Supporting Information

Palladium-catalyzed synthesis of indene-1-acetates via sequential double carbopalladation and aryloxycarbonylation

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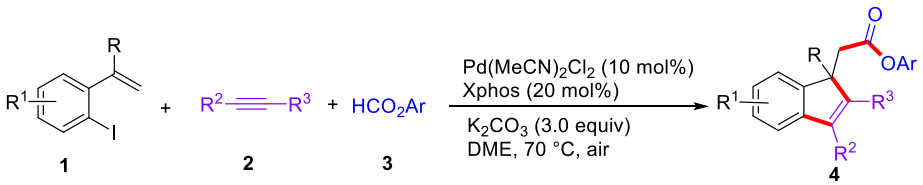
1. General considerations

All reactions were carried out under N_2 atmosphere. Materials were obtained from commercial suppliers or prepared according to standard procedures unless otherwise noted. Solvents were purified and dried according to standard methods prior to use. For product purification by flash column chromatography, silica gel (200~300 mesh) and light petroleum ether (bp. 60~90) are used. ^{1}H NMR spectra were recorded on a Bruker advance III 400 MHz in $CDCl_3$ and $^{13}C\{^1H\}$ NMR spectra were recorded on 101 MHz in $CDCl_3$ using TMS as internal standard. Data for ^{1}H NMR are recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, br = broad singlet, dd = doublet of doublet, dt = triplet of doublets, ddd = doublet of doublet of doublets, coupling constant (s) in Hz, integration). Data for ^{13}C NMR is reported in terms of chemical shift (δ, ppm). High-resolution mass spectral analysis (HRMS) data were measured on a Bruker Apex II.

2. Preparation of substrates

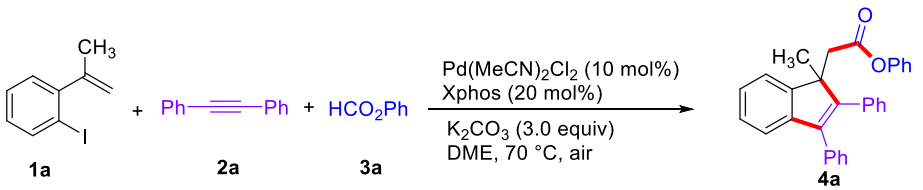
Substrates **1** were synthesized according to the known literature.[1-5] Substrates **2** were prepared from the coresponding ternal alkynes via Sonogashira coupling through the known literatures.[6-8] Substrates **3** were synthesized according to the known literature. [9]

3. Experiment procedure



O-iodostyrenes **1** (0.2 mmol, 1.0 equiv), internal alkynes **2** (0.4 mmol, 2.0 equiv), formates **3** (0.6 mmol, 3.0 equiv), $Pd(MeCN)_2Cl_2$ (10 mol%), xphos (20 mol%), K_2CO_3 (0.6 mmol, 3.0 equiv) were added to a sealed tube, DME (1.0 mL) were added via syringe. The mixture was heated at 70 ℃ in an oil bath about for 12 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **4** or **5**.

4. Scale-up reaction

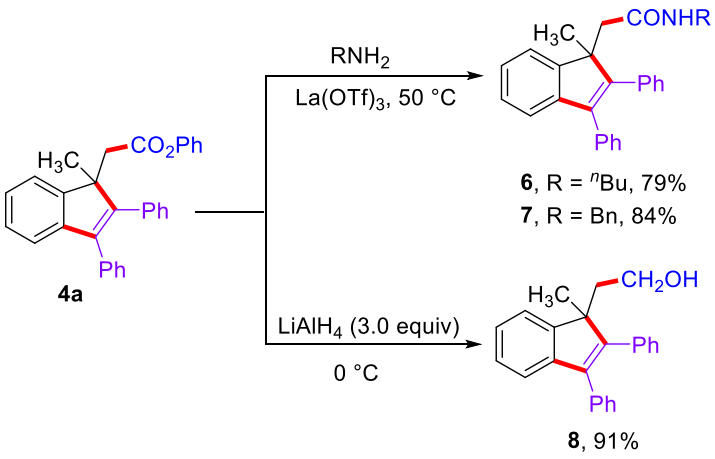


0.86 g, 52% yield

1-iodo-2-(prop-1-en-2-yl)benzene **1a** (4.0 mmol, 976 mg, 1.0 equiv), 1,2-diphenylethyne **2a** (8.0 mmol, 1.424 g, 2.0 equiv), phenyl formate **3a** (12.0 mmol, 1.464 g, 3.0 equiv), $Pd(MeCN)_2Cl_2$ (10 mol%, 103.6 mg), xphos (20 mol%, 381.3 mg), K_2CO_3 (12.0 mmol, 1.656 mg, 3.0 equiv) were added to a sealed tube, DME (20.0 mL) were added via syringe. The mixture was heated at 70 ℃

in an oil bath about for 12 h until completion (monitored by TLC). After cooling at room temperature, the reaction mixture was filtered through celite. The solvent in the filtrate was evaporated under reduced pressure. The residue was purified through silica gel chromatography to afford the products **4a** in 52% yield.

5. Synthetic transformations of 4a

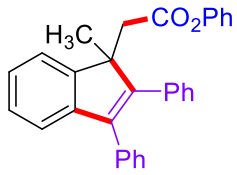


N-butyl-2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetamide (**6**) was synthesized according to the following procedure. To a solution of **4a** (0.2 mmol) in 1 mL $^{n}BuNH_2$ was added $La(OTf)_3$ (6 mg, 5 mol%). The reaction mixture was stirred at 50 ℃ for 4 h. After cooling at room temperature, the mixture was extracted with ethyl acetate, dried with anhydrous sodium sulfate and concentrated under reduced pressure. The residue was purified through silica gel chromatography (petroleum ether/EtOAc = 5:1) to give amide **6** with 79% yield.

N-benzyl-2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetamide (**7**) was synthesized according to the following procedure. To a solution of **4a** (0.2 mmol) in 1 mL $BnNH_2$ was added $La(OTf)_3$ (6 mg, 5 mol%). The reaction mixture was stirred at 50 ℃ for 4 h. After cooling at room temperature, the mixture was extracted with ethyl acetate, dried with anhydrous sodium sulfate and concentrated under reduced pressure. The residue was purified through silica gel chromatography (petroleum ether/EtOAc = 5:1) to give amide **7** with 84% yield.

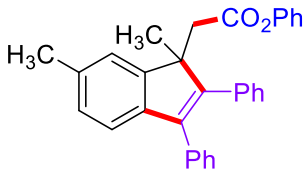
2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)ethan-1-ol (**8**) was synthesized according to the following procedure. To a solution of **4a** (0.2 mmol, 84 mg) in THF (2.0 mL) was added $LiAlH_4$ (0.6 mmol, 22.8 mg, 3.0 equiv) at 0 ℃ under air. Then the reaction mixture was allowed to room temperature, and stirred for 1 h. The reaction mixture was filtered through Celite. The solvent in the filtrate was evaporated under reduced pressure, and the crude product was purified by flash chromatography (petroleum ether/ethyl acetate = 10:1~5:1, v/v) to afford the pure product **8** with 91% yield.

6. Spectra data



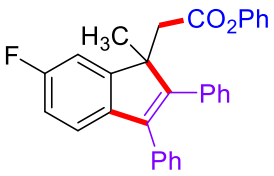
4a

phenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4a***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 51 mg, 61% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52-7.48 (m, 1H), 7.30 (dd, *J* = 6.3, 2.6 Hz, 1H), 7.27-7.12 (m, 14H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.52-6.40 (m, 2H), 2.98 (q, *J* = 13.8 Hz, 2H), 1.50 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 150.5, 150.1, 149.4, 143.7, 140.2, 136.1, 134.8, 130.4, 129.6, 129.4, 128.3, 128.2, 127.4, 127.3, 127.2, 125.80, 125.77, 122.7, 121.5, 121.0, 53.5, 41.7, 24.4. HRMS (ESI-TOF) calcd for $C_{30}H_{25}O_2$ $[M+H]^+$: 417.1849, found: 417.1854.



4b

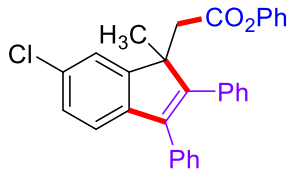
phenyl 2-(1,6-dimethyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4b***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow oil, 46 mg, 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (d, *J* = 1.5 Hz, 1H), 7.32-7.18 (m, 13H), 7.14-7.08 (m, 2H), 6.57 (dd, *J* = 8.0, 1.6 Hz, 2H), 3.08-2.97 (m, 2H), 2.43 (s, 3H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.2, 150.6, 149.7, 149.1, 141.1, 140.0, 136.2, 135.5, 135.0, 130.5, 129.6, 129.4, 128.2, 128.12, 128.05, 127.2, 127.1, 125.7, 123.6, 121.5, 120.7, 53.3, 41.8, 24.5, 21.8. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_2$ $[M+H]^+$: 431.2006, found: 431.2009.



4c

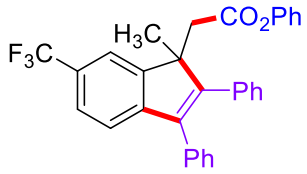
phenyl 2-(6-fluoro-1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4c***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow solid, Mp = 98-100 ℃, 49 mg, 57% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32-7.26 (m, 7H), 7.25-7.21 (m, 7H), 7.15-7.11 (m, 1H), 7.04-6.98 (m, 1H), 6.67-6.60 (m, 2H), 3.09-2.98 (m, 2H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.9, 162.1 (d, *J* = 245.7 Hz), 151.8 (d, *J* = 7.7 Hz), 150.4, 149.7 (d, *J* = 4.1 Hz), 139.5 (d, *J* = 2.3 Hz), 139.4, 135.8, 134.6,

130.4, 129.51, 129.47, 128.33, 128.25, 127.4, 127.3, 125.9, 121.7 (d, *J* = 8.4 Hz), 121.5, 114.0 (d, *J* = 22.5 Hz), 110.5 (d, *J* = 23.5 Hz), 53.4 (d, *J* = 2.1 Hz), 41.6, 24.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -116.43. HRMS (ESI-TOF) calcd for $C_{30}H_{24}FO_2$ $[M+H]^+$: 435.1755, found: 435.1755.



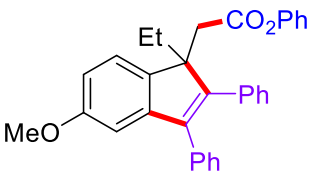
4d

phenyl 2-(6-chloro-1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4d***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow oil, 45 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55-7.54 (m, 1H), 7.27 (q, *J* = 7.2, 6.1 Hz, 8H), 7.22 (d, *J* = 8.0 Hz, 6H), 7.15-7.11 (m, 1H), 6.67-6.64 (m, 2H), 3.03 (q, *J* = 14.2 Hz, 2H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.8, 151.4, 150.40, 150.39, 142.2, 139.5, 135.6, 134.4, 131.7, 130.3, 129.5, 128.4, 128.3, 127.5, 127.4, 125.9, 123.2, 121.9, 121.5, 53.5, 41.5, 24.2. HRMS (ESI-TOF) calcd for $C_{30}H_{24}ClO_2$ $[M+H]^+$: 451.1459, found: 451.1466.



4e

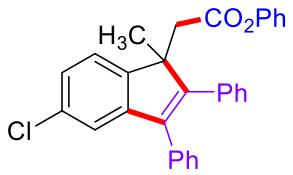
phenyl 2-(1-methyl-2,3-diphenyl-6-(trifluoromethyl)-1H-inden-1-yl)acetate (***4e***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale red oil, 49 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 1.6 Hz, 1H), 7.59 (dd, *J* = 8.1, 1.6 Hz, 1H), 7.44 (d, *J* = 8.0 Hz, 1H), 7.31 (d, *J* = 4.7 Hz, 5H), 7.25-7.21 (m, 7H), 7.15-7.11 (m, 1H), 6.60 (dd, *J* = 7.8, 1.6 Hz, 2H), 3.15 (d, *J* = 14.4 Hz, 1H), 3.04 (d, *J* = 14.3 Hz, 1H), 1.60 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.7, 153.0, 150.3, 150.1, 147.3, 139.6, 135.4, 134.1, 130.1, 129.50, 129.49, 128.4 (d, *J* = 7.7 Hz), 127.7, 127.5, 125.9, 124.9 (d, *J* = 4.0 Hz), 121.4, 121.0, 119.5 (d, *J* = 3.9 Hz), 53.6, 41.3, 24.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.32. HRMS (ESI-TOF) calcd for $C_{31}H_{24}F_3O_2$ $[M+H]^+$: 485.1723, found: 485.1731.



4f

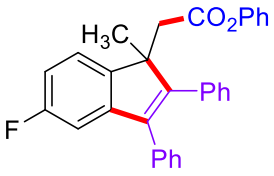
phenyl 2-(1-ethyl-5-methoxy-2,3-diphenyl-1H-inden-1-yl)acetate (***4f***): Purification by column

chromatography on silica gel (petroleum ether/ethyl acetate = 20:1~10:1, v/v) affords the title compound as a pale yellow viscous oil, 53 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (d, *J* = 8.1 Hz, 1H), 7.23-7.11 (m, 12H), 7.05-6.99 (m, 1H), 6.83 (d, *J* = 2.4 Hz, 1H), 6.77 (dd, *J* = 8.2, 2.5 Hz, 1H), 6.53-6.47 (m, 2H), 3.71 (s, 3H), 2.97 (s, 2H), 1.98 (q, *J* = 7.2 Hz, 2H), 0.58 (t, *J* = 7.2 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 159.6, 150.5, 148.5, 146.4, 139.5, 136.2, 130.1, 129.7, 129.4, 128.3, 128.2, 127.3, 127.2, 125.7, 123.1, 121.5, 111.2, 106.8, 57.4, 55.6, 41.7, 30.3, 8.2. HRMS (ESI-TOF) calcd for $C_{32}H_{29}O_3$ $[M+H]^+$: 461.2111, found: 461.2112.



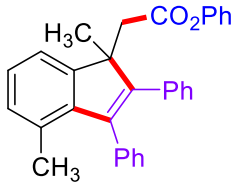
4g

phenyl 2-(5-chloro-1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4g***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale brown oil, 43 mg, 48% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.9 Hz, 1H), 7.33 (d, *J* = 1.7 Hz, 1H), 7.30-7.21 (m, 13H), 7.16-7.12 (m, 1H), 6.64-6.59 (m, 2H), 3.04 (q, *J* = 14.1 Hz, 2H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.9, 151.7, 147.7, 145.6, 135.6, 134.1, 133.4, 130.2, 129.5, 129.5, 128.36, 128.35, 127.6, 127.5, 125.9, 125.6, 123.7, 121.4, 121.2, 53.2, 41.45, 24.3. HRMS (ESI-TOF) calcd for $C_{30}H_{24}ClO_2$ $[M+H]^+$: 451.1459, found: 451.1459.



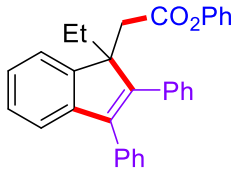
4h

phenyl 2-(5-fluoro-1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4h***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow oil, 48 mg, 55% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (dd, *J* = 8.2, 5.0 Hz, 1H), 7.31-7.20 (m, 12H), 7.15-7.11 (m, 1H), 7.06 (dd, *J* = 9.2, 2.5 Hz, 1H), 6.99 (ddd, *J* = 9.2, 8.2, 2.5 Hz, 1H), 6.63-6.58 (m, 2H), 3.09-2.99 (m, 2H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.0, 163.0 (d, *J* = 244.3 Hz), 152.1, 150.4, 145.8 (d, *J* = 8.8 Hz), 144.7 (d, *J* = 2.5 Hz), 139.5 (d, *J* = 2.9 Hz), 135.7, 134.3, 130.2, 129.5, 129.4, 128.34, 128.31, 127.5, 127.4, 125.9, 123.6 (d, *J* = 9.1 Hz), 121.4, 112.2 (d, *J* = 22.9 Hz), 108.3 (d, *J* = 23.7 Hz), 53.0, 41.6, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.31. HRMS (ESI-TOF) calcd for $C_{30}H_{24}FO_2$ $[M+H]^+$: 435.1755, found: 435.1758.



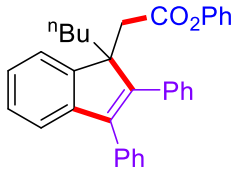
4i

phenyl 2-(1,4-dimethyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4i)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow solid, Mp = 88-90 ℃, 51 mg, 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 7.4 Hz, 1H), 7.27-7.10 (m, 14H), 7.04 (d, *J* = 7.5 Hz, 1H), 6.59-6.52 (m, 2H), 3.00 (q, *J* = 13.8 Hz, 2H), 1.87 (s, 3H), 1.54 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 151.1, 150.6, 149.5, 137.7, 135.9, 132.1, 130.4, 130.3, 130.2, 129.5, 129.4, 127.9, 127.8, 127.7, 127.0, 126.8, 125.8, 125.6, 121.6, 120.4, 52.8, 41.7, 24.4, 20.2. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_2$ $[M+H]^+$: 431.2006, found: 431.2006.



4j

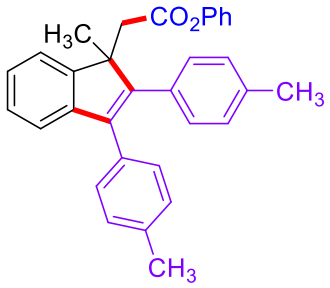
phenyl 2-(1-ethyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4j)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow solid, Mp = 89-91 ℃, 43 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (dd, *J* = 5.6, 2.9 Hz, 1H), 7.37-7.34 (m, 1H), 7.33-7.29 (m, 4H), 7.26-7.17 (m, 10H), 7.11-7.06 (m, 1H), 6.50 (dd, *J* = 7.5, 1.7 Hz, 2H), 3.08 (d, *J* = 2.9 Hz, 2H), 2.09 (m, 2H), 0.65 (t, *J* = 7.3 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.0, 150.5, 147.5, 147.2, 145.1, 142.3, 136.2, 135.1, 130.2, 129.7, 129.4, 128.3, 128.2, 127.3, 127.3, 127.1, 125.8, 125.7, 122.6, 121.5, 120.8, 58.1, 41.6, 30.2, 8.2. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_2$ $[M+H]^+$: 431.2006, found: 431.2014.



4k

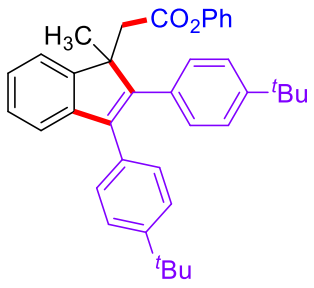
phenyl 2-(1-butyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4k)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow viscous oil, 44 mg, 48% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52-7.49 (m, 1H), 7.37-7.34 (m, 1H), 7.32-7.27 (m, 5H), 7.24-7.17 (m, 9H), 7.09 (d, *J* = 7.4 Hz, 1H), 6.50 (dd, *J* = 7.8, 1.8 Hz, 2H), 3.11-3.03 (m, 2H), 2.07-2.01 (m, 2H), 1.22 (dd, *J* = 6.9, 4.7 Hz, 4H), 0.80 (d, *J* = 7.0 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.0, 150.5, 147.9, 147.6, 144.8, 142.0, 136.2, 130.2, 129.7, 129.3, 128.3, 128.2, 127.26, 127.25, 127.1, 125.73, 125.69, 122.6, 121.5,

120.8, 57.6, 41.8, 37.1, 25.6, 22.9, 14.1. HRMS (ESI-TOF) calcd for $C_{33}H_{31}O_2$ $[M+H]^+$: 459.2319, found: 459.2322.



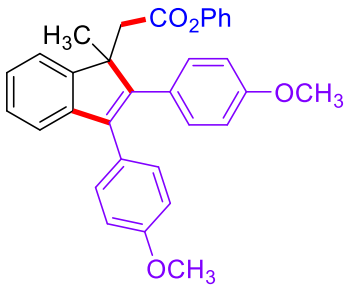
4l

phenyl 2-(1-methyl-2,3-di-p-tolyl-1H-inden-1-yl)acetate ***(4l)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale brown oil, 40 mg, 45% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.53 (m, 1H), 7.39-7.35 (m, 1H), 7.32-7.27 (m, 2H), 7.21 (m, 4H), 7.15-7.07 (m, 5H), 7.03 (d, *J* = 7.8 Hz, 2H), 6.53 (dd, *J* = 7.8, 1.7 Hz, 2H), 3.13-2.93 (m, 2H), 2.30 (d, *J* = 14.3 Hz, 6H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.2, 150.5, 149.8, 149.5, 144.0, 136.8, 136.6, 133.1, 132.0, 130.2, 129.5, 129.4, 129.0, 128.9, 127.3, 125.7, 125.6, 122.7, 121.5, 120.9, 53.4, 41.8, 24.4, 21.4. HRMS (ESI-TOF) calcd for $C_{32}H_{29}O_2$ $[M+H]^+$: 445.2162, found: 445.2163.



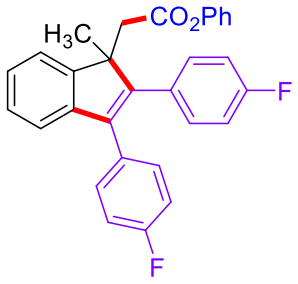
4m

phenyl 2-(2,3-bis(4-(tert-butyl)phenyl)-1-methyl-1H-inden-1-yl)acetate ***(4m)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a brown solid, Mp = 130-132 ℃, 67 mg, 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.53 (m, 1H), 7.42-7.39 (m, 1H), 7.32-7.28 (m, 4H), 7.25-7.21 (m, 5H), 7.21-7.15 (m, 3H), 7.13-7.08 (m, 1H), 6.58-6.52 (m, 2H), 3.08-2.94 (m, 2H), 1.57 (s, 3H), 1.30 (s, 9H), 1.27 (s, 9H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.3, 149.8, 149.7, 149.6, 144.0, 133.1, 131.9, 130.0, 129.4, 129.2, 127.3, 125.7, 125.5, 125.04, 124.97, 122.6, 121.6, 121.1, 53.5, 41.8, 34.6, 31.5, 31.4, 24.4. HRMS (ESI-TOF) calcd for $C_{38}H_{41}O_2$ $[M+H]^+$: 529.3101, found: 529.3102.



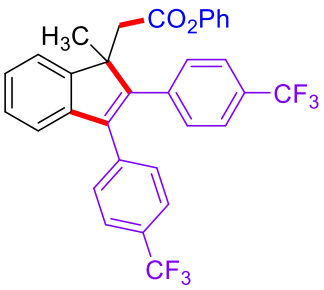
4n

*phenyl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (**4n**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a brown viscous oil, 54 mg, 57% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.52 (m, 1H), 7.37 (dd, *J* = 7.1, 1.7 Hz, 1H), 7.29 (ddd, *J* = 6.1, 3.8, 1.5 Hz, 2H), 7.26-7.23 (m, 2H), 7.17 (dt, *J* = 8.6, 3.1 Hz, 4H), 7.09 (d, *J* = 7.5 Hz, 1H), 6.82 (d, *J* = 8.7 Hz, 2H), 6.76 (d, *J* = 6.9 Hz, 2H), 6.55-6.49 (m, 2H), 3.75 (s, 3H), 3.72 (s, 3H), 3.03 (q, *J* = 13.6 Hz, 2H), 1.55 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.2, 158.7, 158.5, 149.4, 149.1, 139.4, 131.5, 130.8, 129.6, 129.3, 128.4, 127.3, 125.7, 125.6, 122.6, 121.5, 120.8, 115.4, 113.7, 113.6, 55.18, 55.17, 53.4, 41.8, 24.4. HRMS (ESI-TOF) calcd for $C_{32}H_{29}O_4$ $[M+H]^+$: 477.2060, found: 477.2060.



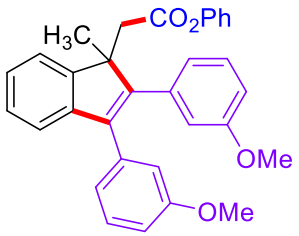
4o

*phenyl 2-(2,3-bis(4-fluorophenyl)-1-methyl-1H-inden-1-yl)acetate (**4o**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow oil, 49 mg, 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52-7.47 (m, 1H), 7.28-7.18 (m, 5H), 7.15-7.07 (m, 4H), 7.02 (t, *J* = 7.4 Hz, 1H), 6.90 (t, *J* = 8.5 Hz, 2H), 6.83 (t, *J* = 8.6 Hz, 2H), 6.39 (d, *J* = 7.8 Hz, 2H), 3.01 (d, *J* = 13.6 Hz, 1H), 2.90 (d, *J* = 13.6 Hz, 1H), 1.46 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.9, 162.1 (dd, *J* = 247.7, 25.6 Hz), 150.4, 149.1 (d, *J* = 3.0 Hz), 143.4, 139.8, 132.1 (d, *J* = 8.1 Hz), 131.7 (d, *J* = 3.4 Hz), 131.2 (d, *J* = 8.0 Hz), 130.6 (d, *J* = 3.2 Hz), 129.4, 127.6, 126.1, 125.9, 122.8, 121.4, 120.8, 115.5, 115.4, 115.3, 115.2, 53.5, 41.7, 24.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.49, -114.52. HRMS (ESI-TOF) calcd for $C_{30}H_{23}F_2O_2$ $[M+H]^+$: 453.1661, found: 453.1666.



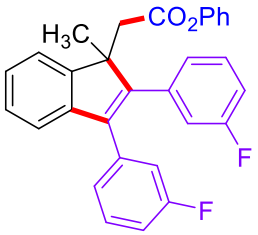
4p

*phenyl 2-(1-methyl-2,3-bis(4-(trifluoromethyl)phenyl)-1H-inden-1-yl)acetate (**4p**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a brown solid, Mp = 120-122 ℃, 49 mg, 44% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64-7.56 (m, 3H), 7.48 (dd, *J* = 14.4, 8.0 Hz, 4H), 7.39-7.35 (m, 2H), 7.34-7.30 (m, 3H), 7.25-7.19 (m, 2H), 7.12 (t, *J* = 7.5 Hz, 1H), 6.46 (dd, *J* = 7.9, 1.6 Hz, 2H), 3.14 (d, *J* = 13.7 Hz, 1H), 3.00 (d, *J* = 13.7 Hz, 1H), 1.58 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.8, 150.3, 149.6, 149.1, 142.8, 140.2, 139.5, 138.1 (d, *J* = 1.7 Hz), 130.7, 129.8, 129.7 (dd, *J* = 32.9, 23.2 Hz), 129.5, 127.8, 126.6, 126.0, 125.5 (t, *J* = 3.4 Hz), 122.9, 121.4, 121.0, 54.0, 41.7, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.53 (d, *J* = 5.4 Hz). HRMS (ESI-TOF) calcd for $C_{32}H_{23}F_6O_2$ $[M+H]^+$: 553.1597, found: 553.1599.



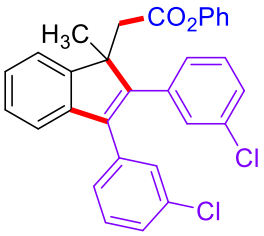
4q

*phenyl 2-(2,3-bis(3-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (**4q**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 20:1~10:1, v/v) affords the title compound as a yellow viscous oil, 55 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50-7.44 (m, 1H), 7.34-7.30 (m, 1H), 7.25-7.19 (m, 2H), 7.11 (q, *J* = 3.7 Hz, 2H), 7.07-6.99 (m, 2H), 6.85-6.81 (m, 2H), 6.79-6.76 (m, 1H), 6.72-6.68 (m, 2H), 6.64 (td, *J* = 6.2, 4.9, 1.9 Hz, 2H), 6.43 (dd, *J* = 7.9, 1.6 Hz, 2H), 3.58 (s, 3H), 3.49 (s, 3H), 2.98 (d, *J* = 3.4 Hz, 2H), 1.48 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 159.4, 159.3, 150.4, 149.9, 149.3, 143.5, 140.0, 137.4, 136.1, 129.6, 129.4, 129.24, 129.17, 127.4, 125.84, 125.76, 122.7, 122.0, 121.4, 121.0, 116.0, 115.4, 114.5, 113.4, 112.9, 55.2, 55.1, 53.5, 41.7, 24.5. HRMS (ESI-TOF) calcd for $C_{32}H_{29}O_4$ $[M+H]^+$: 477.2060, found: 477.2062.



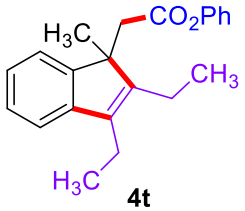
4r

phenyl 2-(2,3-bis(3-fluorophenyl)-1-methyl-1H-inden-1-yl)acetate (***4r***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 41 mg, 46% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (ddd, *J* = 4.6, 3.1, 1.7 Hz, 1H), 7.35 (q, *J* = 2.6 Hz, 3H), 7.28-7.16 (m, 4H), 7.14-7.06 (m, 3H), 7.01-6.87 (m, 4H), 6.49 (dd, *J* = 8.1, 1.6 Hz, 2H), 3.11 (d, *J* = 13.8 Hz, 1H), 3.01 (d, *J* = 13.8 Hz, 1H), 1.55 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.8, 162.9 (dd, *J* = 247.1, 4.1 Hz), 150.4, 149.3 (d, *J* = 2.0 Hz), 149.1, 143.0, 139.8 (d, *J* = 2.1 Hz), 137.9 (d, *J* = 8.1 Hz), 136.7 (d, *J* = 8.0 Hz), 129.9 (t, *J* = 8.9 Hz), 129.5, 127.7, 126.3, 126.2 (d, *J* = 3.0 Hz), 125.9, 125.3 (d, *J* = 3.0 Hz), 122.8, 121.4, 121.0, 117.2 (d, *J* = 21.5 Hz), 116.3 (d, *J* = 21.8 Hz), 114.5 (d, *J* = 20.9 Hz), 53.7, 41.6, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -112.80, -113.22. HRMS (ESI-TOF) calcd for $C_{30}H_{23}F_2O_2$ $[M+H]^+$: 453.1661, found: 453.1670.



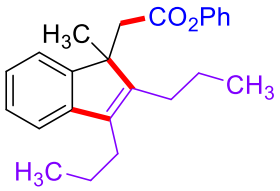
4s

phenyl 2-(2,3-bis(3-chlorophenyl)-1-methyl-1H-inden-1-yl)acetate (***4s***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale brown viscous oil, 43 mg, 44% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.55 (m, 1H), 7.39-7.32 (m, 4H), 7.26-7.09 (m, 9H), 7.05 (m, 1H), 6.53-6.43 (m, 2H), 3.11 (d, *J* = 13.8 Hz, 1H), 3.00 (d, *J* = 13.8 Hz, 1H), 1.55 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.8, 150.3, 149.2, 149.0, 139.8, 137.5, 136.3, 134.3, 134.1, 130.0, 129.71, 129.68, 129.5, 129.3, 128.8, 127.89, 127.87, 127.69, 127.67, 126.3, 125.9, 122.8, 121.4, 121.0, 53.7, 41.6, 24.4. HRMS (ESI-TOF) calcd for $C_{30}H_{23}Cl_2O_2$ $[M+H]^+$: 485.1070, found: 485.1071.



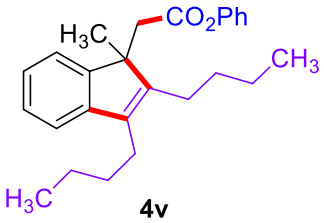
4t

phenyl 2-(2,3-diethyl-1-methyl-1H-inden-1-yl)acetate ***(4t)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a brown oil, 44 mg, 68% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.31 (m, 1H), 7.19 (d, *J* = 5.9 Hz, 2H), 7.15-7.08 (m, 3H), 7.03-6.98 (m, 1H), 6.52-6.45 (m, 2H), 2.95 (d, *J* = 13.2 Hz, 1H), 2.77 (d, *J* = 13.1 Hz, 1H), 2.41 (m, 3H), 2.28 (dd, *J* = 14.6, 7.3 Hz, 1H), 1.34 (s, 3H), 1.11 (t, *J* = 7.7 Hz, 3H), 1.05 (t, *J* = 7.6 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 150.5, 149.5, 149.1, 144.3, 138.7, 129.2, 127.1, 125.6, 124.5, 122.1, 121.5, 118.7, 52.4, 42.2, 23.8, 18.8, 18.5, 14.8, 13.7. HRMS (ESI-TOF) calcd for $C_{22}H_{25}O_2$ $[M+H]^+$: 321.1849, found: 321.1853.



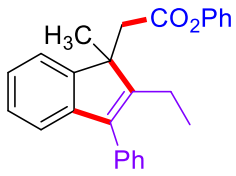
4u

phenyl 2-(1-methyl-2,3-dipropyl-1H-inden-1-yl)acetate ***(4u)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a brown oil, 47 mg, 67% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 7.3 Hz, 1H), 7.19-7.10 (m, 5H), 7.02 (dt, *J* = 7.3, 1.2 Hz, 1H), 6.49 (dd, *J* = 7.7, 1.5 Hz, 2H), 2.97 (d, *J* = 13.3 Hz, 1H), 2.77 (d, *J* = 13.3 Hz, 1H), 2.41-2.37 (m, 2H), 2.35-2.29 (m, 1H), 2.24 (dt, *J* = 8.3, 6.6 Hz, 1H), 1.54-1.46 (m, 4H), 1.35 (s, 3H), 0.95 (t, *J* = 7.3 Hz, 3H), 0.87 (t, *J* = 7.3 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.2, 150.5, 149.6, 148.4, 144.6, 137.3, 129.3, 127.0, 125.6, 124.5, 122.1, 121.5, 118.9, 52.4, 42.3, 28.2, 28.0, 24.0, 23.4, 22.2, 15.2, 14.6. HRMS (ESI-TOF) calcd for $C_{24}H_{29}O_2$ $[M+H]^+$: 349.2162, found: 349.2166.



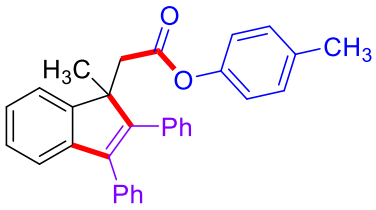
4v

phenyl 2-(2,3-dibutyl-1-methyl-1H-inden-1-yl)acetate ***(4v)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a brown oil, 45 mg, 60% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 7.3 Hz, 1H), 7.27-7.16 (m, 5H), 7.09 (t, *J* = 7.4 Hz, 1H), 6.56 (dd, *J* = 7.7, 1.6 Hz, 2H), 3.04 (d, *J* = 13.3 Hz, 1H), 2.84 (d, *J* = 13.3 Hz, 1H), 2.50-2.38 (m, 3H), 2.35-2.29 (m, 1H), 1.55-1.35 (m, 11H), 0.97 (t, *J* = 7.2 Hz, 3H), 0.88 (t, *J* = 7.3 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 150.5, 149.6, 148.3, 144.6, 137.4, 129.2, 127.0, 125.6, 124.4, 122.0, 121.5, 118.9, 52.4, 42.3, 32.3, 31.1, 25.7, 25.6, 24.0, 23.8, 23.12, 14.1. HRMS (ESI-TOF) calcd for $C_{26}H_{33}O_2$ $[M+H]^+$: 377.2475, found: 377.2475.



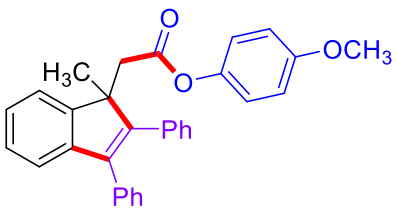
4w

phenyl 2-(2-ethyl-1-methyl-3-phenyl-1H-inden-1-yl)acetate (***4w***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 31 mg, 42% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53-7.50 (m, 1H), 7.43-7.34 (m, 7H), 7.27 (dd, *J* = 7.3, 1.5 Hz, 1H), 7.23-7.19 (m, 2H), 7.12-7.08 (m, 1H), 6.52-6.48 (m, 2H), 2.97 (d, *J* = 13.6 Hz, 1H), 2.84 (d, *J* = 13.6 Hz, 1H), 2.36 (m, 2H), 1.47 (s, 3H), 1.05 (t, *J* = 7.5 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.2, 150.5, 149.5, 148.3, 143.8, 141.0, 136.3, 130.1, 129.3, 128.4, 127.4, 127.3, 125.7, 125.3, 122.7, 121.5, 119.8, 53.0, 41.5, 24.1, 19.3, 14.0. HRMS (ESI-TOF) calcd for $C_{26}H_{25}O_2$ $[M+H]^+$: 369.1849, found: 369.1844.



4x

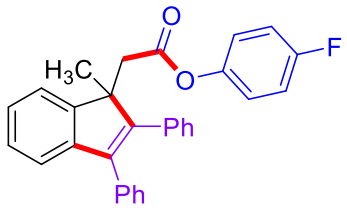
p-tolyl-2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4x***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale brown solid, Mp = 98-99 ℃, 43 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58-7.55 (m, 1H), 7.38-7.35 (m, 1H), 7.33-7.28 (m, 5H), 7.26-7.17 (m, 7H), 7.00 (d, *J* = 8.2 Hz, 2H), 6.41 (d, *J* = 8.4 Hz, 2H), 3.03 (q, *J* = 13.7 Hz, 2H), 2.25 (s, 3H), 1.57 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.3, 150.2, 149.4, 148.2, 143.7, 140.1, 136.1, 135.4, 134.9, 130.4, 129.9, 129.6, 128.2, 128.1, 127.4, 127.3, 127.1, 125.8, 122.8, 121.2, 120.9, 53.5, 41.7, 24.4, 20.9. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_2$ $[M+H]^+$: 431.2006, found: 431.2009.



4y

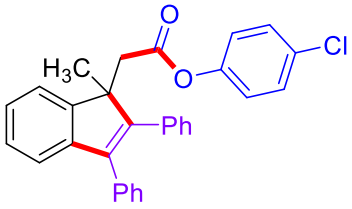
4-methoxyphenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4y***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 46 mg, 52% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58-7.55 (m, 1H), 7.39-7.36 (m, 1H), 7.34-7.29 (m, 5H), 7.26-7.18 (m, 7H), 6.72 (d, *J* = 9.0 Hz, 2H), 6.44 (d, *J*

= 9.0 Hz, 2H), 3.70 (s, 3H), 3.09-2.98 (m, 2H), 1.56 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 169.5, 157.2, 150.2, 149.4, 143.9, 143.7, 136.1, 130.4, 129.6, 128.2, 128.1, 127.4, 127.3, 127.1, 125.8, 122.8, 122.2, 120.9, 114.4, 55.6, 53.5, 41.7, 24.4. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_3$ $[M+H]^+$: 447.1955, found: 447.1958.



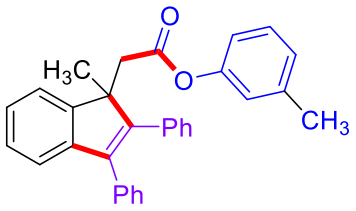
4z

4-fluorophenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4z)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow solid, Mp = 95-97 ℃, 41mg, 47% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.54 (m, 1H), 7.39-7.36 (m, 1H), 7.31 (m, 5H), 7.27-7.19 (m, 7H), 6.88 (dd, *J* = 9.6, 7.6 Hz, 2H), 6.47-6.42 (m, 2H), 3.09-3.00 (m, 2H), 1.56 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 169.1, 160.2 (d, *J* = 244.9 Hz), 150.0, 149.3, 146.2 (d, *J* = 3.0 Hz), 143.7, 140.2, 136.0, 134.7, 130.4, 129.6, 128.2 (d, *J* = 9.1 Hz), 127.46, 127.35, 127.2, 125.8, 122.9, 122.8, 122.7, 121.0, 116.0 (d, *J* = 23.5 Hz), 53.5, 41.6, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -117.16. HRMS (ESI-TOF) calcd for $C_{30}H_{24}FO_2$ $[M+H]^+$: 435.1755, found: 435.1757.



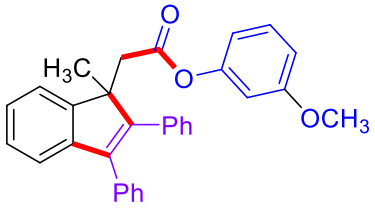
4aa

4-chlorophenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4aa)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow solid, Mp = 109-111 ℃, 52 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56-7.53 (m, 1H), 7.39-7.36 (m, 1H), 7.31 (dt, *J* = 4.7, 2.0 Hz, 5H), 7.26-7.20 (m, 6H), 7.15 (d, *J* = 8.8 Hz, 3H), 6.42 (d, *J* = 8.8 Hz, 2H), 3.09-3.00 (m, 2H), 1.56 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 168.8, 149.9, 149.2, 148.9, 143.7, 135.9, 134.7, 131.1, 130.3, 129.5, 129.4, 128.3, 128.2, 127.5, 127.4, 127.2, 125.8, 122.9, 122.7, 121.0, 53.5, 41.7, 24.3. HRMS (ESI-TOF) calcd for $C_{30}H_{24}ClO_2$ $[M+H]^+$: 451.1459, found: 451.1459.



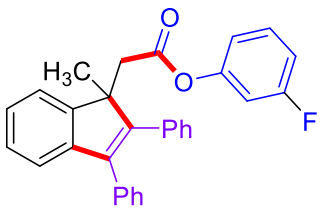
4ab

*m-tolyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (**4ab**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 45 mg, 53% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59-7.56 (m, 1H), 7.39-7.36 (m, 1H), 7.32 (tq, *J* = 5.1, 2.2 Hz, 5H), 7.27-7.19 (m, 7H), 7.09 (t, *J* = 7.7 Hz, 1H), 6.91 (d, *J* = 7.6 Hz, 1H), 6.35-6.30 (m, 2H), 3.04 (q, *J* = 13.8 Hz, 2H), 2.22 (s, 3H), 1.57 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.2, 150.4, 150.1, 149.4, 143.8, 140.1, 139.5, 136.1, 134.8, 130.4, 129.6, 129.1, 128.3, 128.1, 127.4, 127.3, 127.1, 126.6, 125.8, 122.8, 122.1, 121.0, 118.4, 53.5, 41.7, 24.4, 21.3. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_2$ $[M+H]^+$: 431.2006, found: 431.2007.



