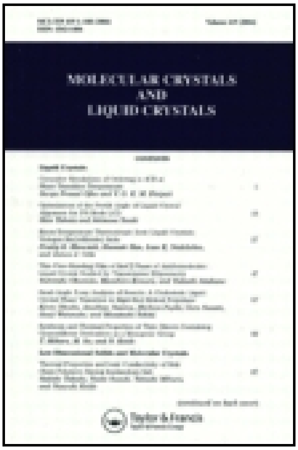

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Field-Induced Director Dynamics of Nematic 4-OCTYL-4′-Cyanobiphenyl: A Study By Deuterium NMR Spectroscopy

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FIELD-INDUCED DIRECTOR DYNAMICS OF NEMATIC 4-OCTYL-4′-CYANOBIPHENYL: A STUDY BY DEUTERIUM NMR SPECTROSCOPY

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Deuterium NMR spectroscopy has been used to investigate the director dynamics in the nematic phase of perdeuteriated 4-octyl-4′-cyanobiphenyl-d_{25} *(8CB-*d_{25}*) When the electric field is applied to the nematic film, the director moves from being parallel to the magnetic field to being at an angle with respect to it. After the electric field is switched off, the director relaxes back to being parallel to the magnetic field. Deuterium NMR spectra were recorded during the turn-on and the turn-off alignment processes as a function of time. This particular technique was chosen because the spectral peaks associated with each rigid group in the molecule are clearly resolved and of comparable intensity. For all of the experiments at different temperatures in the nematic phase of 8CB-*d_{25} *we find that the field-induced relaxation times are independent of the group used to determine the director orientation during the alignment process.*

Keywords: nematic liquid crystal; director dynamics; rotational viscosity; deuterium nuclear magnetic resonance

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1. INTRODUCTION

With the development of spectroscopic techniques for the study of liquid crystals it became possible to determine the director orientation using tensorial properties associated with specific fragments of the mesogenic molecules. For example, for a nematogen such as 4-pentyl-4′-cyanobiphenyl (5CB) vibrational spectroscopy can be used to measure the director orientation via the intensity of peaks associated with the aromatic core or the pentyl chain attached to it. In these techniques [1–7] an electric field was used to create the non-equilibrium state. Other spectroscopic techniques can also provide molecular site specific information and one of the most important of these for liquid crystals is NMR spectroscopy. This technique has been used to monitor the time dependence of the director alignment in 5CB by observing the change in chemical shifts of carbon-13 nuclei in both the chain and the core [8]. Deuterium NMR has also been used to study the dynamics of the alignment by a magnetic field for 5CB-d_{15} [9]. In view of the observation of a site dependence for the director dynamics for some but not all of these studies a new study using deuterium NMR spectroscopy [10] was undertaken [11]. The nematogen investigated was 5CB in order to facilitate comparison with previous work for this compound which is extensive. The experiment differs from the two earlier NMR investigations [8,9], in which the non-equilibrium state was created by spinning the sample, in that an electric field was used to create the non-equilibrium state. This avoids the need to spin the sample which necessarily induces flow that could be responsible for the unpredicted induction period found for these studies. In addition the director dynamics during alignment by the electric field was investigated since this makes a comparison with the experiments using vibrational spectroscopy more direct. There is the added advantage that the relaxation time can be altered by varying the strength of the electric field and its orientation with respect to the magnetic field. The studies revealed that the director dynamics for 5CB are independent of the molecular site of the deuterons used to determine the director orientation.

In order to ensure that the results found for 5CB are not specific to this mesogen it is clearly desirable to study other compounds. We have, therefore, undertaken an analogous study of the director dynamics in the nematic phase of the mesogen 4-octyl-4′-cyanobiphenyl (8CB). This particular compound was chosen partly because of its long terminal alkyl chain which should increase the possibility that the director dynamics for the core and chain should be different. In addition, the cyanobiphenyl mesogenic core for 8CB is the same as for 5CB which facilitates the comparison of the results for these two compounds. In this paper we report studies using deuterium NMR spectroscopy of perdeuteriated 8CB-d_{25} where the director is aligned by either a magnetic or an electric field. This particular experimental technique is the same as that used in Ref. [11], it was chosen because the spectral peaks associated with each rigid group in the molecule are clearly resolved and of comparable intensity. The following section gives the theoretical background to the investigation while the experiments are described in Section 3. The results of these experiments are described and discussed in Section 4 and our conclusions are in the final section.

