ABSTRACT

Introduction:

Ultrasonic is an area of intense scientific and technological research. During the last few decades, ultrasonic study of liquid mixtures has gained much importance in studying the nature of molecular interactions and investigating the physicochemical behavior of ion-solvent interactions. Ultrasonic waves have acquired the status of an important probe for the study of structure and properties of matter. The use of ultrasound is one of the well recognized, approaches for the state of the liquid and molecular interaction. The structural arrangement is influenced by the shape of the molecules as well as by their mutual interaction. Science and technology of ultrasonic is widely used for the industrial, medical imaging, cancer treatment and extraction of enzymes applications. The study of behavior of propagation of ultrasonic waves in liquid system is effective for examining certain physical properties of the solvents. The nature and relative strength of the molecular interaction between the components of the liquid mixtures have been successfully investigated by the ultrasonic method. These interactions help in better understanding the nature of the solute and solvent i.e. whether the solute modifies or distorts the structure of the solvent. Organic solvents are constantly present in the pharmaceutical production processes. Ultrasonic investigations of liquid mixtures consist of polar and non-polar components are of considerable importance in understanding intermolecular interactions between the component molecules and find applications in several industrial and technological processes. Ultrasonic technique has been employed to investigate the properties of any substance to understand the nature of molecular interactions in pure liquid, liquid mixtures, solutions, aqueous, non aqueous and mixed electrolytic solution etc have led to new insights into the process of ion-ion and ion-solvent interaction. The growing interest in the study of the thermodynamic properties and intermolecular interactions of drug is due to the fact that these interactions are the key to understand the structural and characteristics property of drug molecules. A number of researchers have investigated the molecular interaction in aqueous solution of different antibiotics in the recent years. Structure affecting behavior of antidiabetic drug Metformin Hydrochloride was studied by U. D. Chapke at 300.15 K. The existence of solute-solvent and solute-solute interactions resulting in attractive forces promote the structure making tendency of the antioxidant ascorbic
acid studied by Arti Gupta. Acoustic and volumetric properties of aqueous solution of levofloxacin nickel complexes were measured by Monalisa Das. Aqueous combiflame system was studied by Poonam Sharma to investigate molecular interaction present in system. Recent literature on the volumetric and acoustical properties of drugs and other materials of biological importance shows increasing interest by many workers in this area of study. The literature review of the work done on ultrasonic velocities, densities and viscosities in liquid media confirms the view that they are certainly important physical parameters. In recent year ultrasonic tool is used to study physicochemical interactions in drugs. Physicochemical studies on molecular interactions of curcumin with mono and divalent salts at different salts at different temperature were carried out by Archana Pandey to study the molecular interaction of antioxidant with metal ions. In some recent publications, efforts have been made to correlate biological activity with calculated physical parameters with the help of densities and ultrasonic velocity for mixtures at different temperatures. But a molecular interaction study of the metal ions with antioxidants has not been investigated so far. Therefore the present investigation reports on intermolecular interactions of Piper Nigrum with metal ions ZnCl2 and MgCl2. The interaction of ions and antioxidants provide important information about mechanism of their metabolism in living system and play a key role in the wide range of biochemical process such as immunology, biosynthesis, pharmacology and medicine.

Drug used for the present investigation is Piper Nigrum. The main chemical constituents of Piper Nigrum is the alkaloid piperine (a trans-trans isomer of 1-piperoly piperidine), which has many pharmacological properties. Zn++ ions play major role in digestive and Mg++ in respiratory system. The drug Piper Nigrum used in the treatment of digestive and respiratory system. Therefore Zn++ and Mg++ ions are selected to study the interaction with Piper Nigrum as an antioxidant.

Molecular interaction studies of the metal ions like Zn++ and Mg++ with antioxidant drugs Piper Nigrum will be useful in understanding the mechanism of action of antioxidants in the living system. To interpret the physicochemistry of biological systems, it is essential to examine the properties of drug with metal ions. Only a few physicochemical studies of antioxidant herbal drugs have been outlined so far. Therefore, we have undertaken a systematic study on the ultrasonic investigation of an antioxidant ethanolic extract of Piper Nigrum with zinc chloride and magnesium chloride to investigate interactions present in that system. A vital role is played by
drug–metal ion interactions in all the metabolic pathways or biological processes occurring inside the body. Studies of such interactions led to modern drug discovery.

From the experimental values of ultrasonic velocity (U), density (ρ) and viscosity(η) other derived parameters like adiabatic compressibility (β), intermolecular free length (Lf), acoustic impedance (Z), relaxation time (τ) can be calculated.

