Deuterium NMR Study of Static and Dynamic Non-Uniform Director Alignments for a Nematic Liquid Crystal

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Deuterium NMR spectroscopy has been employed to investigate the static and dynamic director alignment processes in a thin nematic film. One of the prime advantages in the use of deuterium NMR spectroscopy to determine the director orientation is that the form of the spectrum is influenced by the distribution of the director with respect to the magnetic field. This situation obtains because when the director is not uniformly aligned the observed spectrum is a weighted sum of the spectra from all director orientations.

We have studied the uniform and non-uniform director distributions in a thin nematic liquid crystal cell using a combination of deuterium NMR spectroscopy, continuum theory, and the director distribution function [1], which gives the probability density for finding the director at an angle. The sample was confined between two glass plates and subject to magnetic and ac electric fields. In the absence of the electric field the director for 4-pentyl-d_2-4'– cyanobiphenyl (5CB-d_2), is aligned parallel to the magnetic field. When an electric field is applied then the director will be aligned with respect to the electric field (turn-on process). It has been found that for a range of cyanobiphenyls the sample moves as a monodomain during the turn-on process even when the angle, α, between the magnetic and electric fields, is as large as 89.0°. In marked contrast, when α is equal to about 90°, following the application of the electric field the director mainly moves away from being parallel to the magnetic field as the time-resolved NMR spectra recorded with α=89.7°. During the dynamic process, however, part of the director remains parallel to the magnetic field for a fairly long time and other parts show a broad director distribution in which it adopts a range of orientations between 0° and 90°. That is, the sample adopts non-uniform director states during the alignment process.

A series of deuterium NMR spectra was also acquired as a function of the applied electric field to explore the director distribution. Uniform and non-uniform director alignments have been observed for the geometry of α=89.1°and α=89.9°, respectively. On the basis of detailed static experimental results we discuss the factors causing the uniform and non-uniform director distributions. When α is closed to right angle, a small variation of the film thickness over the entire cell causes a director distribution in a wide range of the angle around the threshold electric potential. If the probability for finding the director at each angle in a wide range over the entire film is constant, resultant director distribution will give a powder pattern of the spectrum, not the spectrum having two clear doublets. When the director is distributed in a small range of the angle, 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. It was found that the inhomogeneity of the thickness of the cell is a dominant factor to influence the director distribution, which is a factor dependent on the experimental condition.

On the basis of detailed experimental results to explore the factors that influence the nature of the non-uniform director distribution, we discuss the unanswered questions created by the measurements of the director dynamics.

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Reference [1] S. M. Fan, G. R. Luckhurst, S. J. Picken, J. Chem. Phys., **101**, 3255 (1994).