Development of Self Cleaning Gossypium Fabric with Nano Technology through Water Repellent Methodology

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Abstract - Self-cleaning coating in nano-technology is getting pace in the globalization because now customer wants the products which are sustainable and less hazardous or time taking. The water droplets can work to collect dirt and residue just by rolling over the fabric surface. The objective of the study is to develop self-cleaning property in textile materials such as 100% cotton fabric is chosen to investigate the effect of self-cleaning finish. The grey cotton fabric is treated with fluorinated water repellent finish, after application of finish fabric is dried in stenter frame at 100°c for 2 mins, and then spray test method is applied to check the water repellent finish. After the analysis of results, it is concluded that a simple cotton fabric can have self-cleaning properties.

Keywords -- Gossypium, Self-Cleaning, Nanotechnology, Water repellent

I. INTRODUCTION

1.1 Self-cleaning or water repellent

The self-cleaning coatings technology has evolved rapidly in recent years. As a consumer product, their potential is immense and their market is truly global [1]. Textile surfaces are also referred to as self-cleaning textiles, from which drops of water roll off residue-free, taking any impurities with them. Botanist Wilhelm Barthlott, who studied at the University of Heidelberg, investigated self-cleaning surfaces back in the 1970s. He first sees the effect on the Lotus Leaf [1, 2]. Lotus is a kind of plant which grows in the mud without letting mud affect the purity of the plant. It is a type of lotus leaf plant that grows in mud, without letting the mud affects the purity of the plant. The waxy surfaces of the lotus create an extremely hydrophobic atmosphere according to the existence of microscopic structures [3,18].

Nanotechnology offers a modern idea of self-cleaning textiles that offers day-to-day self-cleaning as well as fresh clothes, which not only benefits technologically but also benefits techno economically. In the modern era of today, peoples are so busy with their jobs that they have no time to clean their clothing. Military communities must also live in such a harsh situation that they cannot wash their clothes. The key factor leading to the growing demand for self-cleaning textiles is the use of excess water and energy consumption in running laundry machines. The usage of chemical detergents to clean clothes has environmental consequences and is not environmentally friendly. The cost of fabric laundry (or dry-cleaning costs) and clothing cleaning can be reduced by using textiles which are self-cleaning [2].

Everyone is worried about the cleanliness of clothes in daily life and so it takes a lot of water, energy and time. Self-cleaning clothes are no longer the stuff of dreams with the scientific and technological advancement. It's a genius nanotechnology technique that has also made it possible to obtain these properties on clothes and other materials. The technology uses the treatment of nanocrystals by controlling wettability and contact between the surfaces.

II. LITERATURE REVIEW

Nano-Tex improves the water-repellent ability of the fabric by producing nano-whiskers, which are hydrocarbons and 1/1000 of the size of standard cotton fiber, functional to the fabric to produce an appearance of peach hair without decreasing cotton strength. The gaps on the fabric between the whiskers are smaller than the usual drop of water but still larger than water molecules; hence, the water stays on top of the whiskers and above the fabric surface [13]. However, air, if pressure is applied, will still move through the fabric. The success while retaining breathability is permanent. In addition to Nano-Tex, the Swiss textile company Schoeller has created the Nano-Sphere to manufacture water-repellent fabrics (figure 1). Impregnation of the Nano-Sphere involves a three-dimensional surface arrangement with gel-forming additives that keep away water and put off the attachment of dirt particles [13, 19]. The system is related to the outcome of lotus which occurs in nature. Lotus plants have extremely hydrophobic, rough, and textured surfaces. When water droplets land on them, water droplets bead together and roll-off if the surface slopes slightly. Consequently, even after a vigorous shower, the surfaces remain dry [12,15].

