# ACOUSTIC PROPERTIES OF LIQUIDS, GASES, CERAMICS AND CRYSTALS UNDER THE INFLUENCE OF ULTRASONIC WAVES

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## ABSTRACT

In the study of material and characterization of their properties, our major concern is to invent various new materials and improvise the existing information about the known substances by developing in-depth understanding of physical and chemical properties corresponding to different physical conditions. For this certain important physical parameters such as adiabatic compressibility, specific acoustic impedance, relative association, intermolecular free length, relaxation time, free volume, Rao's constant, Wada's constant etc. are evaluated using ultrasonic velocity, density and viscosity of liquids, gases, ceramics and crystals.

**Key Words:** *Adiabatic compressibility, liquids, gases, ceramics and crystals, acoustic parameters, ultrasonic velocity*.

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**INTRODUCTION**

As gas is characterized by three variables such as temperature, pressure and volume liquid is characterized by parameters free volume, internal pressure and temperature. The associate nature of water with solute is learnt by its hydration Number [1]. While its structure making or breaking property is got from its free volume and internal pressure. To determine these parameters the ultrasonic velocity is a simple probe used by physicist along with basic quantities like density and viscosity [2]. The physico-chemical behavior and molecular interaction in pure liquid components and their mixtures is studied on the basis of acoustic and thermodynamic properties[3].The ultrasonic study is also useful to understand behavior of biomolecules [4]. Literature survey shows that ultrasonic study of liquid mixture is highly useful in understanding the nature of molecular interaction [5-7] and physicochemical behavior of liquid mixture[8-10]. In continuation of our work [11-12] in the present investigation the ultrasonic velocity, density of liquids, gases, ceramics and crystals the acoustic parameters have been used from the data compiled by Xactex Corporation. From these parameters the effect of ultrasonic velocity on molecular interaction is interpreted.

**Some Formulae of the parameters to be calculated**

The adiabatic compressibility ($\beta_a$) of the system is

(1) $$\beta_a = \frac{1}{\rho C^2}$$

The specific acoustic impedance ($Z$) is expressed as

(2) $$Z = \rho . C$$

where, $C$ is the ultrasonic velocity, $\rho$ is the density of the compound taken

**Accoustic Properties for Gases**

| Gases | Velocity | Density $(g/cm^3)$ | Acoustic Impedance(z) $g/cm^2$-sec | adiabatic compressibility $\beta_a(=1/\rho c^2)$ |
|---|---|---|---|---|
| | cm/µs | | $x10^5$ | ×10-3 |
| Argon | 0.0319 | $1.78x10^{-3}$ | 0.00057 | 552.0756997 |
| Helium | 0.097 | $.179 \times 10^{-3}$ | 0.00017 | 593.749833 |
| Hydrogen | 0.128 | $.09 \times 10^{-3}$ | 0.00012 | 678.1684028 |
| Methane | 0.043 | $.74 \times 10^{-3}$ | 0.00032 | 730.8552468 |
| Neon | 0.043 | $.90 \times 10^{-3}$ | 0.00039 | 600.9254252 |

Fig 1

| Plastics, Resins, and Phenolics | Longitudinal Velocity | Density $g/cm^3$ | Acoustic Impedance $g/cm^2$-sec | $\beta_a(=1/\rho c^2)$ adiabatic compressibility |
|---|---|---|---|---|
| | cm/µs | | $x10^5$ | |
| Acrylic Resin | 0.267 | 1.18 | 3.151 | 11.88764 |
| Bakelite | 0.259 | 1.4 | 3.626 | 10.64811 |
| Cellulose Acetate | 0.245 | 1.3 | 3.185 | 12.81517 |
| Lucite | 0.268 | 1.18 | 3.1624 | 11.79909 |
| Phenolic | 0.142 | 1.34 | 1.903 | 37.00995 |
| Polyethylene | 0.267 | 1.1 | 2.937 | 12.75219 |
| Polyimide (Vespel SP-1) | 0.244 | 1.48 | 3.61 | 11.34903 |
| Polystyrene | 0.267 | 1.1 | 2.937 | 12.75219 |

| | | | | |
|---|---|---|---|---|
| Refrasil | 0.375 | 1.73 | 6.488 | 4.110469 |
| Teflon | 0.135 | 2.2 | 2.97 | 24.94077 |

