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DILATOMETRIC STUDY TO ESTIMATE THERMO DYNAMICAL PARAMETERS OF TWO CBOnO.m LIQUID CRYSTALLINE COMPOUNDS

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ABSTRACT

The specially designed pykanometre and dilatometer is used to measure the temperature variation of density of two liquid crystalline CBOnO.m compounds namely

1. α-(4-cyanobiphenyl-4 heptyloxy)-ω-4-n-alkylanilinebenzylidene-4oxy)decane (C_1)
2. α-(4-cyanobiphenyl-4 decyloxy)-ω-4-n-alkylanilinebenzylidene-4oxy)decane (C_2)

Using density and thermal expansion coefficient data the temperature dependence of number of thermo dynamical parameters are estimated for the above two compounds. The results reveal that all the parameter shows a characteristic change at phase transition. The results are discussed in the light of the literature data available for number of liquid crystalline compounds.

INTRODUCTION

The liquid crystalline research involves the design, synthesis and characterization of new materials and to test their suitability in different applications by measuring various physical, optical and thermo dynamical properties. The thermodynamic parameters provide the necessary input to understand different kinds of interactions involved in the molecular formation. In the present paper the temperature variation of density is measured using Dilatometric technique (Nagi Reddy *et al.,* 2011, Datta Prasad *et al.,* 2009, Ajeetha *et al.,* 2006; Gogoi *et al.,* 2005; Alapati *et al.,* 1988; Rao *et al.,* 1988). By density data the thermal expansion coefficient and various thermo dynamical 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 (β^-), isothermal, isochoric and isobaric Gruneisen parameter (Γ_{ith}, Γ_{ich}, Γ_{iba}), Beyer's nonlinearity parameter (B/A), Huggins parameter (F), the isothermal microscopic Gruneisen parameter (Γ) have been evaluated for the above liquid crystalline compounds. The results are critically discussed with the literature data available on number of liquid crystalline compounds.

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Experimental

The density of the LC compounds is measured by using dilatometer, which consists of specially designed Pyknometer. The Pyknometer consists of capillaries with a diameter of about 250 microns and 0.05-0.10 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. The pyknometer was kept in heating chamber at a temperature 5°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 vernier

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 monitor with a very high magnification. By the above technique the temperature variation of density was measured and hence thermal expansion coefficient was evaluated to estimate various thermo dynamical parameters.

Theory and expressions: The theory for the estimation of different thermodynamic parameters using the coefficient of thermal expansion (α) is reported by several authors (Ranga Reddy *et al.,* 1999; Fakruddin *et al.,* 2010). The Moelwyn-Hughes parameter (Moelwyn-Hughes, 1951), Beyer's nonlinearity parameter and the reduced molar volume ($\tilde{V}$) are evaluated from the following expressions.

$$C_1 = \frac{13}{3} + (\alpha T)^{-1} + \frac{4}{3}(\alpha T) \quad (1)$$

$$\frac{B}{A} = C_1 - 1 \quad (2)$$

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

Using the coefficient of thermal expansion Haward and Parker (Haward and Parker, 1968) obtained an expression for the isochoric temperature coefficient of internal pressure (X) as

$$X = \frac{-2(1+2T)}{V^{C_1}} \quad (4)$$

The Sharma parameter (S_o) (Sharma, 1983; Reddy *et al.,* 2007) is given by the expression

$$S_o = \frac{-X}{2}(3 + 4\alpha T) \quad (5)$$

The isothermal microscopic Gruneisen parameter (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 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

$$f = \left(\frac{V_a}{V}\right) = \left(\frac{1}{\Gamma+1}\right) \quad (7)$$

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.

$$A^* = \left(\frac{1+f^2}{1-f}\right) = 1 + \left(\frac{f}{\Gamma}\right) \quad (8)$$

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

$$\Gamma_P = \left(\frac{2}{3}\right)\alpha T + \left(\frac{1}{2\alpha T}\right) + 2 \quad (9)$$

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

$$\Gamma_{ich} = \Gamma_{ith} + \Gamma_{iba} \quad (10)$$

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

$$\Gamma_{ich} = -\frac{E-F}{F} \quad (11)$$

Where

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

The Huggins parameter (F) of a liquid crystal is related to S_O by the equation

$$F = 2\left[1 + \left(\frac{S_O}{3+4\alpha T}\right)\right] - \left(3 + \frac{4\alpha T}{3}\right) \quad (12)$$

RESULTS AND DISCUSSION

The temperature variation of density for the liquid crystalline compounds is measured and illustrated in Figures 1-2.

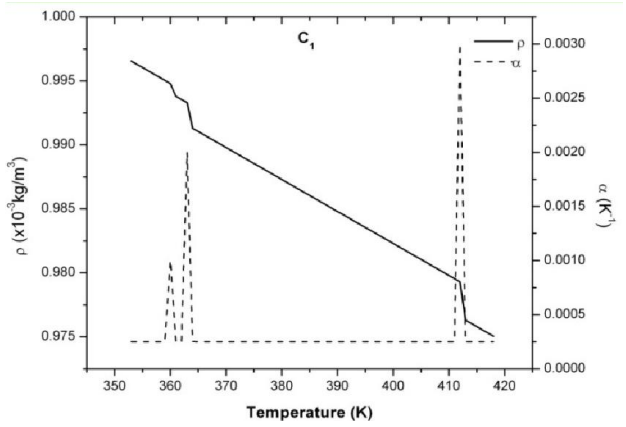

Figure 1. Variation of density and thermal expansion coefficient with temperature in (C_1)