2. THEORETICAL BACKGROUND

According to the Leslie-Ericksen hydrodynamic theory [12], we need to consider the one-dimensional distortion of the director across the cell. All of the deuterium NMR spectra in our study are consistent with the sample being a monodomain which allows us to determine a unique director orientation. In this brief analysis, we therefore treat the director as being uniformly aligned. The electric field, **E**, makes an angle α with the magnetic field, **B**, of the NMR spectrometer. Provided both the dielectric anisotropy, $\Delta\tilde{\varepsilon}$, and the diamagnetic anisotropy, $\Delta\tilde{\chi}$, are positive, as they are for 8CB, the director is confined to the plane formed by the two fields. When the director makes an arbitrary angle, θ, with respect to the magnetic field the rate of change of the director orientation is given, for the turn-on process, by the torque-balance equation which for a monodomain nematic is

$$\gamma_1 \frac{d\theta(t)}{dt} = -\frac{\Delta\tilde{\chi}}{2\mu_0} B^2 \sin 2\theta(t) + \frac{\varepsilon_0 \Delta\tilde{\varepsilon}}{2} E^2 \sin 2(\alpha - \theta(t)). \tag{1}$$

Here γ_1 is the rotational viscosity coefficient, μ_0 is the magnetic permeability and $\varepsilon_0$the dielectric permittivity of a vacuum. The solution of Eq. (1) is obtained analytically as [10]

$$\theta(t) = \theta_\infty + \tan^{-1}[\tan(\theta_0 - \theta_\infty) \exp(-t/\tau)], \tag{2}$$

where θ_∞ is the limiting value of $\theta(t)$ as t tends to infinity, τ is the field-induced relaxation time, and θ_0 is the initial angle. The limiting angle,θ_∞, is given by

$$\cos 2\theta_\infty = \frac{U_m + U_e \cos 2\alpha}{\sqrt{U_m^2 + 2U_m U_e \cos 2\alpha + U_e^2}}\,, \tag{3}$$

where

$$U_m = (\Delta\tilde{\chi}/2\mu_0)B^2\,, \qquad U_e = (\varepsilon_0 \Delta\tilde{\varepsilon}/2)E^2,$$

are the strengths of the magnetic and electric interactions, respectively. The relaxation times for the turn-on (τ_{on}) and turn-off (τ_{off}) processes are then

$$\tau_{on} = 1 \Big/ \sqrt{\tau_m^{-2} + 2\tau_m^{-1}\tau_e^{-1}\cos 2\alpha + \tau_e^{-2}}, \tag{4}$$

and

$$\tau_{off}(\equiv \tau_m) = \gamma_1/(2U_m), \tag{5}$$

$$\tau_e = \gamma_1/(2U_e)\,, \tag{6}$$

respectively and τ_e is the electric field-induced relaxation time. Equations (3)–(5) give the following simple relationships used in the analysis of our results [13],

$$\sin^2 2\alpha = \frac{R^2 \sin^2 2\theta_\infty}{R^2 - 2R\cos 2\theta_\infty + 1}, \tag{7}$$

$$\begin{aligned} \frac{U_m}{U_e} &= \frac{B^2}{\mu_0 \varepsilon_0 E^2}\left(\frac{\Delta\tilde{\chi}}{\Delta\tilde{\varepsilon}}\right), \\ &= \frac{1}{\sqrt{R^2 - 2R\cos 2\theta_\infty + 1}}, \end{aligned} \tag{8}$$

where

$$R = \tau_{off}/\tau_{on}. \tag{9}$$

Equations (7) and (8) give the values of α and $\Delta\tilde{\chi}/\Delta\tilde{\varepsilon}$ respectively, by using τ_{on}, τ_{off} and θ_∞. It is also evident from Eqs. (5) and (8) that $\Delta\tilde{\chi}$ and γ_1 can only be determined if $\Delta\tilde{\varepsilon}$ is known from an independent experiment.

