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Short communication

Nano polyurethane based surface modification on the anti-felting functionalization of wool fabrics

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ABSTRACT

Nano polyurethane (Nano PU) was used for the fabrication of multilayer nanocomposite film deposition on wool fabrics by electrostatic self-assembly to improve the anti-felting properties. Oppositely charged cationic poly (diallyldimethylammonium chloride) (PDDA) and anionic Nano PU were alternately deposited on the surface of wool fabrics. 8, 12 and 16 multilayer films of PDDA/Nano PU were deposited on the wool fabric surfaces using a padder. Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (FTIR-ATR) and Scanning Electron Microscopy (SEM-EDX) were used to verify the presence of deposit nanolayers. Breaking strength, whiteness and yellowness value analysis was performed on the fabrics before and after the treatment with Nano PU by the electrostatic self-assembly method. The build-up of the multilayer films and the level of colour strength (K/S) achieved are discussed after the acid dyeing process. To examine the anti-felting properties of the multilayered fabrics, the fabric shrinkage after washing was determined.

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1. Introduction

Polymer-based multilayer films created by electrostatic self assembly (ESA) are currently used to modify the surface properties of materials used in various fields of science. The label process is based on the alternating adsorption of charge cationic and anionic species [1–3]. Polyelectrolyte and nanoparticle self-assemblies of different textile fibers and structures were studied about the use of nanoparticles for multilayer film deposition on the textile fibers. In our previous studies, we investigated the possibility of nanoparticle film deposition on cotton fabrics with electrostatic self-assembly deposition. The process begins by charging a substrate appropriately. To impart cationic sites to the surface of the cotton fibers, we used a chemical modification technique named cationization and we showed that the electrostatic self-assembly process could be used to obtain functional textiles with nanoparticles [3–9].

Wool is a high-quality fiber material with characteristic properties that are excellent in many respects (comfort properties, breathability, moisture absorption and buffering, resilience, low odour and odour absorption, softness, flame resistance, biodegradability etc.) as compared to synthetic fibers. Controlling the felting shrinkage in wool fiber processing is a adversity problem. Undesirable felt-shrinkage generating by home washing is mainly associated with the surface properties of wool and it is called as directional friction effect (DFE). To reduce felting, this directional dependency must be reduced. Due to this phenomenon, there have been many shrinkproofing methods developed by applying a variety of surface modification techniques. The Hercosett process which includes chlorination and polymer deposition, is still the most widely used industrialized method. However, the production has encountered not only environmental problems (Absorbable Organic Halogen (AOX)), but also deterioration of mechanical and surface properties of wool fibers, such as fabric handle, dyeability and so on [10–13].

In this research work, we have shown that the surface of wool fibers could be coated by ESA treatment, a process which is necessary to improve the felting behaviour of the wool.

2. Materials and methods

Nano polyurethane (Baypret Nano PU, particle size <100 nm) anionic dispersion was purchased from Tanatex Chemicals. Aqueous solution of Nano PU was prepared at concentrations of 40 g/l using deionized water and the pH of the Nano PU suspension was adjusted to 5 using HCl. Poly(diallyldimethylammonium chloride) (PDDA, Mw = 100,000–200,000) was purchased from Aldrich and

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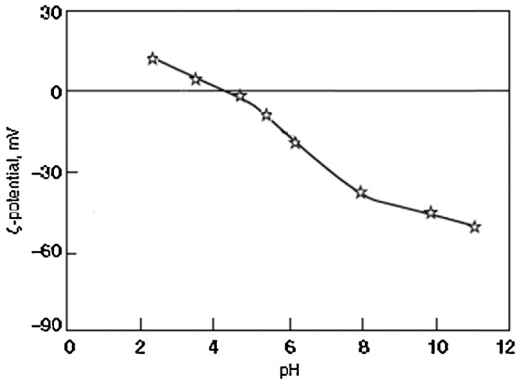

Fig. 1. The electrokinetic potential of the standard wool fabrics at various pH [14].

aqueous solution PDDA was prepared at concentrations of 5 mM/l using deionized water. The pH of PDDA solution was adjusted to 9 by using NaOH. 100% wool woven fabric was used as substrate which will support the multilayer film for the ESA process. The isoelectric point of wool fibers was at pH 4.7 and wool fibre has an anionic character at pH 8–10 due to the presence of numerous carboxylate groups as shown in Fig. 1 [14].

In the PDDA/Nano PU multilayer film deposition process, the wool fabrics were applied in the following solutions alternately as seen as Fig. 2: (a) the cationic PDDA solution, (b) the deionized water, (c) the anionic Nano PU solution, and (d) the deionized water. 8, 12 and 16 PDDA/Nano PU multilayer films were deposited on the wool fabrics by using a laboratory-type padding machine. Multilayer film coated wool fabrics were dried and cured at 130 °C for 3 min.

