Fabrication of Gas Sensor By Using ($PEO+KNO_3$+Nano Al_2O_3) Composite Polymer Electrolyte

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Abstract- *($PEO+KNO_3$+Nano Al_2O_3) Composite Polymer Electrolytes (CPE) were prepared by using solution casting technique. The pure poly (ethylene oxide) (PEO) and alkali salt KNO_3 were separately dissolved in methanol and these solutions were mixed together. The nano Al_2O_3 filler was doped to mixed solution. Afterward, the solution was stirred together for about 24 hours. ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes layer was coated on aluminium tube (sample substrate) by dipping several times in the solution and every time it was allowed to evaporate at room temperature. The same process was employed for the preparation of various ratios of ($PEO+KNO_3$+Nano Al_2O_3) (90:10), (80:20) & (70:30). The Aluminium tube was placed in the gas sensor setup and carbon monoxide gas was sent through the gas sensor setup. The sensitivity of ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes was calculated at various temperatures as well as at different gas concentrations. From this experimental observation it was found that, the sensitivity of ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes were increase with increase of temperature and as well as with increase of gas concentrations.*

Keywords- poly (ethylene oxide), Composite polymer electrolytes, Solution casting technique, Gas sensor, Sensitivity.

I. INTRODUCTION

To prove that the technological compensations such as long self-life, extreme miniaturization, and extensive temperature range of operation allowed us to prepare solid state polymer electrolytes at low cost many research efforts has been carried out in world of science. These polymer electrolytes show significant large applications and ionic conductivities at their operating temperatures [1-7]. When polymer electrolytes were transformed in to thin films, then it reduces internal resistance. This leads to gas sensing material applications Polymer electrolytes and their application to gas sensors are materialized in few scientifically proven reports. The preparation of sensors using ($PEO+KNO_3$+Nano Al_2O_3) is not attempted with witness. Considering these aspects, in this present study the authors prepared ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes by using solution casting technique. The sensitivity behaviour of theses composite polymer electrolytes were observed at various temperatures as well as at different carbon monoxide gas concentrations.

II. EXPERIMENTAL

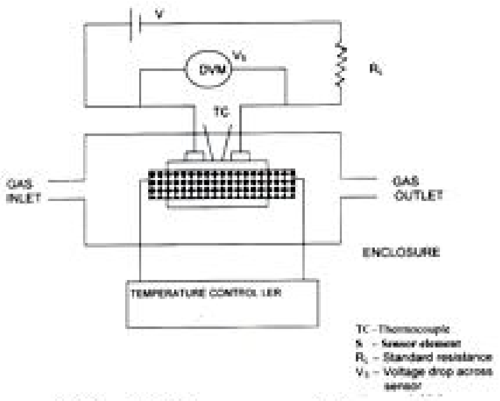
Solution casting technique procedure is normally used to fabricate polymer electrolyte films. The experimental process begins with the polymer PEO, as this is the host and the salt KNO_3 is dissolved in adequate reciprocal compositions in methanol.

The pure poly (ethylene oxide) (PEO) [Aldrich: Molecular Weight ($4X10^5$)] and alkali salt KNO_3 were separately dissolved in methanol for few hours, then the dissolved solution were mixed together. Nano Al_2O_3 filler (particle size ~10nm) was doped to mixed solution and it was stirred together for about 24 hours. ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes film was coated on aluminium tube (sample substrate) by dipping several times in the solution and every time it was allowed for evaporation at room temperature. The same process was continued for the preparation of composite polymer electrolytes of various ratios i.e. (90:10), (80:20) & (70:30). This aluminium tube substrate is provided with two silver electrodes [8].

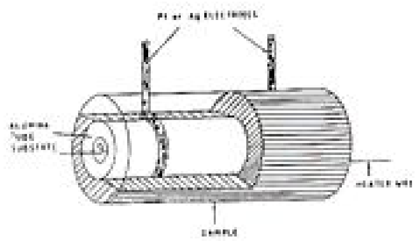
To calculate resistance of sensor element, aluminium tube was situated on temperature controlled tungsten coil heater in the interior part of a glass enclosure. Fig.1. shows the schematic of the measurement setup. A load resistor R_L was connected in series with the sensor element R_s. The input circuit operating voltage 10V was applied across R_s and R_L. Carbon monoxide gas was allowed to pass to attachment through the inlet. The resistance of the sensor was obtained by measuring the voltage drop Vs across the sensor element [9-11]. A chromet-alumel thermocouple (T_C) was situated on the device to indicate the operating temperature. This temperature measurement is within an accuracy of ±2°C, the sensitivity of the sensor was the ratio of the variation in electrical resistance in the presence of gas R_a -R_g = ΔR, to that in air, R_a.