3. EXPERIMENT

The nematogen used for our study was 8CB-d_{25}, which was perdeuteriated in both the octyl chain and the biphenyl core of 8CB. This was prepared using a procedure described elsewhere [14]. A cell was prepared in which 8CB-d_{25} was contained between two glass plates coated with transparent In_2O_3 electrodes separated by 96.0 μm spacers. The smectic A-nematic and nematic-isotropic transition temperatures for the sample in the cell are 305.0 K and 311.0 K, respectively. The surfaces of the electrodes were not treated in any way and so the surface anchoring strength was of the order of 10^{-7} J/m^2 corresponding to weak anchoring. This is consistent with our neglect of surface interactions in the torque-balance equation (see Eq. (1)). The cell was placed in the probe head of a JEOL Lambda 300 NMR spectrometer, which has a magnetic flux density, B, of 7.05 T, so that the electric field made an angle α with the magnetic field. It is necessary to position the sample cell in the probe head so that the electric field makes an angle of about 40° with the magnetic field. To do this the cell was first placed in the goniometer of the probe head so that the angle between the cell normal and the vertical direction, that is $\mathbf{B}$, is approximately 40° as judged by eye. The orientation of the cell was then determined more accurately by measuring the quadrupolar splitting when the sample was subject to an electric field of 88.5 V_{RMS}. The angle, θ, made by the director with the magnetic field can be determined from the quadrupolar splitting, $\Delta\tilde{v}(\theta)$, by using

$$\Delta\tilde{v}(\theta) = \Delta\tilde{v}_0 P_2(\cos\theta)\,, \tag{10}$$

where $\Delta\tilde{v}_0$ is the splitting when the director is parallel to the magnetic field and $P_2(\cos\theta)$ is the second Legendre function. Two classes of experiment were performed to investigate the director dynamics. In one, the so-called turn-on process, the director is first aligned parallel to the magnetic field of the NMR spectrometer and then the electric field is applied. After a given period of time, ranging from 0 to 30 ms, the free-induction decay (FID) was measured using a quadrupole echo sequence with a 90° pulse width of 5.8 μs and an interpulse delay of 13.4 μs. The electric field was then switched off and the director was realigned parallel to the magnetic field. This sequence was repeated and the FIDs averaged to obtain a spectrum with a good signal-to-noise ratio; typically 4000 FIDs were accumulated. In the second, turn-off, experiment the electric field was first applied to align the director at an angle to the magnetic field. Then the electric field was removed and the FID captured after an interval of time in the range 0 to 30 ms. The electric field was reapplied to align the director and the process repeated until sufficient FIDs had been averaged to obtain a spectrum with a good signal-to-noise ratio; typically 4000 FIDs were again accumulated in this way. All of the measurements were made at different temperatures of 305.5, 306.0, 307.0, 308.0, and 309.0 K in the nematic phase of 8CB-d_{25}.

4. RESULTS AND DISCUSSION

We begin with the deuterium NMR spectrum of 8CB-d_{25} with the director aligned parallel to the magnetic field; it is here that the quadrupolar splittings are the largest (see Eq. (10)). The spectrum shown in Figure 1 was measured for the nematic phase at the lowest temperature of 305.5 K; it is clearly composed of a series of quadrupolar doublets centred essentially on a common frequency. The ten quadrupolar splittings observed

