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13 PHYSICAL SCIENCES

MEASUREMENT OF ULTRASONIC VELOCITY IN PHARMACEUTICAL SOLUTIONS

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Key words: Ultrasonic velocity in liquids, Pharmaceutical solutions, Density and viscosity of pharmaceutical solutions, Structural dependence of ultrasonic velocity

ABSTRACT

In recent years, the measurement of ultrasonic velocity has been adequately employed in understanding the nature of molecular interaction in pure liquids and liquid mixtures and their strength in relation with thermo-acoustical parameters and excess thermodynamic function. The properties of liquid mixtures basically depend on its local structure, expressed in terms of packing density, free volume or radial distribution function. However this local structure depends on forces between molecules and their forms and volume of molecules. It changes with compositions. The variation of ultrasonic velocity and related parameters throw light on the structural changes associated with the liquid mixtures having weakly interacting components as well as strongly interaction components. Such studies are useful in gaining an insight into the structure and bonding of associated molecular complexes and other molecular processes. Further they play an important role in many chemical reactions due to their ability to undergo self-association with manifold internal structures.

In the present investigation we measured the density, viscosity and ultrasonic velocity in seven widely used Pharmaceutical solutions (drugs) namely Alergin (Cetirizine), Piclin, Betadine, Cital, Vensetron, Asthalin, and Xylomist to understand molecular interaction of pharmaceutical solutions. Cetirizine used for allergic rhinitis. Piclin used in the treatment for constipation, Betadine used as a disinfectant and antiseptic, Cital for used as an antioxidant in food, Vensetron used to prevent nausea and vomiting , Asthalin used to treat bronchospasm and Xylomist used in easing nasal congestion.

INTRODUCTION

Now a day the measurement of ultrasonic velocity has been effectively used in understanding the nature of molecular interaction in pure liquids and in solutions. The intermolecular and intra molecular association, dipolar interactions, complex formations and related structural changes affect the compressibility of the system which in turn produces corresponding variations in the ultrasonic velocity, for that the acoustical parameters give valuable information regarding the behavior of liquid systems. The acoustical and thermo dynamical parameters obtained in ultrasonic study show that the ion solvation accompanied by the destruction or enhancement of the solvent structure. The study of ultrasonic velocity provides lots of information about the state of solution (N.Karunanidhi, et.al. 1999). The measurement of ultrasonic velocity in a substance is now become a basic test to study the properties of the substance (S.C. Bhat, et. al. 1999). The measurement of ultrasonic velocity and the determination of acoustical parameters in the solution are of significant interest in understanding the intermolecular interactions in solute-solvent mixture (Rita Mishra, et. al. 2000 and Pankaj K. Singh, et. al. 2010). It also gives valuable information regarding the nature and strength of molecular interaction, formation of hydrogen bond etc. (V. Lalitha, et. al. 2000).

Properties of liquid –liquid mixtures are thermodynamically very important as a part of studies of thermodynamic, acoustic and transport aspects. The compositional dependence of thermodynamic properties are very useful in understanding the nature and extent of pattern of molecular aggregation resulting from intermolecular interaction between components. This type of study is very useful of characterizing the various aspects of physico chemical behavior of liquid mixtures and studying the interaction between molecules (Nikkim P.S. et. al. 1997 and Oswal S. L. et. al. 1995)

A pharmaceutical drug (medicine or medication and officially medicinal product) is a drug used in health care. Such drugs aid the diagnosis, cure, treatment, or prevention of disease. Drug therapy (pharmacotherapy) is an important part of the medical field and relies on the science of pharmacology for continual advancement and on pharmacy for appropriate management.

Pharmaceutical or drug or medicines are classified in various other groups besides their origin on the basis of pharmacological properties like mode of action and their pharmacological action or activity, such as by chemical properties, mode or route of administration, biological system affected, or therapeutic effects. An elaborate and widely used classification system is the Anatomical Therapeutic Chemical Classification System (ATC system) [S.C Bhatt et.al.1999].

