Research Article

IJCRR
Section: General Science
Sci. Journal Impact Factor 4.016
ICV: 71.54

A Study on Comparative Analysis of Polypropylene Glycol

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ABSTRACT

Polypropylene glycol or polypropylene oxide is the polymer of propylene glycol. Chemically it is a polyether. The term polypropylene glycol or PPG is reserved for low to medium range molar mass polymer when the nature of the end-group, which is usually a hydroxyl group, still matters. PPG is used as a rheology modifier, surfactant, wetting agent, calibrant in mass spectrometry. In the present study, we have tried to compute the ultrasonic velocity and refractive index of binary liquid mixture of Polypropylene glycol (Molar mass : 1000) (PPG 1000) with benzene at different molar concentrations (0, 0.0215, 0.0554, 0.0809, 0.1166, 0.2603 and 1), at different temperatures (303 K, 308 K, 313 K & 318 K). The experimental ultrasound velocities are compared with various theoretical values like Nomotto's relation, Impedance relation and Junjie's relation. The experimental refractive index values are compared with various theoretical methods like Arago-Biot relation, Gladstone-Dale equation and Eyring-John equation. The most reliable method that matches with experimental method is identified by calculating average percentage error (APE) and discussions are made in the light of molecular interactions occurring in the binary liquid systems.

Key Words: Binary mixture, Polypropylene glycol, Refractive index, Ultrasonic velocity

INTRODUCTION

Study of ultrasonic velocity of liquid mixtures is very important to investigate the nature of molecular interactions in the binary liquid mixtures [1]. It is one of the ways to derive information about physical behaviour of liquid mixtures [2] and also employed to identify the conformational transition from native to denatured states of bio-molecules and macromolecules [3]. Complex formation in liquid mixtures has been extensively studied using optical and ultrasonic technique by many researchers [4–6]. The study of the solution properties of liquid mixtures consisting of polar as well as non - polar components finds applications in industrial and technological processes [7]. Measurement of refractive index in combination with density, boiling point, melting point and other analytical data are useful industrially [8]. In the present work the computed values of ultrasonic velocity in binary liquid mixtures of PPG 1000 and benzene at 303 K over the entire mole fraction range of PPG 1000 have been evaluated by using Nomoto, impedance relation, and Junjie's relation [9] and are compared with the experimental values.

The experimental refractive index values are compared with various models like Arago-Biot relation, Gladstone-Dale equation and Eyring-John equation [8]. The most reliable method that matches with experimental method is identified by calculating average percentage error.

EXPERIMENTAL DETAILS

Polypropylene glycol (PPG 1000) (Alfa Aser make) is obtained from SOUTHERN INDIA SCIENTIFIC COMPANY, Trichy, India. The calculated volumes of the liquid are added to get different molar concentrations (0, 0.0215, 0.0554, 0.0809, 0.1166, 0.2603 and 1). Magnetic stirrer [REMI make] was used for this purpose at a rate of 1000 rpm. The mixtures were kept in special airtight bottles. The ultrasonic velocity measurements are performed using Mittal make single frequency Ultrasonic interferometer at 2 MHz (F- 81 model) (uncertainty ± 0.01m/s). The refractive index measurements are performed by Abbe Refractometer (MITTAL make, Accuracy : ±0.001). The temperature of interferometer and refractometer are maintained at 303K by circulating water from a thermostat having a thermal stability of ± 0.05 K.

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ISSN: 2231-2196 (Print) **ISSN:** 0975-5241 (Online)

Received: 28.02.2017 **Revised:** 08.04.2017 **Accepted:** 02.05.2017

RESULTS AND DISCUSSIONS

Theoretical Estimation of Ultrasonic velocity

Ultrasonic velocity studies are performed for the above systems at 303K. The experimental values along with the values calculated mathematically using Nomoto's relation, impedance relation and Jungie's relation are given in Table 1.