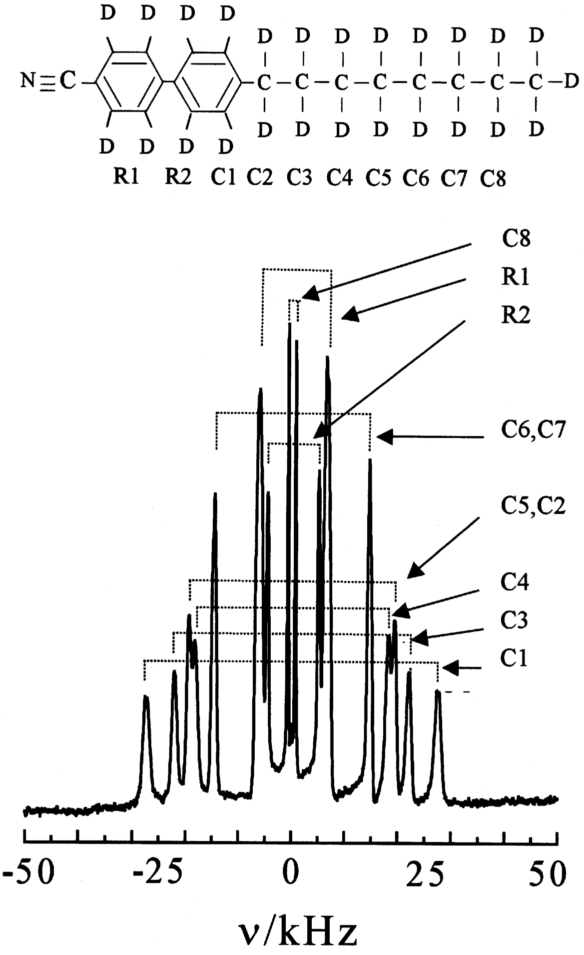

FIGURE 1 The chemical structure of perdeuteriated 8CB together with its deuterium NMR spectrum in the nematic phase at 305.5 K with the director parallel to the magnetic field.

have been assigned, based on the specific deuterium labeling of the octyl chain [15], to the group of deuterons in 8CB-d25 and this assignment is shown on the peaks according to the labeling indicated on the chemical structure, also given in Figure 1. The octyl chain contains eight groups of equivalent deuterons, seven methylene and one methyl, and the quadrupolar doublets associated with all of these except for C2, which overlaps with C5, are readily apparent in the spectrum. The eight deuterons in the two phenyl rings are only strictly equivalent in pairs but because the C-D bonds make essentially the same angle with the para-axis of the phenyl rings the quadrupolar splittings are expected to be very similar. In fact three pairs of deuterons are essentially equivalent with the remaining pair having a slightly smaller quadrupolar splitting. It is apparent that the peaks associated with the core and the chain are well-separated in the spectrum and so it is an easy task to use deuterium NMR spectroscopy to follow the dynamics for the director associated with these two fragments. Indeed the peaks originating from the eight groups in the octyl chain are also well resolved and so it is possible to monitor the dynamics not just for the chain but for the individual rigid groups within it. This is an advantage over the use of vibrational spectroscopy which is normally unable to separate the peaks coming from the different groups. The ability to study the groups individually is clearly important. In the practical measurements the peaks, C1, C5, C6 ($\equiv$C7), and R1 and R2, which are well-resolved during the director rotation at different temperatures in the nematic phase, were used to investigate the field-induced director dynamics.

We now consider our results for the turn-on and turn-off experiments to follow the field-induced alignment of the director. Typical deuterium NMR spectra for the turn-on and turn-off processes are shown in Figures 2(a) and 2(b), respectively, for the sample studied at 305.5 K. In the turn-on process the director starts parallel to the magnetic field and so following the application of the electric field the quadrupolar splittings decrease with increasing time. They reach their smallest values when the director reaches the limiting angle of θ_∞ $(t = \infty)$ with respect to the magnetic field. After 0.6 ms the quadrupolar splittings have decreased as the director moves away from being parallel to the magnetic field. The spectral lines remain relatively sharp showing that the director is still uniformly aligned as its orientation changes. There is, however, a small broadening of the spectral lines which is seen to increase with the quadrupolar splitting in a spectrum. Since the methyl and aromatic deuterons have similar splittings which are the smallest the broadening of these spectral lines is also similar as well as small; it will not, therefore, affect the accuracy with which the director orientation associated with these two extreme groups can be determined. After 2.0 ms the quadrupolar splittings have decreased still further showing that the director has continued to move away from the magnetic field. In keeping with this increase in θ is an increase in the spectral linewidths, especially for those associated with the largest quadrupolar splitting. The increase in the linewidths means that the difference in the quadrupolar splittings for the deuterons at positions 2, 3, and 4 in the octyl chain of 8CB is not resolved. Nonetheless those for the other deuterons, except for position 8 in the octyl chain, are clearly resolved which allows the director orientation to be determined for the other positions in the molecule. The continuing motion of the director away from parallel to the magnetic and towards the electric field is clearly apparent from the spectrum recorded after 4.0 ms (see Fig. 2(a)). Again there is an increase in the linewidth associated with the increase in θ which results from a small spread of director orientations [11]. Despite this increase in the width of the spectral lines the resolution is clearly sufficient to determine both quadrupolar splittings for the aromatic core and for three of the positions in the octyl chain needed to determine the director

