Efficient Thermally Activated Delayed Fluorescence Molecules Utilizing Donor-Acceptor Structure and Their Application for Highly Efficient Organic Light Emitting Diodes

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論 文 名：Efficient Thermally Activated Delayed Fluorescence Molecules Utilizing Donor-Acceptor Structure and Their Application for Highly Efficient Organic Light Emitting Diodes
(電子ドナーと電子アクセプター連結構造を用いた熱活性型遅延蛍光材料の開発と高効率有機ELデバイスの実現)

区　　分　：甲

論 文 内 容 の 要 旨

In this thesis, I proposed a new scheme to obtain high efficiency blue OLEDs employing thermal activated delayed fluorescence (TADF). The photoluminescence (PL) and electroluminescence (EL) mechanisms of TADF were introduced in Chapter 1.

In Chapter 2, bluish green to red TADF emission was demonstrated from four pretwisted intramolecular charge-transfer (CT) molecules that have the same donor of 5-phenyl-5,10-dihydrophenazine (PPZ) but different acceptor units. These compounds have small singlet–triplet CT state splitting but different energy relationships between their CT triplet (^{3}CT) and locally-excited triplet (^{3}LE) states. The lowest-energy triplet (T_1) state of PPZ-TRZ is a ^{3}CT state, while those of the other three emitters were ^{3}LE states localized on a PPZ unit. However, the ^{3}CT state of PPZ-DPO was found to be close to its ^{3}LE state. As a result, PPZ-TRZ and PPZ-DPO emitted short-lifetime TADF, and devices using them as emitters showed reduced efficiency roll-off at high current density. In contrast, the large energy difference (ΔE_{ST}) between the T_1 states and lowest-energy singlet states (S_1) in PPZ-3TRZ and PPZ-4TRZ led to inefficient energy up-conversion from their T_1 to S_1 states and very long TADF lifetimes in doped films. Organic light-emitting diodes (OLEDs) using them also suffered serious efficiency roll-off.

In Chapter 3, blue and bluish green TADF emission was demonstrated from four monomeric and dimeric carbazolylcyanobenzenes. By changing the substitution position of the cyano groups on the phenyl rings, the twisting angle between the donor and acceptor moieties could be adjusted. Ortho-substitution was found to lead to a larger twisting angle and a more efficient separation of the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO). Of the two dimeric carbazolylcyanobenzenes whose ^{3}LE states are higher than their ^{3}CT states, the 2,6-dicyano substituted derivative (3-bis-2-CzIPN) had a smaller ΔE_{ST}, a faster TADF decay rate, and a reduced EL efficiency roll-off at high current density compared to the analogous 3,5-dicyano substituted derivative (3-bis-5-CzIPN).

In Chapter 4, the PL and EL properties of three blue-emitting TADF compounds were investigated in detail. These three bipolar molecules have the same acceptor unit of diphenylsulphone (DPS) but different donor units of 3,6-di-tertbutylcarbazole (BCZ), 1,4-dimethyl-9H-carbazole (DMCZ) or 9,9-dimethyl-9,10-dihydroacridine (DMAC). The device based on DMAC–DPS, which can emit efficient and short-lifetime TADF, exhibited an external quantum efficiency of 19.5% and reduced efficiency roll-off characteristics at high luminance comparable to those of today's best blue phosphorescent OLEDs, confirming that TADF materials can realize high-performance blue OLEDs.

Finally, the research is summarized in Chapter 5.

〔作成要領〕

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