Supplementary Information

Switchable intramolecular oxidative amidation of 4-arylquinoline-3-carboxamides: divergent access to dibenzo[*c*,*f*][2,7]naphthyridinones and spirocyclohexadienones

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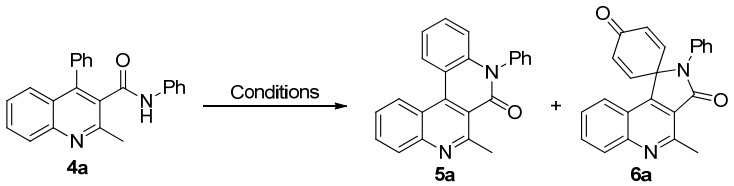
CONTENTS

1. General information

^{1}H NMR and ^{13}C NMR spectra were recorded with a Bruker AVIII-400 spectrometer at ambient temperature with $CDCl_3$ or DMSO-d_6 as the solvent. ^{1}H NMR spectra were referenced to tetramethylsilane (δ = 0.00 ppm) or DMSO-d_6 (δ = 2.50 ppm), and ^{13}C NMR spectra were referenced to $CDCl_3$ (δ = 77.0 ppm) or DMSO-d_6 (δ = 39.52 ppm). High-resolution mass spectra were recorded by Bruker Apex IV Fourier Transform Ion Cyclotron Resonance Mass Spectrometer. All melting points were measured on a WRS-2A melting point apparatus and uncorrected. IR spectra were recorded as KBr pellets on a Nicolet Nexus 470 FTIR spectrometer. 2-Aminobenzophenones **S-1** (R^1 = 4-$CO_2{}^t$Bu or 3-$CO_2{}^t$Bu, R^2 = H) were prepared according to the literature procedure.[1a] Acetoacetanilides **S-2** were prepared according to the literature procedure.[1b-1d] Other chemicals were purchased from Energy Chemical without further purification.

2. Optimization of Reaction Conditions

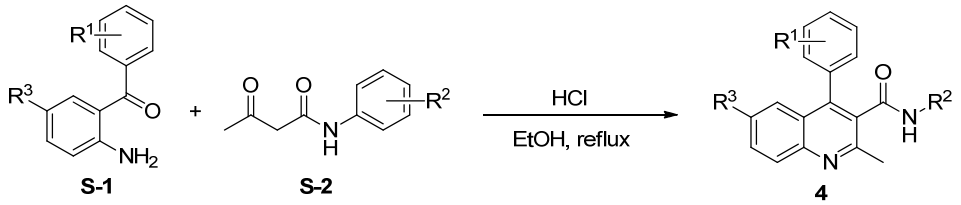
Table S1. Optimization of Reaction Conditions[a,b]



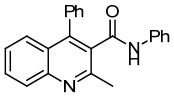
Entry	Oxidant (equiv.)	Catalyst	Solvent	Time (h)	Temp. (°C)	**5a** Yield (%)	**6a** Yield (%)
1[c]	$Na_2S_2O_8$ (2)	–	EtOAc/H_2O (1:1, 30 mL)	5	60	27	0
2[d]	$Na_2S_2O_8$ (2)	–	EtOAc/H_2O (1:1, 5 mL)	2	Reflux	32	0
3	$Na_2S_2O_8$ (2)	–	EtOAc/H_2O (1:1, 10 mL)	2	Reflux	61	0
4	$Na_2S_2O_8$ (2)	–	EtOAc/H_2O (1:1, 30 mL)	2	Reflux	76	0
5[d]	$Na_2S_2O_8$ (3)	$AgNO_3$	CH_3COCH_3/H_2O (1:1, 5 mL)	8	RT	Trace	9
6[d]	$Na_2S_2O_8$ (3)	$AgNO_3$	CH_3COCH_3/H_2O (1:1, 10 mL)	8	RT	Trace	26
7[d]	$Na_2S_2O_8$ (3)	$AgNO_3$	CH_3COCH_3/H_2O (1:1, 30 mL)	8	RT	Trace	40
8	$Na_2S_2O_8$ (3)	$AgNO_3$	CH_3COCH_3/H_2O (1:1, 60 mL)	8	RT	Trace	47
9	$Na_2S_2O_8$ (3)	$AgNO_3$	CH_3COCH_3/H_2O (1:1, 120 mL)	8	RT	Trace	53
10[d]	$Na_2S_2O_8$ (2)	–	H_2O (15 mL)	2	Reflux	35	0
11[e]	$Na_2S_2O_8$ (2)	–	EtOAc (15 mL)	2	Reflux	0	0
12[e]	$Na_2S_2O_8$ (2)	–	MeCN (15 mL)	2	Reflux	Trace	0
13[e]	$Na_2S_2O_8$ (2)	–	AcOH (15 mL)	2	80	0	0
14[e]	$Na_2S_2O_8$ (2)	–	CH_3Cl (15 mL)	2	Reflux	0	0
15[e]	$Na_2S_2O_8$ (3)	$AgNO_3$	CH_3COCH_3 (60 mL)	8	RT	0	0

[a] Reaction conditions: **4a** (1 mmol), catalyst (20 %mol), oxidant (2 or 3 equiv.). [b] Isolated yield. [c] 50% of **4a** was recovered. [d] Some insoluble side products were formed during the reaction. [e] **4a** remained unreacted as detected by TLC.

3. Preparation of Friedländer Products 4

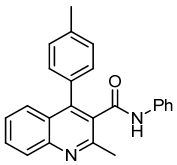


A mixture of 2-aminobenzophenone **S-1** (10 mmol), acetoacetanilide **S-2** (10 mmol), concentrated hydrochloric acid (36%, 2 ml), and EtOH (20 mL) was added to a round bottom flask (100 mL). The mixture was stirred under reflux (oil bath temperature 90 ^{o}C) for 1–5 h (monitored by TLC). After completion of reaction, the mixture was cooled to room temperature. Then, ammonia water (25%) was added to adjust pH to 7–8. The solid was filtrated, washed with water for three times, and dried under vacuum to afford the product **4**, which was pure enough for NMR analysis.



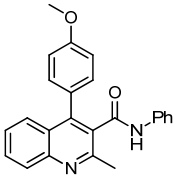
2-Methyl-*N*,4-diphenylquinoline-3-carboxamide (4a)[2-4]

White solid (2.8 g, 82%); mp > 280 °C (lit.[2] 279–285 °C); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.38 (s, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.84–7.76 (m, 1H), 7.60–7.35 (m, 9H), 7.30–7.20 (m, 2H), 7.07–7.01 (m, 1H), 2.73 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.7, 154.4, 146.8, 144.2, 138.4, 134.8, 130.8, 130.0, 129.3, 128.6, 128.5, 128.3, 128.1, 126.6, 125.9, 124.9, 123.8, 119.6, 23.1.



2-Methyl-*N*-phenyl-4-*p*-tolylquinoline-3-carboxamide (4b)

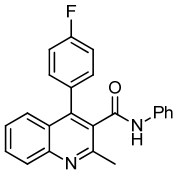
Yellow solid (2.4 g, 68%); mp 234–235 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.40 (s, 1H), 8.06 (d, J = 8.4 Hz, 1H), 7.84–7.73 (m, 1H), 7.58–7.40 (m, 4H), 7.39–7.20 (m, 6H), 7.08–7.00 (m, 1H), 2.72 (s, 3H), 2.33 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.5, 154.1, 146.6, 143.9, 138.2, 137.3, 131.6, 130.6, 129.6, 129.0, 128.4, 128.4, 128.2, 126.3, 125.7, 123.5, 119.3, 22.8, 20.5; IR (KBr, cm^{-1}): v 3249, 3060, 2921, 1651, 1599, 1541, 1493, 1442, 1319, 755; HRMS (ESI): m/z calcd for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648, found 353.1647.



4-(4-Methoxyphenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4c)

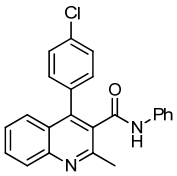
Pale yellow solid (3.0 g, 82%); mp 220–222 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.37 (s, 1H), 8.05 (d, J = 8.4 Hz, 1H), 7.83–7.74 (m, 1H), 7.53 (d, J = 4.1 Hz, 2H),

7.46 (d, J = 7.7 Hz, 2H), 7.38 (d, J = 8.6 Hz, 2H), 7.30–7.22 (m, 2H), 7.08–7.02 (m, 3H), 3.77 (s, 3H), 2.71 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.6, 158.8, 154.2, 146.6, 143.7, 138.2, 130.7, 130.4, 129.6, 128.4, 128.2, 126.6, 126.2, 125.7, 125.0, 123.5, 119.3, 113.3, 54.8, 22.8; IR (KBr): v 3266, 3061, 2927, 1651, 1601, 1539, 1517, 1493, 1442, 1250, 758; HRMS (ESI): m/z calcd for $C_{24}H_{21}N_2O_2$ $[M+H]^+$ 369.1598, found 369.1598.



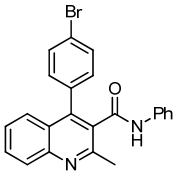
4-(4-Fluorophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4d)

White solid (2.6 g, 73%); mp 257–258 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.40 (s, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.84–7.78 (m, 1H), 7.60–7.52 (m, 1H), 7.51–7.38 (m, 5H), 7.37–7.30 (m, 2H), 7.30–7.23 (m, 2H), 7.09–7.02 (m, 1H), 2.73 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.6, 162.00 (d, $J_{C\text{-}F}$ = 245.3 Hz), 154.4, 146.8, 143.2, 138.3, 131.6 (d, $J_{C\text{-}F}$ = 8.5 Hz), 131.2 (d, $J_{C\text{-}F}$ = 3.3 Hz), 131.0, 130.1, 128.7, 128.6, 126.8, 125.7, 124.9, 123.9, 119.6, 115.2 (d, $J_{C\text{-}F}$ = 21.7 Hz), 23.0; IR (KBr, cm^{-1}): v 3239, 3067, 2924, 1648, 1601, 1540, 1492, 1443, 1325, 1223, 757; HRMS (ESI): m/z calcd for $C_{23}H_{18}FN_2O$ $[M+H]^+$ 357.1398, found 357.1395.



4-(4-Chlorophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4e)[4]

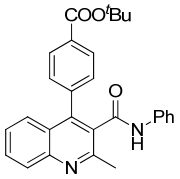
Pale yellow solid (3.1 g, 83%); mp 264–265 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.43 (s, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.85–7.77(m, 1H), 7.56–7.52 (m, 3H), 7.50–7.40 (m, 5H), 7.31–7.23 (m, 2H), 7.10–7.02 (m, 1H), 2.73 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.5, 154.4, 146.8, 143.0, 138.3, 133.7, 133.3, 131.2, 130.8, 130.1, 128.7, 128.6, 128.2, 126.9, 125.7, 124.6, 124.0, 119.6, 23.1; IR (KBr, cm^{-1}): v 3265, 3062, 2923, 1649, 1598, 1538, 1485, 1442, 1318, 757; HRMS (ESI): m/z calcd for $C_{23}H_{18}ClN_2O$ $[M+H]^+$ 373.1102, found 373.1100.



4-(4-Bromophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4f)

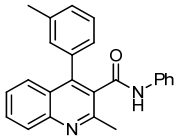
Pale yellow solid (3.3 g, 79%); mp 267–268 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.44 (s, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.84–7.78 (m, 1H), 7.70 (d, J = 8.4 Hz, 2H), 7.59–7.52 (m, 1H), 7.50–7.33 (m, 5H), 7.32–7.24 (m, 2H), 7.10–7.02 (m, 1H), 2.73 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.2, 154.1, 146.5, 142.7, 138.0, 133.8, 131.2, 130.9, 130.4, 129.9, 128.5, 128.3, 126.6, 125.4, 124.3, 123.7, 121.7, 119.3,

22.8; IR (KBr, cm^{-1}): *v* 3251, 3062, 2924, 1650, 1598, 1541, 1485, 1442, 1319, 758, 691; HRMS (ESI): *m/z* calcd for $C_{23}H_{18}BrN_2O$ $[M+H]^+$ 417.0597, found 417.0597.



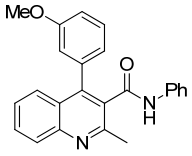
***tert*-Butyl 4-(2-methyl-3-(phenylcarbamoyl)quinolin-4-yl)benzoate (4g)**

White solid (2.9 g, 66%); mp 137–138 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.48 (s, 1H), 8.09 (d, J = 8.4 Hz, 1H), 8.00 (d, J = 8.1 Hz, 2H), 7.85–7.78 (m, 1H), 7.59–7.51 (m, 3H), 7.47–7.39 (m, 3H), 7.29–7.23 (m, 2H), 7.08 –7.02 (m,1H), 2.74 (s, 3H), 1.54 (s, 9H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.9, 165.0, 154.9, 147.3, 143.7, 139.9, 138.9, 131.7, 131.0, 130.7, 130.2, 129.3, 129.2, 129.1, 127.4, 126.2, 125.0, 124.5, 120.0, 81.5, 28.2, 23.5; IR (KBr, cm^{-1}): *v* 3278, 3064, 2978, 1714, 1652, 1539, 1443, 1297, 1166, 756; HRMS (ESI): *m/z* calcd for $C_{28}H_{27}N_2O_3$ $[M+H]^+$ 439.2016, found 439.2015.



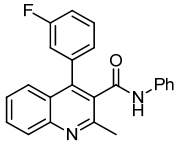
2-Methyl-*N*-phenyl-4-*m*-tolylquinoline-3-carboxamide (4h)

Pale yellow solid (2.3 g, 65%); mp 262–263 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.38 (s, 1H), 8.06 (d, J = 8.3 Hz, 1H), 7.82–7.76 (m, 1H), 7.57–7.47 (m, 2H), 7.43 (d, J = 7.6 Hz, 2H), 7.39–7.33 (m, 1H), 7.32–7.21 (m, 5H), 7.08–7.02 (m, 1H), 2.73 (s, 3H), 2.31 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.7, 154.4, 146.8, 144.2, 138.4, 137.1, 134.8, 130.7, 129.9, 129.9, 129.0, 128.6, 128.5, 128.0, 126.6, 126.4, 126.0, 124.9, 123.8, 119.7, 23.0, 21.0; IR (KBr, cm^{-1}): *v* 3357, 3190, 2919, 2850, 1642, 1554, 1442, 1324, 757; HRMS (ESI): *m/z* calcd for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648, found 353.1649.



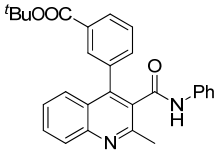
4-(3-Methoxyphenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4i)

White solid (2.7 g, 74%); mp 249–251 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.40 (s, 1H), 8.06 (d, J = 8.4 Hz, 1H), 7.84–7.75 (m, 1H), 7.58–7.51 (m, 2H), 7.47–7.37 (m, 3H), 7.30–7.24 (m, 2H), 7.07–6.97 (m, 4H), 3.72 (s, 3H), 2.73 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.2, 159.2, 154.9, 147.3, 144.5, 139.0, 136.7, 131.1, 130.5, 129.8, 129.2, 129.0, 127.2, 126.4, 125.3, 124.4, 122.2, 120.1, 115.5, 114.5, 55.6, 23.6; IR (KBr, cm^{-1}): *v* 3237, 3066, 1646, 1601, 1544, 1443, 1240, 757; HRMS (ESI): *m/z* calcd for $C_{24}H_{21}N_2O_2$ $[M+H]^+$ 369.1598, found 369.1596.



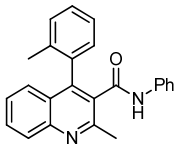
4-(3-Fluorophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4j)

White solid (2.7 g, 76%); mp > 280 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.41 (s, 1H), 8.08 (d, J = 8.3 Hz, 1H), 7.90–7.78 (m, 1H), 7.62–7.46 (m, 3H), 7.42 (d, J = 7.7 Hz, 2H), 7.33–7.24 (m, 5H), 7.09–7.03 (m, 1H), 2.74 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.4, 161.6 (d, $J_{C\text{-}F}$ = 244.6 Hz), 154.4, 146.8, 142.7, 138.3, 137.2 (d, $J_{C\text{-}F}$ = 8.1 Hz), 130.7, 130.3 (d, $J_{C\text{-}F}$ = 8.6 Hz), 130.1, 128.7, 128.6, 126.9, 125.7, 125.6, 124.5, 124.0, 119.6, 116.4 (d, $J_{C\text{-}F}$ = 22.3 Hz), 115.4 (d, $J_{C\text{-}F}$ = 20.8 Hz), 23.0; IR (KBr, cm^{-1}): v 3233, 3066, 2922, 1641, 1554, 1443, 1323, 787, 766, 755; HRMS (ESI): m/z calcd for $C_{23}H_{18}FN_2O$ $[M+H]^+$ 357.1398, found 357.1396.



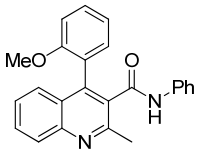
***tert*-Butyl 3-(2-methyl-3-(phenylcarbamoyl)quinolin-4-yl)benzoate (4k)**

White solid (3.0 g, 68%); mp 176–177 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.52 (s, 1H), 8.10–8.01 (m, 2H), 7.99–7.93 (m, 1H), 7.86–7.79 (m, 1H), 7.69–7.54 (m, 3H), 7.47–7.38 (m, 3H), 7.28–7.22 (m, 2H), 7.08–7.02 (m, 1H), 2.74 (s, 3H), 1.49 (s, 9H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.9, 164.9, 154.9, 147.4, 143.7, 138.7, 135.7, 134.3, 131.4, 130.7, 130.2, 129.5, 129.1, 129.0, 127.4, 126.2, 125.1, 124.5, 120.2, 81.5, 40.6, 28.2, 23.6; IR (KBr, cm^{-1}): v 3282, 3063, 2977, 1714, 1652, 1537, 1442, 1299, 1162, 753; HRMS (ESI): m/z calcd for $C_{28}H_{27}N_2O_3$ $[M+H]^+$ 439.2016, found 439.2016.



2-Methyl-*N*-phenyl-4-*o*-tolylquinoline-3-carboxamide (4l)

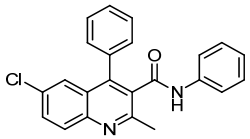
Pale yellow solid (2.0 g, 54%); mp 263–264 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.36 (s, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.82–7.74 (m, 1H), 7.54–7.48 (m, 1H), 7.41 (d, J = 7.6 Hz, 2H), 7.36–7.22 (m, 6H), 7.19 (d, J = 7.8 Hz, 1H), 7.07–7.01 (m, 1H), 2.74 (s, 3H), 1.94 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.6, 154.5, 146.7, 144.0, 138.4, 136.0, 134.5, 130.8, 130.0, 129.7, 129.1, 128.6, 128.6, 128.5, 126.8, 125.4, 125.3, 124.7, 123.8, 119.6, 23.1, 19.5; IR (KBr): v 3238, 3186, 3062, 2922, 2851, 1657, 1600, 1553, 1443, 1321, 754; HRMS (ESI): m/z calcd for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648,found 353.1647.



4-(2-Methoxyphenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (4m)

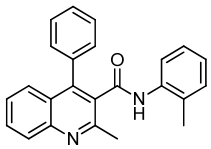
White solid (2.8 g, 76%); mp 250–251 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.28 (s, 1H), 8.04 (d, J = 8.3 Hz, 1H), 7.79–7.72 (m, 1H), 7.51–7.39 (m, 4H), 7.33–7.23 (m, 4H), 7.14 (d, J = 8.2 Hz, 1H), 7.07–7.00 (m, 2H), 3.62 (s, 3H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.1, 157.1, 155.0, 147.1, 142.6, 139.0, 131.9, 131.0, 130.7,

130.3, 129.1, 128.9, 126.9, 126.5, 125.7, 124.2, 124.0, 120.6, 120.1, 111.9, 56.0, 23.6; IR (KBr, cm^{-1}): *v* 3271, 3136, 3071, 2954, 1646, 1602, 1553, 1487, 1443, 1248, 758; HRMS (ESI): *m/z* calcd for $C_{24}H_{21}N_2O_2$ $[M+H]^+$ 369.1598, found 369.1592.



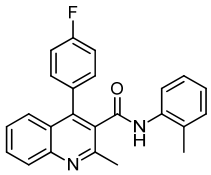
6-Chloro-2-methyl-*N*,4-diphenylquinoline-3-carboxamide (4n)[3,4]

White solid (2.5 g, 70%); mp 213–214 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.42 (s, 1H), 8.10 (d, J = 9.0 Hz, 1H), 7.83 (dd, J = 9.0, 2.3 Hz, 1H), 7.56–7.36 (m, 8H), 7.29–7.22 (m, 2H), 7.02–7.08 (m, 1H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.2, 155.3, 145.3, 143.5, 138.2, 134.1, 131.5, 131.1, 130.8, 130.5, 129.3, 128.7, 128.7, 128.3, 125.8, 124.4, 124.0, 119.7, 23.1; IR (KBr, cm^{-1}): *v* 3360, 3184, 2920, 1658, 1601, 1560, 1485, 1444, 829, 758, 692; HRMS (ESI): *m/z* calcd for $C_{23}H_{18}ClN_2O$ $[M+H]^+$ 373.1102, found 373.1102.



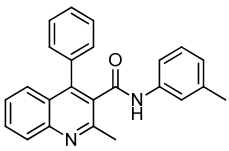
2-Methyl-4-phenyl-*N*-*o*-tolylquinoline-3-carboxamide (4o)

White solid (2.9 g, 82%); mp 236–237 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.83 (s, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.83–7.76 (m, 1H), 7.60–7.44 (m, 7H), 7.17–7.03 (m, 3H), 6.99 (d, J = 7.7 Hz, 1H), 2.81 (s, 3H), 1.90 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.9, 154.6, 146.8, 144.0, 135.4, 135.0, 132.5, 130.9, 130.2, 129.8, 129.6, 128.5, 128.4, 128.1, 126.6, 125.8, 125.8, 125.7, 125.3, 124.9, 23.1, 17.4; IR (KBr, cm^{-1}): *v* 3230, 3059, 2924, 2853, 1646, 1580, 1524, 1455, 1307, 1257, 751, 701; HRMS (ESI): *m/z* calcd for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648, found 353.1647.



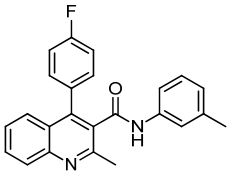
4-(4-Fluorophenyl)-2-methyl-*N*-*o*-tolylquinoline-3-carboxamide (4o')

White solid (3.2 g, 86%); mp 211–212 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.87 (s, 1H), 8.08 (d, J = 8.3 Hz, 1H), 7.85–7.77 (m, 1H), 7.60–7.45 (m, 4H), 7.44–7.36 (m, 2H), 7.19–7.01 (m, 4H), 2.80 (s, 3H), 1.92 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.9, 162.2 (d, $J_{C\text{-}F}$ = 245.4 Hz), 154.5, 146.7, 143.1, 135.4, 132.5, 131.9 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.3 (d, $J_{C\text{-}F}$ = 3.4 Hz), 131.1, 130.3, 129.9, 128.5, 126.7, 125.9, 125.8, 125.7, 125.3, 125.0, 115.2 (d, $J_{C\text{-}F}$ = 21.5 Hz), 23.1, 17.4; IR (KBr, cm^{-1}): *v* 3222, 3063, 2924, 2853, 1645, 1514, 1492, 1226, 761; HRMS (ESI): *m/z* calcd for $C_{24}H_{20}FN_2O$ $[M+H]^+$, 371.1554 found 371.1554.



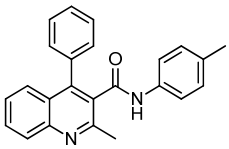
2-Methyl-4-phenyl-*N*-*m*-tolylquinoline-3-carboxamide (4p)

White solid (2.7 g, 77%); mp 212–213 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.31 (s, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.83–7.75 (m, 1H), 7.58–7.40 (m, 7H), 7.29 (s, 1H), 7.25–7.04 (m, 2H), 6.86 (d, J = 7.3 Hz, 1H), 2.72 (s, 3H), 2.23 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.6, 154.4, 146.8, 144.2, 138.4, 137.8, 134.9, 130.8, 129.9, 129.3, 128.5, 128.4, 128.3, 128.1, 126.6, 125.8, 124.9, 124.5, 120.0, 116.8, 23.0, 21.1; IR (KBr, cm^{-1}): v 3357, 3058, 2919, 2849, 1653, 1613, 1563, 1488, 1318, 758, 692; HRMS (ESI): *m/z* calcd for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648, found 353.1644.



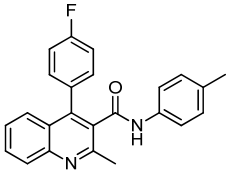
4-(4-Fluorophenyl)-2-methyl-*N*-*m*-tolylquinoline-3-carboxamide (4p')

White solid (2.8 g, 76%); mp 184–185 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.32 (s, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.83–7.74 (m, 1H), 7.59–7.45 (m, 4H), 7.38–7.27 (m, 3H), 7.22–7.11 (m, 2H), 6.87 (d, J = 7.4 Hz, 1H), 2.72 (s, 3H), 2.24 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.6, 162.0 (d, $J_{C\text{-}F}$ = 245.3 Hz), 154.4, 146.8, 143.2, 138.3, 137.9, 131.6 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.2 (d, $J_{C\text{-}F}$ = 3.4 Hz), 131.0, 130.0, 128.6, 128.5, 126.7, 125.7, 124.9, 124.6, 120.0, 116.7, 115.2 (d, $J_{C\text{-}F}$ = 21.6 Hz), 23.0, 21.1; IR (KBr, cm^{-1}): v 3249, 3063, 2923, 2854, 1650, 1610, 1549, 1490, 1228, 765; HRMS (ESI): *m/z* calcd for $C_{24}H_{20}FN_2O$ $[M+H]^+$ 371.1554, found 371.1555.



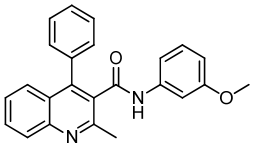
2-Methyl-4-phenyl-*N*-*p*-tolylquinoline-3-carboxamide (4q)[4]

Yellow solid (3.2 g, 91%); mp 264–265 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.36 (s, 1H), 8.13 (d, J = 8.4 Hz, 1H), 7.87–7.80 (m, 1H), 7.61–7.38 (m, 7H), 7.29 (d, J = 8.3 Hz, 2H), 7.05 (d, J = 8.1 Hz, 2H), 2.76 (s, 3H), 2.22 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.0, 154.5, 135.8, 134.7, 132.9, 131.0, 130.4, 129.3, 129.0, 128.5, 128.1, 127.6, 127.0, 126.0, 125.0, 119.7, 22.6, 20.4; IR (KBr, cm^{-1}): v 3181, 3032, 2922, 2852, 1650, 1602, 1534, 1514, 1407, 1319, 1253, 764, 701; HRMS (ESI): *m/z* calcd for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648, found 353.1648.



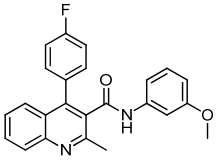
4-(4-Fluorophenyl)-2-methyl-*N*-*p*-tolylquinoline-3-carboxamide (4q')

Yellow solid (2.9 g, 78%); mp 233–234 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.31 (s, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.83–7.78 (m, 1H), 7.59–7.52 (m, 1H), 7.50–7.44 (m, 3H), 7.38–7.27 (m, 4H), 7.07 (d, J = 8.2 Hz, 2H), 2.72 (s, 3H), 2.22 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.3, 162.0 (d, $J_{C\text{-}F}$ = 245.0 Hz), 154.5, 146.6, 143.3, 135.8, 133.0, 131.6 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.2 (d, $J_{C\text{-}F}$ = 3.4 Hz), 131.1, 130.1, 129.0, 128.4, 126.8, 125.7, 124.9, 119.6, 115.2 (d, $J_{C\text{-}F}$ = 21.5 Hz), 23.0, 20.4; IR (KBr, cm^{-1}): v 3239, 3119, 2924, 2853, 1650, 1603, 1514, 1407, 1318, 1227, 817, 764; HRMS (ESI): m/z calcd for $C_{24}H_{20}FN_2O$ $[M+H]^+$, 371.1554 found 371.1554.



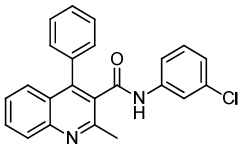
_N_-(3-methoxyphenyl)-2-methyl-4-phenylquinoline-3-carboxamide (4r) [4]

White solid (2.9 g, 79%); mp 200–201 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.36 (s, 1H), 8.07 (d, J = 8.4 Hz, 1H), 7.84–7.76 (m, 1H), 7.59–7.39 (m, 7H), 7.19–7.12 (m, 1H), 7.09 (s, 1H), 6.97 (d, J = 7.9 Hz, 1H), 6.63 (d, J = 7.9 Hz, 1H), 3.69 (s, 3H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.7, 159.4, 154.4, 146.8, 144.2, 139.5, 134.8, 130.8, 130.0, 129.4, 129.3, 128.5, 128.4, 128.1, 126.7, 125.9, 124.9, 111.9, 109.1, 105.5, 54.9, 23.1; IR (KBr, cm^{-1}): v 3254, 3060, 2926, 1651, 1607, 1544, 1489, 1454, 1427, 1241, 766, 701; HRMS (ESI): m/z calcd for $C_{24}H_{21}N_2O_2$ $[M+H]^+$ 369.1598, found 369.1597.



4-(4-Fluorophenyl)-_N_-(3-methoxyphenyl)-2-methylquinoline-3-carboxamide (4r')

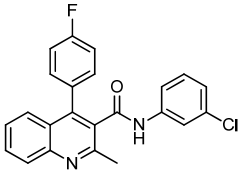
White solid (2.8 g, 73%); mp 170–171 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.37 (s, 1H), 8.07 (d, J = 8.3 Hz, 1H), 7.84–7.78 (m, 1H), 7.60–7.52 (m, 1H), 7.50–7.44 (m, 3H), 7.38–7.30 (m, 2H), 7.20–7.13 (m, 1H), 7.11–7.07 (m, 1H), 6.97 (d, J = 9.0 Hz, 1H), 6.65 (dd, J = 8.1, 2.1 Hz, 1H), 3.69 (s, 3H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.6, 162.0 (d, $J_{C\text{-}F}$ = 245.1 Hz), 159.4, 154.4, 146.8, 143.2, 139.4, 131.5 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.1 (d, $J_{C\text{-}F}$ = 3.3 Hz), 131.0, 130.0, 129.5, 128.5, 126.8, 125.7, 124.8, 115.2 (d, $J_{C\text{-}F}$ = 21.5 Hz), 111.8, 109.1, 105.5, 54.9, 23.0; IR (KBr, cm^{-1}) v 3250, 3064, 2925, 2853, 1650, 1606, 1492, 1230, 765; HRMS (ESI): m/z calcd for $C_{24}H_{20}FN_2O_2$ $[M+H]^+$ 387.1503, found 387.1505.



_N_-(3-Chlorophenyl)-2-methyl-4-phenylquinoline-3-carboxamide (4s) [4]

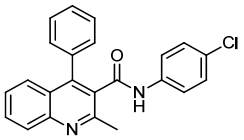
White solid (3.3 g, 88%); mp 215–216 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.59 (s, 1H), 8.08 (d, J = 8.3 Hz, 1H), 7.85–7.77 (m, 1H), 7.61 (s, 1H), 7.58–7.52 (m, 1H), 7.52–7.40 (m, 6H), 7.29 (d, J = 5.1 Hz, 2H), 7.13–7.07 (m, 1H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.0, 154.3, 146.9, 144.5, 139.8, 134.7, 133.0, 130.4,

130.4, 130.2, 129.2, 128.5, 128.4, 128.1, 126.8, 125.9, 124.8, 123.6, 118.8, 117.8, 23.0; IR (KBr, cm^{-1}): *v* 3271, 3055, 2921, 1657, 1593, 1543, 1480, 1424, 1316, 756; HRMS (ESI): *m/z* calcd for $C_{23}H_{18}ClN_2O$ $[M+H]^+$ 373.1102, found 373.1100.



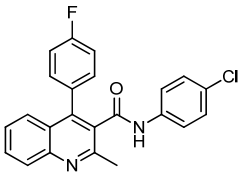
***N*-(3-Chlorophenyl)-4-(4-fluorophenyl)-2-methylquinoline-3-carboxamide (4s')**

White solid (3.1 g, 79%); mp 198–197 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.61 (s, 1H), 8.08 (d, J = 8.3 Hz, 1H), 7.85–7.78 (m, 1H), 7.65–7.61 (m, 1H), 7.60–7.53 (m, 1H); 7.51–7.43 (m, 3H), 7.39–7.27 (m, 4H), 7.16–7.08 (m, 1H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.9, 162.0 (d, $J_{C\text{-}F}$ = 245.0 Hz), 154.2, 146.9, 143.4, 139.7, 133.0, 131.5 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.0 (d, $J_{C\text{-}F}$ = 3.3 Hz), 130.6, 130.5, 130.2, 128.6, 126.9, 125.7, 124.8, 123.6, 118.8, 117.8, 115.2 (d, $J_{C\text{-}F}$ = 21.8 Hz), 23.0; IR (KBr, cm^{-1}): *v* 3237, 3176, 3062, 2924, 2853, 1655, 1594, 1538, 1514, 1482, 1424, 1231, 765; HRMS (ESI): *m/z* calcd for $C_{23}H_{17}ClFN_2O$ $[M+H]^+$ 391.1008, found 391.1009.



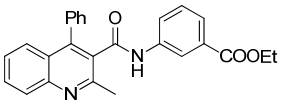
***N*-(4-Chlorophenyl)-2-methyl-4-phenylquinoline-3-carboxamide (4t)**[2-4]

White solid (3.4 g, 91%); mp 263–264 °C (lit.[2] 260–262 °C); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.52 (s, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.85–7.78 (m, 1H), 7.59–7.52 (t, J = 7.6 Hz, 1H), 7.52–7.40 (m, 8H), 7.32 (d, J = 8.8 Hz, 2H), 2.72 (s, 3H).



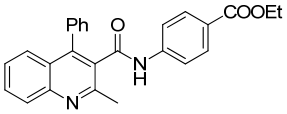
***N*-(4-Chlorophenyl)-4-(4-fluorophenyl)-2-methylquinoline-3-carboxamide (4t')**

Yellow solid (3.2 g, 82%); mp 240–241 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.57 (d, J = 4.1 Hz, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.85–7.77 (m, 1H), 7.60–7.53 (m, 1H), 7.51–7.41 (m, 5H), 7.37–7.27 (m, 4H), 2.73 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.7, 162.0 (d, $J_{C\text{-}F}$ = 245.4 Hz), 154.3, 146.8, 143.5, 137.2, 131.5 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.0 (d, $J_{C\text{-}F}$ = 3.3 Hz), 130.8, 130.2, 128.7, 128.5, 127.6, 126.9, 125.7, 124.8, 121.0, 115.2 (d, $J_{C\text{-}F}$ = 21.5 Hz), 23.0; IR (KBr, cm^{-1}): *v* 3236, 3176, 3110, 3045, 2925, 2853, 1652, 1598, 1514, 1492, 1400, 1231, 828, 764; HRMS (ESI): *m/z* calcd for $C_{23}H_{17}ClFN_2O$ $[M+H]^+$, 391.1008 found 391.1008.



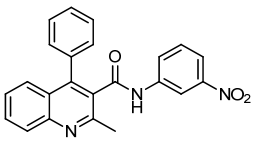
Ethyl 3-(2-methyl-4-phenylquinoline-3-carboxamido)benzoate (4u)

White solid (3.1 g, 76%); mp 131–132 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.60 (s, 1H), 8.12–8.06 (m, 2H), 7.84–7.78 (m, 1H), 7.67–7.62 (m, 2H), 7.58–7.52 (m, 1H), 7.50–7.39 (m, 7H), 4.30 (q, J = 7.1 Hz, 2H), 2.73 (s, 3H), 1.30 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.5, 165.9, 154.8, 147.4, 144.9, 139.2, 135.3, 131.0, 130.9, 130.6, 129.8, 129.7, 129.1, 128.9, 128.6, 127.2, 126.4, 125.3, 125.0, 124.4, 120.4, 61.3, 23.6, 14.6; IR (KBr, cm^{-1}): v 3290, 3063, 2983, 1720, 1656, 1544, 1487, 1290, 755; HRMS (ESI): m/z calcd for $C_{26}H_{23}N_2O_3$ $[M+H]^+$ 411.1703, found 411.1707.



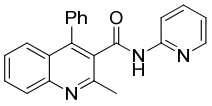
Ethyl 4-(2-methyl-4-phenylquinoline-3-carboxamido)benzoate (4v) [4]

White solid (3.1 g, 76%); mp 218–220 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.72 (s, 1H), 8.08 (d, J = 8.4 Hz, 1H), 7.88–7.78 (m, 3H), 7.59–7.53 (m, 3H), 7.50–7.40 (m, 6H), 4.27 (q, J = 7.1 Hz, 2H), 2.72 (s, 3H), 1.29 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.7, 165.7, 154.7, 147.4, 145.0, 143.2, 135.2, 130.9, 130.6, 129.8, 129.1, 128.9, 128.6, 127.3, 126.4, 125.3, 125.3, 119.2, 61.0, 23.6, 14.7; IR (KBr, cm-1): v 3297, 2982, 1715, 1687, 1596, 1526, 1408, 1277, 1174, 1107, 766, 700; HRMS (ESI): m/z calcd for $C_{26}H_{23}N_2O_3$ $[M+H]^+$ 411.1703, found 411.1708.



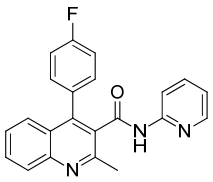
2-Methyl-*N*-(3-nitrophenyl)-4-phenylquinoline-3-carboxamide (4w)

Yellow solid (3.6 g, 94%); mp 230–231 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.91 (s, 1H), 8.48–8.44 (m, 1H), 8.09 (d, J = 8.4 Hz, 1H), 7.91 (dd, J = 8.2, 1.6 Hz, 1H), 7.85–7.79 (m, 1H), 7.73 (d, J = 8.1 Hz, 1H), 7.60–7.53 (m, 2H), 7.52–7.38 (m, 6H), 2.74 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.4, 147.9, 146.9, 144.7, 139.4, 134.6, 130.3, 130.2, 130.1, 129.2, 128.5, 128.5, 128.2, 126.9, 125.9, 125.3, 124.7, 118.4, 113.3, 23.1; IR (KBr, cm^{-1}): v 3258, 3060, 2924, 2853, 1658, 1530, 1485, 1429, 1350, 766, 736; HRMS (ESI): m/z calcd for $C_{23}H_{18}N_3O_3$ $[M+H]^+$ 384.1343, found 384.1345.



2-Methyl-4-phenyl-*N*-(pyridin-2-yl)quinoline-3-carboxamide (4x)[2]

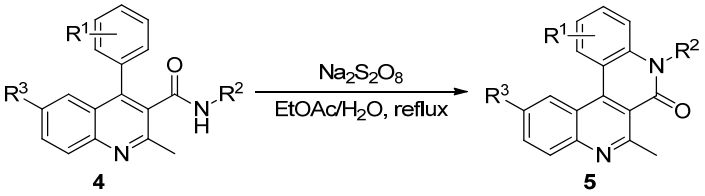
White solid (2.4 g, 71%); mp 272–273 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.92 (s, 1H), 8.28–8.23 (m, 1H), 8.06 (d, J = 8.4 Hz, 1H), 7.92 (d, J = 8.3 Hz, 1H), 7.82–7.69 (m, 2H), 7.55–7.52 (m,1H), 7.49–7.39 (m, 6H), 7.12–7.06 (m, 1H), 2.70 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 166.7, 154.2, 151.4, 148.0, 146.9, 144.2, 138.1, 134.9, 130.6, 129.9, 129.4, 128.5, 128.4, 128.1, 126.6, 125.9, 124.9, 119.9, 113.8, 23.1.



4-(4-Fluorophenyl)-2-methyl-*N*-(pyridin-2-yl)quinoline-3-carboxamide (4x')

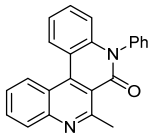
White solid (2.3 g, 64%); mp 240–241 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.93 (s, 1H), 8.30–8.24 (m, 1H), 8.06 (d, J = 8.4 Hz, 1H), 7.94 (d, J = 8.3 Hz, 1H), 7.83–7.71 (m, 2H), 7.56–7.44 (m, 4H), 7.35–7.25 (m, 2H), 7.13–7.07 (m, 1H), 2.70 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 167.1, 162.5(d, $J_{C\text{-}F}$ = 245.3 Hz), 154.7, 151.8, 148.5, 147.4, 143.7, 138.7, 132.1 (d, $J_{C\text{-}F}$ = 8.4 Hz), 131.7 (d, $J_{C\text{-}F}$ = 3.4 Hz), 131.2, 130.5, 129.1, 127.2, 126.3, 125.4, 120.5, 115.6 (d, $J_{C\text{-}F}$ = 21.6 Hz), 114.3, 23.6; IR (KBr, cm^{-1}): v 3177, 3018, 1682, 1599, 1528, 1434, 1307, 1227, 764; HRMS (ESI): *m/z* calcd for $C_{22}H_{17}FN_3O$ $[M+H]^+$ 358.1350, found 358.1346.

4. Preparation of Dibenzo[*c*,*f*][2,7]naphthyridinones 5



In a typical procedure, a mixture of substrate **4** (1 mmol), $Na_2S_2O_8$ (2 mmol), and EtOAc/H_2O (1:1, 30 mL) was added to a round bottom flask (100 mL). The mixture was vigorously stirred under reflux (oil bath temperature 90 ^{o}C) for 2–4 h (monitored by TLC). After completion of reaction, the mixture was cooled, and extracted with EtOAc (3×50 mL). The combined organic extracts were washed with brine, dried with anhydrous Na_2SO_4, and concentrated. The residue obtained was purified by column chromatography on silica gel (petroleum ether/EtOAc) to afford the product **5**

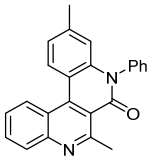
Note: The reaction was performed in CH_3CN/H_2O (1:1, 30 mL) for the preparation of products **5e**–**5g**, **5k** and **5u**–**5x**. $Na_2S_2O_8$ (6 mmol) was used for the preparation of product **5n.**



7-Methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5a)

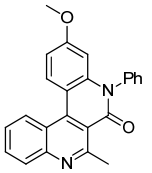
White solid (255 mg, 76%); mp 243–244 °C;^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, J = 8.5 Hz, 1H), 8.56 (d, J = 8.1 Hz, 1H), 8.18 (d, J = 7.8 Hz, 1H), 7.88–7.82 (m, 1H), 7.69–7.53 (m, 4H), 7.47–7.30 (m, 4H), 6.80 (d, J = 8.4 Hz, 1H), 3.22 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.3, 160.4, 148.6, 142.1, 140.9, 138.0, 131.0, 130.8, 130.3, 129.8, 129.3, 129.0, 128.9, 127.2, 126.3, 122.2, 121.8, 118.1, 117.6, 116.7,

28.06; IR (KBr, cm^{-1}): *v* 3060, 2921, 2850, 1657, 1601, 1554, 1492, 1453, 1397, 1309, 761, 699; HRMS (ESI): *m/z* calcd for $C_{23}H_{17}N_2O$ $[M+H]^+$ 337.1335, found 337.1334.



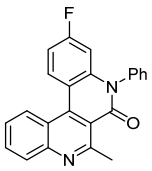
3,7-Dimethyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5b)

Yellow solid (272 mg, 78%); mp 268–270 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 8.70 (d, J = 8.4 Hz, 1H), 8.44 (d, J = 8.3 Hz, 1H), 8.16 (d, J = 8.3 Hz, 1H), 7.86–7.80 (m, 1H), 7.71–7.52 (m, 4H), 7.43–7.33 (m, 2H), 7.15 (d, J = 8.3 Hz, 1H), 6.57 (s, 1H), 3.21 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.4, 160.4, 148.6, 142.1, 141.7, 141.0, 138.0, 130.9, 130.3, 129.6, 129.2, 129.0, 128.8, 127.2, 126.1, 123.5, 121.8, 117.6, 116.7, 115.3, 28.0, 21.8; IR (KBr, cm^{-1}): *v* 3058, 2922, 2851, 1656, 1611, 1490, 1399, 775, 760; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O$ $[M+H]^+$ 351.1492, found 351.1490.



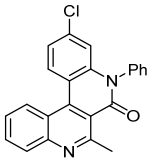
3-Methoxy-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5c)

White solid (121 mg, 33%); mp > 280 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 8.66 (d, J = 8.4 Hz, 1H), 8.48 (d, J = 9.1 Hz, 1H), 8.14 (d, J = 7.9 Hz, 1H), 7.87–7.78 (m, 1H), 7.69–7.51 (m, 4H), 7.40–7.34 (m, 2H), 6.91 (dd, J = 9.1, 2.5 Hz, 1H), 6.22 (d, J = 2.5 Hz, 1H), 3.73 (s, 3H), 3.19 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.6, 161.5, 160.5, 148.6, 142.9, 142.3, 138.0, 131.4, 130.9, 130.3, 129.2, 128.9, 128.9, 127.2, 126.0, 121.8, 116.7, 111.4, 109.4, 101.0, 55.3, 28.0; IR (KBr, cm^{-1}): *v* 3044, 2919, 2849, 1656, 1607, 1488, 1398, 1311, 1226, 762, 748; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1443.



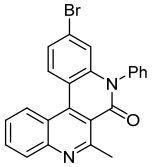
3-Fluoro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5d)

Pale yellow solid (197 mg, 56%); mp > 280 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 8.64 (d, J = 8.5 Hz, 1H), 8.60–8.52 (m, 1H), 8.18 (d, J = 8.3 Hz, 1H), 7.90–7.82 (m, 1H), 7.71–7.54 (m, 4H), 7.41–7.34 (m, 2H), 7.10–7.02 (m, 1H), 6.48 (dd, J = 10.6, 2.5 Hz, 1H), 3.21 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.7 (d, $J_{C\text{-}F}$ = 252.1 Hz), 161.2, 160.3, 148.6, 142.8 (d, $J_{C\text{-}F}$ = 11.0 Hz), 137.5, 132.0 (d, $J_{C\text{-}F}$ = 10.0 Hz), 131.1, 130.5, 129.3, 129.2, 128.7, 126.8, 126.4, 126.4, 121.5, 117.3, 114.1, 110.1 (d, $J_{C\text{-}F}$ = 22.9 Hz), 103.5 (d, $J_{C\text{-}F}$ = 27.0 Hz), 28.0; IR (KBr, cm^{-1}): *v* 3045, 2928, 1659, 1617, 1551, 1490, 1377, 1187, 839, 745; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}FN_2O$ $[M+H]^+$ 355.1241, found 355.1238.



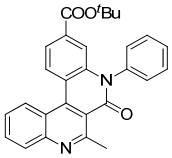
3-Chloro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5e)

Pale yellow solid (178 mg, 48%); mp > 280 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.64 (d, J = 8.5 Hz, 1H), 8.49 (d, J = 8.7 Hz, 1H), 8.18 (d, J = 8.3 Hz, 1H), 7.87 (t, J = 7.5 Hz, 1H), 7.74–7.54 (m, 4H), 7.37 (d, J = 7.4 Hz, 2H), 7.30 (d, J = 8.7 Hz, 1H), 6.78 (d, J = 1.8 Hz, 1H), 3.21 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 160.3, 148.7, 141.8, 141.4, 137.3, 137.0, 131.2, 131.0, 130.5, 129.4, 129.3, 128.8, 126.8, 126.5, 122.5, 121.6, 116.3, 116.1, 117.8, 28.0; IR (KBr, cm^{-1}): ν 3043, 2920, 2849, 1664, 1594, 1488, 1427, 1378, 771, 724; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O$ $[M+H]^+$ 371.0946, found 371.0950.



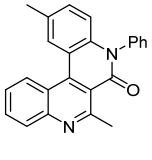
3-Bromo-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5f)

Pale yellow solid (200 mg, 48%); mp 264–265 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.63 (d, J = 8.4 Hz, 1H), 8.41 (d, J = 8.7 Hz, 1H), 8.18 (d, J = 8.1 Hz, 1H), 7.92–7.83 (m, 1H), 7.73–7.53 (m, 4H), 7.44 (dd, J = 8.7, 1.9 Hz, 1H), 7.39–7.34 (m, 2H), 6.93 (d, J = 1.9 Hz, 1H), 3.20 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 160.3, 148.7, 141.8, 141.4, 137.3, 131.2, 131.0, 130.5, 129.4, 129.3, 128.8, 126.7, 126.5, 125.4, 125.3, 121.5, 119.3, 117.9, 116.4, 28.0; IR (KBr, cm^{-1}): ν 3044, 2920, 2850, 1666, 1589, 1489, 1423, 1378, 734, 715; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}BrN_2O$ $[M+H]^+$ 415.0441, found 415.0441.



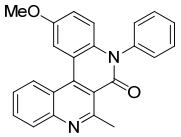
***tert*-Butyl 7-methyl-6-oxo-5-phenyl-5,6-dihydrodibenzo[*c*,*f*][2,7]naphthyridine-3-carboxylate (5g)**

White solid (183 mg, 42%); mp 206–207 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, J = 8.5 Hz, 1H), 8.59 (d, J = 8.5 Hz, 1H), 8.21–8.17 (m, 1H), 7.93–7.85 (m, 2H), 7.70–7.64 (m, 3H), 7.61–7.55 (m, 1H), 7.47–7.34 (m, 3H), 3.23 (s, 3H), 1.54 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.5, 161.2, 160.4, 148.7, 141.2, 140.8, 137.5, 133.7, 131.3, 130.5, 129.8, 129.5, 129.2, 129.0, 127.0, 126.7, 122.4, 121.8, 120.5, 118.7, 117.7, 81.9, 77.3, 28.0; IR (KBr, cm^{-1}): ν 3059, 3010, 2977, 2931, 1714, 1665, 1310, 1166, 763; HRMS (ESI): *m/z* calcd for $C_{28}H_{25}N_2O_3$ $[M+H]^+$ 437.1860, found 437.1865.



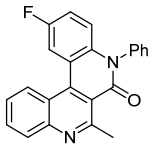
2,7-Dimethyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5h)

Yellow solid (214 mg, 61%); mp 160–172 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (d, J = 8.5 Hz, 1H), 8.36 (s, 1H), 8.17 (d, J = 7.8 Hz, 1H), 7.90–7.82 (m, 1H), 7.70–7.52 (m, 4H), 7.39–7.34 (m, 2H), 7.26–7.22 (m, 1H), 6.69 (d, J = 8.6 Hz, 1H), 3.22 (s, 3H), 2.49 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 160.5, 148.6, 142.0, 138.9, 138.0, 131.9, 131.7, 130.9, 130.2, 129.6, 129.2, 129.0, 128.8, 127.2, 126.2, 121.9, 118.1, 117.5, 116.6, 28.0, 21.0; IR (KBr): v 2922, 2851, 1659, 1556, 1494, 760, 750; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O$ $[M+H]^+$ 351.1492, found 351.1493.



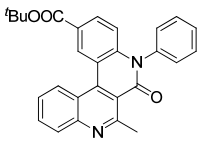
2-Methoxy-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5i)

Yellow solid (256 mg, 70%); mp 179–180 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.77 (d, J = 8.6 Hz, 1H), 8.20–8.14 (m, 1H), 8.08–8.04 (m, 1H), 7.88–7.80 (m, 1H), 7.67–7.61 (m, 3H), 7.58–7.52 (m, 1H), 7.40–7.35 (m, 2H), 7.08–7.02 (m, 1H), 6.73 (d, J = 9.2 Hz, 1H), 3.89 (s, 3H), 3.22 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.6, 160.5, 154.8, 148.6, 141.6, 138.1, 135.4, 131.0, 130.3, 129.4, 129.1, 128.9, 126.8, 126.3, 122.0, 118.5, 118.3, 118.0, 113.3, 55.9, 28.1; IR (KBr, cm^{-1}): v 3060, 3004, 2928, 1656, 1555, 1494, 1307, 759; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1440.



2-Fluoro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5j)

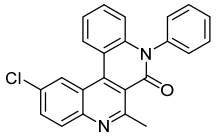
Pale yellow solid (176 mg, 50%); mp 223–224 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, J = 8.5 Hz, 1H), 8.29 (dd, J = 10.1, 2.6 Hz, 1H), 8.19 (d, J = 8.3 Hz, 1H), 7.91–7.85 (m, 1H), 7.73–7.54 (m, 4H), 7.37 (d, J = 7.3 Hz, 2H), 7.22–7.12 (m, 1H), 6.78 (dd, J = 9.3, 5.0 Hz, 1H), 3.22 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.9, 160.4, 157.9 (d, $J_{C\text{-}F}$ = 242.0 Hz), 148.6, 140.9 (d, $J_{C\text{-}F}$ = 2.8 Hz), 137.8, 137.4, 131.2, 130.4, 129.5, 129.1, 128.9, 126.7, 126.4, 121.6, 118.5, 118.5, 118.4, 118.3, 118.2, 115.3 (d, $J_{C\text{-}F}$ = 25.0 Hz), 28.0; IR (KBr, cm^{-1}): v 3061, 2923, 2851, 1660, 1556, 1493, 1397, 1296, 774, 760, 697; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}FN_2O$ $[M+H]^+$ 355.1241, found 355.1237.



***tert*-Butyl 7-methyl-6-oxo-5-phenyl-5,6-dihydrodibenzo[*c*,*f*][2,7]naphthyridine-2-carboxylate (5k)**

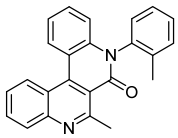
White solid (188 mg, 43%); mp 222–223 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.28 (s, 1H), 8.75 (d, J = 8.5 Hz, 1H), 8.20 (d, J = 8.3 Hz, 1H), 8.04–8.00 (m, 1H), 7.92–7.86 (m, 1H), 7.74–7.57 (m, 4H), 7.39–7.35 (m, 2H), 6.81 (d, J = 8.8 Hz, 1H), 3.22 (s, 3H),

1.63 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 164.8, 161.4, 160.2, 148.8, 143.6, 141.8, 137.7, 131.8, 131.4, 130.5, 129.5, 129.3, 128.9, 127.0, 126.8, 125.9, 121.7, 118.1, 117.1, 116.5, 81.6, 77.2, 28.3; IR (KBr, cm^{-1}): *v* 3062, 3010, 2974, 2931, 1711, 1669, 1611, 1494, 1278, 1161, 1125, 759; HRMS (ESI): *m/z* calcd for $C_{28}H_{25}N_2O_3$ $[M+H]^+$ 437.1860, found 437.1865.



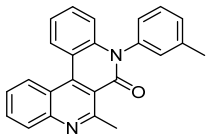
11-Chloro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5n)

Yellow solid (253 mg, 68%); mp > 280 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (d, *J* = 1.9 Hz, 1H), 8.50 (d, *J* = 8.0 Hz, 1H), 8.11 (d, *J* = 8.9 Hz, 1H), 7.79 (dd, *J* = 8.9, 2.2 Hz, 1H), 7.70–7.54 (m, 3H), 7.49–7.43 (m, 1H), 7.41–7.34 (m, 3H), 6.80 (dd, *J* = 8.4, 0.9 Hz, 1H), 3.20 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.0, 160.8, 147.0, 141.1, 141.0, 137.8, 132.3, 131.6, 131.1, 130.9, 130.4, 129.3, 129.0, 128.9, 126.2, 122.6, 122.6, 118.7, 117.2, 116.8, 28.0; IR (KBr, cm^{-1}): *v* 3064, 2925, 2852, 1600, 1599, 1553, 1482, 1454, 1384, 1307, 762, 706; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O$ $[M+H]^+$ 371.0946, found 371.0943.



7-Methyl-5-(*o*-tolyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5o)

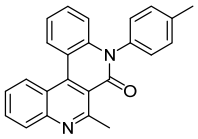
Pale yellow solid (244 mg, 70%); mp 225–226 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 (d, *J* = 8.5 Hz, 1H), 8.60 (d, *J* = 8.0 Hz, 1H), 8.19 (d, *J* = 7.8 Hz, 1H), 7.90–7.83 (m, 1H), 7.70–7.63 (m, 1H), 7.52–7.42 (m, 4H), 7.37–7.31 (m, 1H), 7.29–7.23 (m, 1H), 6.72 (dd, *J* = 8.4, 0.7 Hz, 1H), 3.23 (s, 3H), 2.09 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.6, 160.5, 148.6, 142.0, 140.2, 136.7, 136.3, 131.7, 131.1, 131.0, 129.9, 129.3, 129.2, 128.8, 127.9, 127.2, 126.2, 122.2, 121.8, 118.1, 117.5, 116.0, 28.0, 17.5; IR (KBr, cm^{-1}): *v* 3061, 2924, 2852, 1658, 1601, 1557, 1191, 1454, 1398, 1308, 753; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O$ $[M+H]^+$ 351.1492, found 351.1490.



7-Methyl-5-(*m*-tolyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5p)

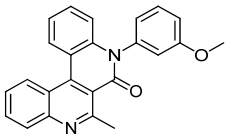
Pale yellow solid (258 mg, 74%); mp 217–218 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, *J* = 8.5 Hz, 1H), 8.56 (d, *J* = 8.0 Hz, 1H), 8.18 (d, *J* = 8.4 Hz, 1H), 7.90–7.81 (m, 1H), 7.70–7.61 (m, 1H), 7.53 (t, *J* = 7.7 Hz, 1H), 7.47–7.41 (m, 1H), 7.40–7.30 (m, 2H), 7.20–7.15 (m, 2H), 6.82 (dd, *J* = 8.4, 0.9 Hz, 1H), 3.23 (s, 3H), 2.47 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 160.4, 148.6, 142.0, 141.0, 140.4, 137.8, 130.9, 130.7, 130.1, 129.8, 129.7, 129.4, 129.3, 127.2, 126.2, 125.8, 122.1, 121.8, 118.1, 117.5, 116.7, 28.1, 21.4; IR (KBr, cm^{-1}): *v* 3057, 2923, 2852, 1659, 1601, 1560, 1490, 1454, 1398, 1308, 759; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O$ $[M+H]^+$ 351.1492,

found 351.1491.



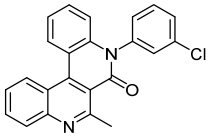
7-Methyl-5-(*p*-tolyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5q)

Pale yellow solid (178 mg, 51%); mp 252–253 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, J = 8.4 Hz, 1H), 8.56 (d, J = 8.1 Hz, 1H), 8.17 (d, J = 8.4 Hz, 1H), 7.90–7.80 (m, 1H), 7.69–7.62 (m, 1H), 7.44–7.40 (m, 3H), 7.35–7.30 (m, 1H), 7.25 (d, J = 8.1 Hz, 2H), 6.85 (dd, J = 8.4, 0.7 Hz, 1H), 3.22 (s, 3H), 2.49 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.3, 160.4, 148.6, 142.0, 141.1, 138.9, 135.2, 130.9, 130.7, 129.7, 129.2, 128.6, 127.2, 126.2, 122.0, 121.8, 118.1, 117.5, 116.7, 28.0, 21.3; IR (KBr, cm^{-1}): v 3024, 2923, 2852, 1658, 1602, 1555, 1509, 1452, 1398, 1308, 763; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O$ $[M+H]^+$ 351.1492, found 351.1492.



