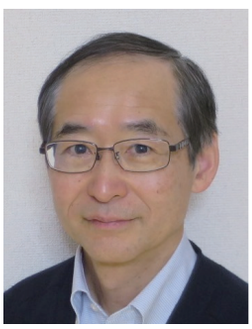
Plenary Lecture I

14:00-14:40, October 28, Monday

Chair: Prof. Wen-Chang Chen (National Taiwan University, Taiwan)



New Photoalignment and Morphing Strategies in Liquid Crystalline Polymer Films

Prof. Takahiro Seki

Department of Molecular and Macromolecular Chemistry,
Graduate School of Engineering,
Nagoya University, Japan

Abstract

The surface photoalignment of liquid crystal (LC) materials has extensively been achieved on solid surfaces, which now constitutes an important area in LC display fabrication industry. We have recently developed a new strategy to control the alignment of LCs from the free (air) surface side.[1] A photoresponsive skin layer at the free surface is prepared on LC polymer films by surface segregation or inkjet printing of an azobenzene (Az)-containing photoresponsive LC polymer. The non-photoresponsive mesogens up to 10 mm thickness can be achieved by a photoresponsive skin layer of 20 nm thickness existing at the free surface. Inkjet drawing followed by irradiation with linearly polarized visible light provided a clear patterned birefringent image ascribed to a homeotropic-homogeneous alignment patterning.[1]

Reversible control of the mesogen orientation between the homeotropic and planar modes were also possible by alternative irradiation with UV and visible light in suitable temperature conditions.[2] The mesogen alignment changes could be repeated at least several times. This reversible photoalignment process can be compared with the original command layer system on the solid surface initiated by Ichimura et al. in 1988.[3]

In this presentation, some other recent attempts will also be provided on the polymer processing procedures based on the free surface stragegy such as formation of high density polymer brush via surface segregation and self-assembly4 and photoinitiated Marangoni flow that takes place at inkjet printed areas on LC polymer surfaces. The latter can be proposed as a new microfabrication procedure (Figure 1).[5]

Acknowledgment: These projects have been performed with great efforts of research associates and students shown in the references.

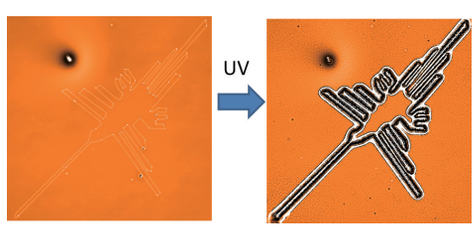


Figure 1. Photoinduced Marangoni flow on azobenzene side chain LC polymer film processed at inkjet-printed regions.[5]

References:

[1] K. Fukuhara, S. Nagano, M. Hara, and T. Seki, ***Nat. Commun***. 2014, 5, 3320 (2014); T. Seki, Polym. J. (review) 2014, 16, 751: S. Nagano, Lagnmuir (Future Article), 2019, ASAP.

[2] T. Nakai, D. Tanaka, M. Hara, S. Nagano, T. Seki, ***Langmur*** 2016, 32, 909.

[3] K. Ichimura, Y. Suzuki, T. Seki, A. Hosoki, K. Aoki, ***Langmuir*** 1988, 4, 1214.

[4] K. Mukai, M. Hara, S. Nagano, ***Angew. Chem. Int. Ed.*** 2016, 55, 14028.

