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Thermodynamic Studies on Liquid Crystalline Benzoates

C.M. Subhan
Department of Physics,
S.K. University,
Anantapuramu (A.P), India.
subhan.physics@gmail.com

R. Jeevan Kumar
Department of Physics,
S.K. University,
Anantapuramu (A.P), India.
rjkskuphy@yahoo.com

N.V.S. Gupta
Department of Physics,
G.P.R. College of Engineering,
Kurnool (A.P), India.
guptanvs@gmail.com

K. Fakruddin
Department of Physics,
Ghousia College of Engineering,
Ramanagaram, India.
drfakruddin2008@gmail.com

Abstract: *The thermodynamic parameters viz., Moelwyn-Hughes parameter (C_1), the reduced molar volume ($\tilde{V}$), the isochoric temperature coefficient of internal pressure (X), the Sharma's parameter(S_0), fractional free volume (f), Thermal parameter (A^*), Gruneisen parameter (Γ_p), the reduced bulk modulus ($\beta^{\sim}$), isothermal microscopic Gruneisen parameter (Γ), Huggins parameter (F) isothermal, isochoric and isobaric Gruneisen parameters (Γ_{ith}, Γ_{ich}, Γ_{iba}), Beyer's nonlinearity parameter (B/A), isochoric temperature coefficient of volume expansivity (X^1), pressure coefficient of bulk modulus (C_1^*) have been evaluated using the thermal expansion coefficient (α) obtained from density data in the two liquid crystalline compounds namely, (E)-4-((octyloxy)benzylidene)amino)phenyl 4-(butoxy benzoate) and (E)-4-((octyloxy)benzylidene)amino)phenyl 4-(tridecycloxy benzoate). Sharma's parameter has been found to be 1.117±0.001. The results revealed that all the thermo dynamic parameters show the characteristic changes at the phase transformation.*

Keywords: *Liquid crystals, thermal expansion coefficient, thermodynamic parameters, phase transformation.*

1. INTRODUCTION

The importance of liquid crystalline materials lies in their extensive applications in diverse fields. Liquid crystals find their applications already in display devices from small watch displays to the flat TV screen and computer panels. There are many other applications in information storage and possible elements to combine with other in the creation of nanoeee scale devices. Physical properties of liquid crystalline materials govern their use in different devices. The study of thermodynamic parameters provides the necessary input to understand the intermolecular interactions involved in molecular formation.

In the present investigation the temperature variation of density is measured [1-4] which provide information regarding the nature of the phase transition and the growth of the pre transitional effects. During the phase transition the free energy of the system remains continuous while thermodynamic quantities like entropy, heat capacity etc., undergoes discontinuous changes. Using density data, thermal expansion coefficient and various thermo dynamical parameters have been evaluated and their changes at phase transformations are observed for the liquid crystalline benzoates.

2. EXPERIMENTAL

The density of the LC compounds is measured by using dilatometer, which consists of specially constructed Pyknometer. The Pyknometer consists of capillaries with a diameter of about 250 microns and 0.07-0.12 m length is mounted on a U-shaped glass tube. The Pyknometer was calibrated by measuring the molar volume of water at different temperatures. The sample is filled in pyknometer and its mass was measured by using chemical balance with an accuracy of 0.0001

x 10^{-3} Kg. The pyknometer was kept in heating chamber at a temperature 10^{o}C above the clearing temperature. Then the sample was slowly cooled until the sample level reaches the mark in capillaries. The excess sample in the cups of the capillaries was removed by syringe. Conventional cathetometer was used to measure the liquid crystal levels in the capillaries. The main scale and verneir scale is replaced with a digital scale instead of viewing the liquid levels through the telescope eyepiece a CCD camera is attached to the telescope and the levels of capillary were observed on a TV with a very high magnification. The experimental setup used to measure the densities and the molecular structures of the present investigated liquid crystalline compounds are shown in Fig. 1-3.

