Supporting Information for:

Chromenoquinoline-based fluorescent *off-on* thiol probe for bioimaging

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I. General Methods.

All reactions were conducted under the nitrogen atmosphere. All the chemicals were purchased from commercial sources and used as received unless stated otherwise. Solvents: petroleum ether and ethyl acetate (EtOAc) were distilled prior to thin layer and column chromatography. *N*,*N*-Dimethylformamide (DMF) and dichloromethane (DCM) were pre-dried over calcium hydride and then distilled under vacuum. Column chromatography was performed on Merck silica gel (100–200 mesh). TLC was carried out with E. Merck silica gel 60-F-254 plates.

II. Physical Measurements and Theoretical Calculations.

The ^{1}H and ^{13}C spectra were recorded on 400 MHz Jeol ECS-400 (or 100 MHz for ^{13}C) spectrometers using either residual solvent signals as an internal reference or from internal tetramethylsilane on the δ scale ($CDCl_3$ δ_H, 7.24 ppm, δ_C 77.0 ppm). The chemical shifts (δ) are reported in ppm and coupling constants (*J*) in Hz. The following abbreviations are used: m (multiplet), s (singlet), br s (broad singlet), d (doublet), t (triplet) dd (doublet of doublet). Low-resolution mass spectra were recorded on an Applied Biosystems 4800 Plus MALDI TOF/TOF analyzer. High-resolution mass spectra were obtained from MicroMass ESI-TOF MS spectrometer. Absorption spectra were recorded on a PerkinElmer, Lambda 45 UV-Vis spectrophotometer. Steady State fluorescence experiments were carried out in a micro fluorescence cuvette (Hellma, path length 1.0 cm) on a TCSPC instrument (Horiba Jobin Yvon, Fluorolog-3). (FT-IR) spectra were obtained using NICOLET 6700 FT-IR

spectrophotometer as KBr disc and reported in cm^{-1}. Melting points were measured using a VEEGO Melting point apparatus. All melting points were measured in open glass capillary and values are uncorrected. Crystal structures were recorded on a Bruker single crystal X-Ray diffractometer. All theoretical calculations (DFT and TDDFT) were carried out using Gaussian 03 software.[S1]

III. Theoretical Calculations.

Table S1 Atomic coordinates calculated for **2** from DFT B3LYP/6-311G(d,p) geometry optimization.

Atom #	Atom Type	x	y	z
1	C	1.220	-0.803	0.222
2	C	2.631	-0.839	0.238
3	C	3.354	0.295	-0.067
4	C	2.686	1.503	-0.393
5	C	1.315	1.556	-0.397
6	C	0.539	0.410	-0.092
7	N	-0.816	0.507	-0.123
8	C	-1.549	-0.554	0.164
9	C	-0.949	-1.813	0.504
10	C	0.412	-1.931	0.515
11	C	-1.877	-2.933	0.858
12	C	-3.025	-0.514	0.070
13	C	-3.673	-1.741	-0.080
14	O	-3.021	-2.939	0.000
15	C	-3.827	0.687	0.018
16	C	-5.231	0.575	-0.250
17	C	-5.806	-0.705	-0.466
18	C	-5.050	-1.839	-0.374
19	C	-3.312	1.990	0.252
20	C	-4.128	3.099	0.212
21	C	-5.504	2.982	-0.068
22	C	-6.040	1.738	-0.293
23	N	4.780	0.259	-0.079
24	C	5.564	-0.815	-0.557
25	C	6.993	-0.398	-0.379
26	C	7.027	0.814	0.168
27	C	5.623	1.291	0.387
28	O	5.158	-1.855	-1.008
29	O	5.274	2.341	0.864
30	H	3.137	-1.766	0.470
31	H	3.266	2.385	-0.625
32	H	0.793	2.472	-0.646
33	H	0.883	-2.880	0.754
34	H	-2.225	-2.833	1.897
35	H	-1.405	-3.908	0.740
36	H	-6.866	-0.772	-0.686
37	H	-5.471	-2.827	-0.512
38	H	-2.258	2.102	0.446
39	H	-3.701	4.078	0.401
40	H	-6.131	3.866	-0.101

41	H	-7.098	1.623	-0.503
42	H	7.806	-1.045	-0.675
43	H	7.875	1.423	0.444

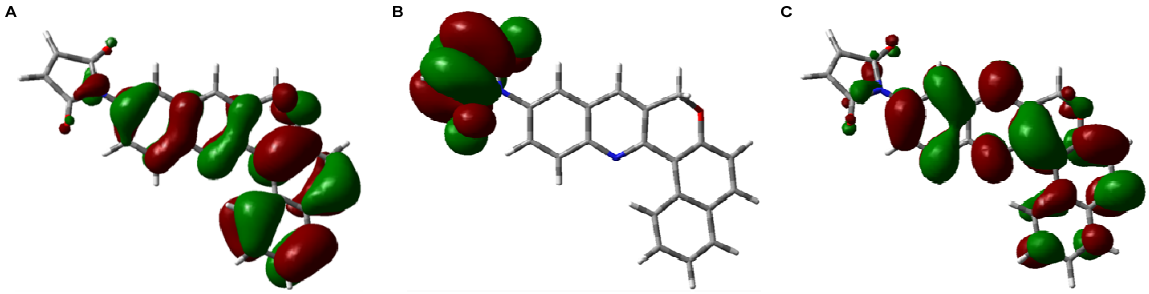


Fig. S1 View of the frontier molecular orbitals (MOs), HOMO (**A**), LUMO (**B**) and LUMO+1 (**C**) of probe **2** generated from DFT B3LYP/6-311G(d,p) geometry optimization.

Table S2 Atomic coordinates calculated for **2+Cys** from DFT B3LYP/6-311G(d,p) geometry optimization.

Atom #	Atom Type	x	y	z
1	C	-0.696	-1.132	0.142
2	C	0.677	-1.413	-0.034
3	C	1.374	-0.823	-1.065
4	C	0.724	0.067	-1.956
5	C	-0.607	0.359	-1.791
6	C	-1.358	-0.229	-0.741
7	N	-2.676	0.080	-0.625
8	C	-3.386	-0.462	0.350
9	C	-2.800	-1.374	1.290
10	C	-1.480	-1.709	1.172
11	C	-3.689	-1.890	2.378
12	C	-4.840	-0.215	0.465
13	C	-5.576	-1.163	1.179
14	O	-4.995	-2.185	1.872
15	C	-5.560	0.857	-0.183
16	C	-6.993	0.863	-0.129
17	C	-7.676	-0.179	0.550
18	C	-6.988	-1.164	1.199
19	C	-4.929	1.939	-0.851
20	C	-5.665	2.948	-1.431
21	C	-7.074	2.939	-1.390
22	C	-7.720	1.911	-0.747
23	N	2.759	-1.129	-1.260
24	C	3.295	-2.431	-1.172
25	C	4.769	-2.348	-1.535
26	C	5.097	-0.853	-1.550
27	C	3.737	-0.169	-1.572
28	O	2.678	-3.422	-0.884
29	O	3.522	0.996	-1.804
30	H	1.167	-2.109	0.633
31	H	1.288	0.524	-2.755
32	H	-1.119	1.035	-2.464

33	H	-1.023	-2.410	1.865
34	H	-3.791	-1.144	3.180
35	H	-3.314	-2.818	2.809
36	H	-8.761	-0.171	0.566
37	H	-7.486	-1.956	1.744
38	H	-3.853	1.952	-0.913
39	H	-5.150	3.763	-1.929
40	H	-7.639	3.737	-1.856
41	H	-8.803	1.888	-0.695
42	H	5.355	-2.932	-0.824
43	S	6.027	-0.436	-0.003
44	H	4.902	-2.802	-2.520
45	H	5.680	-0.539	-2.415
46	C	6.316	1.371	-0.234
47	C	6.439	2.037	1.143
48	H	5.490	1.796	-0.800
49	H	7.248	1.508	-0.786
50	H	6.692	3.096	0.959
51	N	7.415	1.339	1.968
52	C	5.113	2.090	1.899
53	H	7.185	1.444	2.950
54	H	8.356	1.673	1.802
55	H	3.302	2.523	1.654
56	O	4.985	1.849	3.072
57	O	4.104	2.502	1.111

