Iran Polym J (2012) 21:661–668
DOI 10.1007/s13726-012-0073-7

ORIGINAL PAPER

Modification of silica nanoparticles with hydrophilic sulfonated polymers by using surface-initiated redox polymerization

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Received: 28 December 2011 / Accepted: 7 July 2012 / Published online: 7 August 2012

Abstract Sulfonated polymer/silica hybrid nanoparticles were prepared by free radical polymerization of 2-acrylamido-2-methyl-1-propane sulfonic acid (PAMPS-*g*-SN) and styrene sulfonic acid sodium salt (PSSA-*g*-SN), initiated on the surfaces of aminopropyl-functionalized silica nanoparticles (ASN). Ce(IV) ammonium nitrate/nitric acid and sodium dodecyl sulfate were used as redox initiator and stabilizer, respectively. ASN Nanoparticles were synthesized by a covalently attached 3-aminopropyltriethoxysilane onto the surface of silica nanoparticles. Sulfonated monomers (AMPS or SSA) were then grafted onto the ASN nanoparticles, ultrasonically dispersed in water, using redox initiator system at 40 °C. ASN, PAMPS-*g*-SN and PSSA-*g*-SN nanoparticles were characterized by Fourier transform infrared (FTIR), thermogravimetry, scanning electron microscopy (SEM) and transmission electron microscopy (TEM) analyses. FTIR and TGA results indicated that both AMPS and SSA monomers were successfully grafted onto the silica nanoparticles. The grafted amounts of sulfonated polymers onto the silica nanoparticles were estimated from TGA thermograms to be 46 and 22 % for PAMPS and PSSA, respectively. From SEM and TEM micrographs, the average-diameters of the polymer-grafted silica nanoparticles were measured to be <50 nm with a (semi)spherical morphology, in which several silica nanoparticles were able to form a core with PAMPS or PSSA existing around the silica nanoparticles.

Keywords Hybrid organic/inorganic nanoparticles · Surface-initiated free radical polymerization · Redox initiation · Silica nanoparticles · Sulfonated monomer

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Introduction

Nowadays, preparation of organic/inorganic hybrid (nano)materials through modification of inorganic fillers (such as, silica, titanium dioxide, iron oxide, gold and etc.) with a polymer shell is increasingly gaining interest due to their application in numerous fields including nanomaterials [1], optoelectronic devices [2], electrochemical sensors [3], photo-catalysts, pharmaceuticals [4], and electronic devices [5]. Polymer shell can change the interfacial properties of these modified particles [6]. Among inorganic particles, silica nanoparticles have received much attention due to the facile synthesis, high specific surface area, and hydrophilic surface, whereby water helps to maintain their special properties and commercial availability of these particles in different sizes. Moreover, the presence of silanol groups facilitates chemical modification on the surface of these particles [7].

Polymer can be grafted onto the surface of inorganic nanoparticles via a covalent grafting technique. Covalent grafting technique can be performed by either 'grafting to'