Multi-component Cascade Reactions of HKAs: Synthesis of Highly Functionalized 5*H*-Chromeno[4,3-*d*]pyrimidines

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Supporting Information

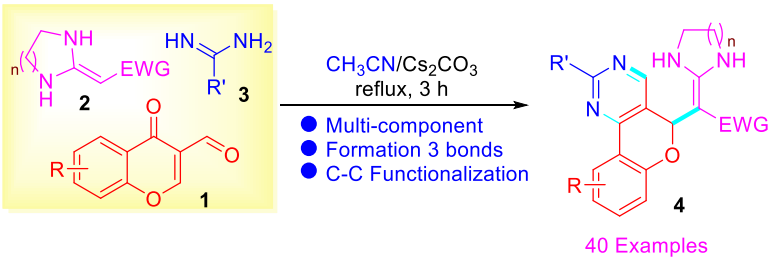
Table of Contents

General Information

All compounds were fully characterised by spectroscopic data. The NMR spectra were recorded on a Bruker DRX600. Chemical shifts (δ) are expressed in ppm, J values are given in Hz, and deuterated Chloroform-*d* were used as solvent. IR spectra were recorded on a FT-IR Thermo Nicolet Avatar 360 using a KBr pellet. The reactions were monitored by thin layer chromatography (TLC) using silica gel GF_{254}. The melting points were determined on a XT-4A melting point apparatus and are uncorrected; HRMS were performed on an Agilent LC/Msd TOF instrument.

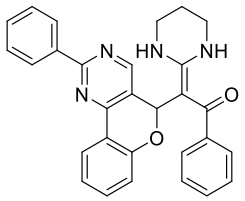
The materials were purchased from Adamas-beta Corporation Limited. All chemicals and solvents were used as received without further purification unless otherwise stated. HKAs **1** were prepared according to the literature.[1]

General Procedure for the Synthesis of 5*H*-Chromeno[4,3-*d*]-pyrimidines 4a-4n'



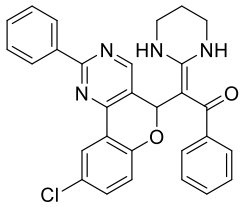
A 25-mL round bottom flask was charged with the 3-formylchromone **1** (0.22 mmol), the HKA **2** (0.2 mmol), and acetonitrile (4 mL). While stirring, the amidine hydrochloride **2** (0.22 mmol) were added to the mixture, which was refluxed until completion of the reaction while monitoring by thin-layer chromatography (TLC, approximately 3 hours). After cooling the reaction mixture to room temperature, the product and cesium salts precipitated out of solution and were collected by suction filtration. The product was isolated from the cesium salts after adding dichloromethane (DCM) to the filter cake to dissolve the product, and the filtrate was recrystallized by DCM to afford the white compounds **4a–4n'**.

1-Phenyl-2-(2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4a)



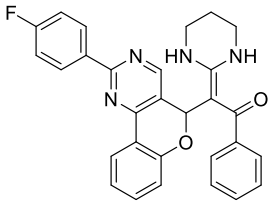
White solid (68mg, 74%); Mp: 260.2–260.6 ℃; IR (KBr): 3403, 1589, 1537, 1393, 1342, 1255, 1195, 1108, 759 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.33 (s, 1H, NH), 8.61 (d, *J* = 0.9 Hz, 1H, ArH), 8.54 (dd, *J* = 7.5, 2.2 Hz, 2H, ArH), 8.37 (dd, *J* = 7.7, 1.5 Hz, 1H, ArH), 7.53–7.47 (m, 3H, ArH), 7.47–7.44 (m, 2H, ArH), 7.43 – 7.37 (m, 1H, ArH), 7.26 (q, *J* = 7.6, 6.8 Hz, 3H, ArH), 7.15 (t, *J* = 7.9 Hz, 1H, ArH), 7.07 (d, *J* = 8.1 Hz, 1H, ArH), 6.14 (d, *J* = 0.9 Hz, 1H, CH), 5.53 (s, 1H, NH), 3.58–2.98 (m, 4H, CH_2), 1.98–1.90 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.6, 164.2, 160.2, 158.0, 156.9, 153.8, 142.4, 137.6, 133.3, 130.8, 128.6, 128.5, 128.2, 128.2, 126.6, 125.5, 124.5, 122.8, 122.0, 117.8, 85.1, 78.5, 39.3–37.7 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{24}N_4O_2$ [$(M+H)^+$], 461.1972; found, 461.1973.

2-(9-Chloro-2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-phenyl-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4b)



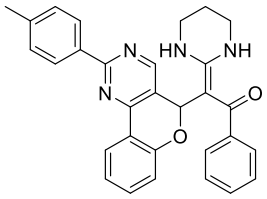
White solid (78mg, 70%); Mp: 248.1–248.5 ℃; IR (KBr): 3417, 3367, 3323, 1609, 1436, 1391, 1105, 879, 698, 667 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.62 (d, 1H, ArH), 8.53 (dd, *J* = 6.6, 3.1 Hz, 2H, ArH), 8.30 (d, *J* = 2.6 Hz, 1H, ArH), 7.51 (dd, *J* = 5.1, 1.9 Hz, 3H, ArH), 7.45 (dd, *J* = 7.3, 2.0 Hz, 2H, ArH), 7.35 (dd, *J* = 8.7, 2.6 Hz, 1H, ArH), 7.30–7.24 (m, 3H, ArH), 7.02 (d, *J* = 8.7 Hz, 1H, ArH), 6.12 (s, 1H, CH), 5.42 (s, 1H, NH), 3.60–3.01 (m, 4H, CH_2), 1.99–1.94 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.8, 164.4, 160.1, 156.5, 155.9, 154.1, 142.3, 137.3, 133.0, 131.0, 128.7, 128.6, 128.2, 128.1, 126.6, 125.1, 124.4, 123.2, 119.3, 84.8, 78.8, 39.6–37.5 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{23}ClN_4O_2$ [$(M+H)^+$], 495.1582; found, 495.1588.

2-(2-(4-Fluorophenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-phenyl-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one（4c）



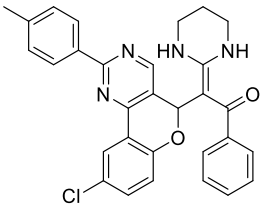
White solid (69mg, 72%); Mp: 241.1–241.6 ℃; IR (KBr): 3425, 3391, 1607, 1418, 1391, 1344, 1141, 1106, 760, 608 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.59 (s, 1H, ArH), 8.54 (dd, *J* = 8.7, 5.7 Hz, 2H, ArH), 8.36 – 8.32 (m, 2H, ArH), 7.47–7.44 (m, 2H, ArH), 7.44–7.40 (m, 1H, ArH), 7.26 (q, *J* = 6.0 Hz, 3H, ArH), 7.19–7.13 (m, 3H, ArH), 7.08 (d, *J* = 8.2 Hz, 1H, ArH), 6.13 (s, 1H, CH), 5.53 (s, 1H, NH), 3.50–3.16 (m, 4H, CH_2), 1.99–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.7, 164.8 (d, J_1 = 250.4 Hz), 163.3, 160.2, 158.0, 157.0, 153.8, 142.4, 133.8, 133.8, 133.4, 130.3 (d, J_3 = 8.7 Hz), 128.5, 128.2, 126.6, 125.5, 124.4, 122.8, 121.9, 117.9, 115.5 (d, J_2 = 22.4 Hz), 85.1, 78.4, 39.4–37.7 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{23}FN_4O_2$ [$(M+H)^+$], 479.1878; found, 479.1874.

1-Phenyl-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-2-(2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)ethan-1-one (4d)



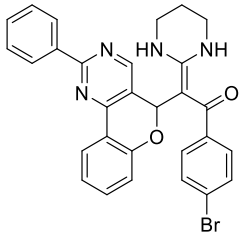
Yellow solid (72mg, 76%); Mp: 225.4–225.8 ℃; IR (KBr): 3404, 1614, 1585, 1418, 1380, 1191, 1103, 749, 664, 616 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.33 (s, 1H, NH), 8.59 (d, *J* = 0.8 Hz, 1H, ArH), 8.43 (d, *J* = 8.2 Hz, 2H, ArH), 8.37 (dd, *J* = 7.7, 1.5 Hz, 1H, ArH), 7.46–7.44 (m, 2H, ArH), 7.43–7.39 (m, 1H, ArH), 7.30 (d, *J* = 8.1 Hz, 2H, ArH), 7.28–7.23 (m, 3H, ArH), 7.15 (t, *J* = 7.8 Hz, 1H, ArH), 7.07 (d, *J* = 8.1 Hz, 1H, ArH), 6.12 (s, 1H, CH), 5.53 (s, 1H, NH), 3.53–3.11 (m, 4H, CH_2), 2.43 (s, 3H, CH_3), 2.00–1.92 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.6, 164.3, 160.2, 158.0, 156.8, 153.7, 142.4, 141.0, 134.9, 133.2, 129.3, 128.5, 128.2, 128.1, 126.6, 125.5, 124.1, 122.8, 122.0, 117.8, 85.1, 78.4, 39.0 – 37.9 (m), 21.5, 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{30}H_{26}N_4O_2$ [$(M+H)^+$], 475.2129; found, 475.2128.

2-(9-Chloro-2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-phenyl-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4e)



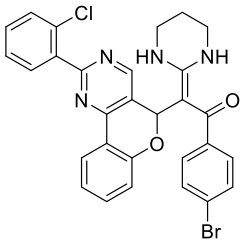
White solid (81 mg, 80%); Mp: 231.0–231.5 ℃; IR (KBr): 3410, 1609, 1581, 1186, 1102, 771, 657, 607 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.59 (d, *J* = 0.9 Hz, 1H, ArH), 8.41 (d, *J* = 8.2 Hz, 2H, ArH), 8.29 (d, *J* = 2.6 Hz, 1H, ArH), 7.44 (dd, *J* = 7.4, 2.0 Hz, 2H, ArH), 7.34 (dd, *J* = 8.7, 2.6 Hz, 1H, ArH), 7.30 (d, *J* = 8.0 Hz, 2H, ArH), 7.28–7.25 (m, 3H, ArH), 7.01 (d, *J* = 8.7 Hz, 1H, ArH), 6.10 (d, *J* = 0.8 Hz, 1H, CH), 5.42 (s, 1H, NH), 3.52–3.14 (m, 4H, CH_2), 2.43 (s, 3H, CH_3), 1.98–1.94 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.8, 164.5, 160.1, 156.5 , 155.8, 154.0, 142.3, 141.3, 134.6, 132.9, 129.4, 128.6, 128.2, 128.2, 128.1, 126.6, 125.1, 124.0, 123.3, 119.3, 84.8, 78.8, 39.3–37.7 (m), 21.5, 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{30}H_{25}ClN_4O_2$ $[(M+H)^+]$, 509.1739; found, 509.1743.

1-(4-Bromophenyl)-2-(2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4f)



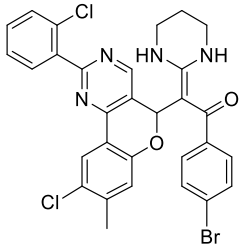
White solid (81mg, 75%); Mp: 290.2–290.8 ℃; IR (KBr): 3391, 3344, 1606, 1422, 1389, 1193, 1131, 1107, 722 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.22 (s, 1H, NH), 8.58 (s, 1H, ArH), 8.54 (dd, *J* = 6.6, 3.0 Hz, 2H, ArH), 8.39 (dd, *J* = 7.7, 1.4 Hz, 1H, ArH), 7.51 (dd, *J* = 5.1, 1.7 Hz, 3H, ArH), 7.46–7.42 (m, 1H, ArH), 7.40 (d, *J* = 8.5 Hz, 2H, ArH), 7.35 (d, *J* = 8.4 Hz, 2H, ArH), 7.18 (t, *J* = 7.5 Hz, 1H, ArH), 7.07 (d, *J* = 8.1 Hz, 1H, ArH), 6.06 (s, 1H, CH), 5.54 (s, 1H, NH), 3.58–3.11 (m, 4H, CH_2), 1.99–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.2, 164.4, 160.2, 157.9, 156.9, 153.7, 141.2, 137.5, 133.4, 131.4, 130.8, 128.6, 128.4, 128.2, 125.6, 124.3, 123.0, 122.7, 122.0, 117.8, 85.2, 78.3, 39.2–37.8 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{23}BrN_4O_2$ $[(M+H)^+]$, 539.1077; found, 539.1075.

1-(4-Bromophenyl)-2-(2-(2-chlorophenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4g)



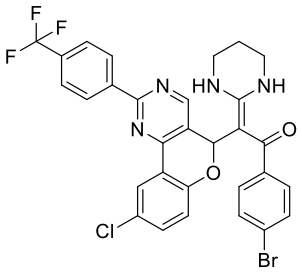
White solid (76 mg, 66%); Mp: 256.3–256.9 ℃; IR (KBr): 3424, 3366, 1612, 1587, 1421, 1390, 1193, 1134, 1105 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.20 (s, 1H, NH), 8.61 (s, 1H, ArH), 8.30 (dd, *J* = 7.7, 1.3 Hz, 1H, ArH), 7.86 (dd, *J* = 6.0, 3.4 Hz, 1H, ArH), 7.52 (dd, *J* = 5.8, 3.4 Hz, 1H, ArH), 7.45–7.43 (m, 1H, ArH), 7.42 (d, *J* = 8.3 Hz, 2H, ArH), 7.40–7.37 (m, 4H, ArH), 7.14 (t, *J* = 7.5 Hz, 1H, ArH), 7.08 (d, *J* = 8.2 Hz, 1H, ArH), 6.09 (s, 1H, CH), 5.54 (s, 1H, NH), 3.39 (s, 4H, CH_2), 2.00–1.96 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.3, 165.1, 160.2, 157.9, 157.0, 153.3, 141.1, 137.5, 133.6, 133.0, 131.9, 131.4, 130.8, 130.5, 128.5, 126.8, 125.9, 124.4, 123.1, 122.9, 121.7, 117.7, 85.0, 78.3, 39.0–38.1 (m), 20.1; HRMS (TOF ES^{+}): *m/z* calcd for $C_{29}H_{22}BrClN_4O_2$ [$(M+H)^{+}$], 573.0687; found, 573.0688.

1-(4-Bromophenyl)-2-(9-chloro-2-(2-chlorophenyl)-8-methyl-5*H*-chromeno[4,3-*d*] pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4h)



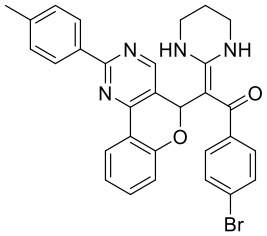
Yellow solid (92 mg, 74%); Mp: 243.5–244.1 ℃; IR (KBr): 3466, 3409, 1612, 1582, 1422, 1392, 1145, 1104, 706, 641 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.17 (s, 1H, NH), 8.59 (s, 1H, ArH), 8.22 (s, 1H, ArH), 7.87–7.82 (m, 1H, ArH), 7.54–7.50 (m, 1H, ArH), 7.43 (d, *J* = 8.3 Hz, 2H, ArH), 7.41–7.38 (m, 2H, ArH), 7.36 (d, *J* = 8.2 Hz, 2H, ArH), 6.97 (s, 1H, ArH), 6.05 (s, 1H, CH), 5.48 (s, 1H, NH), 3.49–3.23 (m, 4H, CH_2), 2.41 (s, 3H, CH_3), 2.00–1.95 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.4, 165.2, 160.1, 156.2, 153.4, 142.2, 141.0, 137.3, 133.0, 131.9, 131.4, 130.8, 130.6, 128.9, 128.5, 126.8, 125.7, 124.0, 122.9, 120.6, 119.9, 84.8, 78.6, 39.1–38.1 (m), 20.7, 20.1; HRMS (TOF ES^{+}): *m/z* calcd for $C_{30}H_{23}BrCl_2N_4O_2$ [$(M+H)^{+}$], 621.0454; found, 621.0449.

1-(4-Bromophenyl)-2-(9-chloro-2-(4-(trifluoromethyl)phenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4i)



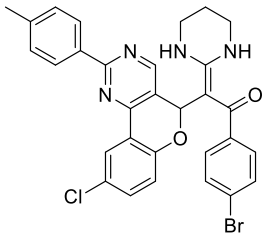
Yellow solid (86 mg, 67%); Mp: 245.2–245.6 ℃; IR (KBr): 3409, 1606, 1439, 1392, 1328, 1191, 1099, 647 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.20 (s, 1H, NH), 8.65 (d, *J* = 8.2 Hz, 2H, ArH), 8.61 (d, *J* = 1.0 Hz, 1H, ArH), 8.31 (d, *J* = 2.6 Hz, 1H, ArH), 7.77 (d, *J* = 8.3 Hz, 2H, ArH), 7.45–7.37 (m, 3H, ArH), 7.34 (d, *J* = 8.4 Hz, 2H, ArH), 7.04 (d, *J* = 8.7 Hz, 1H, ArH), 6.05 (d, *J* = 0.9 Hz, 1H, CH), 5.40 (s, 1H, NH), 3.56–3.19 (m, 4H, CH_2), 2.01–1.96 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.4, 163.1, 160.1, 156.3 (d, J_2 = 21.6 Hz), 154.1, 141.0, 140.5, 133.4, 132.7, 132.5, 131.4, 128.5, 128.5, 128.4, 125.5 (d, J_3 = 3.7 Hz), 125.2, 125.0, 123.2, 122.9 (d, J_3 = 5.8 Hz), 119.3, 84.7, 78.7, 39.5–37.3 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{30}H_{21}BrClF_3N_4O_2$ [$(M+H)^+$], 641.0561; found, 641.0558.

1-(4-Bromophenyl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-2-(2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)ethan-1-one (4j)



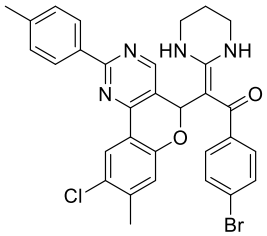
White solid (73 mg, 68%); Mp: 267.6–268.3 ℃; IR (KBr): 3411, 2962, 1419, 1391, 1195, 1106, 758, 656, 614 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.20 (s, 1H, NH), 8.56 (s, 1H, ArH), 8.43 (d, *J* = 8.1 Hz, 2H, ArH), 8.38 (dd, *J* = 7.7, 1.5 Hz, 1H, ArH), 7.45–7.42 (m, 1H, ArH), 7.40 (d, *J* = 8.5 Hz, 2H, ArH), 7.34 (d, *J* = 8.4 Hz, 2H, ArH), 7.31 (d, *J* = 8.0 Hz, 2H, ArH), 7.17 (t, *J* = 7.1 Hz, 1H, ArH), 7.07 (d, *J* = 8.1 Hz, 1H, ArH), 6.05 (s, 1H, CH), 5.54 (s, 1H, NH), 3.50–3.28 (m, 4H, CH_2), 2.44 (s, 3H, CH_3), 1.99–1.95 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.2, 164.5, 160.2, 157.9, 156.8, 153.6, 141.1, 134.8, 133.3, 131.3, 129.3, 128.4, 128.1, 125.6, 123.9, 122.9, 122.7, 122.0, 117.7, 85.2, 78.3, 39.1–37.9 (m), 21.5, 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{30}H_{25}BrN_4O_2$ [$(M+H)^+$], 553.1234; found, 553.1237.

1-(4-Bromophenyl)-2-(9-chloro-2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4k)



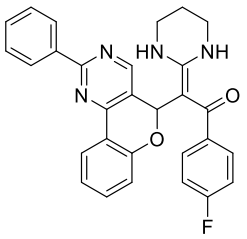
White solid (89 mg, 76%); Mp: 269.1–269.6 ℃; IR (KBr): 3428, 3284, 1606, 1388, 1349, 1192, 1132, 1105, 714, 603 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.19 (s, 1H, NH), 8.57 (s, 1H, ArH), 8.42 (d, *J* = 8.0 Hz, 2H, ArH), 8.32 (d, *J* = 2.4 Hz, 1H, ArH), 7.41 (d, *J* = 8.2 Hz, 2H, ArH), 7.37 (dd, *J* = 8.7, 2.4 Hz, 1H, ArH), 7.34 –7.30 (m, 4H, ArH), 7.01 (d, *J* = 8.7 Hz, 1H, ArH), 6.03 (s, 1H, CH), 5.43 (s, 1H, NH), 3.51–3.19 (m, 4H, CH_2), 2.44 (s, 3H, CH_3), 2.00–1.95 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.3, 164.6, 160.1, 156.3, 155.9, 153.9, 141.4, 141.1, 134.5, 133.0, 131.4, 129.4, 128.4, 128.3, 128.2, 125.2, 123.8, 123.3, 122.8, 119.2, 84.9, 78.7, 21.5, 20.1; HRMS (TOF ES^{+}): *m/z* calcd for $C_{30}H_{24}BrClN_4O_2$ [$(M+H)^{+}$], 587.0844; found, 587.0839.

1-(4-Bromophenyl)-2-(9-chloro-8-methyl-2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4l)



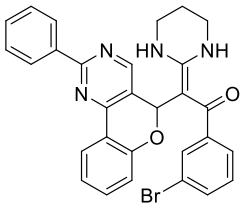
White solid (77 mg, 64%); Mp: 279.1–279.6 ℃; IR (KBr): 3379, 1607, 1420, 1391, 1194, 1129, 1104, 724, 647, 601 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.22 (s, 1H, NH), 8.54 (s, 1H, ArH), 8.42 (d, *J* = 8.1 Hz, 2H, ArH), 8.29 (s, 1H, ArH), 7.41 (d, *J* = 8.3 Hz, 2H, ArH), 7.32 (dd, *J* = 8.0, 4.3 Hz, 4H, ArH), 6.95 (s, 1H, ArH), 6.00 (s, 1H, CH), 5.44 (s, 1H, NH), 3.47–3.23 (m, 4H, CH_2), 2.44 (s, 3H, CH_3), 2.42 (s, 3H, CH_3), 1.99–1.95 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.3, 160.1, 156.2, 156.0, 153.7, 141.8, 141.3, 141.1, 134.6, 131.4, 129.4, 128.7, 128.4, 128.2, 125.4, 123.5, 122.8, 121.0, 119.9, 85.0, 78.6 , 21.5, 20.7, 20.1; HRMS (TOF ES^{+}): *m/z* calcd for $C_{31}H_{26}BrClN_4O_2$ [$(M+H)^{+}$], 601.1000; found, 601.0998.

1-(4-Fluorophenyl)-2-(2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4m)



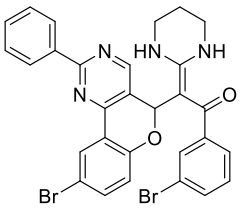
Yellow solid (64 mg, 67%); Mp: 268.8.6–269.3 ℃; IR (KBr): 3398, 1605, 1372, 1193, 1122, 712, 668 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*): δ = 12.25 (s, 1H, NH), 8.59 (s, 1H, ArH), 8.54 (dd, *J* = 6.6, 2.9 Hz, 2H, ArH), 8.39 (dd, *J* = 7.7, 1.3 Hz, 1H, ArH), 7.50 (dd, *J* = 5.2, 1.7 Hz, 3H, ArH), 7.47 (dd, *J* = 8.4, 5.6 Hz, 2H, ArH), 7.45–7.42 (m, 1H, ArH), 7.17 (t, *J* = 7.5 Hz, 1H, ArH), 7.08 (d, *J* = 8.1 Hz, 1H, ArH), 6.95 (t, *J* = 8.7 Hz, 2H, ArH), 6.10 (s, 1H, CH), 5.53 (s, 1H, NH), 3.53–3.15 (m, 4H, CH_2), 2.00–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*): δ = 187.4, 164.3, 163.7, 162.1, 160.2, 157.42 (d, J_1 = 153.8 Hz), 153.7, 138.5 (d, J_2 = 13.6 Hz), 137.5, 133.4, 130.84, 128.7 (d, J_3 = 8.2 Hz), 128.6, 128.2, 125.6, 124.4, 122.9, 122.0, 117.8, 115.1 (d, J_2 = 21.4 Hz), 85.1, 78.4, 39.2–37.8 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{23}FN_4O_2$ [$(M+H)^+$], 479.1878; found, 479.1875.

1-(4-Fluorophenyl)-2-(2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4n)



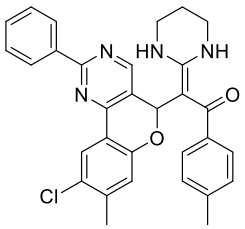
White solid (77 mg, 71%); Mp: 246.9–247.3 ℃; IR (KBr): 3392, 1611, 1422, 1391, 1195, 1132, 1105, 696, 612 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.14 (s, 1H, NH), 8.58 (s, 1H, ArH), 8.56–8.52 (m, 2H, ArH), 8.38 (d, *J* = 7.6 Hz, 1H, ArH), 7.68 (s, 1H, ArH), 7.50 (d, *J* = 4.3 Hz, 3H, ArH), 7.44 (t, *J* = 7.4 Hz, 1H, ArH), 7.38 (d, *J* = 7.7 Hz, 2H, ArH), 7.17 (t, *J* = 7.5 Hz, 1H, ArH), 7.15–7.09 (m, 2H, ArH), 6.05 (s, 1H, CH), 5.55 (s, 1H, NH), 3.53–3.16 (m, 4H, CH_2), 1.97 (p, *J* = 5.3 Hz, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 186.6, 164.4, 160.1, 157.9, 156.9, 153.7, 144.3, 137.5, 133.4, 131.6, 130.8, 130.1, 129.8, 128.6, 128.2, 125.6, 125.2, 124.3, 123.0, 122.0, 117.9, 85.2, 78.2, 38.9–38.2 (m), 20.1; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{23}BrN_4O_2$ [$(M+H)^+$], 539.1077; found, 539.1081.

2-(9-Bromo-2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-(3-bromophenyl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4o)



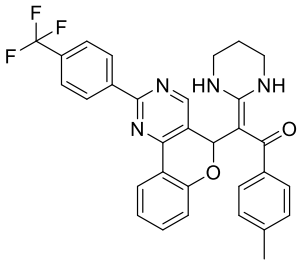
White solid (80 mg, 65%); Mp: 254.1–254.5 ℃; IR (KBr): 3380, 1604, 1585, 1433, 1404, 1327, 1103, 715, 649, 605 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.09 (s, 1H, NH), 8.58 (s, 1H, ArH), 8.53 (dd, *J* = 6.6, 3.0 Hz, 2H, ArH), 8.46 (d, *J* = 2.4 Hz, 1H, ArH), 7.67 (s, 1H, ArH), 7.55–7.49 (m, 4H, ArH), 7.38 (dd, *J* = 15.8, 7.8 Hz, 2H, ArH), 7.14 (t, *J* = 7.8 Hz, 1H, ArH), 7.00 (d, *J* = 8.6 Hz, 1H, ArH), 6.03 (d, *J* = 1.1 Hz, 1H), 5.43 (s, 1H, NH), 3.54–3.18 (m, 4H, CH_2), 2.01–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 186.8, 164.5, 160.1, 156.8, 155.8, 154.0, 144.1, 137.2, 135.9, 131.7, 131.0, 130.1, 129.8, 128.6, 128.2, 128.1, 125.2, 124.1, 123.7, 122.4, 119.7, 115.6, 84.9, 78.6, 39.1–37.9 (m), 20.1; HRMS (TOF ES^{+}): *m/z* calcd for $C_{29}H_{22}Br_2N_4O_2$ [$(M+H)^{+}$], 619.0162; found, 619.0159.

2-(9-Chloro-8-methyl-2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4p)



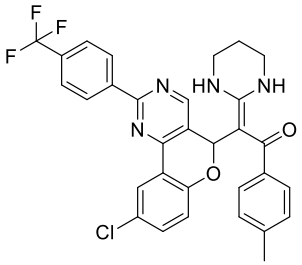
White solid (72 mg, 69%); Mp: 267.0–267.6 ℃; IR (KBr): 3415, 3384, 3344, 1604, 1390, 1195, 1108, 756, 719, 682, 606 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.33 (s, 1H, NH), 8.59 (s, 1H, ArH), 8.53 (dd, *J* = 7.2, 2.3 Hz, 2H, ArH), 8.28 (s, 1H, ArH), 7.51 (dd, *J* = 5.2, 1.7 Hz, 3H, ArH), 7.34 (d, *J* = 7.9 Hz, 2H, ArH), 7.08 (d, *J* = 7.9 Hz, 2H, ArH), 6.96 (s, 1H, ArH), 6.14 (s, 1H, CH), 5.40 (s, 1H, NH), 3.58–3.06 (m, 4H, CH_2), 2.41 (s, 3H, CH_3), 2.27 (s, 3H, CH_3), 2.00–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.9, 164.3, 160.2, 156.4, 156.1, 153.9, 141.8, 139.5, 138.5, 137.4, 130.9, 128.8, 128.6, 128.5, 128.2, 126.6, 125.3, 124.2, 121.0, 120.0, 84.8, 78.9, 21.2, 20.6, 20.2; HRMS (TOF ES^{+}): *m/z* calcd for $C_{31}H_{27}ClN_4O_2$ [$(M+H)^{+}$], 523.1895; found, 523.1890.

2-(Tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)-2-(2-(4-(trifluoromethyl)phenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)ethan-1-one (4q)



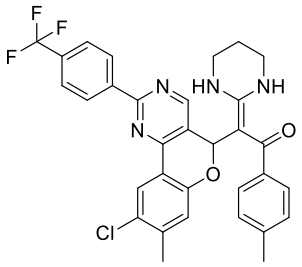
White solid (73 mg, 67%); Mp: 218.3–218.7 ℃; IR (KBr): 3393, 1609, 1423, 1328, 1122, 872, 767, 615 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.34 (s, 1H, NH), 8.65 (d, *J* = 8.1 Hz, 2H, ArH), 8.62 (d, *J* = 1.1 Hz, 1H, ArH), 8.36 (dd, *J* = 7.7, 1.5 Hz, 1H, ArH), 7.75 (d, *J* = 8.3 Hz, 2H, ArH), 7.47–7.42 (m, 1H, ArH), 7.37 (d, *J* = 8.0 Hz, 2H, ArH), 7.19–7.15 (m, 1H, ArH), 7.11–7.06 (m, 3H, ArH), 6.20 (d, *J* = 0.9 Hz, 1H, CH), 5.49 (s, 1H, NH), 3.53–3.16 (m, 4H, CH_2), 2.27 (s, 3H, CH_3), 2.00–1.94 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.9, 162.8, 160.2, 158.1, 157.2 , 153.9, 140.9, 139.5, 138.5, 133.6, 132.4, 132.2, 128.8, 128.4, 126.7, 125.5, 125.5 (d, J_3 = 3.7 Hz), 124.2 (d, J_1 = 272.1 Hz), 122.9, 121.7, 117.9, 84.9, 78.6, 39.4–37.6 (m), 21.2, 20.2; HRMS (TOF ES^+): *m/z* calcd for $C_{31}H_{25}F_3N_4O_2$ $[(M+H)^+]$, 543.2002; found, 543.2000.

2-(9-Chloro-2-(4-(trifluoromethyl)phenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4r)



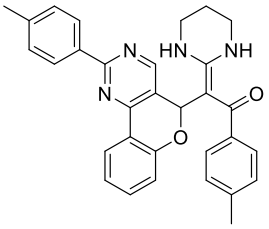
Yellow solid (89 mg, 71%); Mp: 214.8–215.6 ℃; IR (KBr): 3407, 3312, 1382, 1326, 1130, 1096, 779, 744, 605 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.65 (d, *J* = 8.2 Hz, 2H, ArH), 8.63 (d, *J* = 1.0 Hz, 1H, ArH), 8.29 (d, *J* = 2.6 Hz, 1H, ArH), 7.76 (d, *J* = 8.3 Hz, 2H, ArH), 7.39–7.35 (m, 3H, ArH), 7.08 (d, *J* = 7.9 Hz, 2H, ArH), 7.05 (d, *J* = 8.7 Hz, 1H, ArH), 6.18 (d, *J* = 0.9 Hz, 1H, CH), 5.39 (s, 1H, NH), 3.50–3.17 (m, 4H, CH_2), 2.28 (s, 3H, CH_3), 2.00–1.95 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 189.1, 163.0, 160.1, 156.6, 154.2, 140.6, 139.3, 138.7, 133.2, 132.6, 132.4, 128.8, 128.5, 128.2, 126.7, 125.5(d, J_3 = 7.4 Hz), 125.4, 125.1, 125.0, 123.2, 123.0, 119.4, 84.5, 79.0, 39.6–37.6 (m), 31.6, 22.6, 21.2, 20.2, 14.1; HRMS (TOF ES^+): *m/z* calcd for $C_{31}H_{24}ClF_3N_4O_2$ $[(M+H)^+]$, 577.1613; found, 577.1608.

2-(9-Chloro-8-methyl-2-(4-(trifluoromethyl)phenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4s)



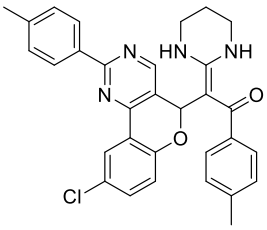
Yellow solid (86 mg, 73%); Mp: 219.2–219.6 ℃; IR (KBr): 3389, 1613, 1418, 1385, 1327, 1132, 749, 685, 608 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.64 (d, *J* = 8.1 Hz, 2H, ArH), 8.60 (d, *J* = 1.0 Hz, 1H, ArH), 8.26 (s, 1H, ArH), 7.76 (d, *J* = 8.3 Hz, 2H, ArH), 7.35 (d, *J* = 8.0 Hz, 2H, ArH), 7.08 (d, *J* = 7.9 Hz, 2H, ArH), 6.98 (s, 1H, ArH), 6.15 (d, *J* = 0.9 Hz, 1H, CH), 5.41 (s, 1H, NH), 3.49–3.19 (m, 4H, CH_2), 2.42 (s, 3H, CH_3), 2.28 (s, 3H, CH_3), 1.99–1.95 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 189.0, 162.9, 160.2, 156.4, 156.4, 154.0, 142.1, 140.7, 139.4, 138.6, 132.5, 132.3 , 128.8, 128.6, 128.5, 126.7, 125.5 (d, J_3 = 3.7 Hz), 125.3, 125.0, 123.2, 120.7, 120.1, 84.7, 78.86 , 39.9–37.3 (m), 21.2, 20.7, 20.2; HRMS (TOF ES^+): *m/z* calcd for $C_{32}H_{26}ClF_3N_4O_2$ [$(M+H)^+$], 591.1769; found, 591.1769.

2-(Tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)-2-(2-(p-tolyl)-5*H*-chromeno[4, 3-*d*]pyrimidin-5-yl)ethan-1-one (4t)



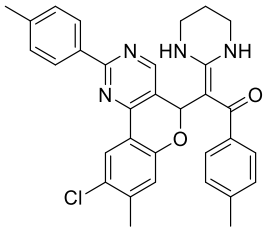
White solid (75 mg, 77%); Mp: 226.7–227.2 ℃; IR (KBr): 3433, 3391, 1611, 1419, 1387, 1125, 764, 714, 680, 623 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 12.36 (s, 1H, NH), 8.58 (d, *J* = 0.8 Hz, 1H, ArH), 8.43 (d, *J* = 8.1 Hz, 2H, ArH), 8.37 (dd, *J* = 7.7, 1.4 Hz, 1H, ArH), 7.44 – 7.39 (m, 1H, ArH), 7.36 (d, *J* = 8.0 Hz, 2H, ArH), 7.30 (d, *J* = 8.0 Hz, 2H, ArH), 7.15 (t, *J* = 7.5 Hz, 1H, ArH), 7.07 (dd, *J* = 7.6, 4.8 Hz, 3H, ArH), 6.17 (s, 1H, CH), 5.51 (s, 1H, NH), 3.52–3.11 (m, 4H, CH_2), 2.43 (s, 3H, CH_3), 2.26 (s, 3H, CH_3), 1.98–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.8, 164.3, 160.2, 158.1, 156.8, 153.8, 141.0, 139.6, 138.4, 134.9, 133.2, 129.3, 128.8, 128.1, 126.7, 125.5, 124.2, 122.7, 122.1, 117.8, 85.0, 78.6, 39.2–37.6 (m), 21.5, 21.2, 20.2; HRMS (TOF ES^+): *m/z* calcd for $C_{31}H_{28}N_4O_2$ [$(M+H)^+$], 489.2285; found, 489.2288.

2-(9-Chloro-2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimi din-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4u)



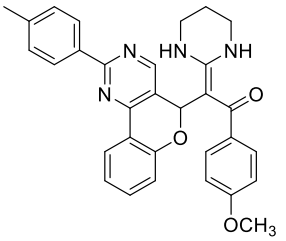
White solid (79 mg, 76%); Mp: 254.3–254.9 ℃; IR (KBr): 3379, 3253, 1612, 1432, 1191, 1131, 787, 689, 602 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.58 (d, *J* = 1.0 Hz, 1H, ArH), 8.42 (d, *J* = 8.2 Hz, 2H, ArH), 8.30 (d, *J* = 2.6 Hz, 1H, ArH), 7.35 (dd, *J* = 8.6, 2.6 Hz, 3H, ArH), 7.31 (d, *J* = 8.0 Hz, 2H, ArH), 7.07 (d, *J* = 7.9 Hz, 2H, ArH), 7.02 (d, *J* = 8.7 Hz, 1H, ArH), 6.15 (d, *J* = 1.0 Hz, 1H, CH), 5.40 (s, 1H, NH), 3.50–3.15 (m, 4H, CH_2), 2.43 (s, 3H, CH_3), 2.27 (s, 3H, CH_3), 1.98–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 189.0, 164.4, 160.1, 156.6, 155.9, 154.1, 141.3, 139.5, 138.6, 134.6, 132.9, 129.4, 128.8, 128.2, 128.0, 126.7, 125.1, 124.1, 123.3, 119.3, 84.7, 79.0, 39.8–37.5 (m), 21.5, 21.2, 20.2; HRMS (TOF ES^+): *m/z* calcd for $C_{31}H_{27}ClN_4O_2$ $[(M+H)^+]$, 523.1895; found, 523.1891.

2-(9-Chloro-8-methyl-2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4v)



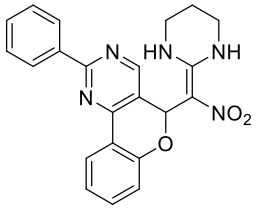
White solid (86 mg, 80%); Mp: 259.6–260.3 ℃; IR (KBr): 3378, 1607, 1582, 1144, 1099, 881, 798, 715, 682 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.33 (s, 1H, NH), 8.56 (s, 1H, ArH), 8.41 (d, *J* = 8.1 Hz, 2H, ArH), 8.27 (s, 1H, ArH), 7.34 (d, *J* = 7.9 Hz, 2H, ArH), 7.31 (d, *J* = 8.0 Hz, 2H, ArH), 7.07 (d, *J* = 7.9 Hz, 2H, ArH), 6.95 (s, 1H, ArH), 6.13 (s, 1H, CH), 5.39 (s, 1H, NH), 3.50–3.12 (m, 4H, CH_2), 2.43 (s, 3H, CH_3), 2.40 (s, 3H, CH_3), 2.27 (s, 3H, CH_3), 1.98–1.93 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.9, 164.4, 160.1, 156.4, 156.0, 153.8, 141.6, 141.2, 139.5, 138.5, 134.7, 129.3, 128.8, 128.5, 128.1, 126.6, 125.3, 123.8, 121.0, 120.0, 84.9, 78.9, 39.8–37.2 (m), 21.5, 21.2, 20.6, 20.2; HRMS (TOF ES^+): *m/z* calcd for $C_{32}H_{29}ClN_4O_2$ $[(M+H)^+]$, 537.2052; found, 537.2047.

1-(4-Methoxyphenyl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-2-(2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)ethan-1-one (4w)



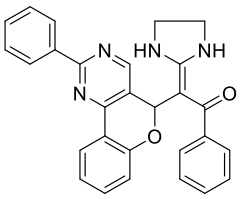
Yellow solid (73 mg, 72%); Mp:212.0–212.5 ℃; IR (KBr): 3410, 1606, 1385, 1191, 1137, 1105, 713, 644, 612 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 12.31 (s, 1H, NH), 8.57 (s, 1H, ArH), 8.43 (d, *J* = 8.1 Hz, 2H, ArH), 8.38 (d, *J* = 8.9 Hz, 1H, ArH), 7.44 (t, *J* = 7.8 Hz, 3H, ArH), 7.31 (d, *J* = 8.0 Hz, 2H, ArH), 7.16 (t, *J* = 7.5 Hz, 1H, ArH), 7.09 (d, *J* = 8.1 Hz, 1H, ArH), 6.79 (d, *J* = 8.7 Hz, 2H, ArH), 6.21 (s, 1H, CH), 5.48 (s, 1H, NH), 3.73 (s, 3H, OCH_3), 3.49–3.16 (m, 4H, CH_2), 2.43 (s, 3H, CH_3), 1.98–1.92 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.4, 164.3, 160.2, 160.0, 158.1, 156.8, 153.8, 141.0, 135.0, 134.9, 133.2, 129.3, 128.4, 128.1, 125.5, 124.3, 122.7, 122.1, 117.8, 113.4, 84.9, 78.7, 55.2, 39.5–37.6 (m), 21.5, 20.2; HRMS (TOF ES^+): *m/z* calcd for $C_{31}H_{28}N_4O_3$ [$(M+H)^+$], 505.2234; found, 505.2235.

5-(Nitro(tetrahydropyrimidin-2(1*H*)-ylidene)methyl)-2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidine (4x)



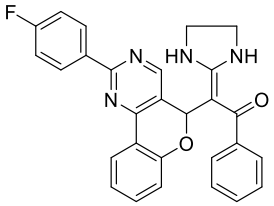
Yellow solid (69 mg, 58%); Mp: 216.8–217.6 ℃; IR (KBr): 3403, 1512, 1393, 1345, 1253, 1197, 1112, 762 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*): δ = 8.60 – 8.52 (m, 2H, ArH), 8.44 (d, *J* = 7.7 Hz, 1H, ArH), 8.38 (s, 1H, ArH), 7.55 – 7.51 (m, 3H, ArH), 7.46 (t, *J* = 7.7 Hz, 1H, ArH), 7.36 (s, 1H, CH), 7.23 (t, *J* = 7.4 Hz, 1H, ArH), 7.06 (d, *J* = 8.1 Hz, 1H, ArH), 3.50 – 3.38 (m, 4H, CH_2), 2.35 (t, *J* = 6.6 Hz, 1H, NH), 2.04 – 1.99 (m, 2H, CH_2), 1.88 (dt, *J* = 12.8, 6.4 Hz, 1H, NH); ^{13}C NMR (150 MHz, Chloroform-*d*): δ = 164.8, 157.1, 156.9, 155.1, 152.8, 137.4, 133.4, 130.9, 128.6, 128.3, 125.7, 123.5, 121.9, 121.9, 117.8, 105.4, 74.4, 38.9, 19.3; HRMS (TOF ES^+): *m/z* calcd for $C_{22}H_{20}N_5O_3$ [$(M+H)^+$], 402.1561; found, 402.1559.

2-(Imidazolidin-2-ylidene)-1-phenyl-2-(2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)ethan-1-one (4y)



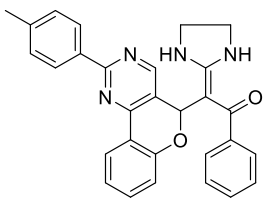
Yellow solid (70 mg, 75%); Mp: 234.5–235.1 ℃; IR (KBr): 3447, 3279, 1599, 1536, 1397, 1196, 1104, 746, 715, 690 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 10.36 (s, 1H, NH), 8.59 (s, 1H, ArH), 8.55 (dd, *J* = 7.3, 2.3 Hz, 2H, ArH), 8.39 (dd, *J* = 7.7, 1.4 Hz, 1H, ArH), 7.50 (dd, *J* = 5.4, 1.6 Hz, 3H, ArH), 7.44 (dd, *J* = 6.5, 2.9 Hz, 2H, ArH), 7.43–7.39 (m, 1H, ArH), 7.30–7.26 (m, 3H, ArH), 7.15 (t, *J* = 7.3 Hz, 1H, ArH), 7.05 (d, *J* = 8.1 Hz, 1H, ArH), 6.14 (s, 1H, CH), 5.11 (s, 1H, NH), 3.87–3.67 (m, 2H, CH_2), 3.60–3.44 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 190.3, 165.8, 164.3, 158.0, 156.8, 154.2, 141.9, 137.6, 133.4, 130.8, 128.9, 128.6, 128.2, 128.2, 126.6, 125.5, 123.9, 122.7, 121.8, 117.7, 84.7, 77.5, 43.5, 43.0; HRMS (TOF ES^+): *m/z* calcd for $C_{28}H_{22}N_4O_2$ [$(M+H)^+$], 447.1816; found, 447.1813.

2-(2-(4-Fluorophenyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(imidazolidin-2-ylidene)-1-phenylethan-1-one (4z)



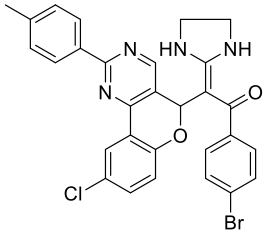
White solid (64 mg, 69%); Mp: 253.7–254.5 ℃; IR (KBr): 3451, 1603, 1537, 1408, 1195, 1104, 758, 714, 608 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 10.36 (s, 1H, NH), 8.58–8.54 (m, 3H, ArH), 8.35 (d, *J* = 7.6 Hz, 1H, ArH), 7.44 (dd, *J* = 6.5, 2.9 Hz, 2H, ArH), 7.41 (d, *J* = 8.3 Hz, 1H, ArH), 7.30–7.26 (m, 3H, ArH), 7.16 (dt, *J* = 12.5, 8.1 Hz, 3H, ArH), 7.05 (d, *J* = 8.2 Hz, 1H, ArH), 6.13 (s, 1H, CH), 5.10 (s, 1H, NH), 3.85–3.74 (m, 2H, CH_2), 3.60–3.48 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 190.3, 165.8, 164.8 (d, J_1 = 250.5 Hz), 163.4, 158.1, 156.9, 154.2, 141.8, 133.8 (d, J_3 = 2.9 Hz), 133.4, 130.3 (d, J_3 = 8.7 Hz), 128.9, 128.2, 126.5, 125.5, 123.8, 122.7, 121.7, 117.8, 115.5 (d, J_2 = 21.6 Hz), 84.7, 77.5, 43.5, 43.0; HRMS (TOF ES^+): *m/z* calcd for $C_{28}H_{21}FN_4O_2$ [$(M+H)^+$], 465.1721; found, 465.1718.

2-(Imidazolidin-2-ylidene)-1-phenyl-2-(2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)ethan-1-one (4a')



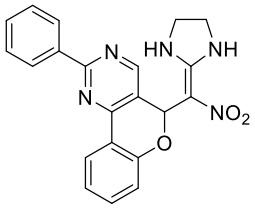
Yellow solid (59 mg, 64%); Mp: 205.1–205.7 ℃; IR (KBr): 3419, 3388, 1600, 1531, 1193, 757, 713, 636, 614 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 10.35 (s, 1H, NH), 8.57 (s, 1H, ArH), 8.44 (d, *J* = 8.0 Hz, 2H, ArH), 8.37 (d, *J* = 7.5 Hz, 1H, ArH), 7.43 (dd, *J* = 6.3, 2.6 Hz, 2H, ArH), 7.40 (t, *J* = 7.2 Hz, 1H, ArH), 7.30 (d, *J* = 8.0 Hz, 2H, ArH), 7.28–7.25 (m, 3H, ArH), 7.14 (t, *J* = 7.5 Hz, 1H, ArH), 7.04 (d, *J* = 8.1 Hz, 1H, ArH), 6.12 (s, 1H, CH), 5.12 (s, 1H, NH), 3.84–3.73 (m, 2H, CH_2), 3.58–3.46 (m, 2H, CH_2), 2.42 (s, 3H, CH_3); ^{13}C NMR (150 MHz, Chloroform-*d*) δ 190.3, 165.8, 164.4, 158.0, 156.7, 154.1, 141.9, 141.1, 134.9, 133.3, 129.3, 128.9, 128.2, 128.1, 126.5, 125.5, 123.5, 122.6, 121.9, 117.7, 84.8, 77.5, 43.5, 43.0, 21.5; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{24}N_4O_2$ [$(M+H)^+$], 461.1972; found, 461.1969.

1-(4-Bromophenyl)-2-(9-chloro-2-(p-tolyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(imidazolidin-2-ylidene)ethan-1-one (4b')



White solid (80 mg, 70%); Mp: 262.3–262.9 ℃; IR (KBr): 3465, 3382, 1594, 1539, 1435, 1406, 1193, 1107, 755, 703 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 10.28 (s, 1H, NH), 8.54 (s, 1H, ArH), 8.42 (d, *J* = 8.1 Hz, 2H, ArH), 8.32 (d, *J* = 2.5 Hz, 1H, ArH), 7.42 (d, *J* = 8.3 Hz, 2H, ArH), 7.35 (dd, *J* = 8.7, 2.5 Hz, 1H, ArH), 7.31 (dd, *J* = 8.3, 2.7 Hz, 4H, ArH), 6.98 (d, *J* = 8.7 Hz, 1H, ArH), 6.04 (s, 1H, CH), 5.05 (s, 1H, NH), 3.86–3.76 (m, 2H, CH_2), 3.61–3.51 (m, 2H, CH_2), 2.44 (s, 3H, CH_3); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 189.0, 165.7, 164.6, 156.4, 155.8, 154.3, 141.4, 140.5, 134.5, 133.0, 131.4, 129.4, 128.3, 128.2, 128.1, 125.1, 123.3, 123.1, 123.1, 119.1, 84.4, 77.7, 43.5, 43.0, 21.5; HRMS (TOF ES^+): *m/z* calcd for $C_{29}H_{22}BrClN_4O_2$ [$(M+H)^+$], 573.0687; found, 573.0679.

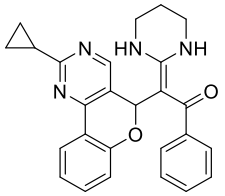
5-(Imidazolidin-2-ylidene(nitro)methyl)-2-phenyl-5*H*-chromeno[4,3-*d*]pyrimidine (4c')



Yellow solid (83 mg, 71%); Mp: 264.5–265.2 ℃; IR (KBr): 3446, 3275, 1516, 1387, 1189, 1107, 756, 713, 682 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*): δ = 8.62 (s, 2H, NH), 8.51 (d, *J* = 4.8 Hz, 2H, ArH), 8.38 (d, *J* = 6.7 Hz, 2H, ArH), 7.57 (d, *J* = 5.3 Hz, 3H, ArH), 7.46 (t, *J* = 7.9 Hz, 1H, ArH), 7.16 (t, *J* = 7.6 Hz, 1H, ArH), 6.98 (d, *J* = 8.2

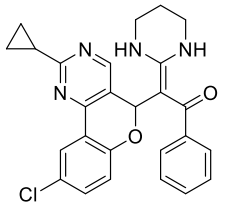
Hz, 1H, ArH), 6.78 (s, 1H, CH), 3.71 (s, 4H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*): δ = 162.9, 160.4, 158.3, 155.9, 153.1, 137.7, 133.9, 131.2, 129.2, 128.2, 125.2, 123.0, 122.1, 120.2, 117.4, 105.7, 72.8, 43.9; HRMS (TOF ES^+): *m/z* calcd for $C_{21}H_{18}N_5O_2$ [$(M+H)^+$], 388.1404; found, 388.1404.

2-(2-Cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-phenyl-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4d')



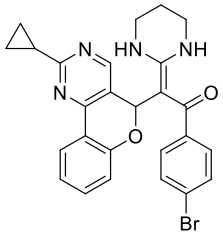
Yellow solid (56 mg, 66%); Mp: 218.7–219.3 ℃; IR (KBr): 3424, 1613, 1440, 1193, 1122, 763, 712, 668 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*): δ = 12.32 (s, 1H, NH), 8.37 (d, *J* = 1.0 Hz, 1H, ArH), 8.16 (dd, *J* = 7.7, 1.6 Hz, 1H, ArH), 7.41 (dd, *J* = 7.6, 1.7 Hz, 2H, ArH), 7.40–7.35 (m, 1H, ArH), 7.28–7.22 (m, 3H, ArH), 7.09 (td, *J* = 7.7, 0.9 Hz, 1H, ArH), 7.03 (d, *J* = 8.2 Hz, 1H, ArH), 6.04 (d, *J* = 1.0 Hz, 1H, CH), 5.47 (s, 1H, NH), 3.59–3.08 (m, 4H, CH_2), 2.31–2.23 (m, 1H, CH), 1.98–1.93 (m, 2H, CH_2), 1.21–1.17 (m, 2H, CH_2), 1.09–1.05 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*): δ = 188.6, 171.8, 160.2, 158.0, 156.5, 153.2, 142.5, 133.1, 128.4, 128.1, 126.6, 125.3, 123.1, 122.6, 121.9, 117.7, 85.0, 78.3, 39.2–37.8 (m), 20.1, 18.2, 10.6; HRMS (TOF ES^+): *m/z* calcd for $C_{26}H_{24}N_4O_2$ [$(M+H)^+$], 425.1972; found, 425.1969.

2-(9-Chloro-2-cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-phenyl-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4e')



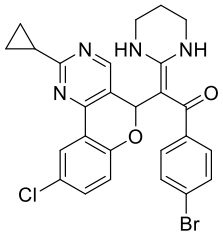
White solid (64 mg, 70%); Mp: 265.4–266.2 ℃; IR (KBr): 3398, 1606, 1514, 1441, 1349, 1193, 1133, 714, 689 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 12.26 (s, 1H, NH), 8.38 (s, 1H, ArH), 8.10 (d, *J* = 2.4 Hz, 1H, ArH), 7.42–7.38 (m, 2H, ArH), 7.31 (dd, *J* = 8.7, 2.4 Hz, 1H, ArH), 7.26–7.24 (m, 3H, ArH), 6.98 (d, *J* = 8.7 Hz, 1H, ArH), 6.02 (s, 1H, CH), 5.37 (s, 1H, NH), 3.53–3.12 (m, 4H, CH_2), 2.35–2.23 (m, 1H, CH), 1.99–1.92 (m, 2H, CH_2), 1.22–1.16 (m, 2H, CH_2), 1.11–1.07 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.7, 172.1, 160.1, 156.5, 155.5, 153.5, 142.3, 132.8, 128.6, 128.2, 128.0, 126.6, 124.9, 123.1, 123.0, 119.2, 84.7, 78.7, 39.4 – 37.7 (m), 20.1, 18.2, 10.9; HRMS (TOF ES^+): *m/z* calcd for $C_{26}H_{23}ClN_4O_2$ [$(M+H)^+$], 459.1582; found, 459.1583.

