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Electronic Supplementary Information

Metal-free oxidative C(sp^3)-H bond functionalization of alkanes coupled with radical dearomatization of *N*-phenylcinnamamides

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Contents:

1. General Information

All regents were AR regents commercial available and used directly unless other noted. All reactions were carried out under N_2 atmosphere. Thin Layer Chromatography (TLC) was used to detect the progress of reactions and separate products. ^1H NMR, ^{19}F NMR and ^{13}C NMR spectra were recorded by 400 MHz spectrometer at room temperature, using $CDCl_3$ as solvent with TMS as internal standard. Chemical shifts (δ) are determined in ppm downfield from tetramethylsilane. Abbreviations for signal couplings are: s, singlet; d, doublet; t, triplet; m, multiplet.

2. Experment procedure

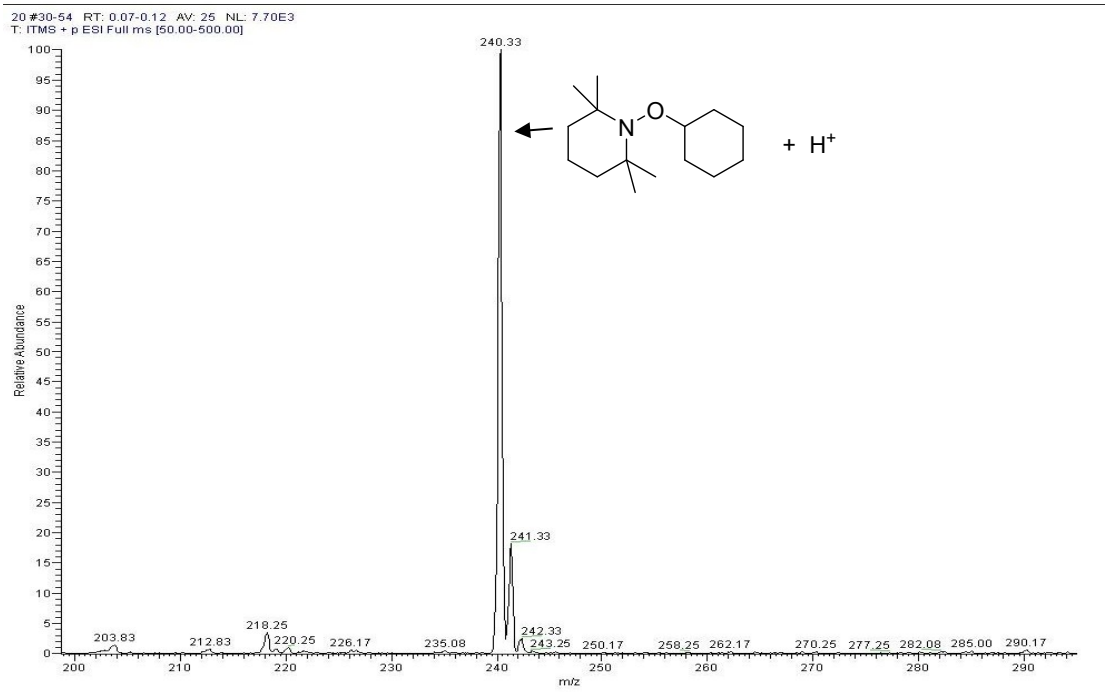
N-(4-hydroxyphenyl)-*N*-alkyl-cinnamamides (**1**, 0.1 mmol), dry cycloane (1 mL), TBPB (0.3 mmol, 3 equiv) and a stir bar were added into a sealed tube. The sealed tube was degassed by alternating vacuum evacuation and N_2 backfill for three times. Then the sealed tube was heated at 100 ^oC for 12 h as the TLC shows that the reaction is finished. The mixture was cooled to room temperature and concentrated in vacuum. The residue was purified using TLC on silica gel (GF254) to give the corresponding products (**2**).

3. Research on the Mechanism

3.1 Free Radical Capture Experiments

N-(4-hydroxyphenyl)-*N*-methylcinnamamide (**1a**) (0.1 mmol), dry cycloane (1 mL), TBPB (0.3 mmol, 3 equiv), 2,2,6,6-tetramethylpiperidine oxide (TEMPO) (0.3 mmol, 3 equiv) and a stir bar were added into a sealed tube. The sealed tube was degassed by alternating vacuum evacuation and N_2 backfill for three times. Then the sealed tube was heated at 100 ^oC for 12 h. As the reaction was finished, the mixture was cooled to room temperature and concentrated in vacuum. The residue was detected using TLC on silica gel (GF254) and MS (Fig S1).

Fig S1 The MS spectrum of the adduct formed by TEMPO and cyclohexane radical.



3.2 The KIE Studies on Cyclohexane

N-(4-hydroxyphenyl)-*N*-methylcinnamamide (**1a**) (0.1 mmol), dry cyclohexane (0.5 mL), cyclohexane-d_{12} (0.5 ml), TBPB (0.3 mmol, 3 equiv) and a stir bar were added into a sealed tube. The sealed tube was degassed by alternating vacuum evacuation and N_2 backfill three times. Then the sealed tube was heated at 100 ^{o}C for 12 h. And the mixture was concentrated in vacuum and the residue was purified using TLC on silica gel (GF254) to give the corresponding product **2a** and **2a**'. As shown in Scheme Fig 2, the ratio of **2a** and **2a**' is nearly 5.5. (Fig S2).

Scheme S1. KIE experiment of cyclohexane and D_{12}-cyclohexane

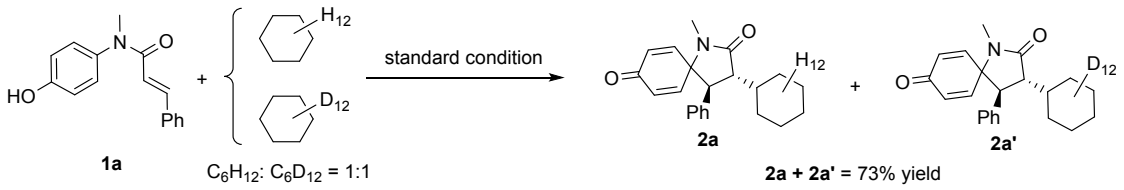
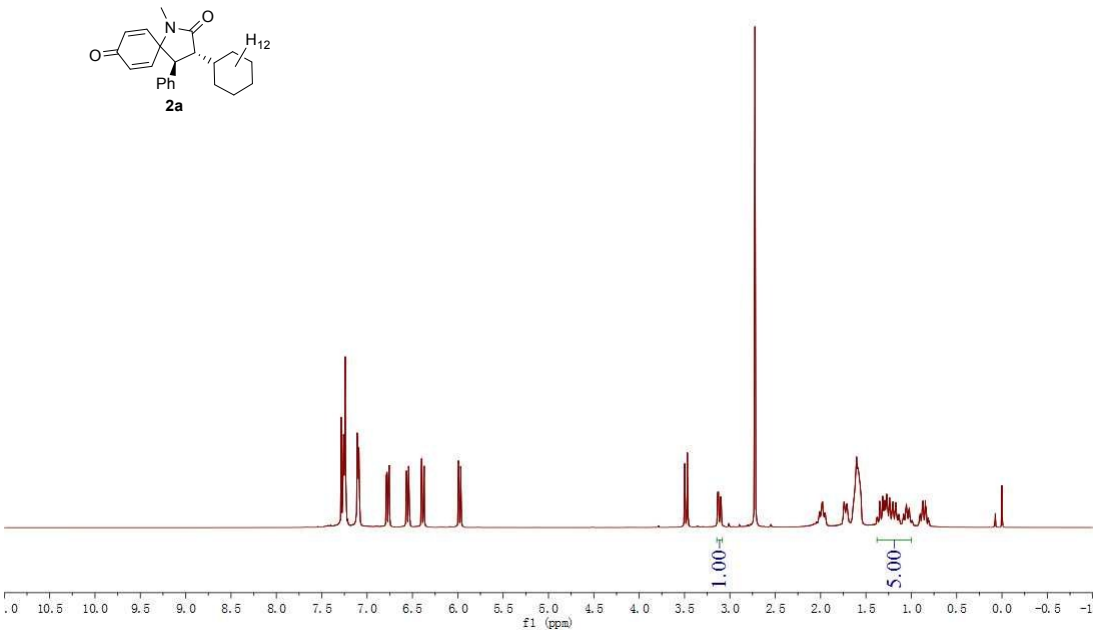
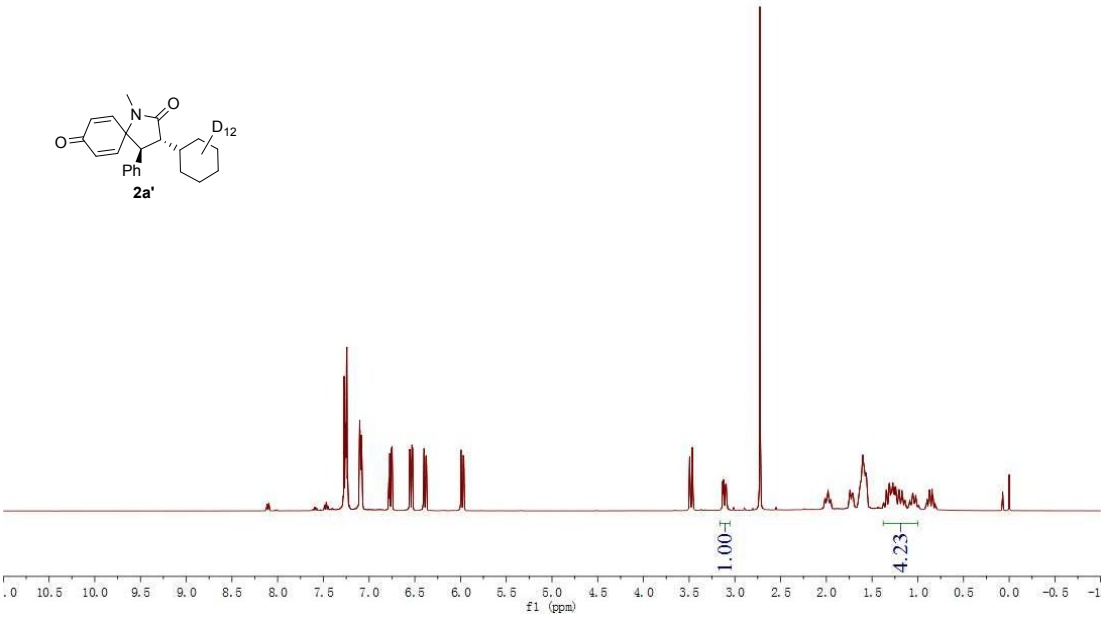


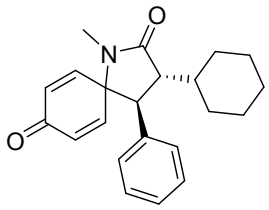
Fig S2. The ^{1}H NMR spectrum of the KIE results.





4. Characterization Data for the Products

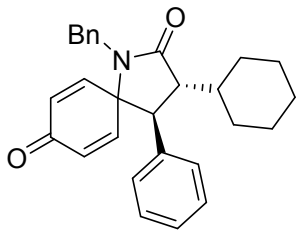
3-cyclohexyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2a**)



2a

white solid, mp 75-77 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.28 – 7.21 (m, 3H), 7.10 (dd, *J* = 7.4, 2.0 Hz, 2H), 6.77 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.55 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.39 (dd, *J* = 10.1, 2.0 Hz, 1H), 5.98 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.48 (d, *J* = 11.9 Hz, 1H), 3.12 (dd, *J* = 11.9, 3.4 Hz, 1H), 2.72 (s, 3H), 2.01 – 1.94 (m, 1H), 1.73 (d, *J* = 11.1 Hz, 1H), 1.63-1.57 (m, 3H), 1.38 – 1.00 (m, 5H), 0.90 – 0.81 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.35, 175.15, 149.34, 146.98, 134.98, 132.20, 131.33, 128.50, 128.10, 64.88, 50.93, 48.69, 38.17, 30.84, 29.04, 27.04, 26.59, 26.44, 26.11. HRMS (ESI) calcd. for $C_{22}H_{26}NNaO_2^+$ (M+Na$^+$): 336.1958, found: 336.1960.

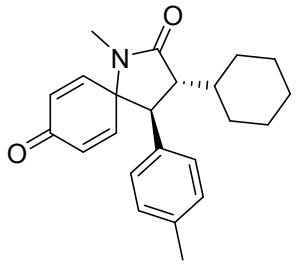
1-benzyl-3-cyclopentyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2b**)



2b

white solid, mp 74-76 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.27-7.17 (m, 9H), 7.03 (dd, *J* = 6.7, 2.8 Hz, 2H), 6.52 (dd, *J* = 10.0, 3.0 Hz, 1H), 6.45 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.17 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.80 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.66 (d, *J* = 15.0 Hz, 1H), 4.06 (d, *J* = 15.0 Hz, 1H), 3.46 (d, *J* = 12.1 Hz, 1H), 3.17 (dd, *J* = 12.1, 3.4 Hz, 1H), 2.07 – 1.99 (m, 1H), 1.76 (d, *J* = 13.4 Hz, 1H), 1.66 – 1.62 (m, 3H), 1.43 – 1.30 (m, 2H), 1.24-1.14 (m, 2H), 1.10 – 1.01 (m, 1H), 0.93 – 0.84 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.58, 175.18, 149.28, 147.15, 137.90, 134.60, 131.26, 130.61, 128.55, 128.52, 128.42, 128.20, 128.14, 127.67, 65.18, 51.40, 48.55, 45.31, 38.24, 30.83, 29.14, 26.65, 26.52, 26.13. HRMS (ESI) calcd. for $C_{28}H_{30}NO_2^+$ ($M+H^+$): 412.2271, found: 412.2272.

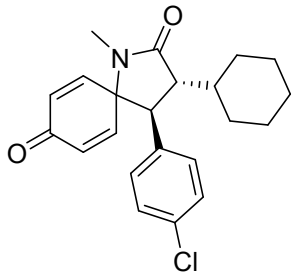
3-cyclohexyl-1-methyl-4-(p-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2c**)



2c

white solid, mp 77-78 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.05 (d, *J* = 7.9 Hz, 2H), 6.96 (d, *J* = 8.1 Hz, 2H), 6.75 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.53 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.38 (dd, *J* = 10.1, 2.0 Hz, 1H), 5.99 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.44 (d, *J* = 11.9 Hz, 1H), 3.07 (dd, *J* = 11.9, 3.4 Hz, 1H), 2.71 (s, 3H), 2.29 (s, 3H), 2.00 – 1.93 (m, 1H), 1.72 (d, *J* = 11.1 Hz, 2H), 1.64-1.57 (m, 3H), 1.35 – 1.29 (m, 1H), 1.23-1.13 (m, 2H), 1.09-1.01 (m, 1H), 0.89-0.83 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.50, 175.25, 149.48, 147.09, 137.81, 132.15, 131.85, 131.33, 129.22, 127.94, 64.96, 50.61, 48.75, 38.15, 30.80, 29.08, 27.05, 26.60, 26.46, 26.13, 21.07. HRMS (ESI) calcd. for $C_{23}H_{28}NO_2^+$ ($M+H^+$): 350.2115, found: 350.2118.

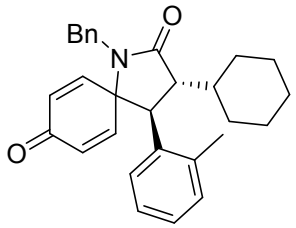
4-(4-chlorophenyl)-3-cyclohexyl-1-methyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2d**)



2d

white solid, mp 93-95 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.24 (d, *J* = 8.5 Hz, 2H), 7.04 (d, *J* = 8.5 Hz, 2H), 6.74 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.51 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.40 (dd, *J* = 10.1, 2.0 Hz, 1H), 6.03 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.44 (d, *J* = 11.9 Hz, 1H), 3.03 (dd, *J* = 11.9, 3.5 Hz, 1H), 2.72 (s, 3H), 2.02 – 1.94 (m, 1H), 1.75 – 1.58 (m, 5H), 1.32-1.27 (m, 1H), 1.24-1.14 (m, 2H), 1.08 – 0.99 (m, 1H), 0.86 – 0.76 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.11, 174.76, 149.02, 146.51, 133.99, 133.61, 132.42, 131.71, 129.40, 128.80, 64.73, 50.37, 48.88, 38.13, 31.06, 28.98, 27.09, 26.57, 26.39, 26.09. HRMS (ESI) calcd. for $C_{22}H_{25}ClNO_2^+$ ($M+Na^+$): 370.1568, found: 370.1564.

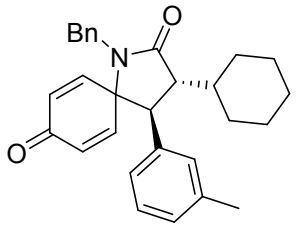
1-benzyl-3-cyclohexyl-4-(o-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2e**)



2e

white solid, mp 92-94 °C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.24 (m, 3H), 7.21-7.17 (m, 2H), 7.13 – 7.04 (m, 4H), 6.61 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.55 (dd, *J* = 10.0, 3.1 Hz, 1H), 6.09 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.91 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.67 (d, *J* = 14.9 Hz, 1H), 4.04 (d, *J* = 15.0 Hz, 1H), 3.84 (d, *J* = 11.5 Hz, 1H), 3.12 (dd, *J* = 11.5, 3.6 Hz, 1H), 2.24 (s, 3H), 2.05 – 1.98 (m, 1H), 1.75 (s, 1H), 1.66-1.58 (m, 3H), 1.48 (d, *J* = 12.9 Hz, 1H), 1.33 – 1.26 (m, 2H), 1.21 – 1.14 (m, 1H), 1.09 – 1.00 (m, 1H), 0.77-0.67 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.60, 175.37, 150.02, 147.78, 137.96, 136.65, 133.70, 131.27, 130.63, 130.50, 128.57, 128.54, 128.00, 127.68, 125.77, 65.27, 51.31, 46.58, 45.22, 38.47, 31.15, 29.31, 26.64, 26.46, 26.24, 20.51. HRMS (ESI) calcd. for $C_{29}H_{31}NNaO_2^+$ ($M+Na^+$): 448.2247, found: 448.2248.

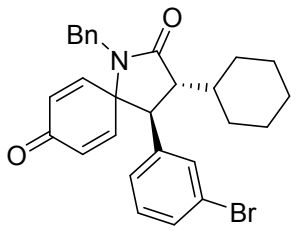
1-benzyl-3-cyclohexyl-4-(m-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2f**)



2f

white solid, mp 109-111 °C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 – 7.22 (m, 3H), 7.20 – 7.16 (m, 2H), 7.10 (t, *J* = 7.6 Hz, 1H), 7.01 (d, *J* = 7.6 Hz, 1H), 6.85 – 6.79 (m, 2H), 6.51 (dd, *J* = 10.0, 3.0 Hz, 1H), 6.44 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.17 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.80 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.64 (d, *J* = 15.0 Hz, 1H), 4.07 (d, *J* = 15.0 Hz, 1H), 3.42 (d, *J* = 12.0 Hz, 1H), 3.16 (dd, *J* = 12.0, 3.4 Hz, 1H), 2.26 (s, 3H), 2.06 – 1.98 (m, 1H), 1.81 – 1.69 (m, 2H), 1.63 (s, 3H), 1.44 – 1.29 (m, 2H), 1.26-1.15 (m, 2H), 1.12-1.02(m, 1H), 0.95 – 0.86 (m, 1H). ^{13}C NMR (100MHz, $CDCl_3$): δ 184.69, 175.25, 149.41, 147.27, 137.97, 137.94, 134.55, 131.17, 130.45, 129.02, 128.91, 128.54, 128.53, 128.24, 127.65, 125.14, 65.17, 51.33, 48.57, 45.28, 38.25, 30.72, 29.18, 26.65, 26.54, 26.14, 21.46. HRMS (ESI) calcd. for $C_{29}H_{31}NNaO_2^+$ ($M+Na^+$): 448.2247, found: 448.2245.

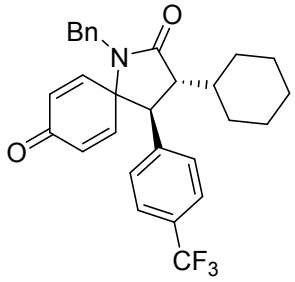
1-benzyl-4-(3-bromophenyl)-3-cyclohexyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2g**)



2g

white solid, mp 73-74 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36 (d, *J* = 7.9 Hz, 1H), 7.28-7.22 (m, 3H), 7.22-7.14 (m, 3H), 7.10 (t, *J* = 7.8 Hz, 1H), 6.97 (d, *J* = 7.6 Hz, 1H), 6.50 (dd, *J* = 10.0, 1.5 Hz, 1H), 6.44 (d, *J* = 10.2 Hz, 1H), 6.20 (d, *J* = 10.0 Hz, 1H), 5.85 (d, *J* = 10.1 Hz, 1H), 4.62 (d, *J* = 14.9 Hz, 1H), 4.10 (d, *J* = 15.0 Hz, 1H), 3.41 (d, *J* = 12.0 Hz, 1H), 3.11 (d, *J* = 10.2 Hz, 1H), 2.03 (t, *J* = 9.9 Hz, 1H), 1.77 (s, 1H), 1.69-1.60 (m, 3H), 1.39 – 1.15 (m, 4H), 1.10-1.02 (m, 1H), 0.91 – 0.81 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.34, 174.69, 148.85, 146.67, 137.72, 137.12, 131.52, 131.37, 131.17, 130.84, 129.98, 128.60, 128.53, 127.77, 126.96, 122.50, 64.96, 50.99, 48.63, 45.34, 38.21, 30.98, 29.06, 26.63, 26.46, 26.09. HRMS (ESI) calcd. for $C_{28}H_{29}NBrNO_2^+$ ($M+H^+$): 490.1376, found: 490.1378.

