C9-Aryl-substituted berberine derivatives with tunable AIE properties for cell imaging application

Qi Meng,[ab] Ye Tan,[a] E E Sang,[b] Qiaoqiao Teng,[a] Pei Chen *[b] and Yuxiang Wang*[a]

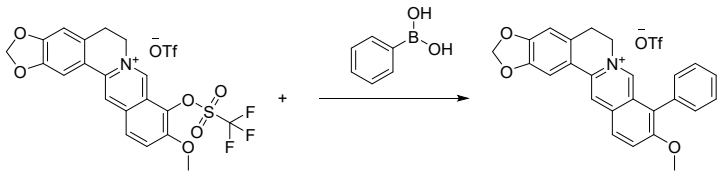
[a]School of Petrochemical Engineering, Changzhou University, Changzhou 213164, China. E-mail: wangyx@cczu.edu.cn

[b]School of Pharmacy & School of Biological and Food Engineering, Changzhou University, Changzhou 213164, China. E-mail: chenpei689@cczu.edu.cn

Table of Contents

1. Reaction optimization

Table S1. Optimization of Suzuki Coupling Reaction [a]



Entry	base	equiv	time (h)	*T* (°C)	yield (%)
1	Na_2CO_3	4	12	80	27
2	$NaHCO_3$	4	12	80	62
3	NaOAc	4	12	80	0
4	$NaHCO_3$	4	12	60	71
5	$NaHCO_3$	4	12	40	59
6	$NaHCO_3$	4	6	60	73
7	$NaHCO_3$	4	24	60	51
8	$NaHCO_3$	4	4	60	64
9	$NaHCO_3$	2	12	60	72
10	$NaHCO_3$	2	6	60	58
11	$NaHCO_3$	1	6	60	64
12	$NaHCO_3$	1	12	60	74

[a] Reaction conditions: 1.0 mmol of compound 1, 2.0 mmol of Phenylboronic acid (2 equiv.), 1.0 mmol of $NaHCO_3$ (1 equiv.), 0.05 mmol of tetratriphenylphosphine palladium (0.05 equiv.), 10 mL of ethanol as solvent

2. Photophysical properties

Table S2. Photophysical properties of 9-aryl berberine derivatives

Compound	DCM solution		Soild		
	λ_{abs} (nm)	λ_{em} (nm)	λ_{em} (nm)	τ (ns)	Φ_F (%)
2a	232, 268, 343, 356, 440	522	512	7.49	9
2b	230, 268, 345, 358, 443	522	520	8.38	9
2c	231, 267, 343, 356, 439	528	506	5.38	17
2d	230, 268, 344, 358, 452	532	524	2.59	7
2e	229, 266, 343, 359, 449	528	540	3.57	-
2f	231, 267, 344, 495	532, 744	682	2.35	10
2g	231, 267, 346, 357, 456	537	672	1.01	-
2h	231, 269, 343, 358, 443	534	510	6.68	17
2i	231, 269, 343, 358, 439	532	508	7.22	24
2j	231, 268, 344, 356, 439	536	524	6.66	12
2k	231, 267, 343, 359, 442	546	536	10.53	8
2l	230, 265, 344, 357, 438	546	547	8.27	4
2m	230, 267, 345, 356, 439	545	578	7.22	0.8
2n	230, 268, 345, 359, 452	544	582	2.48	-
2o	231, 268, 344, 358, 454	656	538	8.80	20
2p	231, 269, 297, 343, 489	470, 738	612	10.53	36
2q	233, 290, 342, 358, 448	644	546	5.21	5

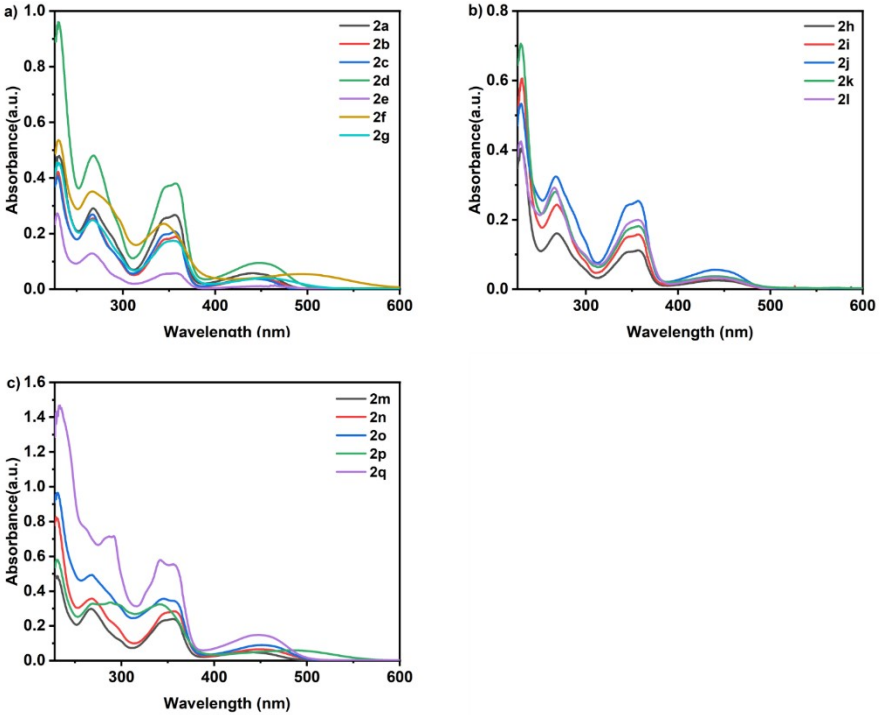


Figure S1. UV-vis absorption spectra of 9-aryl berberine derivatives in dichloromethane solutions (ca. 10^{-5} M).

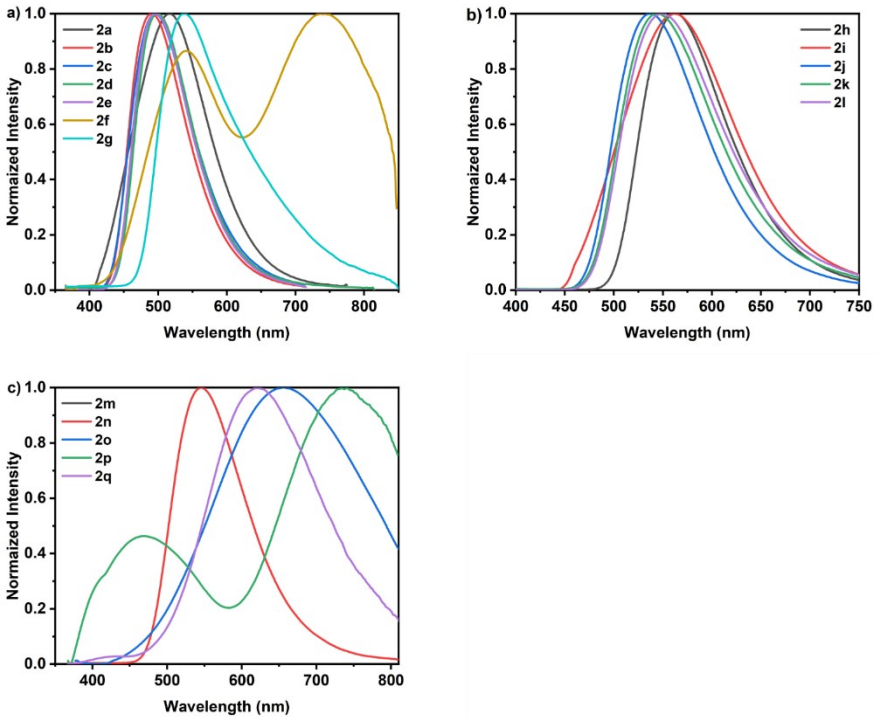


Figure S2. Fluorescence spectra of 9-aryl berberine derivatives in dichloromethane solutions (ca. 10^{-5} M). λ_{ex}: 360 nm.

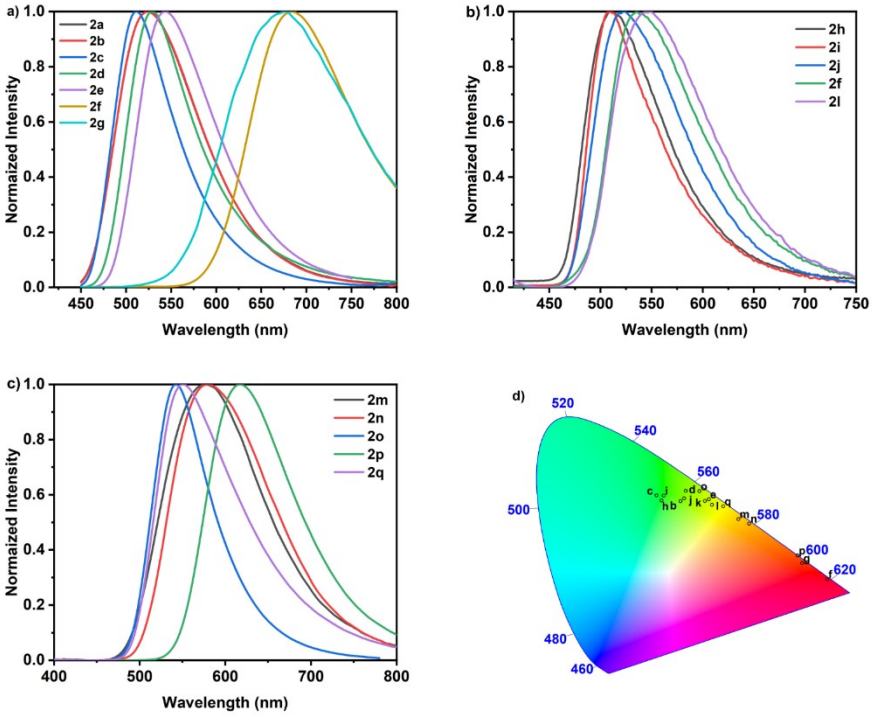


Figure S3. Fluorescence spectra of 9-aryl berberine derivatives in solid state. λ_{ex}: 360 nm.

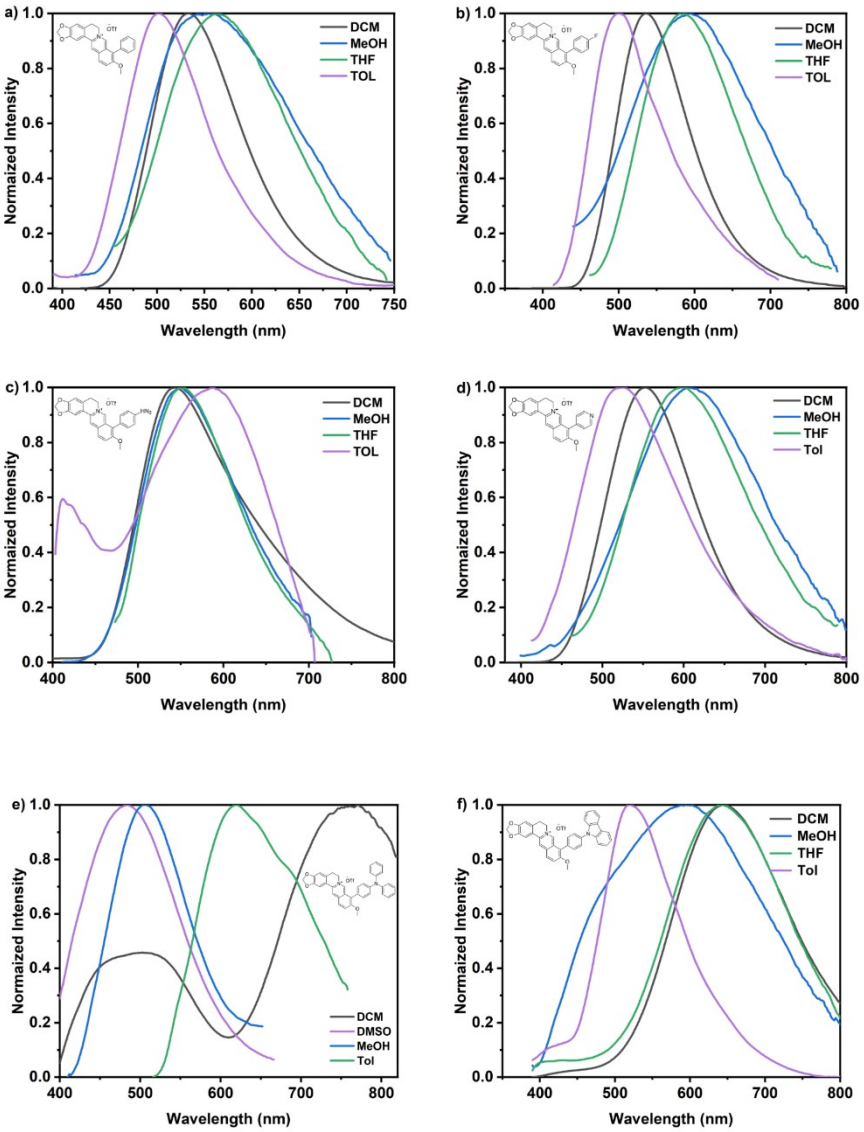


Figure S4. Fluorescence spectra of 9-aryl berberine derivatives in dichloromethane, MeOH, THF, DMSO and Tol solutions (ca. 10^{-5} M). λ_{ex}: 360 nm.

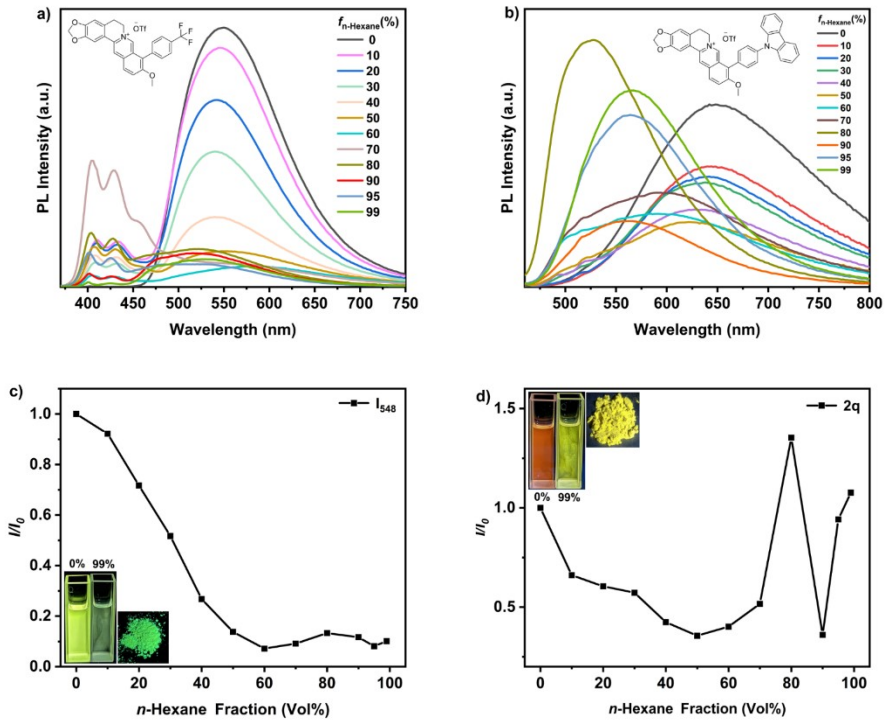


Figure S5. Fluorescence spectra of a) ***2i*** (λ_{ex}: 360 nm) and b) **2*q*** (λ_{ex}: 450 nm) in DCM/*n*-Hexane mixtures (*ca*. 10^{-5} M) with different *n*-Hexane fraction (f_{hex} / %). The relative fluorescence intensity c) ***2i*** and d) **2*q*** to f_{hex}, inset: photographs taken under UV illumination (365 nm).

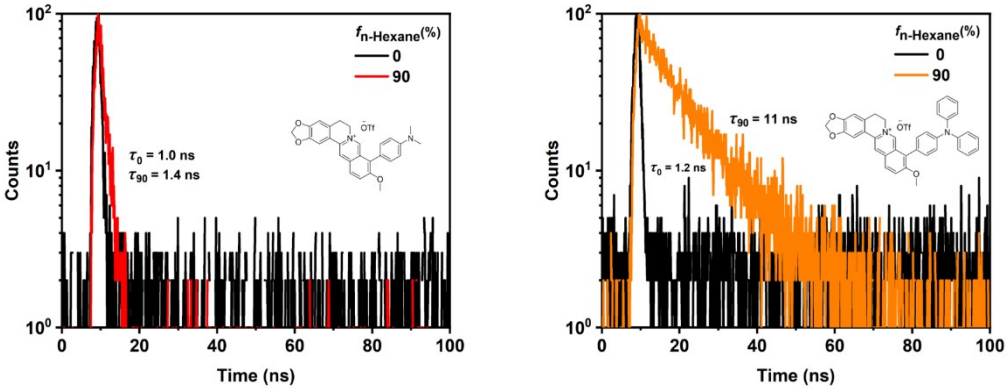


Figure S6. fluorescence lifetimes of ***2f*** and ***2p*** at f_{hex} = 0% and 90%.

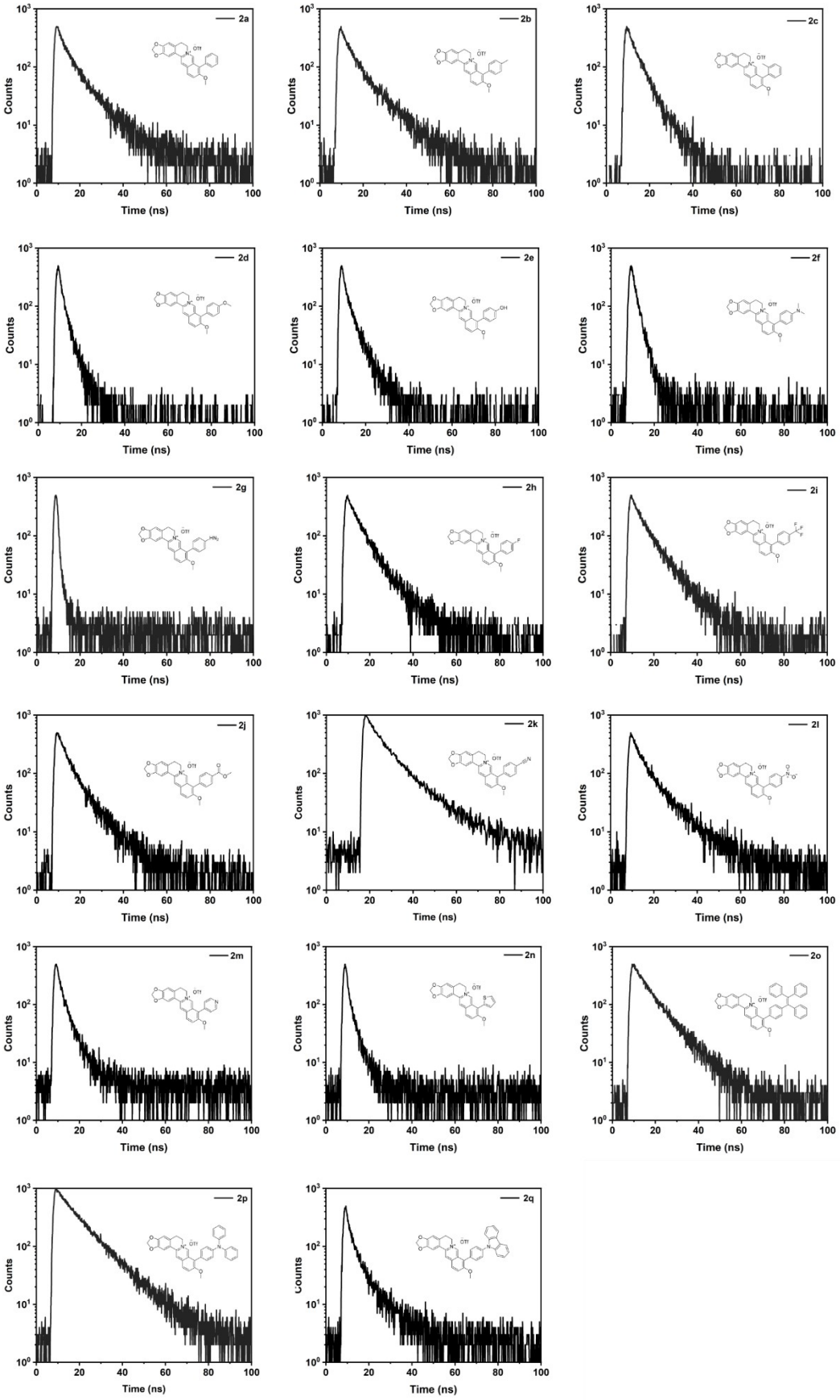


Figure S7. Fluorescence lifetime spectra of 9-aryl berberine derivatives in solid state.