4ac

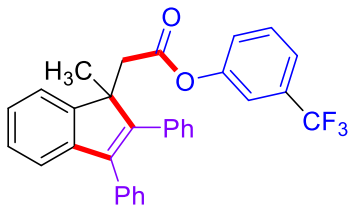
*3-methoxyphenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (**4ac**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 45 mg, 51% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (dd, *J* = 5.7, 3.0 Hz, 1H), 7.29 (dd, *J* = 5.5, 3.4 Hz, 1H), 7.23 (dt, *J* = 12.2, 7.7 Hz, 5H), 7.18-7.08 (m, 7H), 7.02 (t, *J* = 8.2 Hz, 1H), 6.57 (dd, *J* = 8.5, 2.4 Hz, 1H), 6.11 (dd, *J* = 8.1, 2.1 Hz, 1H), 5.87 (t, *J* = 2.4 Hz, 1H), 3.53 (s, 3H), 3.02-2.92 (m, 2H), 1.48 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.0, 160.4, 151.4, 150.1, 149.3, 143.8, 136.0, 134.8, 130.4, 129.7, 129.6, 128.24, 128.15, 127.4, 127.3, 127.2, 125.8, 122.8, 120.9, 113.7, 112.1, 107.1, 55.5, 53.6, 41.7, 24.4. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_3$ $[M+H]^+$: 447.1955, found: 447.1953.



4ad

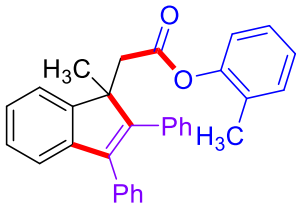
*3-fluorophenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (**4ad**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title

compound as a pale yellow oil, 54 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49-7.46 (m, 1H), 7.32-7.29 (m, 1H), 7.27-7.21 (m, 5H), 7.19-7.06 (m, 8H), 6.74 (dt, *J* = 8.3, 2.5 Hz, 1H), 6.26-6.13 (m, 2H), 3.02-2.92 (m, 2H), 1.49 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.7, 162.8 (d, *J* = 248.3 Hz), 151.3 (d, *J* = 10.9 Hz), 149.9, 149.2, 143.7, 140.3, 136.0, 134.7, 130.4, 130.1 (d, *J* = 9.3 Hz), 129.6, 128.3, 128.2, 127.5, 127.4, 127.2, 125.8, 122.7, 121.0, 117.3 (d, *J* = 3.3 Hz), 112.8 (d, *J* = 21.1 Hz), 109.6 (d, *J* = 24.4 Hz), 53.5, 41.7, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.92. HRMS (ESI-TOF) calcd for $C_{30}H_{24}FO_2$ $[M+H]^+$: 435.1755, found: 435.1760.



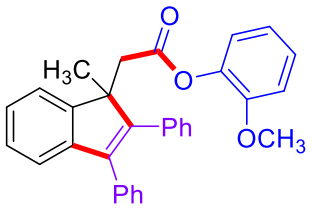
4ae

3-(trifluoromethyl)phenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4ae)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 37 mg, 38% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58-7.55 (m, 1H), 7.42-7.22 (m, 15H), 6.68 (d, *J* = 6.5 Hz, 2H), 3.12-3.03 (m, 2H), 1.60 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.7, 150.5, 149.8, 149.2, 143.7, 140.4, 135.9, 134.7, 131.9 (d, *J* = 33.0 Hz), 130.4, 129.9, 129.5, 128.8, 128.3, 128.2, 127.6, 127.4, 127.2, 125.9, 125.2, 122.8, 122.6 (dd, *J* = 7.6, 3.8 Hz), 121.1, 119.0 (d, *J* = 7.7, 3.9 Hz), 53.6, 41.7, 24.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.66. HRMS (ESI-TOF) calcd for $C_{31}H_{24}F_3O_2$ $[M+H]^+$: 485.1723, found: 485.1726.



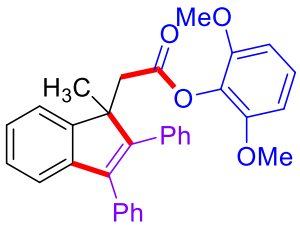
4af

o-tolyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate ***(4af)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 48 mg, 56% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60-7.56 (m, 1H), 7.39-7.34 (m, 2H), 7.31 (ddd, *J* = 8.7, 3.4, 1.9 Hz, 4H), 7.27-7.19 (m, 7H), 7.10-7.07 (m, 1H), 7.05-7.01 (m, 2H), 6.38-6.33 (m, 1H), 3.18-3.04 (m, 2H), 1.80 (s, 3H), 1.57 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.7, 150.1, 149.5, 143.9, 136.1, 134.9, 131.0, 130.4, 130.3, 129.6, 128.2, 128.2, 127.4, 127.3, 127.1, 126.9, 126.0, 125.8, 122.6, 121.7, 121.1, 53.4, 41.4, 24.8, 16.0. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_2$ $[M+H]^+$: 431.2006, found: 431.2006.



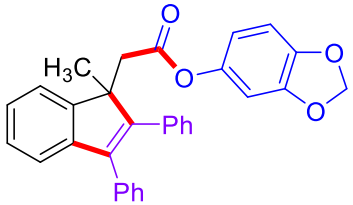
4ag

2-methoxyphenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4ag***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a pale yellow oil, 44 mg, 50% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62-7.58 (m, 1H), 7.38-7.35 (m, 1H), 7.33-7.18 (m, 12H), 7.11-7.05 (m, 1H), 6.85 (dd, *J* = 8.3, 1.4 Hz, 1H), 6.76 (dt, *J* = 7.7, 1.4 Hz, 1H), 6.37 (dd, *J* = 7.9, 1.6 Hz, 1H), 3.68 (s, 3H), 3.17-2.98 (m, 2H), 1.57 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.5, 151.2, 149.6, 143.7, 139.9, 136.1, 134.9, 130.4, 129.6, 128.2, 128.1, 127.2, 127.1, 126.8, 125.7, 122.8, 122.7, 120.8, 120.7, 112.3, 55.7, 53.3, 41.2, 24.1. HRMS (ESI-TOF) calcd for $C_{31}H_{27}O_3$ $[M+H]^+$: 447.1955, found: 447.1956.



4ah

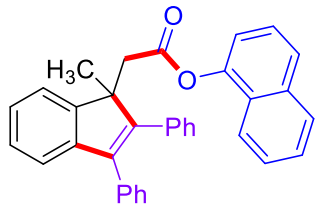
2,6-dimethoxyphenyl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4ah***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 20:1~10:1, v/v) affords the title compound as a pale yellow oil, 39 mg, 41% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (dd, *J* = 5.5, 3.1 Hz, 1H), 7.35 (dd, *J* = 5.6, 3.2 Hz, 1H), 7.30-7.18 (m, 12H), 7.05 (t, *J* = 8.4 Hz, 1H), 6.52 (d, *J* = 8.4 Hz, 2H), 3.67 (s, 6H), 3.18 (d, *J* = 15.0 Hz, 1H), 2.91 (d, *J* = 15.0 Hz, 1H), 1.61 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.5, 152.4, 150.7, 150.0, 136.2, 135.0, 130.4, 129.6, 128.2, 128.1, 127.2, 127.0, 126.2, 125.6, 122.9, 120.7, 104.8, 56.0, 52.9, 40.8, 23.7. HRMS (ESI-TOF) calcd for $C_{32}H_{29}O_4$ $[M+H]^+$: 477.2060, found: 477.2062.



4ai

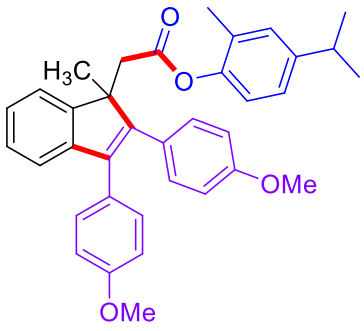
benzo[d][1,3]dioxol-5-yl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4ai***): Purification by

column chromatography on silica gel (petroleum ether/ethyl acetate = 20:1~10:1, v/v) affords the title compound as a pale yellow oil, 49 mg, 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.53 (m, 1H), 7.40-7.36 (m, 1H), 7.34-7.28 (m, 5H), 7.26-7.18 (m, 7H), 6.60 (d, *J* = 8.4 Hz, 1H), 5.99 (ddd, *J* = 8.4, 2.4, 1.1 Hz, 1H), 5.94 (t, *J* = 1.7 Hz, 1H), 5.86 (s, 2H), 3.08-2.97 (m, 2H), 1.56 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.4, 150.0, 149.3, 147.9, 145.3, 144.7, 143.7, 136.0, 134.8, 130.4, 129.6, 128.24, 128.15, 127.4, 127.3, 127.2, 125.8, 122.7, 121.0, 113.8, 107.9, 103.6, 101.6, 53.5, 41.6, 24.4. HRMS (ESI-TOF) calcd for $C_{31}H_{25}O_4$ $[M+H]^+$: 461.1747, found: 461.1749.



4aj

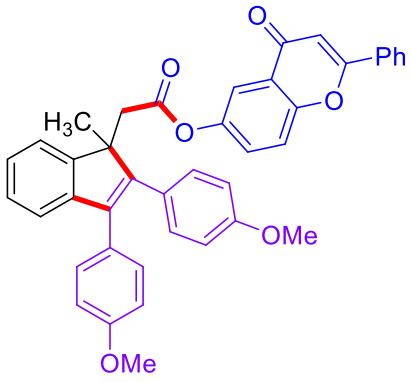
naphthalen-1-yl 2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetate (***4aj***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~10:1, v/v) affords the title compound as a yellow solid, Mp = 131-132 ℃, 43 mg, 46% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.2 Hz, 1H), 7.67-7.59 (m, 2H), 7.44-7.34 (m, 6H), 7.31-7.15 (m, 10H), 7.08 (d, *J* = 8.5 Hz, 1H), 6.64 (d, *J* = 7.5 Hz, 1H), 3.30 (d, *J* = 14.1 Hz, 1H), 3.19 (d, *J* = 14.1 Hz, 1H), 1.62 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.1, 150.1, 136.1, 134.8, 134.6, 130.5, 129.6, 128.3, 128.1, 127.9, 127.6, 127.3, 127.1, 126.4, 126.04, 125.98, 125.4, 122.7, 121.5, 121.2, 117.9, 53.5, 41.6, 24.9. HRMS (ESI-TOF) calcd for $C_{34}H_{27}O_2$ $[M+H]^+$: 467.2006, found: 467.2009.



5a

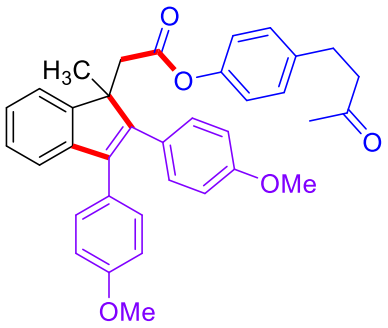
4-isopropyl-2-methylphenyl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (***5a***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1~5:1, v/v) affords the title compound as a pale yellow oil, 52 mg, 49% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 6.6, 1.8 Hz, 1H), 7.38-7.36 (m, 1H), 7.32-7.26 (m, 4H), 7.17 (d, *J* = 8.7 Hz, 2H), 6.98 (d, *J* = 7.8 Hz, 1H), 6.88 (dd, *J* = 7.8, 1.8 Hz, 1H), 6.85-6.81 (m, 2H), 6.78-6.73 (m, 2H), 6.09 (d, *J* = 1.8 Hz, 1H), 3.78 (s, 3H), 3.75 (s, 3H), 3.14-3.02 (m, 2H), 2.71 (m, 1H), 1.77 (s, 3H),

1.55 (s, 3H), 1.10 (d, *J* = 6.9 Hz, 6H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 168.8, 158.5, 149.5, 149.2, 148.0, 144.2, 131.6, 130.8, 130.7, 128.5, 127.4, 125.6, 124.2, 122.7, 120.8, 119.5, 113.7, 113.6, 55.2, 53.4, 41.6, 33.6, 24.9, 24.0, 23.9, 15.6. HRMS (ESI-TOF) calcd for $C_{36}H_{37}O_4$ $[M+H]^+$: 533.2686, found: 533.2688.



5b

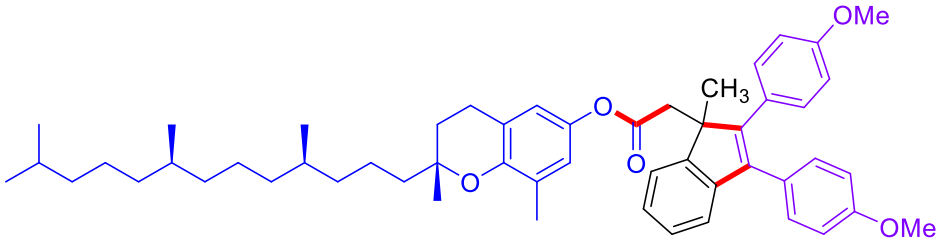
*4-oxo-2-phenyl-4H-chromen-6-yl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (**5b**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a pale red oil, 77 mg, 62% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91-7.85 (m, 2H), 7.59-7.49 (m, 5H), 7.43-7.32 (m, 4H), 7.26-7.22 (m, 2H), 7.21-7.14 (m, 2H), 6.89-6.83 (m, 2H), 6.78 (d, *J* = 8.9 Hz, 3H), 6.65 (dd, *J* = 9.0, 2.8 Hz, 1H), 3.80 (s, 3H), 3.75 (s, 3H), 3.14-2.97 (m, 2H), 1.59 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 177.8, 169.0, 163.6, 158.8, 158.6, 153.7, 149.3, 148.9, 139.6, 131.8, 131.7, 131.5, 130.7, 129.2, 127.9, 127.5, 126.4, 125.7, 122.6, 120.9, 119.4, 117.6, 113.8, 113.7, 107.2, 55.3, 55.2, 53.4, 41.7, 24.4. HRMS (ESI-TOF) calcd for $C_{41}H_{33}O_6$ $[M+H]^+$: 621.2272, found: 621.2273.



5c

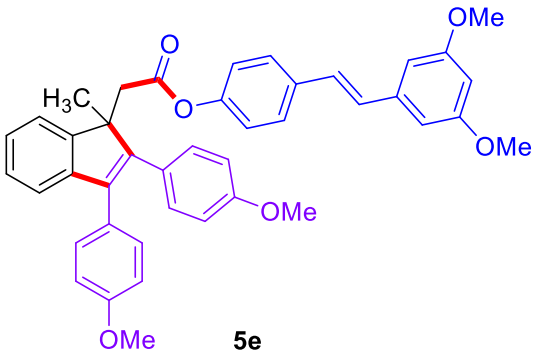
*4-(3-oxobutyl)phenyl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (**5c**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a pale red oil, 63 mg, 58% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (dd, *J* = 7.0, 1.6 Hz, 1H), 7.39-7.36 (m, 1H), 7.29 (ddd, *J* = 6.5, 4.6, 1.5 Hz, 2H), 7.26-7.22 (m, 2H), 7.20-7.14 (m, 2H), 7.01 (d, *J* = 8.5 Hz, 2H), 6.82 (d, *J* = 8.7 Hz, 2H), 6.77 (d, *J* = 8.7 Hz,

2H), 6.42 (d, *J* = 8.5 Hz, 2H), 3.75 (d, *J* = 10.5 Hz, 6H), 3.02 (q, *J* = 13.6 Hz, 2H), 2.77 (d, *J* = 7.3 Hz, 2H), 2.67 (q, *J* = 6.5 Hz, 2H), 2.09 (s, 3H), 1.54 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 208.1, 169.3, 158.6, 158.4, 149.3, 149.1, 148.7, 138.4, 131.5, 130.7, 129.2, 128.3, 127.3, 127.2, 125.5, 122.6, 121.4, 120.7, 113.7, 113.6, 55.2, 55.1, 53.3, 45.1, 41.7, 30.1, 29.0, 24.4. HRMS (ESI-TOF) calcd for $C_{36}H_{35}O_5$ $[M+H]^+$: 547.2479, found: 547.2477.



5d

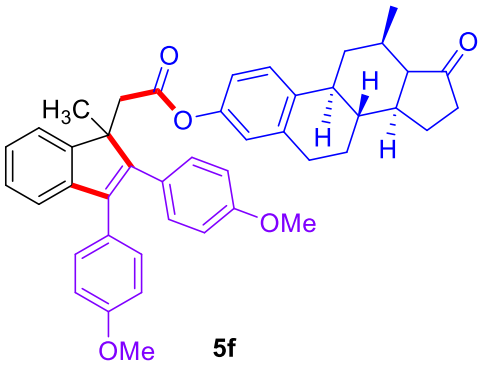
(R)-2,8-dimethyl-2-((4R,8R)-4,8,12-trimethyltridecyl)chroman-6-yl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (***5d***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a pale yellow oil, 69 mg, 44% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56-7.52 (m, 1H), 7.39-7.35 (m, 1H), 7.33-7.28 (m, 2H), 7.26-7.23 (m, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 6.83 (d, *J* = 8.3 Hz, 2H), 6.77 (d, *J* = 8.3 Hz, 2H), 6.07 (dt, *J* = 11.1, 3.1 Hz, 2H), 3.77 (d, *J* = 9.3 Hz, 6H), 3.05-2.90 (m, 2H), 2.57 (t, *J* = 5.9 Hz, 2H), 2.01 (s, 3H), 1.56-1.46 (m, 6H), 1.32-1.19 (m, 18H), 1.15-1.11 (m, 2H), 1.08-1.03 (m, 3H), 0.85 (dd, *J* = 10.6, 6.6 Hz, 12H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 170.0, 158.7, 158.5, 149.3, 131.6, 130.8, 128.5, 127.2, 125.6, 122.8, 121.1, 120.8, 120.7, 119.0, 113.7, 113.6, 76.1, 55.2, 53.4, 41.8, 40.3, 39.5, 37.6, 37.54, 37.53, 37.4, 32.9, 32.8, 28.1, 24.9, 24.6, 24.4, 24.4, 24.3, 22.9, 22.8, 22.4, 21.1, 19.9, 19.8, 16.2. HRMS (ESI-TOF) calcd for $C_{53}H_{69}O_5$ $[M+H]^+$: 785.5140, found: 785.5143.



5e

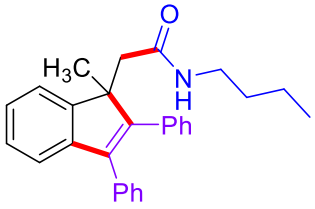
(E)-4-(3,5-dimethoxystyryl)phenyl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (***5e***): Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a pale yellow oil, 80 mg, 63% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.53 (m, 1H), 7.41-7.28 (m, 5H), 7.27-7.22 (m, 2H), 7.21-7.14 (m, 2H), 7.00-6.87 (m, 2H), 6.85-6.80 (m, 2H), 6.80-6.75 (m, 2H), 6.61 (d, *J* = 2.2 Hz, 2H), 6.57-6.43 (m, 2H), 6.37 (t, *J* = 2.2 Hz, 1H), 3.79 (s, 6H), 3.77 (s, 3H), 3.74 (s, 3H), 3.03 (q, *J* = 13.6 Hz, 2H),

1.55 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 169.1, 161.0, 158.7, 158.5, 150.0, 149.4, 149.1, 143.9, 139.3, 134.8, 131.5, 130.7, 128.8, 128.3, 128.3, 127.4, 127.33, 127.27, 125.6, 122.7, 121.7, 120.8, 113.7, 113.6, 104.6, 100.1, 55.4, 55.20, 55.18, 53.4, 41.8, 24.4. HRMS (ESI-TOF) calcd for $C_{42}H_{39}O_6$ $[M+H]^+$: 639.2741, found: 639.2745.



5f

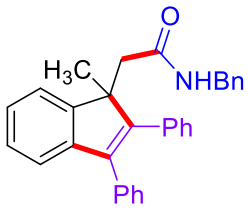
*(8S,9S,12R,14S)-12-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl 2-(2,3-bis(4-methoxyphenyl)-1-methyl-1H-inden-1-yl)acetate (**5f**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a brown oil, 79 mg, 61% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (dd, *J* = 6.2, 2.1 Hz, 1H), 7.39-7.35 (m, 1H), 7.30 (m, 2H), 7.26-7.22 (m, 2H), 7.21-7.14 (m, 2H), 7.12 (d, *J* = 8.5 Hz, 1H), 6.87-6.80 (m, 2H), 6.77 (d, *J* = 8.4 Hz, 2H), 6.30 (dt, *J* = 8.5, 3.1 Hz, 1H), 6.22 (t, *J* = 2.8 Hz, 1H), 3.77 (d, *J* = 9.5 Hz, 6H), 3.13-2.89 (m, 2H), 2.84-2.67 (m, 2H), 2.48 (dd, *J* = 18.9, 8.6 Hz, 1H), 2.37-2.26 (m, 1H), 2.24-1.90 (m, 5H), 1.59-1.31 (m, 9H), 0.87 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 169.5, 158.7, 158.5, 149.5, 149.2, 148.4, 144.0, 139.4, 137.9, 137.2, 131.6, 130.8, 128.4, 127.31, 127.25, 126.3, 125.6, 122.7, 121.6, 120.7, 118.7, 113.7, 113.6, 55.21, 53.4, 50.4, 48.0, 44.2, 41.8, 38.0, 36.0, 31.6, 29.3, 26.4, 25.8, 24.4, 21.7, 13.9. HRMS (ESI-TOF) calcd for $C_{44}H_{45}O_5$ $[M+H]^+$: 653.3262, found: 653.3262.



6

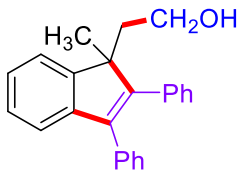
*N-butyl-2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetamide (**6**)*: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a pale yellow solid, Mp = 122-124 ℃, 62 mg, 79% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (dd, *J* = 5.5, 3.1 Hz, 1H), 7.41 (dd, *J* = 5.5, 3.2 Hz, 1H), 7.35-7.18 (m, 12H), 4.92 (t, *J* = 5.7 Hz, 1H), 3.01 (dt, *J* = 13.1, 6.6 Hz, 1H), 2.94-2.72 (m, 3H), 1.42 (s, 3H), 1.11-0.90 (m, 4H), 0.69 (t, *J* = 7.0 Hz, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 169.9, 151.0, 150.2, 143.5, 139.7, 135.7, 134.6, 130.1, 129.5, 128.27, 128.25, 127.5, 127.31, 127.27, 126.1, 121.9, 121.3, 53.4,

44.2, 38.9, 31.3, 24.9, 19.8, 13.7. HRMS (ESI-TOF) calcd for $C_{28}H_{30}NO$ $[M+H]^+$: 396.2322, found: 396.2323.



7

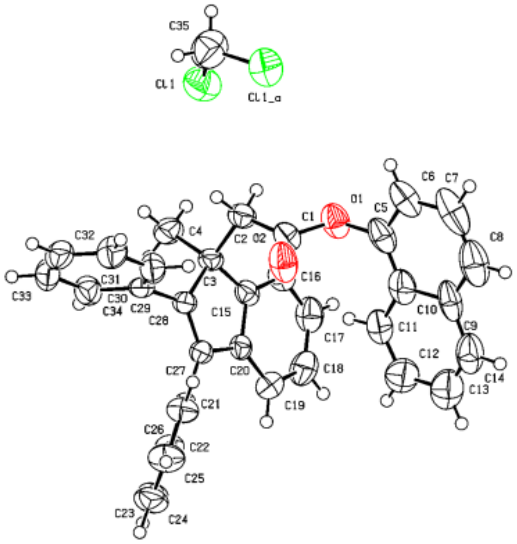
N-benzyl-2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)acetamide ***(7)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a colourless solid, Mp = 124-126 ℃, 72 mg, 84% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47-7.41 (m, 1H), 7.28-7.18 (m, 11H), 7.14-7.02 (m, 5H), 6.85-6.78 (m, 2H), 5.29 (s, 1H), 4.18 (dd, *J* = 14.6, 5.8 Hz, 1H), 4.05 (dd, *J* = 14.6, 5.3 Hz, 1H), 2.87 (q, *J* = 14.9 Hz, 2H), 1.44 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.8, 150.7, 150.0, 143.3, 139.9, 137.7, 135.7, 134.4, 130.1, 129.5, 128.5, 128.3, 128.2, 127.7, 127.5, 127.3, 127.2, 127.2, 126.2, 121.9, 121.5, 53.4, 44.0, 43.5, 25.0. HRMS (ESI-TOF) calcd for $C_{31}H_{28}NO$ $[M+H]^+$: 430.2165, found: 430.2166.



8

2-(1-methyl-2,3-diphenyl-1H-inden-1-yl)ethan-1-ol ***(8)***: Purification by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1~5:1, v/v) affords the title compound as a pale yellow oil, 59 mg, 91% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 (dd, *J* = 5.5, 3.1 Hz, 1H), 7.36 (dd, *J* = 5.5, 3.2 Hz, 1H), 7.30-7.14 (m, 12H), 3.42 (dt, *J* = 10.8, 7.0 Hz, 1H), 3.21 (dt, *J* = 10.8, 7.1 Hz, 1H), 2.22 (t, *J* = 7.2 Hz, 2H), 1.44 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 151.0, 150.6, 143.4, 139.8, 136.3, 135.0, 129.8, 129.6, 128.28, 128.26, 127.2, 127.0, 125.8, 121.9, 121.0, 59.8, 53.9, 40.3, 24.9. HRMS (ESI-TOF) calcd for $C_{24}H_{23}O$ $[M+H]^+$: 327.1743, found: 327.1743.

7. Crystallographic data of 4aj



Structure of 4aj CCDC: 2368290

Datablock:

Bond precision:	C-C = 0.0064 A		Wavelength = 0.71073
Cell:	a = 24.585(4)	b=9.4237(15)	c=23.169(4)
	alpha=990	beta=96.207(3)	gamma=90
Temperature:	296 K		
	Calculated		Reported
Volume	5336.4(15)		5336.3(15)
Space group	C 2/c		C 2/c
Hall group	-C 2yc		-C 2yc
Moiety formula	2(C34 H26 O2), C H2 Cl2		
Sum formula	C69 H54 Cl2 O4		C69 H54 Cl2 N0 O4
Mr	1018.02		1018.02
Dx,g cm-3	1.267		1.267
Z	4		4
Mu (mm-1)	0.173		0.173
F000	2136.0		2136.0
F000’	2138.03		
h,k,lmax	32,12,30		132,12,30
Nref	6212		6068
Tmin,Tmax			
Tmin’			

Correction method = Not given

Data completeness = 0.977	Theta (max) = 27.617
R (reflections) = 0.0905(3549)	wR2 (reflections) = 0.2357(6068)
S = 1.170	Npar = 340

8. Reference

(1) Tripathi, C. B.; Mukherjee, S. *Angew. Chem. Int. Ed.* **2013**, *52*, 8450.

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(5) Lou, Z.; Zhang, S.; Chen, C.; Pang, X.; Li, M.; Wen, L. *Adv. Synth. Catal.* **2014**, *356*, 153.

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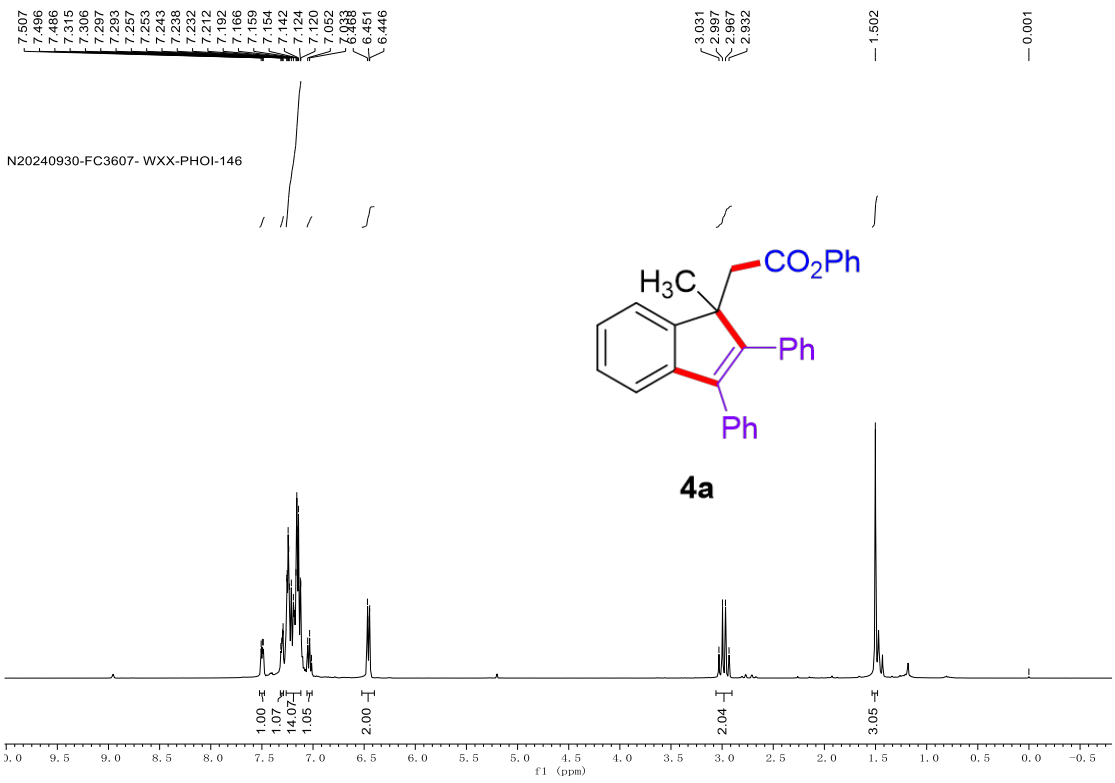
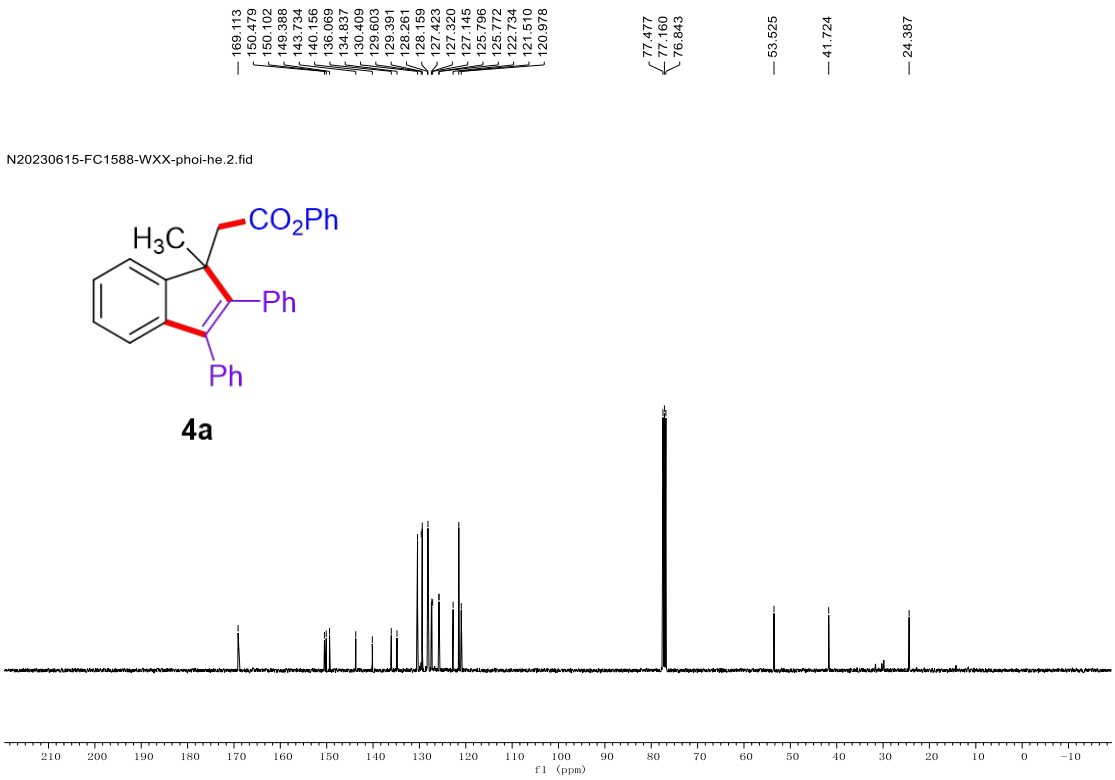
(9) Ueda, T.; Konishi, H.; Manabe, K. *Org. Lett.* **2012**, *14*, 5370.

9. NMR spectra

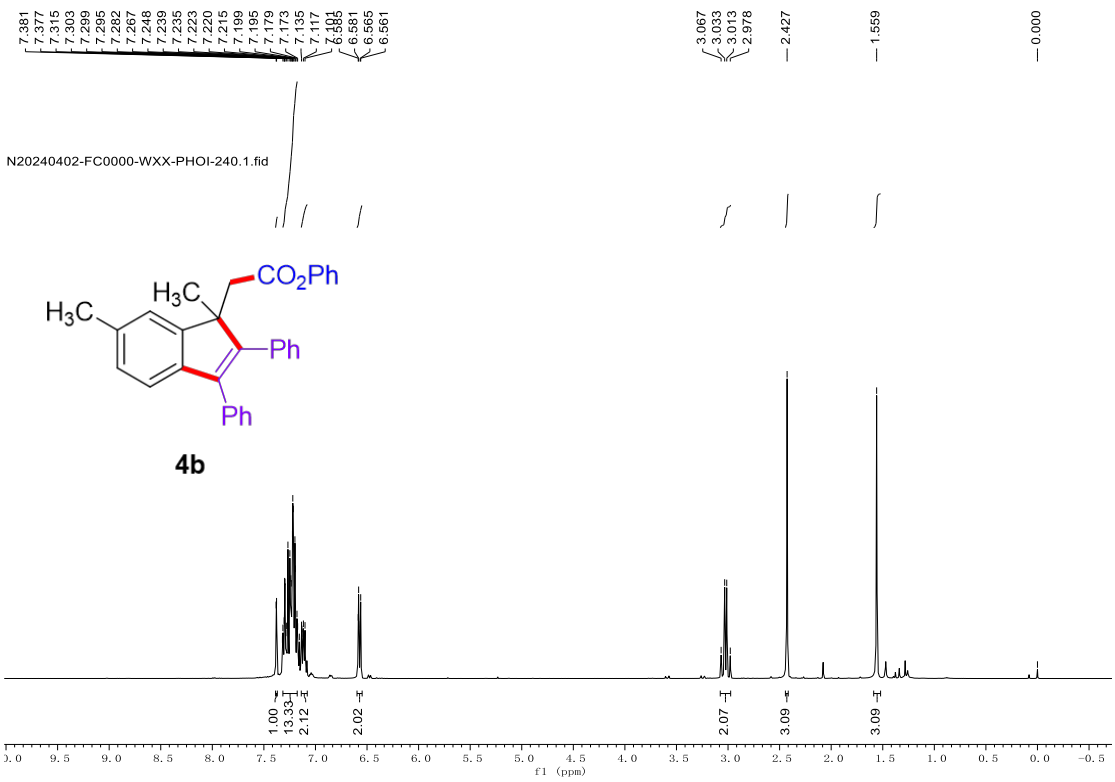
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4a**



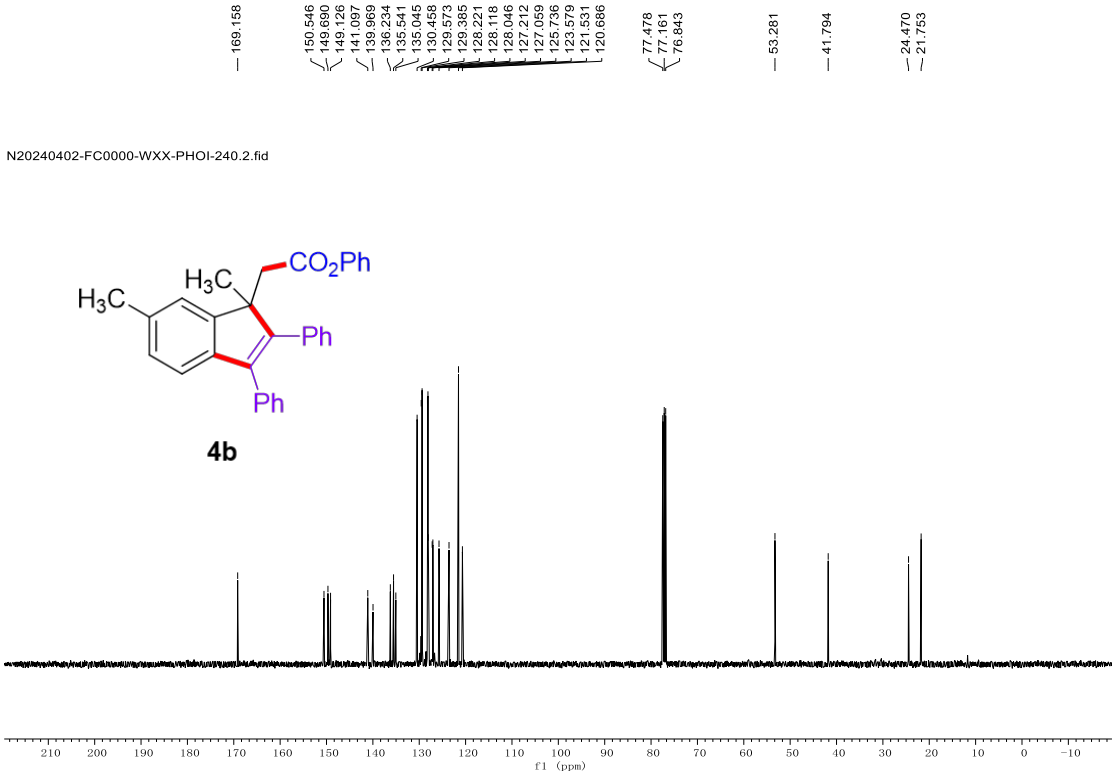
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4a**



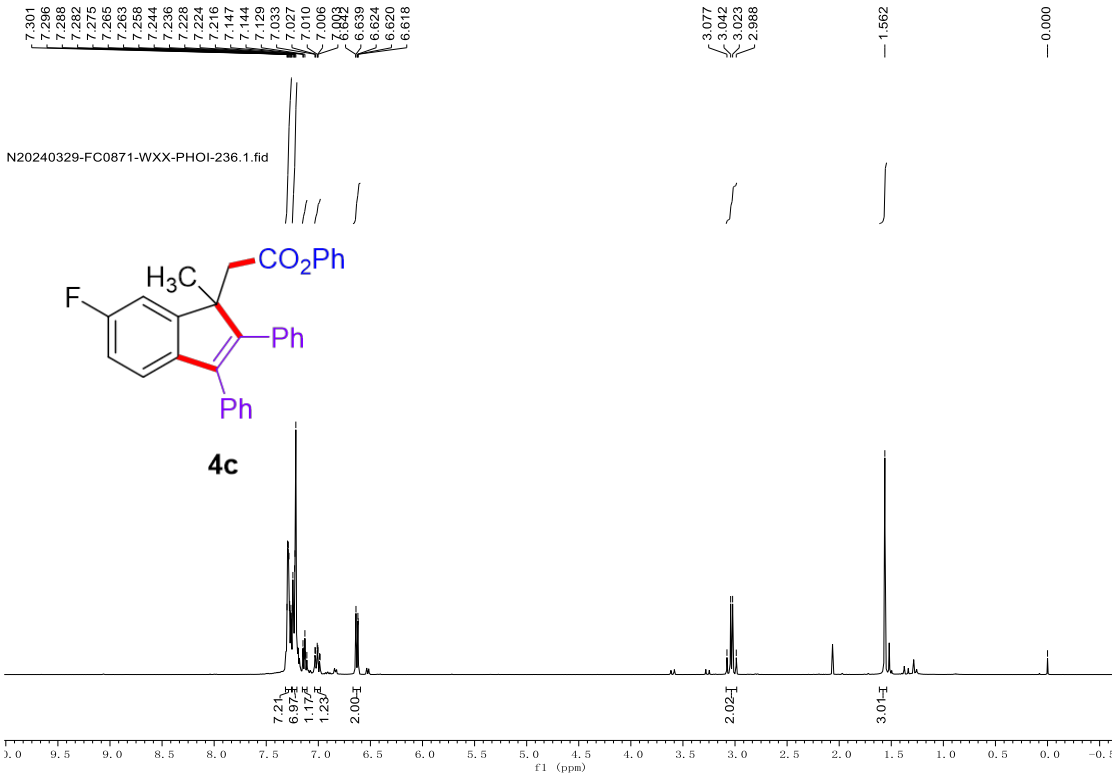
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4b**



