Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supplementary Information for

Transition-metal-free, mild and efficient ring expansion of amino acid derivatives: facile access to densely functionalized azepines

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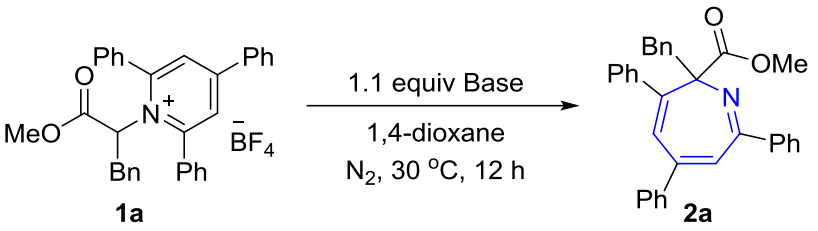
General information

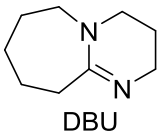
Unless otherwise noted, commercially available reagents were used as received without further purification and all reactions were carried out using standard Schlenk technique under nitrogen atmosphere. Tetrahydrofuran (THF), dichloromethane (DCM), dimethyl sulfoxide (DMSO), and acetonitrile (CH_3CN) were dried using Eminex Solvent Purifier (EX-SPS5-800). Anhydrous dimethylformamide (DMF), dimethylacetamide (DMA), 1,2-dimethoxyethane (DME), and 1,4-dioxane were purchased from J&K Chemical Company. Anhydrous K_3PO_4 was purchased from Acros. Anhydrous K_2CO_3 was purchased from Kelong Chemical Company. Flash column chromatography was performed on silica gel (200-300 mesh). ^1H and ^{13}C NMR spectra were recorded on Bruker 400 MHz and 600 MHz spectrometers at room temperature in $CDCl_3$ (containing 0.03% TMS) solution. ^1H NMR spectra was recorded with tetramethylsilane (0.00 ppm) or solvent residual peak ($CDCl_3$: 7.26 ppm) as internal reference; ^{13}C NMR spectra was recorded with $CDCl_3$ (77.00 ppm) as internal reference. Data are represented as follows: chemical shift, multiplicity (br = broad, s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, m = multiplet), coupling constants (Hz) and integration. High-resolution mass spectra were obtained by using Bruker UHR-ES-TOF MS. The IR spectra were measured on a PerkinElmer Spectrum 400 FT-IR/FT-FIR spectrometer. Single crystal X-ray diffraction data was collected at 293 K for complex **2n** on a SuperNova diffractometer. The corresponding pyridinium salts used in this work were prepared according to literature procedures.[1]

Optimization studies

Table S1. Effect of base[a]

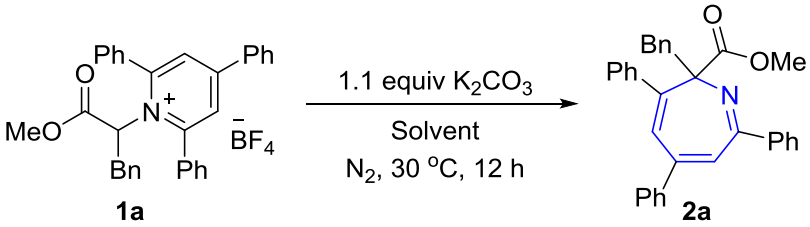


Entry	Base	Yield[b] (%)
1	K_2CO_3	99 (98)[c]
2	K_3PO_4	92
3	KO^{t}Bu	78
4	Cs_2CO_3	89
5	$RbCO_3$	90
6	NaOEt	78
7	Et_3N	0
8	DBU	76



[a] Conditions: **1a** (0.3 mmol, 167.2 mg), base (0.33 mmol), 1,4-dioxane (3.0 mL), 30 °C, 12 h, in a sealed tube, under N_2 atmosphere. [b] NMR yields with 1,3,5-trimethoxybenzene as an internal standard. [c] Isolated yield.

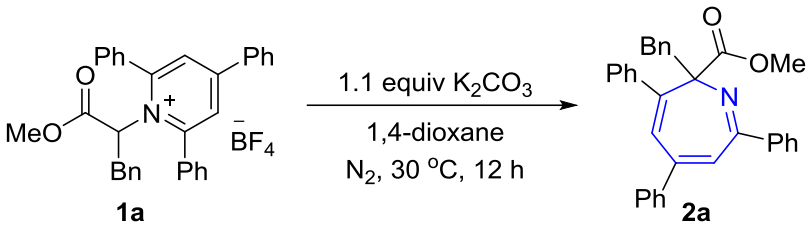
Table S2. Effect of solvent[a]



Entry	Solvent	Yield[b] (%)
1	1,4-dioxane	99 (98)[c]
2	THF	93
3	DME	89
4	DMF	80
5	DMA	93
6	DMSO	86
7	MeCN	26
8	DCM	27

[a] Conditions: **1a** (0.3 mmol, 167.2 mg), K_2CO_3 (0.33 mmol, 45.6 mg), solvent (3.0 mL), 30 °C, 12 h, in a sealed tube, under N_2 atmosphere. [b] NMR yields with 1,3,5-trimethoxybenzene as an internal standard. [c] Isolated yield.

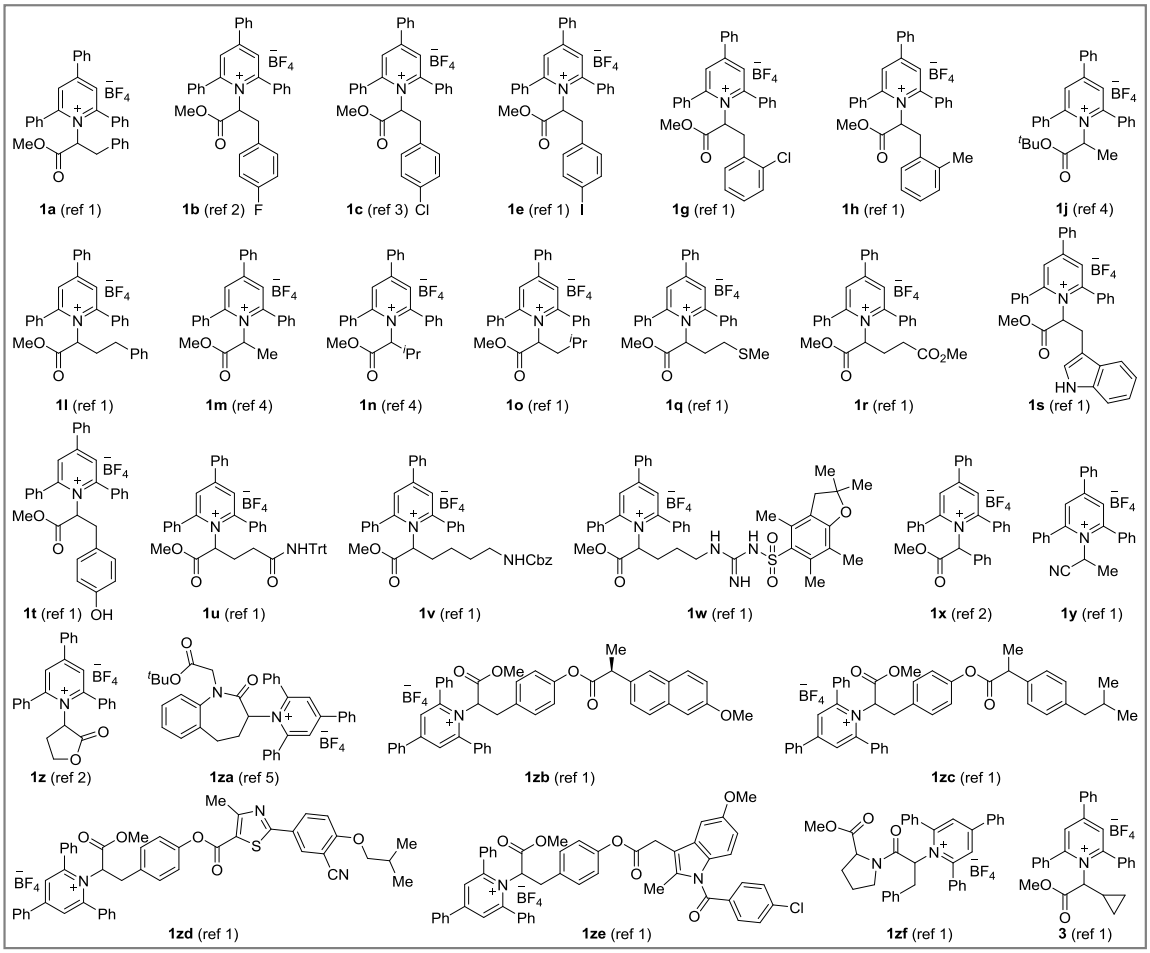
Table S3. Effect of other parameter[a]



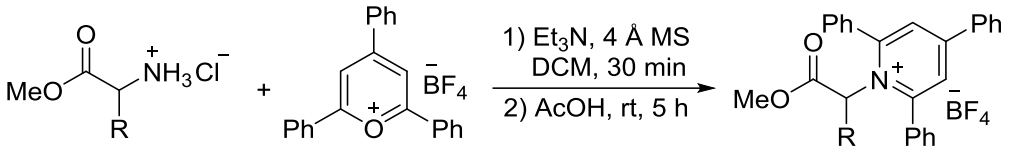
Entry	Variations	Yield[b] (%)
1	No K_2CO_3	0
2	In the dark	95
3	In air	80
4	2.0 equiv H_2O added	96

[a] Conditions: **1a** (0.3 mmol, 167.2 mg), K_2CO_3 (0.33 mmol, 45.6 mg), 1,4-dioxane (3.0 mL), 30 °C, 12 h, in a sealed tube, under N_2 atmosphere. [b] NMR yields with 1,3,5-trimethoxybenzene as an internal standard.

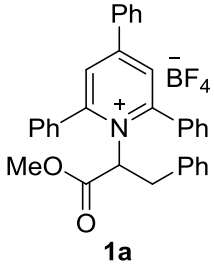
Table S4. For all known pyridinium salts used in this work



General procedure for the synthesis of pyridinium salts

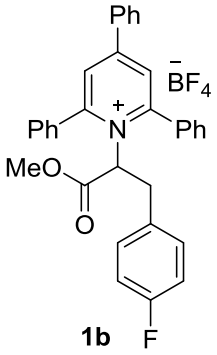


According to the previous reported procedure,[1] amino acid methyl ester (1.0 equiv), crushed 4 Å MS (0.5 g/mmol), 2,4,6-triphenylpyrylium tetrafluoroborate (1.0 equiv), dichloromethane (0.5 M with respect to amino acid methyl ester), and Et_3N (2.0 equiv) were added to a round-bottomed flask fitted with a stir bar, sequentially. After stirring at room temperature for 30 min, acetic acid (2.0 equiv) was added via syringe. The reaction mixture was stirred at room temperature for an additional 5 h. Then, the resulting mixture was filtered through a short pad of celite and rinsed with dichloromethane. The filtrate was washed with aqueous HCl (1 M), saturated aqueous $NaHCO_3$, water, and brine, and dried over anhydrous Na_2SO_4. Then, the organic layer was filtered, and concentrated under the reduced pressure. The residue was purified by column chromatography on silica gel to afford the target pyridinium salt product.



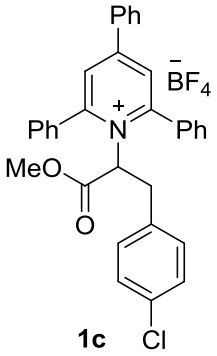
1a

1-(1-Methoxy-1-oxo-3-phenylpropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1a). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.92 (s, 2H), 7.83-7.79 (m, 4H), 7.62-7.44 (m, 11H), 7.13-7.05 (m, 3H), 6.76 (d, J = 6.8 Hz, 2H), 5.64 (dd, J = 4.4, 7.6 Hz, 1H), 3.70 (s, 3H), 3.43 (dd, J = 4.4, 14.4 Hz, 1H), 2.95 (dd, J = 7.6, 14.4 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.7, 156.89, 156.85, 136.1, 133.6, 132.4, 132.1, 131.5, 129.6, 129.5, 129.0, 128.9, 128.6, 128.5, 127.7, 127.2, 70.1, 53.7, 37.6. The spectroscopic data are in agreement with that previously reported.[1]



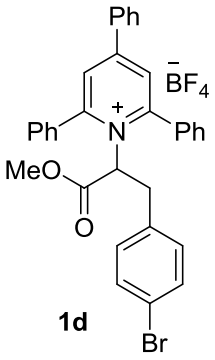
1b

1-(3-(4-Fluorophenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1b). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.91 (s, 2H), 7.81-7.80 (m, 4H), 7.61-7.47 (m, 11H), 6.81-6.73 (m, 4H), 5.57 (dd, *J* = 3.6, 8.4 Hz, 1H), 3.70 (s, 3H), 3.43 (dd, *J* = 3.0, 14.4 Hz, 1H), 2.91 (dd, *J* = 8.4, 14.4 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.6, 161.7 (d, *J* = 243.9 Hz), 156.9, 156.7, 133.6, 132.3, 132.2 (d, *J* = 3.3 Hz), 132.1, 131.5, 130.6 (d, *J* = 7.7 Hz), 129.6, 129.2, 129.0, 128.4, 127.7, 115.2 (d, *J* = 20.7 Hz), 69.9, 53.7, 36.8. The spectroscopic data are in agreement with that previously reported.[2]



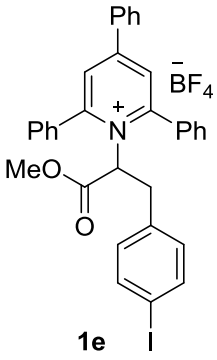
1c

1-(3-(4-Chlorophenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1c). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.92 (s, 2H), 7.82-7.80 (m, 4H), 7.62-7.46 (m, 11H), 7.02 (d, *J* = 8.0 Hz, 2H), 6.75 (d, *J* = 8.4 Hz, 2H), 5.57 (dd, *J* = 2.8, 8.4 Hz, 1H), 3.69 (s, 3H), 3.47 (dd, *J* = 2.4, 14.4 Hz, 1H), 2.86 (dd, *J* = 8.8, 14.4 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.6, 157.0, 156.6, 135.2, 133.7, 132.9, 132.3, 132.2, 131.5, 130.4, 129.6, 129.3, 129.1, 128.5, 128.4, 127.8, 69.8, 53.7, 37.1. The spectroscopic data are in agreement with that previously reported.[3]



1d

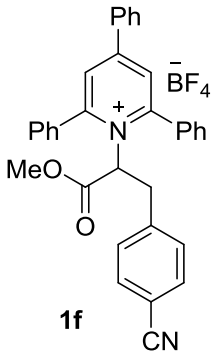
1-(3-(4-Bromophenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1d). 10.0 mmol scale, purification of the crude product by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 5:1 to dichloromethane: acetone = 10:1, gradient) afforded the title product in 38% yield (2.42 g) as a light-red solid. M.p. = 131-132 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.95 (s, 2H), 7.84-7.70 (m, 4H), 7.63-7.49 (m, 11H), 7.18 (d, *J* = 8.4 Hz, 2H), 6.70 (d, *J* = 8.4 Hz, 2H), 5.57 (dd, *J* = 8.4, 2.4 Hz, 1H), 3.68 (s, 3H), 3.51 (dd, *J* = 14.4, 2.4 Hz, 1H), 2.82 (dd, *J* = 14.4, 8.8 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.3, 156.8, 156.5, 135.5, 133.5, 132.2, 132.0, 131.4, 131.3, 130.7, 129.5, 129.1, 129.0, 128.3, 127.6, 120.9, 69.5, 53.7, 37.0. ^{19}F NMR (565 MHz, $CDCl_3$): δ -152.52, -152.57. IR (neat): 3061, 2957, 1749, 1618, 1596, 1557, 1491, 1229, 1050, 1011, 886, 764, 702 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{27}BrNO_2$ $[M\text{-}BF_4]^+$: 548.1220, found 548.1221.



1e

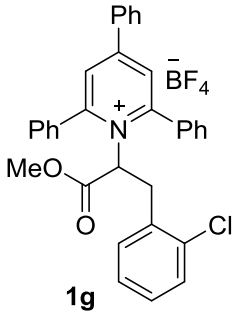
1-(3-(4-Iodophenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1e). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.92 (s, 2H), 7.82-7.74 (m, 4H), 7.61-7.46 (m, 11H), 7.37 (d, *J* = 8.4 Hz, 2H), 6.55 (d, *J* = 8.0 Hz, 2H), 5.57 (dd, *J* = 2.8, 8.4 Hz, 1H), 3.68 (s, 3H), 3.45 (dd, *J* = 2.8, 14.4 Hz, 1H), 2.83 (dd, *J* = 8.4, 14.0 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.6, 157.0, 156.6, 137.4, 136.4, 133.7, 132.3, 132.2,

131.5, 131.0, 129.6, 129.3, 129.1, 128.5, 127.8, 92.6, 69.7, 53.8, 37.2. The spectroscopic data are in agreement with that previously reported.[1]



1f

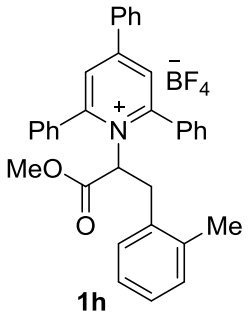
1-(3-(4-Cyanophenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1f). 6.0 mmol scale, purification of the crude product by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 5:1 to dichloromethane: acetone = 10:1, gradient) afforded the title product in 54% yield (1.89 g) as a light-red solid. M.p. = 130-131 ^{o}C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.93 (d, *J* = 4.2 Hz, 2H), 7.81-7.80 (m, 4H), 7.62-7.47 (m, 11H), 7.34 (dd, *J* = 8.4, 1.2 Hz, 2H), 6.98 (d, *J* = 7.2 Hz, 2H), 5.56 (dd, *J* = 8.4, 1.2 Hz, 1H), 3.70 (s, 3H), 3.63 (dd, *J* = 13.8, 4.2 Hz, 1H), 2.94-2.90 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.5, 157.1, 156.5, 142.4, 133.6, 132.4, 132.1, 131.6, 129.9, 129.6, 129.2, 129.1, 128.4, 127.8, 118.5, 110.8, 69.2, 53.9, 37.7 *(1 aromatic carbon signal is not observed due to signal overlap).* ^{19}F NMR (565 MHz, $CDCl_3$): δ -152.30, -152.35. IR (neat): 3065, 2957, 2226, 1745, 1618, 1559, 1231, 1050, 999, 889, 763, 703 cm^{-1}. HRMS (ESI) calcd. for $C_{34}H_{27}N_2O_2$ $[M\text{-}BF_4]^+$: 495.2067, found 495.2067.



1g

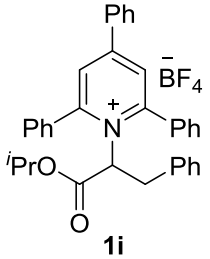
1-(3-(2-Chlorophenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium

tetrafluoroborate (1g). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.94 (s, 2H), 7.88-7.86 (m, 3H), 7.63-7.61 (m, 4H), 7.57-7.51 (m, 7H), 7.18-7.16 (m, 2H), 7.10-7.08 (m, 2H), 6.83 (d, *J* = 7.2 Hz, 1H), 5.88 (dd, *J* = 4.8, 8.4 Hz, 1H), 3.76 (s, 3H), 3.41 (dd, *J* = 4.8, 15.0 Hz, 1H), 3.26 (dd, *J* = 8.4, 15.0 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.3, 157.4, 157.1, 134.2, 133.2, 132.7, 132.3, 131.9, 131.7, 130.7, 129.75, 129.68, 129.4, 129.3, 129.2, 128.6, 127.8, 68.1, 54.0, 34.7. The spectroscopic data are in agreement with that previously reported.[1]



1h

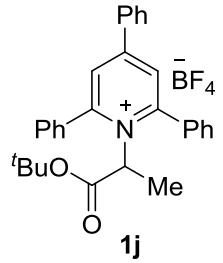
1-(1-Methoxy-1-oxo-3-(*o*-tolyl)propan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1h). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 (s, 2H), 7.86-7.80 (m, 3H), 7.64-7.49 (m, 10H), 7.40-7.17 (m, 2H), 7.07 (t, *J* = 7.6 Hz, 1H), 6.98 (d, *J* = 7.2 Hz, 1H), 6.90 (t, *J* = 7.6 Hz, 1H), 6.41 (d, *J* = 7.6 Hz, 1H), 5.75 (t, *J* = 6.8 Hz, 1H), 3.72 (s, 3H), 3.25-3.15 (m, 2H), 1.74 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.4, 157.1, 156.9, 136.8, 133.3, 133.2, 132.6, 132.0, 131.6, 130.8, 129.7, 129.5, 129.1, 128.5, 128.0, 127.7, 127.5, 126.3, 68.7, 53.8, 34.0, 18.7. The spectroscopic data are in agreement with that previously reported.[1]



1i

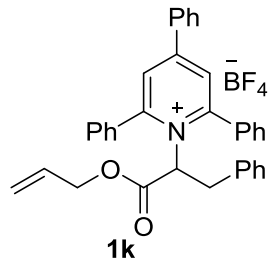
1-(1-Isopropoxy-1-oxo-3-phenylpropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1i). 10.0 mmol scale, purification of the crude product by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 5:1 to dichloromethane: acetone = 10:1, gradient) afforded the title product in 24% yield (1.43 g)

as a light-red solid. M.p. = 103-104 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (s, 2H), 7.87-7.66 (m, 5H), 7.63-7.50 (m, 10H), 7.10-7.06 (m, 3H), 6.83-6.80 (m, 2H), 5.60 (dd, *J* = 8.8, 3.2 Hz, 1H), 4.96-4.87 (m, 1H), 3.50 (dd, *J* = 14.4, 3.2 Hz, 1H), 2.70 (dd, *J* = 14.4, 8.8 Hz, 1H), 1.16 (d, *J* = 6.4 Hz, 3H), 1.08 (d, *J* = 6.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.0, 156.6, 156.3, 136.1, 133.1, 132.1, 132.0, 131.2, 129.3, 129.1, 128.8, 128.5, 128.2, 128.1, 127.3, 126.8, 72.0, 70.4, 37.1, 21.1, 20.8. ^{19}F NMR (565 MHz, $CDCl_3$): δ -152.76, -152.81. IR (neat): 2982, 1728, 1619, 1594, 1374, 1048, 999, 889, 760. 699 cm^{-1}. HRMS (ESI) calcd. for $C_{35}H_{32}NO_2$ $[M\text{-}BF_4]^+$: 498.2428, found 498.2428.



1j

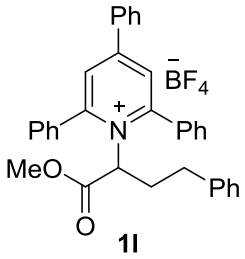
1-(1-(*tert*-Butoxy)-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1j). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.90 (s, 3H), 7.81-7.80 (m, 3H), 7.63-7.60 (m, 3H), 7.55-7.50 (m, 8H), 5.47 (q, *J* = 7.2 Hz, 1H), 1.41 (s, 9H), 1.30 (d, *J* = 9.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.3, 156.9, 156.3, 133.8, 133.2, 132.1, 131.2, 129.5, 128.9, 128.2, 84.7, 65.9, 27.6, 16.9. The spectroscopic data are in agreement with that previously reported.[4]



1k

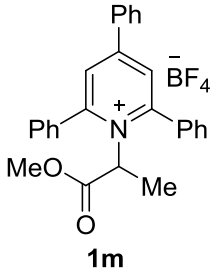
1-(1-(Allyloxy)-1-oxo-3-phenylpropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1k). 5.0 mmol scale, purification of the crude product by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 5:1 to dichloromethane: acetone = 10:1, gradient) afforded the title product in 18% yield (0.52 g)

as a light-purple solid. M.p. = 95-96 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (s, 2H), 7.87-7.79 (m, 4H), 7.63-7.50 (m, 11H), 7.10-7.05 (m, 3H), 6.79 (dd, *J* = 7.2, 1.2 Hz, 2H), 5.82-5.72 (m, 1H), 5.67 (dd, *J* = 8.4, 3.6 Hz, 1H), 5.28 (dd, *J* = 10.4, 0.8 Hz, 1H), 5.21 (dd, *J* = 17.2, 1.2 Hz, 1H), 4.59-4.49 (m, 2H), 3.51 (dd, *J* = 14.4, 3.6 Hz, 1H), 2.85 (dd, *J* = 14.4, 8.4 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.1, 156.8, 136.1, 133.5, 132.4, 132.1, 131.5, 130.0, 129.6, 129.4, 129.0, 128.9, 128.5, 128.4, 127.7, 127.1, 120.5, 70.2, 67.7. 37.4 *(1 aromatic carbon signal is not observed due to signal overlap).* ^{19}F NMR (565 MHz, $CDCl_3$): δ -152.72, -152.77. IR (neat): 3061, 1745, 1618, 1596, 1562, 1493, 1048, 999, 936, 891, 764, 700 cm^{-1}. HRMS (ESI) calcd. for $C_{35}H_{30}NO_2$ $[M\text{-}BF_4]^+$: 496.2271, found 496.2271.



1l

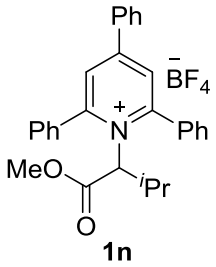
1-(1-Methoxy-1-oxo-4-phenylbutan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1l). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88 (s, 2H), 7.80-7.78 (m, 2H), 7.74-7.69 (m, 2H), 7.56-7.45 (m, 11H), 7.15-7.11 (m, 3H), 6.93-6.91 (m, 2H), 5.36 (dd, *J* = 2.8, 9.2 Hz, 1H), 3.72 (s, 3H), 2.46-2.33 (m, 3H), 2.06-1.99 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.3, 156.82, 156.76, 138.6, 133.7, 132.3, 132.2, 131.3, 129.6, 129.1, 128.8, 128.5, 128.44, 128.35, 127.8, 126.4, 67.9, 53.7, 33.2, 33.0. The spectroscopic data are in agreement with that previously reported.[1]



1m

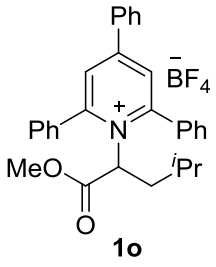
1-(1-Methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1m).

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.87 (s, 2H), 7.79-7.74 (m, 4H), 7.67-7.59 (m, 4H), 7.57-7.53 (m, 5H), 7.49-7.47 (m, 2H), 5.53 (q, *J* = 7.2 Hz, 1H), 3.68 (s, 3H), 1.48 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 168.7, 156.9, 156.6, 133.8, 132.5, 132.1, 131.3, 129.5, 129.0, 128.9, 128.3, 127.7, 64.4, 53.6, 17.1. The spectroscopic data are in agreement with that previously reported.[4]



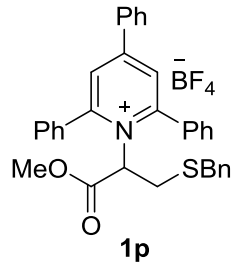
1n

1-(1-Methoxy-3-methyl-1-oxobutan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1n). ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.03 (s, 2H), 7.92-7.90 (m, 2H), 7.71 (br, 2H), 7.68-7.61 (m, 7H), 7.58-7.52 (m, 4H), 5.17 (d, *J* = 10.4 Hz, 1H), 3.77 (s, 3H), 2.13-2.07 (m, 1H), 0.77-0.75 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.8, 157.1, 157.0, 133.0, 132.8, 131.9, 131.8, 129.8, 129.4, 128.9, 128.6, 127.7, 73.5, 53.7, 29.9, 22.3, 19.2. The spectroscopic data are in agreement with that previously reported.[4]



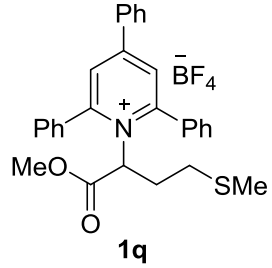
1o

1-(1-Methoxy-4-methyl-1-oxopentan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1o). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92 (s, 2H), 7.84-7.82 (m, 2H), 7.74 (br, 2H), 7.64-7.62 (m, 3H), 7.59-7.53 (m, 6H), 7.51-7.48 (m, 2H), 5.49 (dd, *J* = 4.2, 8.4 Hz, 1H), 3.77 (s, 3H), 1.75-1.71 (m, 1H), 1.62-1.57 (m, 1H), 1.35-1.32 (m, 1H), 0.59 (d, *J* = 6.6 Hz, 3H), 0.44 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 168.7, 156.7, 156.6, 133.6, 132.4, 132.2, 131.4, 129.5, 129.3, 129.0, 128.4, 127.8, 67.2, 53.7, 40.3, 26.0, 22.2, 20.6. The spectroscopic data are in agreement with that previously reported.[1]



1p

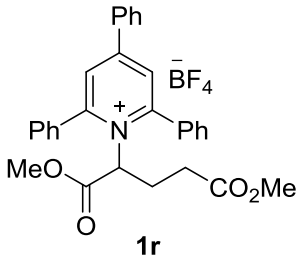
1-(3-(Benzylthio)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1p). 5.0 mmol scale, purification of the crude product by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 5:1 to dichloromethane: acetone = 10:1, gradient) afforded the title product in 36% yield (1.08 g) as a white solid. M.p. = 105-106 ºC. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.95 (s, 2H), 7.84-7.83 (m, 2H), 7.71-7.62 (m, 5H), 7.58-7.51 (m, 8H), 7.24-7.19 (m, 3H), 7.04-7.03 (m, 2H), 5.71 (dd, *J* = 8.4, 5.4 Hz, 1H), 3.71 (s, 3H), 3.60 (d, *J* = 12.6 Hz, 1H), 3.30 (d, *J* = 12.6 Hz, 1H), 3.08 (dd, *J* = 14.4, 4.8 Hz, 1H), 2.73 (dd, *J* = 14.4, 8.4 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.3, 157.2, 136.8, 133.5, 132.6, 132.1, 131.7, 129.7, 129.3, 128.9, 128.52, 128.50, 127.6, 127.2, 69.0, 54.0, 37.1, 32.7 *(2 aromatic carbon signals are not observed due to signal overlap).* ^{19}F NMR (565 MHz, $CDCl_3$): δ -152.37, -152.43. IR (neat): 3065, 1747, 1618, 1557, 1494, 1236, 1051, 999, 912, 763, 726, 701 cm^{-1}. HRMS (ESI) calcd. for $C_{34}H_{30}NO_2S$ $[M\text{-}BF_4]^+$: 516.1992, found 516.1993.



1q

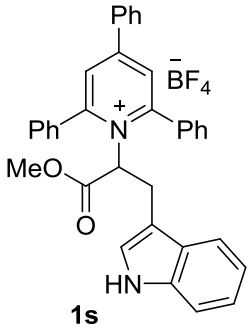
1-(1-Methoxy-4-(methylthio)-1-oxobutan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1q). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.90 (s, 2H), 7.81-7.80 (m, 5H), 7.63-7.53 (m, 8H), 7.50-7.48 (m, 2H), 5.95 (dd, *J* = 2.4, 9.0 Hz, 1H), 3.75 (s, 3H), 2.35-2.30 (m, 2H), 2.27-2.24 (m, 1H), 1.91-1.89 (m, 1H), 1.85 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 168.5, 156.9, 133.8, 132.5, 132.1, 131.4, 129.5, 129.0, 128.4, 128.0, 66.6, 53.7, 31.3, 30.6, 14.6. The spectroscopic data are in agreement with that previously

reported.[1]



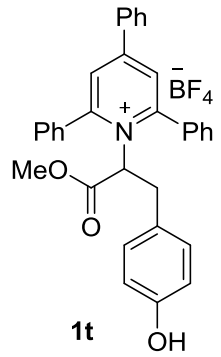
1r

1-(1,5-Dimethoxy-1,5-dioxopentan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1r). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 (s, 2H), 7.84-7.82 (m, 2H), 7.76-7.72 (m, 2H), 7.63-7.55 (m, 8H), 7.54-7.48 (m, 3H), 5.61 (t, *J* = 6.4 Hz, 1H), 3.73 (s, 3H), 3.48 (s, 3H), 2.29-2.17 (m, 3H), 2.13-2.06 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.9, 168.0, 157.0, 133.6, 132.4, 132.2, 131.5, 129.6, 129.2, 128.5, 127.9, 67.5, 53.8, 51.6, 30.6, 26.9. The spectroscopic data are in agreement with that previously reported.[1]



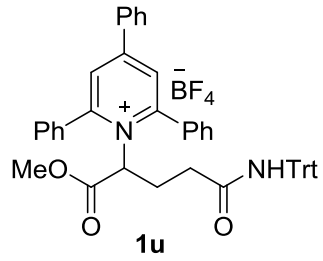
1s

1-(3-(1*H*-Indol-3-yl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1s). ^{1}H NMR (600 MHz, $CDCl_3$): δ 9.18 (s, 1H), 7.82-7.81 (m, 5H), 7.56-7.44 (m, 10H), 7.36-7.35 (m, 3H), 7.06-7.04 (m, 1H), 6.81-6.76 (m, 3H), 5.73 (dd, *J* = 4.8, 10.2 Hz, 1H), 3.79 (s, 3H), 3.31 (dd, *J* = 4.2, 15.6 Hz, 1H), 3.15 (dd, *J* = 10.2, 15.6 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 168.0, 156.9, 136.0, 133.1, 132.7, 131.7, 131.4, 129.7, 129.0, 128.5, 126.3, 123.6, 121.9, 119.3, 116.8, 112.0, 106.3, 69.4, 53.9, 26.9. The spectroscopic data are in agreement with that previously reported.[1]



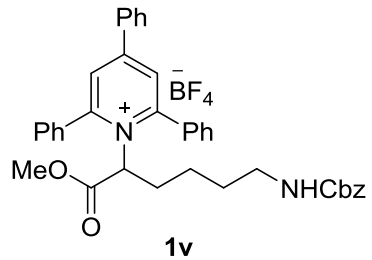
1t

1-(3-(4-Hydroxyphenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1t). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.85 (s, 2H), 7.79-7.77 (m, 2H), 7.69 (br, 2H), 7.57-7.46 (m, 9H), 7.18 (br, 2H), 7.07 (s, 1H), 6.58 (d, *J* = 8.4 Hz, 2H), 6.39 (d, *J* = 8.4 Hz, 2H), 5.56 (t, *J* = 6.6 Hz, 1H), 3.68 (s, 3H), 3.08 (dd, *J* = 7.2, 15.0 Hz, 1H), 2.89 (dd, *J* = 6.0, 15.0 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.6, 157.2, 156.7, 156.2, 133.1, 132.7, 131.8, 131.7, 129.7, 129.6, 129.1, 128.4, 127.5, 125.7, 116.0, 70.5, 53.8, 36.4. The spectroscopic data are in agreement with that previously reported.[1]



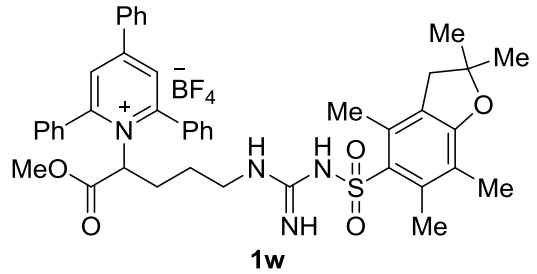
1u

1-(1-Methoxy-1,5-dioxo-5-(tritylamino)pentan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1u). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.94 (s, 2H), 7.84-7.79 (m, 3H), 7.70 (s, 2H), 7.61-7.42 (m, 11H), 7.24-7.14 (m, 15H), 5.54 (dd, *J* = 4.8, 10.4 Hz, 1H), 3.71 (s, 3H), 2.56-2.48 (m, 1H), 2.21-2.15 (m, 1H), 2.10-2.02 (m, 1H), 1.51-1.46 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.6, 169.2, 157.3, 144.7, 133.8, 132.7, 132.3, 131.5, 129.6, 129.2, 128.6, 128.5, 127.6, 126.5, 70.1, 69.0, 53.8, 31.7, 25.5. The spectroscopic data are in agreement with that previously reported.[1]



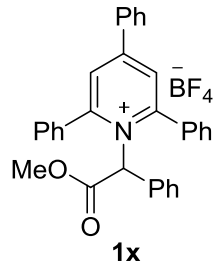
1v

1-(6-(((Benzyloxy)carbonyl)amino)-1-methoxy-1-oxohexan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1v). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.90 (s, 2H), 7.80-7.77 (m, 2H), 7.72-7.67 (m, 2H), 7.61-7.53 (m, 8H), 7.50-7.47 (m, 2H), 7.32-7.24 (m, 6H), 5.44 (t, *J* = 6.0 Hz, 1H), 5.32 (t, *J* = 6.6 Hz, 1H), 5.03 (s, 2H), 3.70 (s, 3H), 3.02 (q, *J* = 6.0 Hz, 1H), 1.82-1.76 (m, 1H), 1.70-1.64 (m, 1H), 1.35-1.28 (m, 1H), 1.24-1.16 (m, 1H), 1.13-1.08 (m, 1H), 1.06-0.97 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 168.3, 156.8, 156.5, 136.8, 133.6, 132.3, 131.5, 129.6, 129.5, 129.1, 129.0, 128.4, 128.34, 128.30, 127.8, 127.7, 127.6, 68.9, 66.0, 53.7, 39.8, 30.9, 28.4, 23.9. The spectroscopic data are in agreement with that previously reported.[1]



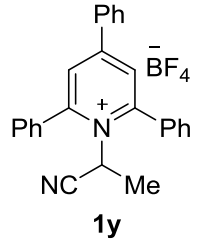
1w

1-(1-Methoxy-1-oxo-5-(3-((2,2,4,6,7-pentamethyl-2,3-dihydrobenzofuran-5-yl)sulfonyl)guanidino)pentan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1w). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.98 (s, 2H), 7.85-7.83 (m, 2H), 7.75-7.69 (m, 2H), 7.60-7.50 (m, 8H), 7.47-7.41 (m, 3H), 6.15 (br, 2H), 5.84 (br, 1H), 5.30 (dd, *J* = 4.8, 6.6 Hz, 1H), 3.70 (s, 3H), 3.01-2.98 (m, 1H), 2.93-2.91 (m, 3H), 2.52 (s, 3H), 2.47 (s, 3H), 2.06 (s, 3H), 1.94-1.90 (m, 1H), 1.73-1.71 (m, 1H), 1.45 (s, 6H), 1.34-1.31 (m, 1H), 1.07 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.8, 158.3, 156.7, 155.9, 138.0, 133.2, 133.1, 132.5, 131.9, 131.8, 131.7, 129.6, 129.3, 128.6, 128.2, 124.3, 117.1, 86.1, 68.3, 53.7, 43.0, 39.0, 29.1, 28.4, 26.9, 19.0, 17.7, 12.3. The spectroscopic data are in agreement with that previously reported.[1]



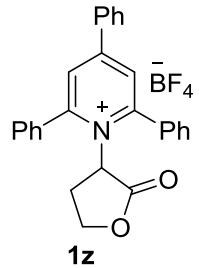
1x

1-(2-Methoxy-2-oxo-1-phenylethyl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1x). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.95 (s, 2H), 7.87-7.86 (m, 2H), 7.81-7.74 (m, 2H), 7.56-7.44 (m, 7H), 7.42-7.26 (m, 2H), 7.13 (t, *J* = 7.8 Hz, 1H), 7.07 (t, *J* = 7.8 Hz, 2H), 6.99 (br, 2H), 6.79-6.78 (m, 3H), 3.91 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.4, 157.4, 157.2, 133.6, 132.8, 132.4, 130.9, 130.7, 129.6, 129.0, 128.9, 128.7, 128.6, 128.5, 128.4, 128.1, 71.5, 54.0. The spectroscopic data are in agreement with that previously reported.[2]



1y

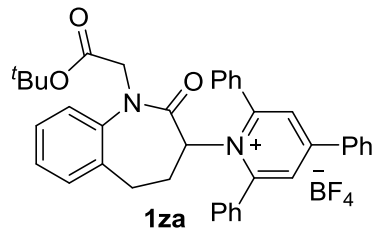
1-(1-Cyanoethyl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1y). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (s, 4H), 7.84-7.80 (m, 4H), 7.71-7.64 (m, 6H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.52 (t, *J* = 7.6 Hz, 2H), 5.74 (q, *J* = 7.2 Hz, 1H), 1.54 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.0, 157.4, 133.6, 132.6, 132.0, 129.8, 129.7, 129.6, 128.5, 128.3, 116.9, 52.6, 19.3. The spectroscopic data are in agreement with that previously reported.[1]



1z

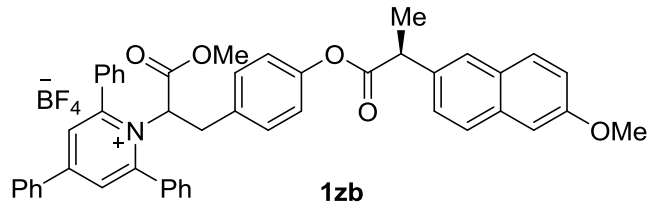
1-(2-Oxotetrahydrofuran-3-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1z). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.04-8.02 (m, 3H), 7.90 (s, 1H), 7.82-7.81 (m, 2H), 7.70

(br, 1H), 7.64-7.57 (m, 6H), 7.54-7.48 (m, 4H), 5.64 (dd, *J* = 9.0, 12.0 Hz, 1H), 3.98 (dd, *J* = 8.4, 16.8 Hz, 1H), 3.35 (td, *J* = 4.2, 9.6 Hz, 1H), 2.98-2.91 (m, 1H), 2.74-2.68 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.8, 159.1, 156.8, 156.2, 133.4, 132.6, 132.5, 131.7, 131.5, 131.13, 131.06, 130.0, 129.7, 129.3, 128.6, 128.3, 126.5, 66.5, 63.5, 27.3. The spectroscopic data are in agreement with that previously reported.[2]



1za

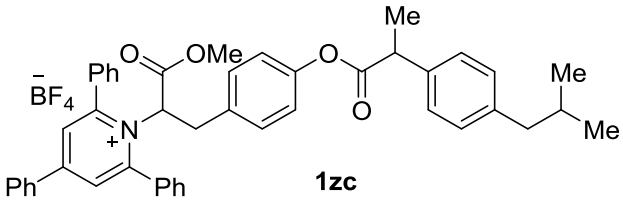
1-(1-(2-(*tert*-Butoxy)-2-oxoethyl)-2-oxo-2,3,4,5-tetrahydro-1H-benzo[b]azepin-3-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1za). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.05 (br, 2H), 7.87 (d, *J* = 2.4 Hz, 1H), 7.77-7.74 (m, 3H), 7.61-7.57 (m, 2H), 7.55-7.47 (m, 6H), 7.42 (t, *J* = 7.8 Hz, 1H), 7.25 (d, *J* = 7.8 Hz, 1H), 7.21 (t, *J* = 7.2 Hz, 1H), 7.06-7.02 (m, 2H), 7.00-6.99 (m, 1H), 6.54-6.53 (m, 1H), 5.54 (dd, *J* = 7.2, 11.4 Hz, 1H), 4.43 (d, *J* = 16.2 Hz, 1H), 4.14 (d, *J* = 16.8 Hz, 1H), 2.74-2.68 (m, 1H), 2.51-2.46 (m, 1H), 2.38-2.35 (m, 1H), 2.00-1.95 (m, 1H), 1.46 (s, 9H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 167.5, 166.9, 158.4, 157.5, 155.7, 139.3, 135.2, 133.9, 133.2, 132.8, 131.9, 130.8, 130.6, 129.7, 129.54, 129.50, 128.8, 128.6, 128.3, 128.2, 127.53, 128.45, 127.4, 126.2, 121.9, 82.4, 69.1, 51.6, 32.5, 27.9, 27.4. The spectroscopic data are in agreement with that previously reported.[5]



1zb

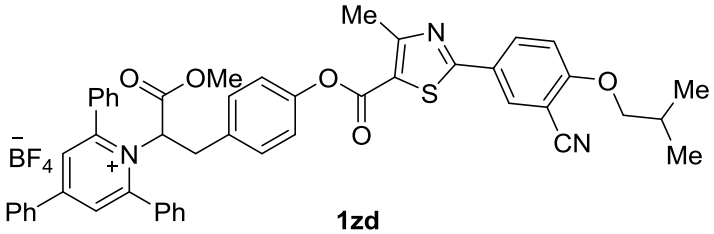
1-(1-Methoxy-3-(4-(((*S*)-2-(6-methoxynaphthalen-2-yl)propanoyl)oxy)phenyl)-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1zb). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.877 (s, 1H), 7.873 (s, 1H), 7.78-7.68 (m, 7H), 7.56-7.39 (m, 12H), 7.14-7.12 (m, 2H), 6.72 (d, *J* = 9.0 Hz, 2H), 6.69 (d, *J* = 9.0 Hz, 2H), 5.56 (dd, *J* = 4.8, 7.2 Hz, 1H), 4.03 (q, *J* = 6.6 Hz, 1H), 3.884 (s, 1.5H), 3.881 (s, 1.5H), 3.669 (s, 1.5H), 3.663 (s, 1.5H),

3.38-3.35 (m, 1H), 2.95-2.91 (m, 1H), 1.65-1.63 (m, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.08, 173.07, 167.4, 157.6, 156.8, 149.9, 134.9, 134.8, 133.7, 133.53, 133.48, 133.4, 132.3, 132.0, 131.5, 129.9, 129.5, 129.4, 129.1, 129.0, 128.8, 128.40, 128.39, 127.31, 127.28, 126.0, 125.92, 125.88, 121.6, 121.5, 119.0, 105.5, 69.9, 55.2, 53.7, 45.3, 36.84, 36.80, 18.34, 18.30. The spectroscopic data are in agreement with that previously reported.[1]



1zc

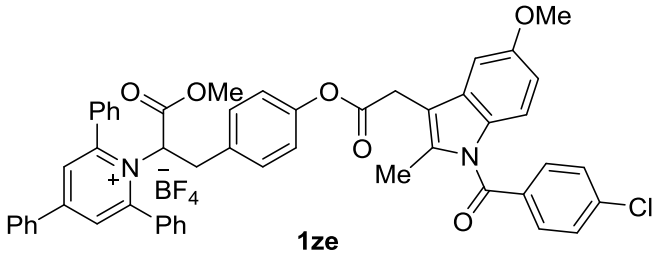
1-(3-(4-((2-(4-Isobutylphenyl)propanoyl)oxy)phenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1zc). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.886 (s, 1H), 7.883 (s, 1H), 7.80-7.74 (m, 4H), 7.58-7.56 (m, 2H), 7.53-7.51 (m, 5H), 7.47-7.40 (m, 4H), 7.26-7.25 (m, 2H), 7.14-7.12 (m, 2H), 6.73 (d, *J* = 8.4 Hz, 2H), 6.70 (d, *J* = 8.4 Hz, 2H), 5.57 (dd, *J* = 5.4, 7.2 Hz, 1H), 3.88 (q, *J* = 7.2 Hz, 1H), 3.682 (s, 1.5H), 3.677 (s, 1.5H), 3.37 (dt, *J* = 4.2, 14.4 Hz, 1H), 2.95 (dd, *J* = 7.2, 14.4 Hz, 1H), 2.46 (dd, *J* = 3.0, 7.2 Hz, 2H), 1.88-1.83 (m, 1H), 1.59-1.55 (m, 3H), 0.91-0.89 (m, 6H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.11, 173.09, 167.3, 156.8, 149.9, 140.7, 137.0, 136.9, 133.5, 133.4, 132.3, 131.9, 131.5, 129.8, 129.5, 129.4, 129.3, 129.0, 128.4, 127.6, 127.02, 127.00, 121.6, 121.5, 69.9, 53.7, 45.0, 44.8, 36.84, 36.79, 30.0, 22.2, 18.36, 18.35. The spectroscopic data are in agreement with that previously reported.[1]



1zd

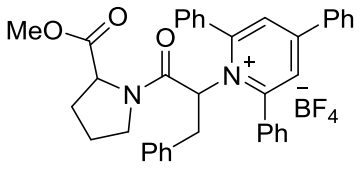
1-(3-(4-((2-(3-Cyano-4-isobutoxyphenyl)-4-methylthiazole-5-carbonyl)oxy)phenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1zd). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.19 (d, *J* = 1.8 Hz, 1H), 8.10 (dd, *J* = 2.4, 9.0 Hz, 1H), 7.96 (s,

2H), 7.85-7.83 (m, 4H), 7.63-7.49 (m, 11H), 7.07 (d, *J* = 9.0 Hz, 1H), 6.93 (d, *J* = 9.0 Hz, 2H), 6.86 (d, *J* = 8.4 Hz, 2H), 5.64 (dd, *J* = 4.2, 7.2 Hz, 1H), 3.92 (d, *J* = 6.0 Hz, 2H), 3.72 (s, 3H), 3.48 (dd, *J* = 4.8, 14.4 Hz, 1H), 2.99 (dd, *J* = 7.8, 14.4 Hz, 1H), 2.78 (s, 3H), 2.20-2.17 (m, 1H), 1.08 (d, *J* = 6.6 Hz, 6H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 168.2, 167.6, 162.9, 162.6, 160.3, 156.9, 149.3, 134.1, 133.5, 132.8, 132.4, 132.1, 132.0, 131.6, 130.2, 129.6, 129.4, 129.1, 128.5, 127.8, 125.6, 121.8, 120.3, 115.3, 112.8, 102.8, 75.6, 70.0, 53.8, 36.9, 28.0, 18.9, 17.6. The spectroscopic data are in agreement with that previously reported.[1]



1ze

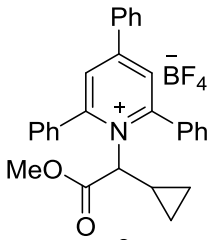
1-(3-(4-(2-(1-(4-Chlorobenzoyl)-5-methoxy-2-methyl-1*H*-indol-3-yl)acetoxy)phenyl)-1-methoxy-1-oxopropan-2-yl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (1ze). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92 (s, 2H), 7.82-7.80 (m, 4H), 7.66-7.64 (m, 2H), 7.59-7.52 (m, 7H), 7.49-7.43 (m, 6H), 7.01 (d, *J* = 3.0 Hz, 1H), 6.89 (d, *J* = 9.0 Hz, 1H), 6.80-6.76 (m, 4H), 6.68 (dd, *J* = 3.0, 9.0 Hz, 1H), 5.59 (dd, *J* = 4.8, 7.2 Hz, 1H), 3.86 (s, 2H), 3.81 (s, 3H), 3.68 (s, 3H), 3.42 (dd, *J* = 4.8, 15.0 Hz, 1H), 2.94 (dd, *J* = 7.2, 14.4 Hz, 1H), 2.41 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 169.2, 168.2, 167.5, 156.9, 156.8, 156.0, 149.7, 139.2, 136.1, 133.8, 133.7, 133.5, 132.4, 132.0, 131.5, 131.1, 130.7, 130.4, 130.0, 129.6, 129.4, 129.1, 128.5, 127.7, 121.6, 114.9, 111.9, 111.6, 101.2, 70.0, 55.7, 53.7, 36.9, 30.3, 13.3. The spectroscopic data are in agreement with that previously reported.[1]



1zf

1-(1-(2-(Methoxycarbonyl)pyrrolidin-1-yl)-1-oxo-3-phenylpropan-2-yl)-2,4,6-tripheny

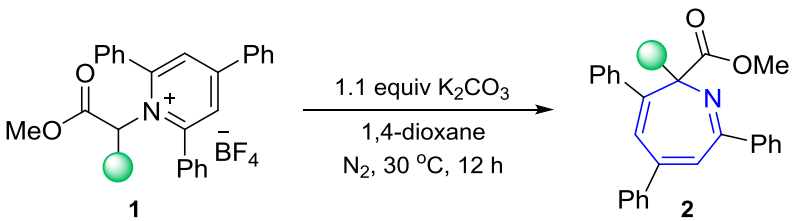
lpyridin-1-ium tetrafluoroborate (1zf). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.23 (br, 2H), 7.87 (s, 2H), 7.80-7.79 (m, 2H), 7.56-7.50 (m, 11H), 7.18-7.14 (m, 4H), 7.12-7.09 (m, 1H), 5.84 (dd, *J* = 3.0, 11.4 Hz, 1H), 4.17 (t, *J* = 6.6 Hz, 1H), 3.75 (s, 3H), 3.54 (dd, *J* = 2.4, 13.2 Hz, 1H), 2.48 (dd, *J* = 4.8, 13.2 Hz, 1H), 1.99-1.94 (m, 1H), 1.64-1.58 (m, 1H), 1.34-1.30 (m, 1H), 1.28-1.24 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.3, 165.7, 157.3, 155.7, 135.9, 134.01, 133.97, 133.7, 132.1, 131.0, 129.7, 129.6, 128.8, 128.6, 128.3, 128.1, 127.2, 72.7, 60.2, 52.1, 46.1, 39.2, 28.4, 24.8. The spectroscopic data are in agreement with that previously reported.[1]



3

1-(1-Cyclopropyl-2-methoxy-2-oxoethyl)-2,4,6-triphenylpyridin-1-ium tetrafluoroborate (3). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.99 (s, 2H), 7.89-7.88 (m, 2H), 7.69 (br, 2H), 7.62-7.51 (m, 11H), 4.71 (d, *J* = 8.0 Hz, 1H), 3.81 (s, 3H), 0.69-0.64 (m, 1H), 0.61-0.58 (m, 2H), 0.43-0.39 (m, 1H), 0.05-0.01 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.3, 156.9, 156.5, 133.5, 132.6, 132.4, 131.5, 129.7, 129.2, 128.5, 128.4, 127.6, 74.5, 54.0, 13.2, 10.7, 4.9. The spectroscopic data are in agreement with that previously reported.[1]

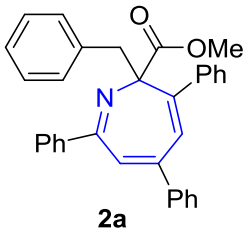
General procedure for the ring expansion of amino acid derivatives



1 **2**

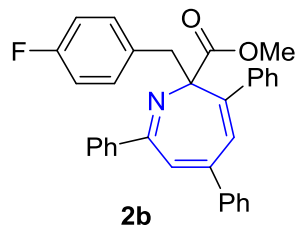
A sealable Schlenk tube (15.0 mL) was heated under vacuum using a heatgun, and evacuated and back-filled with nitrogen for three times. After the tube was cooled to room

temperature, pyridinium salts **1** (1.0 equiv) and K_2CO_3 (1.1 equiv) were added under N_2 atmosphere. Then, the tube was re-evacuated and refilled with nitrogen for three times before adding 1,4-dioxane (0.1 M with respect to **1**) via a syringe. The Schlenk tube was securely sealed and immersed into an oil bath preheated at 30 °C. After stirring at the same temperature for 12 h, the reaction mixture was filtered through a short pad of silica gel, and rinsed with ethyl acetate. Then, the resulting organic layer was evaporated under the reduced pressure, and the residue was purified by column chromatography on silica gel to afford the target azepine product **2**.



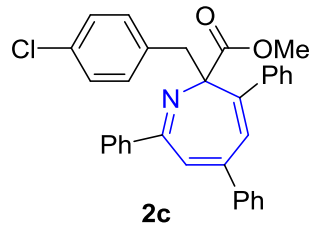
2a

Methyl 2-benzyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2a). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1a** (0.3 mmol, 167.2 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 50:1 to 25:1, gradient) to afford the title product in 98% yield (137.6 mg) as a white solid. M.p. = 97-98 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.82-7.81 (m, 2H), 7.42 (d, *J* = 7.2 Hz, 2H), 7.40 (d, *J* = 6.6 Hz, 2H), 7.36-7.35 (m, 3H), 7.32-7.21 (m, 9H), 7.16 (t, *J* = 7.8 Hz, 2H), 7.10 (q, *J* = 7.2 Hz, 1H), 6.38 (s, 1H), 3.43 (d, *J* = 13.2 Hz, 1H), 3.13 (s, 3H), 3.04 (d, *J* = 13.2 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.3, 164.1, 147.5, 147.3, 140.1, 140.0, 139.7, 137.2, 130.6, 129.83, 129.81, 129.0, 128.8, 128.7, 128.6, 128.3, 128.0, 127.7, 127.4, 127.2, 126.5, 72.2, 51.3, 47.0 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 3027, 1709, 1493, 1257, 1206, 1082, 886, 767, 758, 739, 696 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{28}NO_2$ $[M+H]^+$: 470.2115, found 470.2115.



