

Research Article

Cyclicvoltammetric Studies on PVA/PVP: GO Based Polymers

SK. Shahenoor Basha¹, K. Veera Bhadra Reddy² and M.C. Rao^{3*}¹Solid State Ionics Laboratory, Department of Physics, K. L. University, Guntur – 522502, India²Department of Physics, NRI Institute of Technology, Vijayawada Rural-520010, Krishna District, India³Department of Physics, Andhra Loyola College, Vijayawada- 520008, India**Abstract**

Graphene Oxide (GO) nanoparticles were dispersed in PVA/PVP blend polymer matrix for preparation of nanocomposite polymer films by solution cast technique. AC ionic conductivity studies were performed on to the prepared samples. These studies revealed that the ionic conductivity is found to be maximum for PVA/PVP: GO (0.45:0.3) wt% composition. Electrochemical cell has been constructed with the configuration of $Mg^{+}/(PVA/PVP:GO)/(I_2+C+electrolyte)$ and cyclicvoltammetric studies were carried-out on to fabricated cell. The nanocomposite electrolyte films of PVA/PVP: GO finds potential applications visually as associate conducting material for battery application.

Keywords: PVA/PVP: GO, solution cast technique, AC-conductivity and Cyclicvoltammetric studies

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Introduction

Now a day's carbon nanomaterials like graphene and graphene compound materials are attracted in several potential applications because of their low cost and wonderful structural, electrical, thermal and magnetic properties [1-3]. Nanocomposite polymer area expected to exhibit a serious amendment in wide selection of technological applications and industrial fields like semiconducting coating, sensors, energy storage devices etc. Nanocomposite polymer electrolytes can be prepared easily by doping semiconducting nanoparticles like graphite, carbon nanotubes, carbon fiber and metal particles [4, 5].

Graphene is a monolayer with hexagonally packed carbon atoms has revolutionized the industrial world ever since it comes in to experimental existence [6]. It has enormous novel properties like high modulus, giant theoretical specific area, virtually clear and wonderful physical phenomenon [7]. Out of the many possible functionalized styles of graphene and its composites, graphene based composites area is quite promising as a result of combined options with improved properties of polymers composites [8]. Specially, versatile super electrical condenser and vital energy storage devices are extensively explored in these years [9]. Graphene has wonderful physical and mechanical properties like high thermal physical phenomenon, smart mechanical strength, high specific area and high quality of charge carriers [10]. Graphene is additionally utilized in several applications like batteries, solar cells, fuel cells and super capacitors [11]. Graphene is widely used as nanofiller in composites for many sensible applications on giant scale production [12]. GO primarily based nanocomposites are extensively studied and reported due to their mechanical integrity, high tensile strength and great improvement of electrochemical stability [13-15].

Polyvinyl pyrrolidone (PVP) is chosen because of its smart mechanical, electrical, optical characteristics and film forming nature [16]. PVP has major role in displaying physical property, stability, high dielectric constant with compatibility and resistance. PVP is soluble in polar solvents and also in ionized water [17]. Polyvinyl alcohol (PVA) is employed in the preparation of nanocomposite chemical compound films as a result of its wonderful chemical behavior, smart mechanical, thermal and electrical properties. PVA is freely soluble in water. Due to their excellent polymeric behavior, it is widely used in smart charge storages [18]. Rao et al. presented the results in their earlier studies [19-88]. In the present work, nanocomposite films were prepared by distributed GO nanoparticles with PVA/PVP blend polymers to enhance the ionic and physical phenomenon which is appropriate for battery application.

Experimental**Chemicals Required**

Graphene oxide (acid treated 99% purity) and polyvinyl pyrrolidone with average molecular weight of 36,000 were purchased from Sigma Aldrich chemicals Ltd., India. PVA (98% purity) were purchased from Loba chemicals Ltd., India in the present investigation.

Preparation of Nanocomposite Polymer Films

Nanocomposite films were prepared by dispersing of GO with PVA/PVP blend matrix. Take 200 ml spherical bottomed flask and add 30 ml of distilled water to the blend polymers, PVA/PVP: wt% (0.35/0.35, 0.40/0.40 and 0.45/0.45) (equal wt% ratios of PVA/PVP). Stir all the mixtures until the polymers get dissolved in water, later nanoparticles of GO: x% (0.1, 0.2 and 0.3g) were added to the homogeneous mixture and sonicate the solution to get fine dispersion. Later the obtained homogenous solution was poured in polypropene dishes and placed in hot air oven at 60° C for 48 hrs. A fine nanocomposite polymer film with smooth surface was obtained, which is placed in a decicator until further use.

