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# Article / Book Information

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# 論 文 要 旨

THESIS SUMMARY

| 専攻：<br>Department of | 有機高分子物質　専攻 | 申請学位（専攻分野）：工学　博士<br>Academic Degree Requested | Doctor of (Engineering) |
|---|---|---|---|
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| | | 指導教員（副）：<br>Academic Advisor(sub) | |

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）


The thesis is mainly composed of four parts. The majority of my dissertation deals with a phenomenological description of experimental results about (i) the surface-triggered isotropic-nematic (Iso-N) phase transition, (ii) the surface-triggered orientational structure transition, anchoring transition, in both achiral and chiral NLCs with either first-order or second-order nature, (iii) local dynamic smectic layer structure triggered abnormal elastic behaviors of a NLC in the nematic phase, which has several smectic phases beneath the nematic phase; (iv) newly-synthesized chiral dimeric LCs, built of cholesterol and N-benzylidene-p-toluidine units or and 4-methylazobenzene units connected by flexible alkyl spacer with odd-number carbons, exhibiting some pretty unprecedented curious odd-even effects on the phase behaviors and electro-optic properties.

The first part presents a series of studies of the surface transition triggered by the specific surface local wetting layer, which is well separated from the bulk phase transition in liquid crystals. We have used highly resolution differential scanning calorimetry(HR-DSC), high-resolution AC calorimetry, contact angle measurement, transmittance measurement, microscopic and macroscopic retardation measurements in the vicinity of the Isotropic-Nematic (Iso-N) phase transition, as well as polarizing optical microscopy (POM) to characterize the both phase transitions in two types of LC-contained multicomponent system. First one is a binary system composed of UV curable monomer NOA81 (Norland Optics), which is transparent in the visible light range, and liquid crystalline material. The other is a nano-colloidal dispersions of aerosils into which liquid crystal molecules are embedded. The aerosil (SIL) is made of 70 Å diameter $SiO_2$ particles coated with hydroxyl (-OH) groups. The coating allows the SIL particles combine through hydrogen-bond, to form a gel in an organic solvent. Common to these two systems, NOA81 and SIL act as an external field (anchoring) for liquid crystal molecules to enhance or weaken the molecular orientational order parameter *S*. As a result, in both systems the surface Iso-N transition was observed. In addition, an optically isotropic nematic liquid crystals (IsoN phase) is exhibited in the former system, and is presented. It is realized by fabricating nematic liquid crystal droplets of about 100 nm in their size. So far optically isotropic IsoN phase has been reported only in a liquid crystal microemulsion system. It is a very crucial question for showing if liquid crystalline states are preserved or not in such nanosegregated structures. We clearly observed the NLC nature by light scattering, the phase transition from the isotropic phase, and electro-optic Kerr effect. I also show fundamental superior electrooptical performance of this system in a device manner towards next-generation display devices.

The second part introduces a special structure transition related to the orientational variation in LC director in response to temperature. An amorphous peruoropolymer surface was used in-situ as to possess two competing easy axes for LC alignment. Upon cooling, a planar (homogeneous) alignment turns into homeotropic alignment discontinuously on approaching the nematic-smectic-A phase transition, vice versa upon heating. A large thermal hysteresis region, ranging from 5 to 10 $^{o}$C, was observed, depending on the temperature scan rate. Electric field was found to be able to adjust the transition temperature and also affect the molecular arrangement both on surface and in bulk in a cell, thus allowing us to have unveiled an electric-field-driven critical-like wetting behavior. The results are discussed in light of a mean-field theory. Moreover, methods as like high-resolution differential scanning calorimetry, X-ray diffraction, dielectric measurements, polarizing microscopy, and so on were carried out to explore the underlying mechanism. The results strongly suggest that the surface-assist smectic layer triggers the anchoring transition.

The third part describes that a newly-synthesized calamitic LC has a giant bend elastic constant $K_{33}$ of sub-nN, and the resultant extremely large $K_{33}/K_{11}$ leads to remarkable improvements in electro-optic properties such as a faster response time in LC device. A scenario of why the single-component LC

material can exhibit such large $K_{33}$s over a wide temperature range is proposed based on precise XRD measurements; The existence of smectic-C-type cybotactic clusters embedded in the nematic environment makes bend deformation difficult. The current huge $K_{33}$ values can be predicted by the McMillian model.

Furthermore, an additional content, outlining the extraordinary phase behaviors on a series of asymmetric cholesterol-based dimeric LCs, in Chapter 5. The results would contribute to the field of molecular design for exhibiting several chiral nematic phases with three-dimensional spatial structure (known as blue phases), and simultaneously provides insights on new ground state of untraditional nematic phase. Main results are: (i) several "stable" super-cooled BPs were found for all odd members just below isotropic phase for over 30 $^{o}$C upon cooling, while even members only exhibit smectic-A and cholesteric mesophases with no BPs. The super-cooled BPs are switchable via both the Kerr and electrostriction effect under a high electric field ( ~20-30V/μm) with no transitions to other mesophases; (ii) multiple nematic-nematic phase transitions occur between blue phases (or cholesteric phase). The lowest-tempreature nematic phase was confirmed as a modulated nematic phase with a structure similar to that in Williams domain found in electrohydrodynamic convection.