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TEXTILE SURFACE MODIFICATION BY PYHSICAL VAPOR DEPOSITION – (REVIEW)

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Abstract: *Textile products are used in various branches of the industry from automotive to space products. Textiles produced for industrial use are generally referred to as technical textiles. Technical textiles are nowadays applied to several areas including transportation, medicine, agriculture, protection, sports, packaging, civil engineering and industry. There are rapid developments in the types of materials used in technical textiles. Therefore, modification and functionalization of textile surfaces is becoming more crucial. The improvements of the properties such as anti-bacterial properties, fire resistivity, UV radiation resistance, electrical conductivity, self cleaning, and super hydrophobic, is getting more concern with respect to developments in textile engineering. The properties of textile surfaces are closely related to the fiber structure, the differences in the polymer composition, the fiber mixture ratio, and the physical and chemical processes applied. Textile surface modifications can be examined in four groups under the name mechanical, chemical, burning and plasma.*

Surface modifications are made to improve the functionality of textile products. Textile surface modifications affect the properties of the products such as softness, adhesion and wettability. The purpose of this work is to reveal varieties of vapor deposition modifications to improve functionality. For this purpose, the pyhsical vapor deposition methods, their affects on textile products and their end-uses will be reviewed.

Key words: *Vapor, Deposition, Textile, Functionality, Adhesion, Softness*.

1. INTRODUCTION

Textile products are used in various branches of the industry from automotive to space products. Textiles produced for industrial uses are generally referred to as technical textiles. The natural structures of the textile products to be used for technical textiles may be poor in terms of the properties to be used (anti-static, optic etc.). For this reason, it may be necessary to change the surface properties of these products by physical or chemical methods. This changing/development process can also be described as surface modification.

Textile surface modifications are divided into four groups as mechanical, chemical, incineration and plasma. Since the fiber diameter is a few micrometers, incineration and mechanical methods can not be used for surface modification of fibers [1]. Chemical modification processes can be used for better adhesion of fiber and polymer matrix in fiber reinforced composite materials [2]. However, the chemical modification has some disadvantages, such as the risk of corrosion, the ability to modify the surface in a controlled manner, thereby reducing fiber strength and causing environmental pollution. Plasma technology has been reported to have positive effects on wettability, shrinkage, desizing, adhesion, surface cleaning, dye affinity and printing properties. At the same time, it is an environmentally friendly technology [1], [3].

In this study, physical vapor deposition method which is one of the surface modification types is investigated. The general framework of physical vapor deposition, its application to textile products as well as its usage areas in textile has been examined on literature basis.

2. PHYSICAL VAPOR DEPOSITION (PVD) METHOD

Physical and chemical vapor deposition techniques are types of coatings made on the substrate from the gas phase (vapor phase). Physical vapor deposition (PVD) and chemical vapor deposition (CVD) techniques, which are coating techniques made in the gas phase, have a wide range of applications in industrial applications [4].

Physical vapor deposition coating technology has been known since 1800 years, but it is the thin film coating technique used in the industry last 50 years. In this technique, solid raw material is converted into plasma with high energy and then bonded on the substrat to be coated in a controlled way from the raw material [5]. Advantages of this technique include the following: It can be applied on all kinds of materials, the coatings show excellent adhesion properties, the coating thickness can be made very thin and very thick intervals, high speed production can be achieved, environmental friendliness and can be done at low temperature so that the coated material is not damaged [6], [7]. The working cycle of this method is given in Figure 1.

There are two types of parameters that affect the coating process These are: the thickness of the coating and the temperature of the coating process. [8]. The PVD method has a wider range of uses than other methods because it can be made at lower processing temperatures and a wide range of coating thicknesses can be achieved [9].

The working principles of the PVD method include; vacuum evaporation, ion implantation, magnetron sputtering methods [10]. Vacuum evaporation is the simplest of PVD techniques. The material to be coated is evaporated by any heat effect and the evaporating atoms gradually condense on the substrate [11]. Ion implantation is a material surface modification process by which ions of a material are implanted into another solid material, causing a change in the surface physical and chemical properties of the materials. Ion implantation involves an ion source (ions of the desired element), an accelerator (accelerating the ions electrostatically with a high energy), and a target (ions impinging on a target) [10]. The magnetron sputtering technique provides coatings with high chemical and structural complexity [12].

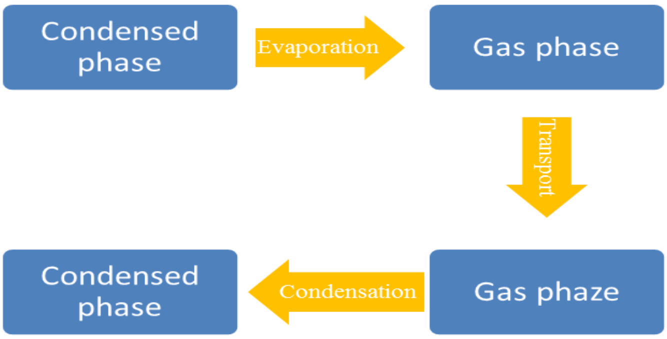

Fig. 1: *Schematic representation of the physical vapor deposition method*

2.1. Use of Physical Vapor Deposition Technique in Textile

Physical vapor deposition technique is a method used to develop functional textiles. With this method, fabrics can be given different properties such as anti-static, protection against electro-magnetic radiation, antibacterial, water-oil repellency, chemical resistance, UV protection, conductivity [13], [14], [15], [16], [17].

