Manufacturing Films of Strengthened Cyclosiloxanes

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At present, the question of developing the methods and reactants to obtain a given uniform alignment of liquid crystals (LCs), planar ($\parallel$) and homeotropic ($\perp$), remains topical [1, 2]. It is known [3] that organosilanes and siloxanes with active functional groups at a silicon atom have been employed for this purpose.

Because of increase of the share of LCD with vertical alignment and LCD for industrial and extreme applications a challenge is to look for new aligning coatings with higher stability to ambient conditions and opportunity to control LC alignment on substrates' surfaces.

For alignment of liquid crystals we investigated for the first time the strained cyclosiloxanes with planar and cubic structure containing no reacting groups while exhibiting the strained bonds in a molecule which, under the effect of active centers (OH-groups) of the substrate, are able to rupture and polymerize into oligoorganosiloxane and to form bonds with the substrate.

To obtain the aligning films, we investigated the cyclosiloxanes which included hexaorganocyclotrisiloxanes (methyl, ethyl, and methylphenyl), step planar dimethylphenylcyclosiloxane, and cubic methylcyclosiloxane.

The aligning films were prepared by the adsorption method through immersion of the substrate in cyclosiloxane solution of the certain concentration (1-40 wt %) at the specified temperature (20-80^{o}C) for the given time (10 min-2 h), rinsing of the substrate with a pure solvent to remove the weakly bonded molecules, and drying at 150-180^{o}C for 1.5 h. Use was made of two variants of substrates: the glasses coated with the layer of indium dioxide and tin oxide serving as a transparent electrode (hereafter, they are referred to as "ITO substrates") and the glasses without electrode (merely "glasses"). Before application the film, the glass substrates were cleaned of dust and the pollutants adsorbed on them via immersion into the boiling solution of hydrogen peroxide and ammonia and then were rinsed with distilled water and dried. As a result, the substrate thus obtained was completely hydrophilic.

The film-surface energy E and its dispersion E^d and polar E^p components are calculated from the wetting angles θ^i of the film with water and methyl iodide using the Ouene-Wendt equation [4].

The surface charge was measured with the help of a V7-30 digital electrometer in a special chamber that rules out the action of external factors.

In order to introduce dimethylsiloxane chains into the polymeric film formed from cubic methylcyclosiloxane, the latter was mixed with the polymethylsiloxane (PMS) liquids with a long chain which differ in viscosity (PMSs of the grades PMS-1.5 - PMS-100, GNIIKHTEOS) and then the mixture thus obtained was dissolved in toluene.

The film thickness was determined by ellipsometry. To study the alignment, different structures of LC materials of the grades ZhK-440 (eutectic mixture of weak-polar azoxy compounds), ZhK-807 (eutectic mixture with polar alkoxycyanobiphenyls), and ZhK-1282 (a commercial mixture of alkoxycyanobiphenyls and cyclohexylcarboxylates; all materials from NIOPIK, Russia) were investigated. The LC alignment was determined on a polarizing microscope when an electric field was applied.

The optimum conditions for obtaining the aligning films from hexaorganocyclotrisiloxanes by the adsorption method which were established are as follows: the concentration of the solution 20 wt %, the 10-min-holding of the substrate in the solution at 80^{o}C, the rinsing with a pure solvent, and the 1.5-h-drying at 150^{o}C. In this case, the alignment in LCs of grades ZhK-440, ZhK-807, and ZhK-1282 is planar on hexaethylcyclotrisiloxane; whereas the alignment in LCs of grade ZhK-440 and in LCs of grades ZhK-807 and ZhK-1282 on hexamethylcyclotrisiloxane is planar and homeotropic, respectively. Trimethyltriphenylcyclotrisiloxane yields the mixed alignment.

The required LC alignment can be achieved by a change-over of the method of application of cyclosiloxane onto the substrate (by its immersion or rotation).

It is shown that from the viewpoint of temperature of the formation of films and resistance to the effect of different factors (e.g., humidity), hexaalkylcyclotrisiloxanes have advantage over the films based on polyvinyl alcohol and polyamide.

When films are obtained from the solution of a mixture of cubic methylcyclosiloxane with polymethylsiloxane liquid, the observed structure of the surface layer varies with time, which leads to a change in the LC alignment.

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