Table S3. Photophysical properties of compounds ***2f*** and ***2m*** in the presence of different equivalences of TFA

TFA/eqiv.	Compound			
	2f		***2m***	
	λ_{abs} (nm)	λ_{em} (nm)	λ_{abs} (nm)	λ_{em} (nm)
0	244, 264, 285, 344, 492	532, 752	231, 265, 345, 355, 440	546
0.1	240, 265, 285, 344, 492	532, 754	233, 265, 344, 355, 440	546
0.2	230, 265, 285, 344, 497	544	233, 264, 354, 440	560
0.5	232, 240, 266, 347, 443	552	232, 264, 353, 439	568
0.8	231, 266, 345, 354, 440	556	232, 264, 354, 440	572
1	231, 267, 345, 354, 441	556	232, 263, 354, 438	570
2	231, 267, 344, 354, 438	566	231, 263, 354, 440	582
3	232, 267, 344, 354, 437	566	231, 263, 354, 441	578
4	230, 266, 344, 355, 438	566	231, 264, 354, 438	582
5	231, 267, 344, 355, 438	568	231, 263, 354, 439	584

3. MTT assay and photostability

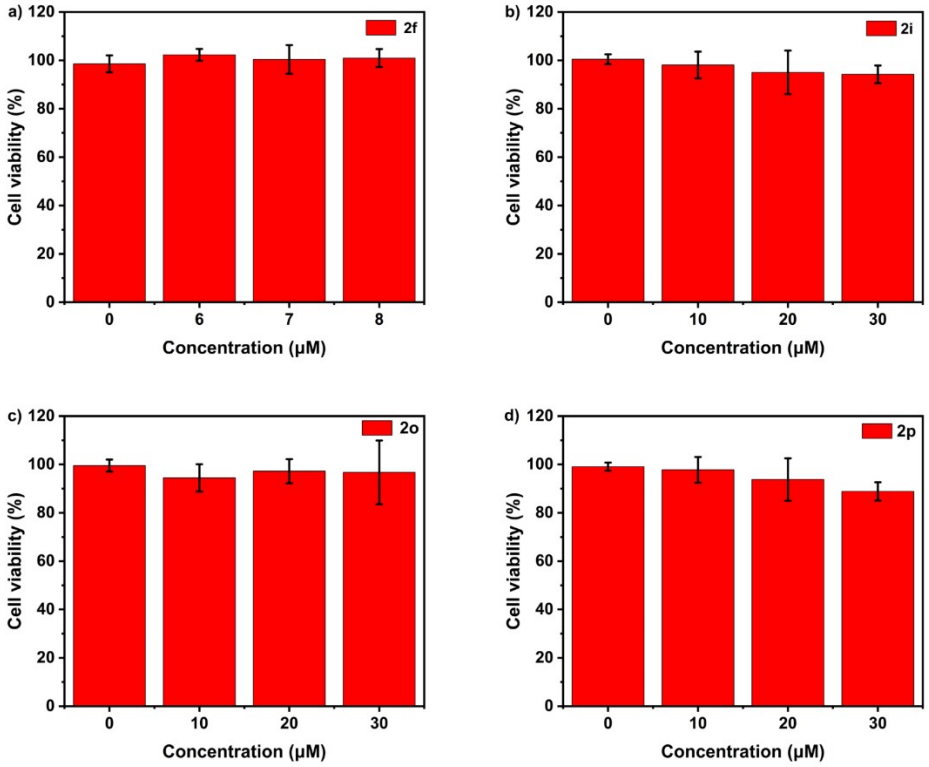


Figure S8. Viability of Caco-2 cells in the presence of different concentrations of ***2f***, ***2i***, ***2o*** and ***2p*** for 24 h. Data were tested at 570 nm expressed as mean value of three separate trials.

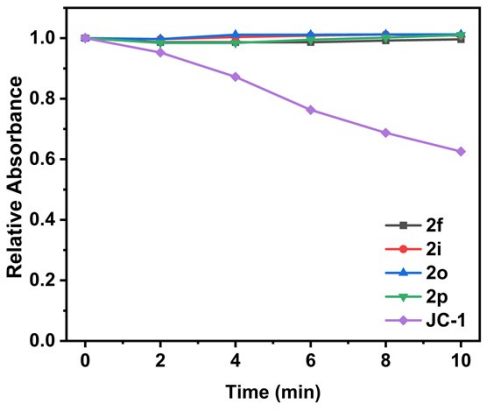


Figure S9. The relative absorbance intensity of ***2f***, ***2i***, ***2o***, ***2p*** and **JC-1** in the molecular state before and after UV irradiation (385 nm, 0.71 W cm^{-2}).

4. NMR Spectra of all the compounds

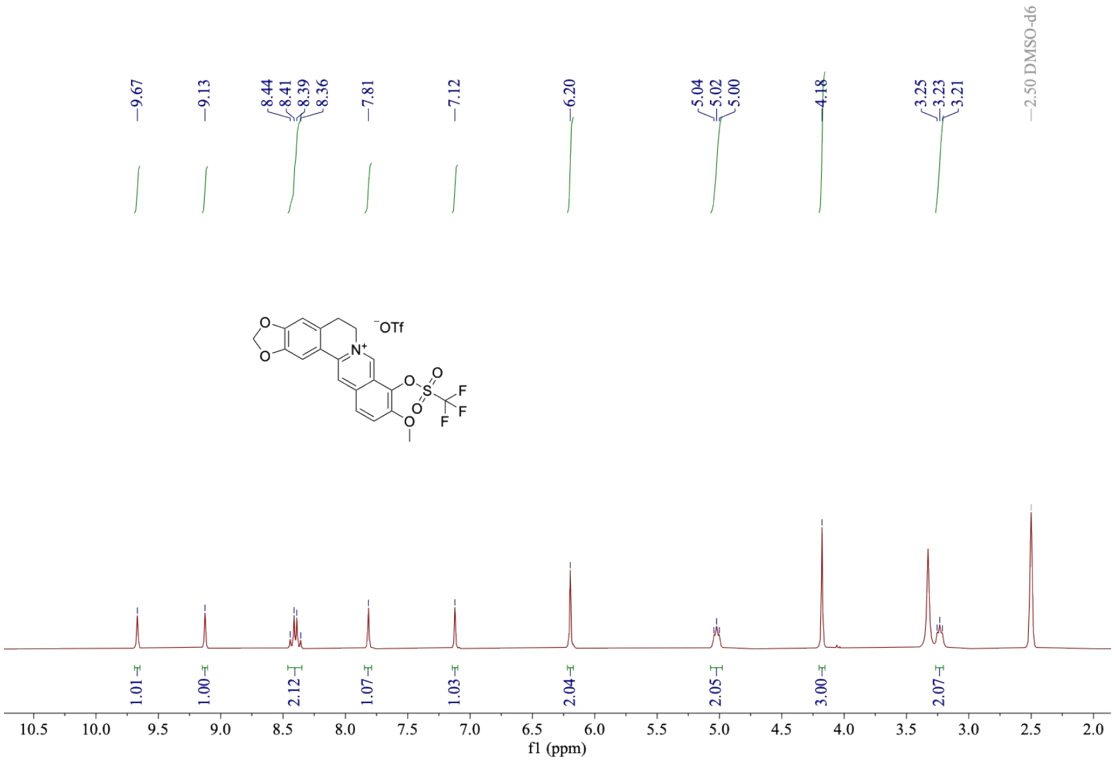


Figure S10. ^{1}H NMR spectrum of ***compound 1*** (300 MHz, DMSO-d_6).

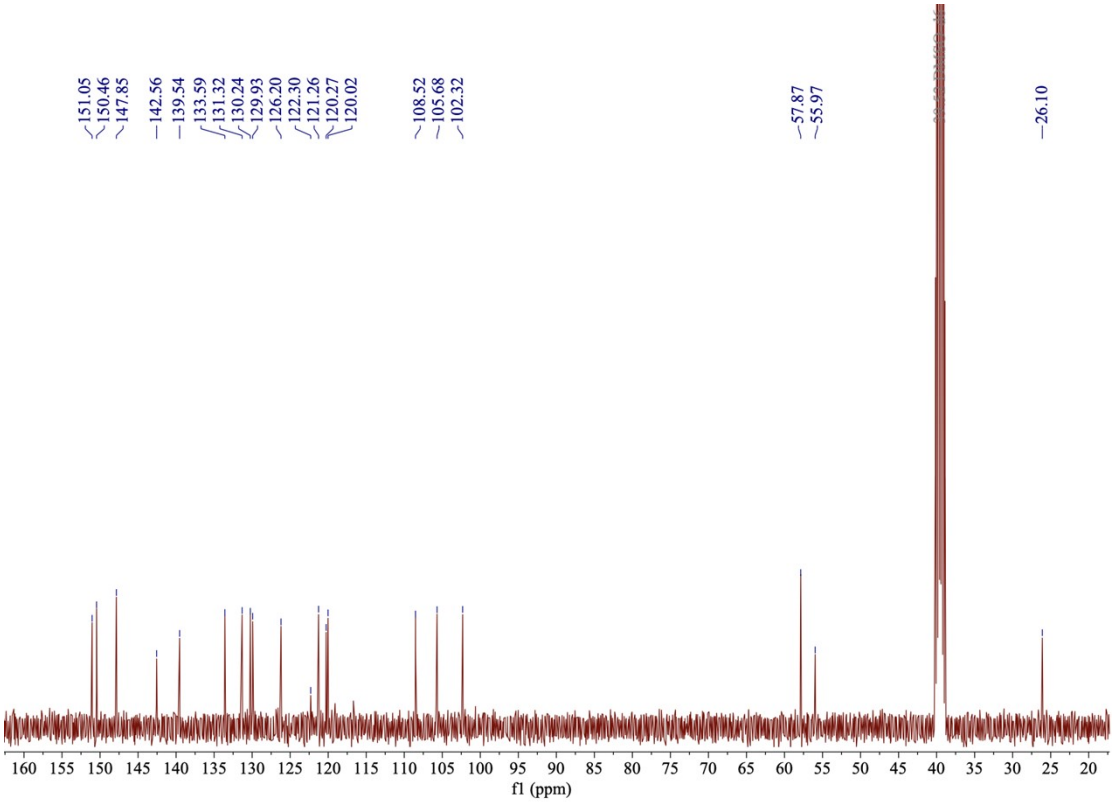


Figure S11. ^{13}C NMR spectrum of ***compound 1*** (101 MHz, DMSO-d_6).

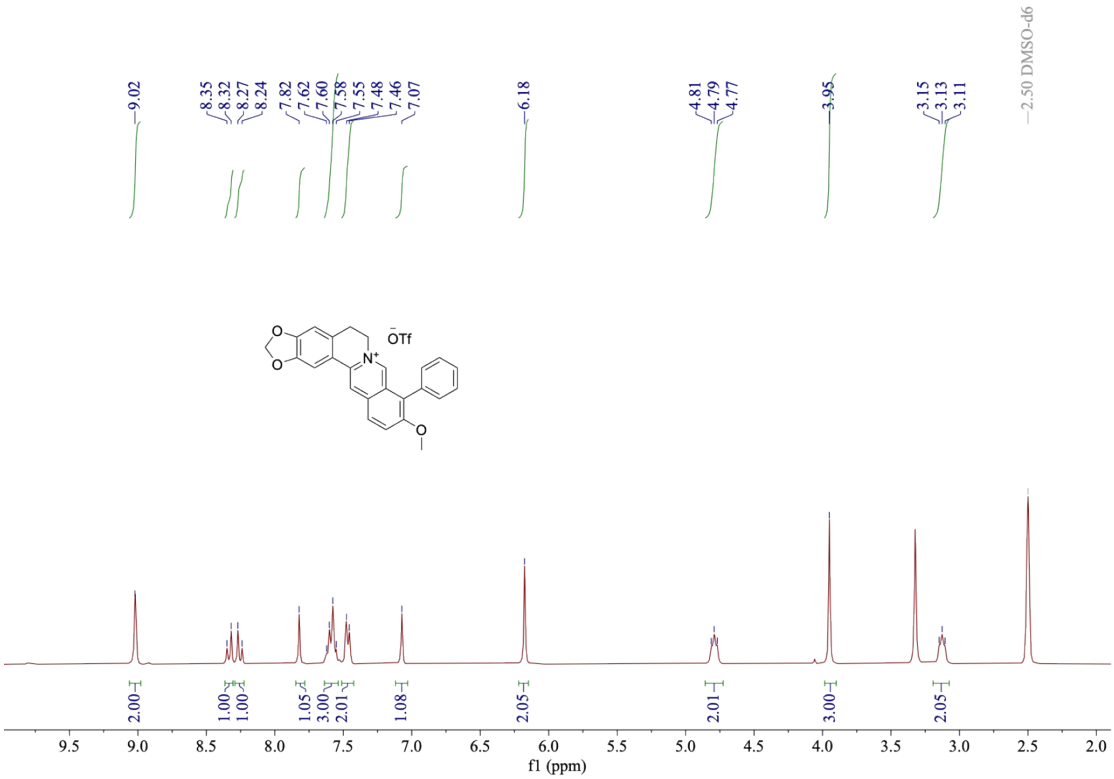


Figure S12. [1]H NMR spectrum of ***2a*** (300 MHz, DMSO-d_6).

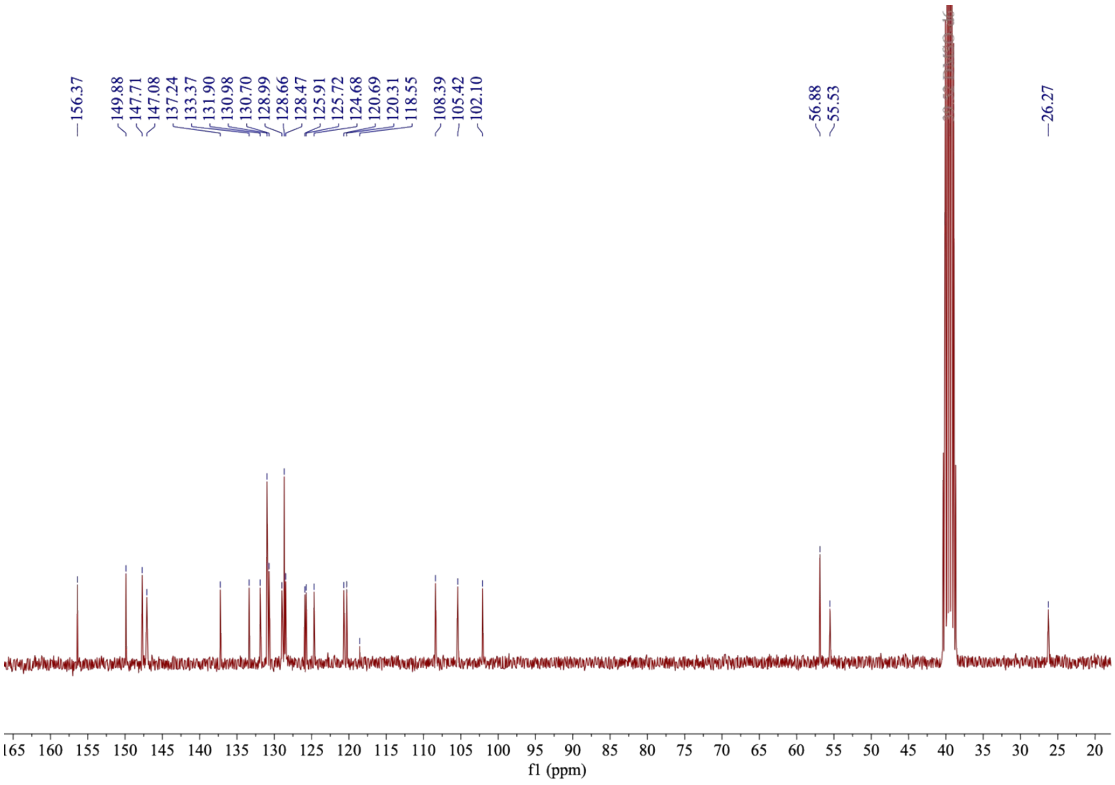


Figure S13. [13]C NMR spectrum of ***2a*** (75 MHz, DMSO-d_6).

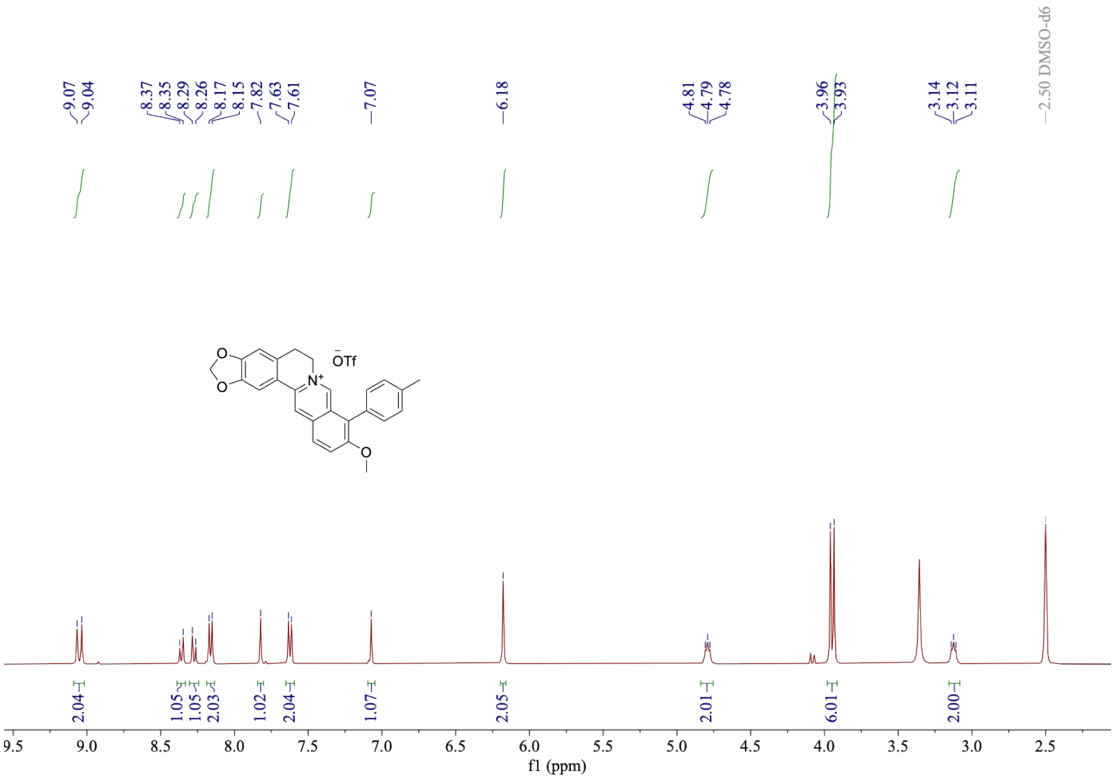


Figure S14. ^{1}H NMR spectrum of ***2b*** (400 MHz, DMSO-d_6).