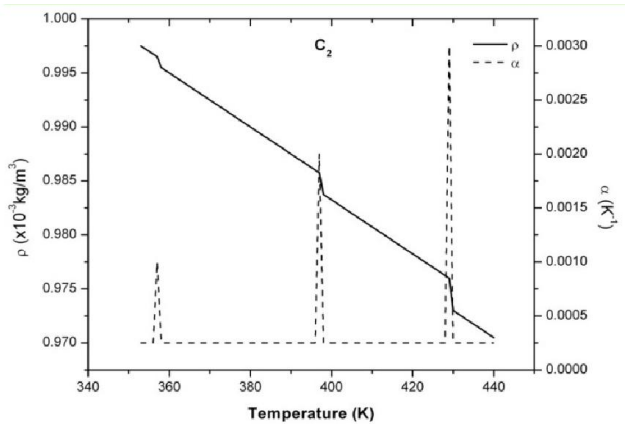

Figure 2. Variation of density and thermal expansion coefficient with temperature in (C_2)

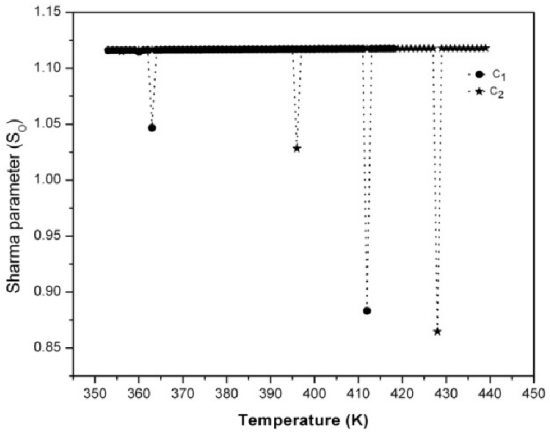

Figure 3. The Variation of Sharma parameter (S_o) with temperature in two liquid crystalline compounds C_1 and C_2

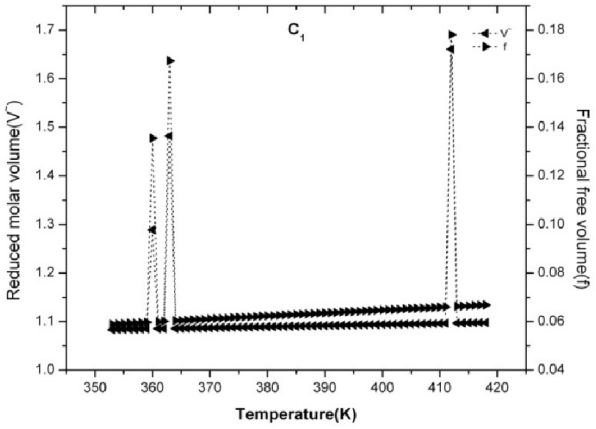

Figure 4. The Variation of Reduced molar volume ($\tilde{V}$) and Fractional free volume (f) with temperature in (C_1)

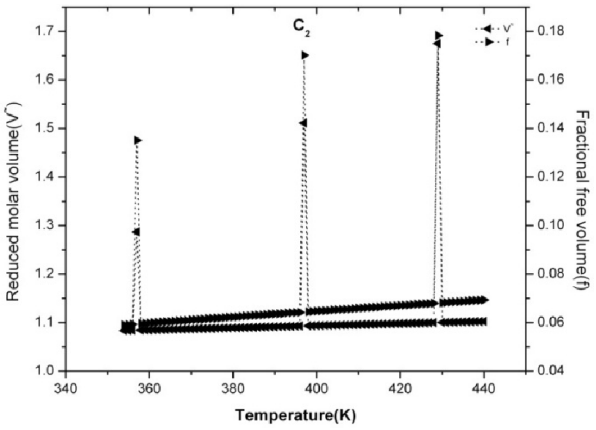

Figure 5. The Variation of Reduced molar volume ($\tilde{V}$) and Fractional free volume (f) with temperature in (C_2)

The density is found to decrease with increase of temperature and density jumps observed at phase transformations. Using the thermal expansion coefficient (α), the various thermo dynamic parameters were estimated and are represented in Tables 1-2. The variation of Sharma parameter (S_o), reduced molar volume ($\tilde{V}$) and fractional free volume (f) with the temperature for the two liquid crystalline compounds is shown in Figures 3-5. The Sharma parameter (S_o) is found to be constant in the two compounds and it is around 1.116 ±0.001. The parameters C_1, Γ_p, β^- and B/A slightly decreases with increase of temperature and in the vicinity of the phase transformation there is abrupt 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 unity.

