Functionally modified monodisperse core–shell silica nanoparticles: Silane coupling agent as capping and size tuning agent

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HIGHLIGHTS

- Monodisperse core–shell silica hybrid spheres were prepared by one-pot process.
- Relative standard deviation below 3% for silica hybrid spheres can be produced.
- Vinyltriethoxysilane was used as capping and size tuning agent of particles.

ABSTRACT

Vinyltriethoxysilane (VTEOS) has been used as capping and size tuning agent to prepare monodisperse core–shell silica hybrid spheres. When VTEOS was used, the relative standard deviation below 3% for silica hybrid spheres can be produced by changing the concentration of VTEOS and the ammonia catalyst. The obtained hybrid particles were characterized and confirmed by various technologies including Fourier transform infrared (FT-IR) spectroscopy, FT-Raman spectroscopy, $^{29}$Si CP (cross-polarization) MAS NMR, thermal analysis, particle size distribution, field emission scanning electron microscopy (FE-SEM) and transmission electron microscopy (TEM). FT-IR, FT-Raman, $^{29}$Si CP MAS NMR spectra and thermal analysis confirm the existence of vinyl groups on hybrid particles. Particle size distribution, FE-SEM and TEM reveal the uniformity in size/shape and the core–shell structure of hybrid particles. The influence of experiment parameters on the resulting particles, the capping and size tuning actions of other silane coupling agents (SCAs) were investigated herein as well.

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1. Introduction

Given their ease of preparation, precursors availability and low isoelectric point in water at pH = 2, silica nanoparticles are considered to be the most versatile colloidal material in both scientific research and industrial exploitation. So far, silica nanoparticles have been used in a myriad of diverse applications including catalysis, humidity sensors, electronic and thermal insulators, drug delivery, pigments, electronic and thin film substrates, stabilizing agent for semiconductor nanoparticles and colloidal template [1–8].

However, as far as we know, most of above mentioned efficient applications of silica nanoparticles are based on the functionalization of silica nanoparticles [9]. A number of organic compounds including long chain alkyl alcohols or acids, PEG, polymers, organic isocyanates, PMHS and silane coupling agents (SCAs), can be adopted as modifying agent to get organo-functionalized silica nanoparticles for various purposes [10–15]. Among organo-functionalized silica nanoparticles, a series of nanoparticles, whose structure is core–shell and coated by thin organic layer, are of particular interest. It has been proved that the core–shell silica nanoparticles exhibit special electronic, optical or optoelectronic properties [16,17]. Methods for preparing core–shell silica spheres,