

Polysiloxane Sheltered Nanoparticle-Containing Intercalated Nanolayers

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In previous researches, we have reported using cross-linkable polysiloxane (XPs) as a guideline for the design of a novel technique to stabilize different nanostructures on the textile surfaces. This followed by creating multiple-size nano-roughness on the textile surfaces using oppositely charged inorganic nanoparticles and cross-linkable polysiloxane resin to develop durable multifunctional textiles. In present study, creating multiple-size nano-roughness on the textile surfaces has been targeted via using nano-layers accompanied with nanoparticles for the textile modifications. A colloidal solution of nanoparticle-containing intercalated nanolayers has been prepared via pre-mixing of nanoparticles and nanolayers under ultrasound irradiation. Then, fabrics have been treated with the colloidal solution via the ultrasound-assistant exhaustion process. To compare the effect of combining nanoparticles and nanolayers, some samples were also produced in the absence of each component. Then, cross-linkable polysiloxane resin has been applied as a post-treatment on the nano-functionalized fabrics. The hydrophobic features of modified fabrics have been examined. According to the results, water droplet absorption time and contact angle of water droplets have been significantly increased via using the nanoparticle-containing intercalated nanolayers.

Keywords: Intercalated nanolayers, Polysiloxane, Nanoparticles, Nano-coating, Textiles.

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1. INTRODUCTION

Nanostructures have already recorded numerous outstanding potential to produce high-tech products. They are driving a fast-developing research interest in textile modifications [1]. However, designing a good engineered process to apply different kind of nanostructures, accompanied together, can facilitate achieving the desirable properties [2]. Among of nanostructures with different shape and geometries, nanoparticles and nonolyeres are two the most used species. Among the nanoparticles, TiO_2 , and among nanolayers, clay, are the most reported. They are the safest nanostructures with remarkable properties and wide range of applications [1]. One of the most weak point of TiO_2 is the fast recombination of the electron-hole pair limiting their photocatalytic activities [3]. Using TiO_2 with clay nanolayers may have an improving effect to cover the weak point. Moreover, they can have a synergistic effect for some applications. We have already reported using cross-linkable polysiloxane as a guideline for the design of a novel technique to stabilize different nanostructures on the textile surfaces [4] which can act also as a novel photo-catalyst assistant [3, 5]. In this point of view, the TiO_2 -containing nanolayered silicate has been used for ultrasound-assistant exhaustion process on textiles, followed by the polysiloxane post-treatment.

2. EXPERIMENTALS

2.1 Materials

Natural montmorillonite, Cloisite® Na⁺, supplied by Southern Clay Company, was used to prepare the intercalated nanolayers colloidal solution. TiO_2 P25 nano titanium dioxide was kindly provided by Evonik

Degussa Corporation. TiO_2 P25 contains 80 wt% anatase and 20wt% rutile structure and having 25–30 nm particle size [6]. Polysiloxane CT 208 E emulsion was kindly provided by Wacker Finish.

2.2 Methods

At first, a colloidal solution of 0.1 wt% clay nanolayers (NLs) have been prepared using magnetic stirrer and ultrasonic waves. Then, keeping the dispersing powers, the TiO_2 NPs have been gradually added to the clay colloidal solution. The cotton fabrics have been treated via exhaustion process under ultrasonic waves for 45 min. Some samples have been also designed applying only (NLs) or (NPs), to compare the effect of each component. The after-treatment by XPs performed as follows. Each sample was immersed in 2wt% polysiloxane solution for 1 min and squeezed by pad to 100% wet pick-up. Then the padded samples were dried at 100°C. The produced samples have been coded by their treatment components as TiO_2 , Clay and TiO_2 /Clay.

2.3 Characterizations

The hydrophilicity of samples was studied by measuring the time required for water droplet to be completely spread on the fabric surfaces. To this end, water was dropped from 1cm on the fabric surface by a small syringe. The time of the complete absorption of 10 μl water droplets on the fabric surfaces was measured for 10 replicates and the average value was reported. Contact angle (CA) of a 10 μl distilled water droplet dropped from distance of 0.5 cm after 5 seconds placing on the fabric surface was measured using a self-developed goniometer apparatus equipped with a high resolution camera and suitable lens. The volume of the

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droplets was exactly controlled using a special capillary connected to an Atom Syringe Pupm S-1235, Japan. The average of contact angles of two sides of 6 drops, determined using MB-Ruler software, was calculated and reported as CA of each sample.