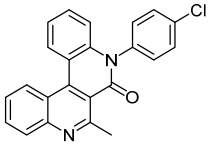
7-Methyl-5-(3-nitrophenyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5r)

Pale yellow solid (227 mg, 62%); mp 224–225 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, J = 8.5 Hz, 1H), 8.56 (d, J = 8.1 Hz, 1H), 8.18 (d, J = 8.3 Hz, 1H), 7.89–7.82 (m, 1H), 7.68–7.62 (m, 1H), 7.48–7.41 (m, 1H), 7.48–7.42 (m, 1H), 7.36–7.30 (m, 1H), 7.14–7.08 (m, 1H), 6.99–4.94 (m, 1H), 6.90 (t, J = 2.1 Hz, 1H), 6.85 (dd, J = 8.4, 0.8 Hz, 1H), 3.86 (s, 3H), 3.23 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 161.1, 160.4, 148.6, 142.0, 140.8, 139.0, 131.0, 131.0, 130.8, 129.7, 129.3, 127.2, 126.2, 122.1, 121.8, 121.0, 118.0, 117.5, 116.7, 114.9, 114.4, 55.4, 28.0; IR (KBr, cm^{-1}): v 3061, 2921, 2850, 1658, 1601, 1490, 1453, 761; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1439.

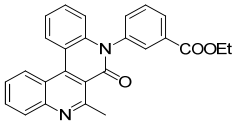


5-(3-Chlorophenyl)-7-methyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5s)

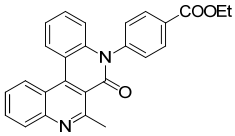
Yellow solid (218 mg, 59%); mp 256–257 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (d, J = 8.5 Hz, 1H), 8.57 (d, J = 8.2 Hz, 1H), 8.18 (d, J = 8.4 Hz, 1H), 7.91–7.81 (m, 1H), 7.69–7.53 (m, 3H), 7.50–7.28 (m, 4H), 6.79 (d, J = 8.4 Hz, 1H), 3.21 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 160.2, 148.7, 142.1, 140.5, 139.0, 135.8, 131.2, 131.1, 130.9, 129.9, 129.5, 129.4, 129.3, 127.5, 127.2, 126.4, 122.4, 121.8, 117.9, 117.6, 116.4, 28.0; IR (KBr, cm^{-1}): v 3046, 2919, 2850, 1658, 1550, 1489, 1455, 751; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O$ $[M+H]^+$ 371.0946, found 371.0945.



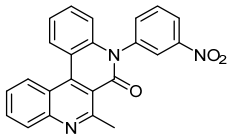
5-(4-Chlorophenyl)-7-methyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5t)
White solid (247 mg, 67%); mp 218–219 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (d, J = 8.5 Hz, 1H), 8.57 (d, J = 8.1 Hz, 1H), 8.18 (d, J = 8.3 Hz, 1H), 7.90–7.82 (m, 1H), 7.71–7.59 (m, 3H), 7.50–7.41 (m, 1H), 7.38–7.30 (m, 3H), 6.80 (d, J = 8.4 Hz, 1H), 3.21 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 160.2, 148.7, 142.1, 140.6, 136.4, 134.9, 131.1, 130.9, 130.6, 130.5, 129.9, 129.3, 127.1, 126.3, 122.4, 121.7, 117.9, 117.7, 116.4, 28.0; IR (KBr, cm^{-1}): v 3046, 2923, 2851, 1658, 1601, 1561, 1491, 1307, 760; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O$ $[M+H]^+$ 371.0946, found 371.0948.



Ethyl 3-(7-methyl-6-oxodibenzo[*c*,*f*][2,7]naphthyridin-5(6*H*)-yl)benzoate (5u)
White yellow solid (174 mg, 43%); mp 169–170 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, J = 8.5 Hz, 1H), 8.58 (d, J = 8.1 Hz, 1H), 8.27 (d, J = 7.8 Hz, 1H), 8.18 (d, J = 8.3 Hz, 1H), 8.08 (s, 1H), 7.90–7.84 (m, 1H), 7.78–7.72 (m, 1H), 7.69–7.59 (m, 2H), 7.48–7.42 (m, 1H), 7.38–7.32 (m, 1H), 6.75 (d, J = 8.4 Hz, 1H), 4.40 (q, J = 7.1 Hz, 2H), 3.21 (s, 3H), 1.38 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.5, 161.3, 160.3, 148.7, 142.2, 140.7, 138.2, 133.7, 133.0, 131.2, 131.0, 130.5, 130.3, 130.2, 130.0, 129.4, 127.2, 126.4, 122.5, 121.8, 118.0, 117.7, 116.5, 61.4, 28.1, 14.3; IR (KBr, cm^{-1}): v 3062, 2980, 1719, 1661, 1602, 1560, 1292, 1264, 756; HRMS (ESI): *m/z* calcd for $C_{26}H_{21}N_2O_3$ $[M+H]^+$ 409.1547, found 409.1549.

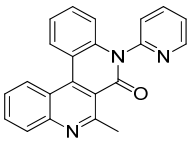


Ethyl 4-(7-methyl-6-oxodibenzo[*c*,*f*][2,7]naphthyridin-5(6*H*)-yl)benzoate (5v)
Pale yellow solid (208 mg, 51%); mp 207–209 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, J = 8.5 Hz, 1H), 8.57 (d, J = 8.0 Hz, 1H), 8.34 (d, J = 8.2 Hz, 2H), 8.18 (d, J = 8.3 Hz, 1H), 7.90–7.83 (m, 1H), 7.69–7.63 (m, 1H), 7.50–7.42 (m, 3H), 7.39–7.31 (m, 1H), 6.75 (d, J = 8.5 Hz, 1H), 4.46 (q, J = 7.1 Hz, 2H), 3.21 (s, 3H), 1.44 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.8, 161.0, 160.3, 148.8, 142.2, 142.1, 140.5, 131.7, 131.2, 131.1, 131.0, 130.0, 129.4, 129.3, 127.2, 126.4, 122.5, 121.8, 117.9, 117.7, 116.4, 77.2, 61.4, 28.0, 14.4; IR (KBr, cm^{-1}): v 3160, 2981, 1717, 1660, 1603, 1560, 1274, 1104, 762; HRMS (ESI): *m/z* calcd for $C_{26}H_{21}N_2O_3$ $[M+H]^+$ 409.1547, found 409.1541.



7-Methyl-5-(3-nitrophenyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5w)
Pale yellow solid (132 mg, 35%); mp > 280 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, J = 8.5 Hz, 1H), 8.60 (d, J = 8.0 Hz, 1H), 7.47–7.43 (m, 1H), 8.32 (t, J = 2.0 Hz, 1H), 8.19 (d, J = 8.4 Hz, 1H), 7.93–7.83 (m, 2H), 7.81–7.77 (m, 1H), 7.72–7.65 (m, 1H), 7.52–7.45 (m, 1H), 7.43–7.36 (m, 1H), 6.73 (dd, J = 8.4, 0.8 Hz, 1H), 3.20 (s,

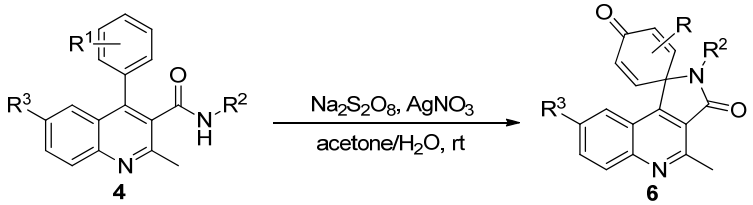
3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.1, 160.1, 149.6, 148.8, 142.2, 140.1, 139.1, 135.8, 131.4, 131.1, 131.1, 130.2, 129.4, 127.1, 126.5, 124.9, 123.9, 122.8, 121.7, 117.9, 117.7, 116.0, 27.9; IR (KBr, cm^{-1}): *v* 3033, 2920, 2850, 1659, 1527, 1351, 750; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}N_3O_3$ $[M+H]^+$ 382.1186, found 382.1181.



7-Methyl-5-(pyridin-2-yl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (5x)

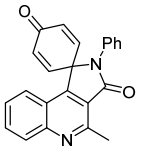
Yellow solid (107 mg, 32%); mp 230–231 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.86–8.80 (m, 1H), 8.70 (d, *J* = 8.5 Hz, 1H), 8.55 (d, *J* = 8.1 Hz, 1H), 8.17 (d, *J* = 8.3 Hz, 1H), 8.08–8.02 (m, 1H), 7.88–7.83 (m, 1H), 7.68–7.62 (m, 1H), 7.57–7.50 (m, 2H), 7.47–7.41 (m, 1H), 7.37–7.31 (m, 1H), 6.63 (d, *J* = 8.4 Hz, 1H), 3.22 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.4, 160.3, 151.6, 150.8, 148.8, 142.5, 140.0, 139.4, 131.2, 131.0, 130.0, 129.3, 127.3, 126.4, 124.8, 124.3, 122.6, 121.9, 118.0, 117.8, 116.1, 28.0; IR (KBr, cm^{-1}): *v* 3059, 3006, 2850, 1659, 1602, 1562, 1433, 1310, 761; HRMS (ESI): *m/z* calcd for $C_{22}H_{16}N_3O$ $[M+H]^+$ 338.1288, found 338.1290.

5. Preparation of Spirocyclohexadienones 6



In a typical procedure, a mixture of substrate **4** (1 mmol), $AgNO_3$ (0.2 mmol), $Na_2S_2O_8$ (3 mmol), and CH_3COCH_3/H_2O (1:1, 120 mL) was added to a round bottom flask (250 mL). The mixture was vigorously stirred at room temperature under air atmosphere for 5–24 h (monitored by TLC). After completion of reaction, the mixture was extracted with EtOAc (3×50 mL). The combined organic extracts were washed with brine, dried with anhydrous Na_2SO_4, and concentrated. The residue obtained was purified by column chromatography on silica gel (petroleum ether/EtOAc) to afford the product **6.**

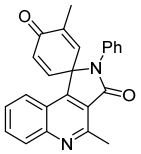
Note: $AgNO_3$ (0.5 mmol) and $Na_2S_2O_8$ (6 mmol) were used for the preparation of products **6h**, **6m–6p**. CH_3COCH_3/H_2O (1:1, 10 mL) was used for the preparation of **6o** and **6p**. The corresponding fluorinated substrate **4'** (R^1 = 4-F) was used for the preparation of **6i–6n** and **6r**.



4'-Methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',

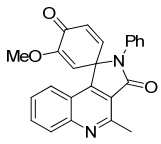
4(2'*H*)-dione (6a)

White solid (185 mg, 53% from **4a**); mp 267–268 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, J = 8.5 Hz, 1H), 7.87–7.80 (m, 1H), 7.76 (d, J = 8.4 Hz, 1H), 7.57–7.51 (m, 1H), 7.46–7.37 (m, 3H), 7.33–7.27 (m, 2H), 6.81 (d, J = 10.1 Hz, 2H), 6.56 (d, J = 10.1 Hz, 2H), 3.14 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.0, 167.2, 157.2, 149.3, 148.4, 145.9, 134.7, 132.3, 131.8, 130.2, 129.4, 128.7, 128.4, 127.5, 123.0, 122.2, 121.2, 65.1, 21.9; IR (KBr, cm^{-1}): v 3060, 2921, 2851, 1706, 1667, 1627, 1496, 1422, 1348, 883, 767, 747; HRMS (ESI): *m/z* calcd for $C_{23}H_{17}N_2O_2$ $[M+H]^+$ 353.1285, found 353.1284.



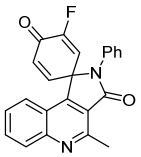
3,4'-Dimethyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6b)

Pale yellow solid (187 mg, 51%); mp 268–269 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, J = 8.5 Hz, 1H), 7.85–7.79 (m, 1H), 7.72 (d, J = 8.3 Hz, 1H), 7.55–7.50 (m, 1H), 7.44–7.34 (m, 3H), 7.30–7.26 (m, 2H), 6.77 (dd, J = 9.8, 3.0 Hz, 1H), 6.69–6.55 (m, 1H), 6.54 (d, J = 9.8 Hz, 1H), 3.14 (s, 3H), 1.96 (d, J = 1.4 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.9, 167.2, 157.2, 149.3, 149.0, 145.6, 140.9, 139.4, 134.8, 132.1, 131.6, 130.1, 129.3, 128.5, 128.4, 127.4, 123.0, 122.3, 121.2, 65.7, 21.8, 15.8; IR (KBr, cm^{-1}): v 3062, 2922, 2851, 1702, 1667, 1641, 1495, 1421, 1321, 755; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1440.



3-Methoxy-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6c)

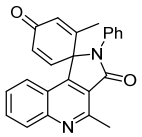
Yellow solid (140 mg, 37%); mp 240–241 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, J = 8.5 Hz, 1H), 7.81–7.86 (m, 1H), 7.77 (d, J = 8.4 Hz, 1H), 7.56–7.50 (m, 1H), 7.44–7.38 (m, 3H), 7.29–7.25 (m, 2H), 6.81 (dd, J = 9.8, 2.6 Hz, 1H), 6.56 (d, J = 9.8 Hz, 1H), 5.67–5.62 (m, 1H), 3.62 (s, 3H), 3.14 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.6, 167.1, 157.2, 153.2, 149.7, 149.4, 146.5, 134.7, 131.8, 131.6, 130.2, 129.4, 128.8, 128.6, 127.5, 122.8, 122.4, 121.1, 112.8, 66.8, 55.5, 21.9; IR (KBr, cm^{-1}): v 3062, 2964, 2933, 1710, 1680, 1643, 1613, 1494, 1424, 1210, 770; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_3$ $[M+H]^+$ 383.1390, found 383.1388.



3-Fluoro-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6d)

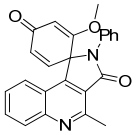
White solid (166 mg, 45%); mp 268–270 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (d, J

= 8.5 Hz, 1H), 7.89–7.83 (m, 1H), 7.75 (d, *J* = 8.2 Hz, 1H), 7.63–7.55 (m, 1H), 7.49–7.40 (m, 3H), 7.28–7.22 (m, 2H), 6.81 (dd, *J* = 9.8, 2.6 Hz, 1H), 6.56 (dd, *J* = 9.9, 6.8 Hz, 1H), 6.38 (dd, *J* = 10.9, 2.7 Hz, 1H), 3.13 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 177.0 (d, $J_{C\text{-}F}$ = 22.4 Hz), 166.8, 157.2, 155.3 (d, $J_{C\text{-}F}$ = 273.0 Hz), 149.4, 148.0, 146.9 (d, $J_{C\text{-}F}$ = 2.5 Hz), 134.1, 132.0, 131.3 (d, $J_{C\text{-}F}$ = 4.1 Hz), 130.3, 129.5, 129.0, 128.7, 127.7, 122.8, 122.2 (d, $J_{C\text{-}F}$ = 14.9 Hz), 121.9, 121.0, 66.6 (d, $J_{C\text{-}F}$ = 8.6 Hz), 21.8; IR (KBr): *v* 3059, 2920, 2850, 1708, 1687, 1658, 1494, 1422, 1334, 760; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}FN_2O_2$ $[M+H]^+$ 371.1190, found 371.1189.



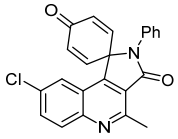
2,4'-Dimethyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6f)

White solid (202 mg, 55%); mp 225–226 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.5 Hz, 1H), 7.88–7.81 (m, 1H), 7.71 (d, *J* = 7.7 Hz, 1H), 7.56–7.50 (m, 1H), 7.44–7.29 (m, 5H), 6.72 (d, *J* = 9.8 Hz, 1H), 6.54 (dd, *J* = 9.8, 1.7 Hz, 1H), 6.51–6.48 (m, 1H), 3.17 (s, 3H), 1.68 (d, *J* = 1.2 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.7, 167.6, 157.1, 154.7, 149.3, 149.3, 146.2, 134.9, 131.9, 131.7, 131.7, 130.2, 129.3, 128.2, 127.6, 126.8, 123.4, 121.9, 120.8, 67.6, 21.9, 18.5; IR (KBr): *v* 3059, 2920, 2850, 1704, 1667, 1494, 1421, 1322, 760; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1441.



2-Methoxy-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6g)

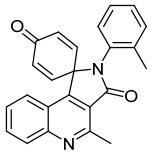
White solid (207 mg, 54%); mp 266–269 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.5 Hz, 1H), 7.86–7.80 (m, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.55–7.49 (m, 1H), 7.45–7.35 (m, 3H), 7.25–7.19 (m, 2H), 6.63–6.57 (m, 1H), 6.52–6.48 (m, 1H), 5.82–5.80 (m, 1H), 3.59 (s, 3H), 3.14 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 186.2, 169.7, 168.1, 157.1, 149.2, 149.2, 141.9, 134.6, 131.8, 131.5, 130.1, 129.4, 128.8, 128.2, 127.5, 121.1, 123.6, 122.0, 105.8, 66.7, 56.3, 21.9; IR (KBr, cm^{-1}): *v* 3060, 3013, 2950, 1708, 1662, 1600, 1425, 1344, 1225, 756; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_3$ $[M+H]^+$ 383.1390, found 383.1389.



8'-Chloro-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6h)

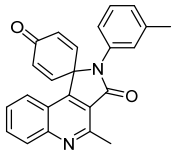
White solid (140 mg, 36%); mp 250–251 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, *J* = 9.0 Hz, 1H), 7.76 (dd, *J* = 9.0, 2.3 Hz, 1H), 7.69 (d, *J* = 2.2 Hz, 1H), 7.46–7.38 (m,

3H), 7.31–7.27 (m, 2H), 6.78 (d, J = 10.1 Hz, 2H), 6.59 (d, J = 10.1 Hz, 2H), 3.12 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 183.6, 166.8, 157.5, 147.7, 147.5, 145.3, 134.4, 133.4, 132.7, 132.6, 131.7, 129.4, 128.8, 128.4, 123.8, 121.8, 121.1, 65.0, 21.8; IR (KBr, cm^{-1}): v 3044, 2922, 1705, 1668, 1494, 1395, 1330, 753, 693; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O_2$ $[M+H]^+$ 387.0895, found 387.0894.



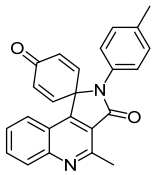
4'-Methyl-2'-(*o*-tolyl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6i)

White solid (197 mg, 54%); mp 261–262 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, J = 8.5 Hz, 1H), 7.88–7.81 (m, 1H), 7.75 (d, J = 8.3 Hz, 1H), 7.57–7.50 (m, 1H), 7.35–7.28 (m, 2H), 7.22–7.17 (m, 1H), 7.12 (d, J = 7.7 Hz, 1H), 6.89 (dd, J = 10.0, 3.0 Hz, 1H), 6.79 (dd, J = 10.0, 3.0 Hz, 1H), 6.62 (dd, J = 10.0, 1.8 Hz, 1H), 6.46 (dd, J = 10.0, 1.8 Hz, 1H), 3.15 (s, 3H), 2.29 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.0, 166.4, 157.3, 149.3, 146.1, 144.0, 137.5, 132.7, 132.6, 132.1, 131.8, 131.6, 130.1, 129.8, 129.3, 127.5, 126.5, 122.8, 122.2, 121.3, 65.6, 21.8, 18.9; IR (KBr): v 2919, 2850, 1704, 1667, 1631, 1423, 1346, 1325, 758; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1440.



4'-Methyl-2'-(*m*-tolyl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6j)

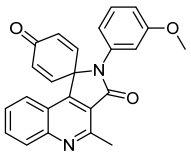
Pale yellow solid (262 mg, 72%); mp 269–270 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, J = 8.5 Hz, 1H), 7.86–7.80 (m, 1H), 7.76 (d, J = 8.4 Hz, 1H), 7.57–7.51 (m, 1H), 7.29 (t, J = 7.7 Hz, 1H), 7.19 (d, J = 7.7 Hz, 1H), 7.10 (s, 1H), 7.07 (d, J = 7.9 Hz, 1H), 6.80 (d, J = 10.1 Hz, 2H), 6.56 (d, J = 10.1 Hz, 2H), 3.14 (s, 3H), 2.37 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 182.4, 167.2, 157.2, 149.3, 148.5, 146.0, 139.4, 134.4, 132.3, 131.7, 130.2, 129.6, 129.2, 129.1, 127.4, 125.4, 123.1, 122.2, 121.2, 77.2, 65.1, 21.8, 21.3; IR (KBr, cm^{-1}): v 3040, 2920, 2850, 1708, 1666, 1630, 1423, 1346, 767; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1441.



4'-Methyl-2'-(*p*-tolyl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6k)

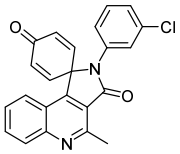
Pale yellow solid (168 mg, 46%); mp 267–269 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, J = 8.5 Hz, 1H), 7.88–7.80 (m, 1H), 7.76 (d, J = 8.3 Hz, 1H), 7.57–7.50 (m,

1H), 7.21 (d, *J* = 8.3 Hz, 2H), 7.15 (d, *J* = 8.3 Hz, 2H), 6.78 (d, *J* = 10.1 Hz, 2H), 6.55 (d, *J* = 10.1 Hz, 2H), 3.14 (s, 3H), 2.37 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.1, 167,3, 157.2, 149.3, 148.5, 146.0, 138.8, 132.3, 131.8, 131.7, 130.1, 130.0, 128.4, 127.4, 123.1, 122.2, 121.2, 65.1, 21.8, 21.1; IR (KBr, cm^{-1}): *v* 3057, 2920, 2851, 1706, 1669, 1629, 1509, 1421, 1346, 1324, 775; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_2$ $[M+H]^+$ 367.1441, found 367.1439.



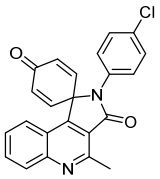
2'-(3-Methoxyphenyl)-4'-methylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6l)

White solid (268 mg, 70%); mp 268–270 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.6 Hz, 1H), 7.86–7.80 (m, 1H), 7.76 (d, *J* = 8.4 Hz, 1H), 7.56–7.50 (m, 1H), 7.32 (t, *J* = 8.1 Hz, 1H), 6.95–6.84 (m, 3H), 6.80 (d, *J* = 10.1 Hz, 2H), 6.58 (d, *J* = 10.1 Hz, 2H), 3.80 (s, 3H), 3.14 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 184.1, 167.1, 160.1, 157.2, 149.3, 148.4, 146.0, 135.8, 132.3, 131.8, 130.2, 130.0, 127.5, 123.0, 122.2, 121.2, 120.4, 114.5, 114.0, 65.2, 55.4, 21.9; IR (KBr): *v* 2920, 2850, 1711, 1666, 1600, 1486, 1422, 768; HRMS (ESI): *m/z* calcd for $C_{24}H_{19}N_2O_3$ $[M+H]^+$ 383.1390, found 383.1395.



2'-(3-Chlorophenyl)-4'-methylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6m)

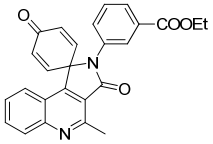
White solid (104 mg, 27%); mp 260–261 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.5 Hz, 1H), 7.88–7.82 (m, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.58–7.52 (m, 1H), 7.39–7.32 (m, 3H), 7.23–7.19 (m, 1H), 6.79 (d, *J* = 10.1 Hz, 2H), 6.61 (d, *J* = 10.1 Hz, 2H), 3.13 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 183.8, 167.1, 157.1, 149.4, 148.5, 145.6, 136.0, 134.9, 132.6, 132.0, 130.3, 130.2, 128.9, 128.5, 127.6, 126.2, 122.6, 122.1, 121.1, 65.1, 21.9; IR (KBr, cm^{-1}): *v* 3042, 2922, 2852, 1710, 1668, 1477, 1422, 1323, 762; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O_2$ $[M+H]^+$ 387.0895, found 387.0896.



2'-(4-Chlorophenyl)-4'-methylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6n)

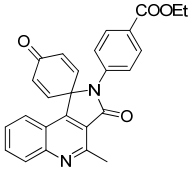
White solid (147 mg, 38%); mp 267–269 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.5 Hz, 1H), 7.88–7.81 (m, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.57–7.52 (m, 1H), 7.39 (d, *J* = 8.7 Hz, 2H), 7.26–7.24 (m, 2H), 6.78 (d, *J* = 10.1 Hz, 2H), 6.59 (d, *J* = 10.1 Hz,

2H), 3.13 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 183.8, 167.2, 157.1, 149.4, 148.5, 145.6, 134.5, 133.3, 132.5, 131.9, 130.2, 129.6, 129.5, 127.6, 122.7, 122.1, 121.1, 65.1, 21.8; IR (KBr, cm^{-1}): *v* 2920, 2850, 1706, 1667, 1491, 1422, 1327, 765; HRMS (ESI): *m/z* calcd for $C_{23}H_{16}ClN_2O_2$ $[M+H]^+$ 387.0895, found 387.0896.



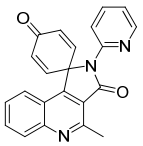
Ethyl 3-(4'-methyl-3',4-dioxospiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-dien-2'(3'*H*)-yl)benzoate (6o)

White solid (140 mg, 33%); mp 265–267 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (d, *J* = 8.6 Hz, 1H), 8.07 (d, *J* = 7.0 Hz, 1H), 8.00 (s, 1H), 7.88–7.82 (m, 1H), 7.77 (d, *J* = 8.3 Hz, 1H), 7.58–7.48 (m, 3H), 6.84 (d, *J* = 9.7 Hz, 2H), 6.60 (d, *J* = 9.7 Hz, 2H), 4.38 (q, *J* = 7.1 Hz, 2H), 3.14 (s, 3H), 1.39 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 183.9, 167.2, 165.4, 157.2, 149.4, 148.6, 145.7, 135.0, 132.6, 132.6, 132.0, 130.3, 129.7, 129.5, 129.3, 127.6, 122.8, 122.2, 121.2, 77.2, 65.2, 61.4, 21.9, 14.3; IR (KBr, cm^{-1}): *v* 3040, 2980, 1708, 1665, 1442, 1418, 1315, 1269, 760, 748; HRMS (ESI): *m/z* calcd for $C_{26}H_{21}N_2O_4$ $[M+H]^+$ 425.1496, found 425.1494.



Ethyl 4-(4'-methyl-3',4-dioxospiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-dien-2'(3'*H*)-yl)benzoate (6p)

Pale yellow solid (123 mg, 29%); mp 254–-256 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.5 Hz, 1H), 8.11–8.06 (m, 2H), 7.88– 7.82 (m, 1H), 7.76 (d, *J* = 8.3 Hz, 1H), 7.58–7.51 (m, 1H), 7.47– 7.43 (m, 2H), 6.82 (d, *J* = 9.8 Hz, 2H), 6.60 (d, *J* = 10.0 Hz, 2H), 4.39 (q, *J* = 7.1 Hz, 2H), 3.14 (s, 3H), 1.40 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 183.8, 167.1, 165.6, 157.2, 149.4, 148.4, 145.9, 139.3, 132.6, 132.1, 130.7, 130.3, 130.2, 127.7, 127.2, 122.7, 122.2, 121.1, 65.3, 61.3, 22.0, 14.3; IR (KBr, cm^{-1}): *v* 3060, 2981, 1712, 1669, 1510, 1422, 1276, 761; HRMS (ESI): *m/z* calcd for $C_{26}H_{21}N_2O_4$ $[M+H]^+$ 425.1496, found 425.1496.

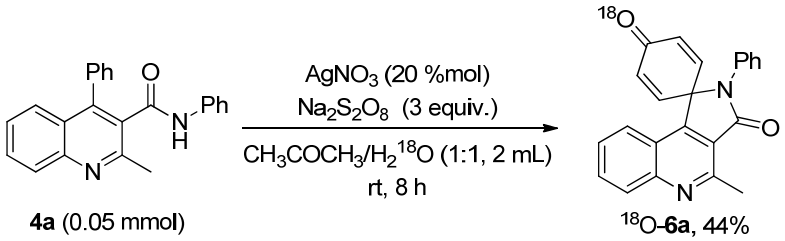


4'-Methyl-2'-(pyridin-2-yl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (6r)

White solid (152 mg, 43%); mp 245–245 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40–8.12 (m, 3H), 7.92 (d, *J* = 8.5 Hz, 1H), 7.85–7.74 (m, 2H), 7.58–7.50 (m, 1H), 7.14–7.08 (m,1H), 6.83 (d, *J* = 9.8 Hz, 2H), 6.66 (d, *J* = 9.8 Hz, 2H), 3.16 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 185.5, 166.7, 157.1, 150.4, 149.5, 147.7, 147.6, 147.5, 137.9, 132.0, 131.6, 130.3, 127.5, 123.0, 122.5, 121.1, 120.9, 116.6, 65.5, 22.2; IR

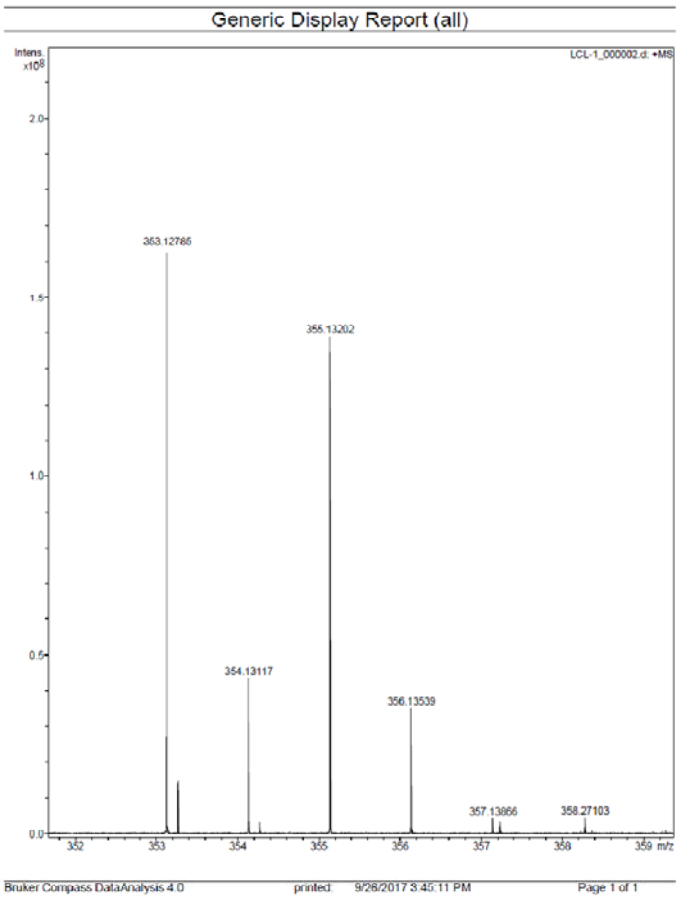
(KBr, cm^{-1}): *v* 3059, 3010, 1711, 1666, 1469, 1423, 1327, 1299, 766; HRMS (ESI): *m/z* calcd for $C_{22}H_{16}N_3O_2$ $[M+H]^+$ 354.1237, found 354.1230.

6. ^{18}O-labeling Experiment

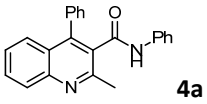


4a (0.05 mmol) ^{18}O-**6a**, 44%

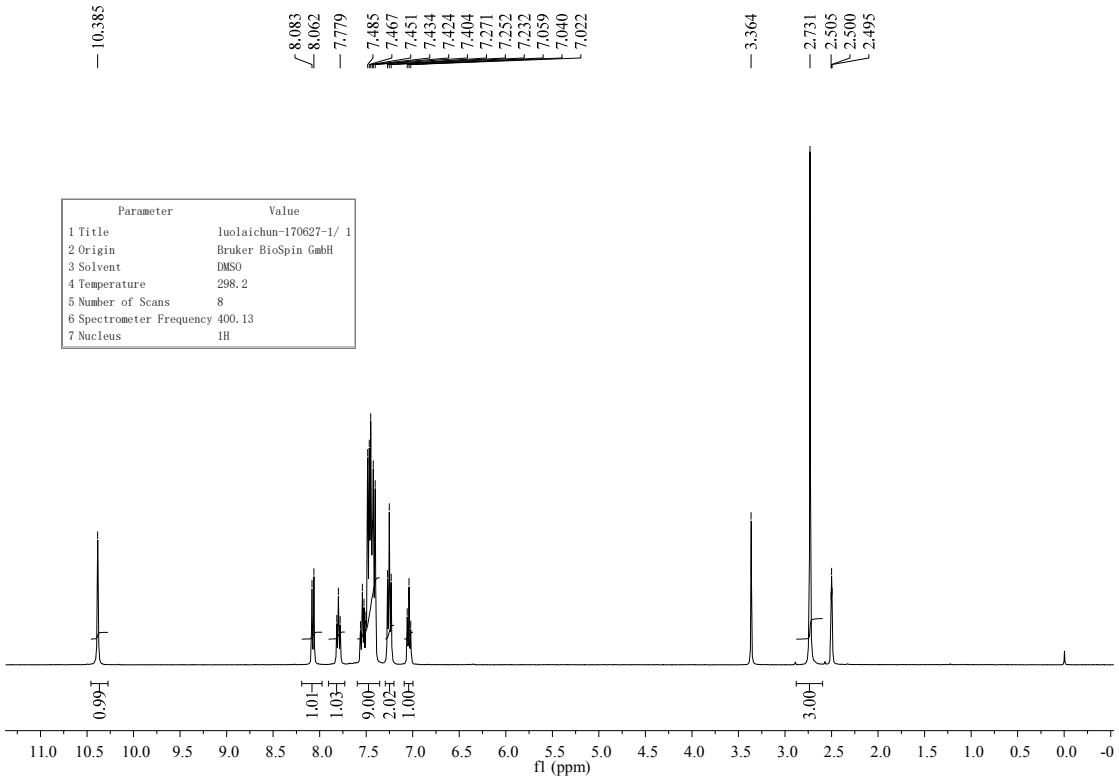
A mixture of substrate **4** (16.9 mg, 0.05 mmol), $AgNO_3$ (1.7 mg, 0.01 mmol), $Na_2S_2O_8$ (35.7 mg, 0.15 mmol), and $CH_3COCH_3/H_2{}^{18}O$ (97 atom % ^{18}O, 1:1, 2 mL) was added to a round bottom flask (5 mL). The mixture was vigorously stirred at room temperature for 8 h. The mixture was extracted with EtOAc (3×5 mL). The combined organic extracts were washed with brine, dried with anhydrous Na_2SO_4, and concentrated. The residue obtained was purified by column chromatography on silica gel (petroleum ether/EtOAc) to afford a white solid (5.6 mg, 44%). HRMS (ESI): *m/z* calcd for ^{18}O-**6a**: $C_{23}H_{17}N_2O^{18}O$ $[M+H]^+$ 355.1327, found 355.1320.

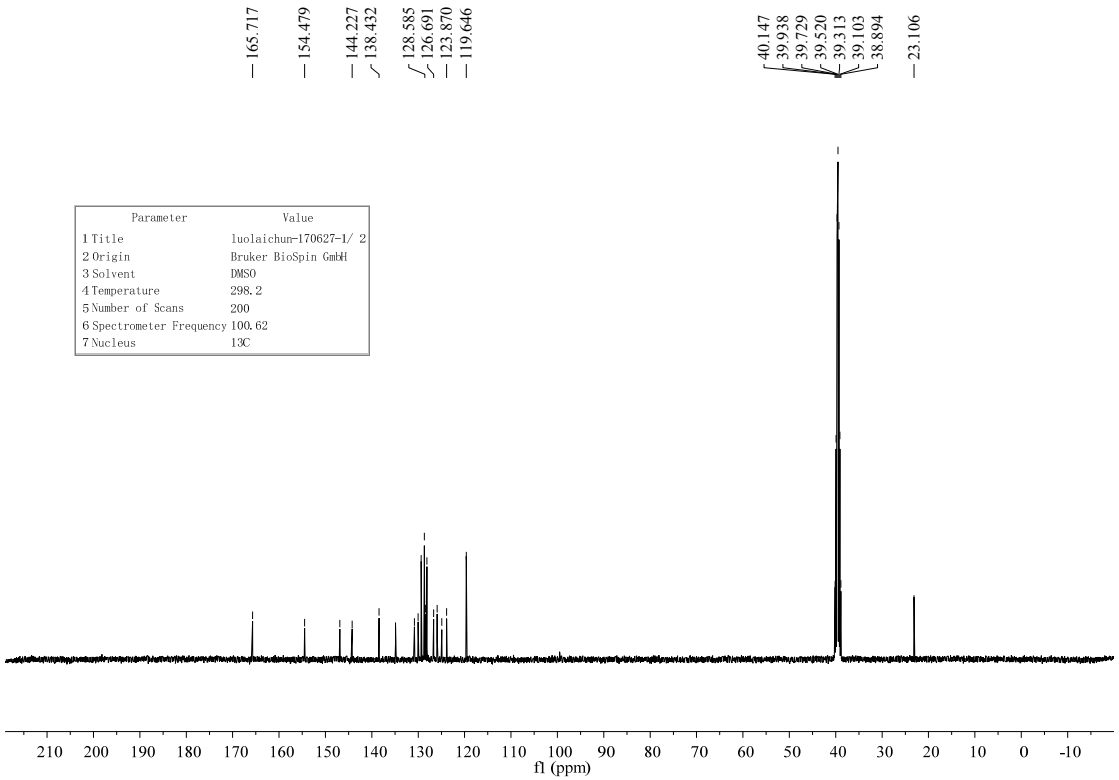


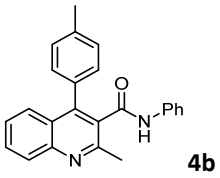
7. ^{1}H NMR and ^{13}C NMR spectra



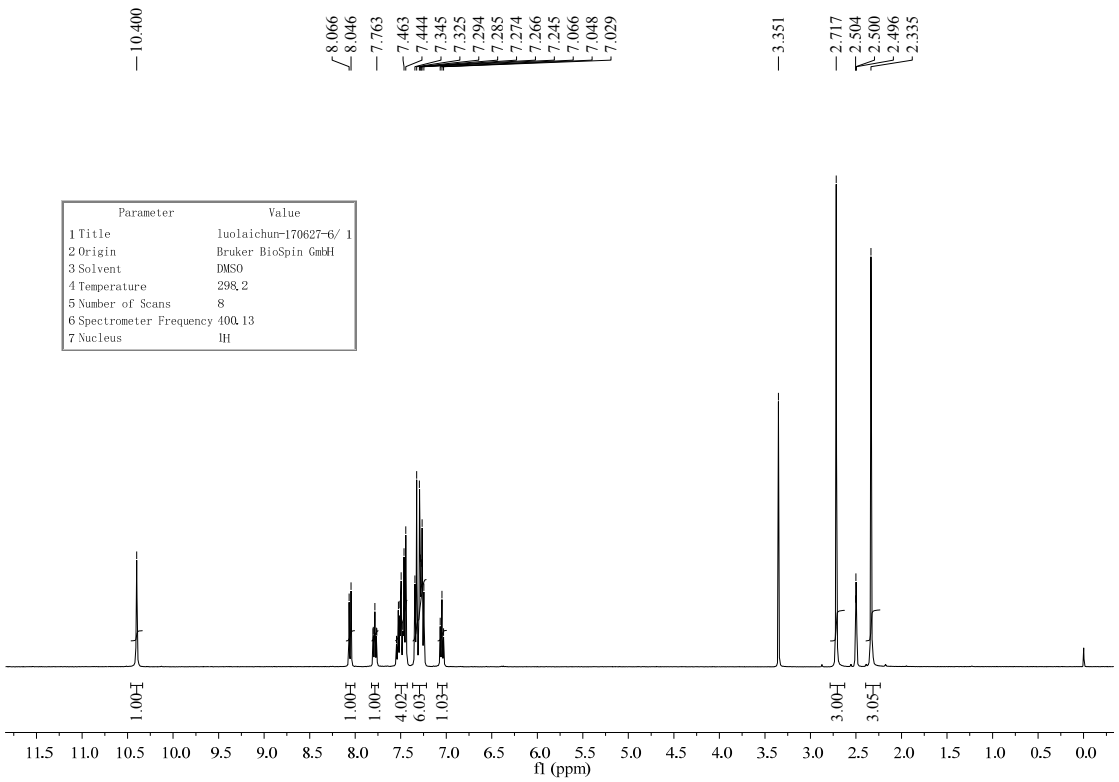
4a

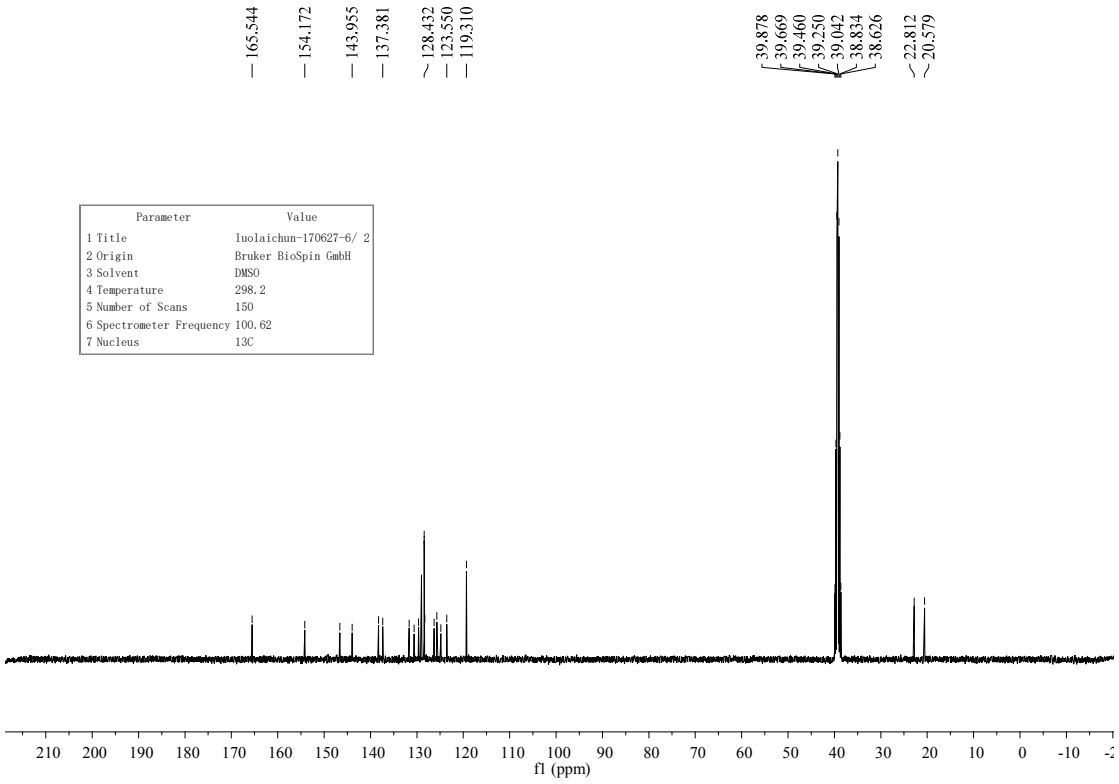


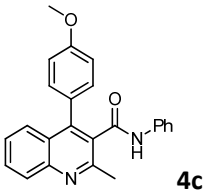




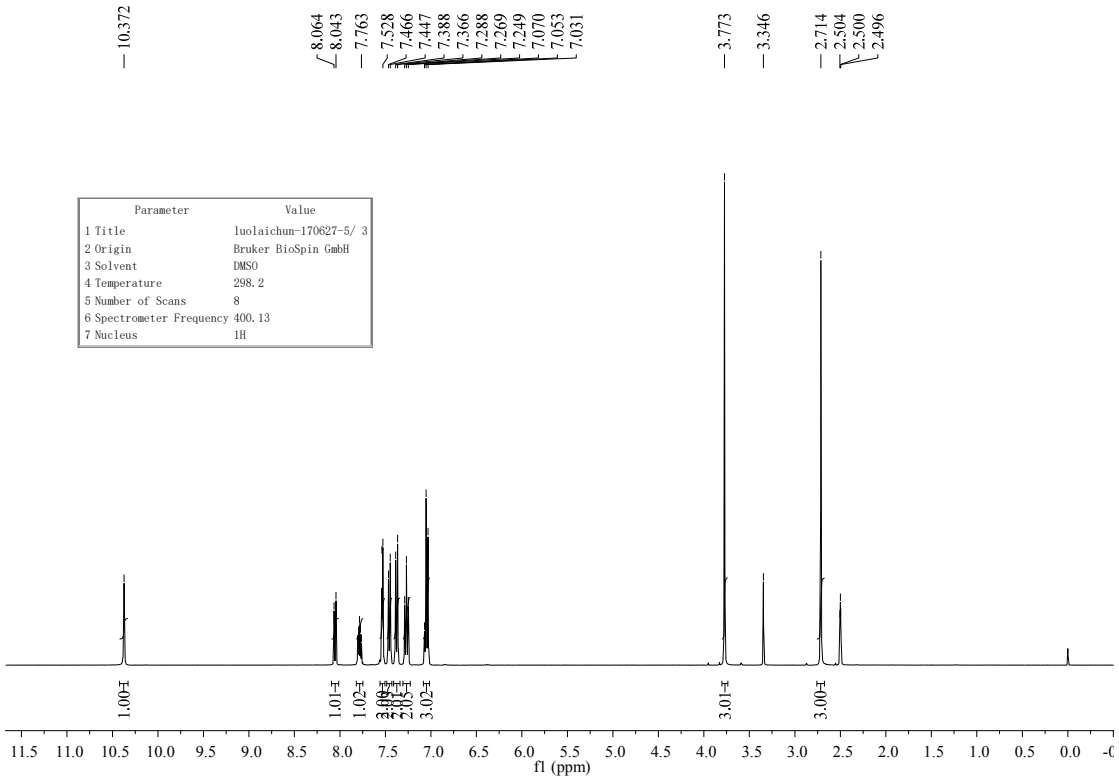
4b

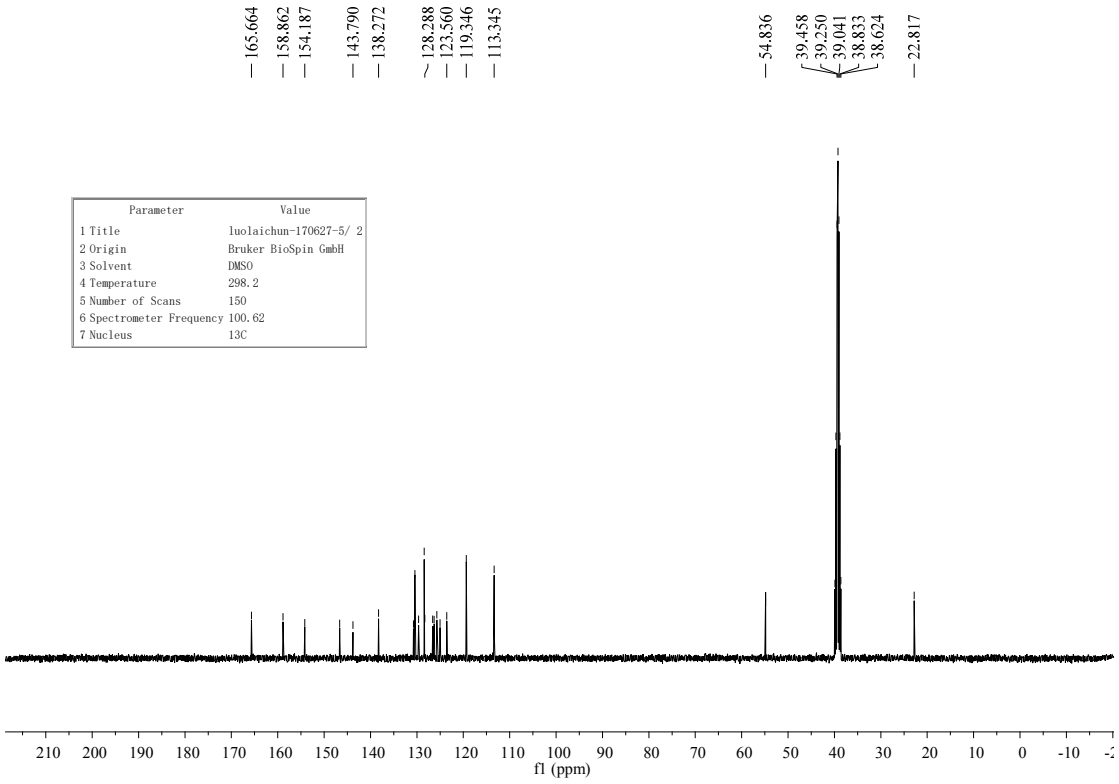

10.400
8.066
8.046
7.763
7.463
7.444
7.345
7.325
7.294
7.285
7.274
7.266
7.245
7.066
7.048
7.029
3.351
2.717
2.504
2.500
2.496
2.335
Parameter Value
1 Title luolaichun-170627-6/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.00
4.02
6.03
1.03
3.00
3.05
f1 (ppm)

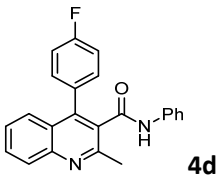

165.544
154.172
143.955
137.381
128.432
123.550
119.310
39.878
39.669
39.460
39.250
39.042
38.834
38.626
22.812
20.579
Parameter Value
1 Title luolaichun-170627-6/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



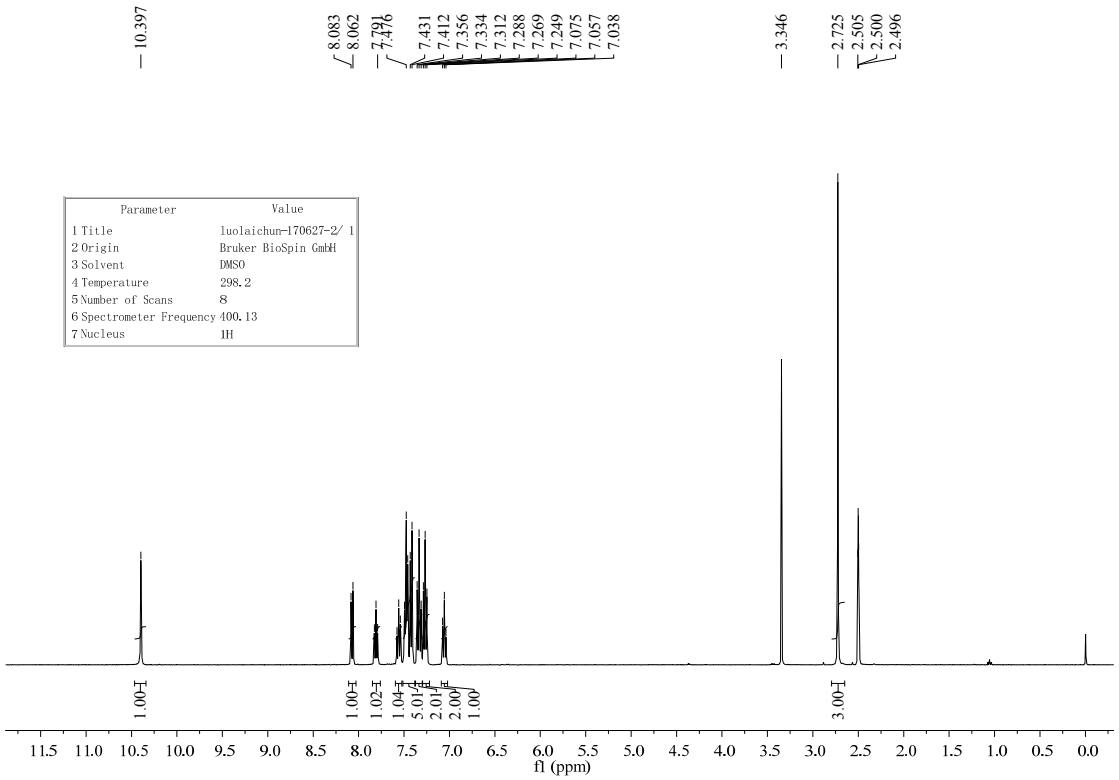
4c

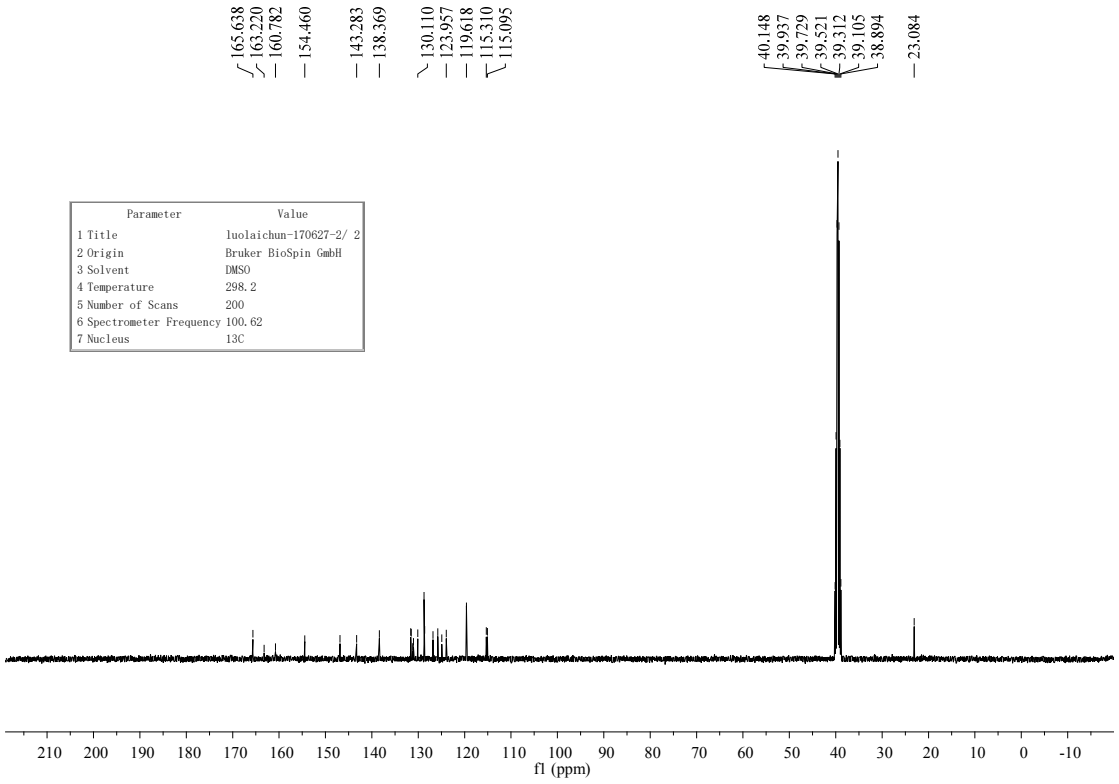

10.372
8.064
8.043
7.763
7.528
7.466
7.447
7.388
7.366
7.288
7.269
7.249
7.070
7.053
7.031
3.773
3.346
2.714
2.504
2.500
2.496
Parameter Value
1 Title luolaichun-170627-5/ 3
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
1.02
3.01
3.00
f1 (ppm)

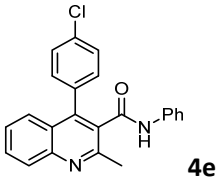

165.664
158.862
154.187
143.790
138.272
128.288
123.560
119.346
113.345
54.836
39.458
39.250
39.041
38.833
38.624
22.817
Parameter Value
1 Title luolaichun-170627-5/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)


F
O
N
Ph
H
N

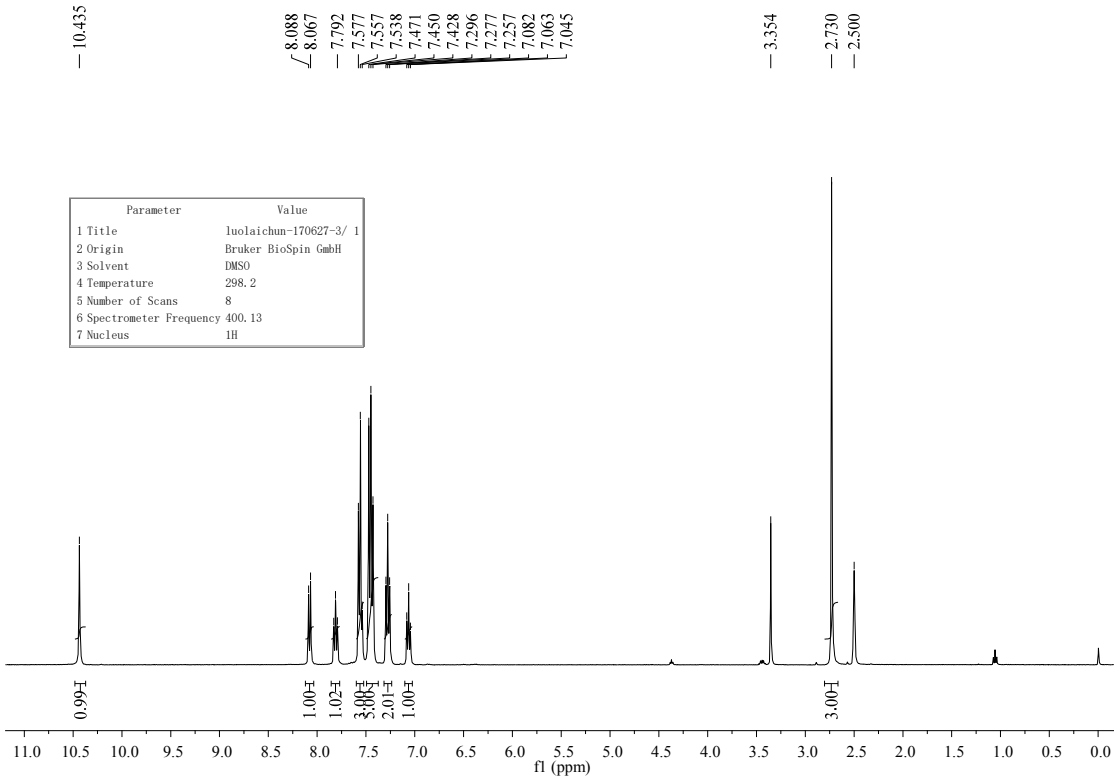
4d

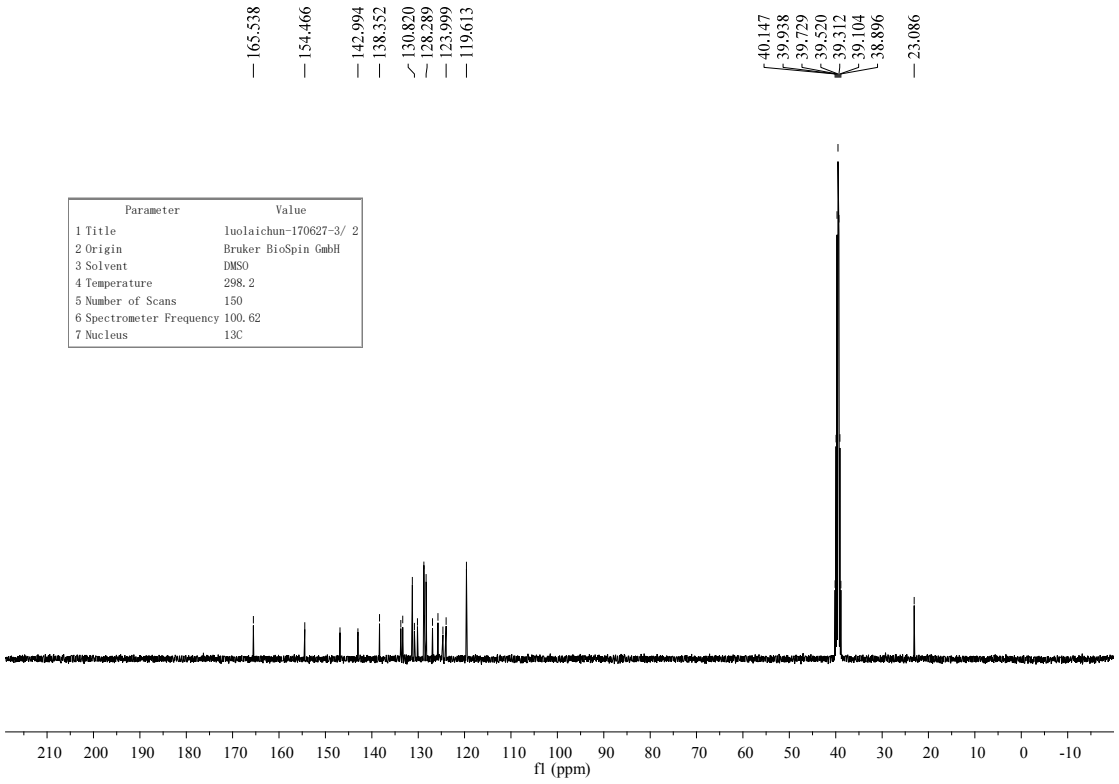

10.397
8.083
8.062
7.791
7.476
7.431
7.412
7.356
7.334
7.312
7.288
7.269
7.249
7.075
7.057
7.038
3.346
2.725
2.505
2.500
2.496
Parameter Value
1 Title luolaichun-170627-2/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.02
1.04
5.01
2.01
2.00
1.00
3.00
f1 (ppm)