2b

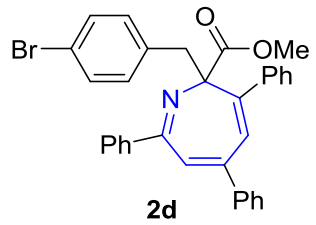
Methyl 2-(4-fluorobenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2b). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1b** (0.3 mmol, 172.6 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 92% yield (134.0 mg) as a white solid. M.p. = 95-96 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.89-7.88 (m, 2H), 7.50 (d, *J* = 7.8 Hz, 2H), 7.47-7.44 (m, 5H), 7.40-7.38 (m, 3H), 7.36-7.31 (m, 4H), 7.26 (dd, *J* = 7.8, 6.0 Hz, 2H), 6.93 (t, *J* = 8.4 Hz, 2H), 6.46 (s, 1H), 3.46 (d, *J* = 13.2 Hz, 1H), 3.23 (s, 3H), 3.09 (d, *J* = 13.2 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.3, 164.3, 161.9 (d, *J* = 242.9 Hz), 147.4, 147.3, 140.0, 139.9, 139.6, 132.9 (d, *J* = 3.3 Hz), 131.9 (d, *J* = 7.7 Hz), 129.9, 129.8, 128.9, 128.8, 128.7, 128.5, 128.3, 128.1, 127.8, 127.5, 127.1, 114.2 (d, *J* = 20.9 Hz), 72.0, 51.3, 46.1. ^{19}F NMR (565 MHz, $CDCl_3$): δ -116.82. IR (neat): 2947, 1723, 1595, 1508, 1220, 1156, 835, 756, 695, 601, 573, 565 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{27}FNO_2$ $[M+H]^+$: 488.2020, found 488.2021.



2c

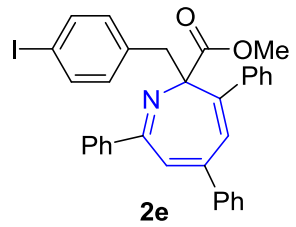
Methyl 2-(4-chlorobenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2c). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1c** (0.3 mmol, 177.6 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title

product in 88% yield (133.3 mg) as a white solid. M.p. = 92-93 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.86 (m, 2H), 7.52-7.50 (m, 2H), 7.45-7.44 (m, 5H), 7.41-7.31 (m, 7H), 7.25-7.20 (m, 4H), 6.46 (d, *J* = 1.2 Hz, 1H), 3.45 (d, *J* = 13.2 Hz, 1H), 3.24 (s, 3H), 3.08 (d, *J* = 13.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.2, 164.3, 147.4, 147.3, 140.0, 139.8, 139.5, 135.8, 132.4, 131.9, 129.9, 129.8, 128.9, 128.8, 128.7, 128.5, 128.3, 128.1, 127.8, 127.6, 127.5, 127.1, 72.0, 51.4, 46.2. IR (neat): 2945, 1721, 1593, 1490, 1174, 1075, 1016, 840, 756, 694, 603, 566 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{27}ClNO_2$ $[M+H]^+$: 504.1725, found 504.1725.



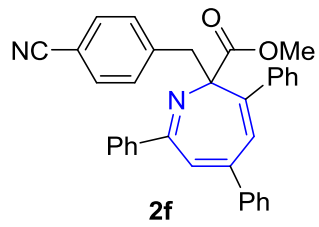
2d

Methyl 2-(4-bromobenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2d). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1d** (0.3 mmol, 190.9 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 93% yield (153.7 mg) as a white solid. M.p. = 106-107 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.78-7.76 (m, 2H), 7.39-7.38 (m, 2H), 7.35-7.32 (m, 5H), 7.28-7.20 (m, 9H), 7.07 (d, *J* = 8.4 Hz, 2H), 6.35 (d, *J* = 1.2 Hz, 1H), 3.33 (d, *J* = 13.2 Hz, 1H), 3.12 (s, 3H), 2.95 (d, *J* = 13.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.1, 164.2, 147.3, 147.2, 139.9, 139.8, 139.4, 136.2, 132.2, 130.5, 129.9, 129.7, 128.80, 128.78, 128.7, 128.5, 128.3, 128.0, 127.8, 127.5, 127.1, 120.6, 71.9, 51.3, 46.2. IR (neat): 2947, 1723, 1487, 1172, 1070, 1012, 836, 755, 694, 644, 603, 563 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{27}BrNO_2$ $[M+H]^+$: 548.1220, found 548.1220.



2e

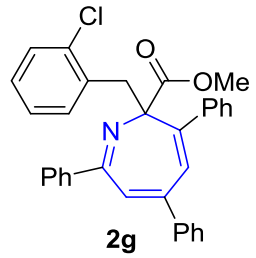
Methyl 2-(4-iodobenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2e). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1e** (0.3 mmol, 205.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 85% yield (151.7 mg) as a white solid. M.p. = 100-101 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.88-7.87 (m, 2H), 7.57 (d, *J* = 9.0 Hz, 2H), 7.52-7.50 (m, 2H), 7.47-7.45 (m, 5H), 7.42-7.34 (m, 7H), 7.05 (d, *J* = 8.4 Hz, 2H), 6.46 (d, *J* = 1.2 Hz, 1H), 3.42 (d, *J* = 13.2 Hz, 1H), 3.25 (s, 3H), 3.04 (d, *J* = 13.2 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.2, 164.3, 147.4, 147.3, 140.0, 139.8, 139.5, 137.0, 136.5, 132.6, 129.9, 129.8, 128.9, 128.84, 128.75, 128.6, 128.4, 128.1, 127.8, 127.5, 127.2, 92.3, 71.9, 51.4, 46.4. IR (neat): 2945, 1723, 1484, 1241, 1172, 1008, 836, 755, 694, 636, 603, 562 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{27}INO_2$ $[M+H]^+$: 596.1081, found 596.1081.



2f

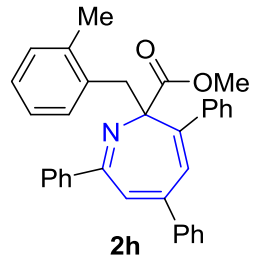
Methyl 2-(4-cyanobenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2f). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1f** (0.3 mmol, 174.7 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 10:1) to afford the title product in 95% yield (141.0 mg) as a white solid. M.p. = 97-98 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.87-7.85 (m,

2H), 7.54-7.49 (m, 4H), 7.46-7.40 (m, 9H), 7.38-7.34 (m, 5H), 6.47 (d, *J* = 1.2Hz, 1H), 3.52 (d, *J* = 13.2 Hz, 1H), 3.25 (s, 3H), 3.13 (d, *J* = 12.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.9, 164.3, 147.4, 146.9, 143.1, 139.7, 139.5, 139.3, 131.3, 131.1, 130.0, 129.7, 128.9, 128.7, 128.4, 128.3, 128.1, 127.8, 127.6, 127.0, 119.1, 110.3, 71.8, 51.4, 46.7 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2945, 2225, 1725, 1241, 1174, 1071, 844, 756, 695, 603, 577, 564 cm^{-1}. HRMS (ESI) calcd. for $C_{34}H_{27}N_2O_2$ $[M+H]^+$: 495.2067, found 495.2068.



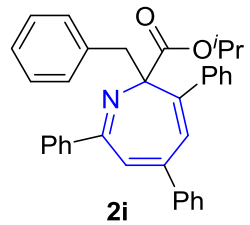
2g

Methyl 2-(2-chlorobenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2g). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1g** (0.3 mmol, 177.6 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 88% yield (132.9 mg) as a white solid. M.p. = 158-159 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.87 (m, 3H), 7.53-7.51 (m, 4H), 7.43-7.41 (m, 3H), 7.40-7.31 (m, 7H), 7.27-7.22 (m, 2H), 7.12 (td, *J* = 8.0, 1.6 Hz, 1H), 6.47 (d, *J* = 1.2 Hz, 1H), 3.58 (d, *J* = 13.2 Hz, 1H), 3.40 (d, *J* = 13.6 Hz, 1H), 3.35 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.7, 163.9, 147.8, 147.6, 140.1, 139.8, 139.6, 135.1, 134.9, 134.1, 129.8, 129.7, 129.0, 128.8, 128.71, 128.69, 128.3, 128.2, 128.0, 127.9, 127.8, 127.6, 127.2, 125.5, 70.8, 51.9, 42.5. IR (neat): 3028, 1719, 1593, 1443, 1251, 1176, 1079, 973, 757, 746, 697, 564 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{27}ClNO_2$ $[M+H]^+$: 504.1725, found 504.1725.



2h

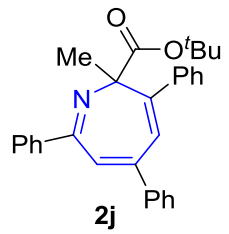
Methyl 2-(2-methylbenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2h). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1h** (0.3 mmol, 171.4 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 92% yield (133.8 mg) as a white solid. M.p. = 149-150 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.86-7.84 (m, 2H), 7.53-7.49 (m, 4H), 7.44-7.37 (m, 9H), 7.36-7.34 (m, 1H), 7.33 (d, J = 1.8 Hz, 1H), 7.11-7.10 (m, 3H), 6.47 (d, J = 1.2 Hz, 1H), 3.53 (d, J = 13.8 Hz, 1H), 3.23 (s, 3H), 3.17 (d, J = 13.8 Hz, 1H), 2.37 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.8, 164.0, 147.9, 147.4, 140.2, 140.1, 139.7, 137.5, 135.7, 131.5, 129.8, 129.72, 129.69, 129.0, 128.8, 128.7, 128.4, 128.2, 127.9, 127.8, 127.4, 127.2, 126.5, 124.8, 72.2, 51.3, 43.0, 20.1. IR (neat): 2922, 1711, 1492, 1445, 1258, 1024, 758, 748, 702, 694, 595, 568 cm^{-1}. HRMS (ESI) calcd. for $C_{34}H_{30}NO_2$ $[M+H]^+$: 484.2271, found 484.2272.



2i

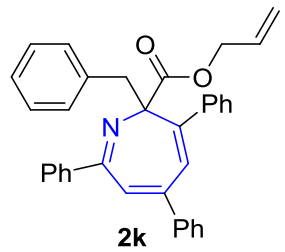
Isopropyl 2-benzyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2i). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1i** (0.3 mmol, 175.6 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 88% yield (131.4 mg) as

a white solid. M.p. = 152-153 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90-7.87 (m, 2H), 7.56-7.54 (m, 2H), 7.50-7.42 (m, 5H), 7.40-7.30 (m, 9H), 7.24 (t, *J* = 6.8 Hz, 2H), 7.19-7.16 (m, 1H), 6.47 (d, *J* = 1.2 Hz, 1H), 4.51-4.44 (m, 1H), 3.50 (d, *J* = 12.8 Hz, 1H), 3.08 (d, *J* = 12.8 Hz, 1H), 0.86 (d, *J* = 6.0 Hz, 3H), 0.61 (d, *J* = 6.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.2, 164.3, 147.8, 146.8, 140.2, 140.1, 139.9, 137.4, 130.8, 129.8, 129.7, 129.0, 128.8, 128.7, 128.6, 128.3, 127.7, 127.40, 127.35, 127.1, 126.4, 71.9, 68.3, 47.2, 21.6, 21.0 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2975, 1715, 1595, 1492, 1368, 1107, 1079, 878, 755, 740, 695, 601 cm^{-1}. HRMS (ESI) calcd. for $C_{35}H_{32}NO_2$ $[M+H]^+$: 498.2428, found 498.2428.



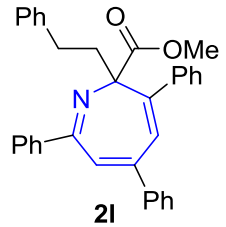
2j

***tert*-Butyl 2-methyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2j).** 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1j** (0.3 mmol, 157.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 50 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 78% yield (101.9 mg) as a white solid. M.p. = 143-144 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90-7.87 (m, 2H), 7.61-7.59 (m, 2H), 7.44-7.34 (m, 9H), 7.33-7.31 (m, 3H), 6.48 (d, *J* = 1.6 Hz, 1H), 1.76 (s, 3H), 1.26 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.3, 164.7, 148.1, 147.5, 140.5, 140.0, 139.8, 129.6, 129.5, 128.9, 128.6, 128.3, 127.60, 127.56, 127.30, 127.28, 127.2, 80.9, 68.4, 28.4, 27.6 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2975, 1725, 1445, 1368, 1233, 1158, 1121, 846, 766, 753, 698, 690, 568 cm^{-1}. HRMS (ESI) calcd. for $C_{30}H_{30}NO_2$ $[M+H]^+$: 436.2271, found 436.2271.



2k

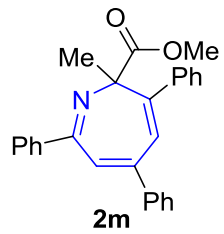
Allyl 2-benzyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2k). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1k** (0.3 mmol, 175.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 94% yield (139.8 mg) as a white solid. M.p. = 64-65 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.81-7.79 (m, 2H), 7.42-7.38 (m, 4H), 7.35-7.34 (m, 3H), 7.30-7.21 (m, 9H), 7.14 (t, *J* = 6.8 Hz, 2H), 7.10-7.06 (m, 1H), 6.38 (d, *J* = 1.2 Hz, 1H), 5.42-5.33 (m, 1H), 4.90-4.82 (m, 2H), 4.11 (dd, *J* = 13.2, 5.6 Hz, 1H), 3.89 (dd, *J* = 13.6, 6.0 Hz, 1H), 3.44 (d, *J* = 12.8 Hz, 1H), 3.03 (d, *J* = 12.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.3, 164.3, 147.5, 147.1, 140.0, 139.8, 137.2, 131.7, 130.6, 129.8, 129.7, 128.9, 128.74, 128.72, 128.6, 128.3, 127.9, 127.7, 127.4, 127.1, 126.5, 117.9, 72.2, 65.1, 47.0 *(2 aromatic carbon signals are not observed due to signal overlap)*. IR (neat): 3026, 1719, 1593, 1492, 1441, 1239, 1172, 1079, 755, 695, 599 cm^{-1}. HRMS (ESI) calcd. for $C_{35}H_{30}NO_2$ $[M+H]^+$: 496.2271, found 496.2270.



2l

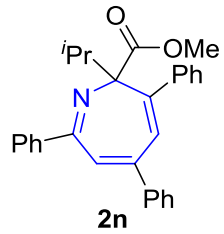
Methyl 2-phenethyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2l). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1l** (0.3 mmol, 171.4 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 50 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent:

petroleum ether: ethyl acetate = 100:1) to afford the title product in 90% yield (130.6 mg) as a white solid. M.p. = 69-70 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.96-7.95 (m, 2H), 7.54 (d, *J* = 7.2 Hz, 2H), 7.46-7.45 (m, 3H), 7.43-7.41 (m, 5H), 7.39-7.36 (m, 1H), 7.33-7.30 (m, 3H), 7.19 (t, *J* = 7.8 Hz, 2H), 7.11 (t, *J* = 7.8 Hz, 1H), 7.01 (d, *J* = 7.8 Hz, 2H), 6.47 (s, 1H), 3.50 (s, 3H), 2.96 (td, *J* = 12.6, 4.2 Hz, 1H), 2.55 (td, *J* = 12.6, 4.2 Hz, 1H), 2.48 (td, *J* = 12.6, 3.6 Hz, 1H), 2.37 (td, *J* = 12.0, 4.2 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.2, 164.3, 147.6, 147.3, 142.3, 140.1, 140.0, 139.5, 129.9, 129.6, 128.9, 128.82, 128.75, 128.5, 128.4, 128.2, 128.0, 127.7, 127.5, 127.2, 125.6, 70.7, 51.9, 42.0, 30.9 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 3023, 1731, 1596, 1493, 1444, 1224, 1169, 1072, 876, 755, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{34}H_{30}NO_2$ $[M+H]^+$: 484.2271, found 484.2273.



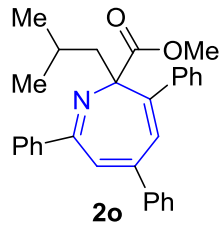
2m

Methyl 2-methyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2m). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1m** (0.3 mmol, 144.4 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 24 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 85% yield (100.5 mg) as a white solid. M.p. = 155-156 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92-7.90 (m, 2H), 7.54 (d, *J* = 7.8 Hz, 2H), 7.44-7.43 (m, 3H), 7.43-7.37 (m, 6H), 7.35-7.31 (m, 3H), 6.49 (d, *J* = 1.2 Hz, 1H), 3.48 (s, 3H), 1.79 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 175.0, 164.4, 148.2, 147.5, 140.1, 140.0, 139.3, 129.8, 129.6, 128.81, 128.76, 128.7, 128.3, 127.8, 127.6, 127.42, 127.38, 127.2, 68.1, 52.0, 28.3. IR (neat): 3050, 1729, 1442, 1368, 1227, 1123, 972, 880, 762, 698, 680 cm^{-1}. HRMS (ESI) calcd. for $C_{27}H_{24}NO_2$ $[M+H]^+$: 394.1802, found 394.1801.



2n

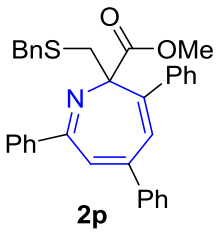
Methyl 2-isopropyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2n). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1n** (0.3 mmol, 152.8 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 24 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 50:1) to afford the title product in 95% yield (120.1 mg) as a white solid. M.p. = 161-162 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.95-7.93 (m, 2H), 7.57-7.55 (m, 2H), 7.45-7.37 (m, 9H), 7.35-7.27 (m, 3H), 6.44 (d, J = 1.2 Hz, 1H), 3.41 (s, 3H), 2.95-2.88 (m, 1H), 1.19 (d, J = 6.8 Hz, 3H), 0.73 (d, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.7, 163.2, 147.6, 147.2, 140.7, 140.0, 139.7, 129.74, 129.67, 129.5, 128.81, 128.77, 128.7, 128.3, 127.8, 127.6, 127.3, 126.9, 74.4, 51.1, 34.3, 18.13, 18.11. IR (neat): 2957, 1732, 1489, 1444, 1325, 1204, 1136, 1036, 872, 768, 707, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{29}H_{28}NO_2$ $[M+H]^+$: 422.2115, found 422.2116.



2o

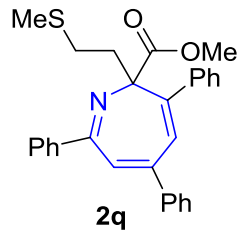
Methyl 2-isobutyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2o). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1o** (0.3 mmol, 157.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 24 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 97% yield (126.1 mg) as a white solid. M.p. = 148-149 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93-7.90 (m, 2H), 7.54-7.52 (m, 2H), 7.46-7.35 (m, 9H), 7.33-7.26 (m, 3H), 6.40 (d, J =

1.2 Hz, 1H), 3.46 (s, 3H), 2.09 (dd, *J* = 14.0, 6.4 Hz, 1H), 1.98 (dd, *J* = 14.0, 4.4 Hz, 1H), 1.92-1.90 (m, 1H), 1.03 (d, *J* = 6.8 Hz, 3H), 0.71 (d, *J* = 6.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.1, 163.8, 147.6, 147.2, 140.13, 140.11, 139.6, 129.8, 129.7, 128.8, 128.7, 128.4, 128.3, 127.9, 127.5, 127.2, 127.1, 71.0, 51.6, 48.9, 24.6, 24.4, 24.3 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2952, 1733, 1594, 1489, 1445, 1366, 1205, 1132, 1029, 876, 756, 695 m^{-1}. HRMS (ESI) calcd. for $C_{30}H_{30}NO_2$ $[M+H]^+$: 436.2271, found 436.2271.



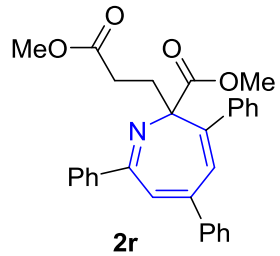
2p

Methyl 2-((benzylthio)methyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2p). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1p** (0.3 mmol, 181.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 20 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 63% yield (97.4 mg) as a white solid. M.p. = 64-65 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.85-7.83 (m, 2H), 7.43 (d, *J* = 6.4 Hz, 2H), 7.35-7.26 (m, 9H), 7.23-7.21 (m, 3H), 7.17-7.07 (m, 5H), 6.35 (d, *J* = 1.2 Hz, 1H), 3.59 (s, 2H), 3.39 (s, 3H), 3.25 (d, *J* = 12.8 Hz, 1H), 3.01 (d, *J* = 12.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.8, 164.5, 147.6, 146.4, 140.0, 139.4, 139.3, 138.5, 129.9, 129.7, 129.0, 128.87, 128.85, 128.7, 128.33, 128.26, 128.0, 127.7, 127.5, 127.1, 126.7, 71.9, 52.0, 41.9, 37.6 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 3059, 1732, 1619, 1594, 1549, 1493, 1444, 1027, 760, 694 cm^{-1}. HRMS (ESI) calcd. for $C_{34}H_{30}NO_2S$ $[M+H]^+$: 516.1992, found 516.1992.



2q

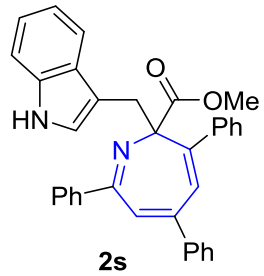
Methyl 2-(2-(methylthio)ethyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2q). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1q** (0.3 mmol, 162.4 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 89% yield (121.1 mg) as a white solid. M.p. = 84-85 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.93-7.91 (m, 2H), 7.53-7.51 (m, 2H), 7.46-7.44 (m, 3H), 7.42-7.36 (m, 6H), 7.35-7.31 (m, 3H), 6.44 (d, *J* = 1.2 Hz, 1H), 3.50 (s, 3H), 2.81 (dd, *J* = 12.0, 8.4 Hz, 1H), 2.48-2.42 (m, 2H), 2.32-2.29 (m, 1H), 1.95 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.8, 164.4, 147.7, 147.0, 140.0, 139.7, 139.3, 129.9, 129.5, 128.9, 128.8, 128.7, 128.4, 128.3, 127.9, 127.8, 127.6, 127.1, 70.4, 52.0, 40.1, 29.1, 15.4. IR (neat): 2970, 1730, 1594, 1491, 1444, 1217, 1165, 1073, 876, 756, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{29}H_{28}NO_2S$ $[M+H]^+$: 454.1835, found 454.1835.



2r

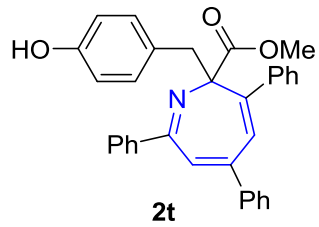
Methyl 2-(3-methoxy-3-oxopropyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2r). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1r** (0.3 mmol, 166.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 10:1) to afford the title product in 93% yield

(130.2 mg) as a white solid. M.p. = 63-64 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92-7.90 (m, 2H), 7.51 (d, *J* = 7.2 Hz, 2H), 7.44-7.43 (m, 3H), 7.41-7.38 (m, 5H), 7.36-7.29 (m, 4H), 6.44 (d, *J* = 1.8 Hz, 1H), 3.60 (s, 3H), 3.48 (s, 3H), 2.79-2.74 (m, 1H), 2.55-2.44 (m, 2H), 2.37-2.32 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.9, 172.7, 164.5, 147.6, 147.1, 139.9, 139.5, 139.2, 129.9, 129.5, 128.8, 128.73, 128.67, 128.3, 128.2, 127.9, 127.7, 127.5, 127.0, 69.5, 51.9, 51.4, 34.8, 29.2. IR (neat): 2948, 1732, 1594, 1491, 1436, 1368, 1220, 1170, 1072, 874, 757, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{30}H_{28}NO_4$ $[M+H]^+$: 466.2013, found 466.2013.



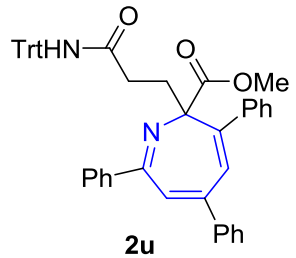
2s

Methyl 2-((1*H*-indol-3-yl)methyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2s). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1s** (0.3 mmol, 178.9 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 60% yield (91.6 mg) as a yellow solid. M.p. = 108-109 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.04 (s, 1H), 7.91-7.90 (m, 2H), 7.56-7.50 (m, 5H), 7.42-7.31 (m, 10H), 7.15-7.14 (m, 1H), 7.07 (d, *J* = 1.2 Hz, 1H), 7.05-7.01 (m, 2H), 6.47 (s, 1H), 3.60 (d, *J* = 14.4 Hz, 1H), 3.47 (d, *J* = 14.4 Hz, 1H), 3.06 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.7, 164.2, 147.8, 147.2, 140.22, 140.19, 139.6, 135.6, 129.8, 129.7, 128.9, 128.7, 128.5, 128.4, 128.3, 128.2, 127.8, 127.4, 127.2, 123.8, 121.3, 119.1, 118.7, 110.82, 110.75, 71.6, 51.6, 36.5 *(1 aromatic carbon signal is not observed due to signal overlap).* IR (neat): 3380, 2921, 1721, 1572, 1491, 1338, 1074, 1006, 876, 756, 740, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{35}H_{29}N_2O_2$ $[M+H]^+$: 509.2224, found 509.2224.



2t

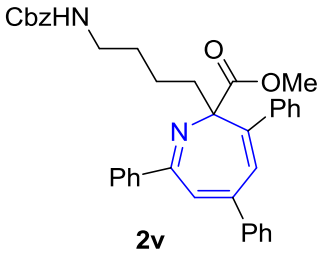
Methyl 2-(4-hydroxybenzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2t). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1t** (0.3 mmol, 172.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and dimethylacetamide (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was quenched with water, extracted with ethyl acetate, and the organic layer was washed with water and brine, and dried over anhydrous Na_2SO_4. The resulting filtrate was concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 5:1) to afford the title product in 87% yield (126.2 mg) as a white solid. M.p. = 113-114 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.91-7.88 (m, 2H), 7.52-7.50 (m, 2H), 7.45-7.41 (m, 6H), 7.40 (s, 1H), 7.38-7.30 (m, 6H), 7.09 (d, *J* = 8.4 Hz, 2H), 6.58 (d, *J* = 8.4 Hz, 2H), 6.47 (d, *J* = 1.2 Hz, 1H), 3.44 (d, *J* = 13.6 Hz, 1H), 3.26 (s, 3H), 3.04 (d, *J* = 13.2 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.6, 164.7, 154.7, 147.6, 147.4, 140.0, 139.9, 139.6, 131.4, 129.9, 129.8, 129.0, 128.8, 128.74, 128.70, 128.6, 128.3, 128.1, 127.7, 127.4, 127.1, 114.6, 72.3, 51.6, 46.1. IR (neat): 3400, 3023, 1723, 1594, 1511, 1442, 1172, 1072, 831, 756, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{33}H_{28}NO_3$ $[M+H]^+$: 486.2064, found 486.2064.



2u

Methyl 2-(3-oxo-3-(tritylamino)propyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2u). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1u** (0.3 mmol, 234.2 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on

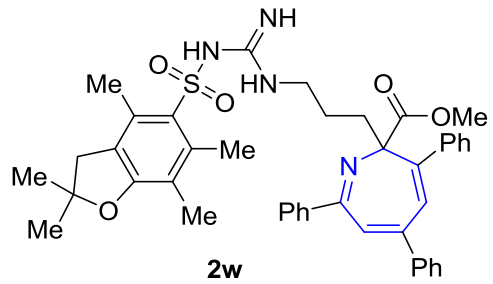
silica gel (eluent: petroleum ether: ethyl acetate = 5:1) to afford the title product in 85% yield (176.1 mg) as a white solid. M.p. = 89-90 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88-7.86 (m, 2H), 7.53-7.51 (m, 2H), 7.43-7.34 (m, 7H), 7.27-7.26 (m, 6H), 7.21-7.17 (m, 9H), 7.12-7.07 (m, 6H), 6.47 (d, *J* = 1.2 Hz, 1H), 3.42 (s, 3H), 2.90-2.80 (m, 1H), 2.47-2.33 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.8, 172.1, 165.4, 148.1, 147.1, 144.8, 139.8, 139.5, 139.1, 130.1, 129.5, 128.95, 128.91, 128.74, 128.67, 128.3, 128.1, 128.0, 127.8, 127.7, 127.6, 127.1, 126.7, 70.2, 69.6, 52.2, 35.4, 32.5. IR (neat): 3288, 2961, 1728, 1487, 1445, 1261, 1219, 1082, 1019, 876, 799, 756, 696 cm^{-1}. HRMS (ESI) calcd. for $C_{48}H_{41}N_2O_3$ $[M+H]^+$: 693.3112, found 693.3111.



2v

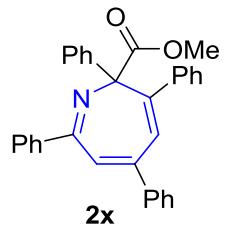
Methyl 2-(4-(((benzyloxy)carbonyl)amino)butyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2v). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1v** (0.3 mmol, 201.8 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 50 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 5:1, gradient) to afford the title product in 84% yield (147.9 mg) as a white solid. M.p. = 124-125 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.89-7.88 (m, 2H), 7.52 (d, *J* = 7.2 Hz, 2H), 7.44-7.40 (m, 5H), 7.39-7.36 (m, 4H), 7.34-7.28 (m, 8H), 6.44 (d, *J* = 0.6 Hz, 1H), 5.07 (s, 2H), 4.72 (s, 1H), 3.47 (s, 3H), 3.11-3.06 (m, 2H), 2.15-2.10 (m, 1H), 2.06-2.01 (m, 1H), 1.69-1.68 (m, 1H), 1.44-1.40 (m, 1H), 1.39-1.34 (m, 1H), 1.23-1.19 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.1, 164.6, 156.3, 147.6, 147.2, 140.1, 139.9, 139.5, 136.7, 129.8, 129.6, 128.8, 128.7, 128.5, 128.4, 128.3, 128.1, 128.01, 127.98, 127.7, 127.4, 127.1, 70.7, 66.4, 51.8, 40.8, 39.8, 29.9, 21.4 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 3465, 2938, 1719, 1489, 1445, 1242, 1193, 1174, 1016, 756, 694 cm^{-1}.

HRMS (ESI) calcd. for $C_{38}H_{37}N_2O_4$ $[M+H]^+$: 585.2748, found 585.2749.



2w

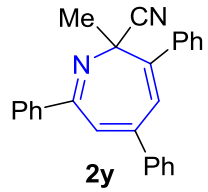
Methyl 2-(3-(3-((2,2,4,6,7-pentamethyl-2,3-dihydrobenzofuran-5-yl)sulfonyl) guanidino)propyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2w). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1w** (0.3 mmol, 245.6 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 ºC for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: acetone = 3:1) to afford the title product in 64% yield (139.9 mg) as a yellow solid. M.p. = 135-136 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.82-7.79 (m, 2H), 7.50 (dd, *J* = 8.0, 1.6 Hz, 2H), 7.43-7.36 (m, 6H), 7.35 (d, *J* = 1.2 Hz, 1H), 7.30 (s, 5H), 6.44 (d, *J* = 1.2 Hz, 1H), 6.17 (br, 1H), 6.03 (br, 2H), 3.45 (s, 3H), 3.17-3.10 (m, 1H), 3.05-3.00 (m, 1H), 2.92 (s, 2H), 2.54 (s, 3H), 2.48 (s, 3H), 2.15-2.07 (m, 4H), 1.95-1.91 (m, 1H), 1.77-1.74 (m, 1H), 1.49-1.43 (m, 7H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.8, 165.4, 158.5, 156.0, 147.6, 147.0, 139.7, 139.5, 139.1, 138.2, 133.2, 132.2, 130.0, 129.5, 129.0, 128.74, 128.65, 128.4, 128.2, 128.1, 127.8, 127.6, 127.0, 124.4, 117.2, 86.1, 70.6, 52.0, 43.1, 41.4, 36.7, 28.5, 24.3, 19.2, 17.8, 12.4. IR (neat): 3440, 3338, 2970, 1728, 1549, 1446, 1368, 1232, 1146, 1090, 756, 697, 665 cm^{-1}. HRMS (ESI) calcd. for $C_{43}H_{47}N_4O_5S$ $[M+H]^+$: 731.3262, found 731.3261.



2x

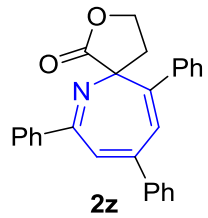
Methyl 2,3,5,7-tetraphenyl-2*H*-azepine-2-carboxylate (2x). 0.3 mmol scale, under N_2

atmosphere, pyridinium salt **1x** (0.3 mmol, 163.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 80 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the title product in 71% yield (97.4 mg) as a yellow solid. M.p. = 104-105 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.83-7.80 (m, 2H), 7.55-7.53 (m, 2H), 7.43-7.36 (m, 4H), 7.33-7.29 (m, 4H), 7.23-7.20 (m, 2H), 7.18-7.13 (m, 6H), 6.77 (d, *J* = 1.6 Hz, 1H), 5.60 (d, *J* = 0.8 Hz, 1H) 3.44 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.4, 148.6, 141.8, 140.9, 139.55, 139.46, 137.0, 131.1, 130.1, 130.0, 129.6, 128.9, 128.6, 128.1, 127.9, 127.8, 127.6, 127.5, 127.1, 126.65, 126.63, 126.5, 52.5, 51.5. IR (neat): 3019, 1736, 1491, 1444, 1261, 1176, 1014, 910, 779, 764, 692, 673 cm^{-1}. HRMS (ESI) calcd. for $C_{32}H_{26}NO_2$ $[M+H]^+$: 456.1958, found 496.1957.



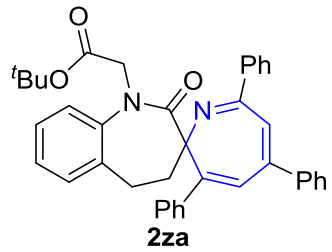
2y

2-Methyl-3,5,7-triphenyl-2*H*-azepine-2-carbonitrile (2y). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1y** (0.3 mmol, 134.5 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 90% yield (97.3 mg) as a green solid. M.p. = 69-70 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67-7.65 (m, 2H), 7.45-7.38 (m, 6H), 7.37-7.26 (m, 7H), 6.72 (s, 1H), 6.12 (d, *J* = 0.8 Hz, 1H), 2.35 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 147.8, 141.2, 137.4, 135.1, 134.2, 130.5, 129.6, 129.0, 128.8, 128.5, 128.3, 127.8, 127.4, 127.1, 127.0, 119.6, 114.2, 35.6, 21.6 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2923, 1732, 1568, 1445, 1220, 1088, 1002, 759, 695, 667 cm^{-1}. HRMS (ESI) calcd. for $C_{26}H_{21}N_2$ $[M+H]^+$: 361.1699, found 361.1699.



2z

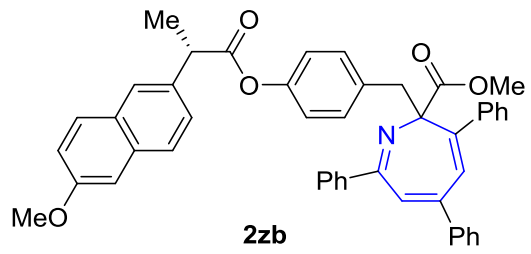
7,9,11-Triphenyl-2-oxa-6-azaspiro[4.6]undeca-6,8,10-trien-1-one (2z). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1z** (0.3 mmol, 143.8 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 24 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate: dichloromethane = 20:1:5) to afford the title product in 83% yield (97.4 mg) as a white solid. M.p. = 168-169 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.82 (d, *J* = 6.6 Hz, 2H), 7.53 (d, *J* = 7.2 Hz, 2H), 7.43 (s, 1H), 7.40-7.33 (m, 6H), 7.24 (s, 5H), 6.59 (s, 1H), 4.36-4.32 (m, 1H), 4.28-4.24 (m, 1H), 2.53-2.49 (m, 1H), 2.22-2.17 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 175.5, 164.4, 149.2, 144.2, 140.1, 139.3, 139.2, 130.1, 129.2, 129.0, 128.94, 128.92, 128.8, 128.4, 128.3, 128.2, 126.9, 126.8, 69.0, 65.1, 34.4. IR (neat): 3021, 1776, 1444, 1376, 1214, 1178, 1033, 963, 870, 756, 715, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{27}H_{22}NO_2$ $[M+H]^+$: 392.1645, found 392.1644.



2za

***tert*-Butyl 2-(2'-oxo-3,5,7-triphenyl-4',5'-dihydrospiro[azepine-2,3'-benzo[*b*]azepin]-1'(2'*H*)-yl)acetate (2za).** 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1za** (0.3 mmol, 200.6 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 24 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to petroleum ether: ethyl acetate: dichloromethane = 25:1:4, gradient) to afford the title

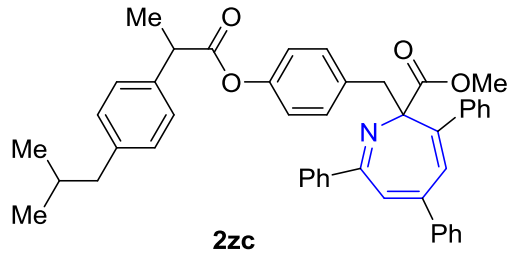
product in 83% yield (145.2 mg) as a white solid. M.p. = 224-225 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.66 (d, *J* = 7.2 Hz, 2H), 7.40 (t, *J* = 7.2 Hz, 2H), 7.36-7.33 (m, 5H), 7.30-7.25 (m, 4H), 7.20-7.16 (m, 3H), 7.03-6.99 (m, 3H), 6.79 (d, *J* = 7.8 Hz, 1H), 6.52 (d, *J* = 1.2 Hz, 1H), 4.28 (d, *J* = 17.4 Hz, 1H), 4.01 (d, *J* = 17.4 Hz, 1H), 3.29-3.25 (m, 1H), 2.92-2.87 (m, 1H), 2.69 (dd, *J* = 13.8, 7.2 Hz, 1H), 2.46 (dd, *J* = 13.2, 7.8 Hz, 1H), 1.22 (s, 9H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.6, 168.0, 161.2, 149.2, 146.6, 143.4, 140.5, 140.0, 139.0, 136.9, 129.7, 129.5, 129.4, 128.9, 128.49, 128.45, 128.3, 128.1, 127.53, 127.50, 127.0, 126.0, 125.7, 122.1, 81.3, 71.5, 52.1, 44.5, 29.2, 27.7 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2974, 1740, 1652, 1596, 1493, 1365, 1272, 1221, 1156, 1025, 870, 755, 703, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{39}H_{37}N_2O_3$ $[M+H]^+$: 581.2799, found 581.2799.



2zb

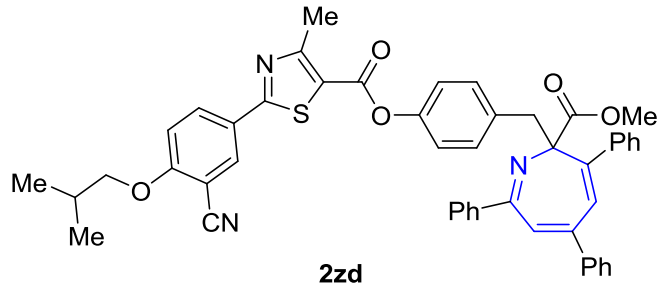
Methyl 2-(4-(((*S*)-2-(6-methoxynaphthalen-2-yl)propanoyl)oxy)benzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2zb). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1zb** (0.3 mmol, 235.7 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1 to 5:1, gradient) to afford a mixture of diastereoisomers (d.r. 1:1) in 89% yield (187.0 mg) as a white solid. M.p. = 95-96 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88-7.85 (m, 2H), 7.74-7.70 (m, 3H), 7.51-7.41 (m, 8H), 7.40-7.31 (m, 7H), 7.26 (d, *J* = 8.4 Hz, 2H), 7.15-7.11 (m, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 6.45 (d, *J* = 1.2 Hz, 1H), 4.05 (q, *J* = 7.2 Hz, 1H), 3.878 (s, 1.5H), 3.876 (s, 1.5H), 3.48 (d, *J* = 13.2 Hz, 1H), 3.17 (s, 1.5H), 3.16 (s, 1.5H), 3.08 (d, *J* = 13.2 Hz, 1H), 1.66 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 173.1, 172.4, (164.20, 164.18), 157.7, 149.6, 147.4, 140.0, 139.9, 139.5, (135.18, 135.17),

134.8, 133.7, 131.3, 129.80, 129.76, 129.3, 128.93, 128.86, 128.8, 128.7, 128.4, 128.3, 128.0, 127.8, 127.5, 127.3, 127.1, 126.14, 126.08, 120.3, 119.0, 105.5, 72.2, 55.2, 51.3, 46.3, 45.5, 18.4 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2935, 1751, 1604, 1504, 1196, 1165, 1130, 1071, 1030, 852, 756, 730, 696 cm^{-1}. HRMS (ESI) calcd. for $C_{47}H_{40}NO_5$ $[M+H]^+$: 698.2901, found 698.2902.



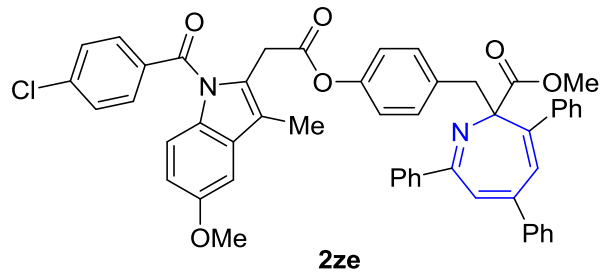
2zc

Methyl 2-(4-((2-(4-isobutylphenyl)propanoyl)oxy)benzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2zc). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1zc** (0.3 mmol, 228.5 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product in 85% yield (171.8 mg) as a white solid. M.p. = 74-75 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79-7.77 (m, 2H), 7.40-7.38 (m, 2H), 7.36-7.31 (m, 5H), 7.29-7.22 (m, 7H), 7.21-7.16 (m, 4H), 7.01 (d, *J* = 7.2 Hz, 2H), 6.80 (d, *J* = 8.4 Hz, 2H), 6.35 (d, *J* = 1.2 Hz, 1H), 3.78 (q, *J* = 7.2 Hz, 1H), 3.39 (d, *J* = 13.2 Hz, 1H), 3.07 (s, 3H), 2.99 (d, *J* = 13.2 Hz, 1H), 2.35 (d, *J* = 7.2 Hz, 2H), 1.80-1.70 (m, 1H), 1.47 (d, *J* = 6.8 Hz, 3H), 0.80-0.78 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.1, 172.4, 164.2, 149.6, 147.4, 140.7, 140.0, 139.9, 139.6, 137.3, 134.8, 131.2, 129.81, 129.78, 129.4, 128.9, 128.8, 128.7, 128.4, 128.3, 128.1, 127.8, 127.5, 127.2, 127.1, 120.3, 72.2, 51.3, 46.3, 45.2, 45.0, 30.1, 22.3, 18.5 *(1 aromatic carbon signal is not observed due to signal overlap)*. IR (neat): 2952, 1752, 1721, 1594, 1504, 1444, 1198, 1165, 1135, 1071, 1018, 756, 696 cm^{-1}. HRMS (ESI) calcd. for $C_{46}H_{44}NO_4$ $[M+H]^+$: 674.3265, found 674.3265.



2zd

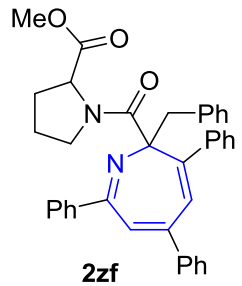
4-((2-(Methoxycarbonyl)-3,5,7-triphenyl-2*H*-azepin-2-yl)methyl)phenyl 2-(3-cyano-4-isobutoxyphenyl)-4-methylthiazole-5-carboxylate (2zd). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1zd** (0.3 mmol, 261.5 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 ºC for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate: dichloromethane = 15:1:3) to afford the title product in 83% yield (195.1 mg) as a yellow solid. M.p. = 124-125 ºC. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.21 (d, *J* = 2.4 Hz, 1H), 8.11 (dd, *J* = 3.0, 2.4 Hz, 1H), 7.91-90 (m, 2H), 7.52 (d, *J* = 6.6 Hz, 2H), 7.49-7.46 (m, 5H), 7.43-7.35 (m, 9H), 7.12 (d, *J* = 8.4 Hz, 2H), 7.01 (d, *J* = 9.0 Hz, 1H), 6.49 (d, *J* = 1.2 Hz, 1H), 3.90 (d, *J* = 6.6 Hz, 2H), 3.53 (d, *J* = 13.2 Hz, 1H), 3.26 (s, 3H), 3.14 (d, *J* = 13.2 Hz, 1H), 2.81 (s, 3H), 2.23-2.17 (m, 1H), 1.09 (d, *J* = 6.6 Hz, 6H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.3, 168.0, 164.3, 162.7, 162.6, 160.3, 149.1, 147.43, 147.39, 140.0, 139.9, 139.6, 135.4, 132.6, 132.2, 131.5, 129.9, 129.8, 128.9, 128.8, 128.7, 128.5, 128.3, 128.1, 127.8, 127.5, 127.2, 125.9, 120.9, 120.5, 115.3, 112.6, 103.0, 75.7, 72.2, 51.4, 46.3, 28.1, 19.0, 17.6. IR (neat): 2957, 1725, 1602, 1504, 1431, 1372, 1329, 1248, 1193, 1165, 1119, 1054, 1012, 818, 756, 695, 661 cm^{-1}. HRMS (ESI) calcd. for $C_{49}H_{42}N_3O_5S$ $[M+H]^+$: 784.2840, found 784.2841.



2ze

Methyl 2-(4-(2-(1-(4-chlorobenzoyl)-5-methoxy-3-methyl-1*H*-indol-2-yl)acetoxy)

benzyl)-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (2ze). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1ze** (0.3 mmol, 274.0 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 1,4-dioxane (3.0 mL) were stirred at 30 °C for 12 h. Then the reaction mixture was filtered through a short pad of silica gel, rinsed with ethyl acetate, and concentrated under vacuum. The residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate: dichloromethane = 15:1:3) to afford the title product in 84% yield (208.0 mg) as a yellow solid. M.p. = 107-108 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90-7.88 (m, 2H), 7.63 (d, *J* = 8.4 Hz, 2H), 7.50 (d, *J* = 6.8 Hz, 2H), 7.47-7.39 (m, 7H), 7.37-7.29 (m, 9H), 7.05 (d, *J* = 2.4 Hz, 1H), 6.97 (d, *J* = 8.8 Hz, 2H), 6.89 (d, *J* = 9.2 Hz, 1H), 6.67 (dd, *J* = 8.8, 2.4 Hz, 1H), 6.46 (d, *J* = 1.2 Hz, 1H), 3.84 (s, 2H), 3.79 (s, 3H), 3.50 (d, *J* = 13.2 Hz, 1H), 3.20 (s, 3H), 3.10 (d, *J* = 13.6 Hz, 1H), 2.41 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.2, 169.1, 168.1, 164.1, 156.0, 149.5, 147.3, 140.0, 139.8, 139.5, 139.1, 136.0, 135.0, 133.8, 131.3, 131.1, 130.7, 130.5, 129.8, 129.7, 129.0, 128.8, 128.74, 128.67, 128.4, 128.3, 128.0, 127.7, 127.4, 127.1, 120.2, 114.9, 112.1, 111.7, 101.1, 72.1, 55.6, 51.3, 46.2, 30.4, 13.3 *(1 aromatic carbon signal is not observed due to signal overlap).* IR (neat): 2940, 1747, 1683, 1592, 1478, 1357, 1318, 1241, 1196, 1165, 1126, 1088, 1066, 1014, 923, 836, 755, 697 cm^{-1}. HRMS (ESI) calcd. for $C_{52}H_{42}ClN_2O_6$ $[M+H]^+$: 825.2726, found 825.2723.

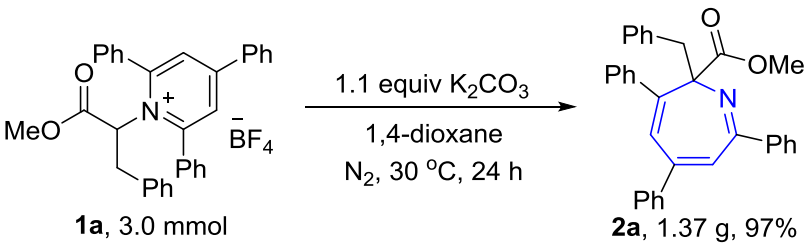


2zf

Methyl (2-benzyl-3,5,7-triphenyl-2*H*-azepine-2-carbonyl)prolinate (2zf). 0.3 mmol scale, under N_2 atmosphere, pyridinium salt **1zf** (0.3 mmol, 196.4 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and dimethylacetamide (3.0 mL) were stirred at 80 °C for 12 h. Then the reaction mixture was quenched with water, extracted with ethyl acetate, and the organic layer was washed with water and brine, and dried over anhydrous Na_2SO_4. The resulting filtrate was concentrated under vacuum. The residue was purified by column chromatography on silica

gel (eluent: petroleum ether: ethyl acetate = 25:1 to 5:1, gradient) to afford a mixture of diastereoisomers (d.r. 1:0.7) in 73% yield (123.7 mg) as a yellow solid. M.p. = 112-113 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.98 (d, *J* = 6.6 Hz, 2H), 7.88 (s, 1.4H), 7.66 (d, *J* = 6.6 Hz, 1.4H), 7.63 (d, *J* = 7.8 Hz, 2H), 7.53-7.52 (m, 2.1H), 7.50-7.49 (m, 3H), 7.44-7.38 (m, 10.2H), 7.34-7.25 (m, 11.9H), 7.20-7.18 (m, 1.7H), 6.46 (s, 0.7H), 6.44 (s, 1H), 4.18 (t, *J* = 7.8 Hz, 1H), 3.87-3.85 (m, 0.7H), 3.76 (s, 2.1H), 3.33 (d, *J* = 13.2 Hz, 1H), 3.27 (s, 1.4H), 3.16 (d, *J* = 13.2 Hz, 1H), 2.84 (s, 3H), 2.56 (t, *J* = 8.4 Hz, 1H), 2.37-2.33 (m, 1H), 2.23-2.22 (m, 0.7H), 1.97 (br, 0.7H), 1.85 (br, 0.7H), 1.80-1.76 (m, 1H), 1.59-1.58 (m, 0.7H), 1.51-1.50 (m, 0.7H), 1.38-1.36 (m, 0.7H), 1.26-1.23 (m, 2H), 0.66-0.62 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 172.8 (minor), 172.7 (major), 171.74 (minor), 171.70 (major), 163.0 (major), 162.3 (minor), 150.7 (minor), 150.5 (minor), 149.9 (major), 149.7 (major), 140.7 (major), 140.6 (minor), 140.4 (major), 140.0 (minor), 139.4 (minor), 139.3 (major), 137.9 (major), 137.2 (minor), 132.5 (minor), 131.2 (major), 130.1 (major), 129.9 (major), 128.9 (minor), 128.7 (major), 128.6 (minor), 128.53 (major), 128.48 (minor), 128.4 (major), 127.9 (major), 127.8 (minor), 127.72 (major), 127.68 (major), 127.6 (minor), 127.44 (major), 127.36 (minor), 127.3 (minor), 127.2 (minor), 127.1 (major), 126.6 (major), 126.4 (minor), 125.8 (major), 124.6 (minor), 72.9 (major), 72.4 (minor), 61.1 (major), 59.9 (minor), 51.8 (minor), 51.1 (major), 50.7 (major), 49.9 (minor), 48.5 (major), 47.3 (minor), 28.0 (minor), 27.7 (major), 25.5 (minor), 25.4 (major) *(several aromatic carbon signals of the isomers are not observed due to signal overlap)*. IR (neat): 2951, 1739, 1622, 1494, 1395, 1166, 874, 757, 697, 603 cm^{-1}. HRMS (ESI) calcd. for $C_{38}H_{35}N_2O_3$ $[M+H]^+$: 567.2642, found 567.2642.

