Electronic Supplementary Material (ESI) for Chemical Communications.

A Newly Designed Heterodiene and Its Application to Construct Six-Membered Heterocycles Containing an N-O Bond

Supporting Information

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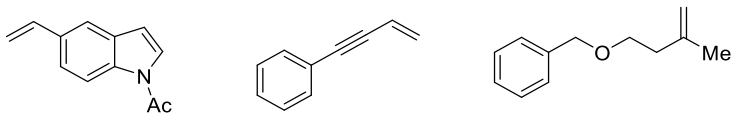
1.General Information

All reactions were carried out in oven-dried glassware with magnetic stirring unless otherwise specified. Hexafluoroisopropanol (HFIP) was purchased from Beijing Ouhe Technology Co. Commercial available olefins and other reagents are purchased from J&K, Adamas, Energy and TCI without further purification.

^{1}H NMR spectra were obtained on a 400 MHz spectrometer, chemical shifts are reported in ppm relative to residual protiated solvent as internal standard. ^{13}C NMR spectra were obtained at 100.6 MHz on a 400 MHz instrument, chemical shifts were recorded relative to the solvent resonance. Both ^{1}H NMR and ^{13}C NMR chemical shifts are reported in parts per million downfield from tetramethylsilane. ^{1}H NMR coupling constants are reported in Hertz and refer to apparent multiplicities and not true coupling constants. Data are reported as follows: chemical shift, integration, multiplicity (s = singlet, br s = broad singlet, d = doublet,t = triplet, q = quartet, qi = quintet, m = multiplet, dd = doublet of doublets, etc.) High-resolution mass spectra (HRMS) were recorded on a Waters Xevo G2 QTOF MS. Chromatographic purifications were performed by flash chromatography using silica gel (200-400 mesh). The yields of the products included refer to isolated yields.

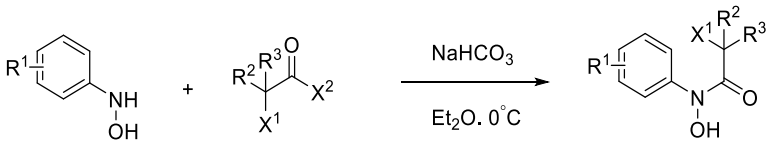
2. Preparation of the alkene substrates



3l **3p** **3v**

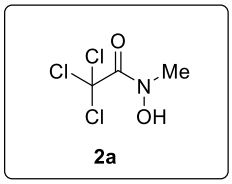
3l[1], **3p**[2], **3v**[3], were prepared according to the known literature procedures, other alkenes are purchased from J&K, Energy and TCI without further purification.

3. General Procedure for Synthesis of α-halo-*N*-hydroxy amides



To a stirred suspension of *N*-methylhydroxyamine hydrochloride (or *N*-benzylhydroxylamine hydrochloride) (5.0 mmol, 1.0 equiv) and $NaHCO_3$ (10.0 mmol, 2.0 equiv) in THF (25 mL) at 0 °C was added slowly a solution of corresponding acyl chloride (5.0 mmol, 1.0 equiv). The mixture was stirred for 5 hours. Then poured into separatory funnel with water, extracted with Et_2O. The combined organic layers were washed with water, dried with $MgSO_4$, filtered, and concentrated in vacuo. The residue was purified by chromatography on silica gel, eluting with petroleum ether/ethyl acetate from (10:1 to 1:1 v/v), to afford the products.

2,2,2-trichloro-*N*-hydroxy-*N*-methylacetamide (4a)



2a

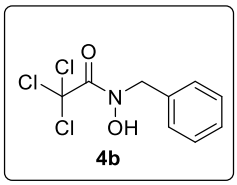
Yield (441 mg, 46%) as white solid via general procedure.

R_f = 0.40 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, DMSO) δ 10.66 (s, 1H), 3.29 (s, 3H).**^{13}C NMR** (101 MHz, DMSO) δ 158.7, 92.3, 38.9. **HRMS**: *m/z* calculated for $C_3H_5Cl_3NO_2$ (M

+ H)$^+$:191.9386, found: 191.9382.

N-benzyl-2,2,2-trichloro-*N*-hydroxyacetamide (4b)



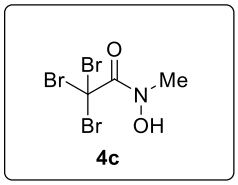
4b

Yield (683 mg, 51%) as white solid via general procedure.

R_f = 0.55 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, DMSO) δ 10.74 (s, 1H), 7.42 – 7.35 (m, 2H), 7.33-7.30 (m, 3H), 4.83 (s, 2H). **^{13}C NMR** (101 MHz, DMSO) δ 159.1, 135.5, 128.6, 127.7, 127.6, 92.3, 54.5. **HRMS**: *m/z* calculated for $C_9H_9Cl_3NO_2$ (M + H)$^+$:267.9699, found:267.9701.

2,2,2-tribromo-*N*-hydroxy-*N*-methylacetamide (4c)



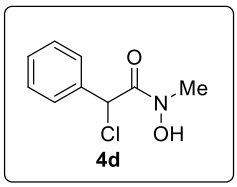
4c

Yield (717 mg, 44%) as white solid via general procedure.

R_f = 0.22 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, DMSO) δ 10.53 (s, 1H), 3.30 (s, 3H).**^{13}C NMR** (101 MHz, DMSO) δ 159.7, 39.8, 34.7. **HRMS**: *m/z* calculated for $C_3H_5Br_3NO_2$ (M + H)$^+$:323.7870, found: 323.7877.

2-chloro-*N*-hydroxy-*N*-methyl-2-phenylacetamide (4d)



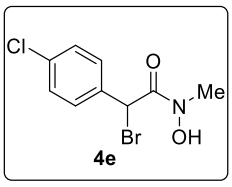
4d

Yield (647 mg, 65%) as white solid via general procedure.

R_f = 0.14 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, DMSO) δ 10.28 (s, 1H), 7.50 (d, J = 7.2 Hz, 2H), 7.42 – 7.32 (m, 3H), 6.21 (s, 1H), 3.14 (s, 3H).**^{13}C NMR** (101 MHz, DMSO) δ 166.5, 136.9, 128.7, 128.5, 128.3, 56.7, 36.3. **HRMS**: *m/z* calculated for $C_9H_{10}ClNNaO_2$ (M + Na)$^+$:222.0298, found:222.0293.

2-bromo-2-(4-chlorophenyl)-*N*-hydroxy-*N*-methylacetamide (4e)



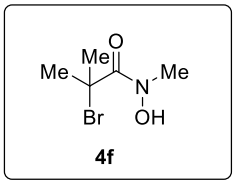
4e

Yield (583 mg, 42%) as white solid via general procedure.

R_f = 0.28 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, DMSO, rotamers) δ 10.36 & 10.31 (s, 1H), 7.60 & 7.53 (d, J = 8.4 Hz, 2H), 7.44 & 7.39 (d, J = 8.3 Hz, 2H), 6.28 & 6.24 (s, 1H), 3.15 (s, 3H). **^{13}C NMR** (101 MHz, DMSO, rotamers) δ 166.7 & 166.6, 136.6 & 136.4, 133.8 &133.9, 131.3 & 130.6, 129.0 & 128.9, 56.3 & 45.0, 36.8 & 36.7. **HRMS**: *m/z* calculated for $C_9H_9BrClNNaO_2$ (M + Na)$^+$: 299.9403, found: 299.9396.

2-bromo-*N*-hydroxy-*N*,2-dimethylpropanamide (4f)



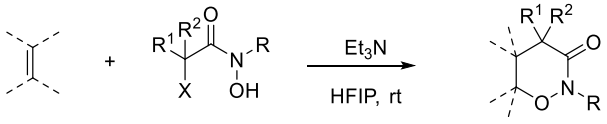
4f

Yield (235 mg, 24%) as white solid via general procedure.

R_f = 0.24 (petroleum ether/ethyl acetate 3:1)

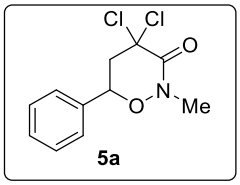
^{1}H NMR (400 MHz, DMSO) δ 9.95 (s, 1H), 3.16 (s, 3H), 1.91 (s, 6H). **^{13}C NMR** (101 MHz, DMSO) δ 168.9, 57.7, 37.9, 31.4. **HRMS**: *m/z* calculated for $C_5H_{11}BrNO_2$ (M + H)$^+$:195.9973, found:195.9971.

4. General Procedure for Synthesis of 1,2-oxazinane-3-ones



Alkene (0.3 mmol. 1.0 equiv), α-halo-*N*-hydroxy amides (0.6 mmol. 2.0 equiv) was dissolved in HFIP(1.5 mL), Et_3N (85 μl, 0.6 mmol, 2.0 equiv) was added slowly with microinjector. The mixture was stirred overnight. After completion, the solvent was evapotated under reduced pressure. The residue was purified via flash column chromatography (petroleum ether/ethyl acetate 20:1 to 3:1) to provide the desired product.

4,4-dichloro-2-methyl-6-phenyl-1,2-oxazinan-3-one (5a)

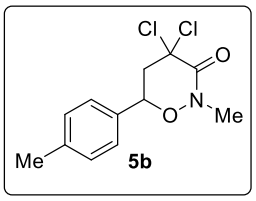


Yield (66 mg, 85%) as white solid via general procedure.

R_f = 0.20 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.36 (m, 5H), 5.39 (dd, J = 9.3, 4.6 Hz, 1H), 3.33 (s, 3H), 3.26 (dd, J = 6.9, 4.6 Hz, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.8, 135.6, 129.6, 129.0, 126.7, 79.0, 78.5, 51.8, 35.7. **HRMS**: *m/z* calculated for $C_{11}H_{12}Cl_2NO_2(M + H)^+$:260.0245, found:260.0249.

4,4-dichloro-2-methyl-6-(p-tolyl)-1,2-oxazinan-3-one (5b)

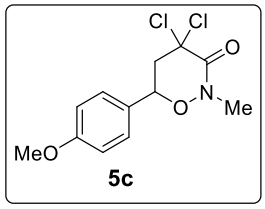


Yield (74 mg, 90%) as white solid via general procedure.

R_f = 0.22 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, J = 8.0 Hz, 2H), 7.23 (d, J = 8.1 Hz, 2H), 5.35 (dd, J = 10.2, 3.6 Hz, 1H), 3.32 (s, 3H), 3.25 (dd, J = 13.9, 6.9 Hz, 2H), 2.38 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.7, 139.7, 132.6, 129.6, 126.8, 79.0, 78.6, 51.7, 35.7, 21.3. **HRMS**: *m/z* calculated for $C_{12}H_{14}Cl_2NO_2$ $(M + H)^+$:274.0402, found:274.0400.

4,4-dichloro-6-(4-methoxyphenyl)-2-methyl-1,2-oxazinan-3-one (5c)

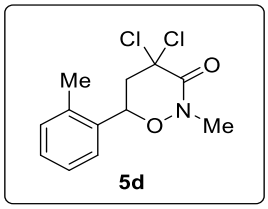


Yield (76 mg, 87%) as white solid via general procedure.

R_f = 0.10 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, J = 8.7 Hz, 2H), 6.94 (d, J = 8.7 Hz, 2H), 5.33 (dd, J = 10.5, 3.3 Hz, 1H), 3.82 (s, 3H), 3.30 (s, 3H), 3.29 – 3.17 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.6, 160.5, 128.5, 127.3, 114.3, 78.8, 78.7, 55.3, 51.5, 35.6. **HRMS:** *m/z* calculated for $C_{12}H_{14}Cl_2NO_3$ $(M + H)^+$:290.0351, found:290.0359.

4,4-dichloro-2-methyl-6-(o-tolyl)-1,2-oxazinan-3-one (5d)



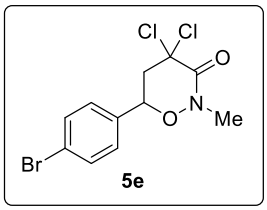
Yield (67 mg, 81%) as white solid via general procedure.

R_f = 0.22 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.34 (m, 1H), 7.33 – 7.20 (m, 3H), 5.61 (dd, J = 9.9, 3.4 Hz, 1H), 3.34 (s, 3H), 3.27 – 3.16 (m, 2H), 2.41 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.4, 135.6, 133.4, 130.8, 129.2, 126.5, 125.2, 78.7, 75.8, 51.1, 35.5, 18.9. **HRMS**: *m/z* calculated for

$C_{12}H_{14}Cl_2NO_2$ (M + H)$^+$:274.0402, found:274.0401.

6-(4-bromophenyl)-4,4-dichloro-2-methyl-1,2-oxazinan-3-one (5e)



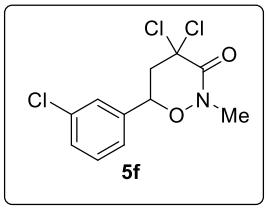
5e

Yield (75 mg, 74%) as white solid via general procedure.

R_f = 0.13 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, J = 8.5 Hz, 2H), 7.27 (d, J = 8.4 Hz, 2H), 5.35 (dd, J = 8.1, 5.8 Hz, 1H), 3.32 (s, 3H), 3.21 (d, J = 2.4 Hz, 1H), 2.99 (d, J = 4.9 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.9, 134.7, 132.2, 128.3, 123.7, 78.3, 78.3, 51.7, 35.7. **HRMS**: *m/z* calculated for $C_{11}H_{11}BrCl_2NO_2$ (M + H)$^+$: 337.9350, found:337.9358.

4,4-dichloro-6-(3-chlorophenyl)-2-methyl-1,2-oxazinan-3-one (5f)



5f

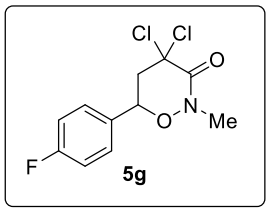
Yield (62 mg, 70%) as white solid via general procedure.

R_f = 0.16 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.37 (m, 3H), 7.30 (d, J = 6.8 Hz, 1H), 5.39 (dd, J = 9.1, 4.7 Hz, 1H), 3.36 (s, 3H), 3.28 – 3.21 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.9, 137.6, 135.0, 130.3, 129.7, 126.8, 124.7, 78.2, 78.2, 51.7, 35.7. **HRMS**: *m/z* calculated for $C_{11}H_{11}Cl_3NO_2$ (M + H)$^+$:293.9855, found:293.9862.

4,4-dichloro-6-(4-fluorophenyl)-2-methyl-1,2-oxazinan-3-one (5g)



5g

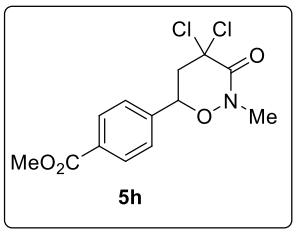
Yield (51 mg, 61%) as white solid via general procedure.

R_f = 0.12(petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (dd, J = 7.5, 5.6 Hz, 2H), 7.11 (t, J = 8.4 Hz, 2H), 5.37 (dd, J = 8.2, 5.6 Hz, 1H), 3.32 (s, 3H), 3.26 – 3.21 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 164.4, 161.8(d, J = 21 Hz), 131.5(d, J = 3 Hz), 128.7 (d, J = 8 Hz), 116.0(d, J = 22 Hz) 78.4, 78.3, 51.7, 35.7.

HRMS: *m/z* calculated for $C_{11}H_{11}Cl_2FNO_2$(M + H)$^+$:278.0151, found:278.0149.

methyl 4-(4,4-dichloro-2-methyl-3-oxo-1,2-oxazinan-6-yl)benzoate (5h)



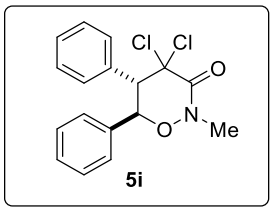
5h

Yield (62 mg, 65%) as white solid via general procedure.

R_f = 0.38 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, J = 8.1 Hz, 2H), 7.46 (d, J = 8.1 Hz, 2H), 5.44 (dd, J = 9.8, 4.0 Hz, 1H), 3.93 (s, 3H), 3.34 (s, 3H), 3.30 – 3.17 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.3, 161.9, 140.4, 131.1, 130.2, 126.4, 78.3, 52.3, 51.7, 39.3, 35.7. **HRMS**: *m/z* calculated for $C_{13}H_{14}Cl_2NO_4$ (M + H)$^+$:318.0300, found:318.0302.

4,4-dichloro-2-methyl-5,6-diphenyl-1,2-oxazinan-3-one (5i)



5i

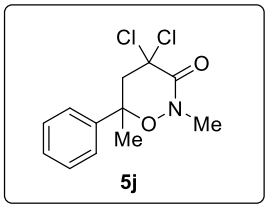
Yield (82 mg, 81%) as white solid via general procedure.

R_f = 0.33 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34-7.29 (m, 10H), 5.50 (d, J = 9.3 Hz, 1H), 4.25 (d, J = 9.3 Hz, 1H), 3.37 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.9, 136.3, 134.1, 130.4, 129.3, 128.8, 128.6, 128.4, 127.3, 84.6, 83.7,

62.3, 35.8. **HRMS**: *m/z* calculated for $C_{17}H_{16}Cl_2NO_2$ $(M + H)^+$:336.0558, found: 336.0565.

4,4-dichloro-2,6-dimethyl-6-phenyl-1,2-oxazinan-3-one (5j)

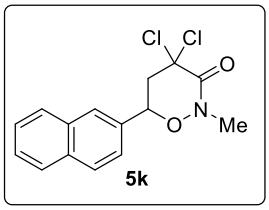


Yield (71 mg, 86%) as white solid via general procedure.

R_f = 0.26 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43-7.38 (m, 4H), 7.33 (dd, J = 8.4, 4.1 Hz, 1H), 3.51 (d, J = 15.0 Hz, 1H), 3.34 (d, J = 15.0 Hz, 1H), 3.29 (s, 3H), 1.72 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 164.4, 144.2, 128.7, 128.1, 124.6, 82.8, 78.8, 54.5, 36.1, 30.1. **HRMS**: *m/z* calculated for $C_{12}H_{14}Cl_2NO_2$ $(M + H)^+$: 274.0402 , found:274.0406.

4,4-dichloro-2-methyl-6-(naphthalen-2-yl)-1,2-oxazinan-3-one (5k)

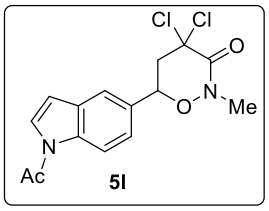


Yield (72 mg, 77%) as white solid via general procedure.

R_f = 0.17 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, J = 8.6 Hz, 1H), 7.87 (d, J = 8.5 Hz, 3H), 7.55 (dd, J = 6.1, 3.2 Hz, 2H), 7.49 (d, J = 8.5 Hz, 1H), 5.56 (dd, J = 10.1, 3.7 Hz, 1H), 3.43 – 3.30 (m, 2H), 3.36 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.8, 133.5, 132.9, 132.8, 128.9, 128.1, 127.7, 127.0, 126.8, 126.3, 123.7, 79.1, 78.5, 51.7, 35.7. **HRMS**: *m/z* calculated for $C_{15}H_{14}Cl_2NO_2$ $(M + H)^+$: 310.0402, found: 310.0407.

6-(1-acetyl-1H-indol-5-yl)-4,4-dichloro-2-methyl-1,2-oxazinan-3-one (5l)

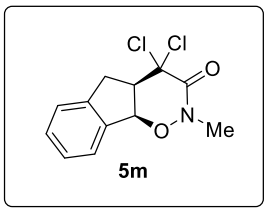


Yield (77 mg, 75%) as white solid via general procedure.

R_f = 0.25 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (d, J = 8.6 Hz, 1H), 7.62 (d, J = 1.5 Hz, 1H), 7.49 (d, J = 3.7 Hz, 1H), 7.37 (dd, J = 8.6, 1.7 Hz, 1H), 6.72 – 6.63 (m, 1H), 5.48 (dd, J = 10.4, 3.4 Hz, 1H), 3.40 – 3.25 (m, 2H), 3.33 (s, 3H), 2.66 (s, 3H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 168.6, 161.7, 135.9, 130.8, 130.6, 126.4, 123.8, 119.4, 117.1, 109.0, 79.3, 78.6, 51.9, 35.7, 23.9. **HRMS**: *m/z* calculated for $C_{15}H_{15}Cl_2N_2O_3$ $(M + H)^+$:341.0460, found:341.0458.

4,4-dichloro-2-methyl-4,4a,5,9b-tetrahydroindeno[2,1-e][1,2]oxazin-3(2H)-one (5m)

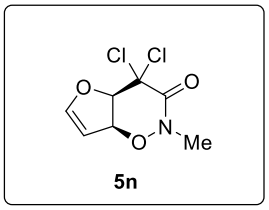


Yield (69 mg, 85%) as white solid via general procedure.

R_f = 0.58 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, J = 7.5 Hz, 1H), 7.38 (t, J = 7.3 Hz, 1H), 7.31 (t, J = 7.4 Hz, 1H), 7.24 (d, J = 7.5 Hz, 1H), 5.62 (d, J = 8.3 Hz, 1H), 3.93 (td, J = 9.0, 6.4 Hz, 1H), 3.33 (dd, J = 17.7, 9.6 Hz, 1H), 3.12 (dd, J = 17.7, 6.1 Hz, 1H), 3.01 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.2, 142.3, 137.5, 130.6, 127.7, 125.9, 124.7, 84.7, 82.9, 53.7, 36.4, 35.6. **HRMS**: *m/z* calculated for $C_{12}H_{12}Cl_2NO_2$ $(M + H)^+$:272.0245, found:272.0251.

4,4-dichloro-2-methyl-4a,7a-dihydro-2H-furo[3,2-e][1,2]oxazin-3(4H)-one (5n)



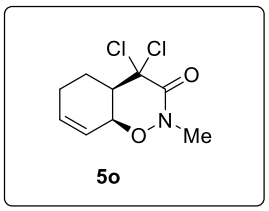
5n

Yield (43 mg, 65%) as white solid via general procedure.

R_f= 0.45 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.70 (d, J = 2.4 Hz, 1H), 5.40 (dd, J = 7.9, 2.0 Hz, 1H), 5.24 (d, J = 8.0 Hz, 1H), 5.21 (t, J = 2.5 Hz, 1H), 3.24 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.7, 152.9, 99.1, 87.1, 83.4, 77.6, 36.2. **HRMS**: *m/z* calculated for $C_7H_8Cl_2NO_3$ (M + H)$^+$:223.9881, found:223.9883.

4,4-dichloro-2-methyl-4a,5,6,8a-tetrahydro-2H-benzo[e][1,2]oxazin-3(4H)-one (5o)



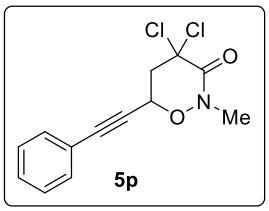
5o

Yield (55 mg, 77%) as white solid via general procedure.

R_f= 0.50 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.27 – 6.16 (m, 1H), 5.82 (d, J = 9.6 Hz, 1H), 4.84 (s, 1H), 3.26 (s, 3H), 2.82 (dt, J = 13.0, 4.2 Hz, 1H), 2.41 – 2.19 (m, 2H), 2.16 – 2.01 (m, 1H), 1.65 (ddd, J = 24.5, 12.7, 5.2 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.7, 136.1, 122.0, 84.3, 72.4, 50.8, 35.5, 24.9, 21.4. **HRMS**: *m/z* calculated for $C_9H_{12}Cl_2NO_2$ (M + H)$^+$:236.0245, found:236.0249.

4,4-dichloro-2-methyl-6-(phenylethynyl)-1,2-oxazinan-3-one (5p)



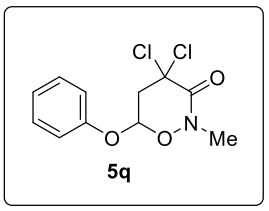
5p

Yield (72 mg, 85%) as colorless oil via general procedure.

R_f= 0.64 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.42 (m, 2H), 7.42 – 7.30 (m, 3H), 5.23 (dd, J = 8.2, 5.8 Hz, 1H), 3.42 (dd, J = 14.9, 5.8 Hz, 1H), 3.36 (s, 3H), 3.19 (dd, J = 14.9, 8.3 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8, 131.9, 129.5, 128.5, 120.9, 88.7, 83.0, 77.8, 67.5, 50.8, 35.9. **HRMS**: *m/z* calculated for $C_{13}H_{12}Cl_2NO_2$ (M + H)$^+$:284.0245, found:284.0247.

4,4-dichloro-2-methyl-6-phenoxy-1,2-oxazinan-3-one (5q)



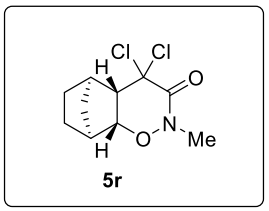
5q

Yield (68 mg, 82%) as white solid via general procedure.

R_f= 0.48 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (dd, J = 8.6, 7.5 Hz, 2H), 7.11 (t, J = 7.4 Hz, 1H), 7.08 – 7.03 (m, 2H), 5.84 (dd, J = 7.0, 5.0 Hz, 1H), 3.59 (dd, J = 15.4, 7.1 Hz, 1H), 3.23 (s, 3H), 3.03 (dd, J = 15.4, 5.0 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.8, 155.7, 129.8, 123.5, 116.6, 97.2, 77.3, 48.8, 35.8. **HRMS**: m/z calculated for $C_{11}H_{12}Cl_2NO_3$ (M + H)$^+$:276.0194, found:276.0199.

4,4-dichloro-2-methylhexahydro-2H-5,8-methanobenzo[e][1,2]oxazin-3(4H)-one (5r)



5r

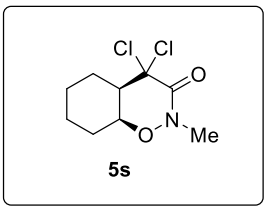
Yield (69 mg, 92%) as white solid via general procedure.

R_f= 0.58 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.19 (d, J = 6.5 Hz, 1H), 3.29 (s, 3H), 2.79-2.74 (m, 1H), 2.60 (d, J = 6.5 Hz, 1H), 2.37 (dd, J = 10.4, 8.3 Hz, 2H), 1.70-1.56 (m, 2H), 1.26 (d, J = 10.6 Hz, 1H), 1.23 – 1.14 (m, 1H), 1.12-1.05 (m, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8, 87.5, 82.1, 60.3,

39.2, 39.1, 34.7, 34.6, 28.8, 24.1. **HRMS**: *m/z* calculated for $C_{10}H_{14}Cl_2NO_2$ $(M + H)^+$:250.0402, found:250.0405.

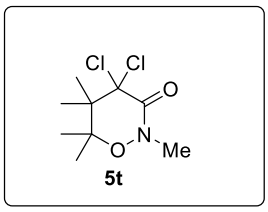
4,4-dichloro-2-methylhexahydro-2H-benzo[e][1,2]oxazin-3(4H)-one (5s)



5s

Yield (36 mg, 51%) as white solid via general procedure.
R_f = 0.65 (petroleum ether/ethyl acetate 3:1)
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.88 (d, J = 1.4 Hz, 1H), 3.27 (s, 3H), 2.55 – 2.47 (m, 1H), 2.23 – 2.06 (m, 2H), 1.89 (dd, J = 10.8, 3.0 Hz, 1H), 1.57 – 1.48 (m, 3H), 1.44 (dd, J = 12.9, 3.4 Hz, 1H), 1.39 – 1.22 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.6, 84.0, 74.2, 51.9, 35.5, 28.9, 24.7, 24.4, 19.2. **HRMS**: *m/z* calculated for $C_9H_{14}Cl_2NO_2$ $(M + H)^+$: 238.0402, found:238.0406.

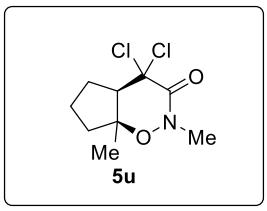
4,4-dichloro-2,5,5,6,6-pentamethyl-1,2-oxazinan-3-one (5t)



5t

Yield (60 mg, 84%) as white solid via general procedure.
R_f = 0.25 (petroleum ether/ethyl acetate 10:1)
^{1}H NMR (400 MHz, $CDCl_3$) δ 3.27 (s, 3H), 1.40 (s, 6H), 1.27 (s, 6H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.9, 90.8, 84.9, 49.9, 36.0, 25.7, 22.9. **HRMS**: *m/z* calculated for $C_9H_{16}Cl_2NO_2$ $(M + H)^+$:240.0558, found:240.0562.

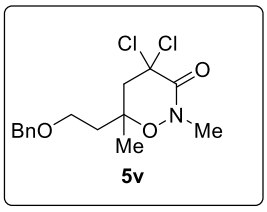
4,4-dichloro-2,7a-dimethylhexahydrocyclopenta[e][1,2]oxazin-3(2H)-one (5u)



5u

Yield (57 mg, 79%) as white solid via general procedure.
R_f = 0.58 (petroleum ether/ethyl acetate 3:1)
^{1}H NMR (400 MHz, $CDCl_3$) δ 3.27 (s, 3H), 2.93 (dd, J = 10.0, 8.2 Hz, 1H), 2.20 – 2.09 (m, 1H), 1.95 (td, J = 12.8, 7.1 Hz, 1H), 1.87 – 1.75 (m, 2H), 1.69 – 1.54 (m, 1H), 1.48 (s, 3H), 1.39 (dt, J = 12.4, 6.4 Hz, 1H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1, 89.8, 83.5, 60.6, 38.3, 36.2, 32.3, 26.7, 22.8. **HRMS**: *m/z* calculated for $C_9H_{14}Cl_2NO_2$ $(M + H)^+$:238.0402, found:238.0406.

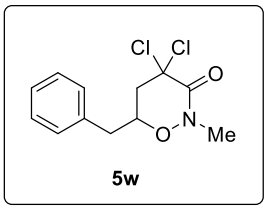
6-(2-(benzyloxy)ethyl)-4,4-dichloro-2,6-dimethyl-1,2-oxazinan-3-one (5v)



5v

Yield (39 mg, 39%) as white solid via general procedure.
R_f = 0.50 (petroleum ether/ethyl acetate 3:1)
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.27 (m, 5H), 4.50 (s, 2H), 3.60 (t, J = 6.3 Hz, 2H), 3.24 (s, 3H), 3.05 (d, J = 15.2 Hz, 1H), 2.82 (d, J = 15.2 Hz, 1H), 2.14 – 1.96 (m, 2H), 1.42 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.7, 137.8, 128.5, 127.8, 127.6, 81.4, 79.1, 73.2, 65.3, 54.1, 39.3, 35.9, 24.8. **HRMS**: *m/z* calculated for $C_{15}H_{20}Cl_2NO_3$ $(M + H)^+$:332.0820, found:332.0828.

6-benzyl-4,4-dichloro-2-methyl-1,2-oxazinan-3-one (5w)

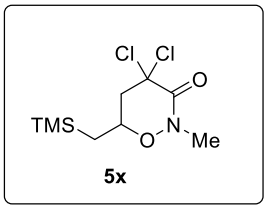


5w

Yield (17 mg, 21%) as white solid via general procedure.
R_f = 0.53 (petroleum ether/ethyl acetate 3:1)
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.21 (m, 5H), 4.63 (ddd, J = 13.1, 6.3, 3.5 Hz, 1H), 3.29 (s, 3H), 3.13-3.27 (m, 2H), 2.92 – 2.79 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.3, 135.3, 129.2, 128.7, 127.2, 78.5, 77.6, 49.9,

39.2, 35.5. **HRMS:** *m/z* calculated for $C_{12}H_{14}Cl_2NO_2$ $(M + H)^+$:274.0402, found:274.0407.

4,4-dichloro-2-methyl-6-((trimethylsilyl)methyl)-1,2-oxazinan-3-one (5x)



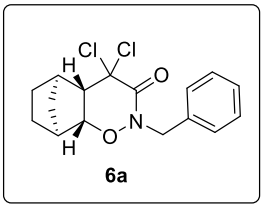
5x

Yield (66 mg, 82%) as colorless oil via general procedure.

R_f = 0.72 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.46 (dtd, *J* = 10.2, 7.4, 2.8 Hz, 1H), 3.27 (s, 3H), 3.01 (dd, *J* = 14.7, 2.8 Hz, 1H), 2.80 (dd, *J* = 14.7, 10.1 Hz, 1H), 1.12 – 1.01 (m, 1H), 0.99 – 0.89 (m, 1H), 0.10 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.5, 78.6, 76.3, 53.5, 35.4, 21.8, -0.9. **HRMS**: *m/z* calculated for $C_9H_{18}Cl_2NO_2Si$ $(M + H)^+$:270.0484, found:270.0482.

2-benzyl-4,4-dichlorohexahydro-2H-5,8-methanobenzo[e][1,2]oxazin-3(4H)-one (6a)



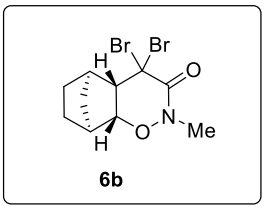
6a

Yield (84 mg, 86%) as white solid via general procedure.

R_f = 0.71 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.28 (m, 5H), 4.92 (d, *J* = 15.1 Hz, 1H), 4.71 (d, *J* = 15.1 Hz, 1H), 3.93 (d, *J* = 6.5 Hz, 1H), 2.77 (s, 1H), 2.58 (d, *J* = 6.5 Hz, 1H), 2.36 (d, *J* = 10.7 Hz, 1H), 2.28 (d, *J* = 3.4 Hz, 1H), 1.66 – 1.49 (m, 2H), 1.27 – 1.09 (m, 2H), 1.02 – 0.90 (m, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.5, 134.7, 128.7, 128.5, 128.1, 88.2, 82.4, 60.2, 51.3, 39.2, 39.0, 34.6, 28.8, 24.1. **HRMS**: *m/z* calculated for $C_{16}H_{18}Cl_2NO_2$ $(M + H)^+$:326.0715, found:326.0717.

4,4-dibromo-2-methylhexahydro-2H-5,8-methanobenzo[e][1,2]oxazin-3(4H)-one (6b)



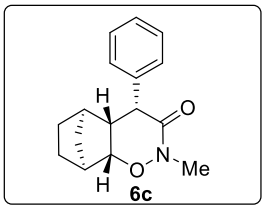
6b

Yield (79 mg, 78%) as white solid via general procedure.

R_f = 0.28 (petroleum ether/ethyl acetate 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.18 (d, *J* = 6.5 Hz, 1H), 3.30 (s, 3H), 2.83 (d, *J* = 6.5 Hz, 1H), 2.76 (d, *J* = 1.5 Hz, 1H), 2.45 (dd, *J* = 14.6, 3.6 Hz, 2H), 1.75 – 1.55 (m, 2H), 1.27 – 1.16 (m, 2H), 1.09 (ddd, *J* = 6.9, 4.5, 2.0 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.9, 87.8, 61.7, 58.1, 41.3, 39.4, 35.2, 34.4, 29.0, 24.4. **HRMS**: *m/z* calculated for $C_{10}H_{14}Br_2NO_2$ $(M + H)^+$:337.9391, found:337.9391.

2-methyl-4-phenylhexahydro-2H-5,8-methanobenzo[e][1,2]oxazin-3(4H)-one (6c)



6c

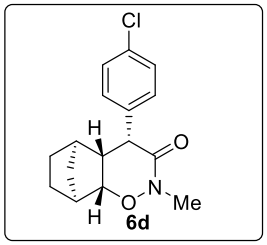
Yield (36 mg, 47%) as white solid via general procedure.

R_f = 0.40 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (t, *J* = 7.3 Hz, 2H), 7.32 (d, *J* = 7.3 Hz, 1H), 7.29-7.24 (m, 2H), 4.18 (d, *J* = 6.4 Hz, 1H), 3.48 (d, *J* = 11.3 Hz, 1H), 3.27 (s, 3H), 2.45 (d, *J* = 4.9 Hz, 1H), 2.15 (dd, *J* = 11.1, 6.4 Hz, 1H), 2.07 (d, *J* = 10.4 Hz, 1H), 2.02 (d, *J* = 3.3 Hz, 1H), 1.70 – 1.57 (m, 1H), 1.52 – 1.41 (m, 1H), 1.22 (d, *J* = 10.3 Hz, 1H), 1.20 – 1.12 (m, 1H), 1.11 – 1.00 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 172.4, 136.7, 129.8, 128.3, 127.1, 86.9, 53.4, 48.3, 40.9, 39.3, 32.9, 32.5, 28.1, 24.2.

HRMS: *m/z* calculated for $C_{16}H_{20}NO_2$ $(M + H)^+$:258.1494, found:258.1496.

4-(4-chlorophenyl)-2-methylhexahydro-2H-5,8-methanobenzo[e][1,2]oxazin-3(4H)-one (6d)



Yield (47 mg, 54%) as white solid via general procedure.

R_f = 0.44 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (d, J = 8.4 Hz, 2H), 7.18 (d, J = 8.4 Hz, 2H), 4.14 (d, J = 6.4 Hz, 1H), 3.43 (d, J = 11.2 Hz, 1H), 3.24 (s, 3H), 2.43 (d, J = 4.9 Hz, 1H), 2.11 – 1.98 (m, 2H), 1.96 (d, J = 3.3 Hz, 1H), 1.68 – 1.54 (m, 1H), 1.44 (tt, J = 12.2, 4.3 Hz, 1H), 1.24 – 1.08 (m, 2H), 1.07 – 0.95 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 171.9, 135.2, 133.0, 131.1, 128.4, 86.8, 53.5, 47.7, 40.8, 39.3, 32.9, 32.5, 28.0, 24.1. **HRMS**: *m/z* calculated for $C_{16}H_{19}ClNO_2$ $(M + H)^+$:292.1104, found:292.1107.

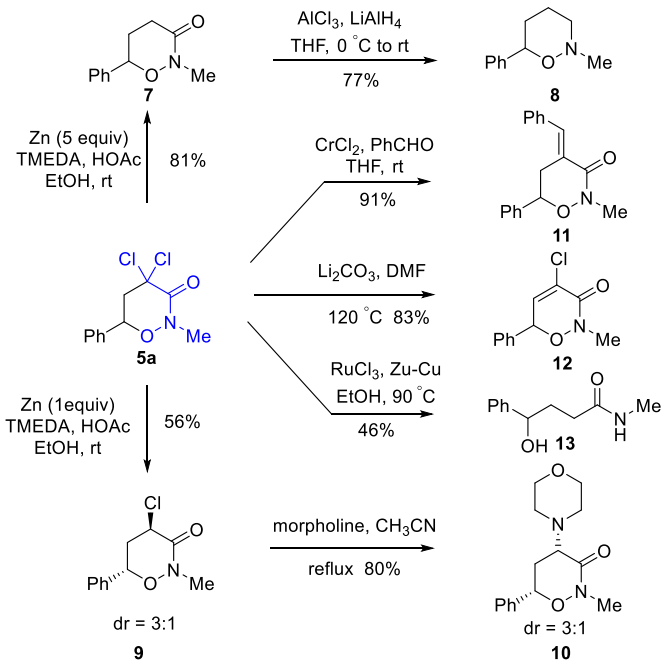
5. Diversification of the Cycloaddut 5a to other Compounds.

To demonstrate the versatility of the cycloaddtion products, the compound 5a was rapidly converted into different products (shown in Scheme S1).The two chlorine atoms could be removed under reductive conditions, providing 2-methyl-6-phenyl-1,2- oxazinan-3-one 7 in 81% yield, which could be further reduced to form tetra-hydro-1,2-oxazine 8 in 77% yield. Treatment of 5a with one equivalent of Zn in similar conditions gave mono chloro compound 9 in moderate yield (56%), which also was a valuable intermediate for further transformations. Other groups could be readily introduced to this intermediate 9 *via* nucleophilic substitution reaction. For example, refluxing 9 with morpholine in CH_3CN generated 10 in 80% yield. Another group could also be installed at the α position directly *via* Cr(II)-mediated olefination with aldehydes, forming new C-C bonds (11).[a] Exposure of 5a to basic conditions led to dihydro-1,2-oxazine 12 in 83% yield, which could then serve as a Michael receptor or coupling partner in further conversions. Finally, cleavage of the N-O bond could supply γ- hydroxy amide 13 as the product, which was not prepared easily by other methods.[b]

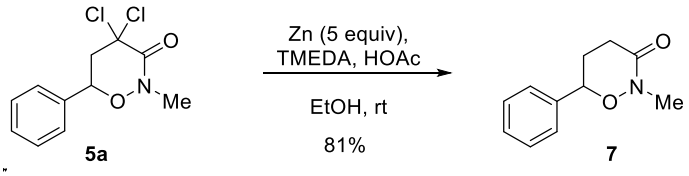
References:

a) D. K. Barma, H. Zhang, C. Mioskowski, J. R. Falck, *J. Am. Chem. Soc.* 2003, **125**, 218.

b) H. Fukuzawa, Y. Ura, Y. Kataoka, *J. Organomet. Chem*. 2011, **696**, 3643.

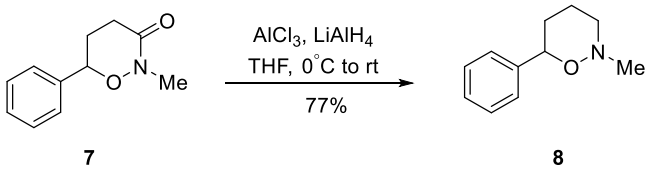


Scheme S1. Diversification of the cycloadduct **5a** to other compounds containing N-O bond.



To a stirred suspension of **5a** (65 mg, 0.25 mmol, 1.0 equiv), Zn powder (82 mg, 5.0 equiv), TMEDA (190 µL, 5.0 equiv) in EtOH (2 mL) at room temperature was added acetic acid (70 µL, 5.0 equiv) dropwise, the mixture was stirred for 2 hours and was filtered through Celite. The solvent was removed under reduced pressure, and the residue was dissolved in EtOAc (5mL) and washed with water (5 mL). The organic layer was separated, dried over $MgSO_4$, and concentrated under reduced pressure. The residue was purified by flash silica gel chromatography (petroleum ether/ethyl acetate 5:1) to give 39 mg (81%) of **7** as a white solid. R_f = 0.17 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.31 (m, 5H), 5.00 (t, J = 7.4 Hz, 1H), 3.23 (s, 3H), 2.64 (dt, J = 14.8, 7.5 Hz, 2H), 2.39 – 2.26 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 170.0, 138.8, 128.7, 128.6, 126.5, 80.7, 33.8, 29.5, 28.7. **HRMS**: *m/z* calculated for $C_{11}H_{16}NO(M + H)^+$: $C_{11}H_{14}NO_2$ 192.1025, found:192.1028.

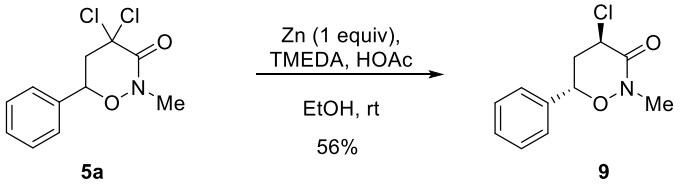


To a stirred suspension of **7** (38 mg, 0.20 mmol, 1.0 equiv), $AlCl_3$ (53 mg, 2.0 equiv) in dry THF (2 mL) at 0°C was added $LiAlH_4$ (12 mg, 1.5 equiv) , the mixture was stirred for 2 hours at room temperature. After completion,the reaction mixture was hydrolyzed with aq sat. Na_2CO_3 solution (5 mL) and the aqueous phase was extracted with ether (5 mL x 3). The combined organic phase was washed

with brine and dried with Na_2SO_4. The solvent was evaporated The residue was purified by flash silica gel chromatography(dichloromethane /methanol 40:1) to give 27 mg (77%) of **8** as colorless oil.

R_f= 0.50 (dichloromethane /methanol 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40-7.33 (m, 4H), 7.33 – 7.29 (m, 1H), 4.83 (d, J = 11.2 Hz, 1H), 3.03 (d, J = 11.6 Hz, 1H), 2.71 (s, 3H), 2.57 (t, J = 11.7 Hz, 1H), 2.12 – 1.96 (m, 1H), 1.96 – 1.82 (m, 2H), 1.64 (ddd, J = 16.8, 12.8, 4.5 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 141.3, 128.3, 127.7, 126.4, 81.1, 57.6, 46.9, 31.0, 24.4. **HRMS**: *m/z* calculated for $C_{11}H_{16}NO(M + H)^+$:178.1232, found:178.1234.

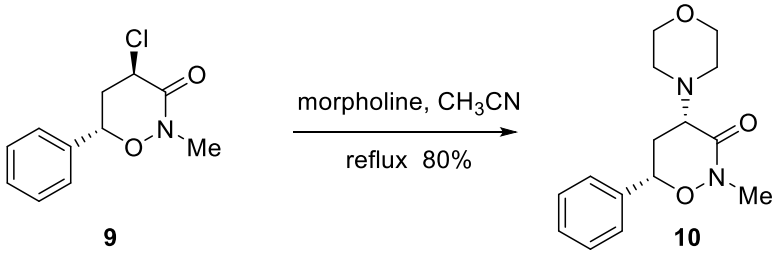


5a **9**

To a stirred suspension of **5a** (65 mg, 0.25 mmol, 1.0 equiv), Zn powder (17 mg, 1.0 equiv), TMEDA (38 μL, 1.0 equiv) in EtOH (2 mL) at room temperature was added acetic acid (14 μL, 1.0 equiv), the mixture was stirred for 2 hours and was filtered through Celite. The solvent was removed under reduced pressure, and the residue was dissolved in EtOAc (5 mL) and washed with water (5 mL). The organic layer was separated, dried over $MgSO_4$, and concentrated under reduced pressure. The residue was purified by flash silica gel chromatography (petroleum ether/ethyl acetate 6:1) to give 31 mg (56%) of **9** as colorless oil.

R_f= 0.38 (petroleum ether/ethyl acetate 3:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.34 (m, 5H), 5.28 (dd, J = 8.9, 5.5 Hz, 1H), 4.74 (t, J = 6.2 Hz, 1H), 3.30 (s, 3H), 2.90-2.82 (m, 1H), 2.65-2.59 (m, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.4, 137.3, 129.1, 128.9, 126.5, 78.4, 51.8, 40.2, 34.5. **HRMS**: *m/z* calculated for $C_{11}H_{13}ClNO_2(M + H)^+$: 226.0635, found:226.0639.



