Supporting information

for

Visible-light-induced bromoetherification of alkenols for the synthesis of β-bromotetrahydrofurans and -tetrahydropyrans

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Additional experimental data and ^{1}H and ^{13}C NMR spectra for products

Contents

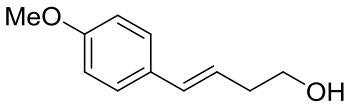
1. General information

All reagents were purchased from commercial sources unless otherwise noted. Solvent was freshly distilled prior to use unless otherwise noted. Reactions were monitored by thin-layer chromatography (TLC) and visualized by UV-light (254 nm) or by treatment with a solution of 10 g phosphomolybdic acid and 100 mL EtOH followed by heating. ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra were obtained on Bruker AV-400 instrument. Chemical shifts for ^{1}H NMR spectra were reported in δ ppm referenced to an internal $SiMe_4$ standard. Chemical shifts for ^{13}C NMR spectra were reported in parts per million relative to the center line signal of the CDCl3 triplet at 77.0 ppm. HR-ESI-MS spectra were recorded on a Bruker Esquire LC mass spectrometer using electrospray ionization.

2. Preparation and characterization of alkenols

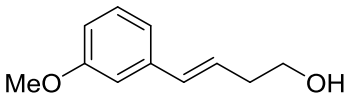
Alkenols **1a-s** were prepared according to reported method[1].

(*E*)-4-(4-methoxyphenyl)but-3-en-1-ol (1a)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.27 (d, J = 8.7 Hz, 2H), 6.82 (d, J = 8.7 Hz, 2H), 6.40 (d, J = 15.9 Hz, 1H), 6.03 (dt, J = 15.7, 7.1 Hz, 1H), 3.77 (s, 3H), 3.69 (t, J = 6.4 Hz, 2H), 2.42 (td, J = 7.3, 1.0 Hz, 2H), 2.18 (brs, 1H). Data are consistent with literature values.[1]

(*E*)-4-(3-methoxyphenyl)but-3-en-1-ol (1b)

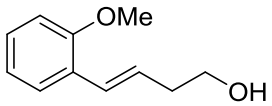


^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.21 (t, J = 7.9 Hz, 1H), 6.95 (d, J = 7.7 Hz, 1H), 6.89 (s, 1H), 6.77 (dd, J = 8.2, 2.4 Hz, 1H), 6.45 (d, J = 15.9 Hz, 1H), 6.23-6.16 (m, 1H), 3.80 (s, 1H), 3.74 (t, J = 6.3 Hz, 2H), 2.47 (q, J = 6.5 Hz, 2H), 1.84 (brs, 1H). Data are

[1] Zeng, X. H.; Miao, C. X.; Wang, S. F.; Xia, C. G.; Sun, W. *Chem. Commun.* 2013, 49, 2418.

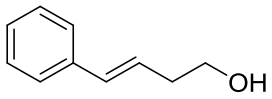
consistent with literature values. [1]

(*E*)-4-(2-methoxyphenyl)but-3-en-1-ol (1c)



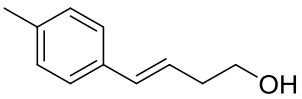
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.43-7.40 (m,1H), 7.26-7.18 (m, 1H), 6.95-6.79 (m, 3H), 6.19 (dt, *J* = 15.9, 7.2 Hz, 1H), 3.84 (s, 3H), 3.76-3.69 (m, 2H), 2.53-2.47 (m, 2H), 1.68 (brs, 1H). Data are consistent with literature values. [1]

(*E*)-4-phenylbut-3-en-1-ol (1d)



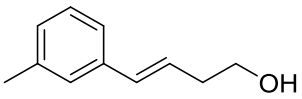
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.36-7.19 (m, 5H), 6.48 (d, *J* = 15.9 Hz, 1H), 6.20 (dt, *J* = 15.8, 7.1 Hz, 1H), 3.76-3.73 (m, 2H), 2.50-2.45 (m, 2H), 1.81 (brs, 1H). Data are consistent with literature values. [1]

(*E*)-4-*p*-tolylbut-3-en-1-ol (1e)



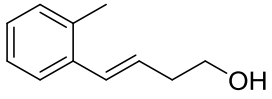
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.16 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 6.36 (d, *J* = 15.9 Hz, 1H), 6.05 (dt, *J* = 15.8, 7.1 Hz, 1H), 3.64-3.60 (m, 2H), 2.36 (td, *J* = 7.3, 0.9 Hz, 2H), 2.23 (s, 3H), 2.00 (brs, 1H). Data are consistent with literature values. [1]

(*E*)-4-*m*-tolylbut-3-en-1-ol (1f)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.24-7.14 (m, 3H), 7.03 (d, *J* = 7.0 Hz, 1H), 6.46 (d, *J* = 15.9 Hz, 1H), 6.18 (dt, *J* = 15.7, 7.1 Hz, 1H), 3.73 (t, *J* = 6.3 Hz, 2H), 2.49-2.44 (m, 2H), 2.33 (s, 3H), 1.66 (brs, 1H). Data are consistent with literature values. [1]

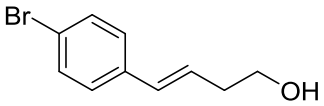
(*E*)-4-*o*-tolylbut-3-en-1-ol (1g)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.16-7.12 (m, 4H), 6.68 (d, *J* = 15.7 Hz, 1H), 6.06 (dt,

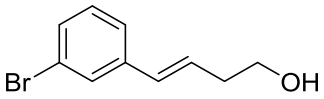
J = 15.5, 7.2 Hz, 1H), 3.73 (t, *J* = 6.4 Hz, 2H), 2.49 (td, *J* = 7.6, 1.3 Hz, 2H), 2.33 (s, 3H), 1.81 (brs, 1H). Data are consistent with literature values. [1]

(*E*)-4-(4-bromophenyl)but-3-en-1-ol (1h)



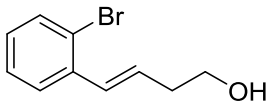
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.41 (d, *J* = 8.4 Hz, 2H), 7.20 (d, *J* = 8.4 Hz, 2H), 6.41 (d, *J* = 15.9 Hz, 1H), 6.19 (dt, *J* = 15.7, 7.1 Hz, 1H), 3.76-3.73 (m, 2H), 2.48-2.43 (m, 2H), 1.72 (brs, 1H). Data are consistent with literature values. [1]

(*E*)-4-(3-bromophenyl)but-3-en-1-ol (1i)



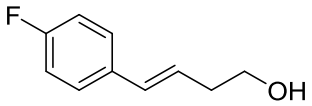
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.50 (s, 1H), 7.32 (d, *J* = 7.9 Hz, 1H), 7.26-7.23 (m, 1H), 7.15 (t, *J* = 7.8 Hz, 1H), 6.40 (d, *J* = 15.9 Hz, 1H), 6.21 (dt, *J* = 15.8, 7.1 Hz, 1H), 3.74 (t, *J* = 6.3 Hz, 2H), 2.47 (td, *J* = 7.3, 1.1 Hz, 1H), 1.83 (brs, 1H). Data are consistent with literature values.[2]

(*E*)-4-(2-bromophenyl)but-3-en-1-ol (1j)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.33-7.24 (m, 4H), 6.43 (d, *J* = 15.9 Hz, 1H), 6.18 (dt, *J* = 15.7, 7.1 Hz, 1H), 3.75 (t, *J* = 6.3 Hz, 2H), 2.50-2.45 (m, 2H), 1.84(brs, 1H). Data are consistent with literature values. [2]

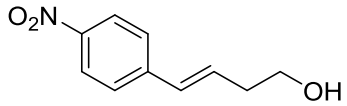
(*E*)-4-(4-fluorophenyl)but-3-en-1-ol (1k)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.32-7.29 (m, 2H), 6.98 (t, *J* = 8.7 Hz, 2H), 6.44 (d, *J* = 15.9 Hz, 1H), 6.15-6.07 (m, 1H), 3.74 (t, *J* = 6.3 Hz, 2H), 2.49-2.44 (m, 3H). Data are consistent with literature values. [1]

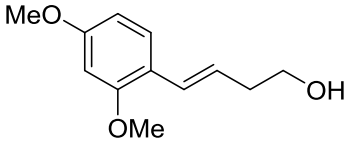
[2] Zeng, X. H.; Miao, C. X.; Wang, S. F.; Xia, C. G.; Sun, W. *Synthesis*, 2013, 45, 2391.

(E)-4-(4-nitrophenyl)but-3-en-1-ol (1l)



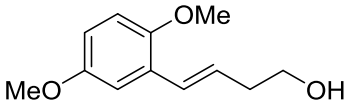
^{1}HNMR ($CDCl_3$, 400 MHz): δ 8.14 (d, J = 8.4 Hz, 2H), 7.47 (d, J = 8.4 Hz, 2H), 6.56 (d, J = 16.0 Hz, 1H), 6.49-6.42 (m, 1H), 3.81 (t, J = 6.1 Hz, 2H), 2.54 (q, J = 6.0 Hz, 2H), 1.79 (brs, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 146.5, 143.7, 132.1, 130.5, 126.5, 123.9, 61.6, 36.4.

(*E*)-4-(2,4-dimethoxyphenyl)but-3-en-1-ol (1m)



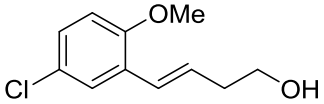
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.35 (d, J = 8.3 Hz, 1H), 6.74 (d, J = 16.0 Hz, 1H), 6.50-6.45 (m, 2H), 6.10 (dt, J = 15.9, 7.2 Hz, 1H), 3.84 (s, 3H), 3.83 (s, 3H), 3.75 (t, J = 6.3 Hz, 2H), 2.53-2.47 (m, 2H), 1.74 (brs, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 160.1, 157.4, 127.2, 127.2, 124.7, 119.4, 104.7, 98.38, 62.1, 55.4, 55.3, 36.8.

(*E*)-4-(2,5-dimethoxyphenyl)but-3-en-1-ol (1n)



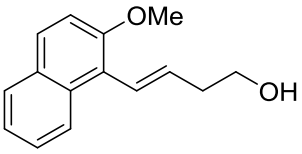
^{1}HNMR ($CDCl_3$, 400 MHz): δ 6.85 (d, J = 2.8 Hz, 1H), 6.78 (dd, J = 8.5, 5.8 Hz, 1H), 6.63 (d, J = 11.6 Hz, 1H), 5.75 (dt, J = 11.6, 7.5 Hz, 1H), 3.78 (s, 3H), 3.77 (s, 3H), 3.71 (t, J = 6.4 Hz, 2H), 2.51 (dd, J = 7.5, 1.5 Hz, 2H), 1.72 (brs, 1H).

(*E*)-4-(5-chloro-2-methoxyphenyl)but-3-en-1-ol (1o)



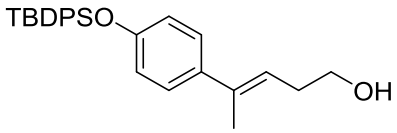
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.38 (d, J = 2.5 Hz, 1H), 7.13 (dd, J = 8.7, 2.5 Hz, 1H), 6.78-6.72 (m, 2H), 6.23-6.16 (m, 1H), 3.81 (s, 3H), 3.75 (t, J = 6.3 Hz, 2H), 2.49 (d, J = 6.8 Hz, 2H), 1.67 (brs, 1H).

(*E*)-4-(2-methoxynaphthalen-1-yl)but-3-en-1-ol (1p)



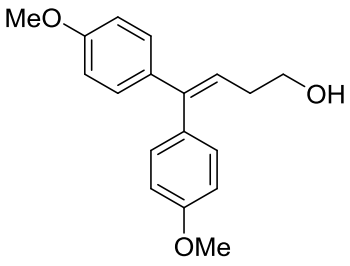
^{1}HNMR ($CDCl_3$, 400 MHz): δ 8.02 (d, J = 8.6 Hz, 1H), 7.68 (t, J = 8.4 Hz, 1H), 7.63 (d, J = 9.0 Hz, 1H), 7.34 (t, J = 7.2 Hz, 1H), 7.24 (dd, J = 12.8, 5.9 Hz, 1H), 7.16 (t, J = 8.6 Hz,1H), 6.73 (d, J = 16.1 Hz, 1H), 6.02 (dt, J = 15.9, 7.0 Hz, 1H), 3.82 (s, 3H), 3.70 (t, J = 6.3 Hz, 2H), 2.52 (q, J = 6.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 153.0, 131.9, 130.6, 128.2, 127.4, 127.2, 125.3, 124.8, 123.3, 122.4, 119.8, 112.1, 60.8, 55.4, 36.3.

(*E*)-4-(4-((*tert*-butyldiphenylsilyl)oxy)phenyl)pent-3-en-1-ol (1q)



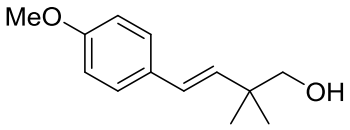
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.66 (dd, J = 7.9, 1.4 Hz, 4H), 7.34 (dd, J = 5.0, 3.6 Hz, 2H), 7.29 (t, J = 7.1 Hz, 4H), 6.86 (d, J = 8.6 Hz, 2H), 6.65 (d, J = 8.6 Hz, 2H), 5.30 (td, J = 7.3, 1.2 Hz, 1H), 3.50 (t, J = 6.5 Hz, 2H), 2.15 (q, J = 6.5 Hz, 2H), 1.90 (s, 3H), 1.04 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 154.3, 139.0, 135.59, 134.2, 133.0, 129.8, 128.7, 127.7, 122.4, 119.3, 62.7, 35.4, 32.6, 26.5, 19.4.

4,4-bis(4-methoxyphenyl)but-3-en-1-ol (1r)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.18-7.14 (m, 2H), 7.12-7.09 (m, 2H), 6.92-6.88 (m, 2H), 6.81-6.78 (m, 2H), 5.96 (t, J = 7.5 Hz, 1H), 3.83 (s, 3H), 3.78 (s, 3H), 3.70 (t, J = 6.6 Hz, 2H), 2.40 (dd, J = 14.0, 6.7 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 158.8, 158.6, 143.4, 135.5, 132.3, 131.0, 128.4, 123.2, 113.6, 113.4, 62.7, 55.3, 55.2, 33.3.

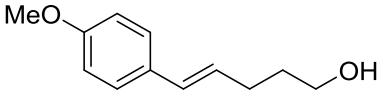
(*E*)-4-(4-methoxyphenyl)-2,2-dimethylbut-3-en-1-ol (1s)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.12 (d, J = 8.2 Hz, 2H), 6.83 (d, J = 8.6 Hz, 2H), 6.54 (d, J = 12.6 Hz, 1H), 5.50 (d, J = 12.6 Hz, 1H), 3.79 (s, 3H), 3.31 (s, 2H), 0.97 (s, 6H).^{13}C NMR ($CDCl_3$, 100 MHz): δ 158.3, 138.2, 129.7, 127.2, 113.9, 113.1, 71.9, 55.1, 39.5, 25.7.

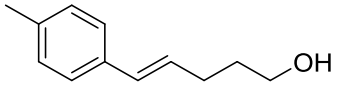
Alkenols **1t-w** were prepared according to reported method.[3]

(*E*)-5-(4-methoxyphenyl)pent-4-en-1-ol (1t)



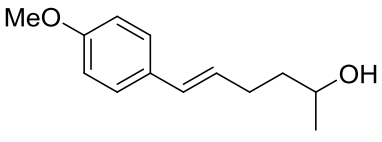
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.21 (d, J = 8.7 Hz, 2H), 6.86 (d, J = 8.7 Hz, 2H), 6.34 (d, J = 11.0 Hz, 1H), 6.06 (dt, J = 15.8, 6.9 Hz, 1H), 3.79 (s, 3H), 3.64 (t, J = 5.7 Hz, 2H), 3.44 (brs, 1H), 2.43-2.37 (m, 1.8 Hz, 2H), 1.75-1.67 (m, 2H). Data are consistent with literature values.[4]

(*E*)-5-*p*-tolylpent-4-en-1-ol (1u)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.23 (d, J = 8.1 Hz, 2H), 7.09 (d, J = 7.9 Hz, 2H), 6.38 (d, J = 15.8 Hz, 1H), 6.16 (dt, J = 15.7, 6.9 Hz, 1H), 3.68 (t, J = 6.5 Hz, 2H), 2.33-2.26 (m, 5H), 1.81-1.69 (m, 3H). Data are consistent with literature values.[5]

(*E*)-6-(4-methoxyphenyl)hex-5-en-2-ol (1v)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.27 (d, J = 8.1 Hz, 2H), 6.83 (d, J = 8.6 Hz, 2H), 6.36

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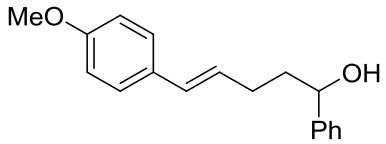
[3] Logan, A.W.J.; Parker, J.S.; Hallside, M.S.; Burton J.W. *Org. Lett.* 2012, 14, 2940.

[4] Belanger, G.; Levesque, F.; Paquet, J.; Barbe, G. *J. Org. Chem.* 2005, 70, 291.

[5] Crombie, L.; Wyvill, R. D. *J. Chem. Soc. Perkin Trans. 1* 1985, 1983.

(d, *J* = 16.0 Hz, 1H), 6.12-6.04 (m, 1H), 3.88-3.83 (m, 1H), 3.79 (s, 3H), 2.34-2.25 (m, 2H), 1.67-1.57 (m, 2H), 1.47 (brs, 1H), 1.22 (d, *J* = 6.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.7, 130.5, 129.6, 128.1, 127.0, 113.9, 67.6, 55.3, 38.8, 29.3, 23.5.

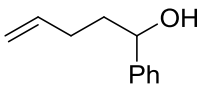
(*E*)-5-(4-methoxyphenyl)-1-phenylpent-4-en-1-ol (1w)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.37-7.25 (m, 7H), 6.83 (d, *J* = 8.7 Hz, 2H), 6.35 (d, *J* = 15.8 Hz, 1H), 6.08 (dt, *J* = 15.7, 6.9 Hz, 1H), 4.74 (t, *J* = 6.5 Hz, 1H), 3.79 (s, 3H), 2.35-2.21 (m, 2H), 2.02-1.85 (m, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ158.7, 144.6, 130.5, 129.8, 128.5, 127.8, 127.6, 127.0, 125.9, 113.9, 74.0, 55.3, 38.6, 29.3.

1x was prepared according to reported method.[6]

1-phenylpent-4-en-1-ol (1x)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.42-7.29 (m, 5H), 5.93-5.83 (m, 1H), 5.11-5.02 (m, 2H), 4.72-4.68 (m, 1H), 2.45-2.08 (m, 3H), 1.97-1.78 (m, 2H). Data are consistent with literature values.[7]

3. General prodedure for photocatalytic bromoetherification of alkenols

General method: To a 10 mL round bottom flask equipped with a magnetic stir bar were added alkenols **1** (0.2 mmol), CBr_4 (132 mg, 0.4 mmol), $Ru(bpy)_3Cl_2$ (4.6 mg, 0.006mmol) and dry DMSO (2 mL). The mixture was irradiated with blue LEDs (1W) at room temperature without degassed for 4 hours. Then water was added and the aqueous layer was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, concentrated. The residue was purified by flash column chromatography to give the final product **2**.

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6 Janza, B.; Studer, A. *J. Org. Chem.* 2005, 70, 6991.

7 Rawal, V.; Singh, S. P.; Dufour, C.; Michoud, C. *J. Org. Chem.* 1993, *58*, 7734.

4. Stereochemical determination of β-bromotetrahydrofuran 2a

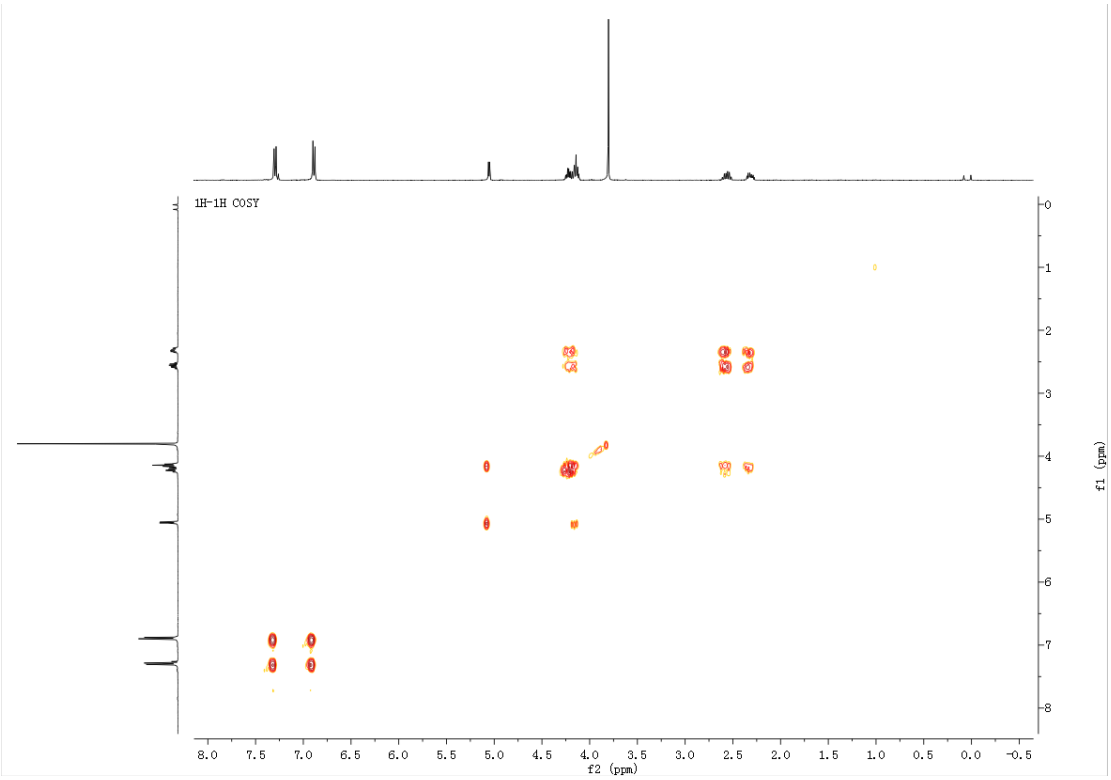


Fig. 1 COSY spectrum of the product **2a**.

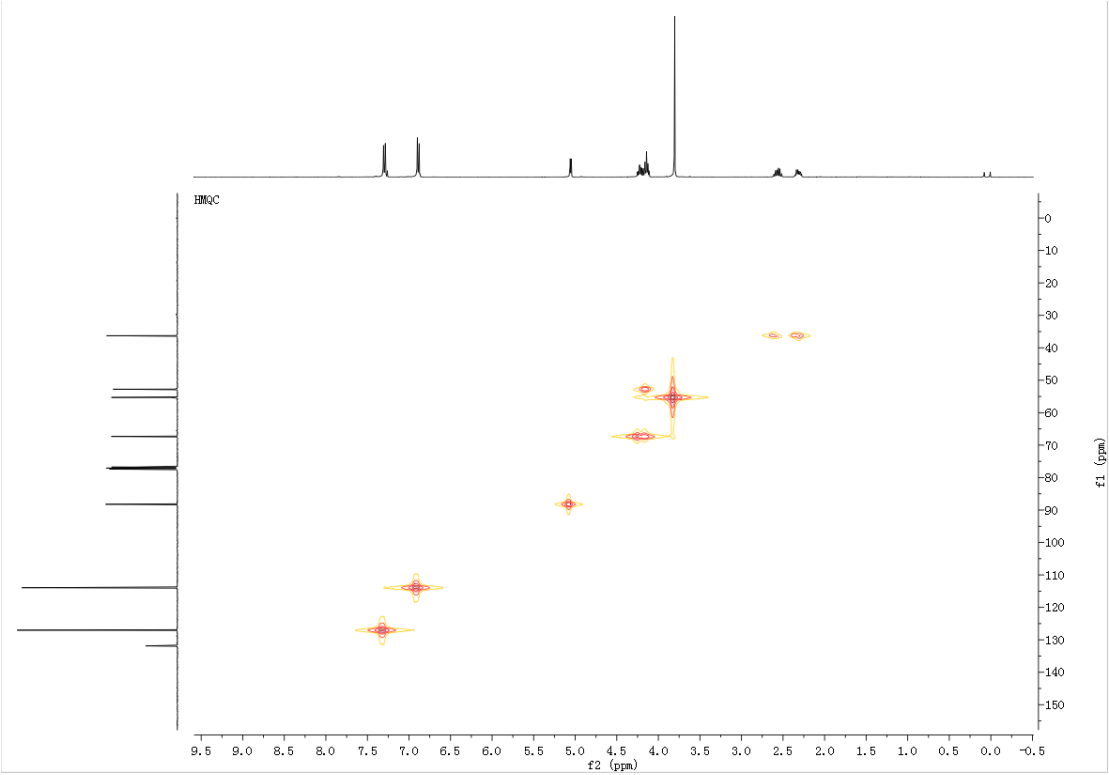


Fig. 2 HMQC spectrum of the product **2a**.

