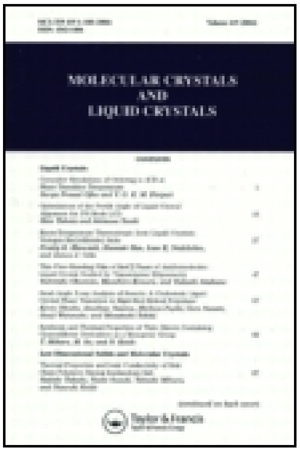


Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl16

Static Dieleciwc Peiwmtmty Measurements on Aligned Smectic-C Phase

A. Buka [a] & L. Bata [a]
[a] Central Research Institute for Physics H-1525 Budapest, P.O.B. 49., Hungary
Version of record first published: 20 Apr 2011.

Mol. Cryst. Liq. Cryst. Vol. 49 (Letters), pp. 159-164

STATIC DIELECTRIC PERMITTIVITY MEASUREMENTS ON ALIGNED SMECTIC-C PHASE

Á. BUKA and L. BATA

Central Research Institute for Physics
H-1525 Budapest, P.O.B. 49., Hungary

(Submitted for Publication November 2, 1978)

Dielectric permittivity was measured in nematic, smectic-A and smectic-C phases. Three permittivity components were determined in the S_C phase.

The dielectric permittivity tensor $\hat{\varepsilon}$ of the uniaxial nematic and smectic-A phases has two nonzero components $\varepsilon_{\parallel}$ and $\varepsilon_{\perp}$ which have already been determined experimentally for a number of compounds[1,2,3]. $\varepsilon_{\parallel}$ and $\varepsilon_{\perp}$ are measured in the directions parallel and perpendicular to the director $\vec{n}$ which is a unit vector characterizing the average orientation of the molecules.

In a biaxial smectic-C phase the molecules are tilted by an angle Ω with respect to the normal of the smectic layer. The direction in which the average tilt takes place is characterized by a unit vector $\vec{c}$ lying in the plane of the layer[4]. The dielectric tensor has three non-equivalent axes in the smectic-C phase which can be chosen as follows,

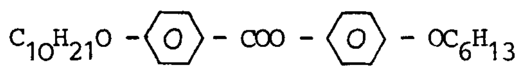
1 - is a direction normal to the smectic layer,

2 - is parallel to the $\vec{c}$ director,

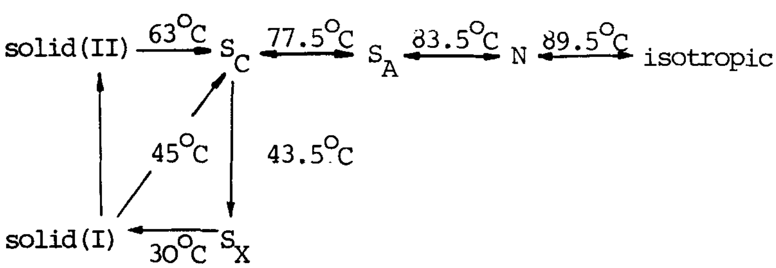
3 - is perpendicular to the 12 plane and lies in the smectic layer.

The purpose of the present experiment was to measure the components of the permittivity tensor in nematic, smectic-A and smectic-C phases. We believe this to be the first investigation of such a kind in smectic-C.

The experiment was carried out on the compound p-n-decyloxybenzoic acid-p-n-hexyloxyphenyl ester (DOBHOP)



The phase transition diagram was determined by a Perkin--Elmer DSC-2 calorimeter and has the scheme



S_X is a liquid crystal phase not determined so far.

Components $\varepsilon_{\parallel}$ and $\varepsilon_{\perp}$ in the nematic and smectic-A phases were measured in a magnetic field of 1.2 T applied respectively parallel and perpendicular to the measuring electric field.

The permittivity components ε_1, ε_2 and ε_3 in the smectic-C phase were determined in three directions 1, 2 and 3, which were chosen as mentioned above. The aligned S_C phase was established by cooling the aligned smectic-A and applying a magnetic field of 1.2 T perpendicular to the initial director $\vec{n}$. The experimental values of the static dielectric permittivity of DOBHOP versus temperature are shown in Fig. 1.

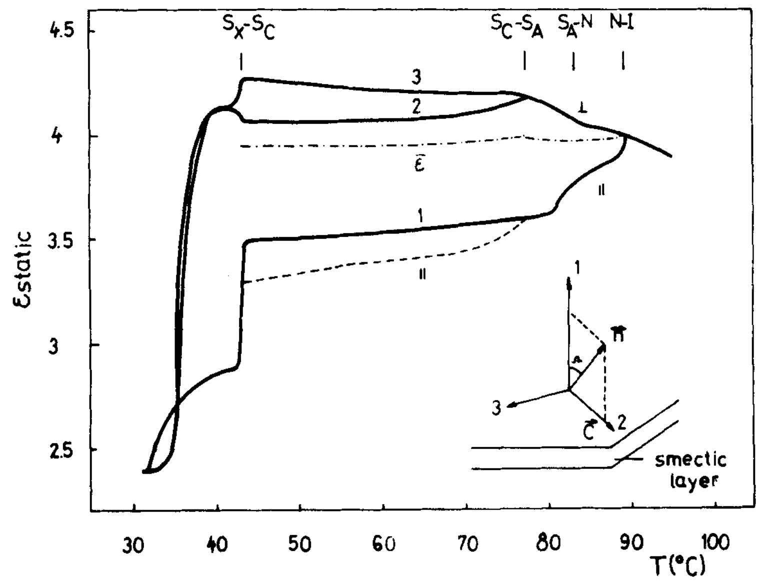


FIG.1. Static dielectric permittivity of DOBHOP vs. temperature: —— measured values; --- parallel component in S_C; -.-.- mean value

When aligned smectic-A was cooled and no magnetic field was applied to align the $\vec{c}$-director in the smectic-C phase it was possible to record only two components of the permittivity, one of them coincided with ε_1, the other was found to be half-way between ε_2 and ε_3.

