INTERCALATIVE NANO-COMPOSITES POLY (ETHYLENE OXIDE)/Cu FOR LPG SENSING APPLICATION

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The screening printing technique has been employed successfully for the fabrication of nano-composite Cu modified with PEO with different weight concentration for the intercalation of poly (ethylene oxide) (PEO) in Cu. In this work, at thick films of PEO/Cu are prepared and printed on alumina substrates. Than the gas sensing properties samples were tested for LPG by measuring the change in resistance at 1000 ppm LPG concentration at an operating temperature. A very high value of sensitivity (SF= 1400) is obtained for LPG gas at an optimum temperature of 47^{o}C for the concentration level of 0.7wt% PEO modified samples, while at low temperature and concentration level 0.2% PEO modified samples are better with low (SF= 700) at low operating temperature 36 ^{o}C. The gas sensing characteristics of these films are strongly influenced by concentration level of the additive. Thus correlating the additive and electrical film properties can lead to an enhancement of the material potential for gas sensing properties.

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Keywords: Nano-composite; LPG sensing, PEO/Cu thick film; Gas sensor

1. Introduction

LPG is the most essential combustible gas for domestic and industrial Application too [1-2]. In the modern age the uses of LPG is broadly expanded and enter in the urban, slums and all kinds of businesses, wherever the heating is required. It is potentially hazardous because of explosion accident might be caused when they leak out by mistake so the detection of LPG in domestic appliances must be identified now a days by investigating highly sensitive gas sensing material which has been discussed in this study.

Conductive polymers are among many novel materials used for the research and development of new sensor technologies [3]. In the current approach, polyethylene oxide was chosen for the development of a liquid petroleum gas (LPG) sensor. This gas sensor will be operating at room temperature, but may be placed in environments subject to a wide range of temperatures. Another specification for the liquid petroleum gas (LPG) sensor was for the detection of liquid petroleum gas (LPG) gas at very low concentrations, In order to facilitate this low level detection, the sensor material was modified with cooper required to have an increased surface area to more readily facilitate absorption of liquid petroleum gas (LPG) gas molecules. These important sensor characteristics were required aside from the obvious performance factors as a liquid petroleum gas (LPG) sensor. To determine the material parameters of the proposed nano-composite material, specific sensor analysis was performed.

In the present study the thick film of PEO/Cu were prepared by screen printing technique. These were than employed as sensor element with proper c-shaped electrode for monitoring LPG gas.

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2. Experimental

Standard commercially available Poly Ethylene Oxide (PEO) is mixed with fixed amount of Cu and Optimization by varying additive concentration. Different concentration of Poly Ethylene Oxide i.e. (0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and1.0 etc.) powder along with Cu mixed and dissolve in a methanol (HPLC) at room temperature and stir it well for an half hour so transparent homogeneous viscous Liquid paste is form which is used for the making of thick film by using screen printing technique. Sensing properties of the thick film was studied by recording the change in the resistance of the film when exposed to LPG and ambient. For the resistance measurement, the input circuit voltage was applied across half bridge of samples (R_s) and reference (R_f). The resistance of the samples was obtained by measuring the voltage across the R_f for LPG in ambient condition. The resistance variation were measured at various temperature and the sensitivity was calculated by $(R_g/R_a)*100$. Where R_a is the resistance of sensor in air and R_g is the resistance of sensor in gas**.**

3. Results and discussion

After carry out the several number additive concentration of the thick film using screen printing technique and subsequent electrical studies of the films, the following optimized condition is obtained (i) Optimization of operating temperature (ii) concentration of additive etc.

