Chemical Engineering Doctoral Defense

Polymer-Gold Composite Particles: Synthesis, Characterization, Application, and Beyond

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abstract

Polymer-gold composite particles are a tremendous research interest. Due to their unique structures, these particles demonstrate superior properties for optical, catalytic and electrical applications. Moreover, the incorporation of "smart" polymers enables the composite particles to synergistically respond to environmental stimuli, such as temperature, pH and light, with promising applications in multiple areas.

In this thesis, a novel Pickering emulsion polymerization route is employed to synthesize core-shell polymer-gold composite particles. It is found that the surface coverage of gold nanoparticles (AuNPs) is influenced by the AuNP concentration and hydrophobicity. More importantly, particles' absorption wavelength is tunable by adjusting the interparticle distance of the AuNPs. Further, these particles demonstrate excellent catalyst recyclability.

Asymmetric polystyrene-gold composite particles are successfully synthesized via a seeded emulsion polymerization route, where AuNPs serve as the seeds, allowing the growth of styrene monomers/oligomers onto them. These particles also demonstrate excellent catalyst recyclability. Furthermore, monomers of "smart" polymers, poly (N-isopropylacrylamide) (PNIPAm), are successfully copolymerized into these composite particles, enabling thermo-responsiveness with significant size variation around the lower critical solution temperature (LCST). The significant size variation gives rise to switchable scattering intensity, demonstrating potential applications in intensity-based optical sensing.

Multi-petal and dumbbell structured gold-polystyrene composite particles are also successfully synthesized via seeded emulsion polymerization. It is intriguing to observe that by controlling the reaction time and size of the AuNPs, tetrapetal-structured, tripetal-structured and dumbbell-structured gold-polystyrene composite are formed. In addition, dumbbell-shaped PNIPAm/polystyrene-gold composite particles are developed and exhibit self-modulated catalytic activity around the LCST.

Finally, carbon black (CB) particles are successfully employed for the synthesis of core-shell PNIPAm/polystyrene-CB particles. The thermo-responsive absorption characteristics of these composite particles enable them potentially suitable to serve as "smart" nanofluids with a self-regulated temperature capability. Compared to AuNPs, the CB particles provide desirable performance in nanofluids, since they show minimum plasmon resonance in the visible wavelength range, whereas the AuNPs' absorption in the visible wavelength range is undesirable.

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