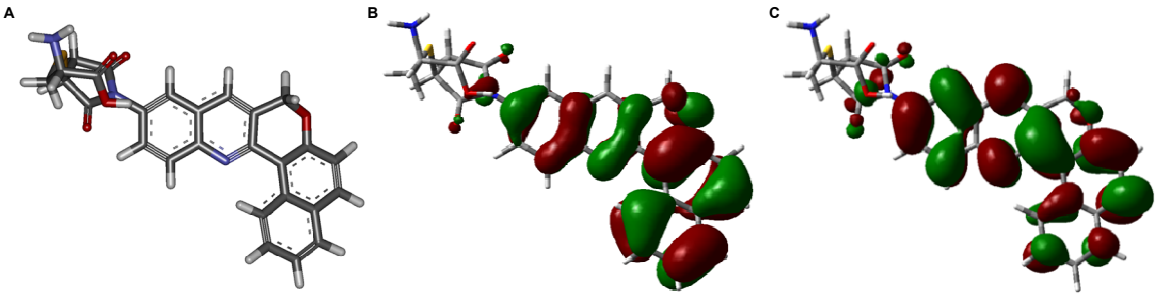


Fig. S2 View of the DFT B3LYP/6-311G(d,p) geometry optimized structure (**A**), the frontier molecular orbitals (MOs), HOMO (**B**), LUMO (**C**) of probe **2+Cys**.

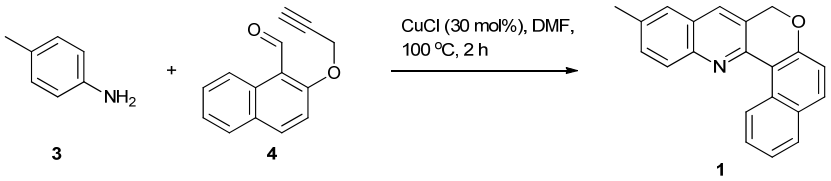
Table S3. Selected electronic excitation energies (eV) and oscillator strengths (*f*), configurations of the low-lying excited states of the probe **2** and **2+Cys**, calculated by TDDFT//B3LYP/6-311G(d,p), based on the optimized ground state geometries.

Molecule	**Electronic transition**	**TDDFT/B3LYP/6-311(d,p)**				
		Energy [a] (eV)	**Wavelength** (nm)	***f*** [b]	**Main configurations** [c]	**CI coefficients** [d]
Probe 2	$S_0 \rightarrow S_1$	2.29	540	0.0005	HOMO→LUMO	0.69365
	$S_0 \rightarrow S_2$	2.95	421	0.0008	HOMO-2→LUMO HOMO-1→LUMO HOMO→LUMO	0.62598 0.28525 0.10701
	$S_0 \rightarrow S_3$	3.19	389	0.0001	HOMO-1→LUMO	0.64468
	$S_0 \rightarrow S_4$	3.22	385	0.3614	HOMO→LUMO+1	0.65526
Probe 2+Cys	$S_0 \rightarrow S_1$	3.32	386	0.3858	HOMO→LUMO	0.65658

	$S_0 \rightarrow S_2$	3.78	328	0.0833	HOMO→LUMO+1	0.61466

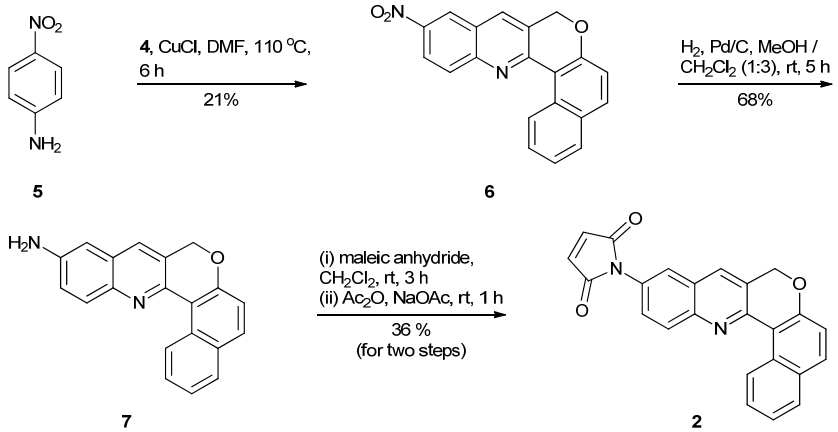
[a] Only the selected low-lying excited states are presented. [b] Oscillator strength. [c] Only the main configurations are presented. [d] The CI coefficients are in absolute values.

IV. Experimental Procedures.



Scheme S1 Synthesis of chromenoquinoline derivative **1**.

Synthesis of 11-methyl-8*H*-benzo[5,6]chromeno[4,3-*b*]quinoline 1: In a 25 ml round bottomed flask placed under nitrogen atmosphere were added 2-(prop-2-ynyloxy)-1-naphthaldehyde **4** (100 mg, 0.47 mmol), CuCl (16 mg, 0.14 mmol) and dissolved in dry DMF (6 mL). Aryl amine **3** (46 mg, 0.43 mmol) was then added and the reaction mixture was stirred at 100 ^{o}C for 2 h. After completion of the reaction, the reaction mixture was poured on crushed ice and extracted with Ethyl acetate (10 mL x 3). The combined organic layer was washed with water (10 mL x 3), brine (20 mL) and dried over Na_2SO_4. The solvent was removed under reduced pressure to obtain a brown residue which was purified by column chromatography over silica gel (Eluent: 2% EtOAc in petroleum ether) to furnish the pure **1** (92 mg, 72.4%) as a yellow solid. M.p. = 174 – 175 ^{o}C; IR (KBr): γ_{max}/cm^{-1} 3435, 2918, 2359, 2349, 1508, 1228, 1024; ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.94 (d, J = 8.7 Hz, 1H), 8.12 (d, J = 9.16 Hz, 1H), 7.84 – 7.81 (m, 3H), 7.69 – 7.65 (m, 1H), 7.55 – 7.53 (m, 2H), 7.48 – 7.44 (m, 1H), 7.22 (d, J = 9.16 Hz, 1H), 5.28 (s, 2H), 2.54 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.44; 150.83, 147.46, 137.07, 133.55, 132.44, 132.07, 131.51, 130.97, 130.07, 129.17, 128.62, 127.85, 127.45, 126.97, 125.20, 118.28, 115.60 (2C), 69.36, 21.85; LRMS (CI): 298 $[M+H]^+$; HRMS (ESI): Calc. for $C_{21}H_{16}NO$ $[M+H]^+$: 298.1232; Found: 298.1234.



Scheme S2 Synthesis of chromenoquinoline-based probe **2**.

Synthesis of 11-nitro-8H-benzo[5,6]chromeno[4,3-b]quinoline 6: In a 25 ml round bottomed flask placed under nitrogen atmosphere were added 2-(prop-2-ynyloxy)-1-

naphthaldehyde **4** (1.0 g, 4.7 mmol), CuCl (139 mg, 1.4 mmol) and dissolved in dry DMF (15 mL). To the mixture was then added *p*-nitroaniline **5** (650 mg, 4.7 mmol) and the reaction mixture was stirred at 100 ^{o}C for 6 h. After completion of the reaction, the reaction mixture was poured on crushed ice and extracted with Ethyl acetate (20 mL x 3). The combined organic layer was washed with water (10 mL x 3), brine (20 mL) and dried over Na_2SO_4. The solvent was removed under reduced pressure to obtain a brown residue which was purified by column chromatography over silica gel (Eluent: 4% EtOAc in petroleum ether) to furnish the pure **6** (328 mg, 21%) as a yellow solid. M.p. = 246 – 247 ^{o}C; IR (KBr): ν_{max}/cm^{-1} 3446, 1619, 1505, 1480, 1331, 1216, 1024; ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.83 (d, *J* = 8.7 Hz, 1H), 8.72 (d, *J* = 2.3 Hz, 1H), 8.44 (dd, *J* = 9.2, 2.8 Hz, 1H), 8.28 (d, *J* = 9.2 Hz, 1H), 8.07 (s, 1H), 7.90 (d, *J* = 9.2 Hz, 1H), 7.84 (d, *J* = 8.2 Hz, 1H), 7.72 – 7.67 (m, 1H), 7.51 – 7.47 (m, 1H), 7.22 (d, *J* =8.6 Hz, 1H), 5.33 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.9, 154.2, 150.2, 145.0, 134.7, 132.2, 131.2, 131.0, 130.7, 128.7, 128.4, 126.9, 125.4, 124.9, 124.0, 123.0, 118.3, 115.4, 68.6; HRMS (ESI): Calc. for $C_{20}H_{13}N_2O_3$ $[M+H]^+$: 329.0926; Found: 329.0925.

