Electronic supplementary information (ESI)

Antiviral Mechanism Study of Gossypol and Its Schiff's Bases Derivatives Based on Reactive Oxygen Species (ROS)

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Contents:

1. Analyze of the H_2O_2 and $O_2^{\cdot-}$

The most important thing for H_2O_2 or $O_2^{\cdot-}$determination was to find the suited standard curve of each compound.

$$NH_2OH + 2O_2^{\cdot-} + H^+ \longrightarrow NO_2^- + H_2O_2 + H_2O$$

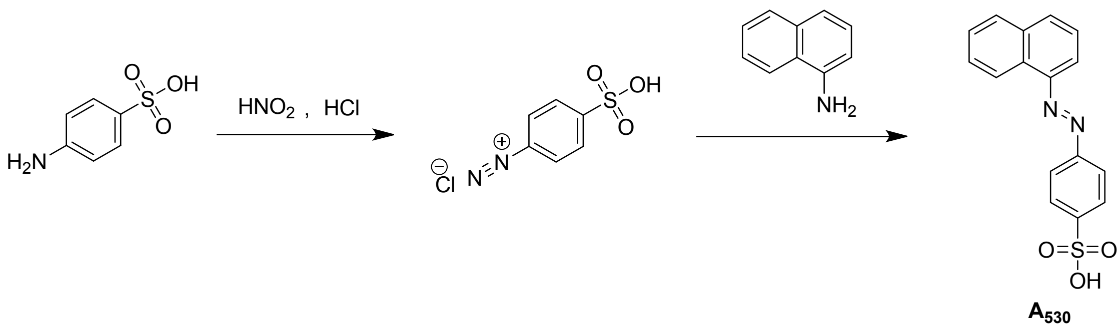


Figure 1. The mechanism of $O_2^{\cdot-}$ detection.

The mechanism for the measurement of $O_2^{\cdot-}$ is shown above. The concentration of $O_2^{\cdot-}$ can be converted to $NaNO_2$ by the equation (1).

$$(1) \quad c(O_2^{\cdot-}) = c(NaNO_2) \times 2$$

The corresponding $NaNO_2$ values can be obtained by plotting against a standard curve of $NaNO_2$. As we can see in below, the equation (2) reflect the standard curve of $NaNO_2$ solution.

$$(2) \quad A_{530} = c(NaNO_2) \times D + E$$

In this equation, $\mathbf{A_{530}}$ stand for the 530 nm absorbance data, and *c(NaNO₂)* stand for the concentration of $NaNO_2$. The constant **E** was the absorbance of blank sample (*c*($NaNO_2$) = 0), which is a background of this method, and **D** was related to its the sensitivity.

In theory, different gossypol schiff's bases may have different $\mathbf{A_{530}}$ at the same time, and the same gossypol schiff's base could have different $\mathbf{A_{530}}$ at different time. To make the equation more reasonable, we add a constant **F**, which represents the $\mathbf{A_{530}}$ of gossypol schiff's bases, to the equation (2). On the base of this, the equation (2) could be transfer to (3). For example, the equation suited for compound 11 (t = 1hr, 25 °C) could be obtain by adding a constant C ($\mathbf{A_{530}}$ = 0.029) to the standard curve of $NaNO_2$.

$$(3) \qquad A_{530} = c(NaNO_2) \times D + E + F$$

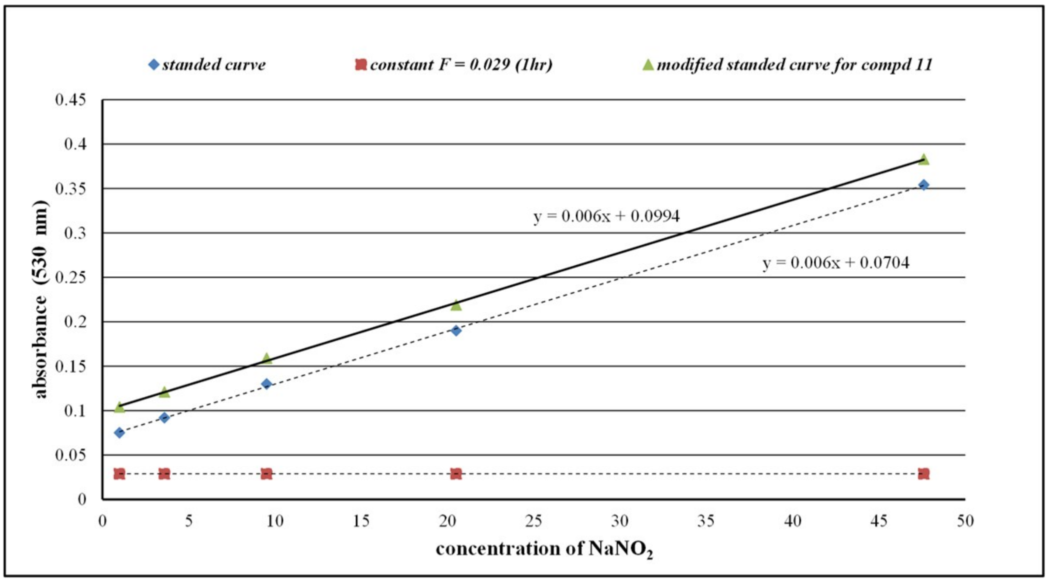


Figure 2. The modified curve of compound 11 (T= 1hr, 25 °C) was obtain by adding a constant **F** (A_{530} = 0.029) to the stand curve of $NaNO_2$.

Because the $O_2^{\cdot -}$ can exit in water in a very short time, the results were the sum of $O_2^{\cdot -}$ in certain period. The equation of the $O_2^{\cdot -}$ production rate could be describe as equation (5).

$$(4)\ \ c\,(O_2^{\cdot -}) = \frac{(A_{530} - E - F) \times 2}{D}$$

$$(5)\ \ rate\,(O_2^{\cdot -}) = \frac{(A_{530} - E - F) \times 2}{D \times T} \quad (T < 20\ \text{min})$$

The H_2O_2 concentration were measured by the equation (6).

$$(6)\ \ c(H_2O_2) = \frac{A_{560} - B - C}{A}$$

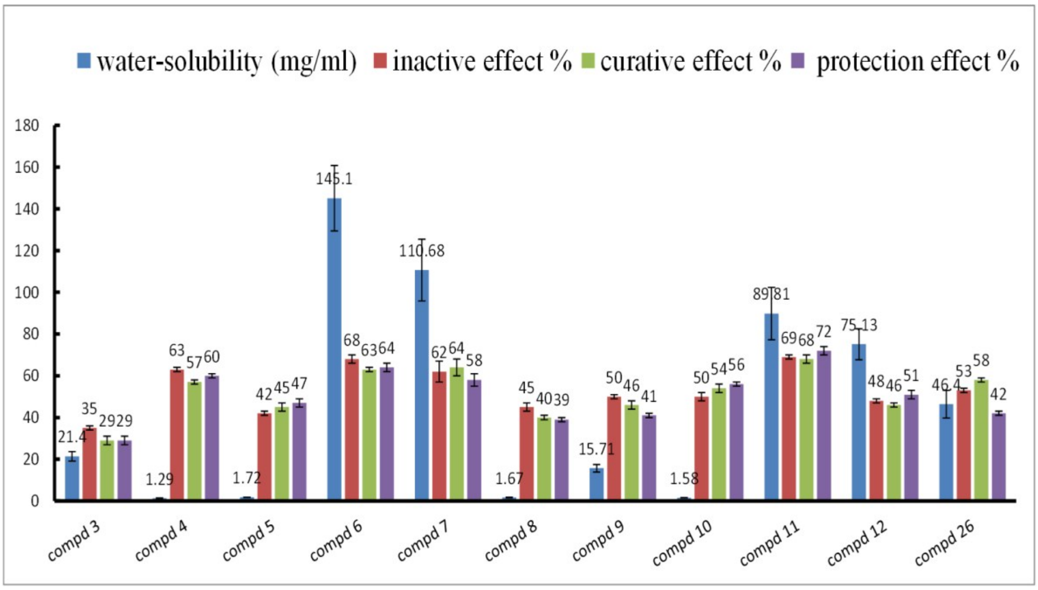
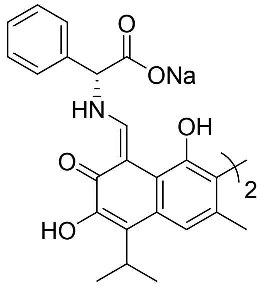
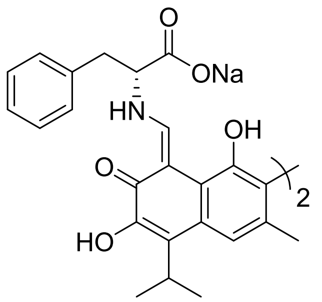


Figure 3. The water-solubility of compound **3-12**, **26 (**at 25 °C) and their anti-TMV activity.

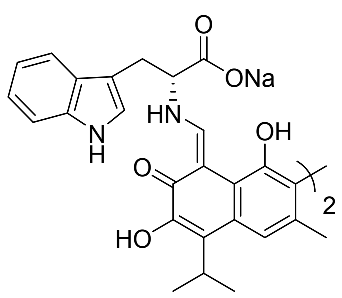
2. Data for key compounds (^{1}H NMR, ^{13}C NMR and HRMS)



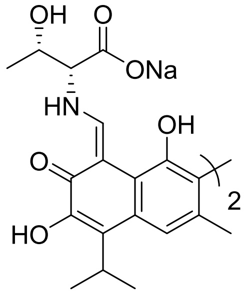
Data for **3**, yellow solid; yield, 53%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.64 (s, 2H), 9.67 (s, 2H), 8.60(s, 2H), 7.35−7.22 (m, 12H), 4.86 (s, 2H), 3.66(s, 2H), 1.83 (s, 6H), 1.42 (s,12H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 171.8, 170.4, 162.3, 160.5, 146.6, 142.0,135.5, 131.3, 129.2, 128.8, 128.6, 128.4, 127.4, 127.3, 126.5, 116.9, 104.3, 68.7, 64.4, 27.0, 20.9. HRMS(ESI) m/z calcd for $C_{46}H_{43}N_2O_{10}$ $(M-2Na+H)^-$ 783.29, found 783.29.



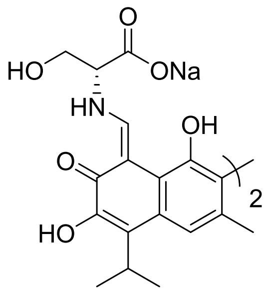
Data for **4**, yellow solid, moisture absorption easily; yield, 72%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.19 (m, 2H), 9.62 (d,J=12.3Hz, 1H), 9.50 (d, J=12.3Hz, 1H), 8.45 (s, 2H), 7.38−7.09 (m, 14H), 3.96 (s, 2H), 3.68 (m, 2H), 3.09−2.85 (m, 4H), 1.92-1.89 (d, J=13.6H, 6H), 1.43 (t, J=5.6Hz, 12H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 171.5, 170.9, 160.5, 149.9, 146.4, 138.1, 130.7, 129.4, 128.1, 126.5, 126.0, 125.5, 120.5, 116.3, 116.1, 103.0, 65.9, 36.9, 26.4, 20.3. HRMS(ESI) m/z calcd for $C_{48}H_{47}N_2O_{10}$ $(M-2Na+H)^-$ 811.32, found 811.32.



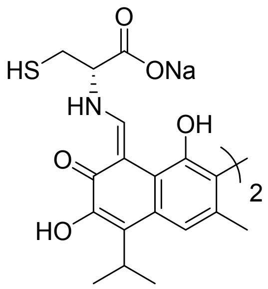
Data for **5**, yellow solid, moisture absorption easily; yield, 43%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.28-13.19 (m, 2H), 10.91 (s, 1H), 10.75 (s, 1H), 9.63 (s, 1H), 9.44 (s, 1H), 8.47 (s, 2H), 7.53−6.84 (m, 12H), 4.04 (s, 2H), 3.66 (m, 2H), 3.15-3.06 (m, 4H), 1.88 (d, J=8Hz, 6H), 1.42 (s, 12H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 172.3, 171.1, 161.1, 146.9, 136.6, 131.0, 127.8, 127.0, 125.7, 124.4, 124.2, 121.0, 118.8, 118.6, 116.6, 111.6, 110.7, 103.27, 65.3, 55.1, 31.2, 26.9, 20.9. HRMS(ESI) m/z calcd for $C_{52}H_{49}N_4O_{10}$ $(M{-}2Na{+}H)^-$ 889.34, found 889.34.



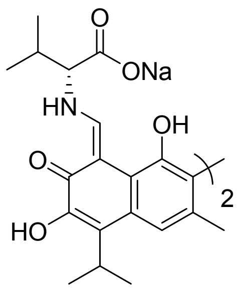
Data for **6**, yellow solid, moisture absorption easily; yield, 39%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.16 (s, 2H), 9.69-9.65 (m, 2H), 8.51 (s, 2H), 7.40-7.39 (m, 2H), 3.89-3.88 (m, 2H), 3.68-3.62 (m, 4H), 1.92 (s, 6H), 1.43–1.41 (m, 12H), 1.05–1.02 (m, 6H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 172.0, 171.3, 161.7, 151.8, 146.7, 131.2, 126.8, 126.2, 122.7, 117.1, 115.9, 103.9, 70.1, 67.7, 55.5, 27.0, 22.7, 20.9, 20.2. HRMS(ESI) m/z calcd for $C_{38}H_{43}N_2O_{12}$ $(M{-}2Na{+}H)^-$ 719.28, found 719.28.



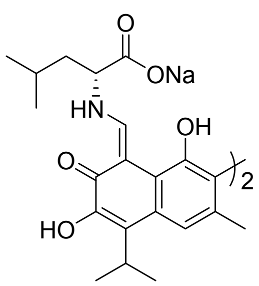
Data for **7**, yellow solid, moisture absorption easily; yield, 67%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.25 (s, 2H), 9.75 (dd, J = 21.3, 12.8 Hz, 2H), 8.52 (s, 2H), 7.39 (d, J = 6.1 Hz, 2H), 3.81 – 3.51 (m, 10H), 1.91 (d, J =10.8Hz, 6H), 1.43-1.42 (m, 12H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 170.8, 169.8, 161.0, 149.9, 146.4, 130.6, 126.5, 125.4, 120.2, 116.5, 116.1, 103.2, 66.4, 63.8, 60.7, 26.4, 20.4, 20.2. HRMS(ESI) m/z calcd for $C_{36}H_{39}N_2O_{12}$ $(M{-}2Na{+}H)^-$ 691.24, found 691.24.



Data for **8**, yellow solid; yield, 86%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.25 (s, 2H), 9.74 (s, 2H), 8.47 (s, 2H), 7.37 (d, J = 12.0 Hz, 2H), 4.18-4.09 (m, 2H), 3.80–3.78 (m, 4H), 3.00-2.90 (m, 2H), 1.88 (t, J = 8.0 Hz, 6H), 1.42-1.38 (m, 12H), 0.83 (s, 2H).

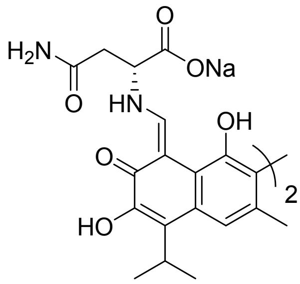


Data for **9**, yellow solid; yield, 86%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.20 (s, 2H), 9.68 (d, J = 12.5 Hz, 2H), 8.52 (s, 2H), 7.39 (s, 2H), 3.68 (m, 2H), 3.51 (s, 2H), 2.21 (m, 2H), 1.92 (s, 6H), 1.43 (t, J = 6.6 Hz, 12H), 0.88-0.84 (m,12H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 172.4, 171.4, 161.3, 150.7, 146.9, 131.1, 126.9, 126.1, 121.3, 117.0, 116.6, 103.5, 71.2, 32.1, 27.0, 20.9, 20.1, 17.7. HRMS(ESI) m/z calcd for $C_{40}H_{47}N_2O_{10}$ $(M{-}2Na{+}H)^+$ 715.32, found 715.32.

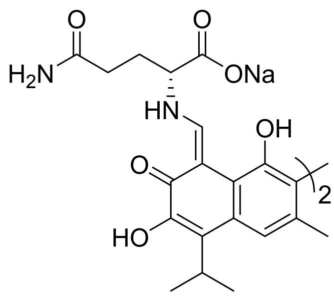


Data for **10**, yellow solid, moisture absorption easily; yield, 82%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.27 (s, 2H), 9.77 (s, 2H), 8.51 (s, 2H), 7.39 (s, 2H), 3.77 (s, 2H), 3.69 (s, 2H), 1.92 (s, 6H), 1.65-1.57 (m, 6H), 1.43 (s, 12H), 0.86 (s, 12H); ^{13}C NMR (100

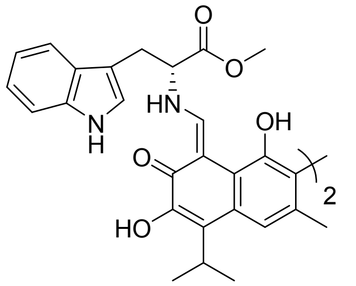
MHz, DMSO-d6), δ 172.9, 171.3, 160.9, 151.0, 146.9, 131.3, 127.0, 126.1, 121.9, 117.3, 116.6, 103.6, 64.0, 43.8, 26.9, 24.6, 23.6, 22.13, 20.8. HRMS(ESI) m/z calcd for $C_{42}H_{51}N_2O_{10}$ $(M-2Na+H)^+$ 743.35, found 743.35.



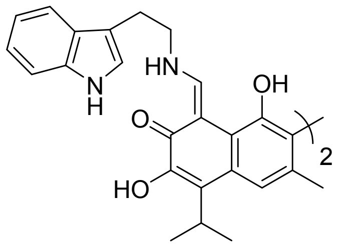
Data for **11**, yellow solid,moisture absorption easily; yield, 43%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.22 (s, 2H), 9.71 (s, 2H), 8.47 (s, 2H), 7.56 (s, 2H), 7.37 (s, 2H), 6.86 (d, *J* = 32.5 Hz, 2H), 4.05 (m, 2H), 3.69 – 3.66 (m, 2H), 2.75-2.71 (m, 2H), 2.44-2.38 (m, 2H), 1.92 (d, *J* = 12 Hz 6H), 1.43 (t, *J* = 6.0 Hz, 12H). ^{13}C NMR (100 MHz, DMSO-d_6), δ 172.0, 171.8, 170.7, 161.1, 151.2, 146.5, 130.6, 126.4, 125.5, 120.7, 116.4, 115.8, 103.0, 61.3 54.8, 26.4, 21.8, 20.3, 20.2. HRMS(ESI) m/z calcd for $C_{38}H_{43}N_4O_{12}$ $(M-2Na+3H)^+$ 747.28, found 747.28.



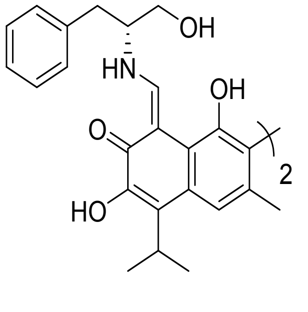
Data for **12**, yellow solid, moisture absorption easily; yield, 42%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.22 (s, 2H), 9.74 (s, 2H), 8.48 (s, 2H), 7.38 (d, *J* = 10.4 Hz, 4H), 6.89 (s, 2H), 3.78–3.68 (m, 4H), 2.09–1.92 (m, 14H), 1.45–1.42 (m, 6H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 174.3, 172.3, 171.4, 160.5, 151.0, 146.9, 131.2, 127.0, 126.1, 121.0 116.9, 109.9, 103.6, 64.5, 64.3, 56.49, 31.8, 30.8, 27.0, 20.9, 20.7. HRMS(ESI) m/z calcd for $C_{40}H_{45}N_4O_{12}$ $(M-2Na+3H)^+$ 775.31, found 775.31.



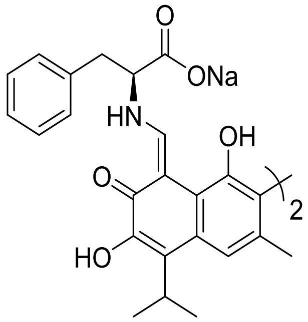
Data for **13**, yellow solid; yield, 71%; ^{1}H NMR (400 MHz, DMSO-d$_6$), δ 13.50-13.44 (m, 2H), 10.93 (d, J = 1.8 Hz, 2H), 9.76 (d, J = 12.5 Hz, 1H), 9.65 (d, J = 12.5 Hz, 1H), 8.45 (s, 2H), 7.84 (s, 1H), 7.61 (s, 1H), 7.47 – 6.92 (m, 12H), 4.78 (s, 6.3 Hz, 2H), 3.67 (s, 8H), 3.43 (s, 4H), 1.92 (s, 6H), 1.42 (d, J = 6.7 Hz, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.4, 170.5, 161.7, 148.8, 147.1, 136.3, 131.8, 129.1, 127.7, 126.8, 124.2, 122.2, 119.8, 118.3, 115.7, 114.5, 111.2, 108.9, 103.5, 62.8, 62.33, 53.0, 30.4, 27.4, 20.3, 19.9.



