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Ultrasonic Characterization of different Polymers and Organic Liquids : A Review

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ABSTRACT

A review on ultrasonic characterization of different polymers and organic liquids gives a perception into the physico-chemical and thermal properties of base liquid. In this present review we have reviewed some research papers for understanding the same. Several acoustical parameters like Adiabatic compressibility (β), acoustic impedance (Z), relaxation time (t), ultrasonic attenuation (α / f^2), free path length (L_f) have been evaluated. From the experimental values of ultrasonic velocity (v), densities (d) and viscosity of base liquids and the investigation about ultrasonic techniques gives an information and idea to understand the molecular responses and intermolecular arrangement of liquids and polymers. The ultrasonic interferometer is used for measuring the ultrasonic velocity while Ostwald viscometer and Pyknometer (specific gravity bottle) are used to determine the viscosity and density respectively.

Keywords: Ultrasonic velocity, Adiabatic compressibility, Acoustic impedance, Relaxation time, Ultrasonic attenuation

I. INTRODUCTION

This review paper consists the ultrasonic technique as an alternate to characterize polymers and organic liquids over other standard techniques. The current review presents ultrasonic technique as more systematic, malleable and appropriate perspective for characterization and fulfills the requirements of industries. Sound velocity measurements are always been attracted due to their various applications, particularly for the chemical industry. Understanding of the sound velocity and its variants are exceptionally useful in characterizing liquids such as electrolytes and organic solutions (Semwal H. K. et al 2015).

In modern years the quantification of ultrasonic velocity has been appropriately worked in consideration of the nature of molecular interconnection in pure liquid and liquids mixture. Ultrasonic parameters submit precious information regarding the behavior of the molecules in liquid system, because intermolecular and intermolecular association, dipolar interaction, complex formation and related structure change and affects the compressibility of the system (Bhatt S. C.et al 2010).

The intermolecular force is a function of the concentration of liquid and temperature but variation in the temperature shows more effect than concentration. At the low concentration there may be less numbers of hydrogen bond and at high concentration there may be more numbers of hydrogen bond (Hariharakrishnan V. et al 2015).

This paper consists the study about molecular behavior in single organic liquid, binary and ternary mixtures of some organic liquids and in polymers. "The investigations regarding The molecular interaction in some organic ternary liquid mixtures as explained (Geetha P. et al 2010).

II. Physico-Chemical Properties

Ultrasound develops physical and chemical changes in a liquid medium and produced destruction of cavitations bubbles. Ultrasound is propagated through a series of rarefaction and compression waves induced in the molecules of the medium through which it passes (Puri S. et al 2013).

Polyvinydene floride (PVDF) has a semicrystalline and a simple chemical structure. PVDF has ferroelectric and piezo, pyro quality. These qualities have vast use in device applications like as sonar instruments, solar cells, ultrasound transducers, nonvolatic memory, sensors, actuators. The literature in PVDF helps us to realize the "effect of concentration and nature of solvents on molecular interconnection in polymer solution" (Kulkarni S. S. et al 2016). The polymer Polyvinyl acetate (PVA) is used in adhesives (Bhatt S. C. et al 2010).

Dimethylformamide (DMF) is a polar molecule which has dipole moment as equal as nitrobenjene. When DMF relate with nitrobenzene then dipoar-dipole interaction is obtained and volume of the mixture going to decrease due to small size of N, N-DMF and linear aliphatic configuration. Nitrobenzene is comparatively complex molecule. It is non-ideal due to its polarity arising out of C-N and N-O bonds. Cyclohexane be a part of alicyclic hydrocarbon and it attracts towards an electrophile or nucleophile at normal temperature. Cyclohexane does not make strong interaction with other components of mixture because of its non-polar poperty (Praharaj M. K.et at 2013). Organic ternary liquids consists the aromatic hydrocarbon group that is highly polar (Geetha P. et al 2010). With the help of measurement of ultrasonic velocity, density and viscosity and using the formulae physico-chemical behavior of liquids can be identified (Semwal H. K. et al 2015).

