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Application of Nano Coating (SiO_2) on Textile Products

Oguz Dogan and Remzi Dag

Necmettin Erbakan University, A.K. Education Faculty, Department of Physics, Konya 42090, Turkey.

Abstract: Liquid SiO_2 solutions produced by silicon-based nano- powder are covered on the fabric surface by using spray method. Fabric surfaces were coated at the room temperature in air with the different spray nozzles. Surface analysis of the coated fabric was performed by using Contact Angle and SEM pictures. According to the Contact Angles measurements, the coated fabric surfaces showed hydrophobic character between 126 and 146 degrees, and the SiO_2 particles sticked to the fabric fibers as seen from SEM picture.

Key words: SiO_2 nano glass, nano coating, nanotechnology, advanced materials, and textile products.

I. Introduction

The maintenance and improvement of current properties and the creation of new material properties are the most important reasons for the functionalisation of textiles. The coating of textiles with chemically or physically modified silica sols with particle diameters smaller than 50 nm "nanosols" enables the manifold alteration of their physico-mechanical, optical, electrical and biological properties.

In present, preparation techniques of water repellent fabrics have several methods such as coating with paraffin wax, treating fiber surface with pyridinium compounds, silicone resin or fluorocarbon. The fluorochemicals are at present the most favorable due to their excellence with respect to water repellency [1, 2]. Typically, the water contact angles between 120° and 130° are obtainable with treatment using the fluorochemicals. Surface hydrophobicity modification using sol-gel method has been introduced as an alternative approach [3, 4]. Particular interest was focused on the self organization of organosilane molecules which creates ordered hybrid materials with hydrophobic properties. The hybrid inorganic-organic nanocomposite coatings were produced using sol-gel reactions via hydrolysis and polycondensation of HDTMS (hexadecyltrimethoxysilane), TEOS (tetraethoxyor-thosilicate), and GPTMS (3-glycidyloxypropyl-trimethoxysilane) mixture. It was reported that the water contact angle of 141° was achieved. The state of superhydrophobicity defined by the water contact angle above 140° was contributable to two main factors; (a) change in the surface geometry from smooth surface to rough surface and (b) hydrophobic properties of roughness surface [5].

Wettability of surfaces with liquids is an important property of materials that is controlled by the chemical composition and the geometry of the surface [6]. Superhydrophobic surfaces that have a water contact angle 90° are attractive because of their importance in industrial applications [7]. Because of the minimized contact with water, chemical reactions or bond formation through water are limited for a superhydrophobic surface. Thus, various phenomena are expected to be inhibited on such a surface, for example, snow sticking, contamination, disease transmission, and current conduction. Recently, with the increasing demands toward functionality of materials that cannot withstand high temperatures, such as textiles and plastics, the control of surface wettability via low-temperature processing is particularly significant. Surface modification with hydrophobic properties using the sol-gel method has been investigated during recent years [8]. Although

Corresponding author: Remzi Dag, master, research fields: fotovoltaic solat cells, grapheme based materials, nanoparticles.

simple sol-gel reactions usually result in the formation of amorphous materials, self-organization of organosilane molecules offers an opportunity to create ordered hybrid materials with hydrophobic properties [9]. Previous studies have been focused on the use of fluoroalkyltrimethoxysilanes to control the chemical properties of surfaces, and the largest contact angle obtained for water has been 115° [10]. However, fluoroalkyl compounds have several economical and ecological disadvantages, such as high cost and potential risk for human health in case of skin contact and for the environment in case of emission of fluorine compounds during and after the coating process [11].

Hence, some producers have stopped their production of water-repellent fluorine-containing compositions during the past few years. In addition to the environmental hazards associated with their production and application, a high-temperature process is usually required for their production. Therefore, the formation of nonfluorinated superhydrophobic surfaces at low temperatures is important for the fabrication of environmentally friendly coatings on substrates with low heat resistance. Transparency and durability of surface coatings are particular requirements for textiles. The durability of water-repellent coatings after washing, especially for those produced on cotton, remains a challenge, because a posttreatment is usually required to restore the hydrophobic properties [12].

2. Experimental

Fabric (Tex, 250 g/m^2) was purchased from "Altınyıldız" (Bursa, Turkey). Fabric substrates were coated layer by layer with spray methods at the room temperature in air. Different spray nozzles having of 1.4, 1, 0.8 mm used, keeping the spray gun at a working distance of 20 cm from the fabric surface and fewer than 3.5 bar spray pressure. Coated samples were allowed to dry for 4 hours, 12 hours and 24 hours various periods at 50 °C in furnace.

Contact angles were measured with a deionized water droplet of 5 µL on instrument at room temperature. All the contact angles and roll-off angles were determined by averaging values measured at 4-5 different points on each sample surface. The surface morphology of the treated samples was studied using a SU-1510 Hitachi Scanning Electron Microscope was used to perform elemental analysis. Fabric pieces (15 mm × 15 mm) were cut and fixed to conductive adhesive tapes and gold-metallized.

