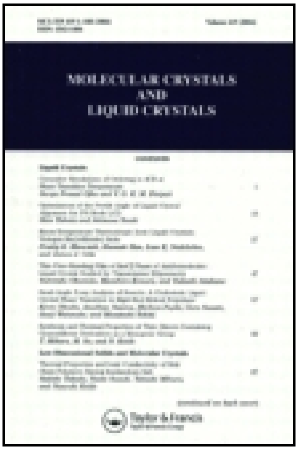

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UV Induced Photoalignment and Colour Change in Nematic Liquid Crystals with Provitamin D Dopant

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Adsorption of provitamin D_3 molecules at glass/quartz substrate surface of a LC cell provided uniform alignment of nematic LCs in homeotropic orientation that was changed to the planar one under linearly polarized UV irradiation. Reversible switching between the two orientations has been achieved by applied electric field. The effects revealed are usable in optical imaging and data storage, in LC display technology and other applications.

Keywords: data storage; optical imaging; photoalignment,

INTRODUCTION

Provitamin D photoisomerization is the first step in the complex network of vitamin D synthesis. UV irradiation of initial provitamin D within its absorption band (240–315 nm) leads to formation of previtamin D by photoinduced hexadiene ring opening which is further converted into vitamin D by thermoinduced intramolecular hydrogen shift. However, previtamin D is not stable to UV radiation and undergoes a number of side photoconversions, its *cis-trans* photoisomerization into tachysterol is the most efficient one (quantum yield $\varphi \sim 0.42$) (Fig. 1) [1].

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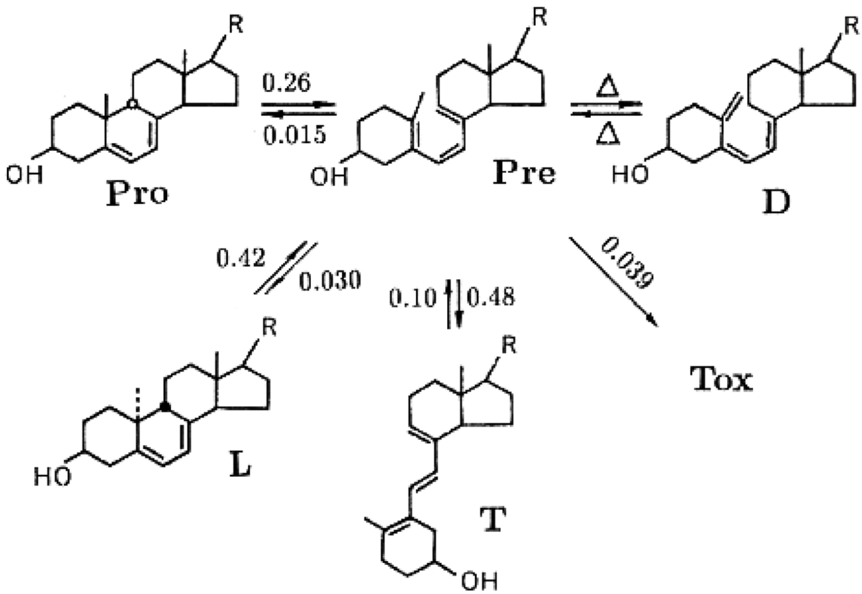

FIGURE 1 The reaction scheme of vitamin D synthesis: **Pro** - provitamin D; **Pre** - previtamin D; **T** - tachysterol; **L** - lumisterol; **Tox** - toxysterols; **D** - vitamin D. $R = C_9H_{17}$, vitamin D_2 series; $R = C_8H_{17}$, vitamin D_3 series. Numbers with arrows denote the photoconversions quantum yields.

Provitamin D_3 (7-dehydrocholesterol, 7-DHC) was used as chiral dopant in the nematic liquid crystalline (NLC) matrix for direct monitoring of the vitamin D synthetic capacity of sunlight [2]. Under UV irradiation the molecular conformation of steroid moiety of provitamin D molecule was altered by the photoconversions and thus affected the cholesteric pitch and the wavelength of selective reflection band. Excellent correlation between the decrease in the Cano-Grandjean lines number and previtamin D accumulation *in vitro* was observed under UV irradiation of the two component LC mixture (NLC + 7-DHC) in the wedge-like cell [3]. In cholesteric LCs dissolution of 7-DHC affected the initial macrohelix pitch and changed it under UV irradiation resulting in the LC sample colour change [4].

In what follows we will present our results on the new, uncommon application of provitamin D photochemistry for the LC photoalignment as far as development of the photoalignment covers that provide homogenous structure of a LC phase is actual problem in the technology of new liquid crystalline materials with specified properties [5–9].

RESULTS

For the first time the photosensitive molecules of provitamin D_3 were incorporated in the PMMA network and the photoaligning ability of the film 7-DHC + PMMA was investigated. Using linearly polarized UV irradiation, the effective photoalignment (planar orientation) was obtained for a number of commercially available nematic LCs (ZLI 4801.000, ZLI 2806 and E7 (Merck) [10]. It is significant that in the case of composite film 7-DHC + PMMA, unlike the majority of known photoaligning coatings, the light-induced orientation axis is parallel to the polarization vector of the incident UV light.