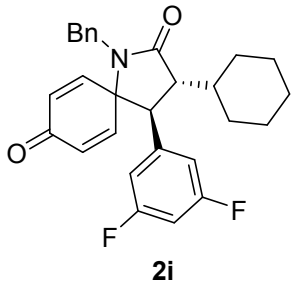
1-benzyl-3-cyclohexyl-4-(4-(trifluoromethyl)phenyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2h**)



2h

white solid, mp 197-199 °C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 8.1 Hz, 2H), 7.30-7.24 (m, 4H), 7.18 (d, *J* = 7.8 Hz, 4H), 6.53 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.44 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.19 (dd, *J* = 10.1, 2.0 Hz, 1H), 5.84 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.66 (d, *J* = 15.0 Hz, 1H), 4.08 (d, *J* = 14.9 Hz, 1H), 3.52 (d, *J* = 12.1 Hz, 1H), 3.17 (dd, *J* = 12.1, 3.5 Hz, 1H), 2.06-2.02 (m, 1H), 1.76 (d, *J* = 7.8 Hz, 1H), 1.67-1.60 (m, 3H), 1.37 – 1.29 (m, 2H), 1.26-1.16 (m, 2H), 1.09 – 1.02 (m, 1H), 0.86 – 0.77 (m, 1H). ^{19}F NMR (376 MHz, $CDCl_3$): δ -62.64. ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.17, 174.63, 148.78, 146.38, 138.92, 137.68, 131.55, 130.98, 128.62, 128.52, 127.80, 125.49, 125.45, δ 123.76 (q, *J* = 272.4 Hz), 64.86, 51.09, 48.70, 45.34, 38.23, 31.06, 29.07, 26.57, 26.43, 26.07. HRMS (ESI) calcd. for $C_{28}H_{29}NF_3NO_2^+$ ($M+H^+$): 480.2145, found: 480.2145.

1-benzyl-3-cyclohexyl-4-(3,5-difluorophenyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2i**)

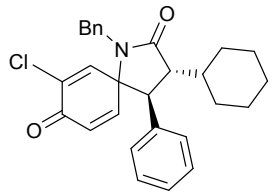


2i

white solid, mp 73-74 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.29 – 7.24 (m, 4H), 7.19 – 7.14 (m, 2H), 6.72-6.66 (m, 1H), 6.62-6.56 (m, 2H), 6.49 (dd, *J* = 10.0, 3.1 Hz, 1H), 6.42 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.22 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.89 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.63 (d, *J* = 15.0 Hz, 1H), 4.09 (d, *J* = 15.0 Hz, 1H), 3.42 (d, *J* = 12.1 Hz, 1H), 3.04 (dd, *J* = 12.1, 3.5 Hz, 1H), 2.07 – 2.00 (m, 1H), 1.79-1.75 (m, 1H), 1.69 – 1.62 (m, 3H), 1.37-1.28 (m, 3H), 1.23-1.18 (m, 1H), 1.11 – 1.02 (m, 1H), 0.88-0.81 (m, 1H). ^{19}F NMR (376 MHz, $CDCl_3$): δ -108.29. ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.16, 174.30, 162.77(d, *J* = 248.3 Hz), 162.64(d, *J* = 248.4 Hz), 148.56, 146.25, 138.90, 137.63, 131.69, 130.95, 128.62,

128.52, 127.82, 111.46, 111.39, 111.28, 111.21, 104.14, 103.89, 103.64, 64.69, 50.97, 48.76, 45.31, 38.19, 31.01, 29.01, 26.59, 26.42, 26.07. HRMS (ESI) calcd. for $C_{28}H_{27}F_2NNaO_2^+$ (M+Na^+): 470.1902, found: 470.1899.

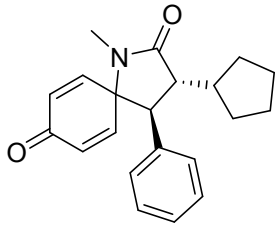
(3R,4S)-1-benzyl-7-chloro-3-cyclohexyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2j**)



2j

white solid, mp 79-80 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.30-7.28 (m, 2H), 7.25-7.22 (d, *J* = 4.3 Hz, 3H), 7.17 (d, *J* = 7.3 Hz, 3H), 7.04 – 7.00 (m, 2H), 6.61 (d, *J* = 2.6 Hz, 1H), 6.46 (dd, *J* = 10.1, 2.6 Hz, 1H), 5.88 (d, *J* = 10.1 Hz, 1H), 4.74 (d, *J* = 14.8 Hz, 1H), 3.99 (d, *J* = 14.8 Hz, 1H), 3.48 (d, *J* = 12.1 Hz, 1H), 3.17 (dd, *J* = 12.2, 3.3 Hz, 1H), 2.06-2.00 (m, 1H), 1.76 (d, *J* = 11.4 Hz, 1H), 1.66-1.61 (m, 3H), 1.35-1.31 (m, 2H), 1.23-1.19 (m, 2H), 1.09-1.04 (m, 1H), 0.90-0.87 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.57, 173.69, 146.40, 144.45, 136.62, 133.29, 133.15, 128.37, 127.73, 127.68, 127.63, 127.36, 126.98, 126.91, 65.93, 50.54, 47.40, 44.40, 37.22, 29.91, 29.80, 28.68, 28.09, 25.58, 25.45, 25.07. HRMS (ESI) calcd. for $C_{28}H_{29}ClNO_2^+$ (M+H^+): 446.1881, found: 446.1883.

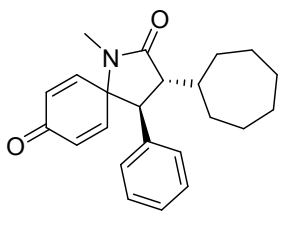
3-cyclopentyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2l**)



2l

white solid, mp 71-73 °C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.21 (m, 3H), 7.12 – 7.05 (m, 2H), 6.78 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.55 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.39 (dd, *J* = 10.1, 2.0 Hz, 1H), 5.99 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.38 (d, *J* = 11.6 Hz, 1H), 3.21 (dd, *J* = 11.6, 5.8 Hz, 1H), 2.73 (s, 3H), 2.25 – 2.17 (m, 1H), 1.92 – 1.85 (m, 1H), 1.63-1.54 (m, 3H), 1.51 – 1.36 (m, 3H), 1.27-1.20 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.39, 175.55, 149.33, 147.02, 134.93, 133.53, 132.21, 131.36, 130.13, 128.55, 128.45, 128.14, 64.94, 53.37, 46.73, 41.10, 29.74, 29.46, 27.03, 25.07, 24.88. HRMS (ESI) calcd. for $C_{21}H_{23}NNaO_2^+$ (M+Na^+): 344.1621, found: 344.1619.

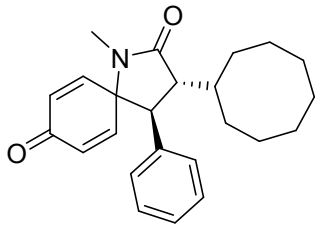
3-cycloheptyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2m**)



2m

white solid, mp 79-81 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.28 – 7.22 (m, 3H), 7.09 (dd, *J* = 7.3, 2.1 Hz, 2H), 6.77 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.54 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.38 (dd, *J* = 10.1, 1.9 Hz, 1H), 5.98 (dd, *J* = 10.2, 1.9 Hz, 1H), 3.46 (d, *J* = 11.8 Hz, 1H), 3.19 (dd, *J* = 11.7, 2.9 Hz, 1H), 2.73 (s, 3H), 2.21 – 2.12 (m, 1H), 1.74 – 1.67 (m, 1H), 1.65 – 1.57 (m, 2H), 1.55 – 1.40 (m, 6H), 1.37 – 1.28 (m, 2H), 1.09-1.00 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.38, 175.27, 149.36, 147.14, 135.02, 132.15, 131.31, 128.54, 128.19, 128.11, 64.99, 51.02, 50.24, 39.44, 32.66, 31.10, 27.90, 27.30, 27.28, 27.17, 27.06. HRMS (ESI) calcd. for $C_{23}H_{28}NO_2^+$ ($M+H^+$): 350.2115, found: 350.2118.

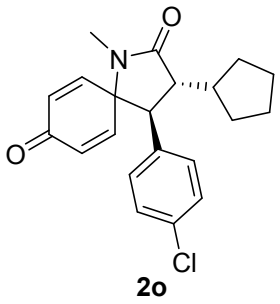
3-cyclooctyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2n**)



2n

white solid, mp 83-85 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.27-7.21 (m, 3H), 7.11 – 7.06 (m, 2H), 6.78 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.54 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.38 (dd, *J* = 10.1, 2.0 Hz, 1H), 5.97 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.43 (d, *J* = 11.7 Hz, 1H), 3.17 (dd, *J* = 11.7, 2.9 Hz, 1H), 2.73 (s, 3H), 2.28 – 2.21 (m, 1H), 1.73 – 1.60 (m, 3H), 1.55 – 1.30 (m, 12H), 1.19-1.12 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.39, 175.35, 149.39, 147.22, 135.04, 132.13, 131.27, 128.55, 128.17, 128.10, 65.00, 51.19, 50.98, 37.16, 31.90, 30.40, 27.06, 26.60, 26.52, 26.12, 26.00, 25.94. HRMS (ESI) calcd. for $C_{24}H_{29}NNaO_2^+$ ($M+Na^+$): 386.2091, found: 386.2085.

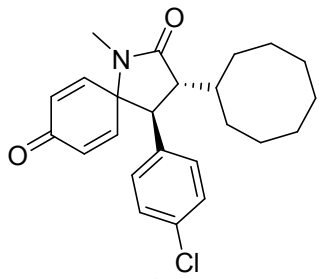
4-(4-chlorophenyl)-3-cyclopentyl-1-methyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2o**)



2o

white solid, mp 91-92 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.24 (d, *J* = 8.5 Hz, 2H), 7.04 (d, *J* = 8.5 Hz, 2H), 6.76 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.53 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.39 (dd, *J* = 10.1, 2.0 Hz, 1H), 6.04 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.35 (d, *J* = 11.7 Hz, 1H), 3.14 (dd, *J* = 11.7, 5.9 Hz, 1H), 2.73 (s, 3H), 2.24 – 2.14 (m, 1H), 1.93-1.85 (m, 1H), 1.78 (s, 1H), 1.56-1.53 (m, 1H), 1.51 – 1.31 (m, 4H), 1.23-1.17 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.11, 175.05, 149.03, 146.58, 134.01, 133.59, 132.39, 131.70, 129.45, 128.80, 64.76, 52.82, 46.88, 41.12, 29.81, 29.52, 27.03, 25.02, 24.83. HRMS (ESI) calcd. for $C_{21}H_{23}NClNO_2^+$ ($M+H^+$): 356.1412, found: 356.1412.

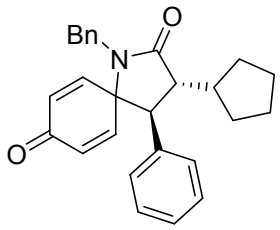
4-(4-chlorophenyl)-3-cyclooctyl-1-methyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2p**)



2p

white solid, mp 94-95 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.24 (d, *J* = 8.5 Hz, 2H), 7.03 (d, *J* = 8.5 Hz, 2H), 6.75 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.51 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.39 (dd, *J* = 10.1, 2.0 Hz, 1H), 6.03 (dd, *J* = 10.2, 2.0 Hz, 1H), 3.40 (d, *J* = 11.8 Hz, 1H), 3.09 (dd, *J* = 11.7, 3.0 Hz, 1H), 2.73 (s, 3H), 2.27 – 2.20 (m, 1H), 1.68 (s, 2H), 1.62-1.55 (m, 3H), 1.49 – 1.33 (m, 8H), 1.16 – 1.09 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.13, 174.90, 149.08, 146.76, 133.96, 133.70, 132.33, 131.64, 129.48, 128.83, 64.83, 51.13, 50.62, 37.12, 32.08, 30.31, 27.08, 26.58, 26.51, 26.10, 25.97, 25.91. HRMS (ESI) calcd. for $C_{24}H_{29}ClNO_2^+$ ($M+H^+$): 398.1881, found: 398.1887.

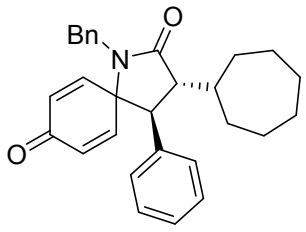
1-benzyl-3-cyclopentyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2q**)



2q

white solid, mp 71-72 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.26 – 7.15 (m, 8H), 7.03 (dd, *J* = 6.7, 2.8 Hz, 2H), 6.54 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.44 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.18 (dd, *J* = 10.1, 2.0 Hz, 1H), 5.79 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.61 (d, *J* = 14.9 Hz, 1H), 4.11 (d, *J* = 14.9 Hz, 1H), 3.37 (d, *J* = 11.8 Hz, 1H), 3.29 (dd, *J* = 11.8, 5.5 Hz, 1H), 2.31 – 2.21 (m, 1H), 1.95 – 1.88 (m, 1H), 1.66 – 1.56 (m, 4H), 1.50-1.41 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.57, 175.45, 149.26, 147.25, 137.91, 134.61, 131.28, 130.53, 128.57, 128.55, 128.45, 128.23, 128.15, 127.69, 65.18, 53.74, 46.48, 45.24, 41.09, 29.70, 29.42, 25.08, 24.91. HRMS (ESI) calcd. for $C_{27}H_{27}NNaO_2^+$ ($M+Na^+$): 420.1934, found: 420.1936.

1-benzyl-3-cycloheptyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2r**)

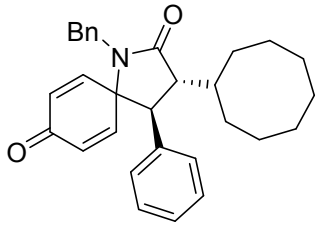


2r

white solid, mp 77-79 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.27-7.16 (m, 9H), 7.03 (dd, *J* = 6.7, 2.8 Hz, 2H), 6.52 (dd, *J* = 10.0, 3.1 Hz, 1H), 6.44 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.16 (dd, *J* = 10.0, 2.0 Hz, 1H),

5.79 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.64 (d, *J* = 14.9 Hz, 1H), 4.09 (d, *J* = 14.9 Hz, 1H), 3.44 (d, *J* = 12.0 Hz, 1H), 3.24 (dd, *J* = 12.0, 2.9 Hz, 1H), 2.22 – 2.14 (m, 1H), 1.77-1.65 (m, 3H), 1.62 – 1.59 (m, 1H), 1.54 – 1.44 (m, 4H), 1.42 – 1.30 (m, 3H), 1.13-1.06 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.59, 175.25, 149.32, 147.34, 137.93, 134.61, 131.19, 130.53, 128.60, 128.54, 128.44, 128.31, 128.14, 127.69, 65.26, 51.58, 50.05, 45.34, 39.54, 32.47, 31.39, 27.84, 27.42, 27.29, 27.18. HRMS (ESI) calcd. for $C_{29}H_{31}NNaO_2^+$ ($M+Na^+$): 448.2247, found: 448.2248.

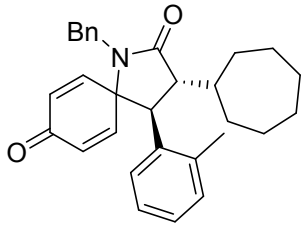
1-benzyl-3-cyclooctyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2s**)



2s

white solid, mp 83-85 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.26 – 7.16 (m, 8H), 7.02 (dd, *J* = 6.7, 2.8 Hz, 2H), 6.53 (dd, *J* = 10.1, 3.0 Hz, 1H), 6.43 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.17 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.78 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.63 (d, *J* = 14.9 Hz, 1H), 4.10 (d, *J* = 14.9 Hz, 1H), 3.41 (d, *J* = 11.9 Hz, 1H), 3.22 (dd, *J* = 11.9, 2.9 Hz, 1H), 2.32 – 2.24 (m, 1H), 1.74-1.67 (m, 2H), 1.63 – 1.55 (m, 4H), 1.49 – 1.31 (m, 7H), 1.22-1.16 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.61, 175.33, 149.35, 147.45, 137.97, 134.66, 131.17, 130.47, 128.63, 128.54, 128.45, 128.28, 128.12, 127.69, 65.28, 51.70, 50.77, 45.33, 37.21, 31.75, 30.63, 26.57, 26.54, 26.10. HRMS (ESI) calcd. for $C_{30}H_{34}NO_2^+$ ($M+H^+$): 440.2584, found: 440.2583.

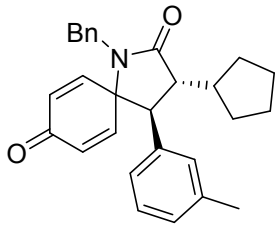
1-benzyl-3-cycloheptyl-4-(o-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2t**)



2t

white solid, mp 99-101 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.28 – 7.24 (m, 3H), 7.22 – 7.18 (m, 2H), 7.13 – 7.04 (m, 4H), 6.61 (dd, *J* = 10.2, 3.0 Hz, 1H), 6.56 (dd, *J* = 10.0, 3.0 Hz, 1H), 6.09 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.90 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.66 (d, *J* = 14.9 Hz, 1H), 4.07 (d, *J* = 14.9 Hz, 1H), 3.84 (d, *J* = 11.5 Hz, 1H), 3.19 (dd, *J* = 11.5, 3.1 Hz, 1H), 2.23 (s, 3H), 2.20 – 2.14 (m, 1H), 1.77 – 1.72 (m, 1H), 1.71-1.67 (m, 2H), 1.59 – 1.54 (m, 2H), 1.50-1.47 (m, 1H), 1.46 – 1.30 (m, 5H), 0.99 – 0.90 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.62, 175.47, 150.05, 147.98, 137.97, 136.75, 133.65, 131.25, 130.61, 130.43, 128.62, 128.57, 128.15, 127.70, 125.80, 65.36, 52.56, 46.61, 45.26, 39.79, 32.78, 31.40, 27.71, 27.33, 27.28, 27.16, 20.48. HRMS (ESI) calcd. for $C_{30}H_{35}NNaO_2^+$ ($M+Na^+$): 476.2560, found: 476.2563.

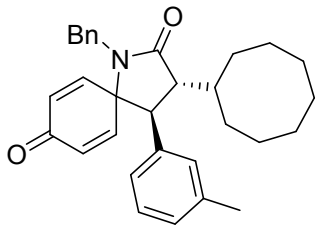
1-benzyl-3-cyclopentyl-4-(m-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2u**)



2u

white solid, mp 102-103 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.27 – 7.22 (m, 3H), 7.21 – 7.17 (m, 2H), 7.10 (t, *J* = 7.6 Hz, 1H), 7.01 (d, *J* = 7.6 Hz, 1H), 6.86 – 6.79 (m, 2H), 6.54 (dd, *J* = 10.1, 3.0 Hz, 1H), 6.44 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.18 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.79 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.59 (d, *J* = 14.9 Hz, 1H), 4.12 (d, *J* = 14.9 Hz, 1H), 3.33 (d, *J* = 11.7 Hz, 1H), 3.27 (dd, *J* = 11.7, 5.3 Hz, 1H), 2.25 (s, 3H), 1.95-1.86 (m, 1H), 1.65 – 1.55 (m, 3H), 1.54-1.44 (m, 3H), 1.32-1.23 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.69, 175.53, 149.40, 147.38, 138.01, 137.95, 134.57, 131.18, 130.38, 129.03, 128.92, 128.57, 128.53, 128.28, 127.66, 125.20, 65.16, 53.69, 46.52, 45.21, 41.07, 29.65, 29.43, 25.10, 24.92, 21.45. HRMS (ESI) calcd. for $C_{28}H_{30}NO_2^+$ ($M+H^+$): 412.2271, found: 412.2272.

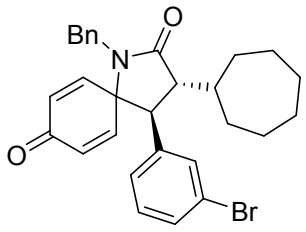
1-benzyl-3-cyclooctyl-4-(m-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2v**)



2v

white solid, mp 116-118 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.27-7.22 (m, 3H), 7.21 – 7.16 (m, 2H), 7.10 (t, *J* = 7.6 Hz, 1H), 7.01 (d, *J* = 7.5 Hz, 1H), 6.84 – 6.78 (m, 2H), 6.52 (dd, *J* = 10.1, 3.0 Hz, 1H), 6.42 (dd, *J* = 10.2, 3.0 Hz, 1H), 6.17 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.78 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.61 (d, *J* = 14.9 Hz, 1H), 4.10 (d, *J* = 14.9 Hz, 1H), 3.37 (d, *J* = 11.8 Hz, 1H), 3.20 (dd, *J* = 11.8, 2.9 Hz, 1H), 2.25 (s, 3H), 1.74-1.67 (m, 3H), 1.63-1.55 (m, 4H), 1.51 – 1.45 (m, 4H), 1.43 – 1.38 (m, 2H), 1.36 – 1.31 (m, 1H), 1.23-1.18 (m, 1H). ^{13}C NMR (100MHz, $CDCl_3$): δ 184.71, 175.41, 149.48, 147.59, 138.01, 137.98, 134.62, 131.07, 130.30, 129.08, 128.89, 128.63, 128.52, 128.27, 127.67, 125.20, 65.26, 51.62, 50.78, 45.31, 37.22, 31.69, 30.70, 26.68, 26.59, 26.56, 26.10, 26.06, 21.47. HRMS (ESI) calcd. for $C_{31}H_{35}NNaO_2^+$ ($M+Na^+$): 476.2560, found: 476.2562.

1-benzyl-4-(3-bromophenyl)-3-cycloheptyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2w**)

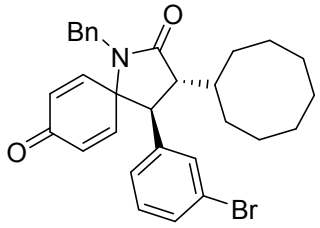


2w

white solid, mp 89-91 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37 – 7.34 (m, 1H), 7.27-7.23 (m, 3H), 7.19-7.16(m, 3H), δ 7.10 (t, *J* = 7.9 Hz, 1H), 6.97 (d, *J* = 7.9 Hz, 1H), 6.51 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.42

(dd, *J* = 10.2, 3.1 Hz, 1H), 6.20 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.84 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.60 (d, *J* = 14.9 Hz, 1H), 4.13 (d, *J* = 15.0 Hz, 1H), 3.39 (d, *J* = 12.0 Hz, 1H), 3.18 (dd, *J* = 12.0, 2.9 Hz, 1H), 2.22-2.16 (m, 1H), 1.74 – 1.64 (m, 2H), 1.62 – 1.54 (m, 4H), 1.50-1.45 (m, 2H), 1.42 – 1.30 (m, 3H), 1.10 – 1.03 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.35, 174.79, 148.89, 146.87, 137.72, 137.13, 131.44, 131.37, 131.27, 130.76, 129.99, 128.60, 128.59, 127.80, 127.07, 122.51, 65.05, 51.16, 50.14, 45.37, 39.50, 32.66, 31.28, 27.79, 27.34, 27.30, 27.13. HRMS (ESI) calcd. for $C_{29}H_{31}BrNNaO_2^+$ ($M+H^+$): 504.1533, found: 504.1530.