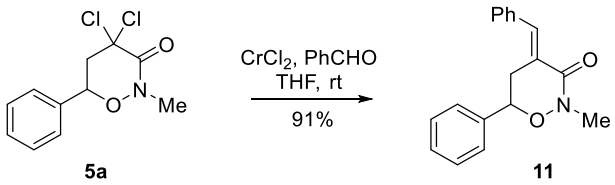
9 **10**

Morpholine (53 μL, 0.6 mmol, 3.0 equiv), **9** (45 mg, 0.2 mmol, 1.0 equiv) were dissolved in CH_3CN (2 mL) in tube. The mixture were refluxed overnight. After removing the acetonitrile under reduced pressure, the residue was dissolved in ethyl acetate and washed with aq sat. Na_2CO_3 solution. The organic layer was separated and concentrated under reduced pressure. The crude product was purified by flash silica gel chromatography (dichloromethane /methanol 50:1) to give 44 mg (80%) of **10** as colorless oil.

R_f= 0.58 (dichloromethane /methanol 10:1)

^{1}H NMR (400 MHz, $CDCl_3$, diastereomers) δ 7.45 – 7.31 (m, 5H, major + minor), 5.09 (dd, J = 10.1, 5.6 Hz, 1H, major + minor), 3.80 – 3.60 (m, 5H, major + minor), 3.24 (s, 0.74H, minor), 3.18 (s, 2.22H, major), 2.94 – 2.71 (m, 4H, major + minor), 2.64 – 2.27 (m, 2H, major + minor). **^{13}C NMR** (101 MHz, $CDCl_3$) major diastereomers:δ 169.4, 138.7, 128.8, 128.7, 126.5, 81.1, 67.3, 61.7, 49.8, 34.2, 32.5.

minor diastereomers: δ 171.3, 139.0, 128.8, 128.7, 126.4, 80.8, 67.3, 60.3, 49.9, 33.3, 33.1. **HRMS**: *m/z* calculated for $C_{15}H_{21}N_2O_3(M + H)^+$:277.1552, found:277.1560.

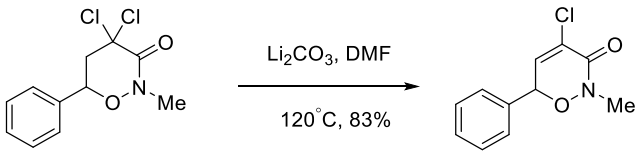


5a **11**

To a solution of of **5a** (65 mg, 0.25 mmol, 1.0 equiv), benzaldehyde (102 μL, 4.0 equiv), in THF (3 mL) at room temperature was added anhydrous $CrCl_2$ (246 mg, 8.0 equiv). After 10 hours, the resultant reaction mixture was quenched with water(5ml), extracted thrice with ether, and the combined extracts were evaporated under reduced pressure. The residue was purified by flash silica gel chromatography (petroleum ether/ethyl acetate 6:1) to give 64 mg (91%) of **11** as white solid.

R_f = 0.38 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (t, J = 2.2 Hz, 1H), 7.45 – 7.35 (m, 10H), 5.10 (dd, J = 8.4, 6.4 Hz, 1H), 3.41 (s, 3H), 3.26 – 3.22 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.1, 137.9, 136.9, 135.3, 130.0, 128.9, 128.8, 128.7, 128.5, 126.5, 125.0, 81.4, 35.9, 35.1. **HRMS**: *m/z* calculated for $C_{18}H_{18}NO_2$ $(M + H)^+$:280.1338, found:280.1345.

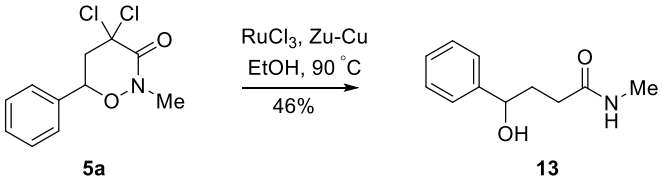


5a **12**

A mixture of **5a** (52 mg, 0.2 mmol, 1.0 equiv), Li_2CO_3(74 mg, 3.0 equiv) in DMF (2 mL) was heated at 120 °C for 1 day. The reaction mixture was added with water (5 mL), extracted with ether (5 mL × 3), and the combined extracts were evaporated under reduced pressure. The residue was purified by flash silica gel chromatography (petroleum ether/ethyl acetate 6:1) to give 37 mg (83%) of **12** as brown solid.

R_f = 0.25 (petroleum ether/ethyl acetate 3:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.34 (m, 5H), 6.90 (s, 1H), 3.99 (s, 1H), 2.74 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 164.8, 143.5, 135.2, 129.1, 129.0, 128.9, 125.8, 90.1, 24.6. **HRMS**: *m/z* calculated for $C_{11}H_{10}ClNNaO_2(M + Na)^+$: 246.0298, found:246.0306.



5a **13**

In glove box, compound **5a** (78 mg, 0.30 mmol, 1.0 equiv), $RuCl_3$ (62 mg, 1.0 equiv) and zinc-copper couple (58 mg, 3.0 equiv) were added into sealed tube with 3 mL anhydrous ethanol. The mixture was stirred at 90°C overnight. After completion, the mixture was then filtered through Celite and washed with ethyl acetate (5 mL × 3), The filtrate was concentrated under reduced pressure and the

crude product was purified via flash column chromatography (dichloromethane /methanol 50:1) to afford product **13** (27 mg, 46% yield) as colorless oil.

R_f = 0.53 (dichloromethane /methanol 10:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.30 (m, 4H), 7.29 – 7.23 (m, 1H), 6.16-5.92 (br, 1H), 4.75 (s, 1H), 4.45 – 4.11 (m, 1H), 2.77 (s, 3H), 2.35-2.25 (m, 2H), 2.16 – 1.87 (m, 2H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 174.3, 144.5, 128.3, 127.2, 125.7, 73.5, 34.3, 32.7, 26.4. **HRMS**: *m/z* calculated for $C_{11}H_{15}NNaO_2$ $(M + Na)^+$:216.1000 , found:216.1005.

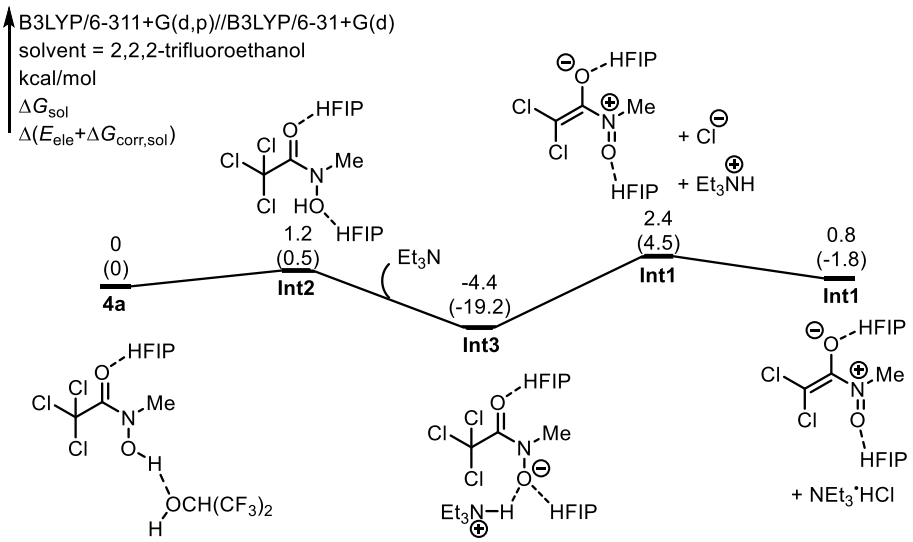
6. DFT Calculations

6.1 Computational methods

All calculations were performed with the Gaussian 09 program [4]. Unless otherwise specified, geometry optimizations of all minima and transition structures were carried out using the hybrid B3LYP functional [5] and the 6-31+G(d)[6] basis set in 2,2,2-trifluoroethanol (ε=26.726) solvent with CPCM[7] model (by IEFPCM calculations with radii and non-electrostatic terms for SMD solvation model[8]). Since there was no solvent model of hexafluoroisopropanol (HFIP) (ε=16.70), we used 2,2,2-trifluoroethanol (ε=26.726) solvent model to mimic the experimentally used solvent. Frequency calculations at the same level were performed to confirm that each stationary point was either a minimum or a transition structure and to evaluate its zero-point energy and the thermal corrections at 298 K. Quasiharmonic corrections were applied during the entropy calculations by setting all positive frequencies that are less than 100 cm^{-1} to 100 cm^{-1}.[9] A standard state of 298 K and 1 mol/L was used for calculating thermal corrections. The orbital analysis had been carried out at the above level by using the optimized structures obtained in solution. To improve the calculation accuracy, single-point energies calculations were carried out using the B3LYP functional and the 6-311+G(d,p)[6] basis set in 2,2,2-trifluoroethanol solvent with CPCM model (by IEFPCM calculations with radii and non-electrostatic terms for SMD solvation model). Transition-state structures were confirmed to connect their corresponding reactants and products by intrinsic reaction coordinate (IRC) calculations [10]. The computed structures were illustrated using CYLView[11]. In the present work, we used Gibbs free energies in solution (ΔG_{sol}) to discuss the reactions, which were a sum of the large basis set single-point energies, Gibbs free energy corrections, quasiharmonic corrections and 1.89 kcal/mol (conversion to the standard state of 298 K and 1 mol/L[12]).

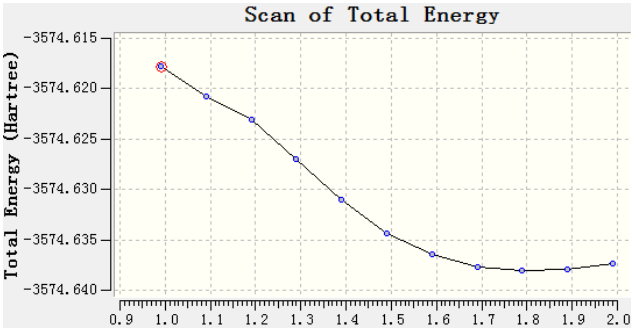
6.2 The formation of heterodiene intermediate

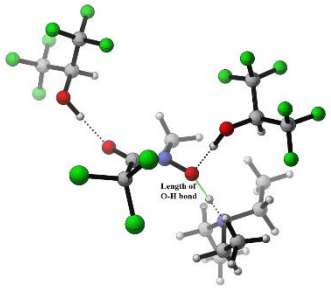
DFT calculations were used to understand how the heterodiene intermediate **Int1** was generated *in situ* (Scheme S1). We tried to locate the transition state of its generation in the presence/absence of alcohols and amines (free amines and protonated amines) but no transition states were located. Therefore, the required energy for its generation was estimated by scanning two bond breaking processes (one is O-H bond breaking and the other is C-Cl bond breaking in substrate **4a**). During the scan of the potential energy surface, only the single-point energy of each structure could be obtained. Due to this, we also gave single-point energies in solution ($\Delta(E_{ele}+\Delta G_{corr,sol})$) in parentheses to discuss the formation of heterodiene intermediate. Relaxed scans of potential energy surfaces were carried out at B3LYP/6-31+G(d) level in 2,2,2-trifluoroethanol solvent with CPCM model (by IEFPCM calculations with radii and non-electrostatic terms for SMD solvation model), and single-point energies used here were obtained at the same level.



Scheme S1

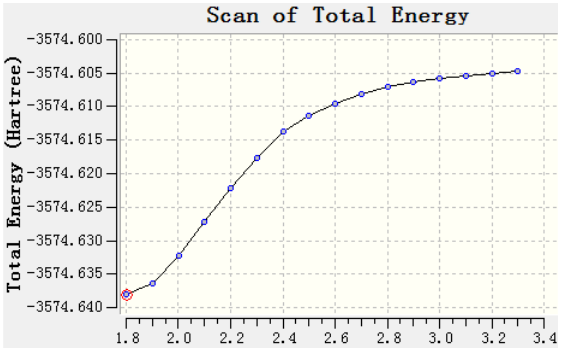
We propose that the generation of this heterodiene had the following two key steps. In the reaction system, one HFIP molecule and **4a** undergoes geometry change to form another complex **Int2**. The first key step in the reaction is the deprotonation by amine from **Int2**. This is a barrierless process, as it can be appreciated by Scheme S2. With the O-H bond lengthening, the single-point energy of this complex decreases. The deprotonation is exothermic by 19.7 kcal/mol (exergonic by 5.6 kcal/mol in terms of Gibbs free energy). A slight increase of the single-point energy in the O-H bond variation (from 1.8 Å to 2.0 Å), can be attributed to the breaking of the O-H hydrogen bonding interaction. The second key step is the dissociation of chloride and protonated amine. When the distance of the C-Cl bond increases, the single-point energy of **Int3** increases, as shown in Scheme S3. Moreover, due to an O-H distance of 2.09 Å in Scheme S5 at the last scan point, the hydrogen bonding interaction of **Int1** and Et_3NH^+ disappears. Nevertheless, the required energies of this dissociation are 23.7 kcal/mol (6.8 kcal/mol in terms of Gibbs free energy). Here we propose that dissociation of chloride anion can be assisted by one HFIP molecule (Scheme S4). In this case, this step only needs 17.0 kcal/mol energy (5.1 kcal/mol in terms of Gibbs free energy), which is much easier compared to the process in Scheme S3. Therefore, we propose that HFIP is also important for dissociation of chloride anion. Finally, a formation of the salt from chloride and protonated amine takes place. Thus, it is concluded that the heterodiene intermediate (**Int1**) formation is feasible and fast for this room temperature reaction. Based on these calculations, together with the experimental results, we propose that HFIP is very critical for the present reaction. Therefore, the formation of heterodiene can be described by deprotonation by amine, followed by dissociation of chloride anion assisted by HFIP (see Scheme S6). Since generation of heterodiene is a multi-component reaction, we further proposed this step could be a rate-determining step for the whole reaction process.

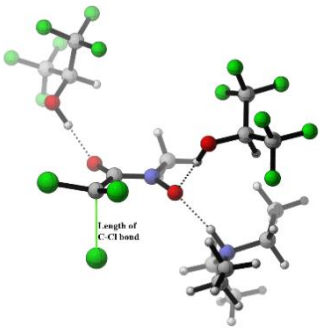




Length of the O-H bond

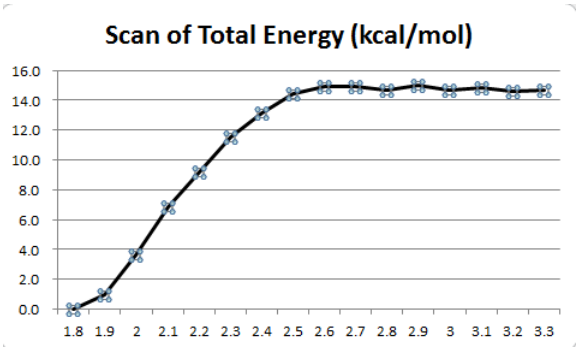
Scheme S2 Deprotonation process

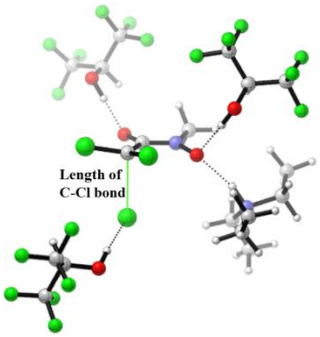




Length of the C-Cl bond

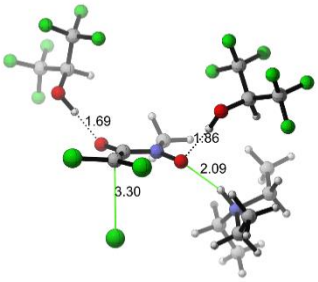
Scheme S3 Dissociation process of Cl anion and ammonium slat

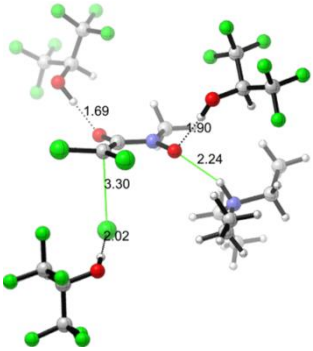




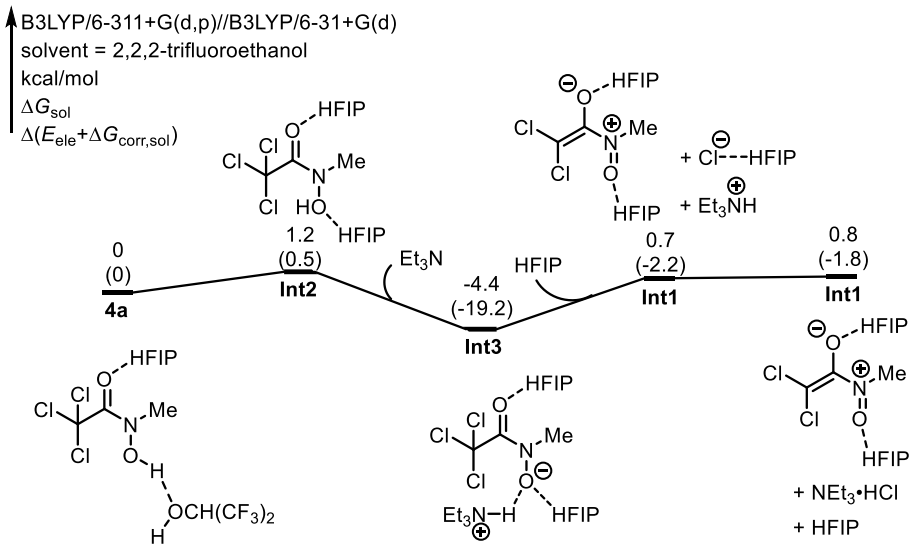
Length of the C-Cl bond

Scheme S4 Dissociation process of Cl anion (with another HFIP molecule) and ammonium slat





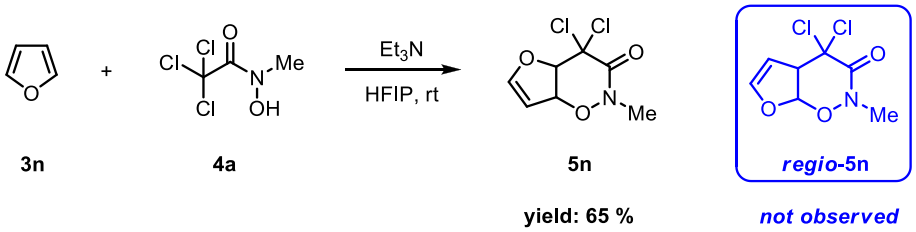
Scheme S5 The structure at the end of dissociation process



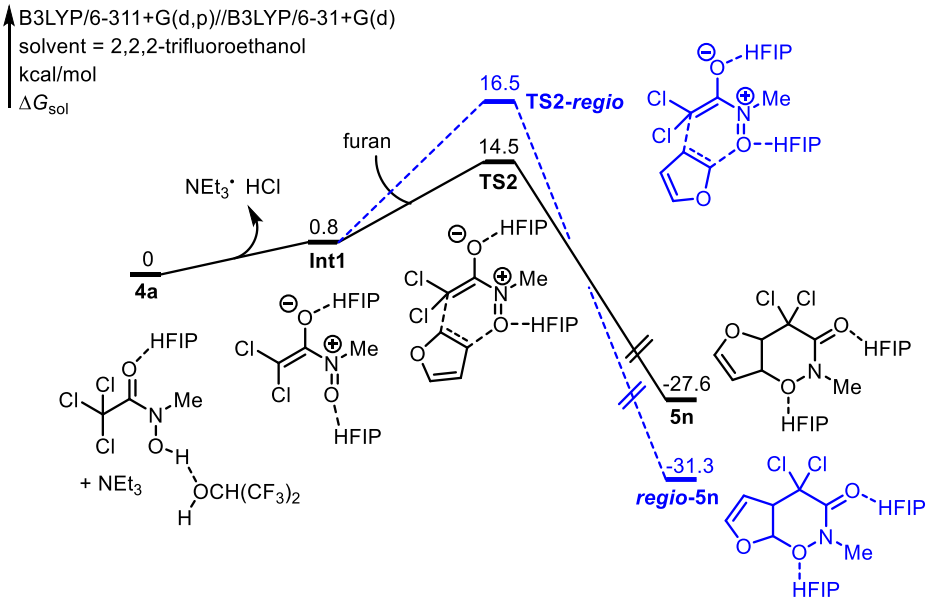
Scheme S6 The favored process of generation of heterodiene

6.3 Regiochemistry and orbital analysis: reactions of the heterodiene intermediate with styrene and furan

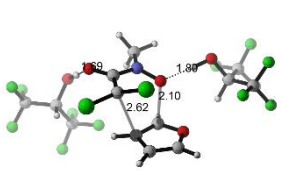
6.3.1 The reaction of the heterodiene intermediate with furan

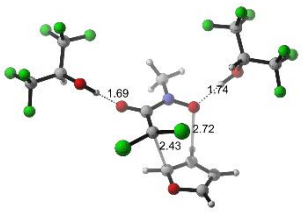


Scheme S7



Scheme S8



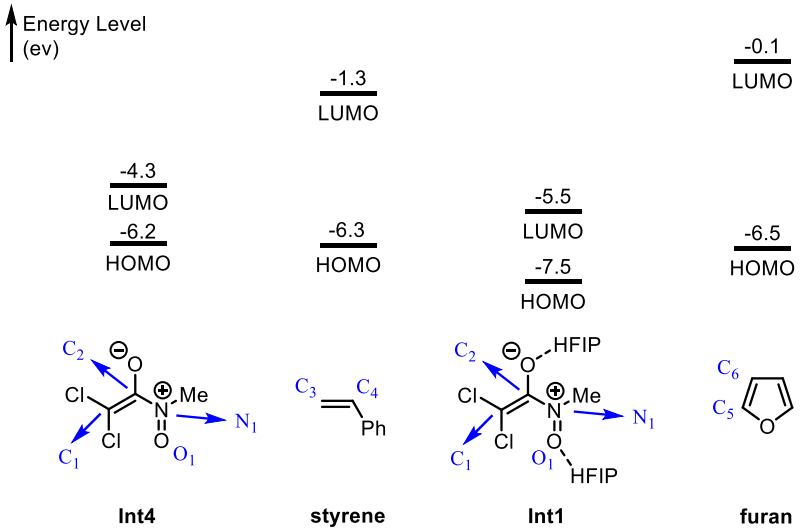


TS2-*regio* **TS2**

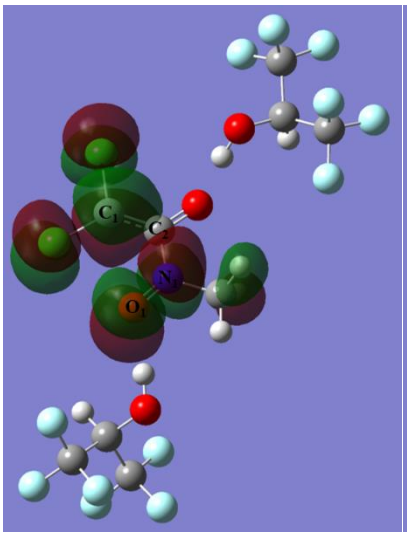
The reaction of **4a** and furan with two HFIP molecules was analyzed by DFT calculations. The product **5n** forms via a concerted pathway (through **TS2**) from **Int1** and furan, which has an activation free energy of 13.7 kcal/mol (14.5 kcal/mol with respect to substrates). Although the product ***regio*-5n** is more stable in thermodynamics, its formation pathway (through **TS2-*regio***) is kinetically disfavored by 2.0 kcal/mol comparing to **TS2**. This result is consistent with the fact that only product **5n** was observed.

6.3.2 Orbital discussion

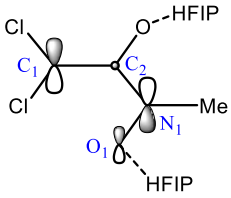
The frontier molecular orbitals of the reactants were also investigated. From Scheme S9, we can find that the interaction takes place between the highest occupied molecular orbital (HOMO) of the styrene and the lowest unoccupied molecular orbital (LUMO) of the heterodiene intermediate (**Int4**). A reduction of 1.2 eV in the HOMO-LUMO energy gap is found when two HFIP molecules are attached to **Int4** via hydrogen bonding interactions, which explains the HFIP molecules can accelerate the reaction. In addition, the orbital coefficient of the C_1 in LUMO of **Int1** is bigger than the O_1, which prefers to react with the C_3 in HOMO of the styrene rather than C_4. This result is also consistent with the experimental observation in which only product **5a** is obtained.



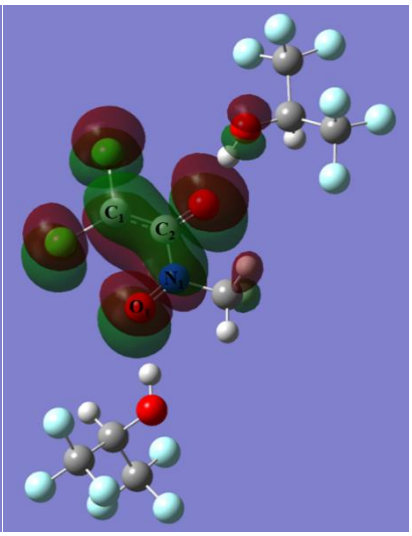
Scheme S9



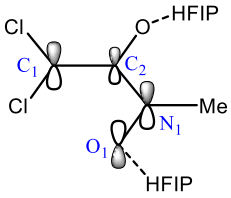
LUMO (Int1)



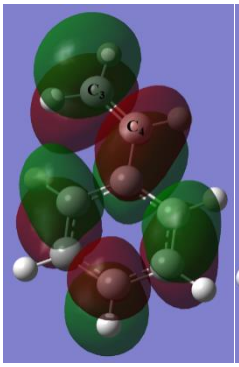
LUMO of **Int1**



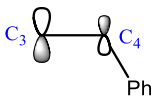
HOMO (Int1)



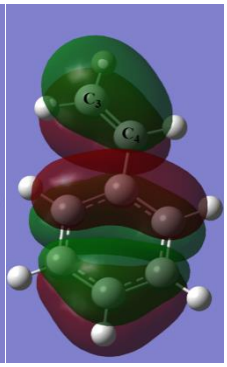
HOMO of **Int1**



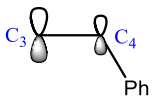
LUMO (styrene)



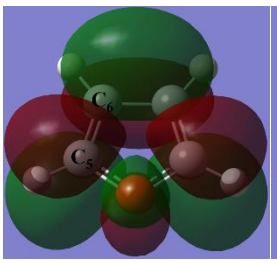
LUMO of **styrene**



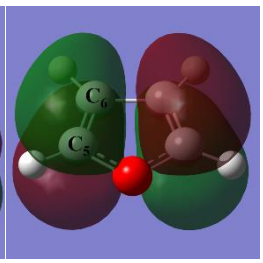
HOMO (styrene)



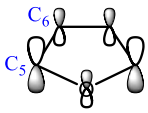
HOMO of **styrene**



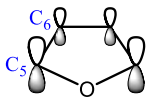
LUMO (furan)



HOMO (furan)



LUMO of **furan**



HOMO of **furan**

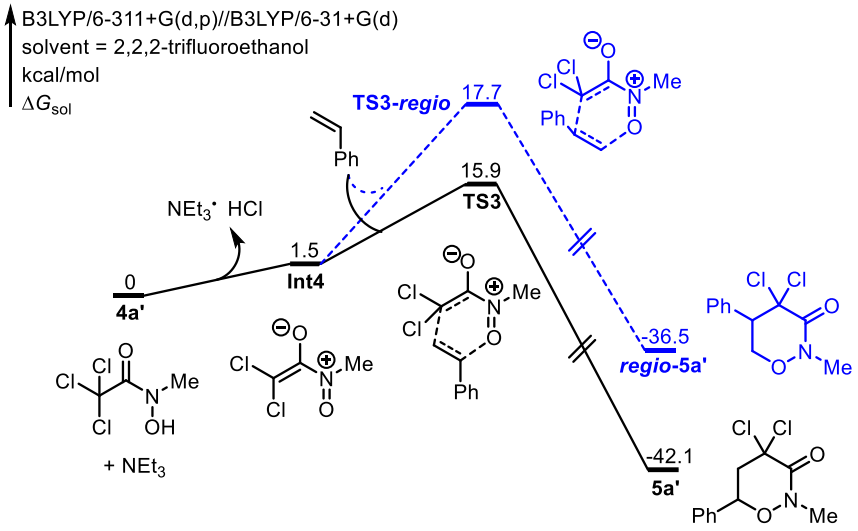
		Coefficients							
		Int1				**styrene**		**furan**	
		C_1	**C_2**	**N_1**	**O_1**	**C_3**	**C_4**	**C_5**	**C_6**
LUMO	$2p_z$	**-0.36**	-0.02	0.37	-0.34	0.29	-0.23	0.33	-0.19
	$3p_z$	**-0.31**	-0.01	0.31	-0.26	0.32	-0.24	0.40	-0.22
HOMO	$2p_z$	-0.27	-0.16	-0.22	0.29	**0.31**	0.21	**0.38**	0.23
	$3p_z$	-0.21	-0.10	-0.18	0.22	**0.22**	0.13	**0.25**	0.15

Orbital Coefficients

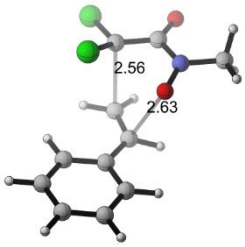
From Scheme S9, we can also find that the HOMO of furan and the LUMO of the heterodiene intermediate (**Int1**) dominate the [4+2] cycloaddition reaction, indicating that this [4+2] reaction is inverse-electron demanded. In addition, the HOMO-LUMO energy gap between them is calculated to be 1.0 eV. The orbital coefficient of the C_5 in HOMO of furan is bigger than that of C_6, which prefers to react with the C_1 in LUMO of the heterodiene intermediate (**Int1**) rather than C_2. The orbital analysis can explain the experimental observation that only product **5n** is obtained.

6.4 The computed potential energy profiles without HFIP

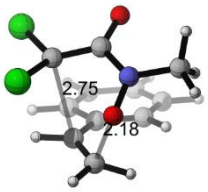
As indicated above, HFIP is very critical for the generation of the heterodiene. Here we want to know whether in the cycloaddition process, hydrogen bonding is important or not. The reaction of **4a'** and styrene was investigated by DFT calculations in the absence of HFIP molecules participation. In the presence of base, the substrate **4a'** loses one molecule of hydrogen chloride to form the heterodiene (**Int 4**), which is endergonic by 1.5 kcal/mol in terms of Gibbs free energy. The final product **5a'** can be obtained via a concerted pathway (through **TS3**) from **Int 4** and styrene, which has an activation free energy of 14.4 kcal/mol (15.9 kcal/mol with respect to substrates). Through a similar pathway (**TS3-*regio***), the regio-product ***regio*-5a'** can also be found. These completion pathways would give a calculated ratio >20:1 for **5a'**/***regio*-5a'**. The present process is only disfavored by 1.4 kcal/mol than the cycloaddition process with HFIP. This suggests that HFIP has just very small effect on the cycloaddition reaction, but it mainly affects the generation of heterodiene.



Scheme S10



TS3



TS3-*regio*

6.5 Energy data

	Gibbs Free Energy Corrections (a.u.)[a]	Quasiharmonic Corrections (kcal/mol)[a]	Single-Point Energies (a.u.)[b]
4a	0.127351	1.201507	-3282.786728
Et_3N	0.171993	0.042884	-292.507379
$Et_3N{\cdot}HCl$	0.184239	0.088859	-753.399054
Int1	0.115200	1.237758	-2821.893932
styrene	0.102247	0.033910	-309.738084
TS1	0.241343	1.401545	-3131.631332
TS1-*regio*	0.241091	1.489780	-3131.628814
5a	0.249143	1.364972	-3131.728008
***regio*-5a**	0.249264	1.369489	-3131.720183
Int2	0.128261	1.179298	-3282.785710
Int3	0.323464	1.553708	-3575.322702
Cl^-	-0.015023	0	-460.407687
$Et3NH^+$	0.188344	0.034681	-292.980895
HFIP	0.025073	0.093477	-790.069092
Cl^--HFIP	0.021042	0.222319	-1250.487630
furan	0.043408	0	-230.090312
TS2	0.180877	1.324720	-3051.981947
TS2-*regio*	0.182467	1.255942	-3051.980218

5n	0.187512	1.264927	-3052.055501
***regio*-5n**	0.185761	1.417024	-3052.059939
4a'	0.040142	0.056055	-1702.635742
Int4	0.028642	0.079664	-1241.742480
TS3	0.153014	0.240343	-1551.477041
TS3-*regio*	0.154034	0.186944	-1551.475107
5a'	0.160840	0.168873	-1551.577250
***regio*-5a'**	0.161533	0.158960	-1551.568874

[a]Computed at the B3LYP/6-31+G(d) level.

[b]Computed at the B3LYP/6-311+G(d,p) level.

6.6 Cartesian coordinates of all stationary points

4a

C	-0.42195400	1.09756100	-0.16212900
N	0.41611100	0.11679200	-0.52169200
C	-0.04014300	-1.21709500	-0.90530400
H	-0.31581000	-1.23533900	-1.96578100
H	0.78111100	-1.91283900	-0.72304500
H	-0.89500700	-1.49558200	-0.28904800
O	-1.63767500	0.92328300	-0.01977900
C	0.17279300	2.52846900	0.09846800
Cl	1.52517000	2.48270900	1.28604100
Cl	0.71851500	3.24362900	-1.46505800
Cl	-1.11613200	3.57854300	0.77436400
O	1.70895500	0.43722000	-0.92286400
H	2.31061800	-0.01378000	-0.27854000
C	-4.66237800	-0.61689300	0.16314100
H	-4.40299200	0.11824000	0.93298500
C	-4.89285500	-1.95791900	0.88565400
C	-5.91275200	-0.08446500	-0.56074900
O	-3.64387000	-0.79101400	-0.78275800
H	-2.87560000	-0.22144400	-0.54078500
F	-5.21905400	-2.95788200	0.03510800
F	-3.75674900	-2.32947400	1.51884400
F	-5.86802800	-1.88530900	1.81941800
F	-6.32441000	-0.90272700	-1.55571500
F	-5.63562900	1.11473900	-1.12083900
F	-6.95888800	0.09379400	0.27750800
C	4.70286500	-1.29105200	0.71897300
H	5.10299800	-1.78469200	1.60995500
C	5.59549100	-0.06996200	0.43600000
C	4.69527900	-2.33963800	-0.41251500
O	3.39565900	-0.81337100	0.92416600
H	2.99017800	-1.25546000	1.69048700

F	5.17026300	0.64600700	-0.62856800
F	5.58426800	0.75666700	1.50402800
F	6.87764900	-0.42372900	0.20722500
F	4.24574000	-1.84236100	-1.58522000
F	3.87592600	-3.35913400	-0.07030500
F	5.92232000	-2.85977100	-0.63088700

Et_3N

N	0.16380100	0.02448000	0.39211600
C	-0.90498200	-0.94308200	0.71135900
H	-0.47966400	-1.66031900	1.42477000
H	-1.69537400	-0.40875700	1.25032500
C	1.36401800	-0.63853600	-0.14950800
H	1.47129800	-1.59813500	0.37012000
H	1.24522400	-0.87405800	-1.22375300
C	-0.27861500	1.12704800	-0.47920600
H	0.59127400	1.76582200	-0.66228400
H	-0.59857700	0.75167400	-1.46968400
C	-1.38935700	1.99196000	0.11692000
H	-1.56552800	2.85760700	-0.53409000
H	-2.33973200	1.45434200	0.21031100
H	-1.10923500	2.36726700	1.10975800
C	-1.53287000	-1.71871800	-0.45789000
H	-0.78839600	-2.30751500	-1.00750500
H	-2.28429000	-2.41707600	-0.06621300
H	-2.03855200	-1.05806000	-1.17242200
C	2.65321200	0.16202300	0.04747400
H	3.50716600	-0.41597200	-0.32938500
H	2.64254600	1.11695700	-0.49052400
H	2.82679700	0.37069200	1.11086800

$Et_3N{\cdot}HCl$

N	-0.33892100	0.17769500	-0.03775400
C	-1.02022900	-0.57823000	-1.16028300
H	-0.51611600	-0.25610600	-2.07507200
H	-0.78266500	-1.63232500	-1.00660500
C	-0.37227500	1.67201600	-0.27756600
H	-0.04359100	1.80975600	-1.31092200
H	-1.41411100	1.98898300	-0.19893100
C	-0.82734400	-0.18884000	1.34545700
H	-0.15274000	0.31205200	2.04132300
H	-1.82307200	0.24663100	1.46157100
C	-0.83283300	-1.68632500	1.62200200
H	-1.06920400	-1.83028500	2.68263200

H	-1.58670000	-2.22206700	1.03749600
H	0.14825900	-2.13569900	1.43290500
C	-2.52377300	-0.36455700	-1.26231700
H	-2.78636100	0.67722100	-1.47105000
H	-2.88952800	-0.97207800	-2.09829800
H	-3.05334800	-0.68847400	-0.36059000
C	0.51618500	2.46794300	0.67001200
H	0.54289800	3.50417400	0.31350700
H	0.13581800	2.48174600	1.69573900
H	1.54345100	2.08726900	0.67580000
Cl	2.69483500	-0.73141800	-0.47537600
H	0.66886300	-0.11259700	-0.09766400

Int1

C	-0.43565100	2.41168100	0.14569500
C	-0.63051600	1.02238100	0.35742900
N	0.44885100	0.14026400	0.10193100
C	0.19216100	-1.28735900	0.34647100
H	-0.64403500	-1.60419900	-0.28424100
H	1.10680100	-1.82540200	0.10618000
H	-0.09211600	-1.41514600	1.39552200
O	-1.71101500	0.52052400	0.77574900
O	1.57422300	0.49513500	-0.30104300
Cl	-1.77477100	3.41837600	0.48856000
Cl	0.96309500	3.20745700	-0.39923700
C	4.95544000	-0.36394900	0.00616900
H	4.62826200	0.62189000	0.35407400
C	5.99295600	-0.12202600	-1.10534500
C	5.52117100	-1.10578100	1.23125000
O	3.90450400	-1.12466900	-0.52713500
H	3.06953100	-0.61361700	-0.46332800
F	6.47799000	-1.27302900	-1.62377000
F	5.41605400	0.56030600	-2.12025400
F	7.04665900	0.60795500	-0.67660200
F	5.94510100	-2.35465700	0.93303500
F	4.55457400	-1.22703300	2.16958400
F	6.55663000	-0.44963800	1.80138900
C	-4.78468200	-0.66364400	0.13876600
H	-4.39134400	-0.77465600	1.15580300
C	-4.96757600	-2.08598200	-0.42429300
C	-6.10137100	0.12575400	0.25332100
O	-3.91842500	0.04686600	-0.70064100
H	-3.08066200	0.25025300	-0.20576100
F	-5.49095400	-2.09050000	-1.67190500

F	-3.76524700	-2.70117400	-0.49528900
F	-5.76577800	-2.85323500	0.35275100
F	-6.66755200	0.36847200	-0.95085800
F	-5.86132500	1.32642200	0.82759200
F	-7.02234800	-0.50826800	1.01405300

styrene

C	2.26956700	0.26299100	0.00001900
C	1.78433700	-1.04821600	0.00002000
C	0.40679700	-1.28509000	0.00000100
C	-0.51597700	-0.22124000	-0.00002500
C	-0.01046700	1.09519600	-0.00003100
C	1.36396100	1.33299300	-0.00000500
H	3.34037100	0.45215500	0.00003800
H	2.47591600	-1.88758900	0.00003900
H	0.03641800	-2.30850000	0.00000300
H	-0.69459800	1.93980100	-0.00005900
H	1.73176500	2.35653100	-0.00001100
C	-1.95754200	-0.53233300	-0.00003700
H	-2.18885200	-1.59841400	-0.00011200
C	-2.98181500	0.33709000	0.00004700
H	-2.84496900	1.41678600	0.00013500
H	-4.00921600	-0.01912000	0.00003100

TS1

C	-0.67240700	-1.99537700	0.54004100
C	-1.03695000	-0.98214400	-0.41732100
N	-0.04347500	-0.12770500	-0.86075300
C	-0.41468700	0.92010600	-1.82060400
H	-0.71563600	0.44713400	-2.76254000
H	0.46242900	1.54812400	-1.96692200
H	-1.25489500	1.49484000	-1.42480900
O	-2.19510300	-0.89247800	-0.92108700
O	1.18646000	-0.32624800	-0.59847100
Cl	-1.91972100	-3.11695000	0.93991000
Cl	0.56402500	-1.86386800	1.72363200
C	3.42376000	2.23119400	0.10702400
H	2.65078500	2.03005900	0.85689200
C	4.77510900	1.87753500	0.75576000
C	3.29526900	3.71558200	-0.27997600
O	3.26620500	1.45692000	-1.05020500
H	2.49494300	0.85292700	-0.93504000
F	5.82200100	2.08230100	-0.07613300
F	4.78379600	0.56834800	1.09247100

F	5.00887200	2.58503000	1.88420000
F	4.19339400	4.08697500	-1.22076200
F	2.06456600	3.94373600	-0.79225300
F	3.45008700	4.54278100	0.77825700
C	-5.20674200	0.50323300	-0.21955500
H	-4.80625000	0.71978000	-1.21669700
C	-6.60839000	-0.09925800	-0.42189900
C	-5.21998400	1.83621800	0.55375300
O	-4.43043900	-0.42322700	0.48495600
H	-3.58853700	-0.60299600	-0.01731500
F	-7.20919100	-0.42151600	0.74666700
F	-6.51364200	-1.23702400	-1.14649200
F	-7.43923400	0.73416100	-1.08857800
F	-5.69872000	1.70406600	1.81195000
F	-3.95679900	2.31038300	0.65738400
F	-5.95702000	2.78829800	-0.06237400
C	5.54378400	-3.45900300	0.36057100
C	5.41961600	-2.53504700	-0.68404000
C	4.18132700	-2.33180000	-1.29118900
C	3.03976700	-3.04836100	-0.87076800
C	3.18257000	-3.97846100	0.18361100
C	4.42102000	-4.17840500	0.79050300
H	6.50855200	-3.61980700	0.83534000
H	6.28688800	-1.97310500	-1.02149700
H	4.08470100	-1.60956400	-2.09869800
H	2.32721600	-4.55510000	0.52267600
H	4.51400700	-4.89949800	1.59882700
C	1.77137000	-2.80491000	-1.55356700
H	1.82072100	-2.11265200	-2.39133200
C	0.57413500	-3.40630800	-1.28529000
H	0.48310300	-4.20921600	-0.55991000
H	-0.27826400	-3.23944900	-1.93680100

TS1-*regio*

C	-0.45895500	1.67575400	-0.51308800
C	-0.90857100	0.66181700	0.38720300
N	0.02078400	-0.27686100	0.82153300
C	-0.41382400	-1.30909300	1.76666800
H	-0.63940600	-0.84501200	2.73473000
H	0.40368500	-2.02244800	1.86712500
H	-1.31175400	-1.79637600	1.38307500
O	-2.08324400	0.61674900	0.85955100
O	1.27951700	-0.05021500	0.69400400
Cl	-1.55741800	2.96627000	-0.82204500

Cl	0.80265800	1.52797500	-1.66925200
C	3.88039400	-2.21692000	-0.05515700
H	3.38773900	-1.71624500	-0.89576900
C	5.31876400	-1.66897200	0.00879900
C	3.80912200	-3.72921200	-0.33210600
O	3.24648100	-1.96706200	1.16921800
H	2.52177800	-1.31289600	1.03401200
F	6.04778600	-2.22794600	1.00120500
F	5.28255200	-0.33732700	0.24330100
F	5.99459000	-1.85505100	-1.14772500
F	4.34453100	-4.46528700	0.66792600
F	2.51618600	-4.10610500	-0.45503400
F	4.44143800	-4.07634000	-1.47549800
C	-4.99436500	-0.83156900	0.16274300
H	-4.49599700	-1.09252000	1.10355600
C	-6.39226500	-0.30552800	0.53610600
C	-5.02255100	-2.11331200	-0.69118900
O	-4.31845700	0.16991600	-0.54281400
H	-3.46384900	0.37882000	-0.07260800
F	-7.11556000	0.07079900	-0.54328300
F	-6.26712600	0.78259100	1.32993100
F	-7.12441100	-1.21687300	1.21643800
F	-5.60864700	-1.92568800	-1.89593700
F	-3.75545900	-2.52581700	-0.92647000
F	-5.66925800	-3.13167800	-0.07927600
C	3.01907800	5.76976500	-0.87169600
C	1.80290100	5.99387800	-0.21486300
C	1.23412100	4.98649600	0.56225200
C	1.87288400	3.73317900	0.70851200
C	3.09778800	3.52173900	0.03231400
C	3.66113400	4.53068900	-0.74560200
H	3.46502800	6.55508300	-1.47690700
H	1.30074600	6.95351900	-0.30823500
H	0.29501700	5.16488900	1.08036700
H	3.61159700	2.56889900	0.11913200
H	4.60365400	4.35222700	-1.25726800
C	1.24932300	2.72592700	1.55304900
H	0.28382200	2.99349100	1.97752000
C	1.85378700	1.56920800	2.00968800
H	2.89496900	1.34749000	1.80131800
H	1.40183800	1.02127600	2.82959800

5a

C	-0.57104900	-1.58505600	1.02946500

C	-0.73072000	-0.47463800	-0.03642100
N	0.27721000	-0.31265000	-0.90909500
C	0.26735500	0.64751300	-2.00376300
H	0.80853600	0.20721700	-2.84386400
H	-0.76798300	0.83802100	-2.28668500
H	0.74573500	1.58384200	-1.69679300
O	-1.78600300	0.17063600	-0.14388700
O	1.56350100	-0.85404000	-0.70473300
Cl	-1.69808100	-2.92377300	0.49097300
Cl	-1.16120800	-0.93964200	2.61218500
C	3.30661500	-3.57155100	-1.28908500
C	2.91986700	-2.76149300	-0.21014500
C	3.85707900	-2.46415400	0.79145400
C	5.15618200	-2.97349000	0.71335500
C	5.53303700	-3.78211400	-0.36418500
C	4.60526600	-4.08072700	-1.36710300
H	2.58474400	-3.80667600	-2.06797900
H	3.58529500	-1.83610800	1.63458700
H	5.87342800	-2.73777300	1.49558200
H	6.54409300	-4.17809500	-0.42050700
H	4.88954900	-4.71007400	-2.20672200
C	1.50768100	-2.23055400	-0.18271100
H	0.89419300	-2.80401300	-0.88424700
C	0.84634200	-2.13268300	1.18649600
H	0.81832500	-3.10093900	1.69285000
H	1.41195300	-1.43373800	1.80978900
C	3.64461800	1.98848200	-0.22636500
H	3.10057800	1.94870700	-1.17646800
C	5.13785700	1.80223500	-0.56064800
C	3.32226000	3.34821800	0.41787100
O	3.24985500	0.98307300	0.66686900
H	2.67900000	0.33317700	0.19985700
F	5.92902600	1.84298700	0.53501400
F	5.32059000	0.59287800	-1.13857500
F	5.59400800	2.73525500	-1.42664100
F	3.92270500	3.50881200	1.61898000
F	1.98975700	3.44922100	0.62233600
F	3.69068800	4.38782900	-0.36381400
C	-5.13230000	0.52320500	-0.38257800
H	-4.51536600	0.66250200	-1.27741200
C	-5.87294300	1.85104600	-0.13986400
C	-6.06996800	-0.66373100	-0.67177100
O	-4.37200600	0.23088200	0.75708800
H	-3.42260000	0.14223600	0.49974300