Gram scale study



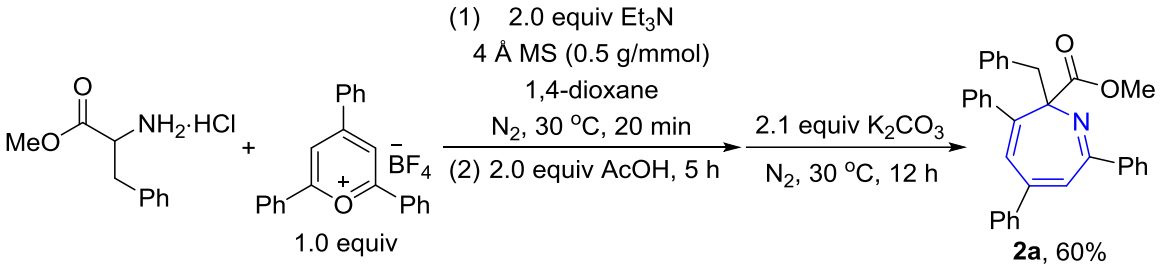
1a, 3.0 mmol

2a, 1.37 g, 97%

To an oven-dried sealable Schlenk tube (100.0 mL) equipped with a stir bar was

added pyridinium salts **1a** (3.0 mmol, 1.67 g) and K_2CO_3 (3.3 mmol, 456.1 mg) under N_2 atmosphere. Then, the tube was re-evacuated and refilled with nitrogen for three times before adding 1,4-dioxane (30.0 mL, 0.1 M with respect to **1a**) via a syringe. The Schlenk tube was securely sealed and immersed into an oil bath preheated at 30 °C. After stirring at the same temperature for 24 h, the reaction mixture was filtered through a short pad of silica gel, and rinsed with ethyl acetate. Then, the resulting organic layer was evaporated under the reduced pressure, and the residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 100:1 to 25:1, gradient) to afford the target azepine product **2a** in 97% yield (1.37 g) as a white solid. *This result highlights the robustness and scalability of this process, as almost no loss in yield was observed when it was conducted on gram-scale experiment.*

One-pot transformation



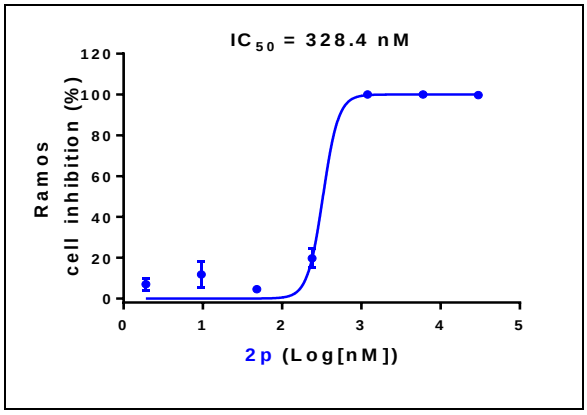
To an oven-dried sealable Schlenk tube (15.0 mL) equipped with a stir bar was added methyl phenylalaninate hydrochloride (0.3 mmol, 64.7 mg), pyrylium salt (0.3 mmol, 118.9 mg), 4 Å MS (150.0 mg), 1,4-dioxane (3.0 mL, 0.1 M with respect to methyl phenylalaninate hydrochloride) and Et_3N (0.6 mmol, 60.7 mg) under N_2 atmosphere. After stirring at 30 °C for 20 min, AcOH (0.6 mmol, 36.0 mg) was added via a syringe. Then, the Schlenk tube was securely sealed and stirred at 30 °C for 5 h. Subsequently, K_2CO_3 (0.63 mmol, 87.1 mg) was directly added into the reaction mixture under N_2 atmosphere without further purification *(Note: when 1.1 equivalents of K_2CO_3 was used, the pyridinium salt could not be completely consumed due to the presence of a slight excess of acid in the one-pot conditions)*. After stirring at the same temperature for 12 h, the reaction mixture was filtered through a short pad of silica gel, and rinsed with ethyl acetate. The resulting organic layer was evaporated under the reduced pressure, and the residue was purified by

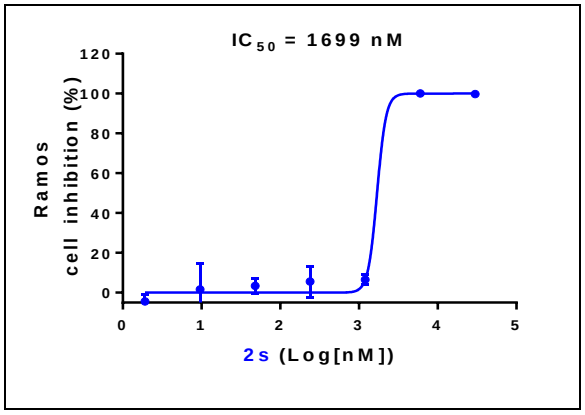
column chromatography on silica gel (eluent: petroleum ether: ethyl acetate: dichloromethane = 100:1:3) to afford the target azepine product **2a** in 60% overall yield (84.5 mg) as a white solid. *This result would have many advantages in terms of practicability, as it avoids the separation of the resulting pyridinium salt and reduces the waste of solvents in purifications.*

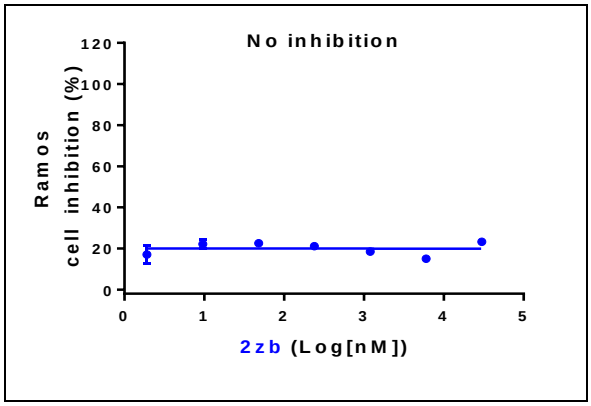
Bioactivity testing for selected azepine derivatives

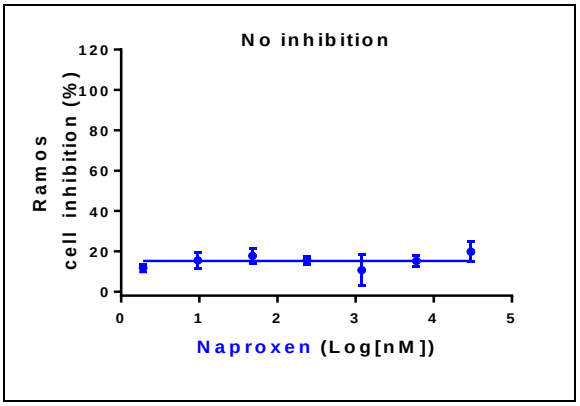
Cell antiproliferative assay: Cell antiproliferative activity was evaluated by the CellTiter-Glo (Promega, USA) assay. Make 1000× compounds solution in DMSO，add 1 μL 1000× compounds to 49 μL growth medium to make 20× compounds. Dilute cell suspensions in growth medium to desired density and 95 μL were taken to 96-well plate. Add 5μL 20× compounds into 96-well plate. Final DMSO concentration in each well was 0.1%. Then the cell was incubated at 37℃, 5% CO_2 for 72 h. Equilibrate the assay plate to room temperature before measurement. Add 20 μL of CellTiter-Glo® Reagent into each well. Mix contents for 2 minutes on an orbital shaker to induce cell lysis. Incubate at room temperature for 10 minutes to stabilize luminescent signal. Record luminescence using EnVision Multilabel Reader (PerkinElmer). Cell viability (CV%) was calculated relative to vehicle (DMSO) treated control wells using following formula: Cell viability (%) = (RLU compound -RLU blank)/(RLU control-RLU blank)*100%. The IC_{50} values were calculated using GraphPad Prism 6.0 software, fitting to a 4-parameter equation to generate concentration response curves.

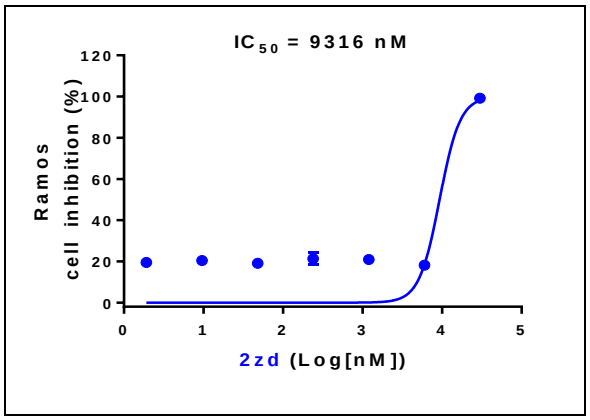
Data for bioactivity study:

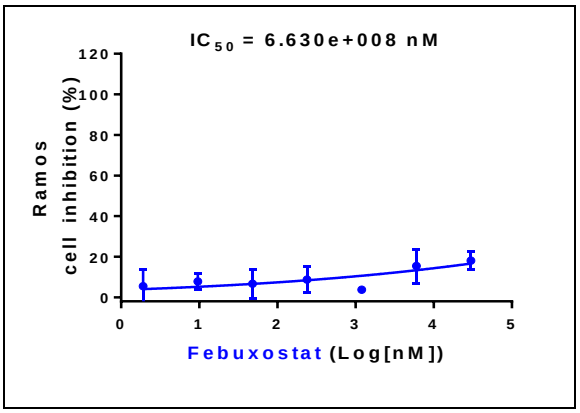


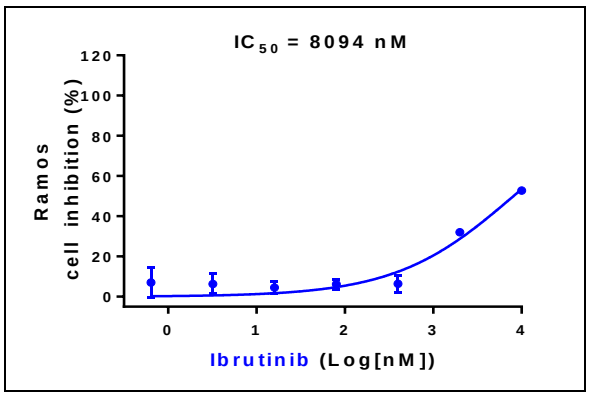


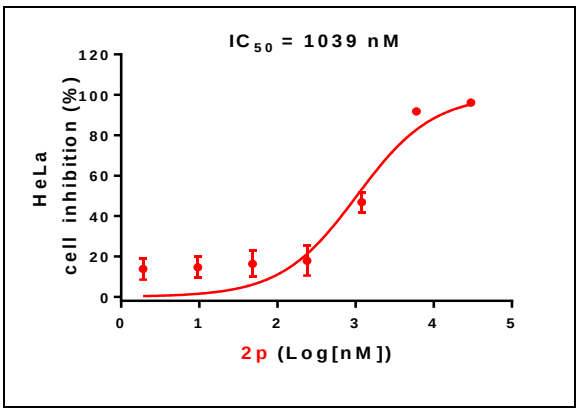

No inhibition
Ramos
cell inhibition (%)
2zb (Log[nM])

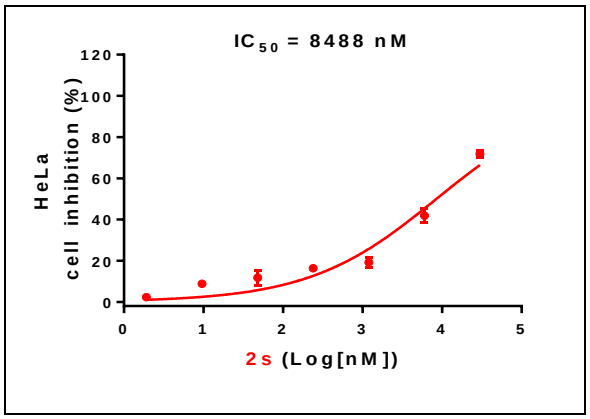

No inhibition
Ramos
cell inhibition (%)
Naproxen (Log[nM])

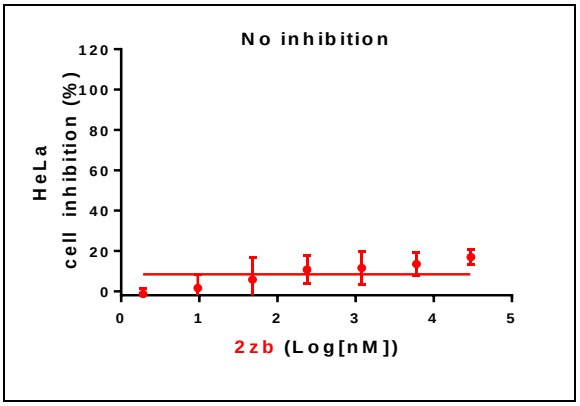

IC50 = 9316 nM
Ramos
cell inhibition (%)
2zd (Log[nM])

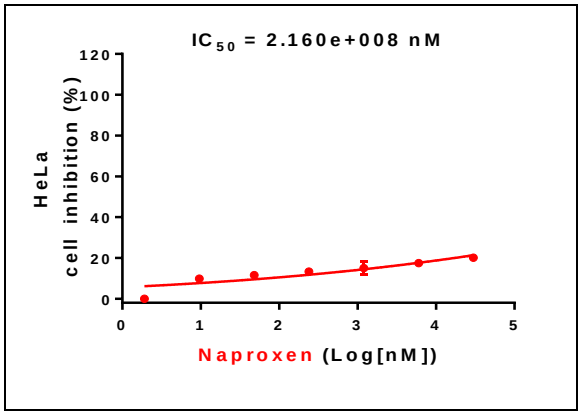

IC50 = 6.630e+008 nM
Ramos
cell inhibition (%)
Febuxostat (Log[nM])

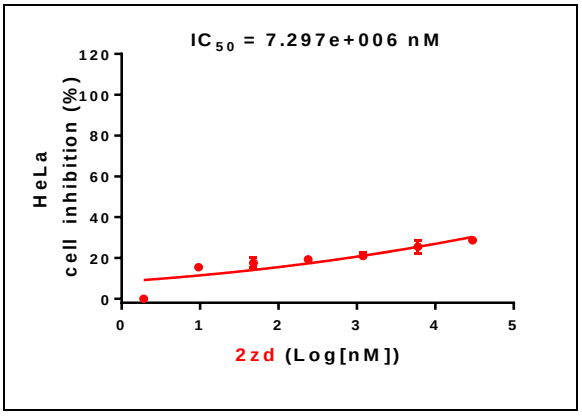

IC50 = 8094 nM
Ramos
cell inhibition (%)
Ibrutinib (Log[nM])

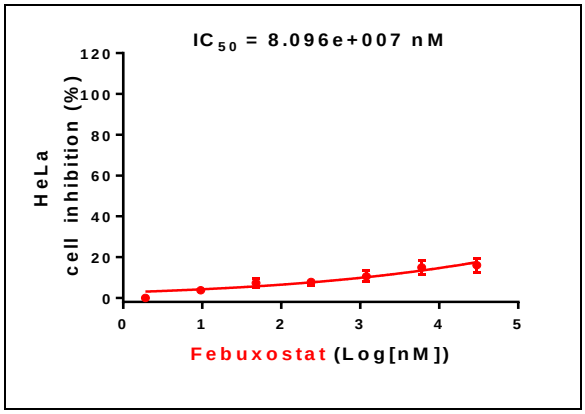

IC50 = 1039 nM
HeLa
cell inhibition (%)
2p (Log[nM])

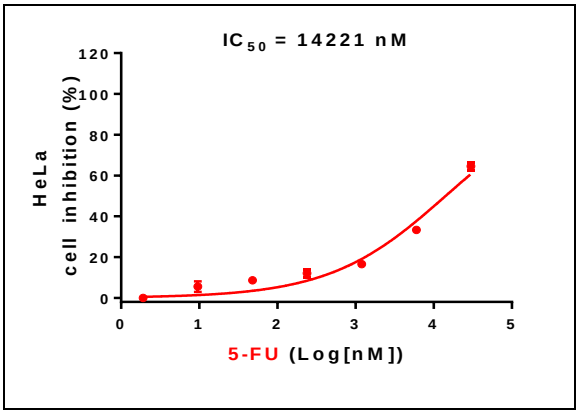

IC50 = 8488 nM
HeLa
cell inhibition (%)
2s (Log[nM])

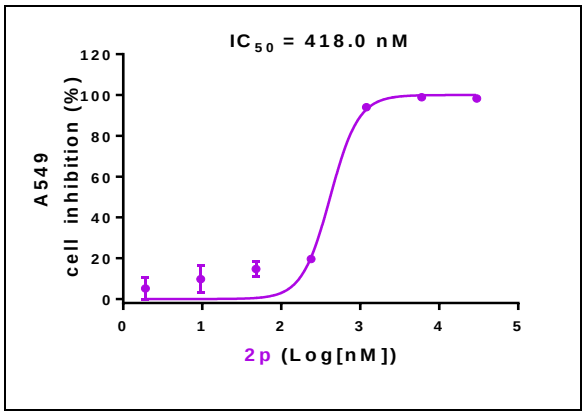

No inhibition
HeLa
cell inhibition (%)
2zb (Log[nM])

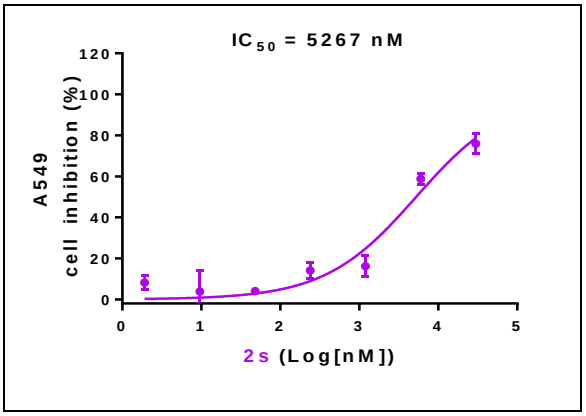

IC50 = 2.160e+008 nM
HeLa cell inhibition (%)
Naproxen (Log[nM])

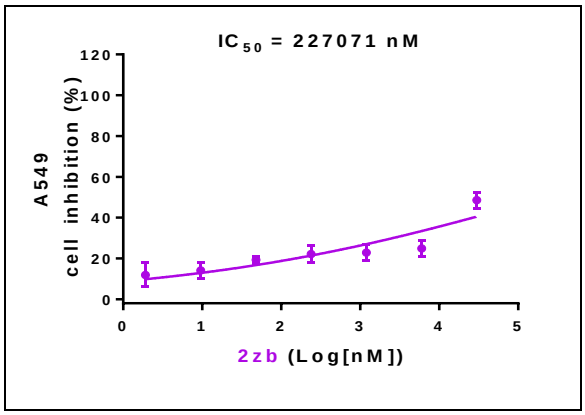

IC50 = 7.297e+006 nM
HeLa cell inhibition (%)
2zd (Log[nM])

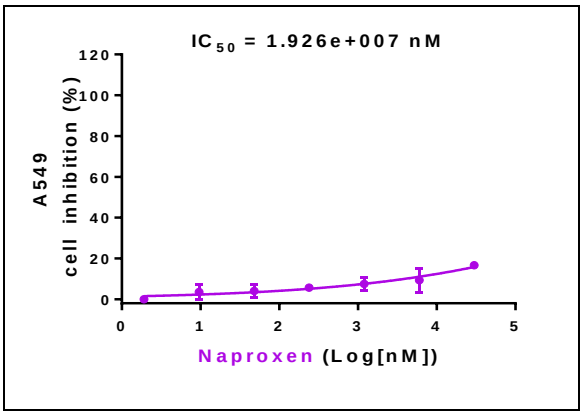

IC50 = 8.096e+007 nM
HeLa cell inhibition (%)
Febuxostat (Log[nM])

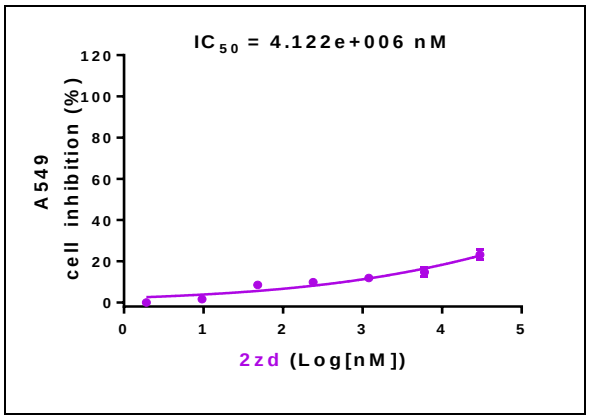

IC50 = 14221 nM
HeLa cell inhibition (%)
5-FU (Log[nM])

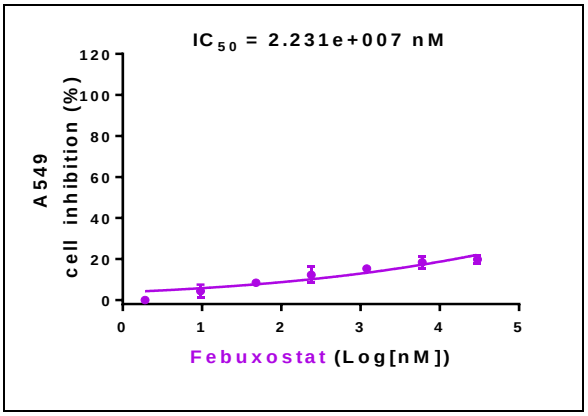

IC50 = 418.0 nM
A549 cell inhibition (%)
2p (Log[nM])

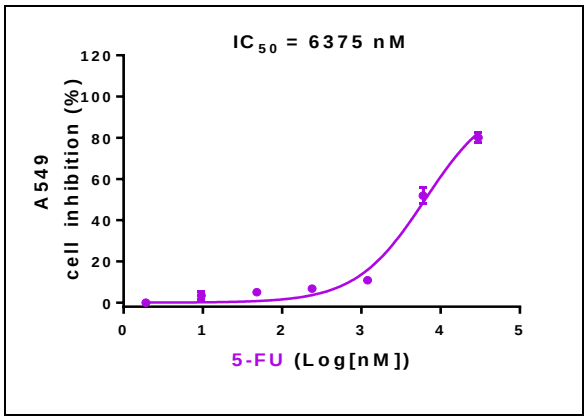

IC50 = 5267 nM
A549 cell inhibition (%)
2s (Log[nM])


IC50 = 227071 nM
A549 cell inhibition (%)
2zb (Log[nM])

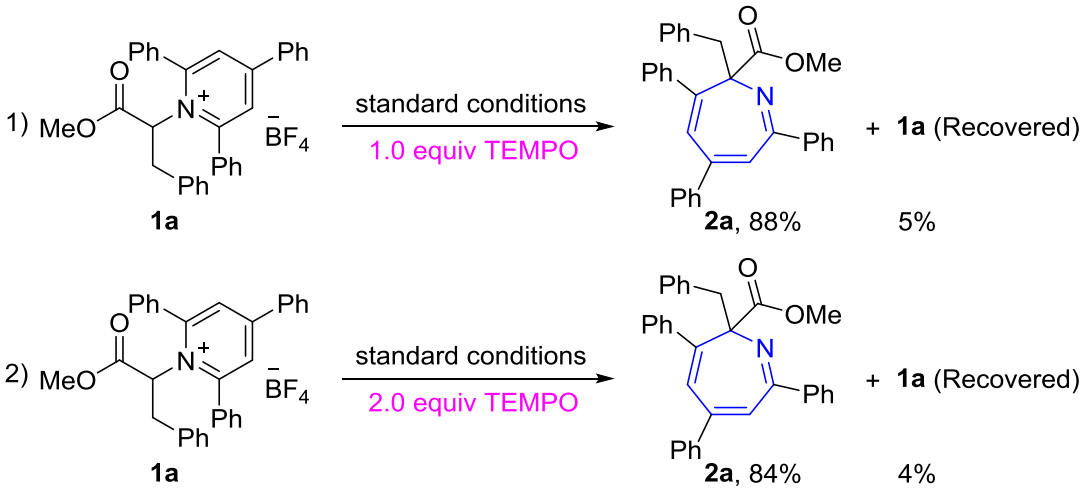

IC50 = 1.926e+007 nM
A549 cell inhibition (%)
Naproxen (Log[nM])







Radical trap experiment

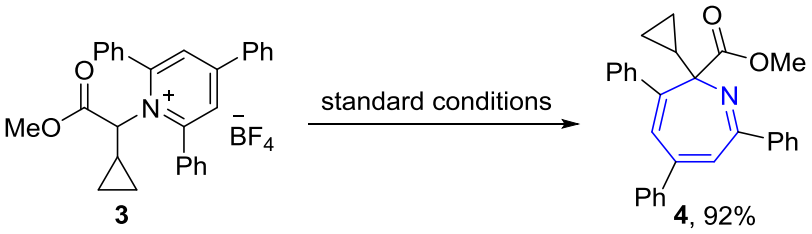


A sealable Schlenk tube (15.0 mL) was heated under vacuum using a heatgun, and evacuated and back-filled with nitrogen for three times. After the tube was cooled to room temperature, pyridinium salts **1a** (0.3 mmol, 167.2 mg), K_2CO_3 (0.33 mmol, 45.6 mg) and 2,2,6,6-tetramethylpiperidine-*N*-oxyl (TEMPO, 1.0 or 2.0 equiv) were added successively under nitrogen atmosphere. Then, the tube was re-evacuated and refilled with nitrogen for three times before adding 1,4-dioxane (3.0 mL, 0.1 M with respect to **1a**) via a syringe.

The Schlenk tube was securely sealed and immersed into an oil bath preheated at 30 °C. After stirring at the same temperature for 12 h, the reaction mixture was filtered through a short pad of silica gel, and rinsed with ethyl acetate. The resulting organic layer was evaporated under the reduced pressure, and the residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 50:1 to 25:1, gradient) to afford the target azepine product **2a** in 88% (123.7 mg) and 84% (119.0 mg) yields, respectively. *(Note: the slightly lower yield in this case was attributed to the incomplete consumption of the pyridinium salt **1a**.)*

Conclusion: These results indicate that a free radical pathway is not likely to be involved in this process.

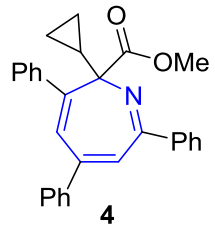
Radical clock experiment



A sealable Schlenk tube (15.0 mL) was heated under vacuum using a heatgun, and evacuated and back-filled with nitrogen for three times. After the tube was cooled to room temperature, pyridinium salts **3** (0.3 mmol, 152.2 mg) and K_2CO_3 (0.33 mmol, 45.6 mg) were added successively under nitrogen atmosphere. Then, the tube was re-evacuated and refilled with nitrogen for three times before adding 1,4-dioxane (3.0 mL, 0.1 M with respect to **3**) via a syringe. The Schlenk tube was securely sealed and immersed into an oil bath preheated at 30 °C. After stirring at the same temperature for 12 h, the reaction mixture was filtered through a short pad of silica gel, and rinsed with ethyl acetate. Then, the resulting organic layer was evaporated under the reduced pressure, and the residue was purified by column chromatography on silica gel (eluent: petroleum ether: ethyl acetate = 25:1) to afford the title product **4** in 92% yield (115.8 mg) as a white solid, while no ring-opened product was observed in the reaction mixture.

Conclusion: This result shows that an alkyl radical species might not be generated

in the reaction, otherwise the ring-opened product would be the main product.



4

Methyl 2-cyclopropyl-3,5,7-triphenyl-2*H*-azepine-2-carboxylate (4). M.p. = 184-185 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.82-7.80 (m, 2H), 7.45 (d, *J* = 7.2 Hz, 2H), 7.35-7.31 (m, 8H), 7.27 (t, *J* = 7.2 Hz, 1H), 7.24-7.19 (m, 3H), 6.38 (d, *J* = 1.2 Hz, 1H), 3.41 (s, 3H), 1.14-1.10 (m, 1H), 1.05-1.01 (m, 1H), 0.89-0.85 (m, 1H), 0.38-0.33 (m, 1H), 0.14-0.10 (m, 1H). ^{13}C NMR (150 MHz, $CDCl_3$): δ 174.0, 163.5, 148.6, 147.8, 140.6, 140.3, 139.5, 129.8, 128.73, 128.71, 128.6, 128.2, 127.90, 127.85, 127.3, 127.2, 127.1, 68.7, 51.9, 19.5, 3.7, 2.1 *(1 aromatic carbon signal is not observed due to signal overlap).* IR (neat): 3023, 1728, 1598, 1489, 1442, 1225, 1161, 1049, 1028, 876, 756, 695 cm^{-1}. HRMS (ESI) calcd. for $C_{29}H_{26}NO_2$ $[M+H]^+$: 420.1958, found 420.1955.

X-ray diffraction data of 2n

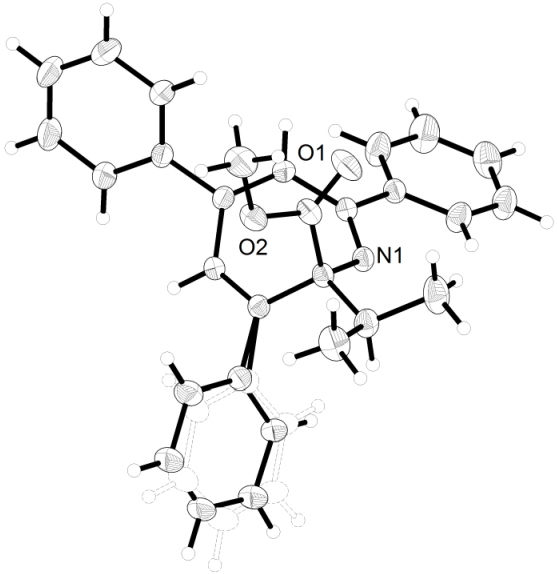


Figure S1. X-ray crystal structure of **2n** (Ellipsoid probability: 30%)

Note: The single crystal of **2n** suitable for X-ray diffraction was obtained by volatilizing a mixed solution of **2n** in ethyl acetate and petroleum ether at room temperature.

Table S5. Crystal data of **2n** (CCDC 2181086)

Bond precision: C-C = 0.0039 A Wavelength=1.54184

Cell: a=14.4625(4) b=9.6213(2) c=17.4857(4)
alpha=90 beta=106.550(3) gamma=90
Temperature: 293 K

	Calculated	Reported
Volume	2332.30(10)	2332.30(10)
Space group	I a	I 1 a 1
Hall group	I -2ya	I -2ya
Moiety formula	C29 H27 N O2	C29 H27 N O2
Sum formula	C29 H27 N O2	C29 H27 N O2
Mr	421.52	421.51
Dx,g cm-3	1.200	1.200
Z	4	4
Mu (mm-1)	0.584	0.584
F000	896.0	896.0
F000'	898.49	
h,k,lmax	17,11,21	17,11,21
Nref	4541[2273]	2984
Tmin,Tmax	0.907,0.943	0.472,1.000
Tmin'	0.885	

Correction method= # Reported T Limits: Tmin=0.472 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.31/0.66 Theta(max)= 71.339

R(reflections)= 0.0331(2905) wR2(reflections)= 0.0913(2984)

S = 1.066 Npar= 348

References:

[1] X. Zhang, C. Jiao, D. Qi, X. Liu, Z. Zhang and G. Zhang, Nickel-catalyzed deaminative allenylation of amino acid derivatives: catalytic activity enhanced by an amide-type NN_2 pincer ligand, *Org. Lett.*, 2022, DOI: 10.1021/acs.orglett.2c02042.

[2] C.-S. Zhang, L. Bao, K.-Q. Chen, Z.-X. Wang and X.-Y. Chen, Photoinduced α-alkenylation of Katritzky salts: synthesis of β,γ-unsaturated esters, *Org. Lett.*, 2021, **23**, 1577-1581.

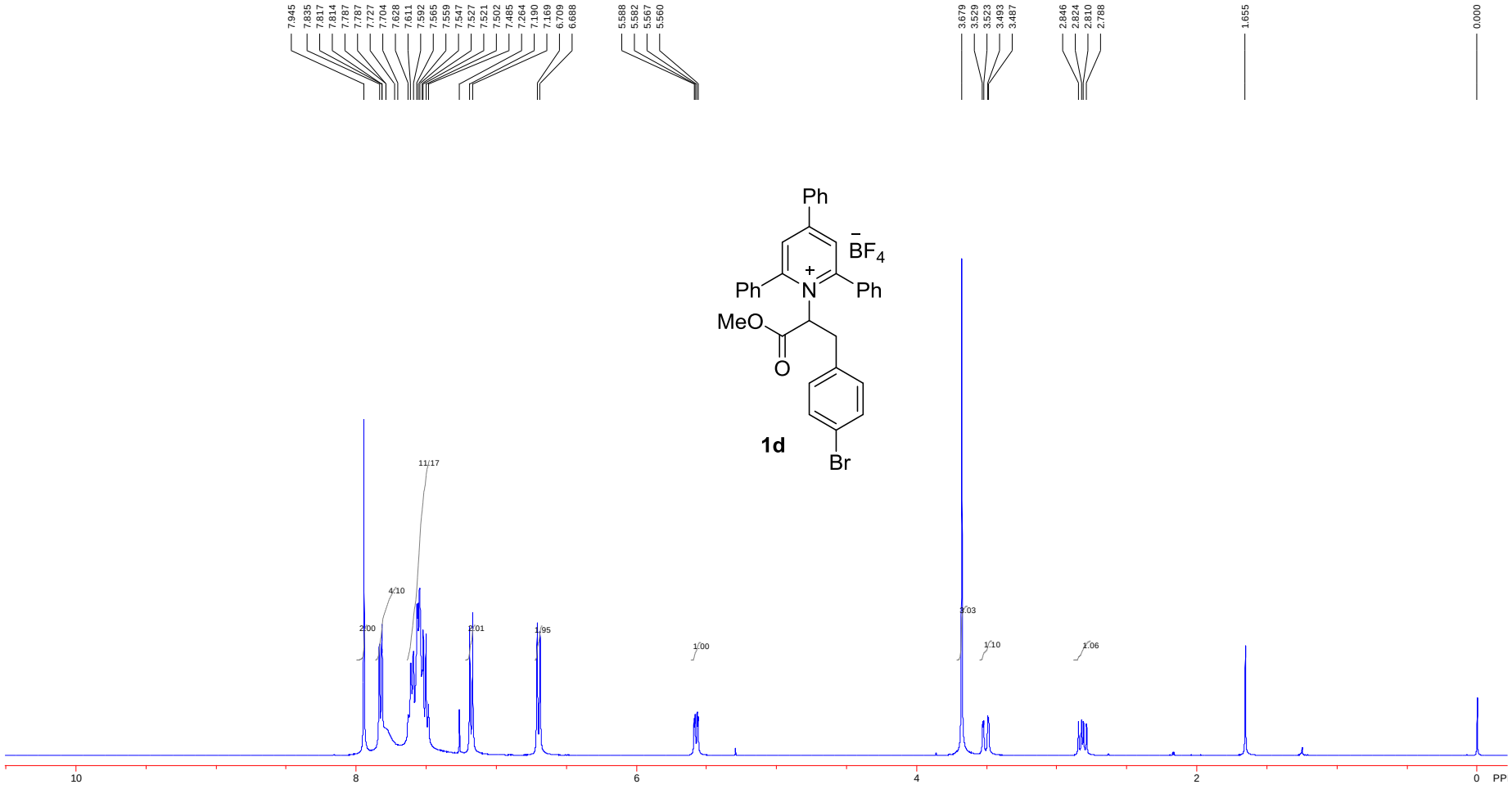
[3] F. J. R. Klauck, M. J. James and F. Glorius, Deaminative strategy for the visible-light-mediated generation of alkyl radicals, *Angew. Chem. Int. Ed.*, 2017, **56**, 12336-12339.

[4] M. E. Hoerrner, K. M. Baker, C. H. Basch, E. M. Bampo and M. P. Watson, Deaminative arylation of amino acid-derived pyridinium salts, *Org. Lett.*, 2019, **21**, 7356-7360.

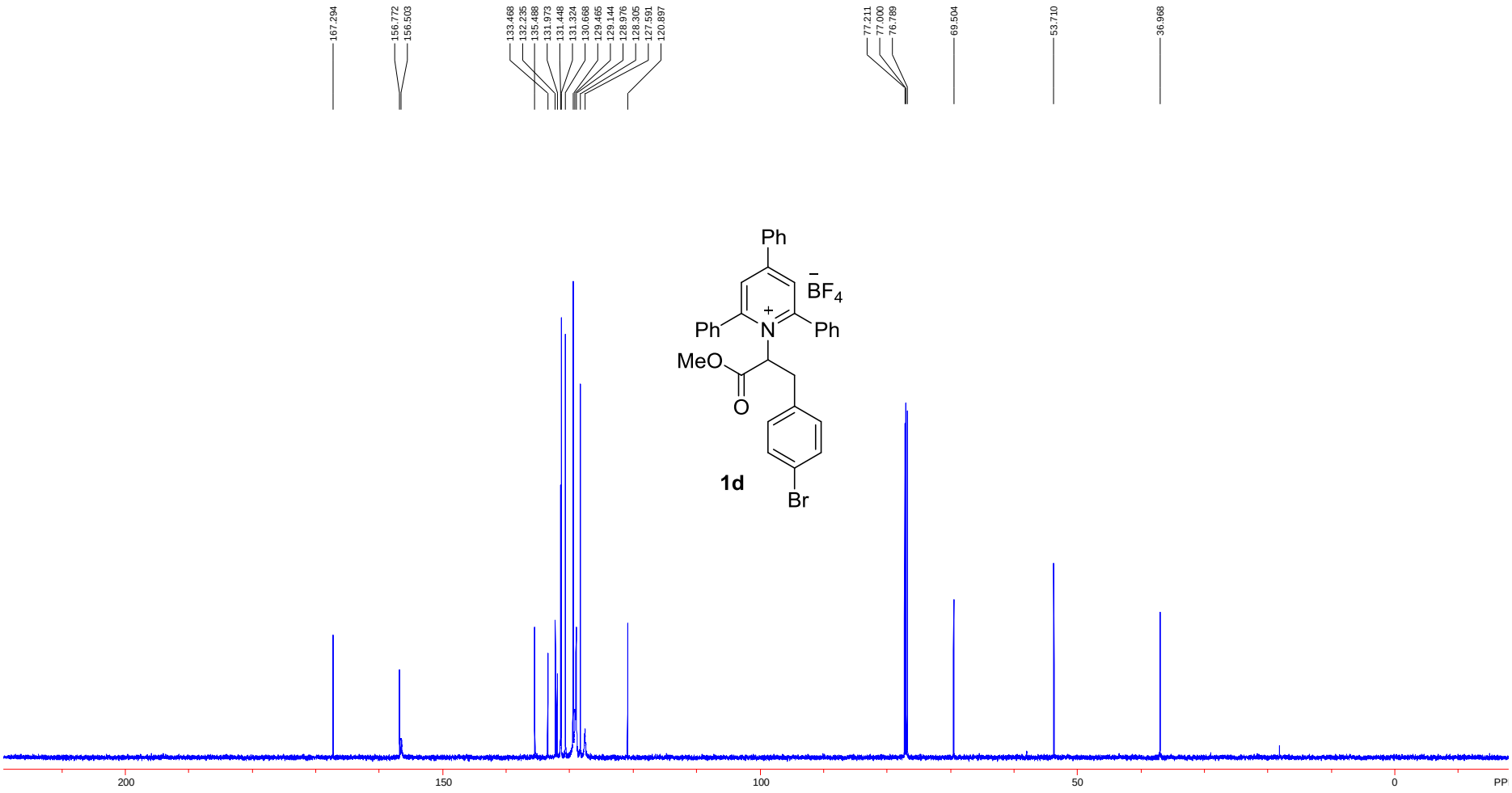
[5] X. Jiang, M.-M. Zhang, W. Xiong, L.-Q. Lu and W.-J. Xiao, Deaminative (carbonylative) alkyl-Heck-type reactions enabled by photocatalytic C-N bond activation, *Angew. Chem. Int. Ed.*, 2019, **58**, 2402-2406.

NMR spectra of all new compounds

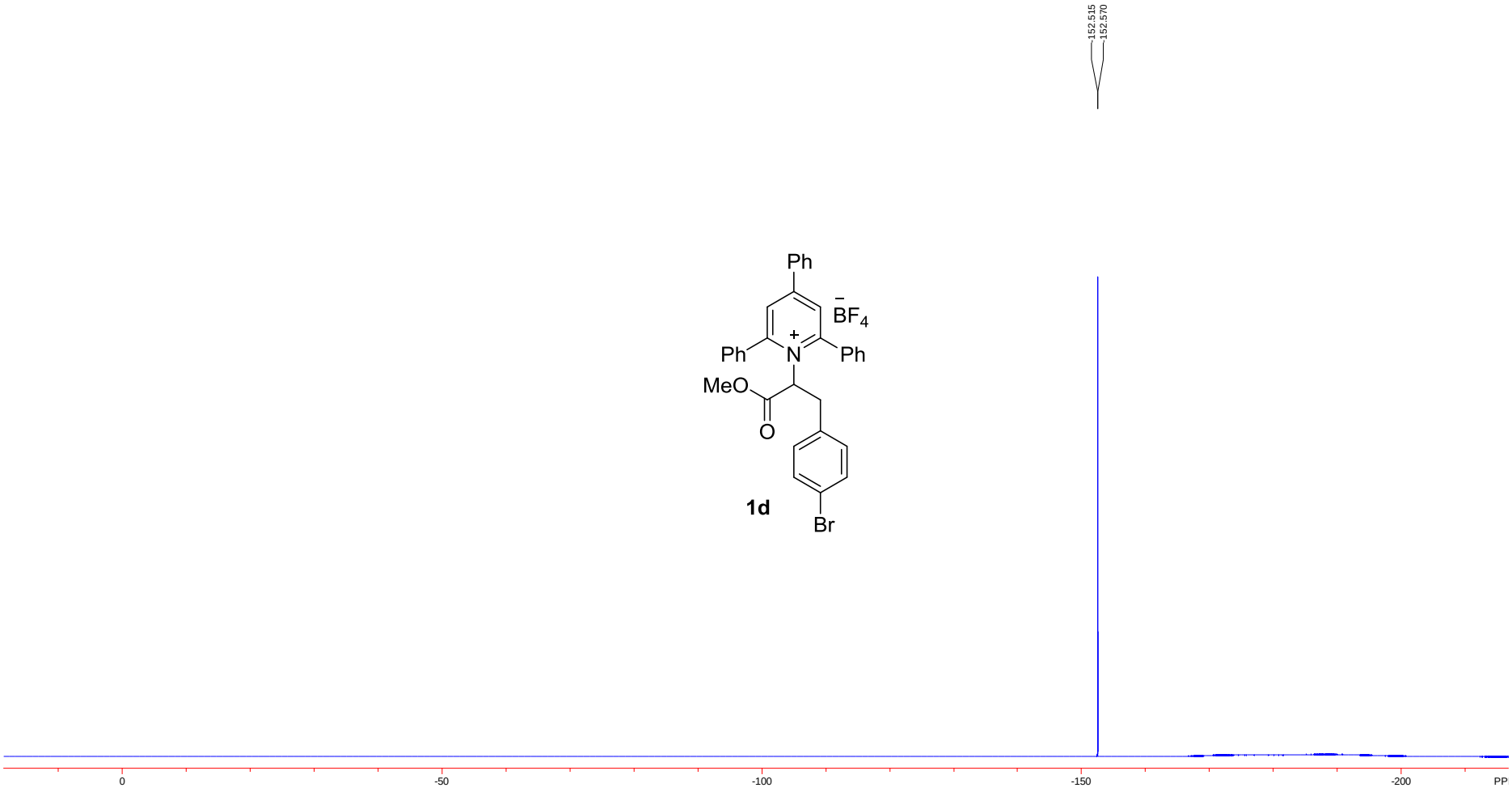
^{1}H NMR(400 MHz, $CDCl_3$)



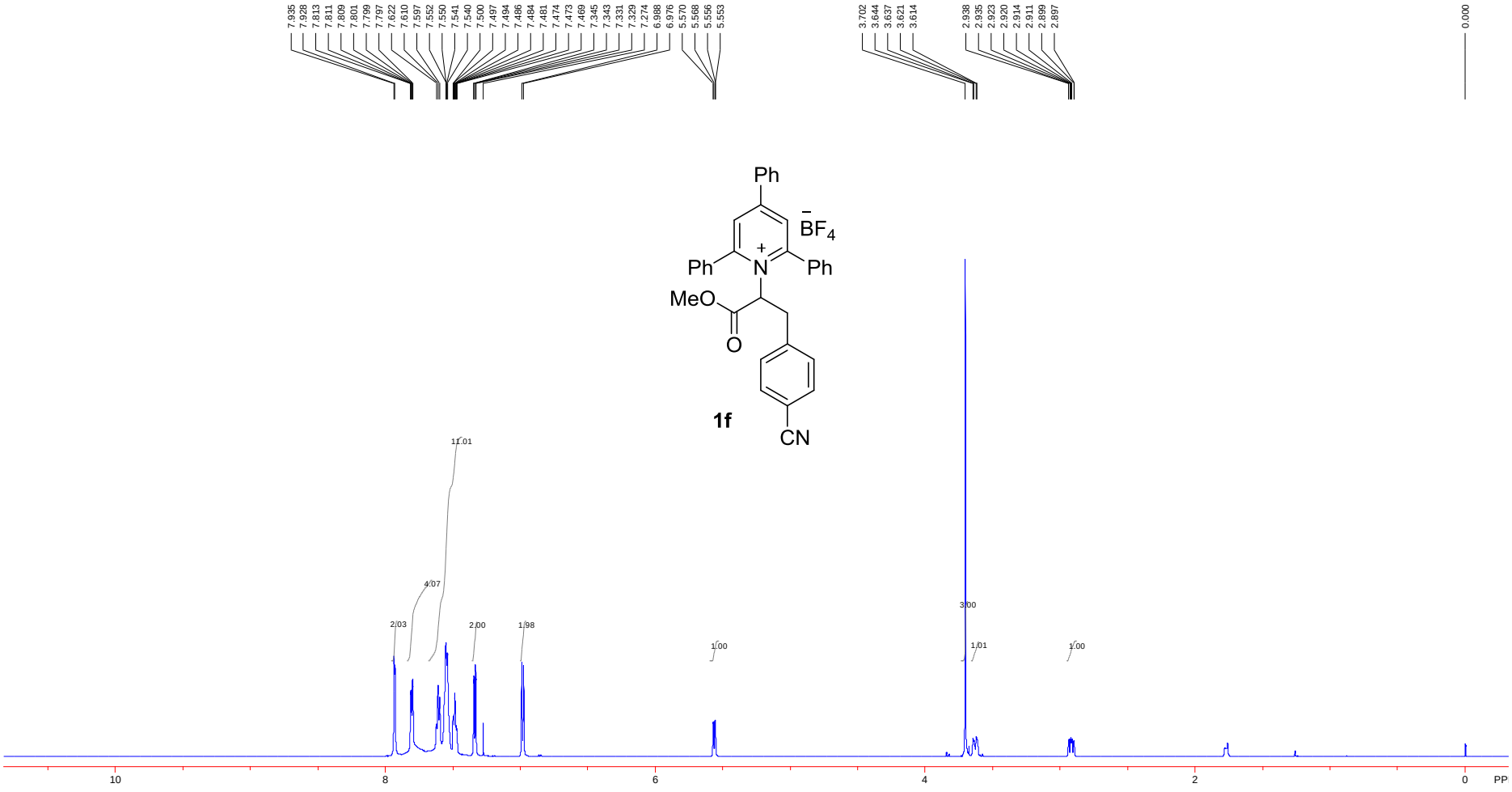
^{13}C NMR(150 MHz, $CDCl_3$)



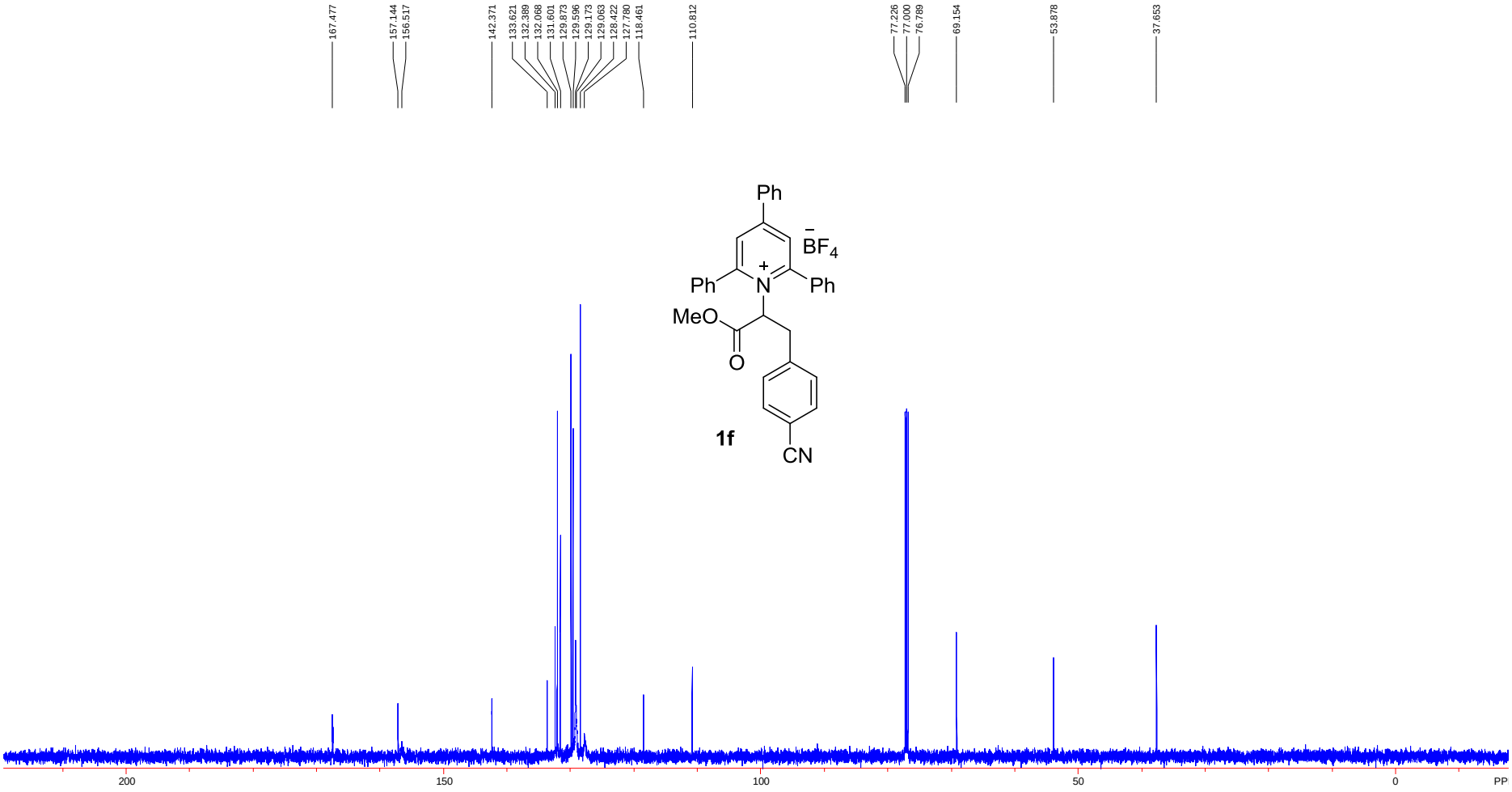
^{19}F NMR(565 MHz, $CDCl_3$)



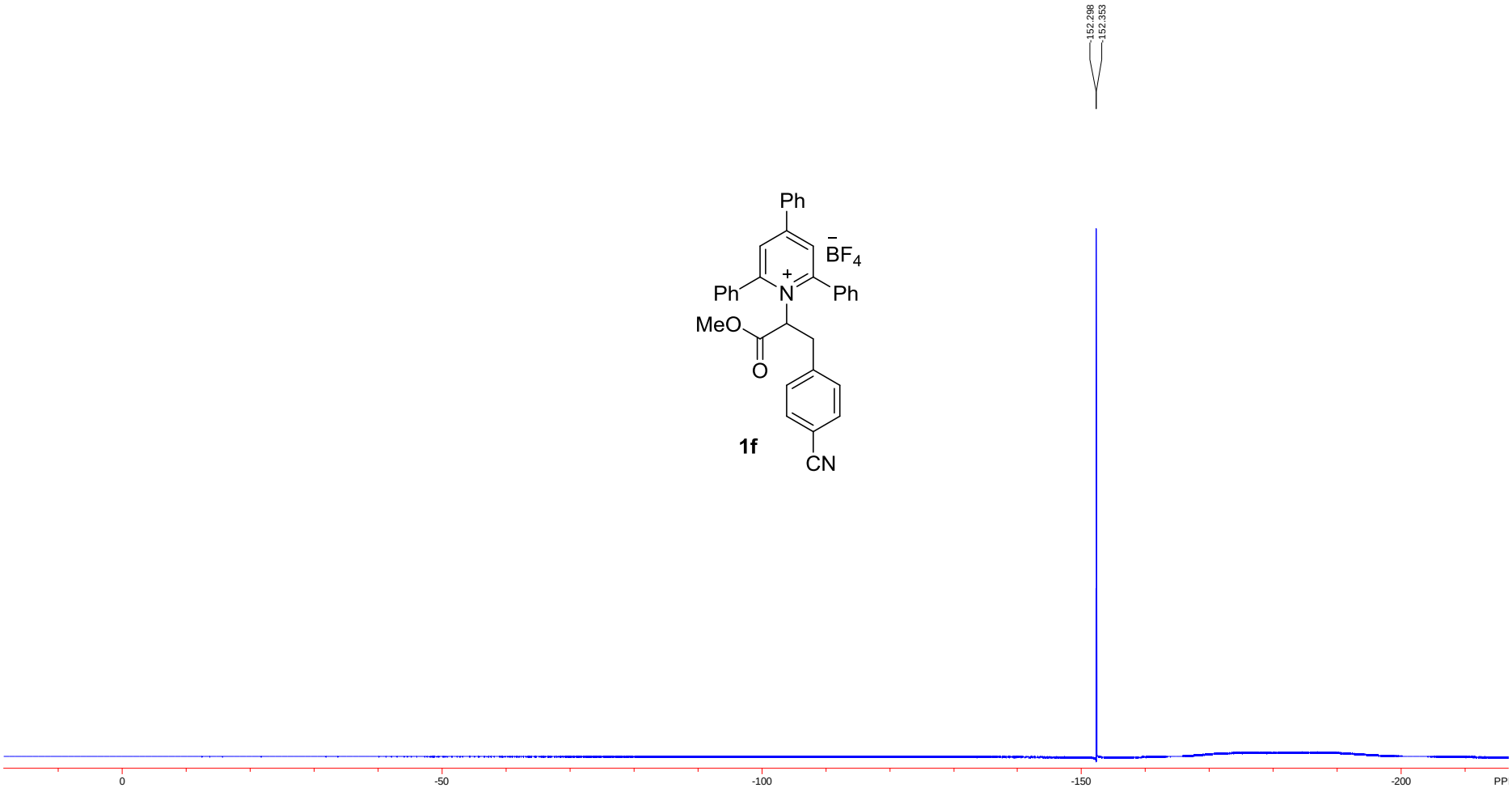
^{1}H NMR(600 MHz, $CDCl_3$)



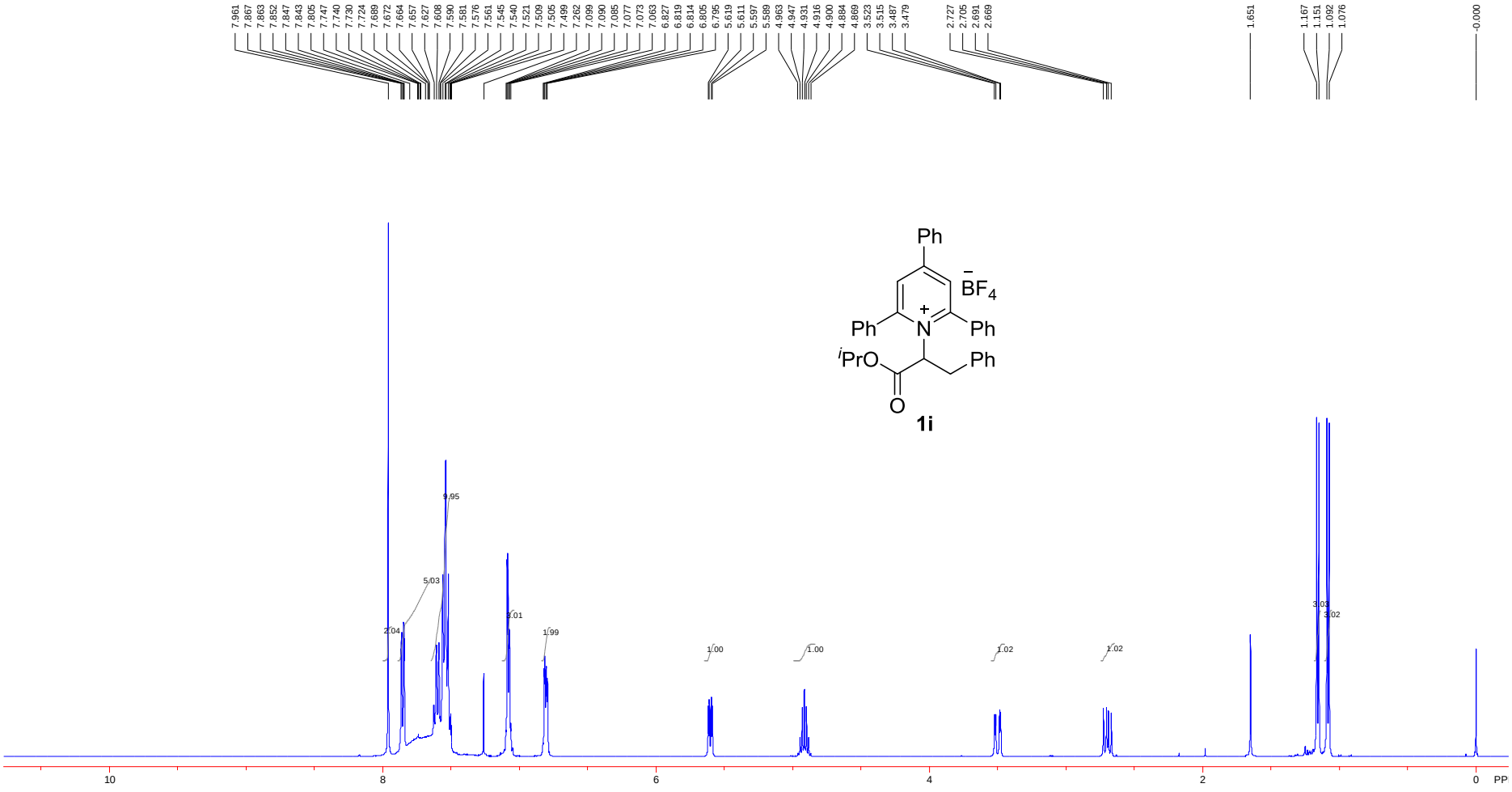
^{13}C NMR(150 MHz, $CDCl_3$)



