Supporting Information

Concise Synthesis of Ketoallyl Sulfones through an Iron-Catalyzed Sequential Four-Component Assembly

Fuhong Xiao*, Chao Liu, Dahan Wang, Huawen Huang, Guo-Jun Deng*

[a] Key Laboratory of Environmentally Friendly Chemistry and Application of Ministry of Education, College of Chemistry, Xiangtan University, Xiangtan 411105, China. Fax: (+86)0731-58292251; Tel: (+86)0731-58298280; E-mail: fhxiao@xtu.edu.cn; gjdeng@xtu.edu.cn

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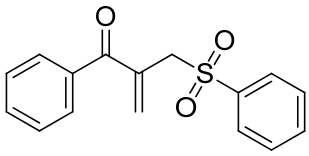
General information

All reactions were carried out under an atmosphere of air. Column chromatography was performed using silica gel 48-75 μm. ^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker-AV (400 and 100 MHz, respectively) instrument internally referenced to tetramethylsilane (TMS) or chloroform signals. Mass spectra were measured on Agilent 5975 GC-MS instrument (EI). High-resolution mass spectra were recorded at the Institute of Chemistry, Chinese Academy of Sciences. The structures of known compounds were further corroborated by comparing their ^{1}H NMR, ^{13}C NMR data and MS data with those of literature. Most reagents were obtained from commercial suppliers and used without further purification.

General procedure (3aa)

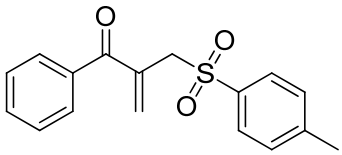
A 10 mL oven-dried reaction vessel was charged with $K_2S_2O_8$ (189.2 mg, 7 mmol), sodium dodecyl (5.8 mg, 0.02 mmol), $FeCl_3$ (4 mg, 0.02mmol), acetophenone (**1a**, 23.4 μL, 0.2 mmol), sulfatesodium benzenesulfinate (**2a**, 82 mg, 0.5mmol), and DMA (1.2 mL) under air. The sealed reaction vessel was stirred at 110 ^{o}C for 14 h. After cooling to room temperature, the reaction was diluted with ethyl acetate (5 mL) and washed with saturated sodium chloride solution. The organic layer was separated, and the aqueous layer was extracted with ethyl acetate for three times. The combined organic layer was dried over magnesium sulfate and the volatiles were removed under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3aa** as white solid (49.8 mg, 87% yield), mp = 99-101 ^{o}C.

phenyl-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3aa)



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93-7.91 (m, 2H), 7.67-7.50 (m, 6H), 7.43 (t, J = 7.6 Hz, 2H), 6.29 (s, 1H), 6.05 (s, 1H), 4.37 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.7, 138.8, 136.2, 135.7, 134.1, 133.9, 132.6, 129.6, 129.2, 128.36, 128.3, 57.7. HRMS calcd. for: $C_{16}H_{14}O_3SNa^+$ $(M+Na)^+$ 309.05559, found 309.05591

1-phenyl-2-(tosylmethyl)prop-2-en-1-one (3ab)

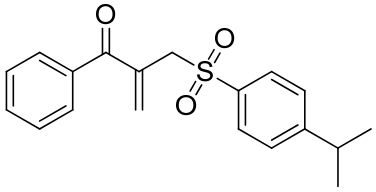


The reaction was conducted with sodium acetophenone (**1a**, 23.4 μL, 0.2 mmol), and 4-methylbenzenesulfinate

(**2b**, 89 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ab** as yellow oil. (43.2 mg, 72% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, J = 8.2 Hz, 2H), 7.68-7.65 (m, 2H), 7.55 (t, J = 7.4 Hz, 1H), 7.43 (t, J = 7.8 Hz, 2H), 7.30 (d, J = 8.3 Hz, 2H), 6.25 (s, 1H), 6.02 (s, 1H), 4.35 (s, 2H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.7, 144.9, 136.1, 135.8, 135.7, 133.9, 132.6, 129.8, 129.6, 128.3, 128.2, 57.7, 21.6. HRMS calcd. for: $C_{17}H_{17}O_3S^+$ $[M+H]^+$ 301.08929, found 301.08908.