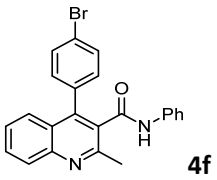

165.638
163.220
160.782
154.460
143.283
138.369
130.110
123.957
119.618
115.310
115.095
40.148
39.937
39.729
39.521
39.312
39.105
38.894
23.084
Parameter Value
1 Title luolaichun-170627-2/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 200
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)


Cl
O
N
Ph
H
N

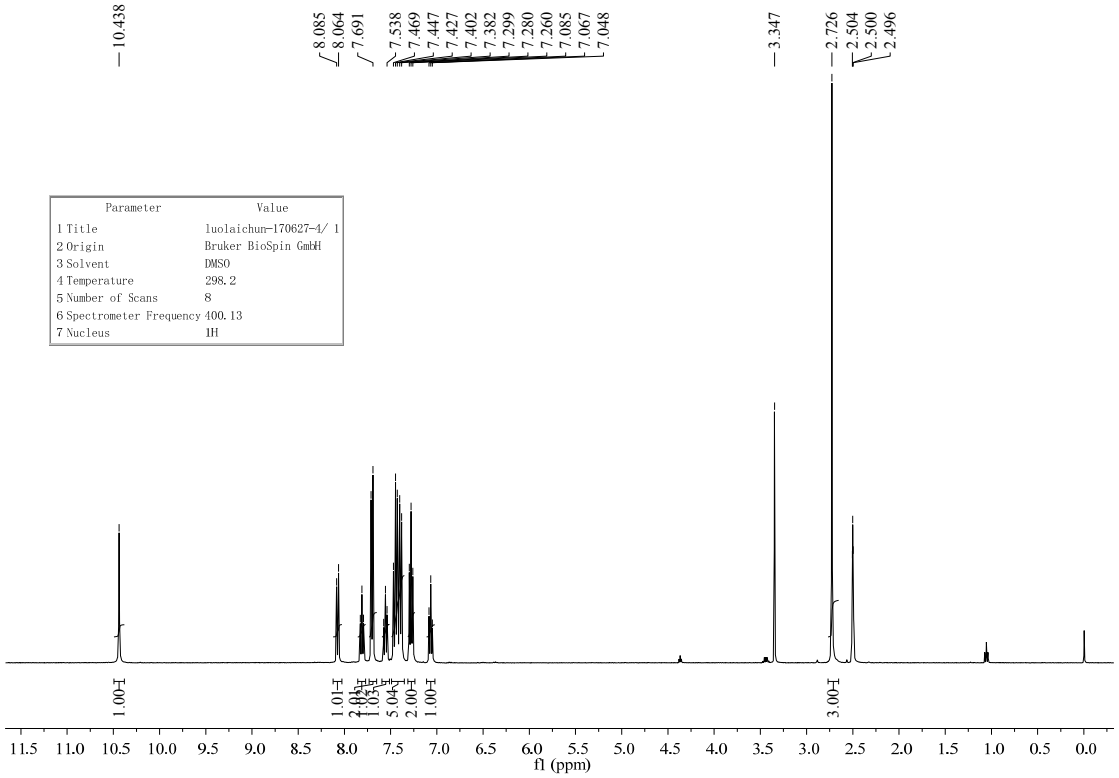
4e

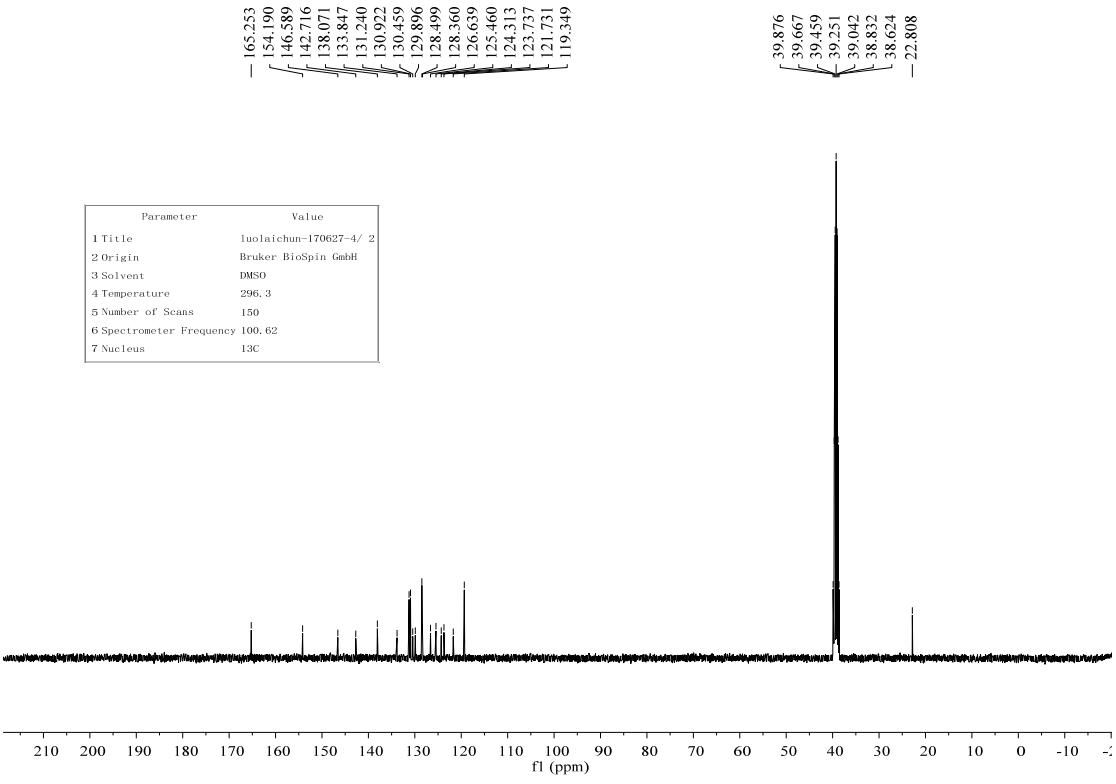

10.435
8.088
8.067
7.792
7.577
7.557
7.538
7.471
7.450
7.428
7.296
7.277
7.257
7.082
7.063
7.045
3.354
2.730
2.500
Parameter Value
1 Title luolaichun-170627-3/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
0.99
1.00
1.02
3.00
3.00
2.01
1.00
3.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

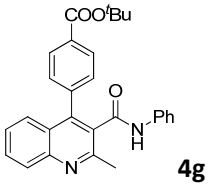

165.538
154.466
142.994
138.352
130.820
128.289
123.999
119.613
40.147
39.938
39.729
39.520
39.312
39.104
38.896
23.086
Parameter Value
1 Title luolaichun-170627-3/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Br
O
N
Ph
H
N

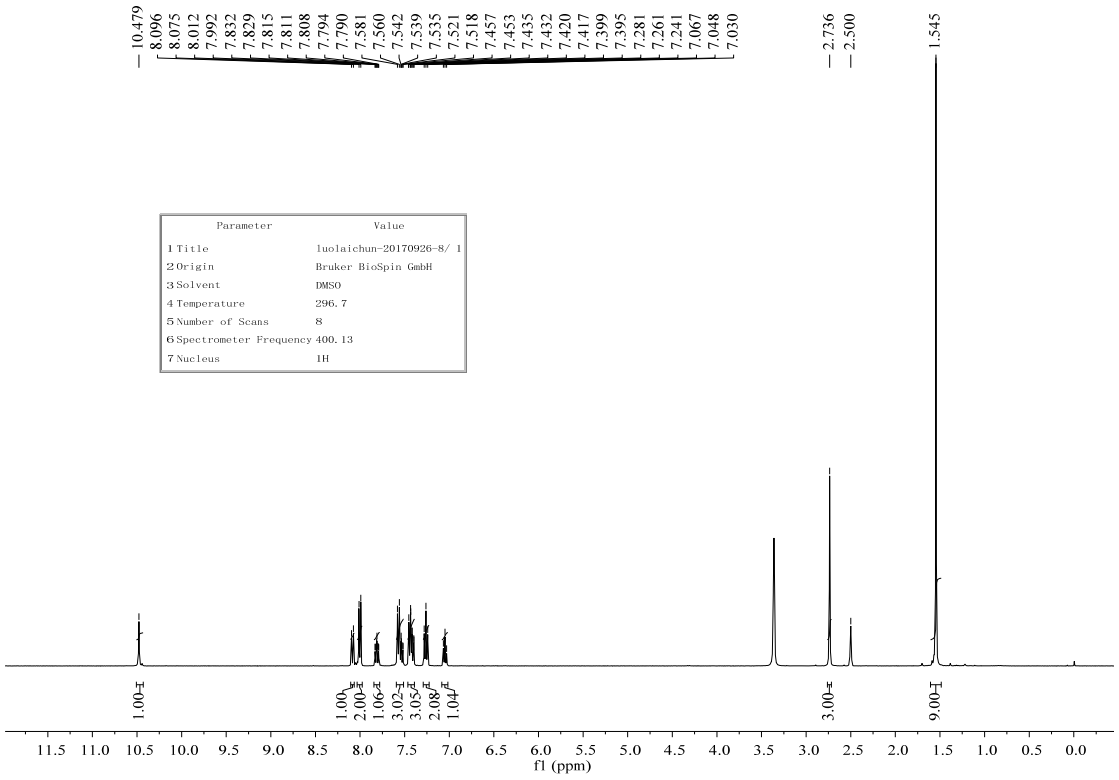
4f


10.438
8.085
8.064
7.691
7.538
7.469
7.447
7.427
7.402
7.382
7.299
7.280
7.260
7.085
7.067
7.048
3.347
2.726
2.504
2.500
2.496
Parameter Value
1 Title luolaichun-170627-4/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
2.04
1.05
5.04
2.00
1.00
3.00
f1 (ppm)

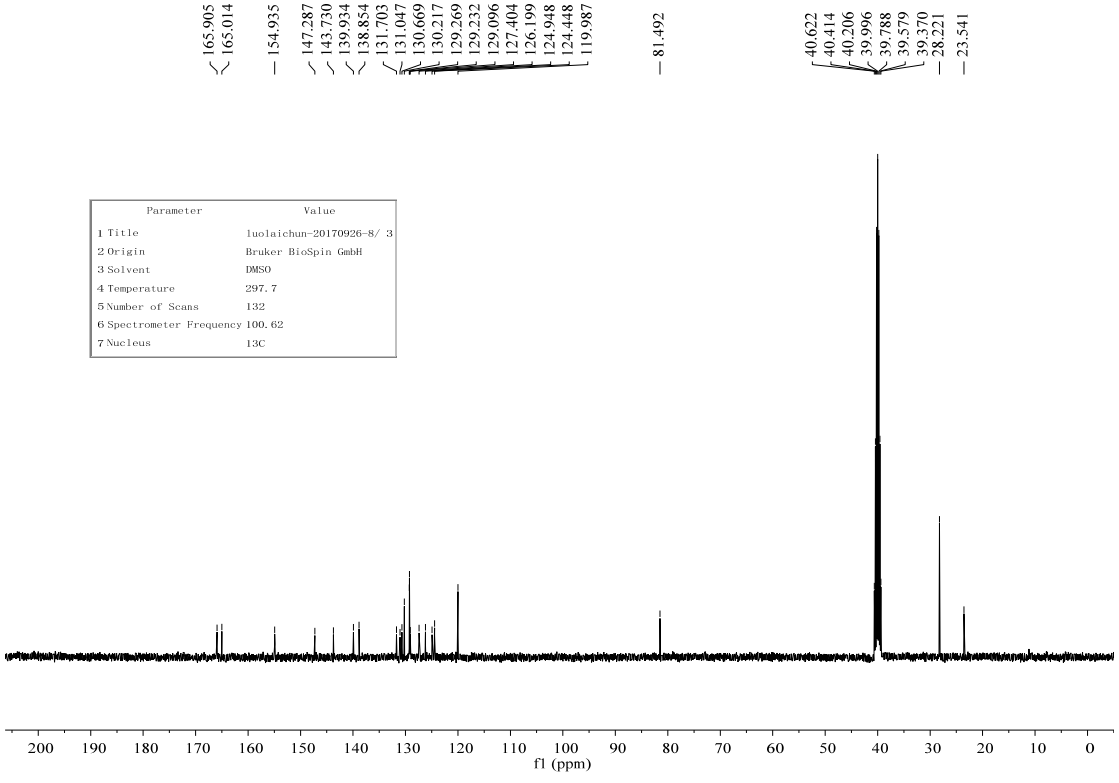

165.253
154.190
146.589
142.716
138.071
133.847
131.240
130.922
130.459
129.896
128.499
128.360
126.639
125.460
124.313
123.737
121.731
119.349
39.876
39.667
39.459
39.251
39.042
38.832
38.624
22.808
Parameter Value
1 Title luolaichun-170627-4/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 296.3
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



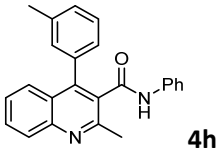
4g



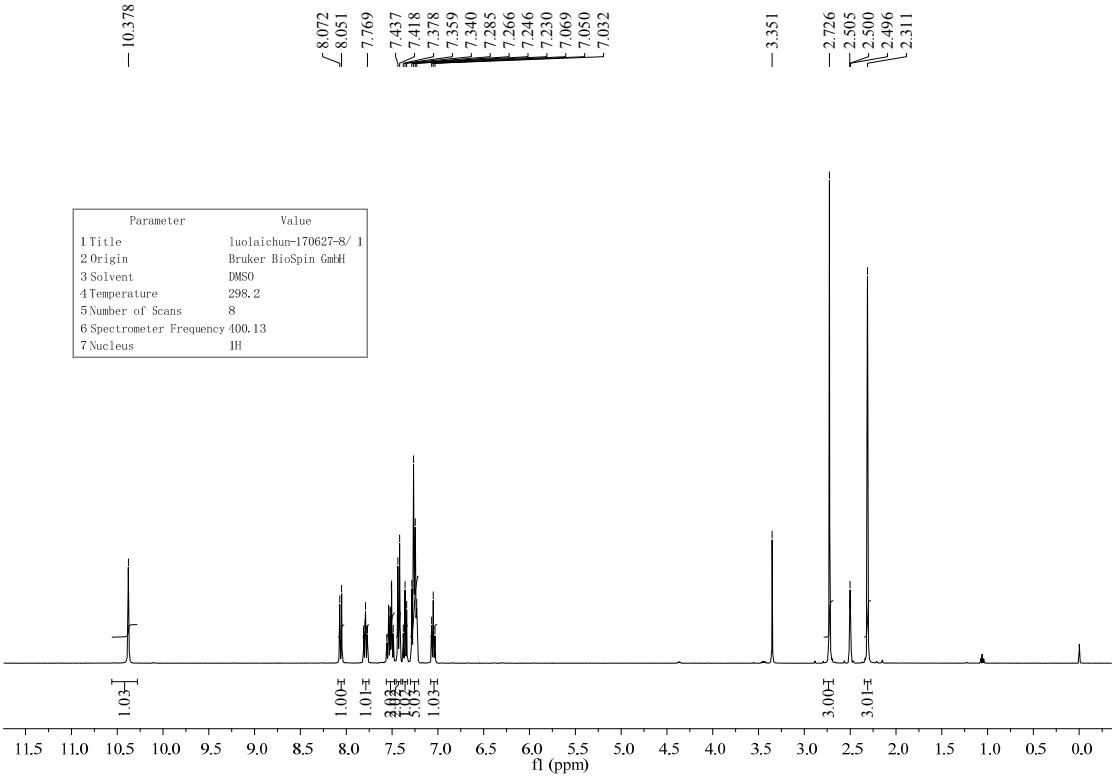
Parameter	Value
1 Title	luolaichun-20170926-8/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	296.7
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

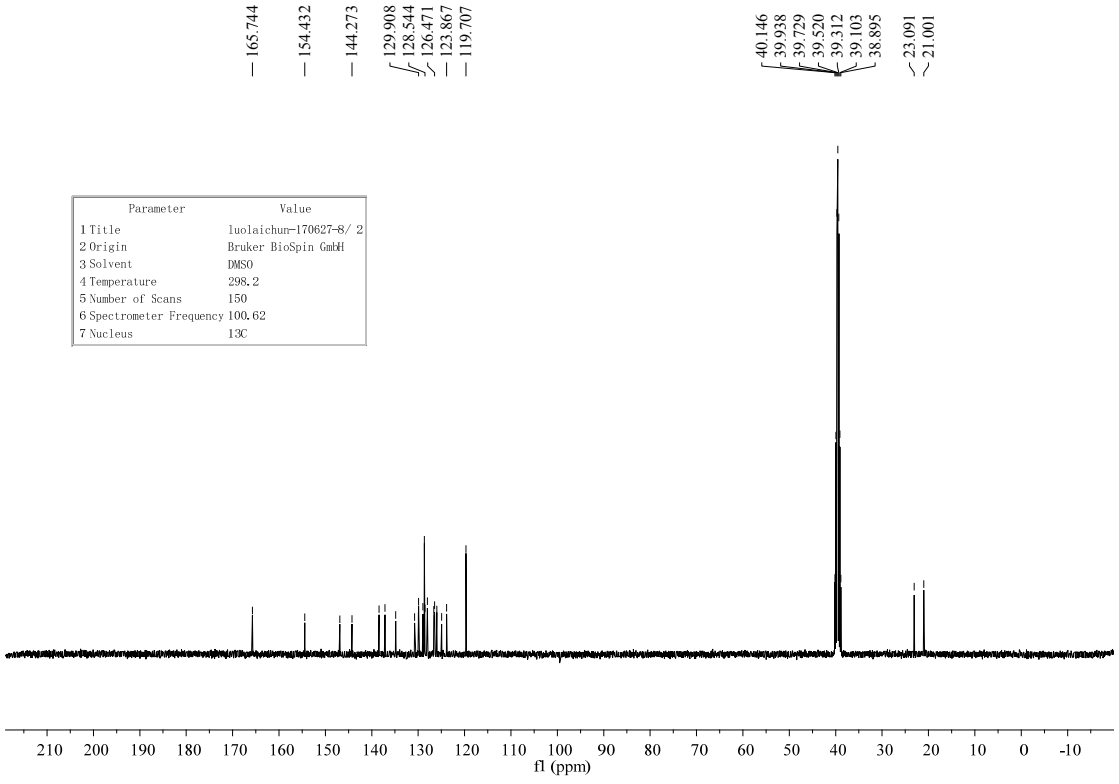


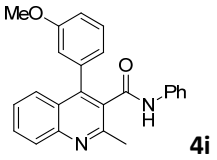
Parameter	Value
1 Title	luolaichun-20170926-8/ 3
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	297.7
5 Number of Scans	132
6 Spectrometer Frequency	100.62
7 Nucleus	13C



4h

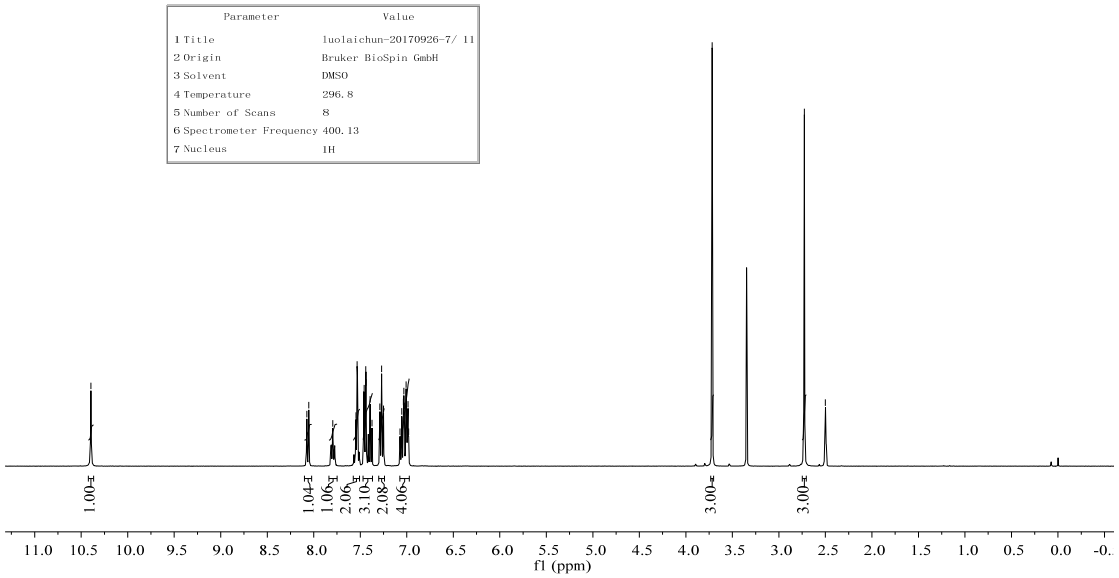

10.378
8.072
8.051
7.769
7.437
7.418
7.378
7.359
7.340
7.285
7.266
7.246
7.230
7.069
7.050
7.032
3.351
2.726
2.505
2.500
2.496
2.311
Parameter Value
1 Title luolaichun-170627-8/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.03
1.00
1.01
1.03
3.00
3.01
fl (ppm)

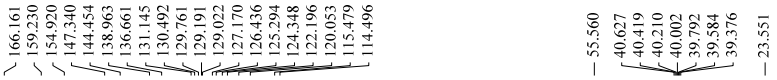

165.744
154.432
144.273
129.908
128.544
126.471
123.867
119.707
40.146
39.938
39.729
39.520
39.312
39.103
38.895
23.091
21.001
Parameter Value
1 Title luolaichun-170627-8/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
fl (ppm)



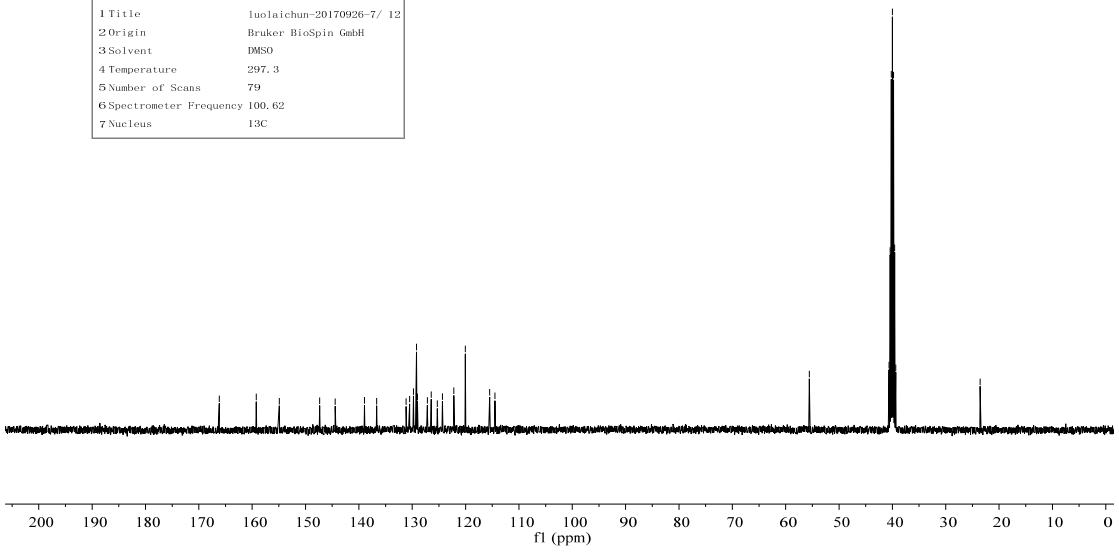
4i

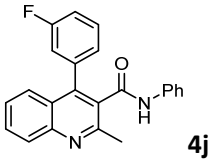
Parameter	Value
1 Title	luolaichun-20170926-7/ 11
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	296.8
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



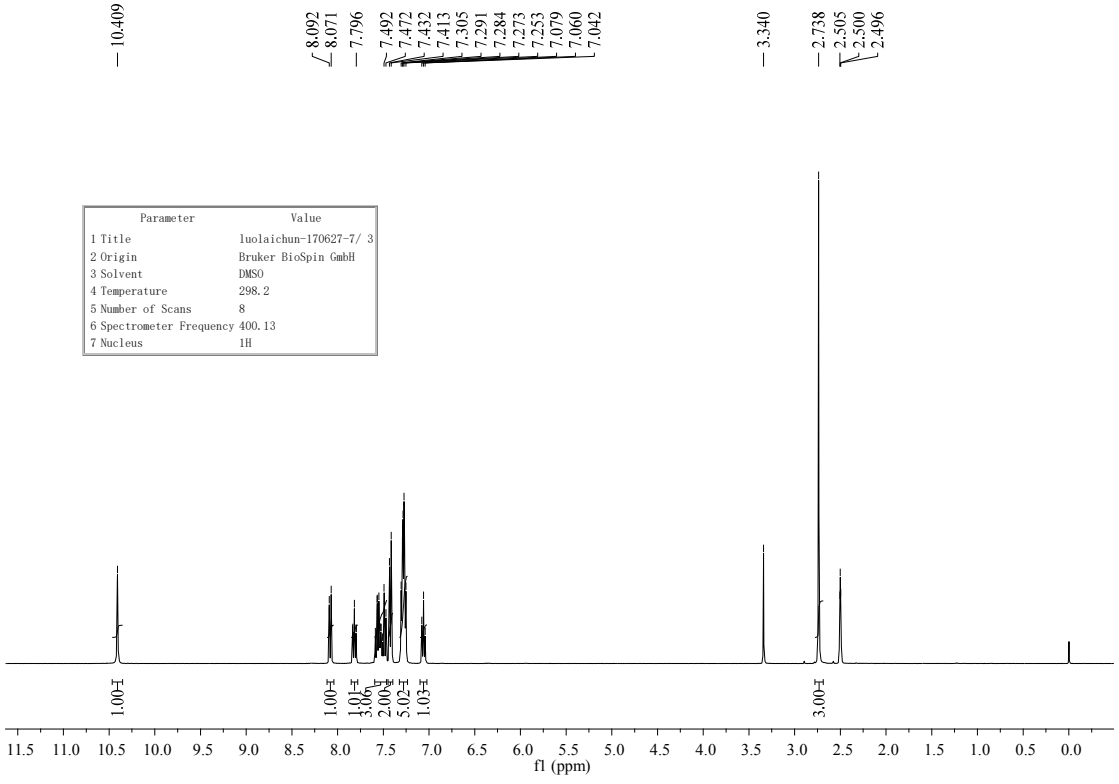


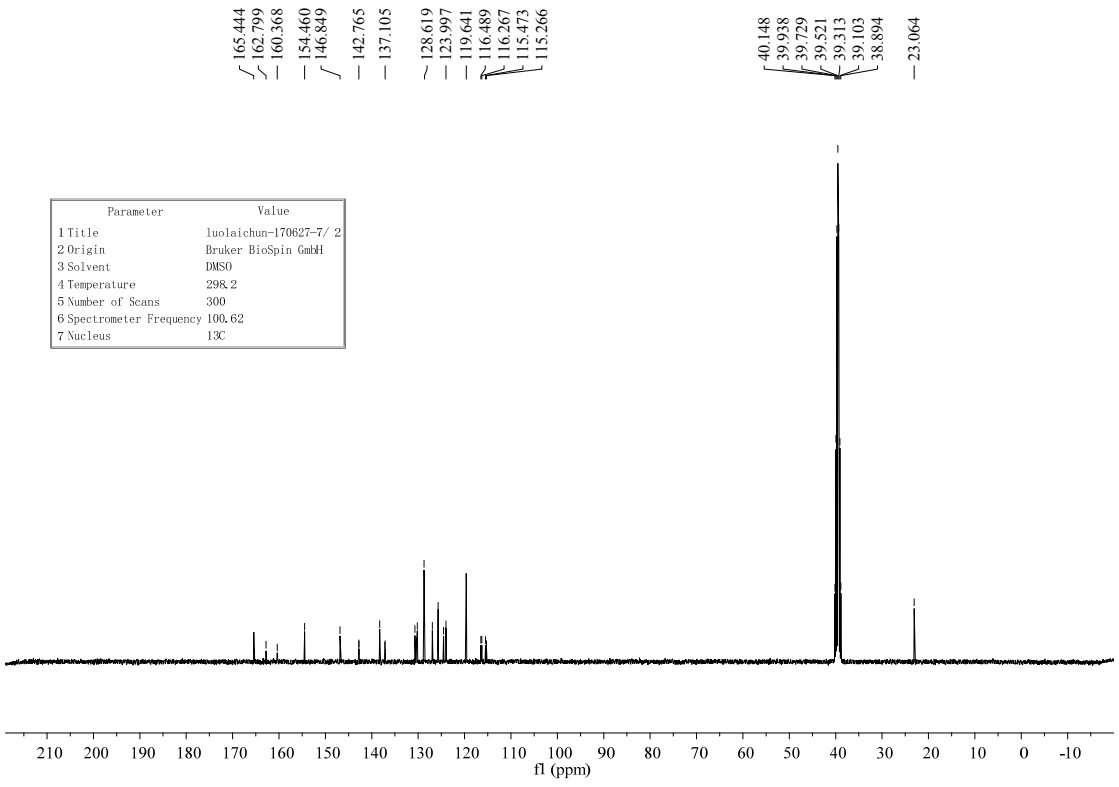
Parameter	Value
1 Title	luolaichun-20170926-7/ 12
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	297.3
5 Number of Scans	79
6 Spectrometer Frequency	100.62
7 Nucleus	13C

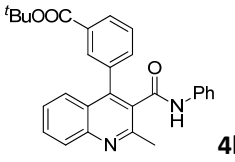



F
O
N
Ph
H
N

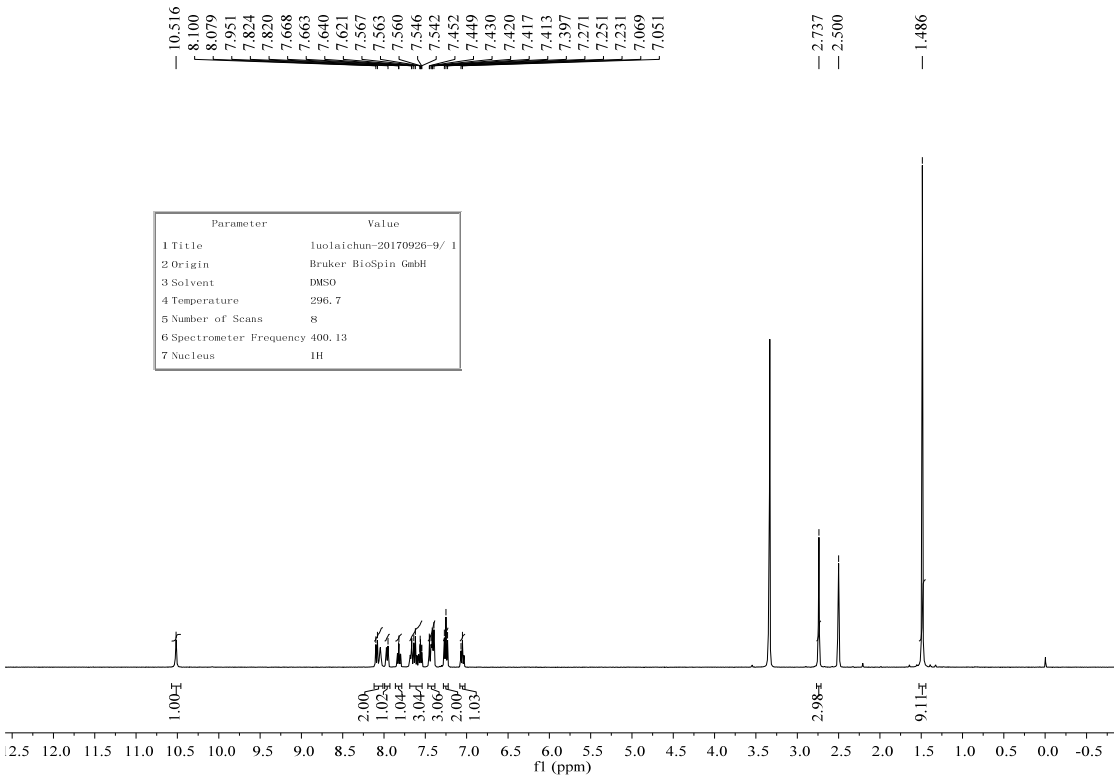
4j

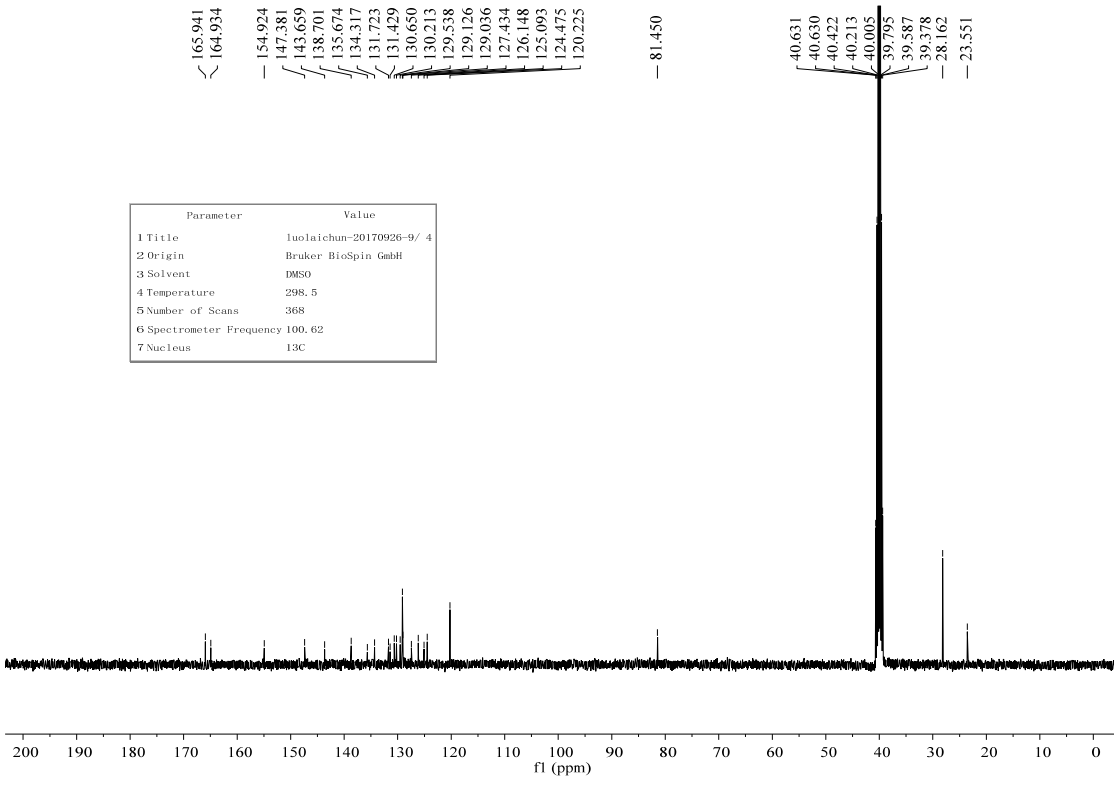

10.409
8.092
8.071
7.796
7.492
7.472
7.432
7.413
7.305
7.291
7.284
7.273
7.253
7.079
7.060
7.042
3.340
2.738
2.505
2.500
2.496
Parameter Value
1 Title luolaichun-170627-7/ 3
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.01
3.06
2.00
5.02
1.03
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

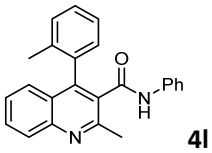

165.444
162.799
160.368
154.460
146.849
142.765
137.105
128.619
123.997
119.641
116.489
116.267
115.473
115.266
40.148
39.938
39.729
39.521
39.313
39.103
38.894
23.064
Parameter Value
1 Title luolaichun-170627-7/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 300
6 Spectrometer Frequency 100.62
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


tBuOOC
O
N
Ph
H
N

4k


10.516
8.100
8.079
7.951
7.824
7.820
7.668
7.663
7.640
7.621
7.567
7.563
7.560
7.546
7.542
7.452
7.449
7.430
7.420
7.417
7.413
7.397
7.271
7.251
7.231
7.069
7.051
2.737
2.500
1.486
Parameter Value
1 Title luolaichun-20170926-9/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 296.7
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
2.00
1.02
1.04
3.04
3.06
2.00
1.03
2.98
9.11
f1 (ppm)

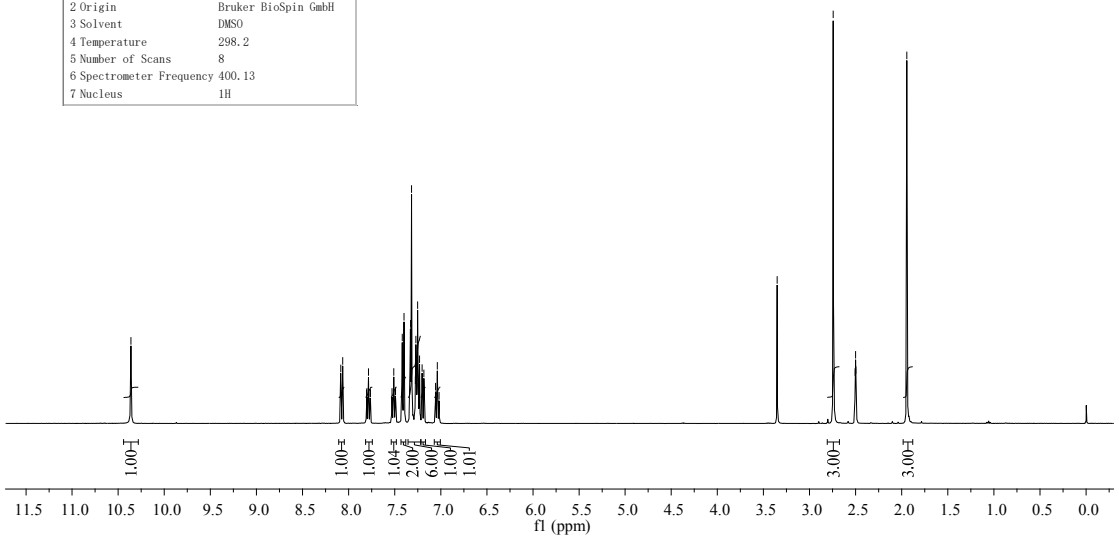

165.941
164.934
154.924
147.381
143.659
138.701
135.674
134.317
131.723
131.429
130.650
130.213
129.538
129.126
129.036
127.434
126.148
125.093
124.475
120.225
81.450
40.631
40.630
40.422
40.213
40.005
39.795
39.587
39.378
28.162
23.551
Parameter Value
1 Title luolaichun-20170926-9/ 4
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.5
5 Number of Scans 368
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



4l

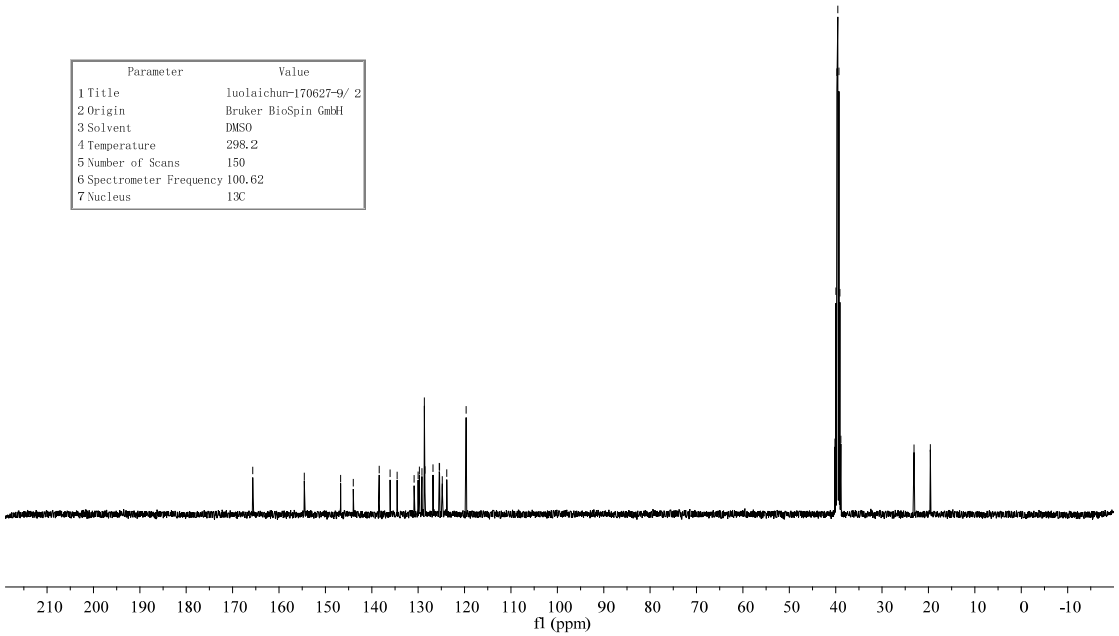
10.362
8.085
8.065
7.764
7.400
7.329
7.318
7.276
7.270
7.251
7.231
7.203
7.183
7.056
7.038
7.020
3.351
2.743
2.500
2.496
1.945

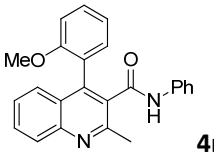
Parameter	Value
1 Title	luolaichun-170627-9/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



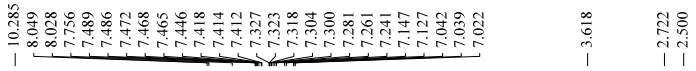
165.671
154.547
143.986
138.409
128.643
125.471
123.837
119.672
40.147
39.937
39.728
39.521
39.312
39.102
38.897
23.110
19.584

Parameter	Value
1 Title	luolaichun-170627-9/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	150
6 Spectrometer Frequency	100.62
7 Nucleus	13C

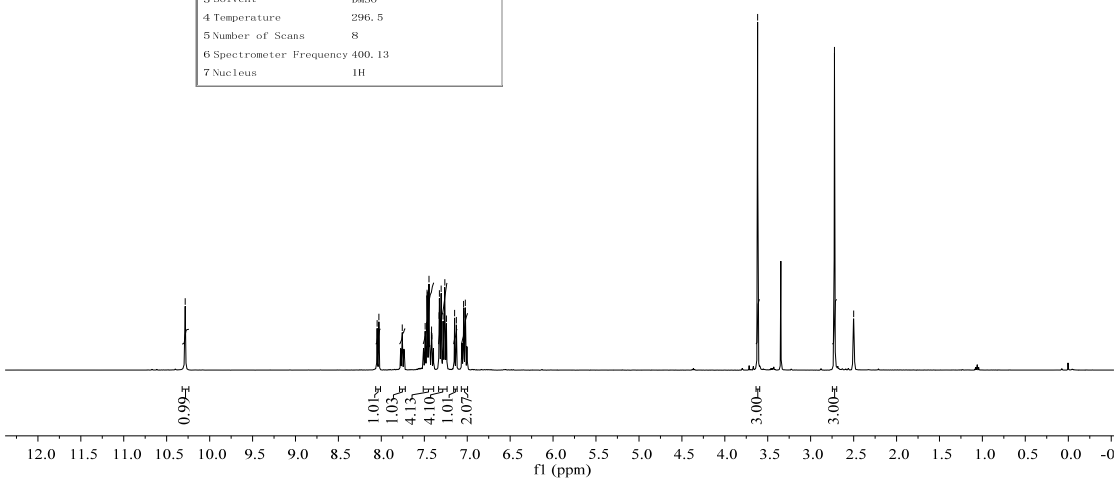




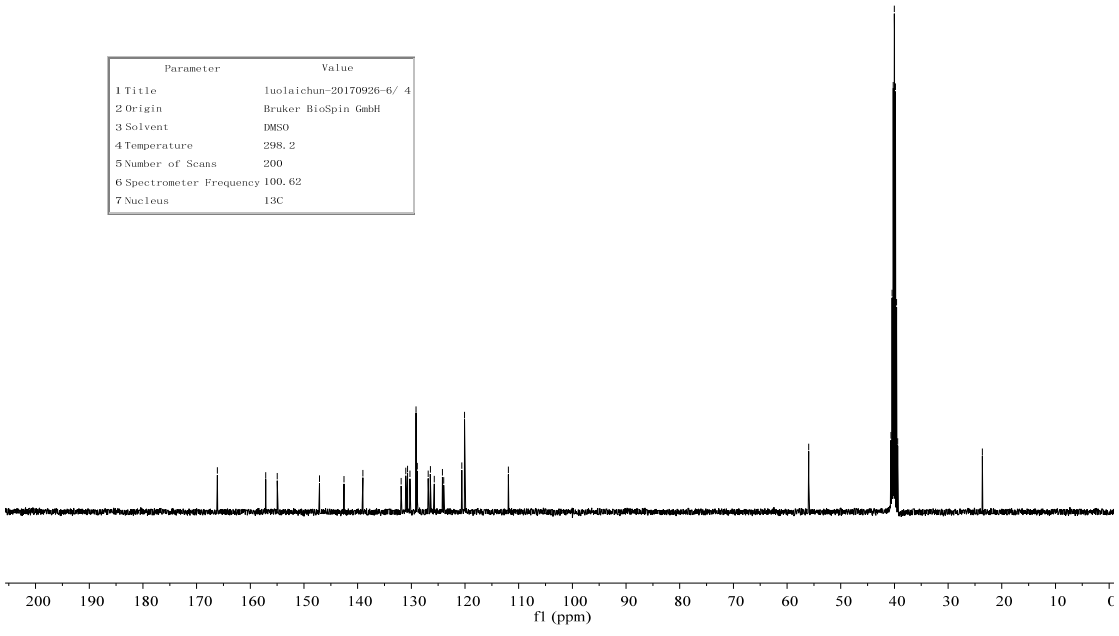
4m

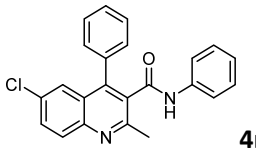


Parameter	Value
1 Title	luolaichun-20170926-6/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	296.5
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

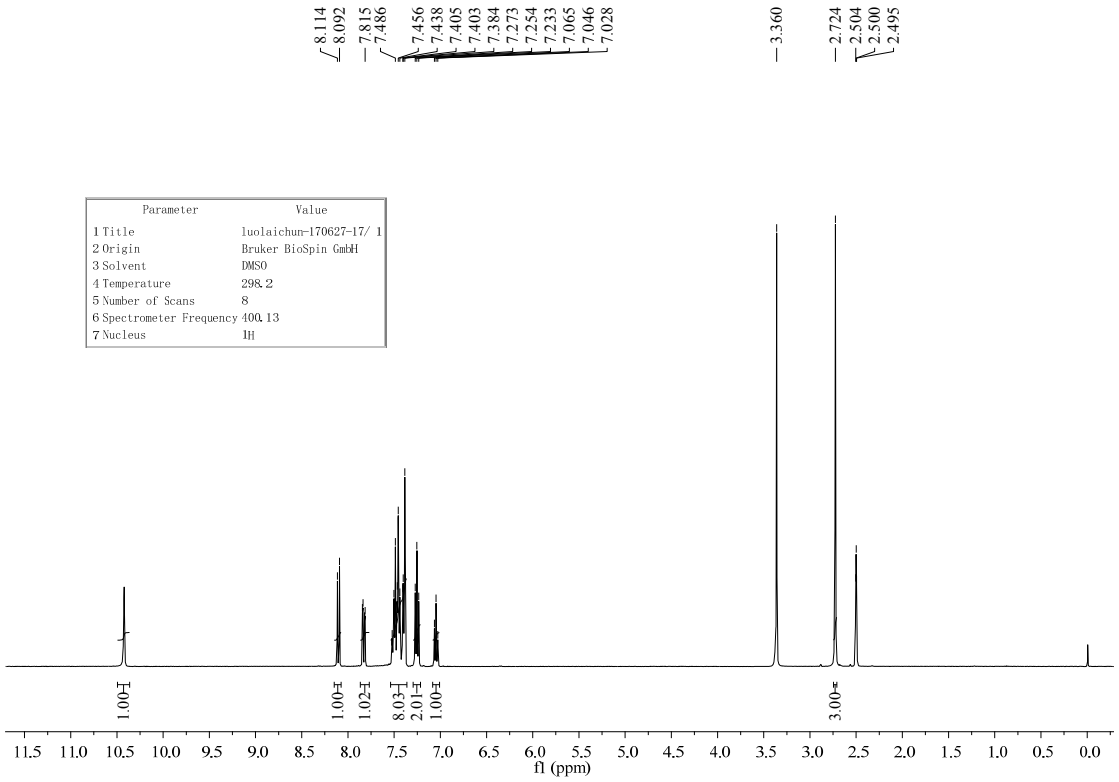


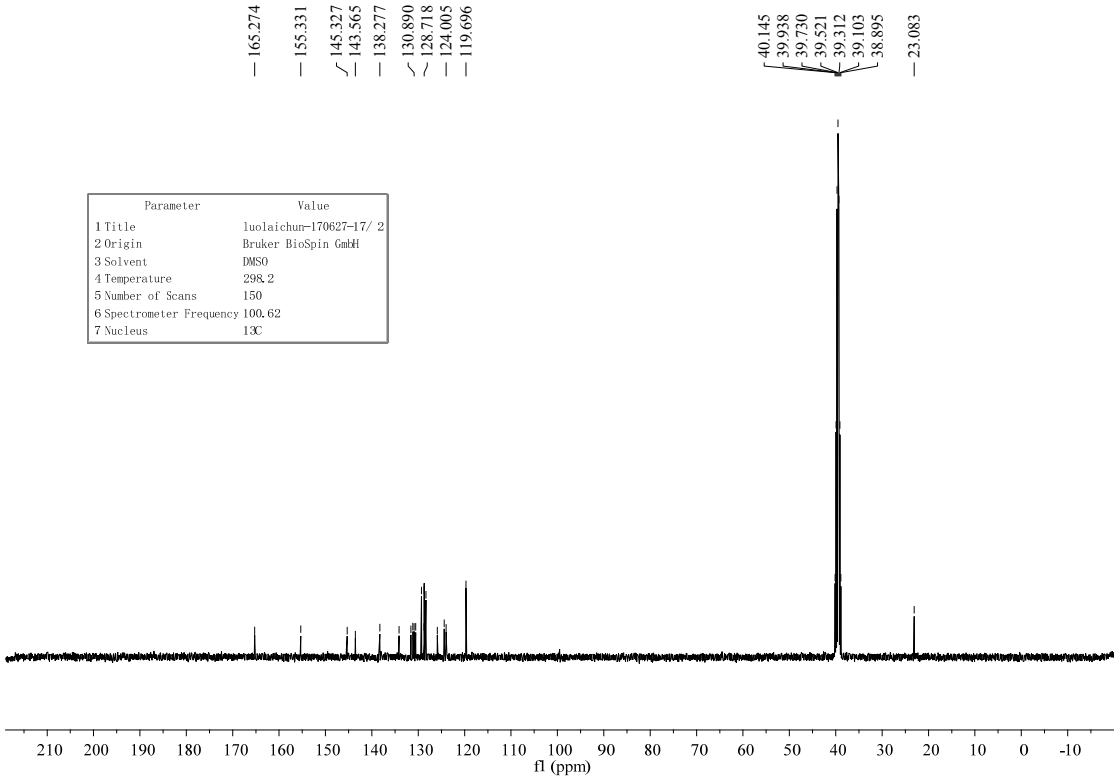
Parameter	Value
1 Title	luolaichun-20170926-6/ 4
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	200
6 Spectrometer Frequency	100.62
7 Nucleus	13C

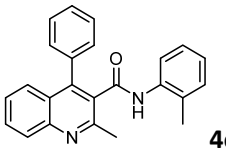



Cl
O
N
H
N

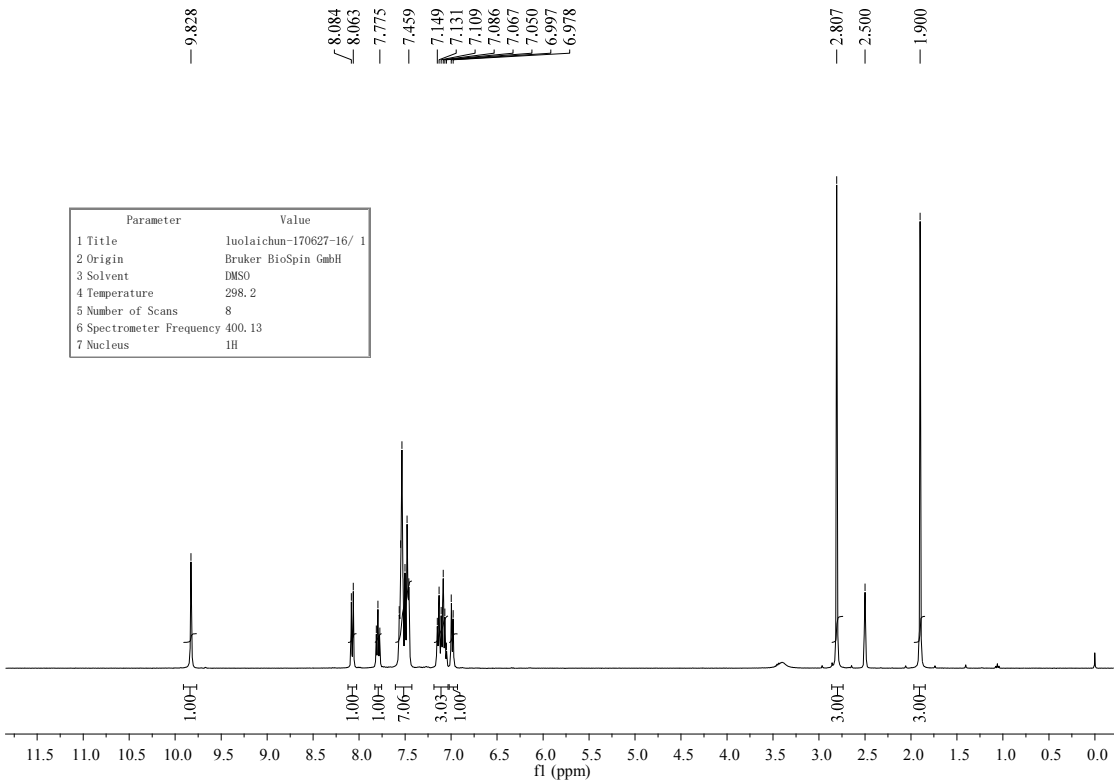
4n

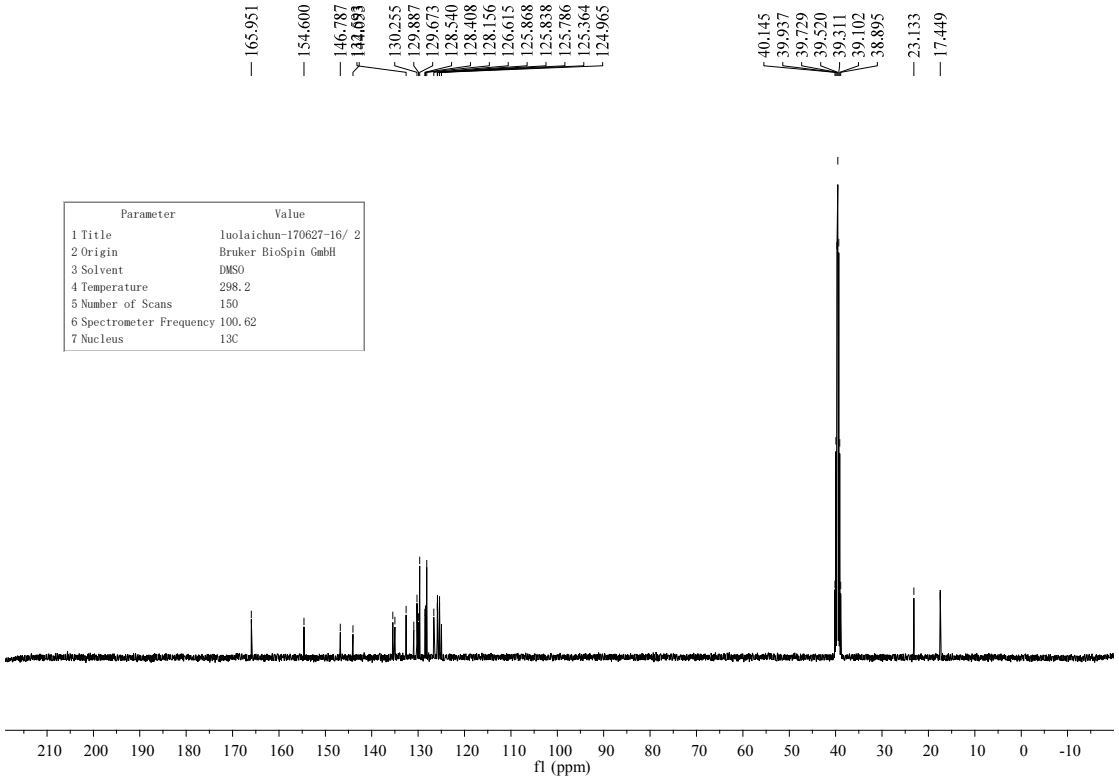

8.114
8.092
7.815
7.486
7.456
7.438
7.405
7.403
7.384
7.273
7.254
7.233
7.065
7.046
7.028
3.360
2.724
2.504
2.500
2.495
Parameter Value
1 Title luolaichun-170627-17/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.02
8.03
2.01
1.00
3.00
f1 (ppm)

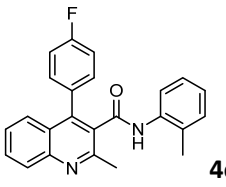

165.274
155.331
145.327
143.565
138.277
130.890
128.718
124.005
119.696
40.145
39.938
39.730
39.521
39.312
39.103
38.895
23.083
Parameter Value
1 Title luolaichun-170627-17/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



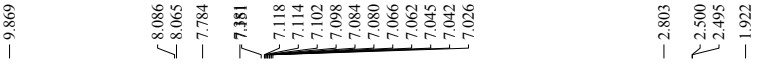
4o


9.828
8.084
8.063
7.775
7.459
7.149
7.131
7.109
7.086
7.067
7.050
6.997
6.978
2.807
2.500
1.900
Parameter Value
1 Title luolaichun-170627-16/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.00
7.06
3.03
1.00
3.00
3.00
f1 (ppm)