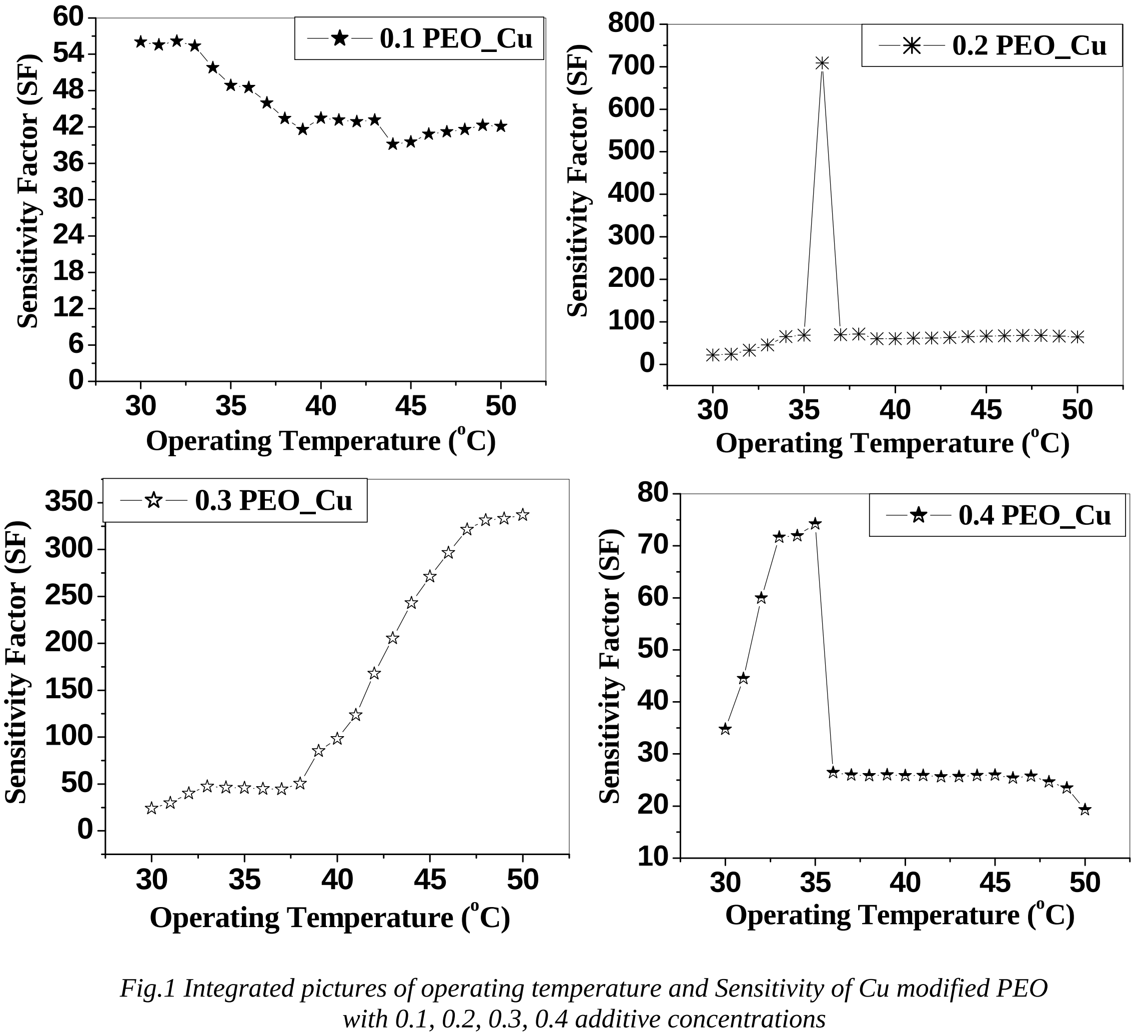

Fig.1 Integrated pictures of operating temperature and Sensitivity of Cu modified PEO with 0.1, 0.2, 0.3, 0.4 additive concentrations

In Fig.1 the graph of operating temperature versus sensitivity of Cu modified PEO with 0.1, 0.2, 0.3, 0.4 additive concentrations (exposed all at 1000 ppm gas concentration) show the increase in sensitivity with operating temperature successively. In case of 0.1 PEO modified sample show sensitivity factor around SF = 40-55 but from 30°C to 50°C uniformly, it is not showing any temperature selectivity to the particular temperature. In case of 0.2 PEO modified samples the sensitivity factor increases with operating temperature at around 36°C the sensitivity increase suddenly up to SF= 700 and above the temperature it decrease simultaneously up to 50°C. From graph it is reveals that the 36 ~ 37°C is an optimum operating temperature for LPG and selective for that particular temperature. In case of 0.3 and 0.4 concentration of PEO the sample shows sensitivity in both the cases but on temperature selectivity can be observed while the 0.4 % modified samples shows the temperature selectivity at around 35 °C but low sensitivity as compare to 0.3 % PEO modified samples (SF= 340) and also in compression with 0.1 and 0.2 % modified samples. From 0.1 to 0.4 % PEO modified samples only 0.2 % modified sample show temperature selectivity and highest sensitivity for LPG (1000 ppm concentration)

