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Study of polyanilinesilver nanocomposite as humidity sensor

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Study of polyaniline-silver nanocomposite as humidity sensor J. Bhadra, A. Popelka, N. J. Al-Thani, A. Abdulkareem Center for Advanced Materials, Qatar University, Qatar Abstract In this piece of work focus on fabrication of resistive type humidity sensor using polyaniline-silver nanocomposite (PPVA-Ag). Four different nanocomposites using four concentrations of silver (0.5,1.0, 1.5 and 2.0 M) and polyaniline (PANI) dispersed in polyvinyl alcohol matrix (PVA). PANI, and PVA concentrations are kept constant. Thin PPVA-Ag film on interdigited gold electrode fingers gives excellent sensitivity towards humidity at room temperature. Key words: Nanocomposites, surface analysis and humidity sensor, 1. Introduction Since last few decades the information of nanoscience and nanotechnology has been explored extensively to obtain functionalized nanomaterials. One such category of nanomaterial is the polymer- metal nanocomposite, with enhanced mechanical, elastic, optical, electrical and dielectric properties [1]. Polymer nanocomposites are materials with nanosized one dimensional inorganic filler particles (around 10–100 ˚A), dispersed in an organic polymer matrix. An important parameter which has significant importance in many industries such as food, agricultural, clinical equipment and electronics is humidity, it is considered to be one of the most frequently measured physical parameters [2-3]. With the advancement in moisture sensitive technologies, research to achieve high efficient, low cost, reliable and miniature size of material sensitive to humidity change has gained acceleration. As among metal nanoparticles, Ag has high electrical and thermal conductivities, so the composite of Ag dispersed in PANI-PVA matrix gives rise to a functional materials, with improved antimicrobial activity and sensitivity towards humidity. This paper we focus on surface analysis of the thin film obtained using scanning electron microscopy and study on the humidity sensitivity. 2. Methods 2.1 Synthesis of Ag nanoparticles Four different concentrations of silver nitrate

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(AgNO3) is dispersed in aqueous PVA solution under constant stirring and heating at 60°C followed by photo reduction using UV-lamp having wavelength 390 nm for 24 hours. After exposing the above solutions with UV light for 24 hours, finally, yellowish-red colloid of Ag nanoparticles with average diameters of 30 nm and 70 nm uniformly dispersed in PVA are obtained. 2.2. Synthesis of PANI-Ag nanocomposite and pure PANI: The PANI-Ag nanocomposite blend is synthesized by in-situ chemical polymerization (Figure-1) of aniline monomer in the colloid solution obtained from section 2.1. During this process, aniline-DBSA is added to the Ag-PVA colloidal solution, followed by addition of the aqueous APS solution dropwise. The resulting blend mixture is left to react for 24 h under constant stirring at 5–10 °C. The colloidal solution obtained are used to prepare thin film on glass slide and interdigitated gold electrode washed with DI water and acetone and dried. Keeping the other concentrations and methods constant four different PPVA-Ag nanocomposites are prepared with 0.5, 1.0,1.5 and 2.0 M of AgNO3 Figure 1: Steps followed to prepare PANI-Ag nanocomposites 2.3. Study of Effect of humidity on the PPVA-Ag nanocomposites A homemade setup is used to study of effect of humidity on the PPVA-Ag nanocomposites coated on the interdigited gold electrode fingers using dropcast method. The humidity chamber consists of transparent polymer with three holes for nitrogen gas inlet, humidity inlet and electrical wires for conductivity measurement. The schematic diagram of the setup is shown in the Figure 2. Humidity meter and the polymer coated electrodes are placed inside the chamber. The control of humidity inside the chamber has been done using humidifier and N2 gas during the experiment. And keithley sourcemeter 2400 has been used to measure the resistivity. Figure 2: Schematic diagram of humidity measurement setup 3.1 Scanning Electron Microscopy studies The results of surface morphology analysis using SEM are shown in Figure 3. From the images it is seen that Ag nanoparticles are well dispersed in PANI-PVA matrix. Such results are observed because chemical method of preparation has been adopted. With the increase of Ag concentration there are not much changes in the particle size, however the degree of agglomeration increase, that causes the increase in surface roughness Figure 3: SEM images of (a) PPVA-Ag-0.5, (b) PPVA-Ag-1.0, (c) PPVA-Ag-1.5 and (d) PPVA-Ag-2.0. 3.2 Effect of Humidity We have used all the four types of composites for this measurement. For this measure at first the humidity chamber is blown with N2 gas for few minutes to reduce the humidity to RH 20 % at room temperature. Once the reading in the humidity meter is stable, resistance of the thin film has been measured. Each time for resistance measurement voltage reading for 10 mA current has been repeated for 10 times with time sweep of 500 ms. In order to reduce the error we repeated the whole measurement for 15 times at each RH measured, shown in Figure 4 for PPVA-Ag 1.0M sample. During the experimental process each step is maintained at constant parameters till the electrical signals reading reached a steady value. All the four plots describing resistance change as a function of humidity for each composite measured has been shown in inset of Figure 4. It is has been observed that, there is not much difference between the resistance curves as a function humidity for all the four composites. As the humidity increases water vapour contributes to the reducing the conductivity in two ways, firstly water molecules donate electrons to the valence band of PANI molecules, therefore decreasing the number of holes and increasing the bandgap and secondly as PVA is hydrophilic, so it absorbs water molecules and get expanded, this leads to increase the interparticular distances between the conducting fillers of the composites, and reducing the conductivity. Because of these two reasons higher the RH level lower the electrical conductivity. Figure 4: The effect of Relative humidity on the resistance of PPVA-Ag-1.0M, Inset The effect of Relative humidity on the resistance of four PPVA-Ag samples. 4.

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