Flavin as Photo-Active Acceptor for Efficient Energy and Charge Transfer in a Model Donor-Acceptor System

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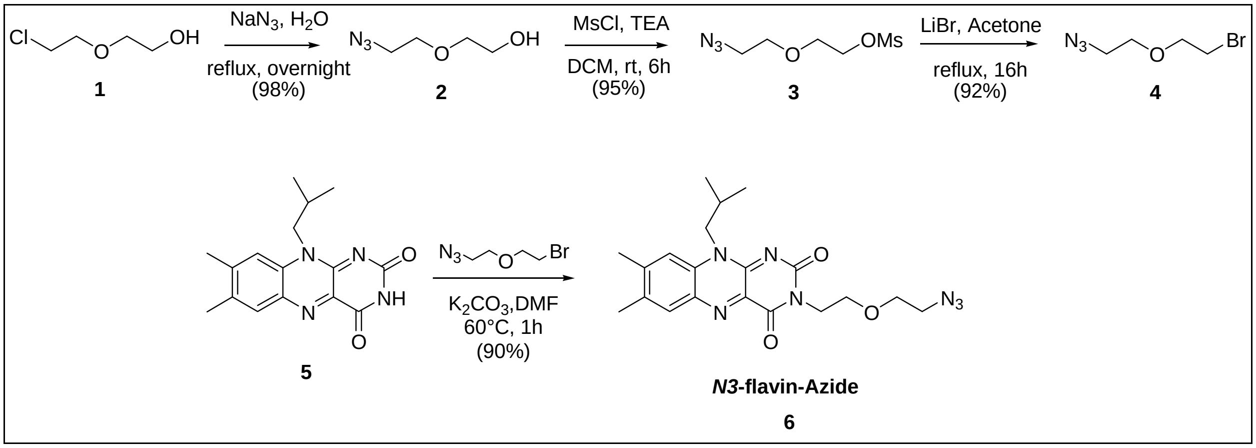


Scheme-S1. Synthetic scheme for the synthesis of compound **6**.

Synthesis of compound 2:

2-(2-Chloroethoxy)ethanol **1** (40 mmol) and sodium azide (20 mmol) in 100 ml H_2O were heated under reflux overnight. Upon cooling the reaction mixture was extracted with CH_2Cl_2 (3 x 25 ml), the organic layers were combined, washed with brine, anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Yield: 98%.

Synthesis of compound 3:

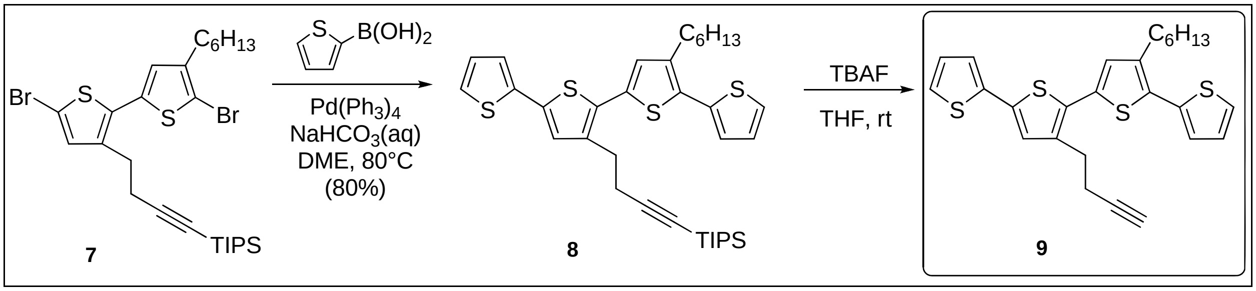
To a solution of **2** (30 mmol) and Et_3N (60 mmol) in dry CH_2Cl_2 (50 ml) at 0 ^{0}C, mesityl Chloride (MsCl, 45 mmol) was added dropwise. Then, reaction was stirred at rt for 6h. The reaction mixture was washed with H_2O. The aqueous phase was extracted with CH_2Cl_2 (3 x 25 ml), and the organic layers were combined, washed with brine, anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Yield: 95%.

Synthesis of compound 4:

Compound **3** (28.5 mmol) and LiBr (84.5 mmol) are refluxed in acetone for 16 h. The reaction mixture was evaporated and washed with H_2O. Aqueous phase was extracted with CH_2Cl_2 (3 x 25 ml), the organic layers were combined, washed with brine, anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Yield: 92%. ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.80 (t, J= 6.2 Hz, 2H), 3.68 (t, J= 5.0 Hz), 3.46 (t, J= 6.2 Hz, 2H), 3.39 (t, J=5.0, 2H).