Table 1. α-(4-cyanobiphenyl-4heptyloxy)-ω-4-n-alkylanilinebenzylidene-4oxy)decane (C_1)

T (K)	C_1	$\tilde{V}$	B/A	X	S_o	F	Γ
353	15.7788	1.0833	14.7788	-0.6657	1.1160	1.5480	15.9508
354	15.7471	1.0835	14.7471	-0.6655	1.1161	1.5475	15.9147
355	15.7156	1.0837	14.7156	-0.6653	1.1161	1.5470	15.8787
356	15.6843	1.0839	14.6843	-0.6651	1.1161	1.5465	15.8430
357	15.6531	1.0841	14.6531	-0.6649	1.1161	1.5459	15.8074
358	15.6222	1.0844	14.6222	-0.6648	1.1162	1.5454	15.7721
359	15.5914	1.0846	14.5914	-0.6646	1.1162	1.5449	15.7369
360	7.5865	1.2887	6.5865	-0.5020	1.1145	1.0220	6.3760
361	15.5303	1.0850	14.5303	-0.6642	1.1162	1.5439	15.6672
362	15.5000	1.0853	14.5000	-0.6640	1.1163	1.5434	15.6326
363	6.6729	1.4823	5.6729	-0.3546	1.0468	0.3866	4.9725
364	15.4400	1.0857	14.4400	-0.6637	1.1163	1.5423	15.5641
365	15.4102	1.0859	14.4102	-0.6635	1.1163	1.5418	15.5301
366	15.3806	1.0861	14.3806	-0.6633	1.1164	1.5413	15.4963
367	15.3512	1.0864	14.3512	-0.6631	1.1164	1.5408	15.4626
368	15.3219	1.0866	14.3219	-0.6629	1.1164	1.5403	15.4292
369	15.2928	1.0868	14.2928	-0.6627	1.1164	1.5397	15.3959
370	15.2638	1.0870	14.2638	-0.6626	1.1164	1.5392	15.3628
371	15.2350	1.0873	14.2350	-0.6624	1.1165	1.5387	15.3299
372	15.2063	1.0875	14.2063	-0.6622	1.1165	1.5382	15.2972
373	15.1778	1.0877	14.1778	-0.6620	1.1165	1.5377	15.2647
374	15.1495	1.0879	14.1495	-0.6618	1.1165	1.5372	15.2323
375	15.1213	1.0881	14.1213	-0.6617	1.1166	1.5366	15.2001
376	15.0933	1.0884	14.0933	-0.6615	1.1166	1.5361	15.1680
377	15.0654	1.0886	14.0654	-0.6613	1.1166	1.5356	15.1362
378	15.0377	1.0888	14.0377	-0.6611	1.1166	1.5351	15.1045
379	15.0101	1.0890	14.0101	-0.6609	1.1167	1.5346	15.0730
380	14.9826	1.0892	13.9826	-0.6607	1.1167	1.5341	15.0416
381	14.9553	1.0895	13.9553	-0.6606	1.1167	1.5336	15.0104
382	14.9282	1.0897	13.9282	-0.6604	1.1167	1.5330	14.9794

……*Continue*

383	14.9012	1.0899	13.9012	-0.6602	1.1167	1.5325	14.9485
384	14.8743	1.0901	13.8743	-0.6600	1.1168	1.5320	14.9178
385	14.8476	1.0903	13.8476	-0.6598	1.1168	1.5315	14.8873
386	14.8210	1.0906	13.8210	-0.6597	1.1168	1.5310	14.8569
387	14.7945	1.0908	13.7945	-0.6595	1.1168	1.5305	14.8267
388	14.7682	1.0910	13.7682	-0.6593	1.1169	1.5300	14.7966
389	14.7421	1.0912	13.7421	-0.6591	1.1169	1.5294	14.7667
390	14.7160	1.0914	13.7160	-0.6589	1.1169	1.5289	14.7369
391	14.6901	1.0917	13.6901	-0.6587	1.1169	1.5284	14.7073
392	14.6644	1.0919	13.6644	-0.6586	1.1170	1.5279	14.6778
393	14.6387	1.0921	13.6387	-0.6584	1.1170	1.5274	14.6485
394	14.6132	1.0923	13.6132	-0.6582	1.1170	1.5269	14.6194
395	14.5879	1.0925	13.5879	-0.6580	1.1170	1.5264	14.5903
396	14.5626	1.0928	13.5626	-0.6578	1.1170	1.5258	14.5615
397	14.5375	1.0930	13.5375	-0.6577	1.1171	1.5253	14.5328
398	14.5125	1.0932	13.5125	-0.6575	1.1171	1.5248	14.5042
399	14.4877	1.0934	13.4877	-0.6573	1.1171	1.5243	14.4758
400	14.4630	1.0936	13.4630	-0.6571	1.1171	1.5238	14.4475
401	14.4383	1.0939	13.4383	-0.6569	1.1172	1.5233	14.4193
402	14.4139	1.0941	13.4139	-0.6568	1.1172	1.5228	14.3913
403	14.3895	1.0943	13.3895	-0.6566	1.1172	1.5222	14.3634
404	14.3653	1.0945	13.3653	-0.6564	1.1172	1.5217	14.3357
405	14.3412	1.0947	13.3412	-0.6562	1.1172	1.5212	14.3081
406	14.3172	1.0950	13.3172	-0.6560	1.1173	1.5207	14.2807
407	14.2933	1.0952	13.2933	-0.6559	1.1173	1.5202	14.2534
408	14.2695	1.0954	13.2695	-0.6557	1.1173	1.5197	14.2262
409	14.2459	1.0956	13.2459	-0.6555	1.1173	1.5192	14.1991
410	14.2224	1.0958	13.2224	-0.6553	1.1173	1.5186	14.1722
411	14.1990	1.0961	13.1990	-0.6551	1.1174	1.5181	14.1454
412	6.7829	1.6608	5.7829	-0.2223	0.8832	-0.4256	4.6143
413	14.1525	1.0965	13.1525	-0.6548	1.1174	1.5171	14.0922
414	14.1294	1.0967	13.1294	-0.6546	1.1174	1.5166	14.0658
415	14.1065	1.0969	13.1065	-0.6544	1.1175	1.5161	14.0396
416	14.0837	1.0971	13.0837	-0.6542	1.1175	1.5156	14.0134
417	14.0609	1.0974	13.0609	-0.6541	1.1175	1.5151	13.9874
418	14.0383	1.0976	13.0383	-0.6539	1.1175	1.5145	13.9615

