CHAPTER – I

Introduction and Review of Literature

Abstract

This chapter deals with the applicability of propagation of ultrasound waves for materials [organic liquids (substituted benzenes), amino acids and borate glass] characterization. Much attention has been paid to the role and significance of molecular interactions in determining specific properties and structure of molecular systems related to interacting molecules and also determining the structural and elastic properties of the glass specimen. A brief review of literature pertaining to the present work is also furnished.
2.1. INTRODUCTION

Ultrasonic studies provide a wealth of information about the state of liquid mixtures and solids (Amino acids, organic mixtures). Ultrasonic investigations provide extensive application in characterizing the thermodynamic and physico-chemical behaviour of liquid mixtures. The study of propagation of ultrasonic waves in pure liquids, liquid mixtures, amino acids is well established for determining the nature of intermolecular interactions. Molecular interactions determine the properties and the structure of matter. Molecular interactions are also of prime importance in deciding the structure and properties of biological systems as well as energy transfer in enzymes, phase transitions, etc. In the last few years one has been able to observe fascinating progress in the study of molecular interactions. The field of ultrasonics has grown enormously in the last few decades. It provides much insight into the problems of basic physics, and finds large number of industrial, biological and medical applications by characterizing thermodynamic and physico-chemical behaviour of liquid mixtures. The measurement of ultrasonic velocity enables the accurate determination of some useful acoustical parameters which are highly sensitive to the study of molecular interactions. These acoustical parameters provide qualitative
information about the physical nature and strength of the molecular interactions in the liquid mixtures. Acoustical and thermodynamic parameters have been used to understand different kinds of association, the molecular packing, molecular motion and their respective strength influenced by the size in pure components and in the mixtures.

Ultrasonic techniques of liquid mixtures consisting of polar and non-polar components are of considerable importance in understanding the intermolecular interactions between the component molecules and they find applications in several industrial, biological, bio-chemistry, medicine, engineering, dentistry, polymers, and technological processing.

Ultrasonic velocity together with density and viscosity data furnish sufficient information about the sum of total interactions between ions, dipoles, H-bonding, multi-polar dispersion forces and elastic forces (Rastogi et al., 2002; Acharya et al., 2003). Hence, this technique seems to be complementary to spectroscopic (Hyder et al., 2000; Sati et al., 2000; Baluja and Karia 2000; Ali et al., 2002; Deshmukh et al., 2003) and dielectric methods. The study of molecular
interaction plays an important role in the development of molecular sciences.

The intermolecular distance in liquids and liquid mixtures are so small and the effects of the intermolecular forces are correspondingly so large because of the strongest ionic bonds. The study of intermolecular forces which are responsible for molecular interaction is of considerable importance in the formation of simple to complex liquids and liquid mixtures.

In liquid mixtures, the interactions occur between like molecules and unlike molecules. From a theoretical point of view it is convenient to classify molecular interactions into long and short range interactions. The long range interaction leads to the existence of Van der Waal's force between the molecules in a liquid and the behaviour of the liquid mainly depends on this force. This force arises when the interacting molecules come close together without the overlap of their electron clouds. The hydrogen bond and electron donor-acceptor (charge transfer) interactions arise from short range interaction. This can be augmented by the fact that the hydrogen bond distance is smaller than the Van der Waal's radii. Short range interactions are due to dipole-dipole, dipole-induced dipole,
charge transfer, complex formation and hydrogen bonding interactions. These forces arise when two molecules come close enough together causing a significant overlap of electron clouds and are often highly directional.

To study the property of liquid mixtures, viscosity is also another important parameter. The non-linearity in the variation of viscosity (Pal and Kumar 2004) is explained in terms of hydrogen bond formation between the components of mixture. In order to shed more light on the properties of liquid mixtures, it is necessary to calculate certain acoustical and thermodynamical parameters such as adiabatic compressibility, free length, free volume, internal pressure and Gibb’s free energy. The non-linear variation of these calculated parameters with concentration of the solute may be explained on the basis of structural changes occurring in a liquid mixture, for example, the hydrogen bond formation.

In recent years, there has been considerable advancement in the experimental investigation of excess thermodynamic of properties of liquid mixtures. These properties have been adequately employed in understanding the nature of molecular interactions in binary liquid mixtures. In the chemical industry,
knowledge of the thermodynamic properties of non-electrolyte solutions is essential in the design involving chemical separation, heat transfer, mass transfer, and fluid flow. Furthermore, thermodynamic properties of binary mixtures containing components capable of undergoing specific interactions exhibit significant deviations from ideality arising not only from differences in molecular size and shape but also due to structural changes (Radhamma et al., 2008).

Ultrasonic investigation of binary liquid mixture has revolutionaries the world of medical petrochemical and pharmaceutical industries to a great extent (Ali and Nain 2002; Comeli et al., 2002). The ultrasonic measurements have been widely used to study the molecular structure and molecular interaction mechanism of the matter.

The study of molecular interaction in ternary mixtures provides useful information about the behaviour of different liquids and their functional groups. This information is very useful in the design of industrial processes and in the development of theories for the liquid state and predictive methods (Dharmalingam et al., 2007). Ultrasonic velocity measurement has been successfully employed to detect and
access weak and strong molecular interactions present in binary (Kannappan and Jayasanthi, 2005; Kannappan et al., 2009) and ternary (Jayakumar et al., 1999) liquid mixtures.

During the last two decades, the ultrasonic study of liquid mixtures has gained much importance in assessing the nature of molecular interactions present in the mixtures. Ultrasonic velocity measurements in amino acid and substituted benzenes furnish knowledge about solute-solvent and solute-solute interactions which, in turn help to understand several biochemical processes such as protein hydration.

Ultrasonic study on the amino acids with aqueous solution of electrolytes and non-electrolytes provides useful information in understanding the behaviour of liquid systems, intra and intermolecular associations, complex formation and related structural changes. Amino acids are the fundamental structural units of proteins, certain types of hormones, antibiotics and many other compounds of biological relevance. Since most biological macro molecules are physiologically active in aqueous solutions, knowledge of water-protein interaction is necessary to understand the role of water solvated to soluble organic in the living cells.
The specific interactions due to the hydrogen bond between the polar groups of different components are primarily responsible for the non-ideal behavior of binary associated solutions. In the binary solution containing 1-alkanols, the hydrogen bond energy between the hydroxyl group in the alkanol molecules and the proton accepting group in the other component is found to be more than 2 kcal/mol. When an alkanol is mixed with other organic compounds, some alkanol molecules tend to dissociate from the polymeric aggregates to form the other kinds of hydrogen bonds with different kinds of molecules. The degree of dissociation from polymeric species will be dependent on the proton accepting ability of the functional group in the molecule. Perhaps this is the most decisive factor in determining the sign and magnitude of the deviation from the ideal solution behavior.

The study of carbohydrates/ disaccharides has become a subject of increasing interest because of the multidimensional, physical, biochemical and industrially useful properties of these compounds. In addition to their importance to the food, pharmaceutical and chemical industries, the simple saccharides have received considerable attention for their ability to protect biological macromolecules. Carbohydrates
located at cell surfaces, are important as receptors for the bioactive structures of hormones, enzymes, viruses, antibodies etc. Therefore, the study of carbohydrate-protein interactions is very important for immunology, biosynthesis, pharmacology and medicine. It is widely recognized that sugars help in stabilizing biological macromolecules. This action is performed either due to direct interactions between them and or through alteration of the water structure.

Amino acids are molecules containing an amine group, a carboxylic acid group and a side chain that varies between different amino acids with the general formula NH₂CHRCOOH, where R is an organic substituent. Polar amino acids have R groups that do not ionize in solution but are quite soluble in water due to their polar character. They are also known as hydrophilic, or “water loving” amino acids. Proteins are formed by polymerizing monomers that are known as amino acids, because they contain an amino (-NH₂) and a carboxylic acid (-CO₂H) functional group.

