CHARACTERIZATION OF COMPOSITE METAL OXIDE HUMIDITY SENSOR FOR OIL LUBRICATING SYSTEM-A REVIEW

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Abstract – Humidity measurement is most significant issues in different areas of applications such as instrumentation, automated systems, agriculture, climatology and GIS. Various sorts of humidity sensors fabricated and designed for industrial and laboratory applications. This review concentrates on the RH sensors based upon their organic and inorganic functional materials (e.g. metal oxide, porous ceramic and composite material), preparation of metal oxide and composite material will be discussed in this paper. The composite material SBSI, shows faster response than other types of composite and metal oxides.

Keywords: humidity sensor, relative humidity composite, characteristics, preparation.

I. INTRODUCTION

Humidity sensors have gained advanced applications in industrial processing and environmental control. For manufacturing, highly sophisticated integrated circuits in semiconductor industry, humidity levels are constantly monitored in wafer processing. There are many domestic applications, such as intelligent control of the living environment in buildings, cooking control for microwave ovens, and intelligent controller. In automobile industry, humidity sensors are used in rear window defoggers and motor assembly lines. In medical field, humidity sensors are used in respiratory equipment, sterilizers, pharmaceutical processing, and biological products. In agriculture, humidity sensors are used for green-house air-conditioning, plantation protection (dew prevention), soil moisture monitoring. In general industry, humidity sensors are used for humidity control in chemical gas purification, dryers, ovens, film desiccation, paper and textile production, and food processing. Humidity sensor plays an important role in every part of the Earth and automated industrial processes. To have a desirable surrounding atmosphere, it is essential to monitor, detect and control the ambient humidity under different weather ranging from low temperature to high temperature or in mixtures with other gases by precise and provident sensors. In this paper, our intention to present major review of research and development of humidity sensors for a wide mixture of applications. Because applications in each field require different operating conditions, different types of humidity sensors based on a mixture of sensing materials will be described. Then the relative humidity sensors based on composite material will be discussed.

II. COMPOSITE MATERIAL ANALYSIS FOR HUMIDITY SENSOR

A. Aluminum oxide

In this preparation, all chemicals are analytical-grade reagents without further purification. Polyethylene glycol (5 g) and Aluminum sulfate pentahydrate, (4 g) dissolved in 100 mL distilled water. Then add ammonia (25%) into the above solution, giving rise to milky precipitates at pH = 9. The reaction mixture was stirred for 1 hrs. at room temperature. Then the reaction mixture was carried out in a Parr-Teflon lined stainless steel vessel and it was closed for 48hr then heated at 130°C. Then the reaction mixture was gradually cooled to room temperature. using double distilled water the resulting precipitate was filtered and washed three to four times and to remove polyethylene glycol and other impurities using ethanol. The synthesized Al2O3 powder was dried at 100°C for 1 hrs. and was calcuated at 400°C for 2 hr. Sem image and response of aluminum oxide is shown in Fig (1,2).
The response is very high sensitivity and fast response.

![Fig.1, sem image of aluminum oxide](image1)

Fig.1, sem image of aluminum oxide (11)

![Fig.2, Relative humidity vs time](image2)

Fig.2, Relative humidity vs time (11)

![Fig.3, sem image of zinc oxide](image3)

Fig.3, sem image of zinc oxide (10)

![Fig.4, Relative humidity vs resistance](image4)

Fig.4, Relative humidity vs resistance (10)

**B. Zinc oxide**

Preparation of zinc oxide using precipitation method, ammonium bicarbonate (2.5 mol/l) and Zinc sulfate (1.5 mol/l) were prepared in distilled water and ZnSO4 solution 100ml was added to NH4HCO3 126ml solution while stirring and the reaction mixture was kept at 45°C. The slurry of basic zinc carbonate (BZC) in the form of a white precipitate was obtained and then filtered, washed and dried. By calcining the precipitate at 500°C for 1 hour finally zinc oxide nanoparticle was prepared. The relative humidity varies from 11% to 95%.

