HYDROPHOBIC ANALYSIS OF NANO-FILAMENT POLYESTER FABRIC

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***Abstract**: The aim of this study was to analyze the effect of hydrophobic finish for nano-filament polyester fabric with comparison to hydrophobic finish effect to cotton and Coolmax on the water transport property. nano-filament polyester, cotton and Coolmax fabrics were treated with 1% to 4% solution of hydrophobic finish (ItoguardLJ 100 conc.) to impart hydrophobicity. Hydrophobic behavior of theses fabric samples were measured by contact angle and roll off angle. Air permeability of treated and untreated fabric samples were compared regarding finish percentage applied. The results were as followed. The measured contact angle of water droplet on all fabric samples was 125-135° for 1-4% finish application. The tilting angles of all the samples were 11-18°. The air permeability values were inversely proportional to the finished percentage treatment. The best results were obtained at 3% finish applied on the fabric samples regarding contact angle, roll off angle and air permeability.*

***Keywords:** Nano-filament polyester fabrics, contact angle, roll of angle, air permeability.*

1 INTRODUCTION

Hydrophobicity with contact angles (CA) more than 90º are inspired by natural surfaces such as the lotus leaf, on which water drops show spherical shape and start roll off, removing dirt and dust substances from the surface [1]. Literature has given that hydrophobicity and superhydrophobicity prospective because of the mutual effect of hierarchical micro and nanostructures of the surfaces along with the low surface energy of the materials [2]. Hence, hydrophobic surfaces can be produced by creating roughness or by lowering the surface energy of a rough material. In textile industry, water proofing is considered as one of the likely applications for the superhydrophobic effect.

Superhydrophobic textiles are mostly applicable where textile surfaces are introduced to the environment [3, 4]. Different techniques have been applied to fabricate superhydrophobic fiber and textiles in a different ways as varied as electrospinning, sol-gel, plasma polymerization and surface coating [5, 6].

Polyester fiber has acquired 70% of textile fibre industry that is a significant figure. Although, it is known by its hydrophobic (low moisture regain) and electrostatic nature. To obtain better moisture transport, researchers think about modified polyester, especially with using multifilament and fine filament yarns. Multifilament polyester yarns are made by aggregating many continuous filaments together. They are characterized by their high strength, good chemical properties, acceptable elasticity and its circular cross section. Moreover, the voids between these filaments form capillary channels and facilitate liquid flow [7].

Nowadays we talk about ultrafine filaments or nano-filaments of polyester with diameters in the range of a few nanometers and lengths up to kilometers are used in different range of important technological applications such as functional fabrics, biomedicine, composite, etc. The nano-filaments of polyester are characterized by their high tenacity, large surface area per unit mass and small pore size [8].

2 MATERIALS AND METHODS

2.1 Material

Nano-filament samples were got from a Japanese commercial factory to asses it hydrophilicity and hydrophobicity properties for next to skin fabric. Yarn specifications for nano-filament polyester fabric are given in Table 1 followed by fabric specification Table 2.

Table 1 Mechanical properties of yarn used for the nano-filament fabric

Fineness	**[dtex]**	152±10
Tenacity	**[N]**	4.5±0.3
Elongation at break	**[%]**	32±5
Boil Shrinkage	**[%]**	2±1

Two samples were constructed by this yarn with different GSM. Both samples were fabricated by warp knitted technique and specifications are given in Table 2.

Table 2 Specifications of nano-filament fabric

Sample	GSM [g/m^2]	Thickness [mm]
S1	200±2	0.44
S2	250±2	0.55

SEM images are given below in Figure 1 to show the nano-filaments in yarn used for both sample construction.

