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Article / Book Information

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（博士課程）
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論 文 の 要 約

THESIS OUTLINE

専攻： Department of	化学環境学 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 工学 ）
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Dye-doped liquid crystals (LCs) are attractive materials due to their giant optical nonlinearity, which could lead to various nonlinear optical applications. However, such optical nonlinearity is typically only observed at very high light intensity and thus requires costly laser sources. In the present thesis, the author explored novel materials on the basis of oligothiophene (TR5)-doped polymer-stabilized LC (PSLC), aiming to reduce the light intensity requirement for nonlinear reorientation. In Chapter 2, the polymer concentration in TR5-doped PSLC system was optimized. In Chapters 3 and 4, enhanced nonlinear optical response was achieved through hybrid molecular alignment and polymer network stabilization, respectively. In Chapter 5, the lowest threshold intensity to trigger nonlinear reorientation was obtained by combination of hybrid alignment and polymer network stabilization. Additionally, optical power limiting with extremely low threshold power using the obtained materials was demonstrated.

Chapter 1 [General Introduction] The development of liquid crystal materials for nonlinear optics was introduced, and the research purpose of this thesis was presented.

Chapter 2 [Effect of Polymer Concentration on Nonlinear Reorientation in Oligothiophene -Doped Polymer-Stabilized Liquid Crystals] In this chapter, the author investigated the effect of polymer concentration on nonlinear reorientation in TR5-doped PSLCs in order to optimize the material system. Homeotropic-aligned TR5-doped PSLCs with polymer concentrations ranging from 0 to 13 mol% were prepared. Self-diffraction ring measurements using a 488-nm Ar^+ laser were performed to evaluate the nonlinear reorientation. Results indicate that as polymer concentration increased, the threshold intensity of nonlinear reorientation first decreased then slightly increased, while the maximum number of rings first increased then slightly decreased. The lowest threshold intensity (3.4 W/cm^2) and the largest number of rings (29) were obtained in TR5-doped PSLC with 10 mol% of polymer. Additionally, the possible mechanism of polymer concentration dependence of nonlinear reorientation was also discussed. The author proposed that it is the balance of four factors (bulk elasticity, surface anchoring, photoexcited dye population and the guest host interaction force) that determines the final material performance.

Chapter 3 [Laser-Pointer-Induced Self-Focusing Effect in Hybrid-Aligned Oligothiophene-Doped Polymer-Stabilized Liquid Crystals] In this chapter, the author prepared hybrid-aligned TR5-doped PSLC, aiming to reduce the threshold intensity of nonlinear reorientation by hybrid alignment. Nonlinear reorientation behavior was systematically investigated in such hybrid-aligned cell at four cell arrangements by self-diffraction measurements. When the light was sent to the homeotropic side and the molecules at the homogeneous side aligned parallel to the laser polarization, the lowest threshold intensity was obtained at 0.4 W/cm^2. It was significantly lowered by a factor of 8.5 compared with that of the homoetropic-aligned cell with the same composition. Thanks to such low threshold intensity, self-focusing effect in hybrid-aligned TR5-doped PSLC was successfully demonstrated using a 1-mW handheld laser pointer. Additionally, the hybrid-aligned cell also exhibited incident direction sensitivity, which brought up its potential as a film-type optical isolator. As a result, hybrid alignment was proved very effective at nonlinear reorientation enhancement for dye-doped PSLCs. The bifacial property, especially low threshold intensity could greatly expand the photonic applications of nonlinear optics.

Chapter 4 [Polymer Network-Stabilized Oligothiophene-Doped Liquid Crystals Showing Enhanced Nonlinear Optical Reorientation] In this chapter, the author fabricated homeotropic-aligned TR5-doped polymer network-stabilized LCs (PNSLC), with the expectation of enhancing the nonlinear reorientation in TR5-doped PSLC by polymer network stabilization. Polymer network stabilization of LCs was achieved by photopolymerization of photofunctional monomer A4CB and crosslinker. First, nonlinear reorientation was investigated in TR5-doped PNSLCs with various commonly used crosslinkers. Results revealed that polymer network stabilization could indeed further reduce the threshold intensity of reorientation. The sample using crosslinker HDDA showed the lowest threshold intensity, which was markedly reduced compared with that of the TR5-doped PSLC containing side-chain type of polymer. Moreover, HDDA concentration in TR5-doped PNSLC system was optimized.

Chapter 5 [Optical Power Limiting Based on Hybrid-Aligned Oligothiophene-Doped Polymer Network-Stabilized Liquid Crystals] In this chapter, hybrid-aligned TR5-doped PNSLC was prepared for further reduction of threshold intensity of nonlinear reorientation, aiming to further reduce the threshold intensity by combination of hybrid alignment and polymer network stabilization. Additionally, optical power limiting (OPL) property of the obtained materials was explored. Nonlinear reorientation behavior was also studied at four cell arrangements by self-diffraction ring measurements. The lowest threshold intensity of was observed at homeotropic-0 cell arrangement. To our best knowledge, by far this is the lowest value ever achieved for nonlinear reorientation showing self-focusing effect. What's more, OPL with extremely low threshold power was realized using hybrid-aligned TR5-doped PNSLC. Current state-of-the-art OPL materials typically only work with expensive and intense pulse lasers. The realization of OPL with inexpensive, low-power CW laser sources could enable widely OPL applications in practical, even utilizing weak incoherent light sources or sunlight in the future.

Chapter 6. [Summary] In this chapter, the author summarized the present thesis.