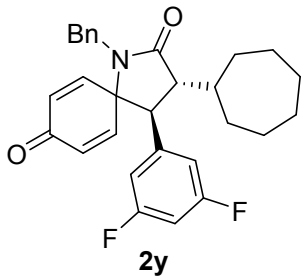
1-benzyl-4-(3-bromophenyl)-3-cyclooctyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2x**)



2x

white solid, mp 102-103 °C, ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37 – 7.33 (m, 1H), 7.27-7.23 (m, 3H), 7.19-7.15 (m, 3H), 7.10 (t, *J* = 7.9 Hz, 1H), 6.96 (d, *J* = 7.9 Hz, 1H), 6.52 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.41 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.20 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.83 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.59 (d, *J* = 14.9 Hz, 1H), 4.14 (d, *J* = 14.9 Hz, 1H), 3.36 (d, *J* = 11.9 Hz, 1H), 3.15 (dd, *J* = 11.8, 3.0 Hz, 1H), 2.34 – 2.24 (m, 1H), 1.77 – 1.69 (m, 2H), 1.66 – 1.55 (m, 5H), 1.49-1.47 (m, 2H), 1.43-1.32 (m, 4H), 1.20 – 1.13 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.38, 174.91, 148.92, 147.00, 137.74, 137.18, 131.42, 131.37, 131.23, 130.69, 130.02, 128.63, 128.59, 127.81, 127.03, 122.53, 65.08, 51.26, 50.85, 45.39, 37.15, 32.02, 30.48, 26.68, 26.59, 26.07, 25.98, 25.95. HRMS (ESI) calcd. for $C_{30}H_{33}BrNO_2^+$ ($M+H^+$): 518.1689, found: 518.1683.

1-benzyl-3-cycloheptyl-4-(3,5-difluorophenyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2y**)

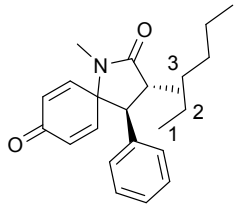


2y

white solid, mp 76-77 °C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28-7.24 (m, 3H), 7.17 (dd, *J* = 7.0, 2.4 Hz, 2H), 6.69 (tt, *J* = 8.7, 2.2 Hz, 1H), 6.58 (dd, *J* = 7.9, 1.9 Hz, 2H), 6.50 (dd, *J* = 10.1, 3.1 Hz, 1H), 6.41 (dd, *J* = 10.2, 3.1 Hz, 1H), 6.21 (dd, *J* = 10.0, 2.0 Hz, 1H), 5.88 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.61 (d, *J* = 14.9 Hz, 1H), 4.13 (d, *J* = 14.9 Hz, 1H), 3.39 (d, *J* = 11.9 Hz, 1H), 3.11 (dd, *J* = 11.9, 2.9 Hz, 1H), 2.24 – 2.16 (m, 1H), 1.76 – 1.71 (m, 1H), 1.69 – 1.54 (m, 6H), 1.50-1.44 (m, 2H), 1.40-1.33 (m, 2H), 1.11-1.04 (m, 1H). ^{19}F NMR (376 MHz, $CDCl_3$): δ -108.27. ^{13}C NMR (100 MHz, $CDCl_3$): δ 184.16, 174.38, 162.77(d, *J* = 248.4 Hz), 163.17(d, *J* = 248.4 Hz), 148.60, 146.44, 138.92, 137.65, 131.60, 130.87, 128.61, 128.60, 127.84, 111.57, 111.50, 111.39, 111.32, 104.15, 103.90, 103.65, 64.77, 51.14, 50.25, 45.34, 39.48, 32.68, 31.23, 27.79, 27.32, 27.27, 27.09. HRMS (ESI) calcd. for $C_{29}H_{30}F_2NO_2^+$ ($M+H^+$):

462.2239, found: 462.2242.

3-hexanyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2z**)

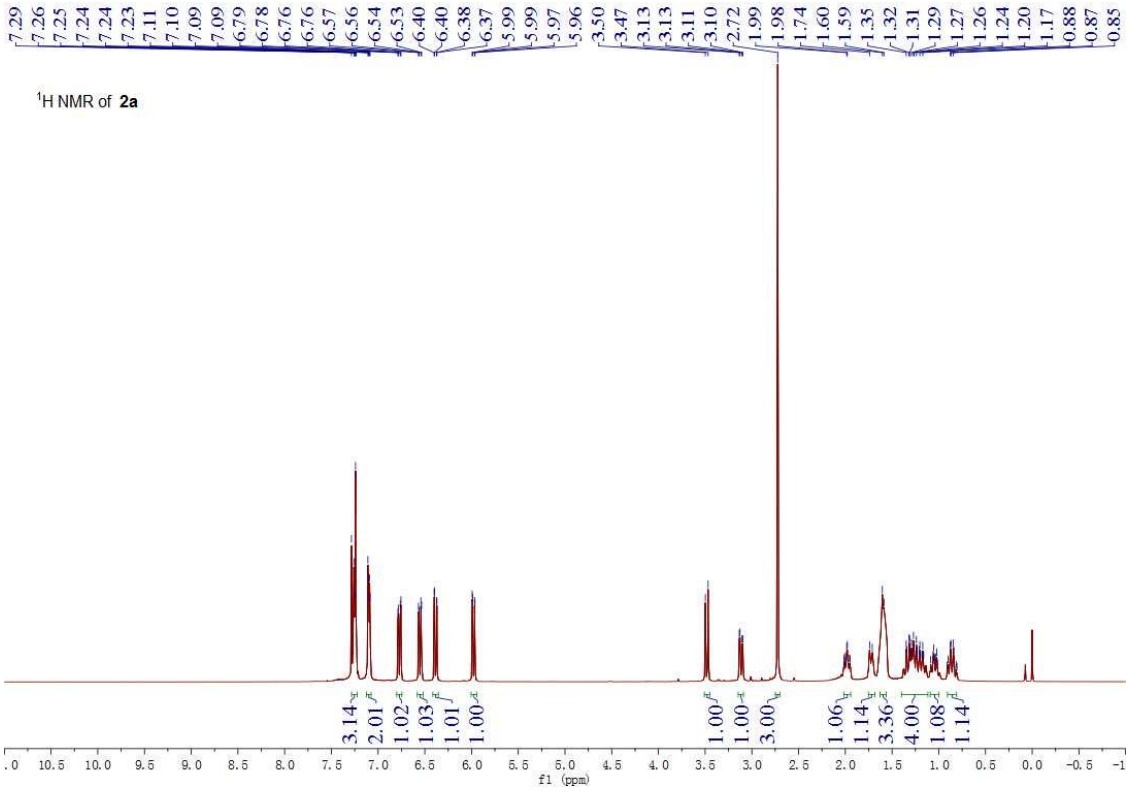


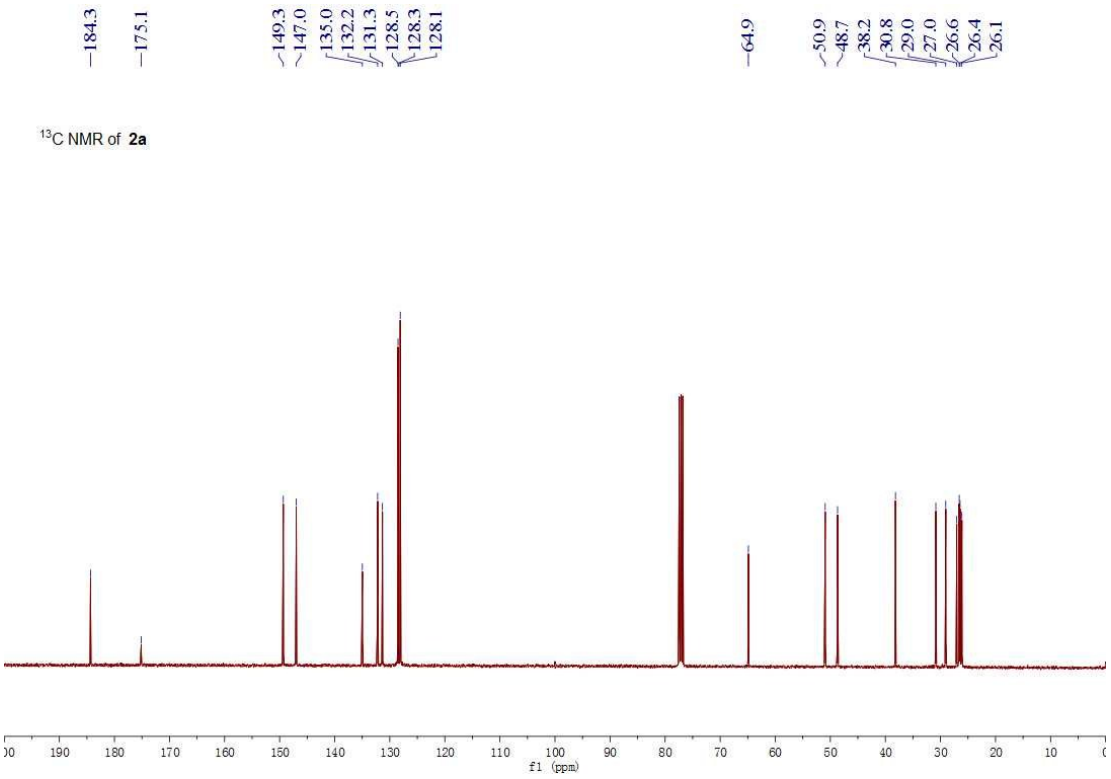
2z

white solid, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 – 7.21 (m, 3H), 7.12-7.07 m, 2H), 6.87 – 6.71 (m, 1H), 6.66 – 6.49 (m, 1H), 6.42-6.35 (m, 1H), 6.03-5.97 (m, 1H), 3.44 (dd, *J* = 11.9, 2.7 Hz, 1H), 3.34 – 3.14 (m, 1H), 2.73 (d, *J* = 4.7 Hz, 3H), 2.28-2.20 (m, 1H), 2.05 – 1.94 (m, 1H), 1.87-1.79 (m, 1H), 1.55-1.47 (m, 1H), 1.40-1.29 (m, 3H), 1.23-1.15 (m, 1H), 1.12 – 1.03 (m, 1H), 0.99 – 0.78 (m, 6H), 0.73 (t, *J* = 7.6 Hz, 1H). HRMS (ESI) calcd. for $C_{22}H_{26}NNaO_2^+$ ($M+Na^+$): 336.1958, found: 336.1955.

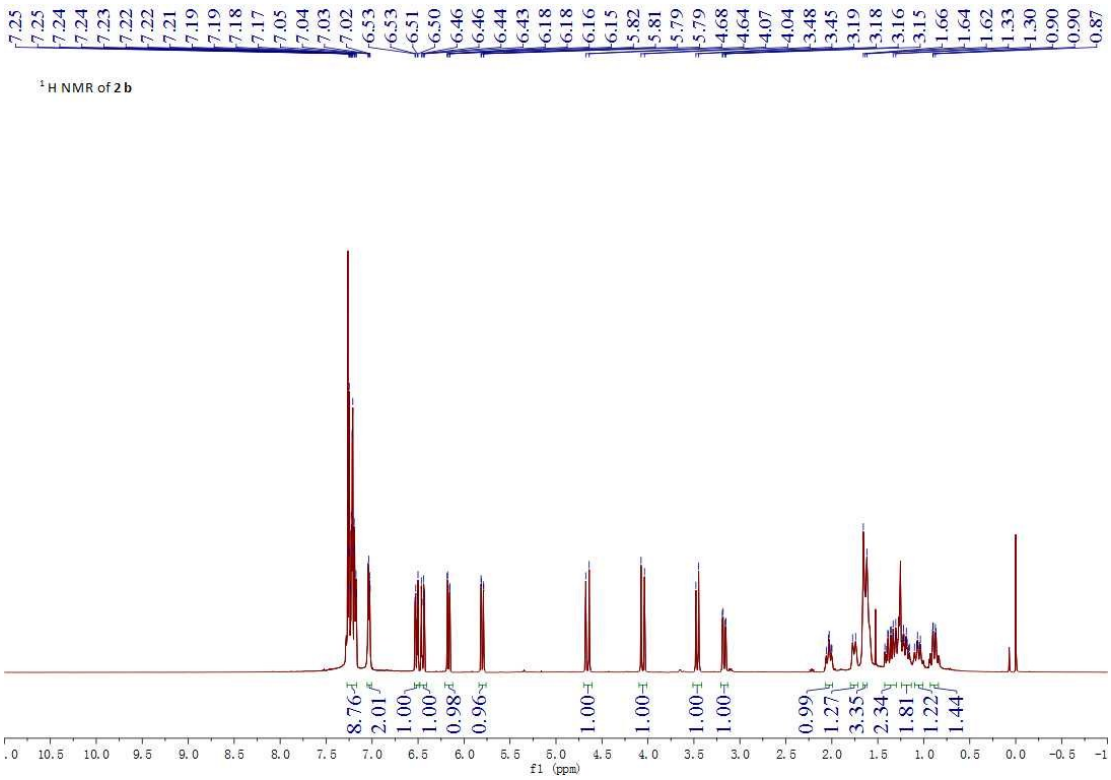
5. Copies of ^{1}H NMR, ^{19}F NMR and ^{13}C NMR sprctra

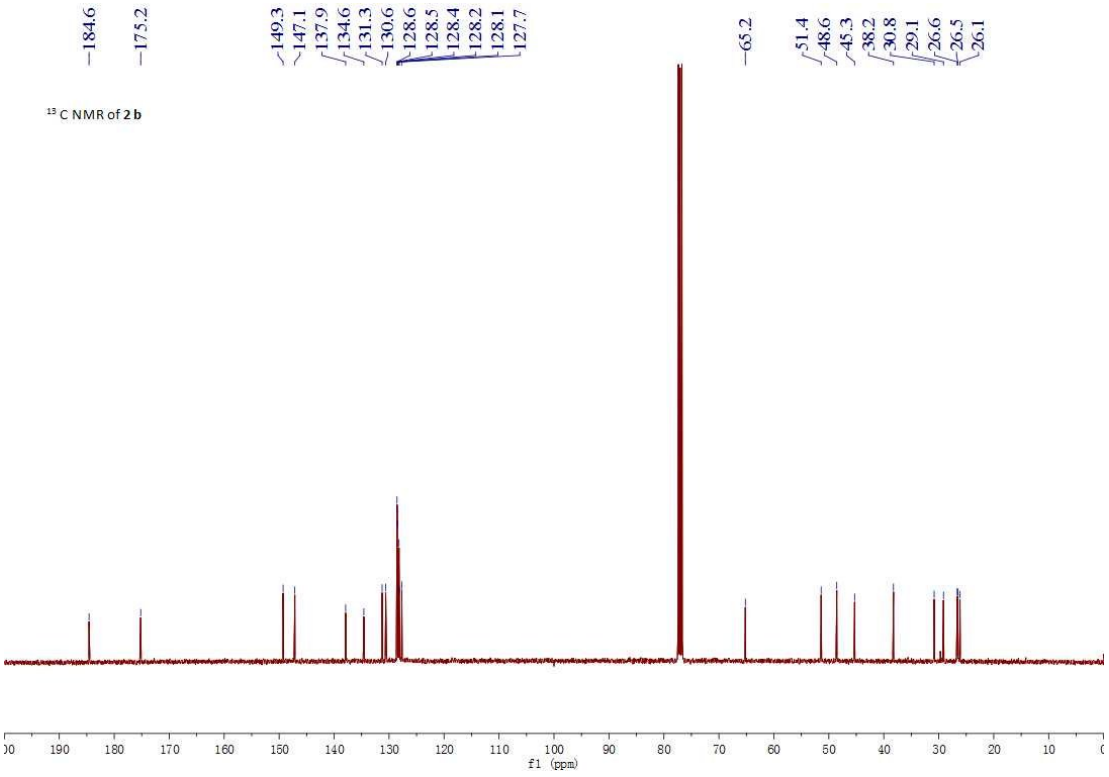
3-cyclohexyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2a**)



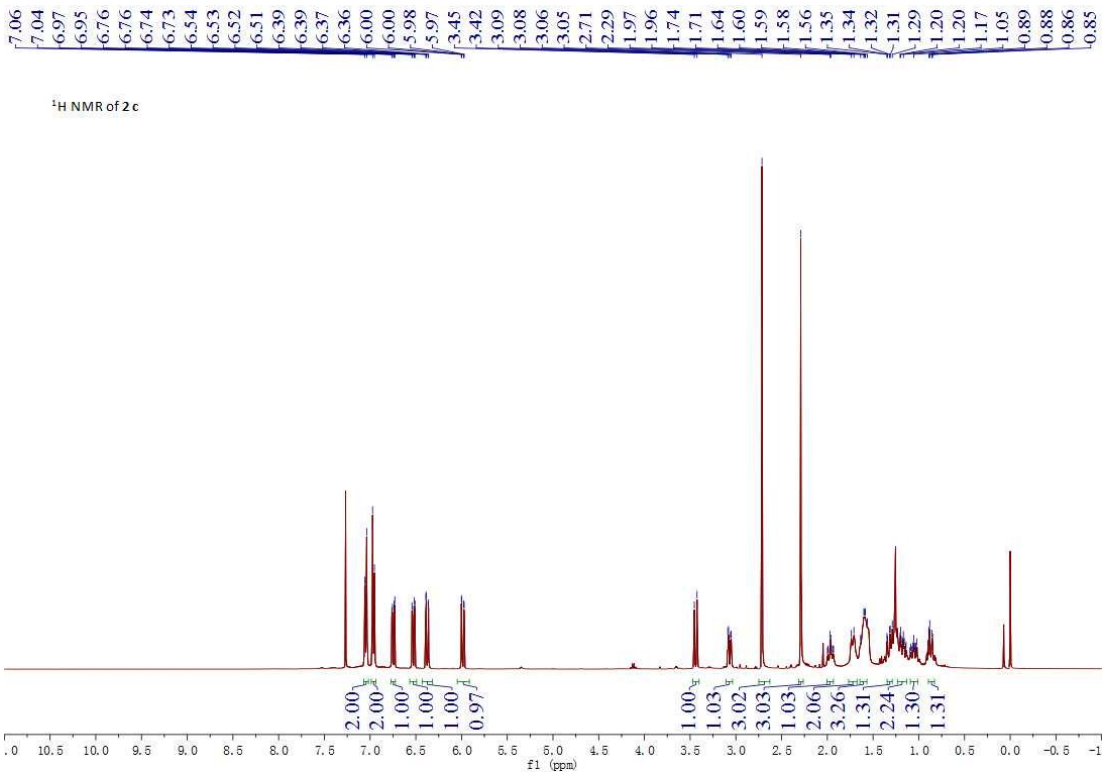


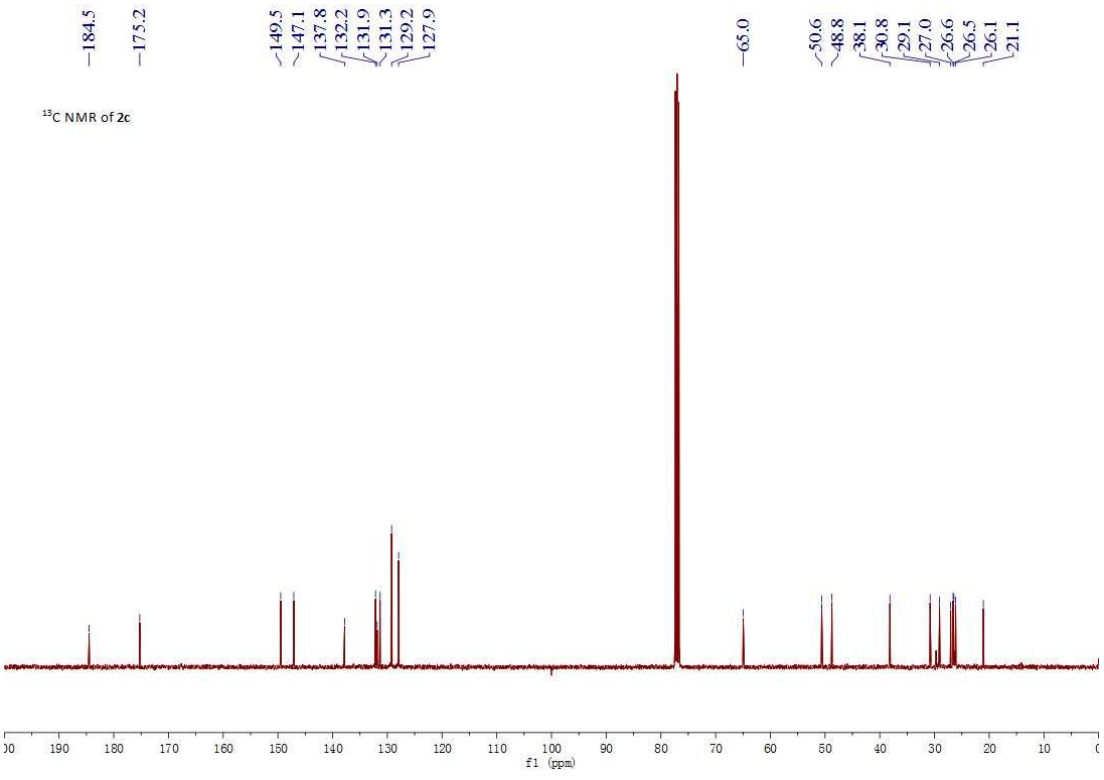
1-benzyl-3-cyclopentyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2b**)



