Received: 12-08-2014
Accepted: 10-09-2014

ISSN: 2321-4902
Volume 2 Issue 3

Online Available at www.chemijournal.com

International Journal of Chemical Studies

Electrical properties of modified polyvinyl alcohol conjugates and doped modified polyvinyl alcohol conjugates

G.H. Murhekar [1*] and A.R. Raut [2]

1. Department of Chemistry, Dr. R. G. Rathod Arts and Science College, Murtizapur, Dist. - Akola -444107, (M. S.), India.
2. Department of Chemistry, Government Vidarbha Institute of Science and Humanities, Amravati, 444604, (M.S.), India.

Corresponding Author: G.H. Murhekar; Department of Chemistry, Dr. R. G. Rathod Arts and Science College, Murtizapur, Dist.-Akola -444107, (M. S.), India

The electrical properties modified polyvinyl alcohol conjugates and doped modified polyvinyl alcohol samples were studied. The electrical conductivity of all the MPVA and DMPVA show a tendency to increase by increasing the temperature upto 403 K and obeys log σ vs. 1/T relation indicating their semiconducting behavior. The variation in the electrical conductivity and activation energy of electrical conduction with the metal ions in DMPVA may be explained on the basis of influence of the incorporation of different metal ions in the MPVAs, which increases the ionization tendency.

Keyword: Electrical properties, Temperature, MPVA, Activation energy and DMPVA

1. Introduction

Polymers have received much experimental attention, due to their unique properties, such as low density, ability to form intricate shapes, versatile electric properties and low manufacturing cost [1]. Significant efforts on international research as a result of a search for high quality conducting polymer have carried out by the several workers. But comparatively little work is available on the studies of electrical conductivity of conducting polymer to modified conducting polymer. Some of the relevant literature concerning with our work is presented as below. The electric and dielectric properties of ultrasound-assisted synthesized CdS nanocrystals-PVA mixture were studied in temperature range of 298 K to 498 K and frequency range from 200 Hz to 1 MHz [2]. Among used polymers, polyvinyl alcohol (PVA) is an important polymer having a high dielectric strength (>1000 kV/mm), good charge storage capacity and dopant dependent electrical and optical properties [3]. The electrical properties of pure and doped films of poly vinly alcohol (PVA) with aluminium and gold electrodes are studied. Al-PVA-Al, Au-PVA-Au and Al-PVA-Au structures are investigated. The current-Voltage characteristics can be explained in terms of the charge transport mechanism operating in the PVA polymer film in the different voltage regions. The width of Schottky barrier is shown to increase with voltage, and decreases with increasing temperature. The temperature dependence of the dc conductivity of the samples has been described by Greaves variable rang hopping (VRH) model [4]. Polyvinyl alcohol (PVA)–polyethylene glycol (PEG) based solid polymer blend electrolytes with magnesium nitrate have been prepared by the solution cast technique. Impedance spectroscopic technique has been used, to characterize these polymer electrolytes. Complex impedance analysis was used to calculate bulk resistance of the polymer electrolytes. The a.c.