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Surface Morphology and Modulus, Wetting Behavior and Photocatalytic Activity of the TiO_2 Coated Materials Based on PMMA/O-MMT Composite Microfibers

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Abstract

Poly(Methyl Methacrylate) PMMA/Organically Modified Montmorillonite (O-MMT) composite microfibers membrane coated with TiO_2 has significant advantages in cationic dyes adsorption and can break down the adsorbed dyes under UV radiation, which is quite useful in water treatment. In this work, PMMA/O-MMT composite microfibers were firstly prepared by emulsion polymerization combined with electrospinning, and then coated by nanosize TiO_2 using RF magnetron sputtering. The effects of TiO_2 sputter coating on morphology and surface modulus was characterized by Scanning Electron Microscope (SEM) and Atomic Force Microscopy (AFM), while the wetting behaviour was studied by drop shape analyzer. The photocatalytic degradation of methylene blue was tested under UV radiation and the properties of the treated and untreated samples were compared. It was observed from SEM images that TiO_2 was well dispersed and deposited on the surface of PMMA/O-MMT microfibers, while the AFM results showed increase in the surface modulus after TiO_2 coating. Besides, the wettability of the microfibers membrane coated with TiO_2 was altered, which facilitated water treatment in practical use. Furthermore, the PMMA/O-MMT microfibers membrane coated with TiO_2 performed well in photocatalytic degradation of methylene blue. In conclusion, PMMA/O-MMT composite microfibers membrane coated with TiO_2 was quite promising in water treatment.

Keywords: Electrospinning; RF (Ratio Frequency) Magnetron Sputtering; TiO_2; Microfibers; Water Treatment

1 Introduction

Comparing to the other conventional fibrous structures, Microfibers have interesting properties due to their extremely high surface to weight ratio and high porosity, which make microfibers ideal

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for use in such application areas as filtration, sensor, protective clothing and functional materials [1-4]. Poly(Methyl Methacrylate) (PMMA) is a common synthetic organic polymer traditionally used in various industrial applications [5]. Besides, clay particles have been shown to be easily electrospun with different polymers such as nylon 66, poly(viny alcohol) or poly(vinylidene fluoride) for various applications [6-10]. Addition of clays into polymer solutions increased the extensional viscosity, the extent of strain hardening and thus the electrospinnability of the resulting polymer/clay dispersions. The electrospun PMMA/O-MMT composite microfibers showed enhanced thermal stabilities at high temperature over the electrospun pristine polymeric microfibers. Composite microfibers electrospun from other polymer/clay dispersions were also shown to exhibit enhanced mechanical properties, such as shear modulus, and higher thermal properties, such as glass transition temperature [11, 12].

Nanoscale titanium dioxide (TiO_2) has a broad range of good properties, such as permanent effect, safe to use and no secondary pollution to the environment [13]. Because of these reasons, various techniques have been developed to produce fabrics with nanoscale titanium dioxide films for a wide range of applications. Magnetron sputtering coating is an ideal way to produce nanoscale titanium dioxide functional films due to the better adhesion between the substrate and the function films and it is an environmentally friendly process. The ability to deposit well-controlled coatings on microfibers would expand the application of microfibers, based on changes to both the physical and chemical properties of the microfibers.

In the present work, the electrospun PMMA/O-MMT composite microfibers were modified with nanosize TiO_2 by magnetron sputter coating. The effects of TiO_2 sputter coating on structure and surface morphology were observed by Scanning Electron Microscope (SEM). Besides, the surface modulus of the treated and untreated microfibers were analyzed and compared by Atomic Force Microscope (AFM). In addition, the wetting behavior and photocatalytic activity were also investigated.

2 Experimental

2.1 Materials Preparation

The Organically Modified Montmorillonite (O-MMT) by hexadecyl trimethyl ammonium bromide (cation exchange capacity, CEC, 97 mequiv./100g of clay) was purchased from Zhejiang Fenghong Clay Chemicals Co., Ltd. The average thickness of the particle was less than 25nm, and the ratio of diameter to thickness was about 200. PMMA and PMMA/O-MMT composite materials were synthesized in our laboratory by in situ emulsion polymerization. Chloroform and N, N-dimethylformamide (DMF) were used as received.

2.2 Preparation of Electrospun Composite Microfibers

PMMA/MMT dispersions were prepared by dispersing the nanocomposite at concentrations of 6 wt.% in chloroform. The solution was vigorously stirred for 8 hrs at room temperature. The polymer solution was electrospun at a positive voltage of 15kv with a working distance of 150 cm, and the flowrate was set as 0.5 mL/h.