Table 1. Continued

T (K)	f	A*	Γ_p	β^-	Γ_{ith}	Γ_{ich}	Γ_{iba}
353	0.0589	1.0036	7.7245	0.2829	7.3894	3.8615	3.5278
354	0.0591	1.0037	7.7087	0.2827	7.3735	3.8533	3.5202
355	0.0592	1.0037	7.6929	0.2825	7.3578	3.8452	3.5125
356	0.0593	1.0037	7.6773	0.2823	7.3421	3.8372	3.5049
357	0.0594	1.0037	7.6617	0.2821	7.3265	3.8292	3.4973
358	0.0596	1.0037	7.6462	0.2819	7.3111	3.8212	3.4898
359	0.0597	1.0037	7.6308	0.2817	7.2957	3.8133	3.4823
360	0.1355	1.0212	3.6288	0.1459	3.2932	1.7079	1.5853
361	0.0599	1.0038	7.6003	0.2813	7.2651	3.7976	3.4675
362	0.0601	1.0038	7.5851	0.2811	7.2500	3.7898	3.4602
363	0.1674	1.0336	3.1727	0.0723	2.8364	1.3579	1.4785
364	0.0603	1.0038	7.5551	0.2807	7.2200	3.7744	3.4456
365	0.0604	1.0038	7.5402	0.2805	7.2051	3.7667	3.4383
366	0.0606	1.0039	7.5254	0.2803	7.1903	3.7591	3.4311
367	0.0607	1.0039	7.5107	0.2801	7.1756	3.7515	3.4240
368	0.0608	1.0039	7.4961	0.2799	7.1609	3.7440	3.4169
369	0.0609	1.0039	7.4815	0.2797	7.1464	3.7365	3.4098
370	0.0611	1.0039	7.4670	0.2795	7.1319	3.7290	3.4028
371	0.0612	1.0039	7.4526	0.2793	7.1175	3.7216	3.3958
372	0.0613	1.0040	7.4383	0.2791	7.1031	3.7143	3.3888
373	0.0614	1.0040	7.4240	0.2789	7.0889	3.7069	3.3819
374	0.0616	1.0040	7.4099	0.2788	7.0747	3.6996	3.3750
375	0.0617	1.0040	7.3958	0.2786	7.0606	3.6924	3.3682
376	0.0618	1.0040	7.3818	0.2784	7.0466	3.6852	3.3614
377	0.0619	1.0040	7.3678	0.2782	7.0327	3.6780	3.3546
378	0.0620	1.0041	7.3540	0.2780	7.0188	3.6709	3.3479
379	0.0622	1.0041	7.3402	0.2778	7.0050	3.6638	3.3412
380	0.0623	1.0041	7.3264	0.2776	6.9913	3.6567	3.3345
381	0.0624	1.0041	7.3128	0.2774	6.9776	3.6497	3.3279
382	0.0625	1.0041	7.2992	0.2772	6.9641	3.6427	3.3213
383	0.0627	1.0041	7.2857	0.2770	6.9506	3.6358	3.3148
384	0.0628	1.0042	7.2723	0.2768	6.9371	3.6288	3.3082
385	0.0629	1.0042	7.2589	0.2766	6.9238	3.6220	3.3017
386	0.0630	1.0042	7.2456	0.2764	6.9105	3.6151	3.2953
387	0.0631	1.0042	7.2324	0.2762	6.8972	3.6083	3.2889
388	0.0633	1.0042	7.2193	0.2761	6.8841	3.6016	3.2825
389	0.0634	1.0042	7.2062	0.2759	6.8710	3.5948	3.2761
390	0.0635	1.0043	7.1932	0.2757	6.8580	3.5881	3.2698
391	0.0636	1.0043	7.1802	0.2755	6.8450	3.5815	3.2635