Synthesis of 8H-benzo[5,6]chromeno[4,3-b]quinolin-11-amine 7: In a 50 ml round bottomed flask placed under nitrogen atmosphere were added compound **6** (650 mg, 1.98 mmol) and dissolved in 30 mL methanol/CH_2Cl_2 (1:3). To the solution was added 10% Pd/C (10% weight of **6**) and the atmosphere was replaced with hydrogen and reaction was carried out at room temperature for 5 h under the ambient hydrogen pressure (balloon). The reaction mixture was filtered using a celite cake and the filtrate was removed under reduced pressure to give a brown residue which was subjected to column chromatography over silica gel (Eluent: 2% Methanol in chloroform) to furnish pure products **7** (400 mg, 68%) as a yellow solid. M.p. = 150 ^{o}C (decomposed); IR (KBr): ν_{max}/cm^{-1} 3421, 2924, 2852, 1560, 1498, 1376, 1225, 1025,1007; ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.95 (d, *J* = 8.68 Hz, 1H); 8.05 (d, *J* = 9.16 Hz, 1H), 7.84 (d, *J* = 7.8 Hz, 1H), 7.83 (d, *J* = 8.72 Hz, 1H), 7.69 – 7.66 (m, 2H), 7.48 – 7.44 (m, 1H), 7.24 (d, *J* = 9.16 Hz, 1H), 7.17 – 7.13 (m, 1H), 6.89 – 6.86 (m, 1H), 5.24 (s, 2H), 4.01 (br s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$); δ 157.03, 147.45, 144.72, 143.15, 132.15, 131.29, 130.90, 130.84, 128.75, 128.44, 128.31, 127.73, 127.24, 127.20, 124.43, 121.39, 118.38, 116.65, 107.47, 68.90; LRMS (MALDI): 337 $[M+K]^+$. HRMS (ESI): Calc. for $C_{20}H_{15}N_2O$ $[M+H]^+$: 299.1184; Found: 299.1171.

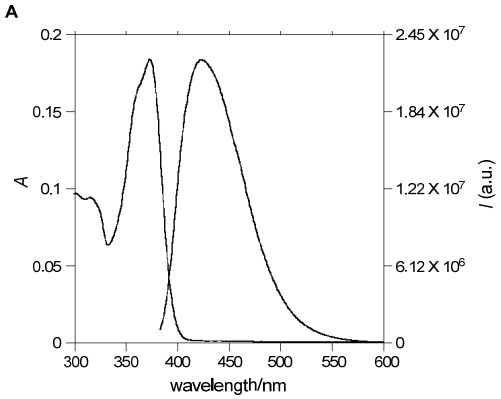
Synthesis of 1-(8H-benzo[5,6]chromeno[4,3-b]quinolin-11-yl)-1H-pyrrole-2,5-dione 2: Amine **7** (50 mg, 0.16 mmol) and maleic anhydride (25 mg, 0.24 mmol) were placed in a dry 50 mL round bottom flask. Dichloromethane (4 mL) was added and the solution was stirred at rt for 3 h. The mixture was then filtered and the recovered solid was rinsed liberally with dichloromethane and then dried under vacuum. To this solid was added acetic anhydride (4 mL) and catalytic sodium acetate (5 mg) and the reaction was stirred vigorously for another 1h. The mixture was then cooled to 4 ^{o}C for 3 h and filtered. The beige solid thus obtained was dried over vacuum to give compound **2** as a yellow solid with 36% yield (25 mg). M.p. = 228 – 229 ^{o}C; IR (KBr): ν_{max}/cm^{-1} 3446, 2924, 1495, 1400, 1370, 1225, 1046; ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.90 (d, *J* = 8.68 Hz, 1H); 8.30 (d, *J* = 9.16 Hz, 1H), 7.95 (s, 1H), 7.87 – 7.81 (m, 3H), 7.73 – 7.66 (m, 2H), 7.48 – 7.44 (m, 1H), 7.22 (d, *J* = 8.72 Hz, 1H), 6.91 (s,

*2*H), 5.30 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.5, 158.1, 151.6, 146.9, 134.4, 133.5, 131.3, 130.9, 130.8, 130.7, 129.1, 128.6, 128.1, 127.5, 127.1, 126.6, 124.7, 123.9, 118.4, 116.0, 68.8; LRMS (MALDI): 379 $[M+H]^+$; HRMS (ESI): Calc. for $C_{24}H_{15}N_2O_3$ $[M+H]^+$: 379.1082; Found: 379.1033.

V. Crystal Structure Parameters.[S2]

Crystal structure of compound 2: $C_{24}H_{14}N_2O_3$; Compound **2** was crystallized from acetic anhydride at 4 °C. A yellow rectangular shaped crystal with approximate dimensions 0.11 x 0.10 x 0.10 mm gave an Orthorhombic with space group *P21/n*; *a* = 9.9766(8) *b* = 16.9632(13) *c* = 10.5391 (8) Å, α = 90° β = 101.076(2)° γ = 90°; *V* = 1750.4(2) Å^3; *T* = 296 (2) K; *Z* = 4; ρ_{calc} = 1.440 Mgm^{-3}; $2\theta_{max}$ = 57.28°; *MoKαλ* = 0.71073 Å. Fine-focus sealed tube source with graphite monochromator. *R* = 0.0569 (for 3740 reflection $I>2\sigma(I)$), *wR* = 0.1291 which was refined against |*F2*| and S = 1.0212 for 262 parameters and 4480 unique reflections. The structure was obtained by direct methods using SHELXS-97.[S3] All non-hydrogen atoms were refined isotropically. The hydrogen atoms were fixed geometrically in the idealized position and refined in the final cycle of refinement as riding over the atoms to which they are bonded. μ = 0.096 mm^{-1}; Minimum/maximum residual electron density 0.000 / 0.000 eÅ^{-3}.

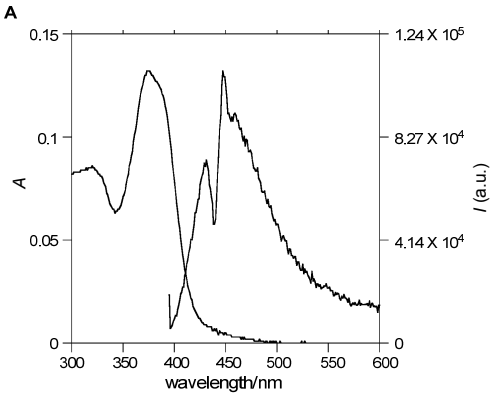
VI. Photophysical Properties:



B

compound	λ_{ex} (nm)	ε (mol cm^{-1} l^{-1})	λ_{ex} (nm)	Φ
1	373	16153	424	0.35

Fig. S3 Photophysical properties of the chromenoquinoline derivative **1** recorded in methanol.



B

compound	λ_{ex} (nm)	ε (mol cm^{-1} l^{-1})	λ_{ex} (nm)	Φ
2	384	14789	446	0.0035

Fig. S4 Photophysical properties of the chromenoquinoline-based probe **2** recorded in DMSO.

VII. Thiols Sensing:

Procedures:

Preparation of the medium: Deionized water was used throughout all experiments. Conjugate addition reactions were carried out in HEPES buffer (10 mM, pH 7.4) with/without 1.0% DMSO (maximum).

Preparation of the solution of 2: A stock solution of **2** (2547 μM) was prepared in DMSO. The stock solution of **2** was then diluted to 100 μM in DMSO. Final concentration of **2** during each assay was 10 μM with 1% DMSO (maximum).

Preparation of the solution of amino acids: Stock solutions of amino acids were prepared in H_2O with varied concentrating ranging from 1952 μM to 12234 μM. Calculated volumes of amino acids were added from respective stock solutions to fluorescence each cuvette to provide 100 μM. Conjugate addition reactions were carried out in HEPES buffer (10 mM, pH 7.4) with maximum 1.0% DMSO. Spectra data were recorded 20 min in an indicated time after the addition of amino acids by exciting at 383 nm. The excitation and emission slit width was 3 nm and 3 nm respectively.

