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A convenient oil-water separator from polybutylmethacrylate/graphene-deposited polyethylene terephthalate nonwoven fabricated by a facile coating method

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ABSTRACT

A convenient oil-water separator of polybutylmethacrylate/graphene (PBMA/GE)-deposited polyethylene terephthalate (PET) nonwoven was fabricated by a casting coating method. The resulting nonwovens were characterized by Scanning electron microscopy (SEM), Fourier transform infrared (FTIR), X-ray photoelectron spectroscopy (XPS) and contact angle measurements. The results reveal a hydrophobic and oleophilic surface with micro-nanoscale hierarchical network structures was formed by PBMA, GE and PET fiber web. Furthermore, we demonstrate the separation of oil–water mixtures using a facile apparatus, solely driven by gravity. As-prepared PBMA/GE-coated nonwovens exhibit high oil-water separation efficiency of over 95% up to eight cycles. Our finding as a facile, inexpensive, high-performance oil-water separator have a promising practical application in the oil spill cleanup and the removal of organic pollutants from water surface.

1. Introduction

Oil-water separation has received much attention in recent years aiming to resolve industrial oily wastewater and oil spill pollution, as well as environmental remediation. In addition to conventional methods such as oil dispersants [1], oil skimmers [2], oil adsorbents [3], etc., photocatalytic degradation[4] and separation membrane[5] recently have been applied to oil-water separation. However, the limitations of the generation of secondary pollutants for dispersant system, low separation efficiency for adsorption and skimming, sensitive lighting condition for photocatalysis, and large-scale energy consume for membrane process, have always caused problems in the practical use, encouraging people to develop facile and low-cost methods. The methods driven by magnetism [6], gravity forces [7] have been put forward facing to low-carbon and green treatment.

More recently, many efforts [8–10] have been concentrated on developing new materials and separation technologies for oil-water separation. Hydrophobic and superoleophilic surfaces were employed for oil-water mixtures because the surface could repel water and let oil flow through freely [11]. Acrylate or (meth) acrylate polymers, as a highlighted oil-loving material have been extensively studied for oil-water separation [12,13]. Graphene, a 2D sheet of covalently bonded carbon atoms, has gained tremendous attention due to its excellent physical properties and high oleophilicity. The graphene-based sponge or foam with micromesh structure has very attractive prospects due to its outstanding adsorption capacity [14]. However, most of oil-water separation process regarding these absorbents is intermittent. Once the absorption capacity was saturated, the graphene-based absorbents cannot adsorb oils or organic solvents any more. Continuous oil-water separation has been advocated by several researchers [15,16].

Here, we reported a convenient oil-water separator of polybutylmethacrylate/graphene-deposited polyethylene terephthalate (PET) nonwoven, which can continuously separate oil-water mixtures driven solely by gravity. Commercial PET nonwoven was coated with PBMA and GE using common casting method. The resulting nonwovens exhibit enhanced oleophilicity and hydrophobicity. We demonstrate the separation of oil–water mixtures using a facile apparatus, solely driven by gravity. The basic parameters, microstructure and properties of the nonwovens are also investigated.

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Table 1
Typical physical parameters of the nonwovens before and after coating.

Composition	Weight (g/ m^{-2})	Thickness (mm)	Air permeability (mm/s)
PET nonwoven	33.8	0.331 ± 0.02	1478 ± 30
PBMA/GE-coated nonwoven	81.5	0.365 ± 0.02	3205 ± 45

2. Experimental

2.1. Materials

Polybutylmethacrylate (PBMA) was synthesized using standard suspension polymerization, as reported in our previous papers [17]. Graphene (GE) sheets (flake size 0.1–5 μm, thickness < 5 nm) were obtained from Xiamen Kaina Graphene Technology Corp. (Xiamen, China). Diesel, kerosene was purchased from Tianjin Petrochemical Co., Ltd., Sinopec Group. N, N-Dimethylacetamide (DMAc) Paraffin was bought from Tianjin Chemical & Regents Co., Ltd. (Tianjin, China). Reactive red was obtained from Qingdao Sanhuan Colorchem Co., Ltd. (Shandong, China). All chemicals were directly used without further purification. Polyethylene terephthalate (PET) nonwoven was kindly provided by Handan Hengyong Protective & Clean Products Co., Ltd. (Hebei, China).

2.2. Coating preparation

0.03 g of GE sheets and 0.25 g of paraffin were placed into 50 mL DMAc, and the solution was mechanically stirred at 65 °C for 1 h. To the resulting solution, 3.5 g of PBMA was added to form a uniform solution under ultrasonic condition at the frequency of Hz for 15 min, and followed by vigorous stirring at 65 °C for 30 min. The resulting solution with PBMA and GE was coated by common casting coating method. The product after coating was dried in oven at 90 °C for 3 h. Finally, the coated nonwovens were washed by absolute ethanol at 70 °C for removing the paraffin and dried to constant weight in air, which were labelled as PBMA/GE-coated nonwoven.