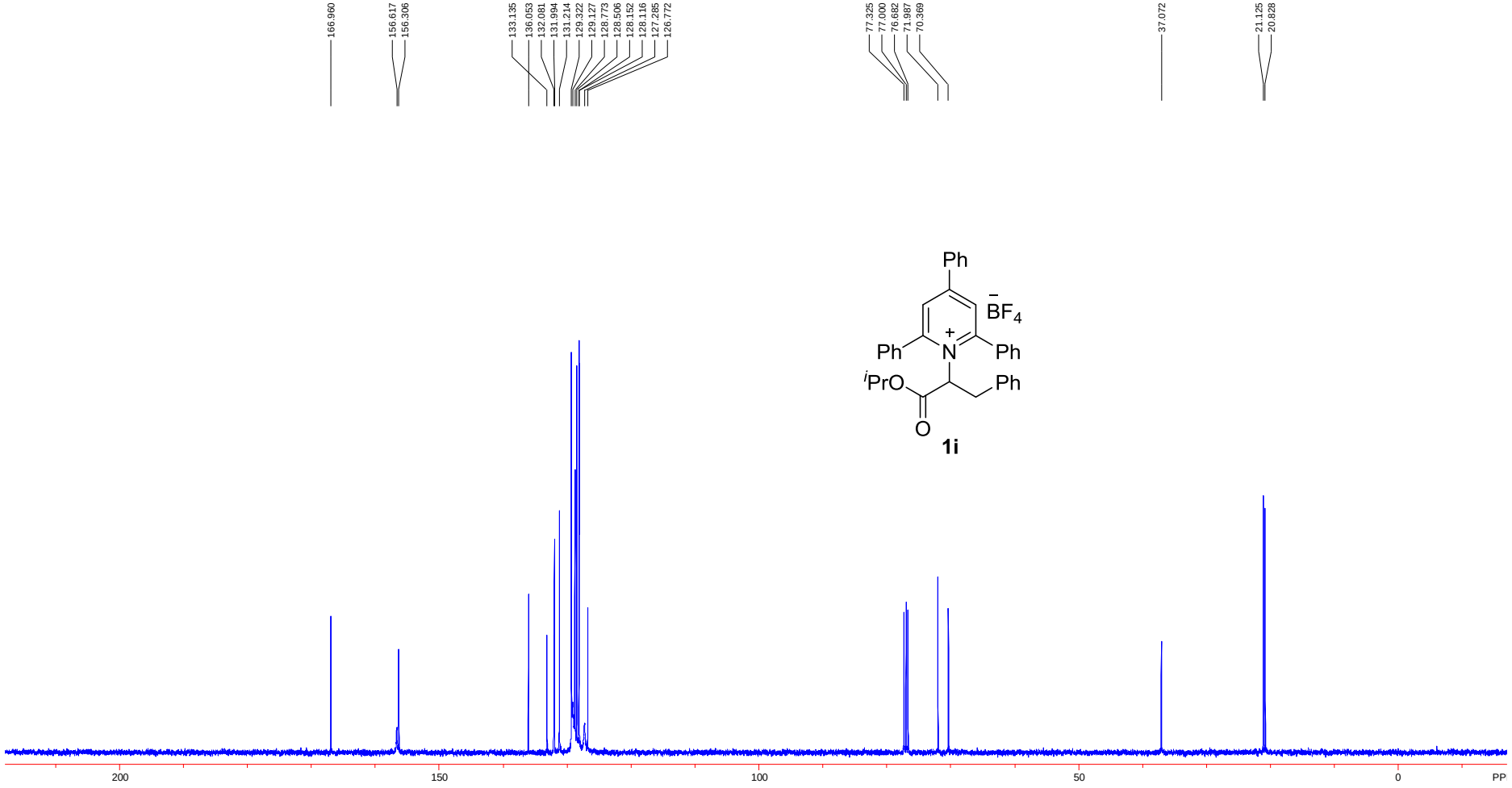
^{19}F NMR(565 MHz, $CDCl_3$)



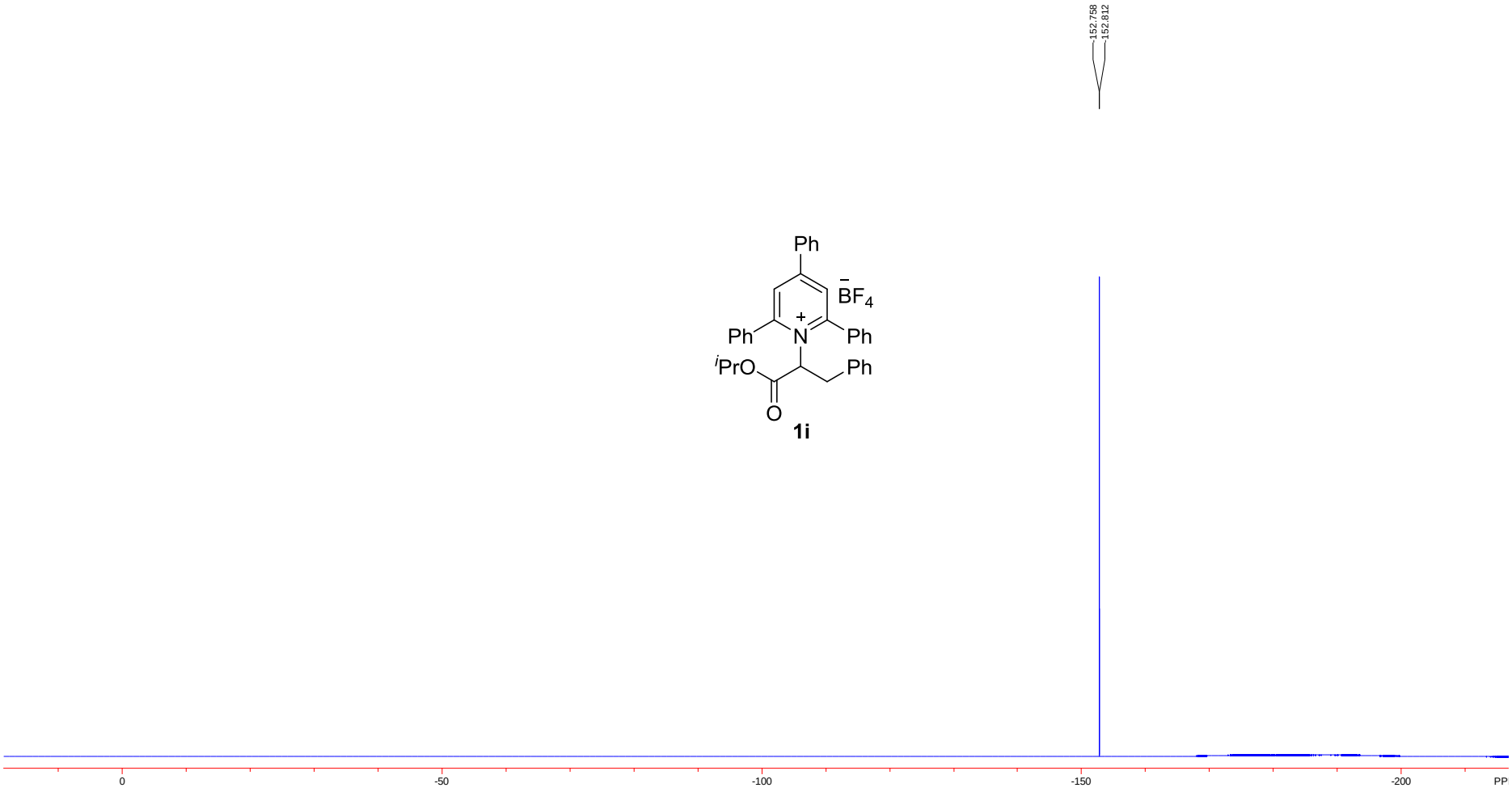
^{1}H NMR(400 MHz, $CDCl_3$)



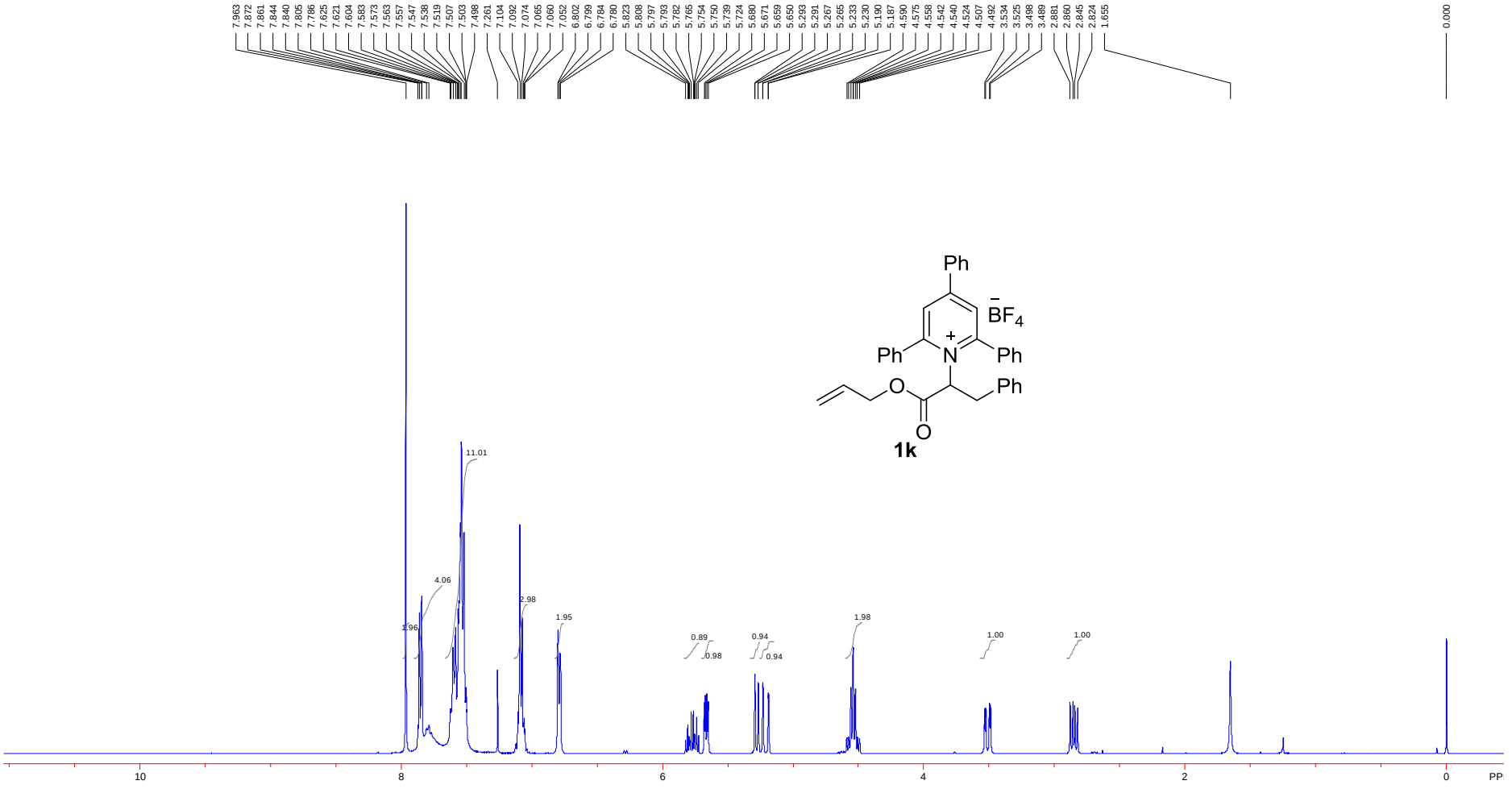
^{13}C NMR(100 MHz, $CDCl_3$)



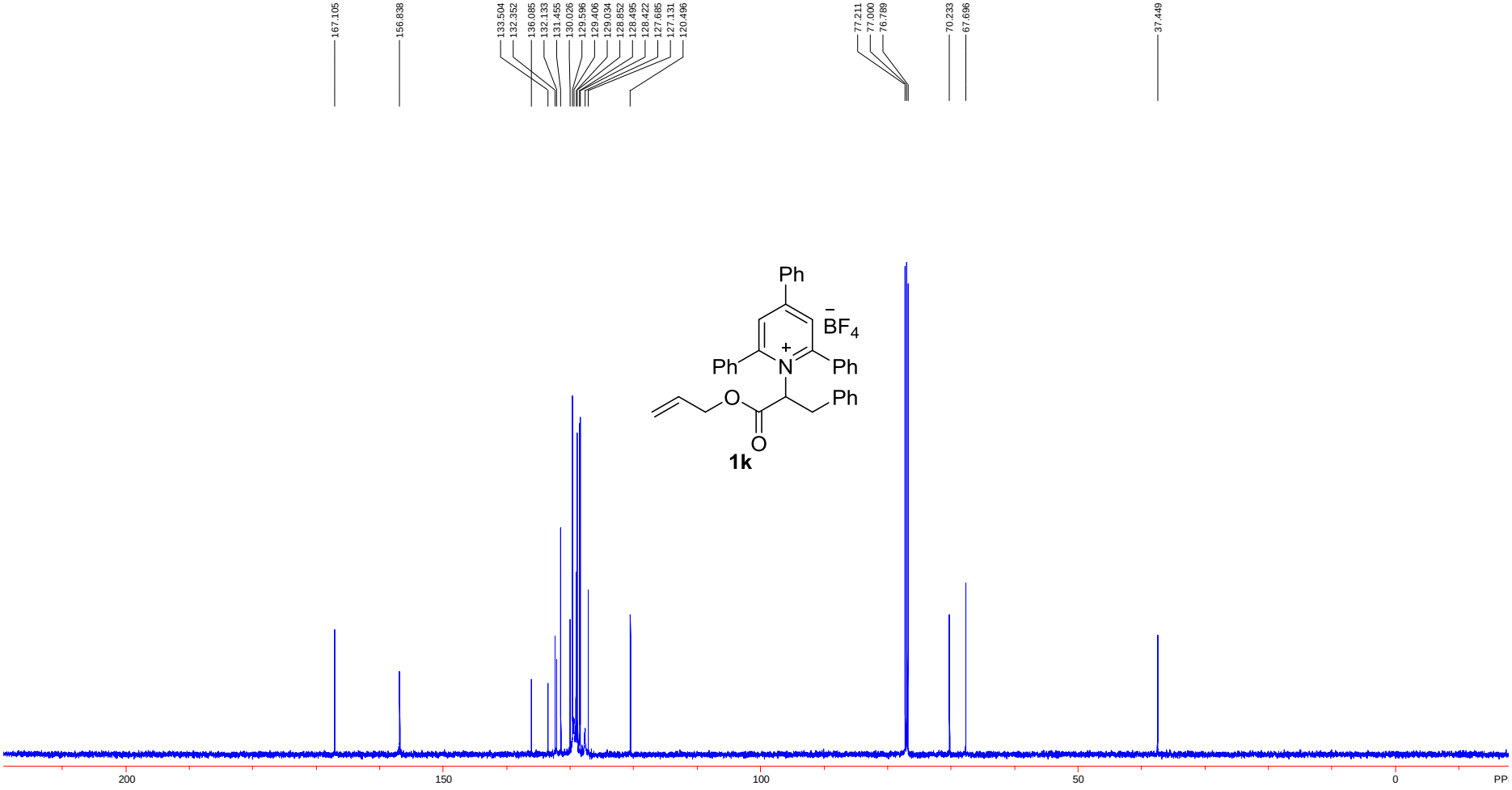
^{19}F NMR(565 MHz, $CDCl_3$)



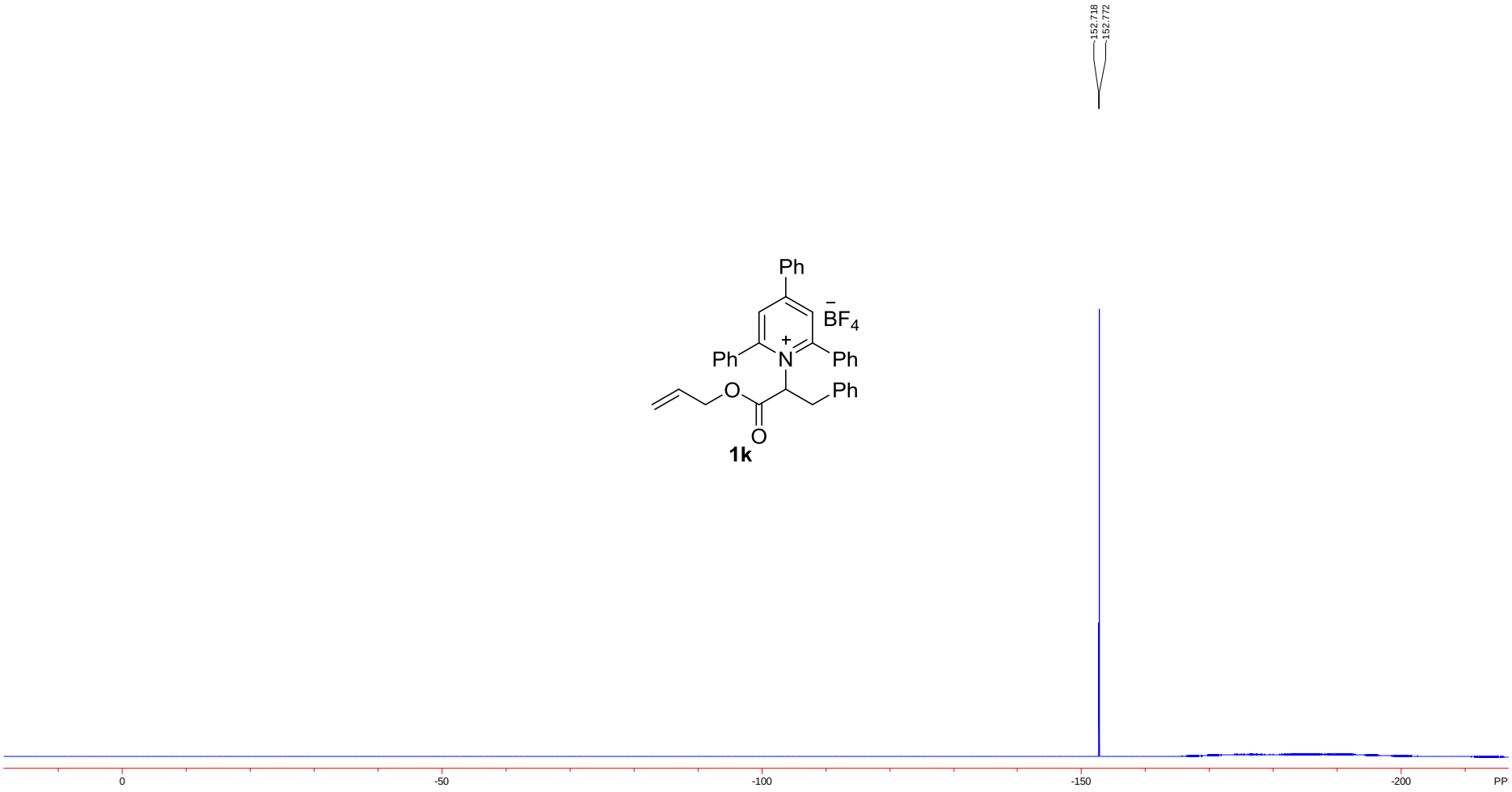
^{1}H NMR(400 MHz, $CDCl_3$)



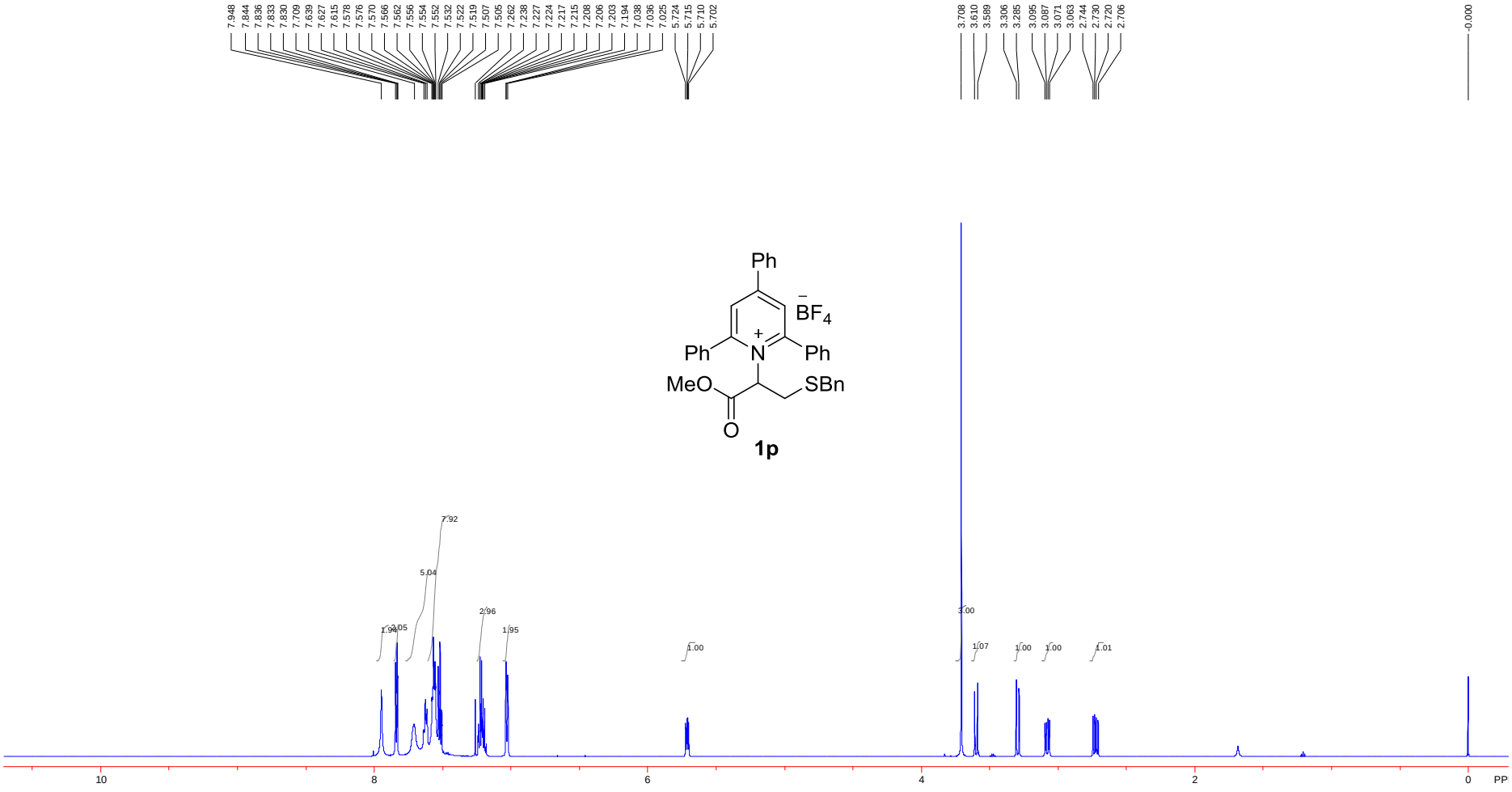
^{13}C NMR(150 MHz, $CDCl_3$)



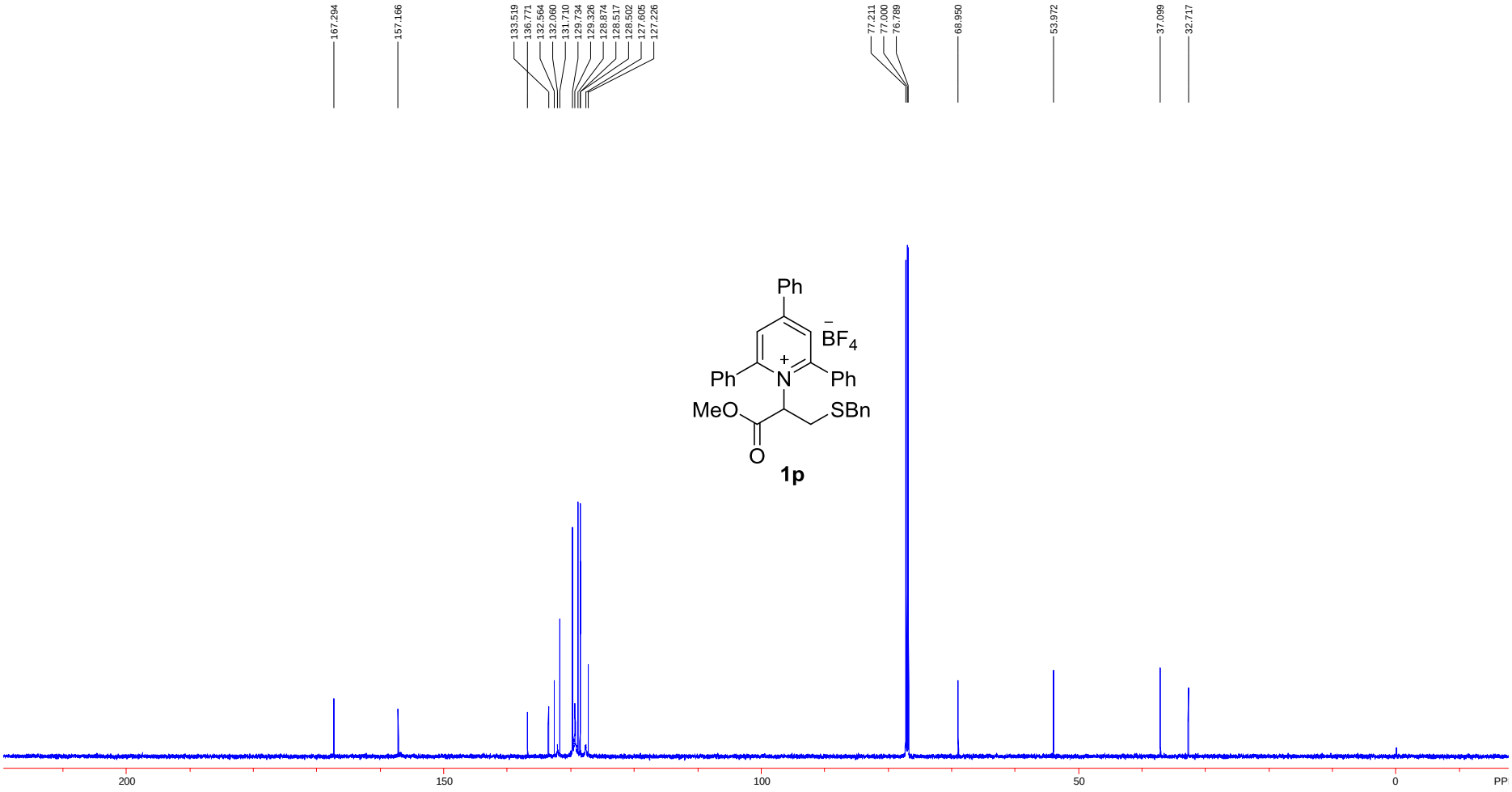
^{19}F NMR(565 MHz, $CDCl_3$)



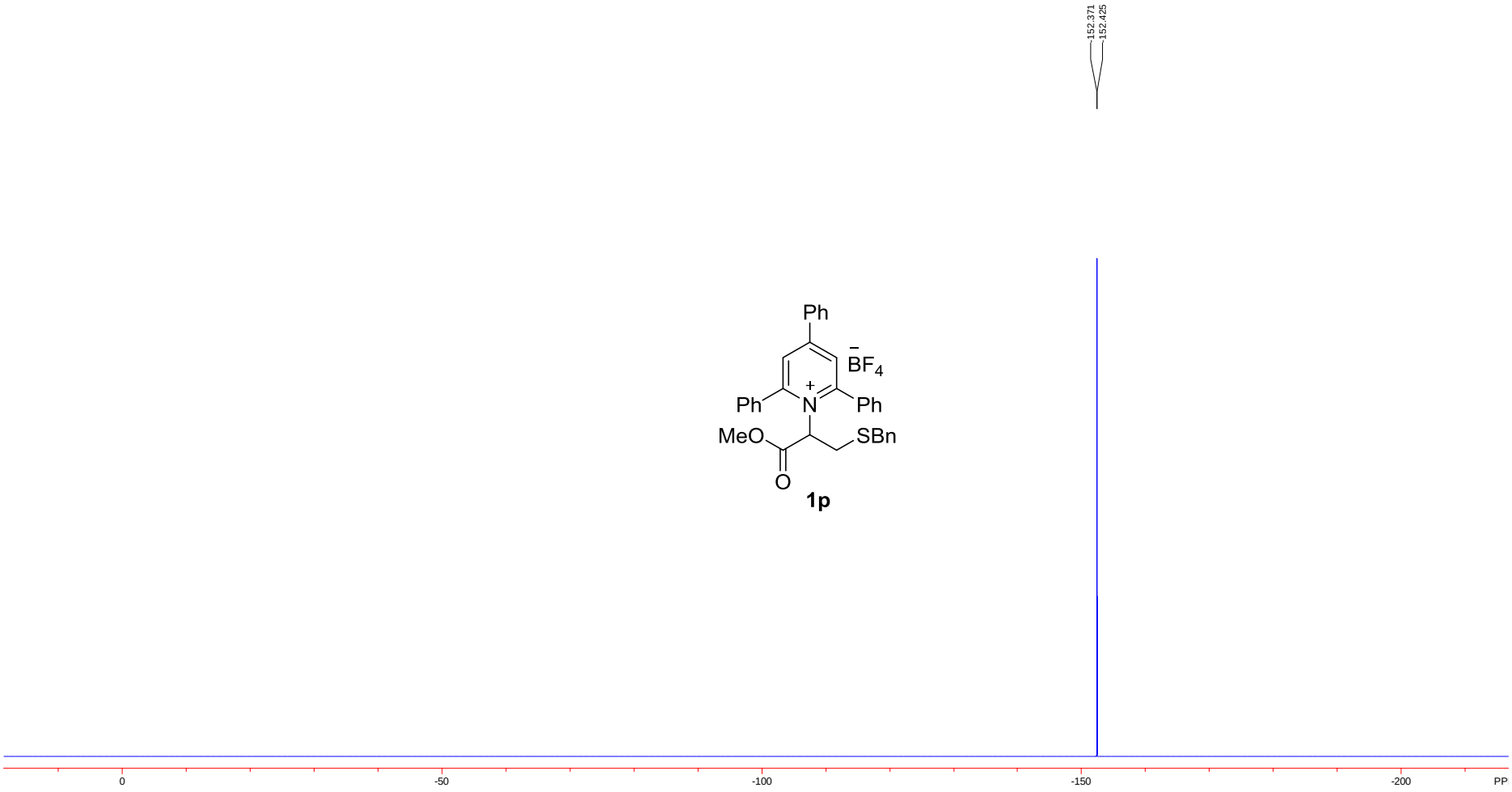
^{1}H NMR(600 MHz, $CDCl_3$)



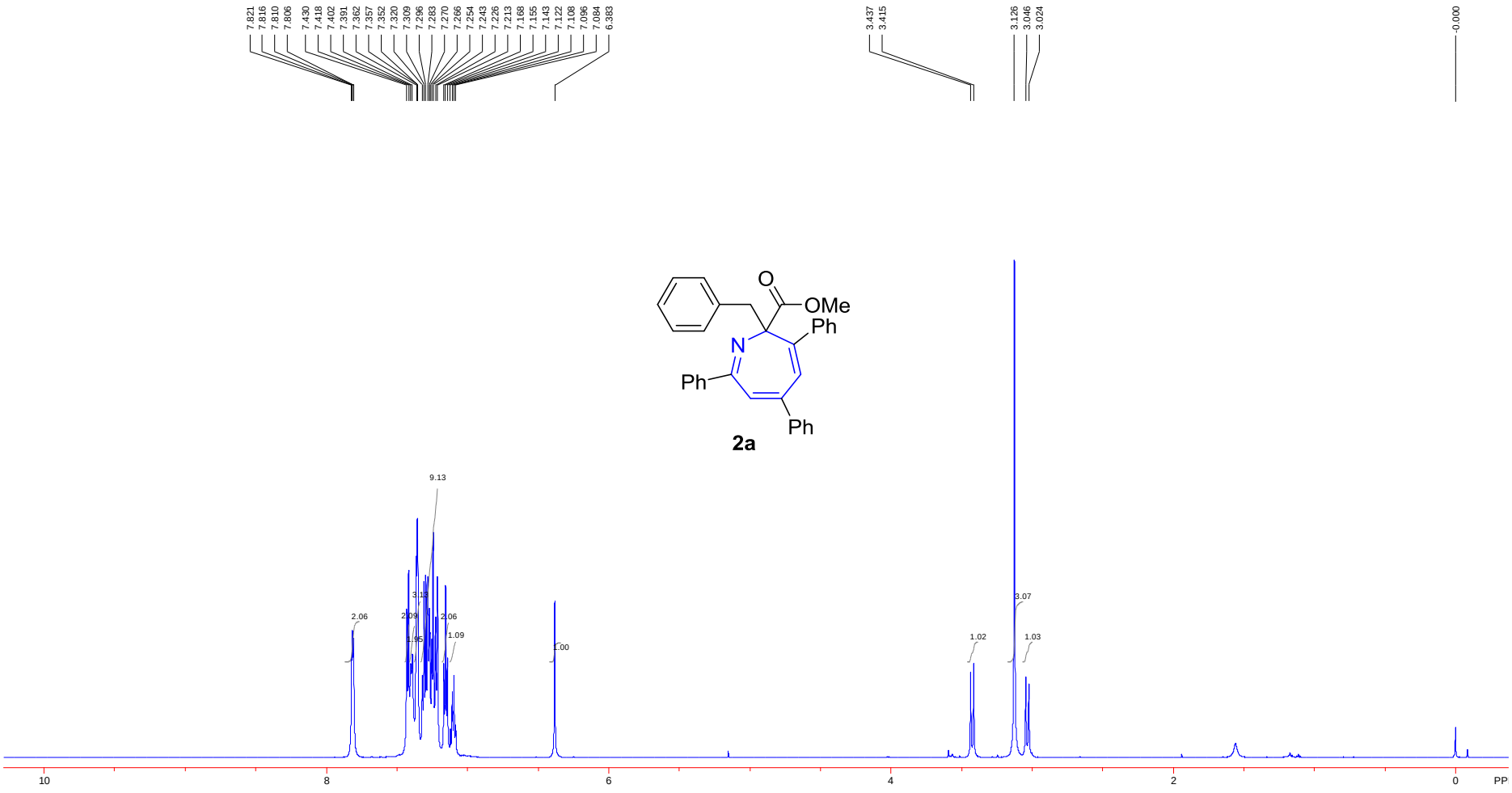
^{13}C NMR(150 MHz, $CDCl_3$)



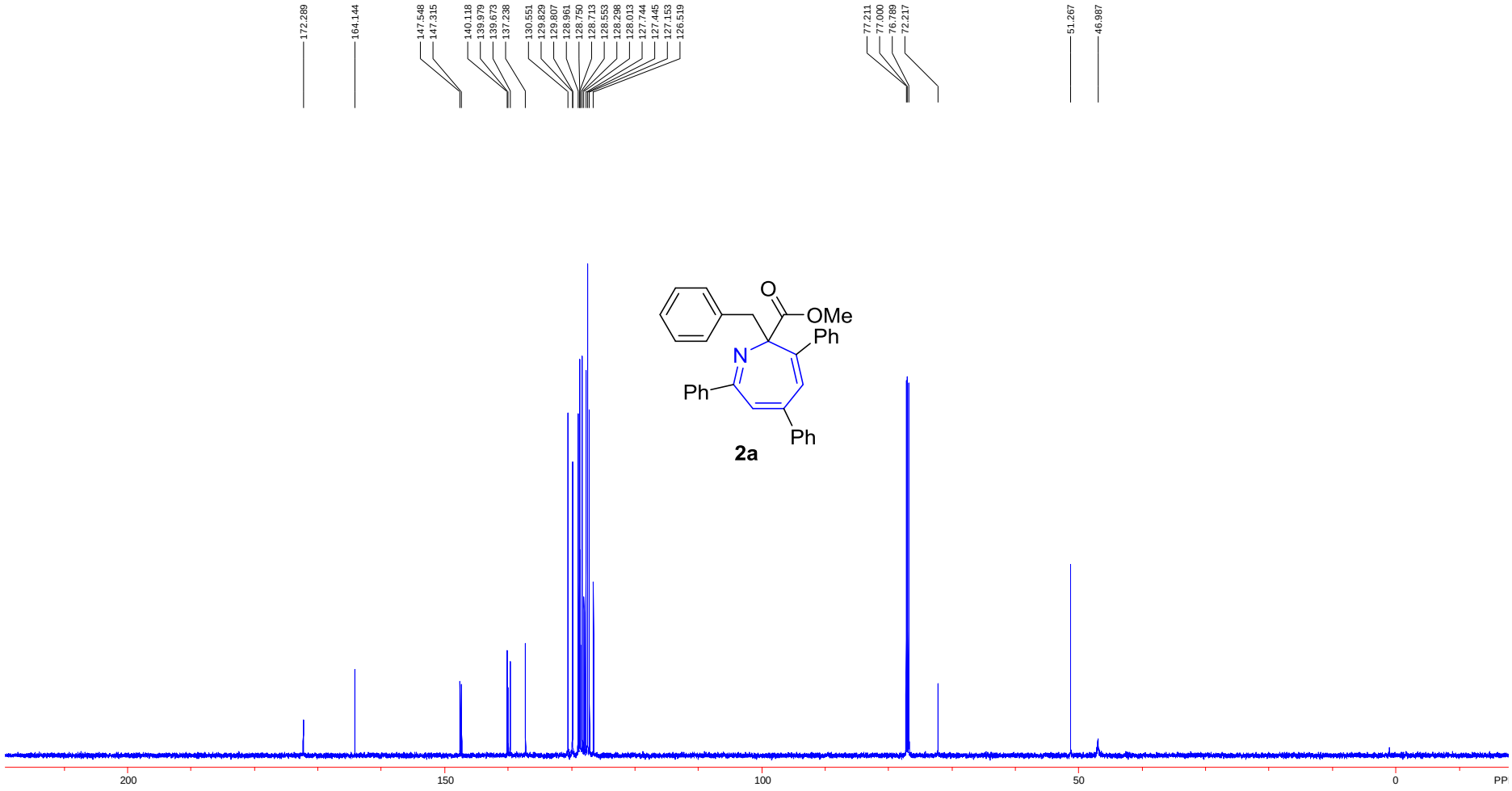
^{19}F NMR(565 MHz, $CDCl_3$)



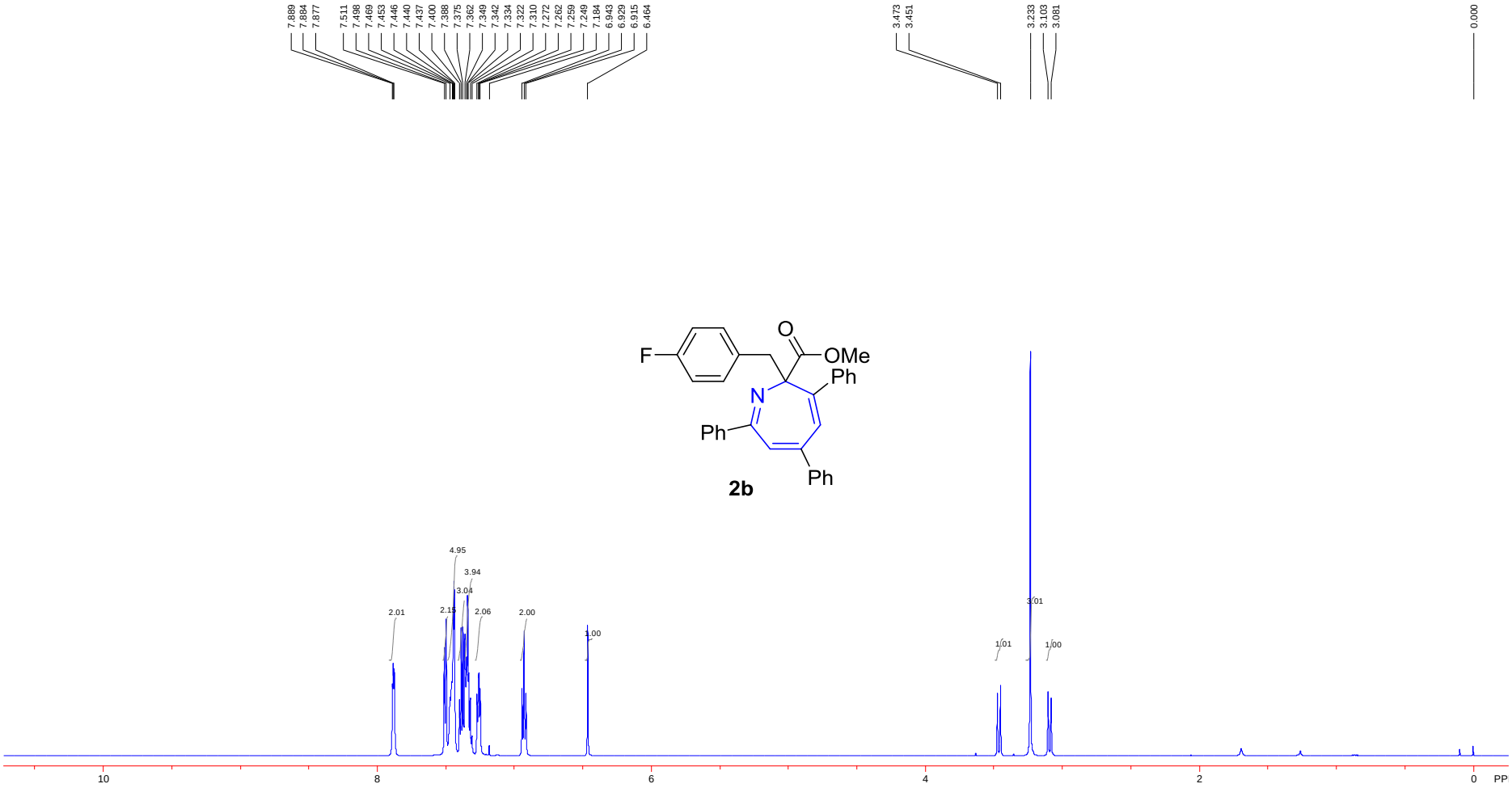
^{1}H NMR(600 MHz, $CDCl_3$)



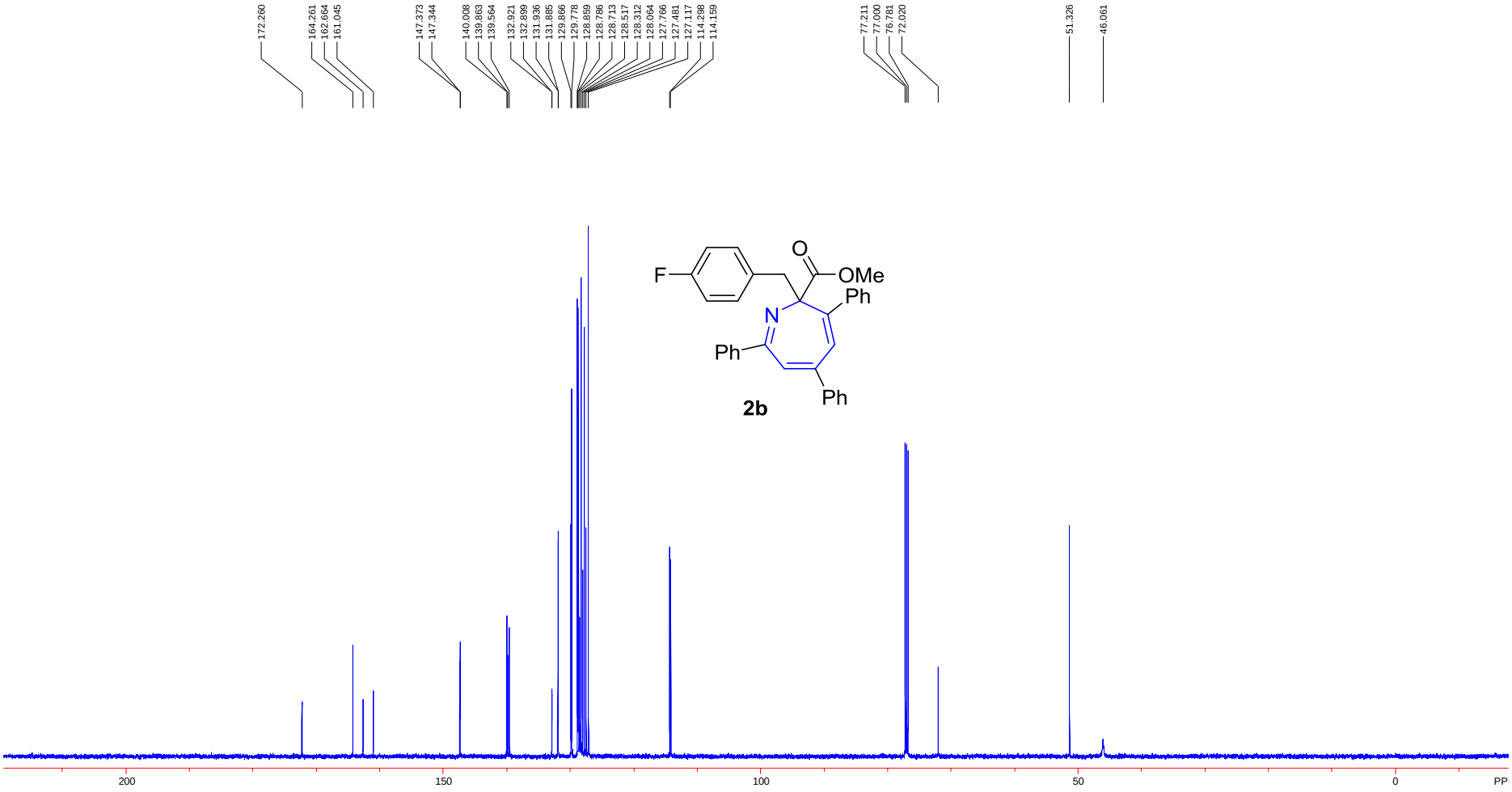
^{13}C NMR(150 MHz, $CDCl_3$)



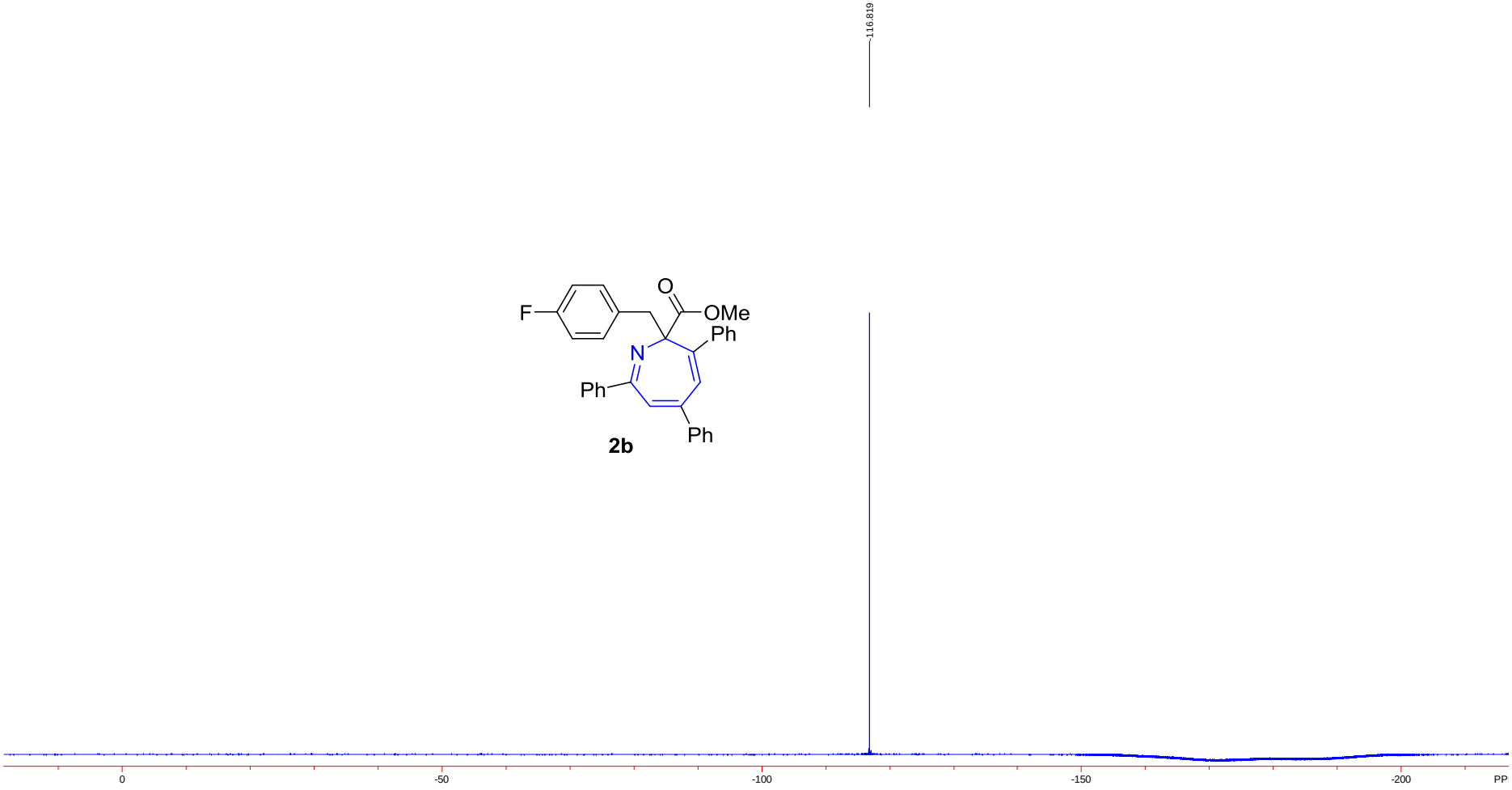
^{1}H NMR(600 MHz, $CDCl_3$)



^{13}C NMR(150 MHz, $CDCl_3$)

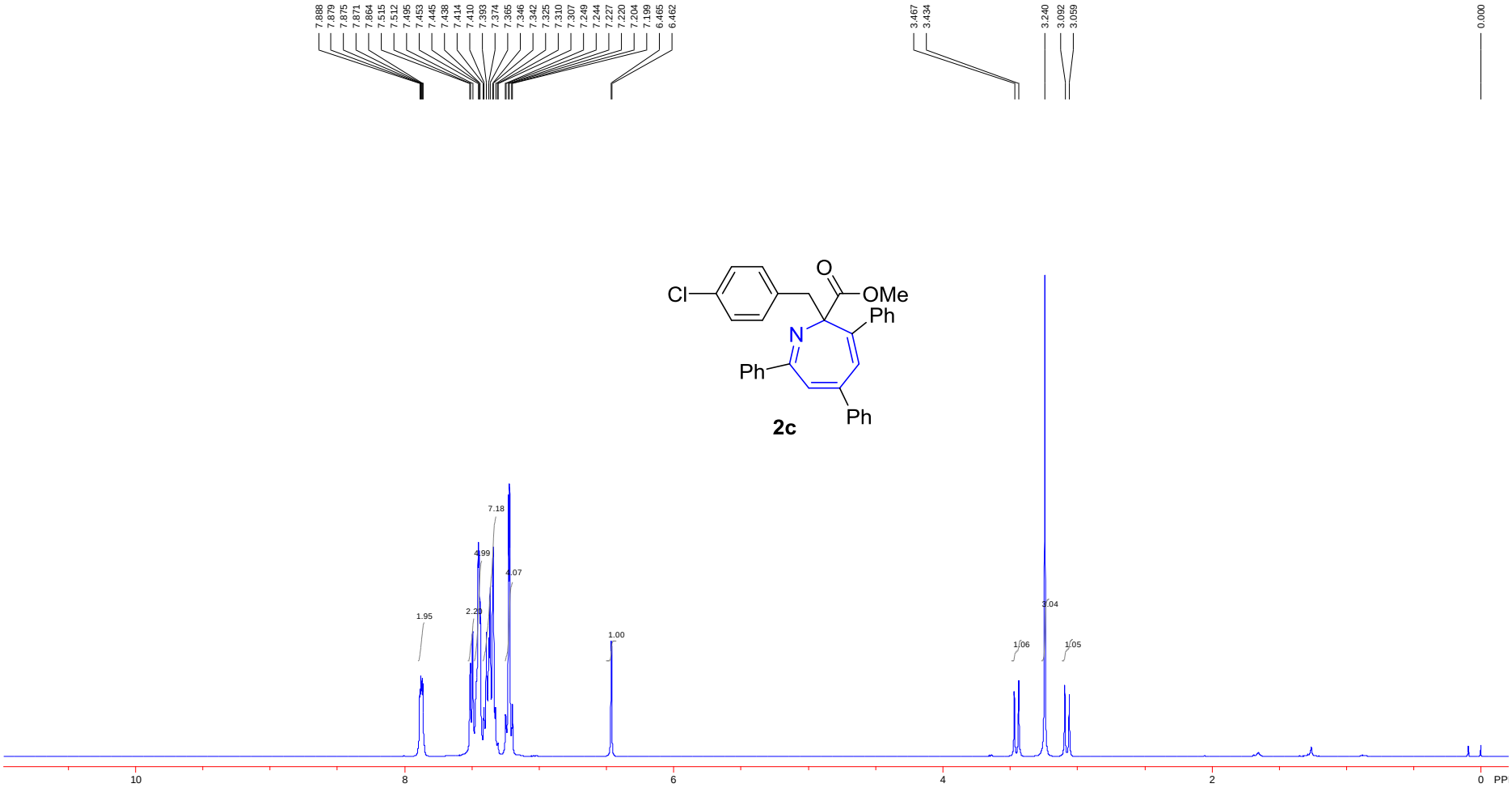


^{19}F NMR(565 MHz, $CDCl_3$)