Table 1. Details of Various Reviewed Parameters

S.No.	Name of liquid studied	Conc. %	Fixed freq.	T (K)	Density Kg/m^3	Viscosity NSm^{-2}	Ultrasonic velocity m/s	A.comp. (ß) X 10^{-10} ($N^{-1}m^2$)	Impadaence $Kg\ m^{-2}/s$	Free path length X 10^{-11}	References
1	PVDF in Acetone	0.2	1 MHz	…… …..	784.1	0.3672	1166.5	…… ……	……..	…….	Kulkarni S. S. et al 2015

2	Aqueous solution of Digitaline + double distilled water	0.6	2 MHz	303K	1.043	0.01064	1543	4.0291	……	1.27	Hariharakrishnan V. et al 2015
3	Isopropyl alcohol% + Benzene %+ cyclohexane %	10 20 70	1 MHz	273K	0.703	--------	1468	--------	1.032	-------	**Semwal H. K. et al 2015**
4	N-N dimethylformamide Cyclohexane Nitrobenzene	0.09 0.4 0.49	2MHz	318K	856.69	0.6459	1170.2	8.3355	1.012	5.864	Praharaj M. K. al 2013
5	Polyvinyl acetate	0.5	1 MHz	35^0 C	1023	0.00102	1020.6	9.381	10.44	-------	Bhatt S. C. et al 2010

Applications and future prospective

The details of various reviewed parameters are as shown in the above table. As observed in the reviewed research papers (as per the details shown in the table) it has been seen that:

For different regions 308.15K, 313.5K and 318.5K in the case of different binary liquids Cyclohexane, benzene, Methylebenzene, 1,2-dimethyl benzene, 1,4-dimethyle benzene and 1,4-dichlorobutane, 1,3,5-trimethylebenzene, the value of intermolecular free path length (L_f) in binary liquid decrease by increasing the mole fraction of 1,4-dichlorobutane in binary mixture at all three temperatures 308.15 K, 313.5 K and 318.5 K.

The value of Acoustic impedance (Z) increase for all the binary mixtures with 1,4-dichlorobutane at the three temperatures 308.15 K, 313.5 K and 318.5 K. Ultrasonic velocity increase by increasing the concentration of nanofluiud because of weak intermolecular force and due to surface effect and hydrogen bonding between particle and water molecules. Density and ultrasonic velocity increase by increasing the concentration because cohesive forces increase due to strong intermolecular attraction.

Intermolecular free path length (Distance between the surfaces of the adjoining molecules) deceases by increasing the velocity. Acoustical impedance (a specific property of the liquid) by increasing the concentration of liquid acoustical impedance also increase, it show strong attraction force between molecules.

At a particular frequency ultrasonic velocity in ternary liquid change with composition (not linear) but at a fix composition ultrasonic velocity increases

by increasing in the frequency in liquid mixture (Isopropyl Alcohol, Benzene and Cyclohexane).

Isentropic compressibility of ternary liquid mixture decreases by increasing the frequency and it changes with composition also.Acoustical impedance of ternary liquid slightly increases by increasing the frequency.

While ultrasonic velocity decreases by increasing the frequency for liquid mixture of N-N-Dimethyleformamide, nitrobenzene, and cyclohexane.

Due to weak interaction between unlike molecules acoustical impedance decreases by increasing frequency in N-N-Dimethyleformamide, nitrobenzene, and cyclohexane liquid mixture. Viscosity of the liquid (polyvinyl acetate) slightly decreases by increasing the temperature at fix concentration while it increases by increasing by concentration of liquid.

Ultrasonic velocity going decreases by increasing the temperature at a particular concentration while velocity increases by increasing the concentration of liquid (polyvinyl acetate).

Therefore from the above observed results from different Research papers as shown in the table as a whole, it can be stated that these findings of various research papers as reviewed will definitely help a lot to different researchers of this area.

III. CONCLUSION

For understanding the nature and strength of intermolecular force in the liquid ultrasonic technique is a important tool. Now a day's ultrasonic is a developing field for research, which has been used in the polymer as well as organic liquids for investigation and conversion. The values of acoustical parameter for polymers, single organic, liquid binary organic liquid, and ternary organic liquids has been successfully understood by reviewing the various research paper of the same area.

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