F	-6.65572600	1.81693500	0.96281800
F	-4.97212100	2.84318000	0.04367200
F	-6.65676500	2.20635700	-1.18291900
F	-6.89476100	-0.94230600	0.36325600
F	-5.33309300	-1.77390400	-0.90283500
F	-6.84185100	-0.45936900	-1.76334400

***regio*-5a**

C	-0.06022400	1.56709000	-0.15202100
C	-0.39265500	0.21222100	-0.83708900
N	0.41726500	-0.20292000	-1.82513700
C	0.22174000	-1.42825700	-2.58656900
H	-0.84206200	-1.66445500	-2.59499200
H	0.78226400	-2.25360900	-2.13413700
H	0.57253800	-1.25189500	-3.60568900
O	-1.42963100	-0.40893500	-0.55653200
O	1.71462400	0.31241600	-2.01224300
Cl	-0.37654400	1.37730100	1.61892800
Cl	-1.29576800	2.72715200	-0.83374200
C	2.27626500	3.71413600	1.29912100
C	1.70179400	3.48522000	0.03849500
C	1.48223700	4.58258600	-0.81040300
C	1.81569400	5.87669900	-0.39878500
C	2.37175900	6.09490200	0.86542000
C	2.60355600	5.00797000	1.71377700
H	2.47502400	2.87286000	1.95842800
H	1.05323000	4.44205100	-1.79792700
H	1.64039000	6.71370700	-1.07030900
H	2.62935300	7.10239800	1.18304500
H	3.04563200	5.16312400	2.69498700
C	1.39171400	2.05737100	-0.38393000
H	2.00647600	1.38824600	0.23047800
C	1.76600800	1.74429000	-1.83238300
H	1.12149500	2.21829900	-2.57915500
H	2.80957900	1.99567100	-2.02853500
C	-4.63136800	-1.01958100	0.05019900
H	-4.14043700	-1.42083900	-0.84336500
C	-5.83705500	-0.19456900	-0.43588600
C	-5.02014200	-2.22623800	0.92509700
O	-3.79050100	-0.18036600	0.79310700
H	-2.90166000	-0.15586900	0.36237200
F	-6.52223000	0.37484500	0.58186900
F	-5.40602500	0.80802000	-1.23452100
F	-6.71439200	-0.93191800	-1.15405000

F	-5.62788300	-1.86029300	2.07689700
F	-3.90682300	-2.91455000	1.26526600
F	-5.84498300	-3.08639000	0.28545100
C	3.68575500	-2.07382100	0.01431200
H	2.61789000	-2.28795100	0.13186500
C	4.24796500	-1.82959500	1.42643600
C	4.31029400	-3.28888500	-0.69782300
O	3.93040300	-0.93029300	-0.75926300
H	3.08859000	-0.59033100	-1.13510400
F	5.57568200	-1.57186900	1.42245000
F	3.63623400	-0.75797600	1.97840200
F	4.03955700	-2.88159100	2.24927200
F	5.63146700	-3.12887100	-0.93622400
F	3.70885900	-3.46410100	-1.89697000
F	4.15842000	-4.43625100	0.00076400

Int2

C	-0.52002000	1.74261200	0.45163200
N	0.15525100	0.91266700	1.26143900
C	-0.40320600	-0.33319000	1.78158800
H	-0.30125100	-1.13900000	1.04721400
H	0.14515100	-0.58376800	2.69207500
H	-1.45333100	-0.17023400	2.02389700
O	-1.70218900	1.55373200	0.15310400
C	0.22046600	3.00876300	-0.11346500
Cl	0.97087200	3.98272000	1.20341300
Cl	1.46574400	2.48902800	-1.30932000
Cl	-0.97306500	4.04581400	-0.95595000
O	1.54276200	1.02761400	1.33988500
H	1.74653300	1.23465600	2.27598900
C	3.94440000	-1.16683100	-0.23605600
H	3.51456100	-0.53300800	-1.02000000
C	4.08221700	-2.57830200	-0.82952700
C	5.29026500	-0.52800300	0.16506600
O	3.11747700	-1.27326000	0.89115500
H	2.53282700	-0.48480500	0.95164500
F	4.51596700	-3.48151700	0.07809500
F	2.87821900	-3.00532500	-1.27177100
F	4.93459200	-2.61279300	-1.87735700
F	5.96372000	-1.25570700	1.08413500
F	5.06150700	0.68906100	0.71105900
F	6.11176200	-0.34551500	-0.89327500
C	-4.33932600	-0.76270800	0.14606100
H	-4.38669400	-0.02054000	0.95113900

C	-4.44244700	-2.14823200	0.80952200
C	-5.50241200	-0.45047200	-0.81542400
O	-3.13561800	-0.70757600	-0.56904800
H	-2.60620700	0.06586200	-0.26425700
F	-4.38803100	-3.16023800	-0.08621300
F	-3.40983800	-2.31937100	1.66573300
F	-5.58350200	-2.29544600	1.51940400
F	-5.55779100	-1.30567000	-1.86192300
F	-5.34474500	0.79223700	-1.32494200
F	-6.70605800	-0.48441300	-0.19998700

Int3

C	0.28138800	-2.12181200	-1.67577400
H	-3.09348800	-1.55063700	0.70752700
O	-1.69846400	-0.79180800	-0.13760200
Cl	-0.94046900	-3.45582100	-1.61683300
Cl	1.81015900	-2.81855700	-2.32520300
Cl	-0.25540900	-0.83755400	-2.82255400
C	0.54109900	-1.55924200	-0.24542200
O	1.66856800	-1.73222700	0.29326000
N	-0.44635600	-0.93024800	0.37550300
C	-0.20800800	-0.39233700	1.71891700
H	0.71082500	0.19996700	1.73316700
H	-1.06071200	0.23700900	1.96959700
H	-0.11823900	-1.20584000	2.44774900
N	-3.90891000	-2.04864700	1.14608900
C	-3.29638900	-2.87997700	2.25578300
H	-2.59319300	-3.55399800	1.76018000
H	-2.71520700	-2.19046100	2.87078600
C	-4.51407400	-2.92057300	0.06724500
H	-3.77373400	-3.69743700	-0.13588100
H	-5.40189800	-3.39393600	0.49170000
C	-4.88457700	-0.99854300	1.62710700
H	-5.15421200	-0.41530400	0.74555600
H	-5.77845500	-1.52477300	1.97194200
C	-4.32570600	-0.07921300	2.70371800
H	-5.06216200	0.71190300	2.88533200
H	-4.15211100	-0.59507000	3.65302200
H	-3.39307300	0.39761200	2.38388200
C	-4.29297500	-3.65794000	3.10258000
H	-4.85514500	-4.39425300	2.51918500
H	-3.72721800	-4.20330100	3.86693000
H	-5.00101500	-3.00243500	3.61926400
C	-4.85381500	-2.16407300	-1.21091200

H	-5.11834300	-2.90056600	-1.97846100
H	-5.70867400	-1.49194900	-1.09044400
H	-3.99878600	-1.58703700	-1.57934800
C	4.51532000	0.01657600	0.72644400
H	3.83734700	-0.05435500	1.58455000
C	4.65757500	1.51377300	0.39451500
C	5.83749800	-0.65213500	1.14586200
O	4.02424700	-0.64496000	-0.40488200
H	3.13706800	-1.04337300	-0.19571300
F	5.45350600	1.73623600	-0.67611600
F	3.44129200	2.02685100	0.09920000
F	5.15661800	2.23164200	1.42699300
F	6.76685800	-0.63077400	0.16299800
F	5.60965900	-1.95020800	1.44882900
F	6.39063100	-0.07590100	2.23765600
C	-2.15432500	2.54998400	-0.13741700
H	-2.06943100	2.14659600	0.87933400
C	-3.49130300	3.30998700	-0.19620600
C	-0.92829700	3.45982000	-0.35086600
O	-2.16349500	1.55773300	-1.11553200
H	-1.94502100	0.64644900	-0.70103900
F	-3.72474500	3.86619000	-1.40785800
F	-4.51052800	2.45484500	0.05062900
F	-3.56926400	4.30026700	0.72343400
F	-0.90608200	4.02751300	-1.57907100
F	0.20286900	2.72632200	-0.23287500
F	-0.85174100	4.46086300	0.55759100

Et_3NH^+

N	0.15349700	0.02006600	0.36686600
C	-0.91914900	-0.99869200	0.71670700
H	-0.44495200	-1.68151500	1.42598500
H	-1.70094500	-0.45309500	1.24768300
C	1.40845900	-0.63575600	-0.18388600
H	1.50938900	-1.58945100	0.33908300
H	1.22374300	-0.83540300	-1.24137500
C	-0.32970100	1.14996700	-0.52044500
H	0.53819200	1.78961100	-0.68725200
H	-0.61382600	0.70171000	-1.47425700
C	-1.46503700	1.95322200	0.09617800
H	-1.64149900	2.83087200	-0.53582400
H	-2.40133800	1.38990100	0.15238300
H	-1.20481900	2.31079900	1.10002100
C	-1.48084500	-1.75053600	-0.47890700

H	-0.70696000	-2.29754900	-1.02681700
H	-2.20260800	-2.48338100	-0.10046700
H	-2.01114100	-1.09331400	-1.17549500
C	2.65433800	0.21338700	0.02422000
H	3.51956200	-0.35946400	-0.32820300
H	2.62760900	1.15315700	-0.53583400
H	2.80934700	0.43730100	1.08672000
H	0.41737300	0.44980800	1.26238500

HFIP

C	-0.00061000	0.56326700	-0.48938800
H	0.00109300	0.56380500	-1.58410700
C	-1.28965300	-0.14777900	-0.03977000
C	1.29032700	-0.14660200	-0.03840800
O	-0.01444700	1.85929900	0.05447500
H	0.07201300	2.51309900	-0.66039600
F	-1.42776900	-0.16693100	1.30492900
F	-2.36300600	0.50316400	-0.54115800
F	-1.35089900	-1.42523500	-0.47490100
F	1.39434200	-0.23810400	1.30641400
F	2.36312800	0.55047200	-0.47514600
F	1.38888000	-1.39721100	-0.54079500

Cl$^-$-HFIP

Cl	3.69139500	0.01076100	-0.17754400
C	-0.03663300	0.00276100	-0.13933000
H	0.44936900	0.00570600	-1.12215800
C	-0.88707100	1.28456300	-0.06359300
C	-0.86936000	-1.29059800	-0.06257500
O	0.87924800	0.00973700	0.91653200
H	1.81575700	0.01024800	0.54956500
F	-1.53929100	1.40918000	1.11564400
F	-0.08673100	2.36730000	-0.19016700
F	-1.81443100	1.35290300	-1.04683000
F	-1.52185400	-1.42192100	1.11576300
F	-0.05414700	-2.36256100	-0.18583300
F	-1.79403900	-1.37347300	-1.04729100

furan

C	1.10418500	-0.34623400	0.00028900
C	0.71988100	0.96008400	0.00000900
C	-0.71983000	0.96011900	0.00017300
C	-1.10420200	-0.34618100	0.00007100
O	-0.00003100	-1.16381000	-0.00050500

H	2.06033100	-0.84976400	0.00041800
H	1.37553600	1.82154500	0.00002500
H	-1.37544000	1.82161300	0.00030700
H	-2.06038100	-0.84964700	0.00004000

TS2

C	-0.29570100	2.07726500	-0.47686700
C	-0.55777100	1.03728200	0.50846100
N	0.51795400	0.42686800	1.09401400
C	0.26443600	-0.62026900	2.09261600
H	-0.27550300	-0.18534500	2.94081700
H	1.23192700	-1.00480300	2.41037200
H	-0.34621200	-1.41068500	1.64882400
O	-1.73091600	0.74710400	0.88877900
O	1.72419400	0.83417400	0.90237400
Cl	-1.71598600	2.82386600	-1.13304900
Cl	1.04193400	2.09799000	-1.55828100
C	4.10130900	-1.37850700	-0.13994000
H	3.47677500	-0.91777800	-0.91394100
C	5.56410700	-1.08558900	-0.51710800
C	3.75269800	-2.87947700	-0.12428100
O	3.86588100	-0.84325900	1.13256100
H	3.06706900	-0.25746600	1.09752500
F	6.44252700	-1.57653100	0.38666400
F	5.75730200	0.25177900	-0.57342600
F	5.89845700	-1.59187500	-1.72529900
F	4.46939900	-3.57337300	0.78923400
F	2.44677900	-3.03206800	0.19524300
F	3.94482500	-3.47068500	-1.32514900
C	-4.62200100	-0.83553900	0.21706600
H	-4.49600700	-0.51057000	1.25642600
C	-6.01861300	-0.37001500	-0.22959100
C	-4.44801100	-2.36790000	0.20743800
O	-3.68371200	-0.26081900	-0.64742700
H	-2.93909000	0.13118100	-0.11346600
F	-6.27515800	-0.66900200	-1.52389900
F	-6.10965300	0.97344100	-0.10671400
F	-7.00958800	-0.91015600	0.51526600
F	-4.59957500	-2.90198200	-1.02615100
F	-3.19911200	-2.67967200	0.62516400
F	-5.31545900	-2.99858100	1.03177800
C	0.39009300	3.83950200	1.05658100
C	1.58683400	3.44626200	1.66153600
C	2.62732800	4.10374600	0.96294800

C	2.02018200	4.87038400	-0.00014800
O	0.66564800	4.75909200	0.07044700
H	-0.62500900	3.83438600	1.42643200
H	1.67302700	2.81265800	2.53211900
H	3.69245200	4.02110500	1.13373200
H	2.39898900	5.52282500	-0.77487800

TS2-*regio*

C	-0.77088100	2.66604000	-0.65580000
C	-1.00733800	1.41700400	-1.33189100
N	0.05814800	0.54081200	-1.41896300
C	-0.11984400	-0.76643300	-2.05669600
H	-0.65856200	-1.43894600	-1.37906200
H	0.87396000	-1.16147000	-2.26782700
H	-0.68927500	-0.64264000	-2.97878100
O	-2.14585800	1.07796800	-1.76562600
O	1.09982600	0.72123000	-0.67040700
Cl	-2.17359400	3.63203400	-0.34080800
Cl	0.69331500	3.56852900	-0.73455100
C	4.18706700	-0.95397600	-0.09266400
H	3.53029000	-0.95762700	0.78370400
C	4.59863400	-2.41525200	-0.34559700
C	5.36931700	-0.02449700	0.24129400
O	3.54838000	-0.48022900	-1.24651500
H	2.66406200	-0.11059900	-1.01354200
F	5.37561500	-2.55514500	-1.44336200
F	3.49137300	-3.16716600	-0.54266600
F	5.26891800	-2.95160200	0.69833700
F	6.26707500	0.06119800	-0.76702700
F	4.90742400	1.22560600	0.47100900
F	6.03937300	-0.41641600	1.34862700
C	-4.29415000	-0.86139900	-0.00070800
H	-4.16572100	0.16602900	0.35896600
C	-5.79029500	-1.03350500	-0.32100300
C	-3.79221500	-1.78924700	1.12255200
O	-3.56118700	-1.11922000	-1.16337800
H	-2.99754100	-0.32661900	-1.38207200
F	-6.08122000	-2.26179100	-0.80725700
F	-6.15703300	-0.13610400	-1.26374300
F	-6.57848200	-0.82757000	0.75901900
F	-3.91106400	-3.10047700	0.81189200
F	-2.47930300	-1.55281500	1.34897000
F	-4.44292300	-1.58913600	2.29142900
C	0.63797000	0.50664700	1.36820000

C	-0.36793300	1.46342900	1.64113000
C	0.28783900	2.53119500	2.32166100
C	1.60820000	2.20125900	2.38432400
O	1.82992900	0.95072500	1.85286900
H	0.55963700	-0.55855100	1.20892600
H	-1.43004500	1.27536700	1.57704700
H	-0.15803500	3.44738200	2.68511700
H	2.48422300	2.70381600	2.76995400

5n

N	-0.47743700	0.42523800	1.24594500
C	0.51682900	0.39123100	0.34052000
C	0.23953500	1.27284900	-0.90637100
C	-0.45306400	2.59034300	-0.50621400
C	-1.64901500	2.35029000	0.45045200
O	-1.71841200	0.93207300	0.83437300
O	1.57435800	-0.21916100	0.52610600
C	-0.53435200	-0.35581400	2.47243700
O	0.49493400	3.39487500	0.23507400
C	-0.12469100	3.78284800	1.40200100
C	-1.34357700	3.26834600	1.58927700
Cl	1.77624900	1.61705100	-1.76322500
Cl	-0.85489900	0.35046000	-2.02906100
H	-2.61668200	2.49157500	-0.03181300
H	-0.74523400	3.15030600	-1.39726500
H	0.48719800	-0.57410900	2.78617300
H	-1.03871100	0.24000800	3.23590000
H	-1.08026400	-1.29063600	2.30316700
H	0.46181500	4.46241400	2.00899600
H	-2.00131400	3.44772800	2.42964900
C	4.95962100	-0.54721900	0.12737800
H	4.67131500	0.38035500	0.63575200
C	6.09525100	-0.18943000	-0.84520100
C	5.37801000	-1.54389500	1.22736500
O	3.91538100	-1.09875100	-0.62631300
H	3.05767100	-0.72718300	-0.31273900
F	6.51011300	-1.25111700	-1.57284300
F	5.66674700	0.74910600	-1.71925200
F	7.17599000	0.31525000	-0.20963700
F	5.78345500	-2.73342100	0.72794400
F	4.31967900	-1.79032300	2.03354200
F	6.37579400	-1.06947800	2.00736000
C	-4.82281200	-0.68368400	-0.12635400
H	-4.39331100	-0.08069300	-0.93357800

C	-6.14357100	-0.00305800	0.28318700
C	-5.00545000	-2.10826500	-0.68083800
O	-3.98547100	-0.76282400	0.99600800
H	-3.21969700	-0.16036700	0.88147500
F	-6.80722100	-0.68371500	1.24459400
F	-5.88071200	1.22853600	0.77618100
F	-6.98745700	0.15290500	-0.76185900
F	-5.46802400	-2.97181600	0.25105300
F	-3.81354100	-2.58385100	-1.10667600
F	-5.85552000	-2.14882100	-1.73110400

***regio*-5n**

N	-0.43831300	1.02369200	1.21593300
C	0.60389900	1.17552900	0.37864300
C	0.24319200	1.97108200	-0.90140900
C	-0.71568500	3.14318300	-0.57909100
C	-1.89276400	2.64965000	0.31482400
O	-1.72687800	1.28797200	0.70931600
O	1.74412500	0.79055400	0.65398900
C	-0.44380400	0.27276300	2.46148200
C	-0.10484700	4.22343200	0.28786400
C	-0.84207400	4.35506600	1.38990000
O	-1.92571200	3.49391000	1.46305400
Cl	1.74413900	2.59045400	-1.67034500
Cl	-0.54323800	0.80291000	-2.06643700
H	-2.87003000	2.65206100	-0.16509900
H	-1.09258000	3.54035500	-1.52684900
H	0.58043300	0.22818300	2.83334700
H	-0.82438500	-0.74072600	2.29405100
H	-1.07688900	0.79940500	3.17887800
H	0.76335800	4.81399700	0.02986700
H	-0.75290500	5.03181600	2.23066100
C	4.69800500	-0.75876800	0.32455500
H	4.48569400	-0.32274200	1.30757600
C	6.17642700	-0.46798900	0.01758100
C	4.36852600	-2.26216700	0.42457600
O	3.93538200	-0.17883800	-0.69841600
H	3.14169400	0.25246400	-0.30226900
F	6.55003400	-0.91294000	-1.20372800
F	6.39075900	0.86662300	0.03745300
F	7.01002600	-1.02415900	0.92487600
F	4.62461000	-2.93196000	-0.72187700
F	3.05047400	-2.41520600	0.68862500
F	5.05088700	-2.87730300	1.41717800

C	-4.40255800	-0.99555300	-0.10202300
H	-4.03033800	-0.38947800	-0.93501900
C	-5.91283700	-0.72194900	0.01434100
C	-4.05855500	-2.46162900	-0.42648600
O	-3.80567800	-0.65823700	1.12255800
H	-3.10501300	0.00876400	0.97255500
F	-6.48368900	-1.39448600	1.03916900
F	-6.11594800	0.59574600	0.23963000
F	-6.58601000	-1.04734600	-1.11151600
F	-4.45307300	-3.31552600	0.54493300
F	-2.71817000	-2.59096200	-0.55030000
F	-4.61296800	-2.87980800	-1.58627300

4a'

C	-0.67885900	0.76420200	-0.06054400
N	-1.81097900	0.03759800	-0.12517100
C	-3.14183600	0.62539800	-0.01891100
H	-3.10696100	1.64843400	-0.39304000
H	-3.82607500	0.03470600	-0.63324200
H	-3.47573700	0.61680000	1.02483200
O	-0.68136600	1.99367600	-0.05674700
C	0.69226100	-0.00787900	-0.00422600
Cl	0.84785700	-0.84745900	1.58470200
Cl	0.85478400	-1.18115300	-1.36359300
Cl	2.02725900	1.18200400	-0.14255700
O	-1.75628600	-1.32921800	0.14640200
H	-2.05084500	-1.77678700	-0.67289200

Int4

C	-0.77915600	0.00868000	-0.00026800
C	0.48535700	-0.63190000	-0.00032600
N	1.65312300	0.19587000	0.00028500
C	2.94152800	-0.51386600	0.00081400
H	2.99200900	-1.15007800	-0.88814200
H	3.72059200	0.24619300	0.00175200
H	2.99074500	-1.15110700	0.88908700
O	0.65341400	-1.87607700	-0.00061000
O	1.65621300	1.43686000	-0.00017300
Cl	-2.14633300	-1.02871500	-0.00006800
Cl	-1.12652500	1.67696000	0.00008300

TS3

C	1.76501100	-0.73951700	-0.21926500
C	2.36897100	0.56043500	-0.05854000

N	1.60043700	1.66065400	-0.43644200
C	2.19868700	2.99389800	-0.29331900
H	3.16197900	3.02023800	-0.80797500
H	1.49696700	3.70430300	-0.72833900
H	2.35613200	3.20355300	0.77098500
O	3.49214300	0.74485900	0.47553500
O	0.37070600	1.56658000	-0.72718800
Cl	2.70130600	-2.05899000	0.39613100
Cl	0.67425600	-1.18997700	-1.47898500
C	-2.98235500	1.26066300	0.39420200
C	-2.11463200	0.19615300	0.71955200
C	-2.53480500	-1.12078200	0.43088100
C	-3.77300500	-1.35736500	-0.16453300
C	-4.62049000	-0.28884400	-0.48482600
C	-4.22061900	1.02248800	-0.20140100
H	-2.67159300	2.28070300	0.60936900
H	-1.89858400	-1.96415700	0.68233800
H	-4.08095900	-2.37828500	-0.37683800
H	-5.58560700	-0.47802100	-0.94834100
H	-4.87287400	1.85731000	-0.44567600
C	-0.83249800	0.50592500	1.35167200
H	-0.68517600	1.55200600	1.61026500
C	0.13367700	-0.39175300	1.71856600
H	-0.01823500	-1.46379800	1.63778500
H	0.97986100	-0.06531600	2.31533500

TS3-*regio*

C	-1.45803300	-0.81524900	-0.31412000
C	-1.14180200	0.38083600	-1.04144800
N	-1.49663100	1.59432500	-0.44258800
C	-1.15211300	2.84297900	-1.13204700
H	-1.55692300	2.81716300	-2.14656400
H	-1.59598200	3.65524400	-0.55731300
H	-0.06394200	2.95330300	-1.18376300
O	-0.49928900	0.39555800	-2.12190100
O	-1.87810500	1.64730000	0.77333700
Cl	-0.79799000	-2.27432400	-0.96012500
Cl	-2.83975600	-1.06071000	0.70027800
C	2.31441400	-1.23880000	0.72959800
C	1.58954800	-0.03860100	0.90034900
C	2.12567600	1.15006700	0.35631600
C	3.34325500	1.13527900	-0.32063400
C	4.05453400	-0.06292500	-0.47379700
C	3.53538400	-1.24982100	0.05450300

H	1.91742800	-2.16115400	1.14690100
H	1.58585400	2.08707300	0.45941500
H	3.74023300	2.05936600	-0.73367200
H	5.00510300	-0.06916300	-1.00132300
H	4.08139200	-2.18313500	-0.05896100
C	0.32946600	-0.07799400	1.63942000
H	-0.00561200	-1.06683700	1.94478700
C	-0.32894500	1.01272200	2.17181900
H	0.09648500	2.01031200	2.13520500
H	-1.13509300	0.85931000	2.87957600

5a'

C	1.70029400	-0.65777100	-0.08235800
C	2.09496300	0.84145600	-0.08484900
N	1.08707600	1.72757100	0.04067700
C	1.26832000	3.17049700	0.06299700
H	0.57108500	3.59488300	0.78945900
H	2.29374600	3.38746700	0.36065500
H	1.07261700	3.59146600	-0.92993300
O	3.28309600	1.18781800	-0.09134800
O	-0.26667500	1.40142300	-0.19338400
Cl	2.17639300	-1.27342600	1.57737900
Cl	2.70717200	-1.51673400	-1.31648900
C	-2.97343300	-0.20601400	1.24382300
C	-2.11991000	-0.04730400	0.14336800
C	-2.66348200	-0.03701400	-1.15122100
C	-4.03997700	-0.18530900	-1.33793000
C	-4.88589900	-0.35277800	-0.23540800
C	-4.35011000	-0.36421700	1.05590100
H	-2.55935100	-0.20868600	2.24954000
H	-2.01576100	0.09138600	-2.01461600
H	-4.45126900	-0.17241300	-2.34428300
H	-5.95648900	-0.47217700	-0.38331800
H	-5.00129300	-0.49064300	1.91728700
C	-0.63571500	0.10800200	0.37127600
H	-0.42709800	0.13693000	1.44587700
C	0.22180800	-0.93840800	-0.33670100
H	-0.02941200	-1.95158600	-0.01224500
H	0.04057300	-0.86767600	-1.41382000

***regio*-5a'**

C	-0.71479000	0.62431900	0.05893400
C	-2.24778400	0.35886700	-0.01532400
N	-2.64127400	-0.91946600	-0.18859100

C	-4.03267700	-1.32921200	-0.29872700
H	-4.64894700	-0.62855100	0.26398900
H	-4.34611700	-1.33917500	-1.34919600
H	-4.12745300	-2.33075100	0.12669700
O	-3.05574400	1.27067400	0.19544300
O	-1.78685000	-1.91653300	-0.70466300
Cl	-0.38545900	2.18579300	-0.79626900
Cl	-0.38660500	0.87256100	1.84090100
C	2.48186400	0.13572500	-1.28322700
C	1.65388900	-0.42072600	-0.29489300
C	2.24947500	-0.93053000	0.87090500
C	3.63528700	-0.86937500	1.04709700
C	4.44813800	-0.29829800	0.06308000
C	3.86663300	0.20276900	-1.10556200
H	2.04058600	0.51329200	-2.20232800
H	1.64220200	-1.38082000	1.65007600
H	4.07767700	-1.27138700	1.95541100
H	5.52546400	-0.25184000	0.20282900
H	4.48855400	0.63958600	-1.88321100
C	0.15613000	-0.50559500	-0.54467400
H	-0.00646300	-0.42270900	-1.62633600
C	-0.46798300	-1.84218900	-0.13850000
H	-0.52551500	-1.99693000	0.94431300
H	0.06568200	-2.67412800	-0.60174600

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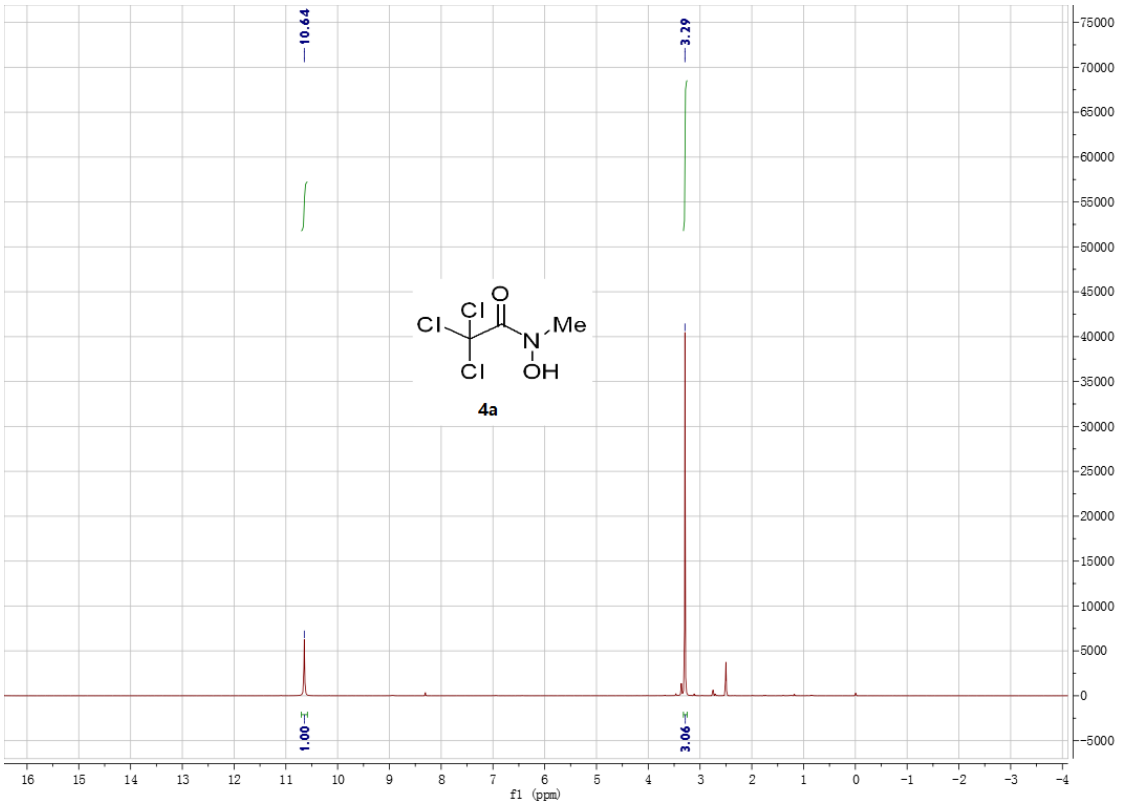
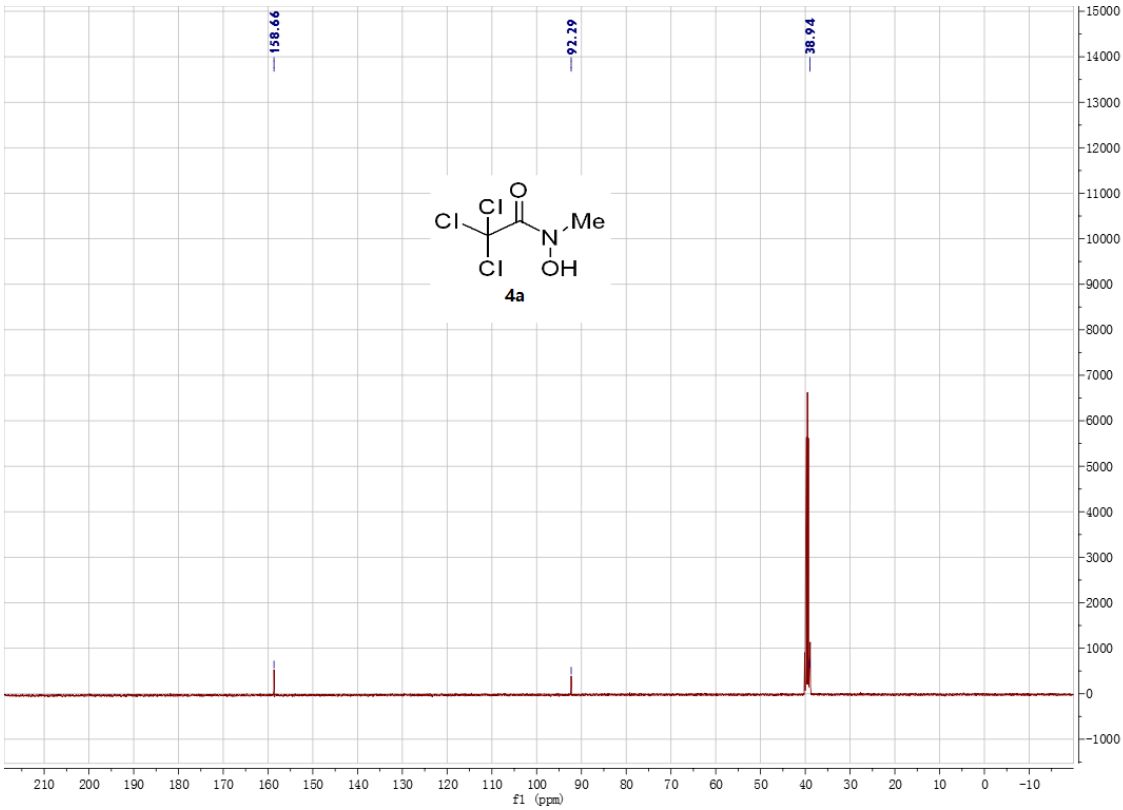
8. NMR spectra



^{1}H NMR (400 MHz, DMSO) of **4a**



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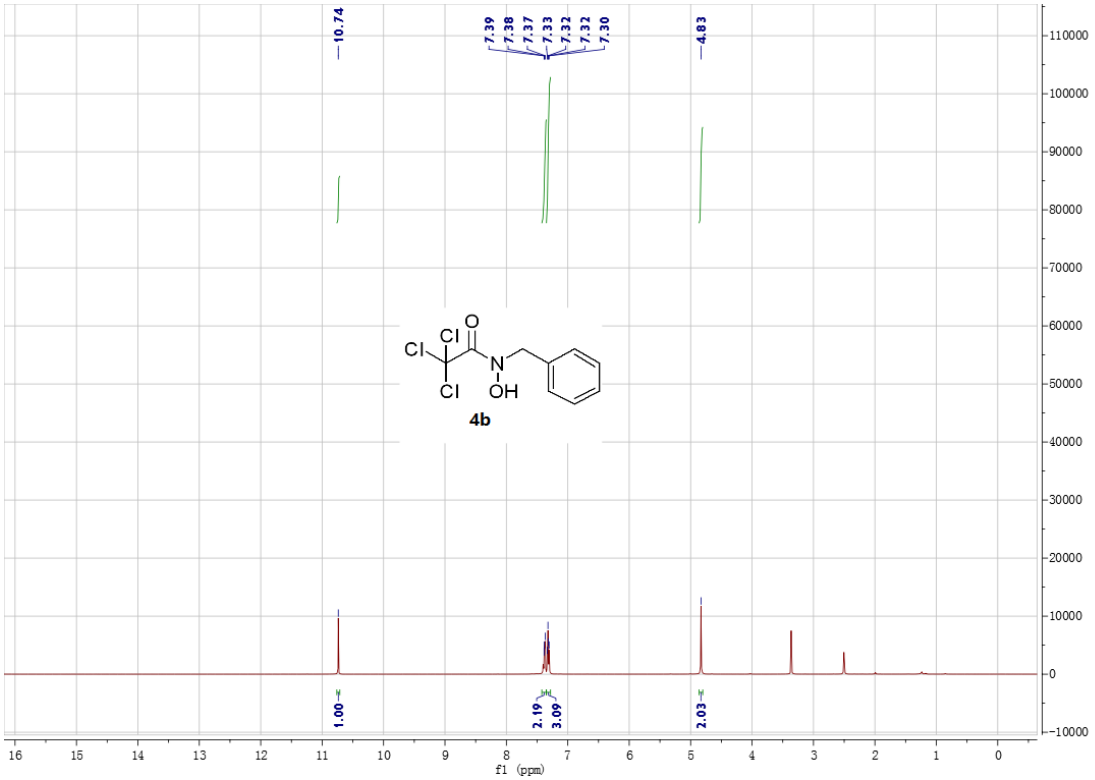

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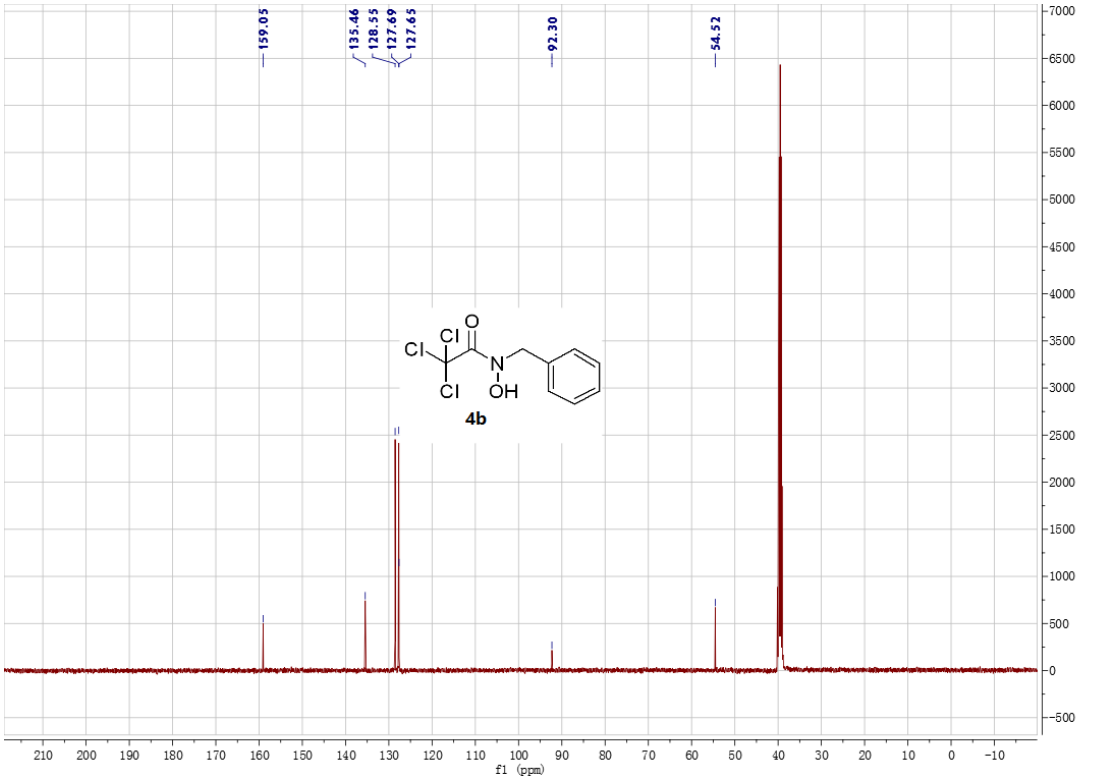

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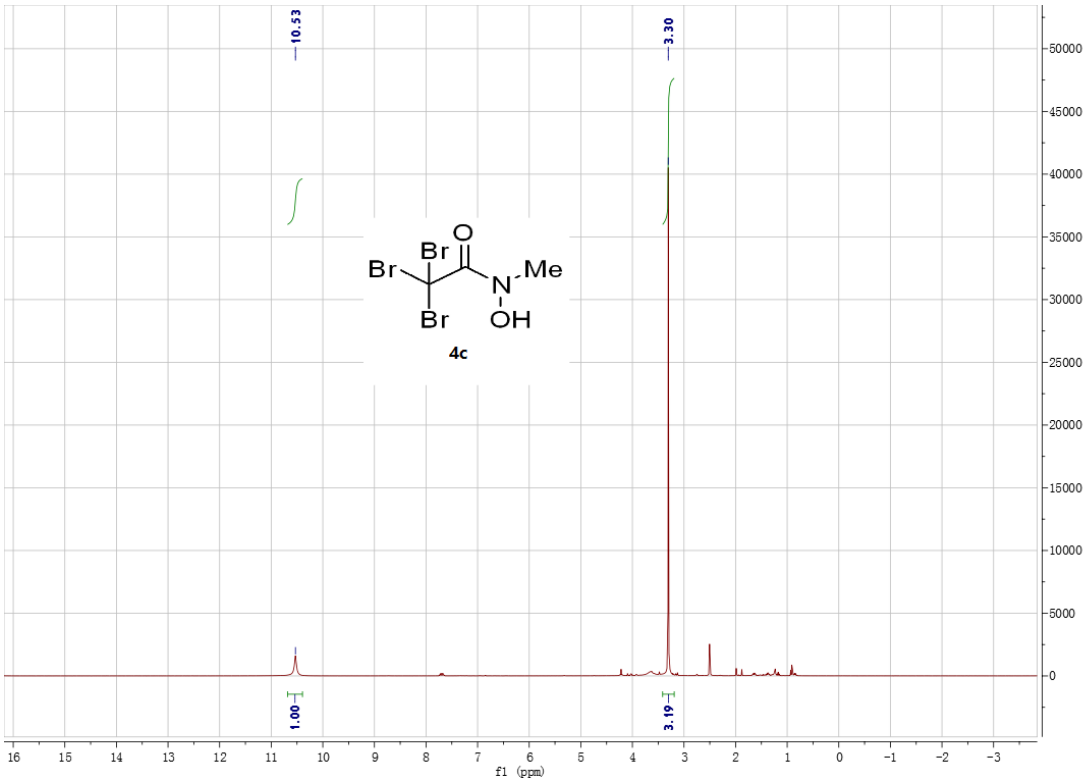

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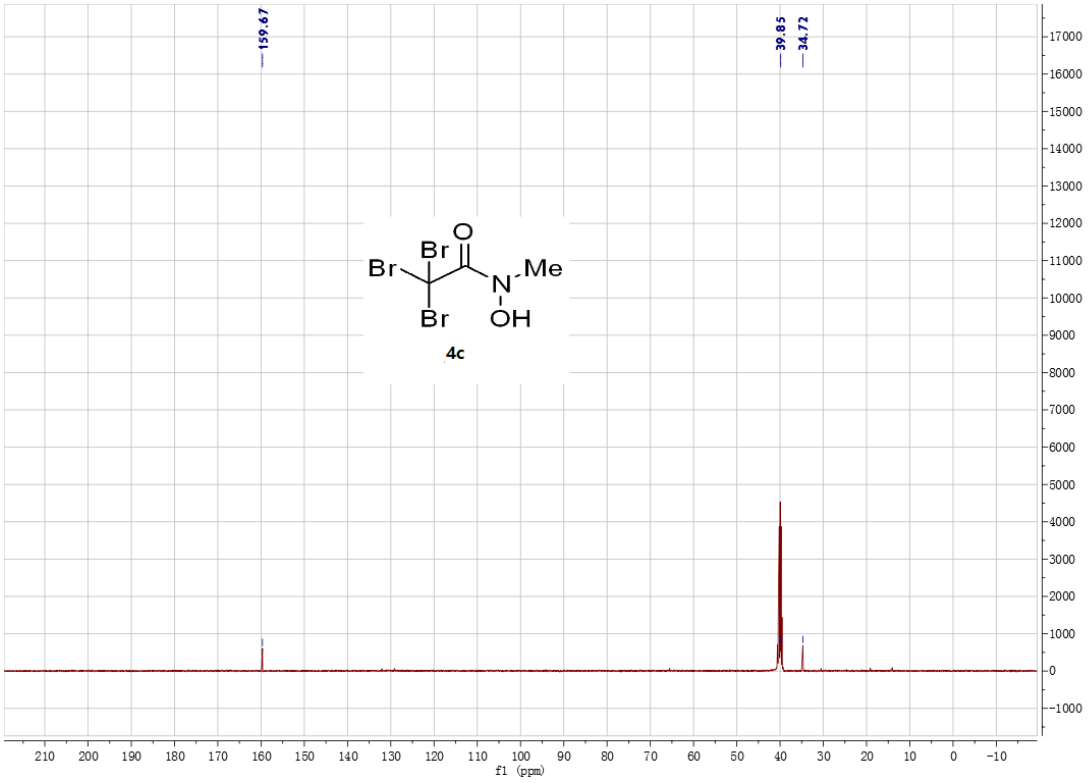
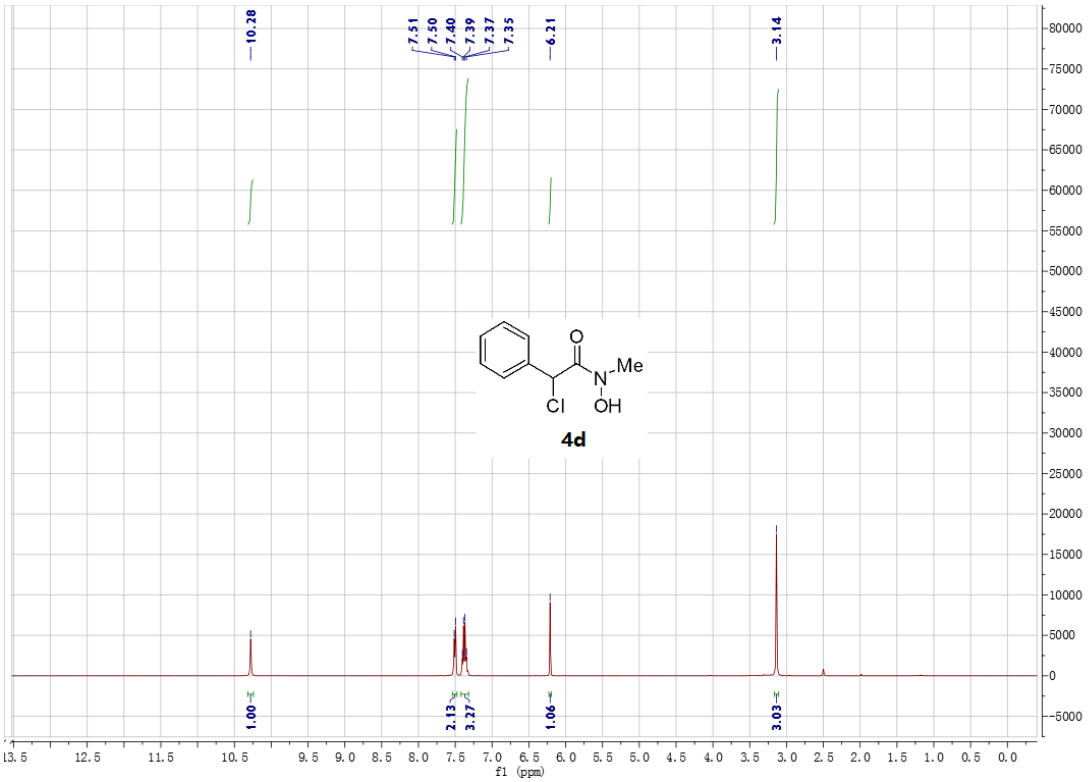
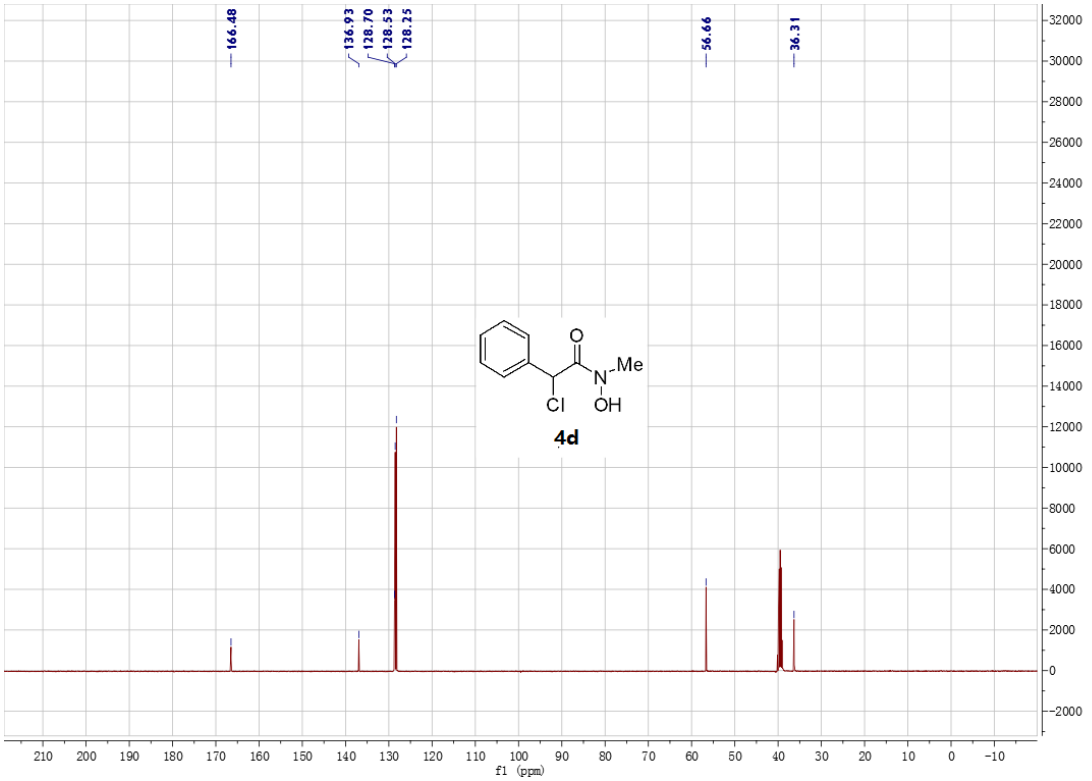


