Applied Innovative Research
Vol. 2, March 2020, pp. 36-38

Density, viscosity and ultrasonic study of polymethylmethacrylate

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Experimental values of density, viscosity and ultrasonic velocity of binary mixture of polymethylmethacrylate and acetic acid are reported in temperature range 30 °C to 65 °C at 0.4% concentration at1MHz frequency. Acoustical parameters like relaxation time and ultrasonic absorption are calculated using experimental data. These properties are used to interpret molecular interactions among component liquids.

Keywords: Ultrasonic velocity, Relaxation time, Ultrasonic absorption

1 Introduction

In recent years, the measurement and interpretation of ultrasonic properties of liquid and liquid mixtures have been studied[1, 2]. The study of molecular interaction in polymer solution is of great importance for engineering applications of polymers. They also provide substantial information on the processes involving polymer production and their uses[3, 4]. Ultrasonic[5, 6] volumetric[7] and viscometric[8, 9] properties of binary liquid mixtures have been investigated by a number of researchers over the past several years. The ultrasonic technique is a powerful and effective tool for investigation of polymer solutions and behavior of polymer chain in an ultrasonic field. These properties are useful for device application such as ultrasound tranducer, nonvolatile memory, sensor, actuator, sonar instruments and solar cell. Polymer dissolution also plays a key role in many industrial applications in a variety of areas and an understanding of the dissolution process allows for the optimization of design and processing conditions as well as selection of suitable solvent[10]. B Dalai *et. al.*[11] have observed experimental value of density, viscosity and ultrasonic velocity of binary liquid mixtures of a nuclear extractant with monocarboxylic acids at 303.15 K temperature. Very few literatures are available on binary mixture of polymethylmethacrylate.

2 Experimental Detail

In the present investigation liquid solution of polymethylmethacrylate (of molecular weight ≈15,000 in solid form) with acetic acid is used. The solutions were prepared by adding known weight of polymethylmethacrylate to fixed volume of acetic acid and stirring under reflex, until a clear solution was obtained. The concentration studied in the solution is 0.4 % (w/v). Different acoustical parameters like relaxation time and ultrasonic absorption were calculated at different temperature and at 0.4 % concentration at 1MHz. The ultrasonic speeds were measured by using variable path ultrasonic interferometer with reproducibility of ±0.4m/s at 35 °C. The temperature of the solution has been kept constant by circulating water from the thermostatically controlled (±0.1°C) water bath. The densities at different temperature were measured using10 ml specific gravity bottle and single pan microbalance. The uncertainty in density measurements was found to be about 0.5 kg/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. 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[12-14].

3 Results and Discussion

Densities, viscosities and ultrasonic velocities of polymethylmethacrylate are shown in Tables 1-3 and Figs 1-3, respectively. Table 1 and Fig. 1 represent the variation of density of polymethylmethacrylate

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Table1 — Density(x10^3kg/m^3) of polymethylmethacrylate(PMMA) with temperature at 0.4% concentration at 1 MHz frequency.

Temperature	Density
65	0.9664
60	0.9774
55	0.9901
50	1.0002
45	1.011
40	1.0184
35	1.0252
30	1.0388

Table 2 — Viscosity (x10^{-1}Pa.s) of polymethylmethacrylate (PMMA) with temperature and 0.4% concentration at 1 MHz frequency.

Temperature	Viscosity
65	0.5
60	0.583
55	0.62
50	0.669
45	0.72
40	0.76
35	0.845
30	0.967

Table 3 — Ultrasonic velocity (m/s) of Polymethylmethacrylate with temperature at 0.4% concentration at 1 MHz frequency.

Temperature	Ultrasonic velocity
65	1158
60	1161.4
55	1162.3
50	1168.5
45	1172.3
40	1177.4
35	1182.1
30	1197.4

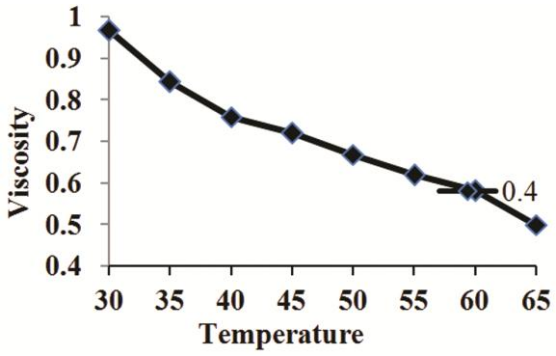

Fig. 1 — Variation of density with temperature at 0.4% concentration.

