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Synthesis and Testing of Functional Mesoporous Silica Nanoparticles for Removal of Cr(VI) Ions From Water

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Abstract: This work reports a reliable and reproducible synthesis and in situ functionalization protocol for the synthesis of amino-functionalized mesoporous silica nanoparticles (MSNs). The porous amino-functional ($pSiO_2$-NH_2) nanoparticles were fully characterized by high-resolution transmission electron microscopy (TEM), X-ray diffraction (XRD), Attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR) and nitrogen adsorption-desorption (BET) analyses. The size of the particles was in the range of 80-200 nm with a specific surface area (SSA) of 721 m^2 $g^{-1,}$ and the pore diameter was 31Å. The $pSiO_2$-NH_2 nanoparticles were tested for their efficiency in removing Cr(VI) ions from water. Almost quantitative removal of the ions was achieved by using the particles just within two hours. The adsorption efficiency of the particles was about 50 mg g^{-1}. The synthesized porous silica particles can be repeatedly used as nano adsorbent for the adsorption removal of Cr(VI) ions from water. The nanoparticles can be potentially used for the selective capture, removal, and recovery of various other metal ions that can be complexed by amino groups.

Keywords: Mesoporous silica; functional silica; metal ions; adsorption; pollutant removal.

1. Introduction

Porous silica nanoparticles ($pSiO_2$) have shown applications in various important technological fields [1–5]. In particular, mesoporous silica nanoparticles (MSNs), which are basically pSiO2 with pore sizes in the range of 2-50 nm, have been used for the removal of various organic and inorganic pollutants by adsorption from water [6,7]. The high adsorption efficiency of the MSNs is due to their high surface area resulting from the porous network [8,9]. The complexation efficiency of the bare MSNs can be further improved by functionalizing them with various organic functional groups [10-14]. The functional groups such as carboxylic acid (-COOH), amino (-NH_2), thiol (-SH), etc. can selectively complex various toxic metal ions from water [6].

Various post-synthesis functionalization strategies were used to prepare MSNs bearing different functional groups [15,16]. The post-synthesis functionalization strategies involve two or even a multi-step process and are time-consuming [17-21]. Further, the grafting of functional