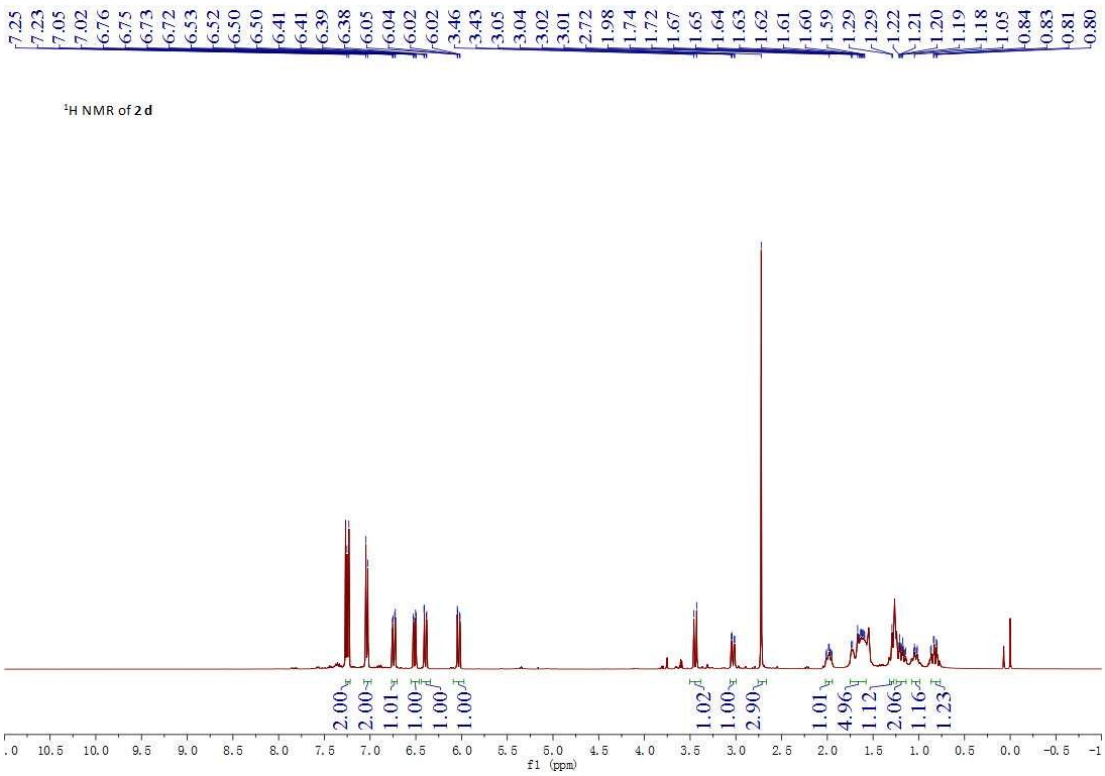


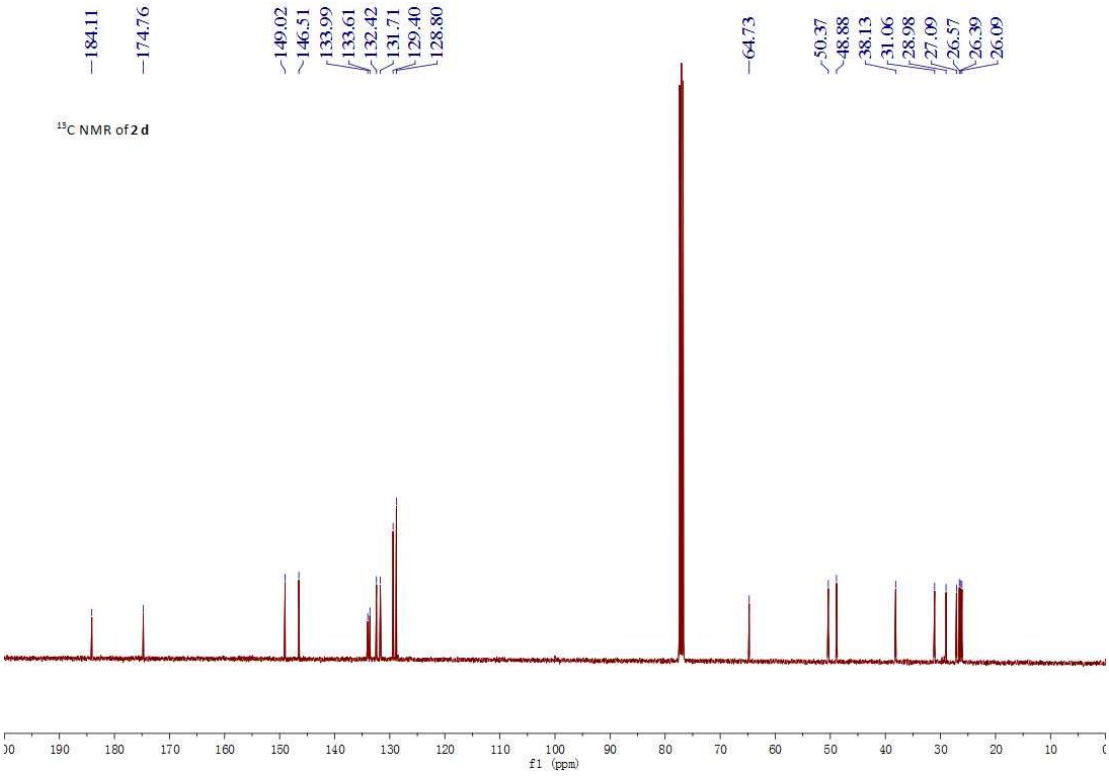
3-cyclohexyl-1-methyl-4-(p-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2c**)



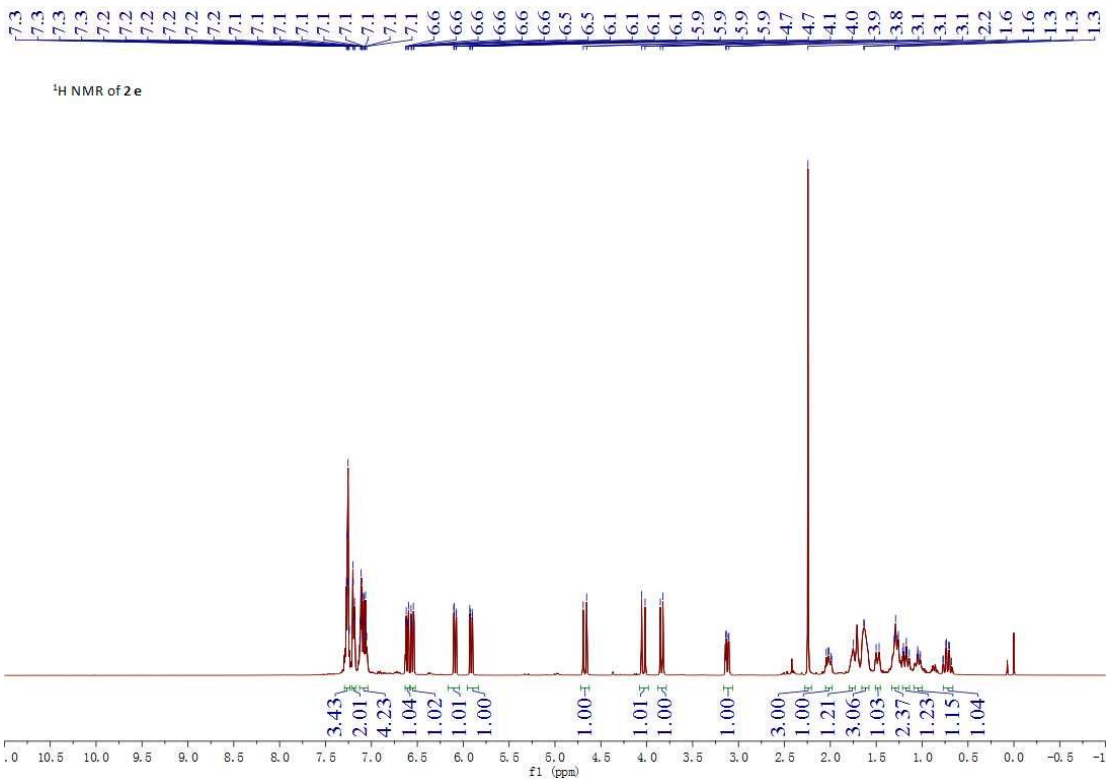


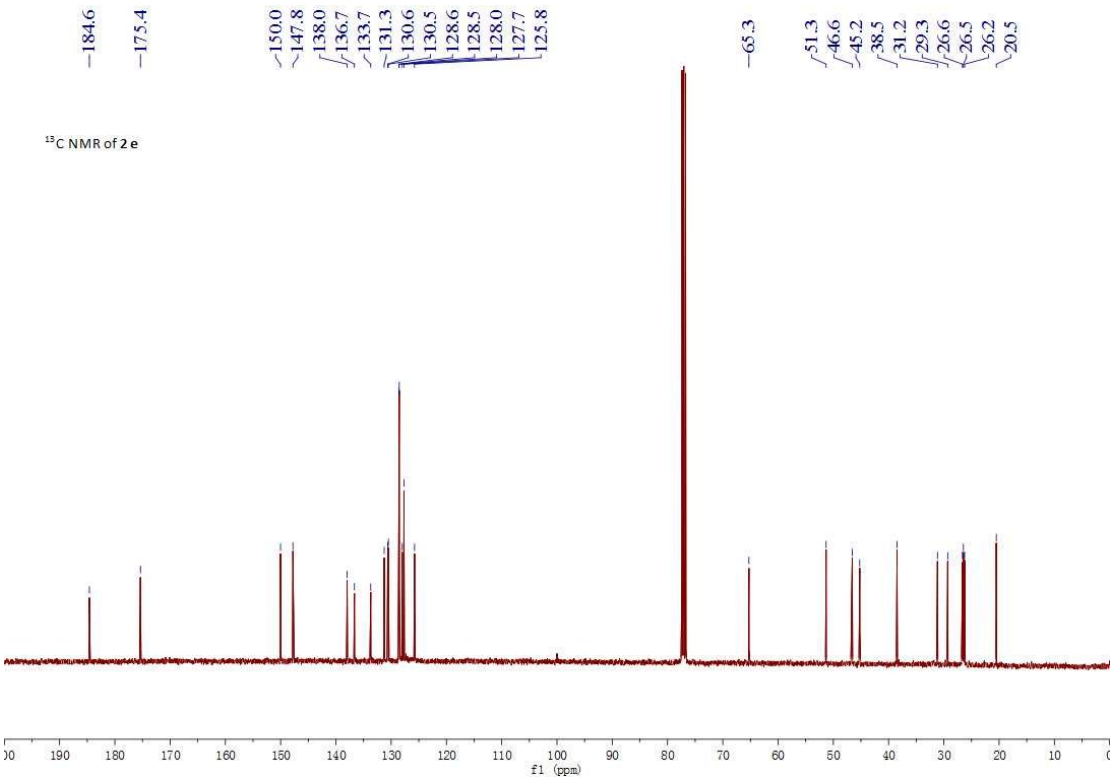
4-(4-chlorophenyl)-3-cyclohexyl-1-methyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2d**)



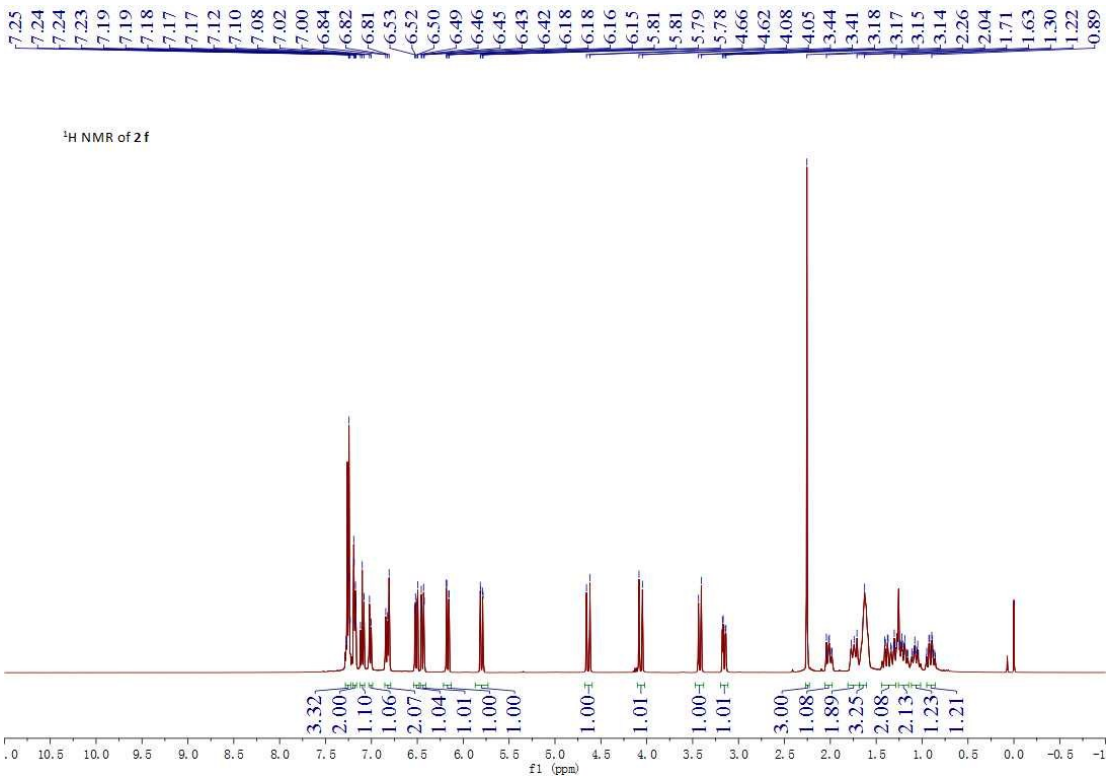


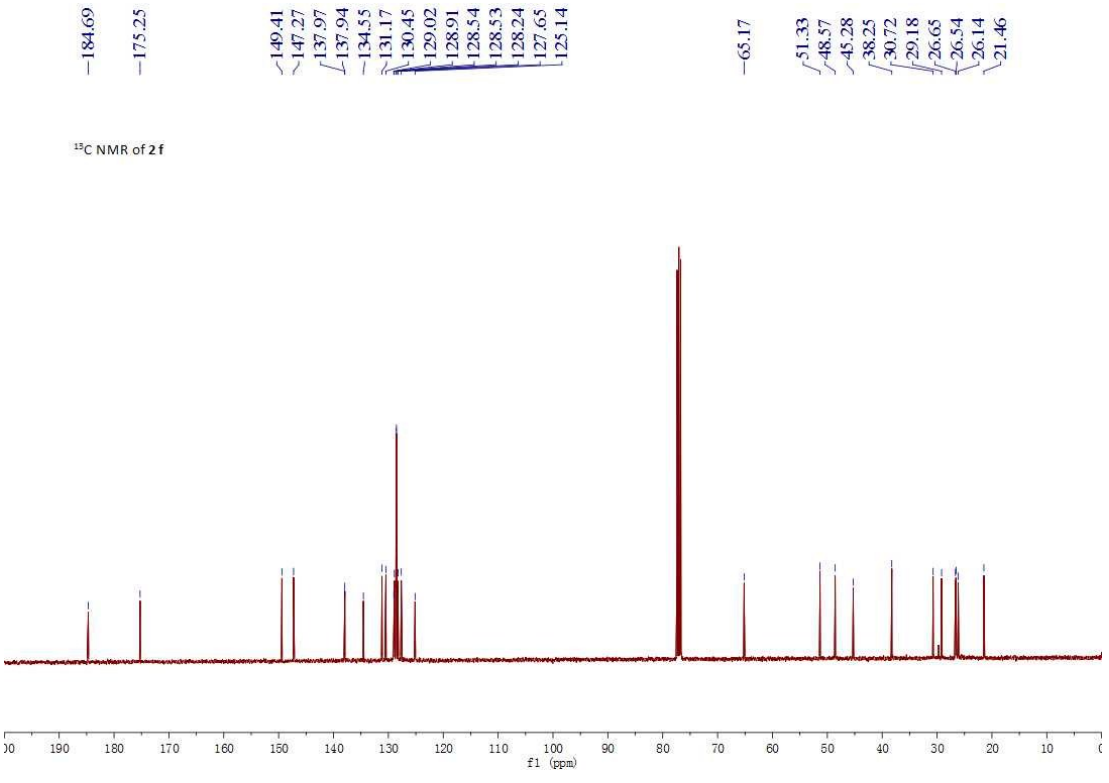
1-benzyl-3-cyclohexyl-4-(o-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2e**)



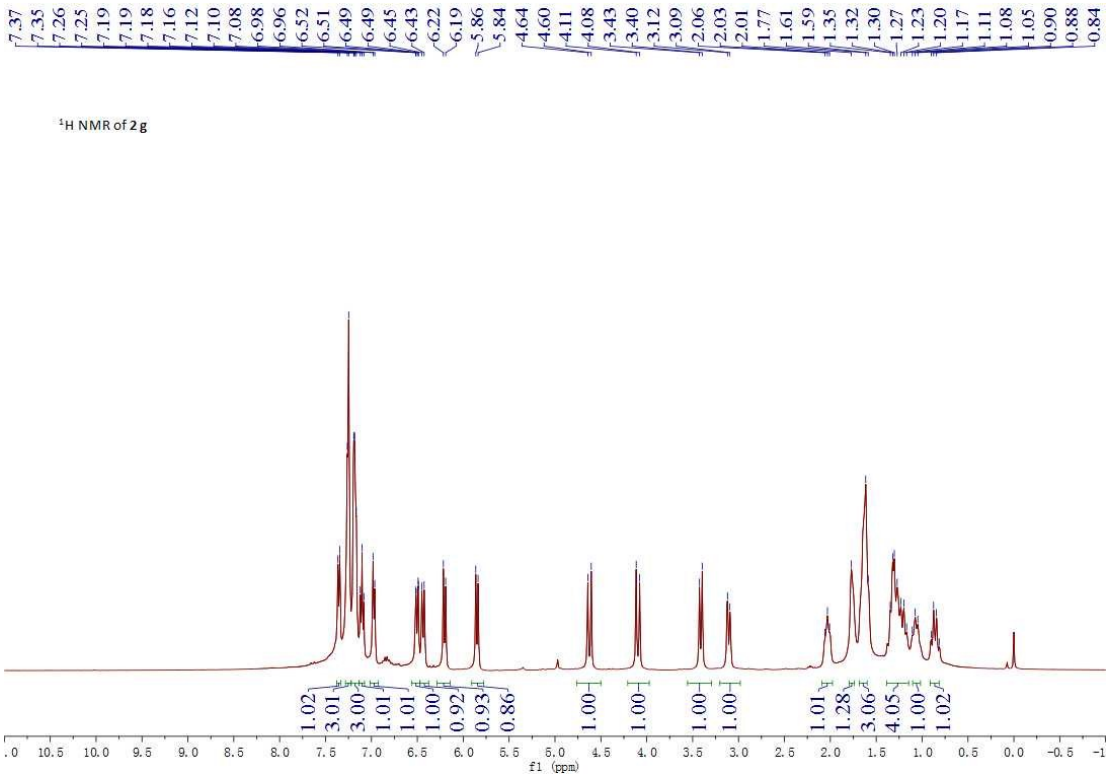


1-benzyl-3-cyclohexyl-4-(m-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2f**)

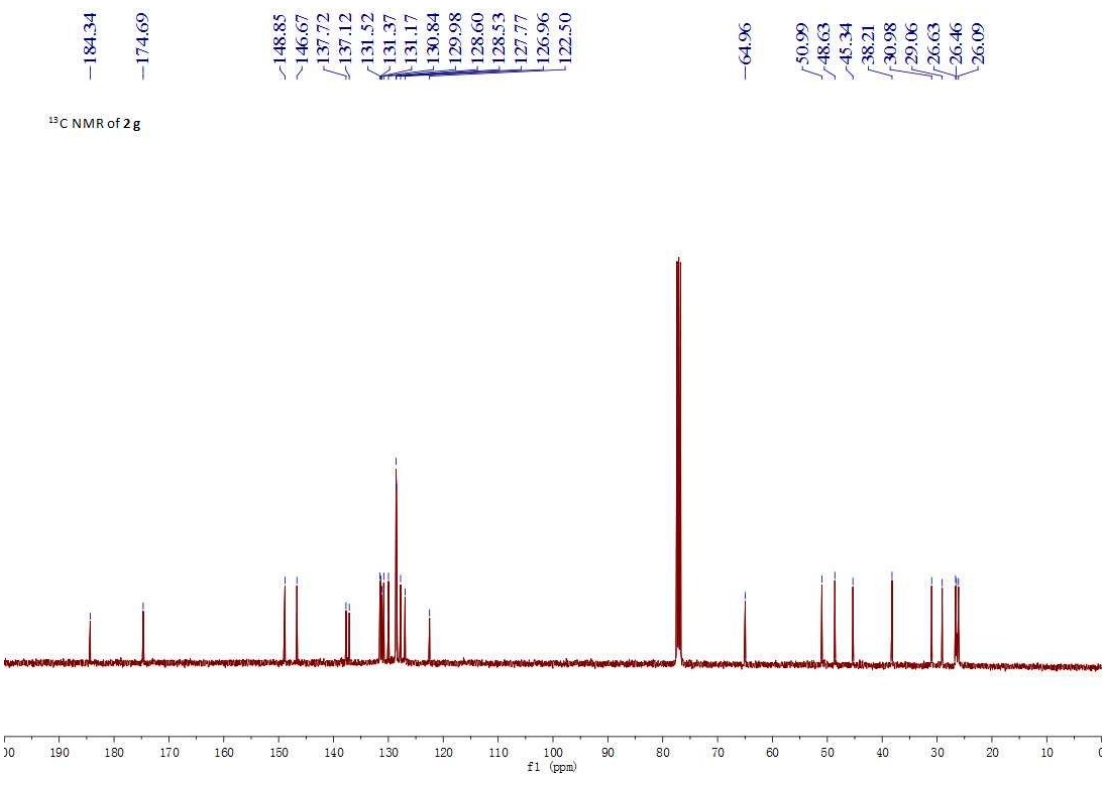




1-benzyl-4-(3-bromophenyl)-3-cyclohexyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2g**)