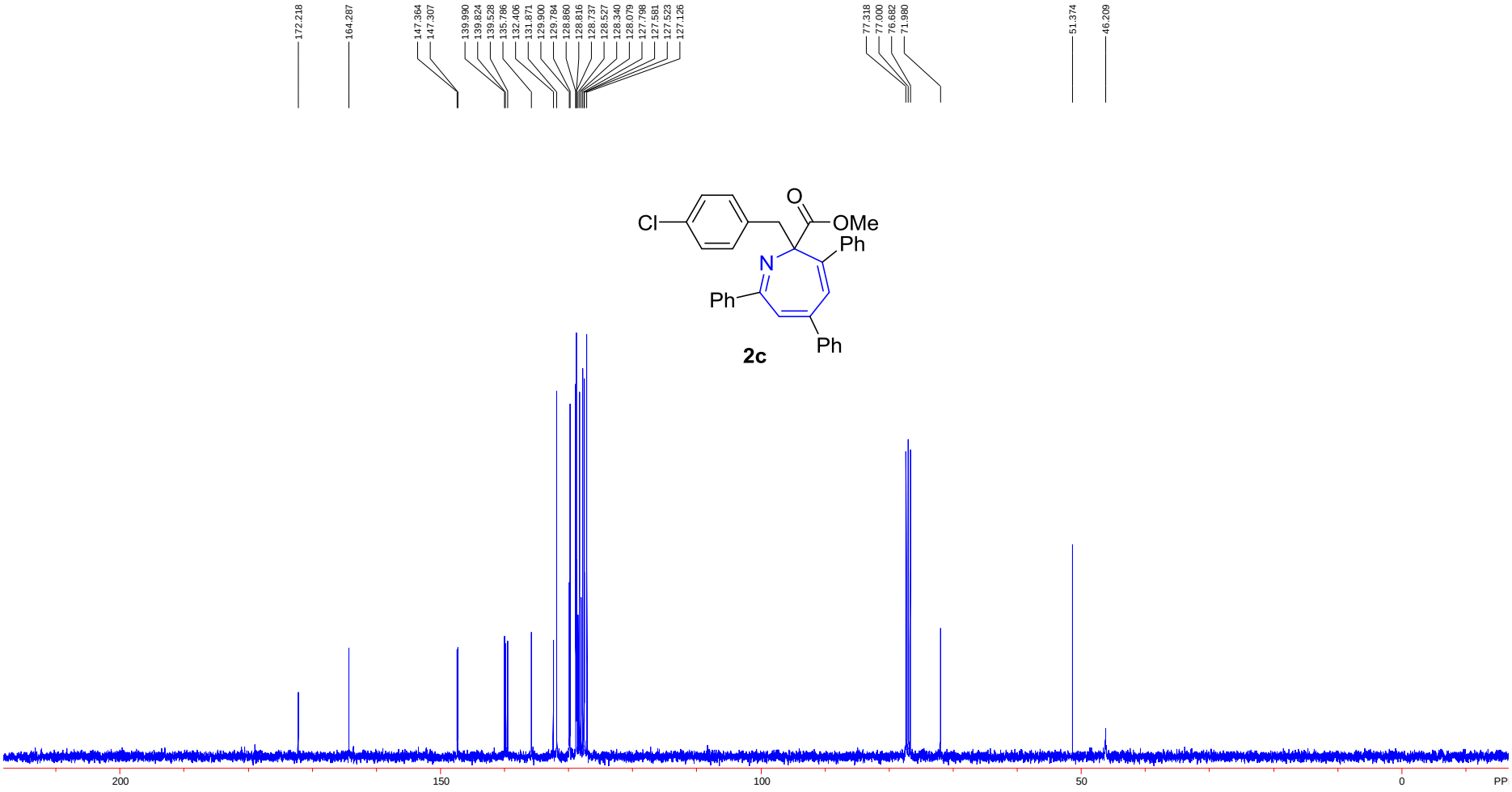


2b

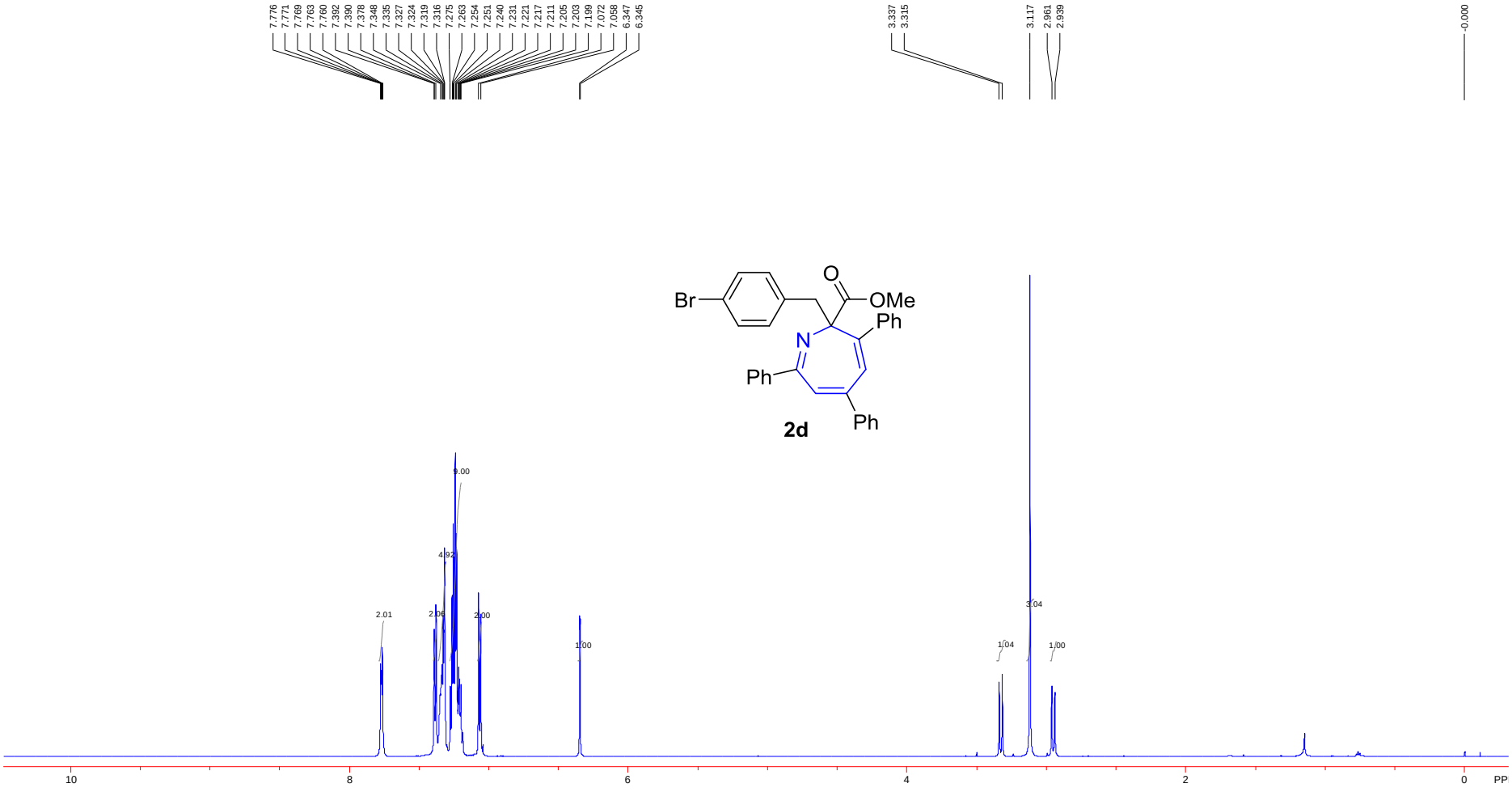
^{1}H NMR(400 MHz, $CDCl_3$)



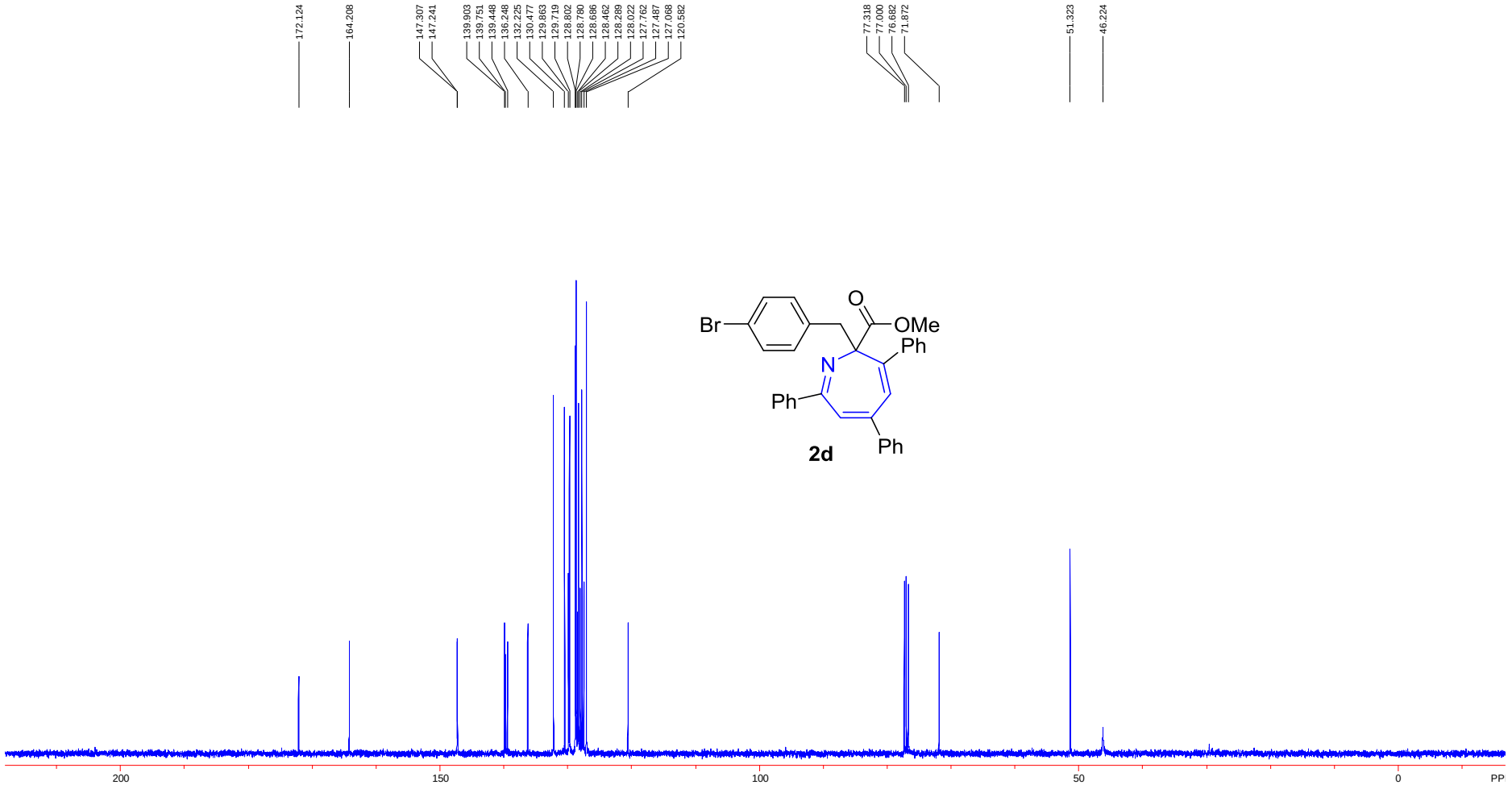
^{13}C NMR(100 MHz, $CDCl_3$)



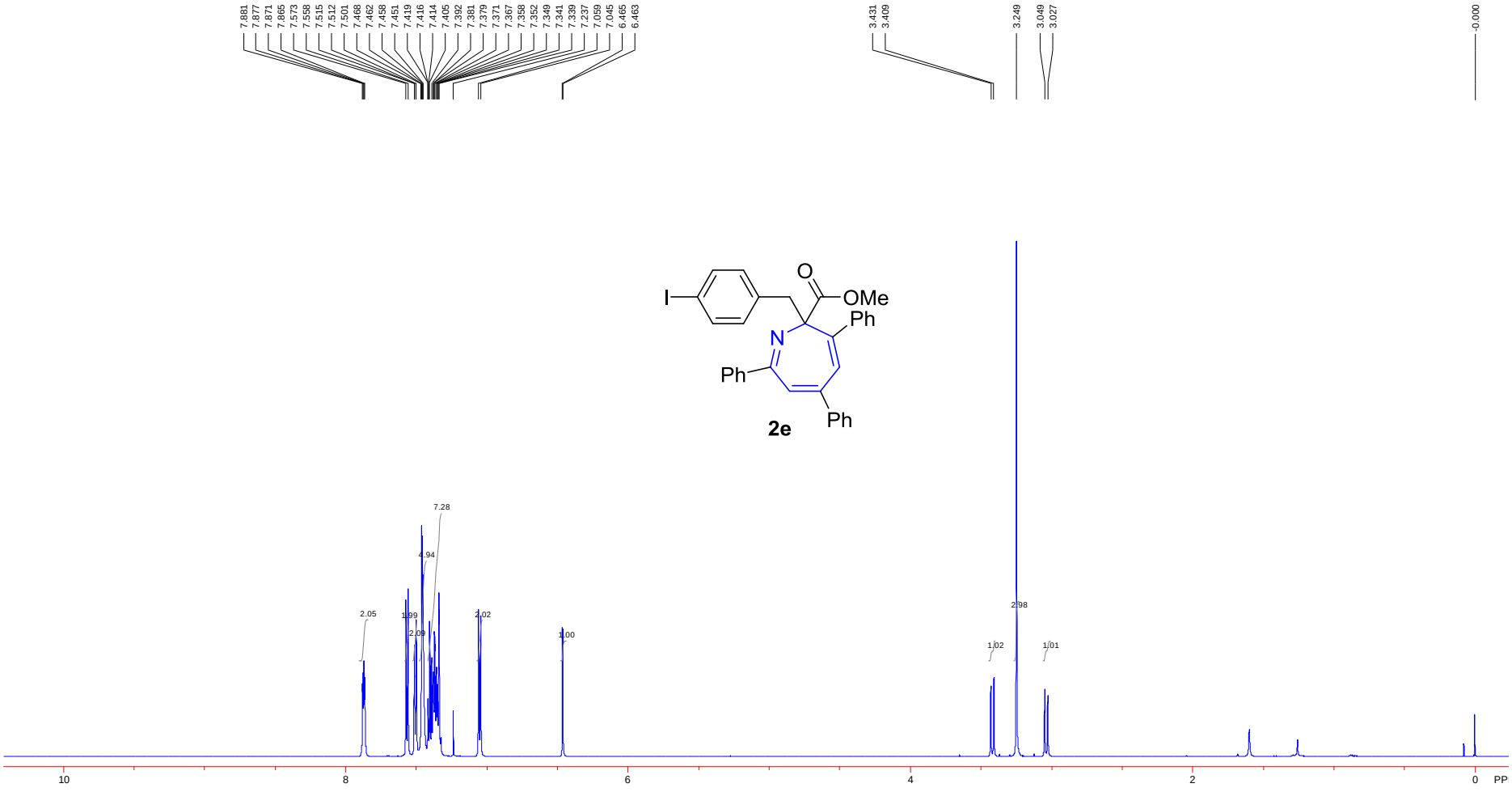
^{1}H NMR(600 MHz, $CDCl_3$)



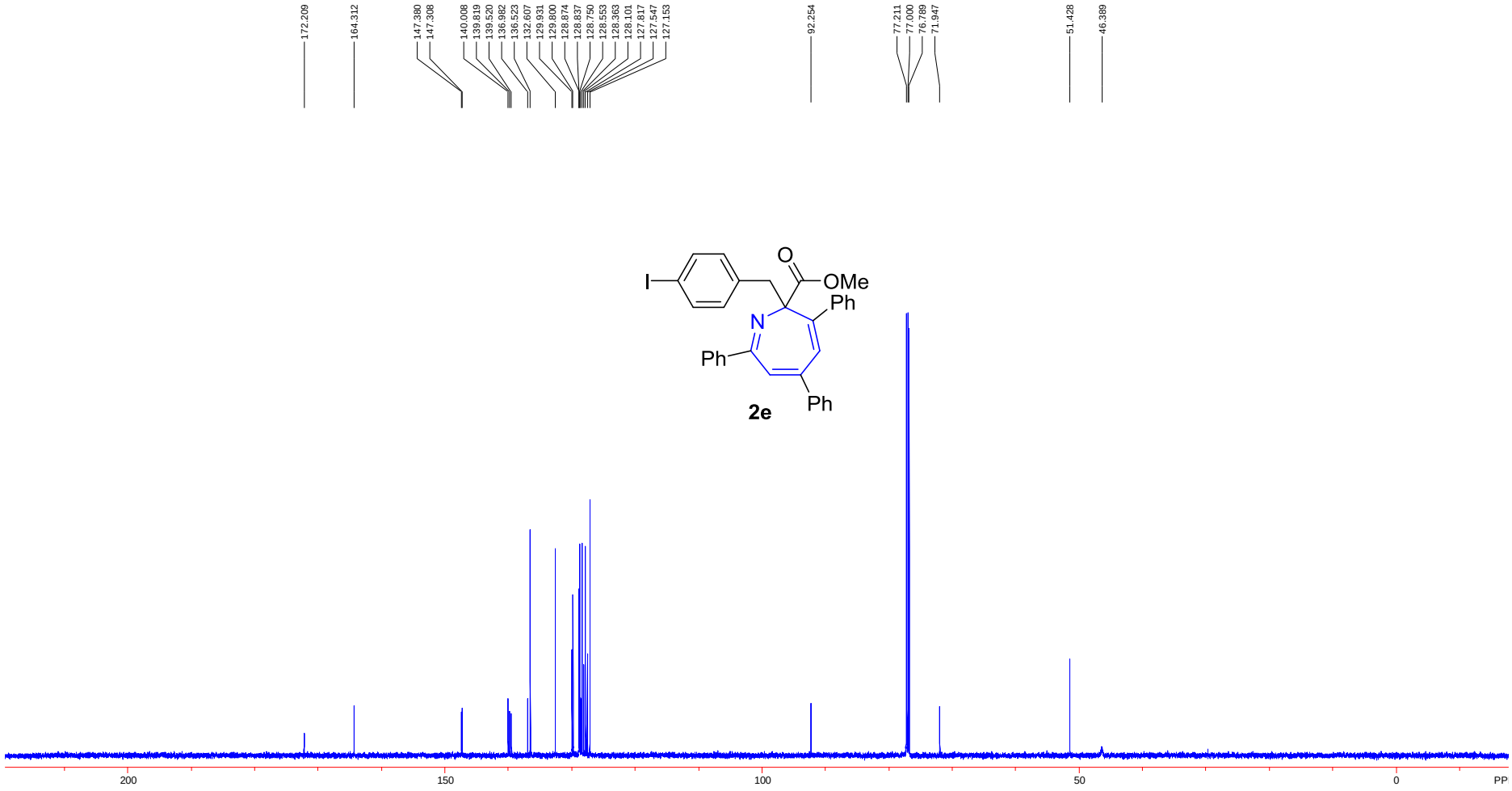
^{13}C NMR(100 MHz, $CDCl_3$)



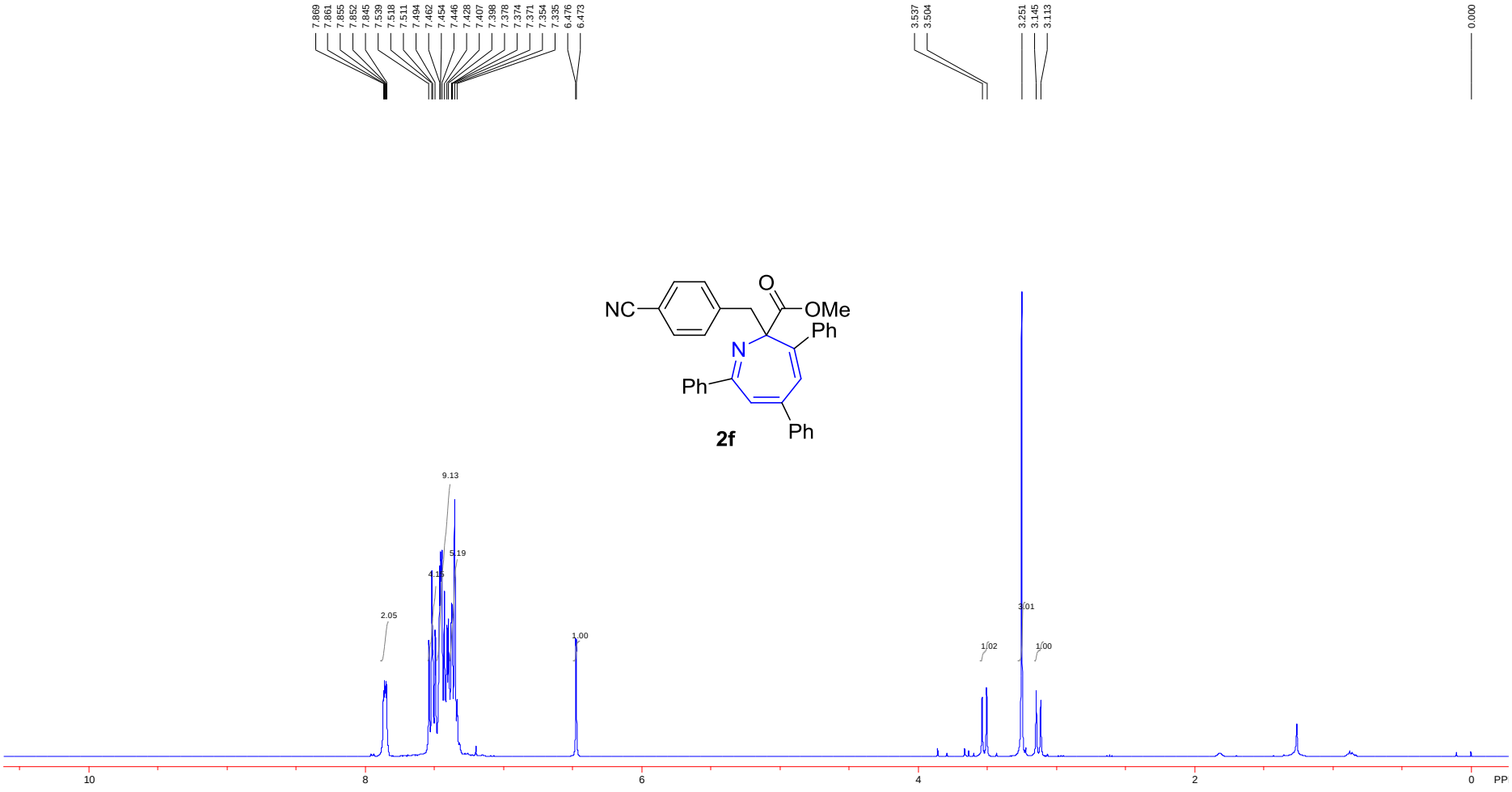
^{1}H NMR(600 MHz, $CDCl_3$)



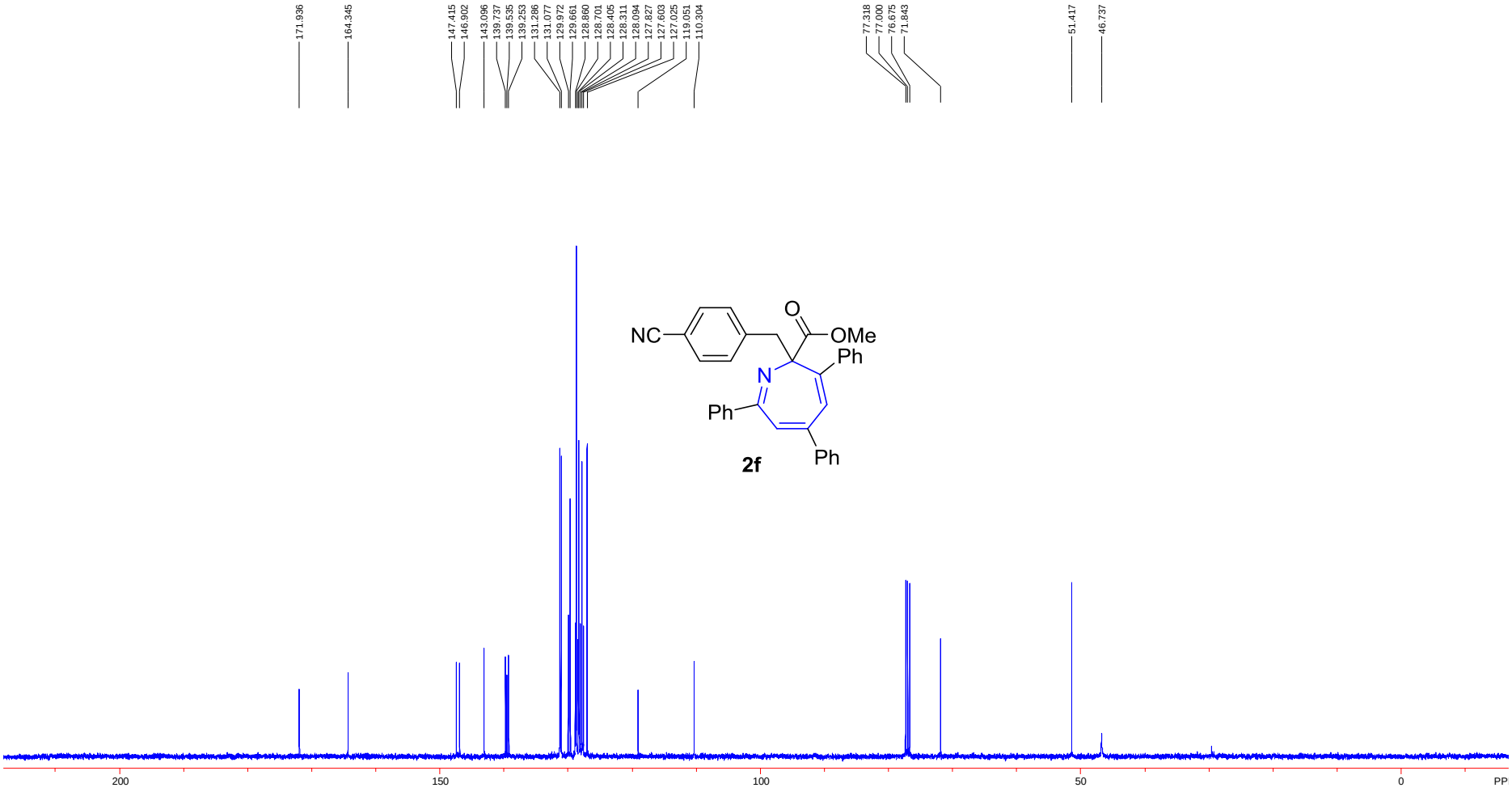
^{13}C NMR(150 MHz, $CDCl_3$)



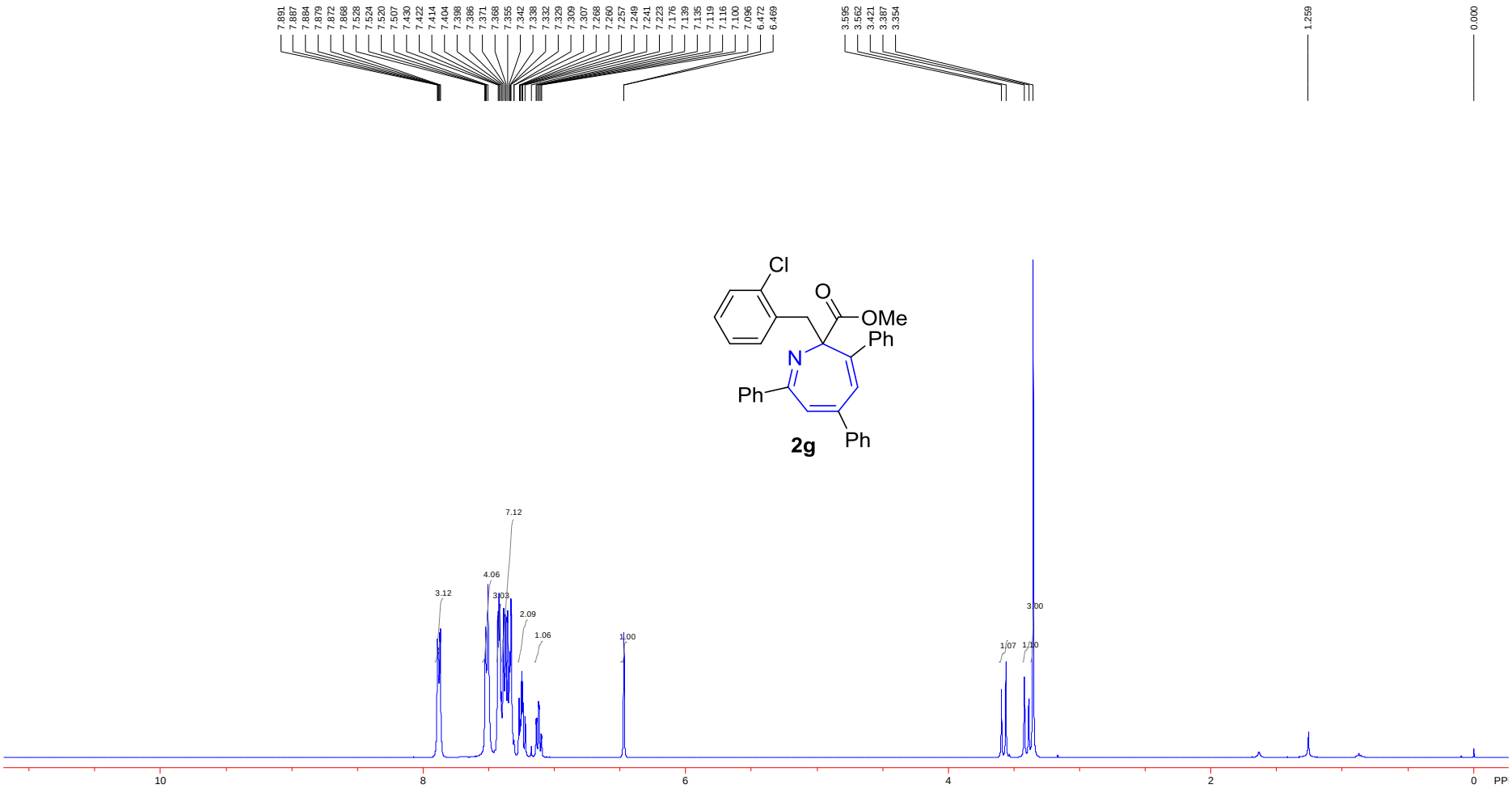
^{1}H NMR(400 MHz, $CDCl_3$)



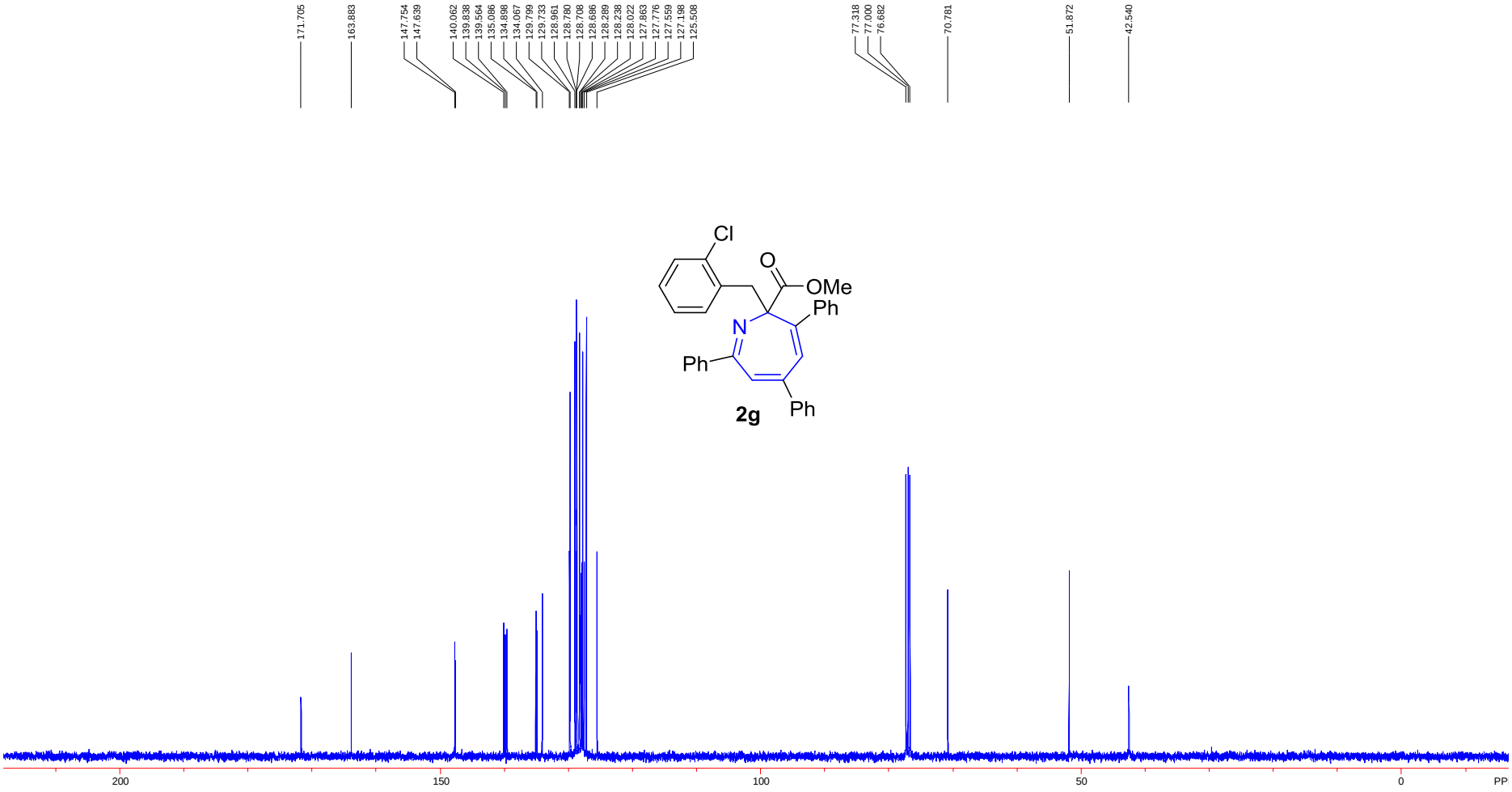
^{13}C NMR(100 MHz, $CDCl_3$)



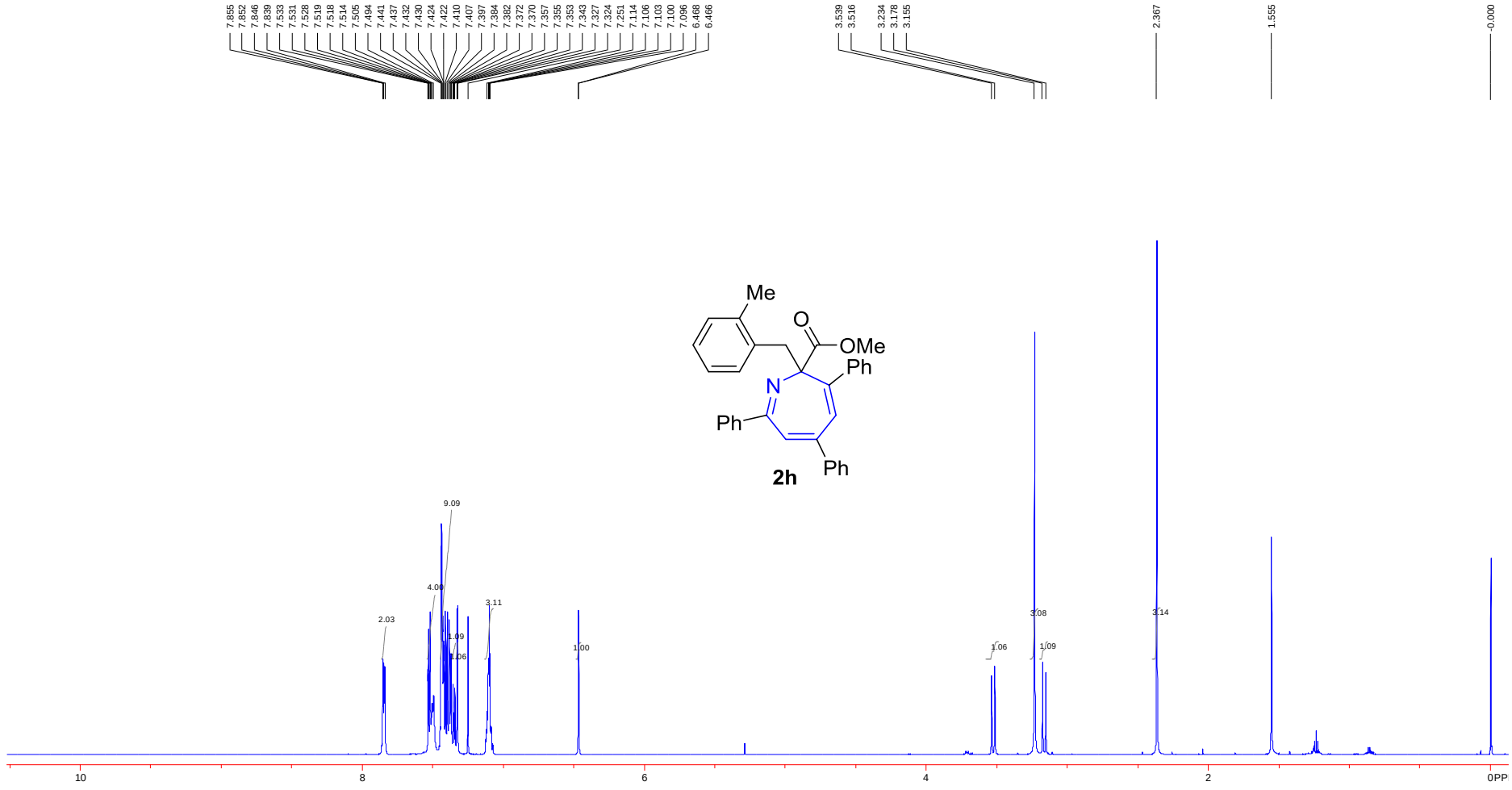
^{1}H NMR(400 MHz, $CDCl_3$)



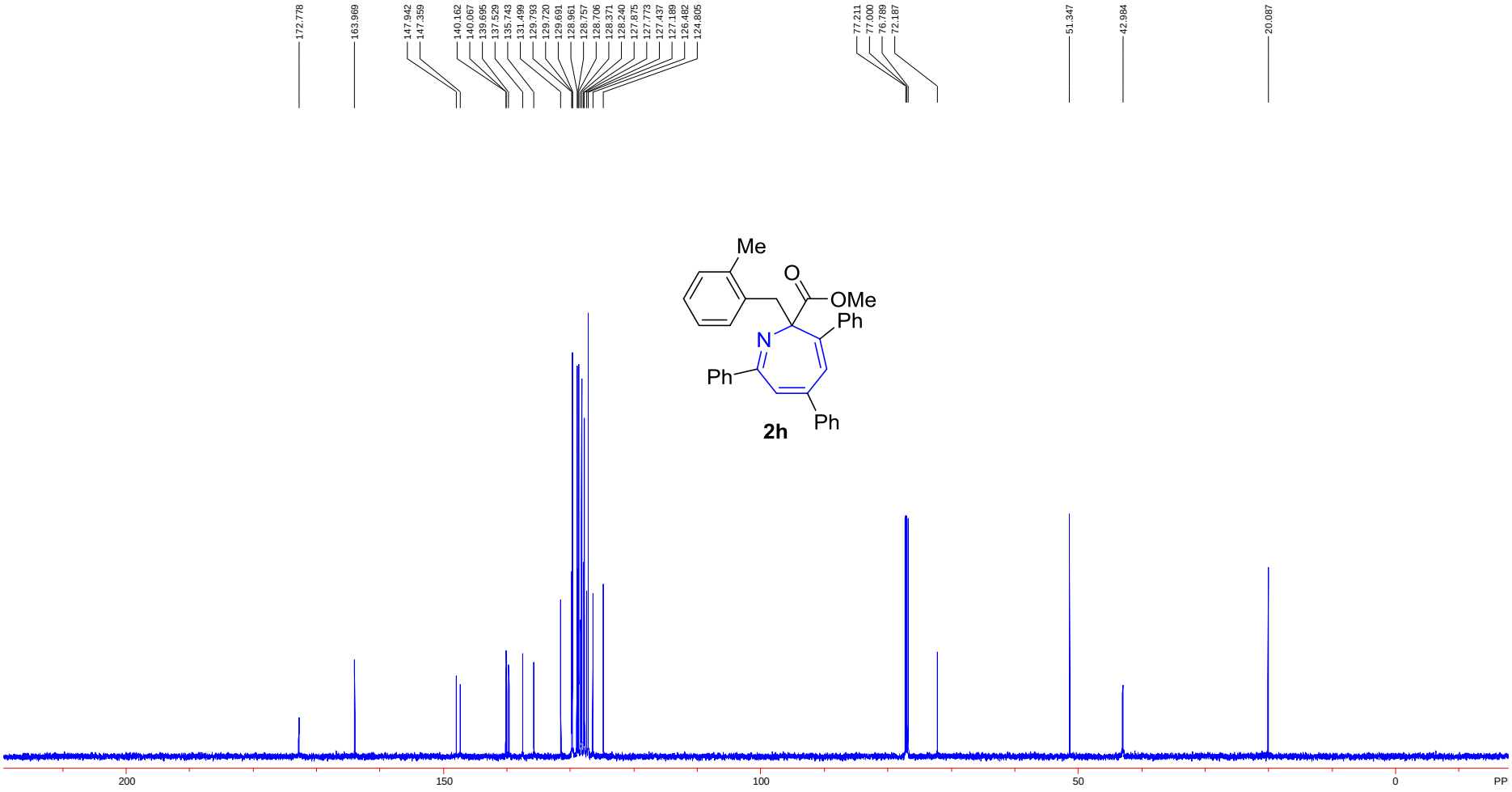
^{13}C NMR(100 MHz, $CDCl_3$)



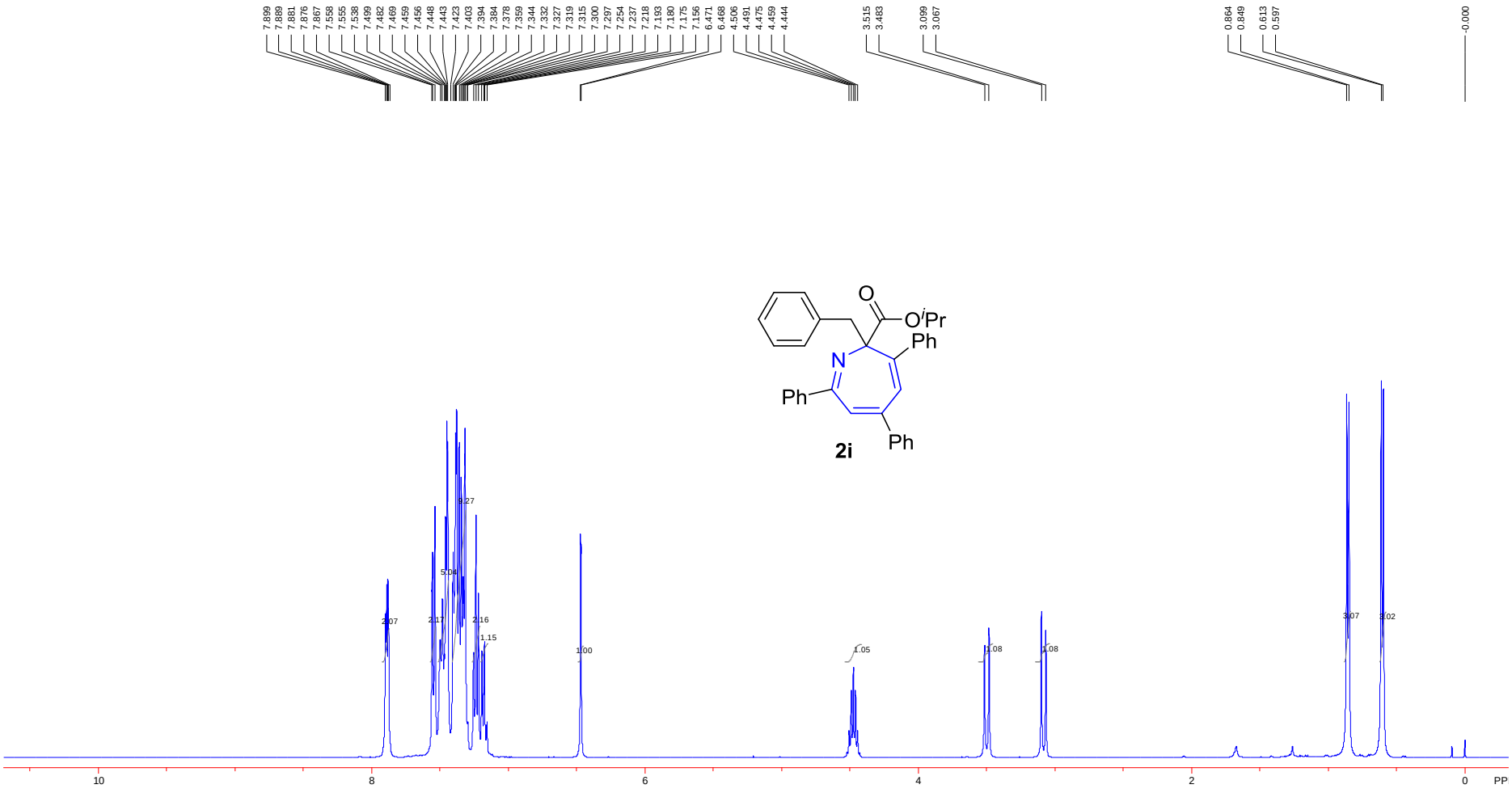
^{1}H NMR(600 MHz, $CDCl_3$)



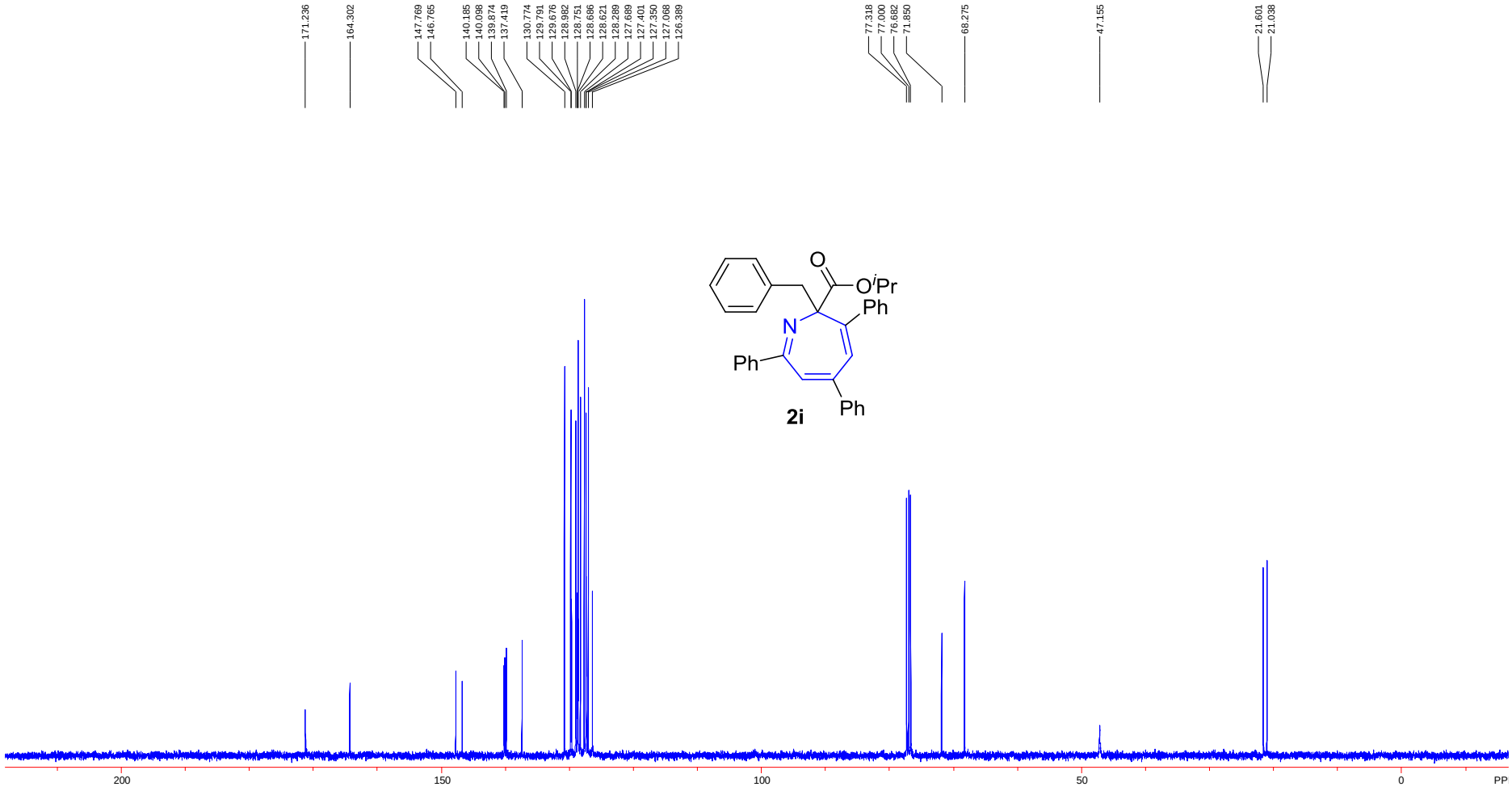
^{13}C NMR(150 MHz, $CDCl_3$)



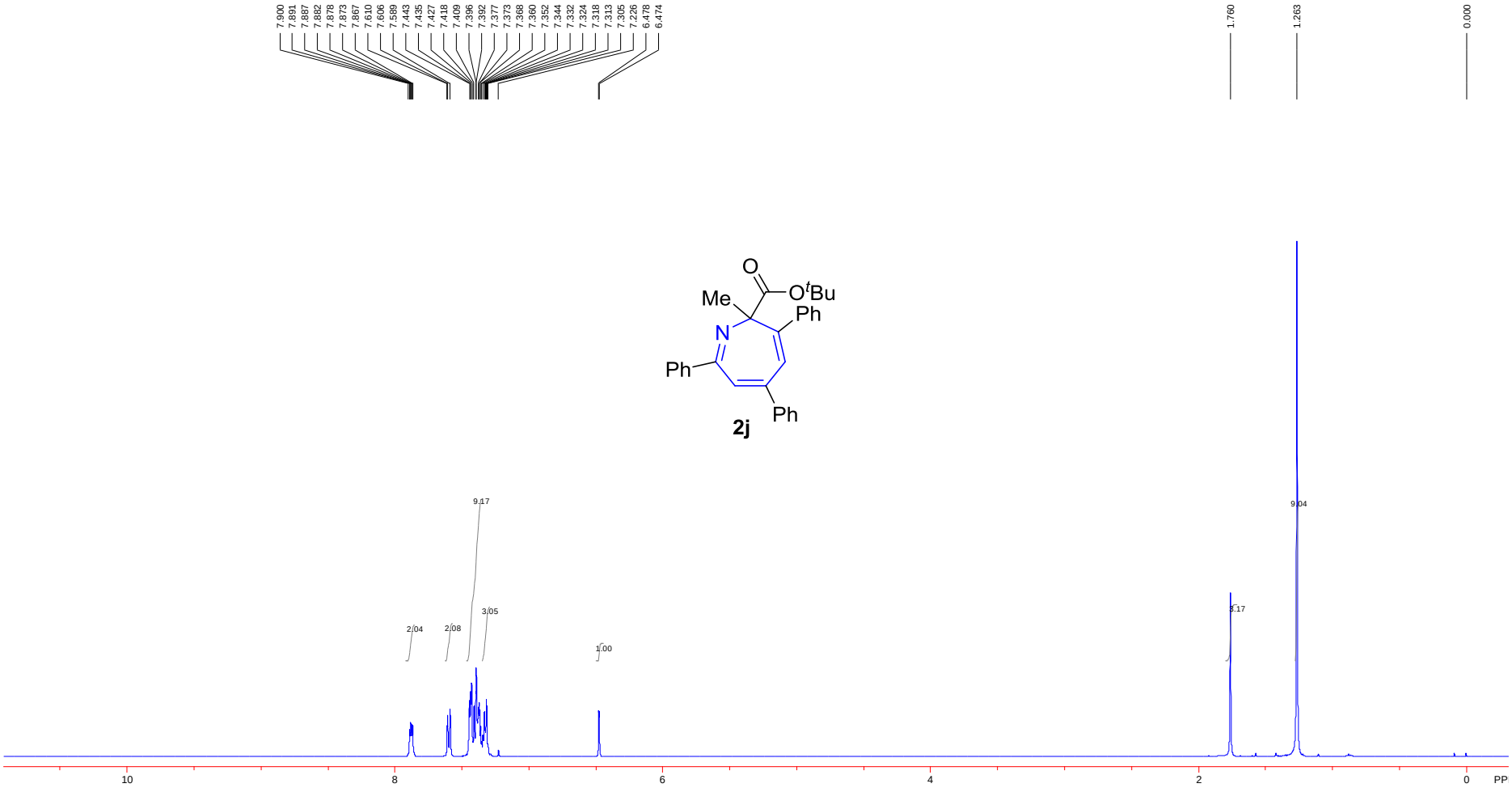
^{1}H NMR(400 MHz, $CDCl_3$)



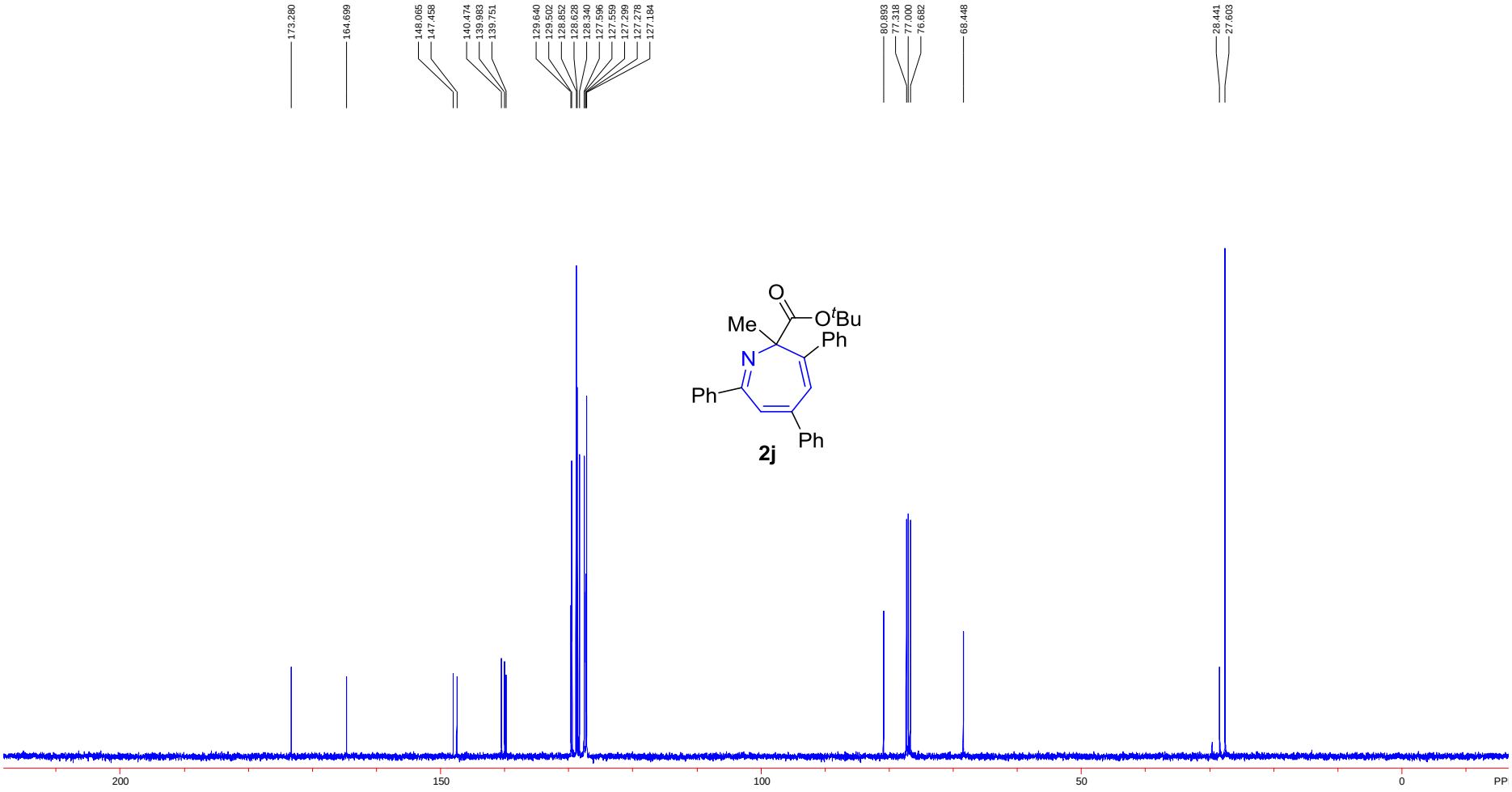
^{13}C NMR(100 MHz, $CDCl_3$)



