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Hydrothermal Growth of TiO_2 Nanoflowers on PET Fabrics for Functional Applications ⋆

Muhammad Zaman Khan [a,*], Jiri Militky [a], Michal Petru [b], Azam Ali [a], Yuanfeng Wang [a], Dana Křemenáková [a],

[a] *Department of Material Engineering, Faculty of Textile Engineering, Technical University of Liberec, Studentská 2, Liberec 46117, Czech Republic*

[b] *Department of Machinery Construction, Institute for Nanomaterials, Advanced Technologies and Innovation (CXI), Studentská 1402/2, 461 17 Liberec 1, Technical University of Liberec, 46117 Liberec, Czech Republic*

Abstract

The main aim of this work is to develop TiO_2 nanoflowers coated polyester (PET) fabric for antibacterial and UV protection applications. The TiO_2 nanoflowers were grown on PET fabric by a two-step method. In first step, the polyester fabric was seeded using sol-gel method and in second step the nanoflowers were grown on the seeded PET fabric by hydrothermal method. The surface morphology and elemental analysis were carried out by using Scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and atomic force microscopy (AFM). The effect of TiO_2 nanoflowers on the functional properties were examined based on antibacterial activity, UV blocking and physiological comfort properties. The TiO_2 nanoflowers coated fabric demonstrated the ability to kill the bacteria and to prevent its growth. During quantitative assessment the 96% and 99% of bacterial reduction was found for E. coli and S. aureus, respectively. The TiO_2 nanoflowers coated polyester fabric exhibited excellent UV blocking properties. The analysis of thermal properties, water vapor permeability and air permeability was also performed to study the physiological comfort of the TiO_2 nanoflowers coated fabrics. The thermal conductivity and thermal absorptivity was found to increase for TiO_2 nanoflowers coated fabrics. Moreover, no significant decrease in water vapor permeability and air permeability was noticed by the growth of the TiO_2 nanoflowers. The developed PET fabrics could be used for functional applications.

Keywords: Titanium Dioxide; Nanoflowers; Antibacterial; UV Protection

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*Corresponding author.
Email address: zamankhan017@yahoo.com (Muhammad Zaman Khan).

1 Introduction

Nanotechnology is used to impart functional properties to the textile materials. Anti-bacterial, UV-protection, self-cleaning, stain repellent, antistatic, moisture management, water proof, fire retardant and thermoregulation properties can be developed at a molecular level by using nanotechnology without affecting comfort and flexibility of the fabric. Nanotechnology deals with structures of sizes between 1 to 100 nm in at least one dimension and involves developing materials or devices possessing dimension within that size. Nanotechnology creates structures that have excellent properties by controlling atoms and molecules, functional materials, devices and systems on the nanometer scale by involving precise placement of individual atoms [1]. Materials at nanoscale can exhibit different properties as compared to a macro scale level. Properties of material change quickly when it reduces to nanoscale. Nanostructure materials have a grain size of less than 100 nm, which increases the surface area of the material and cause excellent change in physical and surface properties [2].

The UV protection property of a textile fabric can be achieved by dye, pigment, delustrant (TiO_2) or UV absorber finish. These materials can provide protection against UV radiation by absorbing and blocking its penetration through a fabric. To achieve UV protection several nanomaterials or nanoparticles can be applied on textile fabric [3-5]. Titanium dioxide and zinc oxide nanoparticles are mostly used for this purpose because they have good UV protection properties [6-8]. They give protection by reflecting, scattering or absorbing harmful UV radiations of sun. They are more stable as compared to organic UV-blocking agents. Nanoparticles of ZnO can be prepared by the wet chemical method [9-11]. Titanium dioxide nanoparticles can be imparted on textile fabric by treating in TiO_2 nanoparticles aqueous solution using a pad-drying-cure method [3, 12]. Organic UV absorbers are mainly derivatives of O-hydroxy benzophenones, O-hydroxy phenyl triazines, O-hydroxy phenyl hydrazine's and they are less stable than inorganic UV absorbers [13]. The humidity, sweat and moisture provides suitable environment for the growth of many types of microbes (pathogenic or non-pathogenic) on the textile inner or outer wear. These microbes can cause diseases, bad odor for the wearer and reduce strength and color properties of the fabric. To avoid all these microbes, we need anti-microbial finish on the fabric. Many antibacterial finishes and disinfection techniques have been developed for all types of textiles. Many materials are used for the antibacterial properties such as nano-sized copper, silver, titanium dioxide and zinc oxide particles. Anti-bacterial effects can be maximized on textile fabric by using nanoparticles because nanoparticles increases the surface area [14]. Some of important antibacterial agents that are used in textile finishing are quaternary ammonium, triclosan, chitosan and metallic salts. Preparation of nano-sized metals and metal oxides mainly silver, titanium dioxide, zinc oxide and cooper oxide has enabled the development of a new generation of biocides [15]. Now a day, the physiological comfort properties of the nanoparticles coated textiles have gained much attention with the increase in consumer awareness. Generally, the comfort of textile may be classified into three categories, such as thermo-physiological comfort, sensorial comfort and psychological comfort. The thermal comfort of the textile is generally related with the movement of heat, moisture, and air through textile materials and keeping the consumer dry while maintaining a constant body temperature [16, 17].

The present study is focused on development of multifunctional polyester fabric. Here, the growth of TiO_2 nanoflowers on surface of polyester fabrics using two step approaches of sol-gel technology and hydrothermal method is reported. Compared to previous studies, it has number of advantages such as simple, inexpensive, high yield, and effective control over phase and