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## 1. Main Research Results

### (1) Banana-shaped Liquid Crystals 6, 7, 9, 13, 14, 16, 28, 29

We continuously studied banana-shaped liquid crystals. Some of the noticeable achievements are : We clearly demonstrated uniaxiality in a phase assigned to a biaxial phase [6]; Banana-shaped mesogens does not show such large flexoelectric effect as in a previous report [7]; Achiral rod-like molecules enhances chirality by a superhelical structure around helical nanofilaments formed by banana-shaped B4 phase [14].

### (2) Other Liquid Crystals 1, 2, 18, 19, 21, 22, 24, 25, 27

Besides banana-shaped liquid crystals, we reported molecular reorientation by a magnetic field in paraelectric liquid crystals [1], discotic liquid crystals with a collanurene core which can be aligned by an electric field [2], spontaneous deracemization in rod-like mesogens [18] and disc-like mesogens [27]. These are collaboration works with Kyoto university, Tokyo university, KAIST, and Center for Liquid Crystals (India).

### (3) Photonic Devices 3, 10, 11, 17, 26, 30, 31

We fabricated many new photonic structures and achieved many results; i.e., Omni-directional lasing by applying an electric field to cholesteric liquid crystals [3], controlling reflectivity and colors by rotating polarization of incident light [26]. We also started material development to achieve low lasing threshold [17].

### (4) Organic Transistors 5, 8, 32

Not only studies on new organic transistors with Mori-Lab [5,8] but also simulation on electron transport [32] have been made.

### (5) Magnetic Materials 4

Under the collaboration with Prof. T. Yamamoto, we measured Faraday rotation in  $\pi$ -conjugated polymer and obtained remarkably large Verdet constant [4]. The materials can be applied to magnetic field sensors.

### (6) Liquid Crystals on Perfluoropolymer surface 12, 15, 20, 23

Problems of liquid crystal on various surfaces are interesting both from fundamental and application viewpoints. In this year, we achieved many interesting studies on liquid crystal alignment on perfluoropolymer surfaces. We found a discontinuous orientation change (anchoring transition) from planar to homeotropic when decreasing temperature of a liquid crystal on a perfluoropolymer surfaces [12]. We proposed and fabricated a bistable device using bistability realized due to a temperature hysteresis of this phenomenon, and demonstrate the performance [15].

We also discussed the relationship between the defects in liquid crystal cells and universe [20]. We also found that this surface provides good shock-free alignment layer for smectic liquid crystals [23].

## 2. List of Publications (Original articles, review article/books)

### Original Papers

- 1) Magnetic-field-induced molecular alignment in the achiral liquid crystal spin-labeled by a nitroxyl group in the mesogen core  
Y. Uchida, R. Tamura, N. Ikuma, S. Shimono, J. Yamauchi, Y. Shimbo, H. Takezoe, Y. Aoki, and H. Nohira  
*J. Mater. Chem.* **19** (2009) 415-418
- 2) Liquid crystalline corannulene responsive to electric field  
D. Miyajima, K. Tashiro, F. Araoka, H. Takezoe, J. Kim, K. Kato, M. Takata, and T. Aida  
*J. Am. Chem. Soc.* **131** (2009) 44-45.
- 3) Electro-controllable omni-directional laser emissions from a helical polymeric network composite film  
B. Park, M. Kim, S. W. Kim, W. Jang, H. Takezoe, Y. Kim, E. H. Choi, Y. H. Seo, G. S. Cho and S. O. Kang  
*Adv. Mater.* **21** (2009) 771-775.
- 4) Large Faraday Rotation in a  $\pi$ -conjugated Poly(aryleneethynylene) Thin Film  
F. Araoka, M. Abe, T. Yamamoto, and H. Takezoe  
*Appl. Phys. Ex.* **2** (2009) 011501-1-3.
- 5) Organic field-effect transistors based on solution-processible debenzotetrathiafulvalene derivatives  
T. Yoshino, K. Shibata, H. Wada, Y. Bando, K. Ishikawa, H. Takezoe, and T. Mori  
*Chem. Lett.* **38** (2009) 200-201.
- 6) Electro-optic technique to study biaxiality of liquid crystals with positive dielectric anisotropy: The case of a bent-core material  
K. V. Le, M. Mathew, M. Chambers, J. Harden, Q. Li, H. Takezoe, and A. Jakli  
*Phys. Rev. E* **79** (2009) 030701(R)1-4.
- 7) Flexoelectric effect in a bent-core mesogen  
K. V. Le, K. Fodor-Csorba, K. Ishikawa, and H. Takezoe  
*Liq. Cryst.* **36** (2009) 1119-1124.
- 8) High carrier mobility in mesophase of a dithienothiophene derivative  
M. Goto, Y. Bando, T. Shirahata, T. Mori, H. Takezoe and K. Ishikawa  
*Appl. Phys. Ex.* **2** (2009) 041502-1-3..
- 9) Syntheses and characterizations of novel asymmetric bent-core mesogens exhibiting polar