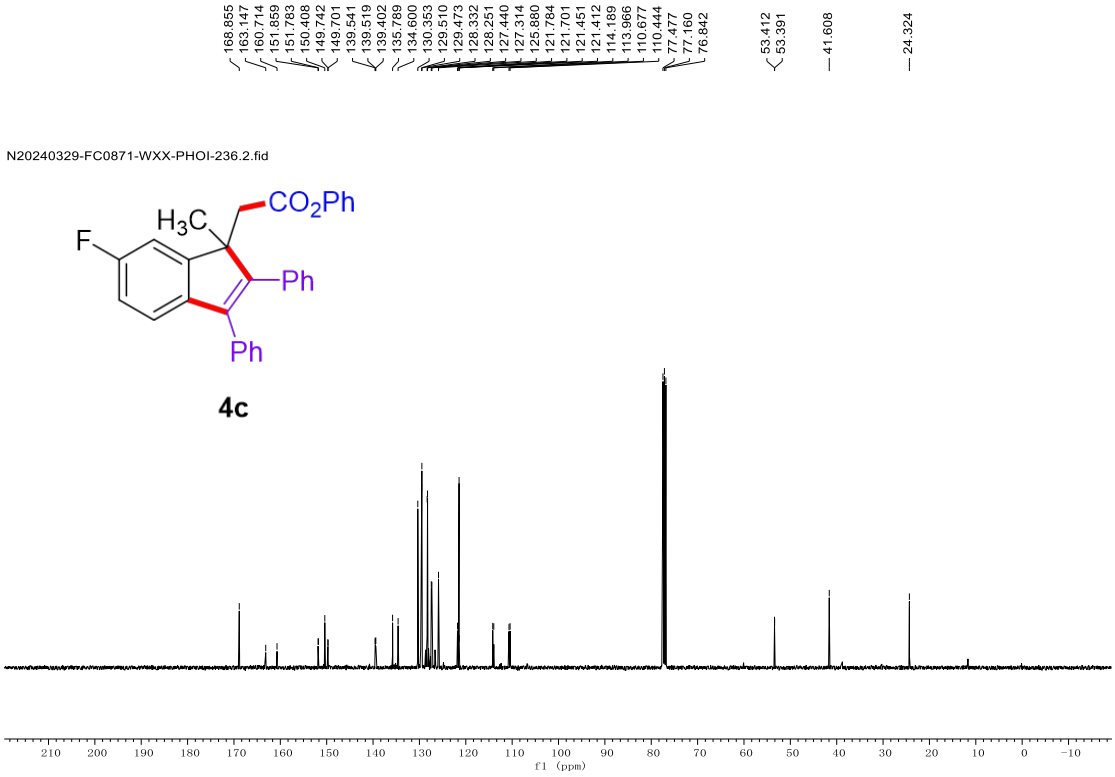
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4b**



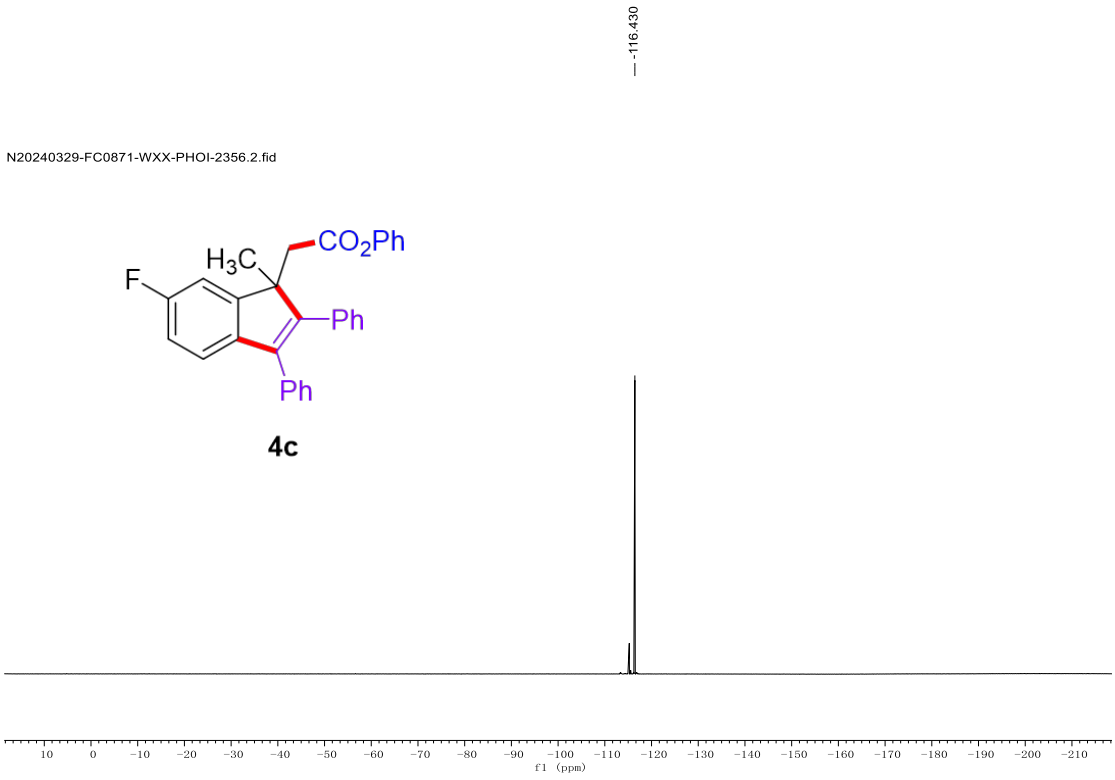
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4c**



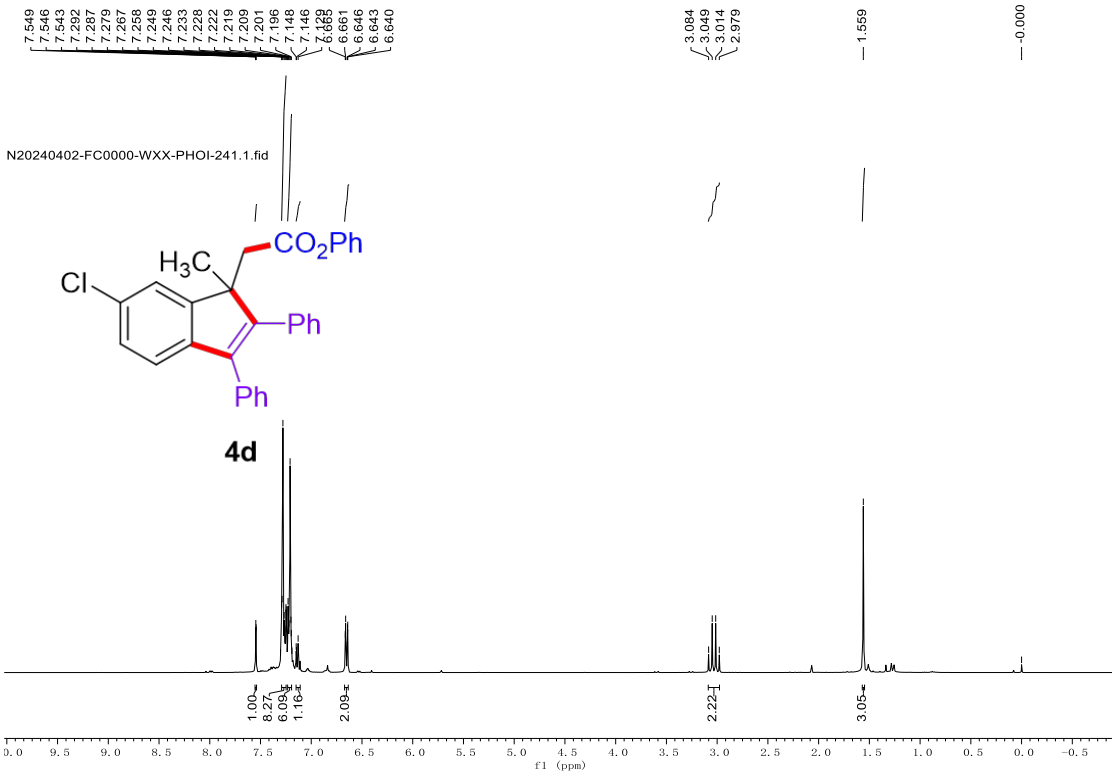
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4c**



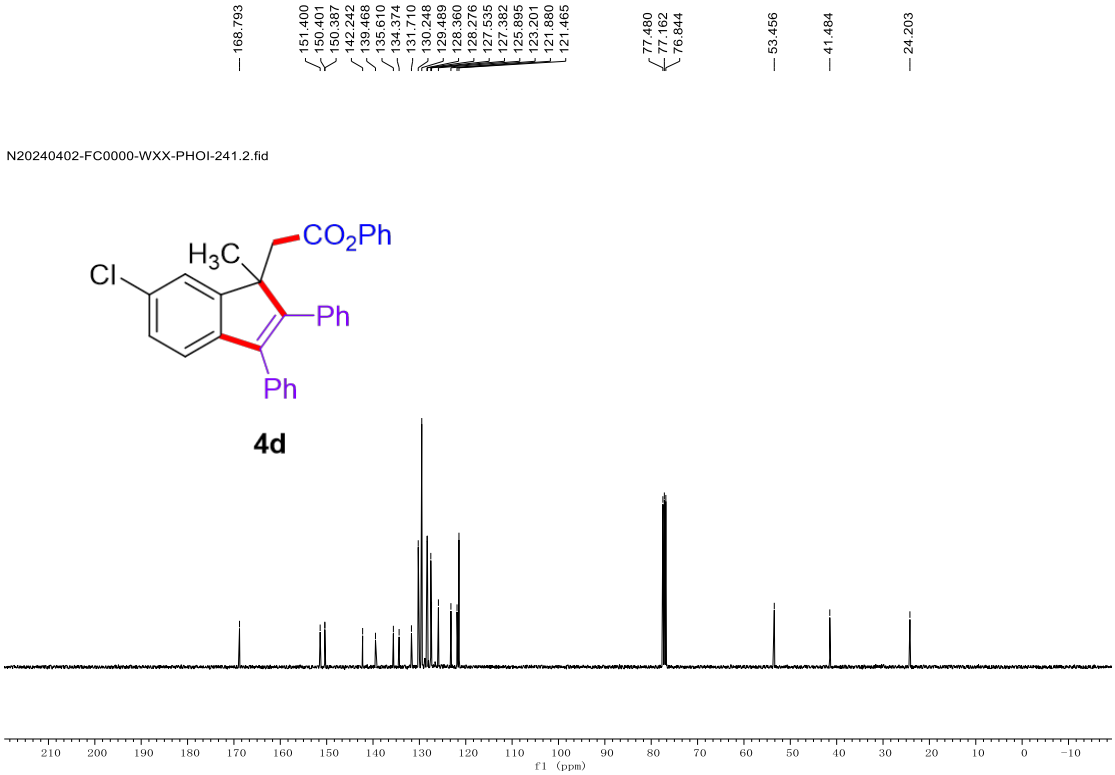
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4c**



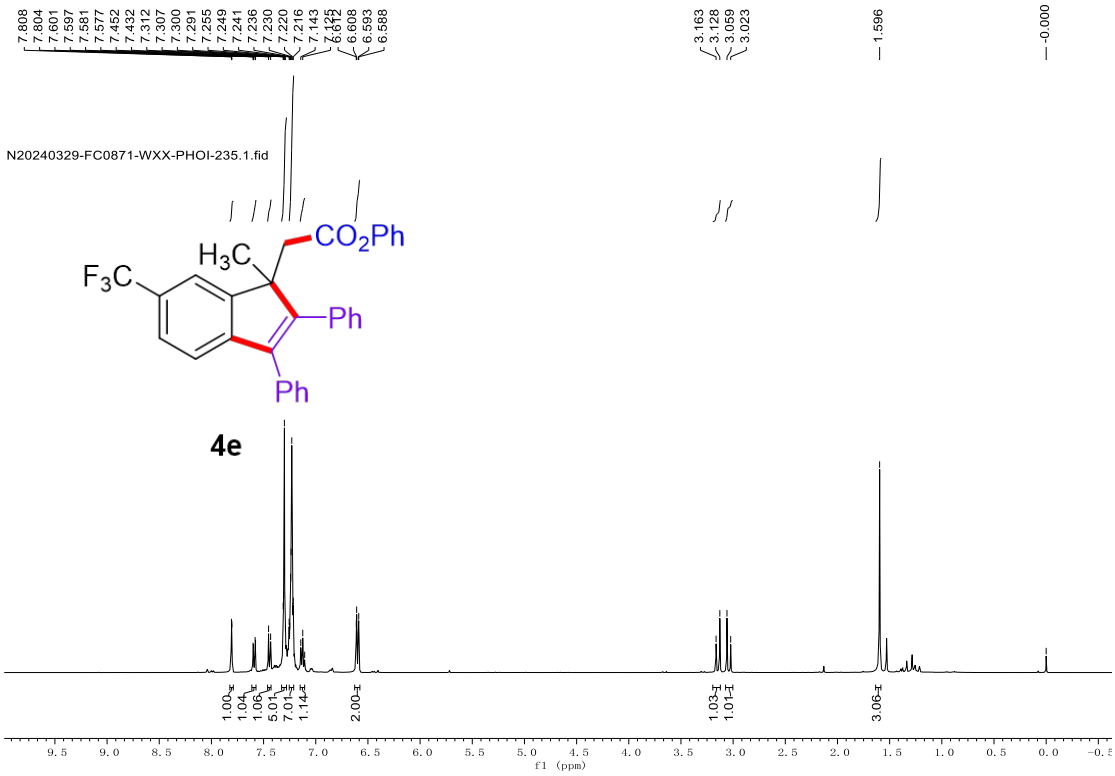
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4d**



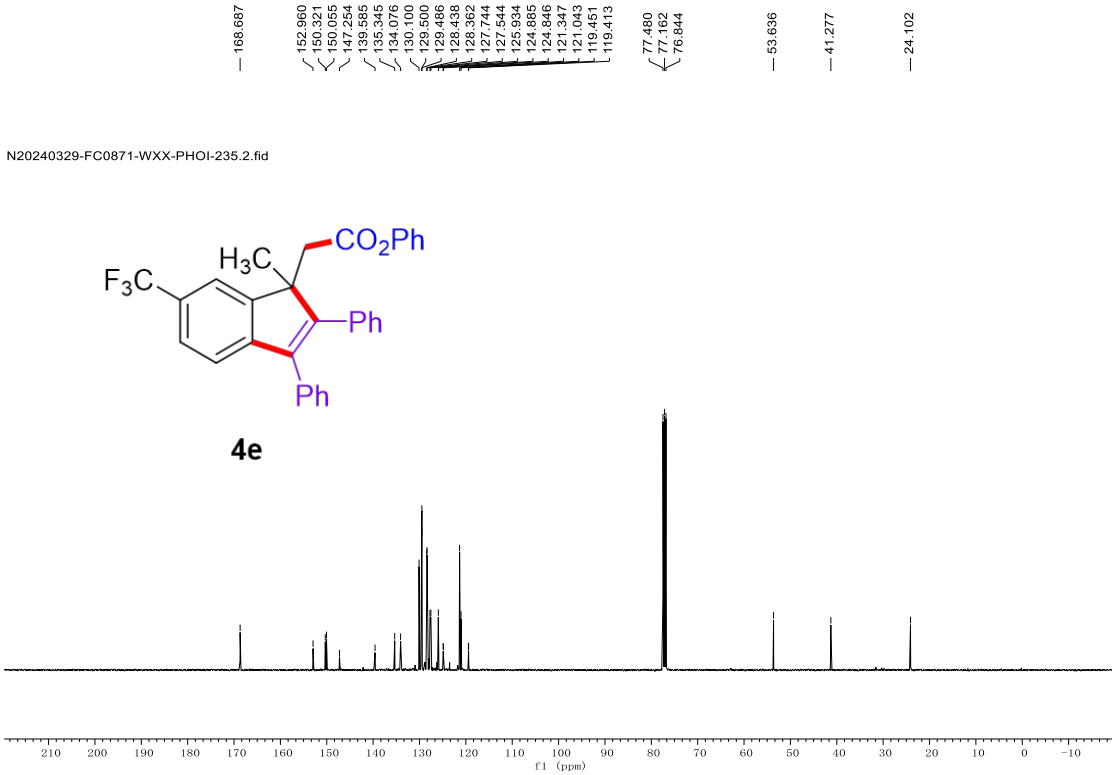
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4d**



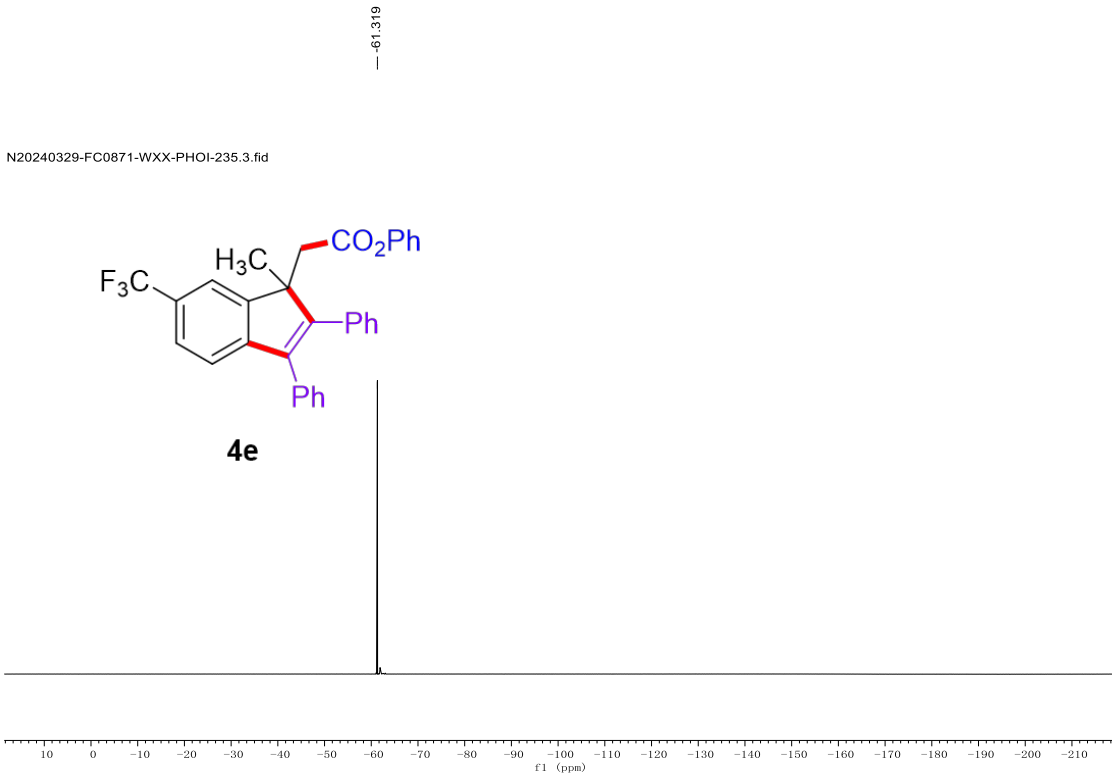
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4e**



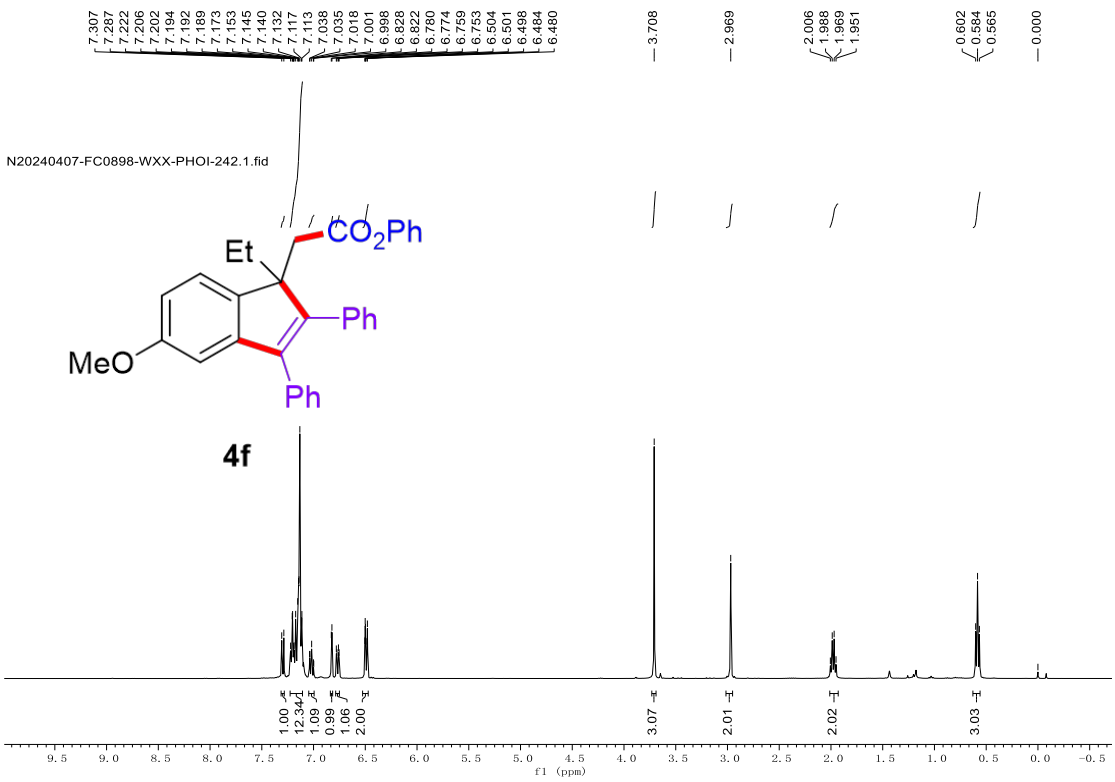
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4e**



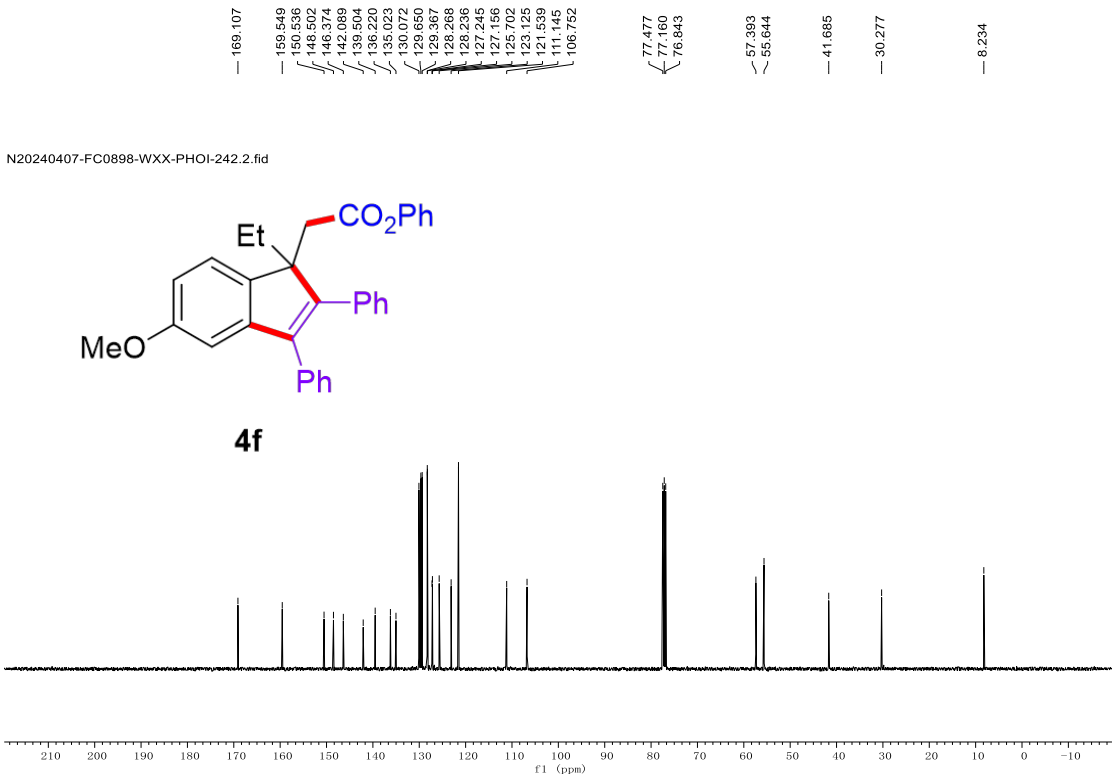
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4e**



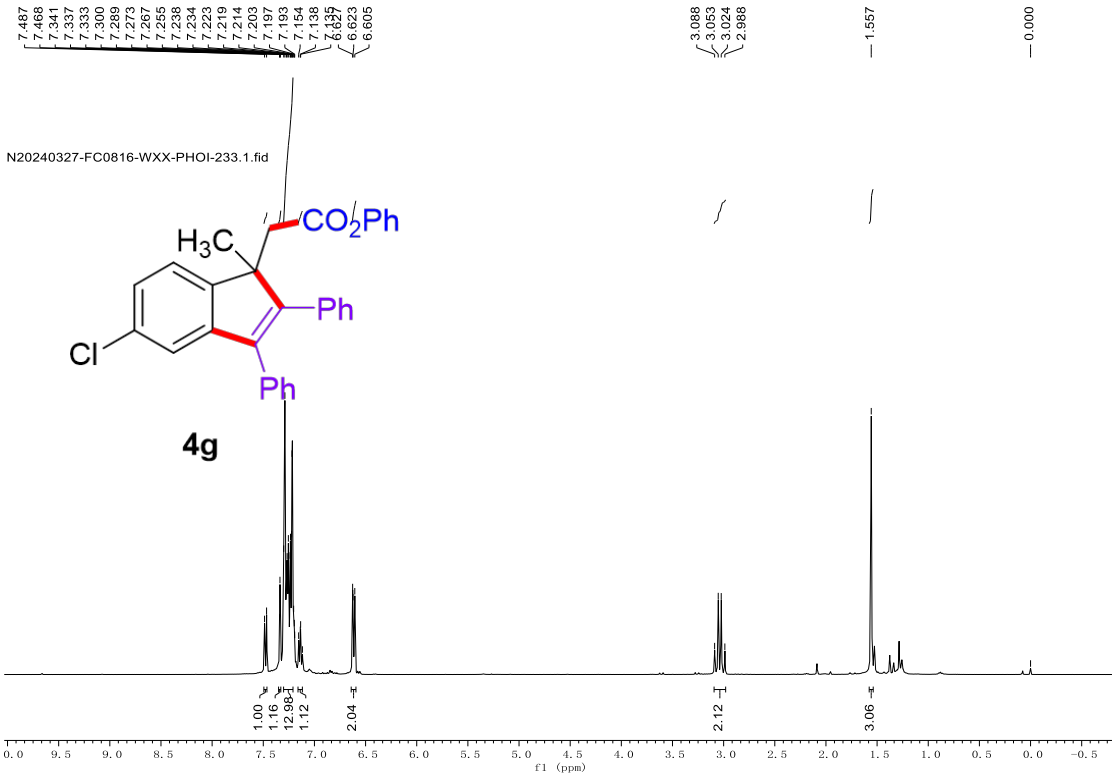
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4f**



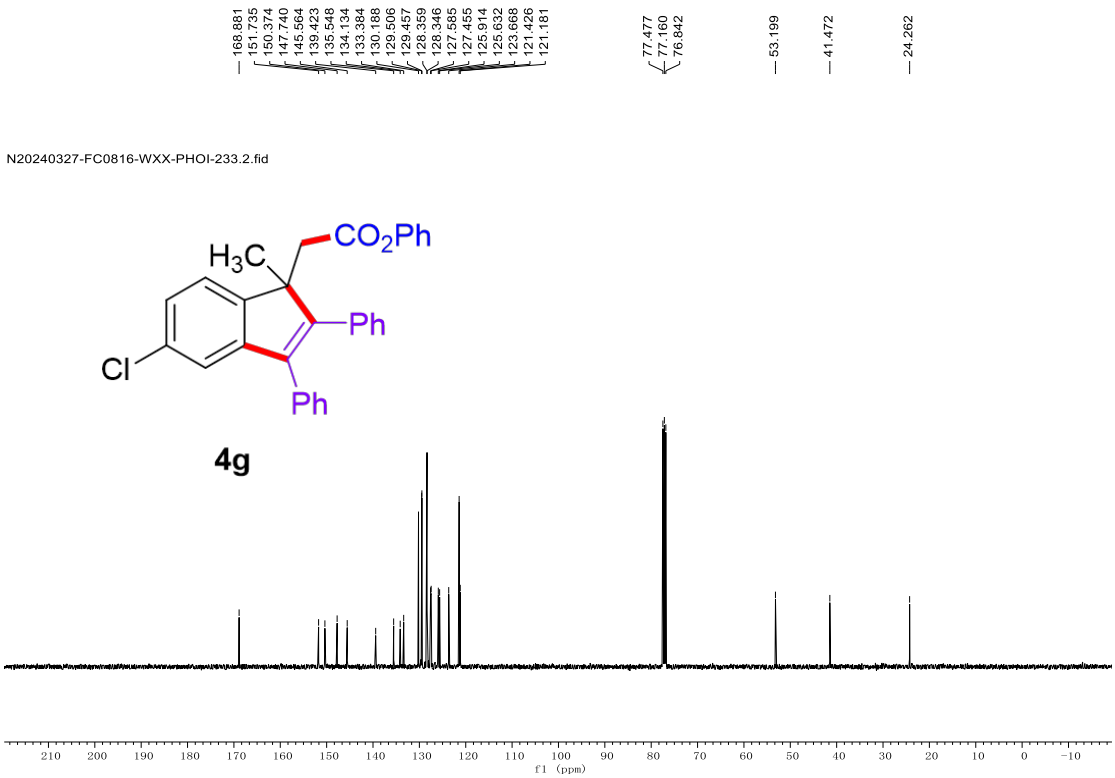
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4f**



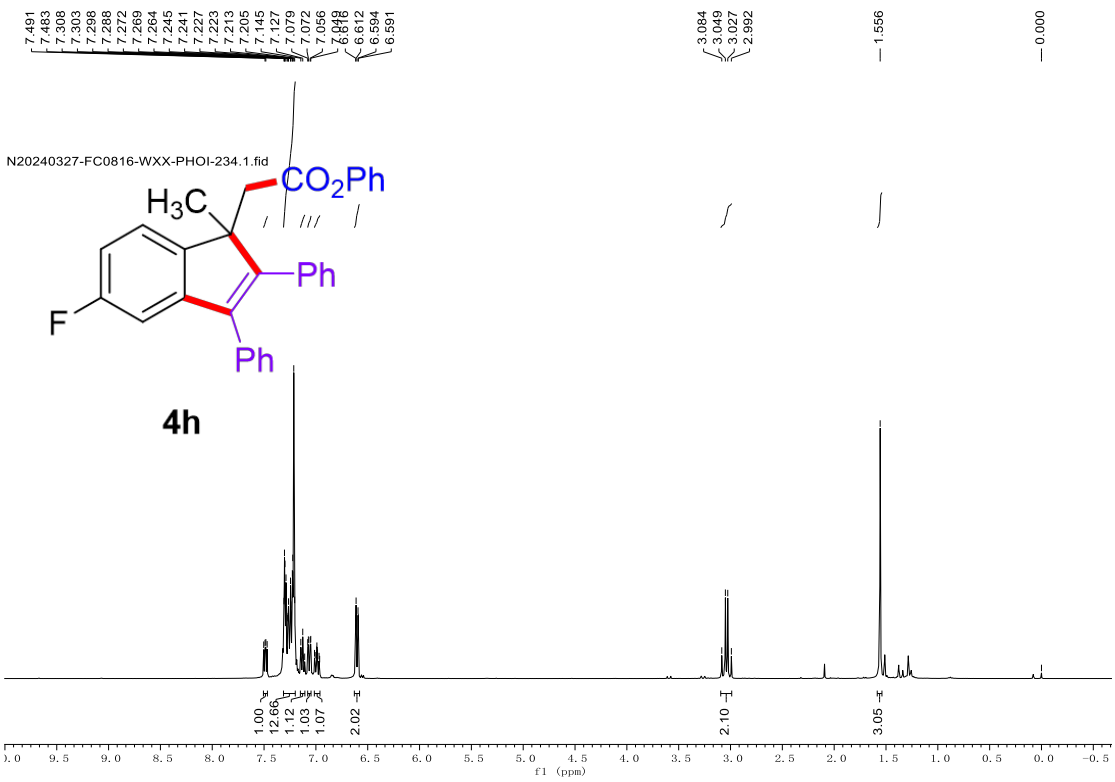
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4g**



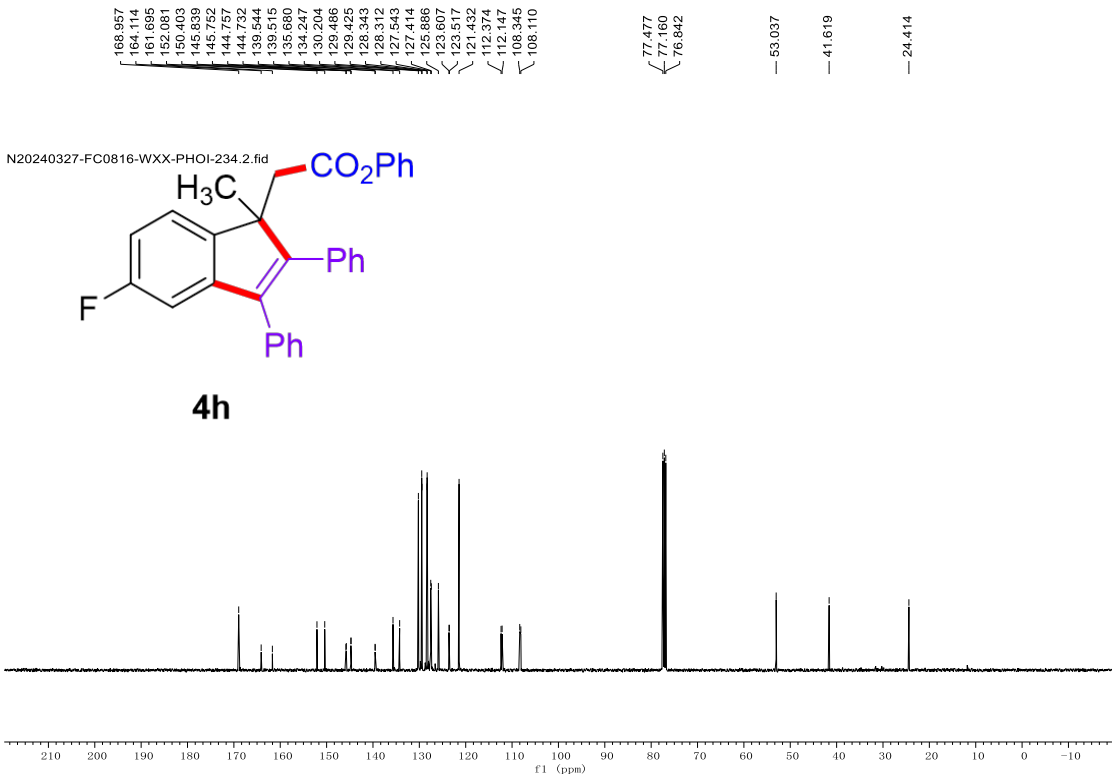
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4g**



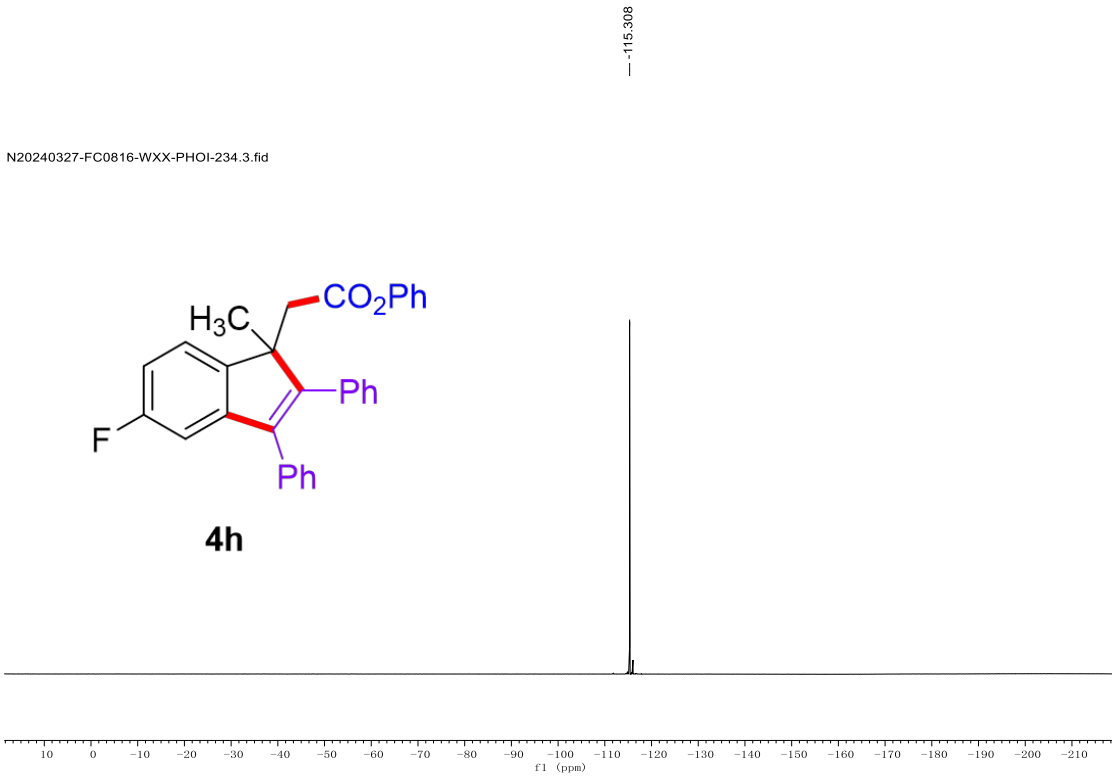
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4h**



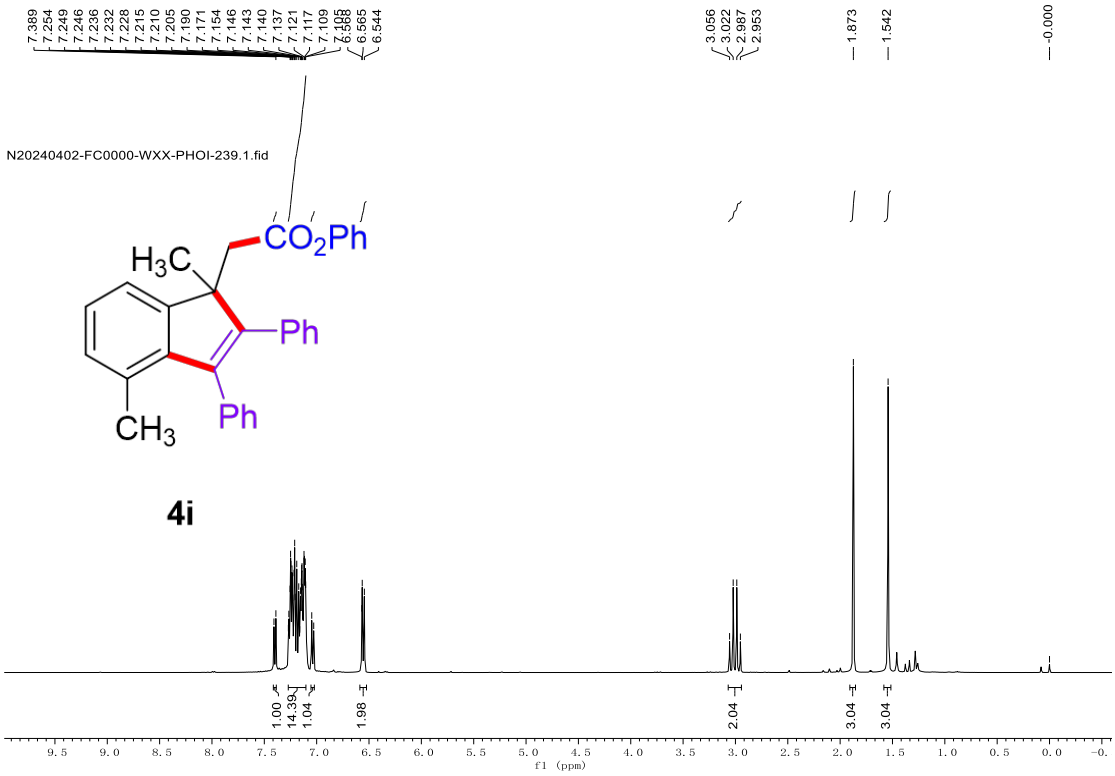
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4h**



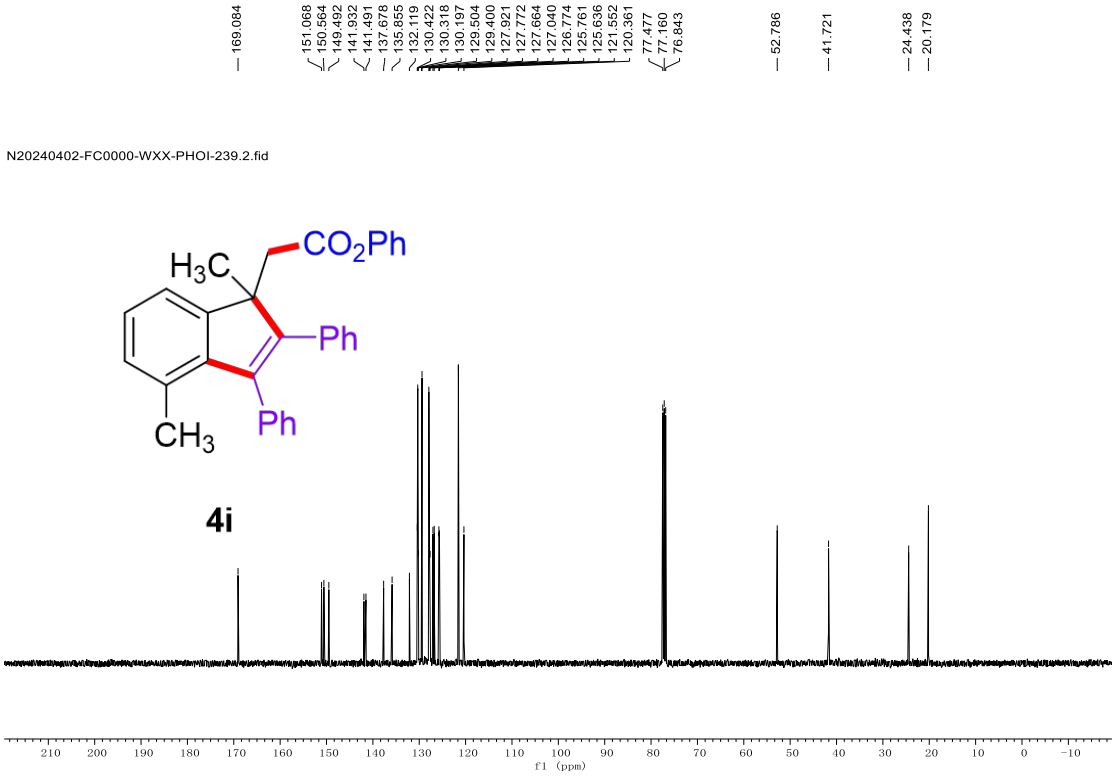
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4h**



