Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 17 Issue 4 Version 1.0 Year 2017
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Physico-Chemical Studies on Polyvinyl Alcohol in Aqueous Media

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GJSFR-A Classification: *FOR Code: 240599p*

PHYSICOCHEMICALSTUDIESONPOLYVINYLALCOHOLINAQUEOUSMEDIA

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Physico-Chemical Studies on Polyvinyl Alcohol in Aqueous Media

Richa Saxena [α] & S C Bhatt [σ]

Abstract- **Density, viscosity and speed of sound of aqueous solution of polyvinyl alcohol of different concentration range from 0.3% to 1% have been measured using ultrasonic interferometer at 1MHz frequency in temperature range 30⁰C-65⁰C. Using these values different acoustical parameters like adiabatic compressibility, acoustic impedance and have been calculated.**

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I. Introduction

The study of thermodynamic properties of binary mixtures contributes to an understanding of behavior of different liquids and their functional group[1-6].This information is very useful in the design of industrial processes and development of theories for the liquid state and predictive methods. Further, the study of excess thermodynamic properties of liquid mixtures is a subject of great interest because it gives information about molecular interactions and packing phenomenon or structural contributions. Polyviylalcohol is one of the simplest of the synthetic water soluble polymers[7]. They also provide substantial information on the processes involving polymer production and their uses[8,9]. Polyvinylalcohol is interesting from several aspects. It is one of the simplest of the synthetic water soluble polymers. Commercially polyvinylalcohol, is synthesized by hydrolysis of polyvinyl acetate, since the hydrolysis is difficult to take to completion a number of partially hydrolysed polymers containing residual acetate groups carry the name of PVA[7, 10, 11].

The speed of sound, intermolecular free length and relaxation time are the properties sensitive to different kinds of association in the pure components and mixtures and often they are related to local order. They have been used to investigate the molecular packing, molecular motion and various types of intermolecular interactions and their strength and chemical nature of components molecules[12].

II. Experimental Details

In the present investigation polyvinyl alcohol in solid form of molecular weight approximately 140,000 is used. The solutions were prepared by adding known volume of polyvinyl alcohol to fixed volume of water and stirring under reflex, until a clear solution was obtained. The concentration range studied in the solution is 0.3%-1.0% (v/v). Different acoustical parameters like, intermolecular free length and relaxation time were calculated at different concentration like 1.0%, 0.8%, 0.6%, 0.5%, 0.4% and 0.3% and at different temperatures 30°, 35°, 40°, 45°, 50°, 55°, 60° and 65°C at 1MHz frequency by using variable path ultrasonic interferometer with reproducibility of ±0.4m/s at 25⁰C. The temperature of the solution has been kept constant by circulating water from the thermostatically controlled (±0.1⁰C) water bath. The densities at different temperatures were measured using 10ml specific gravity bottle and single pan macro balance. The uncertainty in density measurements was found to be about 0.5kg/m³. The viscosity of the mixtures was determined by using Ostwald's viscometer, which was kept inside a double-walled –jacket, in which water from thermostat water bath was circulated. The inner cylinder of this double-wall-glass jacket was filled with water of desired temperature so as to establish and maintain the thermal equilibrium. The accuracy in the viscosity measurements is within ±0.5%. These parameters are calculated by using standard relations[13-17].

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Table 1: Density($x10^3 kg/m^3$) of polyvinyl alcohol (PVA) at different temperature and concentration at 1 MHz frequency

Temperature Concentratio n(v/v)	30	35	40	45	50	55	60	65
1.0%	1.020	0.996	0.992	0.988	0.983	0.979	0.974	0.968
0.8%	0.985	0.983	0.981	0.979	0.977	0.972	0.964	0.956
0.6%	0.981	0.978	0.974	0.972	0.968	0.96	0.954	0.948
0.5%	0.978	0.975	0.971	0.968	0.963	0.958	0.946	0.937
0.4%	0.976	0.973	0.969	0.965	0.955	0.950	0.939	0.934
0.3%	0.974	0.970	0.967	0.962	0.951	0.944	0.931	0.926

