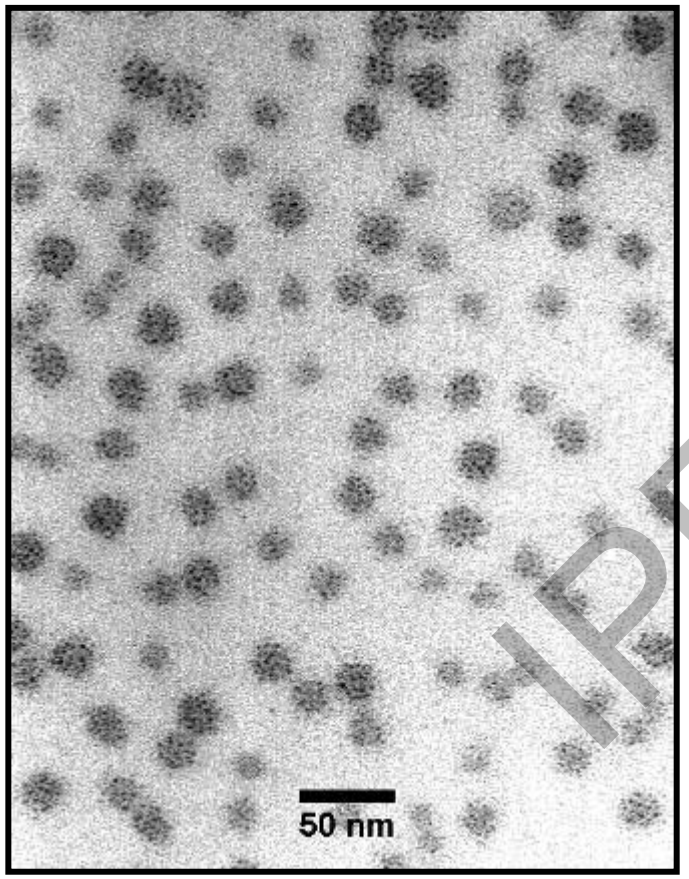


Purified

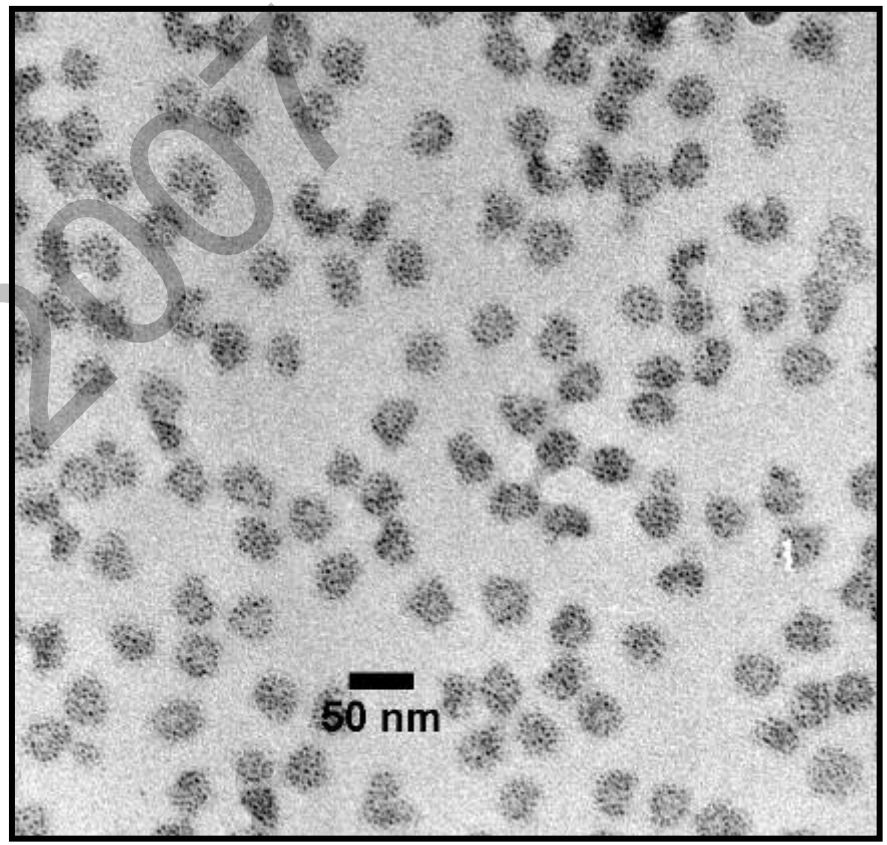
Chromatography



