CHAPTER 7

Study of the order parameter and its critical exponent for some binary smectogenic mixtures

7.1 Introduction

Order parameter is one of the key parameters of the liquid crystalline materials. It controls almost all the anisotropic properties [1-2] and hence most of these properties enable one to determine the order parameter. Diverse experimental techniques [3-12] have been developed to determine the orientational order parameter for the liquid crystalline phases. Some of the well known methods are Vuks method [13] and Neugebauer method [14] in which the isotropic and anisotropic local fields experienced by the nematic (N) liquid crystal (LC) molecules are considered. Determination of the orientational order parameter is simple if the internal field is not considered while consideration of the same makes the process slightly difficult compared to the previous one. The internal field model necessitates the values of molecular polarizabilities, which may not be accurate because the knowledge of molecular symmetry or other related parameters are always not known properly. One of the most commonly used technique for determining the orientational order parameter without considering the local field experienced by the molecule in a liquid crystal phase is the direct extrapolation technique [15,16] in which the order parameter is determined from the optical anisotropy data only. This excludes the prerequisite of individual refractive indices as well as density values and thereby, the determination of the

polarizability of the molecule. Another advantage is that absence of local field assumption makes the direct extrapolation method suitable for determining the order parameter of the LC phases other than the nematic phase.

On the other hand, dielectric anisotropy ($\Delta\varepsilon$) of LCs arises due to the long range molecular ordering and the distribution of the molecular dipole moments with respect to the director axis. Knowledge of the dielectric anisotropy is essential to evaluate the elastic constants of the nematic liquid crystals and to comprehend the electric field effects to the LCs. Apart from that, the dielectric anisotropy ($\Delta\varepsilon$) of LCs is also related to the orientational order parameter, in a more or less complicated way. Therefore, $\Delta\varepsilon$ can be used to assess the order parameter and its critical behavior near phase transition.

Moreover, in the study of phase transition, knowledge of the order parameter is very important because of its dimensionality, which is an essential factor in identifying the possible universality class of the phase transition. Again, order parameter makes it possible to formulate a clear explanation of the phase transition in various critical systems. The exact nature of the phase transitions can be determined from the behavior of order parameter at the phase transition temperatures. There are numerous data available in the literature [17-23] which concerns the temperature dependence of the order parameter for different liquid crystalline phases of pure LC compounds or binary mixtures but the critical characteristics of the same in the vicinity of nematic-isotropic (N-I) phase transition still grabs some attention. The experimental determination of exact universality class of the critical exponents describing critical anomaly at the N-I transition is always very interesting. Keyes *et al.* [24,25] and Anisimov *et al.* [26,27] divulged that the N-I phase transition can be satisfactorily described by tricritical like critical exponents while according to Rosenblatt [28] the classical mean field critical exponents are also very well suited for the same. This reveals a possible ambiguity in determining the critical exponents at the N-I transition. Earlier, Haller [29] made an important contribution by giving an idea that the nematic order parameter can be described by a simple power law expression with an exponent β (known as the order parameter critical exponent) but the experimental outcomes reveal that the β values are very much less than the

theoretical predictions. It has been envisaged that the order parameter critical exponent β which is related to the limiting behavior of the order parameter near the N-I phase transition should presume any one of the possible theoretically predicted values quantitatively 0.25, 0.325 and 0.5 for a tricritical, Ising and critical system, respectively. Recently, the order parameter critical exponent and its universality class have been investigated from various experimental techniques [30-35] and the outcomes are explained within the context of theoretical predictions.

This chapter presents the experimental data on the temperature dependence of refractive index and static dielectric permittivity in the isotropic, nematic and smectic A phases of the binary mixtures comprising of 5-trans-n-butyl-2-(4-isothiocyanatophenyl)-1,3-dioxane (4DBT) and 4-cyano-4′-n-undecyloxy-biphenyl (11OCB) [36,37]. This binary system exhibits an induced nematic phase within the concentration range $0.100 < x_{4DBT} < 0.951$. From the refractive index data, the optical birefringence ($\Delta n = n_e - n_o$) has been calculated and hence this birefringence data has been used to determine the orientational order parameter of the investigated mixtures by a simple extrapolation technique [15,16]. The order parameter values obtained experimentally have also been compared with Maier–Saupe theory [38] for the nematogens and McMillan's model [39,40] for those mixtures showing both the nematic and smectic A phases.

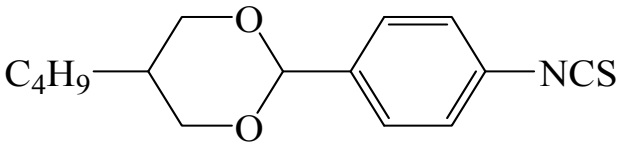
The order parameter critical exponent (β) has been extracted from the birefringence data by using a Haller type expression but it results systematically lower values of the same. Therefore, four parameter power law expressions have been employed to determine the exponent β from the birefringence (Δn) as well as dielectric anisotropy (Δε) data. Fitting results obtained by applying the Haller type fit formula and four parameter model expressions are compared with each other and also with the existing theoretical predictions.

7.2 Materials

The compound 4DBT was obtained from AWAT Co. Ltd., Warsaw, Poland and compound 11OCB was purchased from Merck, U.K. and both were used without further purification. The chemical names, structural formulae and the

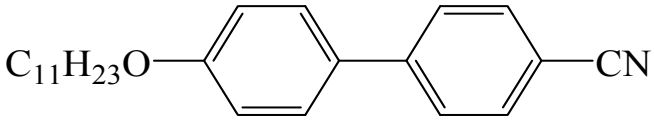
phase transition temperatures of the two liquid crystalline compounds are as follows:

Compound 1: 5-trans-n-butyl-2-(4-isothiocyanatophenyl)-1,3-dioxane (4DBT)



Cr 61^{o}C SmA 75.2^{o}C I

Compound 2: 4-cyano-4′-n-undecyloxy-biphenyl (11OCB)



Cr 71.5^{o}C SmA 87.5^{o}C I

Eleven mixtures were prepared having mole fraction of 4DBT equal to 0.100, 0.208, 0.291, 0.393, 0.491, 0.592, 0.665, 0.707, 0.787, 0.884 and 0.951. The nature of the different phases and corresponding phase transition temperatures were determined by a polarizing optical microscope (Motic BA 300) equipped with a Mettler FP900 hot stage.

7.3 Phase diagram

The compound 4DBT has a monolayer smectic A_1 phase while the second one *i.e.* 11OCB has a partially bilayer smectic A_d phase. When these two smectogens are mixed together, their mixtures show the presence of both the nematic and smectic A phases in a certain concentration range. Figure 7.1 depicts the phase diagram of the binary system of 4DBT+11OCB as obtained from the polarizing optical microscopy [36,37]. An induced nematic phase emerges in the phase diagram within the concentration range of $0.100 < x_{4DBT} < 0.951$ even if both the pure compounds are purely smectogenic. The clearing temperature of the mixtures decreases significantly compared to the pure compounds. Near the centre of the phase diagram, the induced nematic region gets wider and the most stable nematic phase is observed at about $x_{4DBT} = 0.665$. A complete suppression of the smectic phase is observed in the concentration range $0.291 < x_{4DBT} < 0.707$ where only the nematic phase is present.

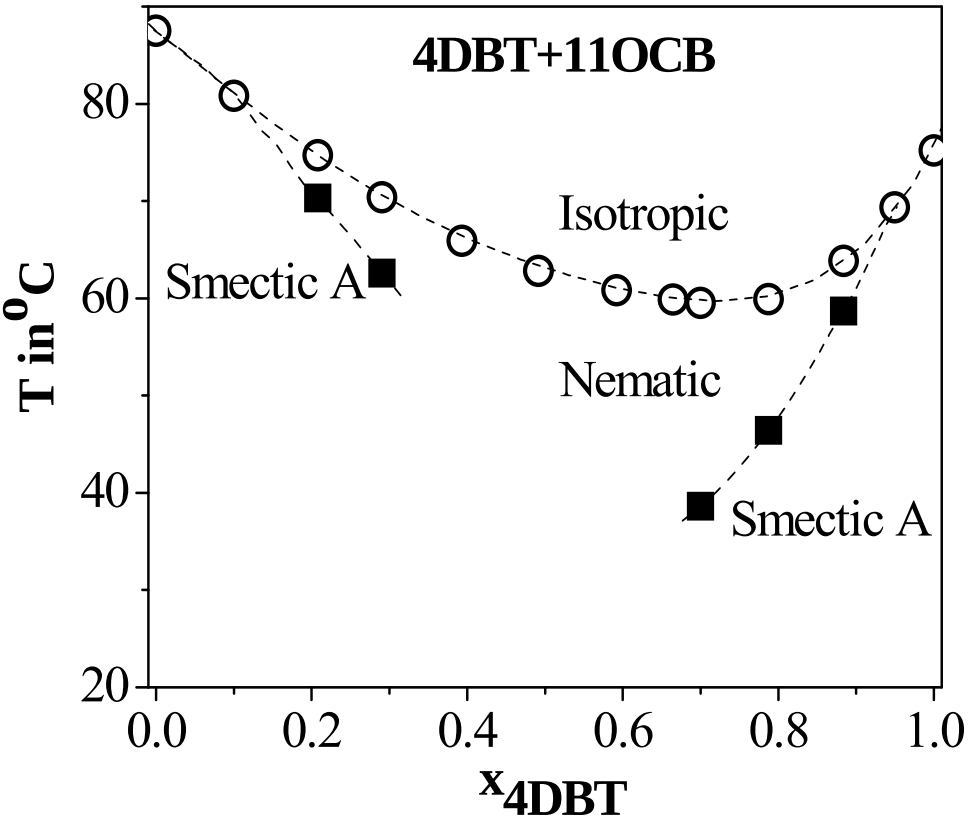


Figure 7.1 Phase diagram of the binary system of 4DBT+11OCB. x_{4DBT} is the mole fraction of 4DBT. (o)- nematic to isotropic (or smectic A to isotropic) phase transition temperature; (■)- smectic A to nematic phase transition temperature.