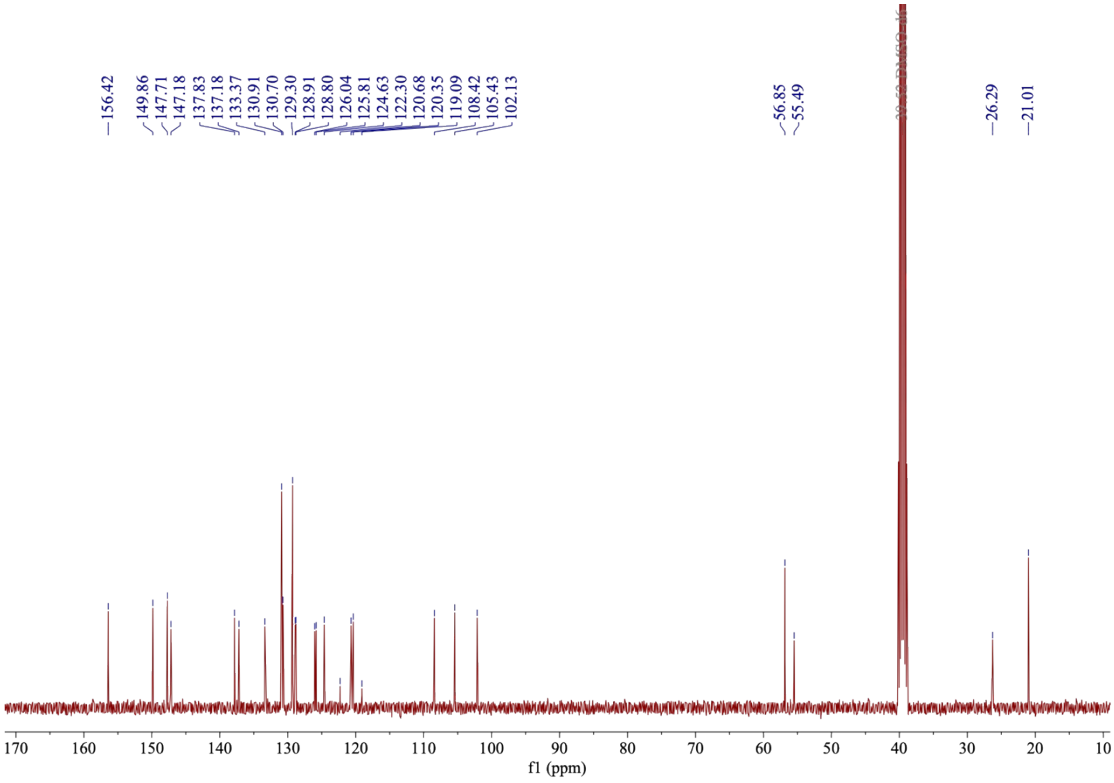


Figure S15. ^{13}C NMR spectrum of ***2b*** (101 MHz, DMSO-d_6).

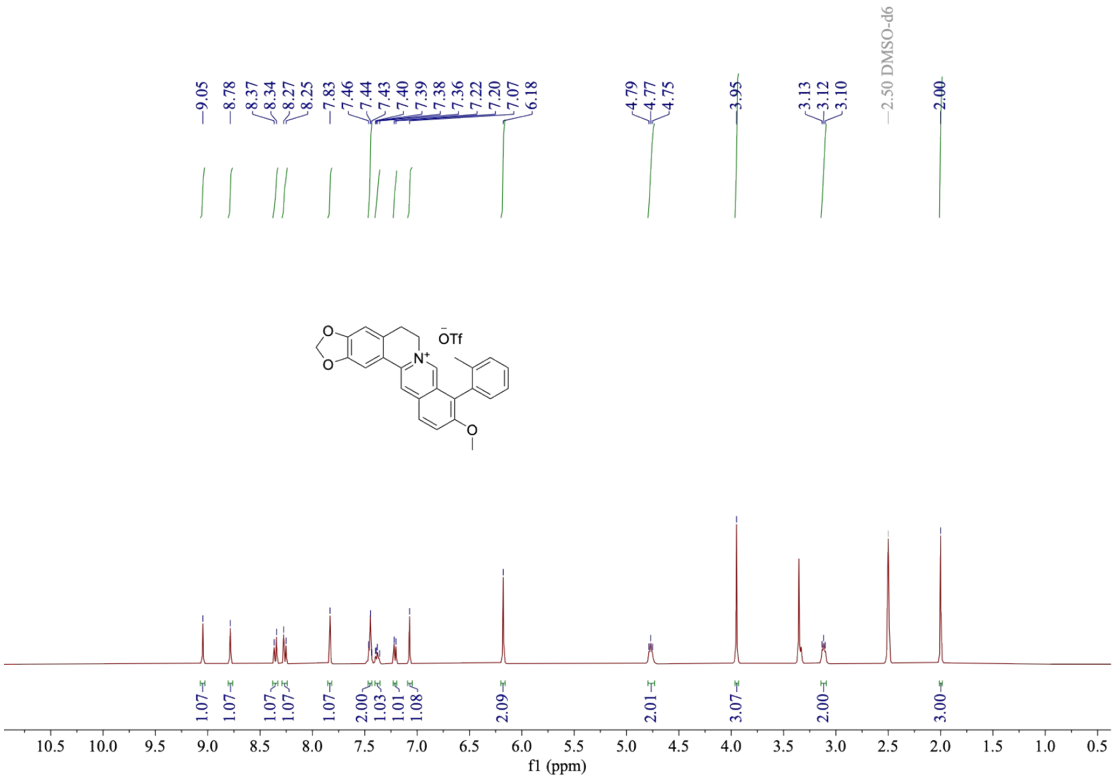


Figure S16. [1]H NMR spectrum of ***2c*** (400 MHz, DMSO-d_6).

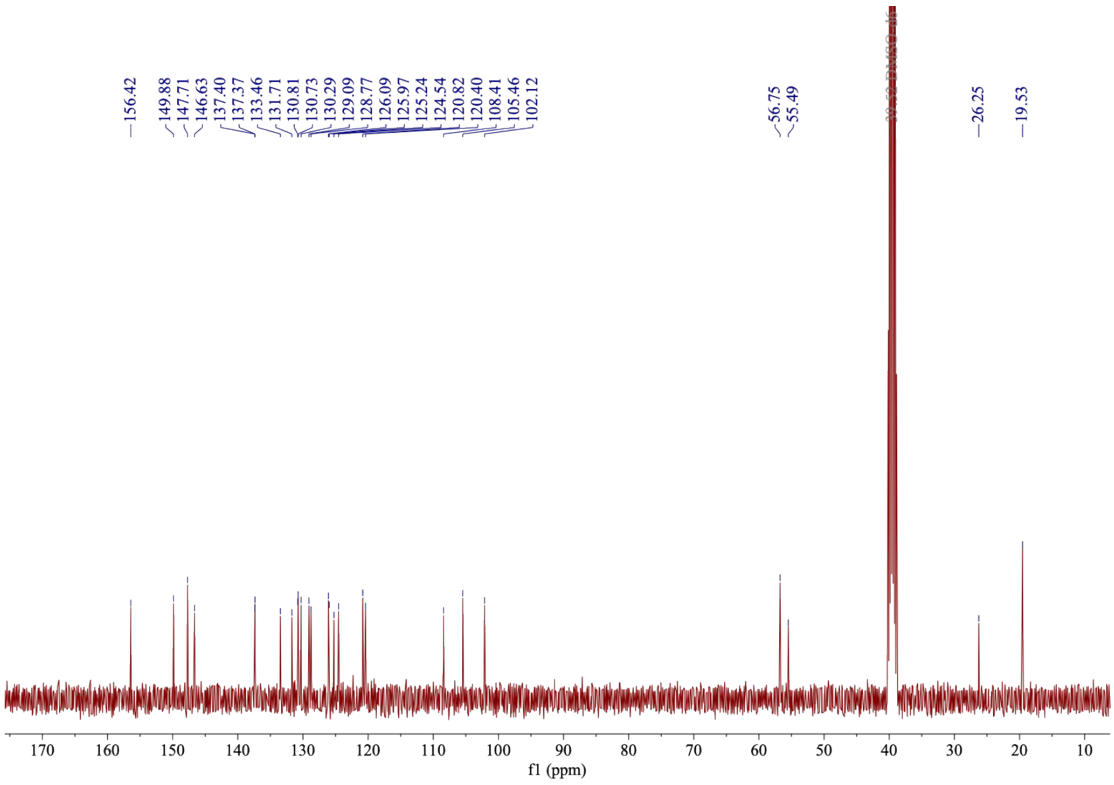


Figure S17. [13]C NMR spectrum of ***2c*** (101 MHz, DMSO-d_6).

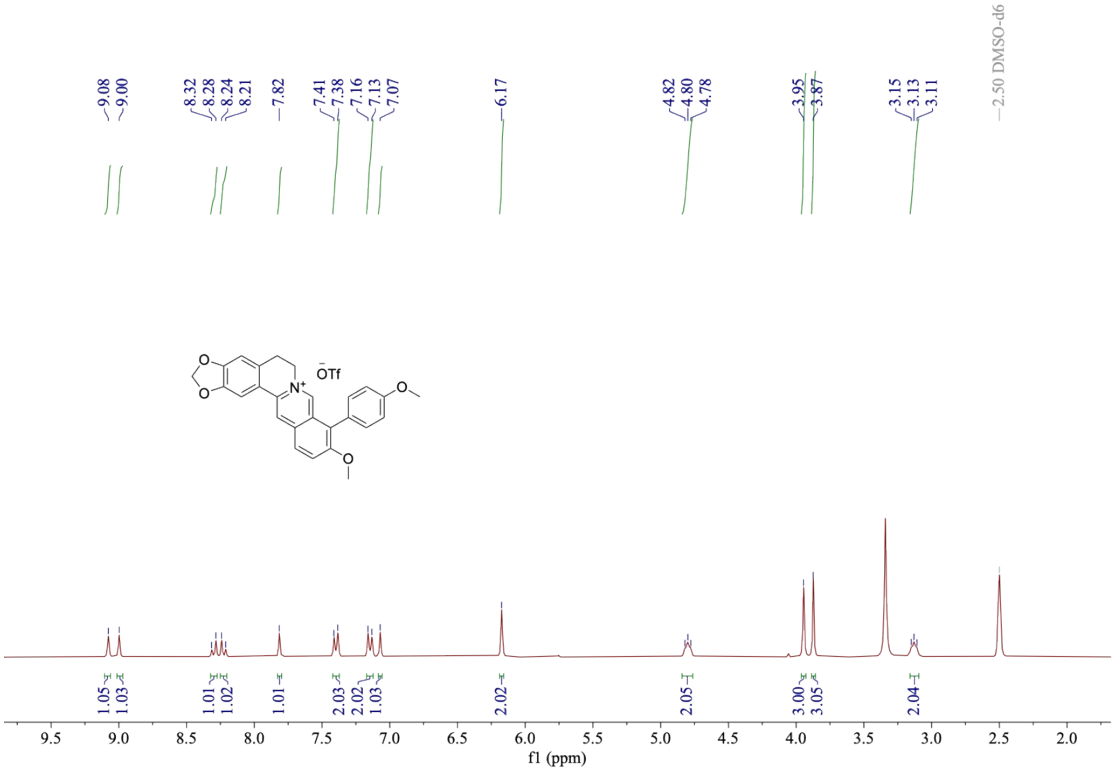


Figure S18. ^{1}H NMR spectrum of ***2d*** (300 MHz, DMSO-d_6).

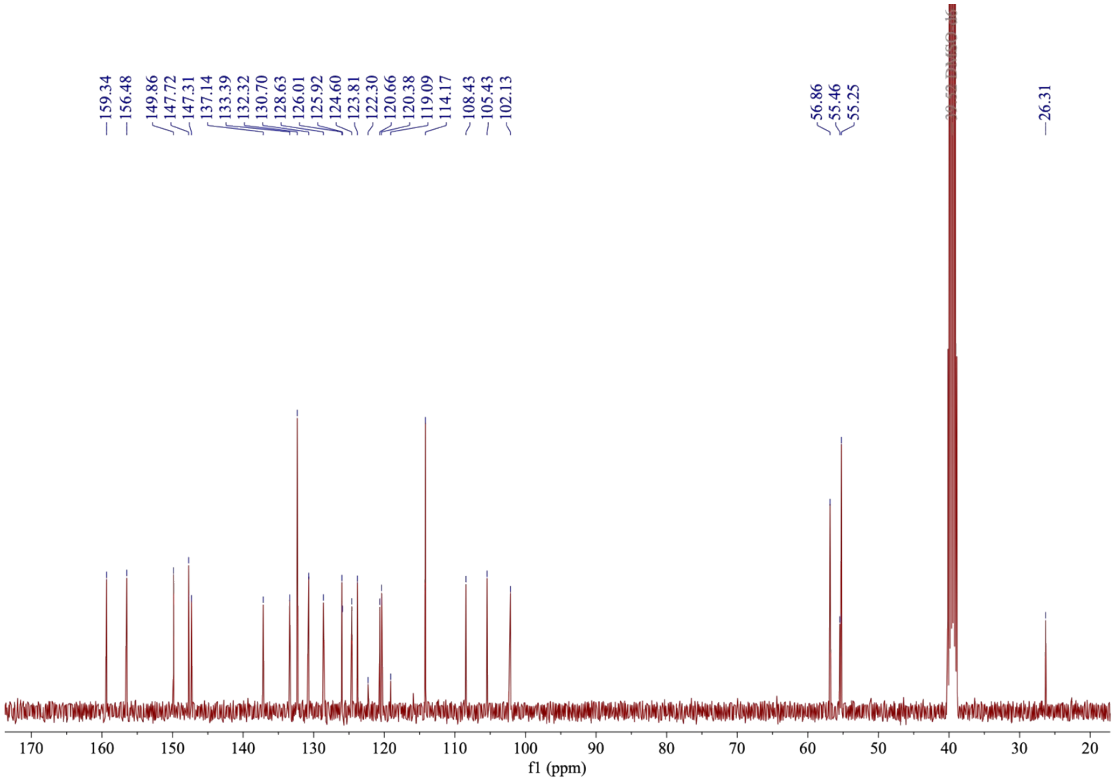


Figure S19. ^{13}C NMR spectrum of ***2d*** (101 MHz, DMSO-d_6).

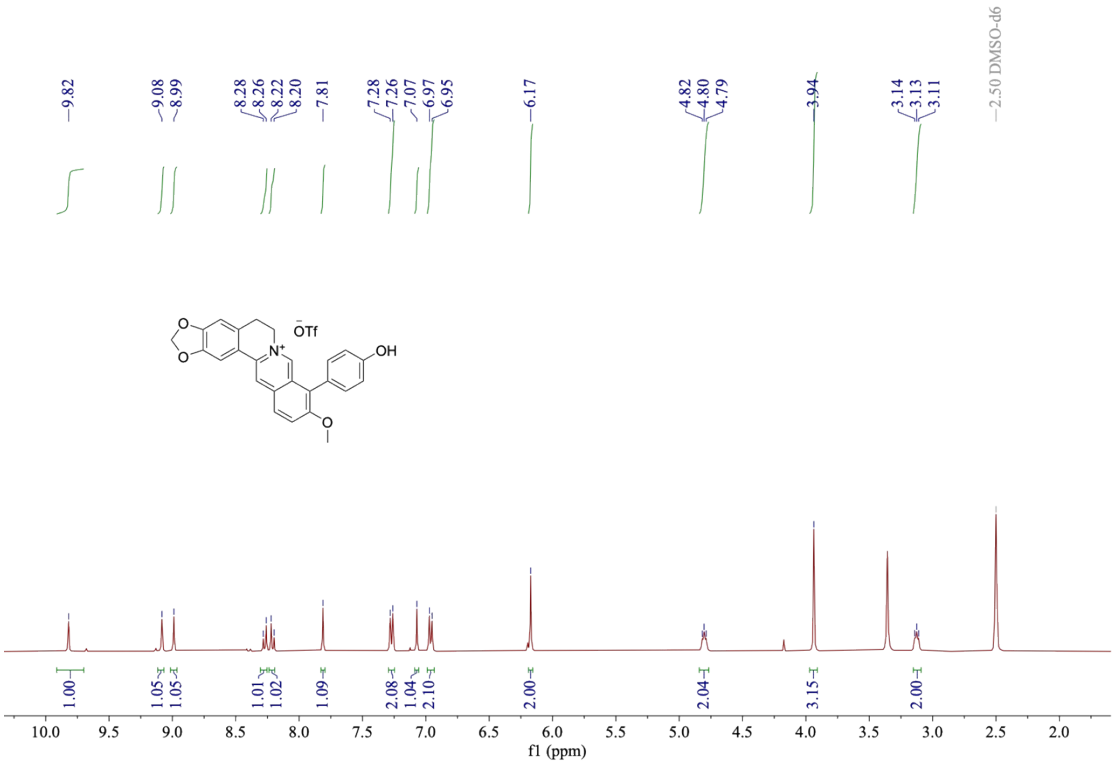


Figure S20. [1]H NMR spectrum of ***2e*** (400 MHz, DMSO-d_6).