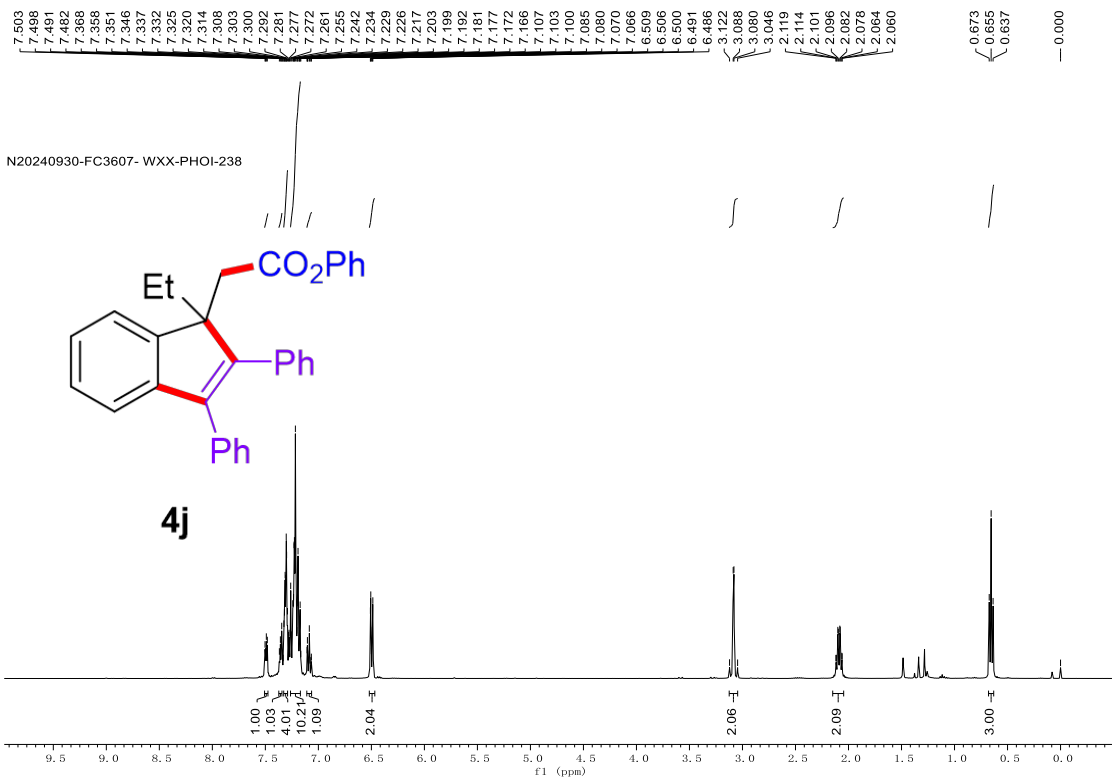
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4i**



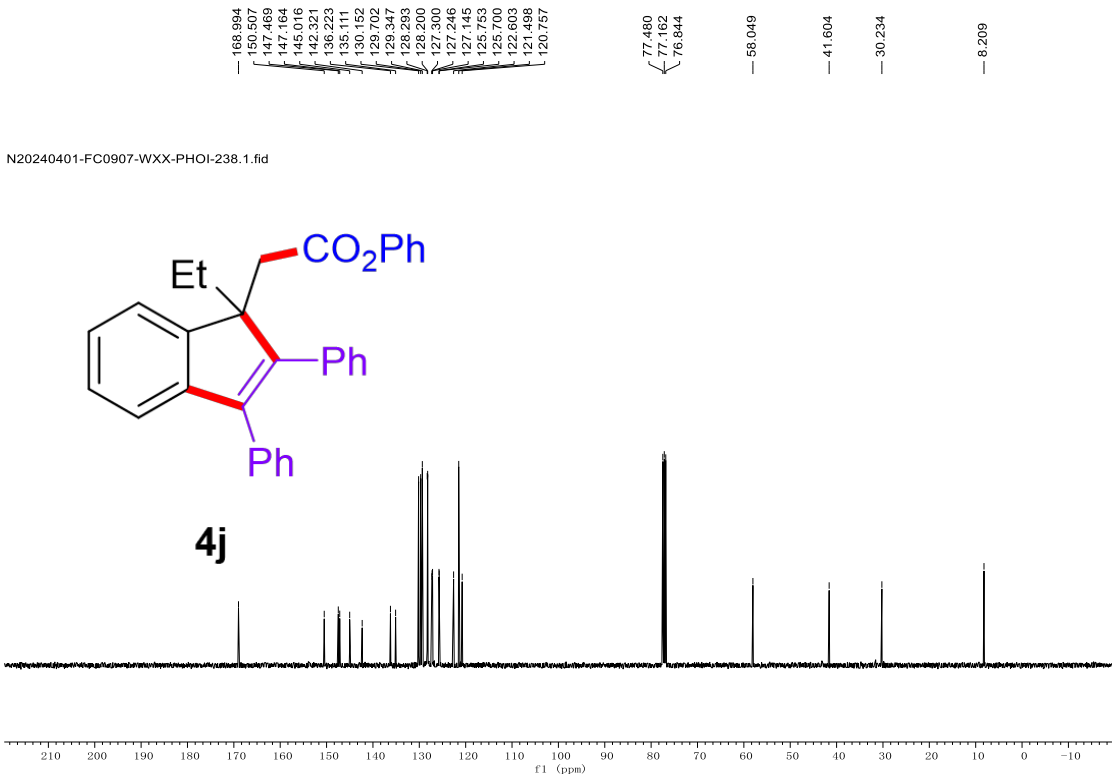
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4i**



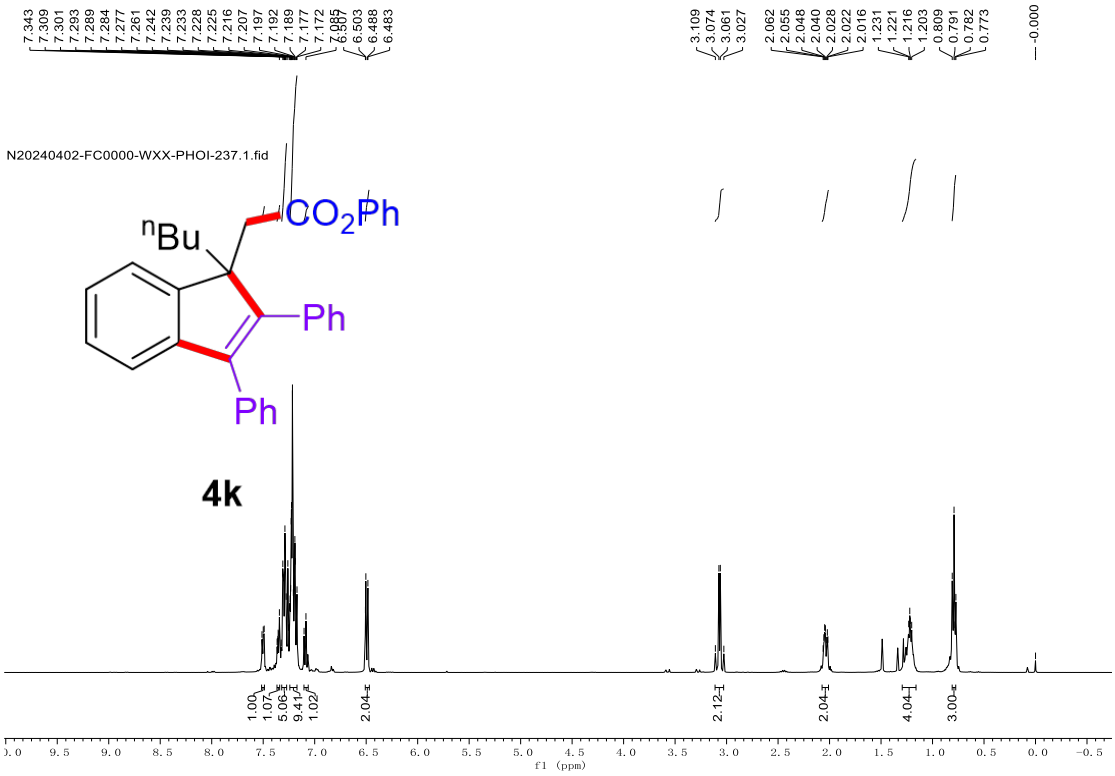
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4j**



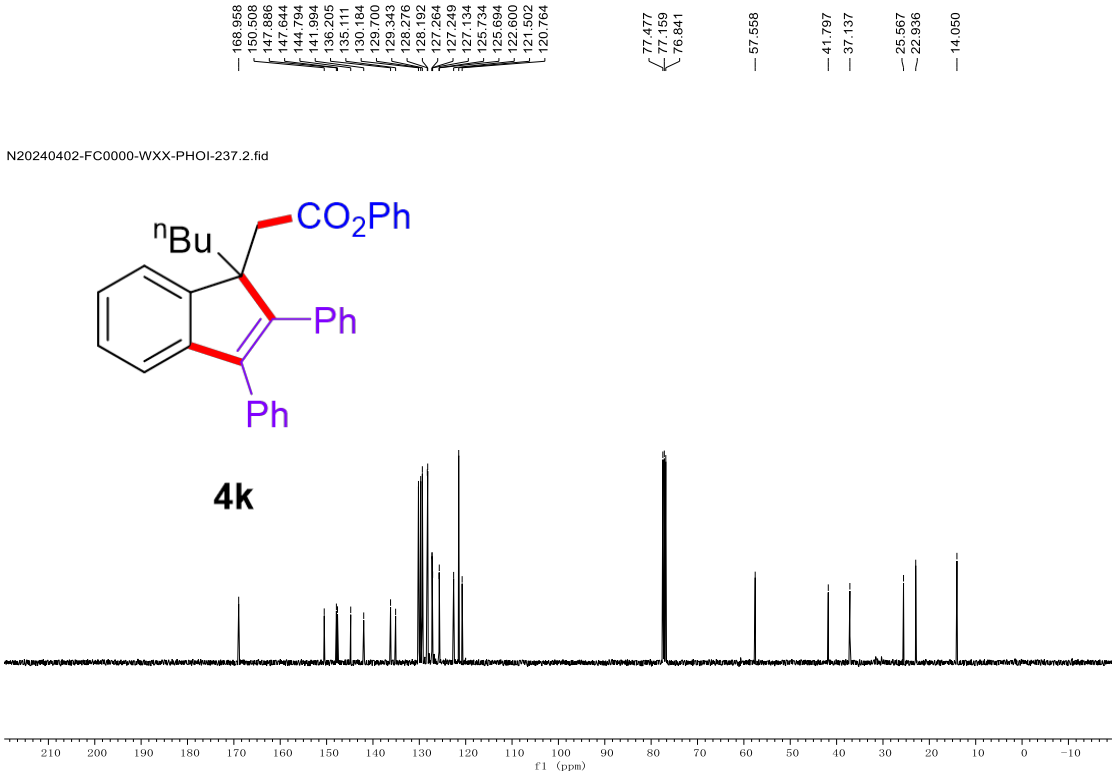
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4j**



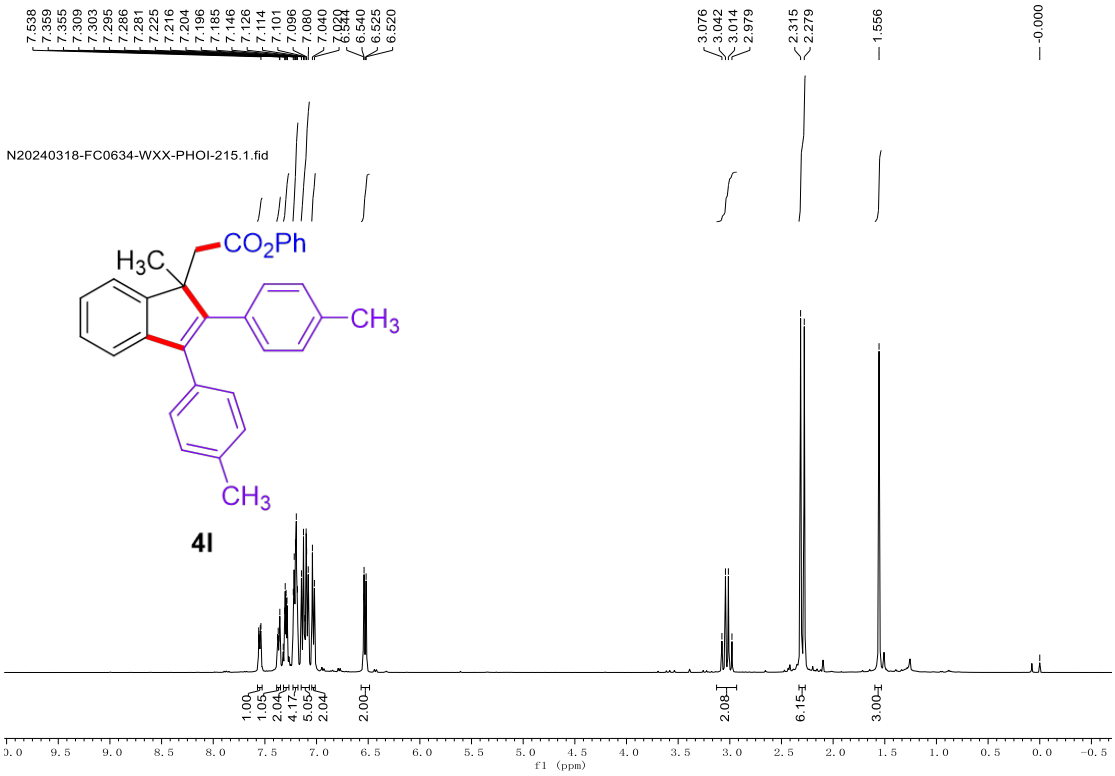
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4k**



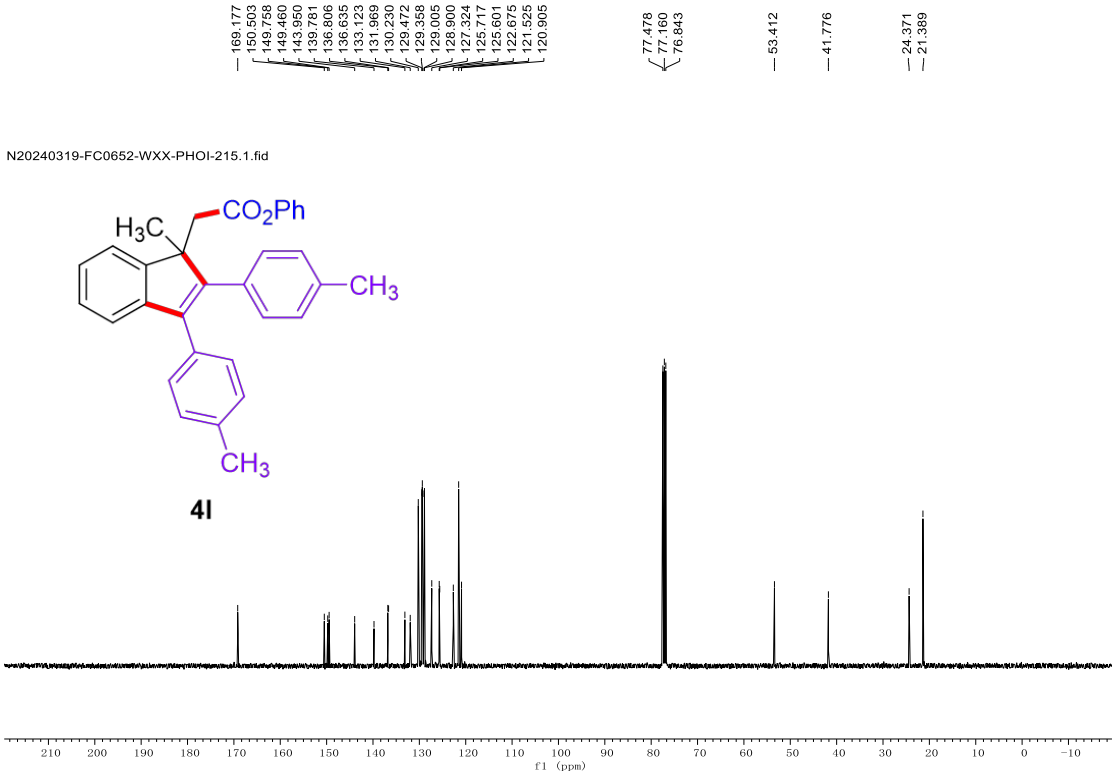
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4k**



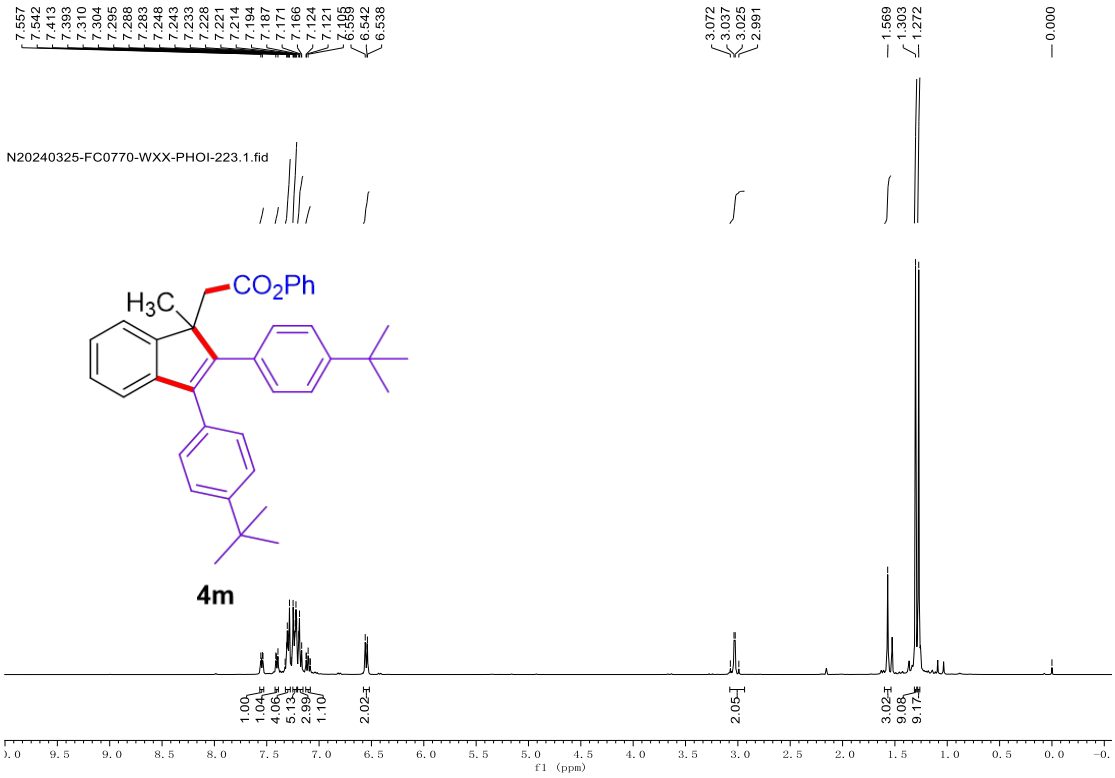
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4l**



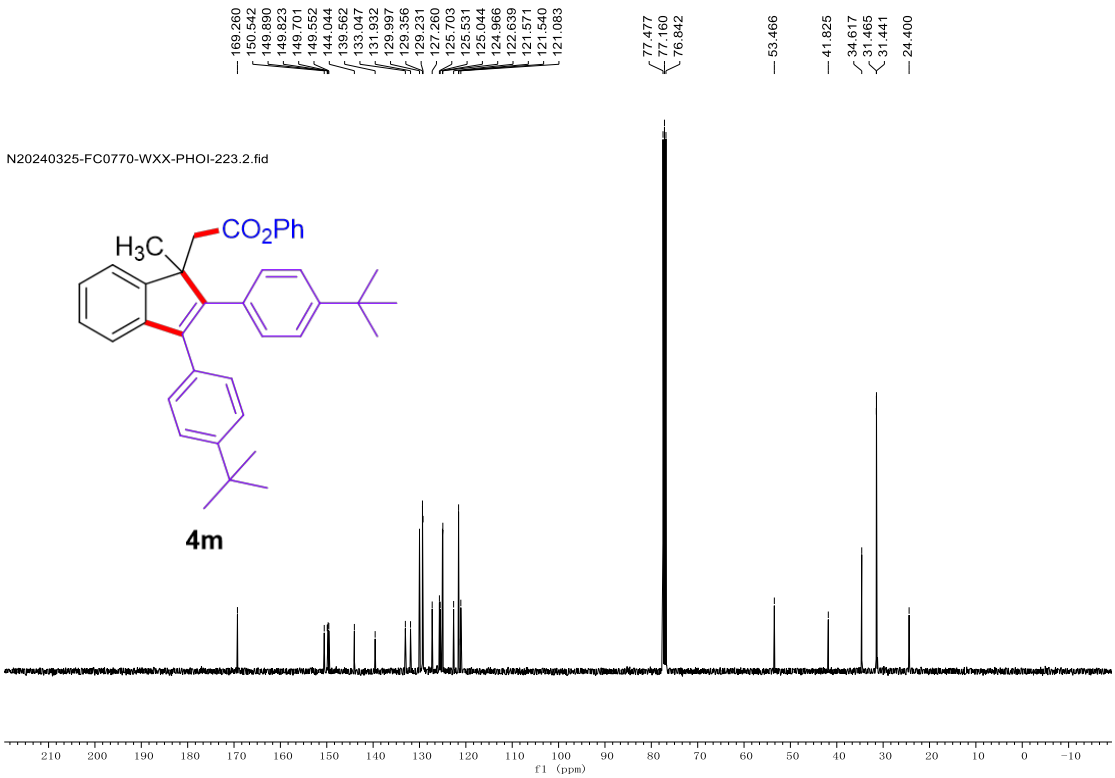
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4l**



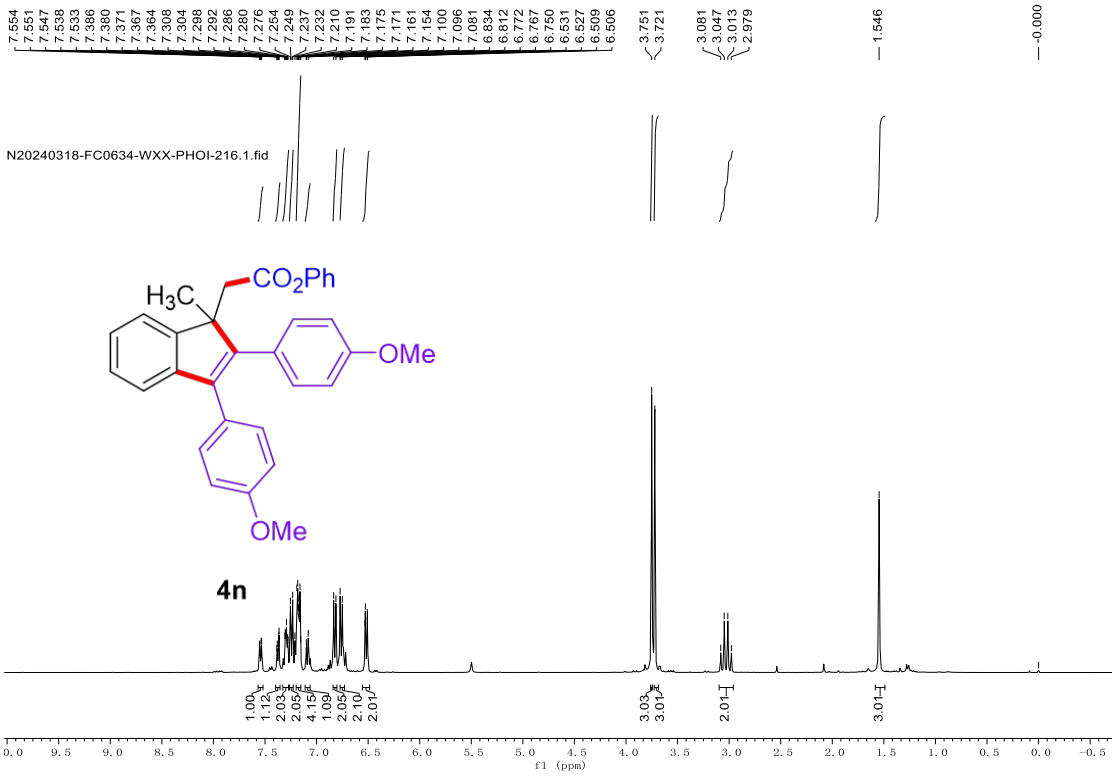
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4m**



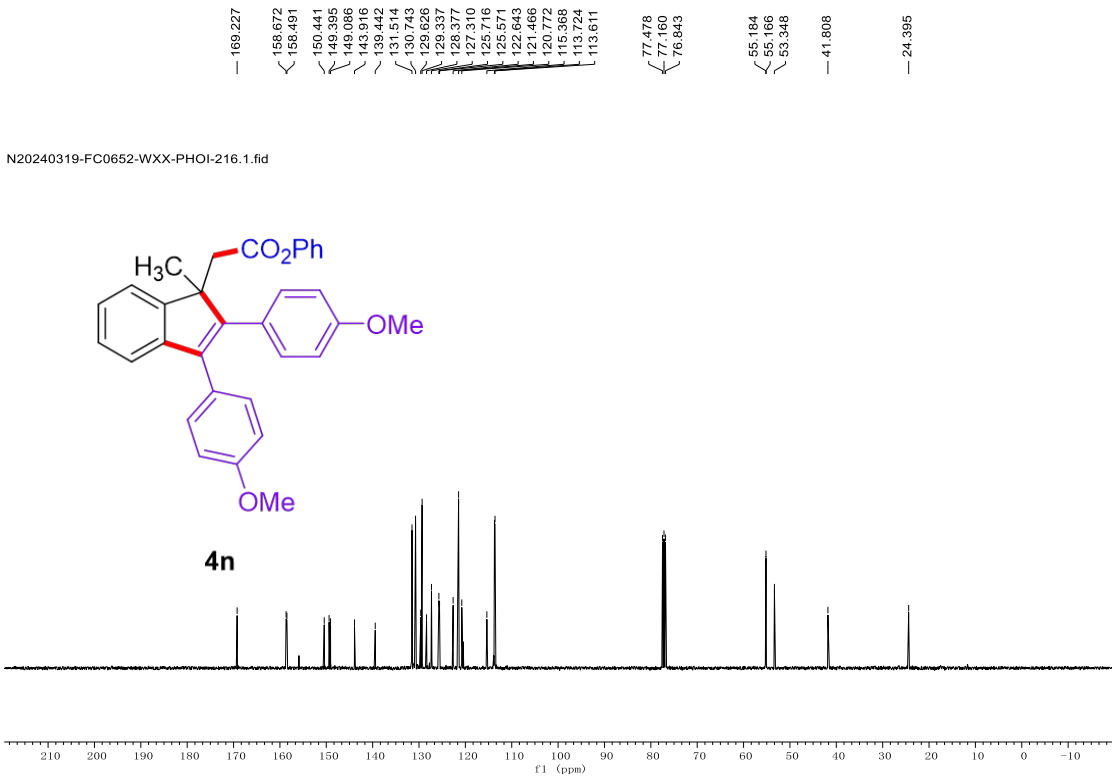
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4m**



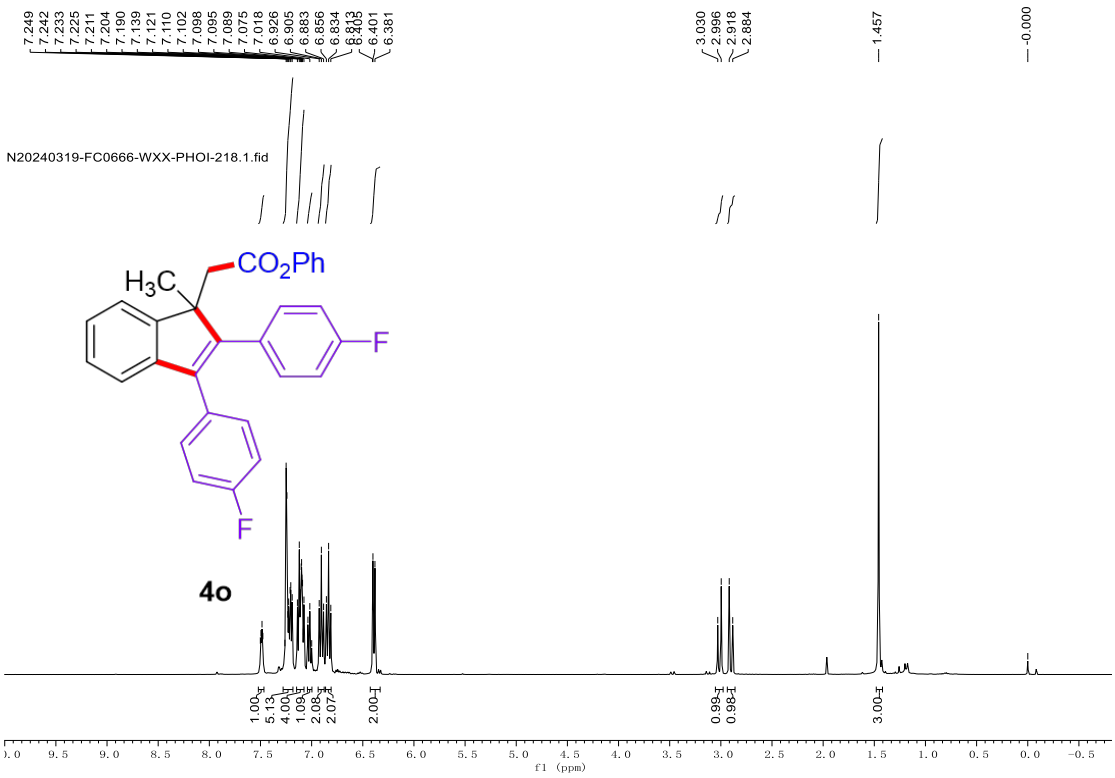
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4n**



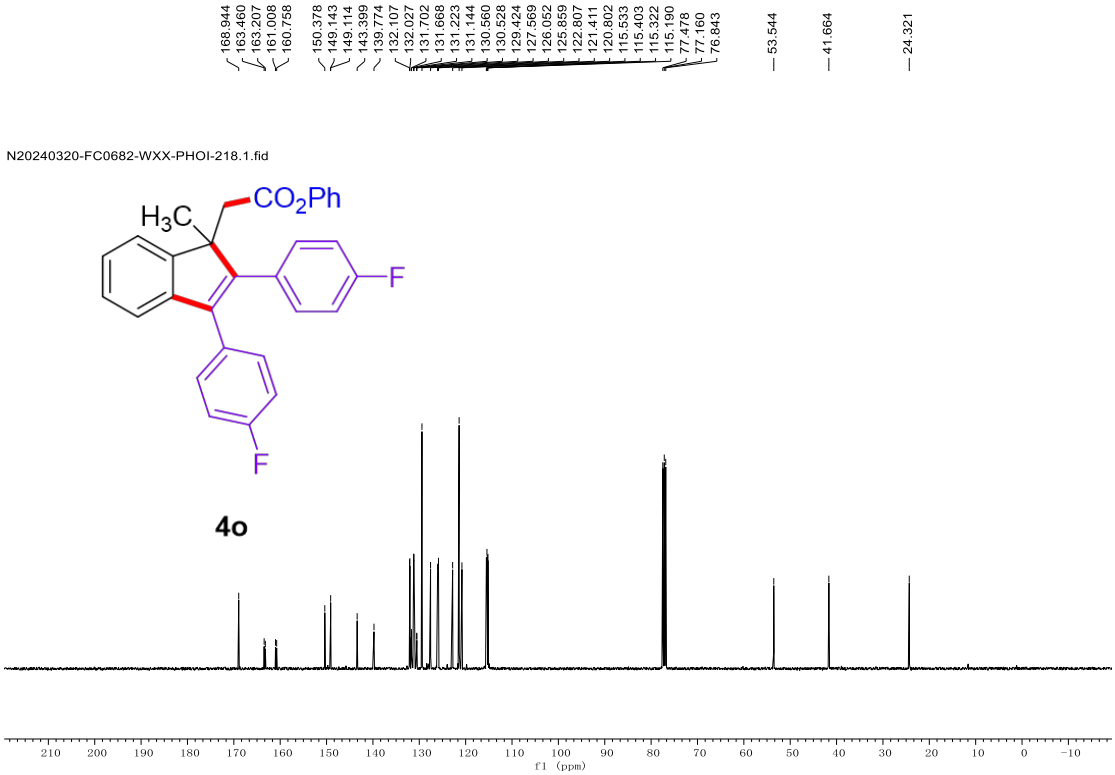
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4n**



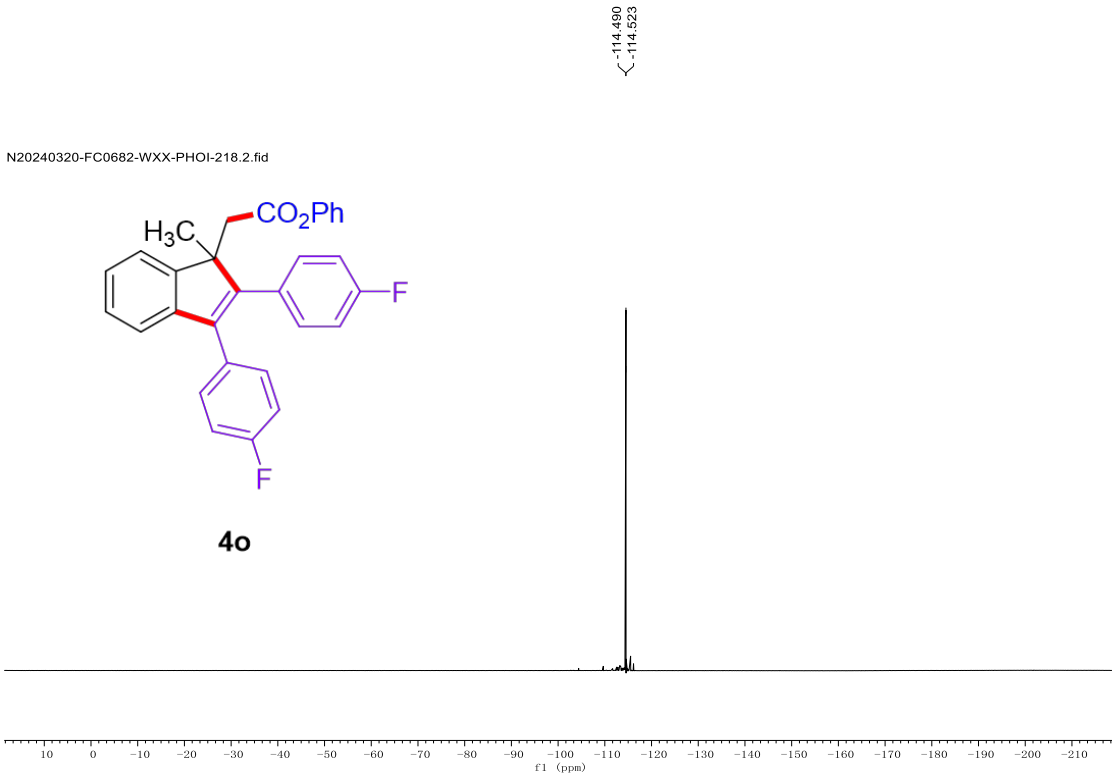
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4o**



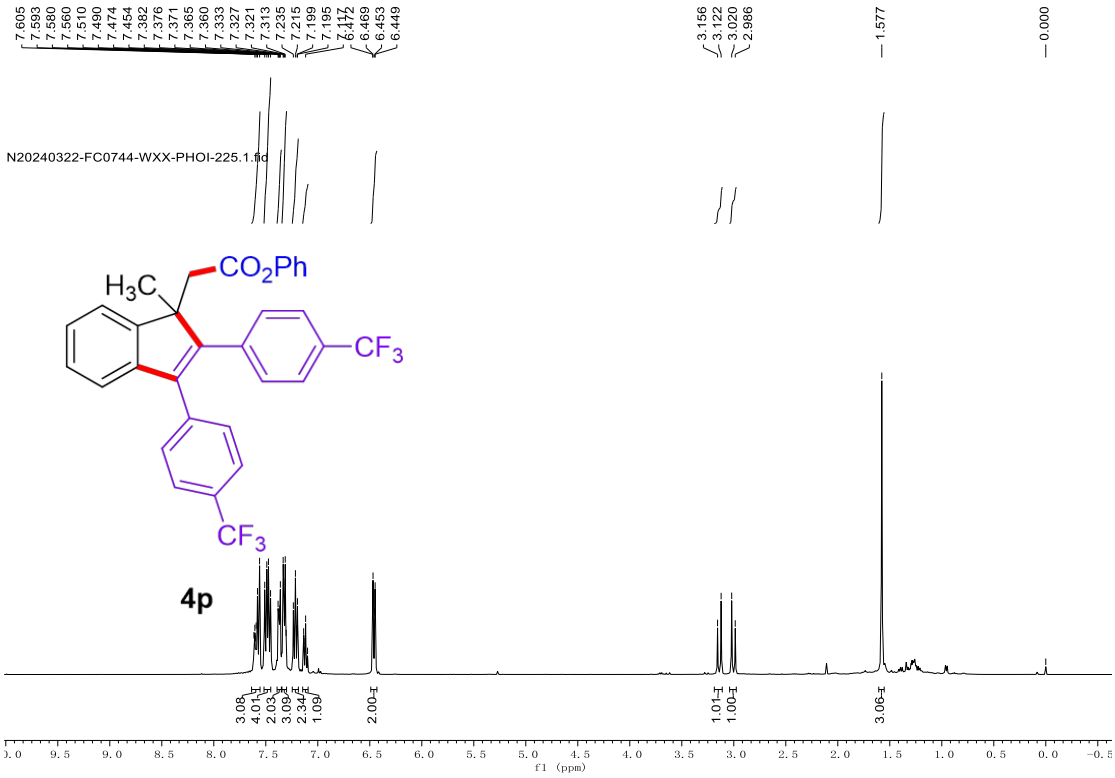
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4o**



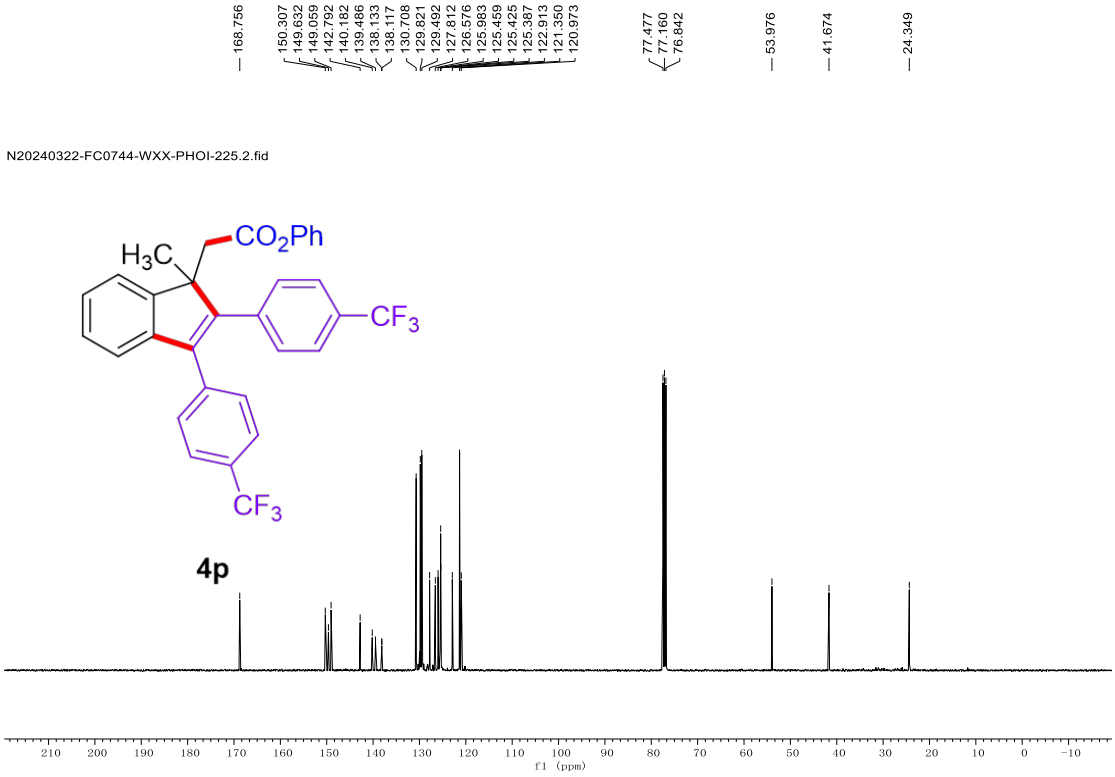
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4o**