**Fig 2**

**Accoustic Properties for Gases in Liquid Form**

| Liquid Gases | Longitudinal Velocity | | Density g/$cm^3$ | Acoustic Impedance g/$cm^2$-sec x$10^5$ |
|---|---|---|---|---|
| | cm/µs | in/µs | | |
| Liquid Argon (-186° C) | .0837 | .033 | 1.404 | 1.175 |
| Liquid Argon (-189° C) | .0863 | .034 | 1.424 | 1.229 |
| Freon MF 21.1 | .0799 | .0315 | 1.485 | 1.187 |
| Freon TF 21.1 | .0968 | .0381 | 1.574 | 1.524 |
| Liquid Helium (-269° C) | .0180 | .0071 | .125 | .023 |
| Liquid Helium (-271.5° C) | .0231 | .0091 | .146 | .034 |
| Liquid Hydrogen (-252.7° C) | .113 | .0445 | .355 | .401 |
| Liquid Nitrogen (-197° C) | .0869 | .0342 | .815 | .708 |
| Liquid Nitrogen (-203° C) | .0929 | .0366 | .848 | .788 |
| Liquid Oxygen (-183.6° C) | .0971 | .0382 | 1.143 | 1.11 |
| Liquid Oxygen (-210° C) | .113 | .0445 | 1.272 | 1.437 |

Fig 3

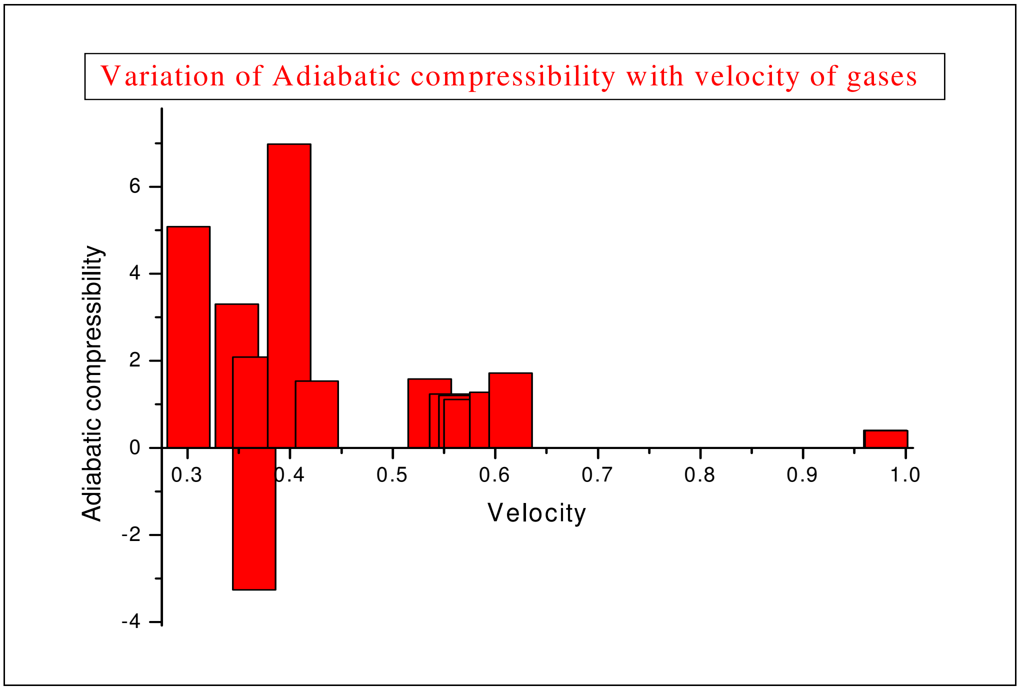
Variation of Adiabatic compressibility with velocity of gases
Adiabatic compressibility
6
4
2
0
-2
-4
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Velocity