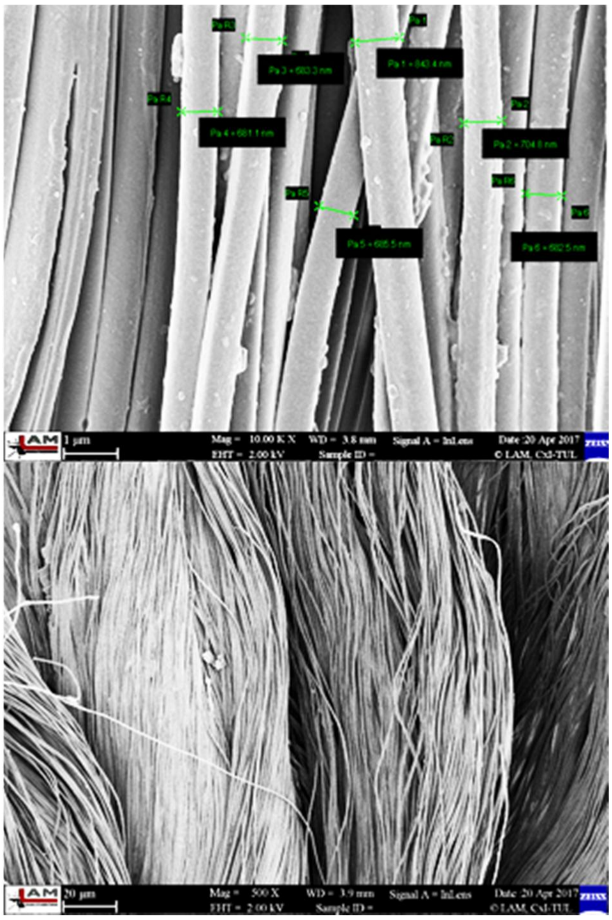

Figure 1 Fabric sample's SEM images with almost 680 nano-meter diameter

Sample 1 and sample 2 were compared with S3 (Coolmax) and S4 (cotton) fabric taken from university laboratory stock.

Table 3 Specifications of Coolmax and cotton

Sample	GSM [g/m^2]	Thickness [mm]	Yarn diameter [mm]	Yarn count
S3 (100% Coolmax)	200±2	0.69	0.12	20/1
S4 (100% cotton)	200±2	0.62	0.15	20/1

2.2 Methods

Lab scale method was used to make the solution of hydrophobic finish for treatment. 10, 30, 40 gram/liter Itoguard LJ 100 conc. finish solution with 2 drops of CH3COOH (conc.) applied onto the fabric samples to get hydrophobic properties [9, 10]. After immersion, samples were dried in the oven at 100°C for 15 minutes. Lastly, contact angle was measure on the fabric samples with contact Goniometry instrument [11]. For the measurement of roll-off angle, manual method was used as shown in Figure 2. The surface wettability of the treated nano-filament fabrics was studied by measuring the contact angle and roll-off angle of a droplet of water on their surfaces. Figure presents the profile of the instrument with both static and tilt position (droplet size, 10 μL).

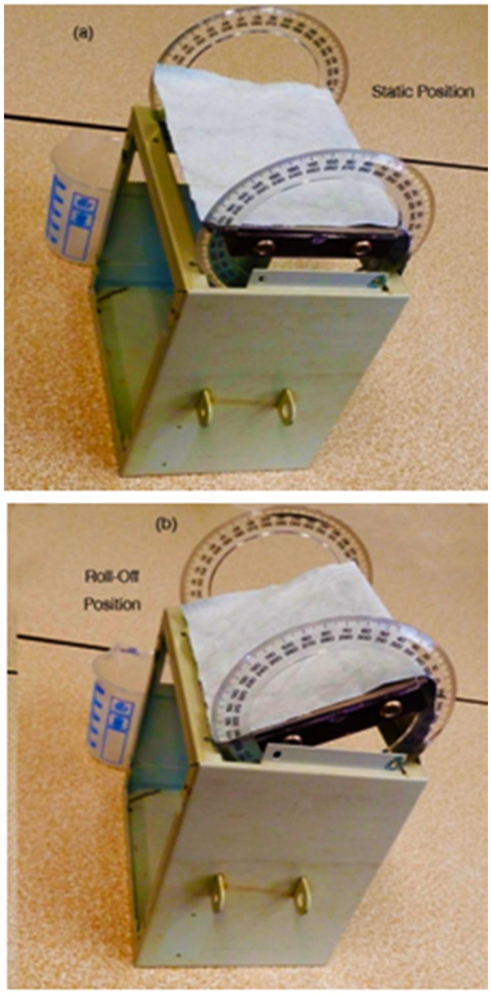

Figure 2 Roll-off angle instrument

Nano-filament polyester fabrics are more water lover as compared to PET spun fabric [8].

