Chapter Seven
Conclusion

Ultrasonic study of liquids and liquid mixtures, due to its non-destructive nature has gained much importance during the last two decades. The study on this field based on several derived parameters helped many investigators in assessing the nature of molecular interactions present in liquid mixtures. In the present study, we have deduced certain new acoustic relations of derived parameters, adiabatic compressibility $\beta_S$ and specific acoustic impedance $Z_A$. The applicability and validity of these relations are examined by applying them in the case of coconut water and binary mixtures.

Chapter one gives an introduction to different types of liquids. Here the liquids are classified as atomic and molecular liquids and the latter are further classified as liquified gases with small molecules, liquids with polar and non-polar molecules and hydrogen-bonded liquids. The important characteristics of these liquids are discussed. The different types of intermolecular bonding such as ionic bonding, covalent bonding, hydrogen bonding, dipole-dipole interaction, Vander Waals interaction etc and intermolecular forces such as dipole forces and dispersion forces are also mentioned briefly. At the end of this chapter, a brief account of the general characteristics of liquid mixtures and solutions is discussed.
In Chapter two, some of the important physical properties of liquids are discussed. Density, sound velocity, surface tension, viscosity, adiabatic compressibility, specific acoustic impedance etc are some of them. These properties are characteristic of each liquid. The effects of temperature on these properties are also briefly mentioned. Moreover, a brief review of some of the earlier works in the field of liquid mixtures is reported.

The deduction of a few new acoustic relations of adiabatic compressibility $\beta_s$ and specific acoustic impedance $Z_A$ of liquids in terms of temperature and concentration coefficients of sound velocity and density is described in Chapter three. The temperature dependent relations are

$$\beta_s = \beta_s' e^{(\alpha + 2\beta)\Delta T}$$
$$Z_A = Z_A' e^{-(\alpha + \beta)\Delta T}$$

where $\beta_s$ and $Z_A$ are the adiabatic compressibility and specific acoustic impedance respectively of a liquid at any higher temperature $T_2$, $\beta_s'$ and $Z_A'$ are the respective values of the same liquid at the lower temperature $T_1$ and $\alpha$ and $\beta$ are the temperature coefficients of density and sound velocity respectively. $\Delta T = T_2 - T_1$ is the difference in temperature between higher and lower temperature.

Similarly, the concentration dependent relations are

$$\beta_s = \beta_s'' e^{-\left(\frac{M+N}{2}\right)\Delta C}$$
and
$$Z_A = Z_A'' e^{\left(M+\frac{N}{2}\right)\Delta C}$$

where $\beta_s$ and $Z_A$ are the adiabatic compressibility and specific acoustic impedance respectively of a liquid mixture or a solution at any higher concentration $C_2$, $\beta_s''$ and $Z_A''$ are the respective values of the solution at the
lower concentration $C_1$, $M$ and $N$ are the concentration coefficients of density and sound velocity respectively and $\Delta C = C_2 - C_1$ is the concentration difference between higher and lower concentration.

Chapter four gives a detailed description of the experimental techniques employed in the measurement of direct parameters, ultrasonic velocity and density of liquids. These parameters are used to find out $\beta_S$ and $Z_A$ because both $\beta_S$ and $Z_A$ have direct link with ultrasonic velocity and density. The ultrasonic velocities of different liquids and their mixtures at different temperatures were determined using a single-crystal ultrasonic interferometer in conjunction with a thermostatically controlled water circulating arrangement and the densities were determined at different temperatures using a double-stem pyknometer. The masses of the liquids were recorded on an electronic balance.

In Chapter five, the application of the new acoustic relations is examined by applying it in the detection and estimation of major sugar content in coconut water. A comparative study of the thermal variation of experimental and theoretical values of $\beta_S$ and $Z_A$ in solutions of glucose, fructose and different samples of coconut water (tender and matured) reveals that the major sugar content in coconut water is fructose. Further from the analysis we found that though temperature as well as concentration dependent relations of $\beta_S$ and $Z_A$ are useful in the detection of fructose in coconut water, the temperature dependent relations are more reliable than concentration dependent relations in the estimation of fructose content in coconut water.

The validity of the new relations is checked by applying them to the case of binary mixtures. For this purpose, nine binary mixtures consisting of both interacting and non-interacting systems were selected and studied and the
results are discussed in Chapter six in terms of molecular interactions in them. It has been found that close agreement between experimental and calculated values of $\beta_S$ and $Z_A$ shows absence of molecular interaction in the system whereas a departure of calculated values from experimental ones shows the existence of molecular interaction in the system. The present study reveals that benzene + toluene, kerosene + diesel, petrol + kerosene and petrol + diesel are all ideal mixtures having no molecular interactions whereas pyridine + water, PMMA + CB, cyclohexane + benzene, ethylacetate + cyclohexane and ethylacetate + benzene are all non-ideal mixtures indicating the presence of molecular interactions in the systems. Both structure breaking and structure making effects are dominant in pyridine + water system whereas it is the polymer-solvent and polymer-polymer interactions which are active in PMMA + CB system. In the case of cyclohexane + benzene, ethylacetate + cyclohexane and ethylacetate + benzene mixtures, it can be seen that structure breaking effect is prominent in the first two systems whereas specific interaction exists in the third system.

Thus it can be concluded that the thermal variation of new acoustic relations is useful in detecting the presence of a substance in a sample and also in predicting the nature of molecular interactions in a system.