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ORIGINAL RESEARCH PAPER

Synthesis of Mesoporous Silica and Modified as a Drug Delivery System of Ibuprofen

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ABSTRACT

In this work we synthesized of mesoporous silica nanoparticles and functionalized with 3-aminopropyltriethoxysilane to improve the loading and release of ibuprofen bonded to 3-aminopropyltriethoxysilane. sample were characterized by Fourier transform infrared spectroscopy, Scanning electron microscopy , X-ray diffraction, and ultraviolet-visible. the Fourier transform infrared spectroscopy result demonstrate that organic group were successfully functionalized onto mesoporous silica nanoparticles. Then, we investigate of the adsorption and release of ibuprofen as a drug delivery system in simulated body fluid. The result demonstrates that high adsorption capacity for drug with functionalized sample and slower drug release rate was achieved.

INTRODUCTION

In recent years, mesoporous silica nanoparticles (MSNs) such as MCM-41 have been well developed as effective drug storage vehicles in drug delivery systems [1-3]. Mesoporous materials have drawn much attention for their excellent properties such as high surface area (>1000 m^2/g), tunable and uniform pore size, ease of functionalization, low toxicity, biodegradability and relatively large pore volume (~1 cm^3/g) [4]. So far, many functionalized mesoporous materials have been synthesized to further increase the ability of drugs loading, transfer them to the target organism and then release in a desirable period of time [5-8]. MCM-41 is a system which consists of parallel channels with an approximately hexagonal cross section, which are arranged in a hexagonal structure. MCM-41 has found many applications. It is used supports for immobilizing biomolecules [9], as a drug delivery system [10,11] catalysts [12] and agents for polymer reinforcement [9] and templates for the synthesis of other materials. Recently, considerable investigations have been carried out for the applications of MCM-41 in drug carrier systems for high drug loading capacity and sustained or controlled drug release, for example, gentamicin [13], vitamin B1 [14], atenolol [15] and some other drugs.[16,17]

The carboxylic modified mesoporous materilas are of great interest in nanomedicine applications because possibility of pH-response delivery for controlled release of drug molecules with free amino functional groups. [18] The influence of synthesis and surface modification of MCM-41 by aminopropyl groups on the immobilization and subsequent release of acetylsalicylic acid was studied in several papers [19-23].

Ibuprofen (Fig. 1) clinically, it is mainly used for treating rheumatoid arthritis and osteoarthritis. Ibuprofen is one of the original non-steroidal drug used for anti-inflammatory which can improve the resistance to therapy and infection of diverse moderate

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pain and inflammation [24].

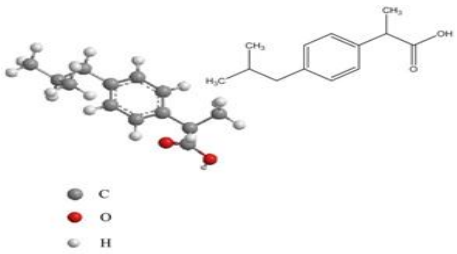

Fig. 1. Structure of ibuprofen

In this study, we preparation of MCM-41 nanoparticles and functionalized by APTES groups (Fig. 2) Then, drug storage and release kinetic in simulated body fluid (SBF) was investigated. This system using ibuprofen (IBU) as a model drug.

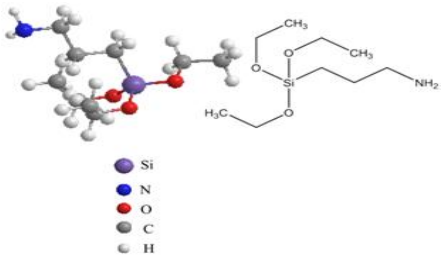

Fig. 2. Structure of APTMS

MATERIALS AND METHODS

All the chemical substance contains: 3-aminopropyltriethoxysilane (APTES), ibuprofen, sodium hydroxide, ethanol, methanol, CTAB, TEOS, toluene, diethyl ether, dichloromethane and hexane were purchased by sigma Aldrich.

Preparation of MCM-41 NPs

MCM-41 nanoparticles were prepared according to the reported method [25]. First, 1g of CTAB was dissolved in 300 ml of distilled water. Then 0.28 g of sodium hydroxide was added into the CTAB solution in 80 °C , in the next step, 5.3 ml of TEOS was added drop-by-drop to the solution under vigorous stirring. After 3h, the white precipitate was appeared. The product was filtered and washed with distilled water and ethanol three times and dyeid. To remove the surfactant template (CTAB), the precipitate was calcinated at 550 for 5h.

Synthesis of APTES modified MCM-41

Modification of the spherical MCM-41 with amino group was preparation by this method: first, 1 g of calcined MCM-41 was added to dry toluene in 250 ml flask. After being stirring for 30 min, 1 ml 3-aminopropyltriethoxysilane (APTES) was added drop wise into the solution. The mixture was stirred for 24 h. In the final step, the product was washed with dichloromethane and diethyl ether and dried in an oven at 100.

Drug loaded and release

The steps of drug loaded and release are as follows:

1. 0.5 g MCM-41@APTES was added into a 50 ml hexane solution containing 0.02 g ibuprofen, the mixture was stirred for 24 h at room temperature. Then the precipitate was separated by centrifugation and washed three times and dried at 60. The efficiency adsorbed drug was measurement by UV-Vis spectroscopy (264 nm).