Fig 4

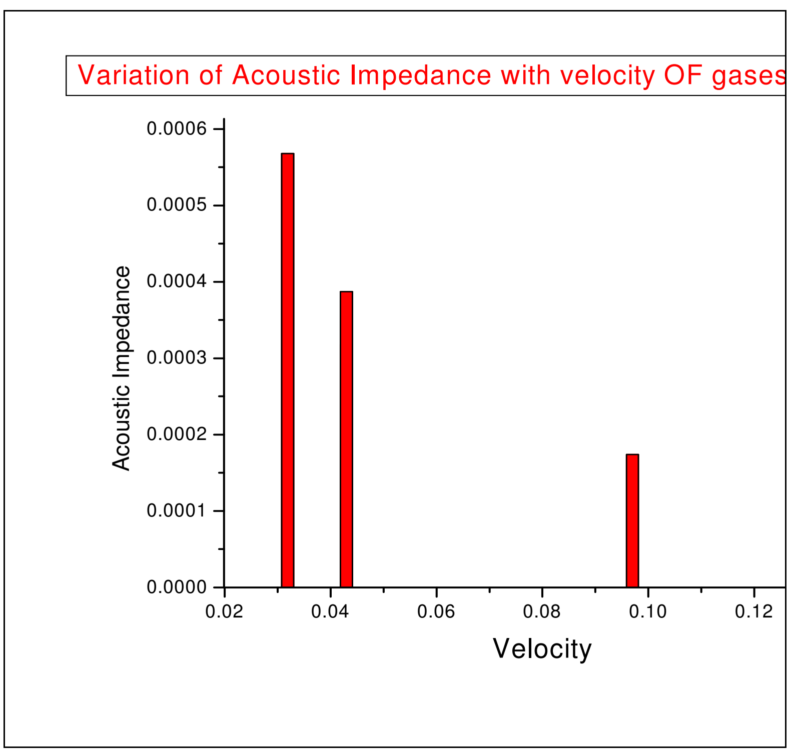
Variation of Acoustic Impedance with velocity OF gases
Acoustic Impedance
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0.02
0.04
0.06
0.08
0.10
0.12
Velocity