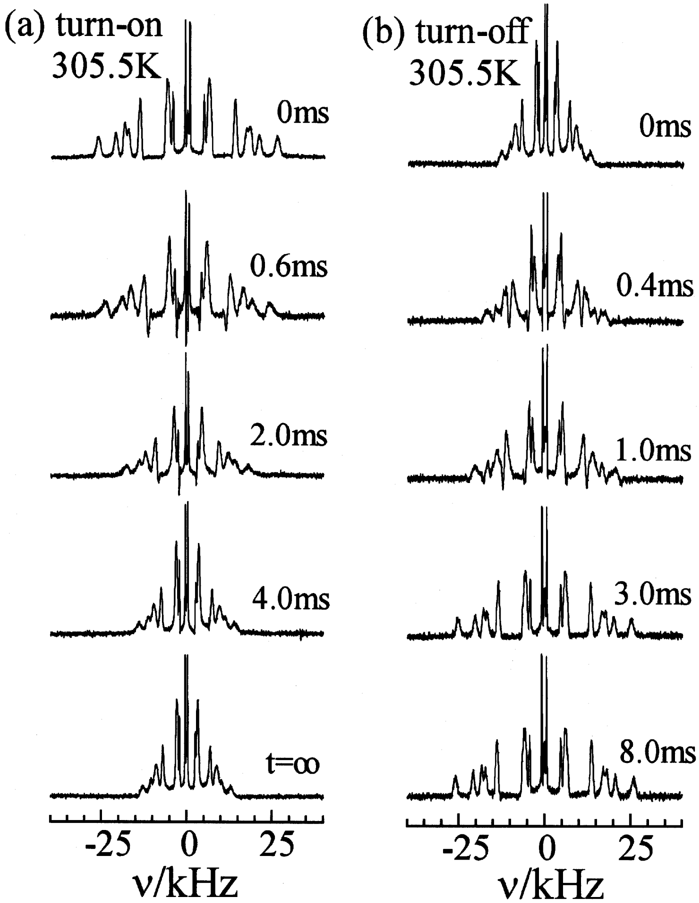

FIGURE 2 The time dependence of the deuterium NMR spectrum of 8CB-d_{25} for (a) turn-on and (b) turn-off processes following the application and removal of the electric field, respectively. For this turn-on process the electric field was 0.92 MV m^{-1}, it was inclined at an angle of 35.5° to the magnetic field and the sample temperature was 305.5 K.

orientation for these different groups in the molecule. Finally after $t = \infty$ the motion of the director ceases and it adopts a fixed angle with respect to the magnetic field.

The ratio of a quadrupolar splitting, $\Delta\tilde{\nu}(\theta)$, to its value when the director is parallel to the magnetic field, $\Delta\tilde{\nu}_0$, is dependent only on the orientation of the director with respect to the magnetic field via $P_2(\cos\theta)$ (see Eq. (10)). Accordingly if the director associated with different groups within 8CB align at different rates then a plot of the time dependence of the ratios, $\Delta\tilde{\nu}(\theta)/\Delta\tilde{\nu}_0$, should result in a series of curves. Conversely, if the field-induced relaxation of the director is site independent then the points for the various molecular sites will fall on a common curve. The results are shown in Figure 3 (a) for the group of six biphenyl deuterons in the core and for positions 1, 5, and 6 in the octyl chain. It is immediately apparent that, to within the experimental error, the points fall on a common curve and that there is no site dependence as found for 5CB-d_{19} [11]. We have determined the relaxation time by fitting our results for the time dependence of $P_2(\cos\theta)$ to the Leslie-Ericksen prediction contained in Eq. (2). The best fit is shown as the solid line in Figure 3(a) and is clearly in good agreement with experiment. The optimum value for the relaxation time, τ_{on}, is found to be 0.84 ms with an experimental error of ± 2%. It is also apparent from the experimental results in Figure 3(a) that the director orientation starts to change immediately the electric field is applied; that is there is no induction period, again as found for 5CB-d_{19} [11].

