Preparation of Superhydrophobic Polyester Fabric by Treating with Nano-silica Particles

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Introduction

Since the discovery of the self-cleaning effect of lotus leaves and insect wings found in nature, superhydrophobic surfaces have received great attention because of their wide field of applications such as water pipes, vehicle windshields, fabrics, etc. It is well-known that to attain superhydrophobic surfaces, modification of surface chemistry is always needed in conjunction with the surface roughness [1]. In many studies, the superhydrophobic surface was obtained via segregated processes to introduce surface roughness and hydrophobicity. Moreover, another separated process was generally needed to immobilize the particles on a surface.

In this work, a novel one-step process for surface roughness and hydrophobicity was investigated to obtain a superhydrophobic surface by synthesizing silica particles having hydrophobic vinyl groups and immobilization the silica with as UV irradiation.

Experimental

The silica with hydrophobic surface was prepared by using triethoxyvinylsilane having vinyl groups ($-CH=CH_2$) through a sol-gel process.(Fig. 1) A kind of photo-initiator was added to the resulting silica suspension for immobilization the particles by UV-grafting to poly(lactic acid) (PLA) fabric. After introducing the particles to the fabric by immersing in the suspension liquid and padding with a mangle, the fabric was treated with UV irradiation.

Thermogravimetric analysis (TGA) was used to determine the amount of the silica particles on the fabric before and after UV irradiation and washing.

Table 1. PLA fabric Samples

Fabric sample code	Padding	UV irradiation	Washing
Fab−P	Yes	No	No
Fab−PUW	Yes	Yes	Yes
Fab−PW	Yes	No	Yes

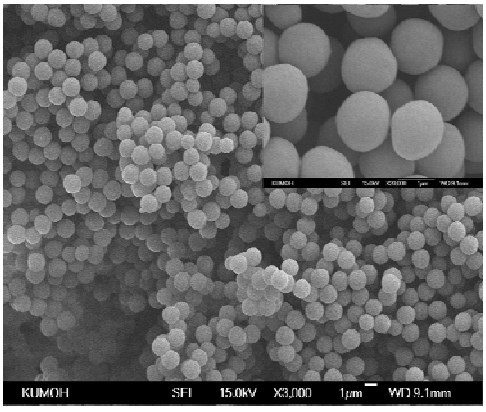

Figure 1. Silica particles.

Results and Discussion

Fig. 2 shows the TGA curves before and after UV-treatment of PLA fabric. It was found that the degree of immobilization of the silica having C=C bond improved up to 86% after UV-irradiation compared to 41% before the treatment. Thus, it can be concluded that the photo-grafting process is an effective method to fix the silica particles on PLA fabric due to presumable forming of kinds of covalent bonds between the silica having C=C bonds and PLA fiber.

The superhydrophobic properties of the PLA fabric were estimated by measuring contact angles using a contact angle

goniometer. The pristine PLA fabric was found to be wet completely when a drop of water was dropped (Fig. 3(B)) while the UV-treated PLA/silica fabric was turned out to be superhydrophobic with a water static contact angle of ~150°. When a water droplet sits on a hydrophobic PLA fabric surface, the wetting behavior can be described by the equation from Cassie and Baxter [3].

$$\cos\theta_{CB} = r_f f \cos\theta_0 + f - 1$$

where f is the fraction of the projected area of the solid surface wetted by water and r_f is the surface roughness of the wetted area. When hybrid silica particles are chemically bonded onto the PLA fabric in our study, r_f is increased. Once r_f reaches a certain level, the air-trap may be formed between hybrid silica particles underneath a water droplet, which contribute to enhance the hydrophobicity of surface.

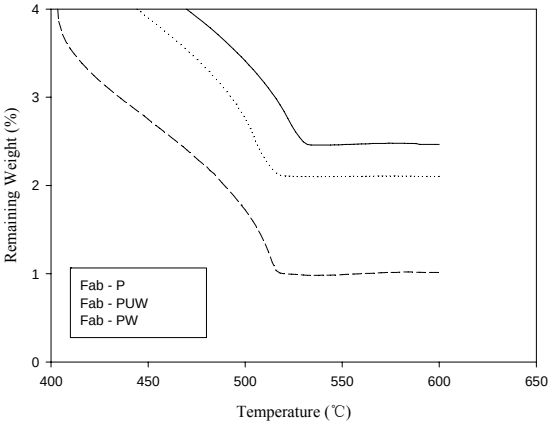

Figure 2. TGA curves of PLA fabric treated with silica nano-particles.

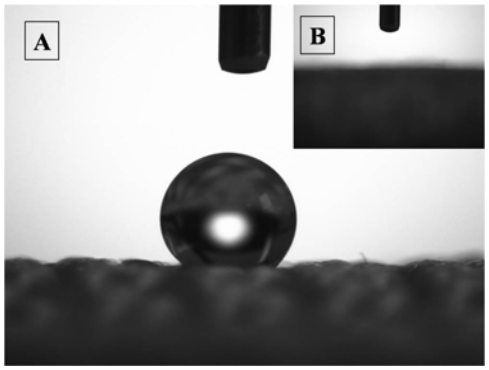

Figure 3. Water droplet onto the silica-treated (A) and pristine PLA fabric (B).

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[1] Bae, G.Y.; Jeong, Y.G.; Lee, S.C.; Jang, J.H.; Koo, G. H.; Min, B.G. *J. Colloid Interf. Sci.* 2009, 337, 170-175.
[2] Cassie, A.B.D.; Baxter, S. *Trans. Faraday Soc.* 1944, 40, 546.