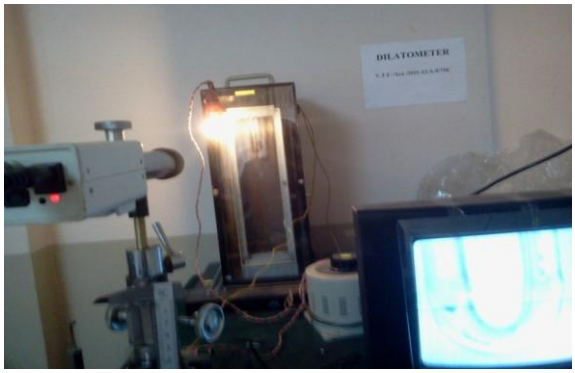

Figure 1. *Experimental setup to measure the density*

Figure 2. *Molecular structure of comp.1*

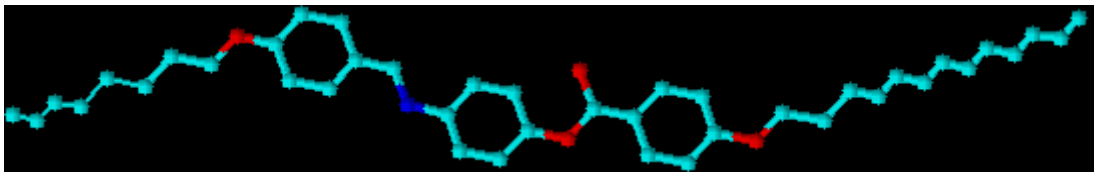

Figure3. *Molecular structure of comp.2*

3. THEORY AND EXPRESSIONS

The procedure for the estimation of different thermodynamic parameters using the coefficient of thermal expansion (α) is described below [5, 6].

The Moelwyn-Hughes parameter [7] and the reduced molar volume ($\tilde{V}$) are evaluated from the following expressions.

$$C = \frac{13}{3} + (\alpha T)^{-1} + \frac{4}{3}(\alpha T) \quad (1)$$

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

Using the coefficient of thermal expansion Haward and Parker [8] obtained an expression for the isochoric temperature coefficient of internal pressure (X) as

$$X = \frac{-2(1+2T)}{V C_1} \quad (3)$$

The isochoric temperature coefficient of volume expansivity (X^1) can be given as

$$X^1 = -2(1 + 2\alpha T) \quad (4)$$

Huggins [9, 10] parameter (F) of a liquid crystal is related to S_o as

$$F = 2\left[1 + \frac{S_0}{3+4\alpha T}\right] - \left(\frac{3+4\alpha T}{3}\right) \quad (5)$$

The isothermal microscopic Gruneisen parameter [11] (Γ) is a measure of volume dependence of the harmonicity of the normal mode frequency (v) of a molecular vibrations of a polymer and is related to F and S_0 as

$$\Gamma = \left(\frac{2}{3}\right)\alpha T + \left(\frac{2+F+4\alpha T}{2\alpha T}\right) \quad (6)$$

The Sharma parameter [12] (S_o) is given by the expression

$$S_o = \frac{-X}{2}3(1 + \alpha T) \quad (7)$$

The fractional free volume (f) is a measure of disorder due to increasing mobility of molecules in a polymer and can be expressed in terms of the isothermal microscopic Gruneisen parameter (Γ) as

$$f = \left(\frac{V_a}{V}\right) = \left(\frac{1}{\Gamma+1}\right) \quad (8)$$

Where V_a is the available volume of a liquid crystal.

Thermal parameter (A^*), is a dimensionless parameter which shows that at low temperatures, a liquid crystal tends to be ordered exhibiting a small thermal expansion and small fractional free volume, thereby making A^* equal to unity.

$$A^* = \left(\frac{1+f^2}{1-f}\right) = 1 + \left(\frac{f}{\Gamma}\right) \quad (9)$$

The Gruneisen parameter(Γ_P) for liquid crystals can be found from

$$\Gamma_P = \left(\frac{2}{3}\right)\alpha T + \left(\frac{1}{2\alpha T}\right) + 2 \quad (10)$$