-impedance data reveal that the ionic conductivity of PVA–PEG–$Mg(NO_3)_2$ system is changed with the concentration of magnesium nitrate, maximum conductivity of $9{\cdot}63 \times 10^{-5}$ S/cm at room temperature was observed for the system of PVA–PEG–$Mg(NO_3)_2$ (35–35–30). However, ionic conductivity of the above system increased with the increase of temperature, and the highest conductivity of $1{\cdot}71 \times 10^{-3}$ S/cm was observed at 100 ^{0}C [5]. The electrical properties of PVA-$CuCl_2{\cdot}2H_2O$ composites were studied. The effects of $CuCl_2.2H_2O$ content and temperature on the D.C electrical conductivity have been investigated. Results showed that the D.C electrical conductivity increased with increasing the $CuCl_2.2H_2O$ concentrations and temperature. Also the activation energy change with increasing of additional $CuCl_2.2H_2O$ [6]. Development and electrical characterization of sisal powder filled polyvinyl alcohol (PVA) composites is reported. Dielectric measurements were conducted on these composites on a LCR meter in the temperature range from 30 to 150 °C and in the frequency range 1 kHz - 10 kHz. The effects of temperature and frequency variation on dielectric constant (ε'), dielectric dissipation factor (tan δ) and on a. c. conductivity (σ a.c.) were determined. On increasing the filler content, dielectric constant increased, it was mainly due to motion of the dipolar groups of the interfacial polarization occurring in the composites. The conductivity increased with rise in temperature [7]. PVA-based polymer electrolytes were prepared with various concentrations of $CdCl_2$ using solvent casting method. AC conductivity in these polymer increases films first and then decreases. These observations are in agreement with XRD results. The highest ionic conductivity of $1.68E-08$ Scm−1 was observed in 4% of $CdCl_2$ in PVA polymer blend. Crystallite ellipsoids for different concentrations of $CdCl_2$ are computed here using whole pattern powder fitting (WPPF) indicating that crystallite area decreases with increase in the ionic conductivity [8]. Poly vinyl alcohol (PVA) / TiO_2 composites were prepared by sol gel method. The electrical conductivity of composites has been investigated at different temperatures at frequency ranging from 50 Hz to 5 MHz. The electrical conductivities of the composites were found to increase with increase in TiO_2 concentration and with increasing temperature [9] Literature Survey reveals that the demands improvement of different properties of various form of MPVA materials. In the present research work, synthesis and characterization of modified PVA polymer have been focus due to their wide range of applications in various fields of human interest. In this chapter the electrical properties MPVA and DMPVA were studied. It was observed that there is remarkable change in electrical properties.