7.4 Refractive index measurements

The extraordinary and ordinary refractive indices for the mixtures under study have been measured by thin prism technique [20] at λ = 632.8nm with an accuracy of ±0.0006. The temperature variation of two principal refractive indices in the nematic and smectic A phases are shown in Figure 7.2(a-i). In the isotropic (I) phase, the measured refractive index (n_{iso}) do not show any significant change with respect to the change in temperature. But in the vicinity of nematic-isotropic (N-I) phase transition, the isotropic refractive index splits into two parts, *i.e.* one with higher and another with lower values than the isotropic value corresponding to the extraordinary (n_e) and ordinary (n_o) refractive indices, respectively. The extraordinary component n_e strongly depends on temperature in the whole

mesomorphic range while the ordinary component n_o exhibits weak temperature dependence but near the nematic-isotropic (N-I) transition, it increases slowly with increases in the temperature. Moreover, the smectic A-nematic (SmA-N) transition is accompanied by a continuous change in the two refractive indices for all the investigated mixtures except $x_{4DBT} = 0.884$, for which a sharp discontinuity in the n_e and n_o values have been clearly observed near the SmA-N transition temperature (T_{SN}). Temperature dependence of optical birefringence ($\Delta n = n_e - n_o$) for the studied mixtures are also shown in the respective figures. It is quite evident that the relatively higher value of Δn in the smectic A phase compared to nematic phase is due to the increased molecular ordering, which results in an enhanced optical anisotropy. Nevertheless, the temperature variation of Δn in the smectic A phase is comparatively sluggish with respect to that in the nematic phase.

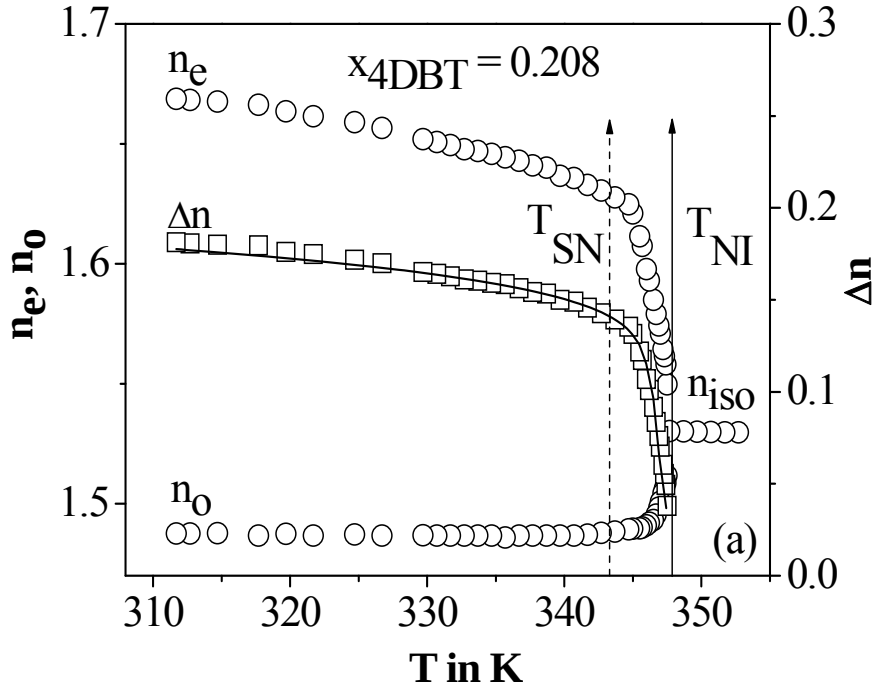


Figure 7.2(a) Refractive indices (n_e, n_o) and birefringence ($\Delta n = n_e - n_o$) as a function of temperature for $x_{4DBT} = 0.208$. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid lines are fit to Equation (7.3).

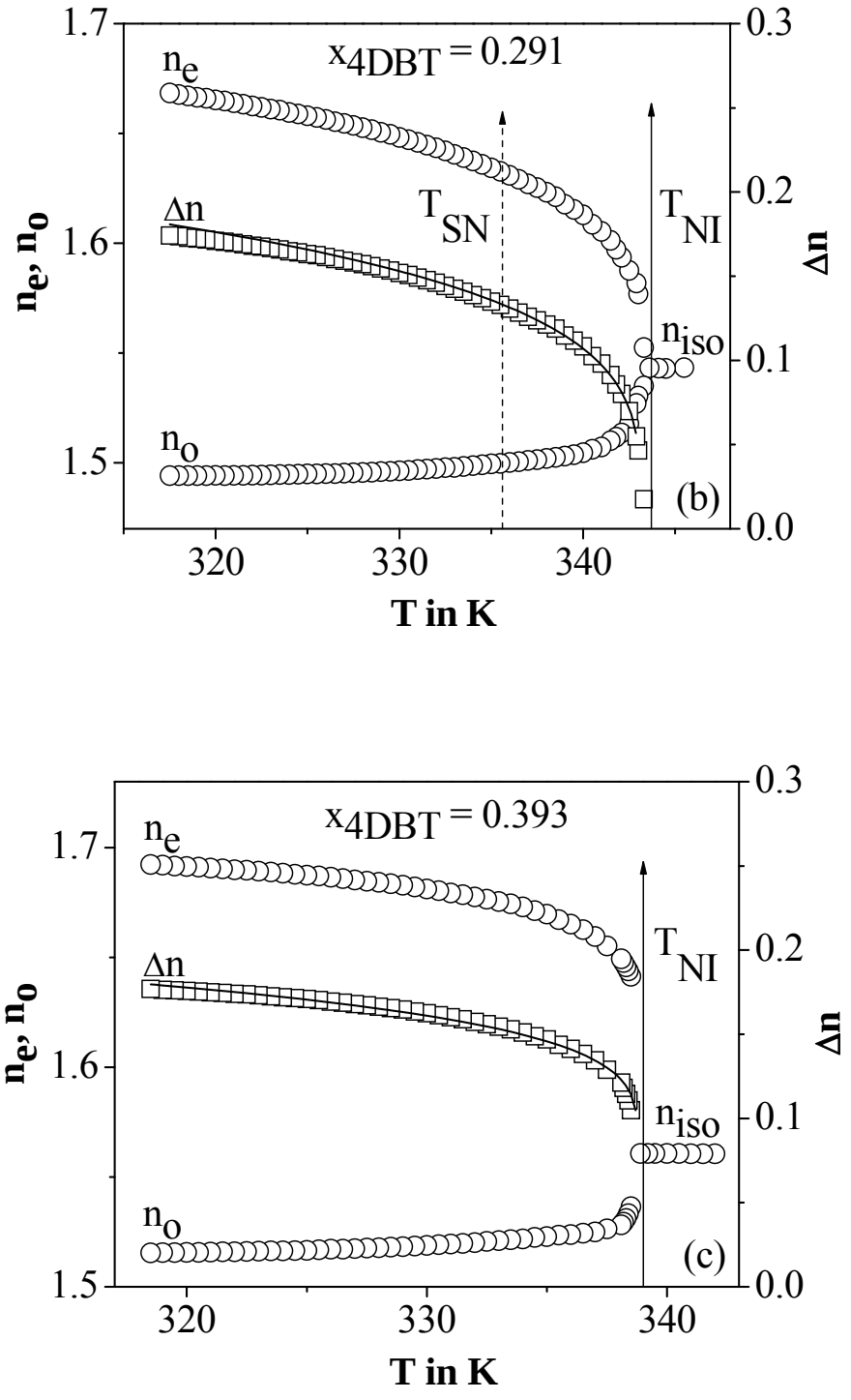


Figure 7.2(b-c) Refractive indices (n_e, n_o) and birefringence ($\Delta n = n_e - n_o$) as a function of temperature for (b) $x_{4DBT} = 0.291$ and (c) $x_{4DBT} = 0.393$. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid lines are fit to Equation (7.3).

