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

# Alignment of Liquid Crystals on the Stretched Polymer Films

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Version of record first published: 21 Mar 2007.

To cite this article: Hiroshi Aoyama, Yoshifumi Yamazaki, Naoki Matsuura, Hitoshi Mada & Shunsuke Kobayashi (1981): Alignment of Liquid Crystals on the Stretched Polymer Films, Molecular Crystals and Liquid Crystals, 72:4, 127-132

To link to this article: http://dx.doi.org/10.1080/01406568108084048

*Mol. Cryst. Liq. Cryst.* Vol. 72 (Letters), pp. 127-132
0140-6566/81/7204-0127$06.50/0

# ALIGNMENT OF LIQUID CRYSTALS ON THE STRETCHED POLYMER FILMS

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(Submitted for publication August 10, 1981)

Abstract: Several kinds of the stretched polymer films, such as those of cellulose, polyvinylalcohol, and polyethylene are shown to have aligning capability for nematic liquid crystals (a mixture of cyanobiphenyls) in the direction of the stretching when the films are stretched over about 100%. Among them polyethylene is only one exceptional case where the initial aligning property lasts only for several days at room temperature.

The fabrication of the well-aligned liquid crystal (LC) phases is of considerable scientific as well as technical interest. For obtaining a uniform parallel or slightly inclined alignment to the substrates, various techniques have been developed: rubbing on the bare glass substrates[1] or those coated with inorganic materials (e.g. $SiO_x$)[2], polymer[3], and silane compound[4]; and oblique evaporations of exides[5,6], or metals[7]. Some polymer films are known to be useful to fabricate the aligning film and to give an opportunity for studying the aligning mechanism which is still not always clear yet.

First we tried the cellulose film for aligning LCs in twisted nematic cells into which LCs of a biphenyl mixture (Merck: E-18 or Chisso: GR-18) were disposed; the cellulose films used in this experiment are commercially available adhesive tapes (e.g. Cellotapes by Nichiban or Cellophane tape by others). As taken (not worked) tapes showed a fairly good aligning capability; if we removed carefully a little residue of the glue on the film surface with a solvent immersed cotton swab we got a better result; and if we rubbed them with a dry cloth in the direction of the length of the tape the result we got was much better. The ordinary adhesive tape has an anisotropy in the refractive index of about 10% which reflects the effect of the stretching in the direction of length.

Then, we rubbed the cellotapes with a cloth in the directions off from that of the stretching; we confirmed that the liquid crystals never align in the newly rubbed directions which were off from that of the stretching.

Table 1. Effect of rubbing on cellotapes used for twisted nematic cells;g/g+b stands for area % of good aligned region (b:bad region)

| $\Delta\Theta$(deg.)* | (n.r.)** | 0 | 30 | 45 | 60 | 90 |
|---|---|---|---|---|---|---|
| q/[q+b](%) | 55 | 93 | 75 | 60 | 30 | 25 |

*) $\Delta\Theta$=[rubbing direction]-[long axis of tape]
**)(n.r.): no rubbing

The results is shown in Table 1; the degree of alignment is evaluated and expressed by taking the area % of the good region among the whole area of the cell.

Figure 1(a) is an electron microphotograph of the rubbed surface of a $SiO_2$ coated glass plate showing the some striations induced by the rubbing;it is well known to prepare a fairly good alignment of LCs. While,Figure 1(b) is a picture of the unworked surface of a cellotape;it is hard to see any grooves at this magnification. Electron microphotographs of rubbed surface of the cellotapes show worked parallel grooves, but they are not capable of aligning LCs if the grooves run not parallel to the direction of stretching.

Then, we tried to examine polyvenylalcohol (PVA) and polyethylene (PE) and made a comparison of aligning properties of both materials. PVA is a well known material for its parallel aligning property of LCs if it is rubbed appropriately.

Figure 2 shows the relationship between the average color contrast expressed by the color difference (1976 CIE L*u*v* space) in the whole area of the TN cells and the degree of the stretching of PVA films which are used for alignment; it is seen that the contrast saturates when the PVA films stretched over 100%. This alignment lasts for a long time if we store the cell in the ordinary condition.

