School Seminar (2015-24)

School of Materials Science & Engineering

"Functional Organic Molecules and Conjugated Polymers for Optoelectronic and Biosensor Application"

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(Dept. of Materials Science & Engineering, Univ. of Michigan)

2015. 08. 19. (Wed.) 16:00

APRI 1F, Auditorium Hall

Functional Organic Molecules and Conjugated Polymers for Optoelectronic and Biosensor Application

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Abstract

Conjugated polymers (CPs) are emerging materials for many useful applications due to their readily tunable properties by variation of their chemical structure. Their optoelectronic applications, such as solar cells, LED, and sensors have gained much interest recently. In this presentation, the design principle of self-signaling and signal amplifying CP sensors for the detection of various chemicals and clinically important biomolecules, such as mercury, potassium, prostate specific antigen, nerve agents, melamine, influenza virus, and antibiotics, will be discussed.[1-3] Our recent development of highly emissive and metal-free purely organic phosphorescence materials will also be presented. Directed intermolecular heavy atom effects are uniquely implemented in aromatic carbonyl molecules to promote spin-orbit coupling and suppress vibrational dissipation. Color tuning by electron density modulation and a prototype PhOLED have been demonstrated.[4-6] Our recent effort for flexible solar cells and high performance plastic electronics by molecular design and directed self-assembly and alignment of CPs is another topic of discussion. The optical and electronic properties of CPs, such as absorption, emission, and conductivity, are highly anisotropic due to the 1-dimensional nature of the conjugated polymer backbone. These unique optoelectronic properties can be fully utilized in device applications only when the conjugated chains are aligned. We recently developed lyotropic liquid crystalline CPs and achieved nanoscopic and macroscopic arrangement and alignment and demonstrated more than 1600 times faster charge carrier mobility along the CP alignment direction than the perpendicular to the alignment direction in a thin film transistor (TFT).[7] If time allows, a recent development of high thermal conductivity in amorphous polymer thin film and shear-triggered lighting-up crystallization of thermally stable organic supercooled liquid will be also briefly discussed.[8,9]

References

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2. Kangwon Lee, Jiseok Lee, Eun Jeong Jeong, Adam Kronk, Kojo Elenitoba-Johnson, Megan S. Lim, Jinsang Kim "Conjugated Polyelectrolyte-Antibody Hybrid Molecules for Live Cell Imaging" ***Adv. Mater.*** **2012**, *24*, 2479.
3. Jiseok Lee, Hyong-Jun Kim, Jinsang Kim "Polydiacetylene Liposome Arrays for Selective Potassium Detection" ***J. Am. Chem. Soc.*** **2008**, *130*, 5010.
4. Onas Bolton, Kangwon Lee, Hyong-Jun Kim, Kevin Lin, Jinsang Kim "Activating Efficient Phosphorescence from Metal-free Organics by Crystal Design" ***Nature Chemistry*** **2011**, *3*, 205.
5. Dongwook Lee, Bolton Onas, Byoung Choul Kim, Ji Ho Youk, Shuichi Takayama, Jinsang Kim "Room Temperature Phosphorescence of Metal-free Organic Materials in Amorphous Polymer Matrices" ***J. of Am. Chem. Soc.*** **2013**, *135*, 6325.
6. Min Sang Kwon[+], Dongwook Lee[+], Sungbaek Seo, Jaehun Jung, Jinsang Kim "Engineering Intermolecular Interactions for Efficient Room Temperature Phosphorescence from Purely Organic Materials in Amorphous Polymer Matrices" ***Angew. Chem. Int. Ed.*** **2014**, *53*, 11177.
7. Bong-Gi Kim, Eun Jeong Jeong, Jong Won Chung, Sungbaek Seo, Bonwon Koo, Jinsang Kim "A Molecular Design Principle of Lyotropic Liquid-Crystalline Conjugated Polymers with Directed Alignment Capability for Plastic Electronics" ***Nature Materials*** **2013**, *12*, 659.
8. Gun-Ho Kim[+], Dongwook Lee[+], Apoorv Shanker[+], Lei Shao, Min Sang Kwon, David Gidley, Jinsang Kim* and Kevin Pipe* "High thermal conductivity in amorphous polymer blends by engineered interchain interactions" ***Nature Materials*** **2014**, *14*, 295.
9. Kyeongwoon Chung, Min Sang Kwon, Brendan Leung, Antek Wong-Foy, Min Su Kim, Jeongyong Kim, Shuichi Takayama, Johannes Gierschner, Adam Matzger, Jinsang Kim "Shear-triggered Crystallization and Light Emission of a Thermally Stable Organic Supercooled Liquid" ***ACS Central Science*** **2015**, *1*, 94.

Biography

Jinsang Kim is a Professor of Materials Science and Engineering having a joint appointment in the Chemical Engineering, Biomedical Engineering, Macromolecular Science and Engineering, and Chemistry at the University of Michigan, Ann Arbor. He holds a M.S (1993) and a B.S. (1991) from Seoul National University, Korea, both in Fiber and Polymer Science. He earned his Ph.D. in 2001 in Materials Science and Engineering from MIT, where he studied the design, synthesis, and assembly of conjugated sensory polymers and energy transport properties in the controlled structures. He is also an expert in genetically engineered protein research. His postdoctoral work in this area at Caltech involved the expression of artificial genes to determine the extent to which artificial genetic information can be used to encode supramolecular assembly in macromolecular systems.

He has won several prestigious awards including 2007 NSF CAREER Award, 2006 Holt Award for excellent teaching, 2002 IUPAC Prize for Young Chemist, 2002 ACS ICI Award, and 2000 MRS Graduate Student Gold Award. He was also named one of emerging investigators by the journal of materials chemistry in 2007. His current research interests at the UM are self-signal amplifying molecular biosensors, flexible solar cells, highly emissive organic emitters, and high performance polymers. His research has been sponsored by NSF BES, NSF ECS, NSF DMR, AFOSR, ARO, DoE, ACS, KIMM, KRF, QIA, Qatar NPRP, Samsung, and Center for Chemical Genomics.

Selected Recent Publications:

1. Kyeongwoon Chung, Min Sang Kwon, Brendan Leung, Antek Wong-Foy, Min Su Kim, Jeongyong Kim, Shuichi Takayama, Johannes Gierschner, Adam Matzger, Jinsang Kim "Shear-triggered Crystallization and Light Emission of a Thermally Stable Organic Supercooled Liquid" ***ACS Central Science*** **2015**, *1*, 94.
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3. Min Sang Kwon[+], Dongwook Lee[+], Sungbaek Seo, Jaehun Jung, Jinsang Kim "Engineering Intermolecular Interactions for Efficient Room Temperature Phosphorescence from Purely Organic Materials in Amorphous Polymer Matrices" ***Angew. Chem. Int. Ed.*** **2014**, *53*, 11177.
4. Dongwook Lee, Bolton Onas, Byoung Choul Kim, Ji Ho Youk, Shuichi Takayama, Jinsang Kim "Room Temperature Phosphorescence of Metal-free Organic Materials in Amorphous Polymer Matrices" ***J. of Am. Chem. Soc.*** **2013**, *135*, 6325.
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