Among numerous amino acids the α-amino acids of general structure H₂N - CH(R) - COOH, where ‘R’ is a side chain where other polar groups (-NH₂, -COOH, -CO, -OH, etc.) can be
bonded are predominantly biologically significant. In relation to the biological activity of amino acids the most important systems that deserve comprehensive studies are their aqueous solutions. In the aqueous environment amino acids exhibit strongly hydrophilic behaviour depending on the ratio between hydrophilic (polar groups) and hydrophobic (hydrocarbon part of the molecule). The hydrophilic character is even more pronounced by the internal dissociation. Since the amino acids exist in ionized Zwitter ionic form + H₃N - CH(R) -COO- in aqueous solutions (Cibulka et al., 2009). A better understanding of this type of interaction may be obtained from dipolar ions. Since amino acids are Zwitterions in aqueous solutions their volume and compressibility properties should reflect structural interaction with water molecules. When a solute is dissolved in a solvent, the compressibility of the solution may be determined by the effects from solvent, solute and solvation. The contribution of solute is made of two parts; due to the solute molecule and due to the solute-solute interaction. For lower concentrations, the second effect becomes negligible and the compressibility of the solute molecules is negligibly small compared to other effects. The volume as well as compressibility of the solution consists of three parts:
i. due to solvated solute
ii. due to the bound solvent and
iii. due to the free solvent.

Apart from the study on liquids, the ultrasonic investigation on glass is gaining importance nowadays. In recent years, interest in glasses has rapidly increased because of improving information technology. Many researchers attempted to elucidate the importance of characterization and structural network of the glasses by means of propagation of ultrasound waves. Generally glass has no definite composition and can be classified into two types namely, physical and chemical glass. Physical glass may be defined as a hard, rigid, under cooled, brittle, non-crystalline substance having no defined melting point and sufficiently high viscosity to prevent crystallization. It is usually transparent, but sometimes opaque or translucent. Chemical glass may be defined as a fused mixture of silicates, alkali and alkaline earth compounds and other glass constituents, such as calcium oxide, magnesium oxide, zinc oxide, lead oxide and manganese oxide. Glass is completely vitrified product. The most important characteristics of glass are hardness, transparency, refractive capacity, dispersive capacity, low coefficient of cubical expansion, high
electrical insulation, low thermal conductivity, capacity of absorbing decorative colours without loss of transparency and chemical inertness under ordinary conditions. A growing interest has developed in glasses like borate, silicate, and borosilicate and high lead due to their technological application in various fields (Singh et al., 1991; Kodama et al., 1991; Ghoneim et al., 1983).

Borate glasses present a special interest for photo induced non-linear optical effects (Kityk et al., 2003). Alkali borate glasses are well known due to their high transparency, low melting point and high thermal stability. Glasses containing transition metals have gained recent interest because of their wide technological applications (Fatma H El-Batal et al., 2009). Transition metal ions are being greatly used in the present days to probe the glass structure since their order d-electron orbital function has a broad radial distribution and due to their high sensitive response to the changes in the surrounding actions (Upender et al., 2009).

Ultrasonic characterization of materials is a versatile tool for the inspection for their microstructure and their mechanical properties. This is possible because of the close association of
the ultrasound waves with the elastic and inelastic properties of the materials. Also, this technique offers the possibility of different frequency ranges and many modes of vibration of the ultrasound waves to probe into any structural level (Souto et al., 1999; Mallawany et al., 2000). Attempts (Bhatti et al., 1989; Lorosch et al., 1984) have been made to interpret the variation of ultrasonic velocity and attenuation on glass composition in terms of structural changes of glasses. Special attention is given to the changes obtained in the various acoustical parameters with addition of network modifier (NWM) in the light of packing state of atom and glass structure. The modifier oxides and make the glasses more stable against devitrification and resistant to moisture.

Hardness is an important solid state property, to determine the mechanical strength of materials. Although, hardness has been defined in several ways, now generally, accepted that it is the resistance offered to dislocation motion. There are several contributions to the dislocation motion and they can be classified into two types (i) the intrinsic resistance which depends on some structure insensitive physical parameter of the crystal and (ii) a disorder parameter which depends on the concentration of the imperfections. The non-linear variation of
Microhardness with composition is due to the presence of imperfections. These imperfections can be vacancies, impurity-vacancy pairs, dislocations, low-angle grain boundaries etc. Microhardness is an important parameter often used to define the mechanical properties of a glass on a microscopic scale. Microhardness is the resistance of network against elastic and plastic deformation as well as against compression (Mott 1956, Neill 1967).

Fourier Transform Infra-Red (FTIR) spectroscopy is one of the important techniques which are used to study the local arrangement in inorganic glasses. The main structural units of borate glasses are BO\textsubscript{3} triangles. By the addition of modifiers it can covert from BO\textsubscript{3} to BO\textsubscript{4} units. These glasses have been studied due their potential applications as optical and electricity memory switching, cathode material for making solid state devices and optical fiber. The transition metal doped borate glasses have been extensively studied by several authors (Gurinder Pal Singh et al., 2011). It is well known that the main structural units of the borate network which are (BO\textsubscript{3}) triangles (BO\textsubscript{4}) tetrahedral, may form different super-structural units; boroxol and metaborate rings, metaborate chains, pentaborate, triborate, diborate, and pyroborate. There are two types of (BO\textsubscript{3})
triangles; the symmetric one with three bridging or non-bridging oxygen and the asymmetric one with one or two non-bridging oxygen (Perince et al., 1999).

In view of the growing interest to analyze the molecular interaction and physico-chemical properties and structural studies of liquid systems and glass specimen respectively by ultrasonic and spectroscopic techniques, an attempt has been made to investigate the following:

i. Thermo-acoustical and excess thermodynamic studies of ternary liquid mixtures of substituted benzenes in aqueous mixed solvent system at 303.15, 308.15 and 313.15 K.

ii. Volumetric and compressibility studies on inter ionic interaction of some α-amino acids in aqueous sucrose solution at varying mass percentages and

iii. Elastic and Mechanical properties as well as structural elucidation of some borate glass specimen by employing ultrasonic and spectroscopic studies.
The literature pertaining to the above studies are reviewed here and the same is given in the following section.

1.2 Review of Literature

Nikam et al., (2000) have measured densities and viscosities of the binary mixtures of toluene with methanol, ethanol, propan-1-ol, butan-1-ol, pentan-1-ol, and 2-methylpropan-2-ol at 303.15, 308.15, and 313.15 K. From these data, excess molar volumes and deviations in viscosity have been calculated. These results are fitted to Redlich-Kister type polynomial equations to estimate the binary coefficients and standard errors.

Indraswati et al., (2001) studied density and viscosity for a binary mixture of ethyl valerate and hexyl acetate with 1-pentanol and 1-hexanol at three different temperatures (293.15, 303.15, and 313.15 K) and at atmospheric pressure. The measurements were carried out over the whole range of composition. Density values were used in the determination of the excess molar volume and the viscosity deviations. The latter were fitted to the Redlich-Kister polynomial equation.

Johnson et al., (2002) had found experimental values of density, viscosity, and speed of sound of the ternary
mixtures of 2-ethoxyethanol (1) + acetophenone(2) + N,N-dimethylacetamide (3) and 2-ethoxyethanol (1) + dimethyl sulfoxide (2) + N,N-dimethylacetamide (3) at 308.15 K and at 18 different concentrations. From the data, the excess volume and the deviations in adiabatic compressibility, viscosity, and speed of sound for the ternary mixtures over the additive values were calculated. The deviations were fitted using the Redlich-Kister equation.

**Nikam and Kharat (2003)** have calculated densities and viscosities of ternary mixtures of N,N dimethylformamide + benzene + chlorobenzene and corresponding binary mixtures of N, N-dimethylformamide + benzene, N,N-dimethylformamide + chlorobenzene, and benzene + chlorobenzene at (298.15, 303.15, 308.15, and 313.15) K. From these data, excess molar volumes and deviations in viscosity have been evaluated. Several empirical equations have been used to predict the excess molar volumes and deviations in viscosity of ternary mixtures. The kinematic viscosities of binary and ternary liquid mixtures have also been correlated with mole fractions by McAllister’s equation.