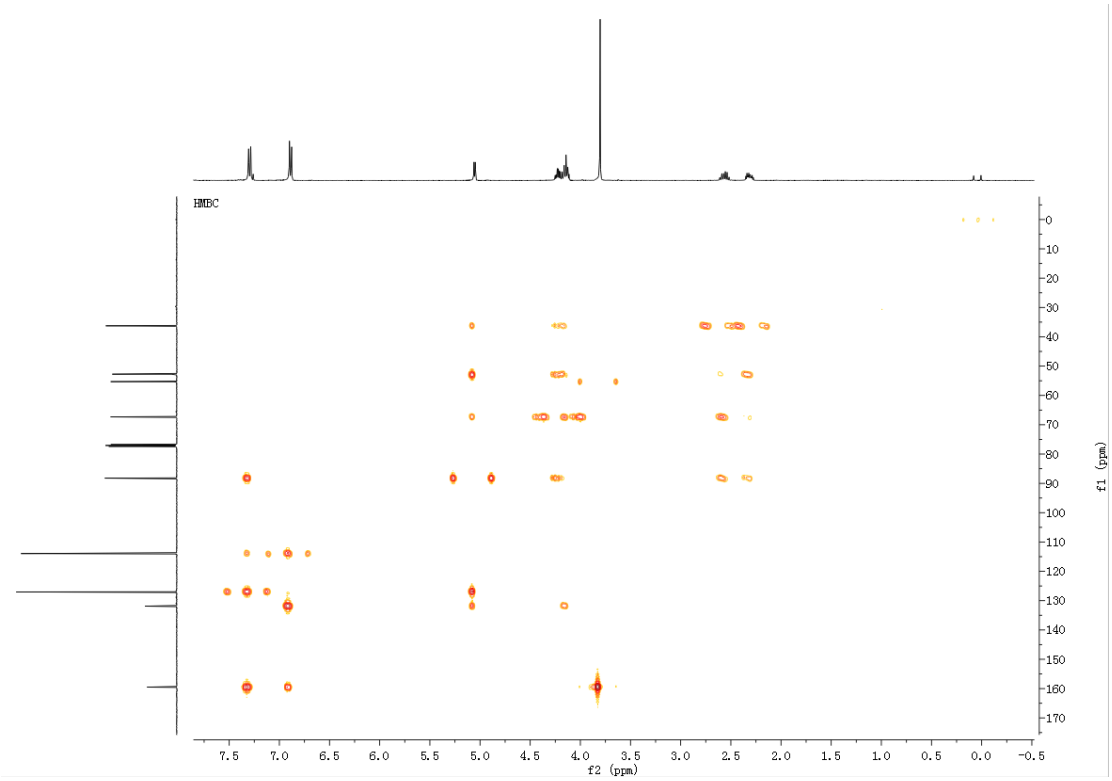


Fig. 3 HMBC spectrum of the product **2a**.

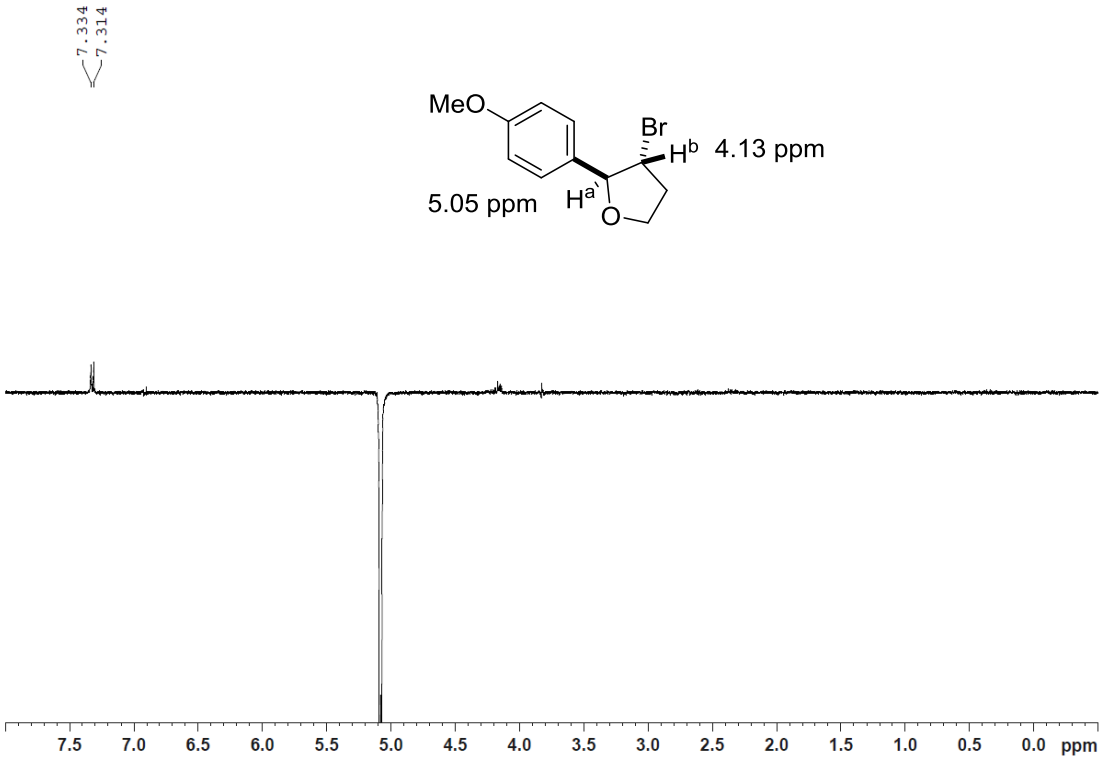
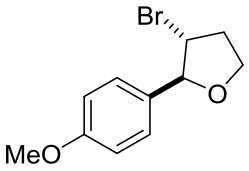


Fig. 4 NOE spectrum of the product **2a**. (There is no NOE between H^a and H^b.)

The NOE data indicate that product **2a** should be *trans* configuration. The stereo-chemistry of all other products was inferred by analogy.

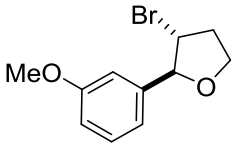
5. Characterization of photocatalytic bromoetherification products

3-bromo-2-(4-methoxyphenyl)tetrahydrofuran (2a)



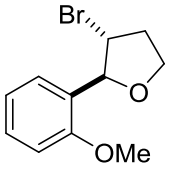
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.30 (d, J = 8.7 Hz, 2H), 6.89 (d, J = 8.7 Hz, 2H), 5.05 (d, J = 5.0 Hz, 1H), 4.23 (td, J = 8.2, 4.1 Hz, 1H), 4.19-4.10 (m, 2H), 3.80 (s, 3H), 2.56 (dd, J = 13.7, 7.3 Hz, 1H), 2.37-2.26 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.5, 131.9, 127.0, 114.0, 88.2, 67.3, 55.3, 52.8, 36.3. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{11}H_{14}BrO_2$ 257.0177, found 257.0176.

3-bromo-2-(3-methoxyphenyl)tetrahydrofuran (2b)



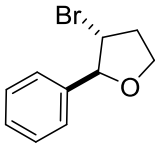
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.27 (t, J = 7.9 Hz, 2H), 6.94 (dd, J = 13.5, 4.8 Hz, 2H), 6.84 (dd, J = 8.1, 2.5 Hz, 1H), 5.13 (d, J = 4.5 Hz, 1H), 4.29 – 4.15 (m, 3H), 3.82 (s, 3H), 2.54 (dd, J = 13.7, 7.0 Hz, 1H), 2.39 – 2.26 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.8, 141.8, 129.6, 117.9, 113.5, 111.2, 88.4, 67.5, 55.3, 52.7, 36.2. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{11}H_{14}BrO_2$ 257.0177, found 257.0175.

3-bromo-2-(2-methoxyphenyl)tetrahydrofuran (2c)



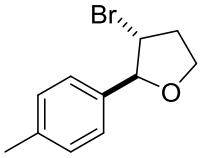
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.35-7.28 (m, 1H), 7.29-7.23 (m, 1H), 6.95 (t, J = 7.4 Hz, 1H), 6.87 (d, J = 8.2 Hz, 1H), 5.52 (s, 1H), 4.50-4.41 (m, 1H), 4.37-4.23 (m, 2H), 3.88 (s, 3H), 2.44-2.29 (m, 1H), 2.28-2.17 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 156.2, 129.4, 128.9, 126.1, 120.5, 110.2, 85.2, 67.7, 55.4, 53.3, 35.3. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{11}H_{14}BrO_2$ 257.0177, found 257.0177.

3-bromo-2-phenyltetrahydrofuran (2d)



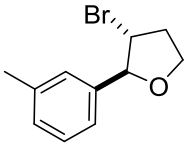
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.43-7.33 (m, 4H), 7.32 (dd, J = 5.8, 2.9 Hz, 1H), 5.14 (d, J = 4.7 Hz, 1H), 4.26 (td, J = 8.2, 4.0 Hz, 1H), 4.23-4.15 (m, 2H), 2.56 (dd, J = 13.8, 7.2 Hz, 1H), 2.40-2.26 (m, 1H), 2.28-2.17 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 140.0, 128.5, 128.1, 125.6, 88.5, 67.5, 52.7, 36.2. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{10}H_{12}BrO$ 227.0072, found 227.0070. Data are consistent with literature values.[8]

3-bromo-2-*p*-tolyltetrahydrofuran (2e)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.26 (d, J = 7.9 Hz, 2H), 7.17 (d, J = 7.9 Hz, 2H), 5.10 (d, J = 4.7 Hz, 1H), 4.30-4.20 (m, 1H), 4.20-4.12 (m, 2H), 2.64-2.45(m, 1H), 2.35 (s, 3H), 2.33-2.27 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 137.8, 137.0, 129.2, 125.5, 88.4, 67.4, 52.8, 36.2, 21.1. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{11}H_{14}BrO$ 241.0228, found 241.0230.

3-bromo-2-*m*-tolyltetrahydrofuran (2f)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.28 (dd, J= 6.7, 4.7 Hz, 1H), 7.24 (d, J = 7.5 Hz, 1H), 7.17 (d, J = 8.9 Hz, 2H), 7.12 (d, J = 7.4 Hz, 1H), 5.11 (d, J = 4.6 Hz, 1H), 4.26 (td, J = 8.2, 4.0 Hz, 1H), 4.22-4.16 (m, 2H), 2.55 (dt, J = 15.1, 8.0 Hz, 1H), 2.36 (s, 3H), 2.35-2.24 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 139.9, 138.2, 128.8, 128.4, 126.2, 122.8, 88.6, 67.5, 52.8, 36.2, 21.4. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{11}H_{14}BrO$ 241.0228, found 241.0230.

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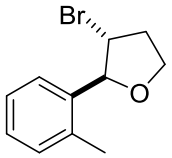
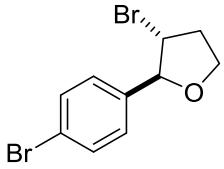
[8] Crich, D.; Sartillo-Piscil, F.; Quintero-Cortes, L.; Wink, D. J. *J. Org. Chem.* 2002, 67, 3360-3364.

3-bromo-2-*o*-tolyltetrahydrofuran (2g)



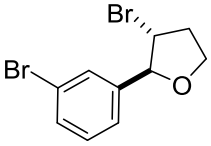
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.33 (dd, J = 5.1, 3.9 Hz, 1H), 7.20 (dd, J = 5.9, 3.3 Hz, 2H), 7.17 (dd, J = 8.1, 3.7 Hz, 2H), 5.44 (d, J = 2.5 Hz, 1H), 4.38 (td, J = 8.2, 2.2 Hz, 1H), 4.33-4.22 (m, 2H), 2.54-2.44 (m, 1H), 2.24 (s, 3H), 2.28 (ddt, J = 13.9, 5.7, 2.3 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 139.2, 134.9, 130.4, 127.8, 126.1, 124.9, 86.7, 67.9, 52.9, 35.6, 19.6. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{11}H_{14}BrO$ 241.0228, found 241.0227.

3-bromo-2-(4-bromophenyl)tetrahydrofuran (2h)



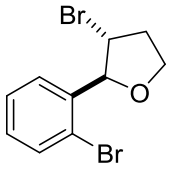
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.48 (d, J = 8.4 Hz, 2H), 7.27 (d, J = 8.2 Hz, 2H), 5.05 (d, J = 5.1 Hz, 1H), 4.23 (td, J = 8.2, 4.3 Hz, 1H), 4.17 (dd, J = 15.5, 8.2 Hz, 1H), 4.08 (dt, J = 7.0, 4.9 Hz, 1H), 2.54 (td, J = 15.1, 7.7 Hz, 1H), 2.39-2.25 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 139.0, 131.8, 127.4, 122.0, 87.8, 67.5, 52.1, 36.3. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{10}H_{11}Br_2O$ 306.9156, found 306.9158.

3-bromo-2-(3-bromophenyl)tetrahydrofuran (2i)



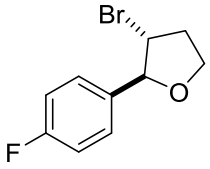
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.54 (s, 1H), 7.44 (d, J = 7.9 Hz, 1H), 7.31 (d, J = 7.7 Hz, 1H), 7.22 (t, J = 7.8 Hz, 2H), 5.08 (d, J = 4.8 Hz, 1H), 4.31-4.08 (m, 3H), 2.53 (dt, J = 15.0, 7.5 Hz, 1H), 2.39-2.27 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 142.4, 131.2, 130.1, 128.7, 124.4, 122.8, 87.7, 67.6, 52.2, 36.3. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{10}H_{11}Br_2O$ 306.9156, found 306.9153.

3-bromo-2-(2-bromophenyl)tetrahydrofuran (2j)



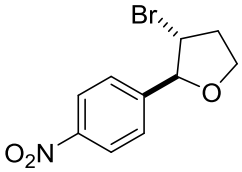
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.56 (d, J = 7.9 Hz, 1H), 7.43-7.27 (m, 2H), 7.21-7.12 (m, 1H), 5.54 (s, 1H), 4.50-4.32 (m, 3H), 2.54-2.20 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 140.7, 132.9, 129.4, 127.5, 127.1, 121.8, 88.5, 68.5, 53.0, 34.7. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{10}H_{11}Br_2O$ 306.9156, found 306.9157.

3-bromo-2-(4-fluorophenyl)tetrahydrofuran (2k)



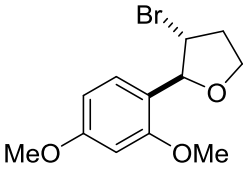
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.36 (dd, J = 8.5, 5.4 Hz, 2H), 7.04 (t, J = 8.7 Hz, 2H), 5.06 (d, J = 5.2 Hz, 1H), 4.28-4.20 (m, 1H), 4.20-4.13 (m, 1H), 4.10 (dt, J = 7.0, 5.0 Hz, 3H), 2.56 (dd, J = 13.7, 7.4 Hz, 1H), 2.38-2.25 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 163.8, 161.3, 135.6, 135.5, 127.5, 127.4, 115.5, 115.3, 87.8, 67.4, 52.3, 36.3. ^{19}F NMR (376MHz, $CDCl_3$): δ -114.2 (S). HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{10}H_{11}BrFO$ 244.9977, found 244.9980.

3-bromo-2-(4-nitrophenyl)tetrahydrofuran (2l)



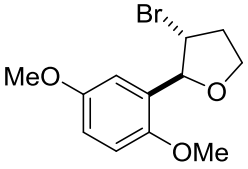
^{1}HNMR ($CDCl_3$, 400 MHz): δ 8.23 (d, J = 8.0 Hz, 2H), 7.60 (d, J = 8.3 Hz, 2H), 5.16 (d, J = 5.0 Hz, 1H), 4.30-4.19 (m, 2H), 4.08 (dd, J = 11.0, 5.7 Hz, 1H), 2.62-2.53 (m, 1H), 2.41-2.33 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 147.8, 147.0, 126.5, 123.8, 87.3, 67.8, 51.3, 36.4. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{10}H_{11}BrNO_3$ 271.9922, found 271.9922.

3-bromo-2-(2,4-dimethoxyphenyl)tetrahydrofuran (2m)



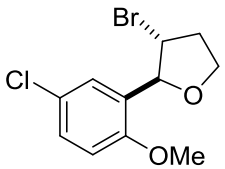
93%, ^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.20 (d, J = 7.9 Hz, 1H), 6.50-6.41 (m, 2H), 5.42 (d, J = 1.9 Hz, 1H), 4.46-4.38 (m, 1H), 4.34-4.20 (m, 2H), 3.84 (s, 3H), 3.80 (s, 3H), 2.38 (d, J = 9.9 Hz, 1H), 2.23 (d, J = 5.8 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 160.7, 157.3, 127.0, 121.7 103.9, 98.4, 85.1, 67.5, 55.4, 55.4, 53.2, 35.3. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{12}H_{16}BrO_3$ 287.0283, found 287.0280.

3-bromo-2-(2,5-dimethoxyphenyl)tetrahydrofuran (2n)



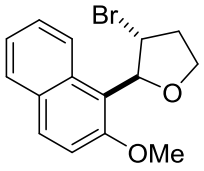
^{1}HNMR ($CDCl_3$, 400 MHz): δ 6.91 (m, 1H), 6.78 (d, J= 2.3 Hz, 2H), 5.48 (s, 1H), 4.44 (d, J= 5.4 Hz, 1H), 4.31 (m, 2H), 3.83 (s, 3H), 3.77 (s, 3H), 2.41-2.28 (m, 1H), 2.26-2.17 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 153.7, 150.4, 130.7, 112.9, 112.7, 111.1, 85.4, 67.8, 55.9, 55.8, 53.3, 35.2. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{12}H_{16}BrO_3$ 287.0283, found 287.0280.

3-bromo-2-(5-chloro-2-methoxyphenyl)tetrahydrofuran (2o)



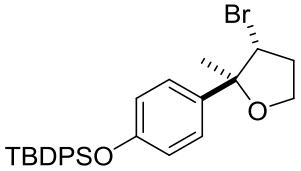
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.28 (d, J = 2.4 Hz, 1H), 7.21 (dd, J = 8.7, 2.6 Hz, 1H), 6.78 (d, J = 8.7 Hz, 1H), 5.46 (s, 1H), 4.39 (d, J = 5.4 Hz, 1H), 4.35 (td, J = 8.2, 1.9 Hz, 1H), 4.32-4.24 (m, 1H), 3.86 (s, 3H), 2.31 (ddd, J = 10.3, 8.3, 5.4 Hz, 1H), 2.22 (dd, J = 13.9, 5.6 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 154.8, 131.4, 128.5, 126.2, 125.8, 111.4, 84.7, 67.9, 55.7, 52.8, 35.3. HRMS-ESI (m/z): $[M+H]^+$ calculated for $C_{11}H_{13}BrClO_2$ 290.9787, found 290.9785.

3-bromo-2-(2-methoxynaphthalen-1-yl)tetrahydrofuran (2p)



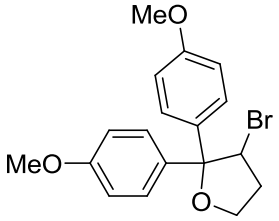
^{1}HNMR ($CDCl_3$, 400 MHz): δ 8.15 (d, J = 8.7 Hz, 1H), 7.81 (dd, J = 18.3, 8.7 Hz, 2H), 7.53-7.41 (m, 1H), 7.39-7.22 (m, 2H), 6.01 (d, J = 6.9 Hz, 1H), 4.84-4.73 (m, 1H), 4.39-4.27 (m, 1H), 4.21-4.09 (m, 1H), 3.96 (s, 3H), 2.99-2.81 (m, 1H), 2.57-2.44 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 156.3, 132.7, 130.8, 129.6, 128.8, 126.7, 123.5, 123.3, 118.1, 114.0, 83.0, 67.3, 57.0, 50.4, 38.2. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{15}H_{16}BrO_2$ 307.0334, found 307.0330.

(4-(3-bromo-2-methyltetrahydrofuran-2-yl)phenoxy)(*tert*-butyl)diphenylsilane (2q)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.77-7.66 (m, 4H), 7.43 (dd, J = 8.4, 6.2 Hz, 2H), 7.36 (dd, J =11.0, 4.1 Hz, 4H), 7.14-7.06 (m, 2H), 6.75-6.68 (m, 2H), 4.50 (dd, J = 5.6, 3.2 Hz, 1H), 4.18 (dd, J = 15.8, 8.1 Hz, 1H), 3.98 (td, J = 8.4, 3.7 Hz, 1H), 2..37-2.30 (m, 1H), 2.26-2.20 (m, 1H), 1.6 (s, 3H), 1.1 (s, 9H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 154.7, 137.7, 135.5, 132.9, 129.9, 127.7, 125.5, 119.5, 86.4, 65.5, 58.7, 36.4, 28.0, 26.5, 19.4. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{27}H_{32}BrO_2Si$ 495.1355, found 495.1358.

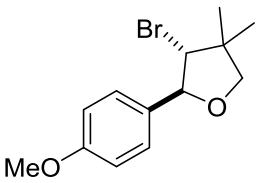
3-bromo-2,2-bis(4-methoxyphenyl)tetrahydrofuran (2r)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.38 (dd, J = 20.5, 8.8 Hz, 4H), 6.82 (dd, J = 14.0, 8.8 Hz, 4H), 5.20 (dd, J = 4.5, 2.6 Hz, 1H), 4.39 (q, J = 8.0 Hz, 1H), 4.05 (td, J = 8.2, 4.4

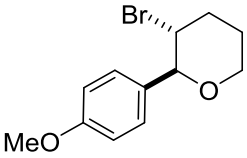
Hz, 1H), 3.75 (d, *J* = 5.2 Hz, 6H), 2.45 (dd, *J* = 7.8, 4.6 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 158.7, 158.3, 136.9, 136.3, 127.3, 126.4, 114.0, 113.0, 90.5, 65.2, 57.3, 55.3, 55.1, 36.58. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{18}H_{20}BrO_3$ 363.0596, found 363.0598.

3-bromo-2-(4-methoxyphenyl)-4,4-dimethyltetrahydrofuran (2s)



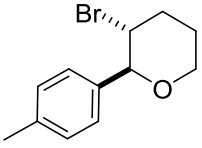
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.35 (d, *J* = 8.6 Hz, 2H), 6.9 (d, *J* = 8.7 Hz, 1H), 4.92 (d, *J* = 9.1 Hz, 1H), 3.92-3.85 (m, 2H), 3.81 (s, 3H), 3.77 (d, *J* = 9.1 Hz, 1H), 1.26 (s, 3H), 1.14 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.6, 131.8, 127.4, 113.8, 85.6, 78.7, 65.3, 55.2, 42.7, 23.9, 23.7. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{13}H_{18}BrO_2$ 285.0490, found 285.0492.

3-bromo-2-(4-methoxyphenyl)tetrahydro-2*H*-pyran (2t)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.31 (d, *J* = 8.7 Hz, 2H), 6.89 (d, *J* = 8.7 Hz, 2H), 4.28 (d, *J* = 10 Hz, 1H), 4.14-4.01 (m, 2H), 3.80 (s, 3H), 3.63 (td, *J* =12.0 , 2.2 Hz, 1H), 2.61-2.56 (m, 1H), 217-2.06 (m, 1H), 1.99-1.87 (m, 1H), 1.75-1.71 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.6, 132.0, 128.7, 113.6, 85.1, 68.7, 55.2, 52.7, 36.2, 28.4. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{12}H_{16}BrO_2$ 271.0334, found 271.0330.

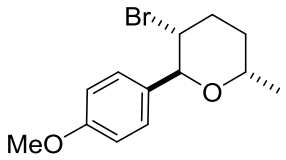
3-bromo-2-p-tolyltetrahydro-2*H*-pyran (2u)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.27 (d, *J* = 8.4 Hz, 2H), 7.17 (d, *J* = 7.9 Hz, 2H), 4.29 (d, *J* = 10.0 Hz, 1H), 4.14-4.03 (m, 2H), 3.63 (td, *J* = 12.0, 2.2 Hz, 1H), 2.61-2.55 (m, 1H), 2.35 (s, 3H), 2.12 (ddd, *J* = 24.8, 13.0, 4.2 Hz, 1H), 2.06-1.84 (m, 1H), 1.74 (dd,

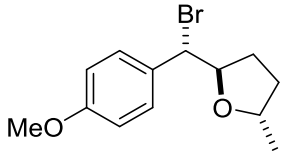
J = 13.7, 2.3 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 138.2, 136.7, 129.0, 127.4, 85.4, 68.7, 52.5, 36.2, 28.4, 21.3. Data are consistent with literature values.[9]

3-bromo-2-(4-methoxyphenyl)-6-methyltetrahydro-2*H*-pyran (2v)



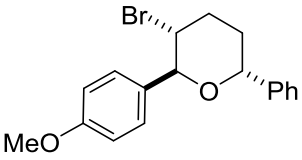
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.30 (d, *J* = 8.7 Hz, 2H), 6.89 (d, *J* = 8.7 Hz, 2H), 4.73 (d, *J* = 8.4 Hz, 1H), 4.23 (ddd, *J* = 14.3, 9.5, 5.1 Hz, 2H), 3.80 (s, 3H), 2.31 (d, *J* = 5.2 Hz, 2H), 2.04-1.91 (m, 1H), 1.75-1.64 (m, 1H), 1.37 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.4, 132.0, 128.5, 113.8, 68.8, 55.3, 53.0, 30.9, 30.3, 17.4. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{13}H_{18}BrO_2$ 285.0490, found 285.0492.

2-(bromo(4-methoxyphenyl)methyl)-5-methyltetrahydrofuran (3v)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.31 (d, *J* = 8.1 Hz, 2H), 6.88 (d, *J* = 8.1 Hz, 2H), 4.34 (d, *J* = 10.0 Hz, 1H), 4.07-3.91 (m, 1H), 3.80 (s, 3H), 3.72 (dd, *J* = 10.6, 5.7 Hz, 1H), 2.54 (d, *J* = 13.4 Hz, 1H), 2.15 (qd, *J* = 13.0, 3.6 Hz, 1H), 1.77 (d, *J* = 13.3 Hz, 1H), 1.58 (d, *J* = 12.0 Hz, 1H), 1.21 (d, *J* = 6.0 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.5, 132.2, 128.7, 113.6, 84.7, 74.6, 55.2, 53.0, 36.2, 35.5, 21.6. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{13}H_{18}BrO_2$ 285.0490, found 285.0492.