To analyze the water transportation of water through fabric samples, in house vertical wicking method was used with Czech standard (Czech national ČSN 80 08 28) was used, as shown in Figure 3. Coolmax and cotton fabrics (200 GSM) were also hanged on the instrument for the comparative results. Sample size was 250x10 mm. Ink drop was put into the reservoir to clear the height of water on the fabric hanged vertically for results.

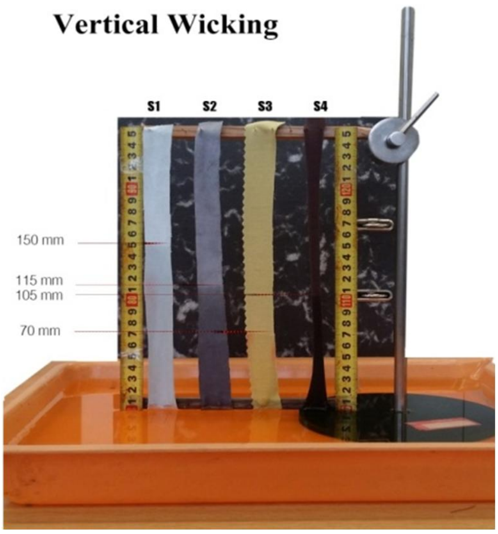

Figure 3 Vertical wicking method

Air permeability (ISO: 9237) SDL M021S method was used as shown in Figure 4. This test shows the level of resistance of the material to the air/wind influence from the outside. The lower permeability of the material the better is its resistance to air/wind.

Figure 4 Air permeability SDL M021S

3 RESULTS AND DISCUSSION

3.1 Vertical wicking

Water absorption and transportation of textiles is important for the optimization of underwear, functional clothing or other health-care products. Properties like vertical wicking should be investigating [12, 13]. Nano-filament fabric S1 with low mass showed better vertical wicking because of it less density. Tight structure of S2 restricted the filament to propagate the water. Coolmax and cotton fabric with porous material remained poorer in vertical wicking behavior as shown in Figure 5.

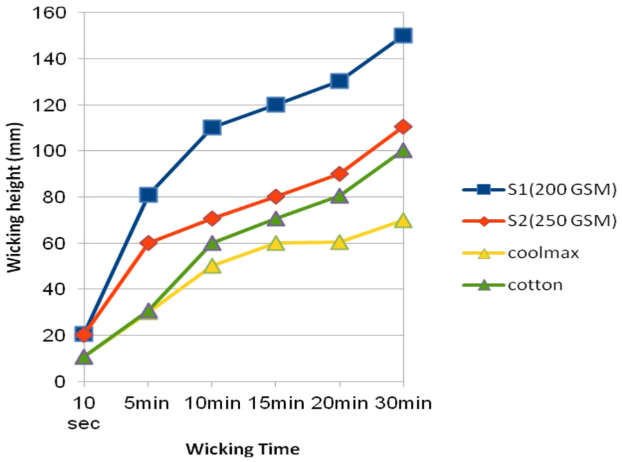

Figure 5 Vertical wicking

3.2 Contact Angle

Water contact angles were measured on Contact goniometry analysis system to determine the wettability of a surface [14, 15]. After applying the finishes when the samples were brought into contact angle measurement the observed contact angle of a water droplet on all fabric samples were 125-135°, for 1-4% finish applied. Graphical representation is showing no significant difference from 2% to 3% finish solution but compared to the 1% as shown below in Figure 6. Hydrophobic treatment with 3% finish is convenient and environmental process because of less use of finish quantity. The results shown in graph were not giving improved results by enhancing the percentage of finish in solution so 3% were found best for this process.

3.3 Roll-off Angle

The droplet roll-off state, because of the small total contact area between the liquid droplet and the surface [15, 16], is inversely proportional to the wettability. The tilting angles of all sample lie between 11-18°, the water droplet started to roll off the fabric surface. In comparison, figure below presents the profile of water droplets on a hydrophilic face. 4% finish solution onto the fabric sample exhibit better roll off angle other than 1-3% as sown in Figure 7.

3.4 Air Permeability

Air permeability of untreated and finished samples (1-4%) were measured by followed formula

$$R = \frac{q_r}{A} \times 10 \qquad (1)$$

Area of the diaphragm where fabric has to place is 20 cm. It was not found any significant difference when the samples were subjected to finish. But the air permeability of untreated fabric was slightly higher than treated fabric as shown in Figure 8.