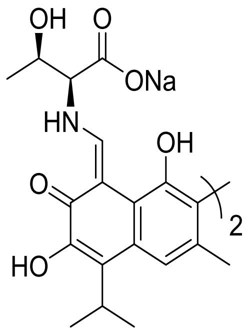
Data for **14**, yellow solid; yield, 71%; ^{1}H NMR (400 MHz, DMSO-d$_6$), δ 13.26–13.23 (m, 2H), 10.89 (s, 2H), 9.81 (d, J = 12.4 Hz, 2H), 8.40 (s, 2H), 7.78 (brs, 2H),7.59(d, 2H), 7.44 (s, 2H), 7.33 (d, J = 7.9 Hz, 2H), 7.21 (s, 2H), 7.05 (t, J = 7.4 Hz, 2H), 6.96 (t, J = 7.4Hz, 2H), 3.84–3.69 (m, 6H), 3.09 (t, J = 6.4 Hz, 4H), 1.94 (s, 6H), 1.45 (t, J = 5.7 Hz, 12H). ^{13}C NMR (100 MHz, DMSO--d$_6$), δ 172.2, 162.8, 150.5, 146.7, 136.8, 131.6, 127.4, 126.8, 123.7, 121.5, 120.8, 118.8, 116.8, 116.4, 111.9, 110.8, 103.7, 51.0, 27.0, 26.8, 20.9, 20.7. HRMS(ESI) m/z calcd for $C_{50}H_{49}N_4O_6$ $(M-H)^+$ 801.37, found 801.36.



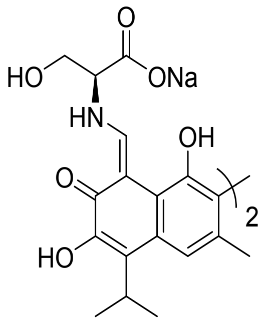
Data for **15**, yellow solid; yield, 76%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.48–13.43 (m, 2H), 9.73 (d, *J* = 12.8 Hz, 2H), 8.42 (s, 2H), 7.72 (s, 2H), 7.54–7.12 (m, 12H), 5.20 (s, 2H), 3.70-3.51 (m, 8H), 3.02-2.88 (m, 4H), 1.91 (s, 6H), 1.39 (m, 12H); ^{13}C NMR (101 MHz, DMSO-d_6), δ 172.2, 162.5, 150.01, 146.7, 138.1 , 131.6, 129.7, 128.9, 127.3, 126.9, 120.4, 117.0, 116.2, 103.7, 64.4, 63.7, 37.7, 27.0, 20.8, 20.7. HRMS(ESI) m/z calcd for $C_{48}H_{51}N_2O_8$ $(M-H)^+$ 783.37, found 783.36.



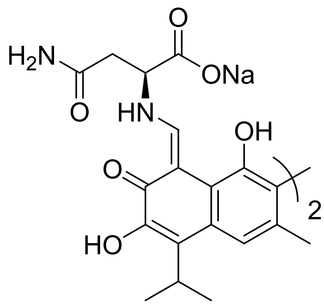
Data for **16**, yellow solid, moisture absorption easily; yield, 70%; ^{1}H NMR (400 MHz,DMSO-d_6), δ 13.16 (m, 2H), 9.62 (d, J=12.3Hz, 1H), 9.58 (d, J=12.3Hz, 1H), 8.46 (s, 2H), 7.38−7.09 (m, 14H), 3.96 (s, 2H), 3.68 (m, 2H), 3.09−2.85 (m, 4H), 1.90-1.87 (d, J = 13.6H, 6H), 1.42 (t, J = 5.6Hz, 12H).



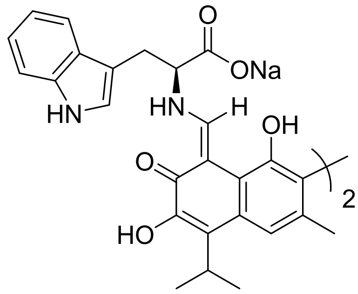
Data for 17, yellow solid, moisture absorption easily; yield, 41%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.12 (s, 2H), 9.73-9.66 (m, 2H), 8.51 (s, 2H), 7.40-7.38 (m, 2H), 3.89-3.88 (m, 2H), 3.68-3.62 (m, 4H), 1.92 (s, 6H), 1.43–1.41 (m, 12H), 1.04–1.00 (m, 6H).



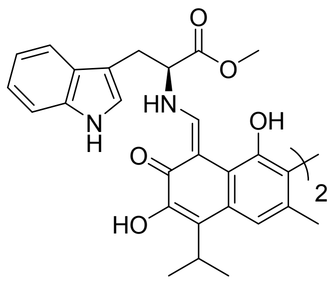
Data for **18**, yellow solid, moisture absorption easily; yield, 71%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.25 (s, 2H), 9.70 (m, 2H), 8.50 (s, 2H), 7.39 (d, J = 6.1 Hz, 2H), 3.76–3.50 (m, 10H), 1.92 (d, J = 10.8Hz, 6H), 1.45-1.42 (m, 12H).



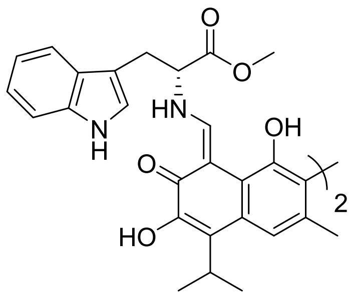
Data for **19**, yellow solid, moisture absorption easily; yield, 46%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.22 (s, 2H), 9.71 (s, 2H), 8.48 (s, 2H), 7.56 (s, 2H), 7.37 (s, 2H), 6.86 (d, J = 32.5 Hz, 2H), 4.05 (m, 2H), 3.71–3.64 (m, 2H), 2.74-2.71 (m, 2H), 2.44-2.38(m, 2H), 1.92 (d, J = 12 Hz 6H), 1.43 (t, J = 6.0 Hz, 12H).



Data for **20**, yellow solid, moisture absorption easily; yield 47%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.28-13.19 (m, 2H), 10.91 (s, 1H), 10.75 (s, 1H), 9.63 (s, 1H), 9.42 (s, 1H), 8.47 (s, 2H), 7.53−6.82 (m, 12H), 4.04 (s, 2H), 3.69-3.63 (m, 2H), 3.39 (m, 2H), 3.16-3.06 (m, 4H), 1.87 (d, J = 8Hz, 6H), 1.42 (s, 12H).



Data for **21**, yellow solid; yield, 71%; ^{1}H NMR (400 MHz, DMSO-d6), δ 13.49-13.44 (s, 2H), 10.93 (s, 2H), 9.76 (d, *J* = 12.5 Hz, 1H), 9.66 (d, *J* = 12.5 Hz, 1H), 8.44 (s, 2H), 7.84 (s, 1H), 7.61 (s, 1H), 7.47–6.91 (m, 12H), 4.81-4.76 (m, 2H), 3.67 (d, J = 4.8 Hz, 8H), 3.43 (s, 4H), 1.92 (d, J = 4.8 Hz, 6H), 1.43 (d, *J* = 6.7 Hz, 12H).



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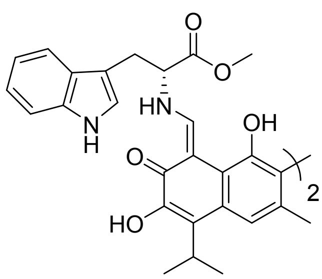
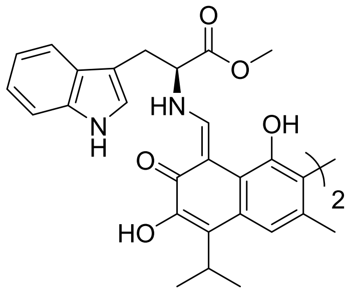
Data for **22**, yellow solid,moisture absorption easily; yield, 75%; ^{1}H NMR (300 MHz, DMSO-d_6), δ 13.47 (dd, J = 4.8, 12.5 Hz, 2H), 10.92 (s, 2H), 9.76 (d, J = 12.6 Hz, 2H), 8.44 (s, 2H), 7.81 (s, 2H), 7.48–6.91 (m, 12H), 4.82–4.76 (m, 2H), 3.66 (s, 8H), 3.46–3.35 (m, 4H), 1.93 (s, 6H), 1.43 (d, J = 6.4 Hz, 12H). ^{13}C NMR (100 MHz, DMSO-d_6), δ 238.34, 173.12, 171.35, 170.3, 161.8, 150.2, 146.7, 136.6, 132.0, 127.6, 127.4, 124.7, 121.5, 121.0, 119.0, 118.5, 117.1, 116.2, 112.0, 108.2, 104.4, 62.5, 53.0, 29.4, 27.0, 20.8, 20.7.



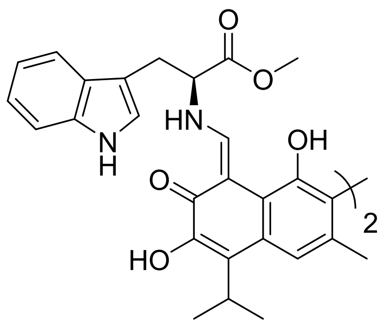
(-)

Data for **23**, yellow solid, moisture absorption easily; yield, 84%; ^{1}H NMR (300 MHz, DMSO-d_6), δ 13.48 (dd, J = 4.8, 12.5 Hz, 2H), 10.92 (s, 2H), 9.64 (d, J = 12.6 Hz, 2H), 8.44 (s, 2H), 7.61 (s, 2H), 7.48–6.89 (m, 12H), 4.82–4.76 (m, 2H), 3.67 (s, 8H), 3.43–3.35 (m, 4H), 1.92 (s, 6H), 1.42 (d, J = 6.4 Hz, 12H); ^{13}C NMR (100 MHz, DMSO-d_6), δ 238.3, 173.1, 171.4, 170.3, 169.0, 161.8, 150.2, 146.7, 136.6, 132.0, 127.6, 127.4, 124.7, 121.5, 121.0, 119.0, 118.5, 117.1, 116.2, 111.0, 108.2, 104.4, 62.5, 53.0, 29.4, 27.0, 20.8, 20.7.



(+)

Data for **24**, yellow solid, moisture absorption easily; yield, 84%; ^{1}H NMR (300 MHz, DMSO-d_6), δ 13.51–13.45 (m, 2H), 10.92 (s, 2H), 9.77 (d, J = 12.6 Hz, 2H), 8.44 (s, 2H), 7.81 (s, 2H), 7.48–6.93 (m, 12H), 4.82–4.76 (m, 2H), 3.66 (s, 8H), 3.46–3.35 (m, 4H), 1.93 (s, 6H), 1.43 (d, J = 6.4 Hz, 12H).



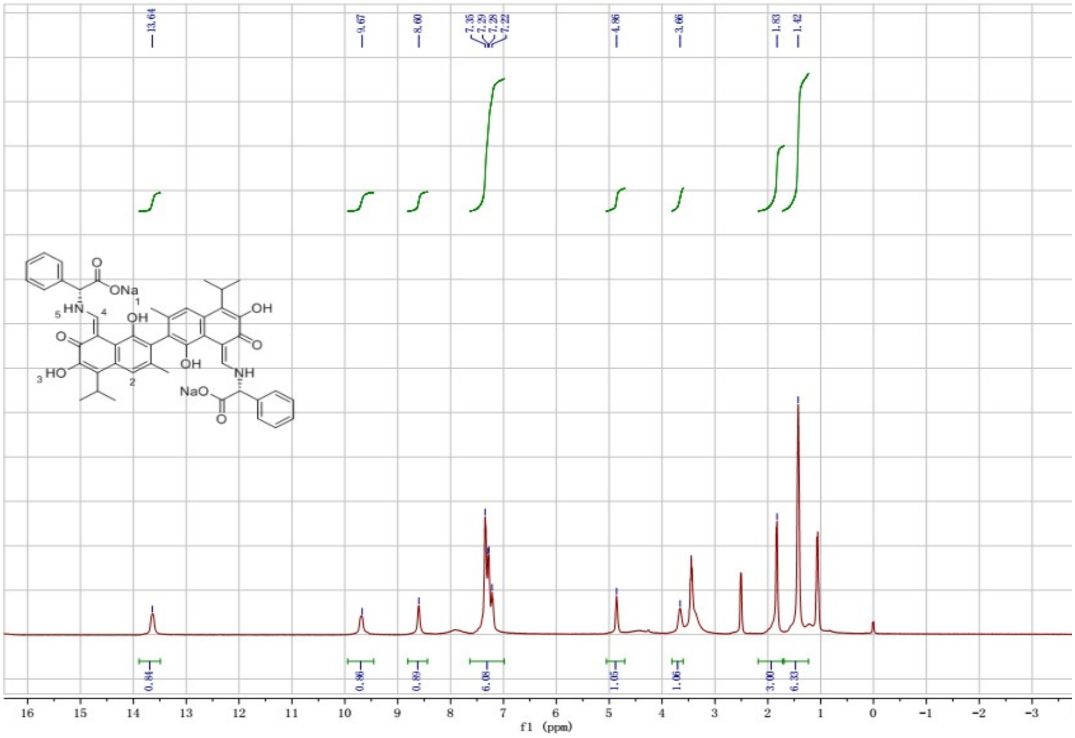
(-)

Data for **25**, yellow solid, moisture absorption easily; yield, 84%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.48–13.43 (m, 2H), 10.92 (s, 2H), 9.64 (d, J = 12.6 Hz, 2H), 8.43 (s, 2H), 7.61 (s, 2H), 7.48–6.89 (m, 12H), 4.82–4.76 (m, 2H), 3.67 (s, 8H), 3.43–3.35 (m, 4H), 1.92 (s, 6H), 1.42 (d, J = 6.4 Hz, 12H).

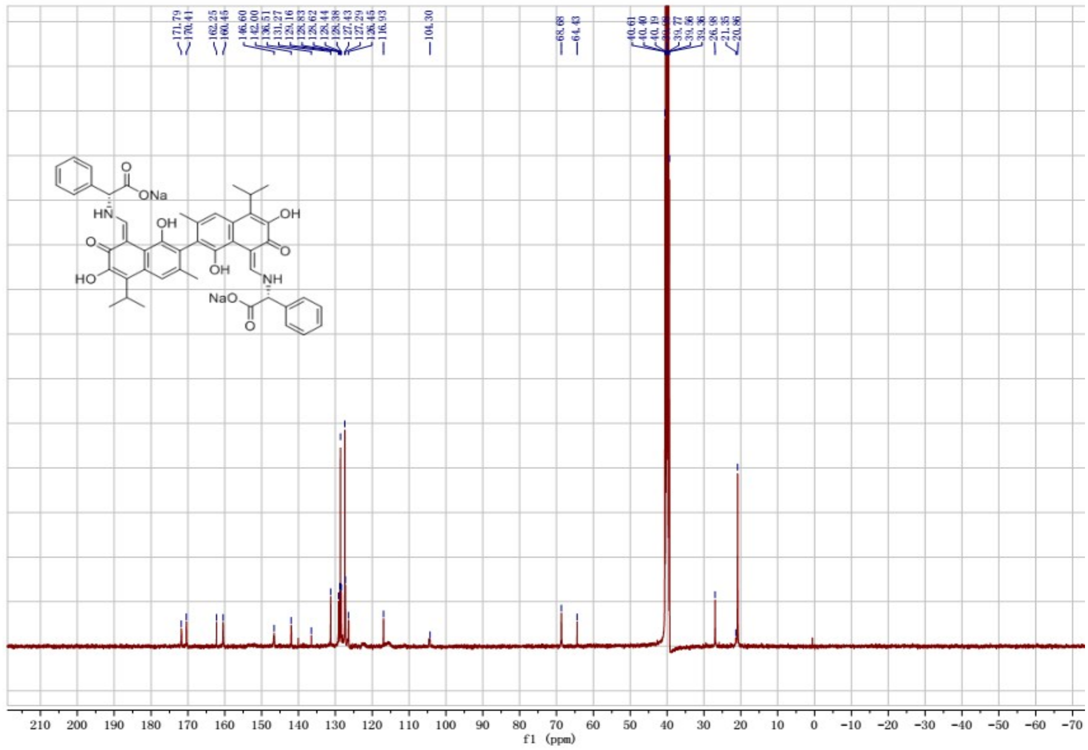
Data for **26**, yellow solid, moisture absorption easily; yield, 88%; ^{1}H NMR (400 MHz, DMSO-d_6), δ 13.25-13.18 (s, 2H), 9.75 (t, J = 12.8 Hz, 2H), 8.50 (s, 2H), 7.39 (s, 2H), 3.88–3.79 (m, 2H), 3.72-3.65 (m, 2H), 2.08–1.81 (m, 20H), 1.45-1.38 (m, 12H).

3. Spectrums of key compounds (^1H NMR, ^{13}C NMR and HRMS)

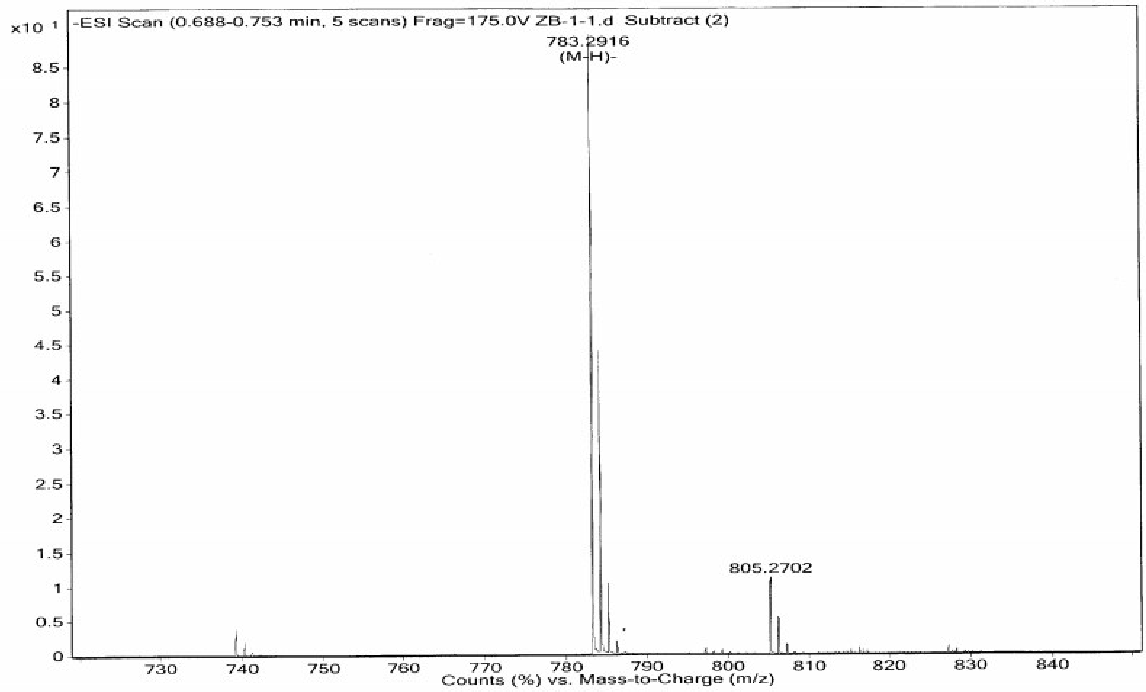
^1H NMR spectrum of compound 3.



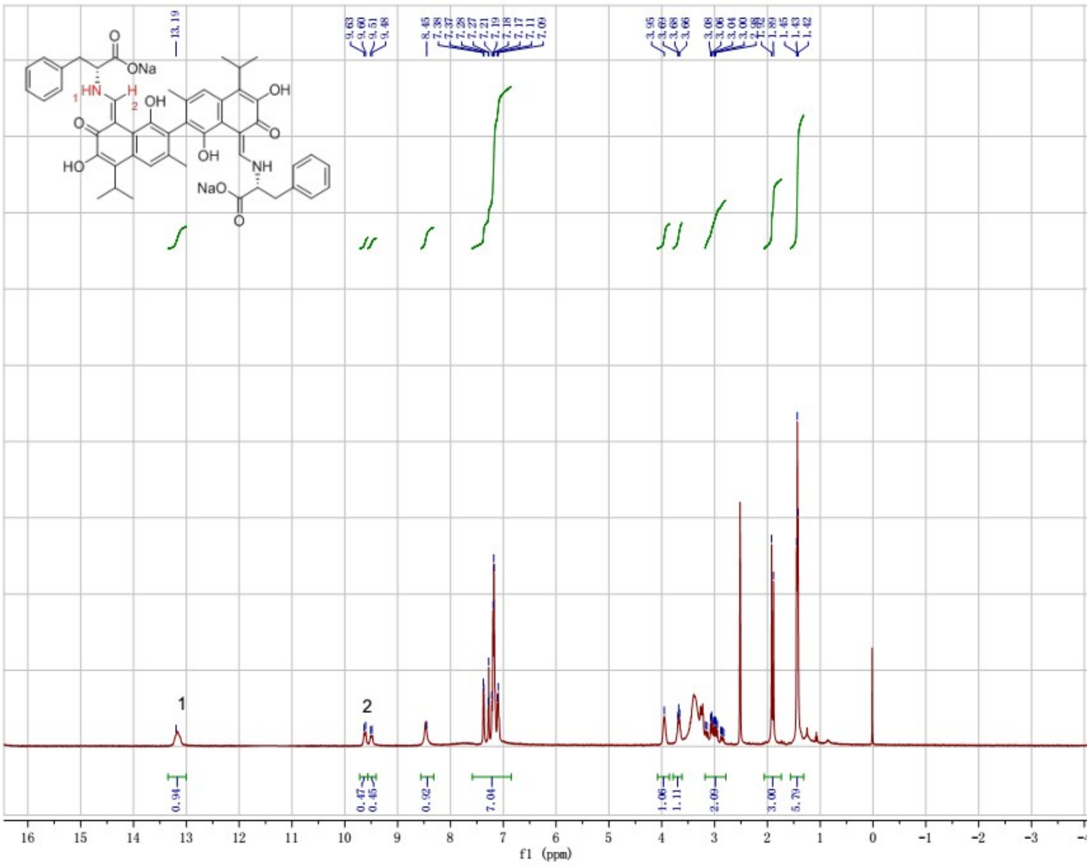
^{13}C NMR spectrum of compound 3.