3-bromo-2-(4-methoxyphenyl)-6-phenyltetrahydro-2*H*-pyran (2w)

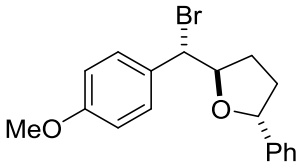


^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.51-7.38 (m, 4H), 7.33 (dd, *J* = 8.4, 5.3 Hz, 3H), 6.95-6.88 (m, 2H), 5.10 (s, 1H), 4.64 (d, *J* = 8.2 Hz, 1H), 4.42 (td, *J* = 9.0, 4.1 Hz, 1H), 3.82 (s, 3H), 2.44 (ddd, *J* = 15.7, 10.1, 5.0 Hz, 2H), 2.33-2.12 (m, 2H); ^{13}C

[9] S. E. Denmark, M. T. Burk, Org. Lett., 2012, 14, 256-259.

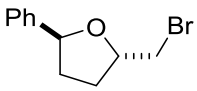
NMR ($CDCl_3$, 100 MHz): δ 159.5, 139.8, 131.6, 128.8, 128.5, 127.4, 126.6, 113.9, 77.8, 73.5, 55.3, 52.3, 30.9, 28.4. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{18}H_{20}BrO_2$ 347.0647, found 347.0648.

2-(bromo(4-methoxyphenyl)methyl)-5-phenyltetrahydrofuran (3w)



^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.32 (ddd, *J* = 27.5, 18.9, 7.3 Hz, 8H), 6.89 (d, *J* = 8.7 Hz, 2H), 4.65 (dd, *J* = 11.2, 2.0 Hz, 1H), 4.53 (d, *J* = 10.0 Hz, 1H), 4.14- 4.02 (m, 1H), 3.80 (s, 3H), 2.66 (dd, *J* = 13.2, 3.7 Hz, 1H), 2.33 (ddd, *J* = 25.3, 13.1, 4.2 Hz, 1H), 2.14-2.00 (m, 1H), 1.90 (ddd, *J* = 25.0, 13.6, 3.8 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.6, 141.8, 132.0, 128.83 (s), 128.3, 127.6, 125.8, 113.5, 85.1, 80.2, 55.2, 52.8, 36.6, 36.1. HRMS-ESI (*m*/*z*): $[M+H]^+$ calculated for $C_{18}H_{20}BrO_2$ 347.0647, found 347.0648.

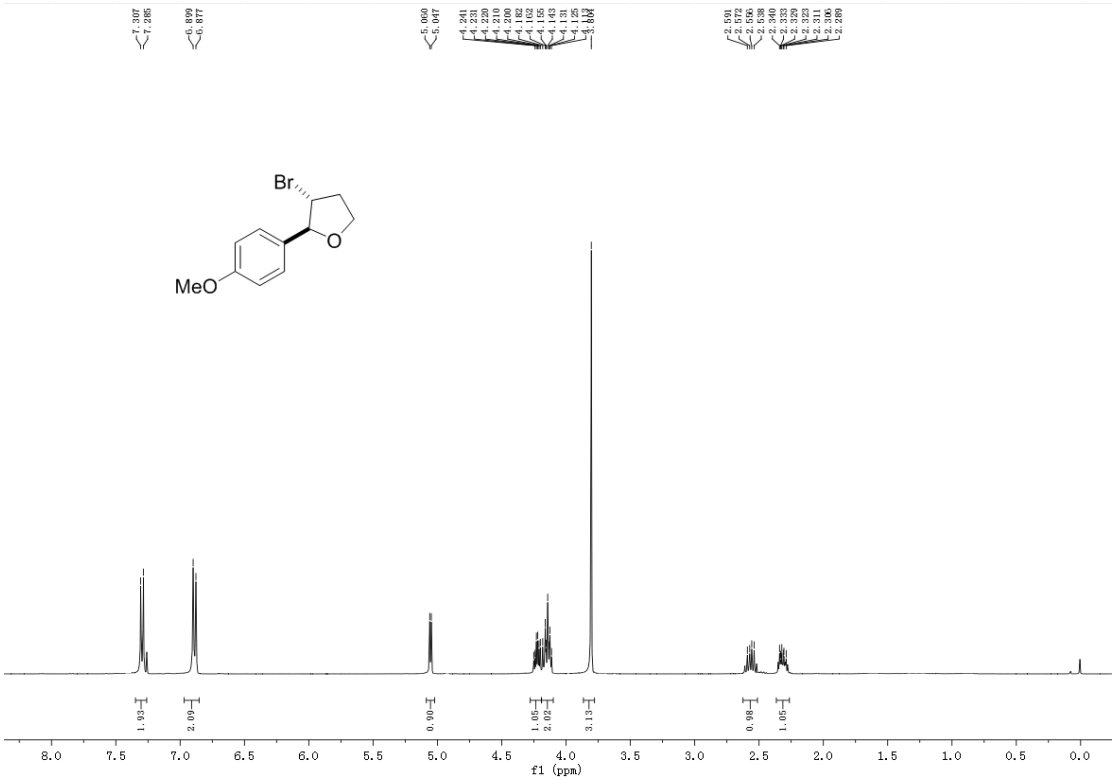
2-(bromomethyl)-5-phenyltetrahydrofuran (3x)

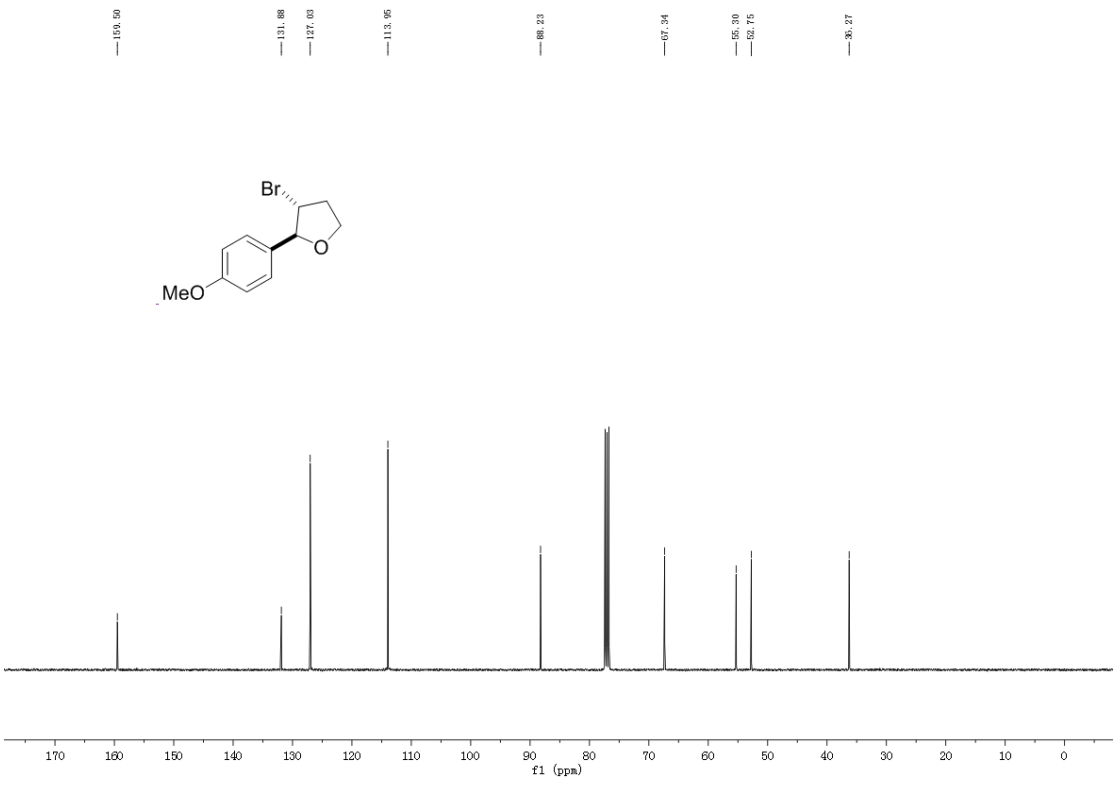


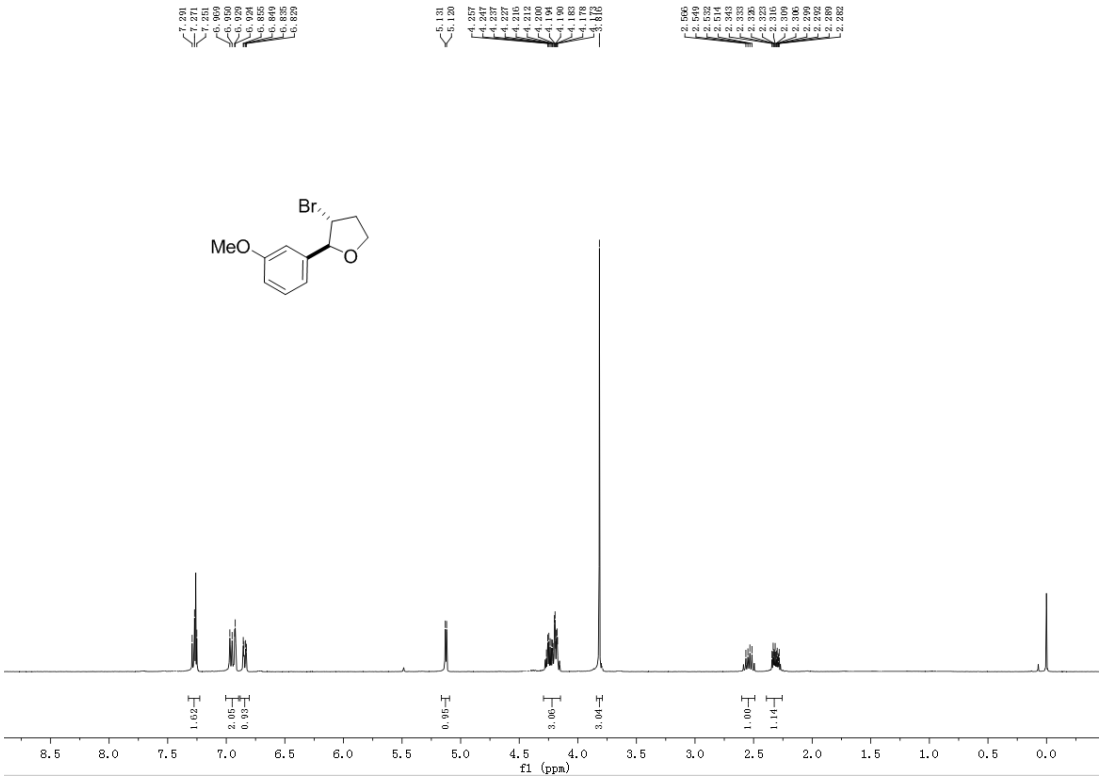
^{1}HNMR ($CDCl_3$, 400 MHz): δ 7.40-7.30 (m, 4H), 5.15-5.05 (m, 1H), 4.58-4.44 (m, 1H), 3.55 (dd, *J*= 10.1, 4.7 Hz, 1H), 3.46 (dd, *J*= 10.1, 6.8 Hz, 1H), 2.41 (dt, *J*= 11.3, 5.6 Hz, 1H), 2.31-2.14 (m, 1H), 2.02-1.76 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 142.7, 128.4, 127.4, 125.6, 81.54 (s), 78.7, 36.0, 35.2, 31.2. Data are consistent with literature values.[10]

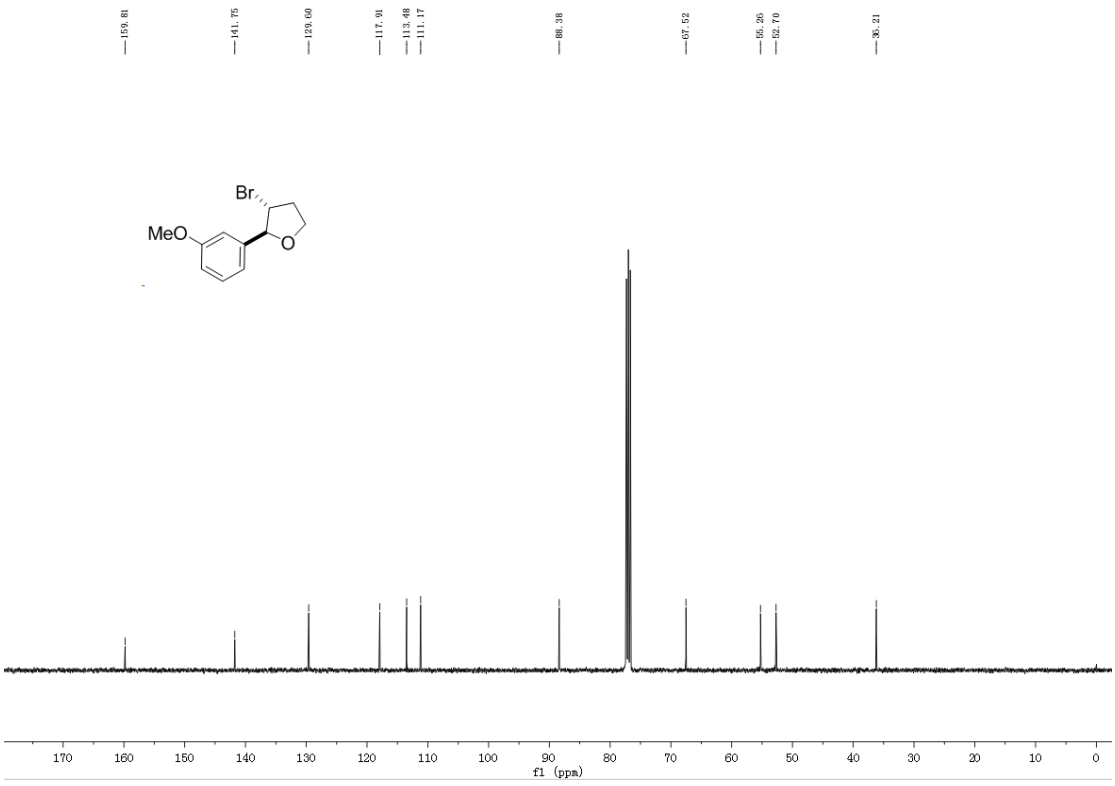
[10] M. Greb, J. Hartung, F. Köhler, K. Spehar, R. Kluge, R. Csuk, *Eur. J. Org. Chem.* **2004**, 3799-3812.

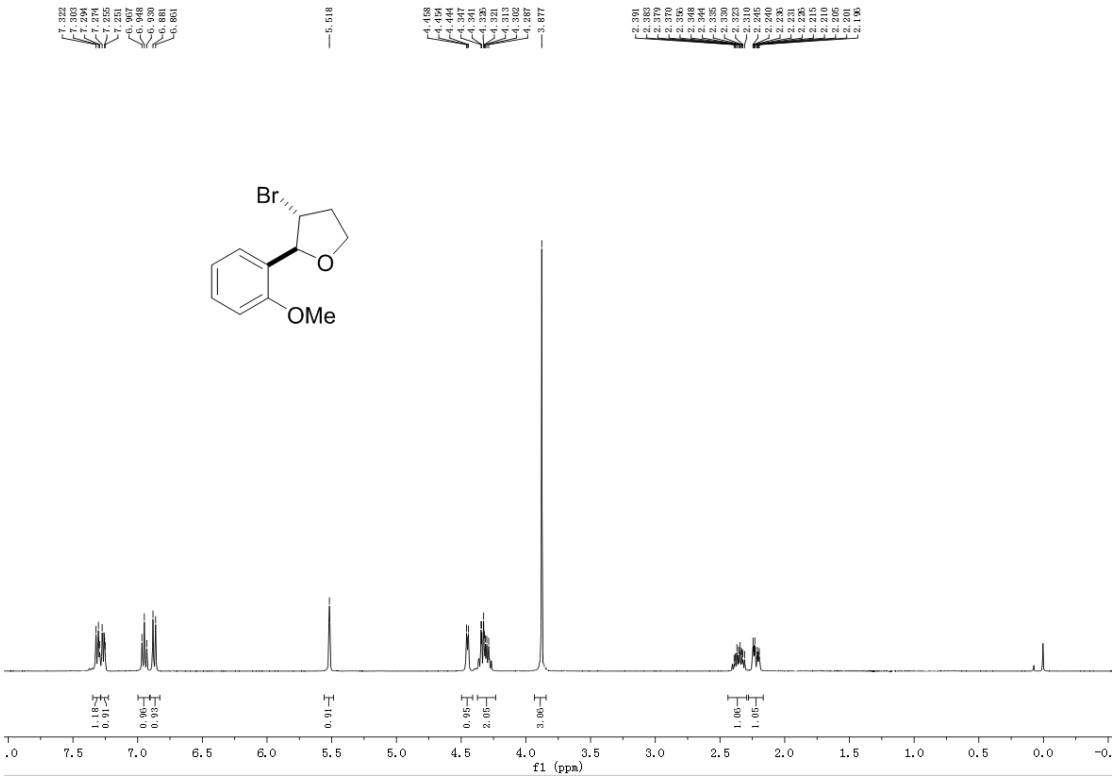
6. ^{1}H and ^{13}C NMR spectra

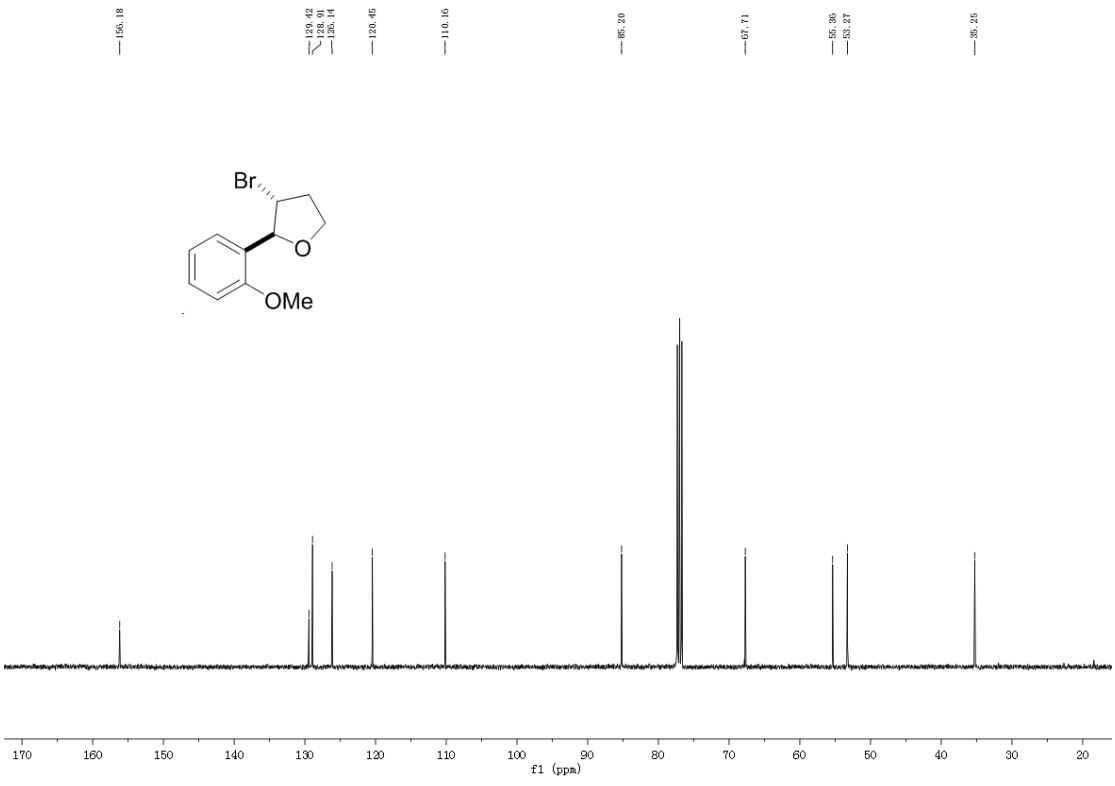


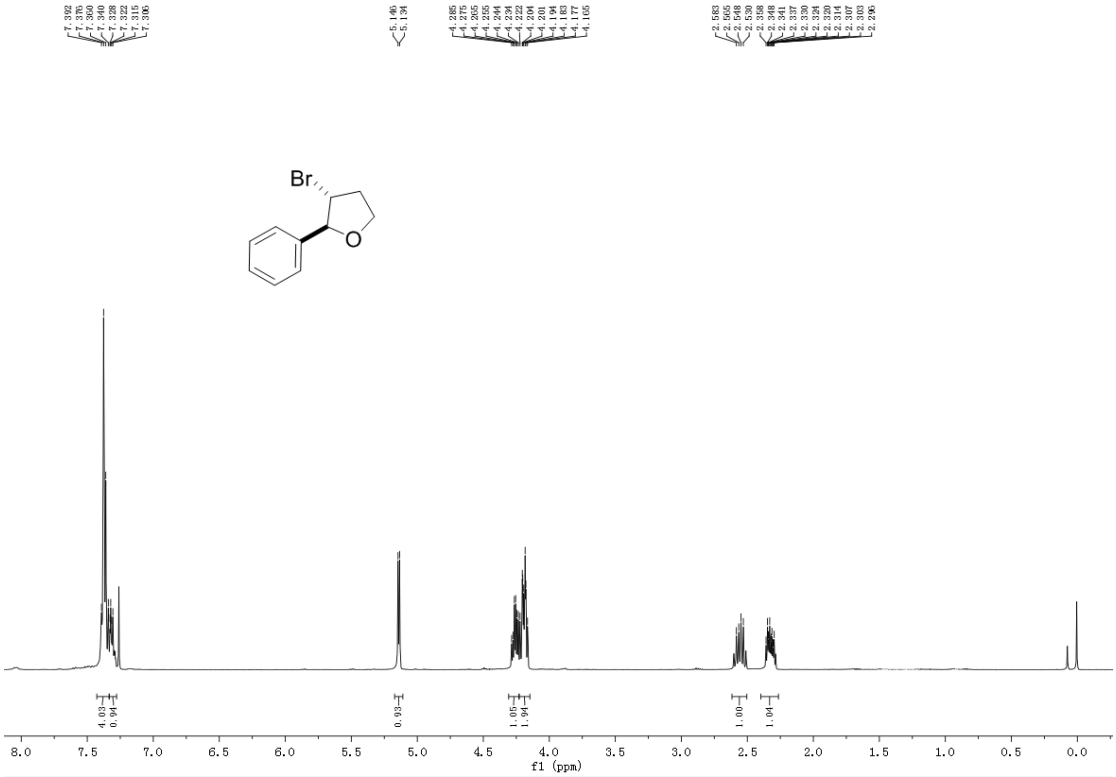


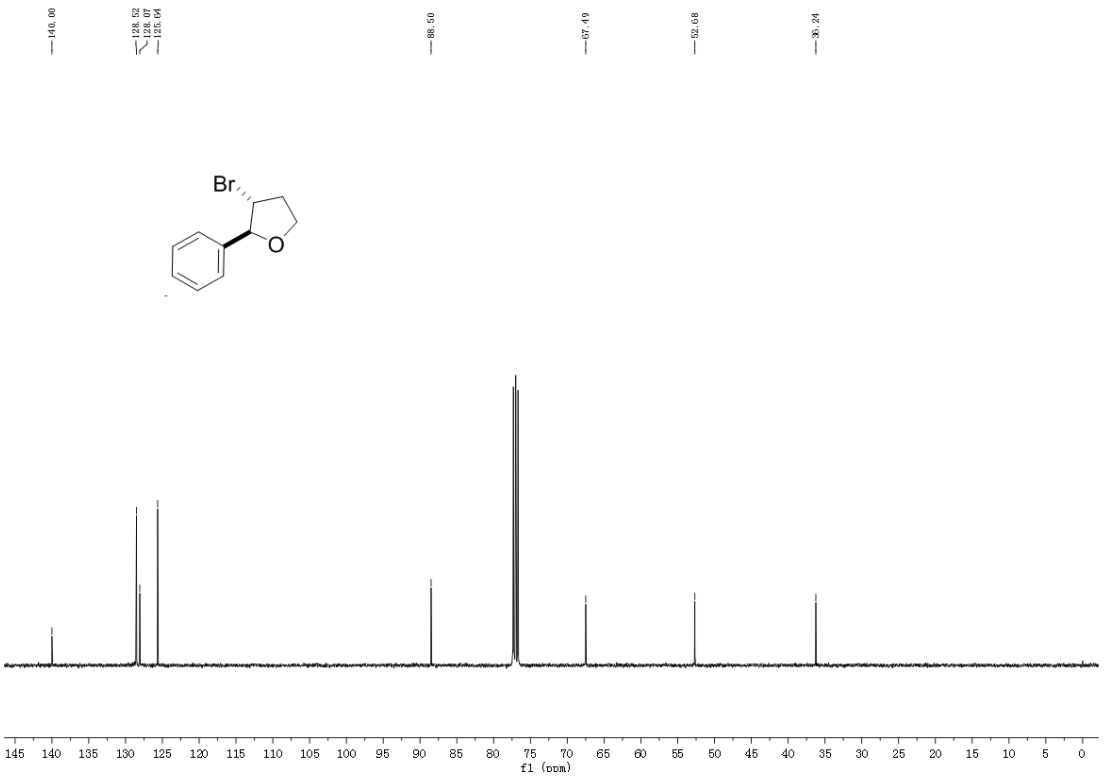

Br
MeO
O
1.62
2.05
0.93
0.95
3.00
3.04
1.00
1.14
f1 (ppm)