1-(4-Bromophenyl)-2-(2-cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4f')



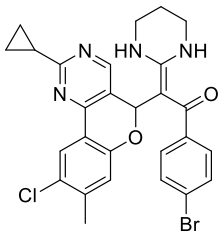
White solid (65 mg, 65%); Mp: 287.1–287.6 ℃; IR (KBr): 3400, 1588, 1540, 1445, 1366, 1193, 1106, 759, 702, 663 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*): δ = 12.20 (s, 1H, NH), 8.33 (d, *J* = 1.0 Hz, 1H, ArH), 8.18 (dd, *J* = 7.7, 1.6 Hz, 1H, ArH), 7.39 (d, *J* = 8.5 Hz, 3H, ArH), 7.31 (d, *J* = 8.4 Hz, 2H, ArH), 7.13–7.09 (m, 1H, ArH), 7.03 (d, *J* = 8.2 Hz, 1H, ArH), 5.96 (d, *J* = 1.0 Hz, 1H, CH), 5.48 (s, 1H, NH), 3.58–3.11 (m, 4H, CH_2), 2.30 – 2.24 (m, 1H, CH), 1.99–1.93 (m, 2H, CH_2), 1.21–1.17 (m, 2H, CH_2), 1.11–1.05 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*): δ = 187.1, 171.9, 160.1, 157.8, 153.1, 141.2, 133.2, 131.3, 128.4, 125.4, 122.9, 122.8, 122.6, 121.8, 117.7, 85.1, 78.2, 39.2–37.7 (m), 20.1, 18.2; HRMS (TOF ES^{+}): *m/z* calcd for $C_{26}H_{23}BrN_4O_2$ [$(M+H)^{+}$], 479.1878; found, 479.1875.

1-(4-Bromophenyl)-2-(9-chloro-2-cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4g')



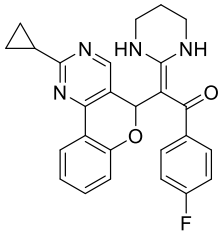
White solid (84 mg, 78%); Mp: 263.1–263.6 ℃; IR (KBr): 3415, 3384, 3336, 1604, 1390, 1195, 1108, 756, 719, 606 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.18 (s, 1H, NH), 8.34 (s, 1H, ArH), 8.12 (d, *J* = 2.6 Hz, 1H, ArH), 7.39 (d, *J* = 8.4 Hz, 2H, ArH), 7.32 (dd, *J* = 8.7, 2.6 Hz, 1H, ArH), 7.29 (d, *J* = 8.3 Hz, 2H), 6.97 (d, *J* = 8.7 Hz, 1H, ArH), 5.94 (s, 1H, CH), 5.38 (s, 1H, NH), 3.53–3.13 (m, 4H, CH_2), 2.33–2.22 (m, 1H, CH), 2.01–1.92 (m, 2H, CH_2), 1.22–1.16 (m, 2H, CH_2), 1.12–1.06 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.3, 172.2, 160.0, 156.3, 155.5, 153.4, 141.1, 132.9, 131.3, 128.4, 128.1, 125.0, 123.1, 122.8, 122.8, 119.2, 84.8, 78.5, 39.4–37.6 (m), 20.0, 18.3, 10.9; HRMS (TOF ES^{+}): *m/z* calcd for $C_{26}H_{22}BrClN_4O_2$ [$(M+H)^{+}$], 537.0687; found, 537.0690.

1-(4-Bromophenyl)-2-(9-chloro-2-cyclopropyl-8-methyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4h')



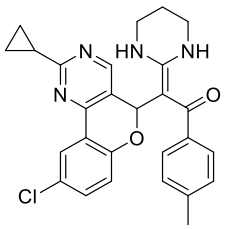
White solid (82 mg, 74%); Mp: 236.3–236.9 ℃; IR (KBr): 3389, 3273, 1607, 1439, 1387, 1193, 1109, 752, 719, 606 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.15 (s, 1H, NH), 8.31 (s, 1H, ArH), 8.09 (s, 1H, ArH), 7.39 (d, *J* = 8.1 Hz, 2H, ArH), 7.29 (d, *J* = 8.1 Hz, 2H, ArH), 6.91 (s, 1H, ArH), 5.91 (s, 1H, CH), 5.40 (s, 1H, NH), 3.50–3.20 (m, 4H, CH_2), 2.39 (s, 3H, CH_3), 2.29–2.24 (m, 1H, CH), 1.98–1.94 (m, 2H, CH_2), 1.20–1.17 (m, 2H, CH_2), 1.11–1.06 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.15 , 172.07 , 160.05 , 156.13 , 155.70 , 153.11 , 141.69 , 141.10 , 131.32 , 128.58 , 128.33 , 125.22 , 122.70 , 122.49 , 120.78 , 119.84 , 84.99 , 78.43 , 39.3–37.9 (m), 20.60 , 20.03 , 18.22 , 10.80; HRMS (TOF ES^{+}): *m/z* calcd for $C_{27}H_{24}BrClN_4O_2$ [$(M+H)^{+}$], 551.0844; found, 551.0845.

2-(2-Cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-(4-fluorophenyl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4i')



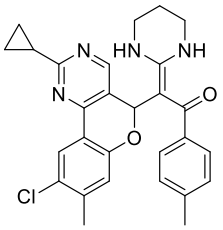
White solid (72 mg, 81%); Mp: 239.2–239.8 ℃; IR (KBr): 3416, 3384, 3336, 1604, 1390, 1193, 1108, 756, 719, 606 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.21 (s, 1H, NH), 8.34 (d, *J* =0.66 Hz, 1H, ArH), 8.18 (dd, *J* = 7.7, 1.6 Hz, 1H, ArH), 7.43 (dd, *J* = 8.5, 5.6 Hz, 2H, ArH), 7.41–7.37 (m, 1H, ArH), 7.14–7.07 (m, 1H, ArH), 7.04 (d, *J* = 8.1 Hz, 1H, ArH), 6.94 (t, *J* = 8.7 Hz, 2H, ArH), 6.00 (d, *J* =0.72 Hz, 1H, CH), 5.48 (s, 1H, NH), 3.64–2.92 (m, 4H, CH_2), 2.35–2.20 (m, 1H, CH), 2.05–1.92 (m, 2H, CH_2), 1.24–1.13 (m, 2H, CH_2), 1.10–1.02 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 187.3, 171.9, 162.81 (d, J_1 = 247.6 Hz), 160.1, 157.9, 156.5, 153.1, 138.5 (d, J_3 = 3.2 Hz), 133.2, 128.7 (d, J_3 = 8.2 Hz), 125.4, 123.0, 122.8, 121.8, 117.7, 115.1 (d, J_2 = 21.4 Hz), 115.0, 85.1, 78.3, 39.3–37.4 (m), 20.1, 18.2, 10.7; HRMS (TOF ES^{+}): *m/z* calcd for $C_{26}H_{23}FN_4O_2$ [$(M+H)^{+}$], 460.1585; found, 460.1588.

2-(9-Chloro-2-cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4j')



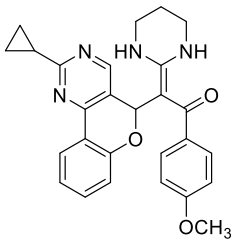
White solid (75 mg, 79%); Mp: 224.4–224.8 ℃; IR (KBr): 3415, 3384, 3336, 1604, 1390, 1195, 1108, 756, 719, 606 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.32 (s, 1H, NH), 8.37–8.35 (m, 1H, ArH), 8.10 (d, *J* = 2.6 Hz, 1H, ArH), 7.31 (d, *J* = 7.6 Hz, 3H, ArH), 7.06 (d, *J* = 7.8 Hz, 2H, ArH), 6.98 (d, *J* = 8.7 Hz, 1H, ArH), 6.06 (s, 1H, CH), 5.34 (s, 1H, NH), 3.51–3.13 (m, 4H, CH_2), 2.29–2.24 (m, 1H, CH), 2.27 (s, 3H, CH_3), 1.99–1.92 (m, 2H, CH_2), 1.21–1.16 (m, 2H, CH_2), 1.11–1.06 (m, 2H, CH_2); ^{13}C NMR (151 MHz, Chloroform-*d*) : δ = 188.9, 172.0, 160.1, 156.5, 155.5, 153.5, 139.4, 138.5, 132.7, 128.8, 127.9, 126.6, 124.8, 123.2, 123.1, 119.2, 84.6, 78.8, 39.4–37.5 (m), 21.2, 20.1, 18.2, 10.8; HRMS (TOF ES^{+}): *m/z* calcd for $C_{27}H_{25}ClN_4O_2$ [$(M+H)^{+}$], 473.1739; found, 473.1740.

2-(9-Chloro-2-cyclopropyl-8-methyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)-1-(p-tolyl)ethan-1-one (4k')



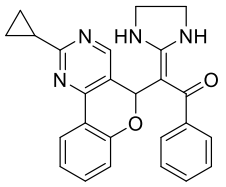
White solid (84 mg, 86%); Mp: 234.6–235.3 ℃; IR (KBr): 3437, 1747, 1613, 1574, 1435, 1191, 1143, 1028, 715, 606 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*) : δ = 12.29 (s, 1H, NH), 8.34 (s, 1H, ArH), 8.08 (s, 1H, ArH), 7.30 (d, *J* = 7.6 Hz, 2H, ArH), 7.06 (d, *J* = 7.7 Hz, 2H, ArH), 6.92 (s, 1H, ArH), 6.04 (s, 1H, CH), 5.36 (s, 1H, NH), 3.51–3.14 (m, 4H, CH_2), 2.38 (s, 3H, CH_3), 2.27 (s, 3H, CH_3), 1.98–1.93 (m, 2H, CH_2), 1.21–1.15 (m, 2H, CH_2), 1.10–1.06 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.82 , 171.87 , 160.08 , 156.34 , 155.68 , 153.30 , 141.52 , 139.49 , 138.42 , 128.76 , 128.36 , 126.58 , 125.12 , 122.81 , 120.86 , 119.91 , 84.79 , 78.73 , 39.4–37.6 (m), 21.21 , 20.59 , 20.14 , 18.21 , 10.73; HRMS (TOF ES^{+}): *m/z* calcd for $C_{28}H_{27}ClN_4O_2$ [$(M+H)^{+}$], 487.1895; found, 487.1895.

2-(2-Cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-(4-methoxyphenyl)-2-(tetrahydropyrimidin-2(1*H*)-ylidene)ethan-1-one (4l')



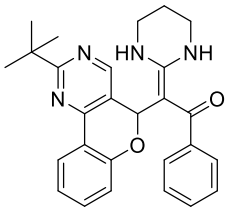
White solid (75 mg, 82%); Mp: 230.2–230.9 ℃; IR (KBr): 3415, 3384, 3344, 1604, 1390, 1195, 1108, 756, 719, 682 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 12.22 (s, 1H, NH), 8.27 (s, 1H, ArH), 8.10 (dd, *J* = 7.7, 1.5 Hz, 1H, ArH), 7.33 (d, *J* = 8.7 Hz, 2H, ArH), 7.32–7.29 (m, 1H, ArH), 7.02 (t, *J* = 7.5 Hz, 1H, ArH), 6.97 (d, *J* = 8.1 Hz, 1H, ArH), 6.70 (d, *J* = 8.7 Hz, 2H, ArH), 6.04 (s, 1H, CH), 5.36 (s, 1H, NH), 3.66 (s, 3H, OCH_3), 3.49–2.98 (m, 4H), 2.23–2.16 (m, 1H, CH), 1.91–1.84 (m, 2H, CH_2), 1.15–1.08 (m, 2H, CH_2), 1.02–0.97 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 188.3, 171.7, 160.2, 159.9, 158.1, 156.5, 153.2, 135.0, 133.1, 128.4, 125.3, 123.3, 122.6, 121.9, 117.7, 113.4, 84.8, 78.5, 55.2, 20.2, 18.2, 10.6; HRMS (TOF ES^+): *m/z* calcd for $C_{27}H_{26}N_4O_3$ [$(M+H)^+$], 455.2078; found, 455.2064.

2-(2-Cyclopropyl-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-2-(imidazolidin-2-ylidene)-1-phenylethan-1-one (4m')



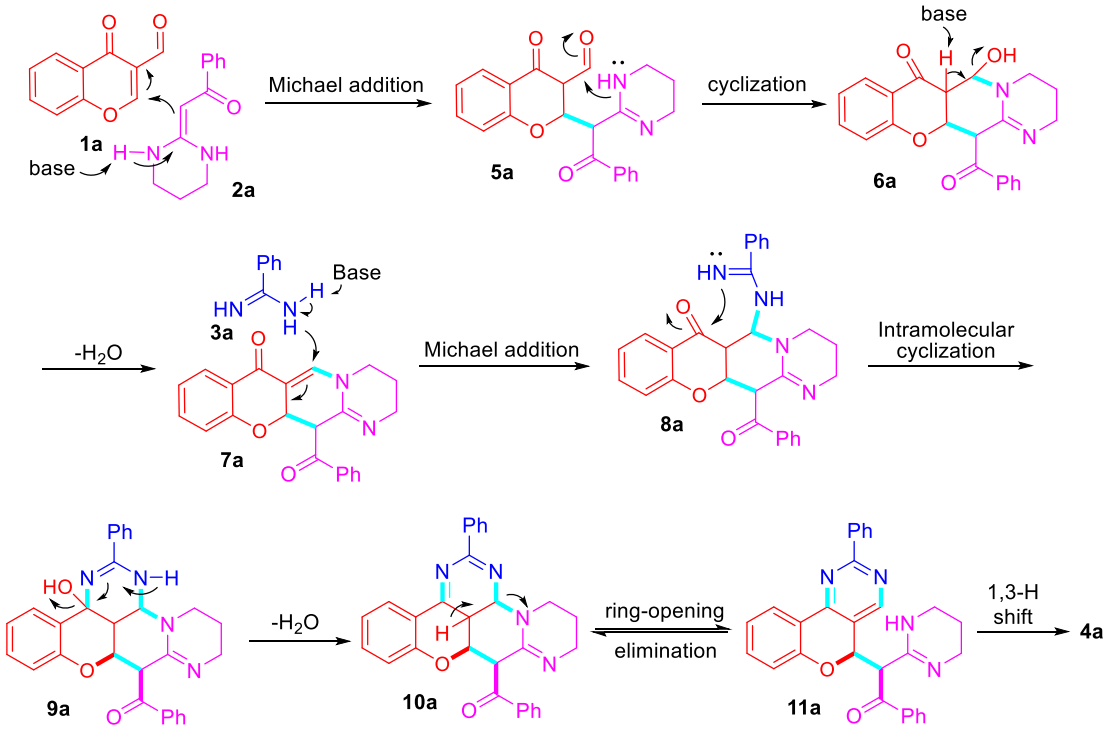
Yellow solid (62 mg, 75%); Mp: 214.4 – 214.8 ℃; IR (KBr): 3400, 3333, 1598, 1537, 1486, 1194, 1105, 730, 702, 615 cm^{-1}; ^1H NMR (600 MHz, Chloroform-*d*) : δ = 10.36 (s, 1H, NH), 8.35 (s, 1H, ArH), 8.18 (dd, *J* = 7.7, 1.5 Hz, 1H, ArH), 7.41 (dd, *J* = 6.6, 2.8 Hz, 2H, ArH), 7.39–7.35 (m, 1H, ArH), 7.27 (d, *J* = 3.2 Hz, 2H, ArH), 7.09 (t, *J* = 7.8 Hz, 1H, ArH), 7.01 (d, *J* = 8.1 Hz, 1H, ArH), 6.05 (s, 1H, CH), 5.01 (s, 1H, NH), 3.86–3.73 (m, 2H, CH_2), 3.61–3.49 (m, 2H, CH_2), 2.31–2.25 (m, 1H, CH), 1.22–1.17 (m, 2H, CH_2), 1.10–1.05 (m, 2H, CH_2); ^{13}C NMR (150 MHz, Chloroform-*d*) : δ = 190.3, 171.9, 165.7, 158.0, 156.4, 153.6, 141.9, 133.2, 128.8, 128.2, 126.5, 125.3, 122.5, 121.7, 117.6, 84.7, 77.4, 43.4, 43.0, 26.9, 18.2, 10.7; HRMS (TOF ES^+): *m/z* calcd for $C_{25}H_{22}N_4O_2$ [$(M+H)^+$], 411.1816; found, 411.1814.

2-(2-(Tert-butyl)-5*H*-chromeno[4,3-*d*]pyrimidin-5-yl)-1-phenyl-2-(tetrahydro-pyrimidin-2(1*H*)-ylidene)ethan-1-one (4n')



White solid (88 mg, 67%); Mp: 282.8–283.4 ℃; IR (KBr): 3393, 2912, 1609, 1421, 1368, 1123, 767, 613 cm^{-1}; ^{1}H NMR (600 MHz, Chloroform-*d*): δ = 12.36 (s, 1H, NH), 8.51 (s, 1H, ArH), 8.28 (dd, *J* = 7.7, 1.6 Hz, 1H, ArH), 7.48 – 7.44 (m, 2H, ArH), 7.44 – 7.39 (m, 1H, ArH), 7.28 (dd, *J* = 7.9, 2.3 Hz, 3H, ArH), 7.13 (t, *J* = 7.6 Hz, 1H, ArH), 7.07 (d, *J* = 8.2 Hz, 1H, ArH), 6.10 (s, 1H, CH), 5.52 (s, 1H, NH), 3.56 – 3.13 (m, 4H, CH_2), 2.00 (q, *J* = 5.9 Hz, 2H, CH_2), 1.47 (s, 9H, CH_3); ^{13}C NMR (150 MHz, Chloroform-*d*): δ = 188.6, 177.0, 160.2, 158.0, 156.1, 153.0, 142.5, 133.0, 128.4, 128.1, 126.6, 125.4, 123.1, 122.7, 122.2, 117.7, 84.9, 78.4, 39.5, 39.1-38.0 (m), 29.6, 20.1; HRMS (TOF ES^{+}): *m/z* calcd for $C_{27}H_{29}N_4O_2$ $[(M+H)^{+}]$, 441.2285; found, 441.2283.

The proposed mechanism of the cascade reaction



Scheme S1. The proposed mechanism of the cascade reaction.

The proposed mechanism of the multi-component cascade reaction is shown in Scheme S1 of the supporting information. Firstly, the nucleophilic α-C of the HKA **2a** underwent Michael addition onto the double bond of the 3-formylchromone **1a** substrate to form intermediate **5a**. Then, the nucleophilic amine nitrogen atom of intermediate **5a** attacked the aldehyde of the chromone moiety through an intramolecular cyclization reaction, which afforded intermediate **6a**. Intermediate **6a** underwent base-mediated dehydration to form **7a**. Next, the amidine nitrogen of substrate **3a** attacked the double bond of intermediate **7a** through another intermolecular Michael addition to form the intermediate **8a**, which then underwent

an intramolecular condensation reaction followed by dehydration to obtain intermediate **10a**. After ring opening and elimination reaction to form the intermediate **11a**, which finally underwent a 1,3-H shift to afford the 5*H*-Chrom -eno[4,3-*d*]pyrimidine product **4a**.

The mechanism of the cascade reaction verified by HPLC-HRMS

To confirm the mechanism of this cascade reaction, the mixture of 4-oxo-4*H*-chromene-3-carbaldehyde **1a**, HKAs **2a**, benzamidine hydrochloride **3a** and 1,4-dioxane was refluxed for 1 h. Subsequently, the reaction mixture was analyzed by high-performance liquid chromatography-high resolution mass spectrometry (HPLC-HRMS). The four molecular ion peaks that appeared in the high-resolution mass spectrumwere: HRMS (TOF ES^+): *m/z* calcd. for $C_{22}H_{21}N_2O_4$ $[M+H]^+$, 377.1496; found, 377.1488. HRMS (TOF ES^+): *m/z* calcd. for $C_{22}H_{21}N_2O_4$ $[M+H]^+$, 377.1496; found, 377.1491. There are the HRMS spectrum of intermediates **5a/6a** (SI, Figure S89−S90); HRMS (TOF ES^+): *m/z* calcd. for $C_{22}H_{19}N_2O_3$ $[M+H]^+$, 359.1390; found,359.1385, which is the HRMS spectra of intermediate **7a** (SI, Figure S91); HRMS (TOF ES^+): *m/z* calcd. for $C_{29}H_{27}N_4O_3$ $[M+H]^+$, 479.2078; found, 479.2065. HRMS (TOF ES^+): *m/z* calcd. for $C_{29}H_{27}N_4O_3$ $[M+H]^+$, 479.2078; found, 479.2070, which are the HRMS spectra of compound **8a/9a** (SI, Figure S92−S93); HRMS (TOF ES^+): *m/z* calcd. for $C_{29}H_{25}N_4O_2$ $[M+H]^+$, 461.1972; found, 461.1957. HRMS (TOF ES^+): *m/z* calcd. for $C_{29}H_{25}N_4O_2$ $[M+H]^+$, 461.1972; found, 461.1955. HRMS (TOF ES^+): *m/z* calcd. for $C_{29}H_{25}N_4O_2$ $[M+H]^+$, 461.1972; found, 461.1954. There are the HRMS spectrum of intermediate **10a/11a** or the target compound **4a** (SI, Figure S94−S96). Based on the molecular ion peaks of intermediate **5a–11a**, the proposed mechanism of the cascade reaction is reasonable (Scheme S1).

X-ray Structure and Dataof 4a

Single crystal culture and confirmation: First, compound **4a** was added to a bottle and dissolved by the addition of DCM (1.5 mL). Then, a few drops of ethyl acetate and a few drops of DCM were added. The bottle was opened in the air at room temperature for 4 days. Some crystals appeared, and for single crystal parsing, crystals were selected with sizes of 0.18 mm x 0.12 mm x 0.11 mm. The Bruker D8 Venture diffractometer was used to obtain single crystal diffraction at 296(2) K with the use of four-circle diffractomete Mo K (lambda = 0.71073 A) for diffraction intensity data collection, using phi and omega scanning. The crystal structure was solved by the atomic method using the SHELXT program (Supporting Information, Figure S1, CCDC 2078187).[2]

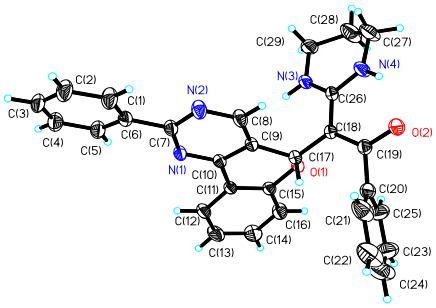


Figure S1.X-Ray crystal structure of **4a**, ellipsoids are drawn at the 30% probability level.

Table S1. Crystal data and structure refinement for **4a**

Identification code	ww
Empirical formula	C29H24N4O2
Formula weight	460.52
Temperature/K	296.15
Crystal system	monoclinic
Space group	P21/c
a/Å	11.343(5)
b/Å	16.715(8)
c/Å	13.695(6)
α/ °	90
β/ °	110.156(7)
γ/ °	90
Volume/Å3	2437.6(19)
Z	4
ρcalcg/cm3	1.255
μ/mm 1	0.081
F(000)	968.0
Crystal size/mm3	0.18 ×0.12 ×0.11
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.536 to 50.018
Index ranges	-11 ≤ h ≤ 13, -19 ≤ k ≤ 18, -15 ≤ l ≤ 16
Reflections collected	12254
Independent reflections	4288 [Rint = 0.0266, Rsigma = 0.0302]
Data/restraints/parameters	4288/1/316
Goodness-of-fit on F2	1.025
Final R indexes [I>=2σ (I)]	R1 = 0.0597, wR2 = 0.1569
Final R indexes [all data]	R1 = 0.0825, wR2 = 0.1770
Largest diff. peak/hole / e Å-3	0.50/-0.29