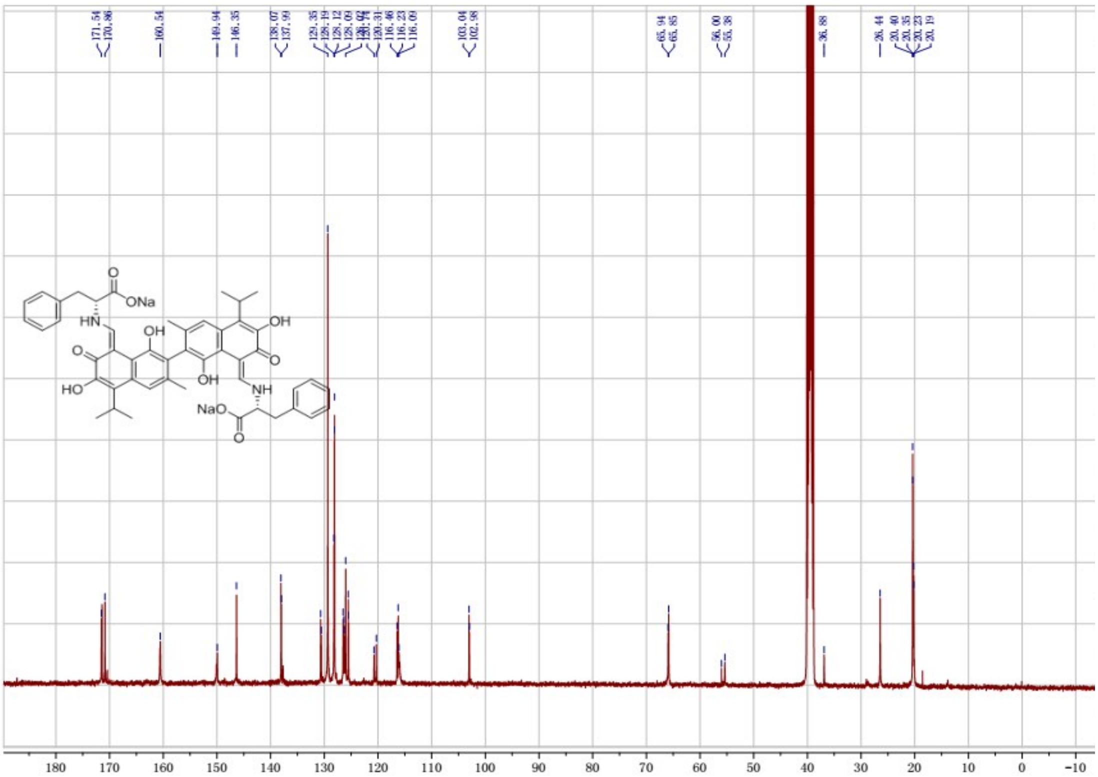
HRMS of compound 3.



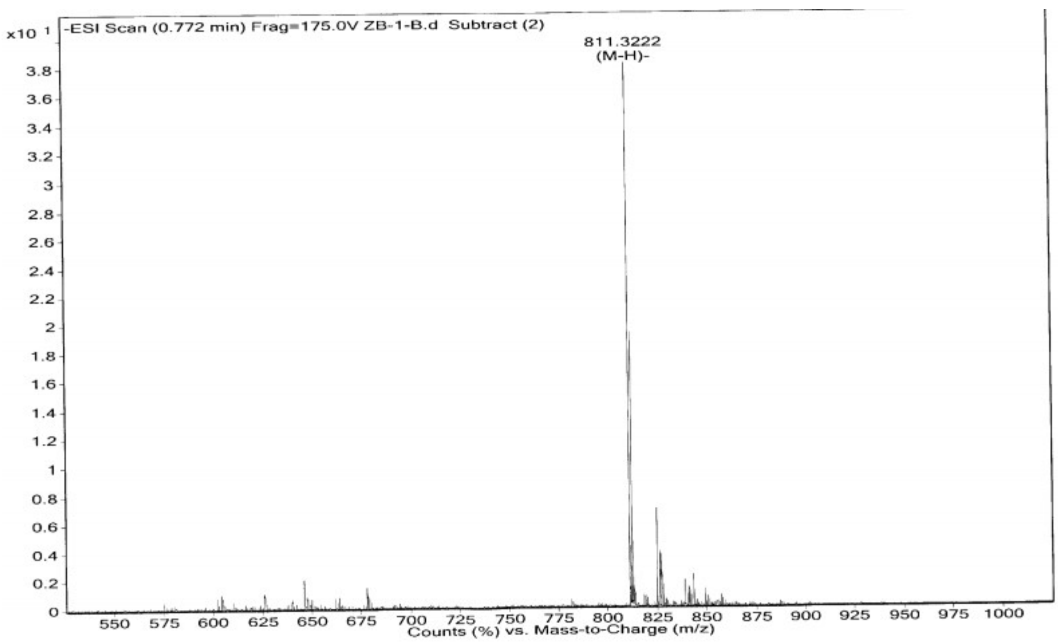
[1]H NMR spectrum of compound 4.



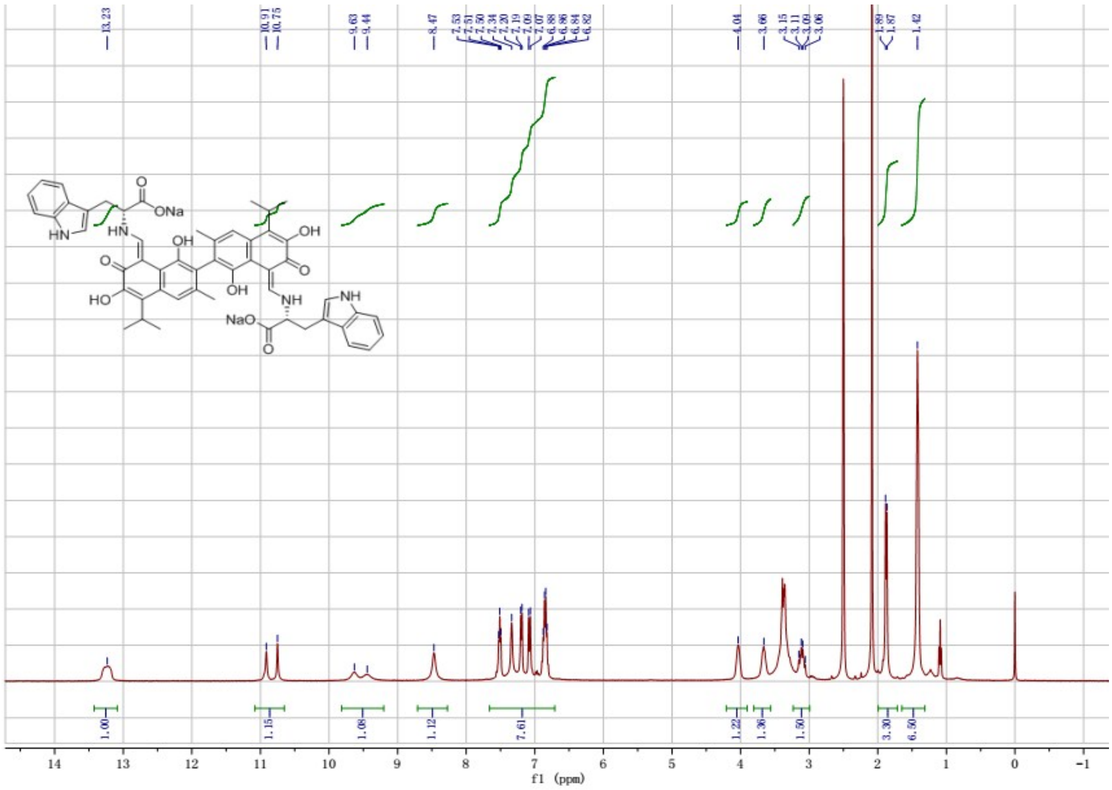
^{13}C NMR spectrum of compound 4.



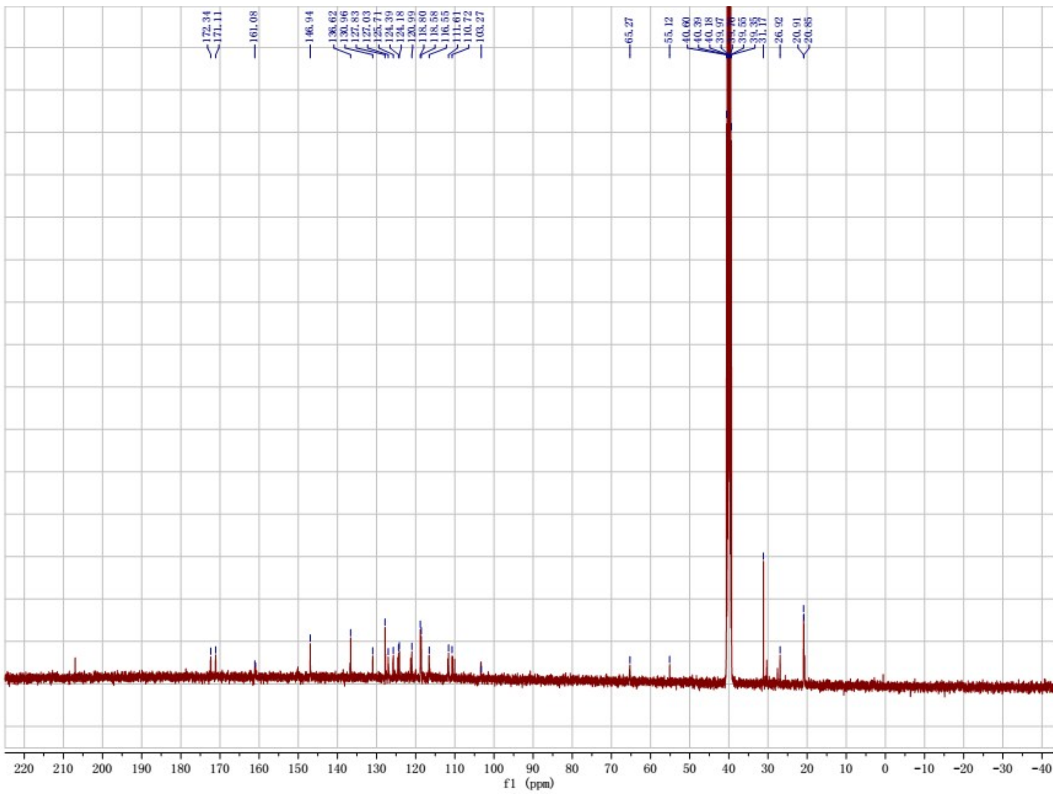
HRMS of compound 4.



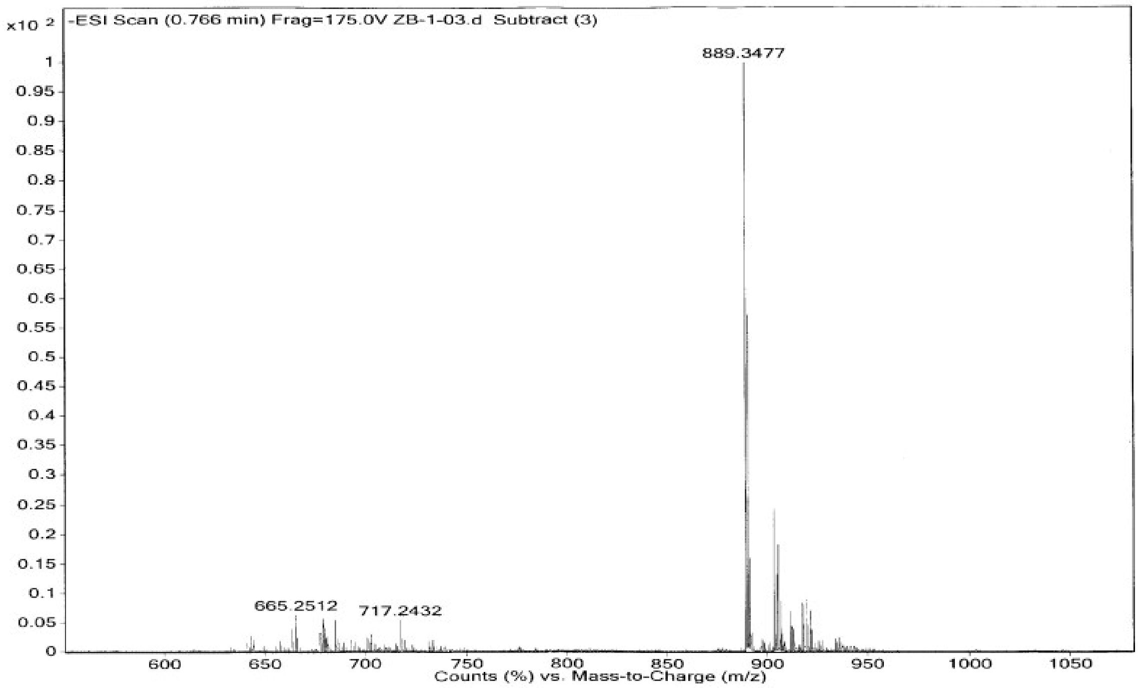
^{1}H NMR spectrum of compound 5.



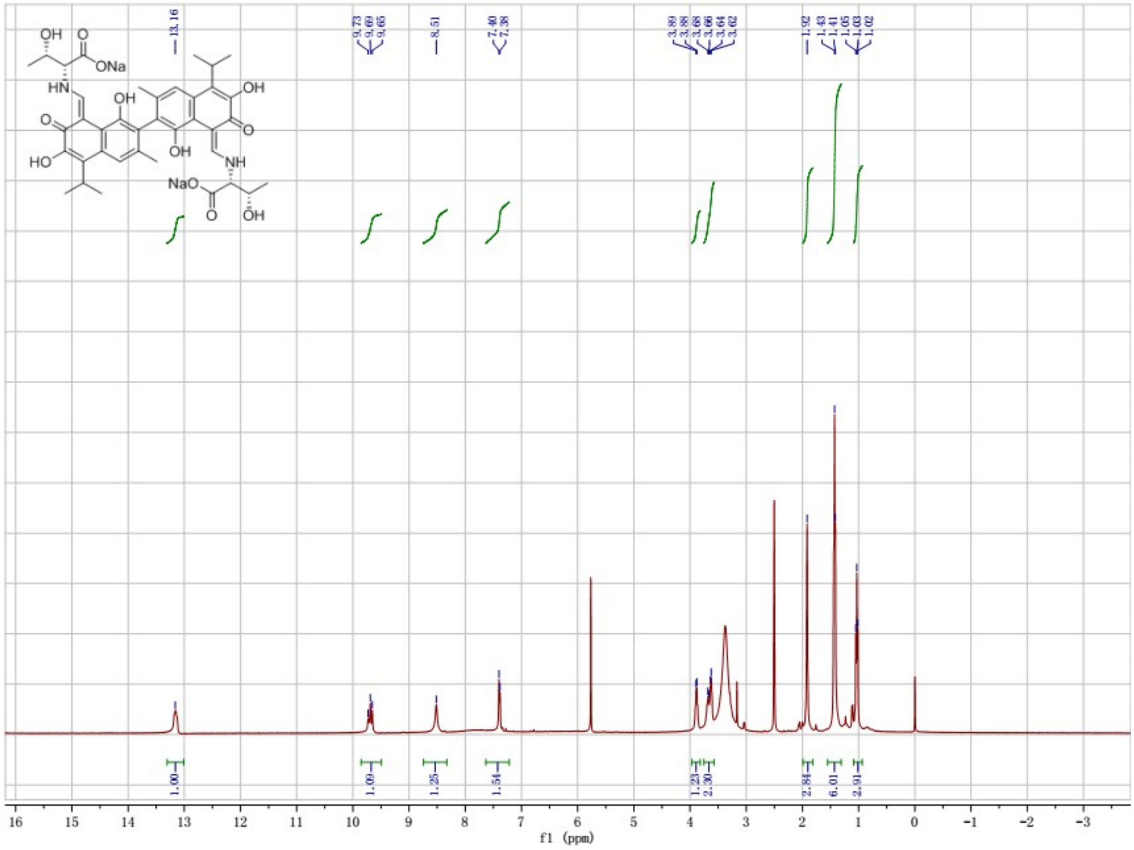
^{1}H NMR spectrum of compound 5.



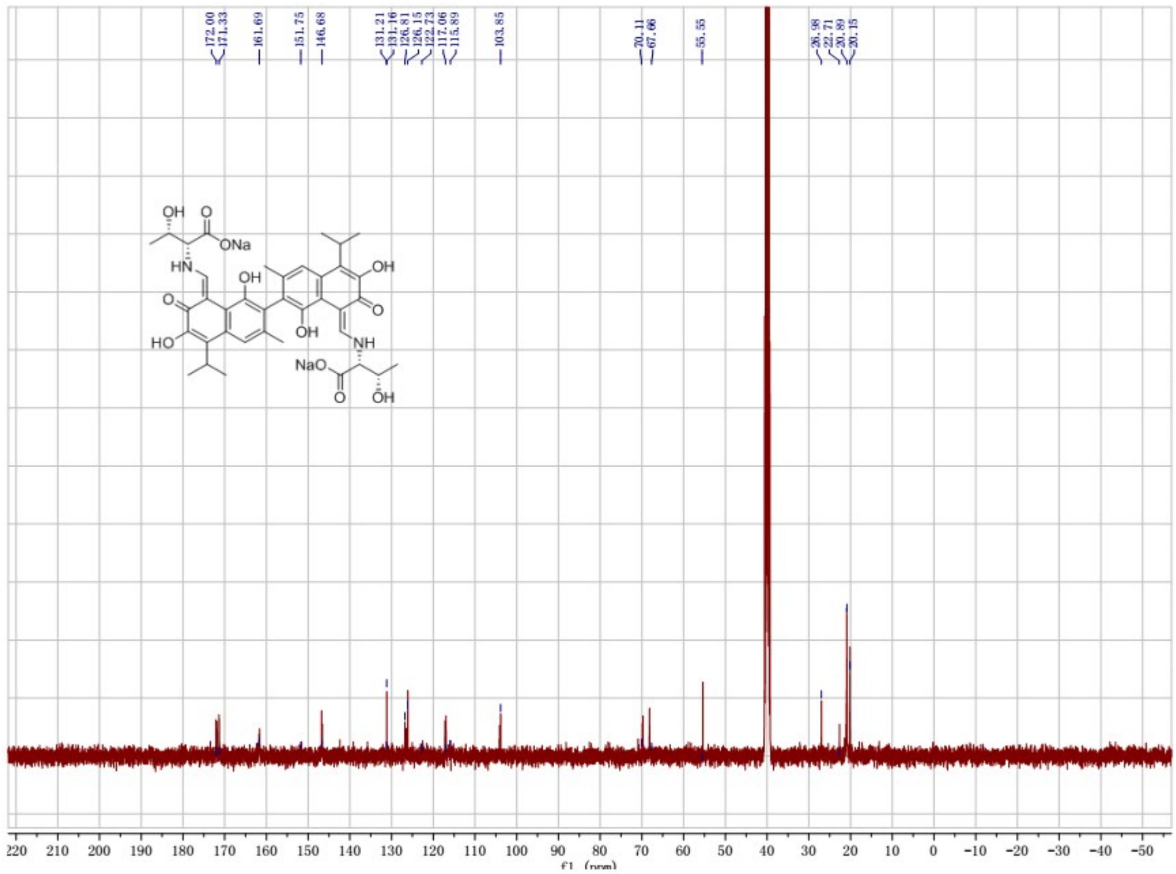
HRMS of compound 5.



