POLYMER - INORGANIC NANOPARTICLE COMPOSITES FOR HUMIDITY SENSOR

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Introduction

PVA film can absorb and desorb water from the moisture when exposed to atmosphere. Cross linking of PVA with some organic electrolytes, like sodium salts of 4-styrene sulphonate (SS), makes it water insoluble, and helps retaining its humidity sensing capabilities [1]. At low humidity (RH), the resistance is very high and the film is not sensitive enough to respond. Therefore suitable electrolytes are added to increase the sensitivity. The polymer chains are cross-linked and thereby improve the stability [2]. Generally, the polymers with polar groups like polyethylene oxide (PEO), Polyvinyl pyrrolidone (PVP) have been used as dopant material with different ammonium salts and acids [3,4].In the present investigation the resistive type humidity sensor has been developed from the composite polymer film of PVA and PEG as a host polymer matrix, and TiO_2 nanoparticles and NaOH and NaCl as dopant salts. At room temperature conductivity of pure PVA is very low, but complexing it with PEG and dopants enhances its conductivity. Thus the composite films can be used for fabrication of sensor.

Experimental

Solutions of PVA, PEG with Alkalies and TiO_2 Nanoparticle were prepared. Ring electrodes of 1.5 cm dia were dipped in the solutions of the above, and subsequently heated at 60˚C in a oven for 30 minutes. Thickness of about 20µm was controlled by dipping time and drying time. To terminals of ring electrode was connected to an electrometer and measurements of resistance v/s humidity were taken (Fig 1)

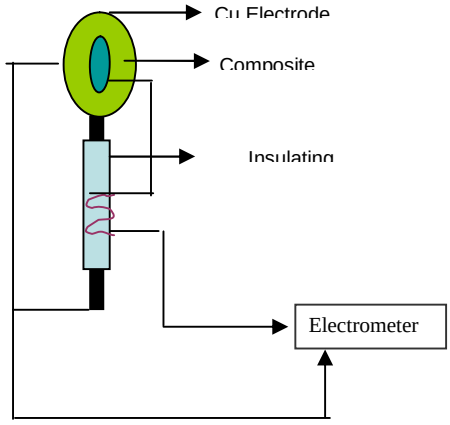

Fig 1 Working principle of ring type electrode

Observations and Results

Resistance v/s Relative humidity (RH) curve for the ring electrode with composite polymer (PVA+ PEG+NaOH+NaCl) at room temperature shows linearity for 40-60 RH range with a sudden drift at 40 RH (fig 2). As such, the linearity range could be utilized for the resistance type sensor . It is also noted that the sensitivity decreases at the lower end, i.e., 30-40 RH as compared to 40-60 RH range. Sensitivity goes down at higher values of RH, i.e., >75RH. 40-60 RH range is most appropriate for humidity measurements.

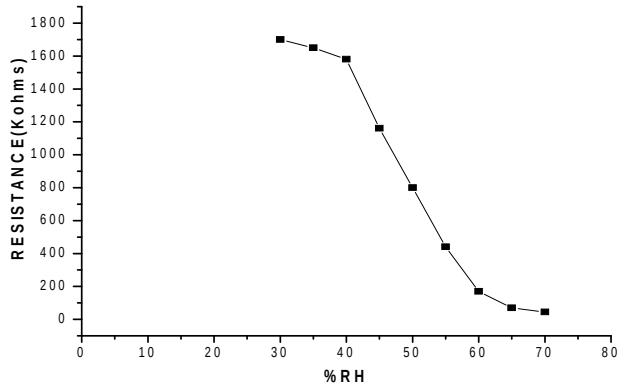

Fig.2 Resistance vs. RH for composite polymer (PVA +PEG+NaOH+NaCl)

It is observed that at room temperature, i.e., 35 ˚C, the curve shows better linearity as compared to 25˚C, 30˚C, 40˚C. (Fig. 3) It is also noted that résistance decreases with increase in temperature. However nature of the curves remains the same.

