

High-performance near-infrared organic light-emitting materials and devices

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1. Introduction

As the extension of visible light, near-infrared (NIR) emitting materials have aroused growing interests due to their great potential for applications spanning from military night-vision displays and information-secured devices to civilian medical diagnostics and phototherapy [1]. However, the development of highly efficient, stable, and low-cost organic NIR-emitting materials is still a formidable challenge according to the energy-gap law. We have developed two classes of novel organic NIR-emitting materials including Ir(III) complexes with extensively π -conjugated ligands and purely organic NIR dyes with high quantum yields.

2. NIR-emitting Ir(III) complexes

Since 2009, we have designed and synthesized series of NIR-emitting Ir(III) complexes based on highly conjugated benzo[g]quinoline, benzo[g]quinoxaline and benzo[g]phthalazine ligands and the NIR-OLEDs based on those Ir(III) complexes demonstrated maximum EQEs up to 4.5% and small efficiency roll-off in the range of 700–900 nm [2,3]. Most notably, the use of benzo[g]-phthalazine derivatives as cyclometalated ligands can allow facile synthesis of homoleptic facial NIR-emitting Ir(III) complexes under mild conditions, thus enabling the successful fabrication of high-performance NIR-OLEDs bearing a peak emission at 760 nm, maximum EQE up to 4.5% with small efficiency roll-off, and high NIR radiance of 4.5 mW/cm², which are amongst the most efficient values for NIR-OLEDs over 750 nm. Importantly, the content percentages of the noble metal in our Ir complexes (~10% Ir) are markedly lowered by about two-thirds than that of typical green-emitting tris(2-phenylpyridine) iridium (~30% Ir)[3].

3. NIR-emitting purely organic materials

Given that the price and rarity of noble metals would limit their mass production and future application, approaches to utilize the 75% triplet excitons of organic fluorescent materials are highly desirable to enable highly efficient NIR-OLEDs with cost advantage. Recently, we realized high-efficiency and low efficiency roll-off fluorescent NIR-OLEDs through efficient triplet fusion of a bipolar host with a special naphthoselenadiazole (NSeD) emitter [4]. By using a thermally activated delayed fluorescence (TADF) material as the sensitizing host and a novel NIR dye TPANSeD, we further improved the device

performances with EQE of up to 2.65% at 730 nm [5]. More recently, we proposed and confirmed a novel design strategy for realizing highly efficient TADF materials via J-aggregates with strong intermolecular charge transfer [6]. These OLEDs exhibit EQE of 15.8% for red emission and 14.1% for NIR emission, which are amongst the best results for NIR-OLEDs based on TADF materials. These findings would open a new avenue for the development of high-efficiency organic emissive materials and devices based on molecular aggregates.

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5. References and Citations

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