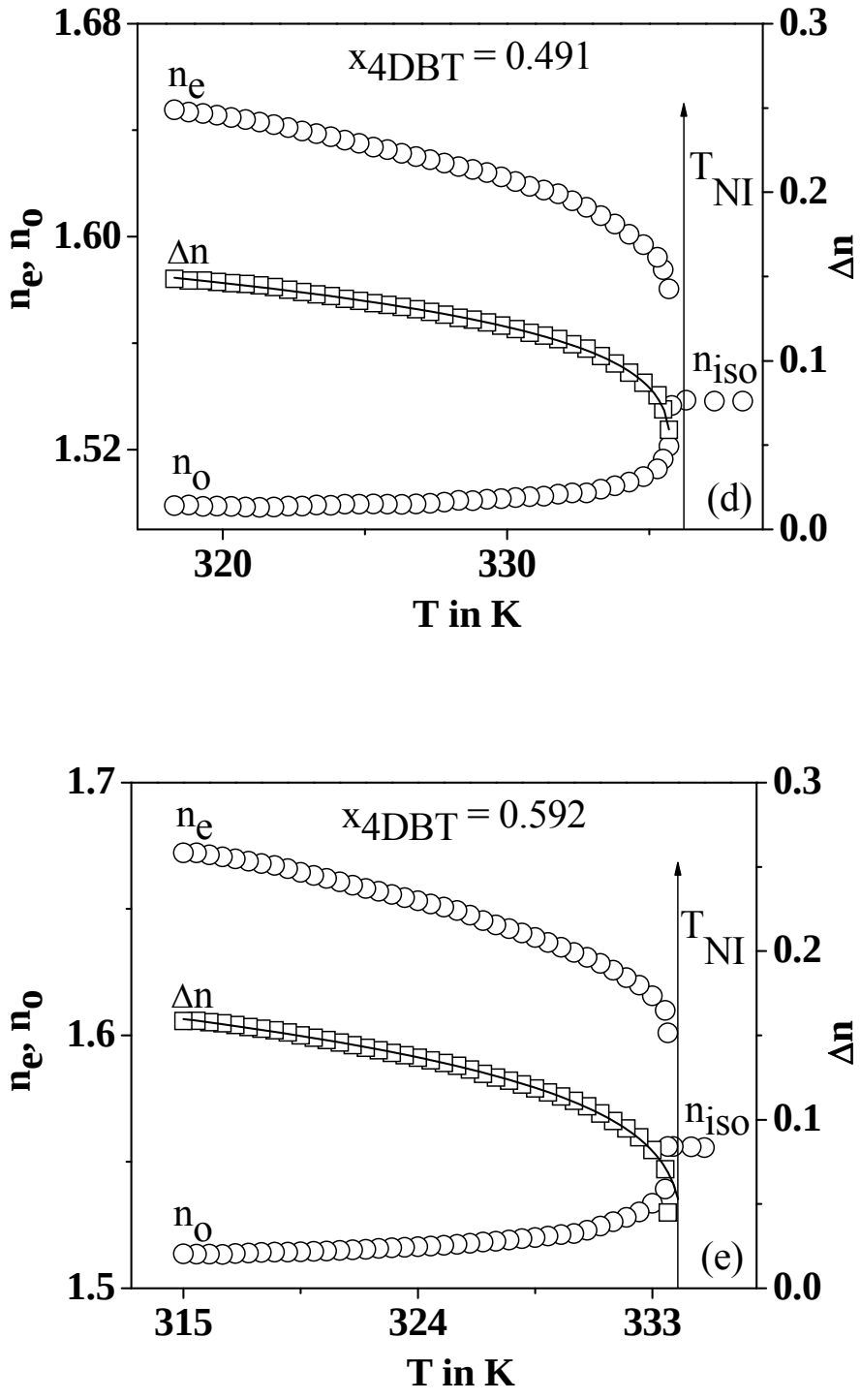


Figure 7.2(d-e) Refractive indices (n_e, n_o) and birefringence ($\Delta n = n_e - n_o$) as a function of temperature for (d) $x_{4DBT} = 0.491$ and (e) $x_{4DBT} = 0.592$. Solid arrow denotes nematic-isotropic transition (T_{NI}) temperature. The solid lines are fit to Equation (7.3).

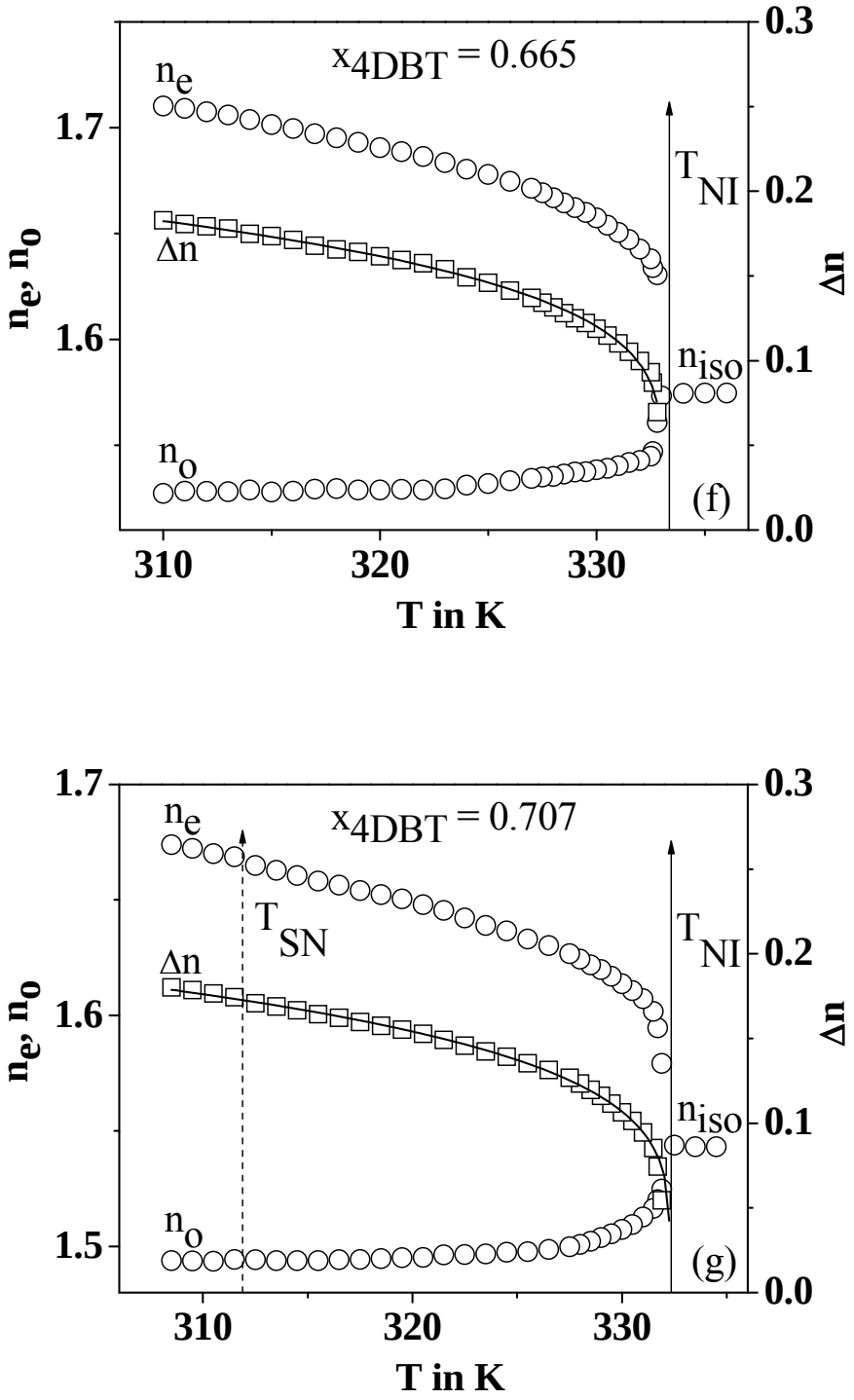


Figure 7.2(f-g) Refractive indices (n_e, n_o) and birefringence ($\Delta n = n_e - n_o$) as a function of temperature for (f) $x_{4DBT} = 0.665$ and (g) $x_{4DBT} = 0.707$. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid lines are fit to Equation (7.3).

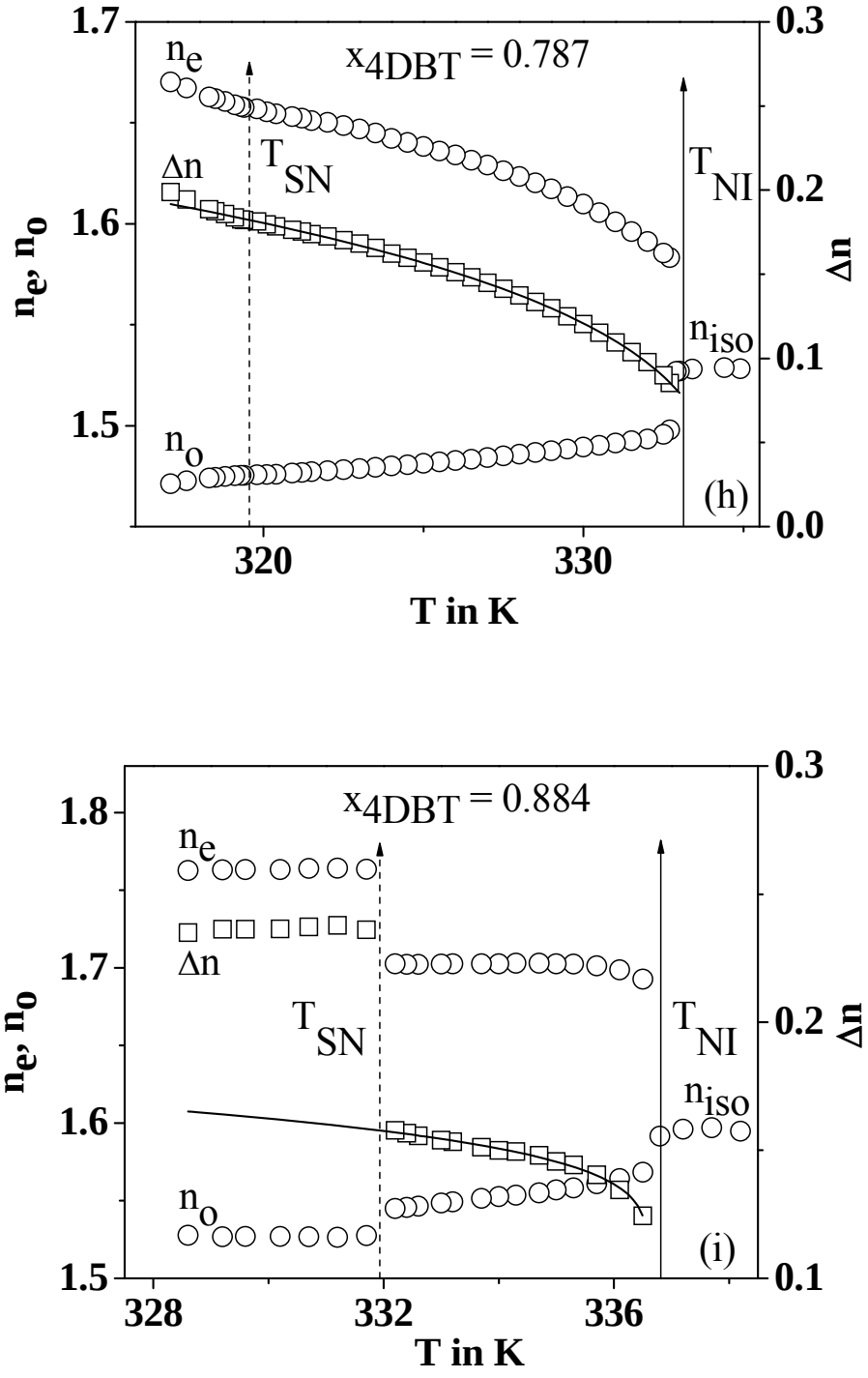


Figure 7.2(h-i) Refractive indices (n_e, n_o) and birefringence ($\Delta n = n_e - n_o$) as a function of temperature for (h) $x_{4DBT} = 0.787$ and (i) $x_{4DBT} = 0.884$. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid lines are fit to Equation (7.3).

