



## Dielectric Constant study of Polyaniline / Dysprosium Oxide (PANI / Dy<sub>2</sub>O<sub>3</sub>) Composites

### KEYWORDS

Polyaniline, Dysprosium oxide, Dielectric constant

Sangshetty Kalyane

Department of Physics, Bheemanna khandre Institute of Technology Bhalki 585 328, Karnataka, India

**ABSTRACT** The conducting polyaniline / Dysprosium oxide (PANI / Dy<sub>2</sub>O<sub>3</sub>) composites were synthesized by single step in situ polymerization technique by placing fine grinded powder of Dy<sub>2</sub>O<sub>3</sub> during the polymerization of aniline. The formation of mixed phases of the polymer together with the conducting emeraldine salt phase was confirmed by spectroscopic techniques like XRD, FTIR & SEM images indicated a systematic morphological variation of particles aggregated in the composite matrix as compared to the PANI. Dielectric constant of these composites were investigated in the frequency range 50 Hz to 5MHz. It is found that Dielectric constant obeyed the power law index and the variation of Dielectric constant with wt% of Dy<sub>2</sub>O<sub>3</sub> could be related to conductivity relaxation phenomenon.

### 1. Introduction

Polymer composites represent a new class of conventionally filled polymer materials which increases strength, heat resistance and decreased flammability [1]. These Polymer Composites materials are formed by dispersion of inorganic particles in an organic polymer matrix to dramatically improve the performance properties of the polymer [2-3]. Metal oxides dispersed polymer composites have attracted a great deal of interest from researchers, because they frequently exhibit unexpected hybrid properties synergistically derived from both components [4-5]. Similarly, conducting polymer composites have attracted considerable interest in recent years because of their numerous applications in variety of electrical and electronic devices. Composites of conducting polymer with suitable compositions with inorganic materials led to desirable properties [6-7]. Conducting polymer composites materials are especially important owing to their bridging role between the world of conducting polymers and that of nano materials. For application of conducting polymers knowing how these conducting polymers composite will affect the behavior in an electric field is a long-standing problem and great importance. The discovery of doping in conducting polymer has led to further dramatic increase in the conductivity of such conjugated polymers.

Combining conducting polymers with metal oxide particles, one could produce polymer composites, the properties of which can be tuned depending upon the composition of metal oxide in the polymer matrix [8]. Polyaniline composites have been widely studied in view of their unique electrical, optical and optoelectrical properties in addition to their ease of preparation and excellent environmental stability.

Conducting Polyaniline and its composites with metal oxides has recently been the subject for the researchers with great interest [9]. The insulating emeraldine base form of PANI consists of equal number of reduced and oxidized repeat units. The conducting emeraldine salt form is achieved by doping with aqueous protonic acids. This leads to an increase in conductivity by more than 10 orders of magnitude depending on the strength of the acids [10-11].

### 2. Experimental

All Chemicals used are analytical grade (AR) and were procured, used as received. The monomer aniline was doubly distilled prior to use. Synthesis of Polyaniline / Dysprosium oxide (Dy<sub>2</sub>O<sub>3</sub>) composites has been carried out by single step in situ polymerization technique. 0.1 mol of aniline was dissolved in 1 M of Hydrochloric acid to form aniline hydrochloride. Fine grinded powder of Dysprosium oxide (Dy<sub>2</sub>O<sub>3</sub>) is added in the weight percent of 10, 20, 30, 40 and 50 to

the above solution with vigorous stirring to keep Dysprosium oxide (Dy<sub>2</sub>O<sub>3</sub>) suspended in the solution. To this reaction mixture, 0.1 M of oxidizing agent ammonium persulphate [(NH<sub>4</sub>)<sub>2</sub>S<sub>2</sub>O<sub>8</sub>] in 1 M of Hydrochloric acid was added slowly with continuous stirring for 4-8 hr at 0-5<sup>o</sup> C to polymerize. The precipitated powder was recovered, vacuum filtered and washed with deionised water. Finally, the resultant precipitate was dried in an oven for 24 hr to achieve constant weight. In this way, five different PANI / Dy<sub>2</sub>O<sub>3</sub> composites with different weight of Dy<sub>2</sub>O<sub>3</sub> (10, 20, 30, 40 and 50) in PANI have been synthesized [12-13]. The pellets of 10 mm diameter are formed with thickness varying up to 2 mm by applying pressure of 10 Tons in a UTM – 40 (40 Ton Universal testing machine). For conductivity measurement, In this experiment, five different samples of each composite varying in their weight percentage are investigated for their frequency dependent Dielectric constant.

