



Supporting Information

© Copyright Wiley-VCH Verlag GmbH & Co. KGaA, 69451 Weinheim, 2018

Suzuki and Heck Processes for the Synthesis of New Anthraquinone-Based Glycoconjugated Dyes

Lorenzo Calugi,* Marco Bonanni, Massimo Corsi, Stefano Chimichi, and Roberto Bianchini*

Supporting information

1. Experimental section p.1
2. ¹H-NMR spectra p. 5
3. ¹³C NMR Spectra p. 17
4. Absorption visible spectra p. 27

Experimental Section

Commercially available reagents and solvents were purchased from Sigma Aldrich and they were used directly. The notation PE refers to the petrol ether fraction boiling between 40 and 60°C. Thin layer chromatography (TLC) analysis was performed using Fluka aluminium foils coated with 25 mm particle size silica gel matrix F254. TLC development involved either UV (254 and 366 nm) or visible light inspection, followed by either treatment with an acid solution of p-anisaldehyde or a basic solution of KMnO₄ and heating. Flash column chromatography was performed on Merck silica gel 60 (particle size 0.040 and 0.063 mm, 230-400 mesh ASTM) according to the procedure of Still.⁵² Melting points were recorded on a Melting Point Apparatus SMP3-STUART SCIENTIFIC. UV-vis spectra were recorded on a Cary-4000 Varian spectrophotometer, using either 1 cm quartz cuvettes. Infrared spectra were recorded in a KBr disk on a Perkin Elmer-Spectrum BX FTIR system. Absorptions are quoted in wavenumbers (cm⁻¹). ¹H- and ¹³C-NMR spectra were recorded at 400 MHz ¹H (100 MHz ¹³C) on a Varian Mercury 400 spectrometer. Spin resonances are reported as chemical shifts (δ) in parts per million (ppm) and referenced to the residual peak of the solvent employed, as follows: CDCl₃ 7.27 ppm (¹H NMR), 77.0 ppm (¹³C-NMR, central band), DMSO-*d*₆ 2.50 ppm (¹H-NMR), 39.5 ppm (¹³C-NMR). Spin multiplicity is indicated by s=singlet, d=doublet, m=multiplet, br=broad. Coupling constants J are reported in Hertz. Mass spectra were recorded on a ThermoScientific LCQ-Fleet mass spectrometer under electrospray ionisation (ESI, +c or -c technique). Mass spectrometric analysis is quoted in the m/z form. **HRMS Spectra Analysis were performed by direct introduction of the samples at a flow rate of 3 μl/min in an Orbitrap high-resolution mass spectrometer (Thermo, San Jose, CA, USA). The instrument was calibrated just before analyses (external calibration). The working conditions were the following: negative polarity, spray voltage - 4 kV, capillary voltage - 55 V, capillary temperature 275° C, tube lens voltage - 30 V. The sheath and the auxiliary gases were set, respectively, at 20 (arbitrary units) and 5 (arbitrary units). Xcalibur 2.0. software (Thermo) was used for spectra acquisition and a nominal resolution (at m/z 400) of 100,000 was used. Elemental analyses were recorded on a THERMO FlashEA 1112 Series Elemental Analyzer. UV spectra were recorded on a Varian Cary 400 using optical glass 1 cm cuvettes. Samples were prepared dissolving about 2 mg of product in 20 mL THF.**

General procedure for compounds **8a-i**: in a 100 mL round-bottom flask Pd(OAc)₂ (0.05 mmol) and PPh₃ (0.2 mmol) were dissolved in 30 mL of a THF under N₂ atmosphere and stirred for 10 minutes. Then a solution of KOH (2.5 mmol) in 8 mL of water was mixed with THF. Compound **3** (1 mmol) and the aryl boronic acid (1.5 mmol) were added and the solution was left at reflux for 2-12 h. The solution was cooled at r.t. and transferred in a 500 mL beaker with 300 mL of H₂O and stirred for 2 h. Then a 10% v/v HCl solution was added until pH 2 was reached and the suspension obtained was decanted. The mixture was filtered under vacuum and the crude obtained was purified with chromatography on silica gel using an eluent with increasing polarity, from DCM to DCM/MeOH 20:1 followed with DCM/MeOH 20:1 with 1% HCOOH to ensure the product recovery as a red powder.

[[4-amino-9,10-dioxo-3-phenyl-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8a); m.p. 218-220 °C. Elem. Anal. Calculated for C₂₂H₁₅NO₅: C 70.77% H 4.05% N 3.75%; found C 70.75 % H 3.72% N 3.60 %; $\nu_{\max}/\text{cm}^{-1}$ 3444, 3064, 1745, 1645, 1589; ¹H NMR (DMSO-*d*₆) δ 8.19-8.17 (m, 1H), 8.12-8.09 (m, 1H), 7.84-7.79 (m, 2H), 7.57-7.53 (m, 2H), 7.49-7.47 (m, 3H), 7.27 (s, 1H), 4.75 (s, 2H); ¹³C NMR (DMSO-*d*₆) δ 184.0, 181.7, 170.3, 149.8, 145.4, 136.8, 136.3, 133.8, 133.6, 133.3, 133.2, 129.1 (2C), 128.7 (2C), 128.5, 127.8, 125.9 (2C), 120.3, 111.7, 67.4; MS: m/z (rel. int.) 372 (100) [M-]

[[4-amino-3-(4-methylphenyl)-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8b); m.p 218-220 °C; Elem. Anal. Calculated for C₂₂H₁₅NO₅: C 71.31% H 4.42% N 3.62%; found C 71.29% H 4.12% N 3.55%; $\nu_{\max}/\text{cm}^{-1}$ 3461, 3041, 2931, 1735; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.20-8.18 (m, 1H), 8.12-8.10 (m, 1H), 7.87-7.82 (m, 2H), 7.40-7.35 (m, 4H), 7.24 (s, 2H), 4.78 (s, 2H), 2.39 (s, 3H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 181.1, 178.6, 167.4, 146.9, 142.5, 135.1, 133.9, 130.9, 130.6, 130.5, 130.5, 130.4, 126.8 (2C), 125.7 (2C), 124.5, 123.0, 117.0, 108.5, 64.2, 17.8; MS: m/z (rel. int.) 386 (100) [M-], 773 (48) [2M-1]

[[4-amino-3-(4-methoxyphenyl)-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8c); m.p. 201-203 °C; Elem. Anal. Calculated for C₂₃H₁₇NO₆: C 68.48% H 4.25% N 3.47%; found C 68.48% H 3.81% N 3.14%; $\nu_{\max}/\text{cm}^{-1}$ 3469, 3282, 1743, 1633; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.18-8.16 (m, 1H), 8.09-8.07 (m, 1H), 7.83-7.78 (m, 2H), 7.40 (d, J=8 Hz, 2H), 7.14 (s, 1H), 7.08 (d, J=8 Hz, 2H), 4.39 (s, 2H), 3.81 (s, 3H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 183.9, 181.7, 170.2, 159.4, 151.6, 144.7, 137.0, 134.1, 133.6, 133.2 (2C), 130.2 (2C), 128.7, 126.0 (3C), 117.9, 114.6 (2C), 111.2, 68.8, 55.2; MS: m/z (rel. int.) 402 (100) [M-]

[[4-amino-3-(4-fluorophenyl)-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8d); m.p. 230-232 °C; Elem. Anal. Calculated for C₂₂H₁₄FN₂O₅: C 67.52% H 3.61% N 3.58% found C 67.51% H 3.23% N 3.68%; $\nu_{\max}/\text{cm}^{-1}$ 3461, 3280, 3051, 1753, 1650; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.21-8.18 (m, 1H), 8.12-8.10 (m, 1H), 7.88-7.83 (m, 2H), 7.56-7.52 (m, 2H), 7.41-7.37 (m, 2H), 7.28 (s, 1H), 4.79 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.1, 181.7, 170.4, 162.2 (d, J=122.5 Hz, C-F), 149.7, 145.6, 136.3, 134.3, 134.0, 133.9, 133.8, 131.6, 131.5, 126.4, 116.6, 116.4, 112.2, 67.8; MS: m/z (rel. int.) 390 (100) [M-], 781 (33) [2M-1]

[[4-amino-3-(4-chlorophenyl)-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8e); m.p. 234-237 °C; Elem. Anal. Calculated for C₂₂H₁₄ClNO₅: C 64.79% H 3.46% N 3.43%; found C 64.67% H 3.45% N 3.33%; $\nu_{\max}/\text{cm}^{-1}$ 3465, 3271, 3062, 1745, 1645; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.20-8.17 (m, 1H), 8.11-8.09 (m, 1H), 7.87-7.82 (m, 2H), 7.63-7.60 (m, 2H), 7.53-7.51 (m, 2H), 7.29 (s, 1H), 4.79 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.6, 170.4, 162.9, 149.7, 145.5, 135.5, 135.2, 133.8, 133.6 (2C), 133.5, 133.4, 138.8 (2C), 129.2 (2C), 127.7, 126.0, 120.5, 111.7, 67.2; MS: m/z (rel. int.) 406 (100) [M-], 813 (33) [2M-1]

[[4-amino-3-(4-cyanophenyl)-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8f); m.p. 260-263 °C; $\nu_{\max}/\text{cm}^{-1}$ 3467, 2225, 1770, 1639; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.18-8.16 (m, 1H), 8.11-8.08 (m, 1H), 7.79 (pd, J=8 Hz, 2H), 7.84-7.82 (m, 2H), 7.69 (pd, J=8 Hz, 2H), 4.77 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.7, 170.3, 149.6, 145.2, 141.3, 134.8, 133.8, 133.5 (2C), 133.4, 132.9 (2C), 130.1 (2C), 127.9, 126.0 (2C), 121.1, 118.6, 112.0, 111.2, 67.3; MS: m/z (rel. int.) 397 (100) [M-]; HRMS (ESI-Orbitrap): calculated for C₂₃H₁₃N₂O₅ [M-H]⁻ 397.0829; found 397.0825

[[4-amino-3-(naphthalen-2-yl)-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8g); m.p. 222-225 °C; Elem. Anal. Calculated for C₂₆H₁₇NO₅: C 73.75% H 4.05% N 3.31%; found C 73.55% H 4.09% N 3.37%; $\nu_{\max}/\text{cm}^{-1}$ 3467, 3278, 3055, 1757, 1645, 1589; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.20-8.17 (m, 1H), 8.13-8.10 (m, 1H), 8.05 (d, J=8.8 Hz, 1H), 8.04 (s, 1H) 7.83-7.81 (m, 2H), 7.59-7.57 (m, 3H), 7.37 (s, 1H), 4.73 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.0, 181.7, 170.5, 150.0, 145.6, 136.8, 133.9 (2C), 133.6, 133.3, 133.2, 133.0, 132.6, 128.6, 128.6, 128.2, 128.1, 127.8, 127.5, 126.6, 126.5 (2C), 126.0, 120.1, 111.7, 67.6; MS: m/z (rel. int.) 422 (100) [M-], 845 (91) [2M-1]

[[4-amino-9,10-dioxo-3-(pyridin-3-yl)-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8h); m.p. 217-219 °C; Elem. Anal. Calculated for C₂₂H₁₅NO₅: C 67.38% H 3.77% N 7.48%; found C 66.85% H 4.28% N 7.09%; $\nu_{\max}/\text{cm}^{-1}$ 3500-2500, 3473, 3552, 3271, 1747; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.67 (m, 2H), 8.24-8.17 (m, 1H), 8.11-8.09 (m, 1H), 7.91 (dt, J=7.8 Hz, J= 1.6 Hz, 1H), 7.84-7.79 (m, 2H), 7.53 (dd, J=7.8 Hz, J=4.8 Hz), 7.31 (s, 1H), 4.72 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.1, 181.7, 170.3, 149.9, 149.3 (2C), 145.6, 136.6, 133.8, 133.6, 133.3 (2C), 133.2, 132.5, 128.0, 125.9 (2C), 123.8, 120.6, 111.9, 67.5; MS: m/z (rel. int.) 373 (49) [M-], 747 (100) [2M-1]; HRMS (ESI-Orbitrap): calculated for C₂₂H₁₄NO₅ [M-H]⁻ 373.0829; found 373.0825

[[4-amino-9,10-dioxo-3-(thiophen-2-yl)-9,10-dihydroanthracen-1-yl]oxy]acetic acid (8i); m.p. 225-228 °C; Elem. Anal. Calculated for C₂₀H₁₃NO₅S: C 63.32% H 3.45% N 3.69% found C 63.22% H 3.00% N 3.77%; $\nu_{\max}/\text{cm}^{-1}$ 3450, 3272, 3082, 1737, 1633; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.20-8.17 (m, 1H), 8.11-8.09 (m, 1H), 7.85-7.83 (m, 2H), 7.78 (dd, J= 5.2 Hz, 1H), 7.62 (dd, J=3.6 Hz, 1H) 7.40 (s, 1H), 7.27 (dd, J= 3.6 Hz, J= 2.4 Hz, 1H), 4.77 (s, 1H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.3, 181.6, 170.4, 149.4, 145.4, 136.9, 133.8, 133.6, 133.5 (2C), 129.1, 128.3 (2C), 128.2 (2C), 128.0 (2C), 127.9 (2C), 126.1 (2C), 126.0 (2C), 120.1, 112.2, 67.3; MS: m/z (rel. int.) 378 (89) [M-], 757 (100) [2M-1]

General procedure for compounds **10a-h**: in a 25 mL round-bottom flask Pd(OAc)₂ (0.05 mmol) and P(*o*-tolyl)₃ (0.2 mmol) were dissolved in 5 mL DMSO under N₂ atmosphere and stirred for 10 minutes. Then compound **3** NEt₃ and styrenes **9a-9h** were added to the reaction mixtures and left at 110 °C under N₂ overnight. The solution was cooled at r.t. and transferred in a 500 mL beaker with 300 mL of H₂O and stirred for 2 h. Then a 10% v/v HCl solution was added until pH 2 was reached and the suspension obtained was decanted. The mixture was then filtered under vacuum and the crude was purified dissolving it in EtOH and stirring for two hours at room temperature. The mixture was filtered and washed with EtOH to recover the product.

[[4-amino-9,10-dioxo-3-[(E)-2-phenylethenyl]-9,10-dihydroanthracen-1-yl]oxy]acetic acid (10a); m.p. 217-219 °C; Elem. Anal: calculated for C₂₄H₁₇NO₆: C 68.90% H 4.10% N 3.37%; found C 68.90% H 4.50% N 3.37%; $\nu_{\max}/\text{cm}^{-1}$ 3452, 3284, 3028, 1755, 1623; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.42 (s, 1H), 8.20-8.17 (m, 1H), 8.10-8.07 (m, 1H), 7.86-7.80 (m, 2H), 7.4 (d, J=8 Hz, 2H), 7.71 (s, 1H), 7.57 (d, J=16 Hz, 1H, Sistema AB), 7.45-7.32 (m, 4H), 4.83 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.5, 170.4, 149.8, 146.4, 136.7, 133.9, 133.6 (2C), 133.5, 133.4, 132.8, 128.7 (2C), 128.5, 127.3 (2C), 126.0 (2C), 122.7, 121.7, 120.4, 111.6, 67.3; MS: m/z (rel. int.) 398 (100) [M-], 797 (30) [2M-1].

[[4-amino-3-[(E)-2-(4-chlorophenyl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl]oxy]acetic acid (10b); m.p. 240-243 °C; Elem. Anal: calculated for C₂₅H₁₉NO₆: C 69.53% H 4.20% N 3.24%; found: C 69.14% H 3.81% N 3.47%; $\nu_{\max}/\text{cm}^{-1}$: 3467, 3286, 3065, 1751, 1623, 1588, 1536; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.18-8.16 (m, 1H), 8.09-8.07 (m, 1H), 7.86-7.80 (m, 2H), 7.75 (d, J=8Hz, 2H), 7.71 (s, 1H), 7.58 (d, J=16 Hz, 1H), 7.49 (d, J=8 Hz, 2H), 7.36 (d, J=16 Hz, 1H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.5, 170.4, 149.8, 146.4, 135.7, 133.8, 133.6, 133.5, 133.4, 132.8, 132.4, 132.2, 128.9 (2C), 128.7 (2C), 126.0 (2C), 122.8, 122.5, 120.6, 111.7, 67.3; MS: m/z (rel. int.) 432 (100) [M-]

((4-amino-3-[(E)-2-(4-methylphenyl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl)oxy)acetic acid (10c); m.p. 238-240 °C; Elem. Anal: calculated for C₂₅H₁₉NO₅: C 69.44% H 4.43% N 3.24%; found: C 69.43% H 4.67% N 3.37%; $\nu_{\max}/\text{cm}^{-1}$ 3444, 3280, 3022, 1747, 1622; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.42 (s, 1H), 8.19-8.17 (m, 1H), 8.10-8.07 (m, 1H), 7.84-7.80 (m, 2H), 7.70 (s, 1H), 7.63 (d, J=8 Hz, 2H), 7.51 (d, J=16 Hz, 1H Sistema AB), 7.33 (d, J=16 Hz, Sistema AB), 7.24 (d, J=8 Hz), 4.3 (s, 2H), 2.33 (s, 3H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.4, 170.4, 149.9, 146.3, 138.1, 134.0, 133.9, 133.6 (2C), 133.4, 133.3, 133.0, 129.3 (2C), 127.3 (2C), 126.0 (2C), 122.4, 120.5, 120.1, 111.6, 67.3, 20.9; MS: m/z (rel. int.) 412 (100) [M-], 825 (26) [2M-1], 847 (62) [2M-1+Na]

((4-amino-3-[(E)-2-(4-methoxyphenyl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl)oxy)acetic acid (10d); m.p. 229-231 °C; Elem. Anal: calculated for C₂₅H₁₉NO₆: C 69.92% H 4.46% N 3.26%; found: C 69.86% H 4.62% N 3.30%; $\nu_{\max}/\text{cm}^{-1}$ 3434, 3276, 2931, 1745, 1622; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.21-8.18 (m, 1H), 8.11-8.09 (m, 1H), 7.85-7.83 (m, 2H), 7.69 (d, J=8Hz, 2H), 7.68 (s, 1H), 7.43 (d, J=16 Hz, 1H), 7.33 (d, J=16 Hz, 1H), 7.01 (d, J= 8.4 Hz, 2H), 4.83 (s, 2H), 3.81 (s, 3H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.4, 170.5, 159.7, 150.1, 146.3, 133.9, 133.6, 133.4 (2C), 133.3 (2C), 129.4, 128.8 (2C), 126.0, 125.9, 122.0, 119.8, 119.2, 114.2 (2C), 111.5, 67.4, 55.3; MS: m/z (rel. int.) 428 (100) [M-]

((4-amino-3-[(E)-2-(4-aminophenyl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl)oxy)acetic acid (10e); m.p. 245-247 °C; Elem. Anal: calculated for C₂₄H₁₈N₂O₅: C 66.51% H 4.19% N 6.46%; found: C 66.50% H 4.41 N 6.81%; $\nu_{\max}/\text{cm}^{-1}$ 3417, 3008, 3258, 1747, 1625; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.43 (s, 1H), 8.20-8.17 (m, 1H), 8.10-8.08 (m, 1H), 7.83-7.76 (m, 2H), 7.61 (s, 1H), 7.44 (d, J=8 Hz, 2H), 7.23 (s, 2H), 6.60 (d, J=8 Hz, 2H), 4.82 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.1, 181.2, 170.5, 150.3, 149.8, 146.3, 134.8, 134.2, 134.0, 133.7, 133.3 (2C), 128.9 (2C), 126.0, 125.9, 124.4, 121.0, 119.0, 115.3, 113.7 (3C), 111.3, 67.3; MS: m/z (rel. int.) 413 (100) [M-]

((4-amino-3-[(E)-2-(4-fluorophenyl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl)oxy)acetic acid (10f); m.p. 244-246 °C; Elem. Anal: calculated for C₂₄H₁₆FNO₅: C 69.06% H 3.86% N 3.86%; found: C 68.95% H 3.55% N 4.11%; $\nu_{\max}/\text{cm}^{-1}$ 3452, 3286, 3068, 1753, 1625; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.41 (s, 1H), 8.18-8.15 (m, 1H), 8.08-8.06 (m, 1H), 7.83-7.76 (m, 2H), 7.68 (s, 1H) 7.50 (d, J=16 Hz, Sistema AB, 1H), 7.35 (d, J= 16 Hz, Sistema AB, 1H), 7.28-7.24 (m, 2H), 4.82 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.6, 181.9, 170.9, 162.6 (d, J=245 Hz, C-F), 150.3, 146.8, 134.3, 134.0, 133.9, 133.8, 133.1, 132.8, 129.7 (d, J=9 Hz, C-F), 126.4, 123.1, 122.0, 120.8, 116.1 (d, J= 22 Hz), 112.1, 67.8; MS: m/z (rel. int.) 416 (100) [M-]

((4-amino-3-[(E)-2-(naphthalen-2-yl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl)oxy)acetic acid (10g); m.p. 241-243 °C; Elem. Anal: calculated for C₂₅H₁₉NO₅: C 71.79% H 4.08% N 2.99%; found: C 71.78% H 4.47% N 2.90%; $\nu_{\max}/\text{cm}^{-1}$ 3438, 3286, 3053, 2356, 1747, 1622; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.47 (s, 1H), 8.17-8.15 (m, 1H), 8.08-8.07 (m, 2H), 8.03 (d, J=9 Hz, 1H, Sistema AB), 7.93 (d, J=9 Hz, 1H, Sistema AB) 7.92-7.90 (m, 2H), 7.81-7.79 (m, 2H), 7.75 (s, 1H), 7.68 (d, J=15.6 Hz, 1H, Sistema AB), 7.53-7.49 (m, 3H), 4.86 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.5, 170.4, 149.6, 146.5, 141.4, 133.8, 133.5 (2C), 133.4 (2C), 132.6 (3C), 131.6 (2C), 127.9 (3C), 126.0 (2C), 125.3, 123.2 (2C), 121.2, 118.9, 111.9, 110.2, 67.4; MS: m/z (rel. int.) 448 (100) [M-], 897 (23) [2M-1]

