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Enhancement of the physical properties of polyacrylonitrile by doping with some nanomaterials

By

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Enhancement of the physical properties of polyacrylonitrile by doping with some nanomaterials

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Summary

An attempt has been made to study the effects of adding two different nanoparticles (NPs) namely strontium hexaferrite (SFO) and nickel cobaltite (NCO) on the physical properties of polyacrylonitrile (PAN). Nanocomposites containing PAN, and different mass contents of SFO and NCO NPs were prepared using the solution casting method. The nanocomposite samples were characterized by using different techniques such as field emission scanning electron microscopy (FE-SEM), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA). The XRD spectrum for PAN shows a semicrystalline structure while the nanocomposites exhibited the peaks of the nanofillers. The FE-SEM showed a good dispersion of both SFO and NCO NPs on the surface of PAN, especially at low content. DSC data also showed that the nanocomposite samples had a broader thermic temperature range and a lower rate of evolving heat. The TGA results exhibited that with increasing the nanofiller content, the nanocomposites are more thermally stable than pure PAN.

The dielectric investigations of all nanocomposites showed that the permittivity and conductivity are considerably enhanced as the content of nanoparticles increased. Optical properties revealed that the absorption and transmittance spectra were significantly affected by adding these nanoparticles to the PAN polymer matrix. The magnetic properties of the SFO NPs and SFO/PAN nanocomposite samples illustrated the ferromagnetic behaviour of the investigated samples and different magnetic parameters are given and discussed.

Because the supercapacitors currently used need to increase their energy storage capacity and energy density by increasing the specific capacitance. As a result, the development of nanocomposites with high capacitance can be considered as the most effective strategy to achieve the desired high energy density. For this propose, electrodes of PAN and PAN doped with NCO NPs were prepared and studied. Cyclic voltammetry (CV), and galvanostatic charge-discharge (GCD) tests were performed to investigate the electrochemical behavior of the studied nanocomposites. It was found that PAN loaded with 10 wt.% NCO NPS attains an excellent specific capacitance of 1241 F/g at a current density of 0.5 A/g. Also, the cycling stability is

significantly enhanced, and the capacitance retention rate approaches 93.2% after 5000 cycles, which provides the possibility of using the studied nanocomposite film for supercapacitor applications.

A comparative analysis of PAN loaded with 10 wt.% SFO as well as NCO NPs was reported. FTIR spectra indicated a high activity of both nanofillers towards PAN matrix and confirmed the interaction between these nanofillers and PAN functional groups. XRD showed that the degree of crystallinity of PAN increased by adding 10 wt.% SFO while it decreased by introducing the same weight percentage of NCO NPs. TGA thermograms confirmed that the PAN loaded with 10 wt.% NCO sample was more thermally stable than pure PAN and PAN loaded with 10 wt.% SFO NPs. The dielectric properties of the two types of nanocomposites comprehensively, implied that the PAN loaded with 10 wt.% NCO not only showed higher dielectric permittivity but also had lower dielectric loss compared to those of SFO doped PAN nanocomposite sample over the range of measurement frequency. This apparently prove its superiority for practical applications. Taking the optical properties of the two types of nanocomposites into account, implying that NCO doped PAN film exhibited higher absorbance, lower transmittance and narrowed the optical band gap (E_g) of the PAN more effectively than PAN doped SFO NPs sample. Moreover, the optical parameters of PAN were improved by adding both nanofillers with superior values in case of PAN loaded with NCO NPs The magnetization curves demonstrated the superparamagnetic behaviour of NCO NPs and the as prepared NCO doped PAN samples with specific saturation magnetization (M_s) values of 2.59 and 0.66 emu/g respectively. Also, the SFO NPs and SFO reinforced PAN nanocomposite showed ferromagnetic properties.

Finally, the results showed that the dielectric, optical, and magnetic properties of PAN are highly dependent on the type of nanofiller and could be controlled by incorporating both SFO and NCO nanoparticles into the polymer matrix implying that these nanocomposites could be a potential candidate for applications.