smectic phases

K. Gomola, G. Lingfeng, S. Dhara, Y. Shimbo, E. Gorecka, D. Pocięcha, J. Mieczkowski, and H. Takezoe

J. Mater. Chem. **19** (2009) 4240-4247.

- 10) Chiroptical properties in azobenzene molecule-doped side-chain polymeric films  
S.-W. Choi and H. Takezoe  
Thin Solid Films **517** (2009) 6142-6145.
- 11) Photoinduced chirality in a photochromic stilbene-molecule-doped polymeric liquid crystal film  
S.-W. Choi and H. Takezoe  
Physica E, **41** (2009) 1648-1650.
- 12) Anchoring transition of transversely polar liquid-crystal molecules on perfluoropolymer surfaces  
S. Dhara, J. K. Kim, S. M. Jeong, R. Kogo, F. Araoka, K. Ishikawa, and H. Takezoe  
Phys. Rev. E **79** (2009) 060701(R)-1-4.
- 13) Electroconvection in nematic mixtures of bent-core and calamitic molecules  
S. Tanaka, H. Takezoe, N. Eber, K. Fodor-Csorba, A. Vajda, A. Buka  
Phys. Rev. E **80** (2009) 021702-1-8.
- 14) Enhanced Optical Activity by Achiral Rod-like Molecules Nano-segregated in the B<sub>4</sub> Structure of Achiral Bent-core Molecules  
T. Otani, F. Araoka, K. Ishikawa, and H. Takezoe  
J. Am. Chem. Soc. **131** (2009) 12368-12372.
- 15) Bistable device using anchoring transition of nematic liquid crystals  
J. K. Kim, F. Araoka, S. M. Jeong, S. Dhara, K. Ishikawa, and H. Takezoe  
Appl. Phys. Lett. **95** (2009) 063505-1-3.
- 16) First symmetrical banana compounds exhibiting SmAP<sub>R</sub> mesophase and unique transition between two orthogonal polar phases  
K. Gomola, L. Guo, E. Gorecka, D. Pocięcha, J. Mieczkowski, K. Ishikawa, and H. Takezoe  
Chem. Commun. 2009, 6592-6594.
- 17) Extremely low threshold in a pyrene-doped distributed feedback cholesteric liquid crystal laser  
Y. Watanabe, M. Uchimura, F. Araoka, G. Konishi, J. Watanabe, and H. Takezoe  
Appl. Phys. Expr. **2** (2009) 102501-1-3
- 18) Spontaneous Chirality Induction and Enantiomer Separation in Liquid Crystals composed of Achiral Rod-Shaped 4-Arylbenzoate Esters  
H. S. Jeong, S. Tanaka, D. K. Yoon, S.-W. Choi, Y. H. Kim, S. Kawauchi, F. Araoka, H. Takezoe, and H.-T. Jung  
J. Am. Chem. Soc. **131** (2009) 15055-15060.