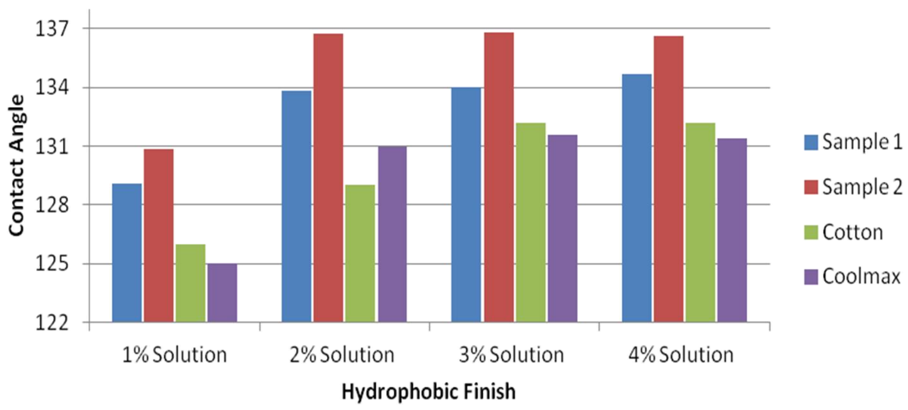

Figure 6 Contact angle measurement

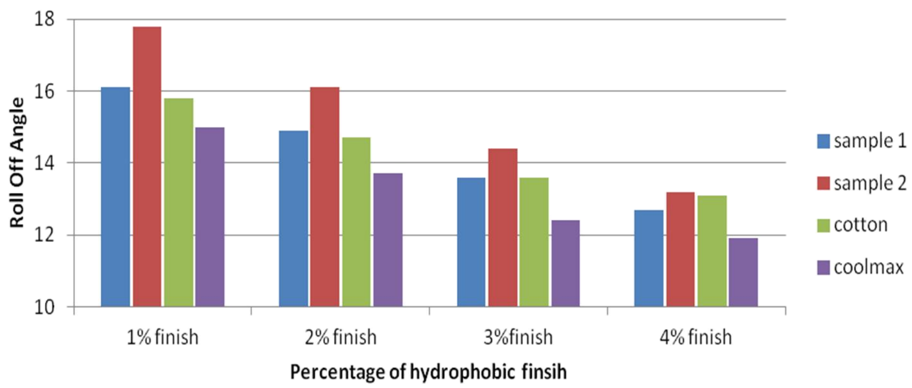

Figure 7 Roll off angle

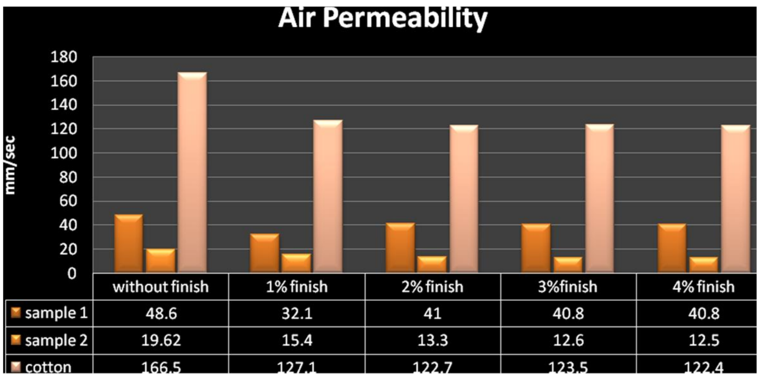

Figure 8 Air permeability index

4 CONCLUSIONS

From the obtained results it is concluded that the application of hydrophobic treatment to nano-filament polyester fabric along with cotton and multichannel fabric is also a promising textile finishing process to produce water repellent surface. In fact high contact angle and roll-off angle values were observed on all treated fabric sample without differentiate the structure and properties of specimens. The quantity of finish applied (%) was considered a significant parameter as compared to varying the fabric sample. The deposition of the hydrophobic finish on samples was 1 to 4%. Moreover, 3% finish applied was enough to confer the desired results. The air permeability values were found inversely proportional to the hydrophobic finished percentage treatment.

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