Detection limit

The detection limit was determined based on the fluorescence titration.[S4] To improve the sensitivity, **2** was employed at 10 μM and the slit was adjusted to 3.0 nm/3.0 nm. To determine the S/N ratio, the emission intensity of **2** without Cys was measured by 4 times and the standard deviation of blank measurements was determined. Under the present conditions, a good linear relationship between the fluorescence intensity and the Cys concentration could be obtained in the 2 - 10 μM (R = 0.99878), as shown in Fig. S5B. The detection limit is then calculated with the equation: detection limit = $3\sigma_{bi}/m$, where σ_{bi} is the standard deviation of blank measurements, m is the slope between intensity versus sample concentration. The detection limit was measured to be 1.94×10^{-8} M (Table S4) at $S/N = 3$ (signal-to-noise ratio of 3:1). Under the comparable conditions the detection limit for GSH and Hcy were 1.46×10^{-8} M and 2.31×10^{-8} M respectively, at $S/N = 3$ (Table S4).

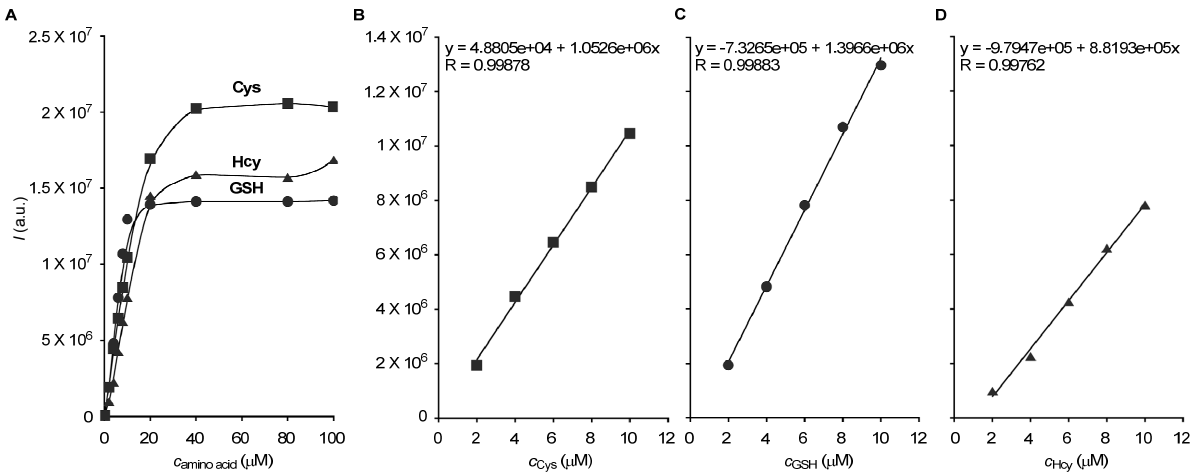


Fig. S5 The I_F vs. *c* plot for the probe **2** titrated against Cys, GSH and Hcy (**A**). The linearity of the Cys (**B**), GSH (**C**) and Hcy (**D**) titration assay.

Table S4: Calculation of detection limit of Cys, GSH and Hcy with the probe **2**.

Entry	**thiol**	σ_{bi}	***m***	*S/N*	detection limit
1	Cys	6797.083	1.0526×10^6	3	1.94×10^{-8} M
2	GSH	6797.083	1.3966×10^6	3	1.46×10^{-8} M
3	Hcy	6797.083	8.8193×10^5	3	2.31×10^{-8} M

Cell imaging:

The MDA-MB 231 cells were purchased from National Centre for Cell Science, Pune (India). MDA-MB 231 cells were grown in RPMI-1640 supplemented with 10% heat inactivated fetal bovine serum (FBS), 100 IU/ml penicillin, 100 mg/ml streptomycin and 2mM L-glutamine. Cultures were maintained in a humidified atmosphere with 5% CO_2 at 37 °C. The cultured cells were subcultured twice each week, seeding at a density of about 2×10^3 cells/ml. Cell viability was determined by the trypan blue dye exclusion method. The MDA-MB 231 cells were incubated with a solution of probe **2** (25 μM in 1:1000 DMSO-PBS v/v, pH 7.4) at 37 ^oC for 30 min and washed 2 times with PBS. For the control experiment, the cells were treated with 5 mM *N*-phenylmaleimide (PEM) in culture media at 37 ^oC for 30 min. After 2 times washing with phosphate buffered saline (PBS) to remove the remaining PEM, the cells were further incubated with 20 μM of **2** (25 μM in 1:1000 DMSO-PBS v/v, pH 7.4) in culture media at 37 ^oC for 30 min. After the incubation remaining amount of **2** was removed by washing with PBS (2 times). The fluorescence images were taken using Olympus inverted fluorescence microscope CKX-41-TR equipped with ProgRes CT3 camera.

Mass Spectrometric Analysis of Thiol Addition Reactions:

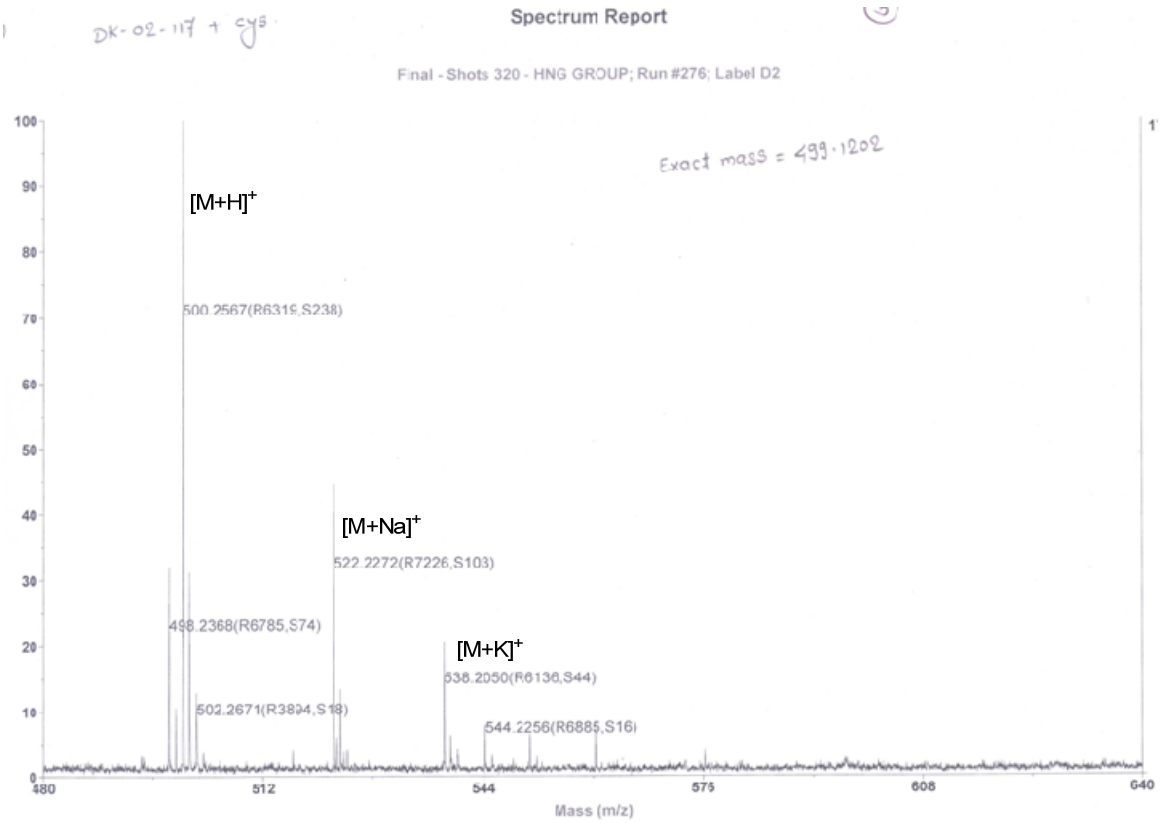


Fig. S6 ESI-MS of the probe **2** titrated with Cys.