In our work the ultrasonic interferometer used is supplied by Mittal Enterprises New Delhi, it is designed for measurement of ultrasonic velocity in liquids for 1 to 8 MHz frequency generated by piezoelectric crystals. In this work we selected seven widely used Pharmaceutical solutions (drugs) namely Alergin (Cetirizine), Piclin, Betadine, Cital, Vensetron, Asthalin, and Xylomist to understand molecular interaction of pharmaceutical solutions. Cetirizine used for allergic rhinitis. Piclin used in the treatment for constipation, Betadine used as a disinfectant and antiseptic, Cital for used as an antioxidant in food, Vensetron used to prevent nausea and vomiting , Asthalin used to treat bronchospasm and Xylomist used in easing nasal congestion. The Density of all drugs were measured using specific gravity bottle of capacity 10 ml. The viscosity of these liquid pharmaceutical solutions was measured using Ostwald viscometer. The measurements were taken for water for standardization. The seven acoustical parameters determined for these pharmaceutical solutions.

EXPERIMENTAL

Table.1. The measured density values of the pharmaceutical solutions used

LIQUIDS	Mass of empty bottle, M_{bott} in gm	Mass of water +bottle, $M_{(l+bott)}$ in gm	Mass of the liquid, $M_l = M_{(l+bott)} - M_{bott}$ in gm	Density , $\frac{\rho_l}{\rho_w} = \frac{m_l}{m_w}$ in kg m^{-3}
Water	**12**	**23.32**	**11.32**	**1149.2386**
Alergin	**12**	**23.32**	**11.32**	**1149.2386**
Piclin	**12**	**23.33**	**11.33**	**1150.2540**
Betadine	**12**	**21.84**	**9.84**	**998.9850**
Cital	**12**	**23.66**	**11.66**	**1183.7560**

Vensetron	12	22.26	10.26	1041.6244
Asthalin	12	23.76	11.76	1193.91
Xylomist	12	22.00	10.00	1015.2284

Table.2. The measured viscosity values of the pharmaceutical solutions used

LIQUIDS	DENSITY in Kgm^{-3}	TIME OF FLOW in seconds				VISCOSITY $\eta_l = \frac{d_l t_l}{d_w t_w}\eta_w$ in Nsm^{-2}
		I	II	III	Mean	
Water	1000	100	101	100	100.33	0.7650×10^{-3}
Alergin	1149.24	515	521	513	516.33	4.4298×10^{-3}
Piclin	1150.25	363	360	357	360	3.1574×10^{-3}
Betadine	998.99	94	95	90	93	0.6936×10^{-3}
Cital	1183.76	283	291	287	287	2.5363×10^{-3}
Vensetron	1041.62	227	216	227	223.33	1.7737×10^{-3}
Asthalin	1193.91	457	465	464	462	4.2058×10^{-3}
Xylomist	1015.23	91	91	91	91	6.4937×10^{-3}

Figure1. Typical plot of anode current in micro ampere versus micrometer reading in mm for PICLIN (SODIUM PICOSULPHATE) at 7MHz