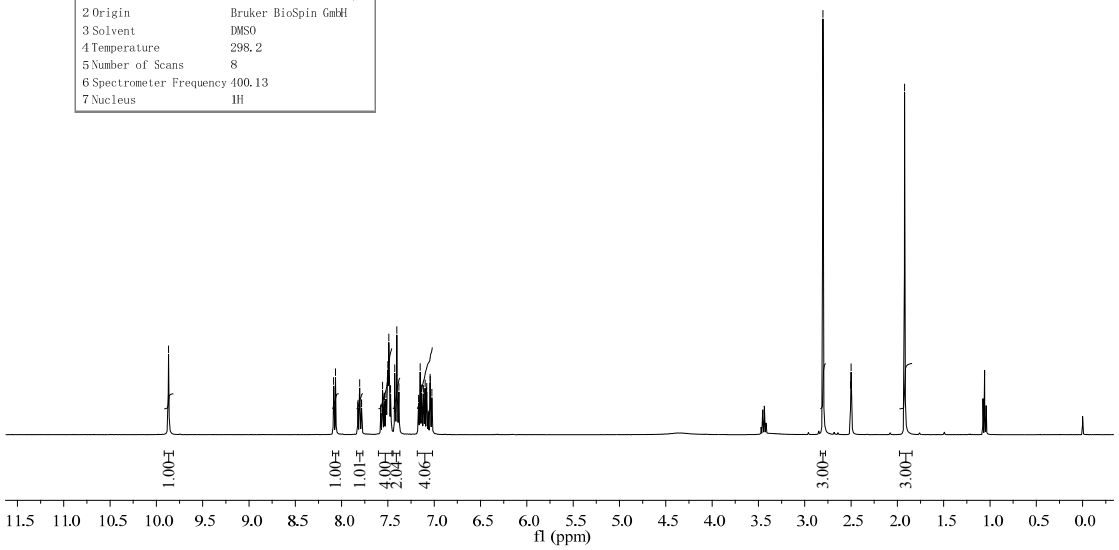

165.951
154.600
146.787
130.255
129.887
129.673
128.540
128.408
128.156
126.615
125.868
125.838
125.786
125.364
124.965
40.145
39.937
39.729
39.520
39.311
39.102
38.895
23.133
17.449
Parameter Value
1 Title luolaichun-170627-16/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



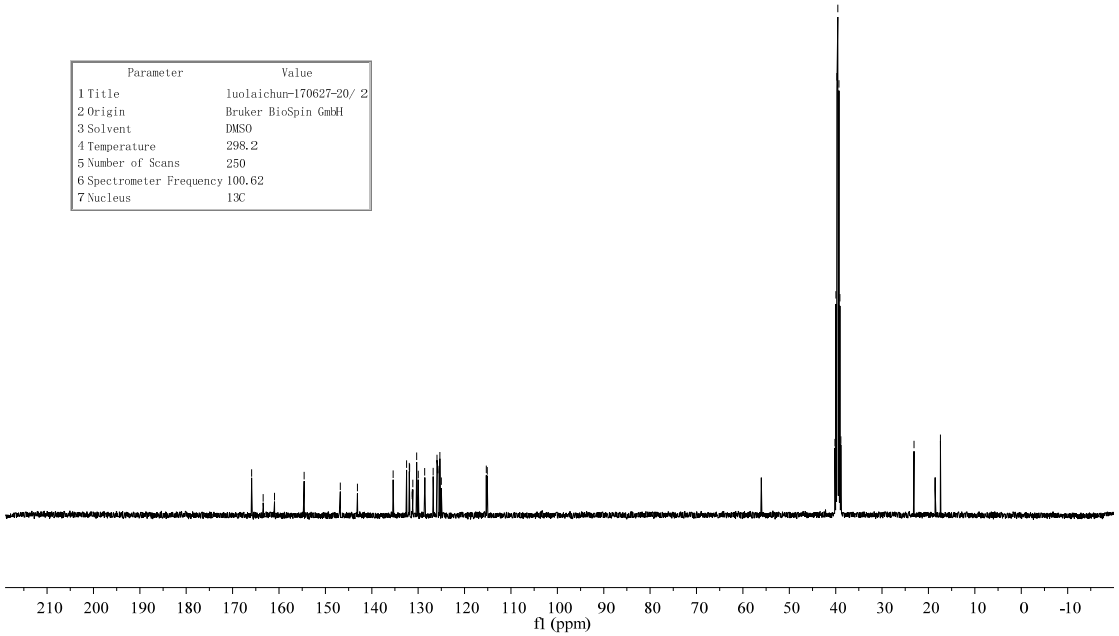
4o'

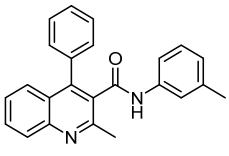


Parameter	Value
1 Title	luolaichun-170627-20/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

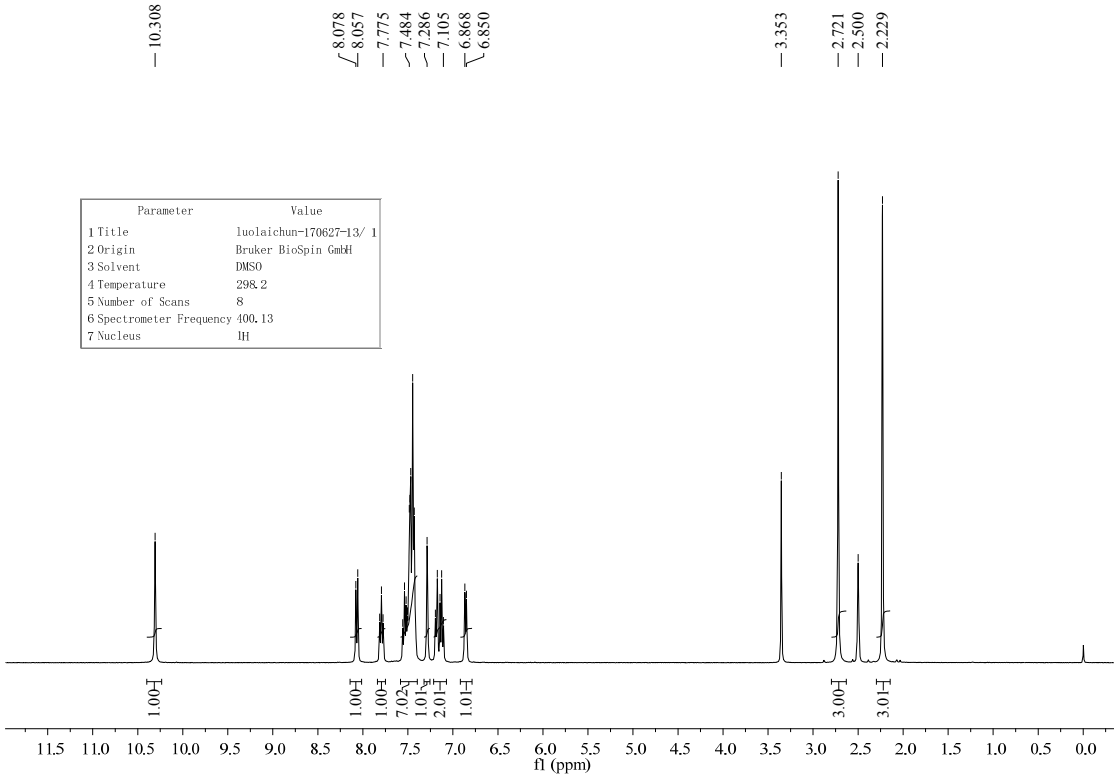


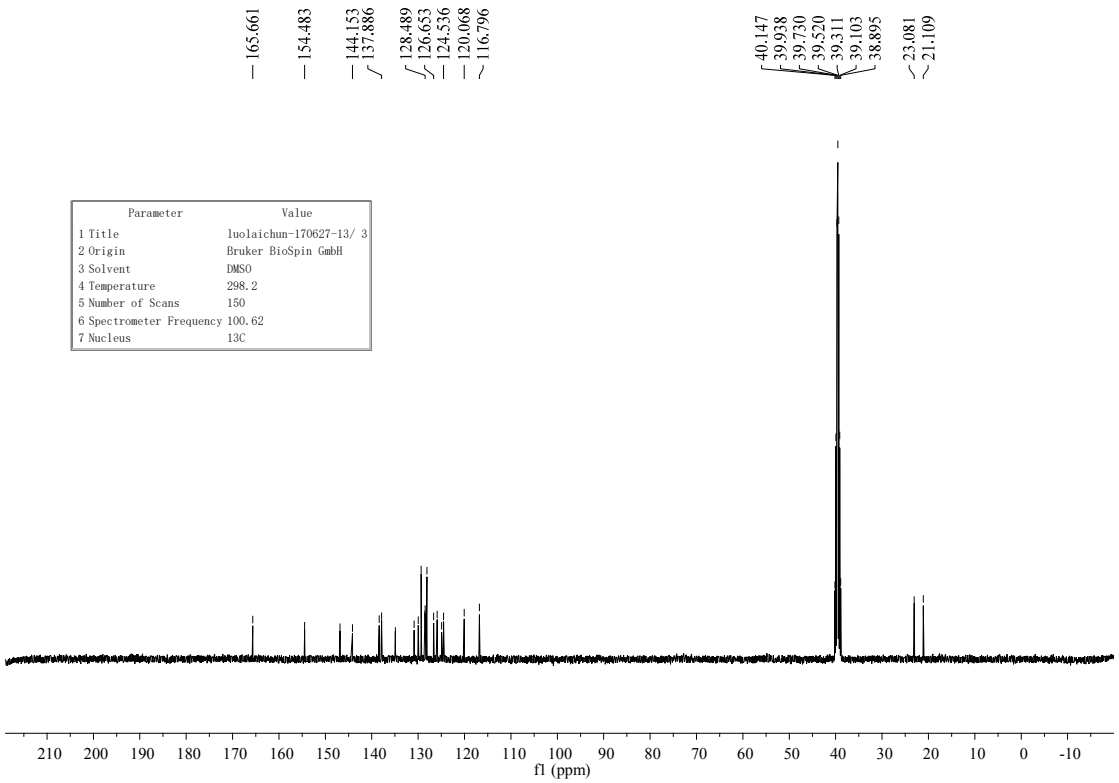
Parameter	Value
1 Title	luolaichun-170627-20/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	250
6 Spectrometer Frequency	100.62
7 Nucleus	13C

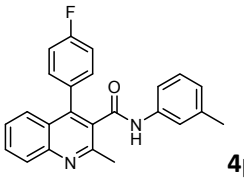




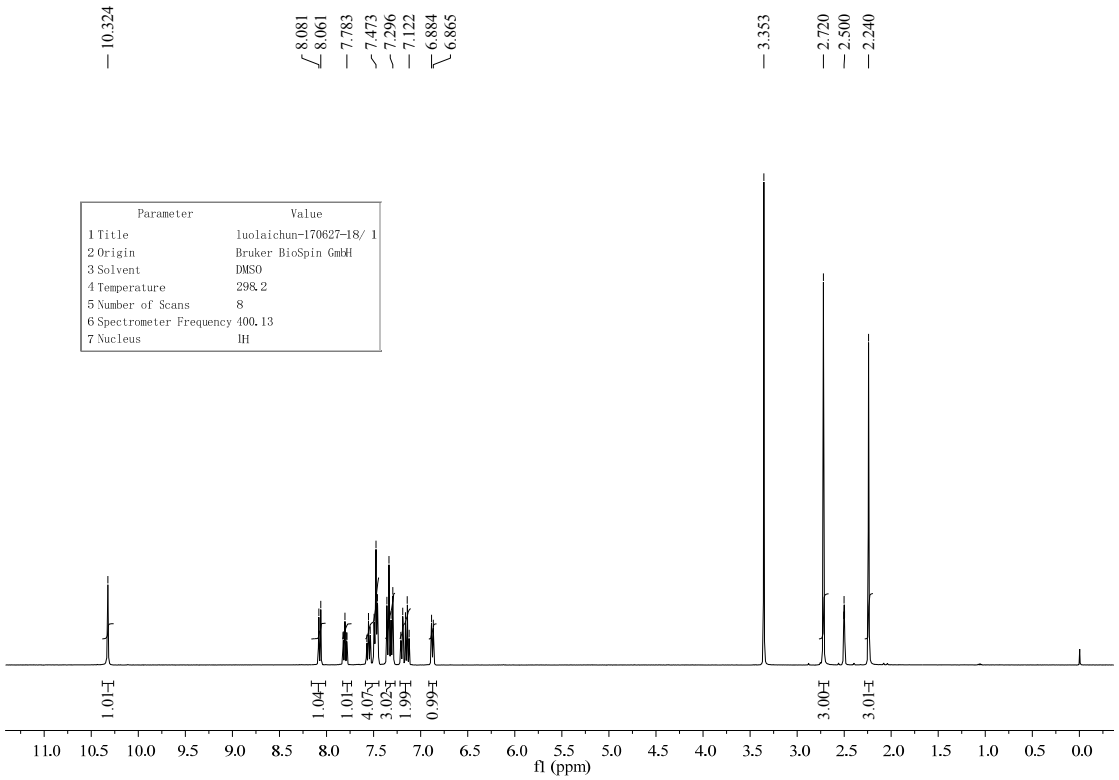
4p

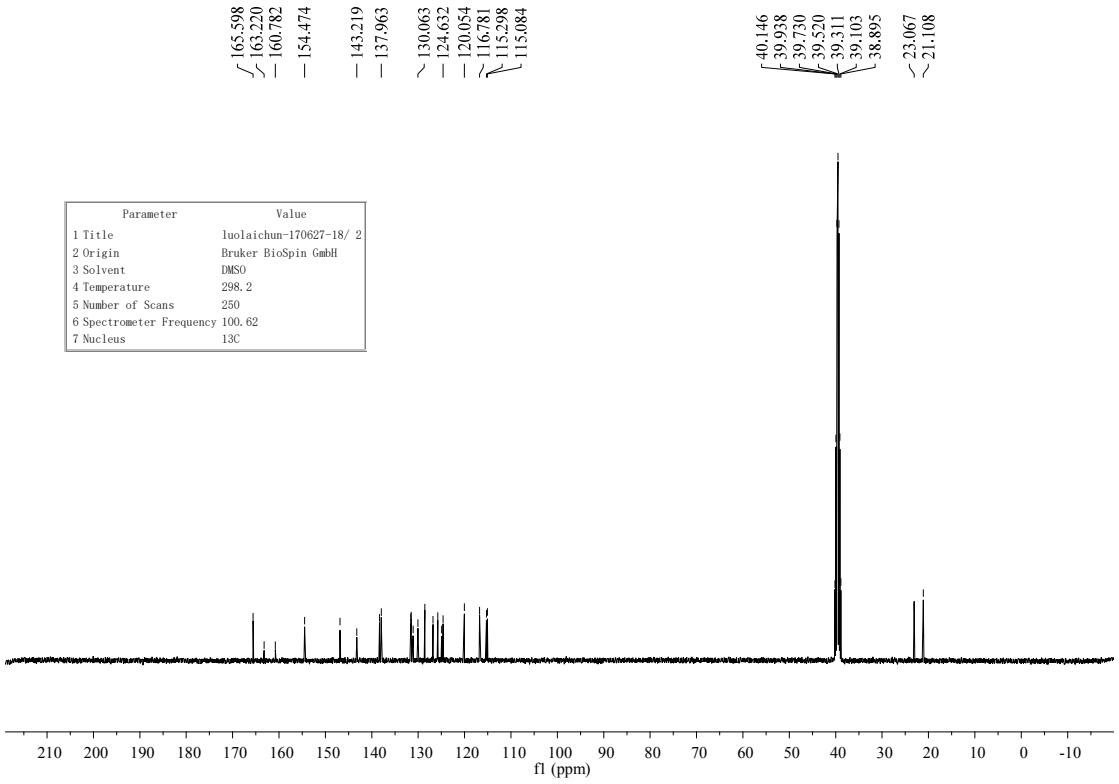

10.308
8.078
8.057
7.775
7.484
7.286
7.105
6.868
6.850
3.353
2.721
2.500
2.229
Parameter Value
1 Title luolaichun-170627-13/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.00
7.02
1.01
2.01
1.01
3.00
3.01
f1 (ppm)

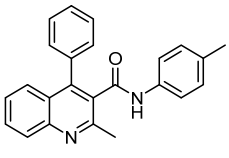

165.661
154.483
144.153
137.886
128.489
126.653
124.536
120.068
116.796
40.147
39.938
39.730
39.520
39.311
39.103
38.895
23.081
21.109
Parameter Value
1 Title luolaichun-170627-13/ 3
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)


F
O
N
H
N

4p'


10.324
8.081
8.061
7.783
7.473
7.296
7.122
6.884
6.865
3.353
2.720
2.500
2.240
Parameter Value
1 Title luolaichun-170627-18/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.01
1.04
1.01
4.07
3.02
1.99
0.99
3.00
3.01
f1 (ppm)


165.598
163.220
160.782
154.474
143.219
137.963
130.063
124.632
120.054
116.781
115.298
115.084
40.146
39.938
39.730
39.520
39.311
39.103
38.895
23.067
21.108
Parameter Value
1 Title luolaichun-170627-18/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 250
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



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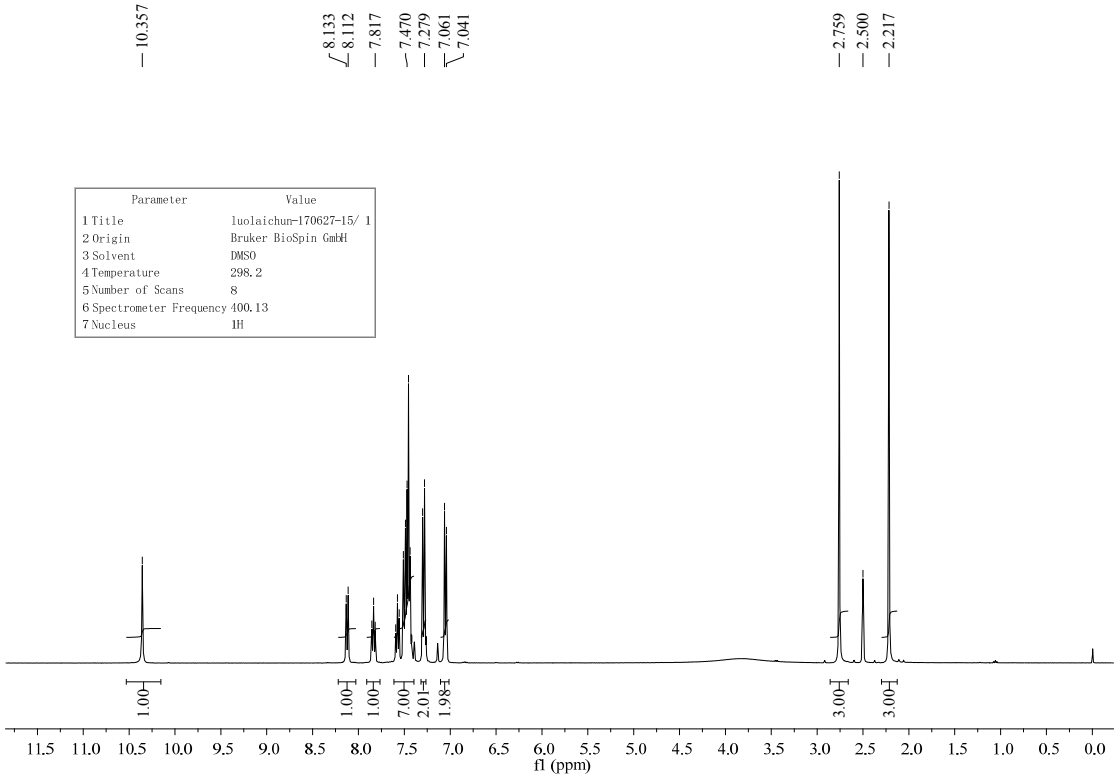
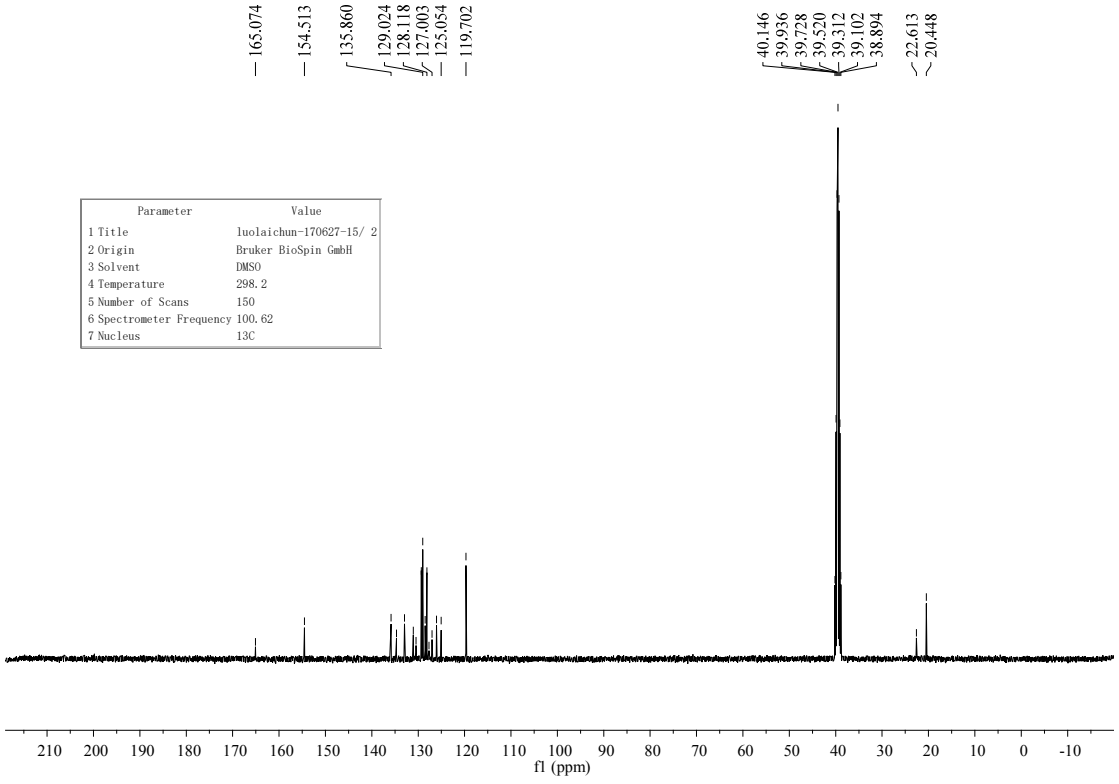
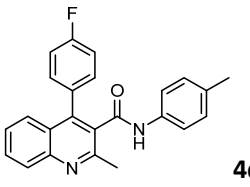
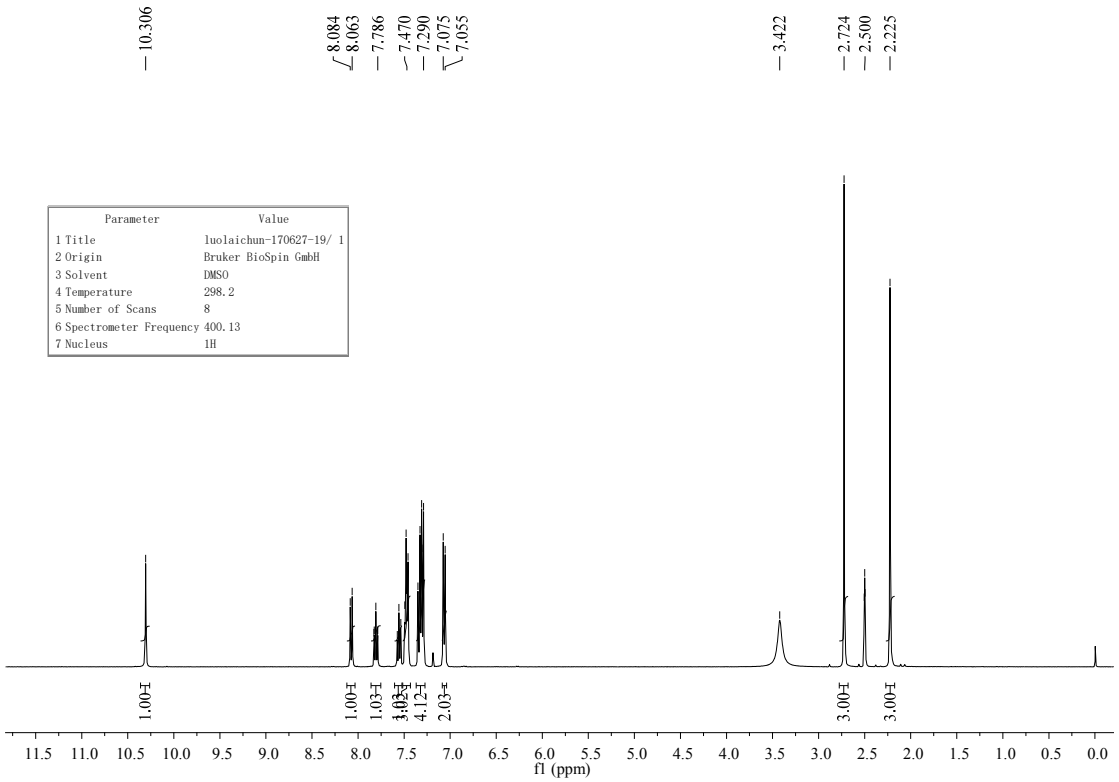
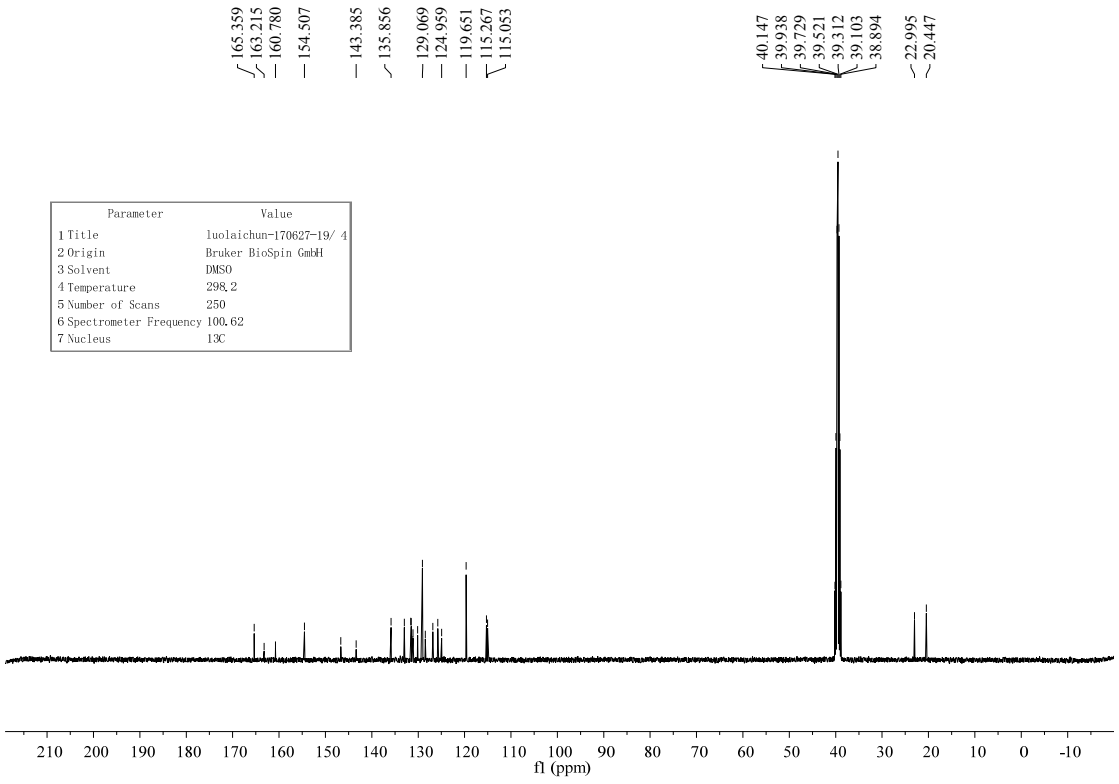

10.357
8.133
8.112
7.817
7.470
7.279
7.061
7.041
2.759
2.500
2.217
Parameter Value
1 Title luolaichun-170627-15/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.00
7.00
2.01
1.98
3.00
3.00
f1 (ppm)

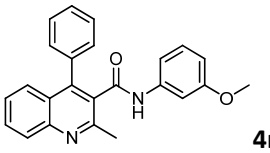

165.074
154.513
135.860
129.024
128.118
127.003
125.054
119.702
40.146
39.936
39.728
39.520
39.312
39.102
38.894
22.613
20.448
Parameter Value
1 Title luolaichun-170627-15/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)


F
O
N
H
N

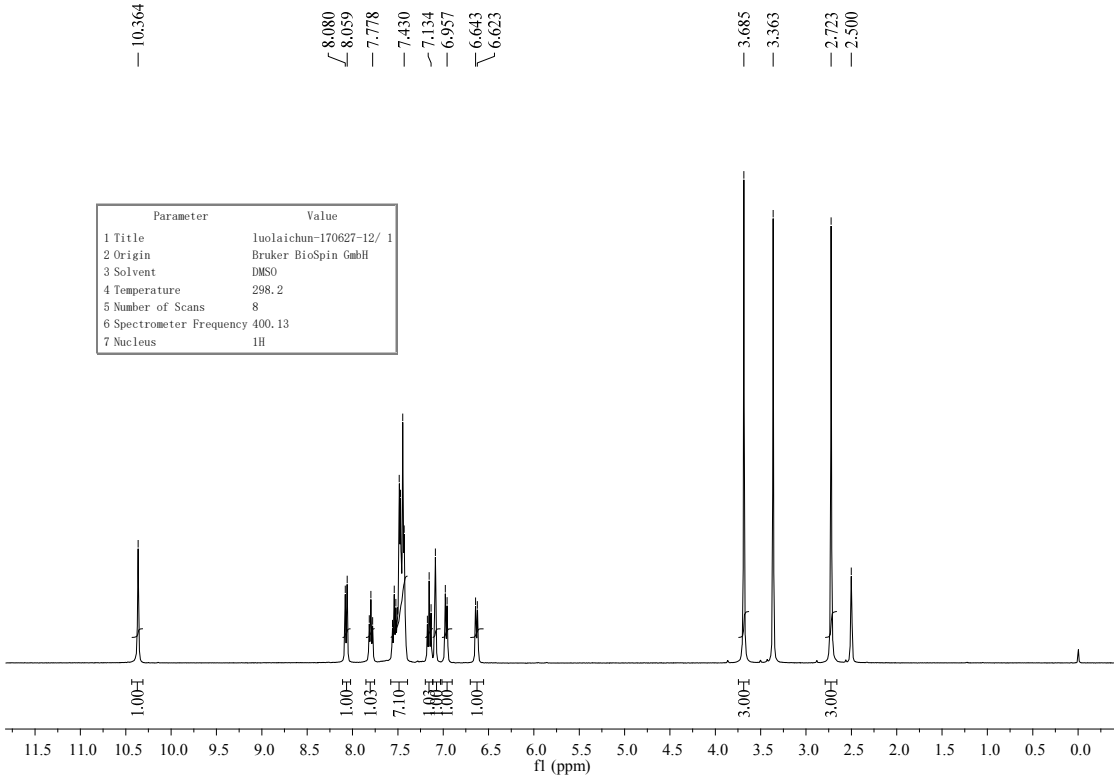
4q'

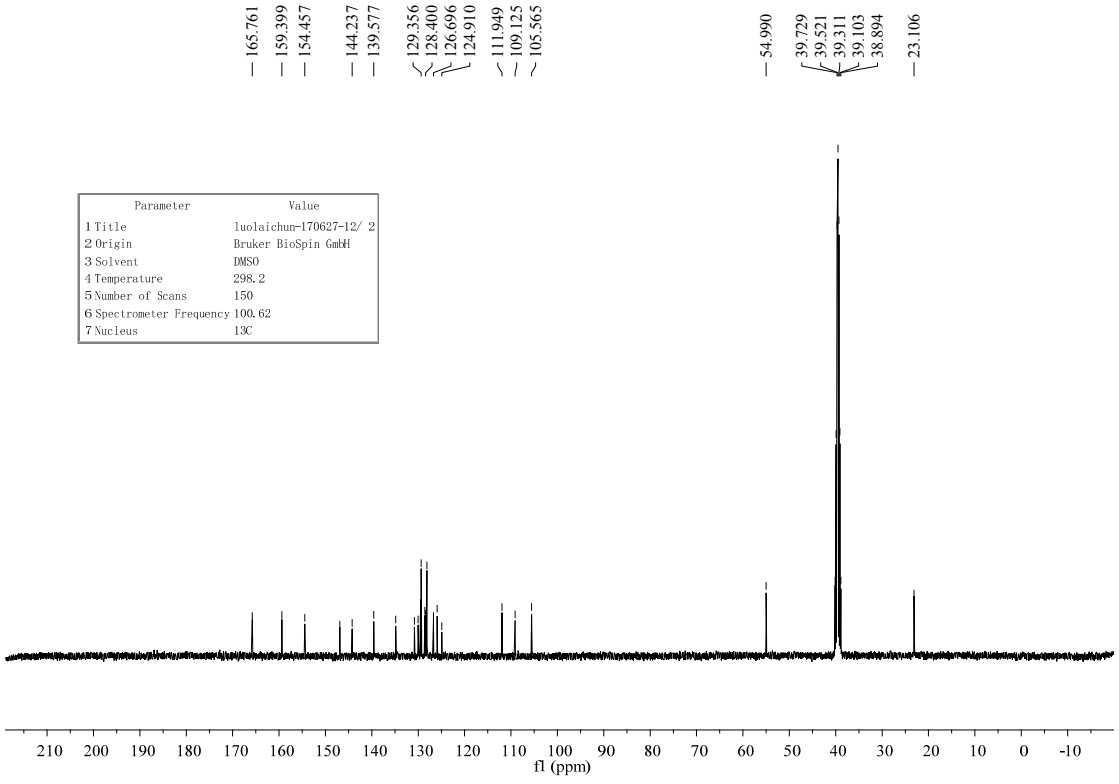

10.306
8.084
8.063
7.786
7.470
7.290
7.075
7.055
3.422
2.724
2.500
2.225
Parameter Value
1 Title luolaichun-170627-19/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.03
1.03
1.03
4.12
2.03
3.00
3.00
f1 (ppm)

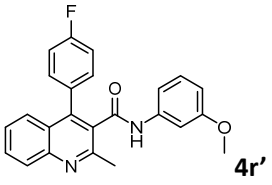

165.359
163.215
160.780
154.507
143.385
135.856
129.069
124.959
119.651
115.267
115.053
40.147
39.938
39.729
39.521
39.312
39.103
38.894
22.995
20.447
Parameter Value
1 Title luolaichun-170627-19/ 4
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 250
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



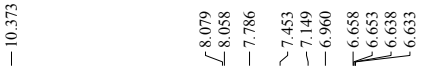
4r


10.364
8.080
8.059
7.778
7.430
7.134
6.957
6.643
6.623
3.685
3.363
2.723
2.500
Parameter Value
1 Title luolaichun-170627-12/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.03
7.10
1.00
3.00
3.00
f1 (ppm)

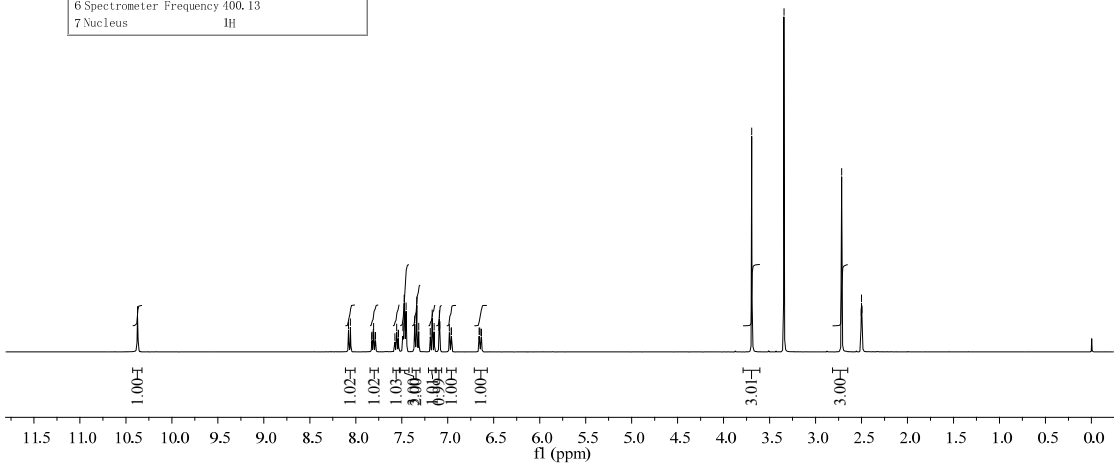

165.761
159.399
154.457
144.237
139.577
129.356
128.400
126.696
124.910
111.949
109.125
105.565
54.990
39.729
39.521
39.311
39.103
38.894
23.106
Parameter Value
1 Title luolaichun-170627-12/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)

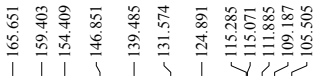


4r'

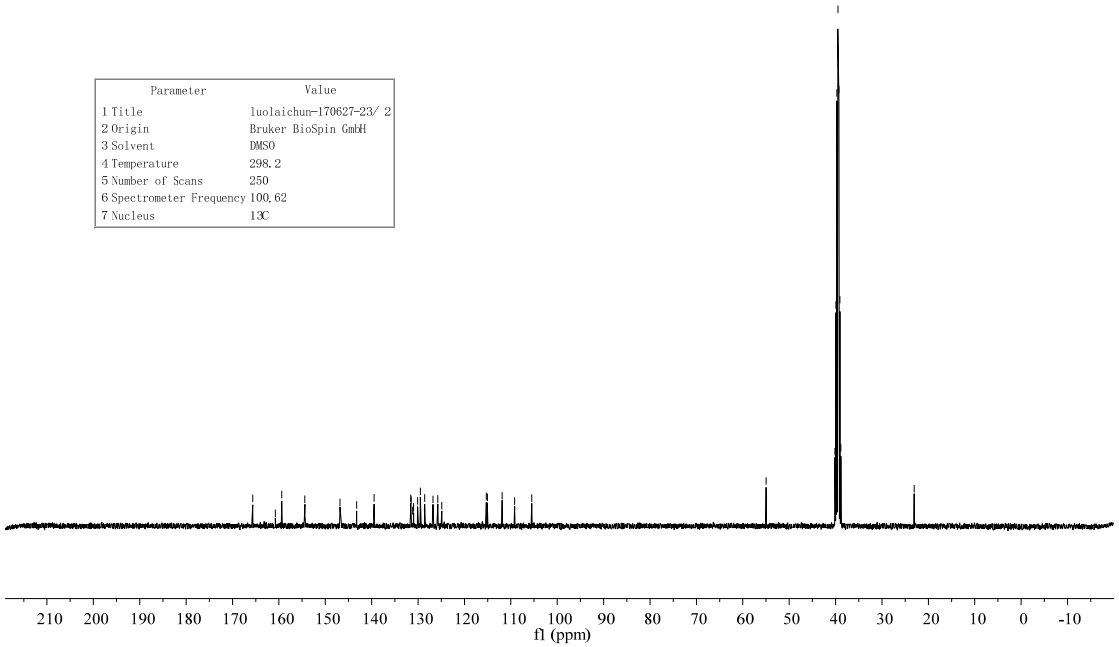


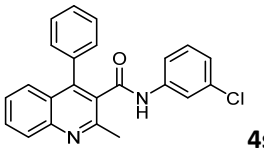
Parameter	Value
1 Title	luolaichun-170627-23/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



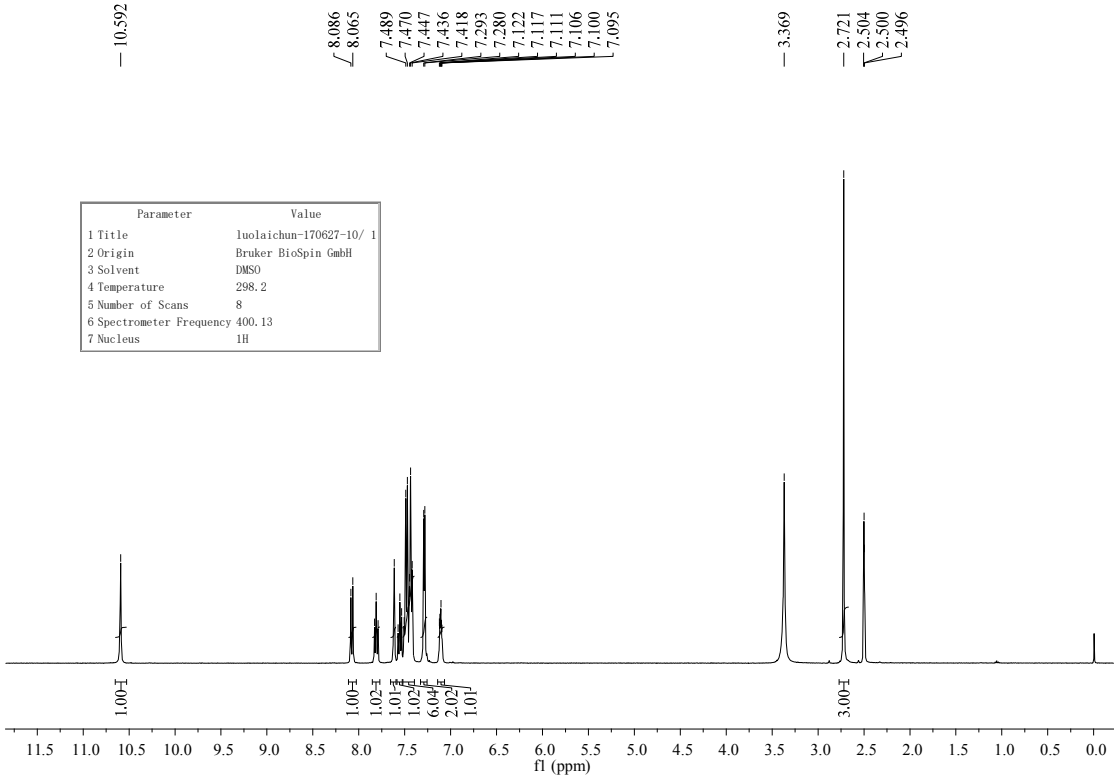


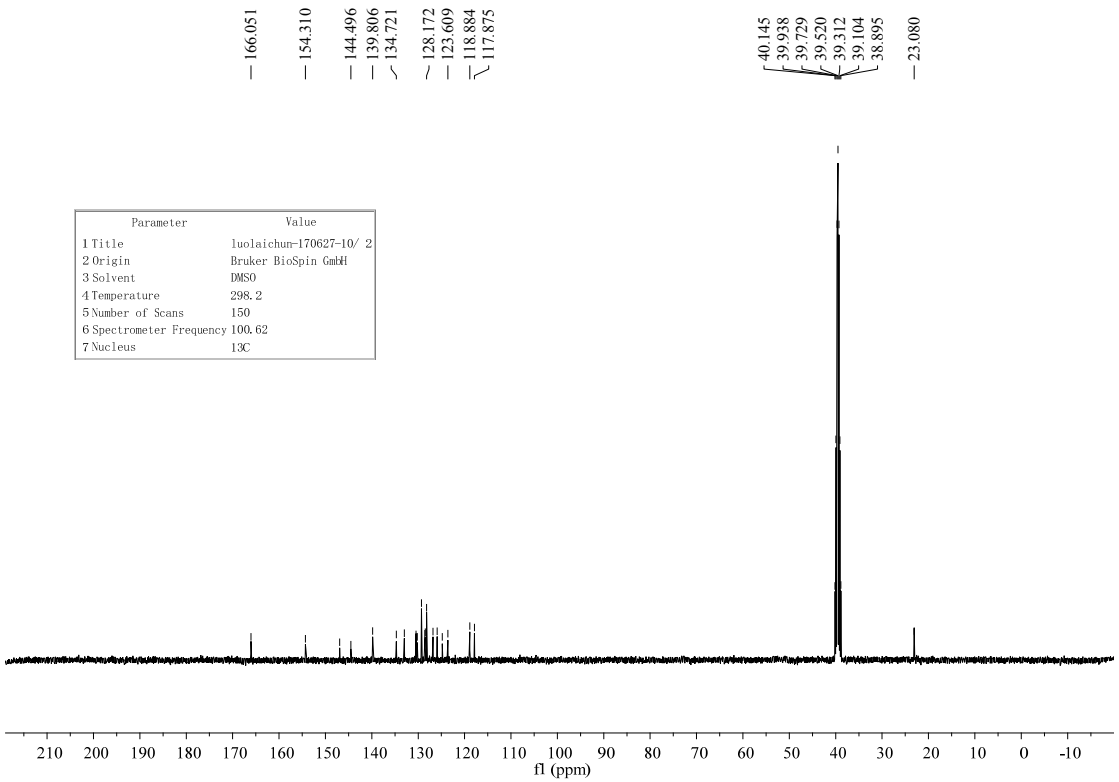
Parameter	Value
1 Title	luolaichun-170627-23/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	298.2
5 Number of Scans	250
6 Spectrometer Frequency	100.62
7 Nucleus	13C

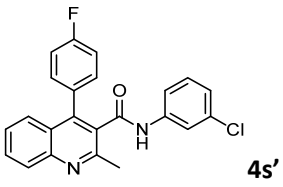




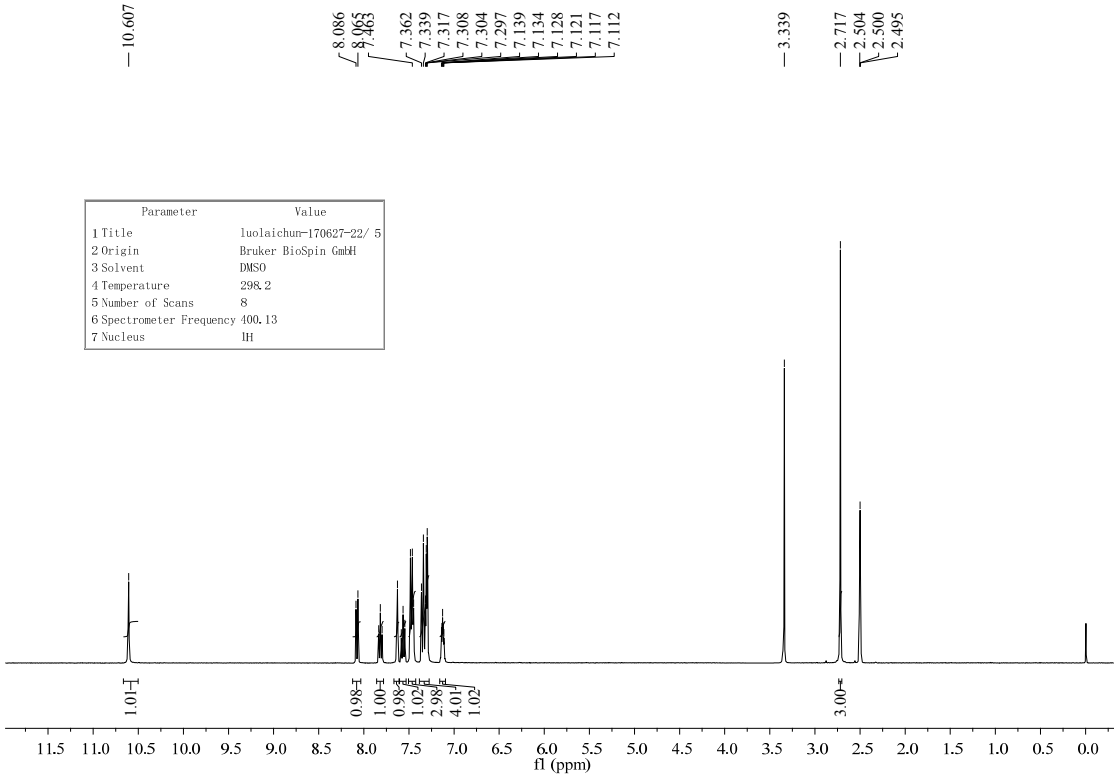
4s

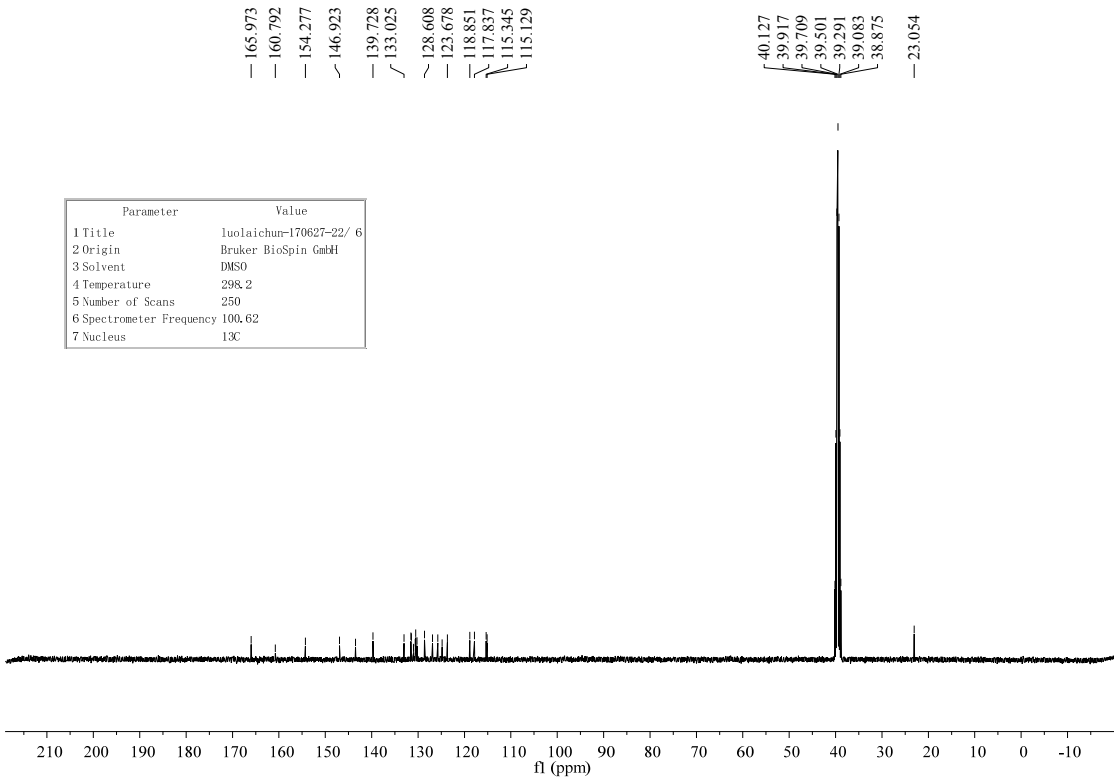

10.592
8.086
8.065
7.489
7.470
7.447
7.436
7.418
7.293
7.280
7.122
7.117
7.111
7.106
7.100
7.095
3.369
2.721
2.504
2.500
2.496
Parameter Value
1 Title luolaichun-170627-10/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.02
1.01
1.02
6.04
2.02
1.01
3.00
f1 (ppm)

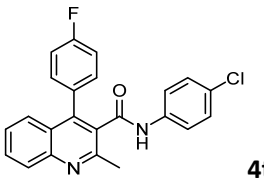

166.051
154.310
144.496
139.806
134.721
128.172
123.609
118.884
117.875
40.145
39.938
39.729
39.520
39.312
39.104
38.895
23.080
Parameter Value
1 Title luolaichun-170627-10/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)


F
O
N
H
Cl
N

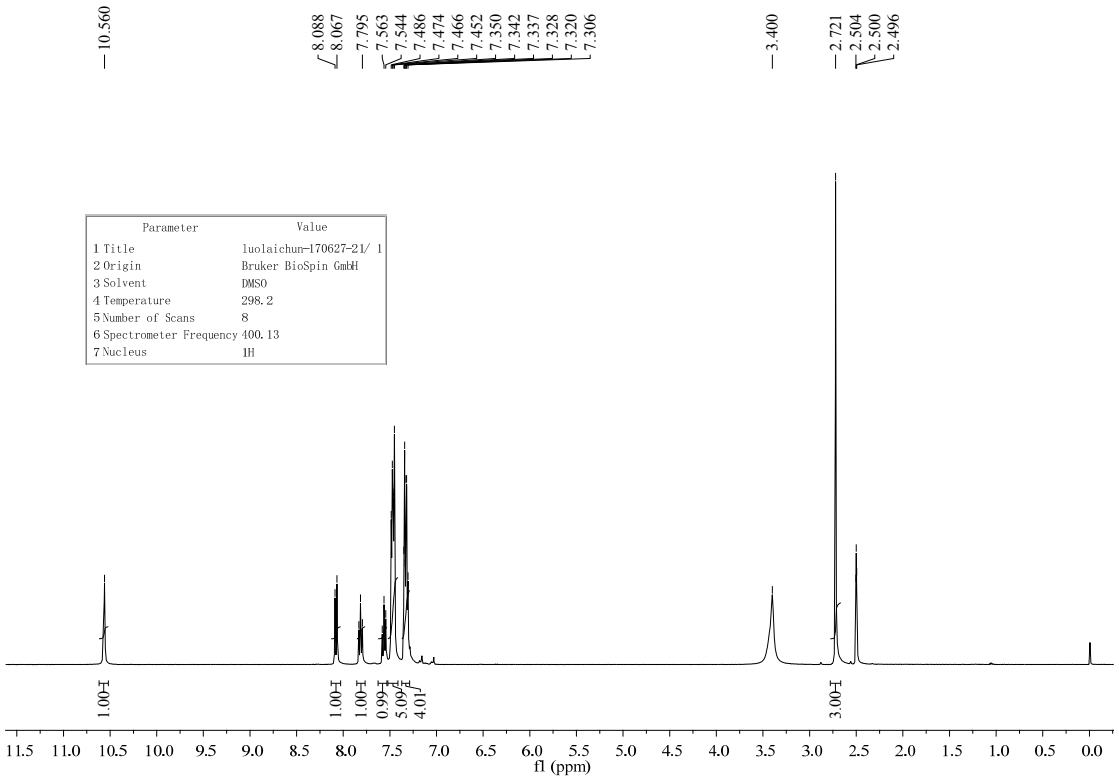
4s'

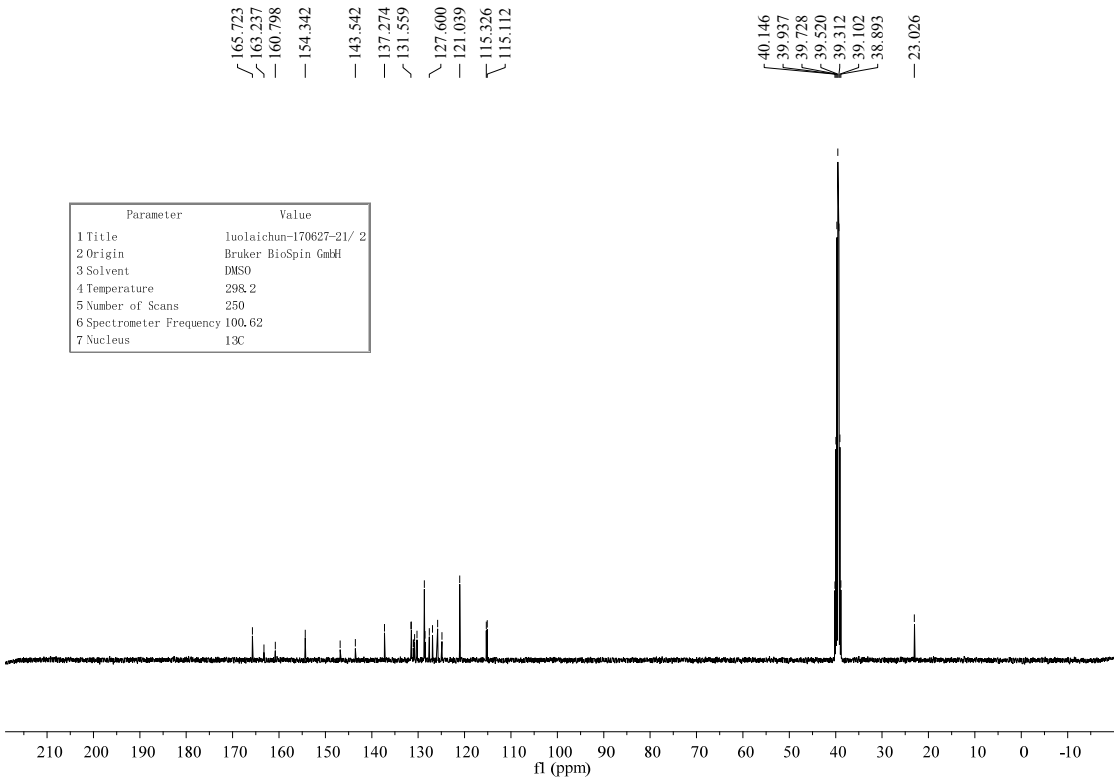

10.607
8.086
8.065
7.463
7.362
7.339
7.317
7.308
7.304
7.297
7.139
7.134
7.128
7.121
7.117
7.112
3.339
2.717
2.504
2.500
2.495
Parameter Value
1 Title luolaichun-170627-22/ 5
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.01
0.98
1.00
0.98
1.02
2.98
4.01
1.02
3.00
f1 (ppm)

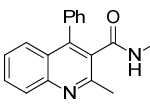

165.973
160.792
154.277
146.923
139.728
133.025
128.608
123.678
118.851
117.837
115.345
115.129
40.127
39.917
39.709
39.501
39.291
39.083
38.875
23.054
Parameter Value
1 Title luolaichun-170627-22/ 6
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 250
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)


F
O
N
H
Cl
N

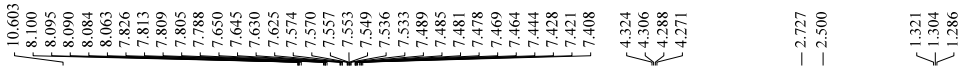
4t'

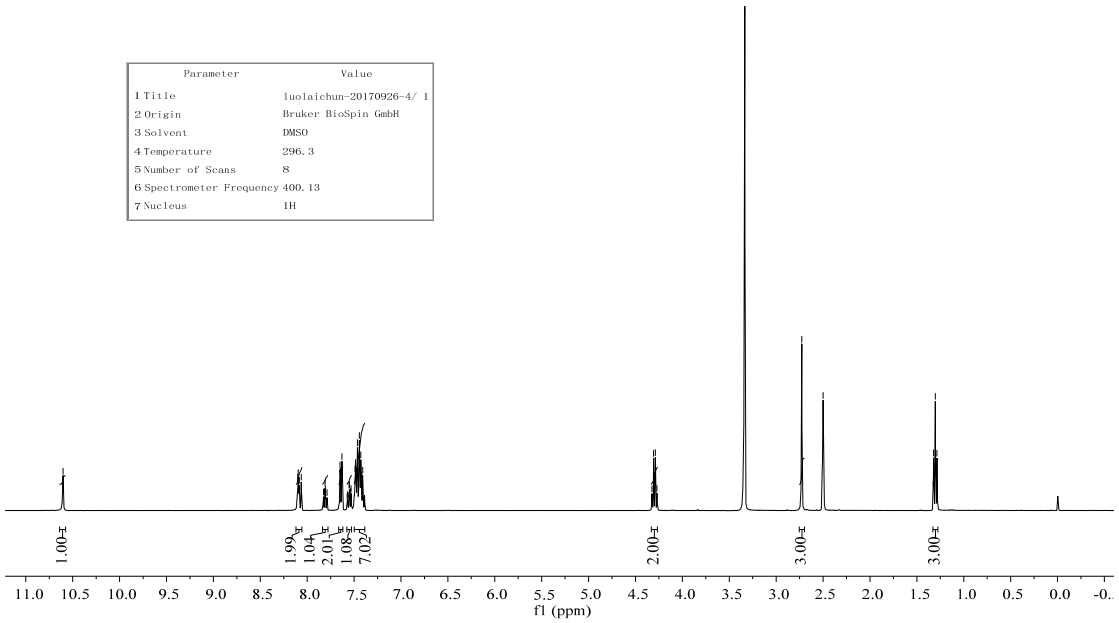

10.560
8.088
8.067
7.795
7.563
7.544
7.486
7.474
7.466
7.452
7.350
7.342
7.337
7.328
7.320
7.306
3.400
2.721
2.504
2.500
2.496
Parameter Value
1 Title luolaichun-170627-21/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.00
0.99
5.09
4.01
3.00
f1 (ppm)