Transmission Electron Microscopy



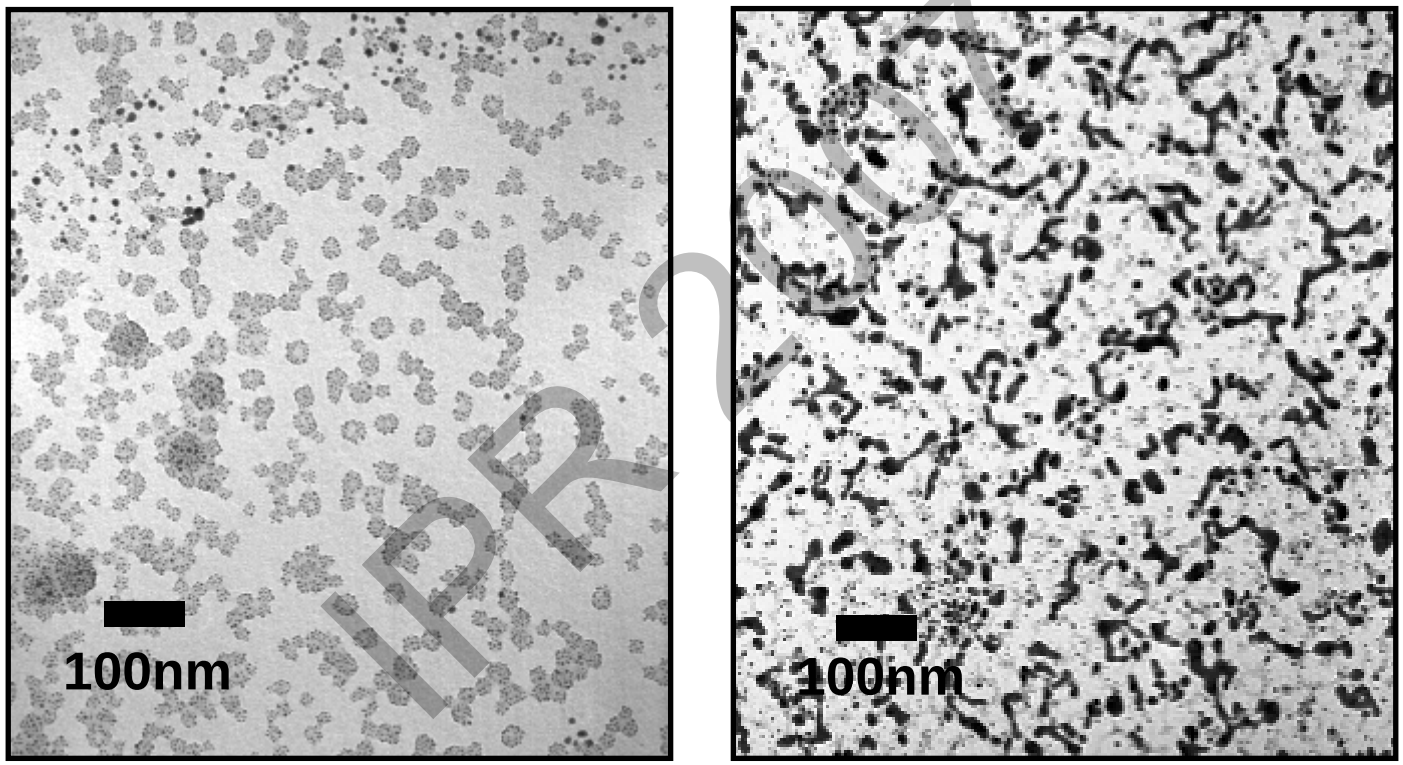
G0



G2

Hydrogen Plasma Etching

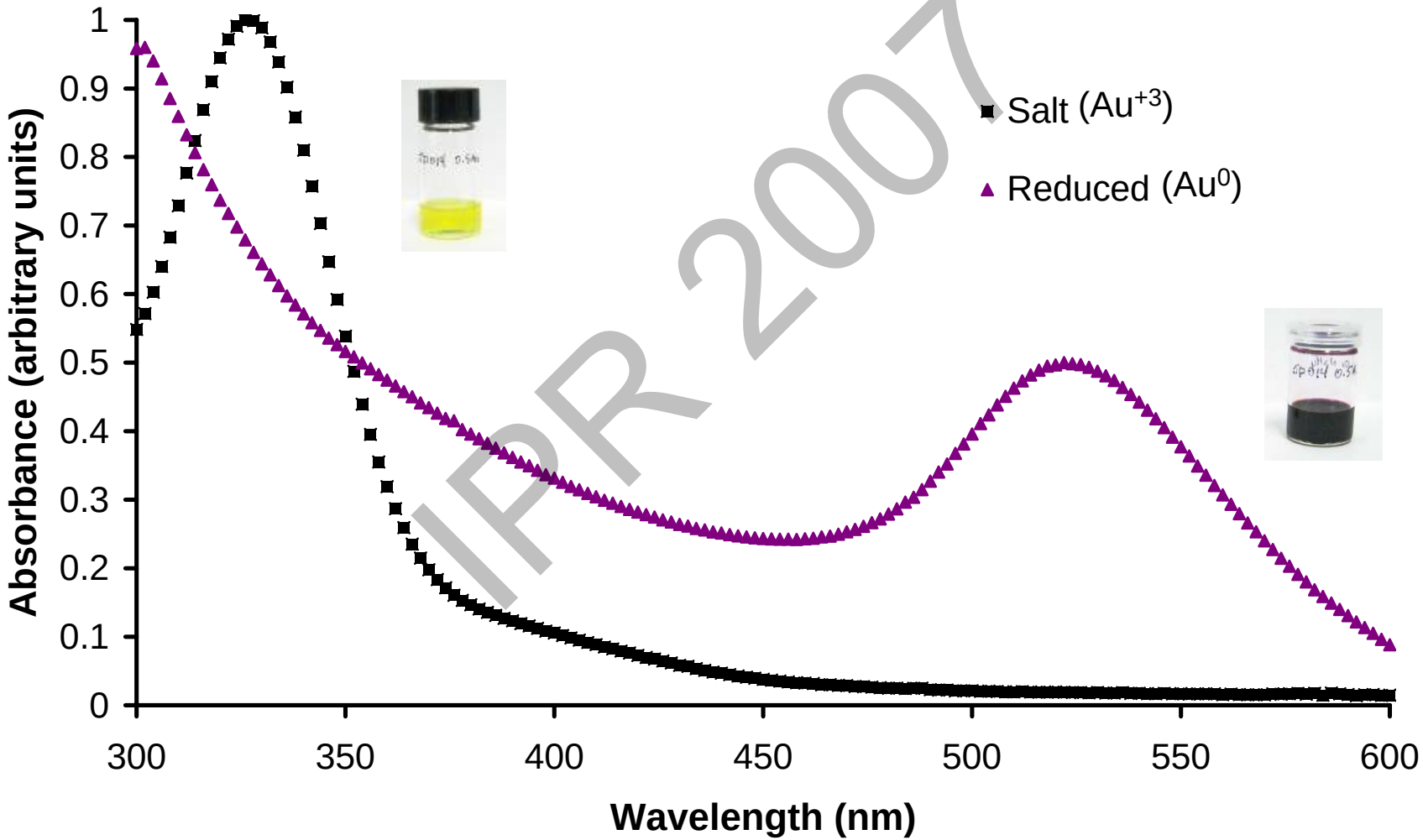