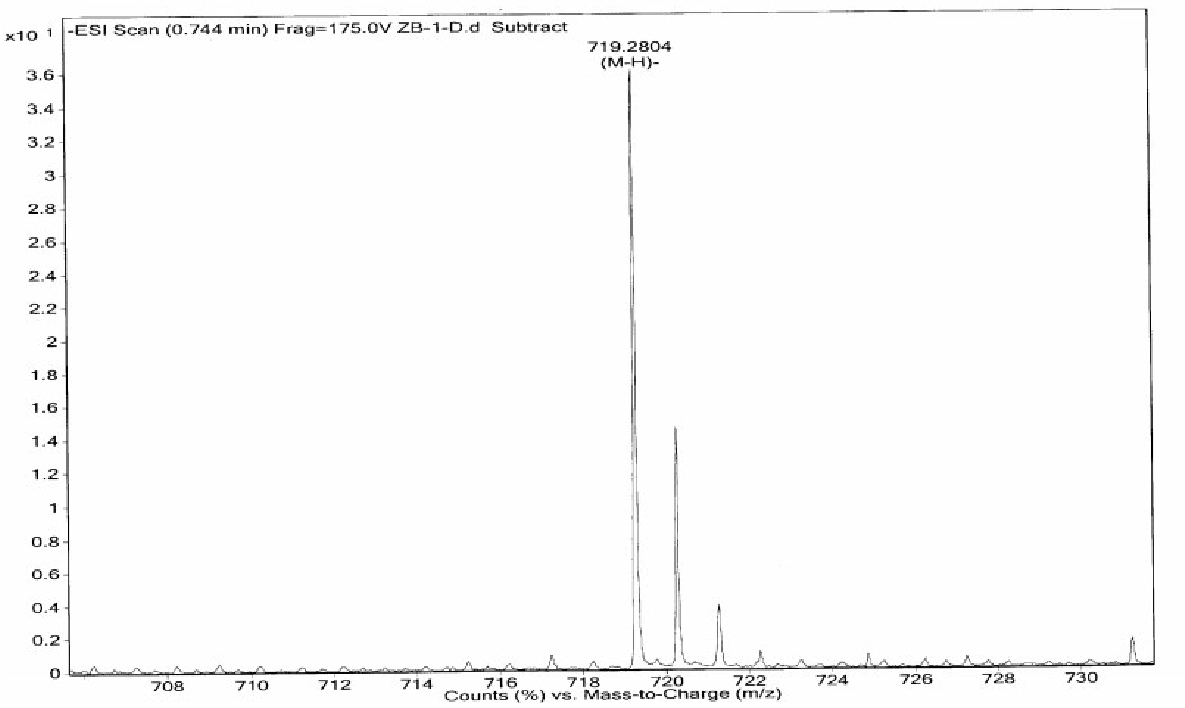
[1]H NMR spectrum of compound 6.



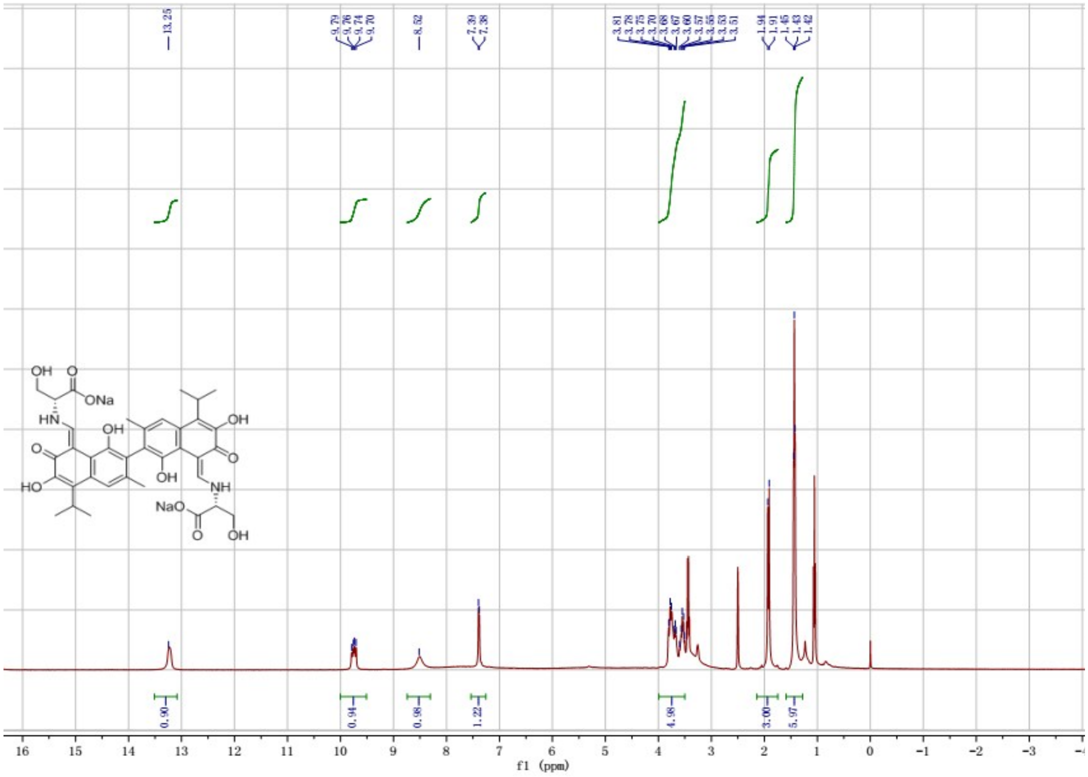
^{13}C NMR spectrum of compound 6.



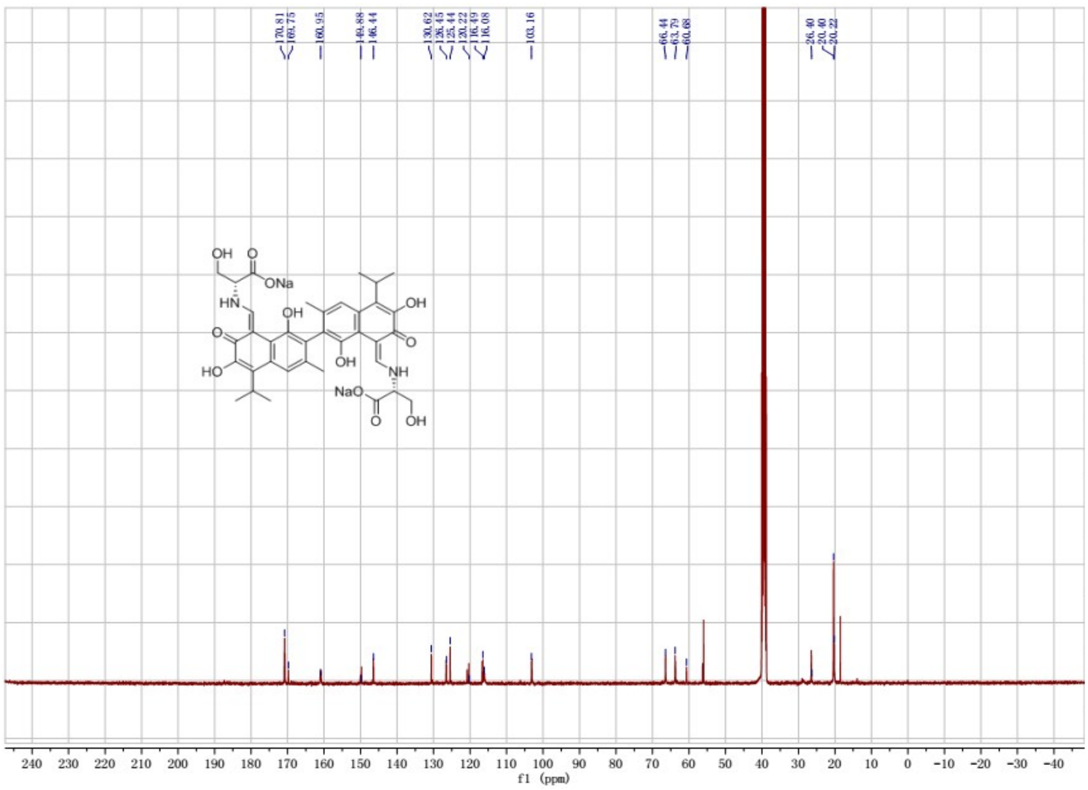
HRMS of compound 6.



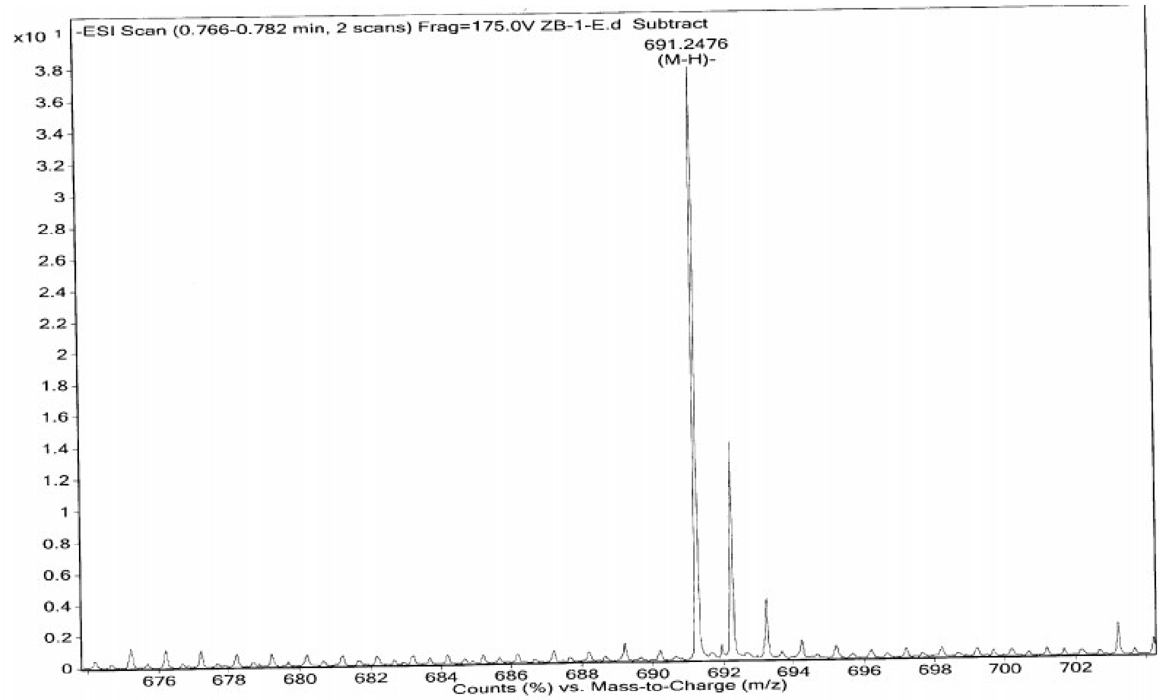
[1]H NMR spectrum of compound 7.



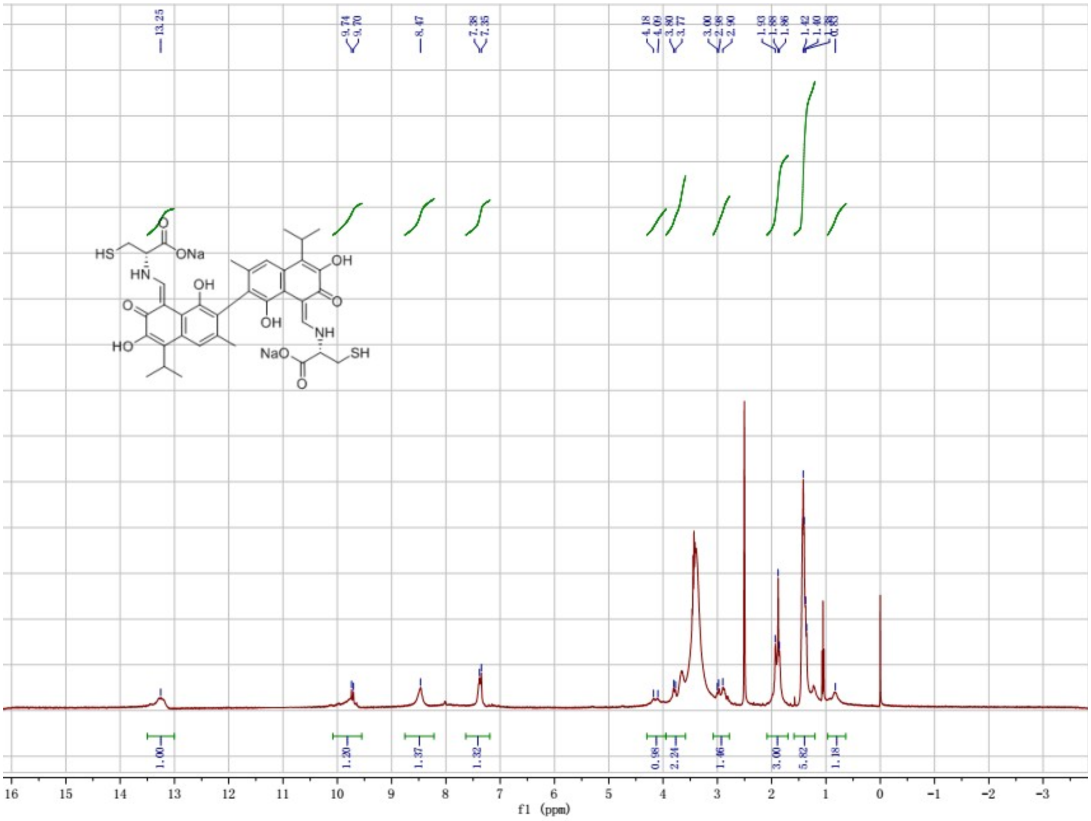
[13]C NMR spectrum of compound 7.



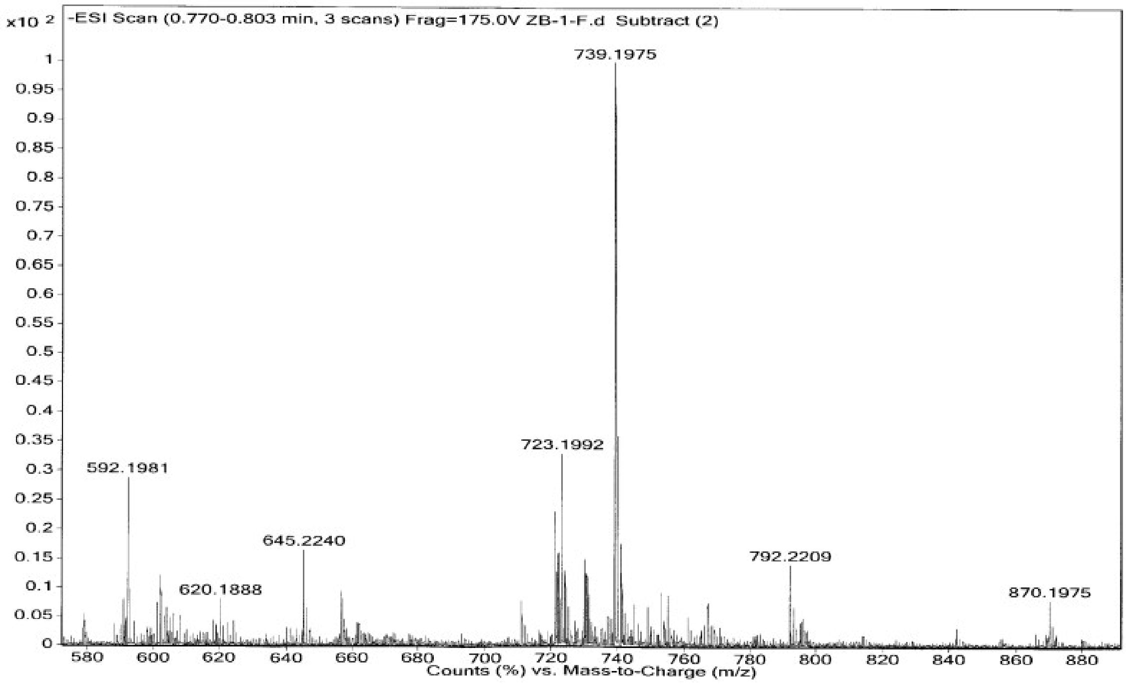
HRMS of compound 7.



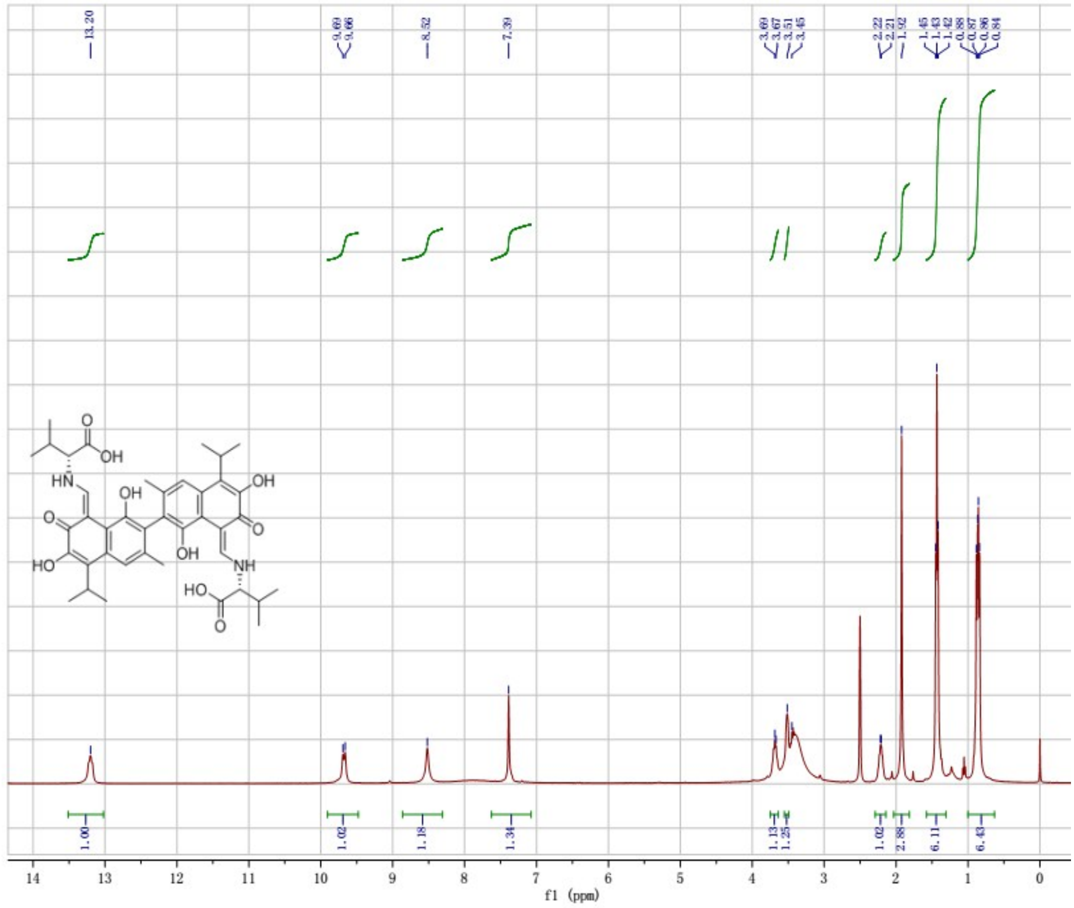
[1]H NMR spectrum of compound 8.



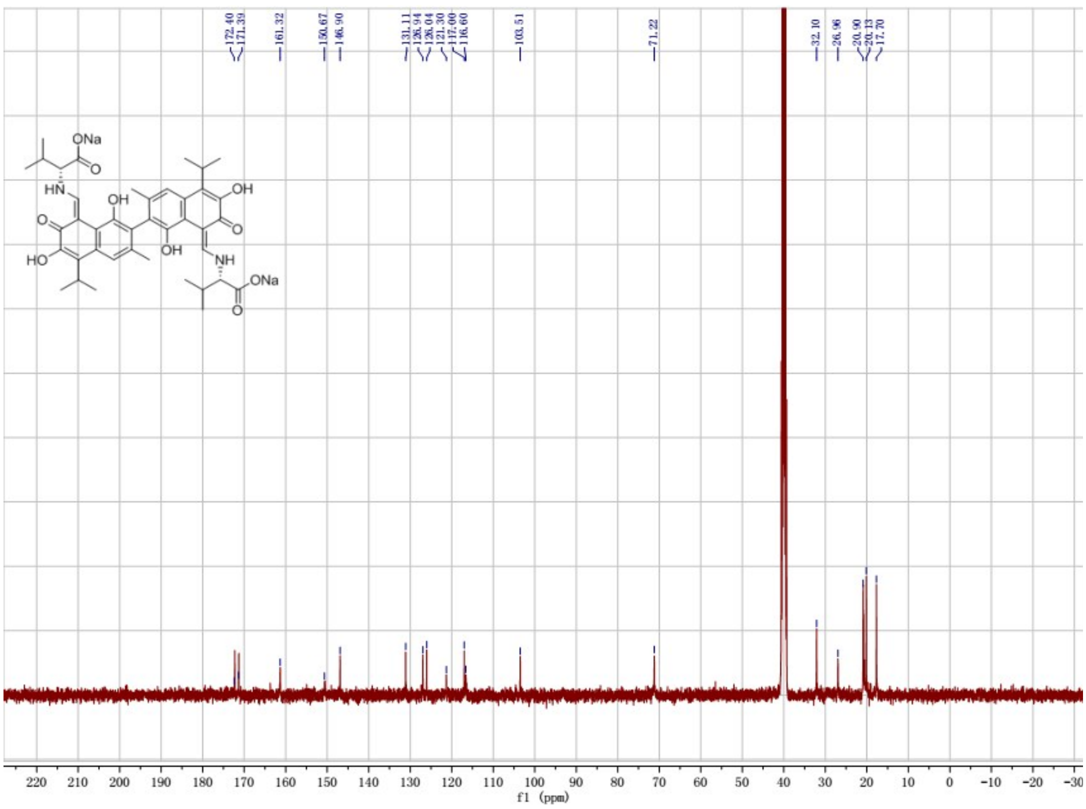
HRMS of compound 8.