7.5 Determination of the orientational order parameter

A simple but very useful technique has been used to determine the orientational order parameter ($<P_2>$) for some of the mixtures under study. According to de Gennes [1], the anisotropy of any physical quantity can be a measure of the orientational order. Furthermore, de Jeu [2] have shown that the optical anisotropy *i.e.* birefringence (Δn) can be used for this purpose. Kuczynski *et al.* [15,16] have also proposed a simple procedure to determine the order parameter directly from the birefringence (Δn) data. This procedure does not consider any internal field to the LC molecule, so it can be applied to evaluate the order parameter of any higher order phase other than the nematic phase. The temperature dependence of optical birefringence (Δn) has been fitted according to the following Haller's type equation [29]:

$$\Delta n = \Delta n_0 \left(1 - \frac{T}{T_{NI}}\right)^{\beta} \tag{7.1}$$

Δn_0 is the extrapolated birefringence in the perfectly ordered state (*i.e.* at T=0K) and β is the critical exponent. Therefore, the orientational order parameter $<P_2>$ can be determined by the relation [2]

$$\left\langle P_2 \right\rangle = \frac{\Delta n}{\Delta n_0} \tag{7.2}$$

Equation (7.1) and (7.2) can be used to determine the orientational order parameter. Since all the mixtures under study have nematic phase and the temperature variation of Δn is different for different phases, fitting has been carried out by considering the Δn data in the nematic phase only. In Figure 7.3(a-i), the orientational order parameter is presented as a function of temperature for the investigated mixtures. It has been observed that near the N-I transition temperature (T_{NI}) the order parameter increases sharply, indiacting a first order nature of the N-I phase transition. As the temperature decreases, a gradual increase in $<P_2>$ has been clearly observed, which is associated with the enhanced molecular ordering in the nematic and smectic A phase.

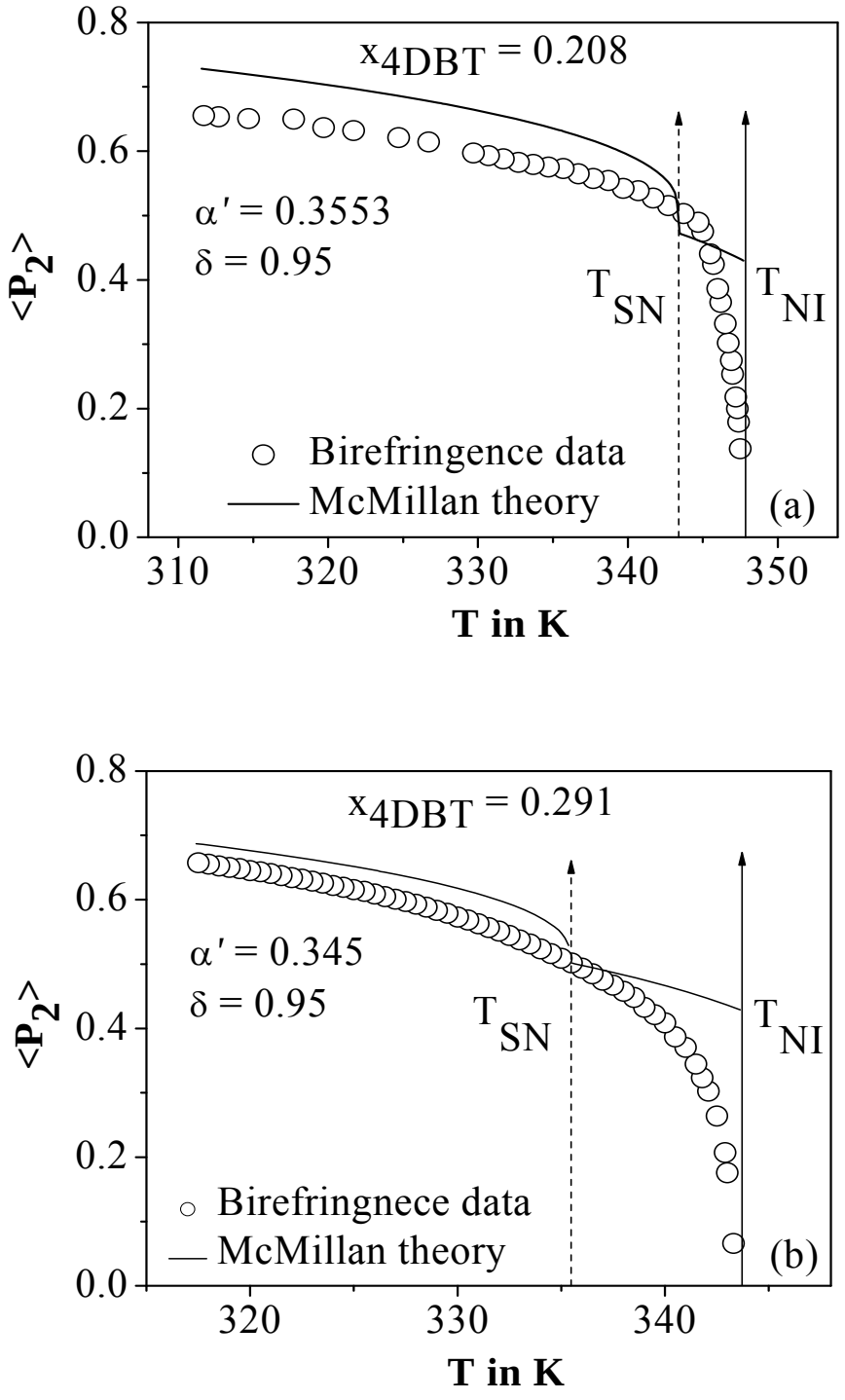


Figure 7.3(a-b) Temperature dependence of order parameter ($<P_2>$) for (a) x_{4DBT} = 0.208 and (b) x_{4DBT} = 0.291. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid line represents $<P_2>$ from the McMillan's theory.

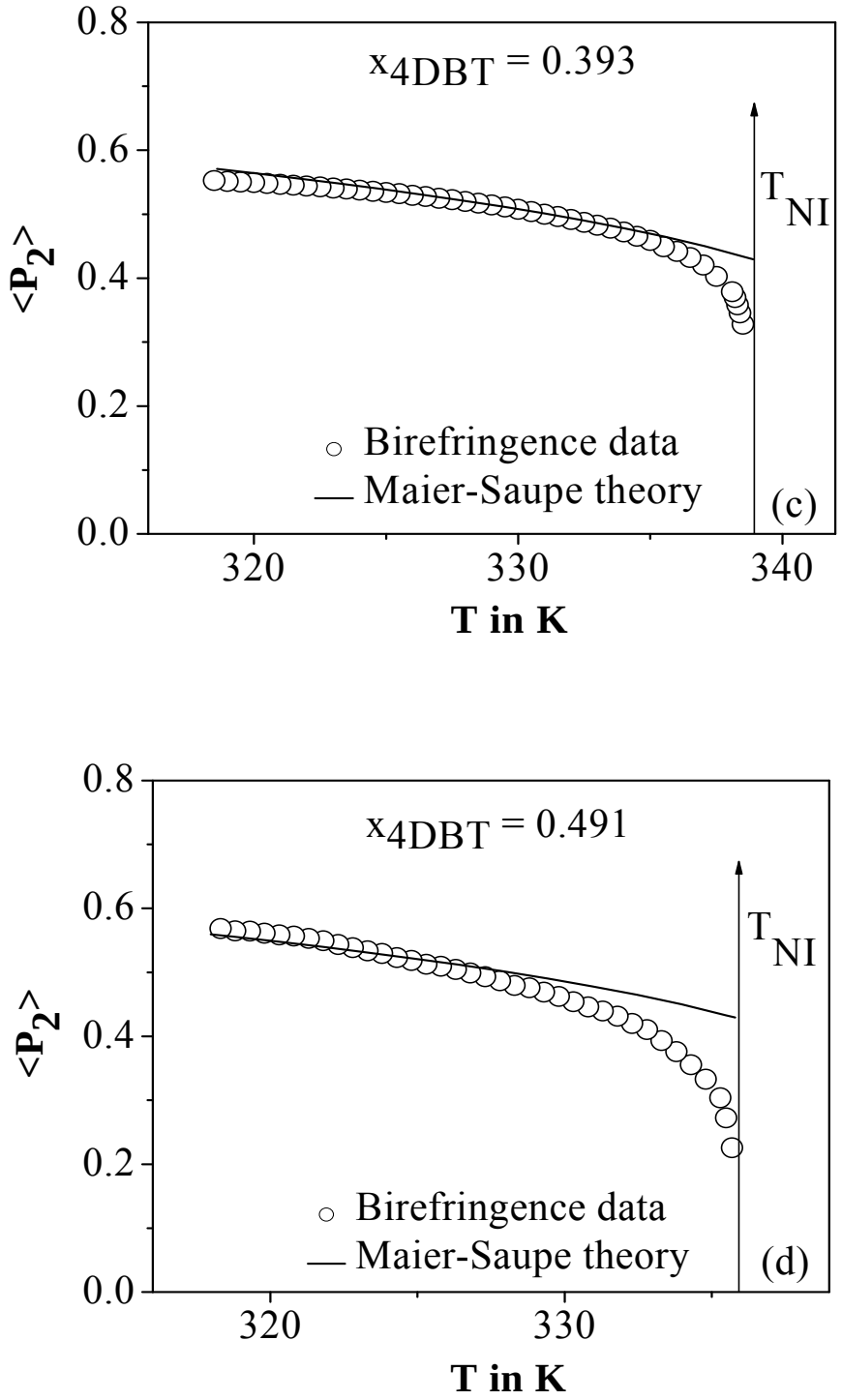


Figure 7.3(c-d) Temperature dependence of order parameter ($<P_2>$) for (c) x_{4DBT} = 0.393 and (d) x_{4DBT} = 0.491. Solid arrow denotes the nematic-isotropic (T_{NI}) transition temperature. The solid line represents $<P_2>$ from the Maier-Saupe theory.