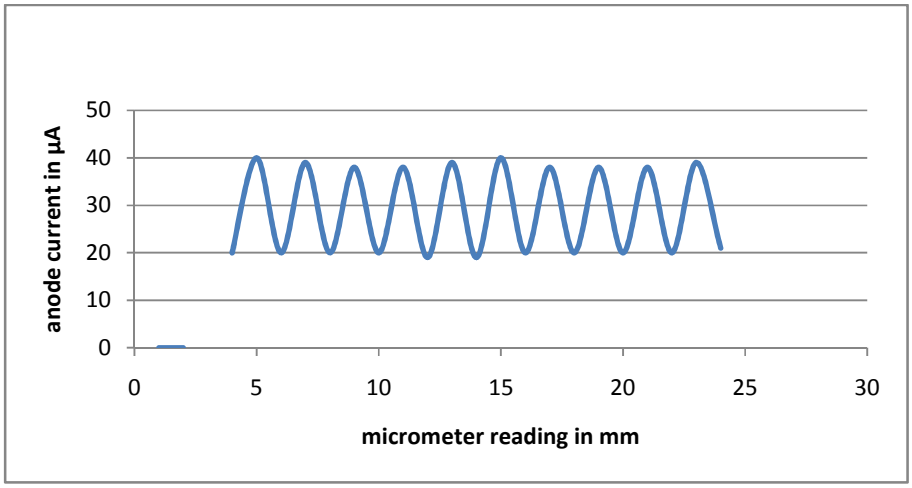


Table 3. Acoustic parameters of ALERGIN (CETIRIZINE) at different frequencies

Freq, f (MHz)	Ultrasonic Velocity V (m/s)	Adiabatic compressibility, β (N/m^2) x 10^{-10}	Acoustic impedance, z (Kg/m/s) x10^6	Relaxation Time τ (s) x 10^{-13}	Free length, L_f (Å)	Free volume V_f x 10^{-3} (m^3/mole)	Ultrasonic attenuation, (α/f^2) (dB)x10^{-13}
1	1728.6	2.9121	1.9866	17.1999	0.3379	6.6647	0.1964
2	1720	2.9413	1.9767	17.3724	0.3396	6.6238	0.1994
3	1762.5	2.8011	2.0255	16.5447	0.3314	6.8737	0.1853
4	1744	2.8609	2.0043	16.8976	0.3349	6.7654	0.1913
5	1722	2.9344	1.9789	17.3321	0.3392	6.6379	0.1987
6	1728	2.9141	1.9859	17.2119	0.3379	6.6728	0.1966
7	1750	2.8413	2.0117	16.7819	0.3338	6.8006	0.1893
8	1744	2.8609	2.0043	16.8976	0.3349	6.7657	0.1913

Table 4. Acoustic parameters of PICLIN (SODIUM PICOSULPHATE) at different frequencies

Freq, f (MHz)	Ultrasonic Velocity V (m/s)	Adiabatic compressibility,β (N/m^2) x 10^{-10}	Acoustic impedance,z (Kg/m/s) x10^6	Relaxation Time τ (s) x 10^{-13}	Free length, L_f (Å)	Free volume V_f x 10^{-41} (m^3/mole)	Ultrasonic attenuation, (α/f^2) (dB)x10^{-13}
1	1716	2.9524	1.9738	12.4394	0.3402	3.2301	0.1431
2	1696	3.0224	1.9508	12.7344	0.3442	3.1739	0.1482
3	1704	2.9941	1.9600	12.6151	0.3426	3.1964	0.1461
4	1704	2.9941	1.9600	12.6151	0.3426	3.1964	0.1461
5	1720	2.9387	1.9784	12.3817	0.3394	3.2415	0.1421
6	1704	2.9941	1.9600	12.6151	0.3426	3.1963	0.1461
7	1708	2.9801	1.9646	12.5561	0.3418	3.2076	0.1451
8	1712	2.9662	1.9692	12.4975	0.3410	3.2188	0.1441

Table 5. Acoustic parameters of BETADINE (POVIDONE IODINE) at different frequencies

Freq, f (MHz)	Ultrasonic Velocity V (m/s)	Adiabatic compressibility,β (N/m^2) x 10^{-10}	Acoustic impedance,z (Kg/m/s) x10^6	Relaxation Time τ (s) x 10^{-13}	Free length, L_f (Å)	Free volume V_f x 10^{-3} (m^3/mole)	Ultrasonic attenuation, (α/f^2) (dB) x10^{-13}
1	1590	3.9596	1.5884	3.6617	0.3939	86.4253	0.04546
2	1564	4.0923	1.5624	3.7844	0.4005	84.3141	0.04776
3	1566.66	4.0784	1.5651	3.7716	0.3999	84.5293	0.04752
4	1555.56	4.1368	1.5539	3.8256	0.4027	83.6325	0.04854
5	1570	4.0611	1.5684	3.7555	0.3990	84.7997	0.04722
6	1560	4.1133	1.5584	3.8039	0.4016	83.9908	0.04813
7	1526	4.2987	1.5245	3.9752	0.4105	81.2599	0.05142
8	1568	4.0714	1.5664	3.7651	0.3995	84.6378	0.04739

Table 6. Acoustic parameters of CITAL (DISODIUM HYDROGEN CITRATE) at different frequencies