((4-amino-3-[(E)-2-(4-cyanophenyl)ethenyl]-9,10-dioxo-9,10-dihydroanthracen-1-yl)oxy)acetic acid (10h); m.p. °C; Elem. Anal: calculated for C₂₅H₁₆N₂O₅: C 67.72% H 3.64% N 6.32%; found: C 67.71% H 4.03% N 6.24%; $\nu_{\max}/\text{cm}^{-1}$ 3438, 3288, 3062, 2225, 1747, 1625; ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.20-8.17 (m, 1-H), 8.09-8.06 (m, 1H), 7.91-7.86 (m, 2H), 7.84-7.81 (m, 2H), 7.75 (s, 1H), 7.73 (d, J=16 Hz, 1H, Sistema AB), 7.43 (d, J=16Hz, 1H, Sistema AB), 4.82 (s, 2H); ¹³C NMR (100 MHz, DMSO-*d*₆) δ 184.2, 181.5, 170.3, 149.6, 146.5, 141.3, 133.8, 133.5 (2C), 133.4, 132.6 (2C), 131.6 (2C), 127.9 (2C), 126.0 (2C), 125.3, 123.2, 121.1, 118.9, 111.9, 110.2, 67.4; MS: m/z (rel. int.) 423 (100) [M-]

1-amino-4-[2-(4-[[3aS,4R,6S,7R,7aR]-6-((R)-[(4S,5R)-5-(dimethoxymethyl)-2,2-dimethyl-1,3-dioxolan-4-yl]](4R)-2,2-dimethyl-1,3-dioxolan-4-yl]methoxy)-7-hydroxy-2,2-dimethyltetrahydro-4H-[1,3]dioxolo[4,5-c]pyran-4-yl]methyl]piperazin-1-yl)-2-oxoethoxy]-2-phenylanthracene-9,10-dione (12): in a 50 ml round-bottom flask compound **8b** (1 mmol) and compound **11** (1.2 mmol) were dissolved in 20 mL THF under N₂ atmosphere and stirred for 7 h at 50 °C. Then 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methyl morpholinium chloride (DMTMM, 1.2 mmol) was added and the mixture was left o/n in the same conditions. Then the solution was cooled at r.t. and THF was evaporated. The slurry was diluted with 50 mL AcOEt and washed with water (2 x 10 mL) and brine (1 x 20 mL). The organic phase was evaporated, and the crude was purified with chromatography on silica gel with DCM/THF 10:1 as eluent. A red powder is obtained; m.p. 107-109°C; Elem. Anal. Calculated for C₅₀H₆₃N₃O₁₅: C 63.48% H 6.71% N 4.44%; found: C 63.37% H 6.60% N 4.29%; $\nu_{\max}/\text{cm}^{-1}$ 3477, 2985, 2935, 2358, 2935, 2358, 2341, 1660; ¹H NMR (400 MHz, CDCl₃, 25 °C) δ 8.28-8.26 (m, 1H), 8.22-8.20 (m, 1H), 7.76-7.70 (m, 2H), 7.33-7.31 (m, 5H), 4.82 (s, 2H), 4.38-4.15 (m, 6H), 4.04-3.95 (m, 4H), 3.90-3.65 (m, 4H), 3.58-3.43 (m, 9H), 2.73-2.49 (m, 3H), 2.43 (s, 3H), 1.68 (s, 3H), 1.49 (s, 6H), 1.43 (s, 2H), 1.38 (s, 3H), 1.36 (s, 3H), 1.33 (s, 3H), 1.31 (s, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 185.2, 182.8, 166.5, 150.3, 145.8, 138.9, 137.5, 134.4, 134.1, 133.4, 133.3, 133.1, 130.1, 128.7, 128.0, 126.5, 125.5, 121.6, 113.0, 110.3, 109.9, 108.3, 106.1, 103.9, 78.9, 78.0, 77.9, 76.4, 75.9, 74.6, 74.3, 71.7, 70.6, 64.7, 58.3, 56.8, 54.6, 54.1, 53.3, 45.5, 42.2, 34.2, 30.3, 28.2, 27.3, 26.5, 26.3, 25.7, 24.6, 21.3; MS: m/z (rel. int.) 946 (11) [M+], 968 (24) [M+Na+], 1914 (100) [2M+Na+]

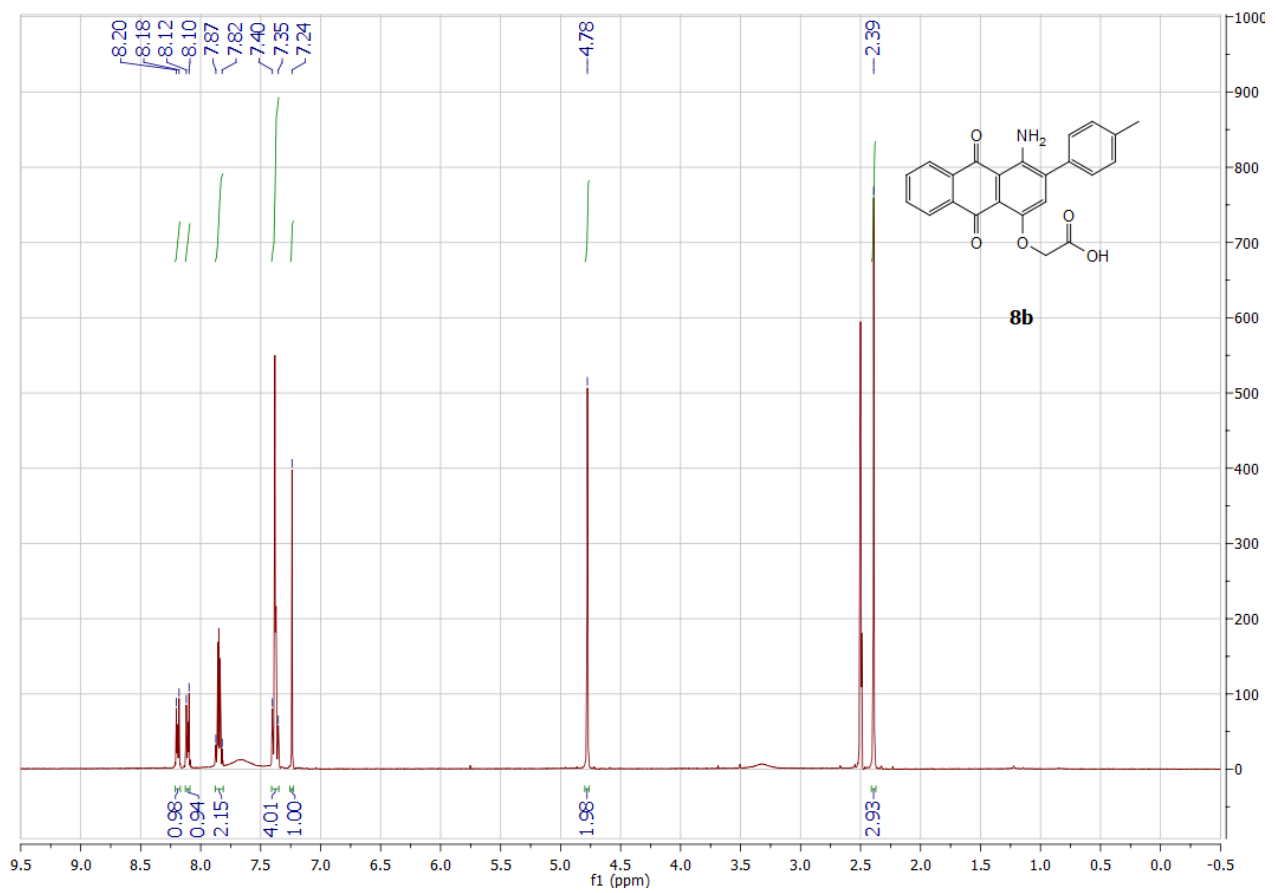
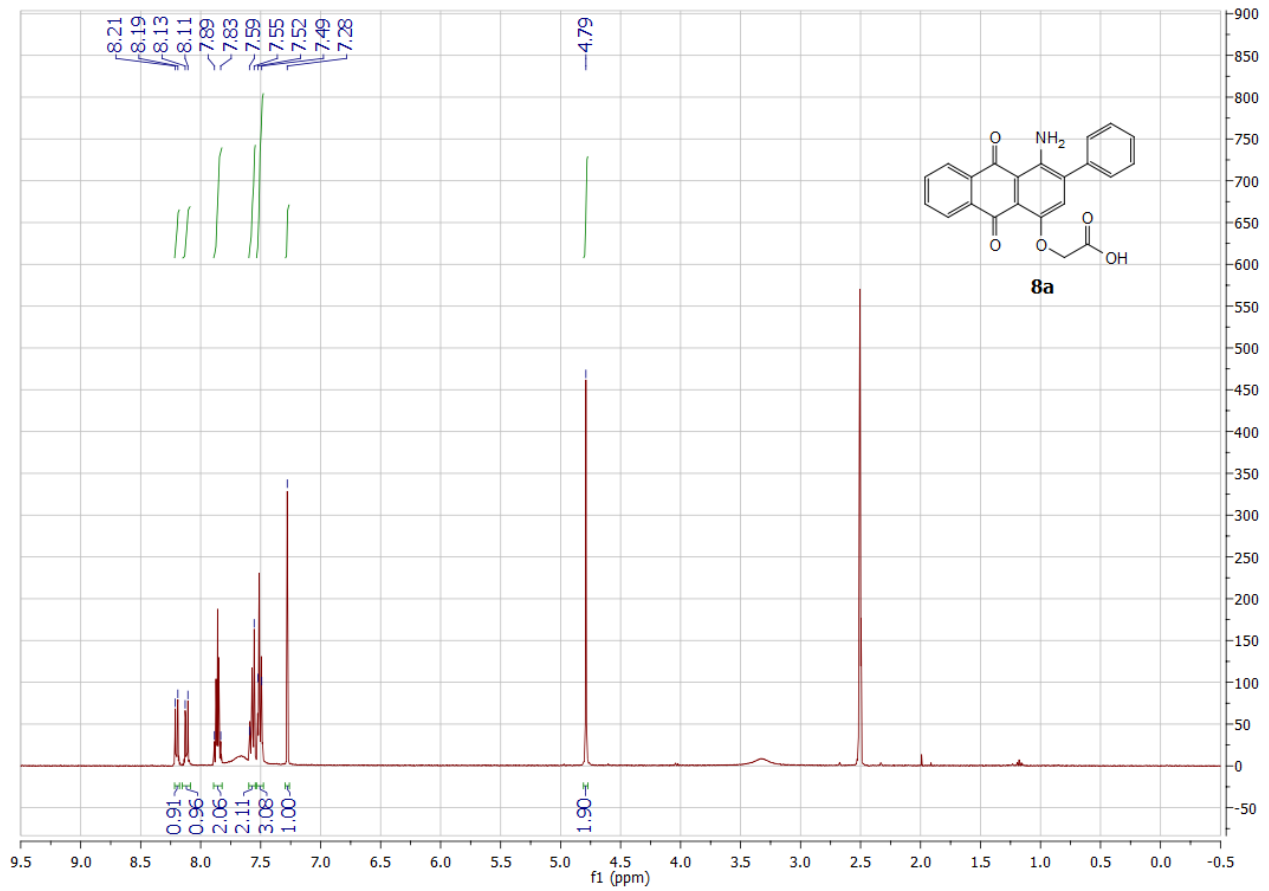
1-amino-4-[2-(4-[[3aS,4R,6S,7R,7aR]-6-((R)-[(4S,5R)-5-(dimethoxymethyl)-2,2-dimethyl-1,3-dioxolan-4-yl]](4R)-2,2-dimethyl-1,3-dioxolan-4-yl]methoxy)-7-hydroxy-2,2-dimethyltetrahydro-4H-[1,3]dioxolo[4,5-c]pyran-4-yl]methyl]piperazin-1-yl)-2-oxoethoxy]-2-[(E)-2-(4-methylphenyl)ethenyl]anthracene-9,10-dione (13): in a 50 ml round-bottom flask compound **9c** (1 mmol) and compound **11** (1.2 mmol) were dissolved in 20 mL THF under N₂ atmosphere and stirred for 7 h at 50 °C. Then 4-(4,6-dimethoxy-1,3,5-triazin-2-yl)-4-methyl morpholinium chloride (DMTMM, 1.2 mmol) was added and the mixture was left o/n in the same conditions. Then the solution was cooled at r.t. and THF was evaporated. The slurry was diluted with 50 mL AcOEt and washed with water (2 x 10 mL) and brine (1 x 20 mL). The organic phase was evaporated, and the crude was purified with chromatography on silica gel with DCM/THF 10:1 as eluent. A deep purple powder is obtained; m.p. 110-112°C; Elem. Anal: calculated for C₅₂H₆₅N₃O₁₅: C 64.25% H 6.74% N 4.32%; found: C 64.39% H 6.56% N 4.68%; $\nu_{\max}/\text{cm}^{-1}$ 3436,

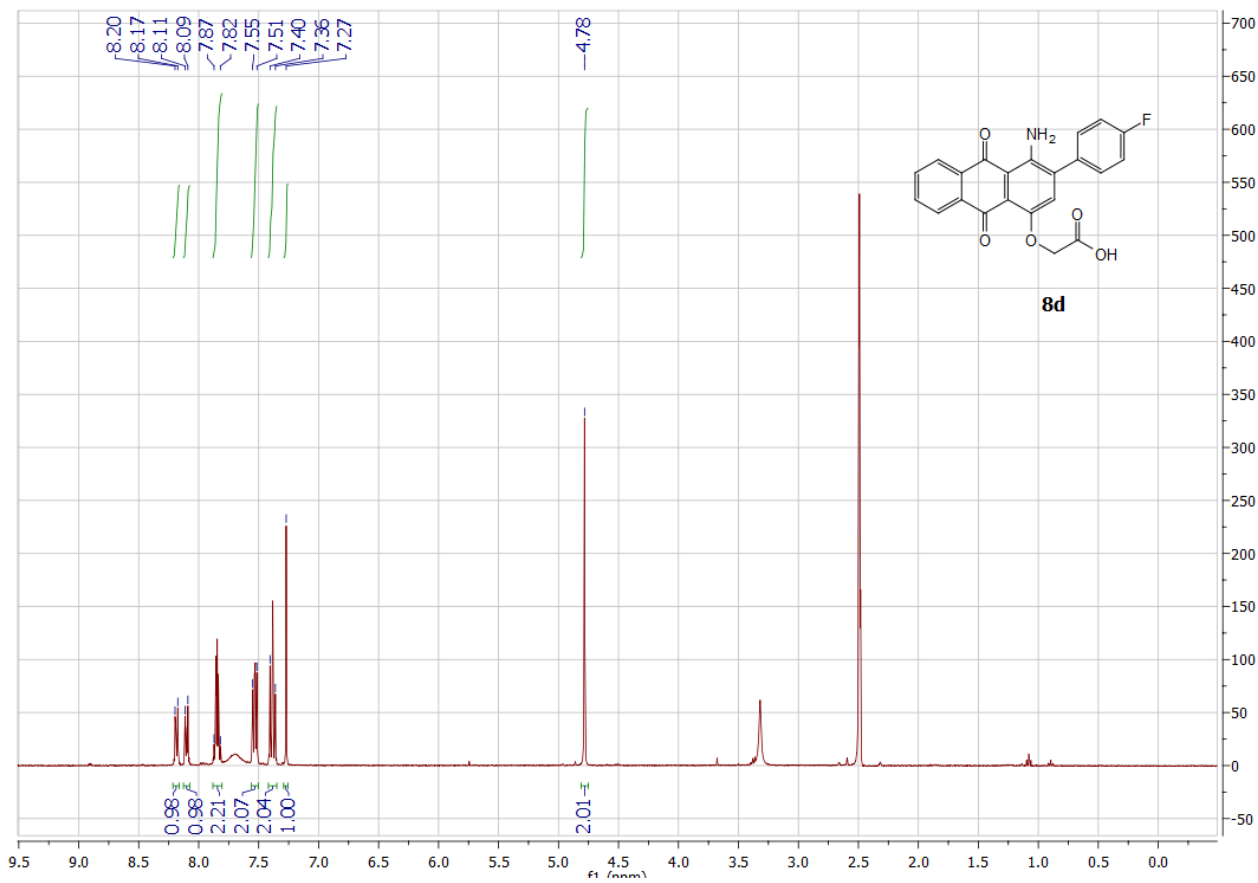
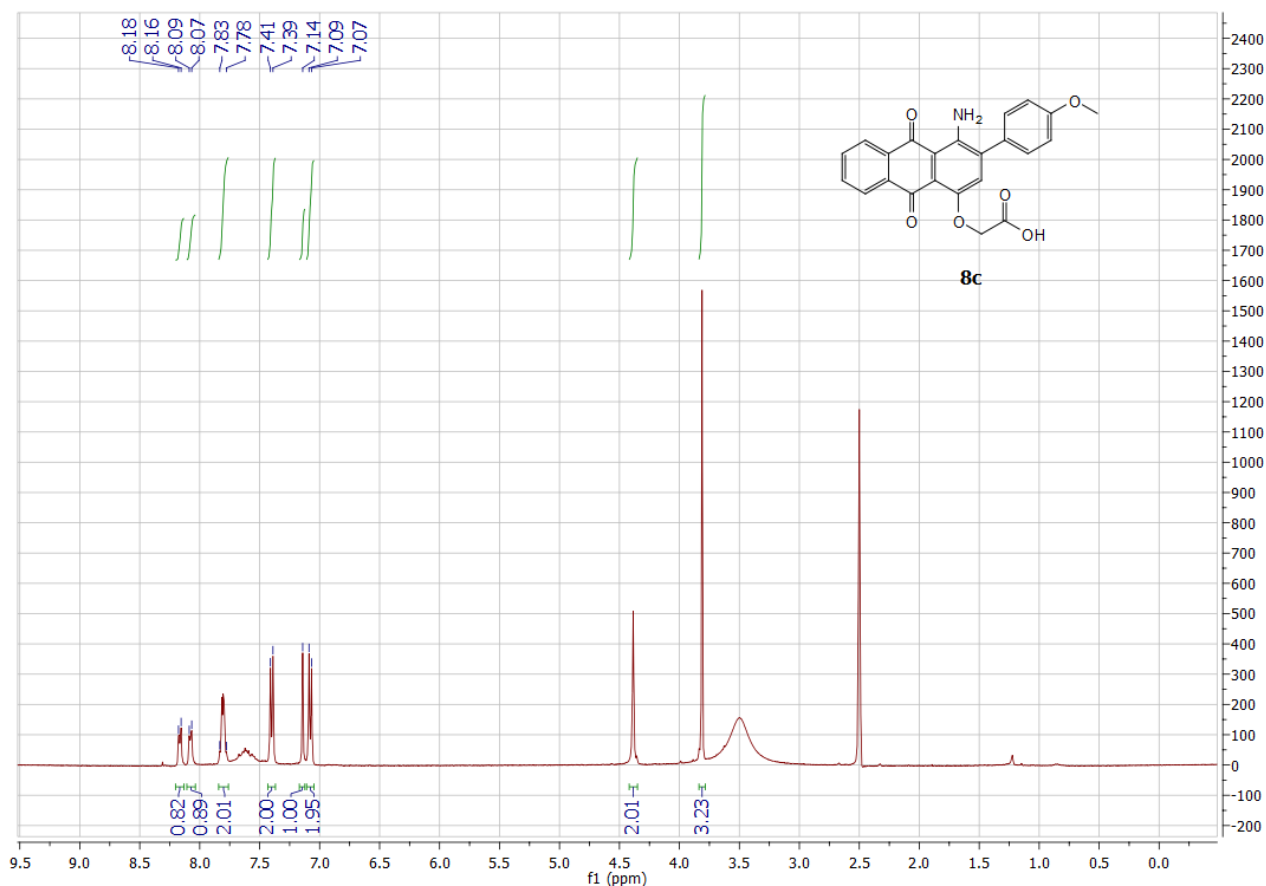
2985, 2933, 1656; ^1H NMR (400 MHz, CDCl_3) δ 8.27-8.25 (m, 1H), 8.20-8.18 (m, 1H), 7.75-7.69 (m, 2H), 7.58 (m, 2H), 7.44 (d, $J=8$ Hz, 2H), 7.28 (s, 1H), 7.19 (d, $J=8$ Hz, 2H), 7.19 (d, $J=16$ Hz, 1H, Sistema AB), 7.06 (d, $J=16$ Hz, 1H, Sistema AB), 4.87 (s, 2H), 4.39-4.36 (m, 2H), 4.30-4.24 (m, 2H), 4.16-3.98 (m, 6H), 3.94-3.50 (m, 8H), 3.42 (s, 6H), 2.27-2.67 (m, 2H), 2.57 (s, 3H), 2.37 (s, 3H), 2.27 (s, 1H), 1.49 (s, 6H), 1.38 (s, 3H), 1.35 (s, 3H), 1.33 (s, 3H), 1.31 (s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 185.5, 182.6, 166.6, 150.7, 145.7, 139.0, 135.7, 135.4, 134.4, 134.0, 133.8, 133.5, 133.2, 129.6, 127.0, 126.5, 125.5, 124.2, 121.6, 120.2, 113.5, 110.3, 109.9, 108.3, 106.1, 103.9, 78.9, 78.1, 77.9, 76.4, 75.9, 74.6, 74.3, 71.7, 70.7, 64.7, 58.3, 56.8, 54.6, 54.1, 53.3, 45.5, 42.2, 34.2, 30.3, 28.2, 27.3, 26.5, 26.3, 25.7, 24.6, 21.4; MS: m/z (rel. int.) 972 (53) $[\text{M}^+]$, 994 (100) $[\text{M}+\text{Na}^+]$