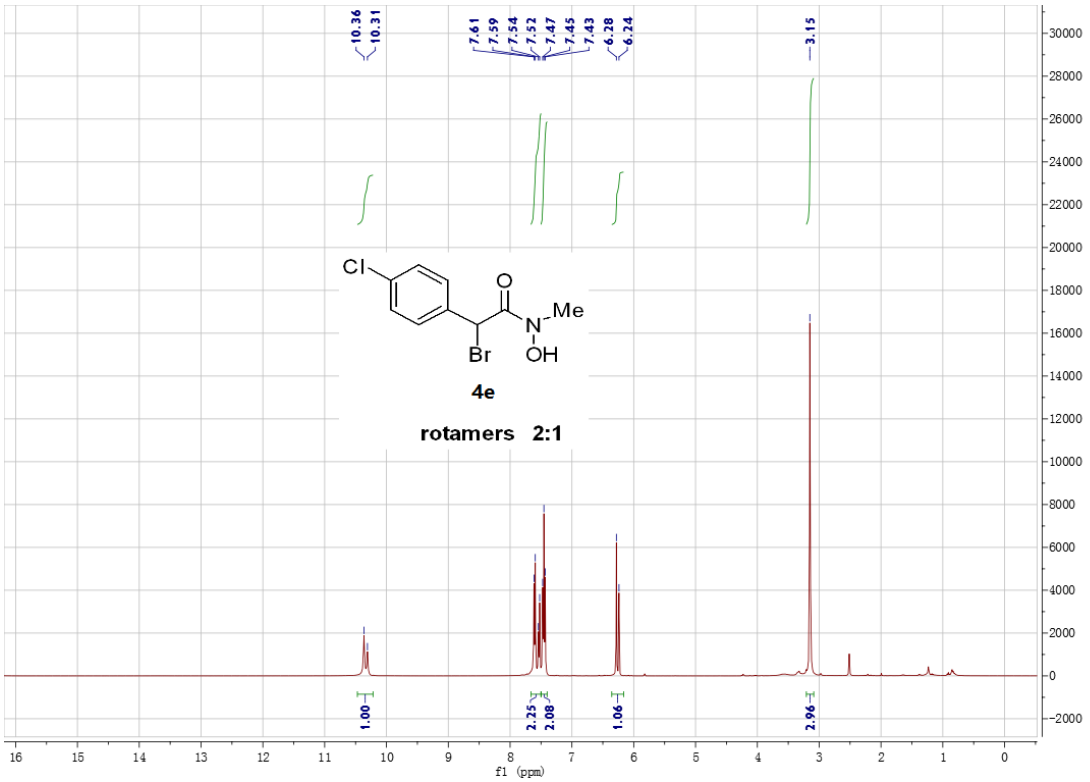
^{13}C NMR (101 MHz, DMSO) of **4c**



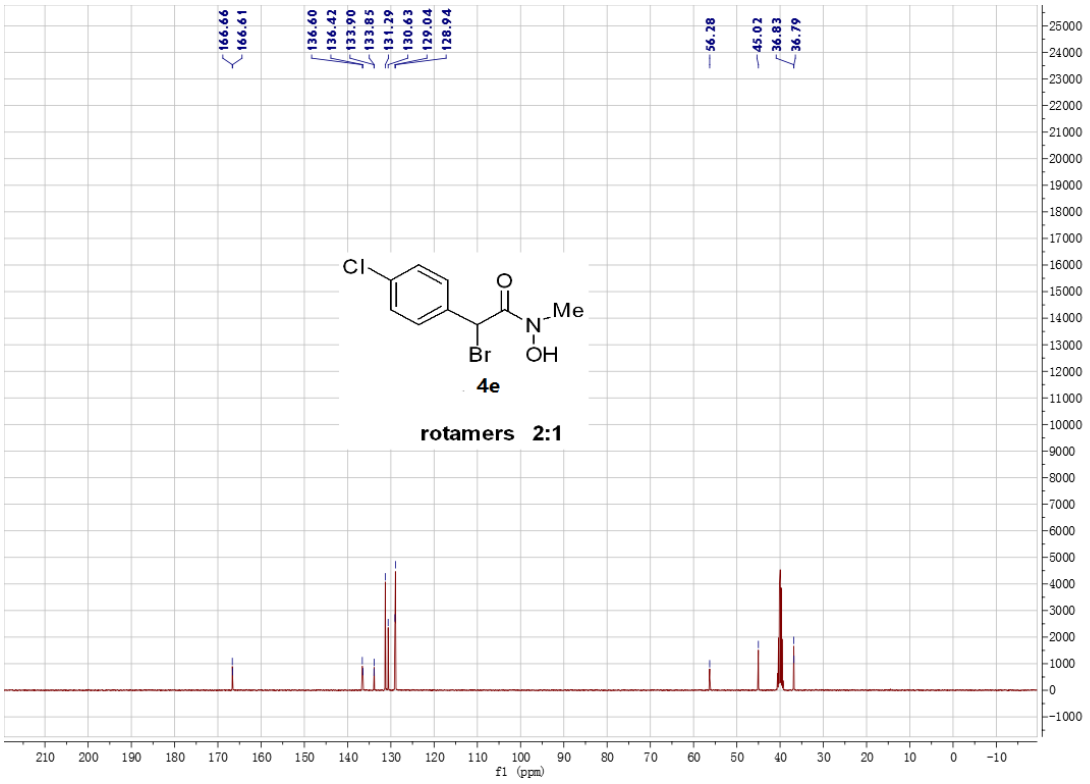
^{1}H NMR (400 MHz, DMSO) of **4d**



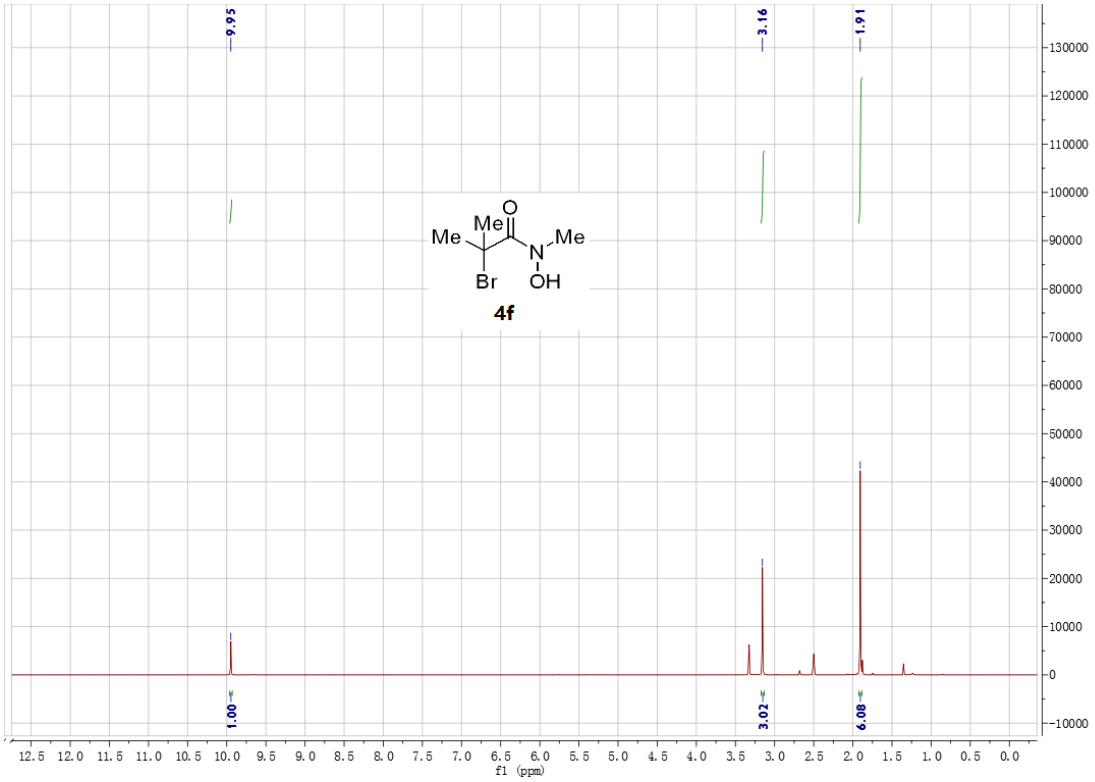
^{13}C NMR (101 MHz, DMSO) of **4d**



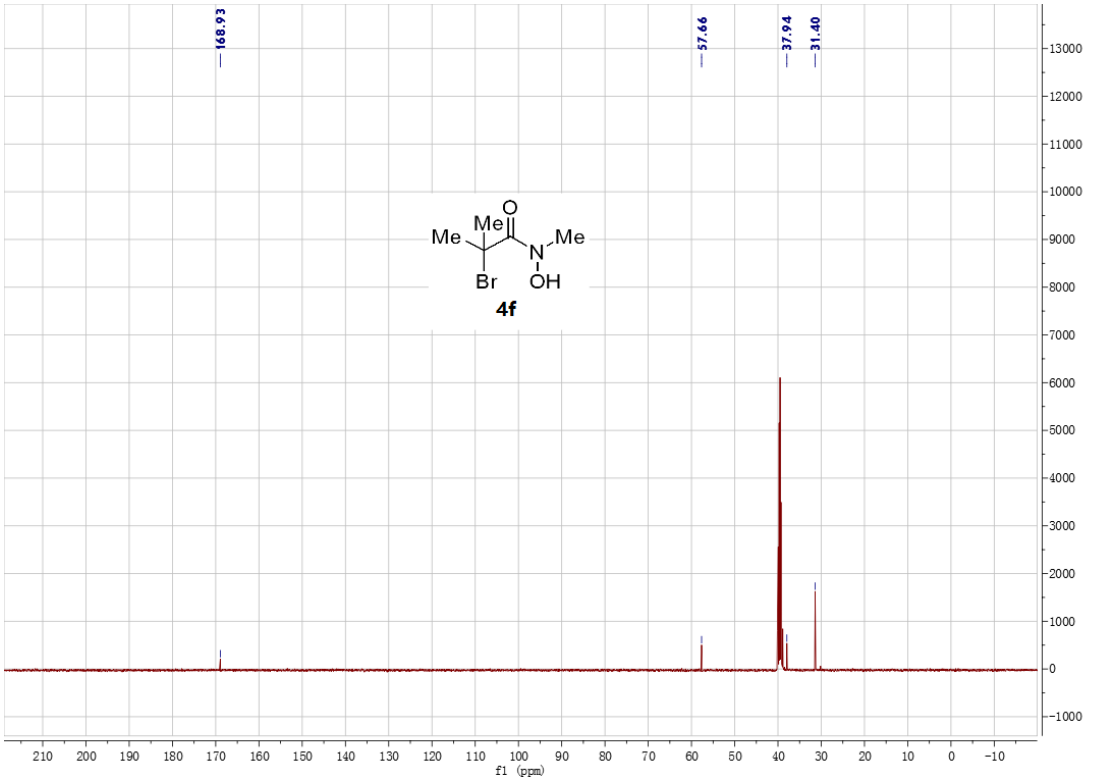
^{1}H NMR (400 MHz, DMSO) of **4e**



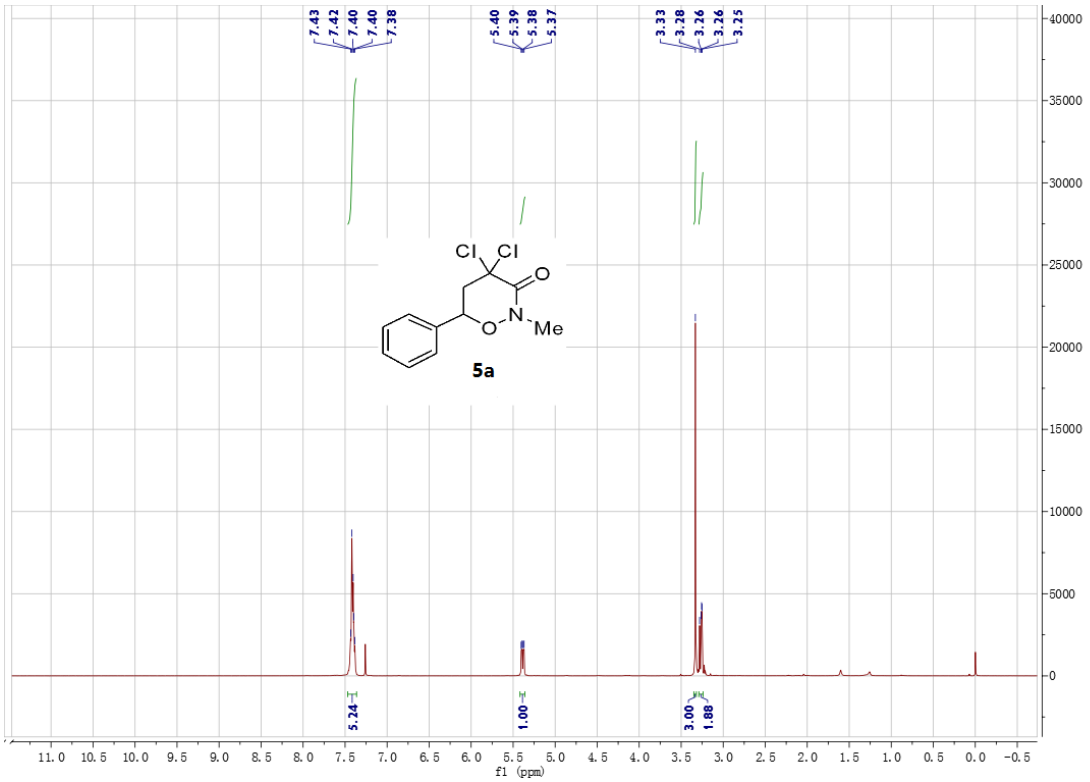
^{13}C NMR (101 MHz, DMSO) of **4e**



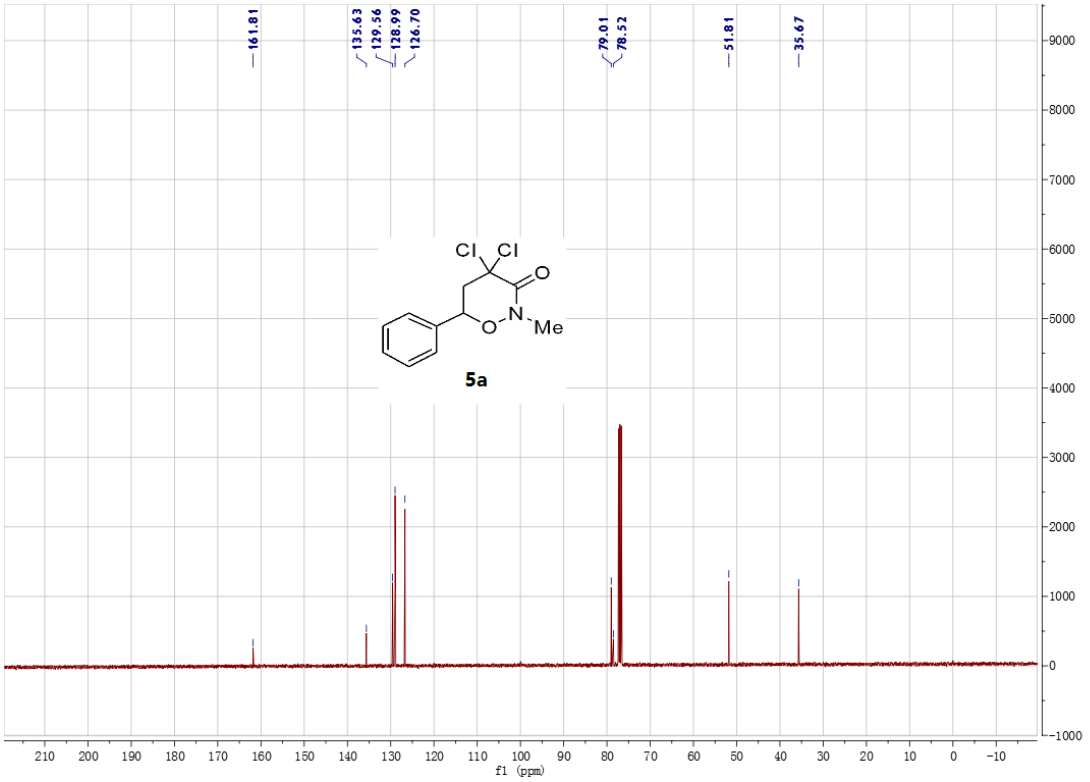
^{1}H NMR (400 MHz, DMSO) of **4f**



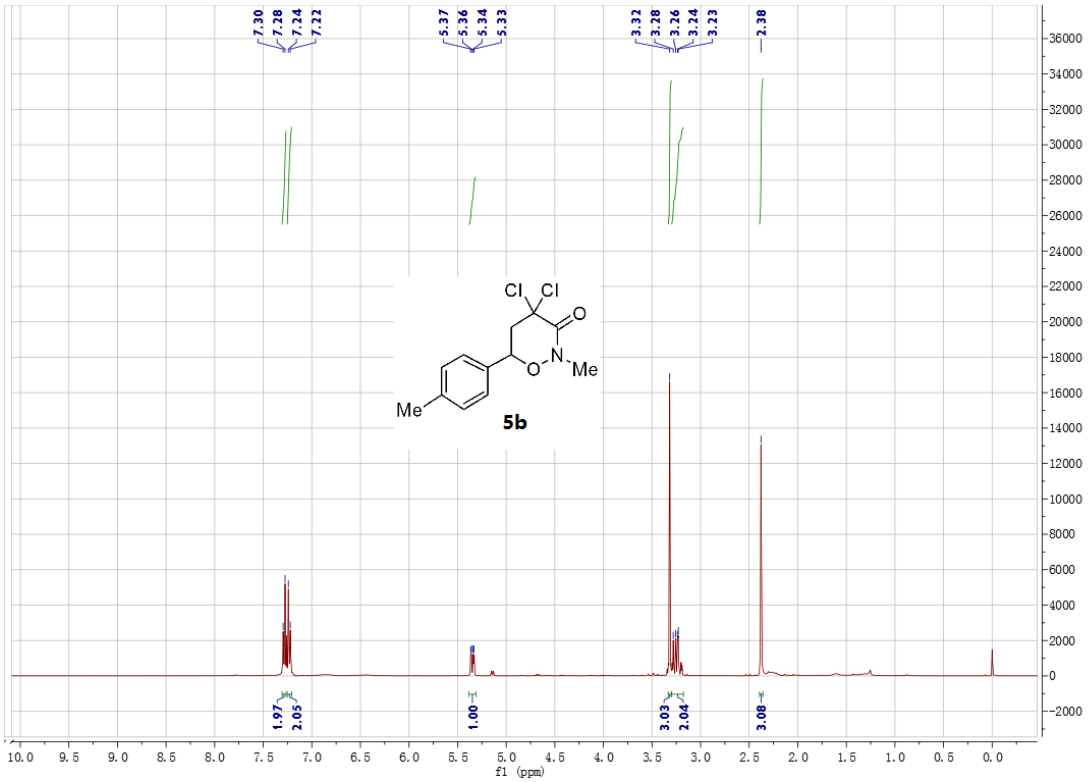
^{13}C NMR (101 MHz, DMSO) of **4f**



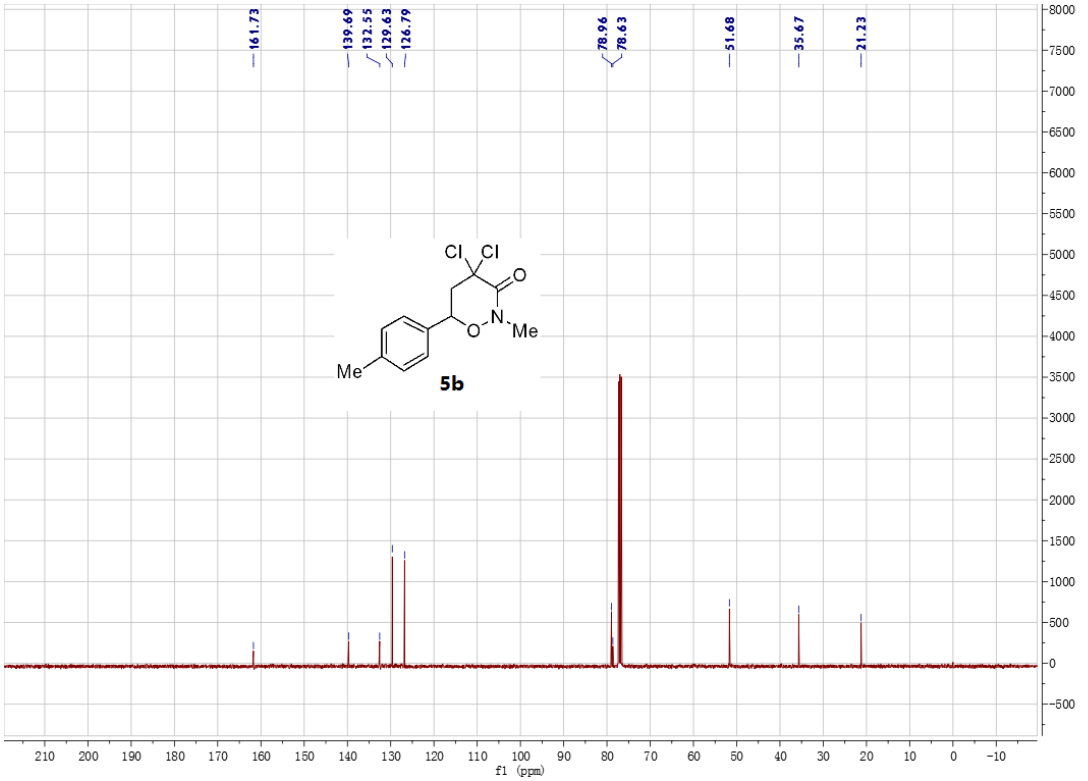
^{1}H NMR (400 MHz, $CDCl_3$) of **5a**



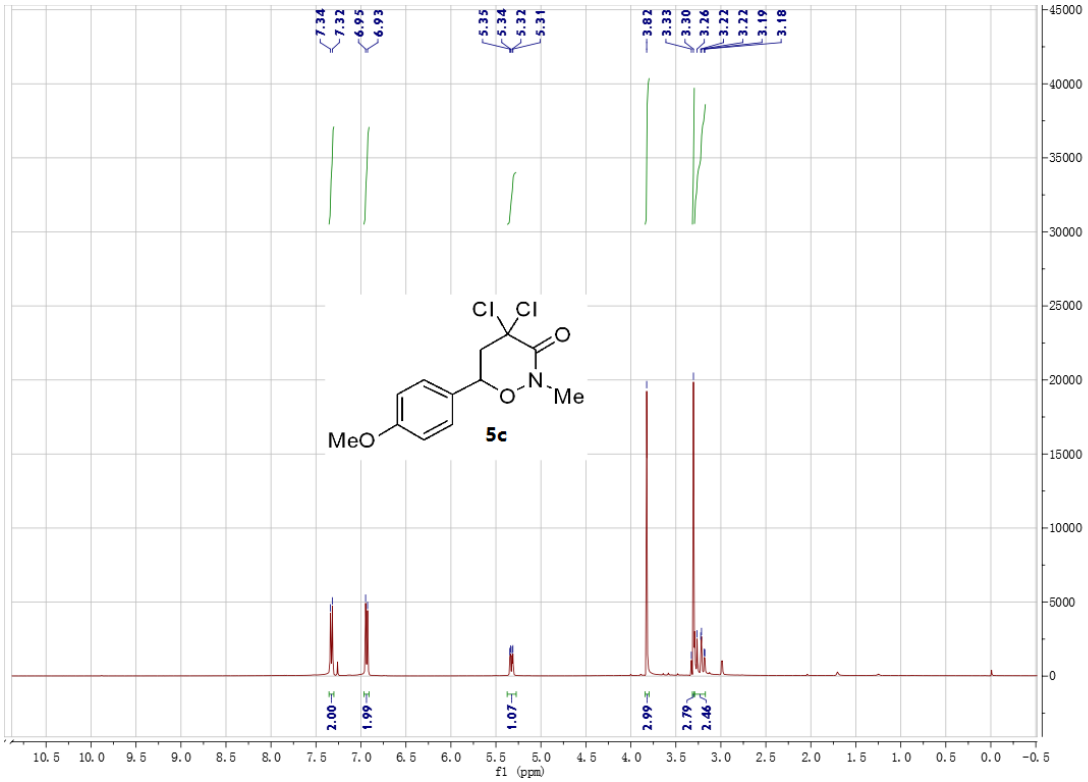
^{13}C NMR (101 MHz, $CDCl_3$) of **5a**



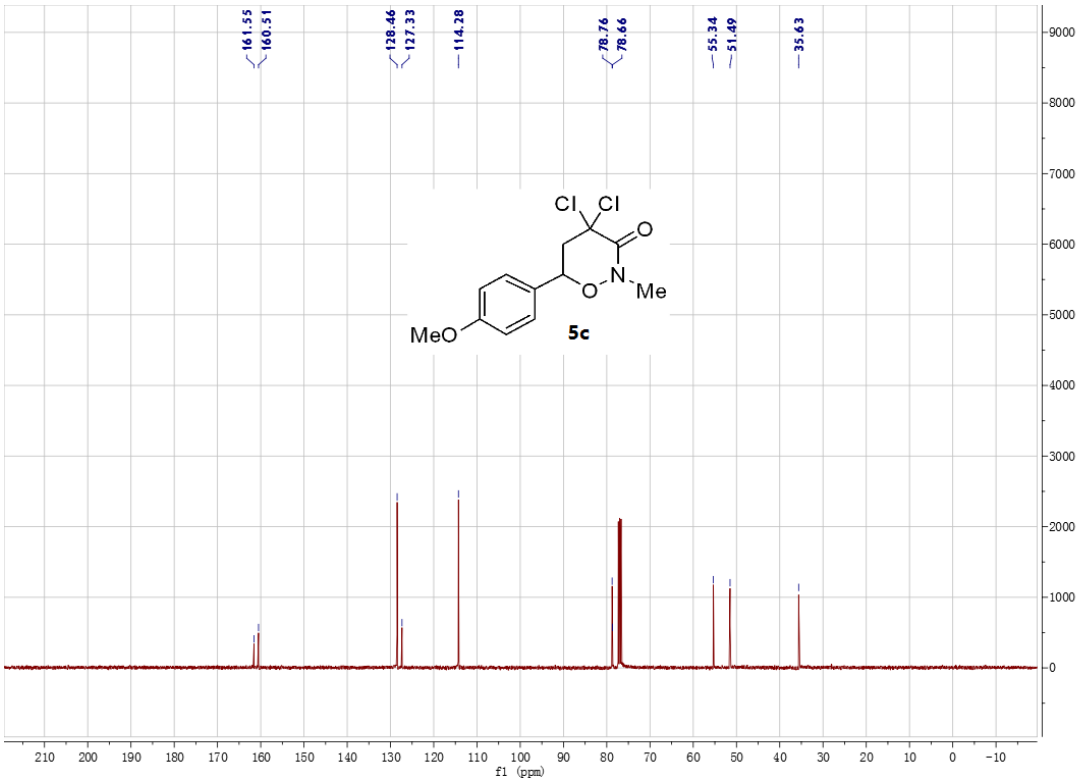
^{1}H NMR (400 MHz, $CDCl_3$) of **5b**



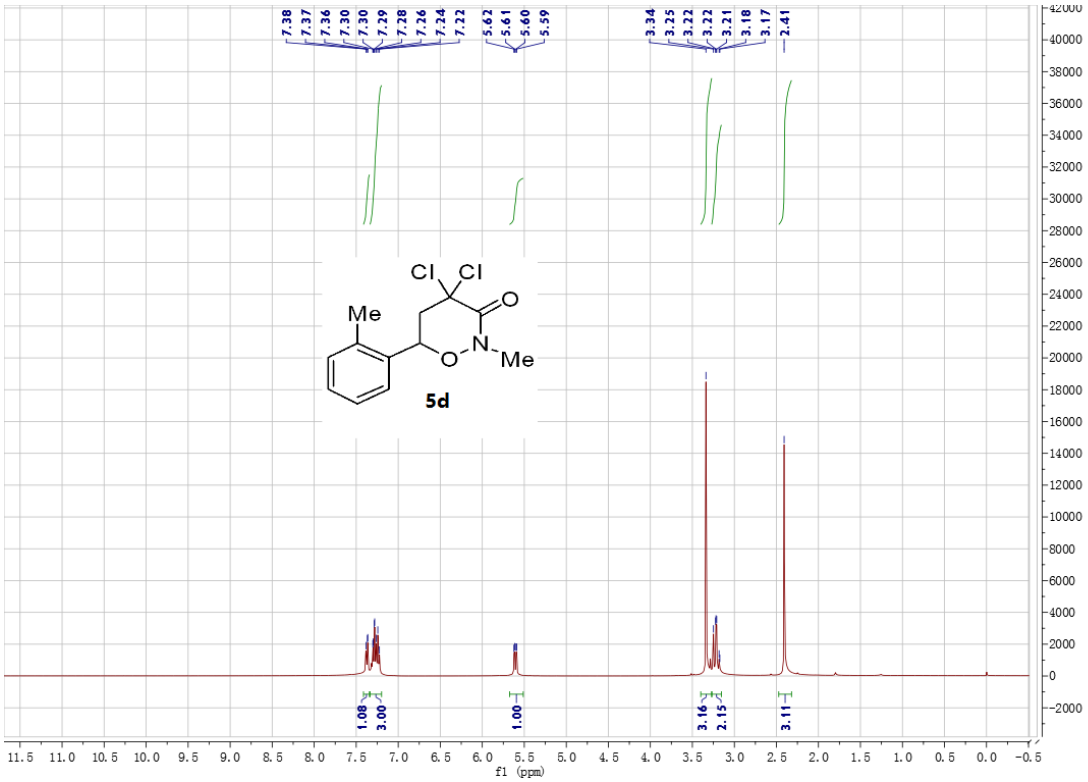
^{13}C NMR (101 MHz, $CDCl_3$) of **5b**



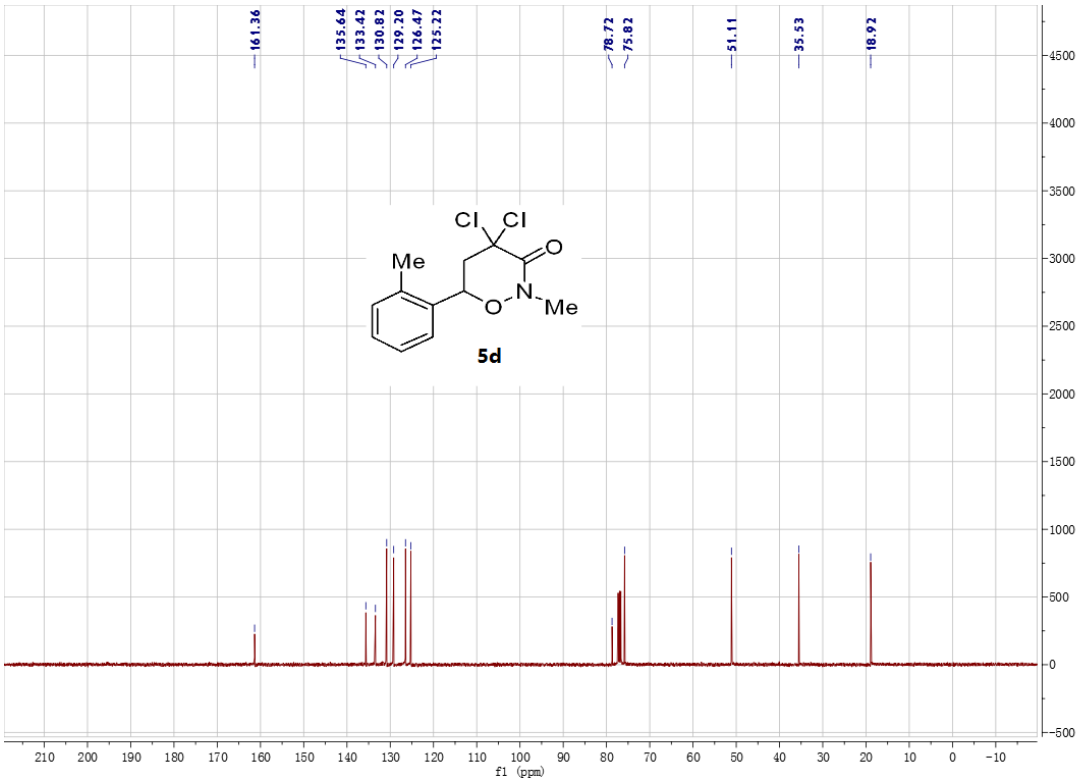
^{1}H NMR (400 MHz, $CDCl_3$) of **5c**



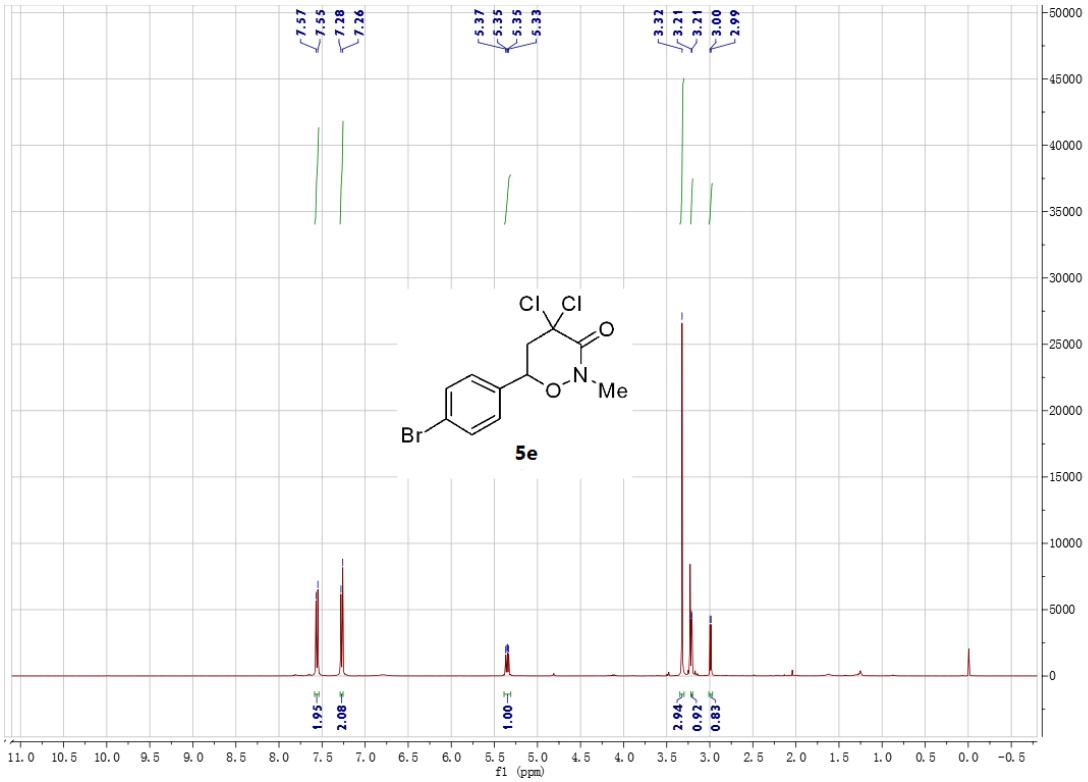
^{13}C NMR (101 MHz, $CDCl_3$) of **5c**



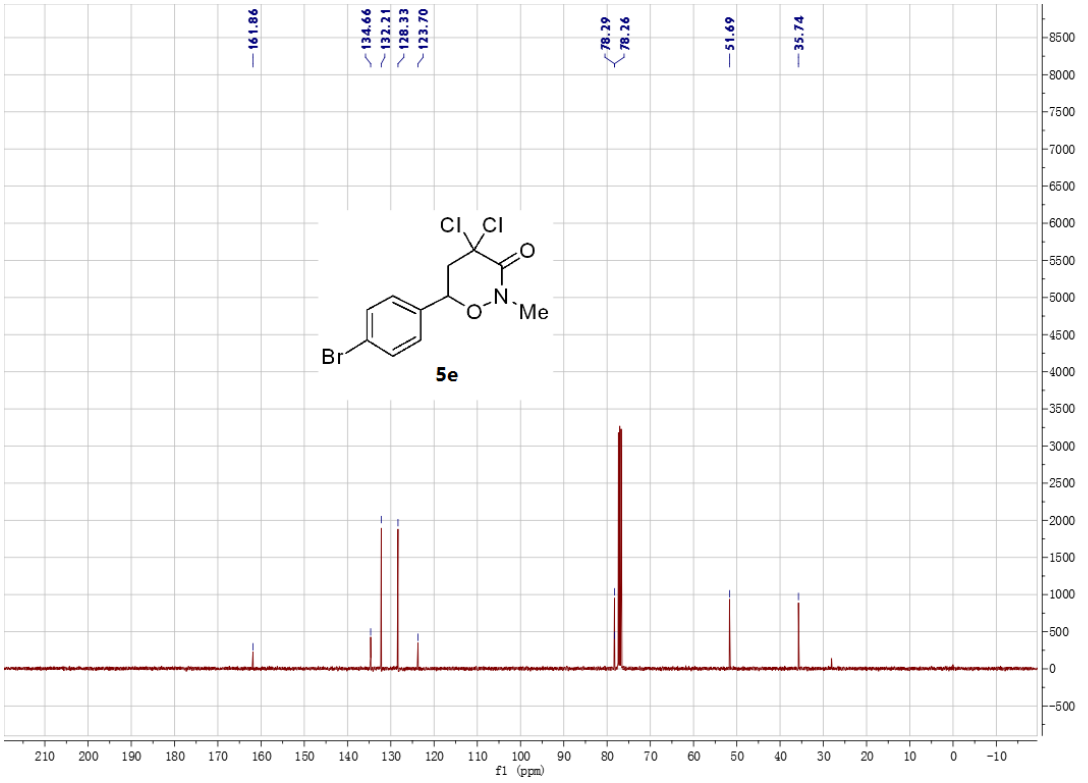
^{1}H NMR (400 MHz, $CDCl_3$) of **5d**



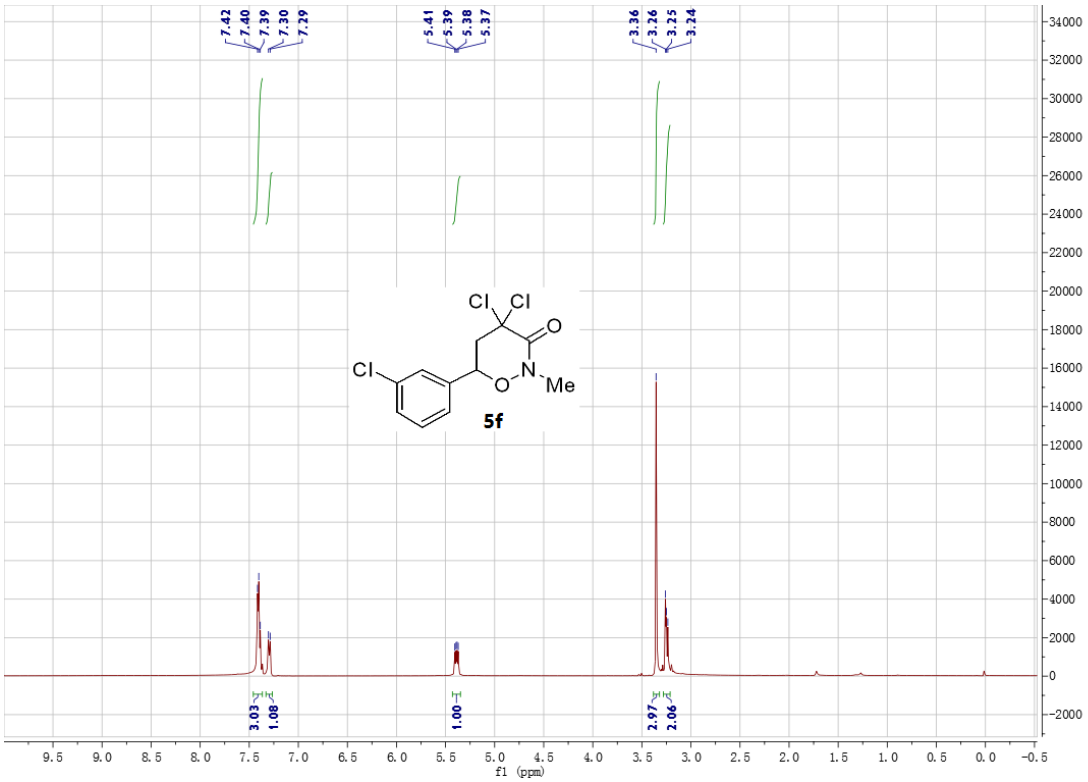
^{13}C NMR (101 MHz, $CDCl_3$) of **5d**



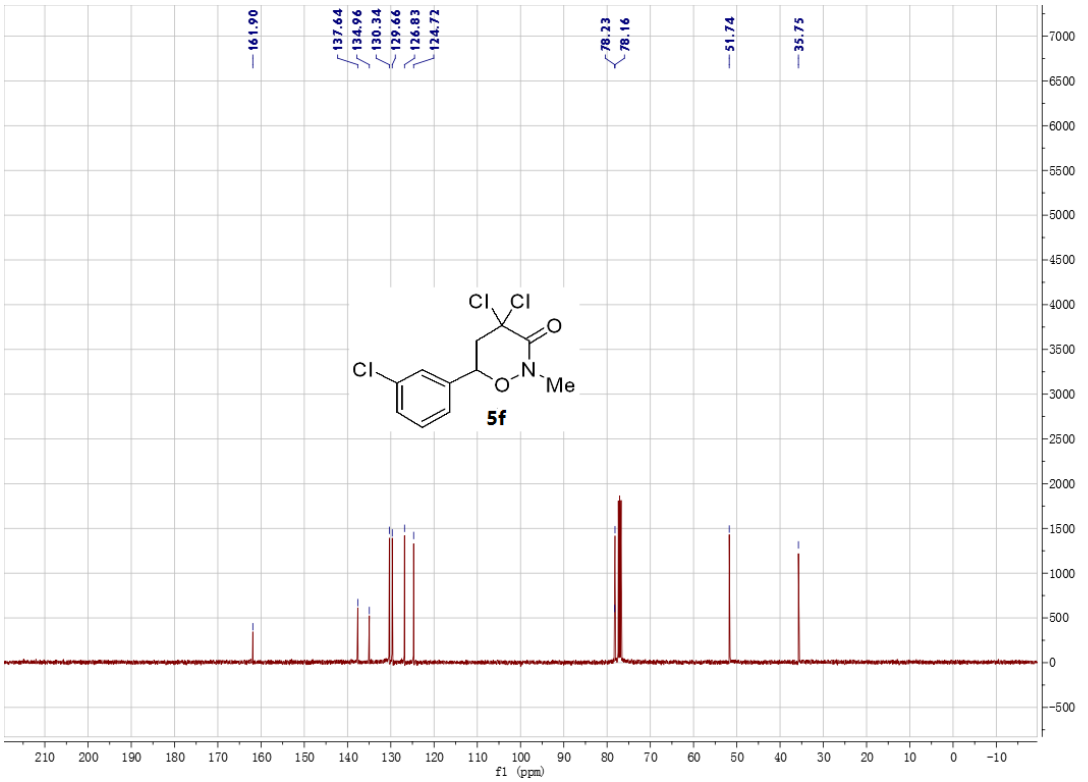
^{1}H NMR (400 MHz, $CDCl_3$) of **5e**



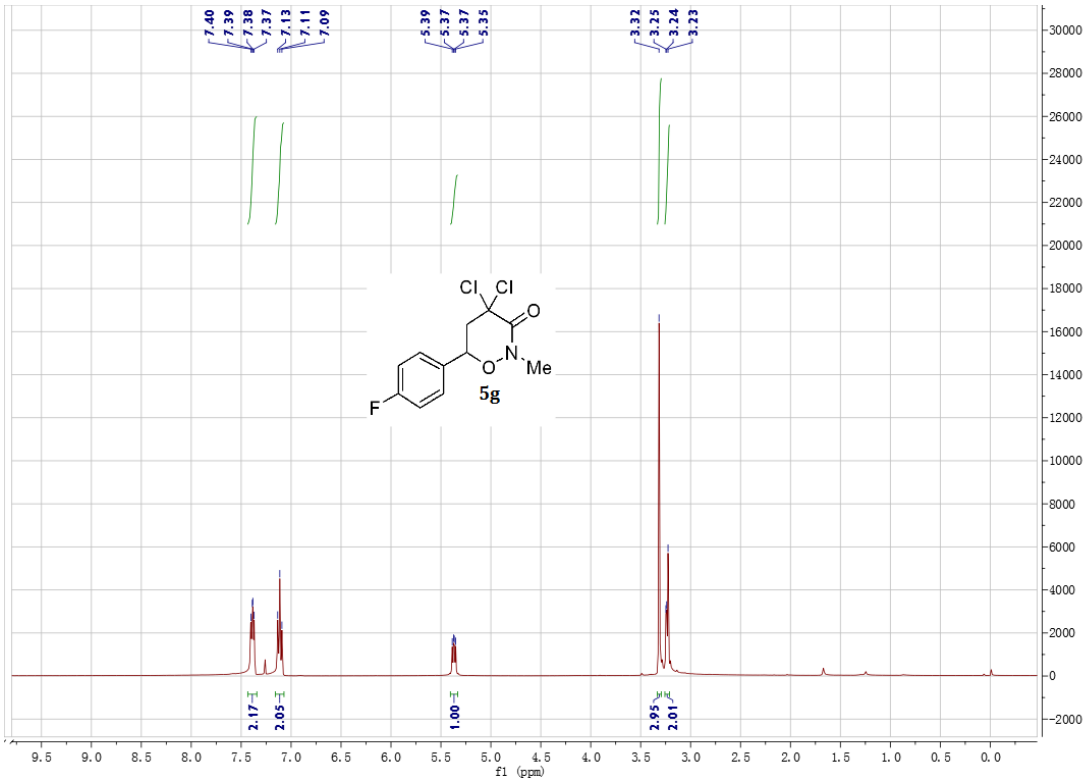
^{13}C NMR (101 MHz, $CDCl_3$) of **5e**