[5] I. Kitamura,K. Oishi, M. Hara, S. Nagano, T. Seki, ***Sci. Rep***. 2019, 9, 2556

Plenary Lecture II

14:40-15:20, October 28, Monday

Chair: Prof. Hiroyuki Nishide (Waseda University, Japan)

Conjugated Molecules and Polymers Containing 1,5-Naphthyridine-2,6-dione (NTD): Novel Bis-lactam Structure for Higher Crystallinity and Enhanced Light Absorption

Prof. Soo Young Park

Department of Materials Science and Engineering, College of Engineering
Seoul National University, Korea

Abstract

In the design of organic electronics materials, bis-lactam units have long been exploited as an efficient electron acceptor moiety with appropriate frontier molecular orbital energies. While the typical bis-lactam structures like diketopyrrolopyrrole (DPP) and isoindigo(IID) units had successfully been utilized for the high performance organic semiconductors, we came to notice that they render somewhat limited molecular planarity and oscillator strength when connected to the lateral conjugated units like thiophene. In this context, we have designed and synthesized a series of high performance organic molecules and polymers containg a novel fused bis-lactam structure of 1,5-naphthyridine-2,6-dione laterally flanked by two thiphene units (NTDT).[1,2] Based on the single crystal structure and photophysical properties, NTDT was shown to have outstanding molecular planarity, tight stacking, and high oscillator strength. Indeed, the D-A polymers containing NTDT as the acceptor unit were synthesized to show 9.63% PCE. [2,3] It was also shown that NTDT is an excellent organic semiconductor with a transistor hole mobility of 1.29 $cm^2V^{-1}s^{-1}$. [4]

References:

[1] T. M. Swager et al., ***Synfacts*** 2017, 13, 0153; https://doi.org/10.1055/s-0036-1589928

[2] W. Yoon et al., ***Macromolecules*** 2016, 49, 8489-8497; https://doi.org/10.1021/acs.macromol.6b01680

[3] W. Yoon et al., ***Adv. Energy. Mat.*** 2017, 8, 1701467, https://doi.org/10.1002/aenm.201701467

[4] J. H. Kim et al., ***ACS Applied Materials & Interfaces***, 2019, 11, 8301−8309; https://doi.org/10.1021/acsami.8b20168

Plenary Lecture III

09:00-09:40, October 29, Tuesday

Chair: Prof. Jungahn Kim (Kyung Hee University, Korea)

Nano Carbon and Polymeric Materials for Energy Conversion and Storage

Prof. Yongsheng Chen

The College of Chemistry and School of Materials Science and Engineering,
Nankai University, China

Abstract

Green energy technologies have been highly demanded for a sustainable development. In this talk, our recent studies for the electricity conversion/storage using nano carbon and polymeric materials will be presented. These will include the material design, synthesis, and device fabrication, targeting for high energy efficiency and understanding the mechanism using simpler or cheap materials.

References:

[1] “Super-elasticity of three-dimensionally cross-linked graphene materials all the way to deep cryogenic temperaturas”, Kai Zhao1,2,*, Tengfei Zhang1,2,*, Huicong Chang1,2, Yang Yang1,2, Peishuang Xiao1,2, Hongtao Zhang1,2, Chenxi Li1,2, Chandra Sekhar Tiwary3, Pulickel M. Ajayan3,† and Yongsheng Chen1,2,† ***Science Advances***, 2019, 5(4), eaav2589.

[2] "A Tandem Organic Solar Cell with PCE of 14.52% Employing Subcells with the Same Polymer Donor and Two Absorption Complementary Acceptors", Lingxian Meng, Yuan-Qiu-Qiang Yi, Xiangjian Wan,* Yamin Zhang, Xin Ke, Bin Kan, Yanbo Wang, Ruoxi Xia, Hin-Lap Yip, Chenxi Li, and Yongsheng Chen* , ***Adv. Mater***, 2019, 1804723.

[3] "Organic and solution-processed tandem solar cells with 17.3% efficiency", Lingxian Meng, Yamin Zhang, Xiangjian Wan*, Chenxi Li, Xin Zhang, Yanbo Wang, Xin Ke, Zuo Xiao, Liming Ding*, Ruoxi Xia, Hin-Lap Yip, Yong Cao, Yongsheng Chen*, ***Science,*** 2018, 361, 1094-1098.

[4] "Monolithic 3D Cross-linked Polymeric Graphene Materials and the Likes: Preparation and Their Redox Catalytic Applications", Yanhong Lu, Yanfeng Ma, Tengfei Zhang, Yang Yang, Lei Wei, and Yongsheng Chen , ***J. Am. Chem. Soc.,*** 2018, 140 (37), pp 11538–11550.

