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Fabrication of hydrophobic and magnetic cellulose aerogel with high oil absorption capacity

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ABSTRACT

Hydrophobic, magnetic and highly porous cellulose aerogel was prepared by a simple method for fast and selective absorption of oil from water surface. The aerogel was able to absorb oil up to about 28 times of its own weight within 10 min and could be easily removed and recovered from the water surface by an external magnet. It could be either reused after washing with ethanol, or incinerated with the absorbed oil. The potential application of cellulose aerogel as an oil absorbent was demonstrated by its ease of preparation, low cost of precursor materials, magnetically retrievability, as well as high oil absorption capacity and efficiency.

1. Introduction

Frequent occurrences of oil spillage on water bodies have caused numerous negative impacts on the aquatic environment [1]. Therefore, there is a pressing need to develop a fast, efficient and economical absorbent for cleaning up oil spills from the water surface. Existing oil absorbents use activated carbons [2], sawdusts [3] and aerogels [4]. Both activated carbon and sawdust suffer from poor oil absorption efficiency due to the co-adsorption of water along with the oil. Being an ultra-light and highly porous material, aerogel has been demonstrated to be a very efficient oil absorbent. Aerogels are usually prepared by drying wet gels via methods such as critical point drying or freeze drying in order to remove liquid without collapsing the porous structure network [5]. Silica aerogels have been widely used as oil absorbents. However, silica aerogels are very fragile and brittle [6]. Recently, carbon nanotube aerogels have been shown to have an oil absorption capacity of 80–180 times of its original weight [7]. However, carbon nanotubes are relatively more costly and are thus unsuitable for large scale oil spill cleanup.

Cellulose-based aerogels show promising potential as oil absorbents as they are renewable, available abundantly, low in cost and exhibits high oil absorption capacity. Besides, cellulose aerogels exhibit high structural flexibility and good mechanical properties [8]. Nanocellulose aerogels were treated with octyltrichlorosilane using vapor phase deposition to obtain hydrophobic surfaces for the separation of oil from oil/water mixture [9]. In another study, nanocellulose aerogels were functionalized with a layer of titanium dioxide (TiO_2) using atomic layer deposition for oil removal [10]. These deposition methods are complicated and required the use of sophisticated equipment. Another challenge of using oil absorbents is their removal from water surfaces after an oil clean up.

In this work, we have reported a facile method for the preparation of hydrophobic and magnetic cellulose aerogel by *in-situ* incorporation of magnetic Fe_3O_4 nanoparticles into the cellulose aerogels and followed by coating the surfaces of aerogels with a thin layer of TiO_2 using the sol–gel process. These magnetic cellulose aerogels could be recovered from water easily by applying an external magnetic field.

2. Experimental

Materials: All chemicals were of reagent grade and used without further purification. Commercial cellulose powder was obtained from Whatman. Ultra-pure water (18.2 MΩ cm) was obtained from a water purifying system (Model: ELGA, Ultra Genetic) and used throughout the experiment.

Sample Preparation—Preparation of magnetite nanoparticles (Fe_3O_4): Magnetic Fe_3O_4 nanoparticles were prepared by the co-precipitation method as reported in our previous studies [11].

Preparation of cellulose aerogel: 1% w/v of cellulose solution was prepared by dissolving cellulose fibers in sodium hydroxide:thiourea:urea (NTU) aqueous solvent system (8:6.5:8 w/v%) to form a homogeneous cellulose solution. Cellulose gel was regenerated by solvent exchange with ethanol. Cellulose aerogel was then obtained by (CO_2) supercritical point drying of the cellulose gel.

Preparation of magnetic cellulose aerogel: 50 mg of Fe_3O_4 nanoparticles were dispersed homogenously in 10 mL of cellulose

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