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PERIODIC STRUCTURE IN PBLG-DIOXANE SYSTEM UNDER ELECTRIC FIELD

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Periodic patterns were observed in PBLG-dioxane system under an electric field which was higher than the threshold field of the isotropic-nematic transition. The size of the well oriented zone became larger with the field strength, while the lattice constant of the pattern was independent of the electric field.

It has been known that the cholesteric phase of a poly(γ-benzyl-L-glutamate) (PBLG) solution is transferred into the nematic phase under an electric or magnetic field[1]. If the concentration of PBLG is not high enough, the solution does not show the liquid crystal phase above the freezing temperature[2]. However, when an electric field is supplied to a PBLG solution of the isotropic phase, the phase transition to the nematic state occurs above the threshold field strength[3]. The above phenomenon was interpreted as the change of the phase transition temperature caused by the difference in the interaction energy with the electric field between the two states. The change of the transition temperature was proportional to the electric field[3].

When a dc voltage was supplied to an isotropic dioxane solution of PBLG placed in a sandwich cell with transparent electrodes, the transition from an optically isotropic state to a rather turbid state was observed around the threshold electric field, E_1, through a polarizing microscope. The turbid appearance continued to a certain electric field strength, E_2. When an applied electric field exceeded E_2, a regular square pattern appeared. An example of the pattern is shown in Figure 1.

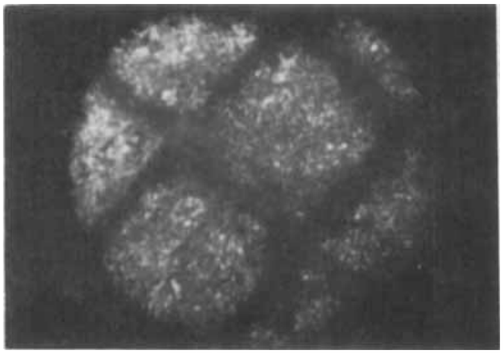

Figure 1. A square pattern induced in the dioxane solution of PBLG under an electric field viewed between crossed nicols. Mean molecular weight of PBLG: 150,000. Concentration of PBLG: 11.57 wt%. Temperature: 50°C. Cell thickness: 123 μm. Applied electric field: 700 V/cm. Threshold electric field of the isotropic -nematic transition: 320 V/cm. Threshold electric field of the square pattern formation: 680 V/cm.

With increasing the electric field the width of the black stripe region in Figure 1 increased, while the lattice constant of the pattern remained constant. The electric field dependency of the lattice

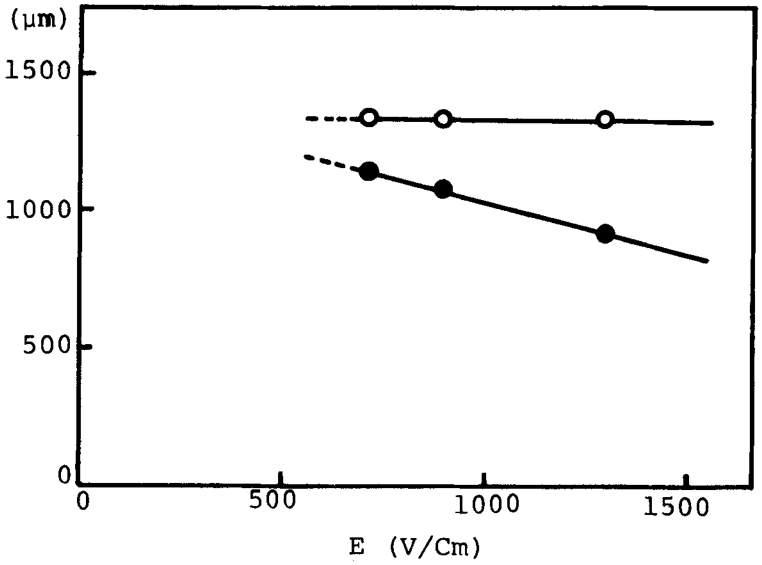

Figure 2. Electric field dependency of the feature of the periodic pattern.
o: Lattice constant. o: Size of each square.

constant and that of the size of the white region are shown in Figure 2. The black stripe region in Figure 1 was not an optically isotropic state, but a uniaxial state with the optical axis parpendicular to the cell surface. In other words, PBLG molecules were arranged with high orientational order directing their molecular axes toward the electrode. When the external electric field was turned off, the black part turned to white between the crossed nicols.

A possible schematic illustration of the molecular arrangement in the periodic pattern is shown in Figure 3. Such a molecular arrangement can not

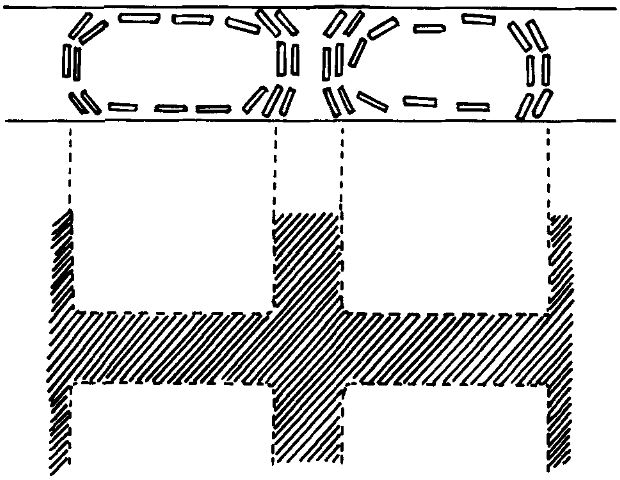

Figure 3. Illustration of the possible arrangement of PBLG molecules in the periodic pattern.

be realized only by the dielectric interaction between molecular dipole moments and an external electric field.

The sandwich cell used in the present experiment was not electrically blocked, so charges could be injected into the PBLG solution. Considering the above condition, we may expect that a similar mechanism to the Felici instability[4] or Carr-Helfrich instability[5,6] exists in the present case. The transit of injected charge carriers through the PBLG-dioxane layer will be able to make a regular flow pattern[4] introducing a periodic shear field in the nematic solution. The shear field thus formed may influence the orientation of PBLG molecules. Thus the actual orientation of the PBLG molecules in the present system will be determined by the competition between the dipole-electric field interaction and the interaction of PBLG molecules with flow field induced by the electric current through the solution.

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