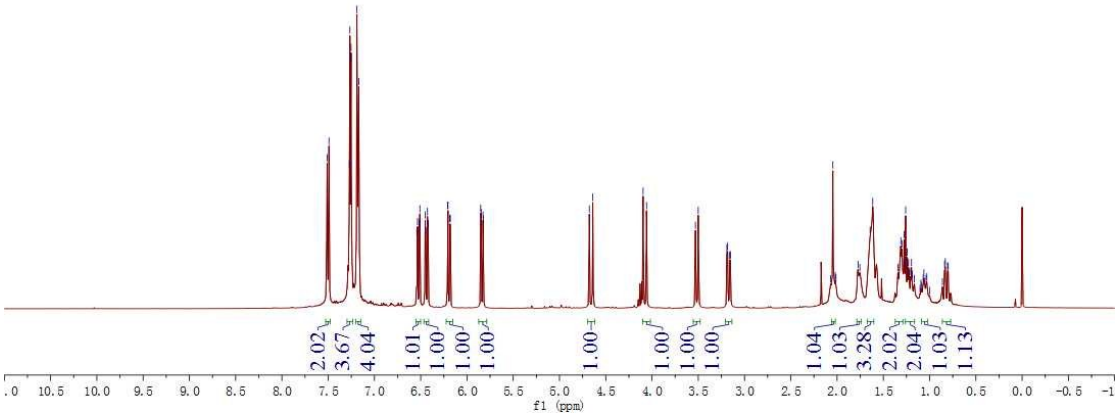
^{1}H NMR of **2g**

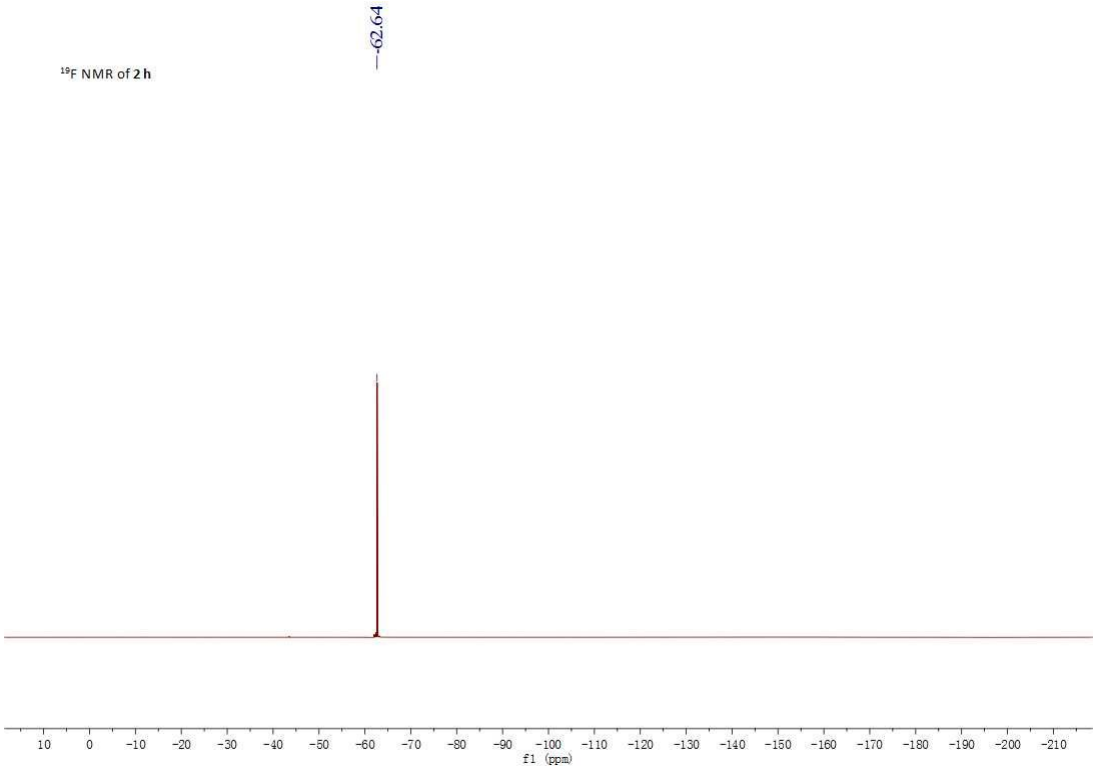


^{13}C NMR of **2g**

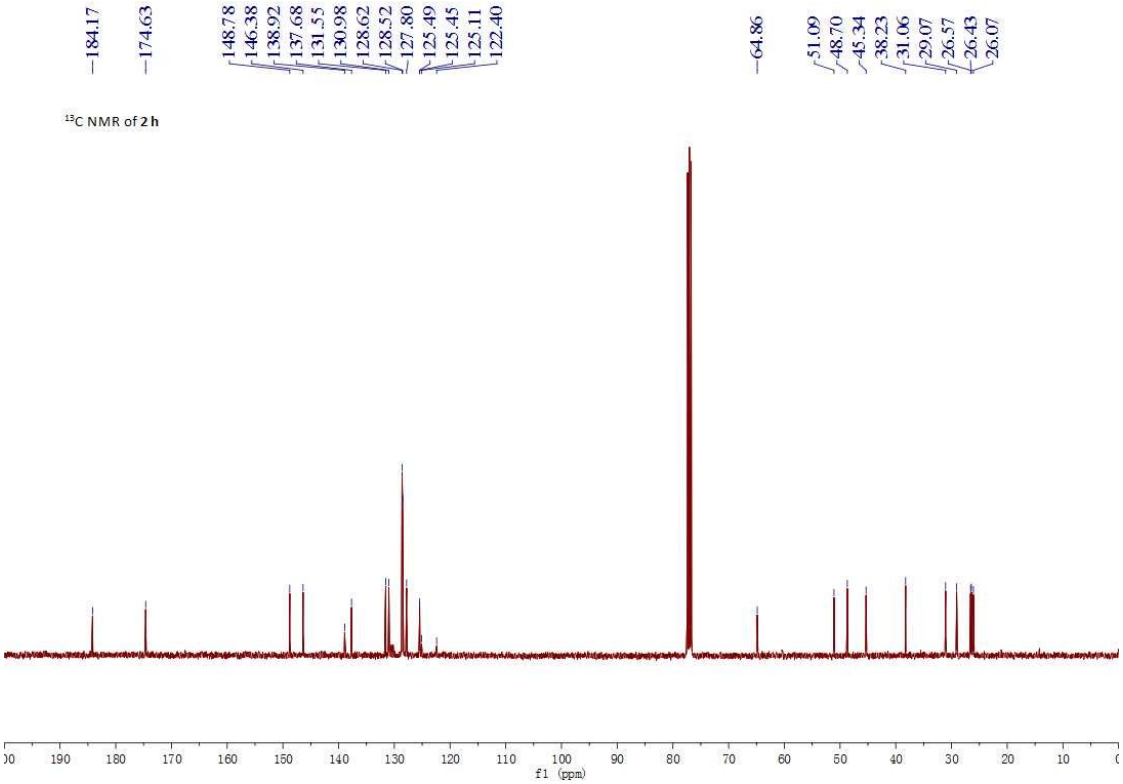
1-benzyl-3-cyclohexyl-4-(4-(trifluoromethyl)phenyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2h**)

^{1}H NMR of **2 h**



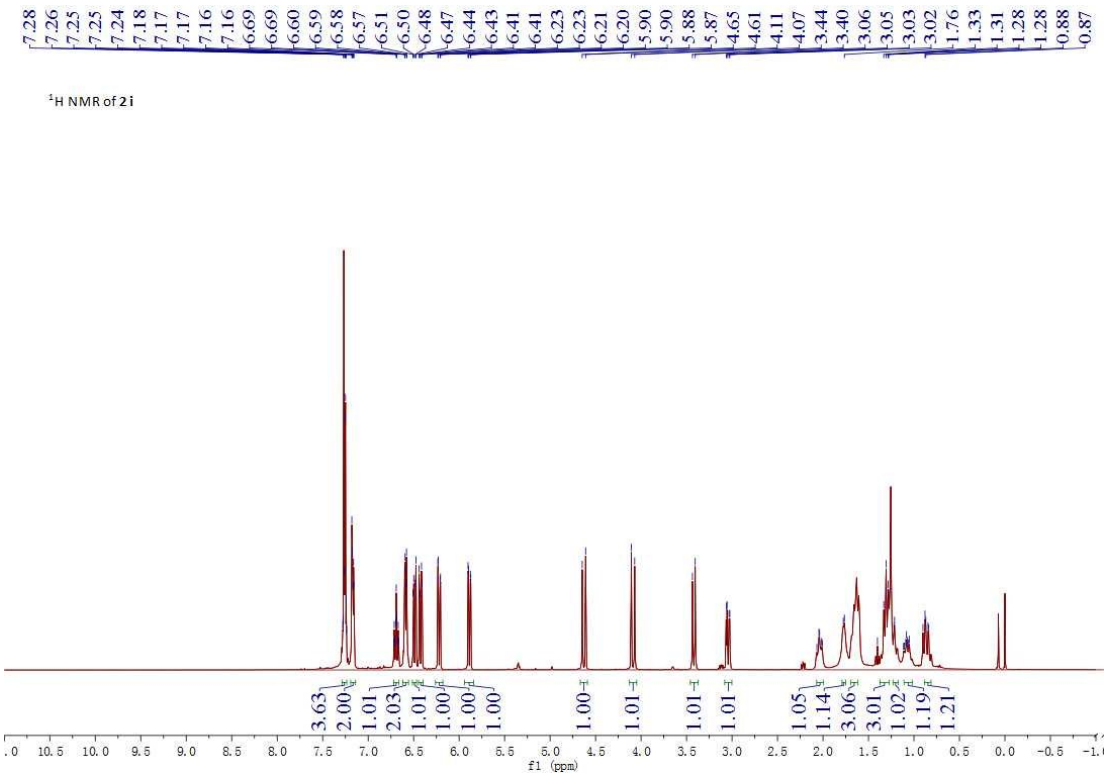


^{19}F NMR of **2 h**



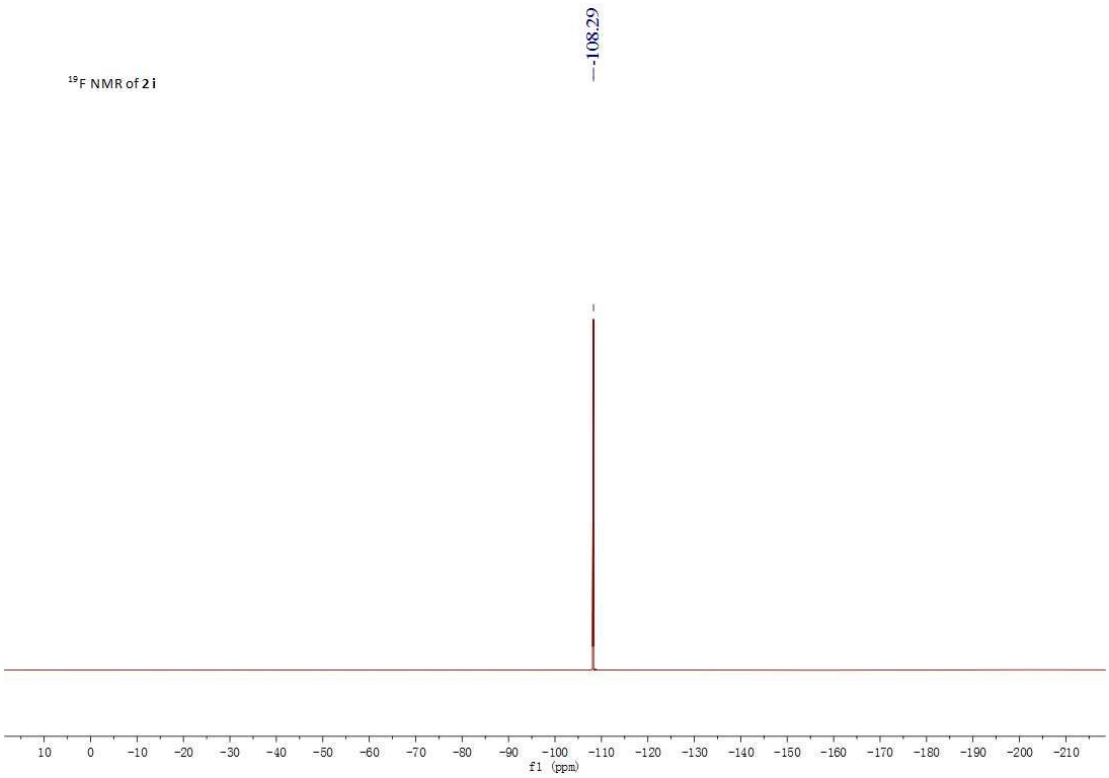
^{13}C NMR of **2 h**

1-benzyl-3-cyclohexyl-4-(3,5-difluorophenyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2i**)

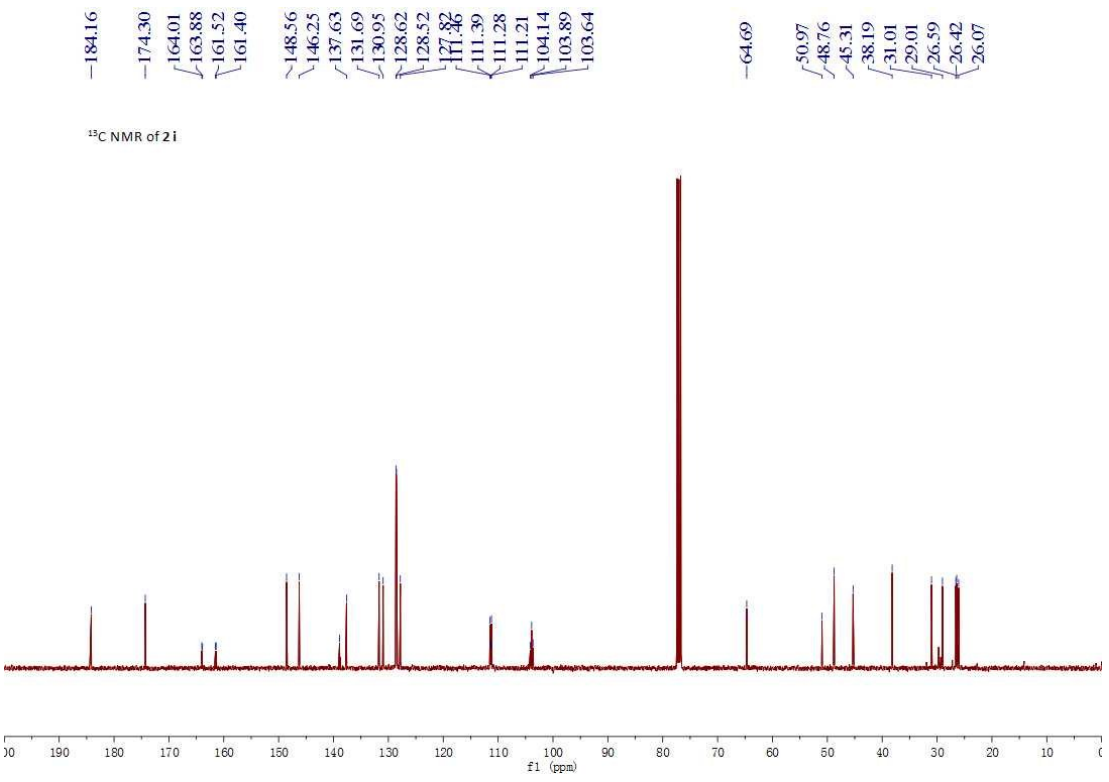


^{1}H NMR of **2 i**

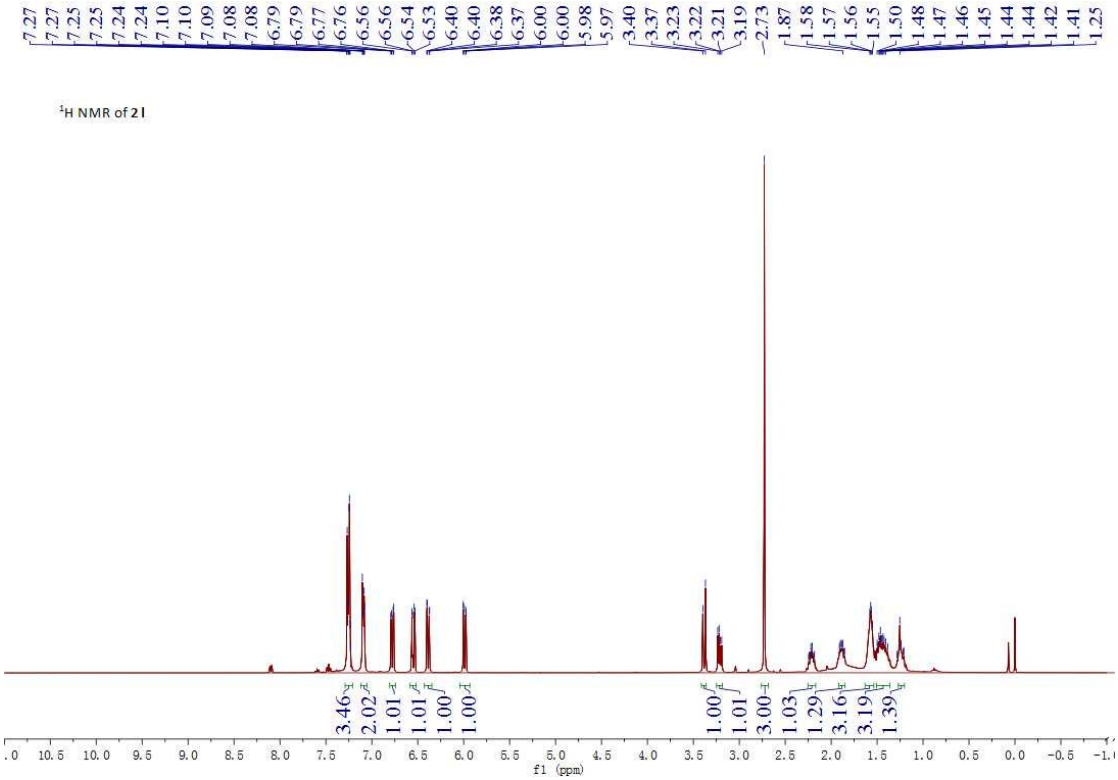
^{19}F NMR of **2 i**

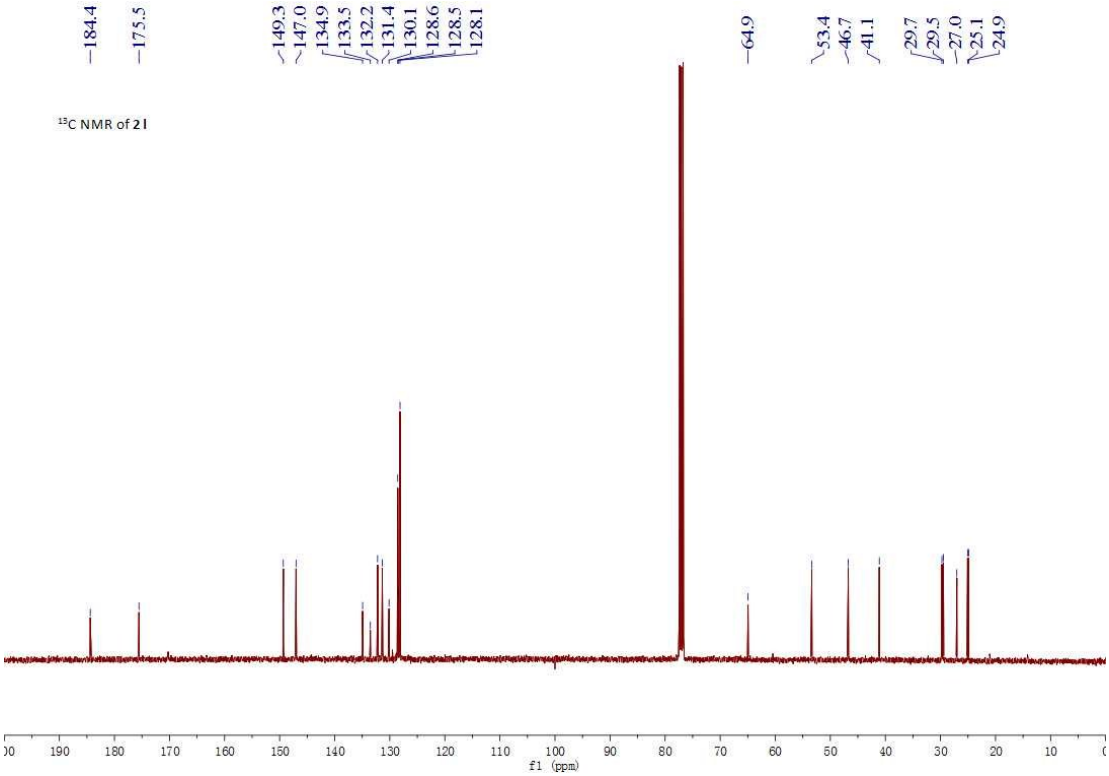


^{13}C NMR of **2 i**

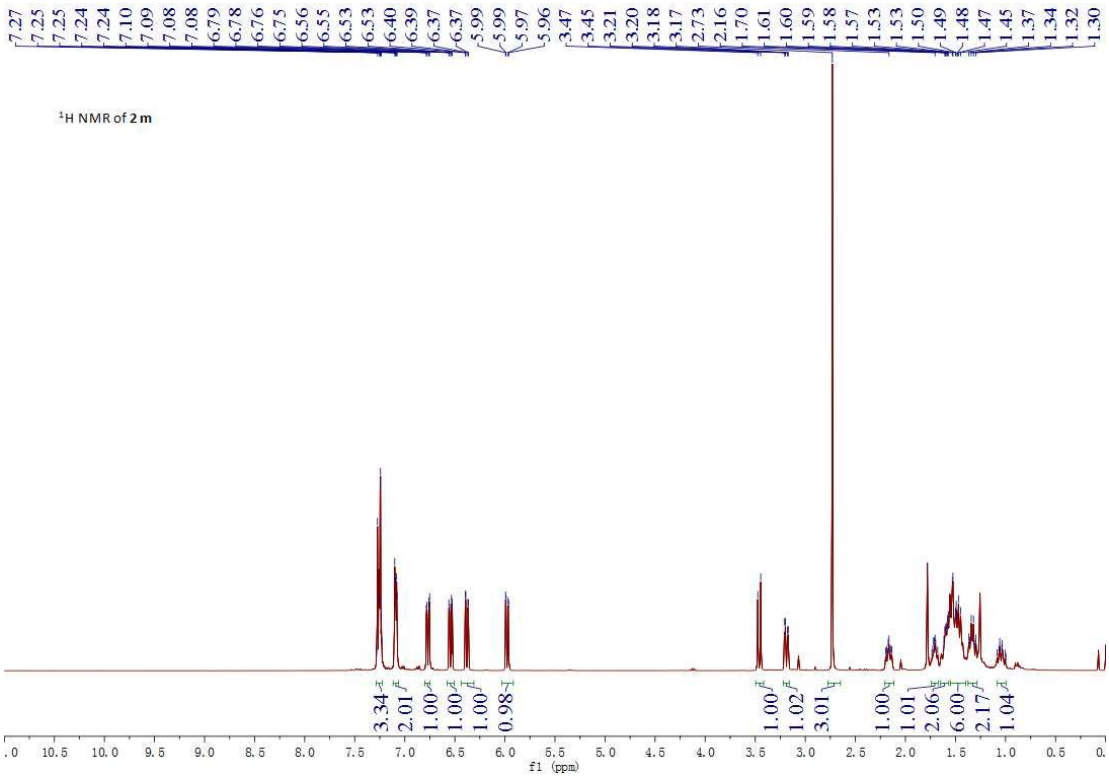


3-cyclopentyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2l**)

