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NOTES

Temperature and Pressure Dependence of the Coefficient of Non-linearity Acoustic Parameters in Higher Alkanes

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Temperature coefficient of the non-linearity acoustic parameters (B/A), (C/A) and (D/A) are calculated for heptane, octane, nonane, dodecane and hexadecane. Pressure dependence of these coefficients are also studied. The results show that the acoustic properties of these five higher alkanes cease to vary at pressure P 400 bar.

In the present report we have studied the pressure and temperature dependence of the non-linearity acoustic parameter coefficients a_1, b_1, a_2, b_2, a_3 and b_3 in heptane, octane, nonane, dodecane and hexadecane in the temperature range of 0° to 60°C and pressure range 0 to 1000 bars.

Theoretical

The measurement of ultrasound propagation constants become unreliable[1, 2] when the amplitude of ultrasound is large. This when put to test, shows deviation with the linearity assumed in ordinary acoustics and predicts the extent of various kinds of non-linearity effects[1], using sound velocity and thermodynamic data. Beyer *et. al*[1, 3] have first of all reported the results of the calculations on the non-linearity acoustic parameter (B/A) for a number of liquids. This parameter is given by the relation

$$\left(\frac{B}{A}\right) = 2\rho_0 C_0 \left(\frac{\partial C}{\partial p}\right)_{T,\,\rho=\rho_0} + \frac{2CT}{C_p}\left(\frac{\partial C}{\partial T}\right)_{P,\,\rho=\rho_0} \quad (1)$$

where the symbols and are respectively instantaneous and equilibrium densities, C_0 is the sound velocity for the waves of infinitesimal amplitude, C_p the specific heat at constant pressure, P the pressure and T absolute temperature.

Beyer and Coppens[1] and Jain *et al.*[4] have carried out the calculations of the third order non-linearity parameter (C/A) in some pure liquids.

$$\left(\frac{C}{A}\right) = \frac{3}{2}\left(\frac{B}{A}\right)^2 + 2\rho_0^2 C_0^3 \left(\frac{\partial^2 C}{\partial p^2}\right) S, \quad \rho = \rho_0 \quad (2)$$

Thakur has carried out the calculation of the non-linearity parameter (D/A) for

a number of liquids

$$\left(\frac{D}{A}\right) = 3\left(\frac{B}{A}\right)^3 + 11\left(\frac{B}{A}\right)C_0^3\rho_0^2\left(\frac{\partial^2 C}{\partial p^2}\right)S,\ \rho = \rho_0 + 22C_0^5\rho_0^3\left(\frac{\partial^3 C}{\partial p^3}\right)S,\ \rho = \rho_0 \quad (3)$$

The results of earlier calculations show[5] that there is a linear variation of (B/A), (C/A) and (D/A) values with temperature. Their relationship with temperature can be shown by the following equations.

$$B/A = a_1 + b_1T \quad (4)$$

$$C/A = a_2 + b_2T \quad (5)$$

$$D/A = a_3 + b_3T \quad (6)$$

where a_1, b_1, a_2, b_2, a_3 and b_3 are constants and we call them as non-linearity acoustic coefficients. Their values have been reported in Table-1 in the pressure range 0 to 100 bar obtained from least square method.

TABLE 1
THE VALUES a_1, b_1, a_2, b_2, a_3 AND b_3 FOR LIQUID HEPTANE, OCTANE, NONANE, DEDECANE AND HEXADECANE.

Liquid	P, bar	(B/A)		(C/A)		(D/A)	
		a_1	b_1	a_1	b_2	a_3	b_3
Heptane	0	10.284	–0.0078	152.022	–0.2349	3255.00	–7.044
	200	9.888	–0.0146	142.200	–0.2707	2764.22	–7.674
	400	8.315	–0.0100	101.070	–0.2400	1722.45	–5.812
	1000	8.139	–0.0088	99.516	–0.2227	1614.44	–4.918
Octane	0	10.552	–0.0149	166.404	–0.4400	3456.30	–9.667
	200	9.735	–0.0047	141.840	–0.1315	2765.67	–3.947
	400	8.361	–0.0087	102.547	–0.1779	1752.75	–5.172
	1000	8.159	–0.0063	99.669	–0.1513	1627.24	–3.648
Nonane	0	10.423	–0.0053	162.795	–0.1652	3395.02	–5.112
	200	9.631	–0.0029	145.057	–0.1784	2684.10	–2.437
	400	8.594	–0.0205	105.663	–0.1379	1739.41	–5.472
	1000	8.387	–0.0114	104.975	–0.2427	1766.46	–6.687
Dedecane	0	10.278	–0.0013	169.428	–0.2801	3257.29	–1.283
	200	9.992	–0.0076	149.236	–0.1844	2986.75	–6.437
	400	8.555	–0.0067	110.111	–0.2022	1877.00	–4.262
	1000	8.487	–0.0081	109.266	–0.2822	1764.71	–3.764
Hexadecane	0	12.094	–0.0451	188.761	–0.7532	4730.95	–36.80
	200	10.588	–0.0184	165.650	–0.5078	3474.05	–15.09
	400	11.995	–0.0502	208.750	–1.4285	4678.41	–40.56
	1000	11.536	–0.0427	193.250	–1.1919	4214.27	–33.30

The variation of a_1, a_2 and a_3 with pressure have show that for hexadecane there is an anomalous variation of a_1, a_2 and a_3 with pressure. From the data it is found that the values of a_1, a_2 and a_3 in the case of rest four alkanes decreases as the pressure is increased from 0 to 400 bar. Further increase of pressure after 400 bar causes a very small decrease in the values of a_1, a_2 and a_3. For practical purposes a_1, a_2 and a_3 remain constant pressure greater than 400 bar. At critical pressure 400 bar all the four higher alkanes namely heptane, octane, nonane and dodecane suddenly change their properties. This is because the all bonds in higher alkanes are compressed to minimum possible values by a pressure P = 400 bar and any higher pressure cannot change the bond length any more. The data also show that the values of a_1, a_2 and a_3 at a particular pressure increases with the addition of a $-CH_2$ group in the higher alkane series. There is no symmetric variation in the values of b_1, b_2 and b_3 which are always negative, with the variation pressure.

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