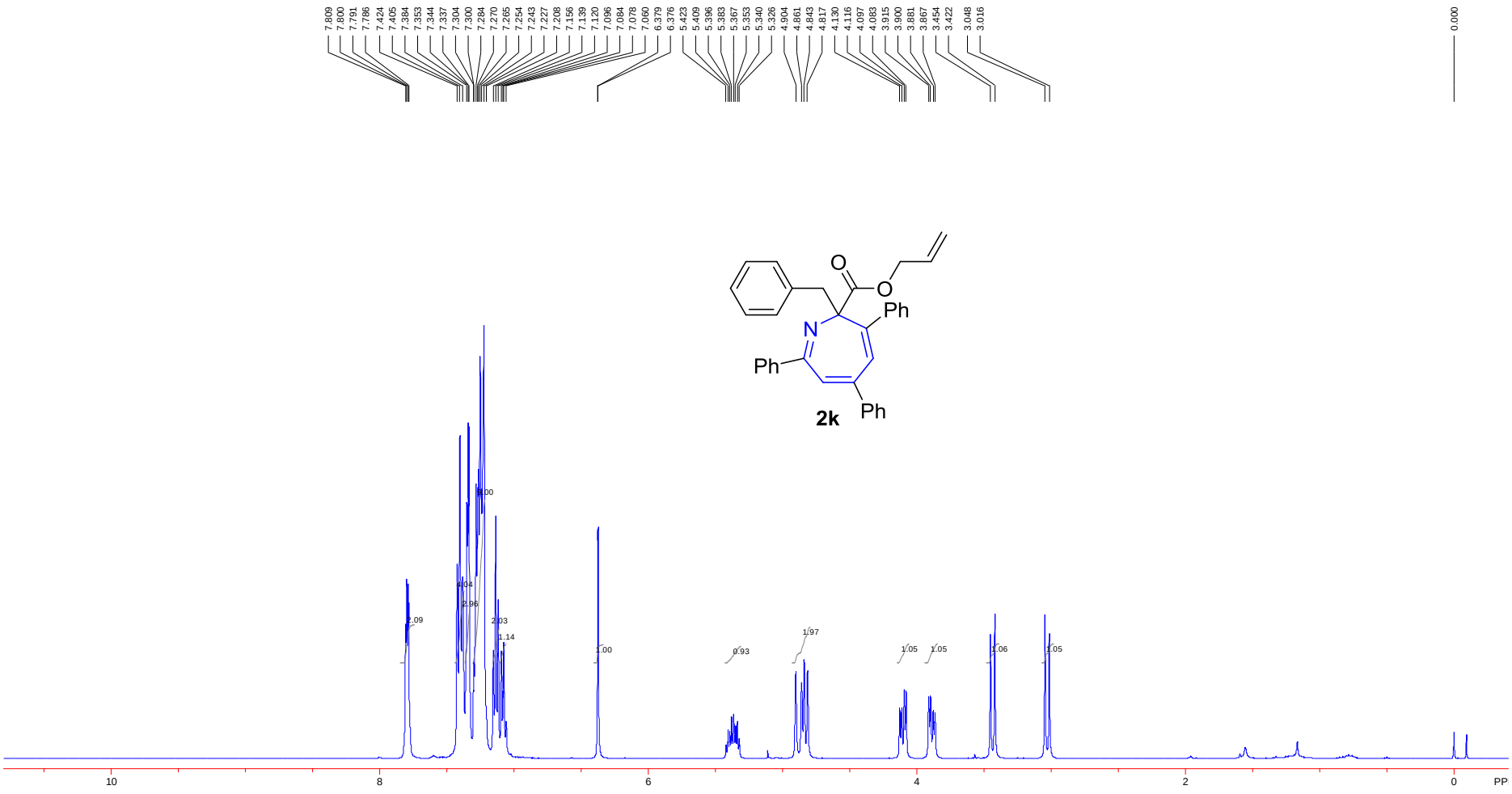
^{1}H NMR(400 MHz, $CDCl_3$)



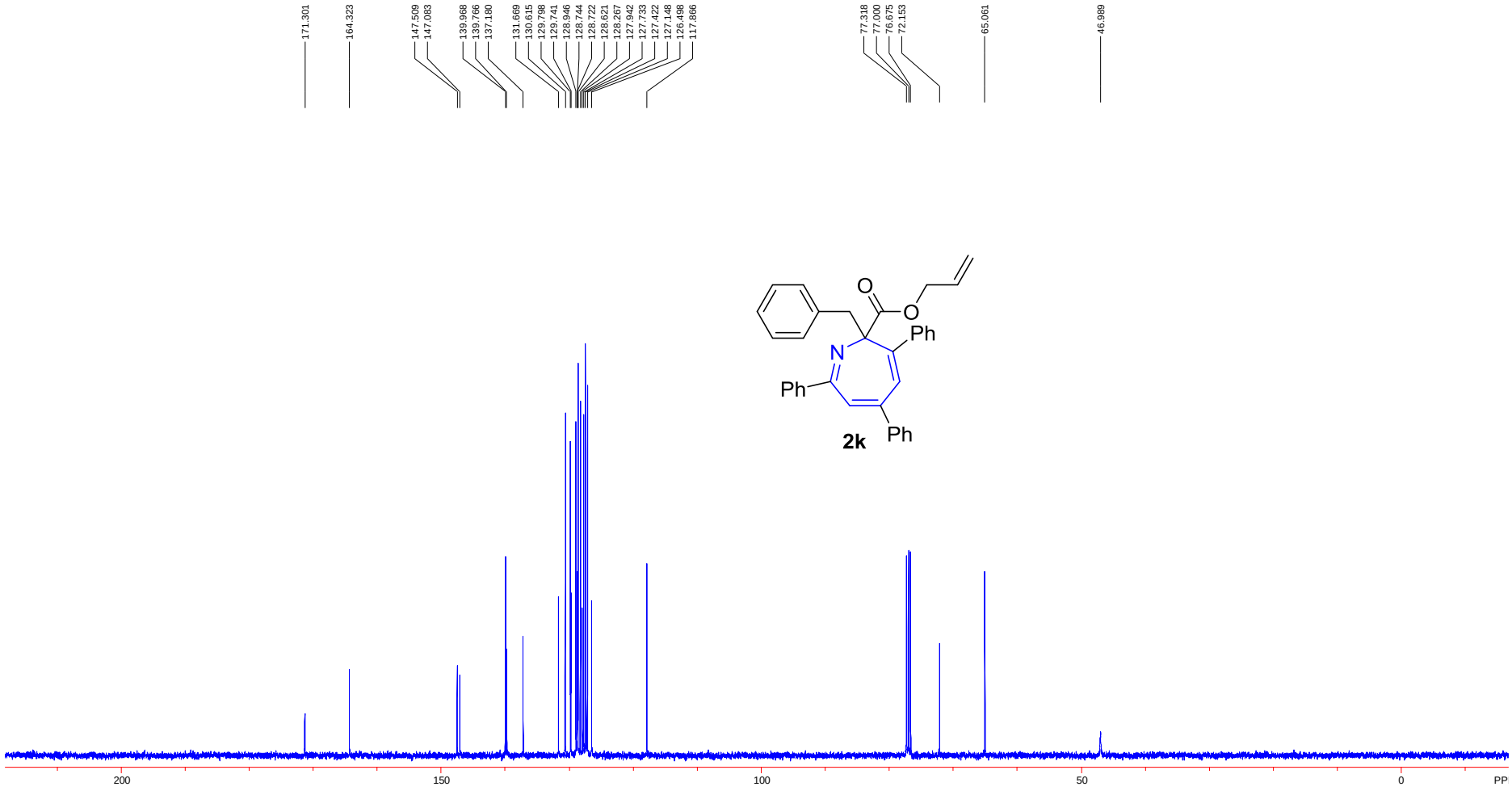
^{13}C NMR(100 MHz, $CDCl_3$)



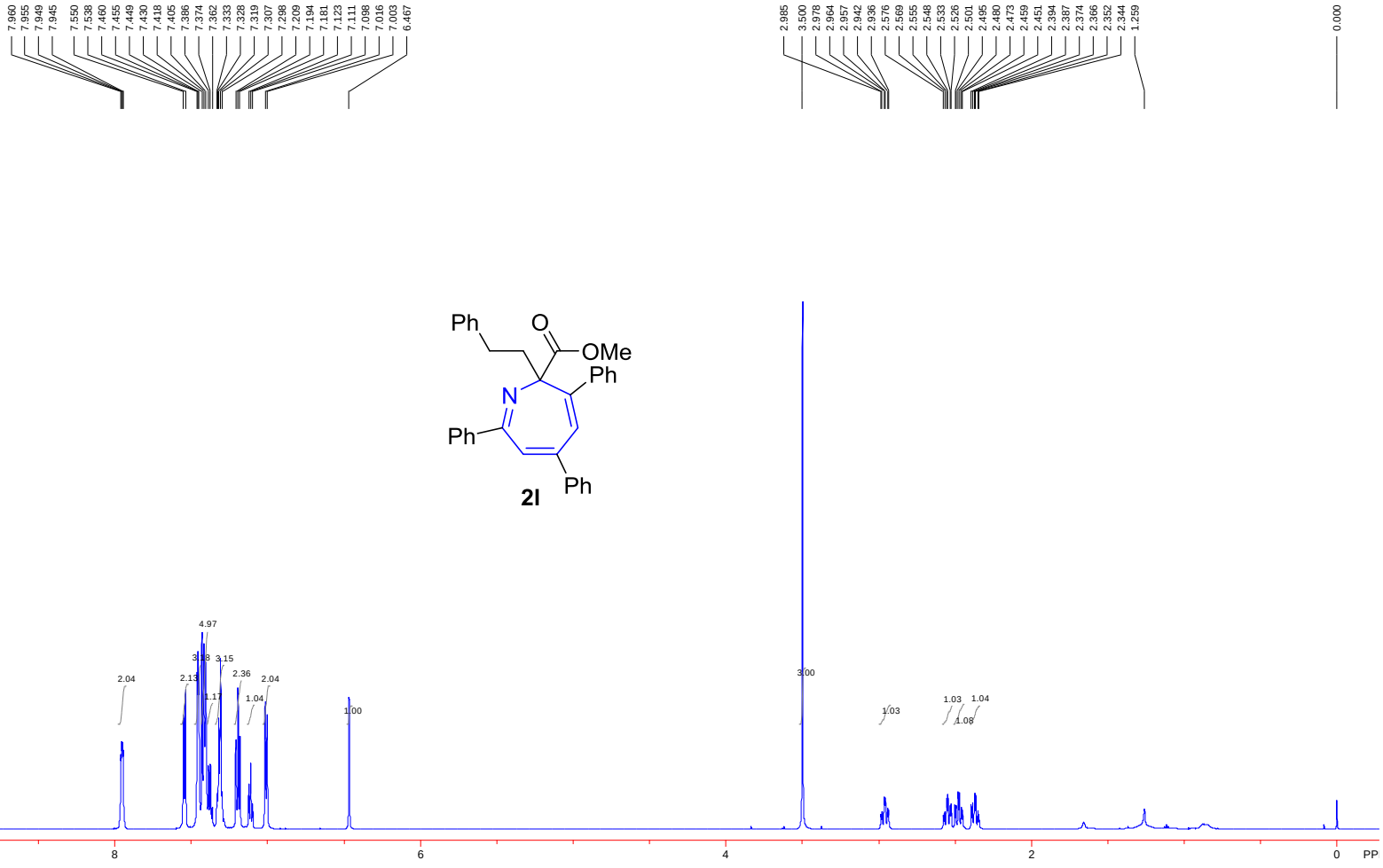
^{1}H NMR(400 MHz, $CDCl_3$)



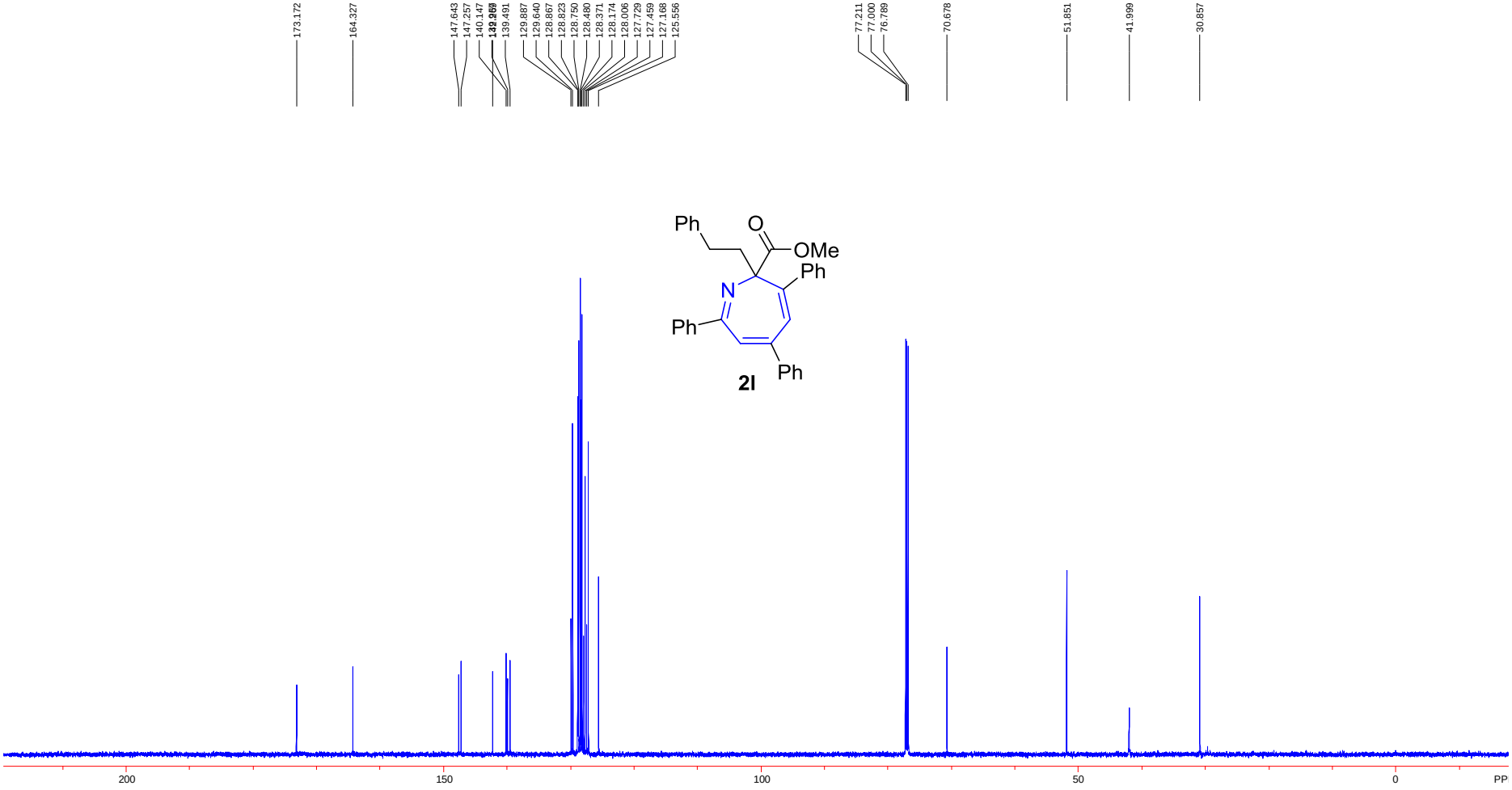
^{13}C NMR(100 MHz, $CDCl_3$)



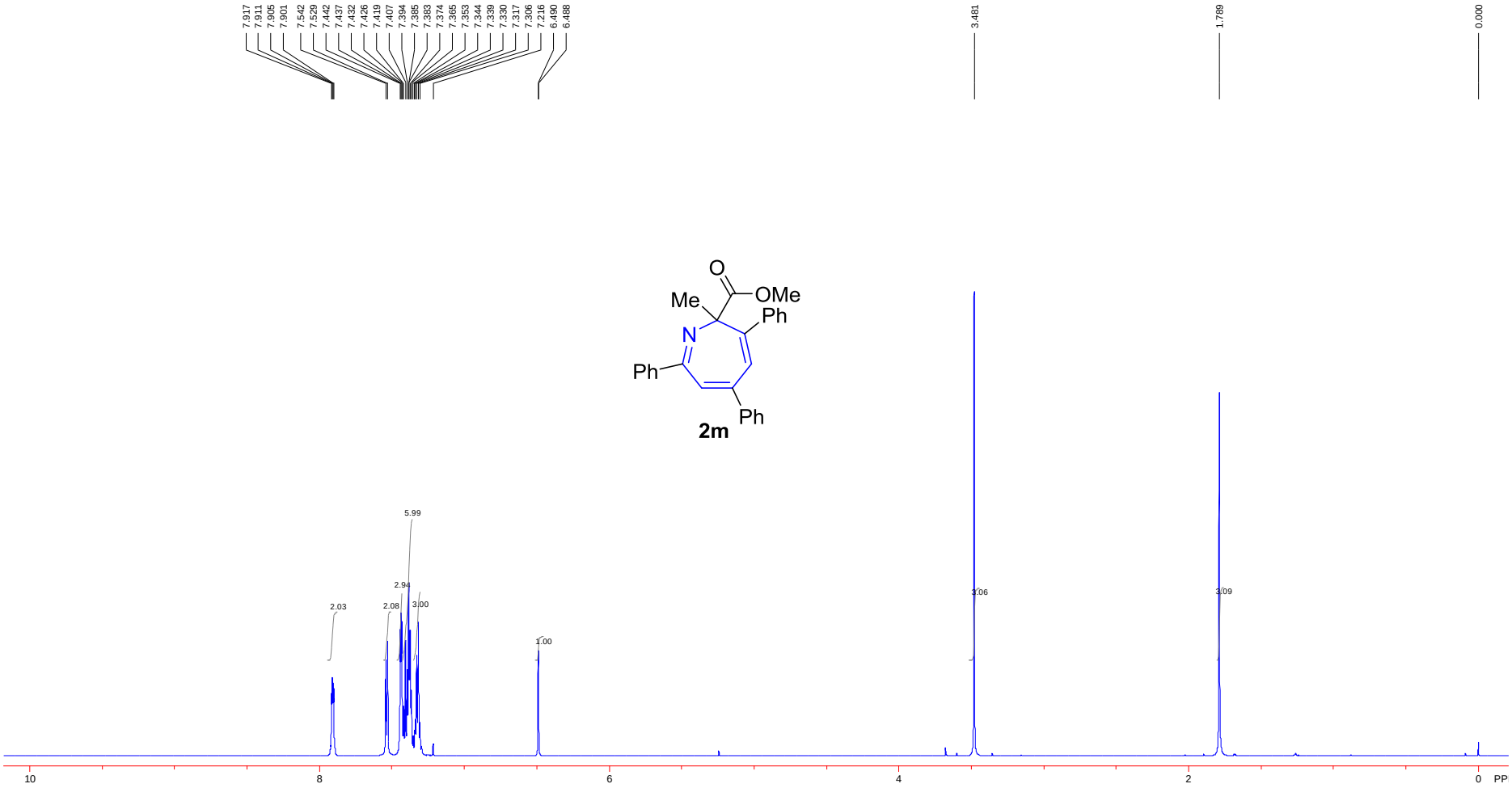
^{1}H NMR(600 MHz, $CDCl_3$)



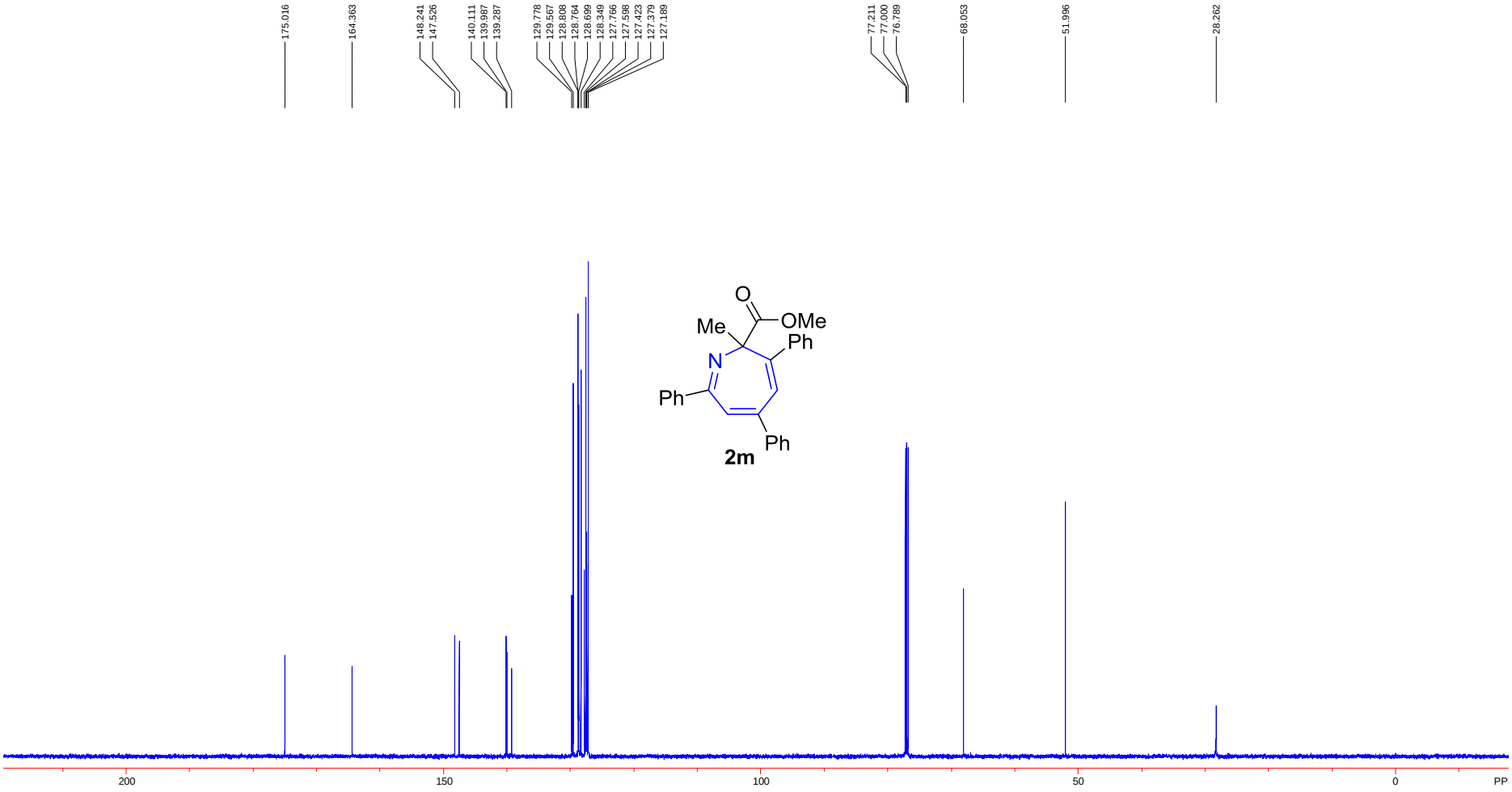
^{13}C NMR(150 MHz, $CDCl_3$)



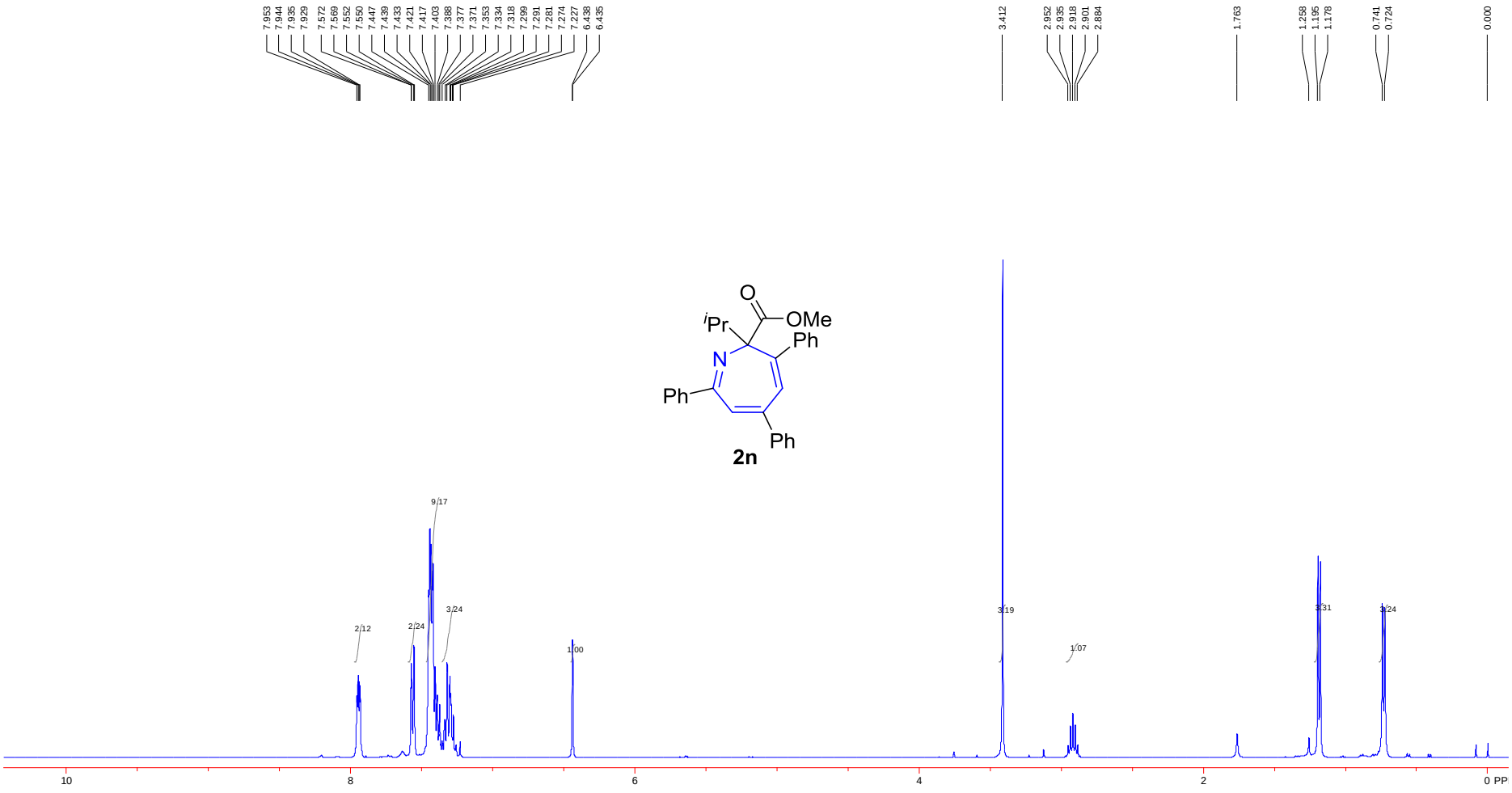
^{1}H NMR(600 MHz, $CDCl_3$)



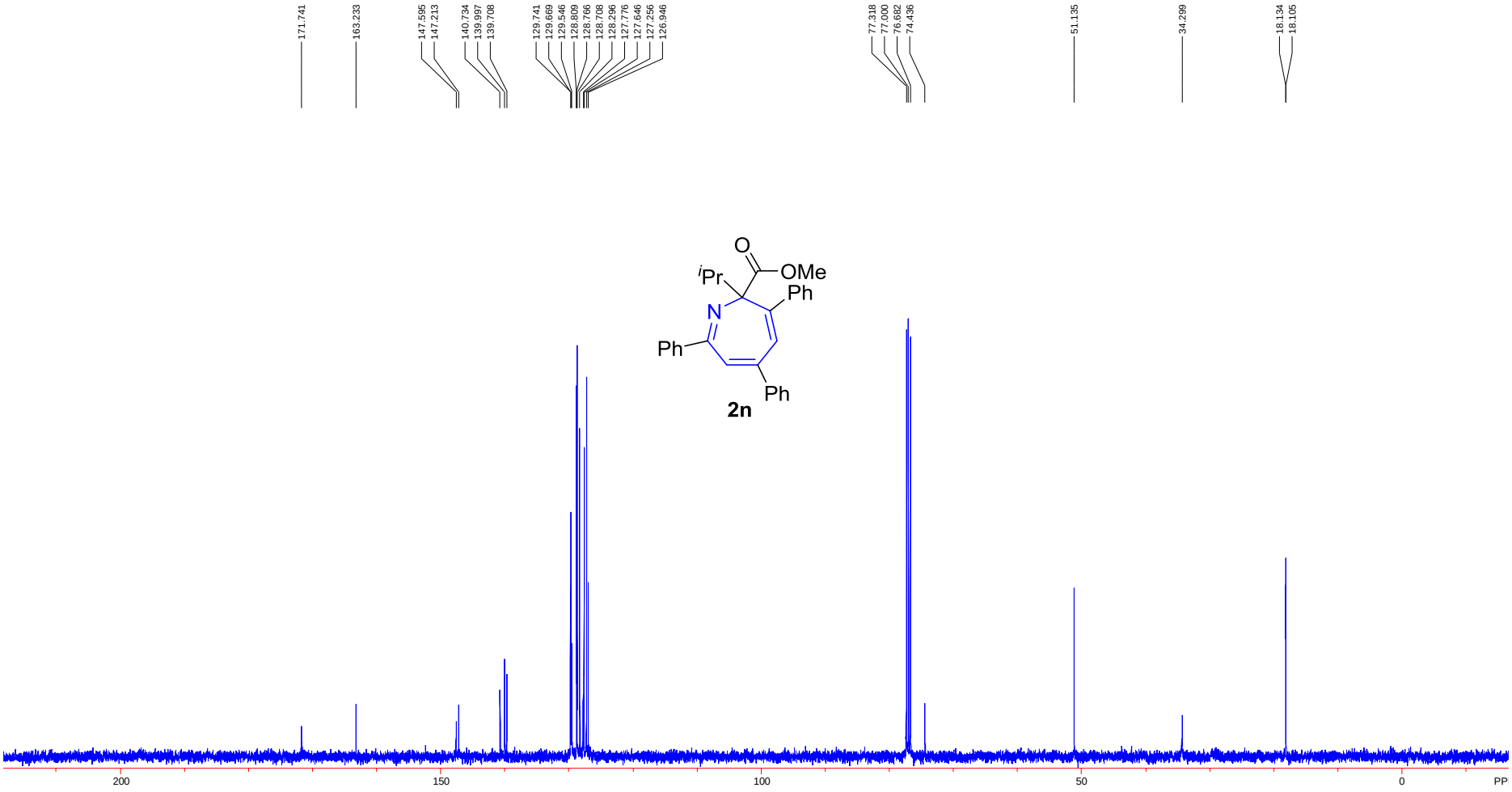
^{13}C NMR(150 MHz, $CDCl_3$)



^{1}H NMR(400 MHz, $CDCl_3$)



^{13}C NMR(100 MHz, $CDCl_3$)



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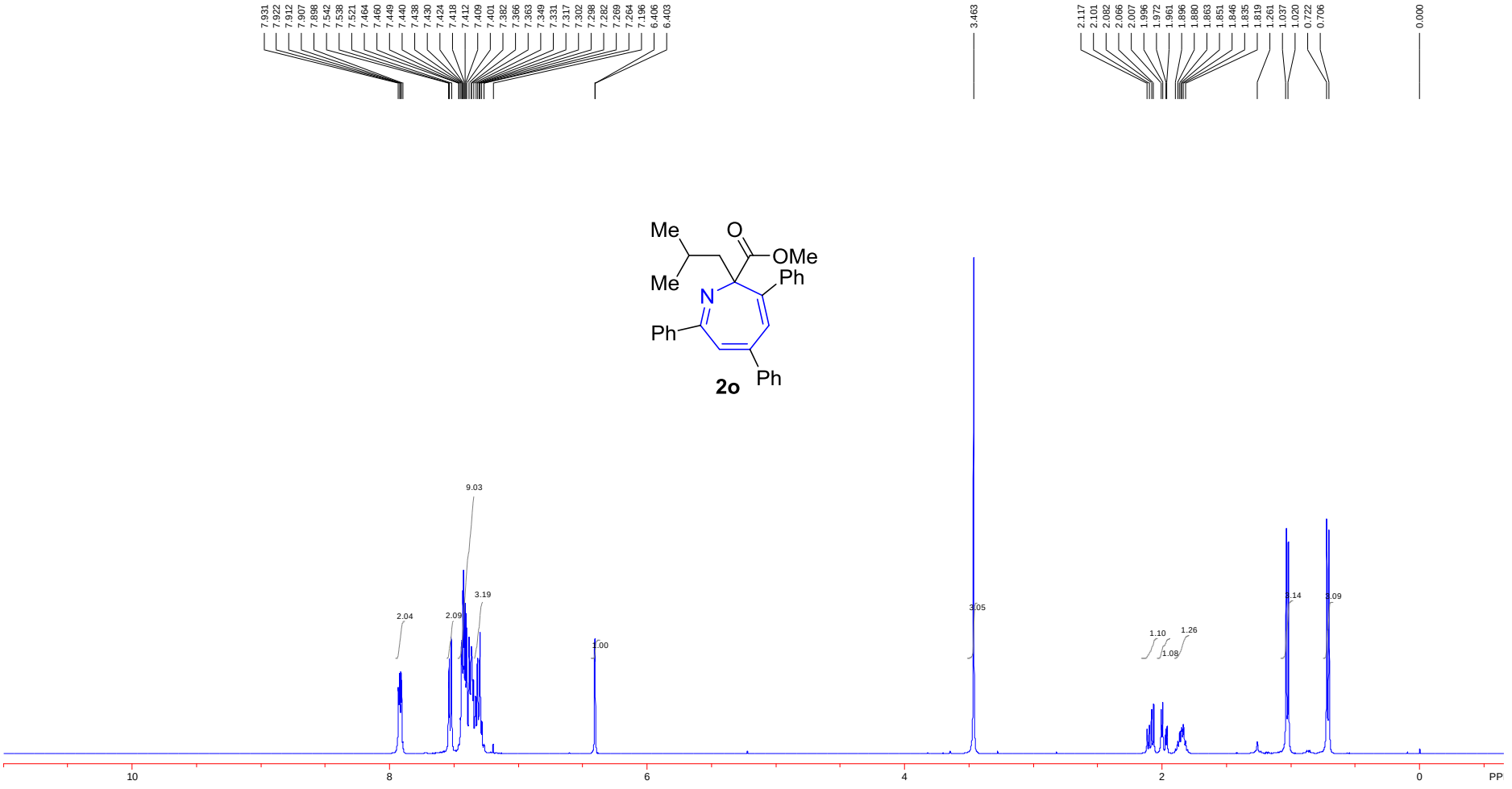
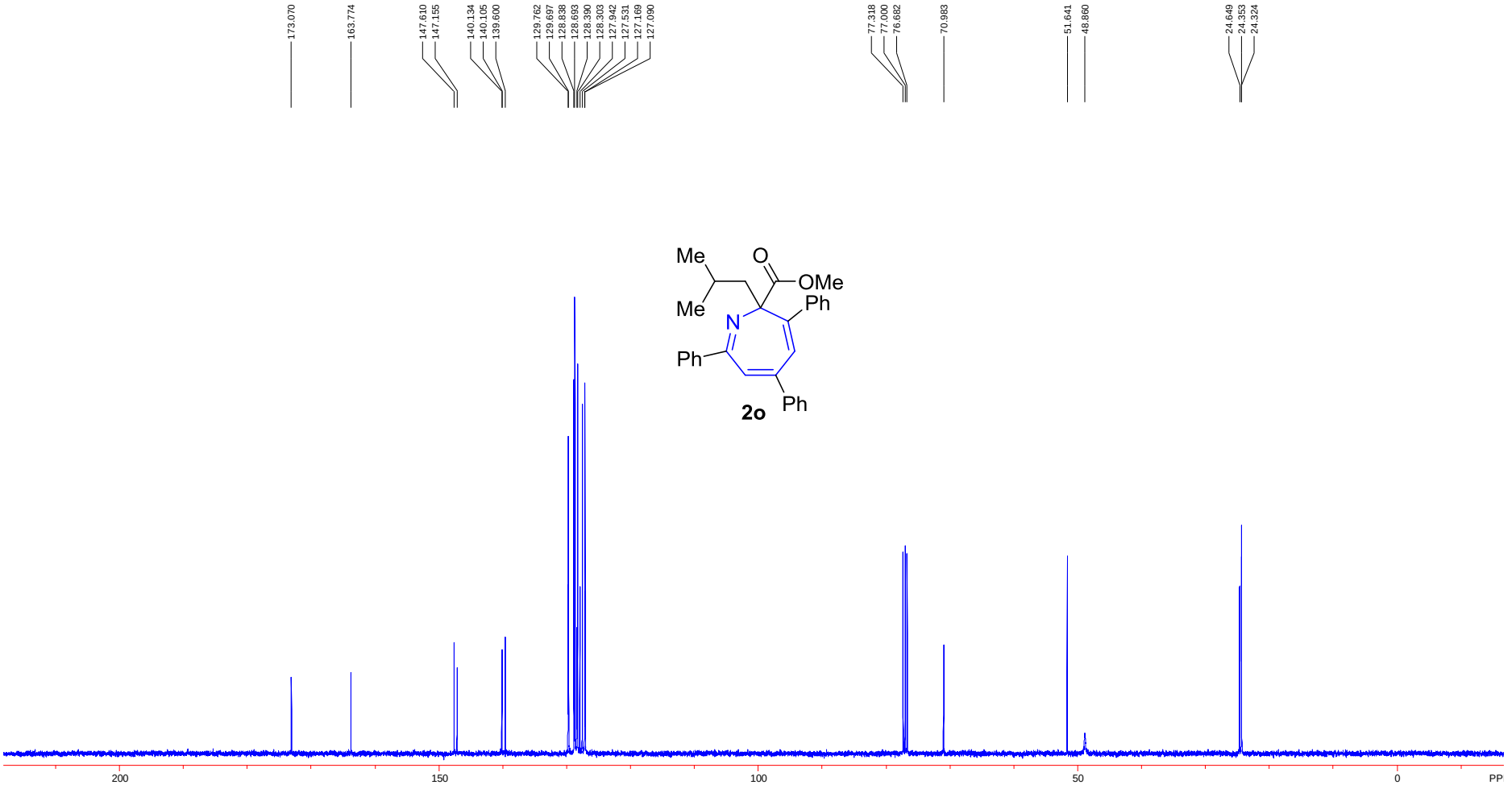
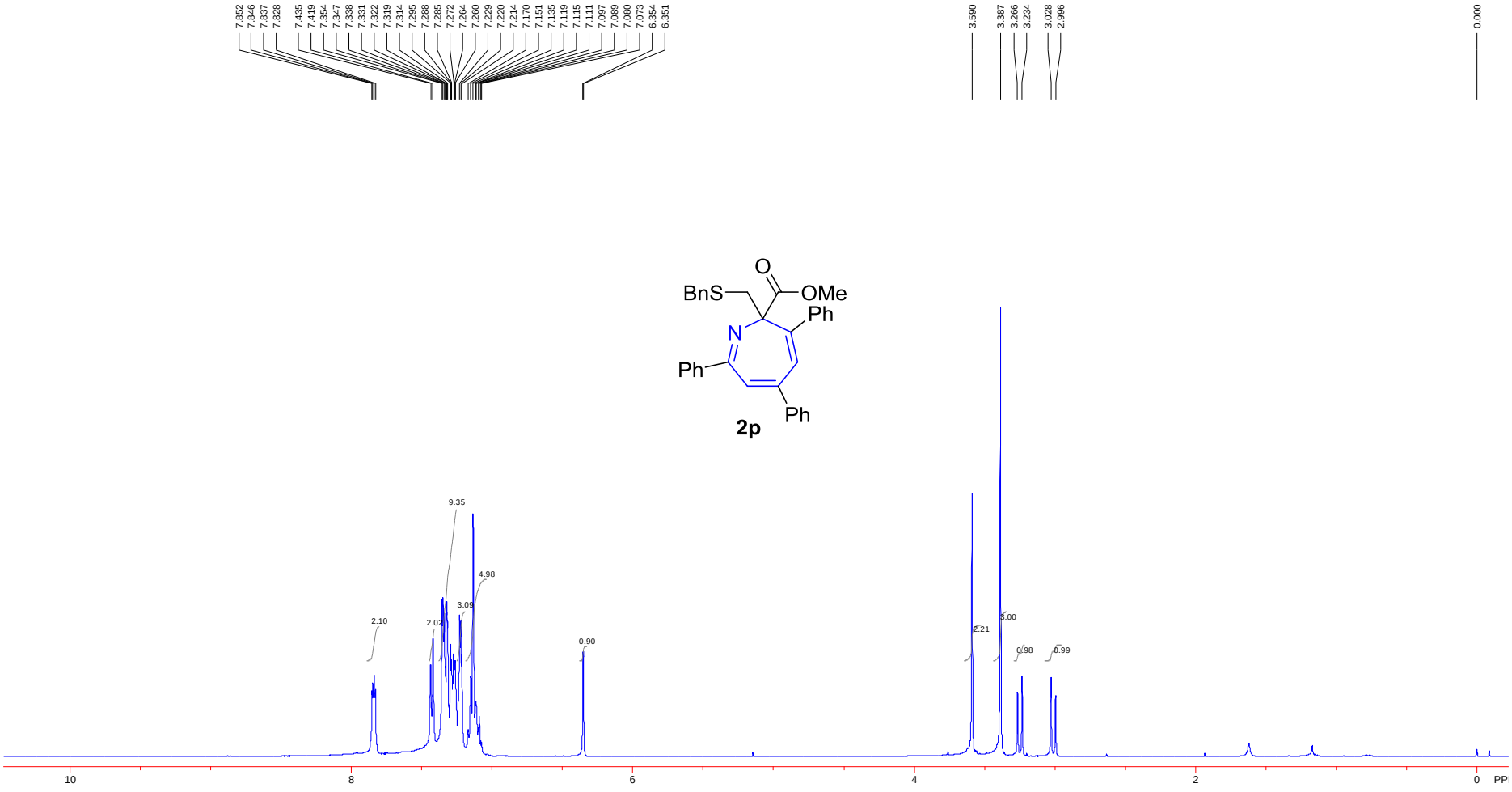


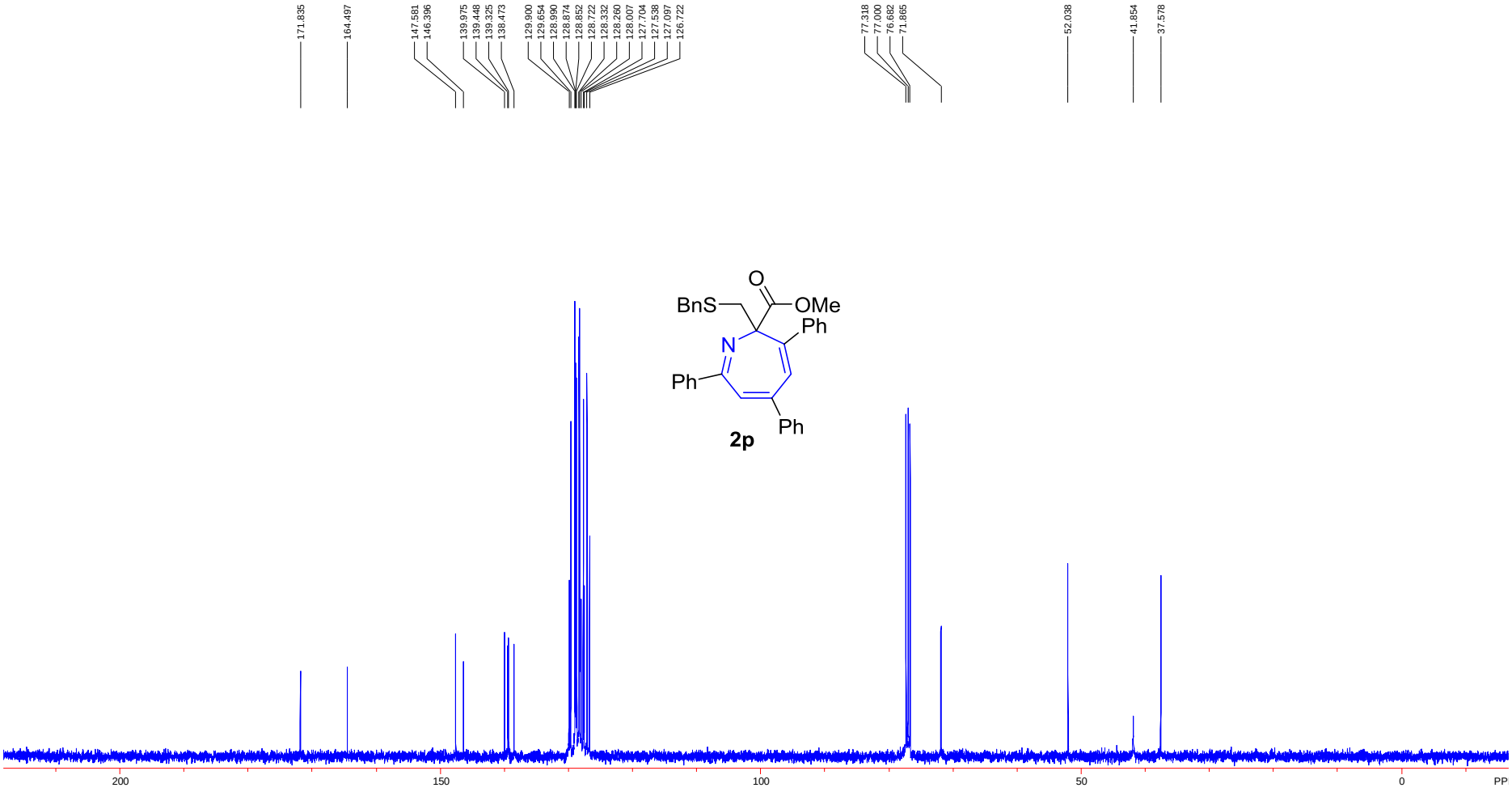
^{13}C NMR(100 MHz, $CDCl_3$)



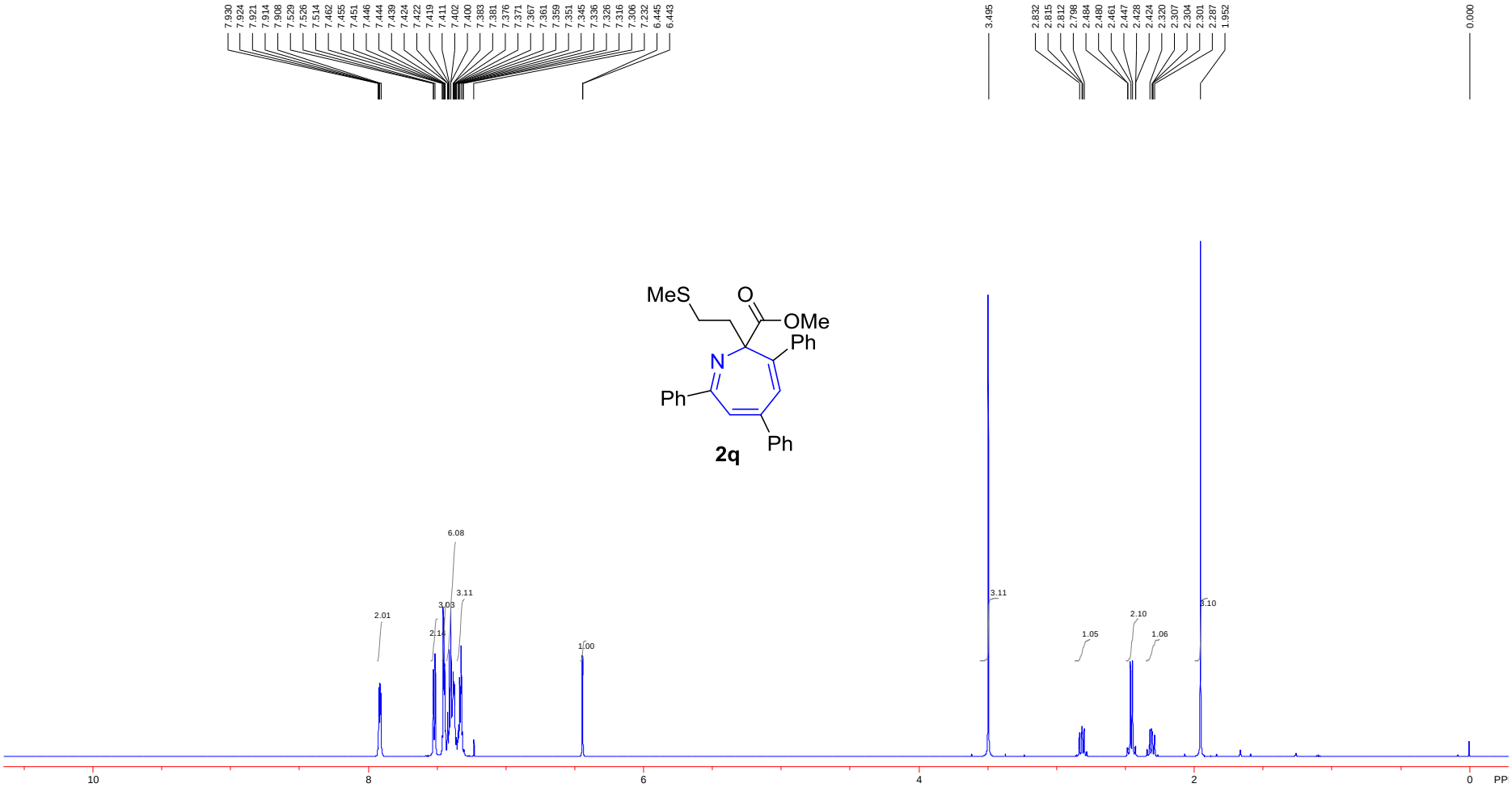
^{1}H NMR(400 MHz, $CDCl_3$)



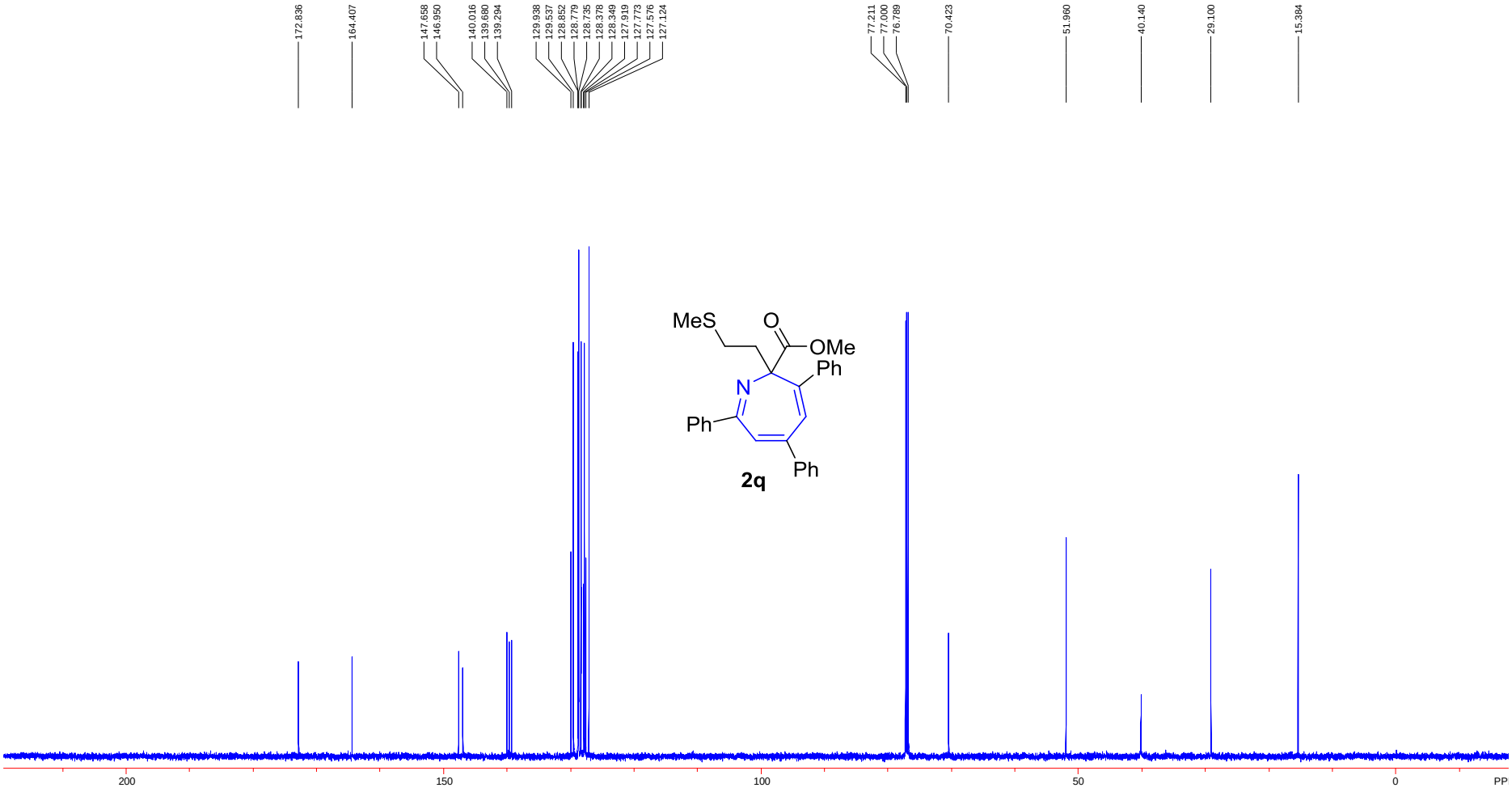
^{13}C NMR(100 MHz, $CDCl_3$)



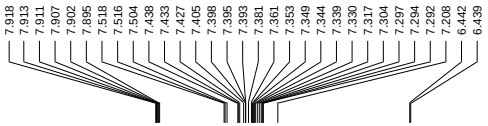
^{1}H NMR(600 MHz, $CDCl_3$)

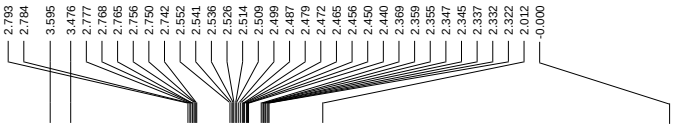


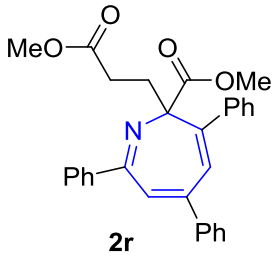
^{13}C NMR(150 MHz, $CDCl_3$)



^{1}H NMR(600 MHz, $CDCl_3$)