Freq, f (MHz)	Ultra sonic Velocity V (m/s)	Adiabatic compressibility,β (N/m^2) x 10^{-10}	Acoustic impedance,z (Kg/m/s) x10^6	Relaxation Time τ (s) x 10^{-13}	Free length, L_f (Å)	Free volume V_f x 10^{-3} (m^3/mole)	Ultrasonic attenuation, (α/f^2) dBx10^{-13}
1	1675	3.0109	1.9828	10.1823	0.3436	6.9530	0.1199
2	1684.4	2.9775	1.9940	10.0691	0.3417	8.2414	0.1179
3	1692	2.9508	2.0029	9.9788	0.3401	7.0591	0.1164
4	1672	3.0218	1.9792	10.1487	0.3442	6.9343	0.1206
5	1677.77	3.0011	1.9861	9.9979	0.3442	6.9703	0.1194
6	1692	2.9508	2.0029	9.4793	0.3401	7.0591	0.1164
7	1736	2.8031	2.0050	10.3174	0.3315	7.3363	0.1078
8	1664	3.0509	1.9698	10.0467	0.3459	6.8846	0.1224

Table 7. Acoustic parameters of ASTHALIN (SALBUTAMOL) at different frequencies

Freq, f (MHz)	Ultrasonic Velocity V (m/s)	Adiabatic compressibility β (N/m^2) x 10^{-10}	Acoustic impedance z (Kg/m/s) x10^6	Relaxation Time τ (s) x 10^{-13}	Free length, L_f (Å)	Free volume V_f x 10^{-3} (m^3/mole)	Ultrasonic attenuation, (α/f^2) (dB)(x10^{-13}
1	1720	2.8312	2.0535	15.8774	0.3332	3.4577	0.1822
2	1704	2.8846	2.0344	16.1769	0.3363	3.4088	0.1874
3	1710	2.8644	2.0416	16.0636	0.3351	3.4277	0.1854
4	1696	2.9119	2.0248	16.3299	0.3379	3.3856	0.1901
5	1710	2.8644	2.0416	16.0636	0.3351	3.4276	0.1854
6	1704	2.8846	2.0344	16.1769	0.3363	3.4095	0.1874
7	1764	2.6917	0.1060	15.0952	0.3248	3.5909	0.1689
8	1696	2.9119	2.0249	16.3299	0.3379	3.3856	0.1901

Table 8. Acoustic parameters of VENSETRON(ONDANSETRON HCl) at different frequencies

Freq, f (MHz)	Ultra sonic Velocity V (m/s)	Adiabatic compressibility,β (N/m^2) x 10^{-10}	Acoustic impedance,z (Kg/m/s) x10^6	Relaxation Time τ (s) x 10^{-13}	Free length, L_f (Å)	Free volume V_f x 10^{-25} (m^3/mole)	Ultrasonic attenuation, (α/f^2) (dB)x10^{-13}
1	1562.5	3.9323	1.6275	9.2999	0.3926	1.1491	1.1175
2	1548	4.0063	1.6124	9.4749	0.3963	1.1384	0.1208
3	1560	3.9449	1.6249	9.3297	0.3933	1.1473	0.1181
4	1552	3.9857	1.6166	9.4261	0.3953	1.1414	0.1199
5	1570	3.8948	1.6353	9.2112	0.3908	1.1546	0.1158
6	1560	3.9449	1.6249	9.3297	0.3933	1.1473	0.1181
7	1568	3.9048	1.6333	9.2347	0.3913	1.1531	0.1163
8	1568	3.9048	1.6333	9.2347	0.3913	1.1531	0.1163

Table 9. Acoustic parameters of XYLOMIST(XYLOMETAZOLINE) at different frequencies