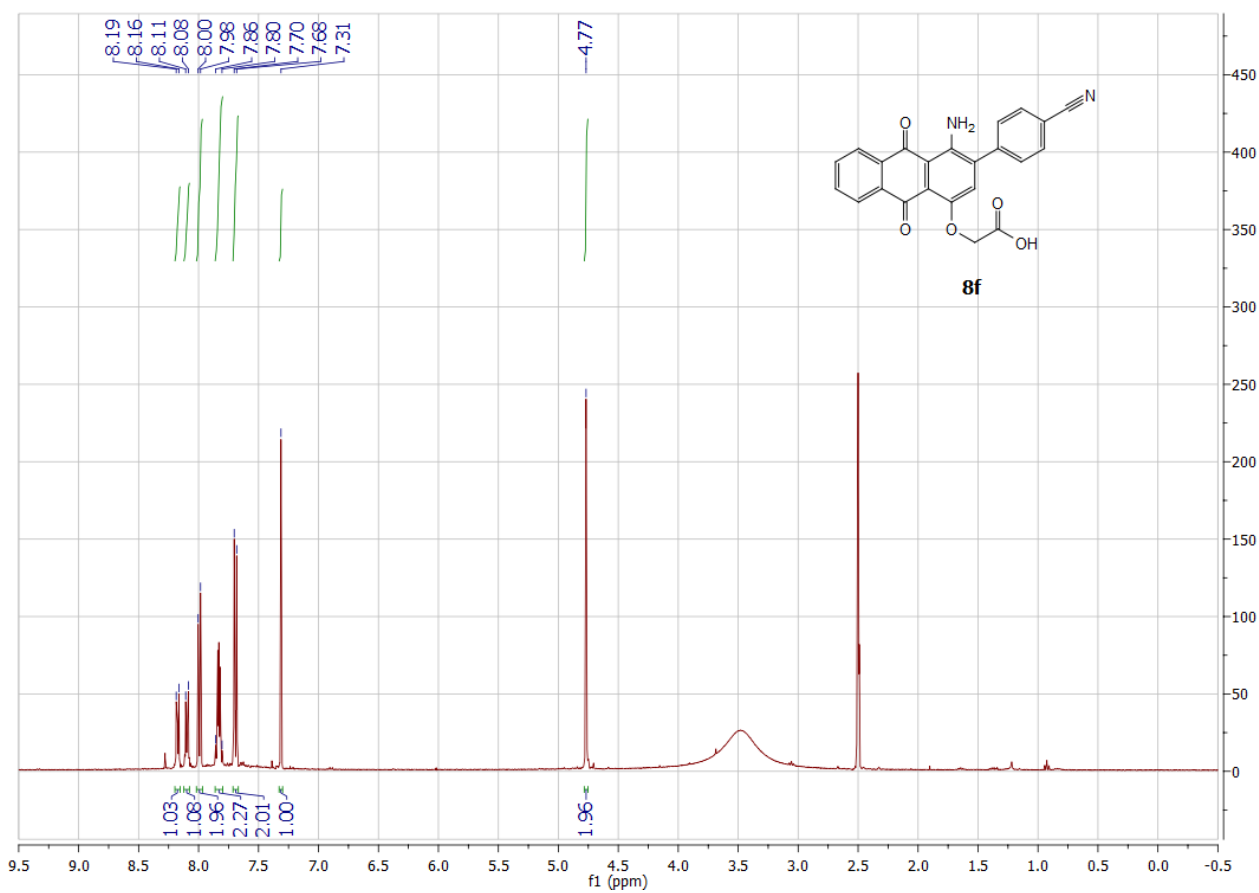
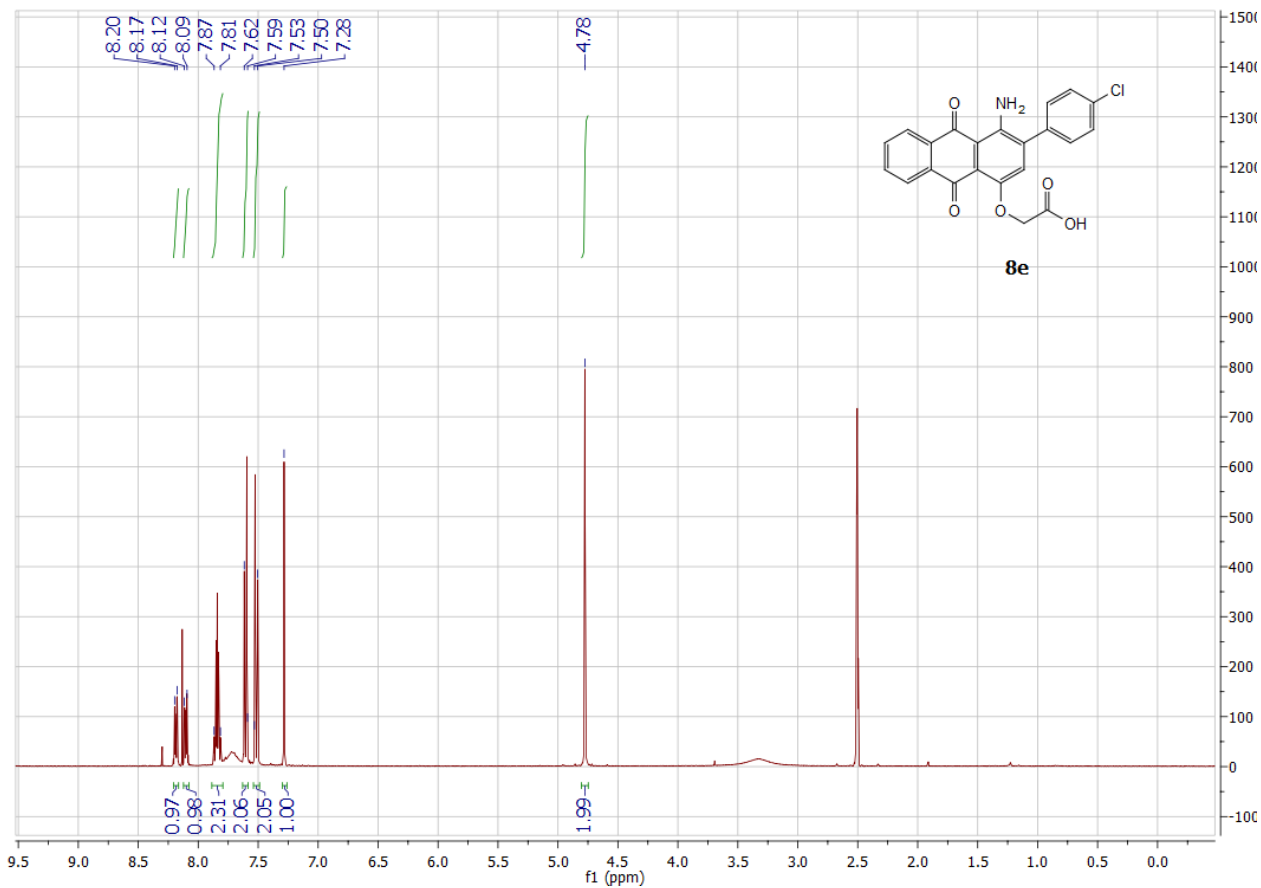
General Procedure for compounds **14 and **15**:** in a 25 mL round-bottom flask compound **12** or **13** (0.5 mmol) was dissolved in 5 mL acetone and cooled to 0 °C under magnetic stirring. Then a solution of HCl conc. (37% w/w, 109 μL) in H_2O (2 mL) was added dropwise and the solution was heated to r.t. and left o/n. Finally, the mixture was diluted with acetone and it was filtered under vacuum washing with acetone. Compounds **14** and **15** were then dried to eliminate any water residual. MS: m/z (rel. int.) 802 (100) $[\text{M}+\text{Na}^+]$, 816 $[\text{M}+\text{OCH}_2+\text{Na}^+]$; HRMS (ESI-Orbitrap): calculated for $\text{C}_{39}\text{H}_{46}\text{N}_3\text{O}_{14}$ $[\text{M}-\text{H}]^-$ 780.2974; found 780.2964

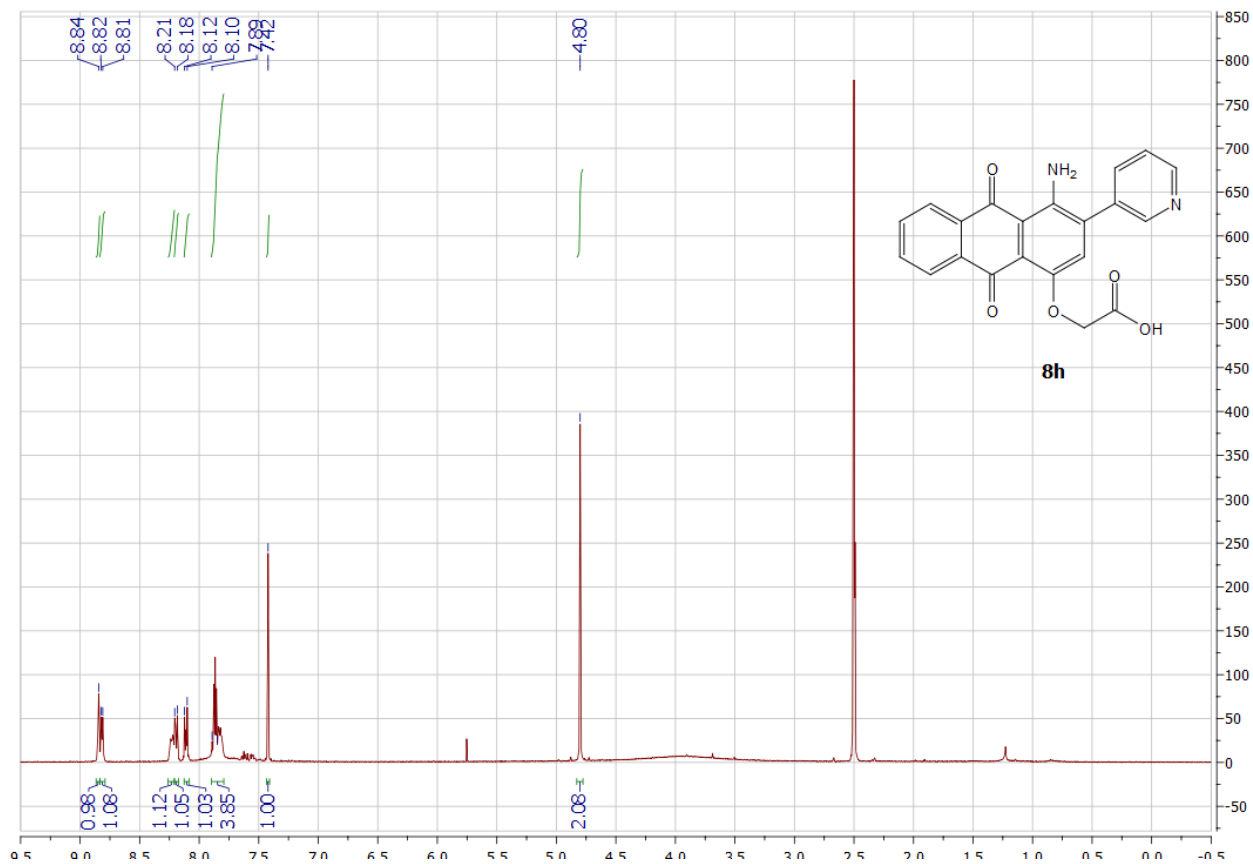
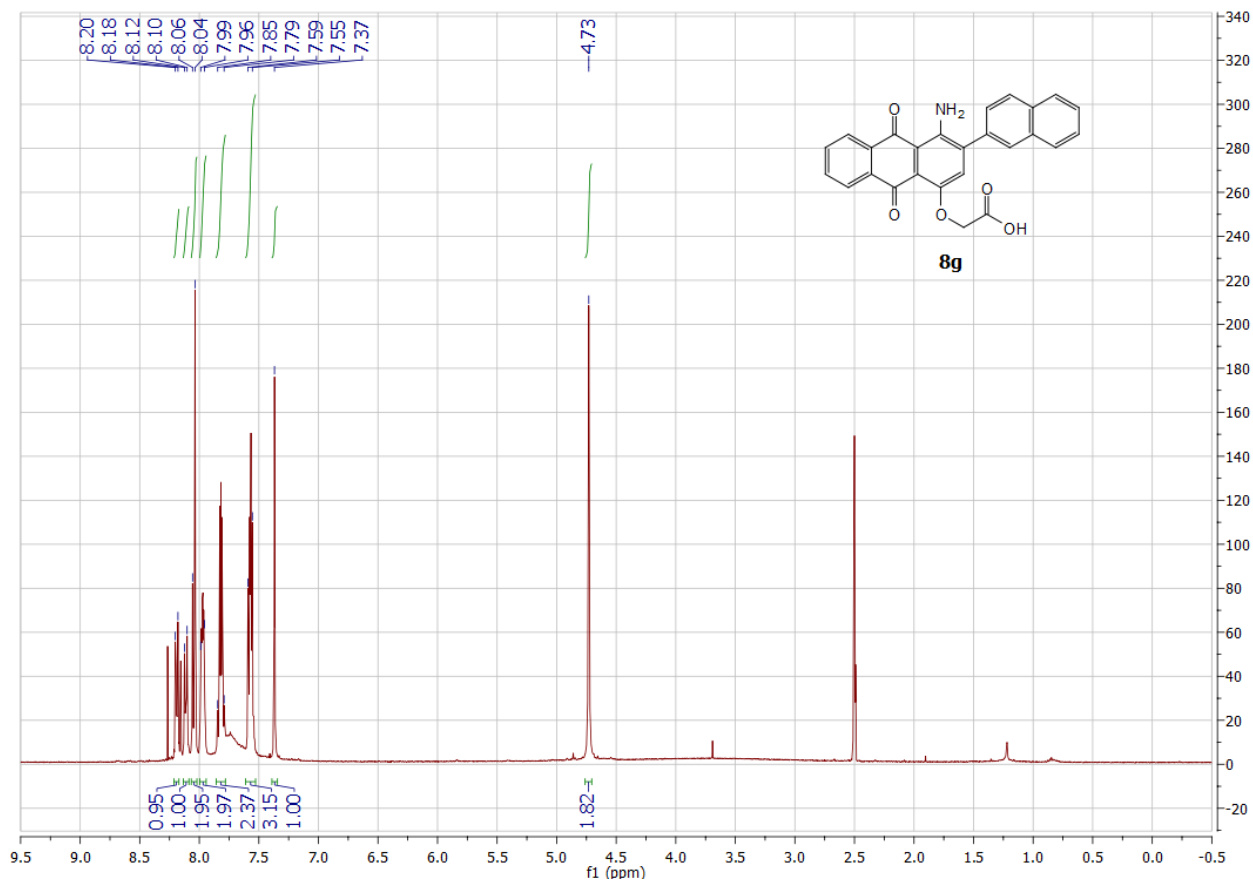
General procedure for compound **15:** in a 25 mL round-bottom flask compound **13** (0.5 mmol) was dissolved in 5 mL acetone and cooled to 0 °C under magnetic stirring. Then a solution of HCl conc. (37% w/w, 109 μL) in H_2O (2 mL) was added dropwise and the solution was heated to r.t. and left o/n. Finally, the mixture was diluted with acetone and it was filtered under vacuum washing with acetone. Compound **15** were then dried to eliminate any water residual. MS: m/z (rel. int.) 828 (100) $[\text{M}+\text{Na}^+]$, 842 $[\text{M}+\text{OCH}_2+\text{Na}^+]$; HRMS (ESI-Orbitrap): calculated for $\text{C}_{41}\text{H}_{48}\text{N}_3\text{O}_{14}$ $[\text{M}-\text{H}]^-$ 806.3130; found 806.3128

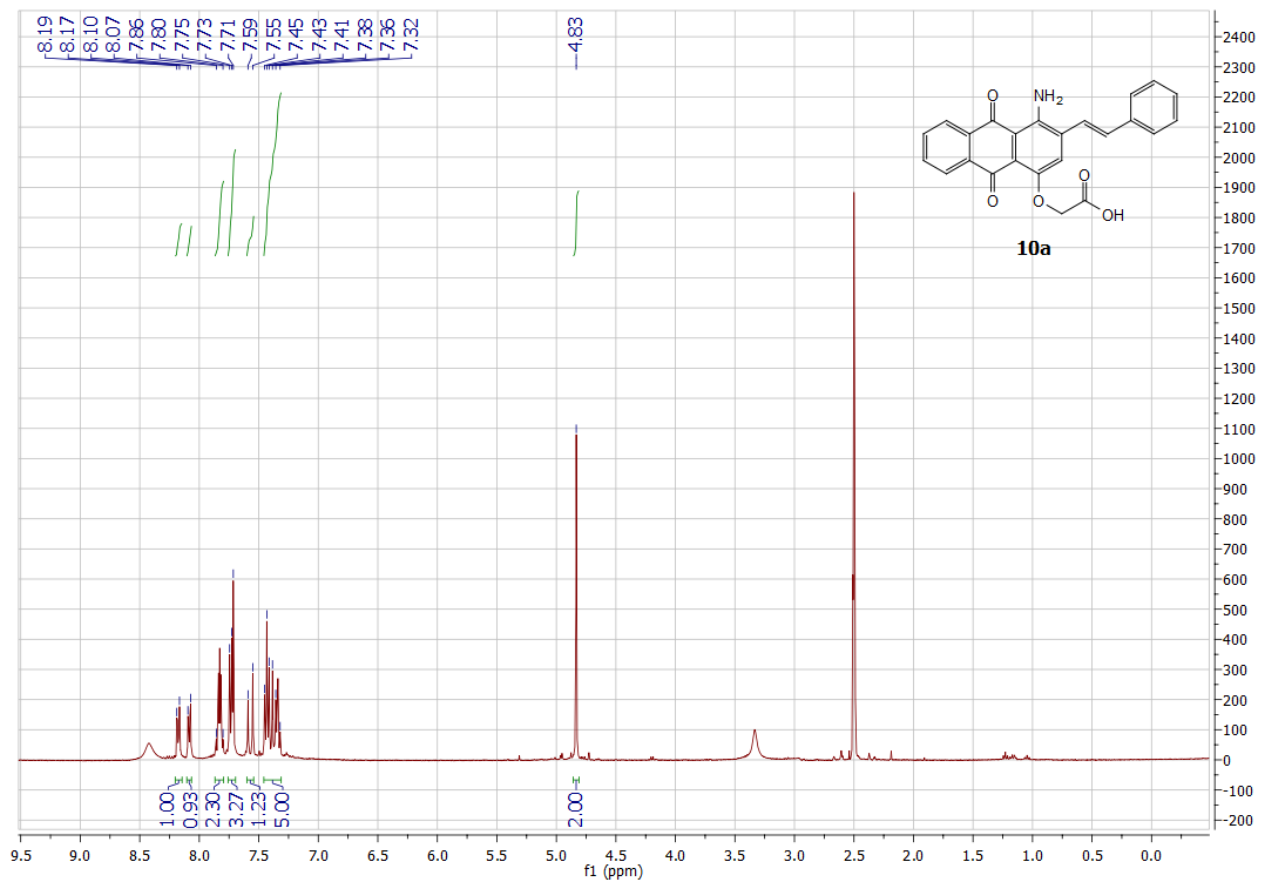
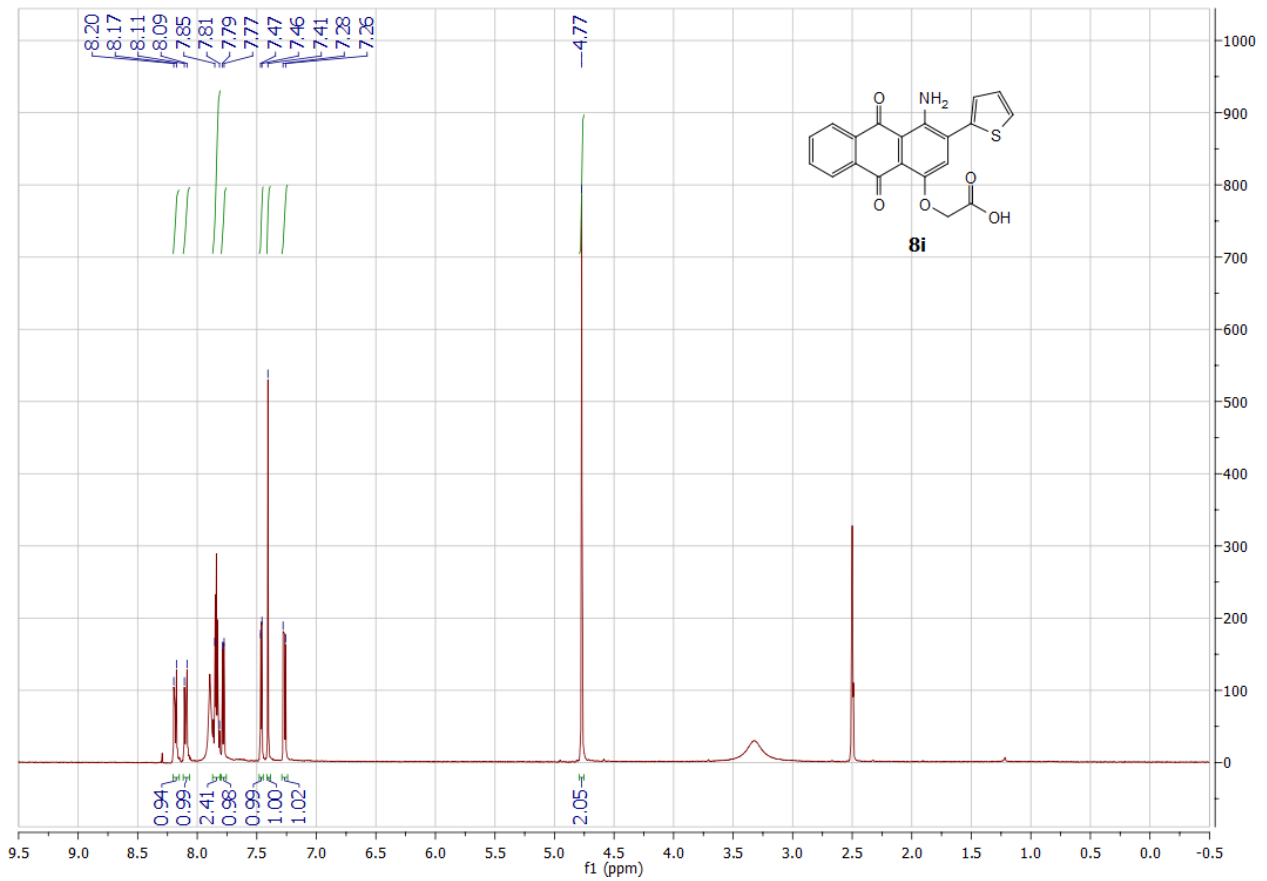
¹H-NMR spectra