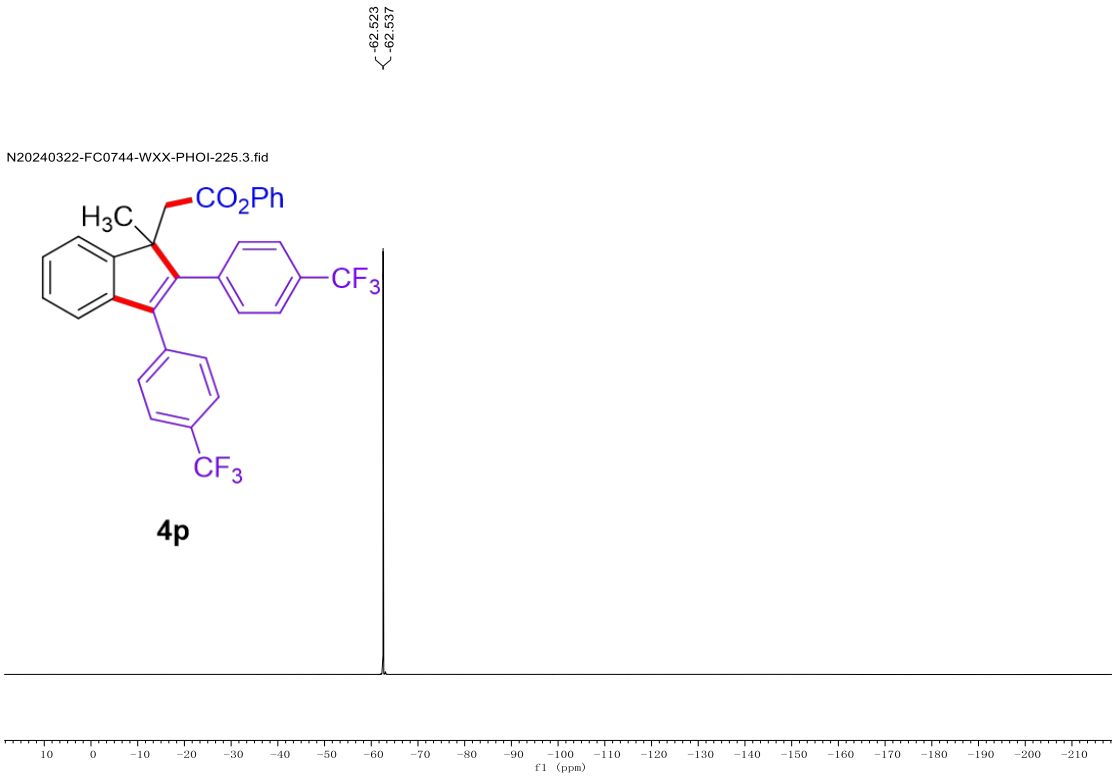
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4p**



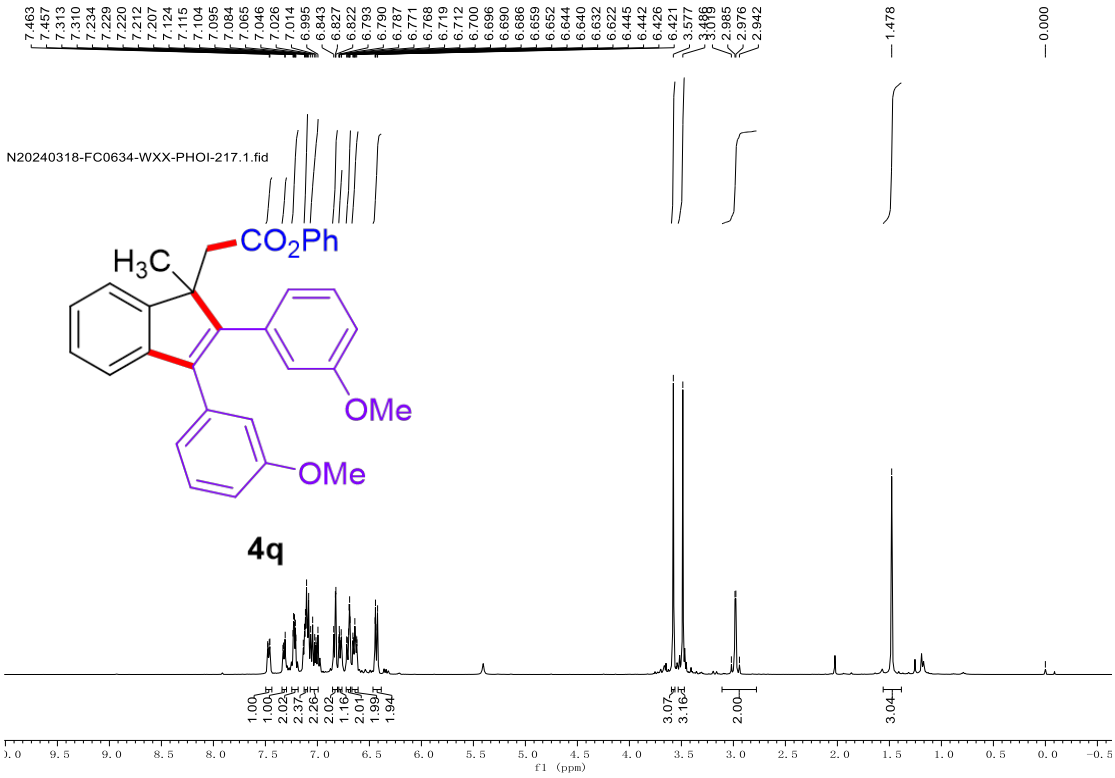
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4p**



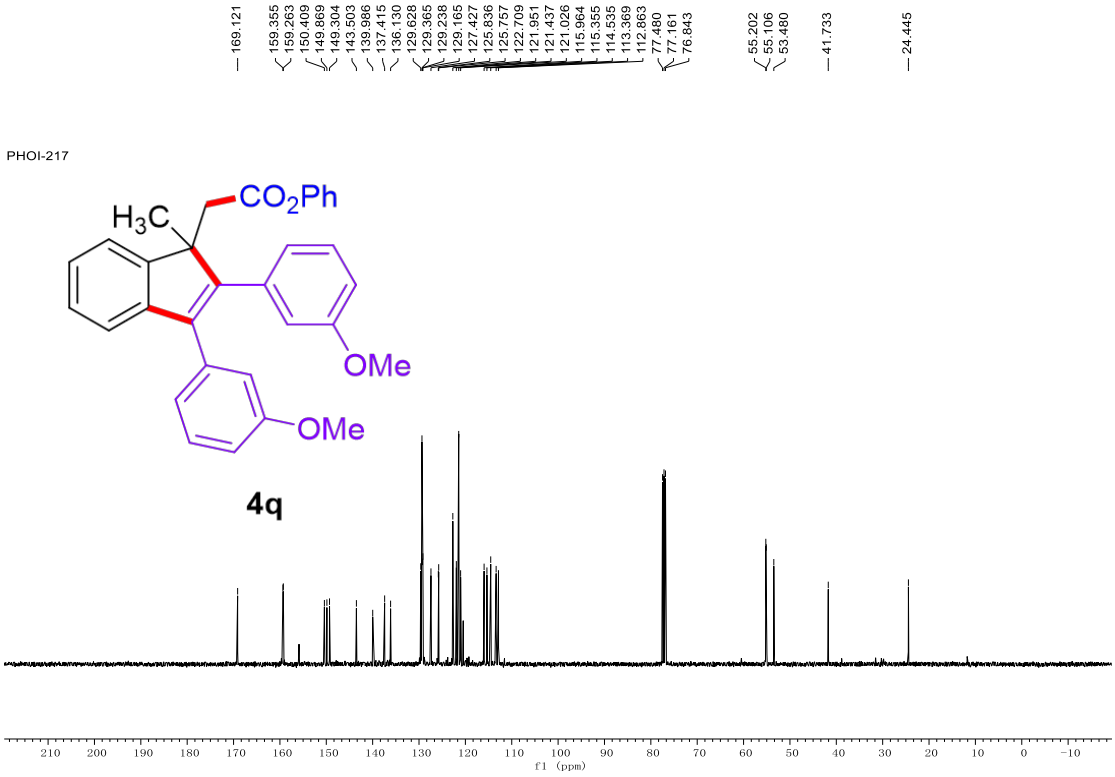
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4p**



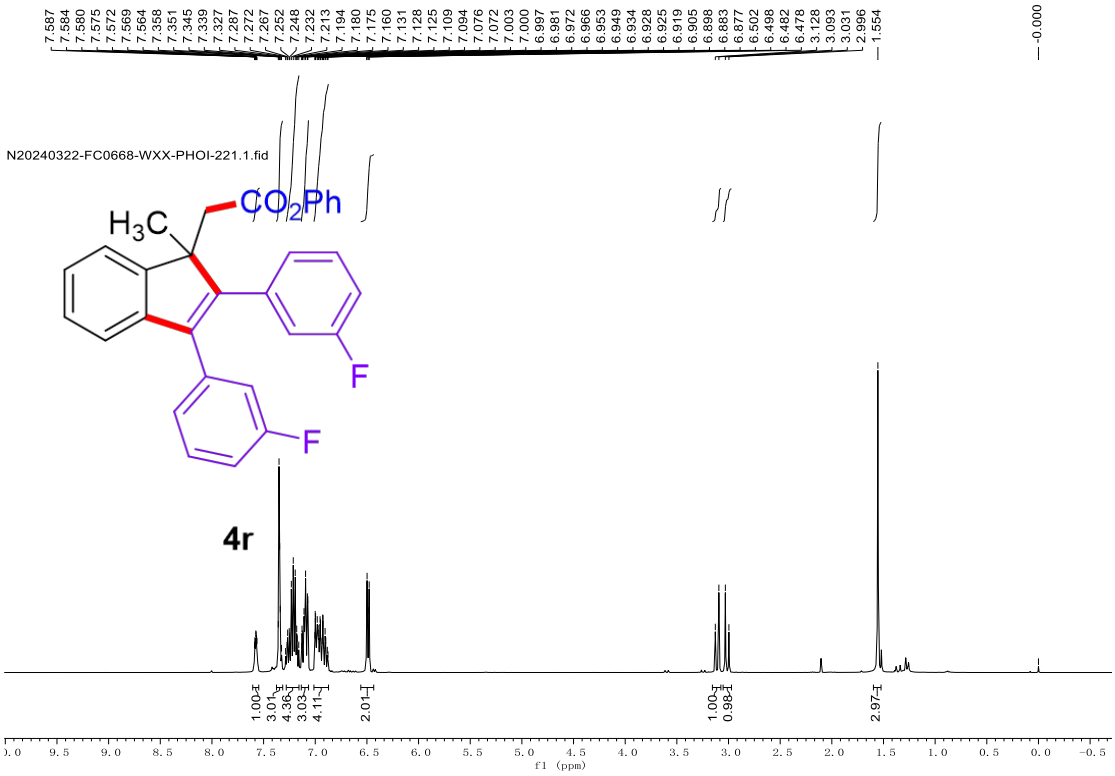
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4q**



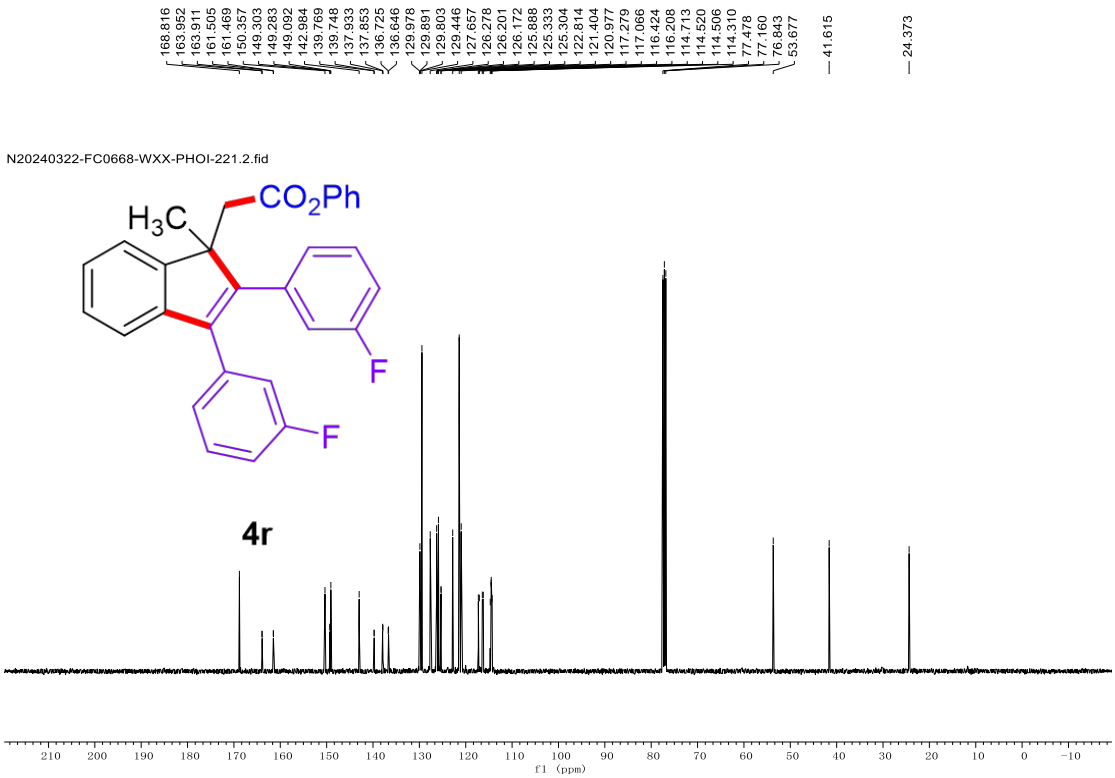
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4q**



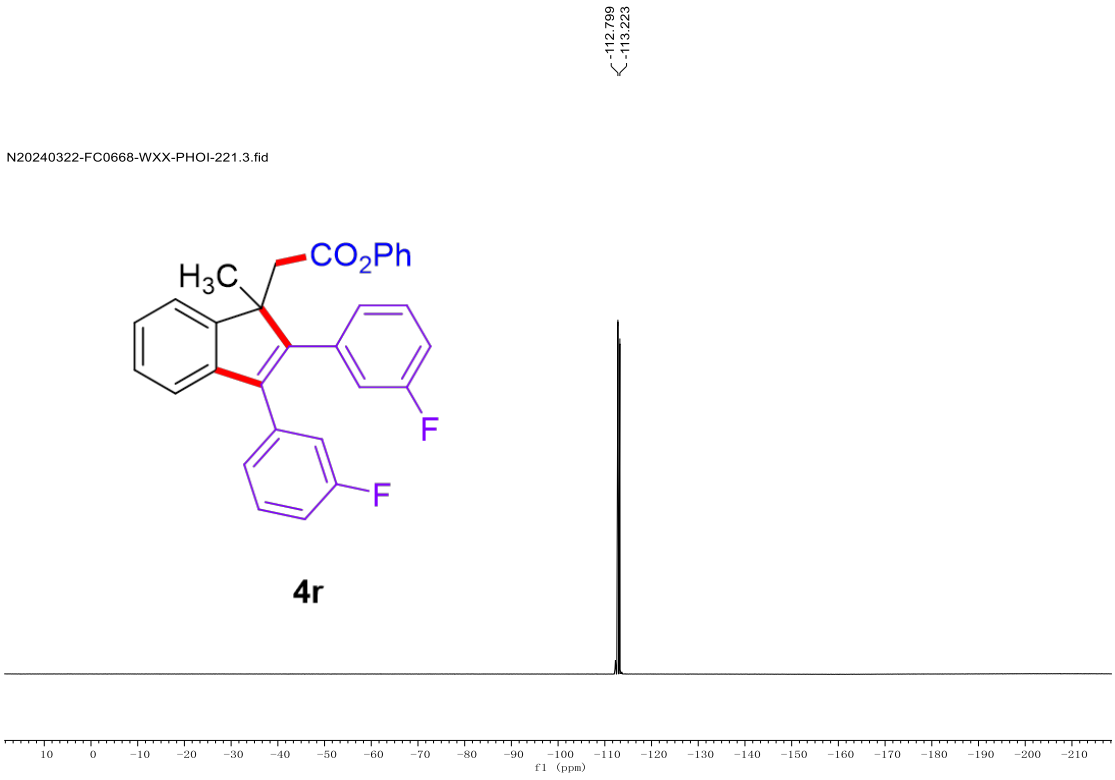
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4r**



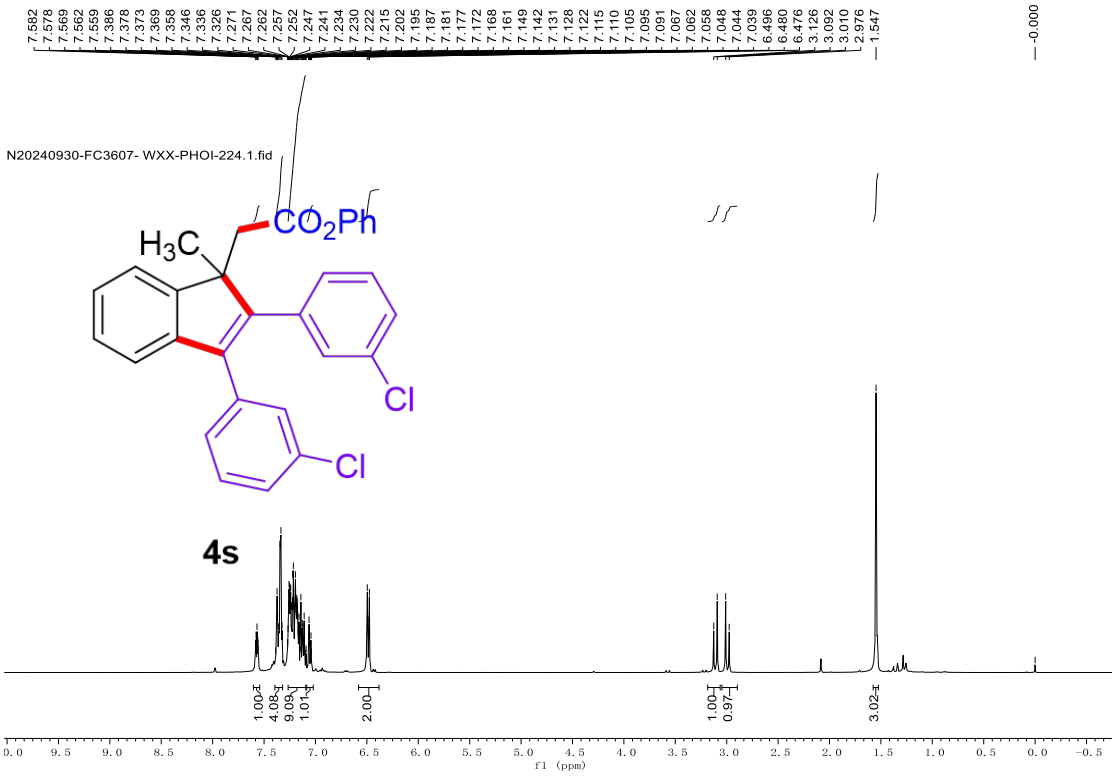
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4r**



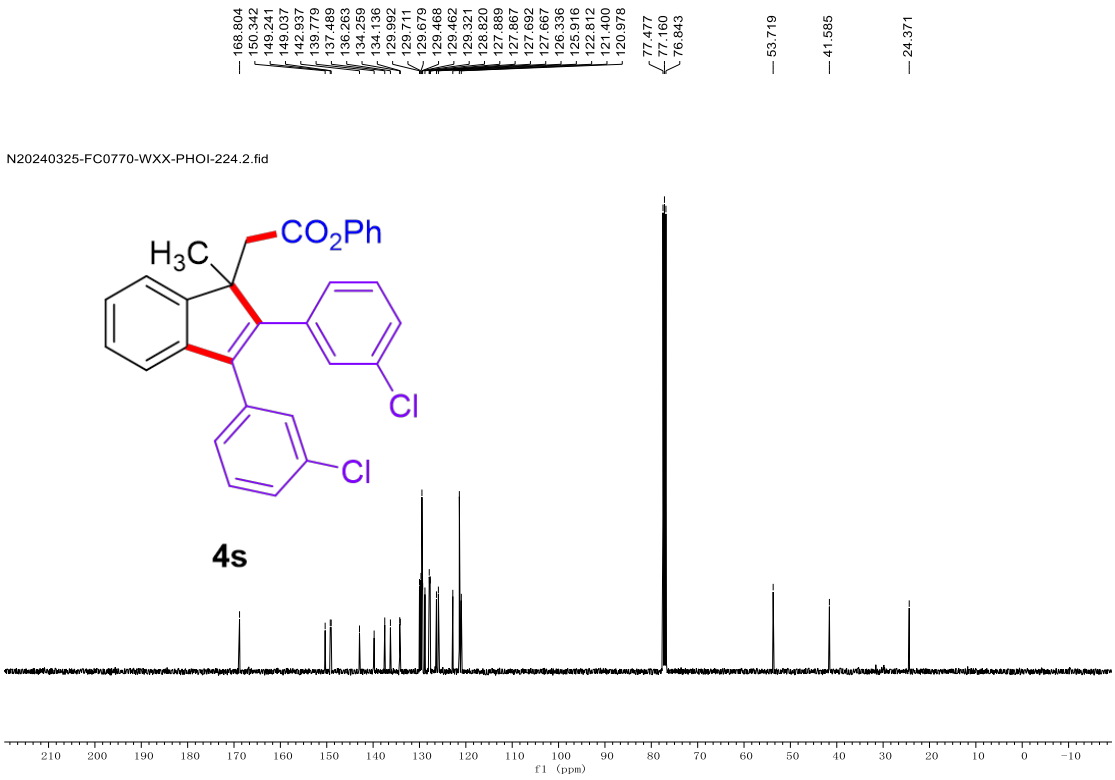
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4r**



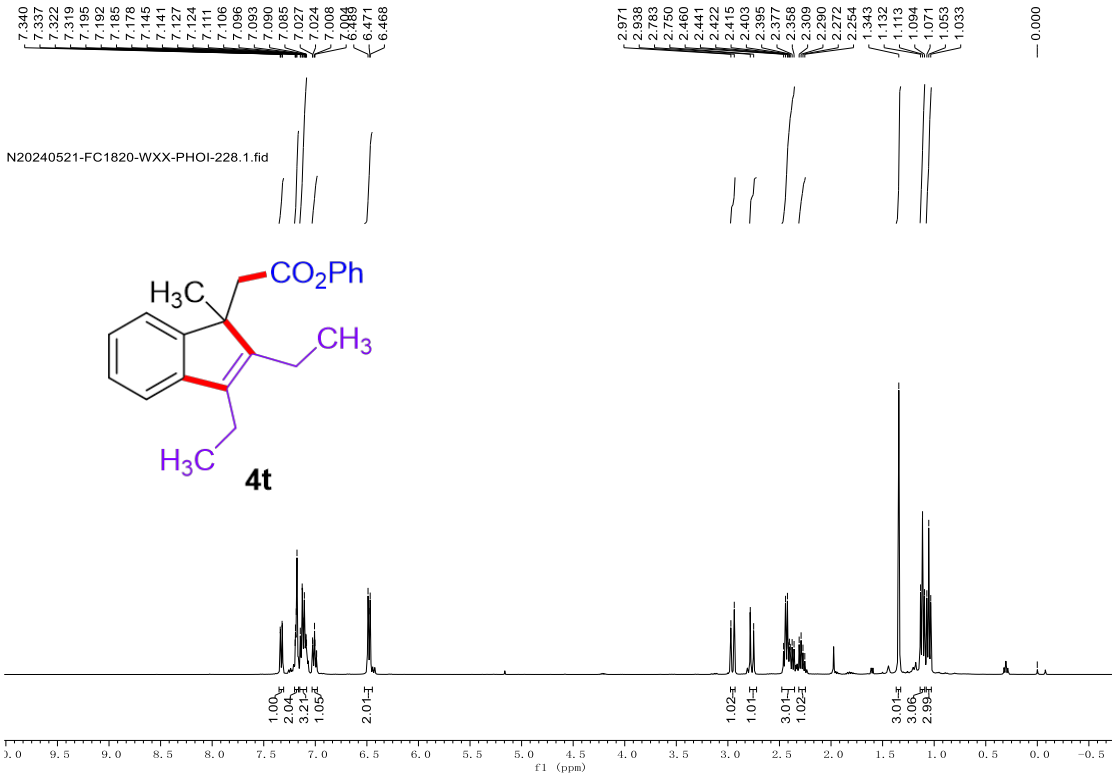
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4s**



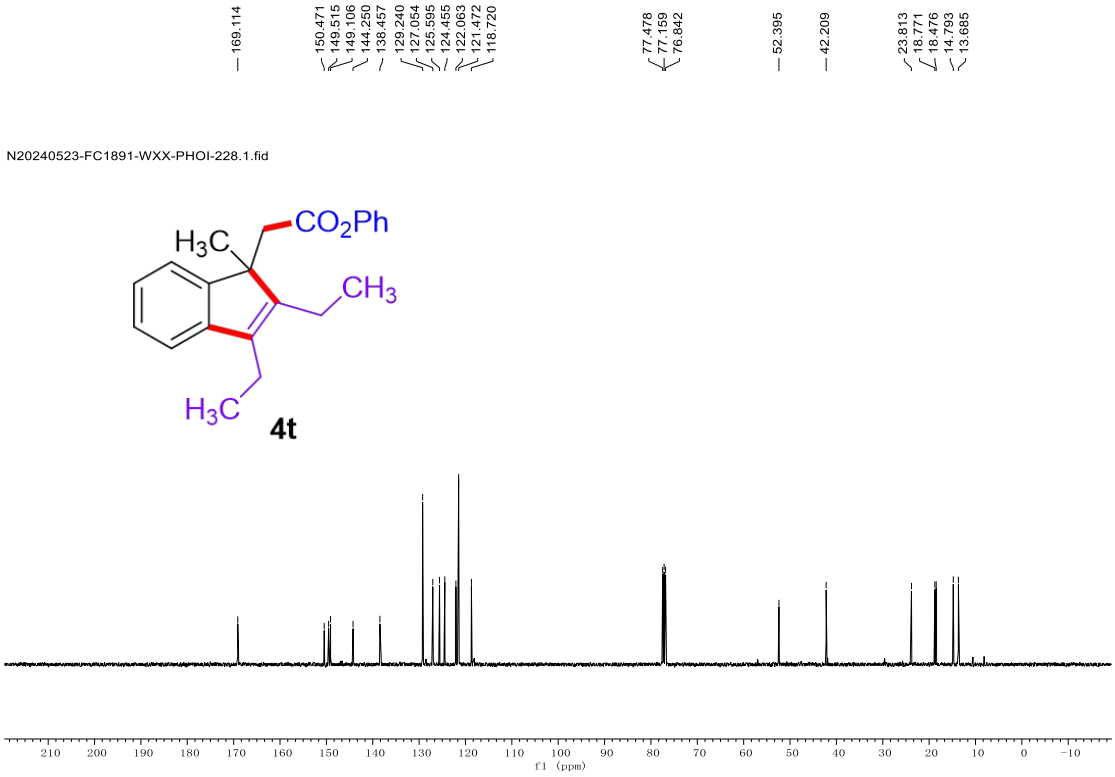
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4s**



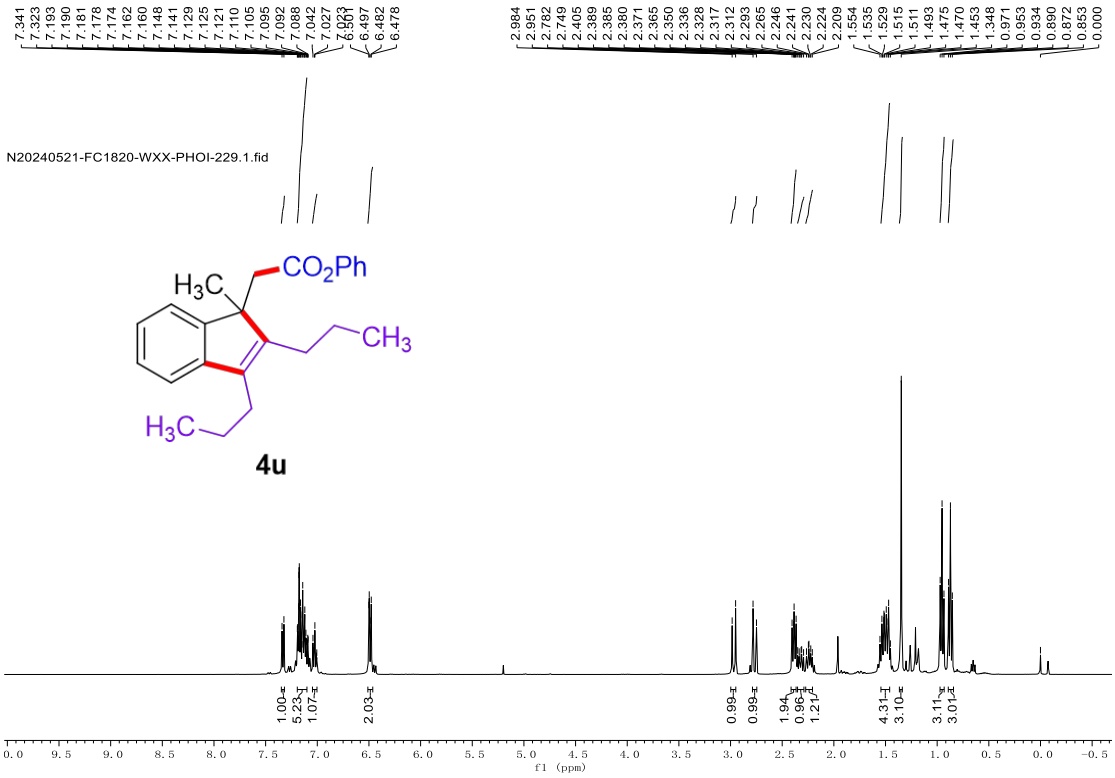
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4t**



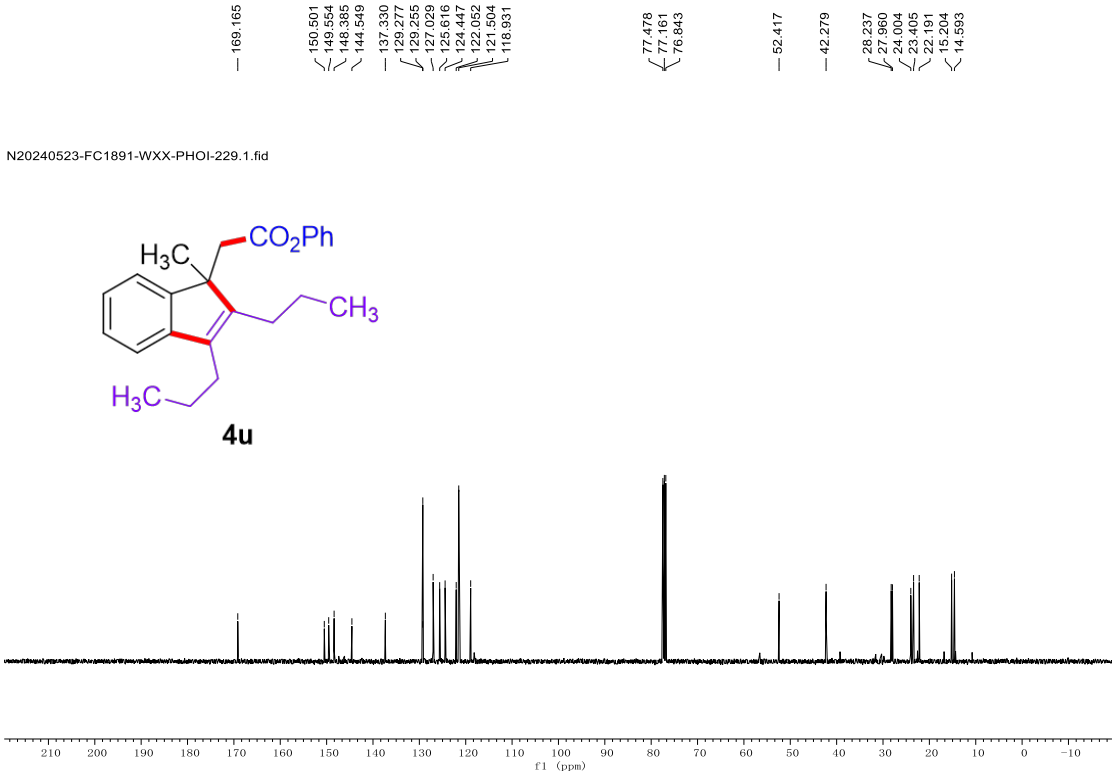
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4t**



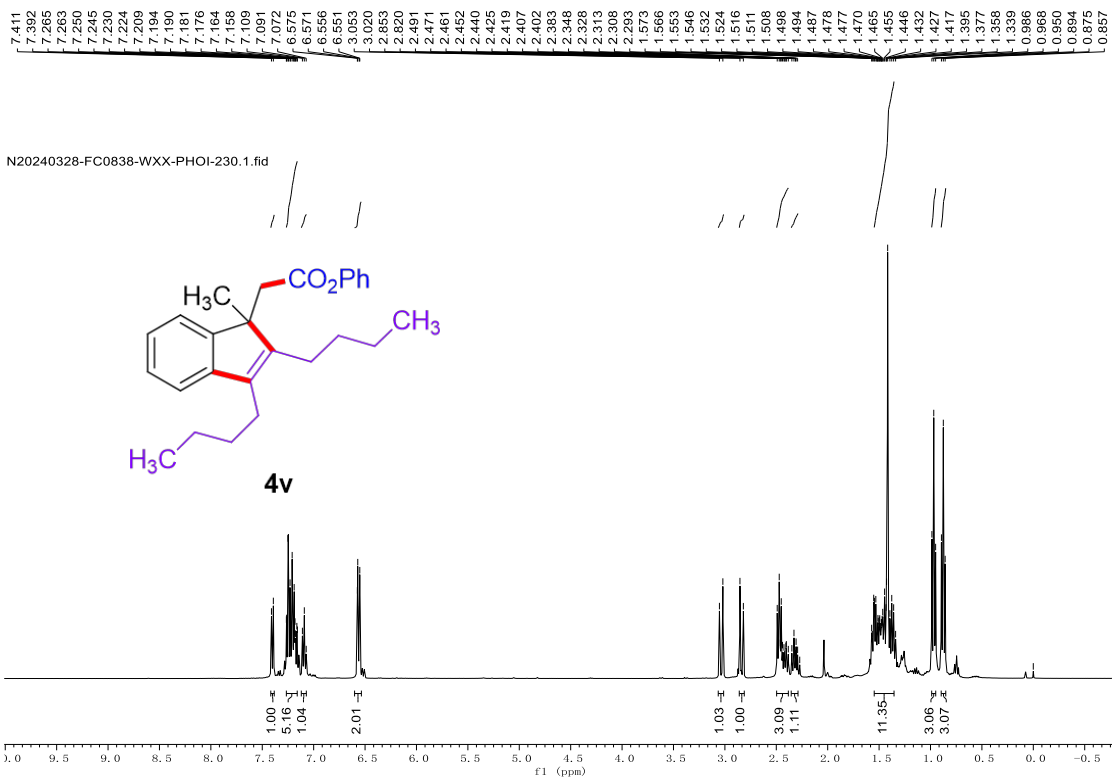
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4u**



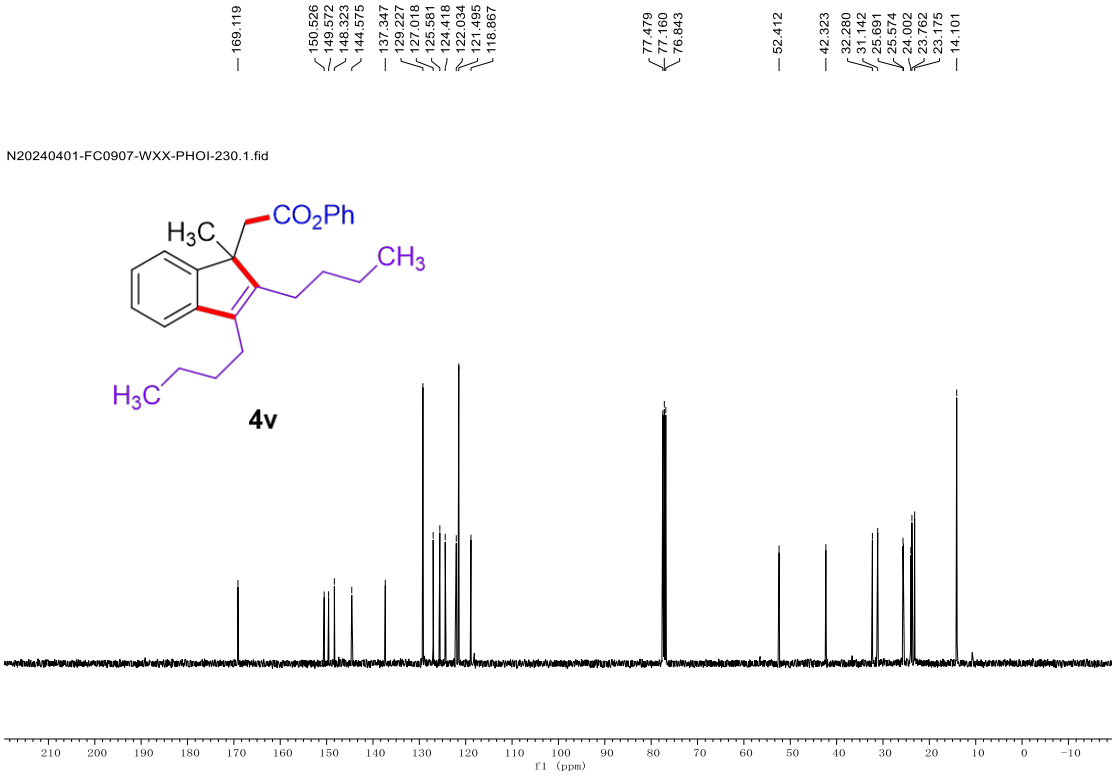
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4u**



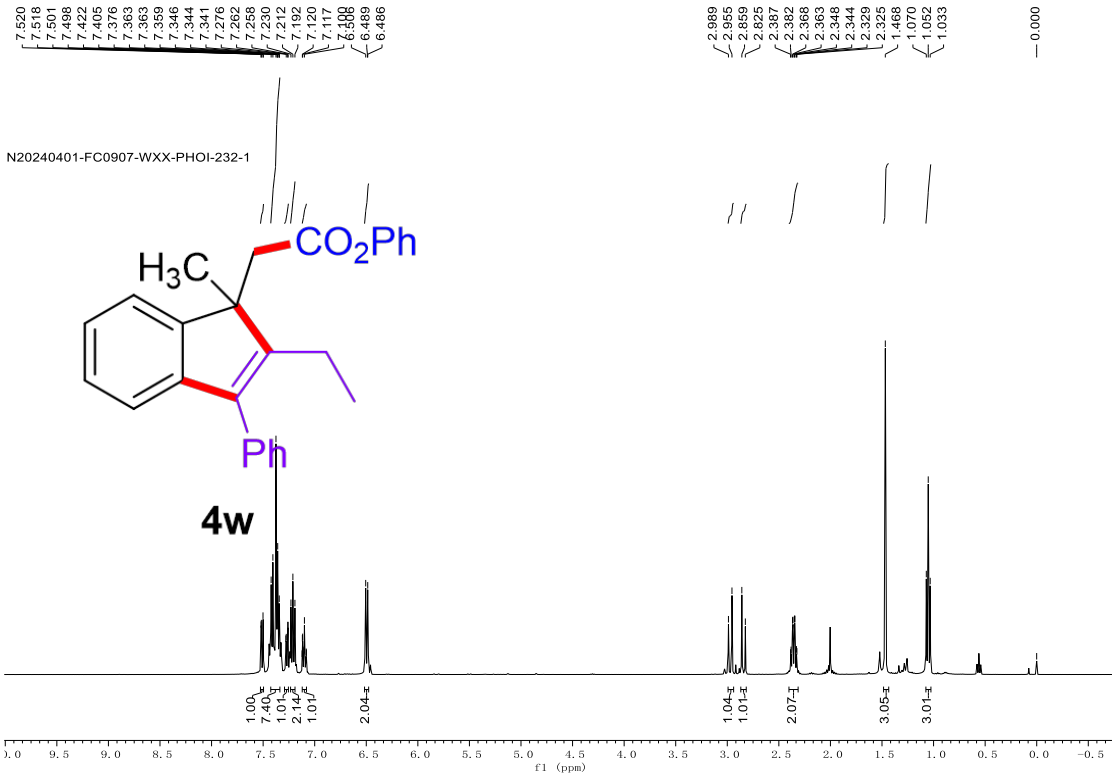
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4v**



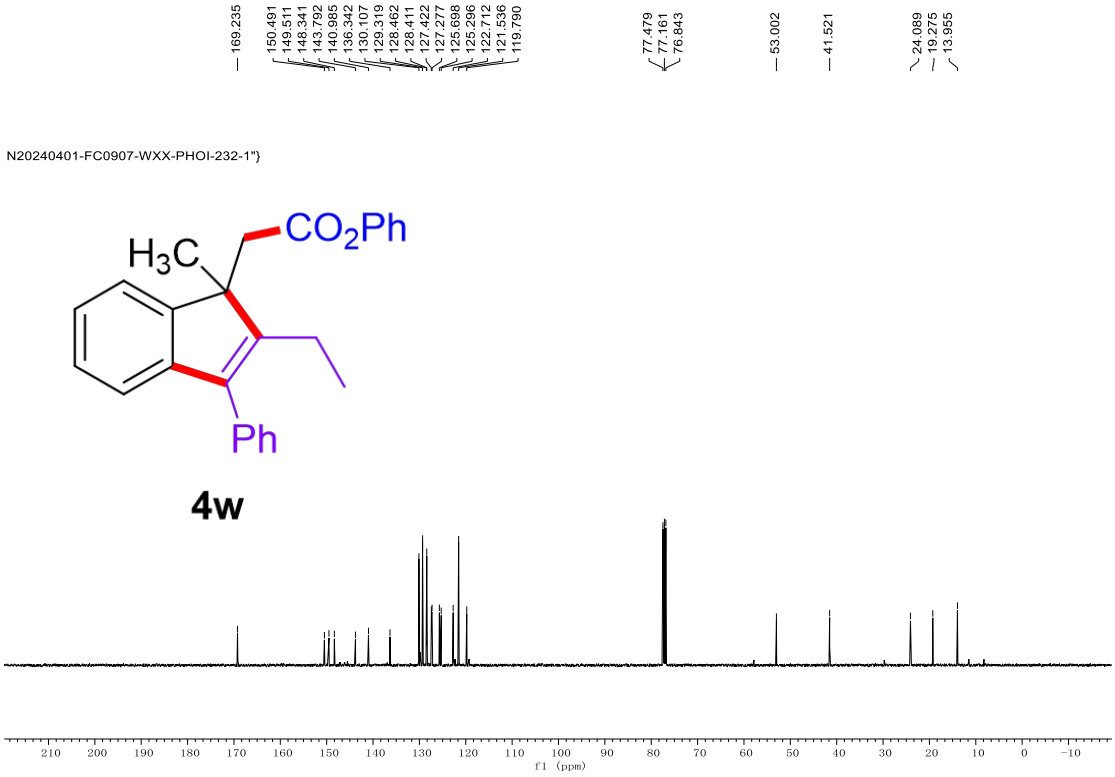
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4v**