Fig 5

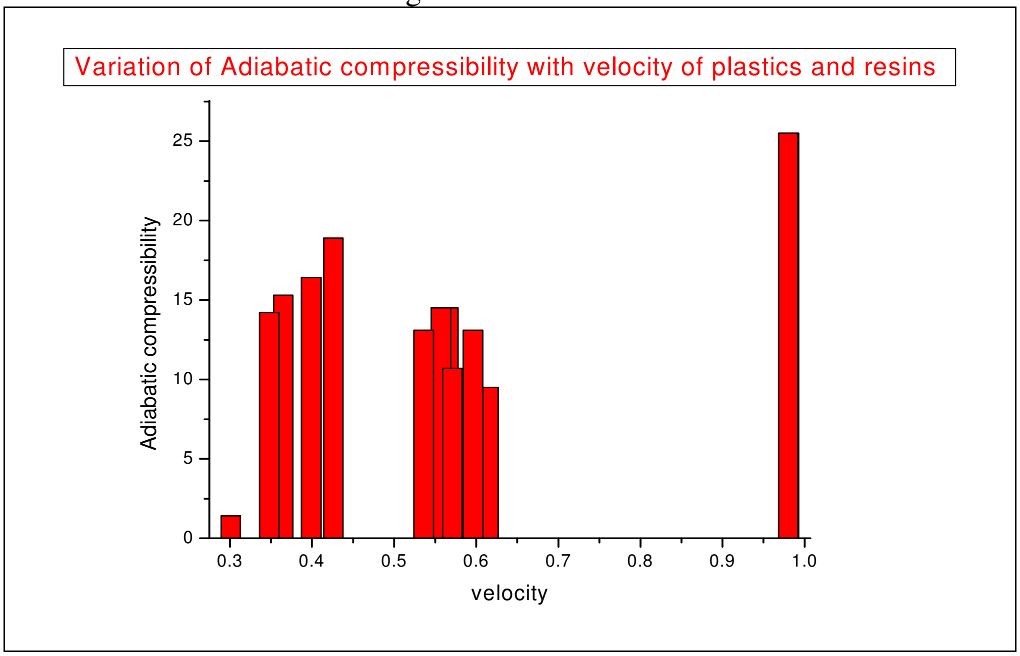


Fig 6

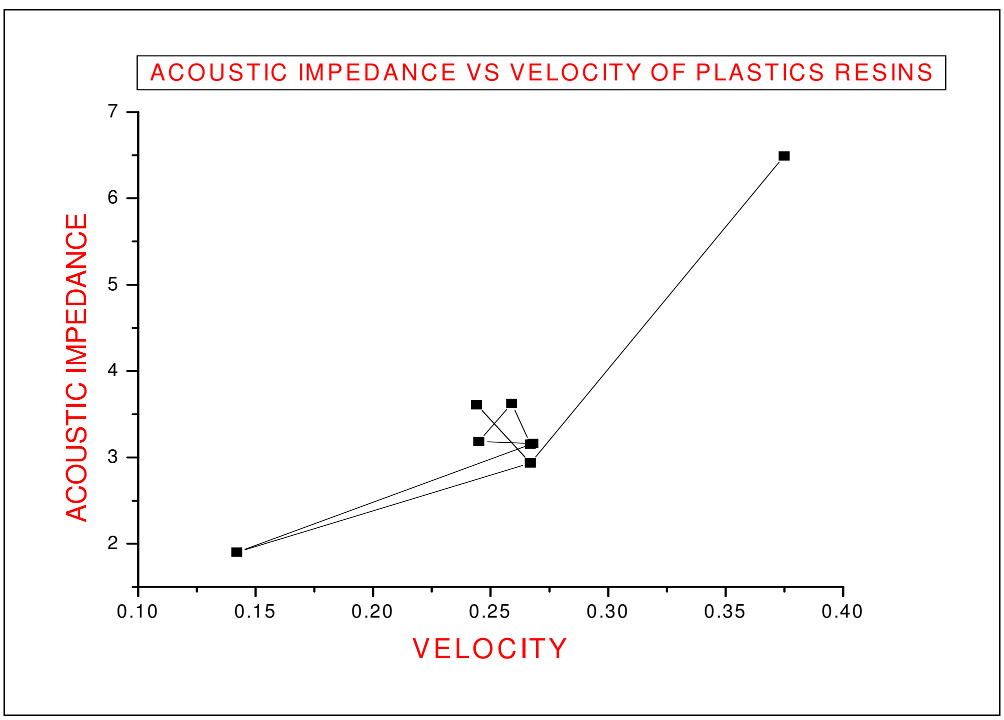


Fig 7

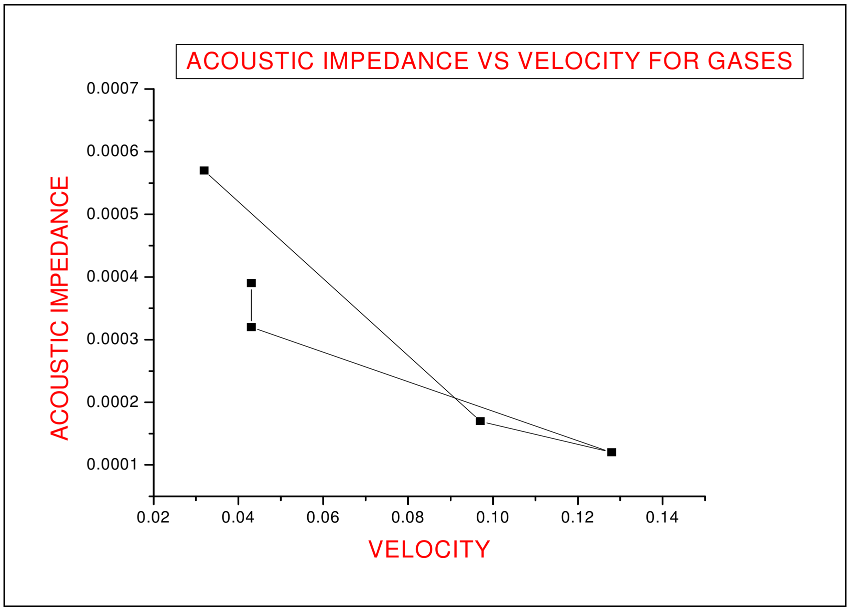
ACOUSTIC IMPEDANCE VS VELOCITY FOR GASES
ACOUSTIC IMPEDANCE
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.02 0.04 0.06 0.08 0.10 0.12 0.14
VELOCITY

