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Inclined Alignment of Nematic Liquid Crystals by Dopants Having Bent Molecules

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The new original film material, which is able to give the LC planar orientation with pretilt angle was established. The new film consists of a photo-aligning material (azodye) doped with specially synthesized substances with bent molecules.

Keywords: inclined alignment of liquid crystals; photoalignment

INTRODUCTION

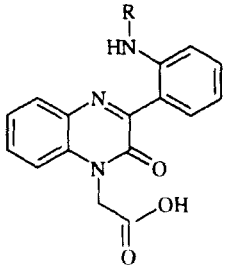
The alignment of nematic liquid crystals (LC) obtained by means of photosensitive film (photo - aligning materials) applied onto the electrodes of a LC cell is very attractive, because it offers many advantages in comparison with the routine rubbing treatment [1]. Thin photosensitive irradiated by linearly polarized monochromatic light (PL) with wave length corresponding to maximum of their absorption band, become anisotropic with a prefixed easy axis. Then they are able to cause a unidirectional LC planar orientation. Up to now several materials were established as well as the methods of their application to photoinduced LC alignment[2-4]. An other important benefit of this alignment method is the possibility to obtain a pretilt angle between the

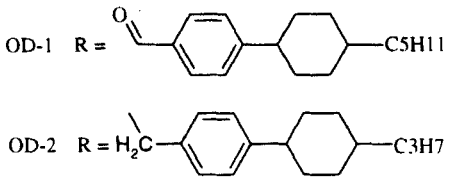
LC director and the orienting surface, using the double exposure technique[2, 5-8]. The presence of this pretilt angle is very important because it makes feasible to avoid the appearing of a reverse tilted domain structure accompanied by disclinations, during the electrooptical LC reorientation. It should be noted that the use of photo - aligning materials usually does not result in the pretilt angle generation: it is necessary to dope these materials with special orienting agents able to provide it [9, 10]. Several surfactants and their fragments are known to be able to play such a role[5 ,8]. The preparation of reliable materials which can combine the photo - aligning properties together with the pretilt angle formation is a challenging problem of high practical importance.

The main goal of this work is the study of the formation process of LC planar alignment with pretilt angle, using an azodye film as a photo - aligning material and bent molecules (quinoxalinone) as the dopant, providing the pretilt angle.

EXPERIMENTAL

We specially synthesized two quinoxalinone substances (called hereafter as OD -1 and OD - 2) with the common formula





The dependence of the pretilt angle on the light exposure time was studied in details for the mixture with OD -2 (50% concentration). In the experiment the exposure time was changed from 0.5 up to 5 min. A 0.5 min exposure was sufficient to obtain the pretilt angle about 2.7°. The increase of the exposition up to 2 min doesn't change the angle; only a 5 min exposure results in a substantial angle increase up to 4.5 -4.7°.

The similar dependence of pretilt angle was reported by other authors[8].

As it was shown, the individual OD -1 and OD -2 were found unable to exhibit planar orientation, but they work being mixed with the photosensitive azodye. To understand the mechanism of the LC tilt orientation by azodyes we performed the following experiment. The LC orientation was obtained by the routine rubbing of the glass covered with the polyimide film. Two cells were prepared; one of them has the rubbed polyimide film doped with OD -2. It turns out that in both cases the same pretilt angle (about 5.7°) takes place.

Thus, it is easy to assume that OD -2 doesn't affect the pretilt angle formation when the light irradiation is absent. Consequently, OD -1 and OD -2 are active from the point of view of LC pretilt orientation only in the presence of photo - aligning material. The particular mechanism of this light-induced orientation is under intensive study in our laboratory; the results of the experiments will be published later.

CONCLUSIONS.

The new original film material, which is able to give the LC planar orientation with pretilt angle was established, its main properties was studied. The new film consists of a photo - aligning material (azodye)

2) be able to form a thin film onto the plates carrying ITO electrodes;
3) be insoluble in the LC material.

At the first stage of our work we examined the relevant properties of all the substances used, showing that they satisfy all conditions mentioned. After it we tested, whether the films of OD -1 and OD -2 are able to play the role of photo - aligning materials by themselves. The result were negative. Only the mixtures of O-1 with either OD -1 or OD - 2 were able to work.

The concentration of OD-1 and OD-2 in the studied mixtures was changed in a full scale: from 0 to 100%W (Table1 and Table2). The films of these mixtures irradiated with the polarized light only were demonstrated to give an excellent planar orientation of LC independently of OD - 1 or OD -2 concentration.

