Scientific HiFunMat Seminar

The past, present, and prospects of organic optoelectronics

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Abstract.

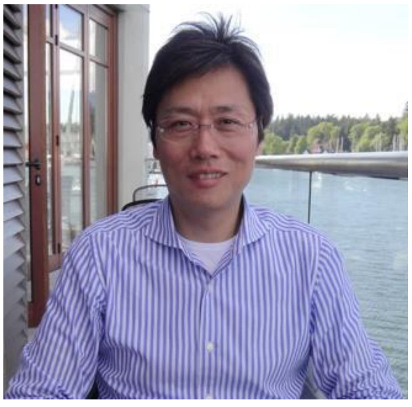
Through the extensive R&D of organic light-emitting diodes (OLEDs) for more than 30 years, plenty of well-elaborated novel organic optoelectronic materials and device architectures have been extensively developed, resulting in the unique commercial utilization of OLEDs for cutting-edge smartphones, large-area TVs, and further new future display applications by taking advantage of light-weight and flexibility.

From the aspect of materials science, the creation of novel light-emitting materials in OLEDs has been the central issue aimed at high electroluminescence quantum efficiency (EQE). Starting from the development of conventional fluorescence materials (**1st generation**) during 1990-2000th, the room-temperature phosphorescence (2000-) (**2nd generation**) and thermally activated delayed fluorescence (TADF) (2012-) (**3rd generation**) continuously pioneered the novel possibilities of organic emitters, resulted in not only high-performance OLEDs but also enriched organic photochemistry. Recently, there have been a wide variety of studies on TADF-OLEDs because of the unlimited possibilities of TADF molecular design. Further, hyperfluorescence (HP)-OLEDs have been developed since they can realize the compatibility of high efficiency and narrow spectral width, which is ideal for practical display applications.

Here we report our recent cutting-edge HP-OLEDs demonstrating high OLED performance by optimizing host, TADF, and terminal emitter (TE) molecules1-3). In particular, we focus on the blue-emission, which can show narrow FWHM and high EL quantum yield. Blue HP-OLEDs based on two new TEs are fabricated, resulting in high external quantum efficiency (EQE) of over 20%, high color purity, and high brightness. By analyzing the transient PL characteristics of the HP-OLEDs, we found the presence of efficient FRET between TADF-assistant dopant (TADF-AD) and TE molecules. Further, transient EL analysis confirmed that a smaller *E*HOMO difference between TADF-AD and TE efficiently helps to decrease hole trapping inside the emitting layer, hence resulting in a lower efficiency rolloff and a longer operational device lifetime. This report provides a designing principle for a TADF and TE in HP-OLEDs with well-matched energy levels, leading to efficient FRET and no significant carrier trapping.

In my talk, we will mention the importance of the charge transfer (CT) phenomenon in designing high-performance organic luminescent molecules in OLEDs. Also, CT issues play a crucial role in maximizing the device's operation. Further, we will outlook the prospect of advanced CT technologies.

References:
[1] C-Y. Chan et al., *Nature Photonics*, **15**, 203 – 207 (2021).
[2] Y-T. Lee et al., *Advanced Electronic Materials*, **7**, 4, 2001090 (2021).
[3] M. Tanaka et al., *ACS Applied Materials & Interfaces*, **12**, 45, 50668 – 50674 (2020).



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Chihaya Adachi is a distinguished professor at Kyushu University and director of Kyushu University's Center for Organic Photonics and Electronics Research (OPERA). He is also the director of the Fukuoka i3 Center for Organic Photonics and Electronics Research. Chihaya Adachi obtained his doctorate in Materials Science and Technology in 1991 from Kyushu University and held positions at the Chemical Products R&D Center at Ricoh Co., the Department of Functional Polymer Science at Shinshu University, the Department of Electrical Engineering at Princeton University, and Chitose Institute of Science and Technology before returning to Kyushu University as a professor.

Adachi's research combines the areas of chemistry, physics, and electronics to advance the field of organic light-emitting materials and devices from both the materials and device perspectives through the design of new molecules with novel properties, the study of processes occurring in individual materials and complete devices, and the exploration of new device structures, and he has co-authored over 600 research papers.

Recent awards he has received include the 24th Nagoya of Organic Chemistry "The silver medal " (2019), Nishina Memorial Prize (2017) and Thomson Reuters Research Front Award (2016), and he was named a 2018 • 2019 • 2020 • 2021 Highly Cited Researcher.