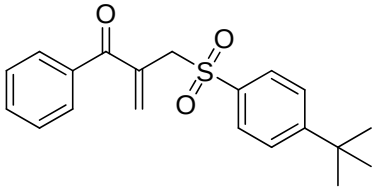
2-(((4-isopropylphenyl)sulfonyl)methyl)-1-phenylprop-2-en-1-one (3ac)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-isopropylbenzenesulfinate (**2c**, 103.1 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ac** as white solid. (32.8 mg, 50% yield), mp = 92-95 °C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 8.4 Hz, 2H), 7.65-7.63 (m, 2H), 7.54 (t, J = 7.4 Hz, 1H), 7.42 (t, J = 7.7 Hz, 2H), 7.33 (d, J = 8.3 Hz, 2H), 6.28 (s, 1H), 6.02 (s, 1H), 4.36 (s, 2H), 2.96-2.89 (m, 1H), 1.19 (d, J = 6.9 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.6, 155.6, 136.1, 136.0, 135.8, 133.7, 132.6, 129.6, 128.5, 128.2, 127.3, 57.7, 34.2, 23.5. HRMS calcd. for: $C_{19}H_{21}O_3S^+$ $[M+H]^+$ 329.12059, found 329.12064.

2-(((4-(tert-butyl)phenyl)sulfonyl)methyl)-1-phenylprop-2-en-1-one (3ad)

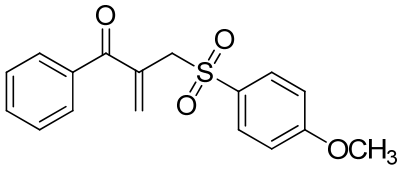


The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-(tert-butyl)benzenesulfinate (**2d**, 110.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ad** as white solid. (37.6 mg, 55% yield), mp = 141-143 °C**.**

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 8.5 Hz, 2H), 7.65-7.63 (m, 2H), 7.54 (t, J = 7.4 Hz, 1H), 7.49 (d, J =

8.5 Hz, 2H), 7.41 (t, J = 7.7 Hz, 2H), 6.28 (s, 1H), 6.01 (s, 1H), 4.37 (s, 2H), 1.27 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.6, 157.9, 136.0, 135.7, 135.6, 133.7, 129.7, 128.3, 128.2, 126.2, 57.7, 35.2, 30.9. HRMS calcd. for: $C_{20}H_{23}O_3S^+$ $[M+H]^+$ 343.13624, found 343.13632.

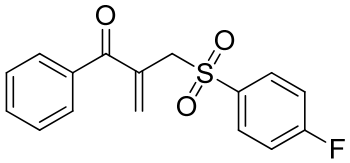
2-(((4-methoxyphenyl)sulfonyl)methyl)-1-phenylprop-2-en-1-one (3ae)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-methoxybenzenesulfinate (**2e**, 97.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 6:1) to yield the desired product **3ae** as yellow oil. (35.1 mg, 47% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, J = 8.9 Hz, 2H), 7.68-7.66 (m, 2H), 7.55 (t, J = 7.4 Hz, 1H), 7.43 (t, J = 7.6 Hz, 2H), 6.95 (d, J = 8.9 Hz, 2H), 6.27 (s, 1H), 6.03 (s, 1H), 4.34 (s, 2H), 3.83 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.8, 163.9, 136.2, 136.0, 133.9, 132.6, 130.5, 130.4, 129.6, 128.3, 114.4, 58.0, 55.6. HRMS calcd. for: $C_{17}H_{17}O_4S$ $[M+H]^+$ 317.08421, found 317.08420.

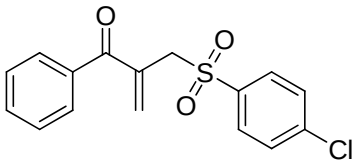
2-(((4-fluorophenyl)sulfonyl)methyl)-1-phenylprop-2-en-1-one (3af)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-fluorobenzenesulfinate (**2f**, 91.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3af** as yellow oil. (44.5 mg, 73% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94-7.91 (m, 2H), 7.67-7.75 (m, 2H), 7.57 (t, J = 7.4 Hz, 1H), 7.44 (t, J = 7.6 Hz, 2H), 7.18 (t, J = 8.6 Hz, 2H), 6.33 (s, 1H), 6.08 (s, 1H), 4.37 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.6, 165.9 (d, J = 255.31 Hz), 136.0, 135.5, 134.9 (d, J = 3.10 Hz), 134.4, 132.7, 131.3 (d, J = 9.58 Hz), 129.5, 128.3, 116.5 (d, J = 22.53 Hz), 57.84. HRMS calcd. for: $C_{16}H_{13}FO_3SNa^+$ $[M+Na]^+$ 327.04616, found 327.04535.