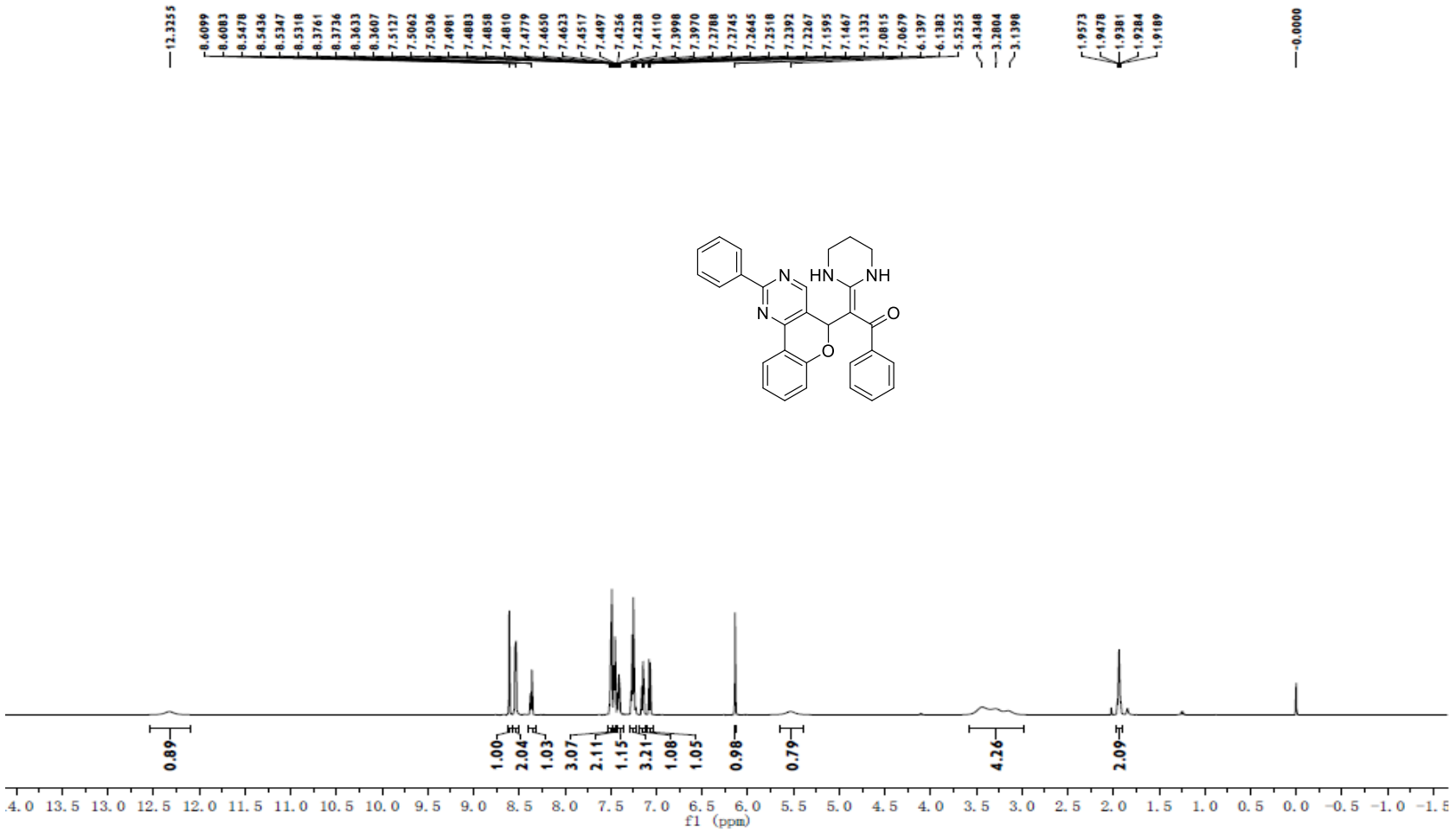


Figure S2. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4a**

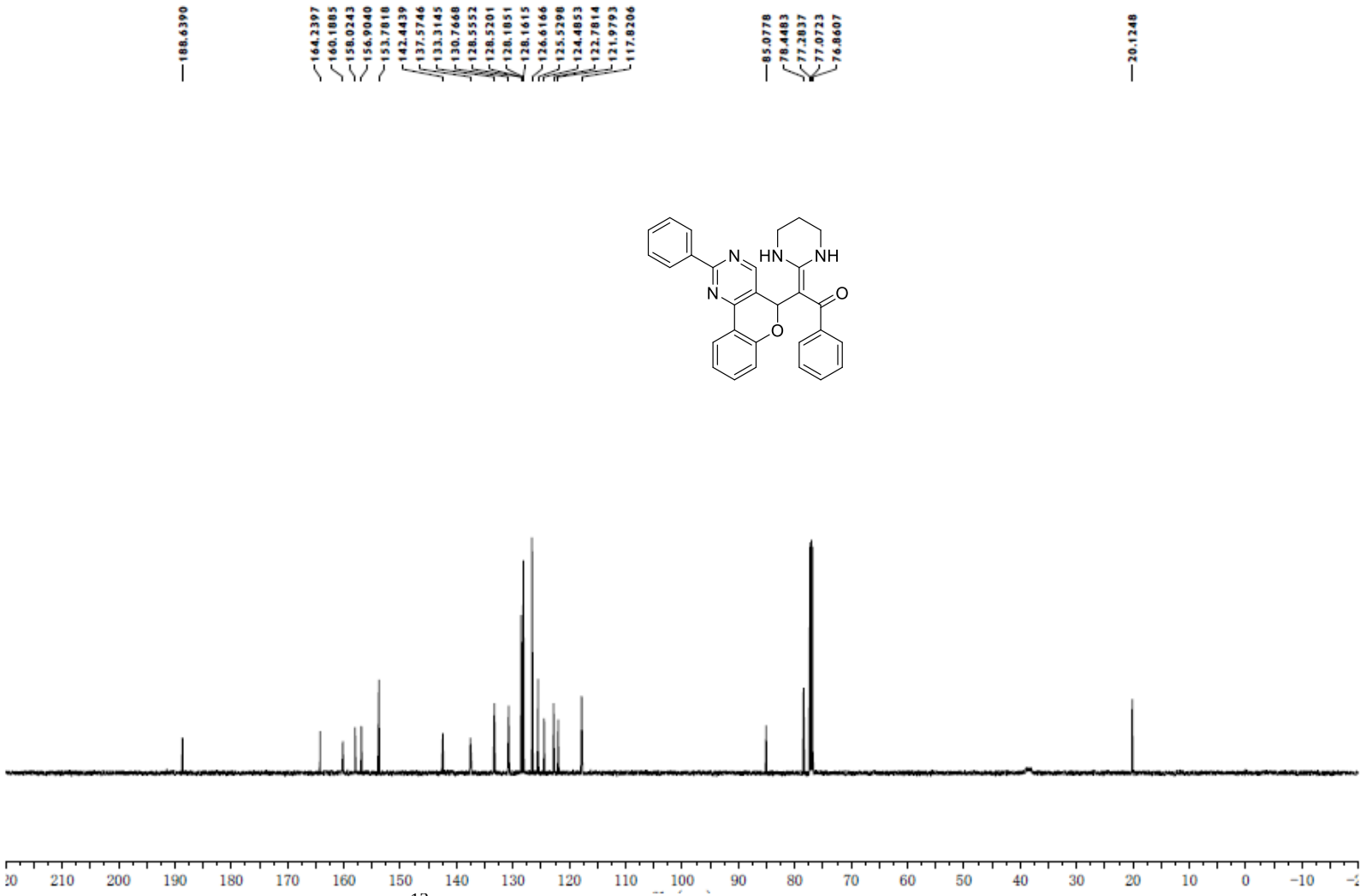


Figure S3. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4a**

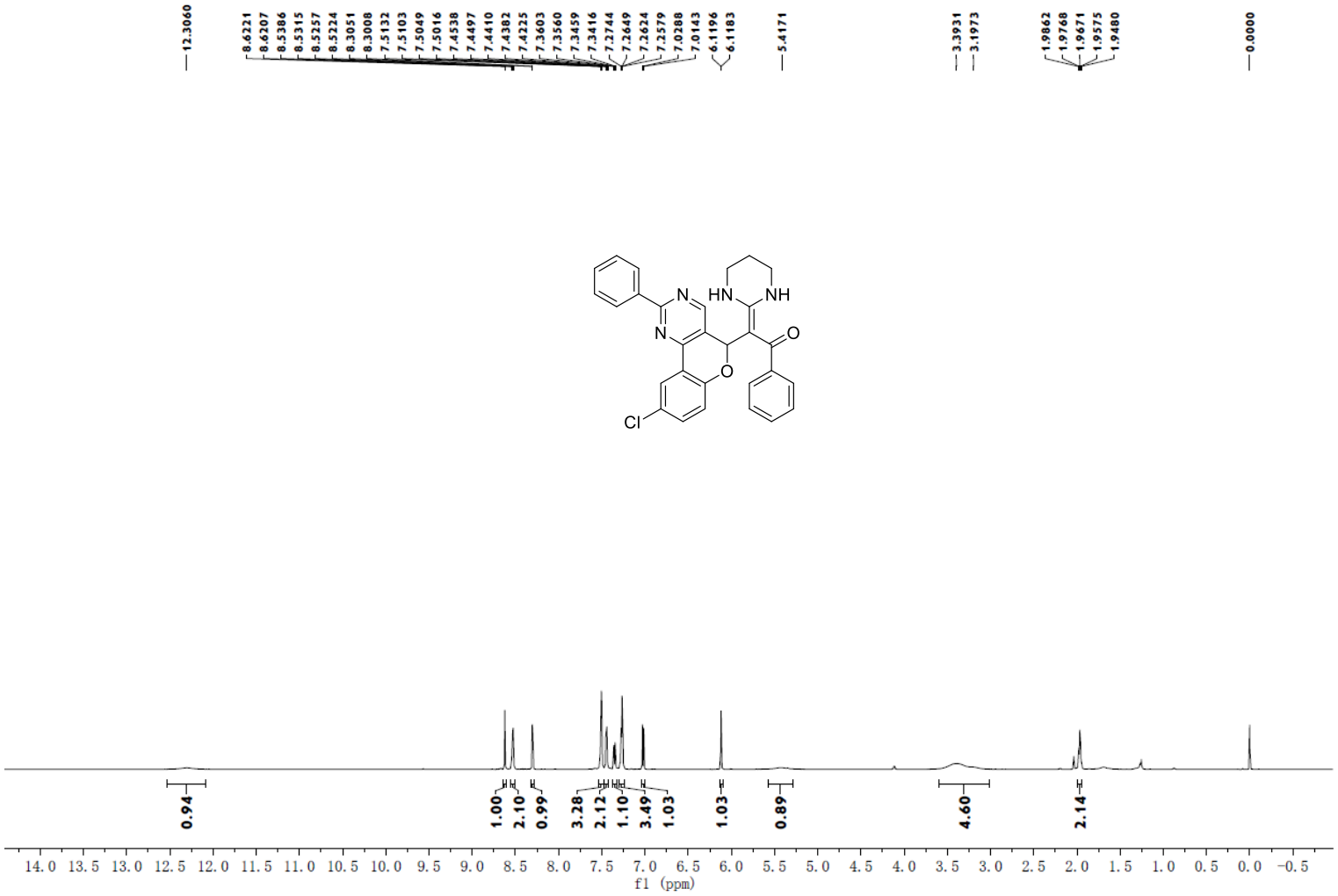


Figure S4. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4b**

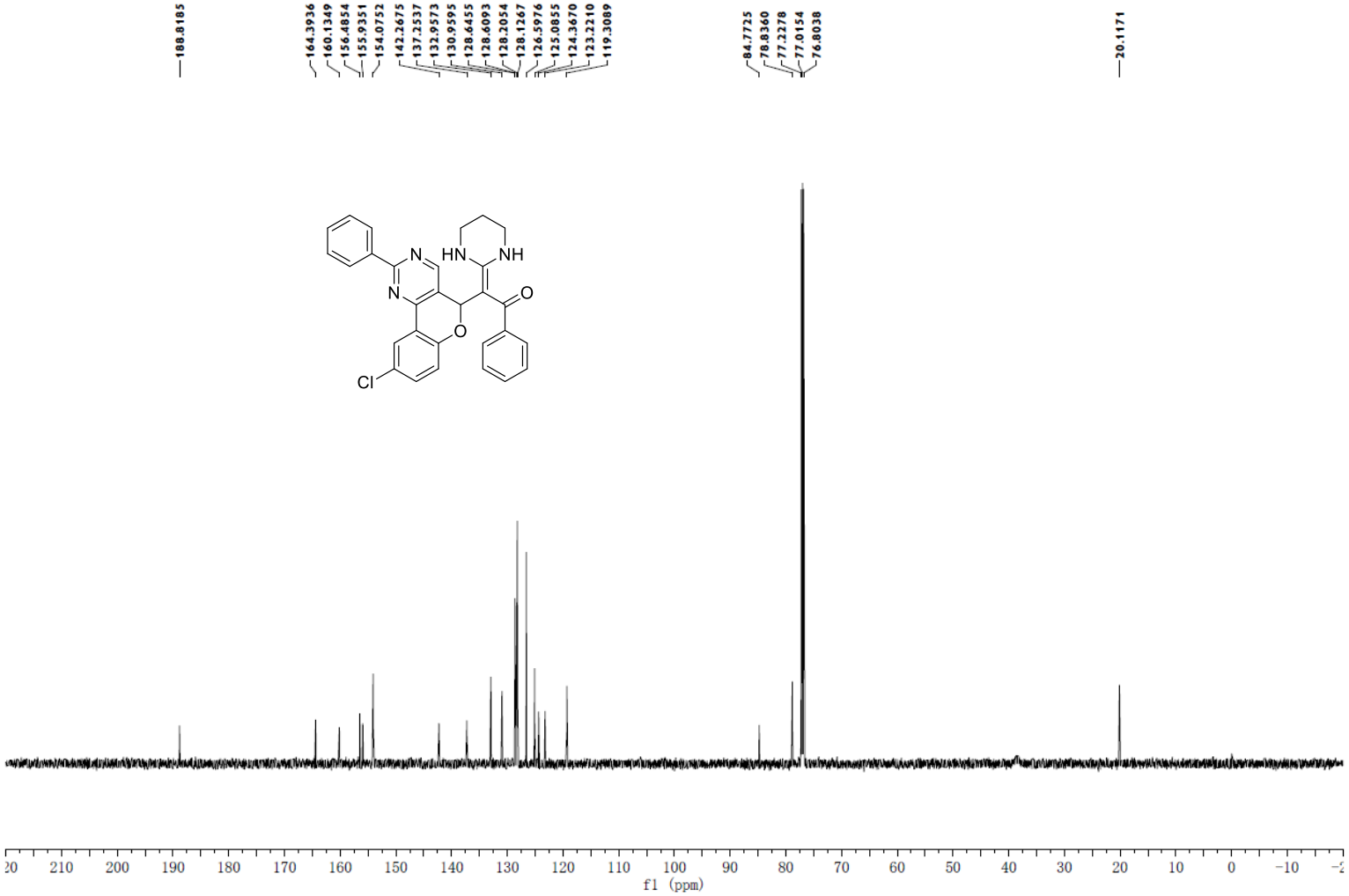


Figure S5. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4b**

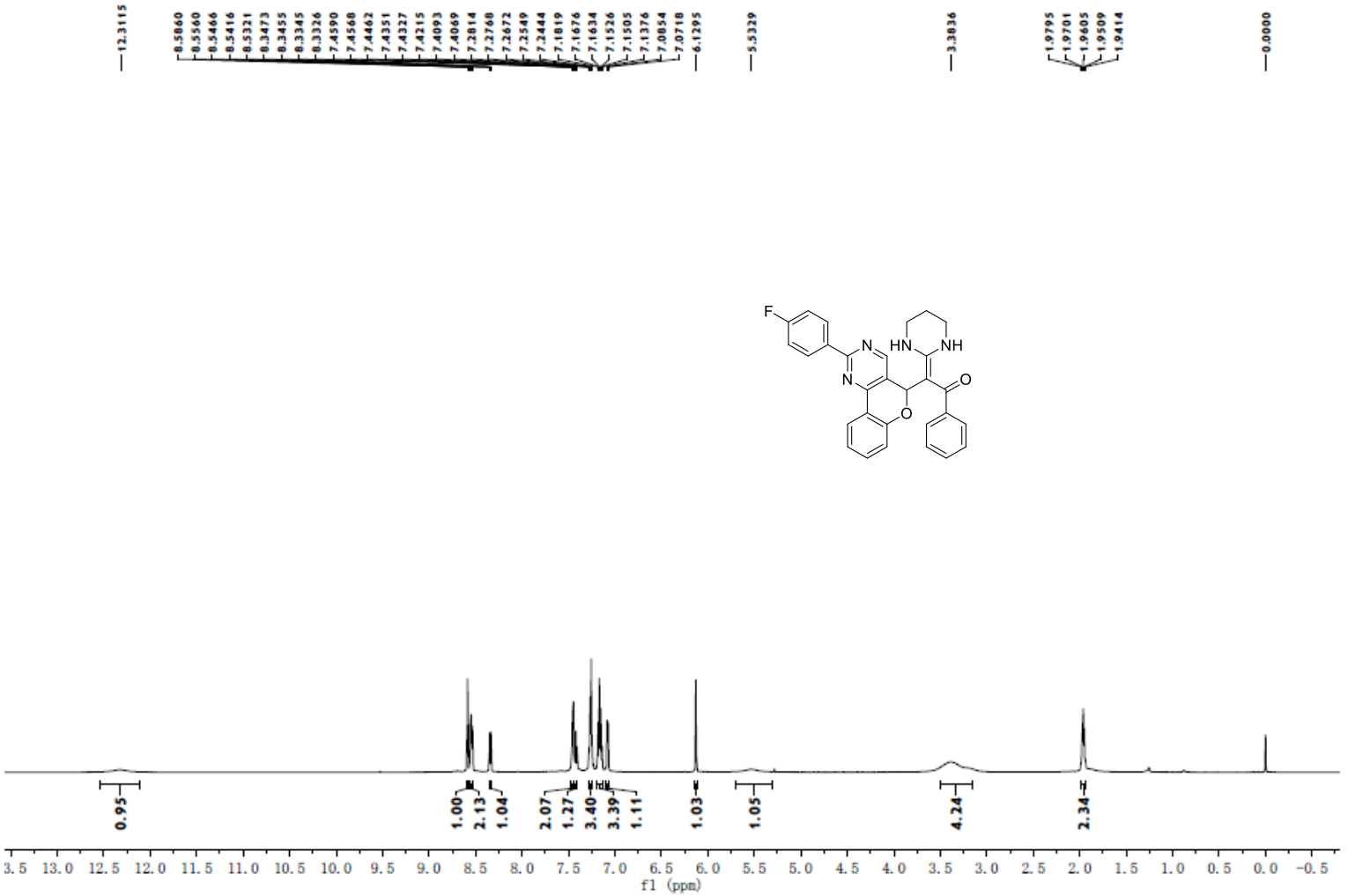


Figure S6. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4c**

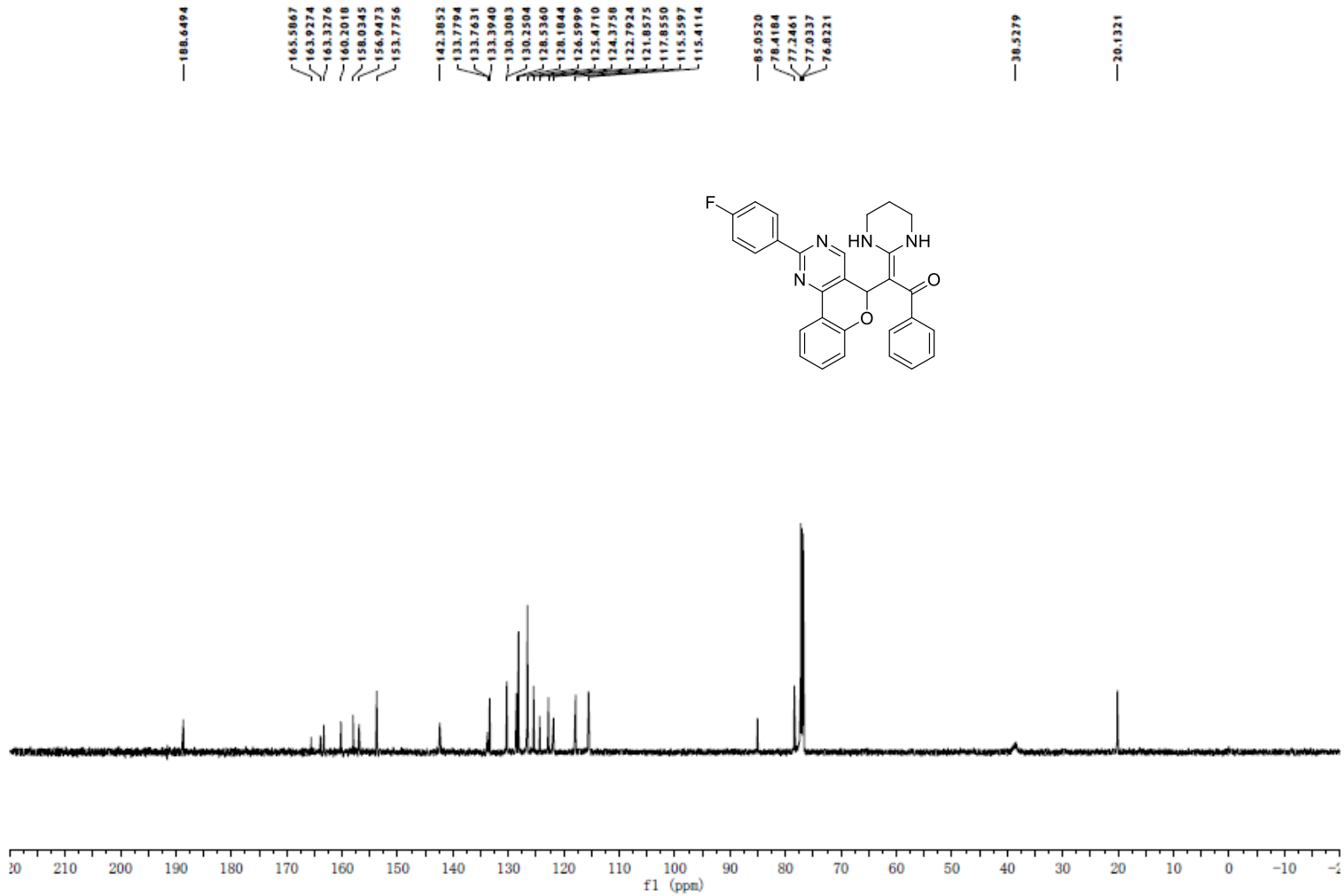


Figure S7. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4c**

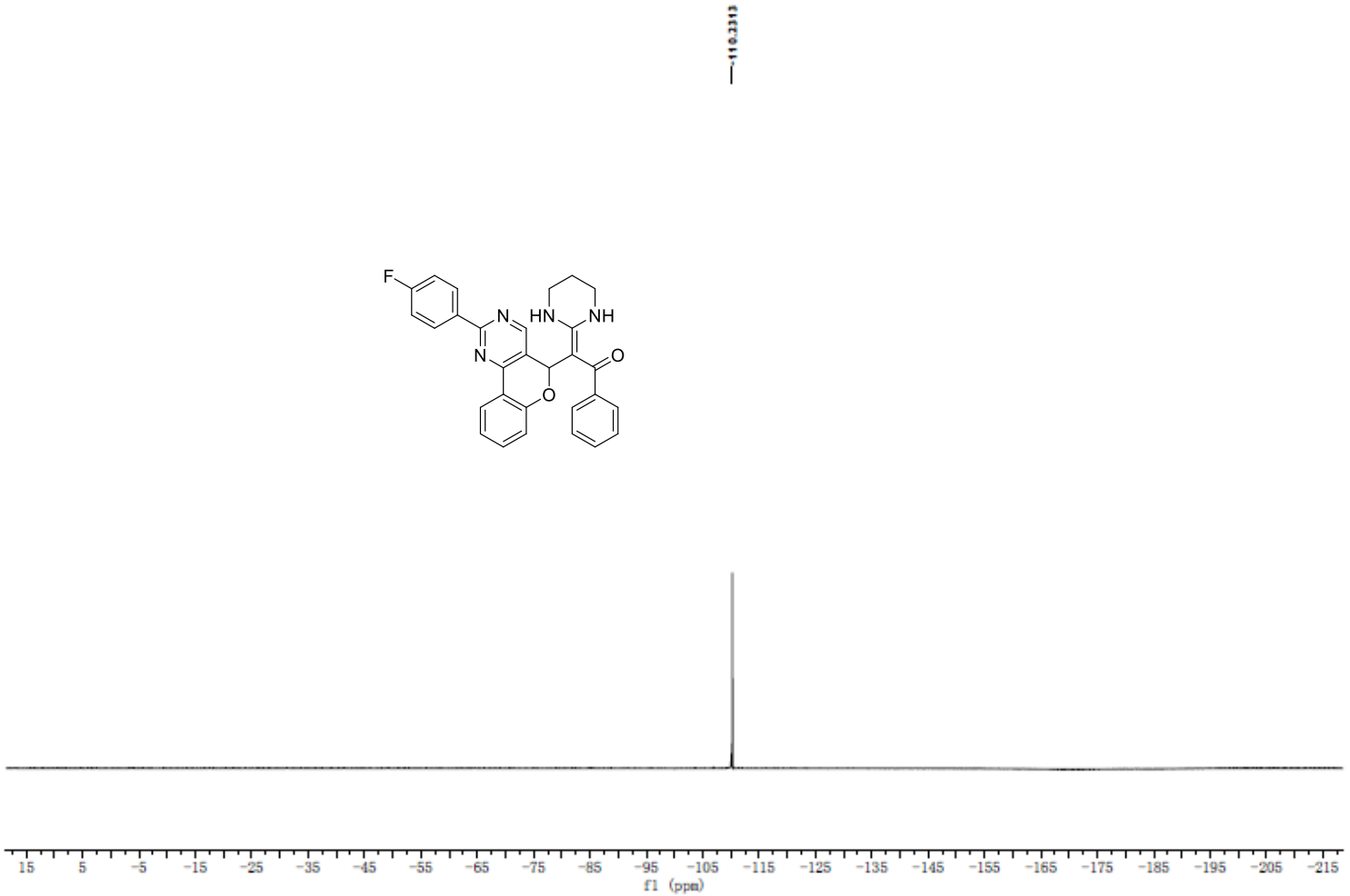


Figure S8. ^{19}F NMR (540 MHz, Chloroform-*d*) spectra of compound **4c**

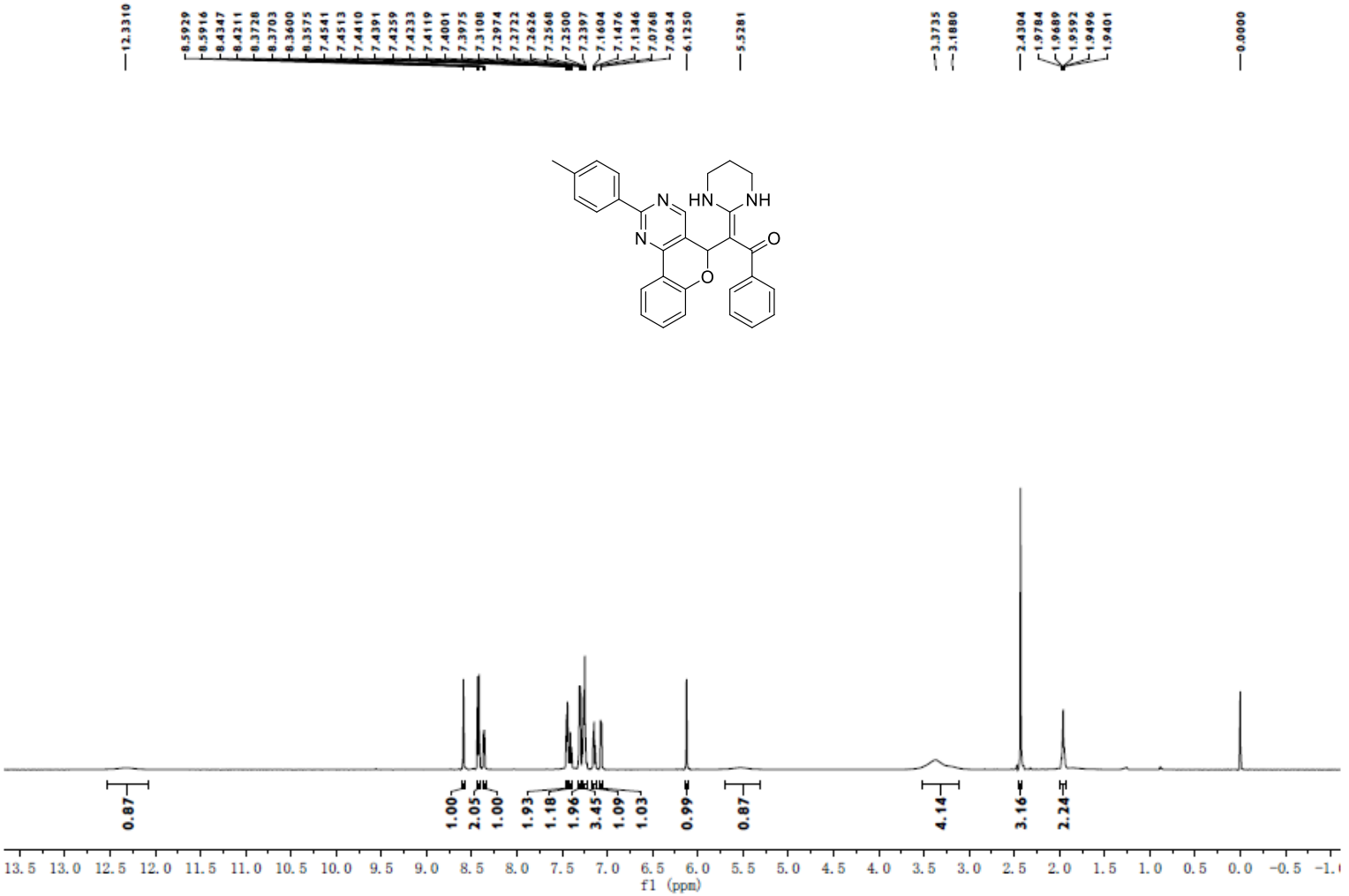


Figure S9. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4d**

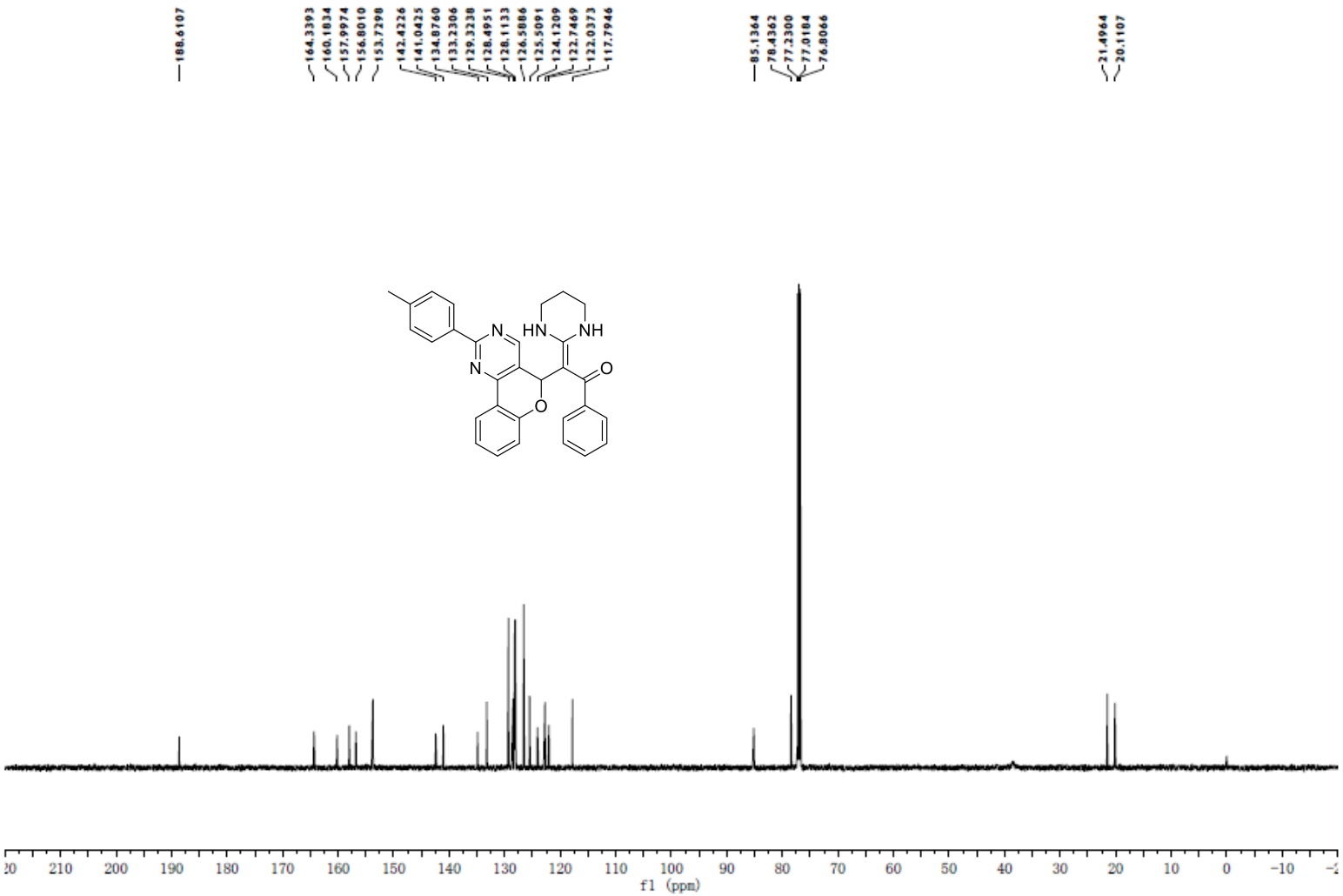


Figure S10. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4d**

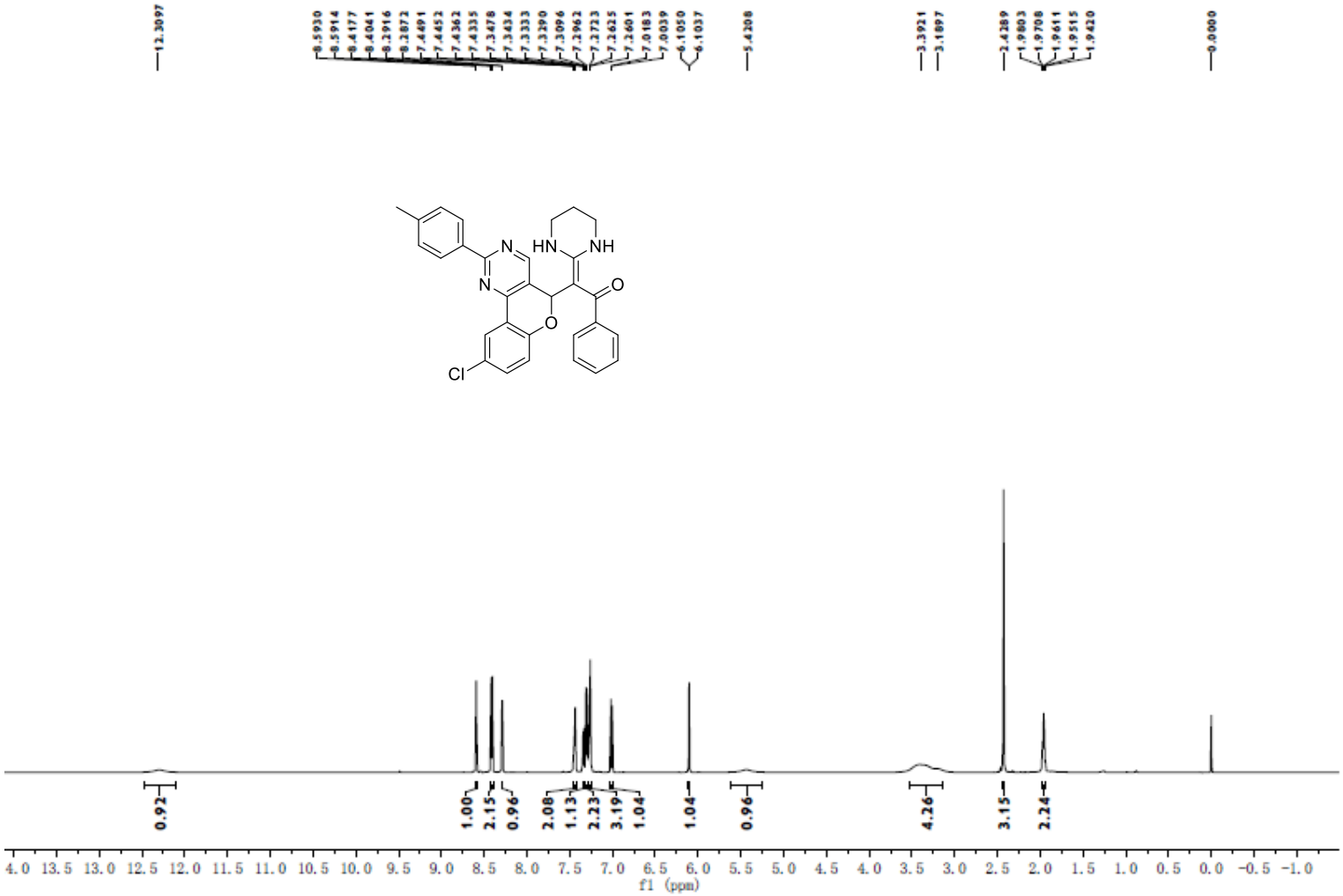


Figure S11. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4e**

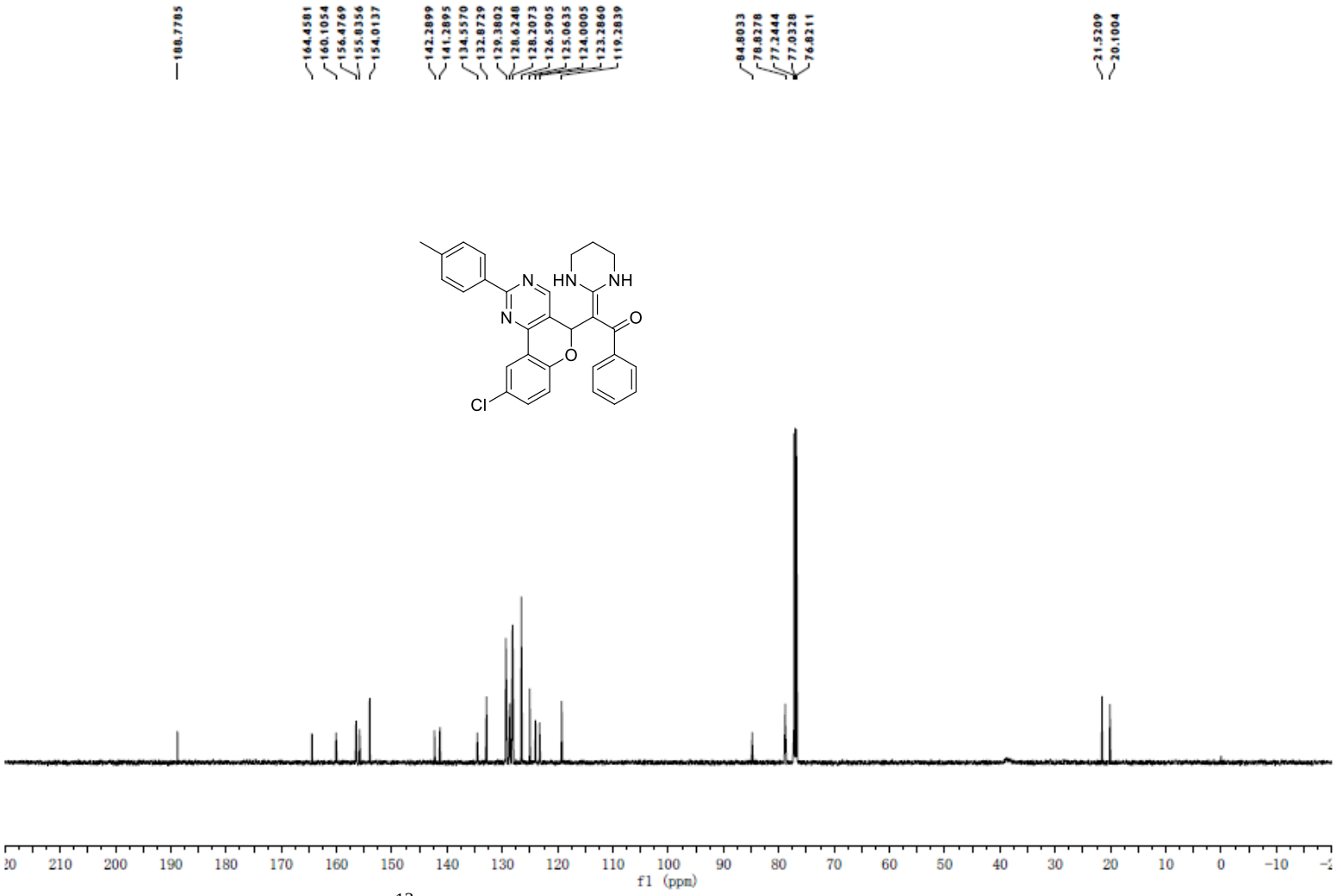


Figure S12. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4e**

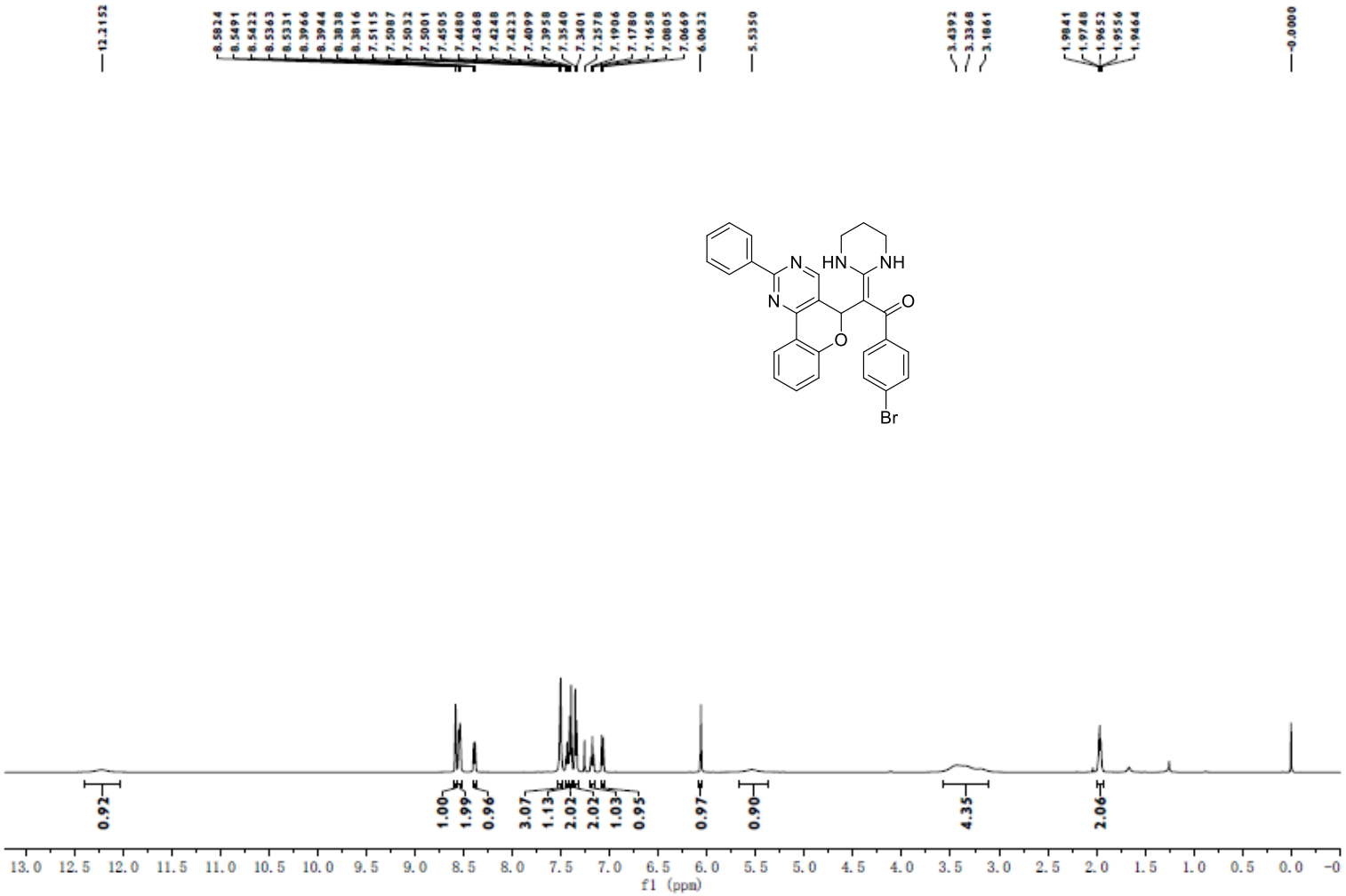


Figure S13. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4f**

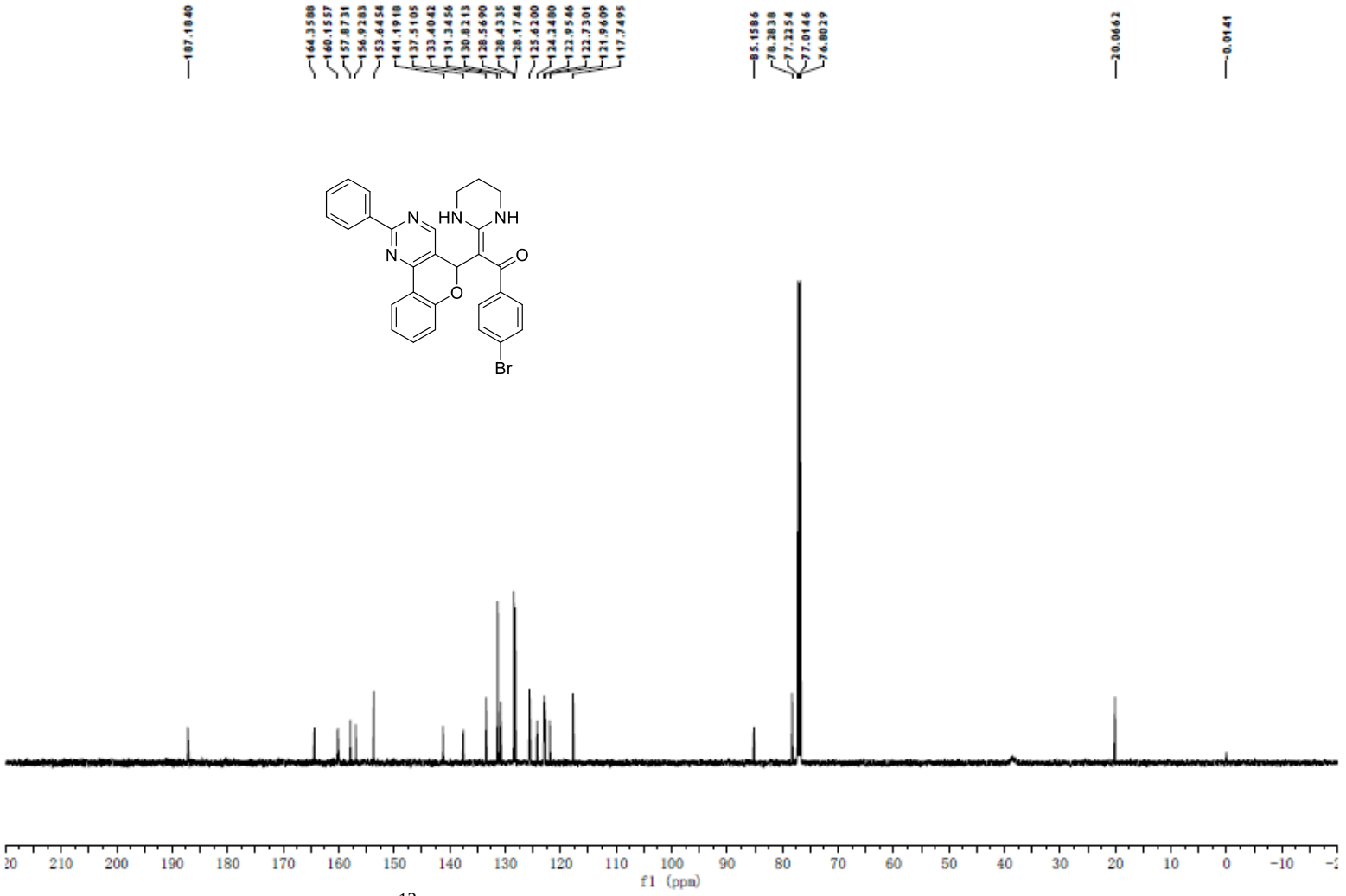


Figure S14. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4f**

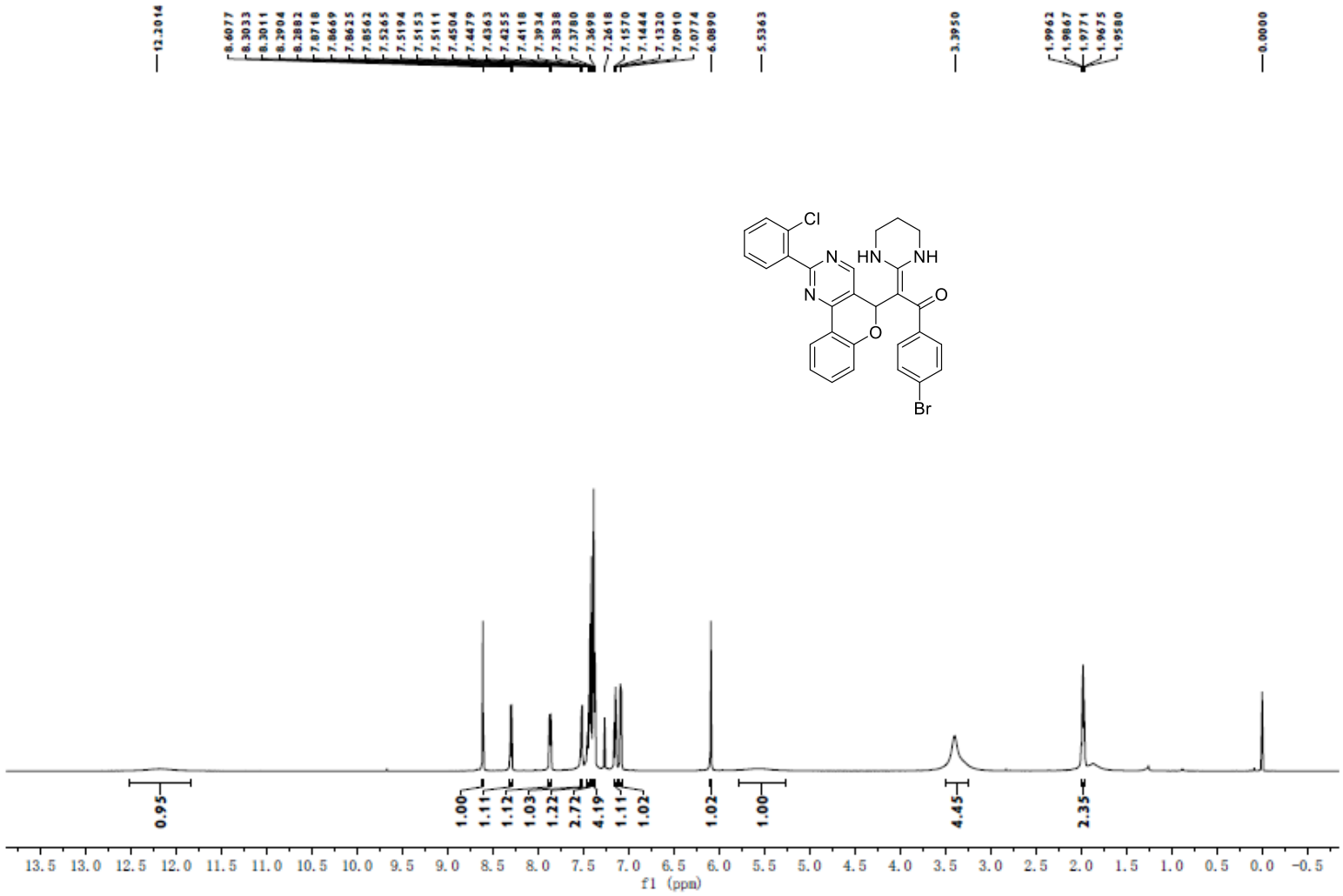


Figure S15. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4g**

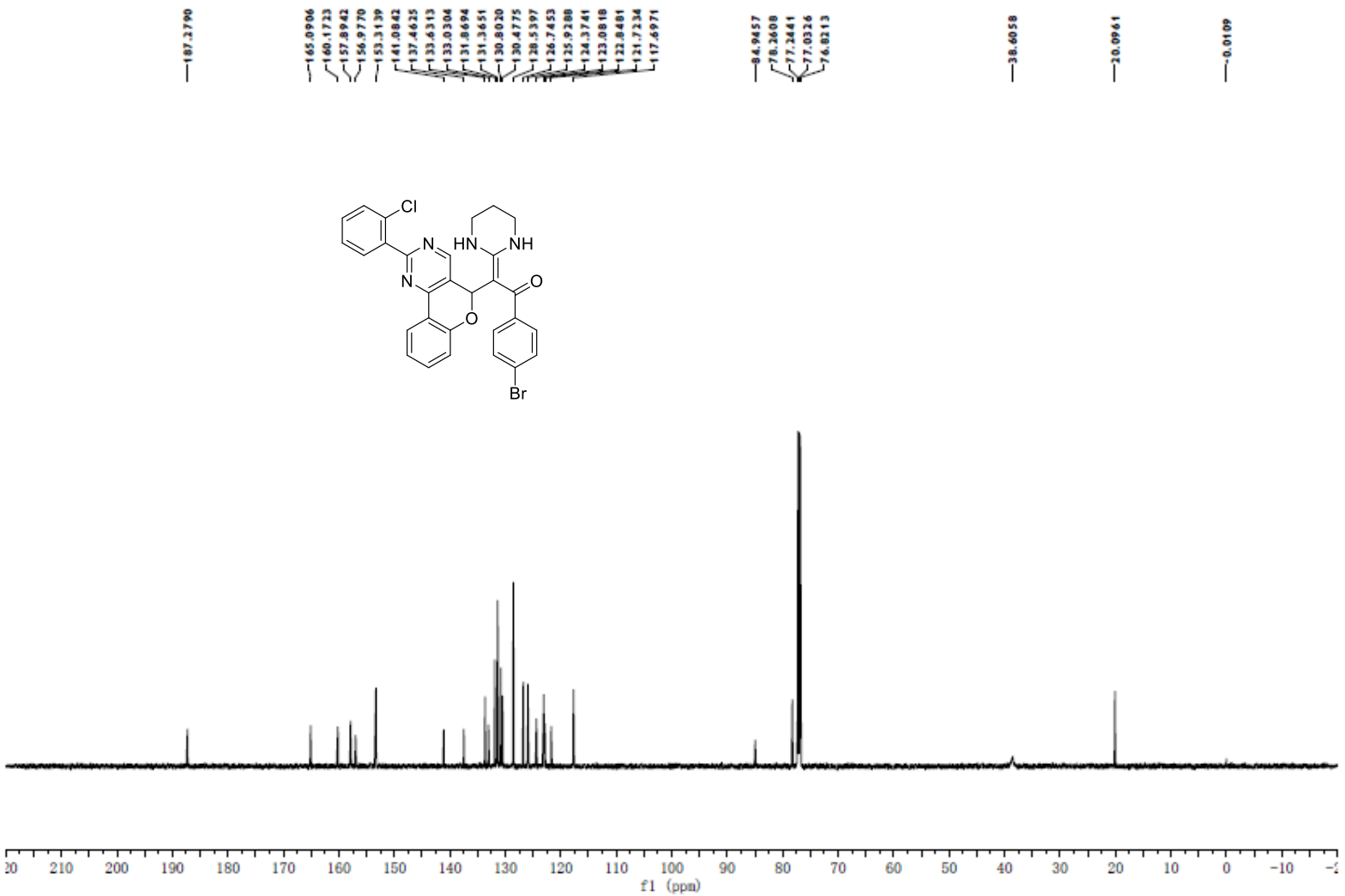


Figure S16. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4g**

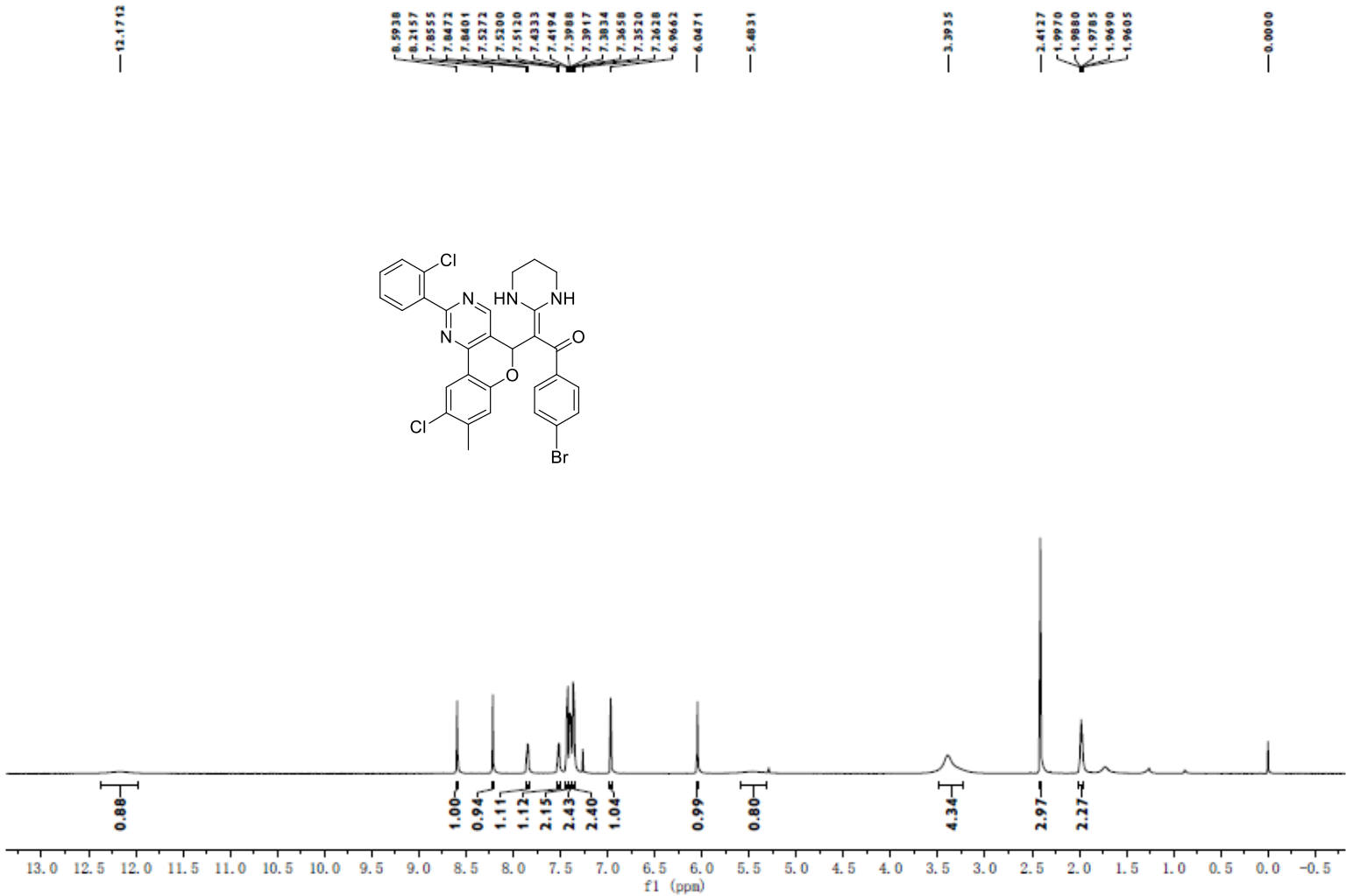


Figure S17. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4h**

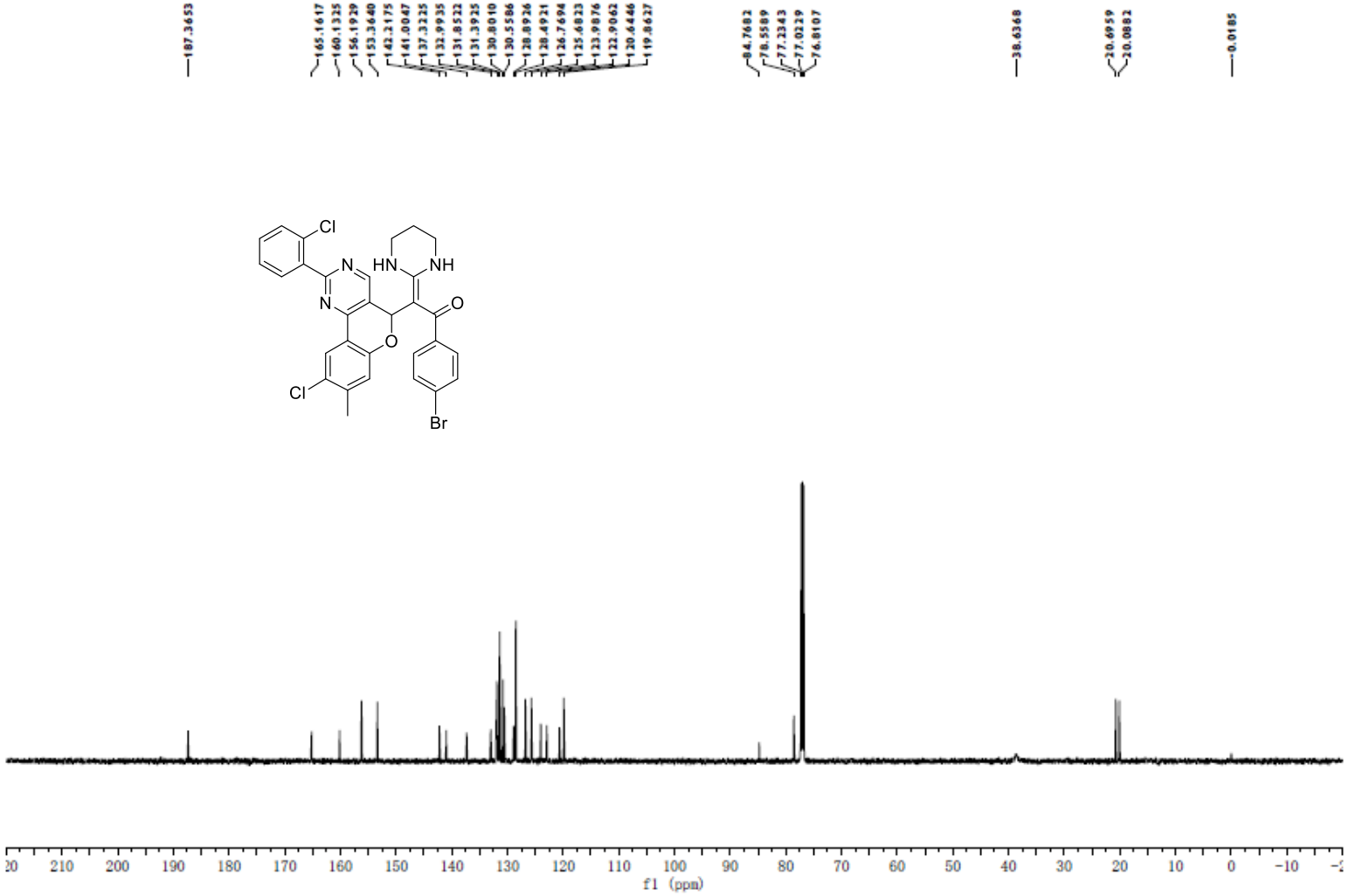