165.723
163.237
160.798
154.342
143.542
137.274
131.559
127.600
121.039
115.326
115.112
40.146
39.937
39.728
39.520
39.312
39.102
38.893
23.026
Parameter Value
1 Title luolaichun-170627-21/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 250
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)

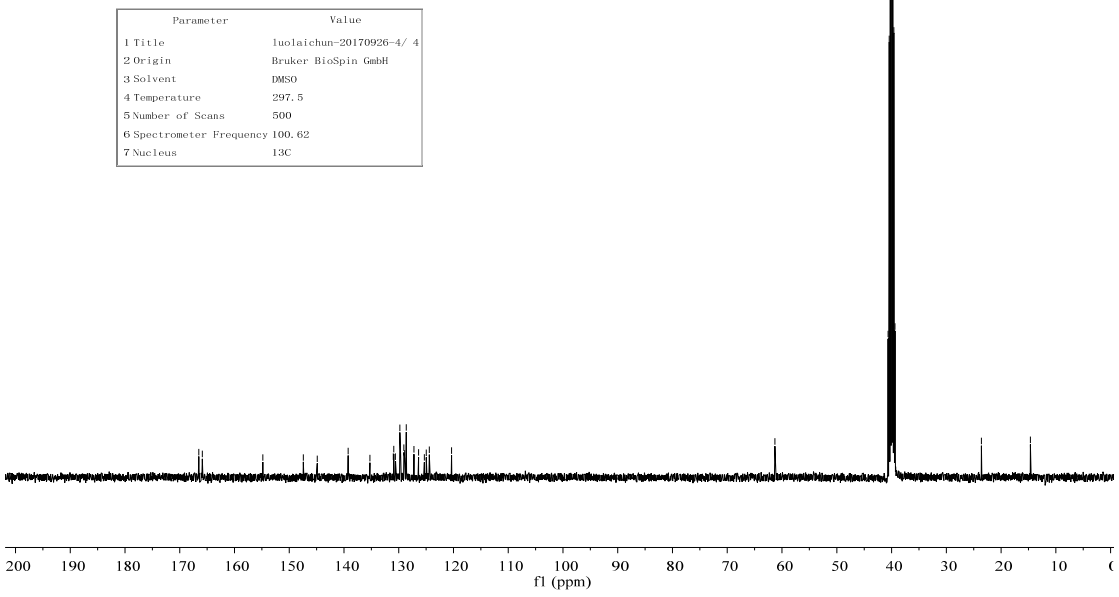

Ph
O
N
H
COOEt
N

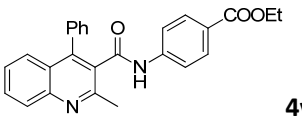
4u


10.603
8.100
8.095
8.090
8.084
8.063
7.826
7.813
7.809
7.805
7.788
7.650
7.645
7.630
7.625
7.574
7.570
7.557
7.553
7.549
7.536
7.533
7.489
7.485
7.481
7.478
7.469
7.464
7.444
7.428
7.421
7.408
4.324
4.306
4.288
4.271
2.727
2.500
1.321
1.304
1.286

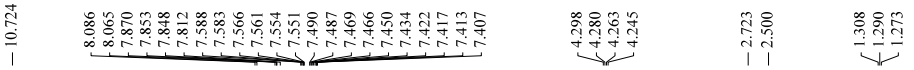

Parameter Value
1 Title luolaichun-20170926-4/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 296.3
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.99
1.04
2.01
1.08
7.02
2.00
3.00
3.00
f1 (ppm)


166.515
165.870
154.833
147.411
144.871
139.227
135.265
130.999
130.894
130.599
129.790
129.665
129.066
128.917
128.626
127.234
126.389
125.309
124.962
124.412
120.360
61.301
40.628
40.419
40.211
40.002
39.794
39.584
39.376
23.586
14.636

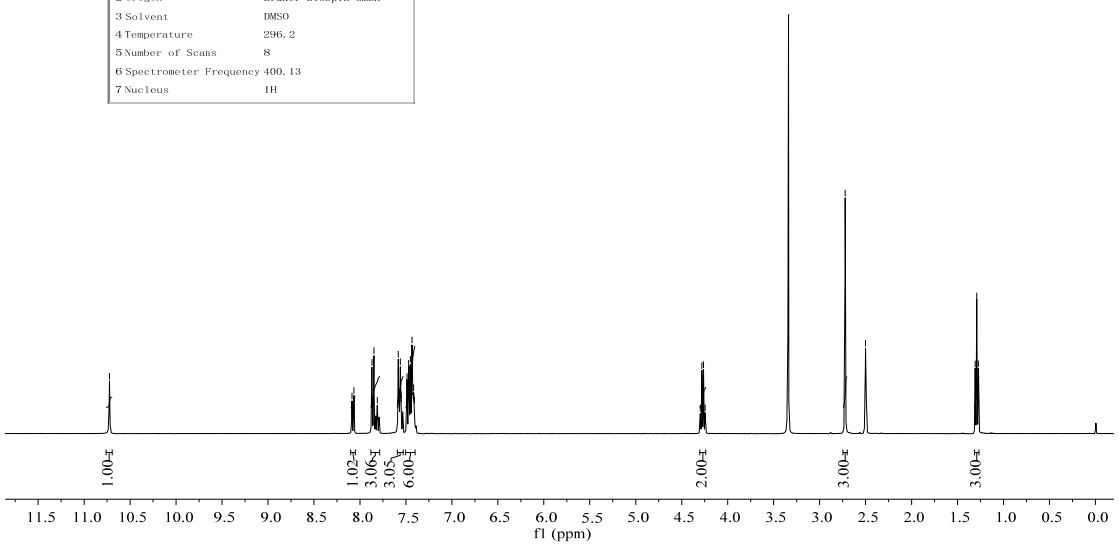

Parameter Value
1 Title luolaichun-20170926-4/ 4
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 297.5
5 Number of Scans 500
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



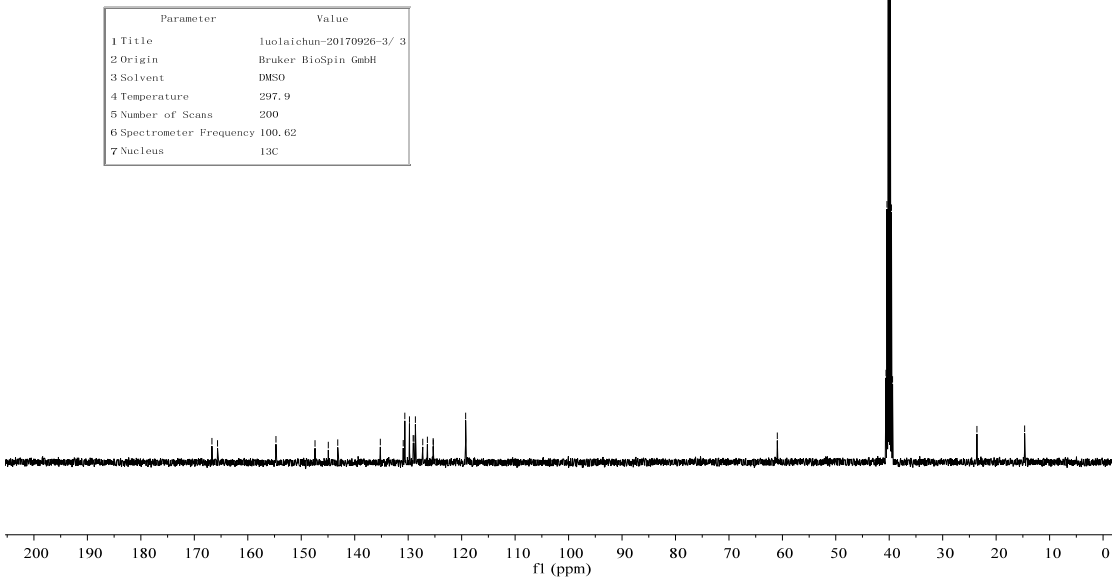
4v

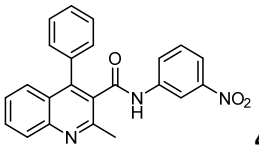


Parameter	Value
1 Title	luolaichun-20170926-3/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	296.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

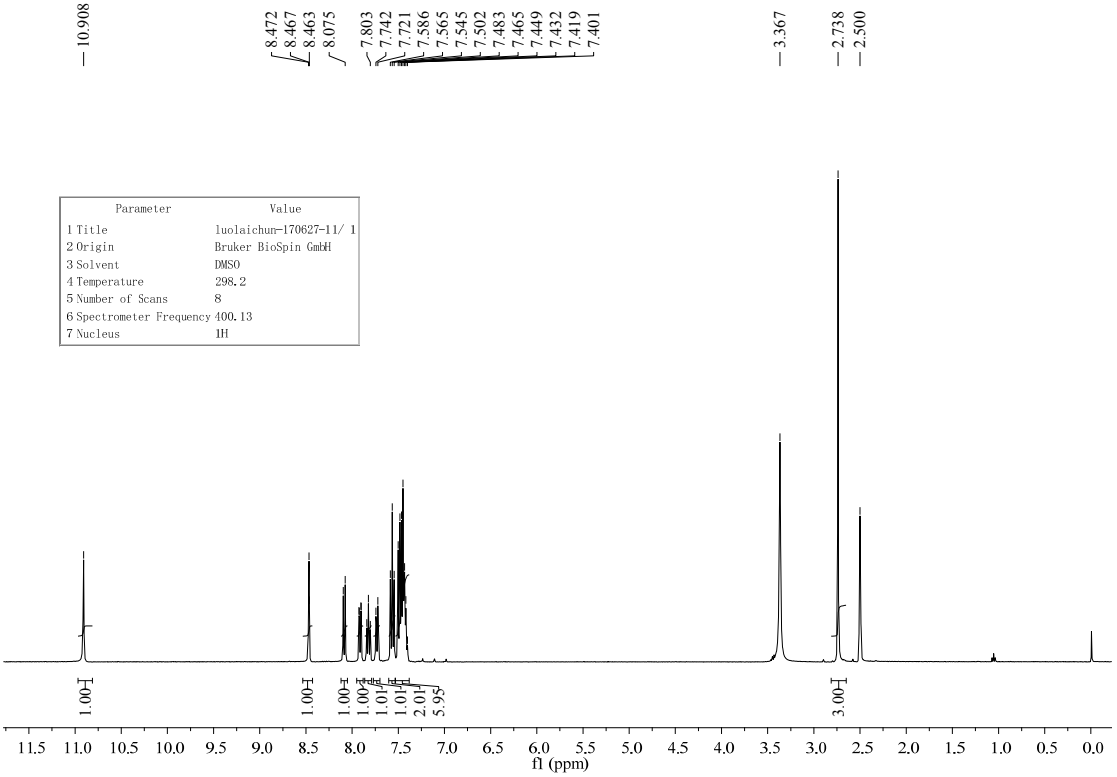


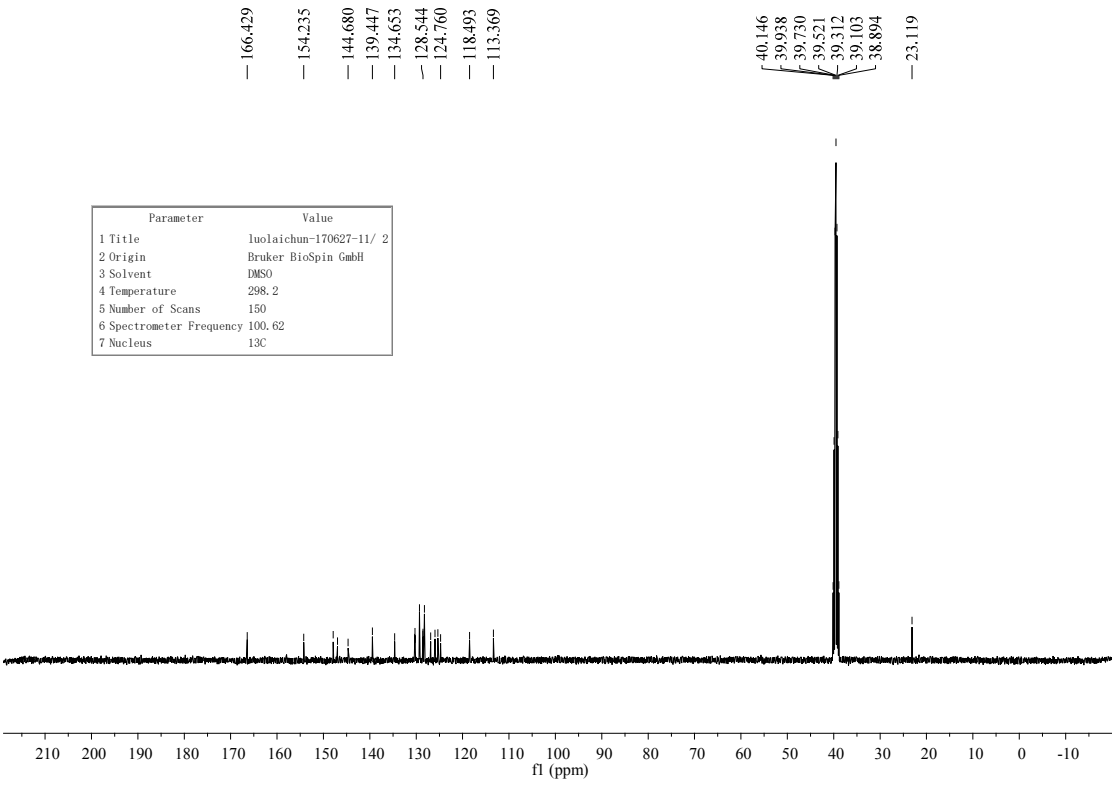
Parameter	Value
1 Title	luolaichun-20170926-3/ 3
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	297.9
5 Number of Scans	200
6 Spectrometer Frequency	100.62
7 Nucleus	13C

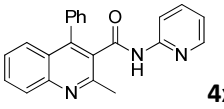




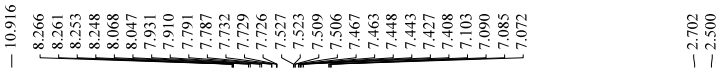
4w


10.908
8.472
8.467
8.463
8.075
7.803
7.742
7.721
7.586
7.565
7.545
7.502
7.483
7.465
7.449
7.432
7.419
7.401
3.367
2.738
2.500
Parameter Value
1 Title luolaichun-170627-11/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
1.00
1.00
1.01
1.01
2.01
5.95
3.00
f1 (ppm)

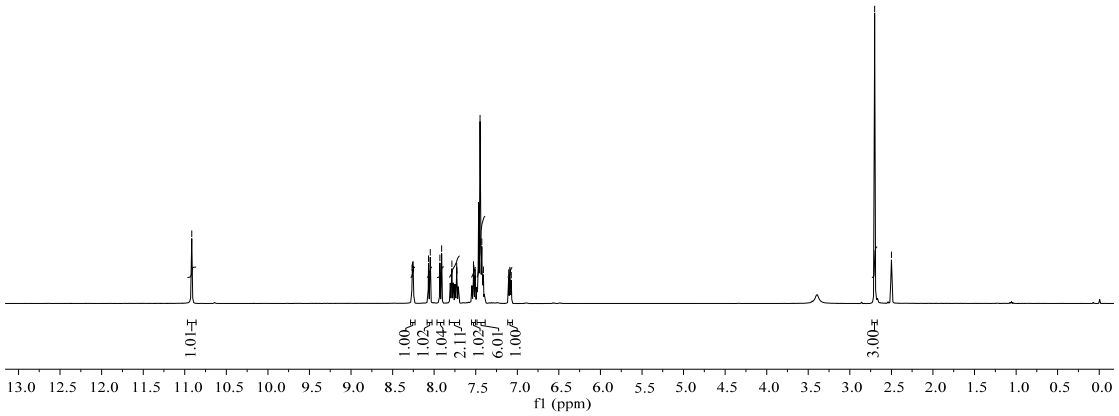

166.429
154.235
144.680
139.447
134.653
128.544
124.760
118.493
113.369
40.146
39.938
39.730
39.521
39.312
39.103
38.894
23.119
Parameter Value
1 Title luolaichun-170627-11/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent DMSO
4 Temperature 298.2
5 Number of Scans 150
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



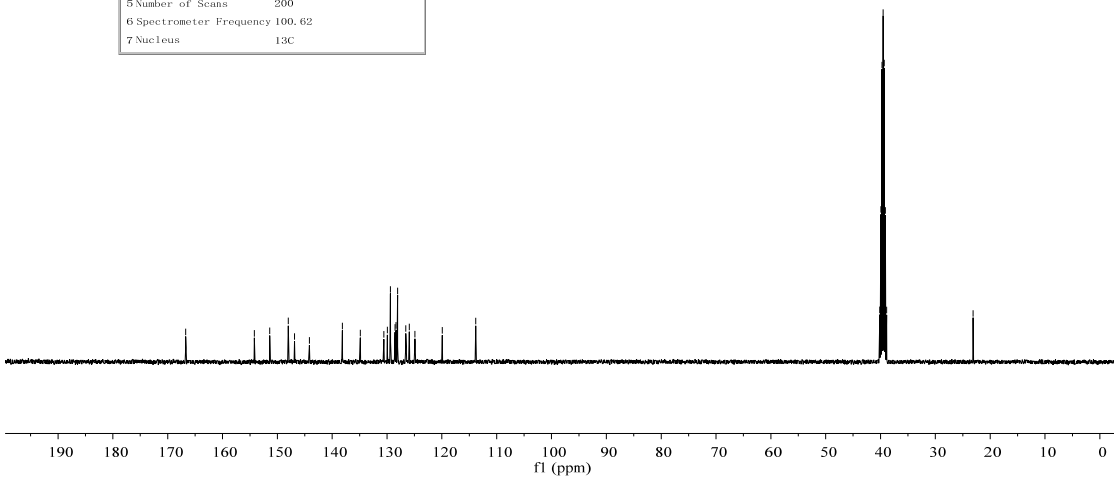
4x

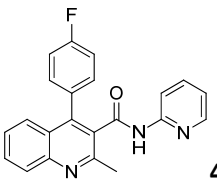


Parameter	Value
1 Title	luoalcihun-20170926-1/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	295.8
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

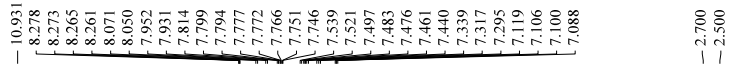


Parameter	Value
1 Title	luolaichun-20170926-1/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	297.6
5 Number of Scans	200
6 Spectrometer Frequency	100.62
7 Nucleus	13C

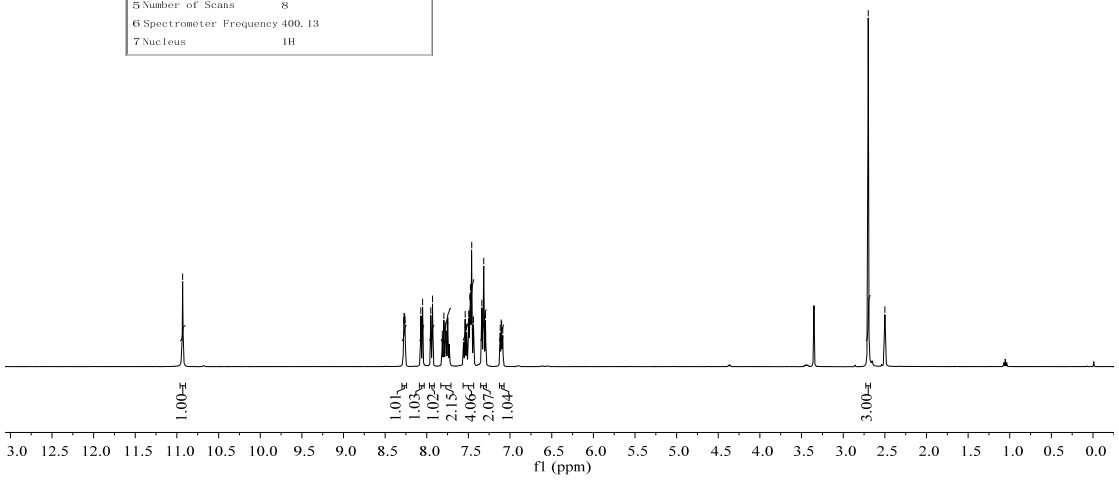


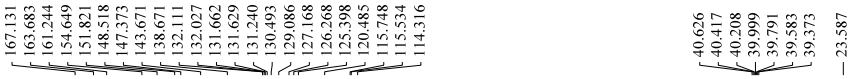


4x'

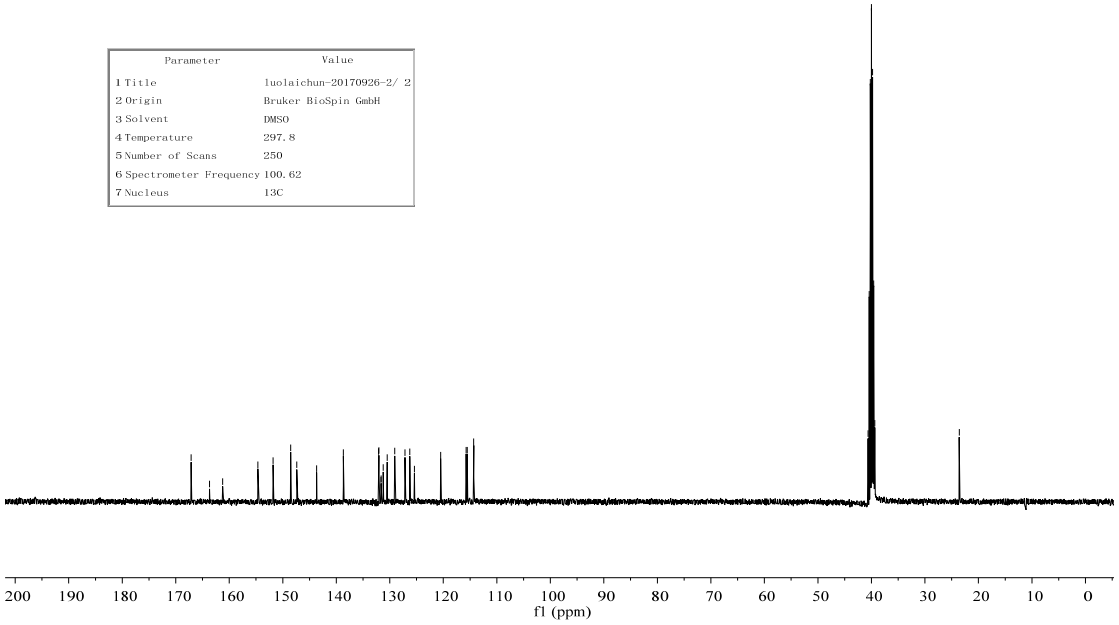


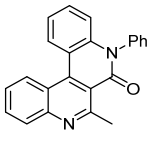
Parameter	Value
1 Title	luolaichun-20170926-2/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	296.0
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



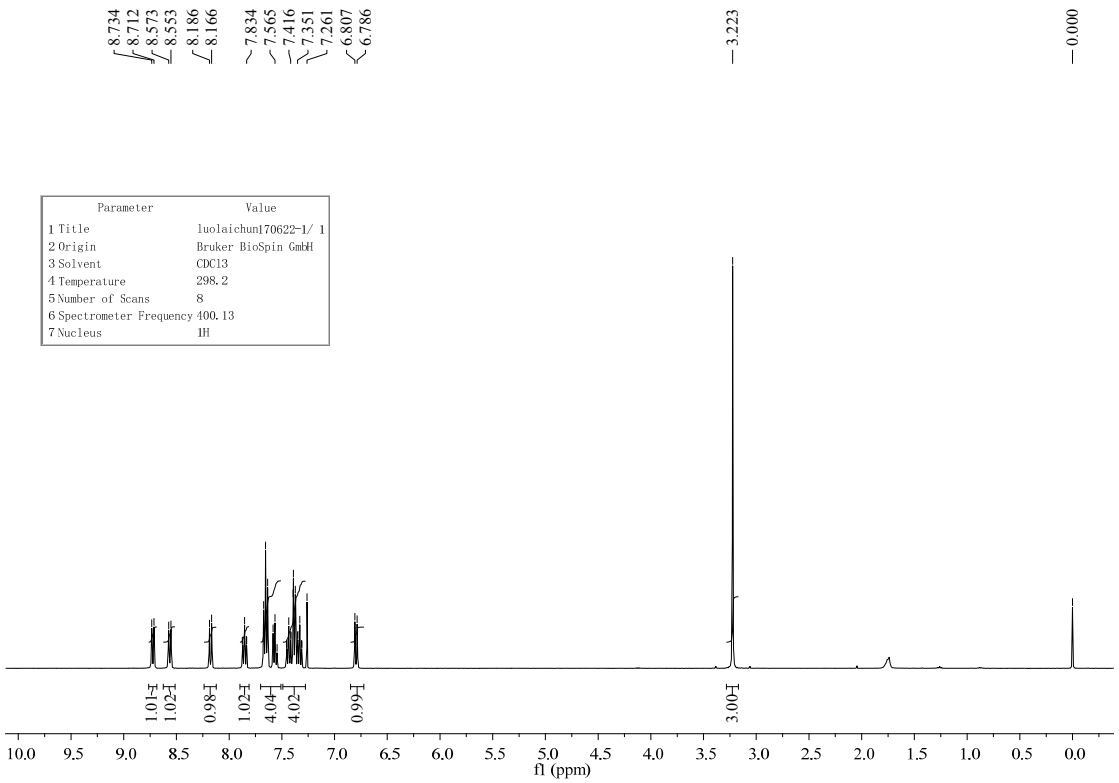


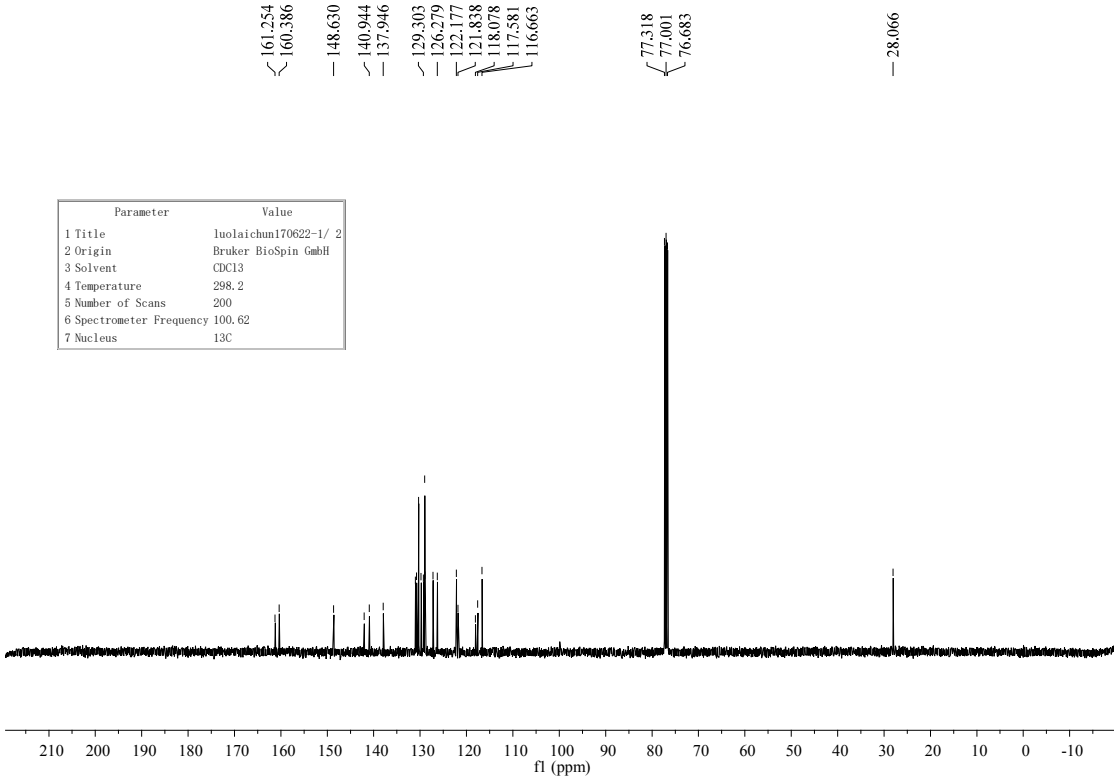
Parameter	Value
1 Title	luolaichun-20170926-2/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	DMSO
4 Temperature	297.8
5 Number of Scans	250
6 Spectrometer Frequency	100.62
7 Nucleus	13C

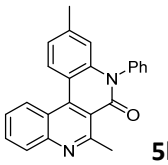



Ph
N
O
N

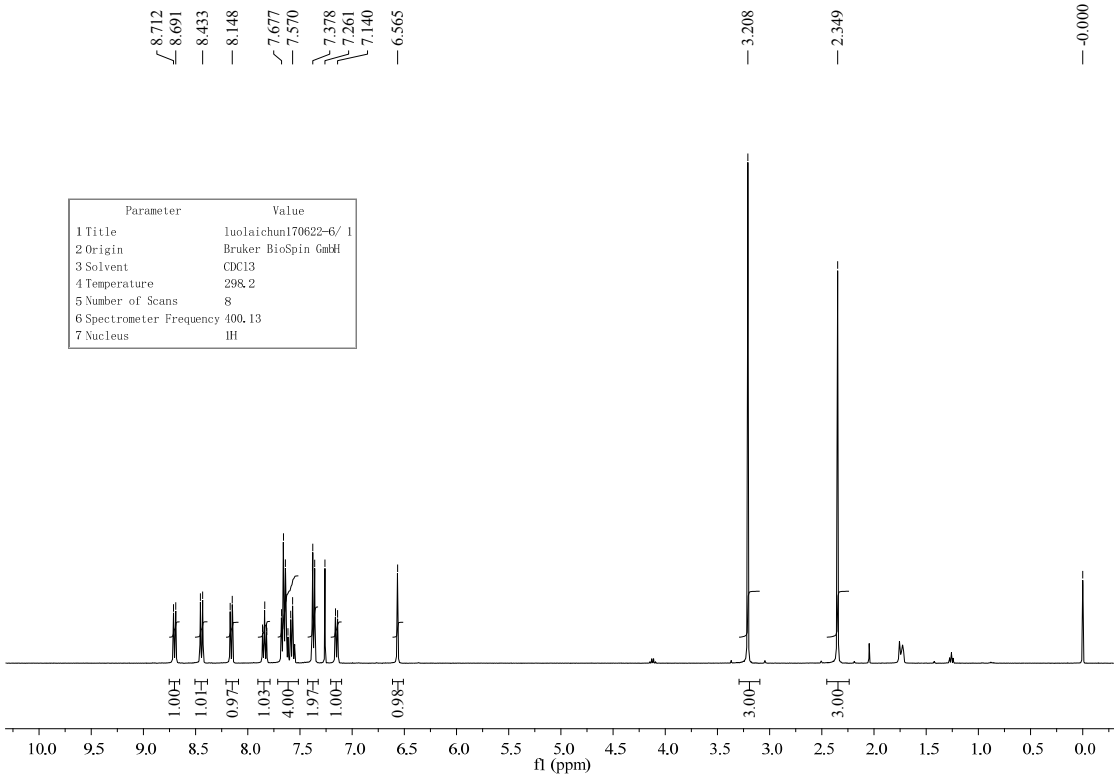
5a

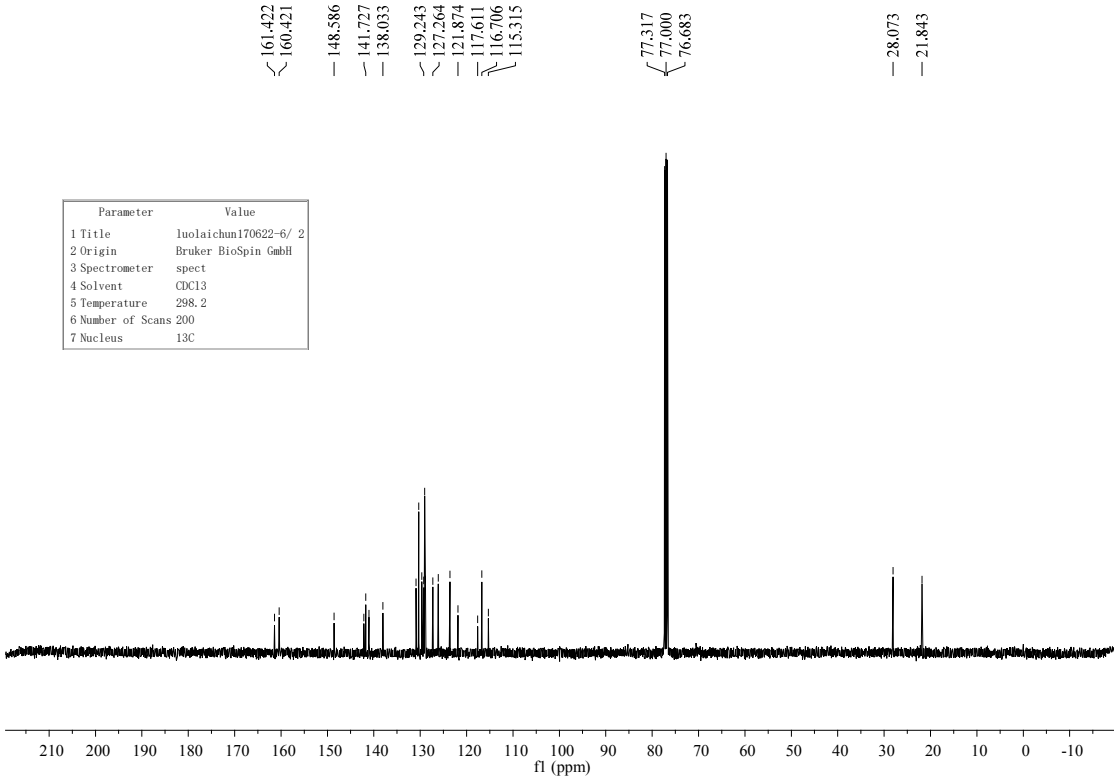

8.734
8.712
8.573
8.553
8.186
8.166
7.834
7.565
7.416
7.351
7.261
6.807
6.786
3.223
0.000
Parameter Value
1 Title luolaichun170622-1/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.01
1.02
0.98
1.02
4.04
4.02
0.99
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

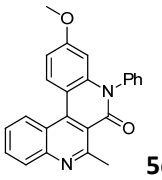

161.254
160.386
148.630
140.944
137.946
129.303
126.279
122.177
121.838
118.078
117.581
116.663
77.318
77.001
76.683
28.066
Parameter Value
1 Title luolaichun170622-1/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 200
6 Spectrometer Frequency 100.62
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Ph
N
O
N

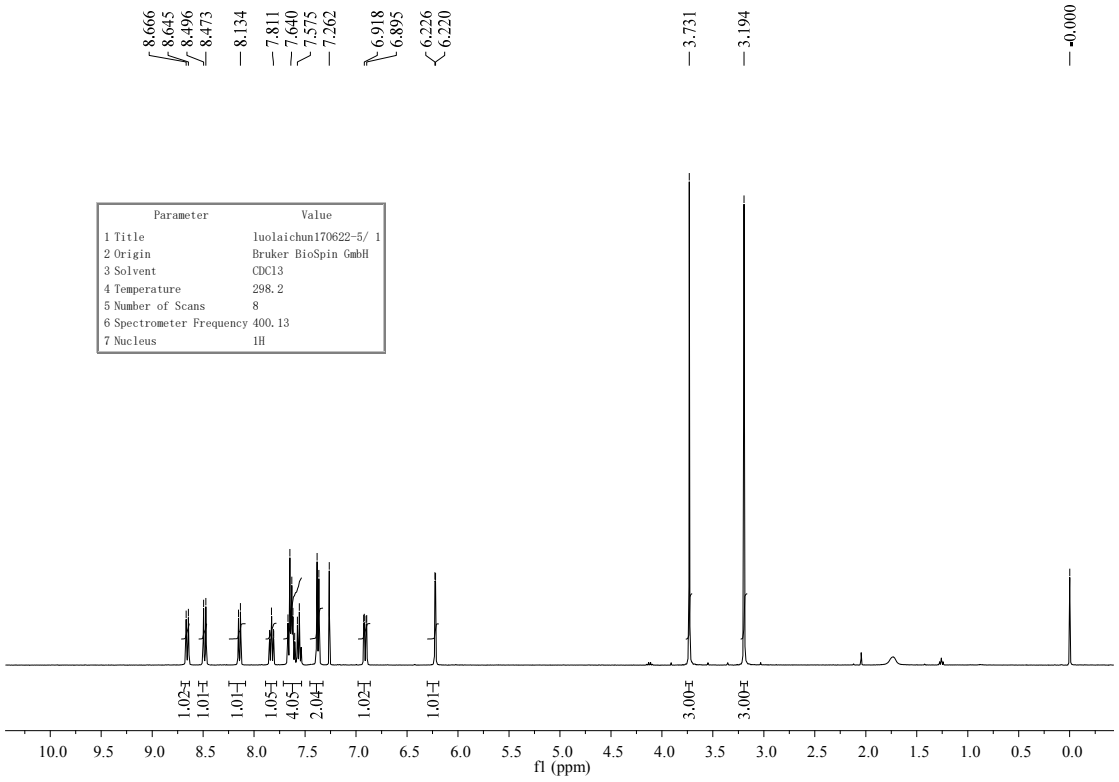
5b

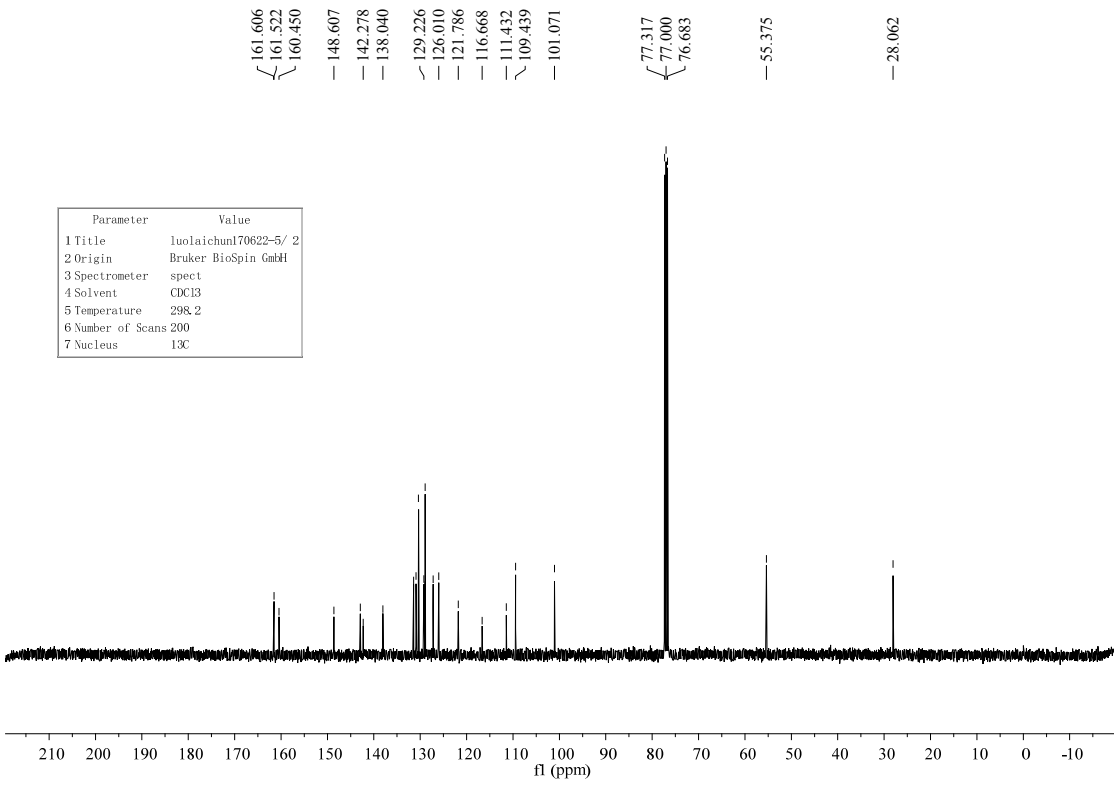

8.712
8.691
8.433
8.148
7.677
7.570
7.378
7.261
7.140
6.565
3.208
2.349
-0.000
Parameter Value
1 Title luolaichun170622-6/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
0.97
1.03
4.00
1.97
1.00
0.98
3.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

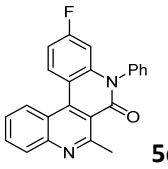

161.422
160.421
148.586
141.727
138.033
129.243
127.264
121.874
117.611
116.706
115.315
77.317
77.000
76.683
28.073
21.843
Parameter Value
1 Title luolaichun170622-6/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


O
Ph
N
O
N

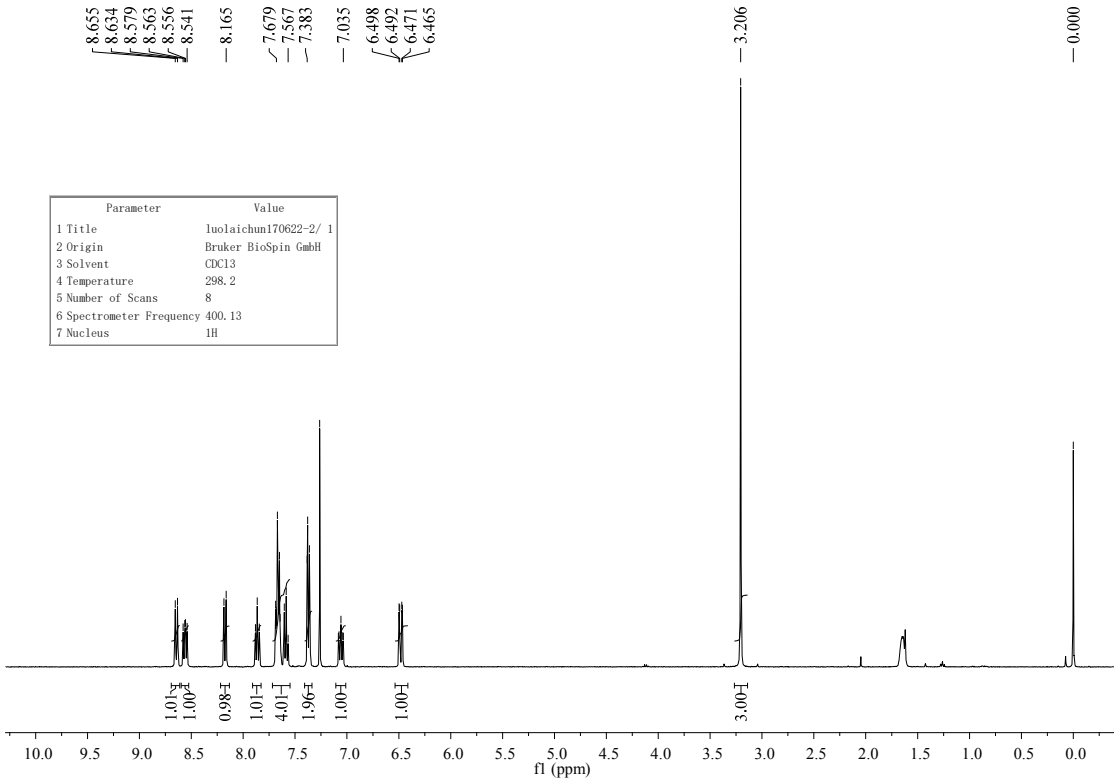
5c

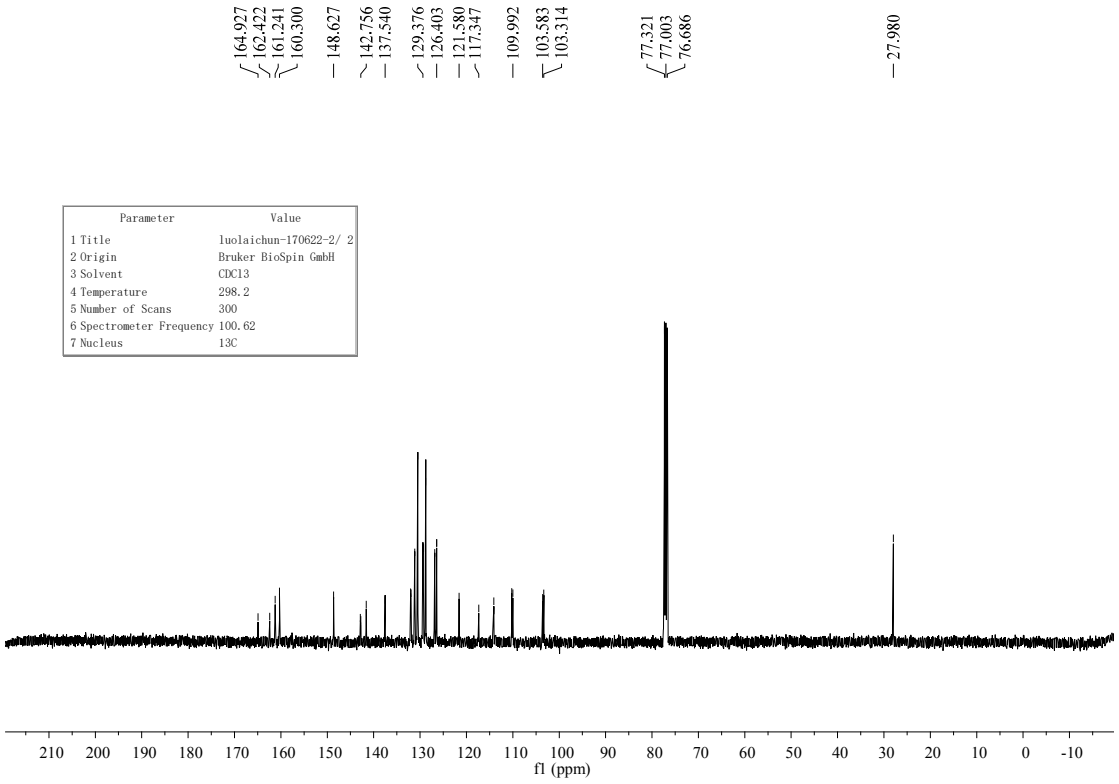

8.666
8.645
8.496
8.473
8.134
7.811
7.640
7.575
7.262
6.918
6.895
6.226
6.220
3.731
3.194
-0.000
Parameter Value
1 Title luolaichun170622-5/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.02
1.01
1.01
1.05
4.05
2.04
1.02
1.01
3.00
3.00
f1 (ppm)

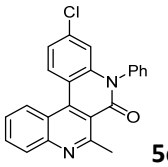

161.606
161.522
160.450
148.607
142.278
138.040
129.226
126.010
121.786
116.668
111.432
109.439
101.071
77.317
77.000
76.683
55.375
28.062
Parameter Value
1 Title luolaichun170622-5/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)


F
Ph
N
O
N

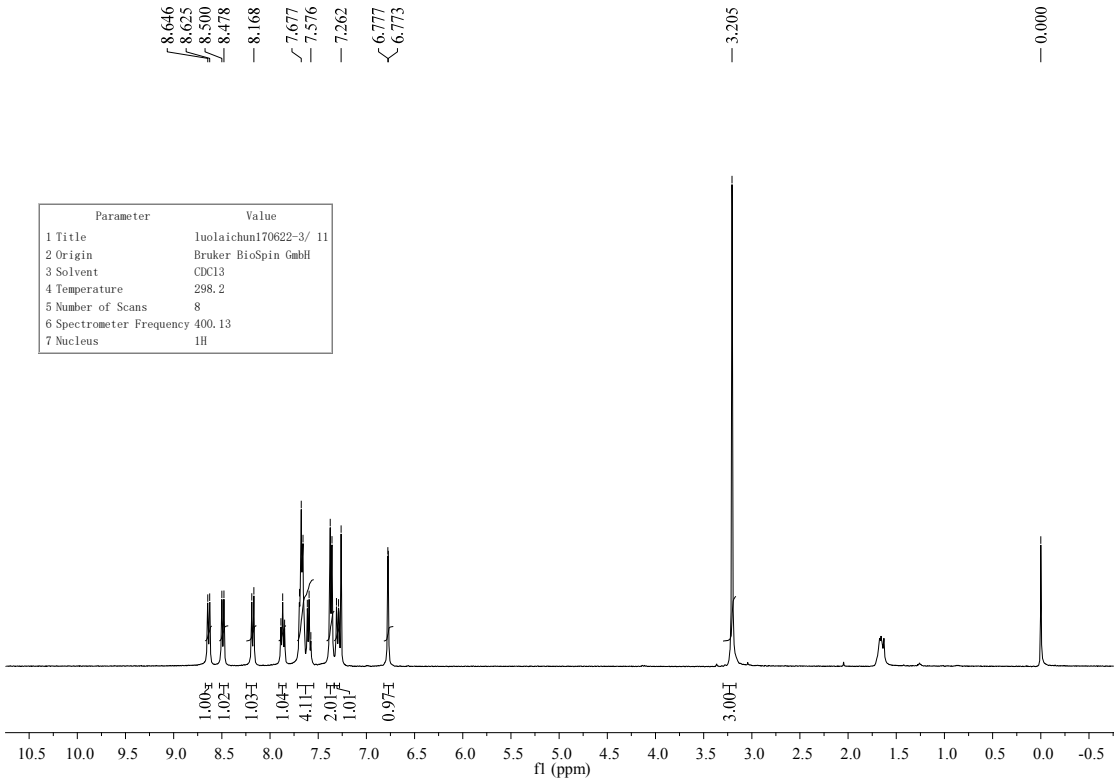
5d

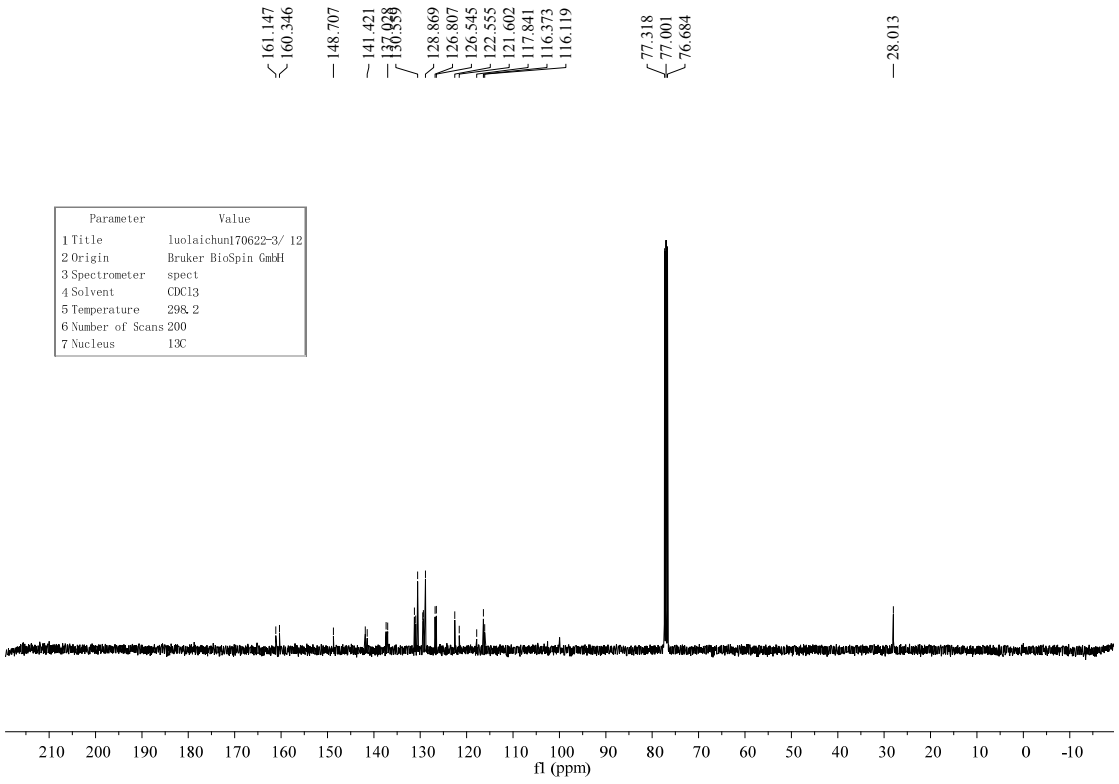

8.655
8.634
8.579
8.563
8.556
8.541
8.165
7.679
7.567
7.383
7.035
6.498
6.492
6.471
6.465
3.206
0.000
Parameter Value
1 Title luolaichun170622-2/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.01
1.00
0.98
1.01
4.01
1.96
1.00
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

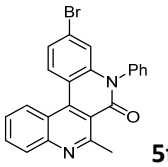

164.927
162.422
161.241
160.300
148.627
142.756
137.540
129.376
126.403
121.580
117.347
109.992
103.583
103.314
77.321
77.003
76.686
27.980
Parameter Value
1 Title luolaichun-170622-2/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 300
6 Spectrometer Frequency 100.62
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Cl
Ph
N
O
N

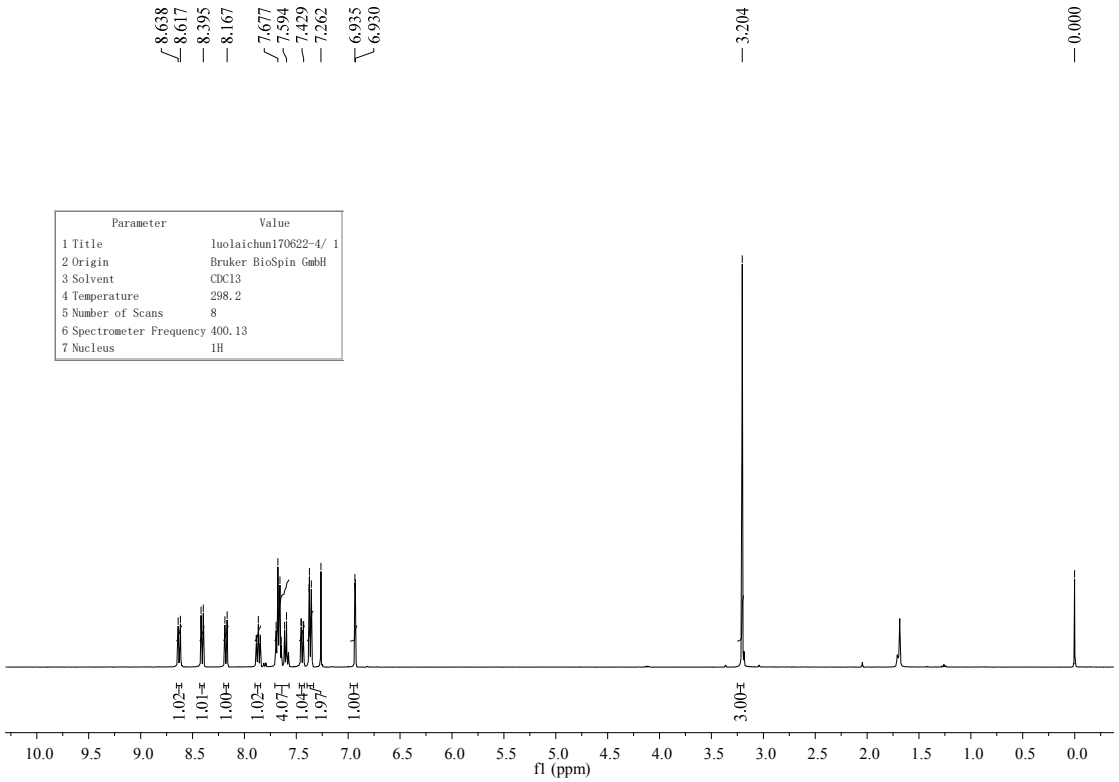
5e

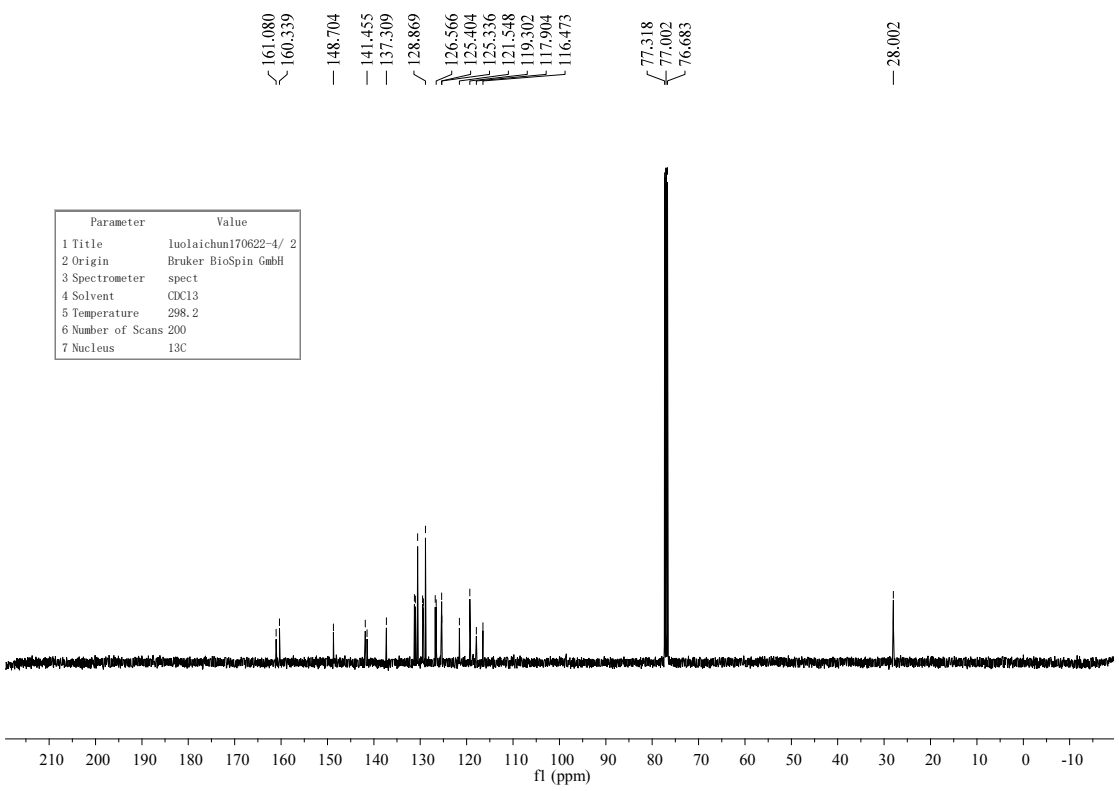

8.646
8.625
8.500
8.478
8.168
7.677
7.576
7.262
6.777
6.773
3.205
0.000
Parameter Value
1 Title luolaichun170622-3/ 11
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.02
1.03
1.04
4.11
2.01
1.01
0.97
3.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

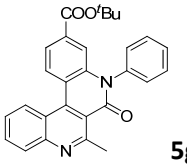

161.147
160.346
148.707
141.421
137.028
130.559
128.869
126.807
126.545
122.555
121.602
117.841
116.373
116.119
77.318
77.001
76.684
28.013
Parameter Value
1 Title luolaichun170622-3/ 12
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Br
Ph
N
O
N