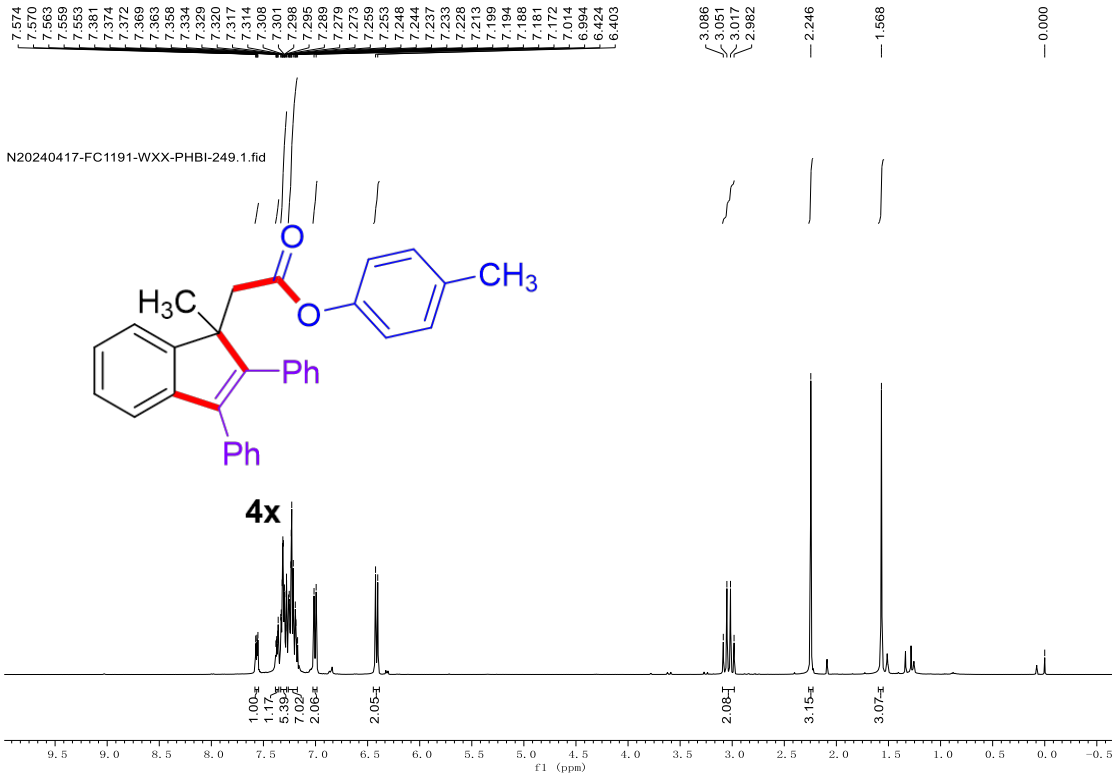
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4w**



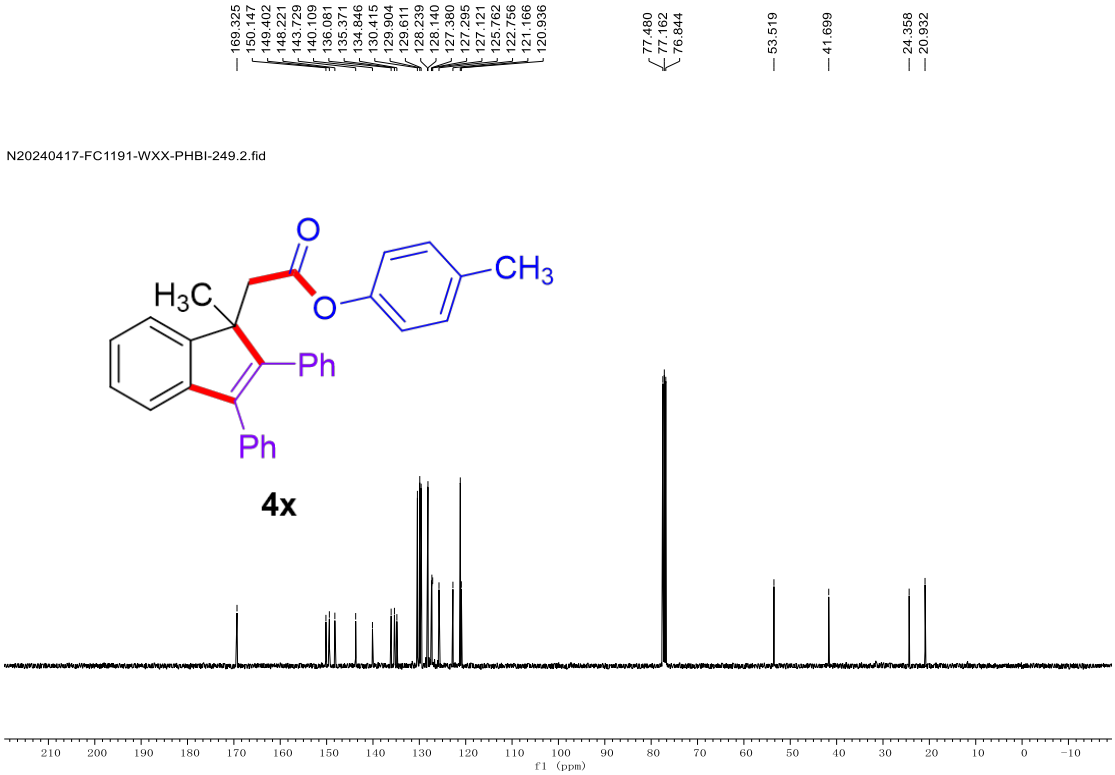
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4w**



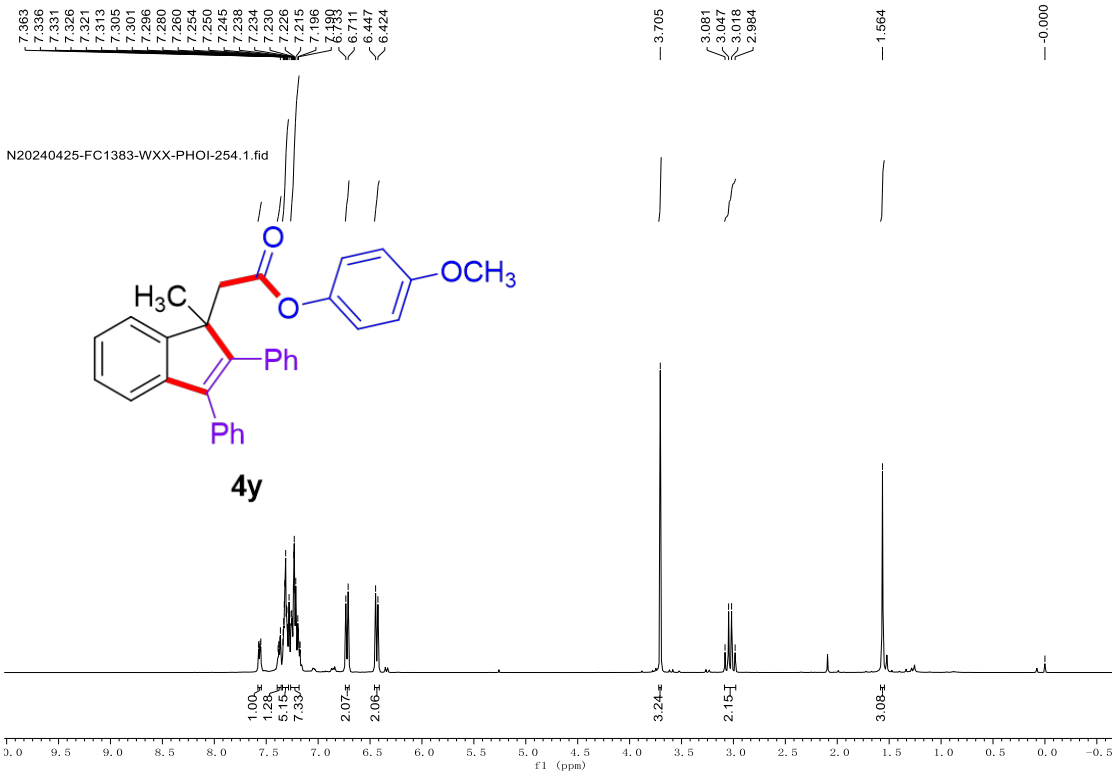
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4x**



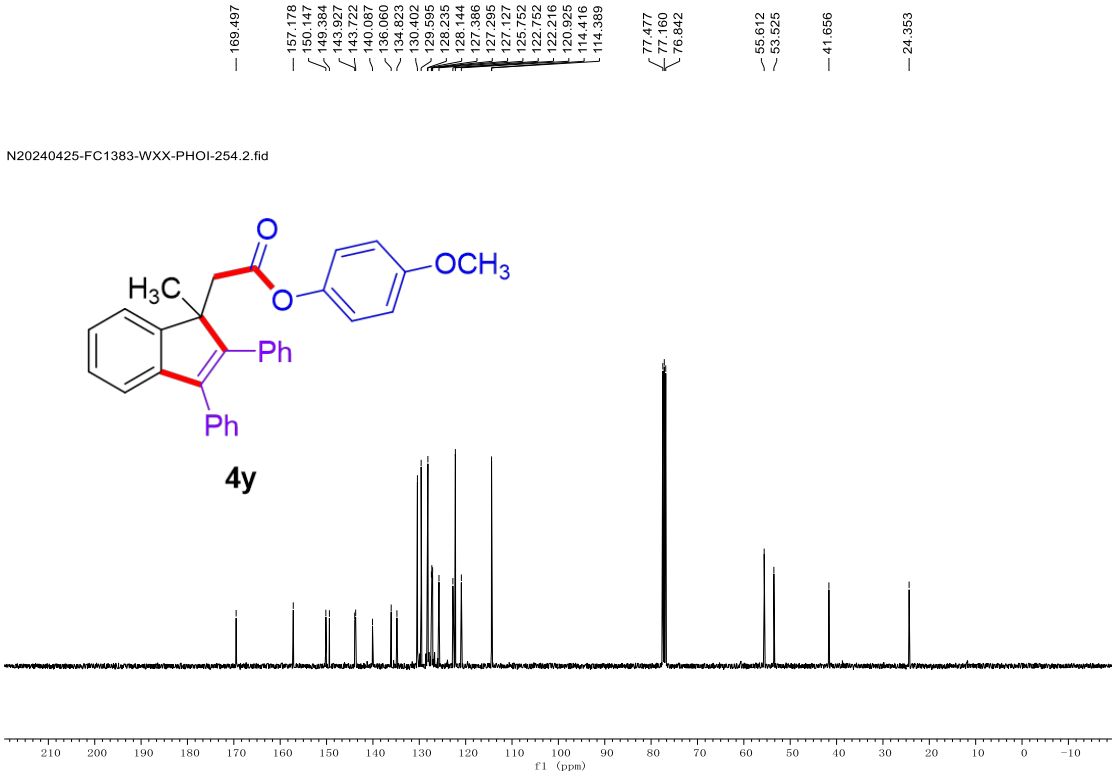
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4x**



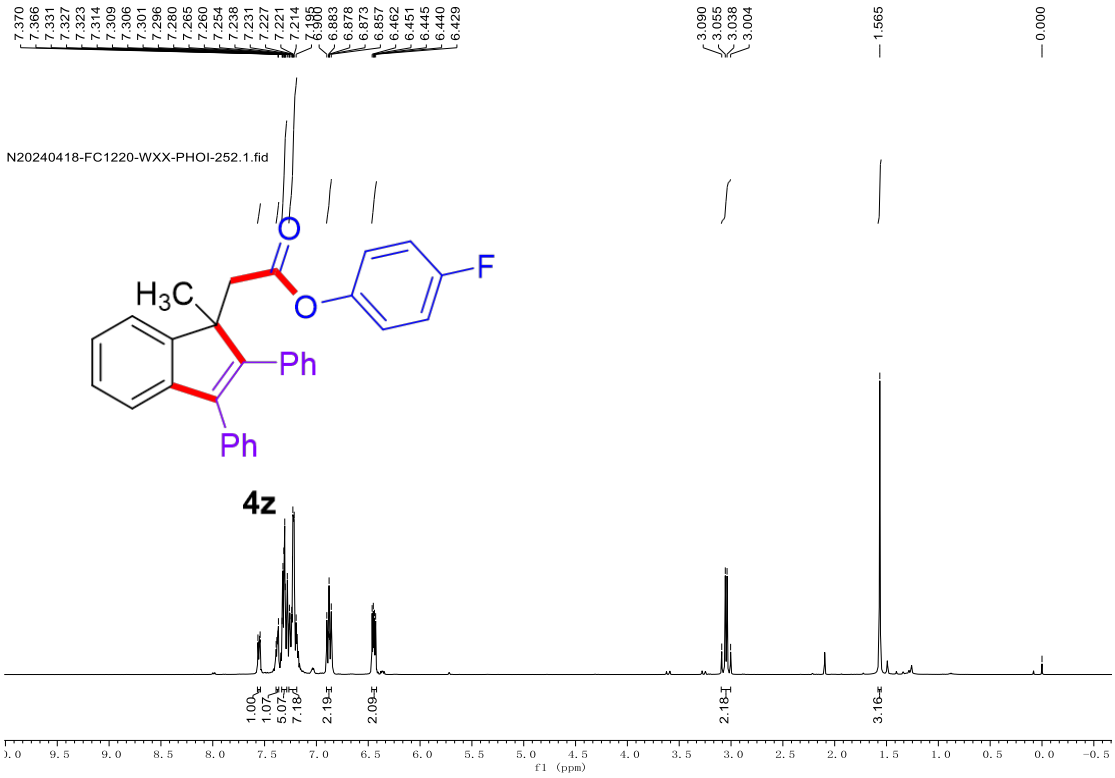
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4y**



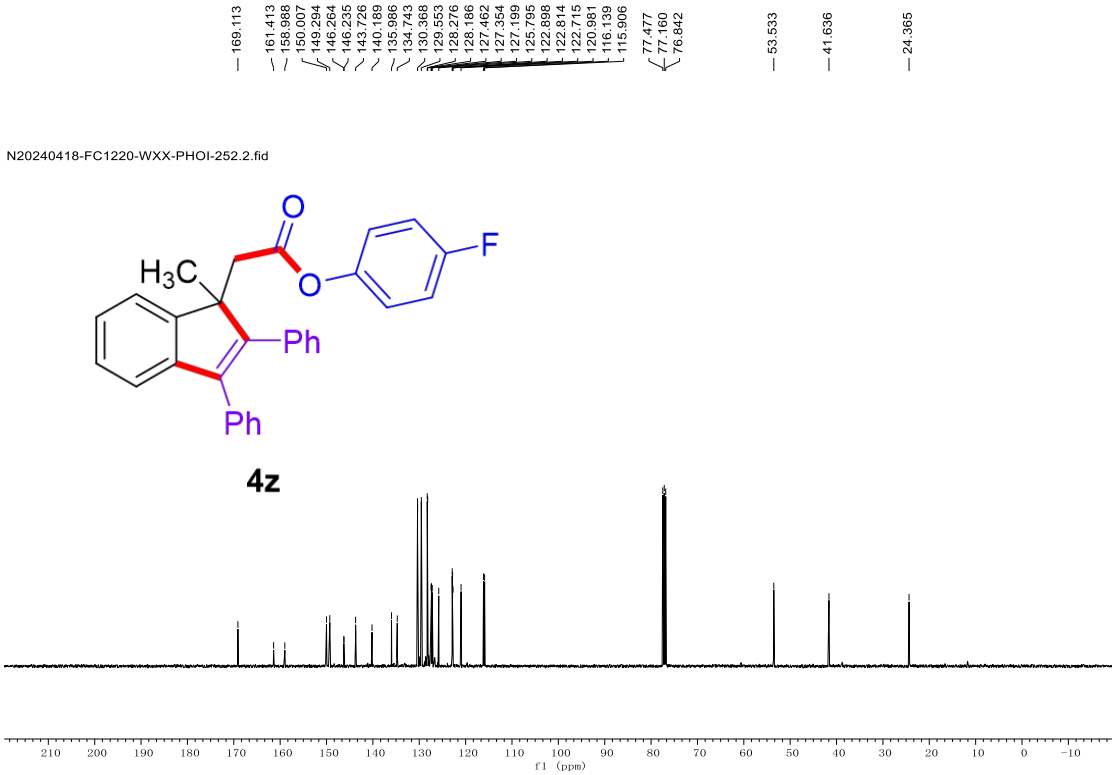
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4y**



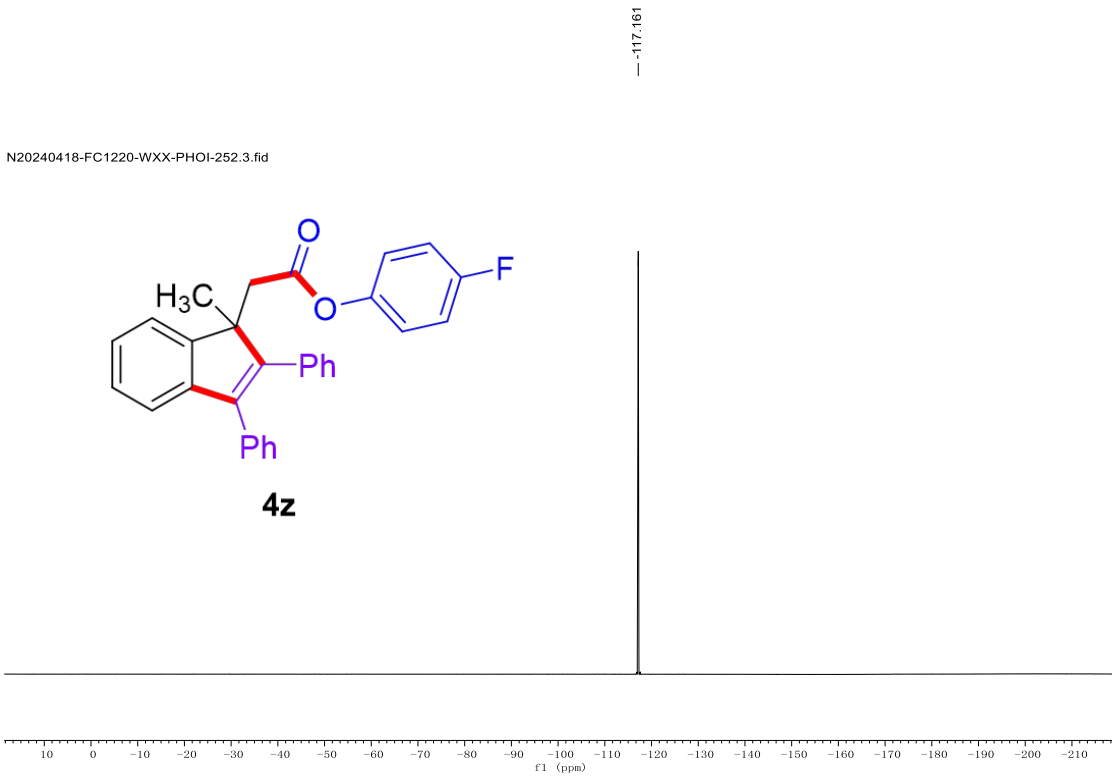
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4z**



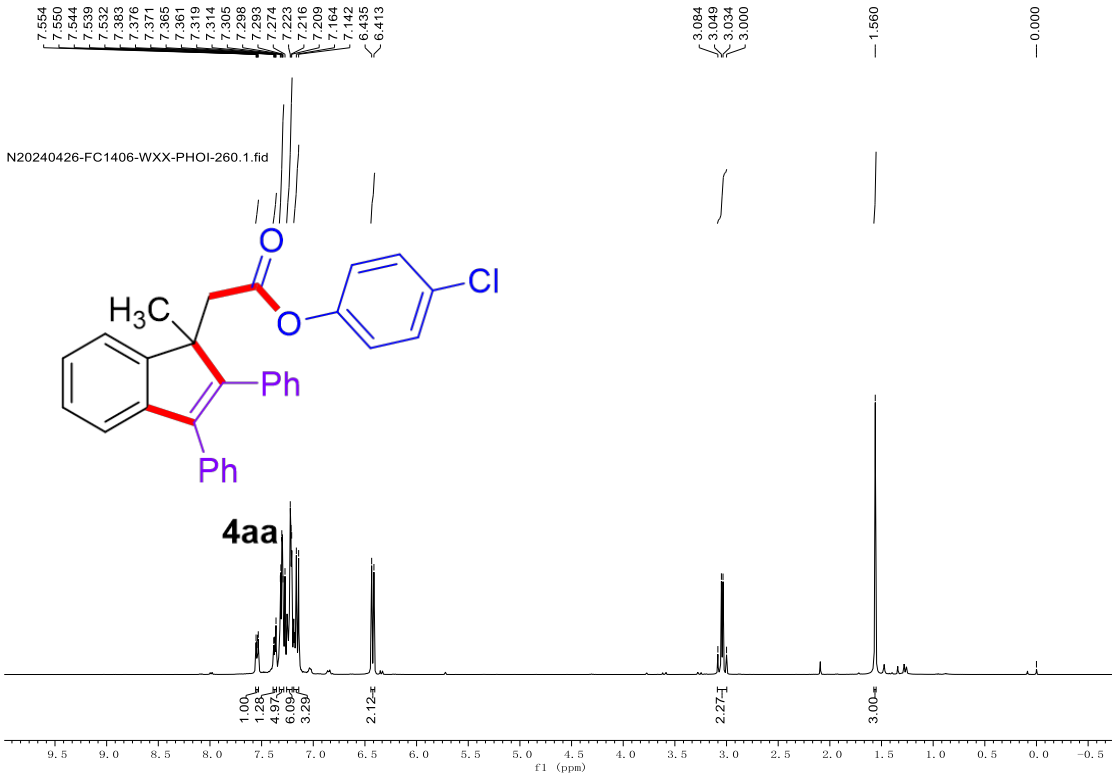
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4z**



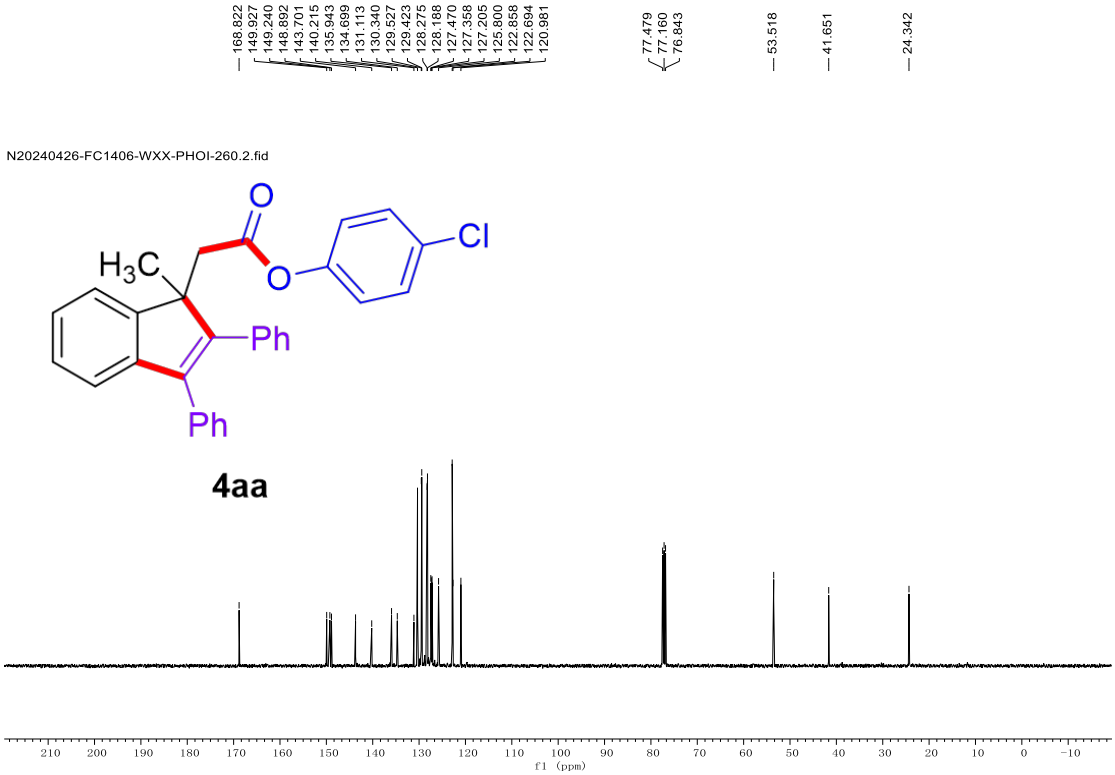
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4z**



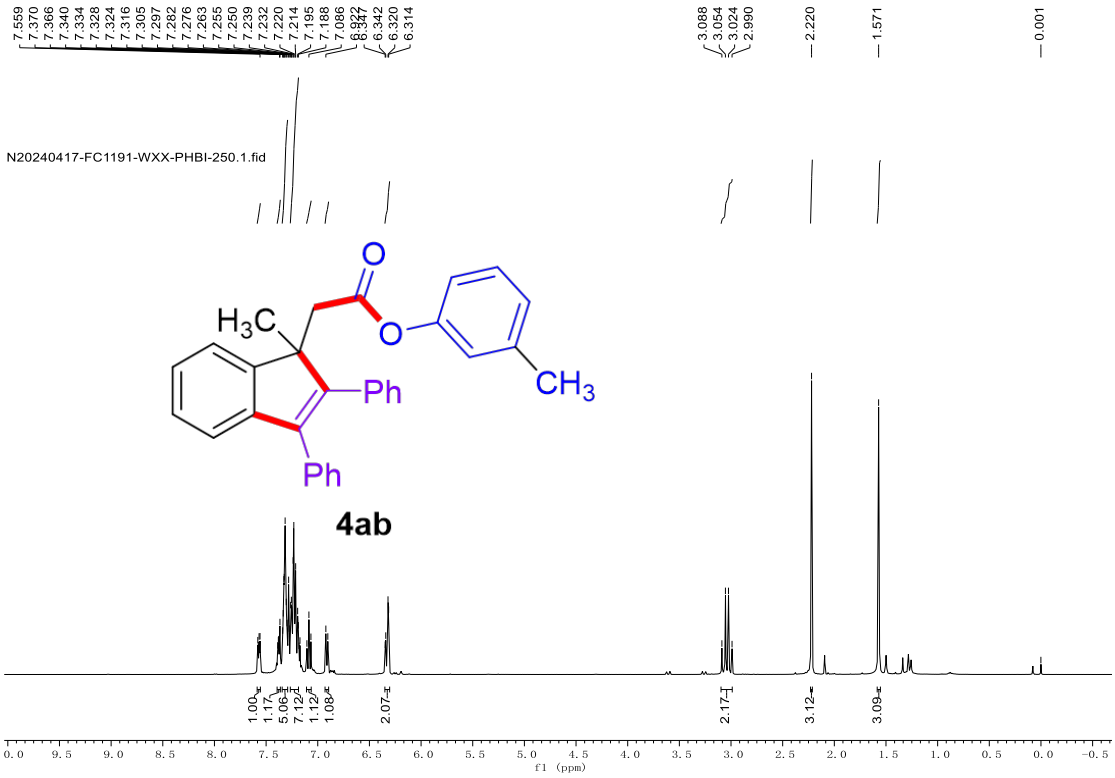
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4aa**



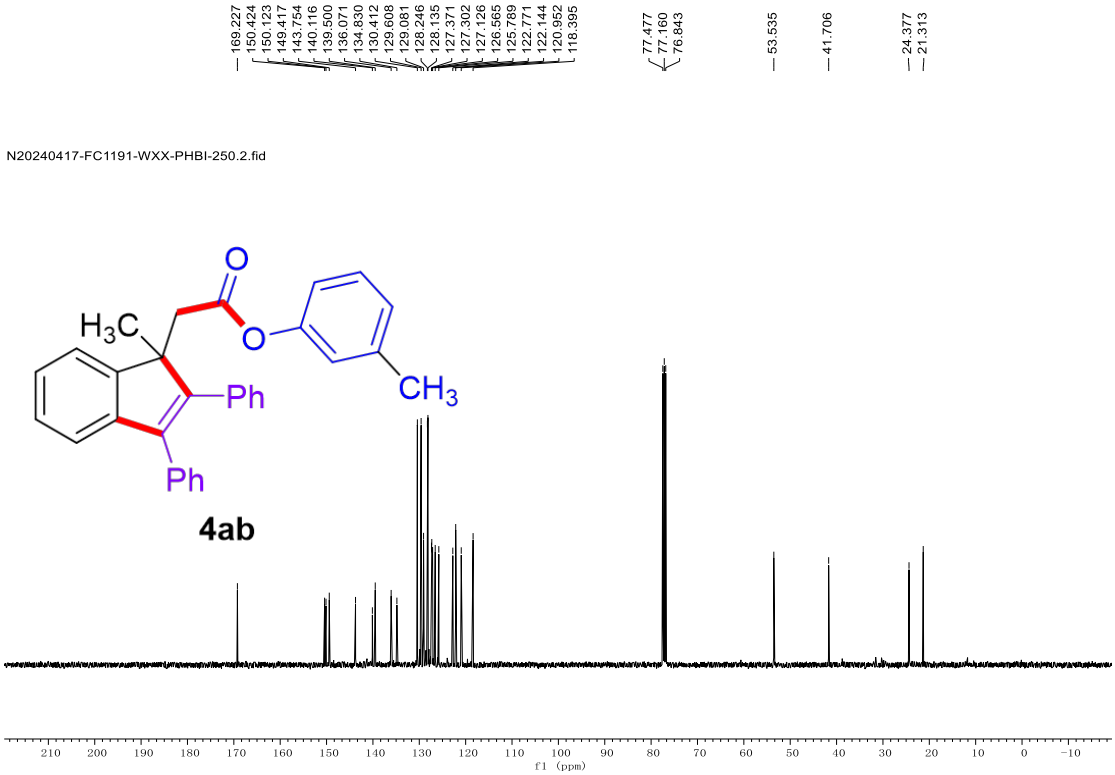
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4aa**



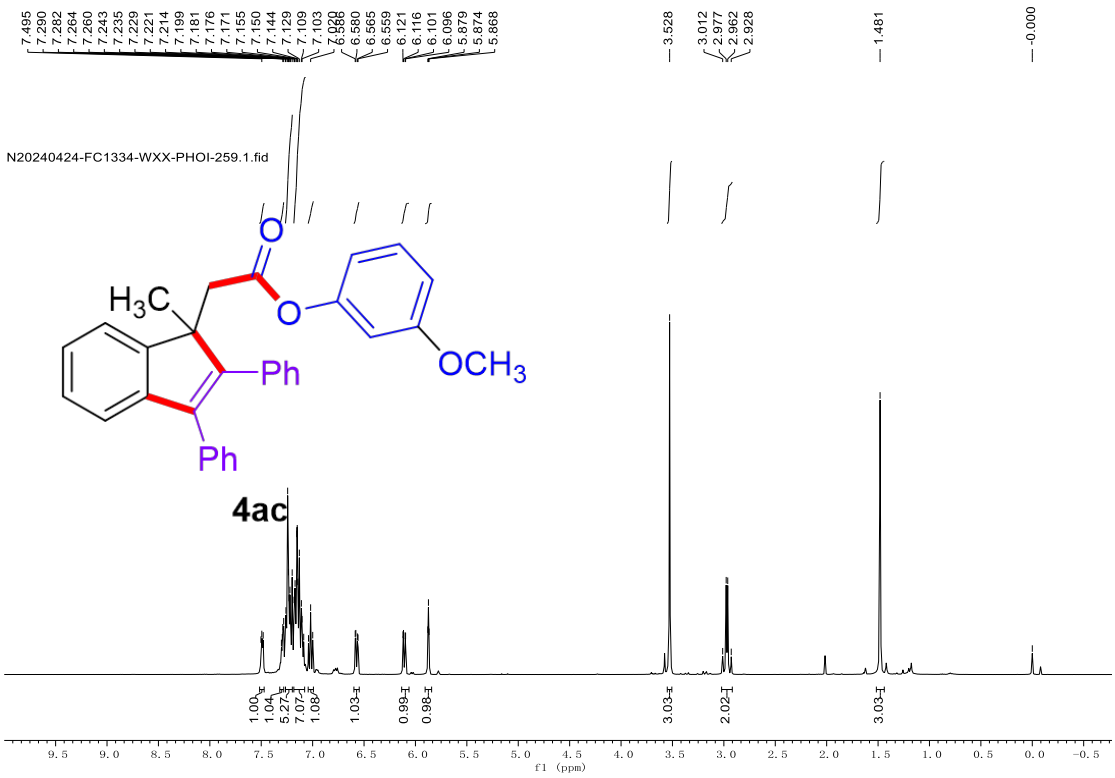
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ab**



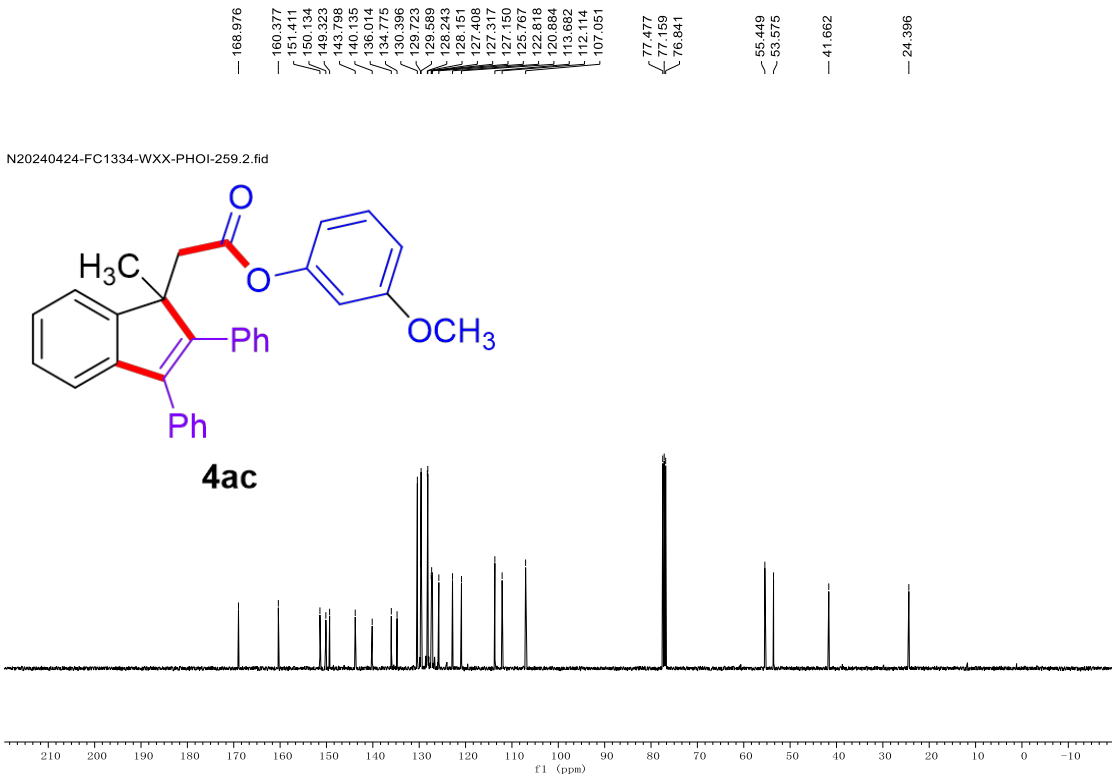
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ab**



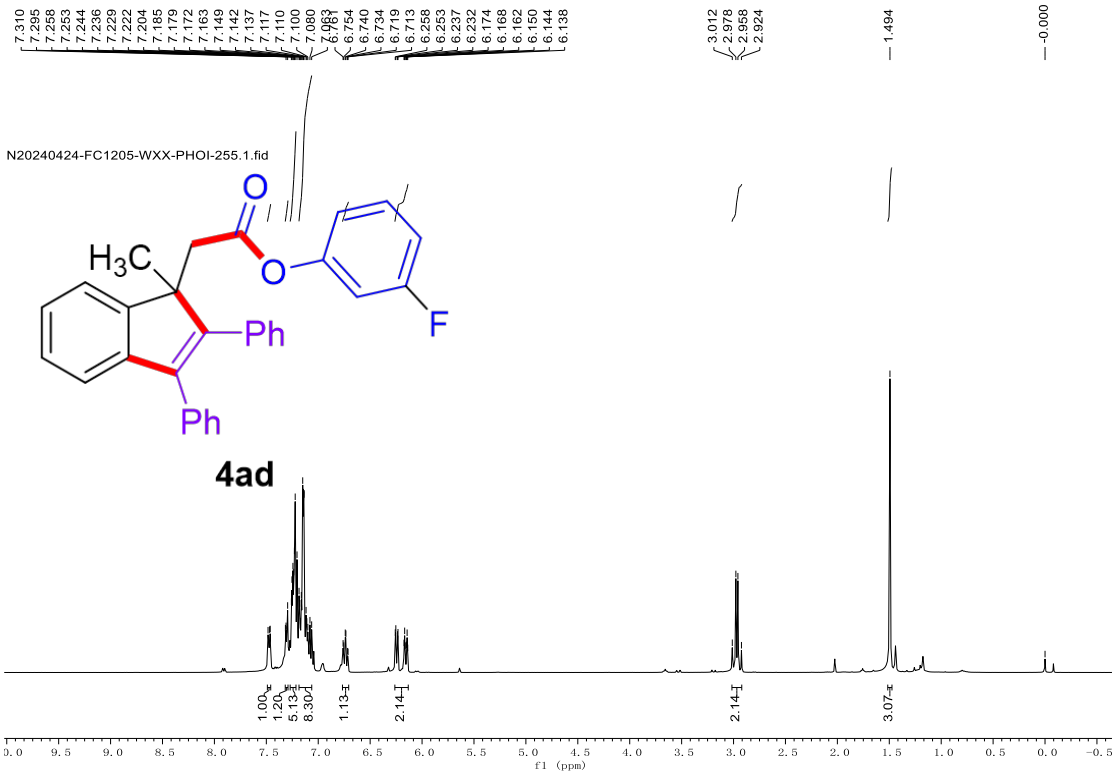
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ac**



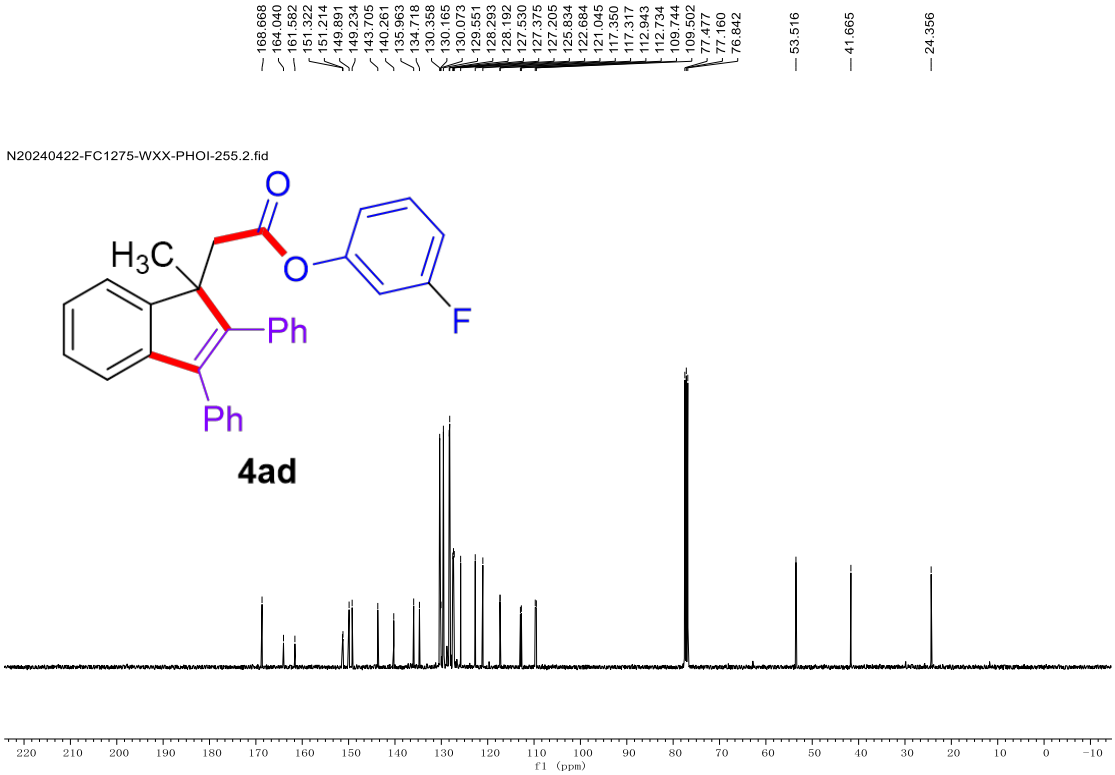
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ac**



