Proceedings of the 2nd International Conference of Theoretical and Applied Nanoscience and Nanotechnology (TANN'18)
Niagara Falls, Canada – June 10 – 12, 2018
Paper No. 128
DOI: 10.11159/tann18.128

Development of Self-Cleaning Cotton Fabric by Using Visible Light Driven Photo-Catalyst

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Extended Abstract

Development of self-cleaning textile fabrics have been practiced by coating with photo-active materials. TiO_2 has been broadly used because of its high oxidative power, low production cost, photo-stability and non-toxicity. However, wide band gap (~3.2eV) and fast electron-hole recombination of TiO_2 reduce its practical applications. To meet increasing demand of self-cleaning textile products, visible light driven photo-catalytic coatings are prerequisites for scalable applications.

We report here the development of self-cleaning cotton fabric by nano-coating of visible light active dye-TiO_2 photo-catalyst on the surface of cotton fabric. Due to high thermal and chemical stability, high quantum yield of singlet oxygen, stable triplet excited state and low toxicity, phthalocyanine reactive dye (RB-25) has been used as a dye sensitizer for TiO_2 in this study. Dye-TiO_2 nano-sol was prepared by sol-gel method. In detail, a total of 8.5mL of titanium tetraisopropoxide (TTIP) was dissolved in 50mL of acetic acid. The TTIP solution was added drop wise to the acidified water (160ml) and absolute ethanol (60ml) mixture at pH of 2. 7ml of the dye solution (0.05g/500ml) was added to the mixture and stirred at 70°C for 18 h. 100% scoured and bleached plain woven cotton fabric was completely washed and dried under standard atmospheric conditions before the coating process. The prepared dye-TiO_2 nano-sol was coated on the cotton fabric by dip–pad–dry–cure method. The cleaned cotton fabric was dipped in the dye-TiO_2 nano-sol for 5min, and pressed with a padder machine (Rapid Labortex Co., Ltd., Taipei, Taiwan). The nip pressure was kept at 2kg/cm^2 to assure the uniform coating amount of dye-TiO_2 on each of the cotton fabric samples. The wet pick up of TiO_2 sol was about 80%. The padded fabrics were neutralized to pH 7 by conventional spraying with aqueous solution of Na_2CO_3. The dye-TiO_2 coated cotton fabric samples were dried in a preheated oven at 80°C for 10 min and finally cured at 120°C in a preheated curing machine (Mathis Labdryer Labor-Trockner Type LTE, Werner Mathis AG Co.,Oberhasli, Switzerland) for 3min. The resulting dye-TiO_2 coated fabrics were first washed with hot water and then with de-ionized water to remove unattached TiO_2 and dye molecules.

Structural and morphological properties of the dye-TiO_2 coated cotton fabrics were studied by Fourier Transform Infrared Spectroscopy (FTIR), UV-visible absorption measurements and scanning electron microscopy (SEM). Photo-catalytic self-cleaning efficiency of the resulting product was evaluated by the degradation of rhodamine B (RhB) dye under visible light irradiation in the presence of dye-TiO_2 coated fabric and stain removal from surface of the final product. SEM results show the successful coating of dye-TiO_2 on the pristine cotton fabric while FTIR and UV-visible absorption measurements confirmed the attachment of RB-25 on the surface of TiO_2 coated cotton fabric. The decrease in the dye concentration of RhB solution in the presence of dye-TiO_2 coated fabric under visible light irradiation confirmed its photo-catalytic properties. Moreover, the final product decomposes the adsorbed stains and contaminants on the surface by using visible light.