- 19) Synthesis of tripod-shaped liquid crystals with sp<sup>3</sup> nitrogen at the apex  
H. C. Jung, S. K. Lee, G. Lee, H. J. Shin, S. J. Park, J. G. Lee, J. Watanabe, H. Takezoe, and K.-T. Kang  
Bull. Kor. Chem. Soc. **30** (2009) 1946-1950.
- 20) Thermotropic Uniaxial Nematic Liquid Crystal with Half-Strength Disclinations: Defect-Antidefect Production and Correlation  
Surajit Dhara, Ken Ishikawa and Hideo Takezoe  
J. Phys. Condens. Mater. **21** (2009) 505103-1-5.
- 21) Octasubstituted dibenzochrysenes: discotic liquid crystals with a twisted core  
S. K. Varshney, H. Nagayama, H. Takezoe and V. Prasad  
Liq. Cryst. **36** (2009) 1409-1415.
- 22)  $\pi$ -conjugated triphenylene twins exhibiting polymesomorphism including the nematic phase  
S. K. Varshney, H. Takezoe, V. Prasad, and D. S. Shankar Rao  
Mol. Cryst. Liq. Cryst. **515** (2009) 16-38.
- 23) Perfluoropolymer surface for shock-free homeotropic alignment of smectic liquid crystals  
S. M. Jeong, J. K. Kim, Y. Shimbo, F. Araoka, S. Dhara, N. Y. Ha, K. Ishikawa, and H. Takezoe  
Adv. Mater. **22** (2010) 34-38.
- 24) Syntheses and Mesogenic Properties of Dimers and Trimers Consisting of Triphenylene Donor and Anthraquinone Acceptor  
S. K. Varshney, H. Nagayama, V. Prasad, and H. Takezoe  
Mol. Cryst. Liq. Cryst. In press
- 25) Antiferroelectric liquid crystals –interplay of simplicity and complexity –  
H. Takezoe, E. Gorecka, and M. Cepic  
Rev. Mod. Phys. in press.
- 26) Colour- and reflectance-tunable multiple reflectors assembled from three polymer films  
N. Y. Ha, S. M. Jeong, S. Nishimura & H. Takezoe  
Adv. Mater. Published online.
- 27) Spontaneous deracemization of disk-like molecules in the columnar phase  
H. Nagayama, S. K. Varshney, M. Goto, F. Araoka, V. Prasad and H. Takezoe  
Angew. Chem. Int. Ed. **49** (2010) 445-448.
- 28) Splay bend elasticity of a bent-core nematic liquid crystal  
P. Sathyanarayana, M. Mathew, V. S. S. Sastry, B. Kundu, K. V. Le, H. Takezoe and S. Dhara  
Phys. Rev. E (rapid) **81** (2010) 010702(R)-1-4.
- 29) Electrooptic and Dielectric Characterization of SmA<sub>d</sub>P<sub>A</sub> Phase of a Asymmetric Bent Core Liquid Crystal

L. Guo, S. Dhara, B. K. Sadashiva, S. Radhika, R. Pratibha, Y. Shimbo, F. Araoka, K. Ishikawa, and H. Takezoe

Phys. Rev. E **81** (2010) 011703-1-6.

- 30) Broad-band Cavity-mode Lasing from Dye-doped Nematic Liquid Crystal Sandwiched by Broad-band Cholesteric Liquid Crystal Bragg Reflectors

H. Choi, J. Kim, S. Nishimura, T. Toyooka, F. Araoka, K. Ishikawa, J. W. Wu, and H. Takezoe

Adv. Mater. accepted.

- 31) Light extraction from organic light emitting diodes enhanced by spontaneously formed buckles

W. H. Koo, S. M. Jeong, F. Araoka, K. Ishikawa, S. Nishimura, T. Toyooka, H. Takezoe

Nature Photonics, in press.

- 32) Electric conduction in liquid crystalline phase of biaxial Gay-Berne particles

M. Goto, H. Takezoe, and K. Ishikawa

J. Chem. Phys. **132** (2010) 054506-1-10.

#### Review Articles and Books

- 1) Controlling liquid crystal laser light

Hideo Takezoe

Polymer **58** (2009) 548-552

- 2) Photonic laser devices using polymer liquid crystals

Fumito Araoka, Hideo Takezoe

Optics **38** (2009) 610-615.

- 1) Liquid crystal photonic devices

Fumito Araoka, Hideo Takezoe

Kagaku to Kogyo **60** (2009) 23-27.