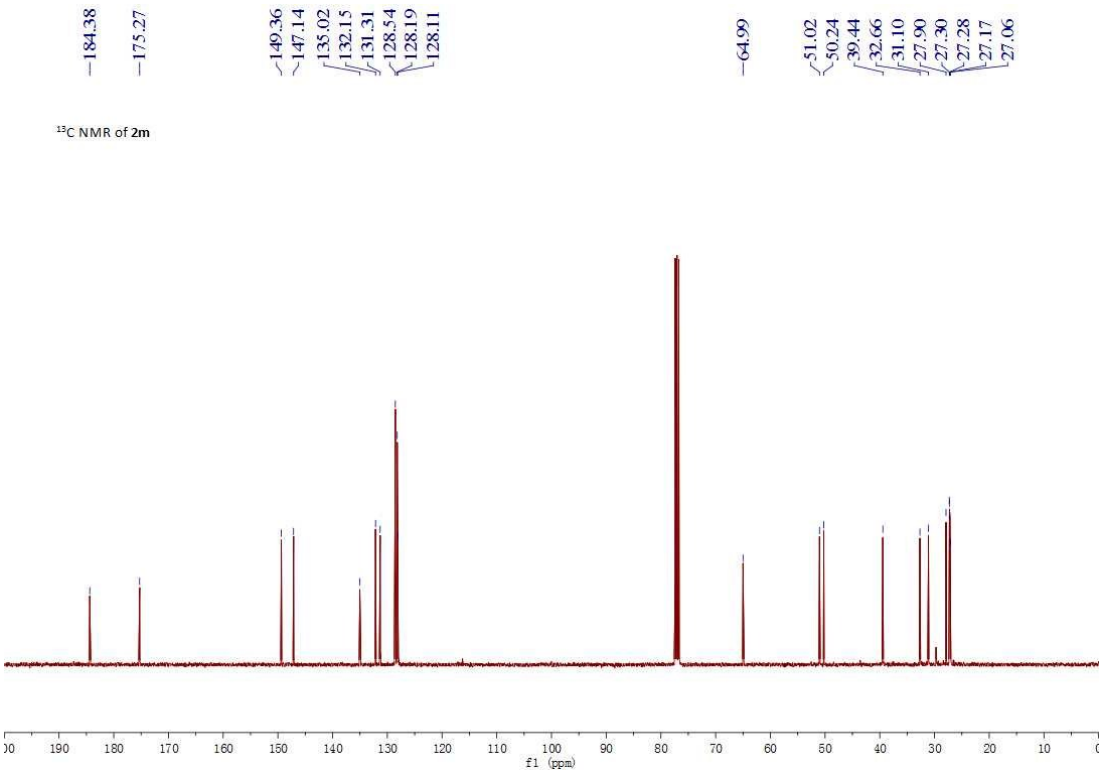




3-cycloheptyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2m**)

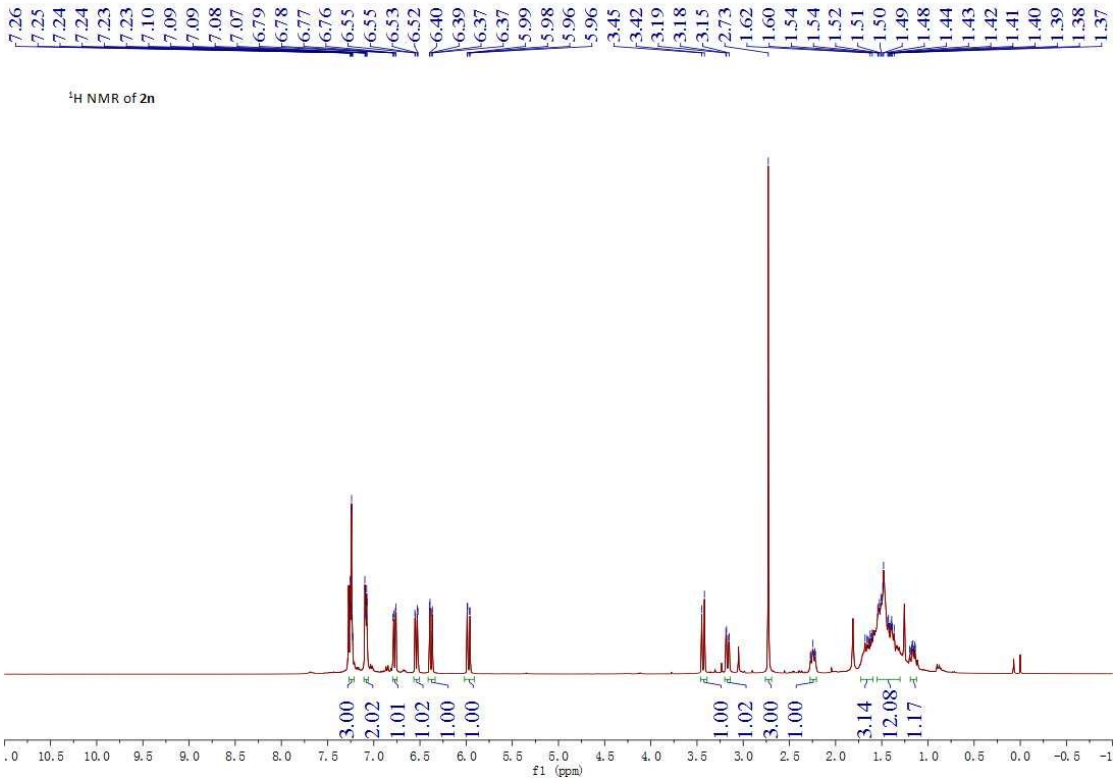


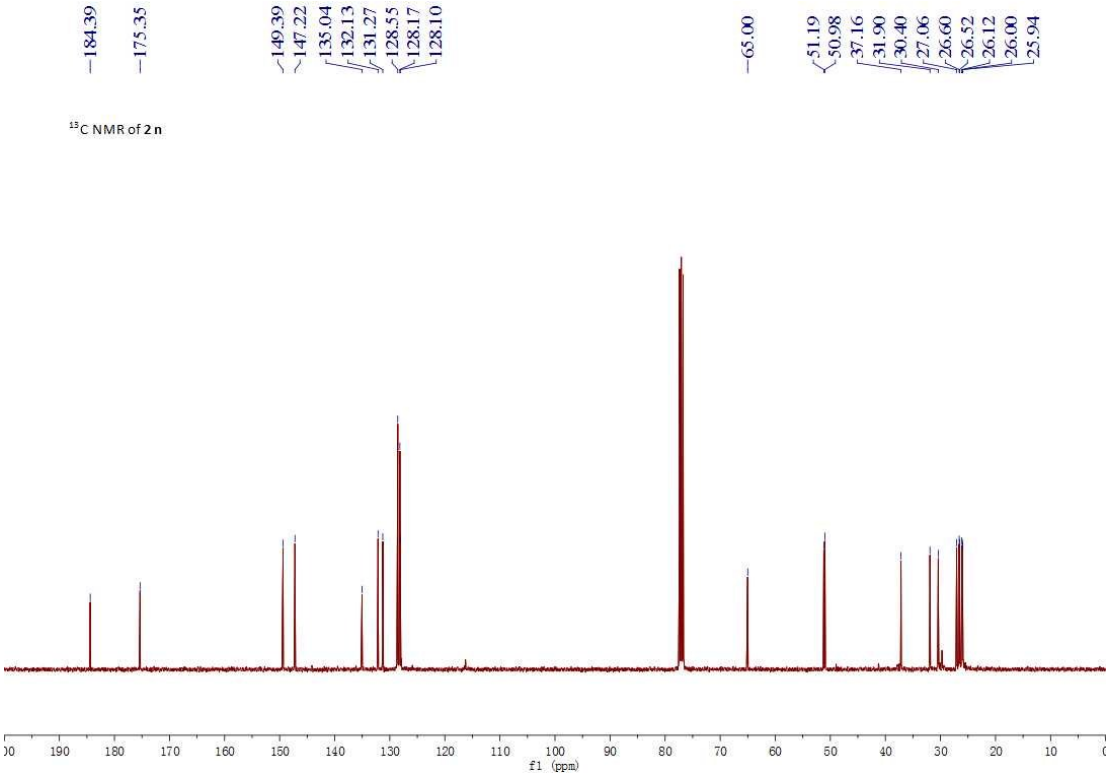
¹H NMR of **2m**



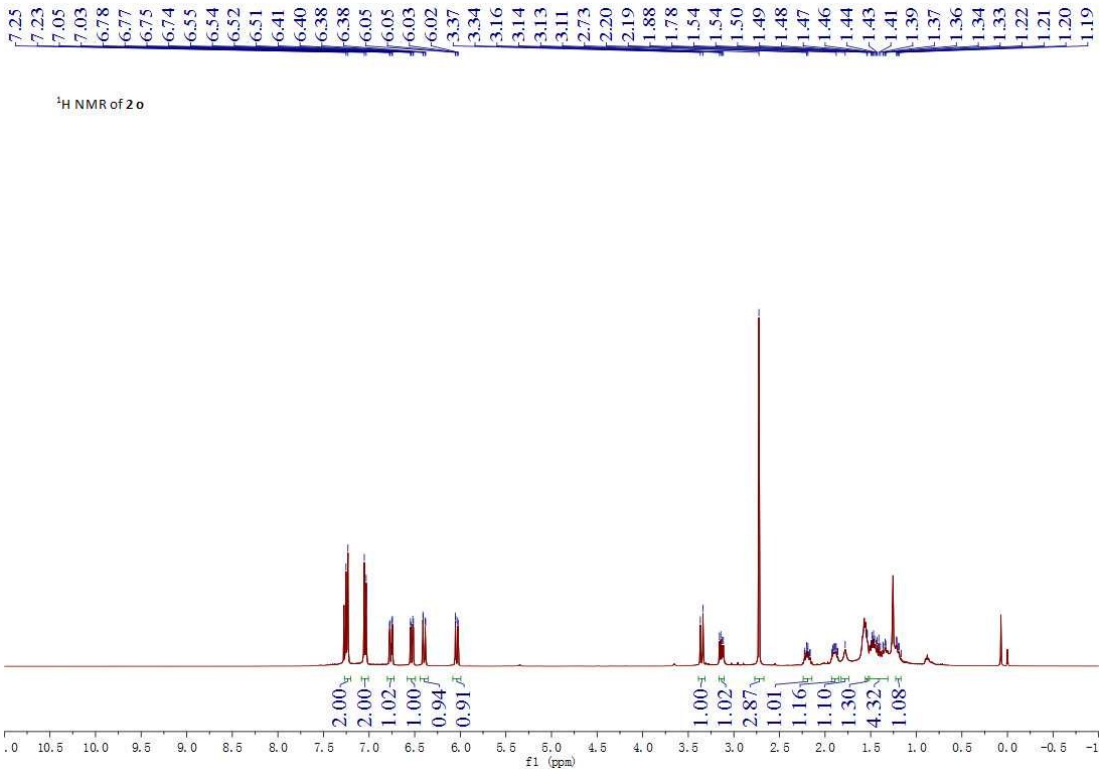
¹³C NMR of **2m**

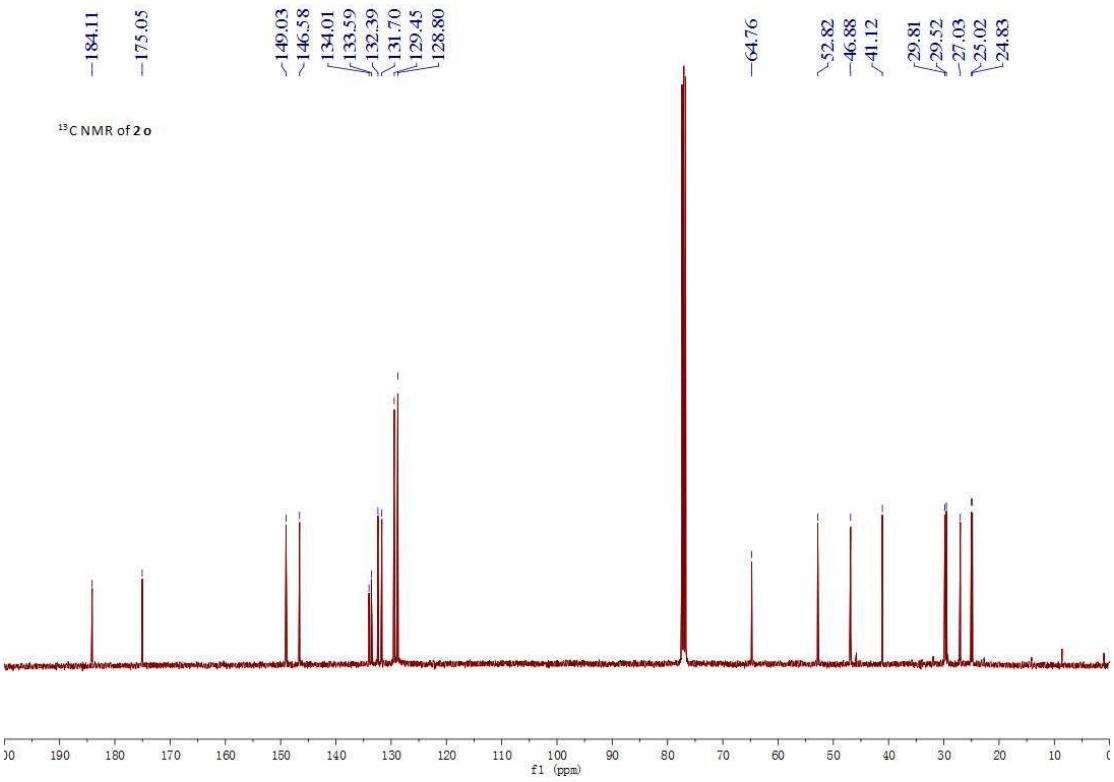
3-cyclooctyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2n**)



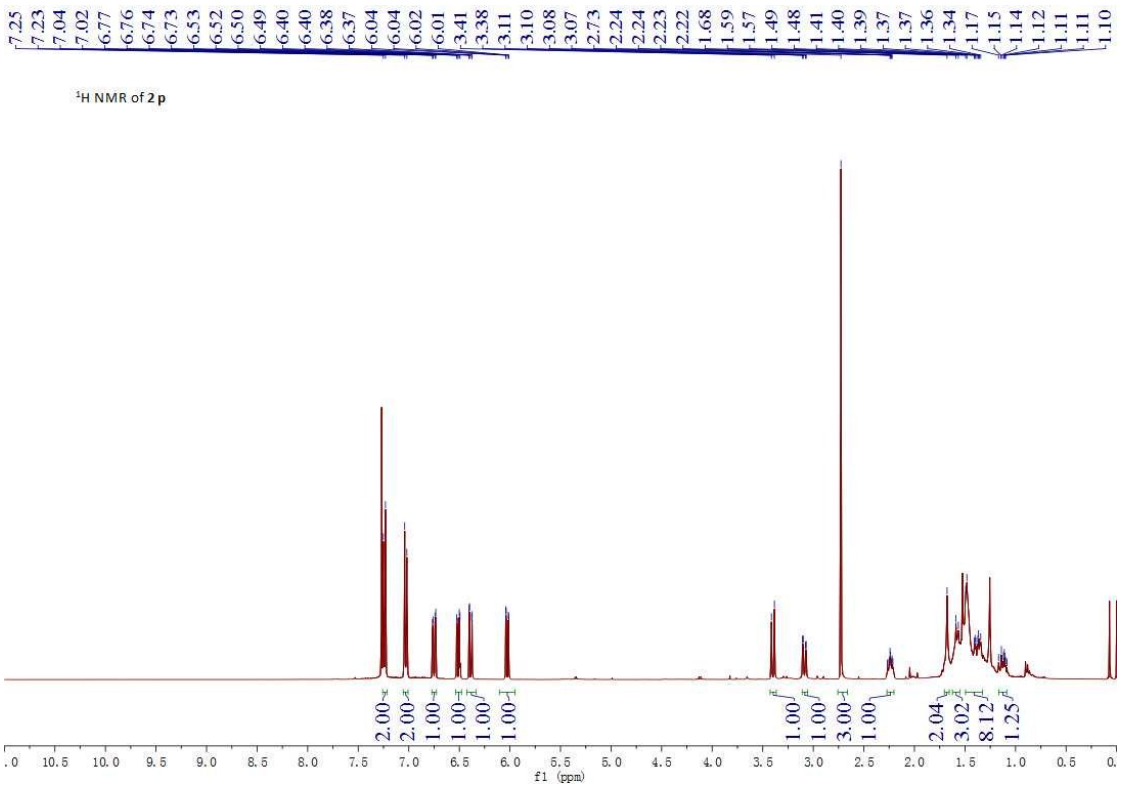


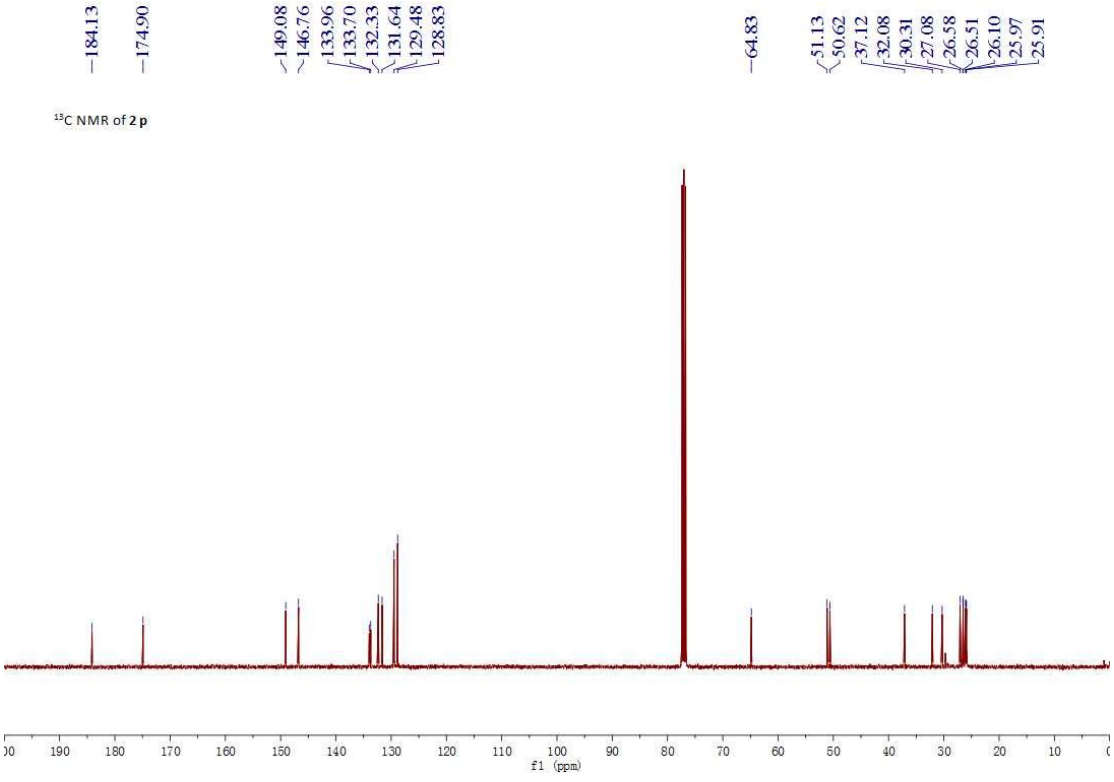
4-(4-chlorophenyl)-3-cyclopentyl-1-methyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2o**)





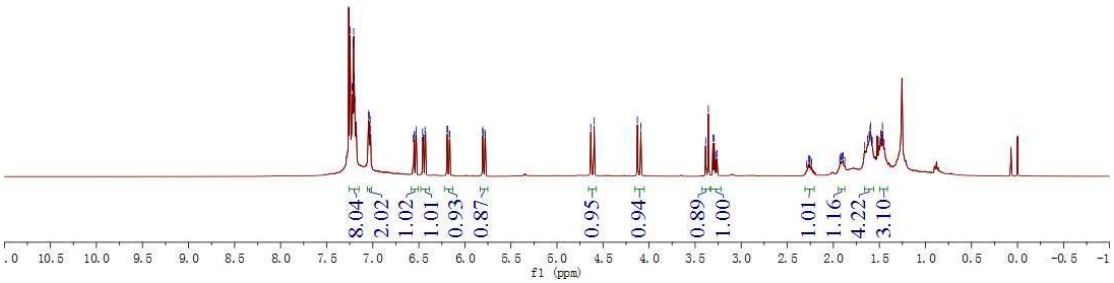
4-(4-chlorophenyl)-3-cyclooctyl-1-methyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2p**)