Characterization

Complex impedance spectroscopy measurements were carried-out by HIOKI 3532-50 LCR Heister to determine the ionic conductivity and dielectric constant of the polymer electrolyte. Electrochemical cell has been fabricated and its discharge characteristics were studied by Keithley electrometer (Keithley Inc., model 6514) for a constant load of 100 k Ω . The cell parameters were calculated.

Results and Discussion

A.C. Conductivity Studies

Figure 1 represents the Cole-Cole plot of prepared nanocomposite polymer films for different wt% ratios. The figure shows a semi-circular arc at high frequency region and a spike at low frequency region. The point where the semicircle intersects the real axis gives the value of the bulk resistance (R_b). The conductivity graph of nanocomposite polymer electrolytes show only spikes. This reveals that the bulk charge carriers flow within the nanocomposite film is usually attributed to ions and therefore physical phenomenon will increase. This is explained on the basis of the relaxation process [89]. The Cole-Cole plot is obtained from the real part (Z^I) vs an imaginary part (Z^{II}) and the ionic conductivity is calculated by the following relation

$$\sigma_{ac} = t/(R_b \times A) \quad (1)$$

Where " R_b " is the bulk resistance, " t " is the thickness of the polymer film and ' A ' is the cross section of the film. The uppermost ionic physical phenomenon for (0.45/0.3) wt% composition is found to be at 6.09×10^{-5} S/cm.

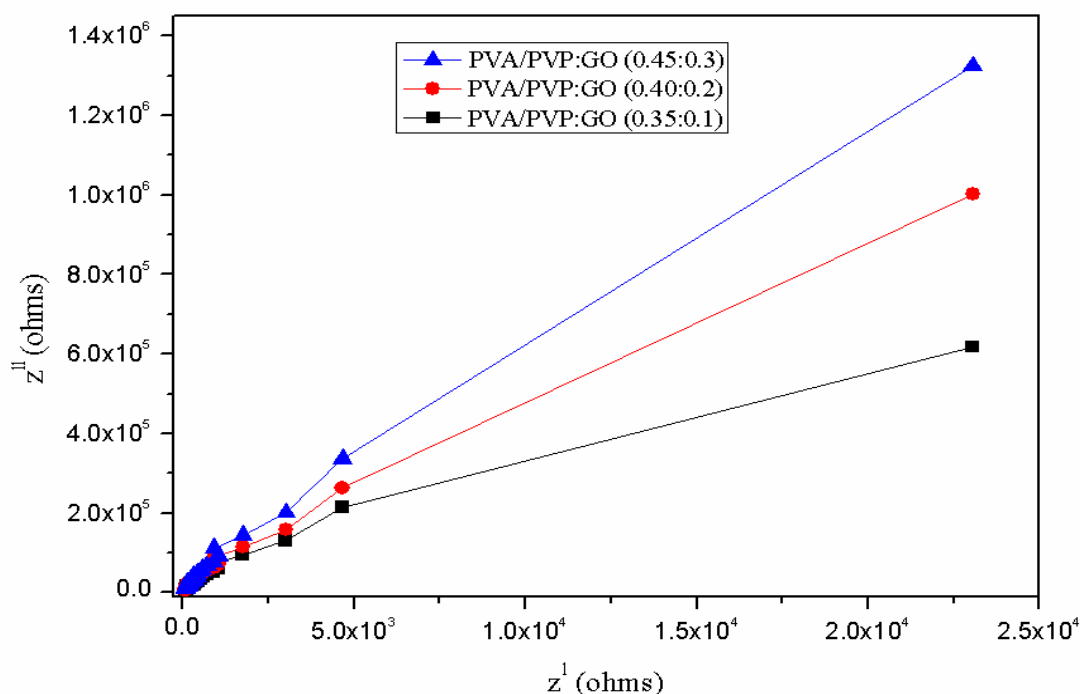


Figure 1 Cole–Cole plots of (a) PVP/PVA: GO (0.35:0.1), (b) PVP/PVA: GO (0.4:0.2), (c) PVP/PVA: GO (0.45:0.3)

Electrochemical Properties

Electrochemical cell has been fabricated with the combination of 0.45 PVA/0.45 PVP: 0.3 GO. The galvanostatic charge/discharge performance was carried-out from 0.5 to 3 V for configuration of $\text{Mg}^+(\text{PVA/PVP}+\text{GO})/(\text{I}_2+\text{C}+\text{electrolyte})$. The chemical stability of the polymer membrane has been found to be stable up to ~ 1.8 V. Initially, a fast decrease within the voltage is occurred; it ensures the polarization effect and therefore the formation of thin layer of Mg at the electrode/electrolyte interfaces. Cell parameters like open circuit voltage (OCV) and discharge capability are evaluated from **Figures 2** and **3**.

