Chemical Science Review and Letters ISSN 2278-6783

Research Article

Dielectric Studies on PVA/PVP: GO Based Nanocomposite Polymer Films

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Abstract

Graphene, a monolayer of hexagonally packed carbon atoms has revolutionized both the academic and industrial world ever since it comes to experimental existence. Graphene oxide (GO) nano-particles were synthesized using modified Hummers method. The synthesized GO nanoparticles were incorporated in PVA/PVP blend polymers for preparation of nanocomposite polymer films by solution cast technique. Impedance spectroscopy was performed for nanocomposite polymer films at room temperature, to find out the best optimum conductivity of samples. The dielectric constant of composite electrolytes increases apparently with the increase of temperature. The abrupt change in dielectric constant has been verified by the ionic conductivity. This is due to the ionic jump orientation, space charge polarization and electronic contribution of Mg^{2+} ions. Nanocomposite polymer films of PVA/PVP: GO holds great promise in many potential applications such as an electrode material for fabrication of electrochemical cells.

Keywords: Graphene oxide, Solution cast technique, PVA/PVP blend polymers, Dielectric properties

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Introduction

Over a past few decades an attractive attention has been made towards carbon nanomaterials such as graphene and graphene oxide due to their low production cost and excellent structural, electrical, thermal and magnetic properties [1-3]. Nanocomposite polymer films are expected to exhibit a major change in wide range of technological applications and industrial fields such as conductive coating, sensors, microwave absorbing and energy storage devices etc. After discovery of graphene and graphene oxide (GO) a focus has been made on the non-volatile memory applications due to its potential behavior [4, 5]. Nanocomposite polymer films are prepared by compounding the polymer and conductive nanoparticles such as graphite, carbon nanotubes, carbon fiber, carbon black and metal particles [6, 7]. When the content of conductive nanoparticle reaches to a critical then the value continuous electrical conductive network is formed rendering the polymer composite electrically conductive [8, 9].

Graphene, a monolayer of hexagonally packed carbon atoms has revolutionized both the academic and industrial world ever since it comes to experimental existence [10, 11]. Graphene has excellent physical and mechanical properties such as high thermal conductivity, good mechanical strength, high specific surface area and high mobility of charge carriers [12]. Graphene is also used in many applications such as batteries, solar cells, fuel cells and super capacitors [13-16].

Polyvinyl pyrrolidone (PVP) and polyvinyl alcohol (PVA) has chosen because it has excellent characteristics such as optical, mechanical and electrical as well as displaying dissolubility, stability, high dielectric constant, compatibility and resistance and large scale screen printing of electrolyte films at low cost. Rao et al. presented their results in their earlier studies [17-77]. In the present investigation, nanocomposite polymer films were prepared by dispersed GO nanoparticles with PVA/PVP blend polymers to improve the ionic conductivity which is suitable for battery application.

Experimental
Chemicals Required

Graphene (acid treated 99% purity) were purchased from Loba chemicals Ltd., polyvinyl pyrrolidone and polyvinyl pyrrolidone with average molecular weight of 36,000 were purchased from Sigma Aldrich chemicals Ltd., India.

Preparation of Nanocomposite Polymer Films

Nanocomposite polymer films are prepared with the combination of GO, PVA and PVP. Take 200 ml round bottom flask and add 30 ml of distilled water with blend polymers PVA/PVP: wt% (0.20/0.20, 0.25/0.25 and 0.30/0.30) (equal wt% ratios of PVA/PVP). Stir all the mixtures till the polymers get dissolved in water, later reduced nanoparticles of GO: x% (0.1, 0.2 and 0.3g) were added to the homogenous mixture and sonicate the solution to get fine dispersion, which was poured in polypropylene dishes and placed in hot air oven at 70 ^{o}C. A fine nanocomposite polymer thin film was obtained which is kept in a decicator until further test.

Results and Discussion
Dielectric Properties

Figure 1 shows the value of ε^{ll} is seen to decrease with increasing frequency at room temperature in nanocomposite polymer electrolyte [78]. Decrease in dielectric constant with increase in frequency is due to polarization takes place at the electrode and electrolyte interfaces and the dipolar relaxation process.

