Dielectric, AC conductivity and electromagnetic shielding behavior of polypyrrole/$CuFe_2O_4$ nanocomposites

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Abstract:

Polypyrrole (PPy)/$CuFe_2O_4$ composites were synthesized by in-situ polymerization. PPy/$CuFe_2O_4$ composites were characterized by X-ray diffraction (XRD) analysis and Fourier transform infrared (FTIR) analysis. Frequency dependence of dielectric and a. c. conductivity (σ_{ac}) studies have been undertaken on the PPy/$CuFe_2O_4$ composites in the frequency range 50Hz-5MHz. The electrical conduction mechanism in the PPy/$CuFe_2O_4$ was found to be in accordance with the electron hopping model. Further, frequency dependence of Electromagnetic Interference (EMI) shielding effectiveness was studied. The EMI shielding effectiveness was found to decrease with an increase in the frequency. PPy/$CuFe_2O_4$ composites were demonstrated as a favorable functional material for the absorbing of EM waves at low frequencies.

Introduction

- The significant increase in the usage of electrical and electronic devices have generated unique forms of electronic pollutions in the environment such as electronic noise, electromagnetic interference (EMI), radiofrequency interference (RFI) etc.
- Developing light-weight and cost effective EMI shielding materials is important to control EMI pollution. The EMI shielding is one of the best techniques to safeguard the environment as well as the health of living beings from the negative impacts of EM waves.
- EMI shielding is a phenomenon that involves the process of reflection and/or absorption of EM waves by a material that act as a shield in preventing the penetration of the harmful EM radiations into the electronic devices.
- Metals are the most traditional and preferred form of EMI shielding materials possessing excellent EMI shielding effectiveness (SE). However, metals are mostly heavy, corrosive, expensive, rigid and difficult to process in addition to high production cost.
- Recently, conductive polymer composites (CPCs) are largely used as EMI shielding materials owing to their low cost, strong resistance to corrosion, lightweight, simple and excellent processability.

Experimental

- The $CuFe_2O_4$ ferrite was prepared by solution combustion method.
- Polypyrrole/$CuFe_2O_4$ ferrite nanocomposites were synthesized by in-situ polymerization method.
- The structural characterization was carried out using the Philips X-ray diffractometer using CuKα_ radiation (λ = 1.5406 Å). The average particle size, D, was determined from line broadening of (311) reflection using Debye - Scherrer formula, $D = k\lambda/\beta \cos\theta$, where, k = 0.9 is a correction factor to account for the particle shapes, β is the full width at a half maximum (FWHM) of the most intense diffraction peak , λ is the wavelength of a Cu target = 1.5406 Å and θ is the Bragg angle. Average particle size was found to be 44nm.
- Dielectric and AC conductivity studies on the as prepared composites have been undertaken using impedance analyzer model HIOKI 3532-50 LCR HiTESTER. The measurements were carried out at room temperature in the frequency range 50Hz-5MHz.

Results and discussion:

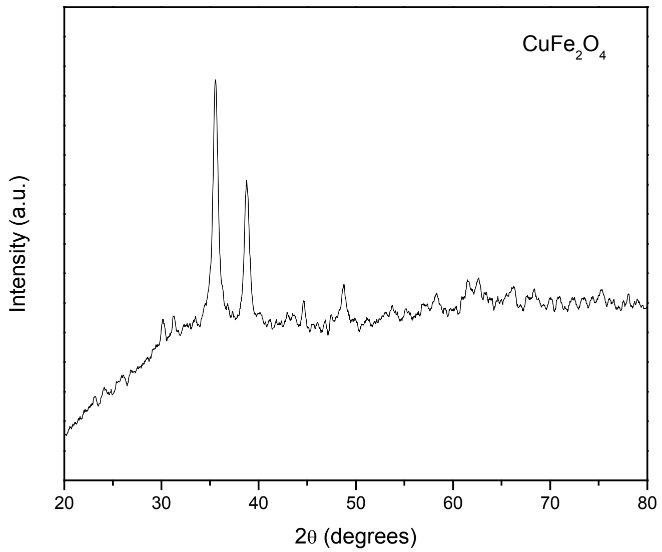

Figure 1. XRD pattern of $CuFe_2O_4$ ferrite .