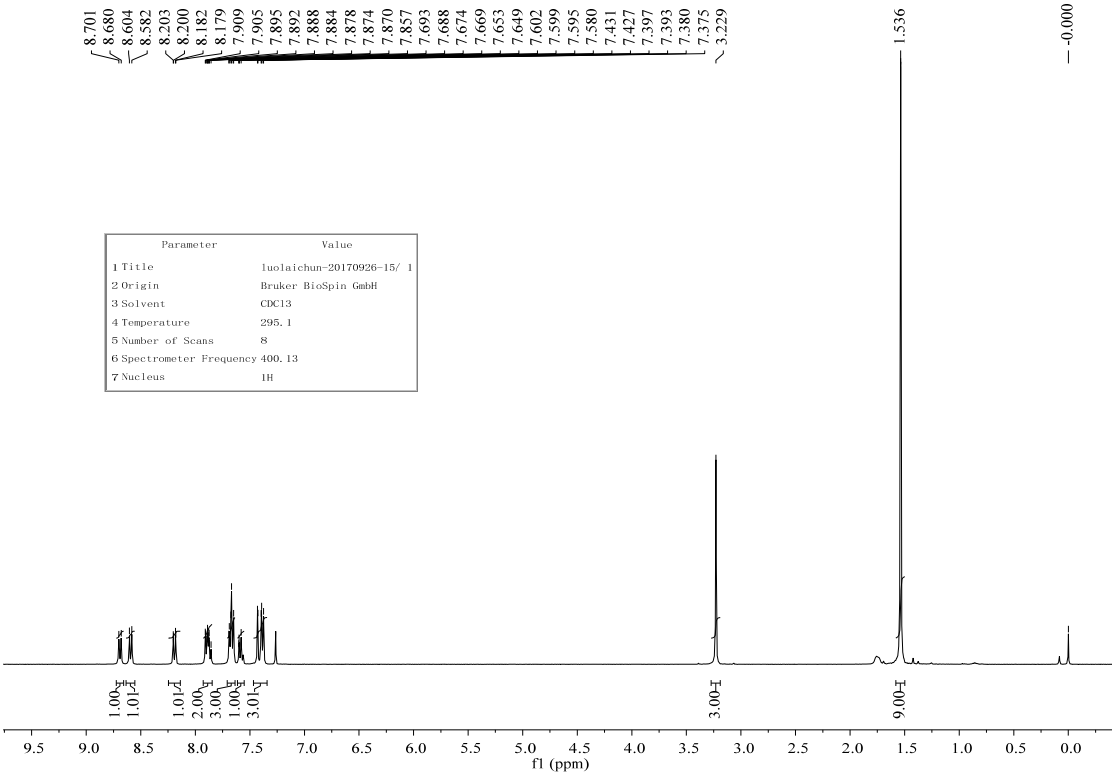
5f

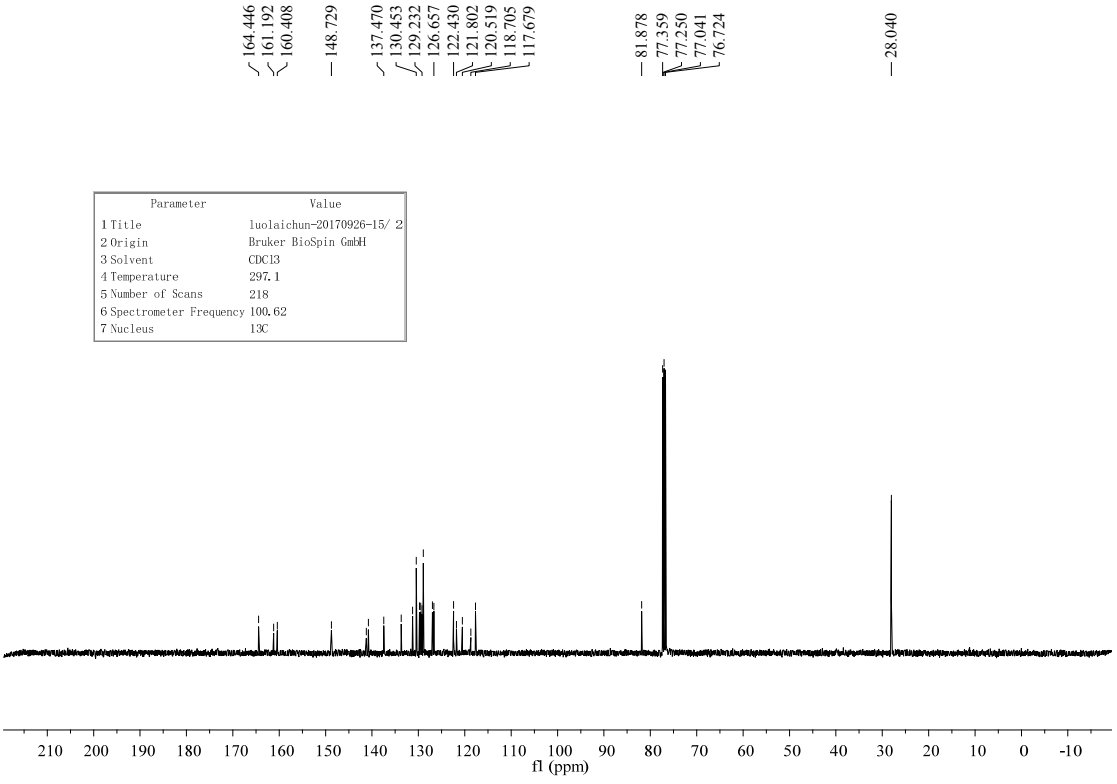

8.638
8.617
8.395
8.167
7.677
7.594
7.429
7.262
6.935
6.930
3.204
0.000
Parameter Value
1 Title luolaichun170622-4/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.02
1.01
1.00
1.02
4.07
1.04
1.97
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

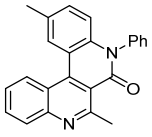

161.080
160.339
148.704
141.455
137.309
128.869
126.566
125.404
125.336
121.548
119.302
117.904
116.473
77.318
77.002
76.683
28.002
Parameter Value
1 Title luolaichun170622-4/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


COO^{t}Bu
N
O
N

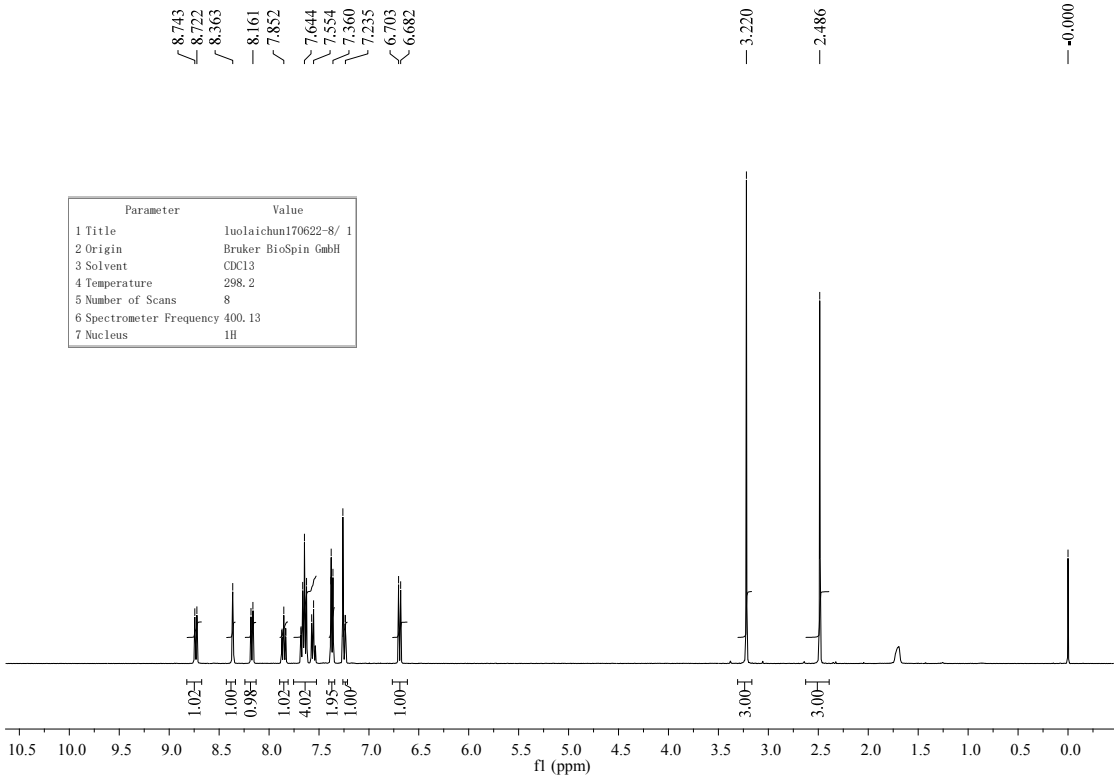
5g

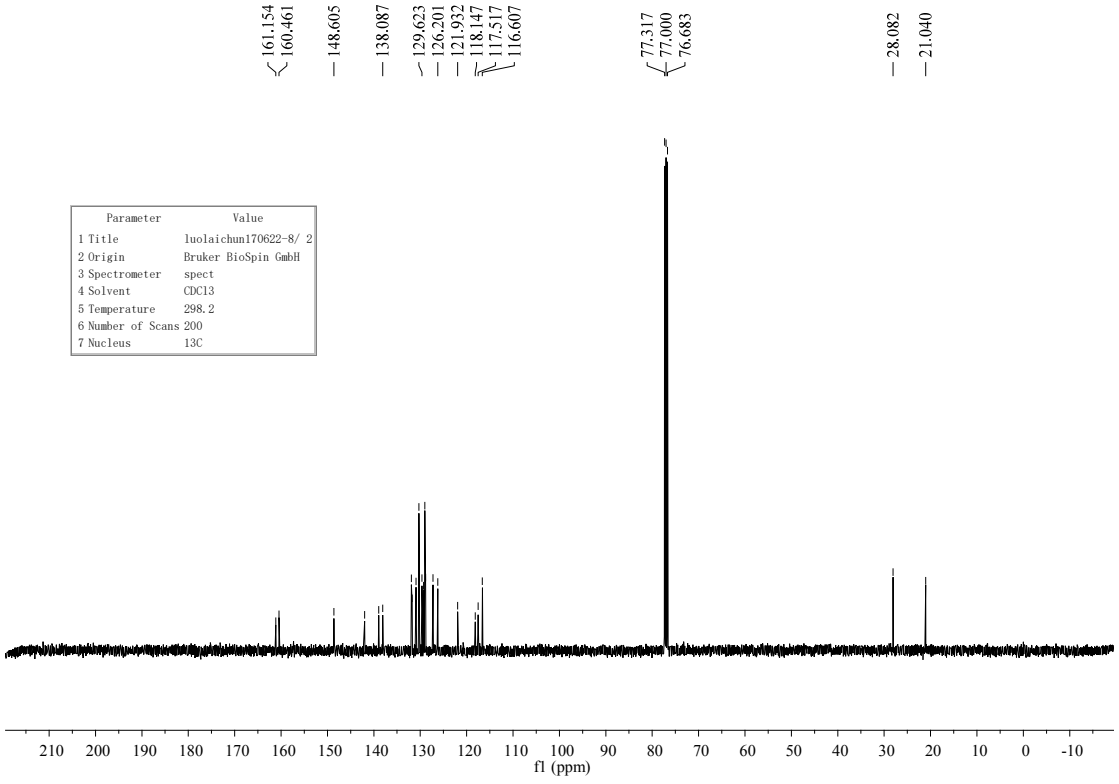

8.701
8.680
8.604
8.582
8.203
8.200
8.182
8.179
7.909
7.905
7.895
7.892
7.888
7.884
7.878
7.874
7.870
7.857
7.693
7.688
7.674
7.669
7.653
7.649
7.602
7.599
7.595
7.580
7.431
7.427
7.397
7.393
7.380
7.375
3.229
1.536
-0.000
Parameter Value
1 Title luolaichun-20170926-15/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 295.1
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
1.01
2.00
3.00
1.00
3.01
3.00
9.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

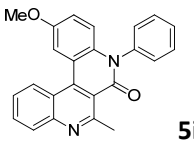

164.446
161.192
160.408
148.729
137.470
130.453
129.232
126.657
122.430
121.802
120.519
118.705
117.679
81.878
77.359
77.250
77.041
76.724
28.040
Parameter Value
1 Title luolaichun-20170926-15/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 297.1
5 Number of Scans 218
6 Spectrometer Frequency 100.62
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Ph
N
O
N

5h

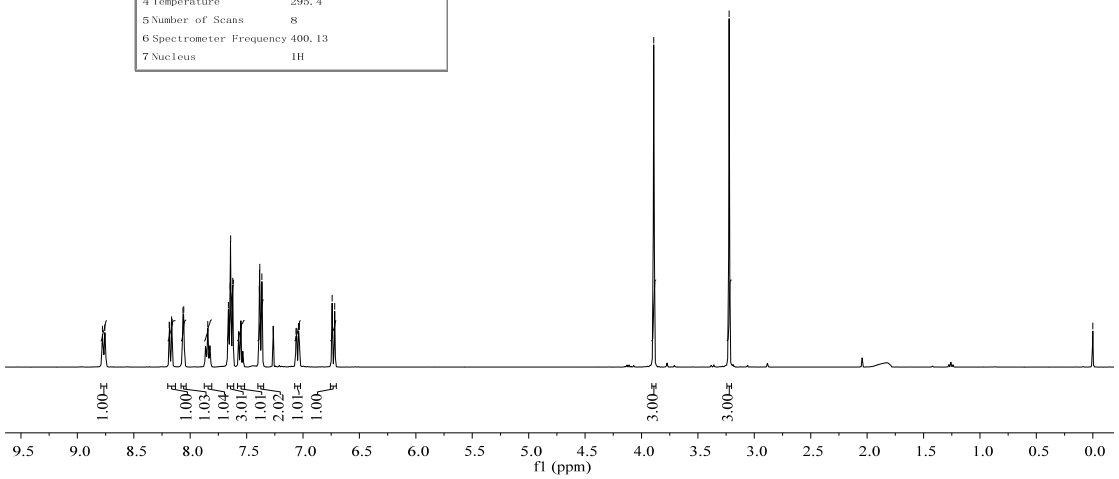

8.743
8.722
8.363
8.161
7.852
7.644
7.554
7.360
7.235
6.703
6.682
3.220
2.486
-0.000
Parameter Value
1 Title luolaichun170622-8/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.02
1.00
0.98
1.02
4.02
1.95
1.00
1.00
3.00
3.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


161.154
160.461
148.605
138.087
129.623
126.201
121.932
118.147
117.517
116.607
77.317
77.000
76.683
28.082
21.040
Parameter Value
1 Title luolaichun170622-8/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

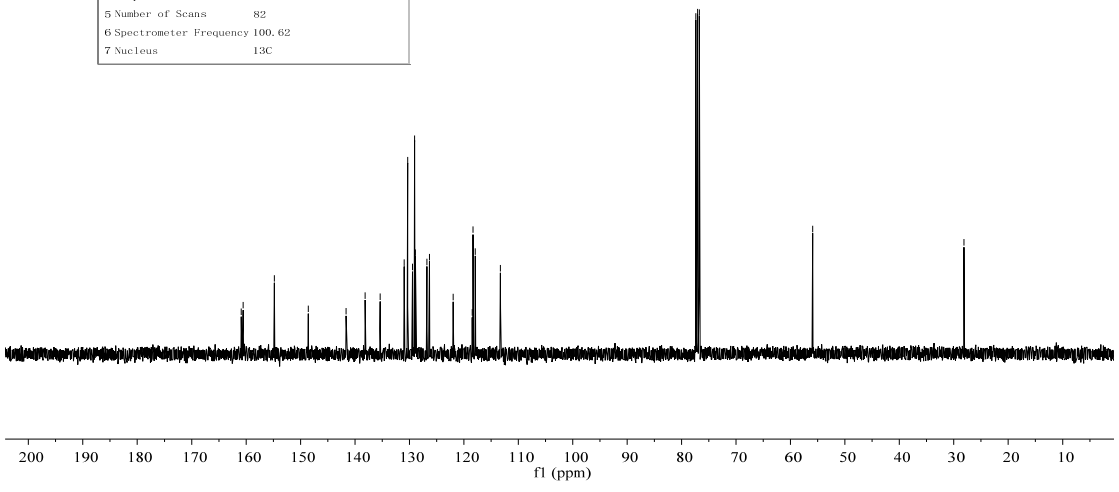


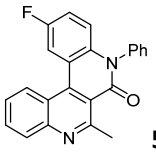
5i

Parameter	Value
1 Title	luolaichun-20170926-14/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	295.4
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

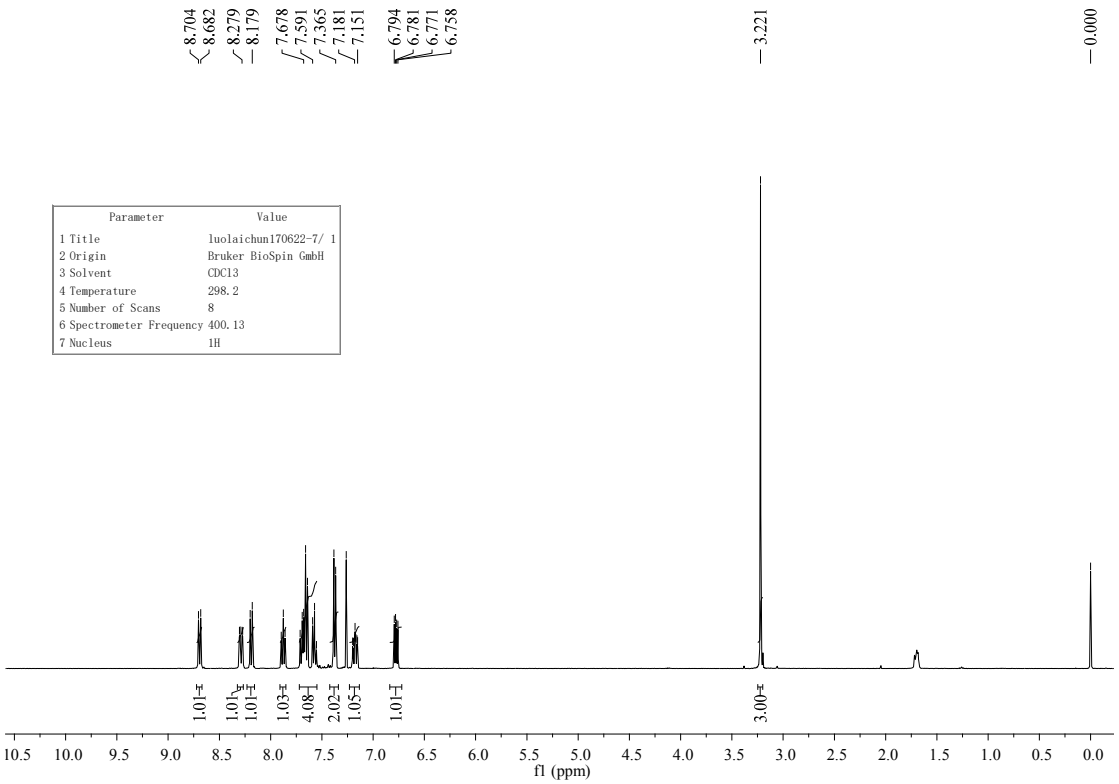


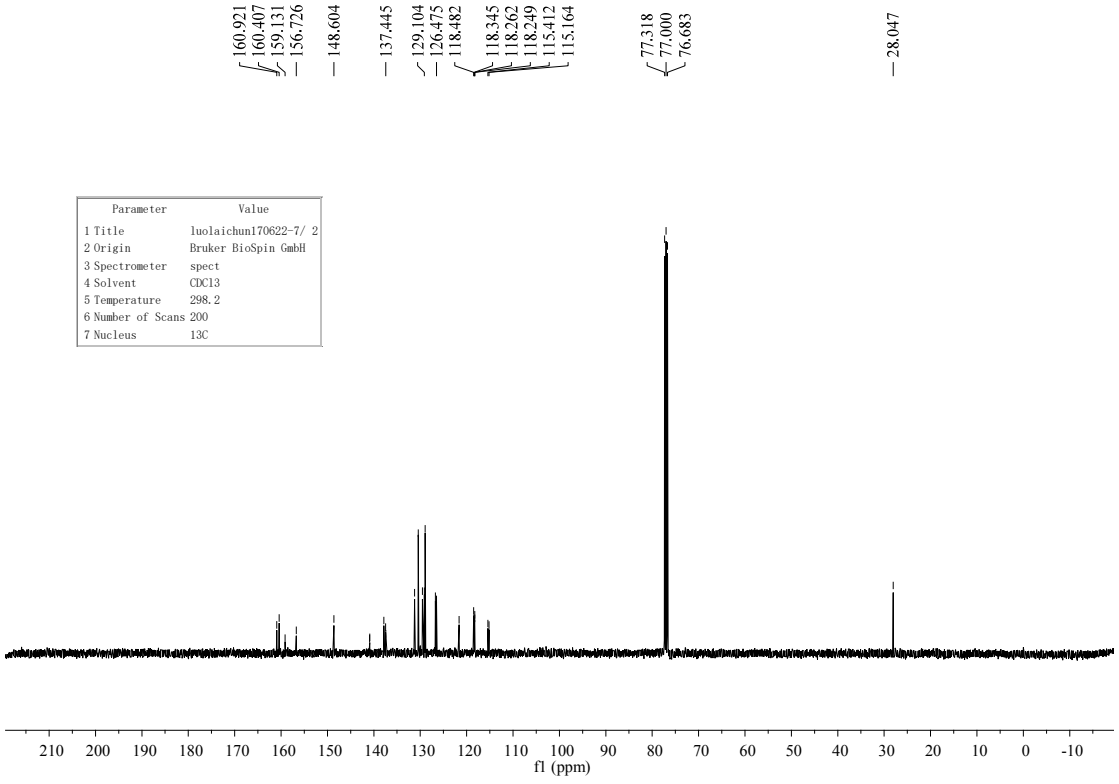
Parameter	Value
1 Title	luolaichun-20170926-14/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	296.3
5 Number of Scans	82
6 Spectrometer Frequency	100.62
7 Nucleus	13C

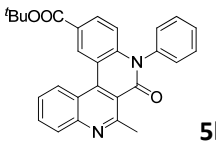



F
Ph
N
O
N

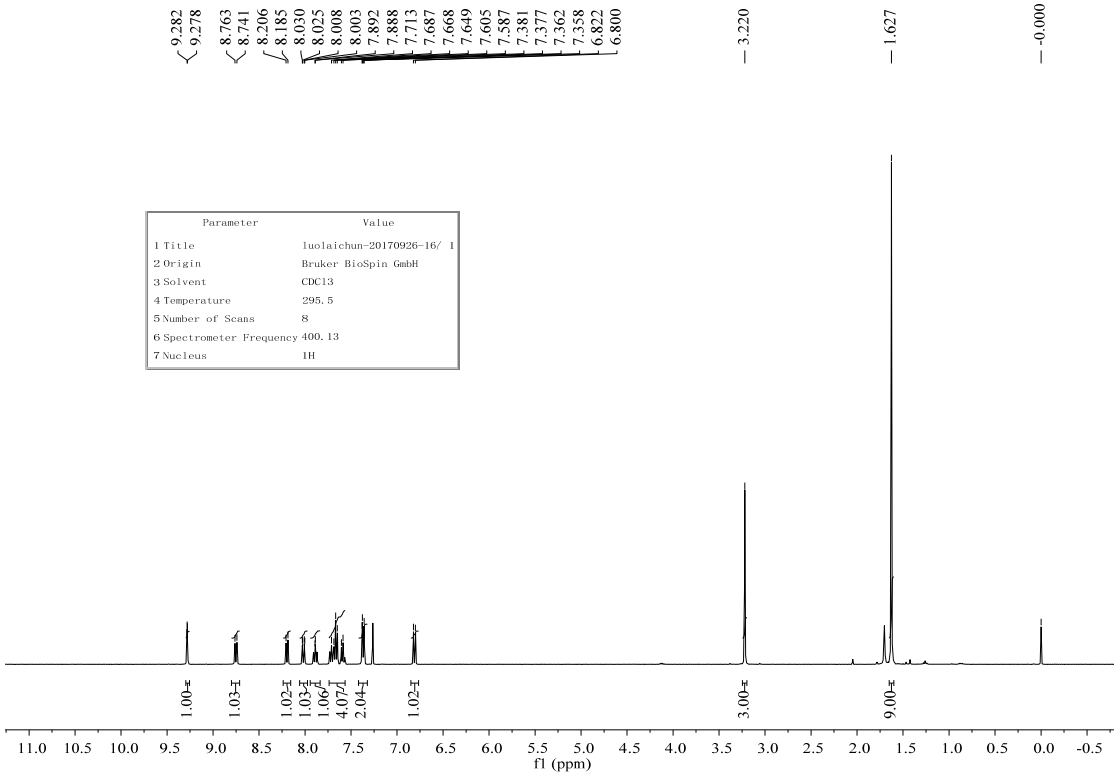
5j

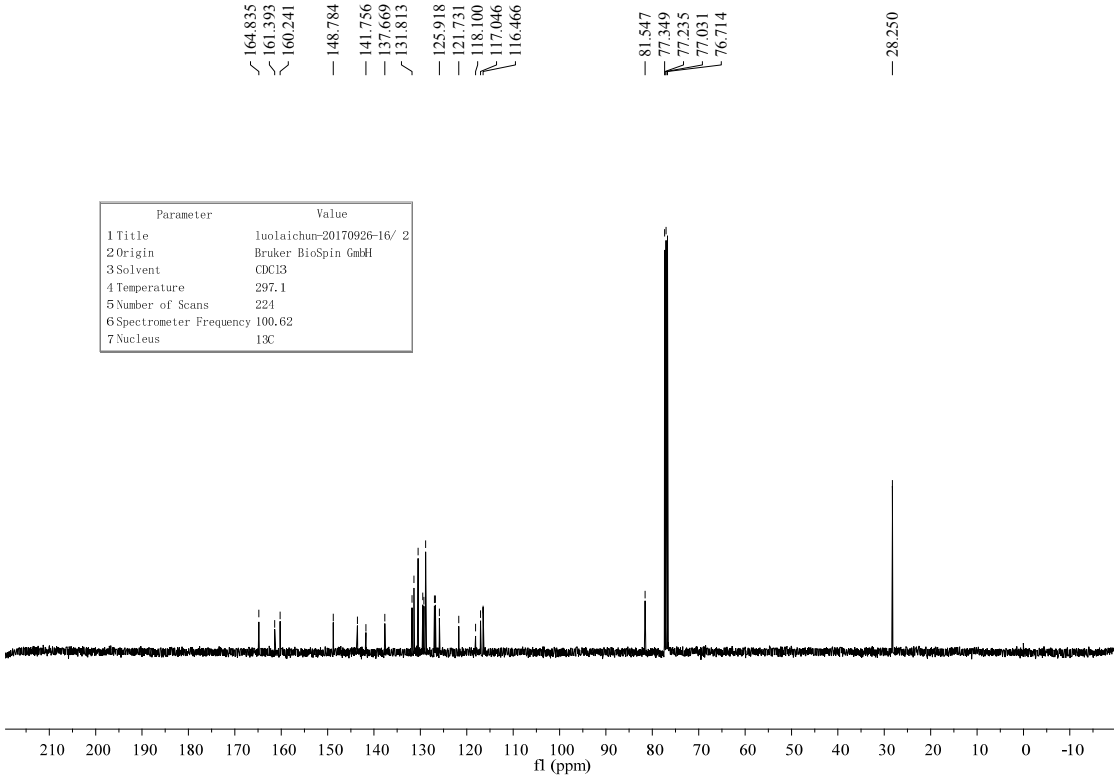

8.704
8.682
8.279
8.179
7.678
7.591
7.365
7.181
7.151
6.794
6.781
6.771
6.758
3.221
0.000
Parameter Value
1 Title luolaichun170622-7/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.01
1.01
1.01
1.03
4.08
2.02
1.05
1.01
3.00
f1 (ppm)

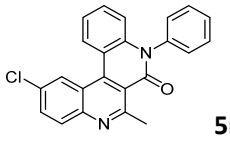

160.921
160.407
159.131
156.726
148.604
137.445
129.104
126.475
118.482
118.345
118.262
118.249
115.412
115.164
77.318
77.000
76.683
28.047
Parameter Value
1 Title luolaichun170622-7/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)


tBuOOC
N
O
N

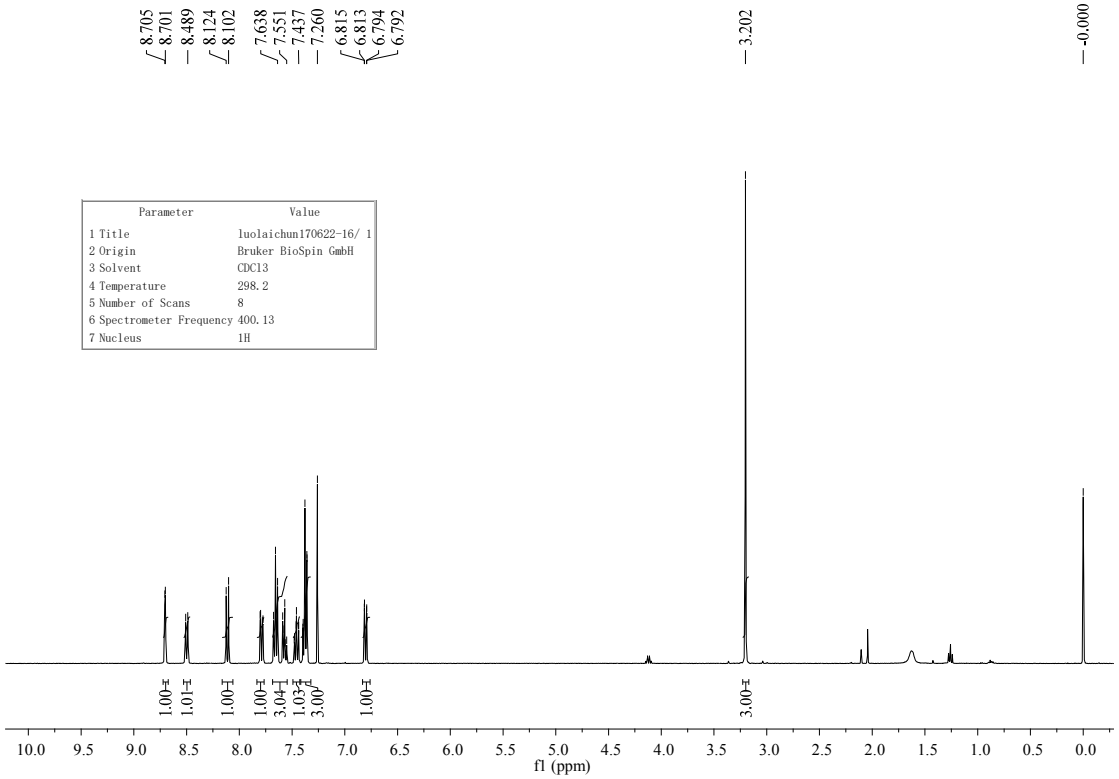
5k

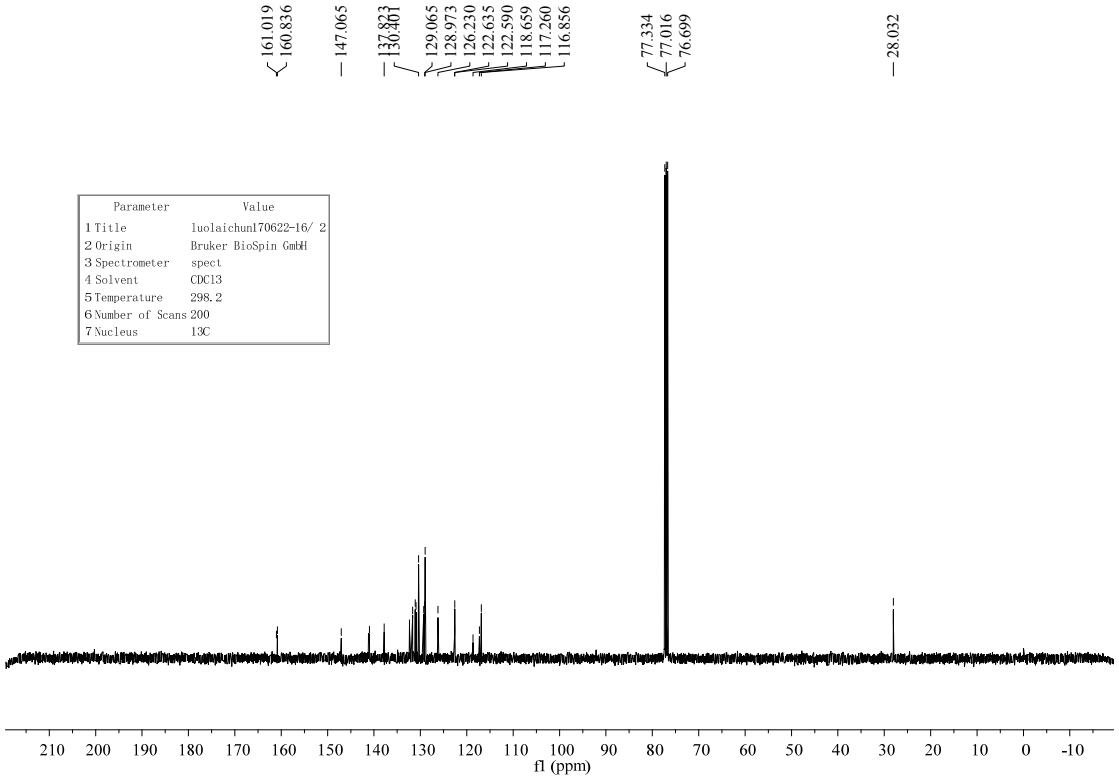

9.282
9.278
8.763
8.741
8.206
8.185
8.030
8.025
8.008
8.003
7.892
7.888
7.713
7.687
7.668
7.649
7.605
7.587
7.381
7.377
7.362
7.358
6.822
6.800
3.220
1.627
-0.000
Parameter Value
1 Title luolaichun-20170926-16/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 295.5
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.03
1.02
1.03
1.06
4.07
2.04
1.02
3.00
9.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

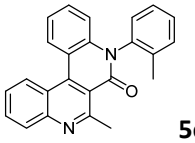

164.835
161.393
160.241
148.784
141.756
137.669
131.813
125.918
121.731
118.100
117.046
116.466
81.547
77.349
77.235
77.031
76.714
28.250
Parameter Value
1 Title luolaichun-20170926-16/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 297.1
5 Number of Scans 224
6 Spectrometer Frequency 100.62
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Cl
N
O
N

5n


8.705
8.701
8.489
8.124
8.102
7.638
7.551
7.437
7.260
6.815
6.813
6.794
6.792
3.202
-0.000
Parameter Value
1 Title luolaichun170622-16/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
1.00
1.00
3.04
1.03
3.00
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


161.019
160.836
147.065
137.823
130.401
129.065
128.973
126.230
122.635
122.590
118.659
117.260
116.856
77.334
77.016
76.699
28.032
Parameter Value
1 Title luolaichun170622-16/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



5o

8.761
8.740
8.612
8.592
8.196
8.177
7.682
7.472
7.425
7.257
6.736
6.734
6.715
6.713
3.232
2.089
0.000

Parameter	Value
1 Title	luolaichun170622-15/ 3
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	16
6 Spectrometer Frequency	400.13
7 Nucleus	1H

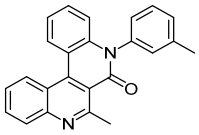
1.00
1.00
0.97
1.01
1.03
4.02
1.01
1.00
0.99
3.00
3.01

10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

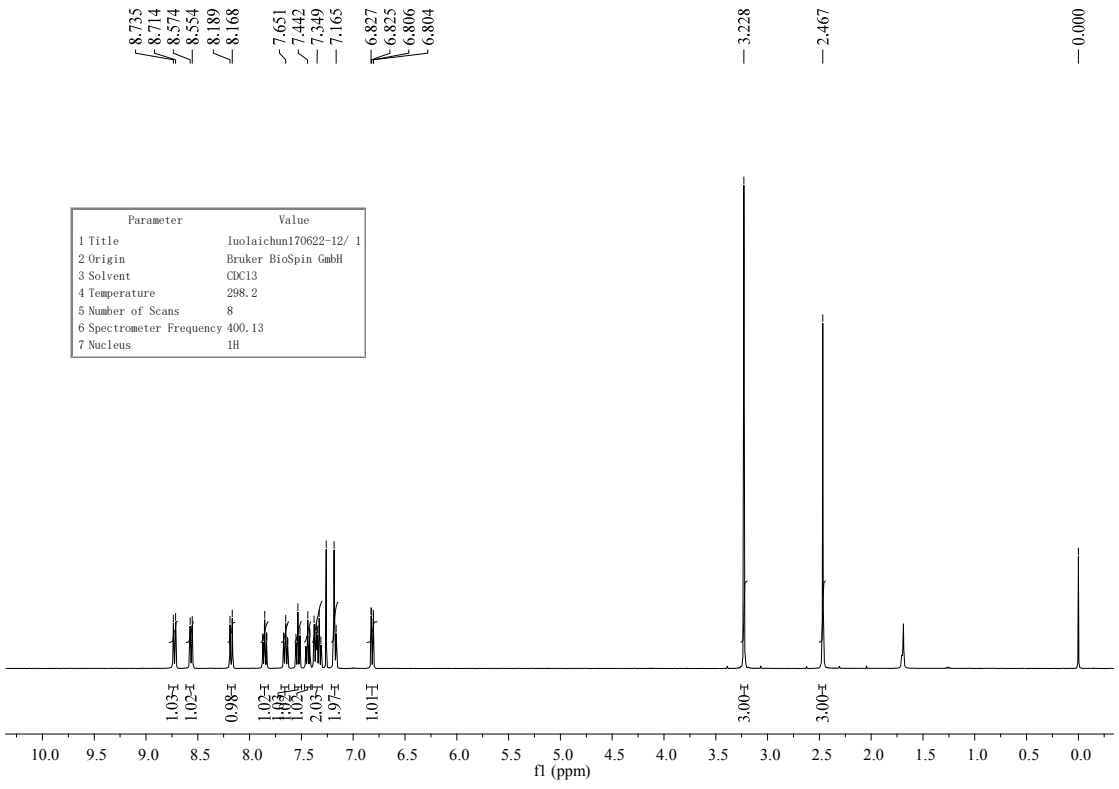
160.634
160.474
148.625
140.208
136.383
136.238
127.914
127.272
126.274
122.230
121.877
118.119
117.557
116.033
77.317
77.001
76.682
28.038
17.554

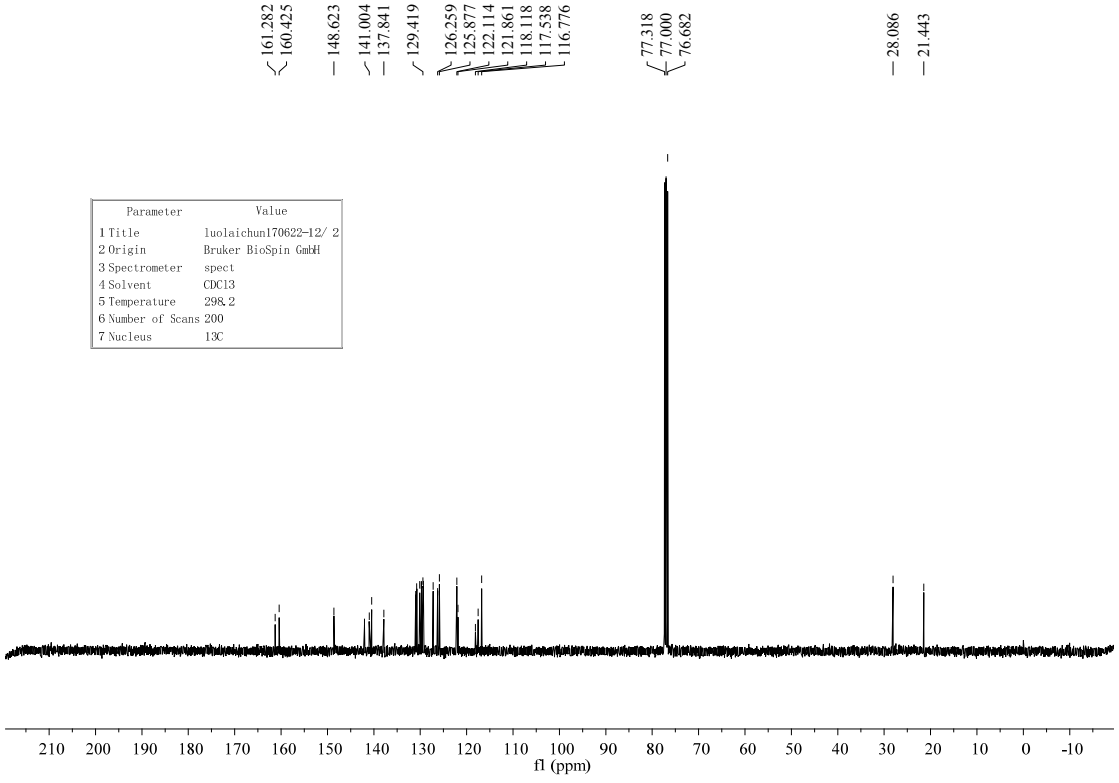
Parameter	Value
1 Title	luolaichun170622-15/ 4
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	250
7 Nucleus	13C

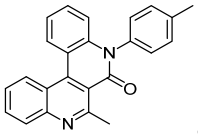
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



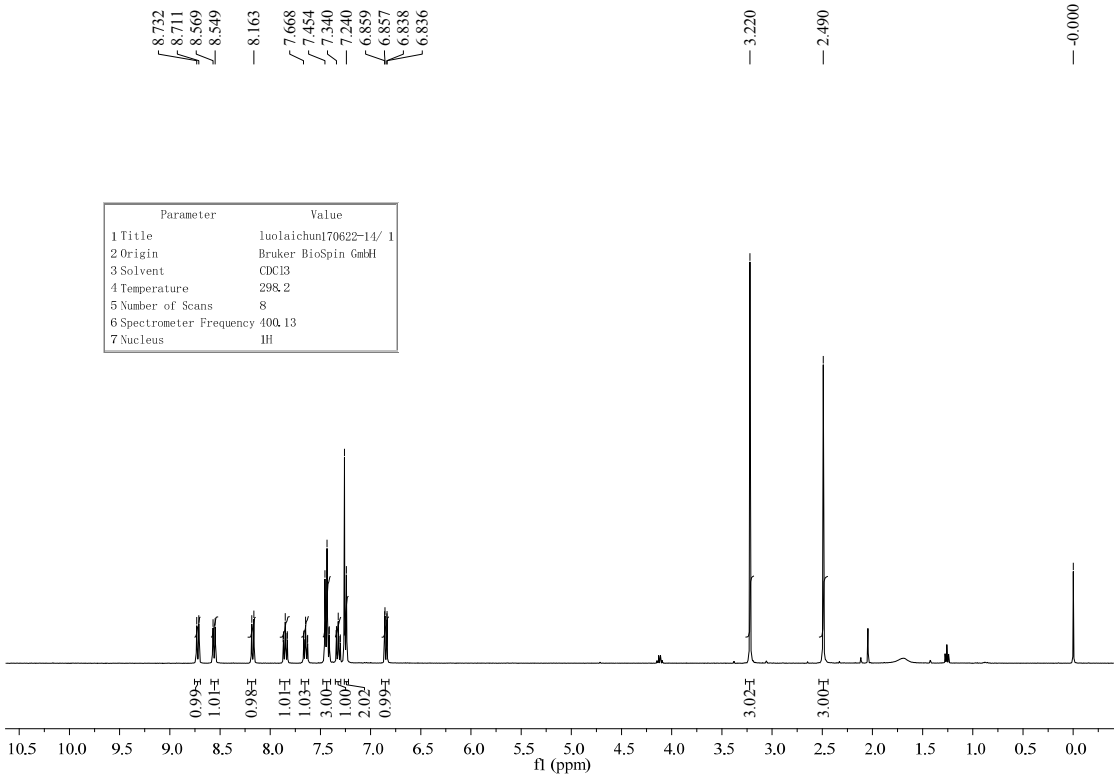
5p

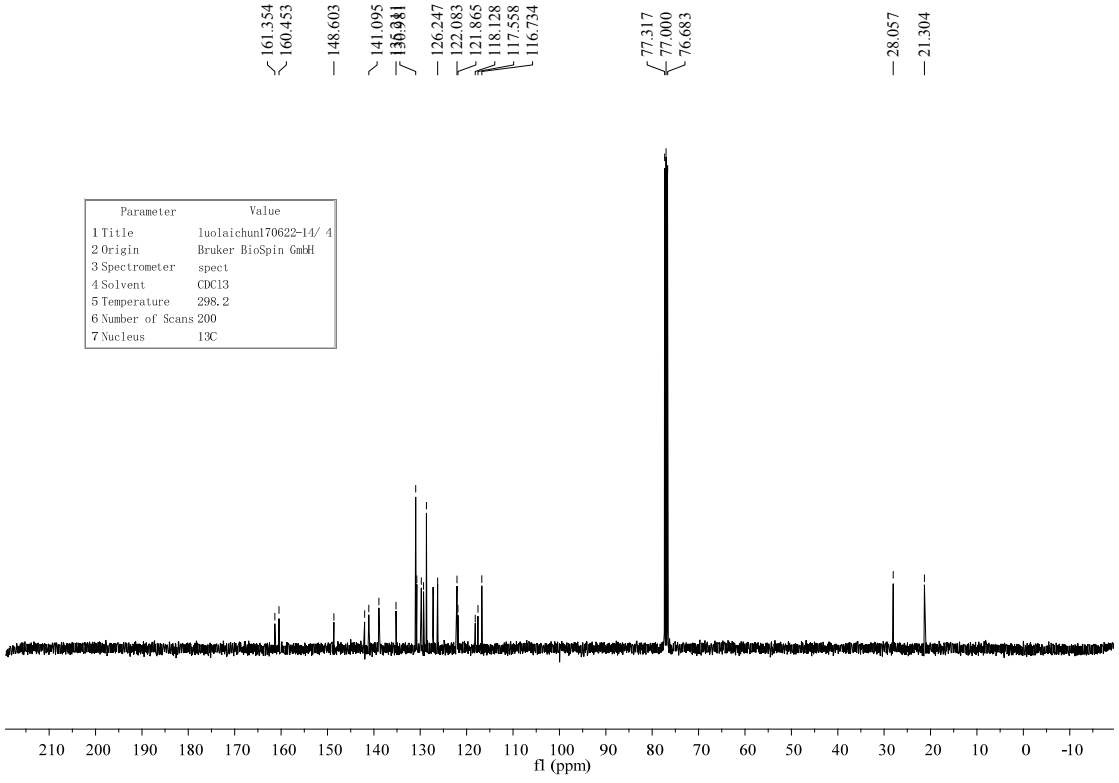

8.735
8.714
8.574
8.554
8.189
8.168
7.651
7.442
7.349
7.165
6.827
6.825
6.806
6.804
3.228
2.467
0.000
Parameter Value
1 Title luolaichun170622-12/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.03
1.02
0.98
1.02
2.03
1.97
1.01
3.00
3.00
f1 (ppm)

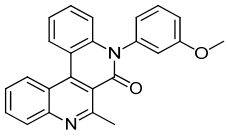

161.282
160.425
148.623
141.004
137.841
129.419
126.259
125.877
122.114
121.861
118.118
117.538
116.776
77.318
77.000
76.682
28.086
21.443
Parameter Value
1 Title luolaichun170622-12/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)



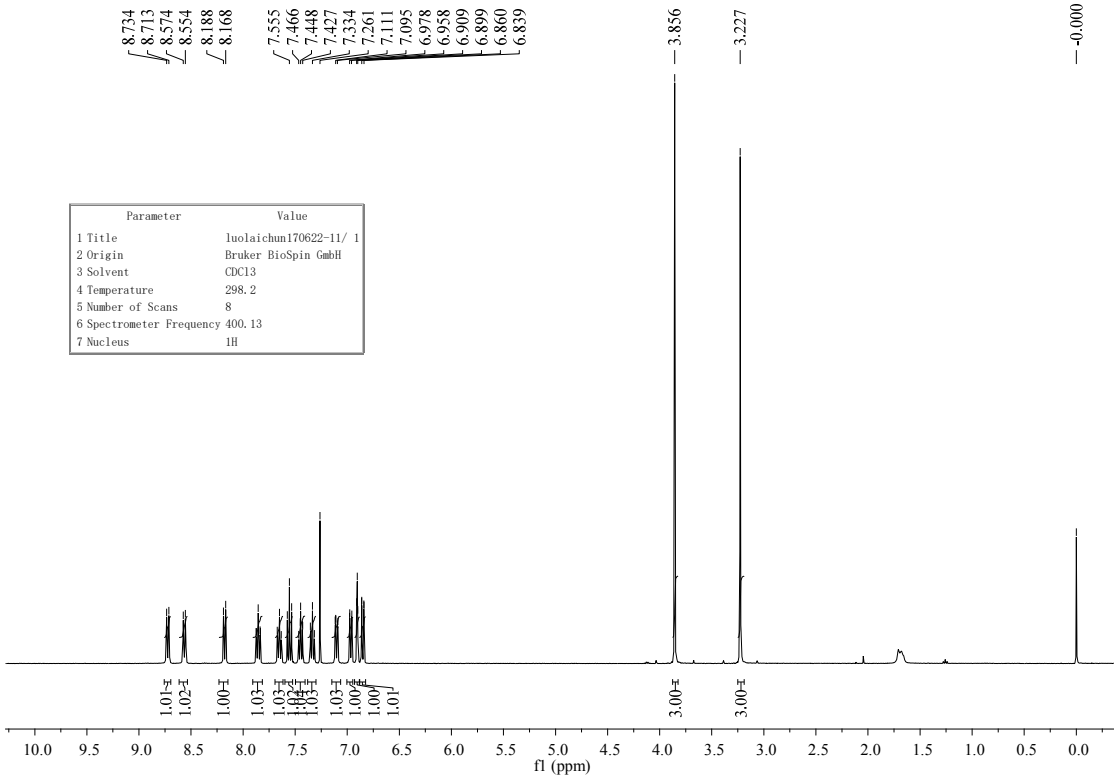
5q


8.732
8.711
8.569
8.549
8.163
7.668
7.454
7.340
7.240
6.859
6.857
6.838
6.836
3.220
2.490
-0.000
Parameter Value
1 Title luolaichun170622-14/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
0.99
1.01
0.98
1.01
1.03
3.00
1.00
2.02
0.99
3.02
3.00
f1 (ppm)

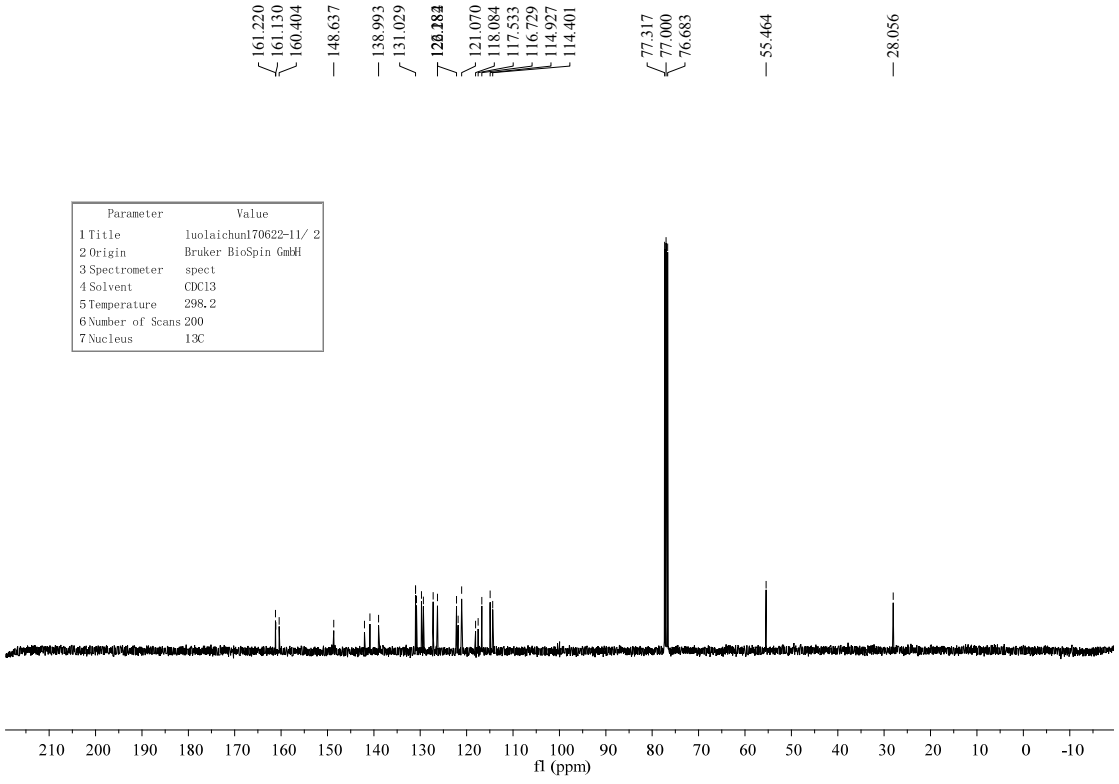

161.354
160.453
148.603
141.095
126.247
122.083
121.865
118.128
117.558
116.734
77.317
77.000
76.683
28.057
21.304
Parameter Value
1 Title luolaichun170622-14/ 4
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)



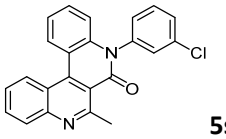
5r



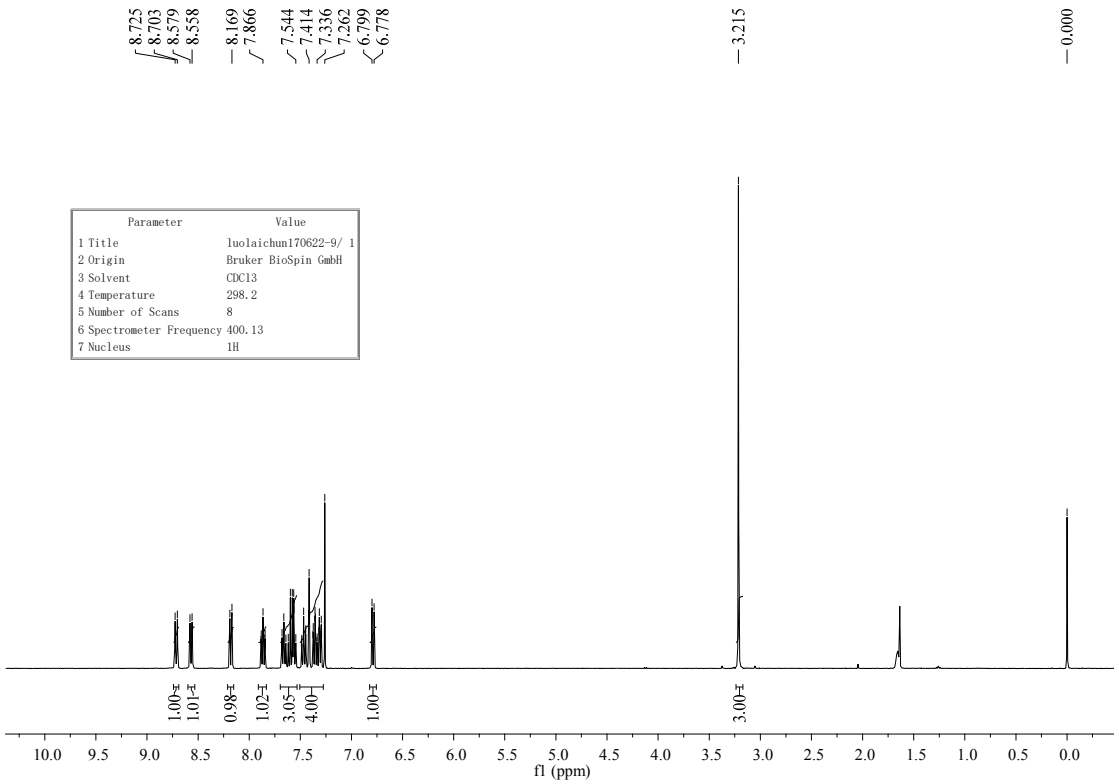
Parameter	Value
1 Title	luolaichun170622-11/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

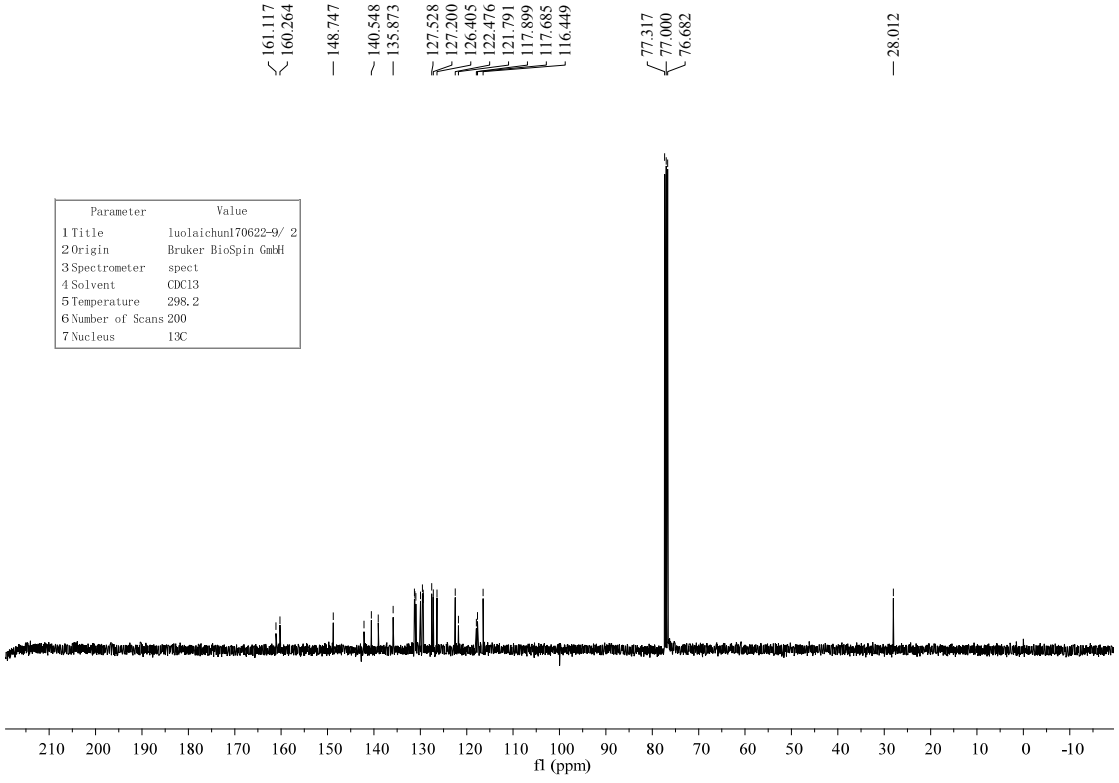


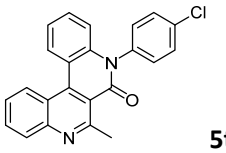
Parameter	Value
1 Title	luolaichun170622-11/ 2
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	200
7 Nucleus	13C


