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Acoustic Parameters of Polar- Non polar Chemicals at Variable Frequencies

KEYWORDS: Polar and Non polar solvents, Ultrasonic interference, Acoustic parameters.

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ABSTRACT *Acoustic parameters of chemicals and the relationship among these parameters is the recent, innovative and informative area in interdisciplinary fields of Physics and Chemistry. In this research various parameters like adiabatic compressibility, acoustic impedance, Wada constant, Rao constant and their relations are observed at variable frequencies. Thus comparison is made between polar and non polar chemicals on these parameters at different frequencies. The said parameters are measured using Ultrasonic interferometer working at 1 M Hz and 3 M H z.*

Introduction:
Acoustic study is found to be very effective as it helps in measuring many Thermodynamic parameters of chemicals. It is also found to be Non destructive technique that is without disturbing or wasting chemicals we can study properties of chemicals. The amount of chemical required is just less than10cc. Using Ultrasonic Interferometer one can determine wavelength of sound in the chemical under study, and since frequency is known velocity at room temperature can be determined. By knowing velocity, density, Molecular weight etc one can determine parameters like Adiabatic compressibility, Acoustic impedance, Wad constant, Rao constant. Further relations are observed between these parameters. This study is extended for different frequencies and change if any is measured due to change in frequency of sound.

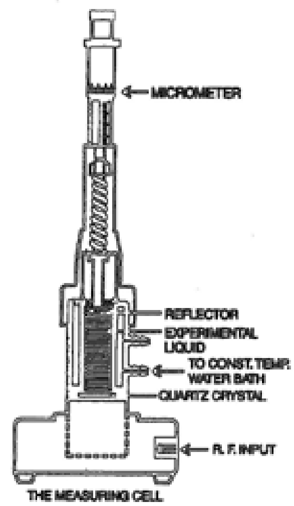
Objectives:

1) To measure the thermo acoustic parameters of polar and non polar chemicals using an ultrasonic interferometer (at 1 M Hz and 3 M Hz).

2) To get a relation between these parameters.

3) To compare the polar chemicals and non polar chemicals in terms of these parameters at different frequiencies..

Methodology:
The solvent under study is poured in the narrow cylinder and is fitted with acoustic reflector. Ultrasonic waves with constant frequency 1 MHz and then 3 MHz are then allowed to pass through, which are reflected back to source forming standing wave pattern. This instrument is connected to supporting sensor device which shows maxima and minima of current, when we moved reflector. These maxima and minima were corresponding to nodes and antinodes formed within the cylinder. By knowing distance between two consecutive maxima one can find the value of half wavelength. By knowing wavelength one can find velocity of ultrasonic sound in that liquid. By knowing density, velocity, and atomic weight, etc one can find various acoustic parameters. The details of apparatus and procedure of measuring wavelength of sound is explained in short note along with schematic diagram of apparatus used for measurement of sound velocity in chemicals. Note that because high accuracy in the measurement of wavelength and précised value of frequency the related values of parameters are determined with good accuracy.



Note: An ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity in liquids with a high degree of accuracy.

The principle used in the measurement of velocity (v) is based on the accurate determination of the wavelength (l) in the medium.

Ultrasonic waves of known frequency (f) are produced by a quartz plate fixed at the bottom of the cell. The waves are reflected by a movable metallic plate kept parallel to the quartz plate. If the separation between these plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. The acoustic resonance gives rise to an electrical reaction on the generator driving the quartz plate and the anode current of the generator becomes maximum. If the distance is now increased or decreased and the variation is exactly one half wavelength (l/2) or multiple of it, anode current again becomes maximum.

Theory: Following properties are observed for the polar and non polar chemicals using Ultrasonic Interferometer along with the given terminology:

1) Adiabatic compressibility $\beta = 1/v^2.d$ where, v = velocity & d = density

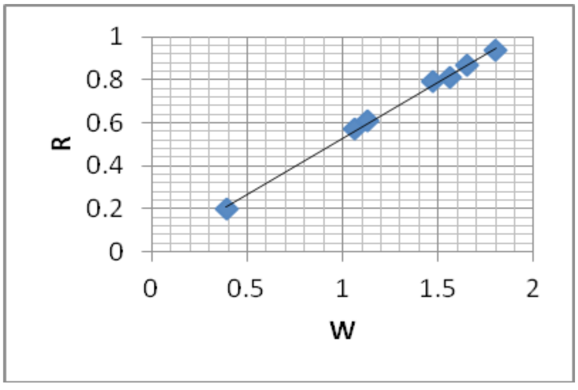
The adiabatic compressibility is the fractional decrease of volume per unit increase of pressure, when no heat flows in or out. If there is no heat flow, the entropy is unchanged, in a reversible process, so that an adiabatic process is one at constant entropy.The compressibility factor is a measure intermolecular attraction.

