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Synthesis of Hollow Silica Spheres using Skim Natural Rubber as a Template

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Extended Abstract

A hollow silica sphere (HSS) has cavity and porous shell, which are produced by thermally removing template and structure-directing agent, making it suitable for applications like drug delivery and catalysis [1, 2]. With two ultimate goals, to make the production of HSS more environmentally-friendly and to increase the value-added price of skim natural rubber (SNR) latex, which is abundant in Thailand, the use of SNR latex as a template for producing HSS from sodium silicate (SS) was of interest. Effects of the synthesis pH and amounts of SNR, cetyltrimethyl ammonium bromide (CTAB), and silica (through adjusting the SS content) on HSS morphology were examined. CTAB was used to diminish the electrostatic repulsion between SNR particles and silica particles.

Images from transmission electron microscopy (TEM) exhibited that SNR particles in the latex were quite spherical and had diameters in the range of 78 nm to 400 nm (an average particle diameter of 176 nm). It was also found that SNR particles could be completely removed by calcinations at 550 °C for 6 h. The experimental results demonstrated that by controlling rates of hydrolysis and condensation, a two-pH adjustment process from the original value to 10 h and from 10 to 7 during mixing SNR latex, SS, and CTAB allowed the silica synthesis to proceed and, simultaneously, form ordered mesoporous silica shells around each NR particle. This eventually generated HSS with the cavity diameters and thickness ranging from 70–200 nm and 3–22 nm, respectively. The control runs showed that CTAB acted as a structure-directing agent by screening charges on both silica particles and SNR particles, allowing both particle types to get close to each other and form core-shell particles. The removal of all organic materials from the core-shell particles was successfully carried out by applying the calcinations conditions, no sign of silica shell collapse. This was due to the existence of mesopores in the shell wall, generated by CTAB removal.

In addition, the experimental results showed that interactions between SNR, silica, and CTAB played important roles in producing HSS. A higher amounts of SNR particles and/or silica particles attracted more CTAB molecules to be adsorbed onto their surfaces via electrostatic attractions, and thus decreasing the surfactant concentration in the water medium, leading to micelle dissociation. Moreover, increasing the SNR amount caused the particles to rapidly flocculate and separate from the slurry of sodium silicate during the pH reduction. Consequently, only disordered porous silica was obtained as a product. The excessive amount of CTAB, however, yielded HSS and porous silica particles with worm-like mesoporous structure.

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