1.1 Experimental
The electrical resistivity of the polymer matrix can be measured with either a.c. or d.c. method. In the present study, the d.c. method was used for resistivity measurements of the MPVA and DMPVA, over a wide range of temperature i.e. 303 K ≤ T ≤ 403 K. Voltage drop method was used for measurement of the resistance of pellet using a Systronic microvoltmeter as a function of temperature in the range 1V to 100 V.

2. Result and Discussion
The d. c. electrical resistivity was determined as a function of temperature in the range 303 K ≤ T ≤ 403 K. The results of electrical conductivity and activation energy are incorporated in Table 1 to 3. The temperature dependence of the electrical conductivity of MPVA and DMPVA are shown in Fig. 1 to 3

- **Electrical conductivity of MPVA polymer conjugates**

The electrical conductivity and activation energy of PVA and MPVA are cited in Table 1 and the temperature dependence of log σ of these complexes is shown in Fig 1. It is observed that,

1. The plots of log σ *vs.* $10^3/T$ are found to be linear in the studied temperature range 303-403 K [10-11].

2. Electrical conductivity of the complexes lies in the range of 1.55×10^{-7} to 5.69×10^{-7} $\Omega^{-1}cm^{-1}$.

3. The electrical conductivity of these complexes follows the order,

PVA< CMPVA < HEPVA < CAPVA < ACPVA

4. The activation energy of electrical conduction of the complexes has been found to increase in the order,

PVA < CAPVA < HEPVA < ACPVA < CMPVA

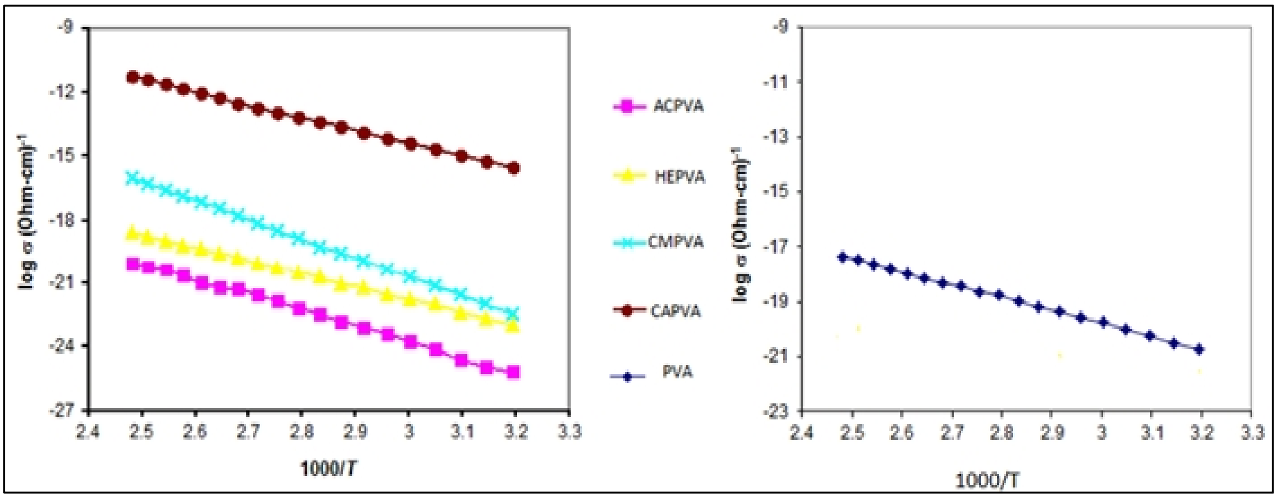

Fig 1: Plot of log σ *vs.* 1000/*T* for PVA AND MPVA

Table 1: Electrical Conductivity at 373 K and Activation Energy of the PVA AND MPVA

S. No.	Samples	σ ($\Omega^{-1}cm^{-1}$)	Ea (eV)
1	PVA	1.55×10^{-7}	0.408
2	CMPVA	1.84×10^{-7}	0.778
3	HEPVA	2.49×10^{-7}	0.537
4	CAPVA	3.61×10^{-7}	0.520
5	ACPVA	5.69×10^{-7}	0.632

❖ Electrical conductivity of DOPED HEPVA Matrix

The electrical conductivity and activation energy of doped HEPVA are cited in Table 2 and the temperature dependence of log σ of these complexes is shown in Fig 2. It is observed that,

1. The plots of log σ *vs.* 10^3/T are found to be linear in the studied temperature range 303-403 K [10-11].

2. Electrical conductivity of the complexes lies in the range of 1.55×10^{-7} to 5.95×10^{-7} $\Omega^{-1}cm^{-1}$.

3. The electrical conductivity of these complexes follows the order,

PVA< HEPVA-Sm(III) < HEPVA-Nd(III) < HEPVA-Pr(III) < HEPVA-La(III)

4. The activation energy of electrical conduction of the complexes has been found to increase in the order,

PVA < HEPVA-La(III) < HEPVA-Pr(III) < HEPVA-Nd(III) < HEPVA-Sm(III)

Table 2: Electrical Conductivity at 373 K and Activation Energy of the PVA AND Doped HEPVA

S. No.	Samples	σ ($\Omega^{-1}cm^{-1}$)	Ea (eV)
1	PVA	1.55×10^{-7}	0.408
2	HEPVA-La(III)	5.95×10^{-7}	0.576
3	HEPVA-Pr(III)	5.19×10^{-7}	0.597
4	HEPVA-Nd(III)	4.13×10^{-7}	0.679
5	HEPVA-Sm(III)	3.65×10^{-7}	0.849