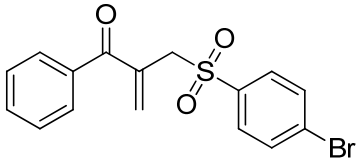
2-(((4-chlorophenyl)sulfonyl)methyl)-1-phenylprop-2-en-1-one (3ag)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-chlorobenzenesulfinate (**2g**, 91.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ag** as yellow oil. (60.9 mg, 95% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85-7.83 (m, 2H), 7.67-7.65 (m, 2H), 7.56-7.55 (m, 1H), 7.50-7.42 (m, 4H), 6.30 (s, 1H), 6.06 (s, 1H), 4.37 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.5, 140.6, 137.2, 136.0, 135.3, 134.3, 132.7, 129.8, 129.48, 129.45, 128.3, 57.73. HRMS calcd. for: $C_{16}H_{13}ClO_3SNa^+$ $[M+Na]^+$ 343.01661,found 343.01630.32.

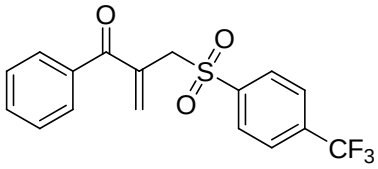
2-(((4-bromophenyl)sulfonyl)methyl)-1-phenylprop-2-en-1-one (3ah)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-bromobenzenesulfinate (**2h**, 139.6 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ah** as yellow oil. (70.8 mg, 95% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78-7.75 (m, 2H), 7.67-7.64 (m, 4H), 7.58-7.54 (m, 1H), 7.46-7.42 m, 2H), 6.29 (s, 1H), 6.06 (s, 1H), 4.37 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.5, 137.8, 135.95, 135.3, 134.3, 132.7, 132.4, 129.8, 129.5, 129.3, 128.3, 57.72. HRMS calcd. for: $C_{16}H_{13}BrO_3SNa^+$ $[M+Na]^+$ 386.96610,found386.96637.

1-phenyl-2-(((4-(trifluoromethyl)phenyl)sulfonyl)methyl)prop-2-en-1-one (3ai)

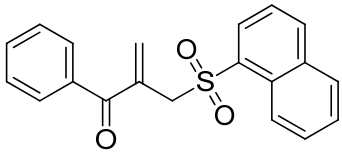


The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium 4-(trifluoromethyl)benzenesulfinate (**2i**, 116.0 mg, 0.5 mmol). The residue was purified by column

chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **3ai** as white solid. (55.0 mg, 78% yield), mp = 99–102 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, J = 8.2 Hz, 2H), 7.79 (d, J = 8.3 Hz, 2H), 7.66-7.64 (m, 2H), 7.57 (t, J = 7.5 Hz, 1H), 7.44 (t, J = 7.7 Hz, 2H), 6.35 (s, 1H), 6.10 (s, 1H), 4.40 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.5, 142.4, 135.9, 135.1, 134.5, 132.9, 129.5, 129.1, 128.4, 126.3 (q, J = 3.64 Hz), 57.76. HRMS calcd. for: $C_{17}H_{13}F_3O_3SNa^+$ $[M+Na]^+$ 377.04297, found 377.04233.

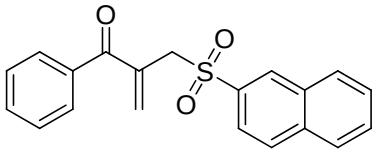
2-((naphthalen-1-ylsulfonyl)methyl)-1-phenylprop-2-en-1-one (3aj)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium naphthalene-1-sulfinate (**2j**, 107.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3aj** as white solid. (35.6 mg, 53% yield), mp = 113–116 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.81 (d, J = 8.7 Hz, 1H), 8.30-8.27 (m, 1H), 8.10 (d, J = 8.2 Hz, 1H), 7.96 (d, J = 8.2 Hz, 1H), 7.79-7.75 (m, 1H), 7.68-7.62 (m, 3H), 7.57-7.52 (m, 2H), 7.43 (t, J = 7.6 Hz, 2H), 6.18 (s, 1H), 5.99 (s, 1H), 4.55 (d, J = 0.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.8, 136.2, 135.6, 135.5, 134.1, 133.9, 133.8, 132.6, 131.0, 129.7, 129.2, 129.0, 128.9, 128.3, 127.2, 124.1, 57.48. HRMS calcd. for: $C_{20}H_{16}O_3SNa^+$ $[M+Na]^+$ 359.07124, found 359.07190.