Synthesis of compound 6 (*N3*-Flavin-Azide):

To a solution of 7,8-dimethoxy-*N10*-isobutylisoalloxazine[1] **5** (1 mmol) and K_2CO_3 (4 mmol) in DMF (5 ml) at 60 °C was added **4** (2 mmol) and the reaction was allowed to proceed overnight. Upon cooling, the reaction was quenched with H_2O and extracted with $CHCl_3$ (3 x 25 ml). The organic layers were combined, washed with brine, anhydrous Na_2SO_4, filtered, and reduced under reverse pressure onto silica gel. The crude product was then purified using flash column chromatography yielding **6.** Yield: 90%. MS(ESI): *m/z* for calcd for $C_{20}H_{25}N_7O_3$ $[M+H]^+$: 412.4679, found 412.0 ^1H NMR (400 MHz, $CDCl_3$): δ 8.07 (s, 1H), 7.40 (s, 1H), 4.62 (b, 2H), 4.40 (t, J=5.6 Hz, 2H), 3.89 (t, J=5.7 Hz, 2H), 3.75 (t, J=5.0 Hz, 2H), 3.35 (t, J=4.9 Hz, 2H), 2.56 (s, 3H), 2.48 (m, 1H), 2.46 (s, 3H), 1.06 (d, J=6.7 Hz, 6H).



Scheme-S2. Synthetic scheme for the synthesis of compound **9**[2].

Synthesis of compound 9:

Suzuki coupling of **7**[3] with commercially available 2-thiophene boronic acid gave **8** in 70% yield. Deprotection of trisopropylsilyl group using TBAF gave **9** in 99% yield. Compound **9** was used without further purification to synthesize dyad OT4-flavin.

Synthesis of Oligothiophene-flavin (OT4-flavin) dyad:

The dyad OT4-flavin was synthesized through the Cu(I)-catalyzed azide–alkyne cycloaddition (CuAAc) reaction[4] between thiophene **9** and *N3*-Flavin-azide **6**. To a round bottom flask, was added $CuSO_4.5H_2O$ (0.185 mmol) and sodium ascorbate (1.0 mmol) followed by the addition of tetrahydrofuran (THF) (15 mL). To this stirred solution, water (5.0 mL) was added followed by the addition of *N3*-Flavin-azide **6** (3.7 mmol) and compound **9** (1.8 mmol). The reaction was stirred for 24 h. The reaction was quenched with water and extracted with ethyl acetate (2x25 mL). The combined organics were washed with water (2x25 mL), brine solution, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification of the residue by silica gel chromatography afforded **OT4-flavin**. Yield: 80%. ^1H NMR (400 MHz, $CDCl_3$): δ 7.97 (s, 1H), 7.51 (s, 1H), 7.32 (dd, J=1.1 Hz, J= 3.9 Hz, 1H), 7.27 (s, 1H), 7.23 (dd, J=1.0 Hz, J= 4.0 Hz, 1H), 7.16 (dd, J=1.0 Hz, J= 2.5 Hz, 1H), 7.12 (dd, J=1.1 Hz, J= 2.4 Hz, 1H), 7.09-7.06 (m, 1H), 7.05-7.01 (m, 1H), 6.93 (s, 1H), 6.91 (s, 1H), 4.50 (t, J= 4.8 Hz, 2H), 4.48 (b, 2H), 4.34 (t, J= 5.2 Hz, 2H), 3.82 (t, J= 4.9 Hz, 2H), 3.78 (t, J= 5.2 Hz, 2H), 3.08-2.98 (m, 2H), 2.97-2.87 (m, 2H), 2.73 (t, J= 7.9 Hz, 2H), 2.47 (s, 3H), 2.42-2.34 (m, 1H), 2.33 (s, 3H), 1.74-1.56 (m, 2H), 1.44-1.24 (m, 6H), 0.98 (d, J= 6.7 Hz, 6H), 0.89 (t, J= 6.9 Hz, 3H). MS(ESI): *m/z* for calcd for $C_{46}H_{51}N_7O_3S_4$ $[M+H]^+$: 901.1898, found 900.6130. ^{13}C NMR ($CDCl_3$, ppm): δ 160.1, 155.6, 149.4, 149.3, 146.6, 140.0, 138.6, 138.4, 137.5, 137.1, 137.1, 137.0, 136.9, 136.6, 135.0, 131.2, 129.2, 128.3, 127.2, 127.1, 126.8, 126.7, 126.6, 125.1, 125.6, 124.5, 121.5, 114.9, 69.1, 68.4, 50.3 50.2, 41.0, 34.8, 32.6, 29.3, 29.1, 28.1, 26.9, 25.1 22.7, 20.7, 19.4, 14.6.

