NOVEL COLLOID-LIQUID CRYSTALLINE COMPOSITES ON THE BASE OF POLYMERS

T.D. IBRAGIMOV
Institute of Physics of National Academy of Sciences,
AZ1143, H. Javid ave., 33, Baku, Azerbaijan

G.M. BAYRAMOV, A.R. IMAMALIEV
Baku State University, AZ1143, Z. Khalilov str., 23, Baku, Azerbaijan

In the work it is noted about the creation of novel small particles-liquid crystalline composites showing three-dimensional network formation. The first experimental data are presented.

Unique properties of liquid crystals (LC) are widely used in the modern engineering including furnishings. Functioning of LC displays, switches of frequency, converters of radiation, and others is based on numerical electrooptic effects in LCs. The basic direction in the investigation of LCs connects with obtaining of the novel compounds with improved operated parameters. On the other hand, a perspective direction of modern science and engineering is to study and to use the properties of very small particles (SP). Christiansen and other effects providing strong dependence of SP properties upon surrounding medium, in combination with numerous optic and electrooptic phenomena (Fredericksz effect, twist and guest –host effects, electrohydrodynamic instability, selective reflection, memory, and ferroelectricity) in different LCs will allow not only for improving the operated parameters but also for building-up novel types of photonic devices.

Recently, researchers from Institute of Liquid Crystals (Kent University, the USA) and Collaborative Optical Spectroscopy Micromanipulation and Imaging Center (University of Edinburgh, Scotland) have found out that at slow cooling through the isotropic-nematic transition of the mechanical mixture of polymethylmethacrylate particles and pentylcyanobiphenyl (liquid crystal 5CB) the particles are expelled by the LC, forming a three dimensional network structure [1-5]. At that case, the composite has unusual soft solid state characterized with significant storage modulus. The birefringent soft solid is potentially important as a switchable electrooptic material that can be readily handled and processed. Researchers focus on the kinetics of the phase transition and viscosity properties of this material. In particular, they have found out that the three dimensional structure varies with the course of time. This fact does not allow wholly using this composite for application.

The purpose of the work is the creation of novel colloid-liquid crystalline composites forming the network with stable characteristics.

At selection of LC and polymer we were guided by following general requirements:

- a melting point of polymer (T_m) and a clarify point of LC (T_{ni}) should be close to each other;
- a density of LC and polymer should be close;
- a polymer should not be dissolved in LC;
- there should be a stabilizer interfering aggregation of polymeric particles at mixing.

The following materials are used for development of composite gels:

- liquid crystals 4-pentylcyano-4'-biphenyl (5CB), 4-methoxybenzilidene - 4' – butylaniline (MBBA), 4-ethoxybenzilidene-4'-butylaniline (EBBA), the mixture of MBBA and EBBA with molar ratio of 1:1 (commercial mark H-37) and 1:3 (commercial mark H-8);
- polymers poly(methylmehacrylate) (PMMA), poly(2-methyl-5-vinylprydine) (PMVP), poly(ethyleneglycol) (PEG), poly(vinylalcohol) (PVA);
- the stabilizer heptixybenzoic acid (HOBA) which also posses mezogene properties.

At first the mixture of polymer and LC was heated above T_m and T_{ni} in the proposed method. At that case, both components are in the state of a transparent liquid. At intermixing with frequency of 1000 revolutions/minute the micron-size drops of polymer in isotropic LC are formed. These drops are transformed to the solid balls at slow cooling of the mixture lower T_m. This transition is accompanied by primary turbidity of the liquid. The isotropic-nematic transition is occurred at further cooling lower T_{ni} which is accompanied the strong turbidity of the mixture. When the mixture cools down to room temperature it assumes the soft solid state.

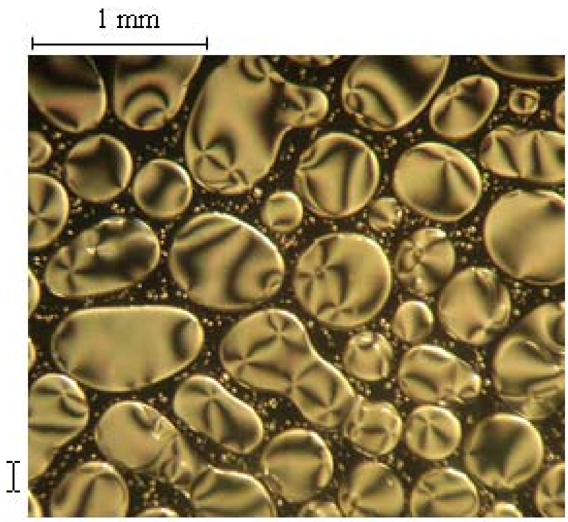

Fig. 1. The texture of H-37 + PMVP with a weight ratio of 11:1 at room temperature and 300-fold magnification.

The electrooptic cell consists of two conductive glasses filled by obtained composites. The thickness of the cell is regulated by the dielectric gasket. The cell has the heating system which allows regulating the rate of temperature change. The magnitude of temperature is indicated by copper-constantan thermocouple with an accuracy of 0.1 degrees. The obtained textures are examined under polarized microscope.

