VERY HIGH FREQUENCY SOUND VELOCITIES IN ACETONE WATER MIXTURES

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1. INTRODUCTION

IN a communication to *Nature*[1] it has just been reported that very high frequency sound waves (up to 100 Mc. per sec.) have been communicated to water and the diffraction pattern obtained in this laboratory by the usual arrangement. In the present investigation, the variation of sound velocity at such high frequencies with composition in the binary mixtures of acetone and water has been studied. Parthasarathy,[2] and Smith and Ewing[3] have done some work in this direction. Parthasarathy studied mixtures of non-electrolytes among themselves and concluded that the sound velocity varies almost linearly with concentration. Smith and Ewing on the other hand reported that in mixtures of acetic acid and water the sound velocity attains a maximum at 30% concentration and then decreases rapidly. Acetone and water are taken in the present investigation as both have a low absorption coefficient enabling high frequency waves to be communicated into the mixtures. Further, acetone is one of the few non-electrolytes which dissolve completely in water and enable sound velocities at all concentrations to be determined.

2. EXPERIMENTAL DETAILS

A very high frequency and high power oscillator is constructed using a Taylor T55 valve which works with its maximum output of 60 watts even up to 120 Mc. A specially built power pack gives the plate supply of 1100 volts. Amphenol parts are used for all the mountings and R. F. chokes to avoid dielectric losses. A flat copper strip is used as the inductance of the tank circuit and the ends of the strip are incorporated in the condenser assembly thus reducing the contact resistance. Improved stability and efficiency of the oscillator are thus achieved. Also a specially designed holder made with amphenol parts is used for mounting the crystal. A tourmaline crystal prepared in this laboratory with a thickness of 5·2 mm. and of a fundamental of about 0·72 Mc. per sec. is made to oscillate up to its 90th harmonic. Stationary waves are set up in a column of the liquid mixture to be studied and the Debye Sears pattern is used in the usual manner for determining the velocity of sound waves. It is found that the temperature of the liquids exposed to these high frequency sound waves increases considerably in a very short time. Hence fringe widths are measured with a good travelling microscope in as short a time as possible to avoid temperature variations. Much heat is liberated when acetone and water are mixed together and hence the mixture is cooled down to the laboratory temperature before observations are taken. All observations are made at the same temperature avoiding changes in sound velocity due to temperature variation. Also for each mixture, the density is determined by the usual laboratory methods. The frequency of the oscillator is maintained constant throughout and is measured by beating it with a standard Phillips heterodyne wavemeter using an audio amplifier for hearing the beat note. Mixtures of definite composition are obtained by mixing known volumes of water and acetone, and from these values the weight percentages of acetone in water are calculated.

3. Results

Table I gives the velocities in mixtures of acetone and water together with percentages by weight of acetone. Density values experimentally determined and the adiabatic compressibilities calculated therefrom are also given. In Fig. 1 are given the curves for the variation of sound velocity,

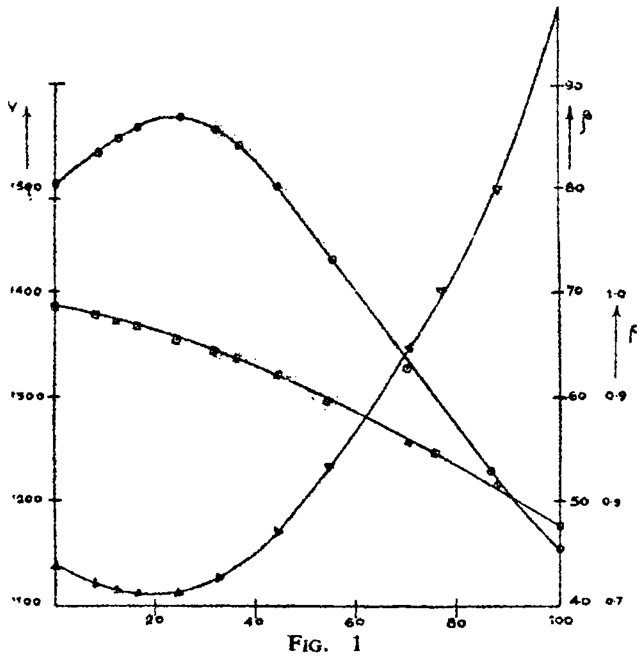

Fig. 1

I. ○ Sound Velocity in Metres/Sec. ——→ Percentage of Acetone by weight.
II. △ Adiabatic Compressibility in $Cm.^2/Dyne$.
III. □ Density in Gm./cc.