Hydrogen Plasma Etching



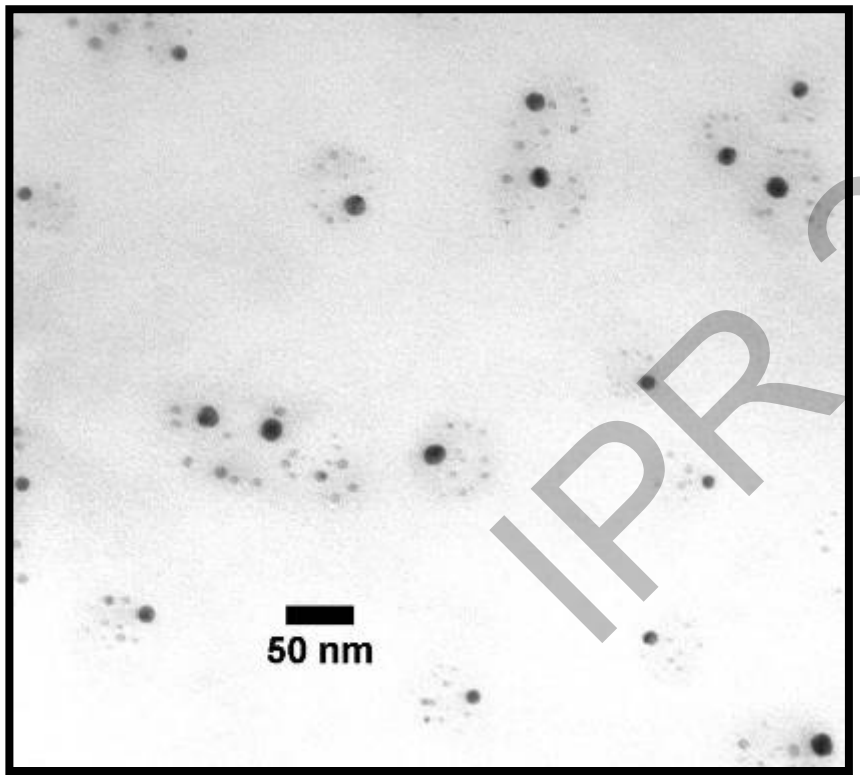
Reduction and polymer removal (solid state)