**Pandharinath S.Nikam et al., (2003)** have studied the densities and viscosities of binary mixtures of N, N-dimethylformamide with benzyl alcohol and acetophenone at different
temperature. Using this experimental data, excess molar volume and deviation in viscosity have been fitted to the Redlich-kister polynomial equation. Mc Allisters three body interaction model has been used to correlate the kinematic viscosities of binary liquid mixtures with mole fractions.

Ali et al., (2004) had calculated the densities and ultrasonic speeds in the binary liquid mixtures of acetonitrile (ACN) with 1-hexanol, 1-octanol and 1-decanol, and in the pure components, as a function of composition at 25, 30, 35, 40 and 45°C. The deviations in isentropic compressibility, excess molar volume, deviations in ultrasonic speed, apparent molar compressibility, apparent molar volume, partial molar compressibility and partial molar volume of 1-alkanols in ACN have been evaluated from the experimental data of densities and ultrasonic speeds. The variations of these parameters with composition of the mixtures indicate that the structure-breaking effect dominates over that of the hydrogen-bonding effect between unlike molecules, suggesting that ACN-alkanol interaction is weaker than ACN-ACN and alkanol-alkanol interactions, and that the interaction (ACN-alkanol) follows the order: 1-hexanol > 1-octanol > 1-decanol. The excess molar volume data have been analysed by using Flory and
Prigogine-Flory-Patterson theories. Further, the ultrasonic speeds in these mixtures were theoretically calculated with the help of several theories and empirical relations using the pure component data. The validity and relative merits of these theories and relations have been eventually discussed.

Anuradha et al., (2005) have determined densities and ultrasonic velocities at 299K for the binary mixtures of acetonitrile (ACN) with acetone/ ethyl methyl ketone/ Methyl isobutyl ketone and acetophenone over entire composition range. From these, isentropic compressibility, intermolecular free length and their deviations namely excess isentropic compressibility and excess intermolecular free length have been calculated and interpreted in terms of intermolecular interactions. Further theoretical values of ultrasonic velocity in the four binary liquid mixtures are calculated using two different theoretical models. The relative merits of these theories and relations have also been discussed.

Prabakar et al., (2005) have been measured ultrasonic velocity and density for binary liquid mixtures of acetone + acetophenone, ethyl methyl ketone + acetophenone and acetone + ethyl methyl ketone at 308.15K. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility, free length, free volume
and internal pressure. The excess values of the above parameters are also evaluated. The experimental results were compared with those predicted by empirical relations.

Prasad et al., (2006) have determined excess volume of five ternary mixtures at 301.15 K. The mixture includes acetophenone and 1-propanol as common components. The non-common component are benzene, toluene, chlorobenzene, bromobenzene and nitrobenzene. The measured excess volume data are found to be negative over the entire composition range in the mixtures containing chlorobenzene, bromobenzene and nitrobenzene.

Zarei (2006) measured the densities of methyl isobutyl ketone (MIBK) + methanol, MIBK + ethanol, MIBK + propan-1-ol, MIBK + propan-2-ol, MIBK + butan-1-ol and MIBK + butan-2-ol for the whole range of composition at temperatures ranging from 298.15 K to 308.15 K in 5K intervals and atmospheric pressure, using an Anton Paar model DMA 4500 oscillating densimeter. The excess molar volume, partial molar volume and excess partial molar volumes of binary mixtures were calculated from the density data. The temperature dependence of the thermodynamic properties in the temperature range of 298.15 K to 308.15 K has also been shown. The excess molar volumes were correlated with
the Redlich-Kister polynomial. The excess molar volumes are negative for methanol, ethanol, propan-1-ol, butan-1-ol and inversion of sign in excess molar volume is observed for ethanol at 308.15 K and rich concentration in MIBK, and positive for propan-2-ol and butan-2-ol. It was found that excess molar volumes in the systems increase with increasing temperature.

Al-Jimaz et al., (2007) calculated isentropic compressibility, excess isentropic compressibility, excess molar volume, viscosity deviations and speed of sound deviations for \{chlorobenzene + 1-hexanol or 1-heptanol, or 1-octanol, or 1-nonanol, or 1-decanol\} binary mixtures at temperatures ranging from (298.15 to 313.15) K and at atmospheric pressure from experimental viscosity, density, and speed of sound. The calculated excess and deviation functions were further fitted to the polynomial relation to estimate the coefficients and standard errors. The experimental viscosity data was compared with the predicted values obtained from empirical expressions and the speeds of sound data was analyzed in term of Schaaffs’ collision factor theory and Jacobson’s intermolecular free length theory of solutions. The effects of n-alkan-1-ol chain length as well as the temperature on the excess molar volume were discussed.
Iloukhani et al., (2007) had studied densities, viscosities, speeds of sound and refractive index of binary systems (diethyl carbonate + acetophenone, diethyl carbonate + 1-heptanol) at 293.15, 303.15, 313.15 and 323.15K. Deviation in viscosity from the mole fraction average, deviation in isentropic compressibility, and deviation in refractive indices from the volume fraction average for the mixtures were derived from the experimental data. The computed results have been fitted to the Redlich-Kister polynomial equation to estimate the smoothening coefficients and standard deviations for this system. The experimental data of the binaries are analyzed to discuss the nature and the strength of intermolecular interactions in these mixtures.

Mozo et al., (2008) have studied densities and speeds of sound of systems formed by 1-butanol (1-BuOH), 1-pentanol (1-PeOH), or 1-HxOH (1-hexanol) and dibutylether (DBE) at (293.15, 298.15, and 303.15) K and atmospheric pressure using a vibrating-tube densimeter and sound analyzer Anton Paar model DSA-5000. The density and speed of sound values were used to calculate excess molar volumes, and deviations from the ideal behavior of the thermal expansion coefficient and of the isentropic compressibilities. The excess
molar volume variation with the chain length of the 1-alkanol shows the existence of structural effects for systems including longer 1-alkanols.

**Thirumaran and Earnest Jayakumar (2009)** have studied ultrasonic velocity, density and viscosity of the mixtures of n-alkanols namely 1-propanol, 1-butanol and 1-pentanol in toluene with nitro benzene at 303K. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility, free length, free volume and internal pressure. The excess values of the above parameters are also evaluated and discussed in the light of molecular interaction such as dipole-dipole interaction through hydrogen bonding between nitrobenzene and 1-alkanols and donor acceptor complexity observed between toluene and nitrobenzene molecules.

**Thirumaran and Ramesh (2009)** have determined ultrasonic velocity, density and viscosity for the mixtures of 1-alkanols, namely, 1-propanol, 1-butanol, and 1-pentanol with N,N-dimethylacetamide (DMA) in cyclohexanone at 303, 308 and 313K. The experimental data have been used to calculate the acoustical parameters, namely excess adiabatic compressibility, excess free length, excess free volume and excess internal pressure. They investigated that the
dissociation of hydrogen bonded structure of 1-alkanols and also the rupture of hydrogen bonds in the associated structure of 1-alkanols when it is mixed with DMA. They also found that the elevation of temperature too induces the rupture of hydrogen bonds of unlike molecules.

**Thirumaran and Thenmozhi (2010)** have measured the ultrasonic velocity, density and viscosity for the mixtures of alkanols, namely, 1-propanol, 1-butanol and 1-pentanol with chlorobenzene in toluene at 303 K. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility, free length, free volume and internal pressure. The excess values of some of the above parameters are also evaluated and discussed in the light of molecular interaction present in the mixtures. Existence of strong molecular association is observed. Such a molecular association is found to be by hydrogen bonding through dipole-dipole interactions. Also, donor-acceptor complexation is observed. They also noticed that the hetro and homo association of molecules decreases with increasing chain length of the carbon atom in alkanols.

