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LETTER

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Facile synthesis of β-cyclodextrin-grafted solid silica nanoparticles

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Abstract

In this work, a simple and reliable method for the synthesis of β-cyclodextrin (β-CD)–grafted silica nanoparticles (SiNPs) is developed. The synthetic protocol included postsynthesis functionalization of silica nanoparticles with aminopropyl trimethoxysilane (APTES) followed by the condensation of the amino groups with imidazole carbamate ester of β-CD. The activated β-CD (carbamate ester) was prepared by reacting it with carbonyldiimidazole (CDI). The grafting of (β-CD) on SiNPs was confirmed by ATIR-IR, DLS, and TGA analyses. The method developed can be easily reproduced with any other oxide nanoparticles for the preparation of β-CD-grafted nanoparticles.

KEYWORDS

β-cyclodextrin, grafting, hybrid nanoparticles, silica nanoparticles, surface modification

1 | INTRODUCTION

The cyclodextrins (CDs) are cyclic oligosaccharides made of 1,4 linked glucopyranose subunits.[1] The glucopyranose subunits are joined together by oxygen bridges and this structure forms hydrophilic outer surface and lipophilic central cavity.[2] The main characteristic property of CDs is their ability to form inclusion complexes with several compounds especially with drug molecules.[3] The drugs which are insoluble in water when complexed inside the hydrophobic cavity of CDs they form a soluble complex hence CDs are used to improve the solubility of drugs.[4] In addition, the CDs are also used extensively in various other applications such as food, cosmetics, and chromatography.[5] There are three main cyclodextrins, namely α-, β-, and γ-cyclodextrin. Out of these, the β-CD is the most common CD in pharmaceutical formulations, and it is the most studied CD for drug delivery applications.

The grafting of β-CD molecules on the surface of nanoparticles produces hybrid core-shell nanomaterial which combines the inclusion complex formation property of β-CD and the intrinsic property of the nanoparticle on which it is grafted. Therefore, a continued interest to prepare β-CD-grafted nanoparticles is observed. Some representative examples of the β-CD-grafted materials include the synthesis of β-CD-grafted magnetic nanoparticles for drug delivery,[6,7] β-CD-grafted TiO_2 nanoparticles for improved dispersability in polymer nanocomposites,[8] β-CD-grafted barium titaniate nanoparticles for improved colloidal or dispersion stability,[9] and β-CD-grafted chitosan nanoparticles for drug delivery.[7,10] The previous works reported in the literature about grafting of β-CDs on various nanoparticles used multistep and complicated synthetic protocols. So, there is a need to develop new, fast, and efficient method for rapid and reliable grafting of β-CDs on nanoparticles. For this purpose, in the present work, a relatively simple, short, and reliable method for grafting of β-CD on silica nanoparticles by preparing the carbamate ester of β-CD and its grafting on amino-functionalized silica nanoparticles (SiNPs) is developed. The importance of the work lies in the fact that the synthetic protocol developed can be easily reproduced with any other oxide nanomaterials to prepare β-CD-grafted nanoparticles.

