

Tunable Structural Color in Copolymer Microgels through Controlled Synthesis and Thermally Induced Assembly

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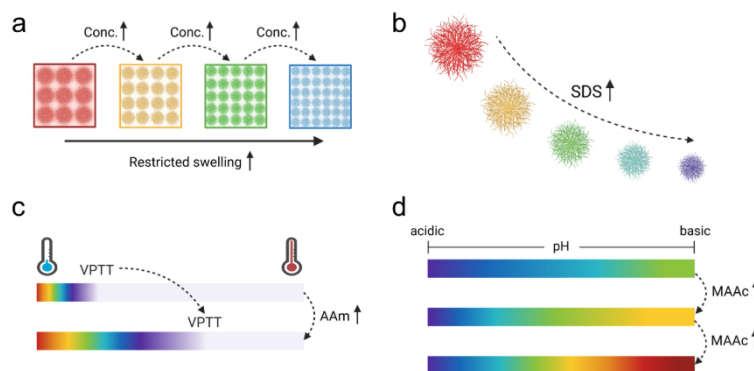
Structural color formation in soft colloidal systems represents a promising and straightforward approach toward stimuli-responsive photonic materials. In this study, we investigated the assembly of poly(N-isopropylacrylamide) (PNIPAm)-based microgels incorporating varying percentages of anionic (methacrylic acid), neutral (acrylamide), and cationic (2-(dimethylamino)ethyl methacrylate) comonomers to create multifunctional colloidal building blocks capable of forming dynamic structural colors. Through systematic synthesis optimization and surfactant-mediated size control, we obtained libraries of copolymer microgels with precisely tailored particle diameter, surface charge, and stimuli-responsive swelling behavior.

We generated structural colors across the visible spectrum by colloidal crystal assembly through thermal annealing and modulated the interparticle spacing and consequently the reflected wavelengths by changing the microgel concentration. Additionally, by fine-tuning the microgel responsiveness, we engineered materials with precise wavelength shifts in the reflected color upon environmental stimuli (temperature or pH).

Our findings provide key insights into the interplay between microgel composition, particle properties, concentration-dependent ordering, response behavior, and resulting optical properties. This offers a foundation for designing dynamic, structurally colored colloidal photonic materials for a broad application range, including multifunctional sensors, optical tags, and responsive coatings.

Keywords:

(PNIPAm)-based copolymer microgels, functional comonomers, temperature- and pH-responsiveness, colloidal assembly, dynamic structural color



Schematic representations of investigated microgel properties and their effect on structural color. a) Microgel concentration affects swelling capabilities. b) Surfactant modulation affects microgel size. c/d) Change of response behavior (temperature/pH) through incorporation of suitable comonomers.

References:

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