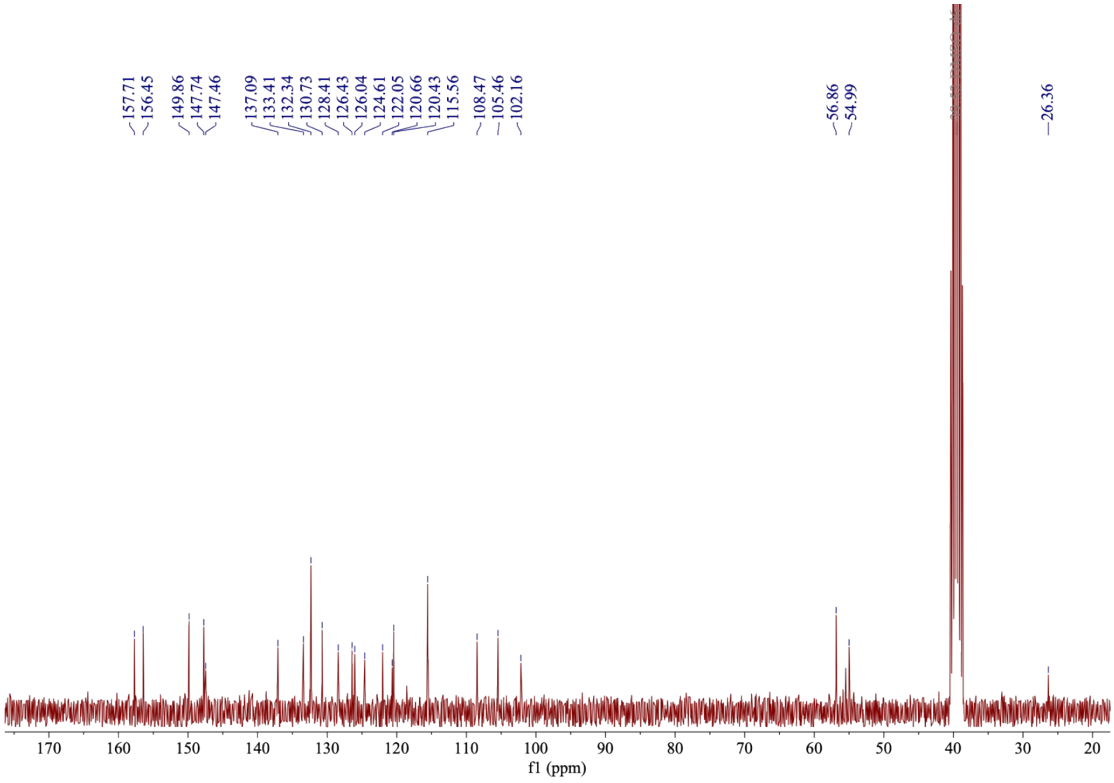


Figure S21. [13]C NMR spectrum of ***2e*** (75 MHz, DMSO-d_6).

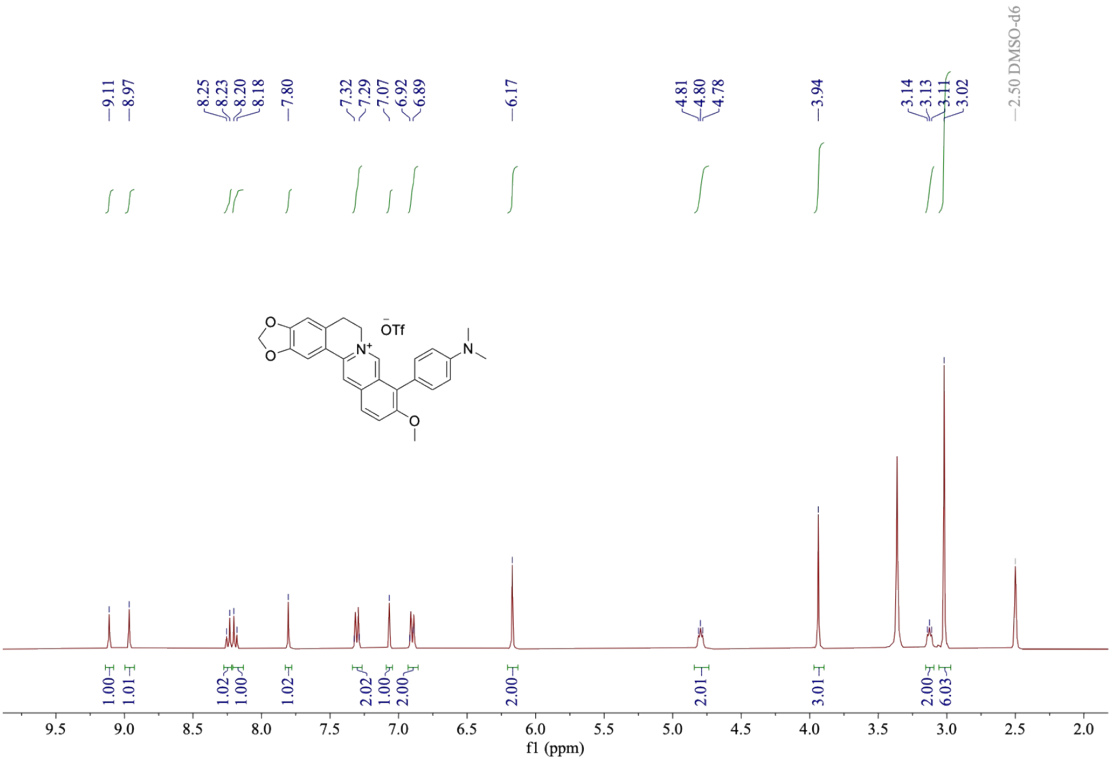


Figure S22. ^{1}H NMR spectrum of ***2f*** (400 MHz, DMSO-d_6).

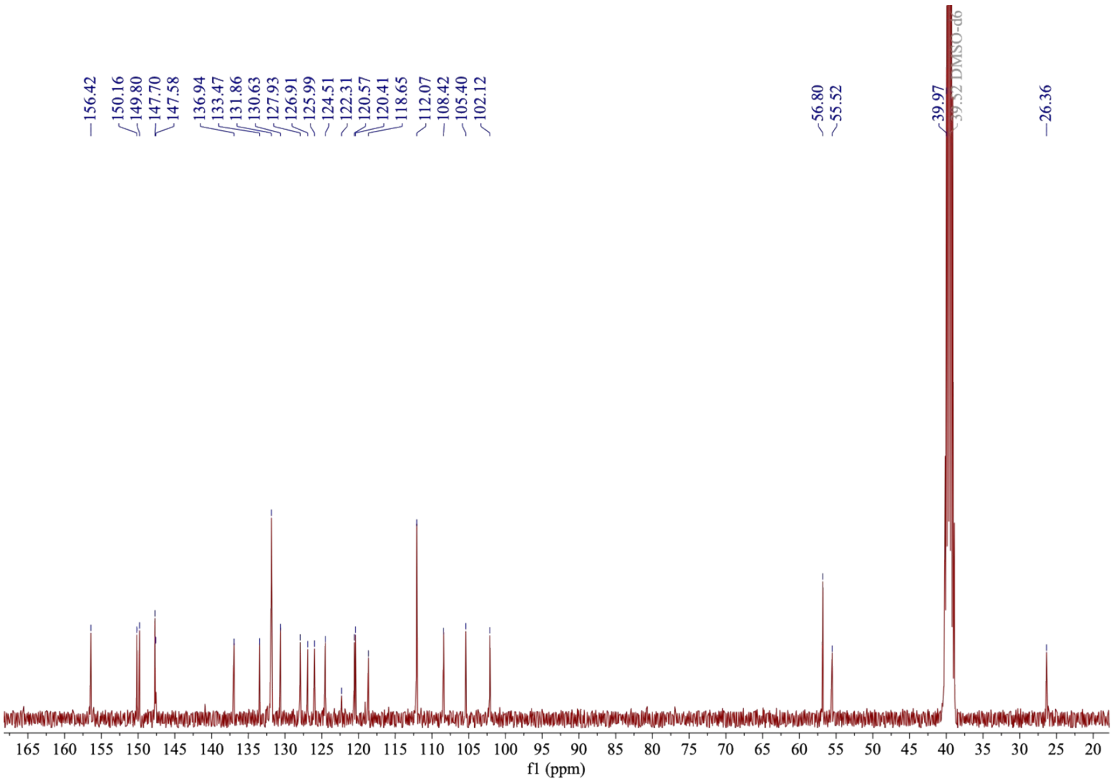


Figure S23. ^{13}C NMR spectrum of ***2f*** (101 MHz, DMSO-d_6).

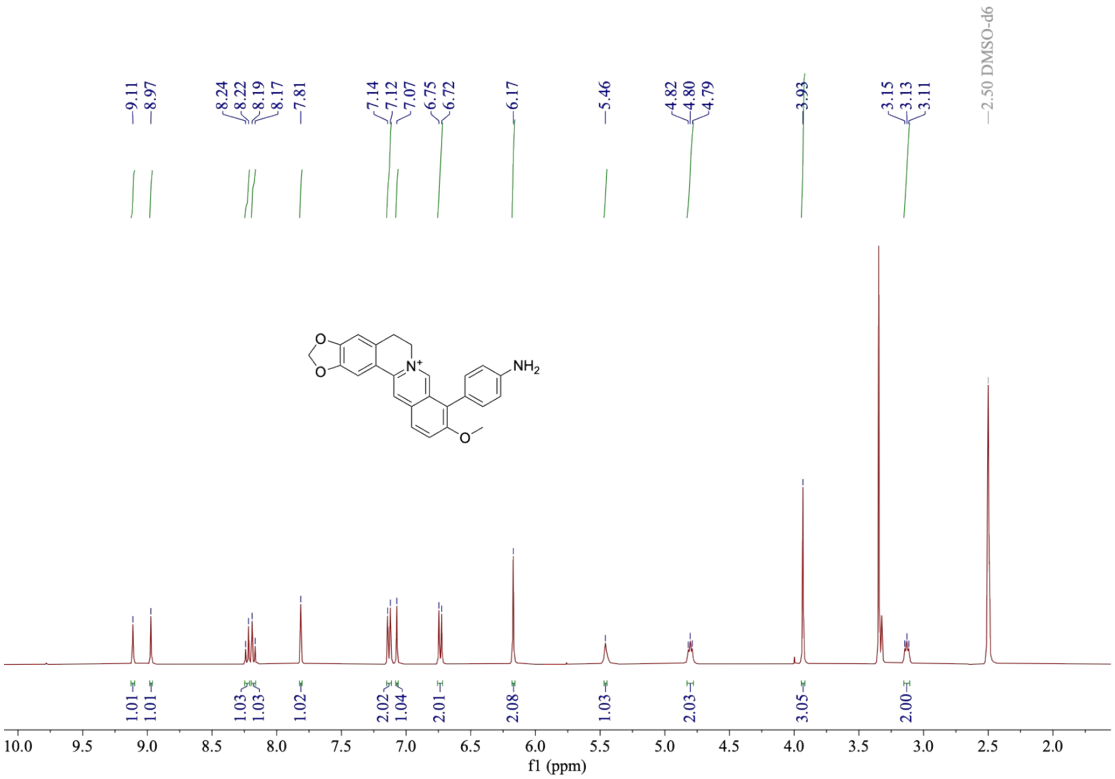


Figure S24. [1]H NMR spectrum of ***2g*** (400 MHz, DMSO-d_6).

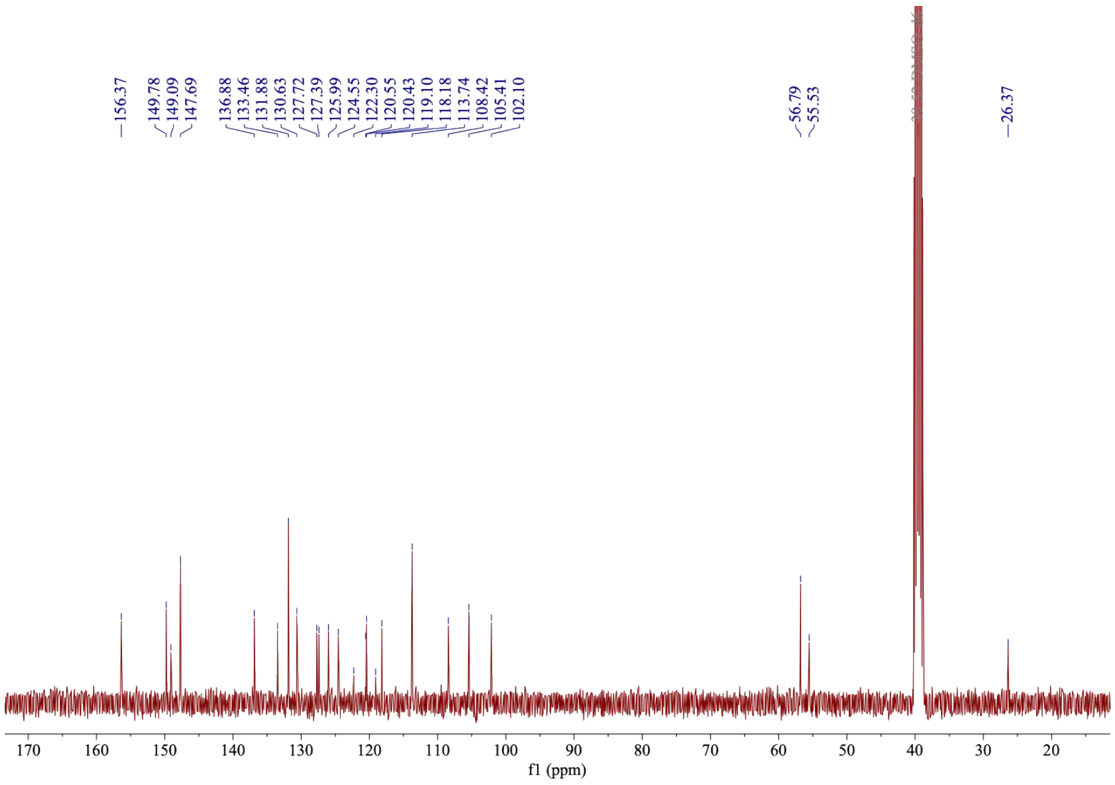


Figure S25. [13]C NMR spectrum of ***2g*** (101 MHz, DMSO-d_6).

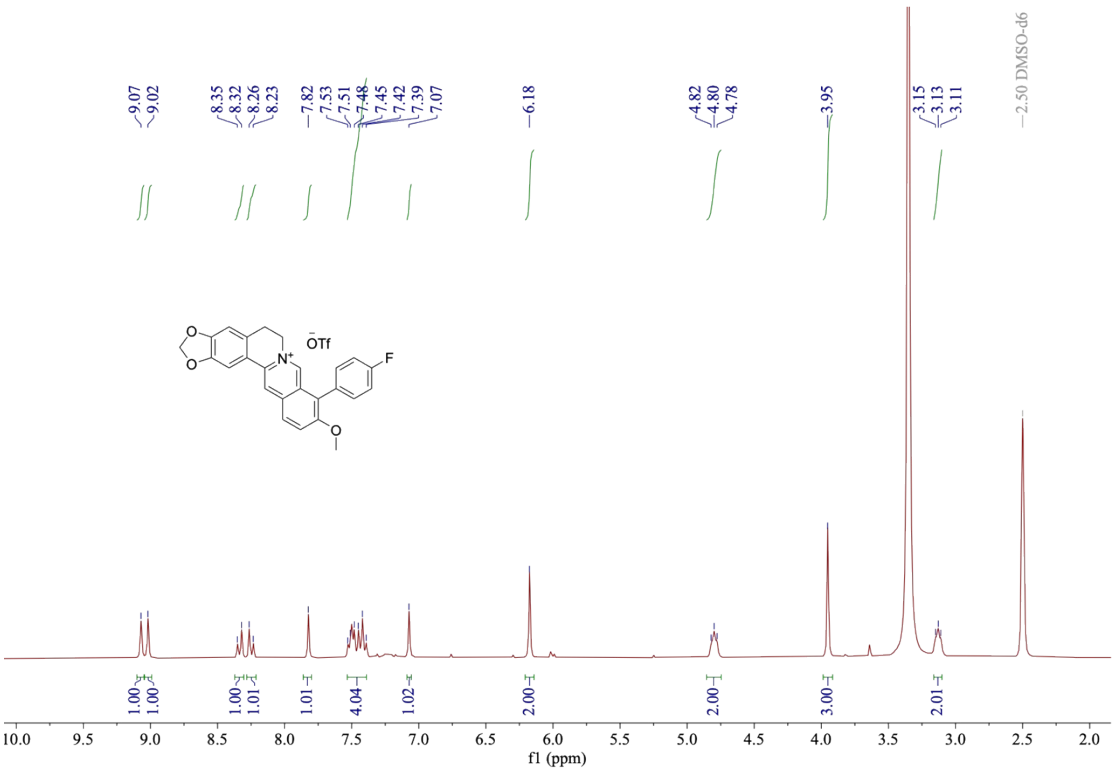


Figure S26. ^{1}H NMR spectrum of ***2h*** (300 MHz, DMSO-d_6).

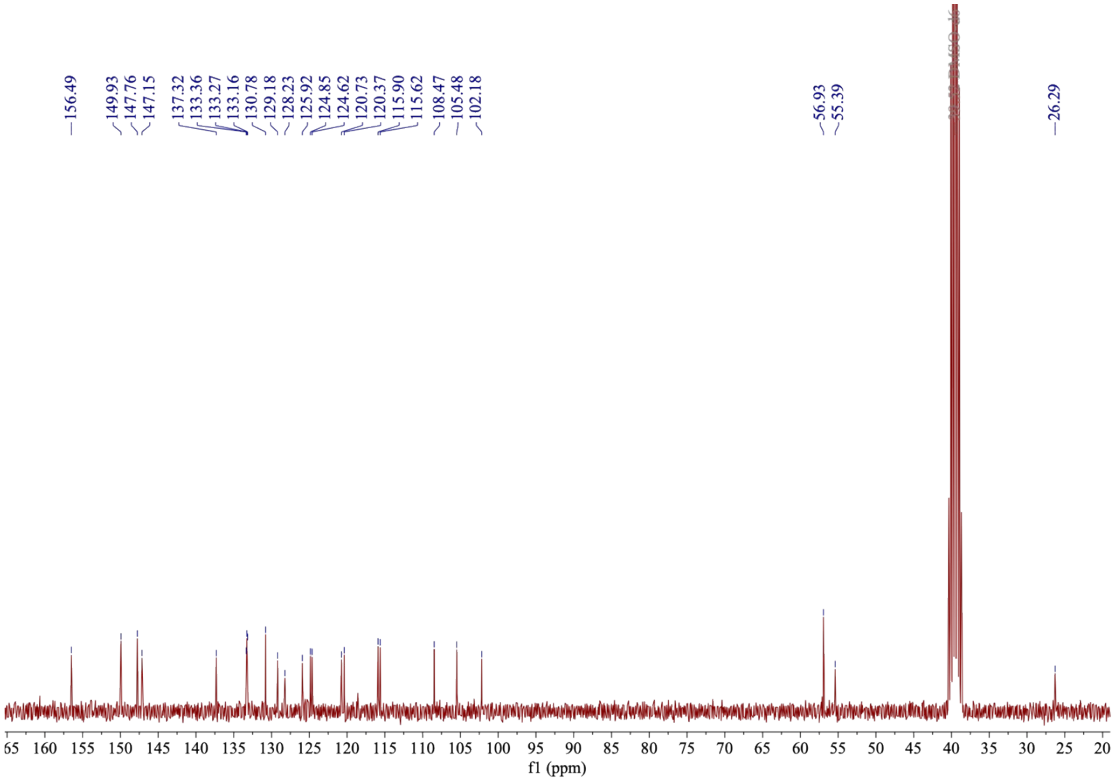


Figure S27. ^{13}C NMR spectrum of ***2h*** (75 MHz, DMSO-d_6).

