Semiconducting properties of Terpolymer derived from p-Hydroxybenzaldehyde, Adipic acid and Ethylene Glycol

Amit N. Gupta
Department of Applied Chemistry
J.D. College of Engineering & Management
Nagpur, India
Email: angupta2020@gmail.com

N. T. Khaty
Rashtrasant Tukadoji Maharaj Nagpur University,
Nagpur, India

Vinay V. Hiwase
Department of Chemistry
Arts, Commerce and Science College, Arvi
Wardha, India

Ashok B. Kalambe
Department of Chemistry
Institute of Science, R. T. Road,
Nagpur, India

Abstract - Terolymer HBAE-II was synthesized by polycondensation using monomers p-hydroxybenzaldehyde (2M), adipic acid (1M) and ethylene glycol (4M) in the presence of polyphosphoric acid as catalyst at 120°C. The resin was found to show semiconducting behavior in the temperature range 302-443 K. The activation energy by conduction was found to be 0.3561kJ mol^{-1}.

Index Terms – *semiconductor, terpolymer, electrical conductivity,; polycondensation.*

*****

I. Introduction

Polymer offers versatility and novelty hence they inhabit the main roll in semiconductor. Application of semiconducting polymer have been found for day to day product, such as antistatic coatings and corrosion protection, in biosensors for coupling of electron transfer, fabrication of electrochemical windows and gas sensors, development of individual electronic devices. Various researchers have been studied the various applications of terpolymer resins [1-12]. Electrical conductivity of p-nitrophenol based resins found in order of 6.91×10^{-11} to 1.96×10^{-11} mho cm^{-1} at wide range of temperature (313–423 K) and activation energy were 109.73 to 156.82 KJ, studied by Chinchamalatpure et al [13]. Kapse et al studied the electrical conductivity of resin derived from p-hydroxyacetophenone-resorcinol-glycerol and found to be the conductivities in order of 2.5912×10^{-6} to 6.4955×10^{-6} mho cm^{-1} at room temperature and activation energy was 11.56 kJ mol^{-1}[14]. In the present work, p-hydroxybenzaldehyde–adipic acid-ethylene glycol terpolymer resin was synthesized in the presence of polyphosphoric acid as catalyst by polycondensation method. The electrical properties of HBAE-II were investigated over a wide range of temperature.

II. Experimental section

A terpolymer resin abbreviated as HBAE-II was prepared by polycondensation of monomers p-hydroxybenzaldehyde (2M), adipic acid (1M) and ethylene glycol (4M) in presence of polyphosphoric acid as a catalyst in oil bath at 120 ± 2°C temperature for 5 hrs. The reddish brown solid crude product was separated, washed, filtered dried and squeezed with ether so as to remove impurity. 81 % yield was found.

III. Result and discussion

Electrical conductivity

The DC conductivities of HBAE-II resin was study of temperature range 302-443 K. The value of specific conductance was determined from specific resistance. The powdered sample of HBAE-II was palatalized by hydraulic press at a pressure of 17 lb inch^{-2}. The surface of the pallet was made to conduct by applying graphite paste. The solid state conductivity as a function of temperature was recorded by two probe method [15]. The electrical conductivity varies exponentially with the absolute temperature according to the well know relationship as given in equation (1).

$$\sigma = \sigma^o \exp.^{(-Ea/kT)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\log \sigma = (-Ea/2.303kT) + \log \sigma^o \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,
σ = Electrical conductivity at temperature T,
σ^o = Electrical conductivity at temperature T→ $\sigma \infty$,
Ea = Activation energy of electrical conductance,
K = Boltzmann constant,

T = Absolute temperature.

The plot of log σ versus 1/T was found to be linear in the temperature range under study, as shown in figure 1 which indicate that the Wilson's exponential equation (2) was satisfied. This indicates the semiconducting nature of the HBAE-II terpolymeric resin in the temperature range under study. The activation energy by conduction was found that 0.3561 kJ mol^{-1}. The electrical conductivity for HBUE-I resin was found in the range of 0.1261×10^{-6} to 0.1402×10^{-6} Scm^{-1} for temperature range 302-443 K.

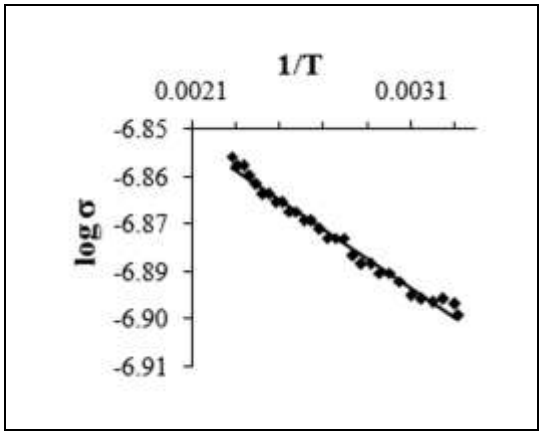

Figure 1 Wilson's plot of HBAE-II terpolymer

IV. Conclusion

It has been found that the terpolymer HBAE-II shows the semiconducting behavior, due to the presence of the linear nature of plot of log σ versus 1/T in mentioned temperature range, the Wilson's exponential law is obeyed. It has been concluded that the terpolymer HBAE-II shows, the semiconducting behavior. The nature of plot further suggests the hopping mechanism of conduction is due to the loosely bound π electrons at the no saturation centers in the polymeric matrix.

