Supporting Information

A Highly Sensitive Triple Ratio Viscosity Probe for Fluorescence Response Across Ultra-Wide Viscosity Ranges

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1. General information

Characterization and spectroscopic instruments

^{1}H NMR spectra were measured on a Bruker AM-400 spectrometer using *d*-chloroform as solvent and tetramethylsilane (TMS, $\delta = 0$ ppm) as internal standard. The UV/Vis spectra were measured on a Hitachi (U-3310) spectrophotometer. The fluorescence spectra were recorded on Edinburgh Instruments Fluorescence Spectrometer FLS1000 fluorimeter. The accurate values of the viscosity of all samples were recorded on Rheology Instruments ARES G2.

Synthesis and materials

The initial substances were procured from Energy Chemical and Aladdin and employed in the experiment without additional refinement. From the commercial products of n-alkane solvents were purchased from TCI with different viscosities at 25 °C, i.e., Hexane (0.30 mPa·s), Octane (0.51 mPa·s), Decane (0.86 mPa·s), Dodecane (1.37 mPa·s), Tetradecane (2.10 mPa·s), Hexadecane, (3.10 mPa·s). Six samples of Mineral Oil Rotational viscosity standards were purchased from Sigma-Aldrich with different viscosities at 25 °C, i.e., RTM-24 (1.008 Pa·s), RTM-31 (5.738 Pa·s), RTM-35 (10.03 Pa·s), RTM-37 (19.58 Pa·s), RTM-38 (40.05 Pa·s), and RTM-39 (72.33 Pa·s). **DPAC-Me** and **DPAC-CF$_3$** were synthesized according to the reported methods[1] without modified. **DPAC-Me**: ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.76-8.73 (m, 2H), 8.33-8.32 (d, 1H), 8.08-8.06 (d, 1H), 7.71-7.61 (m, 4H), 7.52-7.48 (t, 1H), 7.30-7.27 (t, 1H), 7.21-7.19 (d, 1H), 6.97-6.90 (m, 6H), 6.74-6.71 (t, 1H), 6.68-6.64 (t, 1H), 6.54-6.51 (d, 2H), 2.55 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 147.80, 147.14, 146.29, 143.25, 139.58, 139.47, 136.86, 130.73, 130.00, 129.58, 129.47, 128.61, 128.56, 127.33, 127.12, 126.88, 126.64, 126.56, 125.97, 124.78, 124.55, 123.07, 123.02, 121.17, 119.57, 117.44, 114.55, 77.36, 77.05, 76.73, 17.70, 0.04. HRMS ESI (m/z) $[M+H]^+$: calcd. for $C_{33}H_{25}N_2$, 449.2018; Found, 449.2018. **DPAC-CF$_3$**: ^{1}H NMR

(400 MHz, Chloroform-*d*) δ 8.75 (d, 2H), 8.57-8.51 (t, 1H), 8.06 (d, 1H), 7.99 (d, 1H), 7.76 -7.68 (m, 2H), 7.62 (t, 2H), 7.48 (m, 2H), 7.02-6.94 (t, 2H), 6.84 (m, 5H), 6.66 (t, 1H), 6.46 (d, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 150.72, 148.98, 146.05, 141.69, 139.54, 139.25, 130.92, 130.26, 129.74, 129.57, 129.39, 129.09, 128.82, 128.17, 127.74, 126.84, 126.80, 126.47, 124.75, 124.50, 123.22, 122.96, 122.91, 122.76, 122.55, 122.01, 120.45, 119.18, 115.68, 77.35, 77.03, 76.71, 0.02. HRMS ESI (m/z) $[M+H]^+$: calcd. for $C_{33}H_{22}N_2F_3$, 503.1735; Found, 503.1746.

The Preparation of mixture solution with viscosity range from 1-1000 cP.

Different volumetric of RTM-24 (1.008 Pa·s) and hexane were added into a vial (specific values as seen in table S1). Afterwards, the mixture was stirred for 2 hours to get mixture solution with viscosity range from 1-1000 cP.

Table S1. Volumetric of RTM-24 and hexane, percentage of RTM-24 and viscosity of mixture solution.

RTM-24 (mL)	Hexane (mL)	RTM-24 (vol%)	Viscosity (cP)
20	0	100	1000
20	0.3	98.5	886
20	0.5	97.5	622
20	1	95	505
18	2	90	290
16	4	80	60
14	6	70	28
12	8	60	6.3
10	10	50	3.6
8	12	40	2.9
6	14	30	1.9
4	16	20	1.5
2	18	10	1

The Preparation of DPAC-Probes in mixture solution of RTM-24 and hexane.

A standard solution with a concentration of 10^{-2} mol/L was created by dissolving **DPAC-Me** or **DPAC-CF₃** in dichloromethane. The concentrated solution (5 μL) was subsequently transferred to a vial. And then, 5 mL of mixture solution was added into the vial after the dichloromethane was evaporated completely. The mixture was stirred at 50 ℃ for a duration of 2 hours. Subsequently, the freshly prepared solution was transferred to a cuvette for the necessary experimental analyses.

The Preparation of DPAC-Probes in n-alkane.

