

Magnetic field-assisted liquid crystal alignment on a solid substrate: drift of easy orientation axis, anchoring energy and angular distribution of adsorbed liquid crystal molecules

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The anchoring properties of a film of anisotropically adsorbed liquid crystal (LC) molecules on a rigid substrate have been studied. The LC film was prepared by cooling it from the isotropic phase in the presence of a magnetic field parallel to the surface of the substrate. Relationship between the anchoring energy, easy axis direction and angular distribution of the adsorbed molecules, and changes in their angular distribution due to adsorption–desorption, were studied. The dependence of the anchoring energy on the duration and the temperature at which the LC film is annealed allowed an estimation of the activation energy of desorption of LC molecules on ITO surface, $\Delta E \approx 0.55$ eV. The results suggest that hydrogen bonds are responsible for the adsorption of LC molecules on the substrate.

1. Introduction

The traditional description of liquid crystal (LC) alignment on a solid surface suggests that an easy orientation axis results from a direct anisotropic interaction between a physically anisotropic surface and LC molecules, the translation mobility of which does not differ much from the mobility of the molecules in bulk LC. Since the first observation of a memory effect [1–3], it became clear that adsorption of LC molecules on the aligning surface can yield an anisotropic layer which itself aligns the LC. Subsequent studies confirmed that the layer formed of adsorbed molecules plays an important role in orienting the bulk LC that comes in contact with it. For instance, when a cell filled with LC is cooled from the isotropic phase to the nematic phase in the presence of a magnetic field, homogeneous LC orientation can be attained without surface treatment [2–4]. Light-induced adsorption of dye molecules on an isotropic polymer surface from the LC bulk also causes homogeneous alignment of the LC [5]. Investigations of the drift of the easy axis (or the “gliding effect” [4–8]) with time and temperature in electric, magnetic and optical fields showed that this effect is caused by the processes of adsorption and

desorption of LC molecules on the aligning surface. The layer of adsorbed molecules should be considered as a mobile system wherein an active exchange between “bulk” and “surface” molecules occurs via the processes of adsorption and desorption (AD processes) of the LC and dopant molecules.

Macroscopic characteristics of the alignment caused by the adsorbed layer depend on the angular distribution of the adsorbed molecules. Recently, Romanenko *et al.* developed a theory that describes director gliding in terms of changes in the angular distribution function of the adsorbed molecules and rotation of this function due to a bulk torque [9, 10]. This theory connects the macroscopic characteristics of the gliding with microscopic characteristics of the adsorbed LC molecules. For instance, the maximum of the angular distribution function of adsorbed elongated molecules specifies the direction of the easy axis, \mathbf{e} , and the width of the distribution is related to the anchoring energy, W .

The drift of the easy axis due to adsorption–desorption of LC molecules on traditional polymer aligning surfaces is accompanied by a collective reorientation of flexible polymer fragments and LC molecules [11–13]. The latter process results in the drift of the easy axis along with AD processes. Both mechanisms of gliding are described by the same equations (see Romanenko *et al.* [9, 10]). The only

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