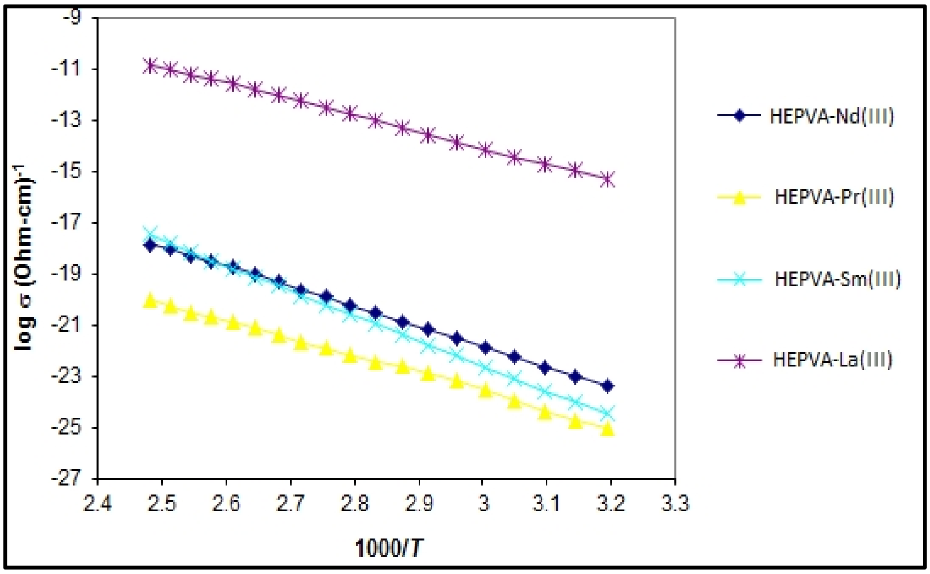

Fig 2: Plot of log σ *vs.* 1000/*T* for Doped HEPVA

❖ **Electrical conductivity of DOPED CMPVA Matrix :**

The electrical conductivity and activation energy of doped CMPVA are cited in Table 3 and the temperature dependence of log σ of these complexes is shown in Fig 3. It is observed that,

1. The plots of log σ *vs.* 10^3/T are found to be linear in the studied temperature range 303-403 K [10-11].

2. Electrical conductivity of the complexes lies in the range of 1.55 x 10^{-7} to 6.45 x $10^{-7}\Omega^{-1}cm^{-1}$.

3. The electrical conductivity of these complexes follows the order,

PVA< CMPVA-Nd(III) < CMPVA-Sm(III) < CMPVA-Pr(III) < CMPVA-La(III).

4. The activation energy of electrical conduction of the complexes has been found to increase in the order,

PVA < CMPVA-La(III) < CMPVA-Nd(III) < CMPVA-Pr(III) < CMPVA-Sm(III)

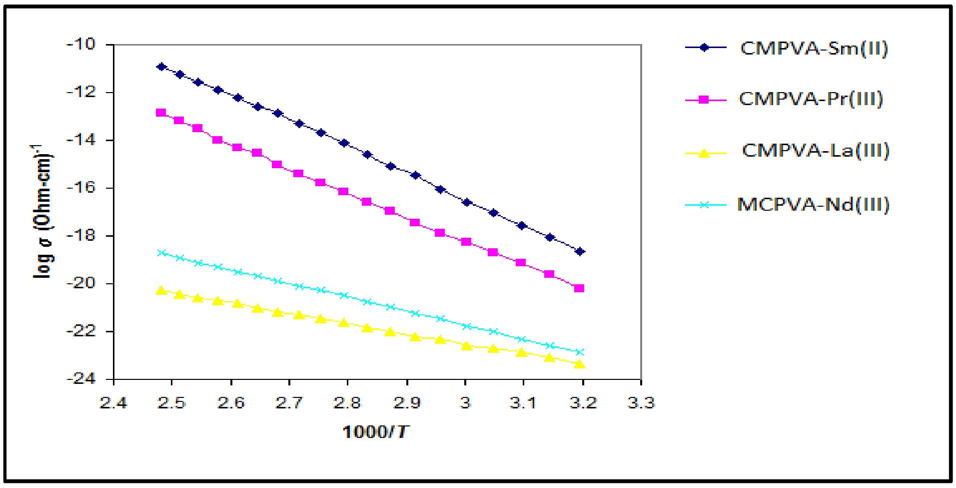

Fig 3: Plot of log σ *vs.* 1000/*T* for Doped CMPVA

Table 3: Electrical Conductivity at 373 K and Activation Energy of the Doped CMPVA

S. No.	Samples	σ ($\Omega^{-1}cm^{-1}$)	Ea (eV)
1	PVA	1.55 x 10^{-7}	0.408
2	CMPVA-La(III)	6.45 x 10^{-7}	0.410
3	CMPVA -Pr(III)	3.10 x 10^{-7}	0.882
4	CMPVA -Nd(III)	2.35 x 10^{-7}	0.507
5	CMPVA -Sm(III)	2.60 x 10^{-7}	0.941