**K. Saravanakumar et al., (2010)** has been investigated the behaviour of mixture of acetophenone and benzene as a function of temperature and composition by measuring
sound velocity in conjunction with density at 303.15, 313.15 and 323.15 K. Derived parameters computed from density (ρ) and sound velocity (U) have been used to determine excess molar volumes, excess isentropic compressibility and excess inter molecular free length. The excess functions have been discussed in terms of intermolecular interactions between the components of binary mixture. The validity of various theoretical approaches of liquids has been tested for the system by comparing theoretical sound speeds with those experimentally determined over the entire composition range in the temperature range 303.15 - 323.15K. The computed results have been fitted to the Redlich-Kister polynomial equation to estimate the smoothening coefficients and standard deviations for this system. The validity of various theoretical approaches of liquids has been tested for the system by comparing theoretical sound speeds with those experimentally determined over the entire composition range in the temperature 303.15-323.15K.

Deepa et al., (2011) have measured acoustic impedance and ultrasonic velocities of binary liquid mixtures Methyl Iso Butyl Ketone (MIBK) with 1-Propanol, 1-Butanol and 1-Pentanol over the wide mixture compositions at
\( T = 303.15 \text{ K.} \) Acoustic Impedance has directly been measured by using a new technique based on pulse echo reflectory method. These data have been used to compute densities, Intermolecular free length, molar volumes, excess intermolecular free length, isentropic compressibility, excess acoustic impedance, excess molar volumes, and excess isentropic compressibility. The values are negative over the wide range of composition for all the studied binary mixtures, while the values of excess acoustic impedance are found positive. The changes in the thermo acoustic parameters as a function of variations in the composition and chain length of alkyl groups in alkanol molecules are discussed in terms of the intermolecular interactions.

**Thirumaran et al., (2012)** have observed experimental parameters such as density, viscosity and ultrasonic velocity of ternary liquid mixtures of primary alkanols such as 1-propanol, 1-butanol, 1-pentanol and 1-hexanol with N-Ndimethylformamide (DMF) in acetophenone at 303.15 K. The observed experimental data have been utilized to evaluate some of the thermo acoustical parameters and also their excess values such as adiabatic compressibility, intermolecular free length, free volume, internal pressure, Gibb’s energy and viscosity. They observed that the
interaction between DMF (Proton acceptor) and 1-alkanols is due to hydrogen bonding and seems to be a dissociation of associated structure of 1-alkanols and decrease in interaction (hydrogen bonding) between acetophenone and alkanols on further addition of DMF resulting in existence of weak molecular interactions.

**Ubagaramary et al., (2012)** have been studied the molecular interaction using ultrasonic technique in the binary liquid mixtures of Chlorobenzene + Isobutyl Methyl Ketone + Cyclohexanol, Isobutyl Methyl Ketone + Acetophenone at 308k. Using the measured values of ultrasonic velocity, density and viscosity, acoustical parameters and their excess values are evaluated. From the properties of these excess parameters the nature and strength of the interactions in these binary systems are discussed.

**Anil Kumar Nain (2013)** have measured the ultrasonic speed of binary mixtures of methyl acrylate with 1-butanol, 1-hexanol, 1-octanol, and 1-decanol, including those of pure liquids, over the entire composition range at temperatures (288.15, 293.15, 298.15, 303.15, 308.15, 313.15, and 318.15)K and at atmospheric pressure. From the experimental results, the isentropic compressibility, intermolecular free length, acoustic impedance, relative
association, molecular association, deviations in isentropic compressibility, excess intermolecular free length, deviations in ultrasonic speed, excess molar isentropic compressibility and excess acoustic impedance have been calculated. The partial molar isentropic compressibility and excess partial molar isentropic compressibility, over the whole composition range, partial molar isentropic compressibility, and excess partial molar isentropic compressibility of the components at infinite dilution have also been calculated.

Thirumaran and Priya (2013) have determined densities (ρ), viscosities (η) and speeds of sound (U) of ternary liquid mixtures of primary alkanols such as 1-propanol, 1-butanol, 1-pentanol and 1-hexanol, with the fixed binary solvent mixtures of N-N dimethylacetamide (DMA) and acetophenone (ratio 4:2 respectively) at 303.15, 308.15 and 313.15K and at normal atmospheric pressure. The observed experimental data have been utilized to evaluate some of the thermo dynamical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), free volume (V_f), internal pressure (π_i), viscous relaxation time (τ) and Gibb’s energy (ΔG). The variation of these parameters with composition was discussed from the point of view that intermolecular interactions in these mixtures.
Pushpalatha et al., (2013) have observed experimental parameters such as Ultrasonic velocity, density and viscosity in a binary mixture of acetophenone with n-butanol at temperatures $T = (303.15, 308.15, 313.15, 318.15$ and $323.15)K$ over the entire mole fraction range. The experimental data is used to calculate various thermo acoustic parameters like Adiabatic compressibility ($\beta$), intermolecular free length ($L_d$), molar volume ($V_m$), free volume ($V_f$), internal pressure ($\pi_i$), enthalpy ($H$), acoustic impedance ($Z$), Rao’s constant ($R$) and Wada’s constant ($w$). The results are explained in the light of molecular interactions.

Thirumaran et al., (2013) have observed experimental parameters such as density, viscosity and ultrasonic velocity of ternary liquid mixtures of (i) water + ethylene glycol + Tetrahydrofuran (THF), (ii) water + ethylene glycol + dimethyl formamide (DMF), and (iii) water + ethylene glycol + dimethyl sulphoxide (DMSO) measured as a function of the composition of $303.15, 308.15$ and $313.15K$. The fixed binary solvent mixture (water + ethylene glycol) has been prepared under the constant ratio of 4:1 respectively. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility, free length,
free volume and internal pressure. The excess values of some of the above parameters are also evaluated and discussed in the light of molecular interaction present in the mixtures.

**Thirumaran and Chitra (2014)** have determined densities (ρ), viscosities (η) and speeds of sound (U) of ternary liquid mixtures of primary alkanols such as 1-pentanol and 1-hexanol, 1-heptanol and 1-octonal with the fixed binary solvent mixtures of N-N dimethylacetamide (DMA) and diethyl ketone (DEK) (ratio 4:2 respectively) at 303.15, 308.15 and 313.15K and at normal atmospheric pressure. The observed experimental data have been utilized to evaluate some of the thermo dynamical parameters such as adiabatic compressibility (β), intermolecular free length (Lf), free volume (Vf), internal pressure (πi), viscous relaxation time (τ), and Gibb’s energy (ΔG). The variation of these parameters with composition was discussed from the point of view that intermolecular interactions in these mixtures. It was observed that the interaction between DMA (proton acceptor) and 1-alkanols is due to hydrogen bonding. The present study observes a dissociation in the associated structure of 1-alkanols when they are further added with binary solvent mixture (DMA + DEK).
Wang et al., (2000) have obtained apparent molar volumes at 298.15 K for the following α-amino acids in aqueous sodium acetate solutions from measurements of density, glycine, DL-α-alanine, DL-α-amino-n-butyric acid, DL-valine and DL-leucine. The infinite dilution apparent molar volumes were calculated by linear extrapolations using the least-squares method. These data were used to derive the standard volumes of transfer of the amino acids from water to aqueous sodium acetate solutions. It was found that both vary linearly with increasing number of carbon atoms in the alkyl chain of the amino acids. An increase in the transfer volume and a decrease in hydration number of the amino acids with increasing electrolyte concentrations have been explained due to strong interactions of sodium acetate with the charged center of zwitterion for the amino acids compared to sodium acetate and nonpolar group interactions. The volumetric interaction parameters of the amino acids with sodium acetate were calculated in water. The pair interaction parameters are found to be positive and decrease with increasing alkyl chain of the amino acids, indicating that more hydrophobic amino acids undergo more dehydration effect of sodium acetate. A comparison of the pair interaction parameters of the amino acids with different
electrolytes has shown that acetate ion has stronger interactions than chloride and thiocyanate ions. These interactions have been rationalized in terms of the co-sphere overlap model.

