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Ultrasonic studies on poly-methyl methacrylate in ethyl methyl ketone

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Abstract : Ultrasonic velocity studies have been carried out in solutions of poly-methylmethacrylate (PMMA) in ethyl methyl ketone (EMK) in the concentration range 0–3% by weight, at radio frequency of 2 MHz at three different temperatures 293 K, 297 K and 301 K. The increase in ultrasonic velocity with increase of PMMA concentration is attributed to the segment-segment interaction which causes molecular association between PMMA and EMK.

Keywords : Ultrasonic parameters, PMMA, EMK

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In recent years, extensive use of polymeric materials in technology has necessiated the study of molecular interactions of polymers with solvents. Acoustics was used as a tool to study the physical properties of the polymers. The present work was undertaken with the view of studying the molecular interaction of solutions of PMMA in EMK at several concentrations and temperatures.

PMMA was dissolved by swirling in the solvent EMK for solute concentrations of 0–3% by weight. Precautions were taken to avoid various types of possible degradation [1]. The measurements of ultrasonic velocity were carried out at three different temperatures.

Ultrasonic time Intervalometer (Model-UTI 101, Innovative Instruments, Hyderabad) was employed to measure ultrasonic velocity in sample solutions at fixed frequency 2 MHz. The accuracy of the measured values of ultrasonic velocities is 2 parts in 10^4. The density was measured using specific gravity bottle. The viscosity was measured using an Ostwald's viscometer. The accuracy of density and viscosity measurements are ± 2 parts in 10^4 and 0.1%. All the above measurements were carried out at three different

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temperatures 293 K, 297 K and 301 K with an accuracy of ± 0.1°C. Constant temperature of the sample was maintained by circulating water from a thermostatically controlled water bath. The molecular weight of PMMA is 52,0838 determined by viscosity method [2].

The density (ρ), ultrasonic velocity (C) and shear viscosity (η) were measured at three different temperatures. Using the above parameters, Rao's number (R) and adiabatic compressibility (β) were calculated using the formula

$$\beta_s = (C^2\rho)^{-1} \tag{1}$$

$$C^{1/3}V = R \tag{2}$$

where C = ultrasonic velocity,

η = viscosity of water,

ρ = density of the solution,

V = molar volume of the solution.

The values of the above parameters are tabulated in Tables 1–3.

Table 1. Ultrasonic and related parameters for solution of PMMA in EMK at 301 K

Concentration (wt%)	Density of solution ρ kgm^{-3}	Ultrasonic velocity C ms^{-1}	Adiabatic compressibility $\beta_s \times 10^{-10}N^{-1}m^2$	Shear viscosity η Nsm^{-2}	Rao's number $R \times 10^3$
0.000	800.73	1170.9	9.1081	0.3688	6.8540
0.200	801.46	1173.7	9.0574	0.5634	6.8549
0.500	802.47	1175.0	9.0256	0.6614	6.8489
0.700	803.48	1177.1	8.9820	0.7986	6.8444
1.000	807.24	1179.3	8.9075	1.2720	6.8140
2.000	814.31	1181.9	8.7903	4.1060	6.7626
3.000	821.19	1188.7	8.6175	10.2126	6.7187

Table 2. Ultrasonic and related parameters for solution of PMMA in EMK at 297 K

Concentration (wt%)	Density of solution ρ kgm^{-3}	Ultrasonic velocity C ms^{-1}	Adiabatic compressibility $\beta_s \times 10^{-10}N^{-1}m^2$	Shear viscosity η Nsm^{-2}	Rao's number $R \times 10^3$
0.000	802.52	1183.8	8.8917	0.4333	6.8655
0.200	804.14	1186.2	8.8379	0.7030	6.8526
0.500	805.29	1188.1	8.7971	0.7868	6.8502
0.700	808.72	1191.7	8.7069	0.8942	6.8279
1.000	811.19	1194.3	8.6427	1.4184	6.8122
2.000	818.62	1197.4	8.5199	4.9463	6.7556
3.000	824.12	1202.2	8.3956	11.2315	6.7200

It can be seen from tables that ultrasonic velocity, at all temperatures, generally increases with increase in solute concentration and for any particular solute concentration,

the ultrasonic velocity decreases with increase of temperature. The adiabatic compressibility decreases with increase of solute concentration at all temperatures. The density and shear viscosity increase with increase in solute concentration.

Table 3. Ultrasonic and related parameters for solution of PMMA in EMK at 293 K

Concentration (wt%)	Density of solution ρ kgm^{-3}	Ultrasonic velocity C ms^{-1}	Adiabatic compressibility $\beta_s \times 10^{-10} N^{-1} m^2$	Shear viscosity η Nsm^{-2}	Rao's number $R \times 10^3$
0 000	804 58	1196 7	8 6792	0 4702	6.8724
0.200	805 51	1199 0	8.6355	0 8295	6.8692
0 500	806 63	1200 4	8 6034	0 9429	6 8623
0 700	808 80	1202.3	8.5532	1 0355	6.8458
1 000	811 37	1204.2	8 4958	1.5808	6.8294
2 000	822 11	1210 4	8.3025	5.9722	6 7517
3 000	827 06	1217 5	8 1568	12.9601	6.7244

The gradual increase in ultrasonic velocity with solute concentration at all temperatures may be due to association between solute and solvent molecules in PMMA in EMK. As the concentration increases, one macromolecule may influence another indirectly, by way of mutual interaction. In more concentrated solutions and bulk polymers, direct segment-segment interaction exists [3]. It can be seen from tables that increase in the ultrasonic velocity in the entire solute concentration range 0–3% is about 20.8 m/s. It has been reported that the increase in ultrasonic velocity for a similar concentration range for solution of PVC in DMF [4] is about 24.3 m/s and PVC in chlorobenzene [5] is about 10 m/s. Since the observed increase in the ultrasonic velocity in the solute concentration range 0–3% in the present study is of the same order, it can be assumed that the conclusion drawn for solutions of PVC in DMF and PVC in CB are applicable to the present study. The van der Waal's interaction may be responsible for association between molecules of PMMA and EMK at low solute concentrations. For any solute concentration, the ultrasonic velocity decreases with increase in temperature and this may be due to weakening of intermolecular forces due to thermal effects. Further work will confirm the above conclusion. From Tables 1–3, it can further be seen that the shear viscosity generally increases with increase in solute concentration. This and the non-linear variation of Rao's number R with solute concentration (at all temperatures studied) give support to the above conclusion.

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