Spring 5-1-2024

Synthesis of Thermoresponsive Poly(N-isopropyl acrylamide) Based Core-Shell and Hollow Shell Nanogel with Tunable Core and Shell Thickness

Mohamad Hijazi
Chapman University, mhijazi@chapman.edu

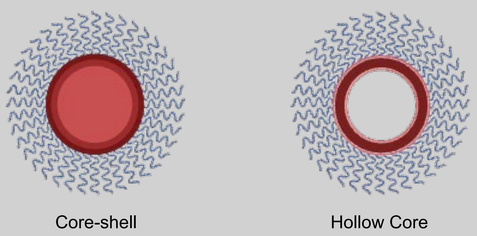
Molla R. Islam
Chapman University, islam@chapman.edu

Synthesis of thermoresponsive poly(N-isopropyl acrylamide) based core-shell and hollow shell nanogel with tunable core and shell thickness

Mohamad Hijazi and Molla Islam
Schmid College of Science and Technology, Chapman University

Background

- Nanogels are three-dimensional polymer networks adaptable in size, shape, and softness.[1,2]
- Can be made responsive to external factors like temperature and pH. [1]
- Traditional types (e.g., ultra-low crosslinked, high crosslinked, core-shell) are used in drug delivery but lack protective compartments.[3,4]
- Hollow core nanogels offer protective storage for drugs, featuring a hollow center.[5]
- Control size and diameter can be manipulated by changing reaction conditions.[6]

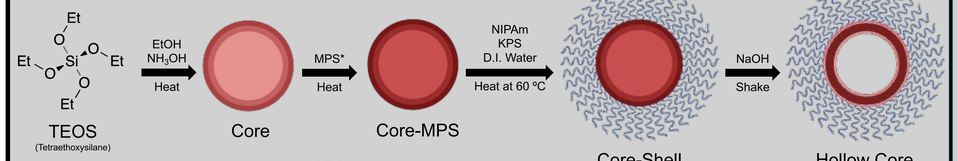


Scheme 1- Structure of traditional and hollow core nanogels

Research Objectives

- Investigate the effect of temperature to control the core particles precursor of hollow-shell nanogels.
- Wrapping the core with ultra-low crosslinked NIPAm shells to improve drug-loading efficiency.
- Dissolve TEOS-based silica cores within core-shell particles to form hollow-core with a precise thickness of the shell.

Methods



* 3-mercaptopropyltrimethoxysilane (MPS)

Scheme 2- Step-wise synthesis of hollow core nanogel.

- SEM and OM were used for particle characterization.
- DLS was used for size measurements.

Results

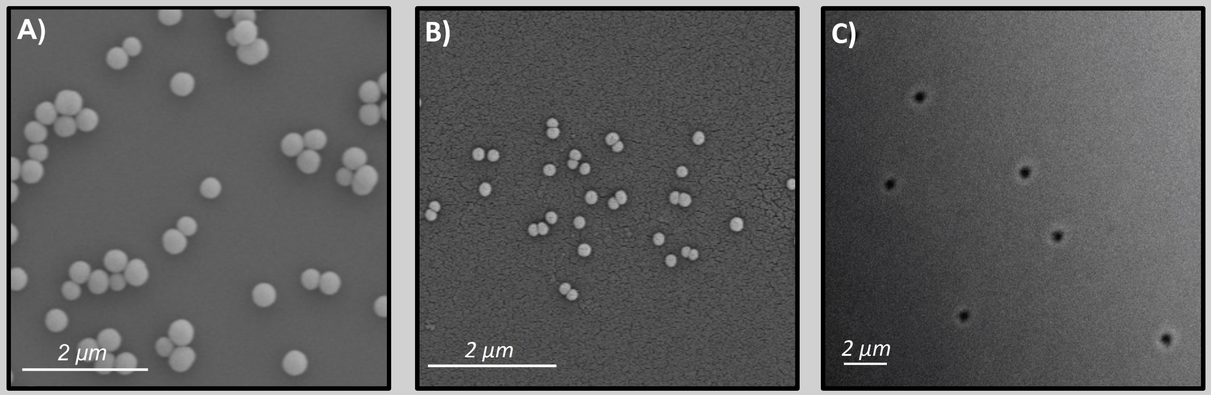


Figure 1. Silica core nanogels were imaged using a Scanning Electron Microscope (SEM) at 30 ºC (A), 60 ºC (B), and core-shell nanogels using Optical Microscopy (OM) (C).

- SEM images reveal uniformly sized spherical particles synthesized at both 30°C and 60°C, with those synthesized at 30°C appearing larger.
- OM images show core-shell structures characterized by a white halo surrounding a dense core.

Synthesis Temperature	Hydrodynamic Radius (nm) (20 ºC)	
	CORE	CORE-SHELL
30 ºC	195 ± 10	449 ± 20
60 ºC	66 ± 3	233 ± 10

Table 1. Average hydrodynamic radius measured with Dynamic Light Scattering (DLS) of core and core-shell of particles synthesized at 30 and 60 ºC.

- Silica core particles synthesized at 30°C measure 195 nm, whereas those synthesized at 60°C are smaller at 66 nm.
- Core-shell particles synthesized at 30°C exhibit a hydrodynamic radius of 449 nm, while those at 60°C have a smaller radius of 233 nm.

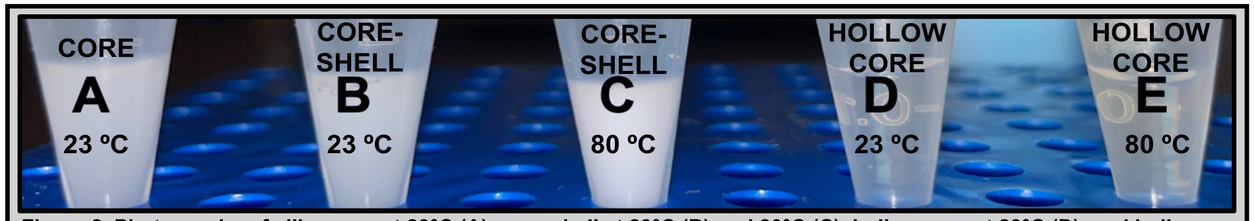


Figure 2. Photographs of silica core at 23°C (A), core-shell at 23°C (B) and 80°C (C), hollow core at 23°C (D), and hollow core at 80°C (E).

- Morphological changes in core-shell particles are evident when heated from 23°C to 80°C, where they shift to a darker white hue at 80°C.
- The hollow core solution, initially clear, transforms into a pearlescent clear color with a slight spectral reflection at 80°C, demonstrating the thermoresponsiveness of the NIPAm shell.

Conclusion

- Particle shape and size distribution remained uniform despite synthesis temperature changes.[6]
- Lower temperatures led to larger particles due to slower nucleation and polymer growth. [7]
- Optical microscope images showed less dense NIPAm shells compared to the silica core.[8]
- Color changes upon heating indicated NiPAM shell's thermoresponsive behavior. [8]
- High temperatures caused NIPAm shell contraction, darkening the solution. [8]

Future Work

- Study drug loading capacity with model drugs like Fluorescein.
- Monitor drug release kinetics for timing and efficiency.
- Manipulate nanogel responsiveness for enhanced control over drug release and targeting.

Acknowledgements

Special thanks to Chapman's Schmid College of Science and Technology, Chapman's Office of Research, the High-Resolution Imaging Facility for their support, and the BIO 494 course.

References