Figure S18. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4h**

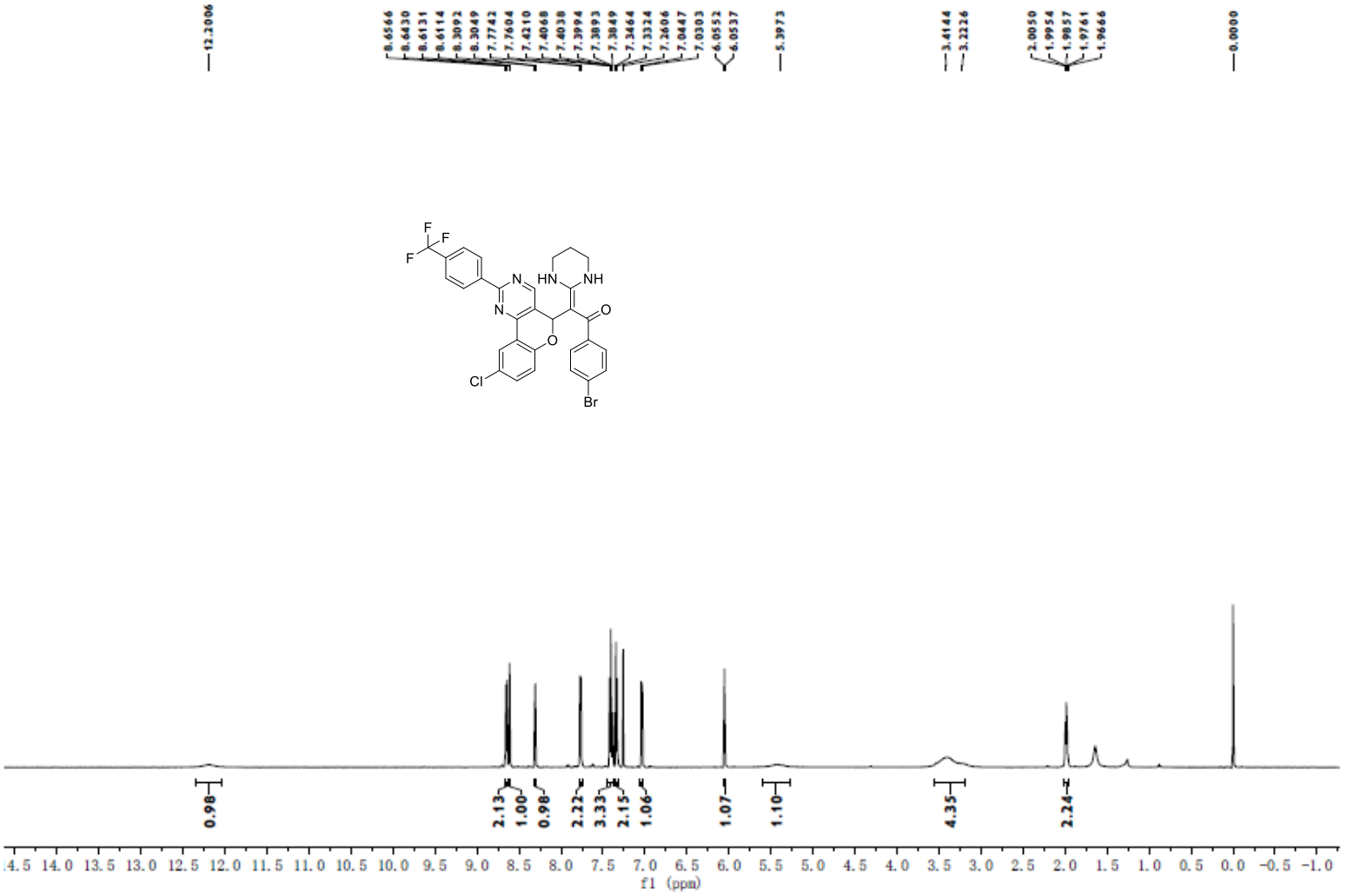


Figure S19. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4i**

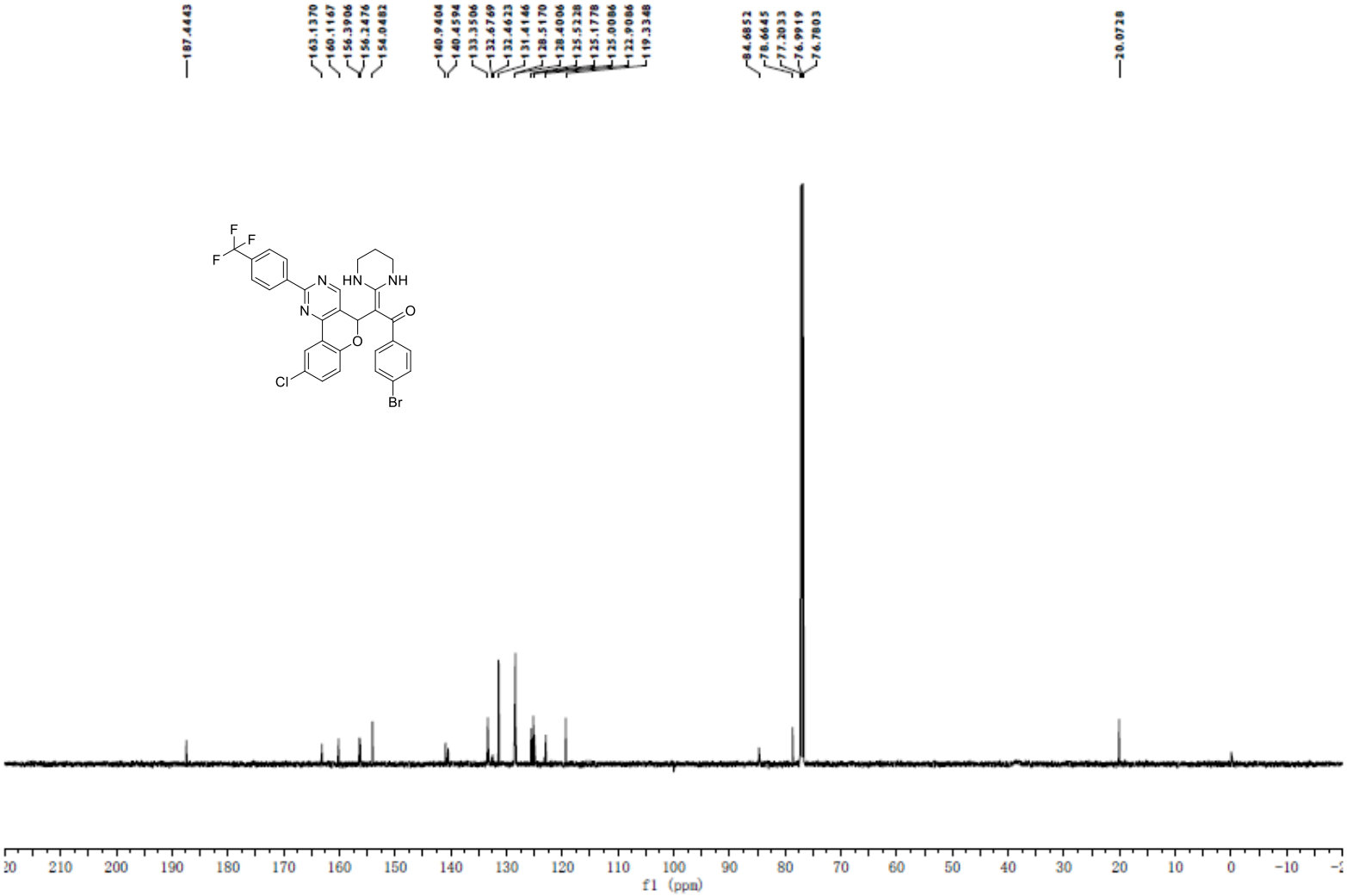


Figure S20. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4i**

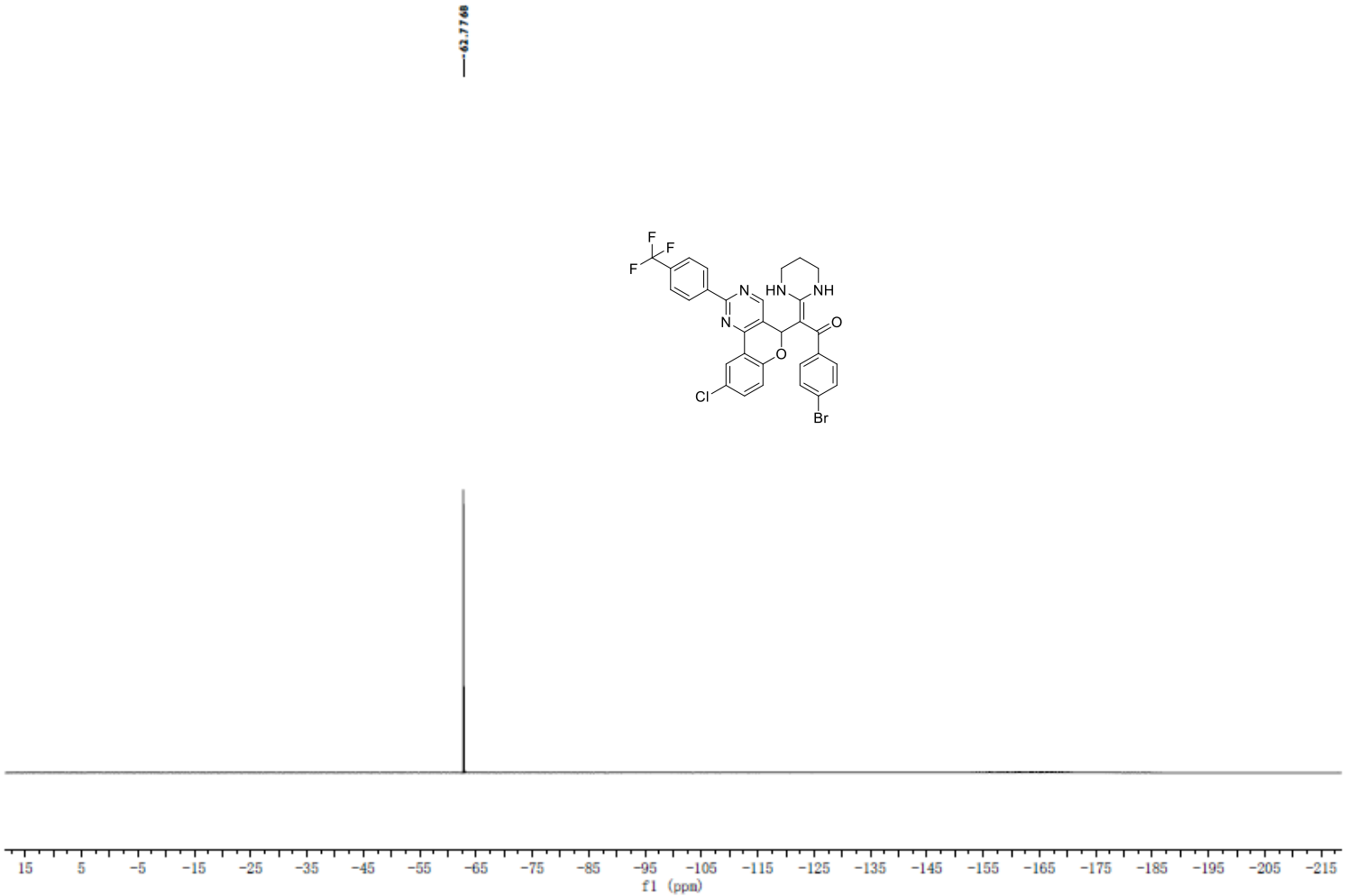


Figure S21. ^{19}F NMR (540 MHz, Chloroform-*d*) spectra of compound **4i**

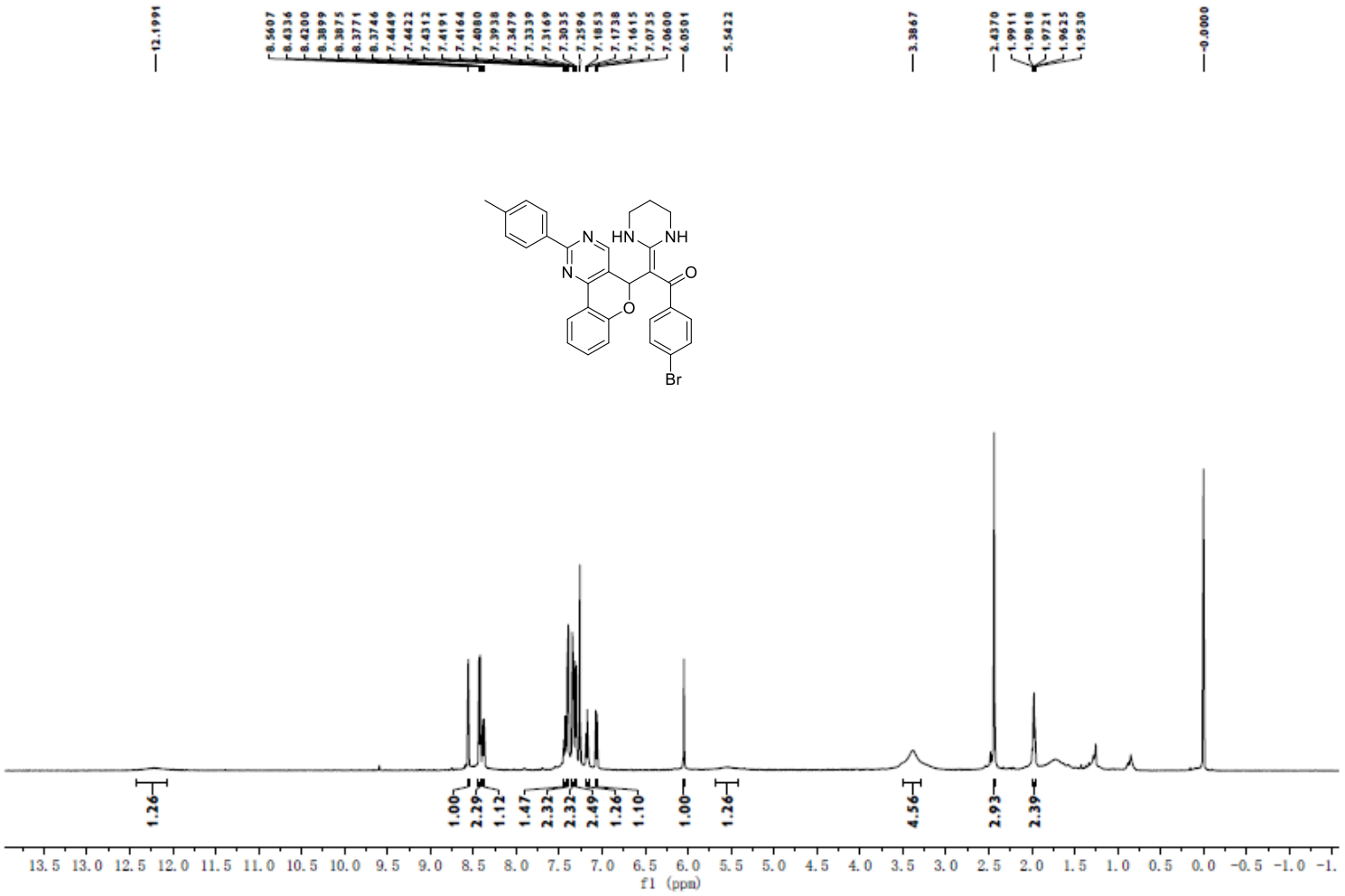


Figure S22. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4j**

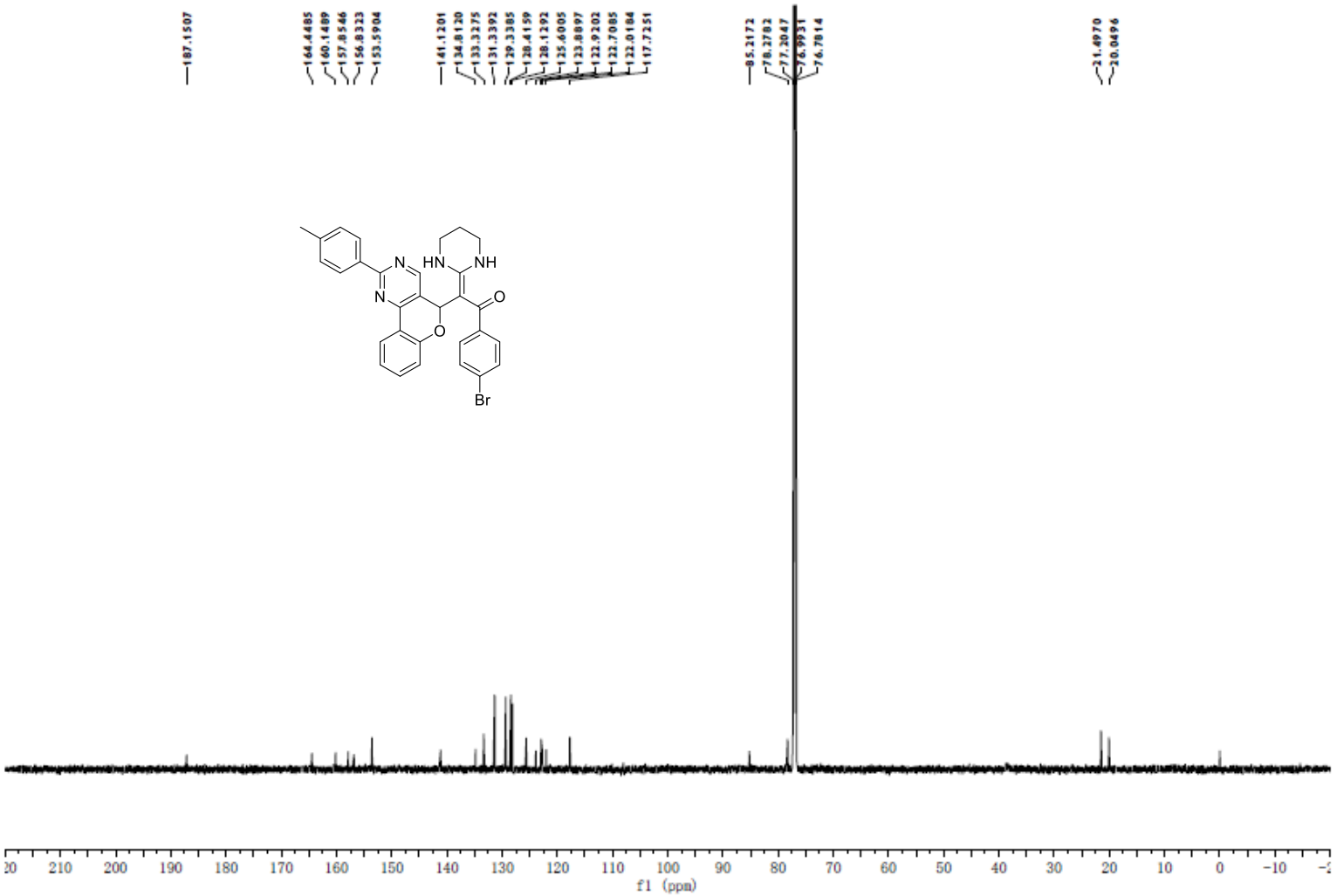


Figure S23. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4j**

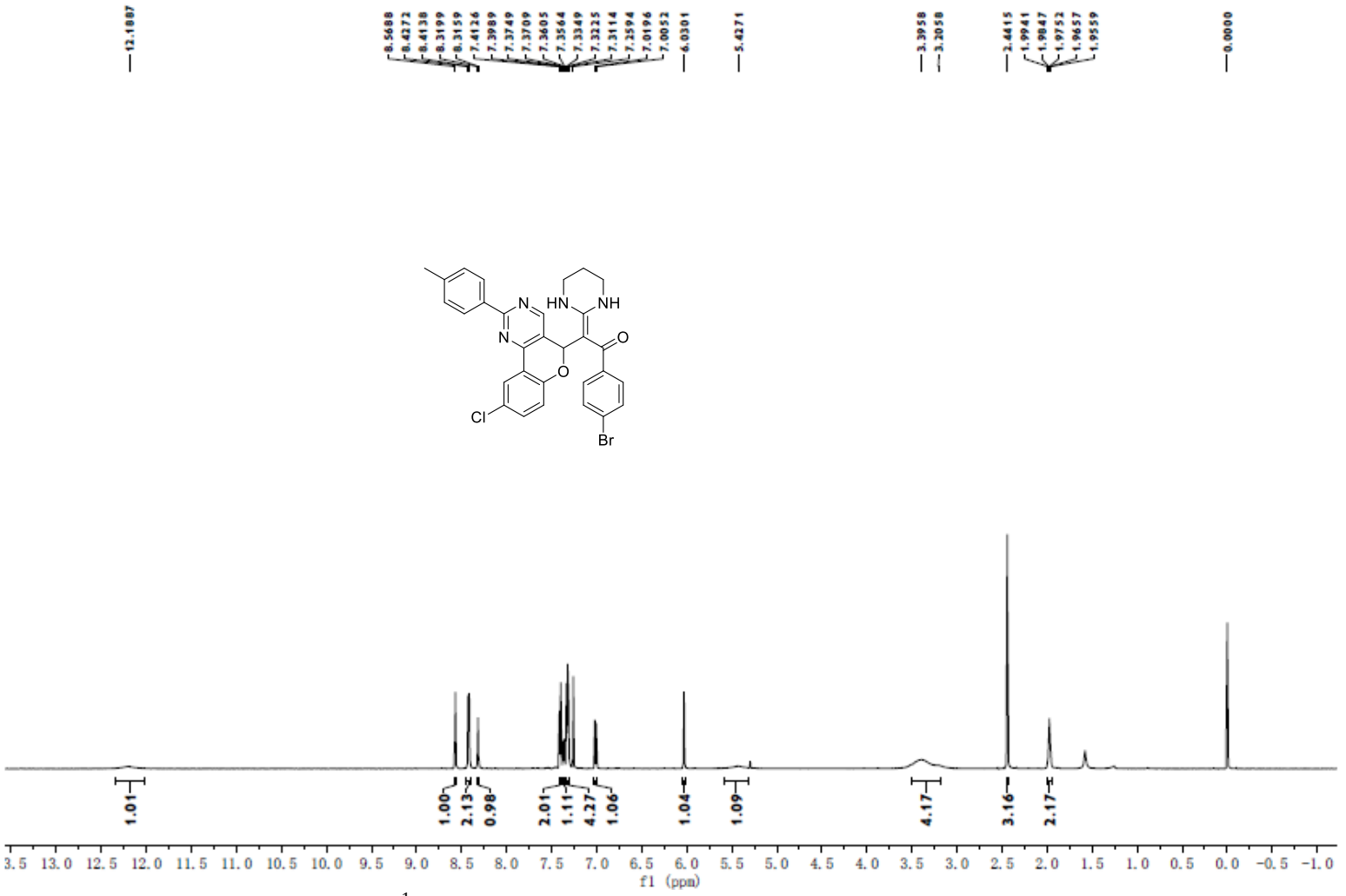


Figure S24. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4k**

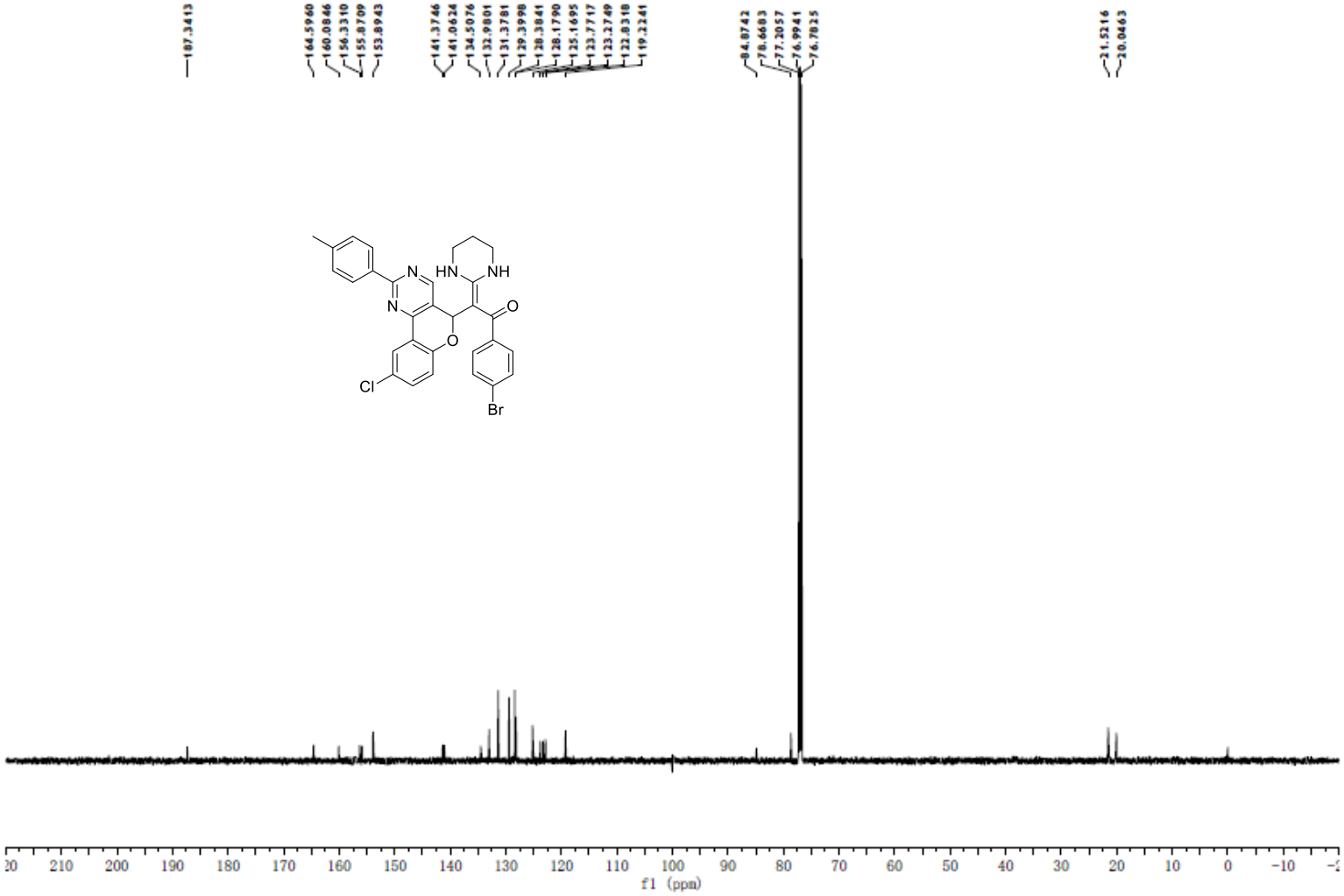


Figure S25. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4k**

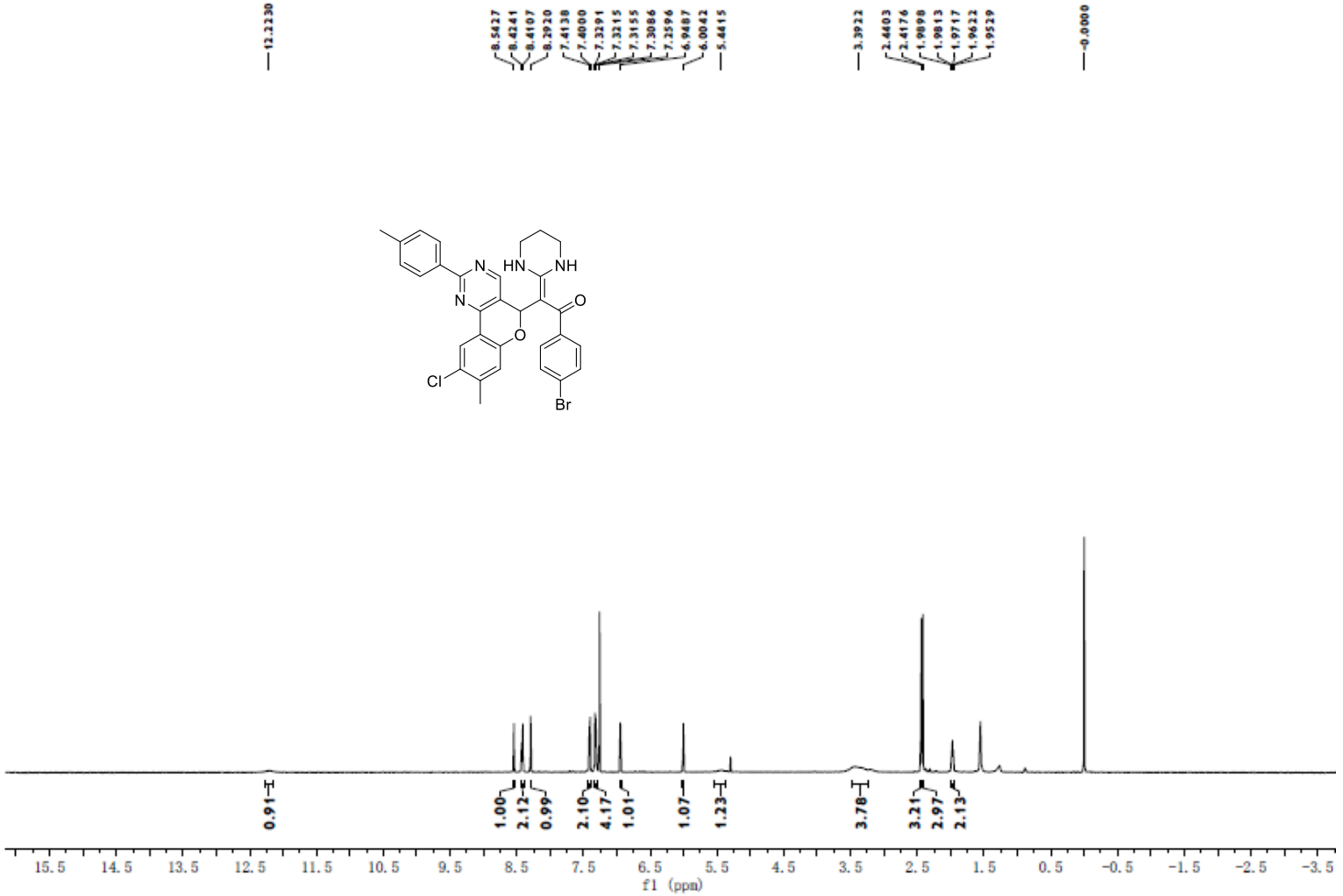


Figure S26. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4l**

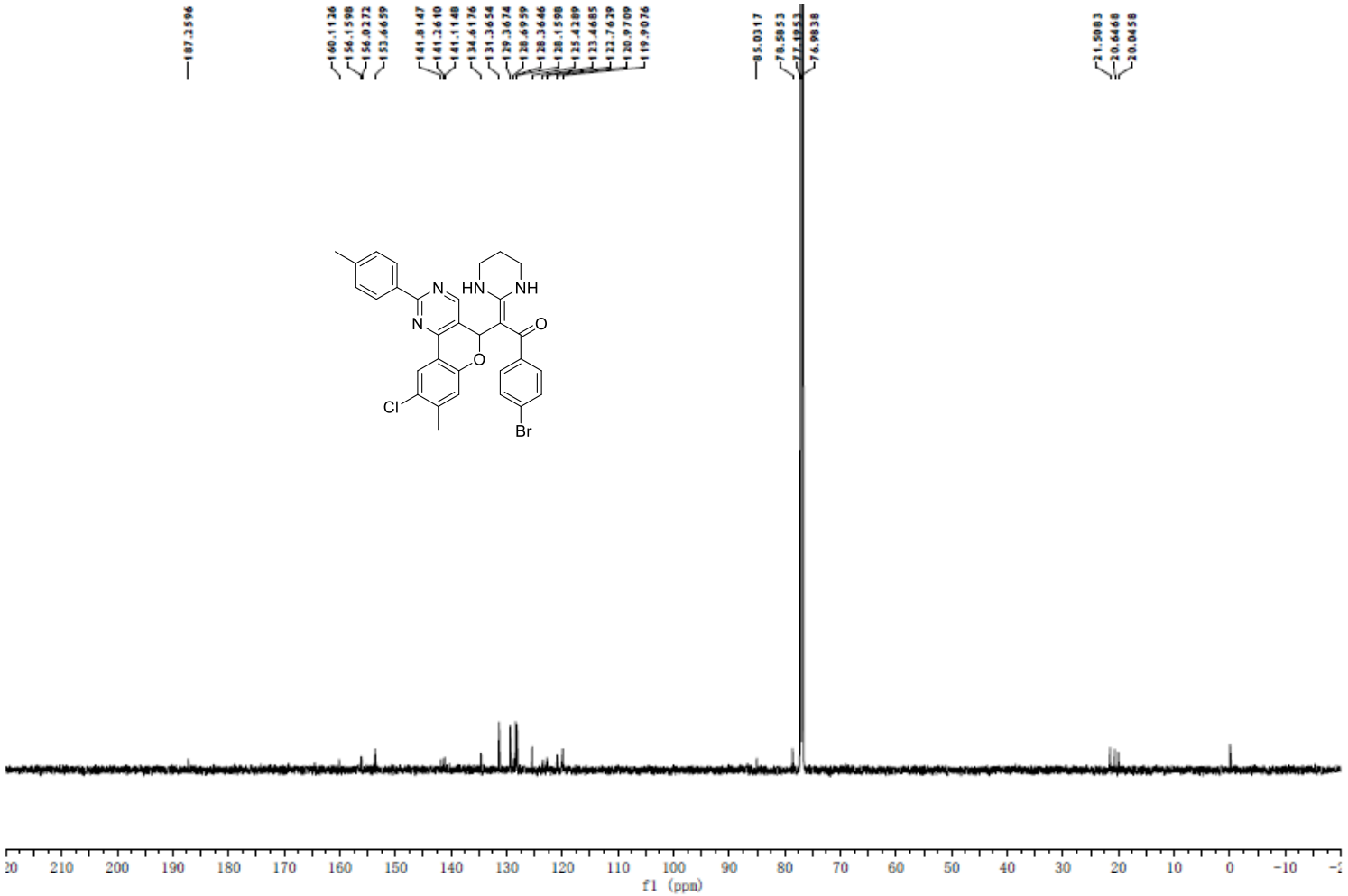


Figure S27. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4l**

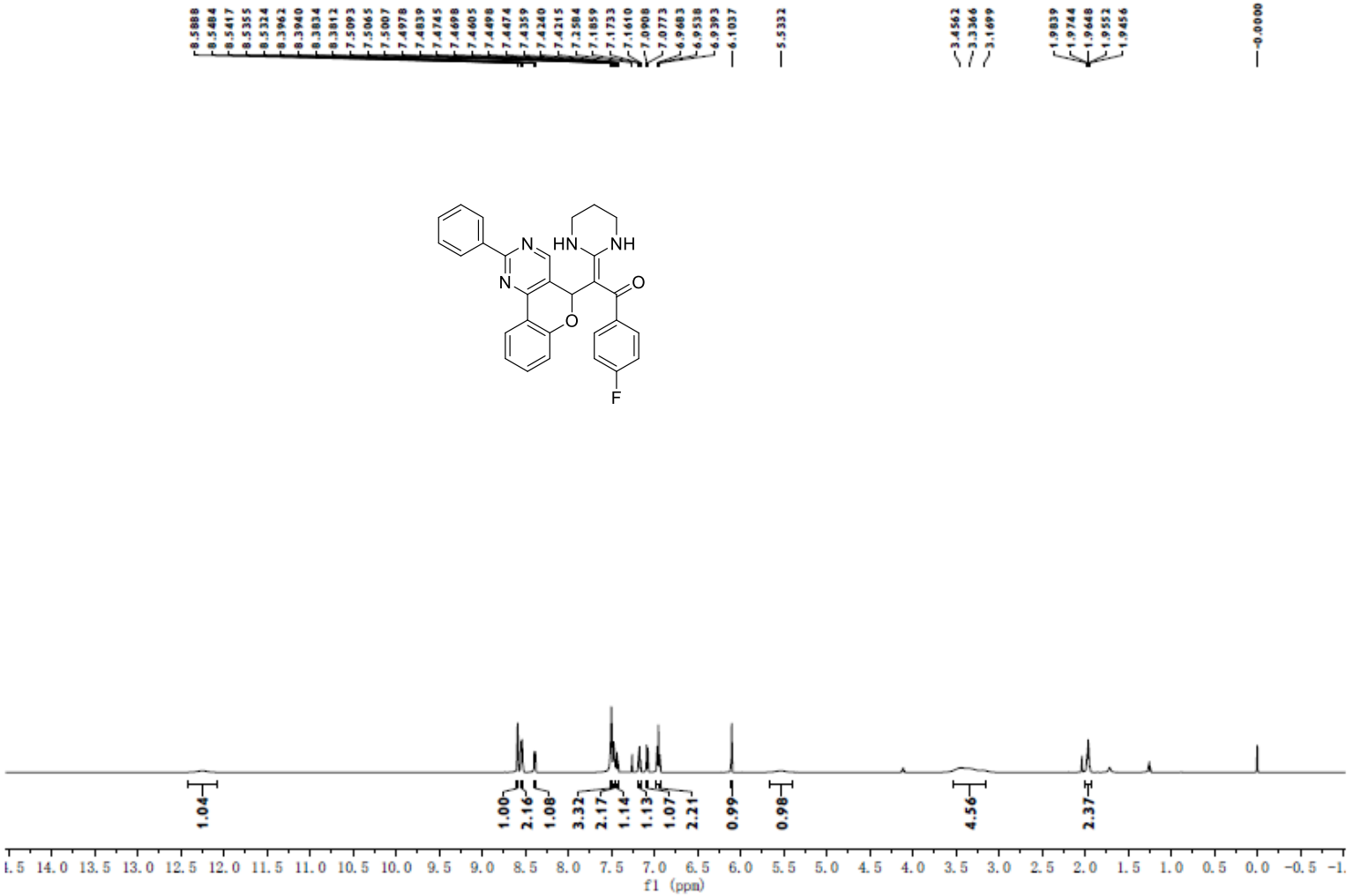


Figure S28. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4m**

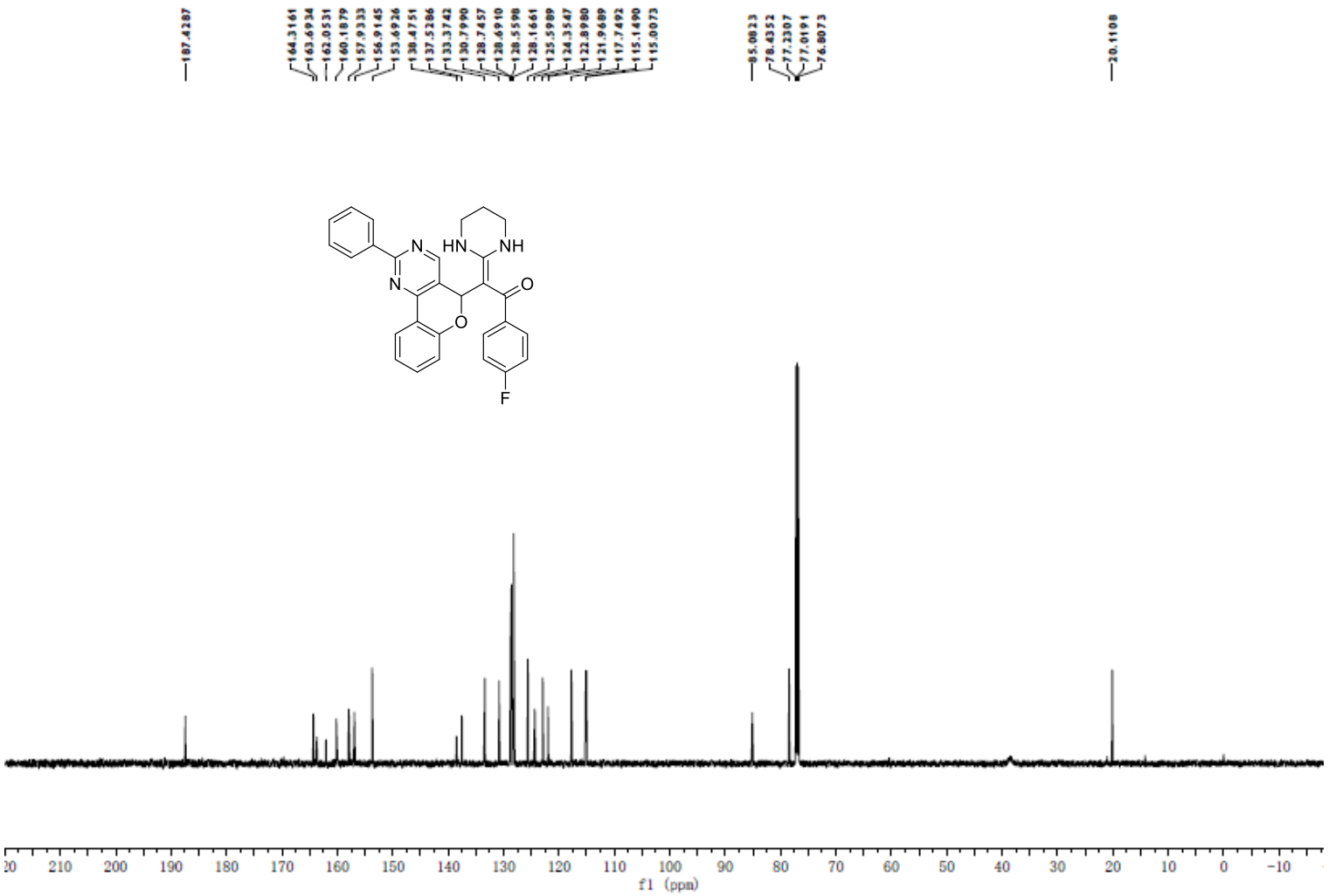


Figure S29. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4m**

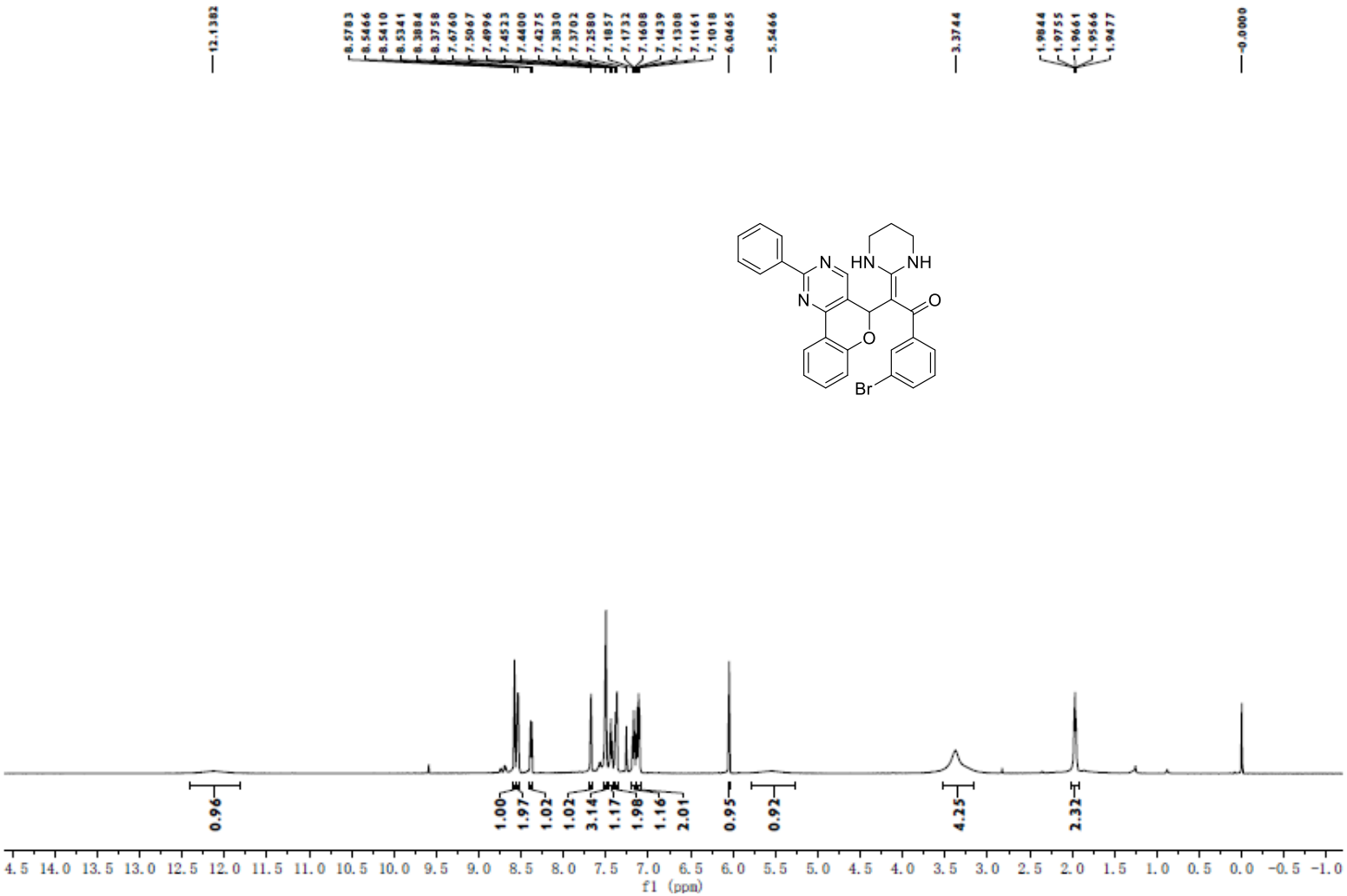


Figure S30. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4n**

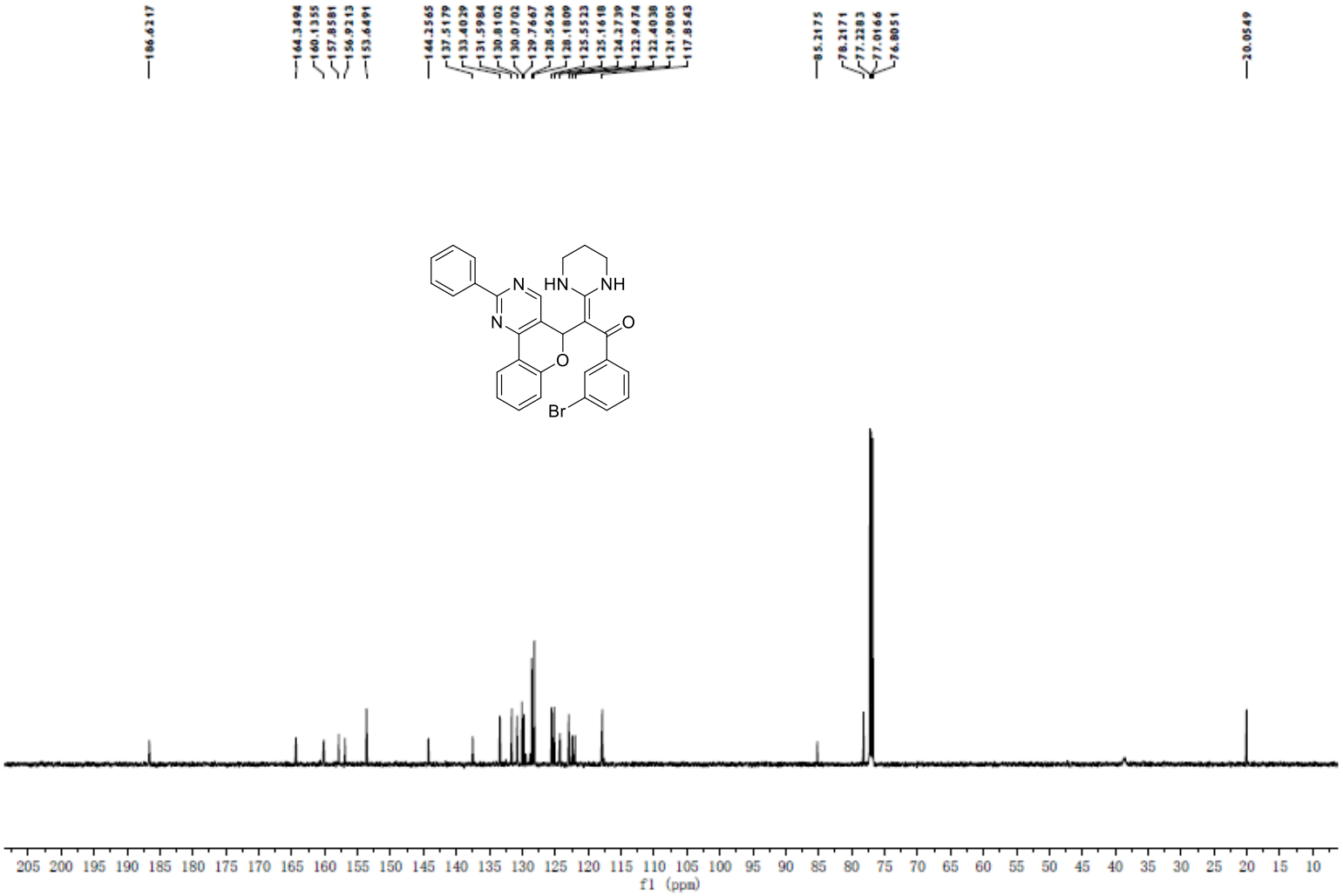


Figure S31. ^{13}C NMR (150 MHz,, Chloroform-*d*) spectra of compound **4n**

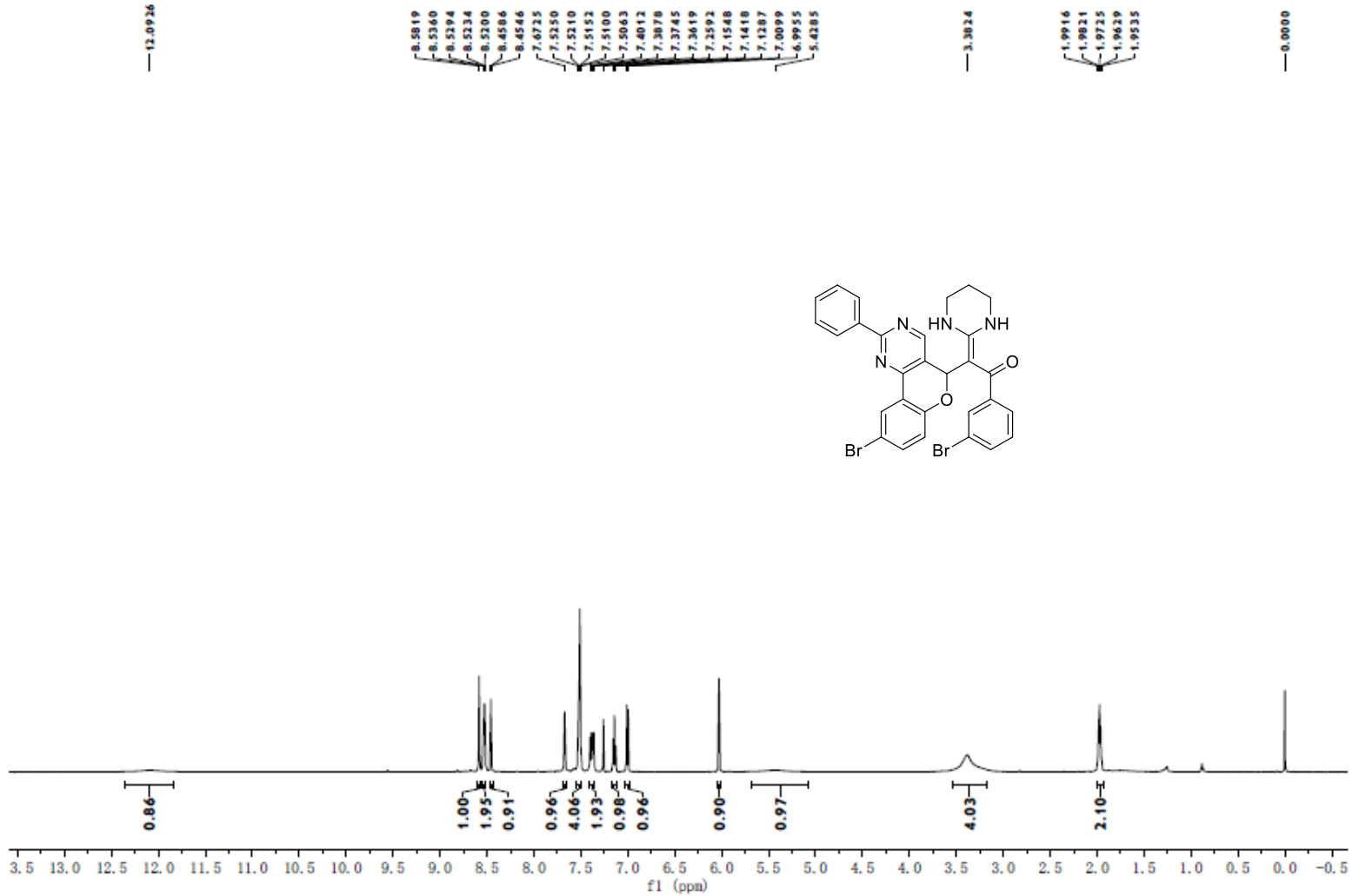


Figure S32. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4o**

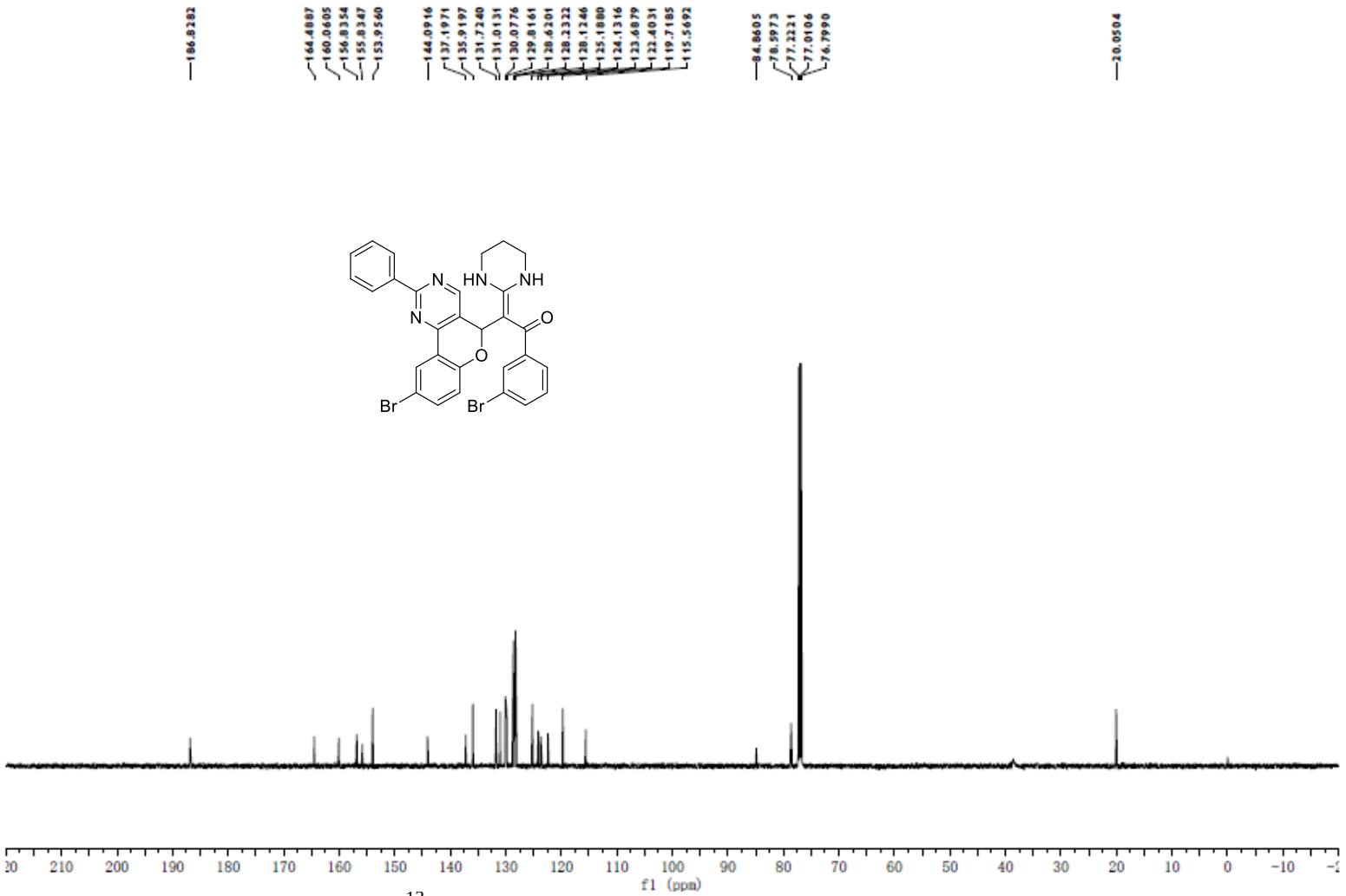


Figure S33. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4o**

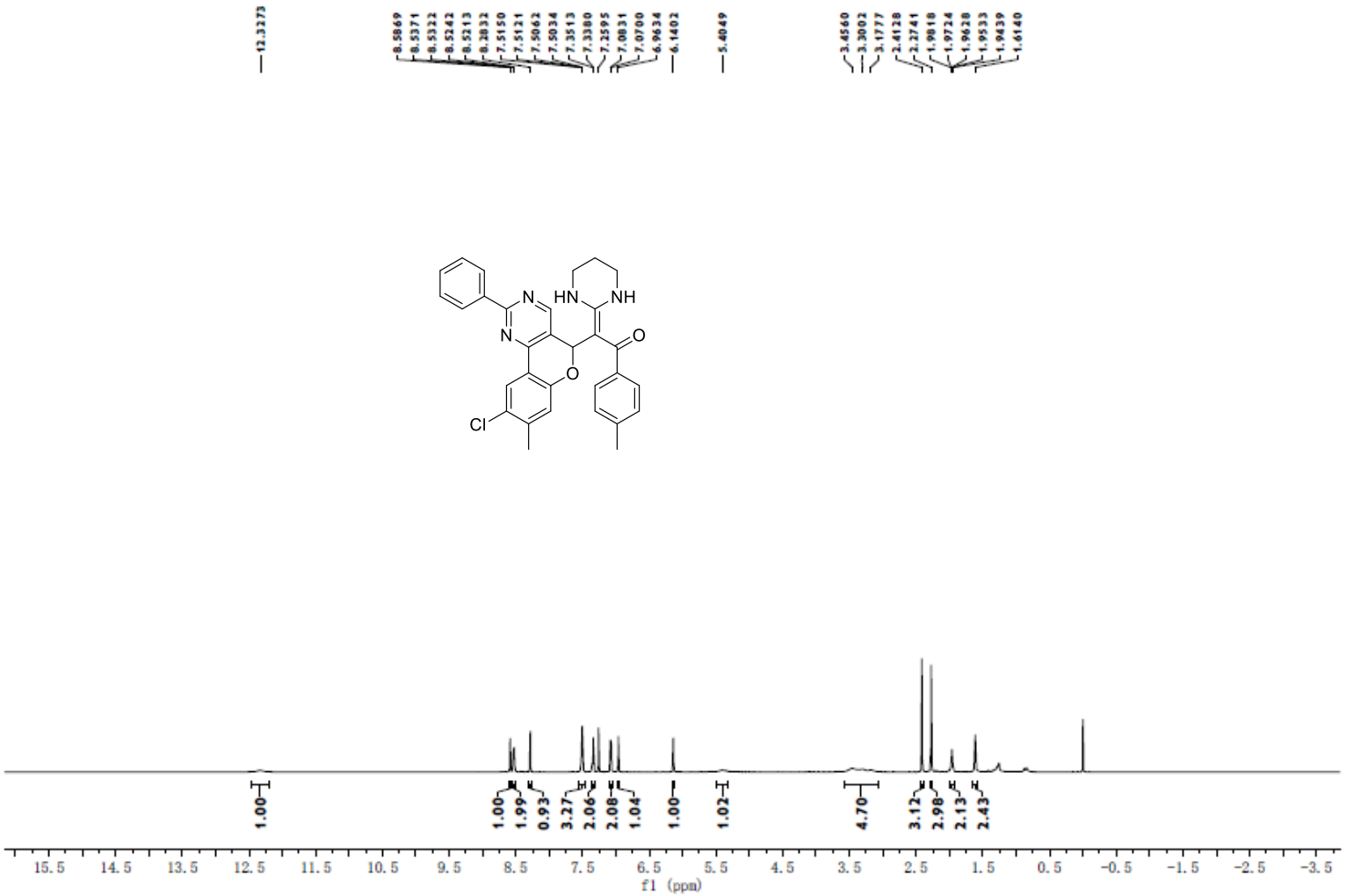