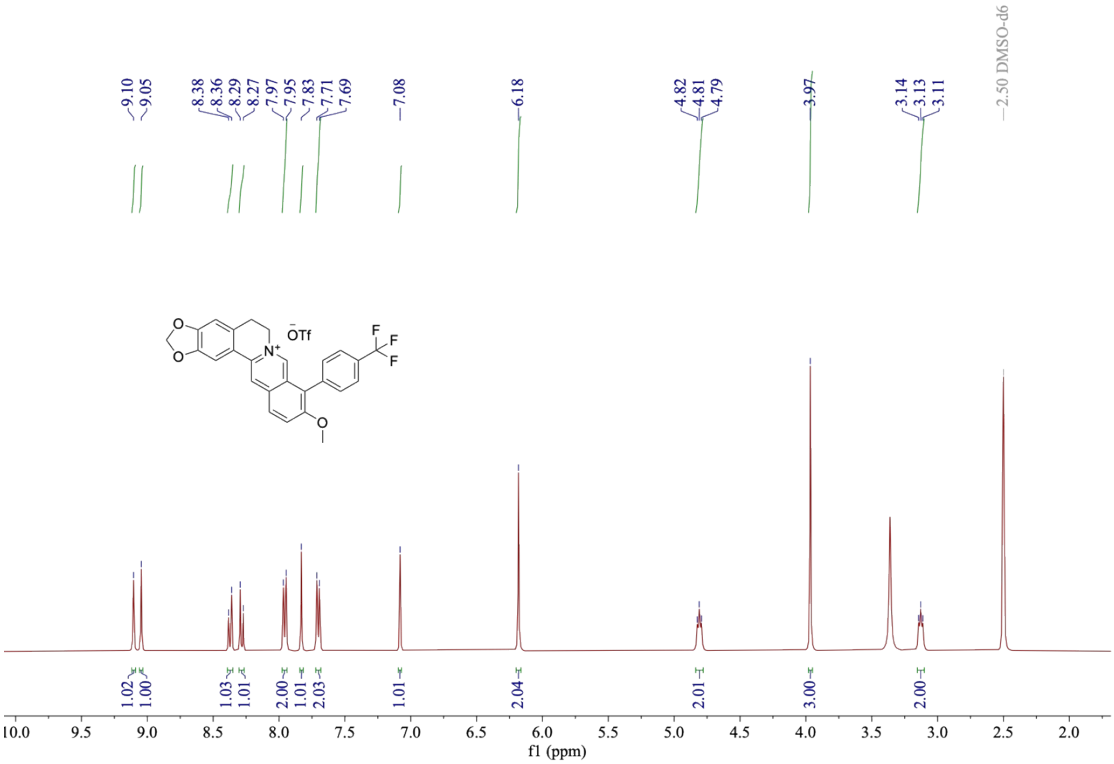


Figure S28. ^{1}H NMR spectrum of ***2i*** (400 MHz, DMSO-d_6).

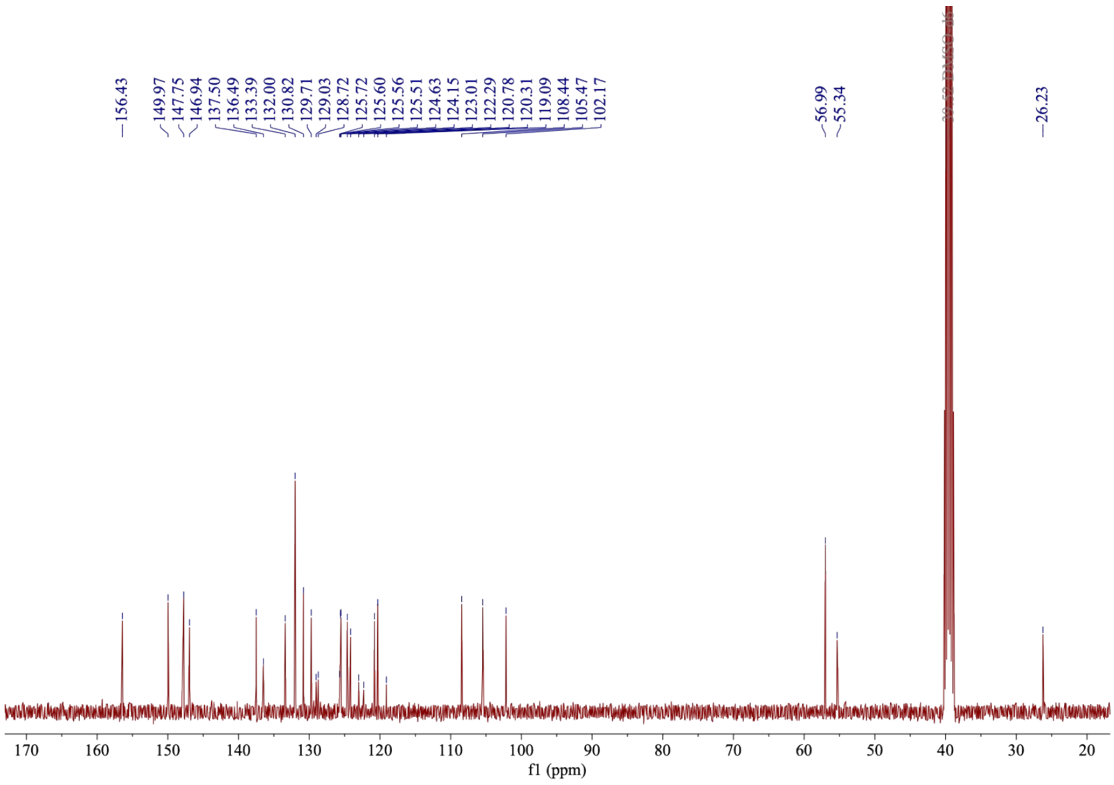


Figure S29. ^{13}C NMR spectrum of ***2i*** (101 MHz, DMSO-d_6).

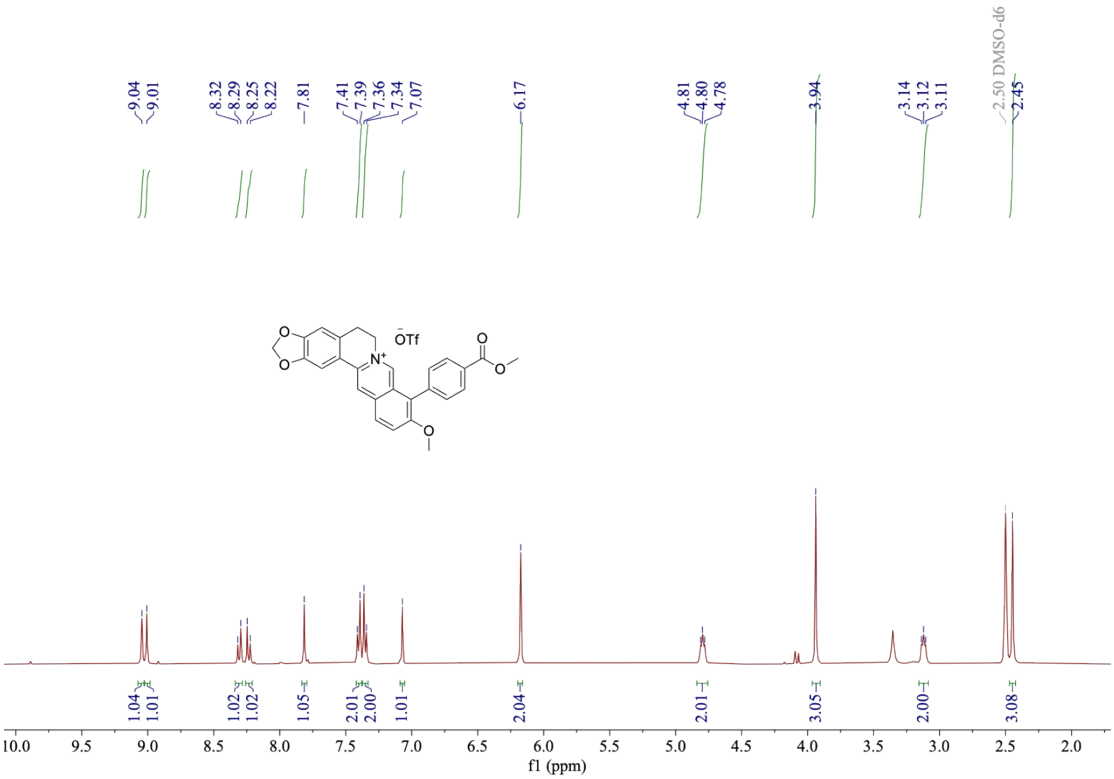


Figure S30. [1]H NMR spectrum of ***2j*** (400 MHz, DMSO-d_6).

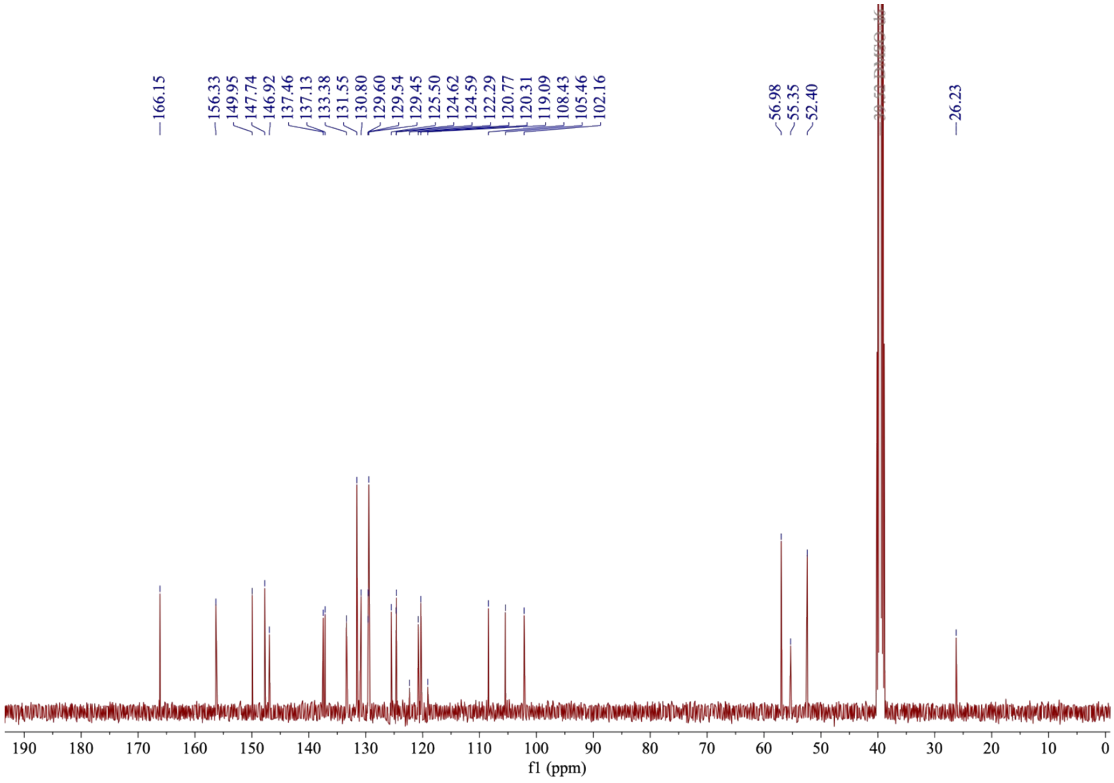


Figure S31. [13]C NMR spectrum of ***2j*** (101 MHz, DMSO-d_6).

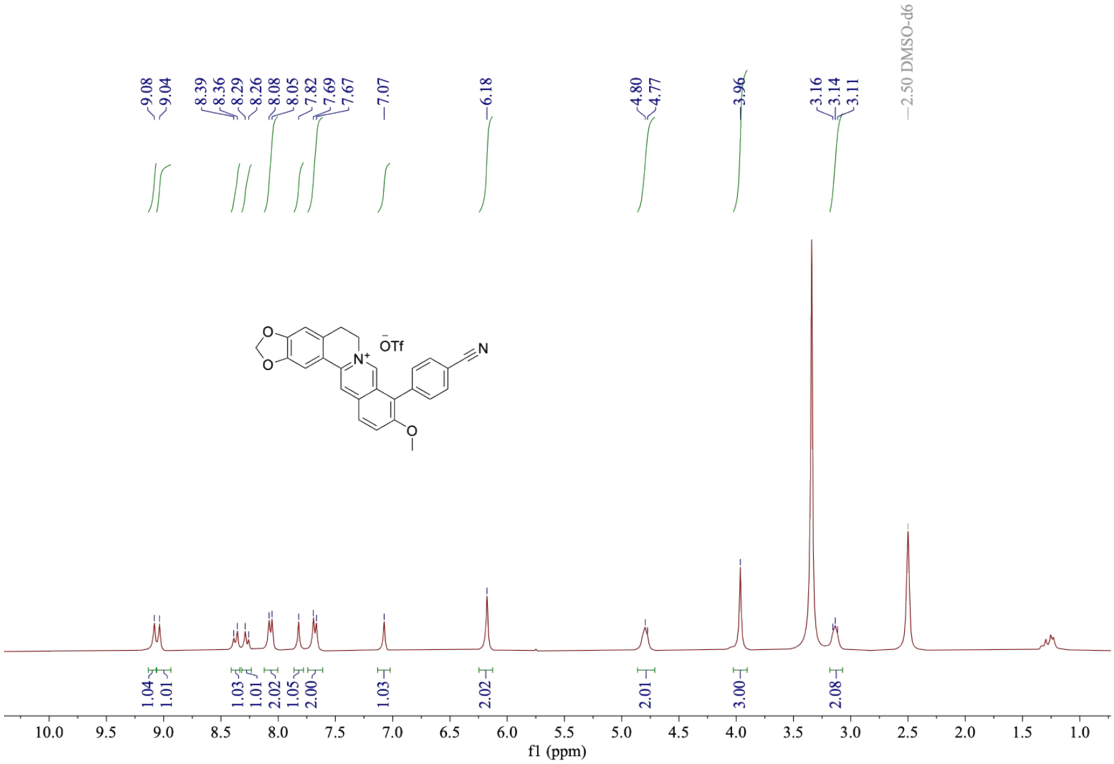


Figure S32. ^{1}H NMR spectrum of ***2k*** (300 MHz, DMSO-d_6).

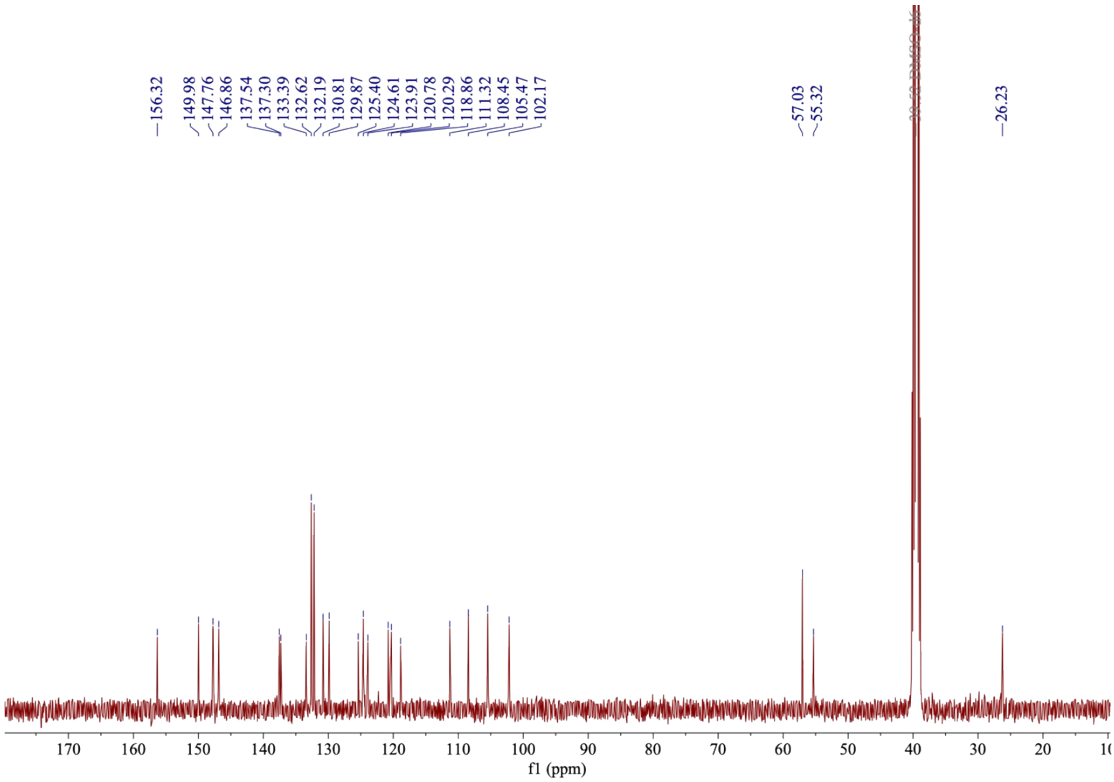


Figure S33. ^{13}C NMR spectrum of ***2k*** (101 MHz, DMSO-d_6).

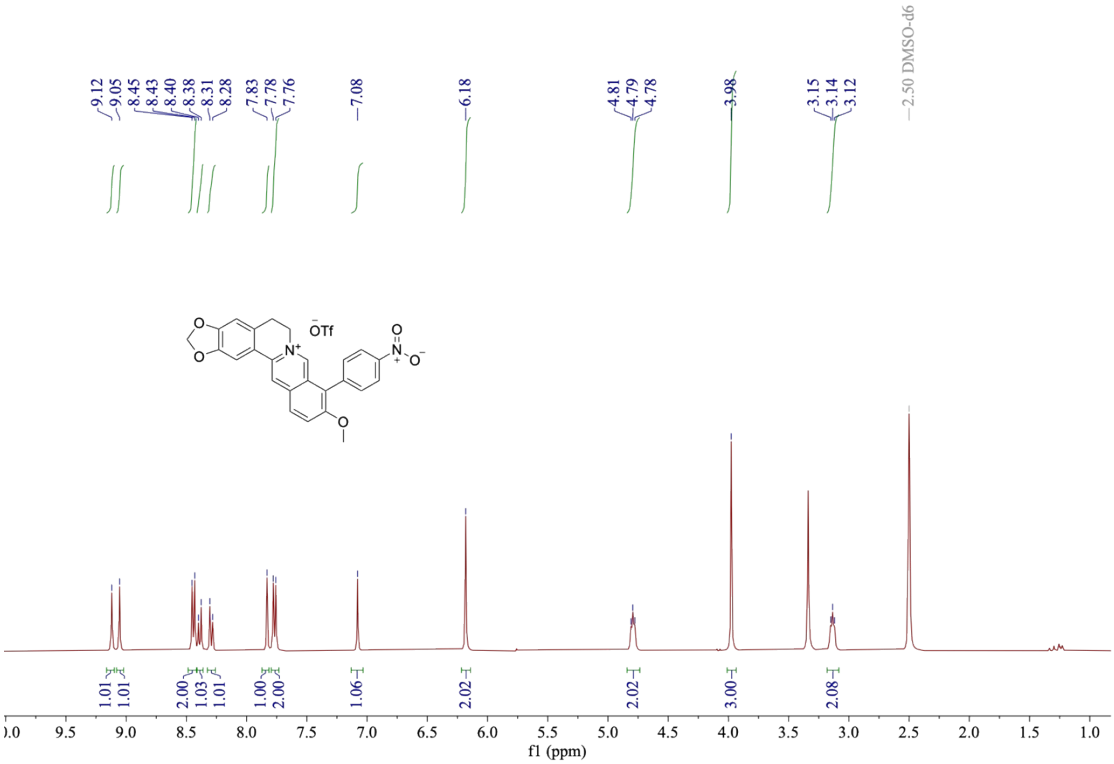


Figure S34. ^{1}H NMR spectrum of ***2l*** (400 MHz, DMSO-d_6).