A standard solution with a concentration of 10^{-2} mol/L was created by dissolving **DPAC-Me** or **DPAC-CF₃** in dichloromethane. The concentrated solution (5 μL) was subsequently transferred to a vial and evaporated to remove the dichloromethane completely. Following this, 5 mL of n-alkane was introduced into the vial and the mixture was stirred at 50 ℃ for a duration of 2 hours. Subsequently, the freshly prepared solution was transferred to a cuvette for the necessary experimental analyses

The Preparation of DPAC-Probes in Mineral Oil Rotational Viscosity Standard (RTM).

A solution of standard concentration at 10^{-2} mol/L was prepared by dissolving **DPAC-Me** or **DPAC-CF₃** in dichloromethane. The concentrated solution (5 μL) was then transferred to a vial and subjected to evaporation to eliminate the dichloromethane entirely. Subsequently, 5 mL of Mineral Oil Rotational Viscosity Standard[2] was added to the vial, and the mixture was agitated at 50 ℃ for a period of 2 hours. Following this, the newly prepared solution was transferred to a cuvette for the required experimental analyses.

Analysis methodology

The measurement of the quantitative relationship between the Fl ratios and viscosity is through Förster–Hoffmann equation[3]:

$$\log I = \mathrm{a} + \mathrm{b}\log\eta$$

In the equation, the I value means Fl emission intensity or Fl ratios and the η value means viscosity, while a and b are constants. According to this equation, plots of log$I$ as a function of logη should provide a straight line with a slope of b. The value of slope can evaluate the sensitivity of the two compounds.

2. Photophysical Properties

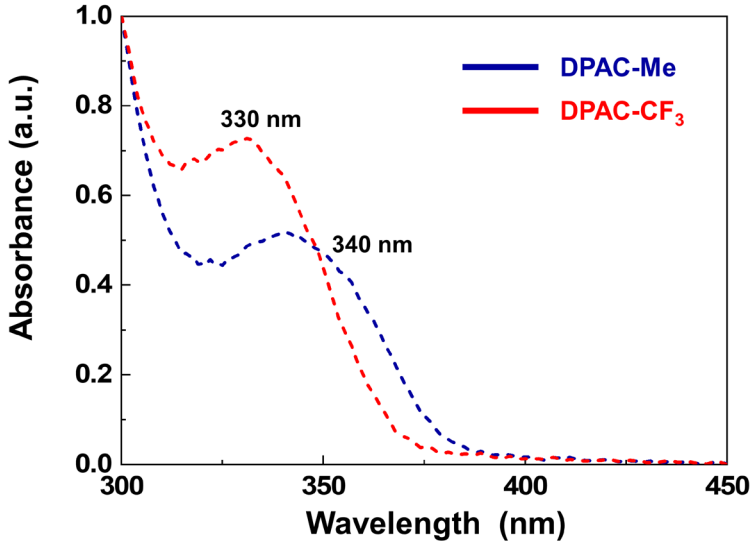


Fig. S1 UV-visible absorption of **DPAC-Me** and **DPAC-CF3** in cyclohexane.

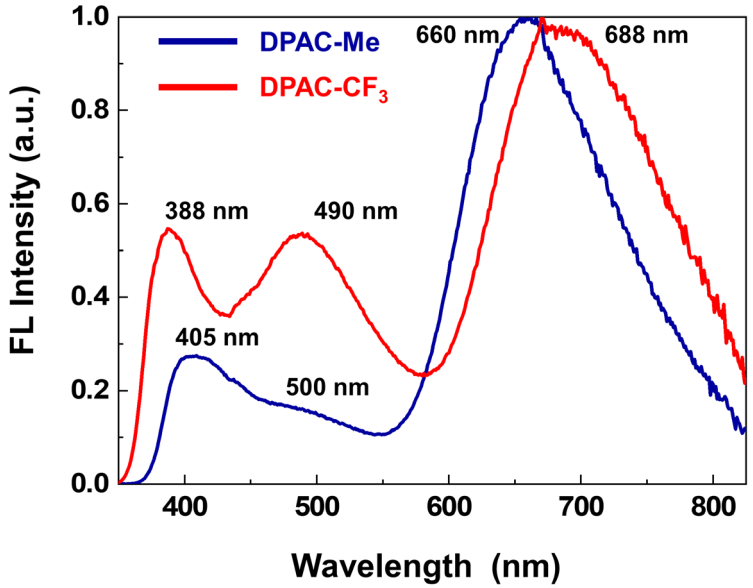


Fig. S2 FL spectra of **DPAC-Me** and **DPAC-CF3** in cyclohexane. The overall quantum yields (Φ_F) in cyclohexene are determined as 3.4% for DPAC-Me, 0.5% for DPAC-CF_3.