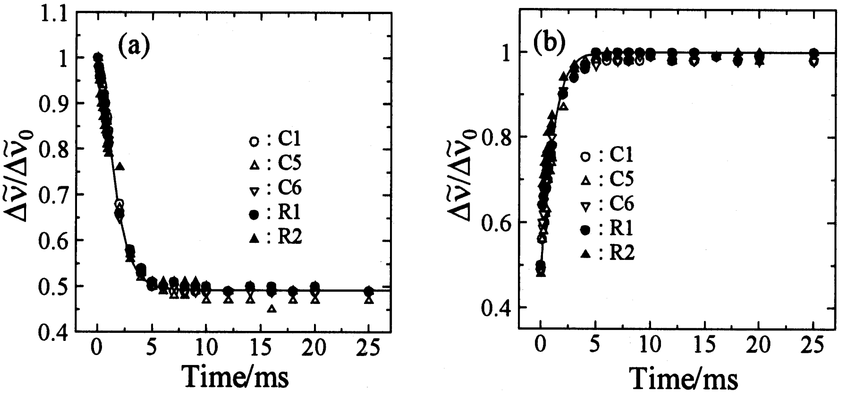

FIGURE 3 The time dependence of the ratio of the quadrupolar splittings, $\Delta\tilde{\nu}(\theta)/\Delta\tilde{\nu}_0$, for the (a) turn-on and (b) turn-off process for the six and two biphenyl deuterons, R1(●) and R2(▲), respectively, and for the deuterons in the octyl chain at positions C1(○), C5(Δ) and C6(▽) following the application of an electric field (0.92 MV m^{-1}) at an angle of 38° to the magnetic field.

We now come to the turn-off experiment in which the director is first aligned at an angle, θ_∞, to the magnetic field, the electric field is removed and the director is then aligned by the magnetic field. A selection of the deuterium NMR spectra recorded after the removal of the electric field is shown in Figure 2(b). The first spectrum was recorded when the director was aligned at the limiting angle of θ_∞ with respect to the magnetic field and from the splittings this angle is estimated to be about 36°. The second spectrum was recorded just 0.4 ms after the removal of the electric field. As might be expected at this orientation the spectral lines are somewhat broad which reduces the resolution and hence the accuracy with which the quadrupolar splittings can be determined, although not to any significant extent. After 3 ms the spectral resolution has improved considerably largely because the quadrupolar splittings have increased although in addition the linewidths have become slightly smaller. Both of the changes are expected as the director is aligned parallel to the magnetic field. The changes in the spectra are rather modest and it is necessary to wait 8 ms until the director is almost parallel to the magnetic field. The spectrum recorded at this time is characterised by narrow lines and large quadrupolar splittings; it is essentially identical to that shown in Figure 1 for the sample with the director parallel to the magnetic field. Although the spectral lines are broadened to a decreasing extent in the turn-off process they are comparable to those observed during the turn-on. In other words, the director is aligned by the magnetic field essentially as a monodomain. The ratio of the quadrupolar splittings, $\Delta\tilde{\nu}(\theta)/\Delta\tilde{\nu}_0$, for the turn-off process is plotted as a function of time in Figure 3(b) for the six and two deuterons in the biphenyl core and for those at positions 1, 5 and 6 in the octyl chain. It is immediately apparent that all of the points fall, to within experimental error, on a common curve. This shows that there is no molecular site dependence for the magnetic field-induced director relaxation, as for the electric field-induced alignment. It is also clear that the relaxation process is slower than for the turn-on process and fitting Eq. (2) to our results gives a relaxation time τ_{off} of 1.52 ms again with an experimental error of ± 2%. This difference in behaviour follows Eqs. (4) and (5), and the large angle between the two fields in the turn-on experiment. We see, therefore, that changing the relaxation time by a factor of about 1.8 does not alter the site independence of the field-induced director alignment. The other feature of interest in these results is the absence of an induction period following the removal of the electric field, again in accord with the theoretical prediction.

