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Photocatalytic Activity, Surface Morphology, and Mechanical Properties of Atmospheric Plasma-treated HTPET Fiber with SnO_2 Coating

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Abstract

SnO_2 hydrosol made in the lab was deposited on HTPET fibers by dip-coating method. In order to improve the deposition of the coating layer and water adsorption properties of the fiber, atmospheric plasma treatment was used as pre-treatment to enhance the interaction at the interface. Photocatalytic properties of the samples coated with SnO_2 under different plasma treatments were analyzed through the degradation of methylene blue under UV-light. The morphologies and surface modulus of SnO_2 coated fibers were characterized by Scanning Electronic Microscope (SEM) and Atomic Force Microscopy (AFM), respectively. The effects of plasma treatment on water adsorption behavior of the fibers were examined by contact angle measurement instrument. Tensile tests were carried out to measure and assess the mechanical properties of HTPET fiber before and after plasma treatment and photocatalysis was done. The study revealed that the photocatalytic activity of SnO_2 coated HTPET fibers were enhanced due to the wettability of HTPET surfaces improved by plasma treatment and varying degrees of surface etching which benefited SnO_2 adhesion on HTPET fibers. Meanwhile, the modulus of monofilament surface increased under plasma treatment but decreased after phtotcatalysis. Mechanical properties of the fibers exhibited an opposite trend. It was found that the best photocatalytic activity of HTPET fibre was obtained under 100 w power plasma treatment.

Keywords: HTPET Fiber; Atmospheric Plasma Treatment; SnO_2 Dip-coating; Photocatalysis; Mechanical Properties

1 Introduction

Tin (IV) oxide, SnO_2 (rutile type structure) is a well established n-type semiconductor with a wide band gap (Egap = 3.6 eV at 300 K), which can be widely applied in gas sensor [1, 2], dye sensitized solar cell [3, 4] and many catalytic processes [5, 6]. The photocatalytic potential of

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SnO_2-based composites in the removal of Methylene Blue (MB) pollutants has been reported [7]. In this regard, the preparation method of tin oxide has been drawing constant research attention [8-10].

These results encouraged us to further investigate the SnO_2/textile material in the degradation of MB. Due to the textile materials with excellent properties (i.e. durability, flexibility and low cost) possess the possibility to use as photocatalytic substrate in special occasions [11, 12]. High-tenacity Polyethylene Terephthalate (HTPET) fibers, providing high modulus and tenacity compared to conventional PET, have optimized conditions to undergo the damage during photocatalysis.

In this paper, ultrasonic hydrolysis method was adopted to produce SnO_2 hydrosol. HTPET fibers were chosen as photocatalytic substrates. One of the key issues in the application of dip-coating method onto fibers is the interfacial adhesion between coated layer and substrate. Therefore, atmospheric plasma treatment, a more economical and ecological pre-treatment process, was performed to enhance the interactions in the interphase by a combination of a plasma induced increase in bonding surface such as micropitting or mechanical interlocking [13]. The primary objective of this study is to analyse the photocatalytic activity of SnO_2 coated HTPET fibers. The morphologies of the SnO_2 coated fibers before and after plasma treatment and photocatalysis reaction, as well as these treatment affect on the mechanical properties were characterized. In addition, the wetting behaviour of the plasma treated fibers was investigated comprehensively.

2 Experimental Details

2.1 Materials

The substrate material used in this study was commercially available High Tenacity Polyethylene Terephthalate (HTPET) fibers supplied by Korteks, Turkey. Yarn count is 110 tex and the number of filaments are 192. The chemicals used for the preparation of SnO_2 sol-gel solution were tintetrachloride ($Sncl_4{\cdot}5H_2O$), ammonia (NH_4OH), and oxalic acid ($C_2H_2O_4{\cdot}2H_2O$), purchased from Sinopharm (China). All the reagents were used as received.

2.2 Atmospheric Plasma Treatment and Surface Activation

The surface of HTPET fibers were modified using non-thermal plasma generated by the Dielectric Barrier Discharge (DBD) at atmospheric pressure in air (Schematic diagram of DBD system shown as Fig. 1). The fibers were cut into about 20 cm in length and were fasted to DBD platform.

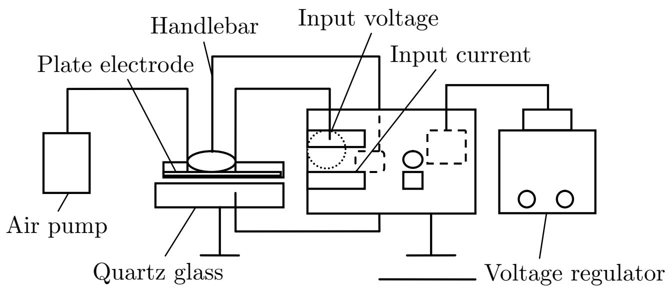

Fig. 1: Schematic diagram of DBD system.