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Ultrasonic studies of intermolecular interactions in binary mixtures of 4-methoxy benzoin with various solvents: Excess molar functions of ultrasonic parameters at different concentrations and in different solvents

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Abstract

Density (ρ), ultrasonic velocity (U), for the binary mixtures of 4-methoxy benzoin (4MB) with ethanol, chloroform, acetonitrile, benzene, and di-oxane were measured at 298K. The solute–solvent interactions and the effect of the polarity of the solvent on the type of intermolecular interactions are discussed here. From the above data, adiabatic compressibility (β), intermolecular free length (L_f), acoustic impedance (Z), apparent molar volume (\emptyset), relative association (RA) have been calculated. Other useful parameters such as excess density, excess velocity and excess adiabatic compressibility have also been calculated. These parameters were used to study the nature and extent of intermolecular interactions between component molecules in the binary mixtures.

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Highlights

► Ultrasonic parameters of 4-methoxy benzoin are calculated. ► Parameters are measured at different solvent and different concentration. ► Excess function of volume, velocity, and adiabatic compressibility are calculated. ► Parameters explain the nature of intermolecular interactions in binary mixture. ► The solute/solvent interaction at different concentration and solvents are measured.

Introduction

The practical application of mixed solvents, rather than single solvents, in industrial and biologic processes has been recognized all over the world, as they provide a wide choice of solvent mixtures with appropriate properties [1], [2]. Experimental studies aimed at finding evidence for intermolecular interactions in binary liquid mixtures have been carried out by us [3]. We focus in this paper the results of ultrasonic studies of binary mixtures of 4-methoxy benzoin (4MB) with solvents of different polarities. The components of these binary mixtures (4MB and various solvents) are interesting, as they have proton donor as well as proton accepting abilities. As a result, significant interaction through hydrogen bonding between unlike molecules in these binary mixtures is expected. Also, it is worthwhile examining the effect of intermolecular interaction between 4MB and various solvents. We report here the results of ultrasonic study of molecular interactions of 4MB at 298K in ethanol, chloroform, acetonitrile, benzene, dioxane binary mixtures. Ethanol is a highly polar but protic solvent. In the liquid state its molecules are associated through hydrogen-bonding. The solvent polarity decreases from ethanol to benzene. The intermolecular interaction varies from polar solvent to non-polar solvent.

Density, viscosity and ultrasonic velocity were experimentally determined for 4MB/solvent systems of different concentrations. From this, ultrasonic parameters like adiabatic compressibility, intermolecular free length and apparent molar volume were calculated using standard formulae [4]. Excess functions such as excess adiabatic compressibility, excess velocity, excess intermolecular free length, excess acoustic impedance, and excess apparent molar volume were also calculated. The values are plotted against concentration and ultrasonic parameters. The graphs obtained are explained on the basis of the various intermolecular interactions present in the system and how the interactions are affected by the change of solvents and concentration.

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Experimental

The solvents ethanol, acetonitrile, chloroform and benzene (S.D. Fine, India, AR) were dried over molecular sieves. All the solutions were prepared by weighing in a dry bottle and were kept in special air tight bottles. 4MB was prepared by the crossed benzoin condensation of benzaldehyde with 4-methoxy benzaldehyde. The molecular structure and conformation were confirmed using single-crystal XRD studies (Fig. 1). Solutions of different mole percent of 4MB with various solvents, were prepared at

Results and discussion

From the variation of densities, viscosities and ultrasonic parameters with concentration and temperature, a qualitative interpretation of the intermolecular interactions in the above binary mixtures can be proposed. A decrease in the density of a solution with dilution is the expected trend [5], [6]. For the system of 4MB and different solvents under study, there is a decrease in density at low concentration region for polar solvents like ethanol, acetonitrile, 1,4-dioxane and there is a

Conclusions

In polar protic solvents, molecules are held together by comparatively strong hydrogen bonds forming a network. A Polar solvent is capable of taking part in dipole–dipole, dipole-induced dipole and hydrogen bonding interactions between themselves, which are being slowly replaced by solvent–solute interaction when a solute is added. This leads to the solvation of the solute molecules, resulting in an increase in volume and a decrease in density of the mixture. In non-polar solvents at higher

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