We have performed similar studies at different temperatures namely, 306, 306, 307, and 308 K with the same electric field strength and experimental geometry used in the measurements at 305.5 K. In all cases the time dependence of the ratios of the quadrupolar splittings exhibits a common behaviour thus confirming the result that there is no molecular site dependence for the field-induced director relaxation in the nematic phase of 8CB-d_{25}. The relaxation times determined from these results are given in Table 1 and agree to within experimental error. The limiting value of θ_∞ can be obtained using $\Delta\tilde{\nu}_\infty$ and Eq. (10) and is listed in Table 1. An accurate value for the angle, α ,between the electric and magnetic fields can be determined from our results without making any further assumptions, to do this we substitute the values for θ_∞, τ_{on} and τ_{off} into Eq.(7). The results for α are listed in Table 1 and are equal to 35.7°, as we can see they are also independent of temperature. This temperature independence provides an internal check on our experiments and analysis for once the sample was positioned in the probe head of the NMR spectrometer this was not changed for the studies at different temperatures. Accordingly α should not change with temperature which is in accord with our results. Our results also allow us to calculate the ratio, $\Delta\tilde{\chi}/\Delta\tilde{\varepsilon}$, via Eq. (8), the results for this important quantity are shown in Table 1. It is immediately apparent that the ratio is independent of temperature, within experimental error. From the values of the relaxation times for the turn-on and turn-off experiments at different temperatures and with the aid of Eqs. (5) and (8) and the values of the dielectric anisotropies for 8CB at different temperatures given by Dunmur ***et al.*** [16] the values of the twist viscosity coefficient γ_1 were calculated at different temperatures and are given in Table 1. Also given are the ratio $\Delta\tilde{\chi}/\Delta\tilde{\varepsilon}$ and the values of $\Delta\tilde{\chi}$. The values of $\Delta\tilde{\chi}$ and γ_1 obtained for

TABLE 1 The experimental conditions and values of the relaxation times, and the limiting angle, θ_∞, measured at different temperatures. Using these values together with Eqs. (7) and (8) gives the angle α and the ratio of the diamagnetic anisotropy to the dielectric anisotropy, $\Delta\tilde{\chi}/\Delta\tilde{\varepsilon}$. From the values of the relaxation times measured at different temperatures together with the aid of Eqs. (5) and (8) and the values of the dielectric anisotropies for 8CB at different temperatures given by Dunmur ***et al.*** [16] the values of the magnetic anisotropy $\Delta\tilde{\chi}$ and the twist viscosity coefficient γ_1 were calculated at different temperatures

T/K	305.5	306.0	307.0	308.0	309.0
$(T_{\mathrm{NI}} - T)$/K	6.0	5.5	4.5	3.5	2.5
$\theta_\infty/°$	35.6	35.5	35.7	35.9	35.8
τ_{on}/ms	1.14	1.12	0.87	0.80	0.70
τ_{off}/ms	1.81	1.75	1.32	1.27	1.07
$\tau_{\mathrm{off}}/\tau_{\mathrm{on}}$	1.59	1.56	1.52	1.59	1.53
$\alpha/°$	36.0	35.8	35.8	35.8	35.2
$\Delta\tilde{\chi}/\Delta\tilde{\varepsilon} \times 10^7$	1.20	1.22	1.24	1.20	1.24
$\Delta\tilde{\varepsilon}^{(a)}$	8.3	8.3	8.2	7.9	7.7
$\Delta\tilde{\chi} \times 10^7$	10	10	10	9.4	9.4
γ_1/Pa s	0.072	0.070	0.053	0.047	0.040

(a) Data from Ref. 16

8CB-d_{25} can be compared with the values reported for 4-α,α-d_2-octyl-4′-cyanobiphenyl (8CB-d_2) [17] with which they are found to be in good agreement.