The isothermal, isobaric and isochoric Gruneisen parameters are identical to the corresponding acoustical parameters so one can write

$$\Gamma_{ich} = \Gamma_{ith} + \Gamma_{iba} \quad (11)$$

The isochoric Gruneisen parameter Γ_{ich} could be evaluated using the following equation

$$\Gamma_{ich} = -\frac{E-F}{F} \quad (12)$$

Where $E = -[2 + (\alpha T)^{-1}]\left[2\alpha\left(\tilde{V}\right)^{C1^{-1}}\right]$ and F=-2α

The isothermal Anderson-Gruneisen parameter δ is known to be an important parameter in the theory of temperature dependence of bulk modulus in solids. It is defined as

$$\delta = 2\Gamma_{\text{iba}} \quad (13)$$

The Anderson-Gruneisen parameter is distinguished from the Moelwyn-Hughes parameter by introducing a new parameter θ as

$$\theta = 2(\Gamma_{ith} - \Gamma_{iba}) + 1 \quad (14)$$

The pressure coefficient of bulk modulusC_1^* as derived from α and V is given as

$$C_1^* = \left(1 + \frac{\delta}{3}\right)\left[1 + (1 + \frac{1}{\alpha T})/(1 + \frac{\delta}{3})\right] \quad (15)$$

4. RESULTS AND DISCUSSION

The temperature variation of density for the liquid crystalline compounds is measured and illustrated in Fig. 4-5. The density is found to decrease with increase of temperature in the liquid crystalline phases except in the vicinity of phase transitions, where it shows a steep increase before it attains equilibrium value of the next phase. Using the density data, the thermal expansion coefficient (α) is estimated. Further by using the thermal expansion coefficient (α) the temperature dependence of a number of thermo dynamic parameters were estimated and represented in Tables 1 and 2.

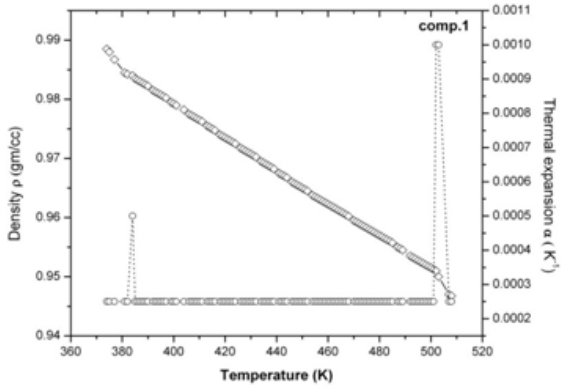

Figure 1. *Variation of density and thermal expansion coefficient with temperature in comp.1*

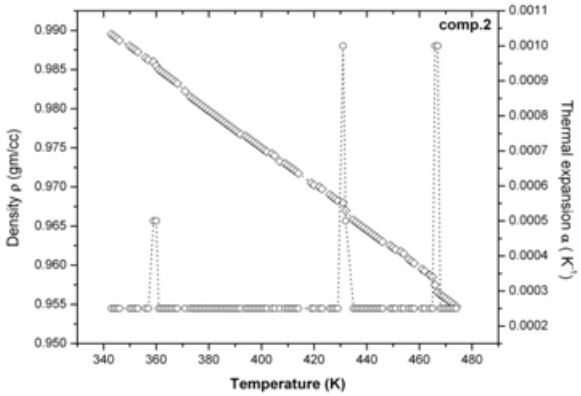

Figure 2. *Variation of density and thermal expansion coefficient with temperature in comp.2*

Table 1. *Thermodynamic parameters of (E)-4-((4-(octyloxy) benzylidene) amino) phenyl 4-butoxy benzoate*

