Surface Modification of Fibre an Aspect of Comfort Properties of Fabric

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Abstract

The most important property of all apparels is comfort. It is a qualitative term and it is one of the most important aspects of clothing. The clothing comfort can be divided into three categories, i.e. physiological, tactile and thermal comfort. Physiological comfort bears little relation to the properties of the fabrics and is mainly related to the latest fashion trend and the acceptability in society. The tactile comfort has relationship with fabric surface and mechanical properties. The thermal comfort is related to the ability of a fabric to maintain the temperature of the skin through transfer of heat and perspiration generated within human body and is determined by movement of heat, moisture and air. Comfort characteristics are related to surface smoothness, air permeability, heat transmittance, and hydrophilicity of fabric. These properties can be attained by fibre surface modification. The surface modification of natural and synthetic fibers through various techniques makes them advantageous by overcoming their inherent drawbacks and successfully utilizing these materials in various applications [1]. This review talks about various fibre surface modification techniques in duding physical and chemical method and their effect on fabric comfort properties.

Keywords: Comfort; Surface Modification; Heat Transmittance; Hydrophobicity

Introduction

The most important property of all apparels is comfort. It is a qualitative term and it is one of the most important aspects of clothing. The clothing comfort can be divided into three categories, i.e. physiological, tactile and thermal comfort. Physiological comfort bears little relation to the properties of the fabrics and is mainly related to the latest fashion trend and the acceptability in society. The tactile comfort has relationship with fabric surface and mechanical properties. The thermal comfort is related to the ability of a fabric to maintain the temperature of the skin through transfer of heat and perspiration generated within human body and is determined by movement of heat, moisture and air [2]. Distinguished aspect of wear comfort of clothing is “Thermo physiological wear comfort” which concerns with the regulation of heat and moisture transport properties of clothing in order to maintain the heat balance of the body during various levels of activity [3]. Thermal and moisture behavior of clothing can be accessed through different parameters such as thermal conductivity, thermal resistivity, thermal absorptivity, diffusion, sorption, evaporation, wicking, and air and water permeability. Fictionalization of fabrics has been studied by many researchers in order to access the comfortable clothing life. Many researchers have been carried out by modifying structure and using different types of fibre and yarn [4,5]. Development of surface modification process with introduction of some functional groups without deteriorating its instinct property of fiber is the need of the hour [6]. Surface modification is effective for improvement in functionality without changing the bulk characteristics of fibres [7]. The modification of the surface energy of textile fibers is pursued with the aim of improving their own hydrophilicity, wettability, and dyeadibility or of conferring functional properties such as hydro and oil repellency, soil release, adhesion improvement, and antistatic performances [8]. Modification changes the composition or structure of fibre resulting in improvement of different fiber properties. Modification methods are divided into two groups i.e. chemical modification which involves change in fibre composition and physical modification which includes change in fibre structure [9]. Chemical method includes (ozone-gas treatment, surface...
grafting, enzymatic modification, sol-gel technique, microencapsulation method and treatment with different reagents) and physical methods include (corona discharge, laser, electron beam and neutron irradiations and ion beam). This paper deals with detailed study about the different modification techniques and their critical analysis.

**Chemical Methods**

Chemical modification utilizes the chemical agents to modify the fibre surface. This treatment aims at increasing fibre strength and adhesion between fibre surface and polymer matrix.

**Ozone gas treatment**

Ozone is excellent oxidizing agent and is used for fibre modification. In this treatment hydrophilic groups are incorporated on fibre surface which results in change in fibre surface chemistry. Oxidation of Wool fibre by ozone gas leads to increase in polymer adsorption by increasing the polarity [10]. Whereas fabric made from Nylon 6 and polyester fibre showed improvement in surface tension of fibres which further increased its moisture regain, water absorption, and dyeing properties in spite of an increase in the crystallinity [11]. Studies showed that increase in moisture absorption will make the fabric comfortable to wear.

**Surface Grafting**

Chemical modification by Graft copolymerization is an important method to enhance fabric comfort properties such as water absorption, moisture regain and thermal properties [12, 13]. Surface grafting can be performed by different methods such as by chemicals, radiation etc and different procedures. It was observed that Poly (ethylene terephthalate) after grafting with acrylic acid using benzoyl peroxide showed better dyeing behavior and good antibacterial properties [12]. Rayon fiber after grafting with acrylonitrile (AN) showed improved swelling, dye uptake and thermal properties [13]. The use of polysaccharide Chitosan is highly recommended to minimize the undesirable activities of the antimicrobial products [14].

**Enzymatic modification**

The use of enzyme in the field of textile and natural fibre modification is rapidly increasing. Enzymatic treatment is eco friendly method of fibre surface modification as it do not discharge harsh effluents to the environment and use milder conditions [15]. Other benefits of this treatment are cost reduction, energy and water saving, improved product quality and potential process integration [16]. This treatment was done on PA 6,6 fabrics by treating with subtilisin enzyme. The results showed significant improvement in hydrophilicity of treated fabric. Hydrophilicity of PET fabric was also improved by using lipase and cutinase enzyme [17]. Improvement in hydrophilicity will make the fabric comfortable to wear.