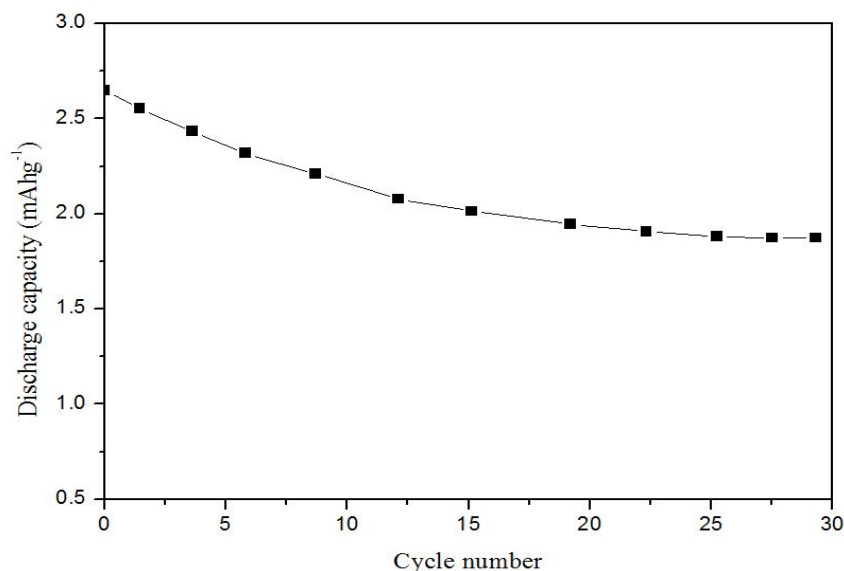


Figure 2 Variation of cycle number with discharge capacity of polymer electrolyte films for (0.45:0.3) wt% ratio

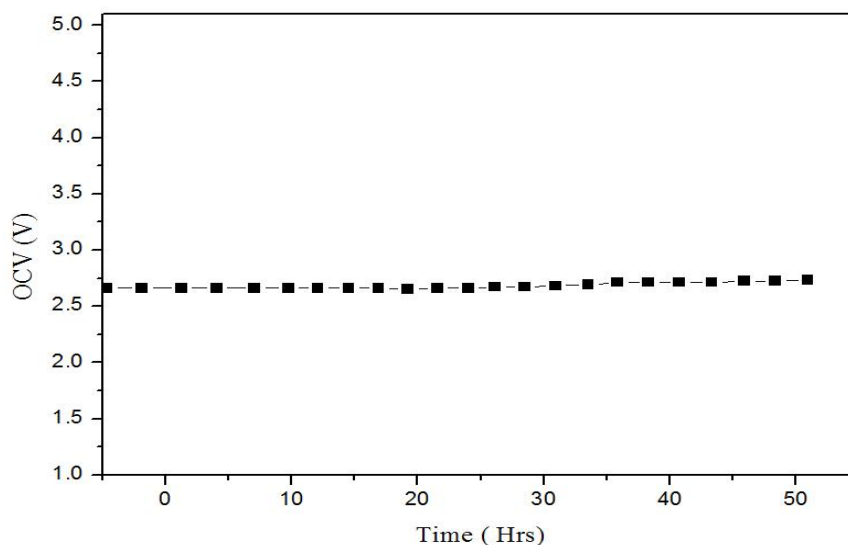


Figure 3 OCV of polymer electrolyte film for (0.45:0.3) wt% ratio

The anode and cathode materials were made in the form of pellets, which boosts its electronic physical phenomenon [90]. As fabricated cell is allowed to equilibrate for 30 min and the OCV measured was 2.6 V. The chemical performance of the cell shows the number of cycles at 2.5 V for about 24 h, which is shown in **Figure 4**.