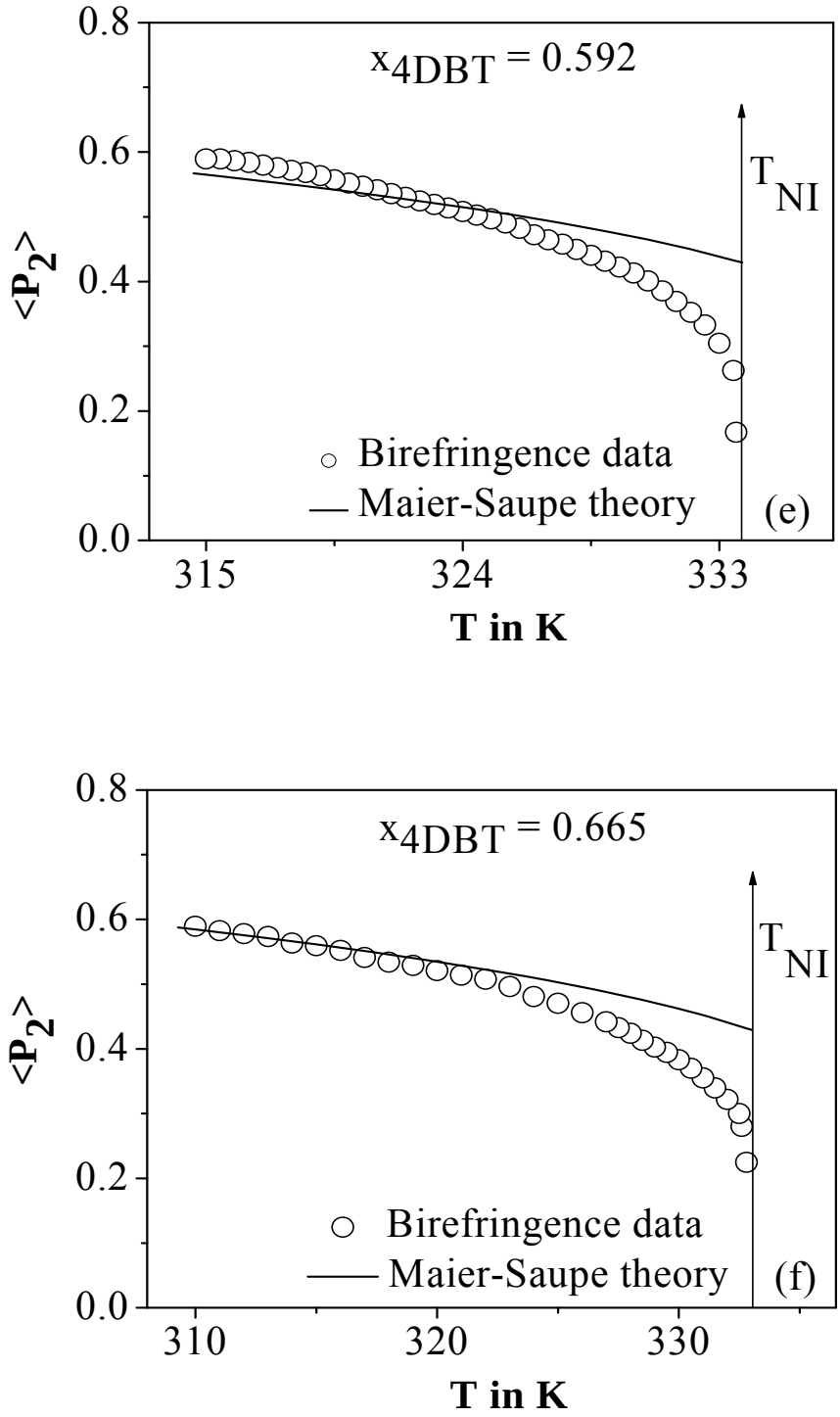


Figure 7.3(e-f) Temperature dependence of order parameter ($<P_2>$) for (e) x_{4DBT} = 0.592 and (f) x_{4DBT} = 0.665. Solid arrow denotes the nematic-isotropic (T_{NI}) transition temperature. The solid line represents $<P_2>$ from the Maier-Saupe theory.

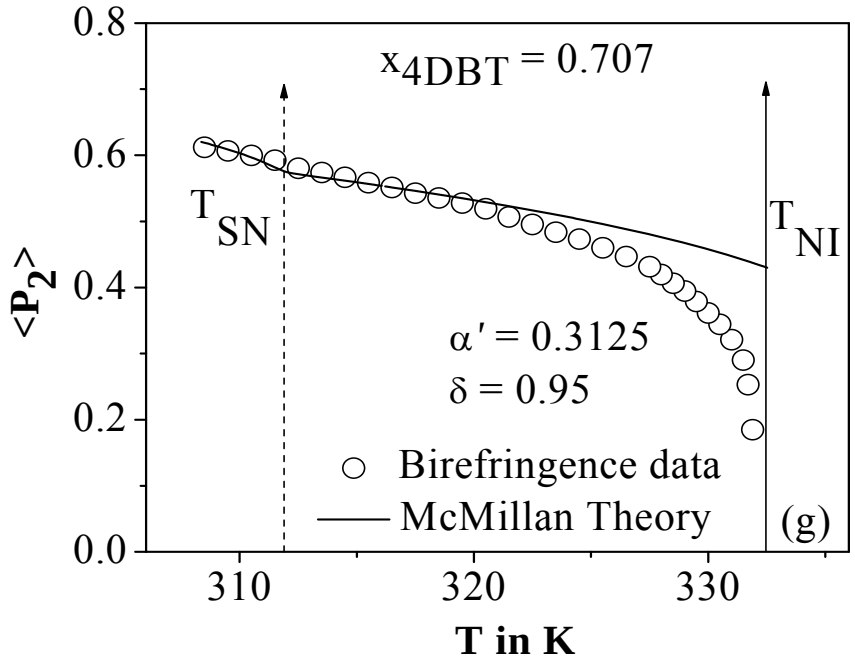


Figure 7.3(g-h) Temperature dependence of order parameter ($<P_2>$) for (g) x_{4DBT} = 0.707 and (h) x_{4DBT} = 0.787. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid line represents $<P_2>$ from the McMillan's theory.

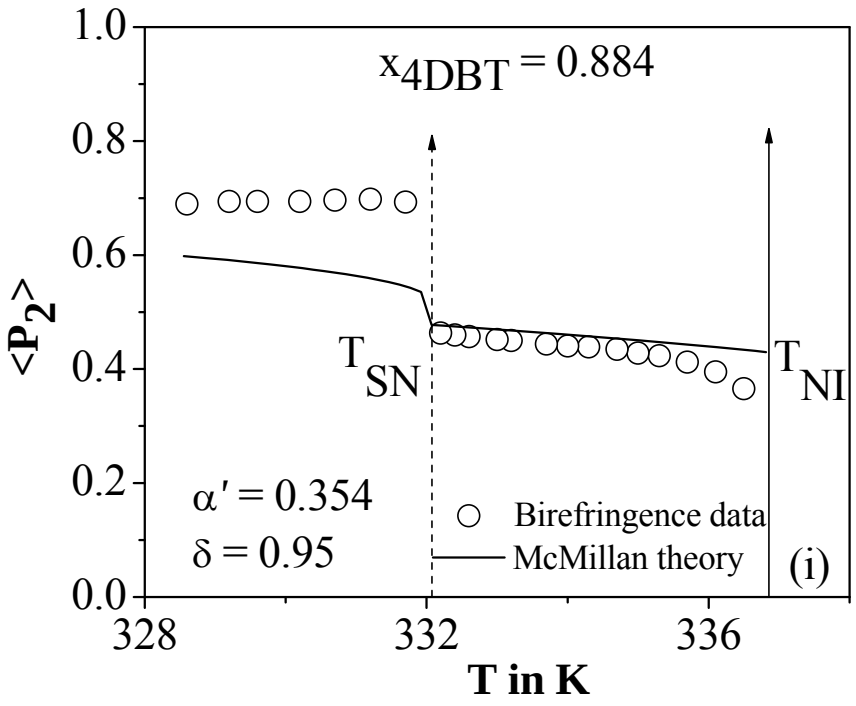


Figure 7.3(i) Temperature dependence of order parameter (<P_2>) for x_{4DBT} = 0.884. Solid arrow and dashed arrow denote the nematic-isotropic (T_{NI}) and smectic A-nematic (T_{SN}) transition temperatures respectively. The solid line represents <P_2> from the McMillan's theory.

In the vicinity of smectic A-nematic (SmA-N) phase transition, all the mixtures under study exhibit a continuous change in order parameter value except for x_{4DBT} = 0.884. For this concentration, a sharp change in the order parameter value near the SmA-N transition temperature (T_{SN}) has been detected, signaling a first order nature of the SmA-N phase transition while in the rest of the mixtures SmA-N transition is second order in nature. The calculated orientational order parameter (<P_2>) has also been compared with the same obtained from Maier-Saupe [38] and McMillan theory [39,40]. At very close to the clearing temperature the experimental <P_2> values fall quicker than those predicted by Maier-Saupe and the quality of agreement between the theoretical and experimental <P_2> value is poor. This type of variation of the order parameter values near the N-I transition has also been reported by others [20,41-44]. But far from the clearing temperature, the experimental <P_2> values can be well portrayed by the theoretical curves for

most of the investigated mixtures and the conformity between the two sets of values is fairly good. The best fitted theoretical curves which was obtained by changing the parameter α' and δ of the McMillan potential (discussed in detail in chapter 2 of this thesis) corresponding to the experimentally obtained order parameter are presented in Figure 7.3(a), (b) and (g)-(i). The parameter δ in McMillan's theory [39,40] being the ratio of the translational to the orientational part of the potential, may be assumed to be almost constant with concentration ($\delta = 0.95$ produces best fit in this case). On the other hand, the parameter α' varies from 0.3125 to 0.3553 for the different concentrations having smectic A phase.