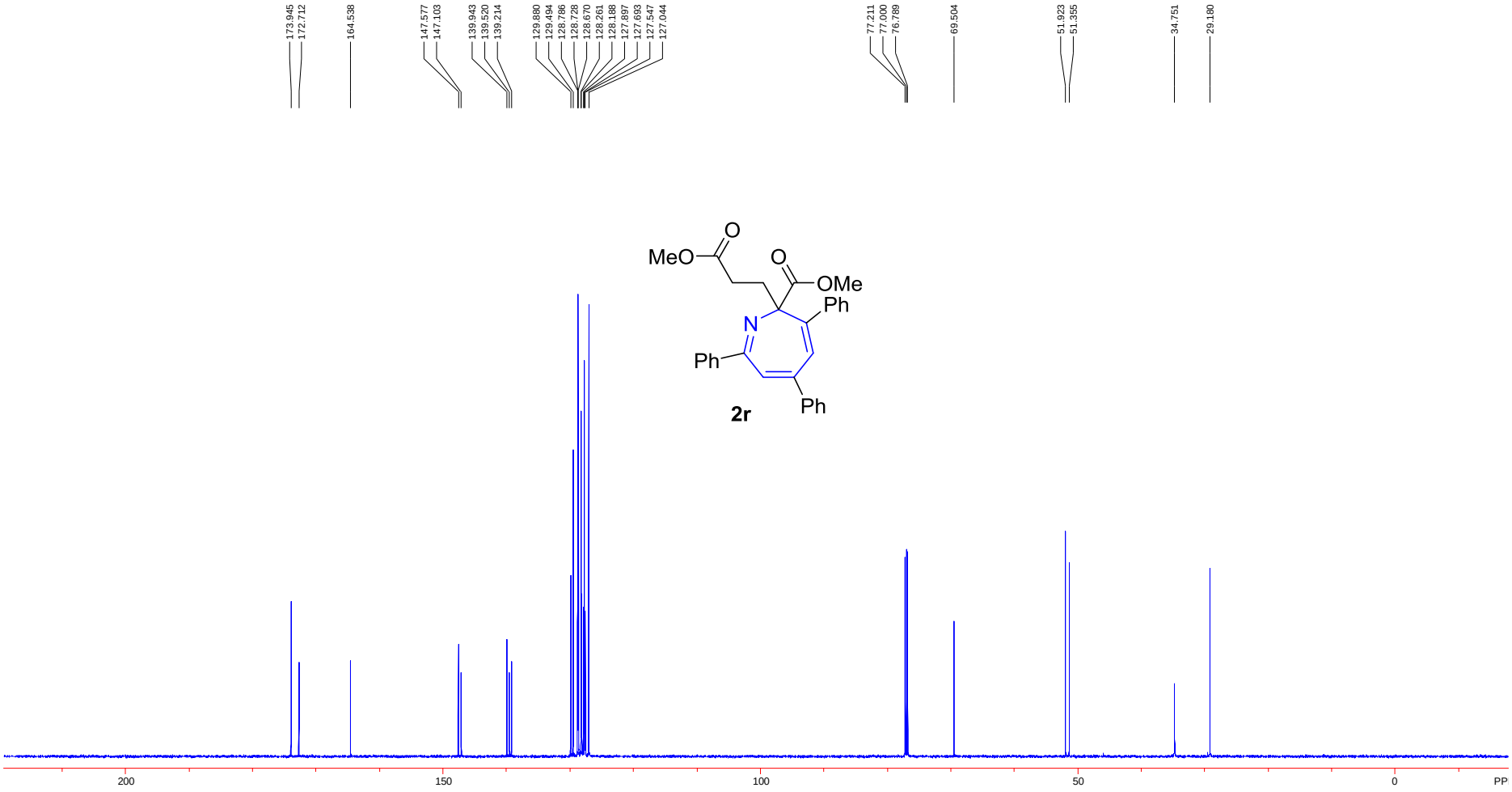




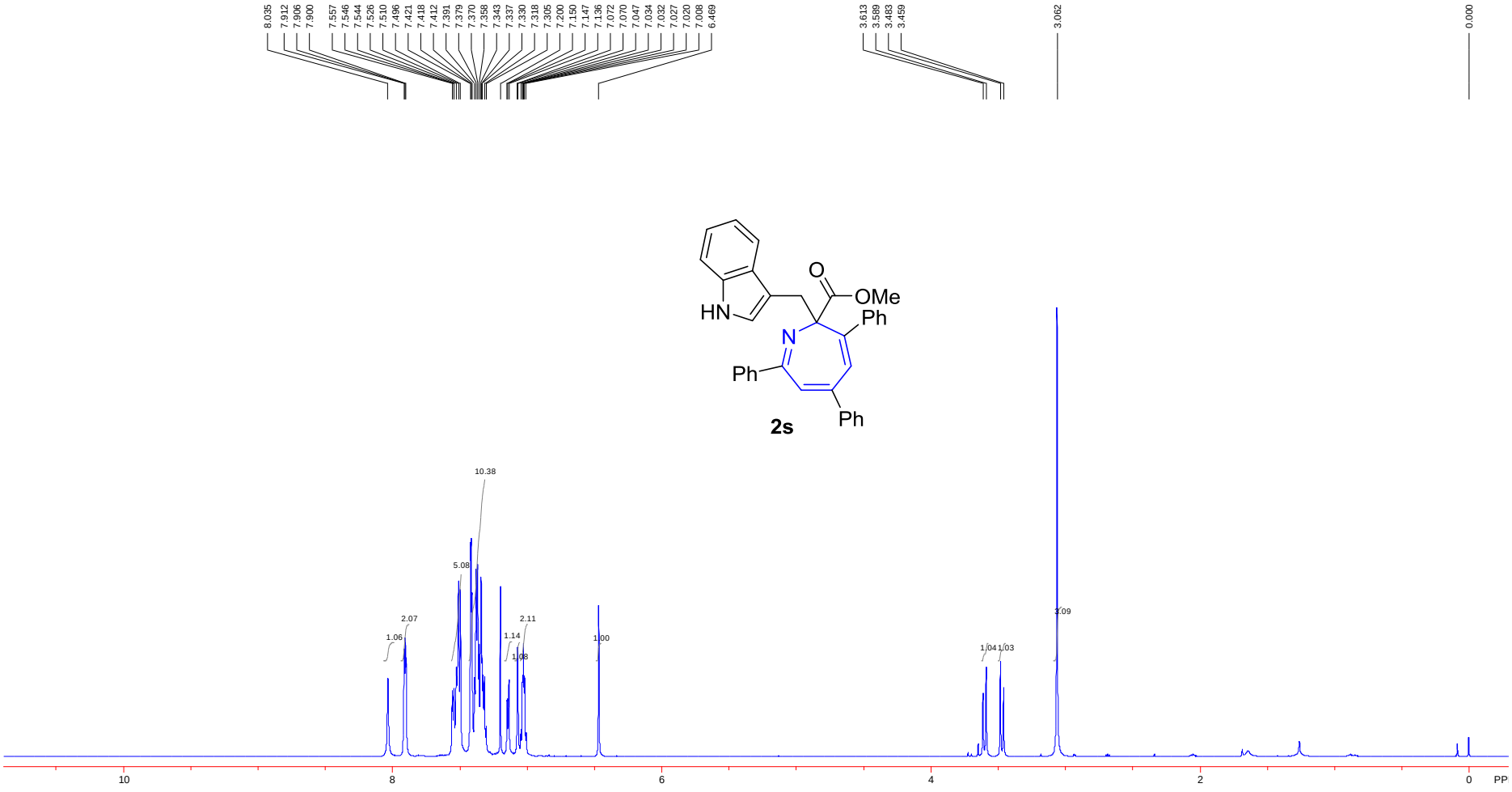


2r

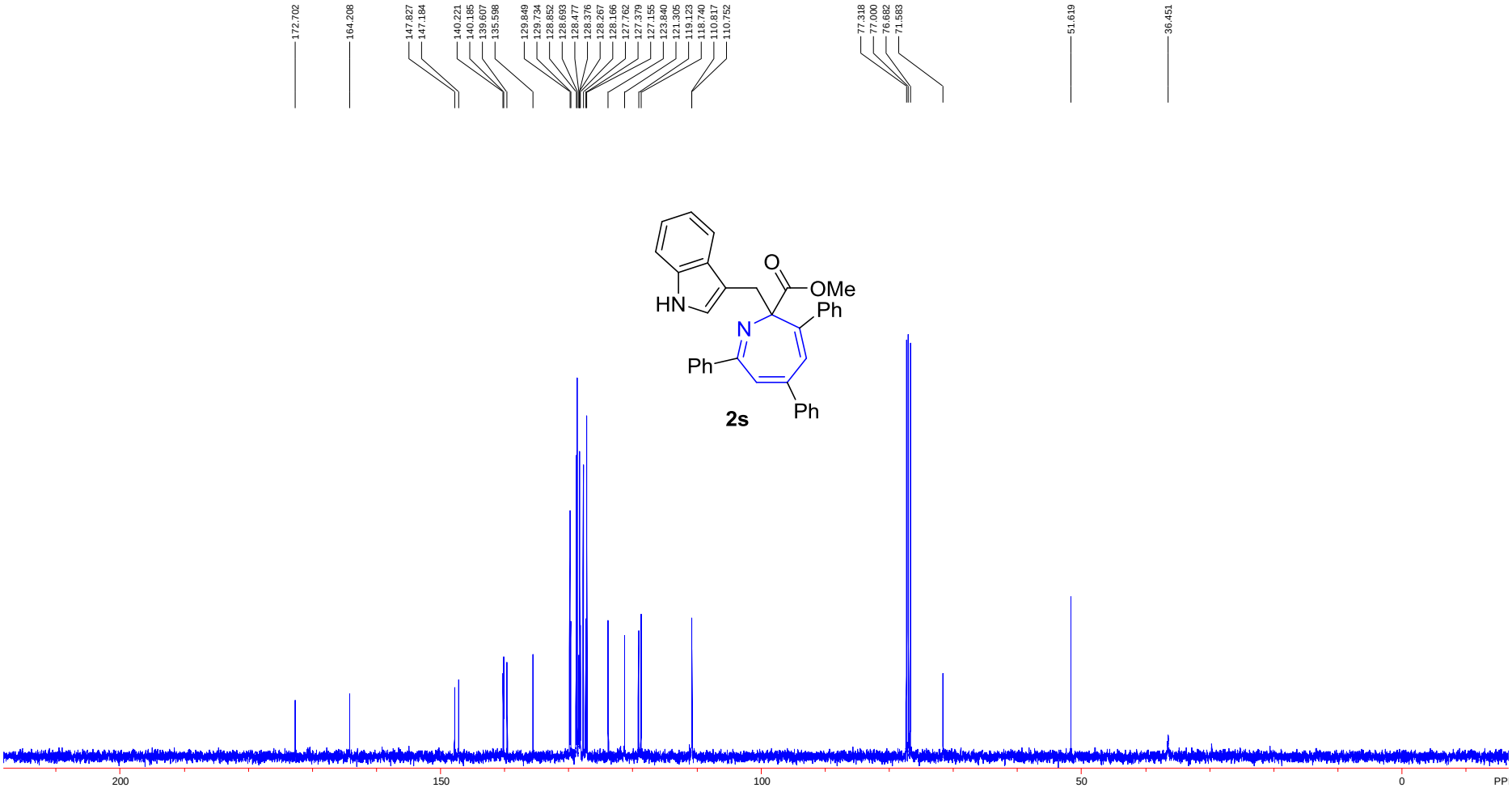
^{13}C NMR(150 MHz, $CDCl_3$)



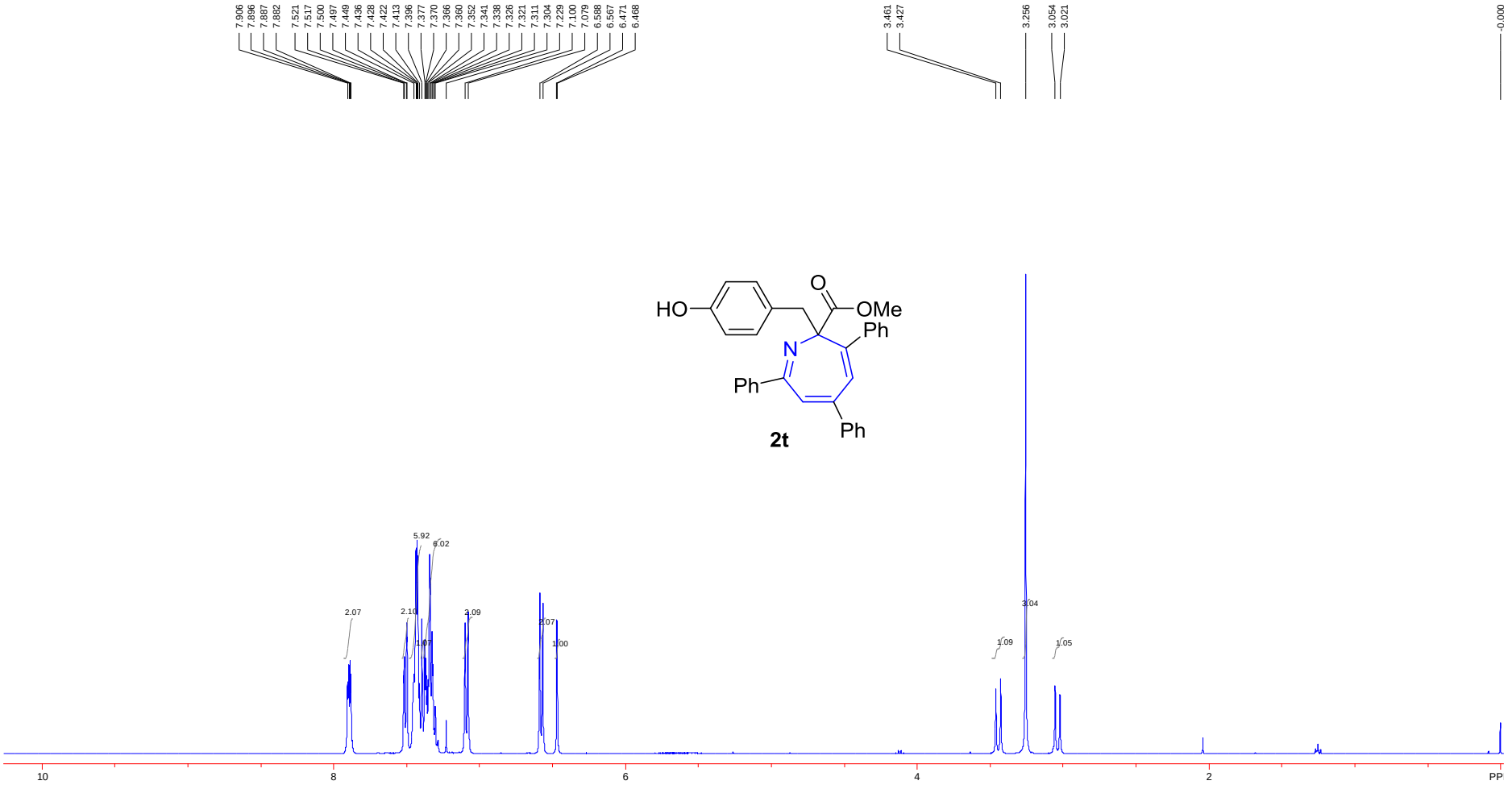
^{1}H NMR(600 MHz, $CDCl_3$)



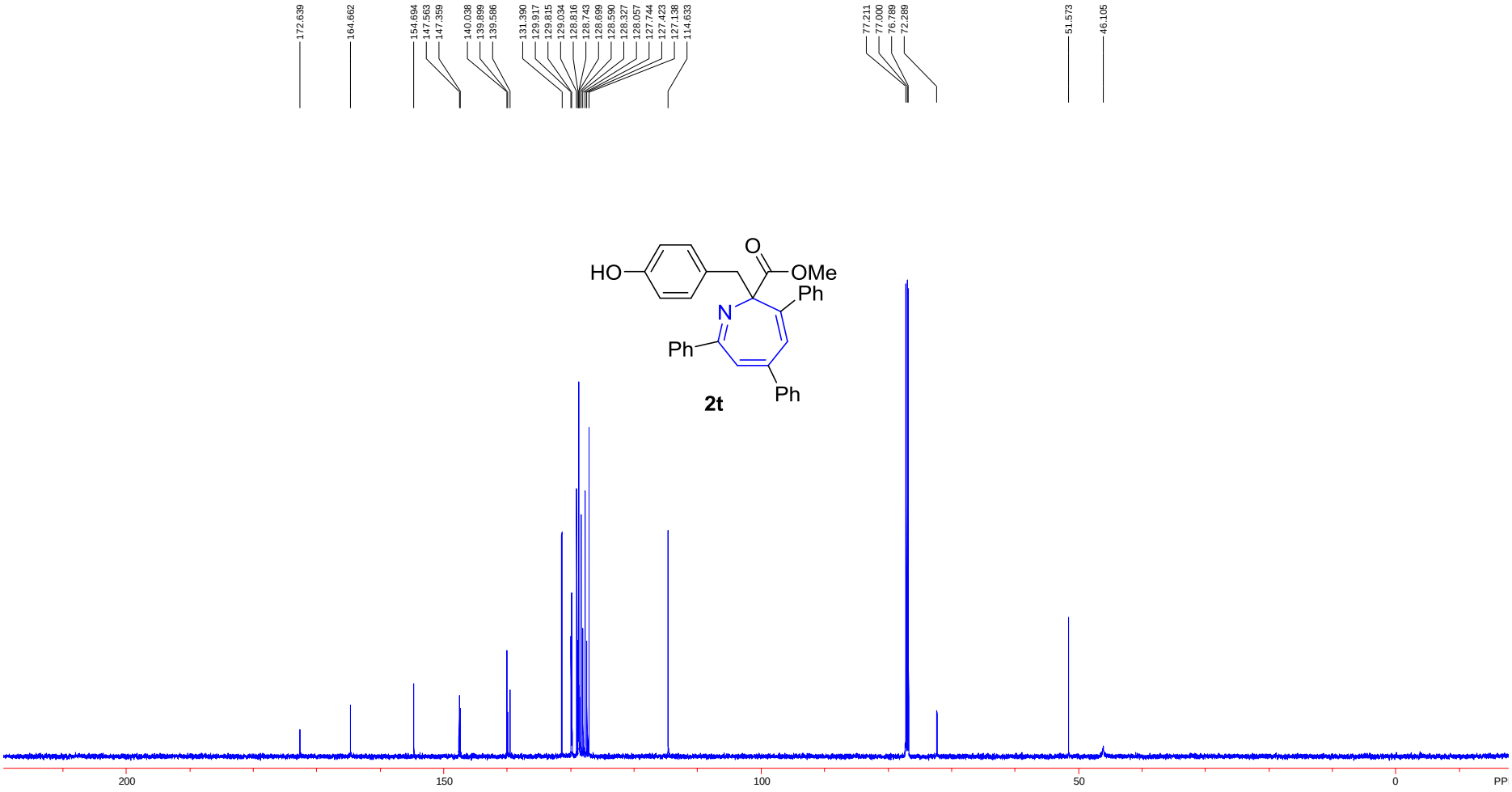
^{13}C NMR(100 MHz, $CDCl_3$)



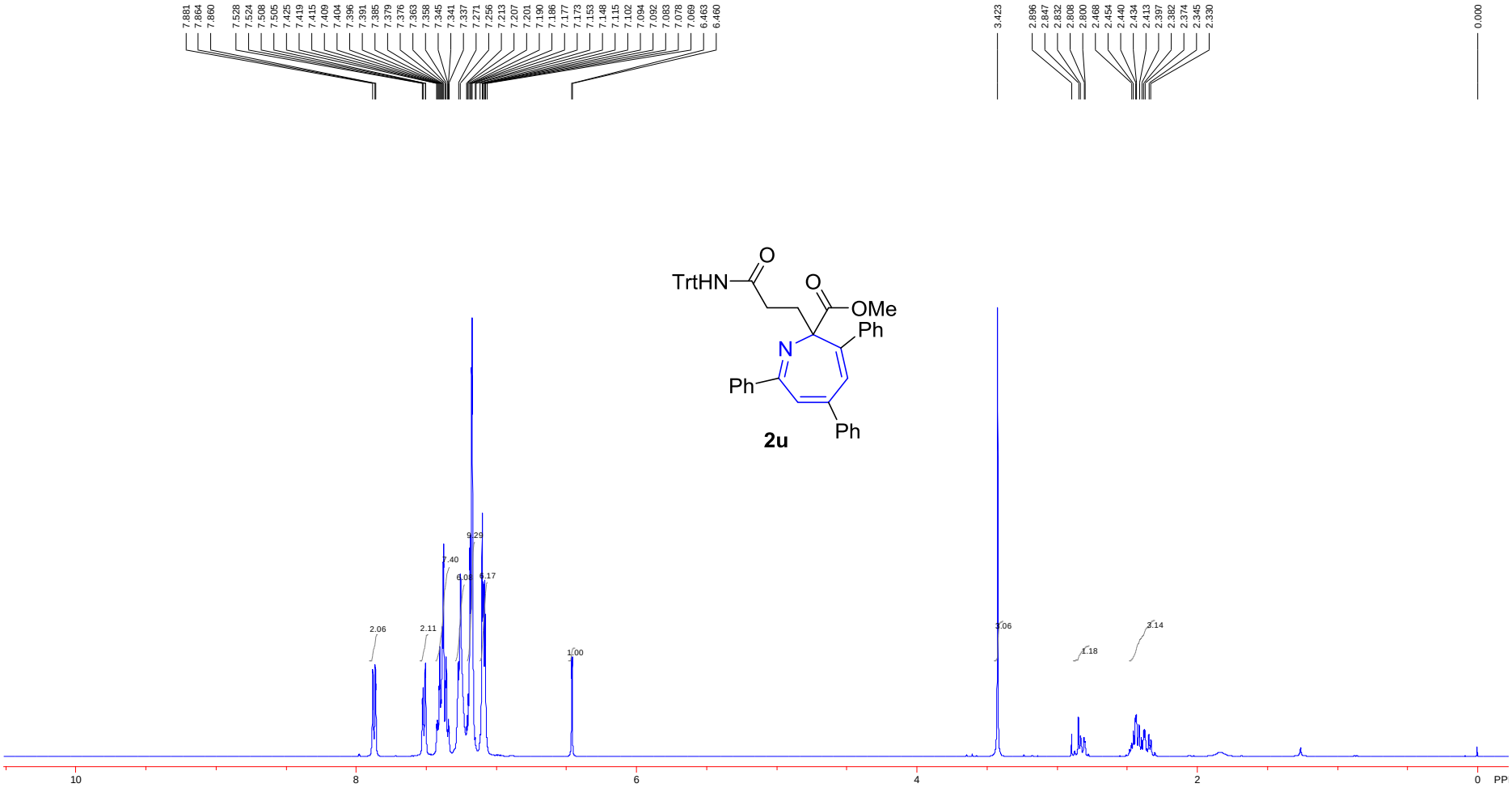
^{1}H NMR(600 MHz, $CDCl_3$)



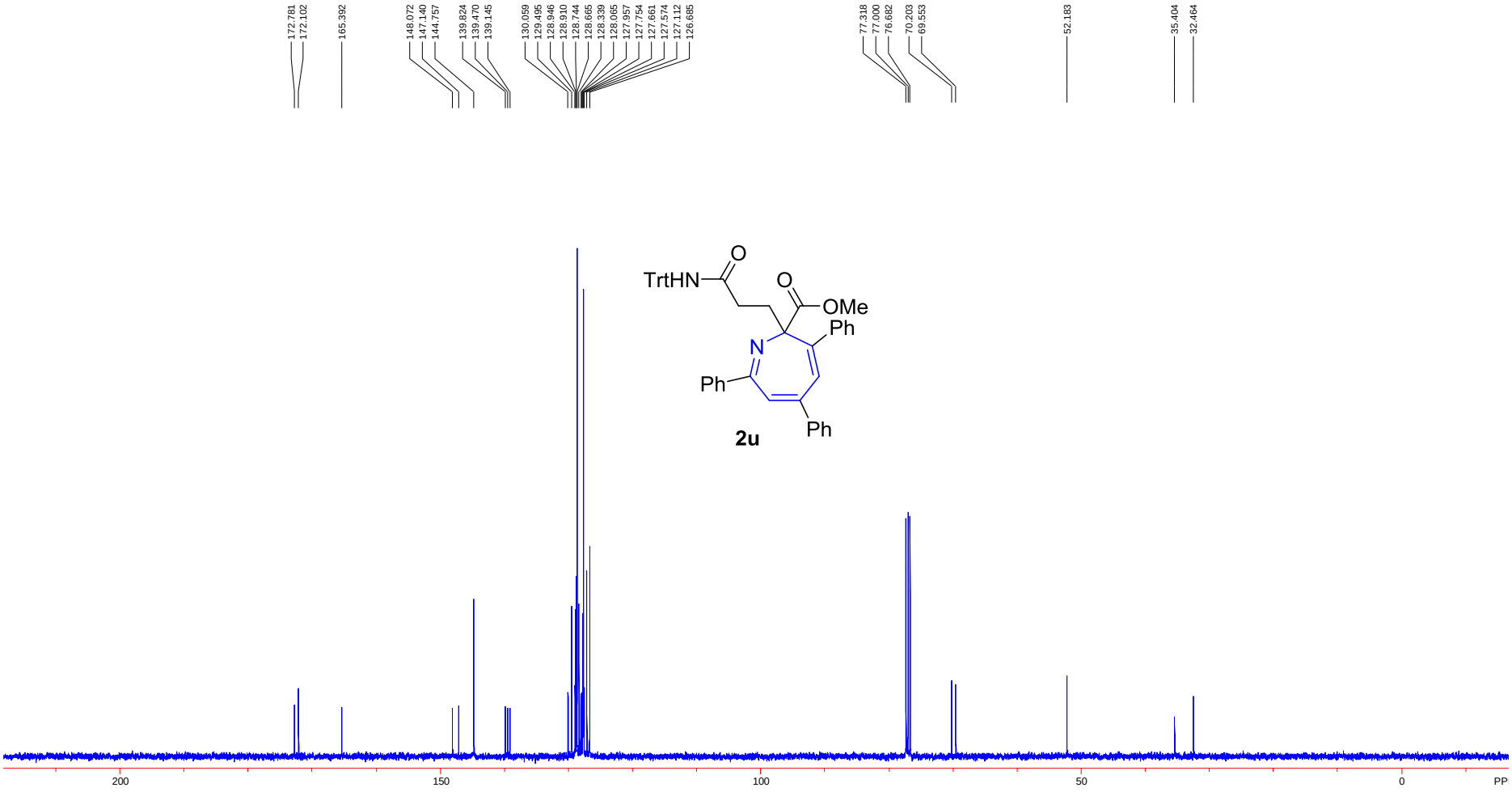
^{13}C NMR(150 MHz, $CDCl_3$)



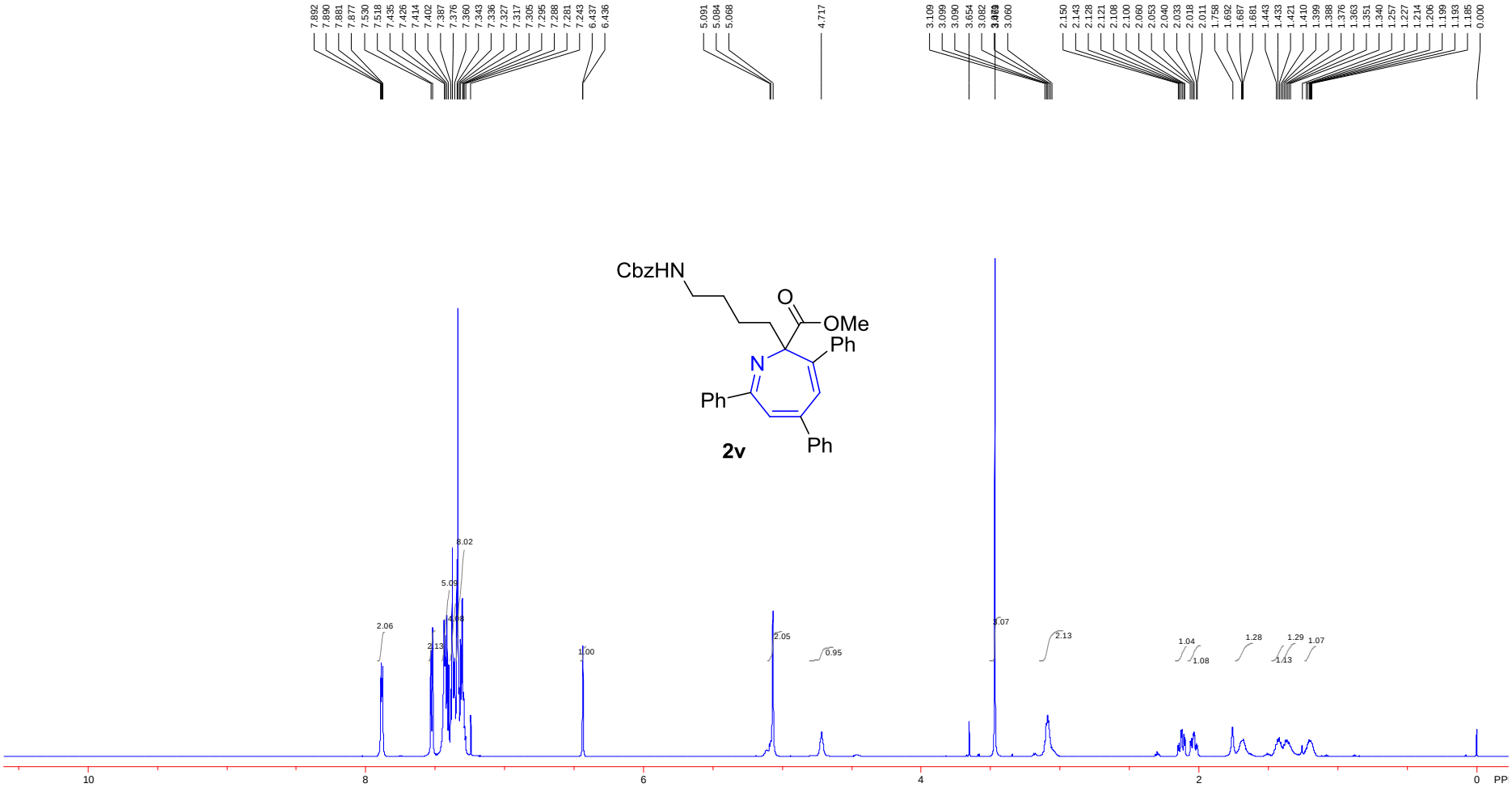
^{1}H NMR(400 MHz, $CDCl_3$)



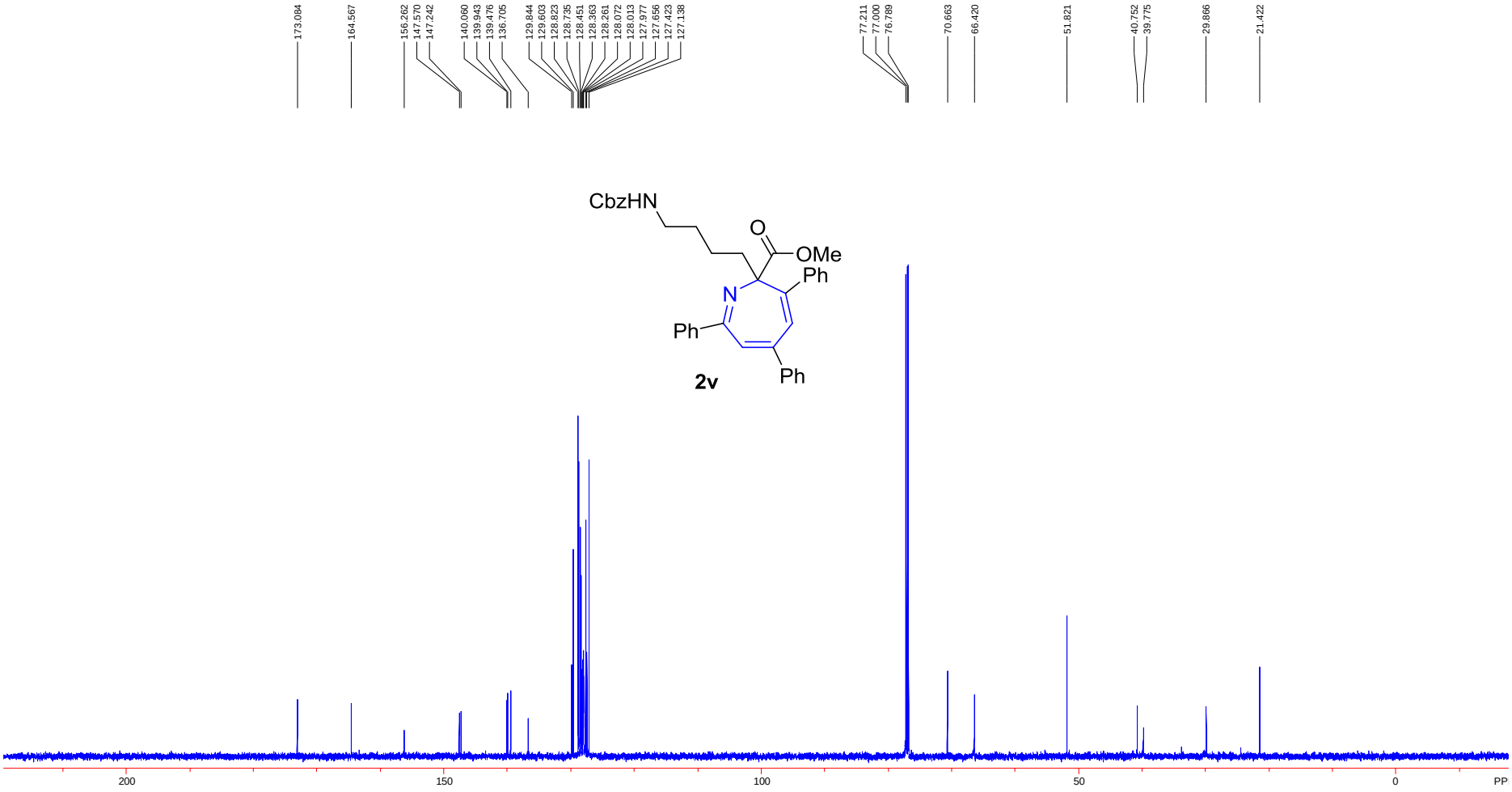
^{13}C NMR(100 MHz, $CDCl_3$)



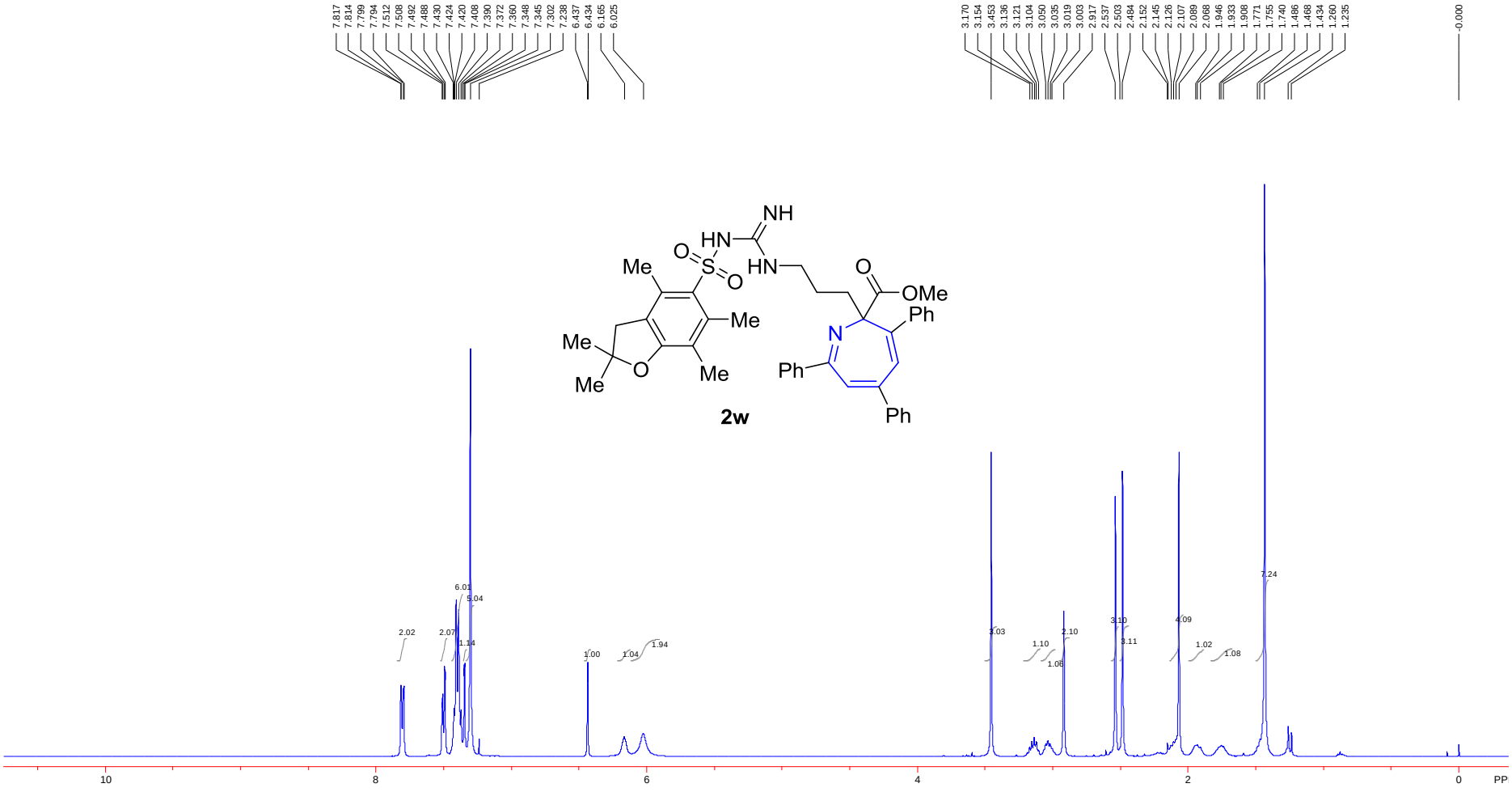
^{1}H NMR(600 MHz, $CDCl_3$)



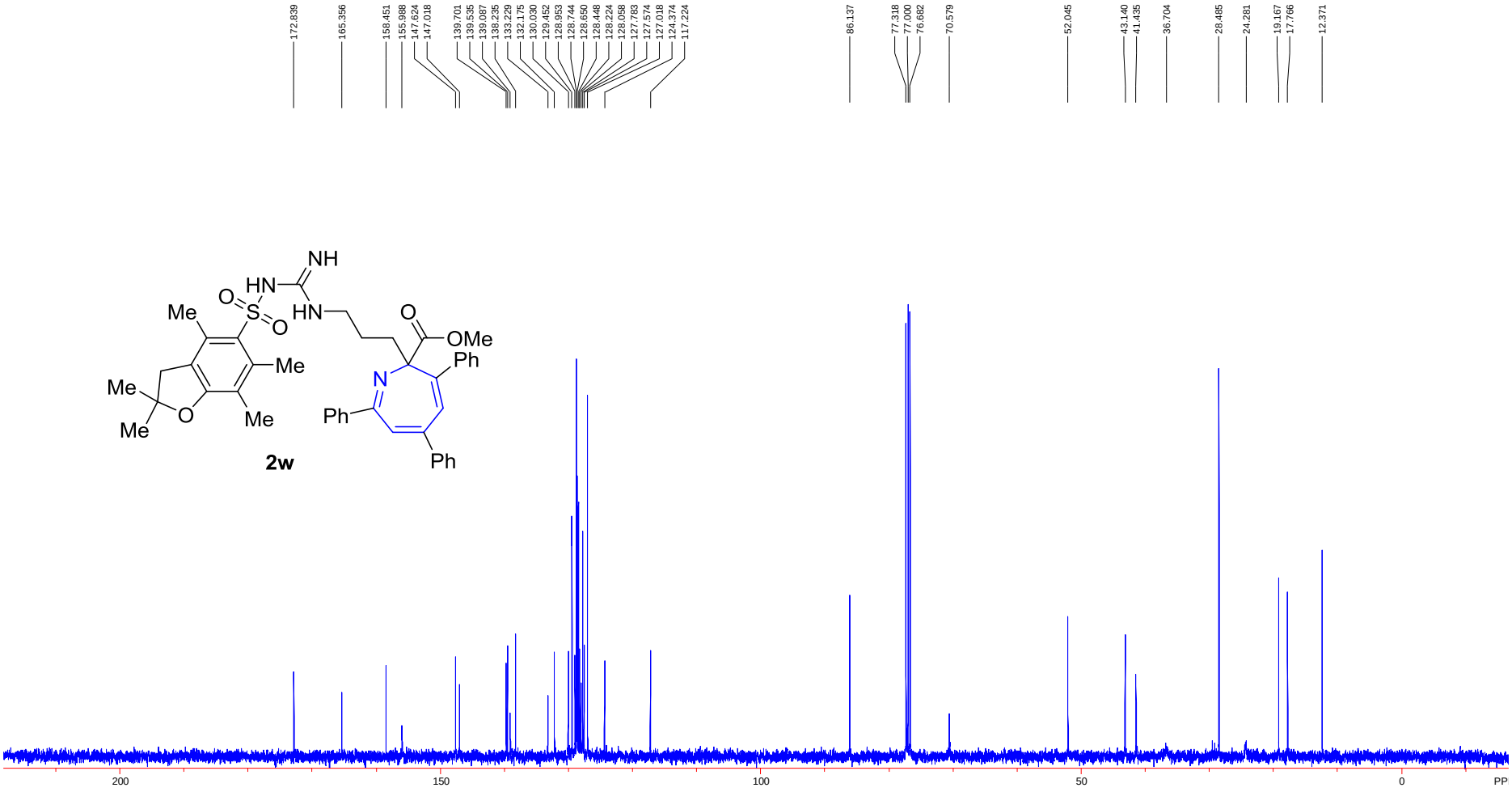
^{13}C NMR(150 MHz, $CDCl_3$)



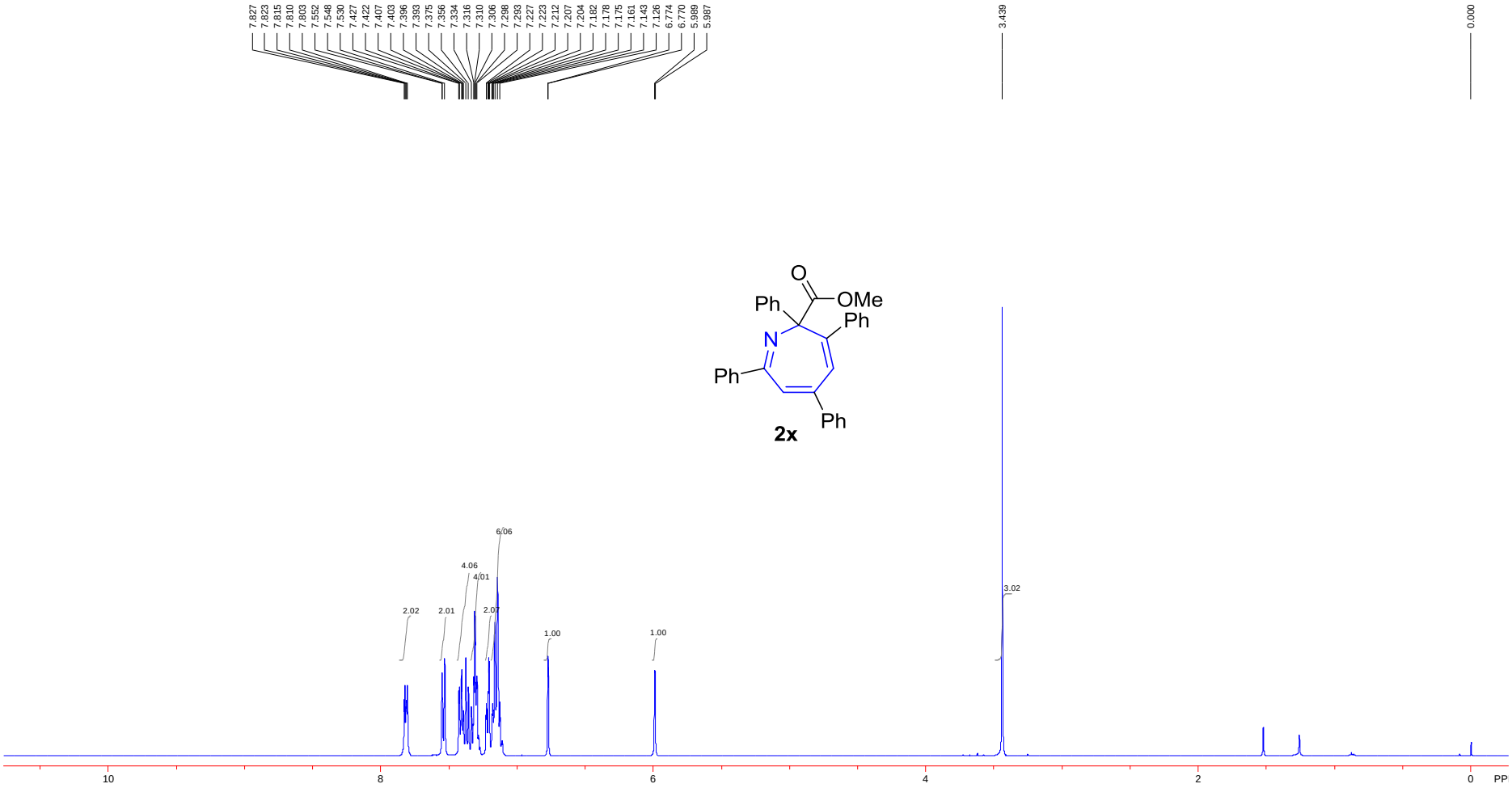
^{1}H NMR(400 MHz, $CDCl_3$)



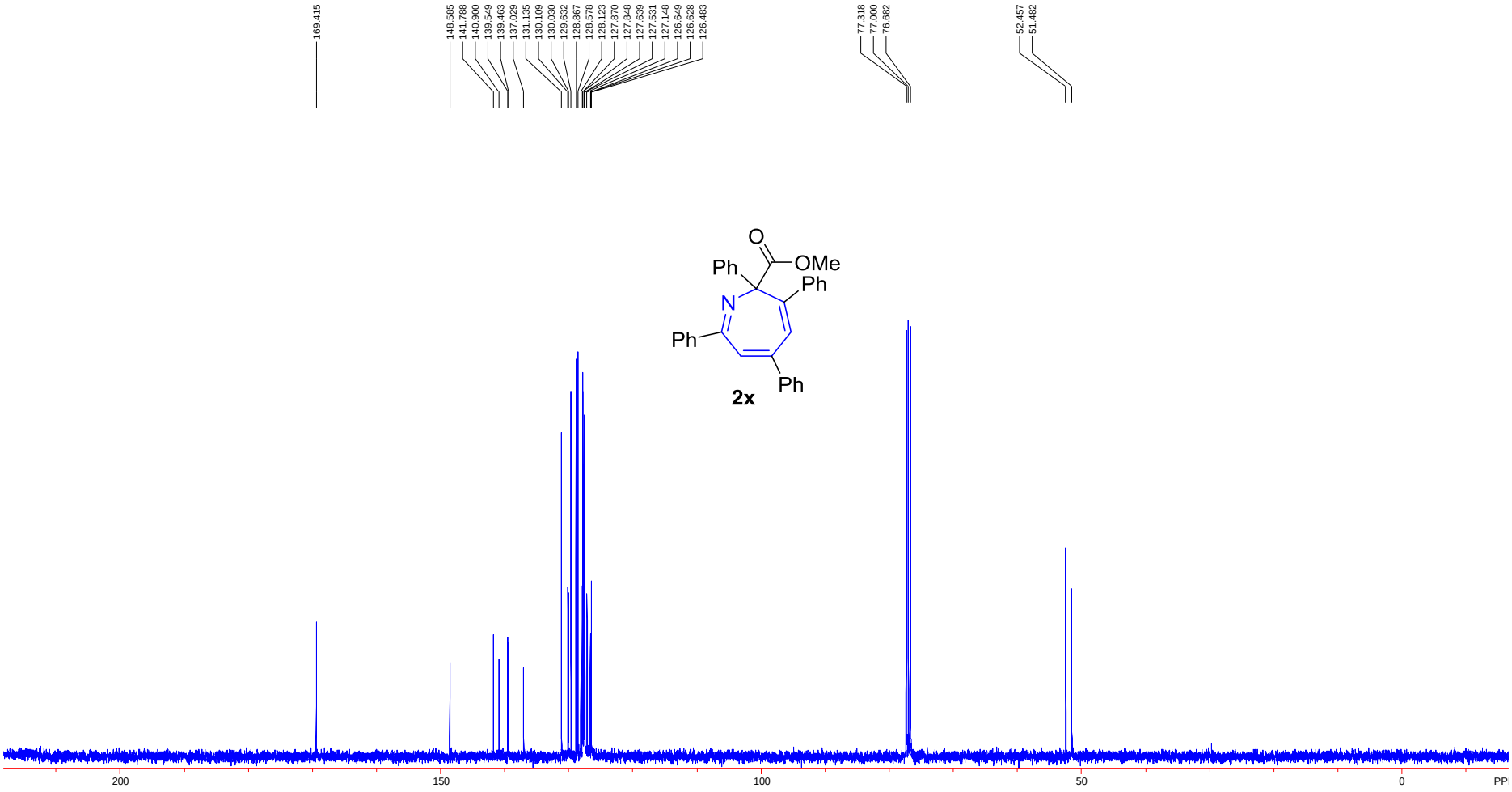
^{13}C NMR(100 MHz, $CDCl_3$)



^{1}H NMR(400 MHz, $CDCl_3$)



^{13}C NMR(100 MHz, $CDCl_3$)



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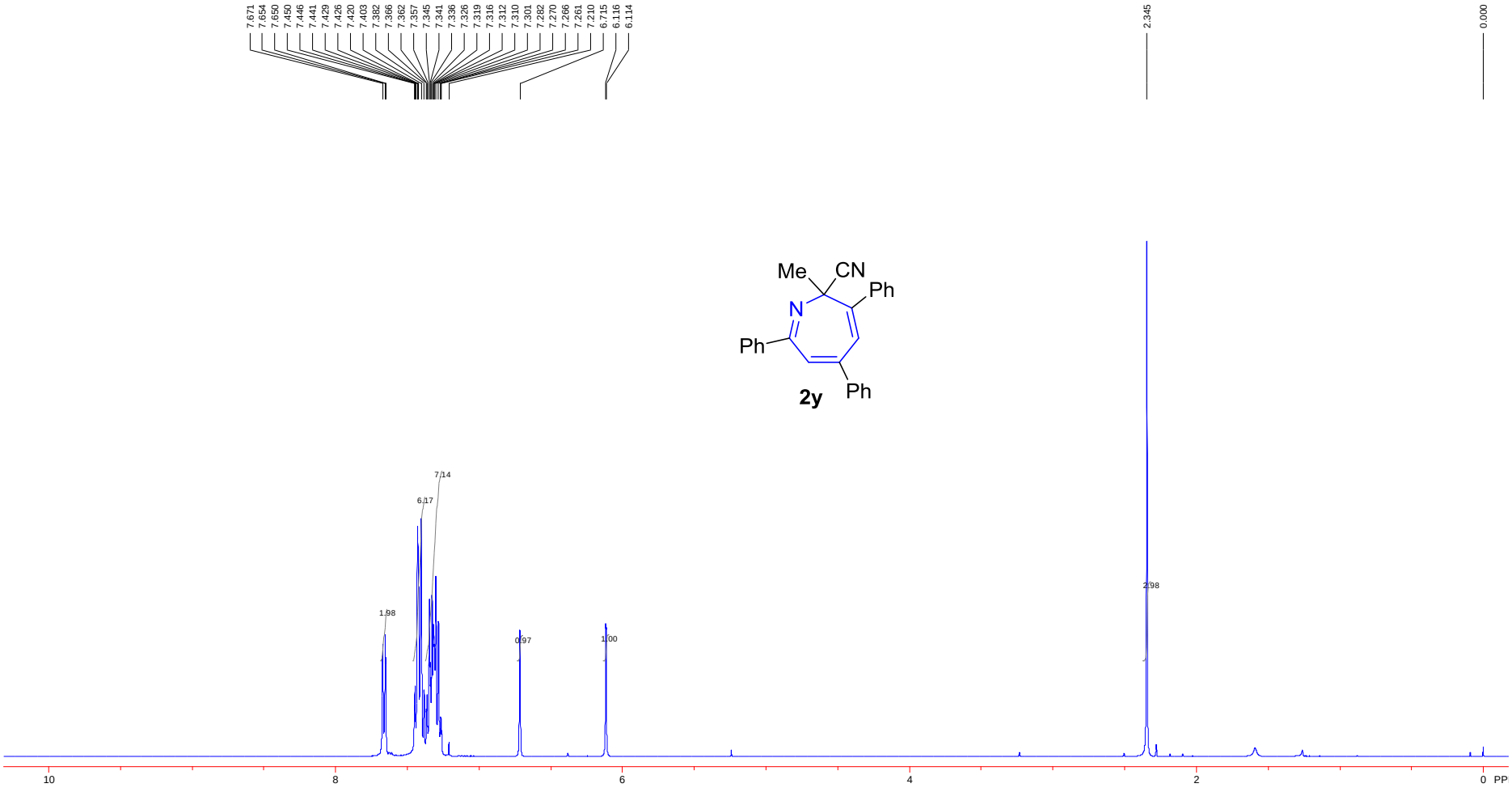
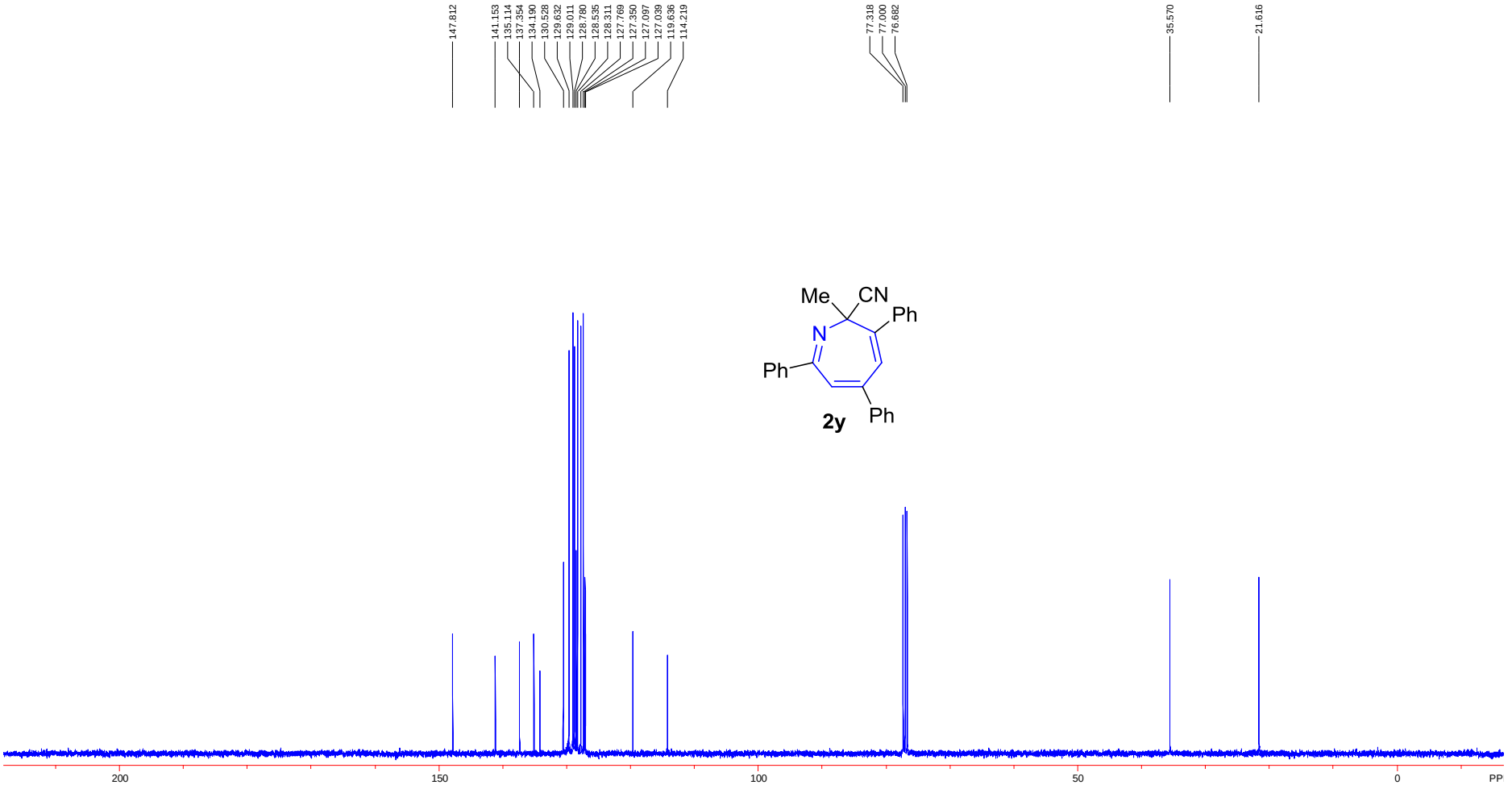
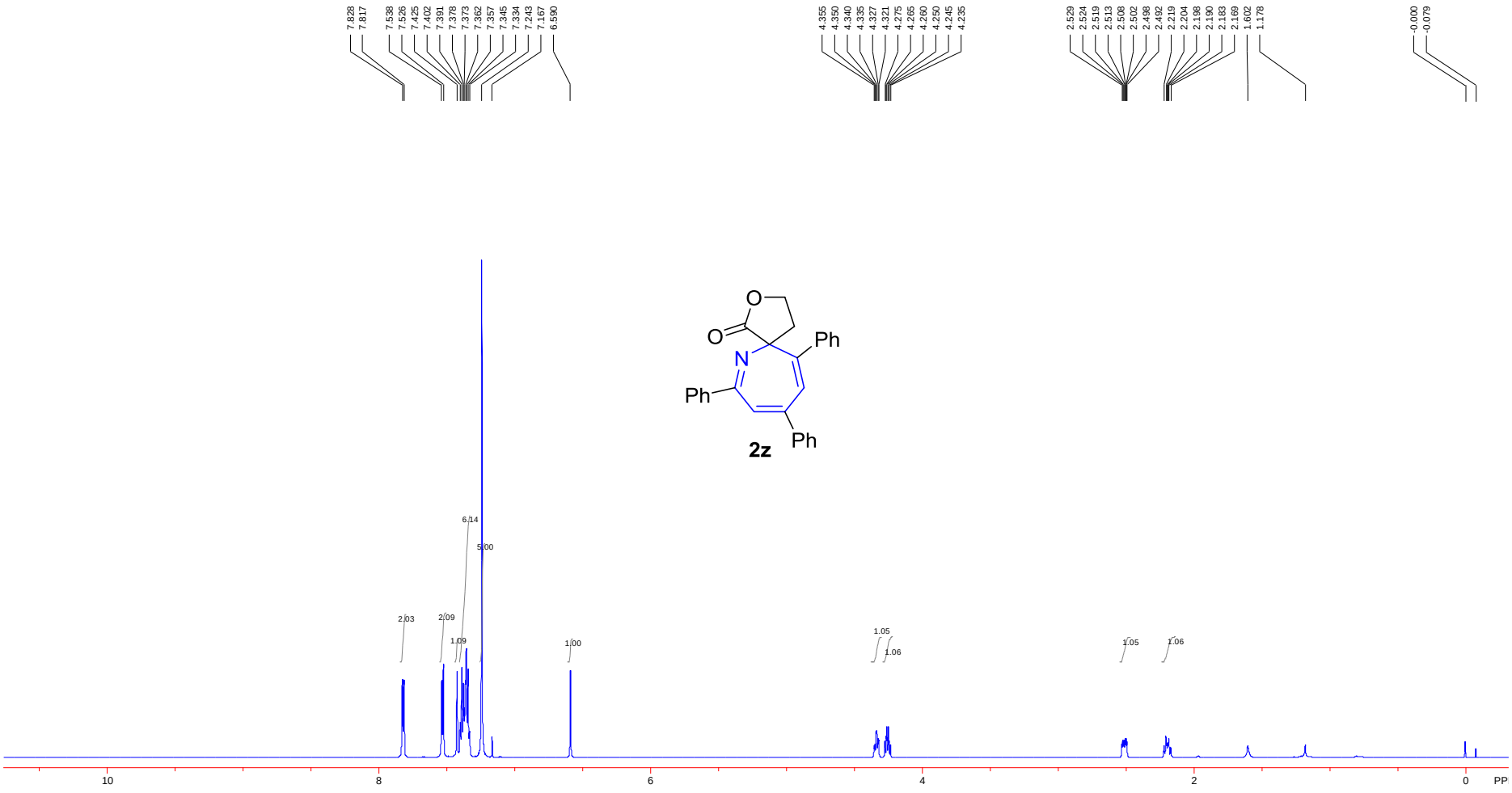