$$S = \frac{(R_a - R_g)}{R_a} = \frac{\Delta R}{Ra} \text{-------} \quad (1)$$

The electrical resistance of the PEO+KNO_3+Nano Al_2O_3) composite polymer electrolyte was obtained in the presence and absence of gas. For the assessment of sensor sensitivity various air / carbon monoxide gas concentrations (ppm) ware employed.



(a) Schematic of the measyrement setup



(b) Schematic of the sensor element setup.

Fig.1. Schematic of measurement setup utilized to obtained gas sensor sensitivity.

III. RESULT AND DISCUSSION

(PEO+KNO_3+Nano Al_2O_3) based composite polymer electrolytes gas sensor was fabricated and applied 10V operating voltage to it. The sensitivity (S) of the sensor was the ratio of change in electrical resistance in the presence of carbon monoxide gas to that in the presence of air and it was shown in equation (1). Different compositions weight percentage of (PEO+KNO_3+Nano Al_2O_3) composite polymer electrolytes sensor sensitivity was determined at different gas concentrations (ppm) of carbon monoxide gas [12].

The sensitivity versus composition (Wt%) of (PEO+KNO_3+Nano Al_2O_3) composite polymer electrolyte was shown in Fig.2. Where gas sensor sensitivity increase with increase composition (Wt%) i.e. with increase KNO_3 salt concentration in the polymer PEO. As KNO_3 salt concentration increase in the polymer PEO, then the degree of crystallinity decreases and this will increase the backbone of the polymer chain. V. Madhusudhana Reddy et al [7 & 13] investigation of XRD studies provided an evidence for above discussion of decrease of degree of crystallinity by addition of KNO_3 salt concentration in the polymer PEO.

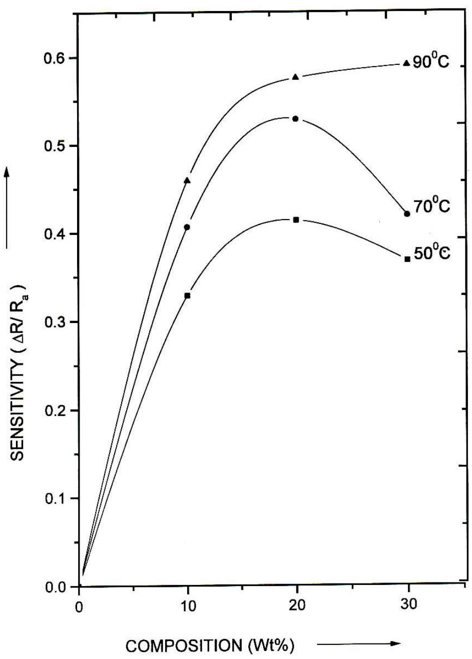


Fig.2. (PEO+KNO_3+Nano Al_2O_3) based gas sensor sensitivity as a function of composition (Wt%) at different temperatures.

Fig.3. shows (PEO+KNO_3+Nano Al_2O_3) (70:30) based gas sensor sensitivity as a function of gas temperatures at different gas concentrations (ppm). From Fig.4 it was observed that, sensor sensitivity increase with increase of temperature. Slimier behaviour was observed even at different gas concentrations (ppm). As temperature increase the sensitivity of (PEO+KNO_3+Nano Al_2O_3) composite polymer electrolyte carbon monoxide gas sensor increases. This was happened due to hopping mechanism between coordinating sites, local structural relaxations and segmental motions of polymer chain [12 & 13]. As amorphous region progressively enlarged, the polymer chain attains rapidly internal modes in which bond rotations creates segmental motion. This will

provide the hopping inter-chain and intra-chain ion movements and the sensitivity of the polymer electrolyte grow to be significant [7-8 &14-15]. The gas sensor sensitivity increase with increase of temperature was observed for various ratios [(90:10), (80:20) & (70:30)] of ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolyte due to hopping inter-chain and intra-chain ion movements. Anther reason for improve of sensitivity was excitants of nano filler Al_2O_3 in the complexed PEO. Because, when nano filler Al_2O_3 doped to complexed PEO, subsequently it decreases the crystallinity of the polymer, inhibit them from re-crystallization and enhance the degree of amorphicity that creates improvement in the sensor sensitivity [16].