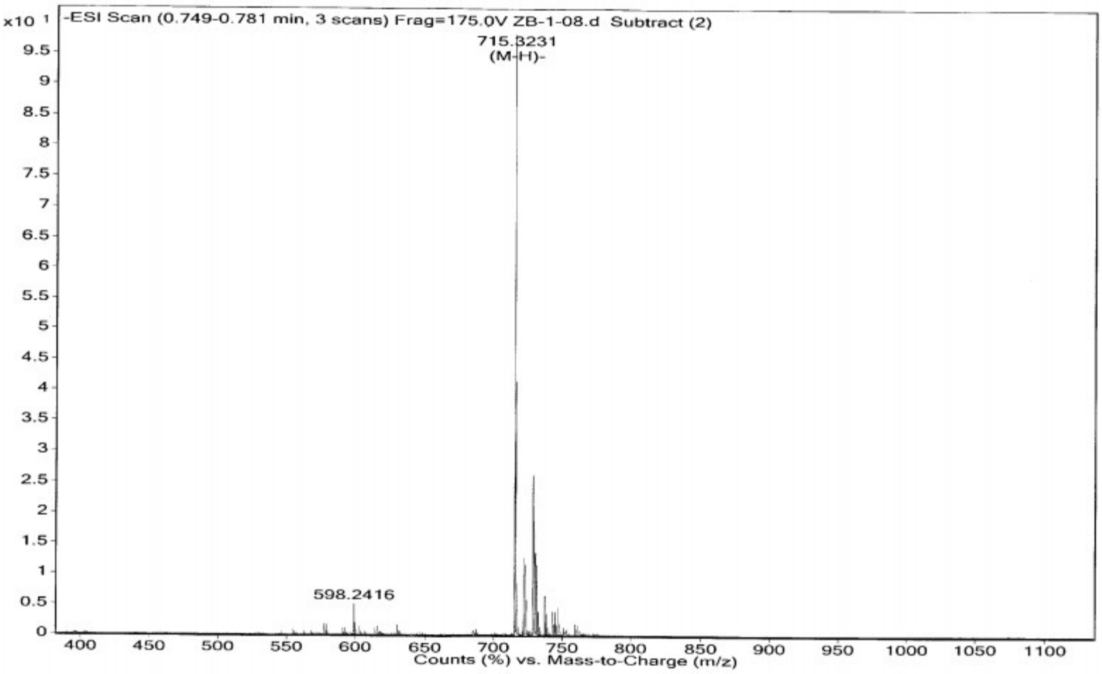
[1]H NMR spectrum of compound 9.



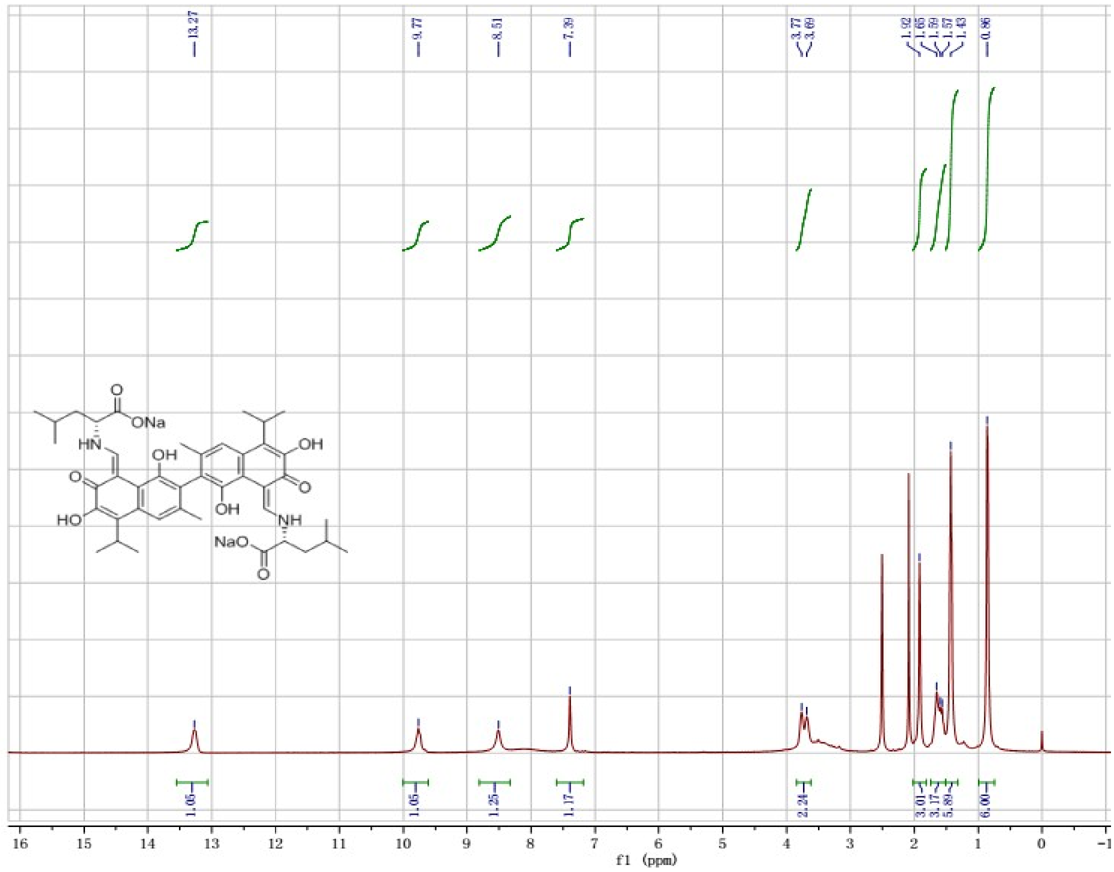
^{13}C NMR spectrum of compound 9.



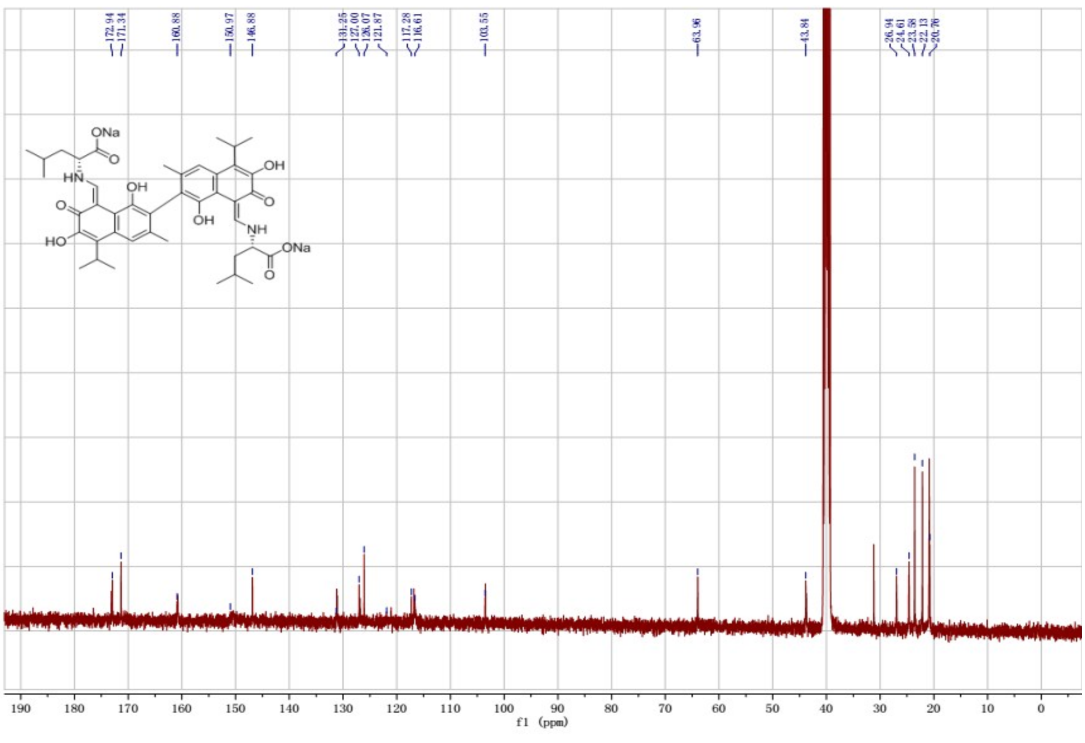
HRMS of compound 9.



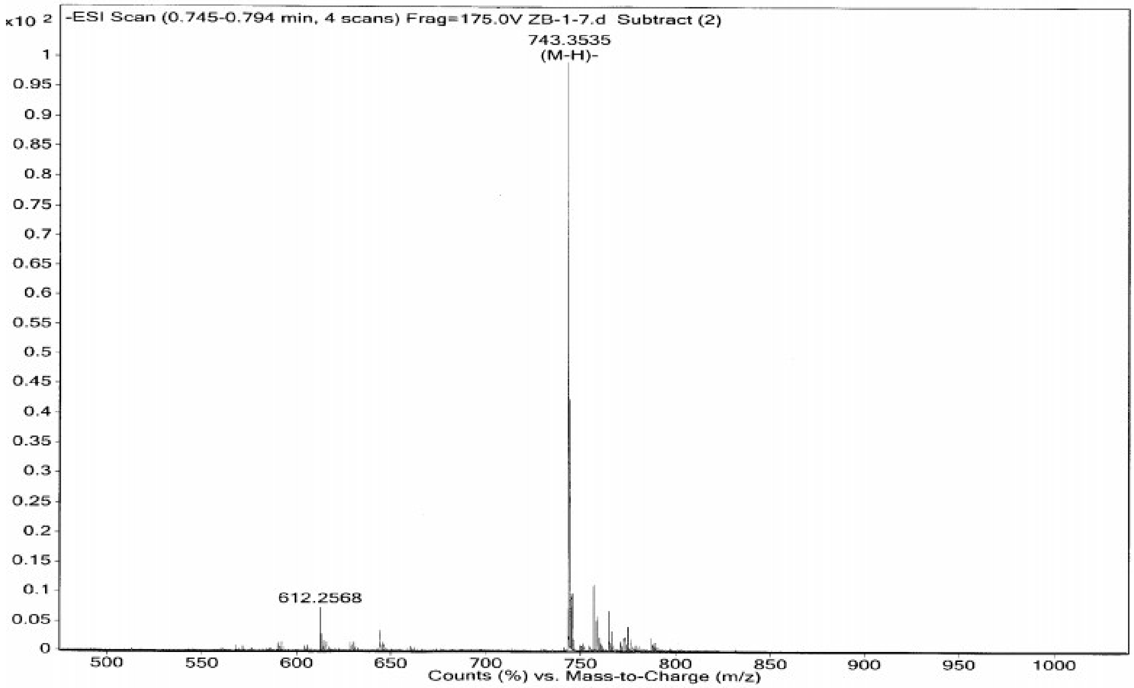
[1]H NMR spectrum of compound 10.



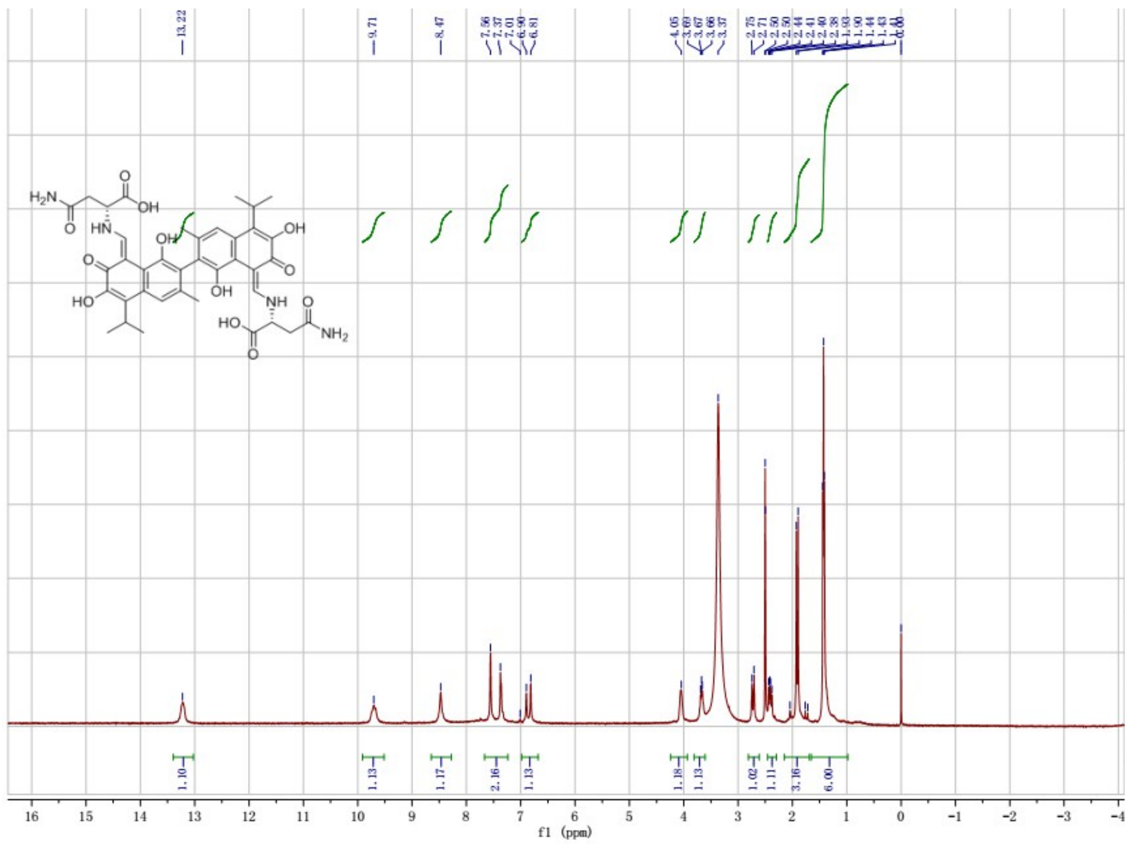
[13]C NMR spectrum of compound 10.



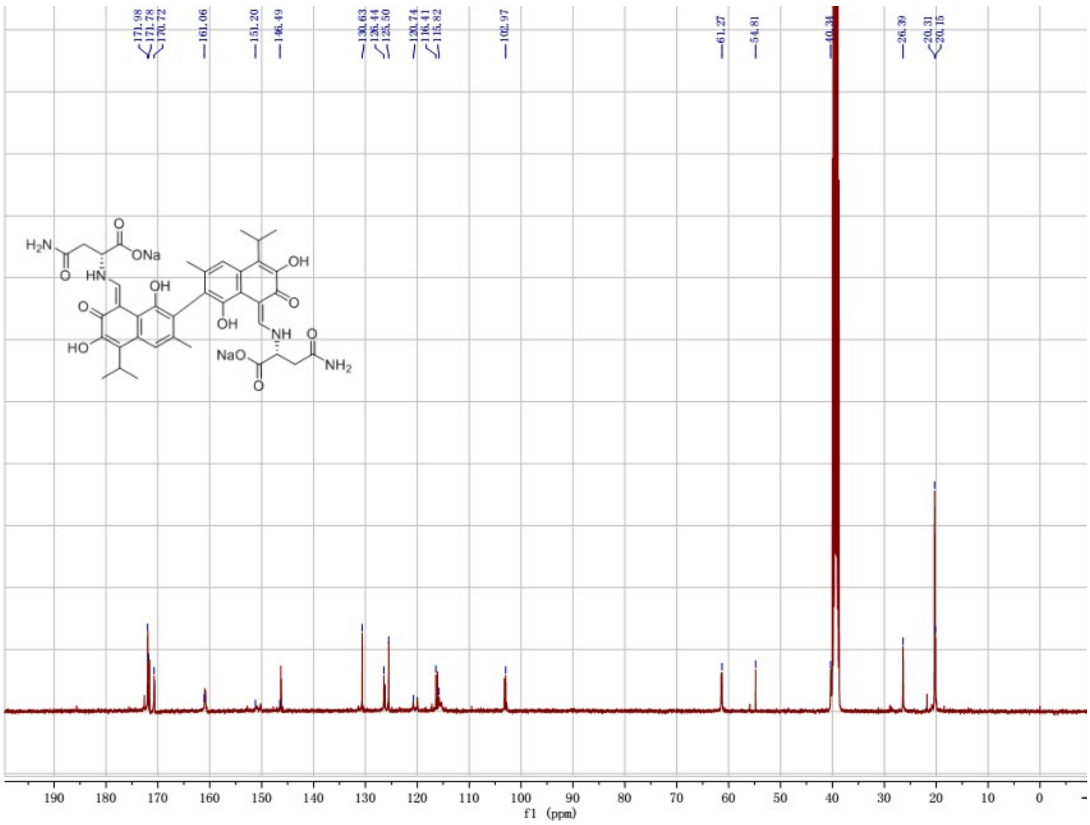
HRMS of compound 10.



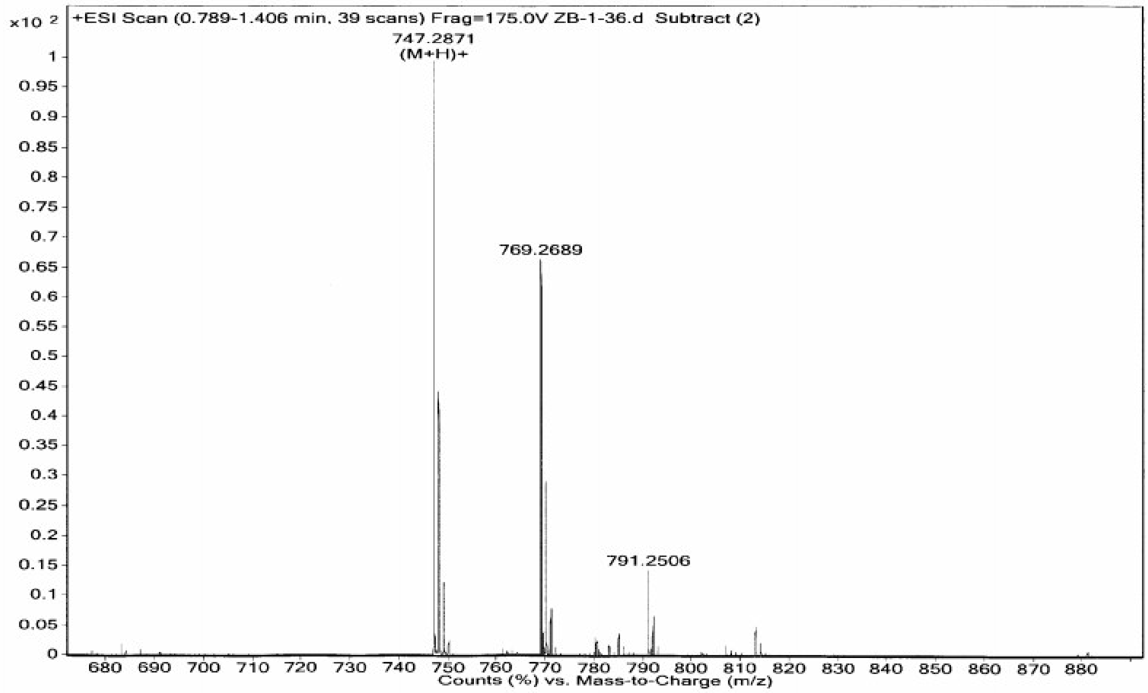
^{1}H NMR spectrum of compound 11.



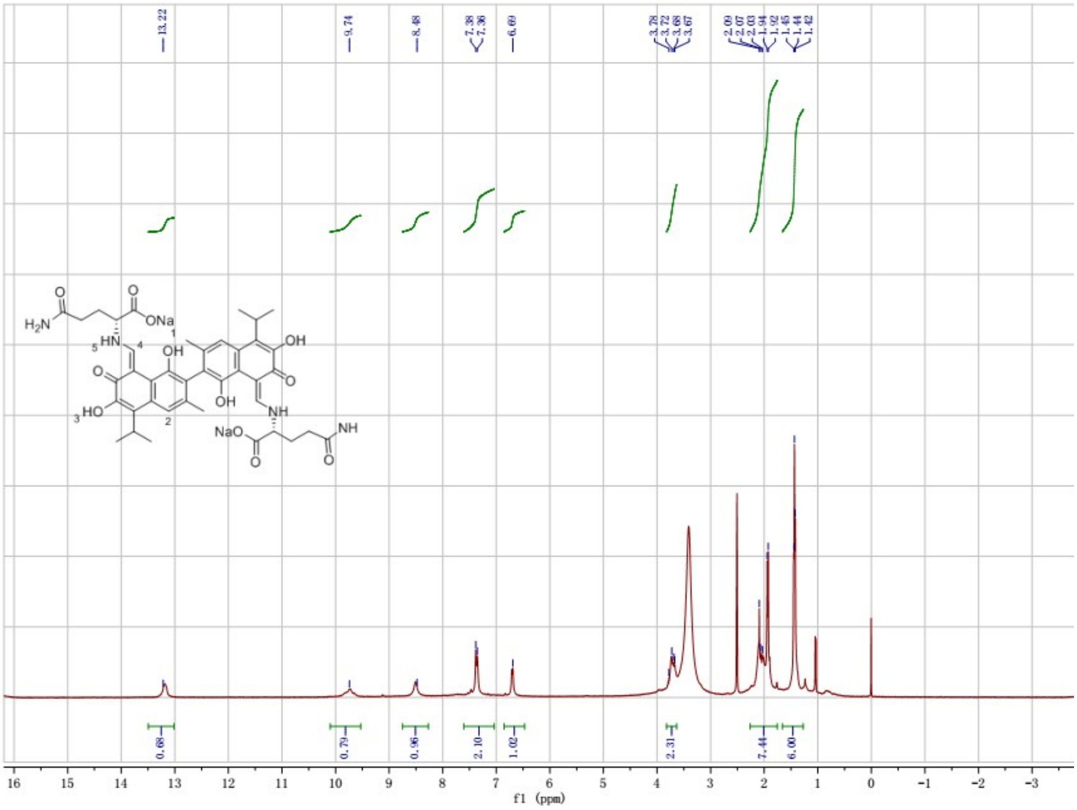
^{13}C NMR spectrum of compound 11.