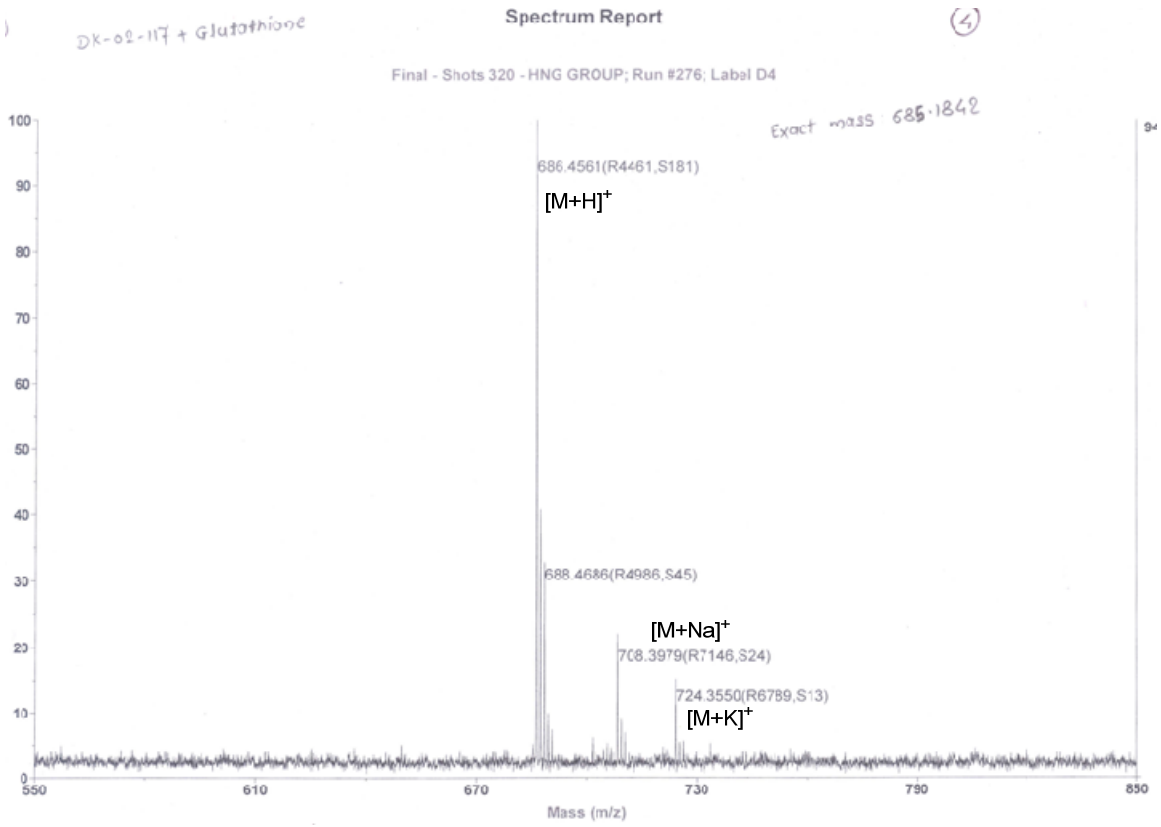


Fig. S7 ESI-MS of the probe **2** titrated with GSH.

VIII. NMR Data.

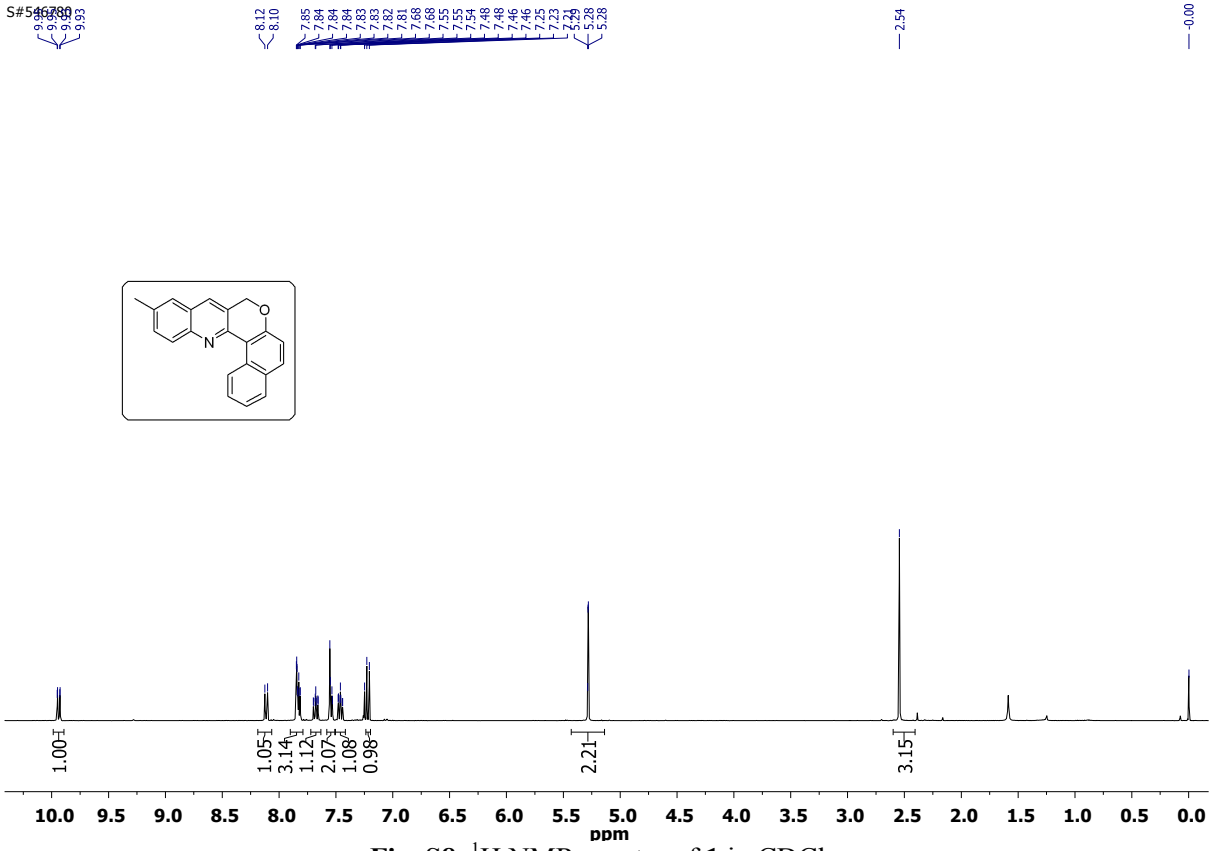


Fig. S8. ^{1}H NMR spectra of **1** in $CDCl_3$.