Freq, f (MHz)	Ultra sonic Velocity V (m/s)	Adiabatic compress ibility,β (N/m^2) x 10^{-10}	Acoustic imped ance,z (Kg/m/s) x10^6	Relaxa tion Time τ (s) x 10^{-13}	Free length , L_f (Å)	Free volume V_f x 10^{-3} (m^3/mole)	Ultrasonic attenuation, (α/f^2) (dB)x10^{-13}
1	1535	4.1804	1.5584	3.5915	0.4048	45.3020	0.0465
2	1540	4.1533	1.5635	3.5961	0.4035	45.5236	0.0461
3	1536	4.1749	1.5594	3.6148	0.4046	45.3463	0.0465
4	1533.33	4.1895	1.5567	3.6274	0.4053	45.2281	0.0467
5	1530	4.2078	1.5533	3.6432	0.4062	45.0808	0.0474
6	1536	4.1749	1.5594	3.6148	0.4046	45.3463	0.0465
7	1536.33	4.0303	1.5871	3.4896	0.3975	45.3609	0.0441
8	1520	4.2633	1.5431	3.6913	0.4088	44.6396	0.0479

RESULT AND DISCUSSION

Fig 2. Variation of ultrasonic velocity with adiabatic compressibility

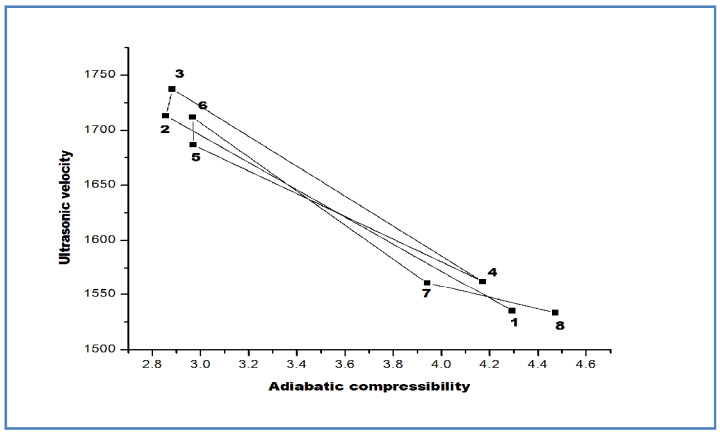