The fit parameters Δn_0 and β for different concentrations are listed in the Table 7.1. The value of the order parameter critical exponent β as obtained from the fitting of Δn data was found to lie in the range 0.161 to 0.203, which is definitely smaller than any of the theoretical predictions. Although, the Haller's type equation is widely used [45-50] in treating the optical anisotropy or the polarizability anisotropy data, it is incompatible with the weakly first order character of the N-I transition [30,51-55], as it envisages a continuous decrease of the order parameter at the clearing temperature.

Table 7.1 Value of the fitting parameters Δn_0 and β obtained from the fit to Haller's type Equation (7.1).

x_{4DBT}	Δn_0	β
0.208	0.277±0.025	0.161±0.019
0.291	0.265±0.016	0.188±0.007
0.393	0.320±0.002	0.190±0.002
0.491	0.262±0.003	0.191±0.003
0.592	0.269±0.012	0.193±0.007
0.665	0.310±0.016	0.203±0.010
0.707	0.294±0.004	0.196±0.004
0.787	0.334±0.004	0.200±0.003
0.884	0.341±0.017	0.194±0.012

Recently, a four parameter power-law expression [31], consistent with the mean-field theory for critical as well as tricritical behavior of the weakly first-

order transition, has been introduced to surpass the difficulty encountered in the Haller's model and expressed in the following form:

$$D = A[B + (1-B)(1-\frac{T}{T^{**}})^{\beta}] \quad (7.3)$$

where D is the physical parameter under consideration (birefringence in this case), A is a term which entails the molecular polarizability and the nematic order parameter, β is the order parameter critical exponent, T** is the effective second-order transition temperature seen from below the clearing temperature and B is a fit parameter. The solid lines in Figure 7.2 (a-i) represent the four parameter fit to the birefringence (Δn) data. The fitting has been performed in the nematic phase only and extrapolated to the smectic A phase. Table 7.2 lists the different fit parameters obtained from the fitting of experimental Δn data to Equation (7.3). It has been observed that the order parameter critical exponent β has the values ranging between 0.239 and 0.254 within the error limit. The consistency of the β value is especially very important because it describes the global behavior of the nematic order parameter. For x_{4DBT} = 0.592, fitting yields β = 0.249±0.009 which represents the closest approach to the theoretically predicted tricritical value of 0.25 [24-27] and strongly supports the tricritical nature of the N-I phase transition. Hence, the four parameter power law expression works better than the three parameter Haller's type expression as far as the β value is concerned.

Table 7.2 Values of the fitting parameters A, B, T** and β obtained from the four parameter fit.

x_{4DBT}	A	B	T**(K)	β
0.208	0.236±0.010	0.421±0.011	347.9±0.7	0.239±0.011
0.291	0.345±0.006	0.002±0.001	343.5±0.1	0.253±0.008
0.393	0.280±0.012	0.286±0.007	339.0±0.6	0.247±0.008
0.491	0.282±0.011	0.110±0.001	335.9±0.8	0.254±0.001
0.592	0.320±0.005	0.005±0.001	334.2±0.6	0.249±0.009
0.665	0.332±0.004	0.081±0.002	333.1±0.9	0.252±0.007
0.707	0.329±0.012	0.049±0.003	332.6±0.1	0.248±0.008
0.787	0.366±0.004	0.102±0.002	333.0±0.2	0.252±0.007
0.884	0.255±0.050	0.414±0.008	336.9±0.7	0.248±0.011

7.6 Static dielectric parameter measurements

The temperature variation of the static dielectric permittivity $\varepsilon_{\parallel}$, $\varepsilon_{\perp}$ in the mesophases and ε_{iso} in the isotropic phase for the studied mixtures [37] are presented in Figure 7.4(a-i). The average dielectric permittivity $\varepsilon_{av}= (\varepsilon_{\parallel}+2\varepsilon_{\perp})/3$ calculated from the measured values of $\varepsilon_{\parallel}$ and $\varepsilon_{\perp}$ is also shown in the respective figures. The perpendicular component of the dielectric permittivity *i.e.* $\varepsilon_{\perp}$ follows almost identical trend with decreasing temperature for all the mixtures while the parallel component *i.e.* $\varepsilon_{\parallel}$ follows a reverse trend as that of $\varepsilon_{\perp}$. But for the two concentrations x_{4DBT} = 0.787 and 0.884, a slight decrease of $\varepsilon_{\parallel}$ has been observed in the SmA phase relative to the nematic phase. All the mixtures exhibit a large positive dielectric anisotropy ($\Delta\varepsilon>0$) due to the presence of terminal polar end groups (NCS and CN) in the two pure compounds. As far as the dielectric anisotropy is concerned, all the mixtures exhibiting induced nematic phase show no appreciable jump in the vicinity of smectic A-nematic (SmA-N) phase transition temperature except x_{4DBT} = 0.787 which shows a noticeable change in $\Delta\varepsilon$ near the SmA-N transition temperature.

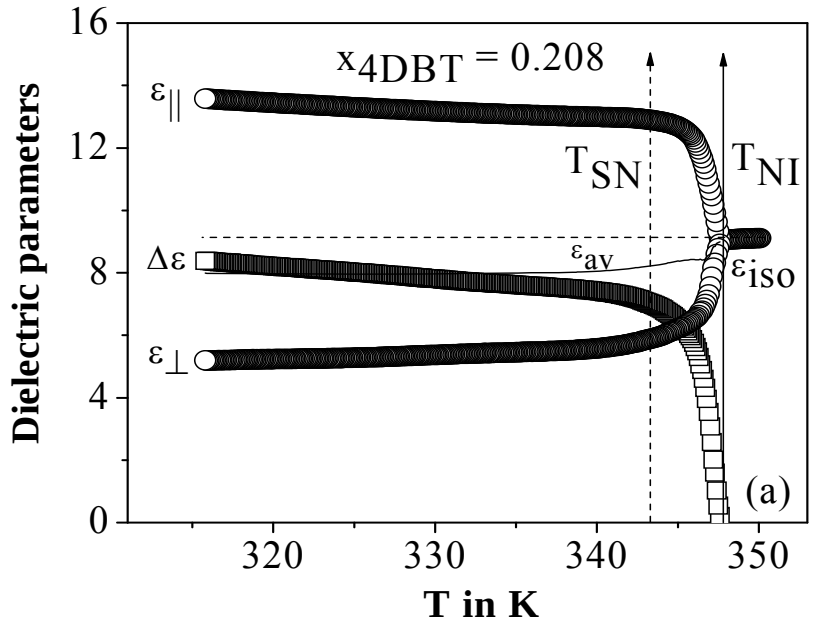


Figure 7.4(a) Temperature variation of the dielectric parameters for x_{4DBT} = 0.208. Solid arrow and dashed arrow indicate nematic–isotropic (T_{NI}) and smectic A–nematic (T_{SN}) phase transition temperatures respectively.

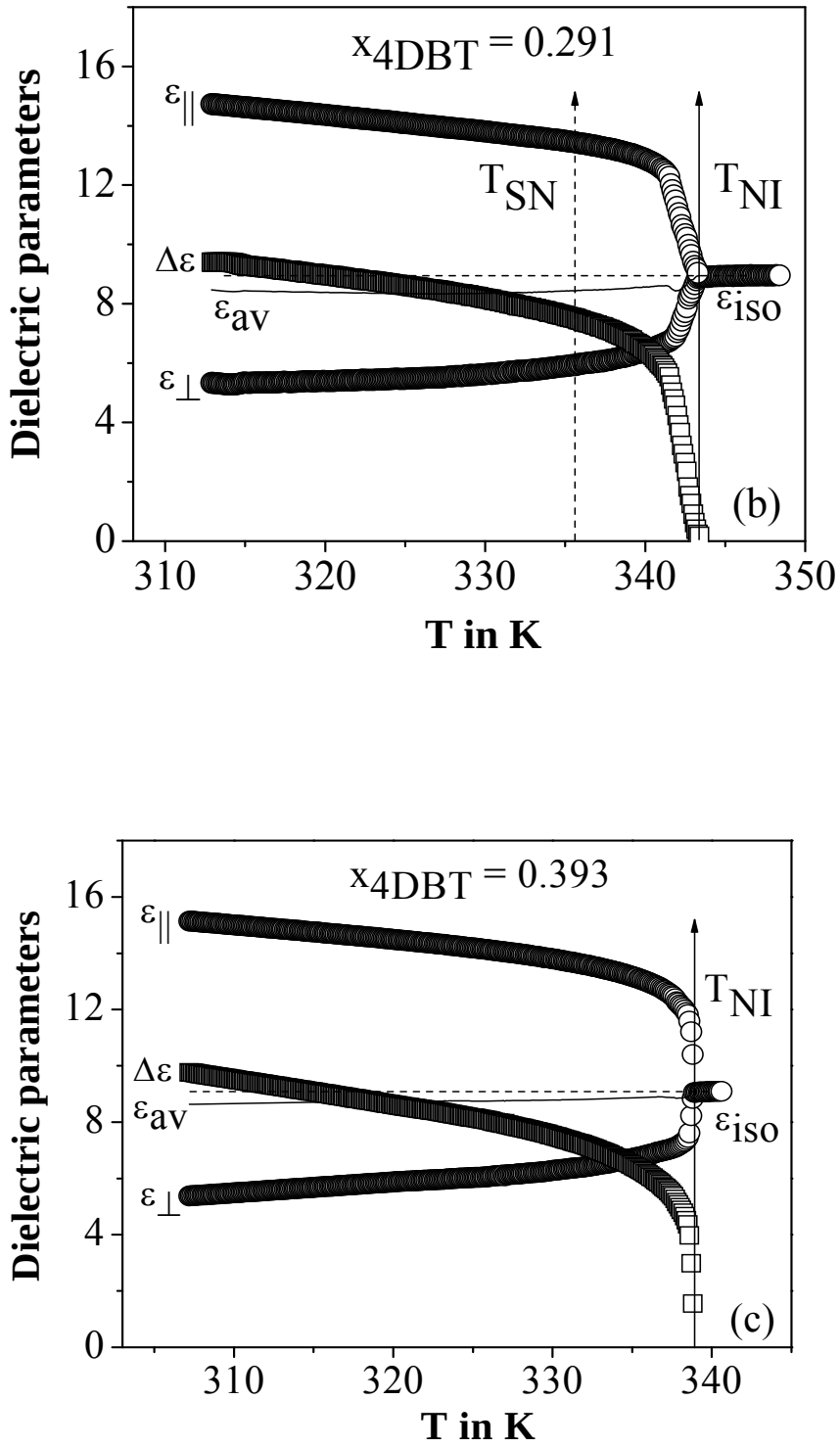


Figure 7.4(b-c) Temperature variation of the dielectric parameters for (b) x_{4DBT} = 0.291 and (c) x_{4DBT} = 0.393. Solid arrow and dashed arrow indicate nematic–isotropic (T_{NI}) and smectic A–nematic (T_{SN}) phase transition temperatures respectively.

