WETTABILITY OF THE COTTON AND POLYESTER TISSUES COATED BY NANOSTRUCTURED INDIUM-DOPED ZINC OXIDE LAYERS

Klochko N.[1], Khrypunova I.[1], Klepikova K.[1], Kopach V.[1], Zhadan D.[1], Petrushenko S.[2], Dukarov S.[2], Lyubov V.[1], Kirichenko M.[1], Khrypunova A.[1]

[1]National Technical University "Kharkiv Polytechnic Institute", 2, Kirpichov st., 61002 Kharkiv, Ukraine

[2]Kharkiv National University named after V. N. Karazin, 4, Svobody Square, 61022, Kharkiv, Ukraine

klochko.np16@gmail.com

In the last few years, the innovation on fiber-based smart materials has increased substantiality because of demands for a comfortable and healthy life, which ask for a superhydrophobic self-cleaning textile, for instance, by mimicking the superhydrophobic lotus leaf in nature, so-called "lotus effect". The use of nanostructured zinc oxide (ZnO) coatings for the functionalization of textile substrates is growing rapidly, since they can provide unique multifunctional properties together with superhydrophobicity, such as photocatalytic self-cleaning, antimicrobial activity, protection against solar ultraviolet, flame retardancy, and thermal insulateon. A common approach for a creating of the superhydrophobic zinc oxide coatings is a required final chemical modification through a processing with environmentally toxic fluoro-containing polymer films or with unreliable silane layers in order to generate low surface energy.

In this work, indium-doped zinc oxide (ZnO:In) thin films were deposited onto cotton (Ct) and polyester (Pe) fabrics via low-temperature cheap and scalable Successive Ionic Layer Adsorption and Reaction (SILAR) method and so obtained comfortable to wear, breathable, nontoxic, light-weight, and air-permeable textile. First, it was investigated the influence of the material of the fibers on the intensity of the build-up of the indium doped zinc oxide layer by the SILAR. Based on the data obtained, the number of SILAR cycles was optimized to grow ZnO:In sharp nanorods with a length of about 1.5 μm and 300-400 nm in diameter very similar to each other on the entire surface of fibers of the Ct and Pe tissues with average cross section of 10-20 μm. Thus, together they formed coral-like hierarchical structures ZnO:In/Ct and ZnO:In/Pe, respectively. Then, analysis of X-ray diffractions of the ZnO:In/Ct and ZnO:In/Pe textiles has revealed that ZnO:In films are single-phased and have polycrystalline wurtzite hexagonal ZnO structure. Calculations of the ZnO:In grain size D by the Scherrer's formula using a broadening of X-ray diffraction peaks give $D \approx 50$ nm in the ZnO:In/Ct(200 cycles) and $D \approx 70$ nm in the ZnO:In/Pe(400 cycles). The latter confirms the nanocrystalline structure of the ZnO:In nanorods on the surface of both tissues. Analysis of XRD data revealed weak microstrains ε and small dislocation densities in the ZnO:In crystal lattice caused by the presence of point defects, in particular, indium in the interstitial and substitutional sites, i.e. In_i and In_{Zn}, respectively. The crystal lattice constants of these ZnO:In nanorods are approximately the same as of the reference ZnO according to JCPDS #36-1451.

Wettability studies together with investigation of morphology and chemical compositeon have shown that type of fiber has a significant effect on the hydrophilicity/hydrophobicity of the textile. In this study, the surface wettability of the textiles ZnO:In/Ct and ZnO:In/Pe was characterized via measuring static contact angle, and through dynamic tilt angle measurements by observations of the differences between advancing and receding contact angles defined as contact angle hysteresis, and by measuring the water sliding angle or roll-off angle. The wetting mechanism for the ZnO:In/Pe fabric is observed through a water-drop evaporation technique. Then, we studied influence of ultraviolet radiation on the ZnO:In/Pe surface wetting. So, we developed method of obtaining the superhydrophobic polyester-based textile by modifying Pe with the nanocrystalline ZnO:In thin layer, and thus ensured superhydrophobicity to the ZnO/Pe tissue without any additional impregnation layer.