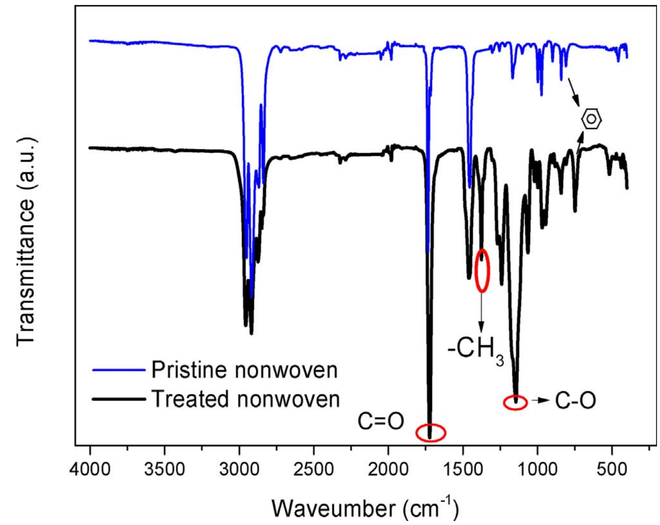

Fig. 2. FTIR spectra of pristine (a) and Treated (b) PET nonwovens.

2.3. Testing and characterization

Mass per unit area each sample was recorded according to ISO 9073-1-1989. The thickness measurement of the nonwoven was carried out by YG141LA fabric thickness gauge (Laizhou electronic instrument Co., Ltd., China), according to ISO 9073-2-1995. The air permeability of the nonwovens was measured by YG (B) 461D fabric ventilation instrument (Wenzhou Darong textile instrument, China) according to ISO 9073-15-2008. The nonwovens were cut into 25 cm × 25 cm size, and the measurements were performed in the area of 20 cm^2 and 5 cm^2 with the jet diameter of 12 mm and 6 mm for the nonwoven before and after coating. Each result was the average of three measurements. The tested values with corresponding standard deviations were displayed in Table 1.

Contact angle measurements (the sessile drop method) were carried out under room temperature using a Krüss DSA 100 apparatus (Krüss GmbH, Hamburg, Germany). Distilled water droplets (~4 μL) and kerosene droplets (~6 μL) were respectively delivered to different points of each specimen. The sample was mounted to a height

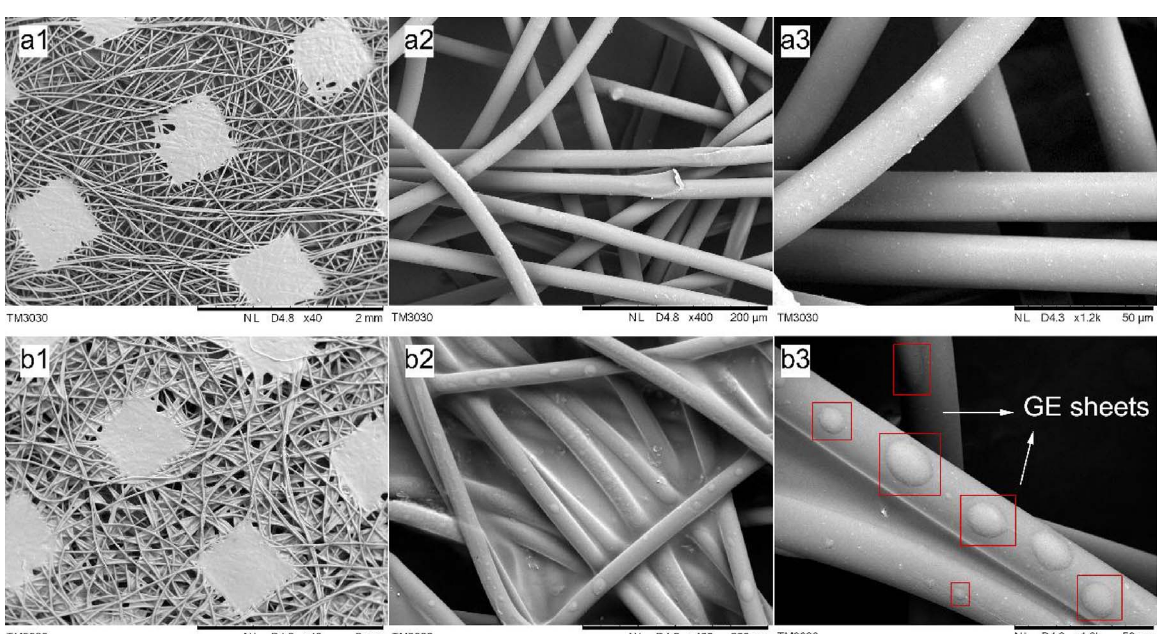

Fig. 1. SEM images of pristine (a) and PBMA/GE-coated (b) PET nonwovens.