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ELECTRO-OPTICAL PROPERTIES OF HIGH PURITY NEMATIC LIQUID CRYSTAL UNDER VACUUM CONDITION

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The effects of impurities having influence on electro-optical properties of nematic liquid crystal, p-methoxybenzylidene-p'-n-butylaniline, have been investigated under d.c. excitation. For the sample prepared in vacuum, no dynamic scattering was observed but a new domain-like pattern was observed following Williams domain and once the vacuum was broken, the domain pattern changed into a wave-like pattern and dynamic scattering occurred as in the ordinary case.

It is well known that the optical properties of nematic liquid crystals are remarkably altered when the electric field is applied. Anomalous alignment "domain" is produced if an appropriate voltage is applied[1)] and "dynamic scattering" occurs at the higher electric field.[2)] It is proposed that the presence of ionic species in liquid crystal may be necessary for such electro-optical properties of liquid crystal.[3,4)] There are, however, very few reports, which clearly describe the contribution of impurities to the appearance of the dynamic scattering in d.c. field.[4)]

In our present report, we wish to demonstrate that the dynamic scattering phenomenon does not occur when contamination of liquid crystal with impurities, especially water, is strictly avoided. A liquid crystal used was p-methoxybenzylidene-p'-n-butylaniline (MBBA). All the measurements were carried out under vacuum condition in order to exclude the effects of the impurities and atmosphere.

Fig. 1(a) shows the experimental arrangement used. At first, the cell was baked sufficiently

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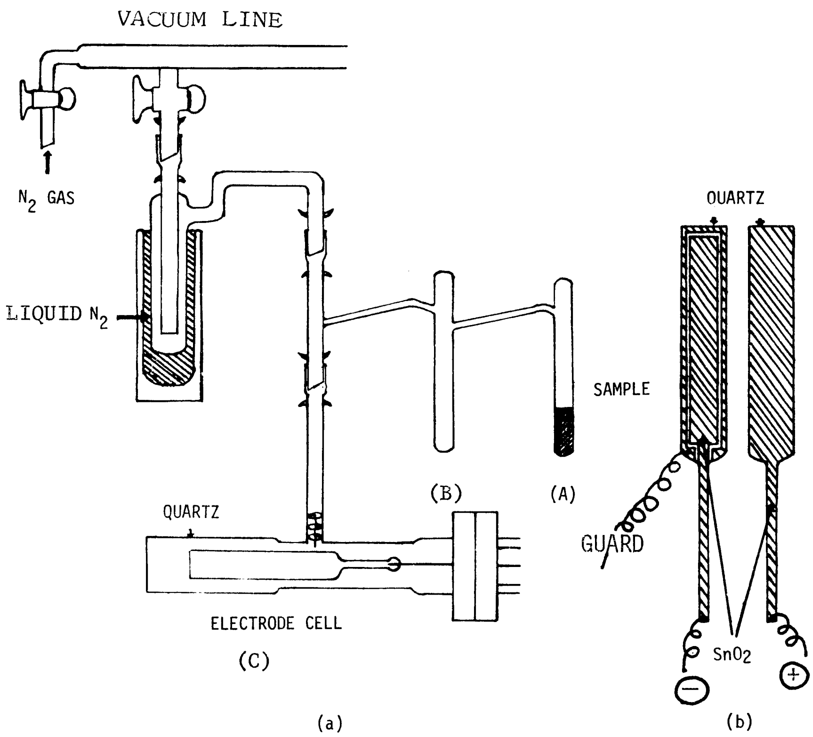


Fig. 1. (a): The experimental arrangement for obtaining pure MBBA under vacuum condition. The sample introduced into part(A) was distilled once into (B) and finally into the electrode cell (C). (b): The nesa-coated quartz electrode with guard ring.

and evacuated below 10^{-3}Torr. Under this condition, moisture in this system is considered to be almost removed. Next, dry nitrogen gas was led into the cell through the vacuum line and pure MBBA distilled twice was introduced into part(A). After several freeze-pump-thaw cycles, this sample was distilled once into (B) and finally into the electrode cell(C). Thus, MBBA was introduced spontaneously between electrodes by capillarity. Keeping the vacuum, the cell was sealed off. The electrode arrangement is shown in Fig. 1(b). Such form of electrode was used in order to exclude the surface current.

The resistivity of the sample prepared thus in vacuum is the order of $10^{11}\Omega$.cm. To the authors' knowledge, preparation of MBBA with such large resistivity can be found only in the report by R.A. Kashnow et al.[5] But once the vacuum was broken and air was allowed to come into the vacuum system, the resistivity of the sample decreased and became the order of $10^{10}\Omega$.cm. As the resistivity of the sample before breaking vacuum is of the order of $10^{11}\Omega$.cm, the number of carriers is estimated to be about $10^{10}\sim10^{11}/cm^3$ if the mobility of ionic carriers is about $10^{-3}cm^2$/volt.sec. As for the sample after breaking the vacuum, the number of carriers is estimated likewise as about $10^{11}\sim10^{12}/cm^3$. Therefore, the number of carriers necessary for the appearance of dynamic scattering will be of the order of $10^{10}\sim10^{12}/cm^3$.