One can see that the compound has negative dielectric anisotropy in the nematic and smectic-A phases and the relation $\varepsilon_3 > \varepsilon_2 > \varepsilon_1$ is fulfilled in the smectic-C phase.

The mean values of the permittivity - shown by a dashed and dotted line in Fig. 1 - were calculated as usual in the nematic and smectic-A phase, viz. $\bar{\varepsilon} = \frac{2\varepsilon_\perp + \varepsilon_\parallel}{3}$ and by the relation $\bar{\varepsilon}=\frac{\varepsilon_1+\varepsilon_2+\varepsilon_3}{3}$ in the smectic-C phase. A small increase in $\bar{\varepsilon}$ appears around the S_A-S_C phase transition and smaller changes appear at the N-S_A and N-I phase transitions than were found during our earlier measurements for OCB and NPOOB[3]. This is probably connected with the fact that the molecule of DOBHOP has a smaller dipole moment along the long axis than OCB and NPOOB, so the antiparallel alignment of the dipoles along the long axis is less remarkable at the phase transition.

The smectic-C phase is usually approximated as being nearly uniaxial[4]. This approximation means that the values measured along the two directions perpendicular to the molecular axes are nearly equal, the tilt angle Ω and $\varepsilon_{\parallel}$ (Fig. 1 dotted line) can be found by the relations

$$\sin^2\Omega = \frac{\varepsilon_3-\varepsilon_2}{2\varepsilon_3-\varepsilon_2-\varepsilon_1} \qquad /1/$$

$$\varepsilon_{\parallel} = \frac{\varepsilon_2\sin^2\Omega-\varepsilon_1\cos^2\Omega}{\sin^2\Omega-\cos^2\Omega} \qquad /2/$$

$$\varepsilon_{\perp} = \varepsilon_3 \qquad /3/$$

The tilt angle as a function of temperature is shown in Fig.2. This temperature dependence is similar to that of TBBA reported earlier[5]. The tilt angle was found from dielectric data by authors Benguigni and Cabib[6] independent on the temperature.

The mean value of the permittivity in the smectic-C phase calculated by $\bar{\varepsilon}=\frac{2\varepsilon_{\perp}+\varepsilon_{\parallel}}{3}$ ($\varepsilon_{\perp}$ and $\varepsilon_{\parallel}$ are taken from /2/ and /3/) gave the same result - within our experimental error - as was found by $\bar{\varepsilon}=\frac{\varepsilon_1+\varepsilon_2+\varepsilon_3}{3}$.

The experimental plot of ε_1, ε_2 and ε_3 versus temperature in the undetermined S_X phase depends slightly on the

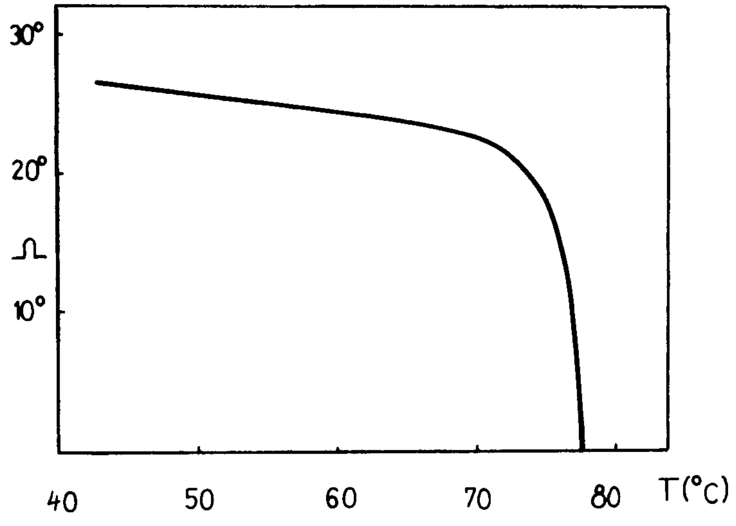


FIG.2. The tilt angle of DOBHOP vs. temperature in S_C phase

conditions (cooling speed), but we should like to draw attention to the fact that ε_2 increases while undergoing the S_C-S_X transition and the tendency of the decrease in ε_2 or ε_3 at lower temperature (rate of crystallization) is different from that of ε_1. The interpretation of these effects needs further investigation, such as identification of the S_X structure and determination of the details of crystallization.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. D.Demus, Halle University, GDR, for synthesizing and supplying us with DOBHOP; J.Szabon for the calorimetric investigation of the compound; and I.Jánossy for helpful discussions.

REFERENCES

1. M.Davies, R.Moutran, A.H.Price, J.Chem.Soc.Faraday Trans. 2.72,1447(1976)

2. C.Druon, J.M.Wacrenier, J. de Physique (Paris) 38,47(1977)

3. L.Bata, Å.Buka, Acta Physica Polonica (in press) KFKI Report, KFK-77-66 (1977)

4. P.G. de Gennes, The Physics of Liquid Crystals (Clarendon Press, Oxford, 1974)

5. T.R.Taylor, S.L.Arora, J.Z.Fergason, Phys.Rev.Lett. 25,722(1970)

6. L.Benguigui and D.Cabib, Physica Status Solidi (a) 47,71(1978)