[5] “Macroscale light propulsion of 3D cross-linked graphene”, Tengfei Zhang†, Huicong Chang†, Yingpeng Wu†, Peishuang Xiao, Ningbo Yi, Yanhong Lu, Yanfeng Ma, Yi Huang, Kai Zhao, Xiaoqing Yan, Zhibo Liu, Jianguo Tian and Yongsheng Chen*, ***Nature Photon.,*** 2015, 9, 471-476.

Plenary Lecture IV

15:40-16:20, October 30, Wednesday

Chair: Prof. S. Ramakrishnan (Indian Institute of Science, India)

Achieving High Performance Organic Solar Cells with Ladder-Type Conjugated Polymers and Non-Fullerene Acceptors

Prof. Chain-Shu Hsu

Department of Applied Chemistry,
Center for Emergent Functional Matter Science,
National Chiao Tung University, Taiwan

Abstract

Polymer solar cells (PSCs) are a promising alternative for clean and renewable energy due to their potential to be fabricated onto large area, light-weight flexible substrates by solution processing at low cost. Our recent progress in the molecular design of p-type conjugated polymers containing multi-fused ladder-type structure and the n-type fullerene derivatives containing cross-linkable styryl or epoxy groups will be presented. Both ladder-type conjugated polymers and n-type fullerene derivatives are used to fabricate high efficient bulk heterojunction PSCs and organic thin film transistors (OTFTs). The cross-linkable fullerene derivatives are also used to fix the morphology of bulk heterojunction (BHJ) layer so as to improve the stability of PSCs. Furthermore, several series of non-fullerene acceptors (NFAs) containing heptacyclic dithienocyclopentacarbazole (DTC)-based cores were synthesized and blended with J71, PBDB-T and PBDB-TF of which featuring complementary absorption and well-matched energy levels. Side-chain engineering strategy was used to design the first two NFAs, DTC(4Ph)-IC and DTC(4R)-IC which contain four alkylphenyl side chains and four alkyl side chains on the DTC unit, respectively. Fluorination approach was used to design the other two NFAs, DTC(4Ph)-4FIC and DTC(4R)-4FIC which contain four fluorine atoms on the IC units. The non-fullerne acceptors were blended PBDB-TF to fabricate PSCs with a PCE value higher than 15 %.

References:

[1] Y. J. Cheng, S. H. Yang, C. S. Hsu, ***Chem Rev.*** 109, 5868 (2009).

[2] C. H. Hsieh, Y. J. Cheng, P. J. Li, C. H. Chen, M. Dubosc, R. M. Liang and C. S. Hsu, ***J. Am. Chem. Soc.*** 132, 4887 (2010).

[3] Y. J. Cheng, C. H. Hsieh, Y. He, C. S. Hsu and Y. F. Li. ***J. Am. Chem. Soc.*** 132, 17381 (2010).

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[5] J.-S. Wu, Y.-J. Cheng, T.-Y. Lin, C.-Y. Chang, P.-I. Shih, C.-S. Hsu, ***Advanced Functional Materials.*** 22, 1711 (2012).

[6] Y.-Y. Lai, Y.-J. Cheng, C.-S. Hsu, ***Energy & Environmental Science. 7,*** 1866 (2014).

[7] C. H. Li, C. C. Chang, Y. H. Hsiao, S. H. Peng, Y. J. Su, S. Heo, K. Tajima, M. C. Tsai, C. Y. Lin, C. S. Hsu, ***ACS Appl Mater Interfaces. 11***, 1,1156 (2019).

[8] T.-W. Chen, Y.-T. Hsiao, Y.-W. Lin, C.-C. Chang, W.-T. Chuang, Y. Li, C.-S. Hsu, ***Mater. Chem. Front. 3,*** 829 (2019).