Research Journal of Chemical Sciences ____ ISSN 2231-606X
Vol. **3(2),** 16-19, February **(2013)** *Res. J. Chem. Sci.*

Dielectric Study of Polyaniline in Frequency Range 100Hz to 500 KHz at Temperature 20^0C and 30^0C

Saxena Dinesh[1], Dwivedi Vivek[2] and Mishra Pankaj Kumar[2]
[1]Department of Physics, D.B.S. College, Kanpur, INDIA
[2]Department of Physics, B.N.D. College Kanpur, INDIA

Available online at: www.isca.in
Received 16th October 2012, revised 23rd October 2012, accepted 23rd November 2012

Abstract

The dielectric behaviour of polyaniline has been investigated in the frequency range 100Hz to 500KHz and at temperature 20^0C and 30^0C respectively. The parameters capacity, permittivity, dielectric loss and dissipation factor have been calculated. The frequency and temperature dependence of these parameters have been qualitatively explained on the basis of hopping of electrons.

Keywords: Polyaniline, dielectric constant and dielectric loss.

Introduction

Conducting Polymers have emerged as a very important class of materials because of their unique electrical, optical and chemical properties leading to the wide range of technological applications[1-3]. This class of materials provides tremendous scope for tuning of their electrical conductivity from semi conducting to metallic regime by way of doping[4-5].

The unique properties of conducting polymers not only provide great scope of their applications but also have led to the development of new models to explain their observed properties; particularly various mechanisms of charge transport[6-8]. Among different conducting polymers, conducting polyanilines are the most extensively studied materials due to the ease of synthesis, better environmental and thermal stabilities and greater scope of playing with chemistry to tailor their properties[9-10].

The common feature of almost all the electro active polymers such as polypyrole polythiophene, polyaniline etc is an extended localization in their polymer backbone.

Polypyrrole (PPY) family of polymers is one of the best candidate materials for various device applications such as in solar cells electromagnetic shielding electrodes for rechargeable batteries, sensors etc. Hence it is worthwhile to examine the mechanism of change transport in this family of polymers[11-12].

Among the various conducting polymers synthesized, polyaniline occupies a prime position, because of its unique characteristics like inexpensiveness of monomer, ease of processing and excellent stability. It is widely investigated in both thin film and bulk forms, because its electronic and photonic properties are interesting Polyaniline in its pure and doped forms find extensive applications in making devices like polymer light emitting diodes photovoltaic, sensors, batteries and super capacitors. The low dielectric thin films based on a.c. plasma polymerized polyaniline may find applications in the microelectronics industry in the from of inter layer dielectrics[13-14].

Preparation of composites of conducting polymer (PANI) has been considered to provide a suitable solution to the possibility problem. These composites have the ability to enhance their material properties with desirable mechanical and physical characteristics.

A review of literature suggests that not much more attention has been paid in the dielectric study of pure polyamiline (PANI) in recent years instead of doping to enhance the conductivity. We report here its dielectric constant, dissipation factor, dielectric loss as a function of frequency and temperature.

Material and Methods

Experiment: This chemical PANI is used for dielectric measurements was obtained in the form of disc by compressing in a die under a load 3-4 tons. The diameter of the pallet was 1 cm and thickness was 0.51 mm. The sample holder was made up of brass coated with nickel and had two parts. The sample was placed between the jaws of two electrodes via a spring arrangement. The temperature was measured with the help of a calibrated copper constantan thermocouple. For dielectric measurement, thin pallet mounted in between the two electrodes of the sample holder, where a vacuum near about 10^{-2} torr was maintained.

The model No. 4255 WAYNE KER LCR capacitance measuring assembly has been used to measure the capacitance. The instrument was used in the parallel capacitance mode where parallel conductance would be measured directly. The loads were of co-axial wire to avoid stray capacitance effect. Lead capacitance was subtracted from the measured capacitance before calculating the dielectric constant.

For the present study of dielectric behavior pallet was coated with silver paint to ensure good electrical contact between the sample and the electrodes of the sample holder.