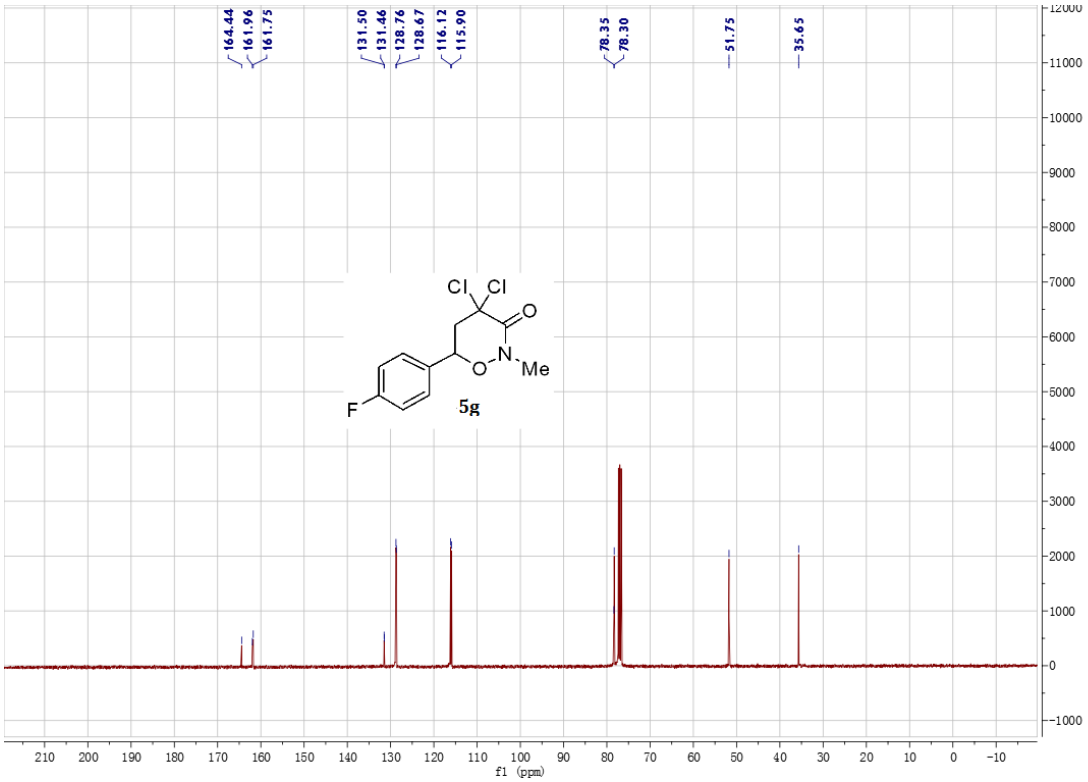
^{1}H NMR (400 MHz, $CDCl_3$) of **5f**



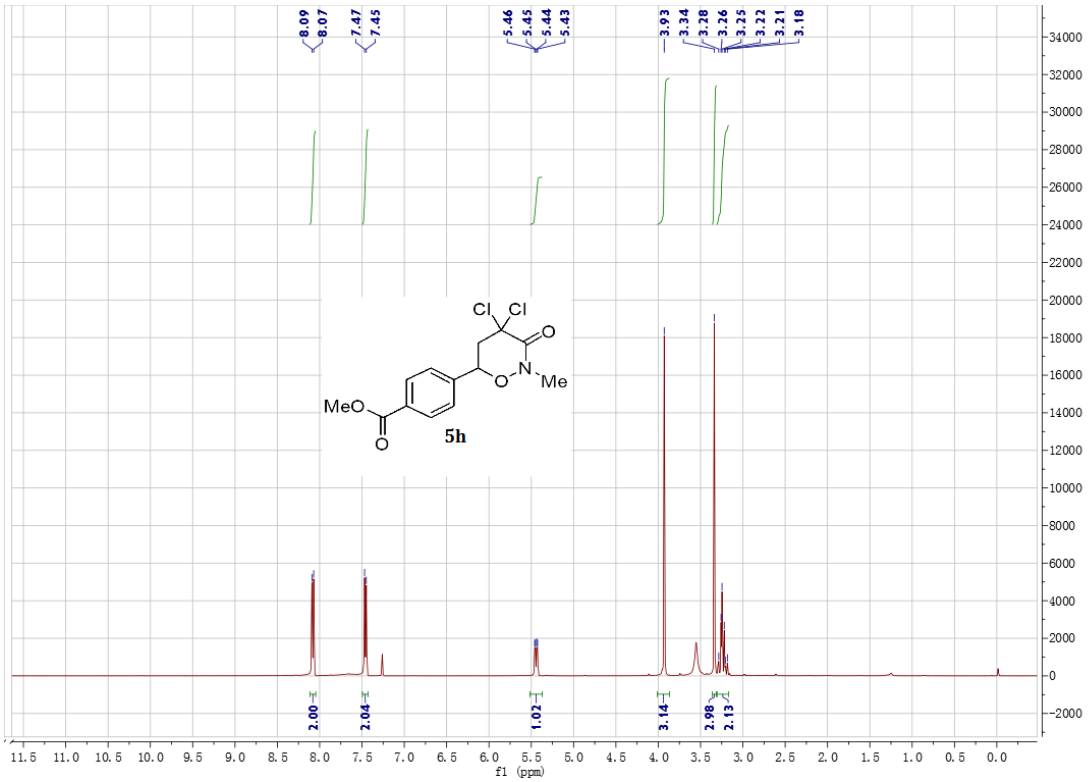
^{13}C NMR (101 MHz, $CDCl_3$) of **5f**



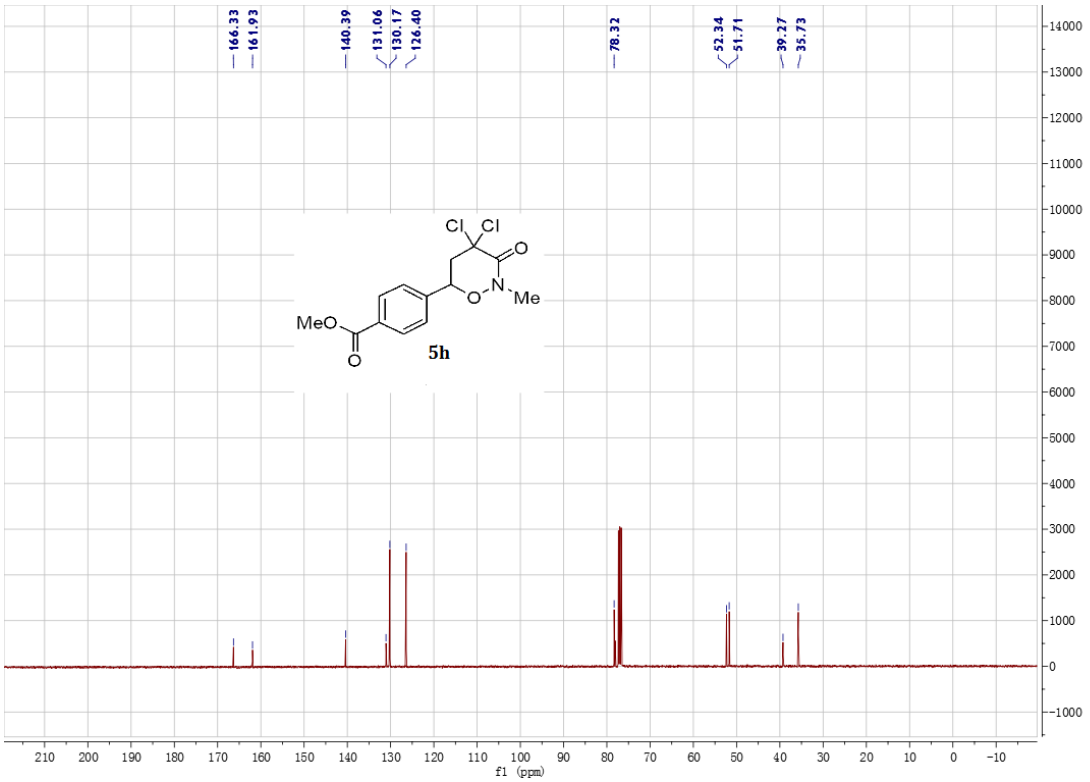
^{1}H NMR (400 MHz, $CDCl_3$) of **5g**



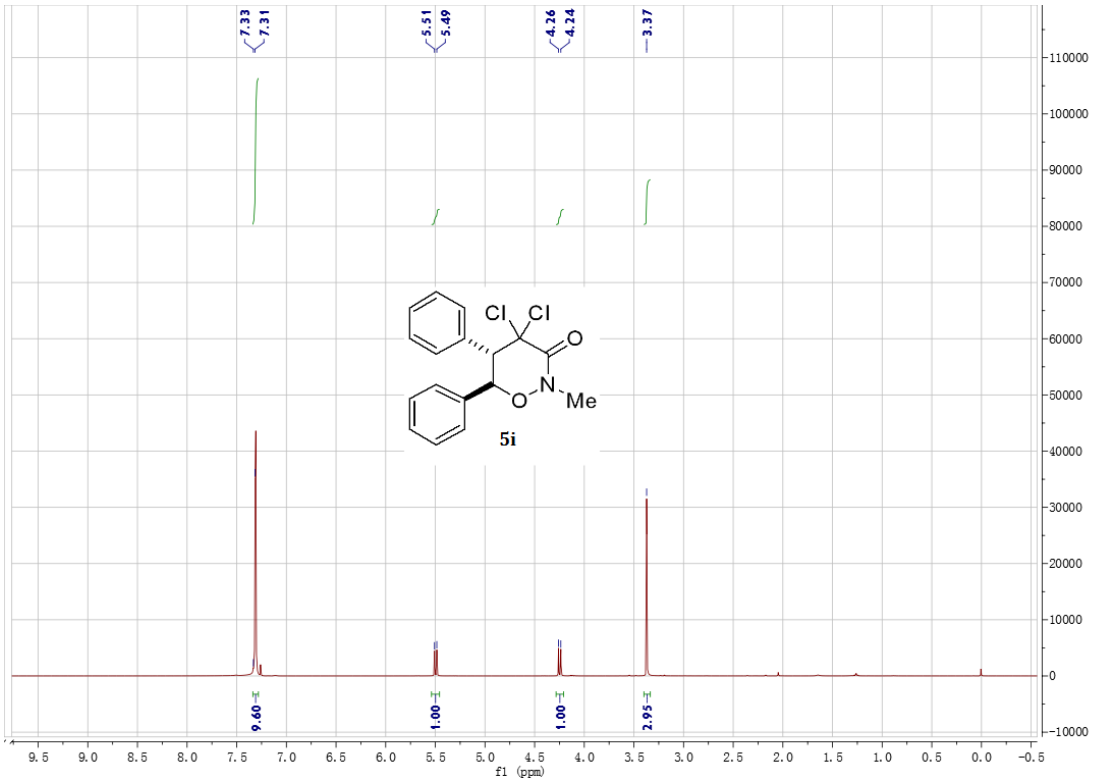
^{13}C NMR (101 MHz, $CDCl_3$) of **5g**



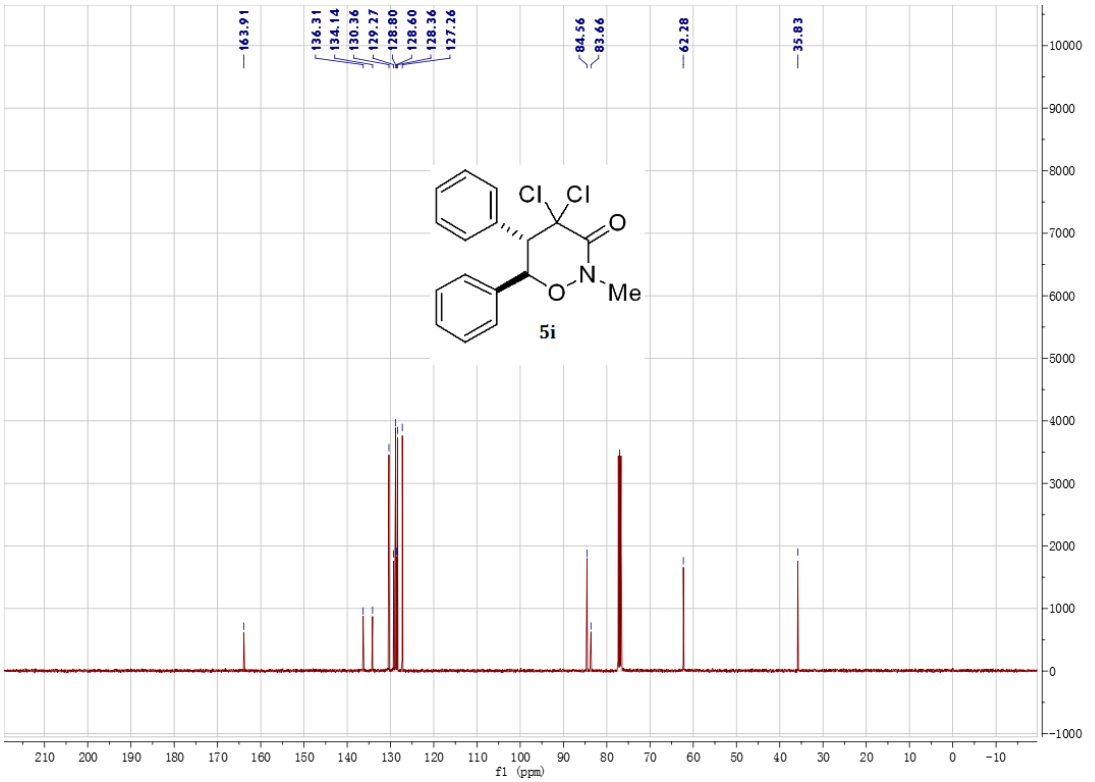
^{1}H NMR (400 MHz, $CDCl_3$) of **5h**



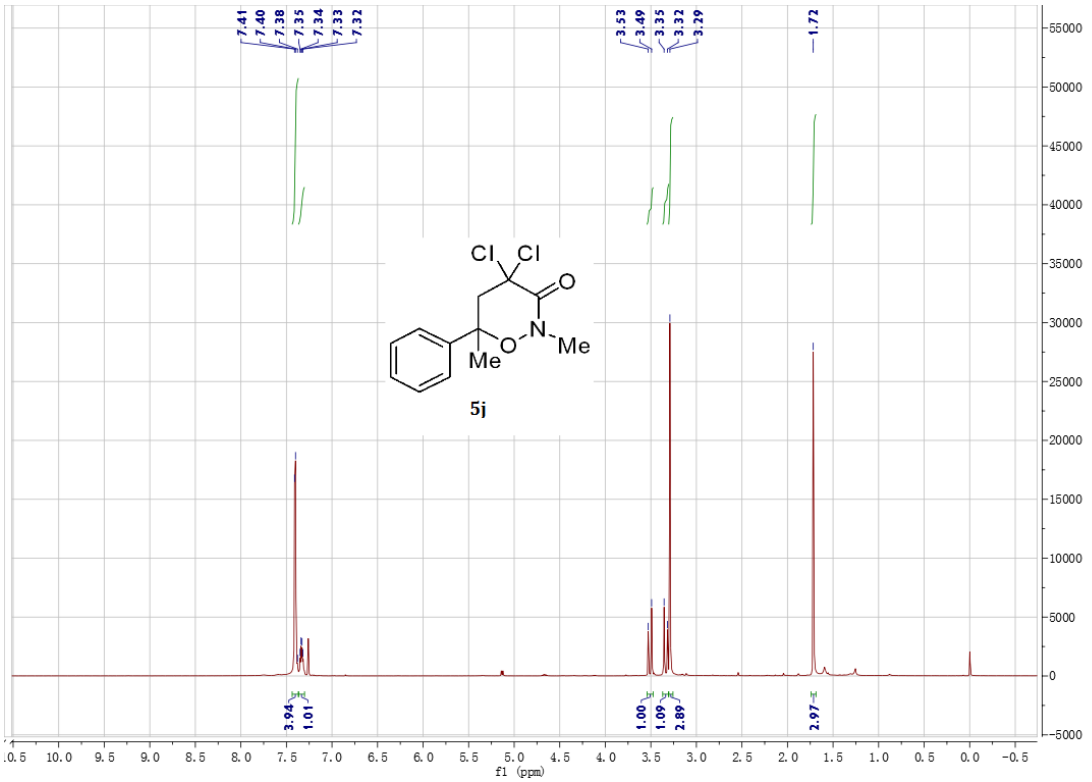
^{13}C NMR (101 MHz, $CDCl_3$) of **5h**



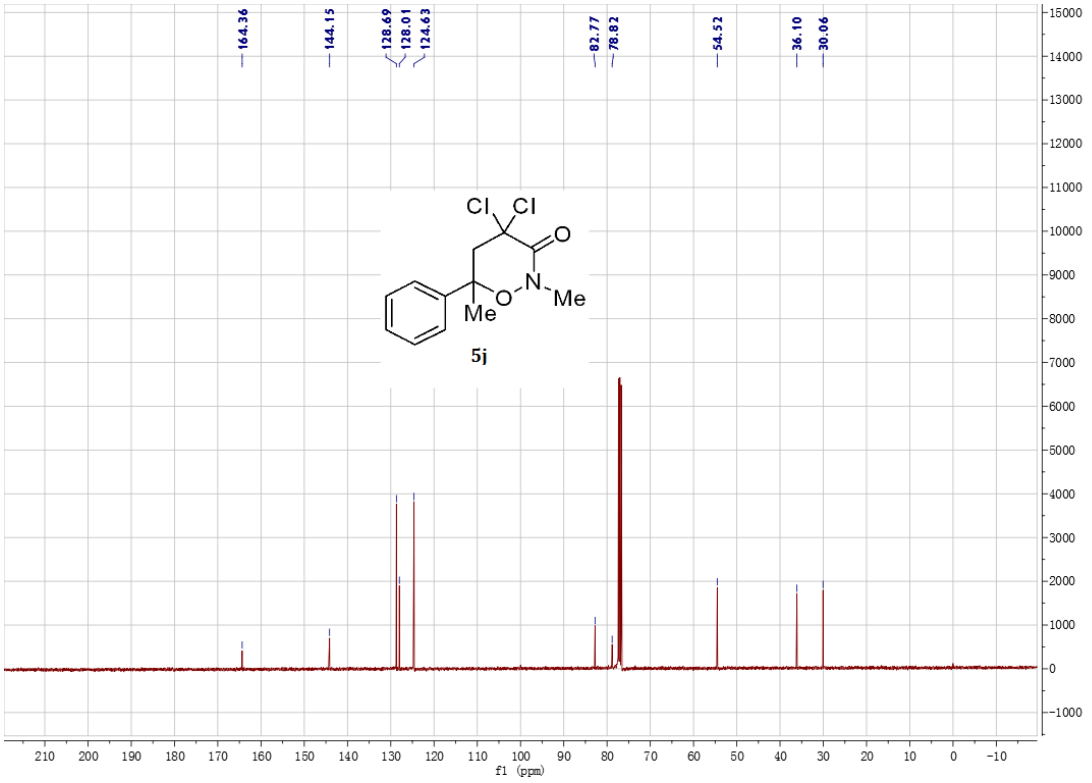
^{1}H NMR (400 MHz, $CDCl_3$) of **5i**



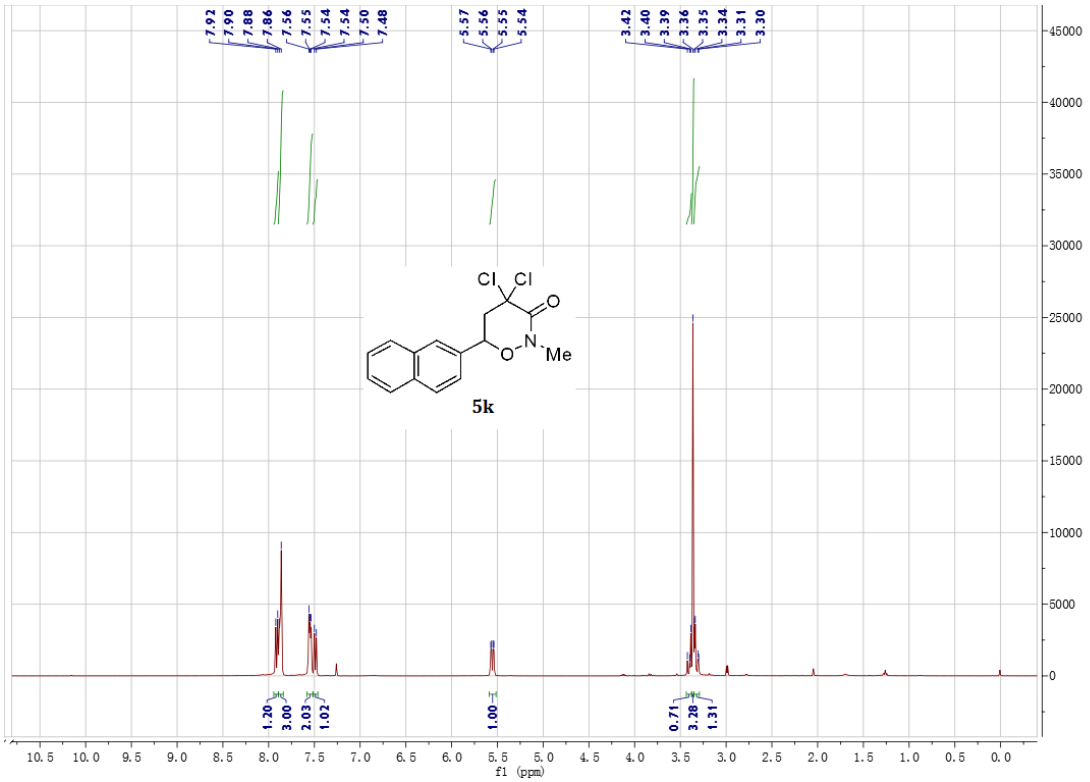
^{13}C NMR (101 MHz, $CDCl_3$) of **5i**



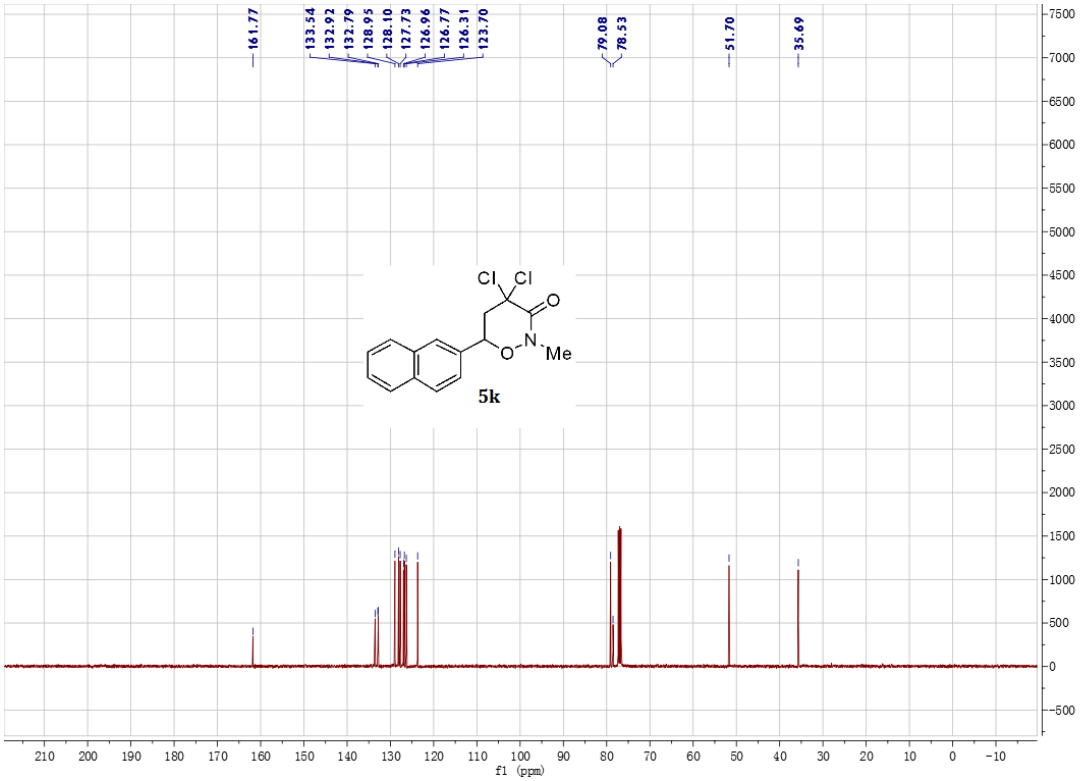
^{1}H NMR (400 MHz, $CDCl_3$) of **5j**



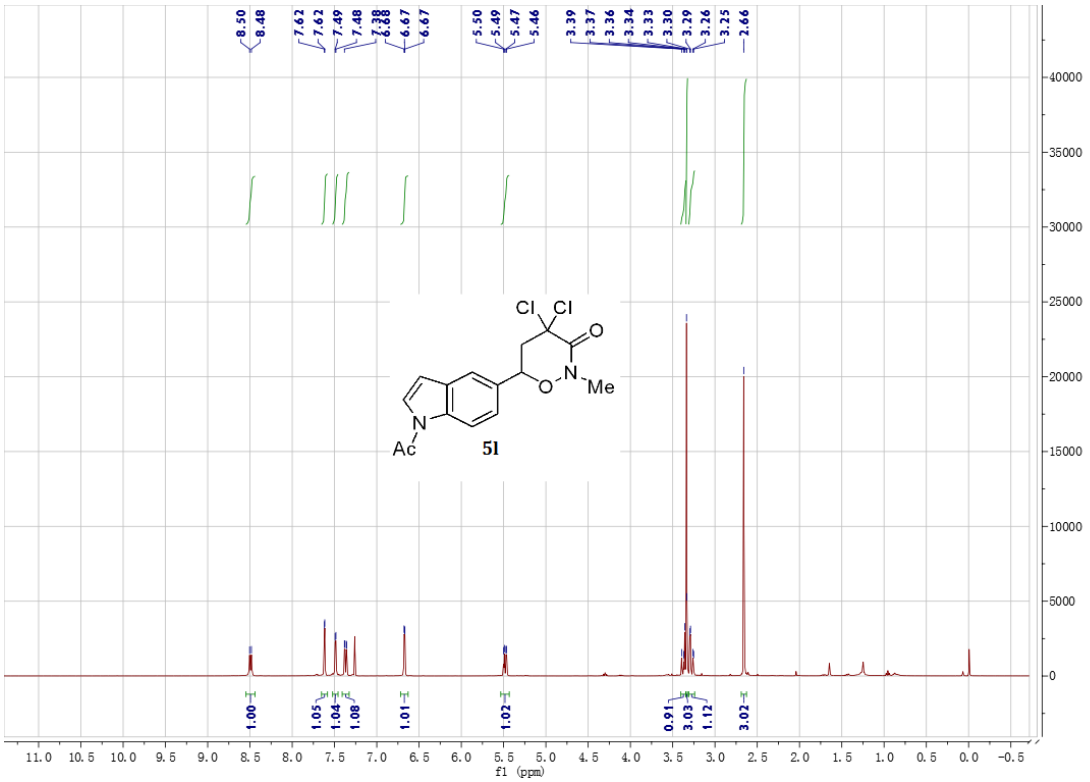
^{13}C NMR (101 MHz, $CDCl_3$) of **5j**



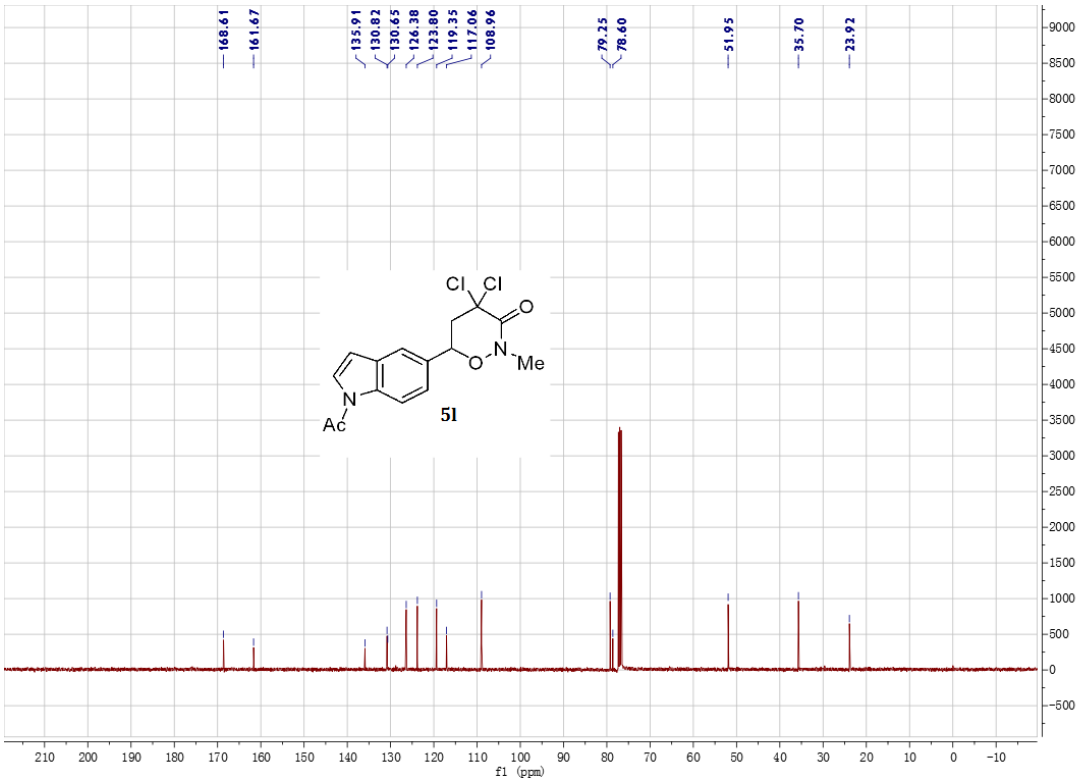
^{1}H NMR (400 MHz, $CDCl_3$) of **5k**



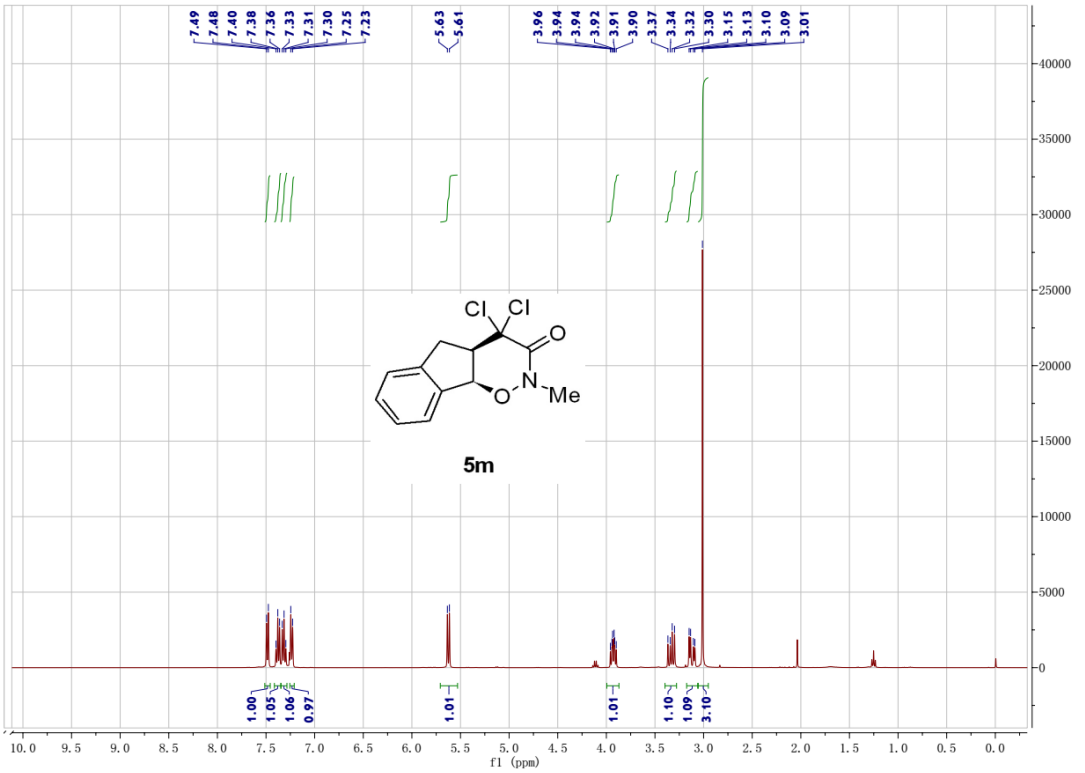
^{13}C NMR (101 MHz, $CDCl_3$) of **5k**



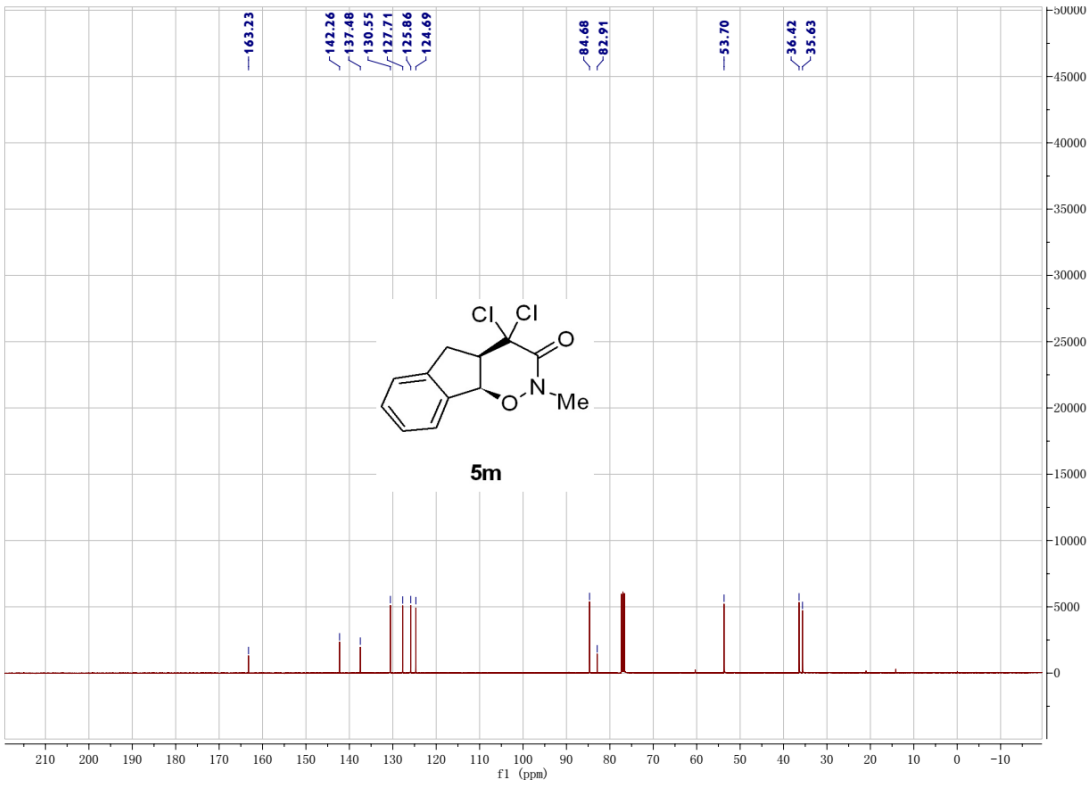
^{1}H NMR (400 MHz, $CDCl_3$) of **5l**



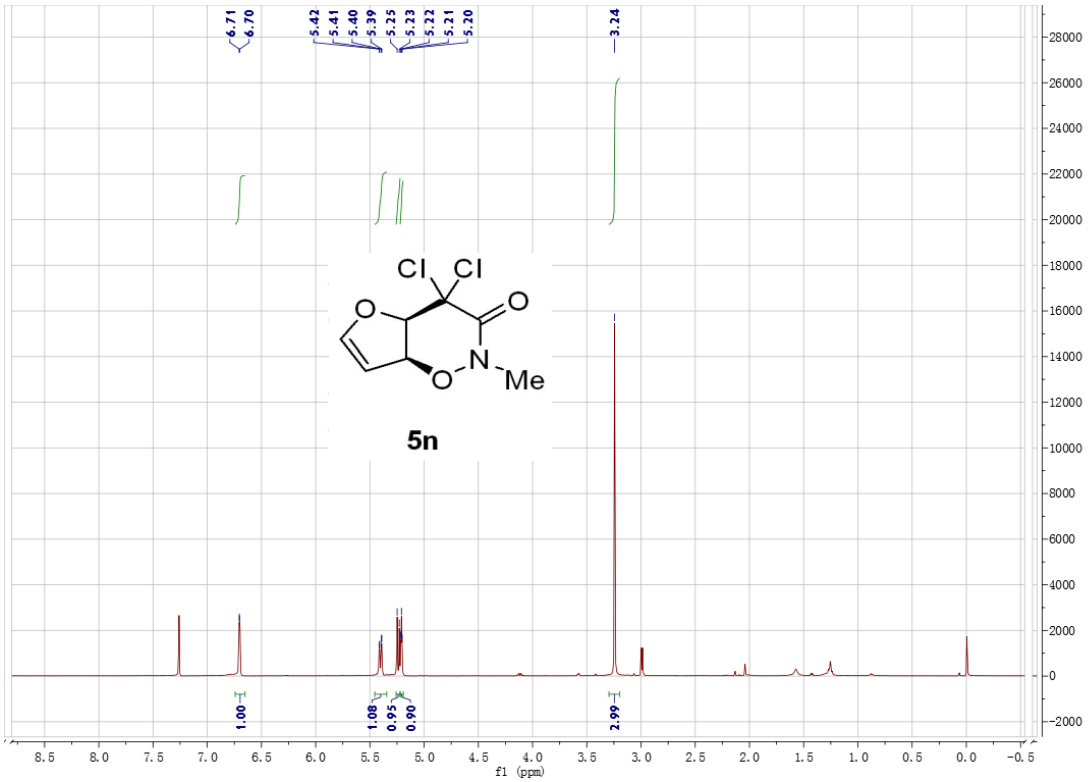
^{13}C NMR (101 MHz, $CDCl_3$) of **5l**



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



^{13}C NMR (101 MHz, $CDCl_3$) of **5m**



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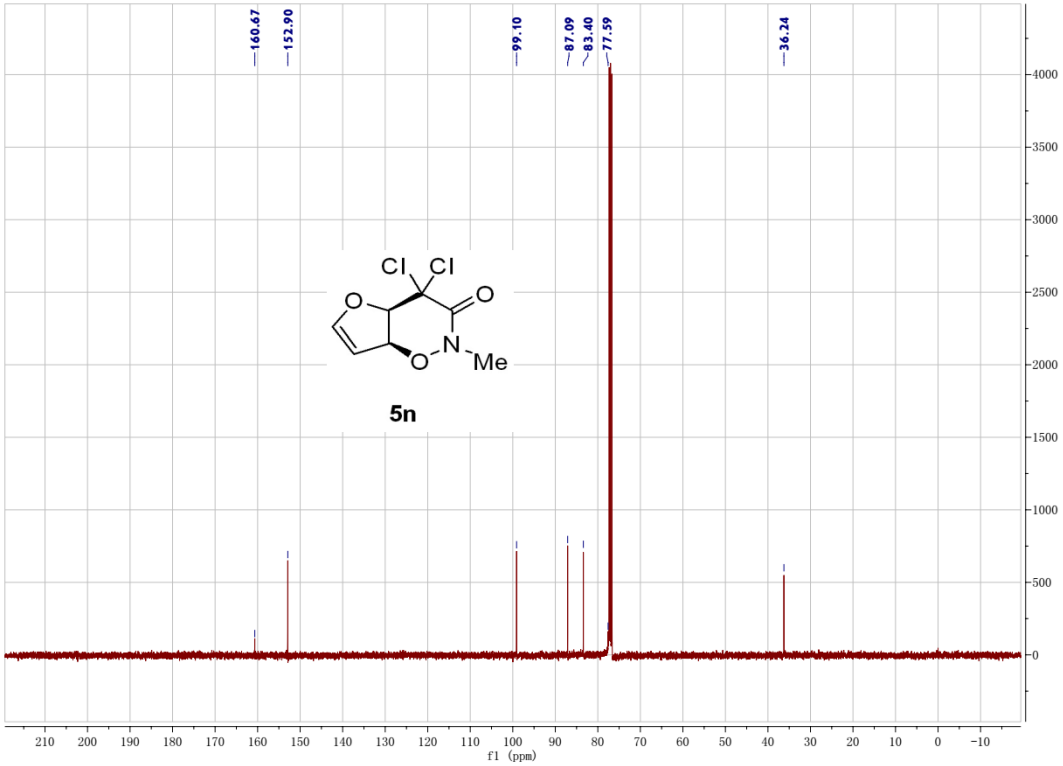
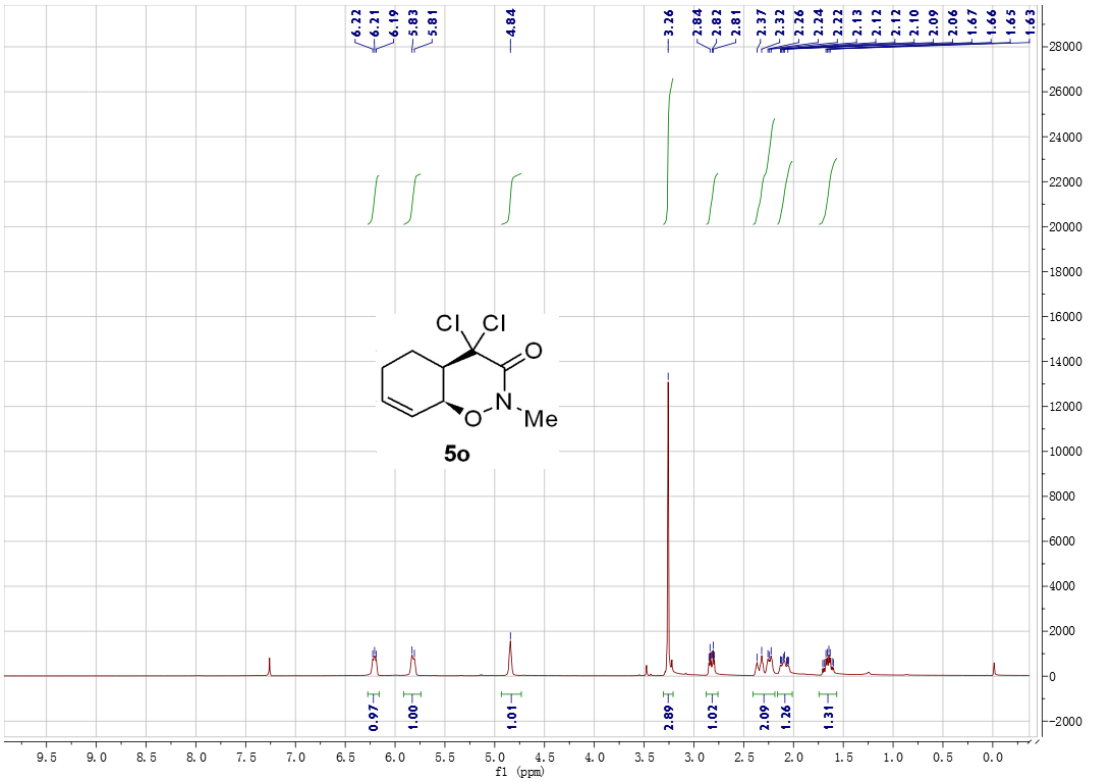