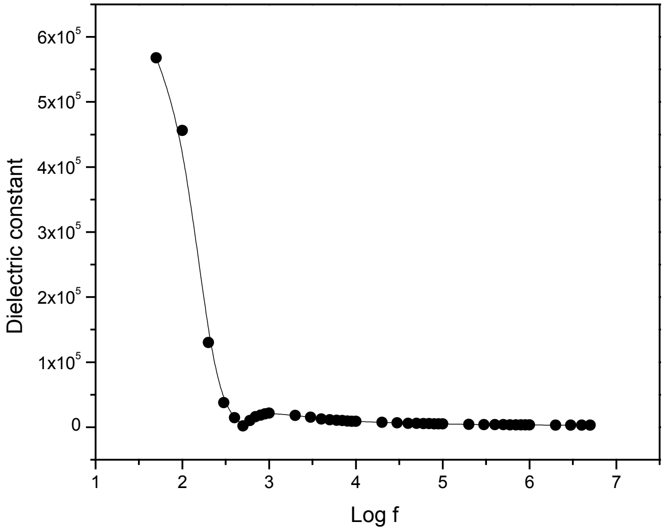

Figure 2. Variation of dielectric constant (ε′) with frequency.

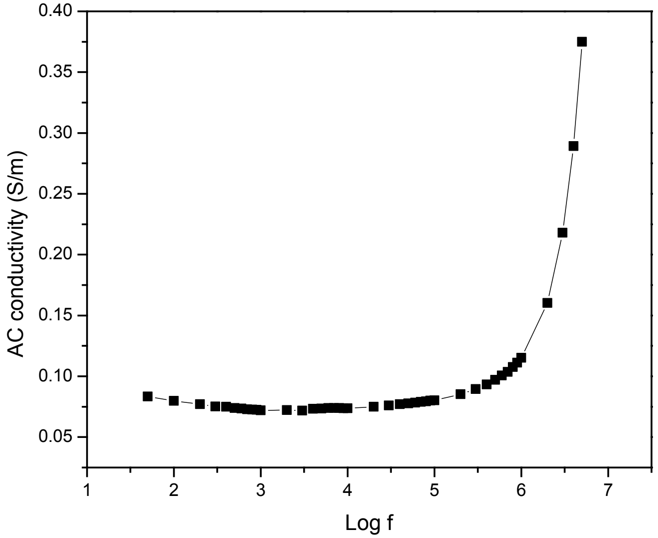

Figure 3. Variation of a. c. conductivity (σ) with the frequency.

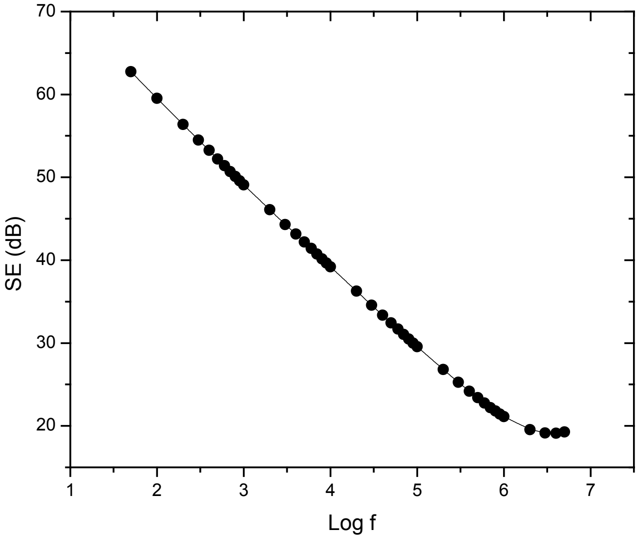

Figure 4. Frequency dependence of shielding effectiveness.

Conclusions:

- Polypyrrole (PPy)/$CuFe_2O_4$ composites were synthesized through a simple in-situ polymerization.
- The dielectric constant (ε′) was found to decrease with an increase in frequency.
- AC conductivity was found to enhance with an increase in the frequency.
- The electrical conduction mechanism in the PPy/$CuFe_2O_4$ was found to be in accordance with the electron hopping model.
- Frequency dependence of Electromagnetic Interference (EMI) shielding effectiveness was studied. The EMI shielding effectiveness was found to decrease with an increase in the frequency.
- PPy/$CuFe_2O_4$ composites were demonstrated as a favorable functional material for the absorbing of EM waves at low frequencies.

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