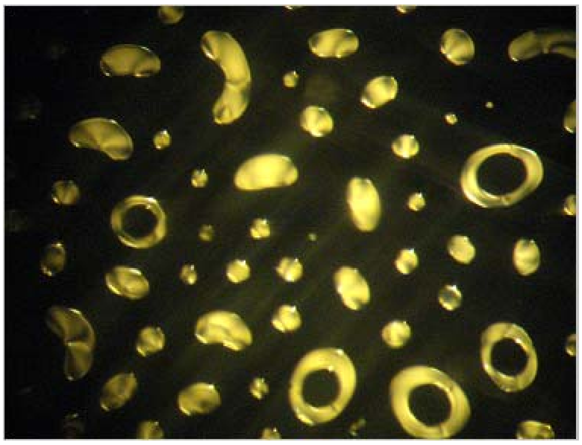

Fig. 2. Ring-like areas of LC at heating of H-37 + PMVP (a weight ratio of 11:1) below nematic-isotropic phase transition.

The study of obtained composites shows that the most stable of them is H-37 + PMVP with a weight ratio of 11:1 and containing 1% of HOVA. In the order to stabilize other composites it is necessary to add greater quantity of the stabilizer and greater time for mixing. In particular, for stabilization of the composite H-8 + PEG is required to add NOVA with quantity of 4%.

The texture of H-37 + PMVP with a weight ratio of 11:1 at room temperature and 300-fold magnification is presented in the Fig.1. Apparently, areas with LC are divided from each other by polymeric walls being a part of unified network. Processing the substrate surfaces of the LC cell by appropriate way it is possible to obtain any initial texture of LC inside these areas. The Shrilen's texture of LC shown in Fig.1 corresponds to weak anchoring of LC molecules with substrate surfaces. At large thickness of the electrooptic cell these LC areas can be imposed. At slow heating of indicated composite near the nematic-isotropic transition the LC areas form ring-like structure inside the dark background (Fig.2). Formation of these rings is connected by that the nematic-isotropic transition begins in the center of them and the transition is complicated on the area edges because of orienting influence of surface forces. Electrooptic properties of the nematic LC little differ from the ordinary LC cell inside indicated areas. In particular, applying the voltage about 2 V onto the cell the planar-homeotropic transition (S-effect) can be observed, William's domens are occurred as strips at the voltage of 10-15 V (Fig.3), and above 20 V – turbulent movement (electrohydrodinamic instability) accompanied strong light scattering.

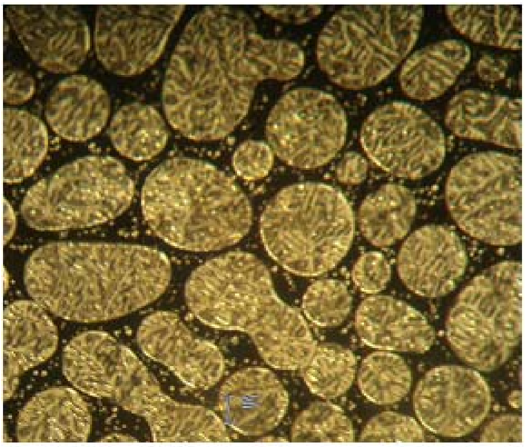

Fig. 3. William's domens in H-37 + PMVP (a weight ratio of 11:1).

These values of voltage almost coincide with corresponding ones for the pure LC H-37. At increasing of polymer concentration the LC area dimensions decrease that result in small increasing of threshold voltage of the specified electrooptic effects owing to increasing of contribution of surface effects.

Thus, proposed method of phase separation allows creating novel small particles-liquid crystalline composites by a variation of type and concentration of LC and polymer, and also regime of mixing and cooling.

The work is supported by Science and Technology Center in Ukraine (grant No 4172).

[1] *D. Vollmer, G. Hinze, B. Ullrich, W. Poon, M. Cates, A. Schofield*. Langmuir, 2005, v.21, p.4921-4930.

[2] *J. Cleaver, D. Vollmer, J. Crain, W. Poon.* Mol. Cryst. Liq. Cryst. 2004, v. 409, p.59-68.

[3] *D. Vollmer, G. Hinze, J. Cleaver, M. Cates.* J. Phys.: Cond. Matter. 2004, v.16, p.227-233.

[4] *J.West, K. Zhang, G. Liao, A. Glushenko, Yu.Resnikov, D. Andrienko, M. Allien*. Mol.Cryst. Liq.Cryst., 2004, v. 410, p. 611-621.

[5] *S.P. Meeker, W. Poon, J. Crain and E.M. Terentiev*, Phys.Rev. E, 2000, v. 61, p.R6083-R6086.

T.C. İbrahimov, G.M. Bayramov, A.R. İmamalıyev

POLİMERLƏR ƏSASINDA YENİ KİÇİK HİSSƏCİK - MAYE KRİSTAL KOMPOZİTLƏRİ

Məqalədə üç ölçülü fəza torunu birüzə verən yeni kiçik hissəcik-maye kristal kompozitlərin yaradılması barədə məlumat, həmçinin təcrübə nəticələri verilmişdir.

Т.Д. Ибрагимов, Г.М. Байрамов, А.Р. Имамалиев

НОВЫЕ КОМПОЗИТЫ МАЛЫЕ ЧАСТИЦЫ - ЖИДКИЙ КРИСТАЛЛ НА ОСНОВЕ ПОЛИМЕРОВ

В работе сообщается о создании новых композитов: малые частицы - жидкий кристалл, проявляющие трехмерную пространственную сетку. Приведены первые экспериментальные данные.

Received:17.01.08