density and adiabatic compressibility with concentration of acetone. The sound velocity in water is found to increase first with addition of acetone gradually until it reaches a maximum value of 1583 meters/sec. at a concentration of 24% by weight of acetone and then it is found to decrease rapidly with further increase of concentration of acetone. The density variation curve on the other hand shows slight concavity towards the concentration axis. The adiabatic compressibility however attains a minimum at a concentration of 22% by weight of acetone. In order to show this peculiar feature of the variation of the sound velocity of the mixture, the diffraction patterns due to pure water, pure acetone and the particular mixture giving maximum velocity are photographed on the same plate and shown in Fig. 2. As acetone is added to water the fringe width is found to

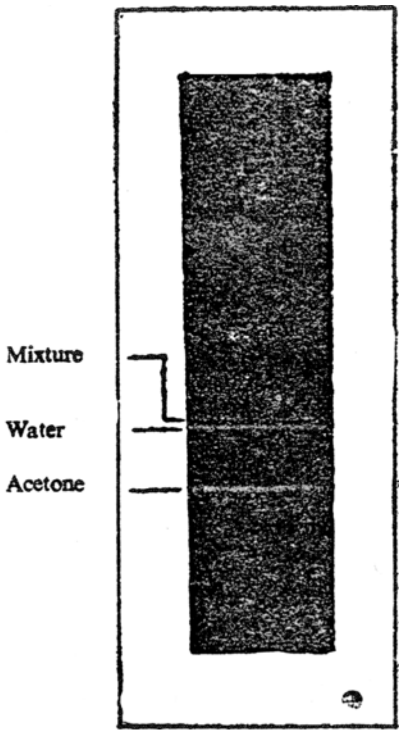

FIG. 2

decrease to a minimum value indicated in the figure and then it rapidly increases to its maximum value namely that of pure acetone. All the velocities are determined at a frequency of 64·36 Mc. per sec. in this investigation, the temperature being 30·6° C.

TABLE I. *Acetone-water mixture*

Composition % by weight of acetone	0	8·16	12·37	16·66	25·53	31·97	36·67	44·37	54·55	70·58	76·19	87·80	100
Fringe widths in cms.	2·502	2·450	2·426	2·414	2·400	2·418	2·440	2·502	2·631	2·850	2·931	3·084	3·284
Ultrasonic velocities in meters per sec.	1517	1547	1563	1571	1581	1569	1554	1517	1440	1331	1294	1229	1154
Densities	·9951	·9841	·9803	·9715	·9612	·9508	·9421	·9218	·9008	·8612	·8493	·8167	·7761
Adiabatic compressibilities in $cm.^2/dyne \times 10^{12}$	43·69	42·46	41·78	41·71	41·61	42·73	43·96	47·13	53·53	65·54	70·30	80·04	96·74

4. Discussion of Results

The variations of sound velocity observed in mixtures of acetone and water by the author are analogous to the variations in viscosity and heats of solution in the same mixture. It is found from the values given in the International Critical Tables that viscosity and heats of solution of the mixtures exhibit a similar maximum at a concentration of about 30% by weight of acetone. Sambasiva Rao[4] studied the influence of acetone on the intensities of the Raman bands of water and concluded that the variations are of the same order as that of weak and strong electrolytes. But acetone being a non-electrolyte cannot dissociate into free ions. That there is no appreciable hydrate formation in aqueous solutions of non-electrolytes has been shown by Jones and his collaborators.[5] By assuming that acetone changes the water equilibrium due to variations in the proportions of single (H_2O), double $(H_2O)_2$ and triple $(H_2O)_3$ molecules, a possible explanation may be given. Acetone dissolved in water probably splits up the triple molecule $(H_2O)_3$ into single or double molecules such that the consequent increase in velocity of water is higher than the decrease due to the presence of acetone and hence there will be an increase in velocity of sound waves in the mixture for the first few concentrations. When most of the polymerized molecules are dissociated so that no more dissociation can take place, the velocity falls down rapidly as more and more of acetone is added. Only acetone among all non-electrolytes gives rise to such anomalous effect presumably because acetone is capable of dissociating more numbers of triple $(H_2O)_3$ molecules with the result that the velocity increases.

5. Summary

Sound velocities are determined in mixtures of acetone and water at a frequency of 64·36 Mc. per sec. for different concentrations. Results show an anomalous increase in velocity of water with addition of acetone reaching a maximum of 1583 m/sec. at a composition of 24% by weight of acetone. A possible explanation is given on the assumption that acetone induces the breaking up of polymerized water molecules into simpler ones.

References

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