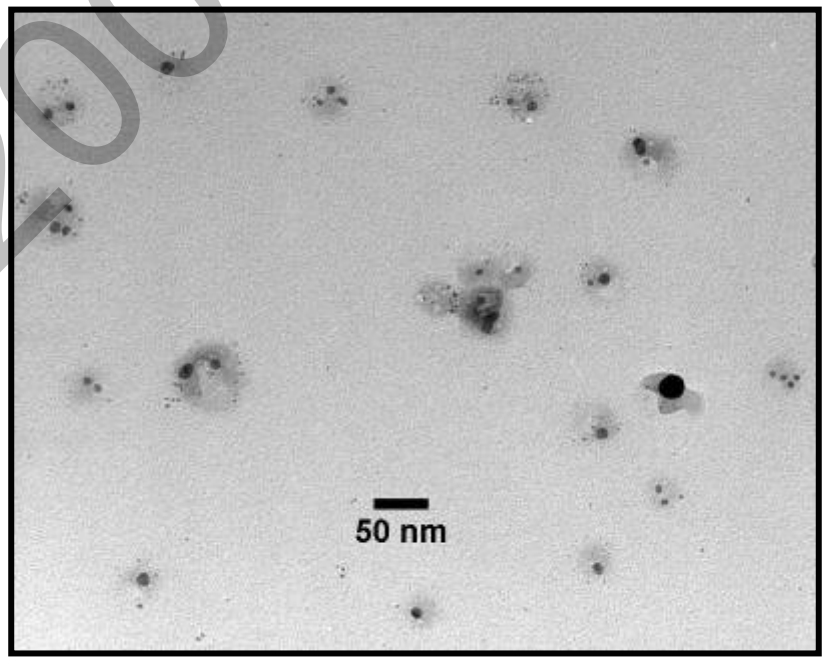
Hydrazine Solution Reduction

UV-Vis Absorbance



G1PS-*g*-(P2VP-*b*-PS)