T(K)	C_1	$\tilde{V}$	X	S_o	f	A^*	Γ_p	$\tilde{\beta}$	F
477	12.874	1.110	-0.643	1.118	0.073	1.003	6.272	0.259	1.484
478	12.857	1.110	-0.643	1.118	0.073	1.003	6.263	0.259	1.483
479	12.840	1.110	-0.643	1.118	0.073	1.003	6.255	0.259	1.483
480	12.822	1.111	-0.642	1.118	0.073	1.003	6.246	0.259	1.482
481	12.805	1.111	-0.642	1.118	0.073	1.003	6.238	0.259	1.482
482	12.789	1.111	-0.642	1.118	0.073	1.003	6.229	0.258	1.481
483	12.772	1.111	-0.642	1.118	0.074	1.003	6.221	0.258	1.481
484	12.755	1.111	-0.642	1.118	0.074	1.003	6.212	0.258	1.480
485	12.738	1.112	-0.642	1.118	0.074	1.003	6.204	0.258	1.480
486	12.722	1.112	-0.641	1.118	0.074	1.003	6.196	0.258	1.479
487	12.705	1.112	-0.641	1.118	0.074	1.003	6.187	0.258	1.479
488	12.688	1.112	-0.641	1.118	0.074	1.003	6.179	0.257	1.478
489	12.672	1.112	-0.641	1.118	0.074	1.003	6.171	0.257	1.478
490	12.656	1.113	-0.641	1.118	0.074	1.003	6.163	0.257	1.477
491	12.639	1.113	-0.641	1.118	0.074	1.003	6.155	0.257	1.235
492	12.623	1.113	-0.640	1.118	0.074	1.003	6.147	0.257	1.476
493	12.607	1.113	-0.640	1.118	0.075	1.003	6.138	0.257	1.476
494	12.591	1.114	-0.640	1.119	0.075	1.003	6.130	0.256	1.475
495	12.575	1.114	-0.640	1.119	0.075	1.003	6.122	0.256	1.475
496	12.559	1.114	-0.640	1.119	0.075	1.003	6.114	0.256	1.474
497	12.543	1.114	-0.640	1.119	0.075	1.003	6.106	0.256	1.474
498	12.527	1.114	-0.639	1.119	0.075	1.003	6.099	0.256	1.473
499	12.511	1.115	-0.639	1.119	0.075	1.003	6.091	0.255	1.473
500	12.496	1.115	-0.639	1.119	0.075	1.003	6.083	0.255	1.472
501	12.480	1.115	-0.639	1.119	0.075	1.003	6.075	0.255	1.472
502	6.989	1.372	-0.437	1.095	0.152	1.032	3.330	0.109	0.768
503	6.987	1.373	-0.437	1.095	0.152	1.032	3.329	0.108	0.766
504	12.434	1.116	-0.638	1.119	0.076	1.003	6.052	0.255	1.470
505	12.418	1.116	-0.638	1.119	0.076	1.003	6.044	0.254	1.470

506	12.403	1.116	-0.638	1.119	0.076	1.003	6.036	0.254	1.469
507	12.388	1.116	-0.638	1.119	0.076	1.003	6.029	0.254	1.469
508	12.372	1.116	-0.638	1.119	0.076	1.003	6.021	0.254	1.468
509	12.357	1.117	-0.637	1.119	0.076	1.003	6.014	0.254	1.468
510	12.342	1.117	-0.637	1.119	0.076	1.003	6.006	0.254	1.467