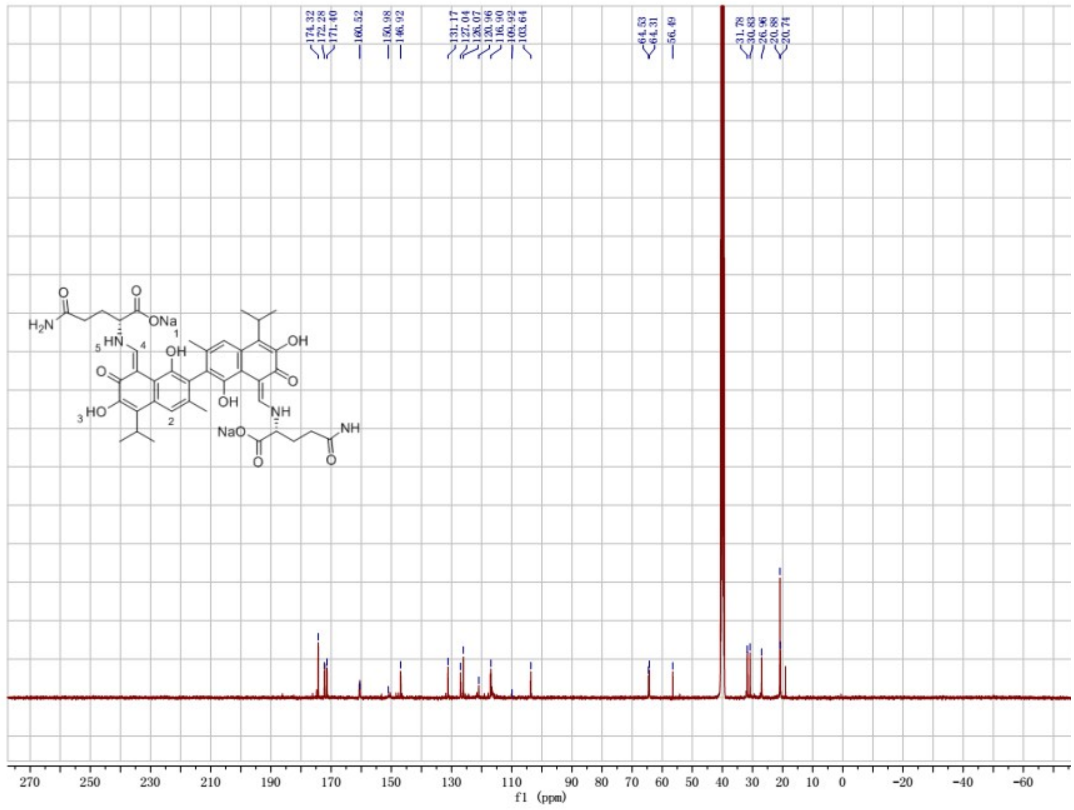
HRMS of compound 11.



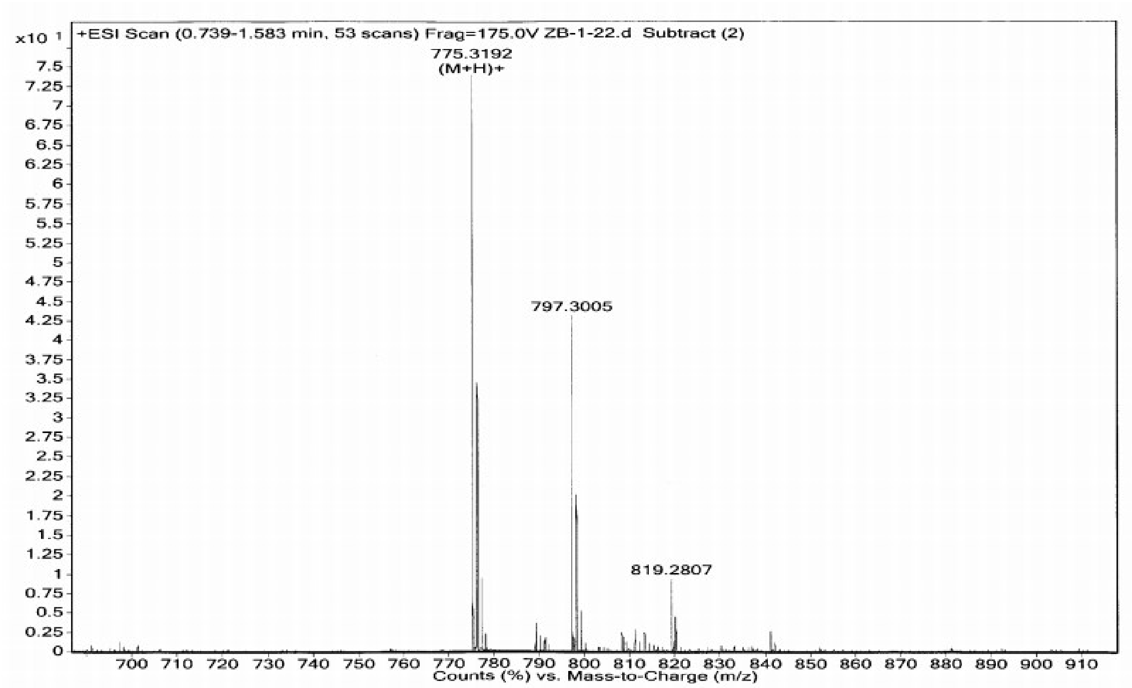
[1]H NMR spectrum of compound 12.



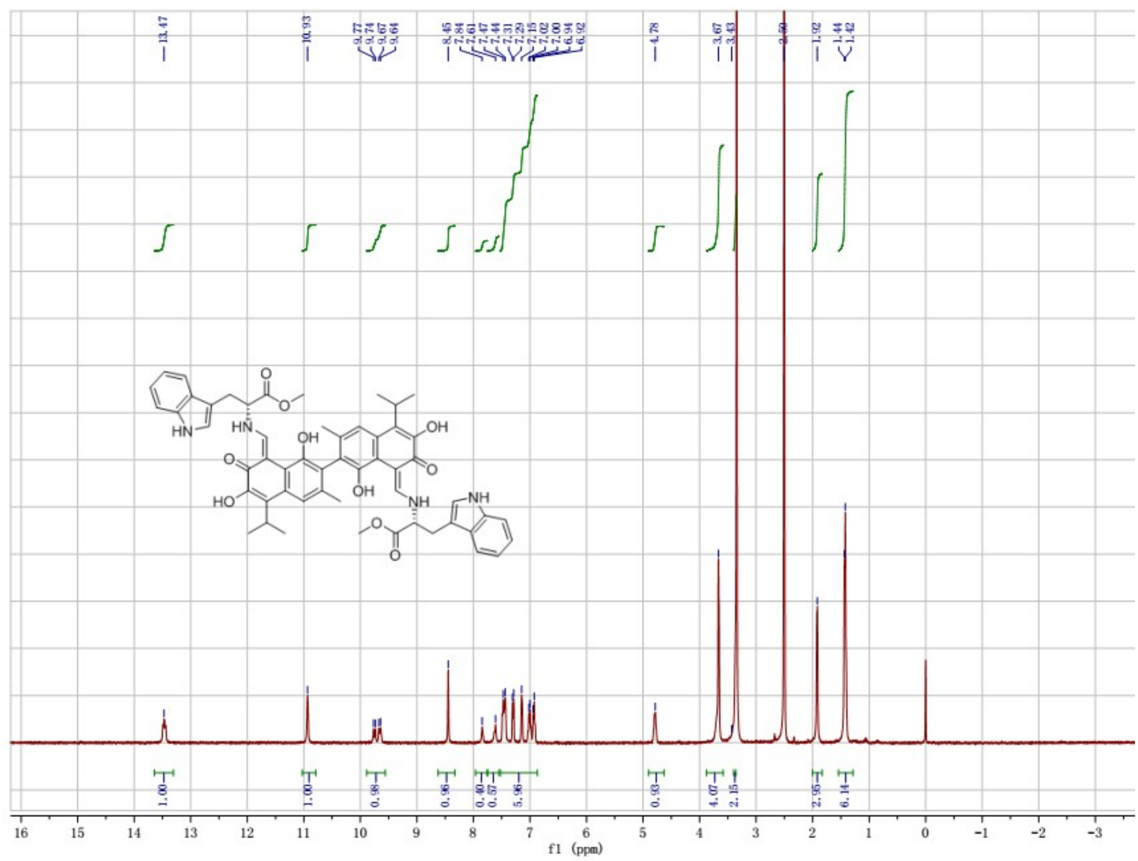
[13]C NMR spectrum of compound 12.



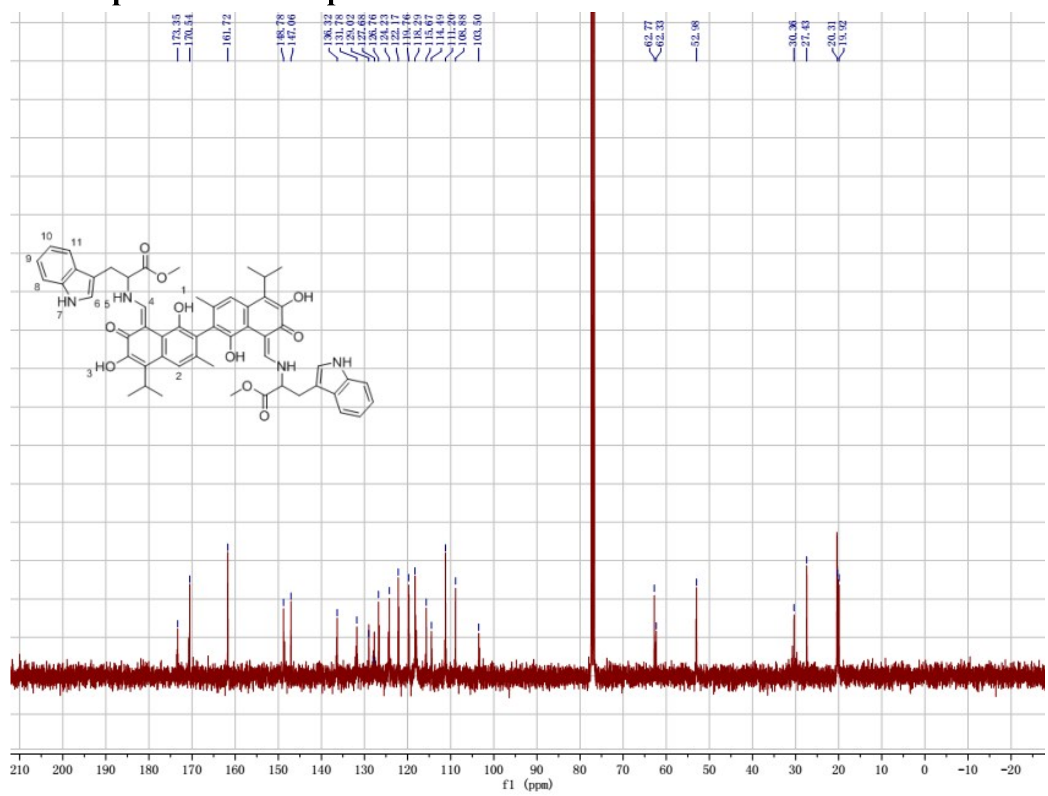
HRMS of compound 12.



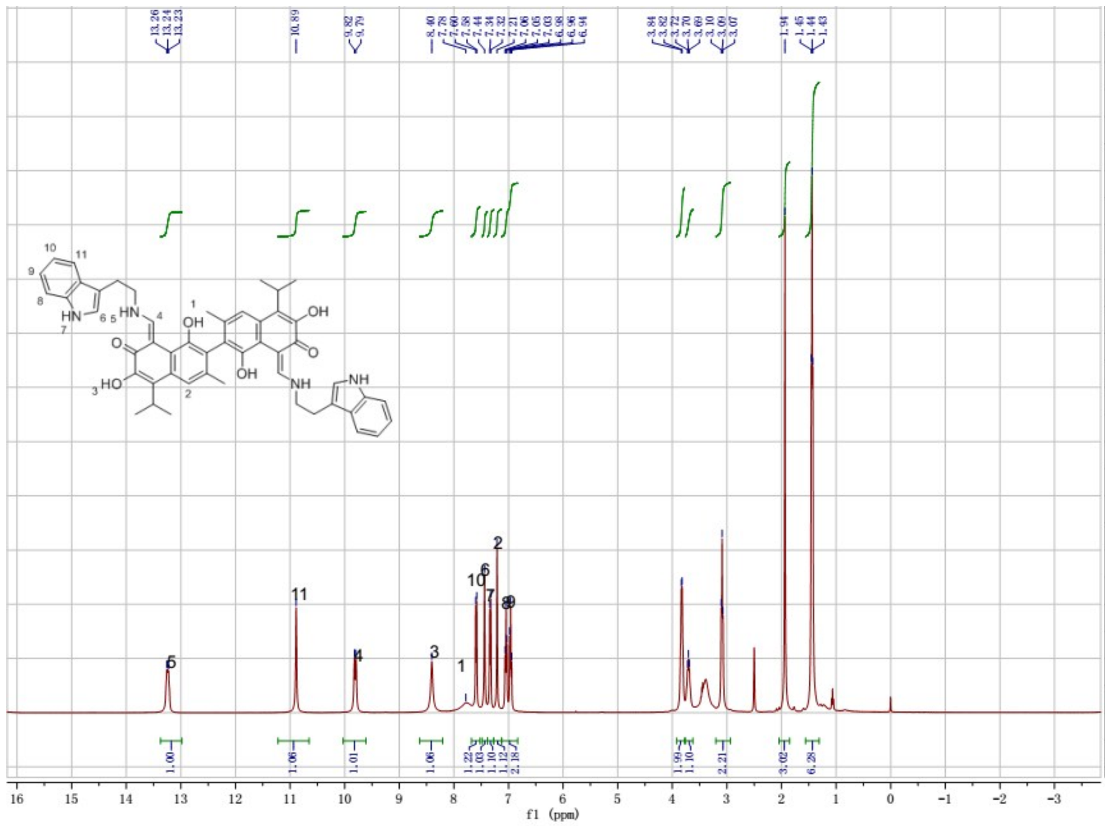
^{1}H NMR spectrum of compound 13.



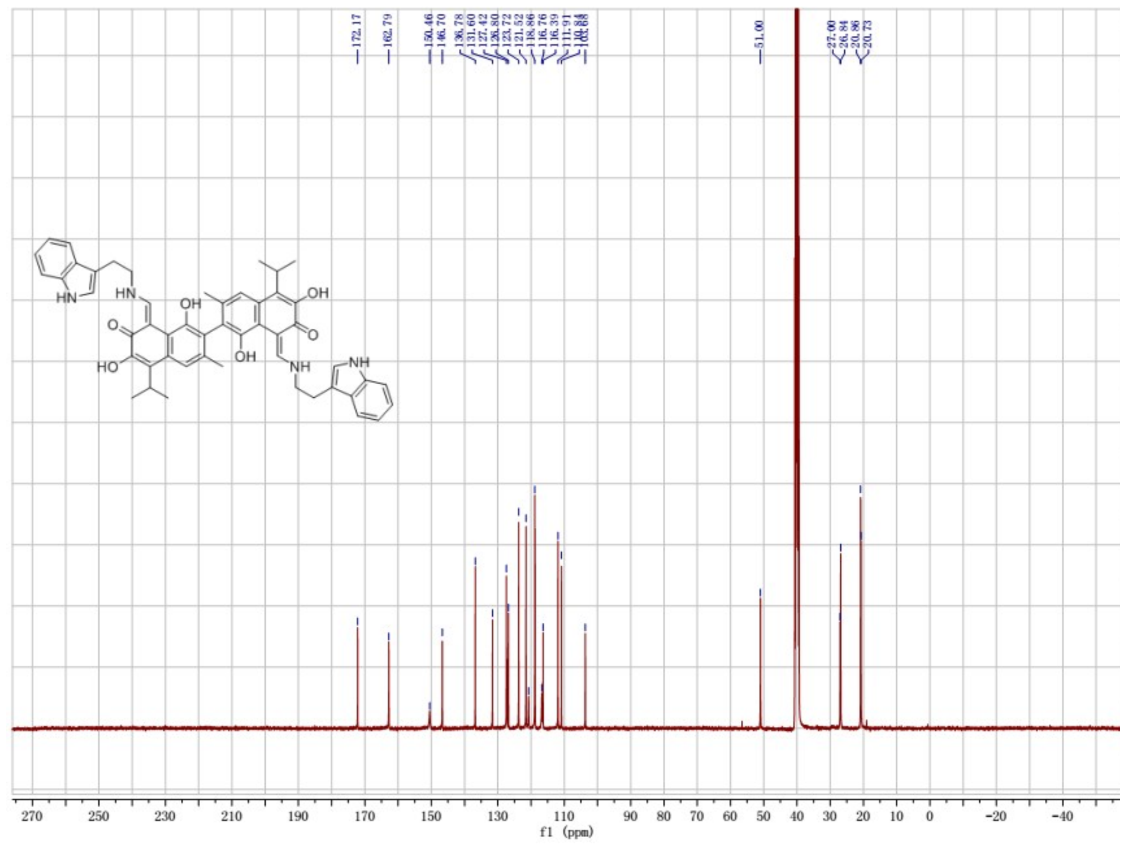
^{13}C NMR spectrum of compound 13.



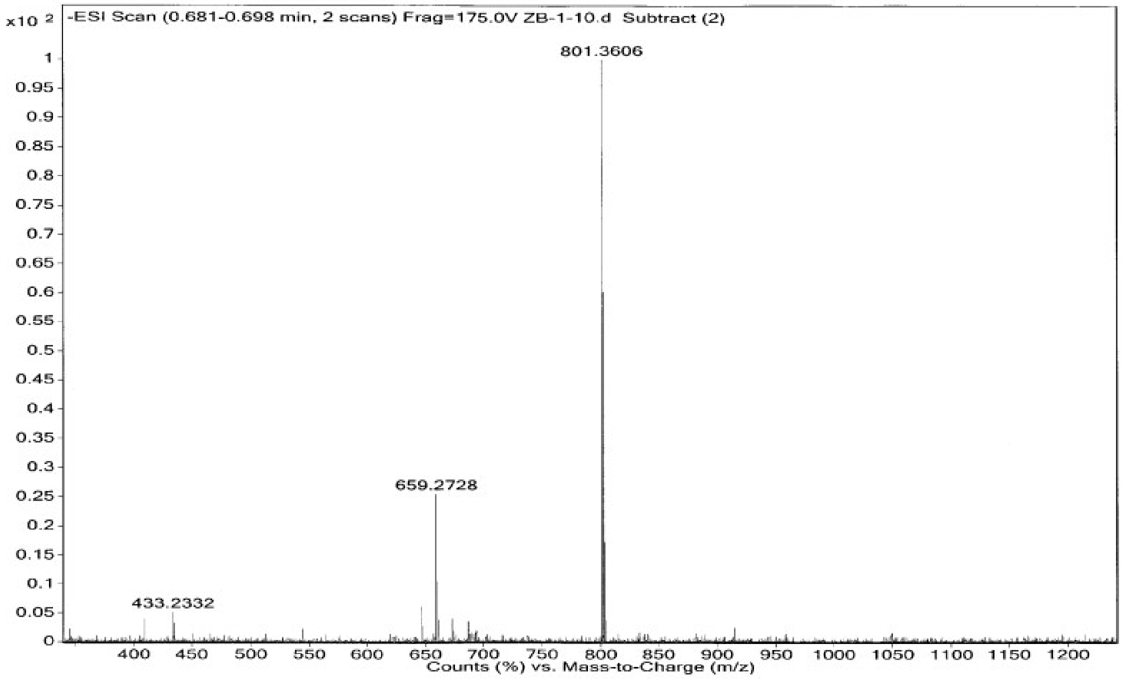
^{1}H NMR spectrum of compound 14.