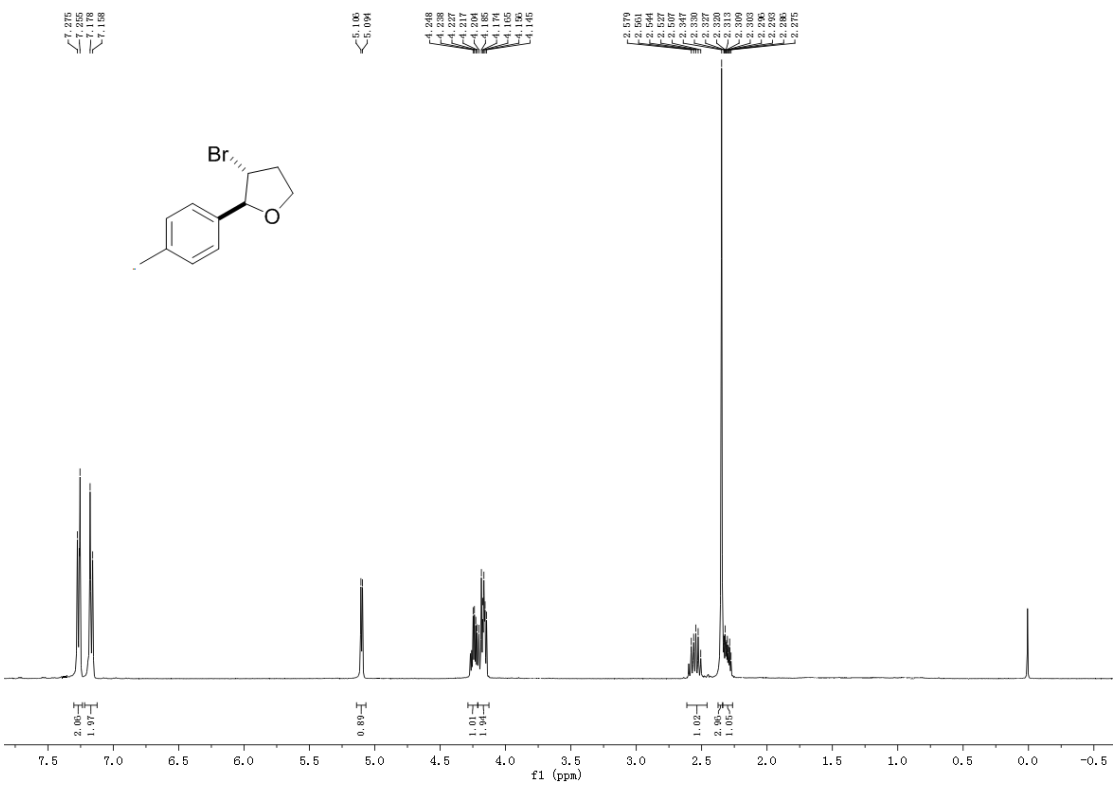

159.81
141.75
129.60
117.91
113.48
111.17
88.38
67.52
55.26
52.70
36.21
Br
MeO
O
f1 (ppm)

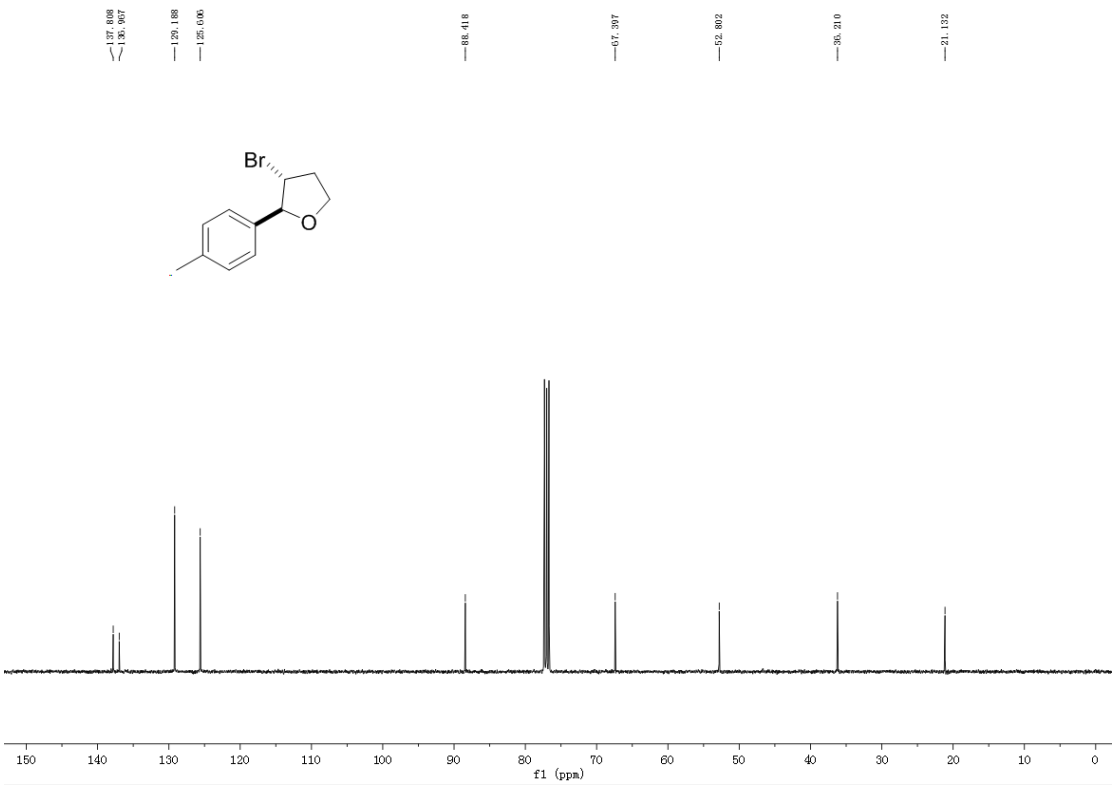

7.322
7.303
7.294
7.274
7.255
7.251
6.967
6.948
6.930
6.881
6.861
5.518
4.458
4.454
4.444
4.347
4.341
4.335
4.321
4.313
4.302
4.287
3.877
2.391
2.383
2.370
2.356
2.348
2.344
2.335
2.330
2.323
2.310
2.305
2.240
2.235
2.231
2.225
2.215
2.210
2.205
2.201
2.196
Br
O
OMe
1.18
0.91
0.98
0.93
0.91
0.95
2.05
3.00
1.06
1.05
f1 (ppm)

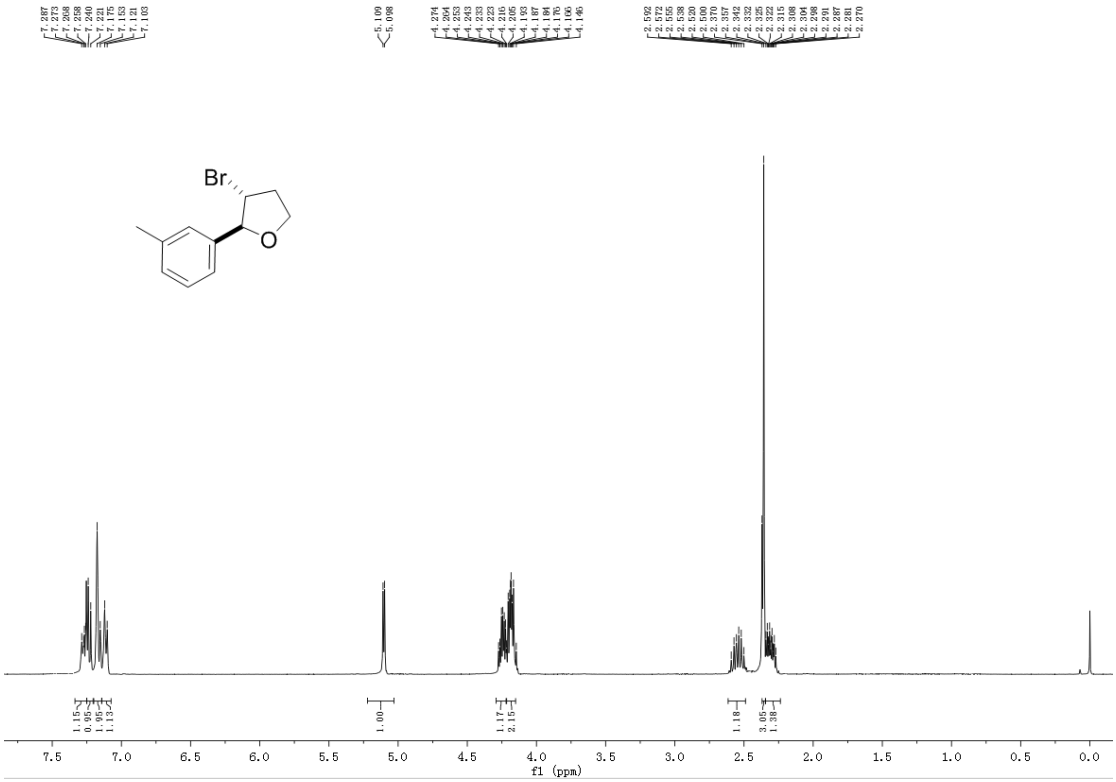

156.18
129.42
128.91
125.14
120.45
110.16
85.20
67.71
55.36
53.27
35.25
Br
O
OMe
f1 (ppm)

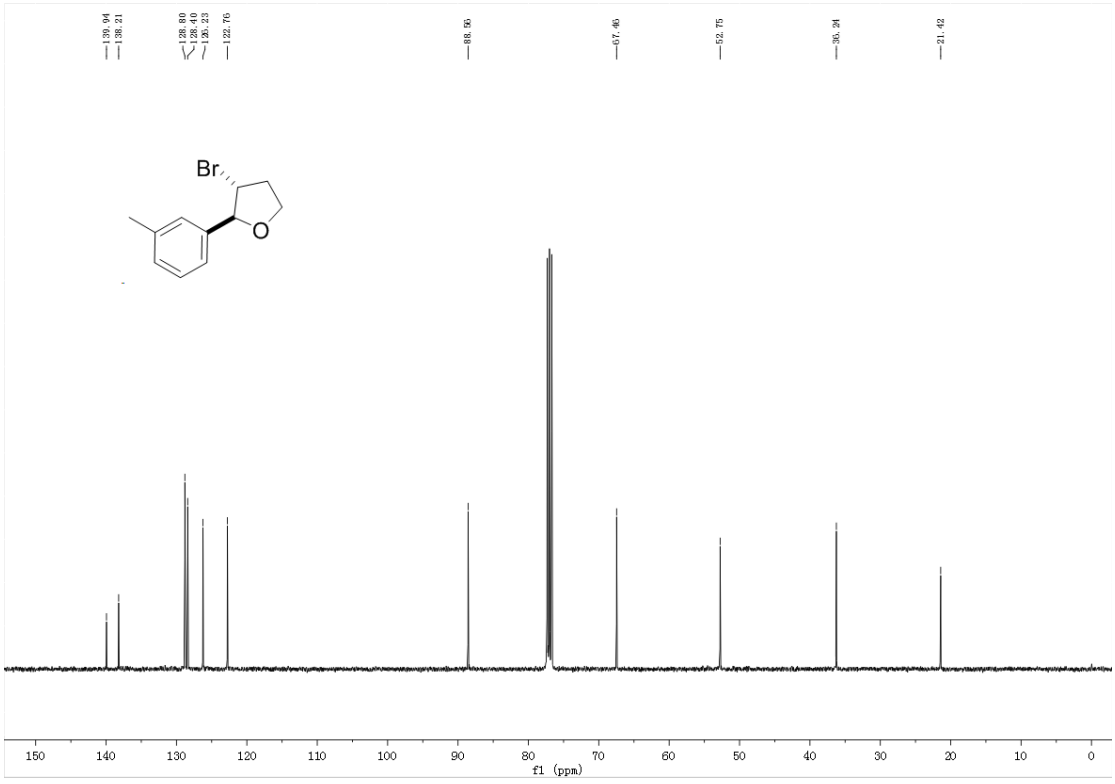

7.392
7.376
7.360
7.340
7.328
7.322
7.315
7.306
5.146
5.134
4.285
4.275
4.265
4.255
4.244
4.234
4.222
4.204
4.201
4.194
4.183
4.177
4.165
2.583
2.565
2.548
2.530
2.358
2.348
2.341
2.337
2.330
2.324
2.320
2.314
2.307
2.303
2.296
Br
O
4.03
0.94
0.93
1.05
1.94
1.00
1.04
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

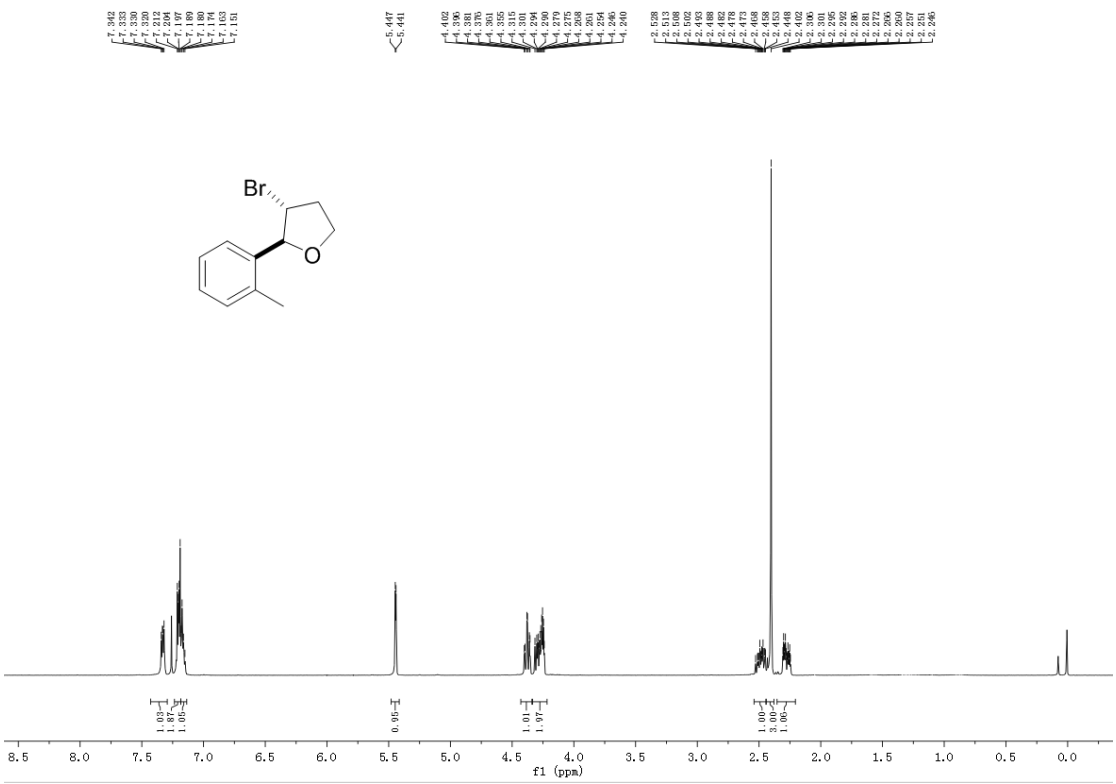

140.00
128.52
128.07
125.64
88.50
67.49
52.68
36.24
Br
O
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
f1 (ppm)

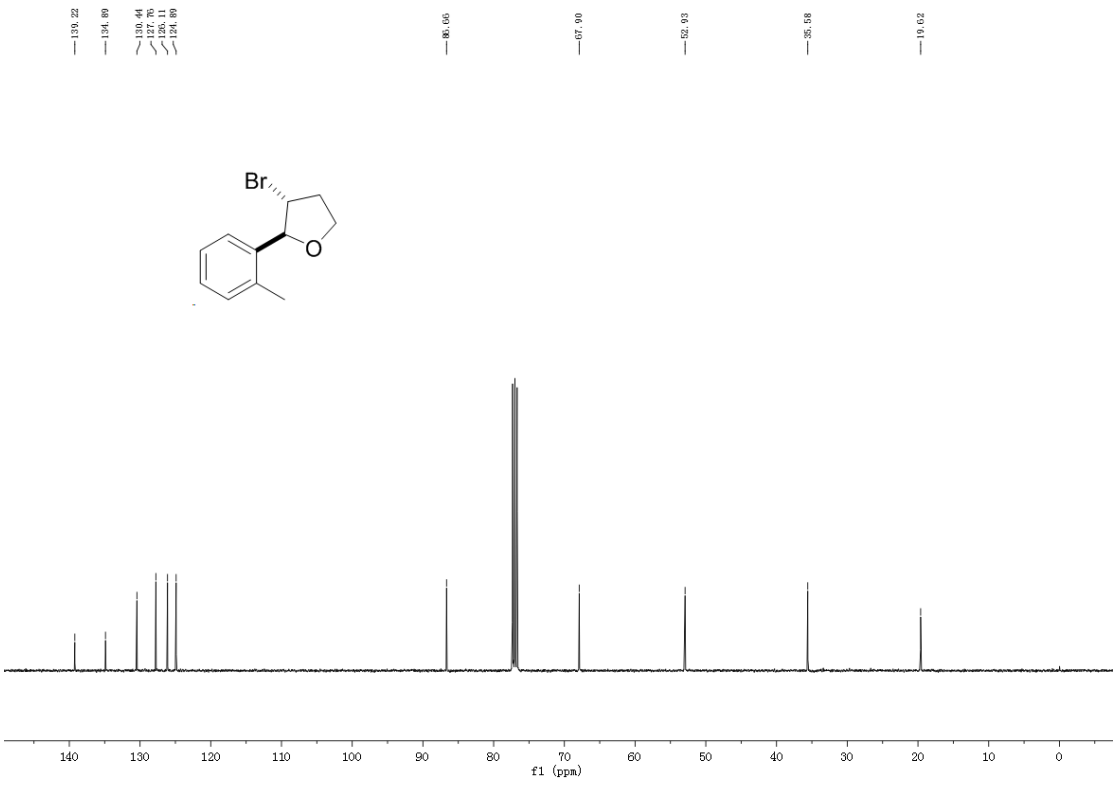

7.275
7.255
7.178
7.158
5.106
5.094
4.248
4.238
4.227
4.217
4.201
4.185
4.174
4.165
4.155
4.145
2.579
2.561
2.544
2.527
2.507
2.347
2.330
2.327
2.313
2.311
2.309
2.303
2.295
2.293
2.286
2.275
Br
O
2.06
1.97
0.89
1.01
1.94
1.02
2.96
1.05
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

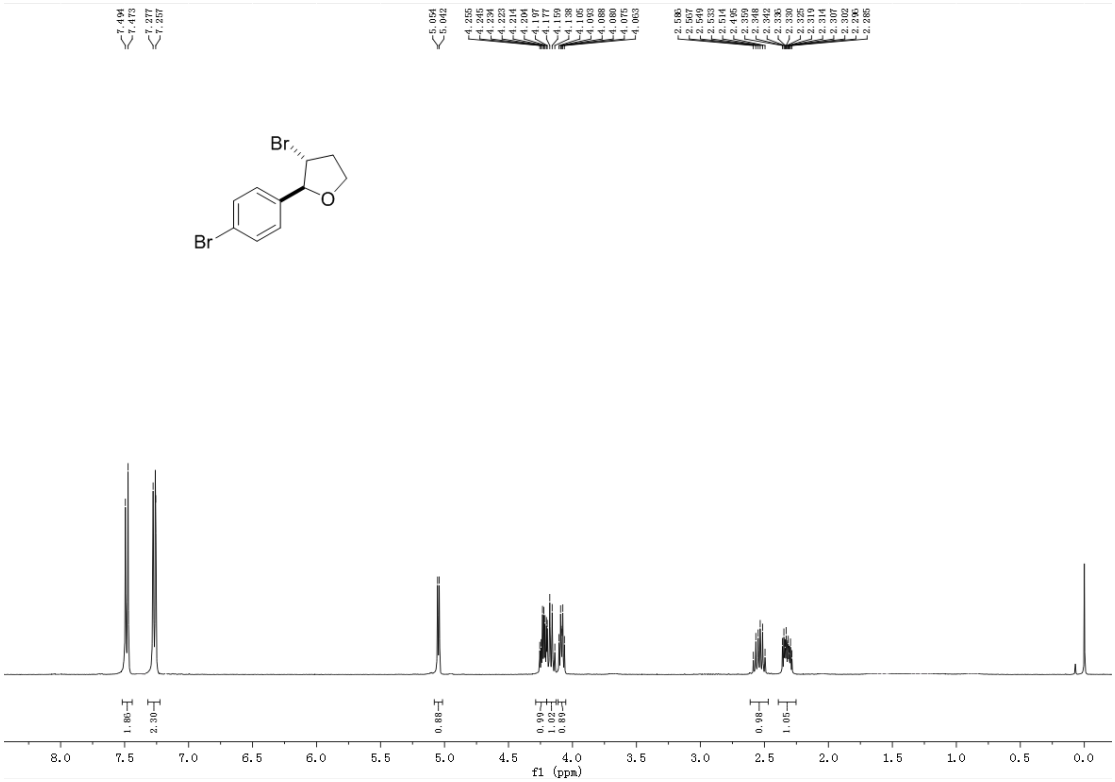

137.898
130.967
129.188
125.696
88.418
67.397
52.802
35.210
21.132
Br
O
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Br
O
f1 (ppm)


Br
O
f1 (ppm)


Br
O
f1 (ppm)


Br
O
f1 (ppm)


7.494
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4.255
4.245
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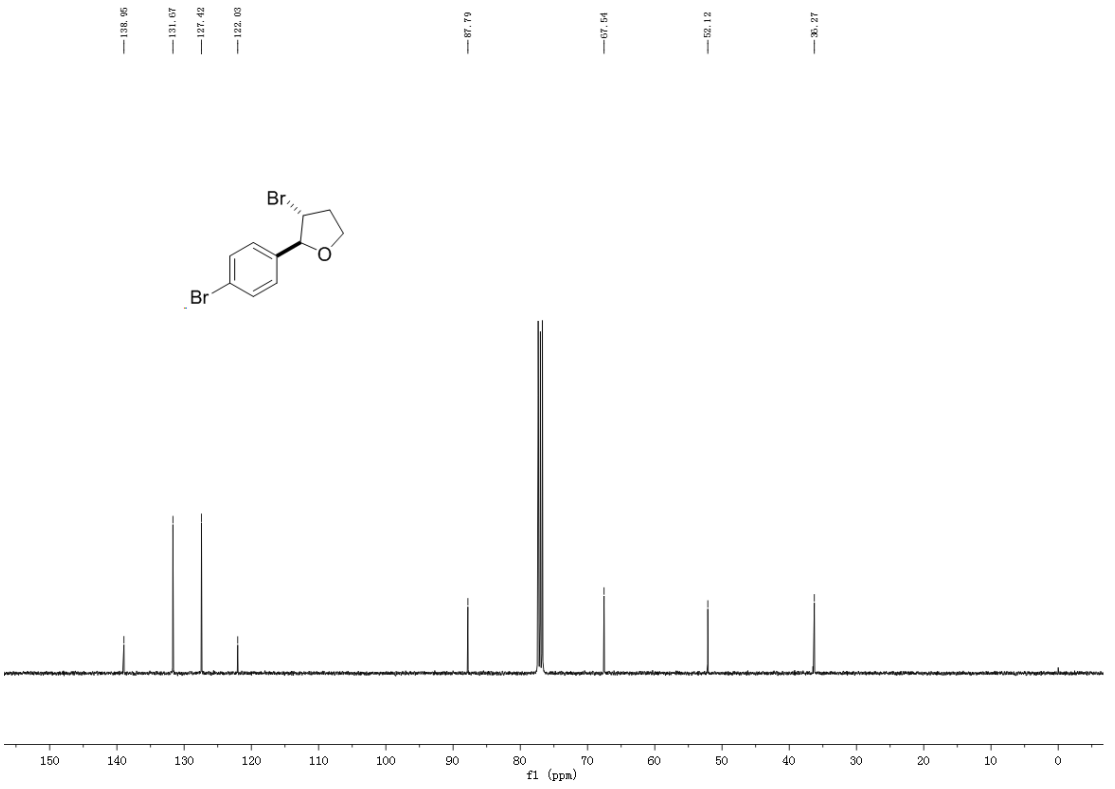
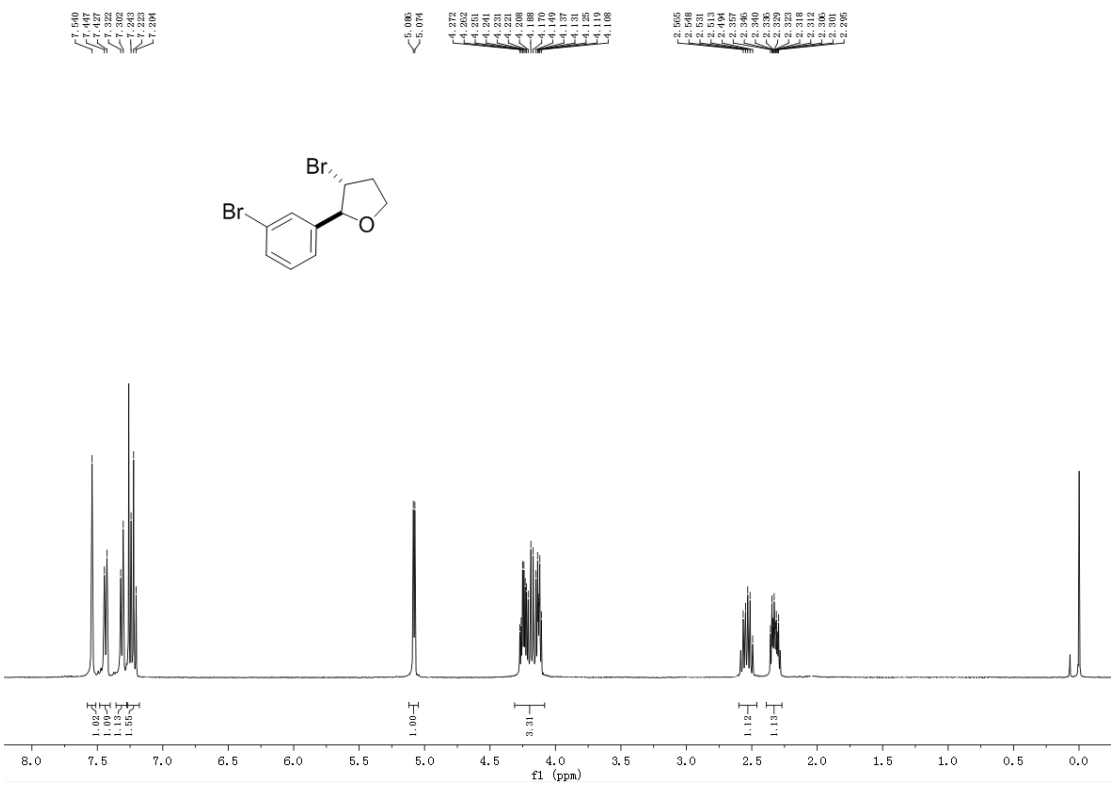
4.214
4.204
4.197
4.177
4.159
4.138
4.105
4.095
4.088
4.080
4.075
4.063
2.586
2.567
2.549
2.533
2.514
2.495
2.359
2.348
2.342
2.335
2.330
2.325
2.319
2.314
2.307
2.302
2.296
2.285
Br
Br
1.80
2.30
0.88
0.99
1.02
0.89
0.98
1.05
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