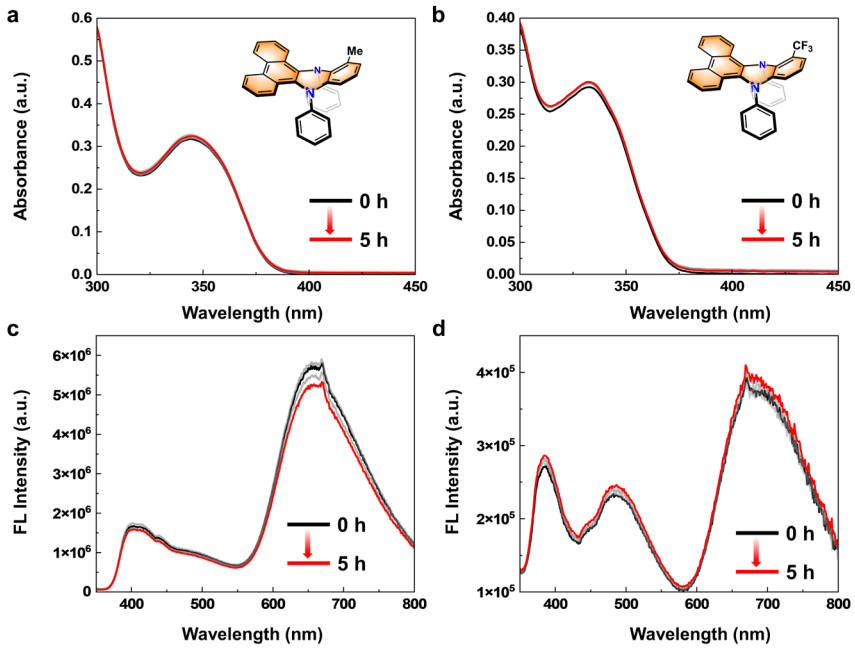


Fig. S3 Absorbance and emission spectra over time for the solutions of (a), (c) **DPAC-Me** and (b), (d) **DPAC-CF₃** in cyclohexane upon irradiation with a 20 W/cm^2 LED lamp using continuous range of visible light 385 ~ 740 nm.

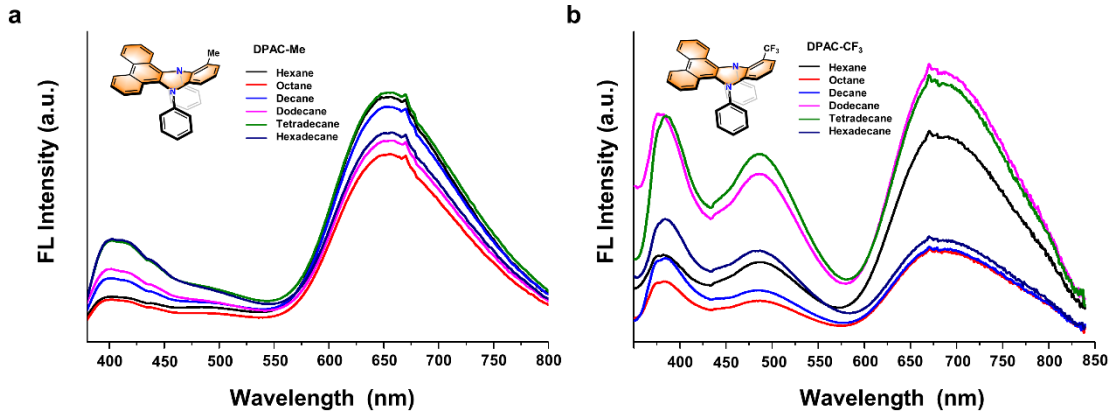


Fig. S4 FL spectra of (a) **DPAC-Me** and (b) **DPAC-CF₃** in various n-alkanes.

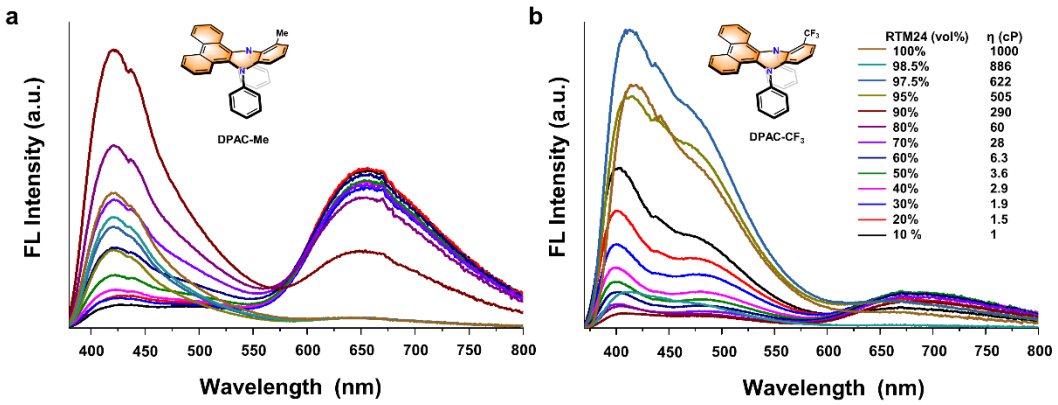


Fig. S5 FL spectra of (a) **DPAC-Me** and (b) **DPAC-CF₃** in mixture solvent of hexane and mineral oil from 1-1000 cP.