Yan et al., (2001) have made an attempt to study densities and viscosities of aqueous solutions of α-amino acids (glycine, dl-alanine, dl-α-amino-n-butyric acid, dl-α-valine, and dl-α-leucine) + sodium butyrate have been measured as a function of concentrations of amino acid and electrolyte at 298.15 K. These data have been used to calculate apparent molar volumes and viscosity B-coefficients of the amino acids. The standard partial molar volumes, standard volumes of transfer and hydration numbers of the amino acids have been determined. They found that standard partial molar volumes, standard volumes of transfer and the B-coefficient vary linearly with increasing number of carbon atoms in the alkyl chain of the amino acids, and they were split into contributions from the charged end group (NH$_3^+$, COO-) and CH$_2$ groups of the amino acids. From the volumetric data, they found that sodium butyrate interacts strongly with the charged center of the zwitterion of the amino acids and has a strong dehydration effect on the amino acids.


**Arumugam (2003)** has studied ultrasonic investigation for three amino acids such as alanine, valine and leusine in aqueous sodium butyrate solution as a function of composition at different temperatures. The results are discussed in the light of weak intermolecular interactions of hydrophobic nature on the basis of evaluated acoustical parameters.

**Pal and Kumar (2004)** have reported viscometric and volumetric studies of amino acids L-glycine, L-alanine and L-valine in aqueous urea solutions ranging from 5 to 25% urea by mass. The values of apparent molal volume, limiting apparent molal volume and relative viscosity have been evaluated from the density and viscosity data. The results were interpreted in the light of ion-ion and ion-solvent interactions and of structural effect of the solutes in solutions.

**Palani (2004)** made an attempt of ultrasonic velocity, density and viscosity studies for three amino acids namely Glycine, L-alanine, and L-serine in the mixture of dimethyl formamide (DMF) and water at different proportions at 298K. Using the experimental values, the adiabatic compressibility, change in adiabatic compressibility, relative change in
adiabatic compressibility, apparent molal compressibility, apparent molal volume, limiting apparent molal compressibility and molal volume and viscosity B-coefficient were calculated for all the ternary systems. The results were discussed in the light of structure-making or structure breaking effects of these amino acids in the solution.

Liu et al., (2005) have measured the enthalpies of solution of glycine, L-alanine and L-serine in water and aqueous solutions of LiNO₃, NaNO₃ and KNO₃ at 298.15 K. Enthalpies of transfer of amino acids from water to aqueous solutions of nitrate salts were derived. The effect of the ion type, concentration and structure of amino acids on the magnitude of the transfer enthalpies are discussed in terms of the electrostatic interaction and the structural hydration interaction model.

Yuan et al., (2006) have calculated the apparent molar volumes of L-alanine, DL-serine, DL-threonine, L-histidine, glycine and glycylglycine in water and in the aqueous solutions of NaCl and DMSO with various concentrations at $T = 298.15$ K from density. The calculated partial molar volumes at infinite dilution have been used to obtain corresponding transfer volumes from water to various solutions. The experimental results show that the standard
partial molar volumes of the above amino acids and peptide at the dilute DMSO aqueous solutions are very close to those in water. However, the volumes show several types of variations with the increase of the concentrations of DMSO due to different types of side chain of amino acids, which were being discussed specifically. The NaCl changes considerably the infinite dilution standard partial molar volumes of the above amino acids and peptide in the aqueous solutions. The infinite dilution standard partial molar volumes of the each amino acids and peptide increase with the concentrations of NaCl and the experimental results have been rationalized by a co-sphere overlap model.

Banipal et al., (2007) had calculated the apparent molar volumes, of L-aspartic acid, L-glutamic acid, L-lysine monohydrate and L-arginine in water and in aqueous (0.1, 0.25, 0.5 and 1.0) mol·kg⁻¹ sodium acetate and sodium propionate, and (0.1, 0.25 and 0.5) mol·kg⁻¹ sodium butyrate solutions have been determined at 288.15, 298.15, 308.15 and 318.15K from density measurements. The partial molar volumes at infinite dilution, obtained and have been used to calculate hydration numbers and partial molar expansibilities of amino acids in water and in the presence of the studied cosolutes at different temperatures. These
parameters have been discussed in terms of various interactions between the acidic/basic amino acids and organic salts in these solutions. The effect of the hydrophobic chain length of the carboxylate ions had also been discussed.

Banipal et al., (2007) had evaluated the densities, speed of sounds and flow time of L-serine and L-threonine in different concentrations of aqueous sodium acetate and magnesium acetate solutions at $T = 298.15K$. These data are used to derive the apparent molar volumes, apparent molar adiabatic compressibilities, relative viscosities, partial molar volumes, partial molar adiabatic compressibilities (at infinite dilution) and viscosity B-coefficients. The activation free energy for viscous flow has been calculated for L-serine and L-threonine in aqueous solutions. The hydration numbers, $n_H$, side chain contributions and interaction coefficients have also been calculated. It was noticed that the influence of magnesium acetate on the transfer properties is greater than sodium acetate in aqueous solutions. A comparison of transport properties values for L-serine and L-threonine with the reported data for DL-$\alpha$-alanine and DL-$\alpha$-amino-n-butyric acid in aqueous sodium acetate and magnesium acetate solutions shows that the values are greater for
L-serine and L-threonine at the same concentration of sodium acetate and magnesium acetate.

Akhtar (2007) had determined densities and viscosities of L-proline and L-glutamine in aqueous metal electrolytes solution containing 0.06 and 0.10 M Cu II nitrate and Ni II chloride at 308 K. From the density and viscosity, the apparent molar volume, relative viscosity, transfer volume at infinite dilution, free energy of activation of viscous flow of solvent and solute were calculated. The partial molar volume, at infinite dilution, Falkenhagen, A and Jones–Dole coefficient, B, were also calculated by least-square method. The results are discussed in terms of the dehydration effect of the electrolyte upon the amino acids. The properties of these amino acids in water and water + electrolytic systems are discussed in terms of the charge, size and hydrogen bonding effect.

Palani and Saravanan (2008) attempted to calculate the speed of sound, density and viscosity for L-glutamine, L-lysine and L-arginine in aqueous magnesium acetate (0, 0.5 and 1 mol kg\(^{-1}\)) at 298.15K. Using these data, they evaluated adiabatic compressibility (\(\beta\)), molal hydration number (\(n_H\)), apparent molal compressibility (\(\varphi_k\)), apparent molal volume (\(\varphi_v\)), limiting apparent molal compressibility (\(\varphi_k^c\)) and its
related constant \((S_k)\), limiting apparent molal volume \((\varphi_v^0)\) and its related constant \((S_0)\), and Viscosity-B coefficients of Jones-Dole equations. They interpreted their results in the light of ion-solvent and ion-ion interactions occurring in these liquid systems.

**Thirumaran and Job Sabu (2009)** made an attempt of ultrasonic velocity, density and viscosity studies for four amino acids namely L-alaline, L-leucine and L-valine and L-proline in aqueous sodium acetate medium at 303, 308 and 313K. Using the experimental values, the adiabatic compressibility, change in adiabatic compressibility, relative change in adiabatic compressibility, apparent molal compressibility, apparent molal volume, limiting apparent molal compressibility and limiting apparent molal volume and viscosity B-coefficient were determined for all the systems. They discussed their results in the light of structure-making or structure breaking effects of these amino acids in the mixture. They eventually observed that L-leucine is an effective structure-maker in aqueous sodium acetate solution than other three amino acids.

**Thirumaran and Kannappan (2009)** had measured ultrasonic velocity, density and viscosity for the three amino acids L-arginine, L-lysine and L-histidine in aqueous sodium
butyrate solution at 303, 308 and 313K. Using these acoustical parameters such as adiabatic compressibility, apparent molal compressibility, apparent molal volume, limiting apparent molal compressibility and limiting apparent molal volume and viscosity B-coefficient were calculated for all the systems. The results were discussed in the light of structure-making or structure breaking effects of these amino acids in the mixture.