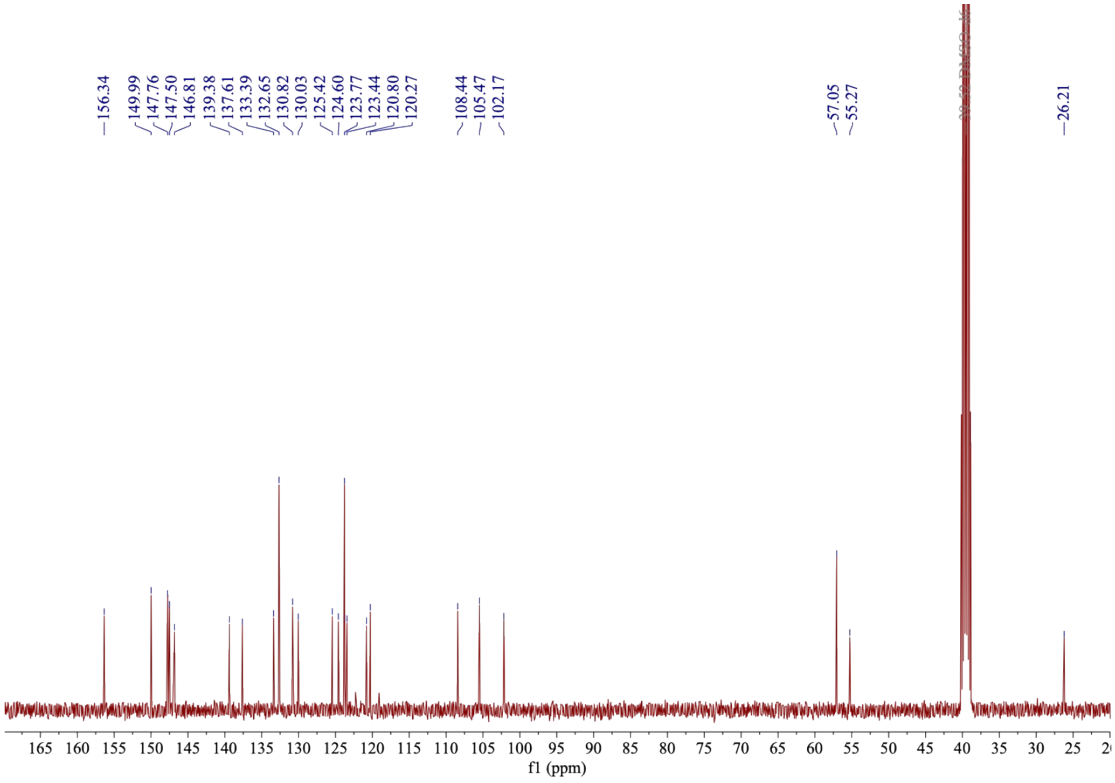


Figure S35. ^{13}C NMR spectrum of ***2l*** (101 MHz, DMSO-d_6).

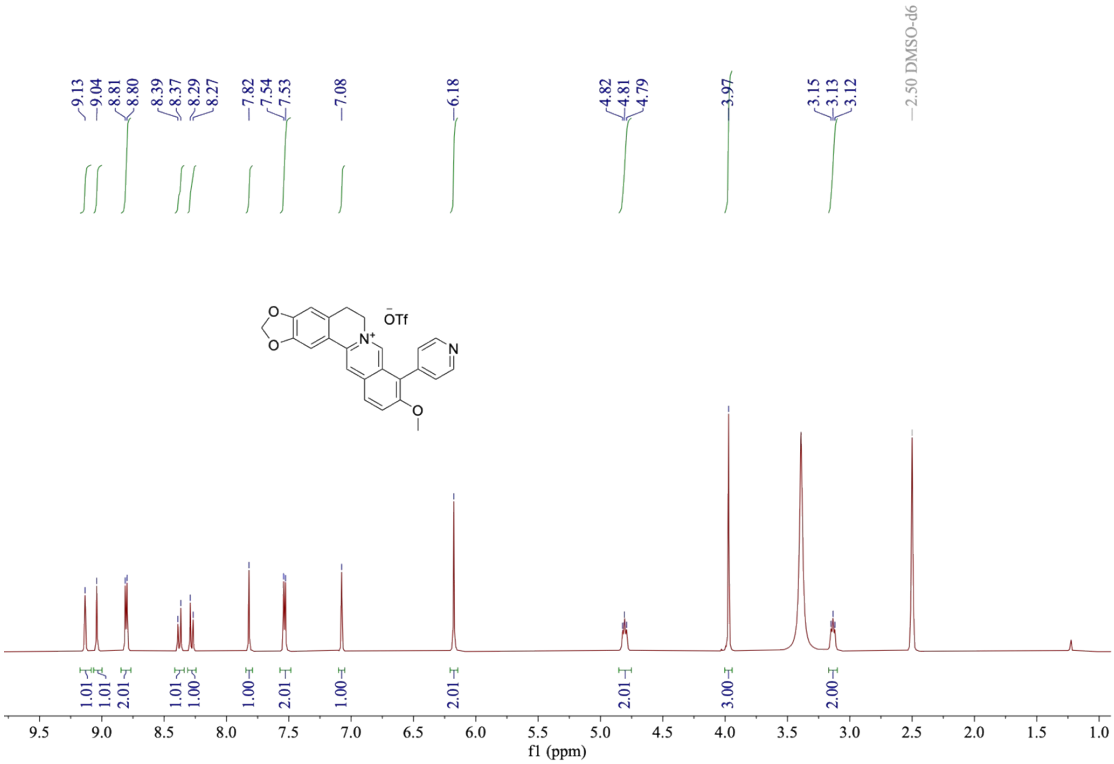


Figure S36. [1]H NMR spectrum of ***2m*** (400 MHz, DMSO-d_6).

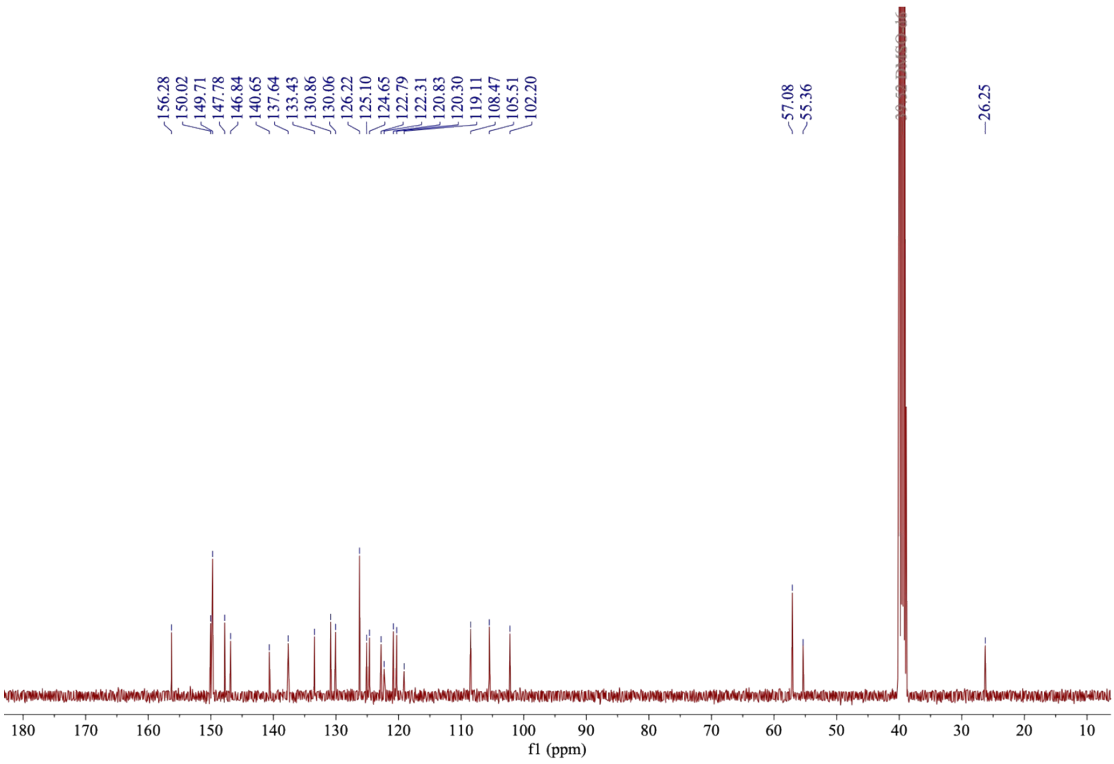


Figure S37. [13]C NMR spectrum of ***2m*** (101 MHz, DMSO-d_6).

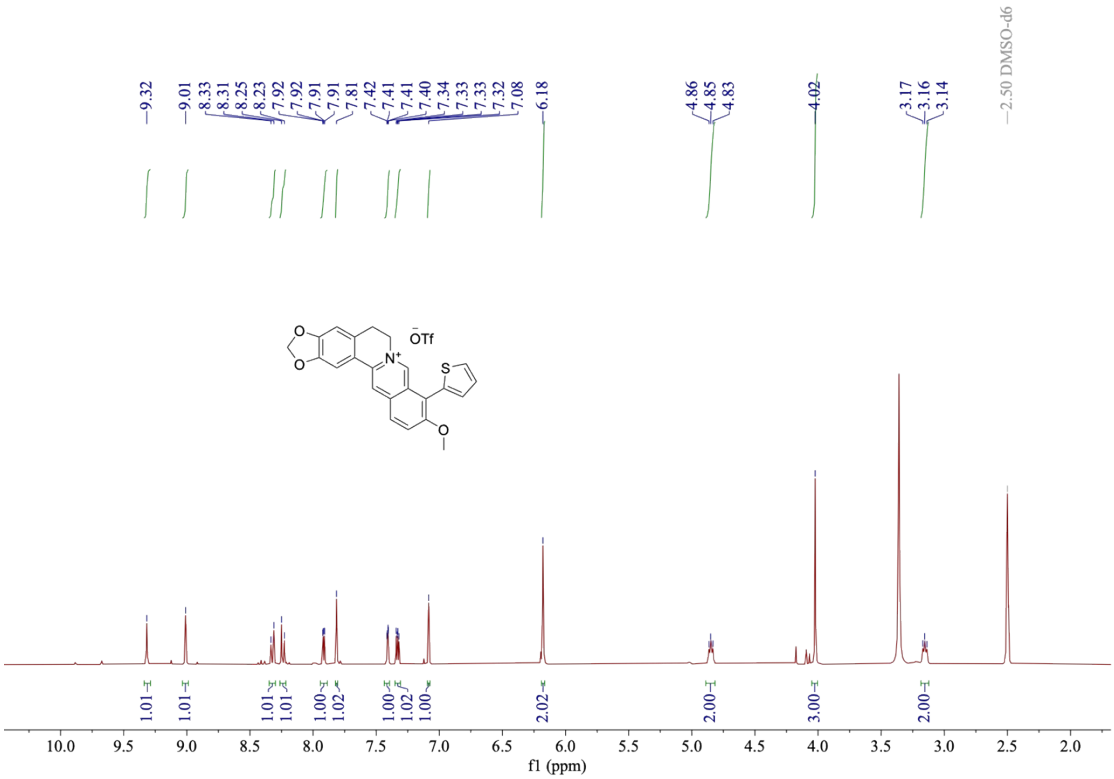


Figure S38. ^{1}H NMR spectrum of ***2n*** (400 MHz, DMSO-d_6).

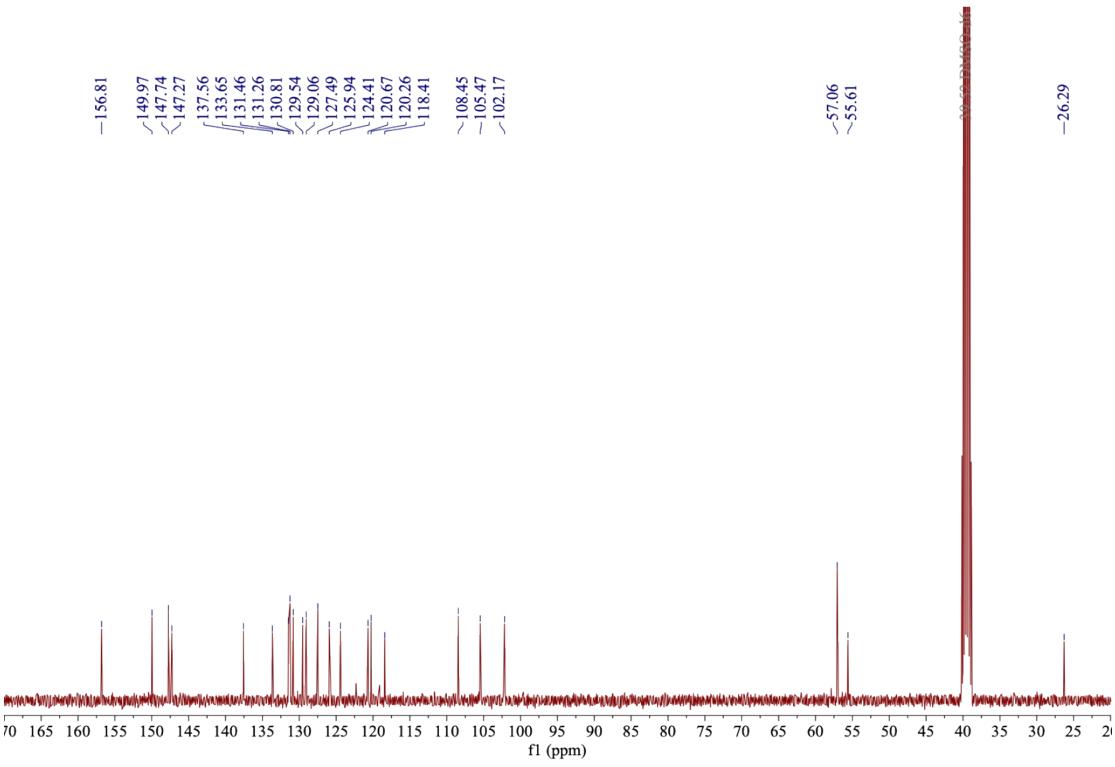


Figure S39. ^{13}C NMR spectrum of ***2n*** (101 MHz, DMSO-d_6).

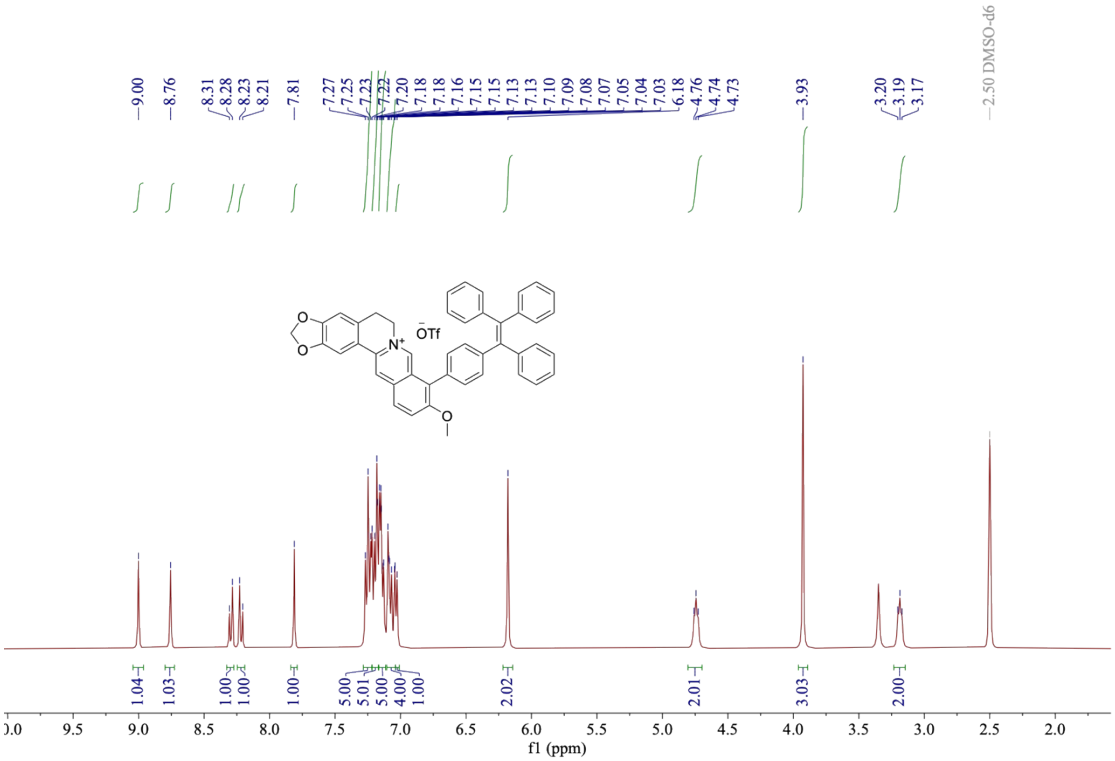


Figure S40. [1]H NMR spectrum of ***2o*** (400 MHz, DMSO-d_6).