Results and Discussion

The dielectric parameters were evaluated by measuring equivalent parallel capacitance C_p and dissipation factor tan δ (D) or the equivalent resistance R_p of the sample by using the equation.

$$\in' = \frac{C_p}{C_o}, \in'' = \frac{\in'}{\omega C_p R_p} \text{ or } \in'' = \in' D$$

Where $C_o = 0.08854 \times A/t$, P_f. is the geometrical capacitance of vacuum of the same dimensions as the sample. A and t are the area and thickness of the sample respectively and f the measuring frequency. C_p is the capacitance measured in P_f, $\in'$ the real dielectric constant and $\in''$ the imaginary dielectric constant. The dielectric constant has been measured for pallet thickness 0.51 mm. while keeping the area and the other preparation conditions same and it was found to be independent of thickness of sample within the accuracy of measurement. So the observed dielectric data at higher temperature cannot be due to the electrode barriers or macroscopic in homogeneities[15-16].

The frequency dependence study of PANI in range 100Hz to 500 KHz at room temperature 20^0C is given in the table 1, and in other range of frequency 300Hz- 5 KHz at 30^0C is shown in table 2. Similarly temperature dependence nature of PANI in the range 15^0C to 67^0C at fixed frequency 500Hz is shown in the table 3.

We observed from the table 1 that the dielectric constant and dielectric loss both decrease with increase in frequency, but it is also evident that both increase in low frequency range. It is evident that the dielectric constant at a given frequency is a slowly varying function of temperature in low temperature region and the dependence increases with increasing temperature. The values of $\in'$, $\in''$ and tan δ at frequencies lover than 1KHz increase with decreasing frequency and increasing temperature, may be attributable to free charge build up at the interface between the sample and the electrode (space charge polarization).

The magnitude of $\in'$ decreases with increasing frequencies which is a typical characteristic of disordered conducting polymer and consistent with the earlier studies[17-18].

At very low frequencies we have $\in' \approx \in_s$ (value of the dielectric constant at quasi-static field). As the frequency increases (with $\omega < 1/\tau$), dipoles begin to lag behind the field and $\in'$ slightly decreases when frequency reaches the characteristic frequency ($\omega = 1/\tau$) the dielectric constant drops (relaxation process). At very high frequencies ($\omega >> 1/\tau$), dipoles no longer follow the field and $\in' \approx \in_\infty$.

Even at lower frequencies and higher temperatures, there is a substantial increase in the dielectric constant that is attributable to a dipolar contribution to $\in'$ (ω) from the hopping of electrons[19-20].

Conclusion

It is observed that the dielectric loss tangent in case of polyaniline decreases as a function of frequency. The sample (polyaniline) used exhibits small value of dielectric loss at higher frequency. Therefore, sample of polyaniline has been used in the present study,

The results clearly suggest that there is an increased coupling among the dipolar motion (Short range order localized motion).

Table-1
Temperature 20^0C

Frequency (Hz)	Cap (Pf.)	C_o (Pf.)		
		$\in'$	$\in''$	Dssi
100	39.61	290.45	272.790	0.9392
200	20.620	151.20	27.61	0.18264
500	18.434	135.17	17.290	0.12792
1KHz	17.247	126.46	15.03	0.11886
2 KHz	16.4185	120.39	15.995	0.13286
5 KHz	15.0726	110.52	15.508	0.14032
10 KHz	14.0722	103.18	13.803	0.13378
20 KHz	13.2090	96.85	11.126	0.11488
50 KHz	12.3980	90.91	7.550	0.08305
100 KHz	11.974	87.80	5.083	0.0579
200 KHz	11.840	86.81	3.715	0.0428
500 KHz	11.685	85.68	2.613	0.0305

Table-2
Temperature 30^{0}C, Pallet Thickness = 0.51mm

Frequency (Hz)	**Cap (Pf.)**	**C_o (Pf.)**		
		∈′	∈″	**Dssi.**
300Hz	17.585	128.946	18.655	0.14468
500 Hz	18.522	135.817	33.918	0.24974
1 KHz	16.752	122.838	30.463	0.24800
1.5 KHz	16.0880	117.969	21.968	0.18622
2.0 KHz	15.5525	114.042	19.419	0.17028
2.5 KHz	15.1610	111.171	18.732	0.16850
3.0 KHz	14.9292	109.472	18.203	0.16628
4.0 KHz	14.5194	106.467	17.162	0.16120
5.0 KHz	14.1988	104.116	16.516	0.15864