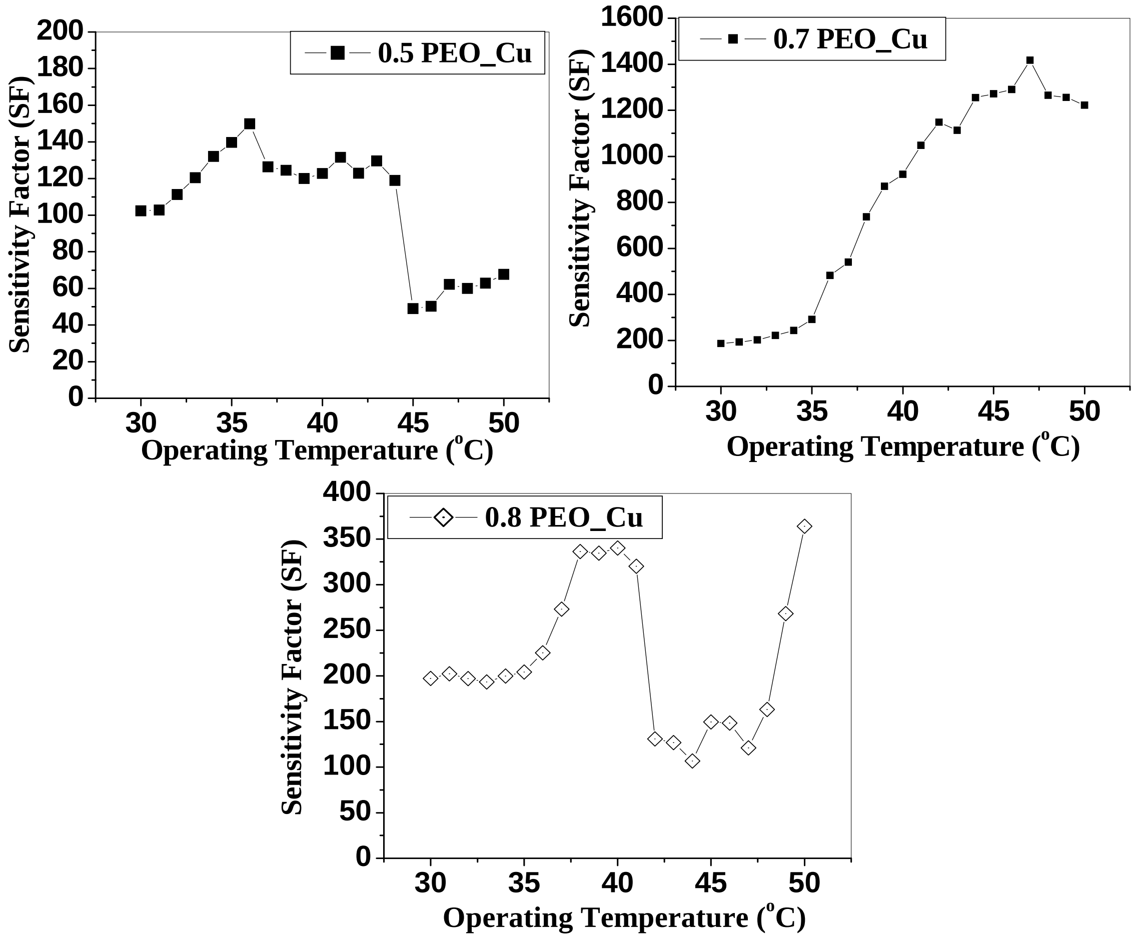

Fig.2 Integrated pictures of operating temperature and sensitivity of Cu modified PEO with 0.5, 0.6, 0.7, 0.8 additive concentrations

In Fig.4.1b the graph of operating temperature verse Sensitivity of Cu modified PEO with 0.5, 0.6, 0.7 and 0.8 additive concentrations (exposed all at 1000 ppm gas concentration) show the increase in sensitivity with operating temperature respectively. In case of 0.5 % PEO modified sample show sensitivity factor around SF = 150 but from 30°C to 45 °C uniformly, it is not showing any temperature selectivity to the particular temperature. In case of 0.6 % PEO modified samples the sensitivity factor increases with operating temperature at around 36 °C the sensitivity increase up to SF= 130 and above the temperature it decrease simultaneously up to 50°C. The graph reveals that the 36°C is an optimum operating temperature for LPG but it is less sensitive compare to 0.2 % modified PEO sample. In case of 0.7 and 0.8% concentration of PEO the sample shows sensitivity in both the cases but on temperature selectivity to 0.8% 35-40^{o}C. It is observed that at 0.7 % PEO modified samples shows the temperature selectivity at around 47 ^{o}C (SF= 1400) and to very high sensitivity as compare to 0.1 % -0.6 and 0.8% PEO modified samples.