^{13}C NMR (101 MHz, $CDCl_3$) of **5n**



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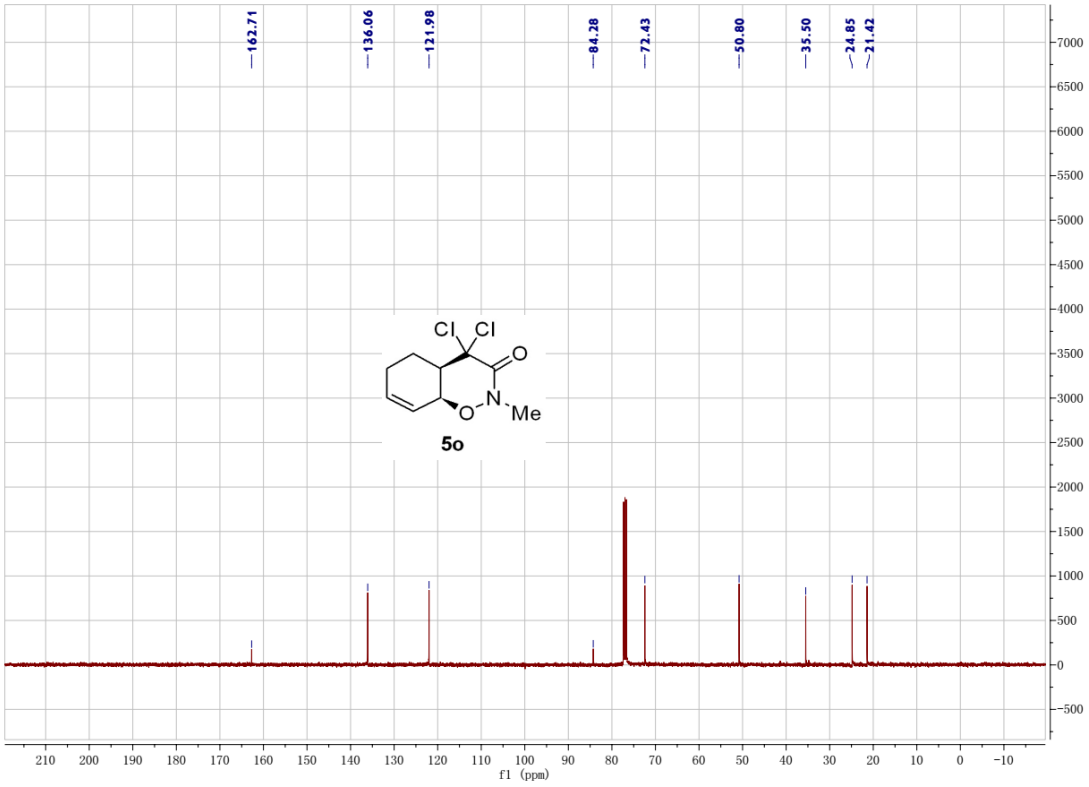
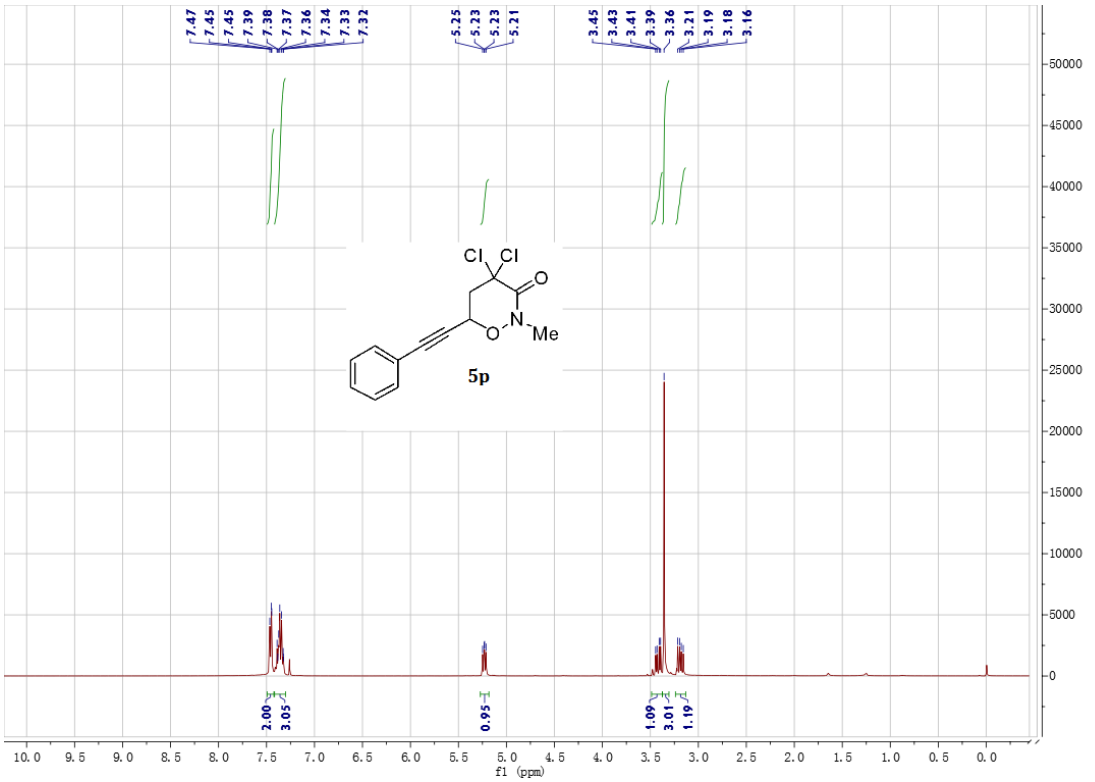
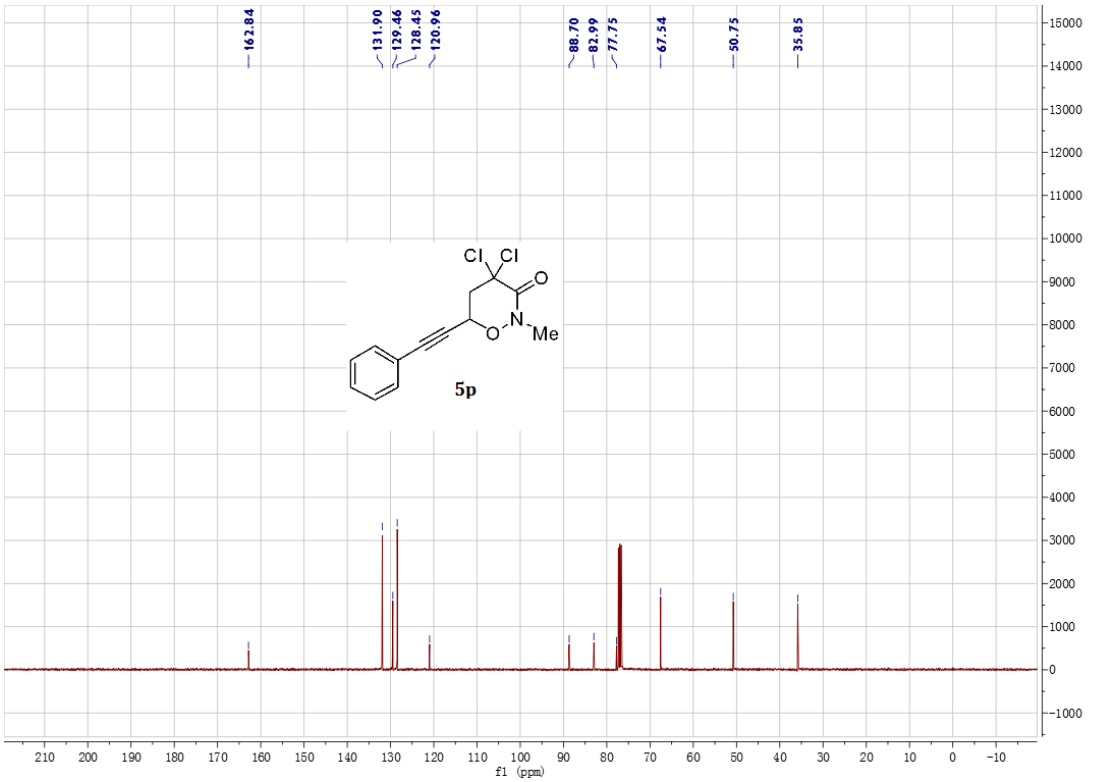


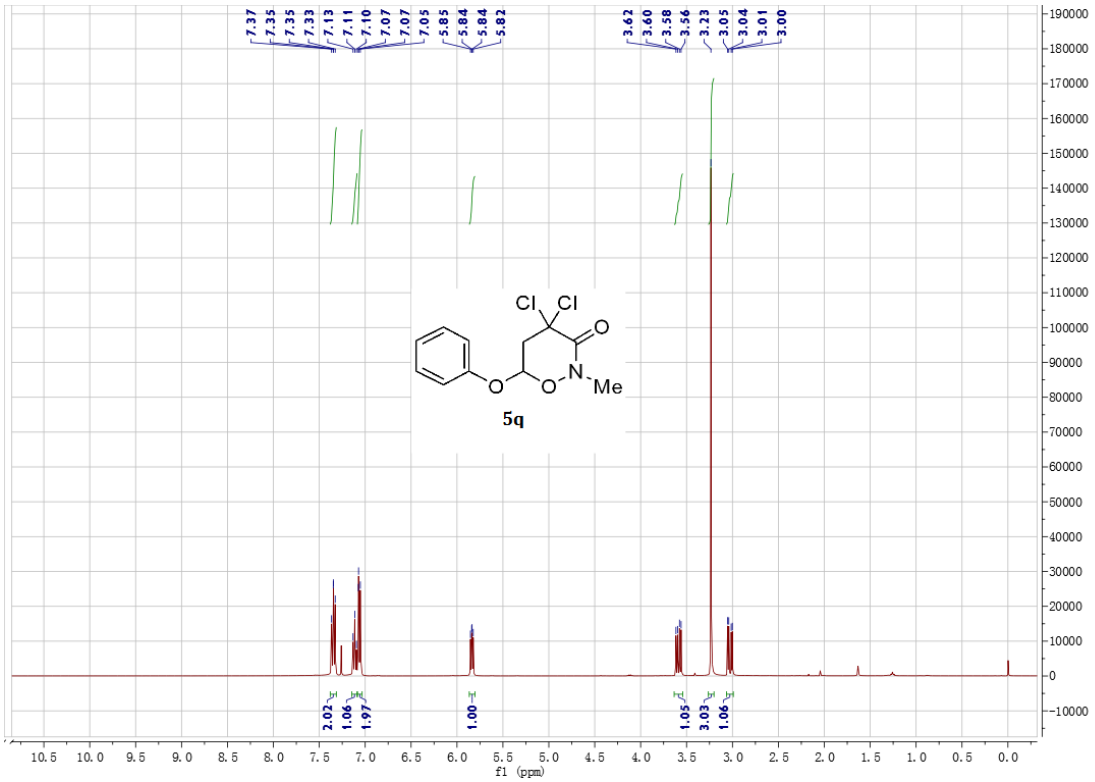
^{13}C NMR (101 MHz, $CDCl_3$) of **5o**



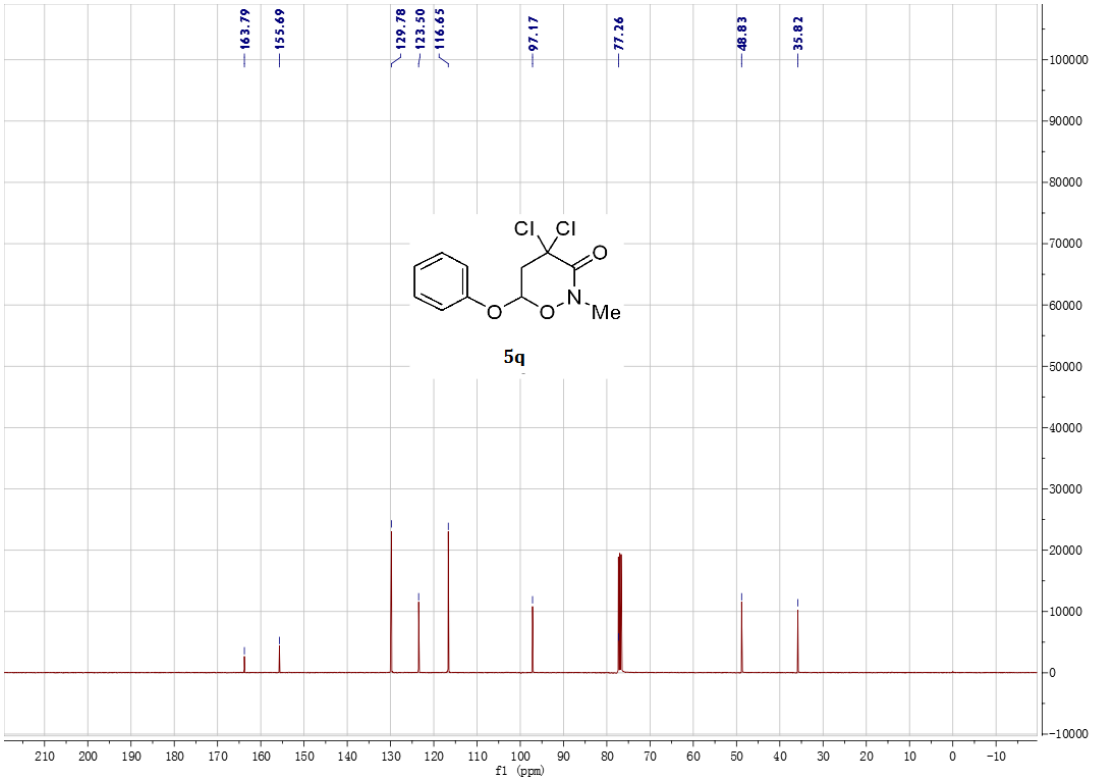
^{1}H NMR (400 MHz, $CDCl_3$) of **5p**



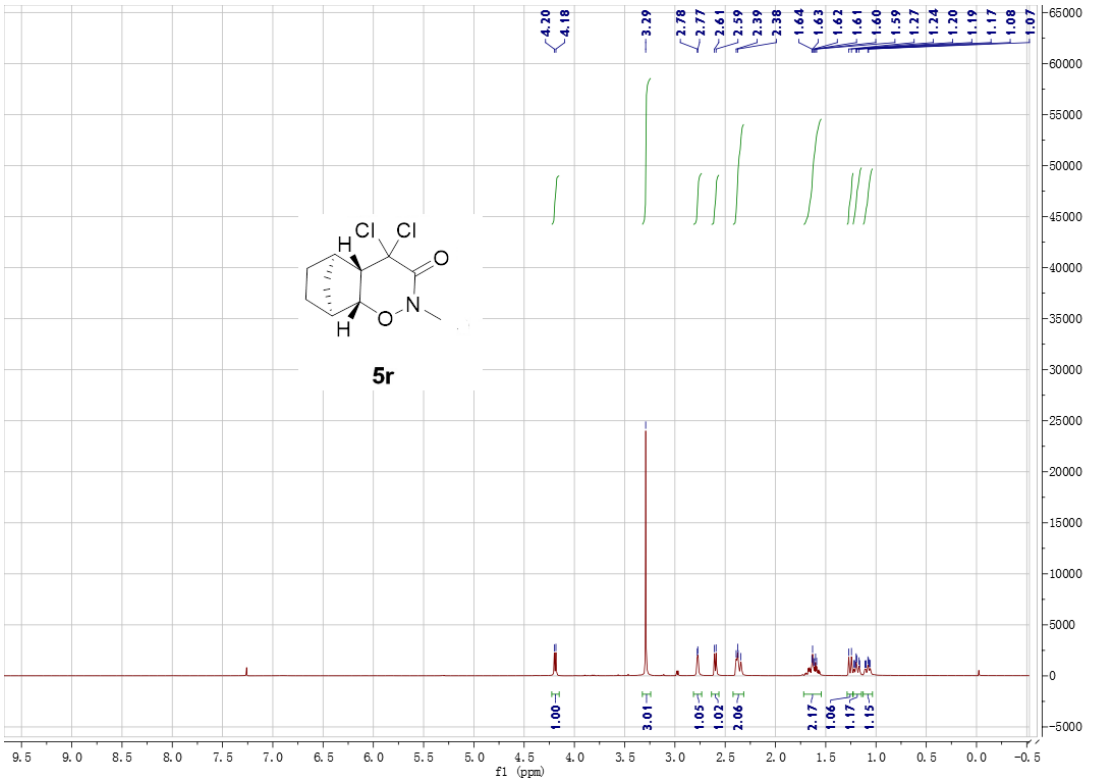
^{13}C NMR (101 MHz, $CDCl_3$) of **5p**



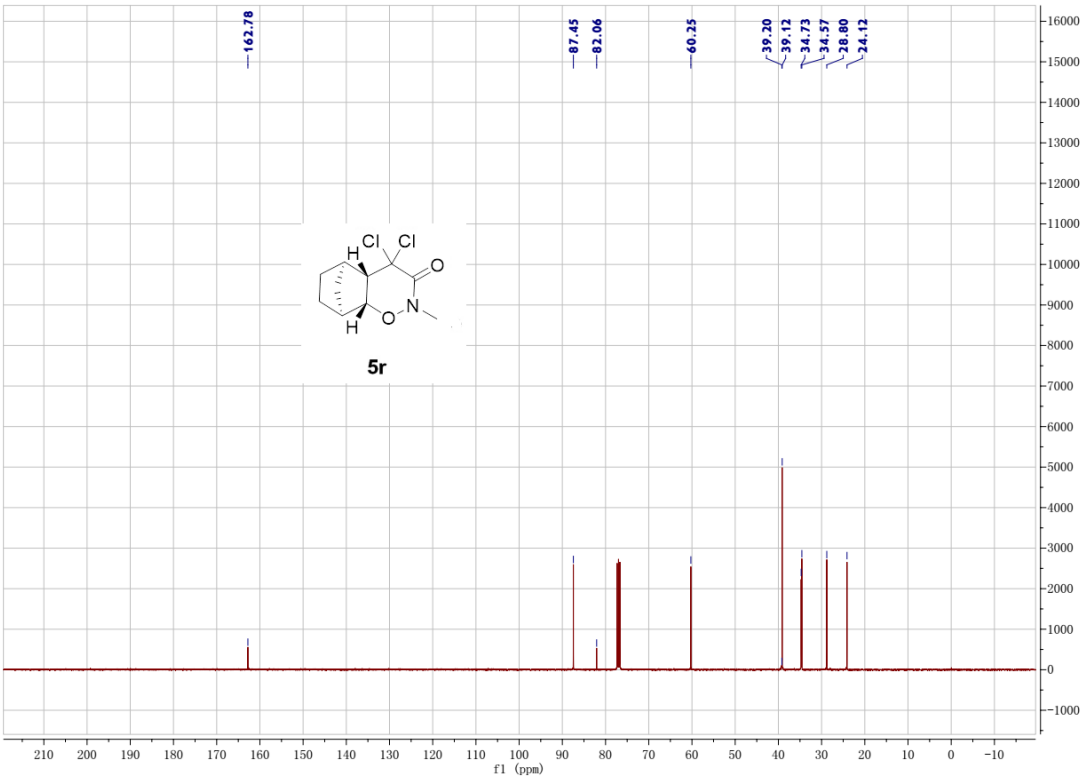
^{1}H NMR (400 MHz, $CDCl_3$) of **5q**



^{13}C NMR (101 MHz, $CDCl_3$) of **5q**



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



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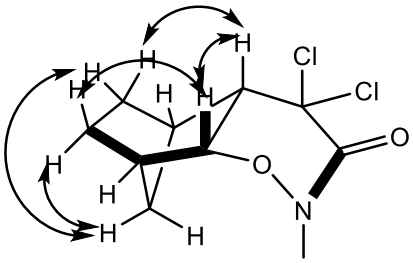
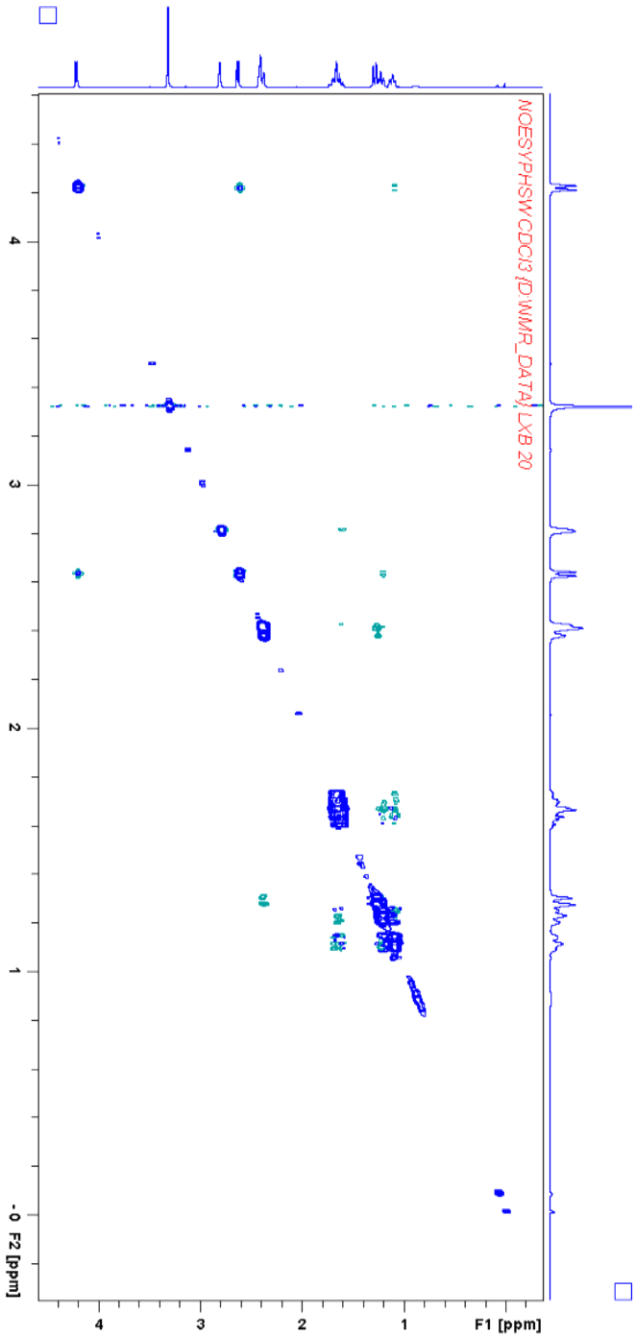


5r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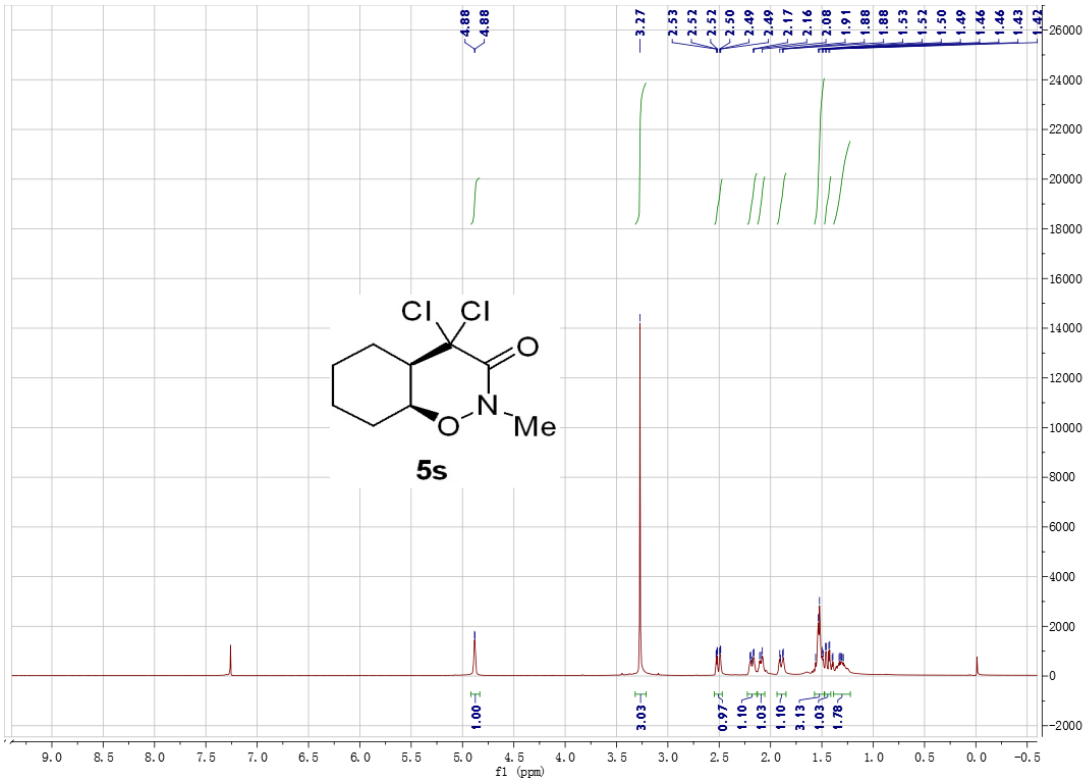
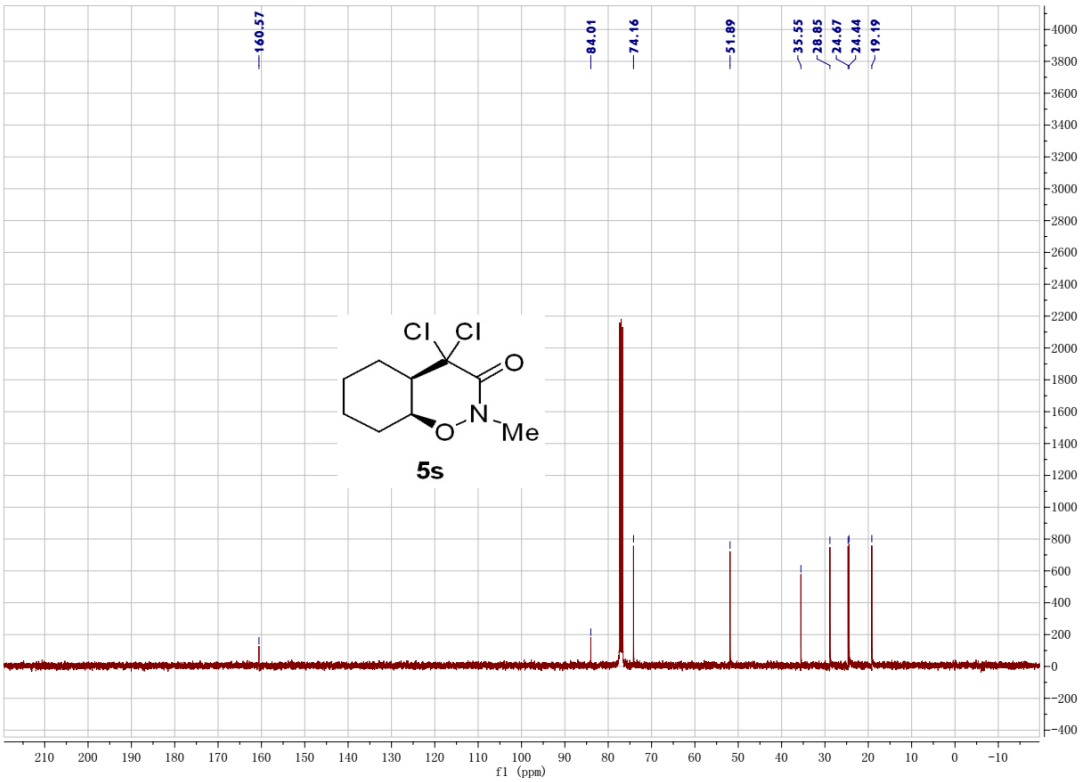
F1 [ppm]
F2 [ppm]
4
3
2
1
0

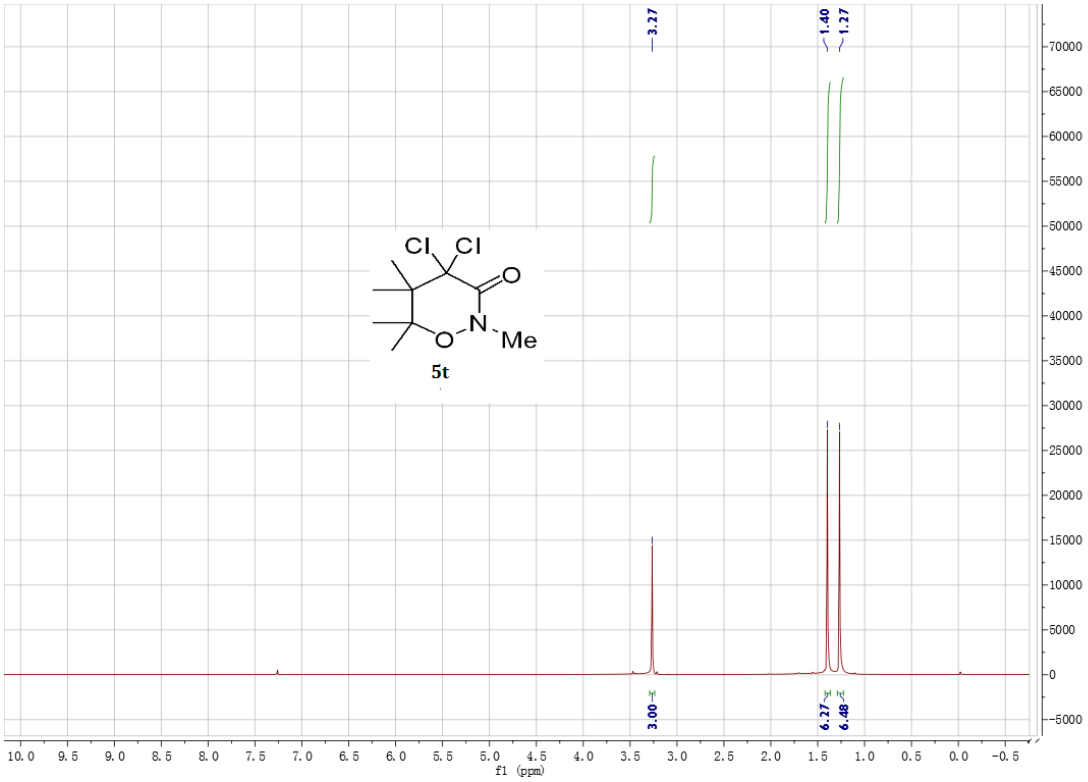
NOE ($CDCl_3$) of **5r**



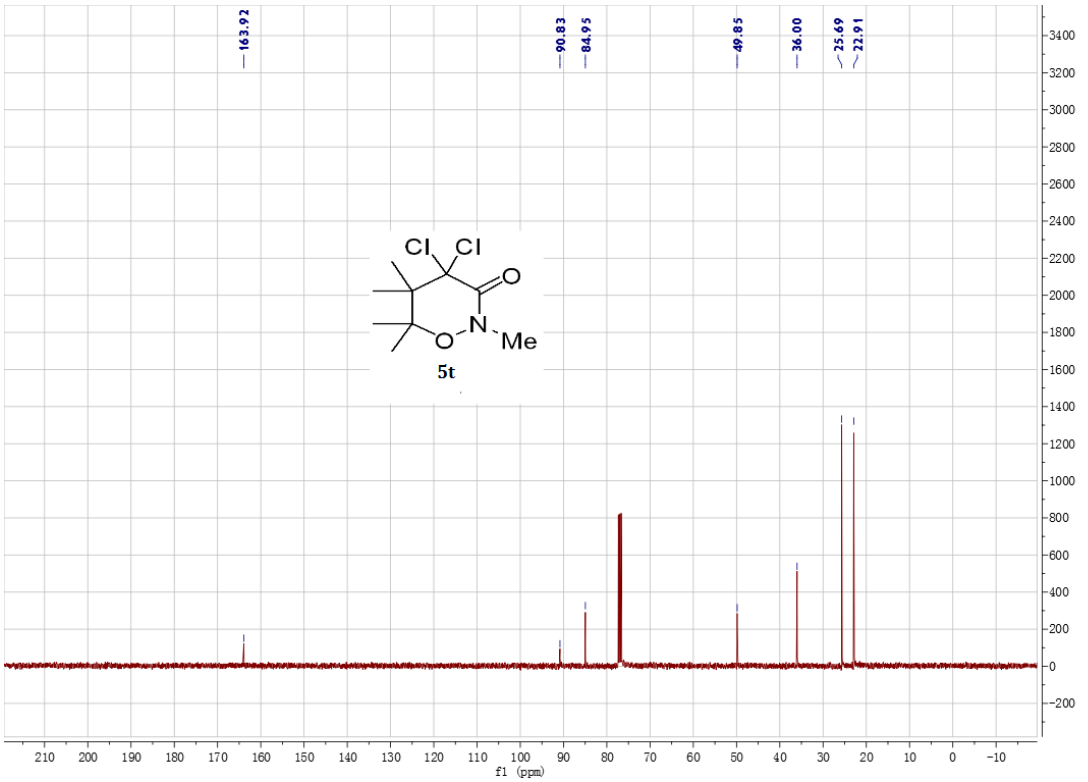
^1H NMR (400 MHz, $CDCl_3$) of **5s**



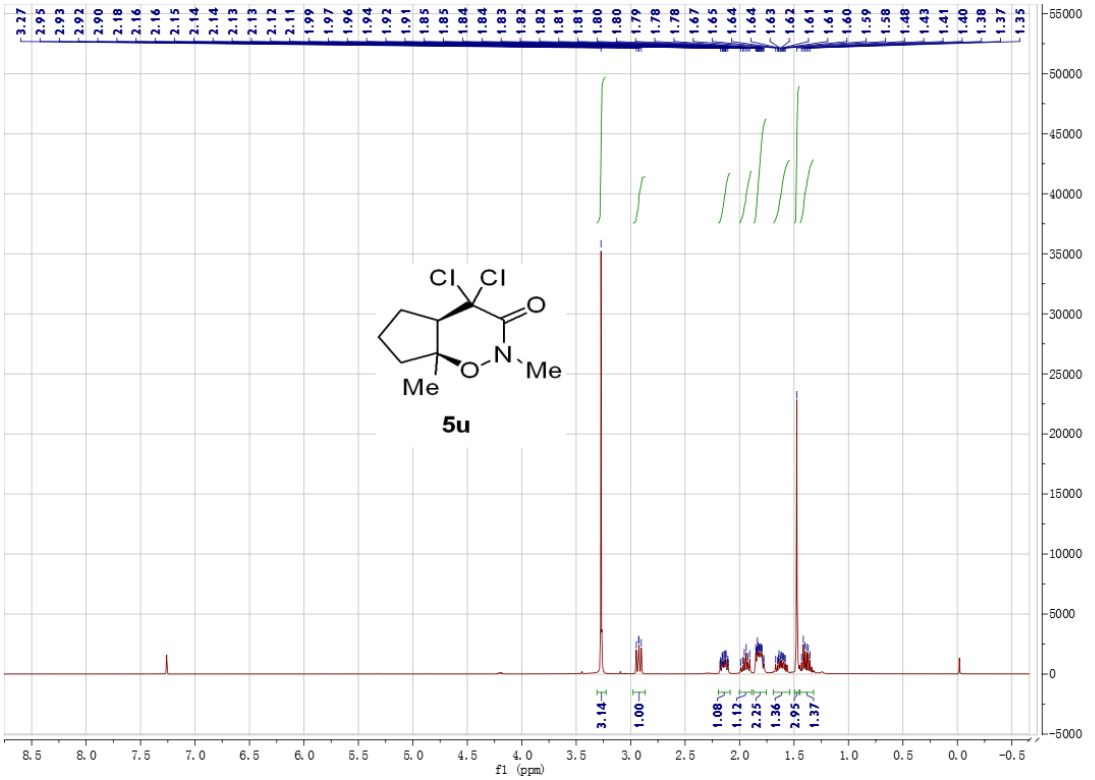
^{13}C NMR (101 MHz, $CDCl_3$) of **5s**



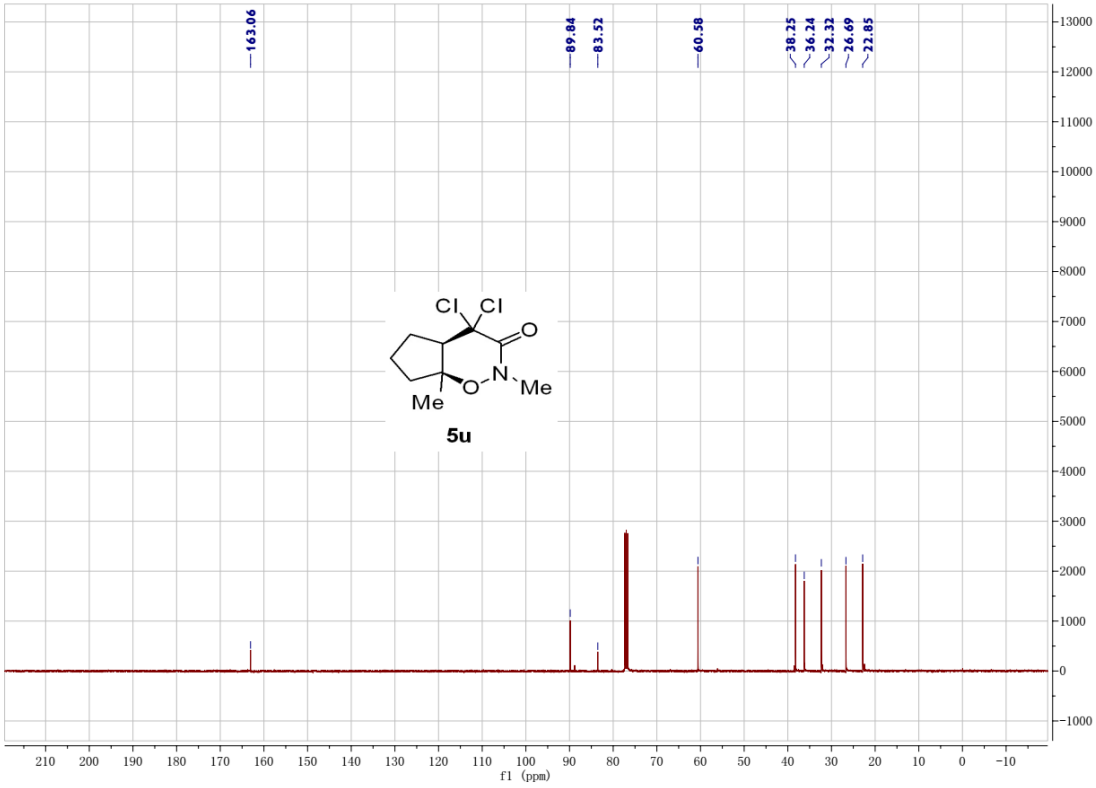
^{1}H NMR (400 MHz, $CDCl_3$) of **5t**



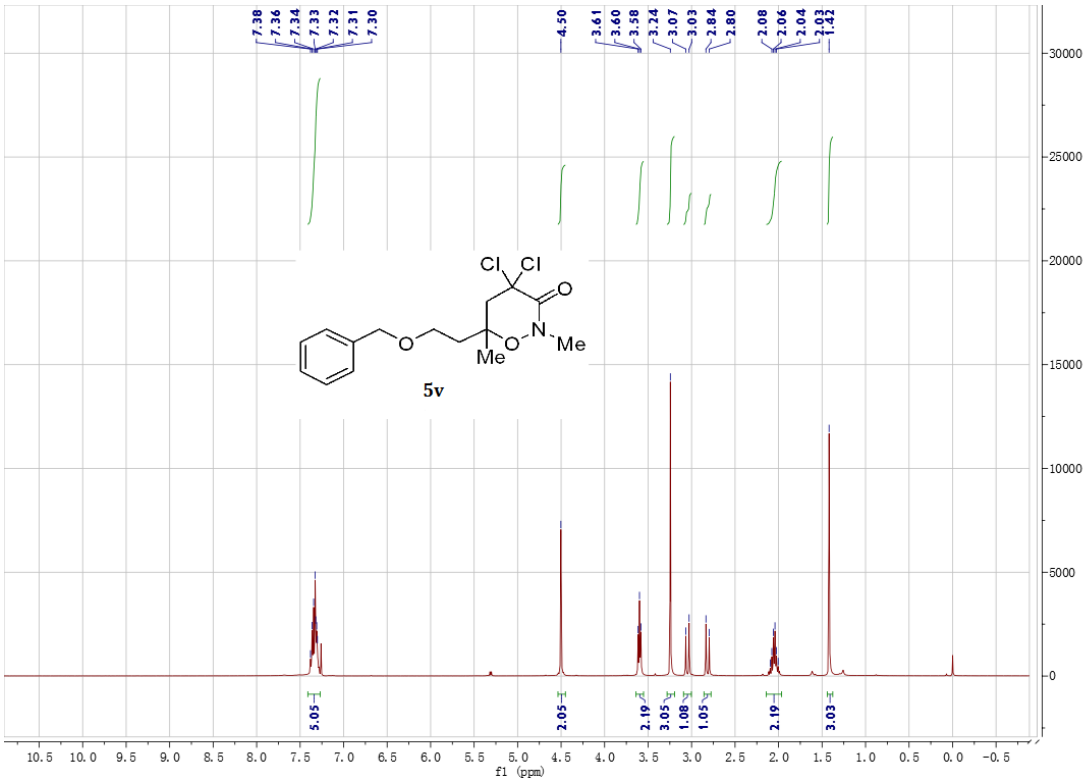
^{13}C NMR (101 MHz, $CDCl_3$) of **5t**



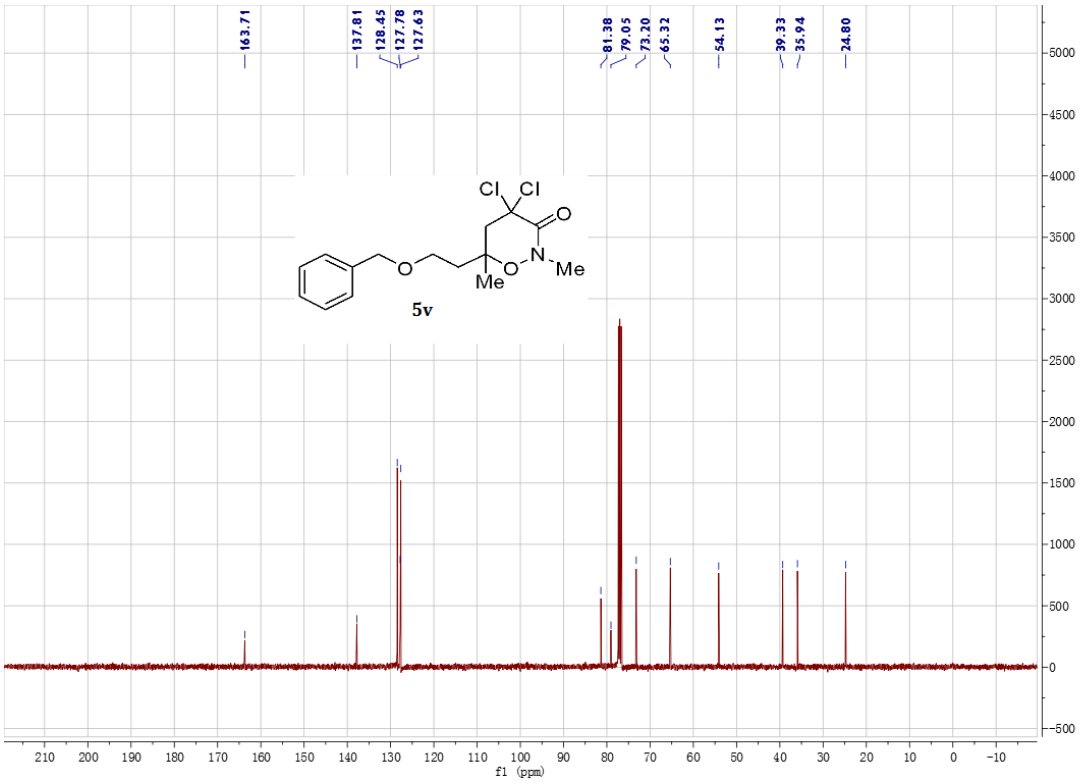
^{1}H NMR (400 MHz, $CDCl_3$) of **5u**



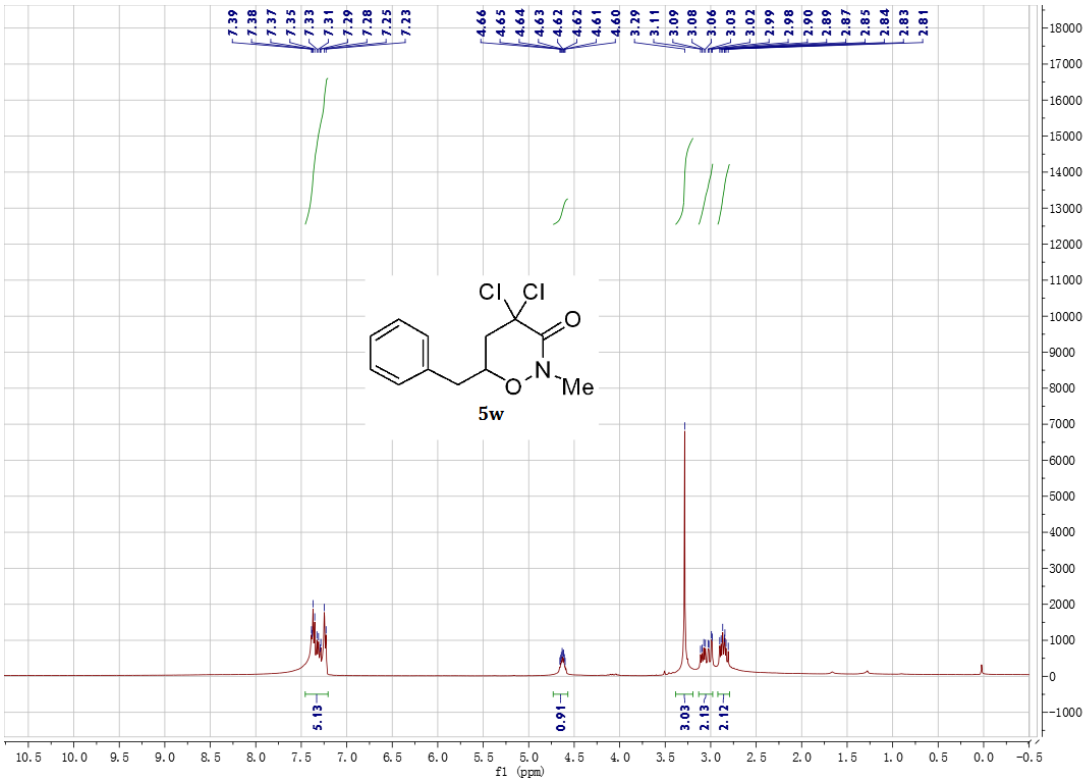
^{13}C NMR (101 MHz, $CDCl_3$) of **5u**