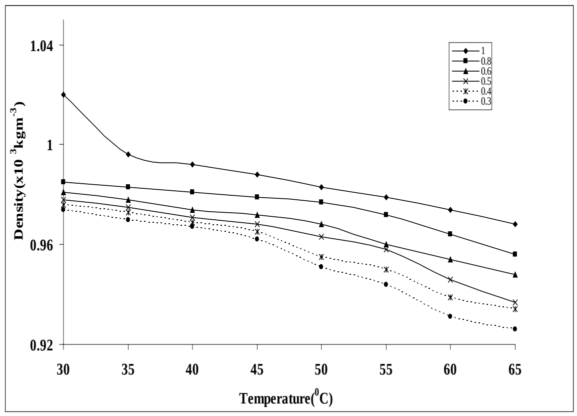

Fig. 1: Variation of density with temperature at different concentration of PVA

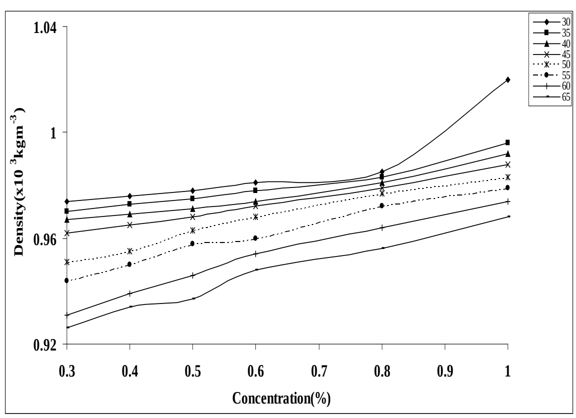

Fig. 2: Variation of density with concentration with at different temperature of PVA

Table 2: Viscosity ($x10^{-1}$Pa.s) of polyvinyl alcohol (PVA) at different temperatur and concentration at 1 MHz frequency

Temperature Concentration	35	35	40	45	50	55	60	65
1.0 %	0.092	0.089	0.087	0.085	0.082	0.079	0.062	0.058
0.8 %	0.09	0.086	0.084	0.081	0.0781	0.069	0.059	0.056
0.6 %	0.089	0.077	0.067	0.061	0.056	0.052	0.044	0.041
0.5 %	0.087	0.074	0.065	0.059	0.054	0.047	0.042	0.038
0.4 %	0.083	0.073	0.064	0.057	0.051	0.043	0.38	0.035
0.3 %	0.078	0.072	0.060	0.054	0.048	0.042	0.033	0.031

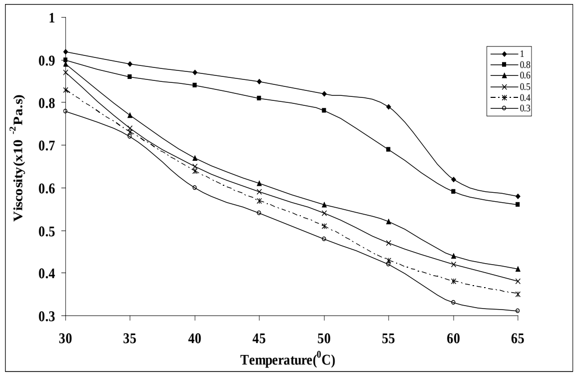

Fig. 3: Variation of viscosity with temperature at different concentration of PVA

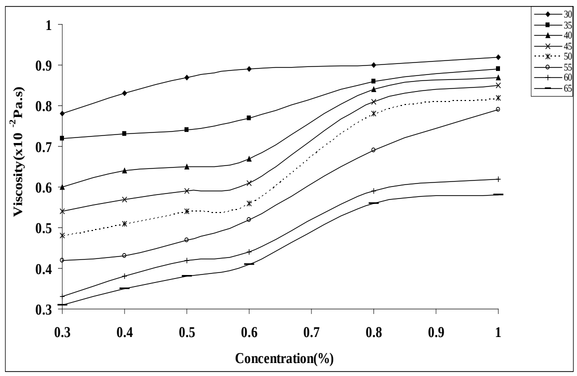

Fig. 4: Variation of viscosity with concentration at different temperature of PVA

Table 3: Ultrasonic velocity (m/s) of polyvinyl alcohol (PVA) at different temperature and concentration at 1 MHz frequency

Temperature → Concentration (v/v) ↓	30°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
1.0%	1512.2	1509.9	1504.2	1501	1495.6	1482.5	1476.5	1472.3
0.8%	1507.6	1503.2	1500.1	1498.8	1488.7	1473.4	1470.6	1467.7
0.6%	1505.1	1501.3	1497.5	1484.4	1472.7	1468.3	1463.6	1461.8
0.5%	1502.4	1495.9	1482.3	1476.7	1468.9	1466.8	1462.7	1460.9
0.4%	1496.5	1483.8	1480.8	1473.5	1466.7	1464.6	1460.3	1458.9
0.3%	1493.7	1482.5	1478.4	1472.3	1462.6	1459.0	1456.2	1454.8