#### 3. Invited Presentations

##### International Conferences

- 1) International Workshop on Mesomorphic Advanced Materials and Nanotechnology (MAMN 2009)

March 9-10, 2009 (Tokyo) Invited

“Induced Optical Activity of Achiral Rod-Like Molecules Nano-Segregated in the B4 Structure of Achiral Bent-Core Molecules”

- 2) European Conference on Liquid Crystal (ECLC 09)

April 19-24, 2009 (Colmar, France) Invited

“Spontaneous Enantiomer Separation in Liquid Crystals Composed of Achiral Rod-Shaped

Esters”

- 3) 12<sup>th</sup> Conference on Ferroelectric Liquid Crystals (FLCC2009)  
Sep. 3, 2009 (Zaragoza, Spain) Invited  
“Giant Optical Activity from Nano-Segregated Achiral Rod-like Molecules in the B4 Structure of Achiral Bent-core Molecules”
- 4) International Conference on Organic Nonlinear Optics, International Conference on Organic Photonics and Electronics (ICONO11/ICOPE2009)  
Sep. 23, 2009 (Beijing, China) Invited  
“Liquid Crystal Lasers”
- 5) 9th International Meeting on Information Display (IMID09)  
Oct. 13, 2009 (Seoul, Korea) Invited  
“Liquid Crystal Display Utilizing Bent-core Liquid Crystals: Advantages and Problems”
- 6) Japan-Belgium Polymer Workshop  
Nov. 10, 2009 (Tokyo, Japan) Invited  
“Polymer Liquid Crystals for Photonic Devices”
- 7) Tsinghua Univ. – Tokyo Tech – Xiamen Univ. Joint Symp. on Advanced Materials  
Nov. 23, 2009 (Xiamen, China) Invited  
“Liquid Crystal Polymer for Photonic Devices”
- 8) Japan-Korea Liquid Crystal Workshop  
Jan. 14, 2010  
“Anchoring Transition –Physics and Application –“
- 9) Advanced Polymeric Materials and Technology Symposium (AMPY2010)  
Jan. 24, 2010 (Jeju, Korea)  
“Liquid Crystal Polymers for Photonic Devices”

#### Domestic conferences

- 1) 日本化学会 89 回年会春期講演会 産学連携プログラム  
March 27-28, 2009 (日大船橋) 招待講演  
「液晶フォトリソグラフィデバイス」
- 2) M&BE 分科会講習会  
Nov. 10, 2009 (東京) 招待講演  
「液晶レーザー 現状と課題」

#### Invited Presentations in Universities and Companies

- 1) LG Yokohama Lab., Yokohama, Feb. 25, 2009  
“Perfluoropolymer CYTOP –Novel Surface for Liquid Crystal Alignment–“

- 2) KU Leuven, Leuven, Belgium, May 6, 2009  
“Liquid Crystal Photonic Devices”
- 3) KU Leuven, Leuven, Belgium, May 7, 2009  
“Spontaneous Deracemization in Nonchiral Liquid Crystals”
- 4) KU Leuven, Leuven, Belgium, May 8, 2009  
“Switchable Columnar Liquid Crystals”
- 5) Kwangwoon Univ., Seoul, Oct. 15, 2009  
“Science and Application in Liquid Crystals”
- 6) LG Displays, Paju, Oct. 15, 2009  
“Flexoelectric Effect and its Display Application”
- 7) Ewha Womens Univ., Seoul, Oct. 16, 2009  
“Liquid Crystal Photonic Devices”
- 8) Center for Liquid Crystal Research, Bangalore, India, Dec. 23, 2009  
“Spontaneous Deracemization in Bent-, Rod- and Disk-shaped Mesogens”
- 9) Raman Research Institute, Bangalore, India, Dec. 24, 2009  
“Spontaneous Deracemization in Bent-, Rod- and Disk-shaped Mesogens”
- 10) Hyderabad Univ., Hyderabad, India, Dec. 30, 2009  
“Liquid Crystal Photonic Devices”
- 11) SungKyunKwan University, Seoul, Jan. 14, 2010  
“Liquid Crystal Photonic Devices”
- 12) 産総研九州センター、鳥栖、Feb. 22, 2010  
“液晶フォトニックデバイス”
- 13) 九州大学先導研究所、福岡、Feb. 23, 2010  
“液晶の不思議 –最近の話題から–”

#### 4. Patent applications

発明の名称：回折格子及びそれを用いた有機 EL 素子、並びにそれらの製造方法

発明者：竹添秀男、ク ウオンへ、西村涼、鄭旬紋

出願人：国立大学法人東京工業大学、新日本石油株式会社

出願番号：特願 2009-168056

提出日（出願日）：2009/7/16