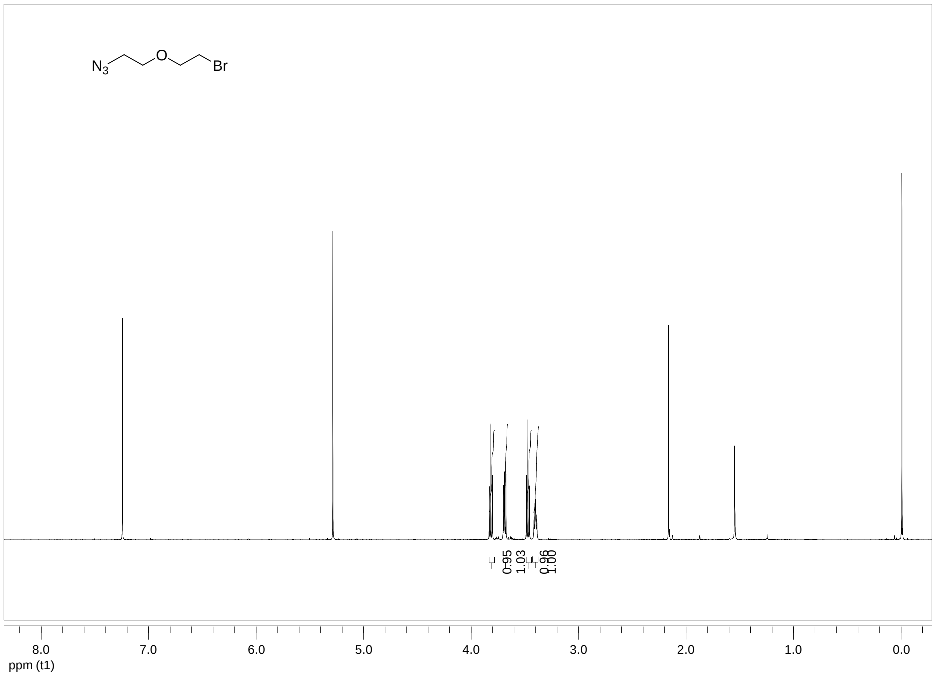


Figure S1. ^1H NMR spectrum of compound **4**

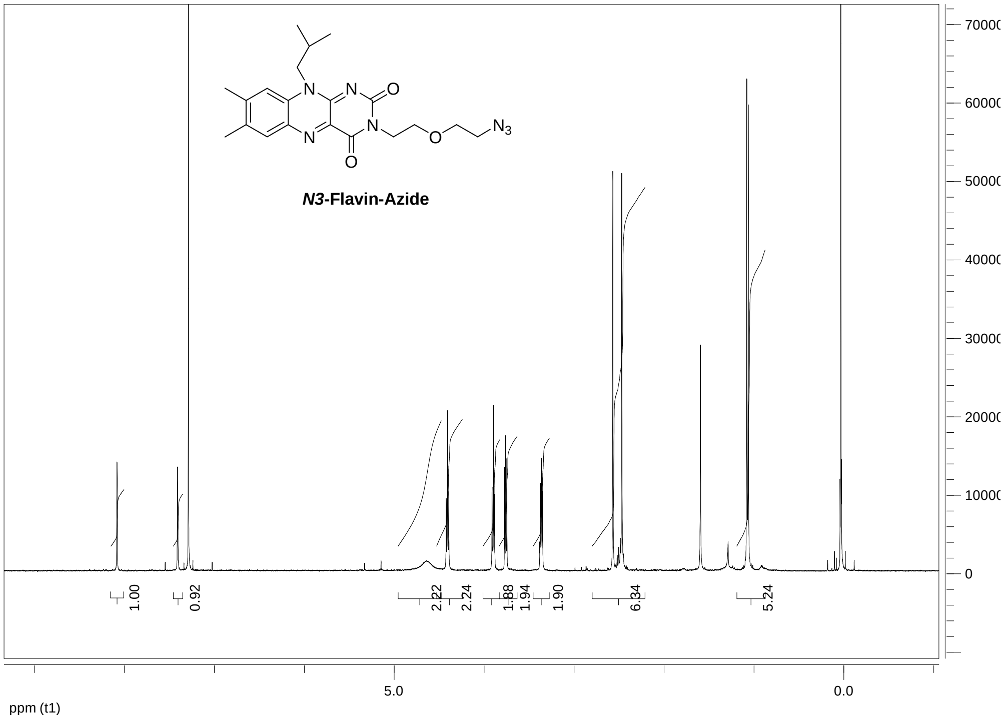


Figure S2. ^{1}H NMR spectrum of compound **6**