The sem image and response of zinc oxide shown in fig (3,4)(10)

**C. Silver oxide added bismuth iron**

By a process of co precipitation method the bismuth iron molybdate, (Bi3FeMo2O12, BFM–1) can be prepared. Bismuth iron molybdate (BFM–1) was placed for 3 hrs. in acetone for the homogeneous powder. Similarly, this BFM–1, 5 (BFM–2) and 10 (BFM–3) mol % of silver nitrate (AgNO3) was added and placed for 2 hr. using a hydraulic press at a pressure of 400MPa the samples were made in the form of cylindrical pellets of dimension 13mm diameter and 2–3mm thickness. Then pellets were sintered for 2h at 700°C in an ambient air atmosphere. BFM: Ag2O3 composites with molecular ratios of 100:0 (BFM–1), 95:5 (BFM–2) and 90:10 (BFM–3) were prepared. %of relative humidity varies from 5% to 98%.

The sem image of silver added bismuth and response is shown in the fig (5,6)(7)
C. Titanium oxide with ethanol cross

In this preparation TiO2 powder was mixed with distilled water for slurry preparation; and then 12 mg of the produced viscous slip is dropped into the junction of two d= 60 µm pure platinum wire segments. After drying, then the sample is sintered at 750°C for 30 min. Ten similar samples are prepared. Samples are cooling in air down to room temperature after they saturated with titanium alkoxide solution in ethanol. The saturated samples again dried at room temperature and subsequently annealed at 600°C which converts the injected sol to titanium dioxide. Relative humidity ranges from 2% to 98%. The sem image of titanium oxide with ethanol crossed and response is shown in fig (7,8)(9).

D. Tin oxide

In this process 0.1 M solution of tin(II) chloride is prepared in ice-cold distilled water to form SnOC12 solution. Tin hydroxide solution was prepared by adding of ammonium hydroxide solution and pH of the solution is maintained at 9 throughout the process. The hydrated stannic hydroxide gel is washed with double distilled water and ethanol to remove chlorine and NH4+ ions and the gel is transferred into round bottom flask, which is fitted with water condenser and the gel is stirred continuously for 5hr temperature at 90 °C. By simple oven the resulting product was filtered and dried at 120°C. Finally the powder was sintered at higher temperature.

Relative humidity varies from 35% to 95%.

Sem image of tin oxide and response is shown in the fig (9,10)(2).
E. Mg Fe$_2$O$_4$

In this preparation MgFe$_2$O$_4$ (sample AG1) and Mg$_{0.9}$Sn$_{0.1}$Fe$_2$O$_4$ (sample AG2) pure grade metal nitrate powder was required. To make a colloidal solution an aqueous solution of 10% polyvinyl alcohol is added. Then, small amounts of NH$_4$OH solution (25% conc) were added to adjust pH = 8. By co precipitation a sol of metal hydroxides and ammonium nitrate were formed. By mixing with a magnetic stirrer for 5 to 10 min, viscous gel was obtained. This is dried for 12 hrs at 120°C and then is ignited in a corner. A combustion wave spontaneously multiply through the dried gel and converts the hydroxides into metal oxides and the fusion between oxides starts to form spinel structure. Due to rapid heating and cooling by passage of a combustion wave from the point of lighting throughout the solid compact, a powder containing very fine crystallites were obtained.

Relative humidity varies from 11% to 98%. Sem image of the MgFe$_2$O$_4$ and response is shown in Fig (11,12).

F. Nickel oxide

In the sol-gel process nickel chloride was transferred to 250mL round bottom flask and dissolved in 70mL of absolute ethanol at room temperature, leading to clear green colored solution. In another beaker NaOH was dissolved in absolute ethanol and NaOH solution was added to the nickel chloride solution dropwise. The mixture was stirred at room temperature for 2Hrs. during this time, the reaction mixture was found to form a light-colored gel. After 2Hrs the gel was filtered, washed thoroughly with distilled water and then finally with ethanol. The mixture was air dried, we get a green colour powder. The green powder is heated at 290 degree Celsius.hence the powder was taken in a porcelain crucible and subjected to calcination at 290 degree Celsius for 30min we get a black colored nickel powder.