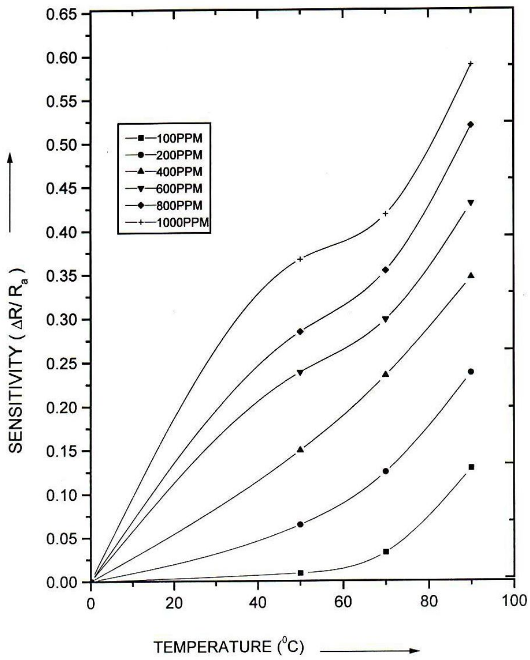


Fig.3. ($PEO+KNO_3$+Nano Al_2O_3) (70:30) based gas sensor sensitivity as a function of gas temperatures at different gas concentrations (ppm).

Sensitivity versus carbon monoxide gas concentration (ppm) plot at different temperatures was shown in Fig.4. From these plots it was observed that, carbon monoxide gas sensor sensitivity increase with increase of gas concentration (ppm) and with increase of temperature. It was turn out due to hopping mechanism among coordinating sites, local structural relaxations and segmental motions of polymer chain [6-8, 12-15 & 17]. The sensor sensitivity at different carbon monoxide gas concentrations (ppm) at 50^0C was tabulated in Table-1.

TABLE 1. ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes gas sensor sensitivity at different gas concentrations (ppm).

Composite Polymer Electrolyte Gas Sensor	Sensitivity at 50^0C				
	200 ppm	400 ppm	600 ppm	800 ppm	1000 ppm
($PEO+KNO_3$ +Nano Al_2O_3) (90:10)	0.090	0.169	0.263	0.301	0.327
($PEO+KNO_3$ +Nano Al_2O_3) (80:20)	0.117	0.218	0.273	0.371	0.366
($PEO+KNO_3$ +Nano Al_2O_3) (70:30)	0.164	0.258	0.342	0.388	0.412

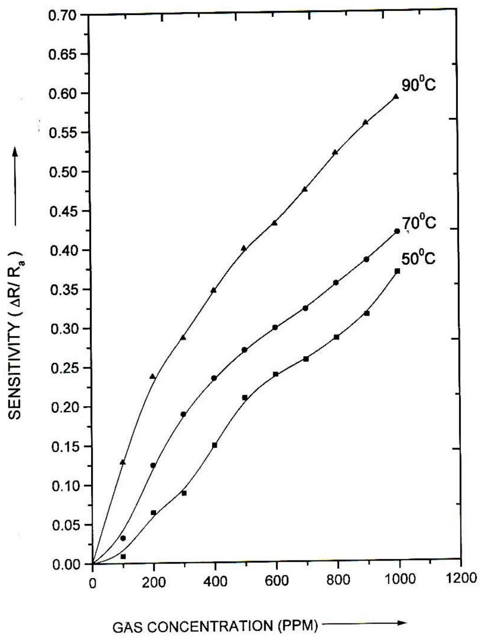


Fig.4. ($PEO+KNO_3$+Nano Al_2O_3) (70:30) based gas sensor sensitivity as a function of gas concentrations (ppm) at different temperatures.

IV. CONCLUSIONS

A gas sensor was fabricated by using ($PEO+KNO_3$+Nano Al_2O_3) composite polymer electrolytes. The sensitivity of the sensor was investigated in the present of carbon monoxide gas. As per the investigation it was found that, the sensor sensitivity increases with increase of composition (Wt%) and increase of temperature. It was also observed that, the sensitivity of the sensor increases with increase of carbon monoxide gas concentration (ppm).

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