In further studies provitamin D_3 molecules were adsorbed at the substrate surfaces of a LC cell and the effect of UV irradiation on the nematic LCs orientation was investigated [11]. Although it is known that orientation of LC molecules can be altered by photochemical transformations of the molecules adsorbed at the substrate surface, this effect is most pronounced for the photoisomerization between *cis* and *trans* configurations that is accompanied by excessive differentiation in their orientation ability for the nematic LC molecules. According to the Friedel-Creagh-Kmetz empirical rule a LC orientation is dependent on the ratio between the critical surface tension of LC (γ_{LC}) and the surface energy of the substrate (γ_S), i.e. homeotropic (**H**) orientation is occurred when $\gamma_{LC} > \gamma_S$ and planar (**P**) orientation is observed in opposite case when $\gamma_{LC} < \gamma_S$ [12].

It has been found that adsorption of provitamin D_3 molecules at glass/quartz substrate surface in a LC cell (thickness of $10 \div 60\,\mu m$) provides uniform alignment in homeotropic orientation of nematic LCs with negative ($\Delta\varepsilon < 0$) and positive ($\Delta\varepsilon > 0$) dielectric anisotropy (ZLI-2806 and E7 correspondingly). The photochemical transformations of adsorbed provitamin D_3 molecules initiated by linearly polarized UV radiation from a high-pressure mercury lamp directed at the fixed angle to the substrate surface were accompanied by the change in the LCs orientation. Depending on the UV exposure the transition from homeotropic to planar orientation has been revealed in both nematic LCs. Well-defined difference between non-irradiated (dark peripheral) and irradiated (bright central) parts of the LC cells (**H** and **P** orientations) was observed when the LC cells were placed between crossed polarizers (Figs. 2a and 2c). It is worth noting that this effect also can be used for optical imaging and data storage.

Additionally a possibility of electrically controlled change in the LC orientation was investigated that is of primary importance for the LC display technology [13]. With this aim provitamin D_3 molecules were

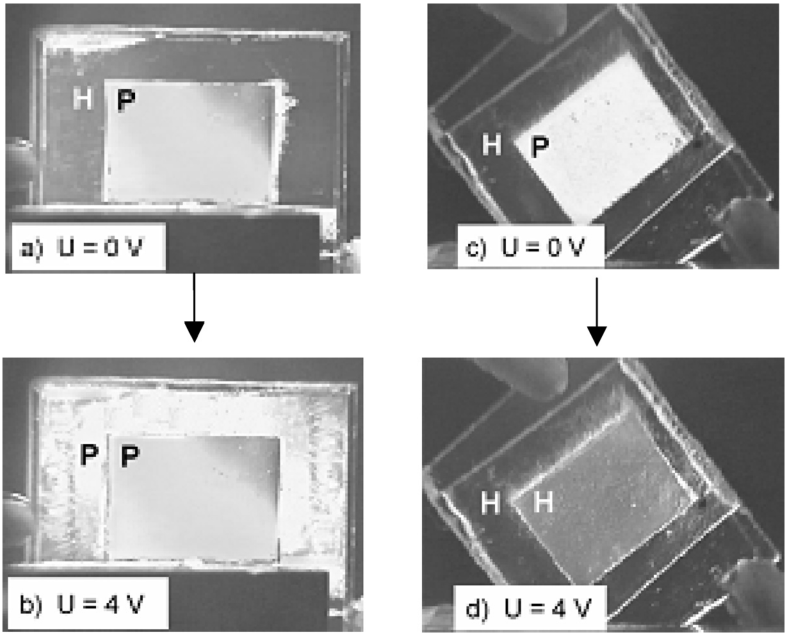

FIGURE 2 Electrically induced **H** ⇒ **P** transition in the non-irradiated part of the LC cell with ZLI-2806 (a, b) and **P** ⇒ **H** transition in the irradiated part of the cell with E7 (c, d)

adsorbed at the glass plates coated with thin ITO (Indium Titan Oxide) film and Transmission-Voltage characteristics of the LC cells were studied using standard optical scheme with He-Ne laser as a light source. In so doing we kept polarizers crossed for the ZLI-2806 sample where the **H** ⇒ **P** transition (B-effect) was expected and the polarizers were parallel for the E7 sample when the **P** ⇒ **H** transition (S-effect) was assumed.

For the both samples it has been observed that the initial transmission was kept close to zero as long as the applied electric field voltage increased from 0 up to 2.5 V. With further voltage increase we observed monotonic transmission increase up to 96% for the non-irradiated peripheral part of the LC cell with ZLI-2806 that was indicative of the **H** ⇒ **P** transition. Nonmonotonic transmission increase up to 90% was observed for the irradiated central part of the LC cell with E7 (**P** ⇒ **H** transition). The remarkable difference in the electrically controlled orientation of the LCs with negative and positive dielectric anisotropy is easily seen in the photographies 2b) and 2d) where both LCs between crossed polarizers are shown for the applied voltage 4 V.

CONCLUSIONS

Uniform homeotropic alignment of nematic LCs was attained by the thin film of adsorbed molecules of provitamin D_3. Homeotropic orientation was changed for the planar one by linearly polarized UV irradiation, and reversible switching between the two orientations was achieved by applied electric fields. We believe the effect revealed is capable to provide high pixel contrast in the LC display technology.

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