Table 1.*Continued*

T(K)	Γ	Γ_{ith}	Γ_{ich}	Γ_{iba}	θ	δ	B/A	X^1	C_1^*
477	16.689	5.937	3.113	2.823	7.226	5.647	11.874	-1.238	9.385
478	16.657	5.928	3.109	2.819	7.218	5.639	11.857	-1.239	9.368
479	16.624	5.919	3.104	2.815	7.209	5.630	11.840	-1.239	9.350
480	16.592	5.911	3.100	2.811	7.200	5.622	11.822	-1.240	9.333
481	16.560	5.902	3.095	2.807	7.191	5.614	11.805	-1.240	9.316
482	16.528	5.894	3.091	2.803	7.182	5.606	11.789	-1.241	9.298
483	16.496	5.886	3.087	2.798	7.174	5.597	11.772	-1.241	9.281
484	16.464	5.877	3.082	2.794	7.165	5.589	11.755	-1.242	9.264
485	16.433	5.869	3.078	2.790	7.156	5.581	11.738	-1.242	9.247
486	16.401	5.861	3.074	2.786	7.148	5.573	11.722	-1.243	9.230
487	16.370	5.852	3.069	2.782	7.139	5.565	11.705	-1.243	9.213
488	16.339	5.844	3.065	2.778	7.131	5.557	11.688	-1.244	9.196
489	16.308	5.836	3.061	2.774	7.122	5.549	11.672	-1.244	9.179
490	16.277	5.828	3.057	2.770	7.114	5.541	11.656	-1.245	9.163
491	8.754	5.819	3.052	2.767	7.105	5.534	11.639	-1.245	9.146
492	16.215	5.811	3.048	2.763	7.097	5.526	11.623	-1.246	9.130
493	16.185	5.803	3.044	2.759	7.089	5.518	11.607	-1.246	9.113
494	16.154	5.795	3.040	2.755	7.080	5.510	11.591	-1.247	9.097
495	16.124	5.787	3.036	2.751	7.072	5.502	11.575	-1.247	9.080
496	16.094	5.779	3.032	2.747	7.064	5.495	11.559	-1.248	9.064
497	16.064	5.771	3.027	2.743	7.055	5.487	11.543	-1.248	9.048
498	16.034	5.763	3.023	2.739	7.047	5.479	11.527	-1.249	9.032
499	16.004	5.755	3.019	2.736	7.039	5.472	11.511	-1.249	9.016
500	15.974	5.748	3.015	2.732	7.031	5.464	11.496	-1.250	9.000
501	15.945	5.740	3.011	2.728	7.023	5.457	11.480	-1.250	8.984
502	5.091	2.994	1.507	1.487	4.014	2.975	5.989	-2.004	2.992
503	5.085	2.993	1.506	1.487	4.012	2.974	5.987	-2.006	2.988
504	15.857	5.717	2.999	2.717	6.999	5.434	11.434	-1.252	8.936
505	15.827	5.709	2.995	2.713	6.991	5.427	11.418	-1.252	8.920
506	15.798	5.701	2.991	2.709	6.983	5.419	11.403	-1.253	8.905
507	15.770	5.694	2.987	2.706	6.975	5.412	11.388	-1.253	8.889
508	15.741	5.686	2.983	2.702	6.967	5.405	11.372	-1.254	8.874
509	15.712	5.678	2.979	2.698	6.959	5.397	11.357	-1.254	8.858
510	15.684	5.671	2.976	2.695	6.952	5.390	11.342	-1.255	8.843

Table 2. *Thermodynamic parameters of (E)-4-((4-(octyloxy) benzylidene) amino) phenyl 4-(tridecycloxy benzoate)*

T(K)	C_1	$\tilde{\boldsymbol{V}}$	X	S_o	f	A^*	Γ_p	$\tilde{\boldsymbol{\beta}}$	F
428	13.818	1.099	-0.652	1.117	0.067	1.002	6.744	0.268	1.509
429	13.796	1.100	-0.651	1.117	0.068	1.002	6.733	0.268	1.508
430	13.775	1.100	-0.651	1.117	0.068	1.002	6.722	0.268	1.508
431	7.223	1.332	-0.468	1.106	0.145	1.026	3.447	0.125	0.893
432	9.246	1.188	-0.580	1.121	0.106	1.009	4.458	0.202	1.292
433	13.711	1.100	-0.651	1.117	0.068	1.002	6.691	0.267	1.506
434	13.690	1.101	-0.651	1.117	0.068	1.002	6.680	0.267	1.506
435	13.670	1.101	-0.650	1.117	0.068	1.002	6.670	0.267	1.505
436	13.649	1.101	-0.650	1.117	0.068	1.002	6.659	0.267	1.505
437	13.628	1.101	-0.650	1.117	0.069	1.002	6.649	0.266	1.504
438	13.608	1.101	-0.650	1.117	0.069	1.002	6.639	0.266	1.504
439	13.587	1.102	-0.650	1.117	0.069	1.002	6.628	0.266	1.503
440	13.567	1.102	-0.650	1.118	0.069	1.002	6.618	0.266	1.503
441	13.546	1.102	-0.649	1.118	0.069	1.002	6.608	0.266	1.502

