PREPARATION AND INVESTIGATION ON ELECTRIC IMPEDANCE, MODULUS, AND DIELECTRIC PROPERTIES OF POLYANILINE/MANGANESE DIOXIDE NANOCOMPOSITES

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Abstract : Polyaniline/Manganese dioxide (PANI /MnO_2) nanocomposites (1 wt %) have been successfully synthesized by in-situ polymerization method. The PANI/MnO_2 nanocomposites were characterized by AC impedance spectroscopy. The impedance spectroscopy was used to analysis their electric impedance, electric modulus, and dielectric behavior. The different temperature impedance, modulus, and dielectric response of the composites were studied in the frequency range of 10 μHz to 8 MHz. The electrode process and mass transfer was explained by impedance spectra. The modulus data of nanocomposites were analyzed as a function of frequency at different range of temperature. The doping of MnO_2 nanoparticles were changes in the PANI/MnO_2 nanocomposites of the dielectric constant and dielectric loss. The relaxation peaks were observed in the frequency dependence of the dielectric loss.

Index Terms - Modulus, Impedance, Dielectric, Temperature.

1. INTRODUCTION

Polyaniline is a conducting polymer [1]. The preparation of PANI and analysis has been of much importance. The PANI has very stuff molecular structure [2]. PANI explains the fundamental materials science of π- bonded macromolecules. The polaron and bipolaron is charge carrier of PANI [3]. The type of charge conduction is produced from the formation of polarons and bipolarons in the energy band. The metal oxide nano particles are prepared. The manganese dioxide nanoparticles are used as sensing components, composites electrodes and chemical analysis [4]. MnO_2 nano particles also possess many electrical properties like electrical conductivity [5], electrical modulus, etc., the electrical properties of polyaniline composites has been increasing when the incorporation of metal oxide nanoparticles [6]. The electrical modulus, impedance and dielectric of such composites might also depend upon the molecular structure of polymer matrix. In the present study, PANI/MnO_2 nanocomposites with one weight percentage of MnO_2 concentration were synthesized by in situ polymerization techniques. In this current work the electric impedance, electric modulus, and dielectric characterizations of nanocomposites are reported.

2. EXPERIMENTAL TECHNIQUE

Hydrochliric acid, Manganese sulphate, Aniline, and Manganese oxalate was purchased from MERCK (AR grade), and Ammonium per sulphate from RANBAXY (AR grade)

2.1. SYNTHESIS OF PANI/MNO$_2$ NANOCOMPOSITES

The pure PANI nanoparticles had been prepared successfully in situ polymerization method and finally got green color powder. The pure MnO_2 nanoparticles had been prepared successfully in microwave solution assisted method and finally got brown color powder. Finally, PANI/MnO_2 nanocomposites had been prepared in situ polymerization method and got green color powder.

2.2. CHARACTERISATION OF PANI/MNO_2 NANOCOMPOSITES

AC impedance spectroscopic analysis was performed using a computer controlled Zahnner zennium IM6 meter within the frequency range 1 to 8 MHz at different temperatures

3. RESULT AND DISCUSSION

3.1. IMPEDANCE ANALYSIS

Cole – Cole plot method was used to analyze the frequency responses of impedance with the adsorption-desorption method of the inorganic materials [7]. The Cole-Cole plots were the plot between impedance Z'' and impedance Z' [8]. The Z'' is the impedance of imaginary part, and Z' is the impedance of real part. The Cole-Cole plot of one weight percentage PANI/MnO_2 nanocomposites was sown in Fig. a. The Z'' and Z' carried at below room temperature (25^0C). The impedance analyzer was used to study the electrical properties of composites materials. The plot was clearly shown in a small continues line at the starting frequency region. But the lines were followed by a partly semicircular arc at raising frequency region. This arc lies on the impedance axis. These studies were confirmed, PANI/MnO_2 nanocomposites have impedances behaviour.