2-((naphthalen-2-ylsulfonyl)methyl)-1-phenylprop-2-en-1-one (3ak)

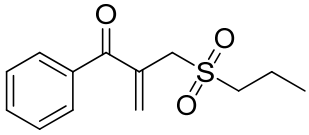


The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium naphthalene-2-sulfinate (**2k**, 107.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ak** as yellow solid. (38.3 mg, 57% yield), mp = 117–120 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (s, 1H), 7.99-7.87 (m, 4H), 7.67-7.58 (m, 4H), 7.51 (t, J = 7.4 Hz, 1H), 7.37 (t, J = 7.7 Hz, 2H), 6.28 (s, 1H), 6.03 (s, 1H), 4.45 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.7, 136.1, 135.7, 135.3, 133.8, 132.6, 132.0, 130.3, 129.6, 129.6, 129.3, 128.2, 128.0, 127.7, 122.8, 57.86. HRMS calcd. for:

$C_{20}H_{17}O_3S^+$ $[M+H]^+$ 337.08929, found 337.08911.

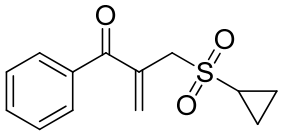
1-phenyl-2-((propylsulfonyl)methyl)prop-2-en-1-one (3al)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium propane-1-sulfinate (**2l**, 65.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ai** as yellow oil. (12.1 mg, 24% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80-7.78 (m, 2H), 7.60 (t, J = 7.4 Hz, 1H), 7.48 (t, J = 7.6 Hz, 2H), 6.43 (s, 1H), 6.13 (s, 1H), 4.20 (s, 2H), 3.01-2.98 (m, 2H), 1.96-1.90 (m, 2H), 1.08 (t, J = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.7, 136.3, 135.7, 134.6, 132.9, 129.7, 128.5, 55.2, 54.9, 15.8, 13.1. HRMS calcd. for: $C_{13}H_{17}O_3S^+$ $[M+H]^+$ 253.08929, found 253.08966.

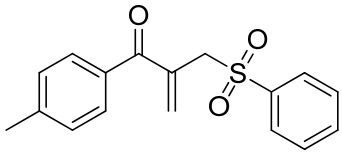
2-((cyclopropylsulfonyl)methyl)-1-phenylprop-2-en-1-one (3am)



The reaction was conducted with acetophenone (**1a**, 23.4 μL, 0.2 mmol) and sodium cyclopropanesulfinate (**2m**, 65.0 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3am** as white solid (15.5 mg, 31% yield). mp = 131–134 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81-7.79 (m, 2H), 7.61-7.57 (m, 1H), 7.50-7.46 (m, 2H), 6.40 (s, 1H), 6.12 (s, 1H), 4.30 (m, 2H), 2.46-2.40 (m, 1H), 1.27-1.23 (m, 2H), 1.03-0.98 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.4, 136.4, 135.9, 134.3, 132.8, 129.7, 128.5, 55.8, 30.2, 5.2. HRMS calcd. for: $C_{13}H_{15}O_3S^+$ $[M+H]^+$ 251.07364, found 251.07408.

2-((phenylsulfonyl)methyl)-1-(p-tolyl)prop-2-en-1-one(3ba)

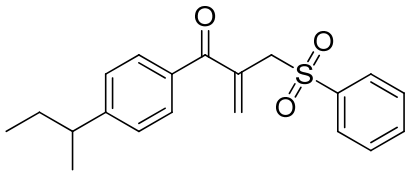


The reaction was conducted with 1-(p-tolyl)ethanone (**1b**, 37 μL,, 0.2 mmol) and sodium benzenesulfinate (**2a**,

82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ba** as white solid (51.9 mg, 87% yield), mp = 133-135 °C.

^{1}H NMR (400 MHz, $CDCl_3$, ppm) δ 7.91-7.89 (m, 2H), 7.59-7.57 (m, 3H), 7.52-7.48 (m, 2H), 7.22 (d, J = 8.0 Hz, 2H), 6.23 (s, 1H), 6.01 (s, 1H), 4.36 (s, 2H), 2.41 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, ppm) δ 194.4, 143.7, 138.9, 135.8, 134.0, 133.6, 133.5, 123.0, 129.3, 129.1, 128.5, 58.0, 21.7. HRMS calcd. for: $C_{17}H_{17}O_3S^+$ $[M+H]^+$ 301.08929, found 301.08929.