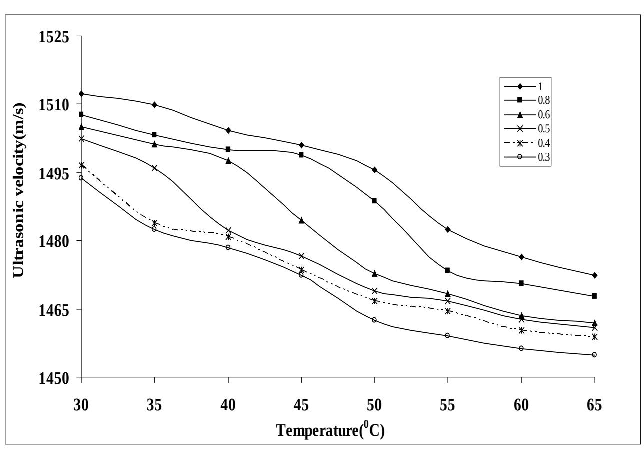

Fig. 5: Variation of ultrasonic velocity with temperature at different concentration of PVA

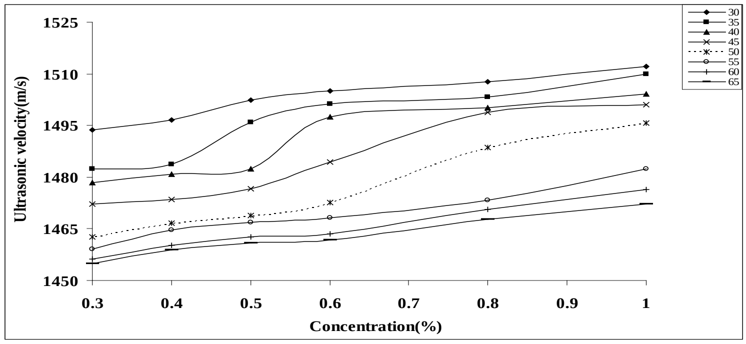

Fig. 6: Variation of ultrasonic velocity with concentration at different temperature of PVA

Table 4: Adiabatic compressibility($x10^{-10}kg^{-1}ms^{2}$) at different temperature and concentration at 1MHz for polyvinyl alcohol (PVA)

Temperature → Concentration(v/v) ↓	30˚C	35˚C	40˚C	45˚C	50˚C	55˚C	60˚C	65˚C
1.0%	4.287	4.404	4.455	4.492	4.548	4.648	4.709	4.766
0.8%	4.467	4.502	4.53	4.547	4.618	4.739	4.747	4.856
0.6%	4.5	4.537	4.578	4.669	4.763	4.832	4.893	4.936
0.5%	4.53	4.583	4.687	4.737	4.813	4.852	4.934	4.994
0.4%	4.575	4.668	4.765	4.773	4.868	4.907	4.994	5.03
0.3%	4.602	4.691	4.766	4.795	4.916	4.976	5.065	5.102

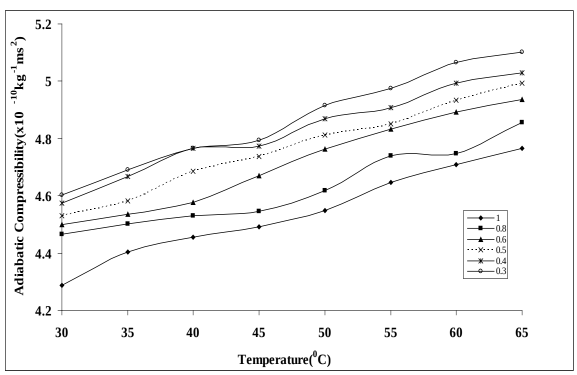

Fig. 4.13: Variation of adiabatic compressibility with temperature at different concentration of PVA

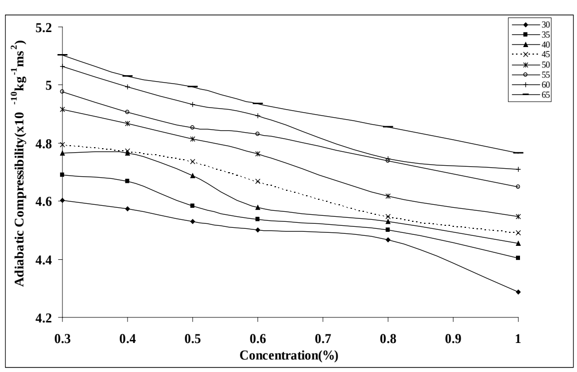

Fig. 4.14: Variation of adiabatic compressibility with concentration at different temperature of PVA

Table 5: Acoustic impedance (x10^3kgm^{2}s^{-1}) at different temperature and concentration at 1MHz for polyvinyl alcohol (PVA)