Palani and Reeginal (2010) calculated density, viscosity and ultrasonic velocity for L-glutamine, L-asparagine and L-lysine in water and aqueous glycerine (0, 0.5 and 1 mol) at 303.15 K. These measurements have been performed to evaluate some acoustical parameters such as adiabatic compressibility, molar hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and their constants, transfer volume and viscosity A and B coefficients of Jones Dole equation. They interpreted their results in terms of solute-co-solute and ion-solvent interactions.

Palani et al., (2010) made an attempt of ultrasonic velocity, density and viscosity studies for three amino acids namely L-asparagine, L-histidine and L-lysine in aqueous K₂SO₄
solution (0.5M) at 303.15K. Using the experimental values, they evaluated adiabatic compressibility, change in adiabatic compressibility, relative change in adiabatic compressibility, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility and molar volume and their constants and viscosity B-coefficient were calculated for all the systems. They analyzed their results in the light of ion-ion and ion-solvent interactions occurring in the mixture.

Riyazuddeen and Usmani (2011) have determined densities and speeds of sound of (L-alanine + 1 mol.L⁻¹ aqueous glucose/1 mol.L⁻¹ aqueous sucrose) and (L-threonine + 1 mol.L⁻¹ aqueous glucose/ 1 mol.L⁻¹ aqueous sucrose) systems have been measured as a function of molal concentration of L-alanine and L-threonine at temperatures: (298.15, 303.15, 308.15, 313.15, 318.15 and 323.15) K. The partial molar volumes, transfer partial molar volumes, partial molar isentropic compressibilities and transfer partial molar isentropic compressibilities have been evaluated. The trends of variations of experimental and computed parameters have been discussed in terms of ionic–hydrophilic, hydrophilic–hydrophilic and hydrophilic–hydrophobic interactions operative in the systems.
Thirumaran and Mary Christina Gardilya (2011) had reported density, viscosity and ultrasonic velocity have been carried out on the amino acids, namely, L-valine, L-lysine and L-histidine with various molar concentrations in aqueous magnesium acetate solution in different molarities (0M, 0.4M & 0.8M) at a temperature of 306.15K. Using these experimental values, the acoustical parameters such as adiabatic compressibility, molar hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and the constants at infinite dilution were evaluated. Transfer Volume at infinite dilution from water to aqueous magnesium acetate solutions has been determined. In addition, Viscosity A and B coefficients of Jone-Dole equation have also been evaluated and these parameters have been critically analyzed and emphasizing the possible interionic interactions such as ion-ion, solute-solvent, ion solvent, solute-co-solute etc., and discussed in terms of structure-making and structure-breaking effects of the amino acids in the solvent mixture.

Thirumaran and Prakash (2012) had measured ultrasonic velocity, density and viscosity for the amino acids L-alanine, L-leucine, L-valine and L-proline in aqueous magnesium
acetate solution under two different molarities (0.5 and 1M) at 301.15K. Using these experimental values, the acoustical parameters such as adiabatic compressibility, molar hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and their constants, transfer Volume and Viscosity B coefficients of Jone-Dole equation were critically analyzed and discussed in terms of structure-making or structure-breaking effects of these amino acids in the aqueous magnesium acetate mixture.

Anil kumar Nain and Renu pal (2013) had measured density of L-theronine in water and in aqueous glucose solvent (5, 10, 15 and 20% of glucose w/w in water) at T= (293.15, 298.15, 303.15, 308.15, 313.15 and 318.15) K and viscosities, of these solution at (298.15, 303.15, 308.15, 313.15 and 318.15) K at atmospheric pressure. From these experimental results, the apparent molar volume, limiting apparent molar volume, and the slope, Sv, transfer volume, Falkenhagen coefficient (A), Jones–Dole coefficient (B), temperature derivative of B-coefficients, dB/dT, Gibbs free energies of activation of viscous flow per mole of solvent, and hydration number nH were calculated. The results are interpreted in terms of solute–solvent and solute–solute
interactions in these systems. It has been observed that there exist strong solute-solvent interactions in these systems, which increase with increase in glucose concentration. It is also observed that L-threonine acts as structure-breaker in these aqueous-glucose solvents. The thermodynamics of viscous flow are also discussed.

**Thirumaran et al., (2013)** had measured ultrasonic velocity, density and viscosity for the ternary mixture of aqueous sucrose in alkali metal halides namely potassium chloride, potassium bromide, potassium iodide and sodium chloride at 303.15K, 308.15K and 313.15K. Using these experimental values, the acoustical parameters such as adiabatic compressibility, molar hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume and the constants at infinite dilution were evaluated. Transfer Volume and Viscosity A and B coefficients of Jone-Dole equation have also been evaluated.

**Sudhakar S. Dhondge et al., (2013)** have determined the values of density (ρ) and speed of sound (U) in aqueous solutions of L-threonine, L-valine and L-arginine at $T = (275.15, 279.15 \text{ and } 283.15)$ K. The derived parameters,
apparent molar volume of solute, isentropic compressibility of solution, apparent molar compressibility of solute in dilute aqueous solutions of L-threonine, L-valine and L-arginine have been computed using values of density and speed of sound (U). The limiting values of apparent molar volume of solute apparent molar isentropic compressibility of solute and apparent molar expansivity are also obtained. The results are discussed in the light of solute-solvent interactions, and structure making and structure breaking abilities of the solute in aqueous medium.

Harsh kumar et al., (2014) made an attempt for the viscosities ($\eta$) of L-alanyl-L-alanine (Ala-Ala), L-alanyl-L-valine (Ala-Val), L-alanyl-L-leucine (Ala-Leu) with drug ampicillin (AMP) as a function of temperature at $T = (305.15, 310.15$ and $315.15)$ K. The change in viscosity of dipeptides with increase in AMP concentration and temperature is attributed to dipeptide – AMP interactions. The viscosity $B$-coefficients and viscosity interaction parameters obtained from Jones–Dole equation and transition state theory respectively have been discussed to interpret interactions between ions of dipeptides and ampicillin.
Anil Kumar Nain et al., (2014) had studied the density, $\rho$ and ultrasonic speed, $u$ of solutions of l-phenylalanine in aqueous-carbohydrate solvents (2.5 and 5% of arabinose/glucose/sucrose, w/w in water) at $T = (293.15, 298.15, 303.15, 308.15, 313.15, \text{and } 318.15)$ K; and viscosities, $\eta$ of these solutions at (298.15, 303.15, 308.15, 313.15, and 318.15) K and at atmospheric pressure. From these experimental results, the apparent molar volume, limiting apparent molar volume, and the slope, transfer volume, apparent molar compressibility, limiting apparent molar compressibility, and the slope, transfer volume, transfer compressibility, limiting apparent molar expansivity, Hepler's constant, Falkenhagen Coefficient, $A$, Jones–Dole coefficient, $B$ and hydration number were calculated. The Gibbs free energies of activation of viscous flow per mole of solvent, and per mole of solute, entropies, and enthalpies of activation of viscous flow were also calculated and discussed in terms of transition state theory. The structure-making/breaking ability of the amino acid has also been discussed. The results have been interpreted in terms of solute–solvent and solute–solute interactions in these systems.
**Souto et al., 1999** have measured the density and sound velocities at room temperature in the ternary borate glasses, B$_2$O$_3$-xLi$_2$O-yLinX ($n = 1$ for X = F, Cl, Br and I; and $n = 2$ for X = SO$_4$), as a function of the concentration for the different ‘doping’ salts (LinX). Two series of ternary glasses with different ratios, $x=0.2$ and 0.6, have been studied. In both series, a structural model where the anion of the ‘doping’ salts are located in interstitial positions inside the boron–oxygen network is used to explain the experimental results in borate glasses ‘doped’ with LiCl, LiBr and LiI. In the case of glasses ‘doped’ by LiF or Li$_2$SO$_4$, there is evidence of a direct participation of the salt anions to the boron–oxygen network. A structural modification is proposed for the LiF-'doped’ borate glasses with $x = 0.2$ and 0.6. Changes in the medium-range order induced by the addition of ‘doping’ salts are also discussed in these ternary glasses.