138.95
131.67
127.42
122.03
87.79
67.54
52.12
36.27
Br
Br
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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Br
O
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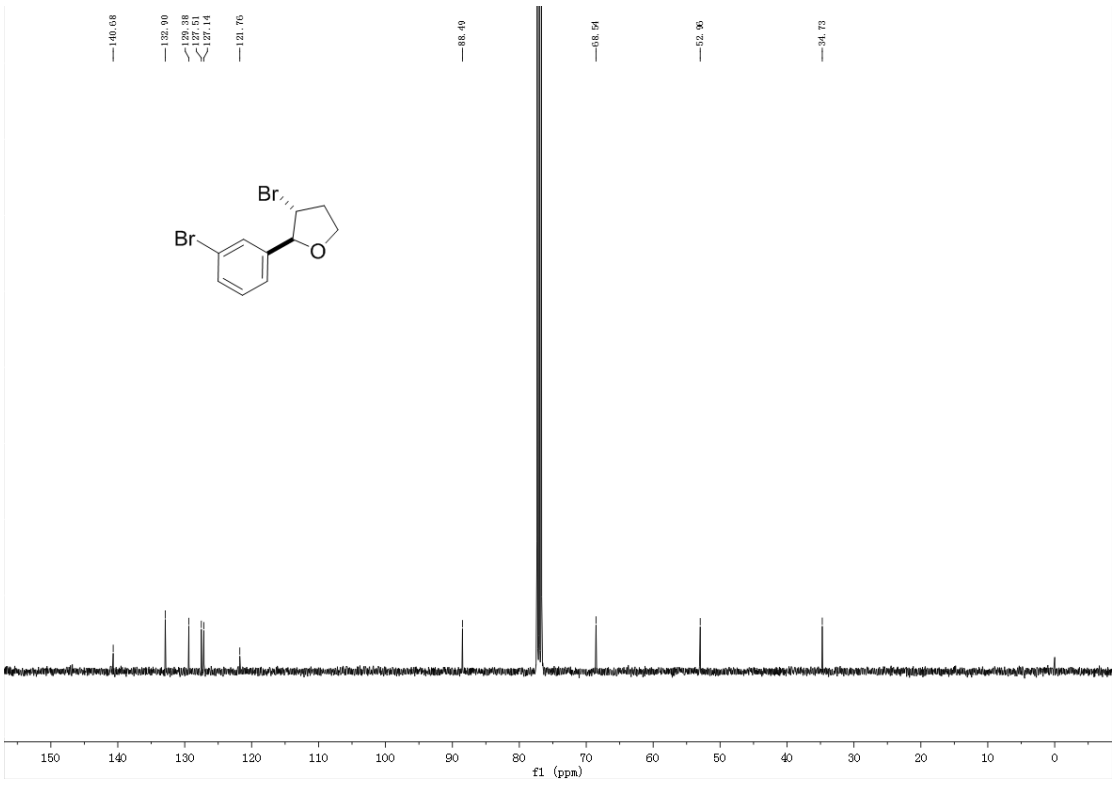
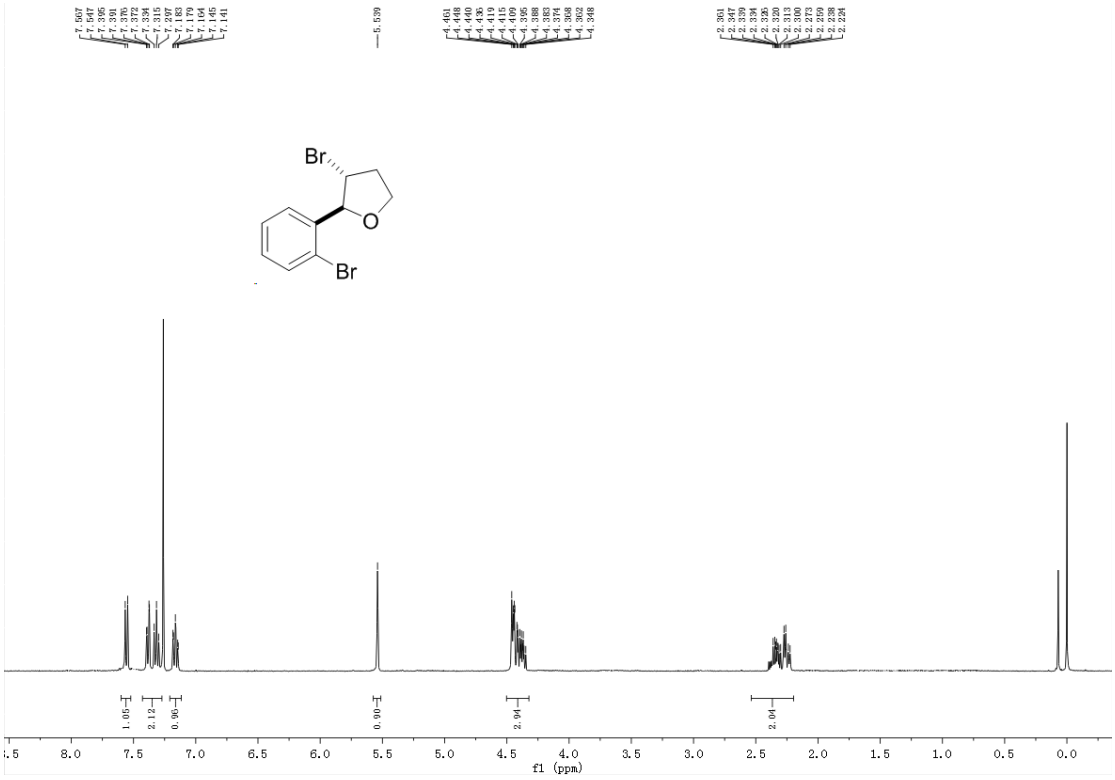
1.13
1.35
1.00
3.31
1.12
1.13
f1 (ppm)


140.68
132.90
129.38
127.51
127.14
121.76
88.49
68.94
52.96
34.73
Br
Br
O
f1 (ppm)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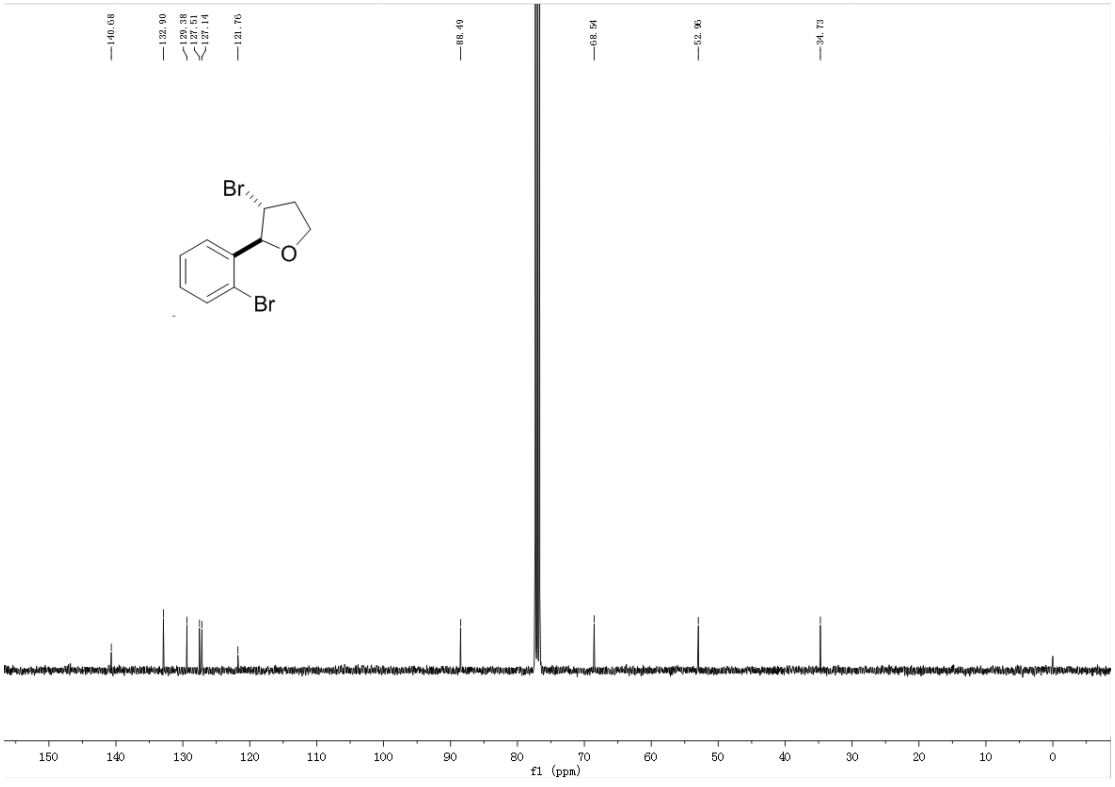
7.547
7.395
7.381
7.376
7.372
7.334
7.315
7.307
7.183
7.179
7.164
7.145
7.141
5.539
4.461
4.448
4.440
4.435
4.419
4.415
4.409
4.395
4.388
4.383
4.374
4.368
4.362
4.348
2.361
2.347
2.339
2.334
2.335
2.320
2.313
2.300
2.273
2.259
2.238
2.224
Br
O
Br
1.05
2.12
0.96
0.90
2.94
2.04
f1 (ppm)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129.38
127.51
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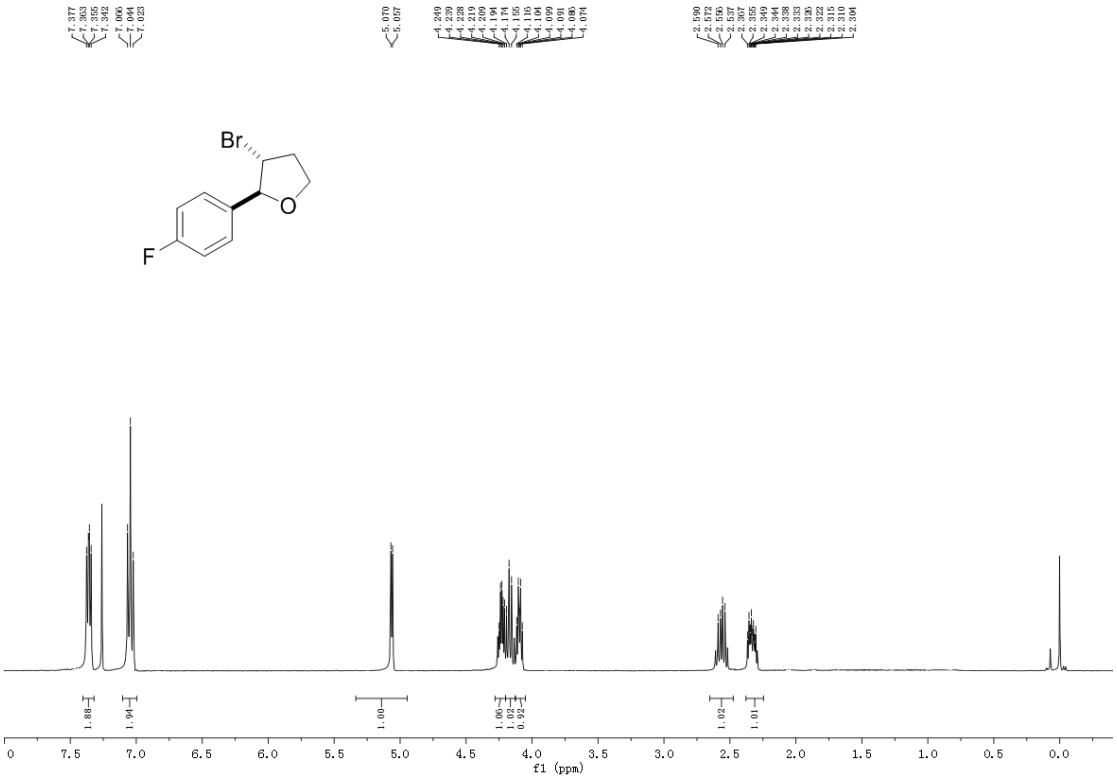
88.49
68.54
52.96
34.73
Br
O
Br
f1 (ppm)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7.066
7.044
7.025
5.070
5.057
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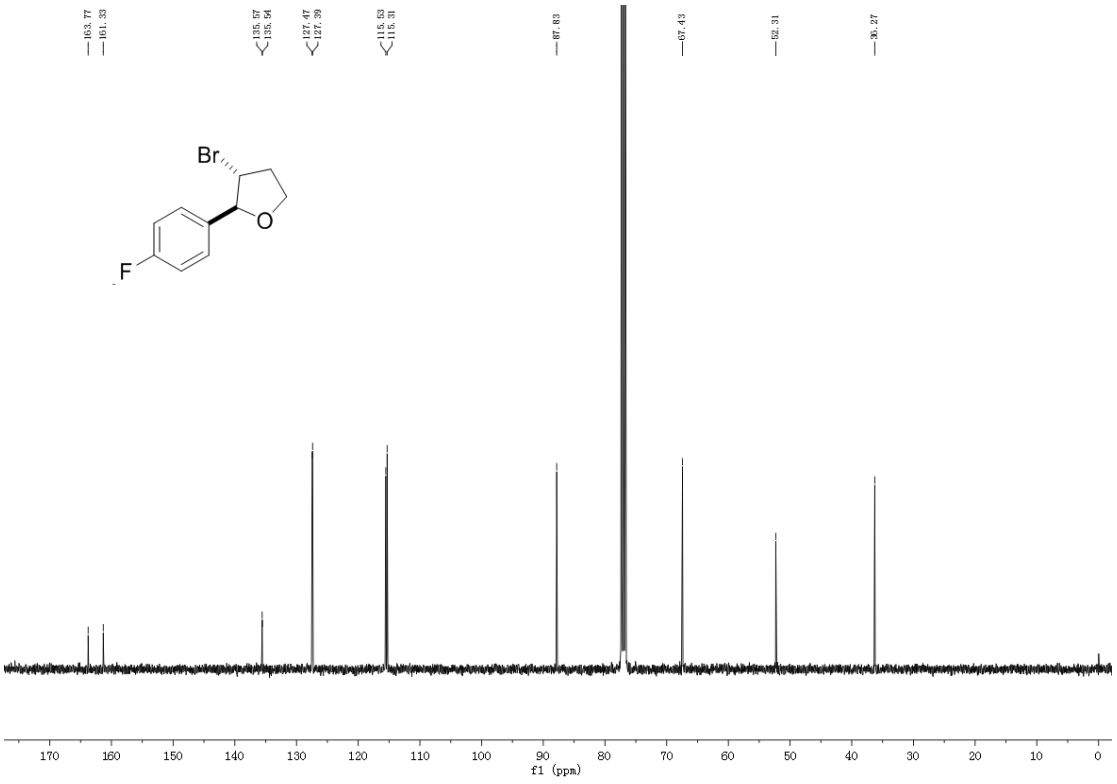
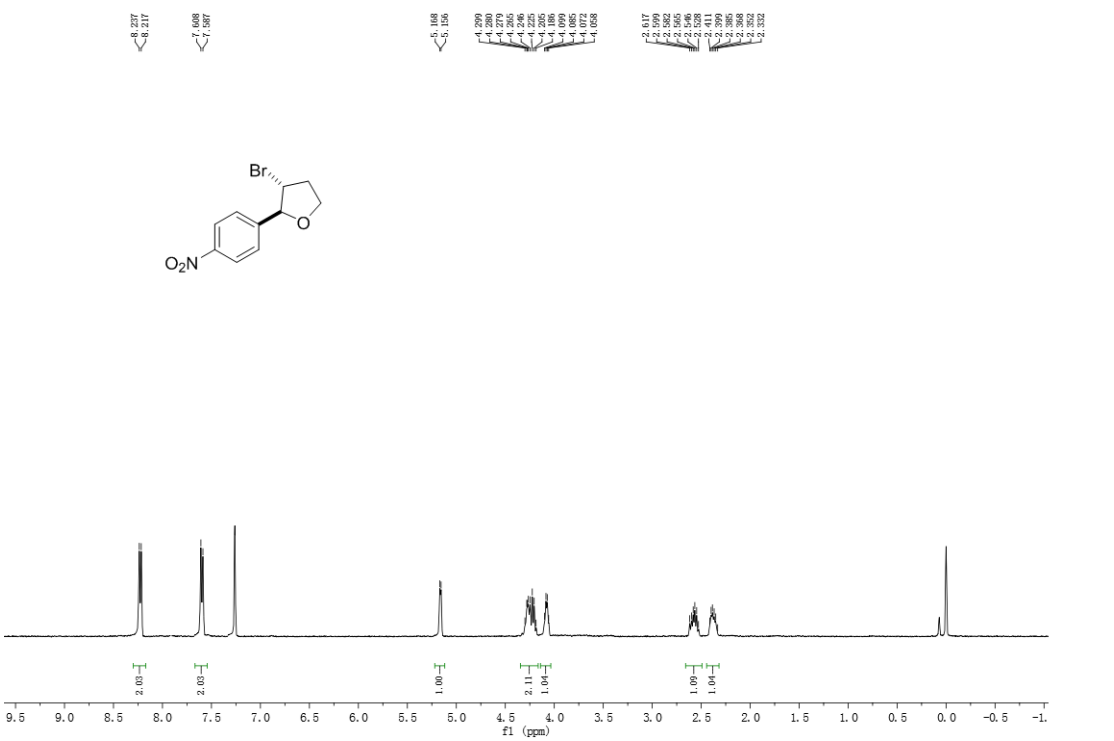
4.239
4.238
4.219
4.209
4.194
4.174
4.155
4.116
4.104
4.099
4.091
4.086
4.074
2.590
2.572
2.556
2.537
2.367
2.355
2.349
2.344
2.338
2.333
2.322
2.315
2.310
2.304
Br
O
F
1.88
1.94
1.00
1.06
1.02
0.92
1.02
1.01
f1 (ppm)


