Deuterium NMR Study on Static Director Distribution for a Low Molar Mass Nematic

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Deuterium nuclear magnetic resonance (NMR) spectroscopy has proved to be a powerful method with which to investigate the director orientation and its distribution because, typically, the observed spectrum is the sum of spectra from each director orientation. In recent years deuterium NMR spectroscopy, combined with continuum theory, has been successfully applied to investigate the static director distribution in thin nematic liquid crystal cells, with different film thicknesses and different surface anchoring strengths, subject to both magnetic and electric fields [1]. In these studies the static director distribution is found to be uniform for those in which the angle, α, made by the magnetic and electric fields is smaller than 45° in keeping with theory.

We have continued our studies of the director distribution which gives the probability density for finding the director at an angle to the magnetic field in thin nematic films using a combination of deuterium NMR spectroscopy and continuum theory [2]. For such experiments the nematic, 4-pentyl-d_2-4'-cyanobiphenyl (5CB), was confined between two glass plates and subject to magnetic and AC electric fields. When an electric field, which is strong enough to overcome the magnetic torque, is applied then the director will tend to be parallel to the electric field because of the positive dielectric anisotropy of 5CB. In contrast to expectations we have found that the director distribution remains uniform even when α is larger than 45°. However, very close to 90° the director distribution is found to be non-uniform, yielding powder NMR spectra. This curious change in behaviour for angles very close to 90° has been studied in detail. Based of our detailed experimental results we discuss the factors likely to cause the switch from uniform to non-uniform director distributions. We find that when α is close to 90°, a small variation of the film thickness distributed over the cell causes a non-uniform director distribution over a wide range of the angles around the threshold electric potential. If the probability for finding the director at each angle over a wide range is constant, then the resultant director distribution will be non-uniform giving the observed spectral powder pattern, not the spectrum having two clear doublets. In contrast when the director is distributed over a small range of the angles, these essentially give the spectra with a line broadening so that with increasing electric field strength the director orientation changes continuously to the limiting value. The probability distribution function for the director together with the inhomogeneity of the film thickness was considered in order to simulate the spectra using the same parameters as for the experiments. These showed good agreement with the experiments. It was found that the inhomogeneity of the thickness of the cell is a major factor influencing the director distribution and its dramatic dependence on α when this is close to 90°.

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References

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