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Editorial

2D-Nanomaterials Shaping Fashion Fabrics

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The garment fabrics, always remaining in intimate human contacts, are bound to be influenced tremendously by the recent trend of integrating them with the devices like transistors, sensors, photodetectors, electro-luminescent devices, supercapacitors, and solar cells, in addition to surface modifications for incorporating the additional functional properties, which would ultimately make the garment 'smart' in addition to using them in creating new fashions. Such textiles/fabrics would have much wider applications in fields other than those of the clothes and garments including the healthcare, military and fashion besides those including aviation, transport, construction, geo-textiles and packaging to name a few. The integration of these smart features to the textile fibres promises to usher in a new era of wearable electronics using textiles [Neves., *et al* 2017].

The R and D activities in the field of fiber and textile surface functionalization and modifications would not be compile without meeting the basic requirements of the ever evolving fashion trends that are primarily set by the fabrics available. All efforts made in improving the physico-chemico-biological properties of the large variety of natural and synthetic fibers by their surface modifications during manufacturing would only be psychologically acceptable once their influences experienced by the wearer are not affected beyond certain point. This subtle requirement of wearer's acceptability puts a basic condition on all textile surface modifications that is possible only by making the upcoming modifications at atomic/molecular levels and if necessary to go for a monolayer conformal coating of the materials used.

The challenges faced in enhancing the functional properties of the fibers and textiles as well as meeting the fast-changing requirements imposed by the fashion fabrics industries, are now getting addressed better by introducing nano surface functionalizations/modifications by employing atomically thin film depositions and even using novel 2D-materials with adjustable properties. Although, it is known that any addition to the natural surfaces of the fibers and fabrics would certainly add some weight that may not be as comfortable to the wearer compared to the unmodified ones. Therefore, the first and foremost condition for choosing the right kind of surface modification technique is to keep the effective weight increase minimum by employing only an atomic or molecular thin addition. For this kind of surface functionalizations/modifications, self-limiting monolayer thin film depositions appear most suited as evidenced while using atomic layer deposition (ALD) in various fields of applications [1].

Such monolayer conformal additions would also be able to address to the problems of environmental degradation of the fibers and fabrics in the humid environment at elevated temperatures as well as UV irradiations that induce oxidations, which needs effective thermal and humidity barriers along with good UV protecting thin films. The ALD metal oxide thin films of silica, alumina, and titania are noted helpful in this context. Another useful route is to modify and employ carbon fibers that are, as such, very prone to temperature dependent oxidation and tensile properties deterioration above 400^0C under humid and oxidizing conditions. Application of ALD silica, alumina, and titania diffusion barriers applied onto the fibers and fabrics has been found viable in protecting them from oxidation. ALD alumina barrier produced using sequential exposures of trimethyl aluminum and water at low temperature (~77^0C) was found enhancing the oxidation temperature of carbon fiber fabrics from 300 to 600 and 660^0C with 30 and 120 nm thin barriers, respectively [2,3].

Difficulties experienced in coloring the carbon fibers due to lack of adequate chemical affinity between the carbon fibers and the dyes used, did not allow to use their exceptionally unique properties comprising of high strengths, stiffness, heat and chemical resistance, low densities, good thermal and electrical conductivities, excellent creep resistance, biological compatibility, and fatigue resistance in a variety of applications. Multicolored carbon fiber fabrics were of course prepared using ALD modifications, which showed vibrant colors by controlling the thickness of the conformal TiO_2 layers while only slightly affecting their mechanical properties [4-6].

UV irradiation are found damaging the fibers and textiles in terms of color fading, polymer degradation, and reduced mechanical strengths. By depositing UV blocking layer onto polyamide/aramid dyed fabrics using ALD could produce functional fabrics that were resistant to high intensity UV radiation. Detailed study of ALD based TiO_2, Al_2O_3, and TiO_2/Al_2O_3 nano layers showed their excellent resistance to high intensity UV radiations and UV-induced mechanical strength degradations. These results confirmed that the ALD could be very effective in improving the properties of dyed fabrics. Especially, the silk fibers surface modified using ALD titania offer an useful example employing sequential exposures of titanium tetraisopropoxide (TIP) and water as precursors @ 100°C. The thermal and mechanical properties of the TiO_2 coated silk fibers exhibited superior thermal stability and mechanical properties compared to those of the uncoated samples. The titania ALD provided the silk fiber with excellent protection against UV radiation by exhibiting increased UV absorption resulting in lesser yellowing besides enhancing their mechanical strength compared with the uncoated silk fibers [7,8].

The future prospects that are foreseen might involve 2D-metal oxide nanosheets synthesized by wet chemical methods in colloidal form onto fibers and fabrics after suitable surface activations at lower cost than employing sophisticated ALD system. Even electrochemical-ALD, once developed appropriately, could be put to use in large scale roll-to-roll (R2R) productions of surface modified fibers and fabrics at much reduced cost under ambient conditions. These proposed routes would not only be cost effective but also be possessing adequate capability of modifying the optical and electronic properties of the coated mono/multiple layers of 2D-materials nanosheets to suit the requirement of fiber and fabric surface modifications better and adding more opportunities to the upcoming fashion designs [9,10].

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