Relative humidity varies from 5% to 98%.

Sem image and response of nickel oxide is shown in fig (13,14).
**G. SbSI Single Nanowire**

Humidity Nano sensors were constructed from single SbSI nanowires so no chemically prepared and welded ultrasonically to Au interdigitated microelectrodes (with $l = 1 \mu m$ spacing), according to the technology described. Electric measurements were performed in nitrogen at pressure $p = 4 \times 10^4$ Pa and in vacuum ($p = 10^{-2}$ Pa) produced by turbo molecular drag pumping station. Humidities were maintained by supplying nitrogen gas to the test chamber over water in special container. In order to control temperature, Pt-100 sensor was placed near to the investigated sample. The temperature measurements were done using 211 temperature monitor.

Relative humidity varies from 3% to 98%.

Response of sbsi fig (15),(6)

**H. copper oxide–Si-adhesive nanocomposite**

The copper oxide Nano sheets were synthesized according to the procedure. In a typical reaction process, 0.1 mol aqueous solution of CuCl2 titrated with NH4OH solution until the pH of the solution turn out to be above 10. The ensuing solution was further stirred at 12 h for 801degree Celsius. After terminating the reaction, black precipitate was obtained. Cleaned and washed with a mixture of distilled water and ethanol, constantly and dried at room-temperature. The dried product was then calcined at 400 1C for 5 hr. Relative humidity varies from 45% to 95%.

Sem image of copper oxide -si adhesive nanocomposite and response shown in fig (16,17),(8)

**I. graphene oxide:**

Graphene oxide were prepared by a modified hummers method. graphite powder was mixed with dilute h2o2and concentrated h2so4 while stirring. after 8hrs mixture was added with deionized water. after mixing vacuum drying is done then the mixture is added with deionized water and added with dilute h2o2 and washed carefully and dried with vacuum.

Then the solid graphene oxide is dispersed in deionized water and hydrazine hydrate was added. after 3 days at room temperature a black graphene powder is obtained.

Relative humidity varies from 5% to 98%. (1)

Sem image and response of graphene oxide is shown in fig (18,19),(1)

**J. Li iron**

Li iron were made by liquid-phase deposition of thin on a porous alumina substrate provided with gold interdigitated contacts evaporated under high vacuum. To deposition the ceramic substrate was cleaned by a standard procedure comprising washing with CH2Cl2, acetone and
ethanol. The deposition occurs as following: a single drop (20 ml) of an aqueous solution of Fe(NO3)3 (0.01 M) is transferred on the ceramic substrate by micro pipetting. Doped with different Li content, ranging from 2.5 to 20% in moles, were prepared by adding the suitable amount of LiNO3 to aqueous Fe(NO3)3 solution before deposition. The sample was then mounted on the holder of the deposition apparatus and maintained in a 5% NH3/He atmosphere at 258C up to and toxic solvents. Recently, we have reported the preparation of metal oxide by a liquid-phase method of deposition method (LPD) using aqueous solutions [8±10]. Doped-iron oxide prepared by this method were found to have good characteristics as humidity sensors. Moreover, it was also noted that the use of a reactive atmosphere (5% NH3 in He) during the deposition enhances the humidity sensing properties. This likely occur through the deposition of iron (oxy hydroxy) species amorphous and with high surface area. These were found more sensitive to humidity than ones deposited at lower pH in the absence of NH3 . The thickness of the deposited ranged between 0.3 and 1 mm and was controlled either by changing the concentration of the precursor solution or by making successive depositions. Thus, we obtain Li-iron. Relative humidity varies from 5% to 90% Sem image and response of Li iron is shown in fig (20,21)(14)

III. CONCLUSION

Review of some of the selected papers for onitoring humidity sensing properties shows that easurement was successfully done by various metal oxides. On reviewing many paper, it is suggested that preparation of zinc oxide is easy and excellent. On reviewing many paper aluminum oxide, graphene oxide, sbsi, have fast response. Reviewing many paper sbsi, silver added bismuth iron molybdate and MgSnFeO have high sensitivity. Finally, conclude sbsi is the best among the materials.

IV REFERENCES


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