

Supporting information for:

Charge Recombination Suppressing in Dye-Sensitized Solar Cells by Tuning Dielectric Constant of Triphenylamine Dyes with Altering π -Bridge from Naphthalene to Anthracene Units

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- 1- FT-IR spectrum of **TpAzo 1**: (KBr, 298 K): aromatic C-H stretch ν [3026 cm^{-1}], in-plane bends aromatic C-H ν [1150 cm^{-1}], out-of-plane bends aromatic C-H ν [725 cm^{-1}], stretch aromatic C=C ν [1550 cm^{-1}], stretch C-N ν [1277 cm^{-1}], stretch N=N ν [2300 cm^{-1}], H-bonded stretch monomer O-H ν [3450 cm^{-1}], stretch dimer H-bonded O-H ν [2950 cm^{-1}], bend out-of-plane O-H ν [937 cm^{-1}], stretch monomer H-bonded C=O ν [1600 cm^{-1}], in-plane bend C-O-H ν [1450 cm^{-1}] and stretch C-O ν [1240 cm^{-1}].

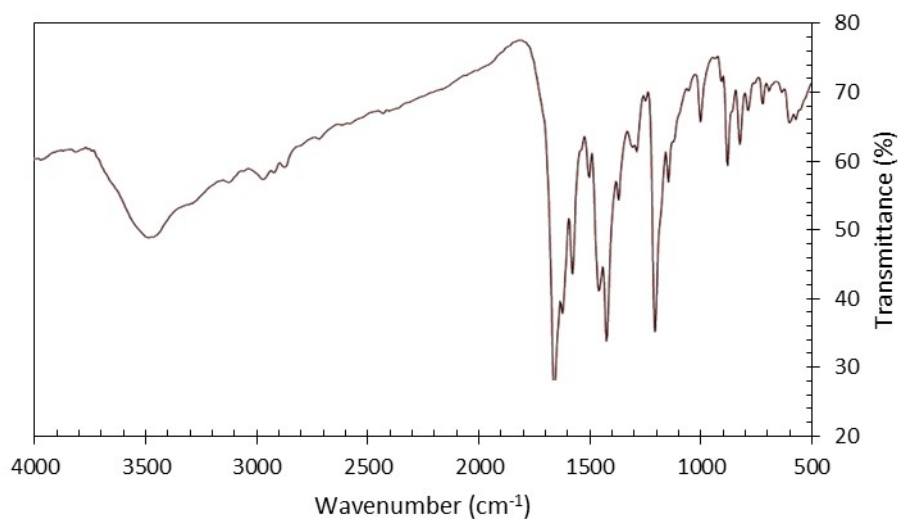


Fig. 1S. FT-IR spectrum of **TpAzo 1**

- 2- FT-IR spectrum of **TpAzo 2**: (KBr, 298 K): stretch aromatic C-H ν [3026 cm^{-1}], in-plane bends aromatic C-H ν [1150 cm^{-1}], out-of-plane bends aromatic C-H ν [725 cm^{-1}], aromatic stretch C=C ν [1550 cm^{-1}], stretch C-N ν [1277 cm^{-1}], stretch N=N ν [2300 cm^{-1}], stretch monomer H-bonded O-H ν [3450 cm^{-1}], stretch dimer H-bonded O-H ν [2950 cm^{-1}], bend out-of-plane O-H ν [937 cm^{-1}], stretch monomer H-bonded C=O ν [1600 cm^{-1}], in-plane bend C-O-H ν [1450 cm^{-1}] and stretch C-O ν [1240 cm^{-1}].