2. 100 mg of MCM-41@APTES loaded with ibuprofen was immersed into 100 ml of simulated body fluid (SBF; pH= 7.4) in a beaker at 37 under static conditions. (The simulated body fluid has an ionic composition similar to the human body plasma). 3ml from top of the solution was used from release estimate at different intervals and replaced immediately three milliliters of fresh SBF is an added into the solution to keep the volume unchanged.

RESULTS AND DISCUSSION

Fourier transform infrared (FT- IR) spectrum was obtained using on Shimadzu 460 spectrometer. The Sample was prepared in KBr pellets for FT-IR analysis. The surface nanoparticles of the sample were obtained by scanning electron microscopy (SEM), by means a LEO-1455VP. The UV-Vis absorption spectra of the samples were measured with a Shimadzu UV-Vis scanning spectrometer. The sample was characterized by X-ray diffraction (XRD) analysis by using Philips PW 1800, X-ray diffractometer using Ni-filtered Cu Kα radiation.

MCM-41 is an amorphous material. Fig 3 gives the XRD pattern of MCM-41 sample within range of *ca.*10-70. The two peaks can be attributed to the non-crystalline silica frameworks (2θ=25,44°). On the basis of the width of diffraction peaks, the average size of the sample is estimated to be *ca.* 28 nm.

Fig. 4 illustrates the FT-IR spectra of all samples in

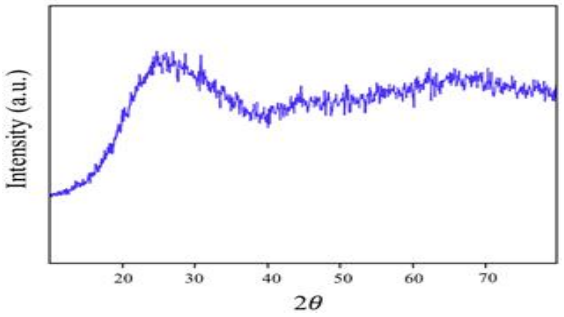

Fig.3. XRD pattern of MCM-41

the range of 400 to 4000 cm^{-1}. the MCM-41 exhibited IR peaks at the bands attributed to Si-O-Si bending, Si-O-Si symmetric stretching, external groups, Si-O-Si asymmetric stretching, are 461 cm^{-1}, 809 cm^{-1}, 957 cm^{-1}, 1076 cm^{-1}, respectively. Absorption band at 1629 cm^{-1} attributed to water molecules retained by siliceous materials and the absorption band at 3426 cm^{-1} was assigned to OH stretching. After functionalized with APTES, the MCM-41 still retained its siliceous structures, displaying no major changes had been occurred in the formation of its framework. The relative intensity of all peaks became more intense compared to the present MCM-41. The band at 1634 cm^{-1} could be attribute to the protonated from of amine groups (-NH_3^+) which were significant due to the presence of adsorbed water or neighboring silanol groups.

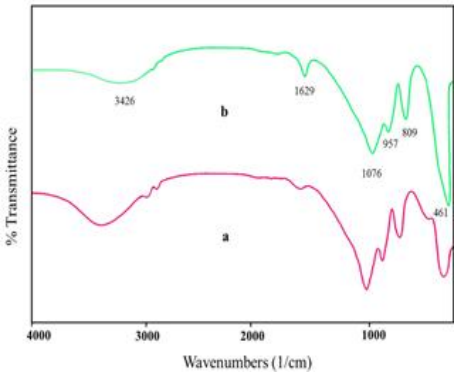

Fig. 4. FT-IR Spectra of (a) MCM-41 (b) APTES-functionalized MCM-41

Fig. 5 illustrates the particles size of the as-synthesized MCM-41 nanoparticles is also estimated by using scanning electron microscopy (SEM). According to fig 5 the morphology of MCM-41 are sphere-like nanoparticles with particle size of 30 nm.

The curve of the percentage of ibuprofen release as function of time was shown in Fig 6. The ibuprofen drug can be adsorbed onto the surface of MCM-41 in the saturation process and liberated by propagation-controlled mechanism. The OH groups on the surface should be the reaction sites to form hydrogen bonding with the carboxyl group of IBU when IBU is adsorbed on the surface. Ibuprofen@MCM-41-NH_2 illustrate up to 25% release at the beginning. It can for this reason: by this initial release the ibuprofen is brought close to the surface. According to this curve, the efficiency of the drug release after 24h was 100%. As well as, the absorption of drug into the MCM-4@APTES is more than pure MCM-41. Because of the interaction between ibuprofen molecules with amine group in MCM-41-APTES is stronger than pure MCM-41.

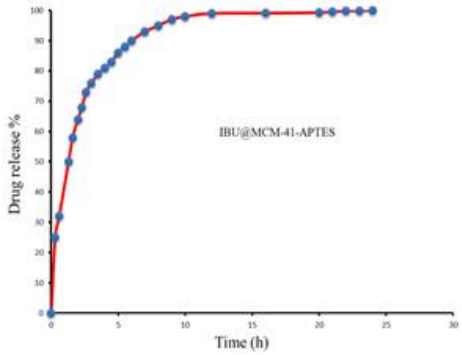

Fig. 6. IBU release by APTES-functionalized MCM-41

CONCLUSION

In this study, we synthesis of MCM-41 and functionalized by APTES. Then, we investigate storage and release properties of the ibuprofen delivery. The result illustrate that modification of the surface of the mesoporous silica with NH2- groups lead toward better carriers ibuprofen in simulated body fluid (SBF). Finally, the release system of IBU@MCM-41-APTES showed slow release for 24h.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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