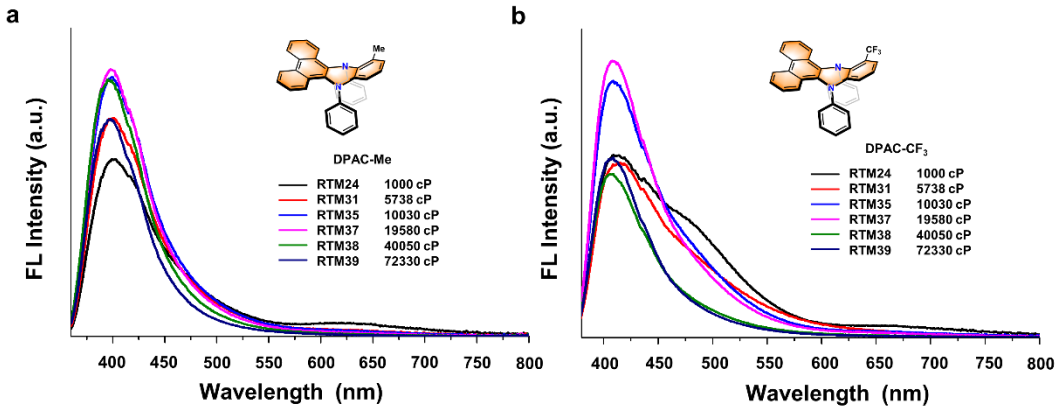


Fig. S6 FL spectra of (a) **DPAC-Me** and (b) **DPAC-CF₃** in a series of mineral oil rotational viscosity standard viscosity with a viscosity range from 1000 cP to 72330 cP.

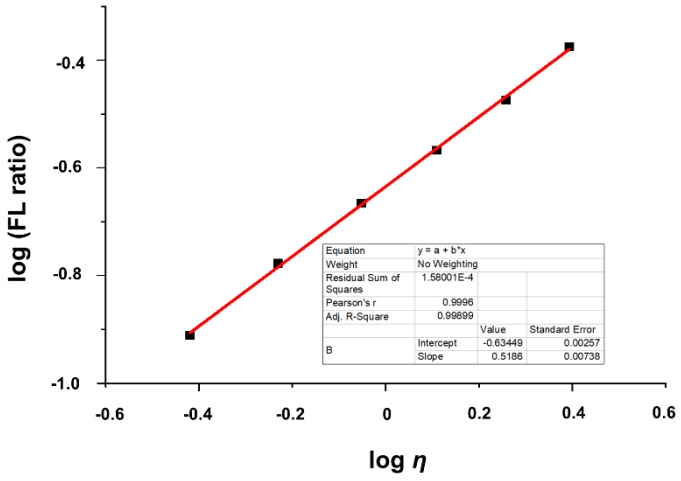


Fig. S7 Förster-Hoffmann plots based on the FL ratio of I_{short}/I_{long} of **DPAC-Me** with viscosity from 0.3-3.1 cP.

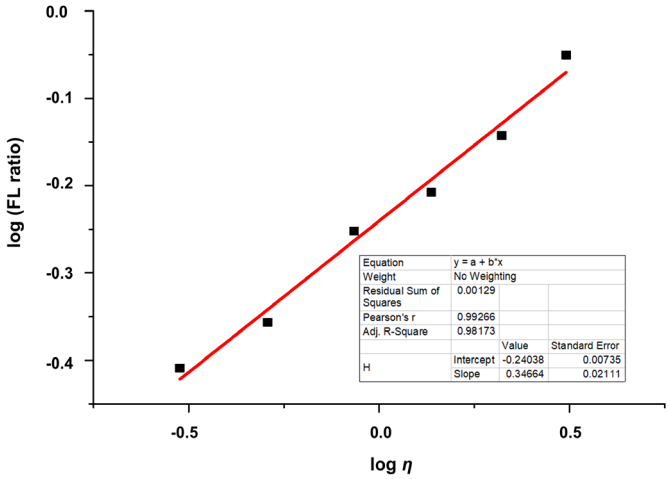


Fig. S8 Förster-Hoffmann plots based on the FL ratio of I_{middle}/I_{long} of **DPAC-CF$_3$** with viscosity from 0.3-3.1 cP.

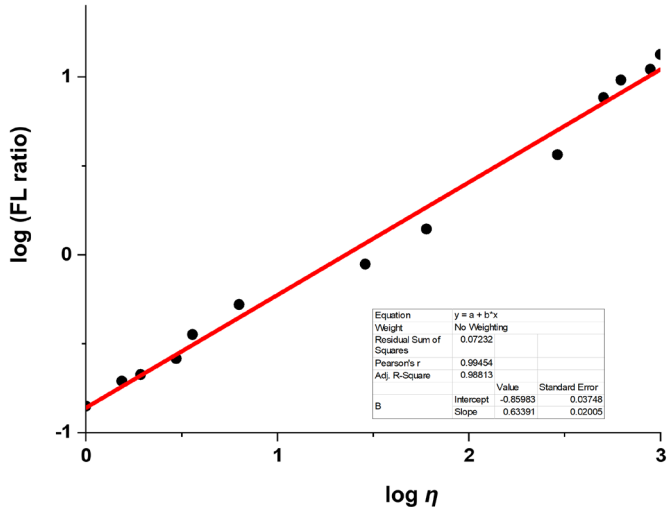


Fig. S9 Förster-Hoffmann plots based on the FL ratio of I_{short}/I_{long} of **DPAC-Me** with viscosity from 1-1000 cP.