Figure S34. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4p**

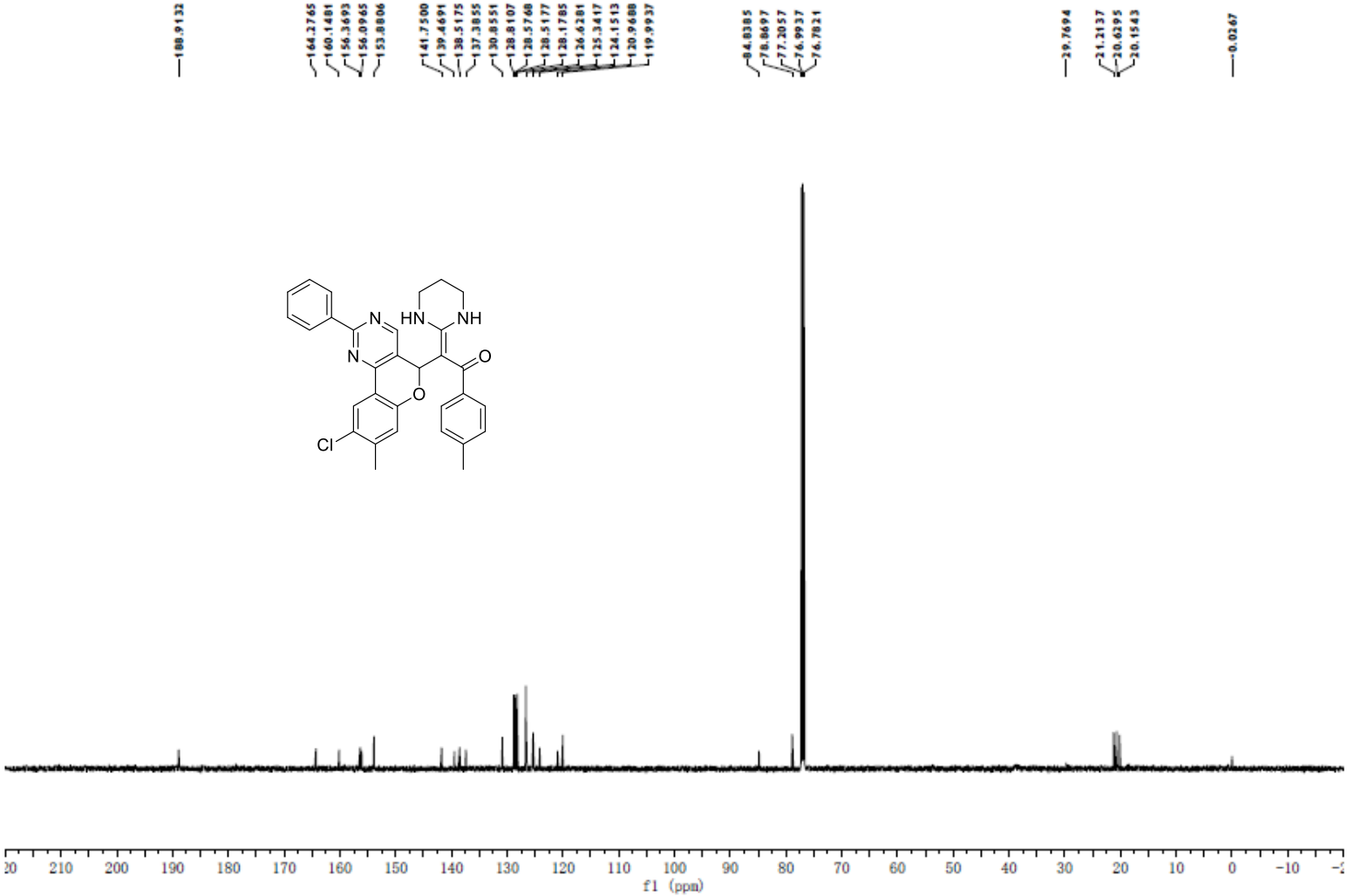


Figure S35. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4p**

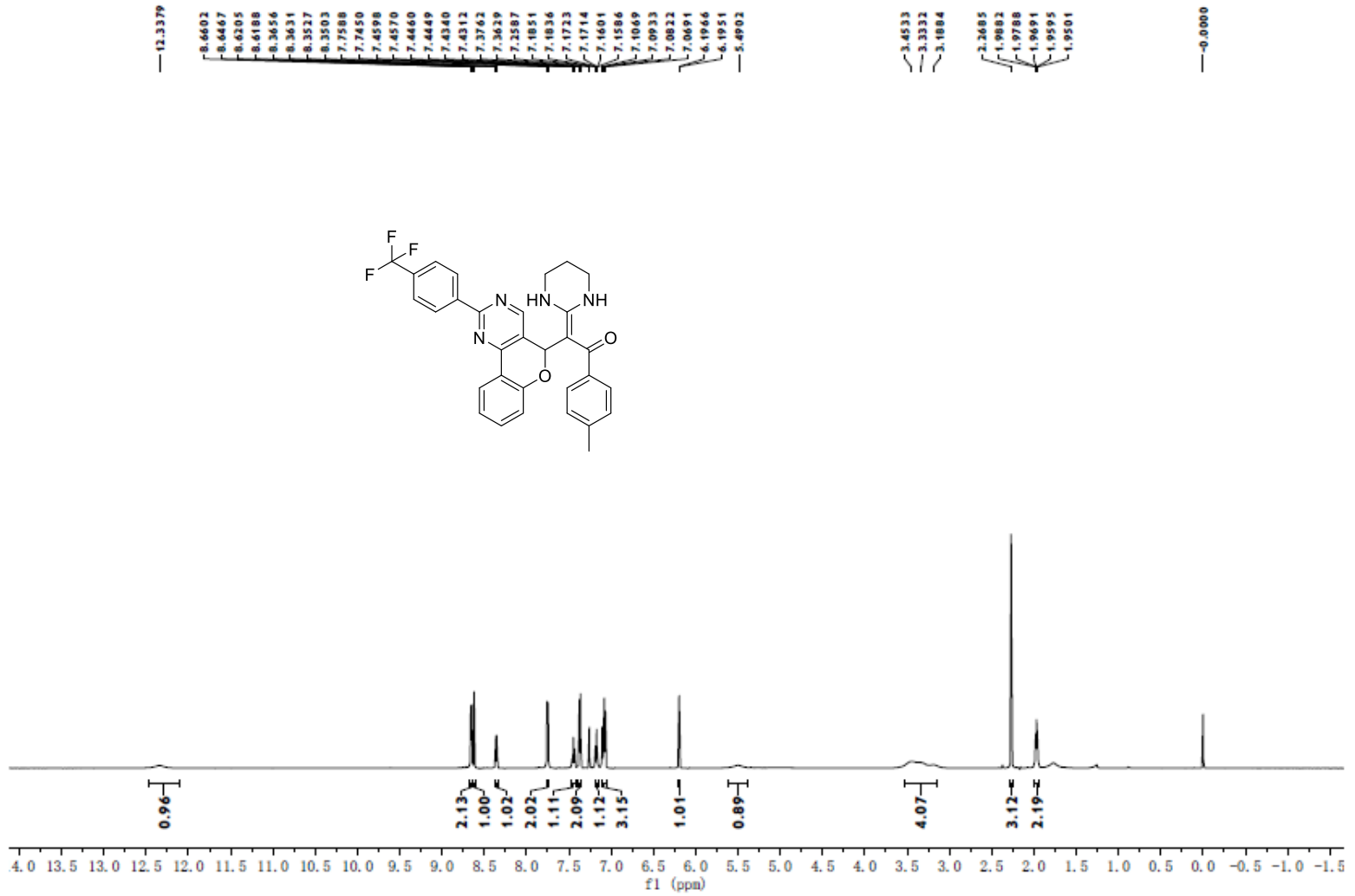


Figure S36. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4q**

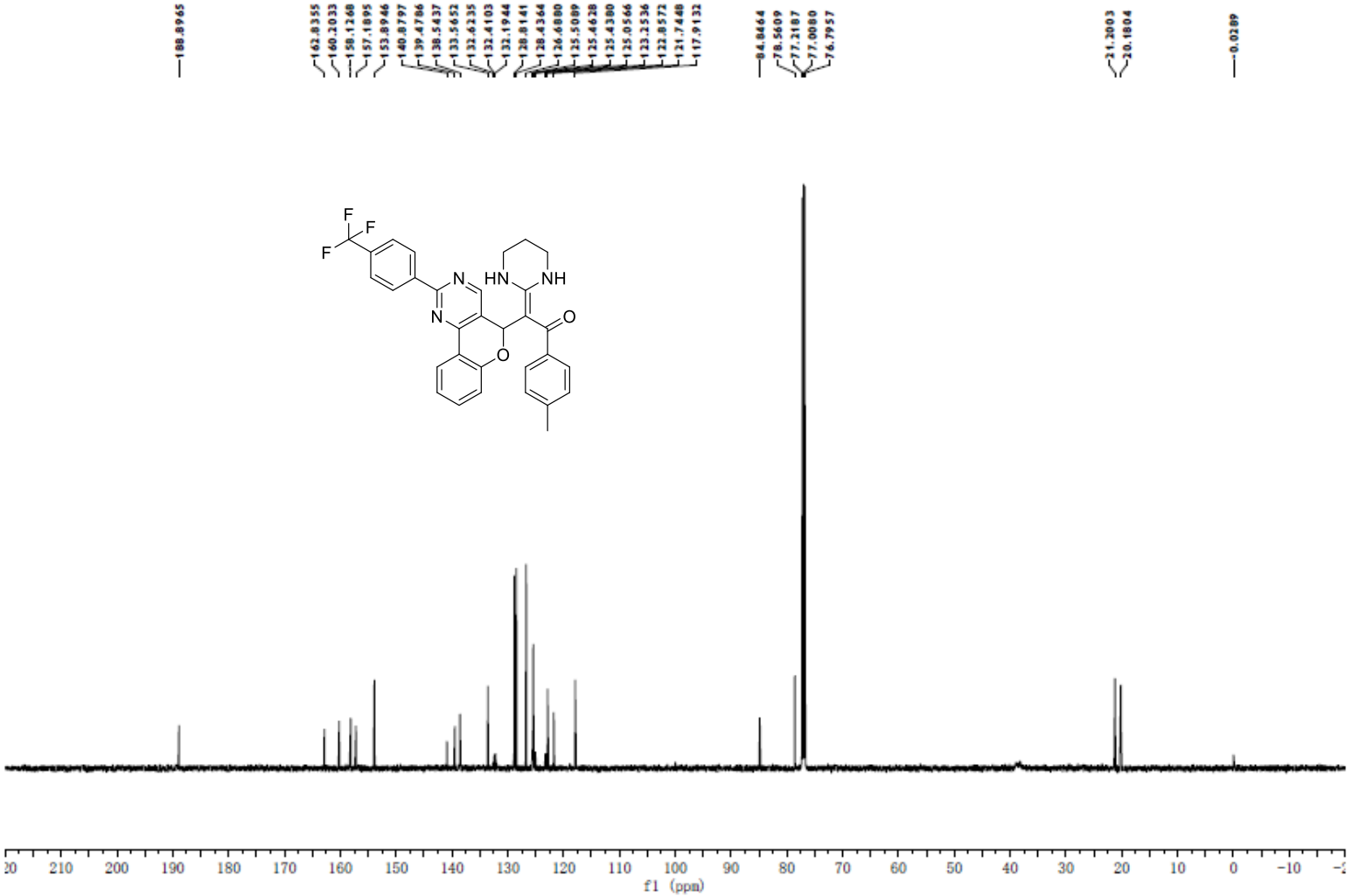


Figure S37. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4q**

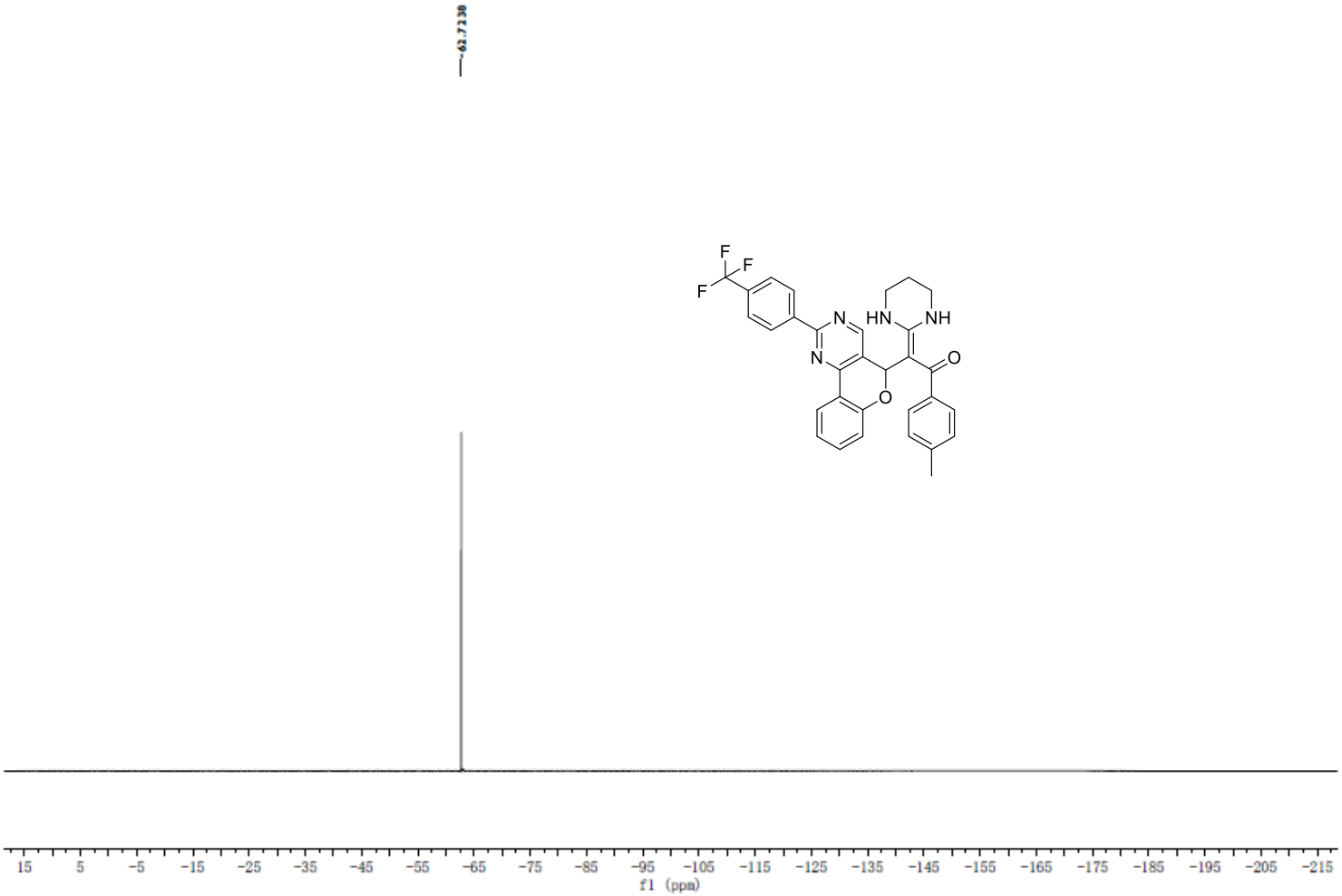


Figure S38. ^{19}F NMR (540 MHz, Chloroform-*d*) spectra of compound **4q**

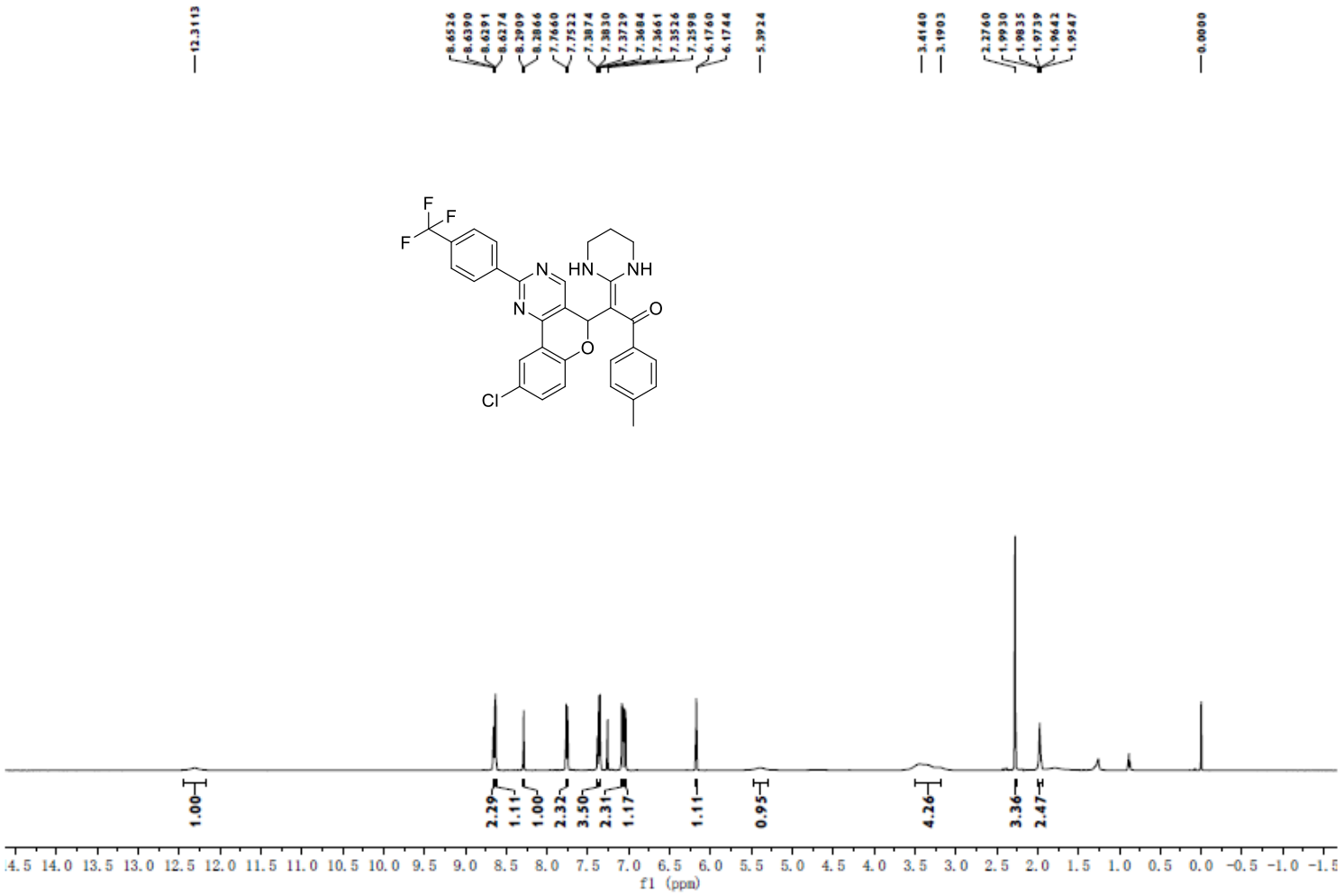


Figure S39. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4r**

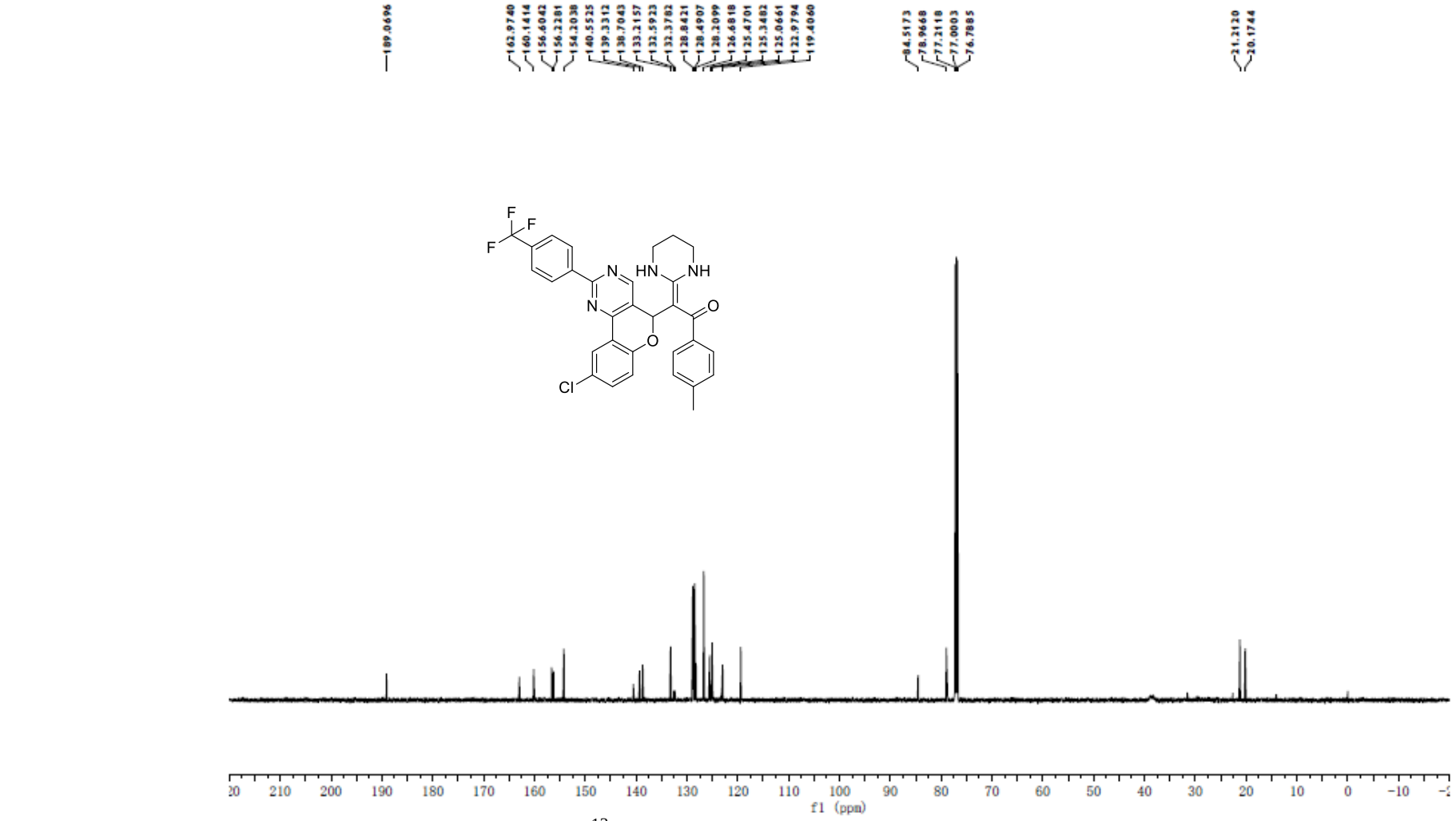


Figure S40. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4r**

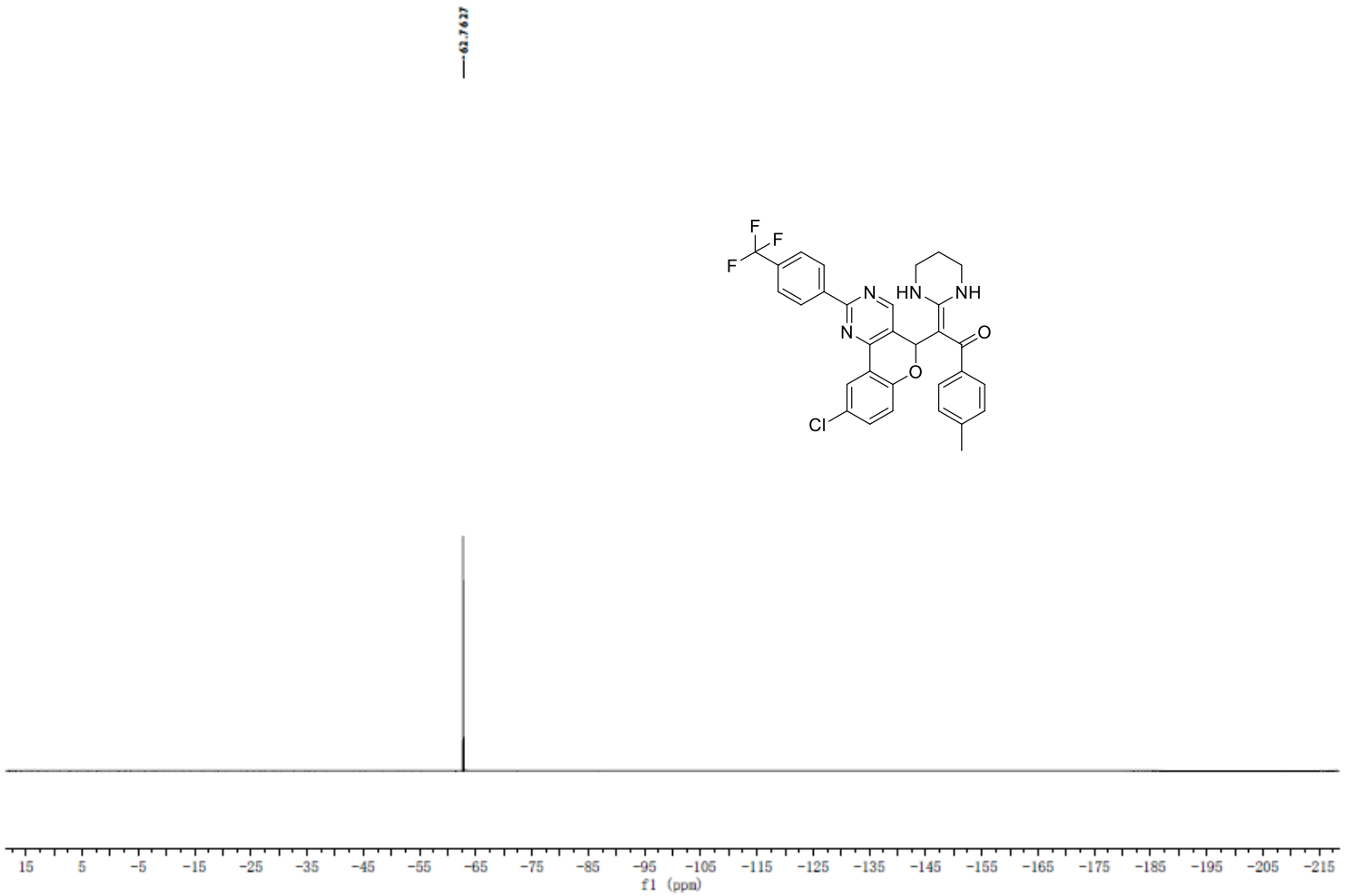


Figure S41. ^{19}F NMR (540 MHz, Chloroform-*d*) spectra of compound **4r**

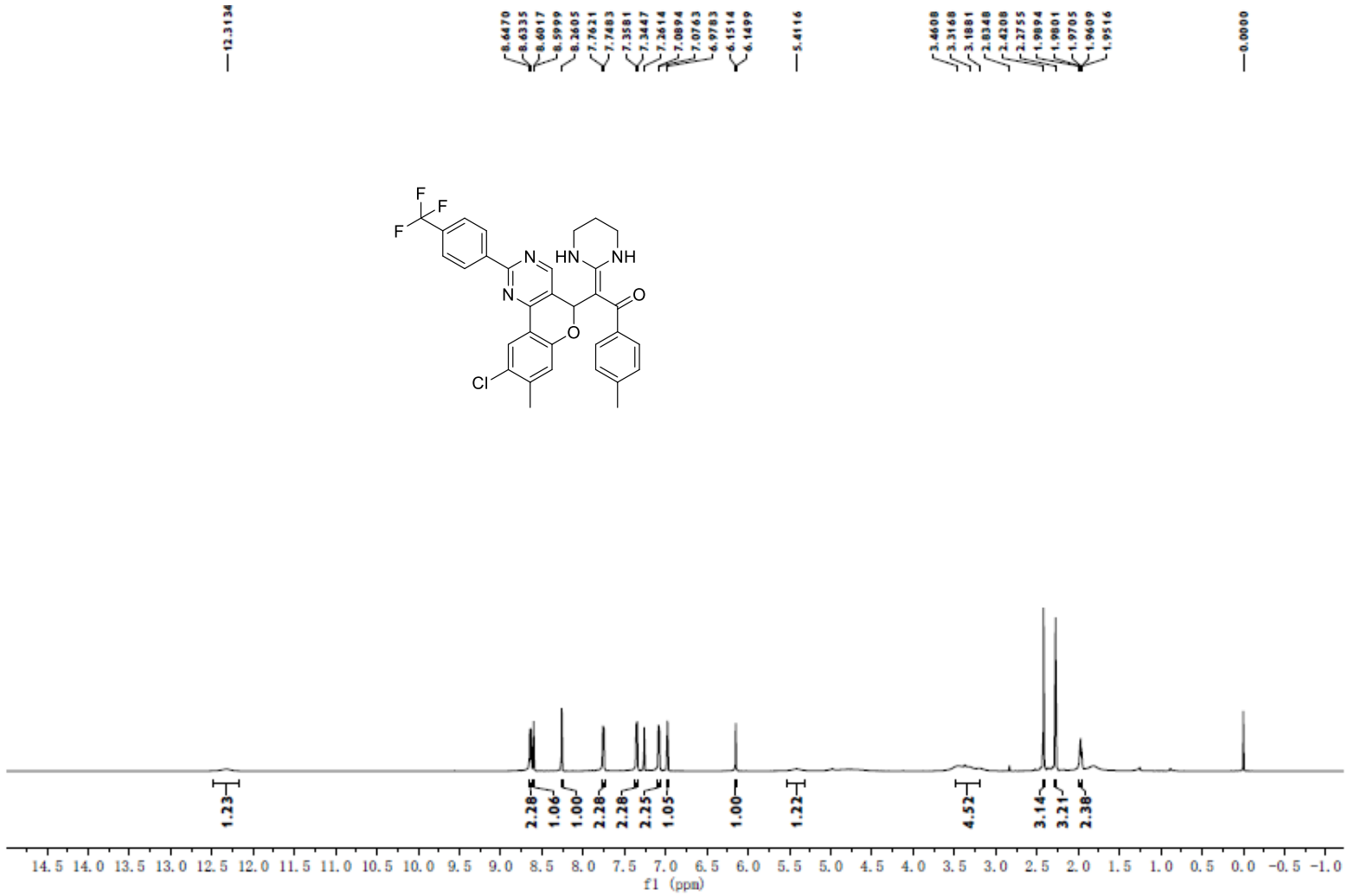


Figure S42. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4s**

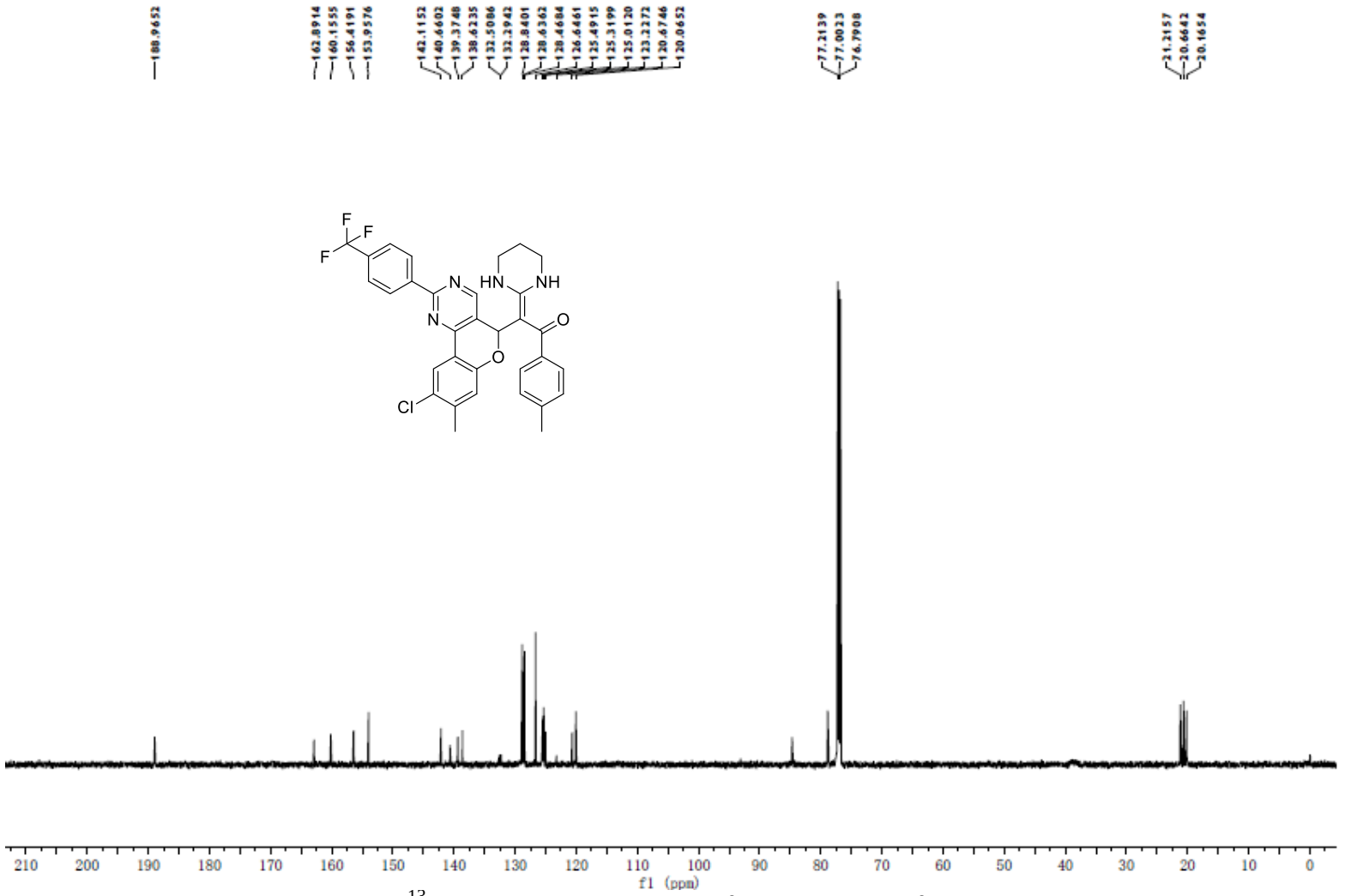


Figure S43. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4s**

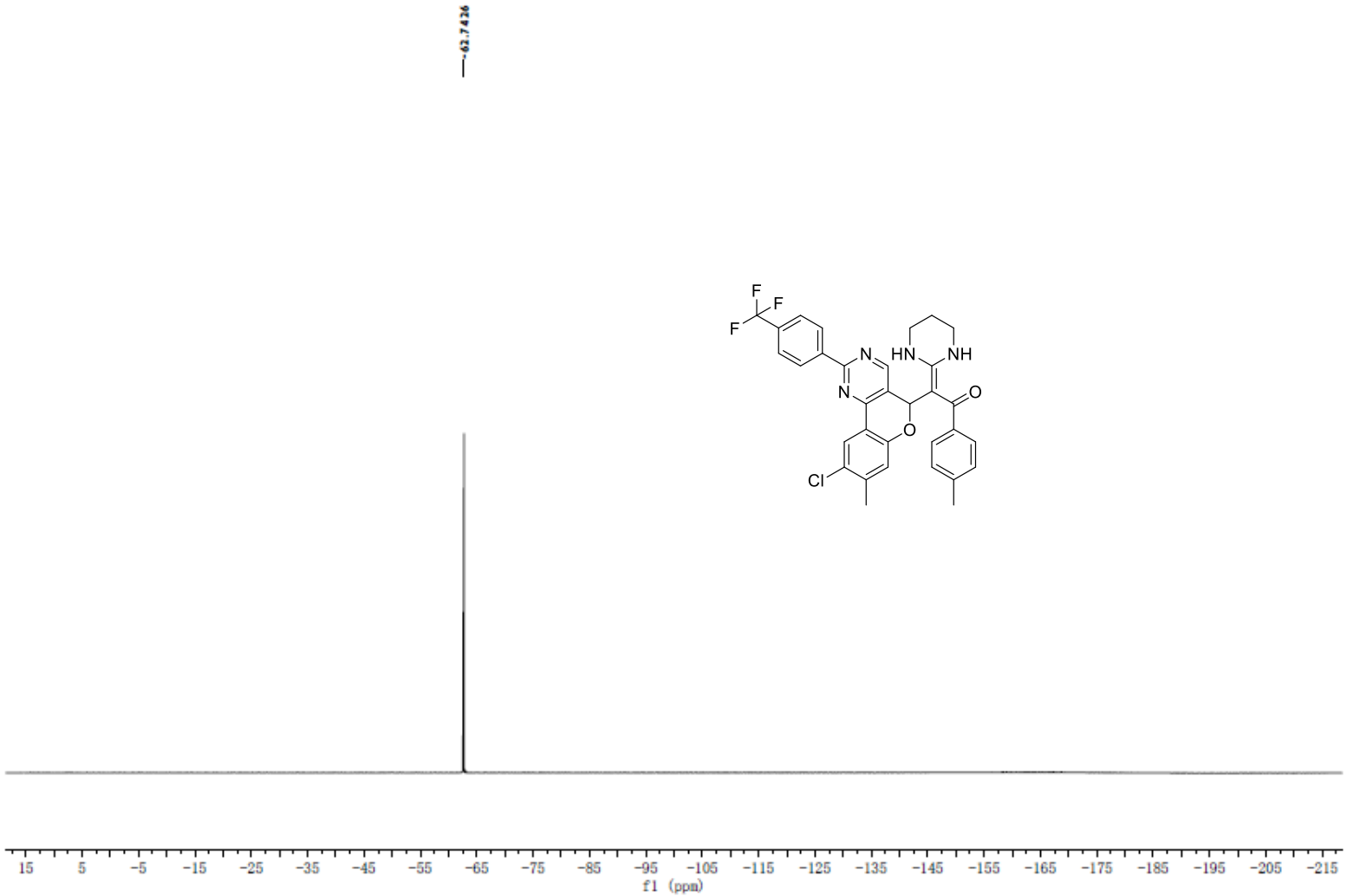


Figure S44. ^{19}F NMR (540 MHz, Chloroform-*d*) spectra of compound **4s**

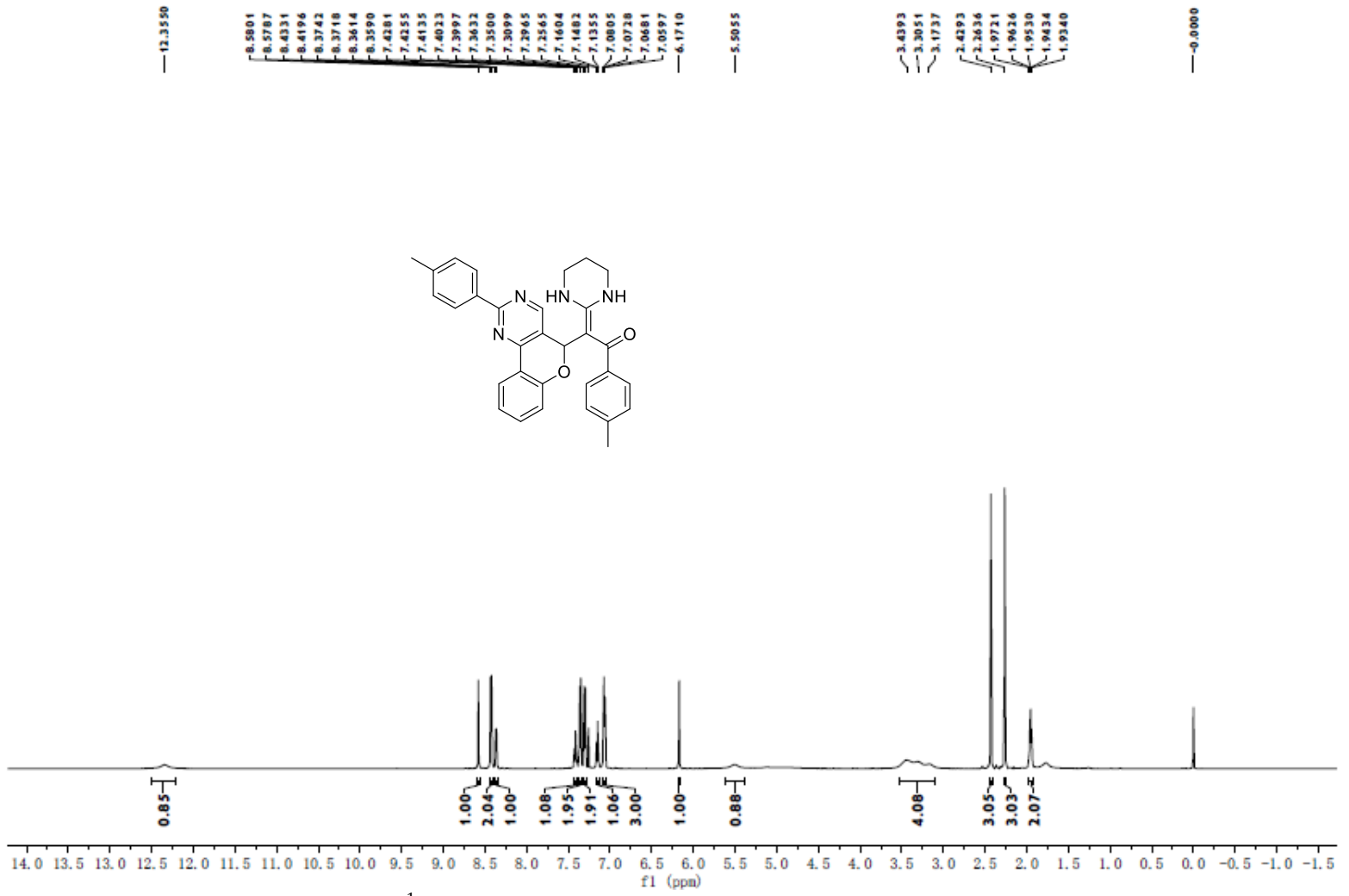


Figure S45. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compo**und 4t**

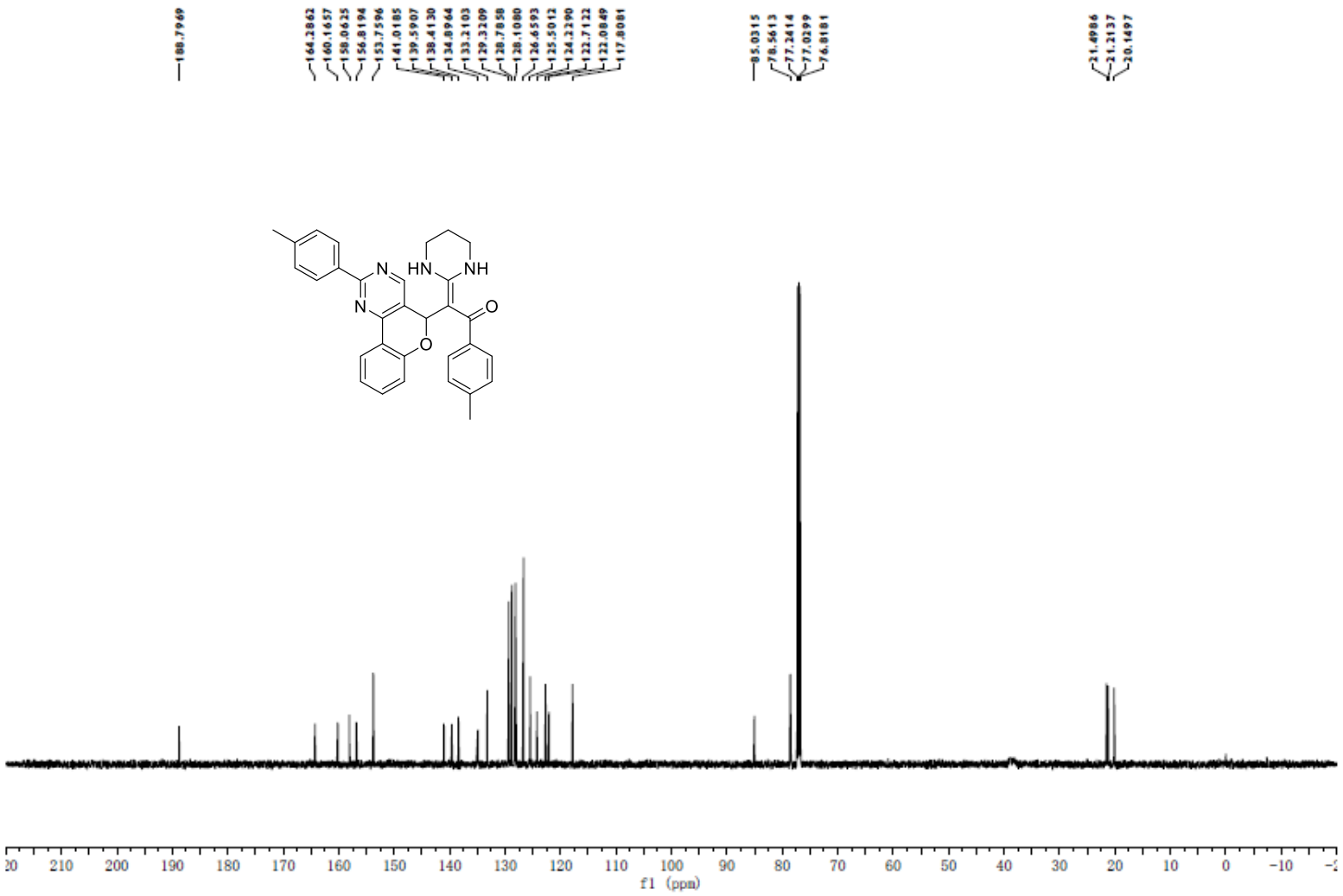


Figure S46. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4t**

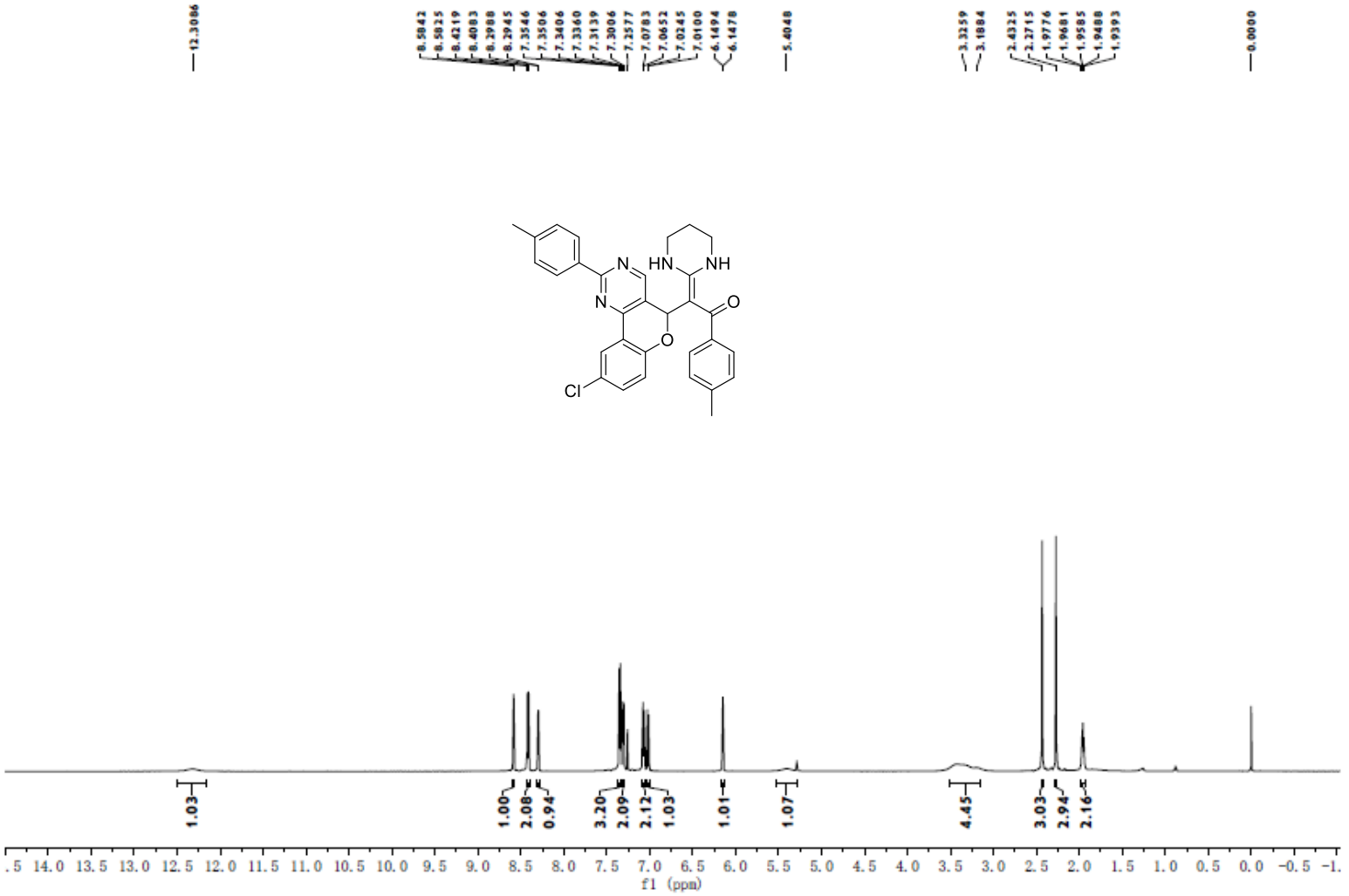


Figure S47. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4u**

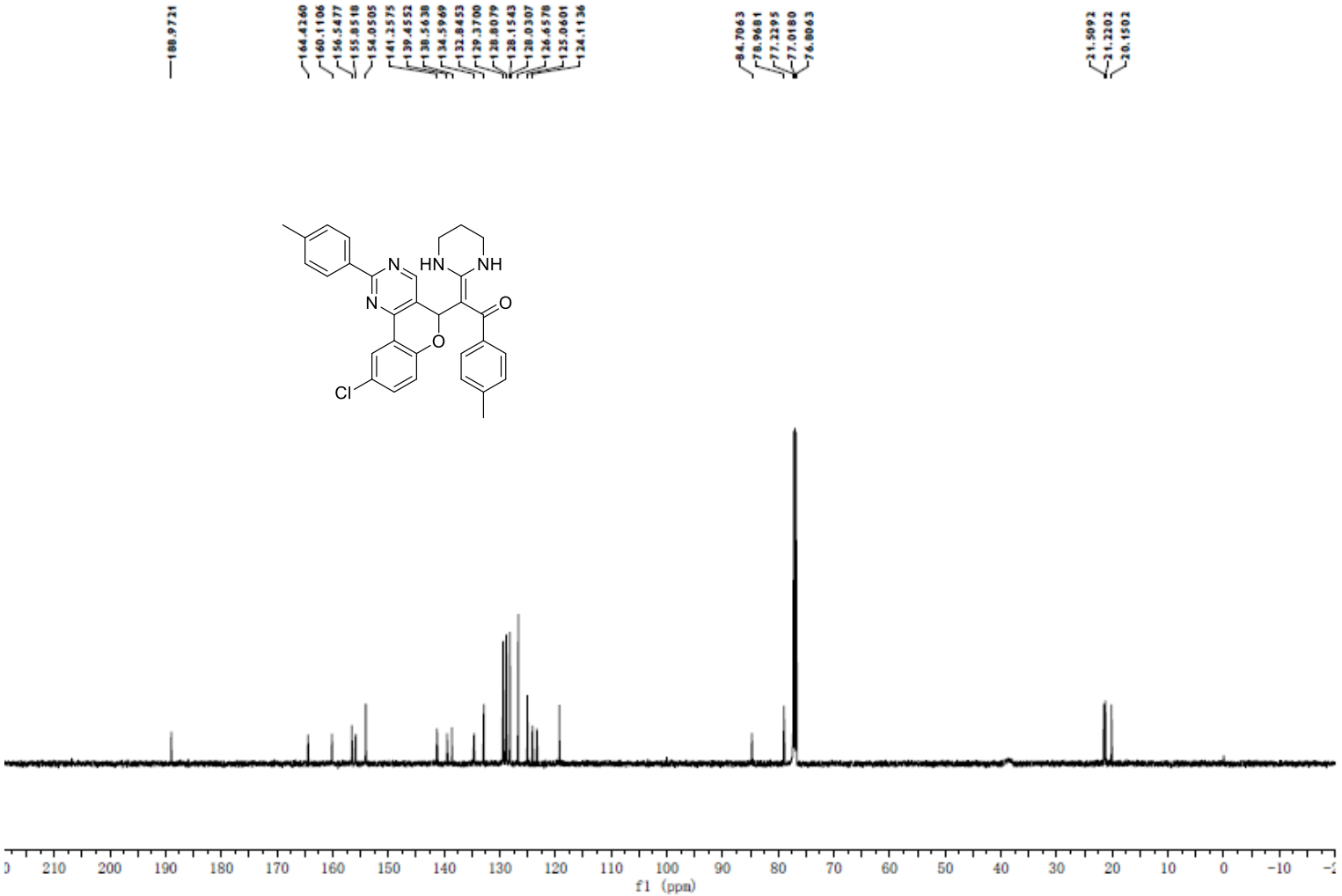


Figure S48. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4u**

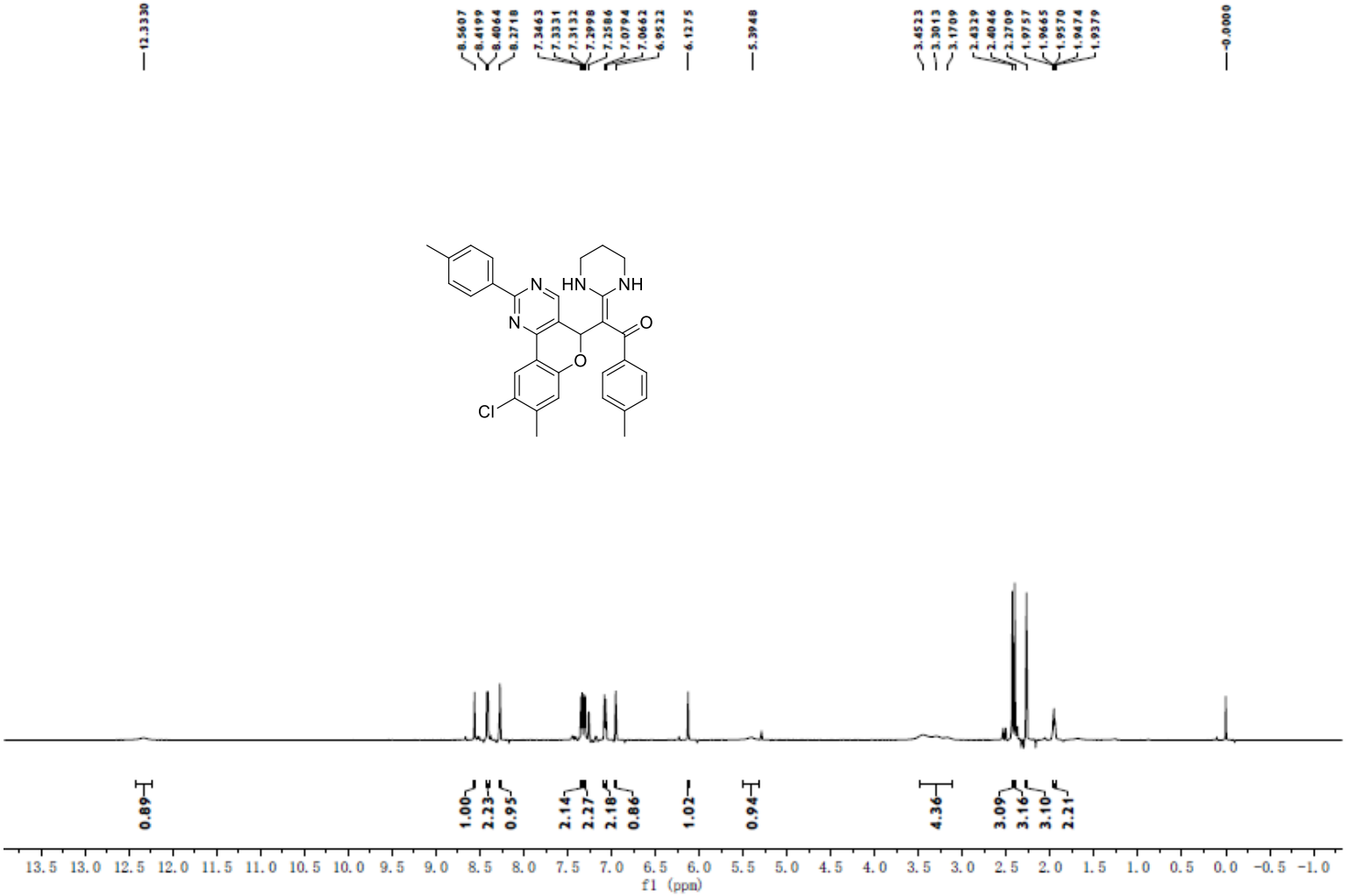


Figure S49. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4v**

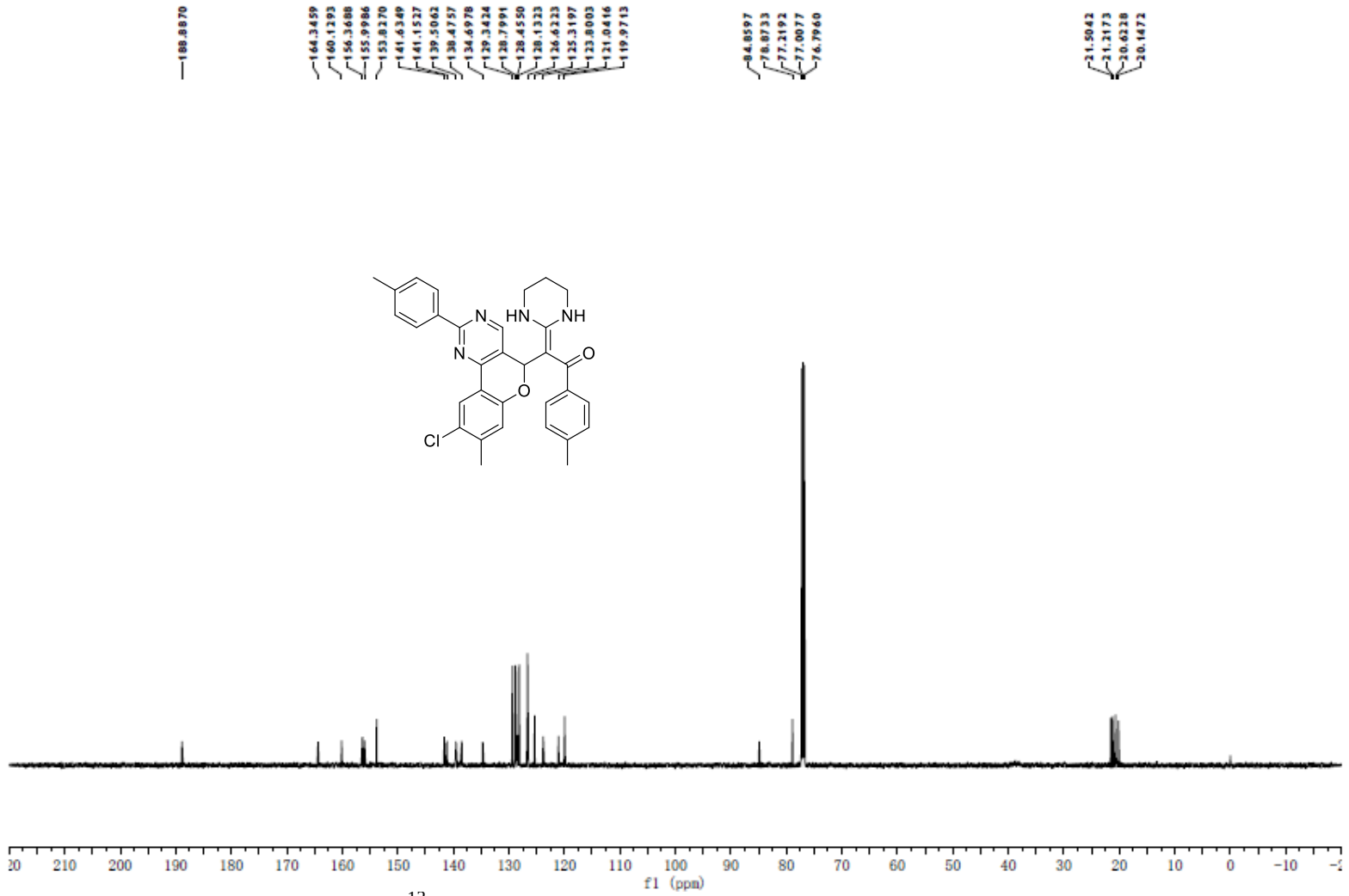


Figure S50. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4v**