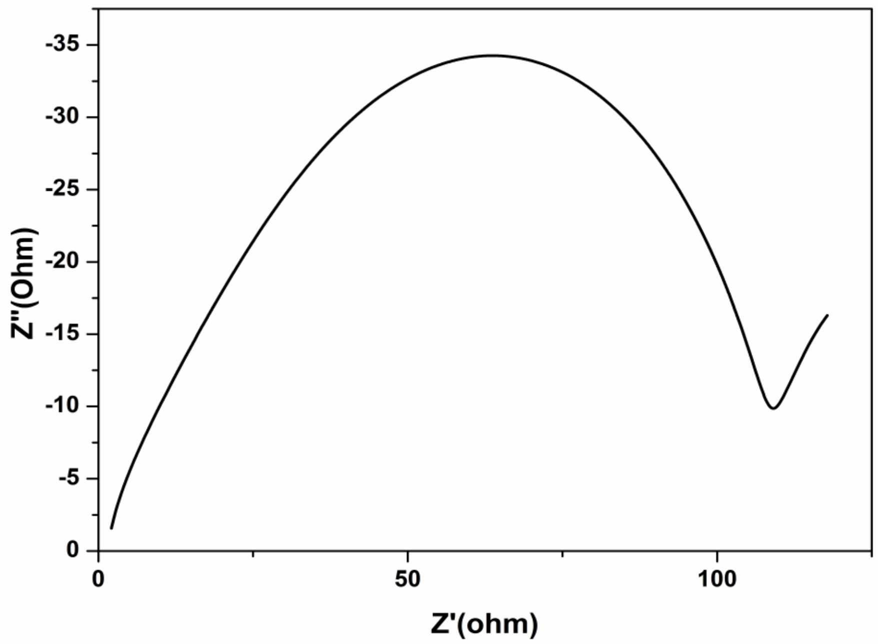

Fig a: Cole – Cole plot PANI/MnO_2 nanocompoaites at 25^0C.

3.2. MODULUS ANALYSIS

Fig. b & c shows the modulus plot of PANI/MnO_2 nanocomposites (one weight percentage), Fig. b & c also shows that the real part of modulus and imaginary part of modulus with angular frequency at 25^0C. The M' is modulus of real part and M" is modulus of imaginary parts; these are evaluated for this system. The M' value is starting with the low-frequency region, it continued and increased in the high-frequency region, so it was confirmed by polarization effect at electrode interface of PANI/MnO_2 nanocomposites [9]. This M' plot gave the information about the distribution of ions. The M" with logarithmic angular frequency for 25^0C is shown in Fig. c. The M'' value is starting with the low-frequency region at high; it continued and decreased in the high-frequency region. This M'' plot gave the information about the distribution of ions.

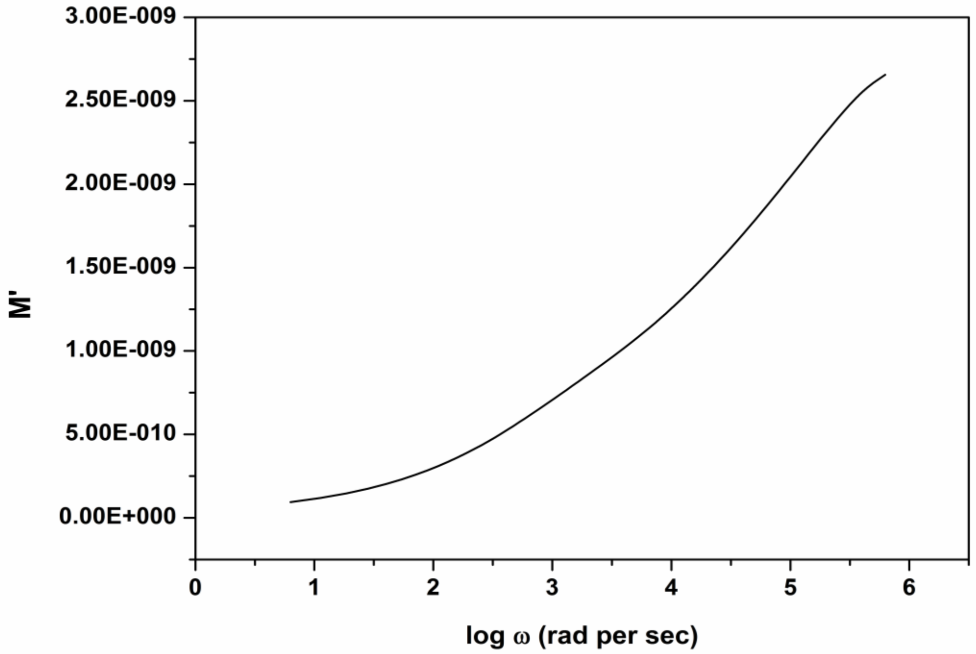

Fig b: Logarithm of omeha versus real part of modulus of PANI/MnO_2 nanocompoaites at 25^0C.