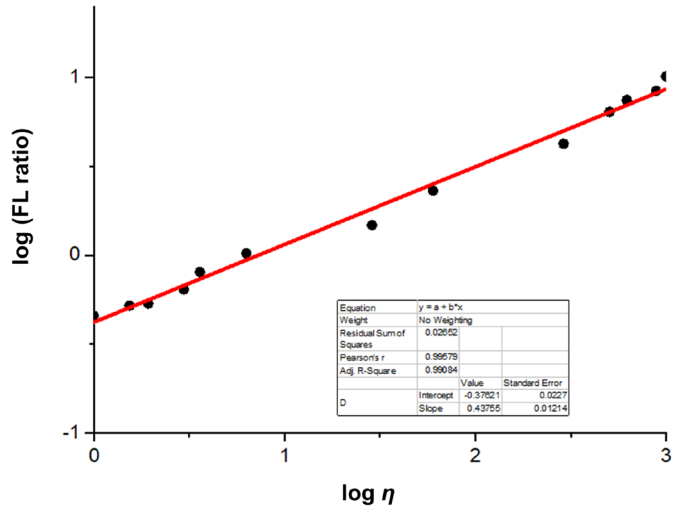


Fig. S10 Förster-Hoffmann plots based on the FL ratio of I_{middle}/I_{long} of **DPAC-CF$_3$** with viscosity from 1-1000 cP.

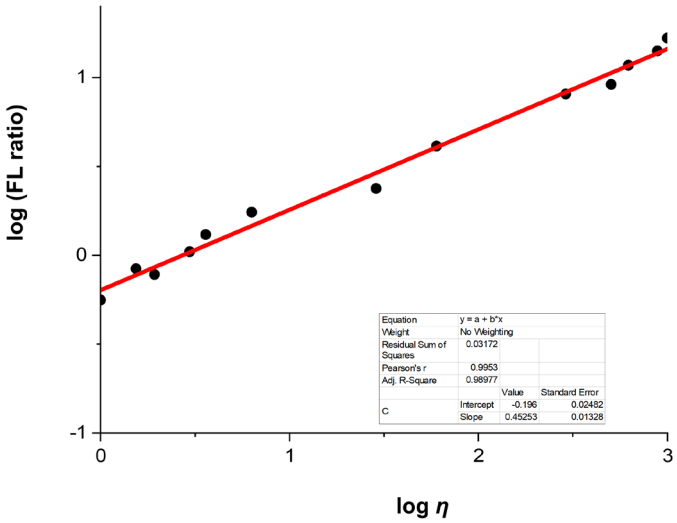


Fig. S11 Förster-Hoffmann plots based on the FL ratio of I_{short}/I_{long} of **DPAC-CF$_3$** with viscosity from 1-1000 cP.

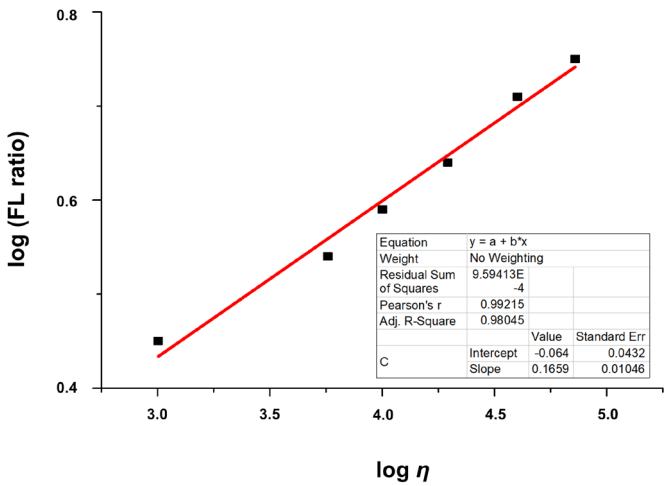


Fig. S12 Förster-Hoffmann plots based on the FL ratio of I_{short}/I_{middle} of **DPAC-Me** with viscosity from 1000-72330 cP.

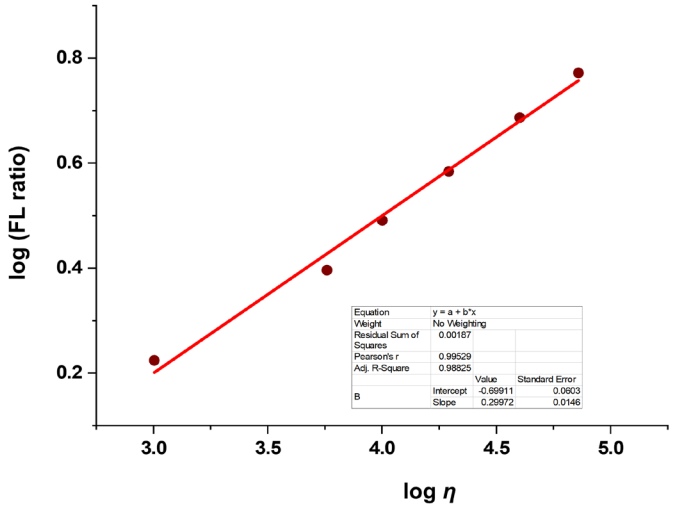


Fig. S13 Förster-Hoffmann plots based on the FL ratio of I_{short}/I_{middle} of **DPAC-CF$_3$** with viscosity from 1000-72330 cP.