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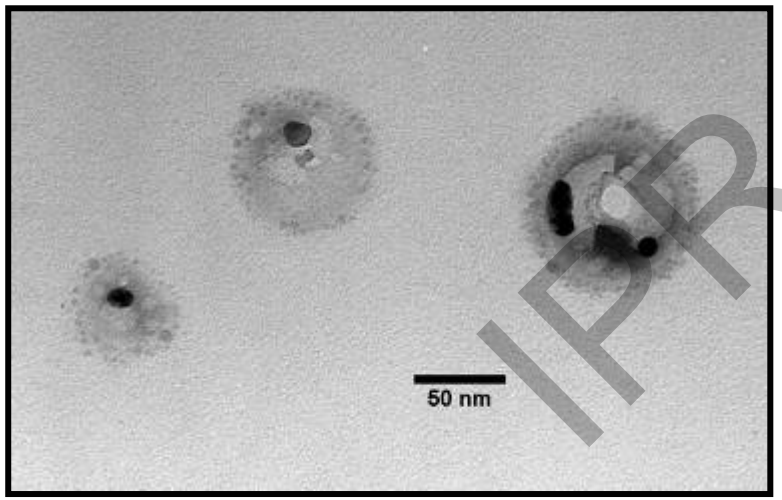
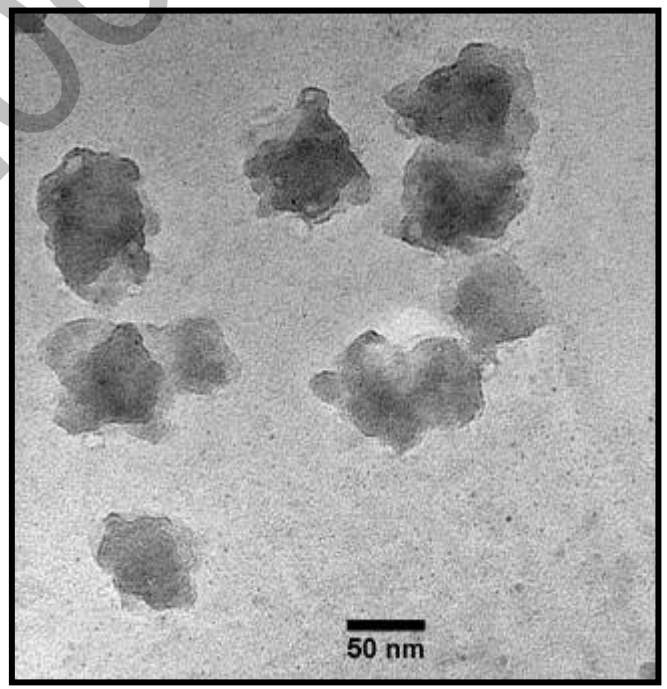
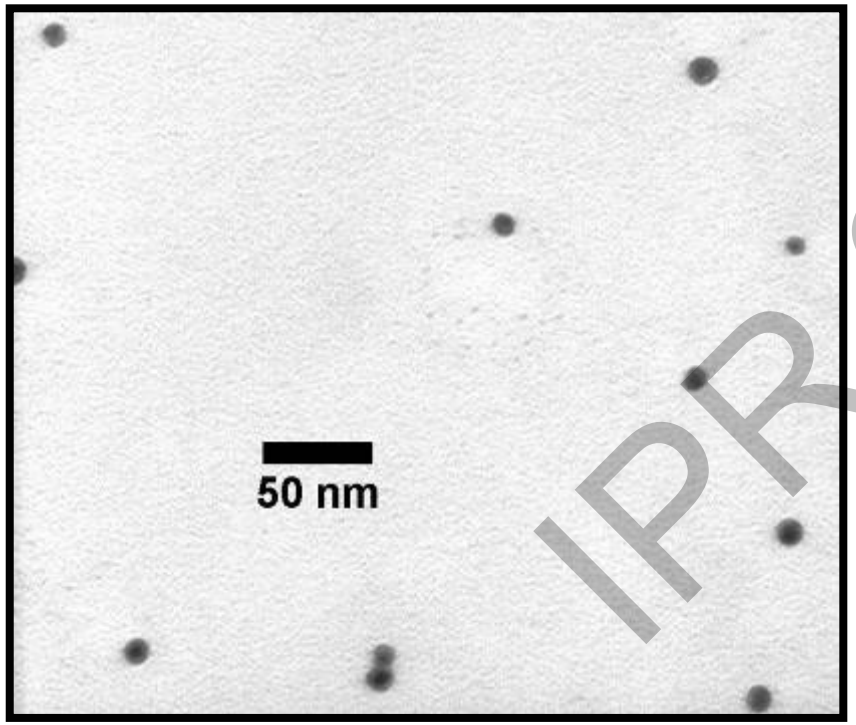
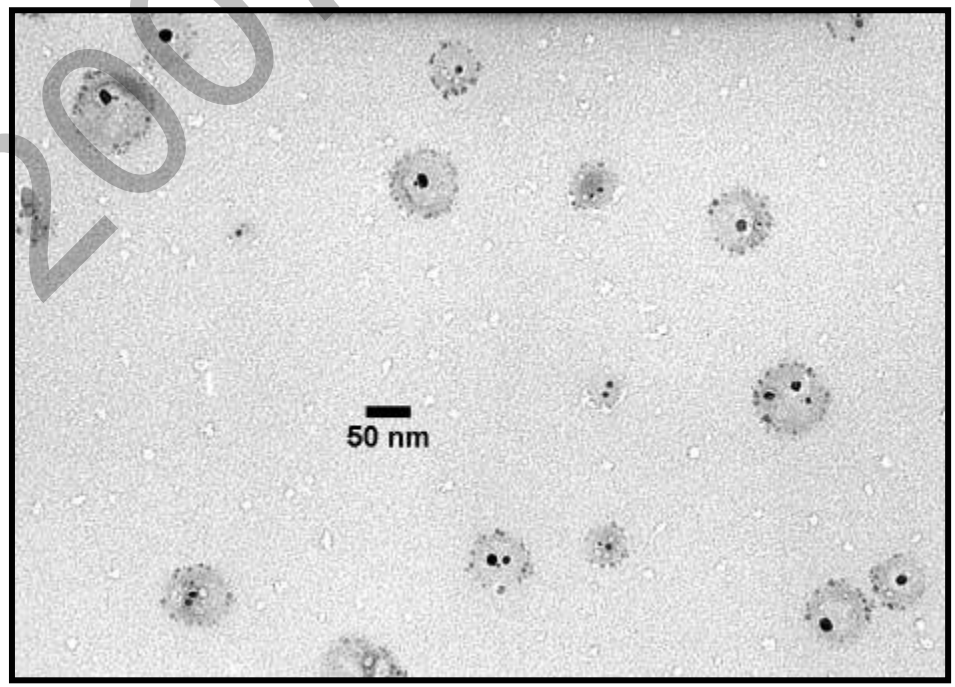