Fig 3. Variation of ultrasonic velocity with acoustic impedenance

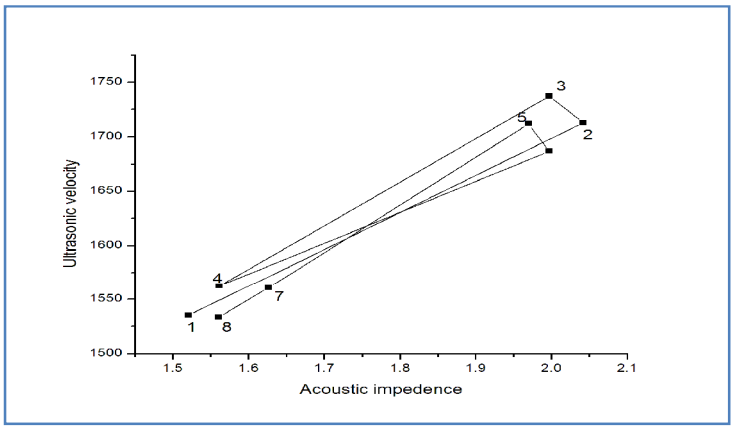


Fig 4. Variation of ultrasonic velocity with relaxation time

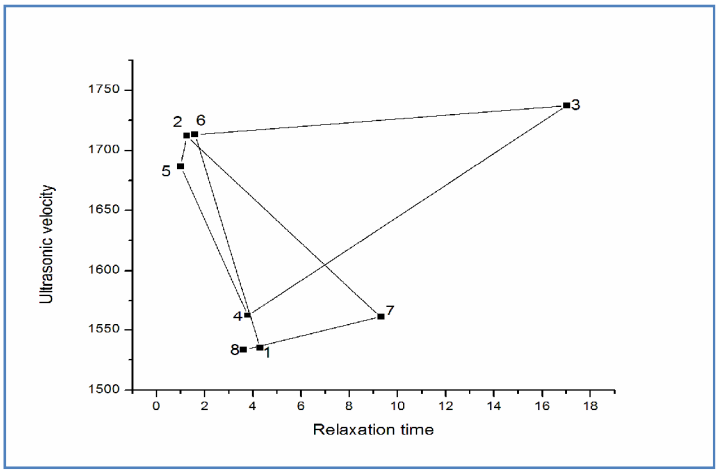


Fig 5. Variation of ultrasonic velocity with free length

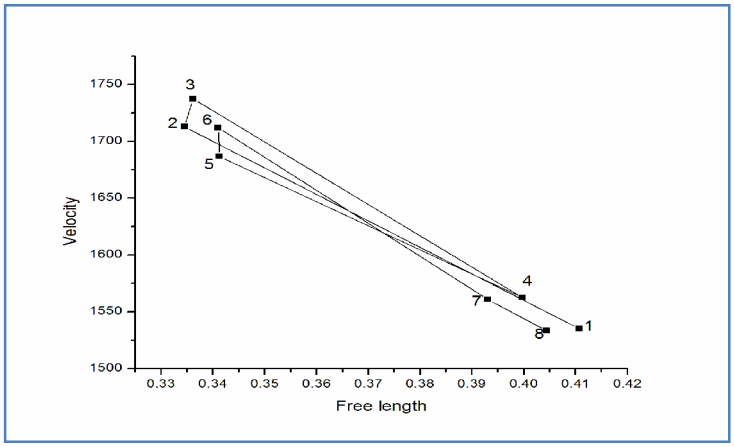


Fig 6. Variation of ultrasonic velocity with ultrasonic attenuation

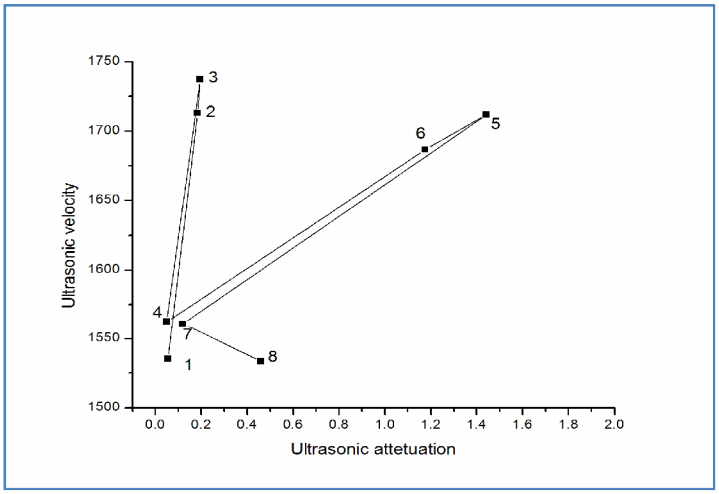
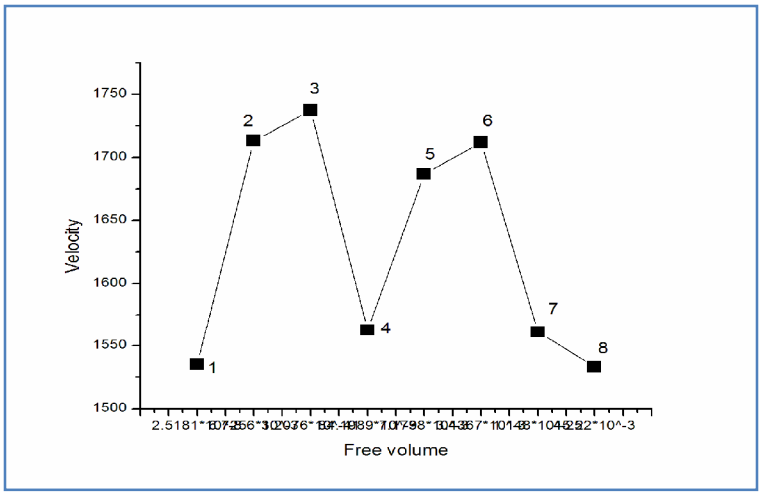


Fig 7. Variation of ultrasonic velocity with free volume



The plot of acoustical parameter variation for different ultrasonic velocities of the pharmaceutical solutions was plotted. The ultrasonic velocity increases with density and viscosity of the solution.

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