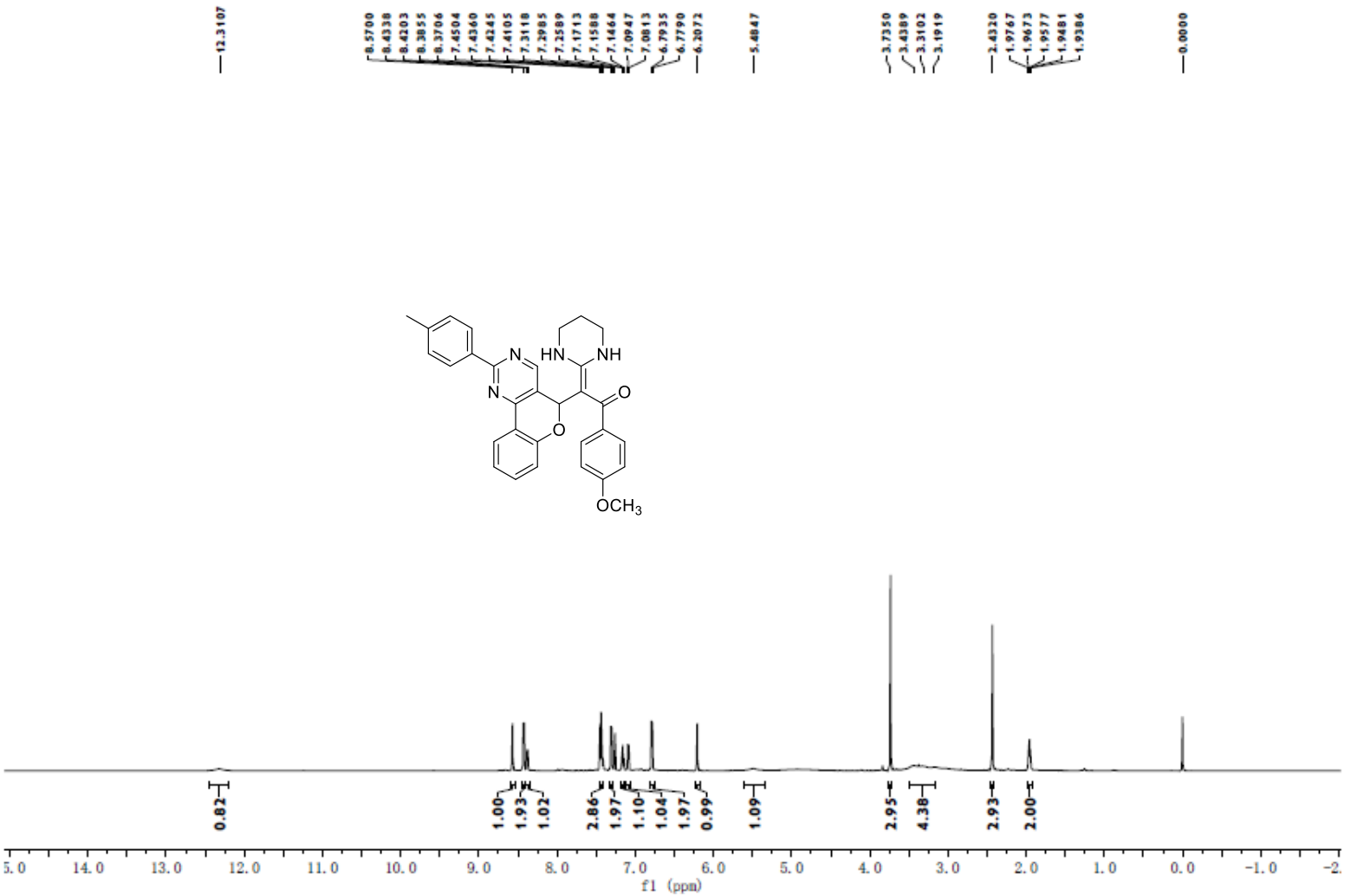


Figure S51. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4w**

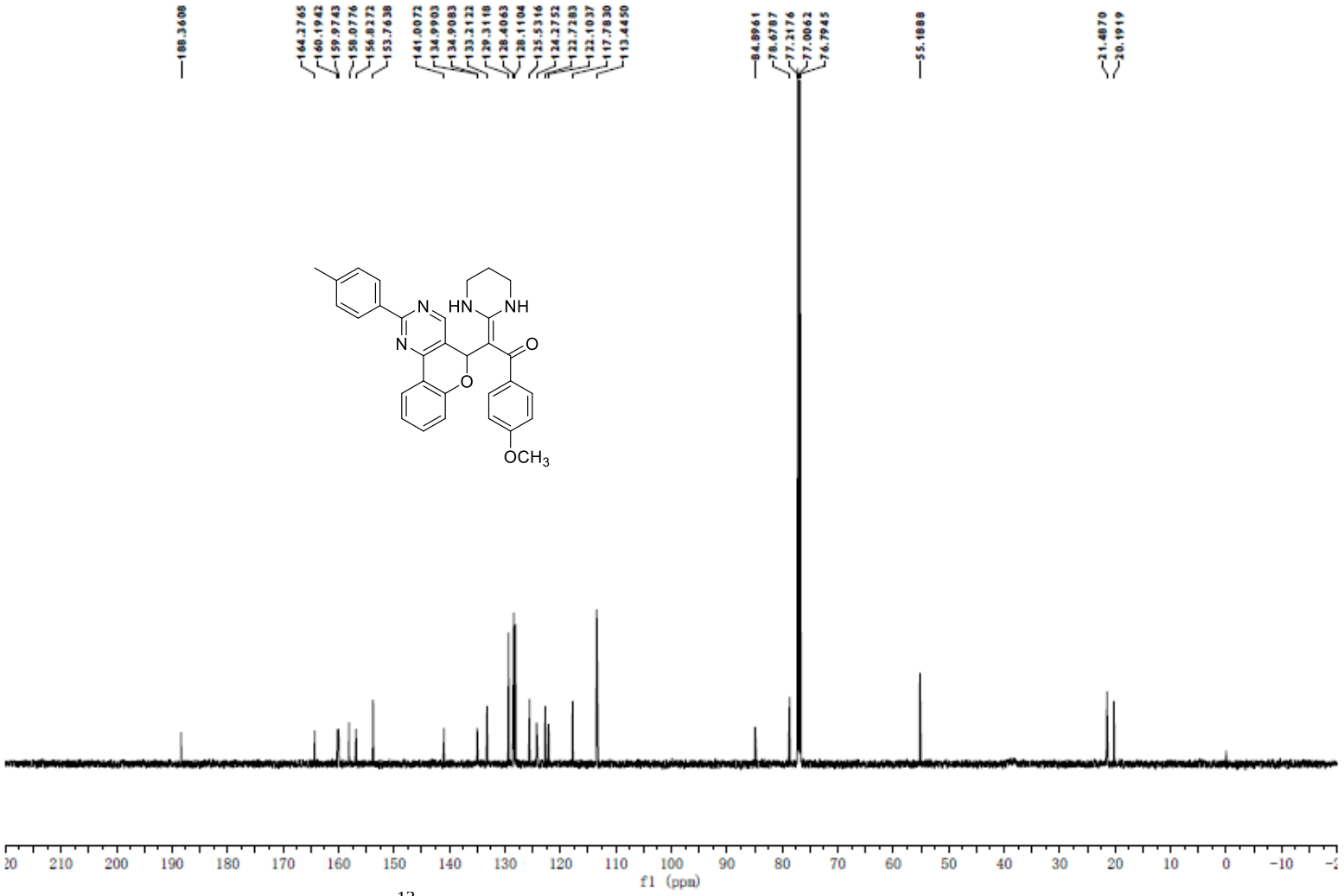


Figure S52. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4w**

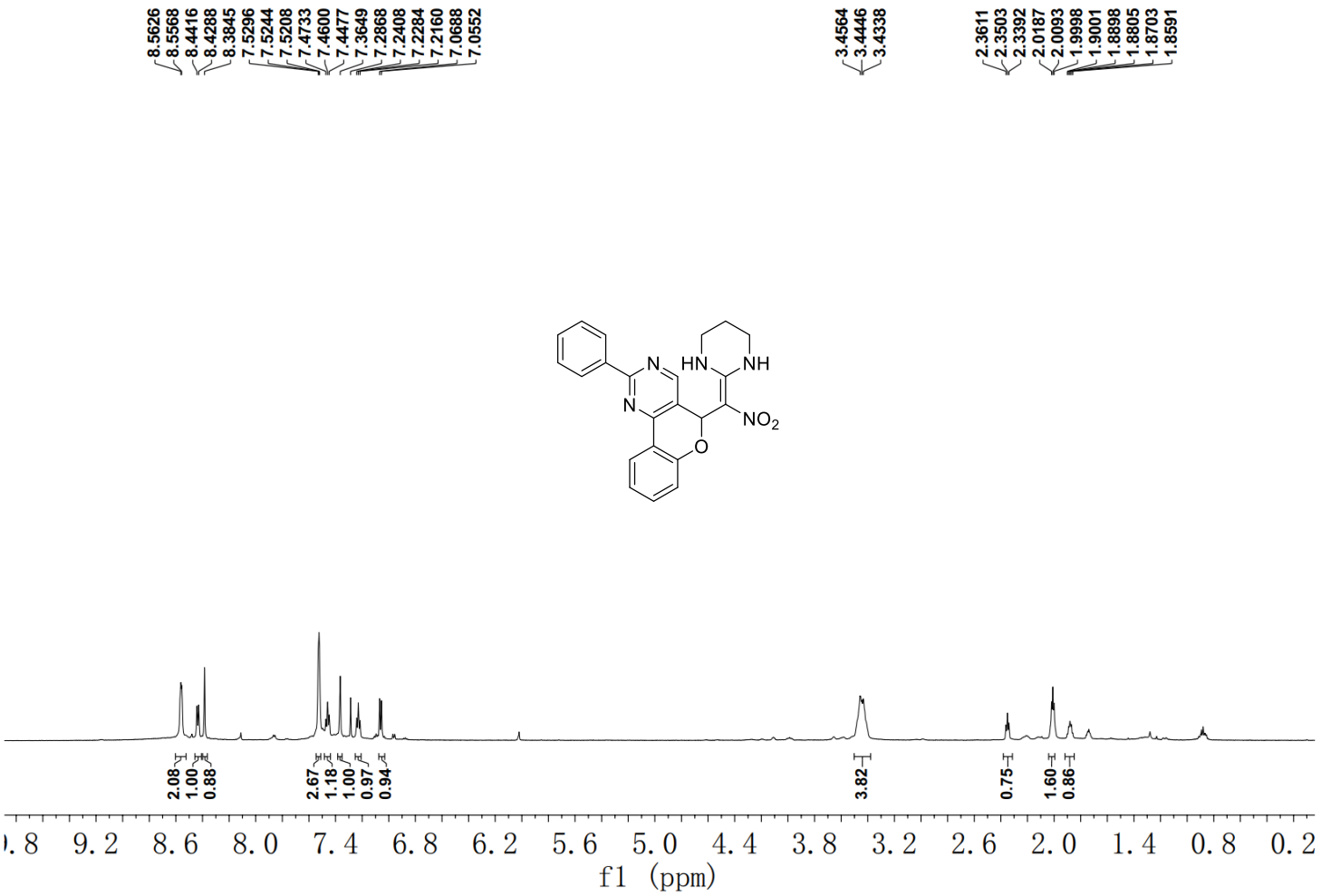


Figure S53. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4x**

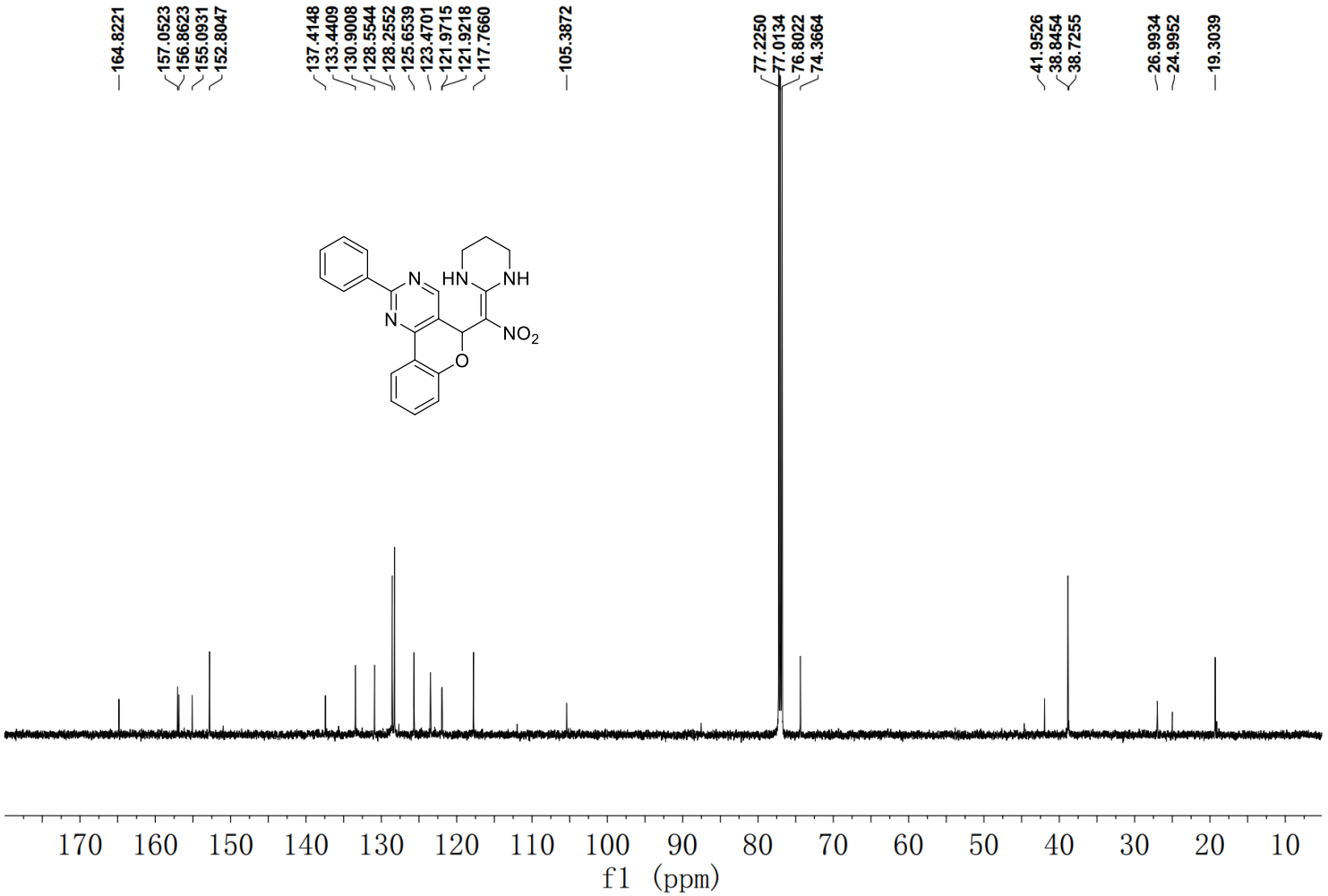


Figure S54. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4x**

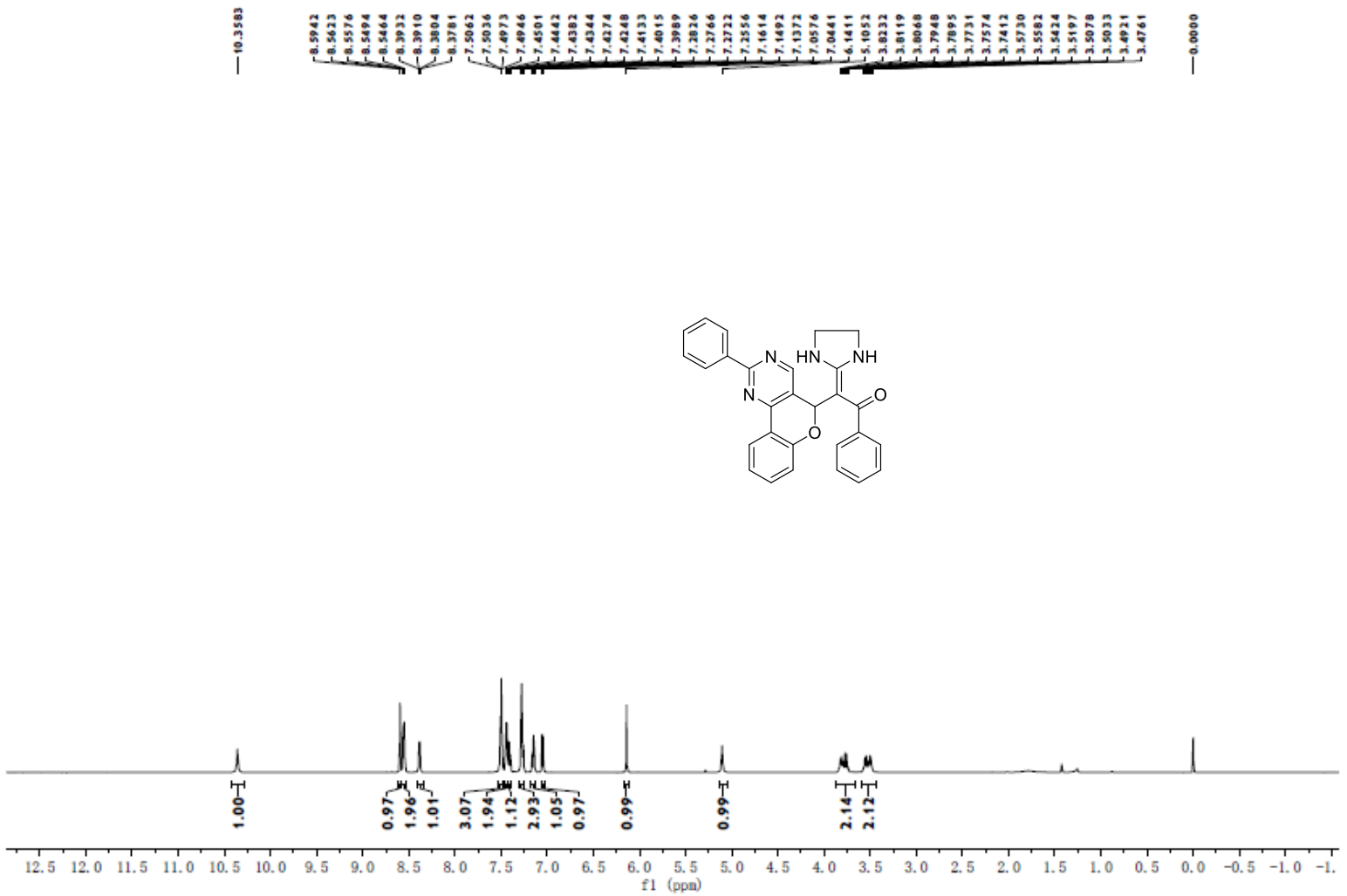


Figure S55. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4y**

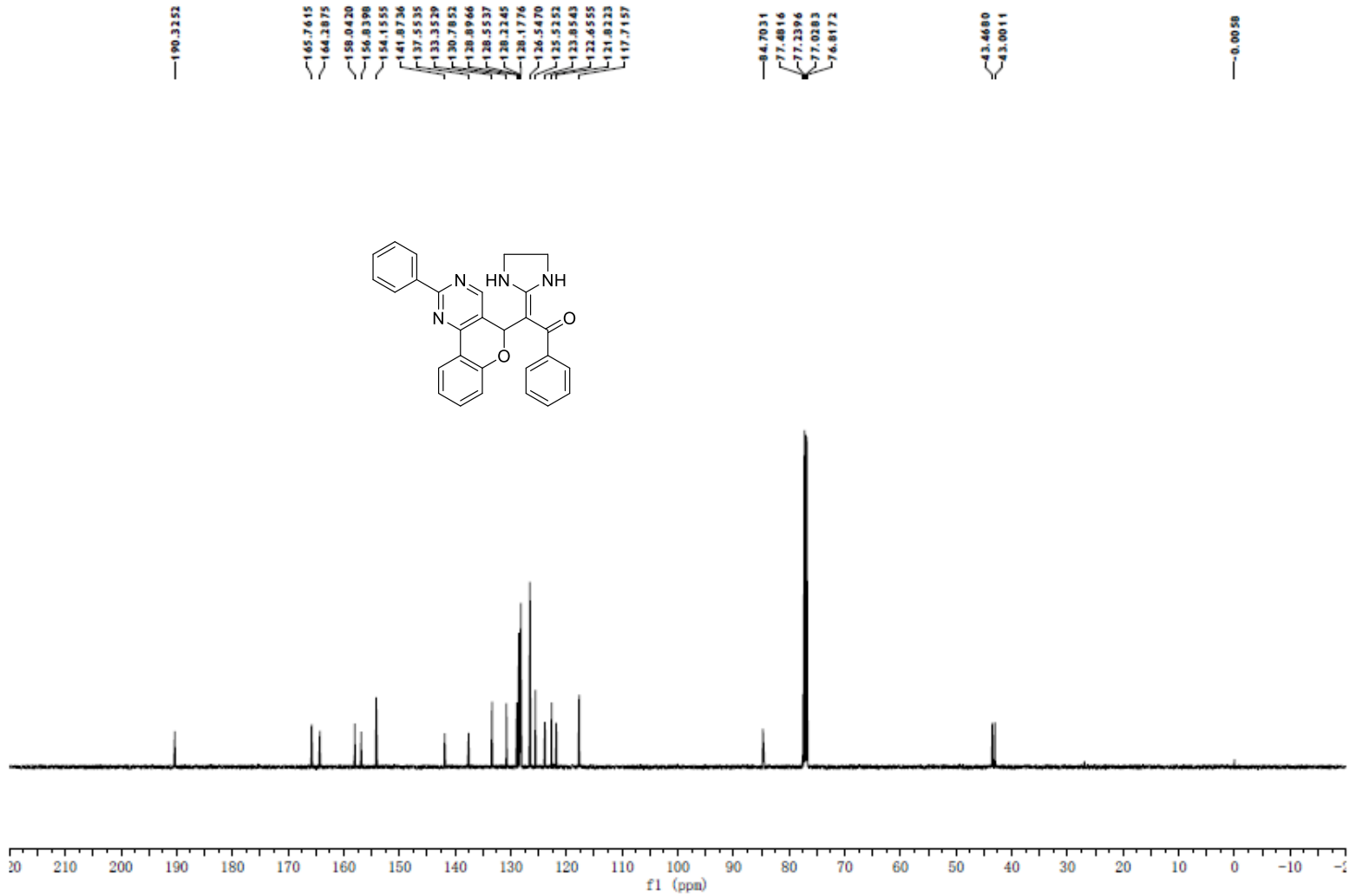


Figure S56. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4y**

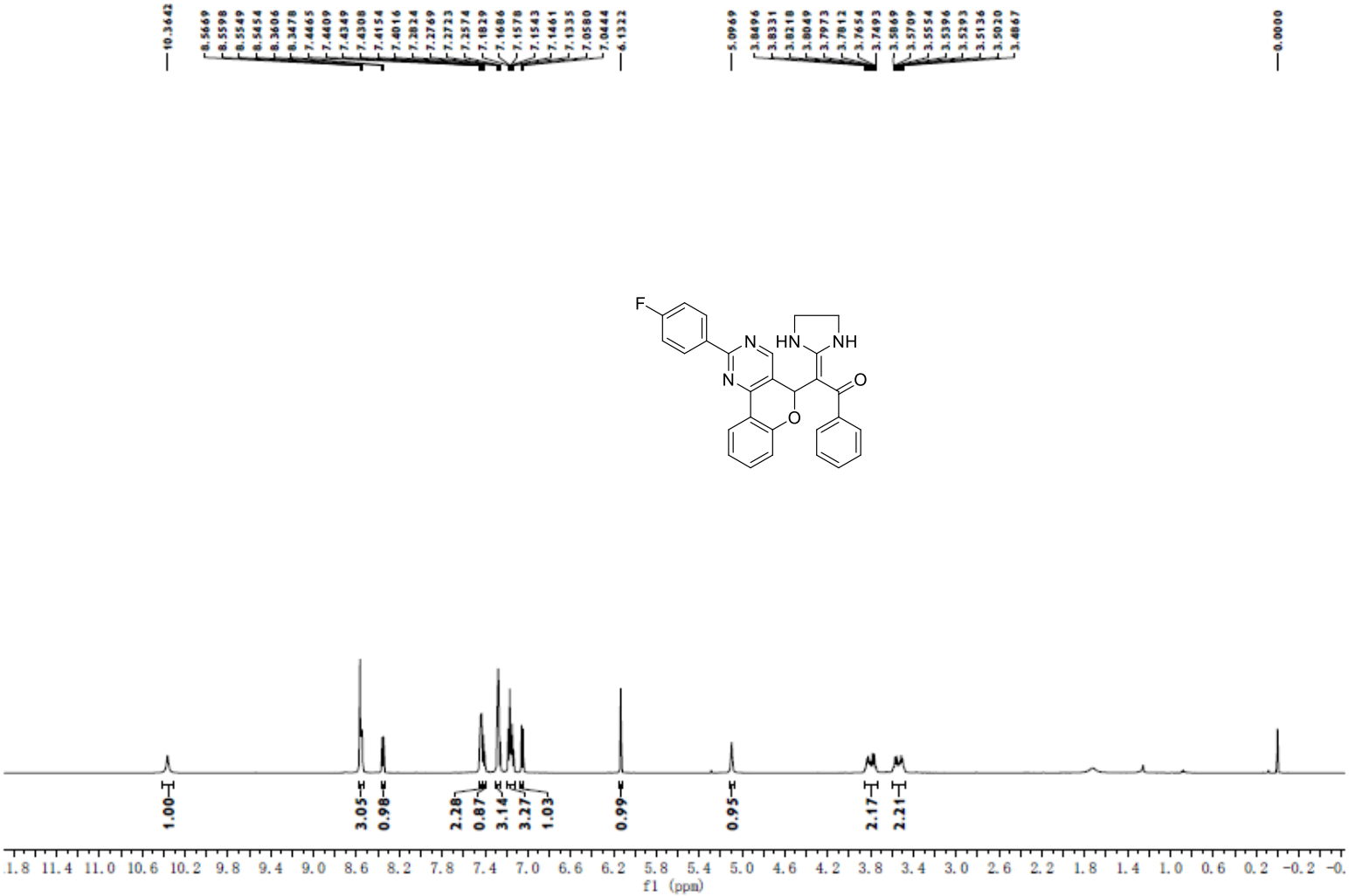


Figure S57. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4z**

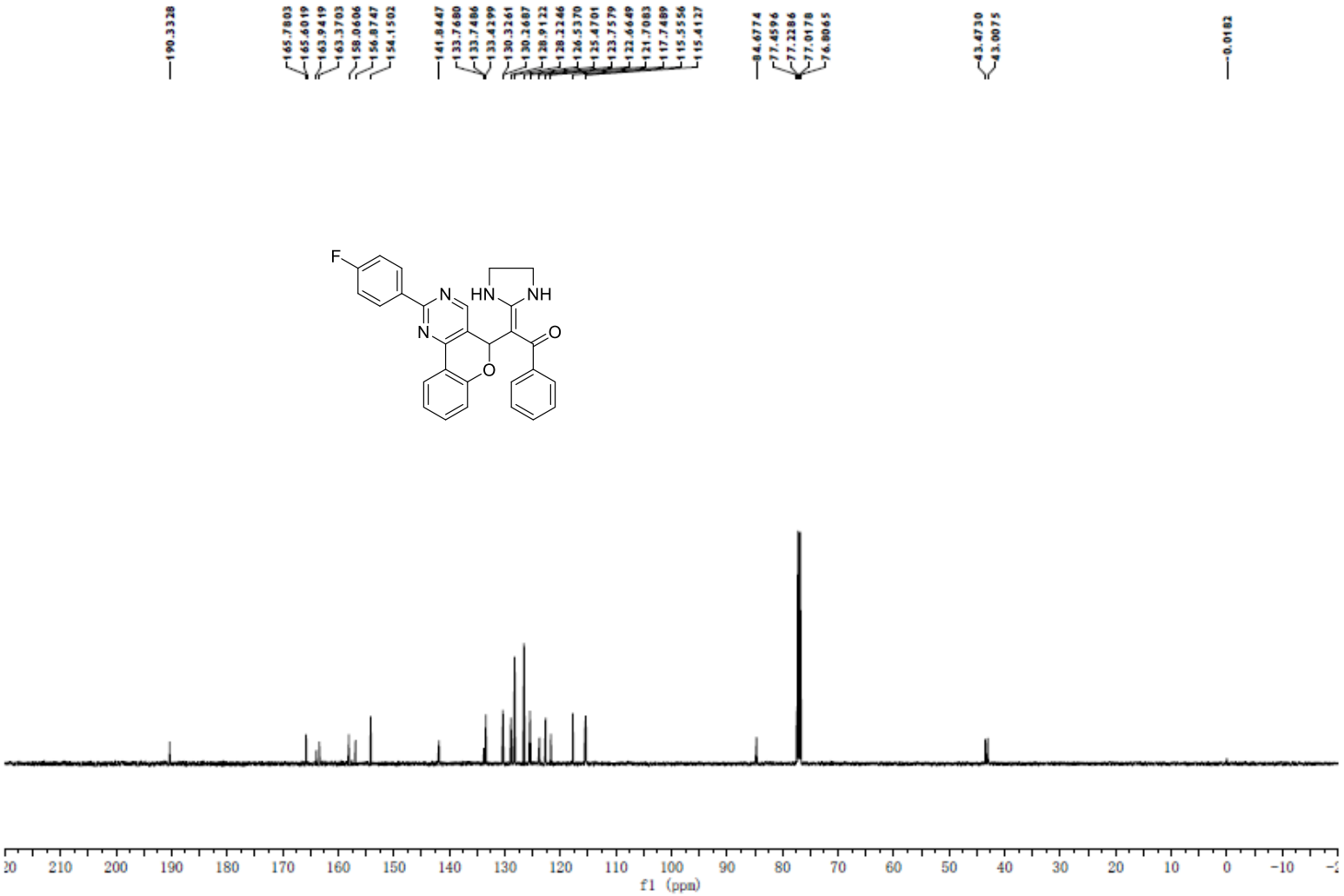


Figure S58. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4z**

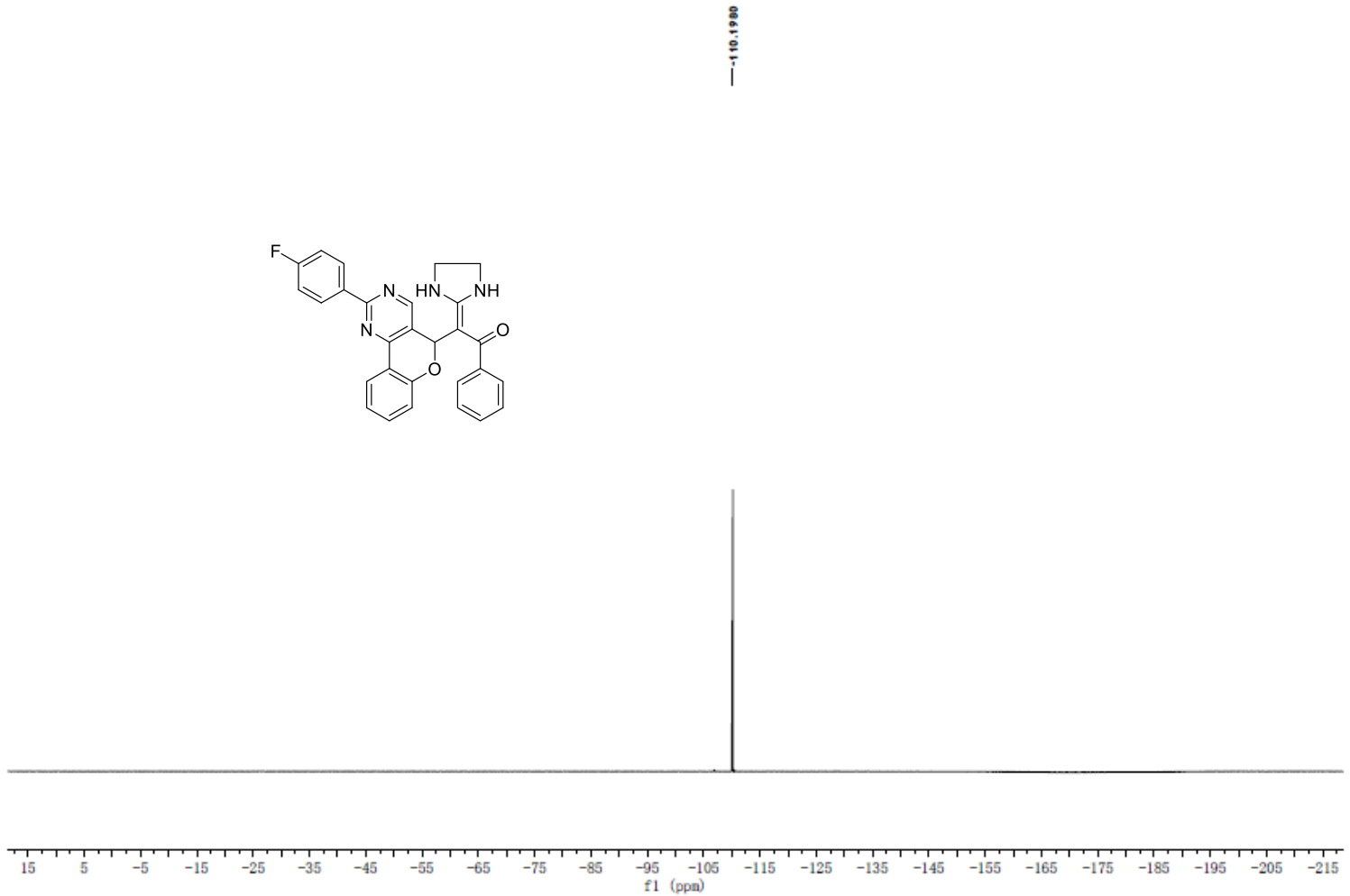


Figure S59. ^{19}F NMR (540 MHz, Chloroform-*d*) spectra of compound **4z**

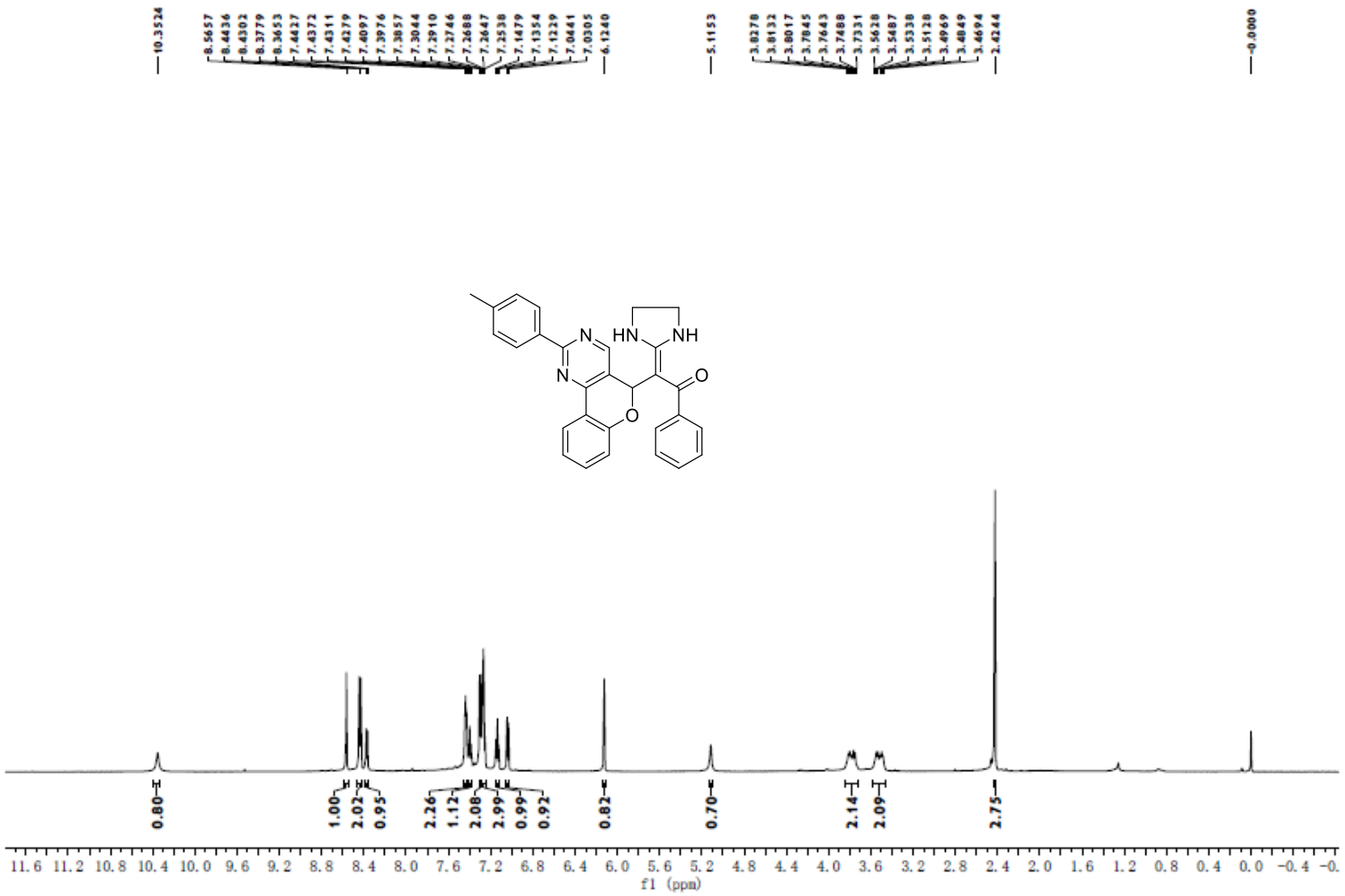


Figure S60. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4a'**

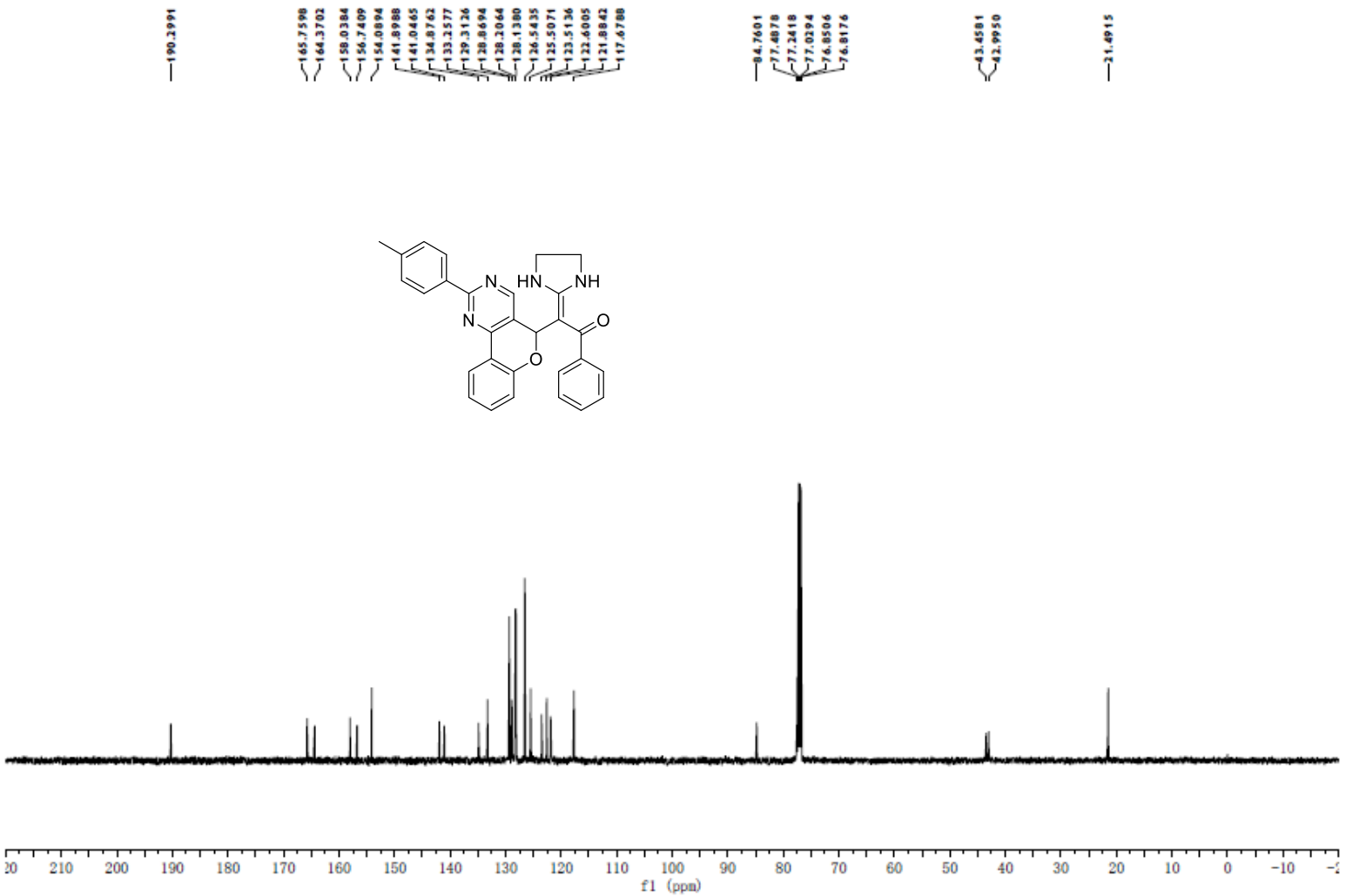


Figure S61. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4a'**

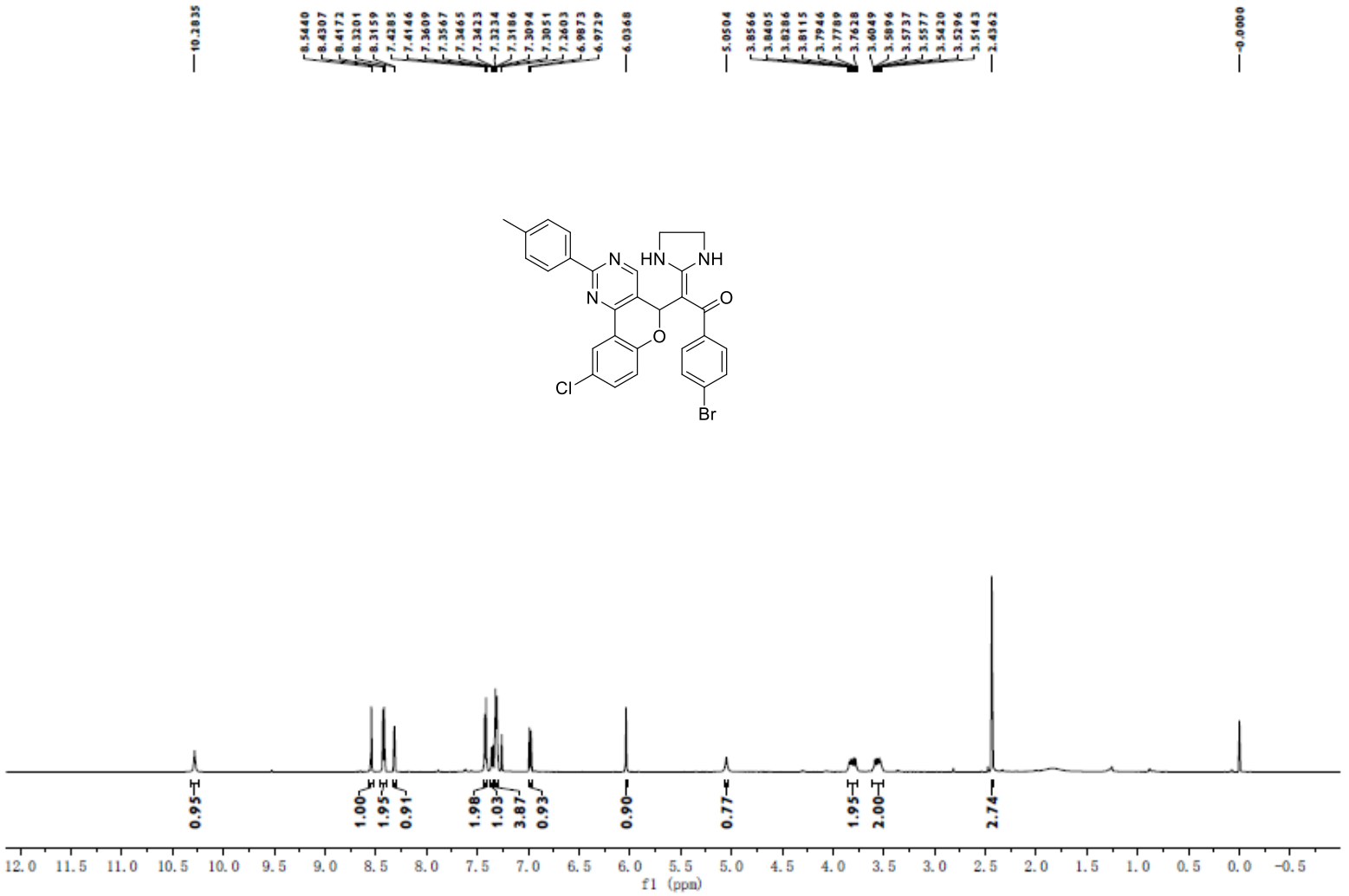


Figure S62. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4b'**

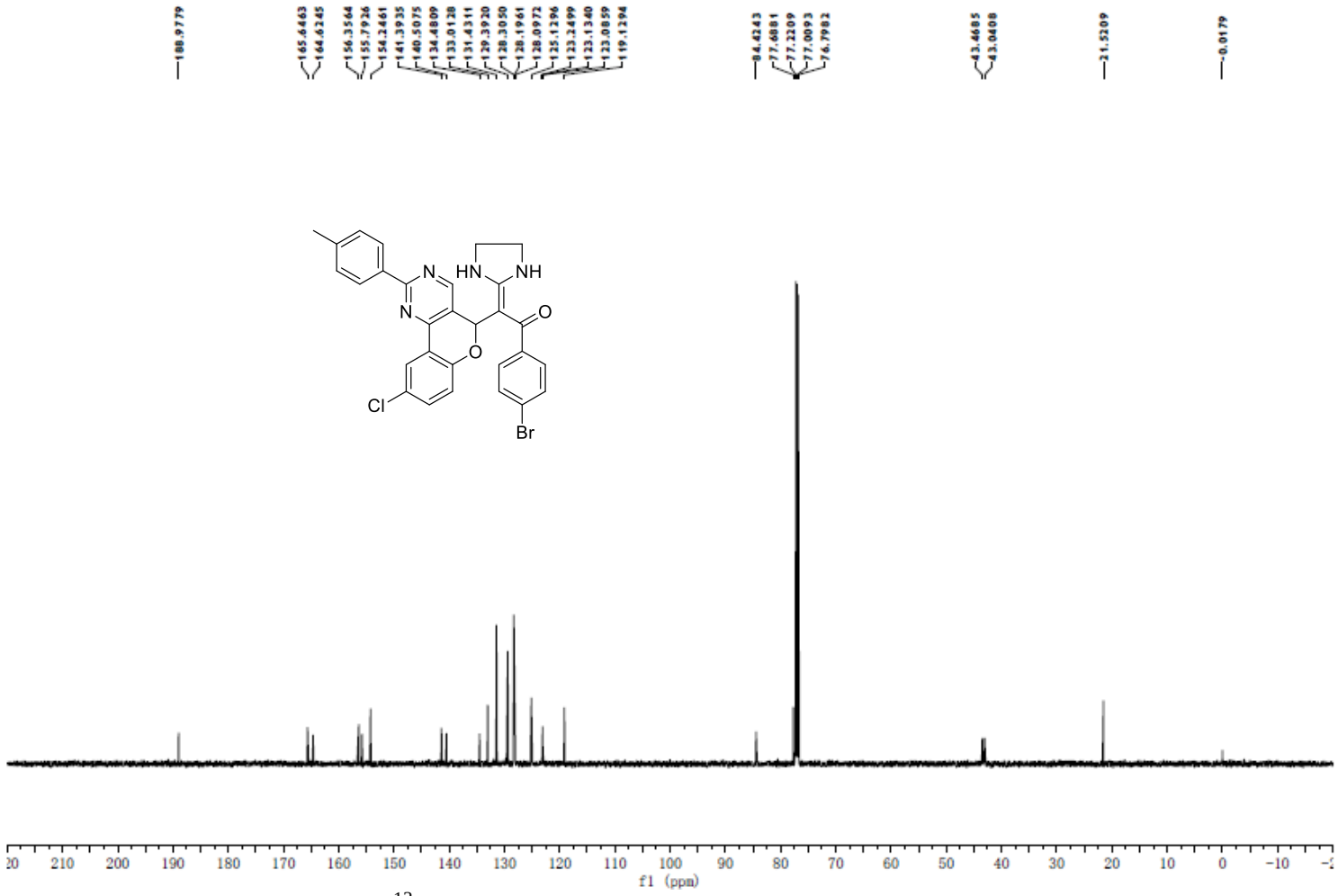


Figure S63. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4b'**

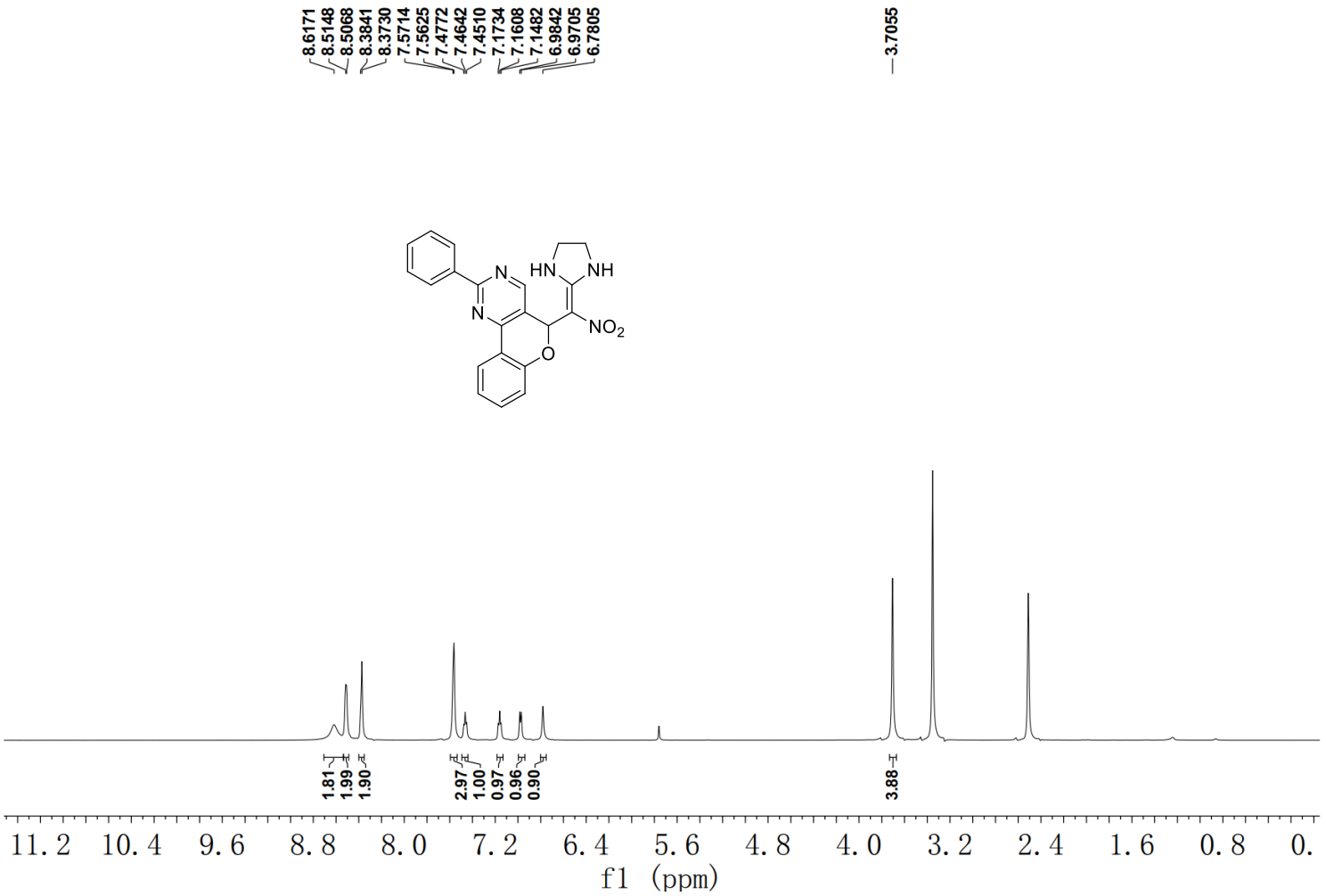


Figure S64. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4c'**

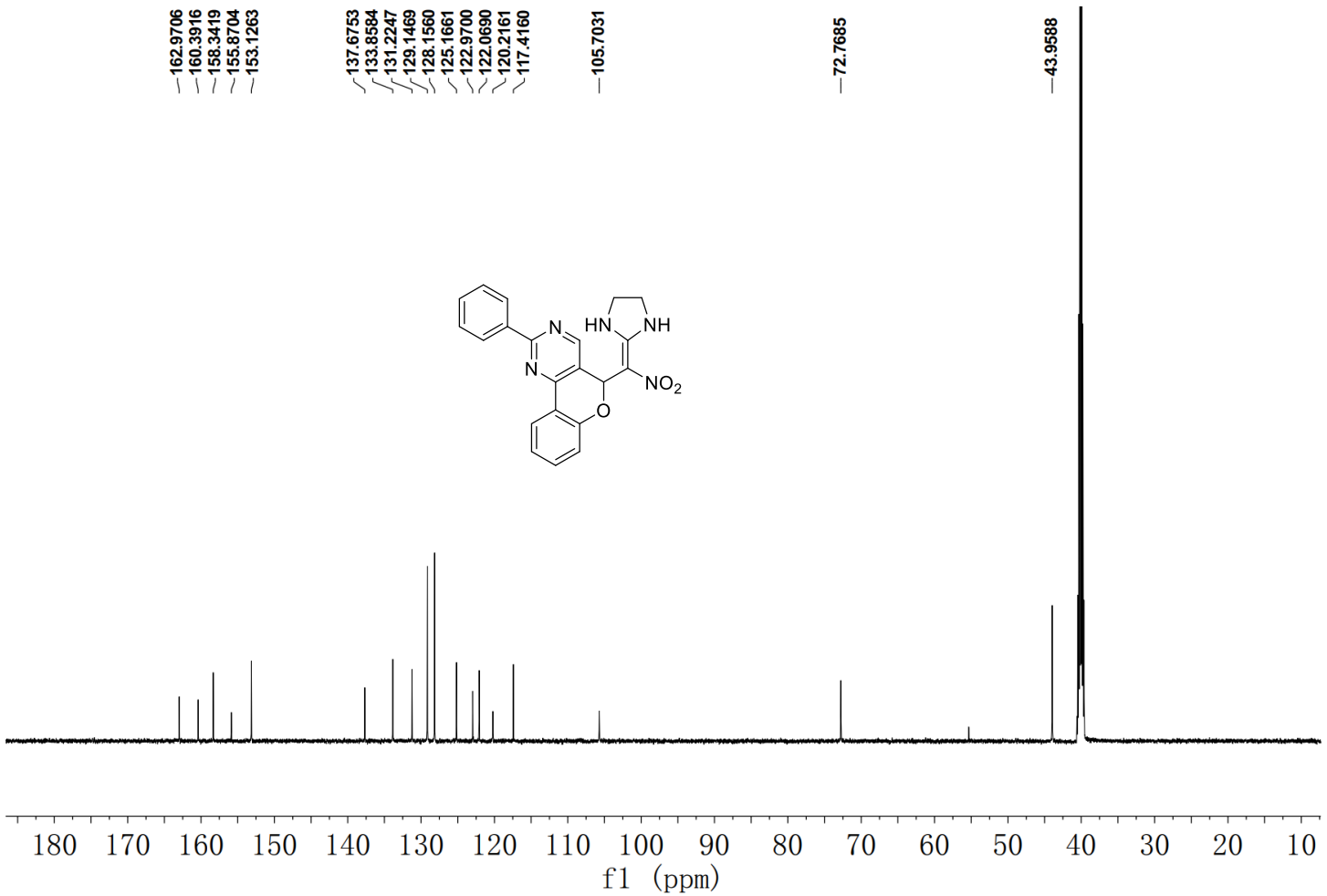


Figure S65. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4c'**

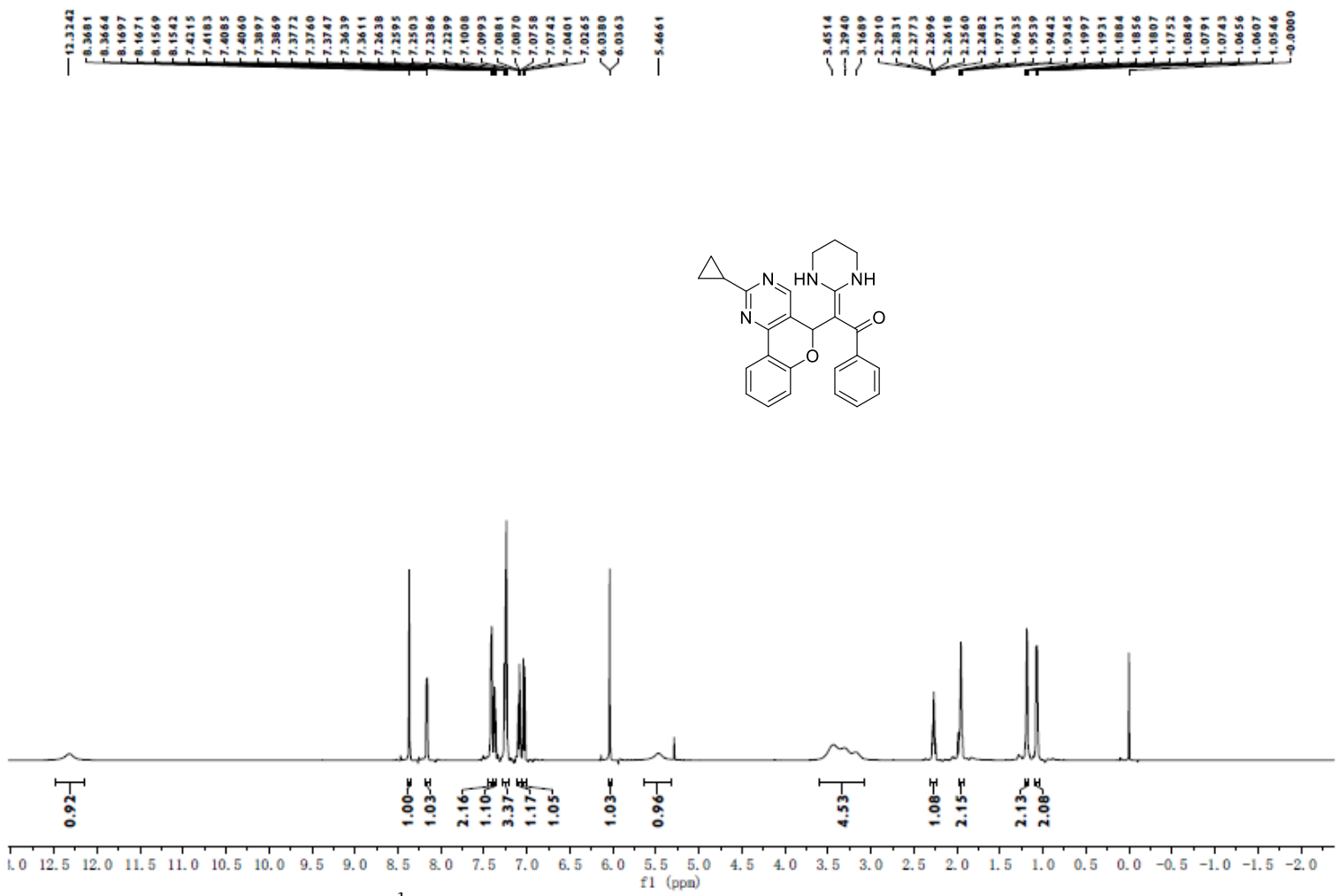


Figure S66. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4d'**