The secondary irradiation of the films with nonpolarized light decreased slightly the quality of the planar orientation but resulted in reproducible pretilt angle; the concentration of OD - 2 here was in the interval 50 -80%W, OD-1 concentration was about 50%W. The increase of OD -2 concentration resulted in the increase of the pretilt angle.

The data of Tables 1 and 2 show that the pretilt angle depend on the type of the doping agent and on the nonpolarized light exposition. The use of OD -2 gives an higher angle with the same concentration (80%) as in O -1 and with the same exposition. This result can be explained by the fact that OD -2 posses a flexible - CH_2- group between the plane of quinoxalinone part of the molecule and its bent tail: on the contrary, in OD -1 these two parts of molecule are bonded by a rigid amide group.

They were used as doping agents for pretilt angle formation. The photo - aligning material giving rise to a planar LC orientation was an azodye, called hereafter O-1. The UV and visible spectra of OD-1, OD-2 and O-1 are given in Fig.1. (Curve 1, 2, 3 refer to OD-1, OD - 2 and O-1 respectively). It is easy to see that the adsorption spectra of the photo-aligning material and of the doping agents coincide, being the irradiation spectral range 320 - 420 nm.

The thin films (100nm) of individual OD-1, OD-2 and O-1 as well as their mixtures were deposited onto the glass plates carrying ITO electrodes. The films were dried, then they were irradiated with a polarized light beam directed normally to the plate and with nonpolarized light directed at 45° with respect to the plate. The irradiation time was 1 - 30 min, the light intensity was 60 mW/cm^2 for the polarized light and 160mW/cm^2 for the nonpolarized one. Then, after assembling, the cells were filled with LC-1630 (according to NIOPIK classification).

The pretilt angles were measured by the crystal rotation method[11, 12] .

RESULTS AND DISCUSSIONS.

The doping agents (OD-1 and OD -2) have bent molecula shape. The presence of substituents with a high volume "growing out " from the molecular plane of quinoxalinone moiety was assumed to be able to give rise to the spontaneous pretilt angle. These substances should satisfy other requirements: in particular, they should: 1) be compatible with the photo-aligning material in a wide range of concentration;

doped with specially synthesized substances with bent molecules. The pretilt angles 5.7° were reached.

TABLE 1.
The effect of the OD -1 concentration on the LC orientation characteristics.

№	O-1concentration, %	OD-1 concentration, %	orientation planar quality[1]	the pretilt angle at the time of the "oblique" exposure[2] 2 min	5 min
1	-	100	no	-	-
2	20	80	excellent	0,7°	1,7°
3	50	50	excellent		
4	80	20	satisfactory	-	-
5	100	-	excellent	-	-

TABLE 2
The effect of the OD - 2 concentration on the LC orientation characteristics.

№	O-1concentration, %	OD-2 concentration, %	orientation planar quality[1]	the pretilt angle at the time of the "oblique" exposure[2] 2 min	5 min
1	-	100	no	-	-
2	20	80	excellent	5°	5,7°
3	50	50	excellent	2,5 °	4,7°
4	80	20	excellent	-	-
5	100	-	excellent	-	-

1) After the exposure with the polarized light
2) After the exposure with both polarized and nonpolarized light.

The orientation quality is characterized by four - step scale: "excellent, good, satisfactory, no orientation".

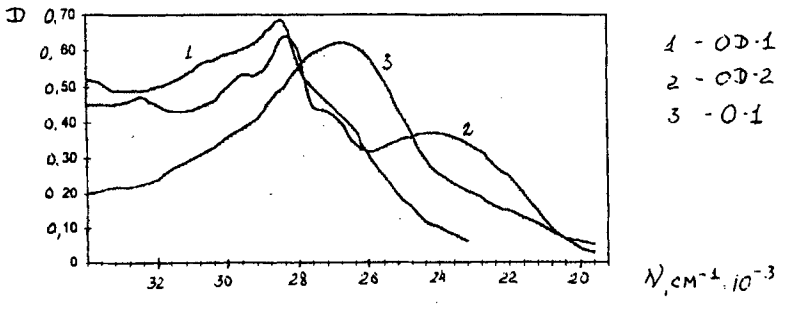


Fig. 1.

The UV - Visible absorption spectra of OD-1, OD -2 and O-1.

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