442	13.526	1.102	-0.649	1.118	0.069	1.002	6.598	0.266	1.502
443	13.506	1.103	-0.649	1.118	0.069	1.002	6.588	0.265	1.501
444	13.486	1.103	-0.649	1.118	0.069	1.002	6.578	0.265	1.501
445	13.466	1.103	-0.649	1.118	0.069	1.002	6.568	0.265	1.500
446	13.446	1.103	-0.648	1.118	0.070	1.002	6.558	0.265	1.500
447	13.427	1.103	-0.648	1.118	0.070	1.003	6.548	0.265	1.499
448	13.407	1.104	-0.648	1.118	0.070	1.003	6.538	0.264	1.499
449	13.387	1.104	-0.648	1.118	0.070	1.003	6.529	0.264	1.498
450	13.368	1.104	-0.648	1.118	0.070	1.003	6.519	0.264	1.498
451	13.349	1.104	-0.648	1.118	0.070	1.003	6.509	0.264	1.497
452	13.329	1.105	-0.647	1.118	0.070	1.003	6.500	0.264	1.497
453	13.310	1.105	-0.647	1.118	0.070	1.003	6.490	0.264	1.496
454	13.291	1.105	-0.647	1.118	0.070	1.003	6.480	0.263	1.496
455	13.272	1.105	-0.647	1.118	0.071	1.003	6.471	0.263	1.495
456	13.253	1.105	-0.647	1.118	0.071	1.003	6.461	0.263	1.495
457	13.234	1.106	-0.647	1.118	0.071	1.003	6.452	0.263	1.494
458	13.215	1.106	-0.646	1.118	0.071	1.003	6.443	0.263	1.494
459	13.197	1.106	-0.646	1.118	0.071	1.003	6.433	0.262	1.493
460	13.178	1.106	-0.646	1.118	0.071	1.003	6.424	0.262	1.493
461	13.160	1.106	-0.646	1.118	0.071	1.003	6.415	0.262	1.492
462	13.141	1.107	-0.646	1.118	0.071	1.003	6.406	0.262	1.492
463	13.123	1.107	-0.645	1.118	0.071	1.003	6.396	0.262	1.491
464	13.104	1.107	-0.645	1.118	0.071	1.003	6.387	0.262	1.491
465	13.086	1.107	-0.645	1.118	0.072	1.003	6.378	0.261	1.490
466	7.095	1.352	-0.452	1.101	0.149	1.029	3.383	0.117	0.831
467	7.092	1.353	-0.452	1.101	0.149	1.029	3.381	0.116	0.829
468	13.032	1.108	-0.645	1.118	0.072	1.003	6.351	0.261	1.489
469	13.014	1.108	-0.644	1.118	0.072	1.003	6.342	0.261	1.488
470	12.996	1.108	-0.644	1.118	0.072	1.003	6.333	0.261	1.488
471	12.979	1.109	-0.644	1.118	0.072	1.003	6.324	0.260	1.487
472	12.961	1.109	-0.644	1.118	0.072	1.003	6.315	0.260	1.487
473	12.943	1.109	-0.644	1.118	0.072	1.003	6.307	0.260	1.486