3. RESULTS AND DISSCUTIONS

The samples were evaluated in the term of hydrophilicity by measuring the time required for water droplet absorption on the fabric surfaces. As shown in Fig. 1, the water droplet absorption times have been increased on the nano-functionalized XPs post-treated samples, especially on the sample treated with clay/TiO₂.

The water droplet absorption time for unmodified cotton was about than 0.3 seconds. Water droplets were also fast spread on all nano-functionalized samples without post-treatment with cross-linkable polysiloxane. The after-treatment with the cross-linkable polysiloxane caused the increase of water droplet absorption times on all samples. This enhancement increased in the case of nano-functionalized samples covered by XPs. Generally, creating hydrophobic nano-roughness can increase the hydrophobic properties of surfaces. In this research, XPs coverage with the suitable concentration can provide the hydrophobic feature on the nano-functionalized samples. Fine nano-roughness can provide more and finer air pocket and increase hydrophobicity.

The nano-roughness created by nano-patterns on

nanostructures can be more efficient. In this research TiO₂ nanoparticles have negative surface charge in the applied conditions.

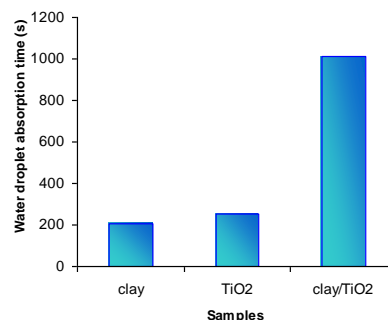


Fig. 1 – Water droplet absorption times on the nano-functionalized XPs post-treated samples

Natural montmorillonite, Cloisite® Na⁺ layers have positive surface charge, due to the presence of Na⁺ on their surfaces. Consequently, nanoparticles can be adsorbed on the nanolayer surfaces, according to their electrostatic interactions. This has been schematically shown in the Fig. 2.

In this way, applying of these two nanostructures can provide the special nano-roughness as well as some other synergistic effect on the practical properties of treated materials.

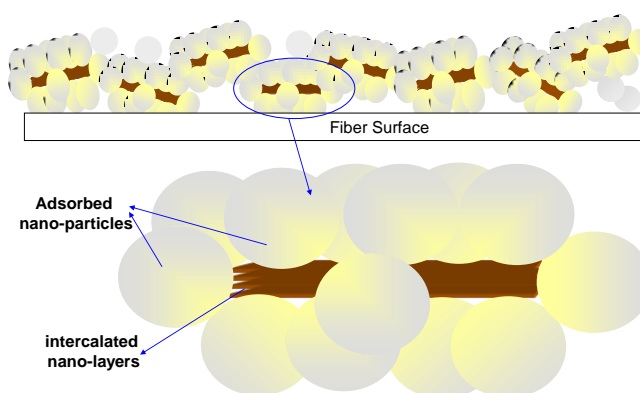


Fig. 2 – Schematic of nanoparticle adsorbed on intercalated nano-layers



Fig. 3 – the water droplet on clay/ TiO₂ sample

This treatment facilitated achieving the contact angle of 149.1 ± 2.5 on the treated cotton fabrics. Fig. 3 shows the water droplet on this sample.

4. CONCLUSIONS

The effect of a cross-linkable polysiloxane post treatment on the nano-functionalized cotton fabrics with the designed nanoparticles adsorbed on intercalated nanolayers has been investigated. The hydrophobic properties of the prepared sample have been reported. The results demonstrated the efficiency of this coating, basis of the polysiloxane sheltered nanoparticle-containing intercalated nanolayers, to achieve the contact angle of 149.1 on the cotton fabrics. An

extensive investigation on multifunctional features of this treatment using different organo-clays and natural montmorillonite on the textile surfaces have been performed, regarding also the effect of pretreatment process, in our group which is considering for publication, hopefully in near future.

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