Organic light emitting diodes operated by 1.5 V battery

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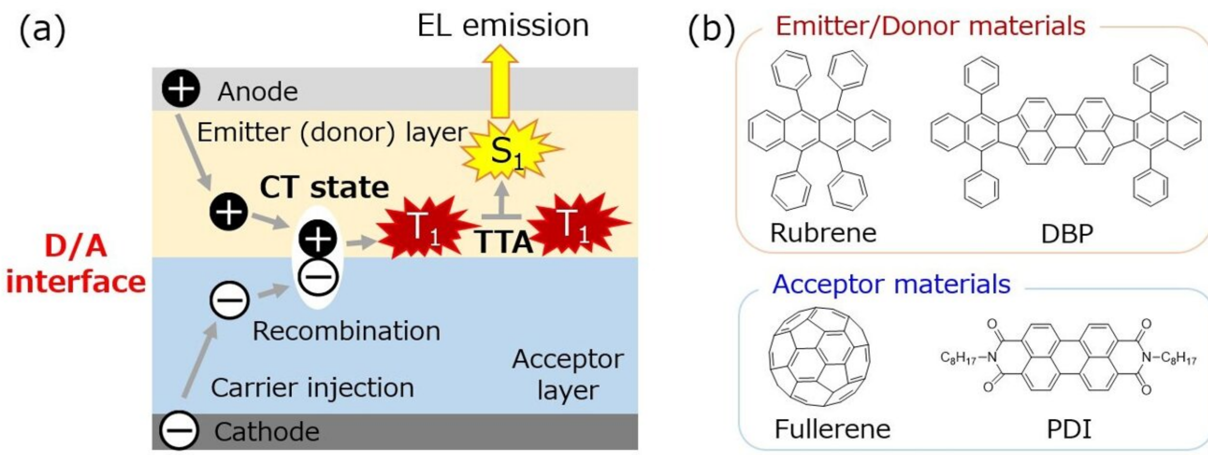

Fig. 1 (a) Schematic of the device structure and the operating mechanism of OLEDs. (b) Chemical structures. Credit: NINS/IMS

Researchers at Institute for Molecular Science, and University of Toyama, in Japan, report an efficient organic light emitting diode (OLED) operable by a 1.5-V battery that produces bright emission equivalent to luminance of a typical display. The OLED is based on the up-conversion transition associated with triplet–triplet annihilation that doubles the energy of excited states.

Properties of organic light-emitting diodes (OLEDs) have been optimized, including current-to-photon conversion efficiency. An external quantum efficiency exceeding 20 percent, with internal quantum efficiency of 100 percent, has been achieved owing to the development of thermally activated delayed fluorescent and phosphorescent materials that manage the spin of excited states. However, the operating voltage of common types of OLEDs is very high; that of an OLED emitting approximately 600 nm light at a luminance of 100 cd/m^2, which is a general display condition, is as high as 4.5 V.

The group of Assistant Professor Seiichiro Izawa and Professor Masahiro Hiramoto at the Institute for Molecular Science , and Associate Professor Masahiro Morimoto and Professor Shigeki Naka at University of Toyama report that the OLED has a smaller turn-on voltage at 0.97 V than the optical energy of emitted photons at 2.04 eV (608 nm). This is because the OLED is based on the up-conversion (UC) transition associated with triplet–triplet annihilation that doubles the energy of excited states (Fig. 1). They reveal that the characteristics of charge transfer (CT) state at the interface are key to efficient UC, and the percentage of excited states deactivated by parasitic loss processes during the UC transition is significantly reduced from over 90 percent to approximately 10 percent by introducing a highly crystalline acceptor material and an emissive dopant. Consequently, the UC-OLED reaches 100 cd/m^2 at a voltage and emission wavelength of 1.33 V and 608 nm (2.04 eV), respectively (Fig. 2a). This is the lowest operating voltage reported for an OLED that achieves a luminance of 100 cd/m^2. It was further demonstrated that the UC-OLED can be operated by a 1.5-V battery to realize luminance of 177 cd/m^2 (Fig. 2b).

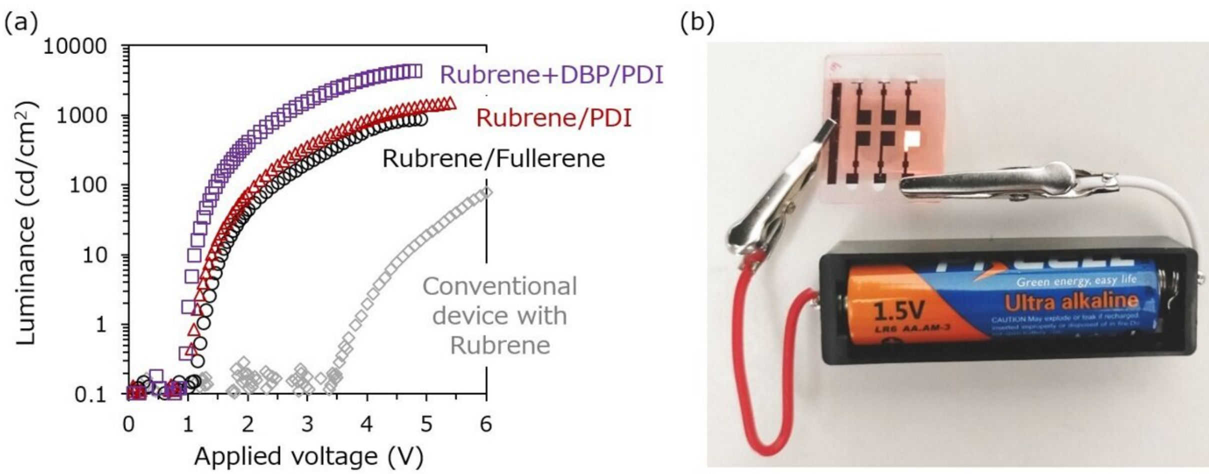

Fig. 2 (a) Luminance–voltage curves for OLEDs. (b) Photograph of an OLED operated by a 1.5-V battery. Credit: NINS/IMS

More information: Seiichiro Izawa et al, Efficient Interfacial Upconversion Enabling Bright Emission at an Extremely Low Driving Voltage in Organic Light-Emitting Diodes, *Advanced Optical Materials* (2022). [DOI: 10.1002/adom.202101710](https://dx.doi.org/10.1002/adom.202101710)

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