Figure 2 shows the dielectric constant is a measure of amount of charge stored. As increasing the frequency the dielectric constant gradually decreases and found to be high for the sample with 0.3 wt %, this concludes that the drifting of ions is high giving raise to conductivity phenomenon. This reveals that the salt is completely dissolute in the polymer chains giving raise to mobile ions. Due to the formation of space charge region at the electrode and electrolyte interfaces. **Figure 3** and **Figure 4** denote the fact that when the frequency is increased, the ionic conductivity and the oriental source of polarizability increase; this is due to the transfer of mobile ions which causes a constant value of dielectric constant [79]. The plateau region describes the space charge polarization at the blocking electrode and is associated with ac conductivity (σ_{ac}) of the complexed polymer electrolyte.

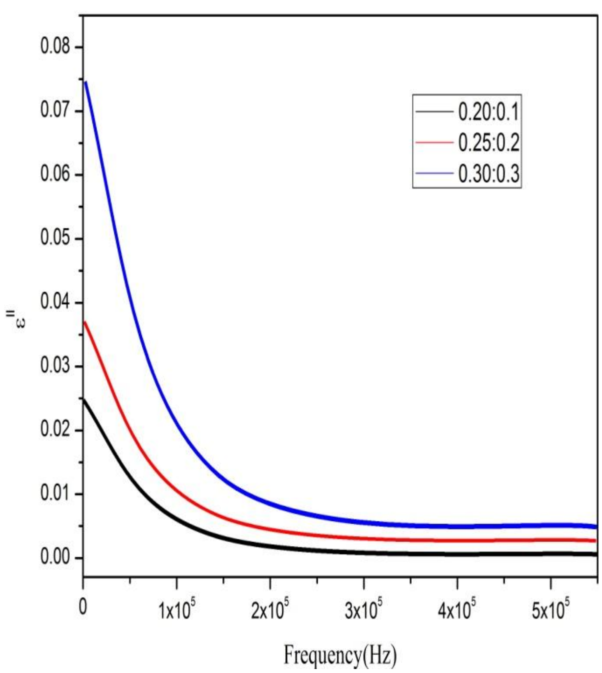

Figure 1 Variation of the imaginary part of dielectric constant with frequency permittivity for different wt% ratios