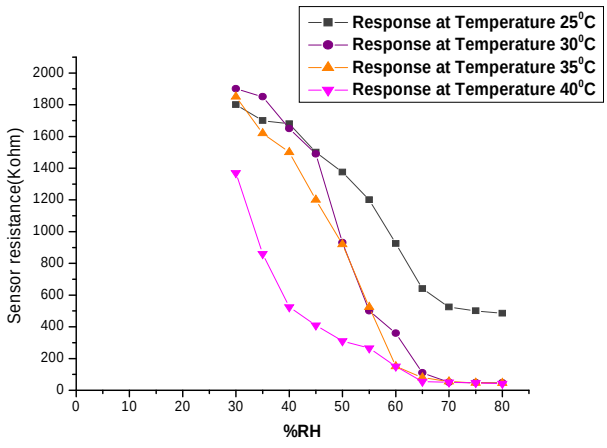

Fig.3 Resistance vs.RH at different temperatures

A single sample was studied for 1, 30, 45 & above 100 days. The result shows that nature of the curve is same with sensor response shift ± 3% over a period of 45 days , and it sustained even after 100 days (Fig 4). Aging of the film is moderately slow.

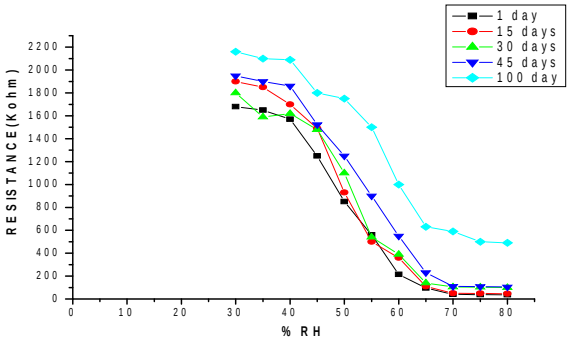

Fig 4 Resistance vs RH for different durations.

Resistance v/s RH of composit film PVA + PEG+ TiO_2 and alkalis is shown in Fig.5. The resistance of the film increased by 10 times. Linearity range expands from 30 RH to 65 RH, making it more suitable composite for wide range of humidity.

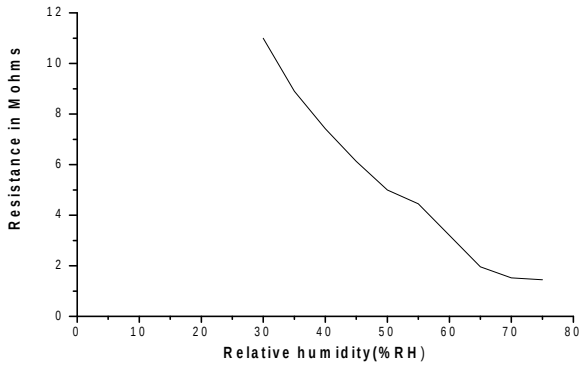

Fig 5 Resistance vs RH for composite polymer (PVA+PEG+ TiO_2+ Alkalies)

Ascending and descending order of Resistance v/s RH almost overlaps indicating repeatability of results.

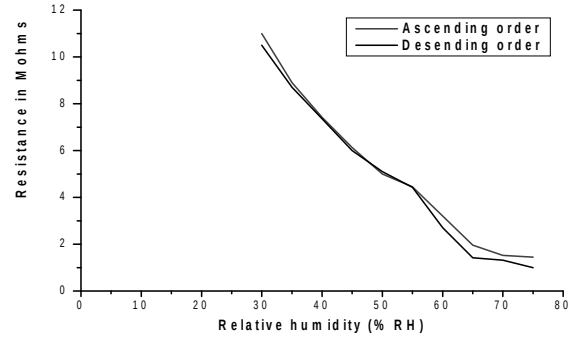

Fig.6 Resistance vs. RH for composite polymer (PVA +PEG+TiO_2+Alkalies) for ascending and descending order.

Discussions

PVA based resistive humidity sensor has been reported by many authors [5]. Due to hydrophilic nature, it adsorbs water molecules in humid atmosphere. PEG is more hydrophilic than PVA, and in presence of TiO_2 in the composite film enhances the affinity to absorb more water molecules, and consequently, increases the conductivity of composite film.

The observation of the absolute linearity of resistance v/s RH for humidity range 30-50 RH, indicates the proportional decrease of resistance with increase of humidity, and thereby suggesting the predominance increase of conductivity due to presence of TiO_2. At higher values of humidity, i.e beyond 65 RH, the resistance becomes stable indicating the condensation of water molecules leading to saturation. There is enormous increase in conductivity at higher humidity. This is the situation as explained by Grotthuss mechanism of protonic conduction, which might hold good here in the composite electrolyte at higher humidity.

The composite film developed in the present investigation works for more than 100 days with the consistent efficiency indicating its mechanical stability, and thus, can be used for humidity sensor for a longer time. It is, therefore concluded that the composite film of PVA, PEG, TiO_2 is well suited for the resistive type humidity sensor for humidity measurements in the range of 30-60 RH.

References

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