Table 2.*Continued*

T(K)	Γ	Γ_{ith}	Γ_{ich}	Γ_{iba}	θ	δ	B/A	X^1	C_1^*
428	13.709	6.409	3.356	3.052	7.713	6.104	12.818	-1.214	10.345
429	13.684	6.398	3.351	3.046	7.702	6.093	12.796	-1.214	10.324
430	13.660	6.387	3.345	3.041	7.691	6.083	12.775	-1.215	10.302
431	5.890	3.111	1.590	1.520	4.181	3.041	6.223	-1.862	3.320
432	8.410	4.123	2.170	1.952	5.341	3.905	8.246	-1.432	5.629
433	13.587	6.355	3.329	3.026	7.659	6.052	12.711	-1.216	10.237
434	13.563	6.345	3.324	3.021	7.648	6.042	12.690	-1.217	10.216
435	13.539	6.335	3.318	3.016	7.637	6.032	12.670	-1.217	10.195
436	13.515	6.324	3.313	3.011	7.626	6.022	12.649	-1.218	10.174
437	13.492	6.314	3.308	3.006	7.616	6.012	12.628	-1.218	10.153
438	13.468	6.304	3.302	3.001	7.605	6.002	12.608	-1.219	10.132
439	13.445	6.293	3.297	2.996	7.595	5.992	12.587	-1.219	10.111
440	13.421	6.283	3.292	2.991	7.584	5.982	12.567	-1.220	10.090
441	13.398	6.273	3.287	2.986	7.574	5.972	12.546	-1.220	10.070
442	13.375	6.263	3.281	2.981	7.563	5.963	12.526	-1.221	10.049
443	13.352	6.253	3.276	2.976	7.553	5.953	12.506	-1.221	10.029
444	13.329	6.243	3.271	2.971	7.543	5.943	12.486	-1.222	10.009
445	13.306	6.233	3.266	2.966	7.532	5.933	12.466	-1.222	9.988
446	13.283	6.223	3.261	2.962	7.522	5.924	12.446	-1.223	9.968
447	13.261	6.213	3.256	2.957	7.512	5.914	12.427	-1.223	9.948
448	13.238	6.203	3.251	2.952	7.502	5.905	12.407	-1.224	9.928
449	13.216	6.193	3.246	2.947	7.492	5.895	12.387	-1.224	9.908
450	13.193	6.184	3.241	2.943	7.482	5.886	12.368	-1.225	9.888
451	13.171	6.174	3.236	2.938	7.472	5.877	12.349	-1.225	9.869
452	13.149	6.164	3.231	2.933	7.462	5.867	12.329	-1.226	9.849

453	13.127	6.155	3.226	2.929	7.452	5.858	12.310	-1.226	9.830
454	13.105	6.145	3.221	2.924	7.442	5.849	12.291	-1.227	9.810
455	13.083	6.136	3.216	2.919	7.432	5.839	12.272	-1.227	9.791
456	13.062	6.126	3.211	2.915	7.422	5.830	12.253	-1.228	9.771
457	13.040	6.117	3.206	2.910	7.413	5.821	12.234	-1.228	9.752
458	13.018	6.107	3.201	2.906	7.403	5.812	12.215	-1.229	9.733
459	12.997	6.098	3.196	2.901	7.393	5.803	12.197	-1.229	9.714
460	12.976	6.089	3.192	2.897	7.384	5.794	12.178	-1.230	9.695
461	12.954	6.080	3.187	2.892	7.374	5.785	12.160	-1.230	9.676
462	12.933	6.070	3.182	2.888	7.365	5.776	12.141	-1.231	9.658
463	12.912	6.061	3.177	2.883	7.355	5.767	12.123	-1.231	9.639
464	12.891	6.052	3.173	2.879	7.346	5.758	12.104	-1.232	9.620
465	12.870	6.043	3.168	2.875	7.336	5.750	12.086	-1.232	9.602
466	5.710	3.047	1.546	1.501	4.092	3.002	6.095	-1.932	3.145
467	5.705	3.046	1.545	1.500	4.090	3.001	6.092	-1.934	3.141
468	12.808	6.016	3.154	2.861	7.308	5.723	12.032	-1.234	9.547
469	12.787	6.007	3.149	2.857	7.299	5.715	12.014	-1.234	9.528
470	12.767	5.998	3.145	2.853	7.290	5.706	11.996	-1.235	9.510
471	12.747	5.989	3.140	2.849	7.281	5.698	11.979	-1.235	9.492
472	12.726	5.980	3.136	2.844	7.272	5.689	11.961	-1.236	9.474
473	12.706	5.971	3.131	2.840	7.262	5.681	11.943	-1.236	9.456

From our investigation it is observed that even in the liquid crystalline state, where the mesogen simultaneously exhibits the anisotropic properties of crystals as well as rheological properties of liquids, the Sharma parameter S_o is found to be constant and is around 1.117±0.001 for the liquid crystalline compounds except in the vicinity of phase transition, where it shows a slight minimum value at the phase transition temperature. The parameters reduced molar volume ($\tilde{V}$) and isochoric temperature coefficient of internal pressure (X) and their variation with temperature are similar to that of thermal expansion coefficient (α) as expected, because they are proportional to (α) in all the compounds.

