ABSTRACT

Metal oxides like Titanium di-oxide and Zinc oxide are useful in imparting multifunctional characteristics when coated to textile substrates. There are several techniques used to synthesise nano-particles from metal oxide such as vapor-phase process, solution precipitation and solid state process. An attempt has been made in this work using sol-gel technique to synthesise nano-particles. In this process, a colloidal suspension or a sol is formed due to the hydrolysis and polymerization reaction of the precursors. When polymerization is completed, the loss of solvent leads to the transition from the liquid sol into a solid gel phase. This can be used to produce thin coatings on textile fabrics using pad-dry-cure method.

The first part of this research work comprises of synthesise, characterization and applications of TiO_2 nano-particles on to the sample followed by the functional testing of the treated fabric samples for four functional properties namely, Anti-bacterial activity, UV protection, soil release property and self cleaning activity.

The second part of this research work comprises of synthesise, characterization and application of ZnO nano-particles on the fabric samples for studying the functional properties such as antibacterial activity, UV protection, soil release property and self cleaning activity.

A detailed investigation has been made in this research work on the multifunctional finishing of 100% cotton woven fabric using titanium dioxide (TiO_2) and zinc oxide (ZnO) nano-particles. The titanium dioxide nano-particles were produced by laboratory synthesise based on sol-gel technique by using titanium iso-propoxide (TIP) and Titanium Tetra Chloride ($TiCl_4$) as

the precursors. Two different types of TiO_2 nano-particles were synthesized with TIP precursor. One with water as the medium (T_1) and the other with ethanol as the medium (T_2). The third type of TiO_2 nano-particle (T_3) was synthesized with Titanium tetrachloride ($TiCl_4$) as the precursor using sol-gel method. Zinc oxide (ZnO) nano-particles were synthesized in laboratory with three different precursors namely, Zinc Acetate (Z_1), Zinc chloride (Z_2) and Zinc Nitrate (Z_3) using sol-gel method. The 100% cotton plain woven fabric samples taken for the research work is of width 122 cm (48"), 96 EPI, 96 PPI, 14 tex yarn count (both warp and weft) and fabric areal density is 118 grams/sq.m with plain weave structure.

The fabric samples were scoured and then bleached using hydrogen peroxide (H_2O_2). The laboratory synthesized TiO_2 and ZnO nano-particles were applied onto the fabric sample using pad- dry-cure method with 1% acrylic binder and 1% Lissapol-N wetting agent with nano-particles concentration levels with respect to fabric weight at 1%, 1.5% and 2%. The coated samples were dried and cured.

In the first part of the research work, two sets of TiO_2 nano-particles were synthesized with titanium iso-propoxide as precursor with water and Ethanol medium (T_1 &T_2 respectively) and Titanium Tetra Chloride as precursor (T_3). Thus synthesized nano-particles were then characterized using the test methods of Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffractometery (XRD) and Particle Size Analyzer (PSA). The treated fabric samples were also characterized using the Scanning Electron Microscopy (SEM) and found the nano-particles embedded on the fabric surface. The PSA results show that, three different sizes of TiO_2 nano-particles say 7nm, 21nm and 35nm. Then the treated fabric samples were tested for the functional properties such as antibacterial activity, UV protection, soil release action and self cleaning activity as per AATCC'S Standardized test methods. The results

showed that the treated samples were having excellent antibacterial activity, UV protection, soil release property and self cleaning activity, when compared with control samples. The treated fabric samples were also tested for the durability of the effect after repeated washes of 5, 10, 15 and 20 and found to have significant effect upto 20 washes.

In the second part of the research work, Zinc oxide nano-particles were synthesized by using three different precursors namely, Zinc acetate, Zinc chloride & Zinc nitrate, designated as Z_1, Z_2, and Z_3 respectively. Thus synthesized ZnO nano-particles were then characterized using FTIR, XRD, and PSA. The PSA test results showed that ZnO nano-particles of three different sizes 9nm, 24nm and 38nm. These three types of ZnO Nano-particles were then applied onto the fabric samples using pad-dry-cure technique. The treated fabric samples were tested for the functional properties of antibacterial activity, UV protection, soil release and self cleaning activity as per AATCC's standardized test methods. The test results showed that the ZnO nano-particles treated samples were having excellent above mentioned functional properties compared to untreated (control) sample. The treated fabric samples were also tested for the durability of the effect after repeated washes of 5, 10, 15 & 20 washes and found to have significant effect upto 20 washes.

The physical characteristics such as fabric weight, thickness, tensile strength, elongation, crease recovery angle, drape co-efficient, bending length, air permeability, bursting strength, tearing strength and abrasion resistance were evaluated as per ASTM standards. The results showed that there is no influence of nano-particles coating on the physical characteristics of the samples. The 't' test statistical analysis has been made for the test results to assess the significance of the individual characteristics. The regression

analysis has been made to assess the washing fastness test results of the samples.

The fabric samples treated with TiO_2 nano-particles found to have UPF values in the range of 30.2 to 39.8 and percentage reduction in bacteria (anti-bacterial property) for Staphylococcus aureus in the range of 92.1% to 99.2% and for Klebsiella pneumoniae in the range of 92.5% to 99.4%. The soil release ratings were found to have improved to a range of 6 to 9 ratings and the percentage decrease in K/S (self cleaning action) value has improved to the range of 39.2% to 77.6%.

In the same manner, the fabric samples treated with ZnO nano-particles found to have UPF values in the range of 30.62% to 42.4% and the percentage reduction in bacteria (anti-bacterial property) for Staphylococcus aureus is found to be in the range of 90.5% to 98.9% and for Klebsiella pneumoniae is in the range of 91.65% to 98.9%. The soil release ratings were found to have improved to a range of 6 to 8 ratings and the percentage decrease in K/S (self cleaning action) value has improved to the range of 34.6% to 69.7%.

The comparative study on the characterization of TiO_2 and ZnO coated samples was carried out and the effects of the particle sizes on functional properties among the six types of nano-particles were analyzed. It was found that the treatment of the fabric with the nano-particles impart excellent functional properties of antibacterial character, UV Protection, soil release and self cleaning activity.

It is concluded that the size of the nano-particles is an important factor is influencing the efficacy of the finish and the durability of the same. It is also found that there is no significant difference in the efficacy of the finish rendered by TiO_2 and ZnO nano-particles.