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New way to create high-speed LCDs based on the use of modified nanomaterials

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Abstract
Modified "detonation nanodiamond" (MDND), graphene oxide (MGO) and nanoclay (MNC) were doped to nematic (NLCs) and ferroelectric liquid crystals (FLCs). The effect of modified nanomaterials on the physical and electro-optical properties of liquid crystals was investigated.

Diamond is one of the most popular materials which can exist in the form of nanoscale particles. Special class of nanodiamond material with characteristic sizes of 4 to 5 nm, often called in the literature "ultradispersed diamond" (UDD) or "detonation nanodiamond" (DND), were produced by detonation of carbon-containing explosives.
For the functionalization of detonation nanodiamonds, we attached carboxylate groups by grafting. Activation of COOH-surface functionalized groups allowed attachment of various organic tails [1]. It is established that the effect of MDND on the dielectric properties of LCs depends on the size of nanoparticles and the type of rod-like elongated organic molecules attached to the MDND. It was found that nanoparticles of small size (4-5 nm) do not significantly affect the LCs parameters. At the same time, MDND-based conglomerates with a diameter of about 50 nm or about 100 nm can increase or decrease the dielectric anisotropy and LCs response time by 1.5-2.5 times, depending on the polarity of the tails.

Liquid crystals with ferroelectric properties are characterized by a very fast switching speed due to the linearity of the electro-optical effect (in the microsecond range). However, the lack of a stable orientation due to its destruction, even with a small mechanical action, is the main obstacle preventing the commercialization of such devices. To solve the above problems, we investigated the influence of graphene on the dielectric properties of LCs, since the dielectric characteristics of LCs have the greatest influence on the threshold and dynamic parameters of various devices based on liquid crystals [2].

From the experiment, we found that the dielectric spectra of pure nematic composition and composition doped with graphene are almost identical, except for one effect. The addition of graphene reduced the dielectric anisotropy sign inversion frequency by 100 kHz. Study in this area is promising, since many research centers are actively involved in the development of dual-frequency LC materials, through the synthesis of new classes of compounds. It is an expensive and lengthy process. In our case, this problem can be solved more easily.

It was found that the addition of graphene significantly affects the dielectric properties of ferroelectric LCs, and also leads to an increase in spontaneous polarization and a decrease in viscosity. The addition of graphene increases spontaneous polarization by 20 - 25% and increases the tilt angle by 15 - 20%. In turn, these parameters have the greatest impact on the response time of the ferroelectric LCDs (reduces the response time by 70 - 90%). It should also be noted that the addition of MGO to FLCs leads to the effect of bistability, improves orientation and resistance to mechanical deformations. Thus, we can conclude that MGO is promising as an additive to LCs for the development of high-speed and bistable displays.
MNC is a very promising candidate for the creation of LCs composites because of the high cation exchange capacity, the very small size of the plates and the large surface area. In addition, the chemical nature and porous structure of the surface of the MNC can be easily modified. Samples of FLCs doped with MNC are characterized by large values of the spontaneous polarization compared with "pure" FLCs. The significant decrease in the switching times observed in the experiments is obviously also due to a significant decrease in the rotational viscosity of the FLCs when MNC is added to it.

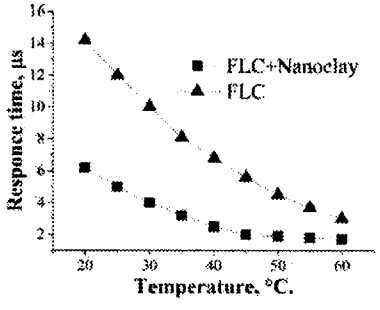

Figure 1: The response time of FLCs and FLCs doped with MNC

References

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