Journal of Fiber Bioengineering and Informatics 8:4 (2015) 733–740
doi:10.3993/jfbim00182

Daylight-triggered Directional Water Transport Fabric Prepared with TiO_2 Sol-gel Method ⋆

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Abstract

To build directional water transport fabric, cotton knitting fabric was finished with TiO_2 sol by two methods: padding and spray. After finishing, the fabrics were irradiated in a self-made UV light box, during which the water contact angle and directional water transport ability were tested. It was found that the fabrics's irradiated side turned from hydrophobic to superhydrophilic within 2 hours, and after 2 hours's irradiation they would recover to hydrophobic within 2 hours. The fabric's directional water transport ability increased with the extend of irradiation time. The sprayed fabric responded more quickly than the padded fabric and took less time to recover than the padded fabric. But the padded fabric had higher maximum one-way water transport capacity.

Keywords: Directional Water Transport; Reversible Wettability; Daylight Triggered; TiO_2 Nanosol

1 Introduction

The ability of fabric materials to transport water directionally is of great significance in keeping skin dry and promoting wearers comfort well-being. Especially when wearer is during active exercises and in hot and humid condition [1]. According to the reports published, Directional Water Transport (DWT) fabrics can be built through the formation of a wettability gradient from hydrophobic side to hydrophilic side across the fabric thickness. Water on the hydrophobic side will penetrate into the hydrophilic side quickly while no water can be easily transferred in opposite way through the fabric. The wettability gradient is achieved by chemical finishing [2-3] or fibres selection [4]. On the other hand, there are also some work concentrating on the structure designing of fabric which creates pressure difference for the water to move from one side to another [5]. There is also work carried out to imitate the branching network of tree to improve fabric's

⋆Project supported by the National Nature Science Foundation of China (No. 21006072).

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DWT effect [6-8]. In recent years, much research has been done to develop smart DWT fabric [9-10]. This kind of fabric can be built by finishing with hydrophobic and photoactive materials. When the fabric is exposed to UV light, the exposed side will turn into hydrophilic while the back side is still hydrophobic. Thus, wettability gradient from hydrophobic side to hydrophilic side will be built. However, once the irradiation is absent the irradiated side will recover to be hydrophobic again, which will give the fabric a resistance to water. This phenomenon has been reported in several papers. However, such fabric has disadvantages in that, the irradiation time needed to change the fabric's wettability is too long. In some cases the process even take several days, and the recovery is also a huge waste of time. Our research is aiming to develop a kind of DWT fabric whose response time as well as recovery time can be sharply decreased. The fabric was prepared by TiO_2 sol-gel method, which is based on TiO_2's reversible wettability controlled by UV light [11-15].

2 Experimental

2.1 Materials

A kind of plain stitch cotton knitting fabric (linear density 20tex, wale 82/5 cm, course 72/5 cm, area weight 252 g/m^2, thickness 5 mm) was used. All of the fabrics were refined in boiled solution for 3 hous to remove the cotton wax. The solution component was as follows: NaOH 10 g/L, Penetrant 3 g/L, fresh water 1.5 L. After refinement the fabric was rinsed with fresh water which was followed by drying with 80°C for 15 minutes. The TiO_2 sol was prepared by adding the mixture of Tetranbutyl Titanate with absolute ethyl alcohol dropwise into a mixture of distilled water with concentrated nitric acid. The resultant mixture was stirred vigorously for 5 hours with magnetic stirrer at room temperature. Before using, the sol needed an aging process which requires a few days. Two methods, namely padding (Fig. 1) and spray (Fig. 2), were adopted to conduct chemical finishing onto the knitting fabric. For the former method, the nanosol was applied onto the fabric by dip-pad process to give a pick up of 48.7% which is the lowest pick up we can get through padding method. And for the latter method, a sprayer was used to spray sol onto the fabric and the pick up is controlled to be 31.8% which is the lowest working pick up we can get through spray method. After the finishing above, the knitting fabric was dried at the temperature of 80 °C for 20 minutes. The amount of TiO_2 deposited on the fabrics is calculated to be 1.81% and 1.18% respectively.

2.2 Characterization

Field Emission Scanning Electron Microscopy (FE-SEM, Zeiss, Ultra Plus) operating at 1 kv

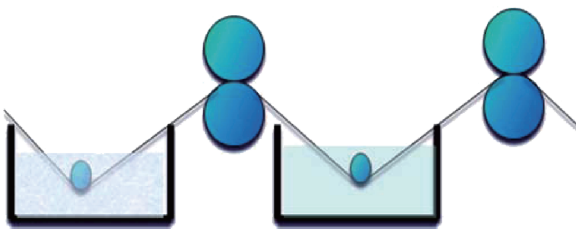

Fig. 1: Schematic of padding process

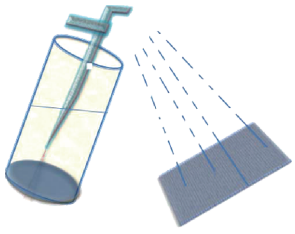

Fig. 2: Schematic of spray process