Almost the same experiments have been conducted on PE instead of PVA; there was no significant difference in the initial aligning properties of PE as compared with PVA, but the experiment showed that the optical contrast of the cells with PE lasted only for 2 days, which means that the deterioration of the surface alignment of the LCs occured. The same is true for the rubbed PE films. The only difference in the molecular structure between PVA and PE is the existence of OH branches in PVA instead of H branches in PE; the latter is known as a saturated hydrocarbon system. From the above mentioned experiments and consideration, we will claim that the OH part may play a role in the anchoring the LC molecules. In general, the polar part in a polymer such as, OH, Cl, F, Br, $CH_3$,etc., may take part in the anchoring. Formation of the microgrooves on surface of the saturated hydrocarbon system is not sufficient to get a stable parallel alignment of LCs. However, in cases of PVA and cellulose, the polar interaction (e.g. that of between OHs with $C \equiv N$ part in biophenyls) is thought to work in cooperation with the anisotropic interactions originated from van der Waals interaction[8,9] and the grooves which induce the elastic deformation of LCs[10].

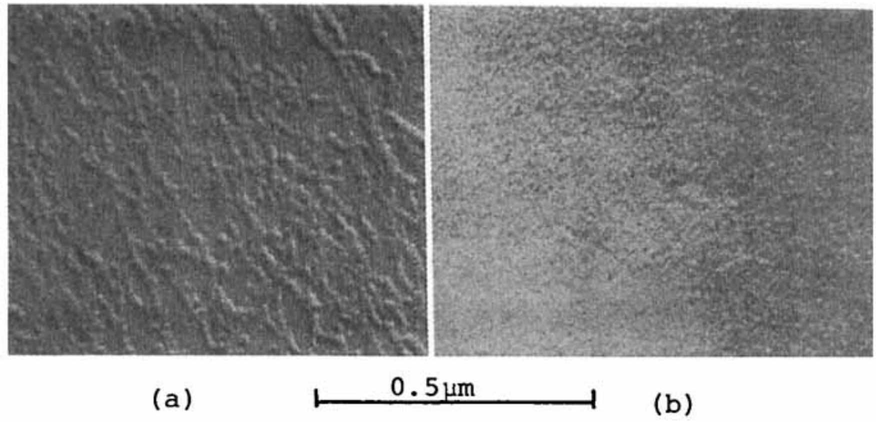

FIGURE 1. Microphotographs; (a) rubbed surface of a $SiO_2$ coated glass, (b) unworked surface of a cellotape.

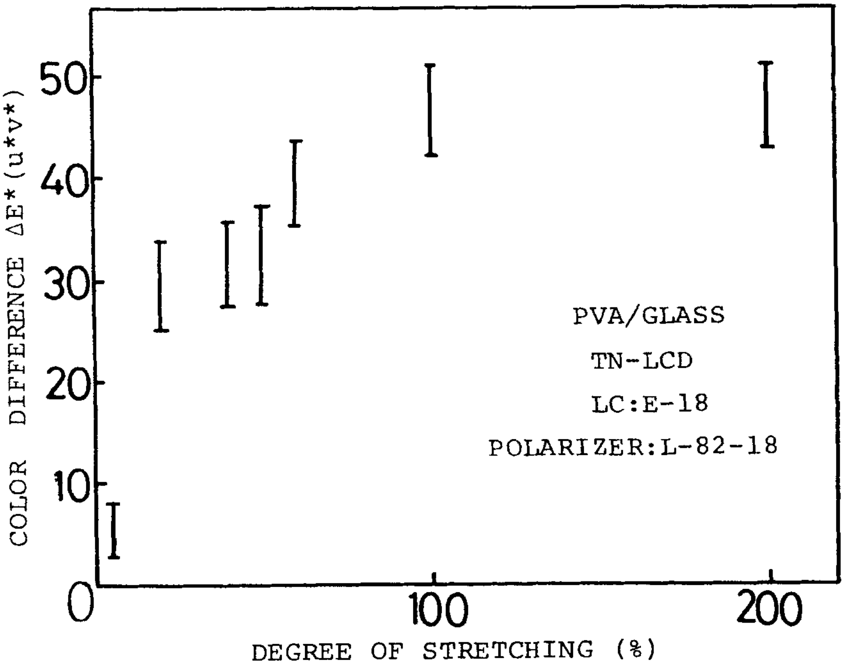

FIGURE 2. Color difference of twisted nematic cell vs. stretching of PVA films used for aligning liquid crystals.

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