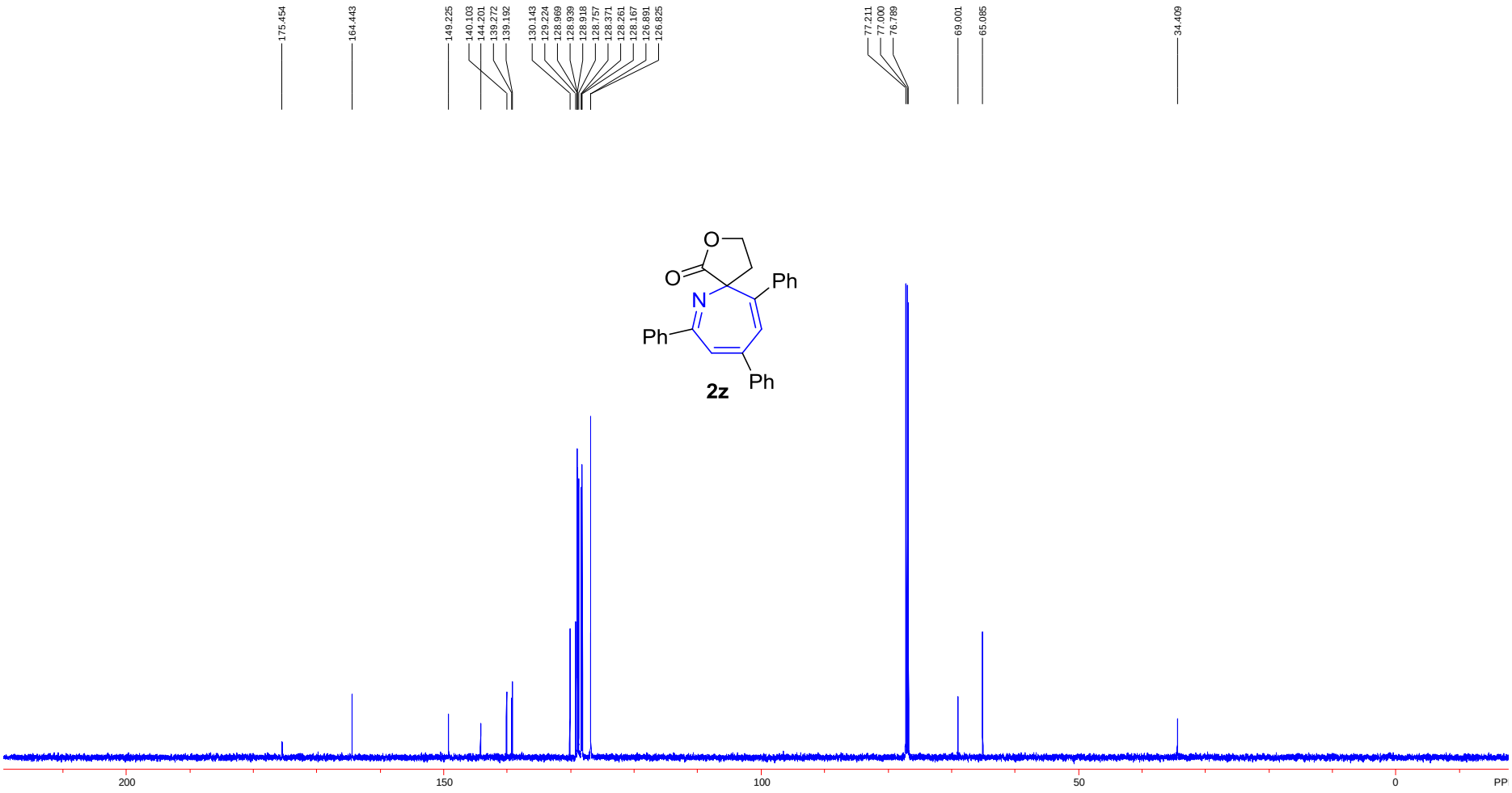
^{13}C NMR(100 MHz, $CDCl_3$)



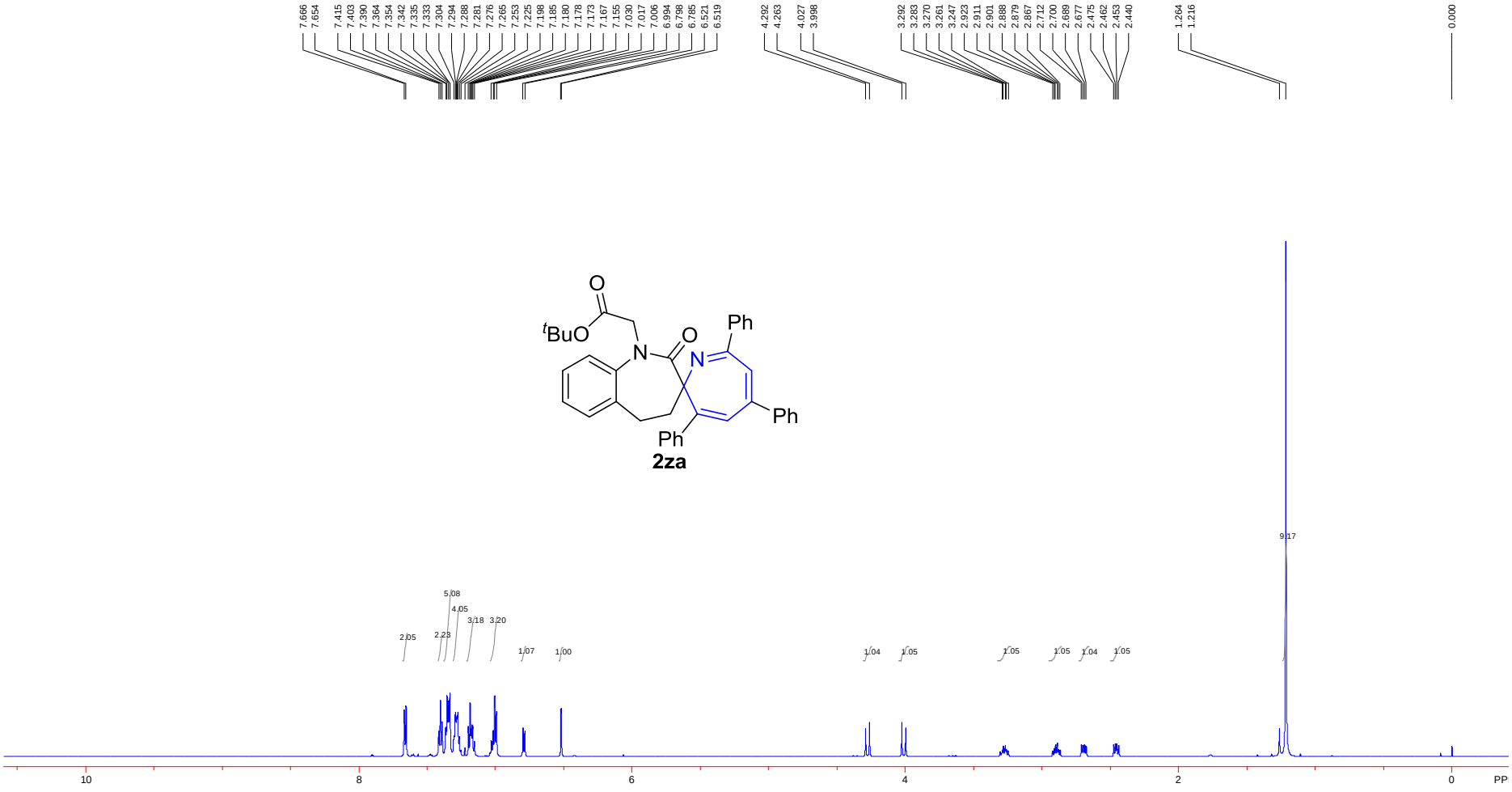
^{1}H NMR(600 MHz, $CDCl_3$)



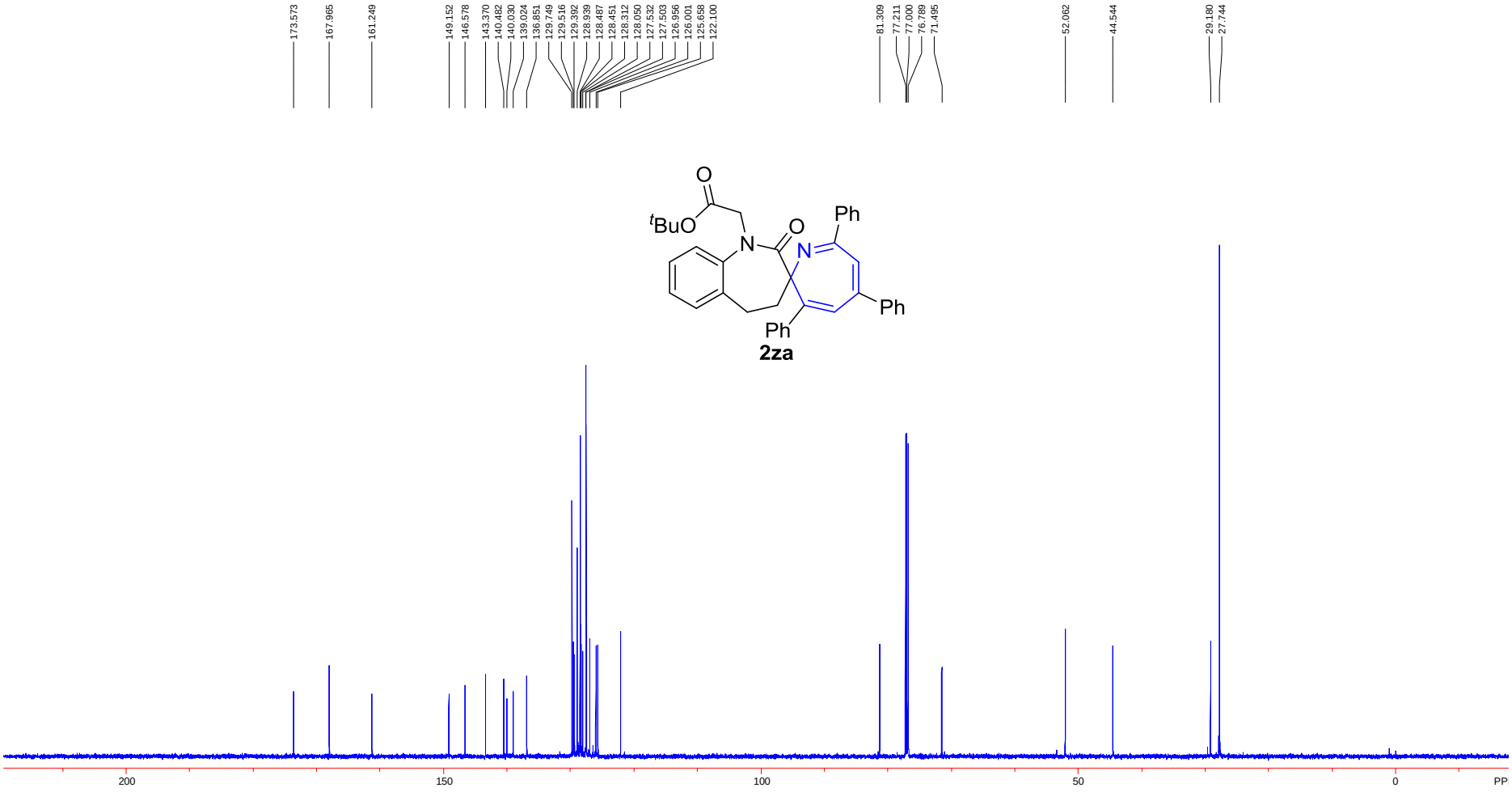
^{13}C NMR(150 MHz, $CDCl_3$)



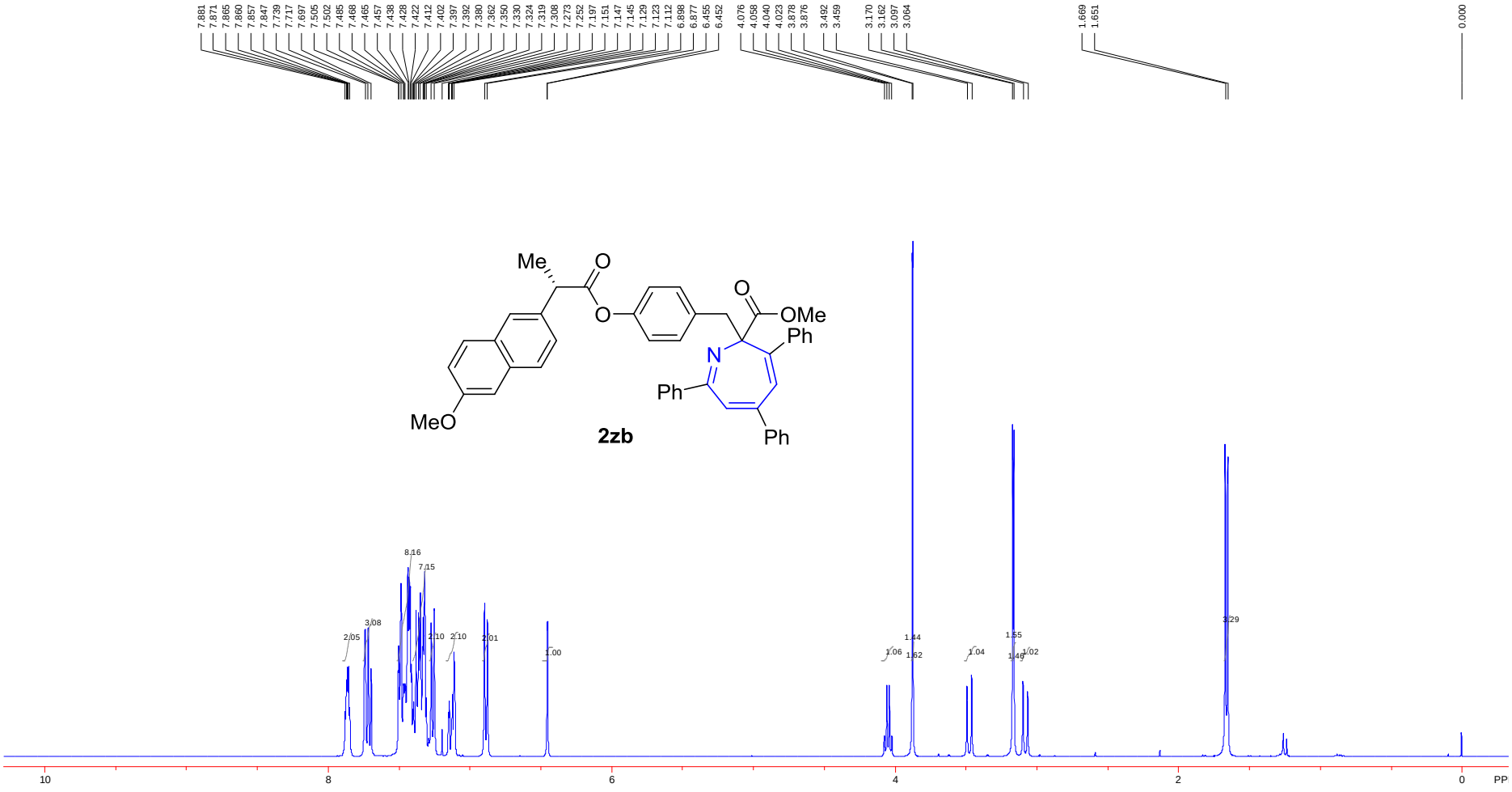
^{1}H NMR(600 MHz, $CDCl_3$)



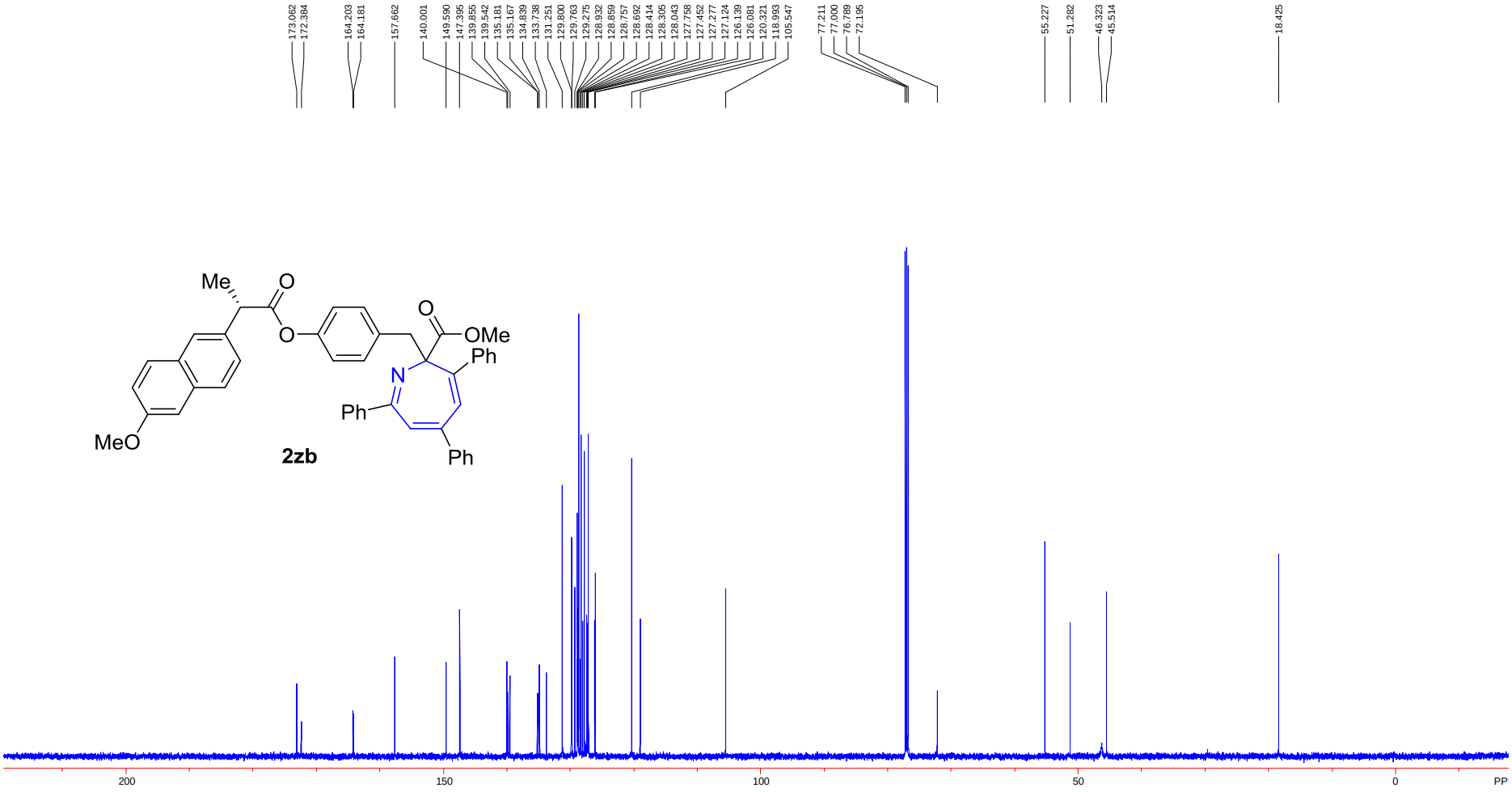
^{13}C NMR(150 MHz, $CDCl_3$)



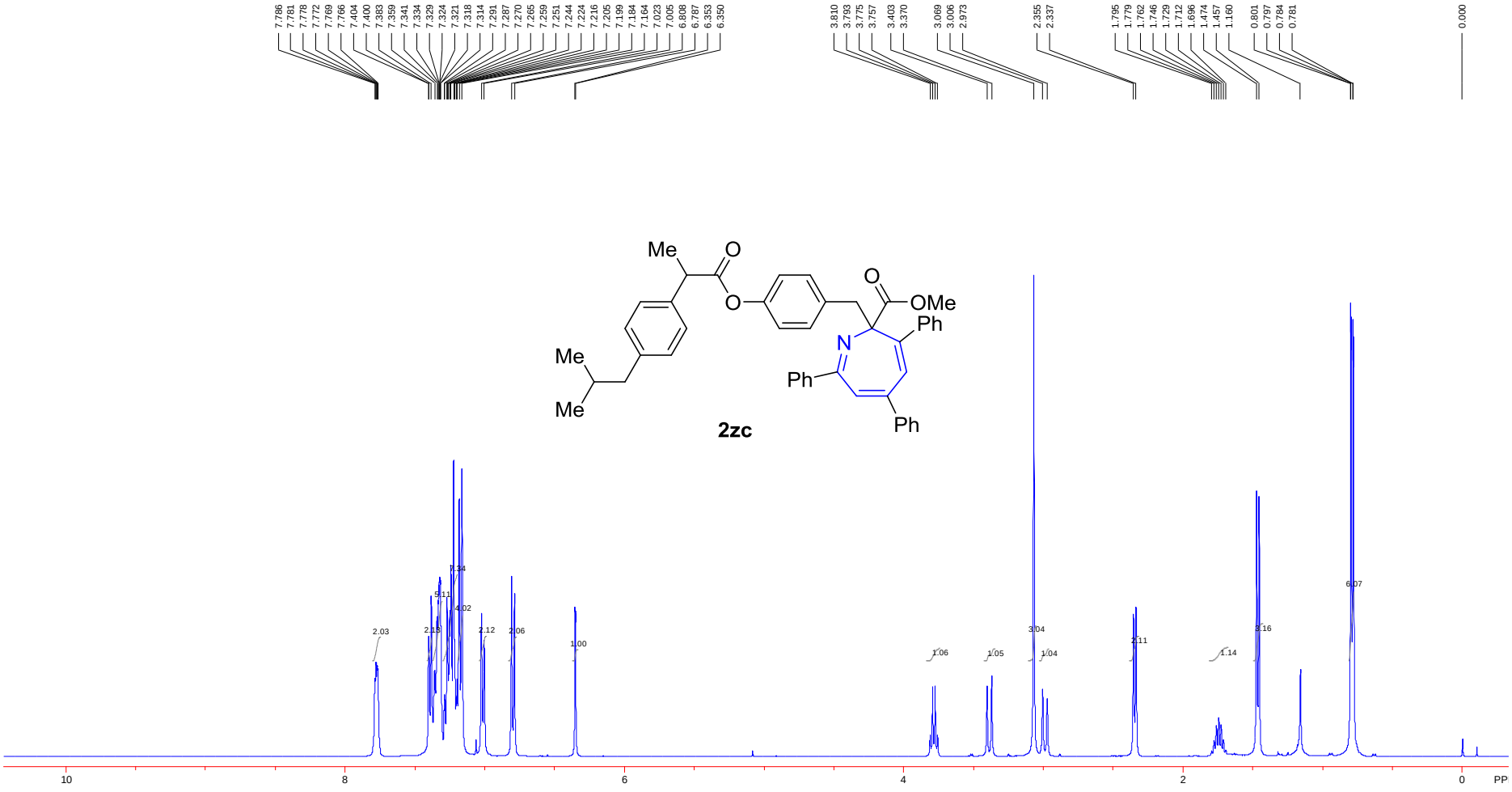
^{1}H NMR(400 MHz, $CDCl_3$)



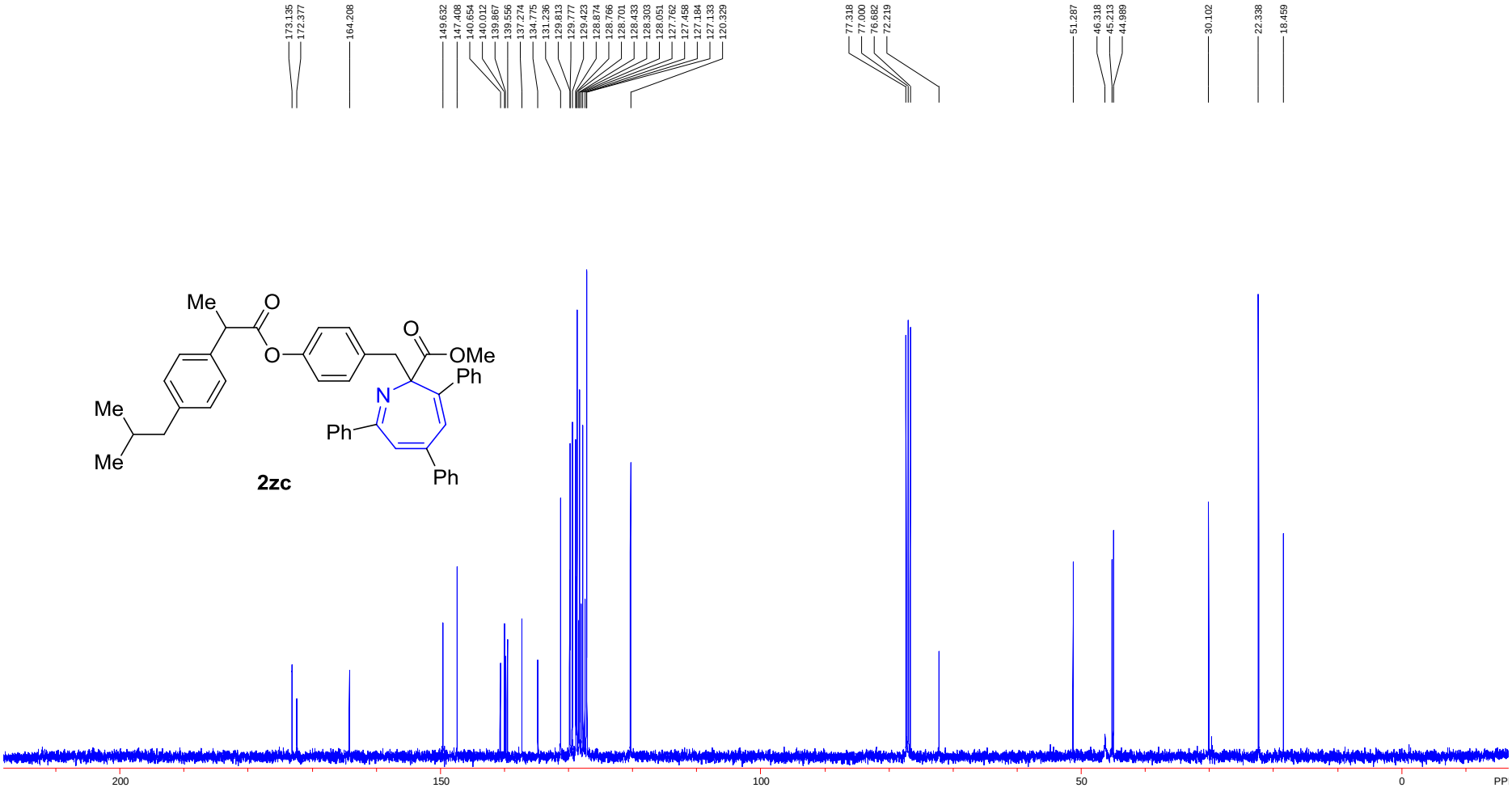
^{13}C NMR(150 MHz, $CDCl_3$)



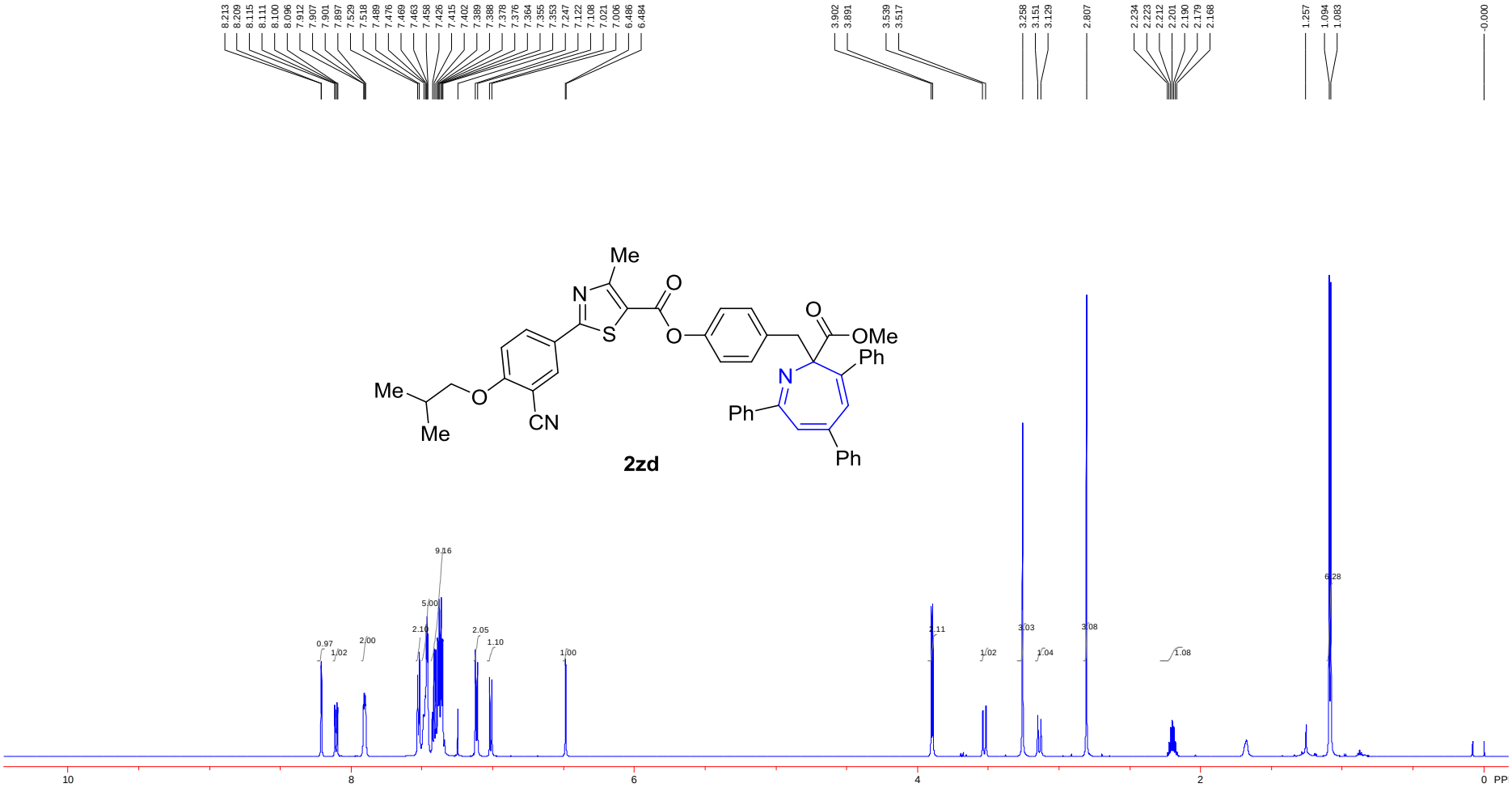
^{1}H NMR(400 MHz, $CDCl_3$)



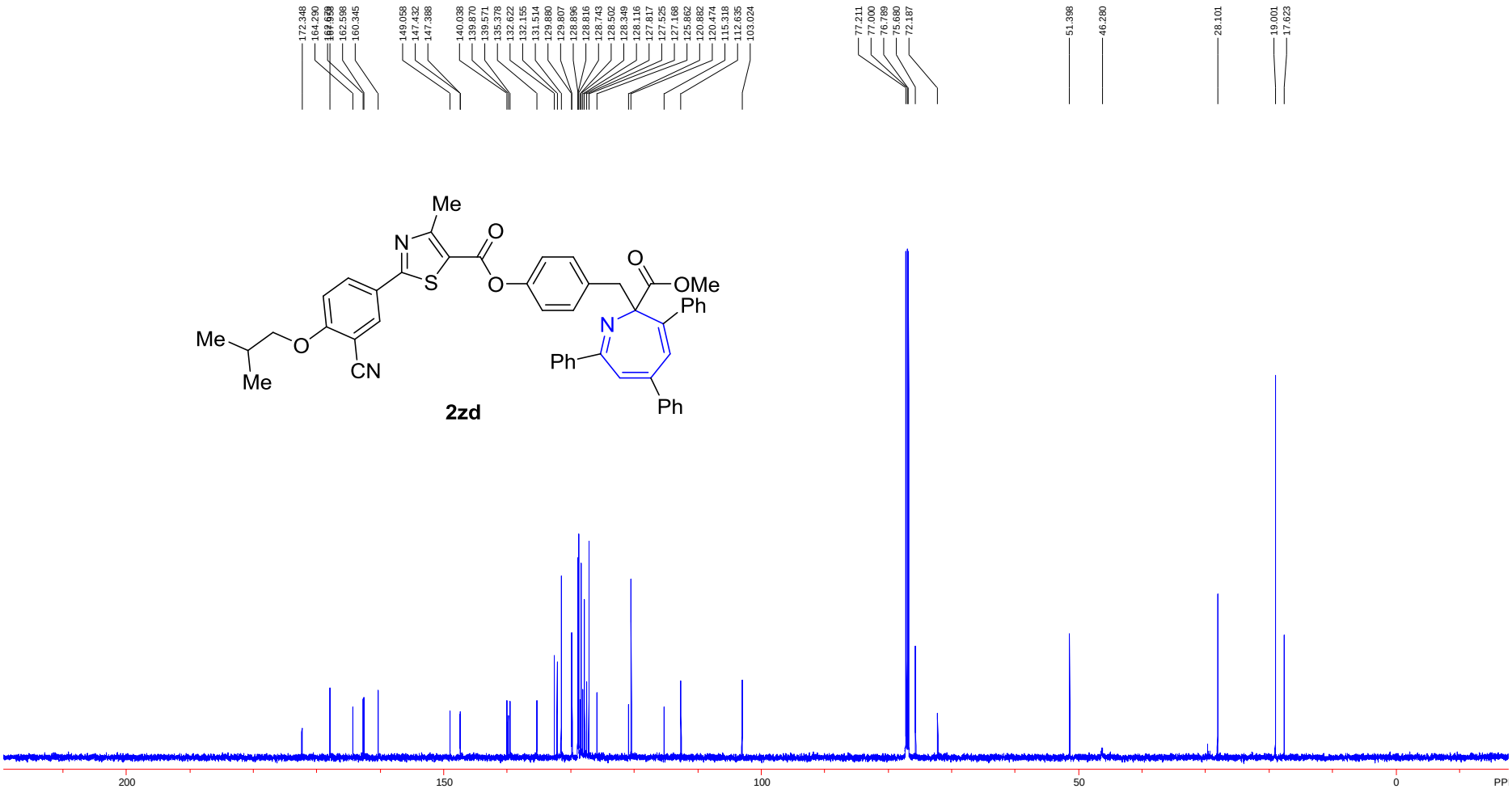
^{13}C NMR(100 MHz, $CDCl_3$)



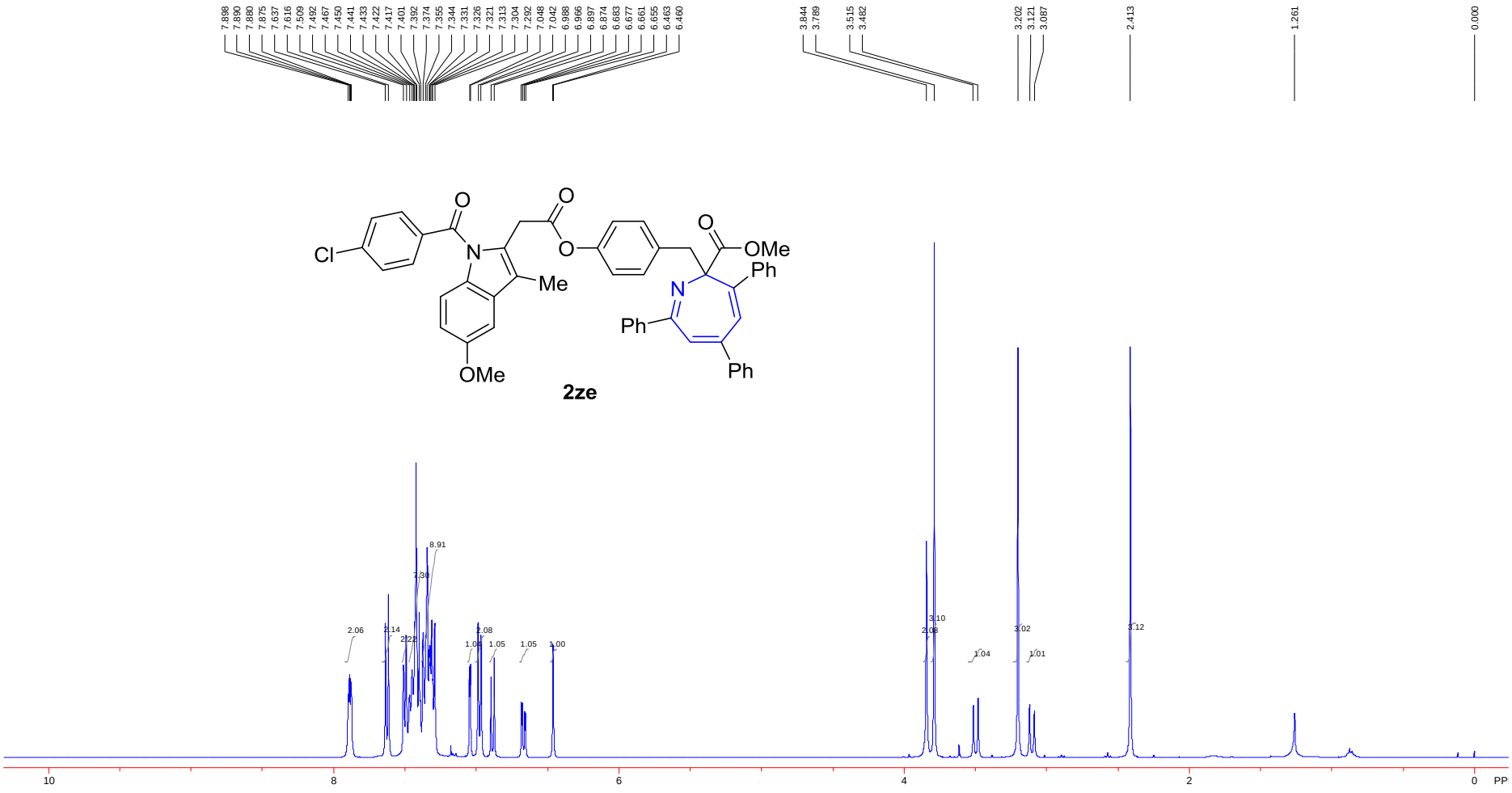
^{1}H NMR(600 MHz, $CDCl_3$)



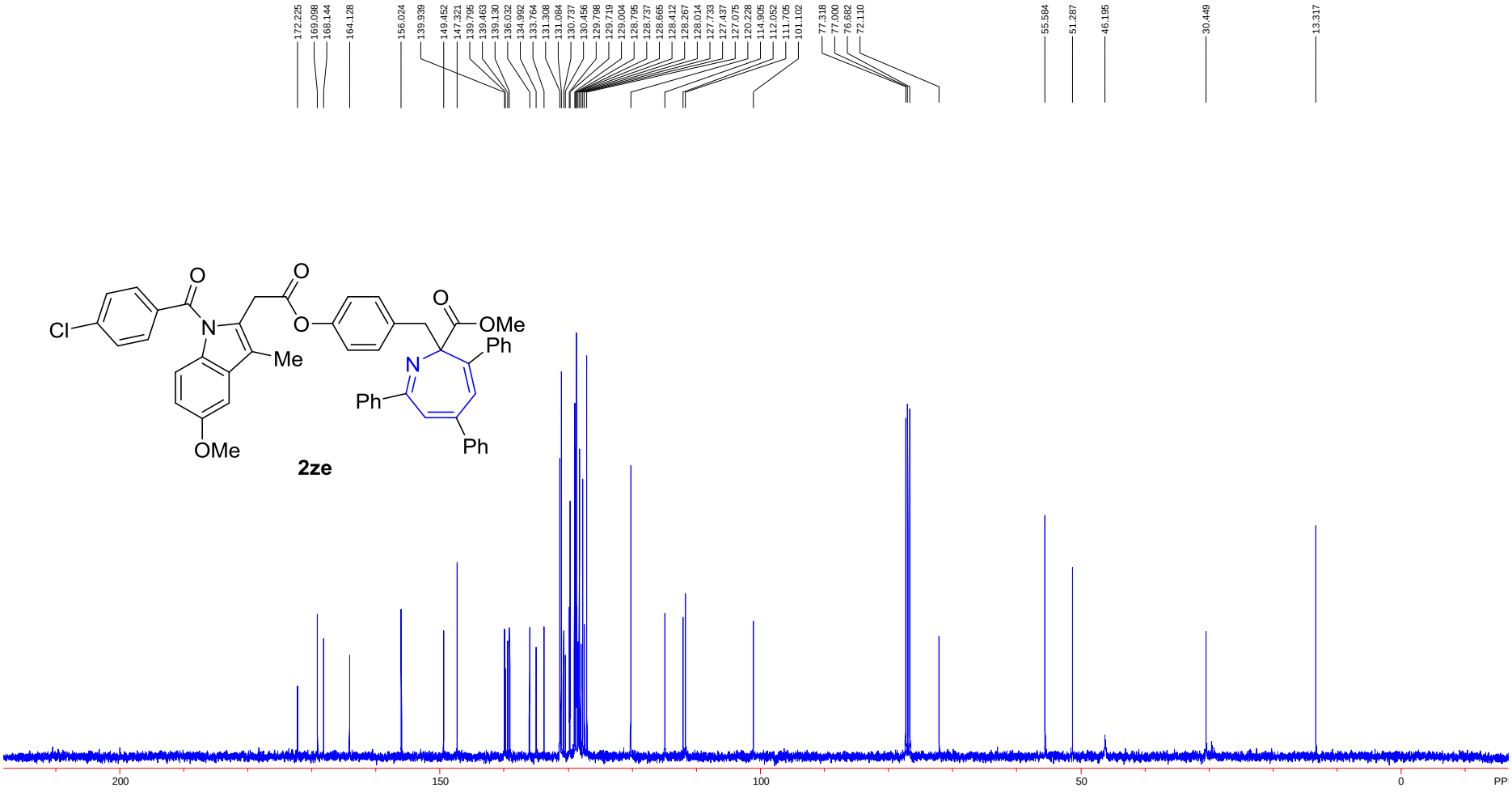
^{13}C NMR(150 MHz, $CDCl_3$)



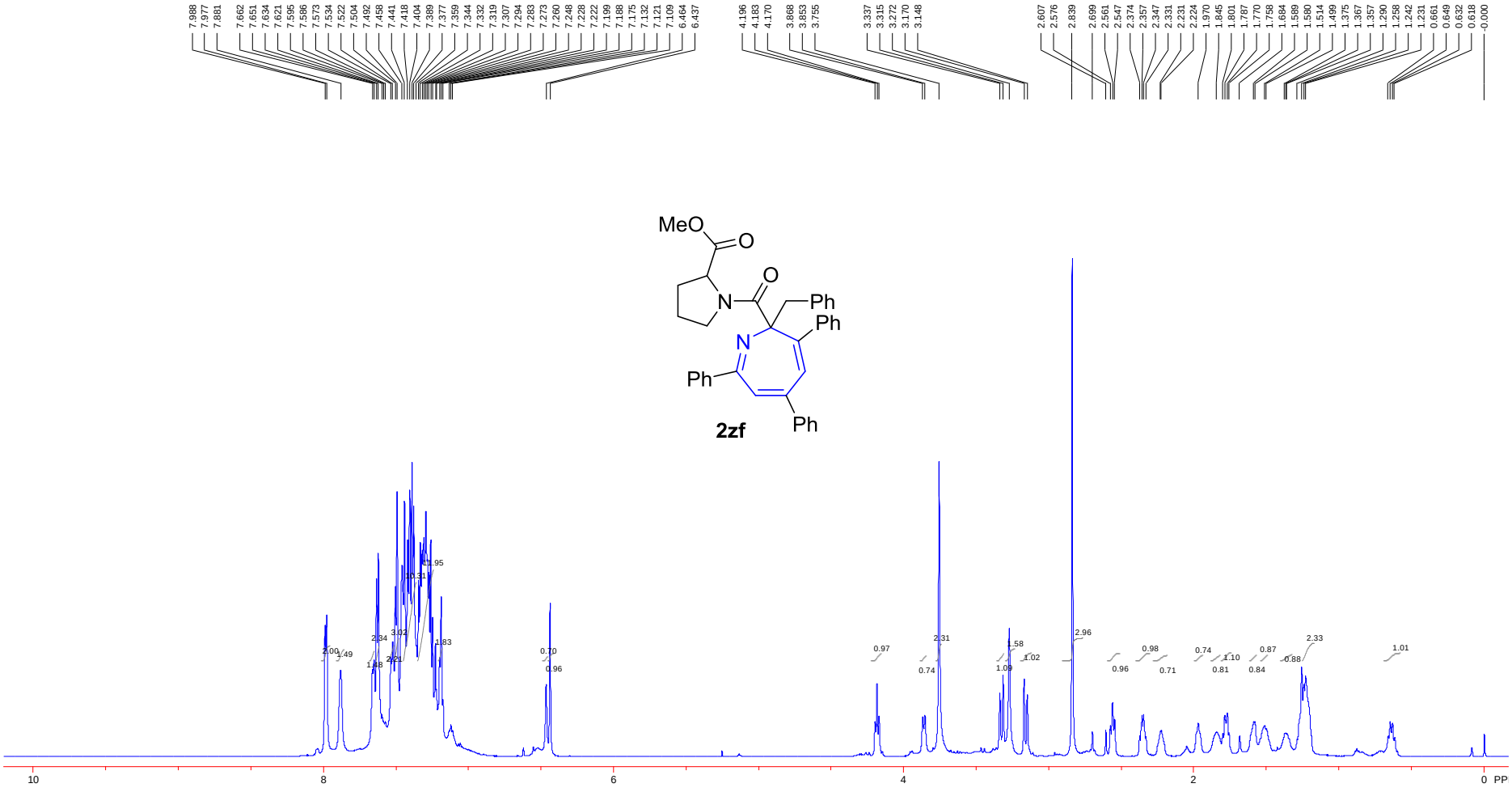
^{1}H NMR(400 MHz, $CDCl_3$)



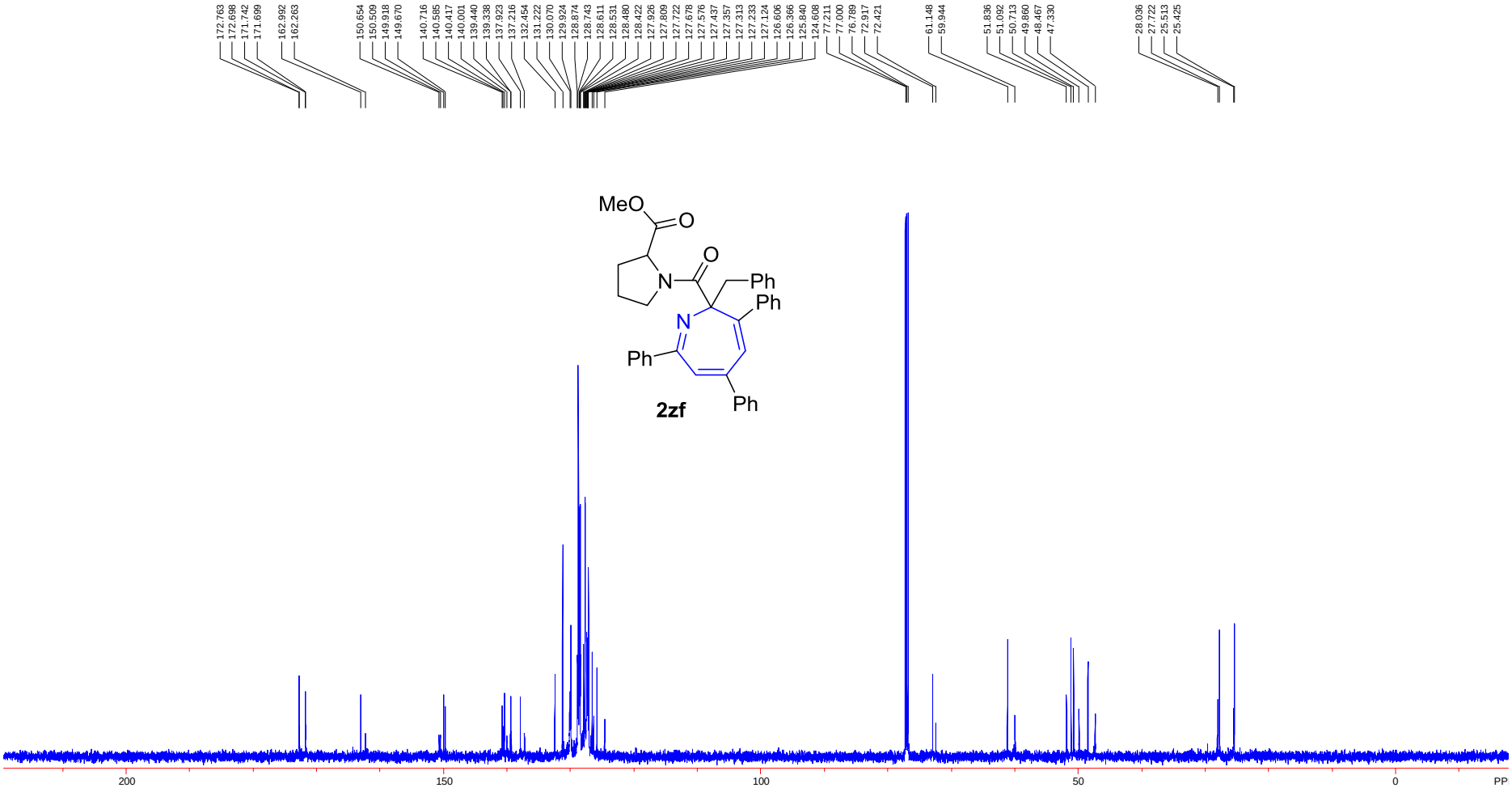
^{13}C NMR(100 MHz, $CDCl_3$)



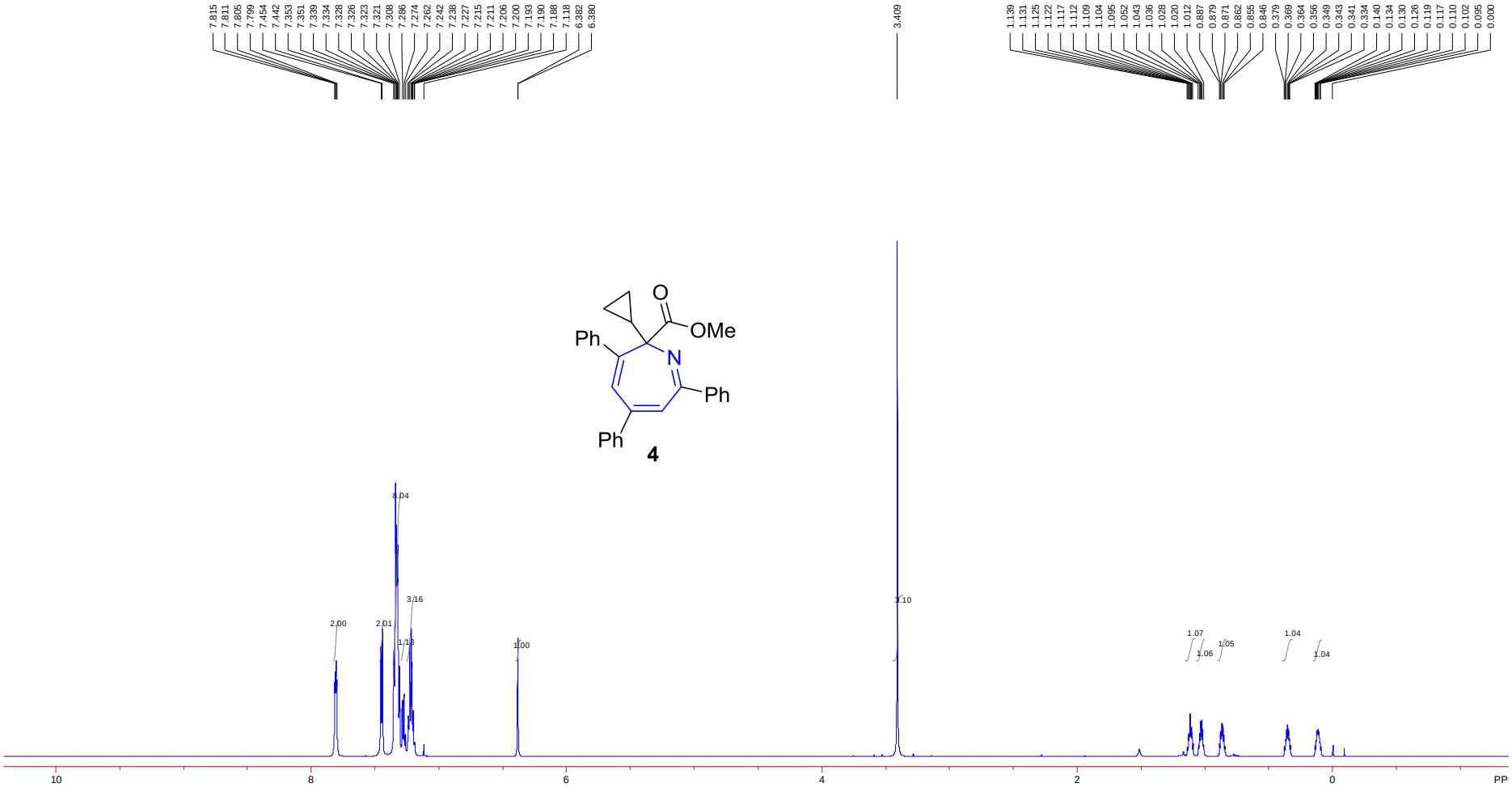
^{1}H NMR(600 MHz, $CDCl_3$)



^{13}C NMR(150 MHz, $CDCl_3$)



^{1}H NMR(600 MHz, $CDCl_3$)



^{13}C NMR(150 MHz, $CDCl_3$)