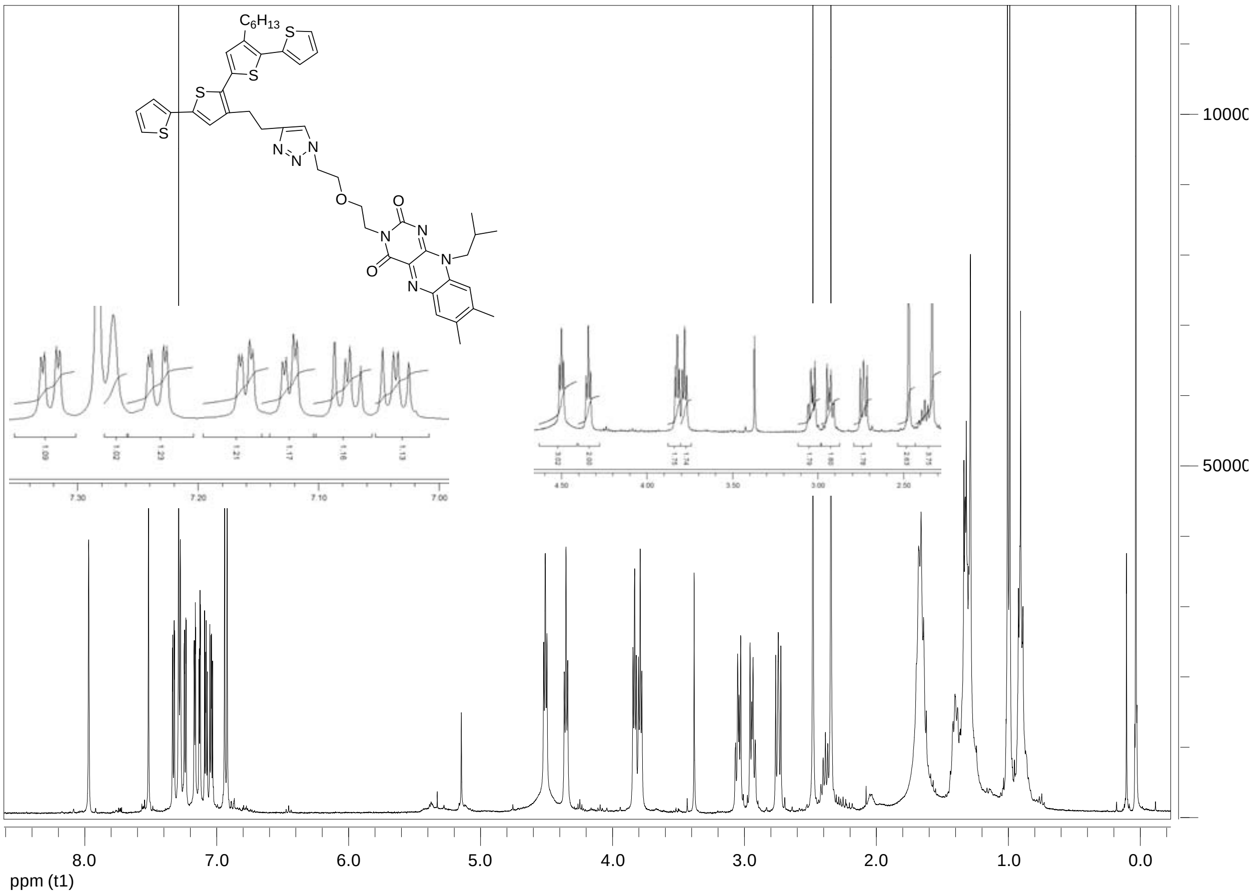


Figure S3. ^{1}H NMR spectrum of dyad **OT4-flavin**

References:

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