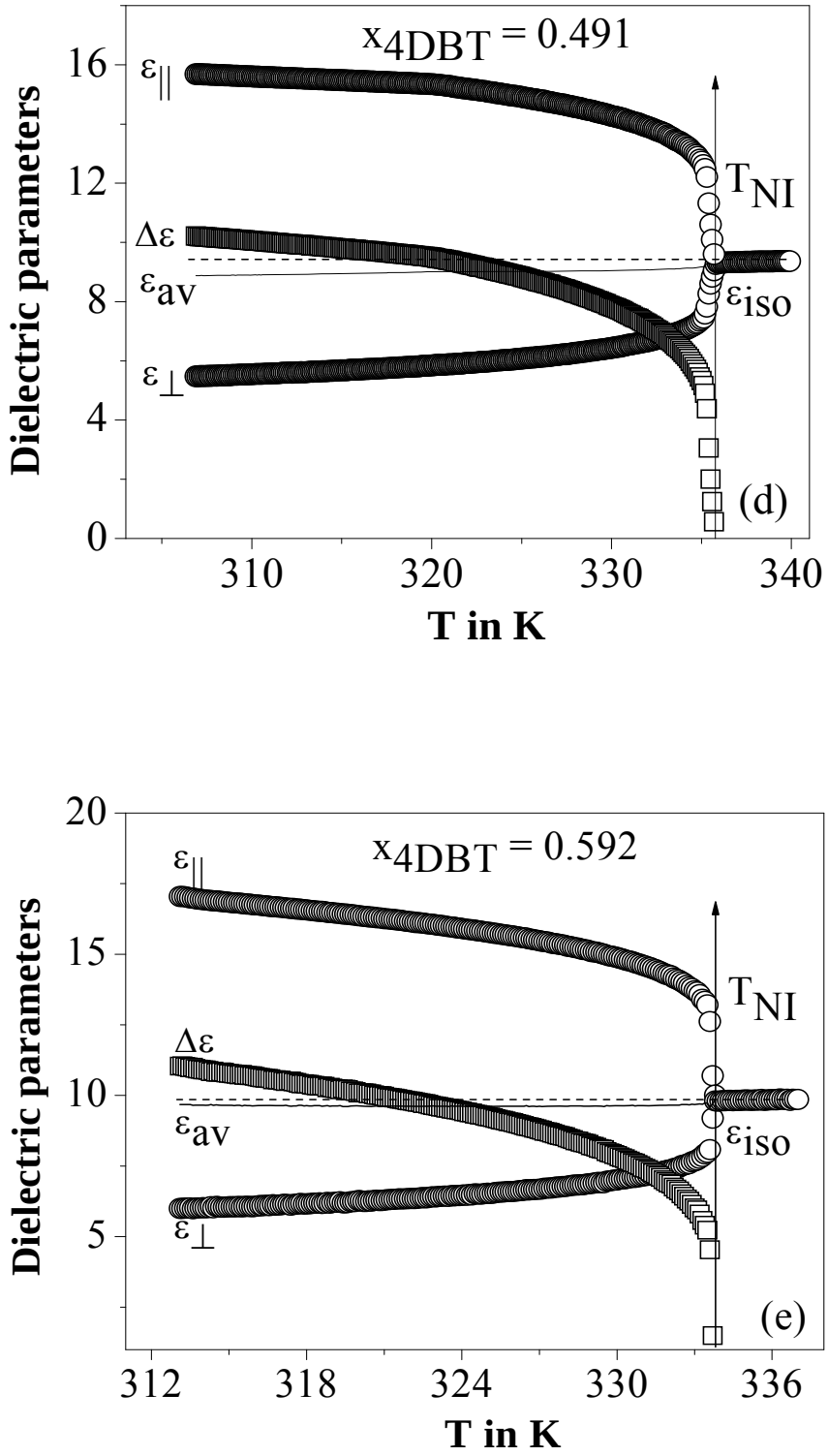


Figure 7.4(d-e) Temperature variation of the dielectric parameters for (d) x_{4DBT} = 0.491 and (e) x_{4DBT} = 0.592. Solid arrow indicates nematic–isotropic phase transition temperature (T_{NI}).

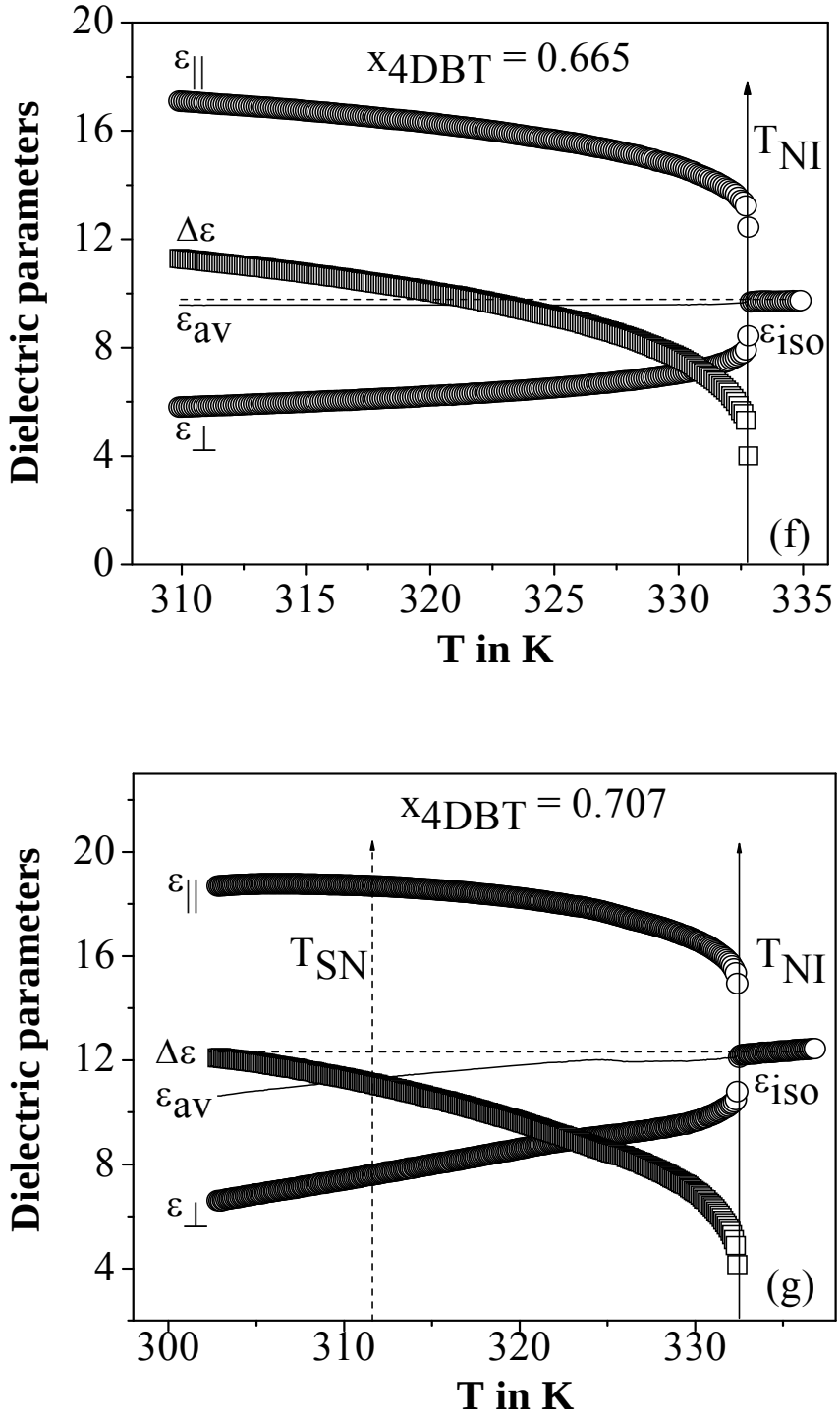


Figure 7.4(f-g) Temperature variation of the dielectric parameters for (f) x_{4DBT} = 0.665 and (g) x_{4DBT} = 0.707. Solid arrow and dashed arrow indicate nematic–isotropic (T_{NI}) and smectic A–nematic (T_{SN}) phase transition temperatures respectively.