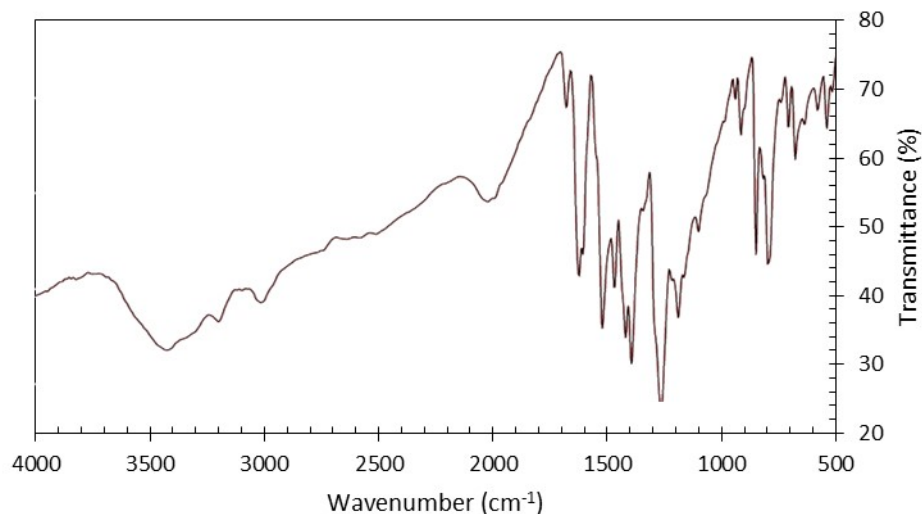
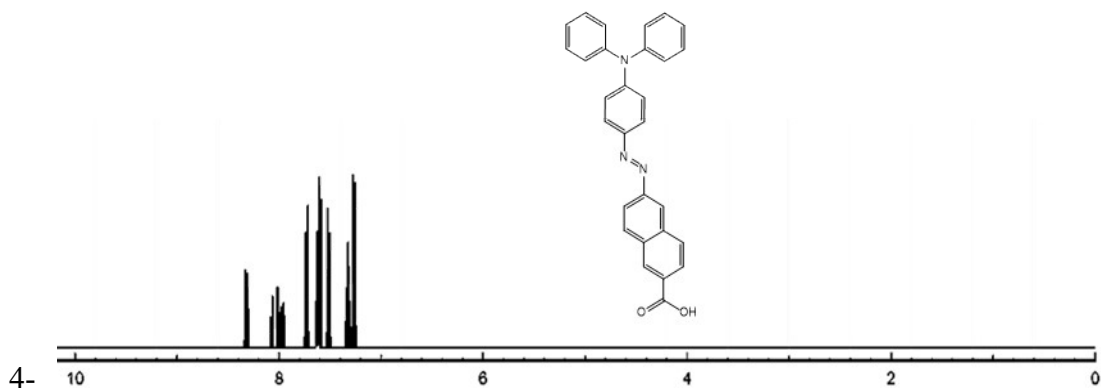


Fig. 2S. FT-IR spectrum of **TpAzo 2**

- 3- ^1H & ^{13}C -NMR and Mass spectra **TpAzo 1**: ^1H NMR (CDCl_3): δ [ppm]: 8.31 (dddt, $J = 1.8, 1.7, 0.5, 0.4$ Hz), 8.29-8.34 (2H, 8.33 (tq, $J = 1.7, 0.4$ Hz), 8.07 (1H, ddt, $J = 7.1, 1.7, 0.4$ Hz), 8.01 (ddd, $J = 7.1, 1.7, 0.4$ Hz), 7.93-8.03 (2H, 7.96 (ddt, $J = 8.8, 1.8, 0.4$ Hz), 7.73 (2H, ddd, $J = 8.6, 2.7, 0.4$ Hz), 7.61 (dddd, $J = 8.3, 7.2, 1.7, 0.5$ Hz), 7.56-7.66 (5H, 7.62 (ddd, $J = 8.8, 1.8, 0.4$ Hz), 7.51 (2H, ddd, $J = 8.6, 1.5, 0.4$ Hz), 7.23-7.35 (6H, 7.26 (dddd, $J = 8.3, 1.3, 1.2, 0.5$ Hz), 7.32 (tt, $J = 7.2, 1.2$ Hz)). ^{13}C NMR (CDCl_3): δ [ppm]: 167.1, 149.5, 147.9, 147.9, 147.3, 132.7, 131.8, 128.9, 128.6, 128.2, 127.8, 127.3, 127.1, 125.0, 124.5, 124.2, 119.2, 115.0, 114.4. Mass [m/z]. $\text{C}_{29}\text{H}_{21}\text{N}_3\text{O}_2$ [M^+], Found. 451; Calcd. 452.



