

Article

Amino Surface Modification and Fluorescent Labelling of Porous Hollow Organosilica Particles: Optimization and Characterization

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Abstract: Surface modification of silica nanoparticles with organic functional groups while maintaining colloidal stability remains a synthetic challenge. This work aimed to prepare highly dispersed porous hollow organosilica particles (pHOPs) with amino surface modification. The amino-surface modification of pHOPs was carried out with 3-aminopropyl(diethoxy)methylsilane (APDEMS) under various reaction parameters, and the optimal pHOP-NH₂ sample was selected and labelled with fluorescein isothiocyanate (FITC) to achieve fluorescent pHOPs (F-HOPs). The prepared pHOPs were thoroughly characterized by transmission electron microscopy, dynamic light scattering, FT-IR, UV-Vis and fluorescence spectroscopies, and microfluidic resistive pulse sensing. The optimal amino surface modification of pHOPs with APDEMS was at pH 10.2, at 60 °C temperature with 10 min reaction time. The positive Zeta potential of pHOP-NH₂ in an acidic environment and the appearance of vibrations characteristic to the surface amino groups on the FT-IR spectra prove the successful surface modification. A red-shift in the absorbance spectrum and the appearance of bands characteristic to secondary amines in the FTIR spectrum of F-HOP confirmed the covalent attachment of FITC to pHOP-NH₂. This study provides a step-by-step synthetic optimization and characterization of fluorescently labelled organosilica particles to enhance their optical properties and extend their applications.

Keywords: hollow silica particles; aminopropyl surface modification; fluorescent labelling

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low stability of the silica structure. This limitation can affect the concentration of organic functional groups on the silica surface because the higher the concentration of functional groups on the surface, the more unstable the silica structure [8,9]. Apart from the direct condensation

1. Introduction

Porous hollow organosilica particles (pHOPs), among several silica nanoparticles, have attracted researchers' attention in many fields due to their unique and functional properties. Their large encapsulated inner space and their porous shell framework gain these particles a larger specific surface area and higher concentration of free silanol groups on the surface than solid silica nanoparticles. Accordingly, these particles have many features that are a general platform for functionalized silica nanomaterials [1,2]. The surface modification of pHOPs with amino groups is an essential strategy for more accessible surface decorations with other functional groups (such as fluorescent markers, contrast agents and other biomolecules), which could expand the diversity in their applications [3,4]. Two conventional approaches for surface modification are usually proposed: post-grafting and direct condensation [5,6]. Each has its drawbacks and advantages. For example, in the post-grafting process, the organic moieties have a non-homogeneous distribution on the surface of nanoparticles, mainly near the inner surface of the pores, which it sometimes transcends to completely block the pores when the concentration of functional moieties is high. In the direct condensation approach, the organic moieties have a homogeneous distribution in the entire silica framework without causing pore-enclosed [5,7]. The direct condensation process suffers from the less functional groups located at the surface and the