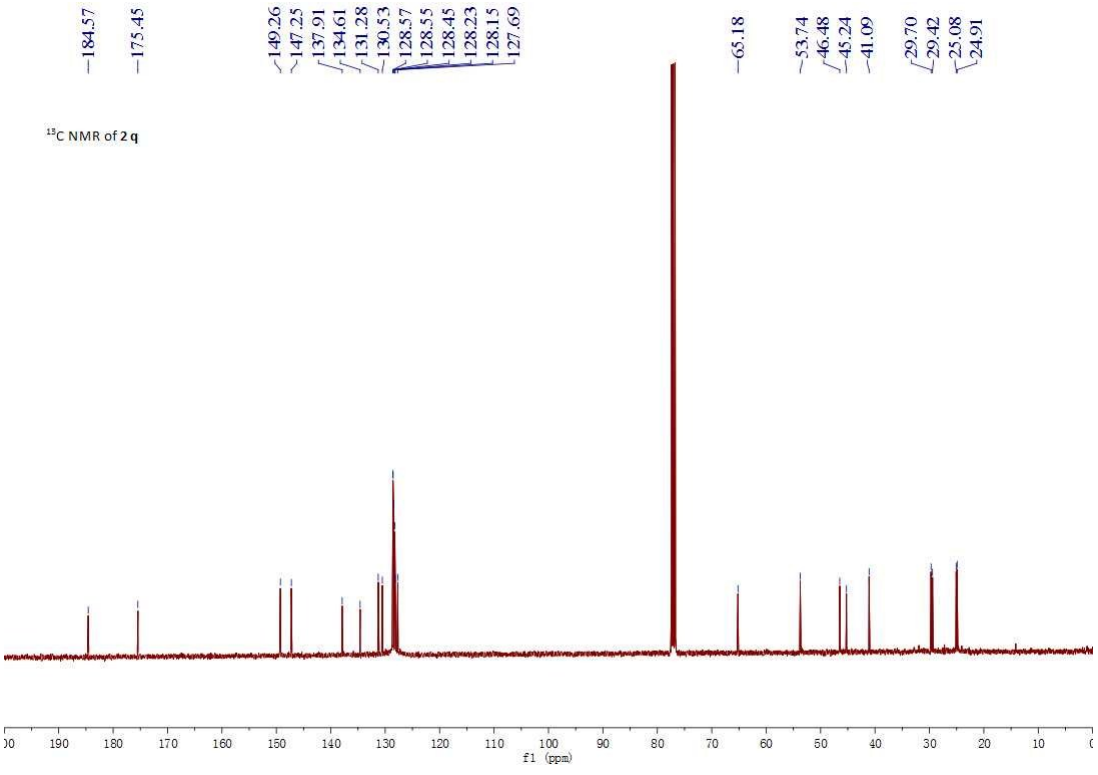




1-benzyl-3-cyclopentyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2q**)

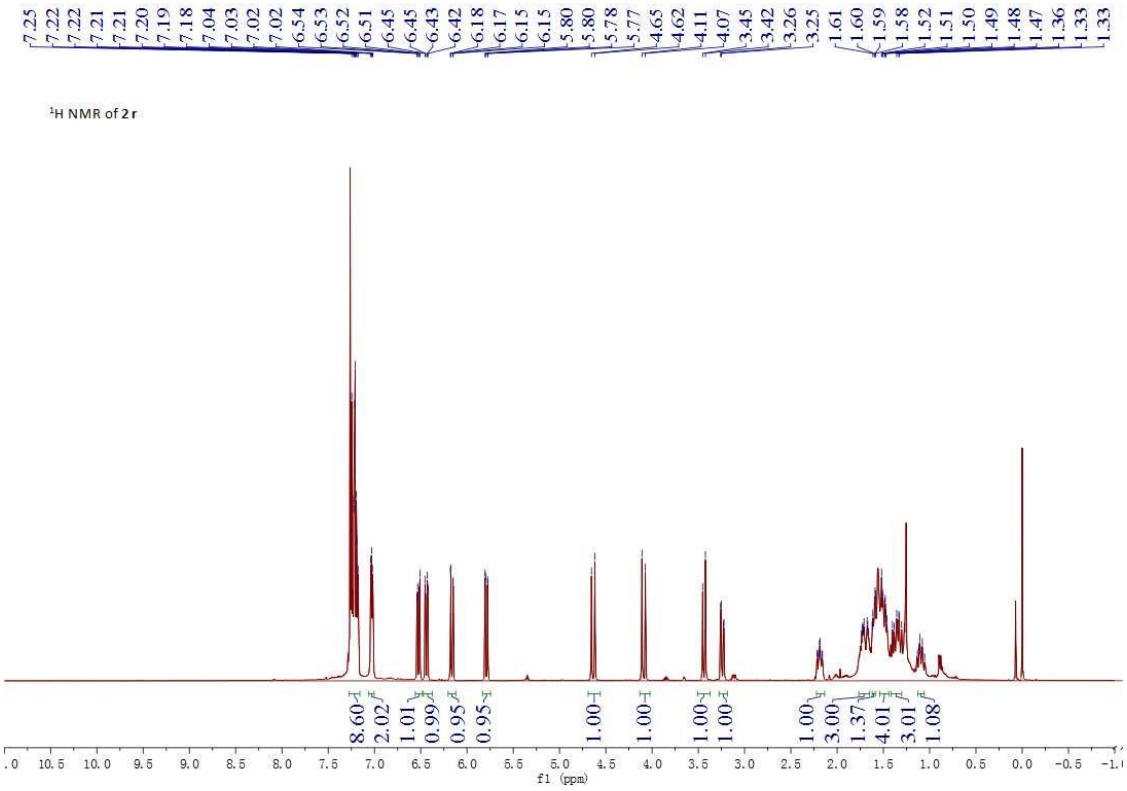
^{1}H NMR of **2q**

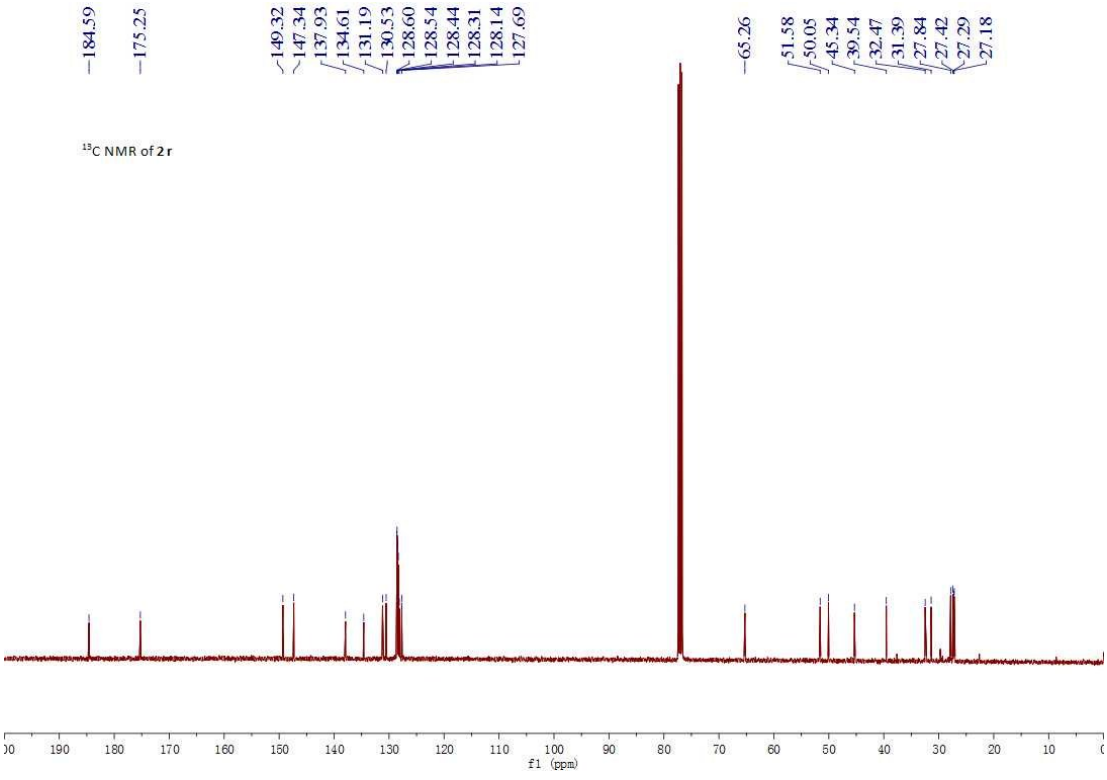




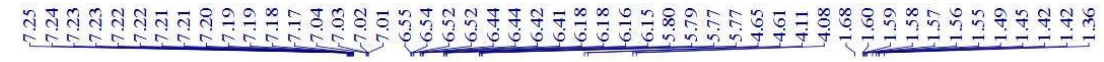
^{13}C NMR of **2q**

1-benzyl-3-cycloheptyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2r**)

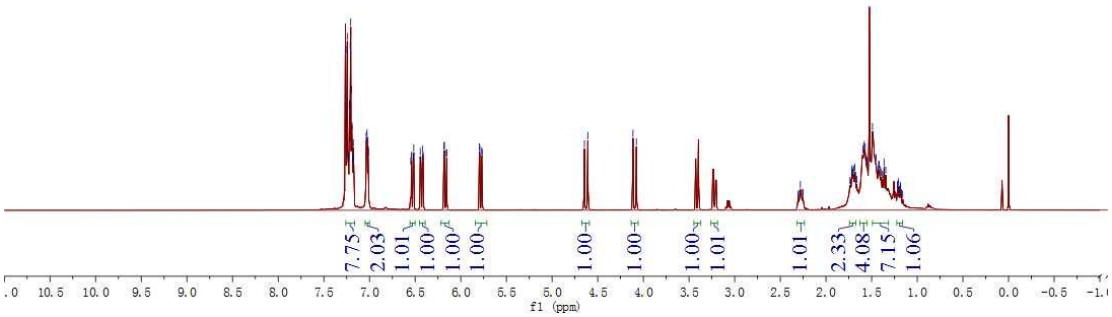




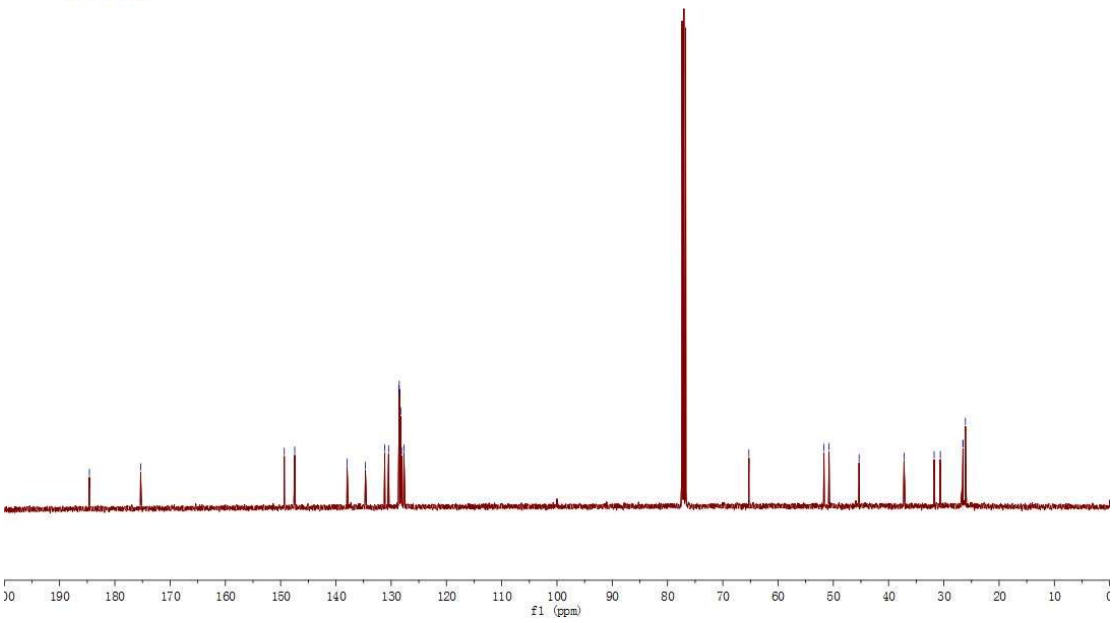
1-benzyl-3-cyclooctyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2s**)



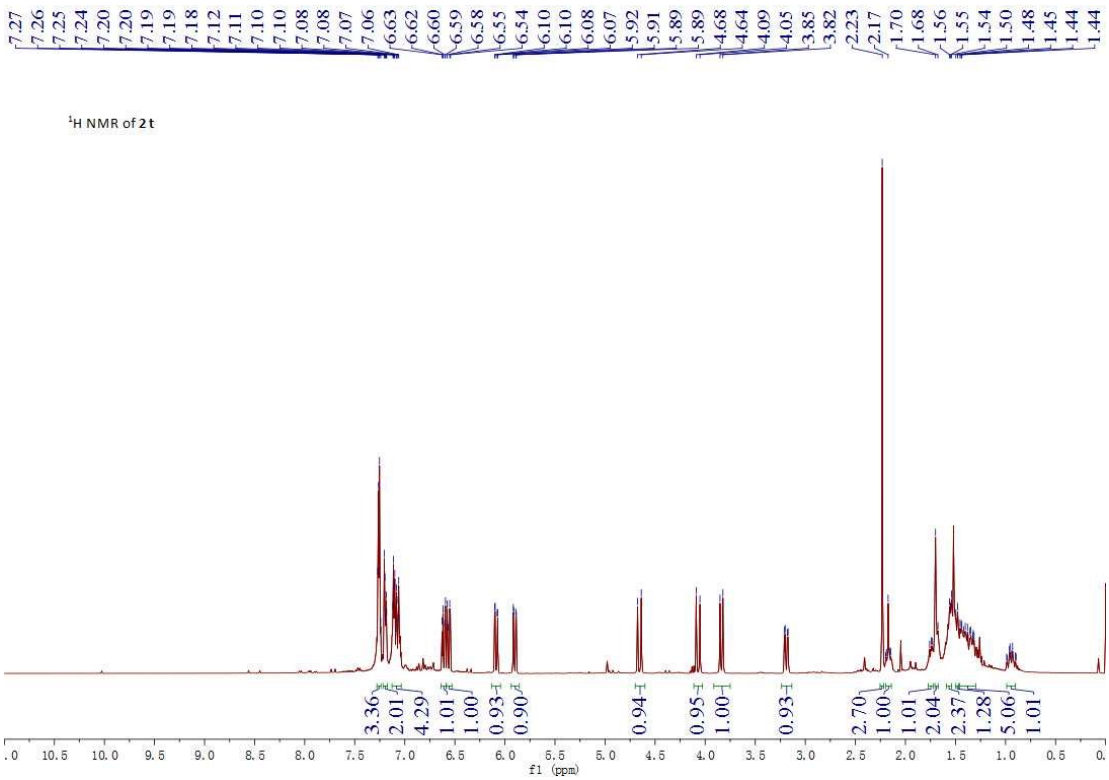
^{1}H NMR of **2s**



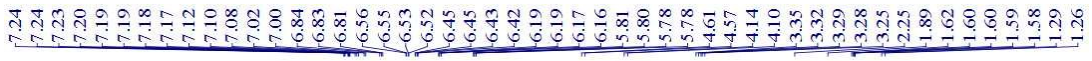
^{13}C NMR of **2s**



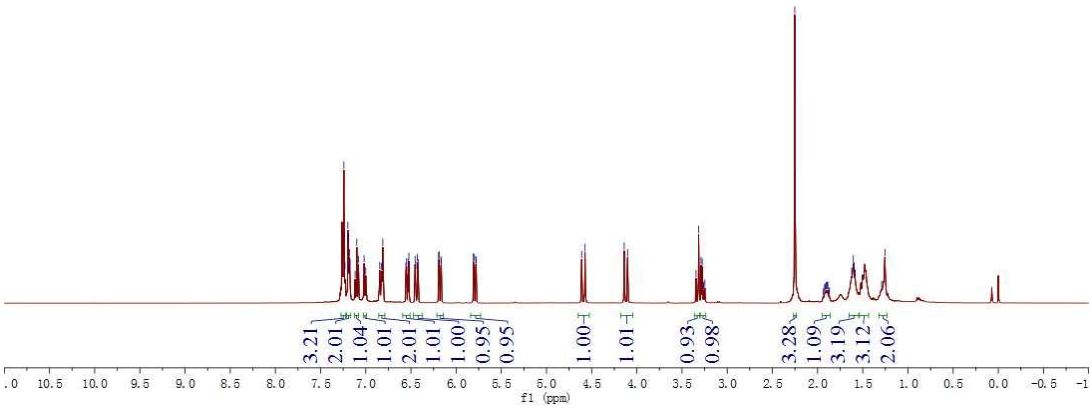
1-benzyl-3-cycloheptyl-4-(o-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2t**)



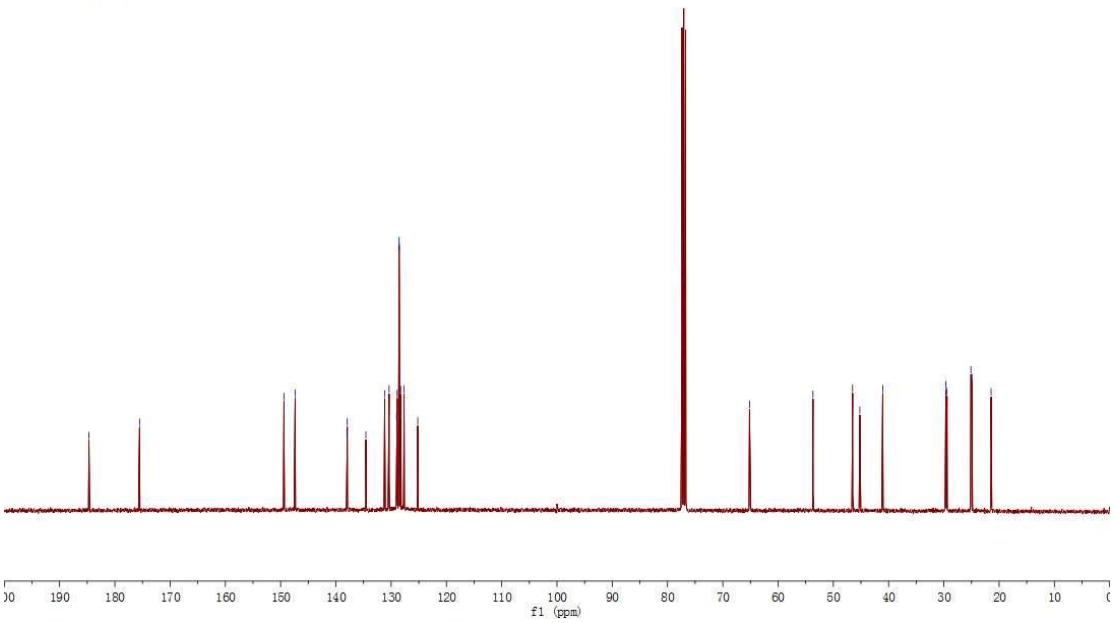
1-benzyl-3-cyclopentyl-4-(m-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2u**)



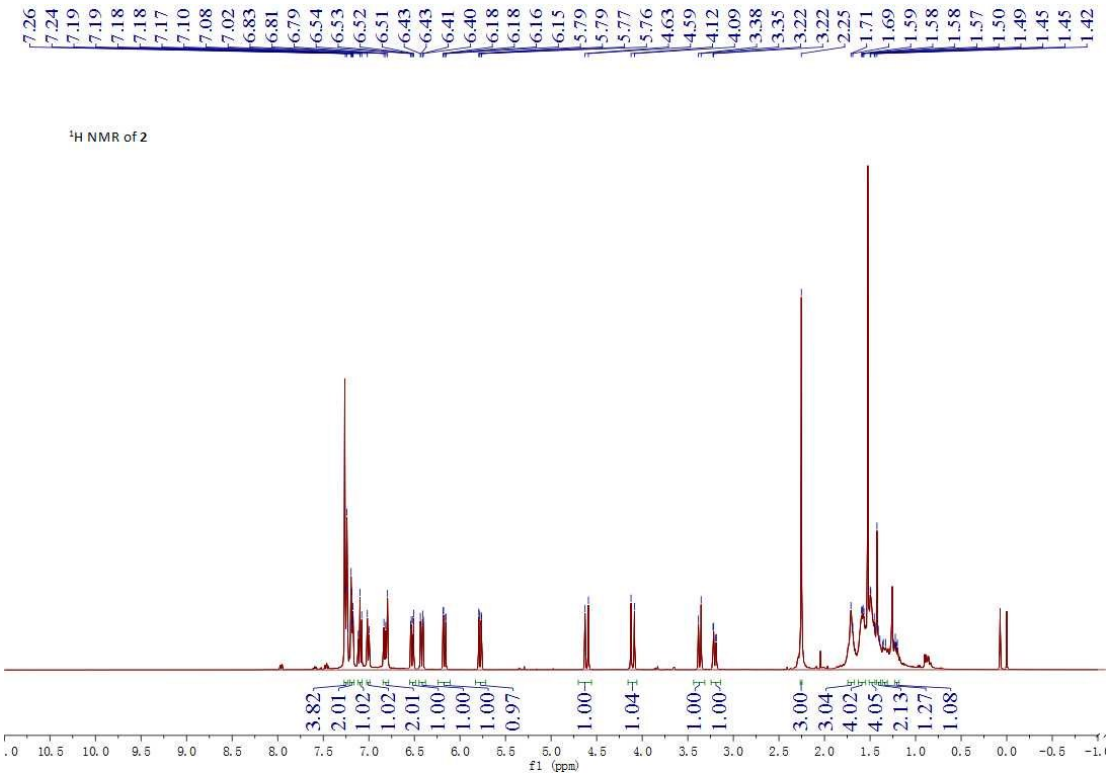
^{1}H NMR of **2**



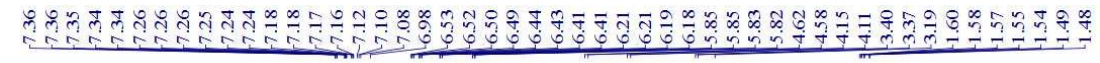
^{13}C NMR of **2 u**



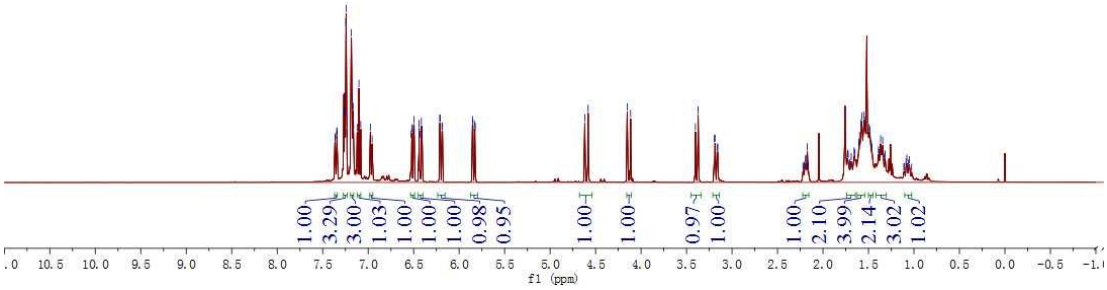
1-benzyl-3-cyclooctyl-4-(m-tolyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2v**)