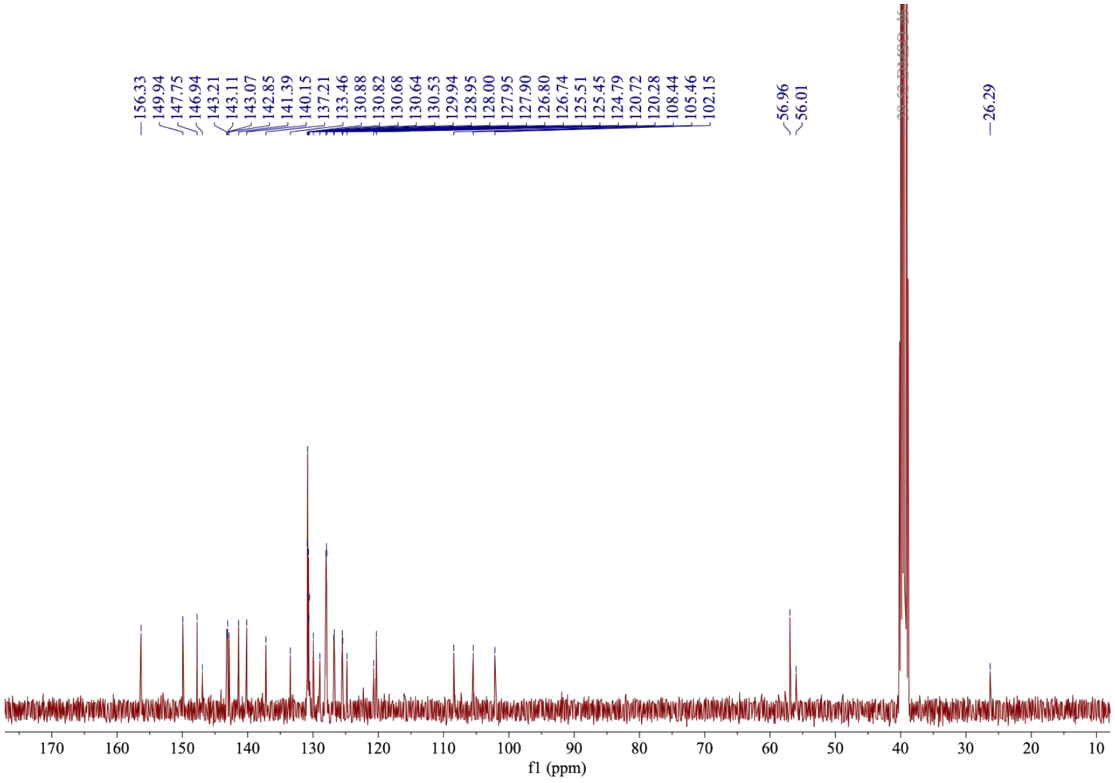


Figure S41. [13]C NMR spectrum of ***2o*** (101 MHz, DMSO-d_6).

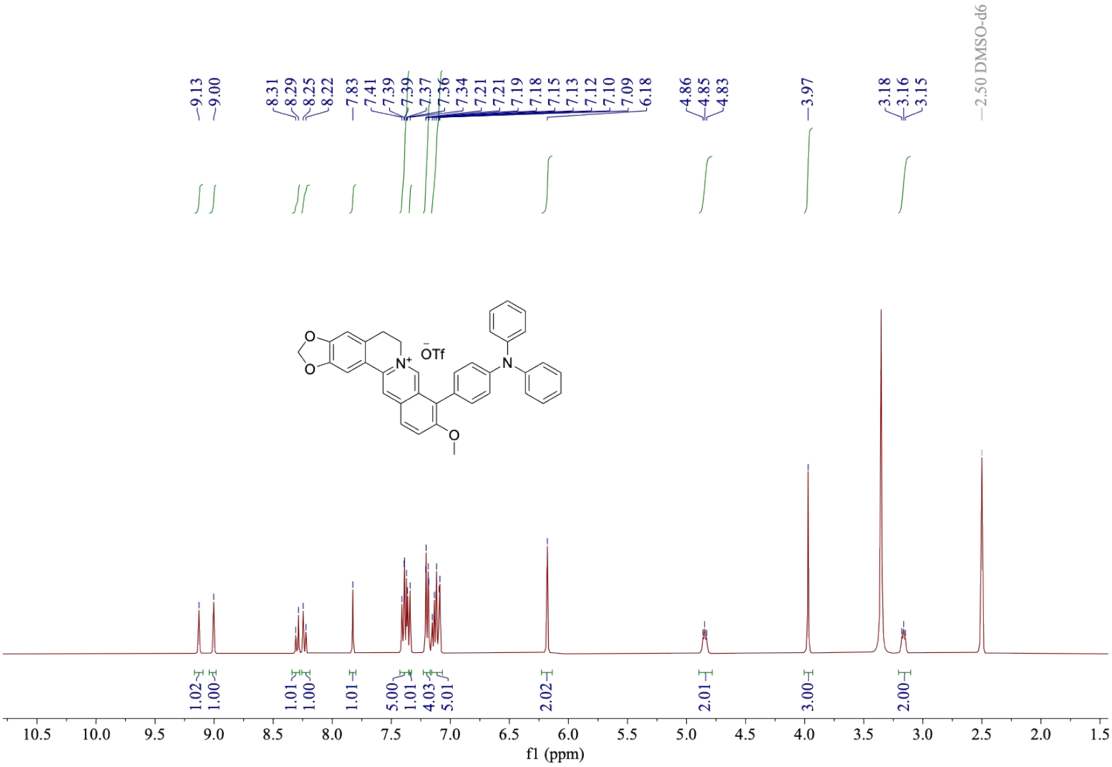


Figure S42. [1]H NMR spectrum of ***2p*** (400 MHz, DMSO-d_6).

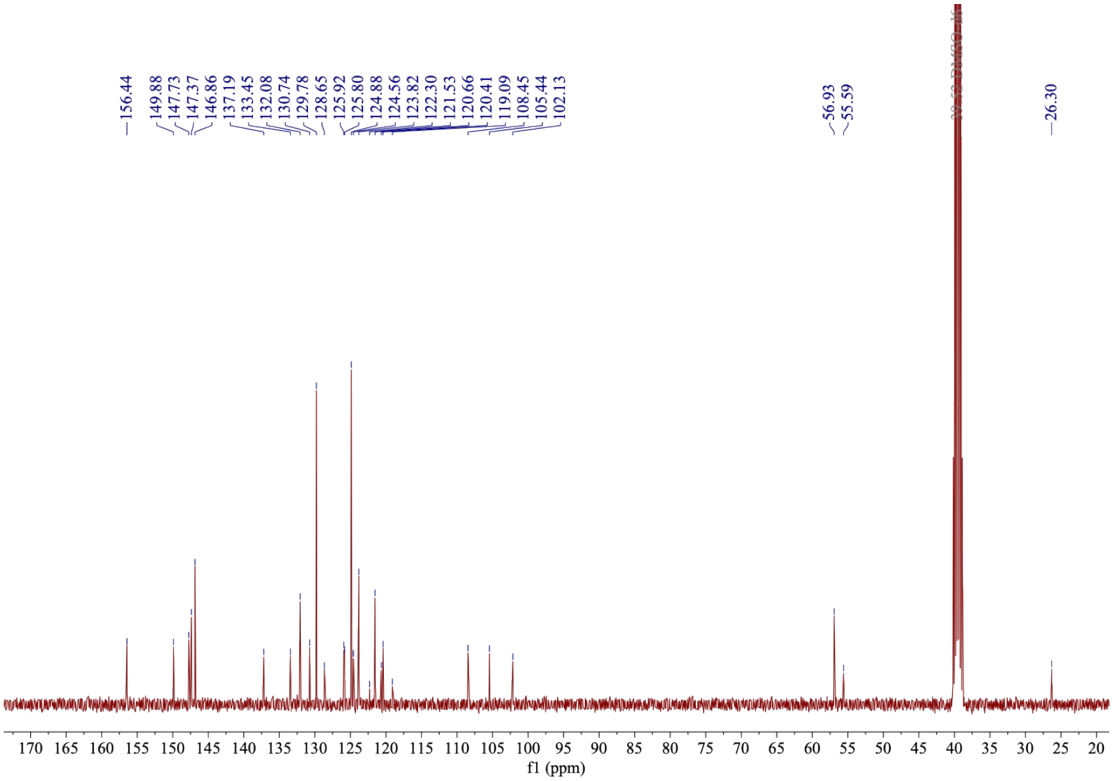


Figure S43. [13]C NMR spectrum of ***2p*** (101 MHz, DMSO-d_6).

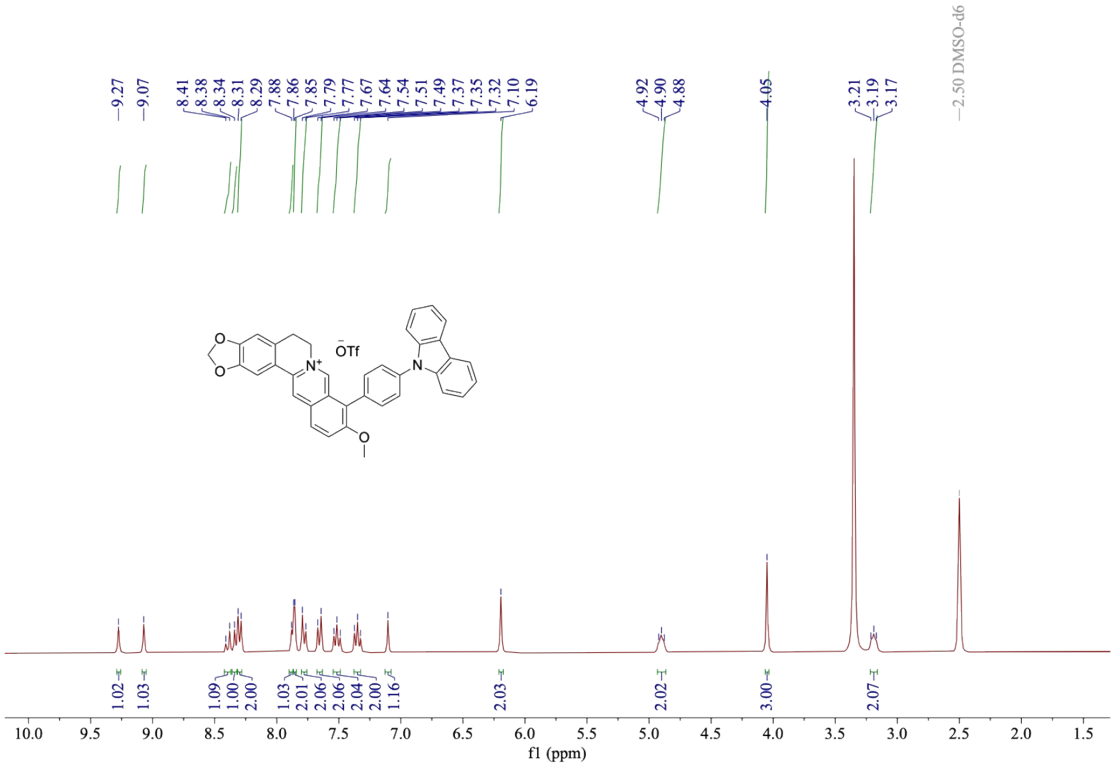


Figure S44. ^{1}H NMR spectrum of ***2q*** (300 MHz, DMSO-d_6).

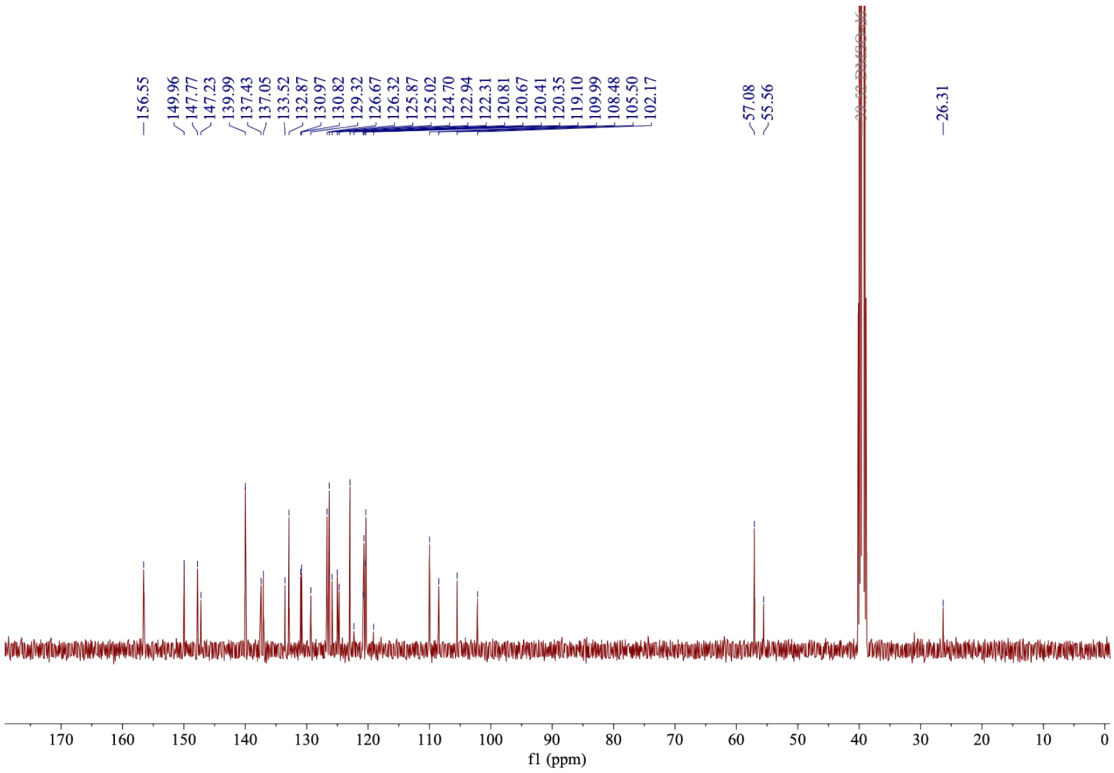


Figure S45. ^{13}C NMR spectrum of ***2q*** (101 MHz, DMSO-d_6).

5. HRMS Spectra of all the compounds

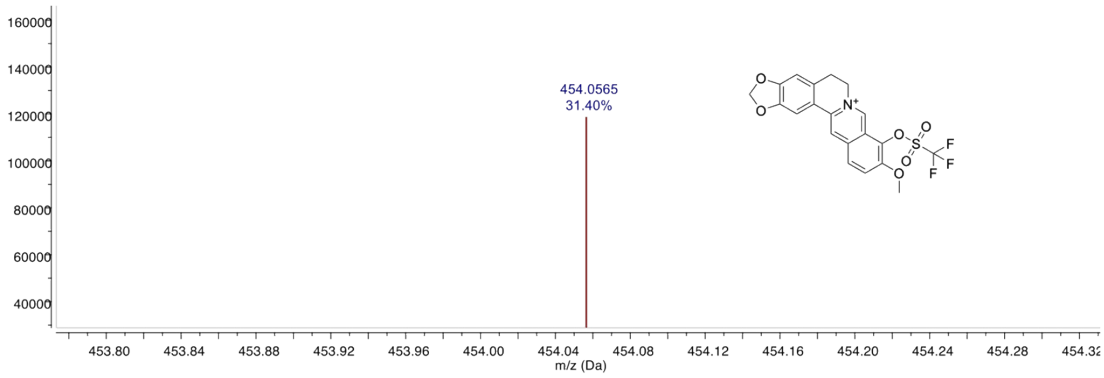


Figure S46. HRMS spectrum of ***compound 1.***

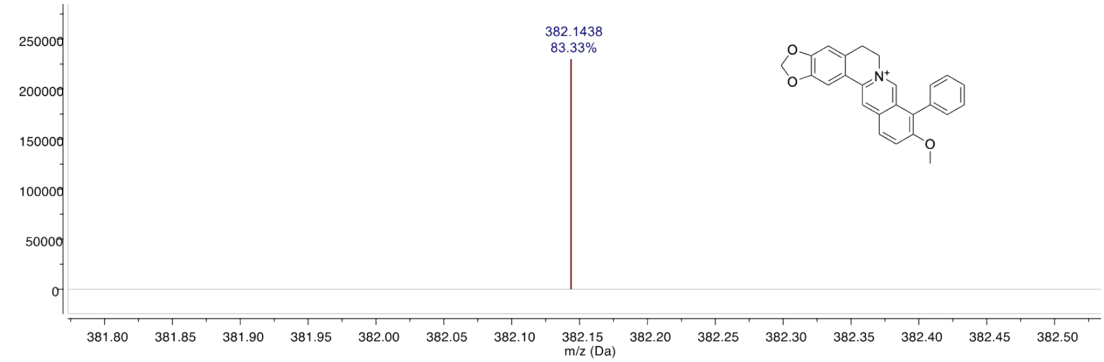


Figure S47. HRMS spectrum of ***2a***.

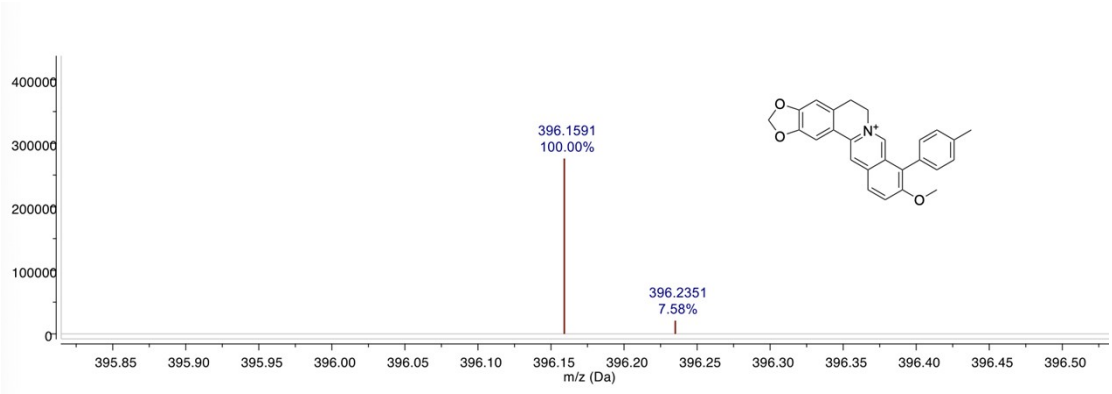


Figure S48. HRMS spectrum of ***2b***.

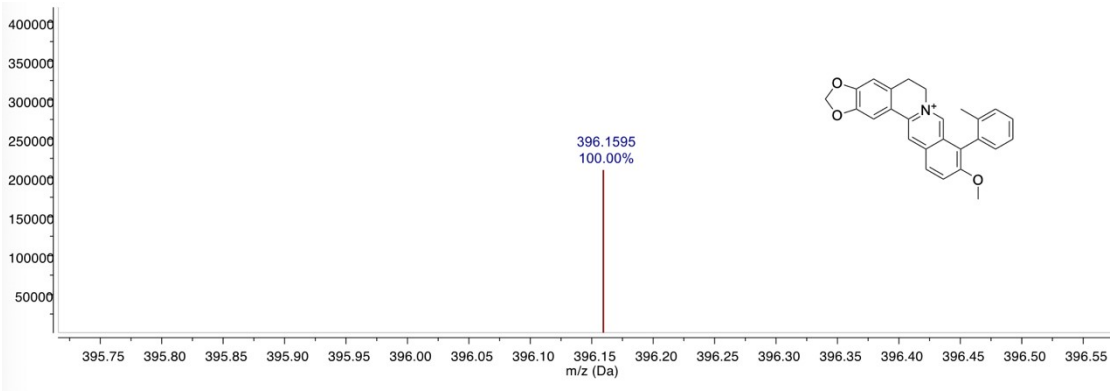


Figure S49. HRMS spectrum of ***2c***.