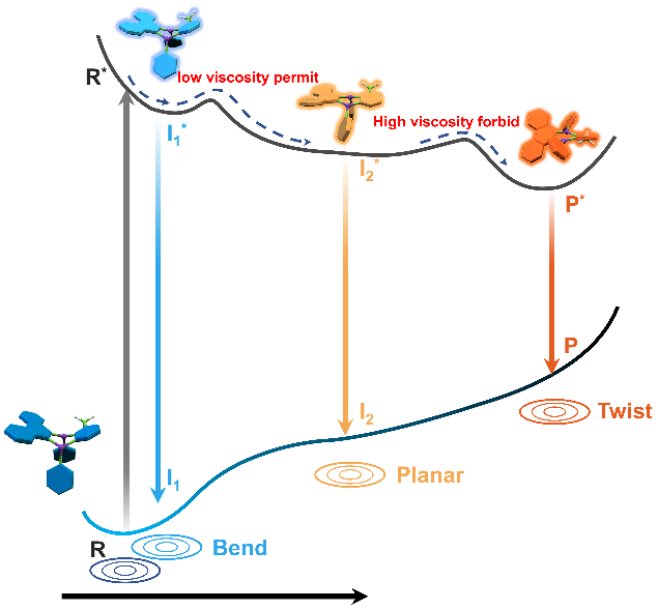


Fig. S14 Schematic potential energy surfaces for the structural evolution of monosubstituted **DPAC**.

3. NMR Spectra

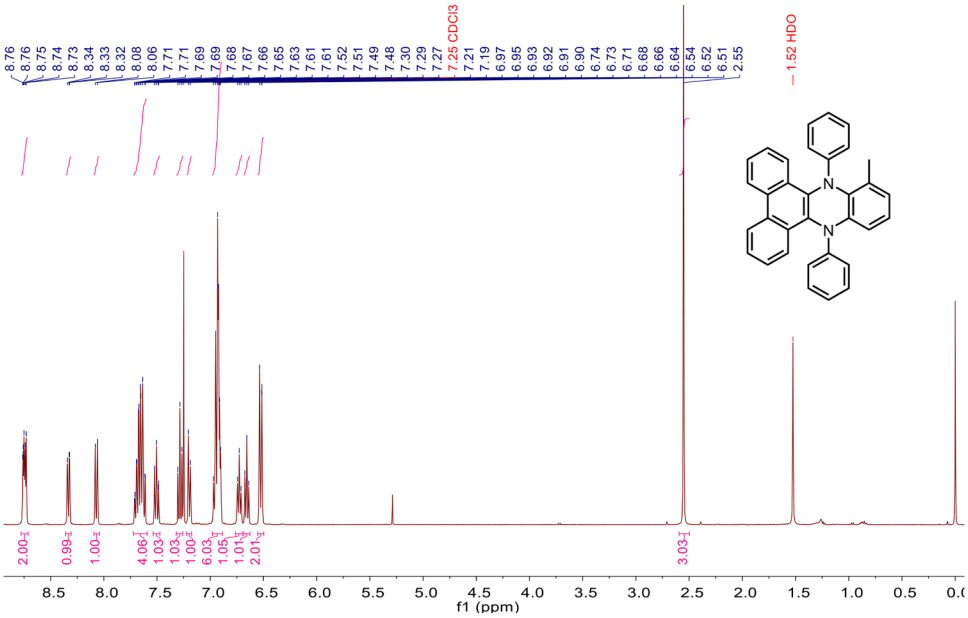


Fig. S15 ^{1}H NMR spectrum of **DPAC-Me** (400 MHz, $CDCl_3$-*d*, ppm)