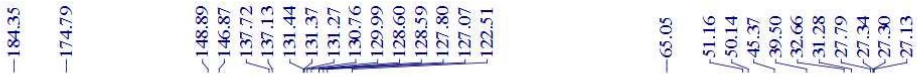


1-benzyl-4-(3-bromophenyl)-3-cycloheptyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2w**)

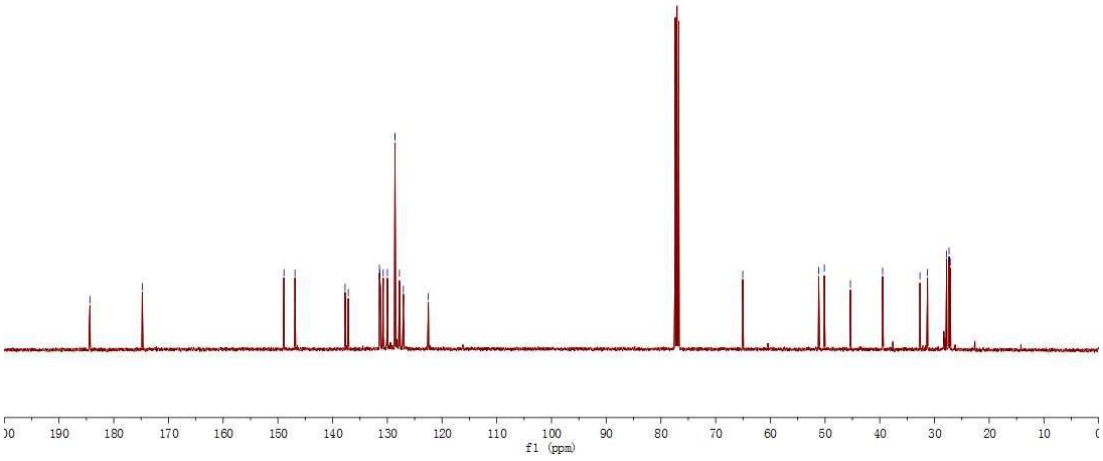


^{1}H NMR of **2w**

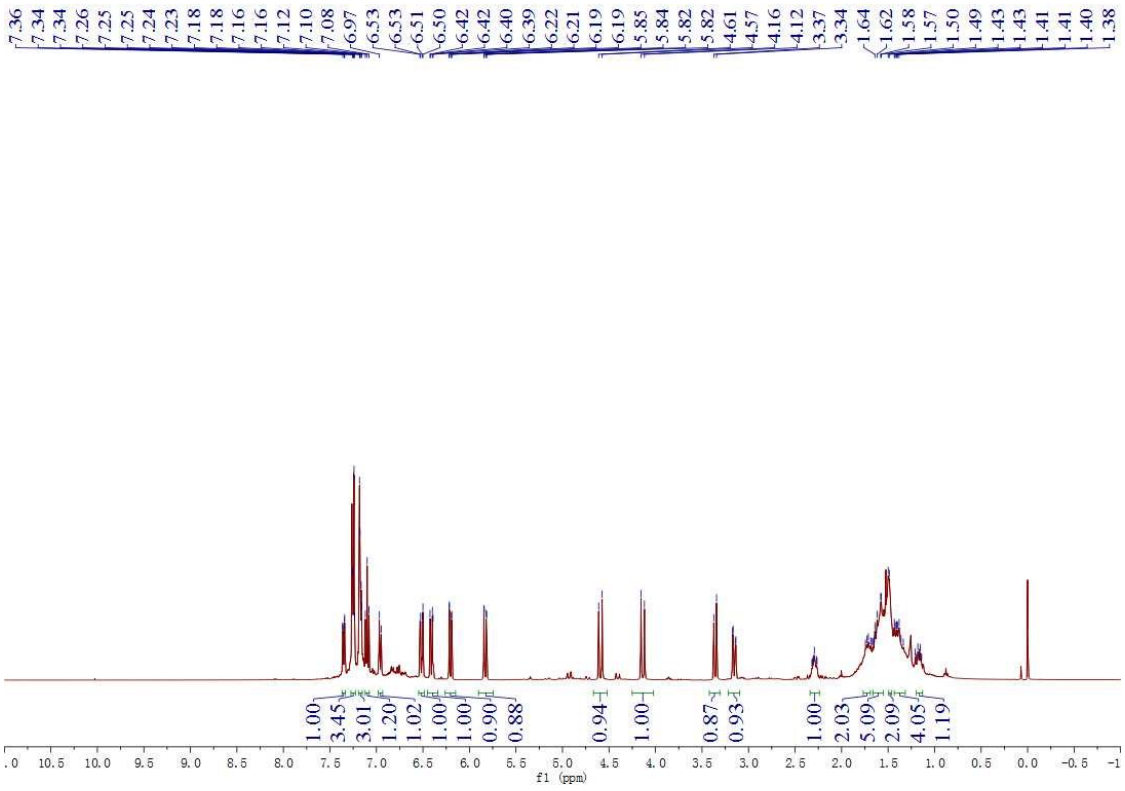


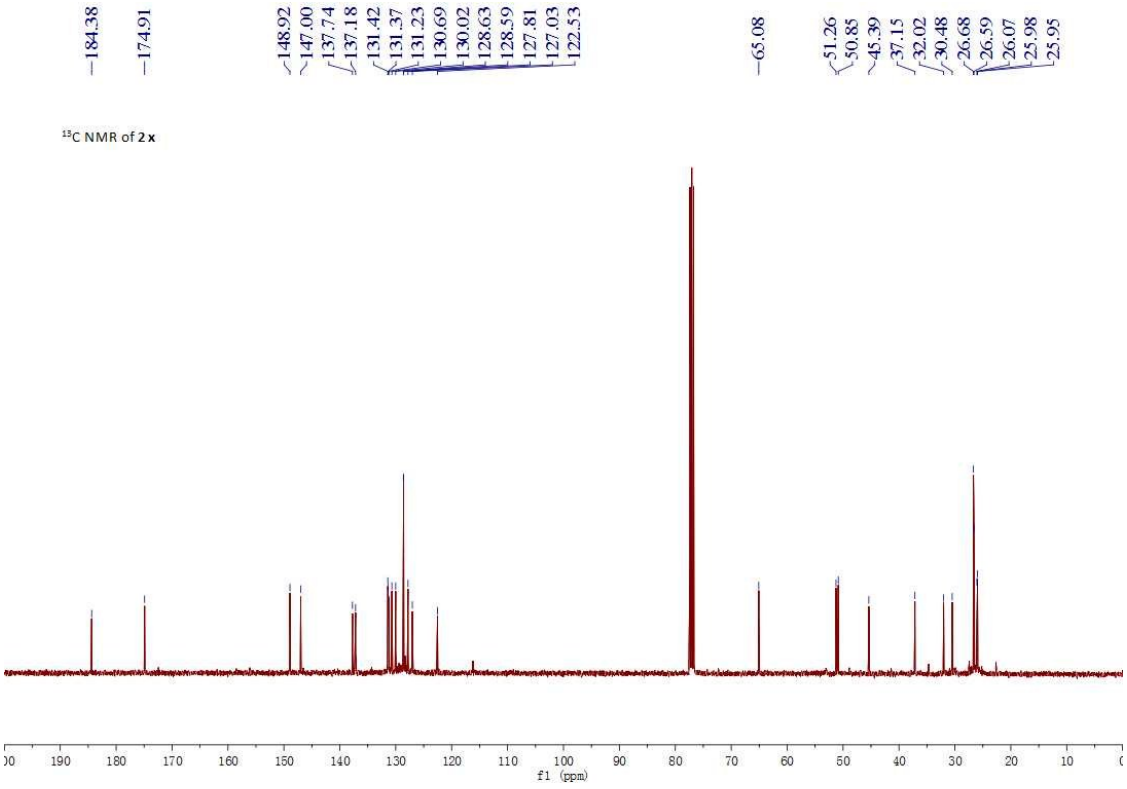


^{13}C NMR of **2w**



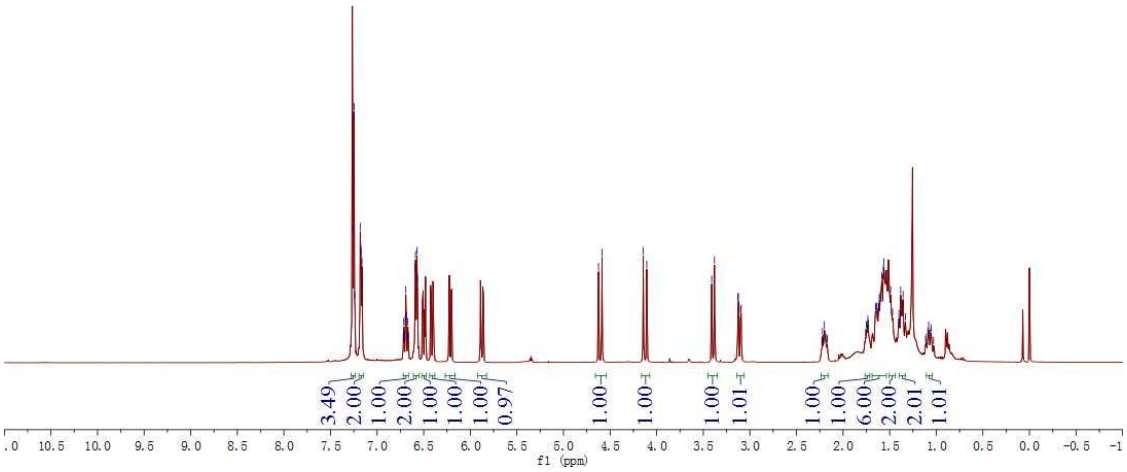
1-benzyl-4-(3-bromophenyl)-3-cyclooctyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2x**)

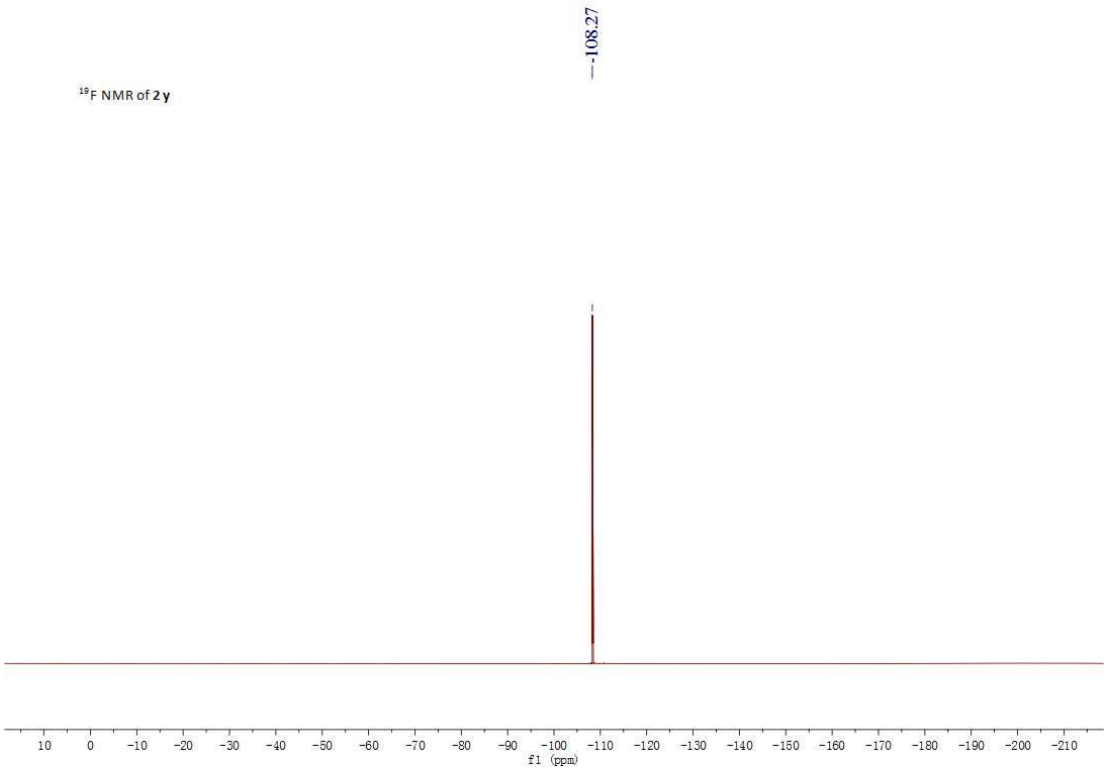




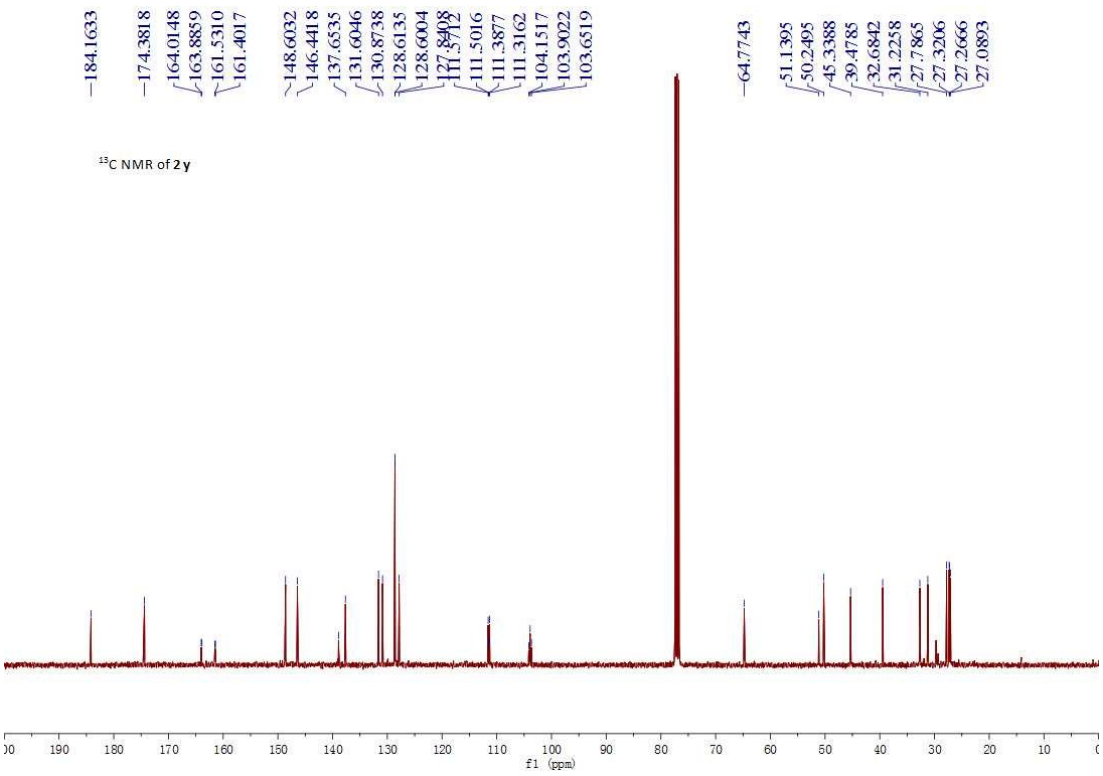
1-benzyl-3-cycloheptyl-4-(3,5-difluorophenyl)-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2y**)

^{1}H NMR of **2y**

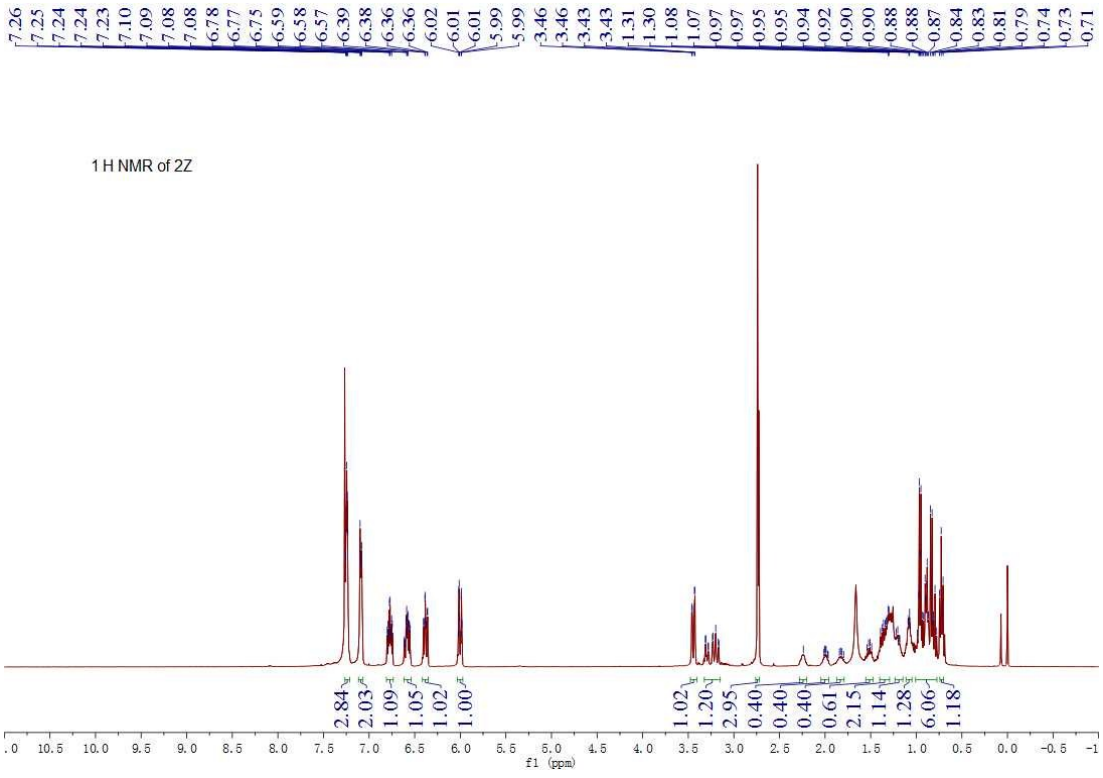


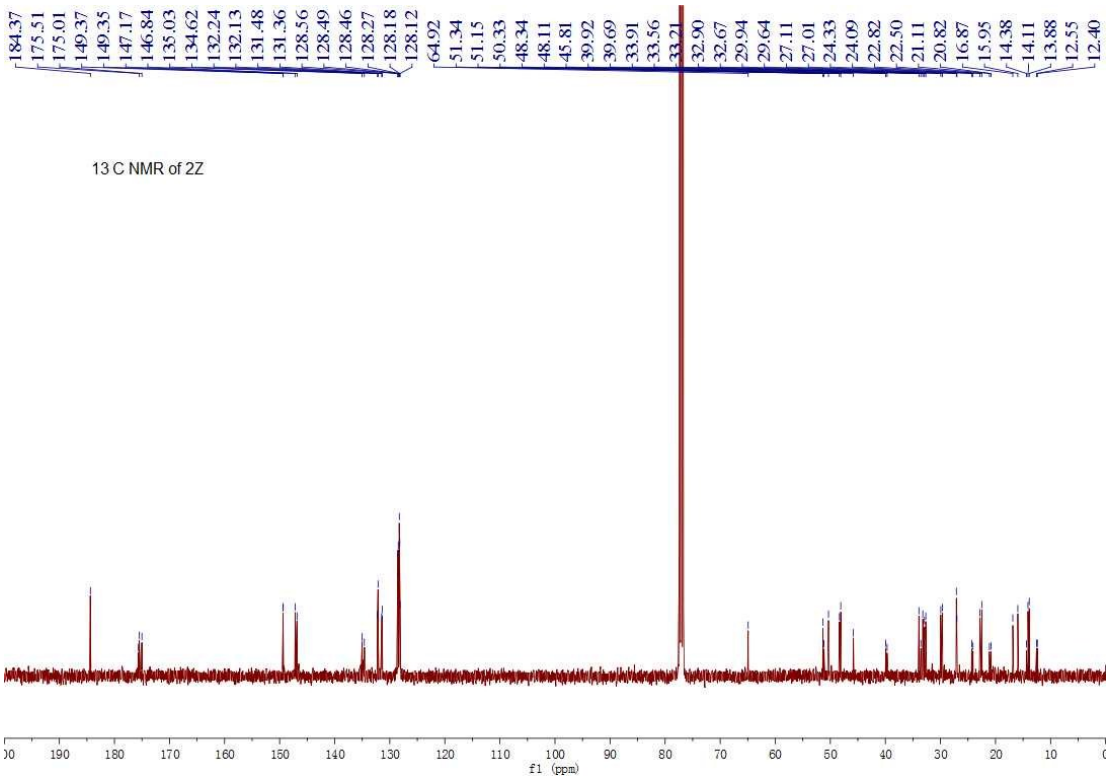


^{19}F NMR of **2y**



3-hexanyl-1-methyl-4-phenyl-1-azaspiro[4.5]deca-6,9-diene-2,8-dione (**2z**)

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175.01
149.37
149.35
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132.24
132.13
131.48
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128.56
128.49
128.46
128.27
128.18
128.12
64.92
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45.81
39.92
39.69
33.91
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29.94
29.64
27.11
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24.33
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21.11
20.82
16.87
15.95
14.38
14.11
13.88
12.55
12.40
13 C NMR of 2Z
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)