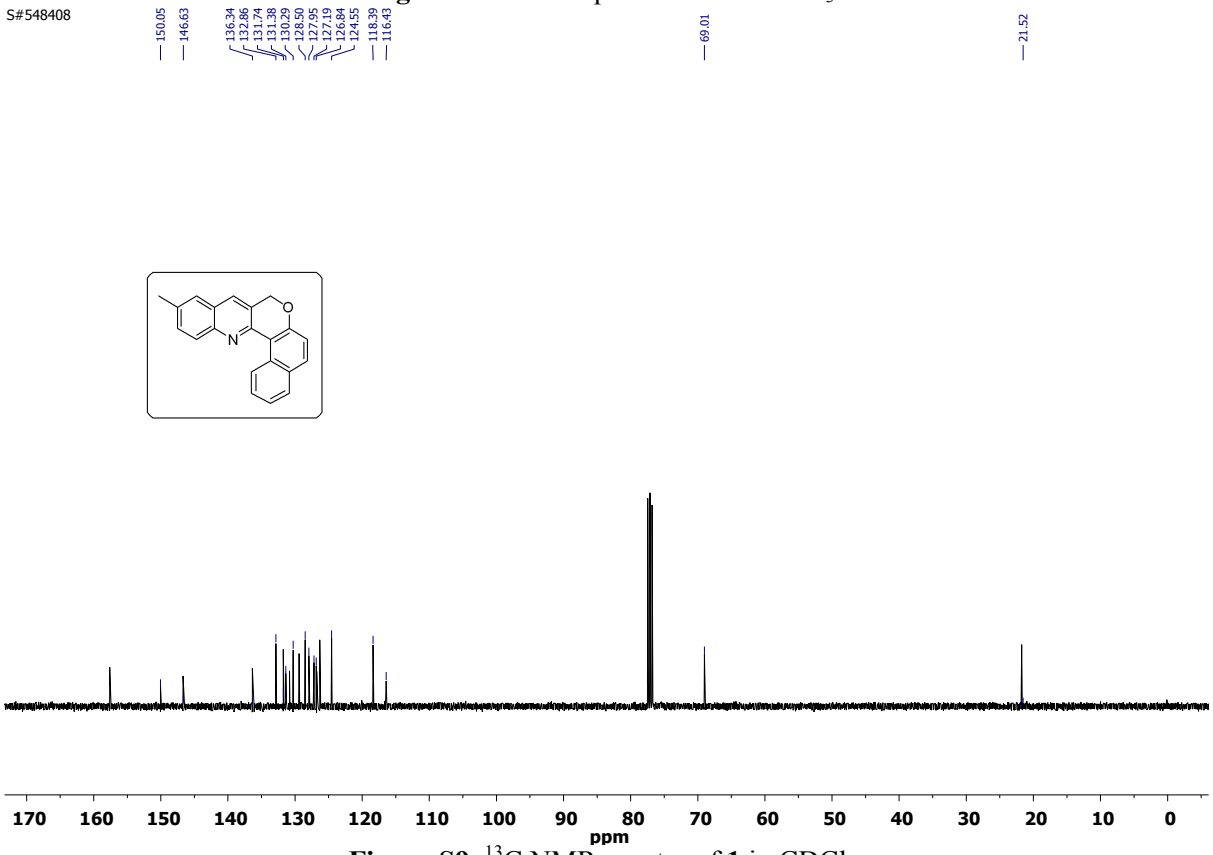


Figure S9. ^{13}C NMR spectra of **1** in $CDCl_3$.

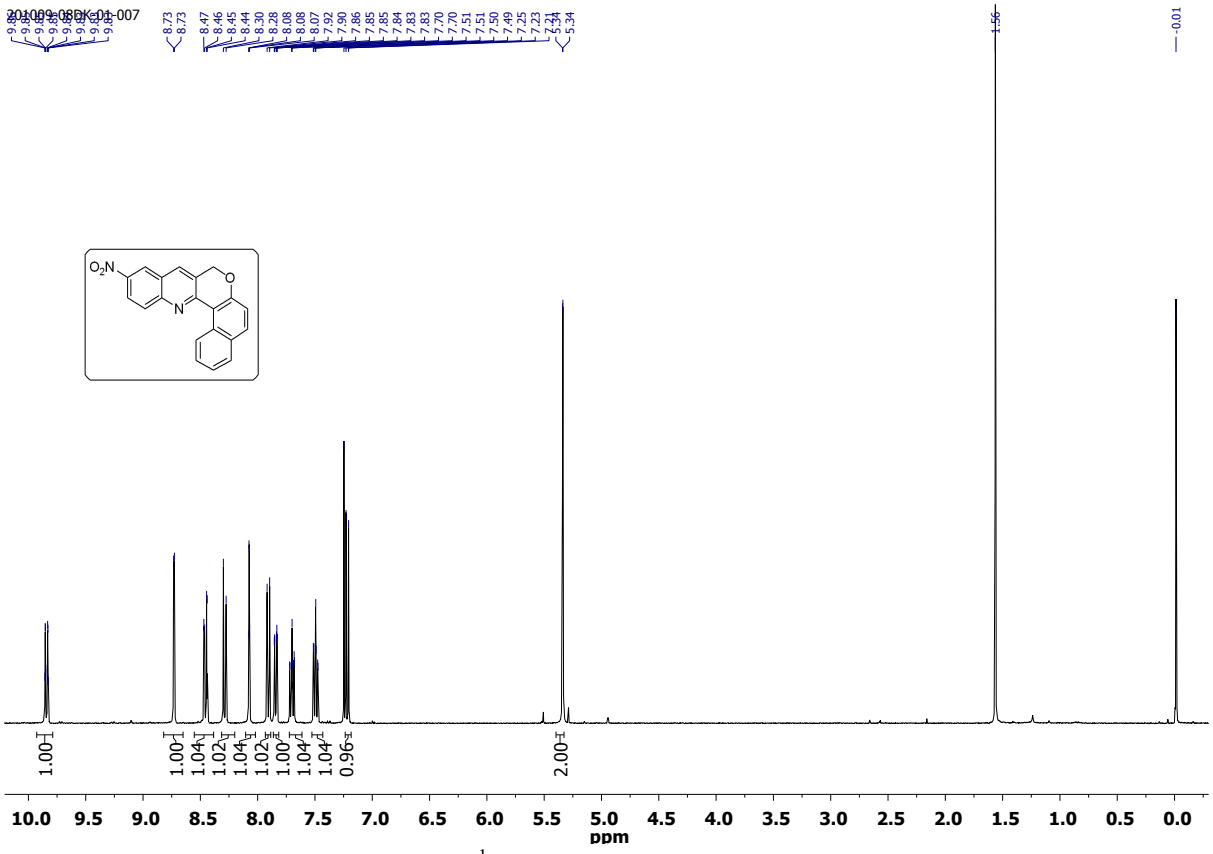


Fig. S10. ^{1}H NMR spectra of **6** in $CDCl_3$.

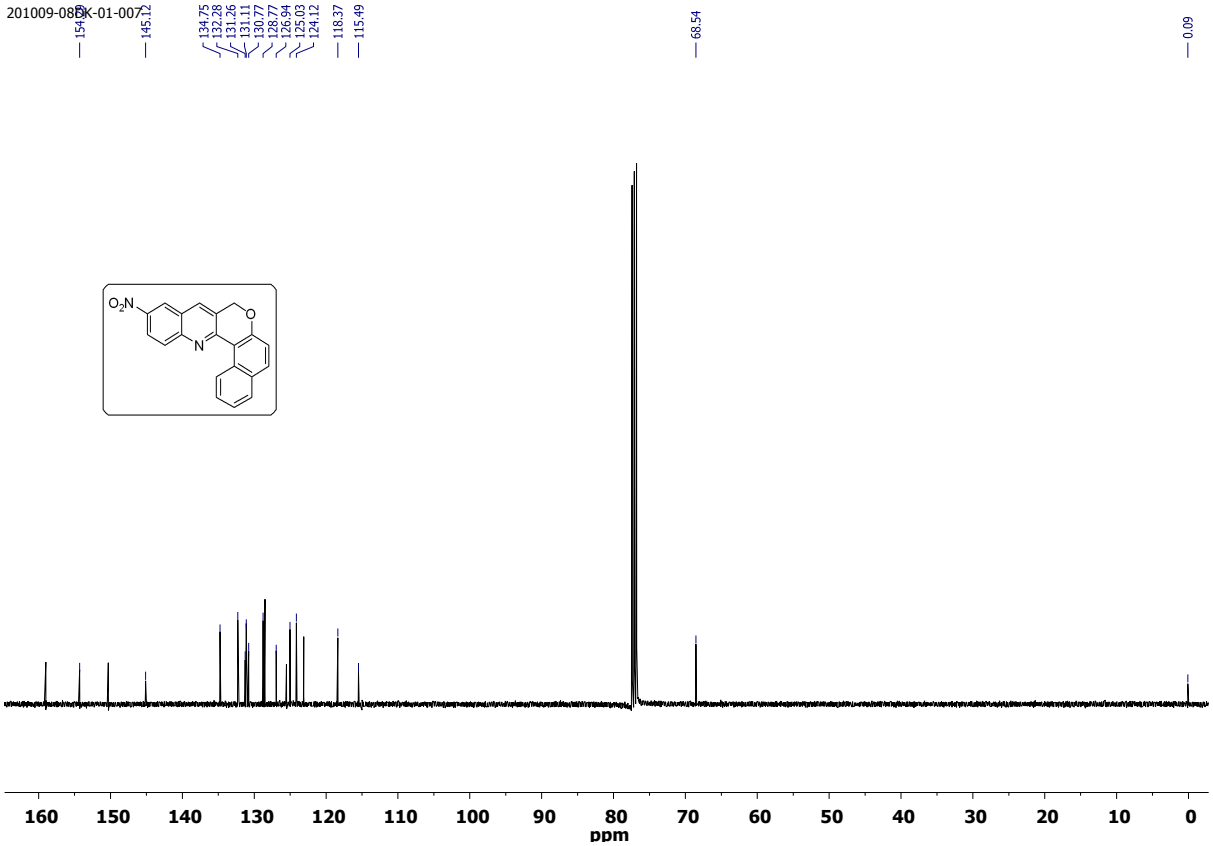


Figure S11. ^{13}C NMR spectra of **6** in $CDCl_3$.