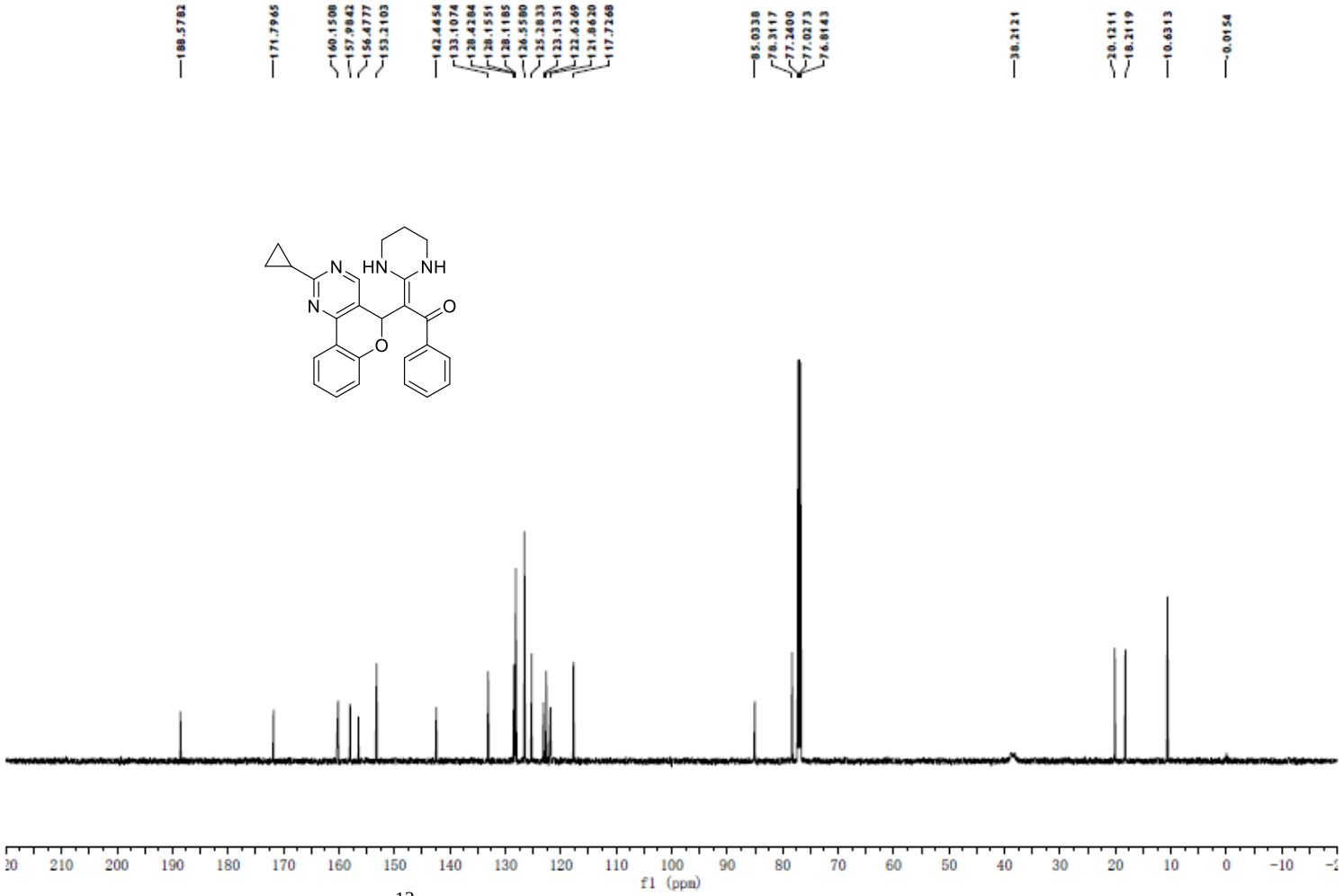


Figure S67. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4d'**

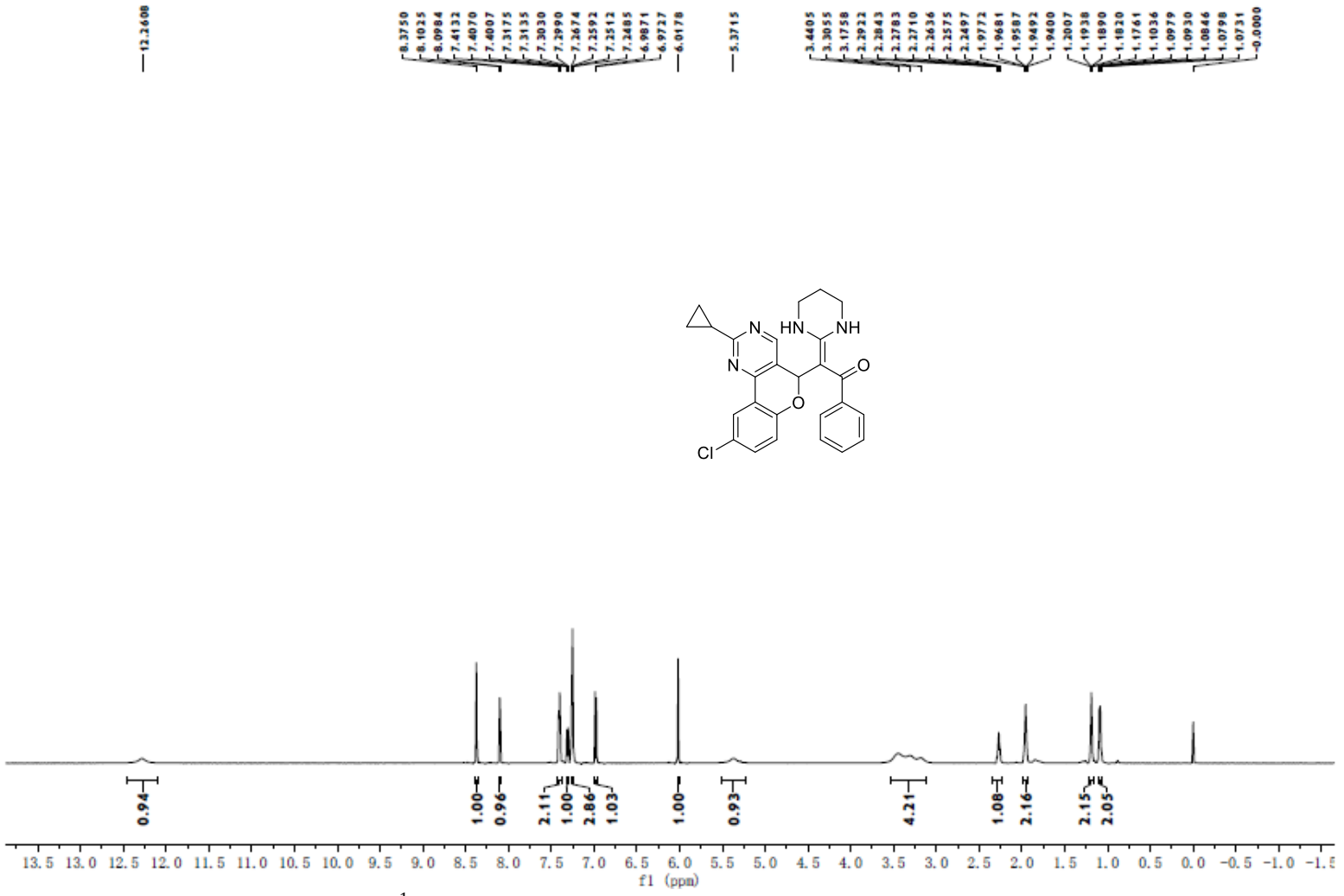


Figure S68. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4e'**

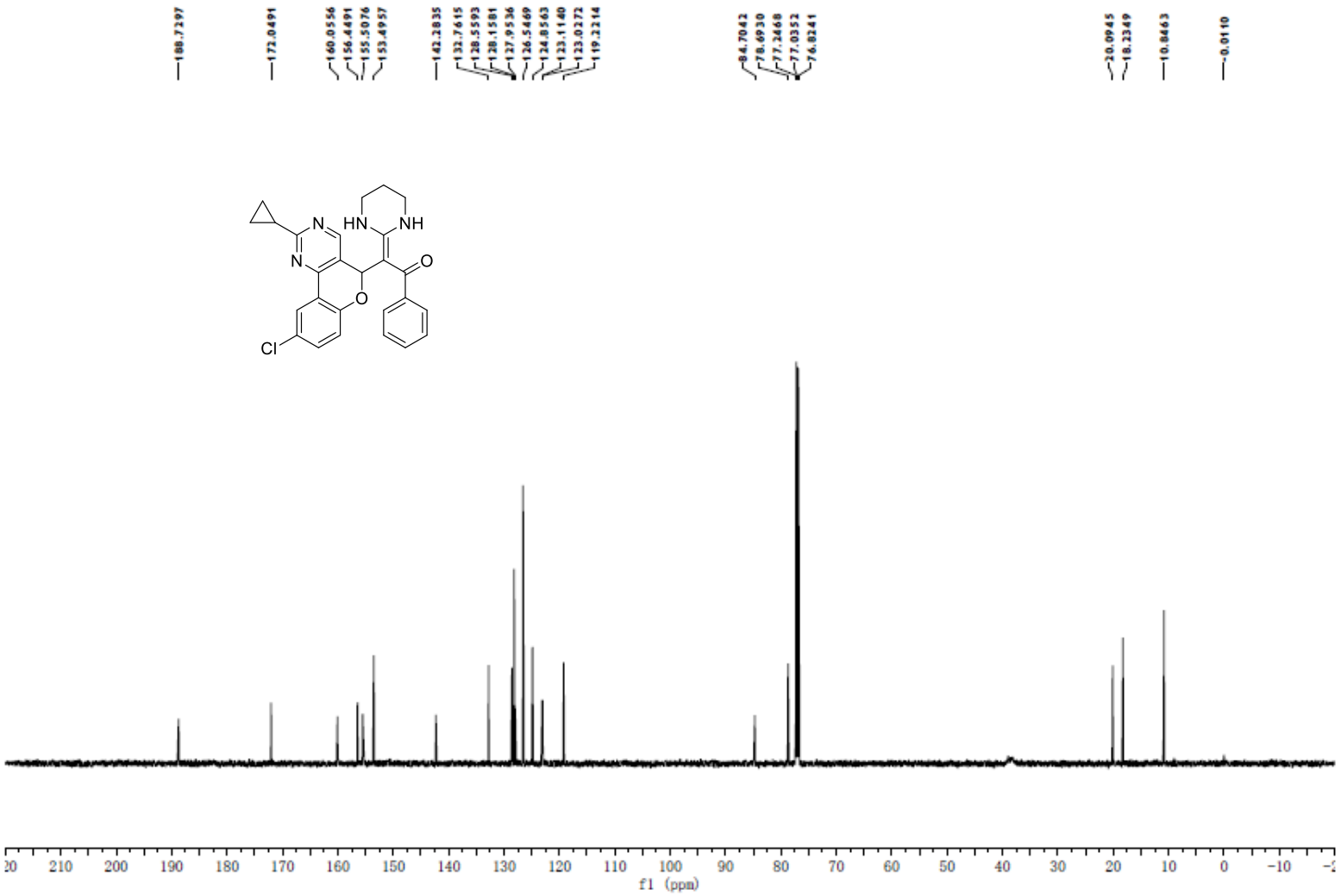


Figure S69. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4e'**

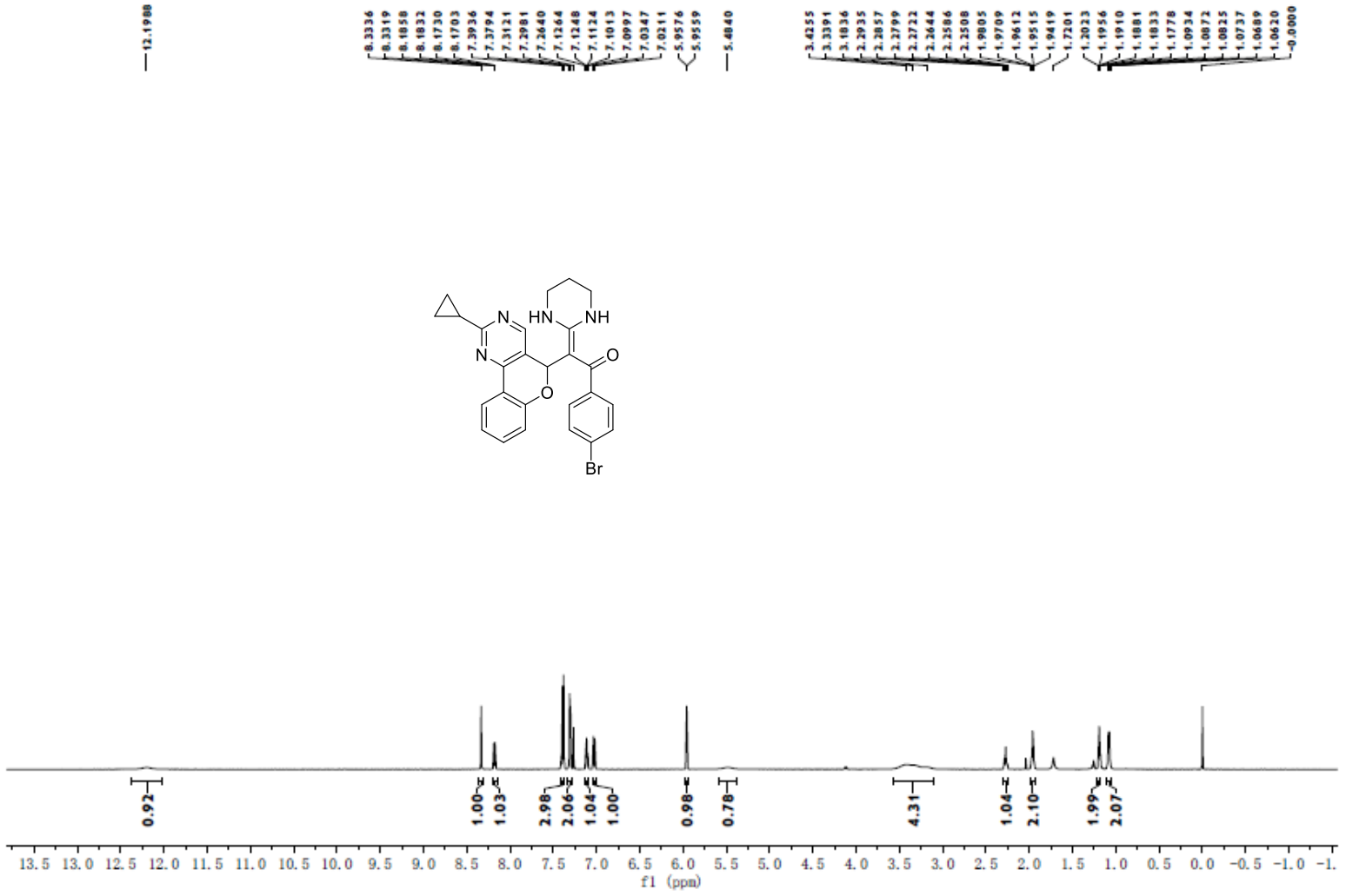


Figure S70. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4f'**

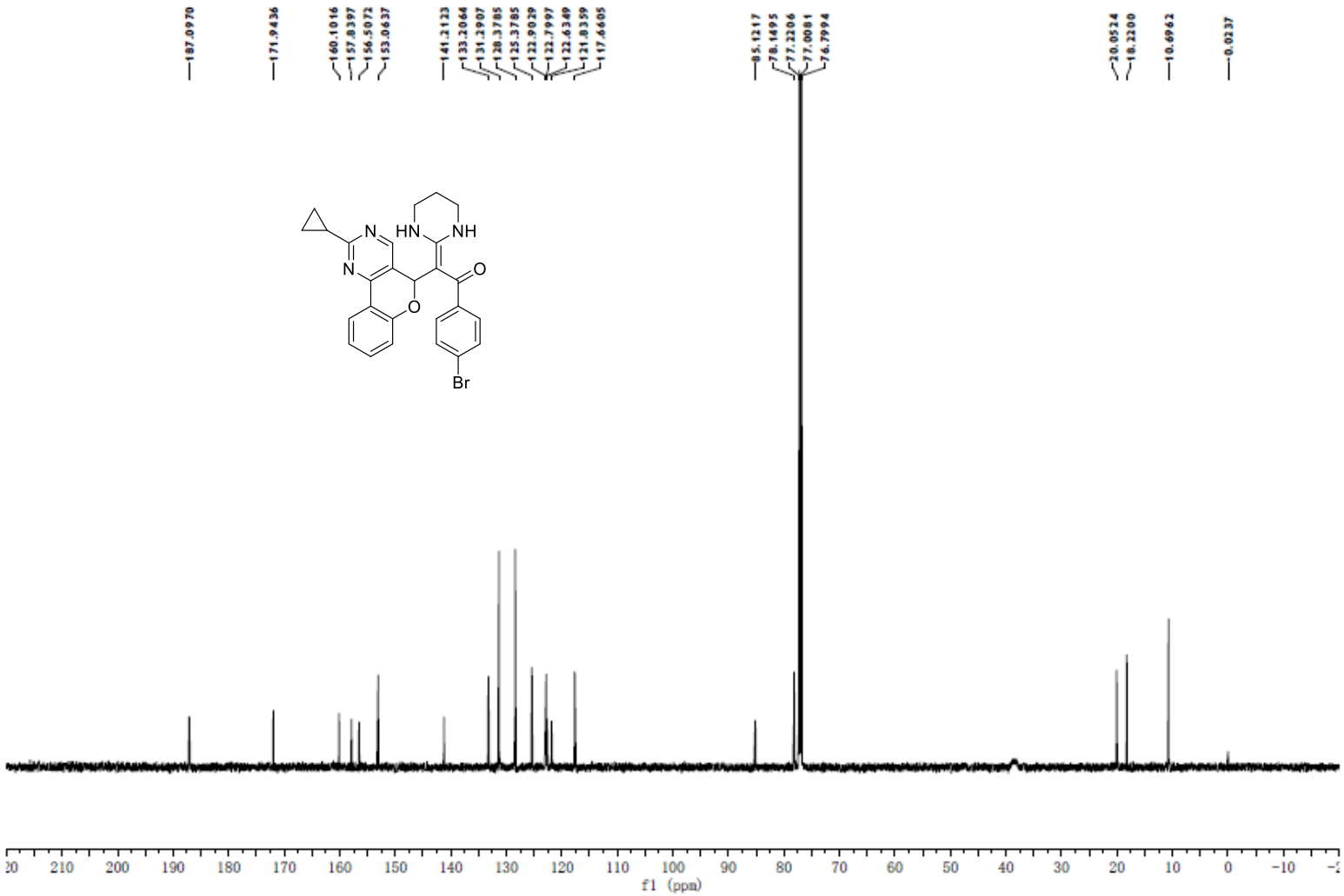


Figure S71. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4f'**

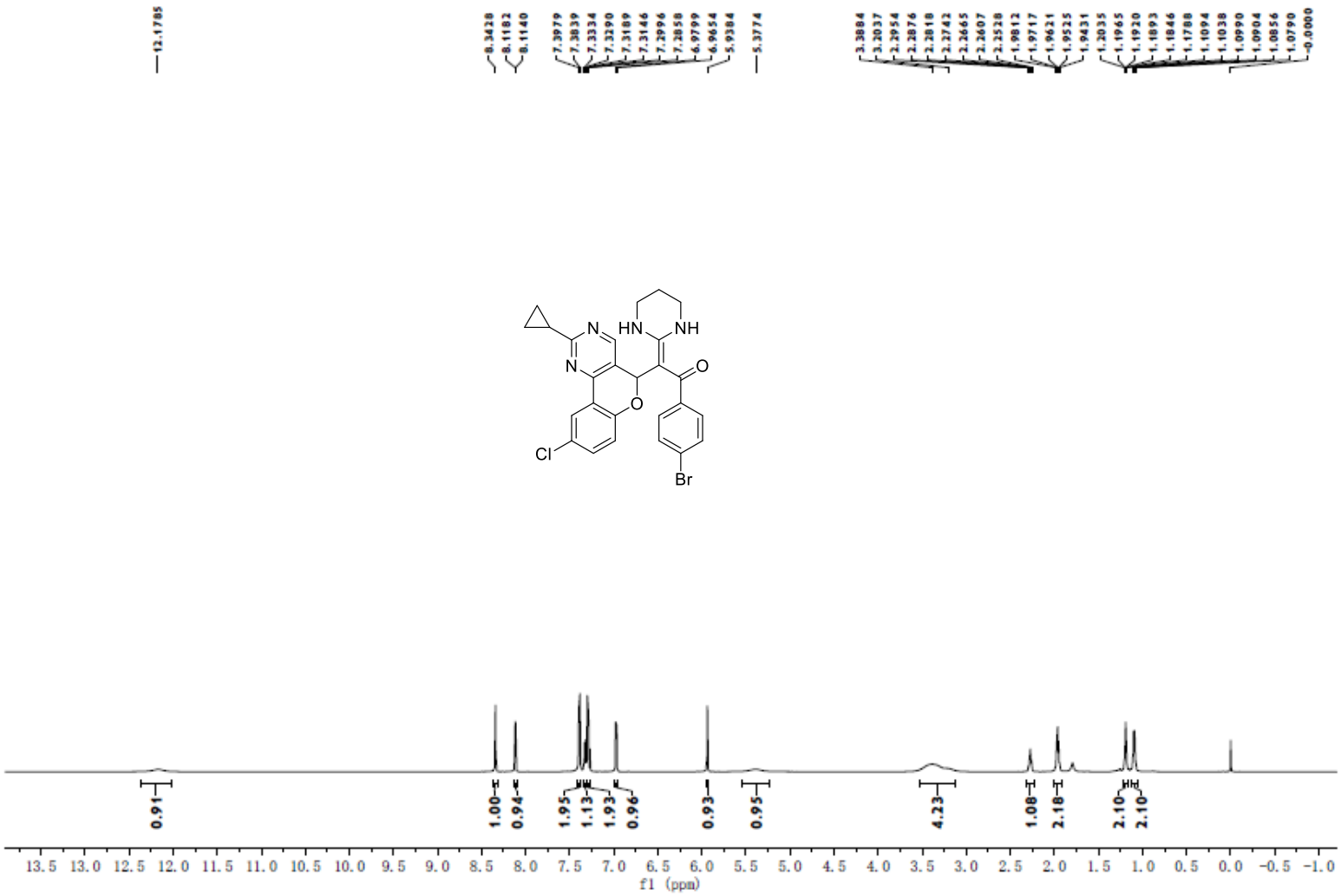


Figure S72. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4g'**

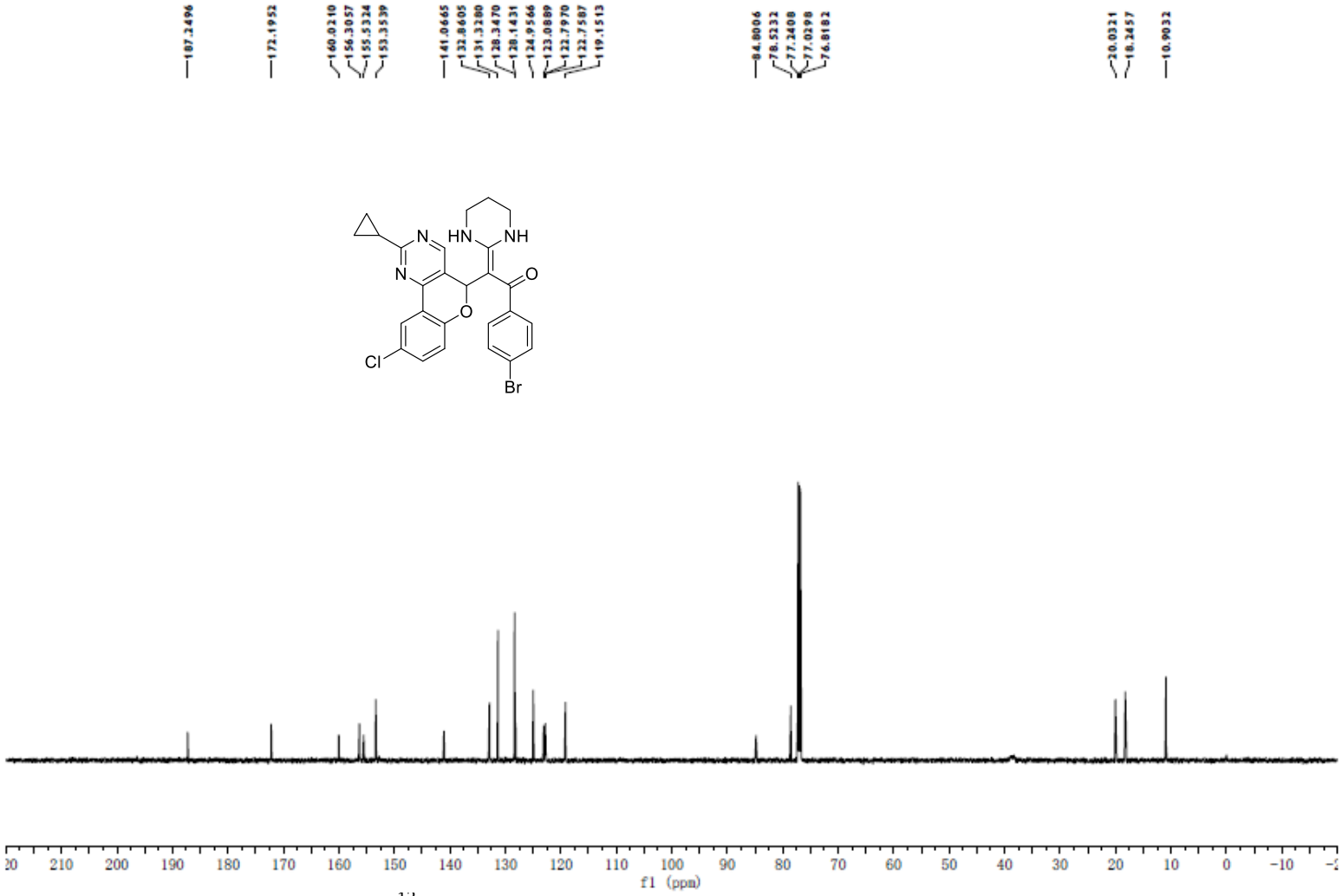


Figure S73. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4g'**

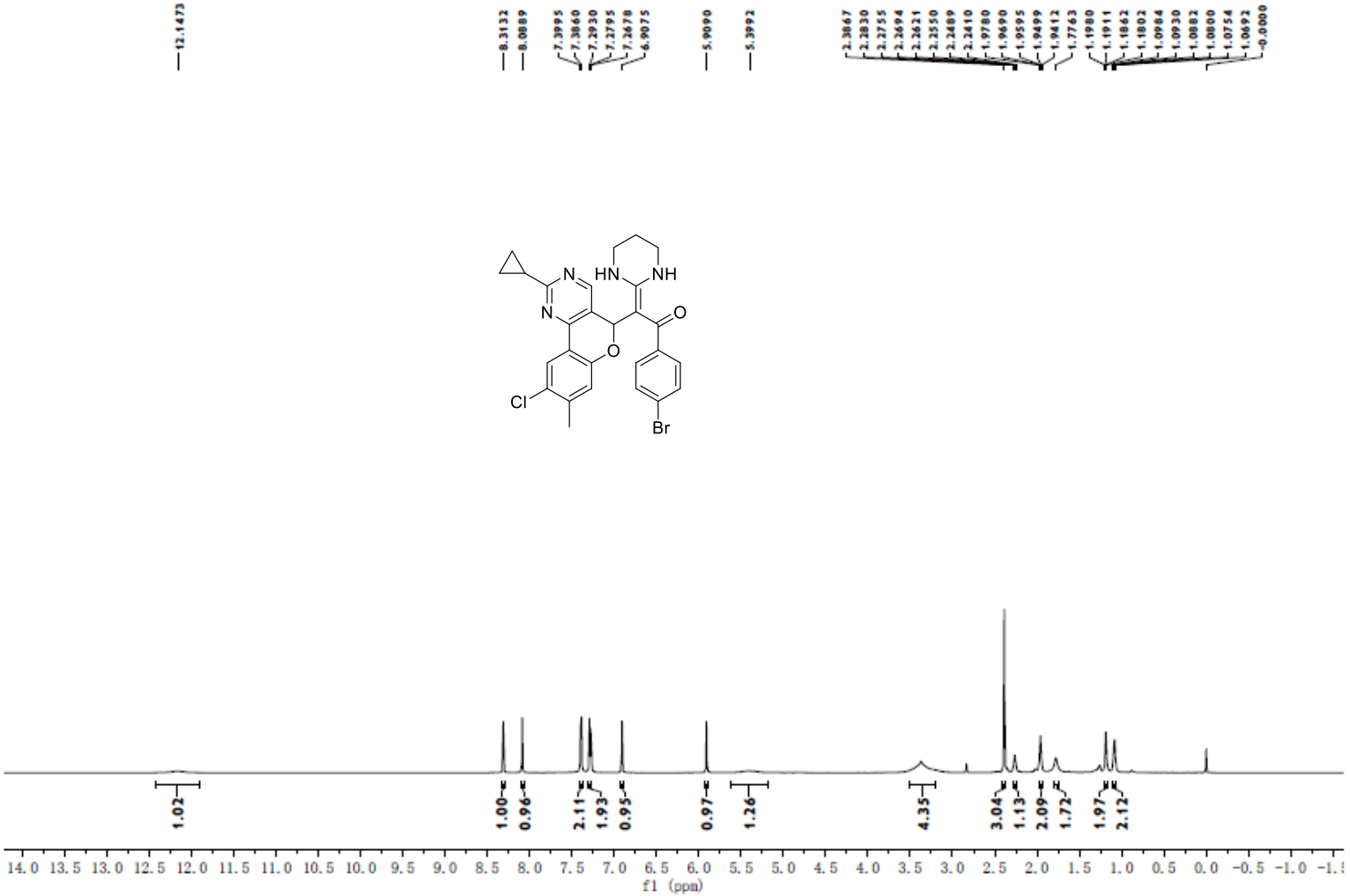


Figure S74. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4h'**

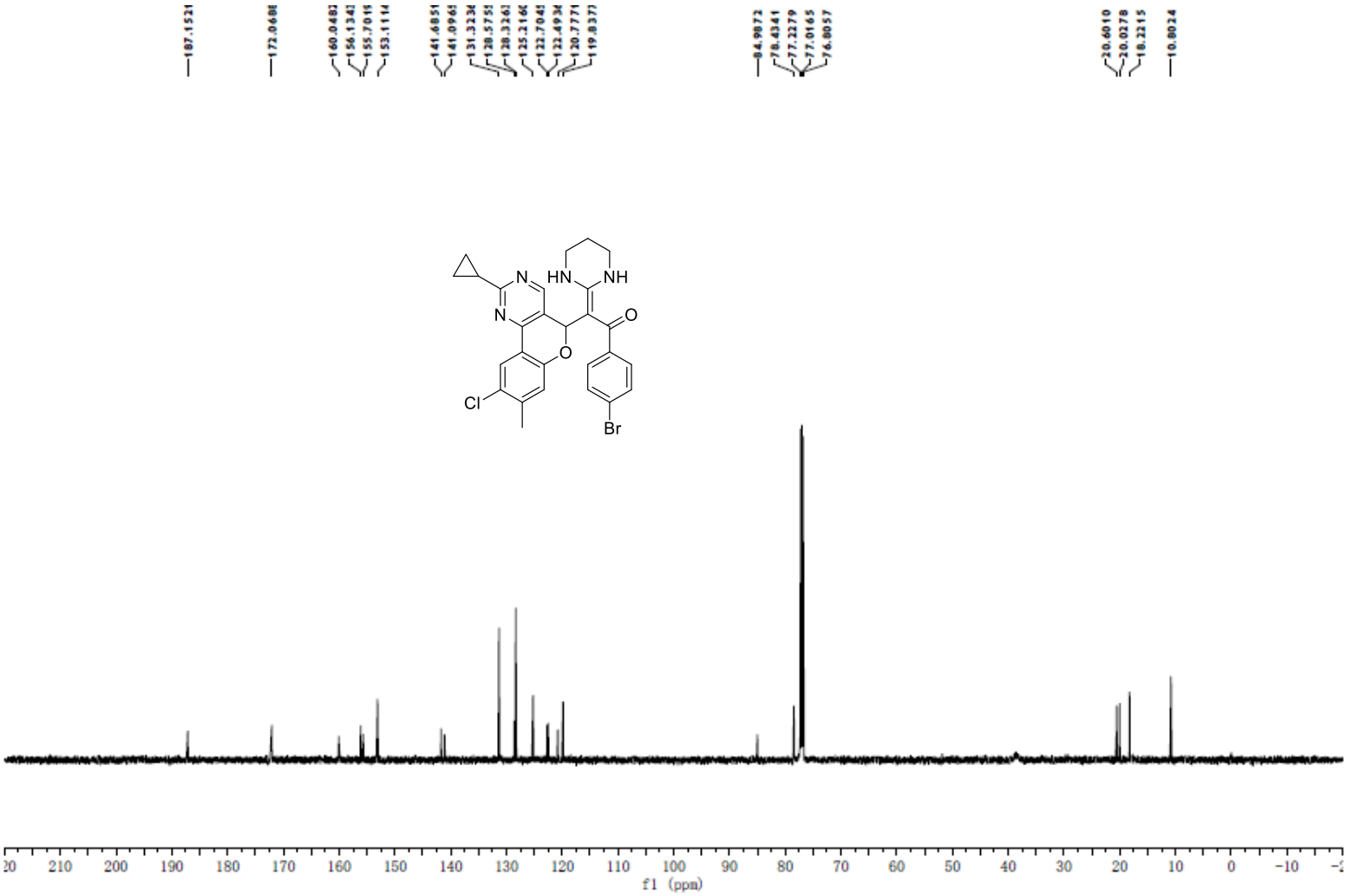


Figure S75. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4h'**

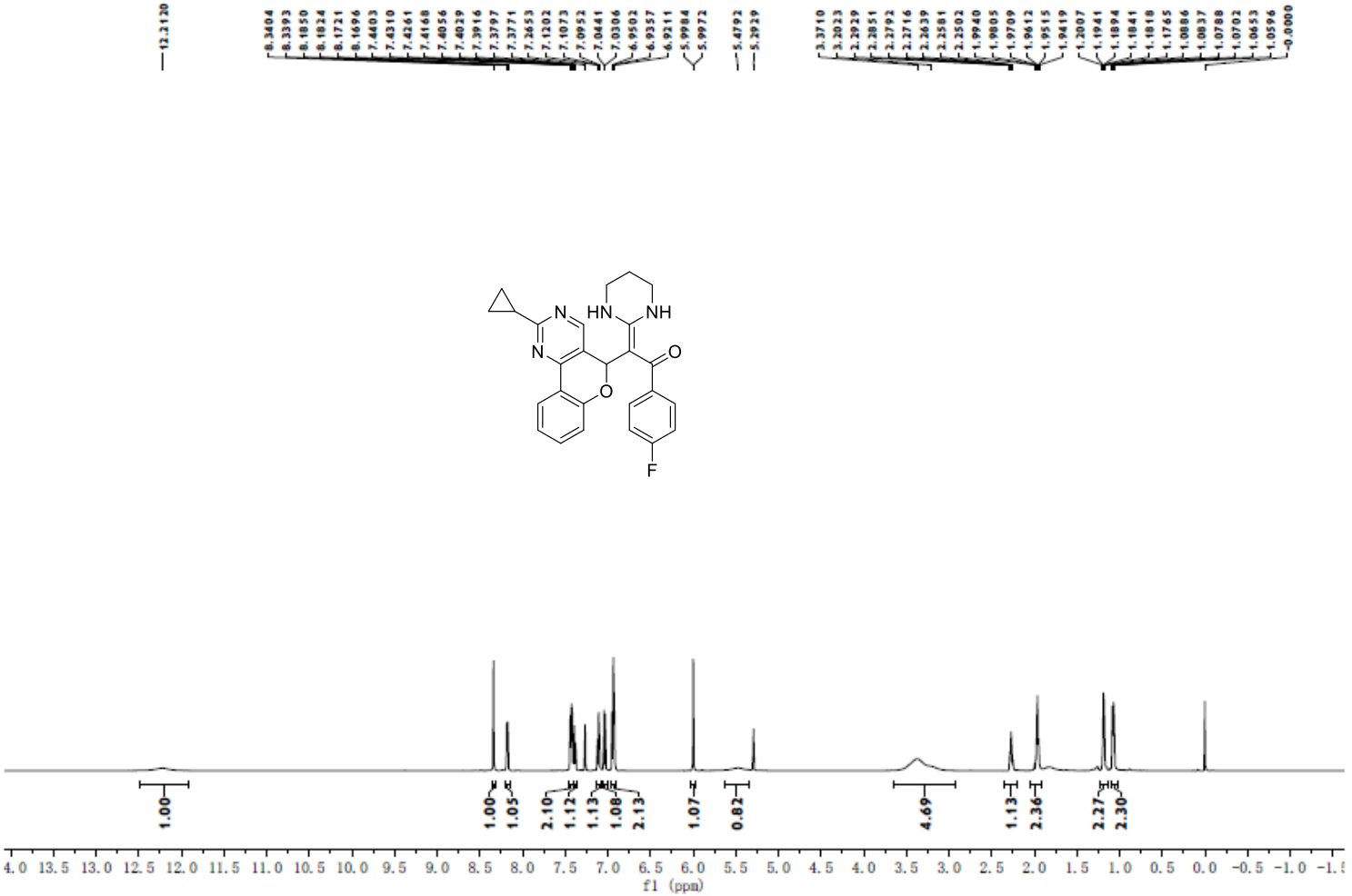


Figure S76. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4i'**

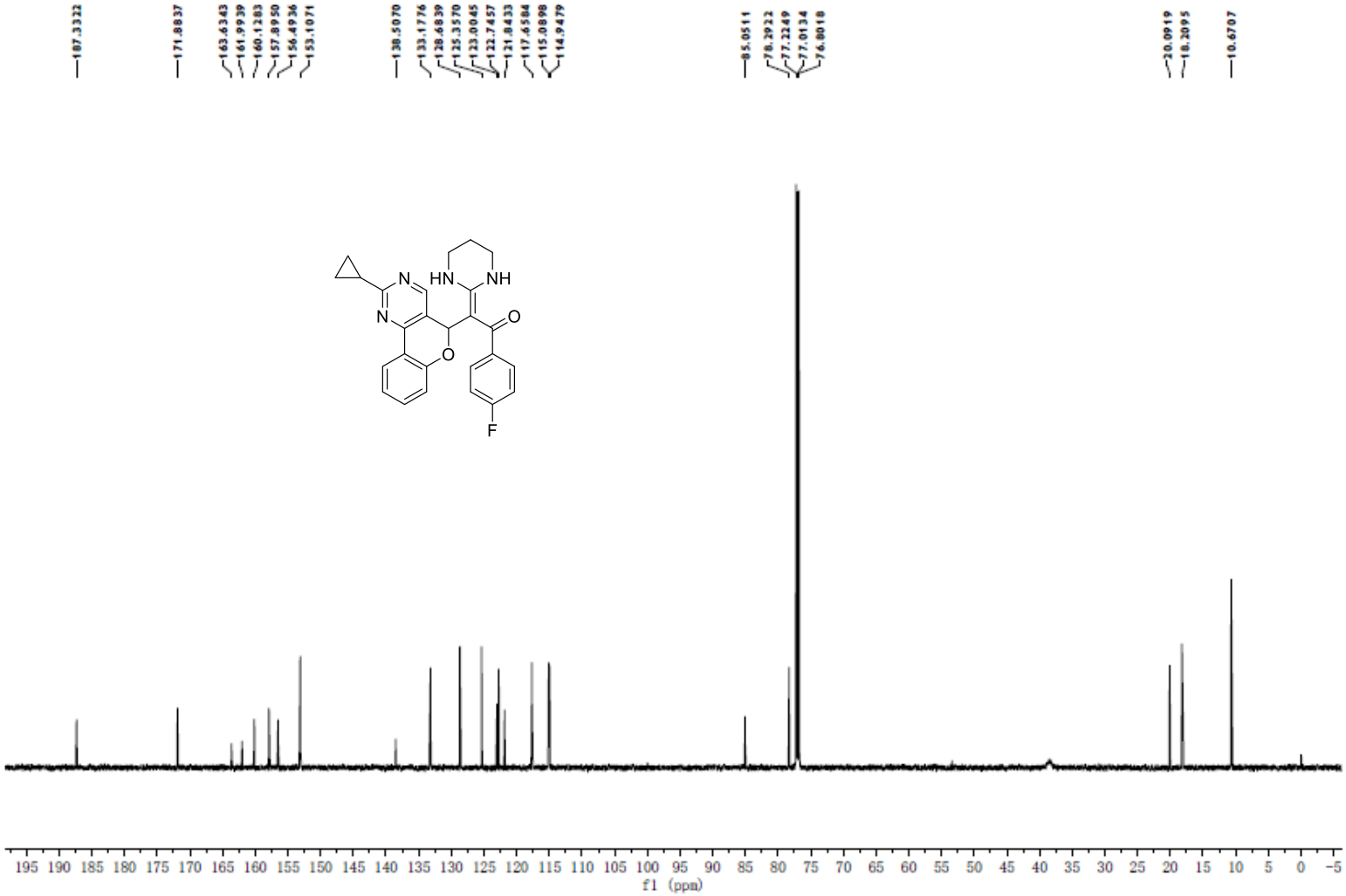


Figure S77. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4i'**

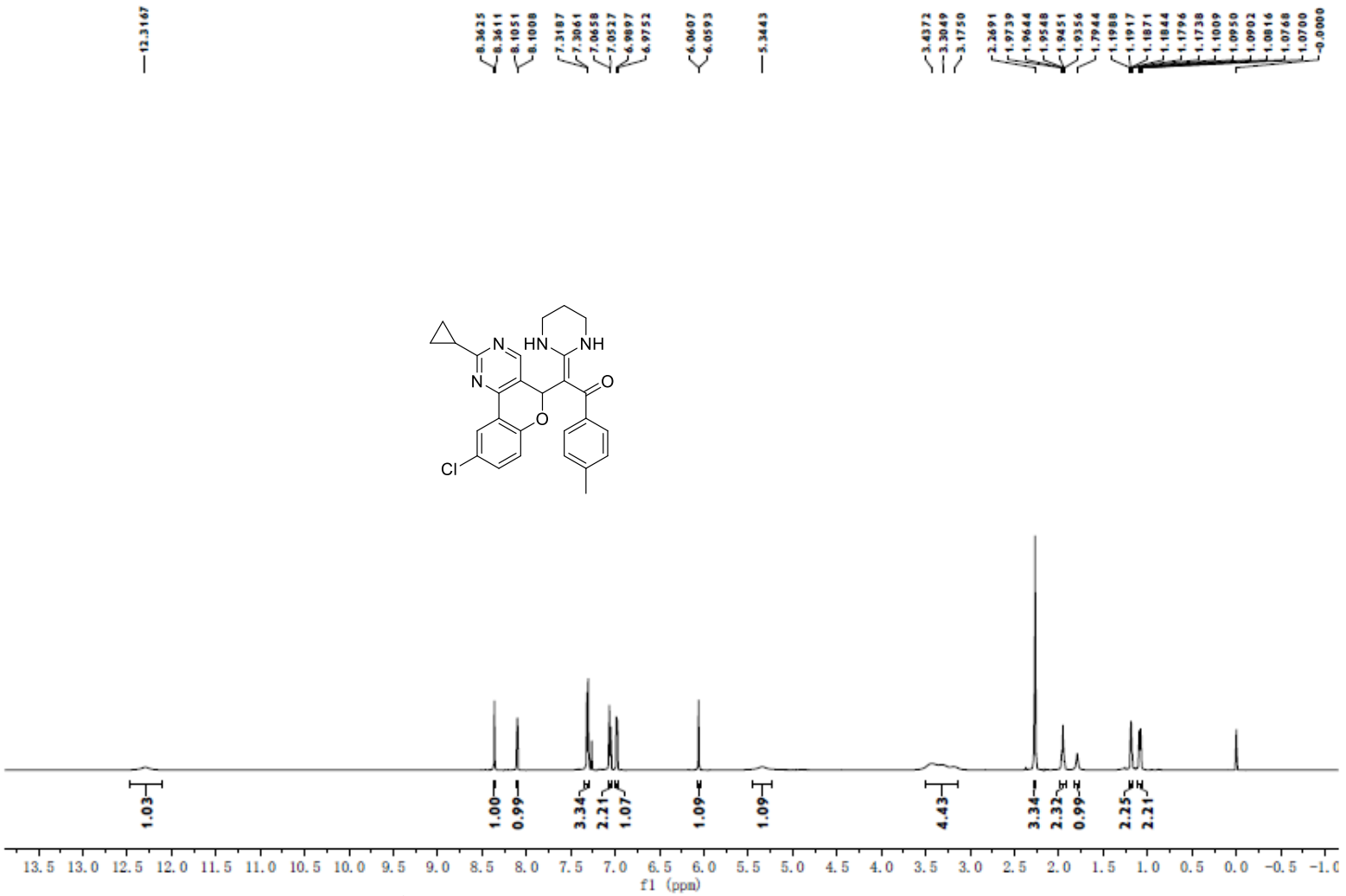


Figure S78. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4j'**

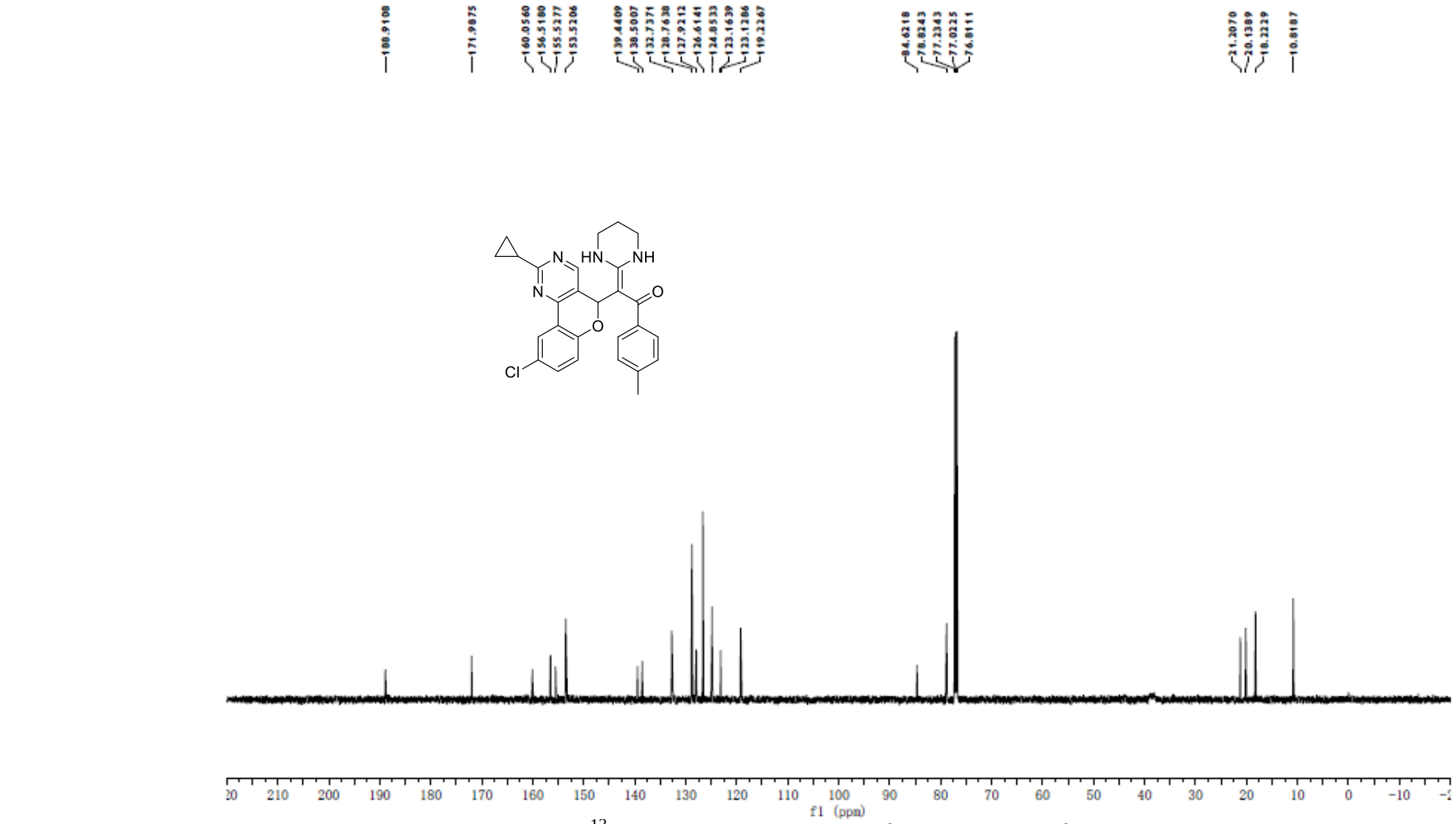


Figure S79. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4j'**

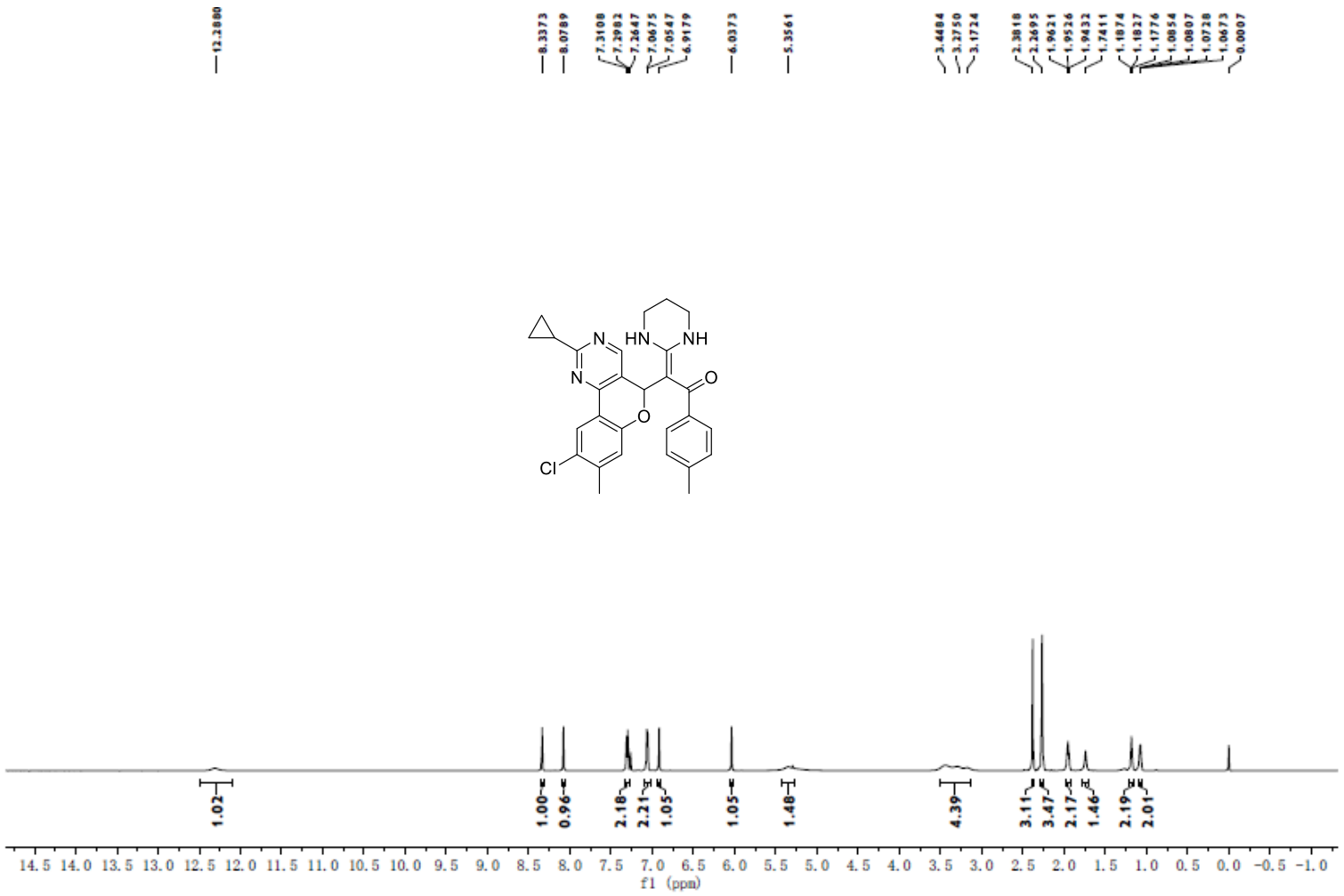


Figure S80. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4k'**

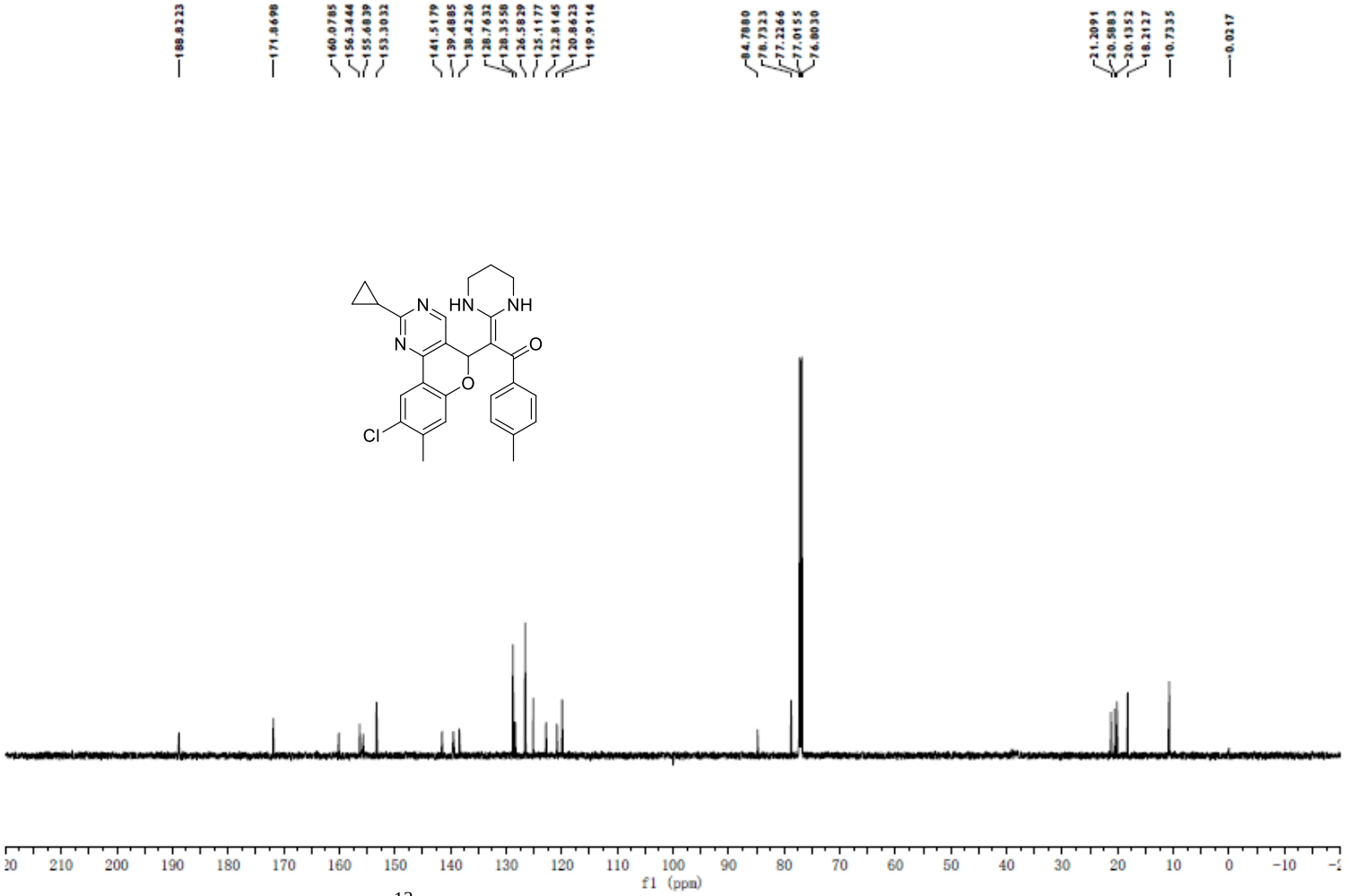


Figure S81. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4k'**

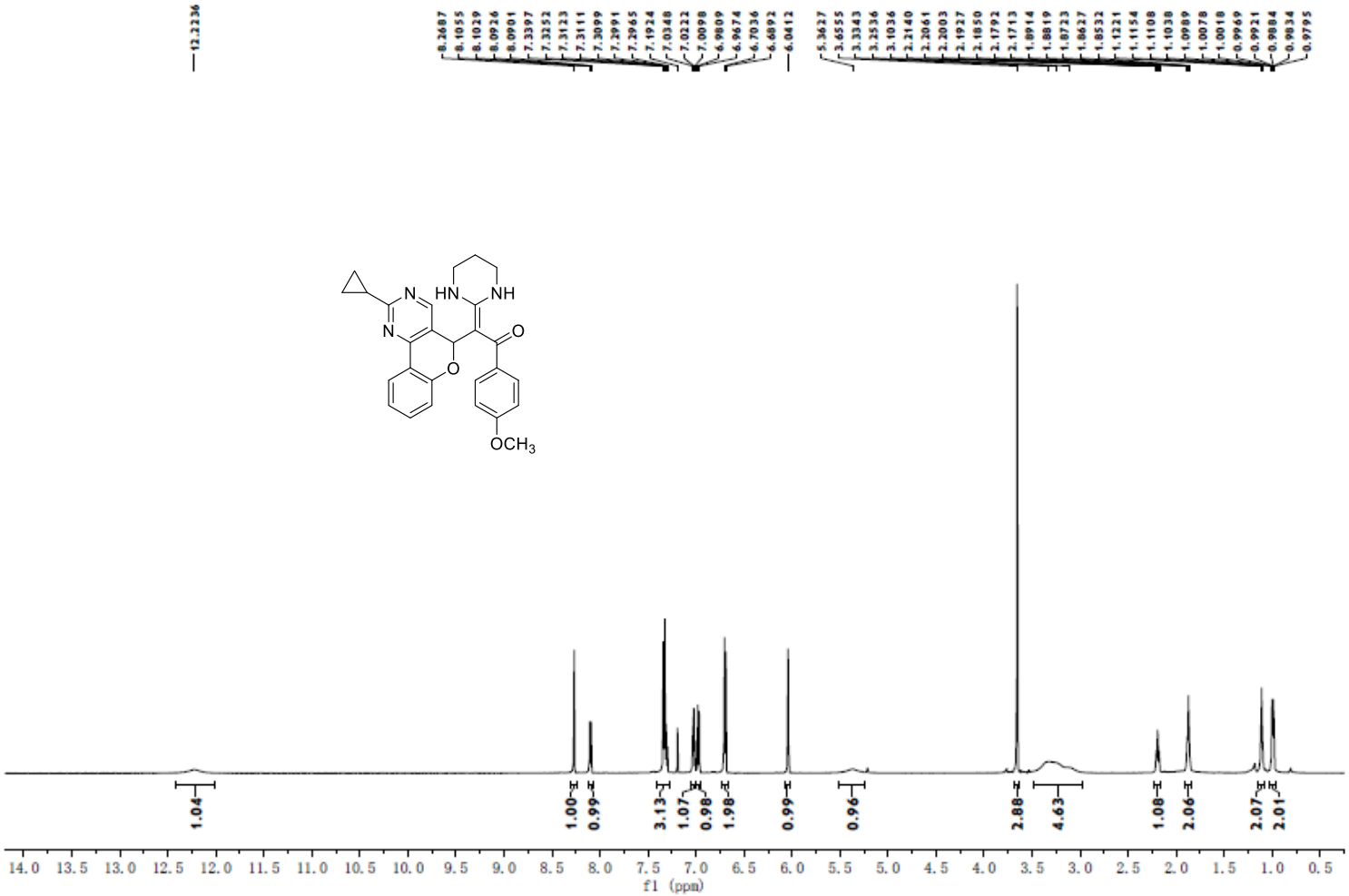


Figure S82. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4l'**

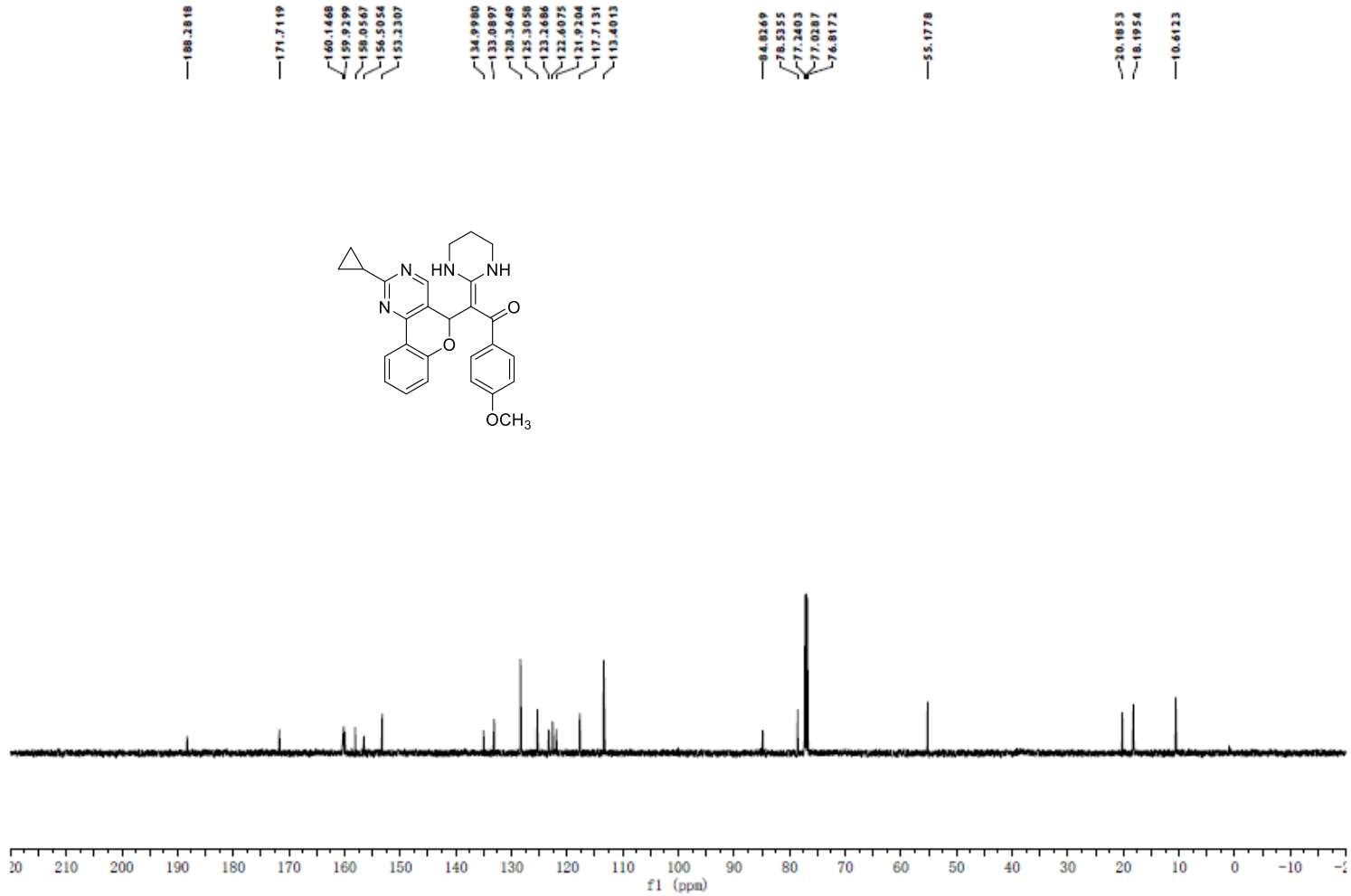