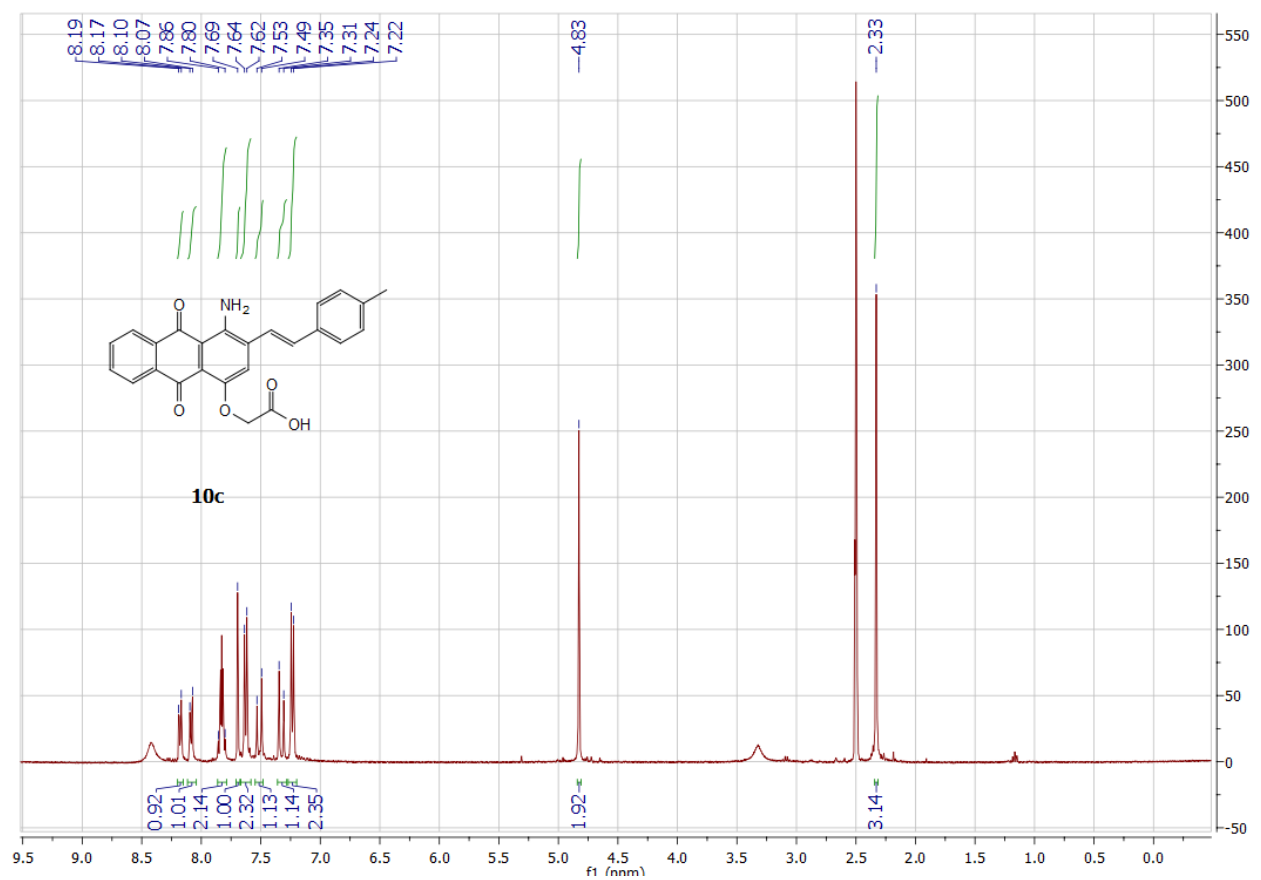
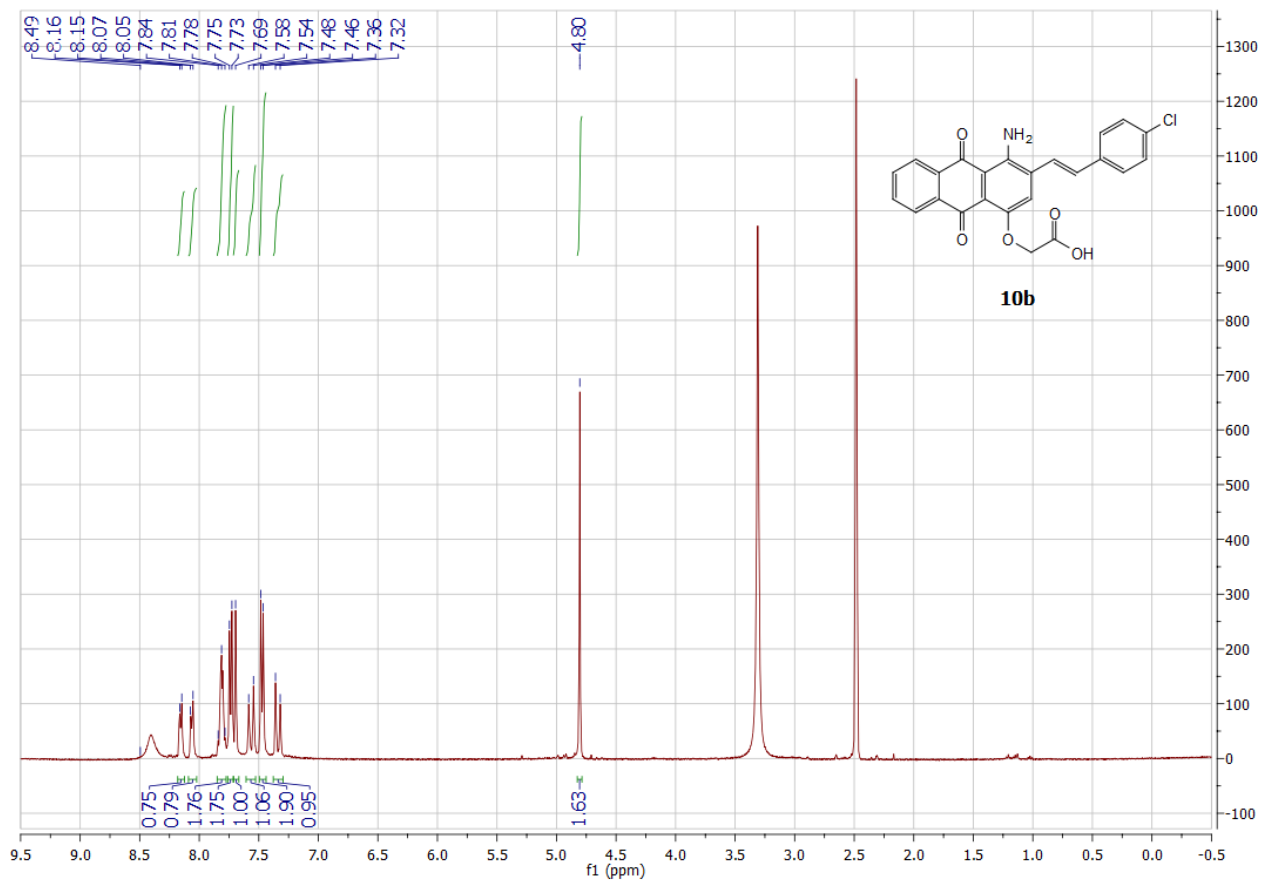


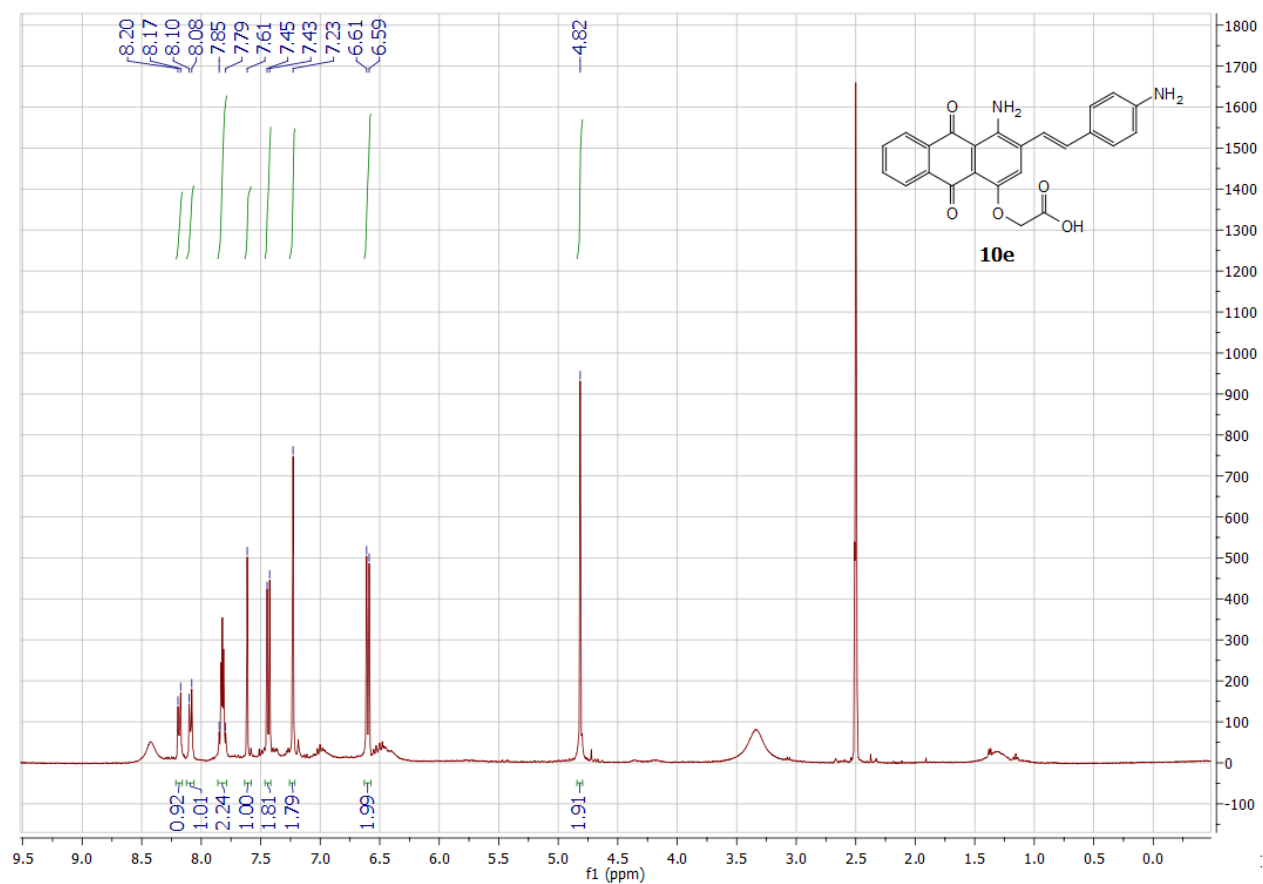
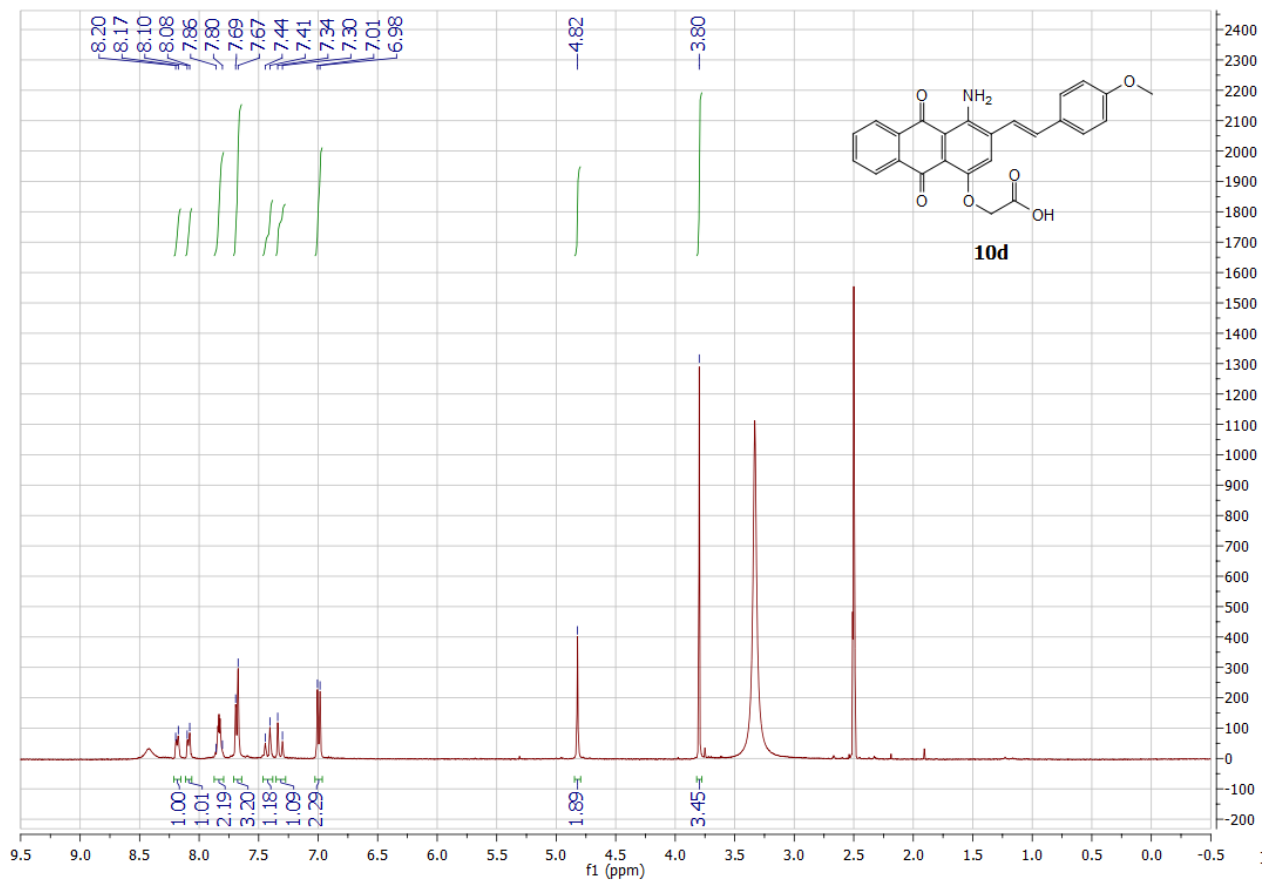


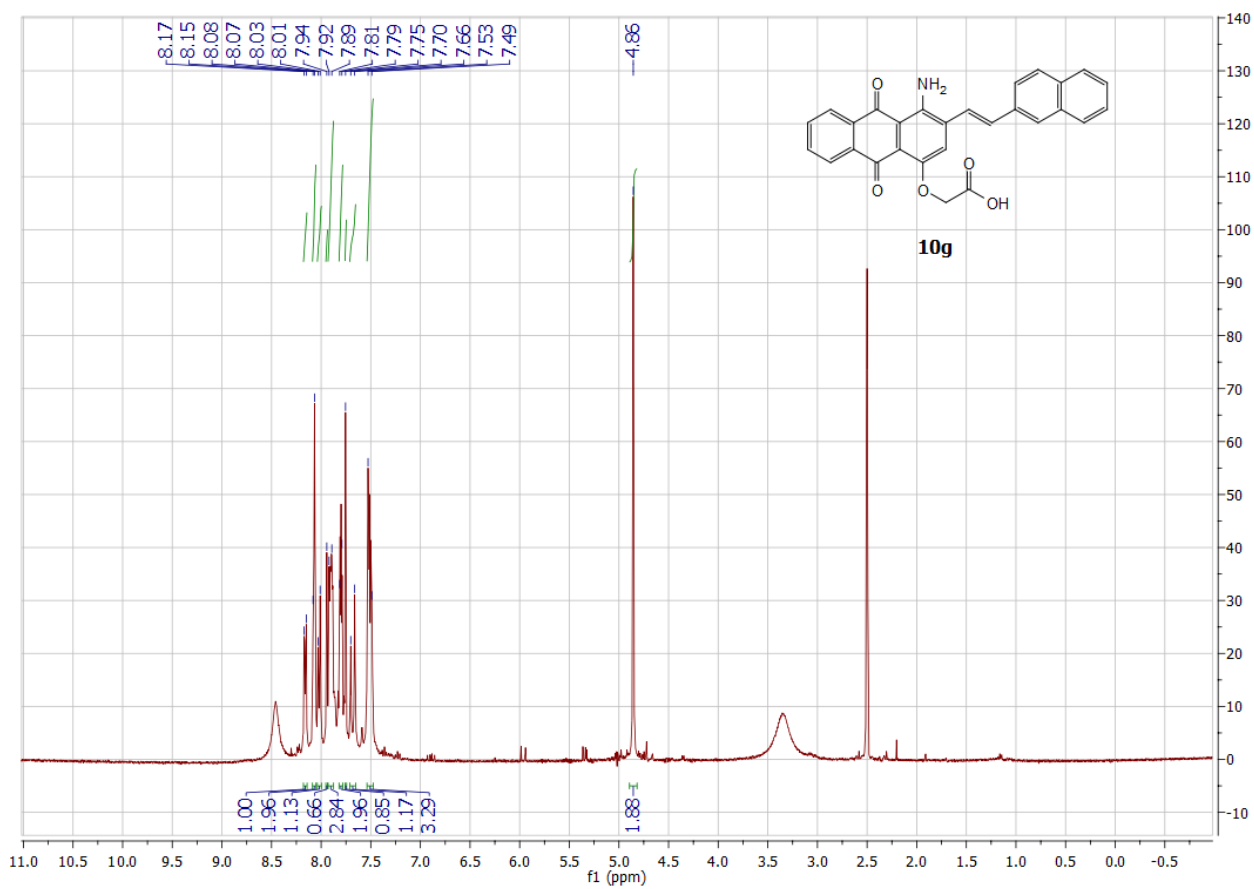
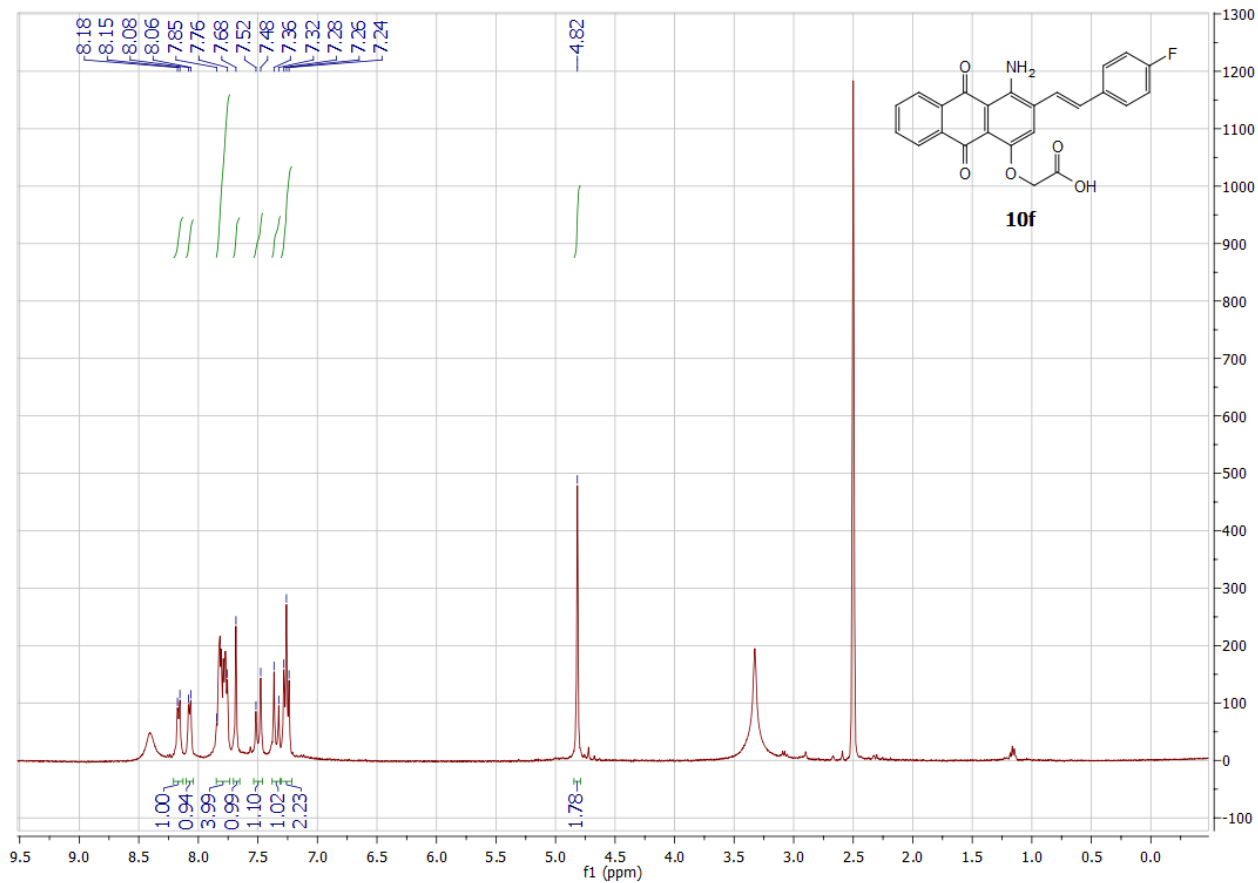


