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Dielectric anisotropy and dielectric loss of some liquid crystals

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A homogeneously oriented layer of a liquid crystalline melt has the optical and dielectric properties of an uniaxial crystal [1] as the result of a molecular order of degree $S = 1 - \frac{3}{2} \overline{\sin^2 \theta}$. θ is the angle between the optical axis of the layer and the axis of greatest length of the molecules (molecular axis). Let the directions parallel respectively perpendicular to the optical axis be designed by 1 respectively 2. The simple molecular statistical theory [2] of nematic liquid crystals combined with the Onsager theory of dielectric polarization gives the two principal dielectric susceptibilities as functions of the following quantities: Permanent dipole moment μ , its angle β with the molecular axis, the two principal polarizabilities parallel (α_{\parallel}) and perpendicular (α_{\perp}) to the molecular axis (the polarizability is supposed to be of rotational symmetry relative to the molecular axis), the degree of order S , the mean value of the dielectric constant ϵ , the density and the temperature. For some nematic melts, viz. 4,4'-Di-n-hexyloxy-azobenzene, 4,4'-Di-n-hexyloxy-, -heptyloxy- and -octyloxy-azobenzene, we measured ϵ_1 and ϵ_2 at the frequencies 0,1; 0,26; 0,65; 1,6 and 4,0 Mhz and determined S from the infrared dichroism and μ from the dielectric constant of the isotropic liquid phase as well as from solutions in benzene. In the case of the three azobenzenes β is known and one gets α_{\parallel} and α_{\perp} . The values obtained are in good agreement with those derived from bond polarizabilities.

The azoxybenzene-compound furnishes an interesting example for a further test of the theory. As far as their electrical properties are concerned its molecules differ from those of the corresponding azobenzene derivative only by the additional dipole moment of the azoxy-group, the principal polarizabilities being essentially the same. Taking the latter from the azobenzene-compound we calculated β from the anisotropy of the dielectric susceptibility and found it to be in good agreement with the value for 4,4'-Di-methoxy-azoxybenzene.

The hexyloxy-azoxybenzene is interesting yet in another sense. We found a pronounced dispersion of ϵ_1 (ϵ_1') and a corresponding dielectric loss ϵ_1'' in our frequency range, whereas ϵ_2 shows no such a frequency dependence. According to the molecular statistical theory such a behaviour is to be expected. The dispersion step $\epsilon_{10} - \epsilon_{1\infty}$ calculated from the theory and the molecular data above is in good agreement with the experimental value.

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