3. Conclusion

From the results of electrical conductivity of all the polymer matrixes under investigation, the following conclusions can be drawn. The electrical conductivity of all the MPVA and DMPVA show a tendency to increase by increasing the temperature upto 403 K and obeys log σ *vs.* 1/*T* relation indicating their semiconducting behavior [12-14]. The electrical conductivity of these complexes lies in between 1.55 x 10^{-7} and 6.45 x 10^{-7} $\Omega^{-1}cm^{-1}$ at 373 K whereas the activation energy of electrical conduction lies in the range 0.408 - 0.941 eV. The variation in the electrical conductivity and activation energy of electrical conduction with the metal ions in DMPVA may be explained on the basis of influence of the incorporation of different metal ions in the MPVAs, which increases the ionization tendency [15]. Activation energy is a direct measure of the band gap of semiconductors, lower the activation energy, lower will be the band gap [16-18]. The activation energy of the La(III)-MPVA is comparatively lower than the Pr(III), Nd(III), Sm(III)- MPVA indicating the lower band gap in them.

4. Reference

1. Varishetty MM, Qiu W, Gao Y, Chen W. Structure, electrical and optical properties of (PVA/$LiAsF_6$) polymer composite electrolyte films. Polym Eng Sci 2010; 50(5):878-884.
2. Kalandaragh YA. Optoelectronic and Advanced materials 2010; 4(11):1655-1658.
3. Subba Reddy CV, Han X, Zho Q, Mai L, Chen W. J Microelectronic Eng 2006; 83281.
4. Abdel-Malik TG, Abdel-Latif RM, 112A. Sawaby, 1S.M. Ahmed; Journal of Applied Sciences Research 2008; 4(3):331-336.
5. Polu AR, Kumar R. AC impedance and dielectric spectroscopic studies of Mg^{2+} ion conducting PVA–PEG blended polymer electrolytes Bull Mater Sci 2011; 34(5):1063-1067.
6. Al-Yasari AHM. Effect of addition Lithium Fluoride on some electrical properties of High Density Polyethylene. Journal College of Education Babylon University, Vol 1, 2010, 5.
7. Archana Nigrawal and Navin Chand; International Journal of Engineering, Science and Technology 2012; 4(2):191-209.
8. Nanda Prakash MB, Manjunath A, Somashekar R. Studies on AC Electrical Conductivity of $CdCl_2$ Doped PVA Polymer Electrolyte, Advances in Condensed Matter Physics. 2013 Article ID 690629, 6.
9. Devikala S, Kamaraj P, Arthanareeswari M. Electrical Conductivity Studies of PVA/TiO2 Composites. See more at: http://www.sciencedomain.org/abstract.php?iid=238&id=7&aid=1590#.VC-SdPmSwt0 International Research Journal of Pure & Applied Chemistry 2013; 3(3):257-263.
10. Sreelalitha K, Thyagarajan K. IJETCAS 13-154, 2013, 309.
11. Juradoa JF, Checaa O, Vargas RA. Revista Mexicana de F´ısica 59(2013)426-432.
12. Zamri MFMA, Zein SHS. Improved electrical conductivity of polyvinyl alcohol/multiwalled carbon nanotube nanofibre composite films with MnO2 as filler synthesised using the electrospinning process. International Journal of Engineering & Technology. IJET-IJENS Vol: 11 No: 06, 21, 2011.
13. Hashim A, Rabee BH, Habeeb MA, Abd-alkadhim N, Saad A. Study of Electrical Properties of (PVA-CaO) Composites. American Journal of Scientific Research ISSN 2301-2005 73(2012):5-8.

14. Begum A, Hussain A. Materials Sciences and Applications, 2011, 2, 163-168
15. Katon JE. Monographs in macromolecular chemistry. Organic Semiconducting Polymers. (Eds) Marcel, Dekker, Inc, New York, 89 (1968).
16. Mohd Faiz Muaz Ahmad Zamri, Sharif Hussein Sharif Zein; International Journal of Engineering & Technology, 11(06), (2011)21.
17. Ahmed Hashim; American Journal of Scientific Research, 73, (2012), 5-8.
18. Anayara Begum, Amir Hussain; Materials Sciences and Applications, 2, (2011), 163.