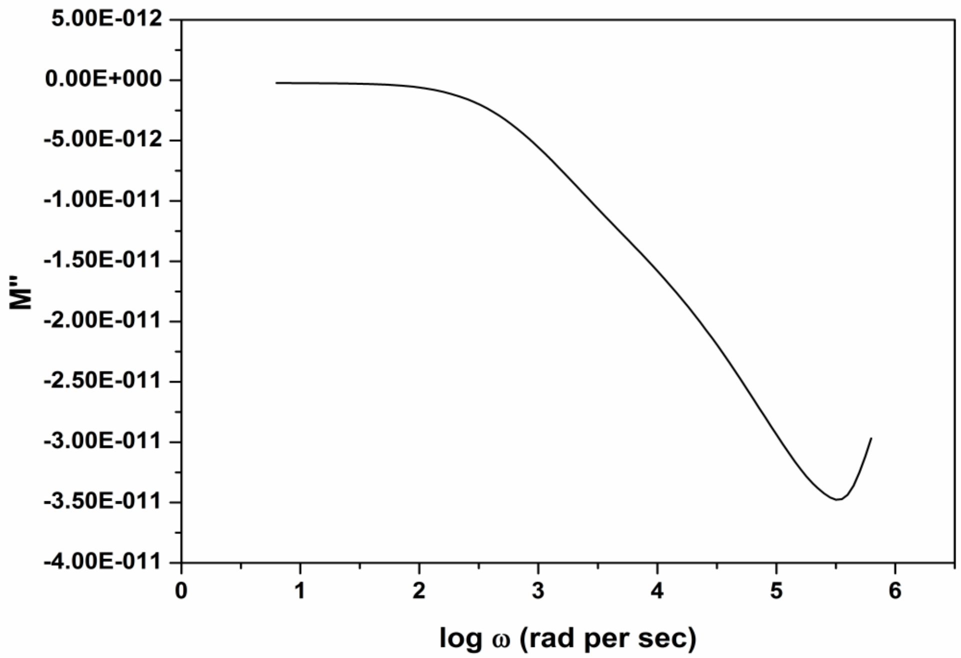

Fig c: Logarithm of omeha versus imaginary part of modulus of PANI/MnO_2 nanocompoaites at 25^0C.

3.3. DIELECTRIC ANALYSIS

Fig. d, e & f shows the dielectric constant, dielectric loss and relaxation peak of PANI/MnO_2 nanocomposites (one weight percentage) at a particular temperature (25^0C). In fig. d, the dependenceε' with logarithmic frequency is classified into three stage. The ε' has been increasing within the range of frequency between 1 to 1.8 (radian per sec) for the first stage. The ε' has been decreasing within the range of frequency between 1.8 to 3.5 (radian per sec) for the second stage, it may be electrical relaxation process. The ε' has been increasing continually within the range of frequency between 3.5 to maximum (radian per sec) for the third stage. The first and third stages are giving the information about the dielectric constant at maximum. In fig. e, the ε'' has been increasing with increasing the frequency at the particular temperature 25^0C, it is giving the information about the dielectric loss maximum at low temperature range. In fig. f, the tanδ decreasing with increasing logarithmic of frequency, it is giving information of electrical relaxation process.

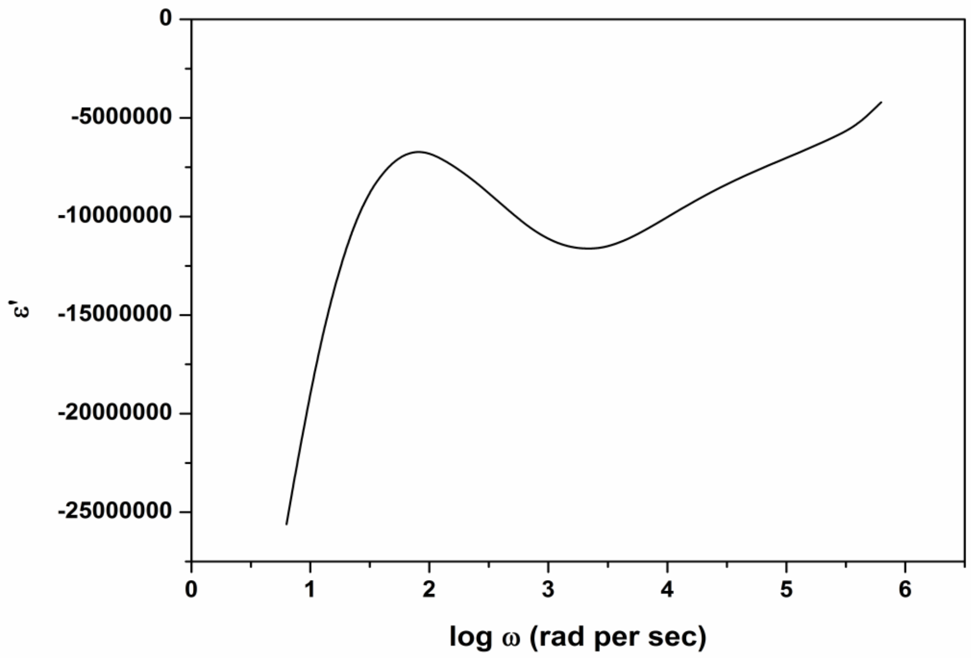

Fig d: Logarithm of omeha versus dielectric constant **ε**' of PANI/MnO_2 nanocompoaites at 25^0C.