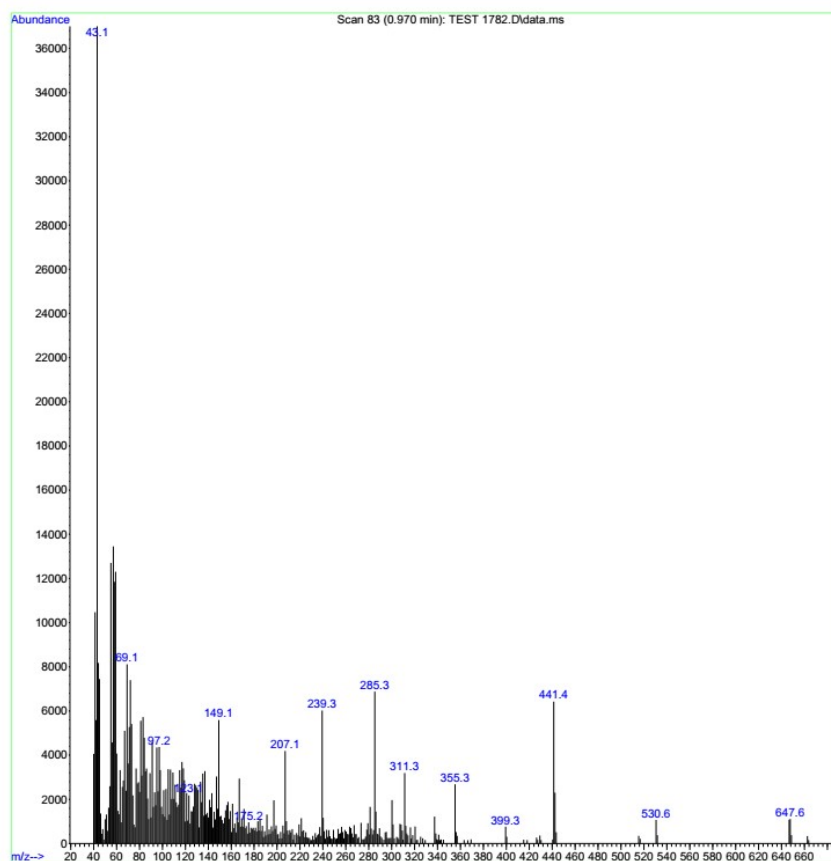
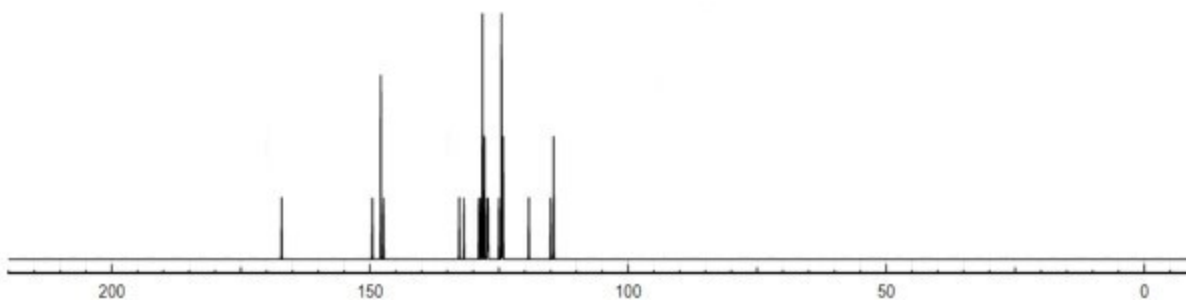


Fig. 3S. ^1H & ^{13}C -NMR and Mass spectra **TpAzo 1**:

- 1- ^1H & ^{13}C -NMR and Mass spectra **TpAzo 2**: ^1H NMR (CDCl_3): δ [ppm]: 8.59 (1H, dd, $J = 1.7, 0.6, 0.4$ Hz), 8.23-8.30 (2H, 8.25 (ddt, $J = 5.9, 1.7, 0.5$ Hz), 8.28 (dddd, $J = 1.7, 1.5, 0.5, 0.4$ Hz)), 7.96 (1H, ddd, $J = 5.9, 1.7, 0.4$ Hz), 7.83-7.92 (2H, 7.88 (dddd, $J = 8.2, 2.2, 1.7, 0.4$ Hz), 7.85 (ddq, $J = 1.7, 1.5, 0.5$ Hz)), 7.78 (ddd, $J = 10.1, 2.2, 0.4$ Hz)), 7.61 (dddd, $J = 8.3, 7.2, 1.6, 0.5$ Hz), 7.71 (ddd, $J = 10.1, 8.2, 0.5$ Hz), 7.56-7.82 (8H, 7.79 (ddd, $J = 7.6, 2.6, 0.4$ Hz), 7.50 (2H, ddd, $J = 7.6, 1.7, 0.4$ Hz), 7.30-7.42 (6H, 7.38 (dtd, $J = 8.3, 1.2, 0.5$ Hz), 7.33 (tt, $J = 7.2, 1.2$ Hz)). ^{13}C NMR (CDCl_3), δ [ppm]: 169.3, 126.8, 126.8, 129.8, 129.6, 129.6, 125.9, 129.6, 129.6, 124.7, 130.3, 128.3, 125.7, 125.7, 125.9, 125.1, 130.8, 125.8, 125.5, 125.7, 125.7, 125.9, 125.1, 120.2, 127.7, 133.2, 130.4,

132.9, 123.0, 124.5, 145.9, 148.1, 149.7, 152.1. Mass [m/z]. $C_{31}H_{23}N_3O_2$ (M^+), Found: 475; Calcd: 476.