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392	0.0637	1.0043	7.1673	0.2753	6.8322	3.5748	3.2573
393	0.0639	1.0043	7.1545	0.2751	6.8193	3.5682	3.2511
394	0.0640	1.0043	7.1418	0.2749	6.8066	3.5617	3.2449
395	0.0641	1.0043	7.1291	0.2747	6.7939	3.5551	3.2387
396	0.0642	1.0044	7.1165	0.2745	6.7813	3.5486	3.2326
397	0.0643	1.0044	7.1039	0.2743	6.7687	3.5422	3.2265
398	0.0644	1.0044	7.0914	0.2741	6.7562	3.5357	3.2204
399	0.0646	1.0044	7.0790	0.2740	6.7438	3.5294	3.2144
400	0.0647	1.0044	7.0666	0.2738	6.7315	3.5230	3.2084
401	0.0648	1.0044	7.0543	0.2736	6.7191	3.5167	3.2024
402	0.0649	1.0045	7.0421	0.2734	6.7069	3.5104	3.1965
403	0.0650	1.0045	7.0299	0.2732	6.6947	3.5041	3.1906
404	0.0652	1.0045	7.0178	0.2730	6.6826	3.4978	3.1847
405	0.0653	1.0045	7.0057	0.2728	6.6706	3.4916	3.1789
406	0.0654	1.0045	6.9937	0.2726	6.6586	3.4855	3.1731
407	0.0655	1.0046	6.9818	0.2724	6.6466	3.4793	3.1673
408	0.0656	1.0046	6.9699	0.2723	6.6347	3.4732	3.1615
409	0.0657	1.0046	6.9581	0.2721	6.6229	3.4671	3.1558
410	0.0659	1.0046	6.9463	0.2719	6.6112	3.4610	3.1501
411	0.0660	1.0046	6.9346	0.2717	6.5995	3.4550	3.1444
412	0.1781	1.0386	3.2285	0.0320	2.8914	1.2188	1.6726
413	0.0662	1.0047	6.9114	0.2713	6.5762	3.4431	3.1331
414	0.0663	1.0047	6.8999	0.2711	6.5647	3.4371	3.1275
415	0.0664	1.0047	6.8884	0.2710	6.5532	3.4312	3.1220
416	0.0666	1.0047	6.8770	0.2708	6.5418	3.4253	3.1164
417	0.0667	1.0047	6.8656	0.2706	6.5304	3.4195	3.1109
418	0.0668	1.0047	6.8543	0.2704	6.5191	3.4136	3.1054

Table 2. Thermodynamic parameters of α-(4-cyanobiphenyl-4 decyloxy)-ω-4-n-alkylanilinebenzylidene-4oxy)decane (C_2)

T (K)	C_1	V~	B/A	X	S_o	F	Γ
354	15.7471	1.0835	14.7471	-0.6655	1.1161	1.5475	15.9147
355	15.7156	1.0837	14.7156	-0.6653	1.1161	1.5470	15.8787
356	15.6843	1.0839	14.684	-0.6651	1.1161	1.5465	15.8430
357	7.6059	1.2868	6.6059	-0.5035	1.1148	1.0275	6.4010
358	15.6222	1.0844	14.6222	-0.6648	1.1162	1.5454	15.7721
359	15.5914	1.0846	14.5914	-0.6646	1.1162	1.5449	15.7369
360	15.5608	1.0848	14.5608	-0.6644	1.1162	1.5444	15.7020
361	15.5303	1.0850	14.5303	-0.6642	1.1162	1.5439	15.6672
362	15.5000	1.0853	14.5000	-0.6640	1.1163	1.5434	15.6326
363	15.4699	1.0855	14.4699	-0.6638	1.1163	1.5428	15.5983
364	15.4400	1.0857	14.4400	-0.6637	1.1163	1.5423	15.5641
365	15.4102	1.0859	14.4102	-0.6635	1.1163	1.5418	15.5301
366	15.3806	1.0861	14.3806	-0.6633	1.1164	1.5413	15.4963
367	15.3512	1.0864	14.3512	-0.6631	1.1164	1.5408	15.4626
368	15.3219	1.0866	14.3219	-0.6629	1.1164	1.5403	15.4292
369	15.2928	1.0868	14.2928	-0.6627	1.1164	1.5397	15.3959
370	15.2638	1.0870	14.2638	-0.6626	1.1164	1.5392	15.3628
371	15.2350	1.0873	14.2350	-0.6624	1.1165	1.5387	15.3299
372	15.2063	1.0875	14.2063	-0.6622	1.1165	1.5382	15.2972
373	15.1778	1.0877	14.1778	-0.6620	1.1165	1.5377	15.2647
374	15.1495	1.0879	14.1495	-0.6618	1.1165	1.5372	15.2323
375	15.1213	1.0881	14.1213	-0.6617	1.1166	1.5366	15.2001
376	15.0933	1.0884	14.0933	-0.6615	1.1166	1.5361	15.1680
377	15.0654	1.0886	14.0654	-0.6613	1.1166	1.5356	15.1362
378	15.0377	1.0888	14.0377	-0.6611	1.1166	1.5351	15.1045
379	15.0101	1.0890	14.0101	-0.6609	1.1167	1.5346	15.0730
380	14.9826	1.0892	13.9826	-0.6607	1.1167	1.5341	15.0416
381	14.9553	1.0895	13.9553	-0.6606	1.1167	1.5336	15.0104
382	14.9282	1.0897	13.9282	-0.6604	1.1167	1.5330	14.9794
383	14.9012	1.0899	13.9012	-0.6602	1.1167	1.5325	14.9485
384	14.8743	1.0901	13.8743	-0.6600	1.1168	1.5320	14.9178
385	14.8476	1.0903	13.8476	-0.6598	1.1168	1.5315	14.8873
386	14.8210	1.0906	13.8210	-0.6597	1.1168	1.5310	14.8569
387	14.7945	1.0908	13.7945	-0.6595	1.1168	1.5305	14.8267
388	14.7682	1.0910	13.7682	-0.6593	1.1169	1.5300	14.7966
389	14.7421	1.0912	13.7421	-0.6591	1.1169	1.5294	14.7667
390	14.7160	1.0914	13.7160	-0.6589	1.1169	1.5289	14.7369
391	14.6901	1.0917	13.6901	-0.6587	1.1169	1.5284	14.7073
392	14.6644	1.0919	13.6644	-0.6586	1.1170	1.5279	14.6778
393	14.6387	1.0921	13.6387	-0.6584	1.1170	1.5274	14.6485
394	14.6132	1.0923	13.6132	-0.6582	1.1170	1.5269	14.6194
395	14.5879	1.0925	13.5879	-0.6580	1.1170	1.5264	14.5903
396	14.5626	1.0928	13.5626	-0.6578	1.1170	1.5258	14.5615
397	6.6454	1.5110	5.6454	-0.3330	1.0284	0.2743	4.8754
398	14.5125	1.0932	13.5125	-0.6575	1.1171	1.5248	14.5042
399	14.4877	1.0934	13.4877	-0.6573	1.1171	1.5243	14.4758
400	14.4630	1.0936	13.4630	-0.6571	1.1171	1.5238	14.4475