Fig. 2 shows the transmitted light intensity as a function of applied field. A HITACHI 124 spectrophotometer was used to determine the transmittance with 650nm incident light beam where absorption of MBBA is not observed. Curve(1) and (2) represent the change of transmittance of the samples in vacuum and in air, respectively. The transmittance of curve(2) begins to decrease at the threshold voltage of domain formation (7V), and reaches almost zero above 40V owing to dynamic scattering, which is characteristic of the liquid crystal possessing negative dielectric anisotropy.[6] On the other hand, the transmittance of the sample in vacuum (curve(1)) falls slightly in the region of 6∿15V, and recovers gradually above this voltage, and finally becomes larger than the original value. This phenomenon clearly demonstrates that the sample prepared in vacuum does not show dynamic scattering.

In addition to the above mentioned experiment, the electro-optical behavior of MBBA was observed by a polarizing microscope between crossed Nicols. Fig. 3 shows the microscope photographs of domain patterns observed in vacuum and in air, respectively. These patterns are very different from each other. For the sample in air, a wave-like pattern is observed at about 7∿9V and dynamic scattering is observed at the higher field. For the sample in vacuum, however, a striped domain pattern is observed at about 6.5∿10V, and this pattern gradually disappears and a new domain-like pattern is produced at the higher field as shown in Fig. 4.

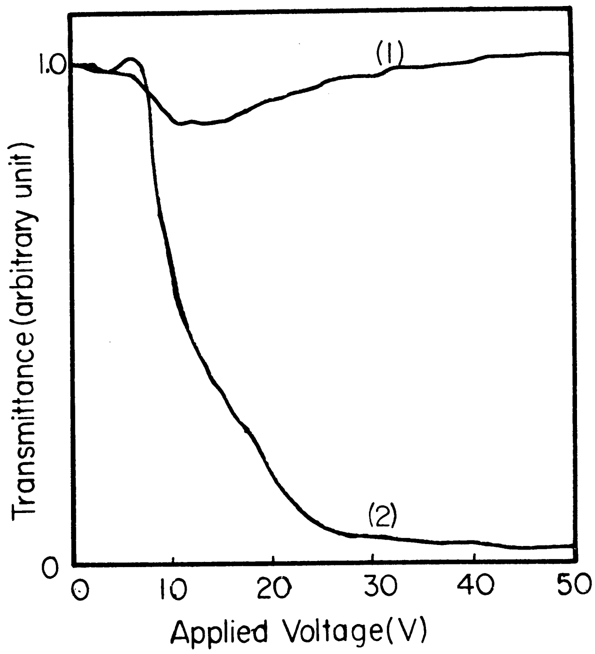
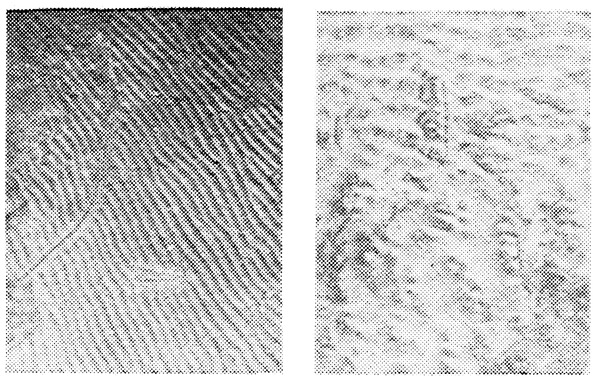
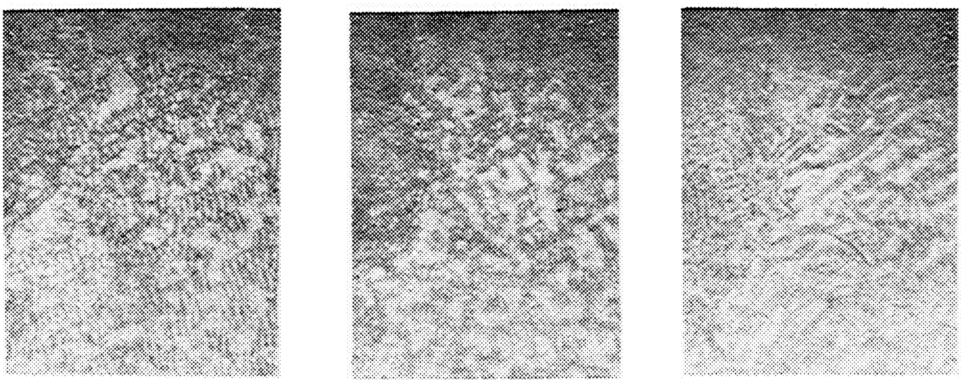


Fig. 2. The transmitted light intensity of MBBA as a function of applied d.c. field at 25°C. (1): measured in vacuum. (2): measured in air. Sample thickness: 50μ



(1) (2)

Fig. 3. The microscope photographs of domain patterns of MBBA at 25°C. (1): observed in vacuum, 7V. (2): observed in air, 7V. Sample thickness; 50μ. Polarizer⊥ Analyzer.



(1) (2) (3)

Fig. 4. The microscope photographs of MBBA observed in vacuum at 25°C. A new domain-like pattern appeared following ordinary Williams domain without producing dynamic scattering. (1): 12V, (2): 20V, (3): 40V. Sample thickness: 50μ. Polarizer ⊥ Analyzer.

These results indicate that impurity, probably water, plays an important role on the domain formation and dynamic scattering of MBBA. Further detailed studies are now in progress.

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