**Vijoy et al., 2001** has studied (1-x-y)(B$_2$O$_3$)-x(Li$_2$O)-y(MCl$_2$), (M = Cd,Zn) glasses of different compositions. The ultrasonic velocities (both longitudinal and transverse) were measured at 5 MHz at room temperature using the pulse echo overlap method. Various parameters, viz., elastic constants, acoustic impedance and Poisson’s ratio were evaluated. The
variations in these parameters are analyzed in terms of the structural changes of the glasses with composition.

Rajendran et al., 2002 have prepared bioactive glasses of the system SiO$_2$–Na$_2$O–CaO–P$_2$O$_5$ by the normal melting and annealing technique. The elastic moduli, attenuation, Vickers hardness, fracture toughness and fracture surface energy have been obtained using the known method at room temperature. The temperature dependence of elastic moduli and attenuation measurements has been extended over a wide range of temperature from 150 to 500 K. The SiO$_2$ content dependence of velocities, attenuation, elastic moduli, and other parameters show an interesting observation at 45 wt% of SiO$_2$ by exhibiting an anomalous behaviour. A linear relation is developed for $T_g$, which explores an influence of Na$_2$O on SiO$_2$–Na$_2$O–CaO–P$_2$O$_5$ bioactive glasses. The measured hardness, fracture toughness and fracture surface energy show a linear relation with Young’s modulus. It is also interesting to note that the observed results are functions of polymerisation and the number of non-bridging oxygens (NBO) prevailing in the network with change in SiO$_2$ content.
Rajendran et al., (2003) have studied tellurite containing vanadate (50-x) V$_2$O$_5$-xBi$_2$O$_3$-50TeO$_2$ glasses with different bismuth (x=0, 5, 10, 15, 20 and 25 wt %) content have been prepared by rapid quenching method. Ultrasonic velocities (both longitudinal and shear) and attenuation (for longitudinal waves only) measurements have been made using a transducer operated at a fundamental frequency 5MHz in the temperature range from 150 to 480 K. The elastic moduli, Debye temperature and Poisson’s ratio have been obtained both as a function of temperature and Bi$_2$O$_3$ content. The room temperature study on ultrasonic velocities, attenuation, elastic moduli, Debye temperature, Poisson’s ratio and glass transition temperature show the absence of any anomalies with addition of Bi$_2$O$_3$ content.

Yasser B. Saddeek (2004) have studied the system (75 - x) B$_2$O$_3$-xBi$_2$O$_3$-25Li$_2$O, where x = 5, 10, 15, and 20 mol% by using pulse-echo technique. Elastic properties of the glass system have been calculated together with Poisson’s ratio and Debye temperature from the measured densities as well as longitudinal and shear ultrasonic velocities at room temperature. Ultrasonic velocity measurements were taken at 4 MHz. Estimated parameters based on Makishima–
Mackenzie theory and bond compression model were calculated in order to analyse the experimental elastic moduli. Addition effect of Bi$_2$O$_3$ on the elastic moduli was investigated in terms of the number of network bonds and the mean cross-link density of the glass systems.

Laksminarayana et al., (2005) have prepared new series of heavy metal oxide (PbO) based zinc borate glasses in the chemical composition of (95-x) B$_2$O$_3$-5ZnO- xPbO (x = 10, 15, 20, 25, 30, 35, 40, 45 and 50 mol %). Measurements concerning X-ray diffraction (XRD), FT-IR, differential scanning calorimeter (DSC) profiles have been carried out for this glass. The FT-IR profile has revealed that the glass has both BO$_3$ and BO$_4$ units.

Abd El-Moneim et al., (2006) have investigated ternary alkaline earth aluminoborate glasses RO–Al$_2$O$_3$–B$_2$O$_3$, where R = Mg, Ca, Sr, by the normal quenching method. Ultrasonic velocities and attenuation were measured in these glasses using the pulse-echo technique to explore the structural role of RO and Al$_2$O$_3$ in these glasses. From the measured densities and velocities, various parameters such as elastic moduli, microhardness and Poisson’s ratio have been
determined. Makishima and Mackenzie theory has been applied to correlate the experimental and theoretical data and good correlation was observed.

Veeranna gowda et al., (2007) have investigated Pseudo-binary sodium borate glasses containing \((1 - y) \text{Na}_2\text{B}_4\text{O}_7-y\text{MaOb}\) (where \(\text{MaOb} = \text{PbO, B}_2\text{O}_3\) and \(\text{TeO}_2\)) \((y = 0.25, 0.5, 0.67\) and \(0.79\)). Sound velocities (longitudinal and shear) have been measured at 10 MHz frequency using quartz transducers. Density, Elastic moduli, Poisson’s ratio and Debye temperature have been calculated. Glass transition temperatures have also been determined.

Narayana Reddy et al., (2008) have prepared the glass system \(\text{Li}_2\text{O} - \text{B}_2\text{O}_3 - \text{V}_2\text{O}_5\) over a wide range of composition. Sound velocities (both longitudinal and transverse) have been measured using a pulse echo superposition method at a frequency of 10MHz at room temperature. Compositional dependence of various elastic moduli, Poisson’s ratio and Debye temperature has been studied as a function of \(\text{Li}_2\text{O}\) and \(\text{V}_2\text{O}_5\) concentrations. In general, the moduli increase with the inter-substitution of \(\text{Li}_2\text{O}/\text{V}_2\text{O}_5\). However, glasses with high \(\text{Li}_2\text{O}\) (>45 mol %) the moduli tend to decrease. The
variation in Poisson’s ratio and Debye temperature shows that these glasses are mainly made up of covalently bonded network and are insensitive to shear stress. The results have been analyzed based on the structure of boro-vanadate glasses.

**Pascuta et al., 2008** have been utilised FTIR spectroscopy on xGd$_2$O$_3$ (100-x)[2Bi$_2$O$_3$·B$_2$O$_3$] system with 0 ≤ x ≤ 25 mol% in order to point out the effect of Gd$_2$O$_3$ addition in the bismuth-borate glass matrix. The FTIR spectroscopy data suggest that the gadolinium ions play the network modifier role in the studied glasses. These data show that the glass structure consists on the BiO$_6$, BO$_3$ and BO$_4$ structural units, and the conversion among these units mainly depends on the Gd$_2$O$_3$ content.

**Gaafar et al., (2009)** Glasses in the system (95-x) [0.25 Na$_2$O-0.75 B$_2$O$_3$]-x P$_2$O$_5$-5 Fe$_2$O$_3$ have been prepared by the melt quenching technique. Elastic properties and FT-IR spectroscopic studies have been employed to study the role of P$_2$O$_5$ on the structure of the glass system. Elastic properties Poisson’s ratio, micro-hardness and Debye temperature have been investigated using sound wave
velocity measurements at 4MHz (both longitudinal and shear) at room temperature. The results showed that the density and the molar volume increase as both sound velocities and the determined glass transition temperatures decrease with increasing contents of P2O5. Infrared spectra of the glasses reveal that the borate network consists of diborate units and is affected by the increase in the concentration of P2O5 content as a second network former. These results are interpreted in terms of the replacement of the diborate units with B–O–B bridges by phosphate units with non-bridging oxygens (NBOs). Therefore, the elastic moduli are observed to decrease with the increase in P2O5 content.