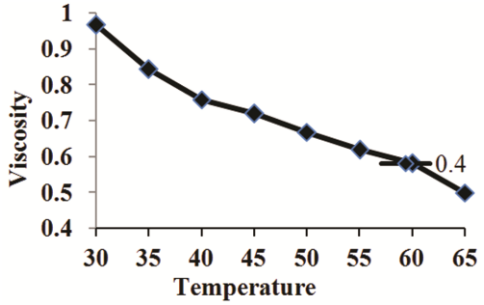

Fig. 2 — Variation of viscosity with temperature at 0.4% concentration.

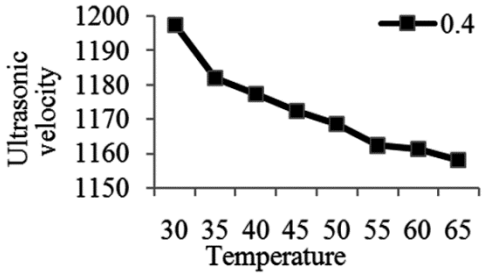

Fig. 3 — Variation of ultrasonic velocity with temperature at 0.4% concentration.

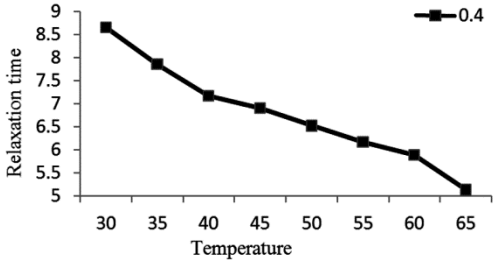

Fig. 4 — Variation of Relaxation time with temperature at 0.4% concentration.

with temperature at 0.4 % concentration. It is clear from Table 1 and Fig. 1 that density decreases with increase in temperature this behavior is in agreement with the results reported by other workers[15]. Table 2 and Fig. 2 show that, viscosity decreases with increase in temperature of polymethylmethacrylate in the solution. Present dependence is in accordance with the reported by other workers[16]. The variations of ultrasonic velocity with temperature have been shown in Table 3 and Fig. 3. Ultrasonic velocity decreases with increase in temperature of PMMA in the solution. It is evident from our investigation that our present results are in good agreement with the results reported by others workers[17]. It is clear from Table 4 and Fig. 4 an that relaxation time decreases

Table 4 — Relaxation time**(x10^{-12}s)** of Polymethylmethacrylate with temperature at 0.4% concentration at 1 MHz frequency.

Temperature(^{0}C)	Relaxation time
65	5.14
60	5.9
55	6.18
50	6.53
45	6.91
40	7.18
35	7.86
30	8.66

Table 5 — Ultrasonic absorption(x10^{-15}s^{2}m^{-1}) with temperature at 0.4% concentration at 1 MHz frequency.

Temperature(^{0}C)	Ultrasonic absorption
65	0.403
60	0.536
55	0.568
50	0.61
45	0.671
40	0.748
35	0.995
30	1.69

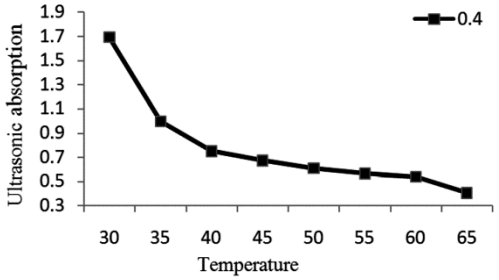

Fig. 5 — Variation of ultrasonic absorption with temperature at 0.4% concentration.

with increase in temperature. Table 5 and Fig. 5 shows that ultrasonic absorption decreases with increase in temperature. This is in agreement with result reported by earlier workers[18].

4 Conclusion

The ultrasonic technique is a powerful and effective tool for the investigation of polymer solutions. The molecular interactions present in polymethyl-methacrylate in acetic acid have been investigated by density, viscosity and ultrasonic velocities. The result show higher degree of interaction between solute and solvent at higher concentration. These results are helpful in understanding the physio chemical behaviour of solute and solvent.

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