

Variation of Ultrasonic and Thermo Acoustic Parameters of CYNO Byphenyl Liquid Crystal(8OCB) With Temperature

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ABSTRACT

This research paper communicates the investigations of variation of Ultrasonic and thermoacoustic parameters with temperature of a technically important Liquid crystal 8OCB (4'-octyloxy-4-cyanobiphenyl). Parameters like adiabatic compressibility, Molar sound velocity, Molar compressibility and intermolecular free length and also certain thermoacoustic parameters like., isochoric temperature coefficient of internal pressure (χ), isochoric temperature coefficient of volume expansivity (χ'), pressure co-efficient of bulk modulus (c_1), reduced compressibility (β), reduced volume ($\tilde{v}$) and Sharma constant (S_0) are also evaluated. The anomalous behaviour observed in ultrasonic and thermoacoustic parameters provide supporting evidence to the smectic A- nematic transitions at 66°C and nematic- isotropic transition at 78°C of the liquid crystal under study.

INTRODUCTION

8OCB is a thermotropic liquid crystal compound consisting of highly polar rod like molecules. It is a low molar mass liquid crystal (LC), which shows different liquid crystalline phases depending on temperature conditions. Under normal temperature conditions 8CB exists only as a bulk smectic-A phase.(1) Temperature variation of Ultrasonic velocity was first used to examine phase transition by Gabrielli and Verдини (2) which was confirmed by other workers (3,4). The ultrasonic parameters viz velocity, adiabatic compressibility, Molar sound velocity, intermolecular free length etc., show anomalous behaviour at the phase transition temperature. In addition to this, thermal microscopy (5,6) studies also used to study the phase transition of liquid crystals. But no attempt is made to use the thermoacoustic parameters to confirm the phase transition of the liquid crystals except the few studied by D.P.Singh *et al* (7). So in the present study an attempt is made to estimate various thermoacoustic parameters including Sharma constant in the liquid crystal 8 OCB using only one parameter namely the co-efficient of volume expansion (α).

Theory

The relations used to estimate the ultrasonic parameters like adiabatic compressibility (β_{ad}), molar sound velocity (R_m), molar compressibility (B) and intermolecular free length (L_f) are given in our earlier communications (8,9). The theoretical procedure for the estimation of various thermo-acoustic parameters employing only the co-efficient of volume expansion (α) is essentially the same as that was given by Sharma and Reddy (10,11) and is followed without any modification only the relations are given below.

Harward and Parker (12) obtained an expression for the isochoric temperature coefficient of internal pressure (χ) as

$$\chi = \left[\frac{d \ln P_i}{d \ln T} \right] = \frac{2}{\beta} \left[\frac{d \ln \alpha}{d \ln T} \right] = \frac{-2(1+2\alpha T)}{\tilde{v} c_1} \quad (1)$$

The reduced volume ($\tilde{V}$) and reduced compressibility ($\tilde{B}$) is obtained from α as

$$\tilde{V} = (V/V^*) = \left[1 + \frac{\alpha T}{3(1+\alpha T)} \right]^3 \quad (2)$$

and $\tilde{B} = (\tilde{V})^{c_1}$ (3)

The isochoric temperature co-efficient of volume expansivity (χ') can be written as

$$\chi' = \left[\frac{d \ln \alpha}{d \ln T} \right] = (1 + 2\alpha T) \quad (4)$$

Molewyn - Hughes (13,14), parameter (c_1) is given as

$$c_1 = (13/3) + (1/\alpha T) + (4\alpha T/3) \quad (5)$$

The Sharma constant is given by

$$S_0 = (-\chi/2) (3 + 4\alpha T) \quad (6)$$

and Huggins (14) parameter (F) is related to S_0 as

$$F = 1 + (2\alpha T/3) + \left(\frac{d \ln \beta}{d \ln T} \right)_V \quad (7)$$

RESULTS AND DISCUSSION

The Ultrasonic, density data required in this investigation are taken from (15,16).

The ultrasonic parameters are presented in Table - 1, and the various thermoacoustic parameters of the liquid crystal 8 OCB estimated in the entire temperature region by the authors are presented in Table 2. The thermal microscopy studies (4) revealed that the liquid crystal 8 OCB has a smectic A - nematic transitions at a temperature of 66°C and a nematic - isotropic transition at 78°C. From the Table -1, it can be observed that at the temperature 339°K adiabatic compressibility has a low value and Molar sound velocity, Molar compressibility has a maximum value. A similar behaviour is also observed at the temperature 351°K. This confirms the smectic A - nematic transition at 339°K and nematic - isotropic transition at 351°K.(16)

From the observation of the Table - 2 it can be noticed that all the thermo acoustic parameters show pre transitional effect at and in the immediate vicinity of transition temperature.