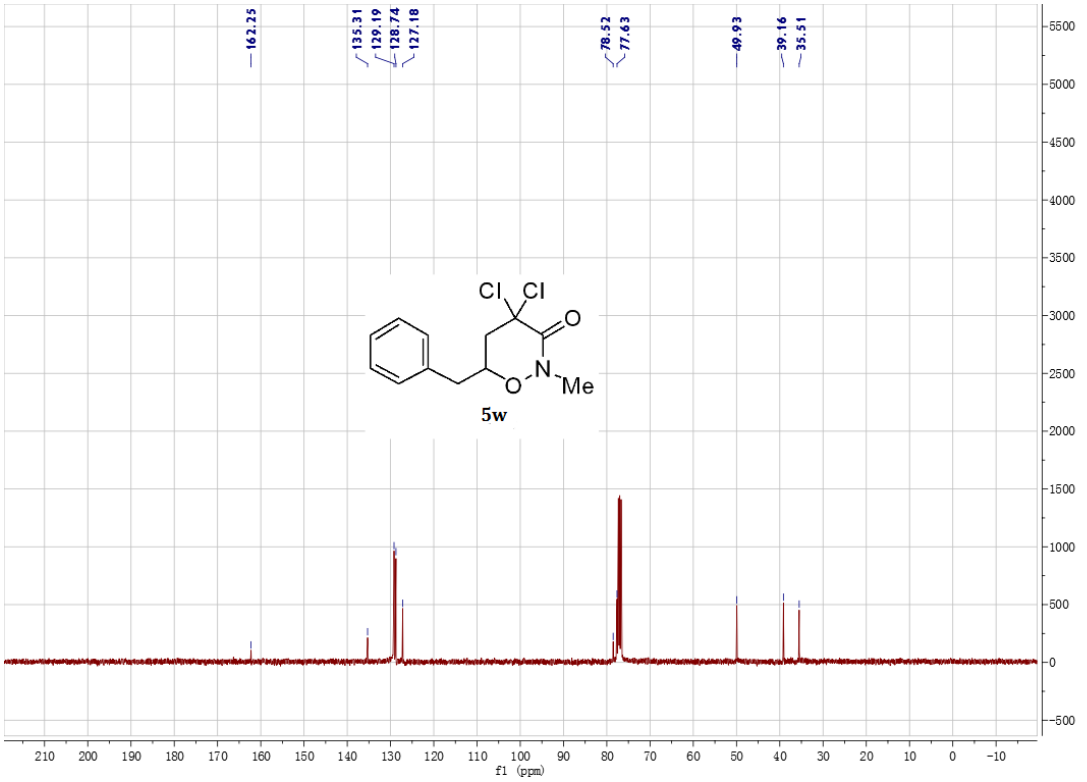
^{1}H NMR (400 MHz, $CDCl_3$) of **5v**



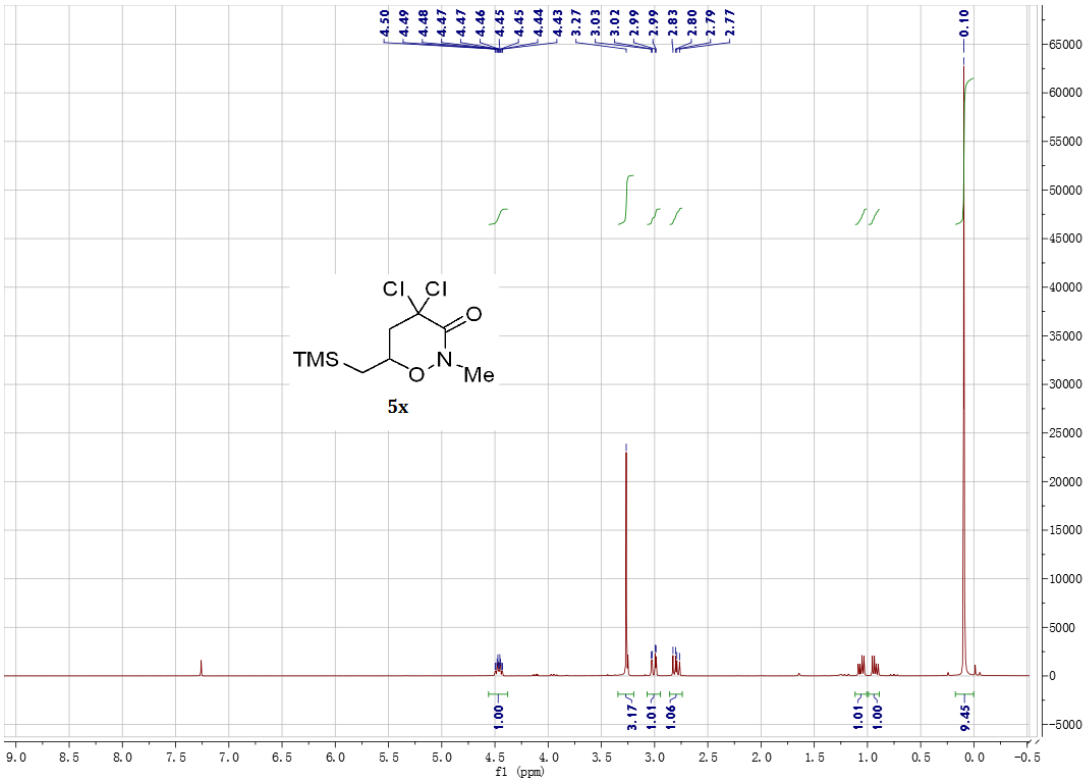
^{13}C NMR (101 MHz, $CDCl_3$) of **5v**



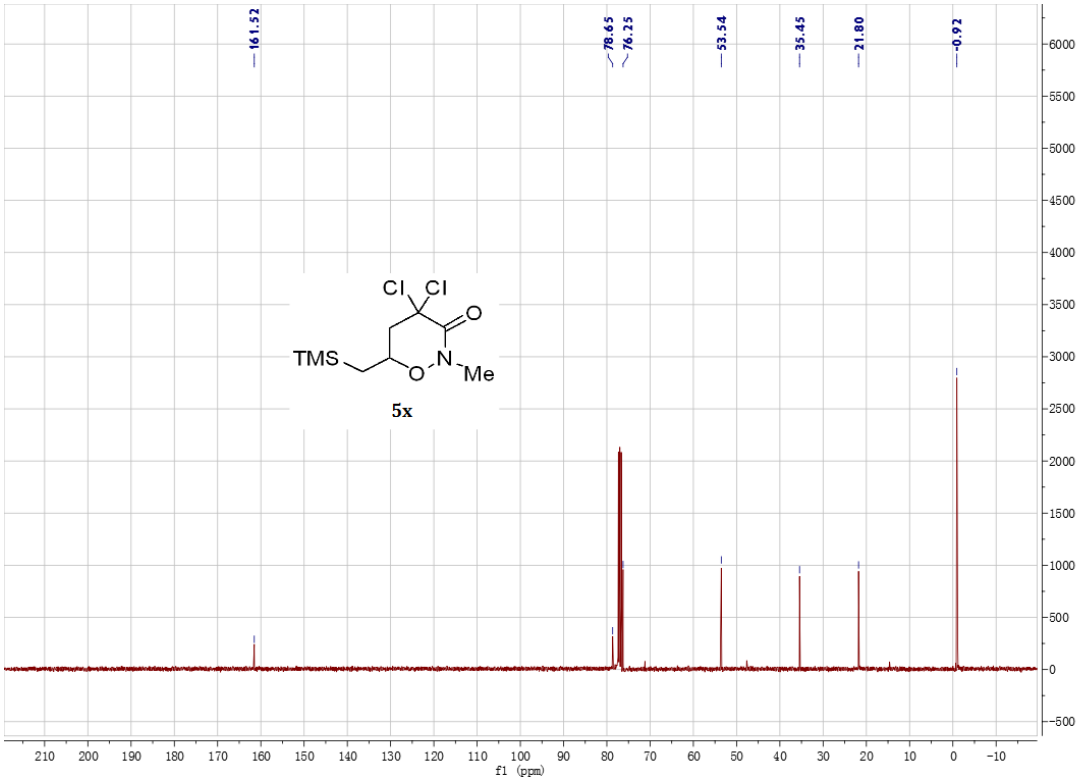
^{1}H NMR (400 MHz, $CDCl_3$) of **5w**



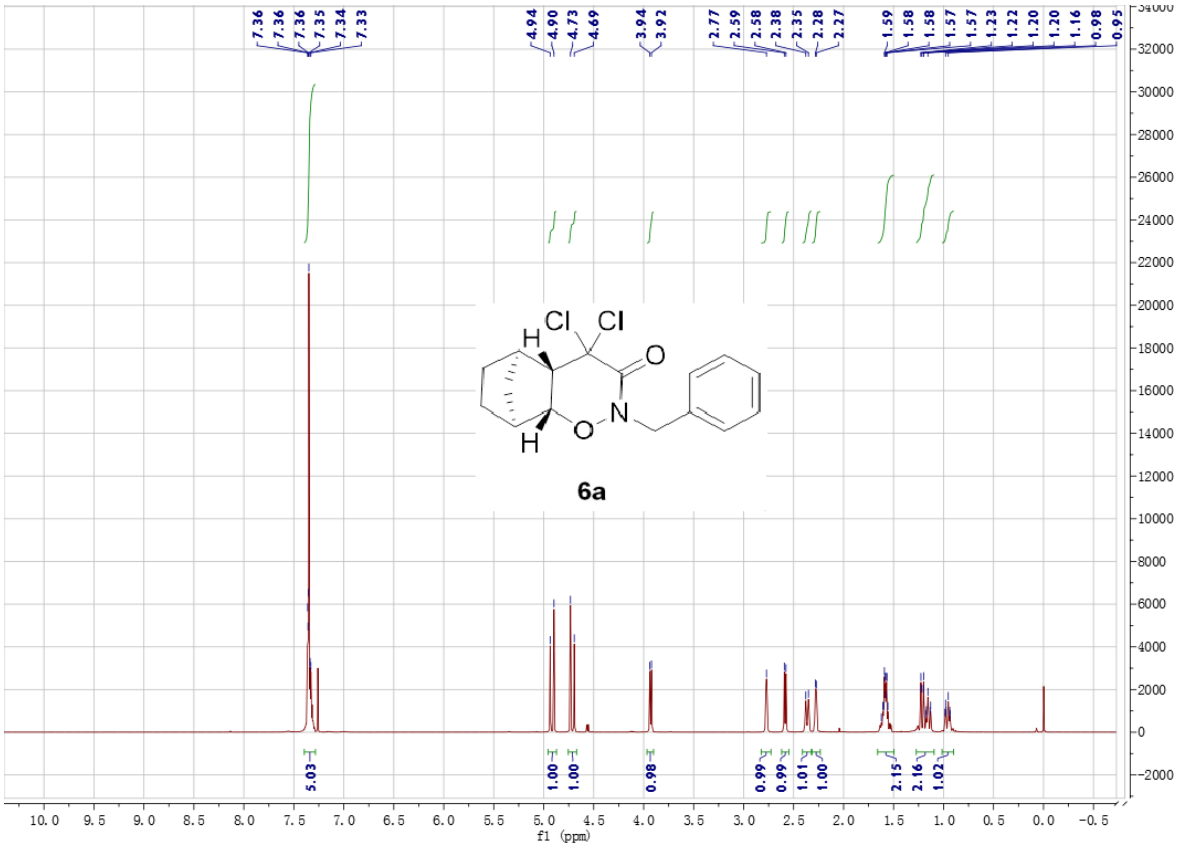
^{13}C NMR (101 MHz, $CDCl_3$) of **5w**



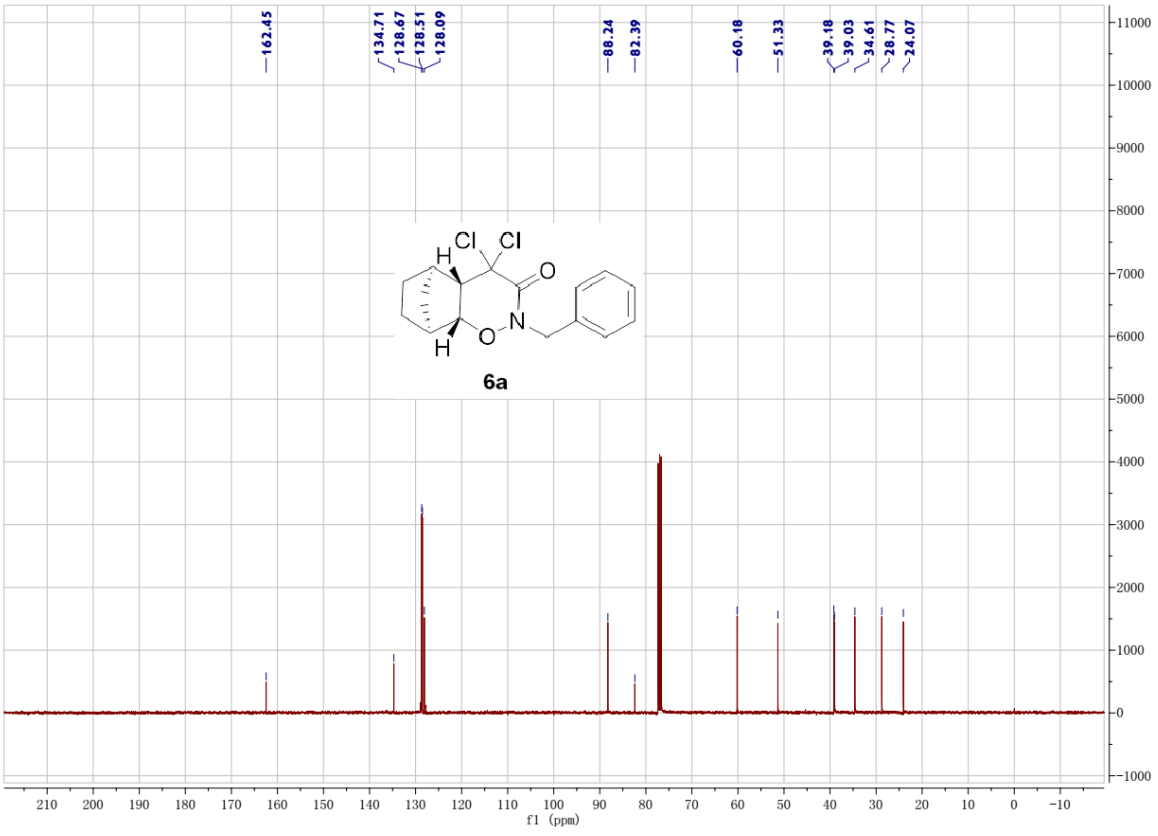
^{1}H NMR (400 MHz, $CDCl_3$) of **5x**



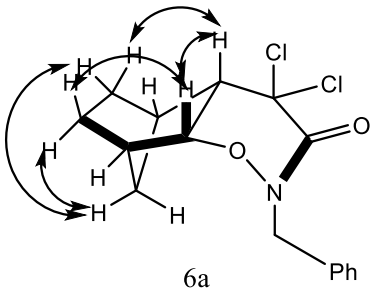
^{13}C NMR (101 MHz, $CDCl_3$) of **5x**



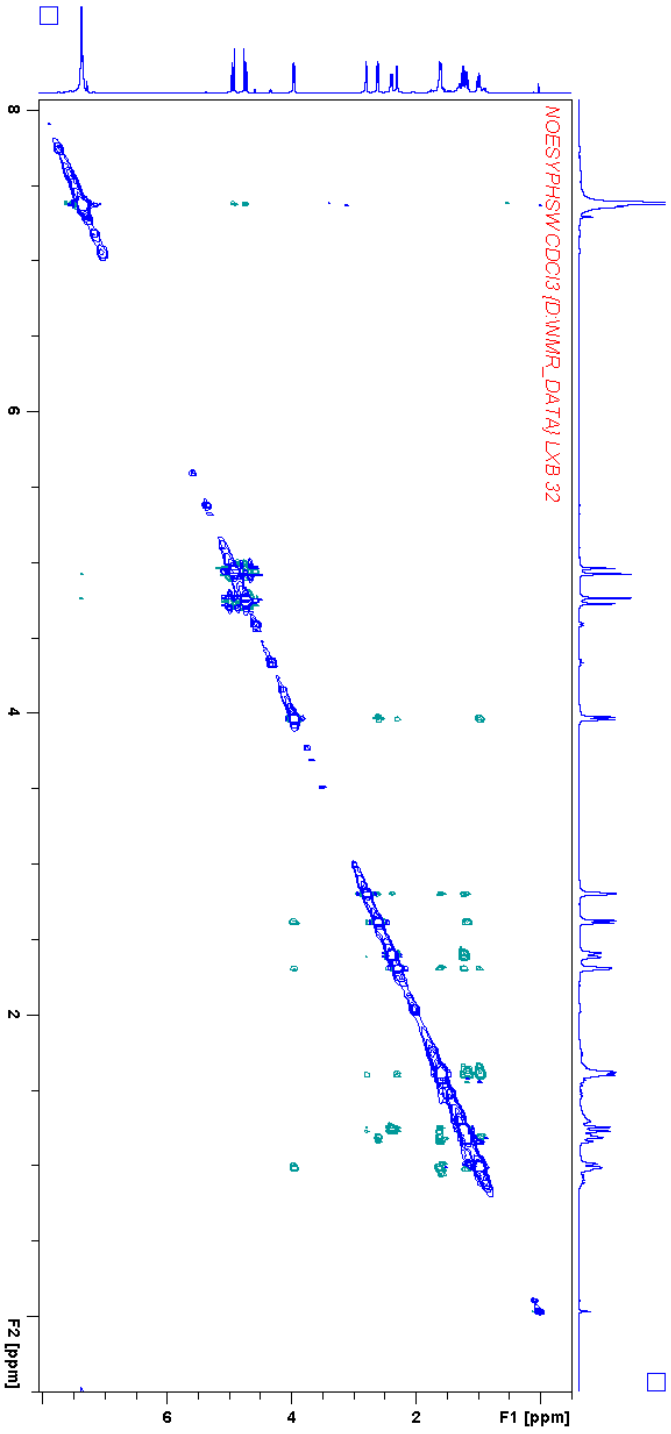
^{1}H NMR (400 MHz, $CDCl_3$) of **6a**



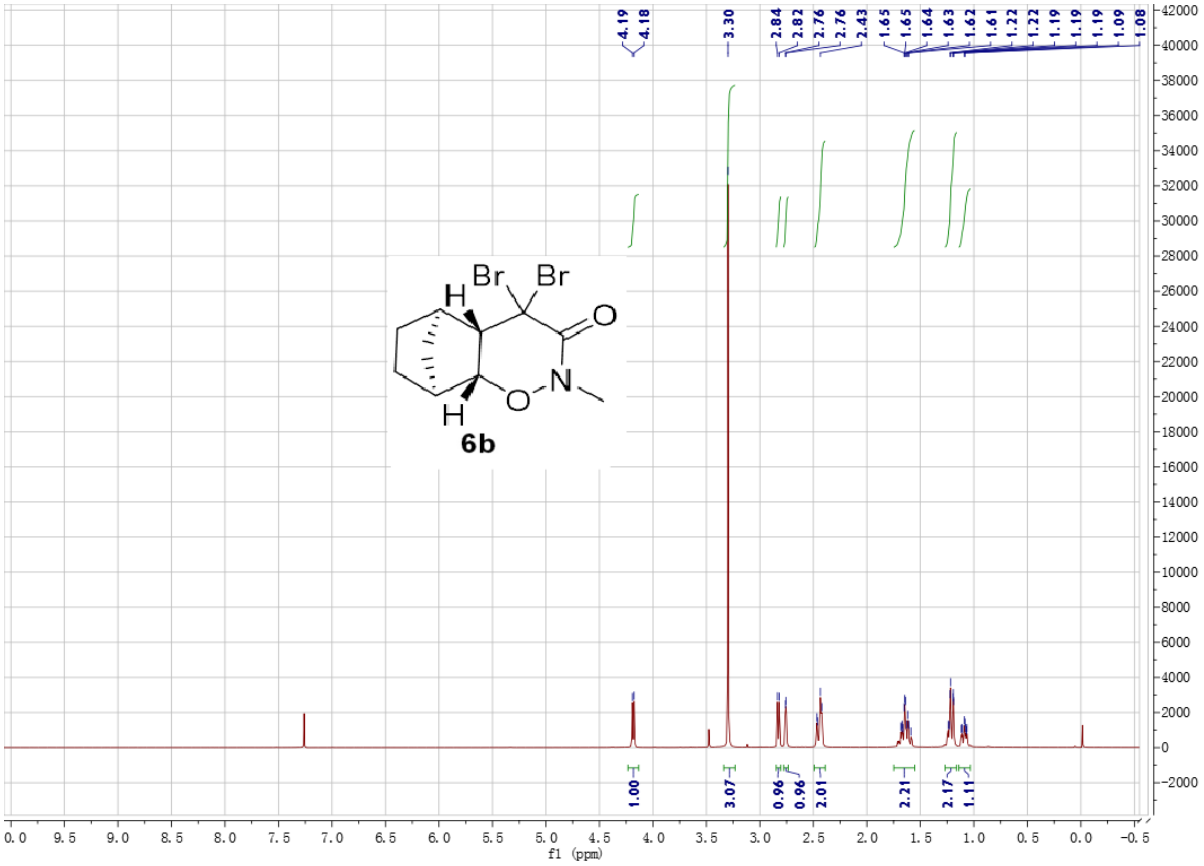
^{13}C NMR (101 MHz, $CDCl_3$) of **6a**



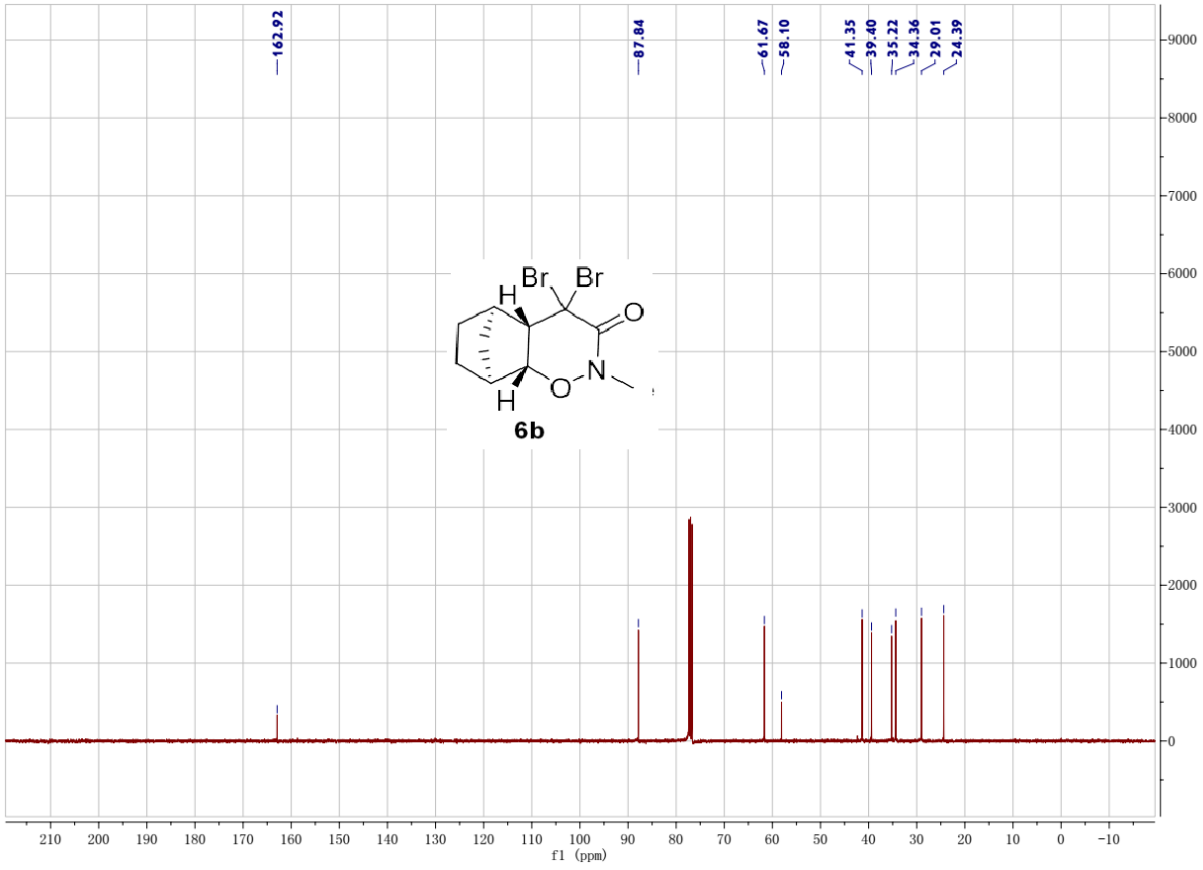
6a


NOESYPHSW CDCl3 {D:\NMR_DATA} LXB 32
F2 [ppm]
F1 [ppm]
8
6
4
2
6
4
2

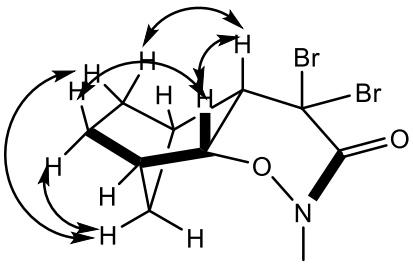
NOE ($CDCl_3$) of **6a**



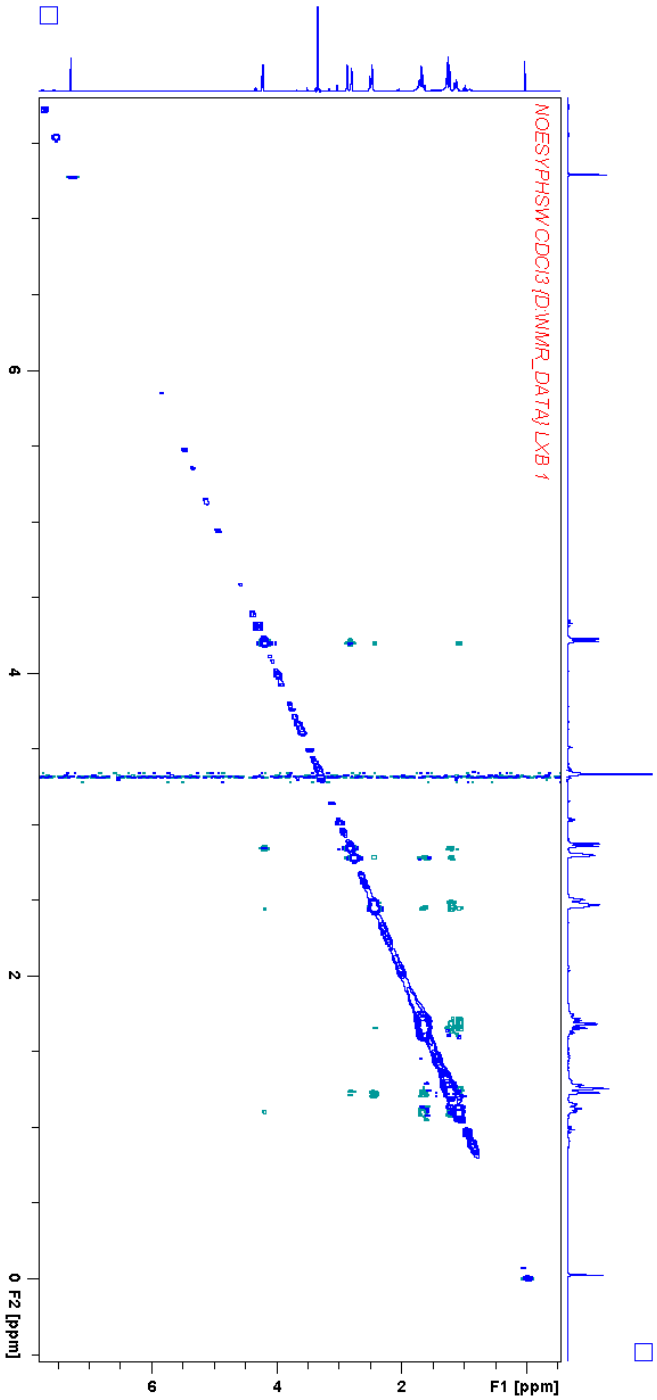
^{1}H NMR (400 MHz, $CDCl_3$) of **6b**



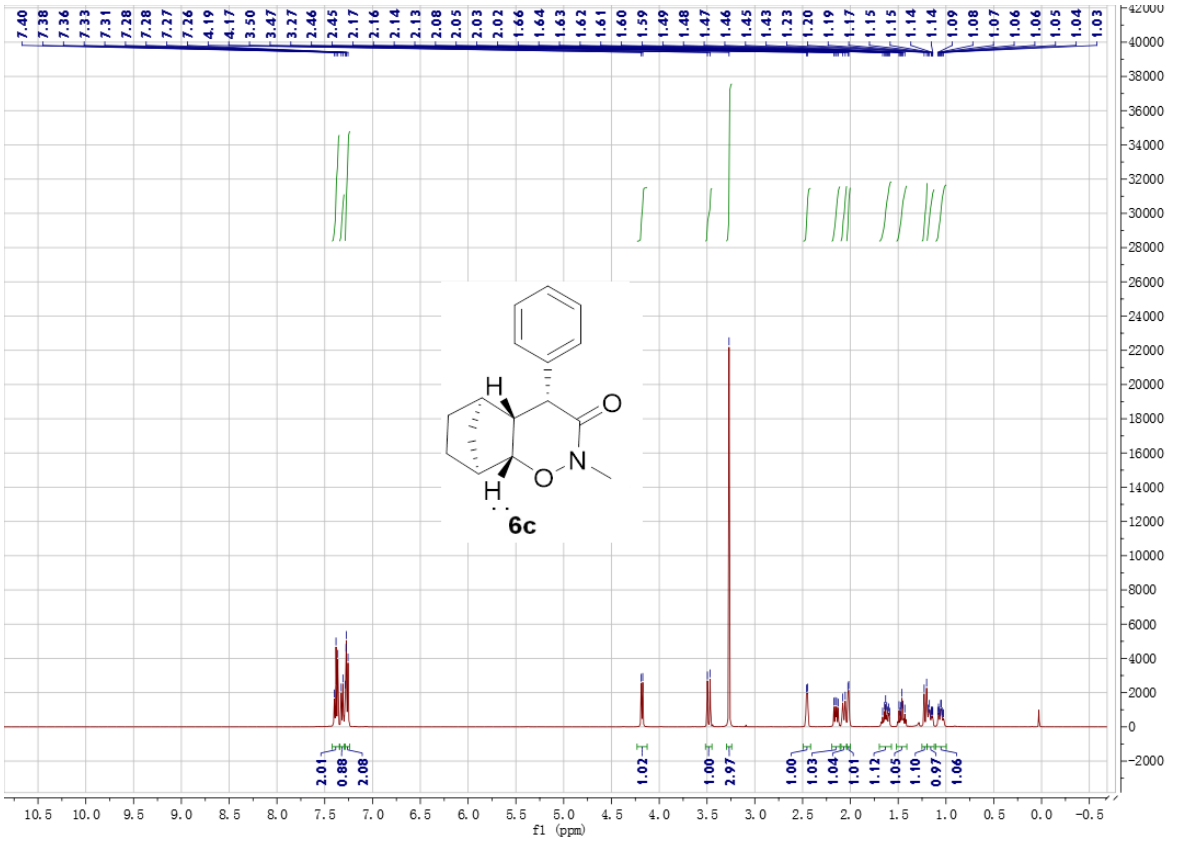
^{13}C NMR (101 MHz, $CDCl_3$) of **6b**



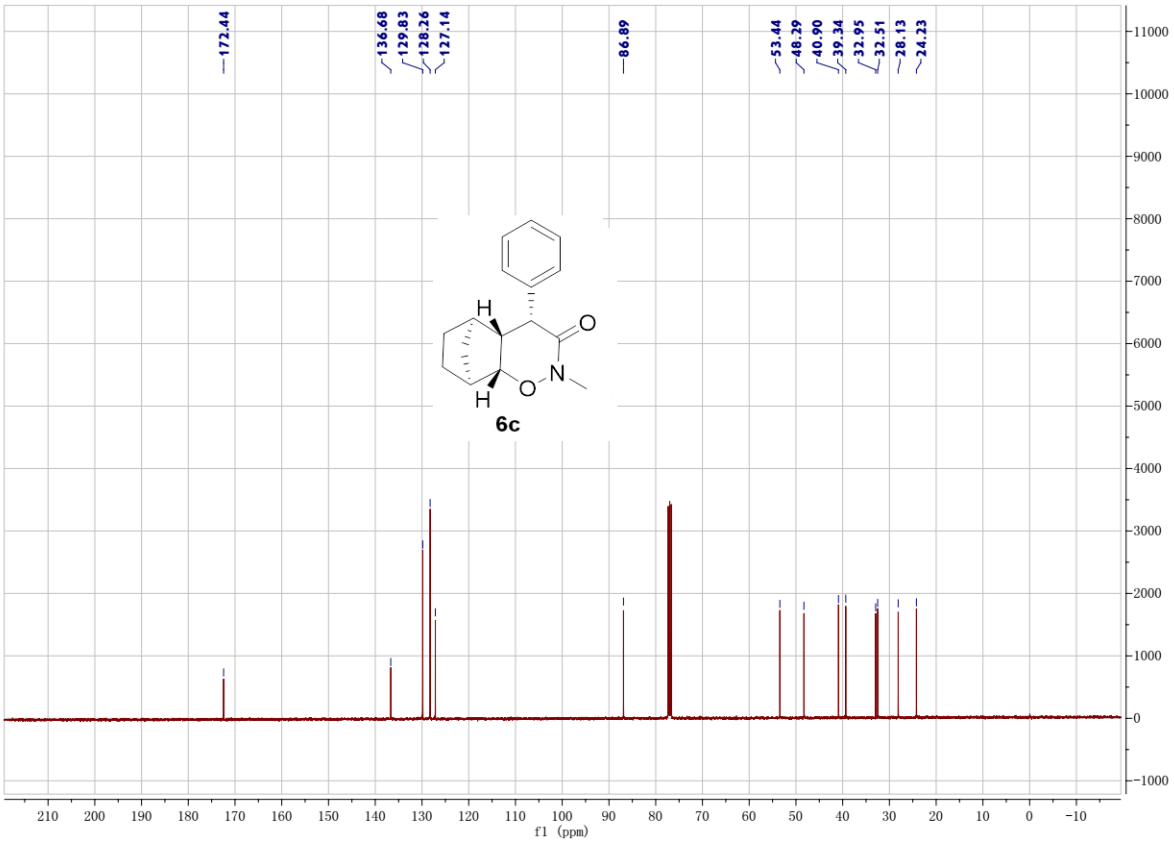
6b


NOESYPHSW CDCl3 {D:\NMR_DATA} LXB 1
6
4
2
0 F2 [ppm]
6
4
2
F1 [ppm]

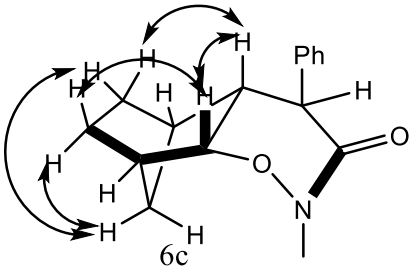
NOE ($CDCl_3$) of **6b**



^1H NMR (400 MHz, $CDCl_3$) of **6c**



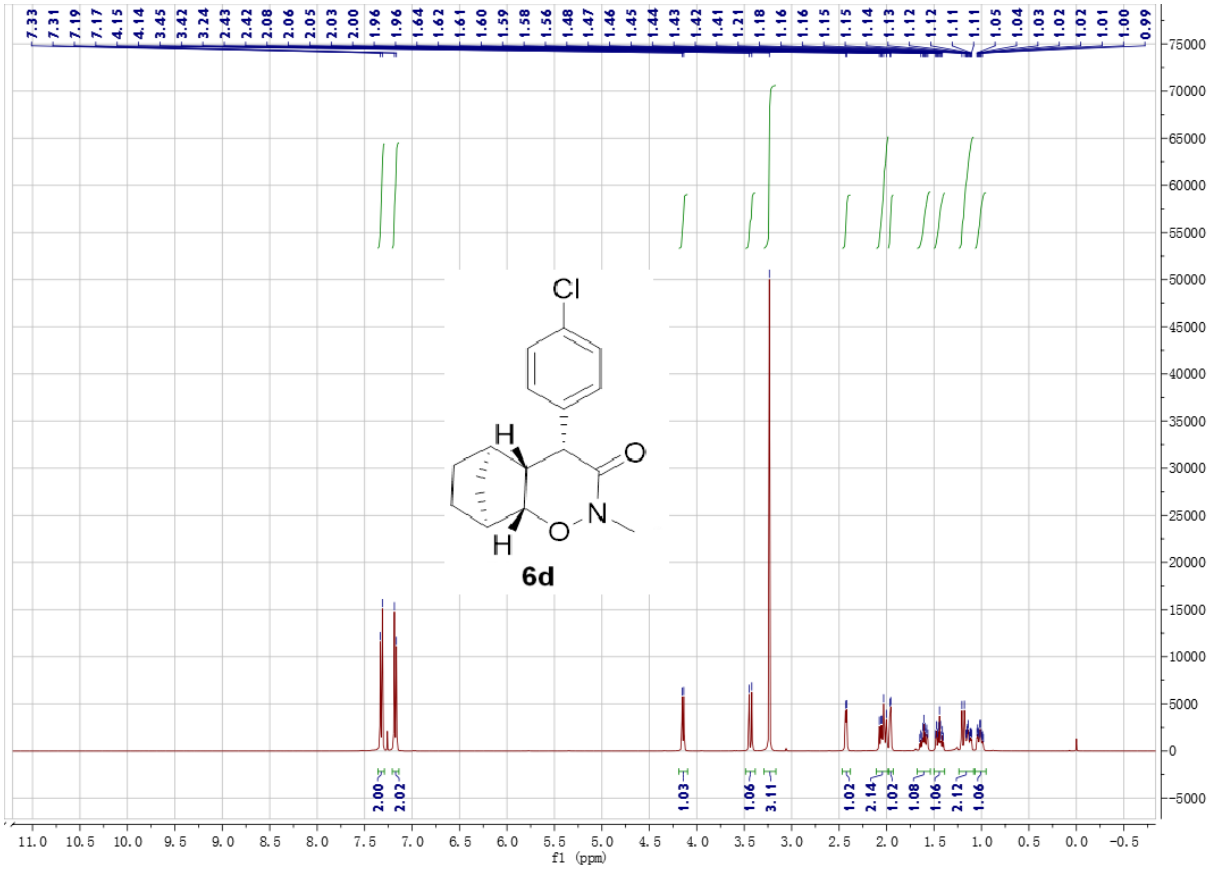
^{13}C NMR (101 MHz, $CDCl_3$) of **6c**



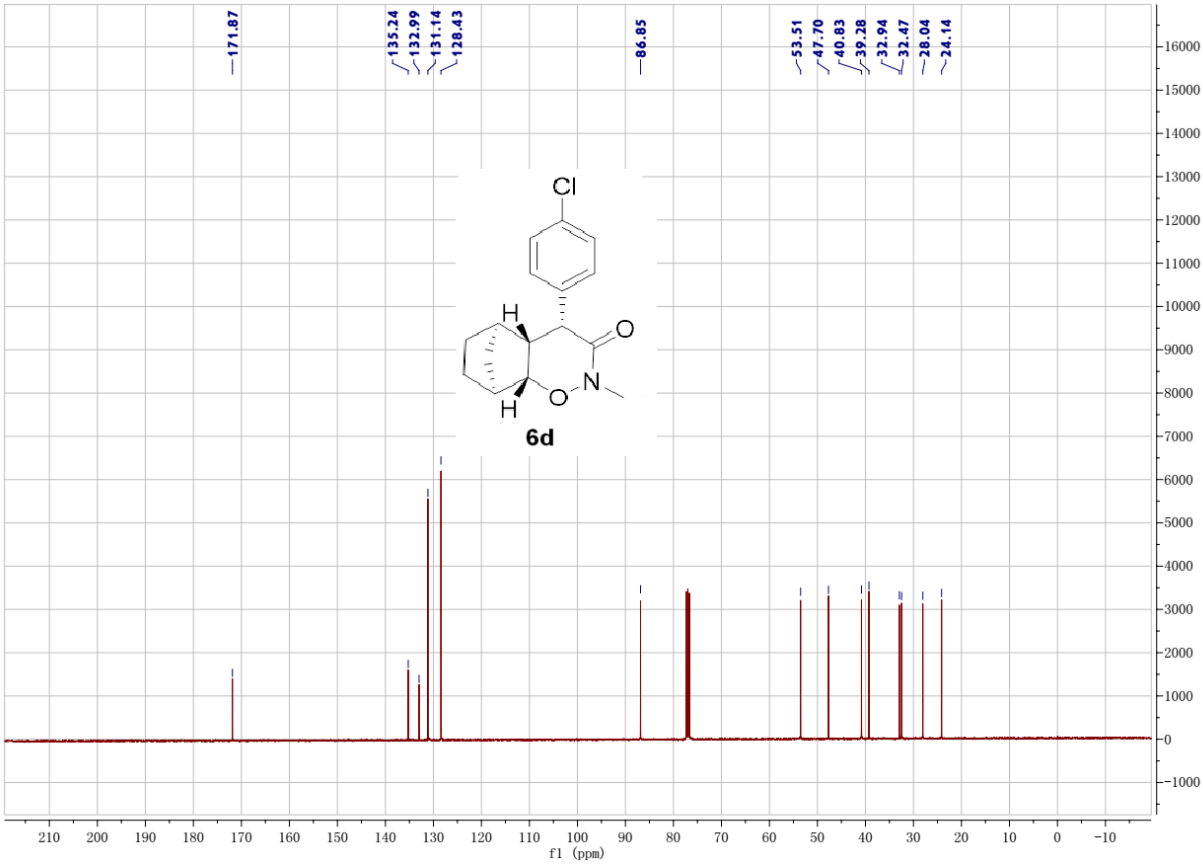
6c

NOESYPHSW CDCl3 {D:\NMR_DATA} LXB 11
8
6
4
2
0 F2 [ppm]
6
4
2
F1 [ppm]

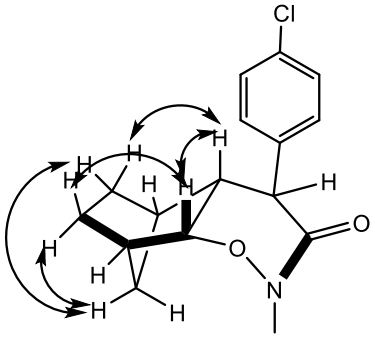
NOE ($CDCl_3$) of **6c**



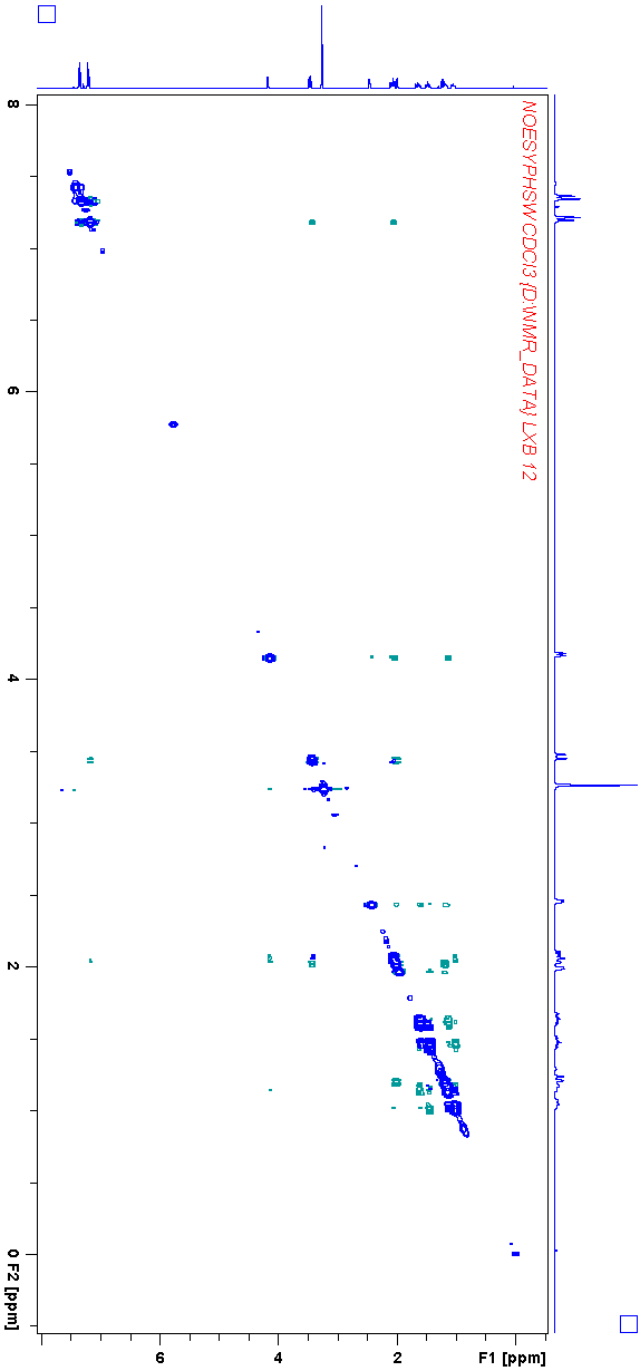
^{1}H NMR (400 MHz, $CDCl_3$) of **6d**



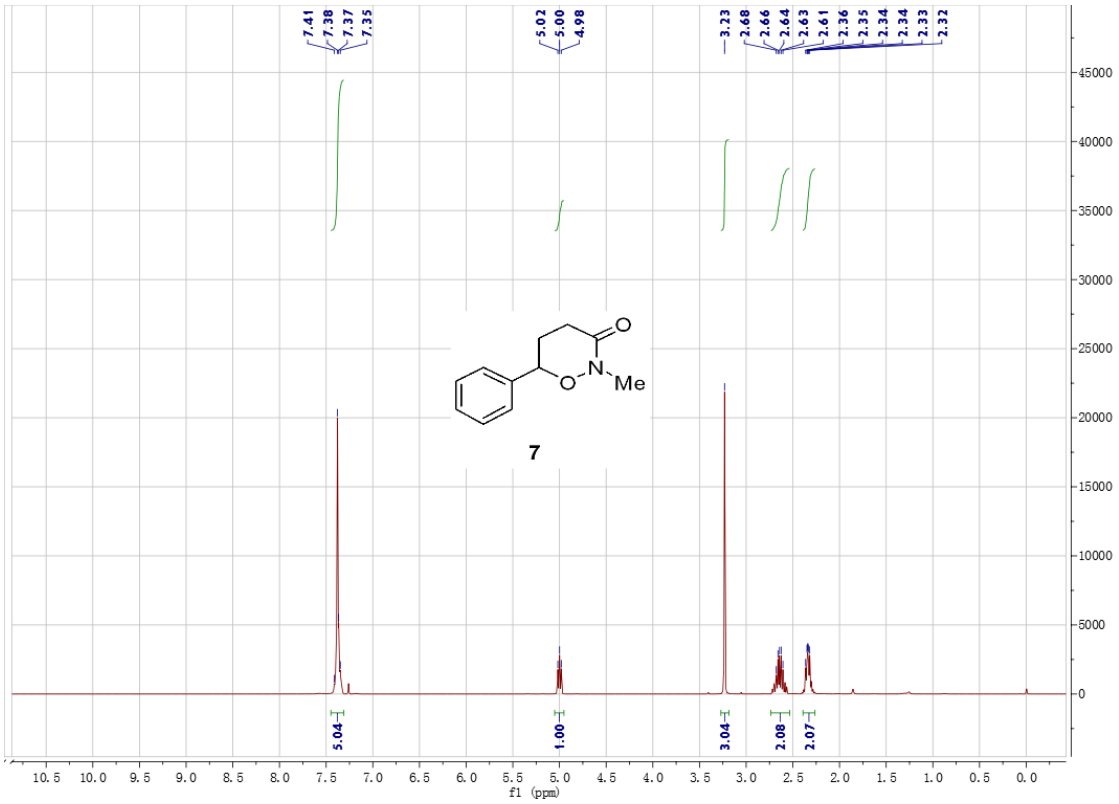
^{13}C NMR (101 MHz, $CDCl_3$) of **6d**