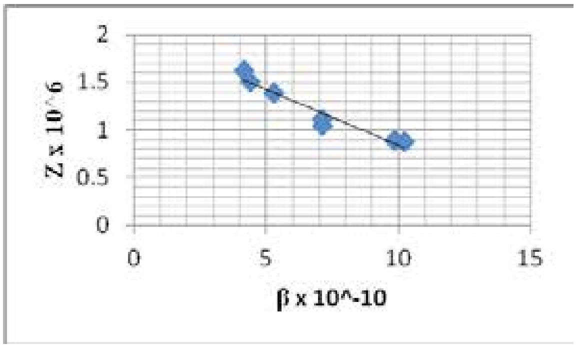
2) Specific acoustic impedance Z = v.d
Specific acoustic impedance is a characteristics property of a medium. The acoustic impedance is analogous to the refractive index of medium.
3) Rao's constant R = [Mw/ d] x $v^{1/3}$ where v is the velocity
Rao established the empirical relationship between molecular weight, density and velocity. The quantity R is also called as Molar sound velocity.
4) Wada constant W= [Mw/ d] x $\beta^{-1/7}$
The molar compressibility is a more direct structural property of a liquid than molar sound velocity. So Wada suggested parameter Wada constant W which is also called as molar compressibility and suggest the strength of molecular interaction in liquids. The behavior Wada constant is analogous to R.

Note:
1) The degree of compressibility of a fluid has strong implications for its dynamics. Most notably, the propagation of sound is dependent on the compressibility of the medium.
2) Molecular interactions can be studied through Rao's constants and Wada'sconstants which are constants in non-interacting substances.
3) Acoustic impedance indicates how much sound pressure is generated by the vibration of molecules of a particular acoustic medium at a given frequency. The acoustic impedance Z (or sound impedance) is frequency (f) dependent.

Observations:
Acoustic parameters for polar chemicals at 1 MHz frequency:

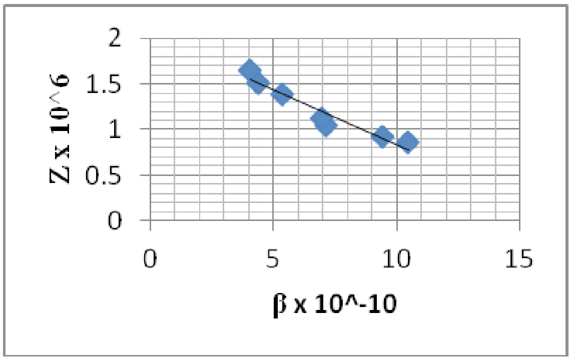
Chemicals	β_{ad} x 10^{-10}	Z x 10^6	W	R
Water	4.38	1.51	0.39	0.2
Acetonitrile	7.13	1.05	1.06	0.57
Ethanol	9.87	0.89	1.13	0.61
DMSO	4.16	1.62	1.56	0.81
THF	7.14	1.11	1.65	0.87
Dioxane	5.31	1.39	1.8	0.94
2 propanol	10.22	0.877	1.47	0.79

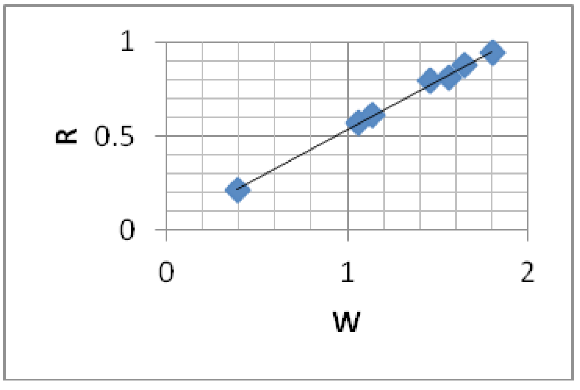




Acoustic paramters for Polar chemicals at 3 M Hz frequency:

Chemicals	β_{ad} x 10^{-10}	Z x 10^6	W	R
Water	4.38	1.51	0.39	0.21
Acetonitrile	7.13	1.05	1.06	0.57
Ethanol	9.42	0.915	1.14	0.61
DMSO	4.05	1.65	1.56	0.81
THF	6.92	1.13	1.65	0.88
Dioxane	5.36	1.38	1.80	0.94
2 propanol	10.44	0.86	1.46	0.79