The charging curve (plateau potential) showed that as increasing the current, the voltage is bit by bit decreases and remains constant at 10 mA; the decrement in curve is attributed to GO with the mixture of iodine and carbon at the cathode interface. Due to the chemical and micro- structural properties of the electrolyte layer, the current density cut-off voltage is gradually decreases which are purely dependant on the thickness of the layer. The cell was cycled galvanostatically at 10 μA as shown in **Figure 5**.

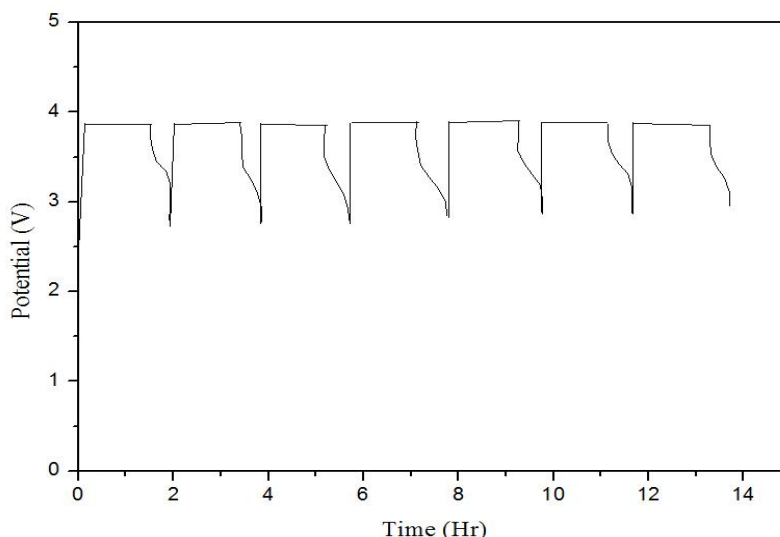


Figure 4 Variation of time vs potential of polymer electrolyte films for (0.45:0.3) wt% ratio

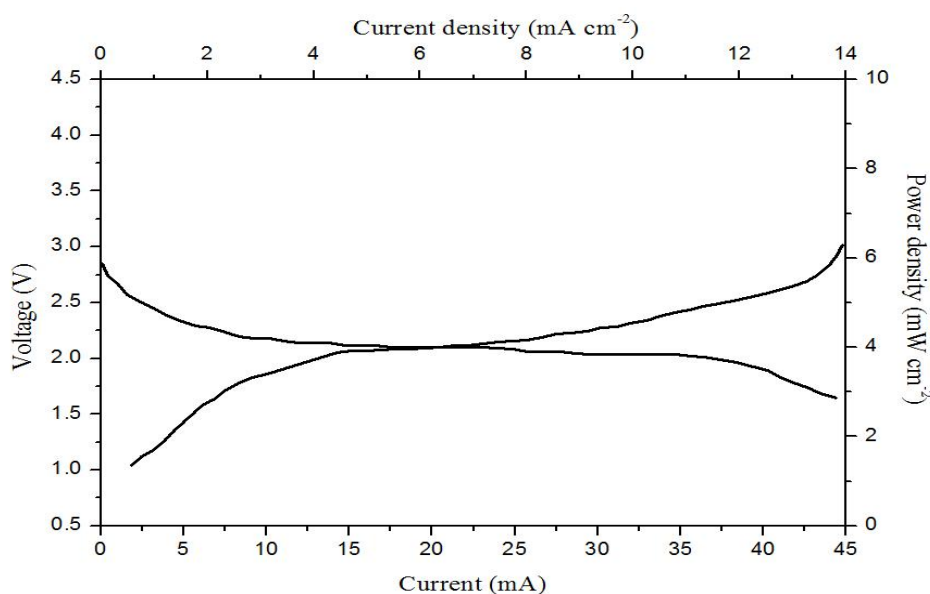


Figure 5 Cell parameters of polymer electrolyte films for (0.45:0.3) wt% ratio

From ionic conductivity and cyclic voltammetric studies one can assume the complexed nanocomposite films with wt% of 0.45 PVA/0.45 PVP: 0.3 GO exhibits the best performance which is appropriate for fabricating electrochemical cell.

Conclusions

Nanocomposite polymer films were prepared with the combination of PVA/PVP: GO by solution cast technique. From the AC conductivity studies, the best conduction for PVA/PVP: GO (0.45:0.3) combination was found to be $6.09 \times 10^{-5} \text{ Scm}^{-1}$ at room temperature. By using these polymer films electrochemical cell has been fabricated and cyclic voltammetric studies were performed.

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