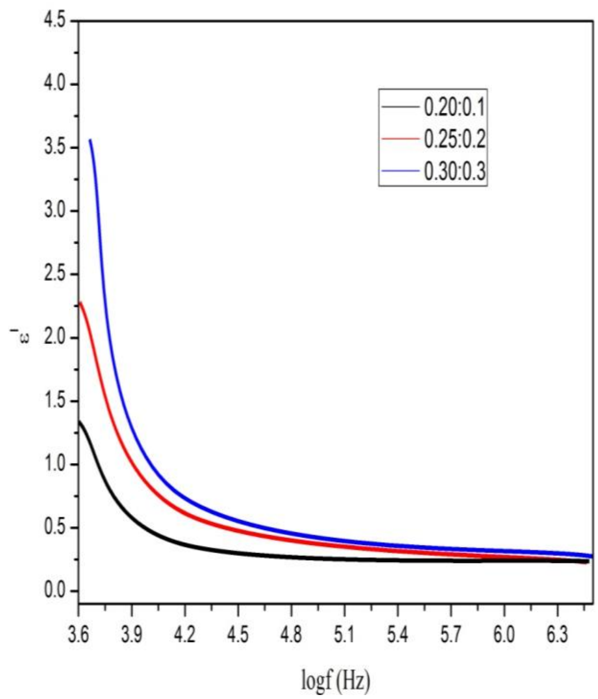

Figure 2 Variation of log f with dielectric constant for different wt% ratios

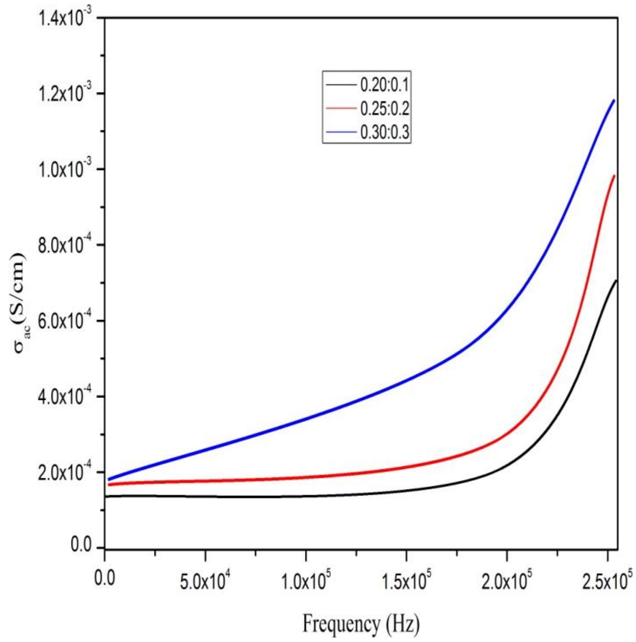

Figure 3 Variation of the ionic conductivity frequency for different wt% ratios

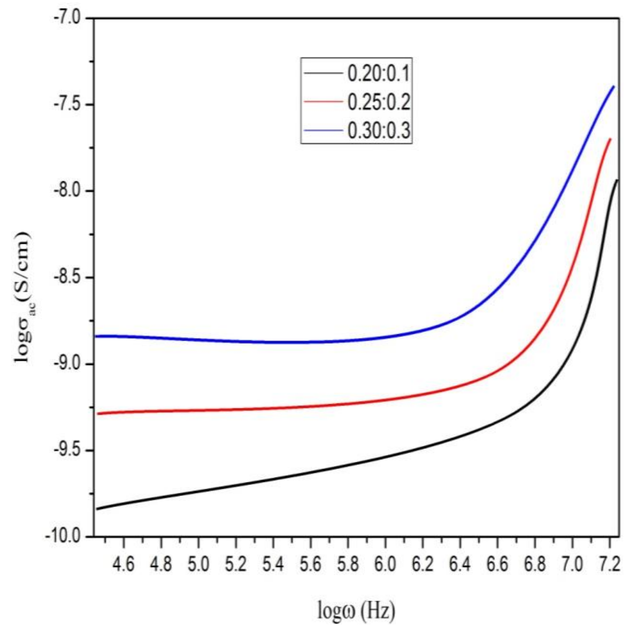

Figure 4 Variation of log ω with with logarithmic conductivity for different wt% ratios

Figure 5 and **Figure 6** show the variation of dielectric permittivity with the logarithmic angular frequency for the PVA/PVP: GO nanocomposite polymer films at room temperature. From these figures it is observed that as increasing the frequency the dielectric permittivity decreases monotonically and at higher frequency the dielectric values remain constant and the similar behavior is observed in reaming samples, which could be due to the dipole interaction and electrode-electrolyte polarization effects. At higher frequencies, the ionic diffusion doesn't takes place in the direction of the field. With the increasing rate of the electric field reversal, there is no time for charge build-up at the interface with increasing frequencies. The polarization due to charge accumulation decreases and it leads to decrease in value of dielectric constant [80, 81].

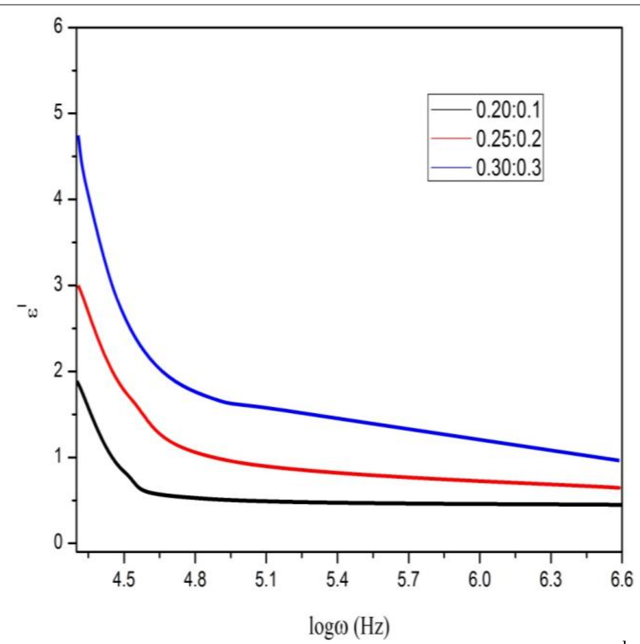

Figure 5 Variation of dielectric constant real part (ε^{l}) with the logarithmic angular frequency for different wt% ratios