Venkata Subba Reddy (2009) have measured the sound velocities and the elastic properties of Na2O-B2O3—V2O5 glasses over a wide range of composition. Sound velocities (transverse and longitudinal) have been measured using a pulse echo superposition method at a frequency of 10 MHz. The elastic moduli Poisson’s ratio and Debye temperature exhibit composition dependent trends. The variation of these parameters has been explained using a structural motifs present and the dimensionally of the glass network.
Kaundal et al., (2010) Glasses of the system PbO–SrO–B$_2$O$_3$ with the value of molar ratio $R$(PbO/B$_2$O$_3$) in the region 0.14 ≤ $R$ ≤ 2.0 were prepared using the melt quenching technique. In order to evaluate gamma ray shielding properties for glass samples, mass attenuation coefficients have been calculated with the XCOM computer program. The longitudinal velocities of ultrasonic waves were measured in the glass samples at room temperature using the pulse echo technique. The results indicate that with increase in $R$ value, stability of glass network decreases. Stability of glass network decreases indicating an increase in the number of boron with non-bridging oxygen at the expense of decrease of tetrahedral borate units. This feature may lead to open glass structure with lesser rigidity of the glass samples. DSC studies have been under taken to measure the glass transition temperature and to get an idea about stability of the glass network with increasing $R$ value.

H. Doweidar et al., (2010) have investigated $x$La$_2$O$_3$–30PbO–(70–$x$)B$_2$O$_3$ (0 ≤ $x$ ≤ 10 mol%) glasses by Fourier Transform Infrared Spectroscopy, and Ultrasonics. Deconvolution of infrared spectra reveals a small increase with $x$ in the
fraction of four-coordinated boron atoms. These results show that La$^{3+}$ ions have priority to form BO$_4$ units at the expense of Pb$^{2+}$ ions. A minimum in the sound velocity, elastic properties and transition temperature of glasses observed at 5 mol% La$_2$O$_3$ is correlated with the change in the packing of glass. Higher rate of increase in density for $x \geq 5$ mol% is considered due to an increase in the concentration of PbO$_4$ units.

Yasser B. Saddeek (2011) have prepared the glasses of $x$ B$_2$O$_3$ 25 Li$_2$O (75−$x$) Bi$_2$O$_3$, (0≤$x$≤75 mol %). The elastic moduli of glasses have been investigated using ultrasonic velocity measurements at 4 MHz. The results revealed an increase of the ultrasonic velocity and Debye temperature with the increase of the B$_2$O$_3$ content. Also, the increase of the elastic moduli with the increase in the B$_2$O$_3$ content is affected with the increase in the dissociation energy, the average cross-link density, the increase of the number of bridging oxygen atoms, and the substitution of high bond strength B\O with low bond strength Bi\O. The optical properties such as the refractive index, the energy gap and the optical polarizability were evaluated from the values of the elastic moduli.
Gurinder Pal Singh et al., (2011) have investigated glass samples of compositions $xV_2O_5-(20-x)$ $MnO_2\cdot20PbO\cdot60B_2O_3$ with $x$ varying from 0 to 15 % by melt quench technique. The structural analysis of glasses is carried out by X-ray diffraction, Fourier Transform Spectroscopy and density measurement techniques. The FTIR spectral studies have pointed out the conversion of structural units of $BO_3$ to $BO_4$ with the presence of $VO_4$ and $VO_5$ structural units of vanadium in these glasses. Due to the formation of $BO_4$ groups, an increase in density from 3.52 to 4.33 $g\cdot cm^{-3}$ for $MnO_2\cdot PbO\cdot B_2O_3$ glasses is observed with an increase in $V_2O_5$ content.

G.E. El-Falaky et al., (2012) have investigated the borate glasses $(1 - x)[29Na_2O - 4Al_2O_3 - 67B_2O_3] - x ZnO$ with $(x \frac{1}{4} 0, 5, 10, 15, 20, 25, 30, \text{ and } 35 \text{ mol\%})$, using the melt quenching technique. The longitudinal ultrasonic attenuation of the prepared sample has been measured using the pulse echo technique at ultrasonic frequencies 2, 4, 6 and 8 MHz in the temperature range between 160 and 300 K. The results showed well defined peak whose position shift toward higher temperature with increasing frequency. The dependence of ultrasonic attenuation on
temperature has been interpreted in terms of a thermally activated relaxation process which arises when ultrasonic waves disturb the equilibrium of an atom moving in a double-well potential in the glass network. The dependence of activation energy on composition suggests that the structure of these glasses changes at 15 mol% ZnO concentration.

Gurinder Pal Singh et al., (2012) have been synthesized xV₂O₅–xCeO₂–(30-x)PbO–(70-x) B₂O₃ glasses by using the melt quench technique. The undertaken studies such as X-ray diffraction, density, molar volume, optical band gap, refractive index and Fourier Transform Spectroscopy are employed to characterize the glasses. FTIR spectroscopy reveals that incorporation of V₂O₅ in glass network helps to convert the structural units of [BO₃] into [BO₄]. At higher concentration of vanadium, vibration of [VO₅] structural units and V–O–V vibration are present. The bond iconicity of glasses increases with incorporation of V₂O₅ contents.

Thirumaran and Jayakumar (2013) have prepared Semi conducting vanadium glasses with different V₂O₅ contents by rapid quenching technique. Ultrasonic velocities
measurements have been performed over a wide range of temperatures from 1020-1060K. Elastic moduli, Debye temperature and poisson’s ratio have been obtained for different V$_2$O$_5$ contents as a function of temperature. The composition dependence of velocities shows a monotonic variation with the addition of V$_2$O$_5$. Ultrasonic velocity measurements (longitudinal and shear velocities) were carried by using pulse-echo technique at 5 MHz frequency showing that the ultrasonic velocity and the glass density are sensitive to the glass composition and behave identically to each other. The X-Ray Diffraction (XRD), FT-IR spectroscopy and Scanning Electron Microscopy (SEM), studies have been employed. Eventually the results are discussed with a view to establish the structural characterization, compactness and mechanical properties of the glass samples.

Vasantharani and Sangeetha (2013) has prepared the glass samples xPbO-(100-x) B$_2$O$_3$ (x = 35, 40, 45, 50 and 55 mol%) and (65-x) PbO-35B$_2$O$_3$-xCuO(x = 10, 15, 20, and 25 mol%) using melt quenching technique. Elastic properties, FT-IR spectroscopic study, X-ray diffraction study and Scanning
electron microscopic study have been employed to the glass system.

**Laila et al., 2013** had attempted to study about the elastic properties of lead vanadate \((55-x) \text{V}_2\text{O}_5-45\text{PbO}-(x)\text{ZnO}\) glasses using ultrasonic velocity measurements by pulse-echo-overlap technique at room temperature. Results from the study showed that both longitudinal and shear velocities decreased at \(x = 5\) mol\% with the increase of ZnO concentration. The independent longitudinal and shear moduli, CL and \(\mu\) and Young’s modulus (Y) also showed decreasing trend at \(x = 5\) mol\% as the fraction of ZnO increases.

**Gaura Gupta et al., 2014** have investigate the influence of bismuth addition on structural, elastic and spectral properties of \([99.5-x) \{4\text{ZnO}-3\text{B}_2\text{O}_3\} -0.5\text{Nd}_2\text{O}_3-x \text{Bi}_2\text{O}_3\) where \(x = 0, 5, 10, 20, 30, 40, 50\) and \(60\) glasses. The measured FTIR reflectance spectra facilitated a thorough insight of methodical modifications that are arising in the glass structure from borate (build by \(\text{BO}_3\) and \(\text{BO}_4\) units) to bismuth ate (\(\text{BiO}_3\) and \(\text{BiO}_6\) units) network due to the increase of bismuth content ensuing with a steady decrease
in host phonon energy ($V_{ph}$). The elastic properties estimated from measured longitudinal and shear ultrasonic velocities ($U_l$ and $U_s$) demonstrated the reduction in network rigidity of glasses on Bi$_2$O$_3$ inclusion. The three phenomenological Judd–Ofelt intensity parameters ($\Omega_2, 4, 6$) were obtained from recorded absorption spectra of Nd$^{3+}$ ions in these glasses and have been used to predict radiative properties as a function of variation in bismuth content.