The analysis of the spectra used to demonstrate the site-independence of the field-induced director relaxation times requires the measurement of the quadrupolar splittings and their scaling with the values when the director is parallel to the magnetic field. However, there is a unique situation when this is not necessary and the common orientation of the director for the different molecular sites is immediately apparent from the spectrum. This occurs when the angle between the director and magnetic field is $\cos^{-1} 1/\sqrt{3}$ or 54.74°, that is the so-called magic angle, for then $P_2(\cos\theta)$ vanishes and all of the quadrupolar splittings are zero irrespective of $\Delta\tilde{\nu}_0$ (see Eq. (10)). A series of spectra recorded during a turn-on experiment at 307 K with an electric field of 0.922 MV m^{-1} which shows this novel effect are given in Figure 4. The quadrupolar splittings are large in the spectrum recorded 4.5 ms after the application of the electric field. The spectrum obtained 5.5 ms after the electric field was applied is essentially a single doublet with a small splitting and an unusual lineshape. It shows clearly a major reduction in the quadrupolar splittings as the director approaches the magic angle with respect to the magnetic field. After 6.2 ms the spectrum has collapsed to a single line with a hint of a shoulder at its base. This spectrum shows immediately that the directors associated with the different deuteriated groups in 8CB-d_{25} all make the same angle, namely the magic angle, with respect to the magnetic field. After 7 ms the quadrupolar splittings have reappeared although they are small and so poorly resolved. Then after 8.5 ms the director has moved further away from the magic angle and as a result the quadrupolar splittings have increased further although they are still somewhat small and so not fully resolved.

5. CONCLUSION

Our studies of the field-induced director relaxation for 8CB using deuterium NMR spectroscopy have revealed that the director dynamics are independent of the molecular site of the deuterons used to determine the director orientation. This independence is particularly striking because the site dependence of the NMR technique allows the study of the biphenyl core and the octyl group at the end of the chain for which the difference in dynamic behaviour is expected to be maximal. The absence of the site dependence in the director alignment is found to hold whether the director is aligned by a magnetic field or an electric field commonly used in studies based on vibrational spectroscopy. In addition, changing the rate of director alignment over a significant range by using turn-on or turn-off experiments

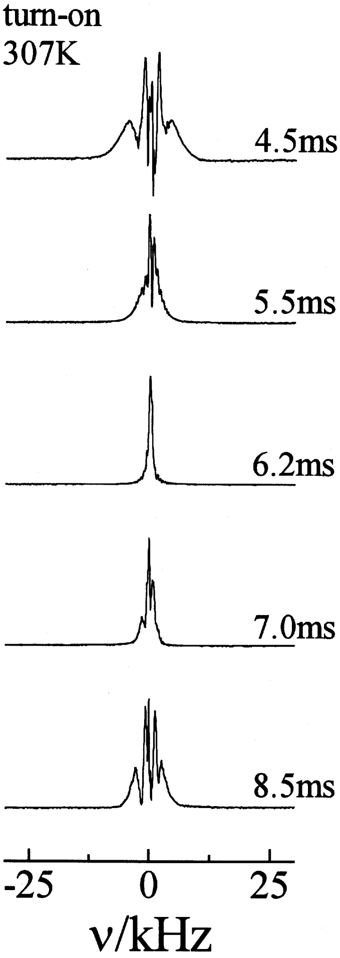

FIGURE 4 The time dependence of the deuterium NMR spectra recorded during the turn-on process for an electric field of 0.922 MV m^{-1}at an angle of about 61° to the magnetic field. The temperature of the 8CB-d_{25} sample was 307 K.

or by altering the temperature has no influence on the site independence of the director dynamics. It is also revealed that there is no induction period for the alignment process for both turn-on and turn-off experiments in accord with the predictions of the Leslie-Ericksen theory. The results found for the nematic phase of 8CB parallel those obtained for that of the lower homologue 5CB and so further support the view that the field-induced director dynamics is independent of the molecular site chosen to determine the director orientation.

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