Double Gradients, Double Control: Advancing Core-Shell Particles

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Core-shell particles are versatile building blocks in colloidal and materials science, where precise control over particle size and shell architecture is essential for tuning functional properties. In template-assisted approaches, removal of the core enables the formation of hollow structures, which are widely used in applications such as drug delivery, waste remediation, and catalysis.[1] Beyond these applications, both core dimensions and shell thickness also strongly influence physical behavior, including optical response, highlighting the need for synthetic strategies that enable independent and continuous control over these parameters.[2] Therefore, our present work focuses on the controlled synthesis of gradient core-shell particles, offering new opportunities for tailoring structure-property relationships in colloidal systems.
Here, we present a double gradient approach to the synthesis of core-shell particles, allowing simultaneous control over core size and shell thickness. Monodisperse polystyrene (PS) particles were first employed as templates to grow silica shells with a controlled thickness gradient via our previously established CrESP [3] method. In a second step, a gradient in core size was introduced using a modified CrEEP [4] approach, yielding PS particles with a well-defined size distribution. Subsequent silica deposition on these gradient cores resulted in core-shell particles exhibiting coupled gradients in both core size and shell thickness. Together, these approaches provide access to mechanistic insights into the silica shell growth process.
The combined control over core size and shell thickness further establishes a versatile platform for designing complex particle architectures with multiple structural gradients. Overall, this approach provides a general route toward advanced colloidal building blocks with independently tunable structural parameters.

Keywords:
Stöber Synthesis, Emulsion Polymerization, Colloidal Particles, Core-Shell, Size Gradient

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