Acknowledgment

The Authors are thankful to the Director and Head of the Department of chemistry, Institute of Science, Nagpur for providing laboratory facilities.

References

[1] M.L Keshtov., A.R. Khokhlov, S.A. Kuklin, F.C. Chen, A.Y. Nikolaev, E.N. Koukarascd and G.D. Sharma, 2016, "Synthesis of alternating D–A1–D–A2 terpolymers comprising two electron-deficient moieties, quinoxaline and benzothiadiazole units for photovoltaic applications," Polym. Chem., 7, pp. 4025-4035, DOI: 10.1039/C6PY00652C.

[2] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, "Semiconducting behavior and thermo kinetic study of terpolymeric resin-i derived from p-hydroxybenzaldehyde, thiourea and ethylene glycol," J. Chem. Pharm. Res. 4(5), pp. 2475-2482, 2012.

[3] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, "Semiconducting behavior and thermokinetic study of terpolymeric resin-I derived from p-hydroxybenzaldehyde, adipic acid and ethylene glycol," Der Pharma Chemica. 4(3), pp. 1153-1159, 2012.

[4] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, "Chelation Ion-Exchange Properties of terpolymer resin-I derived from p-hydroxybenzaldehyde, terephthalic acid and ethylene glycol," Arch. Appl. Sci. Res., 5(2), pp. 89-97, 2013.

[5] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, "Thermal degradation and kinetic study of terpolymer resin-I derived from p-hydroxybenzaldehyde, succinic acid and ethylene glycol," Der Pharmacia Lettre, 5(2), pp.105-112, 2013.

[6] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, "Synthesis, characterization and ion-exchange properties of terpolymer resin-II derived from p-hydroxybenzaldehyde, thiourea and ethylene glycol," Chem. Sci. Trans. 3(1), pp.19-28, 2014, DOI:10.7598/cst2014.576

[7] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, N.T. Khaty, "Structural and thermal study of terpolymer resin-II derived from p-hydroxybenzaldehyde, succinic acid and ethylene glycol," Der Chemica Sinica, 5(2), pp. 23-30, 2014.

[8] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, S.K. Kapse, N.T. Khaty, "Synthesis and structural study of the terpolymer derived from p-hydroxybenzaldehyde, terephthalic acid and ethylene glycol," International Journal of researches in Biosciences, Agriculture & Technology, 2014, 2(1), pp. 1244-1256, 2014.

[9] A.N. Gupta, V.V. Hiwase, A.B. Kalambe, N.T. Khaty, "Structural and thermokinetic parameters of terpolymer resin derived from p-hydroxybenzaldehyde, urea and ethylene glycol," J. Sci. & Tech. Res., 6(2), pp. 1-10, 2014.

[10] A.N. Gupta, "Ion-exchange properties of terpolymer resin-II derived from p-hydroxybenzaldehyde, urea and

ethylene glycol," Der pharmacia Sinica, 6(11), pp. 14-18, 2015.

[11] A.N. Gupta, "Thermokinetic parameters of terpolymer resin-II derived from p-hydroxybenzaldehyde, urea and ethylene glycol," Advances in Applied Science Research, 6(11), pp. 29-36, 2015

[12] A.N. Gupta, "Synthesis and Electrical conductance behavior of terpolymer resin-II derived from p-Hydroxybenzaldehyde, Urea and Ethylene glycol," Perspectives in Sciences, 8, pp. 207-209, 2016.

[13] V.R. Chinchamalatpure, P.P. Kalbende, "Study of electrical conductivity of copolymer resins based on p-nitrophenol," IJPRET; Volume 4 (9), pp. 187-192, 2016.

[14] S.K. Kapse, V.V. Hiwase, A.B. Kalambe, A.N. Gupta, "Synthesis, semiconducting behavior and thermal study of terpolymeric resin derived from p-hydroxyacetophenone, resorcinol and glycerol," Arch. Appl. Sci. Res. 5(6), pp. 88-95, 2013.

[15] A.D. Kushwaha, V.V. Hiwase, A.B. Kalambe, S.K. Kapse, "Semiconducting behavior and Thermal study of Terpolymeric Resin Derived from p-nitrophenol, resorcinol and formaldehyde," Arch. Appl. Sci. Res. 4(3), pp. 1502-1510, 2012.