163.77
161.33
135.67
135.54
127.47
127.39
115.53
115.31
87.83
67.43
52.31
36.27
Br
O
F
f1 (ppm)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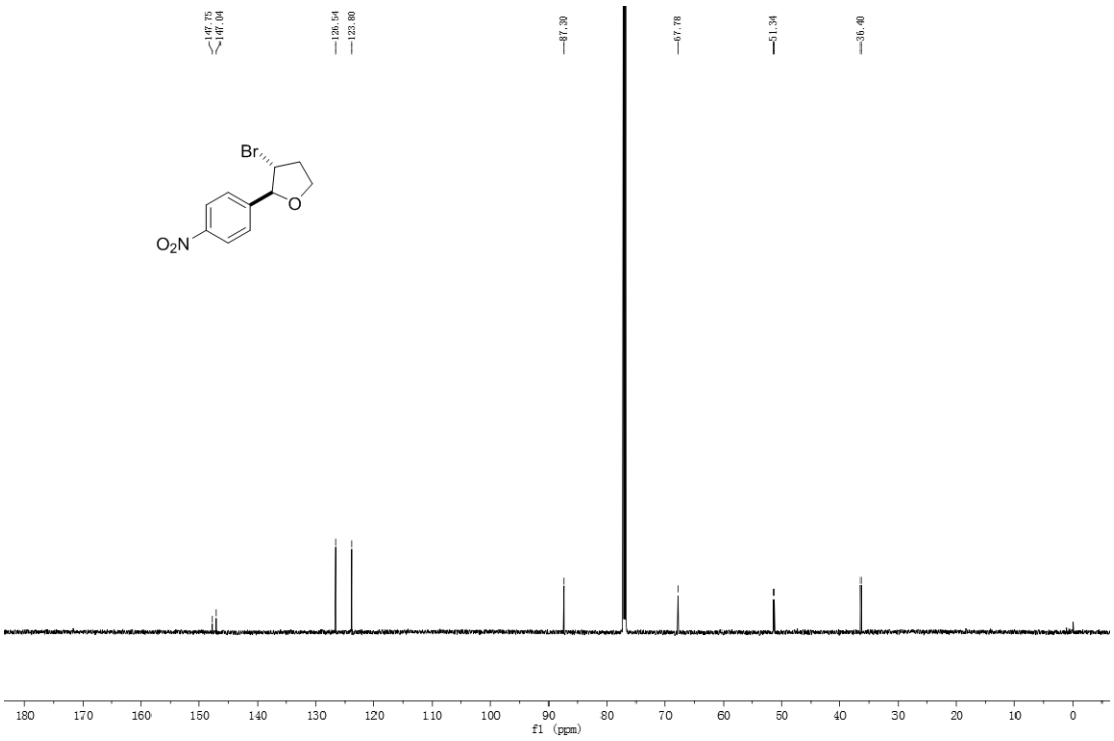
8.217
7.608
7.587
5.168
5.156
4.299
4.289
4.279
4.265
4.256
4.253
4.205
4.186
4.099
4.085
4.072
4.058
2.617
2.599
2.582
2.565
2.546
2.528
2.411
2.399
2.385
2.368
2.352
2.332
Br
O
O2N
2.03
2.03
1.00
2.11
1.04
1.09
1.04
f1 (ppm)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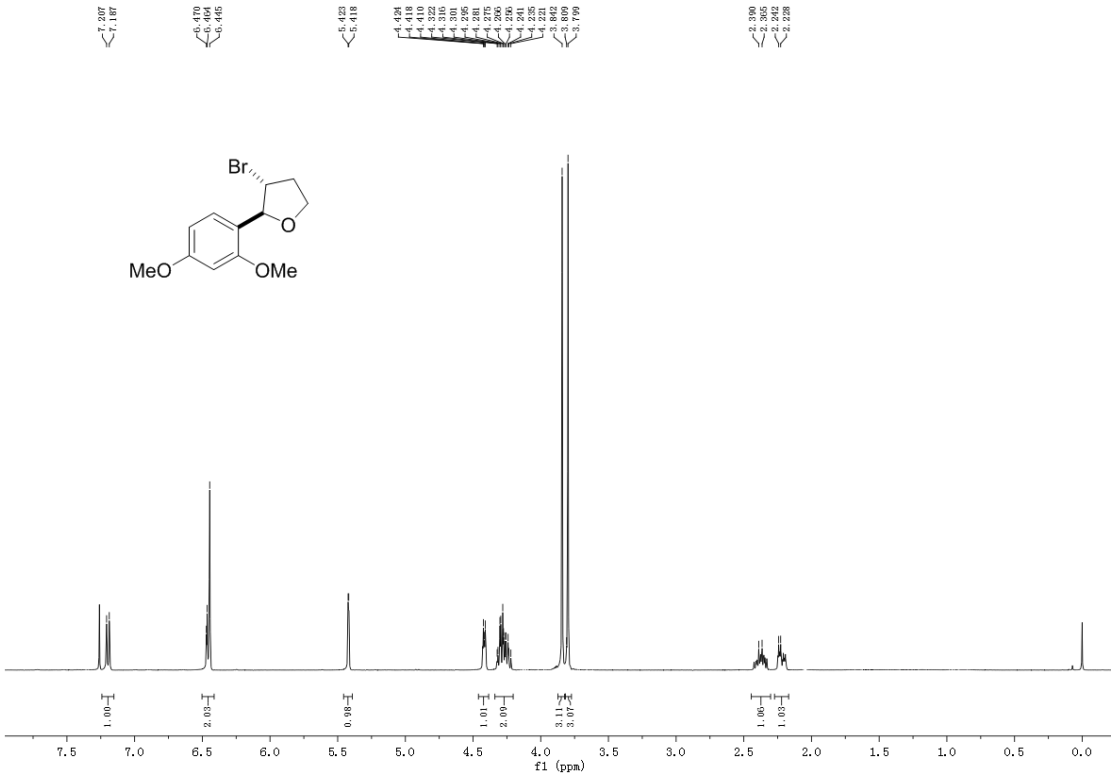
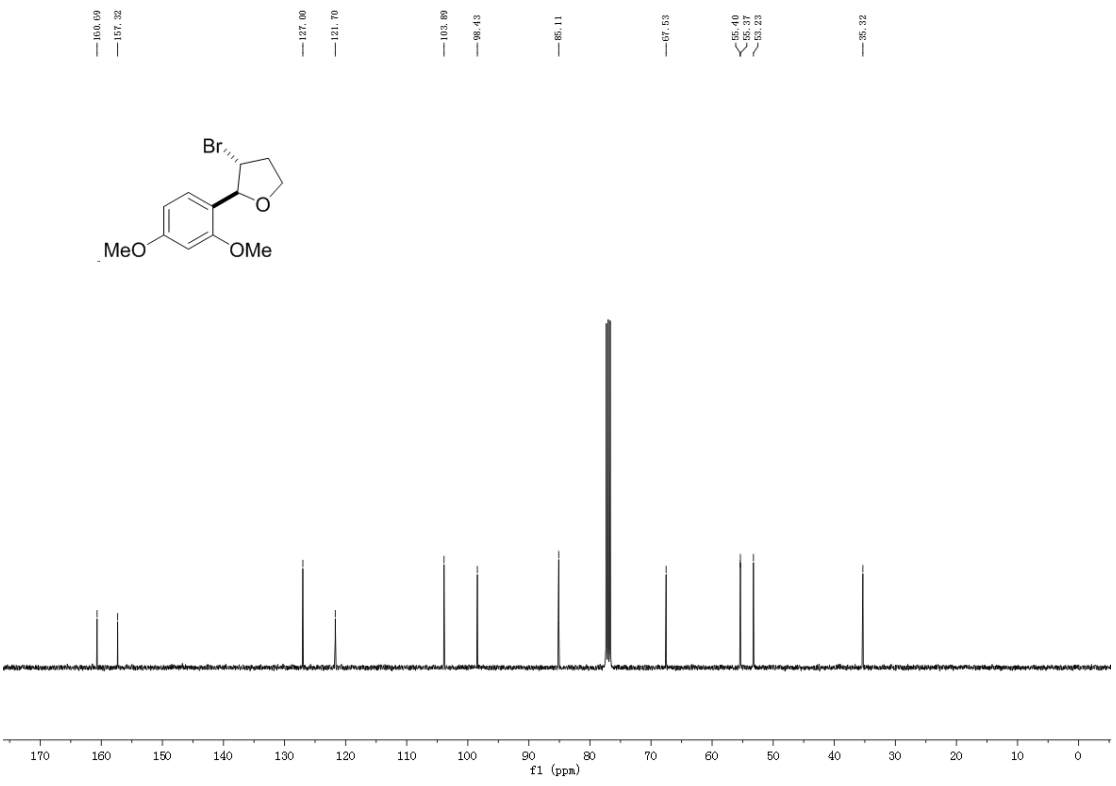
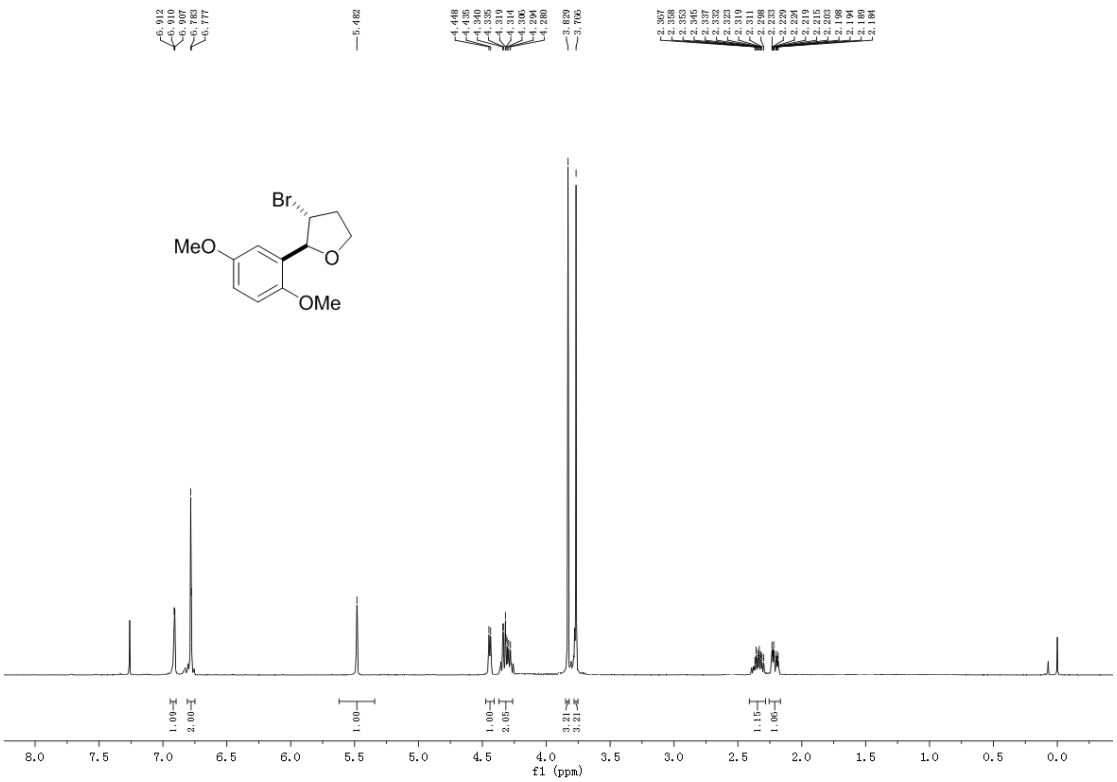
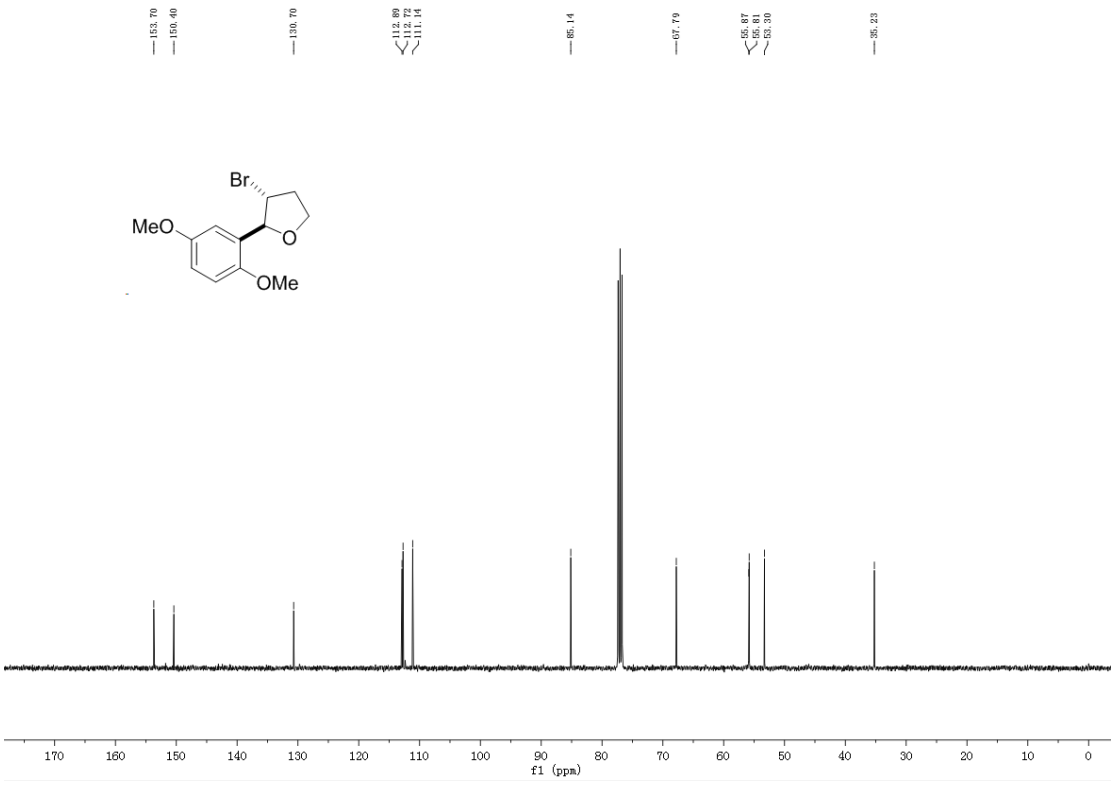
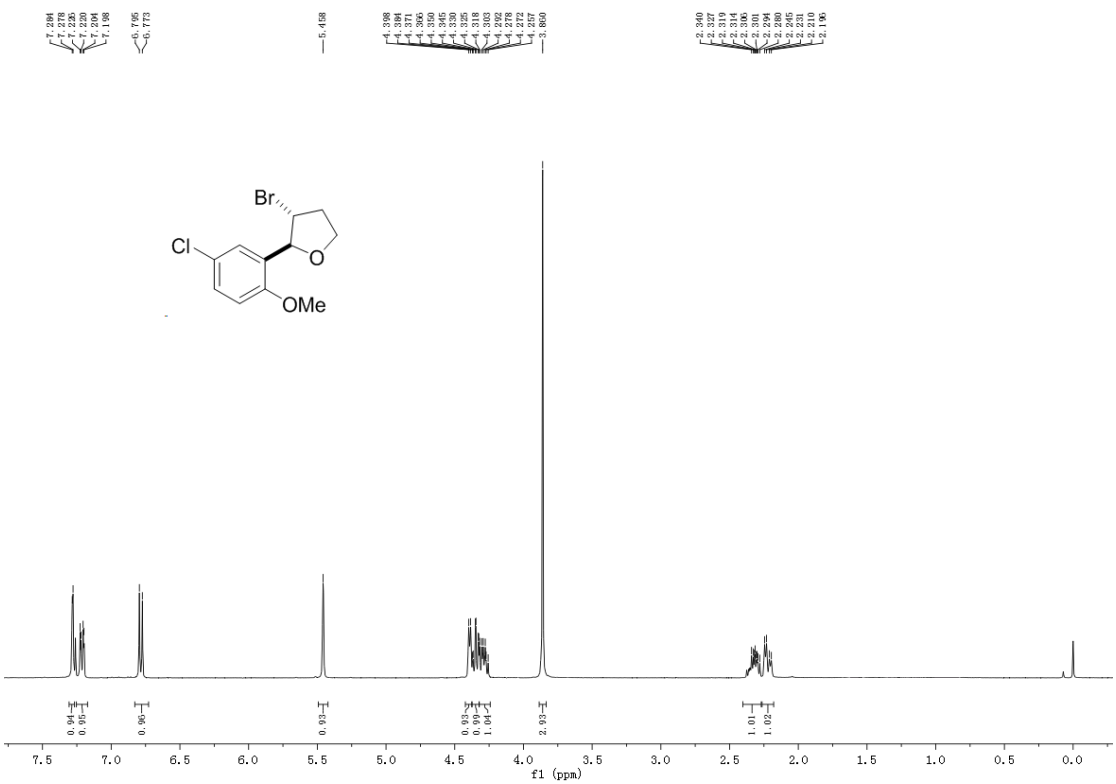
126.54
123.80
87.30
67.78
51.34
36.40
Br
O
O2N
f1 (ppm)

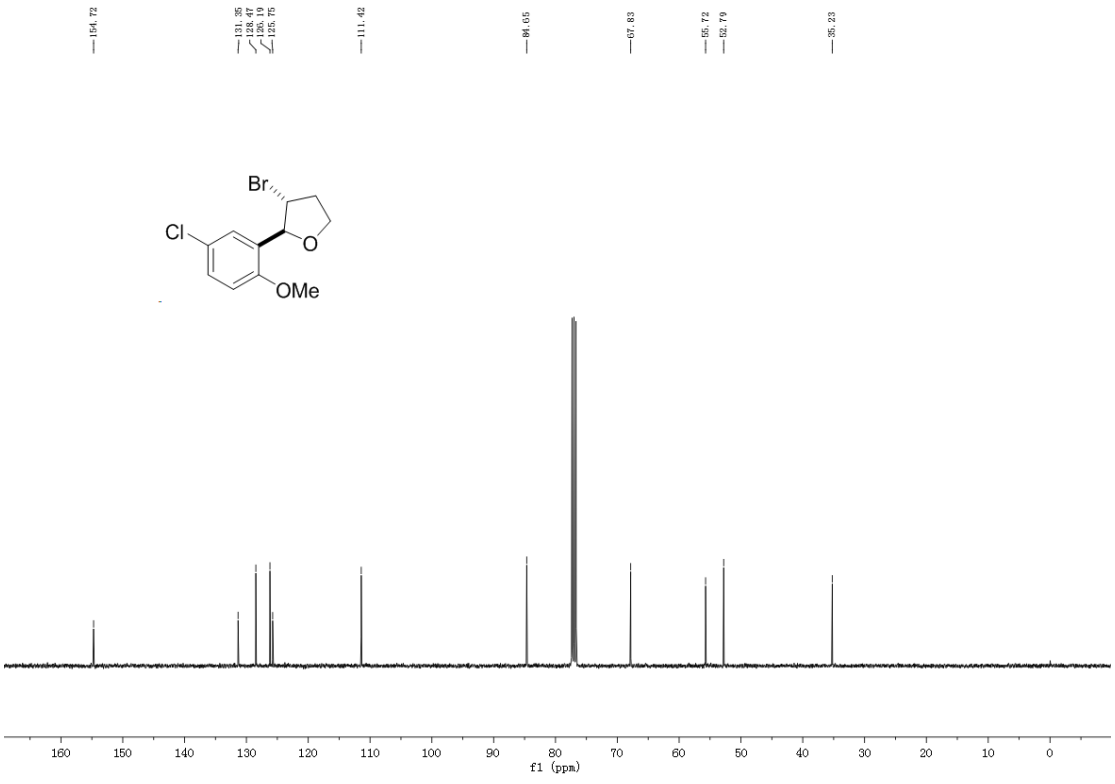

7.207
7.187
6.470
6.464
6.445
5.423
5.418
4.424
4.418
4.410
4.332
4.316
4.301
4.295
4.291
4.275
4.265
4.241
4.235
4.221
3.842
3.809
3.799
2.390
2.365
2.242
2.228
Br
O
MeO
OMe
1.00
2.03
0.98
1.01
2.09
3.11
3.07
1.06
1.03
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

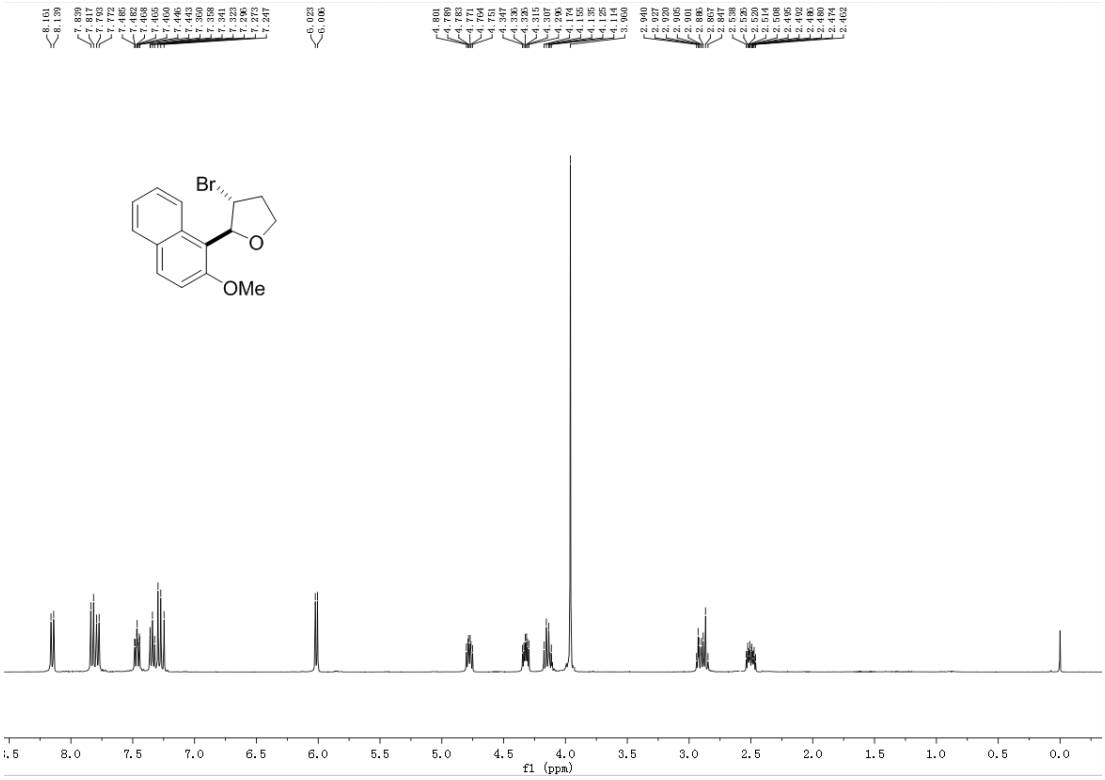

160.69
157.32
127.00
121.70
103.89
98.43
85.11
67.53
55.40
55.37
53.23
35.32
Br
O
MeO
OMe
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


6.912
6.910
6.907
6.783
6.777
5.482
4.448
4.445
4.340
4.335
4.319
4.314
4.306
4.294
4.280
3.829
3.766
2.367
2.358
2.353
2.345
2.337
2.332
2.323
2.319
2.311
2.298
2.293
2.229
2.224
2.219
2.215
2.205
2.198
2.194
2.189
2.184
Br
MeO
O
OMe
1.09
2.00
1.00
1.00
2.05
3.21
3.21
1.15
1.06
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


153.70
150.40
130.70
112.89
112.72
111.14
85.14
67.79
55.87
55.81
53.30
35.23
Br
MeO
O
OMe
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Br
Cl
O
OMe
f1 (ppm)


Br
Cl
O
OMe
f1 (ppm)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7.839
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7.795
7.772
7.485
7.482
7.468
7.465
7.460
7.446
7.443
7.390
7.358
7.341
7.323
7.296
7.273
7.247
6.023
6.005
4.801
4.789
4.783
4.771
4.764
4.751
4.347
4.336
4.315
4.307
4.296
4.174
4.155
4.135
4.125
4.114
3.960
2.940
2.927
2.920
2.905
2.891
2.886
2.867
2.847
2.538
2.535
2.530
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2.508
2.495
2.485
2.480
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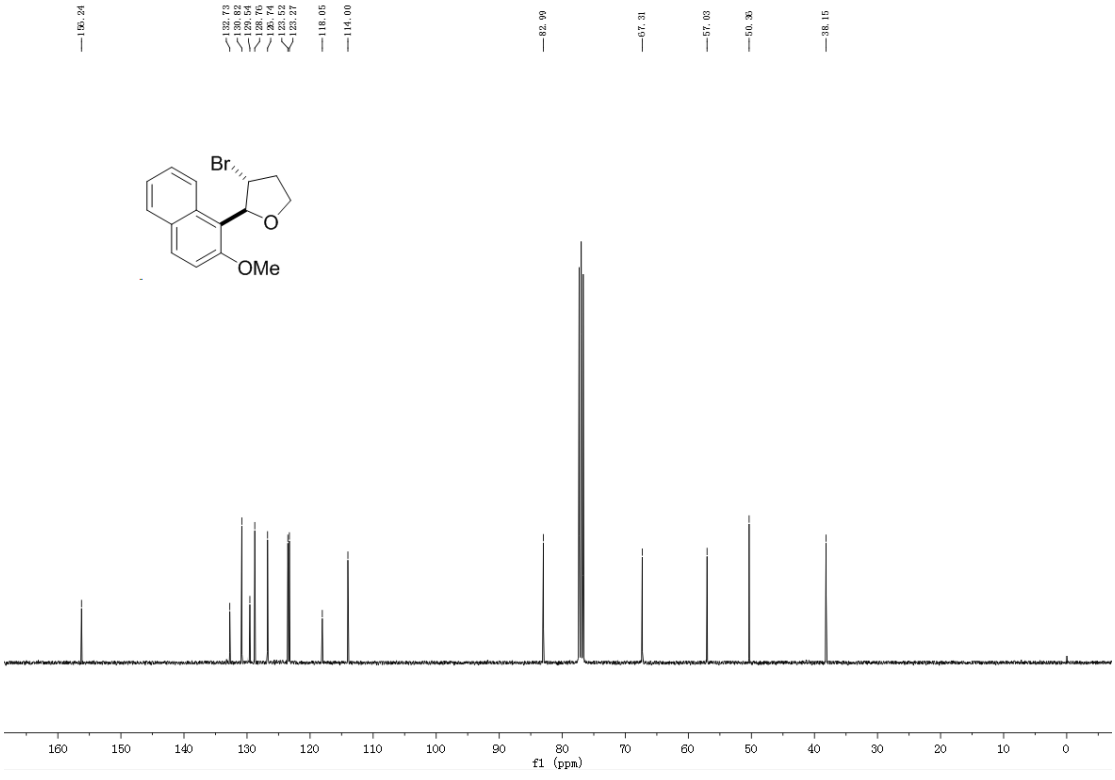
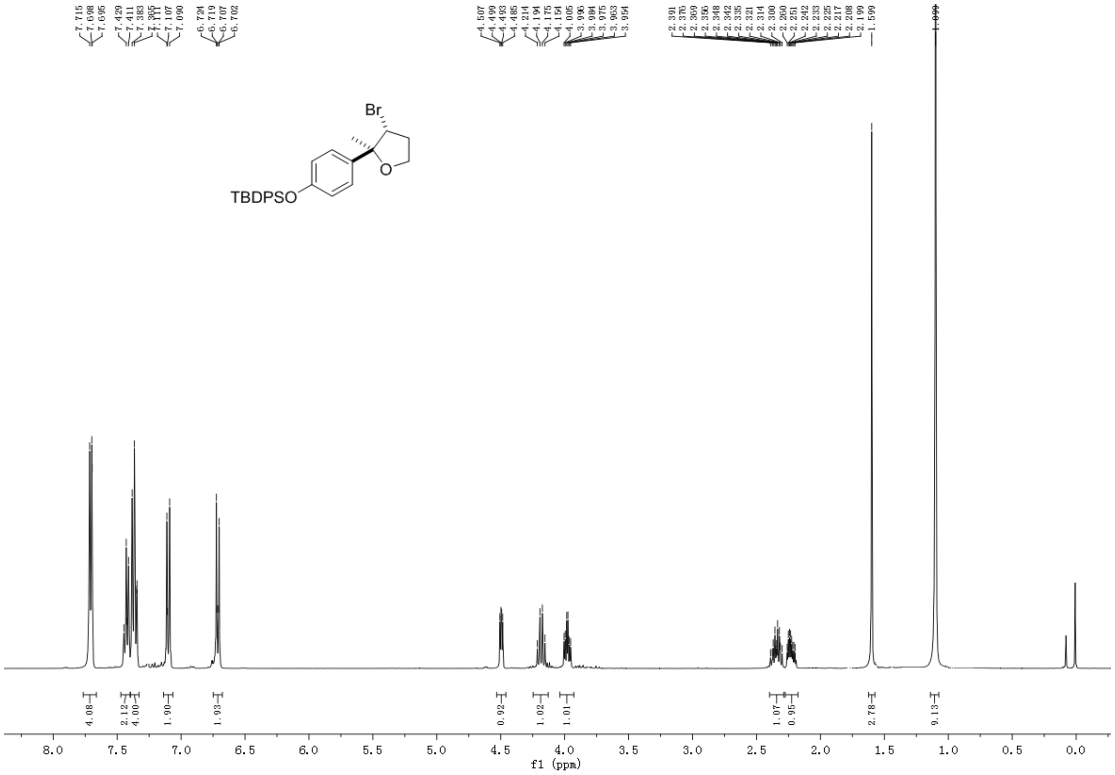
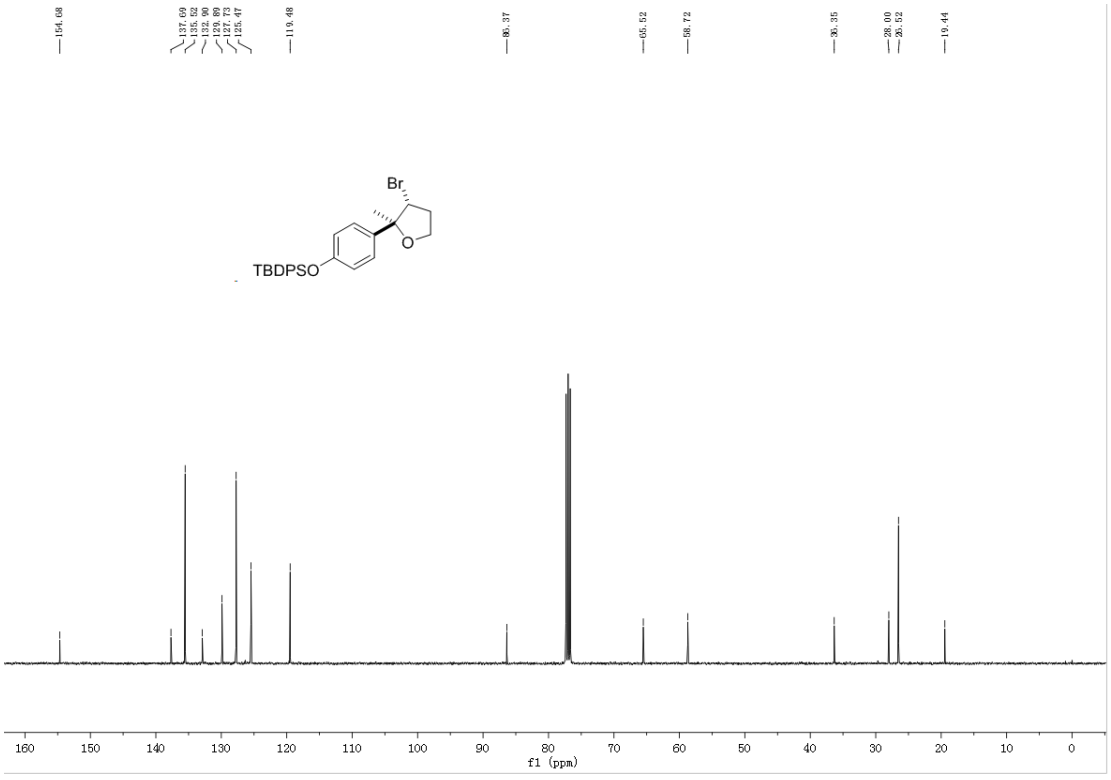
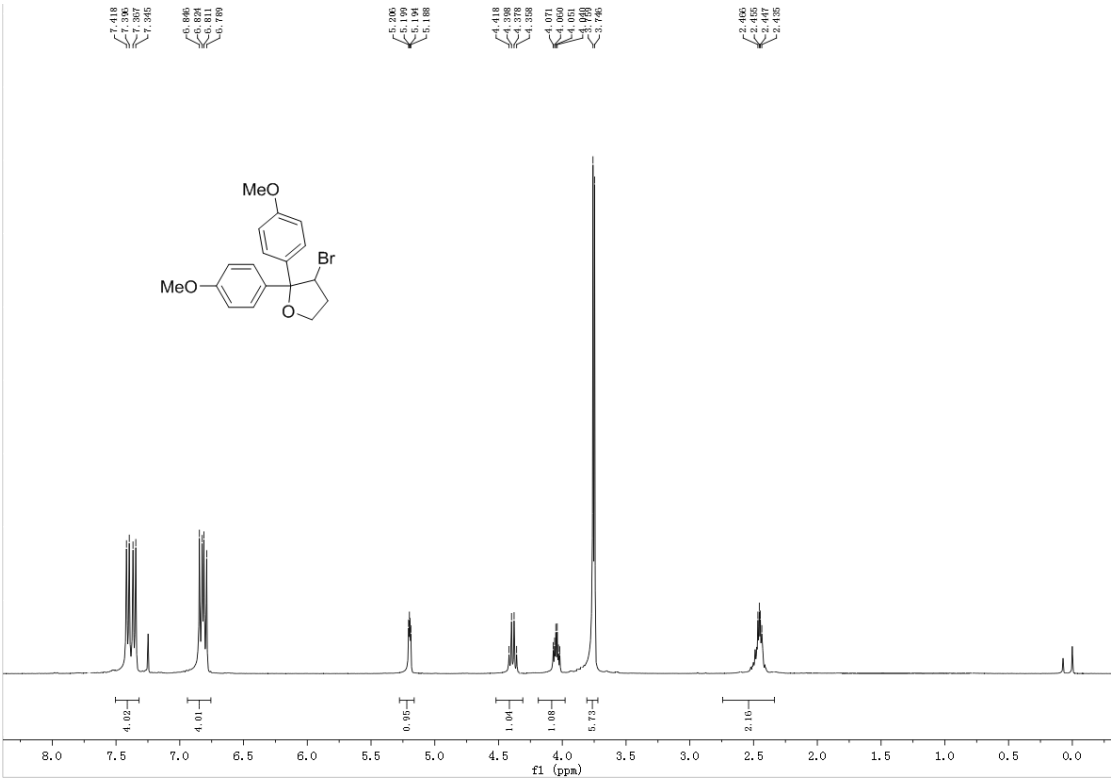
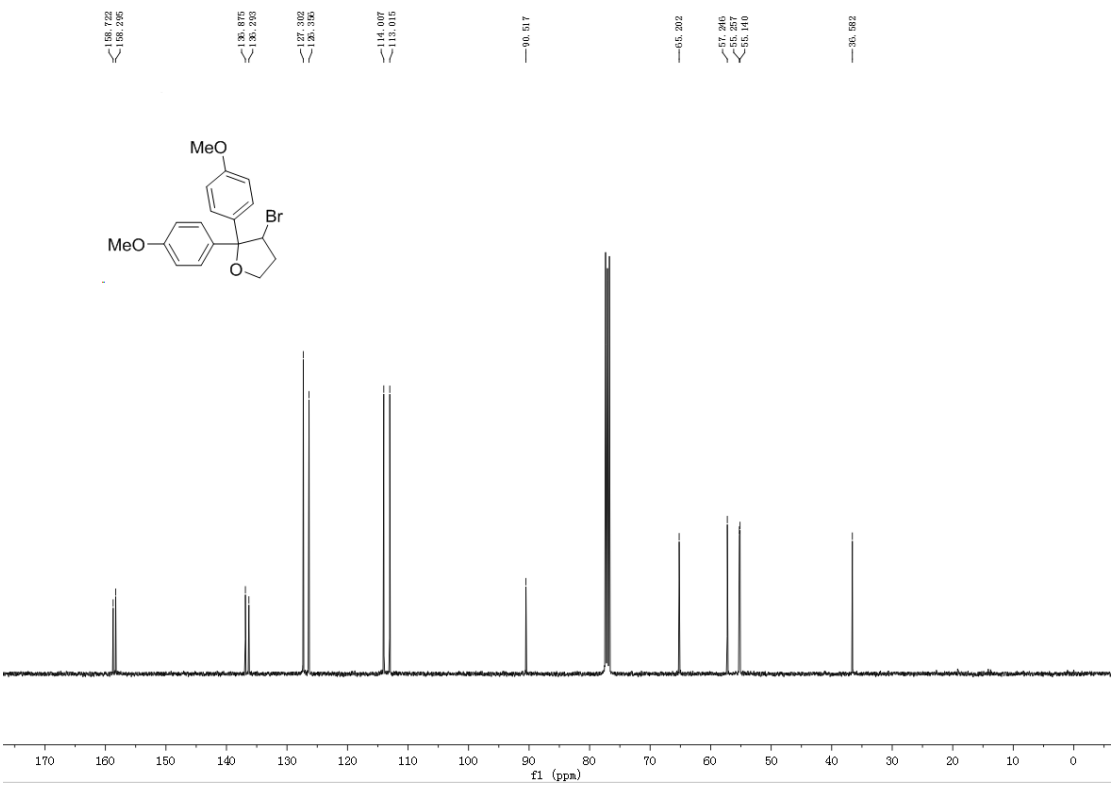
2.462
Br
O
OMe
f1 (ppm)

