

## Light-induced gliding of the easy orientation axis of a dye-doped nematic liquid crystal

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We studied the effect of light-induced gliding of the easy axis of dye-doped nematic liquid crystal on an aligning polymer surface. The observed drift of the easy axis is over tens of degrees and is caused by light-induced anisotropic adsorption and/or desorption of dye molecules on or from the aligning layer in the presence of light-induced bulk torque. We present a theoretical model that explains the experimental data in terms of the light-induced changes of the adsorbed dye molecules angular distribution due to their exchange with the dye molecules from the liquid crystal bulk.

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### I. INTRODUCTION

The traditional description of reorientation of the liquid crystal (LC) director in an electric or magnetic field suggests a fixed position of an easy orientation axis  $\vec{e}$  on aligning surfaces of a cell [1]. Field-induced deviation of the director from the direction  $\vec{e}$ , e.g., due to finite surface anchoring, may result in a gradual drift of the easy axis away from its initial position (so-called *gliding effect*) [2–10]. Adsorption and/or desorption of elongated LC molecules on or from the aligning surface and cooperative reorientation of polymer fragments and LC molecules are considered as possible mechanisms of the gliding. The adsorption and/or desorption mechanism was proposed by Vetter *et al.* [2] for a description of the gliding effect on the polyvinyl-alcohol surface (to our knowledge, it was the first observation of the easy axis drift). According to Vetter, the drift of the easy axis is caused by the rotation of the symmetry axis of the distribution function of the long axes of adsorbed LC molecules under the influence of a reorientation torque. Since the first adsorbed molecules tend to align along the initial direction of the easy axis  $\vec{e}$ , mismatching between director and easy axis due to finite anchoring leads to adsorption of molecules along a new direction of the director,  $\vec{n}$ . As a consequence, the symmetry axis of the angular distribution function of the long axes of adsorbed molecules reorients, i.e., the easy axis changes its orientation. If the reorientation torque keeps acting, the drift of the easy axis continues until the torque disappears.

Later on, the gliding effect caused by adsorption and/or desorption processes was studied experimentally and theoretically in [4–8]. Recently, it was shown that the gliding due to adsorption and/or desorption processes might be accompanied by the cooperative reorientation of director and polymer fragments of the aligning layer [8,10]. Due to weak anchoring, the electric field reorients the director on the polymer surface, which, in turn, drags the flexible polymer fragments. As a result, the electric field reorients both LC

molecules and flexible fragments resulting in a drift of an easy axis.

Until now the gliding effect was observed under the action of an electric or magnetic field, and spontaneous desorption and/or adsorption of LC molecules governed the easy axis drift. At the same time, as it was first shown in [11] and further in [12–18], the light-induced anisotropic adsorption and/or desorption of elongated dye molecules of methyl red (MR) dye on a polymer surface produces an easy orientation axis on this surface. Therefore, one can suggest that the electromagnetic field of the light, on par with electric and magnetic fields of lower frequencies, also causes gliding of the easy axis.

To observe an efficient gliding effect, one needs to have the following.

*Layer of adsorbed anisotropic molecules on an aligning surface.* Existence of a layer of adsorbed MR molecules on a polymer aligning surface of fluorinated polyvinylcinnamate (PVCN-F) was suggested in [14] and was directly observed with x-ray measurements by Francescangeli *et al.* in [17]. This layer is forming during tens of minutes after the cell filling. Its stationary thickness is about 5 nm (at dye concentration 0.5 wt %) that corresponds to 3–5 layers of MR molecules.

*Molecular exchange between an aligning surface and LC bulk due to adsorption and/or desorption.* Characteristics of spontaneous exchange by MR molecules between LC bulk and the surface are not known, although such an exchange should exist because of general physical reasons. Regarding molecular exchange between the bulk and the surface, it exists for sure due to the light-induced adsorption and/or desorption of dye molecules. This exchange determines the stationary characteristics of light-induced anchoring [14–16]. As it was shown by Komitov *et al.* [19], irradiation of MR-doped LC results in light-induced desorption of trans isomers of MR molecules and in light-induced adsorption of cis isomers of MR molecules from the LC bulk. The competition of these processes determines the angular distribution of the long axes of adsorbed MR molecules on the surface and final direction of the light-induced easy axis.

*Finite (preferably weak) anchoring.* Finite anchoring pro-

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