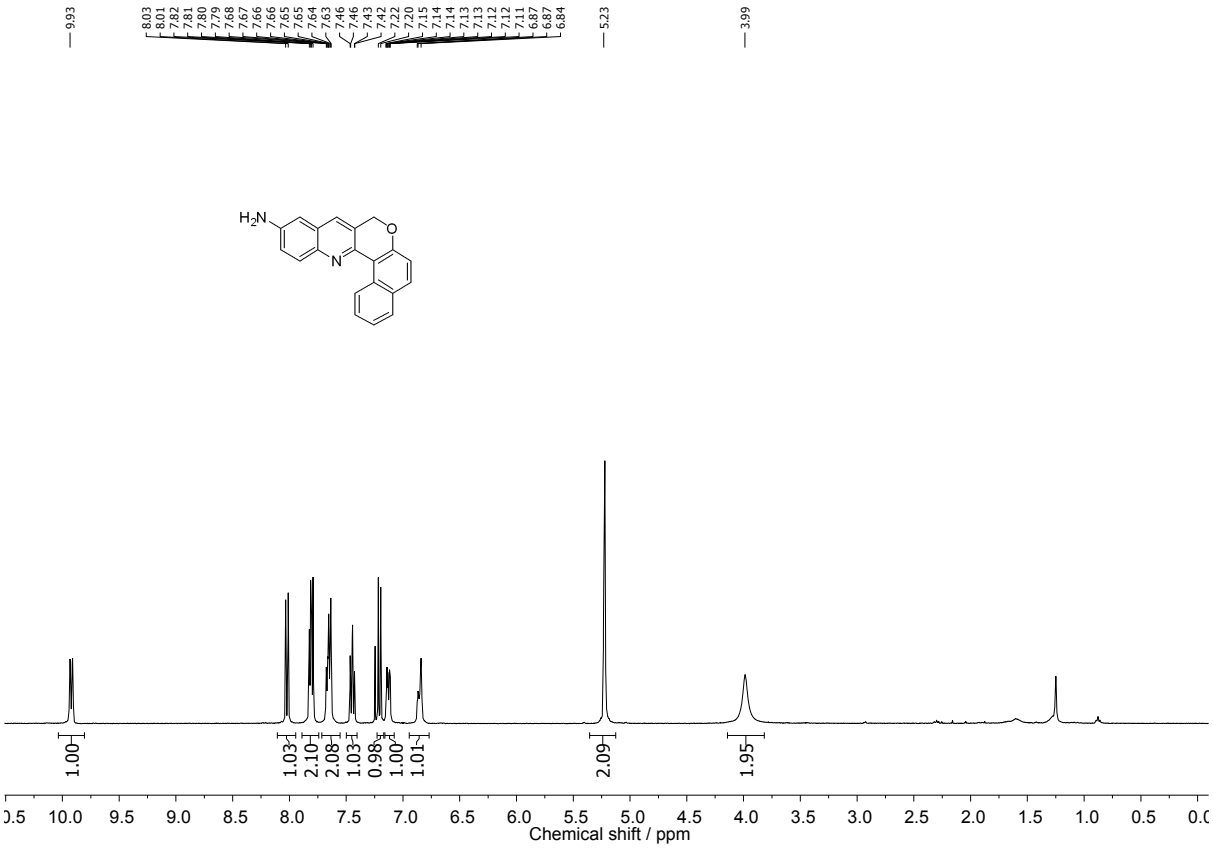


Fig. S12. ^{1}H NMR spectra of **7** in $CDCl_3$.

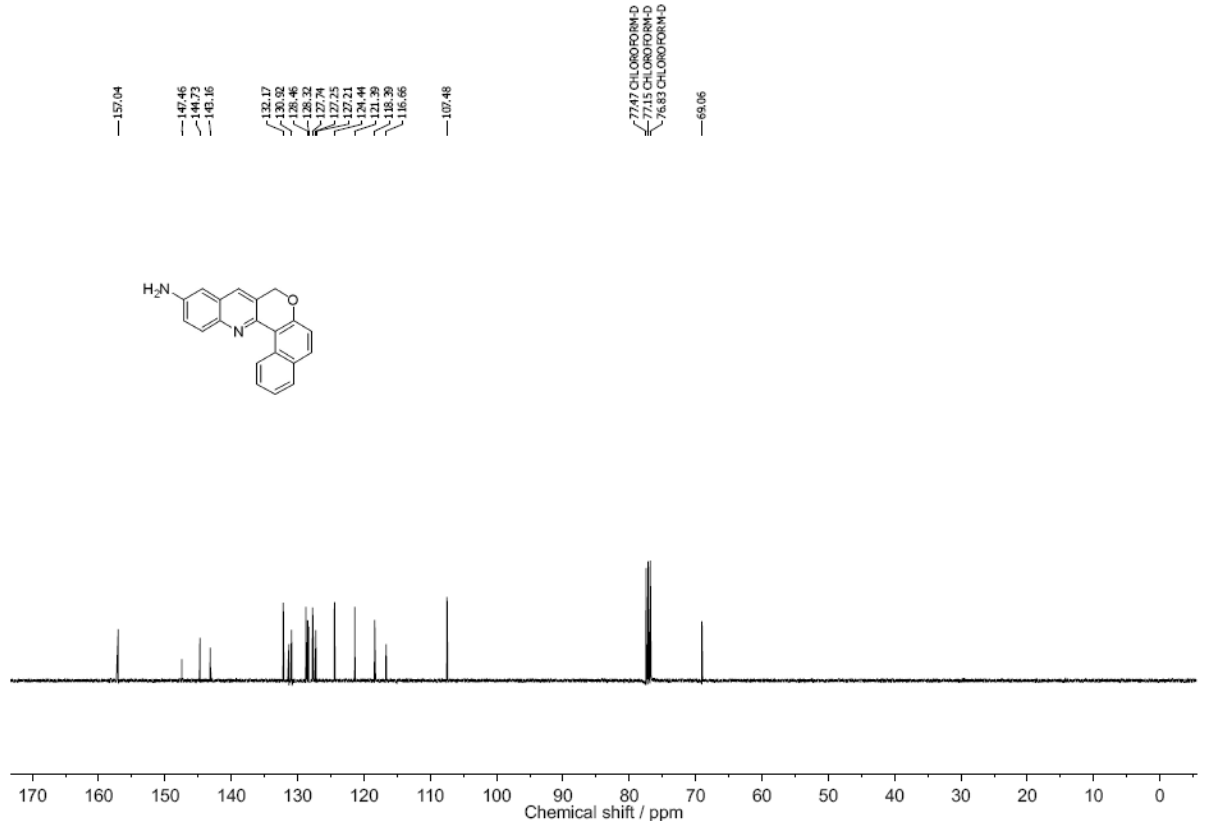


Figure S13. ^{13}C NMR spectra of **7** in $CDCl_3$.