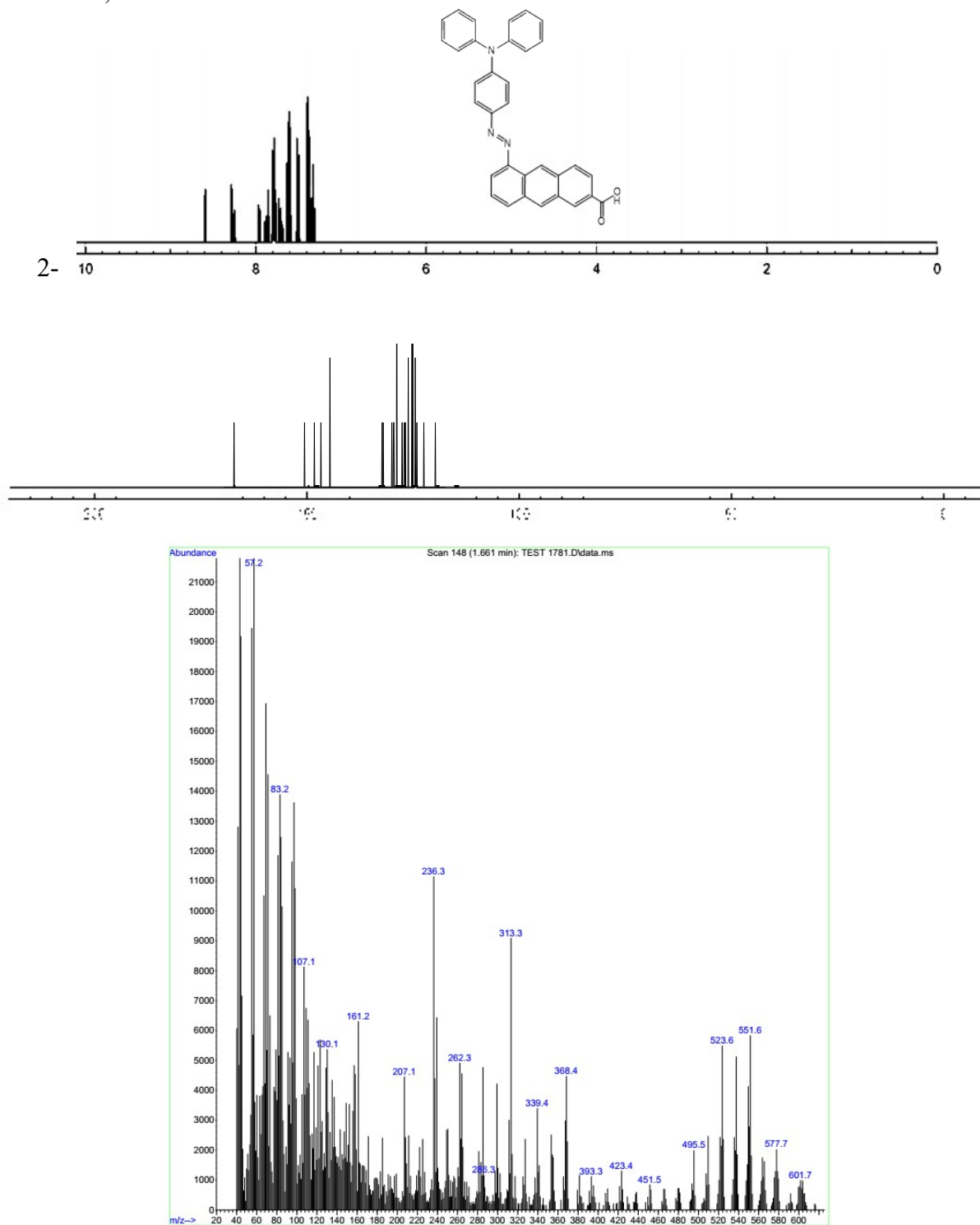


Fig. 4S. 1H -NMR, ^{13}C -NMR and Mass spectroscopy analysis of TpAzo 2 dye