Cl
N
O
N

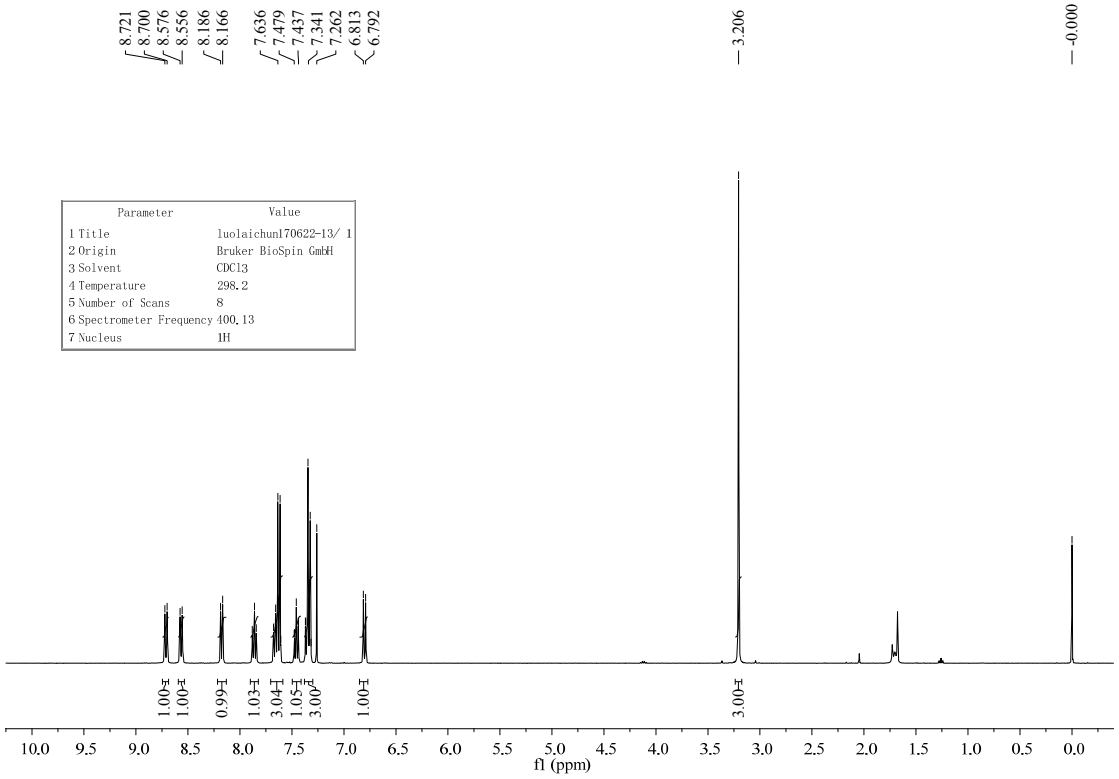
5s

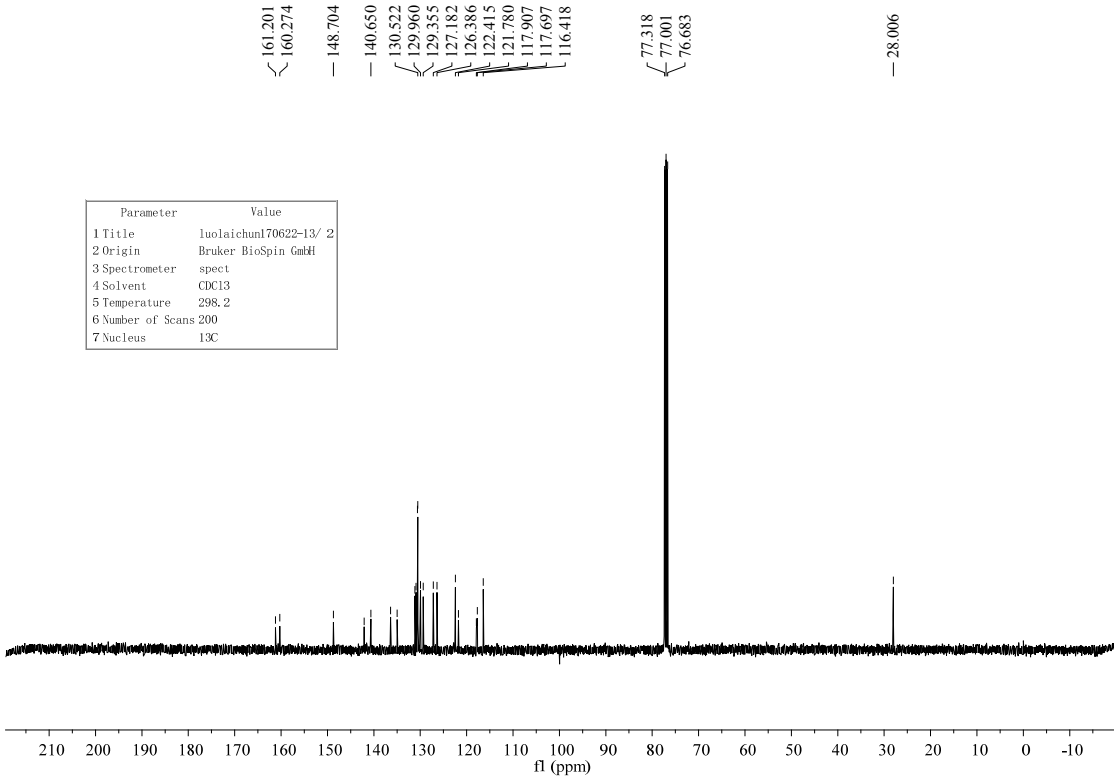

8.725
8.703
8.579
8.558
8.169
7.866
7.544
7.414
7.336
7.262
6.799
6.778
3.215
0.000
Parameter Value
1 Title luolaichun170622-9/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
0.98
1.02
3.05
4.00
1.00
3.00
f1 (ppm)

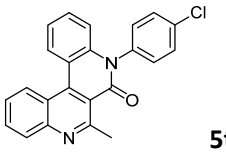

161.117
160.264
148.747
140.548
135.873
127.528
127.200
126.405
122.476
121.791
117.899
117.685
116.449
77.317
77.000
76.682
28.012
Parameter Value
1 Title luolaichun170622-9/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)


Cl
N
O
N

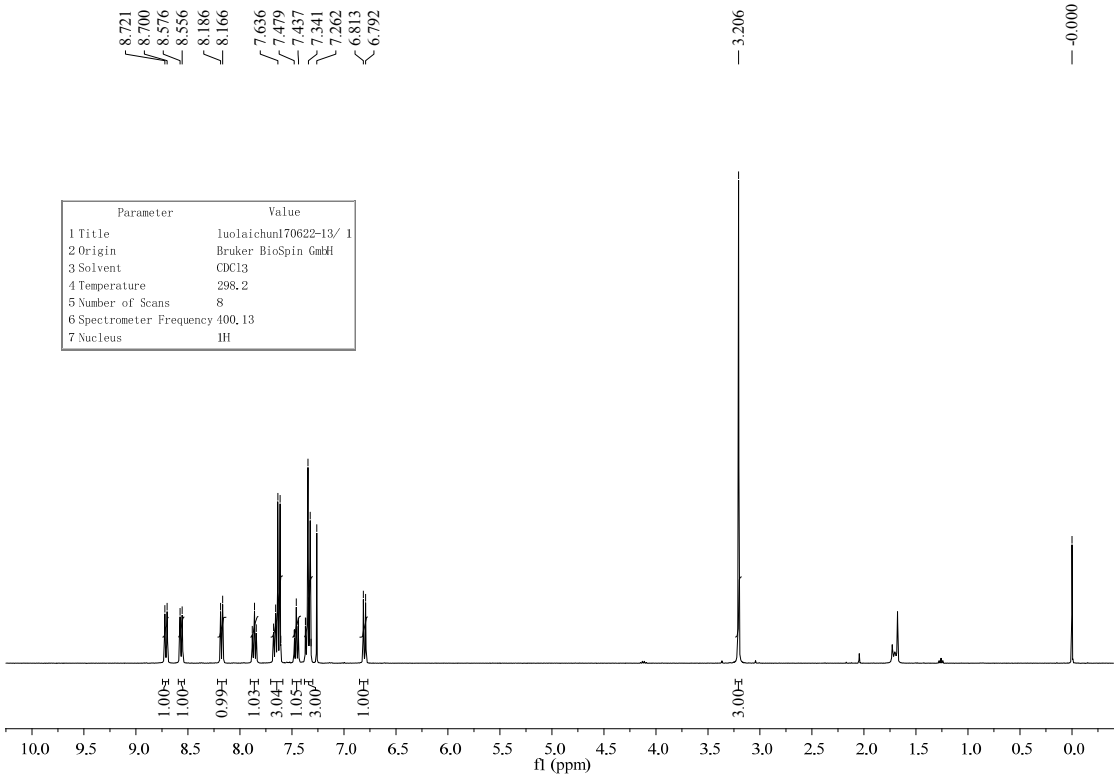
5t

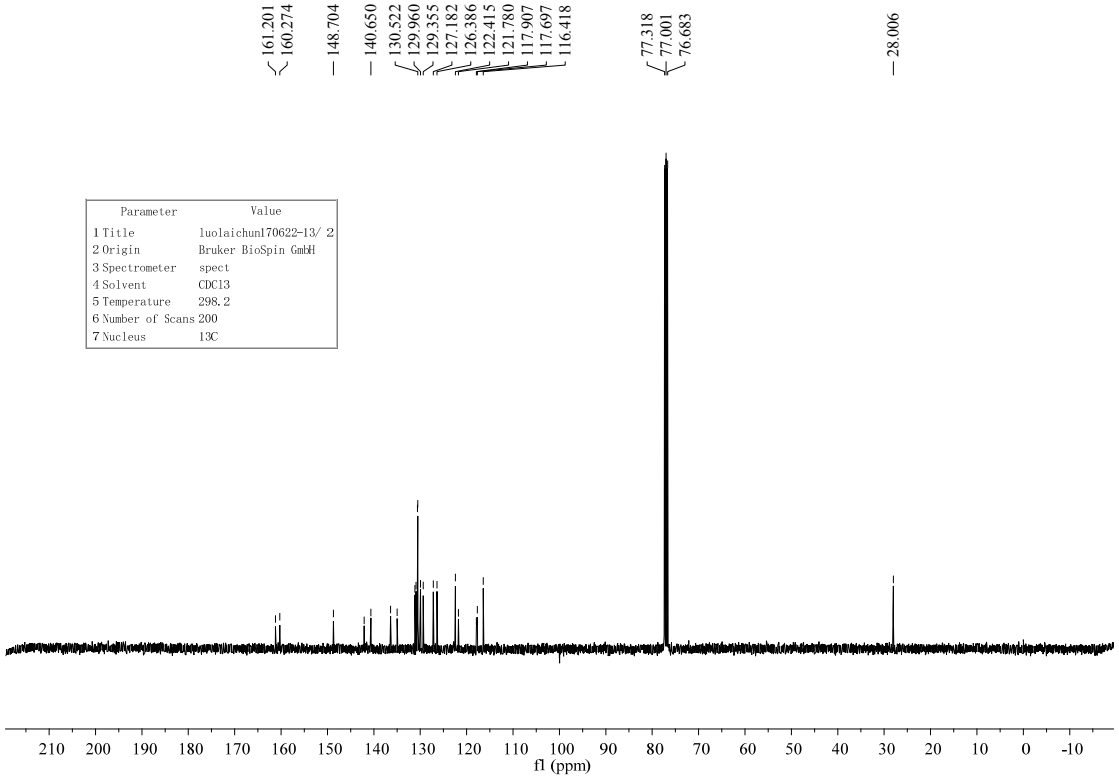

8.721
8.700
8.576
8.556
8.186
8.166
7.636
7.479
7.437
7.341
7.262
6.813
6.792
3.206
-0.000
Parameter Value
1 Title luolaichun170622-13/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
0.99
1.03
3.04
1.05
3.00
1.00
3.00
f1 (ppm)

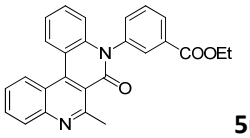

161.201
160.274
148.704
140.650
130.522
129.960
129.355
127.182
126.386
122.415
121.780
117.907
117.697
116.418
77.318
77.001
76.683
28.006
Parameter Value
1 Title luolaichun170622-13/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)


Cl
N
O
N

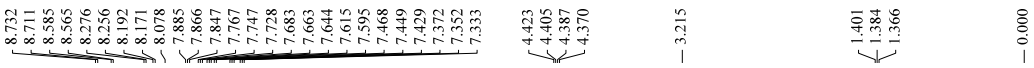
5t


8.721
8.700
8.576
8.556
8.186
8.166
7.636
7.479
7.437
7.341
7.262
6.813
6.792
3.206
-0.000
Parameter Value
1 Title luolaichun170622-13/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.00
0.99
1.03
3.04
1.05
3.00
1.00
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

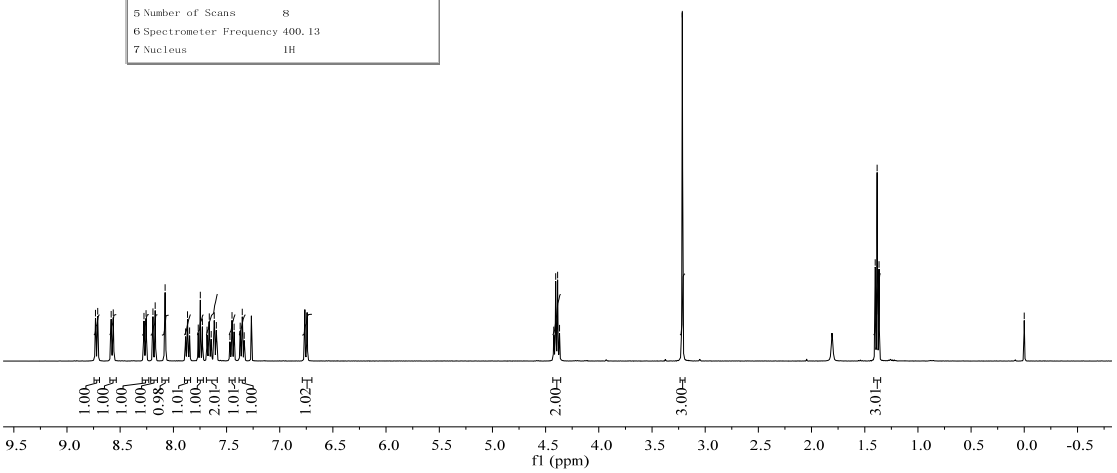

161.201
160.274
148.704
140.650
130.522
129.960
129.355
127.182
126.386
122.415
121.780
117.907
117.697
116.418
77.318
77.001
76.683
28.006
Parameter Value
1 Title luolaichun170622-13/ 2
2 Spectrometer spect
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 200
6 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

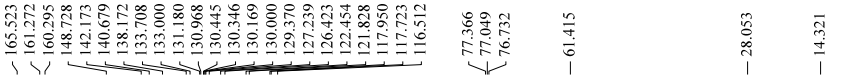


5u

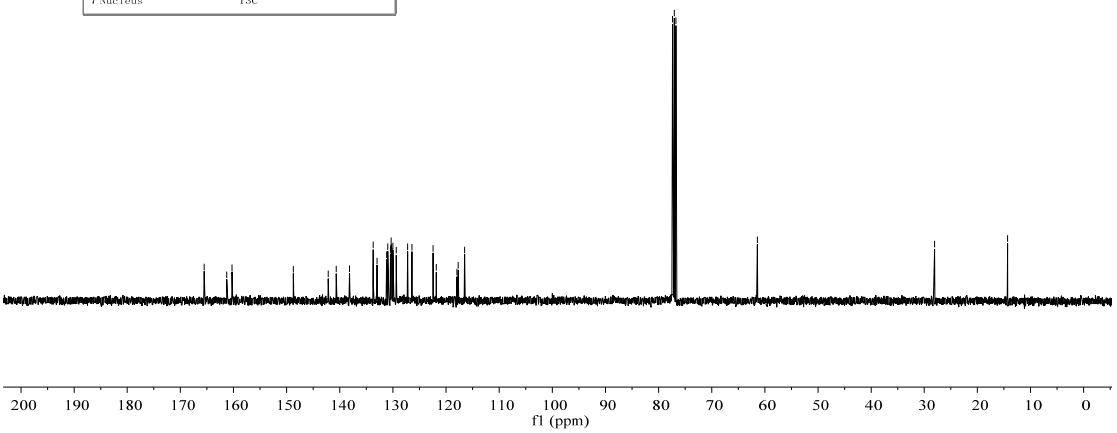


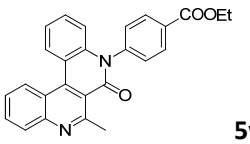
Parameter	Value
1 Title	luolaichun-20170926-12/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	295.3
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



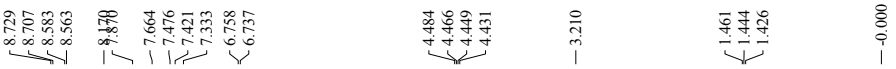


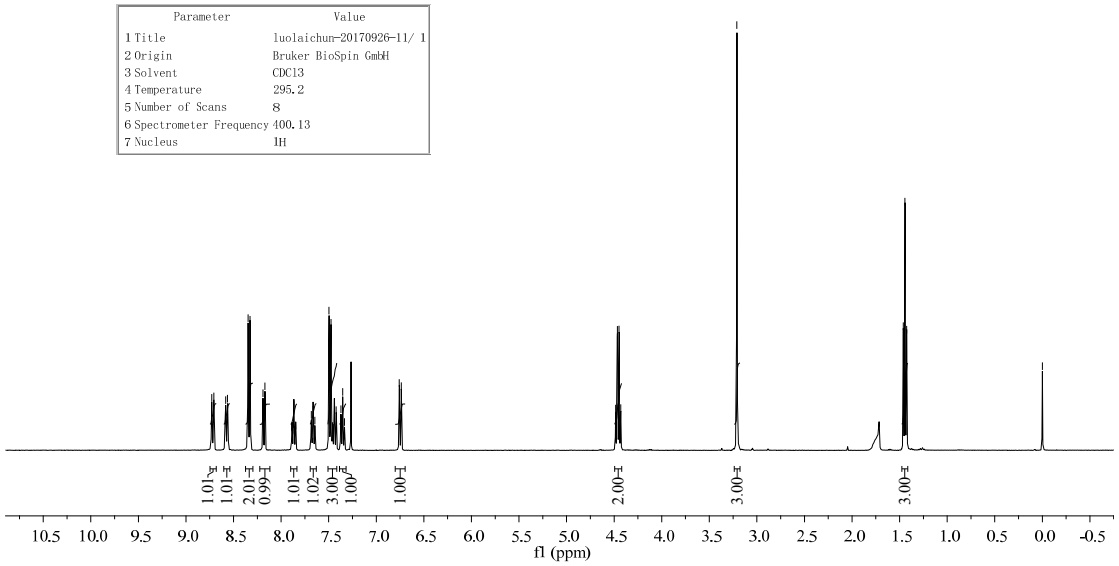
Parameter	Value
1 Title	luolaichun-20170926-12/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	296.8
5 Number of Scans	101
6 Spectrometer Frequency	100.62
7 Nucleus	13C

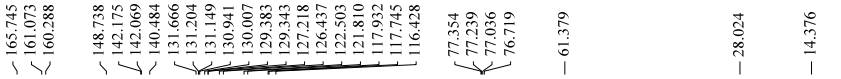


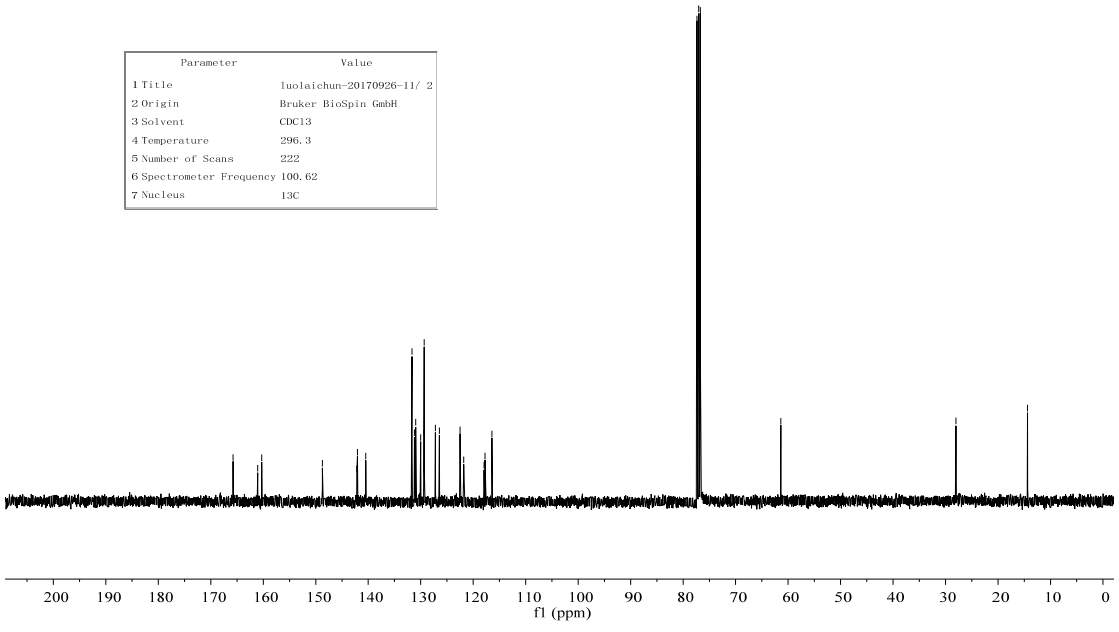

COOEt
N
O
N

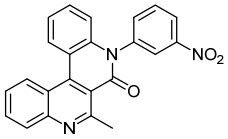
5v


8.729
8.707
8.583
8.563
7.664
7.476
7.421
7.333
6.758
6.737
4.484
4.466
4.449
4.431
3.210
1.461
1.444
1.426
-0.000


Parameter Value
1 Title luolaichun-20170926-11/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 295.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.01
1.01
2.01
0.99
1.01
1.02
3.00
1.00
1.00
2.00
3.00
3.00
f1 (ppm)

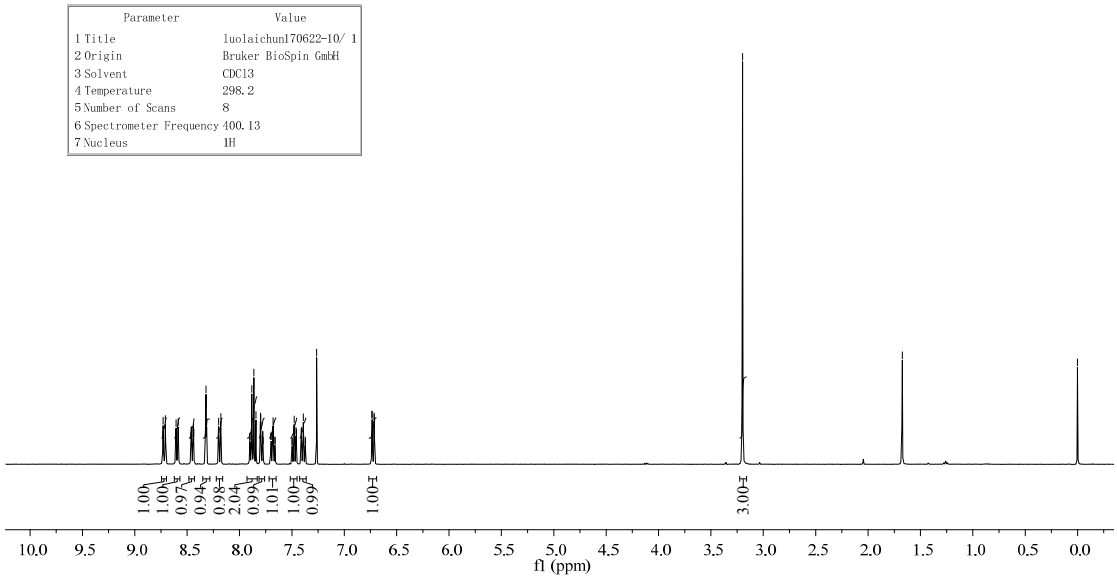

165.745
161.073
160.288
148.738
142.175
142.069
140.484
131.666
131.204
131.149
130.941
130.007
129.383
129.343
127.218
126.437
122.503
121.810
117.932
117.745
116.428
77.354
77.239
77.036
76.719
61.379
28.024
14.376

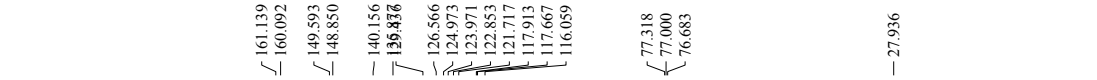

Parameter Value
1 Title luolaichun-20170926-11/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 296.3
5 Number of Scans 222
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



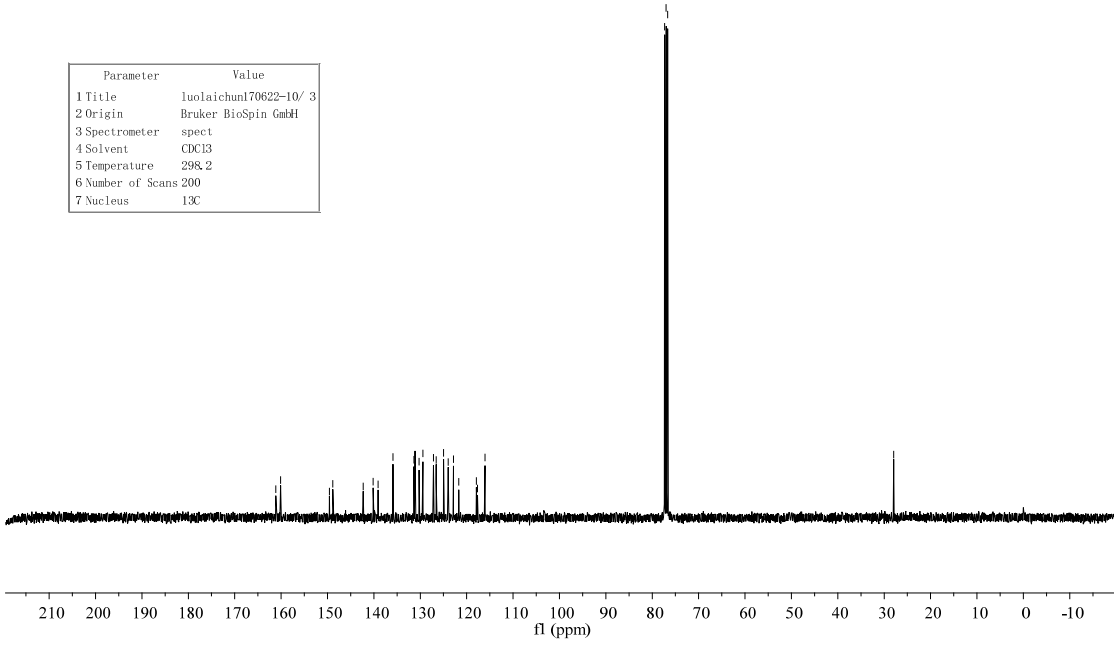
5w

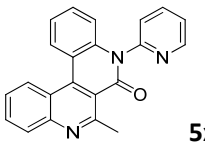
Parameter	Value
1 Title	luolaichun170622-10/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H





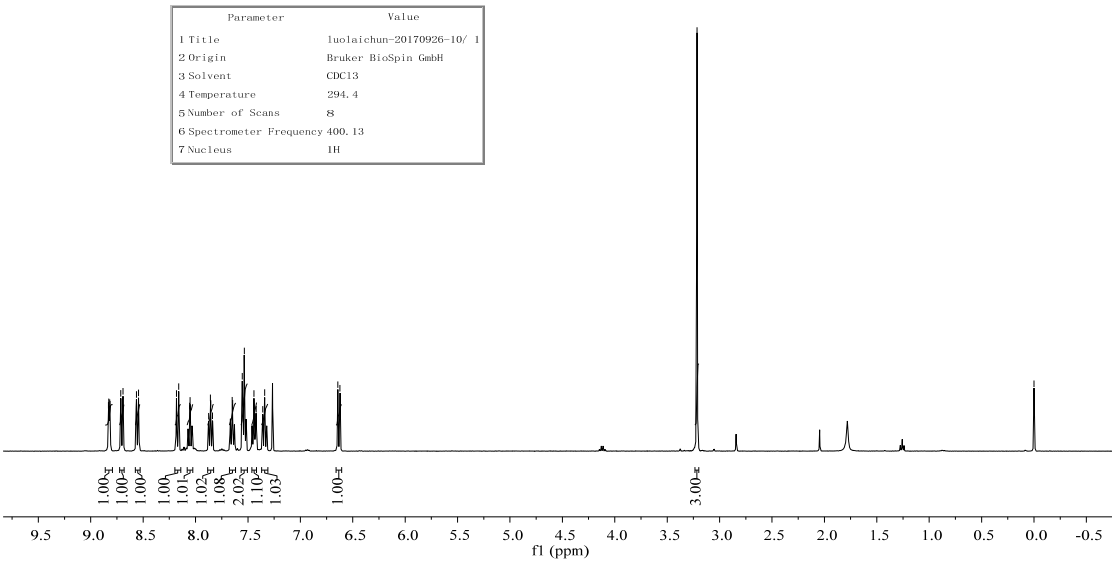
Parameter	Value
1 Title	luolaichun170622-10/ 3
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	200
7 Nucleus	13C

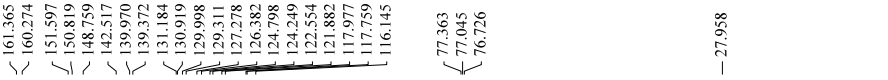




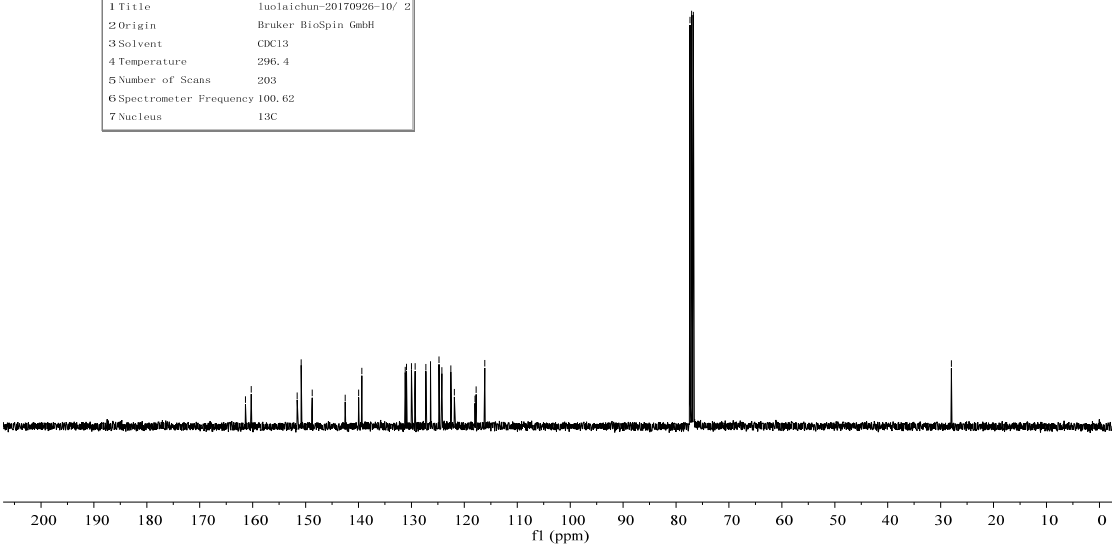
5x

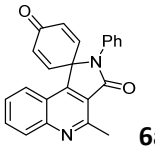
Parameter	Value
1 Title	luolaichun-20170926-10/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	294.4
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



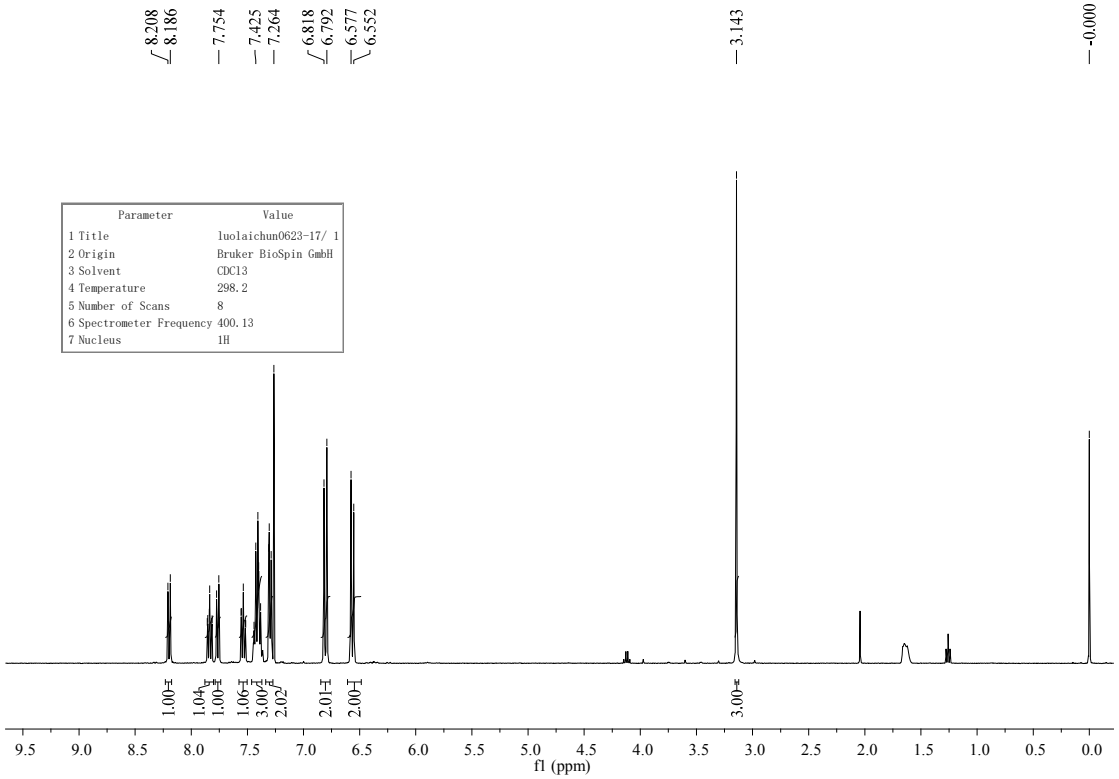


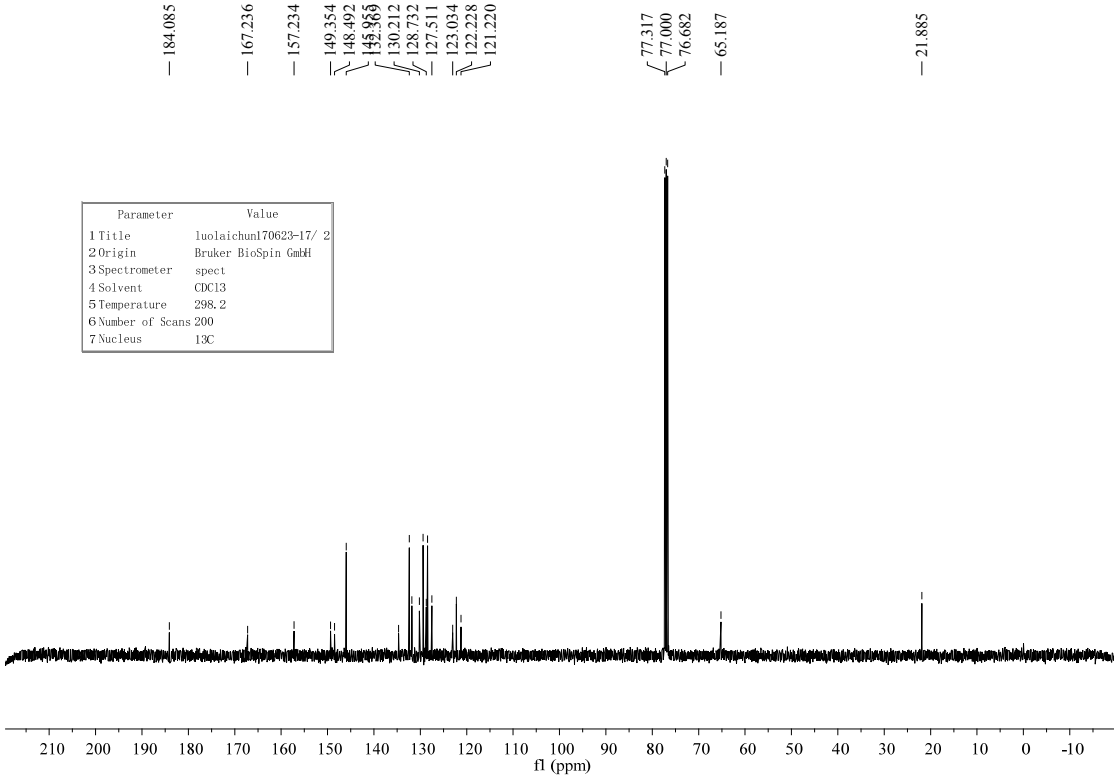
Parameter	Value
1 Title	luolaichun-20170926-10/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	296.4
5 Number of Scans	203
6 Spectrometer Frequency	100.62
7 Nucleus	13C

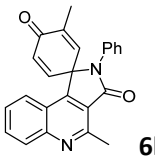



O
Ph
N
O
N

6a


8.208
8.186
7.754
7.425
7.264
6.818
6.792
6.577
6.552
3.143
-0.000
Parameter Value
1 Title luolaichun0623-17/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.04
1.00
1.06
3.00
2.02
2.01
2.00
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

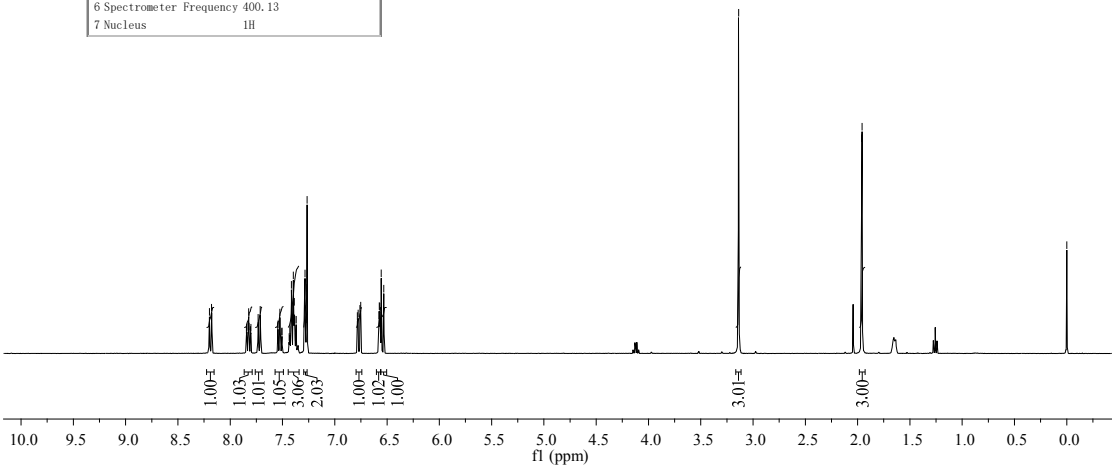

184.085
167.236
157.234
149.354
148.492
130.212
128.732
127.511
123.034
122.228
121.220
77.317
77.000
76.682
65.187
21.885
Parameter Value
1 Title luolaichun170623-17/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



6b

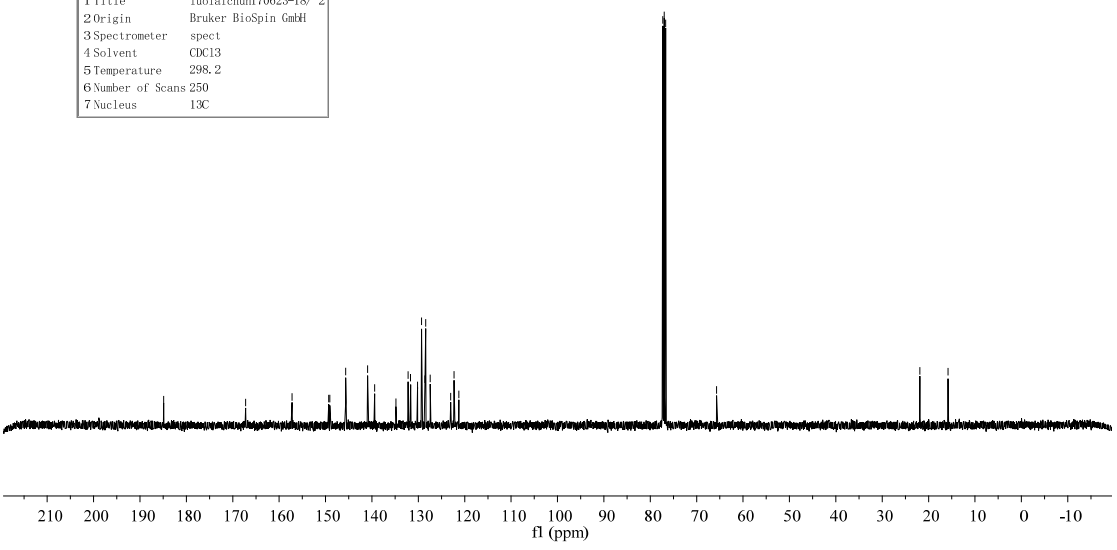
8.199
8.178
7.713
7.431
7.376
7.264
6.784
6.777
6.760
6.752
6.577
6.574
6.570
6.566
6.556
6.532
3.138
1.962
1.958
0.000

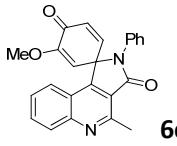
Parameter	Value
1 Title	luolaichun170623-18/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



184.900
167.228
157.216
145.659
139.414
130.166
127.433
123.040
122.286
121.265
77.318
77.000
76.683
65.715
21.884
15.818

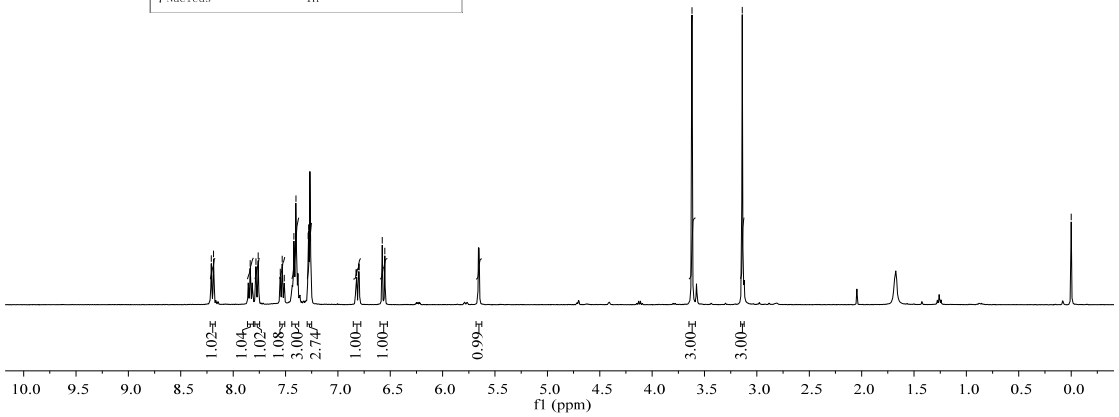
Parameter	Value
1 Title	luolaichun170623-18/ 2
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	250
7 Nucleus	13C



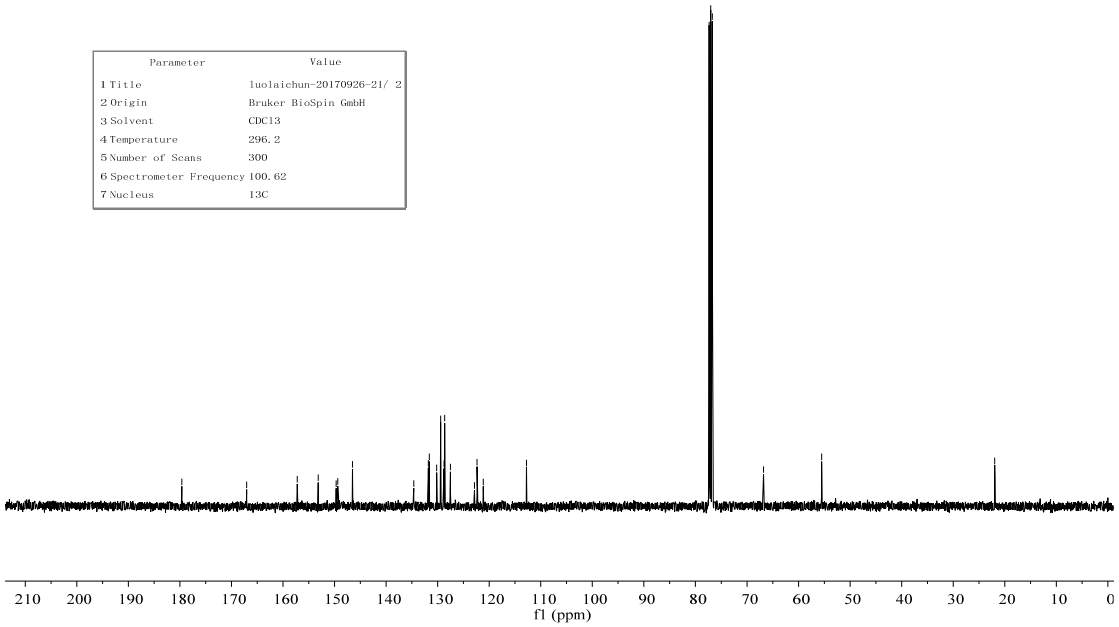


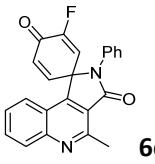
6c

Parameter	Value
1 Title	luolaichun-20170926-21/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	294.9
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H

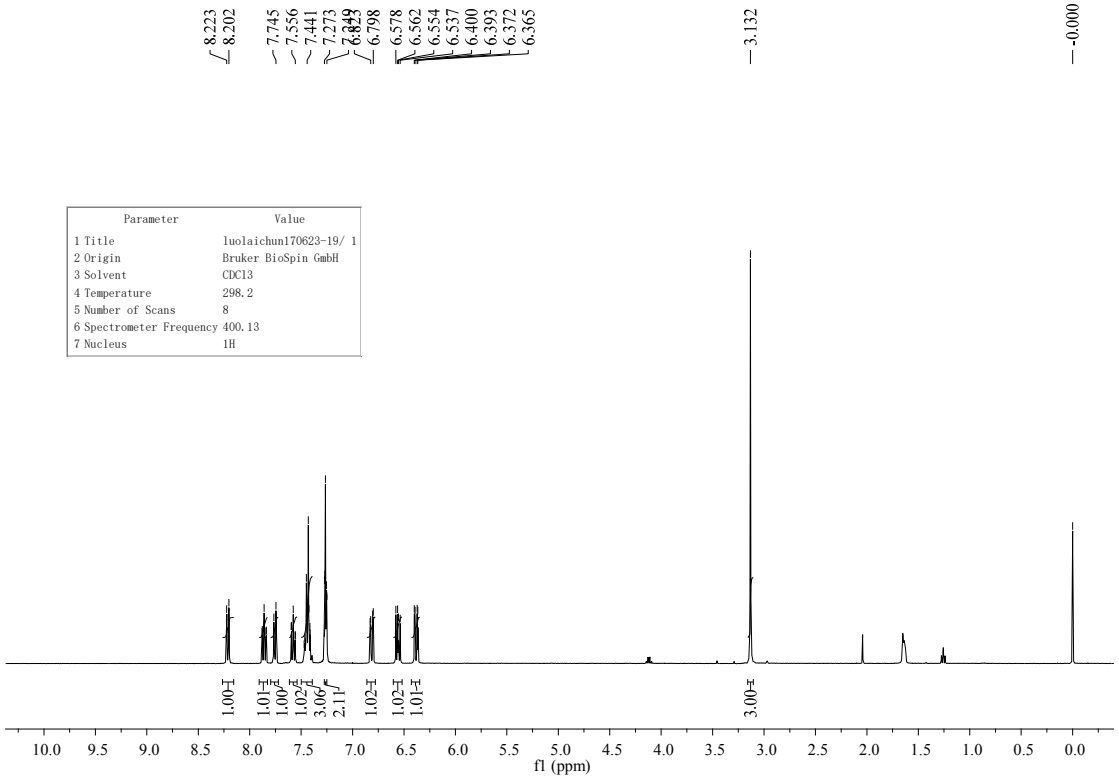


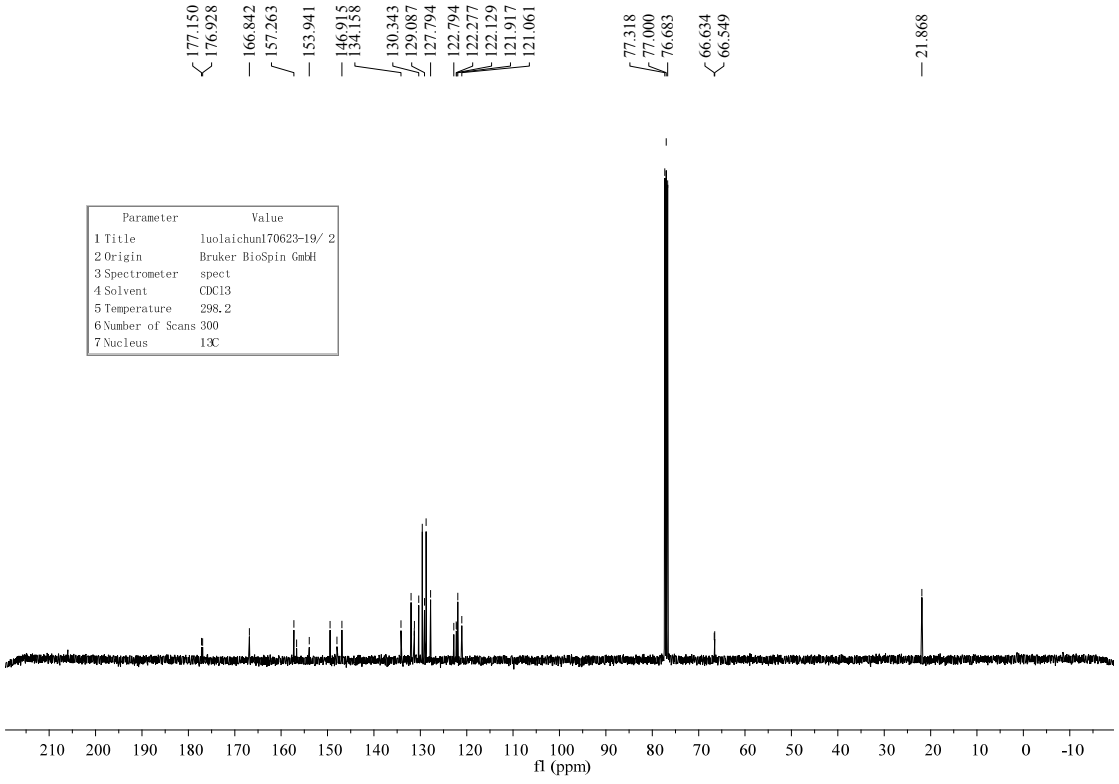
Parameter	Value
1 Title	luolaichun-20170926-21/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	296.2
5 Number of Scans	300
6 Spectrometer Frequency	100.62
7 Nucleus	13C

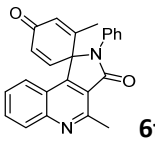



F
O
Ph
N
O
N

6d


8.223
8.202
7.745
7.556
7.441
7.273
6.798
6.578
6.562
6.554
6.537
6.400
6.393
6.372
6.365
3.132
-0.000
Parameter Value
1 Title luolaichun170623-19/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.01
1.00
1.02
3.06
2.11
1.02
1.02
1.01
3.00
f1 (ppm)

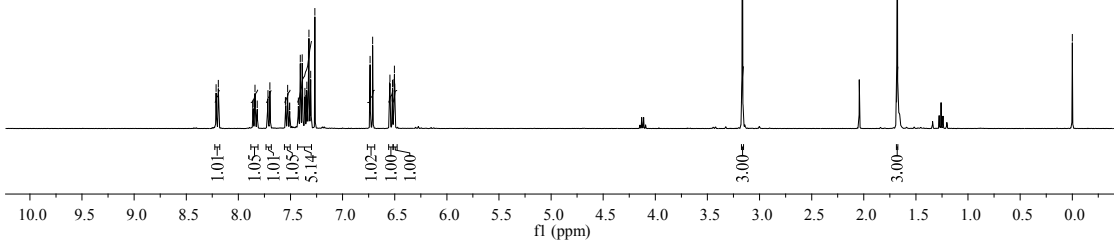

177.150
176.928
166.842
157.263
153.941
146.915
134.158
130.343
129.087
127.794
122.794
122.277
122.129
121.917
121.061
77.318
77.000
76.683
66.634
66.549
21.868
Parameter Value
1 Title luolaichun170623-19/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 300
7 Nucleus 13C
f1 (ppm)



6f

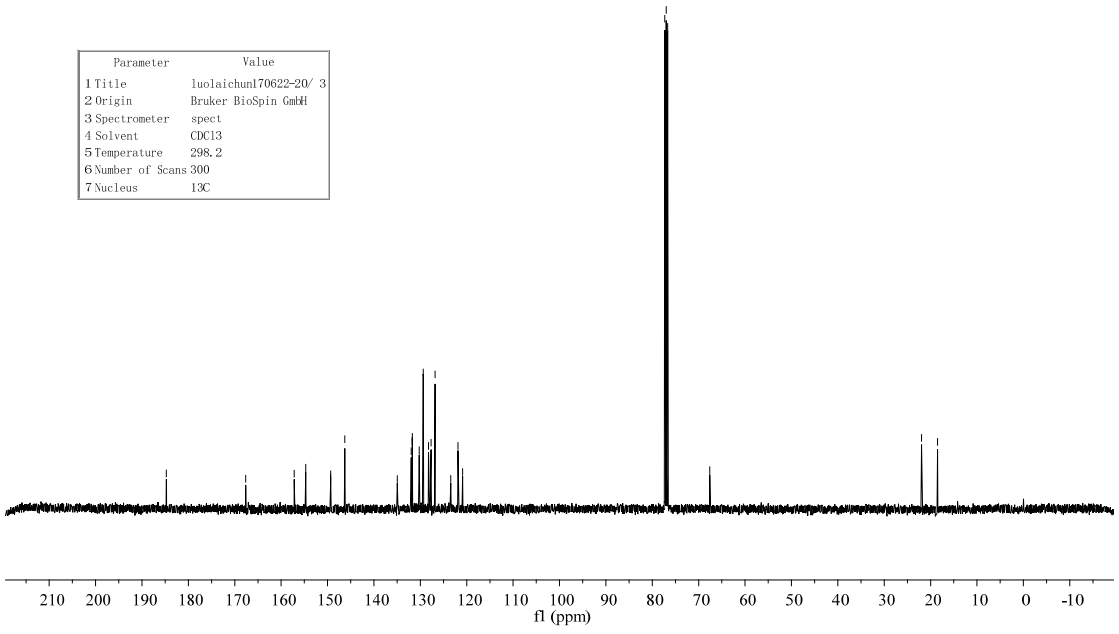
8.213
8.192
7.820
7.510
7.362
7.266
6.736
6.712
6.550
6.545
6.525
6.521
6.507
6.503
6.500
3.165
1.681
1.678
0.000

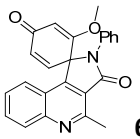
Parameter	Value
1 Title	luolaichun170622-20/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



184.739
167.633
157.182
154.696
149.337
149.311
146.276
131.743
131.709
130.239
129.375
128.231
127.674
126.819
123.437
121.881
120.882
77.318
77.000
76.683
67.620
21.939
18.495

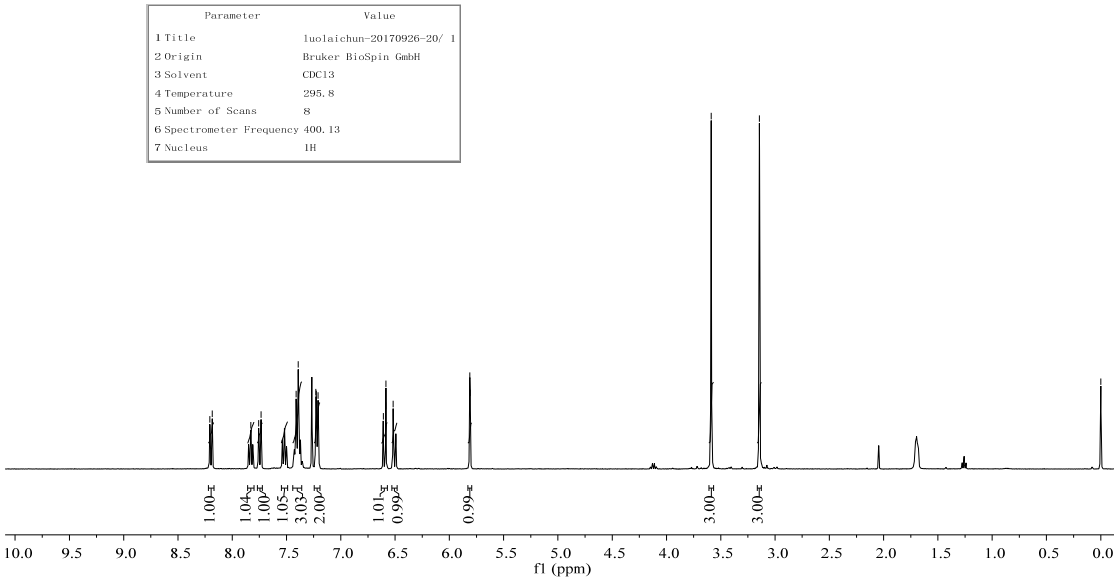
Parameter	Value
1 Title	luolaichun170622-20/ 3
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	300
7 Nucleus	13C



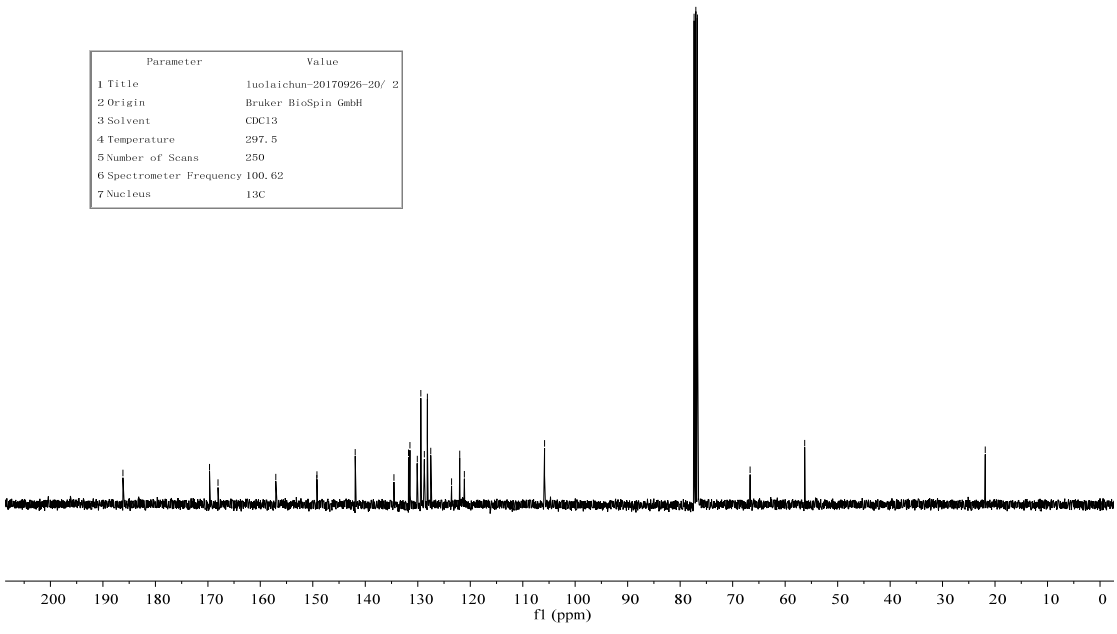


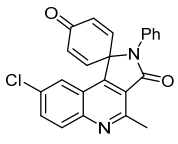
6g


8.206
8.184
7.828
7.756
7.735
7.411
7.392
7.230
7.226
7.209
6.609
6.586
6.584
6.518
6.515
5.812
5.808
3.588
3.144
-0.000


