

Synthesis and Catalytic Properties of Silica-Cobalt Core-Shell Nanoparticles

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Abstract

As one of the most widely studied hybrid nanostructures, core-shell nanoparticles are attracting more and more attention, since properties arising from either core or shell materials can be quite different. Currently, core-shell nanoparticles have been used for many applications, including catalysis, environmental remediation, information storage, biomedical imaging, and energy harvesting. The aim of this work is to synthesize precisely controlled silica-cobalt (SiO₂-Co) core-shell nanoparticles for catalytic applications. The core material of SiO₂ nanoparticles has been synthesized by the Stöber method with an average size of 85 nm. Then, the SiO₂ nanoparticles were subjected to surface modification with 3-aminopropyltrimethoxysilane. The Co shell with controlled thickness was formed by a chemical reduction method. The size and morphology of the SiO₂-Co core-shell nanoparticles have been characterized by the field emission scanning electron microscopy (FE-SEM) and transmission electron microscopy (TEM). The SiO₂-Co core-shell nanoparticle has been used as a catalyst to degrade methyl orange, a common azo dye containing azo functional group (-N=N-). The degradation characteristics and kinetics were investigated by measurement of the absorption of the dye solution with a UV/Vis spectrometer. Kinetic studies revealed that both the surface adsorption and degradation contributed to the absorption spectra and the MO degradation by the silica/cobalt core/shell NPs appeared to be first-order with respect to the dye concentration. Initial pH of the dye solution is an important parameter, and acidic environment facilitated the degradation process. The degradation rate and efficiency increased with a decrease in initial pH of methyl orange solution. At initial PH below 3.5, up to 99% of methyl orange can be degraded within 1 min. Adequate nanoparticle dosage is required to complete the dye treatment. Reductive degradation by the SiO₂-Co core-shell nanoparticle catalyst is a very promising approach to the remediation of azo dye containing waste water due to the fast degradation rate and high degradation efficiency.