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Wpływ sieci polimerowej na właściwości fizyczne i dynamikę molekularną chiralnych ciekłych kryształów

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Abstract

Liquid crystal systems enjoy much interest because of their anisotropic physical properties (mainly optical and electric) that permit their application in optoelectronic and photonic. Increasing demands on the technological parameters, such as e.g. switching times, angles of vision or mechanical resistance, imply continuous search for new solutions. Addressing the growing technological needs in the studies described in the doctoral dissertation I produced and comprehensively characterized polymer-liquid crystal composites making a new group of materials showing specific physicochemical properties.

The main aim of the study was to establish the effect of admixture (monomer or polymer) on molecular dynamics and physical properties of selected rod-like liquid crystals representing a wide group of liquid crystals. I wanted to find out if formation of polymer-liquid crystal systems by photopolymerization may improve the technologically important properties of liquid crystals containing the smectic phase SmC_{α}^{*}. A characteristic feature of this phase is exceptionally fast response of particles to external electric field (in tens or hundreds of microseconds), which is very attractive from the point of view of applications in electrooptical devices. Thermal properties of liquid crystal systems were determined on the basis of dielectric measurements and by the reversal current method (RCM). The measurements unambiguously confirmed the presence of SmC_{α}^{*} phase and permitted determination of its temperature range. Molecular dynamics of the materials was studied by dielectric relaxation and nuclear magnetic relaxation. It should be emphasized that the use of nuclear magnetic resonance, in particular the fast field cyclic NMR, for identification and description of complex molecular dynamic processes in liquid crystal systems is a unique approach, which proved very successful and provided much information.

On the basis of selected theoretical models of NMR relaxation, an analysis of dispersion dependencies of spin-lattice relaxation rate was made for a liquid crystal, a mixture of monomer and liquid crystal and a polymer-liquid crystal system. Taking into account local molecular dynamics (rotations, reorientations and translations) and collective molecular dynamics (smectic layer undulations, tilt direction fluctuations) I proposed a theoretical description of the processes taking place in the isotropic phase and particular liquid-crystal phases. On the basis of the fits of selected models to experimental data, the temperature dependencies of selected physical parameters

(correlation times for rotations around the short and long molecular axis and lower cutoff frequencies) were obtained.

A comparison of the results obtained from the NMR relaxometry with those obtained by complementary methods showed good agreement. Dielectric spectroscopy, similarly as NMR relaxometry, permitted a description of collective dynamics of molecules in smectic phases and a distinction between two main modes related to the change in the molecular inclination angle, the soft mode and Goldstone mode, detection of an additional relaxation process coming from the presence of admixture modifying the dynamics of liquid crystals.

The studies permitted drawing qualitative and quantitative conclusions on the character and temporal scales of particular dynamic processes, identification of differences between the systems studied and the effect of admixture (monomer or polymer) on the liquid crystal properties.