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Investigation of the electrical charge transport mechanism and magnetoresistance response in chloridedoped polyaniline–Fe composite nanofibers

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Abstract

One-dimensional composite nanostructures of chloride-doped polyaniline (PANI-Cl) and Fe nanoparticles (NPs) were fabricated via deposition of Fe NPs onto the PANI nanofiber matrix at room temperature. Morphological and structural characterization performed using microscopic techniques, e.g. scanning electron microscopy and transmission electron microscopy, x-ray diffraction, Fourier transform infrared spectroscopy and x-ray photoelectron spectroscopy confirmed effective deposition of crystalline Fe NPs onto the amorphous PANI-Cl nanofiber matrix. The temperature-dependent magnetic property measurement results revealed the ferromagnetic nature of the prepared PANI-Cl–Fe composite nanofibers (CNFs) structure. Depending on the Fe NP loading, the PANI-Cl–Fe CNFs showed both metallic and semiconducting behaviour. The temperature-dependent resistivity of semiconducting PANI-Cl–Fe CNFs was best described by Efros–Shklovskii variable range hopping (ES-VRH) and Mott three-dimensional variable range hopping (Mott-3D-VRH) mechanisms at low and high temperature regimes. Magnetoresistance (MR) investigation was executed at different temperatures and magnetic fields for the PANI-Cl–Fe CNF pellets in semiconducting form. Room temperature (300 K) negative MR values were detected in both the low and high magnetic field regions. A significant increase in MR values was noted with a decrease in temperature from 300 K to 5 K. Meanwhile, the observed low-field negative MR behaviour of PANI-Cl–Fe CNFs was explained by the forward interference model. Therefore, the implications of these findings might be significant for the application of PANI-Cl–Fe CNFs as sensing materials for magnetic field sensor devices.