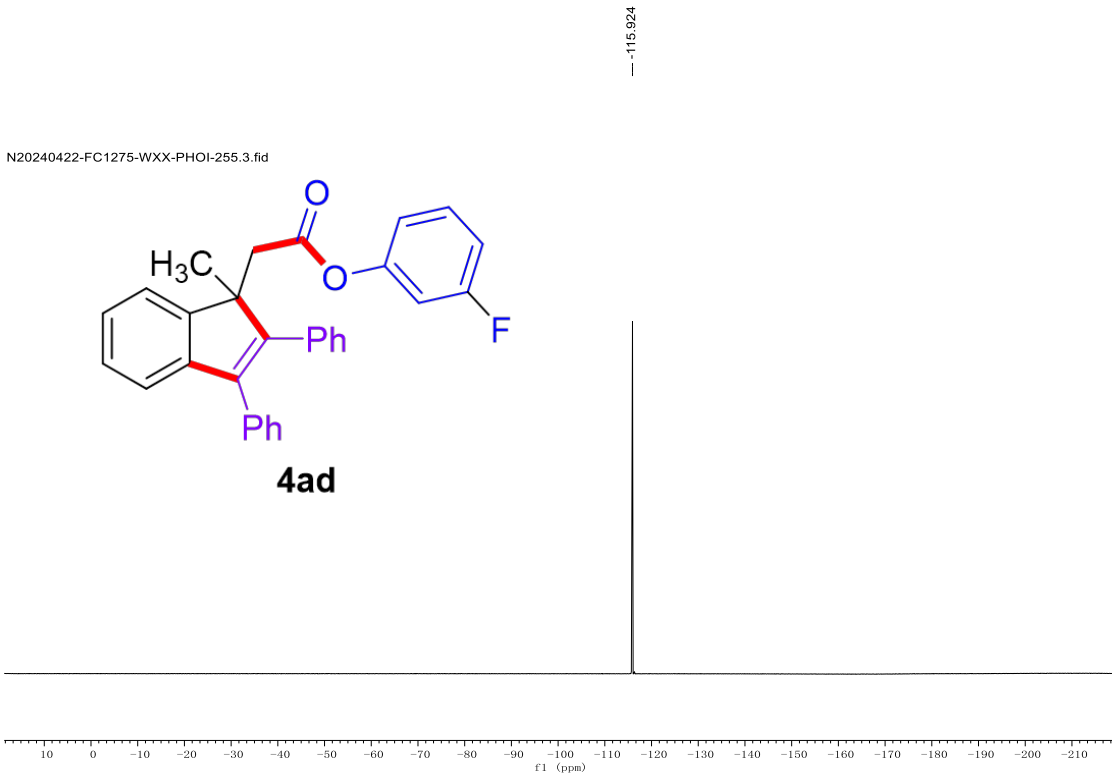
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ad**



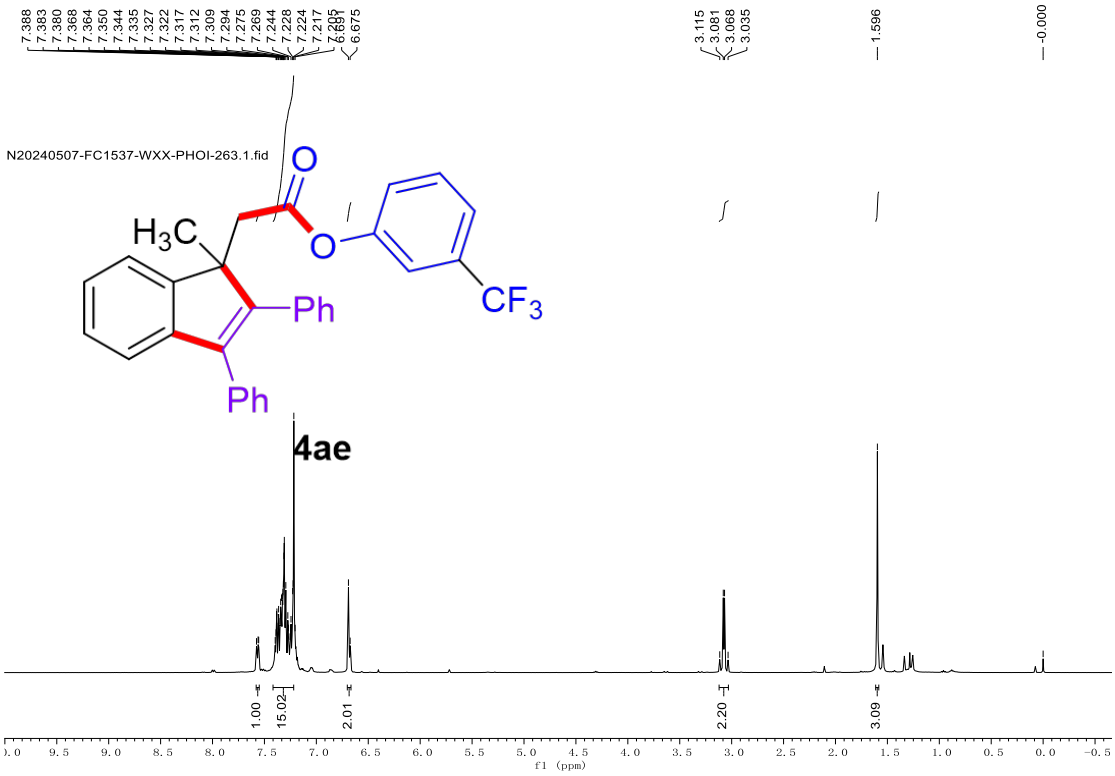
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ad**



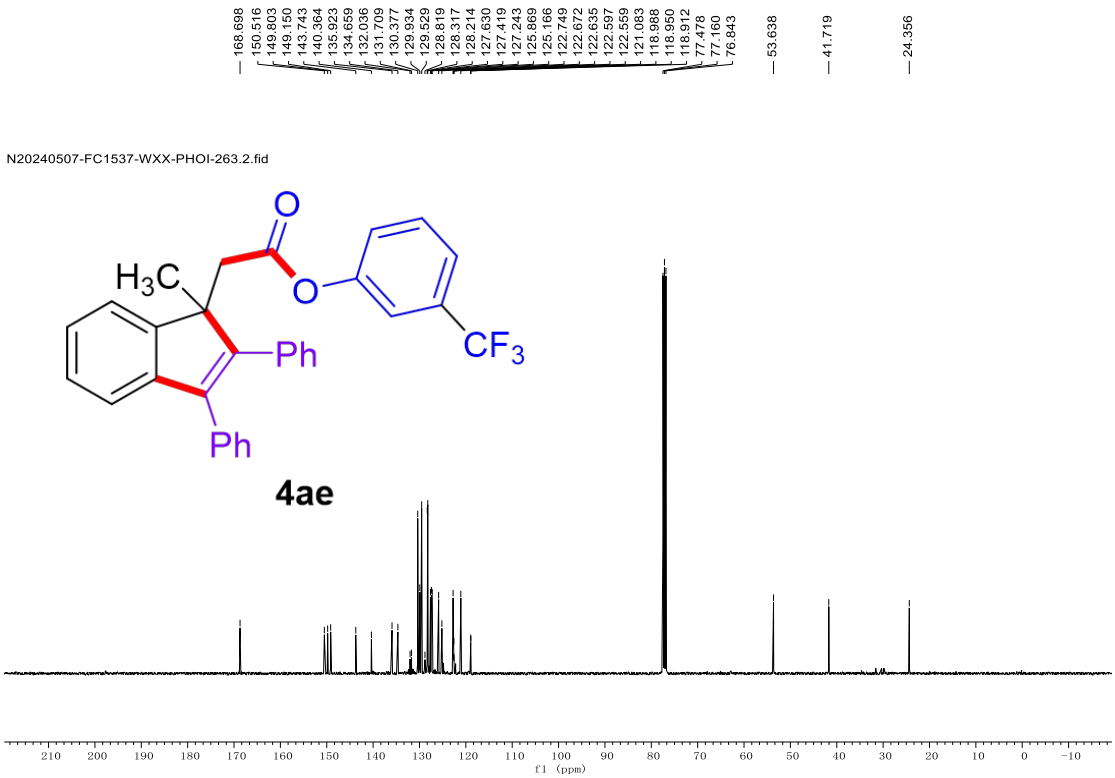
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4ad**



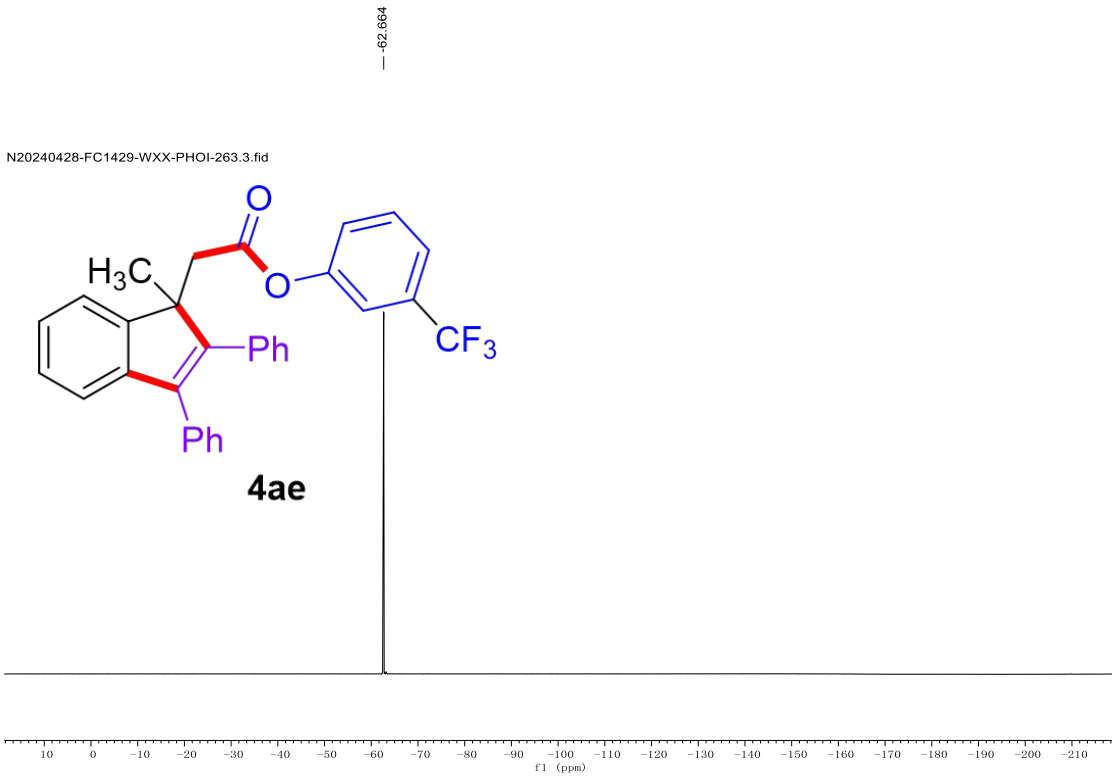
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ae**



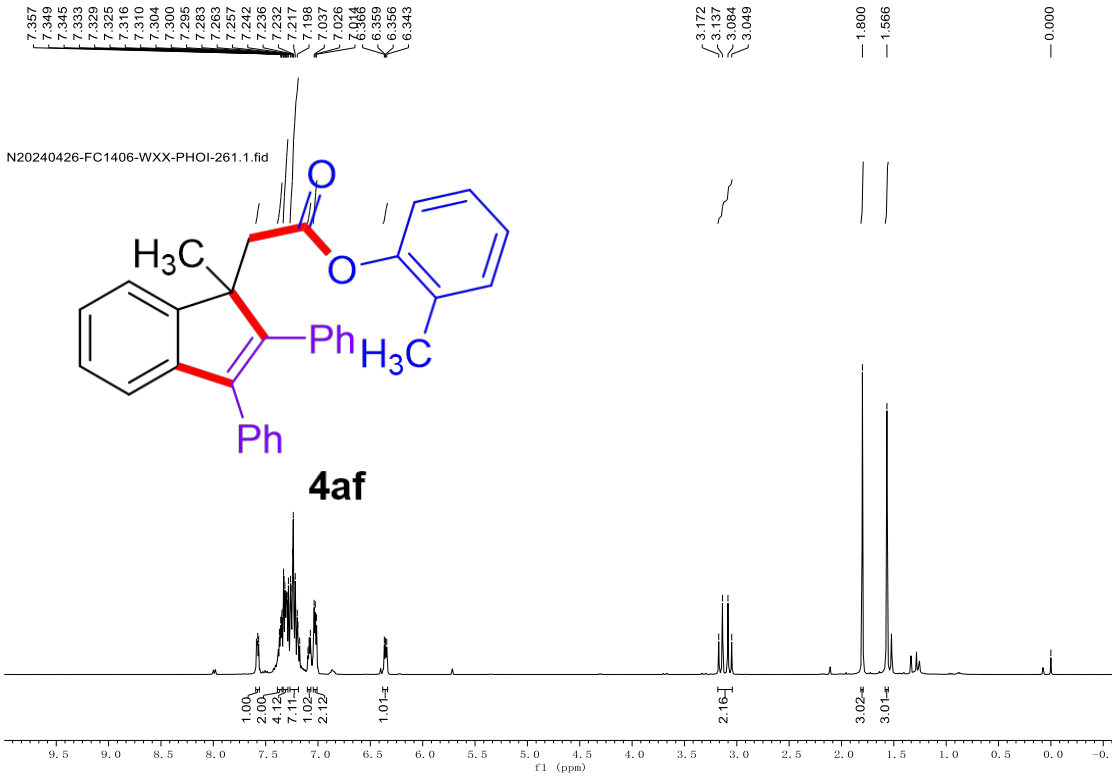
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ae**



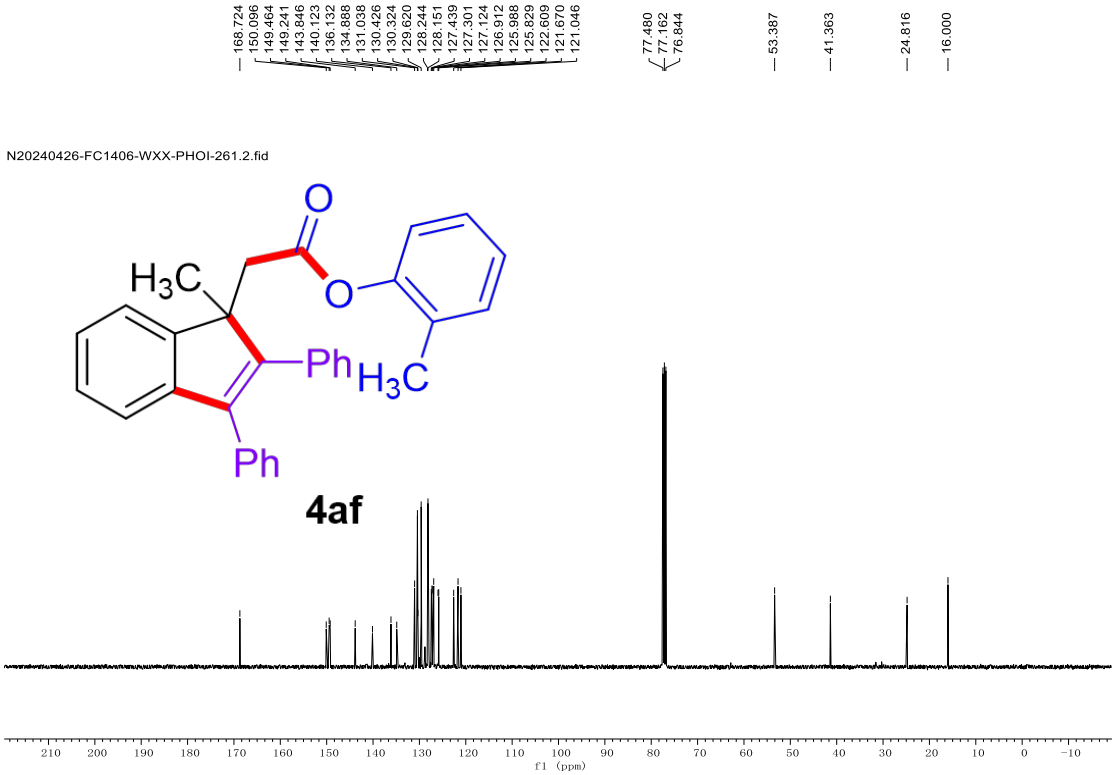
^{19}F NMR (376 MHz, $CDCl_3$) Spectrum of **4ae**



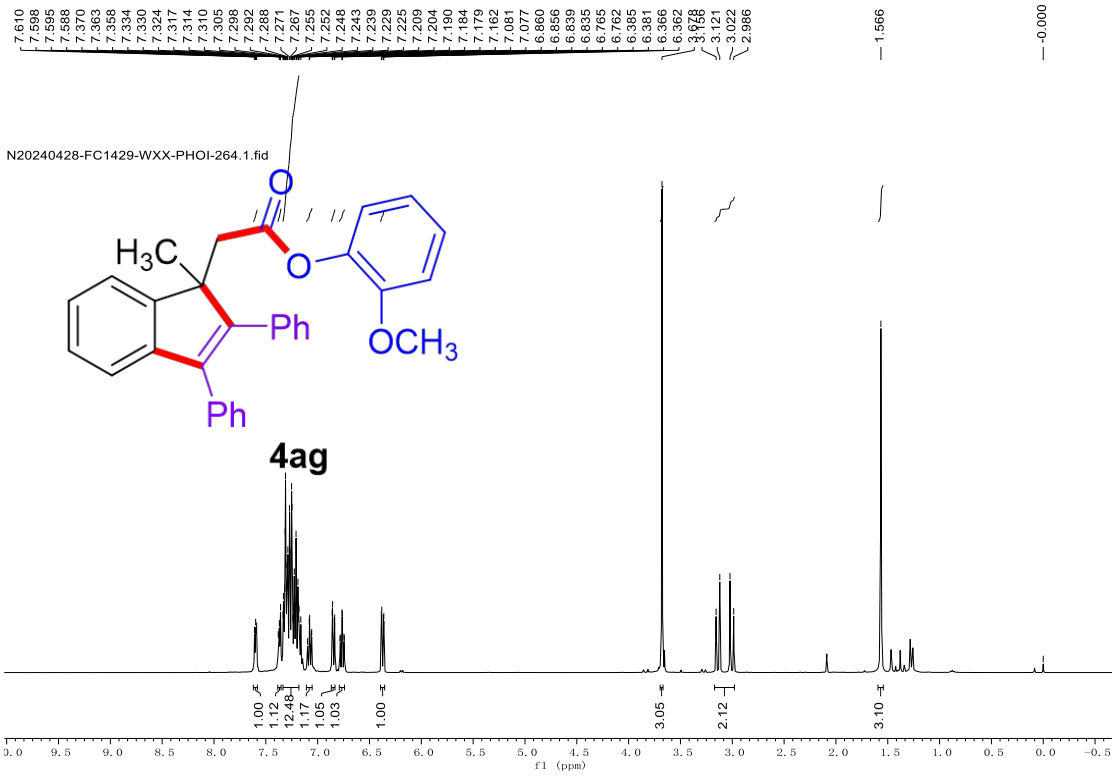
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4af**



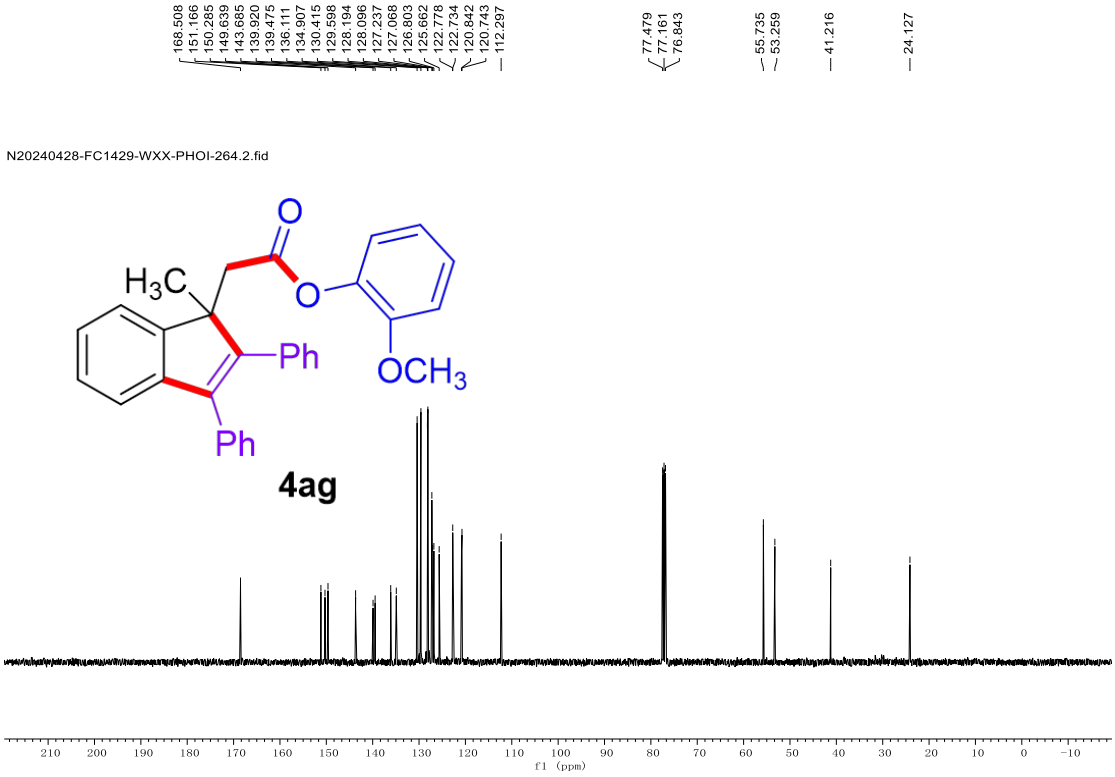
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4af**



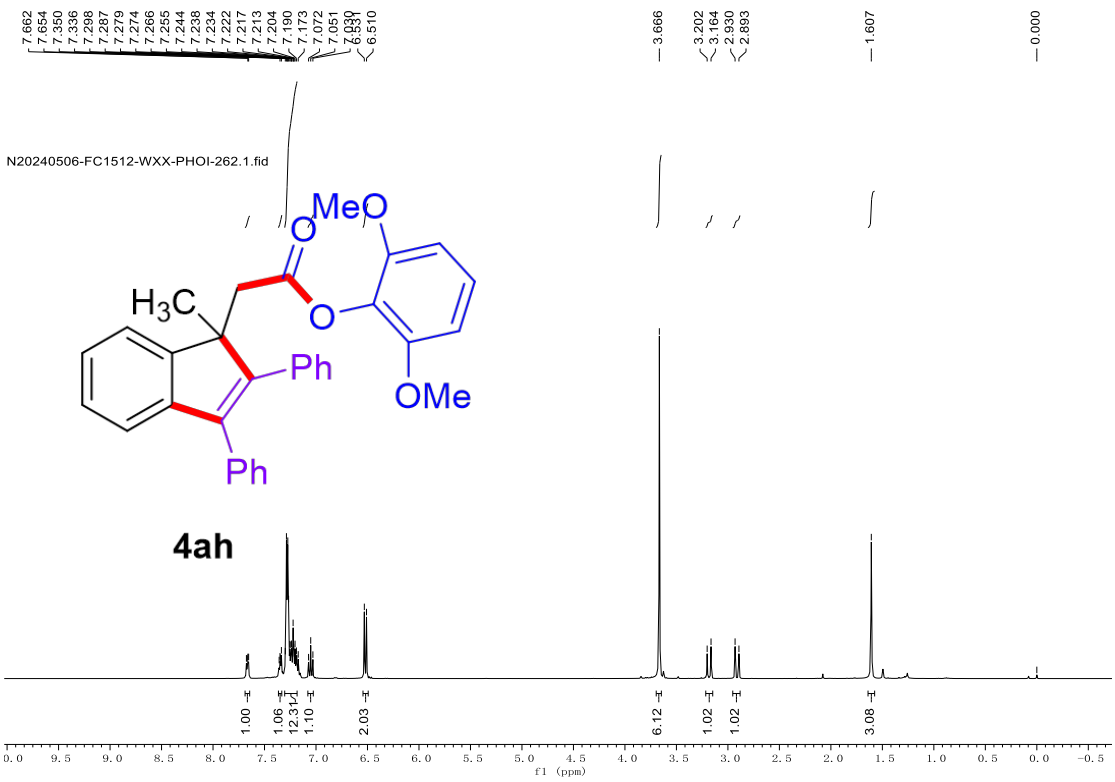
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ag**



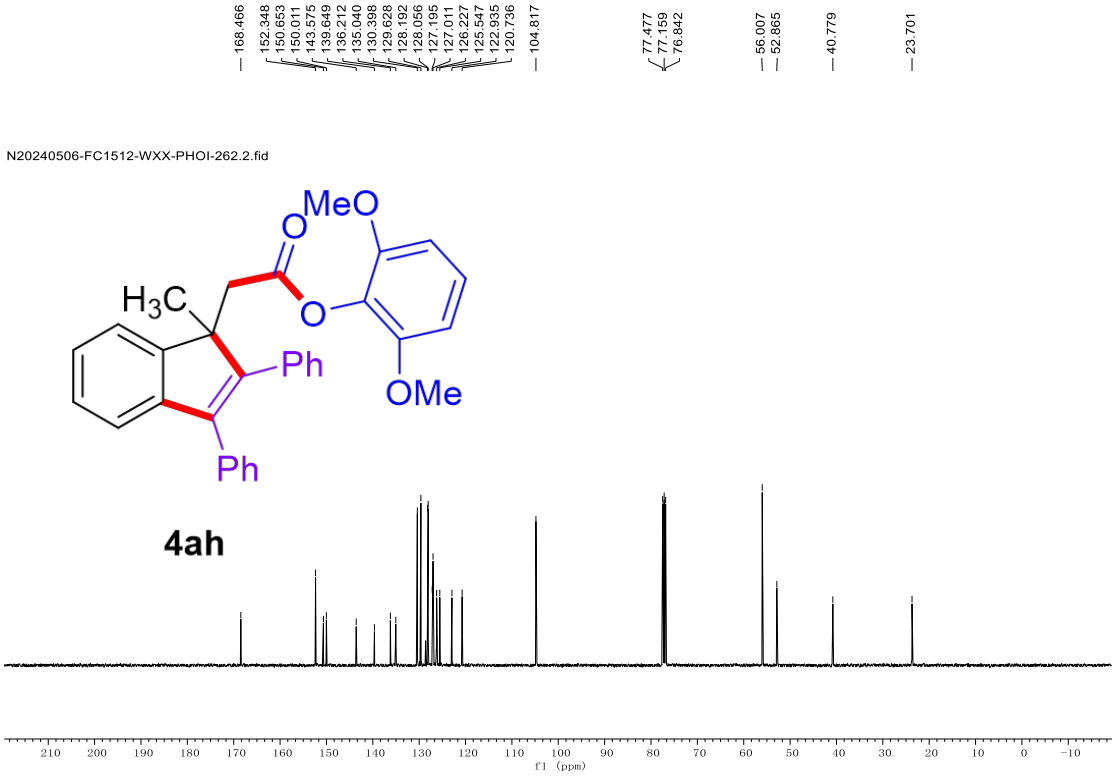
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ag**



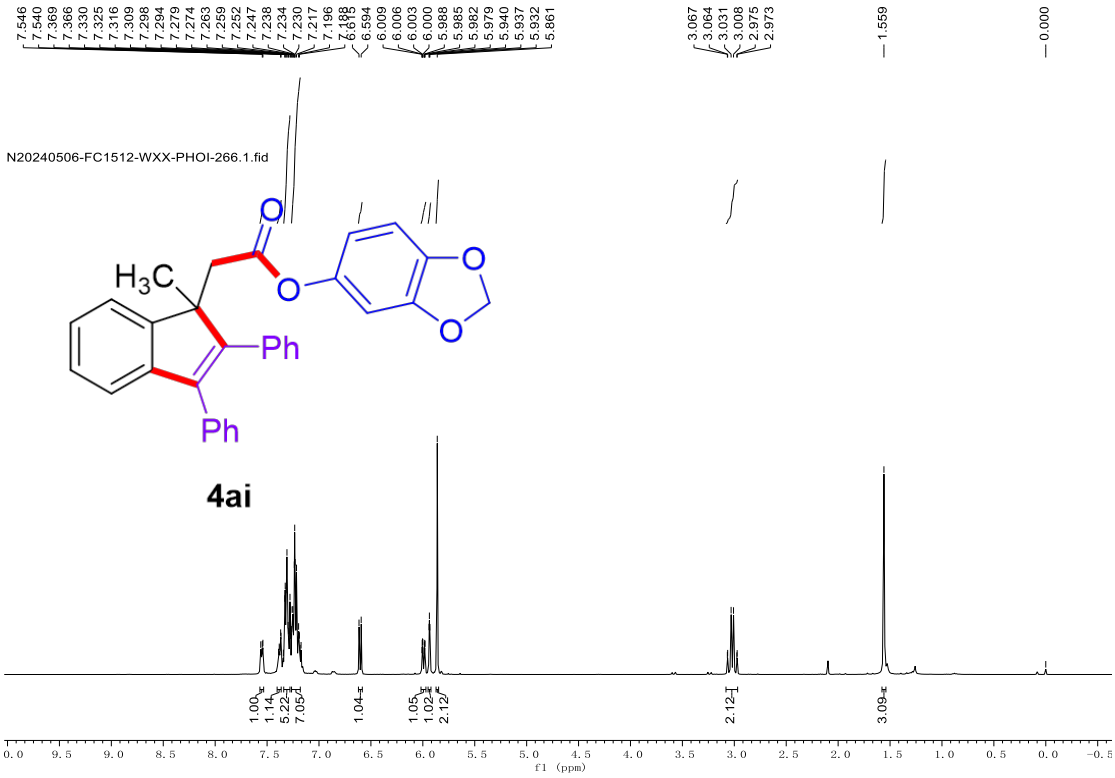
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ah**



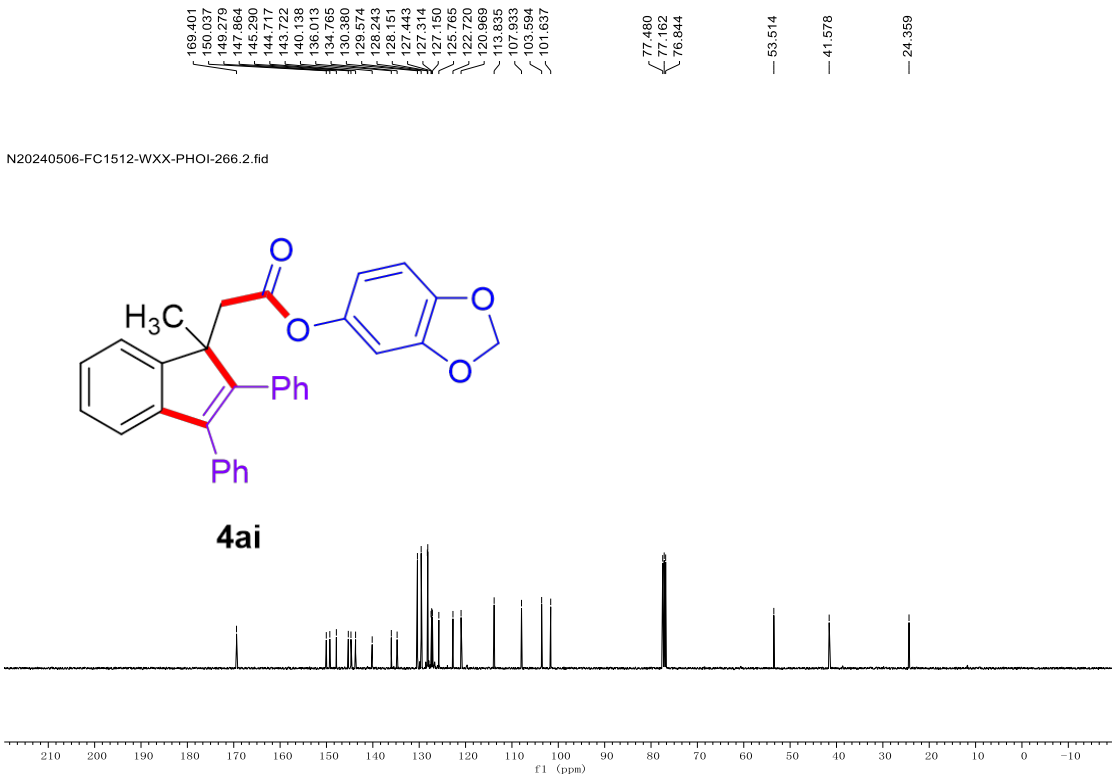
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ah**



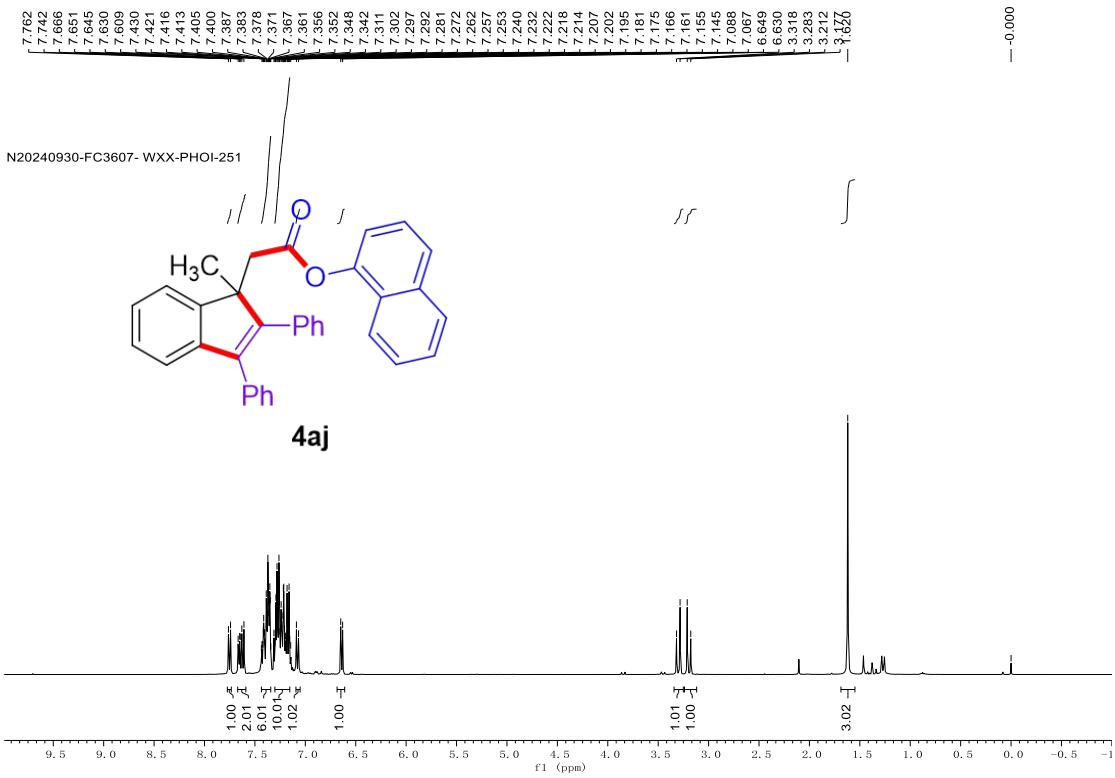
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4ai**



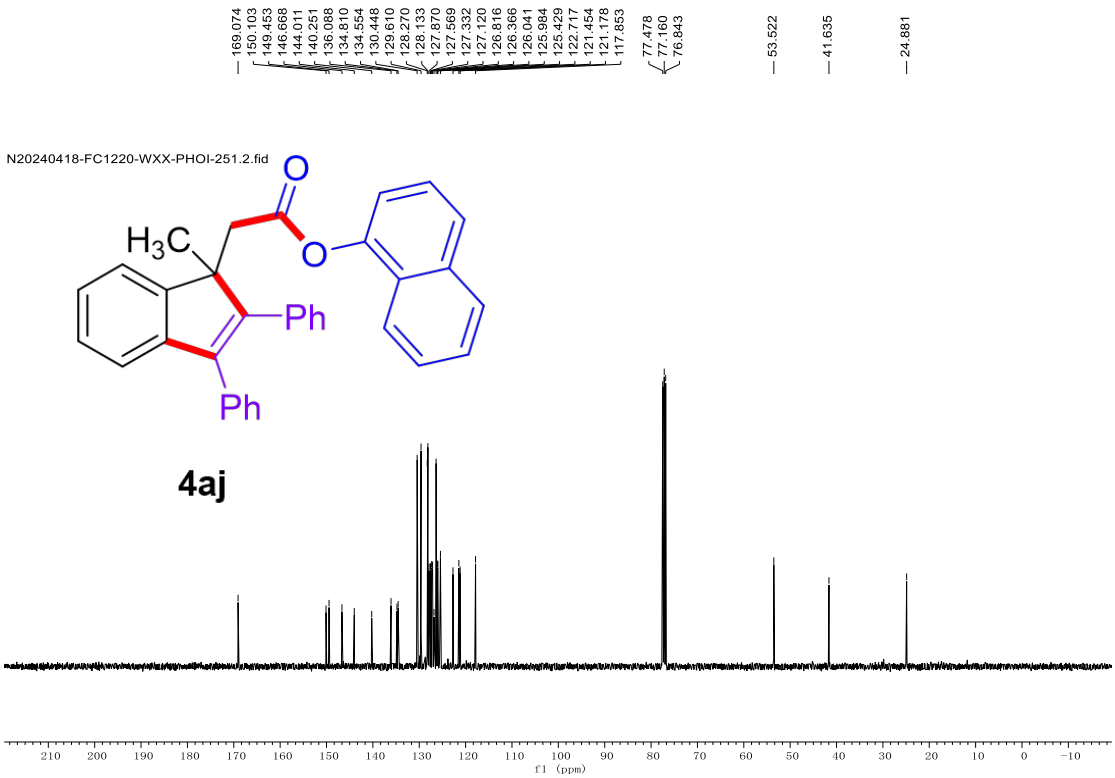
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4ai**



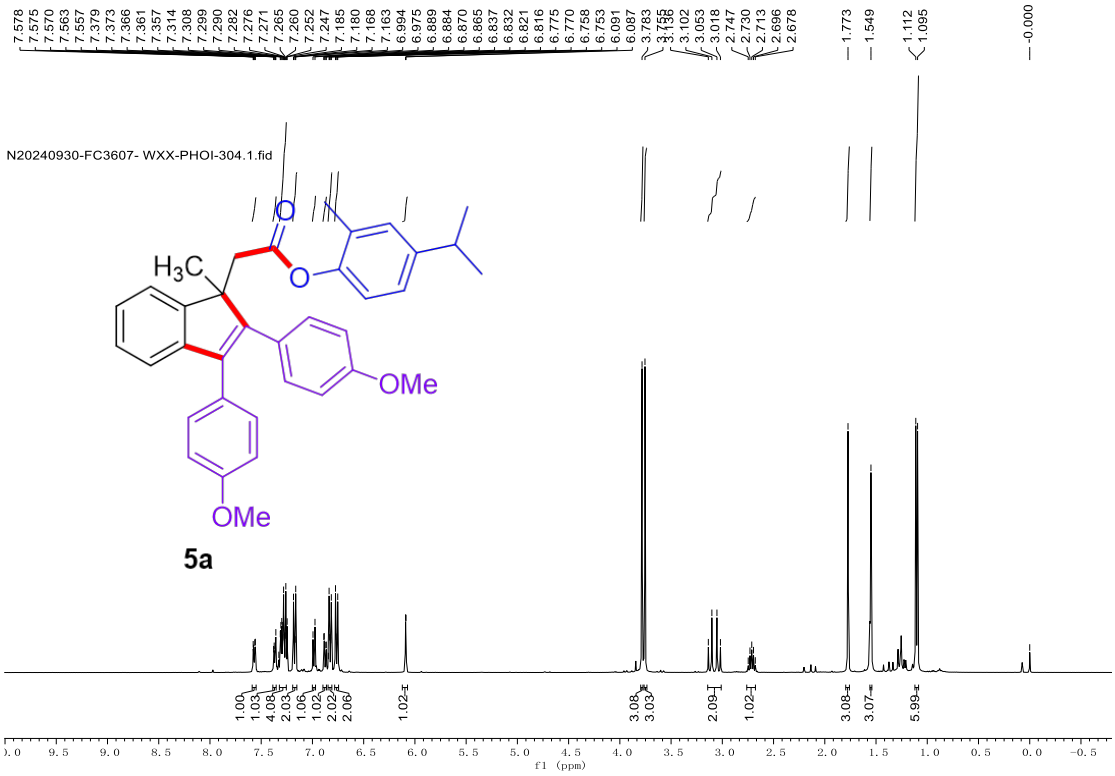
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **4aj**



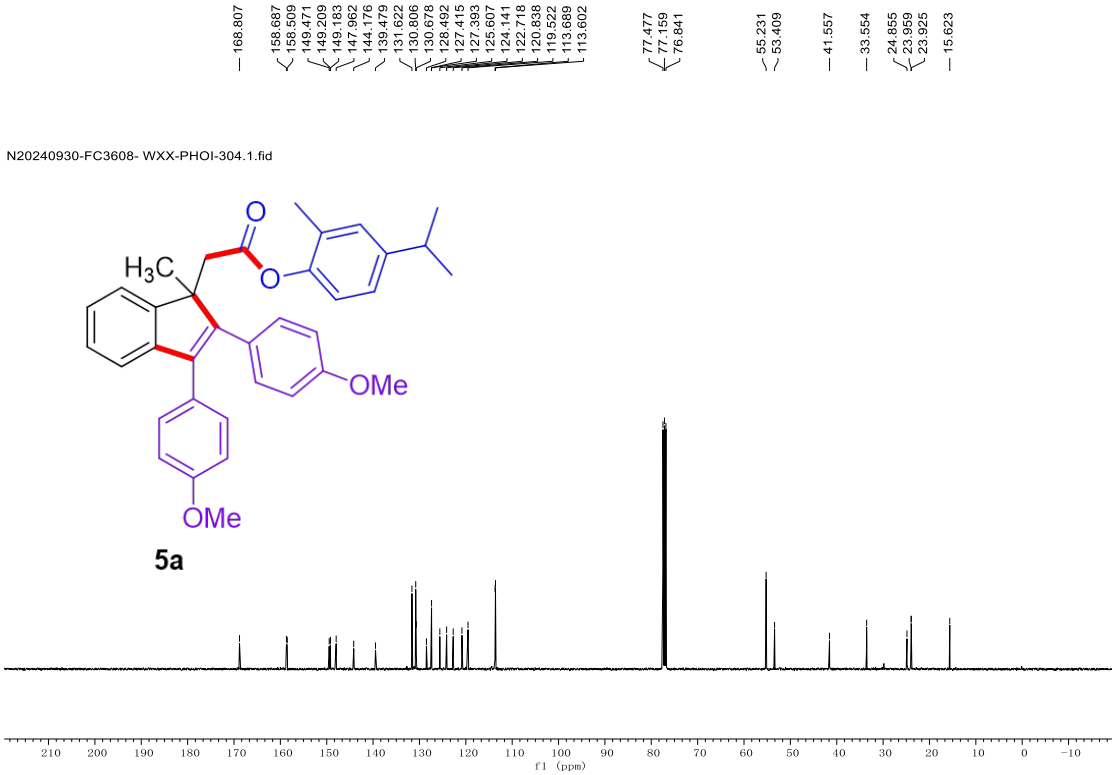
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **4aj**