The parameters C_1, Γ_p, $\tilde{\beta}$, δ, B/A, F, Γ slightly decreases with increase of temperature and in the vicinity of the phase transformation there is steep decrease in the above values. Reduced molar volume ($\tilde{V}$), isochoric temperature coefficient of internal pressure (X), fractional free volume (f) is found to be increase with the increase of temperature and during phase transformation there is a sudden increase in the above values. The thermal parameter (A^*) is found to be almost unity. The isothermal, isochoric, isobaric Gruneisen parameters show the consistent values but decreases in liquid crystalline phases.

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REFERENCES

[1] Datta Prasad P. V., Ramakrishna Nanchara Rao M., Lalitha Kumari J. and Pisipati V. G. K. M., Simulataneous characterization and dilatometry studies on liquid crystalline N-(*p*-*n*-decycloxy and undecycloxybenzylidene)-*p*-toludines, Phys. Chem. Liq. 47(2), 123 (2009).

[2] Srinivasu C. H., Pisipati V. G. K. M., Prabhu C. R., Murthy P. N. and Lakshminarayana S., Phase Transitions in *p*-(Phenyl Benzylidene)-p^1-Alkylaniline Compounds: A Dilatometric Study, Z. Naturforsch. 62(1-2), 75 (2007).

[3] Ajeetha N., Ramakrishna Nanchara Rao M., Datta Prasad P. V. and Pisipati V. G. K. M., Synthesis, Characterization, and Dilatometric Studies on N-(p-nAlkoxybenzylidene)-p-n-pentyloxyanilines Compounds, Mol. Cryst. Liq. Cryst. 457(1), 3 (2006).

[4] Gogoi B., Ghosh T. K. and Alapati P. R., Experimental investigation of phase transitions exhibited by symmetric liquid crystal dimmers, Cryst. Res. Tech. 40(7), 709 (2005).

[5] Ranga Reddy R. N. V., Suryanarayana A. and Rama Murthy V., Coefficient of volume expansion and thermo acoustic parameters in N-(P-hexyloxybenzylidene)-P-toluidine, Cryst. Res. Tech. 34, 939 (1999).

[6] Reddy R. R., Venkatesulu A., Rama Gopal K. and Neelakanteswara Reddy K., Thermo acoustic parameters in the nematic and isotropic phases of 5CB and tetramethyl methane in 5CB, J. Mol. Liq. 130, 112 (2007).

[7] Moelwyn-Hughes E. A., The Determination of Intermolecular Energy Constants from common Physicochemical properties of Liquids, J. Phys. Chem.;55(7), 1246 (1951).

[8] Haward R. N. and Parker B. N., The internal pressure of simple liquids, J. Phys. Chem. 72(5), 1842 (1968).

[9] Huggins M. L., Lattice Energies, Equilibrium Distances, Compressibilities and characteristic frequencies of alkali halides, J. Chem. Phys. 5(2), 143 (1937).

[10] Huggins M., Errata: Lattice Energies, Equilibrium Distances, Compressibilities and characteristic frequencies of alkali halides, J. Chem. Phys. 15(4), 212 (1947).

[11] Anderson O. L. Equations for thermal expansivity in planatery interiors, J. Geophys.Res. 72(14), 3661 (1967).

[12] Sharma B. K., Nonlinearity parameter and its relationship with thermo-acoustic parameters of polymers, *J. Phys. D: Appl. Phys.* 16(10), 1959 (1983).