The Sharma constant S_0 which is a very important parameter throw some light in understanding the molecular order and inter molecular interactions in the condensed phase. It can be seen that even in the liquid crystalline, where the mesogen simultaneously exhibits anisotropic properties of crystal as well as the rheological properties of liquids, the value of Sharma constant is also constant with the same characteristic constant value of 1.11 ± 0.01 as was reported by Sharma and Sharma and Reddy, in certain non-mesomorphic systems.

Only at and in the immediate vicinity of isotropic - nematic transition and smectic A - nematic transitions the value S_0 changes to a lower value which is less than the characteristic value. Exactly at the transition temperature it exhibits lower values which can be used to detect the exact transition.

In a similar way the other thermo acoustic parameters Isochoric temperature co-efficient of volume expansivity (χ'), the isochoric temperature coefficient of internal pressure (χ), reduced compressibility (β), the reduced volume ($\tilde{V}$), the Huggins parameter (F), the parameters S^* and S_0^* also show anomalous behaviour and pre-transitional effects.

Table 1: Variation of Ultrasonic Parameters with Temperature of Liquid Crystal 8 OCB

Temperature T K	Ultrasonic Velocity U m/s	Specific Volume V cm ³ /g	Adiabatic Compressibility B _{ad} × 10 ¹²	Molar sound Velocity	Molar Compressibility B	Intermolecular free length L _f A ^o
331	1600	0.9862	38.52	3546	9321	0.3916
333	1605	0.9871	38.31	3553	9337	0.3906

335	1585	0.9855	39.35	3543	9314	0.3935
337	1575	0.9905	39.29	3542	9335	0.3955
339	1695	0.9921	34.53	3636	9524	0.3708
341	1623	0.9934	37.72	3589	9417	0.3875
343	1595	0.995	39.11	3574	9384	0.3946
345	1590	0.9975	39.46	3577	9395	0.3963
347	1588	0.998	39.56	3579	9396	0.3968
349	1586	1.0014	39.81	3590	9420	0.3981
351	1610	1.004	38.73	3617	9482	0.3926
353	1570	1.0066	40.96	3596	9435	0.4032
355	1550	1.0081	41.96	3986	9412	0.4087

Table 2 : Variation of Thermo-Acoustic Parameters of Liquid Crystal 8 OCB

Temperature	$\chi \times 10^4$	c_1	V	B	χ	χ'	S_0	$\bar{V}$	S_0^*	S^*
331	8.04	8.3634	1.229	5.610	0.5509	1.545	1.12	1.184	1.133	1.364
333	8.10	8.4004	1.228	5.614	0.5484	1.539	1.12	1.189	1.132	1.359
335	8.15	8.3600	1.230	5.644	0.5478	1.546	1.12	1.183	1.133	1.364
337	10.75	7.5767	1.290	6.885	0.5009	1.725	1.11	1.016	1.163	1.483
339	15.21	6.9602	1.380	9.410	0.4317	2.031	1.09	0.743	1.204	1.688
341	10.60	7.5818	1.289	6.854	0.5027	1.723	1.11	1.022	1.163	1.482
343	9.82	7.7513	1.274	6.534	0.5123	1.674	1.11	1.062	1.155	1.499
345	9.80	7.7418	1.275	6.559	0.5111	1.672	1.12	1.064	1.155	1.451
347	9.91	7.6998	1.278	6.611	0.5105	1.688	1.12	1.053	1.157	1.459
349	16.25	6.8528	1.407	10.381	0.4112	2.214	1.08	0.653	1.215	1.756
351	29.56	6.6805	1.601	23.197	0.2651	3.075	0.94	0.118	1.290	2.383
353	18.35	6.7408	1.447	12.069	0.3804	2.296	1.06	0.515	1.232	1.864
355	9.84	7.6618	1.281	6.668	0.5095	1.699	1.12	1.044	1.159	1.466

CONCLUSION

From the results, obtained in the present investigation we can conclude that, the thermo acoustic parameters can also be used to study the phase transition in addition to the Ultrasonic parameters. The sharp change in these values can be used to detect the exact phase transition temperature.

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