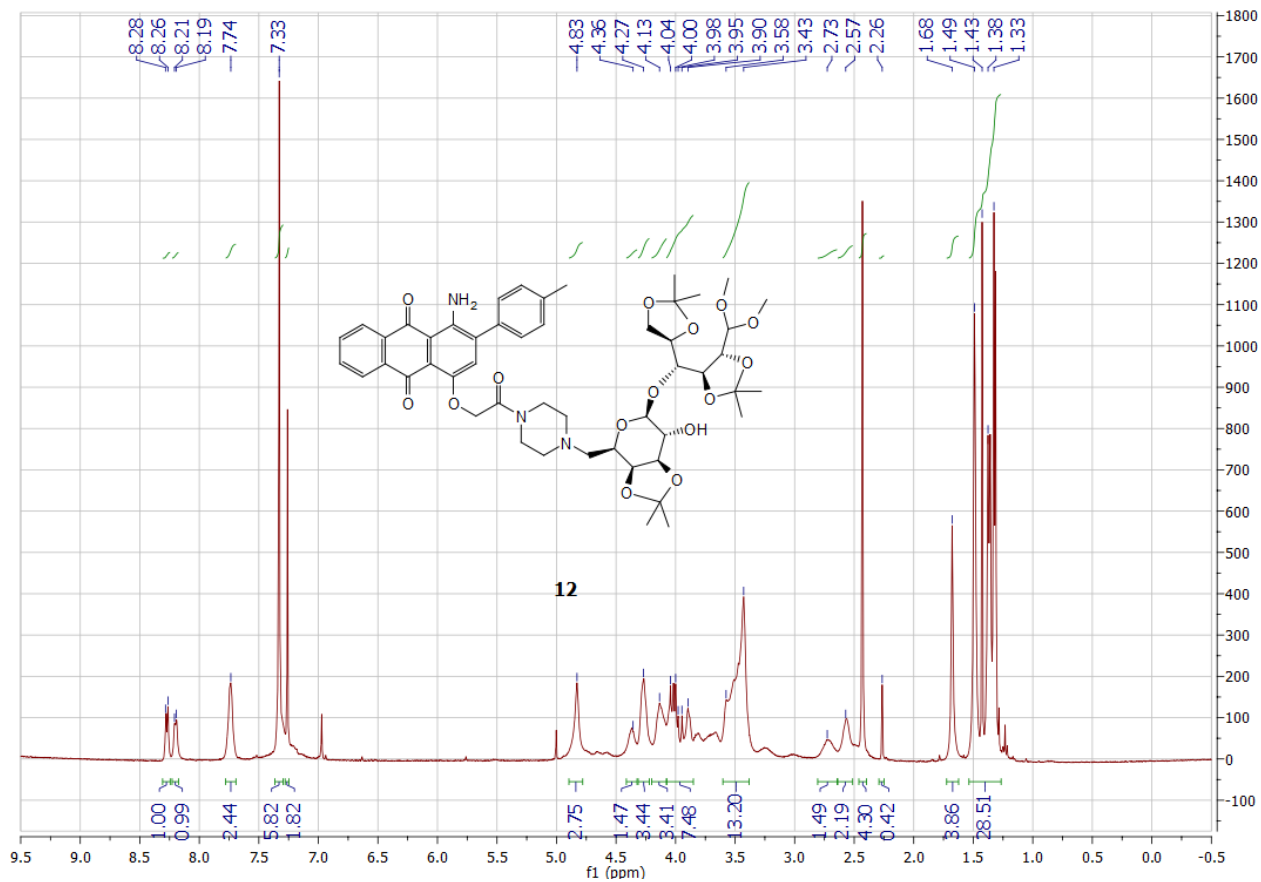
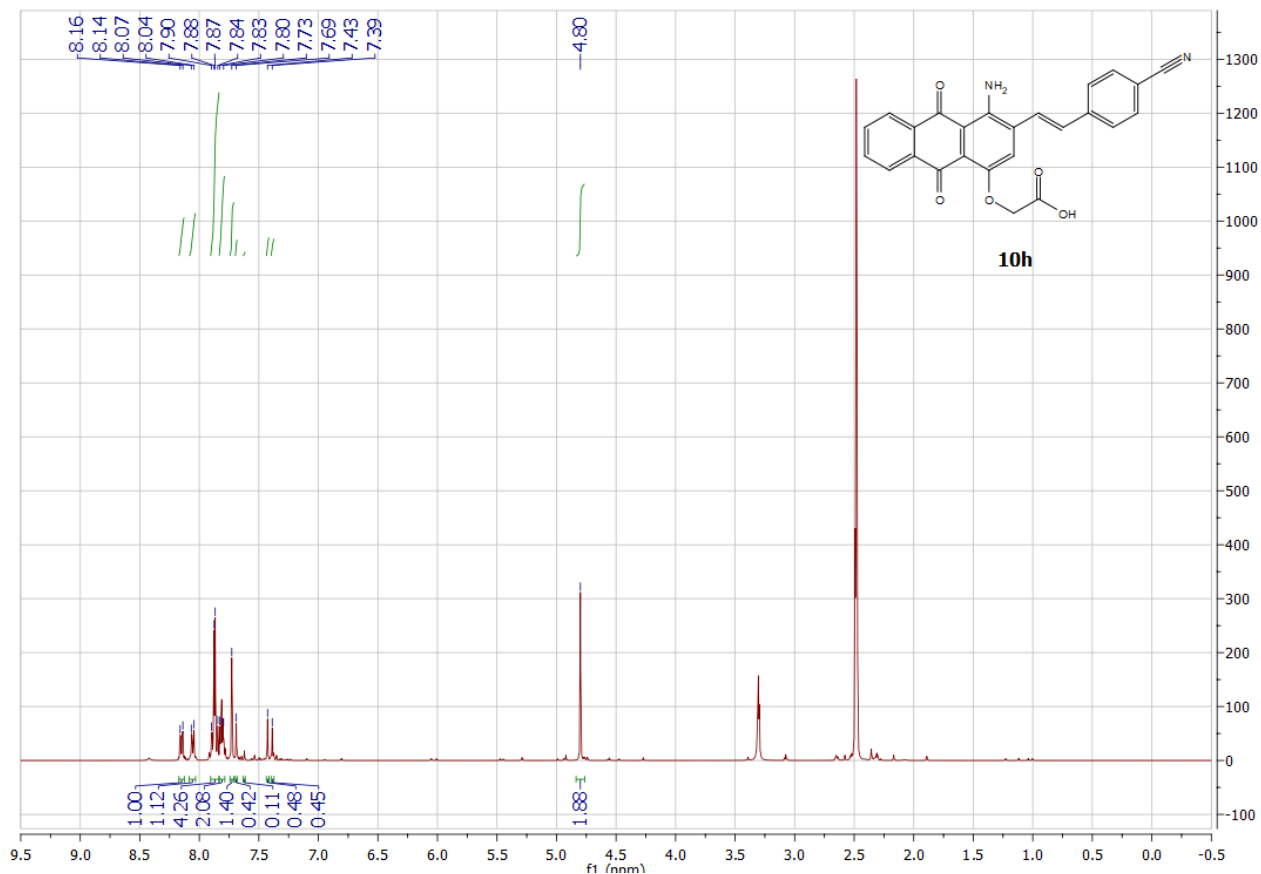


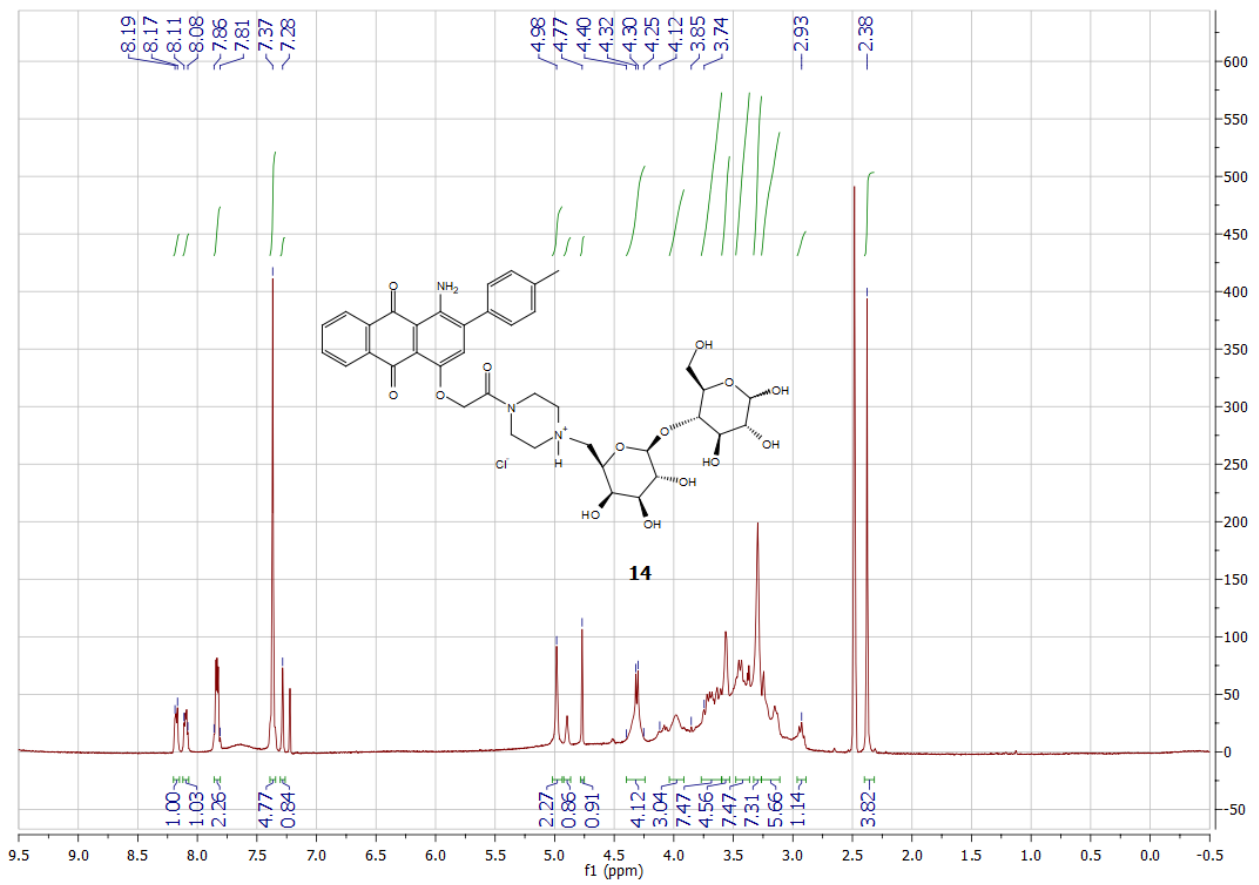
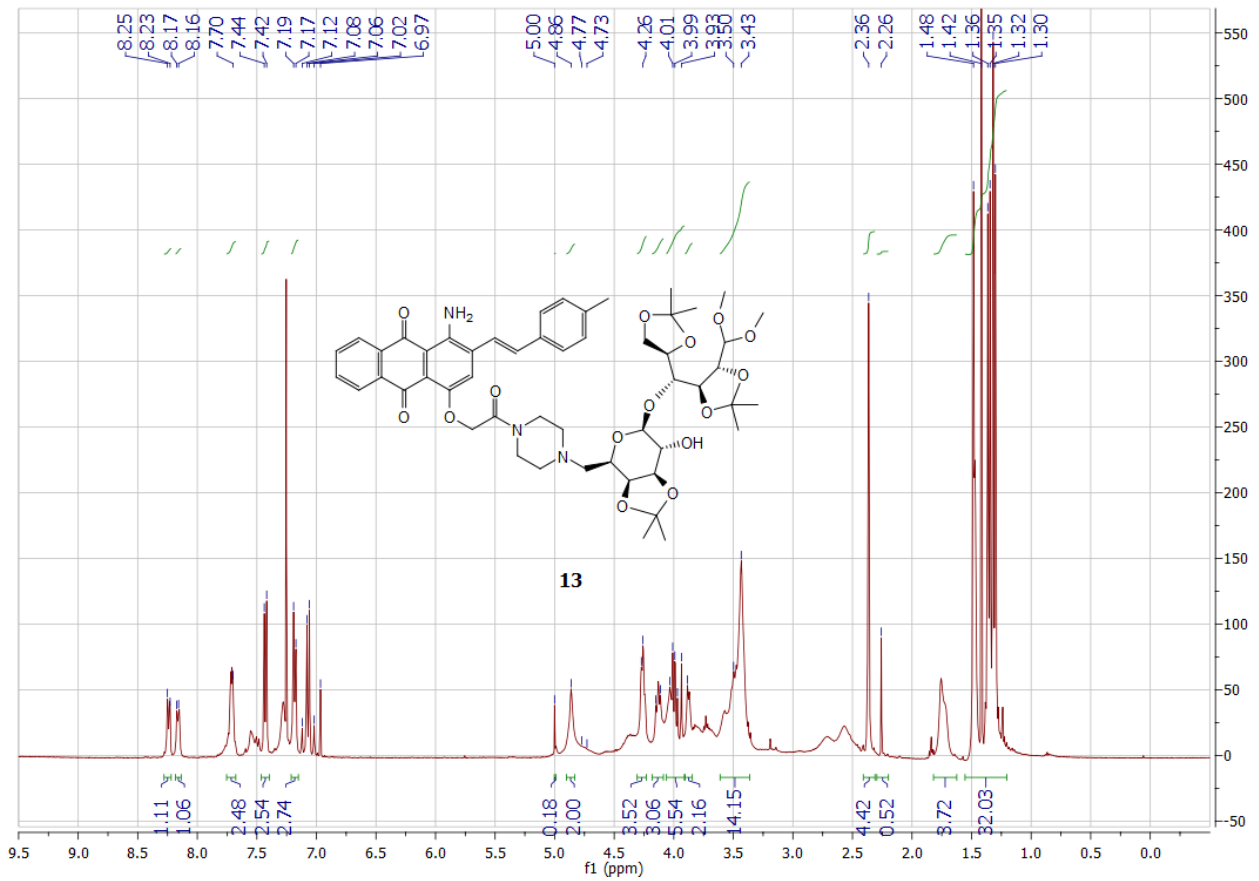