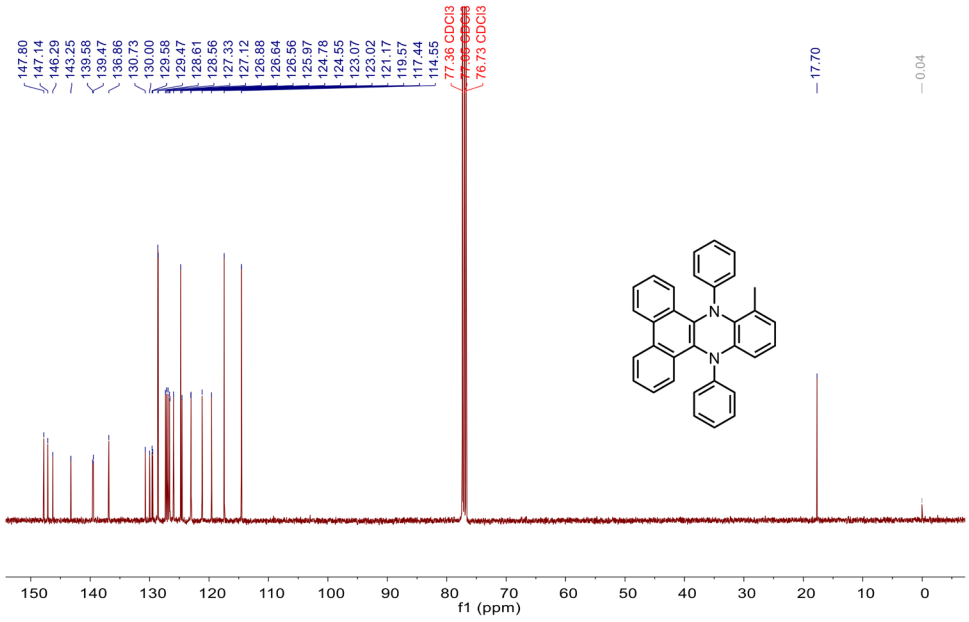


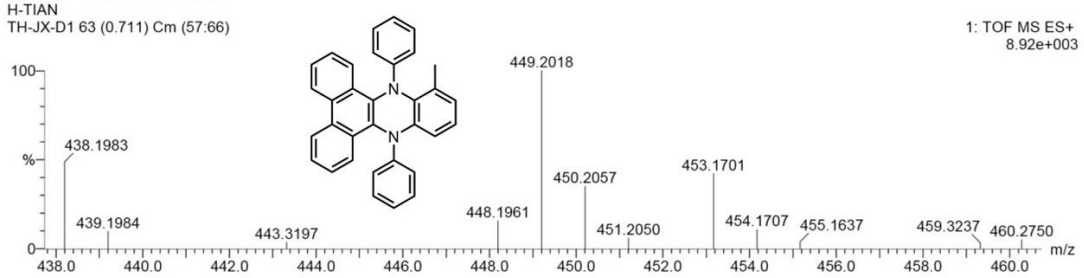
Fig. S16 ^{13}C NMR spectrum of **DPAC-Me** (400 MHz, $CDCl_3$-*d*, ppm)

Elemental Composition Report **Page 1**

Single Mass Analysis
Tolerance = 10.0 PPM / DBE: min = -1.5, max = 50.0
Element prediction: Off
Number of isotope peaks used for i-FIT = 3

Monoisotopic Mass, Even Electron Ions
9 formula(e) evaluated with 1 results within limits (up to 50 best isotopic matches for each mass)
Elements Used:
C: 0-33 H: 0-99 N: 0-2

H-TIAN
TH-JX-D1 63 (0.711) Cm (57:66)



Minimum:				-1.5			
Maximum:		5.0	10.0	50.0			
Mass	Calc. Mass	mDa	PPM	DBE	i-FIT	i-FIT (Norm)	Formula
449.2018	449.2018	0.0	0.0	22.5	13.7	0.0	C33 H25 N2

Fig. S17 HRMS spectrum of **DPAC-Me**

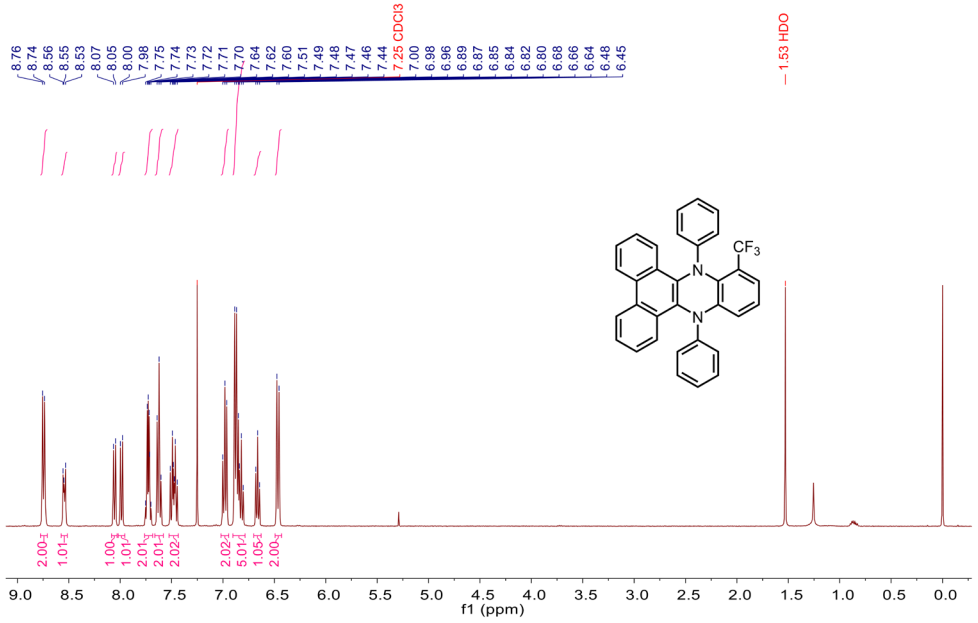


Fig. S18 ^{1}H NMR spectrum of **DPAC-CF$_3$** (400 MHz, $CDCl_3$-*d*, ppm)