Figure S83. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4l'**

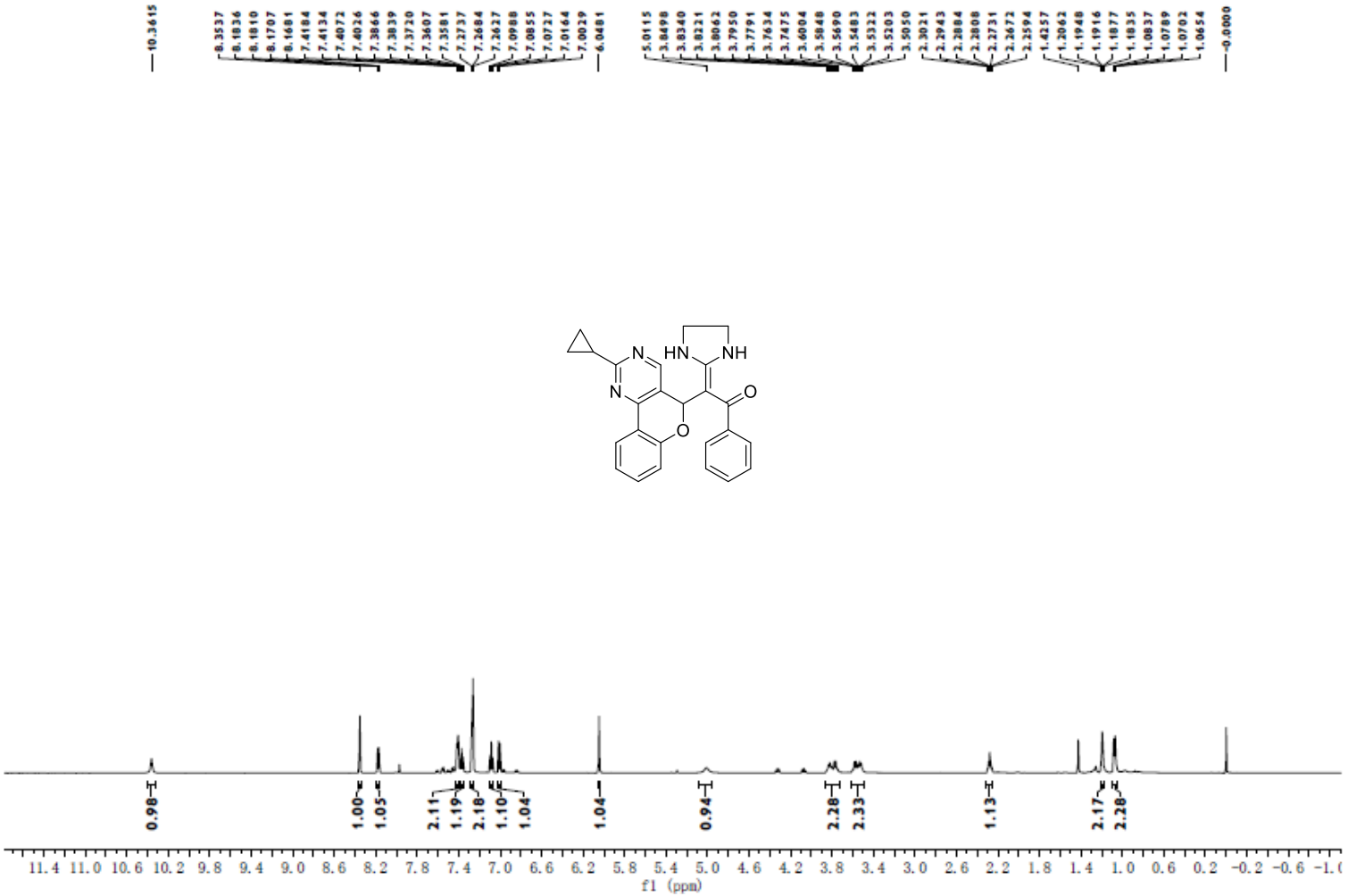


Figure S84. [1]H NMR (600 MHz, Chloroform-*d*) spectra of compound **4m'**

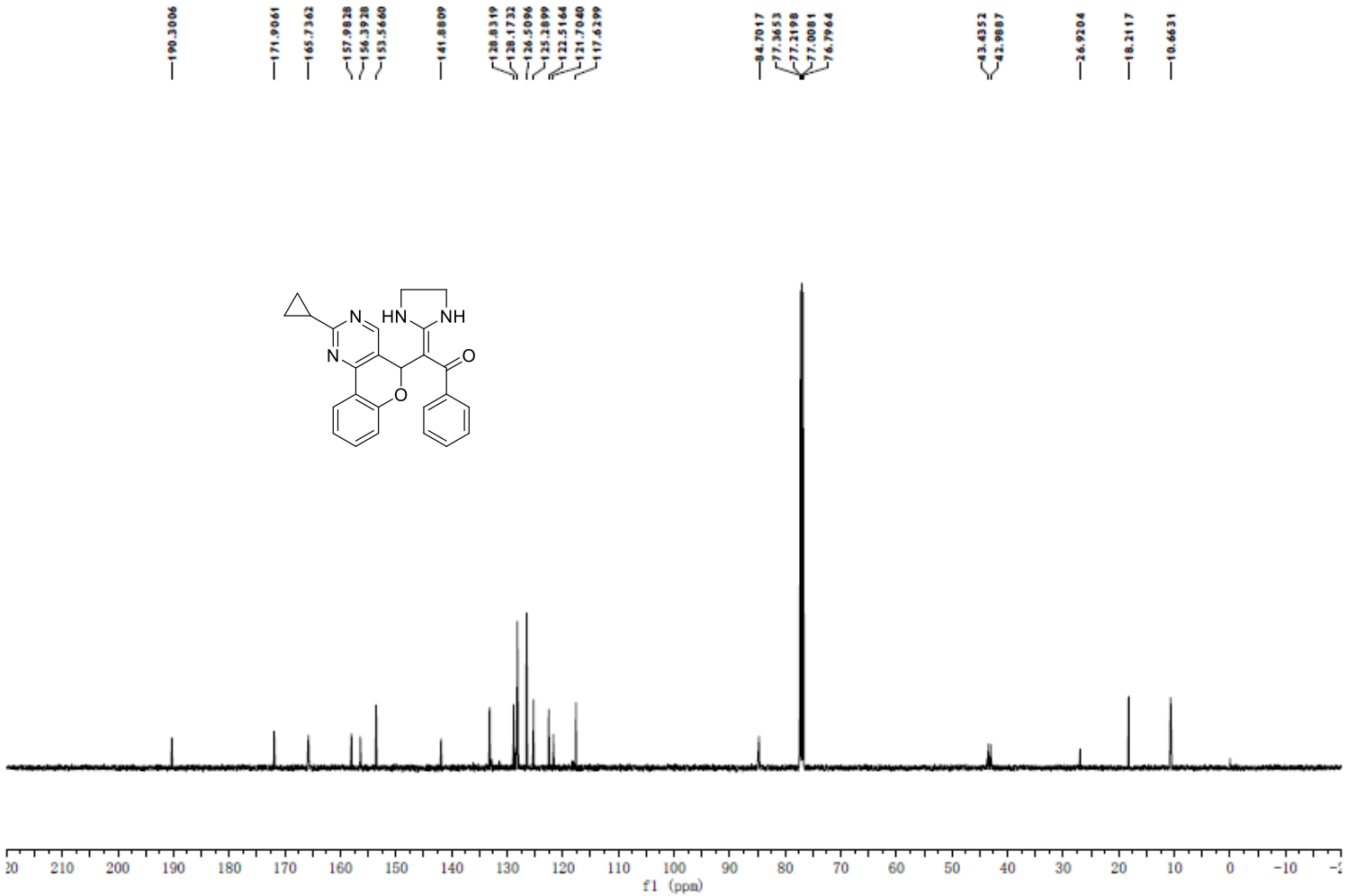


Figure S85. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4m'**

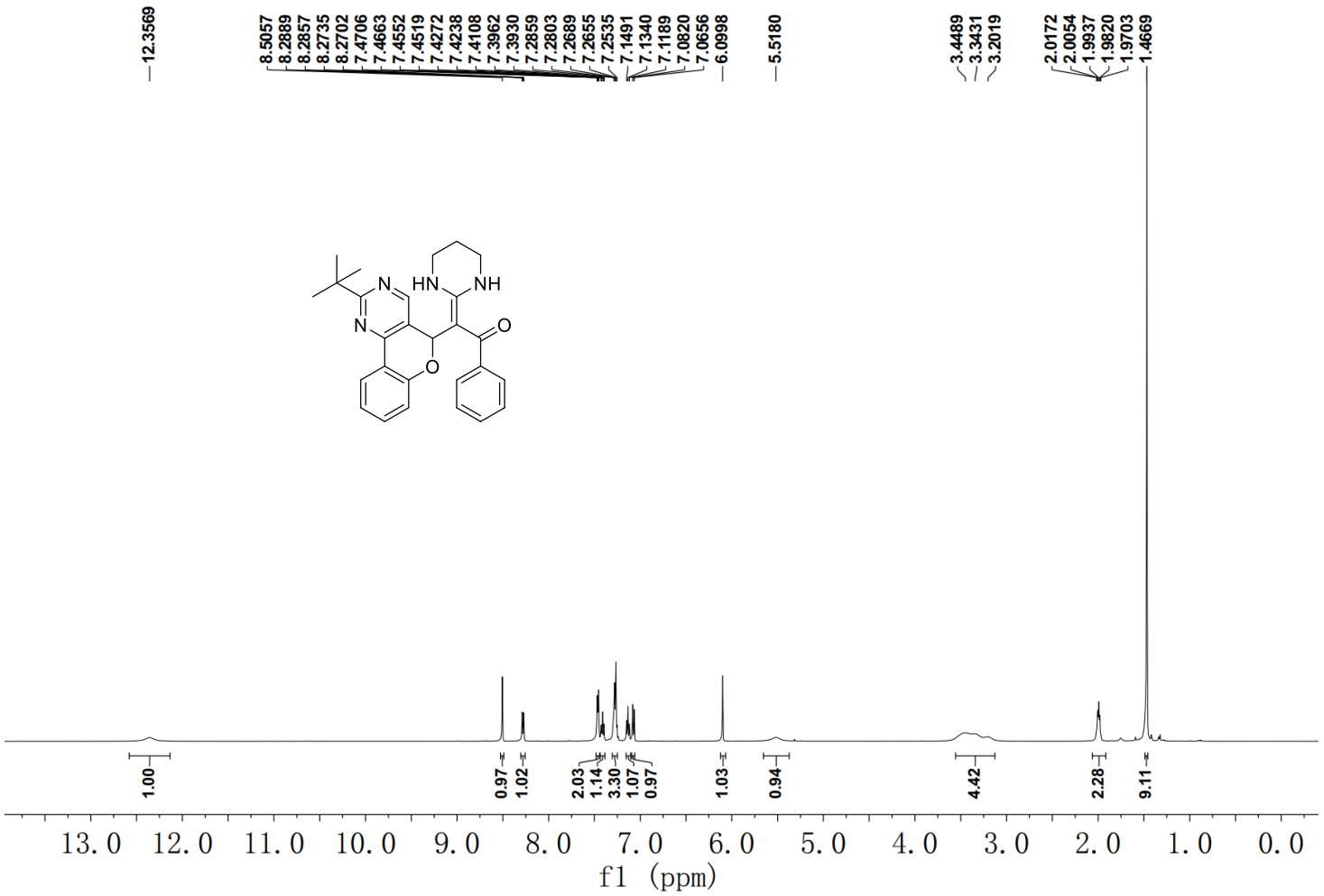


Figure S86. ^{1}H NMR (600 MHz, Chloroform-*d*) spectra of compound **4n'**

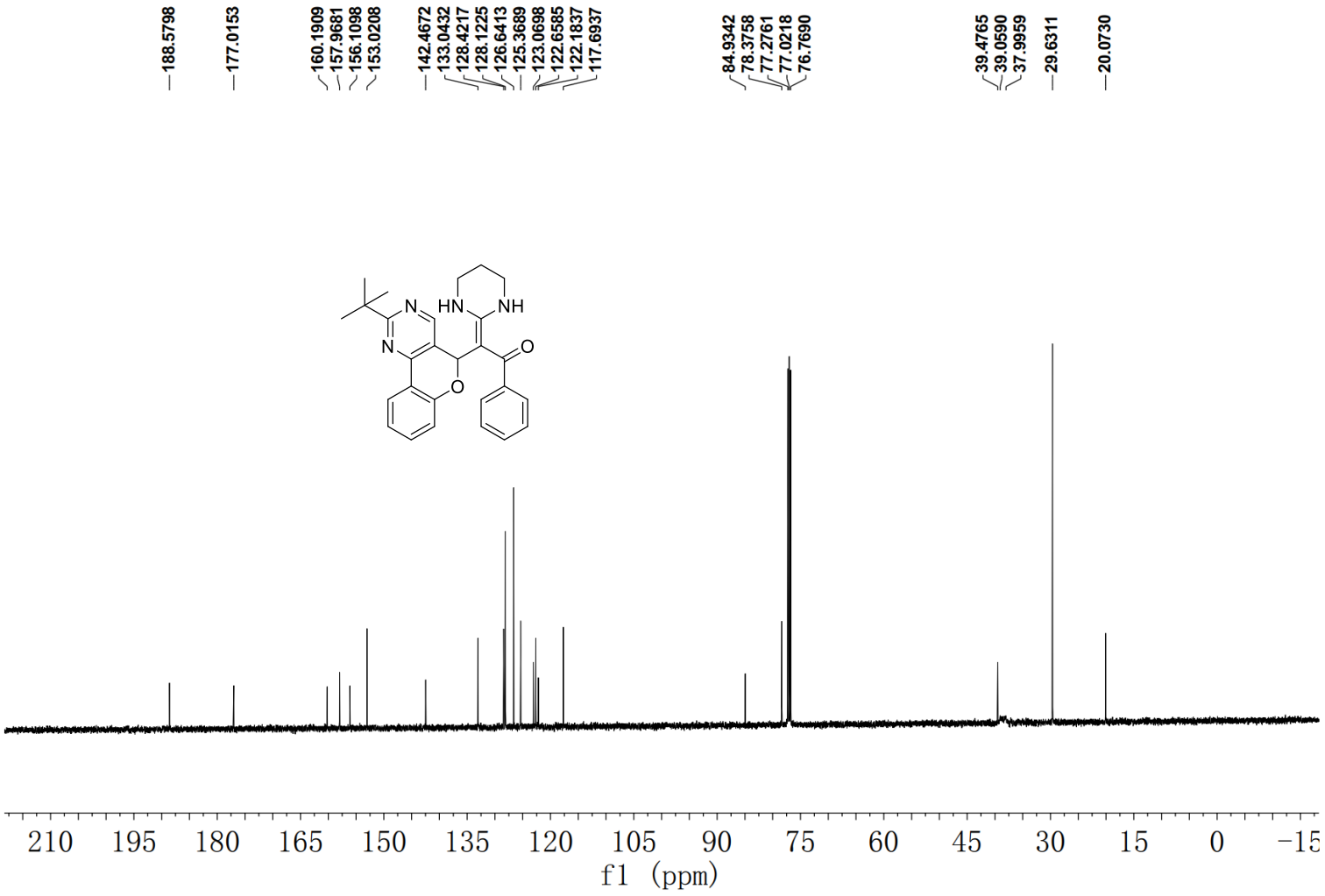


Figure S87. ^{13}C NMR (150 MHz, Chloroform-*d*) spectra of compound **4n'**

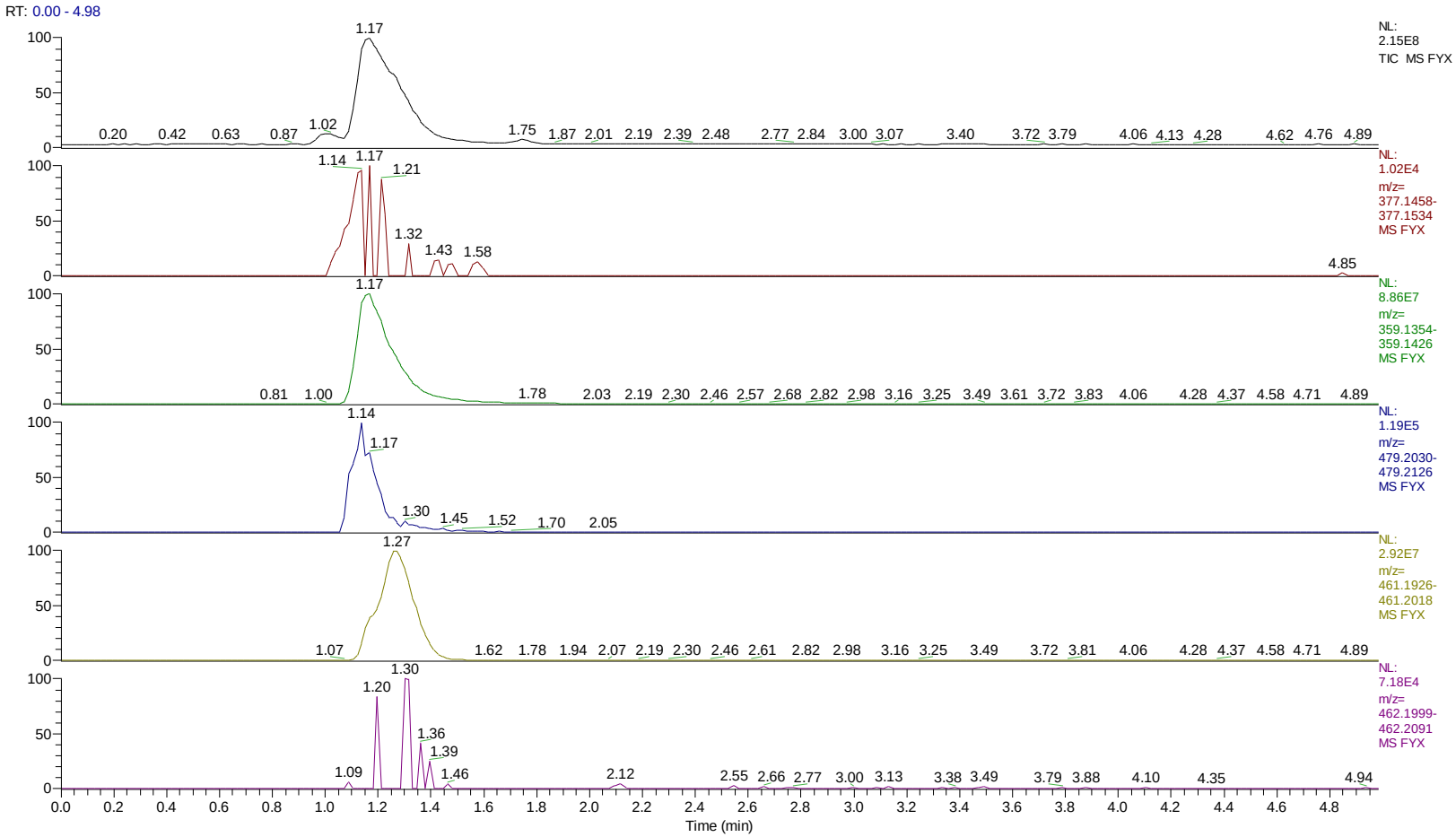


Figure S88. HPLC of the reaction mixture

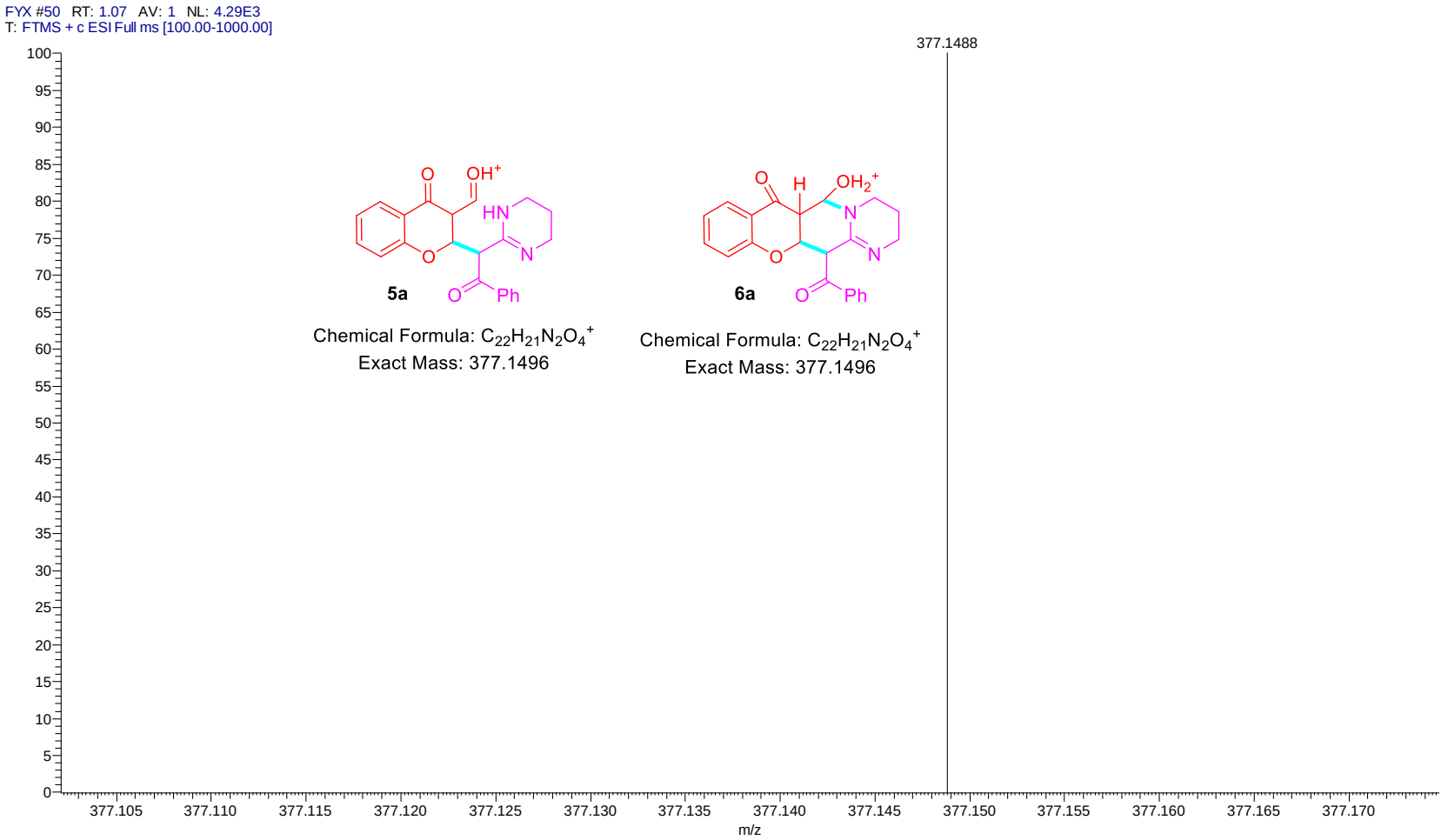


Figure S89. HRMS of intermediate **5a/6a**

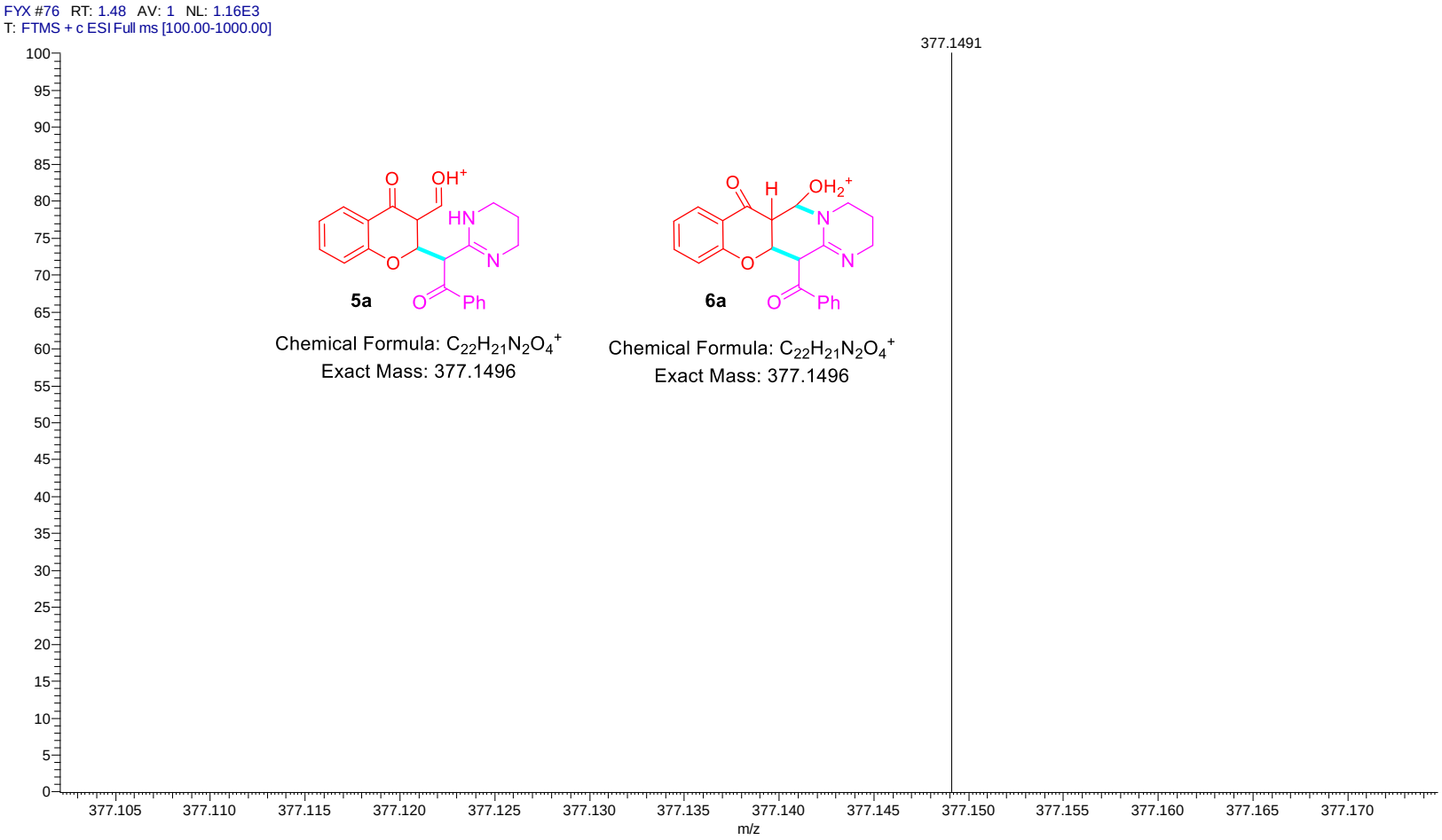


Figure S90. HRMS of intermediate **5a/6a**

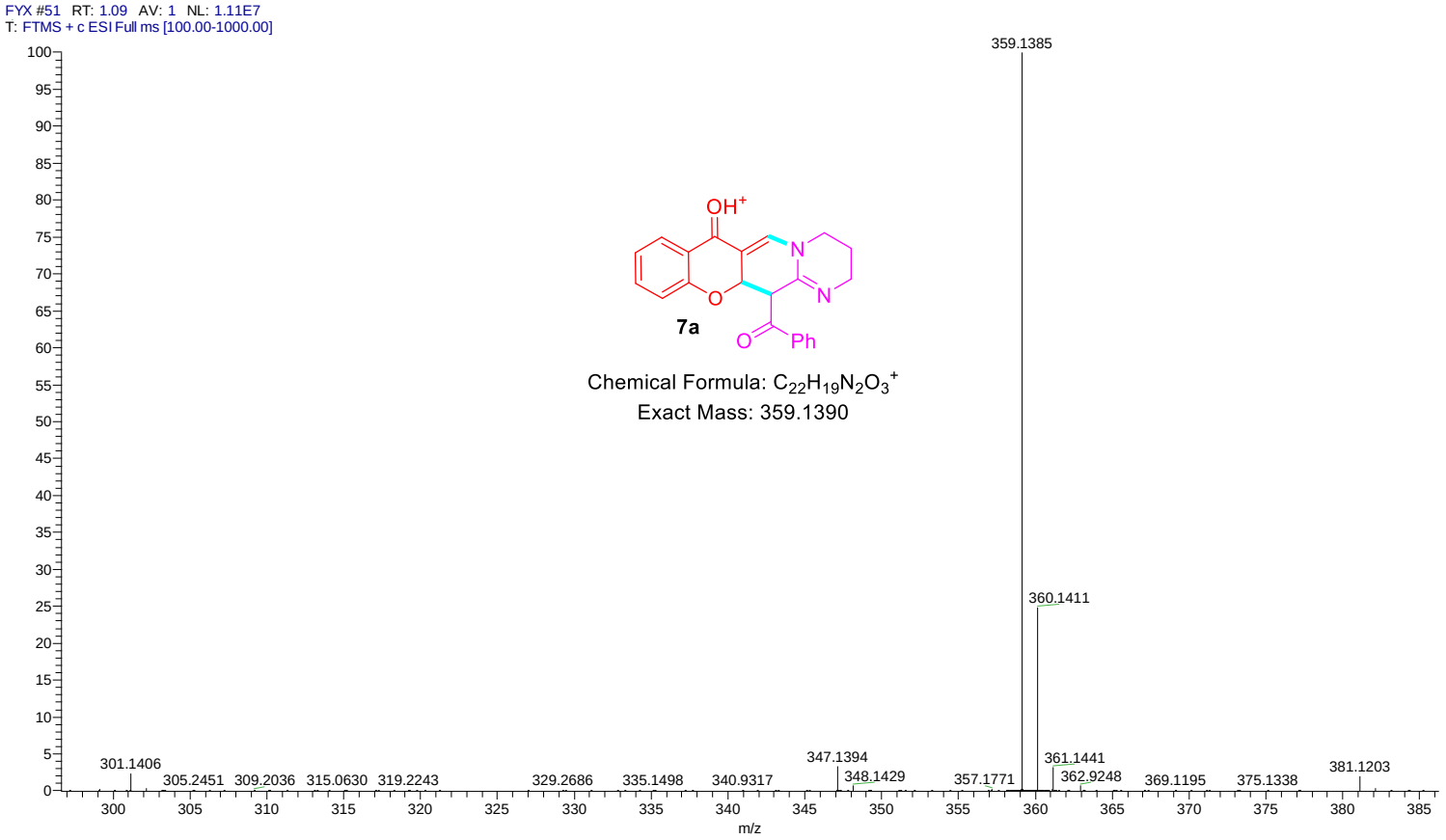


Figure S91. HRMS of intermediate **7a**

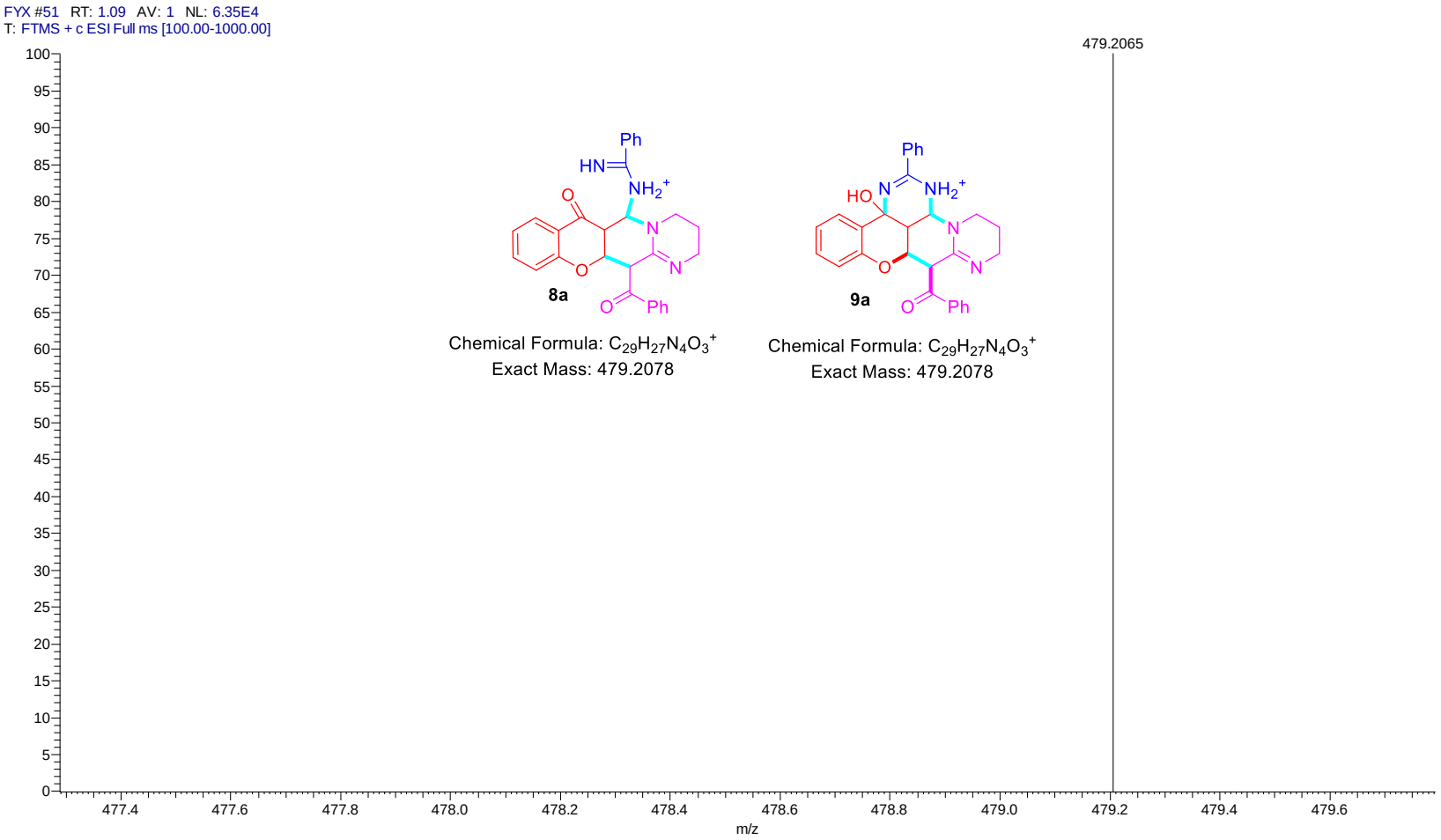


Figure S92. HRMS of intermediate **8a/9a**

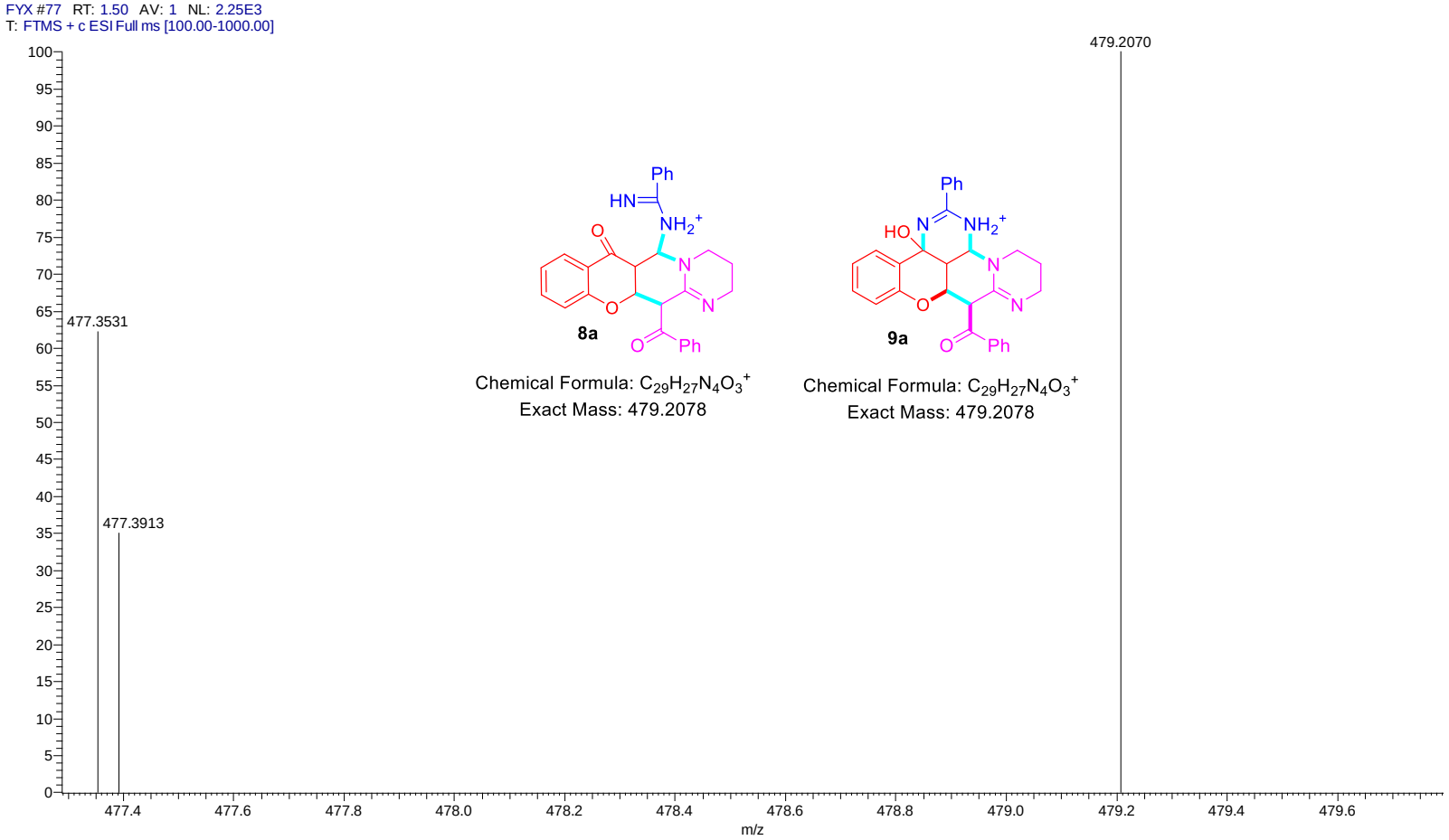


Figure S93. HRMS of intermediate **8a/9a**

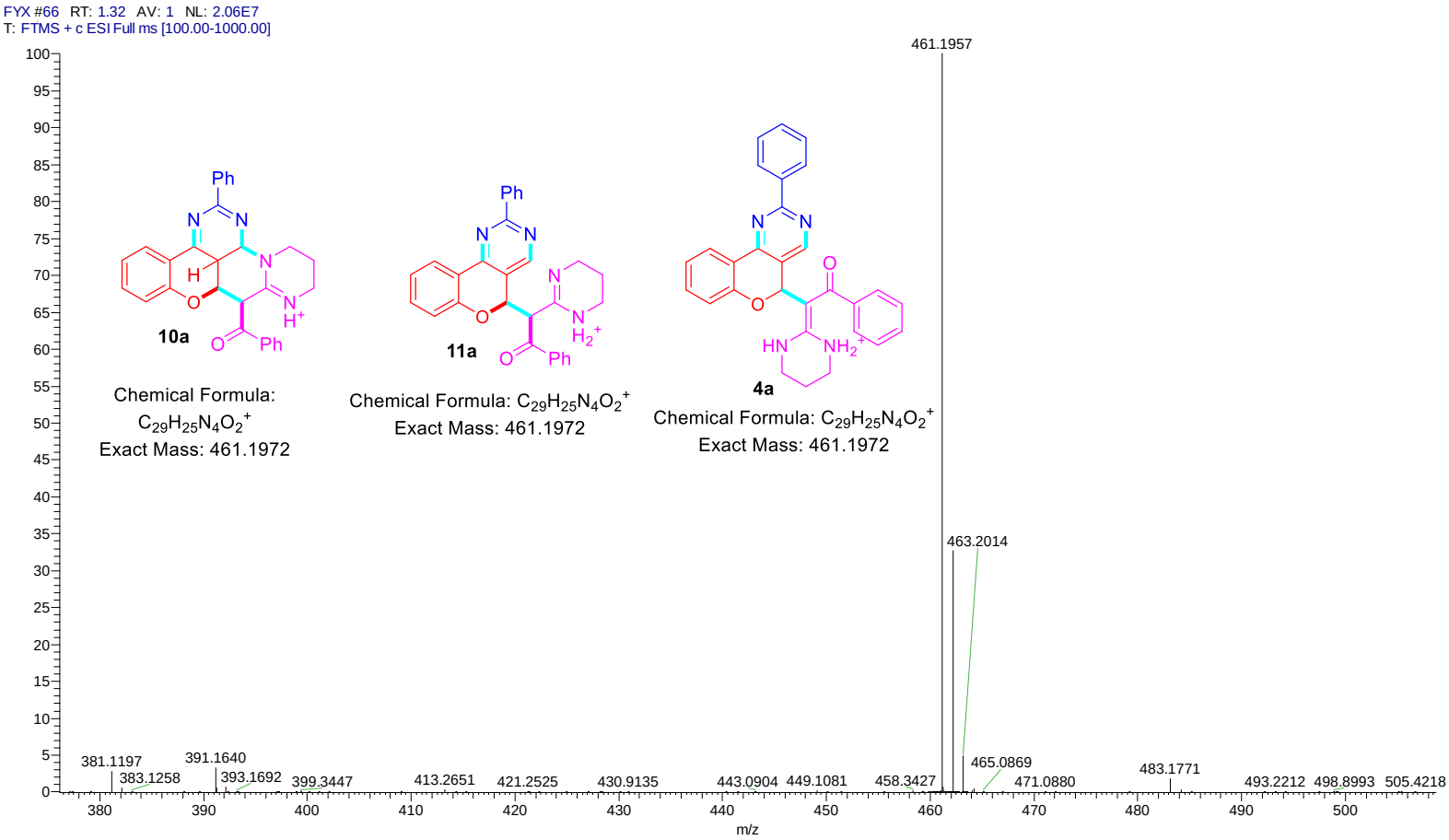


Figure S94. HRMS of intermediate **10a/11a** or target compound **4a**

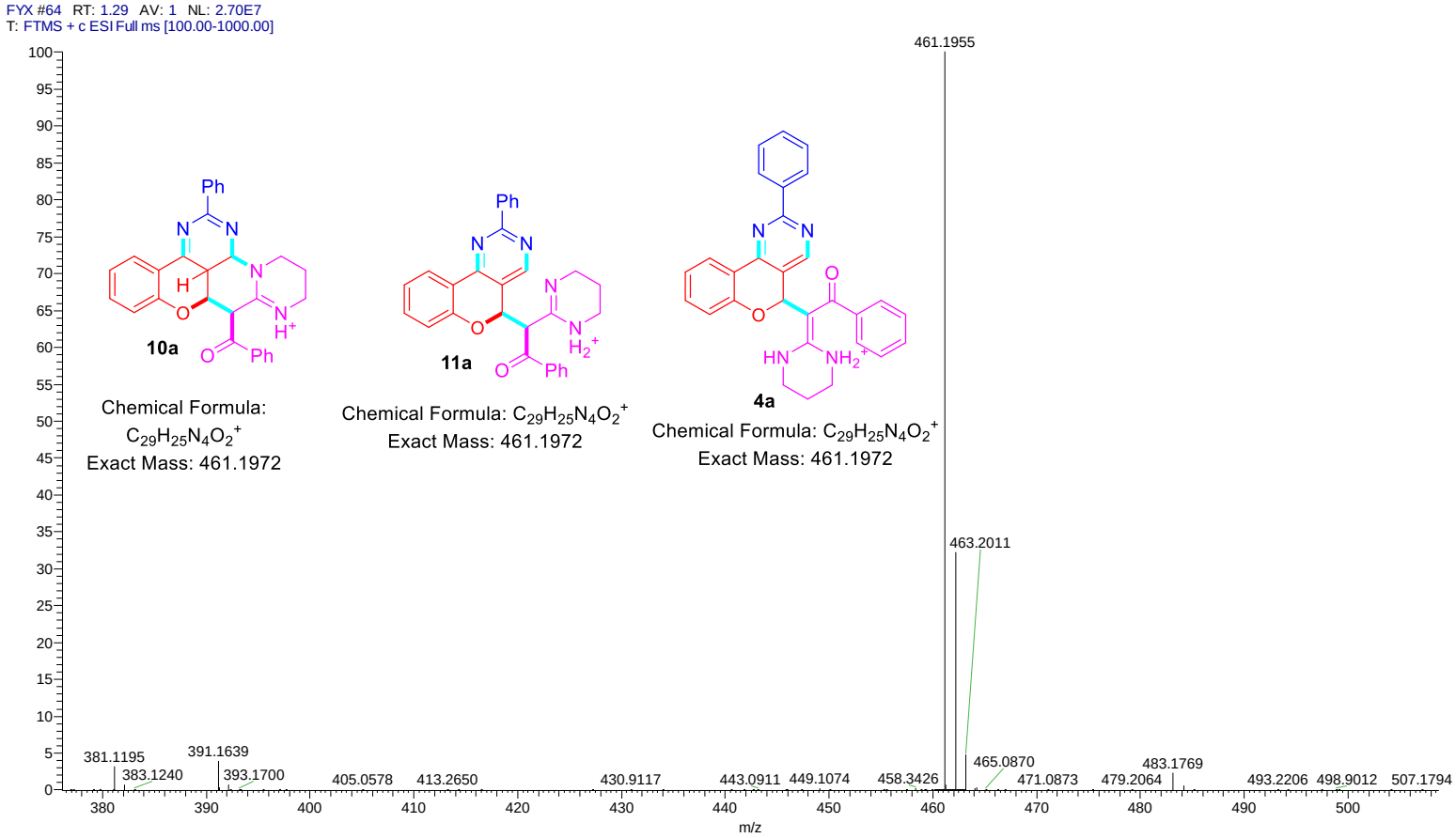


Figure S95. HRMS of intermediate **10a/11a** or target compound **4a**

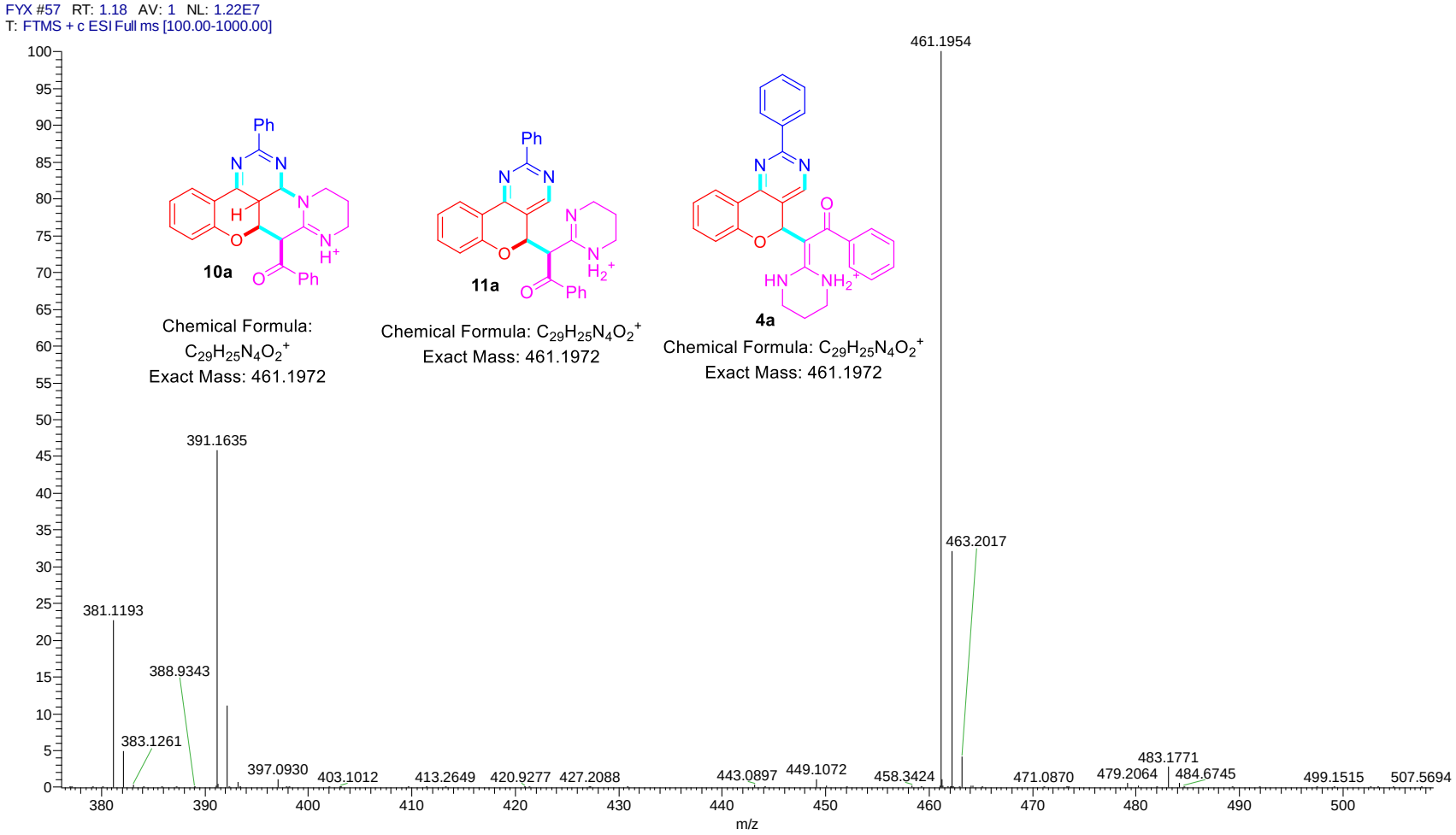


Figure S96. HRMS of intermediate **10a/11a** or target compound **4a**

References and Notes

1. 1. (a) K. Li, L. Chen, Y.-X. Fan, Y. Wei, S.-J. Yan, *J. Org. Chem.*, 2019, **84**, 11971. (b) Q.-X. Zi, C.-L. Yang, K. Li, Q. Luo, J. Lin, S.-J. Yan, *J. Org. Chem.*, 2020, **85**, 327.

2. CCDC 2078187 contain the supplementary crystallographic data for compound **4a**. These data can be obtained free of charge from The Cambridge Crystallographic Data Center *via* www.ccdc.cam.ac.uk/data_request/cif