**Piper Nigrum + ZnCl₂:**

Ultrasonic velocity (U) increases with increase in concentration of *Piper Nigrum* in ZnCl₂. The increase in ultrasonic velocity can be attributed to increase in molecular interaction between *Piper Nigrum* and zinc metal ion. Thus, ultrasonic velocity decreases with increase in temperature for ZnCl₂ and *Piper Nigrum* molecules. The density decreases with increase in concentration of *Piper Nigrum* in ZnCl₂. The decrease in density can be attributed to increase in molecular interaction between *Piper Nigrum* and zinc metal ion. Viscosity decreases with increase in temperature suggests as temperature of the solution increases the ordered structure of molecules breaks and therefore more spacing is formed between the Zn²⁺ ions and *Piper Nigrum* molecules.

The adiabatic compressibility decreases with increase in concentrations of *Piper Nigrum* where as increases with increase in temperature. Intermolecular free length of solution increases with increase in temperature. The increase in specific acoustic impedance may be due to increase in molecular interaction between *Piper Nigrum* and zinc metal ion. The increase in relaxation amplitude with concentration and reverse with temperature can be attributed to increase in molecular interaction between *Piper Nigrum* and zinc metal ion. Viscous relaxation time increases with increase in concentration and decrease with increase in temperature of drug *Piper Nigrum*

**Conclusion:**

The present study of molecular interaction of ZnCl₂ and antioxidant *Piper Nigrum* using ultrasonic investigation provides important information about the physiological system and used to understand the mechanism of their metabolism in the living system. It can be concluded from the above study that the interferometer technique requires minimum efforts. It is a direct method and has its own identity and significance in material science, which can gives an idea about effectiveness of solvent. Change in temperature affects compressibility of solution, which in turn affects molecular interaction in liquid mixtures and solutions. Structural relaxation process occurs and in such a situation molecules gets rearranged due to co-operative
process. When drug is added in Zn\(^{++}\) ion solution, ions attracted certain drug molecules towards it by moving with a violent twist in the bulk of ions due to the force of electrostriction. Thus, the conclusion drawn from all the studies is that the studied drug Piper Nigrum when added in ethanolic Zn\(^{++}\) mixtures act as structure breaker for the system as a function of temperature. Calculated acoustic and thermodynamic parameters also support the existence of drug solvent interactions.

The results obtained from these studies can thus be helpful for pharmacological applications of drugs as well as to understand formokinetic processes such as transport of drug across biological membranes, drug action and physicochemical properties. Complex formation produces displacement of electrons and drug molecules. The chemical interaction may involve the association due to solute-solvent and ion-dipole interaction or due to the formation of charge-transfer complexes.

**Piper Nigrum + MgCl\(_2\):**

At all temperatures the values of ultrasonic velocity of MgCl\(_2\) + Piper Nigrum increases with increase in concentration and decreases with increasing temperature. Density decreases sharply, reaches a maximum decrease for concentration around n = 2.8036, and then increases. Increasing temperature causes a density decrease and shifts the concentration of maximum density towards number of moles (n) of drug values. Decreasing trend suggests the existed intermolecular interaction becomes weak with increasing concentration. As the temperature increases the values of η shows the decreasing trend which suggests the structure breaking tendency of Mg\(^{++}\) ions with Piper Nigrum molecules. Viscosity decreasing trend with rise in temperature suggests as temperature of the solution increases the ordered structure of molecules breaks.

The adiabatic compressibility decreases suggesting interaction between Piper Nigrum in MgCl\(_2\) molecules. Intermolecular free lengths show the decreasing trend as reflected by adiabatic compressibility (β). Intermolecular free length increases with increase of temperature this confirms the decrease of intermolecular forces due to thermal agitation. At concentration n = 3.5045 relaxation amplitude (α/\(f^2\)) decreases for all temperature. Relaxation time increases with increase in concentration except n= 3.5045 and decreases with temperature. At concentration n = 3.5045 relaxation time (τ) and relaxation amplitude (α/\(f^2\)) both decreases for all temperature.
Conclusion:
This system gives evidence of presence of ion-dipole interactions between MgCl₂ + Piper Nigrum system which are investigated as a function of concentration and temperature. It is also observed that the acoustic parameters are highly affected by change in concentration and temperature. Thus, it can be concluded that in describing the thermal and acoustic parameters plays a vital role in unlike molecules. Molecular association becomes maximum, reflected by ultrasonic investigation. When drug is added in Mg²⁺ ion solution, ions attracted certain drug molecules towards it by moving with a violent twist in the bulk of ions due to the force of electrostriction. Thus, the conclusion drawn from all the studies is that the studied drug Piper Nigrum when added in ethanolic Mg ++ mixtures act as structure breaker for the system as a function of temperature. On the basis of experimental and thermo acoustic parameters, it is concluded that there is existence of ion - dipole interaction and charge transfer between the unlike molecules in the liquid mixture of drug Piper Nigrum and MgCl₂.

Ms. Nalle Pallavi. B.  Dr. R. G. Dorik
(Research Student)            (Research Guide)