Fig 8

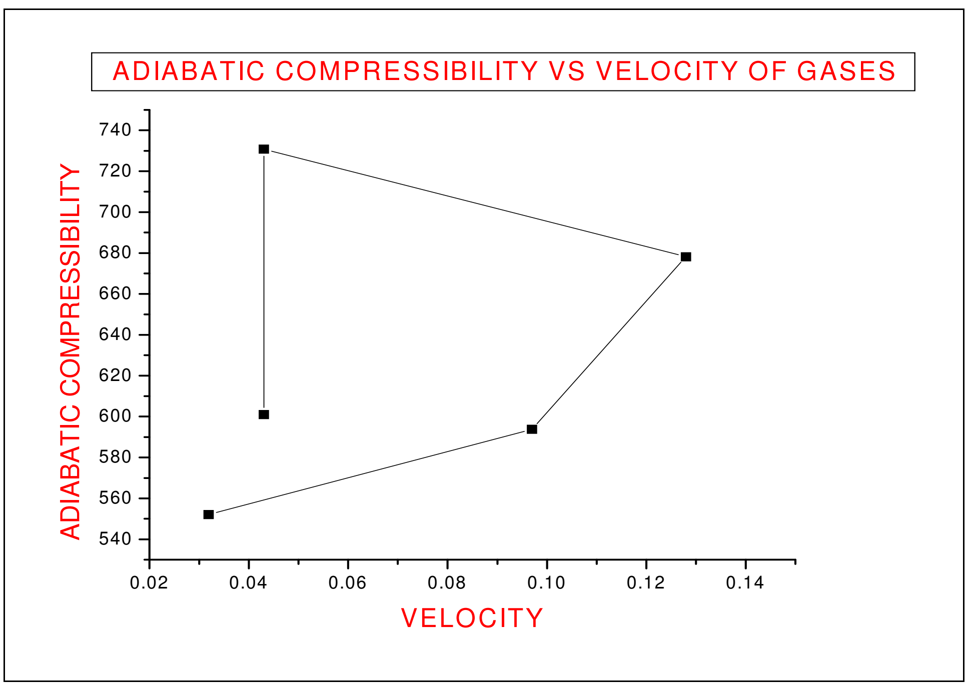
ADIABATIC COMPRESSIBILITY VS VELOCITY OF GASES
ADIABATIC COMPRESSIBILITY
740
720
700
680
660
640
620
600
580
560
540
0.02 0.04 0.06 0.08 0.10 0.12 0.14
VELOCITY

Fig 9

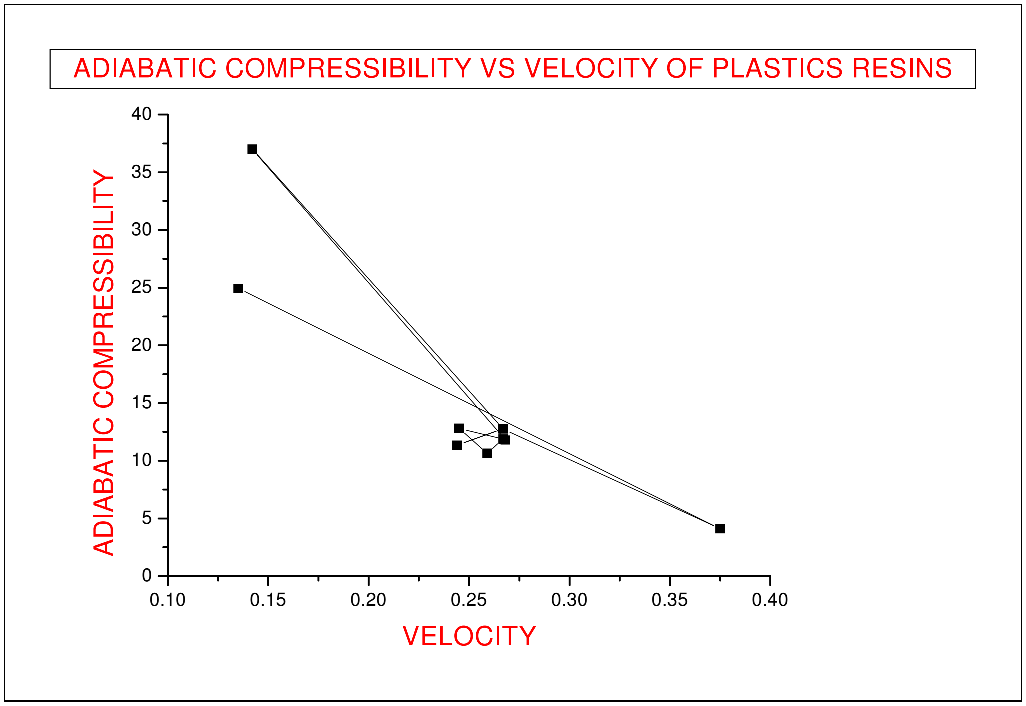


Fig 10

**RESULTS AND DISCUSSION**

From the observed values the acoustic impedance, adiabatic compressibility was calculated. The graphs shows that there is strong interaction between solute and solvent molecules.Various acoustic parameters were measured and their variations are plotted in the graphs shown. Note that these relationships between acoustics parameters were established not for any solute solvent but in general for various types of solvents and shows general interdependence and hence are very important.

**CONCLUSION**

The acoustical and thermodynamic parameters calculated from measured properties suggest the strong molecular interaction in the different types of materials. Ultrasonic investigations in liquids, gases, ceramics and crystals give useful information in understanding interaction of solute with solvent.

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