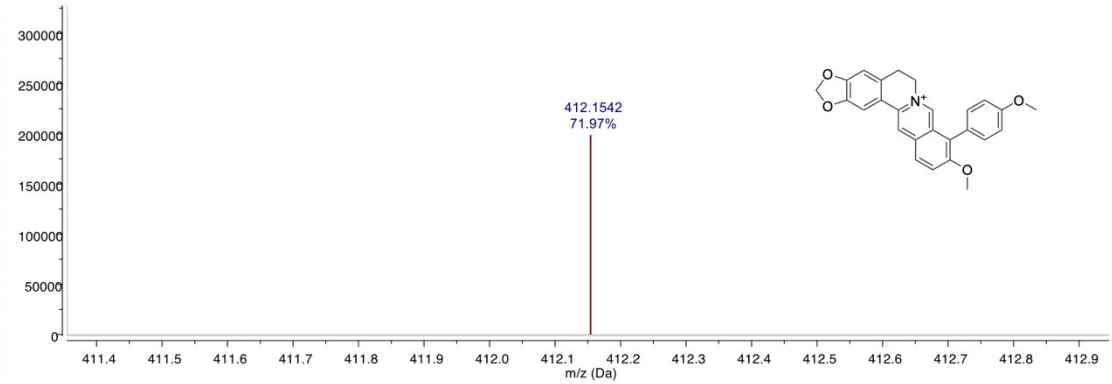


Figure S50. HRMS spectrum of ***2d***.

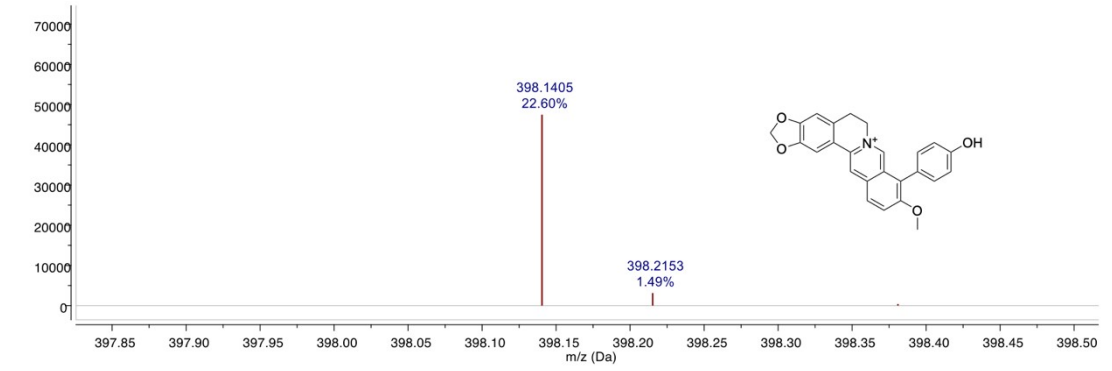


Figure S51. HRMS spectrum of ***2e***.

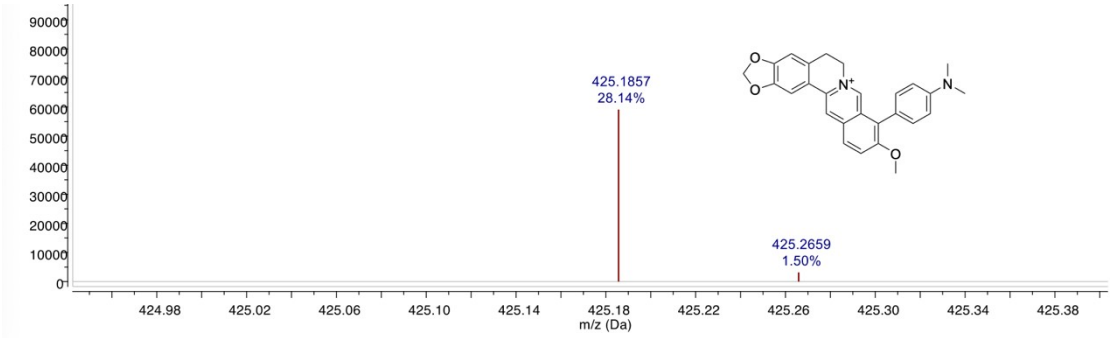


Figure S52. HRMS spectrum of ***2f.***

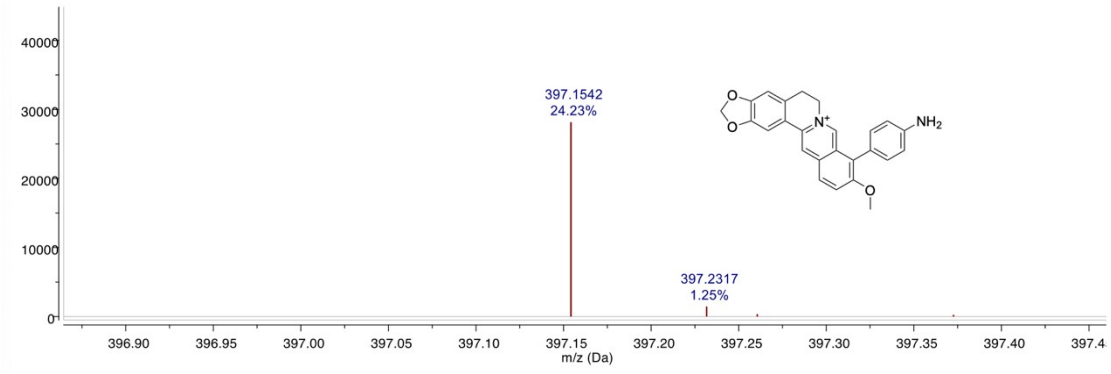


Figure S53. HRMS spectrum of ***2g.***

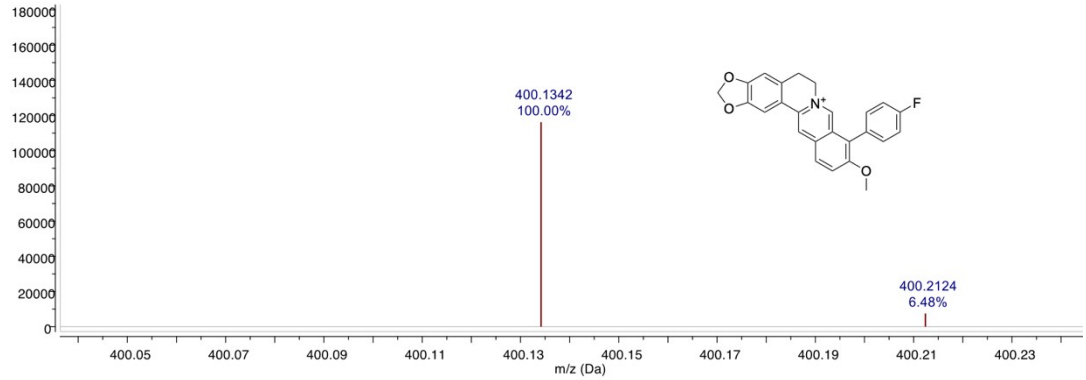


Figure S54. HRMS spectrum of ***2h***.

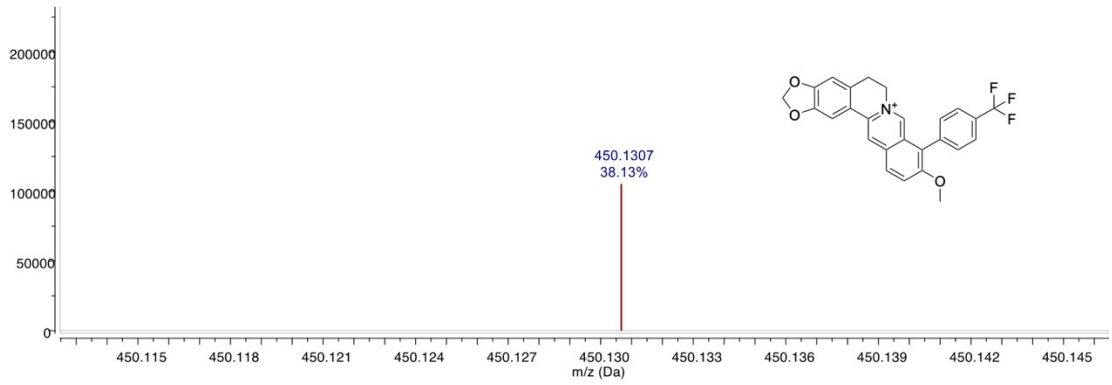


Figure S55. HRMS spectrum of ***2i***.

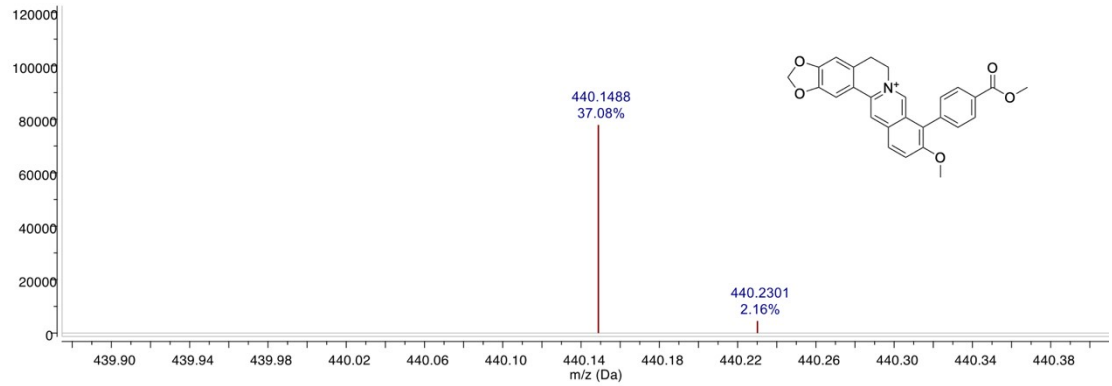


Figure S56. HRMS spectrum of ***2j***.

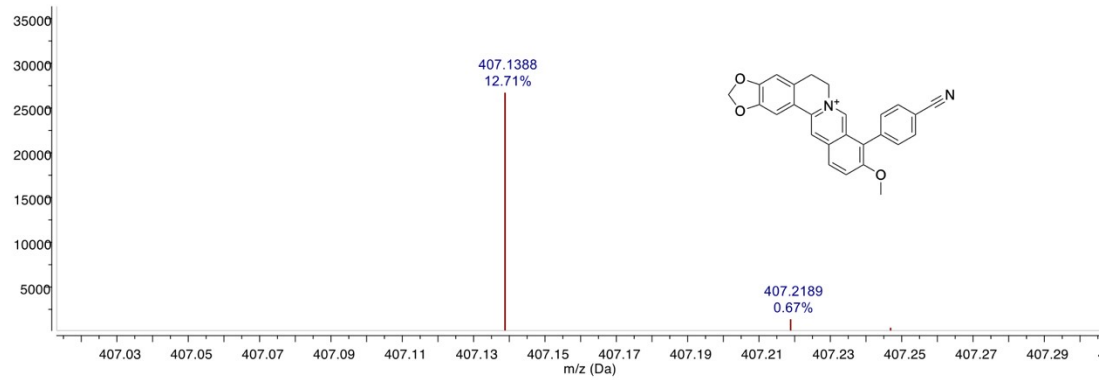


Figure S57. HRMS spectrum of ***2k***.

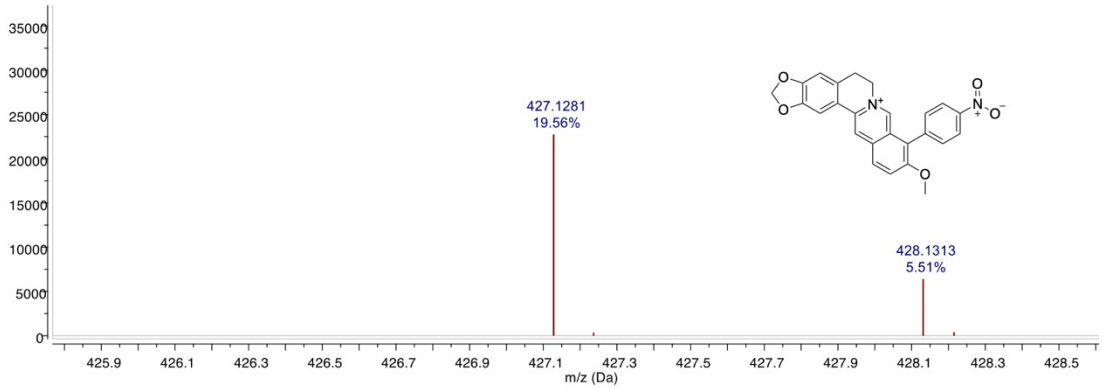


Figure S58. HRMS spectrum of ***2l***.

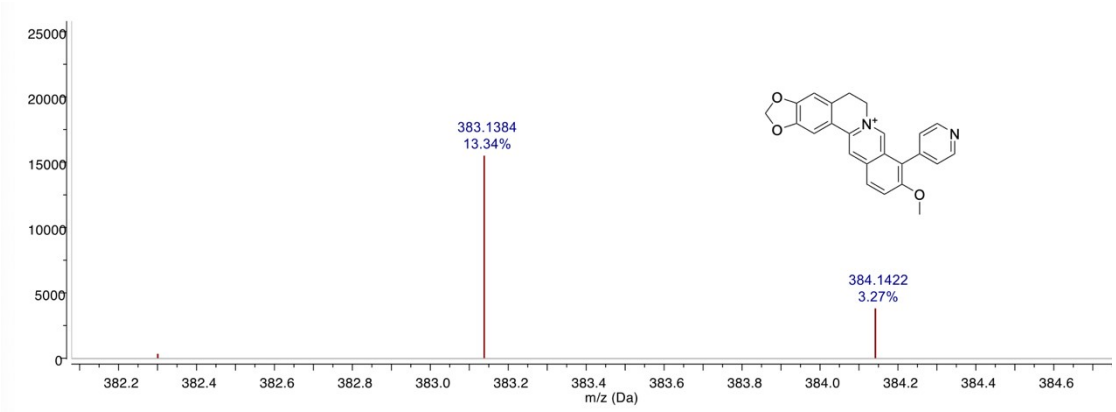


Figure S59. HRMS spectrum of ***2m.***

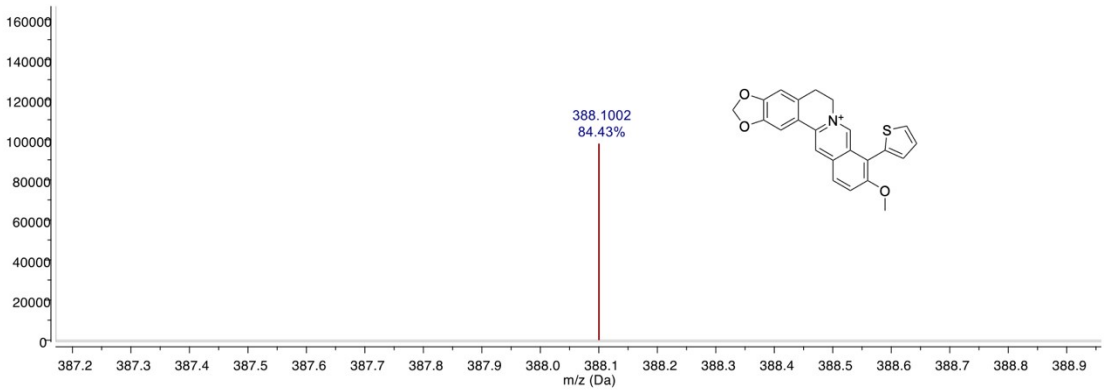


Figure S60. HRMS spectrum of ***2n***

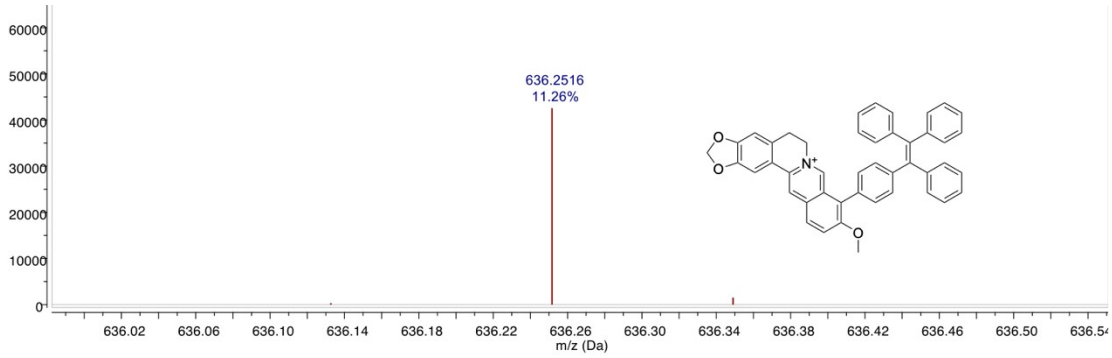


Figure S61. HRMS spectrum of ***2o***.

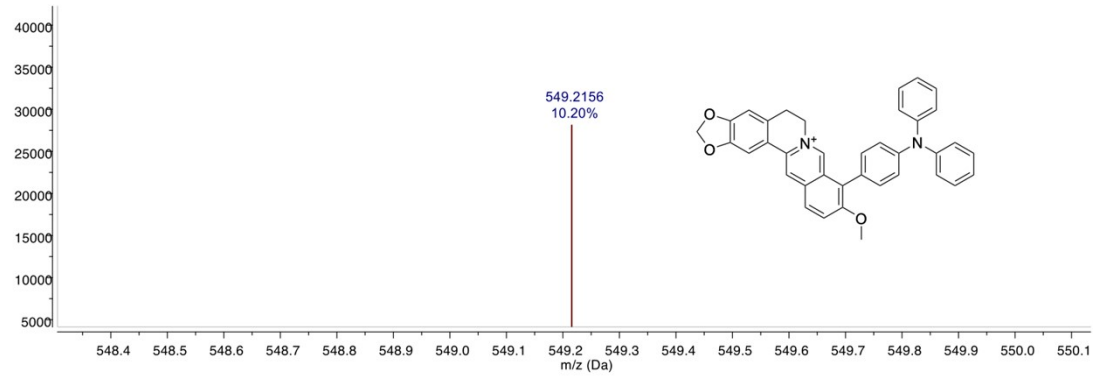


Figure S62. HRMS spectrum of ***2p***.

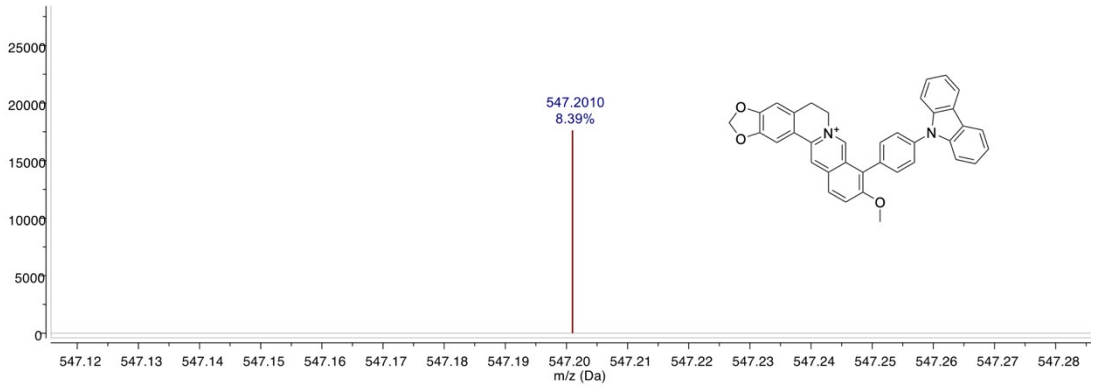


Figure 63. HRMS spectrum of ***2q***.