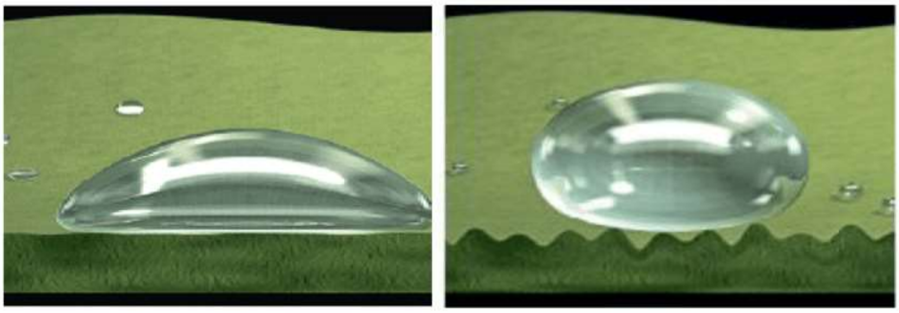

Figure 1.(a) Classic surface (b) Nano-sphere surface

2.1. Hydrophobic and hydrophilic surface

Because of microscopic roughness, many plants and animals show hydrophobic surfaces. They are distinguished by a static angle of contact greater than 150 ° and a low angle of hysteresis that allows a water droplet to roll on a surface with an inclination of less than 10 ° [17, 18]. Neinhuis and Barthlott conducted a study that, there have been existing standing contact angle of two hundred of the hydrophobic plant variety. Most of them displayed an angle of touch greater than 150 ° and were therefore graded as superhydrophobic. The morphological features of these plants' leaves are due to a hierarchical configuration consisting of epidermis cells convex to papillae, with a very dense arrangement. All notorious crystal forms have been found such super-hydrophobic and self-cleaning property, imitation by nanotechnology; have been developed as biomimetic technical advances and unproved under the name "Lotus effect" Textiles with these properties are worn for outerwear, carpets, building materials, and so on. Long before Biomimetic became recognized through the work of [13, 14], the importance of super hydro-phaticity for textiles was emphasized.

Hydrophobic materials can be useful for other applications such as anti-corrosive systems and anti-icing. The superhydrophobic coating can avoid ice forming by inhibiting the mechanism of frost nucleation by using nanoparticle-polymer composite for anti-icing. It has been experiential that the composites are proficient of preventing ice formation depends not only on their super hydro-phaticity but also on the size particles that are exposed to the surface due to the effect of supercooled water in both laboratory and ordinary environment. These findings open up the potential for the coherent design of superhydrophobic anti-icing surface by multi-length amendment of surface textures [5,6]. Super-hydrophobic coatings can also increase fuel efficiency in the marine diligence by dropping skin rubbing drags in ship hulls. Such a coating increases the speed of the ship and also serves as an anticorrosive device, prevent any organic pollutant or marine microorganisms from approaching into contact with the hulls. In cars, superhydrophobic coatings are useful on the glasses to avoid the sticking of rain droplets, in this manner helping to clean up the car itself [8, 11].

A significant amount of work has been done by the US Department of Agriculture's Southern Regional Research Laboratory, the Institute of Textile Technology (ITT), and some of the ITT's affiliate mills to chemically transform cotton to advance its decaying resistance and advance other properties by acetylating and cotton cyanoethylation. Owing to relatively high costs and the loss of fabric strength in manufacturing, these treatments had limited acceptance by the industry. Additionally, the upward usage of man-made fibers such as nylon, acrylics, and polyester, which have a natural resistance to microbial disintegration, has come into wider use in many trade fabrics to substitute cotton [7].

III. MATERIALS AND METHODS

The researcher used this research method to efficiently provide full descriptions of the methods, the machinery, the devices, the techniques, the materials, and the samples generated in the fabric design.
Fluorinated water repellant finishes 200gm/liter

3.1 Instruments

3.1.1 Stenter frame

Function: The stenter machine aims to carry the length and width to predetermine the dimensions as well as the heat setting and it is used for the application of chemical finishing.

Instrument: stenter frame (pin) serial no.92-5-552 and model (TC-M-28) were used for experimentation. The temperature and time were adjustable according to requirements.

3.1.2 Laboratory Padder:

Function:

The water of the wet fabric is squeezed by the squeezing roller. Laboratory padder is also known as the dewatering machine. It is used for squeezing excess water. The fabric absorbs water and squeezes excess amount. The laboratory padder is used for the application of knitted and woven textiles to resin finishing. The pressure is adjustable, and the speed of the padder is around 2 m / min.

Instrument:

The machine is semi-automatic.it has a tub in which liquid is poured. Two padded rollers were used for squeezing.

3.1.3 Fluorocarbons/ Fluorinated water repellant

Long-lasting water repellents (DWRs) are contemporary finishes that are useful to fabrics for defense from grease, water, and dirt. These finishes also prolong product life and keep it looking newer longer. The polymer particle melts and falls on the textile surface to cover the fabric surface when the fabric is drying after it is applied. Fluoroalkyl chains are oriented perpendicular to the surface of the fabric. This could be pictured as minute umbrellas attached to the vertebrae of the polymer

3.1.4 Standard spray test instruments:

Spray tester or tester for water repellence is used to assess tissue resistance to water wetting. This is a new trend in economics. The specimen holder to meet the average is set at 45 °. A special funnel is available which adheres to the average. It includes a 500ml beaker, template & marking pen for cutting.

3.1.5 Application of water repellent finish

Laboratory padder was the instrument used for applying water repellent finish (figure 2). The solution which contains 200gm/liter fluorinated water repellant finish was mixed in a container and strain in the liquor tank. The liquor tank consists of steel rods by which grey cotton fabric pass through towards padders. Padder squeezes 80% of the solution and absorbs the rest amount. Water repellent finish and antibacterial finishes were applied through padder. Afterward, drying of fabric was done through stenter machine at 100°c for 2 minutes (figure 3, 4).

Figure 2. Laboratory padder

Figure 3. fluorinated water repellent finish in padder

Figure 4. Drying of fabric in stenter machine.

