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Natural halloysite nanotubes /chitosan based bio-nanocomposite for delivering norfloxacin, an anti-microbial agent in sustained release manner

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ABSTRACT

Applying nanotechnology to deliver drug could result in several benefits such as prolong duration of action, enhancement in overall bioavailability, targeting to specific site, low initial loading dose require, systemic stability enhancement etc. Halloysite is one of those clay minerals showing maximum effectiveness when consider as a nano drug carriers for different kind applications. Here, we have used norfloxacin as the model drug for loading into halloysite nanotube (HNT) for its anti-bacterial activity. Norfloxacin was loaded into halloysites by vacuum operation and sonication. The nanotubes were evaluated using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), scanning electron microscopy (SEM), optical microscopy, water absorption studies, cytotoxicity studies, antimicrobial studies and in vitro diffusion studies. SEM, FT-IR and XRD analysis data showed that the norfloxacin was successfully loaded into nanotubes. TEM analysis confirmed loading of norfloxacin in halloysites' lumen. The halloysite/chitosan nanocomposites were prepared by solvent casting and freeze-drying method. SEM analysis revealed compact and rugged surface of nanocomposites due to existing norfloxacin loaded halloysite. FTIR and XRD confirmed formation of nanocomposite. The nanocomposites showed good antimicrobial effect and good biocompatibility in cytotoxicity study. The in-vitro release studies revealed that halloysite/chitosan nanocomposites were able to sustain the drug release. Also, the nanocomposites were stable in various humidity conditions. Therefore, all the outcomes suggest that the prepared nanocomposites can provide enhanced therapeutic benefits and they can be very potential nano vehicle for sustaining drug delivery.

1. Introduction

Nowadays nanoscale-controlled drug delivery systems have emerged as the need for pharmaceuticals [1]. Several drug carriers have been used to improve therapeutic effect, drug loading capacity and to lower adverse effects of drug molecules. The need of the hour is green technology which suggests developing environment safe and harmless nano products for the society [2]. Limitation in this field is to achieve the controlled release/sustained release ability of nanomaterial, biocompatibility, cost and availability. Halloysite nanotubes (HNTs) with excellent properties in tuning drug release, biocompatibility and natural abundance have established itself as appropriate nano container for delivering of active molecules. Therefore, these tubular structured nanomaterials are highly desired or being investigated for different novel formulations such as sustained and controlled release of active agents [3].

Halloysite is found in nature as a hydrated mineral formed from rolled aluminosilicate sheets (Fig. 1A) [4] with formula $Al_2Si_2O_5(OH)_4.2H_2O$. The halloysite mineral has a layer periodicity of 10 Å. On heating, halloysite 10 Å dehydrates to halloysite 7 Å (Fig. 1B) having molecular formula of $Al_2Si_2O_5(OH)_4$ [5]. The halloysite nanotubes sizes vary according to their geological deposits. In recent research, *Cavallaro G.* et al. [6], compared the sizes of halloysites from different geological deposits. Pure halloysite measurement ranges are as described here; inner diameter from 10 to 100 nm, outer diameter of 30–190 nm, length 500–1000 nm and wall thickness of 10–15 atomic aluminosilicate sheets [7,8]. There are very less number of hydroxyl (OH) groups on its surface. HNTs have rich biocompatibility and less toxicity. HNTs also exhibit high mechanical and thermal properties.

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