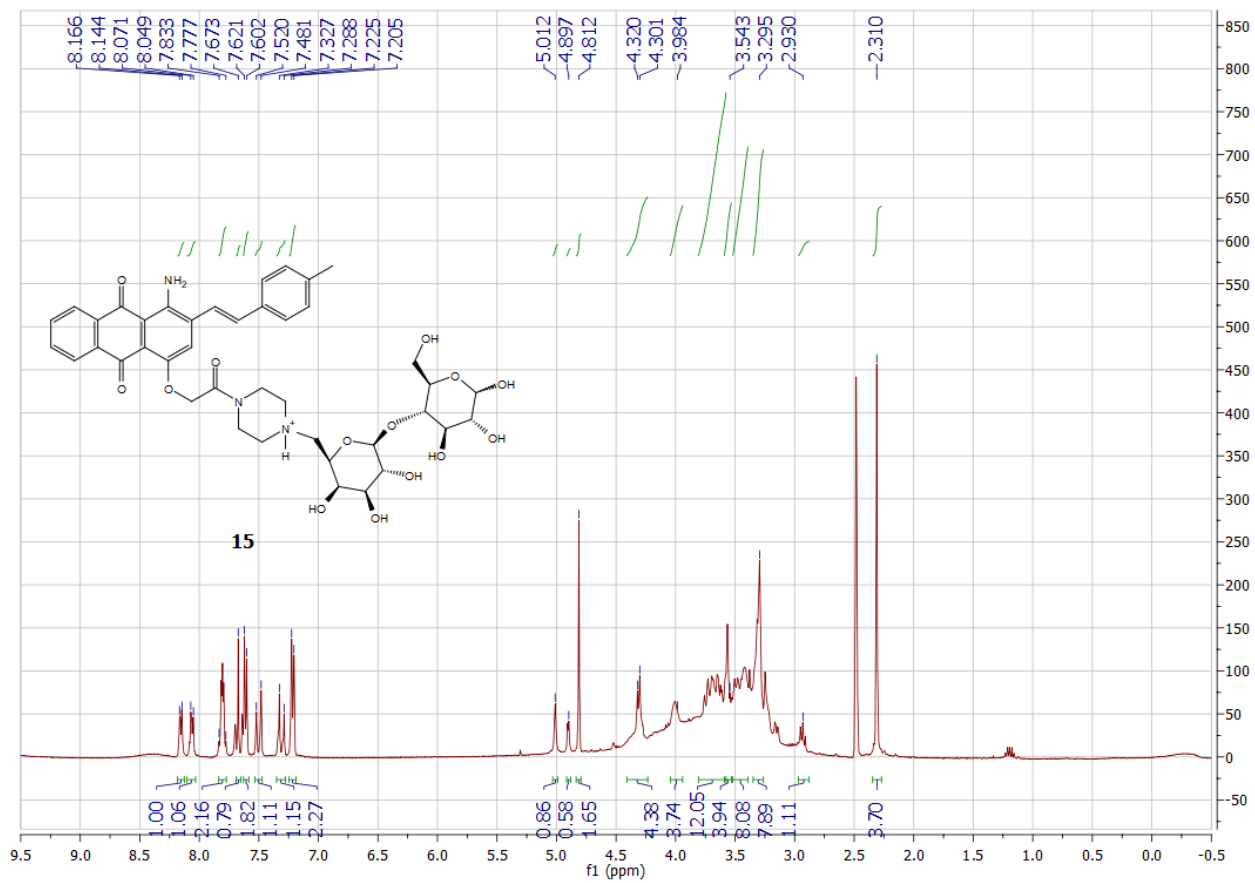




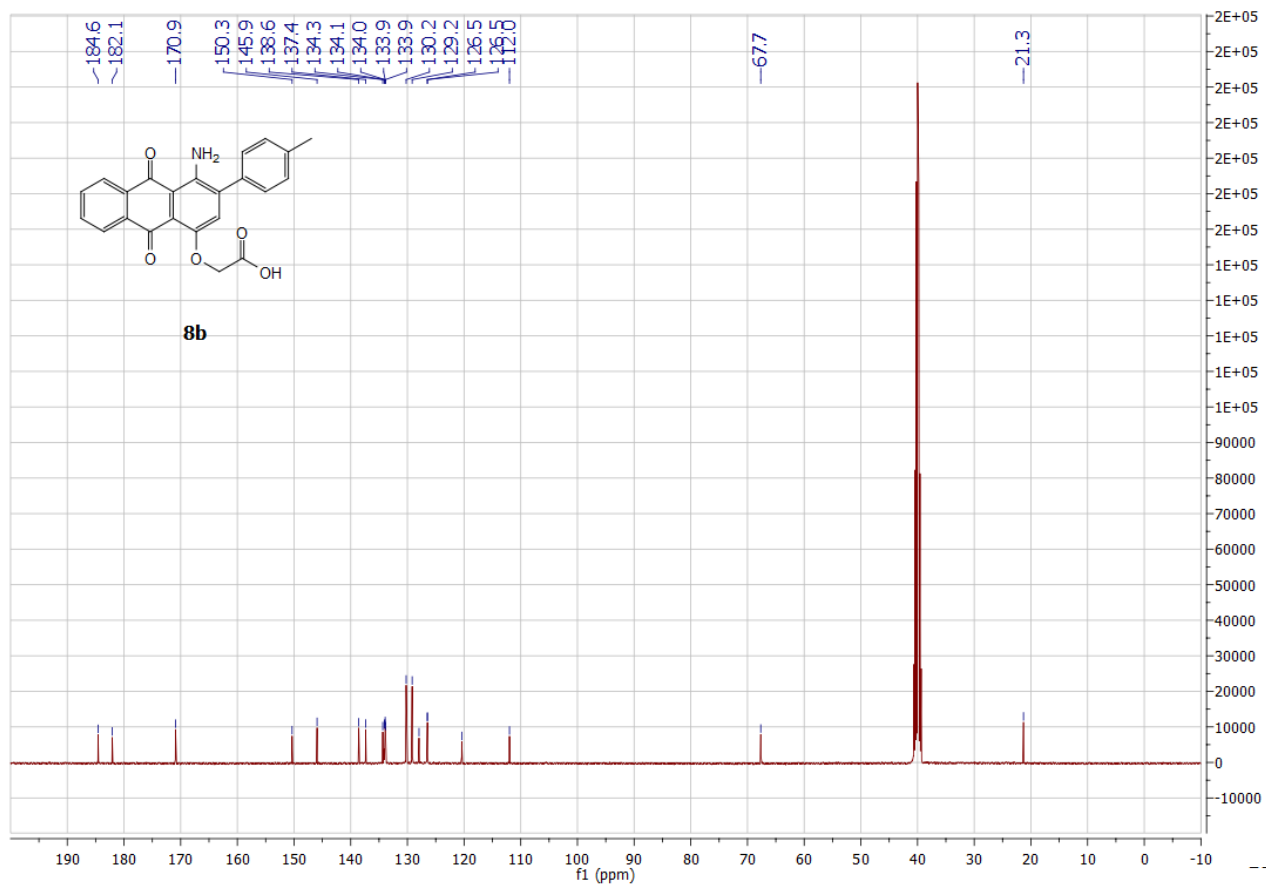
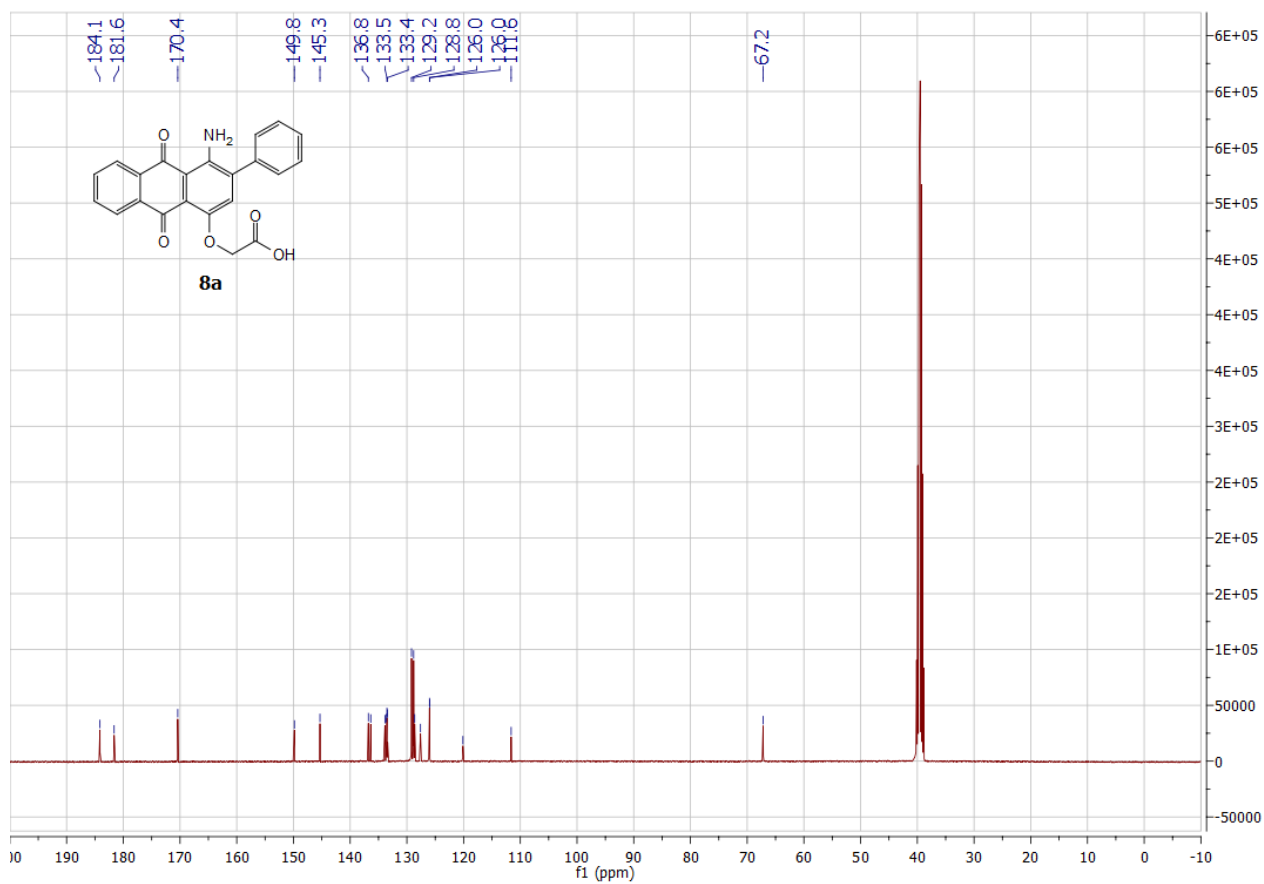


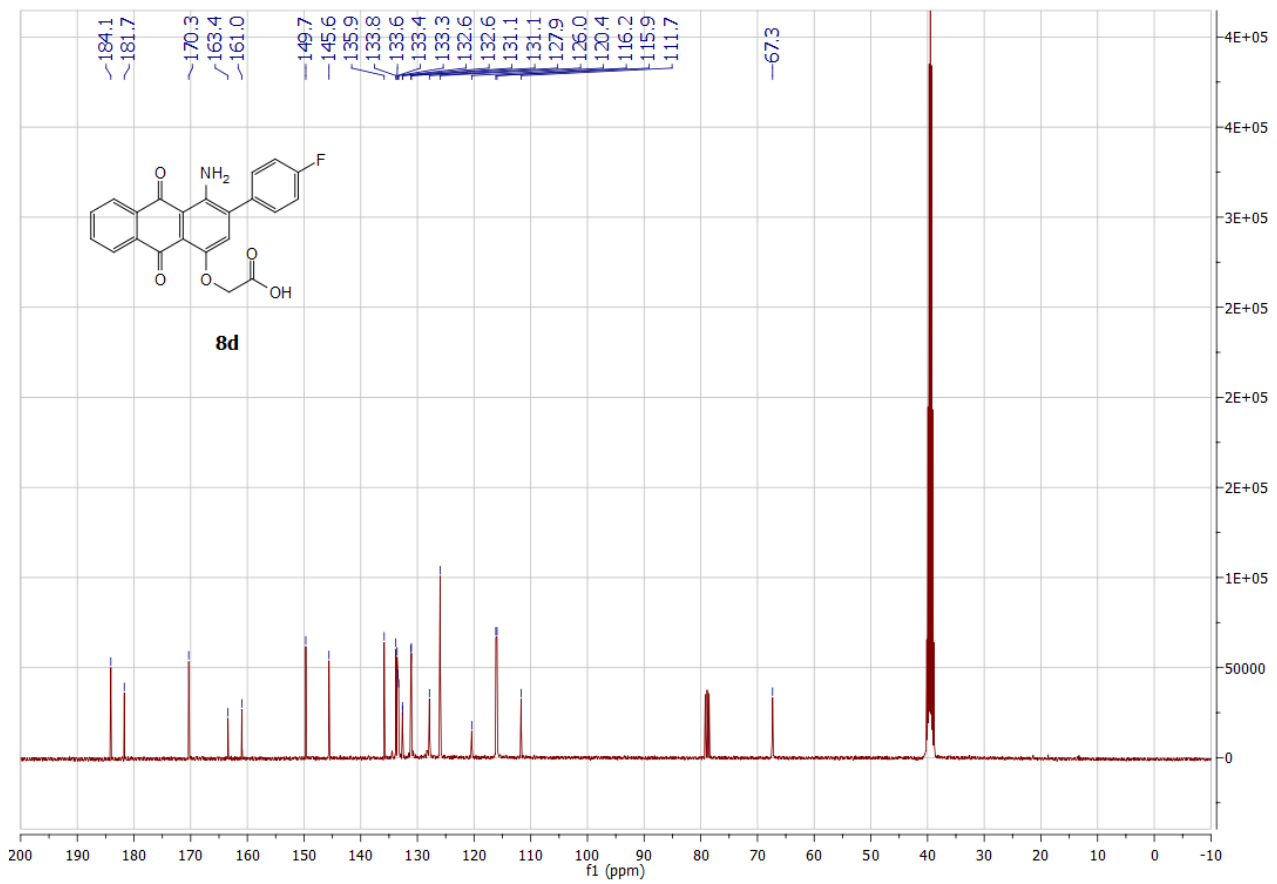
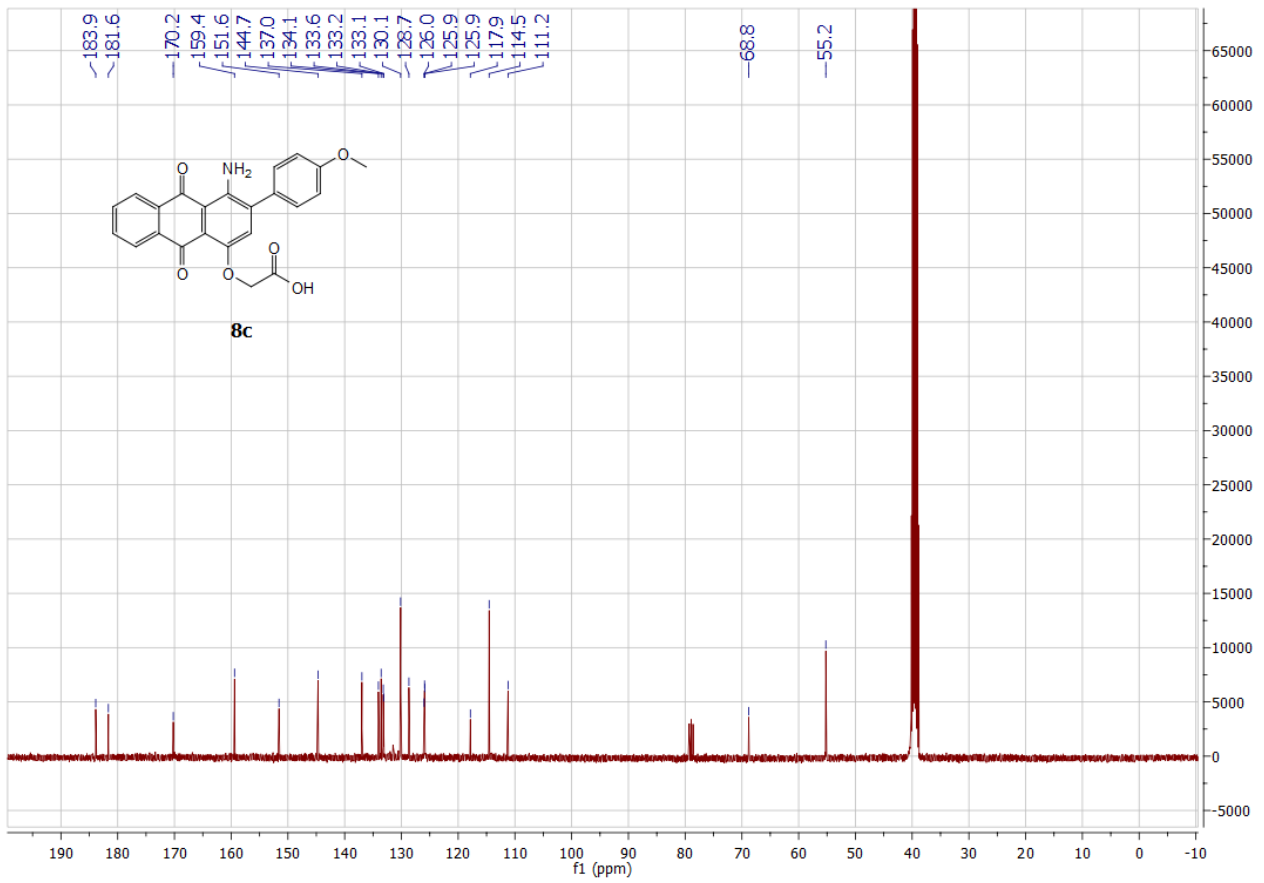


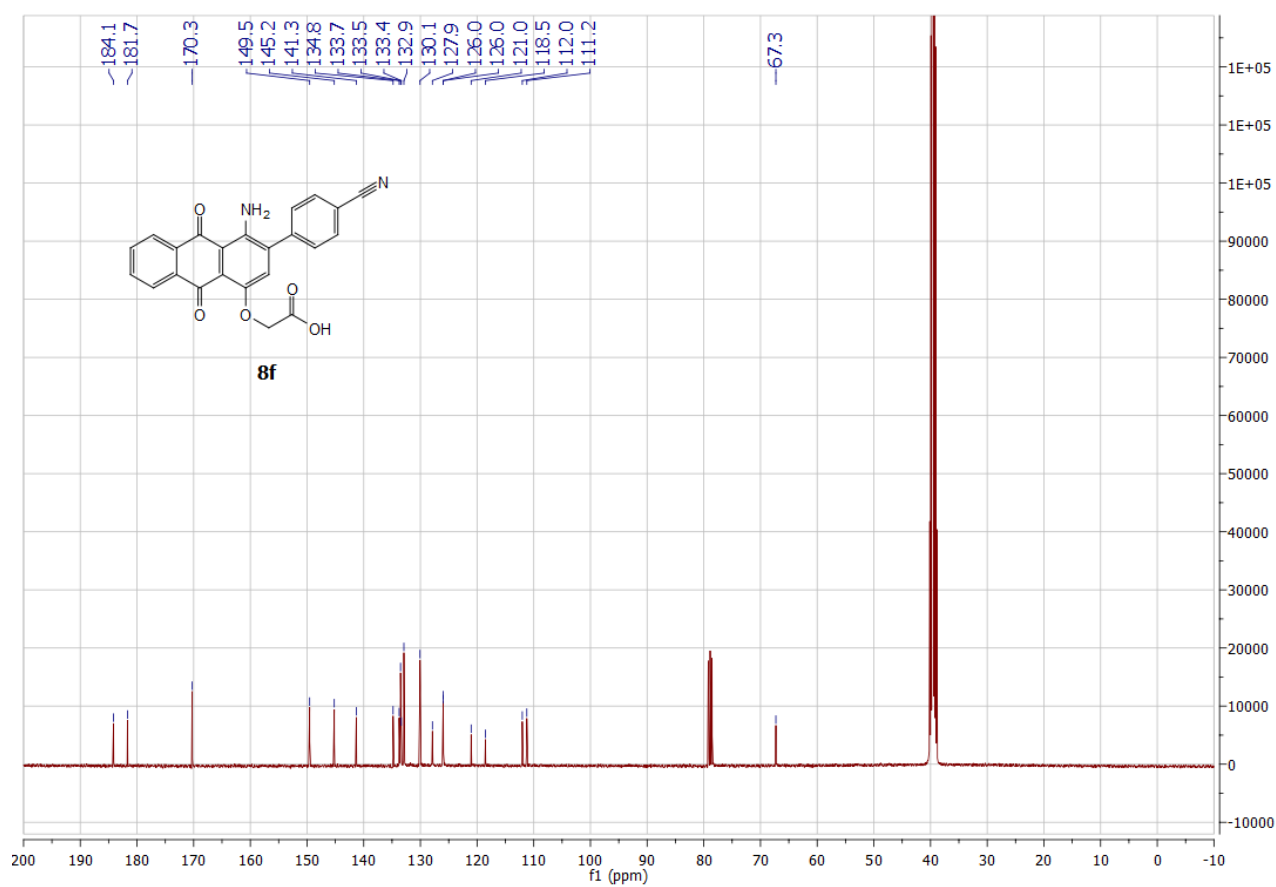
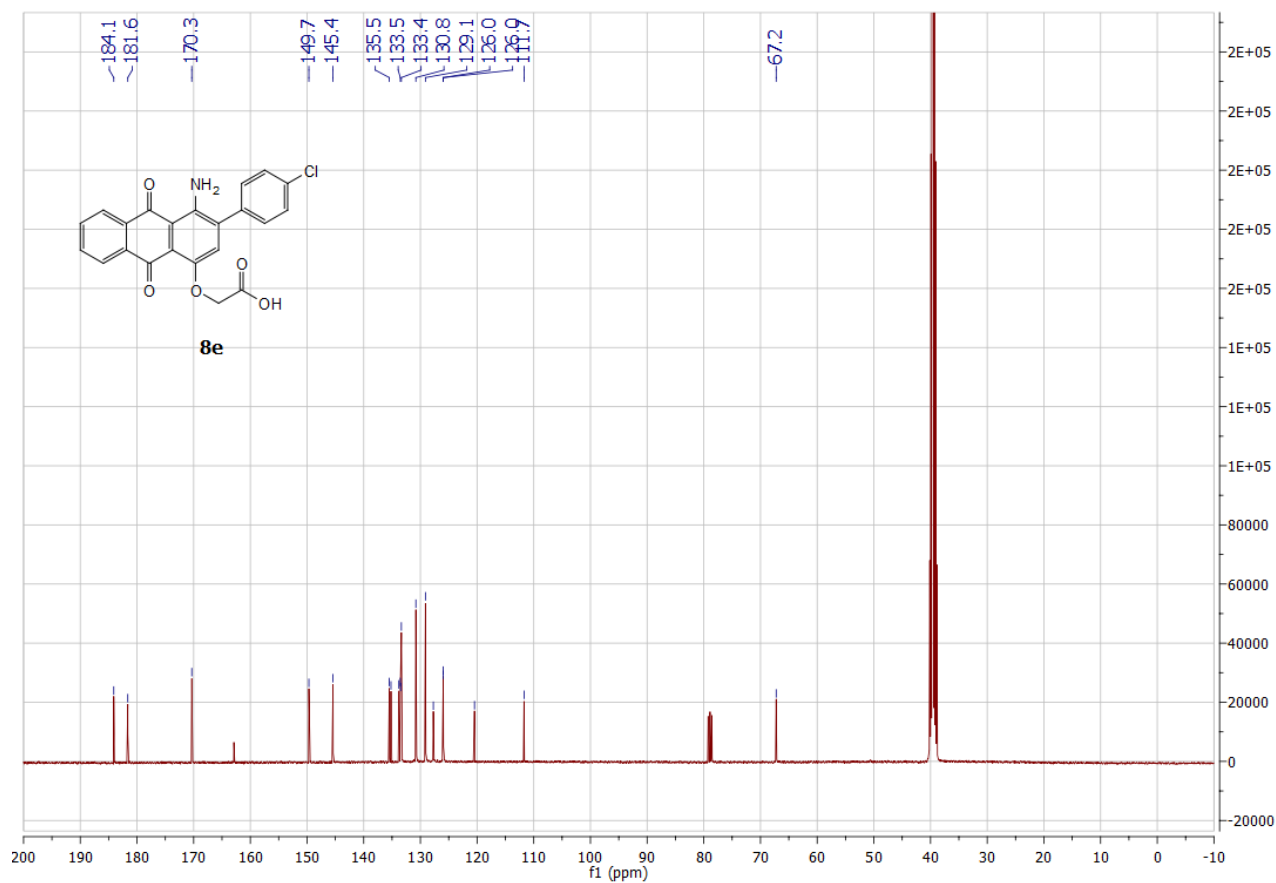