3. Results and Discussion

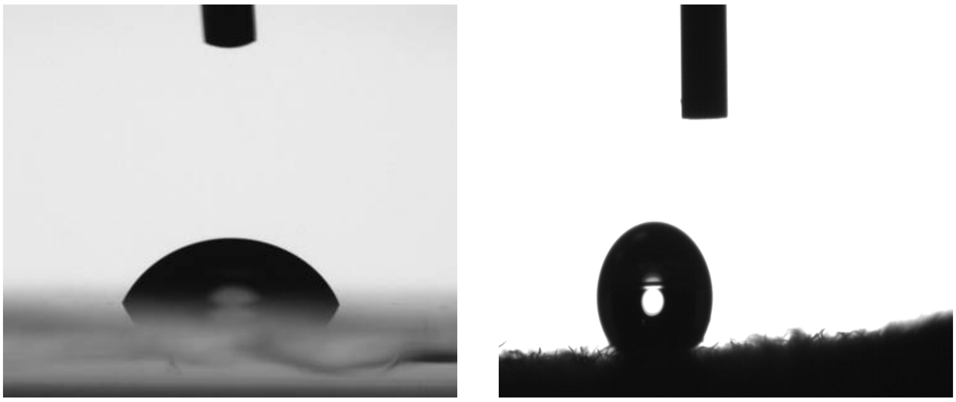
Surface wettability was examined by contact angle measurements. The contact angle pictures are seen in Fig. 1. There are seen the contact angle picture before the SiO_2 coating in Fig. 1a and 24 h dried sample after the SiO_2 coating in Fig. 1b. The water static contact angles for the hydrophobized samples range from 126° to 146° for a 5 µL droplet, being completely water nonwettable whereas the contact angle for original cotton is 0°, because water drops spread instantly when placed on the surface of the substrate. This is due to the cellulose hydroxyl groups of fabric, especially cotton that make fabric superhydrophilic. And the roll-off angles can be measured in a relatively accurate way. For a 50 µL water droplet, the roll-off angle ranges from 5° to 11° for samples.

When a water droplet sits on a hydrophobic cotton fabric surface, the wetting behavior can be described by the equation from Cassie and Baxter [13] :

$$\cos\theta_{CB} = f_{ls}\cos\theta_0 - f_{lv} \quad (1)$$

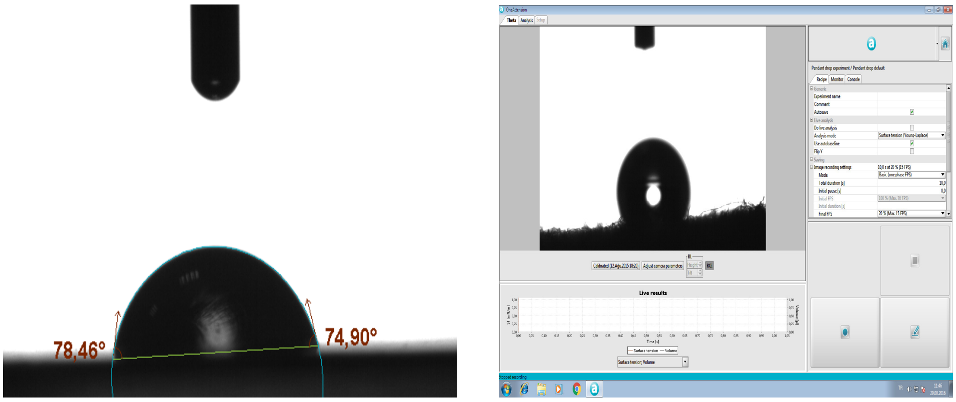
where θ_{CB} is the observed water contact angle on a rough, porous surface, θ_0 is the intrinsic water contact angle on the corresponding smooth surface, f_{ls} is the liquid/solid contact area divided by the projected area, and f_{lv} is the liquid/vapor contact area divided by the projected area. Generally, water contact angle on smooth surfaces cannot exceed 120° through tailoring surface chemistry.

There are two contact angle pictures for 4 h and 12 h dried SiO_2 coating samples in Fig. 2. As can be seen



(a) (b)

Fig. 1 Contact angle images (a) before SiO_2 coating; (b) after SiO_2 coating 24 h dried sample.



(a) (b)

Fig. 2 (a) 4 h dried sample after the SiO_2 coating; (b) 12 h dried sample after the SiO_2 coating.

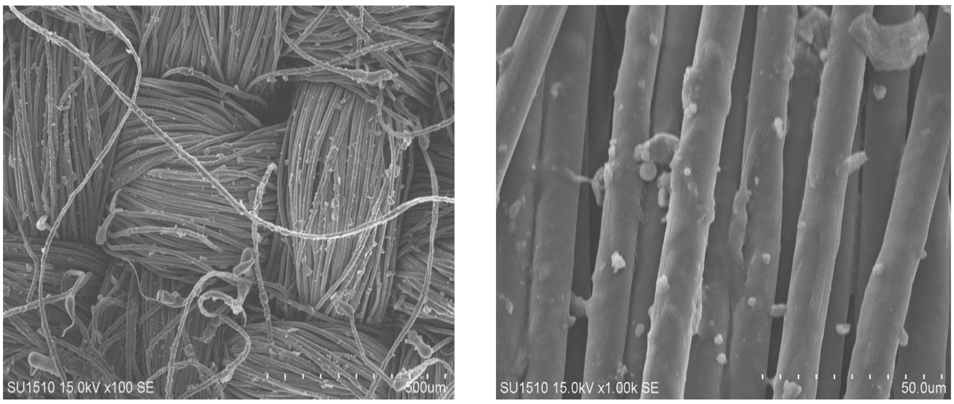


Fig. 3 SEM images, revealed a change in the surface geometry of the fabric after SiO_2 coating.

from these contact angle pictures, the SiO_2 coating does not activate in a short time. It takes more than 12 h to activate the SiO_2 coating.

SEM observations have been performed in order to assess the morphology of the fibres after the spray treatments. When the fibres are layer by layer sprayed, their surface appears covered, and the silica coating appeared rough and grainy on the fabric fibres surface as well evidenced in Fig. 3. In general terms, it is possible to conclude that the spray allows the formation of a more homogeneous and compact coating on the fabric fibres.

4. Conclusion

In the present work, silica based coatings have been deposited on fabric fibres by layer by layer assembly. The effectiveness of layer by layer spray method for homogeneously covering the fabric fibres has been assessed.

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