Temperature → Concentration(v/v) ↓	30˚C	35˚C	40˚C	45˚C	50˚C	55˚C	60˚C	65˚C
1.0%	1542.4	1503.9	1492.2	1483	1470.2	1451.4	1438.1	1425.2
0.8%	1485	1477.6	1471.6	1467.3	1454.5	1432.1	1417.7	1403.1
0.6%	1476.5	1468.3	1458.6	1442.8	1425.6	1409.6	1396.3	1385.8
0.5%	1469.4	1458.5	1439.3	1436.5	1414.6	1405.2	1384.7	1369.8
0.4%	1460.6	1443.7	1436.1	1421.9	1400.7	1391.4	1371.2	1362.6
0.3%	1454.9	1438	1429.6	1416.4	1390.9	1377.3	1355.7	1347.1

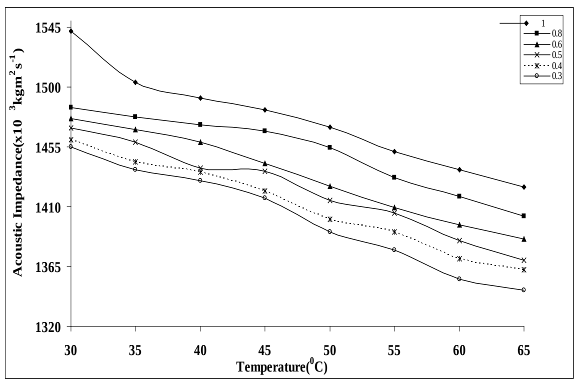

Fig. 4.15: Variation of acoustic impedance with temperature at different concentration of PVA

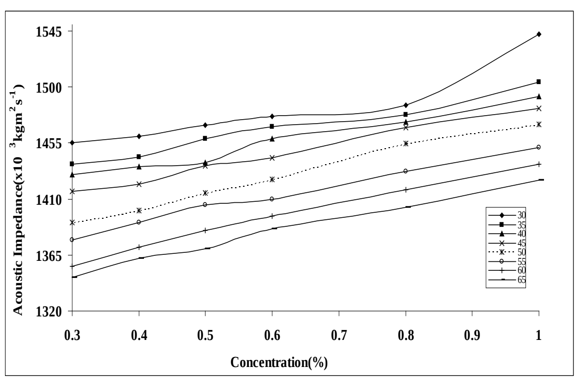

Fig. 4.16: Variation of acoustic impedance with concentration at different temperature of PVA

III. Result and Discussion

In the present work density, viscosity and ultrasonic velocity have been measured at different temperature and concentration of polyvinylalcohol, which is shown in Table-1, 2, and 3 respectively. By using these values for PVA, intermolecular free length and relaxation time have been calculated by using well known relations and the results have been presented in Table-4 and 5, respectively. The variations of these parameters with temperature and concentration have been shown in Fig.1-Fig.6 respectively.

Polyvinyl alcohol in solid form of molecular weight 140,000. Solution were prepared by adding known weight of polyvinyl alcohol of molecular weight approximately 140,000 to fixed volume of water and stirring under reflex, until a clear solution was obtained. Table-1 and Fig.1& 2 represent the variation of density with temperature and concentration respectively. Density decreases with increase in temperature and increases with increase in concentration. These are in agreement with earlier workers[18]. It may be due to electro striction in that solution. This electro striction decreases the volume and hence increases the density as a number of solute molecules increase the electro striction and density. It is evident from Table-2 and Fig.3 & 4 that, viscosity decreases with increase in temperature and increases with increase in concentration of PVA. This is showing similar trend as reported by earlier workers[19]. The variations of ultrasonic velocity with temperature and concentration have been shown in Table-3 and Fig. 5 & 6. Ultrasonic velocity decreases with increase in temperature and increases with increase in concentration of PVA. This indicates interactions between PVA and solvent molecules. The results are in good agreement with earlier workers[20]. Table 4.5 and Fig. 4.13 reports the variation of adiabatic compressibility with temperature. It is clearly seen that adiabatic compressibility increases with temperature. Variation of adiabatic compressibility with concentration is shown in Table 4.5 and Fig. 4.14. It is evident that adiabatic compressibility decreases with increase in concentration of polyvinyl alcohol in solution. Similar results are reported by other workers[21]. This decrease in adiabatic compressibility indicates the enhancement of the bond strength at this concentration. Variation of acoustic impedance with temperature is shown in Table 4.6 and Fig. 4.15. It is observed that it decreases with increase in temperature. Table 4.6 and Fig. 4.16 depict the variation of acoustic impedance with concentration. It is seen that it increases with increase in concentration of polyvinyl alcohol in the solution. This is in agreement with the requirement as both ultrasonic velocity and density increase with increase in concentration of the solute and also effective due to solute-solvent interactions. These results are in agreement with earlier workers[22].

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