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401	14.4383	1.0939	13.4383	-0.6569	1.1172	1.5233	14.4193
402	14.4139	1.0941	13.4139	-0.6568	1.1172	1.5228	14.3913
403	14.3895	1.0943	13.3895	-0.6566	1.1172	1.5222	14.3634
404	14.3653	1.0945	13.3653	-0.6564	1.1172	1.5217	14.3357
405	14.3412	1.0947	13.3412	-0.6562	1.1172	1.5212	14.3081
406	14.3172	1.0950	13.3172	-0.6560	1.1173	1.5207	14.2807
407	14.2933	1.0952	13.2933	-0.6559	1.1173	1.5202	14.2534
408	14.2695	1.0954	13.2695	-0.6557	1.1173	1.5197	14.2262
409	14.2459	1.0956	13.2459	-0.6555	1.1173	1.5192	14.1991
410	14.2224	1.0958	13.2224	-0.6553	1.1173	1.5186	14.1722
411	14.1990	1.0961	13.1990	-0.6551	1.1174	1.5181	14.1454
412	14.1757	1.0963	13.1757	-0.6550	1.1174	1.5176	14.1188
413	14.1525	1.0965	13.1525	-0.6548	1.1174	1.5171	14.0922
414	14.1294	1.0967	13.1294	-0.6546	1.1174	1.5166	14.0658
415	14.1065	1.0969	13.1065	-0.6544	1.1175	1.5161	14.0396
416	14.0837	1.0971	13.0837	-0.6542	1.1175	1.5156	14.0134
417	14.0609	1.0974	13.0609	-0.6541	1.1175	1.5151	13.9874
418	14.0383	1.0976	13.0383	-0.6539	1.1175	1.5145	13.9615
419	14.0158	1.0978	13.0158	-0.6537	1.1175	1.5140	13.9357
420	13.9934	1.0980	12.9934	-0.6535	1.1176	1.5135	13.9101
421	13.9711	1.0982	12.9711	-0.6533	1.1176	1.5130	13.8846
422	13.9489	1.0985	12.9489	-0.6532	1.1176	1.5125	13.8592
423	13.9269	1.0987	12.9269	-0.6530	1.1176	1.5120	13.8339
424	13.9049	1.0989	12.9049	-0.6528	1.1176	1.5115	13.8087
425	13.8830	1.0991	12.8830	-0.6526	1.1177	1.5110	13.7837
426	13.8613	1.0993	12.8613	-0.6525	1.1177	1.5104	13.7588
427	13.8396	1.0995	12.8396	-0.6523	1.1177	1.5099	13.7339
428	13.8181	1.0998	12.8181	-0.6521	1.1177	1.5094	13.7093
429	6.8187	1.6749	5.8187	-0.2122	0.8647	-0.5037	4.6077
430	13.7753	1.1002	12.7753	-0.6517	1.1178	1.5084	13.6602
431	13.7540	1.1004	12.7540	-0.6516	1.1178	1.5079	13.6359
432	13.7329	1.1006	12.7329	-0.6514	1.1178	1.5074	13.6116
433	13.7118	1.1008	12.7118	-0.6512	1.1178	1.5069	13.5875
434	13.6908	1.1011	12.6908	-0.6510	1.1178	1.5064	13.5635
435	13.6700	1.1013	12.6700	-0.6509	1.1179	1.5058	13.5396
436	13.6492	1.1015	12.6492	-0.6507	1.1179	1.5053	13.5158
437	13.6286	1.1017	12.6286	-0.6505	1.1179	1.5048	13.4921
438	13.6080	1.1019	12.6080	-0.6503	1.1179	1.5043	13.4686
439	13.5875	1.1021	12.5875	-0.6501	1.1179	1.5038	13.4451
440	13.5672	1.1024	12.5672	-0.6500	1.1180	1.5033	13.4217