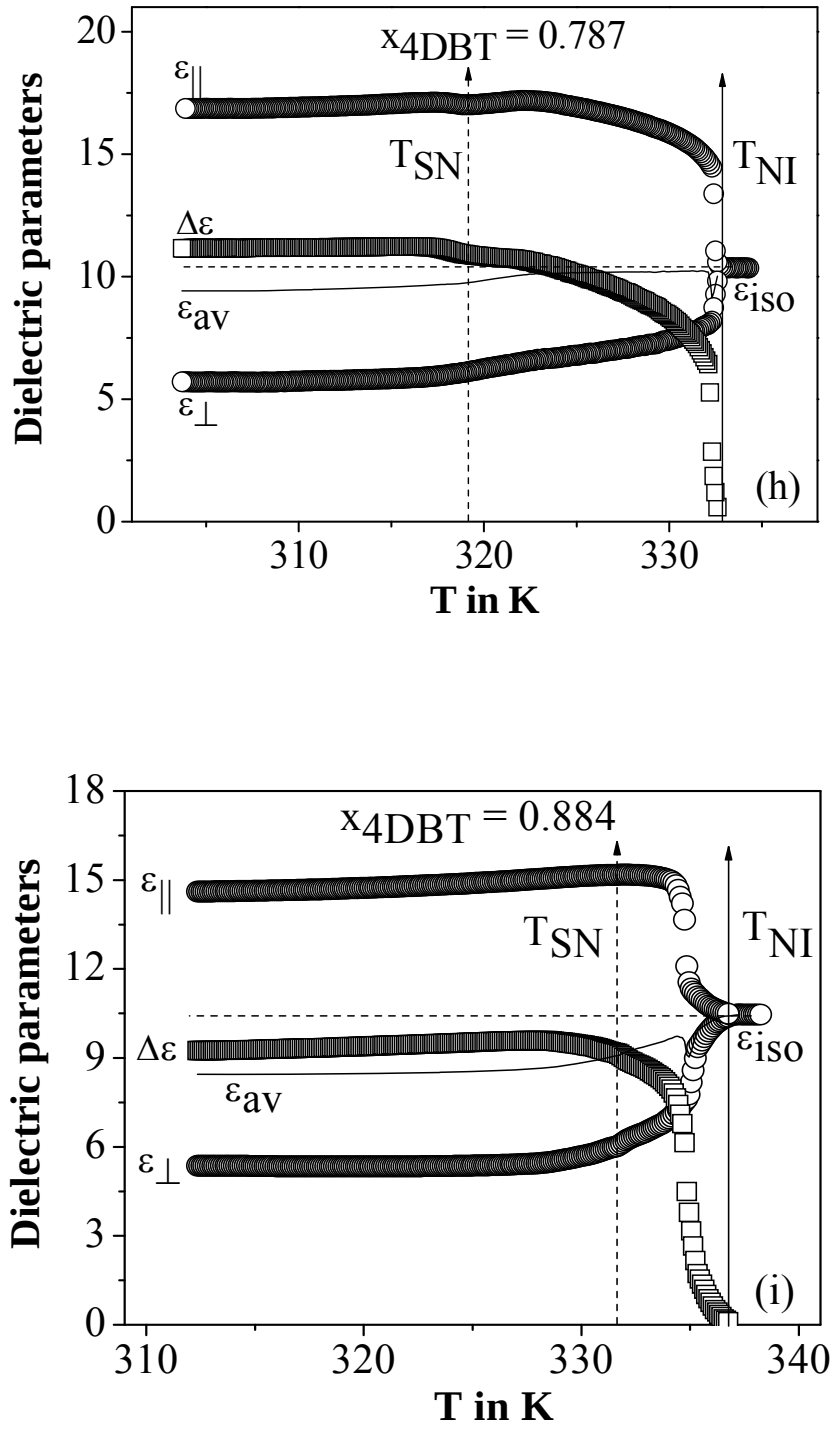


Figure 7.4(h-i) Temperature variation of the dielectric parameters for (h) x_{4DBT} = 0.787 and (i) x_{4DBT} = 0.884. Solid arrow and dashed arrow indicate nematic–isotropic (T_{NI}) and smectic A–nematic (T_{SN}) phase transition temperatures respectively.

Moreover, the dielectric anisotropy (Δε) depends on the degree of parallel alignment of the adjacent LC molecules, which makes the dependence on order parameter particularly important. Maier and Meier [56] have given a comprehensive idea about the relation between the order parameter and dielectric anisotropy but it requires the temperature dependence of density as well as the polarizability anisotropy data similar to the optical method. Further, de Jeu and Bordewijk [57] argued that the Δε data can be used to evaluate order parameter if a particular local field is applied to the LC molecules. Also it is well known that any kind of anisotropy is related to the order parameter, so the dielectric anisotropy (Δε) is directly proportional to the order parameter and can also be used to determine the order parameter critical exponent β which is an important parameter to check the tricritical nature of the N-I transition. The Δε data calculated from the difference between the $\varepsilon_{\parallel}$ and $\varepsilon_{\perp}$ data have been parameterized according to the following expression [30,58,59]:

$$\Delta\varepsilon = \Delta\varepsilon^{**} + B_1 (T^{**} - T)^{\beta} \tag{7.4}$$

where B_1 is an adjustable parameter, Δε** is the dieletric anisotropy at T** which is greater than the clearing temperature (T_{NI}). The fitting to dielectric anisotropy (Δε) data for a representative mixture x_{4DBT} = 0.665 is shown in Figure 7.5. It has been found that the Equation (7.4) described very well the experimental Δε data points. For all the mixtures showing induced nematic phase the fitting were performed considering the data points of the nematic phase only and the fit parameters are listed in Table 7.3. The order parameter critical exponent β lies in between 0.225 to 0.253 [37] which excludes the higher theoretical mean field value (β = 1/2) and also smaller than the non classical value (β = 1/3), supporting the tricritical nature of the nematic-isotropic (N-I) phase transition. In the inset of Figure 7.5 a plot of $\log_{10}$ (Δε–Δε**) as a function of $\log_{10}$ (T**–T) is shown for x_{4DBT} = 0.665. It is quite evident from the figure that the log-log plot exihibits a straight line, the slope of which is the order parameter critical exponent. Again the β value is found nearly equal to 0.255 which is very close to the tricritical value (β = 0.25). Such an outcome has also appeared to be in well agreement with those obtained from the analysis of the birefringence (Δn) data earlier. Therefore, taking

into account the margin of error the obtained β values are almost fully compatible with the tricritical hypothesis (β = 0.25).

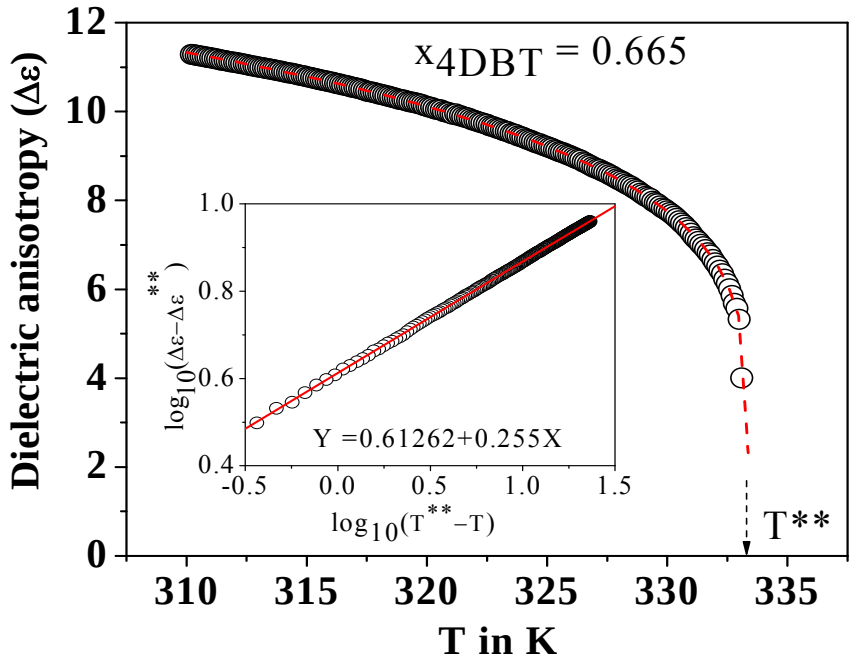


Figure 7.5 Measured dielectric anisotropy (Δε) as a function of temperature for the mixture x_{4DBT} = 0.665. Dotted lower head arrow indicates the temperature T**. The inset shows a double logarithmic plot of (Δε–Δε**) *vs* (T**–T). The dashed lines are fit to the data points according to the Equation (7.4).

Table 7.3 Values of the fitting parameters obtained from the fit to Equation (7.4).

x_{4DBT}	Δε**	B_1	T** in K	β
0.208	4.05±0.15	2.32±0.15	347.5±0.07	0.225±0.014
0.291	3.55±0.73	2.51±0.59	344.1±0.33	0.248±0.033
0.393	2.17±0.40	3.11±0.32	339.5±0.15	0.250±0.014
0.491	2.14±0.42	3.73±0.34	336.6±0.13	0.248±0.013
0.592	2.35±0.11	4.00±0.10	334.1±0.02	0.250±0.005
0.665	2.17±0.29	4.09±0.23	333.4±0.09	0.247±0.008
0.700	1.56±0.12	4.25±0.77	333.2±0.51	0.242±0.059
0.787	2.96±1.47	4.29±1.20	333.5±0.38	0.253±0.042
0.884	5.43±1.01	2.77±1.31	336.8±0.88	0.235±0.041

7.7 Conclusion

A detailed study on the orientational order parameter (<P_2>) has been performed for some mixtures of two smectogenic compounds exhibiting induced nematic phase by means of refractive index measurements. For this, a direct extrapolation technique has been adopted which provides a very simple way to determine the orientational order parameter excluding the requirement of polarizability anisotropy as well as density values. The experimentally determined <P_2> values have been compared with McMillan's theory in the smectic A phase and Maier–Saupe theory in the nematic phase. Haller's type fitting expression results in a very low value of the critical exponent β differing from the theoretical values by a considerable margin, whereas the four parameter fitting expressions, consistent with the mean field theory, describes the critical behavior of the order parameter near the N-I transition with a β value close to 0.25. So, the nematic order parameter presents a unique behavior with a critical exponent in accordance with the tricritical hypothesis. Within the experimental uncertainty, the order parameter critical exponent β obtained from the fitting of dielectric anisotropy (Δε) data revealed to be in excellent agreement with those previously obtained from the optical anisotropy (Δn) data.

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