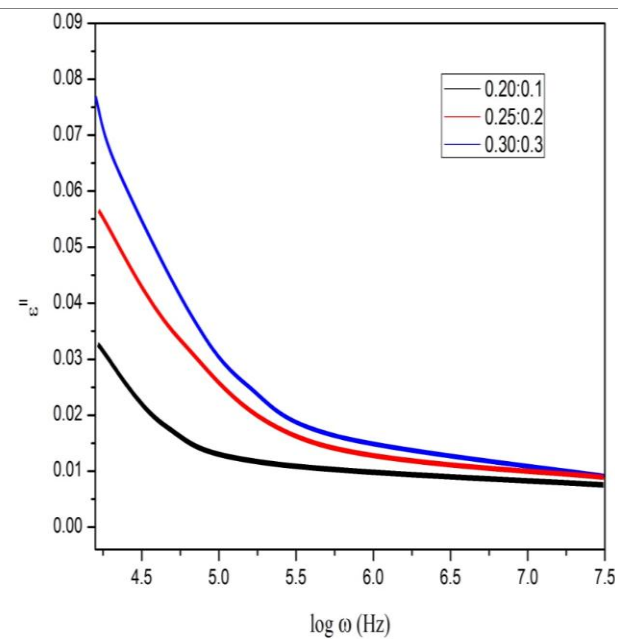

Figure 6 Variation of dielectric constant imaginary part(ε^{ll}) with the logarithmic angular frequency for different wt% ratios

The variation of tangent loss (δ) with logarithmic angular frequency (ω) for various wt% ratios of the polymer electrolyte samples is shown in **Figure 7**. The decrease in the tangent loss results with increase in the log frequency; this may be due to the reduced proportion of amorphous material leading to reduction in the magnitude of dispersion. The appearance of peaks suggests the presence of relaxing dipoles in the samples and also with electrical relaxation process or inability of dipoles [82].

The dielectric constant of composite polymer samples as a function of room temperature is shown in **Figure 8** and **Figure 9** and the variation of temperature with tanδ for different wt% ratios at 303 K is shown in **Figure 10**. The dielectric constant of composite electrolytes increases apparently with the increase of temperature. The increment in dielectric constant peak is observed at room temperature. The abrupt change in dielectric constant has been verified by the ionic conductivity. This is due to the ionic jump orientation, space charge polarization and electronic contribution of Mg^{2+} ions [83-85].

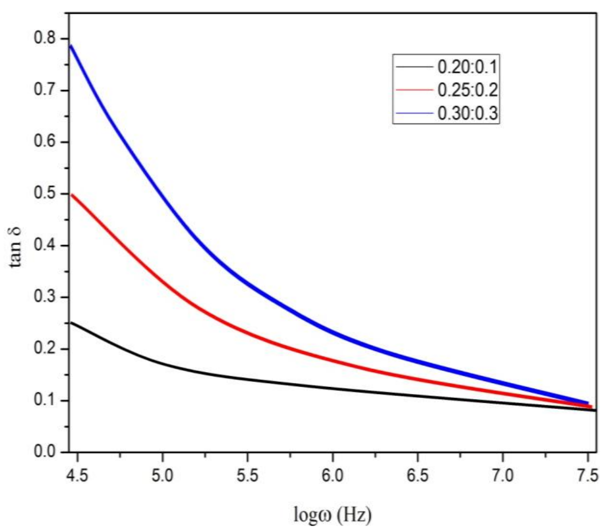

Figure 7 Variation of tangent loss with logarithmic angular frequency (ω) for various wt% ratios