### 3. Results and discussions

Figure 1. shows the X – Ray diffraction pattern of Polyaniline - Dy<sub>2</sub>O<sub>3</sub> composite (50 wt % Dy<sub>2</sub>O<sub>3</sub> in PANI). By comparing the XRD pattern of composite with that of Dy<sub>2</sub>O<sub>3</sub> (JCPDS No. 22-0612) the prominent peaks corresponds to 2θ = 29.59<sup>o</sup> i.e. first peak no change, 31.09<sup>o</sup> shifted to 34.12<sup>o</sup>, 48.55<sup>o</sup> and 58.64<sup>o</sup> are due to (211), (222), (422) and (433) planes of Dy<sub>2</sub>O<sub>3</sub> respectively. By comparing the XRD patterns of the composite and Dy<sub>2</sub>O<sub>3</sub>, it is confirmed that Dy<sub>2</sub>O<sub>3</sub> has retained its structure even though dispersed in PANI during polymerization reaction. The semi sharp peak of PANI at 27<sup>o</sup> has widened this is due to doping Dy<sub>2</sub>O<sub>3</sub> in PANI

Figure 2. Shows the SEM of polyaniline – Dy<sub>2</sub>O<sub>3</sub> composite (50 wt % of Dy<sub>2</sub>O<sub>3</sub> in polyaniline). Among the five composites that were synthesized using Dy<sub>2</sub>O<sub>3</sub> with different wt % (10, 20, 30, 40 and 50), a composite of polyaniline – Dy<sub>2</sub>O<sub>3</sub> with 50 wt % of Dy<sub>2</sub>O<sub>3</sub> in polyaniline is selected to obtain the SEM micrograph.

From SEM micrograph it clearly indicates highly branched chain structure (or fibrillar morphology). The presence of Dy<sub>2</sub>O<sub>3</sub> has a strong influence on various electrical parameters. The contrast in the image is due to the difference in scattering from different surface areas as a result of geometrical differences between polyaniline and Dy<sub>2</sub>O<sub>3</sub>.

The IR spectra of polyaniline – Dy<sub>2</sub>O<sub>3</sub> composite (50 wt % of Dy<sub>2</sub>O<sub>3</sub> in PANI) is shown in Fig 3. The characteristic stretching frequencies are observed at 3450 cm<sup>-1</sup>, 2919 cm<sup>-1</sup>, 2845 cm<sup>-1</sup>, 1739 cm<sup>-1</sup>, 1647 cm<sup>-1</sup>, 1573 cm<sup>-1</sup>, 1486 cm<sup>-1</sup>, 1387 cm<sup>-1</sup>, 1295 cm<sup>-1</sup>, 1245 cm<sup>-1</sup>, 1165 cm<sup>-1</sup>, 1140 cm<sup>-1</sup>, 1116 cm<sup>-1</sup>, 1011 cm<sup>-1</sup>, 887 cm<sup>-1</sup>, 819 cm<sup>-1</sup>, 707 cm<sup>-1</sup>, 618 cm<sup>-1</sup>, 598cm<sup>-1</sup>

and 504  $\text{cm}^{-1}$ . By comparing the IR spectra of polyaniline and polyaniline –  $\text{Dy}_2\text{O}_3$  composite, it is observed that in the composite the characteristic stretching frequencies are shifted toward higher frequency side which may be attributed due to the Vander walls kind of interaction between  $\text{Dy}_2\text{O}_3$  and polyaniline chain .

Figure 4. shows the variation of  $\epsilon'$  as a function of frequency for polyaniline –  $\text{Dy}_2\text{O}_3$  composites (different wt %). In all the cases studied here, it is observed that, the dielectric constant is quite high at low frequency and decreases with increase in applied frequency. The observed behavior may be due to Debye like relaxation mechanism taking place in all these materials.

Figure 5. represents the variation of  $\epsilon'$  as a function of wt% of  $\text{Dy}_2\text{O}_3$  at room temperature and at three different frequencies. It is observed that the values of dielectric constant decreases up to 20wt% and then increases up to 40 wt % and again it decreases as wt % of  $\text{Dy}_2\text{O}_3$  increases in Polyaniline.. All these results go in accordance with the conductivity behavior. The observed change in conductivity is mainly responsible for the anomaly in dielectric constant behavior.

#### 4. Conclusion

Polyaniline composites with different weight percentages of  $\text{Dy}_2\text{O}_3$  in PANI were synthesized by chemical oxidative polymerization of monomer aniline. Detailed characterizations of the composites were carried out using XRD, SEM and IR techniques. The result of XRD and SEM reveals the semi crystalline nature of the PANI /  $\text{Dy}_2\text{O}_3$  composites. The results of Dielectric constant show a strong dependence on the weight percent of  $\text{Dy}_2\text{O}_3$  in polyaniline.