Almost all metallic materials can be transferred to textile surfaces by sputtering [10]. The most commonly used PVD technique in the textile industry is sputtering method [18]. The magnetron sputtering technique is one of the most efficient of film coating techniques due to better adhesion on the substrate, environmental friendliness and low storage temperatures [12]. Magnetron sputtering technology can impart conductivity to textile products [17]. Conductive yarns are rapidly gaining importance for areas such as need, static applications, data transfer, imaging, protection against corrosion and electromagnetic shielding [16]. Metals such as Zn, Ti, Cu, Ag and Al; properties such as conductivity, electromagnetic shield, antibacterial textiles can be imparted to fabrics [13], [19].

Silver (Ag) is a coating material that can impart conductivity, antibacterial, UV protection and hydrophobic properties to textile products (Figure 2) [10], [20]. Silver-containing fibers have potential applications ranging from conductive shielding, packaging and protective materials to electronic sensors [21]. Silver and copper coatings can impart both visible light (300-600 nm) and UV light reflection to fabrics. Metallic nanocomposite coated textile materials have great potential for applications such as antistatic fabric, explosion-proof filters, UV absorbing materials and electromagnetic shielding materials [22]. Aluminum nano coatings have also been shown to reduce the electrical resistance of textile products (nonwoven surfaces) [23].

Metal oxide coatings on textile surfaces have also been demonstrated with various studies [24], [25], [26], [27], [28], [29], [30]. These materials include titanium dioxide (TiO2), zinc oxide (ZnO), indium doped tin oxide, and aluminum doped zinc oxide [10]. Titanium dioxide-coated materials have recently been found to exhibit interesting properties due to their unique dielectric and optical properties [25]. Titanium dioxide-functionalized textiles have great potential for the separation of environmental pollutants or gases [31].

Yu et al. PET Polyester non-woven surfaces are coated with semiconductor zinc oxide (ZnO) by direct current reactive magnetron sputtering. As a result of the study, it has been observed that the UV absorbency and antibacterial properties of ZnO coated polyester nonwoven fabrics are improved [32].

In a study by Dietzel et al. Titanium and zirconium cathodes on polyamide fabrics were coated using physical vapor deposition technology (metallization). As a result of the study, the samples were observed to be antistatic [17].

Wang et al. [13] have attempted to impart anti-bacterial properties by coating the surface of polypropylene nonwoven fabrics with nano-structured silver films. As a result, it has been observed that nonwoven polypropylene fabrics coated with silver film have a serious anti-bacterial property compared to the uncoated. At the same time, the increase in silver film thickness contributed positively to the antibacterial property.

(a) (b)

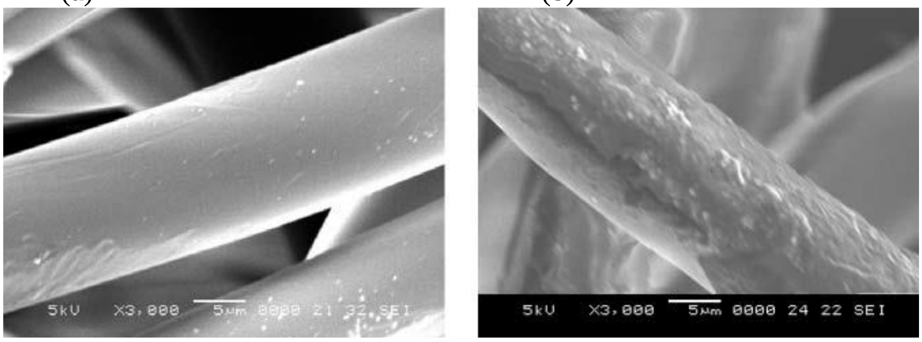

Fig. 2: *SEM images, (a) Original PP fibers, (b) 3 nm thick silver coated PP fibers [10].*

3. CONCLUSIONS

Numerous researches have been carried out to improve the functional properties of textiles and new technologies have been adopted to impart different properties to textile products. An ideal surface modification is to coat the thin and uniform layer on the surface without damaging the fiber. At the same time, the environmentally friendly coating processes are the most desired production technique in today's conditions. For this reason, new technologies tend to take the place of conventional coating techniques. One of these techniques are mentioned in this study.
Physical vapor deposition technique have been mentioned in this study and their use on textile surfaces has been examined. The physical vapor deposition technique can impart properties such as conductivity, antistaticity, radiation protection, antibacterial property, water repellency, UV protection, and resistance to chemicals to textile products.

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