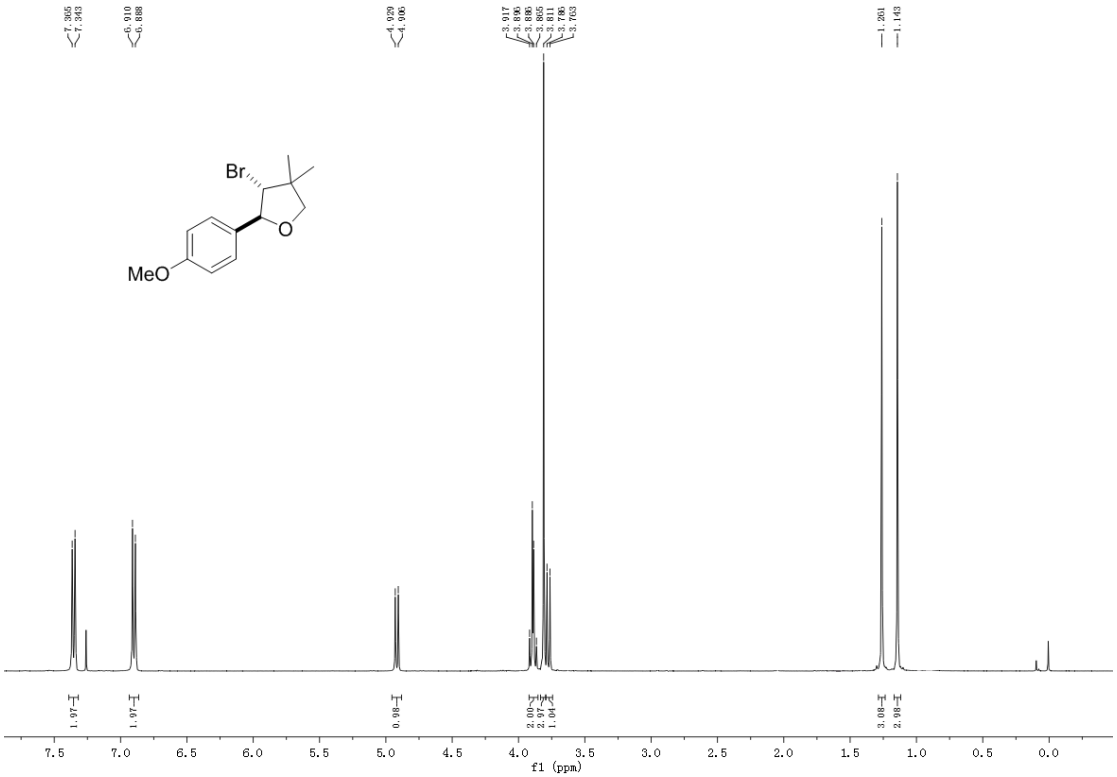

166.24
132.73
130.82
129.54
128.76
125.74
123.52
121.27
118.05
114.00
82.99
67.31
57.03
50.35
38.15
Br
O
OMe
f1 (ppm)


Br
O
TBDPSO
f1 (ppm)


Br
O
TBDPSO
f1 (ppm)


MeO
Br
MeO
O
f1 (ppm)


MeO
Br
MeO
O
f1 (ppm)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3.865
3.811
3.795
3.763
1.201
1.143
Br
O
MeO
1.97
1.97
0.98
2.00
2.97
1.04
3.08
2.98
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
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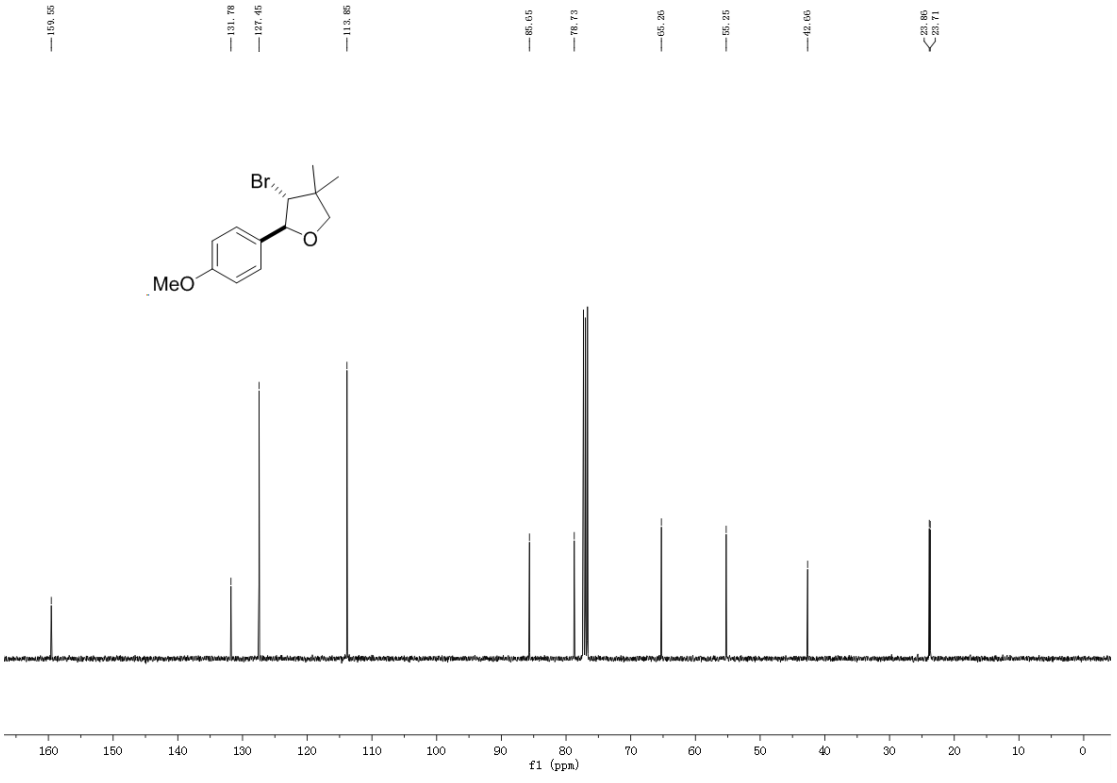
0.0
f1 (ppm)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85.65
78.73
65.26
55.25
42.66
23.86
23.71
Br
O
MeO
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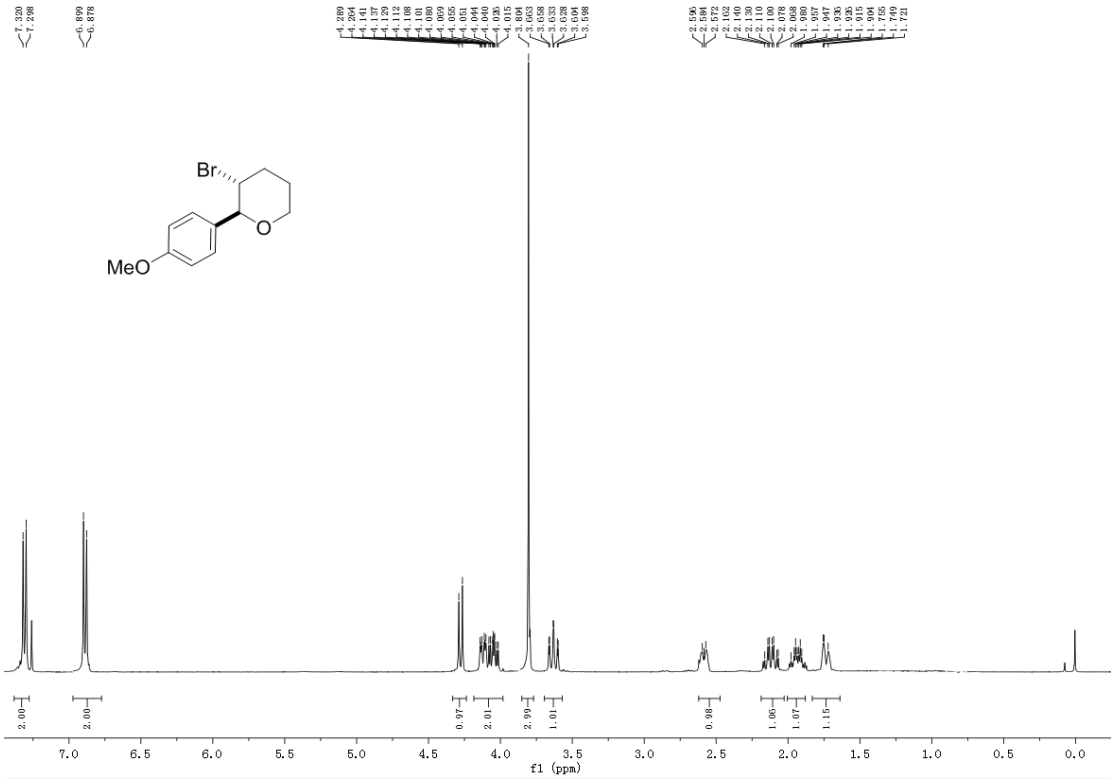
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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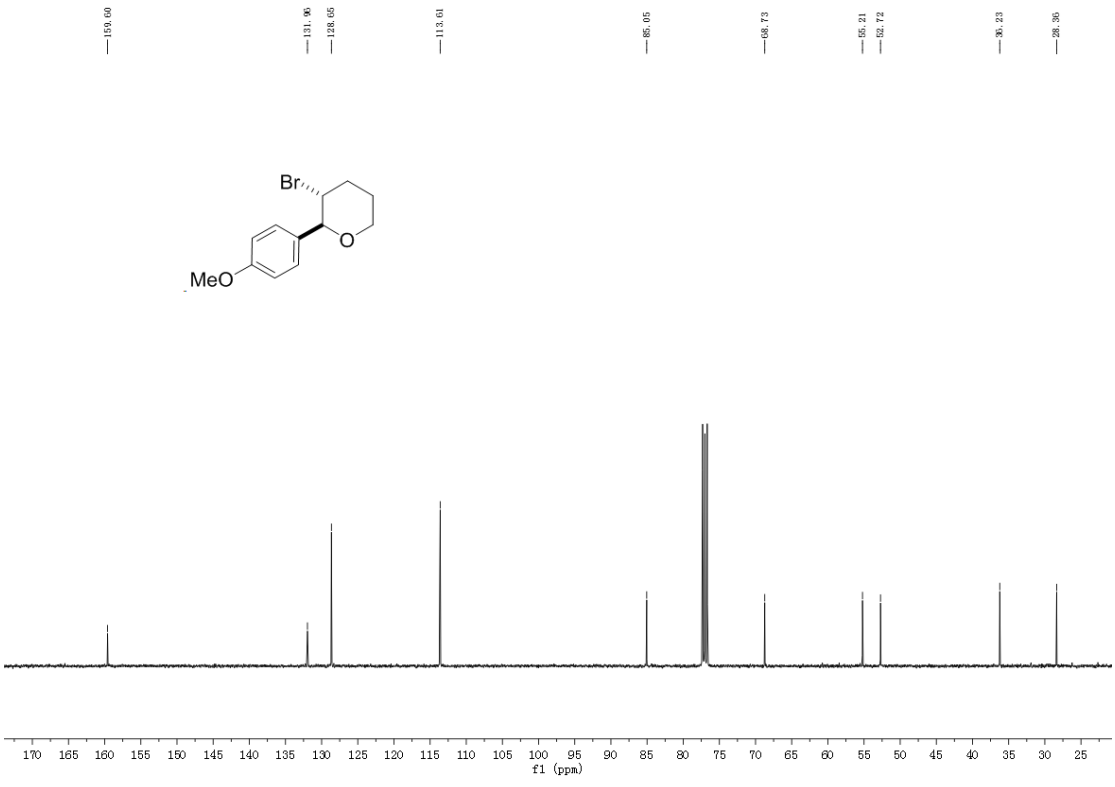
O
MeO
f1 (ppm)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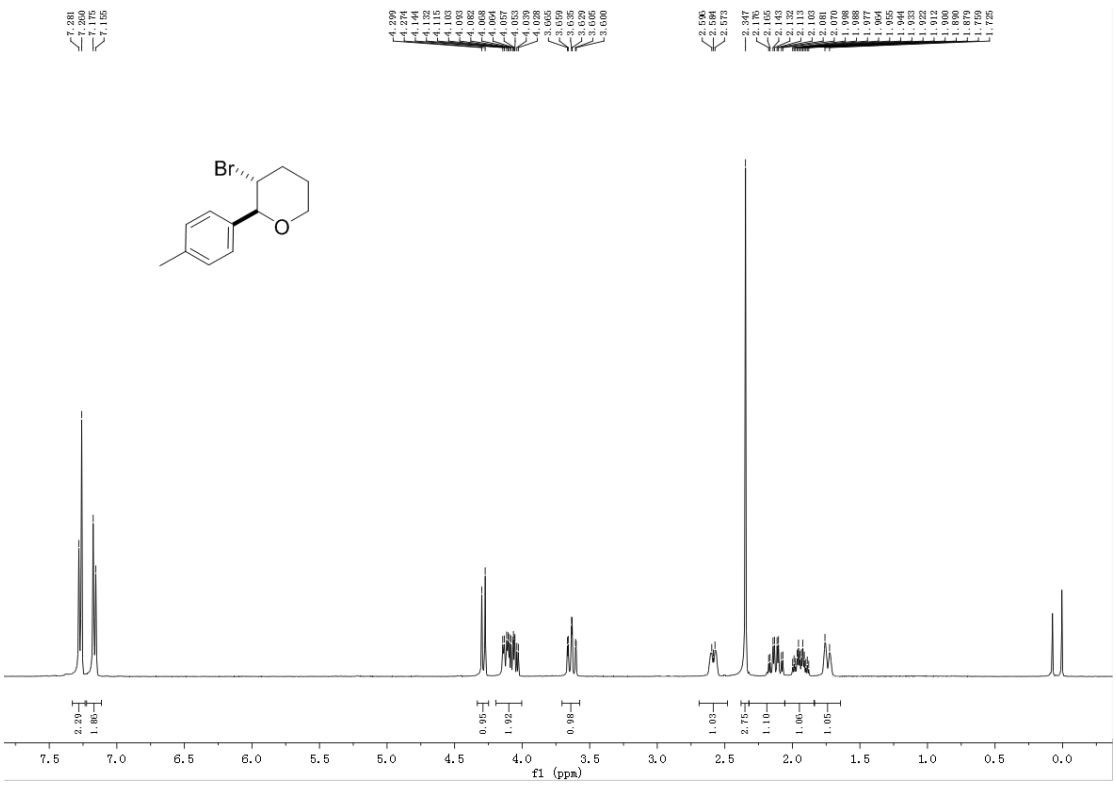
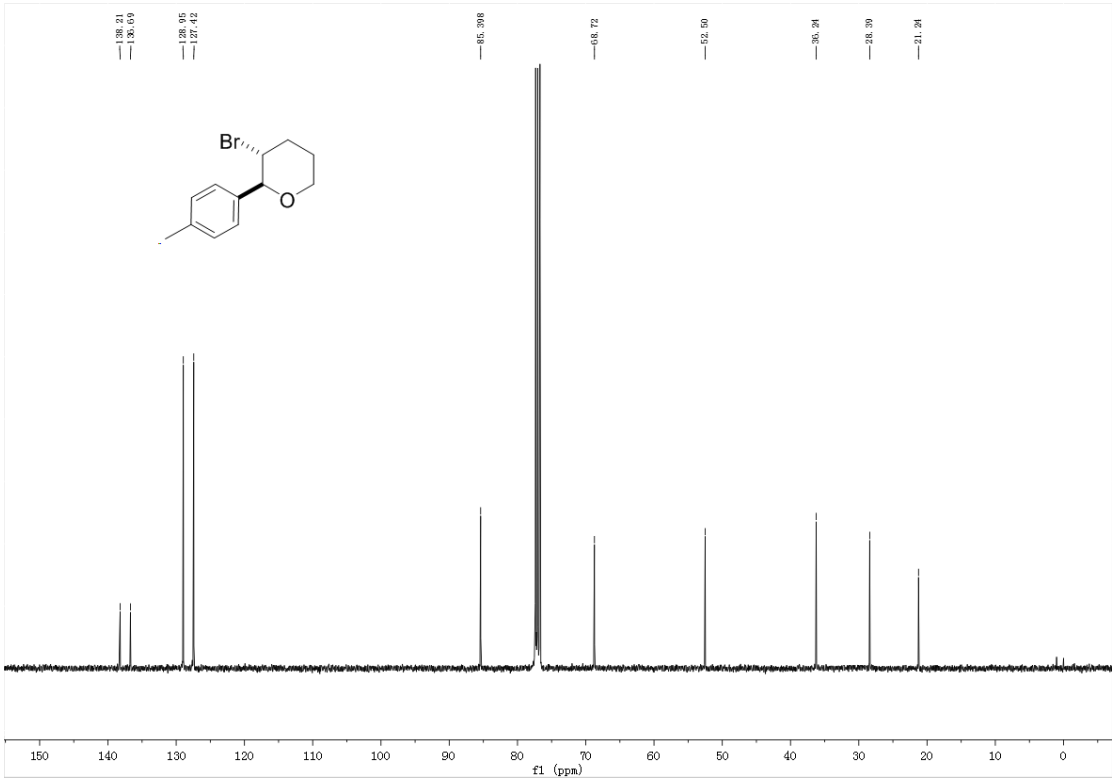
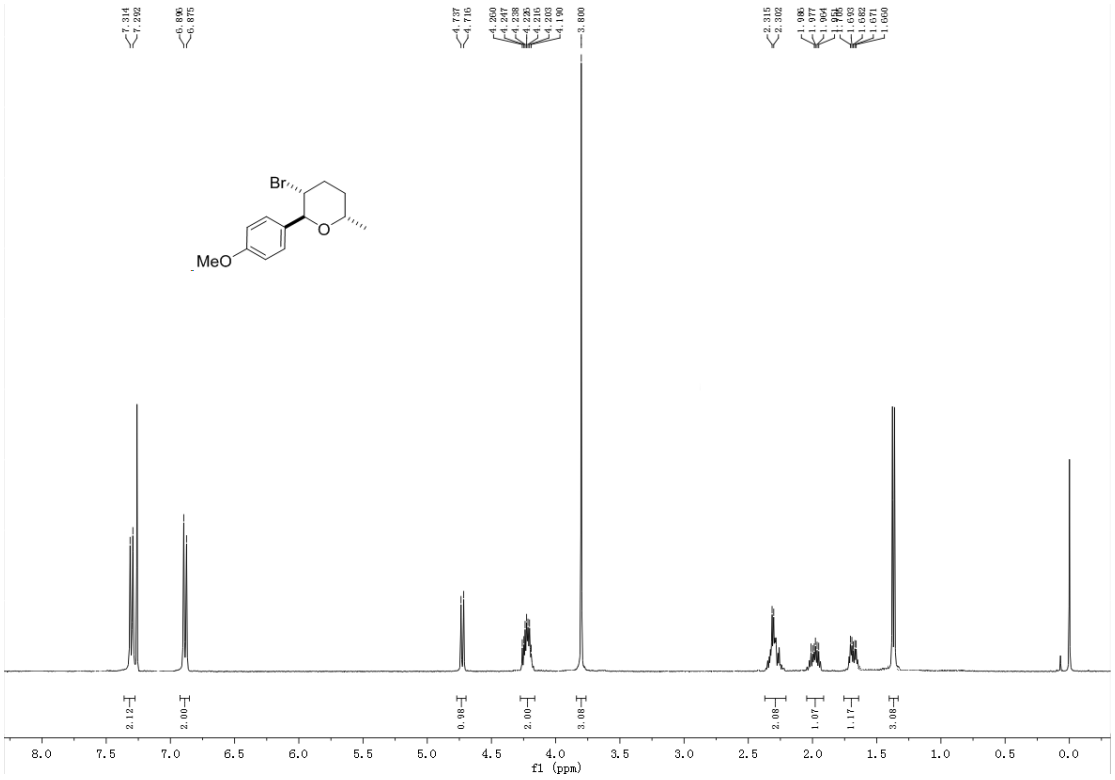
MeO
f1 (ppm)


Br
O
f1 (ppm)