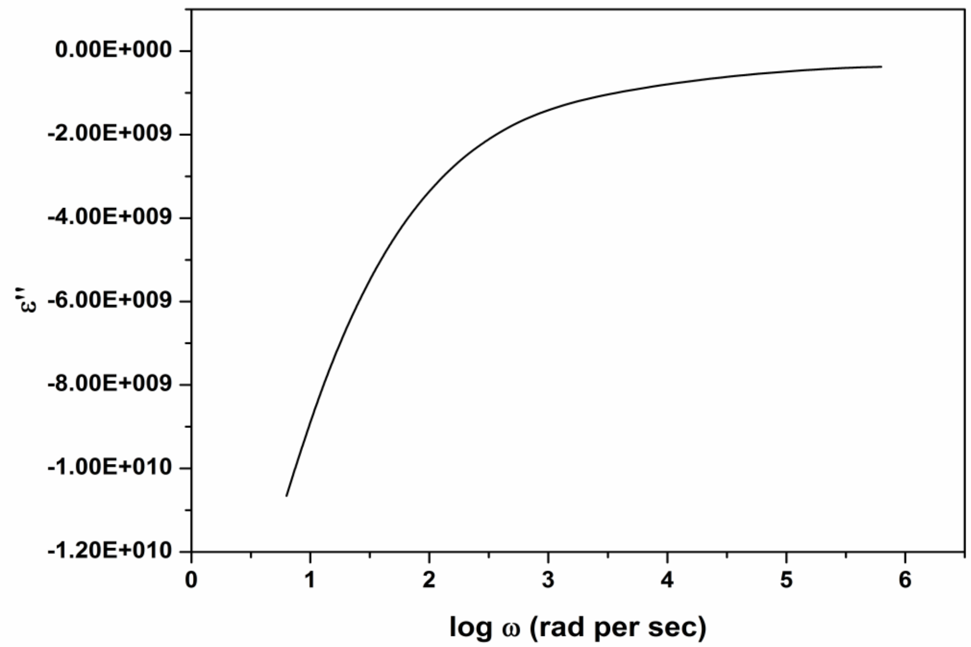

Fig e: Logarithm of omeha versus dielectric loss **ε**" of PANI/MnO_2 nanocompoaites at 25^0C.

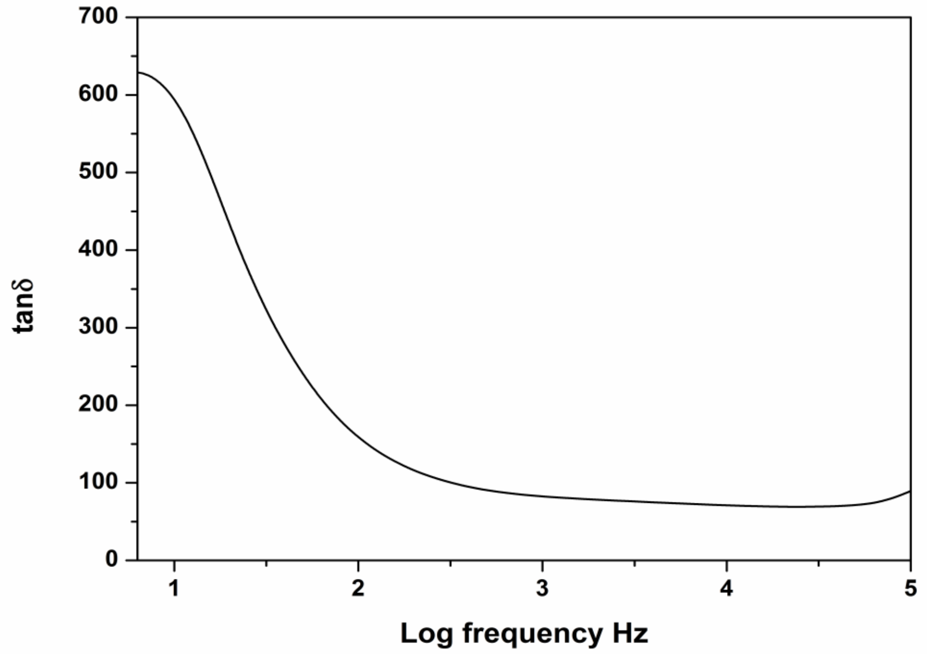

Fig 8: The dielectric relaxation peak for PANI/MnO_2 nanocompoaites at 25^0C.

4. CONCLUSION

The Polyaniline/manganese dioxide nanocomposites have been prepared successfully by in situ polymerization method. The impedance behaviour has been observed from a cole-cole plot. The polarization effect and distribution of ions has been observed from modulus analysis. The Maximum dielectric constant was observed at high frequency region, the relaxation process also observed from the dielectric analysis.

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