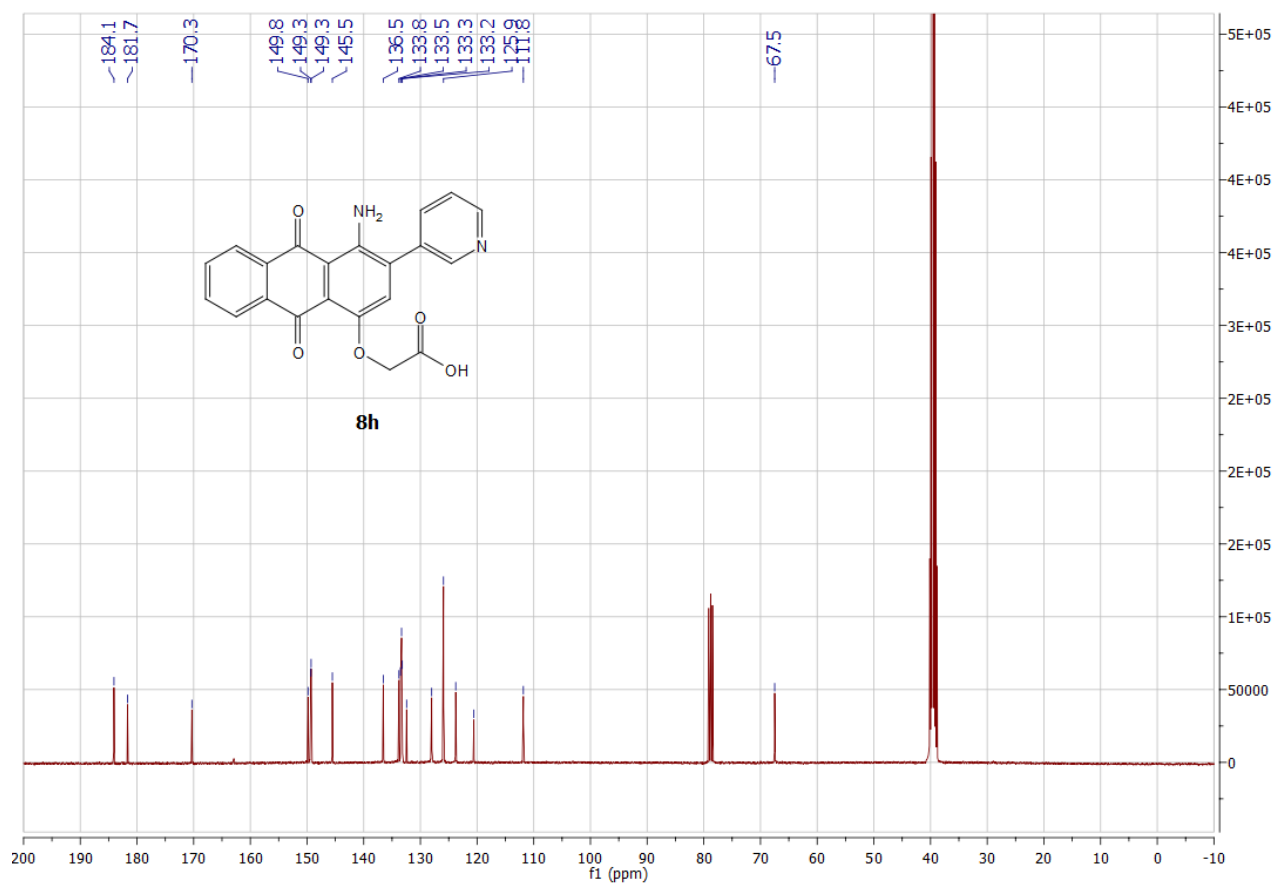
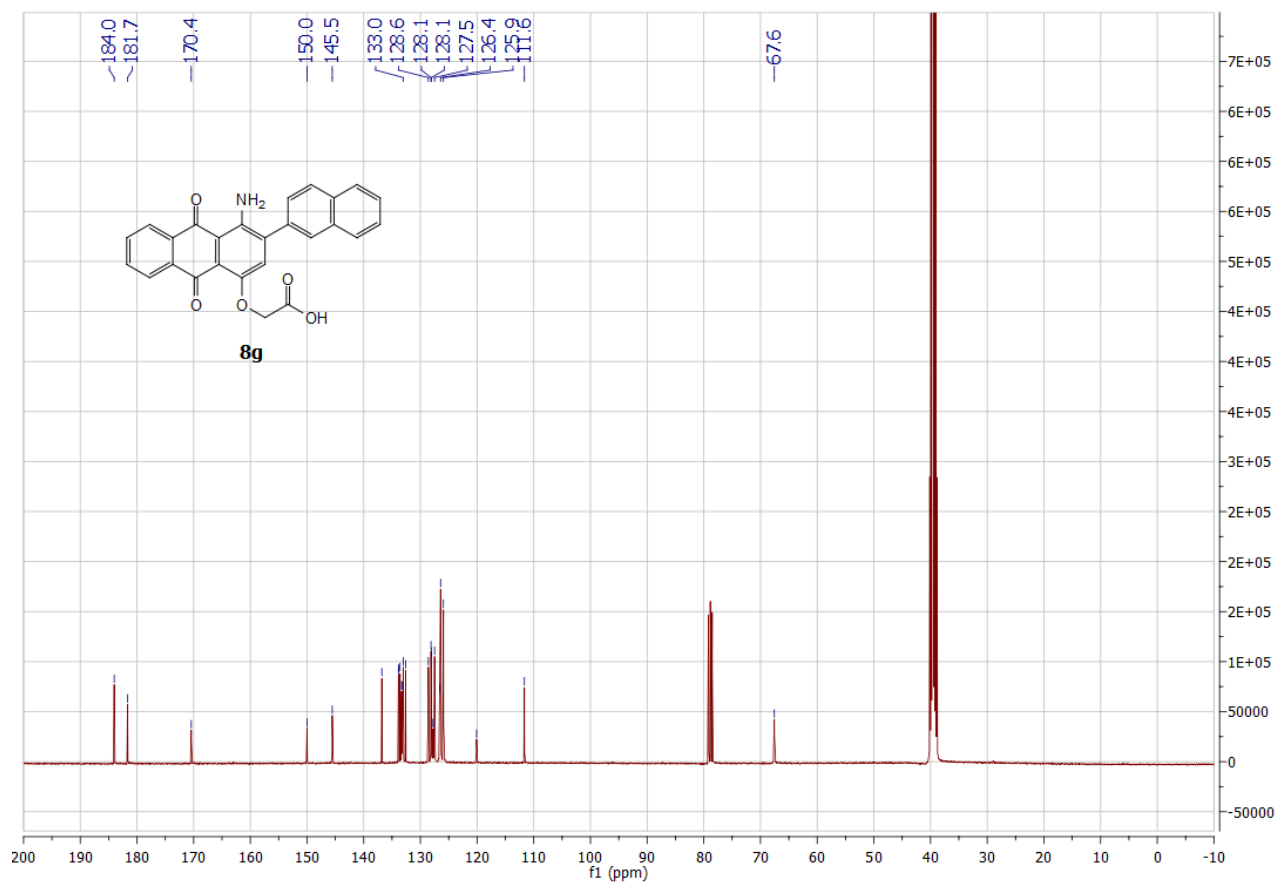


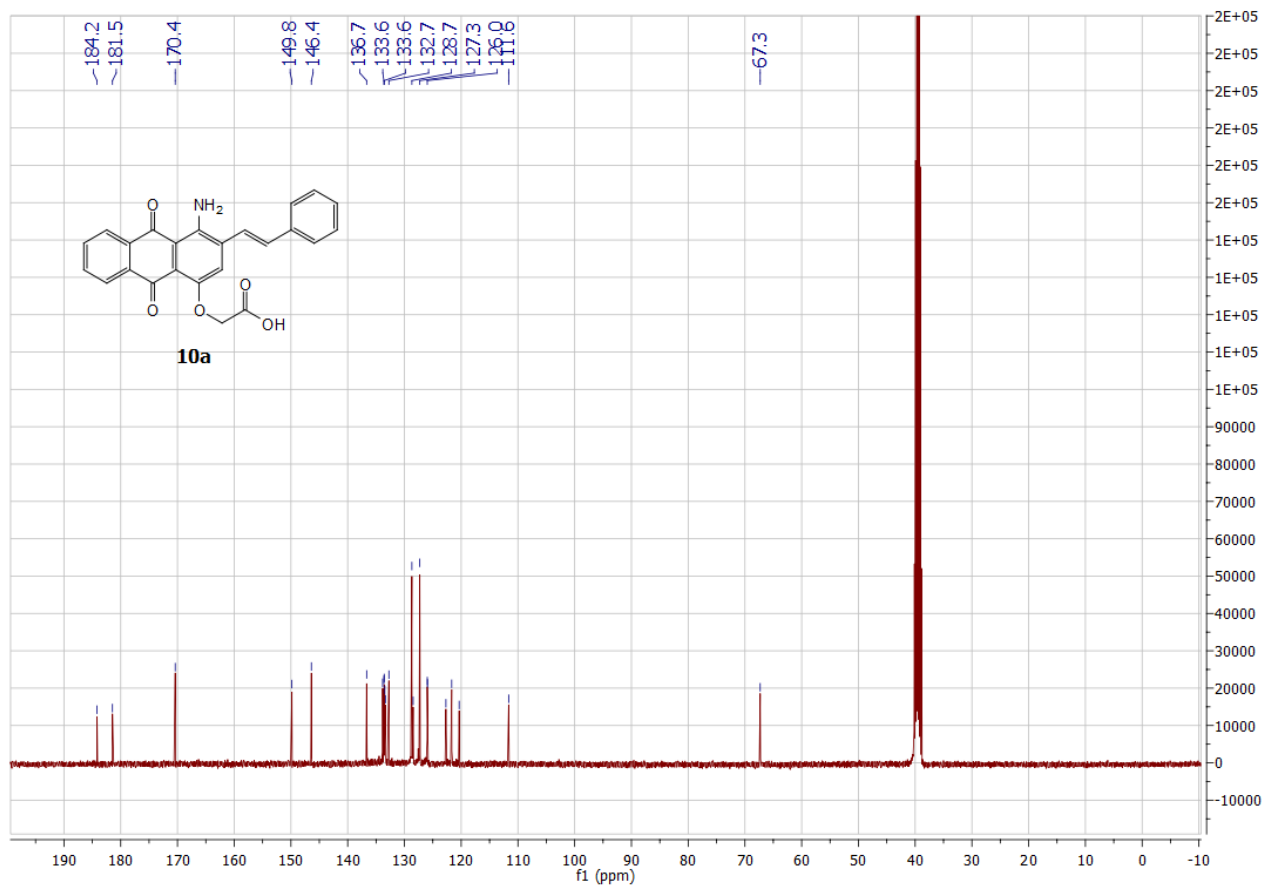
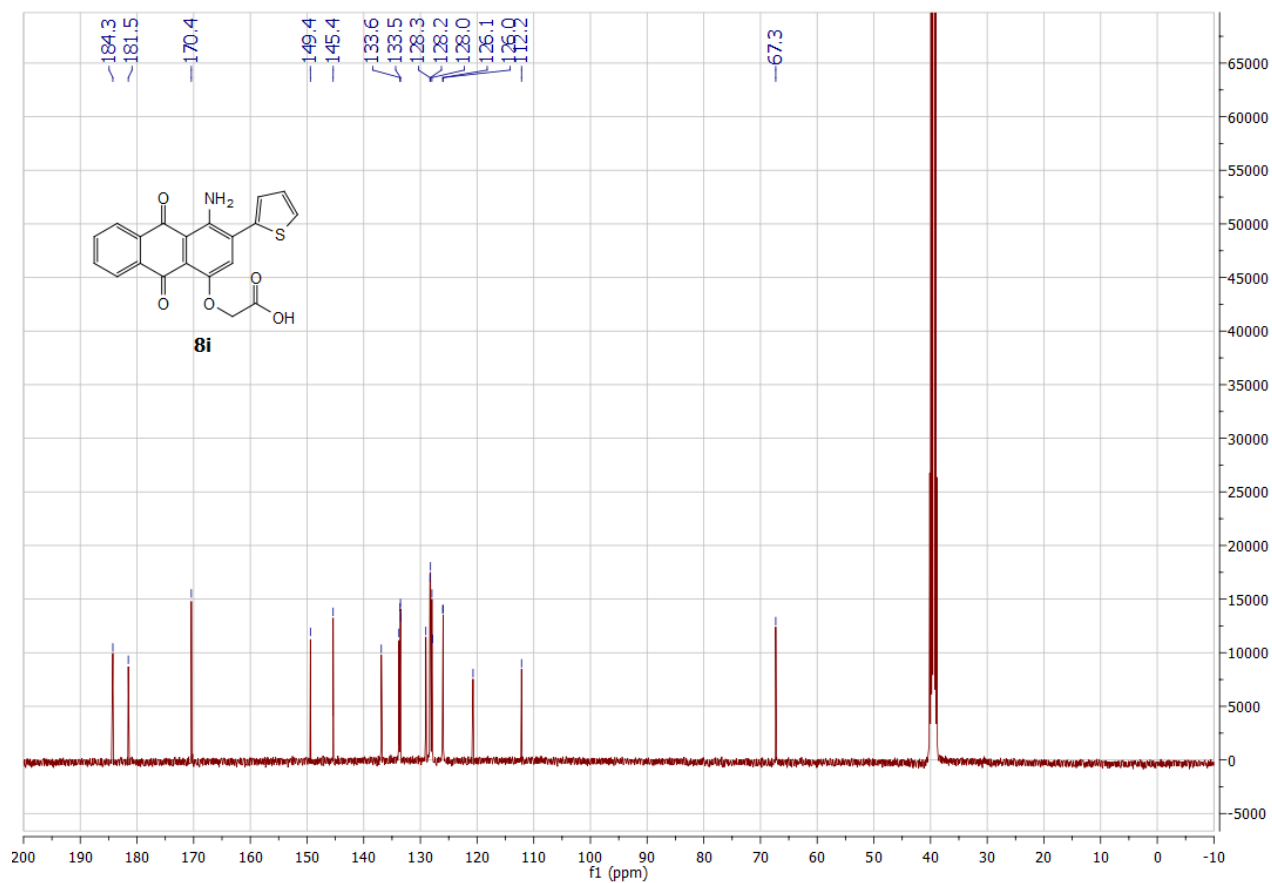
¹³C-NMR

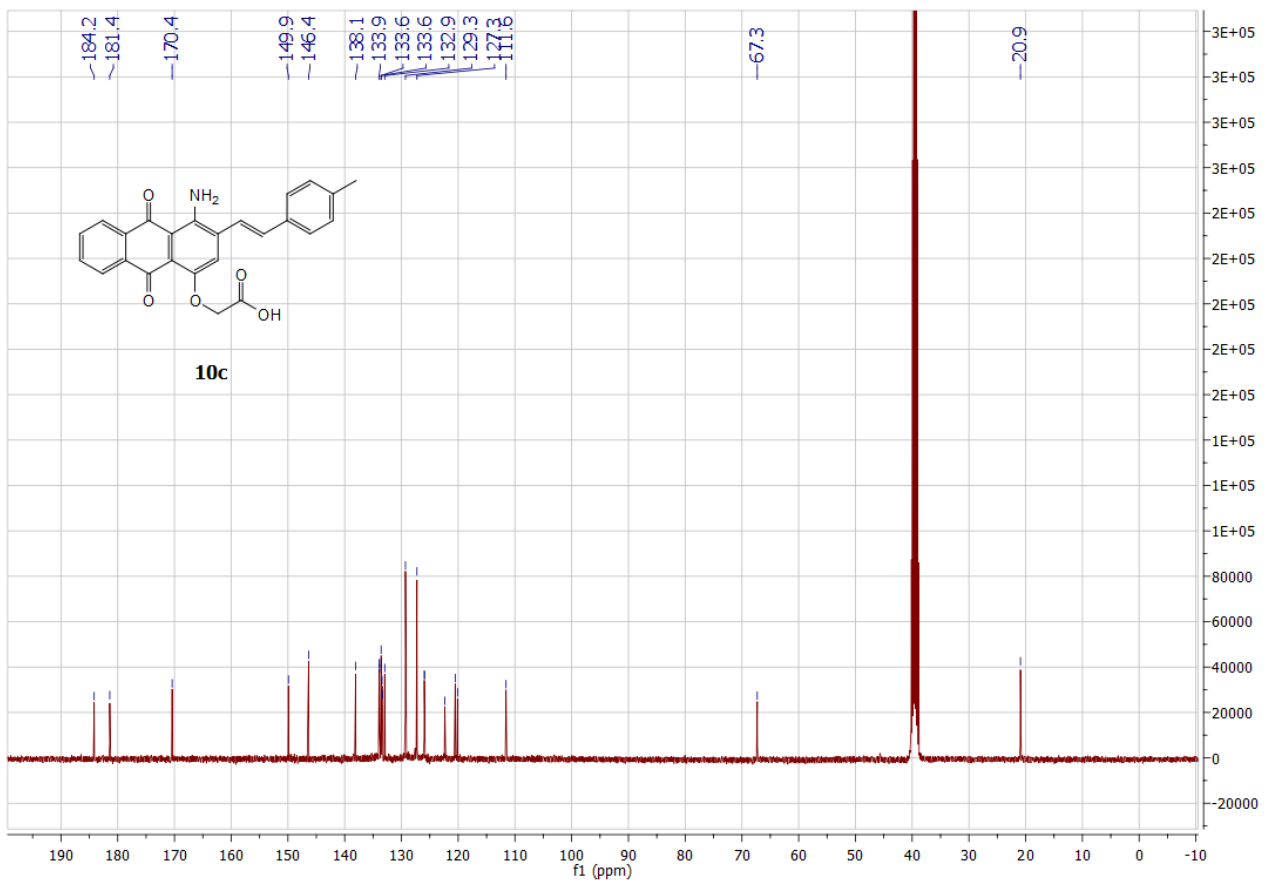
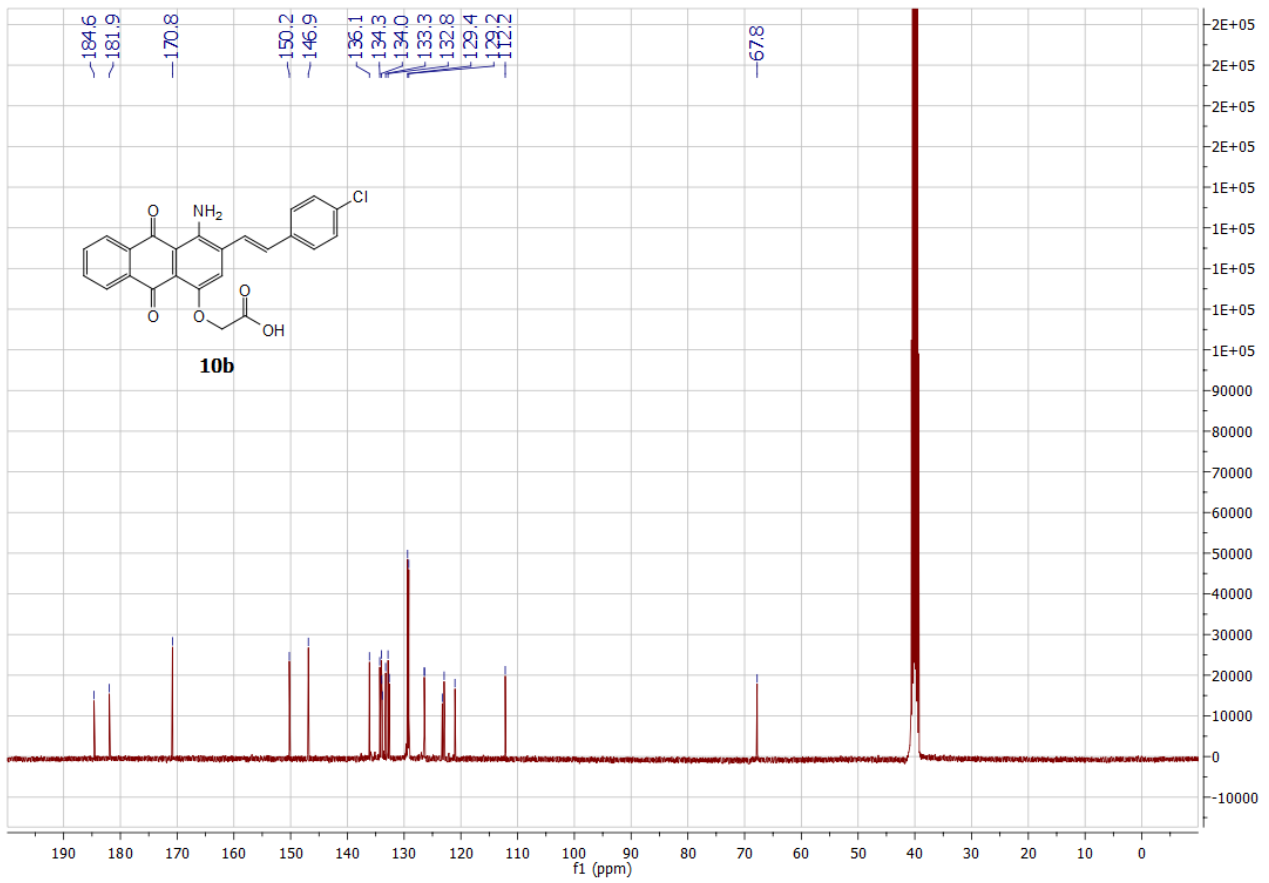


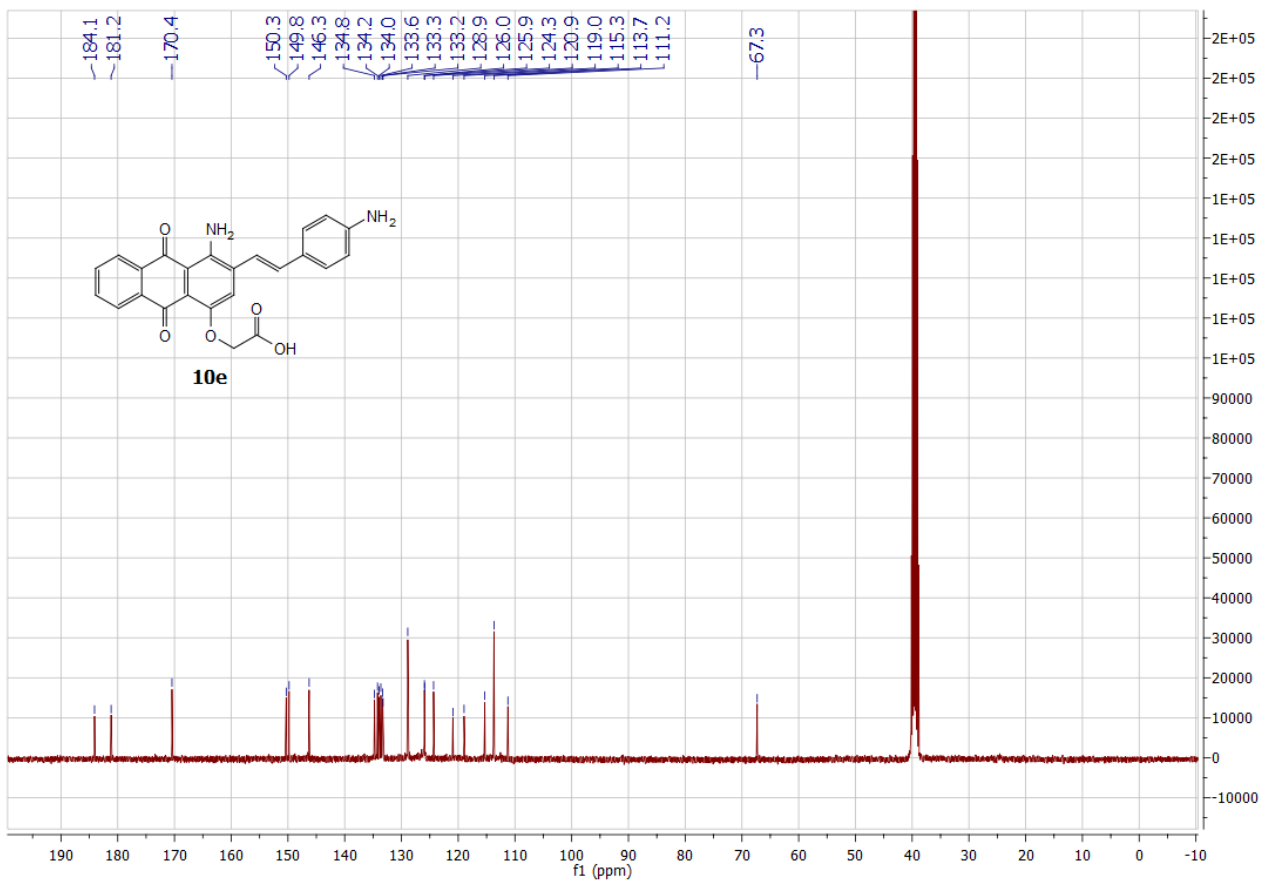
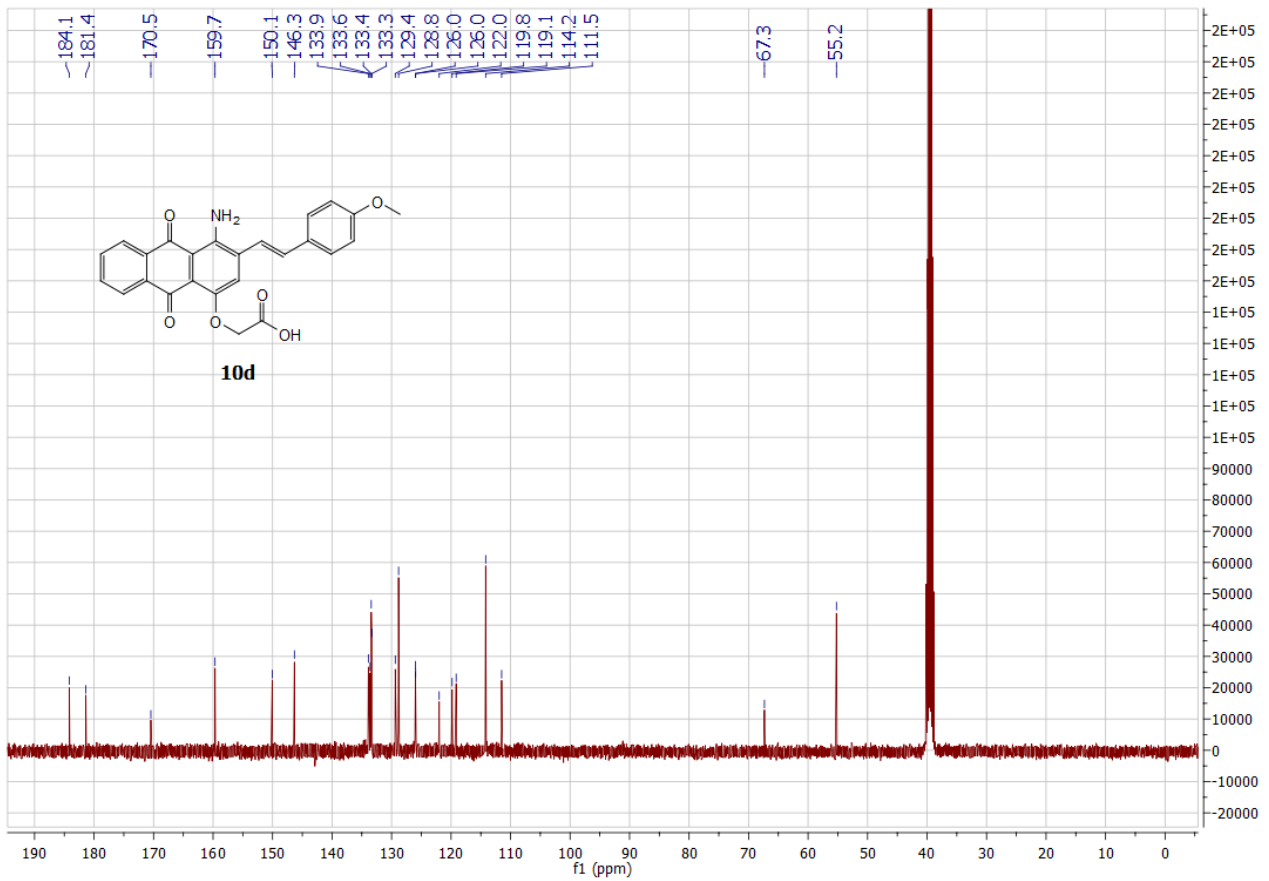