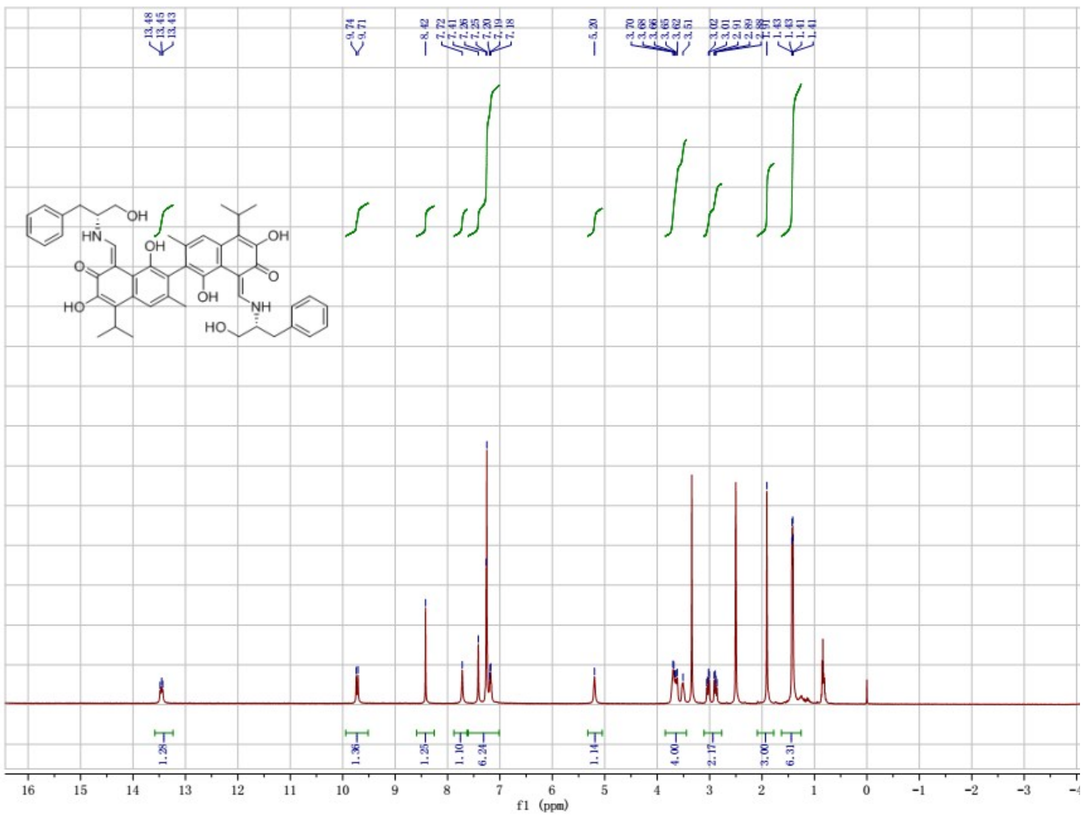
^{13}C NMR spectrum of compound 14.



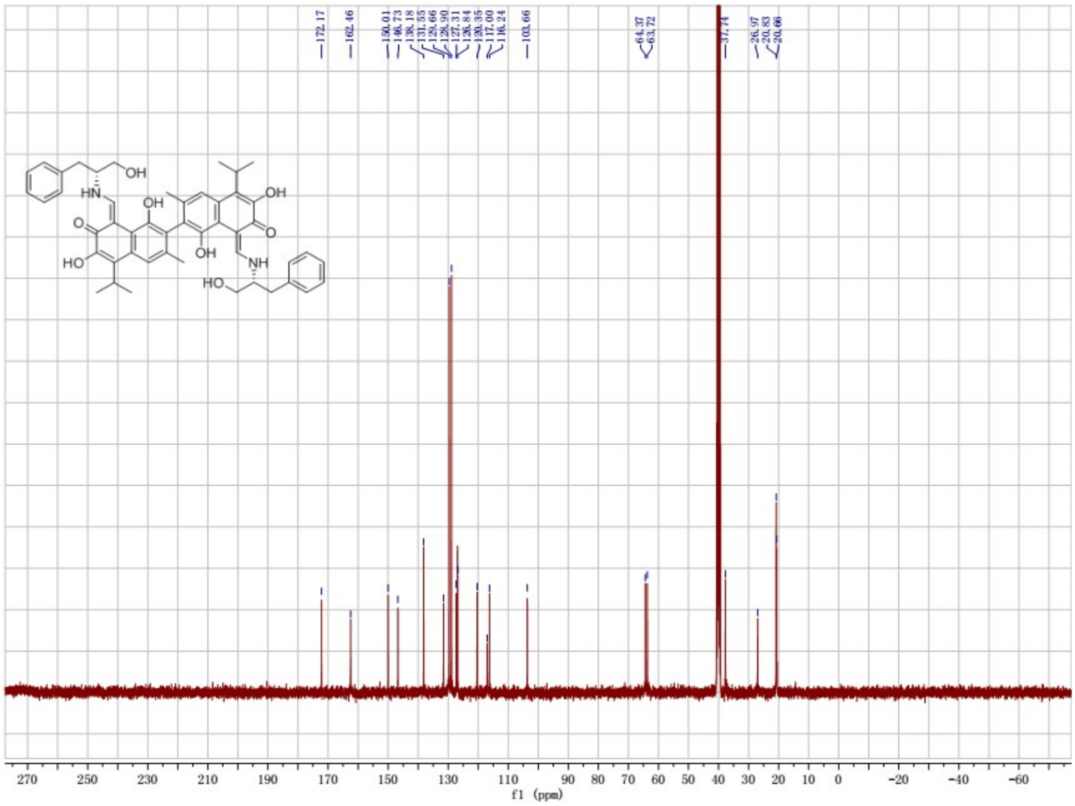
HRMS of compound 14.



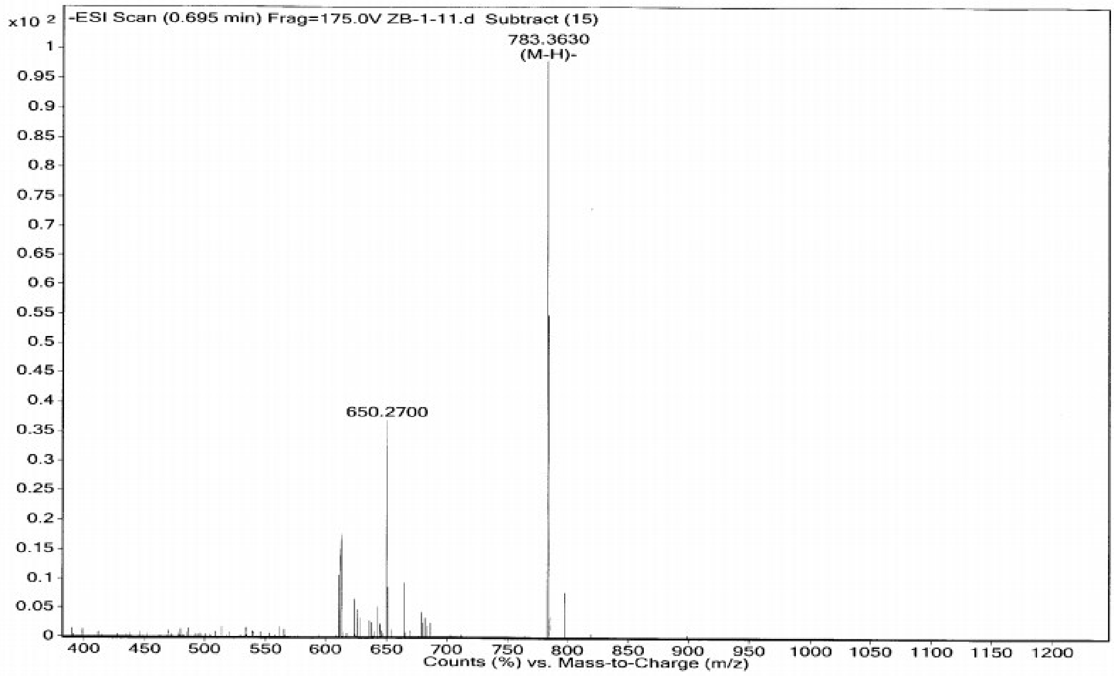
^{1}H NMR spectrum of compound 15.



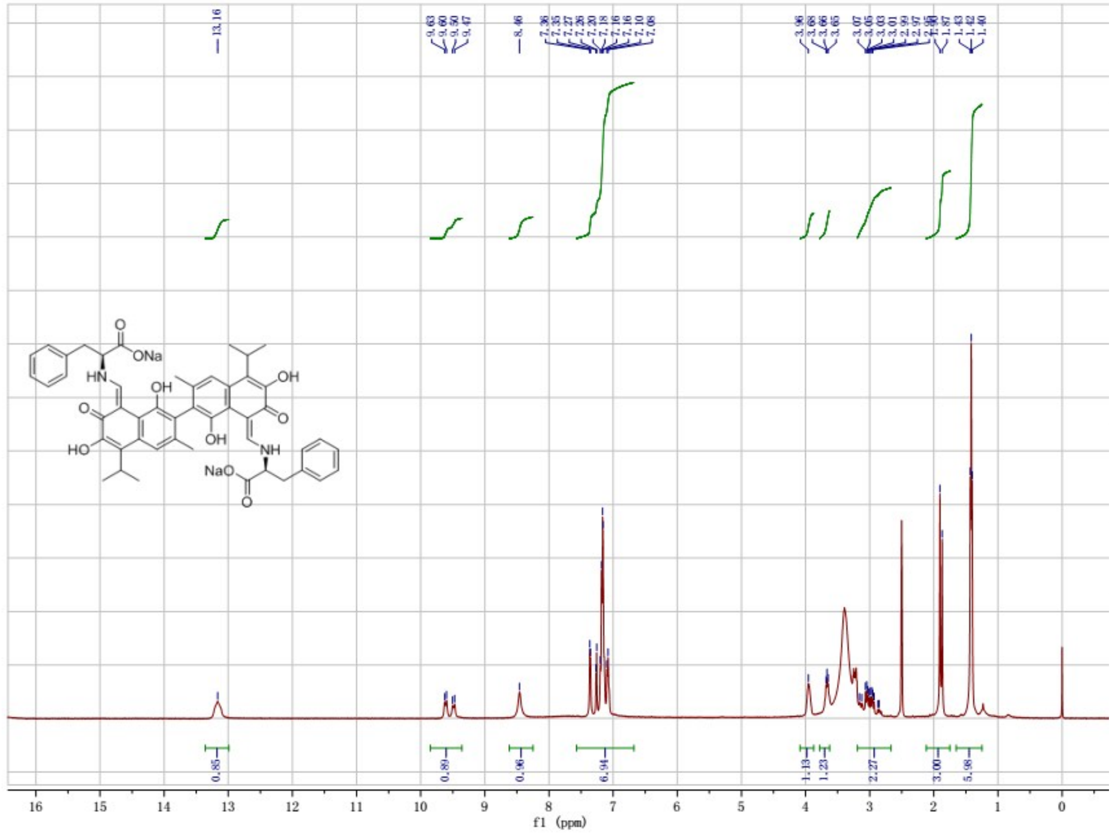
^{13}C NMR spectrum of compound 15.



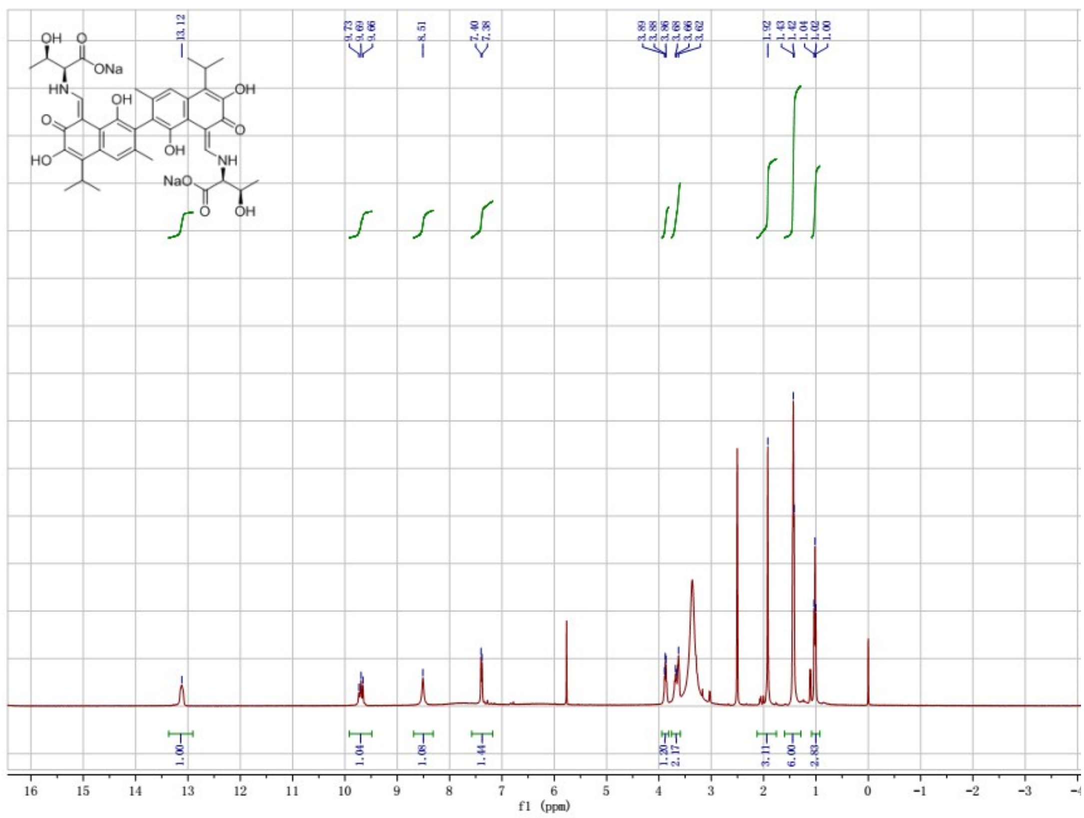
HRMS of compound 15.



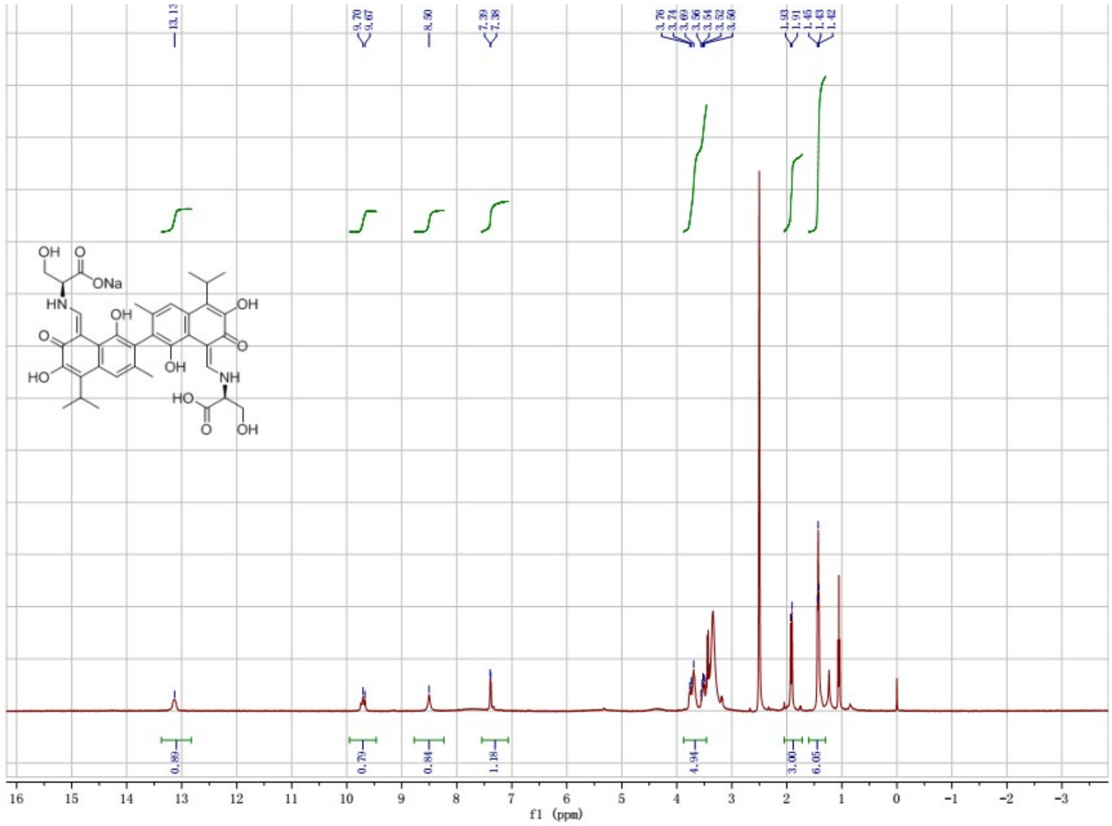
^{1}H NMR spectrum of compound 16.



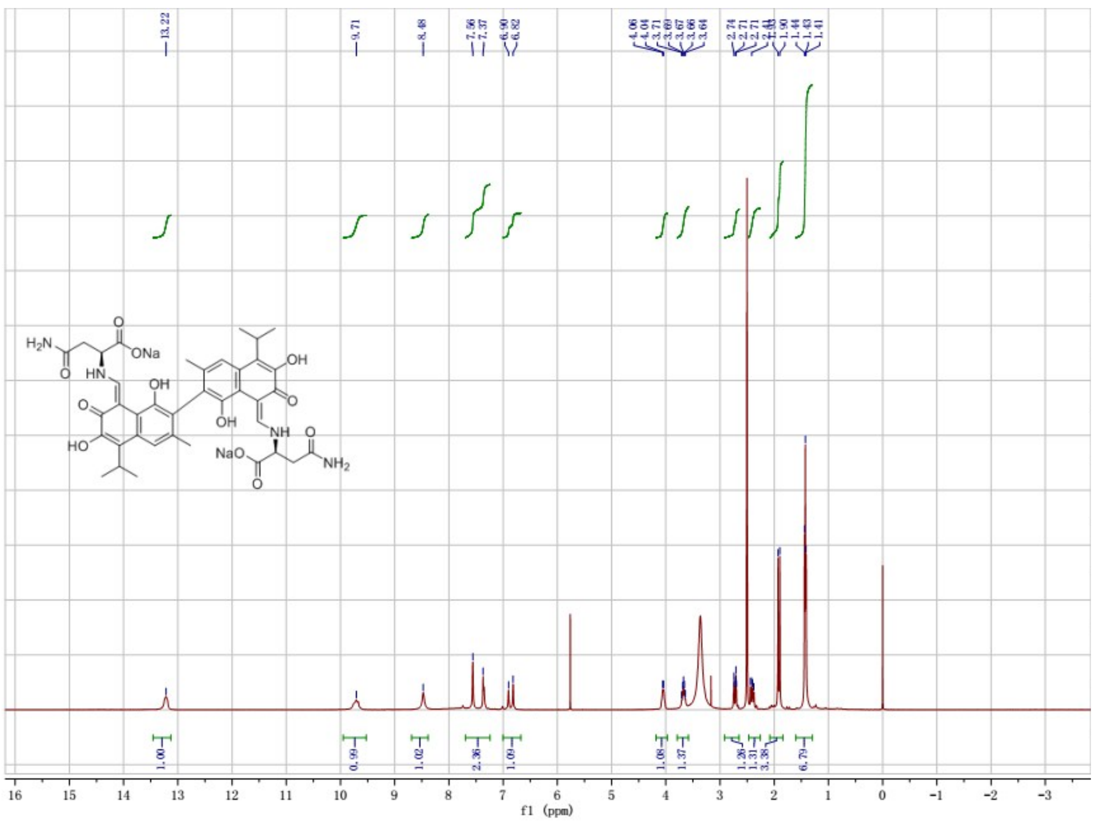
^{1}H NMR spectrum of compound 17.



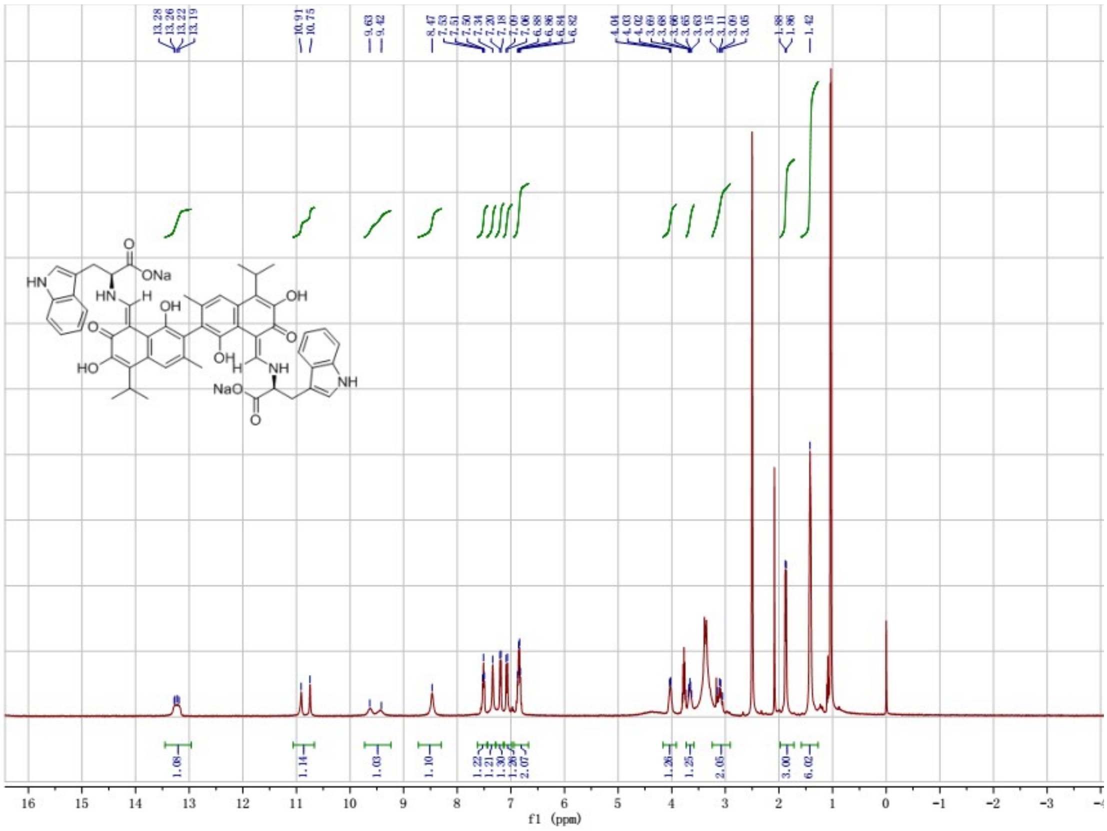
^{1}H NMR spectrum of compound 18.