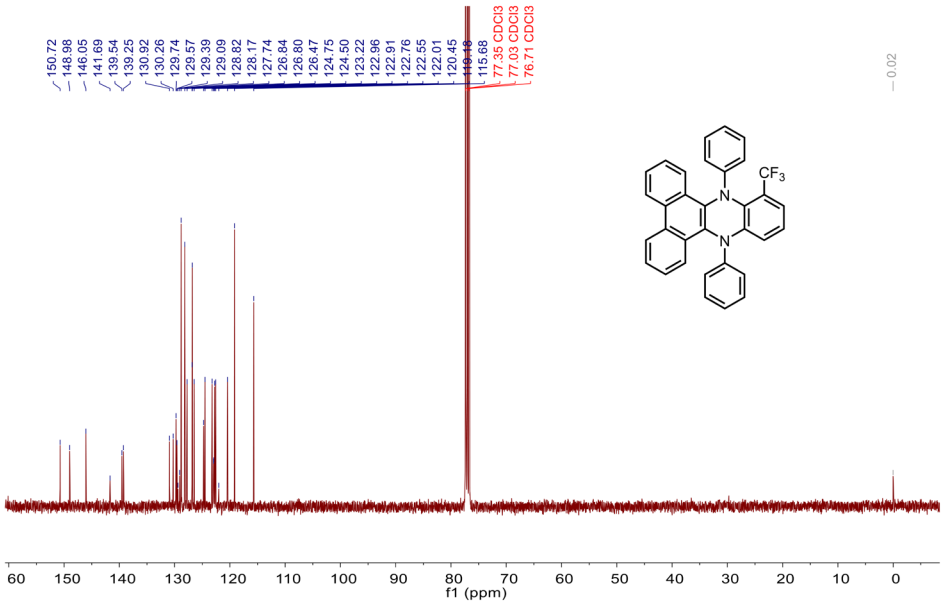


Fig. S19 ^{13}C NMR spectrum of **DPAC-CF$_3$** (400 MHz, $CDCl_3$-*d*, ppm)

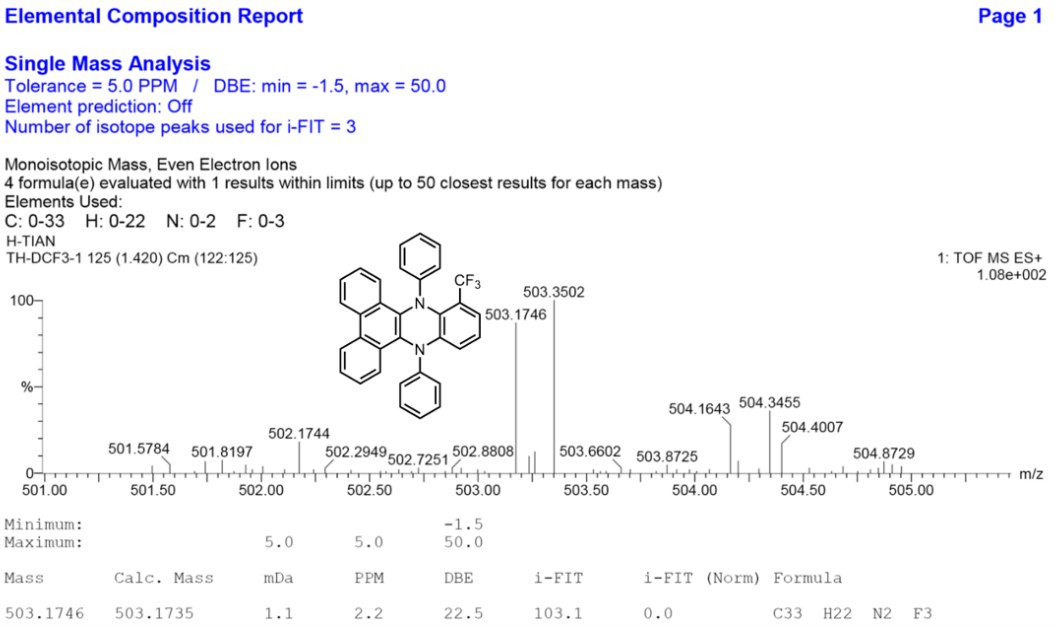


Fig. S20 HRMS spectrum of **DPAC-CF$_3$**

4. References

1. X. Jin, S. Guo, X. Wang, M. Cong, J. Chen, Z. Zhang, J. Su, D.-H. Qu and H. Tian, *Angew. Chem. Int. Ed.*, 2023, **62**, e202305572.
2. X. Chen, S. Yuan, M. Qiao, X. Jin, J. Chen, L. Guo, J. Su, D.-H. Qu and Z. Zhang, , *J. Am. Chem. Soc.*, 2023, **145**, 26494.
3. T. Förster, G. Hoffmann, *Z. Phys. Chem.*, 1971, **75**, 63.