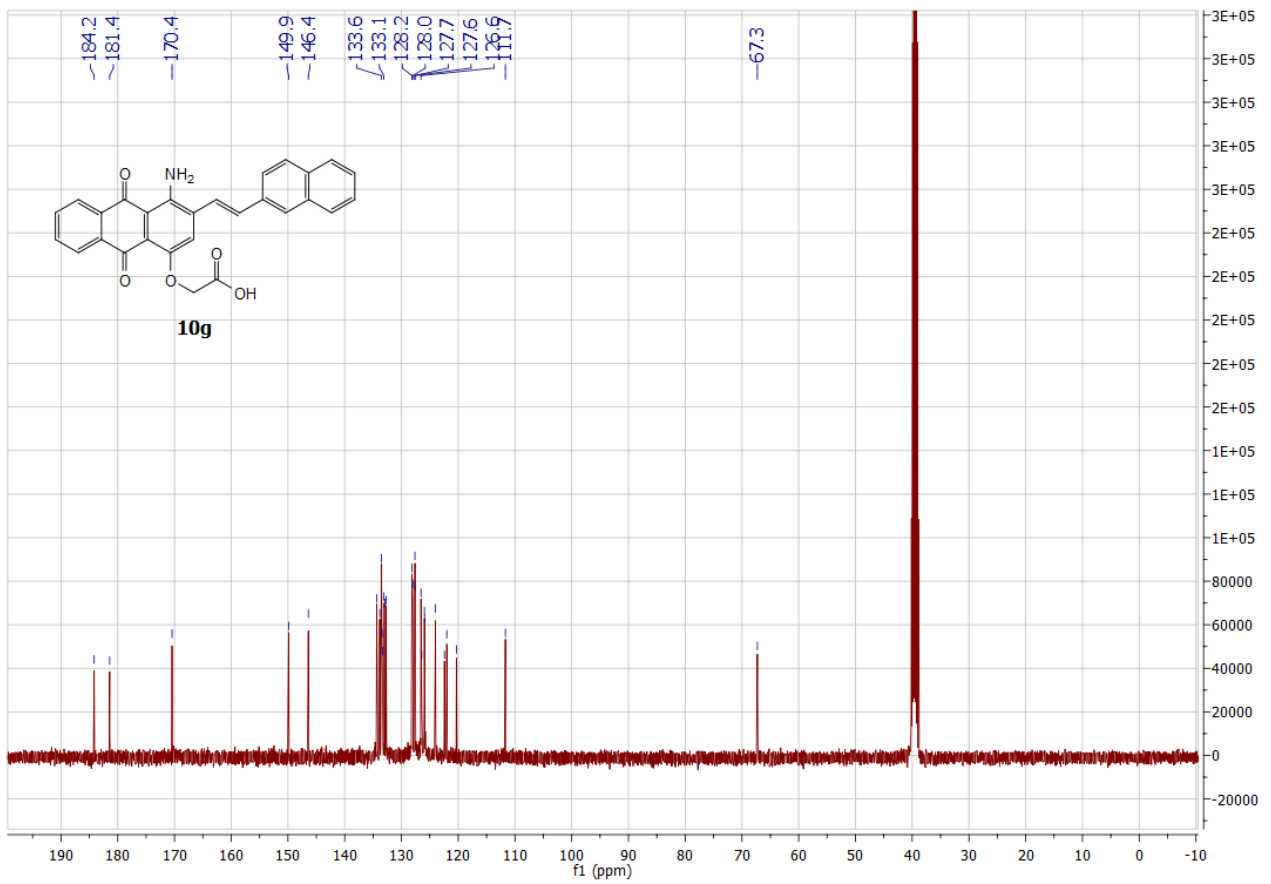
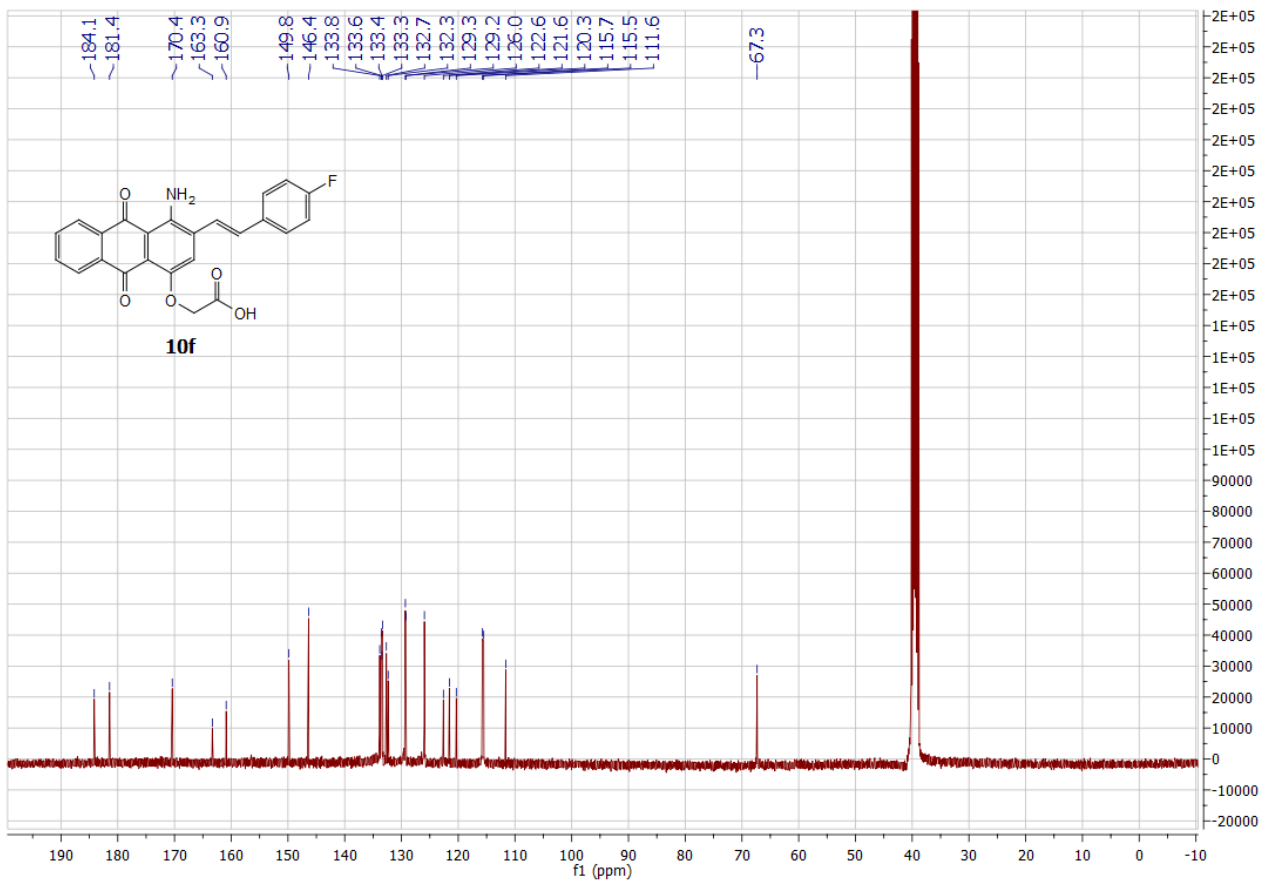


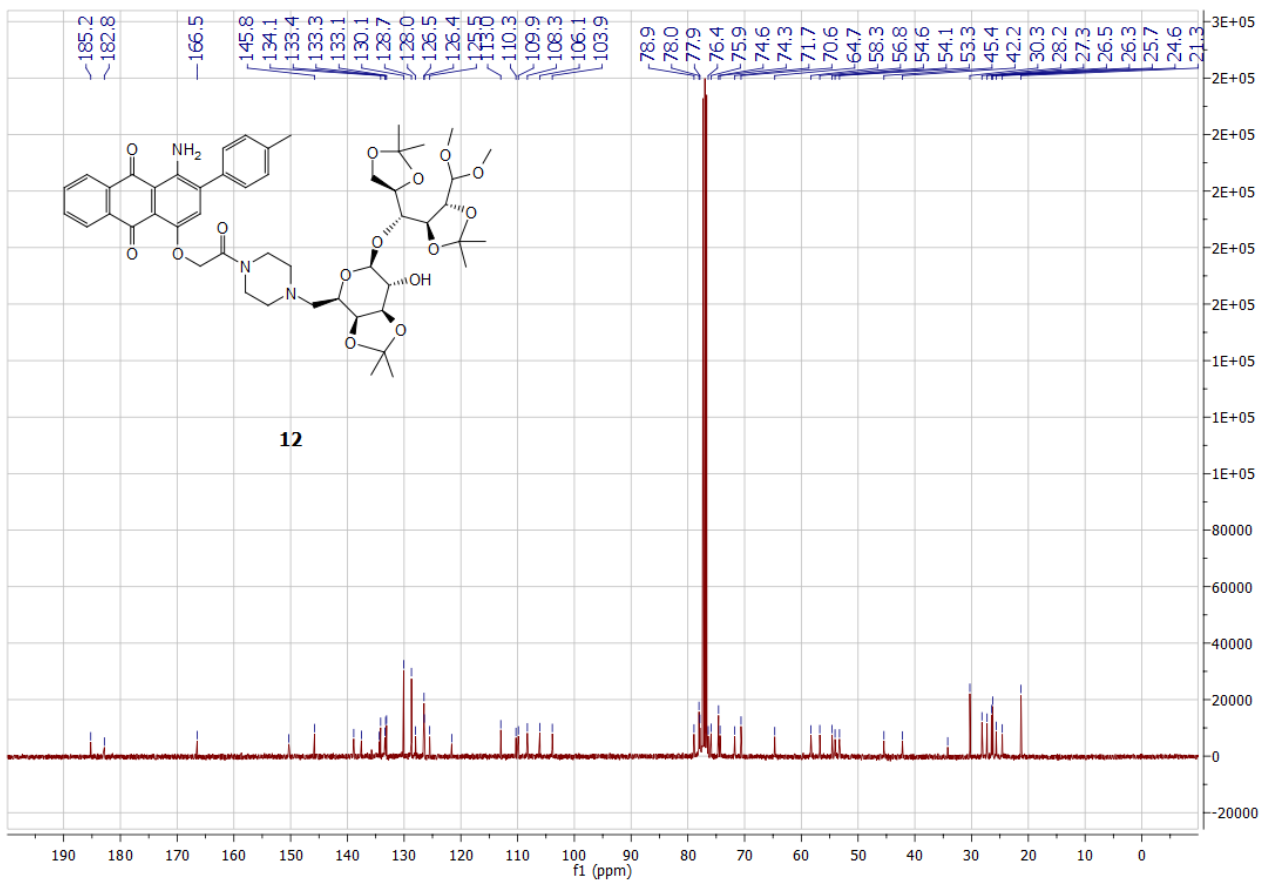
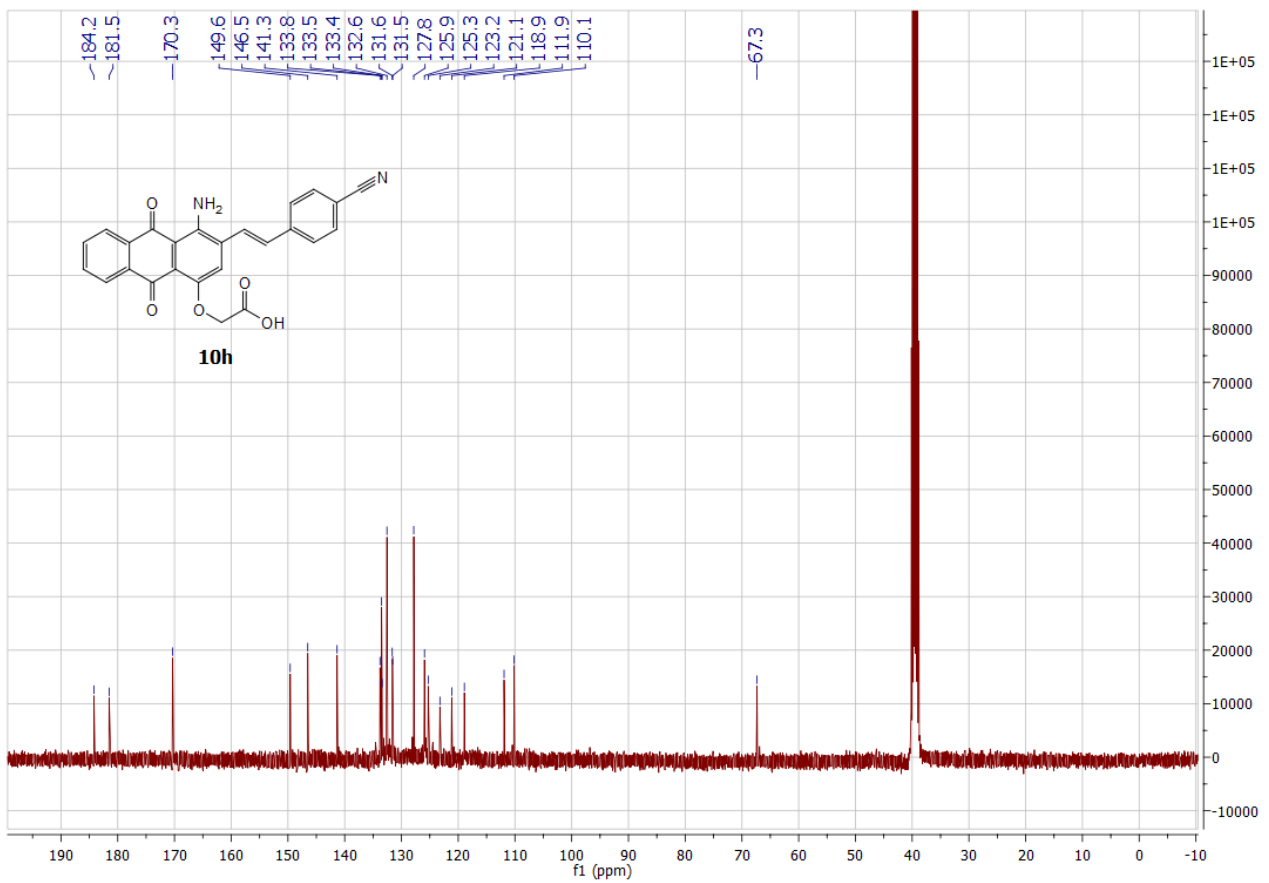


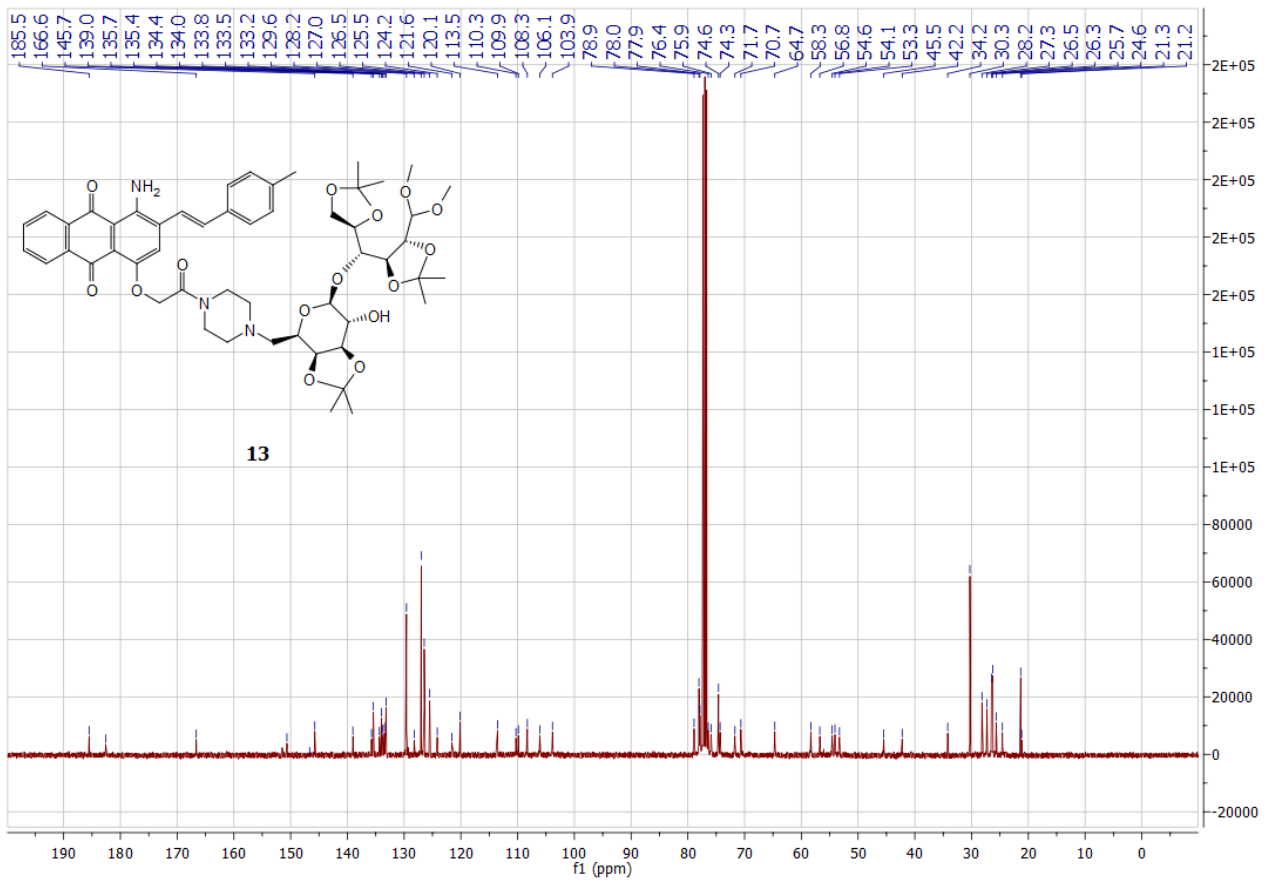












Absorption Visible Spectra

All the UV spectra were recorded on a Varian Cary 400 using optical glass 1 cm cuvettes. Samples **8a-i**, **10a-h** and **12-13** were prepared dissolving about 2 mg of product in 20 mL THF. Sample **14** was prepared dissolving about 2 mg of product in water.