Table 2. Continued

T (K)	f	A*	Γ_p	$\beta^{\sim}$	Γ_{ith}	Γ_{ich}	Γ_{iba}
354	0.0591	1.0037	7.7087	0.2827	7.3735	3.8533	3.5202
355	0.0592	1.0037	7.6929	0.2825	7.3578	3.8452	3.5125
356	0.0593	1.0037	7.6773	0.2823	7.3421	3.8372	3.5049
357	0.1351	1.0211	3.6385	0.1468	3.3029	1.7138	1.5890
358	0.0596	1.0037	7.6462	0.2819	7.3111	3.8212	3.4898
359	0.0597	1.0037	7.6308	0.2817	7.2957	3.8133	3.4823
360	0.0598	1.0038	7.6155	0.2815	7.2804	3.8054	3.4749
361	0.0599	1.0038	7.6003	0.2813	7.2651	3.7976	3.4675
362	0.0601	1.0038	7.5851	0.2811	7.2500	3.7898	3.4602
363	0.0602	1.0038	7.5701	0.2809	7.2349	3.7821	3.4528
364	0.0603	1.0038	7.5551	0.2807	7.2200	3.7744	3.4456
365	0.0604	1.0038	7.5402	0.2805	7.2051	3.7667	3.4383
366	0.0606	1.0039	7.5254	0.2803	7.1903	3.7591	3.4311
367	0.0607	1.0039	7.5107	0.2801	7.1756	3.7515	3.4240
368	0.0608	1.0039	7.4961	0.2799	7.1609	3.7440	3.4169
369	0.0609	1.0039	7.4815	0.2797	7.1464	3.7365	3.4098
370	0.0611	1.0039	7.4670	0.2795	7.1319	3.7290	3.4028
371	0.0612	1.0039	7.4526	0.2793	7.1175	3.7216	3.3958
372	0.0613	1.0040	7.4383	0.2791	7.1031	3.7143	3.3888
373	0.0614	1.0040	7.4240	0.2789	7.0889	3.7069	3.3819
374	0.0616	1.0040	7.4099	0.2788	7.0747	3.6996	3.3750
375	0.0617	1.0040	7.3958	0.2786	7.0606	3.6924	3.3682
376	0.0618	1.0040	7.3818	0.2784	7.0466	3.6852	3.3614
377	0.0619	1.0040	7.3678	0.2782	7.0327	3.6780	3.3546
378	0.0620	1.0041	7.3540	0.2780	7.0188	3.6709	3.3479
379	0.0622	1.0041	7.3402	0.2778	7.0050	3.6638	3.3412
380	0.0623	1.0041	7.3264	0.2776	6.9913	3.6567	3.3345
381	0.0624	1.0041	7.3128	0.2774	6.9776	3.6497	3.3279
382	0.0625	1.0041	7.2992	0.2772	6.9641	3.6427	3.3213
383	0.0627	1.0041	7.2857	0.2770	6.9506	3.6358	3.3148
384	0.0628	1.0042	7.2723	0.2768	6.9371	3.6288	3.3082
385	0.0629	1.0042	7.2589	0.2766	6.9238	3.6220	3.3017

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386	0.0630	1.0042	7.2456	0.2764	6.9105	3.6151	3.2953
387	0.0631	1.0042	7.2324	0.2762	6.8972	3.6083	3.2889
388	0.0633	1.0042	7.2193	0.2761	6.8841	3.6016	3.2825
389	0.0634	1.0042	7.2062	0.2759	6.8710	3.5948	3.2761
390	0.0635	1.0043	7.1932	0.2757	6.8580	3.5881	3.2698
391	0.0636	1.0043	7.1802	0.2755	6.8450	3.5815	3.2635
392	0.0637	1.0043	7.1673	0.2753	6.8322	3.5748	3.2573
393	0.0639	1.0043	7.1545	0.2751	6.8193	3.5682	3.2511
394	0.0640	1.0043	7.1418	0.2749	6.8066	3.5617	3.2449
395	0.0641	1.0043	7.1291	0.2747	6.7939	3.5551	3.2387
396	0.0642	1.0044	7.1165	0.2745	6.7813	3.5486	3.2326
397	0.1702	1.0349	3.1590	0.0643	2.8227	1.3276	1.4950
398	0.0644	1.0044	7.0914	0.2741	6.7562	3.5357	3.2204
399	0.0646	1.0044	7.0790	0.2740	6.7438	3.5294	3.2144
400	0.0647	1.0044	7.0666	0.2738	6.7315	3.5230	3.2084
401	0.0648	1.0044	7.0543	0.2736	6.7191	3.5167	3.2024
402	0.0649	1.0045	7.0421	0.2734	6.7069	3.5104	3.1965
403	0.0650	1.0045	7.0299	0.2732	6.6947	3.5041	3.1906
404	0.0652	1.0045	7.0178	0.2730	6.6826	3.4978	3.1847
405	0.0653	1.0045	7.0057	0.2728	6.6706	3.4916	3.1789
406	0.0654	1.0045	6.9937	0.2726	6.6586	3.4855	3.1731
407	0.0655	1.0046	6.9818	0.2724	6.6466	3.4793	3.1673
408	0.0656	1.0046	6.9699	0.2723	6.6347	3.4732	3.1615
409	0.0657	1.0046	6.9581	0.2721	6.6229	3.4671	3.1558
410	0.0659	1.0046	6.9463	0.2719	6.6112	3.4610	3.1501
411	0.0660	1.0046	6.9346	0.2717	6.5995	3.4550	3.1444
412	0.0661	1.0046	6.9230	0.2715	6.5878	3.4490	3.1387
413	0.0662	1.0047	6.9114	0.2713	6.5762	3.4431	3.1331
414	0.0663	1.0047	6.8999	0.2711	6.5647	3.4371	3.1275
415	0.0664	1.0047	6.8884	0.2710	6.5532	3.4312	3.1220
416	0.0666	1.0047	6.8770	0.2708	6.5418	3.4253	3.1164
417	0.0667	1.0047	6.8656	0.2706	6.5304	3.4195	3.1109
418	0.0668	1.0047	6.8543	0.2704	6.5191	3.4136	3.1054
419	0.0669	1.0048	6.8431	0.2702	6.5079	3.4078	3.1000
420	0.0670	1.0048	6.8319	0.2700	6.4967	3.4021	3.0946
421	0.0671	1.0048	6.8207	0.2698	6.4855	3.3963	3.0891
422	0.0672	1.0048	6.8096	0.2697	6.4744	3.3906	3.0838
423	0.0674	1.0048	6.7986	0.2695	6.4634	3.3849	3.0784
424	0.0675	1.0048	6.7876	0.2693	6.4524	3.3793	3.0731
425	0.0676	1.0049	6.7767	0.2691	6.4415	3.3736	3.0678
426	0.0677	1.0049	6.7658	0.2689	6.4306	3.3680	3.0625
427	0.0678	1.0049	6.7550	0.2687	6.4198	3.3625	3.0573
428	0.0679	1.0049	6.7442	0.2685	6.4090	3.3569	3.0521
429	0.1783	1.0387	3.2465	0.0296	2.9093	1.2107	1.6985
430	0.0682	1.0049	6.7228	0.2682	6.3876	3.3459	3.0417
431	0.0683	1.0050	6.7122	0.2680	6.3770	3.3404	3.0365
432	0.0684	1.0050	6.7016	0.2678	6.3664	3.3349	3.0314
433	0.0685	1.0050	6.6911	0.2676	6.3559	3.3295	3.0263
434	0.0686	1.0050	6.6806	0.2674	6.3454	3.3241	3.0212
435	0.0687	1.0050	6.6702	0.2673	6.3350	3.3187	3.0162
436	0.0688	1.0050	6.6598	0.2671	6.3246	3.3134	3.0111
437	0.0690	1.0051	6.6494	0.2669	6.3143	3.3081	3.0061
438	0.0691	1.0051	6.6392	0.2667	6.3040	3.3028	3.0012
439	0.0692	1.0051	6.6289	0.2665	6.2937	3.2975	2.9962
440	0.0693	1.0051	6.6187	0.2663	6.2836	3.2922	2.9913