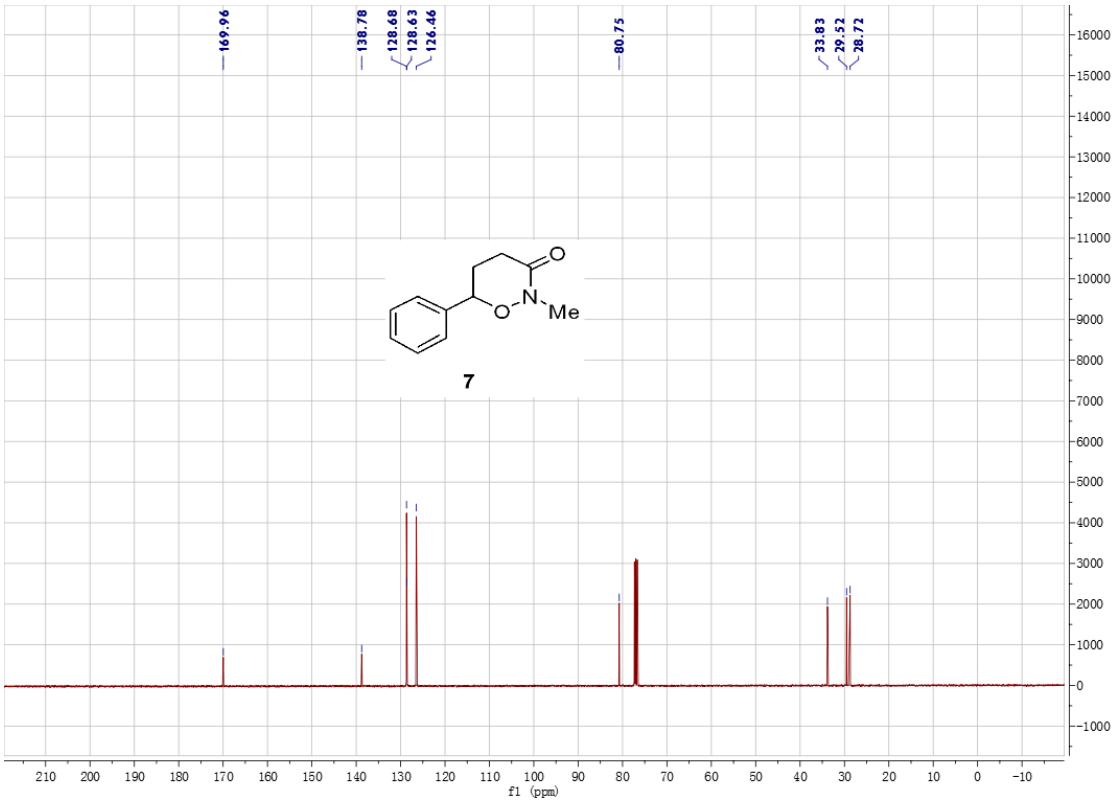
6d


NOESYPHSW CDCl3 [D:\NMR_DATA] LXB 12
8
6
4
2
0 F2 [ppm]
6
4
2
F1 [ppm]

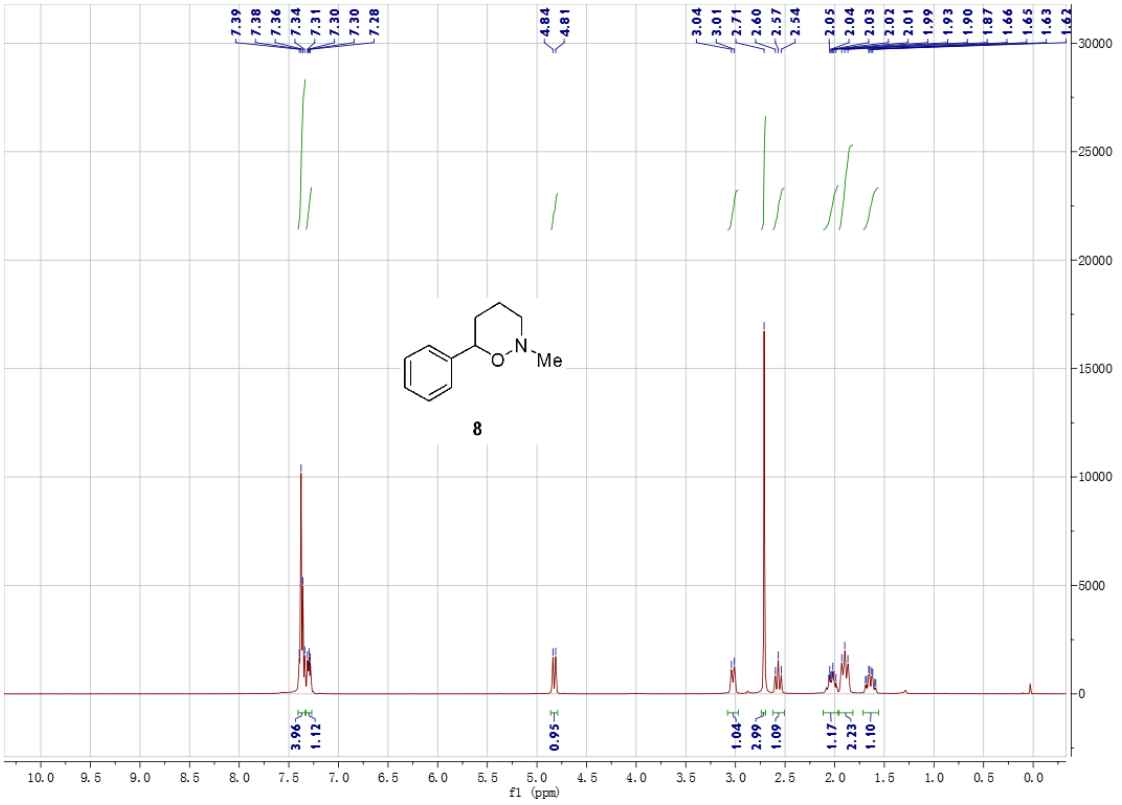
NOE ($CDCl_3$) of **6d**



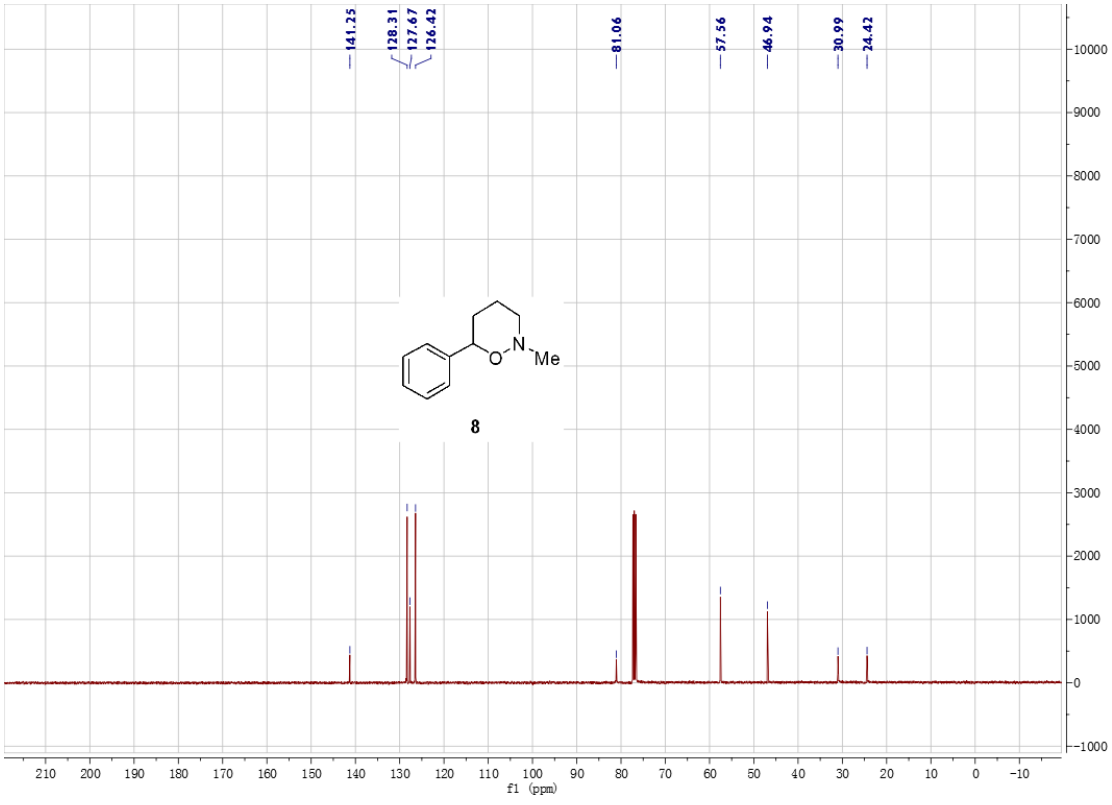
^{1}H NMR (400 MHz, $CDCl_3$) of **7**



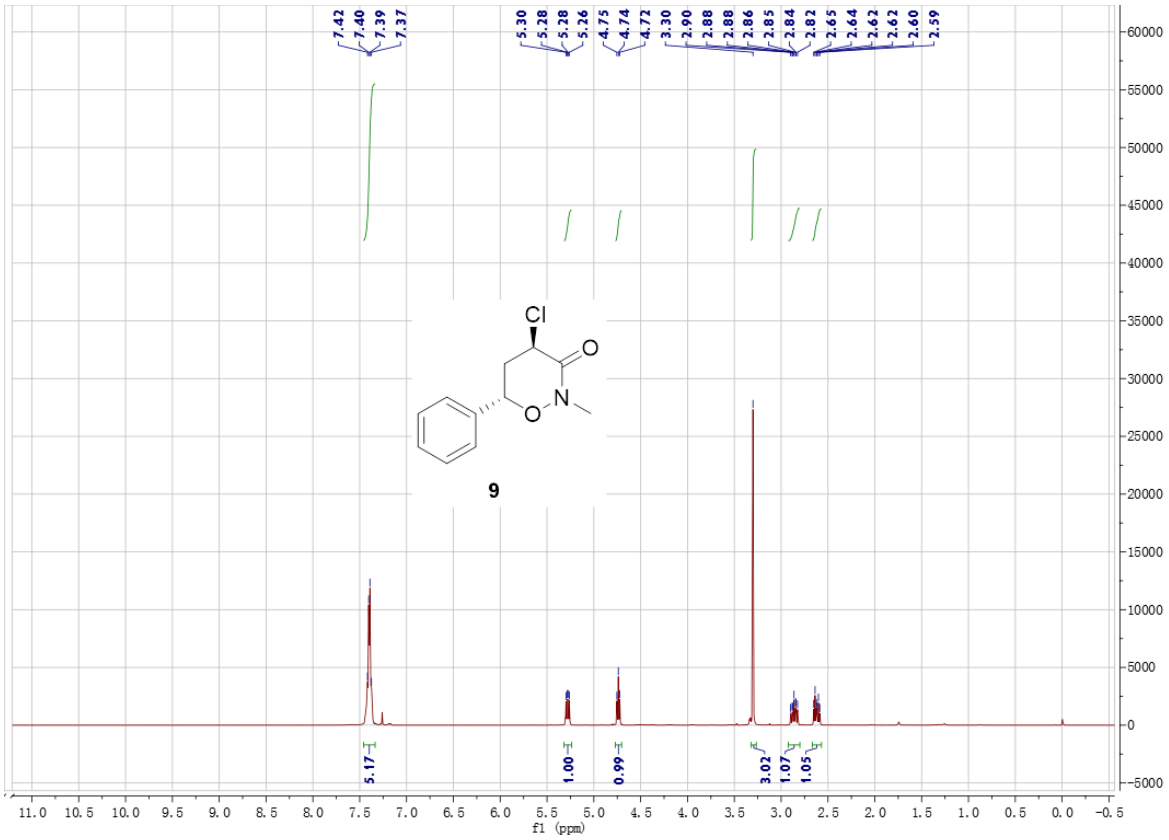
^{13}C NMR (101 MHz, $CDCl_3$) of **7**



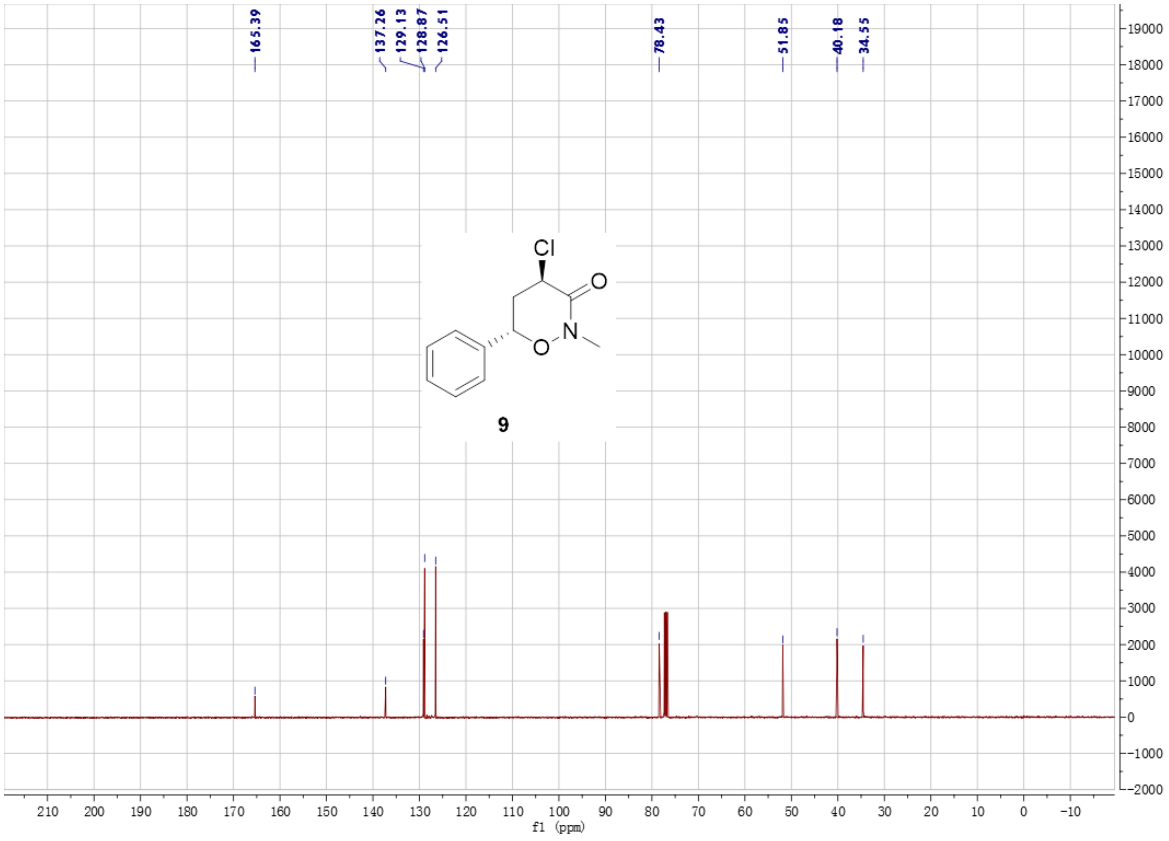
^{1}H NMR (400 MHz, $CDCl_3$) of **8**



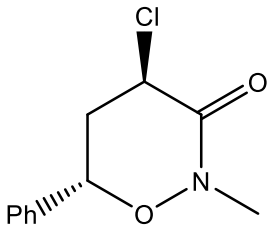
^{13}C NMR (101 MHz, $CDCl_3$) of **8**



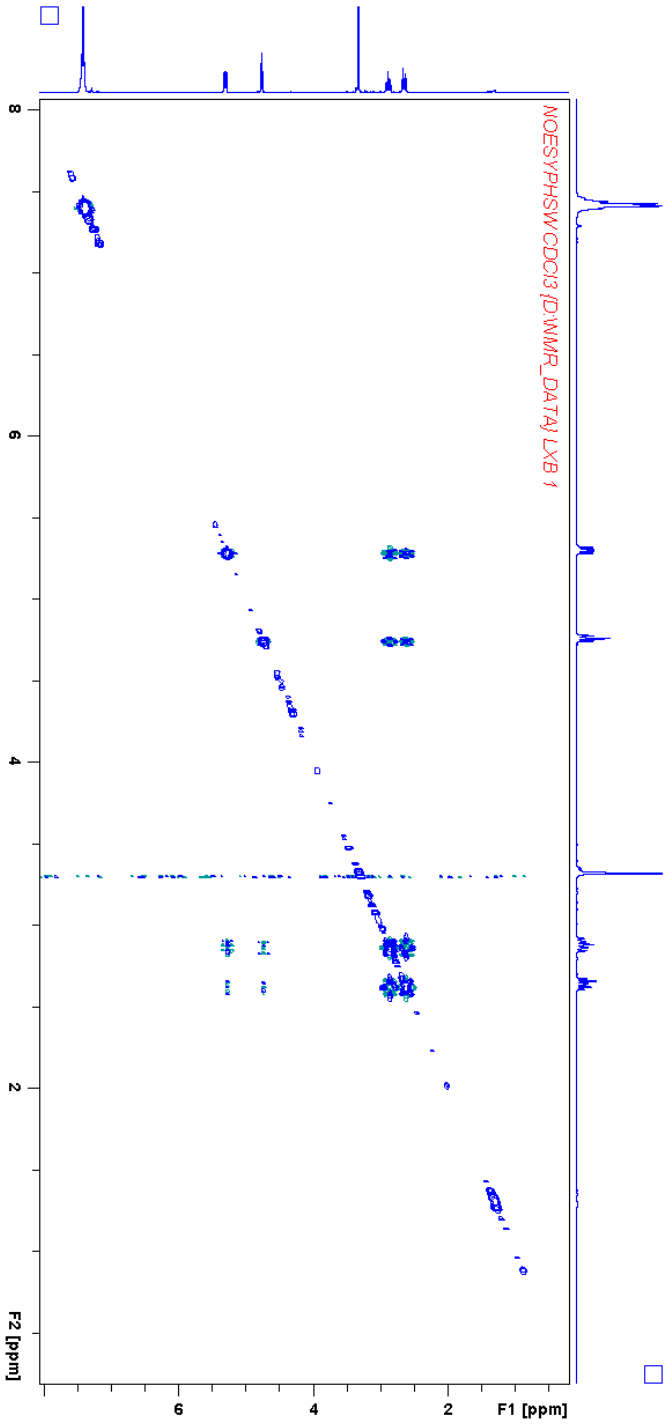
^{1}H NMR (400 MHz, $CDCl_3$) of **9**



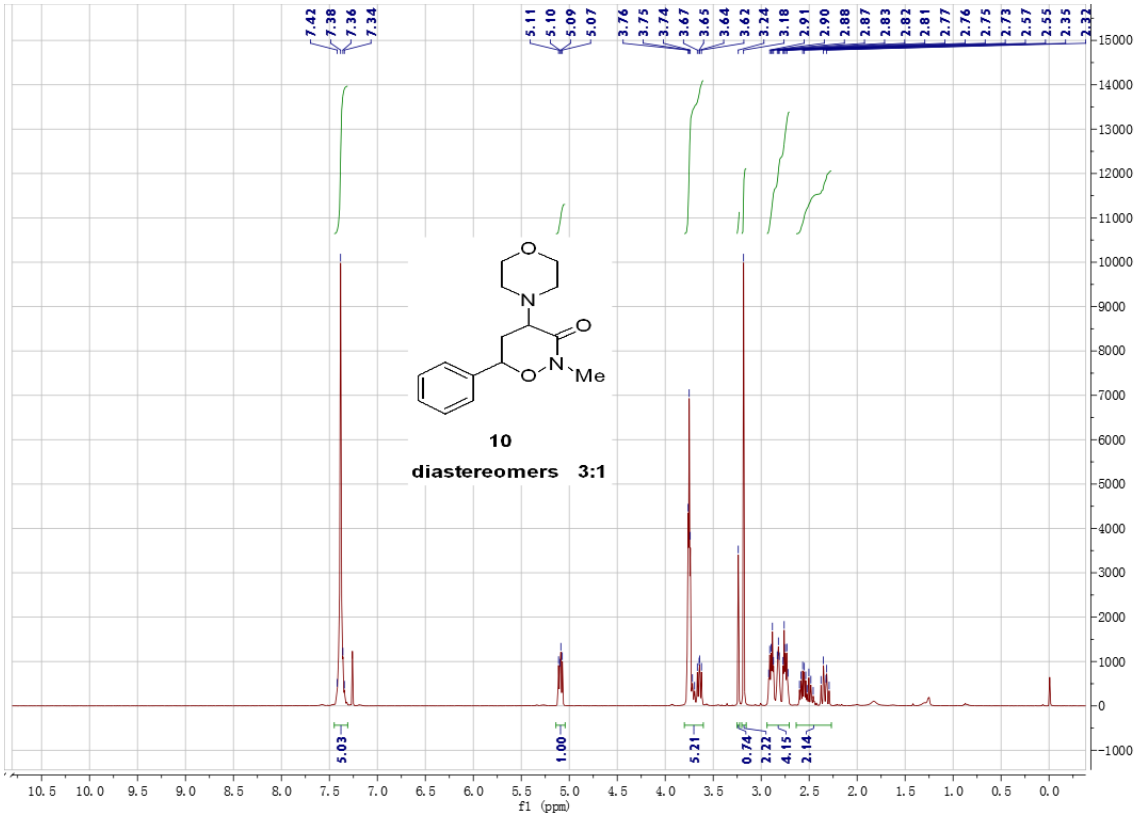
^{13}C NMR (101 MHz, $CDCl_3$) of **9**



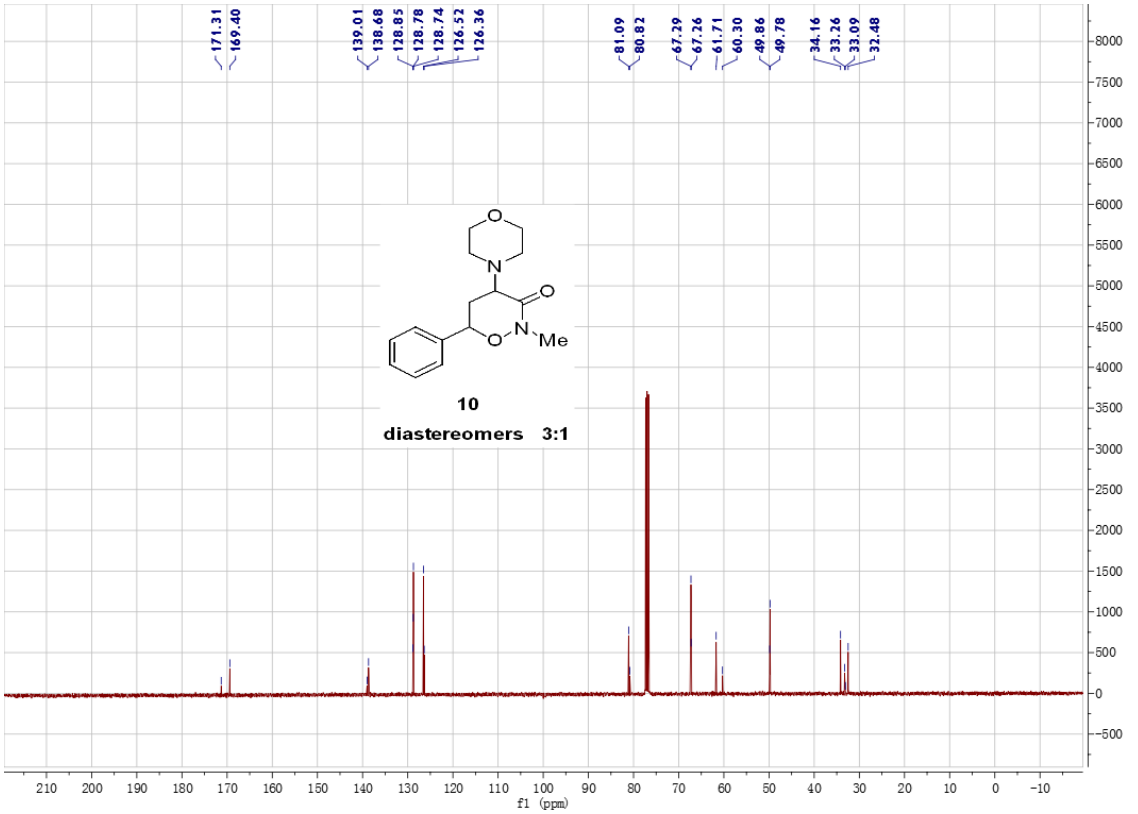
9


NOESYPHSW CDCl3 {D:\WMR_DATA} LXB 1
8
6
4
2
F2 [ppm]
6
4
2
F1 [ppm]

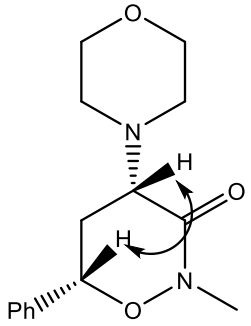
NOE ($CDCl_3$) of **9**



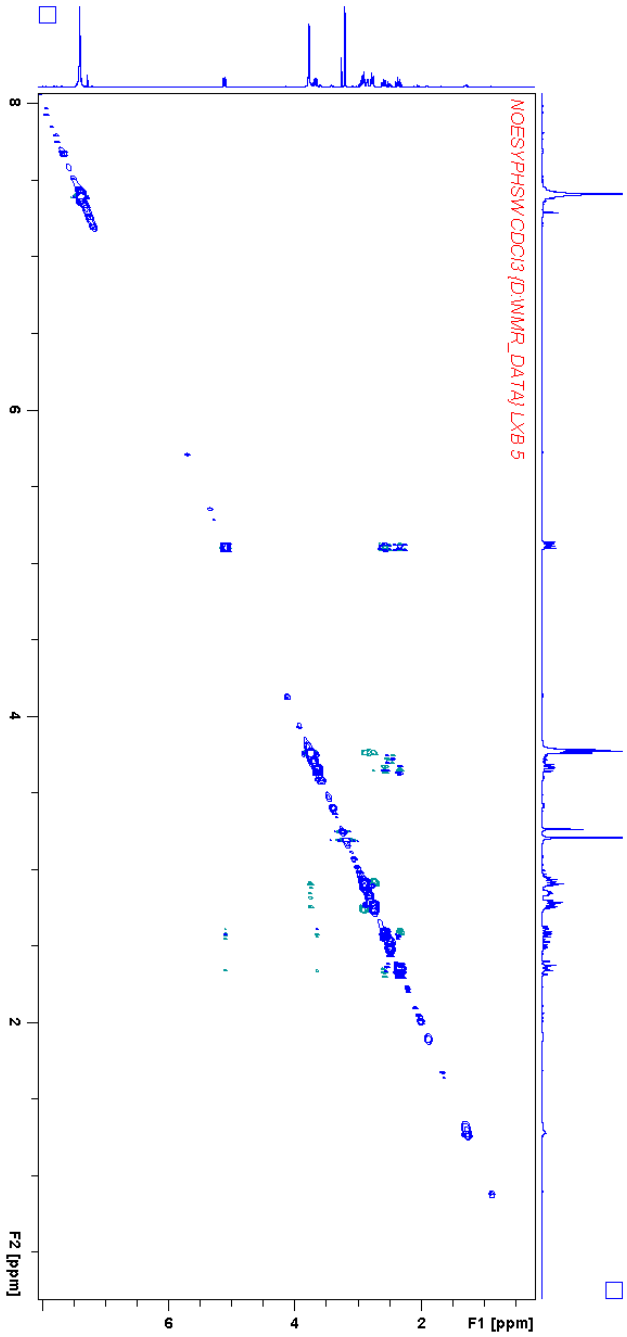
^1H NMR (400 MHz, $CDCl_3$) of **10**



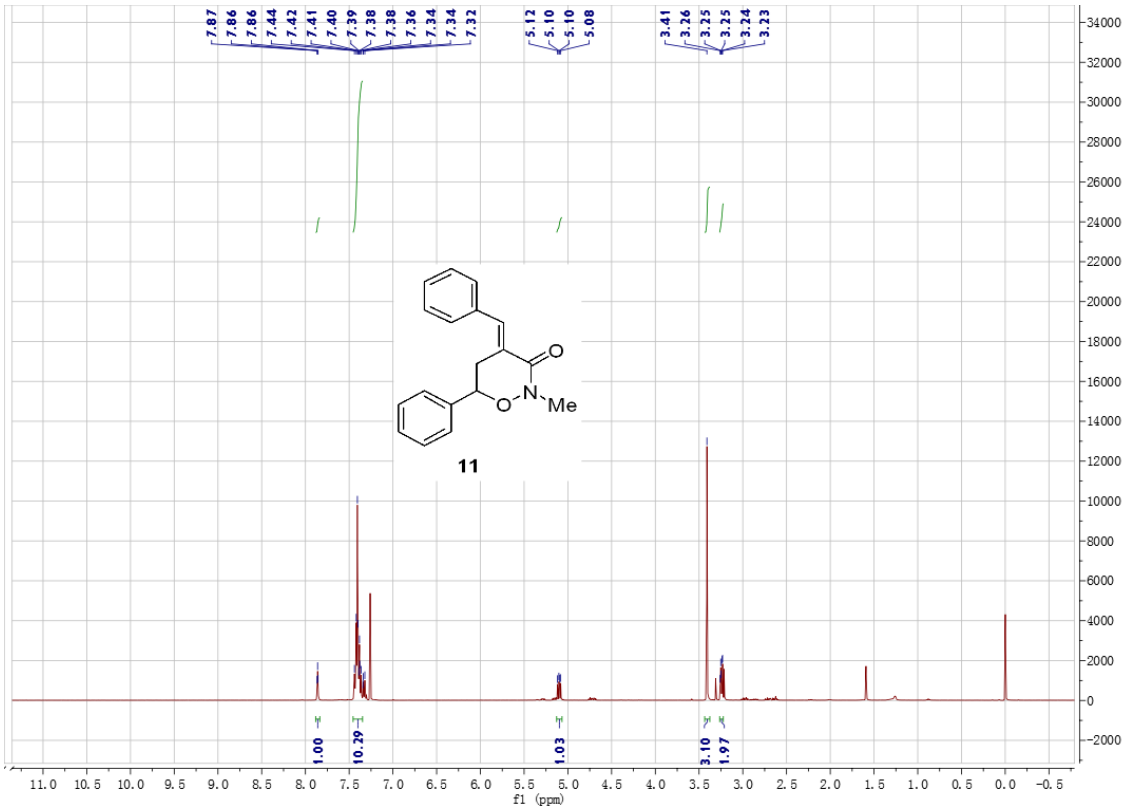
^{13}C NMR (101 MHz, $CDCl_3$) of **10**



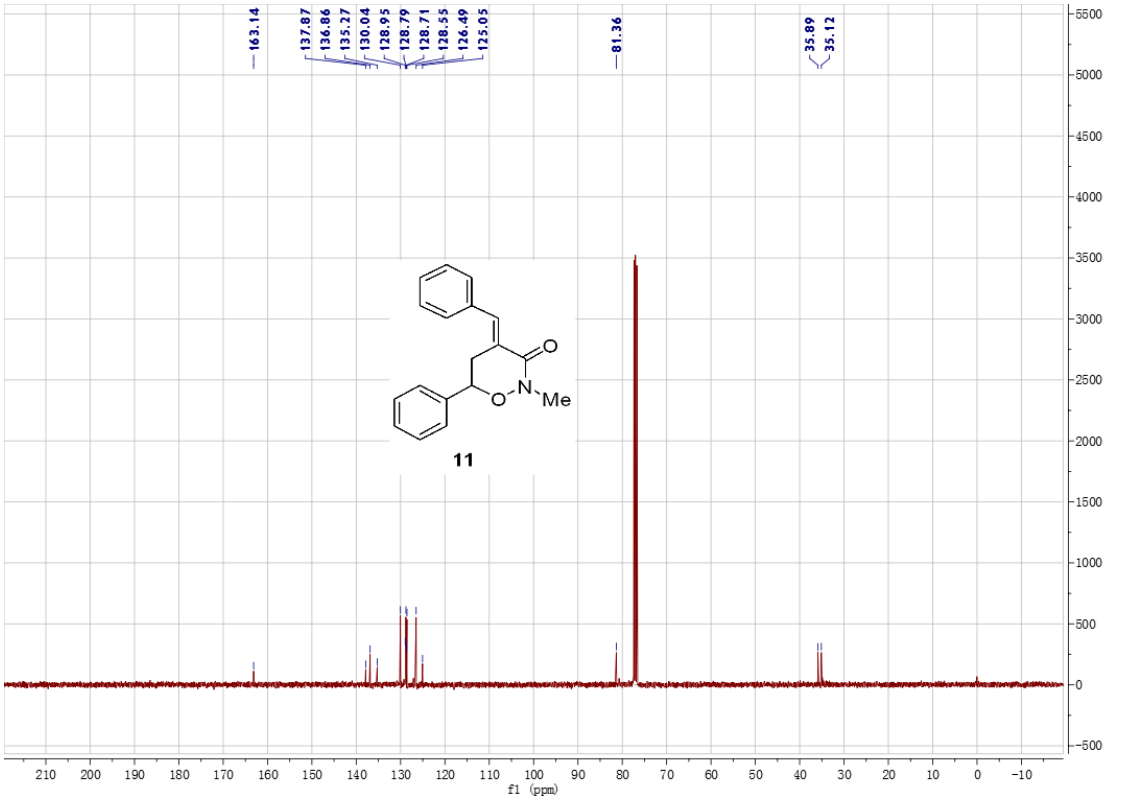
10 (main configuration)


NOESYPHSW CDCl3 {D:\NMR_DATA} LXB 5
F2 [ppm]
F1 [ppm]
8
6
4
2
6
4
2

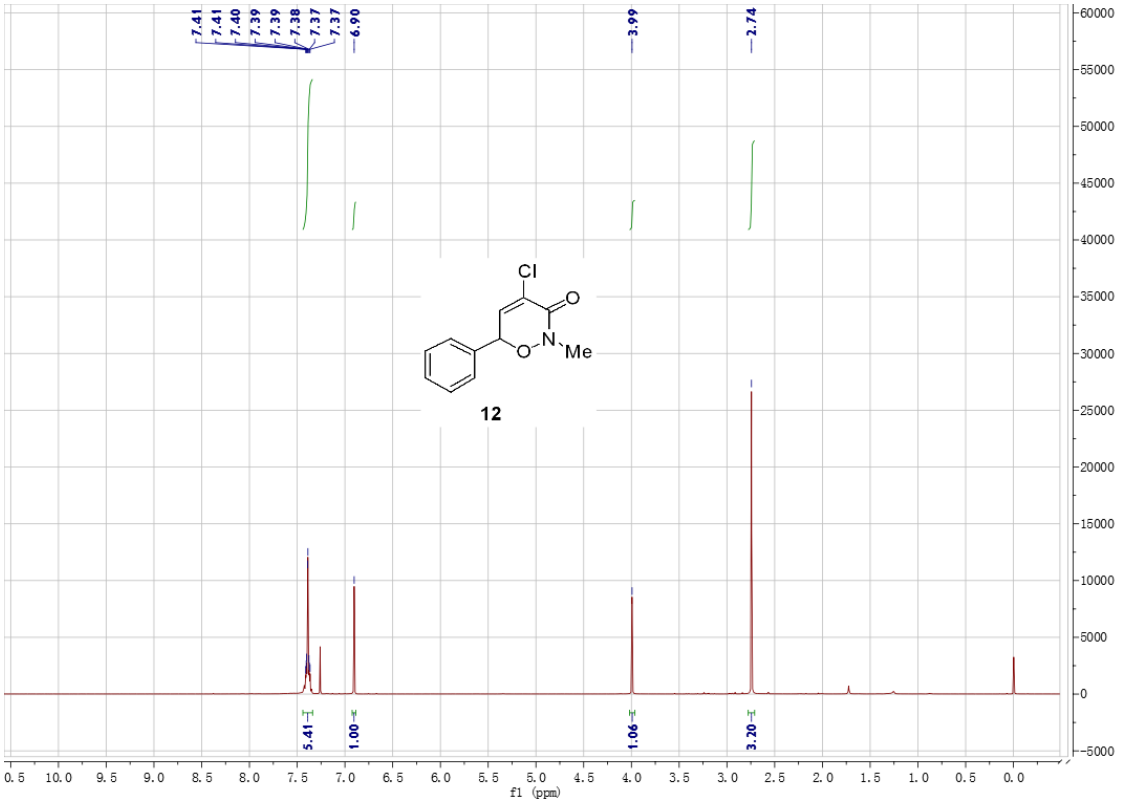
NOE ($CDCl_3$) of **10**



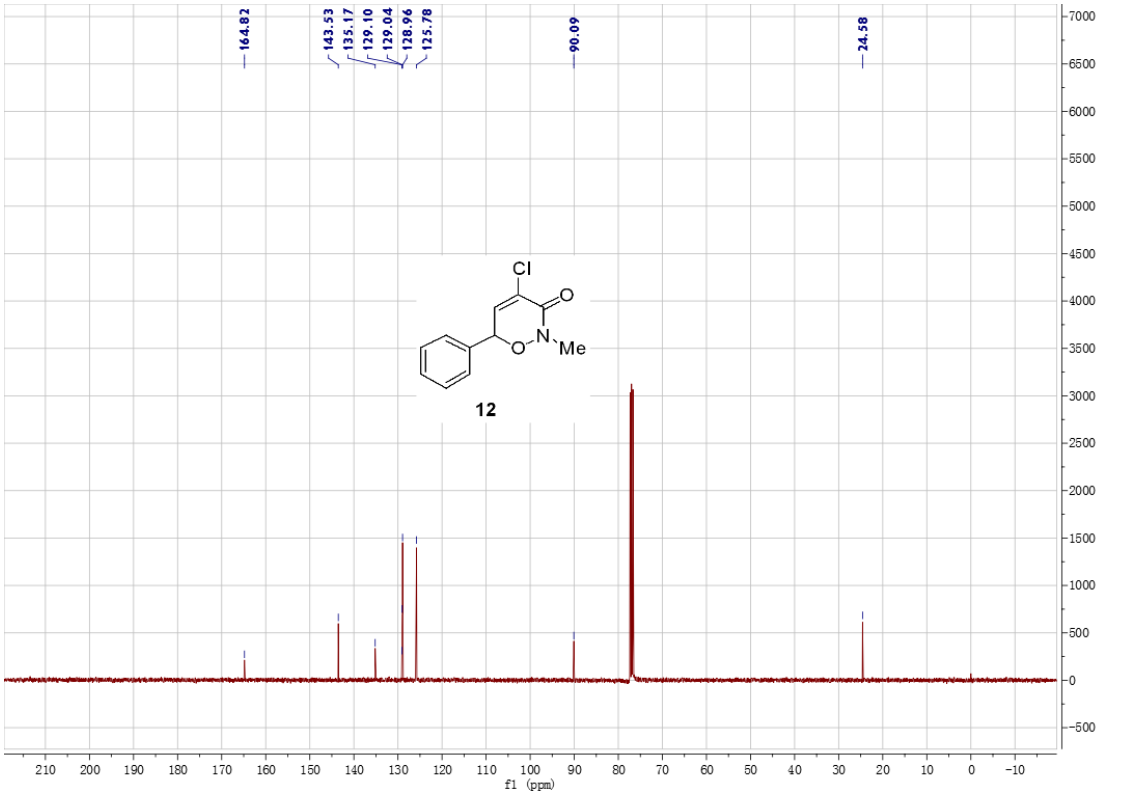
^1H NMR (400 MHz, $CDCl_3$) of **11**



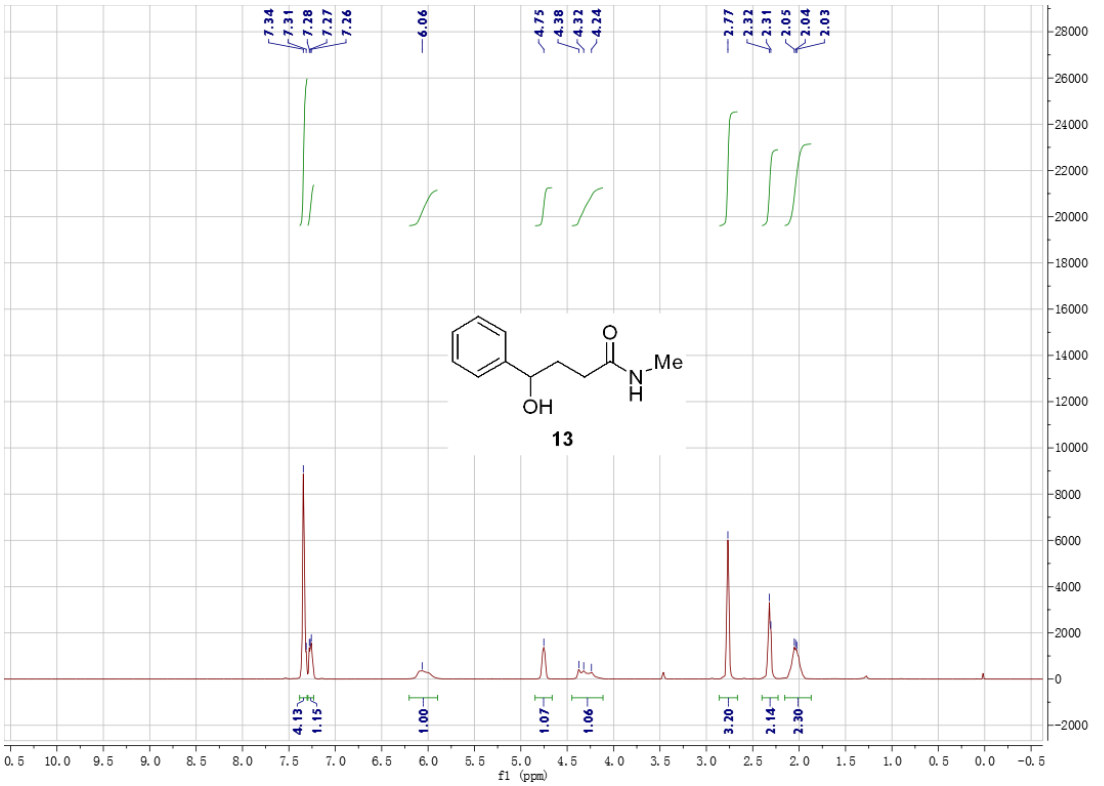
^{13}C NMR (101 MHz, $CDCl_3$) of **11**



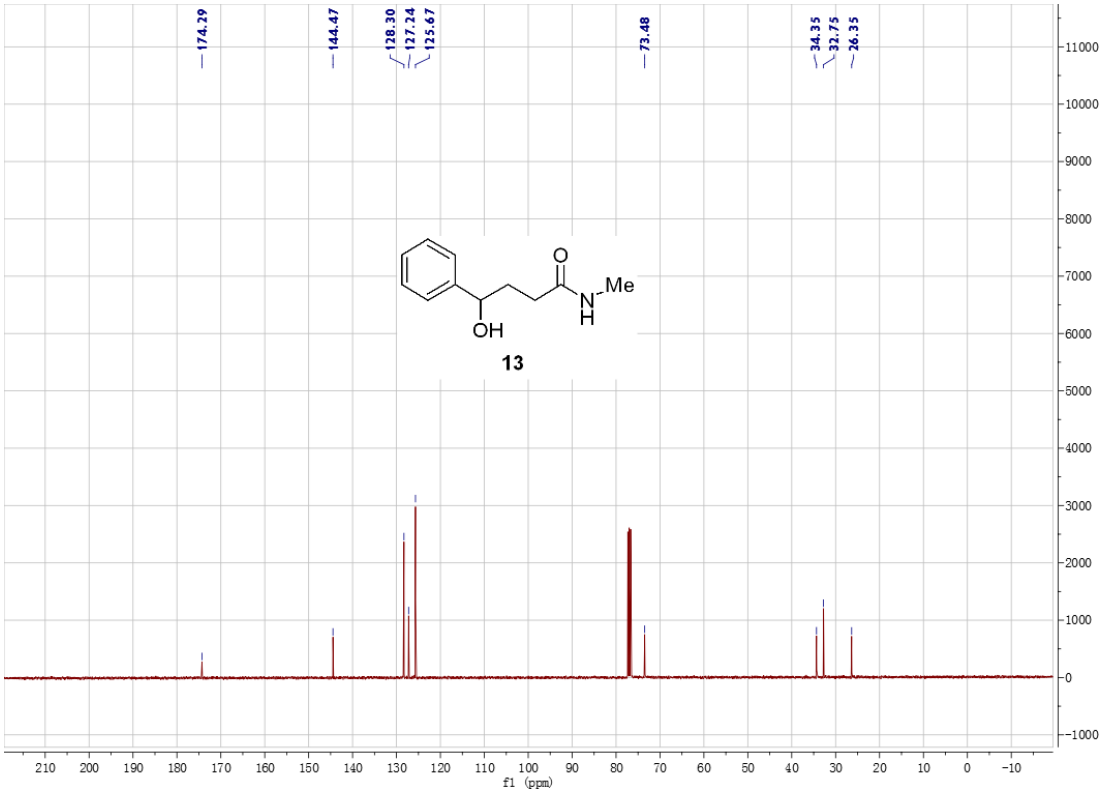
^{1}H NMR (400 MHz, $CDCl_3$) of **12**



^{13}C NMR (101 MHz, $CDCl_3$) of **12**



^{1}H NMR (400 MHz, $CDCl_3$) of **13**



^{13}C NMR (101 MHz, $CDCl_3$) of **13**