Br
O
f1 (ppm)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4.716
4.290
4.267
4.238
4.225
4.215
4.203
4.199
3.800
2.315
2.302
1.996
1.977
1.964
1.693
1.682
1.671
1.660
Br
O
MeO
2.12
2.00
0.98
2.00
3.08
2.08
1.07
1.17
3.08
8.0
7.5
7.0
6.5
6.0
5.5
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4.5
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3.5
3.0
2.5
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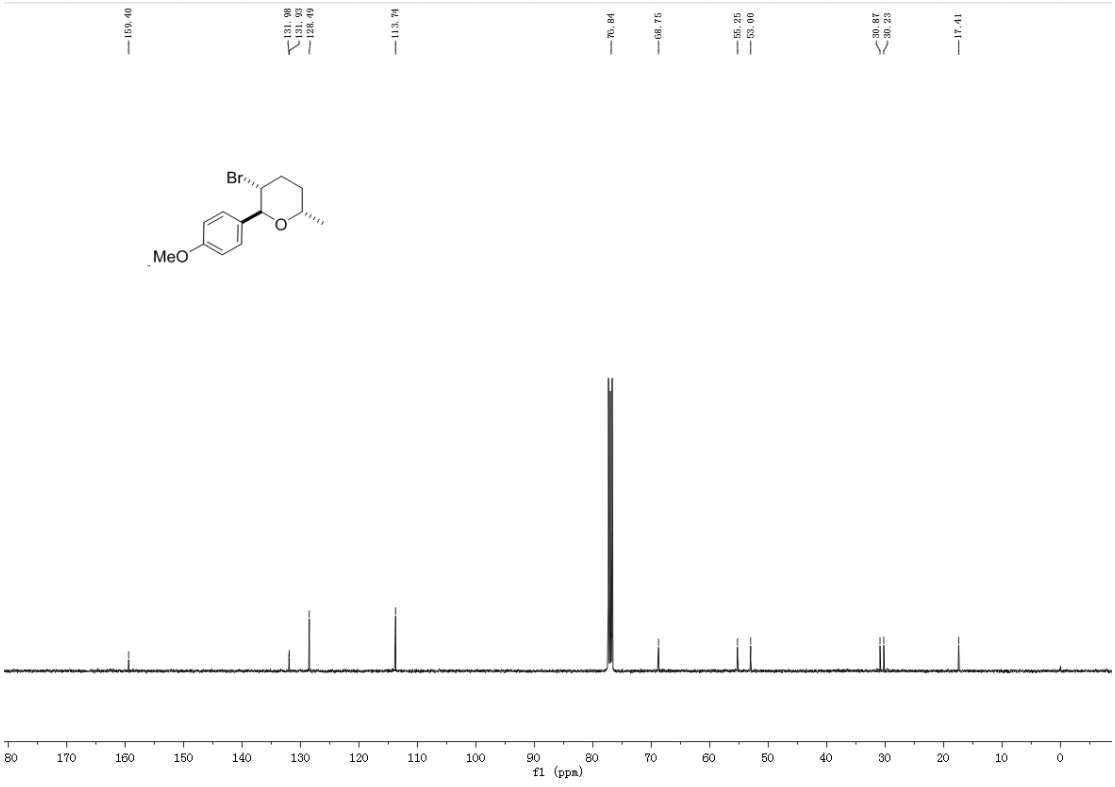
1.0
0.5
0.0
f1 (ppm)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30.23
17.41
Br
O
MeO
80
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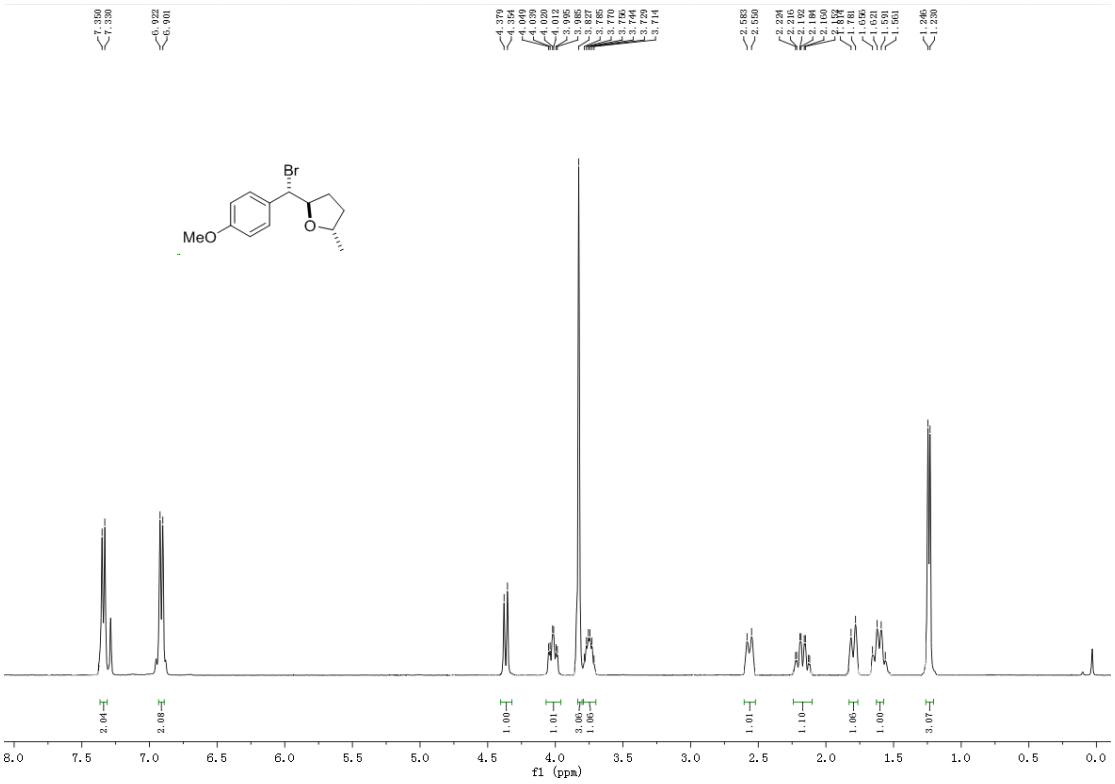
50
40
30
20
10
0
f1 (ppm)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7.330
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6.901
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4.049
4.030
4.012
3.995
3.985
3.957
3.785
3.770
3.766
3.744
3.729
3.714
2.583
2.550
2.224
2.215
2.192
2.184
2.160
1.878
1.858
1.781
1.656
1.621
1.601
1.564
1.246
1.230
Br
MeO
O
2.04
2.08
1.00
1.01
3.06
1.00
1.01
1.10
1.00
1.00
3.07
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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3.5
3.0
2.5
2.0
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1.0
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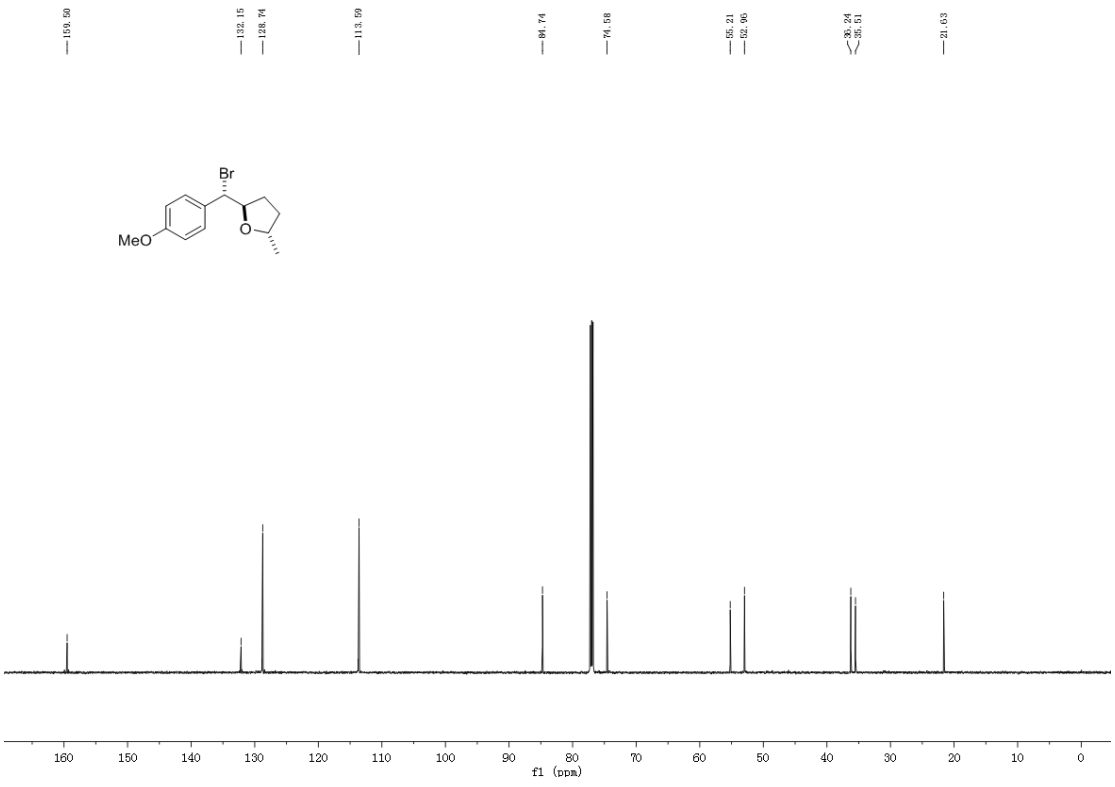
0.0
f1 (ppm)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132.15
128.74
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80.74
74.68
55.21
52.96
36.24
35.51
21.63
Br
MeO
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10
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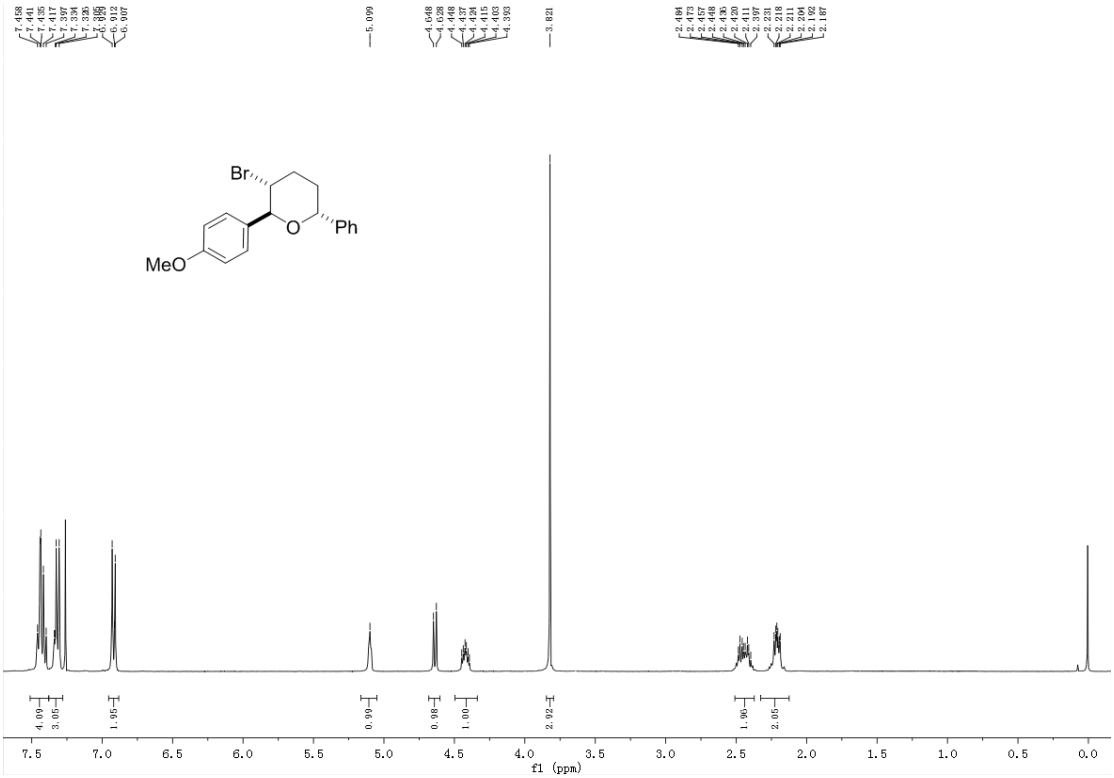
f1 (ppm)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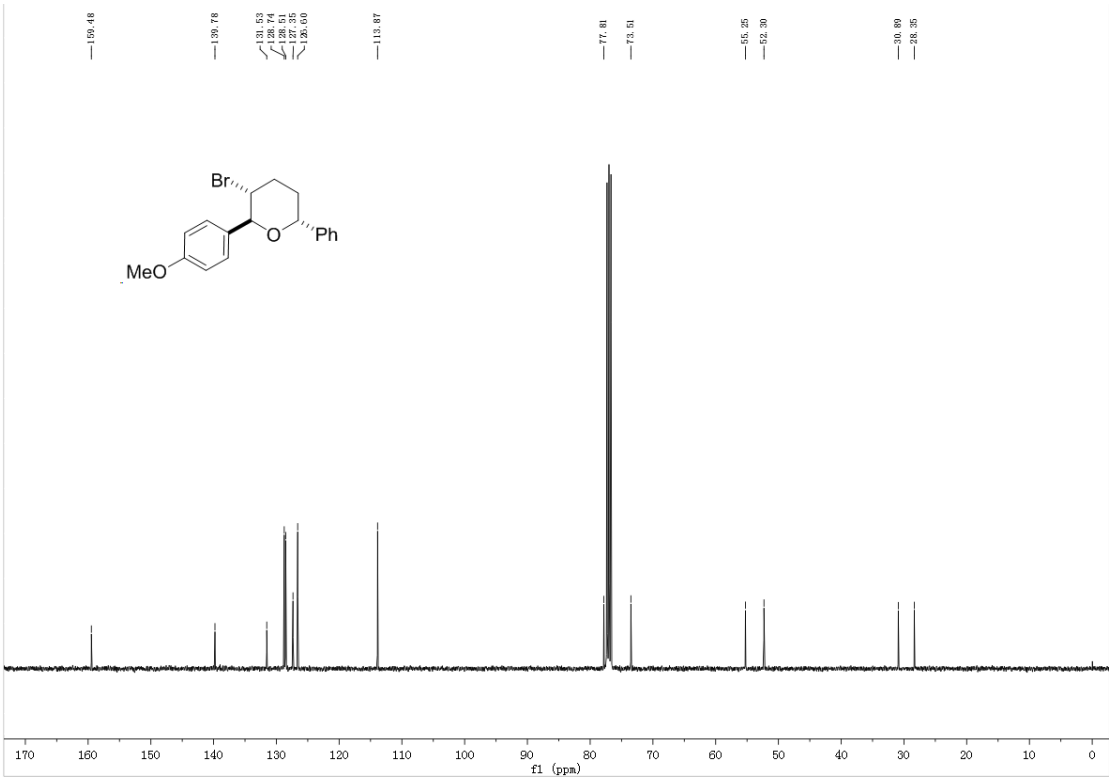
O
Ph
MeO
f1 (ppm)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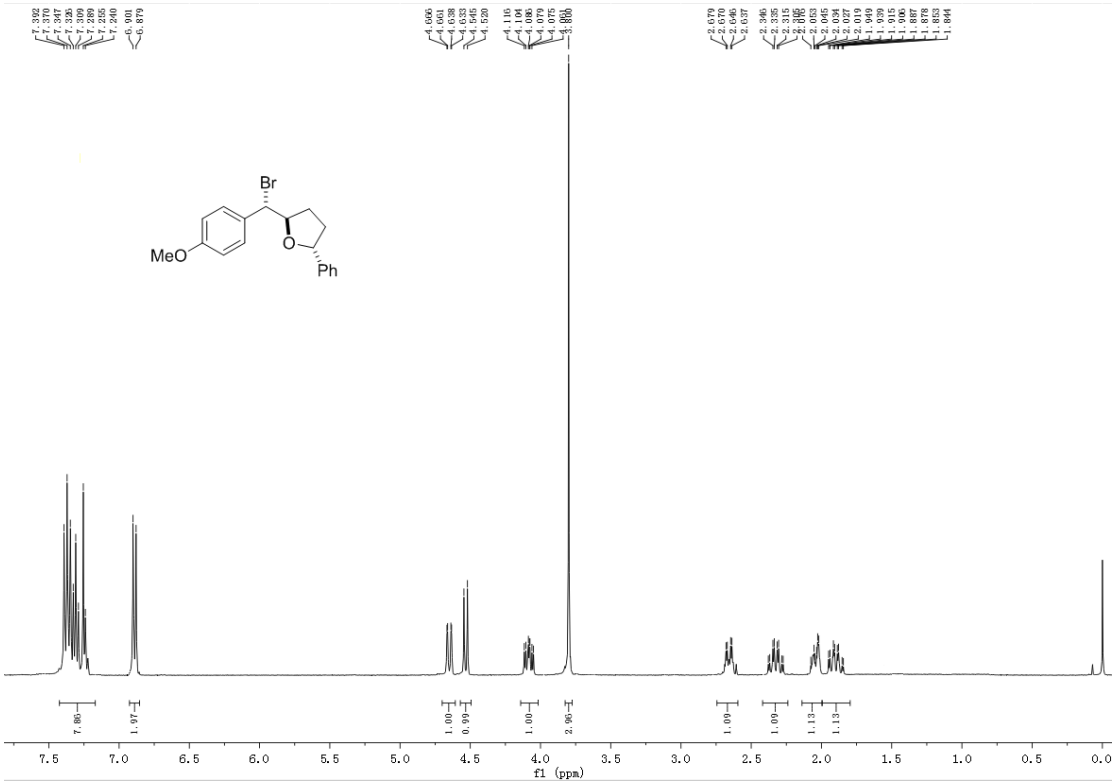
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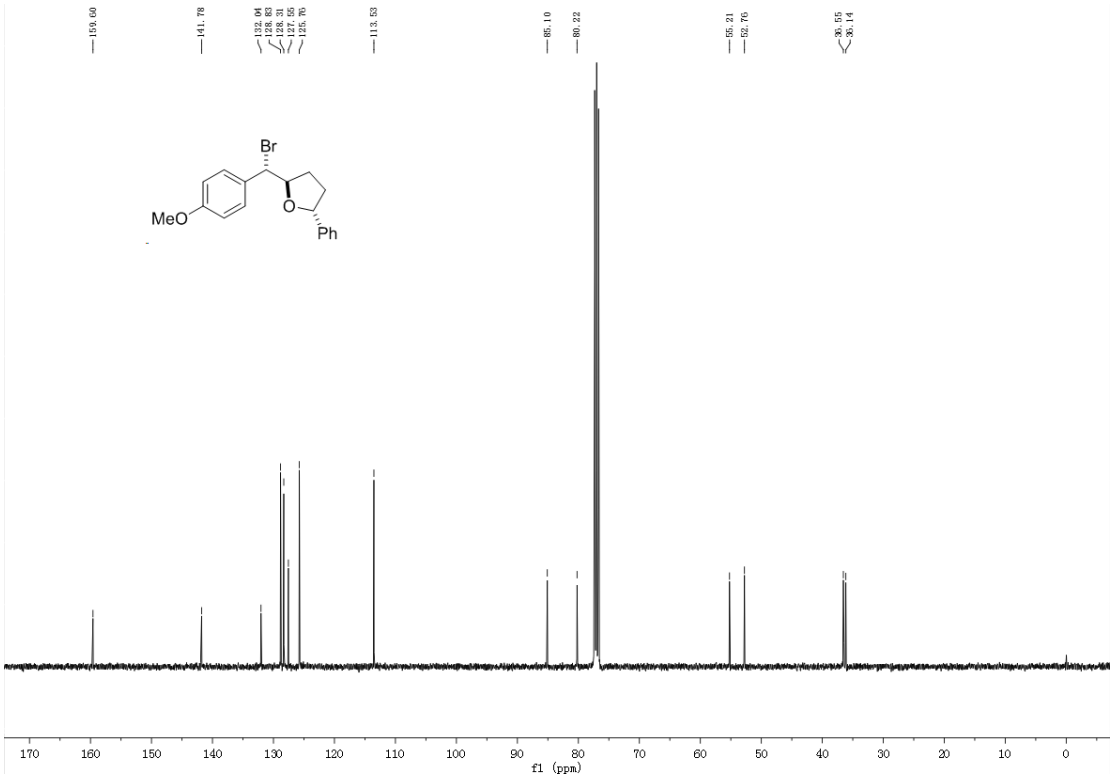
Br
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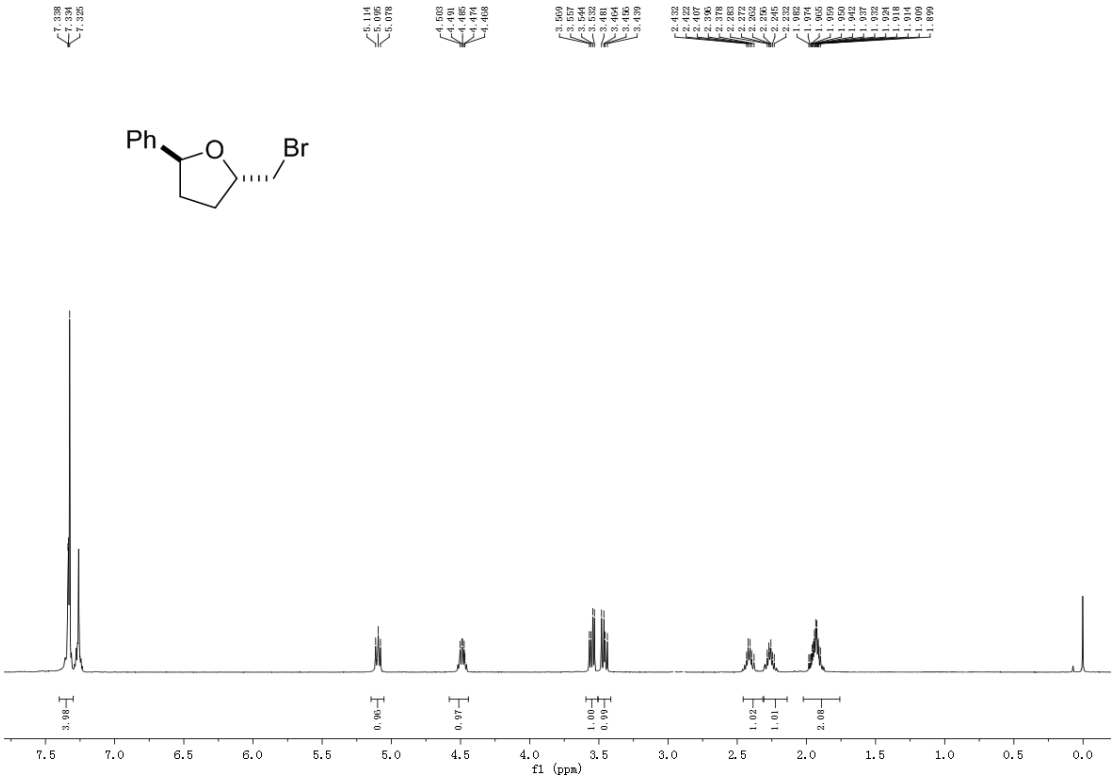
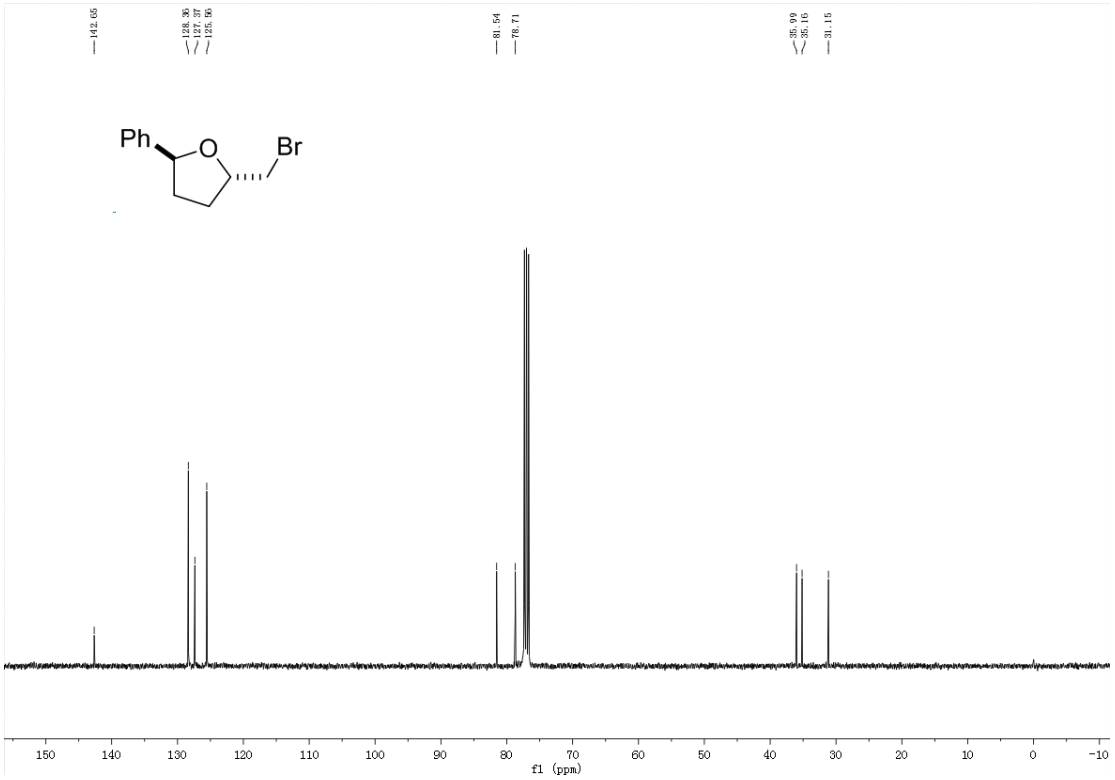
O
Ph
f1 (ppm)


Ph
O
Br
f1 (ppm)


Ph
O
Br
f1 (ppm)