IV. RESULTS OF THE EXPERIMENTAL STUDY

4.1 Water repellent AATCC experiment process 22-2001: spray test

The spray check process tests fabric confrontation to water-wetting. It is appropriate to any fabric, although is particularly appropriate for measure the efficacy of water-repellent finishes practical to fabrics, especially on plain natural fiber. The test technique is not projected to predict the possible confrontation of fabrics to rain penetration; it is because it does not quantify water dispersion into the fabric. For this inspection process, under controlled conditions, water sprayed in opposition to the firm surface of a test sample creates a wetted model whose dimension depends on the comparative repellence of cloth. A typical graph of cloth water repellence rankings of 100, 90, 80, 70, 60, 50, and 0 was contrasted with the wetted pattern on the fabric. A ranking of (0) is allotted to fabrics whose surface is entirely water-wetted, while a ranking of 100 refers to fabrics that have no water-wetting on their surface. The consequences obtain through this test method rely chiefly on the confrontation of fibers, yarns and fabric finish to wetting or water repellence, and not on fabric construction (figure 5, 6, 7, 8). Average spray test rating (figure 6)

Table 1 textiles - fortitude of water repellency of fabric by rain-shower experiment

Ranking	Explanation
100	the upper surface could not adhesives/wets
90	Slight higher sticking or wetting at the random surface
80	Outside Wetting at spray points
70	Part wet of the entire top face
50	Full wet of entire top surface area
0	Full humidification of whole upper and lower surfaces

This test technique describes a spray method to assess the fighting of any textile to surface water wetting that might or might not have been set a resistant/repellent finish (table 1). It is not proposed to be used to forecast the rain-penetration confrontation of materials, as it does not calculate water diffusion throughout the fabric

Figure 5. Water repellency AATCC test instrument

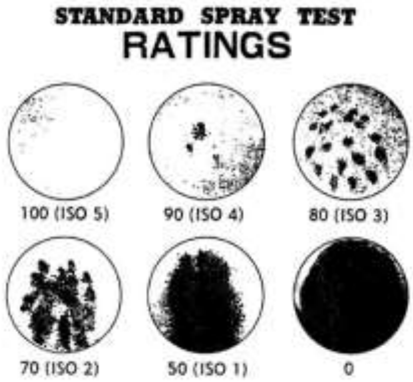

Figure 6. Average table of textile water repellent ratings

Descriptions of average water repellent ratings are given below:
100- No sticking or wetting of the upper surface
90- Slight random sticking or wetting of the upper surface
80- Wetting of upper surface at spray points
70- Partial wetting of whole of the upper surface
50- Complete wetting of whole of the upper surface
0-Complete wetting of whole of the upper and lower surface

Figure 7. *Analysis of grey fabric*

Figure 8. Analysis of water repellent finish

V. DISCUSSIONS

The objective of this study was to develop self-cleaning property in cotton fabric. According to Barthlot & Neinhuis, a hydrophobic surface in 1997 repels water with low wet power properties and touch angles greater than 90°. The higher contact angle decreases the surface adhesion strength and increases hydrophobicity. The surface is called superhydrophobic for a contact angle greater than 150 °. Roughness factor may also control hydrophobicity. The drop direction of water on it will enhance with rougher surfaces, and structure bump that entraps air stuck between the water and the surface. In this superhydrophobic process, the "Lotus Effect" was introduced [4, 9, 10]. The lotus leaf cleans itself by producing a superhydrophobic leaf composed of tiny bumps across the surface of the leaf, which play an important role in its water-repelling property. A rough outside layer on those bumps of minute wax crystals increases the effect. It allows droplets of water rolling, and removes soil. Water & soil encompass larger affinity than outside [4]. Developed a wonderful hydrophobic polymer arrangement by replicating the exterior side of a lotus leave directly [19].

The water repellency property of fabric does not create harmful effects or harshness on the skin. The fabric becomes comfortable for wearing, and the fabric does not require proper caring. Loss of water can be reduced with this finish applied to the fabric. The life of fabric also increases. With the advancement of technology, now a day's chemicals are more eco-friendly and do not have any harsh effects on the skin. When water drops fall on treated fabric, water rolls on fabric and removes dust particles with them. This study depicts that functional textiles can be created and can resolve many problems in our daily lives [13].

VI. CONCLUSIONS

The study revealed that simple cotton (natural) fabric can be converted into functional textile and their properties can also be changed with low labor cost, higher fixation rate, and lower water consumption. It was also explored that this field has opened new opportunities for different fields, i.e., for medical, for housewives, technicians, for fashion and textile students, and many other fields. The idea of self-cleaning provides a great many benefits in a different industries. In particular, self-cleaning material which, suitable to the time, content, power decline, and accordingly cost-efficiency through making, has huge potential meant for product enhancement not just in the textile industry as well in the health department. Also, this system supports environmentally friendly technologies as it efficiently eliminates cleaning activities and conserves a large quantity of water and electricity, while saves time and charge of washing.

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