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Atmospheric Pressure Plasma Vapor Treatment of Thermo-sensitive Poly(N-isopropylacrylamide) and Its Application to Textile Materials

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Abstract

Poly(N-isopropylacrylamide) (PNIPAAm) is a new type of smart thermo-sensitive macromolecule material that is characterized by a sudden precipitation on heating, switching from a hydrophilic to a hydrophobic state. In this paper, using the self-made equipment of atmospheric pressure plasma vapor treatment running in the environment of argon, PNIPAAm was deposited separately to Polybutylene Terephthalate (PBT) melt-blown nonwovens and Polyester (PET) fabrics. It was found that the wettability and water permeability were significantly modified by changing the temperature above and below the Lower Critical Solution Temperature (LCST), according to the data derived from measurements of water contact angle, water permeability time and Scanning Electron Microscopy (SEM) images. Considering human body temperature is close to the LCST, these results are valuable for further application to thermo-sensitive textile materials.

Keywords: Atmospheric Pressure Plasma; Plasma Treatment; Poly(N-isopropylacrylamide) (PNIPAAm); Lower Critical Solution Temperature (LCST); Water Contact Angle; Water Permeability Time

1 Introduction

PBT and PET fibers have fine physico-chemical properties and they are used widely and developed rapidly, but at present these fibrous materials are still not good in terms of wettability. Their surfaces often need to be treated before application [1]. Recently, as an environment friendly technology, plasmas arouse the researchers' widespread interest. Compared with traditional modification processing, the technology of surface modification based on Low-temperature Plasma (LTP) is used to give the material surface new performances including wettability, whereas bulk properties remain unchanged. In this paper, in order to be cost-effective, a renewed interest

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is concentrated in generating high-pressure non-equilibrium plasma, particularly at atmospheric pressure [2-5]. This has been driven by the advantages that these plasmas can offer as compared with those of lower pressure plasmas. We use atmospheric pressure plasma to effectively deposit PNIPAAm coatings onto PBT melt-blown nonwovens and PET fabrics.

PNIPAAm shows a LCST around 32℃ in an aqueous environment. The well-hydrated polymer chains below the LCST have a random coil configuration. Above the LCST, the polymer chains take on a much more compact configuration by sudden dehydration and increased hydrophobic interaction between the polymer chains. In the literature, PNIPAAm has been studied most frequently as a water-soluble polymer and a cross-linked network. When grafted onto solid surfaces, this phase change gives a "smart" surface with varying physical properties that can be controlled by applying an external stimuluss temperature. Below the phase transition temperature, the PNIPAAm-grafted surfaces are hydrophilic, swollen, and nonprotein adsorptive (nonfouling). As the temperature increases above the transition temperature, the grafted polymer chains collapse and the surface becomes hydrophobic and protein-retentive. Considering body temperature is close to the LCST, these results are valuable for further application to thermo-sensitive textile materials [6-10].

2 Experimental

2.1 Materials

PBT melt-blown nonwovens (128 g/m^2); PET fabrics (52.8 g/m^2); NIPAAm (Shanghai Wujing Chemical Technology Co. Ltd.)

2.2 Experimental Methods

PBT melt-blown nonwovens and PET fabrics were repeatedly washed by soap and deionized water, and dried after cleaning in the room. The size of sample 8×8 cm^2 was used to prepare the PBT nonwoven and PET fabrics. The parameters of atmospheric pressure plasma treatment are shown in Table 1.

Table 1: The parameters of plasma treatment

PBT nonwovens	Gas	Discharging voltage/kV	Treatment time/s
1#	Ar	15	20
2#	Ar	15	180
3#	Ar	15	600
PET fabrics	Gas	Discharging voltage/kV	Treatment time/s
1#	Ar	30	20
2#	Ar	30	180
3#	Ar	30	600