The Beyer's nonlinearity parameter (B/A) lies in the range 12-14. In the vicinity of phase transformation there is a sudden change in this value and which is found to be 5-6. The isothermal, isochoric and isobaric Gruneisen parameters (Γ_{ith}, Γ_{ich}, Γ_{iba}) have consistent values in liquid crystalline phase but there is steep decrease in these values at phase transformations.

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REFERENCES

Alapati, P.R., Potukuchi, D.M., Rao N.V.S., Pisipati V.G.K.M., Paranjpe A.S. and Rao U.R.K. 1988. Phase Transition and Structural Investigations in 50.5, 50.6 and 50.7. *Liq. Cryst*., 3:1461-1479.

Ajeetha, N., Ramakrishna Nanchara Rao, M., Datta Prasad P.V. and Pisipati V.G.K.M. 2006. Synthesis, Characterization, and Dilatometric Studies on N-(p-n-Alkoxybenzylidene)-p-n-pentyloxyanilines Compounds. *Mol. Cryst. Liq. Cryst.* 457:3-25.

Datta Prasad, P.V., Ramakrishna Nanchara Rao, M., Lalitha Kumari J. and Pisipati V.G.K.M. 2009. Simulataneous characterization and dilatometry studies on liquid crystalline N-(*p*-*n*-decycloxy and undecycloxybenzylidene)-*p*-toludines. *Phys. Chem. Liq.* 47:123-132.

Fakruddin, K., Jeevan Kumar, R., Pisipati V.G.K.M., Madhavi Latha, D., Madhav, B.T.P. and Datta Prasad P.V. 2010. Phase Transitions and Thermodynamic parameters of N-(p-n-octyloxybenzylidene)-p-n-alkoxyanilines-A Dilatometeric Study. *Mol. Cryst. Liq. Cryst.* 524: 102-118.

Gogoi, B., Ghosh, T.K. and Alapati, P.R. 2005. Experimental investigation of phase transitions exhibited by symmetric liquid crystal dimers. *Cryst. Res. Tech.* 40:709-712.

Haward, R.N. and Parker, B.N. 1968. The internal pressure of simple liquids. *J. Phys. Chem.* 72:1842-1844.

Moelwyn-Hughes, E.A. 1951. The Determination of Intermolecular Energy Constants from common Physicochemical properties of Liquids. *J. Phys. Chem.* 55:1246-1254.

Nagi Reddy. M.V.V., Pardhasaradhi, P., Madhavi Latha, D., Pisipati, V.G.K.M. and Datta Prasad, P. V. 2011. Phase Transitions across different liquid crystalline modifications in compounds with octa decyclaniline as one end group. *Phase Transitions.* 84:4, 391-402.

Rao, N.V.S., Pisipati, V.G.K.M., Alapati, P. R. and Potukuchi, D.M. 1988. Density studies in terephthaldyene-bis-p-n-dodecyl aniline. Mol. Cryst. Liq. Cryst. 162B: 119-125.

Ranga Reddy, R.N.V., Suryanarayana, A. and Rama Murthy, V. 1999. Coefficient of volume expansion and Thermoacoustic Parameters of Alkyl-Cyano-Biphenyl Liquid Crystals. *Cryst. Res.Technol.* 34: 1299-1307.

Reddy, R.R., Venkatesulu, A., Rama Gopal, K. and Neelakanteswara Reddy, K. 2007. Thermo acoustic parameters in the nematic and isotropic phases of 5CB and tetramethyl methane in 5CB. *J. Mol. Liq.* 130:112-118.

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

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