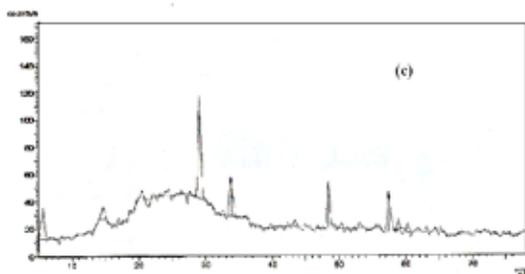


Figure.1 X – Ray diffraction pattern of PANI/  $\text{Dy}_2\text{O}_3$  (50 wt%)

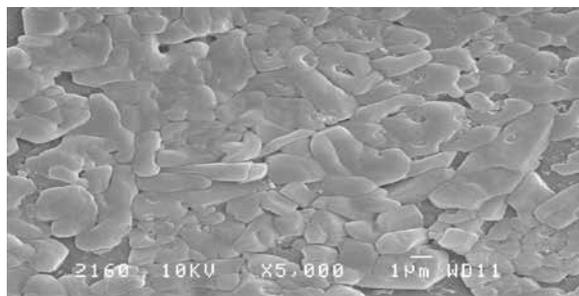


Figure 2 SEM Micrograph of Polyaniline -  $\text{Dy}_2\text{O}_3$  (50 wt %)

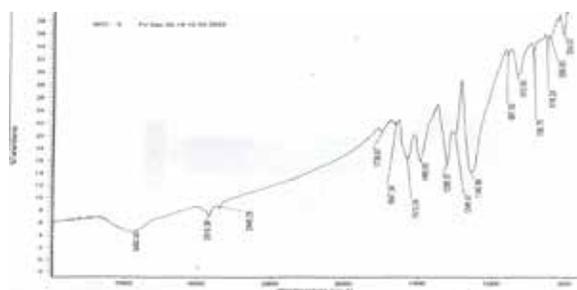


Figure 3 FTIR spectra of PANI / $\text{Dy}_2\text{O}_3$  composite (50 wt %)

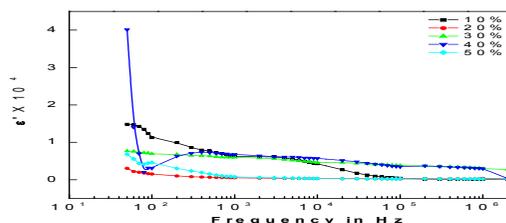


Figure 4.Variation of  $\epsilon'$  as a function of frequency for Polyaniline-  $\text{Dy}_2\text{O}_3$

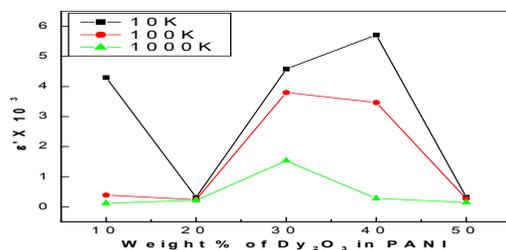


Figure 5. Variation of  $\epsilon'$  as a function of weight % of  $\text{Dy}_2\text{O}_3$  in PANI

#### REFERENCE

1. Arunkumar Lagashetty and Venkataraman A , Resonance, 10(7), 2005 | 2. N.N.Mallikarjuna, A Venkataraman and T.M.Aminabhavi, J.Appl. Poly.Sci.94(2004)2551. | 3. M.V Murgendraappa, M V N Ambika Prasad, Mater.Res.Bull.41(2006)1364. | 4. Maity, A., Biswas, M. J Appl Polym Sci 2004, 94, 803 | 5. Alenxander, M., Dunois, P. Mater Sci Eng 2000, 28,1 | 6. S.C Raghavendra , S Khasim, M Revansiddappa, M.V.N Ambika Prasad, A B Kulkarni, Bull. Mater.Sci.26(7)(2003)733. | 7. H V Vijayanand, L Arunkumar, P M Gurubasavaraj, P M Veerasha Sharma, S Basavaraja, A Saleem, A Venkataraman, Anil Ghanwat and N N Maldar, J Appl. Poly Sci. (In Pres) | 8. Govindraj B, Shastry N V, Venkataraman, A, J.Appl. Poly. Sc.92(2004)1527. | 9. N N Mallikarjuna, S K Manohar, P V Kulkarni, A Venkatarman & T M Aminabhavi, J Appl Poly Sci.,97(2005)1868. | 10. Chiang J C.; MacDiarmid, A. G. Synth Met 1986, 13,193. | 11. Narashima Parvatikar, M V N Ambika Prasad, J.Appl. Poly.Sci100 (2006)1403. | 12. Weon-Pil Tai, Jun-Gyu Kim, Jae-Hee Oh, Young-Sung Kim Sens and Actuators B (2004) | 13. M V Murugendrappa, Syed Khasim and MVN Ambika Prasad. Bull. Mater. Sci. , Vol. 28, No 6, (October 2005),565-69