SEM measurements were used to examine the surfaces of wool fabric samples. FTIR spectrometer was used to obtain the infrared spectra of surfaces using an ATR sampler. After the PDDA/Nano PU multilayer film deposition process, for determining wool fabric dimensional changes, the method according to ISO 6330:2000 6A standard was used. Due to the limited size of the laboratory type padding machine, the dimension of the fabric samples used were 14 cm × 14 cm, with a 10 cm × 10 cm marked inside the fabric. The fabric was conditioned before and after washing. The measurement was then conducted to assess the area shrinkage.

3.0 wt.% of the Acid Red 151 dye were employed for dyeing wool fabrics in laboratory type dyeing machine. The bath ratio was 1:100 (1 g of fiber in 100 ml of dye solution). The following dyeing condition was adopted: an initial temperature of 40 °C, followed by a temperature increase of 2 °C min^{-1} up to 80 °C, holding for 40 min at 80 °C. After dyeing, the fabrics were rinsed with cold–hot–cold water and then dried at room temperature. A

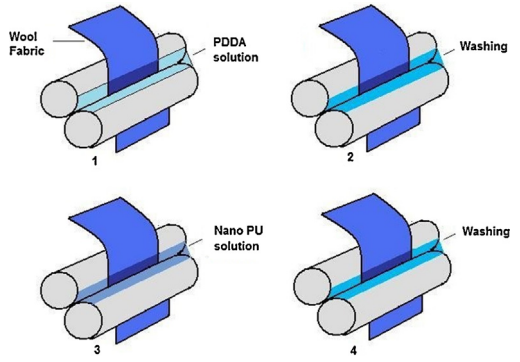

Fig. 2. The schematic representation of the ESA deposition process in padding machine.

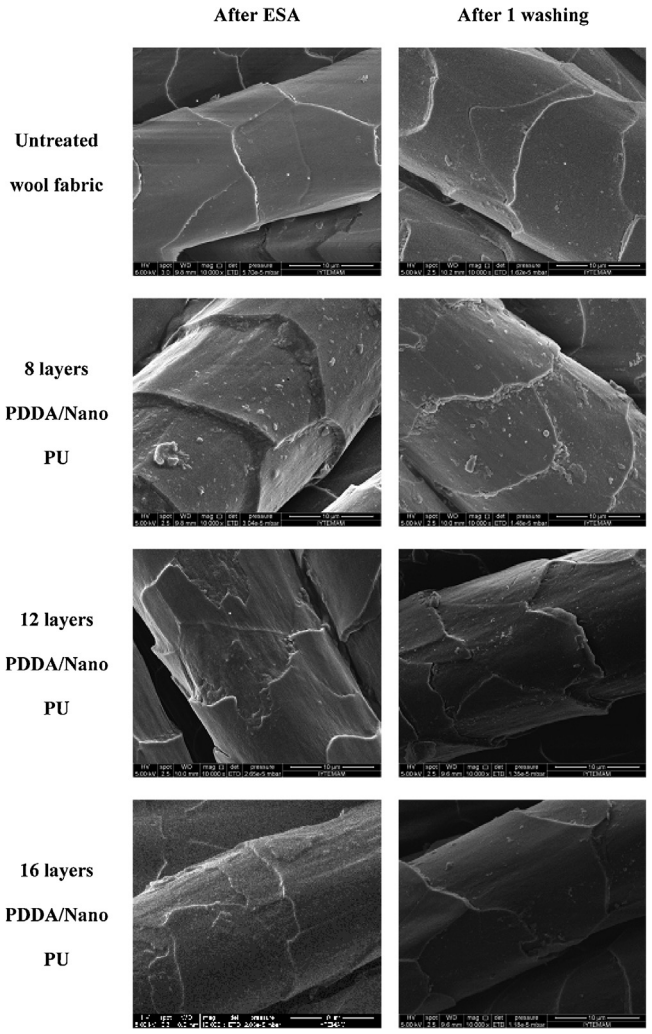

Fig. 3. SEM images of wool fabrics untreated, coated with 8, 12 and 16 layer PDDA/Nano PU and these fabric images after 1 washing process.

Minolta 3600d spectrophotometer was used to obtain the colour strength values, whiteness and yellowness values of the untreated and PDDA/Nano PU multilayer films deposited wool fabrics.

The mechanical tests were performed on a Lloyd LR5K Plus electronic tensile strength machine according to TS EN ISO 13934-1 (Textiles – Tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method) Standard. The breaking strength of the untreated and PDDA/Nano PU multilayer films deposited wool fabrics was tested at fracture. Wool fabrics were kept for 24 h at ambient conditions (20 °C and 65% RH) before the mechanical test.

3. Results and discussion

Scanning electron microscopy was used to verify the presence of the deposited nanolayers on the wool fabrics. Fig. 3 shows SEM images of untreated, 8, 12 and 16 10-layer PDDA/Nano PU deposited wool fabric and these fabric images after 1 washing process. Well-defined contour lines of scale edge can be seen on the surface of the untreated wool fiber clearly. The surface of the treated wool fiber was coated with PDDA/Nano PU layers and scales of wool fiber were covered. In addition, the scale edges of PDDA/Nano PU coated fibers are blunt obviously, which could decrease DFE of wool fabrics and a better anti-felting effect was obtained.

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