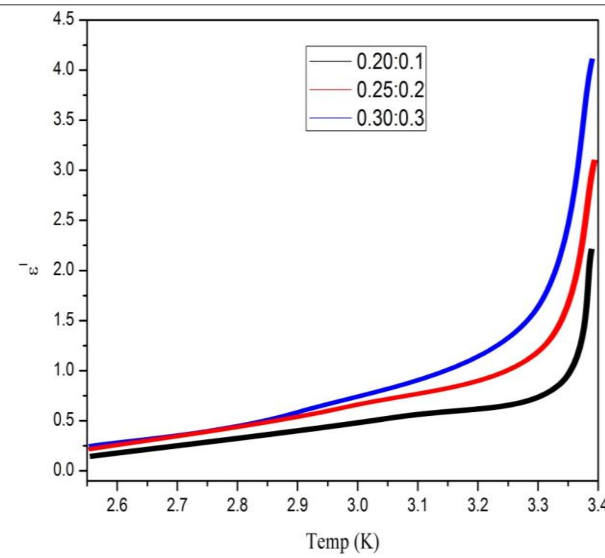

Figure 8 Variation of temperature with dielectric constant real part(ε^{l}) for different wt% ratios

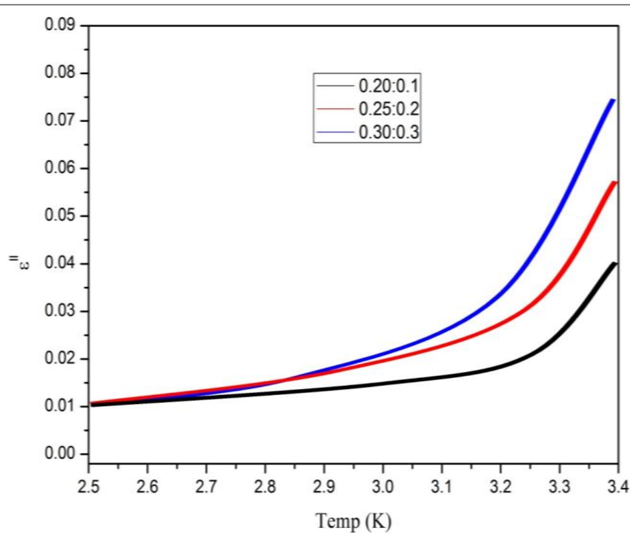

Figure 9 Variation of temperature with dielectric imaginary part(ε^{ll}) for different wt% ratios

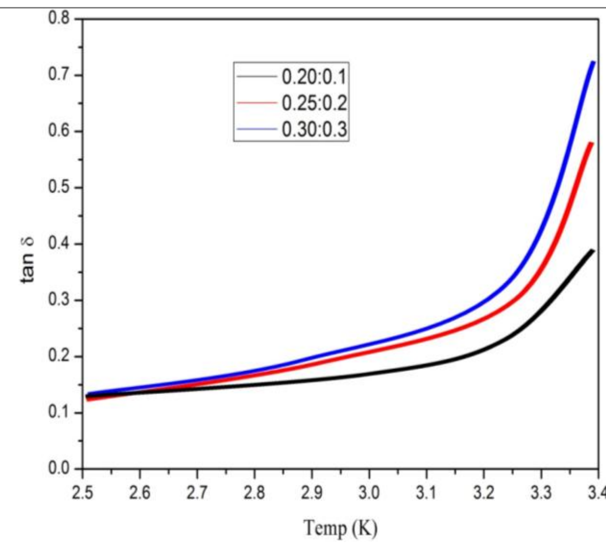

Figure 10 Variation of temperature with tan δ for wt% at 303 K

Conclusions

Nanocomposite polymer thin films were prepared with the combination of PVA/PVP: GO by solution cast technique. Impedance spectroscopy was performed for nanocomposite polymer film at room temperature. The dielectric constant of composite electrolytes increases apparently with the increase of temperature. This is due to the ionic jump orientation, space charge polarization and electronic contribution of Mg^{2+} ions. These nanocomposite polymer films of PVA/PVP: GO holds great promise in many potential applications as an electrode material.

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Publication History
Received 10th Apr 2017
Revised 17th Apr 2017
Accepted 17th Apr 2017
Online 30th Apr 2017