ELECTROMAGNETIC INTERFERENCE SHIELDING AND JOULE HEATING PROPERTIES OF ACTIVATED CARBON FABRICS

Abstract

Recently, the activated carbon fibres gained significant importance due to their wide range of pore size distribution, well-developed internal porous network, and greater specific surface area. However, the major concerns for further advancements of activated carbon fibres in other applications are their poor structural, physical, and handling properties. The research work performed in this thesis deals with improving the physical, and handling properties of activated carbon fabrics besides finding new applications in EMI shielding and joule heating. In the first study, the Kevlar-fibre derived woven activated carbon fabrics were produced using single-stage carbonization and physical activation method. The Box-Behnken design and response surface methodology were employed for the optimization of three process parameters (i.e. charcoal amount, nitrogen gas flow rate, and carbonization temperature) to get high carbon yield and low electrical resistivity of activated carbon fabrics. An optimum amount of charcoal, optimum nitrogen flow rate, and low carbonization temperature were found to provide higher carbon yield. On the other hand, low charcoal amount, high carbonization temperature, and optimum nitrogen flow rate produced low electrical resistivity. Further, the optimized sample of low electrical resistivity showed higher EMI shielding than the other sample of high carbon yield. In the second study, the effect of fabric type (i.e. woven and needlepunched nonwoven) of Kevlar fibres was investigated for physical, structural, electrical, EMI shielding, and joule heating properties of activated carbon fabrics. The Kevlar woven fabric derived activated carbon fabrics showed better physical and mechanical properties, however lower electrical properties as compared to the Kevlar nonwoven fabric derived activated carbon fabrics. The higher EMI shielding, and better joule heating properties were found in the case of nonwoven activated carbon fabrics than the woven activated carbon fabrics. In the third study, the effect

of fibre type (i.e. semicrystalline polyacrylonitrile PAN fibres and highly crystalline Kevlar fibres) was investigated for physical, structural, electrical, EMI shielding, and joule heating properties of nonwoven activated carbon fabrics. The greater carbon yield, low dusting tendency, better mechanical as well as electrical properties were found in case of PAN fibre-derived activated carbon fabrics. However, enhanced flexibility and better shrinkage properties were seen in case of Kevlar fibre-derived activated carbon fabrics. The EMI shielding properties were found to increase with the carbonization temperature for both PAN and Kevlar fibre-derived activated carbon fabrics. Further, the Kevlar fibre-derived activated carbon fabrics showed faster heating, more heating efficiency, and rapid cooling, but at an increased voltage of 5V than 3V of PAN-derived activated carbon fabric. In the fourth study, PAN and Kevlar fibres were blended in different proportions to study the effect of fibre blending on the physical, structural, electrical, EMI shielding, and joule heating properties of nonwoven activated carbon fabrics. Higher carbon yield, reduced dusting tendency, and improved mechanical and electrical properties were observed for the PAN-rich activated carbon fabrics. The Kevlar-rich activated carbon fabrics showed better flexibility and minimum shrinkage. Further, PAN-rich carbonized fabrics exhibited superior EMI shielding and better joule heating properties. In the fifth study, the effect of layering of metalized fabric on physical, structural, electrical, EMI shielding, and joule heating properties of nonwoven activated carbon fabrics was studied. The metalized fabric individually showed relatively higher EMI shielding, but poor prolonged heating performance due to burning. On the contrary, the activated carbon fabrics depicted relatively lower EMI shielding, but robust joule heating properties without any burning. Nevertheless, the layered structure of activated carbon fabric with metalized fabric showed stronger EMI shielding and robust joule heating performance because of enhanced absorption-reflection-reabsorption of the electromagnetic waves.