Table-3
Fixed Frequency 500Hz, Pallet Thickness = 0.51 mm

Temperature (^{0}C)	**Cap (Pf.)**	**C_o (Pf.)**		
		∈′	∈″	**Dssi. (tanδ)**
67	23.556	172.686	93.506	0.54148
64	20.880	153.107	74.832	0.48876
61	20.092	147.329	65.903	0.44732
59	21.386	156.818	50.162	0.31988
56	18.450	135.289	53.109	0.39256
54	19.156	140.466	58.068	0.41340
51	18.038	132.268	47.018	0.35548
49	19.608	143.780	61.377	0.42688
46	18.038	132.268	52.782	0.39906
43	18.048	132.341	47.320	0.35756
41	18.750	137.489	52.144	0.37926
38	17.756	130.200	37.523	0.28820
36	16.048	117.675	23.949	0.20352
33	16.064	117.793	22.376	0.18996
31	16.754	122.852	38.750	0.31542
28	17.932	131.490	16.809	0.12784
26	14.636	107.322	29.919	0.27878
15	15.154	111.120	12.265	0.11038

References

1. Deshpande N.G., Gudage Y.G., Sharma R., Vyas J.C., Kim J.B. and Lee Y.P., *Journals of Sansers and Actuators*, **B138**, 76-84 (**2009**)
2. Li-Ming Huanga, Cheng-Hou chena and Ten-chin wen, *Electrochimica Acta*, **51 (26)**, 5858-5863 (**2006**)
3. Harsha S., Kolla sumedh P., Surmade Alan G., Mac Diarmide and Sajeev K. Manohar, Absolute molecular weight of polyaniline, *J. Am. Chem. Soc*., **127(48)**, 16770-16771 (**2005**)
4. Tran H.D., LiD. and Karner R.B., One dimensional conducting polymer nanostructures; bulk synthesis and applications Adv Mater, **21,** 1487-99 **(2009)**
5. Hamedi M., Forchheimer R. and Inganos O., Towards woven logic from organic electronic fibres, *Nat Mater*, **6** 357-62 **(2007)**
6. Javadpour S., Gharavi A., Fiezpour A., Khanehzar A. and Panahi F., *Journals of Sensors and Actuators*, **B142**, 152-158 **(2009)**
7. Jumali M.H.H., Izzuddin I., Ramli N., Salleh M.M. and Yahaya M., *Journal of solid state Science and Technology*, **17**, 126-131 **(2009)**
8. Freebody N.A., Vaughan A.S. and Levin P.L., *Journal of Phys. Conference Series*, **183(012016)**, 1-5 **(2009)**
9. Praeger M., Saleh E., Vaughan A., Stewart W.J., Loh W.H., *Applied Physics Letters*, **100(6),** 063114 **(2012)**
10. Hosier I.L., Vaughan S., Swingler and Steve G., *Journal of Materials Science*, **45(10),** 2747-2759 **(2010)**
11. Wasserscheid P. and Waton T., *Ionic liquids in Synthesis*, Wiley-VCH, Weinheim Germany (**2008)**

12. Moller S., Perlov C., Jakson W., Taussig C. and Forest S.R., A Polymer/ Semiconductor write-once read-many-times memory, *Nature*, **426**, 166-169 **(2003)**

13. Joseph Mathai C., Saravanan S., Anatharaman M.R., Venkitachalam S. and Jayalekshmi S., *J. Phys., D. Appl. Phys.***,** **35**, 240 **(2002)**

14. Freebody N.A., Vaughan A.S. and Macdonald A.M., *Anal. Bioanal. Chem.*, **396(8),** 2813-2823 **(2010)**

15. Gemeay Ali H., A. Ikhlas Mansour Rohab G.EI Sharkawy, Ahmed B. Zaki, *European polymer Journal*, **41(11)**, 2575-2583 **(2005)**

16. Bile D., Mahanti S.D., Qarez E., Hsu K.F., Pcionek R. and Kanatzidis M.G., *Phys. Rev. Lett.*, **93**, 146403 **(2004)**

17. Heremans J.P., Trush C.M. and Morelli D.T., *Phys. Rev. B*, **70(225)**, 334 **(2004)**

18. Lau K.Y., Vaughan, Alun, Chen., George and Hosier, Ian, *Journal of Physics: Conference Series*, **310**, 012008 (**2011)**

19. Basavaraja C., Pierson R., Do Sung Huh, *Applied Polymer Sci.***,** **275,** 82 **(2008)**

20. Hosier I.L., Cozzarini L., Vanghan A.S. and Swingler S.G., *Journal of Physics: Conference series*, **183**, 1-5 **(2009)**