Table 1: Experimental and Theoretical Ultrasonic velocity of binary mixture of PPG 1000 with benzene

Mole fraction of PPG 1000	Ultrasonic Velocity (m/s)			
	Experimental Values	Nomotto's relation	Impedance Relation	Junjie's Relation
0.0000	1266.08	1174.22	1266.08	1266.08
0.0215	1270.42	1185.73	1267.53	1142.08
0.0554	1282.29	1197.37	1269.79	1010.84
0.0809	1289.43	1203.23	1271.48	941.70
0.1166	1297.11	1209.12	1273.82	869.82
0.2603	1313.20	1221.01	1283.04	720.51
1.0000	1325.42	1233.02	1325.42	1325.42

Table 2: Percentage of Deviation of Ultrasonic velocity of binary mixture of PPG 1000 with benzene

Mole fraction of PPG 1000	Percentage of Deviation (%)		
	Nomotto's relation	Impedance Relation	Junjie's Relation
0.0000	7.2554	0.0000	0.0000
0.0215	6.6661	0.2277	10.1019
0.0554	6.6229	0.9749	21.1693
0.0809	6.6852	1.3924	26.9680
0.1166	6.7829	1.7949	32.9414
0.2603	7.0202	2.2963	45.1331
1.0000	6.9709	0.0000	0.0000
APE	6.8577	0.9552	19.4733

It can be seen from Table 1 that the theoretical values of ultrasonic velocity calculated by using various theories show deviation from experimental values. The limitations and approximation incorporated in these theories are responsible for the deviations of mathematical values from experimental values. Table 2 shows the variation of Average percentage of deviation (APE) with respect to the composition of PPG 1000 in benzene at 303 K [1].

From Table 2, it is observed that the percentage of deviation is more in Junjie's relation method and less in Impedance relation method. From this, it may be concluded that Impedance dependence method is the best suitable mathematical method for estimating the speed of ultrasound waves for the systems taken for analysis.

Theoretical Estimation of Refractive Index

The knowledge of refractive index of liquid mixtures at different temperatures is an important step for their structural characterization. The experimental values along with the values calculated theoretically using Arago-Biot, Gladstone-Dale and Eyring-John equation are given in Table 3.

Table 3: Experimental and Theoretical Refractive Index values for binary liquid mixture of PPG 1000 + benzene

Mole fraction of PPG 1000	Refractive Index			
	Experimental Values	Arago-Biot relation	Gladstone-Dale relation	Eyring and John relation
0.0000	1.495	1.495	1.495	1.495
0.0215	1.468	1.486	1.486	1.486
0.0554	1.464	1.476	1.476	1.476
0.0809	1.46	1.471	1.471	1.471
0.1166	1.459	1.467	1.467	1.467
0.2603	1.454	1.457	1.457	1.457
1.0000	1.448	1.448	1.448	1.448

Table 4: Percentage of Deviation of Refractive Index of binary liquid mixture of PPG 1000 with benzene

Mole fraction of PPG 1000	Percentage of Deviation (%)		
	Arago-Biot relation	Gladstone-Dale relation	Eyring and John relation
0.0000	0.0000	0.0000	0.0000
0.0215	-1.2262	-1.2262	-1.2262
0.0554	-0.8197	-0.8197	-0.8197
0.0809	-0.7534	-0.7534	-0.7534
0.1166	-0.5483	-0.5483	-0.5483
0.2603	-0.2063	-0.2063	-0.2063
1.0000	0.0000	0.0000	0.0000
APE	-0.5077	-0.5077	-0.5077

It is observed from Table 3 that the values of the refractive index calculated by Arago-Biot, Gladstone-Dale and Eyring and John mixing rules are almost same for the above systems. The experimental values of refractive index are compared with the predicted results from the above-mentioned mixing rules and the percentage of deviation is determined (Table 4).

It is evident from Table 4 that in all the three systems, there exists better agreement between experimental and theoretical values of the refractive index calculated by different mixing rules. Thus, from the above investigation, it can be con-

cluded that the above mentioned mathematical mixing rules perform well within the limits of experimental error. The deviation between the theoretical and observed values of refractive index for the above system can be reduced by taking the excess volume into consideration, which is an indirect measure of interaction.

CONCLUSIONS

Ultrasonic velocity and refractive index studies are performed for binary liquid mixtures of PPG 1000 with benzene in the molar concentration range of 0, 0.0215, 0.0554, 0.0809, 0.1166, 0.2603 and 1 at 303K. Nomato's relation, Impedance relation and Junjie's relation were used for mathematical computation of ultrasonic velocities in the binary liquid mixtures. From these theoretically calculated values of ultrasonic velocities, it is concluded that impedance relation is found to be best suited to experimental values by having minimum percentage error over a whole concentration range. Arago-Biot, Gladstone-Dale and Eyring and John mixing rules were used for theoretical computation of refractive index in the binary liquid mixtures. All three theoretical mixing rules are performed well within the limits of experimental error.

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