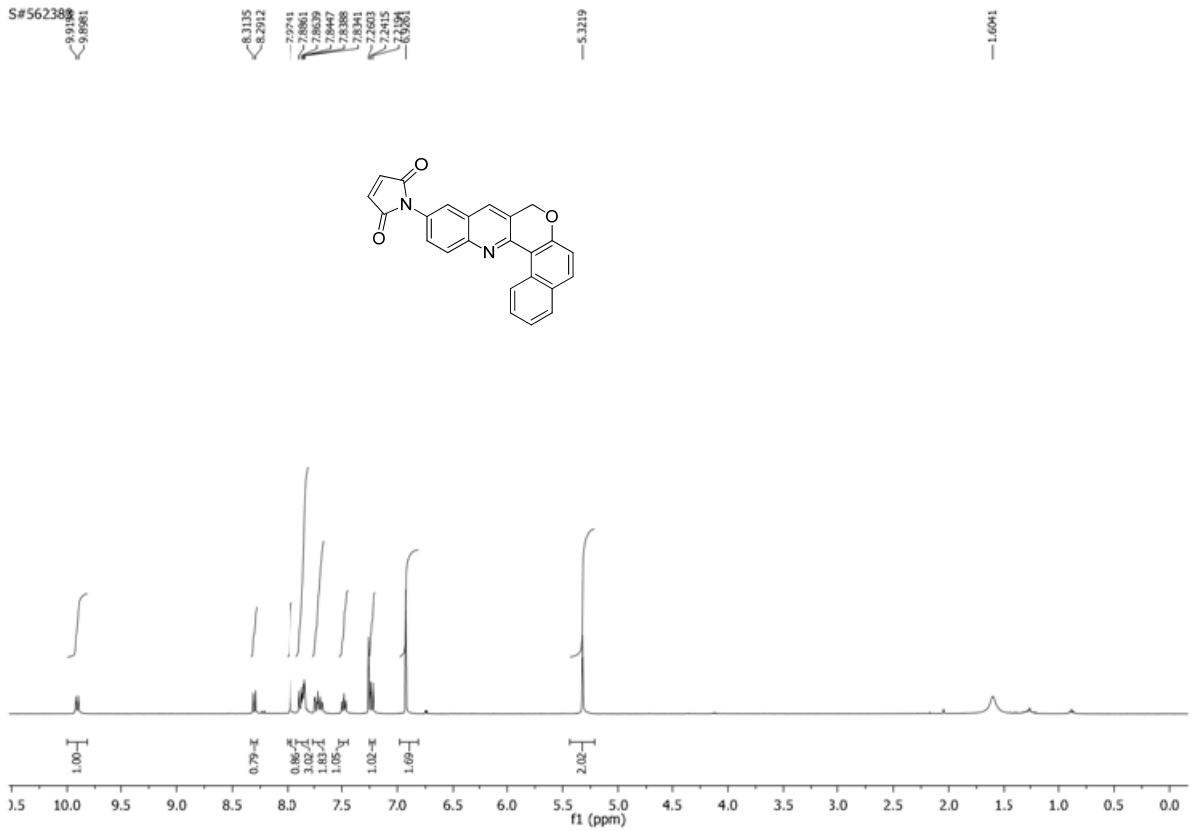


Fig. S14. ^{1}H NMR spectra of **2** in $CDCl_3$.

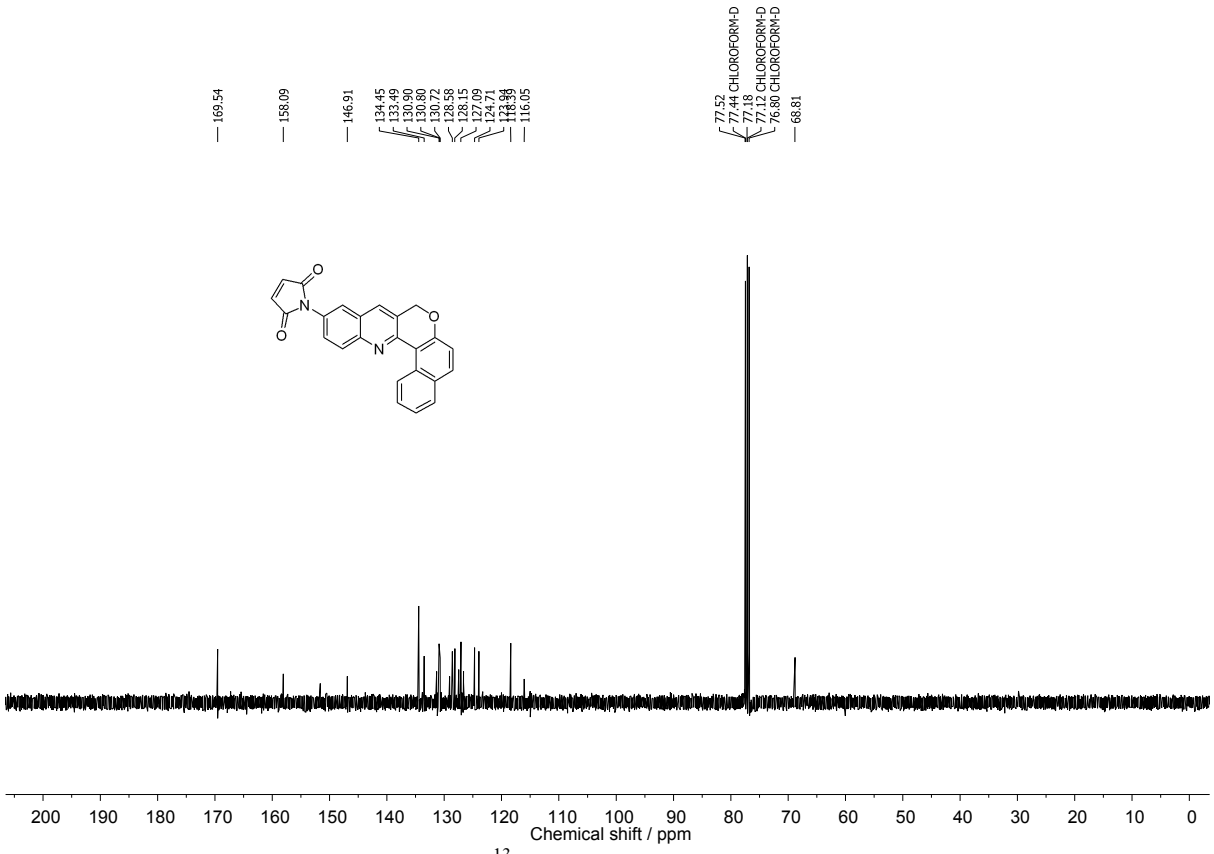


Figure S15. ^{13}C NMR spectra of **2** in $CDCl_3$.

IX. References.

S1 Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Montgomery, J. A.; Vreven, T.; Kudin, K. N.; Burant, J. C.; Millam, J. M.; Iyengar, S. S.; Tomasi, J.; Barone, V.; Mennucci, B.; Cossi, M.; Scalmani, G.; Rega, N.; Petersson, G. A.; Nakatsuji, H.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; Klene, M.; Li, X.; Knox, J. E.; Hratchian, H. P.; Cross, J. B.; Bakken, V.; Adamo, C.; Jaramillo, J.; Gomperts, R.; Stratmann, R. E.; Yazyev, O.; Austin, A. J.; Cammi, R.; Pomelli, C.; Ochterski, J. W.; Ayala, P. Y.; Morokuma, K.; Voth, G. A.; Salvador, P.; Dannenberg, J. J.; Zakrzewski, V. G.; Dapprich, S.; Daniels, A. D.; Strain, M. C.; Farkas, O.; Malick, D. K.; Rabuck, A. D.; Raghavachari, K.; Foresman, J. B.; Ortiz, J. V.; Cui, Q.; Baboul, A. G.; Clifford, S.; Cioslowski, J.; Stefanov, B. B.; Liu, G.; Liashenko, A.; Piskorz, P.; Komaromi, I.; Martin, R. L.; Fox, D. J.; Keith, T.; Al-Laham, M. A.; Peng, C. Y.; Nanayakkara, A.; Challacombe, M.; Gill, P. M. W.; Johnson, B.; Chen, W.; Wong, M. W.; Gonzalez, C.; Pople, J. A. *Gaussian 03, Revision C.02*, 2003.

S2 CCDC 846909 contains the supplementary crystallographic data for the compounds **2**. Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK. fax: (+44) 1223-336-033; www.ccdc.cam.ac.uk/data_request/cif.

S3 (a) SHELXS-97: G. M. Sheldrick, *Acta Crystallogr. Sect A*, 1990, **46**, 467, (b) G. M. Sheldrick, SHELXL-97, Universität Göttingen (Germany) **1997**.

S4 (a) B. P. Joshi, J. Park, W. I. Lee and K. Lee, *Talanta.*, 2009, **78**, 903; (b) H. Guo, Y. Jing, X. Yuan, S. Ji, J. Zhao, X. Li and Y. Kan, *Org. Biomol. Chem.*, 2011, **9**, 3844.