Abstract

Multifunctional wearable smart fabrics have been gained much attention due to their superior performance in healthcare, space, military, fitness, and other modern emerging applications. Among them, conductively coated robust textiles show great promise for use as an antibacterial product, flexible electronics, electromagnetic (EM) protective cloth, and next-generation sensors without compromising the textile comfort and characteristics. Smart textile can be defined by *the material that can sense or react to the active control mechanism to environmental condition and stimuli from electrical, magnetic, chemical, mechanical, or thermal sources*. The study is originated from the detailed investigation of cotton and synthesized (merino wool/nylon) coated fabric with the proper distribution and dispersion of polymer-based metallic nanoparticles (AgNPs), carbonaceous fillers (K-CB, 600JD), and ICPs (PEDOT: PSS). The fabrication of smart fabrics has been done with two different coating procedures such as knife-over-roll and dip-coating. The variation of morphological studies combined with electron microscopy and 3D micro-CT due to the different filler encapsulated fabrics have been studied. The electrical performance has greatly influenced due to the formation of interconnected network architecture of the deposited conducting particles within the textile structure. Surface resistivity of one side coated fabric and DC conductivity of the dip-coated fabrics were calculated against the different filler concentration to correlate with the formation of electrical performances. The excellent electrical property of these fabrics is well suitable for EM absorbing ability and EMI SE of the smart fabrics has been observed over X-band (frequency range 8.2-12.4 GHz). The detailed study reveals that our prepared textiles are enough capable to attenuate harmful EM radiation followed by the absorption dependent shielding mechanism at very low coating thickness (<1mm). This work presents a facile fabrication path with a two-stage wet mixing technique including synthesis of AgNPs decorated graphene sheets over the cotton fabric using non-ionic adhesive such as PVP, which can be used in three different sectors like portable and bendable electronics, EM protective cloth, and bactericidal fabric (due to high antibacterial property). Another study reveals PVA/NRL blended specialty conducting black coating, which is covalently interwoven within the cotton fabric by IPN approach for flexible electronics and high

mechanical performing robust EMI shielding applications. Afterward, the effect of low molecular PEG (M.W. 400) additive on the electrical and EM properties of PEDOT: PSS ornamented fabrics has been investigated. Finally, phase-separated PEDOT: PSS ornamented with reduced graphene oxide nano-sheets has been fabricated which is coated on the newly developed ultra-lightweight, super-hydrophobic, and mechanically enriched merino wool/nylon (W-N) composite textile with the combination of real-life antenna tuned EM protection and soft touch sensing switches for household along with wireless communication via HC-05 Bluetooth module as a textile-based touch switch. These multifunctional fabrics are also tested under different environmental and practical stresses (e.g., prolonged sunlight exposure, flexibility under liquid nitrogen, abrasion, water durability, detergent action, tape adhesion, bending, twisting, thermal air-ageing and organic solvents including ultra-sonication treatment) which is known as Quality Assurance (QA) survey to provide information regarding the sustainability or applicability for outdoor applications. The above mentioned study results in >90% retention of EM performance due to the robust and flexible conducting network formation over the fabric. These exercises illustrate a new potential and effective window for the development of next generation smart garments in the near future.

Keywords**:** *Cotton fabric, Merino wool/Nylon textile, Electrical conductivity, Electromagnetic interference shielding effectiveness, Filler loading, Coating, 3D tomography scanning, Soft touch sensing, QA survey.*