Parameter Value
1 Title luolaichun-20170926-20/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 295.8
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.04
1.00
1.05
3.03
2.00
1.01
0.99
0.99
3.00
3.00
f1 (ppm)


186.168
169.668
168.073
157.058
149.247
149.219
141.920
134.547
131.762
131.488
130.104
129.421
128.747
128.166
127.525
123.547
122.012
121.136
105.833
77.348
77.235
77.030
76.713
66.682
56.264
21.858

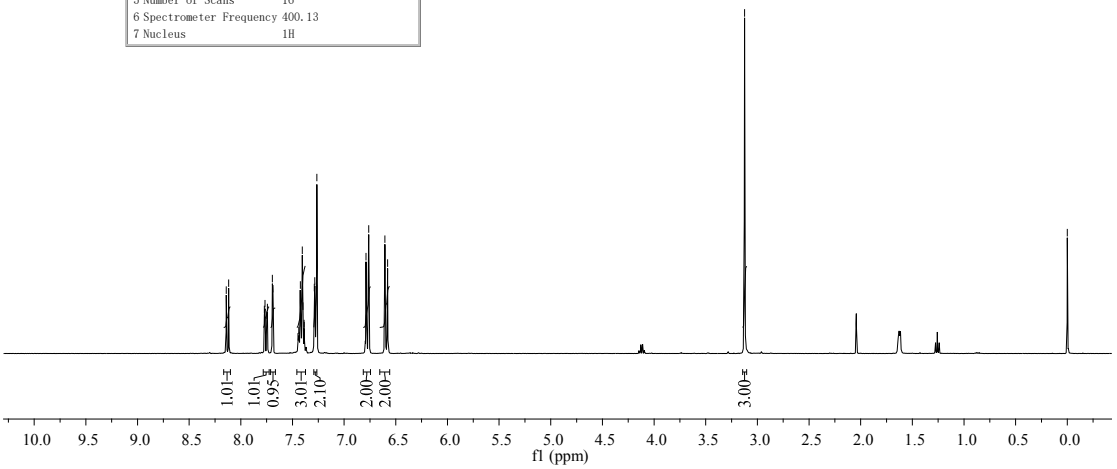

Parameter Value
1 Title luolaichun-20170926-20/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 297.5
5 Number of Scans 250
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)



6h

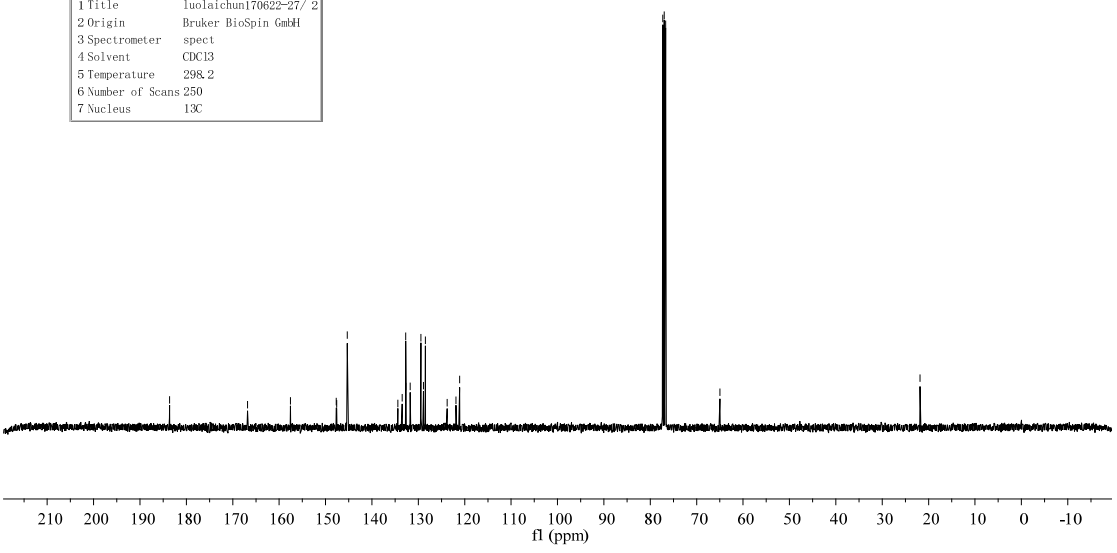
8.140
8.118
7.689
7.264
6.788
6.763
6.605
6.580
3.124
-0.000

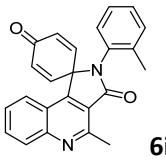
Parameter	Value
1 Title	luolaichun170622-27/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	16
6 Spectrometer Frequency	400.13
7 Nucleus	1H



183.633
166.822
157.550
147.701
147.583
145.318
132.669
129.441
128.475
123.795
121.870
121.106
77.318
77.000
76.683
64.993
21.841

Parameter	Value
1 Title	luolaichun170622-27/ 2
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	250
7 Nucleus	13C

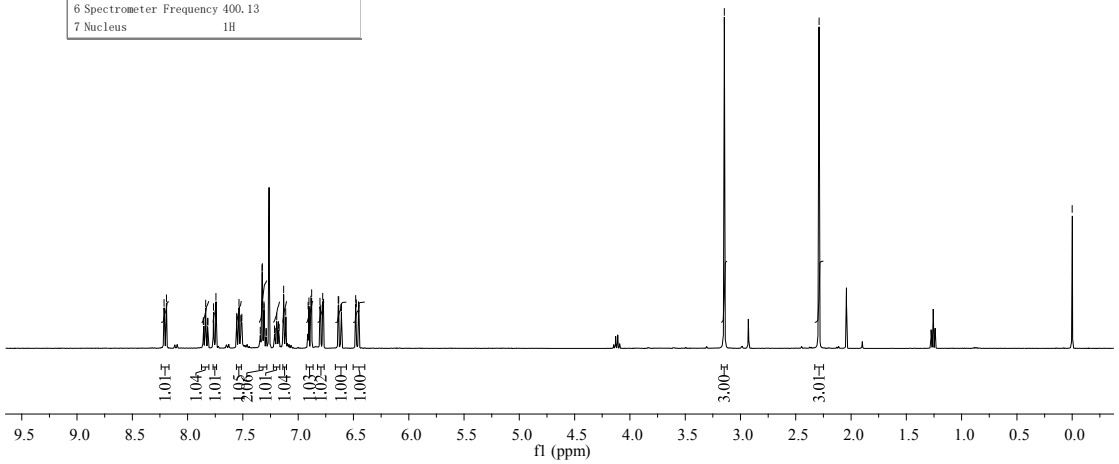




6i

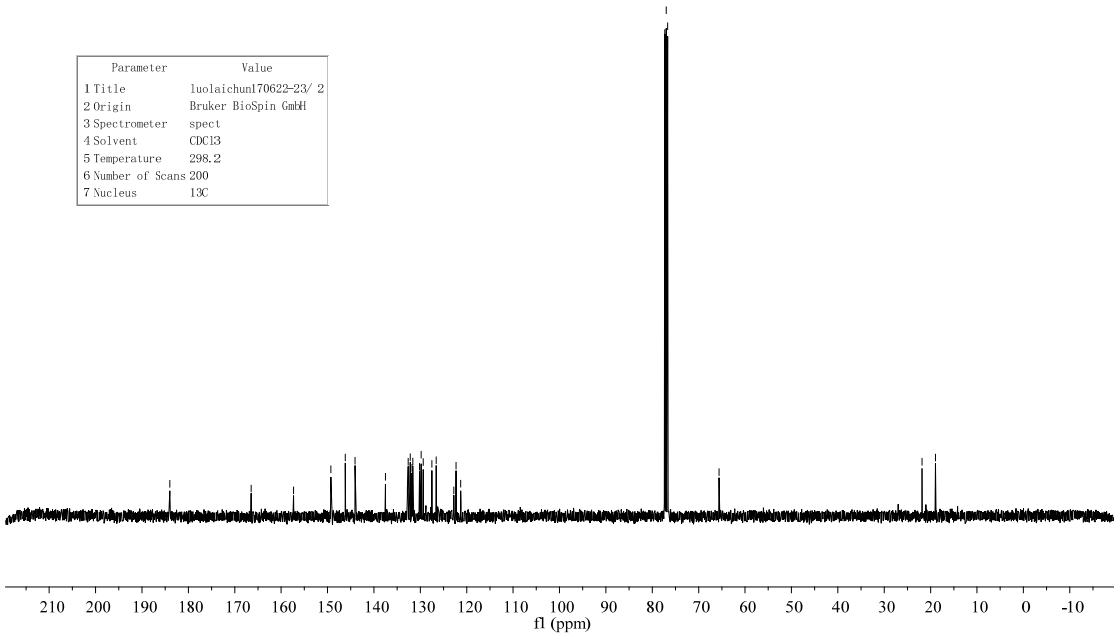
8.212
8.191
7.744
7.327
7.214
7.112
6.878
6.803
6.796
6.778
6.771
6.638
6.634
6.613
6.609
6.479
6.475
6.454
6.450
3.146
2.290
-0.000

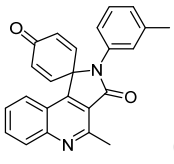
Parameter	Value
1 Title	luolaichun170622-23/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



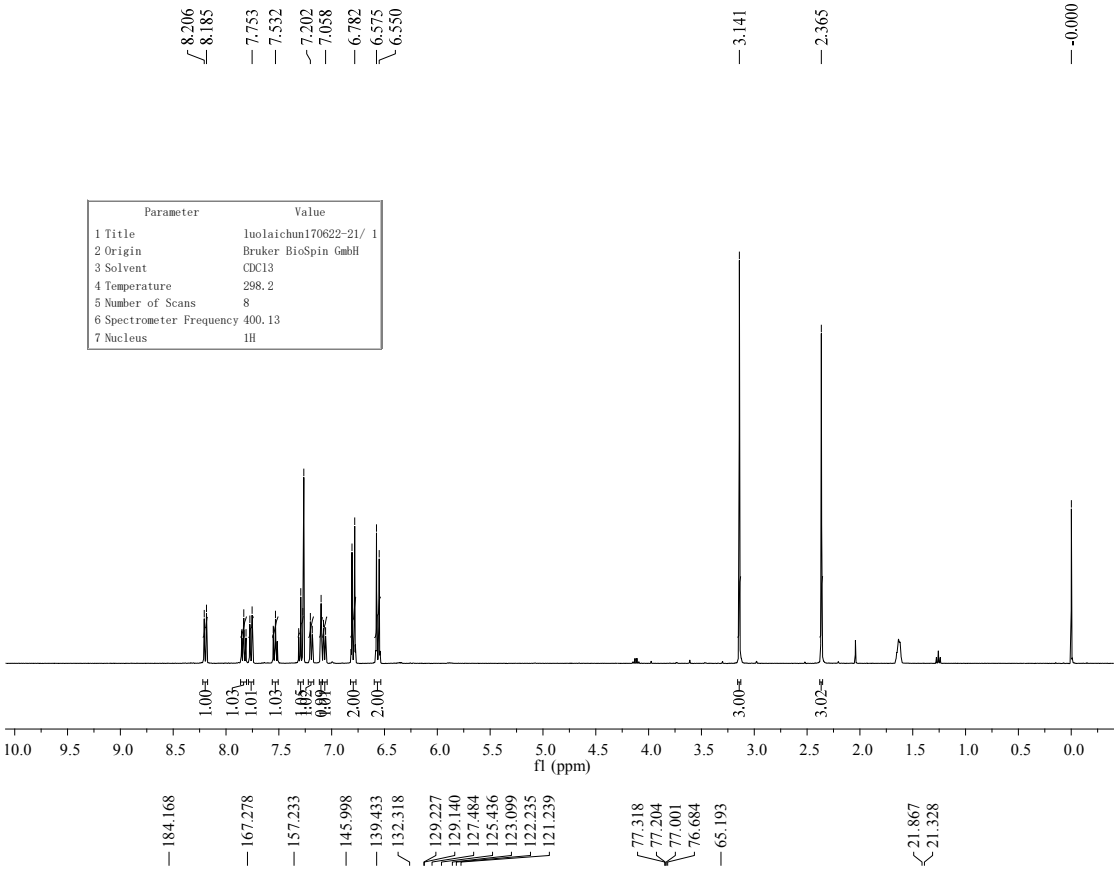
184.012
166.483
157.311
146.171
144.075
137.533
132.158
129.823
129.373
127.497
126.571
122.798
122.284
121.298
77.318
77.000
76.683
65.611
21.843
18.955

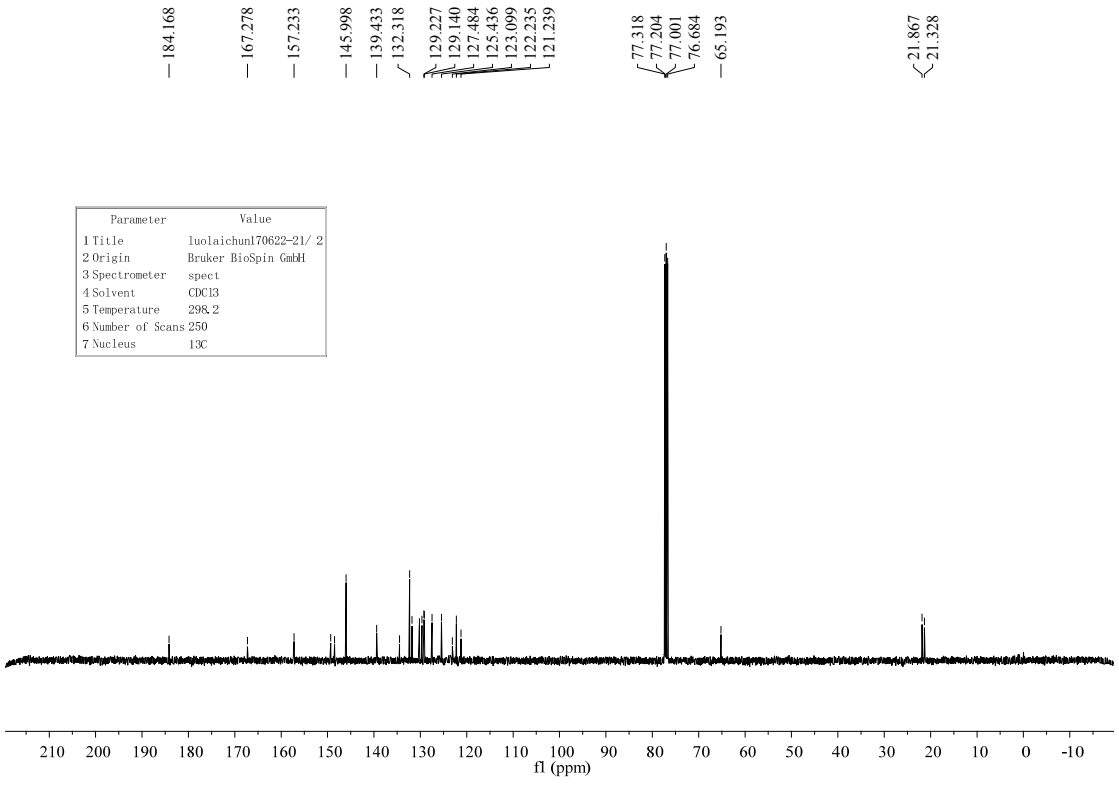
Parameter	Value
1 Title	luolaichun170622-23/ 2
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	200
7 Nucleus	13C

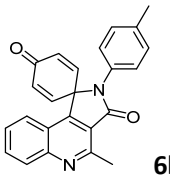




6j


8.206
8.185
7.753
7.532
7.202
7.058
6.782
6.575
6.550
3.141
2.365
-0.000
Parameter Value
1 Title luolaichun170622-21/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.03
1.01
1.03
2.00
2.00
3.00
3.02
f1 (ppm)

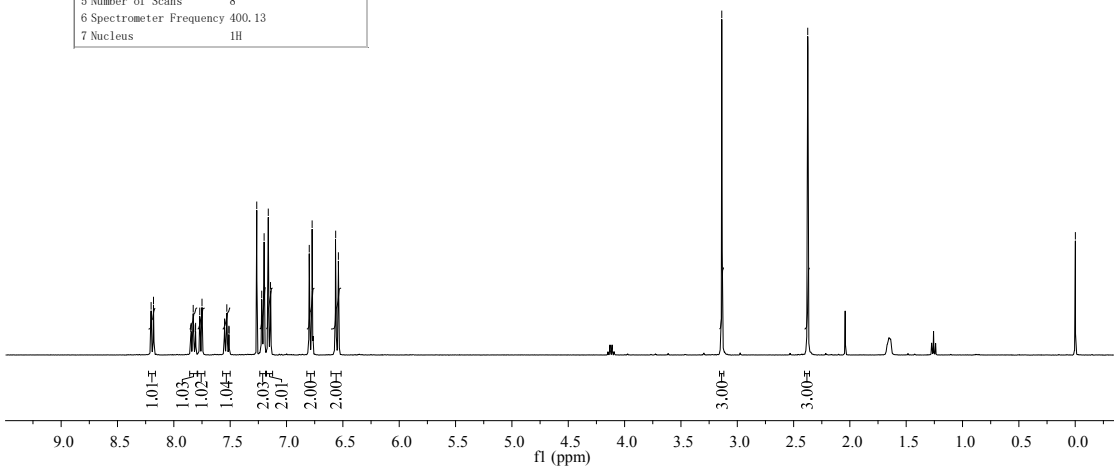

184.168
167.278
157.233
145.998
139.433
132.318
129.227
129.140
127.484
125.436
123.099
122.235
121.239
77.318
77.204
77.001
76.684
65.193
21.867
21.328
Parameter Value
1 Title luolaichun170622-21/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 250
7 Nucleus 13C
f1 (ppm)



6k

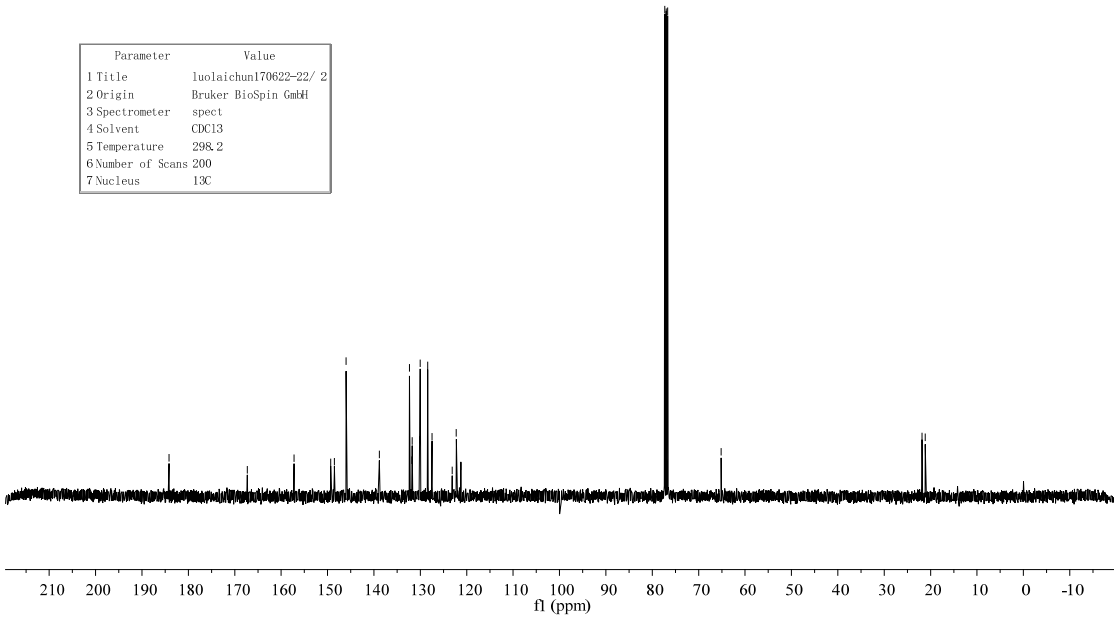
8.201
8.180
7.749
7.509
7.141
6.798
6.772
6.564
6.539
3.137
2.374
-0.000

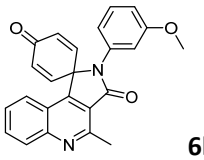
Parameter	Value
1 Title	luolaichun170622-22/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



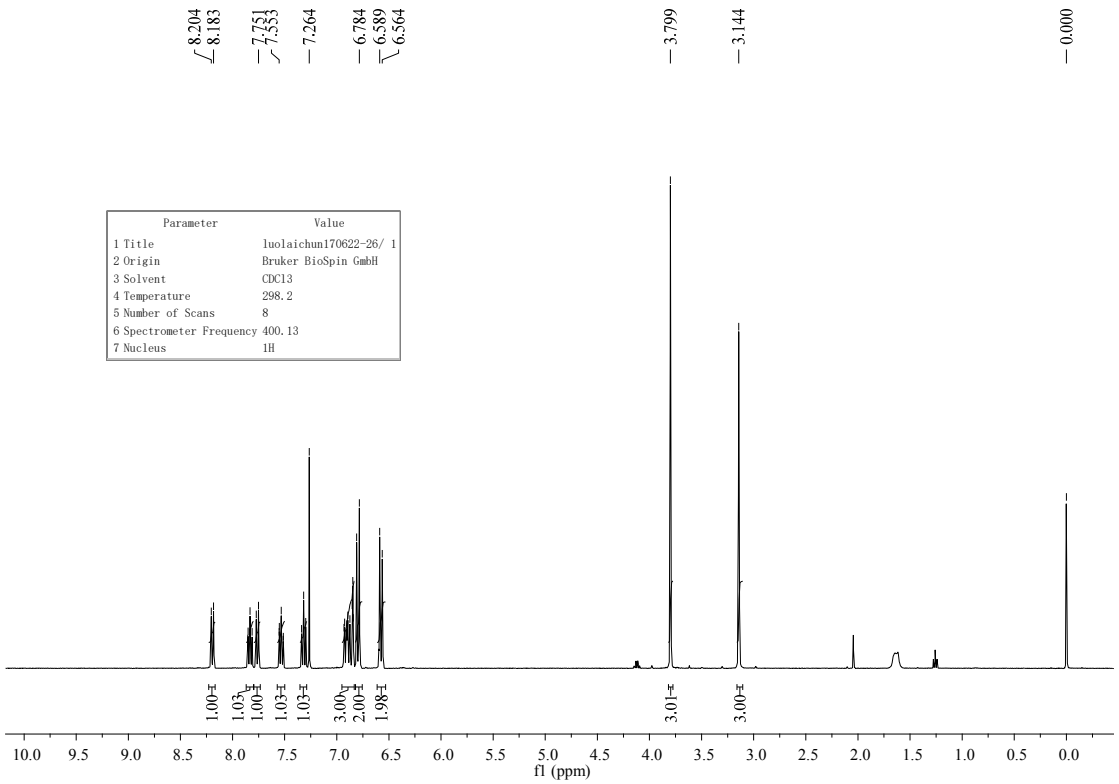
184.159
167.302
157.224
145.992
138.843
132.328
127.464
123.136
122.248
121.259
77.318
77.001
76.683
65.146
21.862
21.154

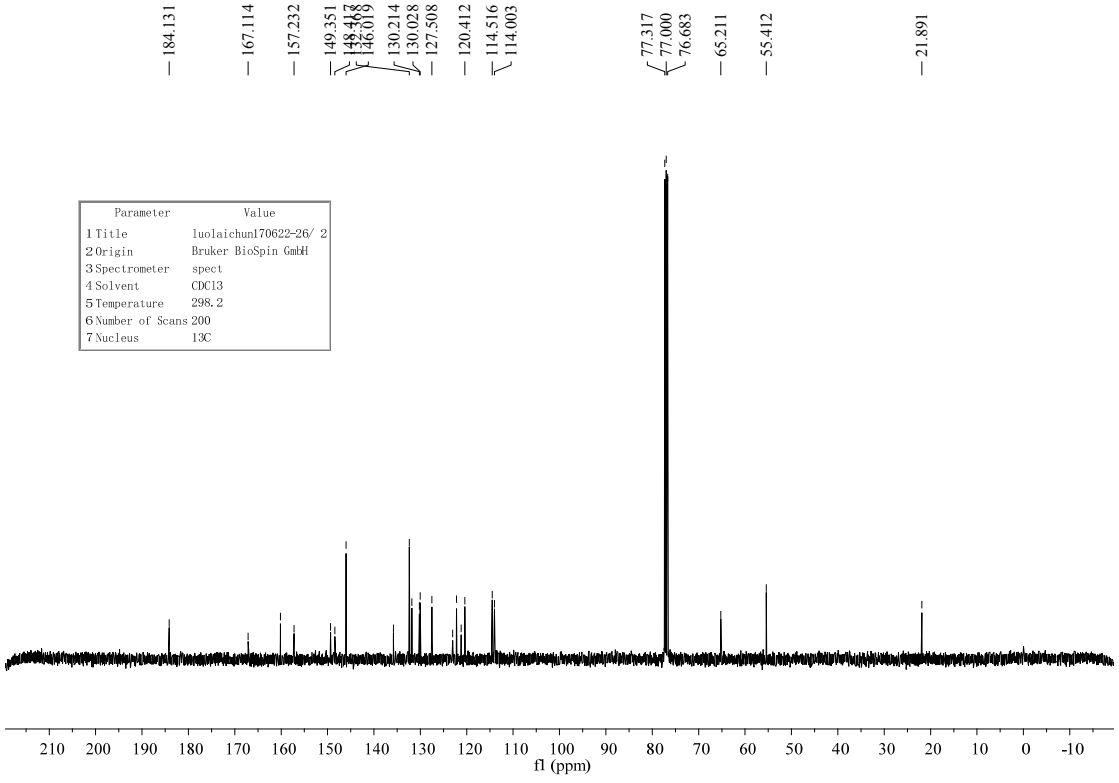
Parameter	Value
1 Title	luolaichun170622-22/ 2
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	200
7 Nucleus	13C

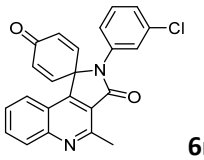




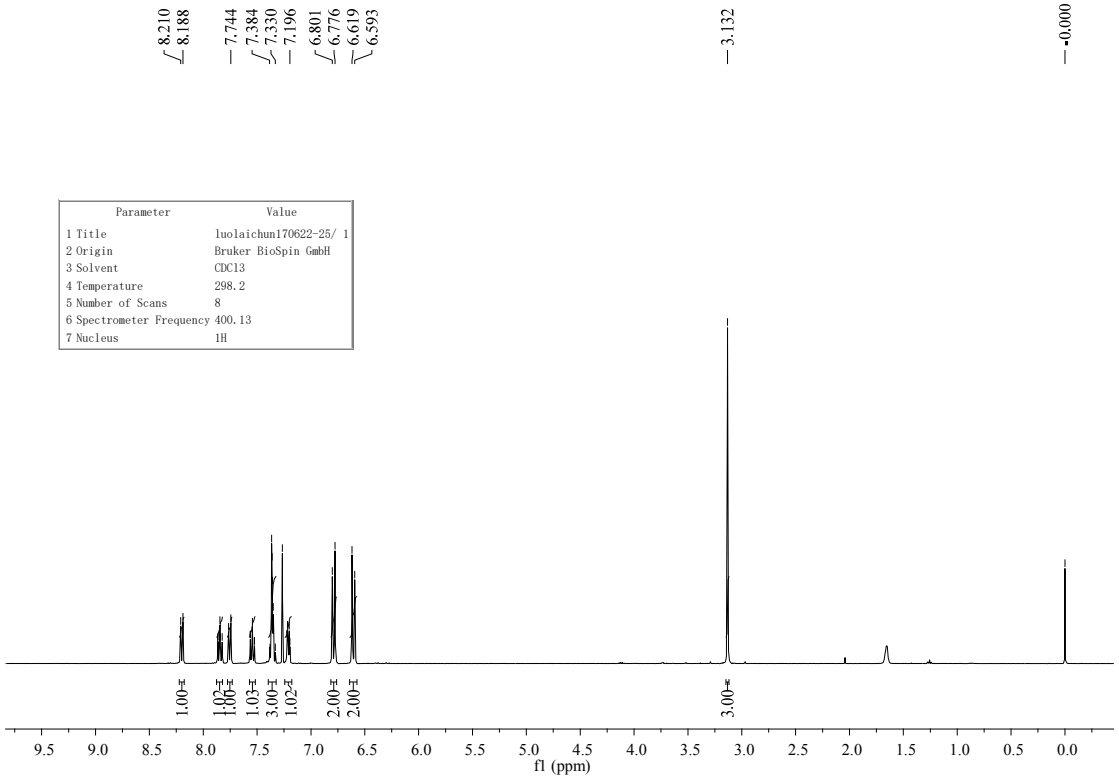
6l

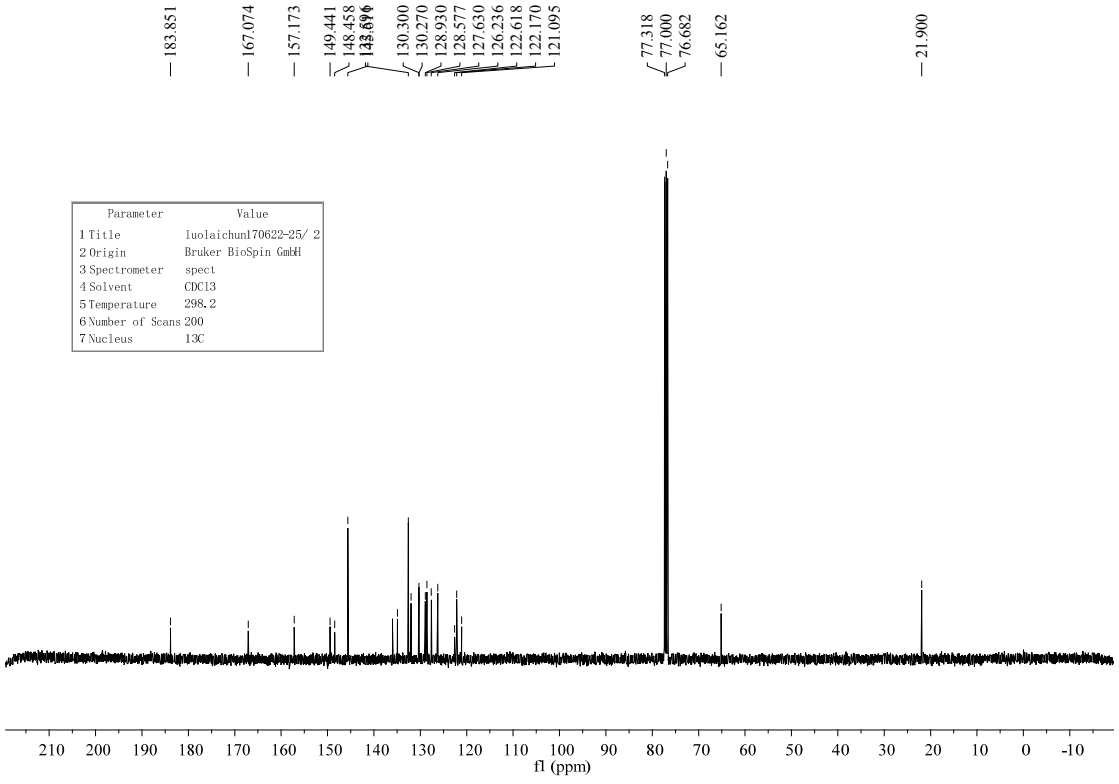

8.204
8.183
7.751
7.353
7.264
6.784
6.589
6.564
3.799
3.144
0.000
Parameter Value
1 Title luolaichun170622-26/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.03
1.00
1.03
1.03
3.00
2.00
1.98
3.01
3.00
f1 (ppm)


184.131
167.114
157.232
149.351
148.417
148.168
146.019
130.214
130.028
127.508
120.412
114.516
114.003
77.317
77.000
76.683
65.211
55.412
21.891
Parameter Value
1 Title luolaichun170622-26/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
f1 (ppm)


O
Cl
N
O
N

6m


8.210
8.188
7.744
7.384
7.330
7.196
6.801
6.776
6.619
6.593
3.132
0.000
Parameter Value
1 Title luolaichun170622-25/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 298.2
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
1.00
1.02
1.00
1.03
3.00
1.02
2.00
2.00
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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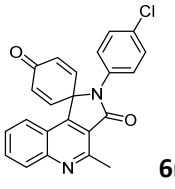
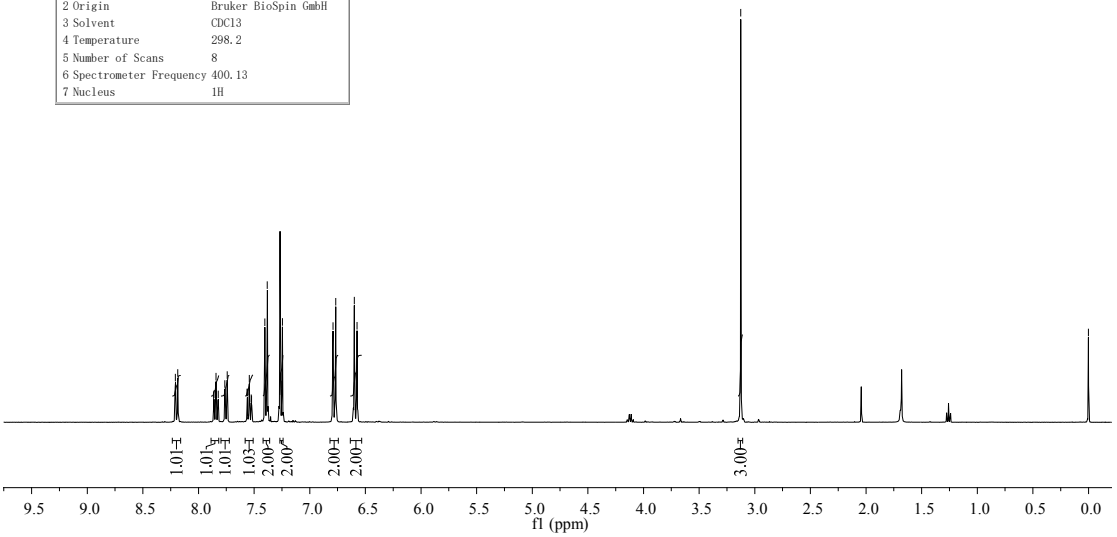
167.074
157.173
149.441
148.458
130.300
130.270
128.930
128.577
127.630
126.236
122.618
122.170
121.095
77.318
77.000
76.682
65.162
21.900
Parameter Value
1 Title luolaichun170622-25/ 2
2 Origin Bruker BioSpin GmbH
3 Spectrometer spect
4 Solvent CDCl3
5 Temperature 298.2
6 Number of Scans 200
7 Nucleus 13C
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



6n

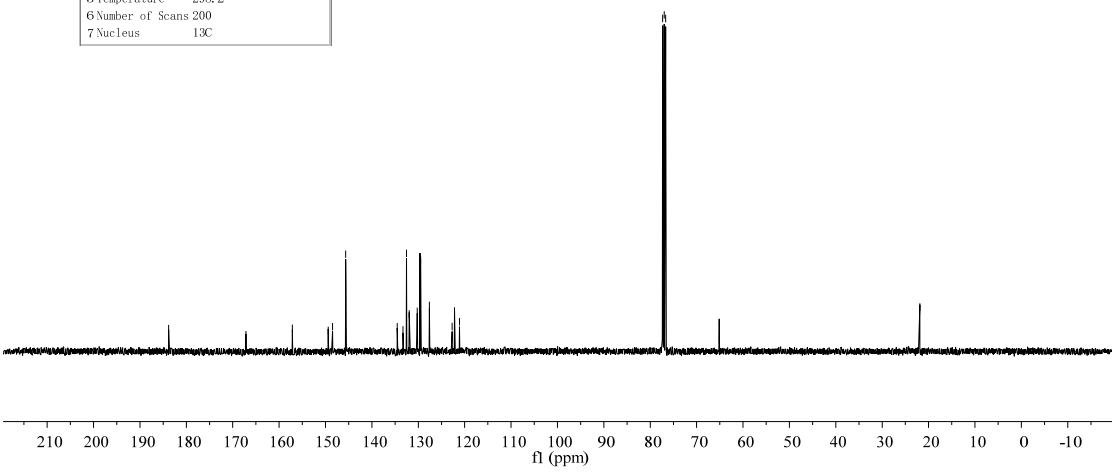
8.207
8.186
7.742
7.564
7.246
6.791
6.766
6.600
6.574
3.126
0.000

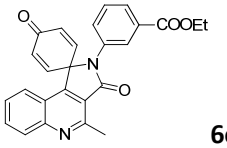
Parameter	Value
1 Title	luolaichun170622-24/ 3
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	298.2
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



183.818
167.156
157.152
149.403
148.491
131.961
129.655
127.614
122.712
122.178
121.119
77.317
77.000
76.682
65.112
21.886

Parameter	Value
1 Title	luolaichun170622-24/ 4
2 Origin	Bruker BioSpin GmbH
3 Spectrometer	spect
4 Solvent	CDCl3
5 Temperature	298.2
6 Number of Scans	200
7 Nucleus	13C

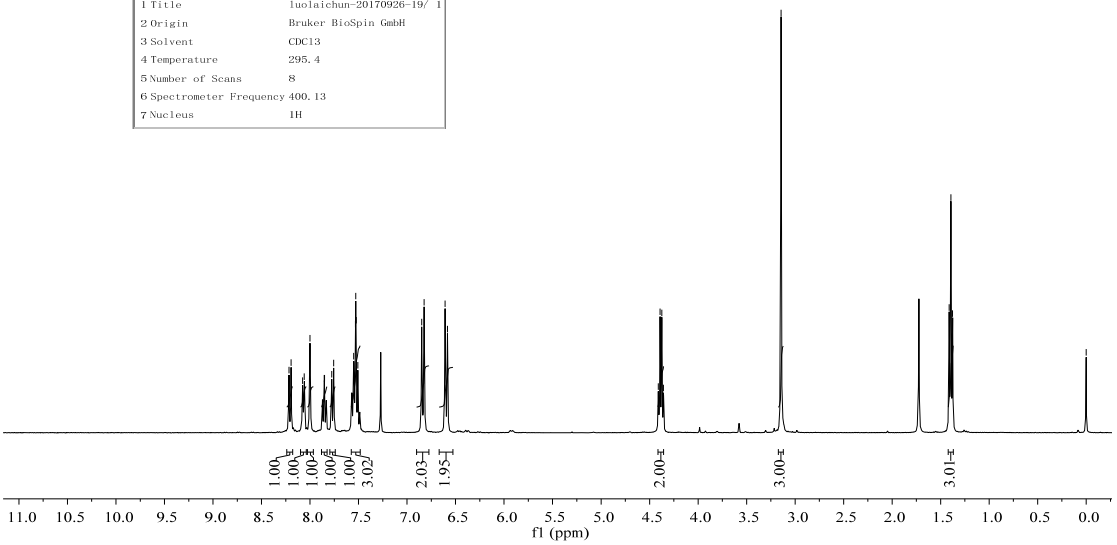




6o

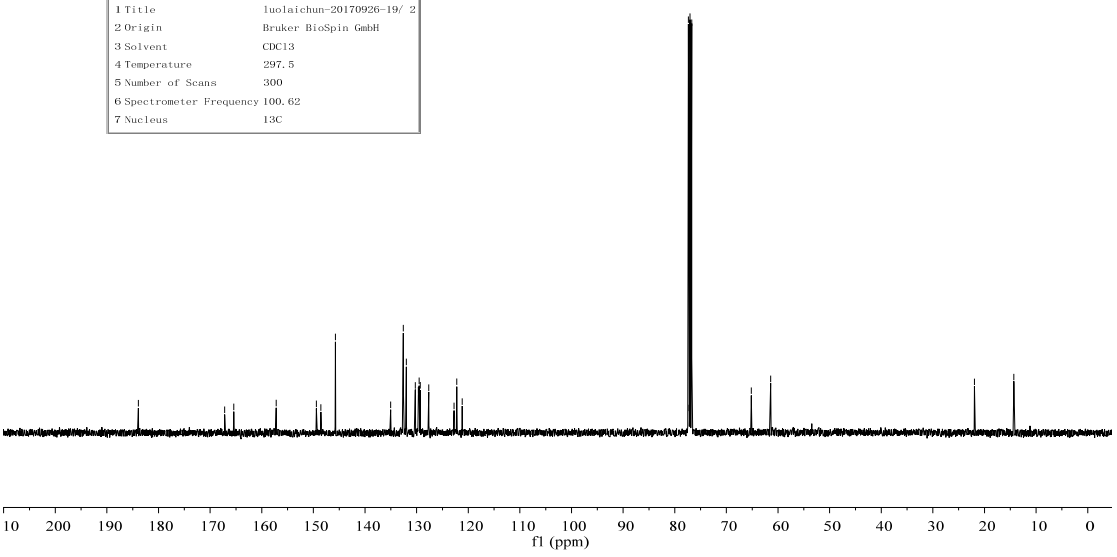
8.217
8.195
8.076
8.059
8.000
7.854
7.851
7.777
7.756
7.550
7.532
7.528
7.524
7.507
6.848
6.824
6.607
6.583
4.410
4.392
4.375
4.357
3.145
1.413
1.395
1.377
0.000

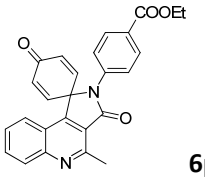
Parameter	Value
1 Title	luolaichun-20170926-19/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	295.4
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



183.917
167.175
165.414
157.212
149.418
148.545
145.737
135.042
132.585
132.549
131.998
130.253
129.670
129.505
129.308
127.643
122.764
122.232
121.160
77.355
77.239
77.037
76.719
65.158
61.412
21.937
14.308

Parameter	Value
1 Title	luolaichun-20170926-19/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	297.5
5 Number of Scans	300
6 Spectrometer Frequency	100.62
7 Nucleus	13C

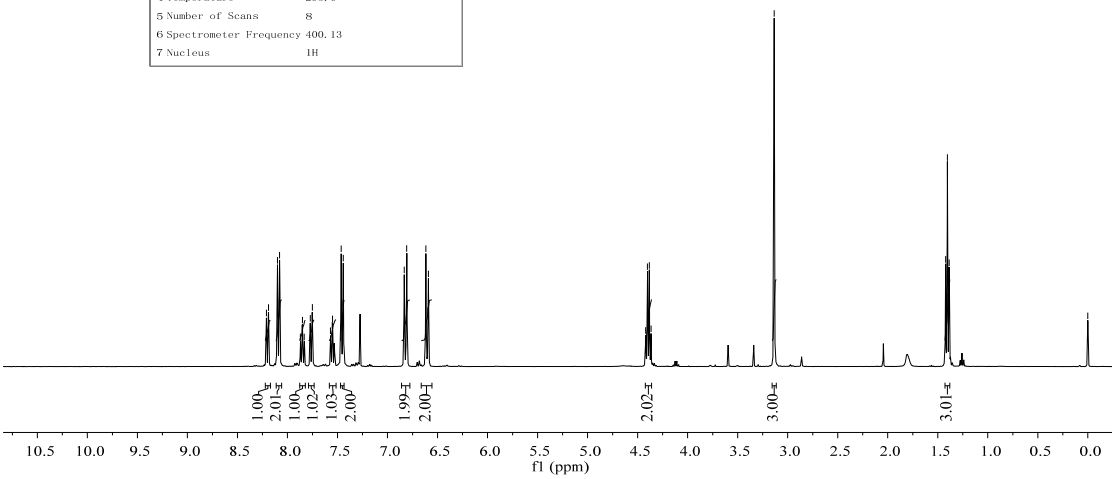




6p

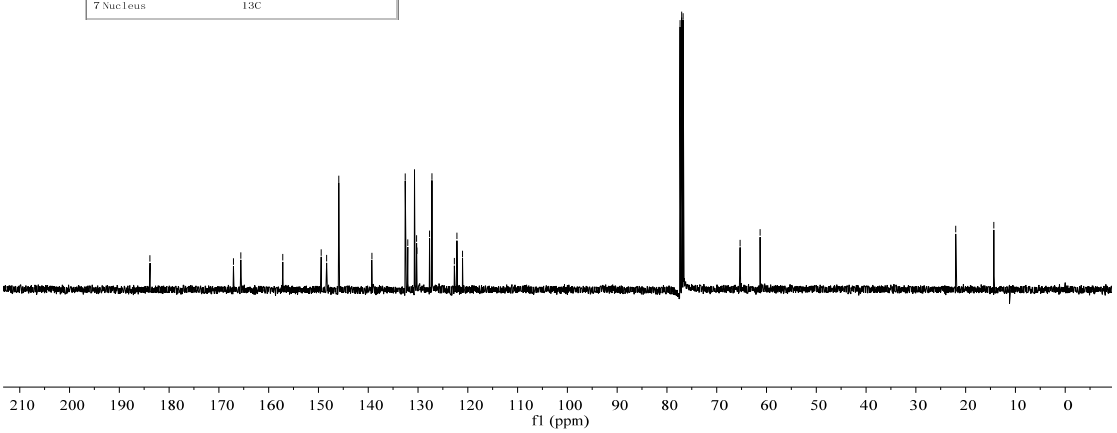
8.211 8.190 8.100 8.083 8.079 7.871 7.853 7.850 7.832 7.773 7.752 7.570 7.553 7.549 7.463 7.446 7.442 6.833 6.808 6.616 6.595 6.591 4.419 4.401 4.384 4.366 3.136 1.422 1.404 1.386 0.000

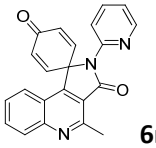
Parameter	Value
1 Title	luolaichun-20170926-18/ 1
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	295.6
5 Number of Scans	8
6 Spectrometer Frequency	400.13
7 Nucleus	1H



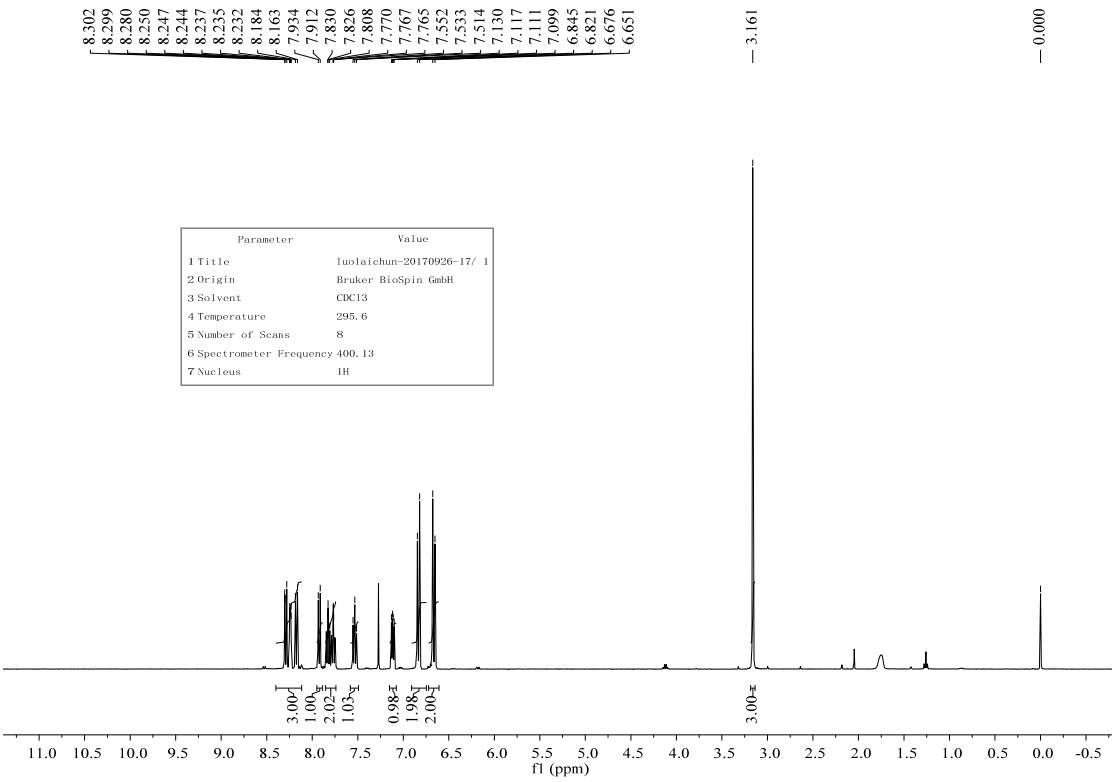
183.836 167.082 165.592 157.177 149.440 148.358 145.908 139.269 132.562 132.047 130.692 130.283 130.203 127.678 127.203 122.707 122.174 121.062 77.366 77.048 76.730 65.297 61.292 21.971 14.320

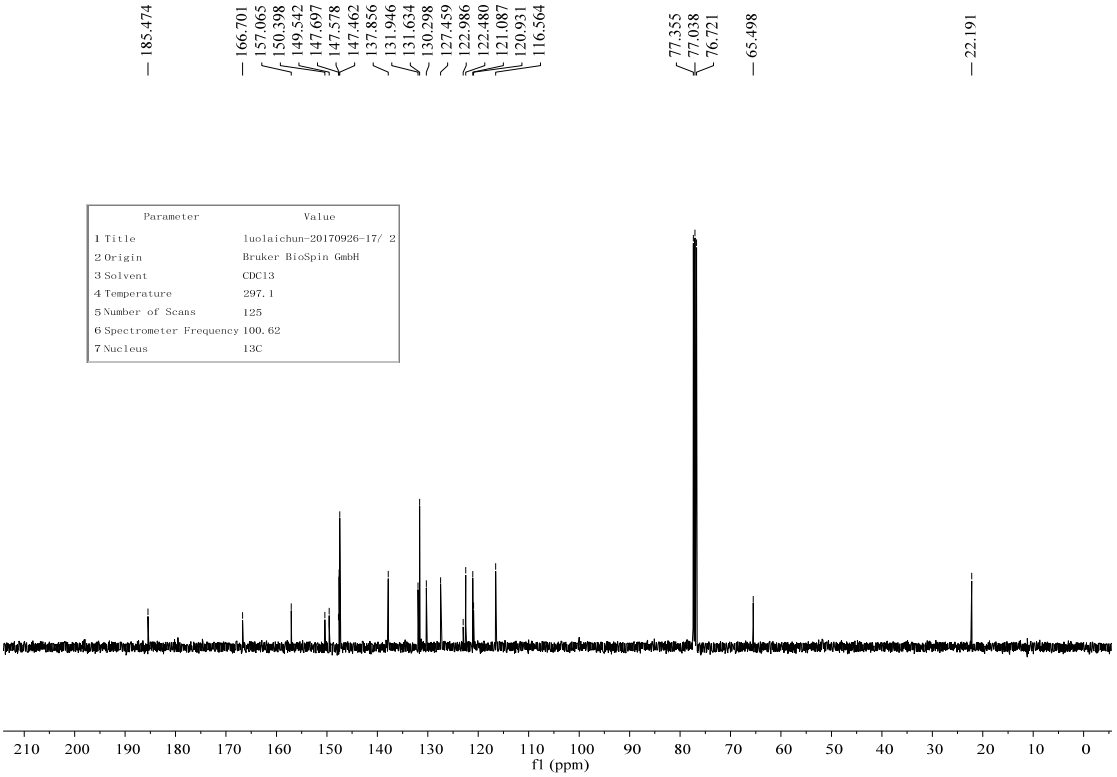
Parameter	Value
1 Title	luolaichun-20170926-18/ 2
2 Origin	Bruker BioSpin GmbH
3 Solvent	CDCl3
4 Temperature	297.2
5 Number of Scans	125
6 Spectrometer Frequency	100.62
7 Nucleus	13C





6r


8.302
8.299
8.280
8.250
8.247
8.244
8.237
8.235
8.232
8.184
8.163
7.934
7.912
7.830
7.826
7.808
7.770
7.767
7.765
7.552
7.533
7.514
7.130
7.117
7.111
7.099
6.845
6.821
6.676
6.651
3.161
0.000
Parameter Value
1 Title luolaichun-20170926-17/ 1
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 295.6
5 Number of Scans 8
6 Spectrometer Frequency 400.13
7 Nucleus 1H
3.00
1.00
2.02
1.03
0.98
1.98
2.00
3.00
f1 (ppm)


185.474
166.701
157.065
150.398
149.542
147.697
147.578
147.462
137.856
131.946
131.634
130.298
127.459
122.986
122.480
121.087
120.931
116.564
77.355
77.038
76.721
65.498
22.191
Parameter Value
1 Title luolaichun-20170926-17/ 2
2 Origin Bruker BioSpin GmbH
3 Solvent CDCl3
4 Temperature 297.1
5 Number of Scans 125
6 Spectrometer Frequency 100.62
7 Nucleus 13C
f1 (ppm)

8. New Compound Index

2-Methyl-*N*-phenyl-4-*p*-tolylquinoline-3-carboxamide (**4b**)
4-(4-Methoxyphenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (**4c**)
4-(4-Fluorophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (**4d**)
4-(4-Bromophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (**4f)**
tert-Butyl 4-(2-methyl-3-(phenylcarbamoyl)quinolin-4-yl)benzoate (**4g**)
2-Methyl-*N*-phenyl-4-*m*-tolylquinoline-3-carboxamide (**4h**)
4-(3-Methoxyphenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (**4i**)
4-(3-Fluorophenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (**4j**)
tert-Butyl 3-(2-methyl-3-(phenylcarbamoyl)quinolin-4-yl)benzoate (**4k**)
2-Methyl-*N*-phenyl-4-*o*-tolylquinoline-3-carboxamide (**4l**)
4-(2-Methoxyphenyl)-2-methyl-*N*-phenylquinoline-3-carboxamide (**4m**)
2-Methyl-4-phenyl-*N*-*o*-tolylquinoline-3-carboxamide (**4o**)
4-(4-Fluorophenyl)-2-methyl-*N*-*o*-tolylquinoline-3-carboxamide (**4o'**)
2-Methyl-4-phenyl-*N*-*m*-tolylquinoline-3-carboxamide (**4p**)
4-(4-Fluorophenyl)-2-methyl-*N*-*m*-tolylquinoline-3-carboxamide (**4p'**)
4-(4-Fluorophenyl)-2-methyl-*N*-*p*-tolylquinoline-3-carboxamide (**4q'**)
4-(4-Fluorophenyl)-*N*-(3-methoxyphenyl)-2-methylquinoline-3-carboxamide (**4r'**)
N-(3-Chlorophenyl)-4-(4-fluorophenyl)-2-methylquinoline-3-carboxamide (**4s'**)
N-(4-Chlorophenyl)-4-(4-fluorophenyl)-2-methylquinoline-3-carboxamide (**4t'**)
Ethyl 3-(2-methyl-4-phenylquinoline-3-carboxamido)benzoate (**4u**)
2-Methyl-*N*-(3-nitrophenyl)-4-phenylquinoline-3-carboxamide (**4w**)
4-(4-Fluorophenyl)-2-methyl-*N*-(pyridin-2-yl)quinoline-3-carboxamide (**4x'**)
7-Methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5a**)
3,7-Dimethyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5b**)
3-Methoxy-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5c**)
3-Fluoro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5d**)
3-Chloro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5e**)
3-Bromo-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5f**)
tert-Butyl 7-methyl-6-oxo-5-phenyl-5,6-dihydrodibenzo[*c*,*f*][2,7]naphthyridine-3-carboxylate (**5g**)
2,7-Dimethyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5h**)
2-Methoxy-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5i**)
2-Fluoro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5j**)
tert-Butyl 7-methyl-6-oxo-5-phenyl-5,6-dihydrodibenzo[*c*,*f*][2,7]naphthyridine-2-carboxylate (**5k**)
11-Chloro-7-methyl-5-phenyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5n**)
7-Methyl-5-(*o*-tolyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5o**)
7-Methyl-5-(*m*-tolyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5p**)
7-Methyl-5-(*p*-tolyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5q**)
7-Methyl-5-(3-nitrophenyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5r**)
5-(3-Chlorophenyl)-7-methyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5s**)
5-(4-Chlorophenyl)-7-methyldibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5t**)
Ethyl 3-(7-methyl-6-oxodibenzo[*c*,*f*][2,7]naphthyridin-5(6*H*)-yl)benzoate (**5u**)

Ethyl 4-(7-methyl-6-oxodibenzo[*c*,*f*][2,7]naphthyridin-5(6*H*)-yl)benzoate (**5v**)
7-Methyl-5-(3-nitrophenyl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5w**)
7-Methyl-5-(pyridin-2-yl)dibenzo[*c*,*f*][2,7]naphthyridin-6(5*H*)-one (**5x**)
4'-Methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6a**)
3,4'-Dimethyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6b**)
3-Methoxy-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6c**)
3-Fluoro-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6d**)
2,4'-Dimethyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6f**)
2-Methoxy-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6g**)
8'-Chloro-4'-methyl-2'-phenylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6h**)
4'-Methyl-2'-(*o*-tolyl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6i**)
4'-Methyl-2'-(*m*-tolyl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6j**)
4'-Methyl-2'-(*p*-tolyl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6k**)
2'-(3-Methoxyphenyl)-4'-methylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6l**)
2'-(3-Chlorophenyl)-4'-methylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6m**)
2'-(4-Chlorophenyl)-4'-methylspiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6n**)
Ethyl 3-(4'-methyl-3',4-dioxospiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-dien-2'(3'*H*)-yl)benzoate (**6o**)
Ethyl 4-(4'-methyl-3',4-dioxospiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-dien-2'(3'*H*)-yl)benzoate (**6p**)
4'-Methyl-2'-(pyridin-2-yl)spiro[cyclohexane-1,1'-pyrrolo[3,4-*c*]quinoline]-2,5-diene-3',4(2'*H*)-dione (**6r**)

9. References

[1] (a) S. V. Frye, M. C. Johnson and N. L. Valvano, *J. Org. Chem.*, 1991, **56**, 3750; (b) J. W. Williams and J. A. Krynitsky, *Org. Synth.*, 1941, **21**, 4; (c) M. Han, K.-D. Nam, H.-G. Hahn and D. Shin, *Tetrahedron Lett.*, 2008, **49**, 5217; (d) A. Maiti, P. V. N. Reddy, M. Sturdy, L. Marler, S. D. Pegan, A. D. Mesecar, J. M. Pezzuto and M. Cushman, *J. Med. Chem.*, 2009, **52**, 1873.

[2] B. Tanwar, A. Kumar, P. Yogeeswari, D. Sriram and A. K. Chakraborti, *Bioorg. Med. Chem. Lett.*, 2016, **26**, 5960.

[3] X. Yan, Z. Zhang, G. Zhang, N. Ma, Q. Liu, T. Liu and L. Shi, *Tetrahedron*, 2016, **72**, 4245.

[4] B. Palakshi Reddy, P. Iniyavan, S. Sarveswari and V. Vijayakumar, *Chin. Chem. Lett.*, 2014, **25**, 1595.