Molecular Interactions in Donor-Acceptor-Donor Skeletons Toward Near-Infrared Organic Lasers

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Organic semiconductor lasers (OSLs) have attracted much interest in the past few decades owing to their unique merits, such as flexibility, lightweight, and feasible chemical tunability. In particular, organic lasing dyes possessing small energy gaps commonly suffer from high thresholds because of the energy-gap law, which induces detrimental nonradiative relaxation. Herein, novel lasing molecules based on alternating donor (D) and acceptor (A) moieties were described. The linear molecules have a D-A-D skeleton where the functional spacer was inserted between D-A. Color-tunable lasing properties from yellow to near-infrared (NIR) wavelengths were obtained via modifying A cores. In more detail, triphenylamine (TPA) was selected as the D moiety, while benzothiadiazole (BTD) and benzo[1,2-c:4,5c′]bis[1,2,5]thiadiazole (BBTD) with strong electron-withdrawing capability were chosen as A cores for yellow [(TPA-F)$_2$BTD] and NIR [(TPA-F)$_2$BBTD] lasing dyes, respectively. Both dyes exhibited high photoluminescence quantum yields and fast fluorescence radiative rates. The corresponding amplified spontaneous emission (ASE) thresholds of yellow and NIR dyes were evaluated as low as 0.5 and 3.8 μJ cm^{-2} with wavelength peaks at 550 and 811 nm, respectively. When incorporating optical resonators, the corresponding yellow and NIR lasers were realized with ~1.0 μJ cm^{-2} thresholds, which are one of the lowest values ever reported. Therefore, such promising molecular design allows the realization of color-tunable lasing toward NIR emission with very low thresholds.

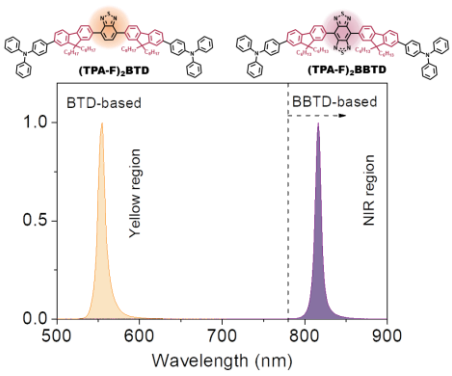

Figure 1. Molecular structures of (TPA-F)$_2$BTD and (TPA-F)$_2$BBTD, and the corresponding ASE spectra ranging from yellow to NIR emission.

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