

ABSTRACT

The share of polyester (polyethylene terephthalate, PET) in textiles has been continuously increasing over the last several years due to its high mechanical durability and low cost and has reached ~ 80%. However, polyester suffers from many problems and most of them arise from its poor hydrophilicity and inability to get functionalized as it lacks sufficient functional groups on its surface. This poor hydrophilicity causes poor absorption, wicking and evaporation of moisture from its surface. Further, the lack of polar groups on the PET surface restricts the formation of a conductive layer which results in the accumulation of static charges on its surface. For the past few years, nanotechnology has emerged as an option to functionalize textiles with improved performance without adversely affecting permeability or hand feel of the fabric. This can also be used to alter the surface properties of polyester for various applications. Nano-SiO₂ and nano-TiO₂ particles have been selected for such modification as they are widely used in cosmetics and food industry. However, the application of these nanoparticles (NPs) on textiles face many challenges such as agglomeration, dispersion, attachment and wash durability.

In this study, SiO₂ and TiO₂ NPs were synthesized using simple sol-gel method. Both synthesized and commercially available SiO₂ and TiO₂ NPs of different sizes and at varying concentrations were mixed with a commercially available nonreactive aliphatic hydrophilic polyester resin and applied on the fabric using a simple pad-dry-cure method to nanomodify the PET substrate. The treated PET fabrics were characterized for changes in the surface morphology and chemical composition both in as-applied state and after several cycles of laundry washes. The treatment effectively and durably enhanced the hydroxyl group concentration on the surface of PET fabric even with the application at a very low concentration of ~ 1 wt%, which is very critical for its industrial viability. This finishing methodology opens

up the possibility of imparting durable functionalities such as photocatalytic, UV absorption, antistatic, and/or moisture management properties to otherwise inert hydrophobic PET fabric.

These nanomodified PET fabric were explored for their moisture management properties i.e. wetting, wicking, and evaporation. The influence of type of NPs, their particle size and concentration on the surface morphology and moisture management behavior of PET was investigated. The composite of NPs and resin exhibited radical improvement in the moisture management behavior of PET substrate, which is crucial for its industrial viability for activewear. At an add-on of < 2 wt%, this nano-finishing agent led to remarkable enhancement in wettability, wickability, and evaporation of moisture. Based on the surface morphology and chemical characteristics of the treated fabrics, a mechanism has been proposed to explain the role of NPs in the enhancement of moisture management properties. It has been shown that in the presence of resin, the NPs form a durable network on the surface of PET fibers and play a synergistic role in moisture and heat management of the finished fabric. It was further shown that the presence of large number of surface OH groups with low binding energy with water molecules on NPs changes the overall dynamics of evaporation by improving absorption, wicking properties thereby making the hydrophobic fabric comfortable as active wear. The properties were observed to be significantly improved with titania NPs as compared to silica NPs treated samples. Infrared thermography has been used to demonstrate the potential of such combination to attain enhanced comfort properties.

Further, the influence of morphology of silica NPs on surface nano modification of PET fibers and its effect on moisture management, UV protection, and antistatic properties of resultant fabric was investigated. Two different types of silica NPs, one sol-gel synthesized solid spherical NPs (SiNsol) and the other having mesoporous structure (MS-silica) were durably applied over the PET fabric surface at different concentrations in combination with a

hydrophilic resin. Though both NPs showed enhancement in the properties, MS-silica NPs were observed to show significantly higher improvement compared to SiNsol NPs owing to their high surface area, large number of surface OH groups, and better dispersibility at higher concentration (1 wt%).

Finally, a rapid and simple process of synthesis to obtain water dispersible aromatic polyester resin is reported. The resin was prepared using glycolysis of polyethylene terephthalate (PET) with polyhydric alcohol (pentaerythritol, PENTA) in the presence of zinc acetate as a catalyst. The influence of process parameters, such as the molar ratio of PENTA to PET, reaction time, and catalyst concentration on water dispersibility and chemical structure of the synthesized resin was investigated. The characterization of resin confirmed the formation of a complex mixture of oligo-ester-diols with large number of hydroxyl groups as confirmed by FTIR, ^1H and ^{13}C NMR, and MALDI-TOF MS. The obtained resins, when applied as it is or in combination with NPs, imparted enhanced moisture management properties as compared to only resin along with good wash durability to the otherwise inert hydrophobic PET fabric.