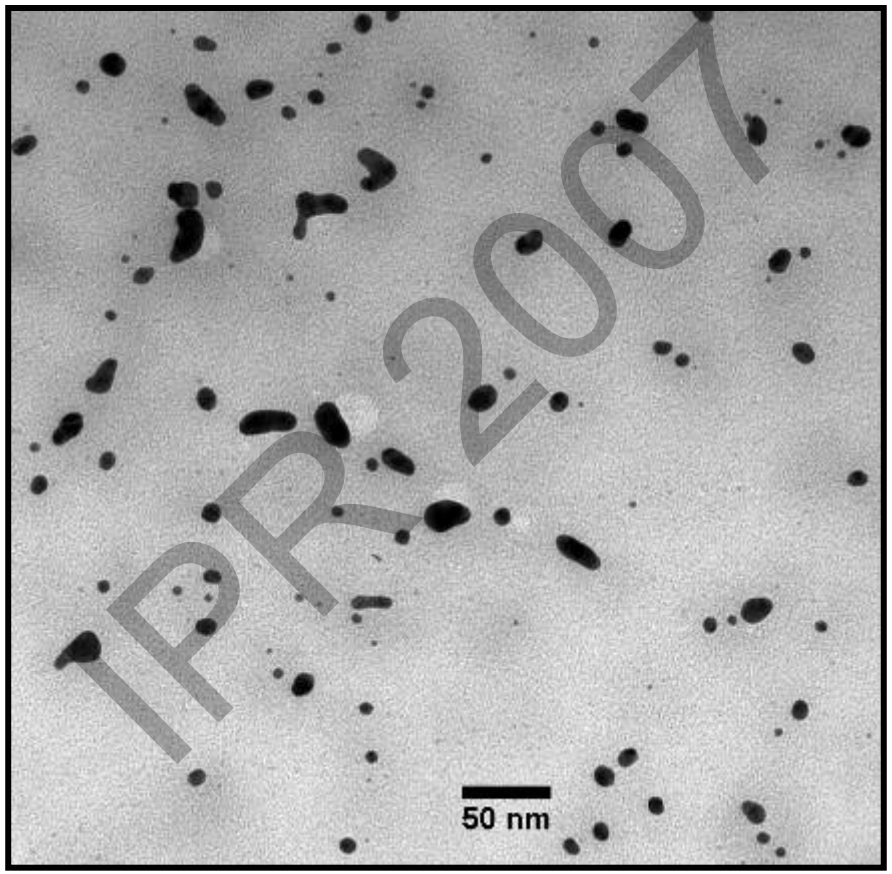
PS-*g*-(P2VP-*b*-PS)





Hydrazine Vapour Reduction (Solid State)

G1PS-*g*-(P2VP-*b*-PS)



Reduction by hydrazine vapour

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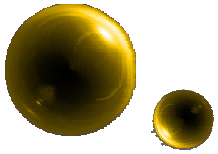
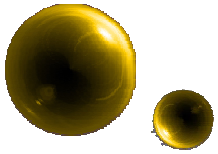


Conclusions

- Different arborescent copolymer templates successfully loaded with gold
- Aggregation can be controlled through synthetic procedure and/or solvent changes
- Procedures developed for purification of graft copolymers
- Absorbance fingerprint typical of nanoparticles
- Ring-like structures observed for salt-loaded templates, consistent with hollow metallic nanosphere morphology
- Reduced gold structures rupture in electron beam (evidence for hollowness?)



Future Work

- Optimization of reduction process to obtain one gold nanoparticle per template molecule.
- Examine and confirm nanoparticle structure and stability.
- Explore use as catalysts after loading with transition metals.

Acknowledgements

Institute for Polymer Research

Lab Colleagues

DWI Institute, RWTH Aachen, Germany

NSERC, OGS, DAAD, Department of Chemistry

University of Waterloo

Thank you!

Questions?