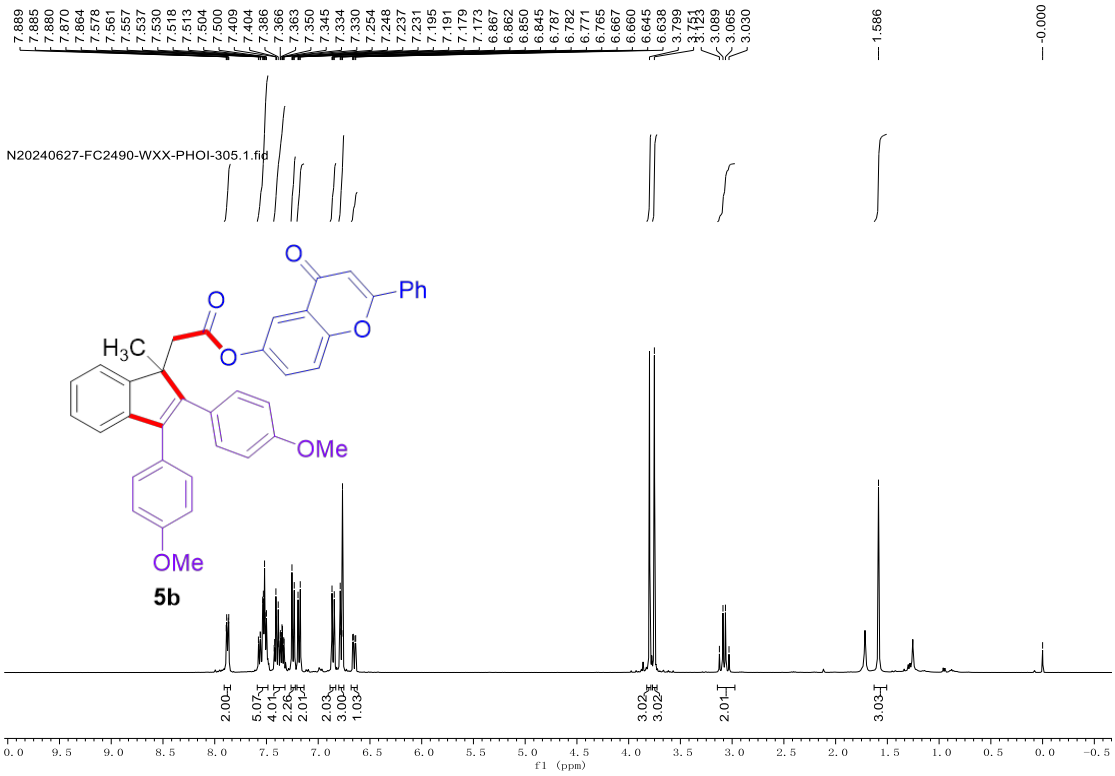
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **5a**



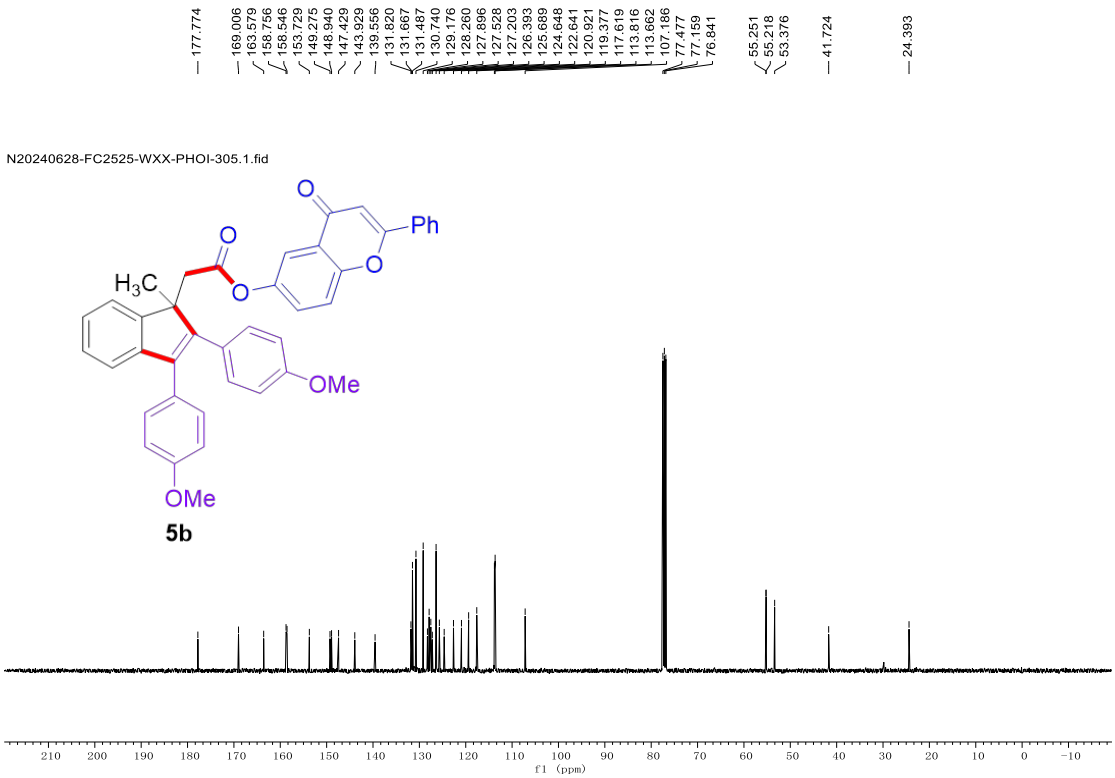
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **5a**



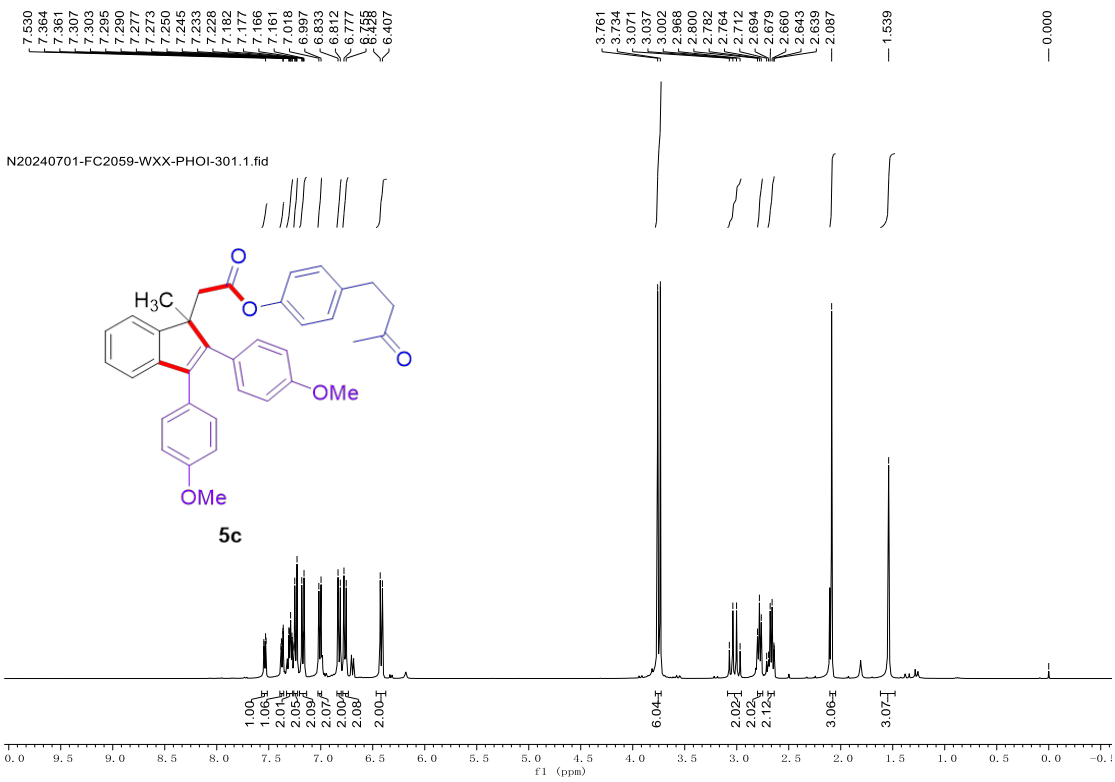
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **5b**



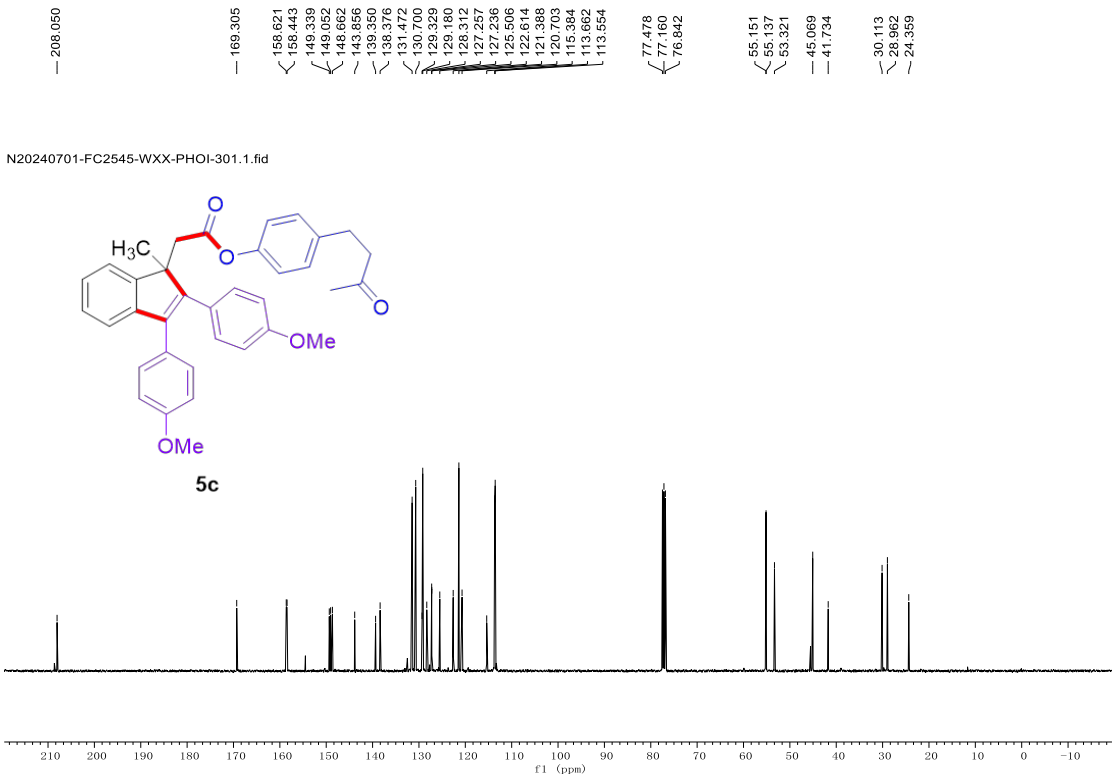
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **5b**



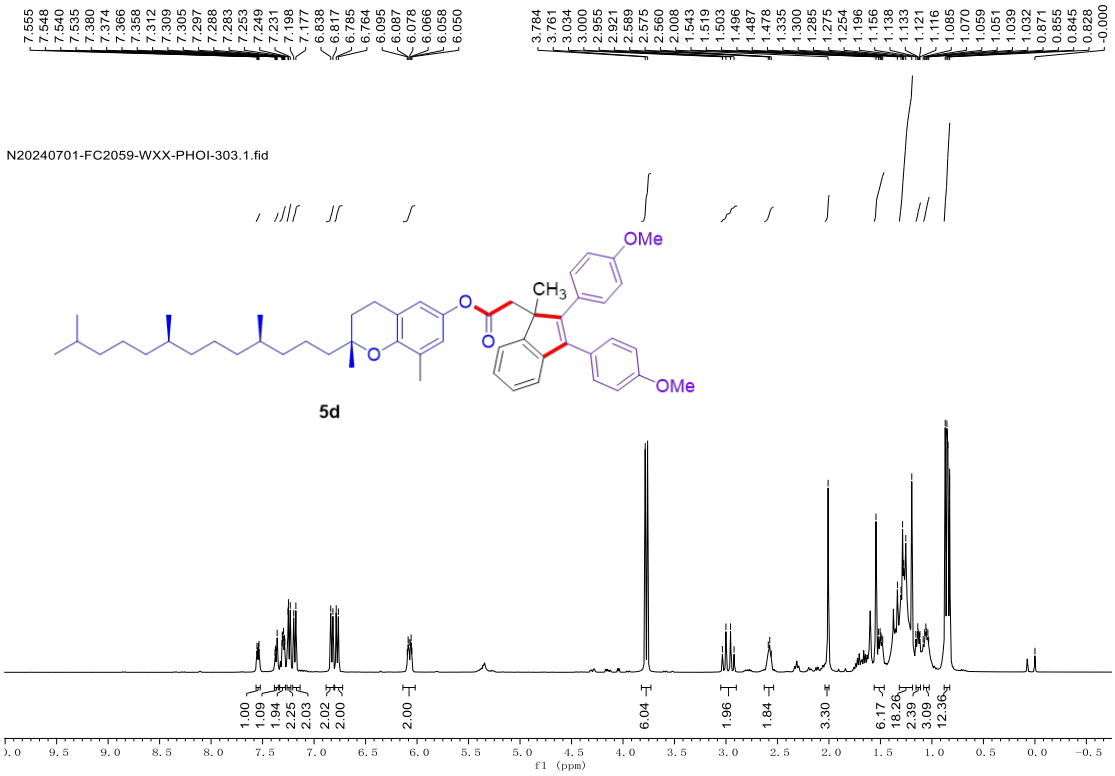
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **5c**



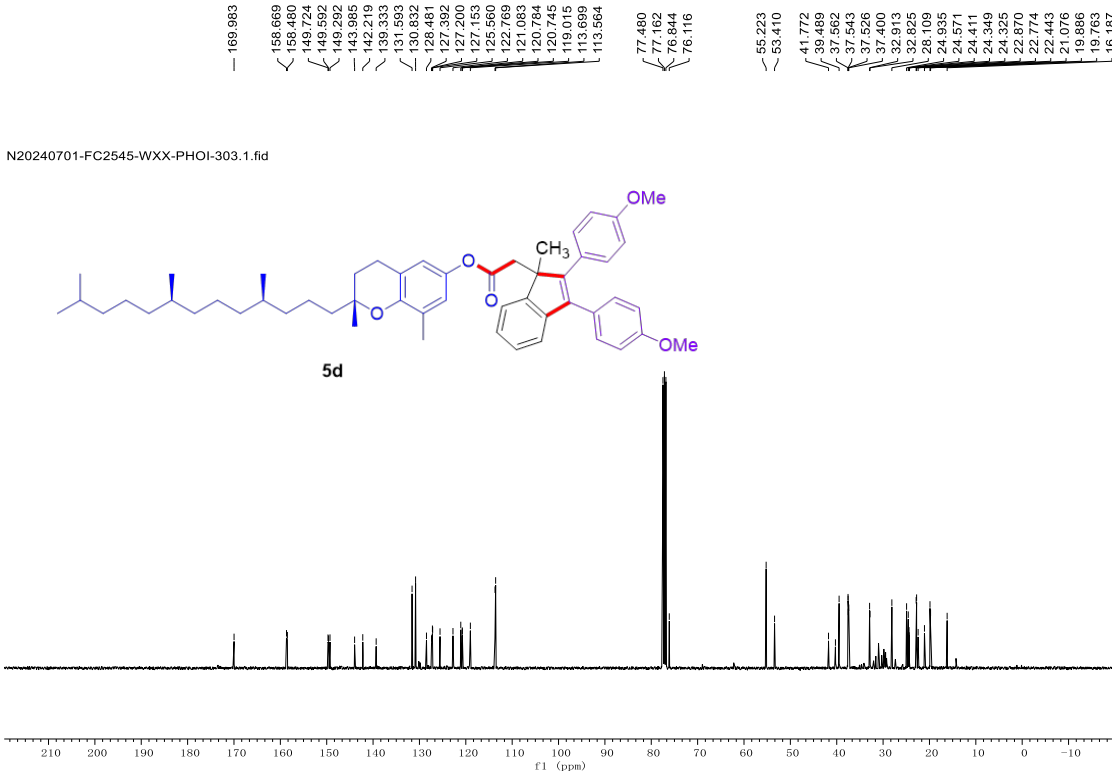
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **5c**



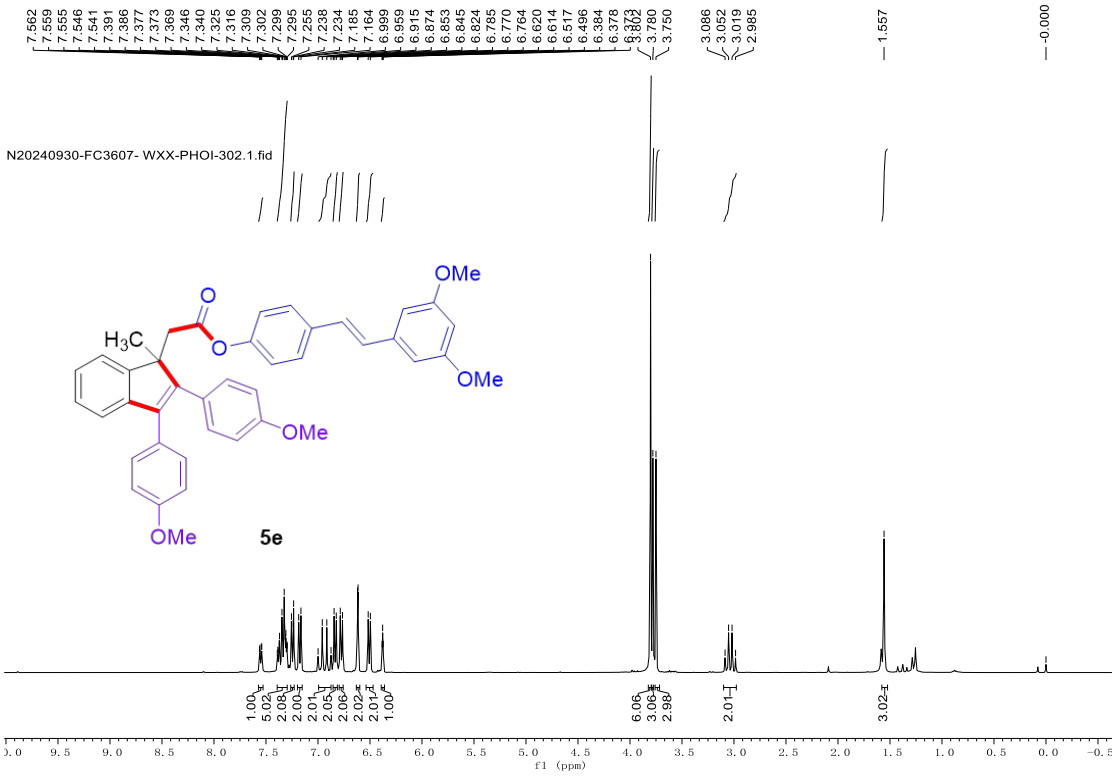
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **5d**



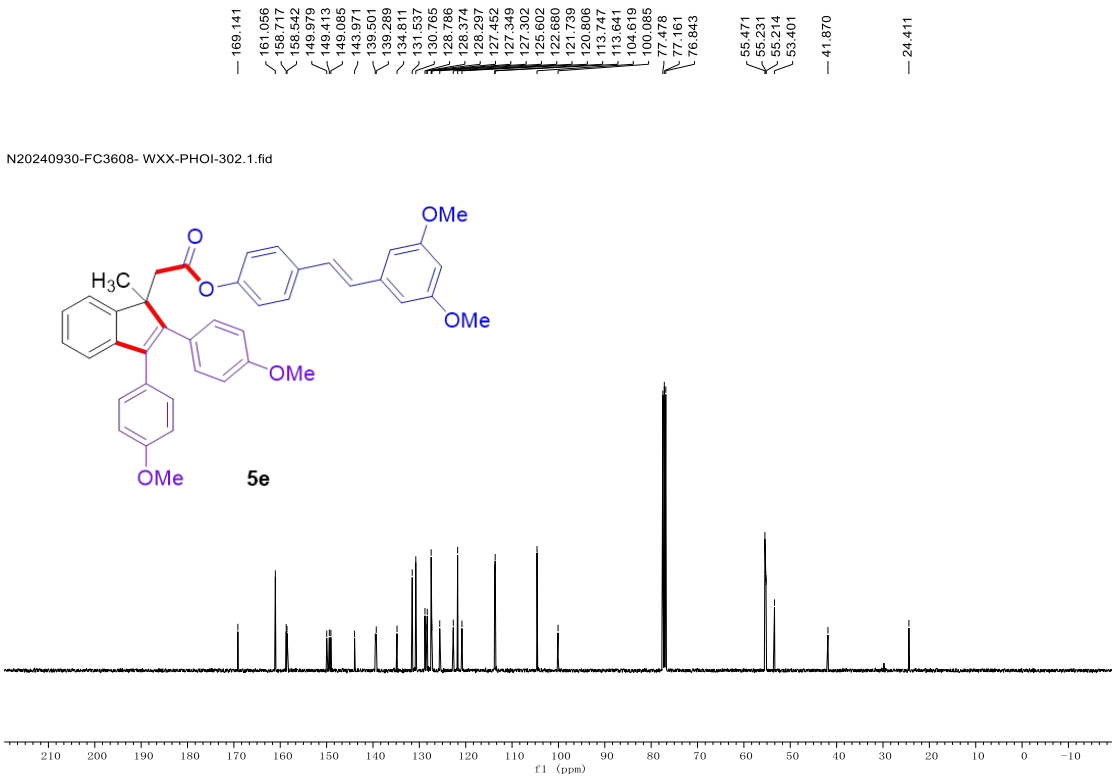
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **5d**



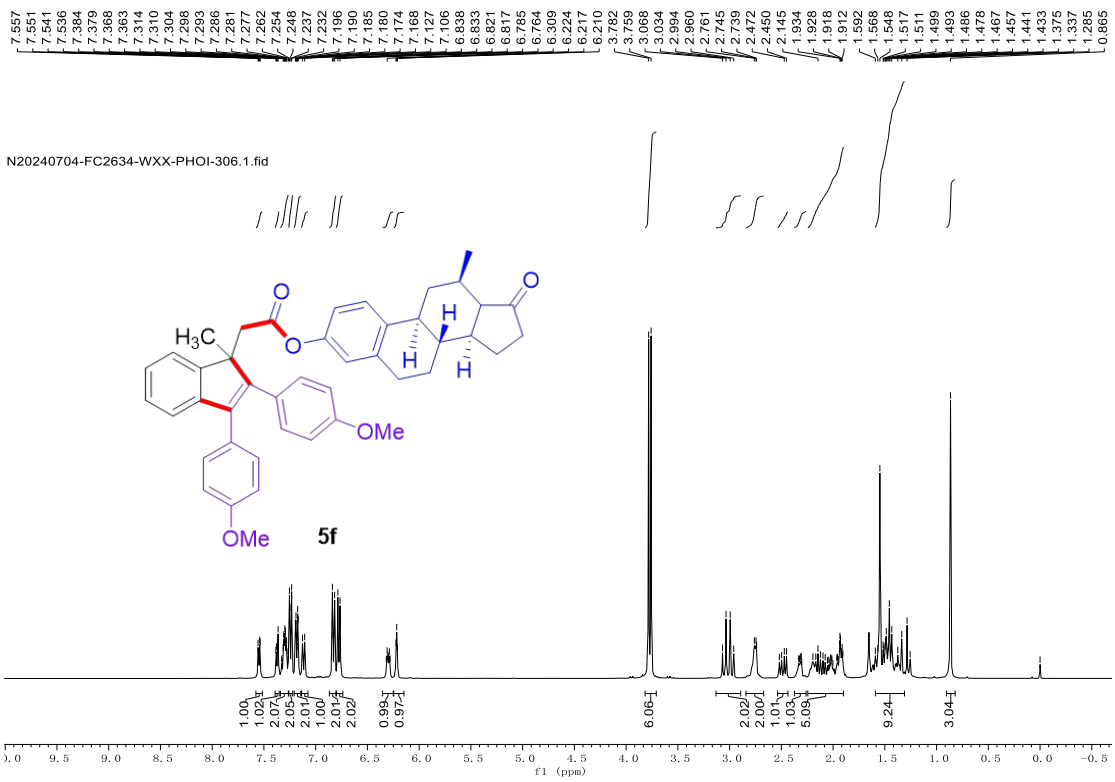
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **5e**



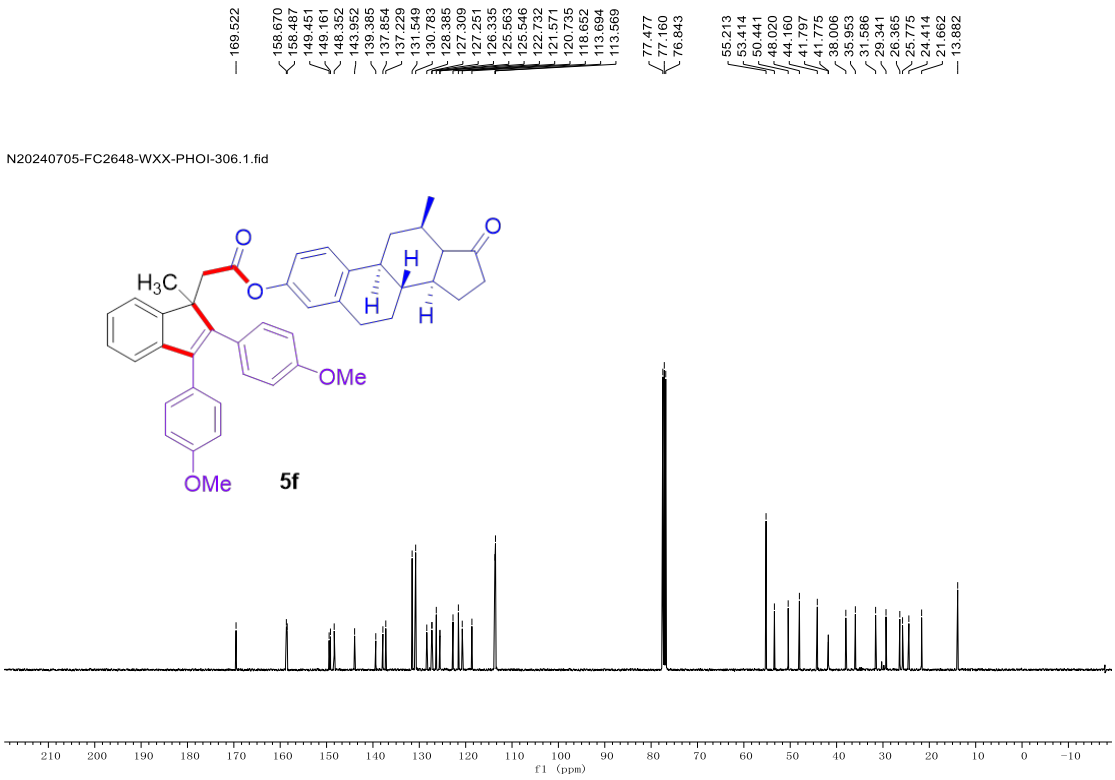
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **5e**



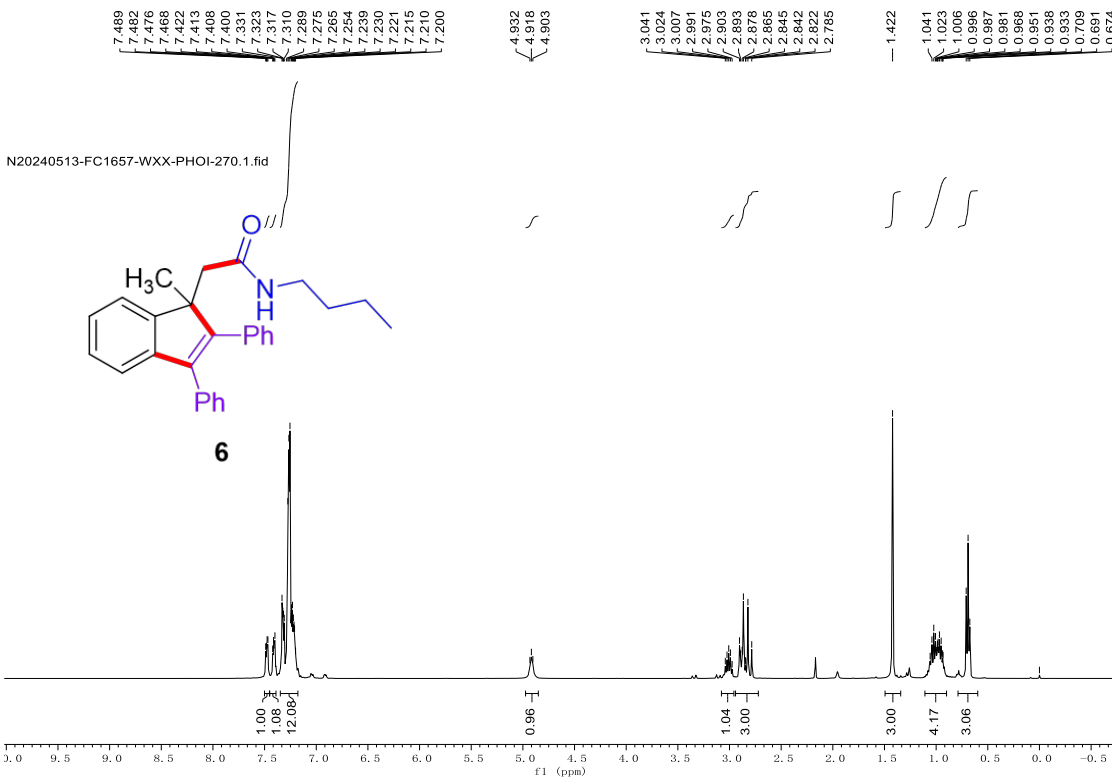
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **5f**



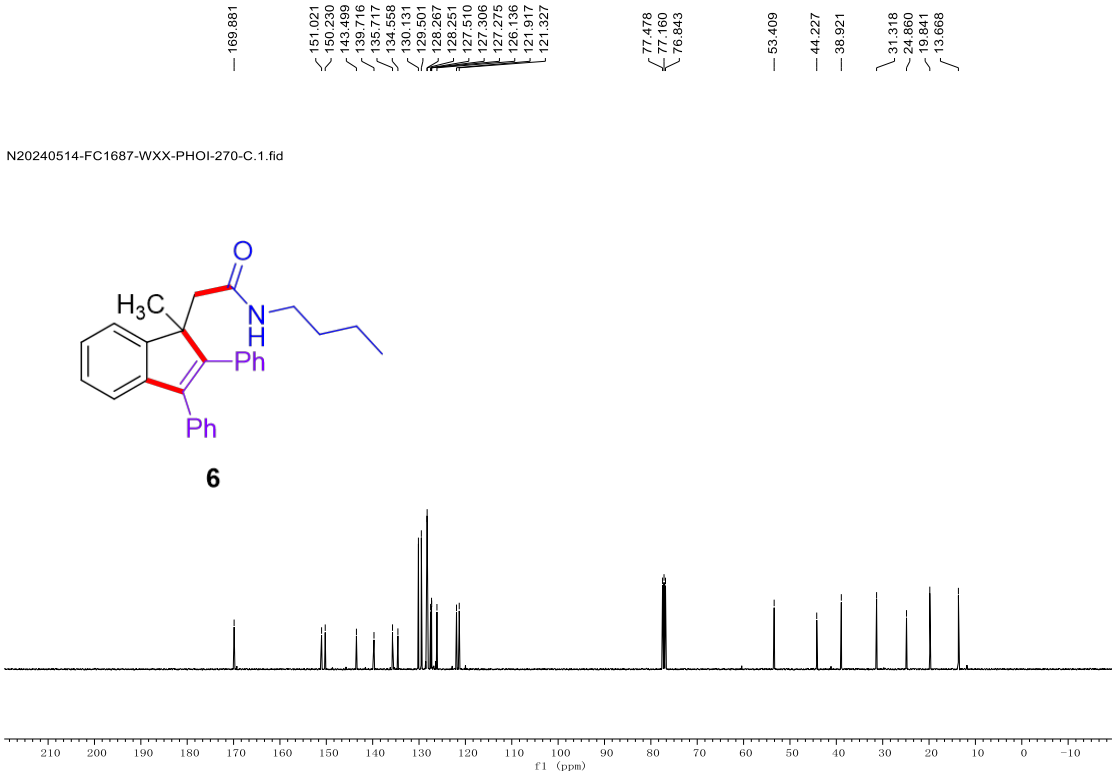
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **5f**



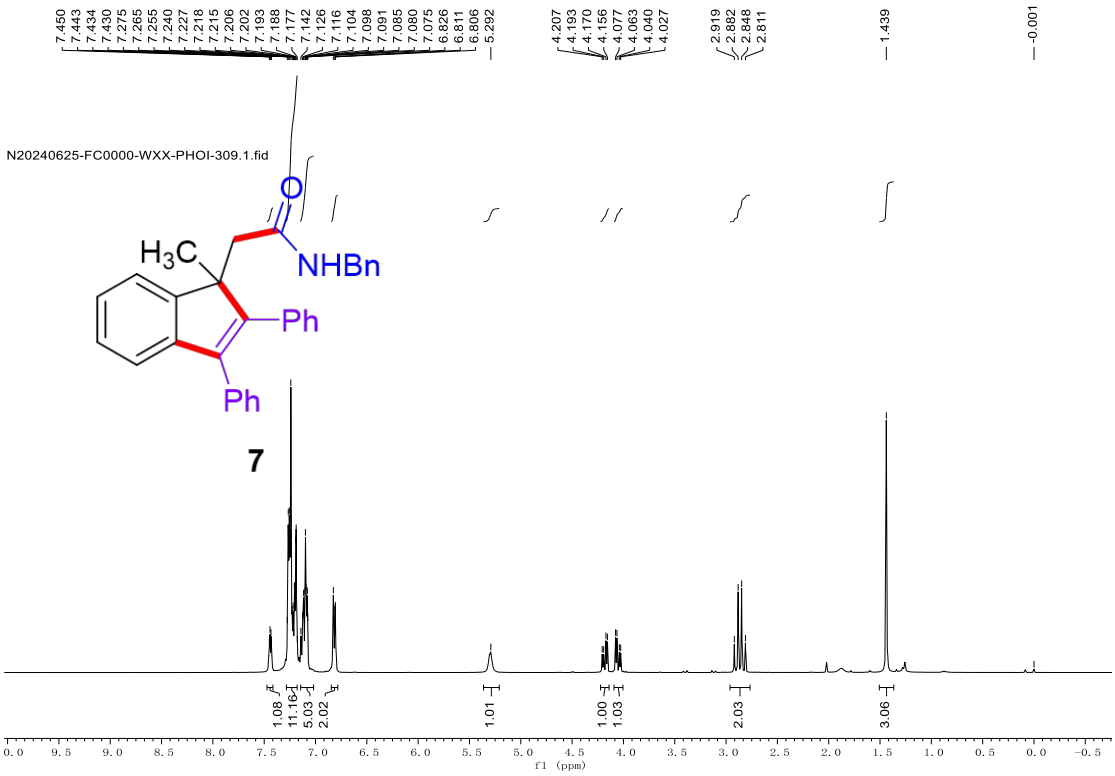
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **6**



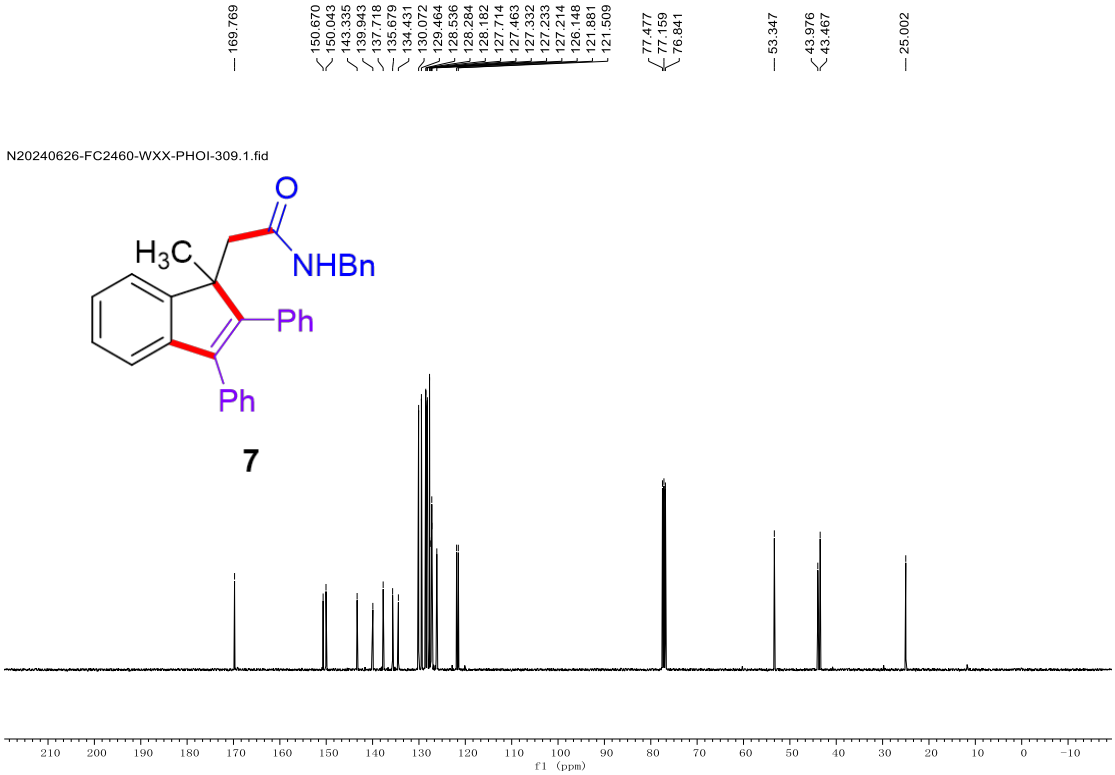
^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **6**



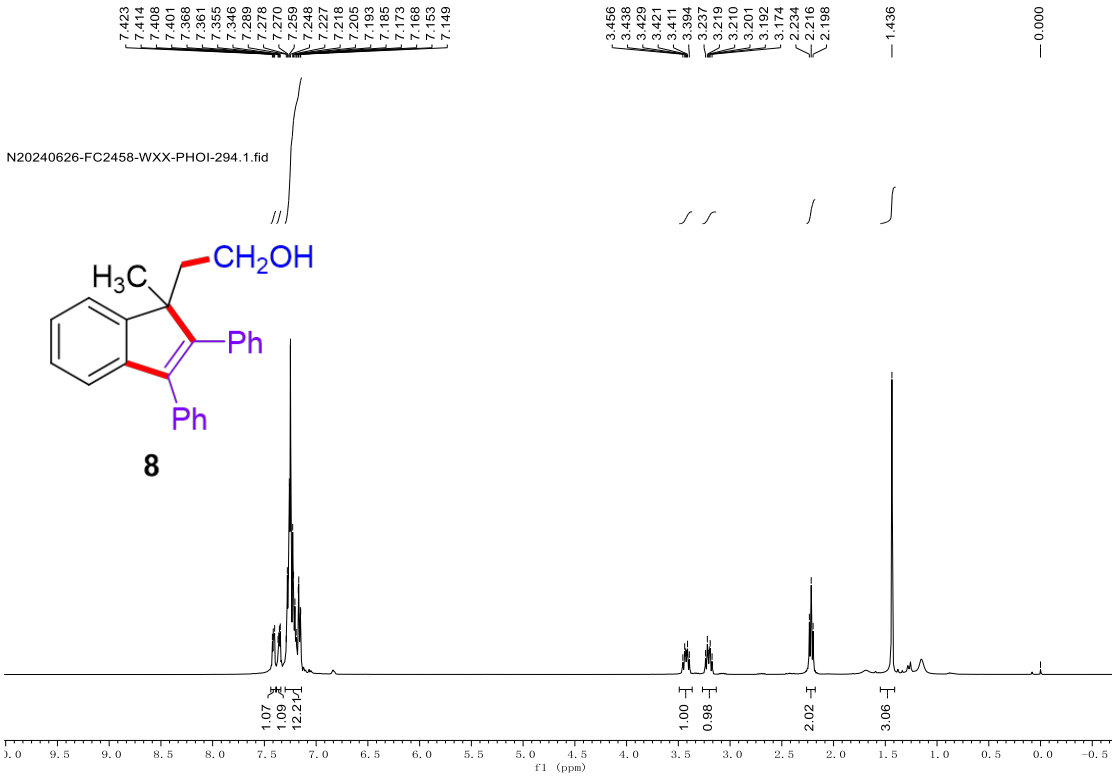
^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **7**



^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **7**



^{1}H NMR (400 MHz, $CDCl_3$) Spectrum of **8**



^{13}C{1H} NMR (101 MHz, $CDCl_3$) Spectrum of **8**