**Sol-Gel Technique**

The sol-gel technique is of particular importance for textile materials. The principles of the sol-gel process include hydrolyzation, application and curing [18]. The Deposition of coating on fibre surface in the form of sol gel is applied to improve some fibre properties such as abrasion resistance, UV protection and attains water repellency [19]. After modifying pure cotton fire by zinc oxide nanosol prepared by the sol-gel method its ultraviolet protection property improved significantly [20]. It was also observed that hybrid sol–gel silica coating on silk fabric was effective to improve abrasion resistance and stain-repellency [21].

**Micro-Encapsulation Method**

In Micro encapsulation method small capsules are made by using tiny particles or droplets surrounded by a coating. This method improves various fabric properties such as fire resistance, anti microbial, thermoregulation of clothing, adds fragrance to fabric and improves dyeability of synthetic fibres [22, 23]. Microcapsules can be applied to textiles by padding, coating, spraying or immersion [24]. It was observed that cotton fabric after being coated with PEG-600 microcapsules (produced by an in-situ polymerization technique using urea formaldehyde) showed improved thermal resistance, which makes the fabric suitable for winter clothing [25].

**Physical Methods**

Chemical methods for modification include the treatment with chemicals that are toxic and sometimes expensive. Whereas physical method includes, irradiation process to modify the fibre structure. Radiation technology involving low energy use, no chemicals, easy handling, and high treatment speed [26].

**Corona Discharge**

Corona is a luminous discharge from highly electrically charged surface of an object. This plasma, operates at standard atmospheric pressure, and modifies chemical structure. This method improves the adhesion and hydrophilic property by a significant increase in polar components of the surface free energy [27, 28]. The main drawback of corona discharge plasma is it lacks uniformity due to their filamentous nature and cause irreversible thermal damage to polymers [29]. PET fabric after getting modified with corona discharge showed increase in the fibre surface energy and its wet ability [30]. It was also observed that the possibility of wool fabric to be worn next to skin increases after Corona discharge treatment due to high absorbency [31]. Research shows that new pores are developed on fibre surface during plasma treatment which allows more air to penetrate, thereby increasing its air permeability. But water vapour permeability decreased in lyocell fabric due to accumulation of more water vapour in pores [32].

**Laser treatment**

Laser method modifies the polymers surface without any changes in its bulk properties. This method creates morphological changes on the smooth surface of synthetic fibers, that further changes its physical (roughness) and chemical properties (water absorption, dyeing). Advantage of laser treatment is that the small area can be treated and depending on the level of power chosen, chemical and physical changes can occur [12]. Research shows that
Pulsed CO\textsubscript{2} laser improves dye adsorption property of polyamide and polyester fabrics and antibacterial properties of cotton fabric [33].

**Electron-beam modification**

Electron beam is a way of radiation that can produce polymer’s free radicals. These free radicals combine with each other to form cross links resulting in the formation of three-dimensional network structure. Research shows that anti creep property was improved in ultra-high molecular weight polyethylene fiber, after the introduction of multifunctional monomer into UHMWPE fibers through supercritical CO\textsubscript{2} pretreatment followed by electron beam irradiation [34]. Polypropylene fabric showed improved wet ability and Dye ability due to formation of (O-H) and (C=O) groups on the surface of samples after electron beam irradiation [35]. Improvement in water uptake was observed for cotton, cotton/ polyester blend and nylon 6 fabrics after electron beam irradiation [36]. It was also observed that irradiation causes cellulose depolymerization and reduced crystallinity [37].

**Neutron irradiations and Ion beam**

Neutron radiation is a kind of ionizing radiation that consists of free neutrons. Displacement of lattice atoms and the generation of helium and hydrogen by nuclear transmutation significantly change the material properties. Increase in % crystallinity was observed in Polyester fibre after irradiation [38]. This increase results from cross-linking of sheath with expanded core region. Ion Implantation method modifies the fibre surface properties and increases its hydrophilicity. The effects induced by energetic ions in polymers strongly depend on ion mass. Heavy ions degrade the material, whereas with light ions the degradation is limited [39]. Research showed that to modify fibre physical and chemical structure energetic O\textsuperscript{+} ions were implanted into polyurethane fibre filament [40]. Due to creation of new functional groups: OH and C=O on the surface of the fabric, improvement in dye-ability of Polypropylene Fibrics was observed after ion implantation treatment [39].

**Conclusion**

Clothing comfort is not a naturally attained, but rather a result of evaluated combination of the wearer, environment and clothing attributes [41]. Comfort characteristics are related to surface smoothness, air permeability, heat transmittance, and hydrophilicity of fabric. These properties can be attained by fibre surface modification. The surface modification of natural and synthetic fibers through various techniques makes them advantageous by overcoming their inherent drawbacks and successfully utilizing these materials in various applications [42]. This review talks about various fibre surface modification techniques including physical and chemical method and their effect on fabric comfort properties.

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