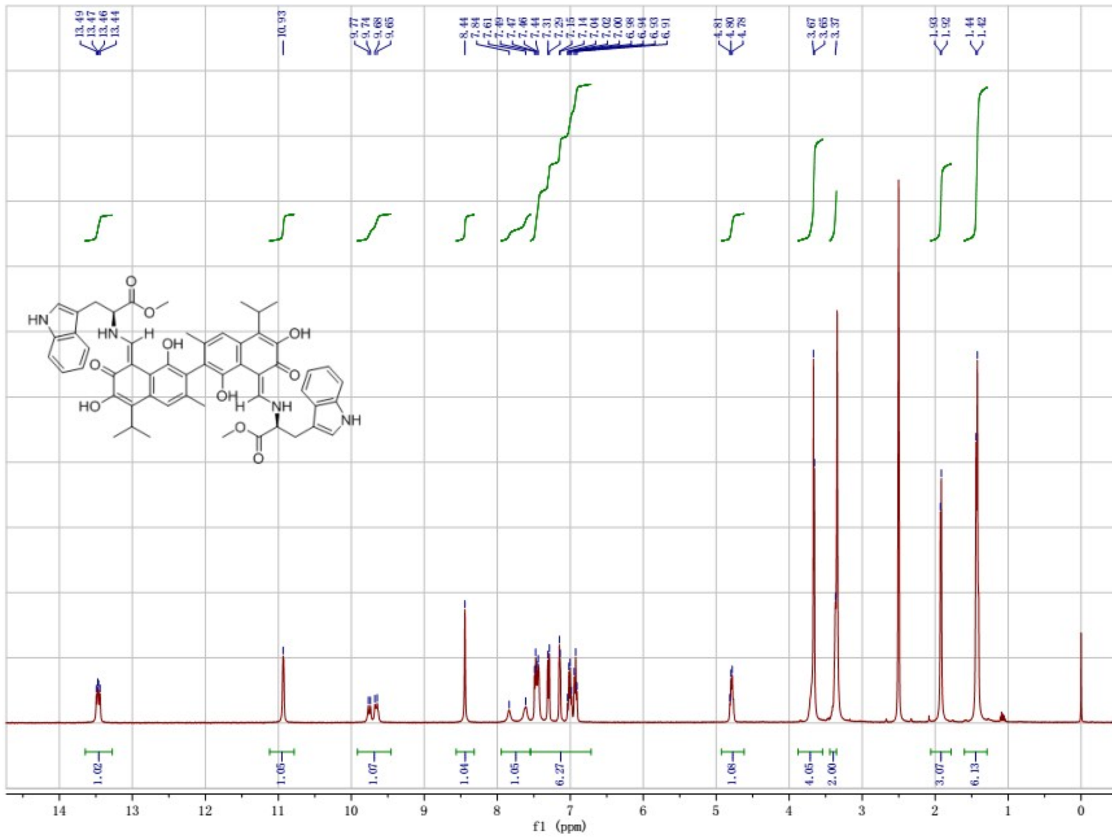
^{1}H NMR spectrum of compound 19.



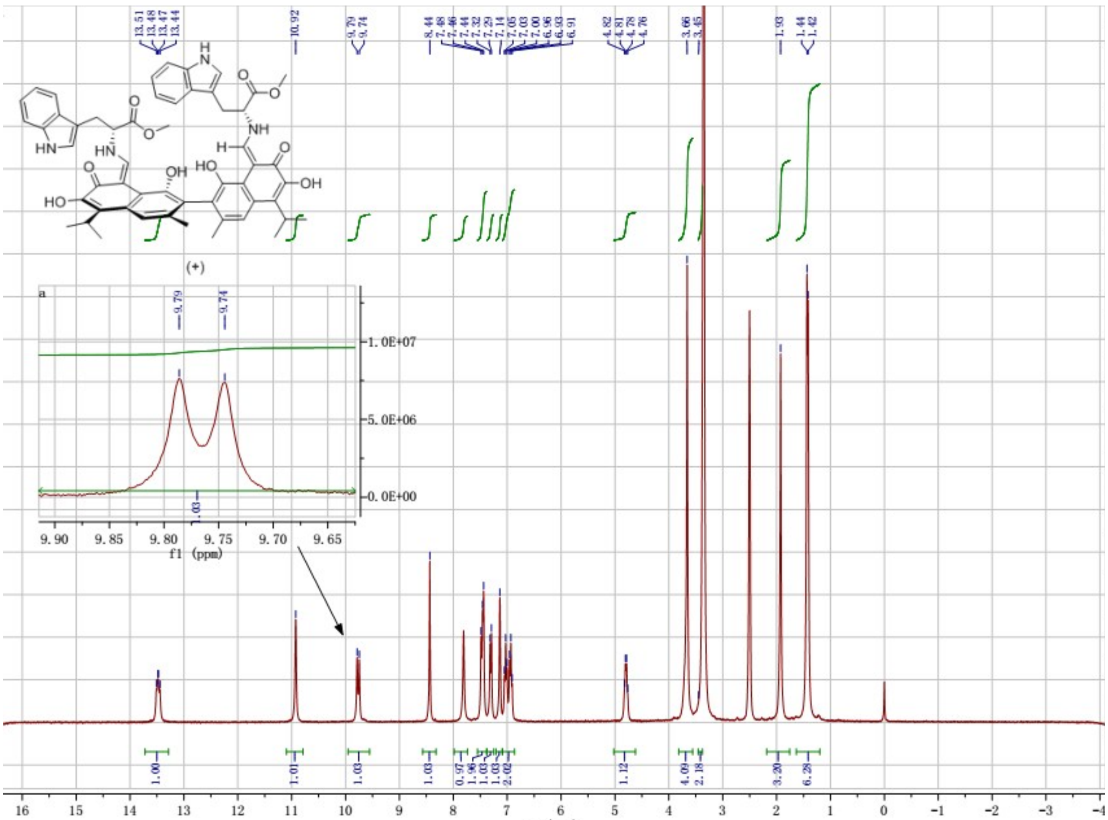
[1]H NMR spectrum of compound 20.



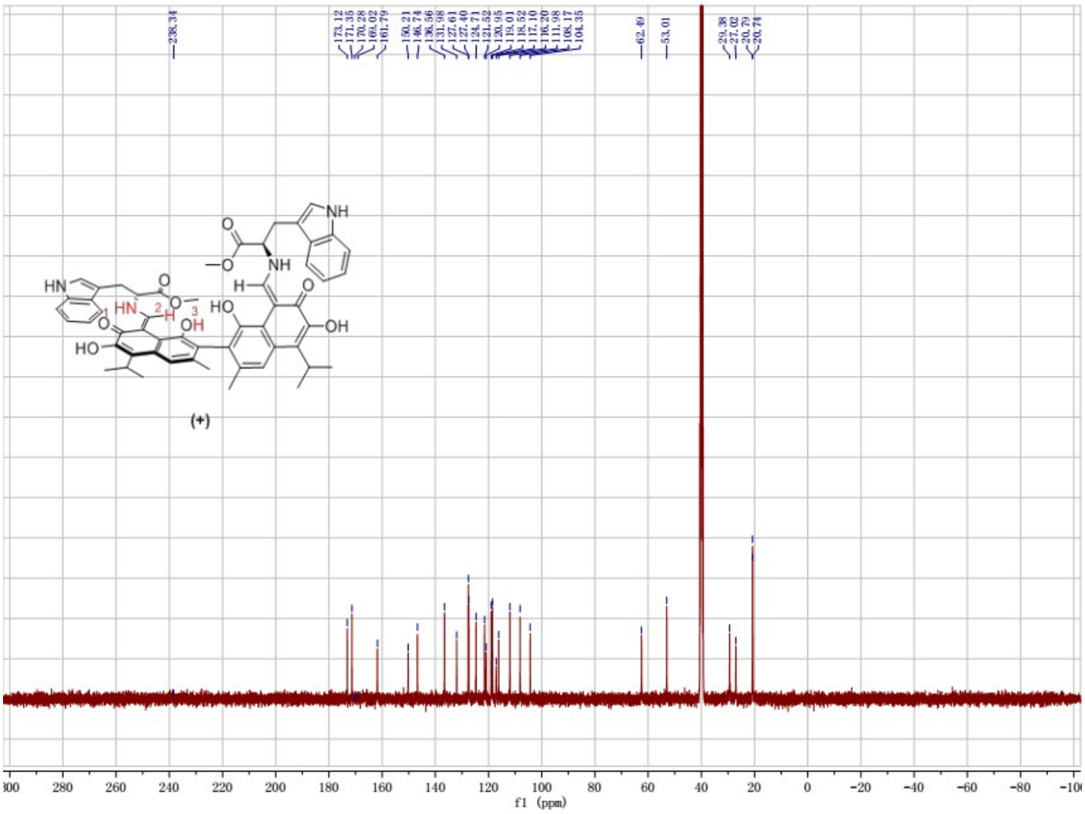
[1]H NMR spectrum of compound 21.



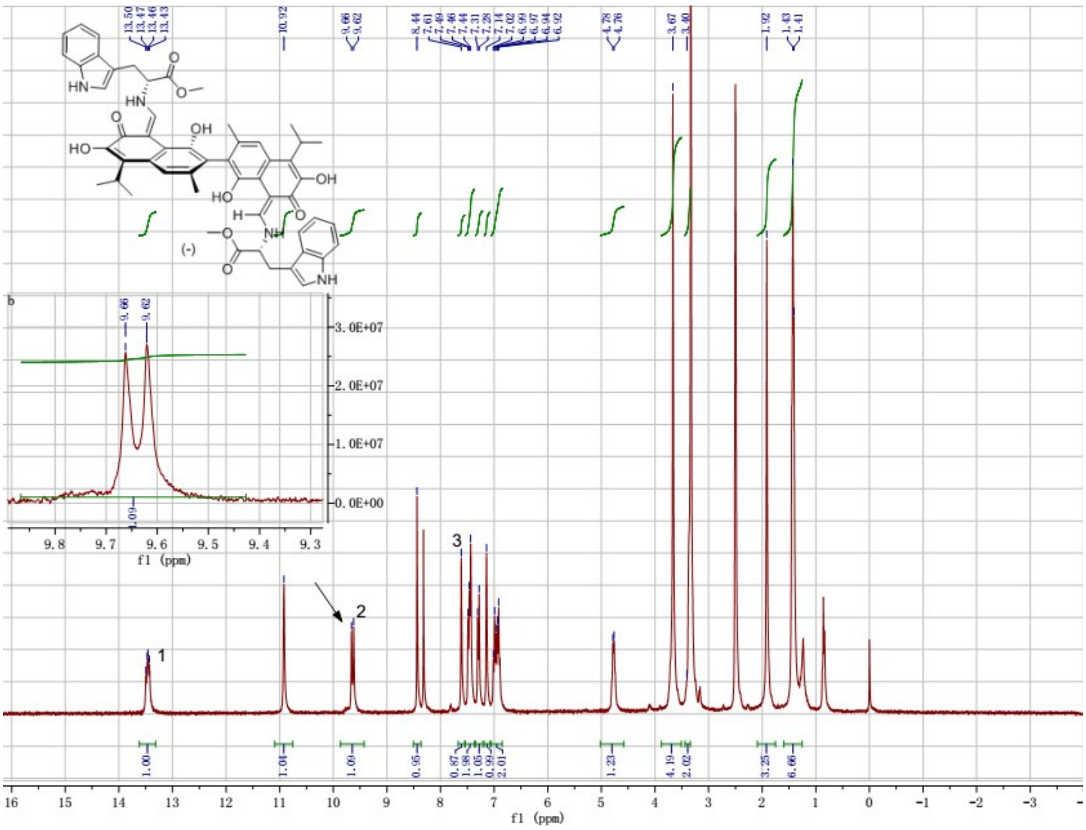
¹H NMR spectrum of compound 22.



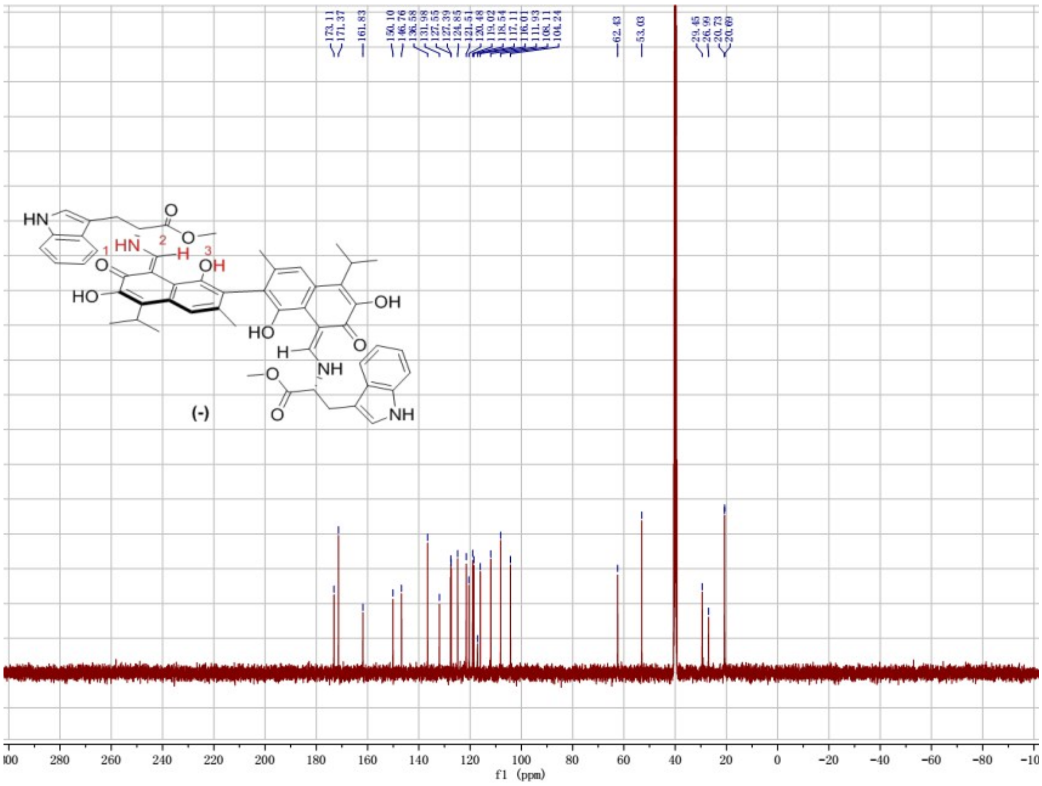
^{13}C NMR spectrum of compound 22.



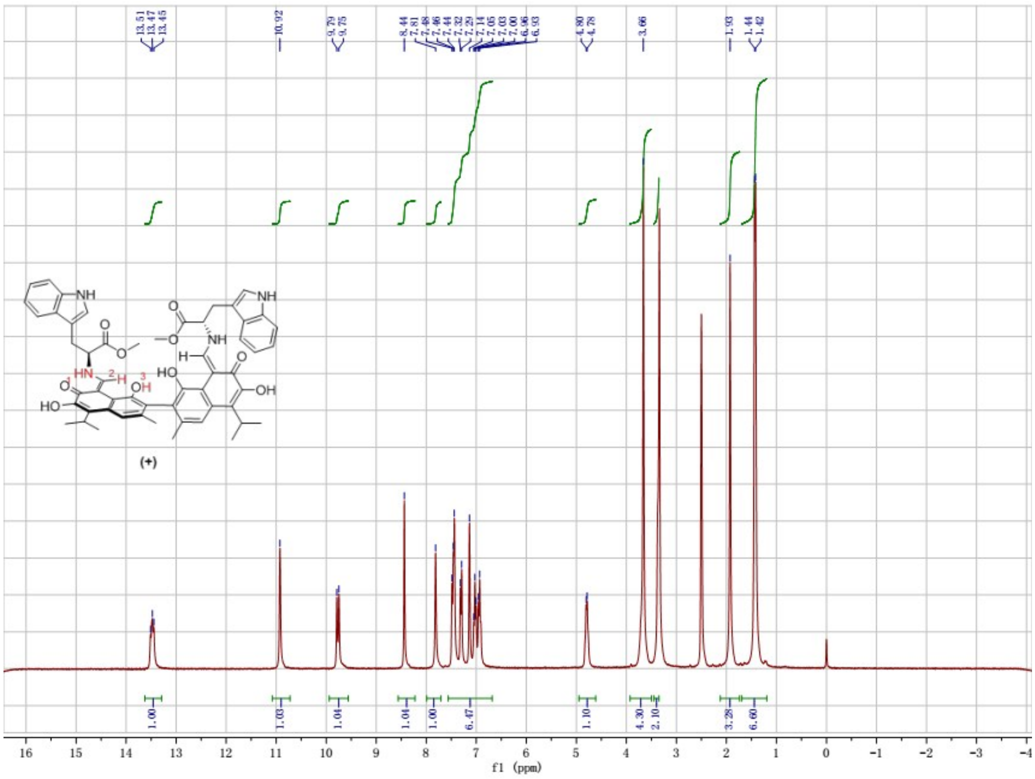
^{1}H NMR spectrum of compound 23.



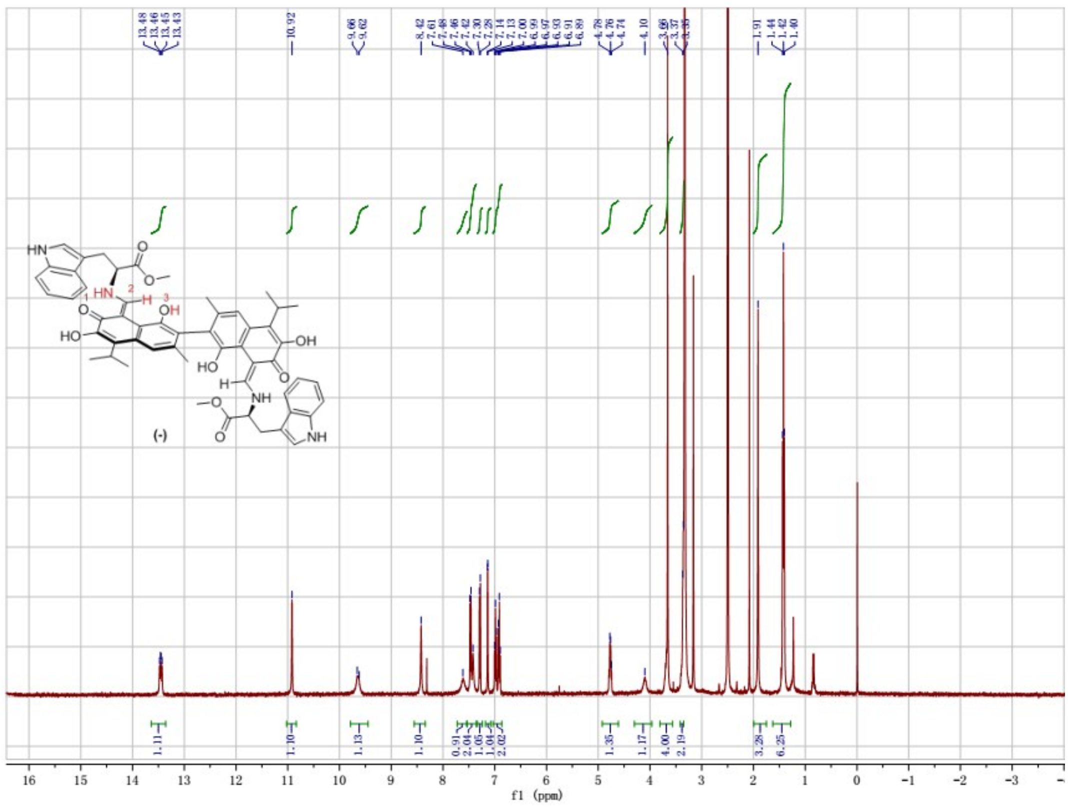
^{13}C NMR spectrum of compound 23.



[1]H NMR spectrum of compound 24.



[1]H NMR spectrum of compound 25.



^{1}H NMR spectrum of compound 26.