Acoustic parameters of Non Polar chemicals at 1 M Hz frequency:

Chemicals	β_{ad} x 10^{-10}	Z x 10^6	W	R
Hexane	14.27	0.68	2.40	1.32
Toluene	6.81	1.13	2.16	1.16
CCl4	7.37	1.47	1.95	0.94
DMF	5.18	1.35	1.63	0.87
DCE	5.90	1.45	1.65	0.83

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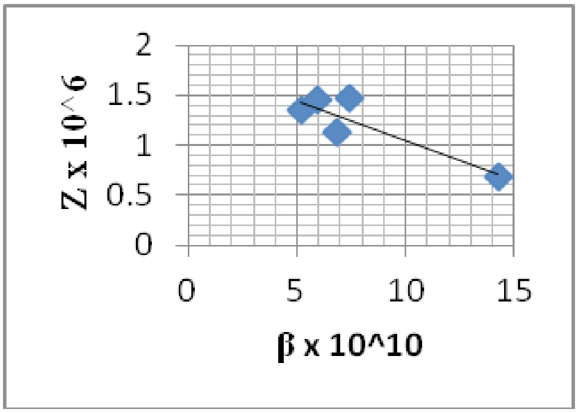
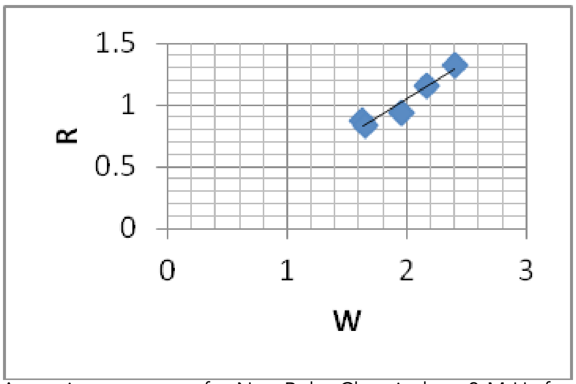
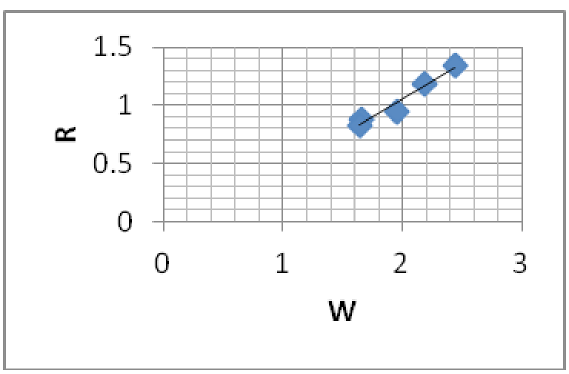
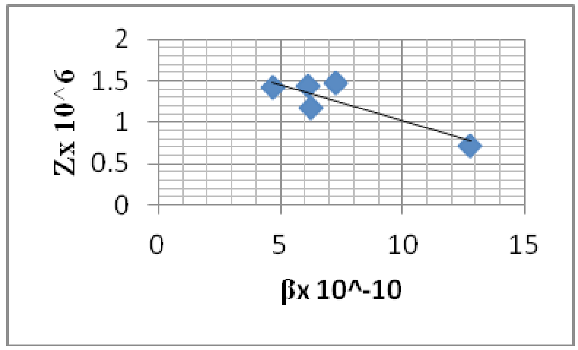




Acoustic parameters for Non Polar Chemicals at 3 M Hz frequency:

Chemicals	$\beta_{ad} \times 10^{-10}$	$Z \times 10^6$	W	R
Hexane	12.79	0.72	2.44	1.34
Toluene	6.24	1.18	2.19	1.18
CCl4	7.26	1.48	1.95	0.94
DMF	4.67	1.42	1.66	0.88
DCE	6.12	1.43	1.64	0.83





Analysis:
The graph of adiabatic compressibility is plotted against Acoustic impedance, and the graph of Wada constant is plotted against Rao constant. It was observed that as adiabatic compressibility decreases the acoustic impedance decreases for polar as well as non polar chemicals, and as Wada constant increases Rao constant also increases for both types of chemicals. This observation is consistent with theory explained.

Result:
1) Adiabatic compressibility and acoustic impedance is inversely proportional, while Wad constant and Rao constant is directly proportional to each other for all frequencies.
2) The variations of these parameters are similar for both polar as well as non polar chemicals and found to be frequency independent.
3) However the relative values of adiabatic compressibility etc are found to be more for polar chemicals than non polar chemicals.

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