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Synthesis, characterization and DC conductivity studies of polypyrrole/copper zinc iron oxide nanocomposites

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ABSTRACT

Polypyrrole and polypyrrole/copper zinc iron oxide (copper zinc ferrite) nanocomposites were synthesized by in-situ polymerization using Ammonium Persulphate as oxidising agent. The nanocomposites were synthesized by mixing polypyrrole and copper zinc iron oxide in different weight percentages. The formation of nanocomposites and changes in the structural properties were investigated by characterizing the samples using XRD, FTIR, SEM and EDX analysis. The size of the particle was analysed by XRD using Scherrer equation and found to be in 20 nm range. DC conductivity was measured in the temperature range 300 K–473 K. The DC conductivity was found to be constant for the temperature range from 300 K–433 K. But the conductivity showed an exponential increase for the temperature 433 K–473 K, and it obeys Arrhenius relation. Activation energies were evaluated from Arrhenius plots for all compositions. Results show that incorporation of additive material significantly reduces the activation energy for the DC conductivity of the composites, and the decrease in the activation energy is also dependent on the amount of the nanoparticles in the composites. As the polymers are used in the various manufacturing products, this study indicates the possibility of using such polymers in the form of composites as superior insulating material in the fields of electrical or electronic insulation and allied areas.

1. Introduction

In the past two decades nanocomposites have become one of the most extensively studied materials all over the world due to their unusual properties and wide range of applications in effective electronic devices, conductive paints, drug delivery, rechargeable batteries, food packaging, sensors etc· Conducting polymers possess good tunable electrical conductivity, but they are chemically sensitive and have poor mechanical properties; on the other hand, oxide nanoparticles possess good mechanical properties. The mechanical properties are also found to be strain-rate dependent [1,2].

The state of dispersion of nanoparticles in the polymeric matrix has often a large impact on the properties of polymers [3]. In polymer nanocomposites conductivity depends on various factors such as filler morphology, size, loading concentration, and interfacial interaction. The dramatically larger chain-particle interface area in the case of nanocomposites makes effects appearing negligible in microcomposites very prominent in nanocomposites [3,4]. The conductivity varies with the addition of nanoparticles into the polypyrrole. In polypyrrole/silver nanocomposite, electrical conductivity measurements were carried and it was found that functionalized silver nanoparticles can act as efficient gas sensor for ammonia. The conductivity increases with ammonia exposure [5]. In another report the effect of polypyrrole on nickel oxide (NiO) anodes for lithium ion batteries was investigated. It is reported that, the electrochemical performance were significantly improved for the NiO–PPy composite compared with the NiO [6,7]

Polypyrrole (Ppy) is one of the most attractive conducting polymers due to its special transport properties, facile synthesis, tunable conductivity and good environmental stability [8]. Nano crystalline ferrites are materials of considerable interest due to their unique dielectric, magnetic and optical properties. Nanocrystalline Spinel copper zinc ferrites ($CuZnFe_2O_4$) have been extensively investigated due to their potential applications in non-resonant device, radio frequency circuits, rod antennas, high quality filters and transformer core [9].

In this paper we report synthesis of PPy/$CuZnFe_2O_4$ nanocomposites of different compositions and the influence of nanoparticles

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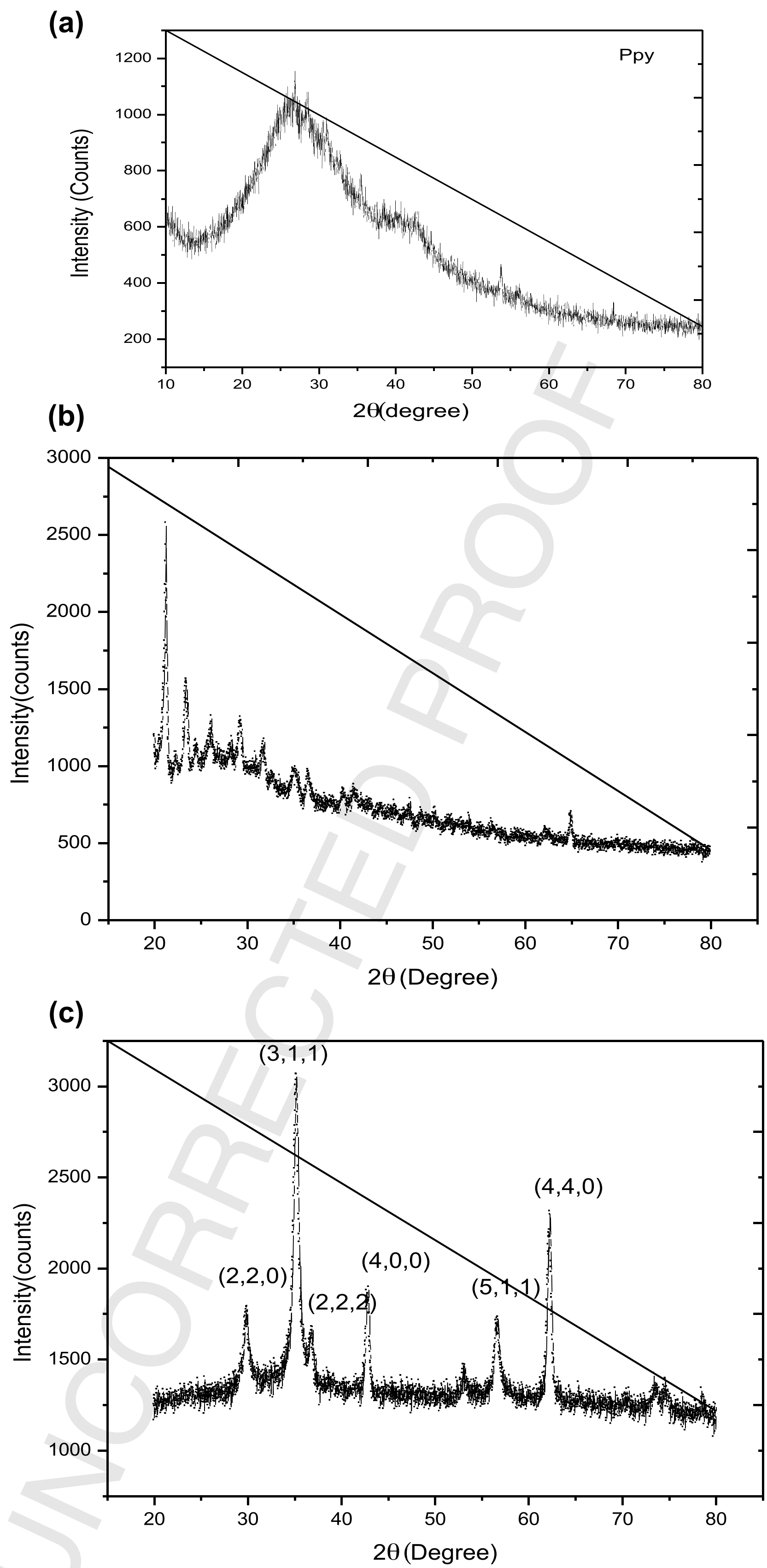

Fig. 1. (a–c) X-ray diffraction pattern of PPy, PPy/$CuZnFe_2O_4$ and $CuZnFe_2O_4$. (a) X-ray diffraction pattern of Ppy. (b) X-ray diffraction pattern of Ppy/$CuZnFe_2O_4$-40%. (c) X-ray diffraction pattern of $CuZnFe_2O_4$.

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