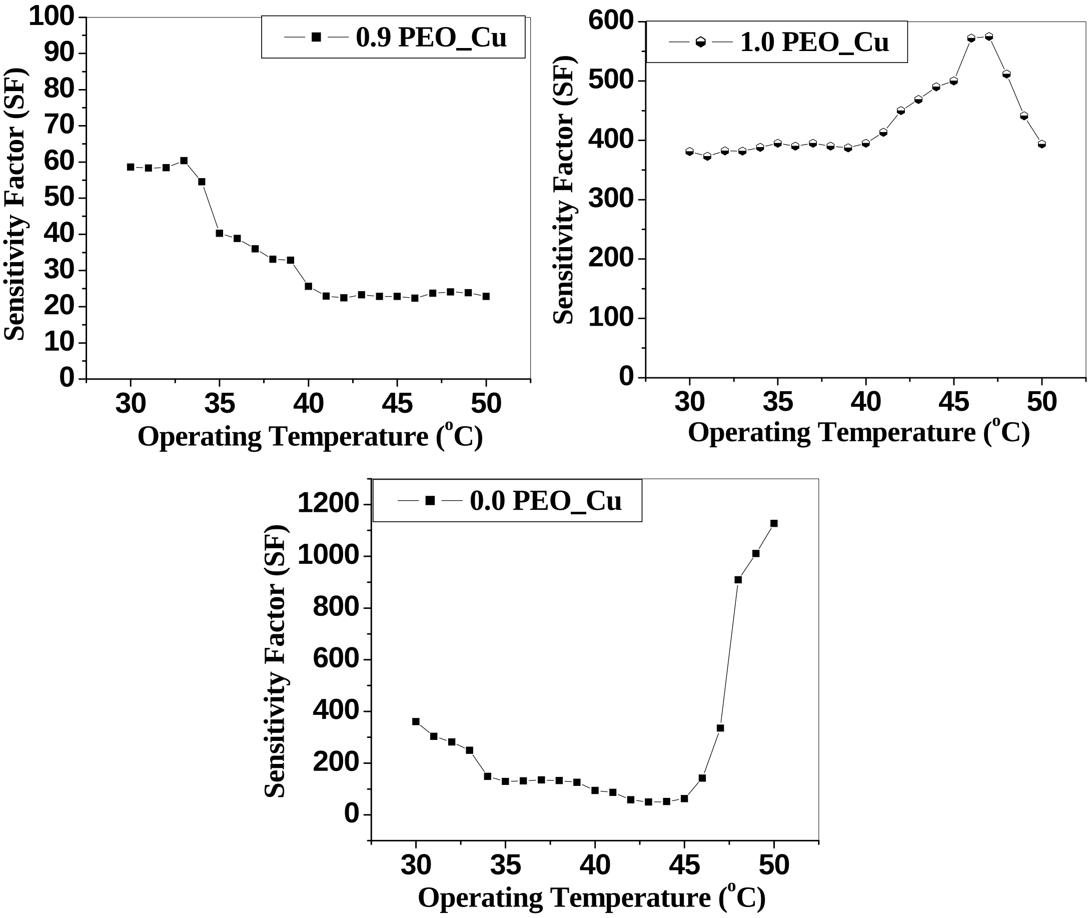

Fig.3 Integrated pictures of operating temperature and Sensitivity of Cu modified PEO with 0.9, 1.0, 0.0 additive concentrations

In Fig.3 the graph of operating temperature verse Sensitivity of Cu modified PEO with 0.0, 0.9 and 1.0 additive concentration, all the samples exposed at 1000 ppm gas concentration which shows the sensitivity with increase in operating temperature respectively. In case of 0.0 % PEO modified sample show sensitivity factor around SF = 50 to 150, it is not showing any temperature selectivity to the particular temperature. In case of 0.9 % PEO modified samples the sensitivity factor increases with operating temperature at around 33 ^{o}C the sensitivity increase up to SF= 30 and above the temperature it decrease simultaneously up to 50^{o}C. From graph it is reveals that the 33^{o}C is an optimum operating temperature for LPG but it is less sensitivity as compare to all other above modified PEO sample. In case of 1.0 % concentration of PEO the sample shows sensitivity (SF= 550) at an operating temperature at 46^{o}.

As described above, the physical properties of conducting polymers strongly depend on their doping levels. Fortunately, the doping levels of conducting polymers can be easily changed by chemical reactions with many Cu at room temperature, and this provides a simple technique to detect the Cu. Most of the conducting polymers are doped / undoped by redox reactions; therefore, their doping level can be altered by transferring electrons from or to the Cu [3-6]. Electron transferring can cause the changes in resistance and work function of the sensing material. The work function of a conducting polymer is defined as the minimal energy needed to remove an electron from bulk to vacuum energy level. This process occurred when PEO and exposed in LPG and other redox-active gases. Electron acceptors can remove electrons from the aromatic rings of than in conducting polymers. When this occurs at a p-type conducting polymer, the doping level as well as the electric conductance of the conducting polymer is enhanced. An opposite process will occur when detecting an electro-donating gas. However, this mechanism has not been understood clearly. Further studies are still needed to make the mechanism clear.

4. Conclusion

In this study, the sensing properties of PEO/Cu Thick films as an LPG gas sensor obtained by screen printing technique were investigated. From the results of experimentation, it is found and be concluded that 0.7% modified is the best candidate (optimized concentration) for LPG detection but at 47^{o}C with highest sensitivity factor (SF= 1400), while at low temperature and concentration level 0.2% PEO modified samples are better with low SF= 700 and at low operating temperature 36 ^{o}C.

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