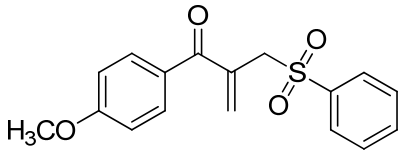
1-(4-(sec-butyl)phenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3ca)



The reaction was conducted with 1-(4-(sec-butyl)phenyl)ethanone (**1c**, 37 μL,, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ca** as white solid (55.1 mg, 80% yield), mp = 91-93 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.89 (m, 2H), 7.61-7.57 (m, 3H), 7.52 – 7.48 (m, 2H), 7.20 (d, J = 8.2 Hz, 2H), 6.22 (s, 1H), 6.02 (s, 1H), 4.37 (d, J = 0.5 Hz, 2H), 2.53 (d, J = 7.2 Hz, 2H), 1.89 (dt, J = 13.5, 6.8 Hz, 1H), 0.91 (d, J = 6.6 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.3, 147.2, 138.7, 135.6, 133.8, 133.6, 133.4, 129.7, 129.1, 129.0, 128.3, 57.8, 45.3, 30.0, 22.3. HRMS calcd. for: $C_{20}H_{23}O_3S^+$ $[M+H]^+$ 343.13624, found 343.13625

1-(4-methoxyphenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3da)

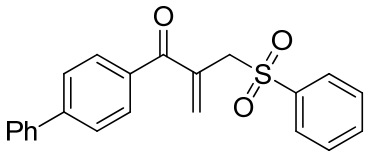


The reaction was conducted with 1-(4-methoxyphenyl)ethanone (**1d**, 31 mg,, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column matography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **3da** as white solid (50.6 mg, 81% yield), mp = 93-95 °C.

^{1}H NMR (400 MHz, CDCl3) δ 7.89 (d, J = 7.4 Hz, 2H), 7.72 (d, J = 8.7 Hz, 2H), 7.59 (t, J = 7.4 Hz, 1H), 7.50 (t, J = 7.7 Hz, 2H), 6.16 (s, 1H), 5.96 (s, 1H), 4.36 (s, 2H), 3.87 (d, J = 0.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ

193.2, 163.4, 138.8, 135.6, 133.8, 132.3, 132.1, 129.1, 128.5, 128.2, 113.5, 58.2, 55.4. HRMS calcd. for: $C_{17}H_{17}O_4S^+$ $[M+H]^+$ 317.08421, found 317.08405.

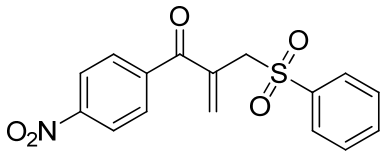
1-([1,1'-biphenyl]-4-yl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3ea)



The reaction was conducted with 1-([1,1'-biphenyl]-4-yl)ethanone (**1e**, 39.2 mg,, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ea** as white solid (55.4 mg, 76% yield), mp = 117–120 °C.

^{1}H NMR (400 MHz, CDCl3) δ 7.92 (dd, J = 5.2, 3.3 Hz, 2H), 7.80-7.71 (m, 2H), 7.67-7.57 (m, 5H), 7.54-7.38 (m, 5H), 6.27 (s, 1H), 6.08 (s, 1H), 4.39 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.2, 145.4, 139.7, 138.8, 135.7, 134.7, 133.9, 133.6, 130.2, 129.2, 128.9, 128.3, 128.2, 127.2, 126.9, 57.8. HRMS calcd. for: $C_{22}H_{18}O_3S^+$ $[M+H]^+$ 363.10494, found 363.10483.

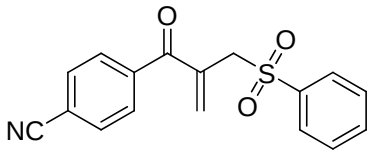
1-(4-nitrophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3fa)



The reaction was conducted with 1-(4-nitrophenyl)ethanone (**1f**, 33 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 6:1) to yield the desired product **3fa** as Yellow solid (36.1 mg, 54% yield), mp = 172-175 °C.

^{1}H NMR (400 MHz, CDCl3) δ 8.33-8.27 (m, 2H), 7.93 (d, *J* = 8.0 Hz, 2H), 7.86-7.80 (m, 2H), 7.66 (dd, J = 11.5, 4.3 Hz, 1H), 7.57 (t, *J* = 7.7 Hz, 2H), 6.38 (s, 1H), 6.02 (s, 1H), 4.37 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.2, 150.0, 141.5, 138.8, 135.5, 135.0, 134.1, 130.4, 129.3, 128.2, 123.5, 57.4. HRMS calcd. for: $C_{16}H_{13}NO_5SNa^+$ $[M+Na]^+$ 354.04066, found 354.04080.

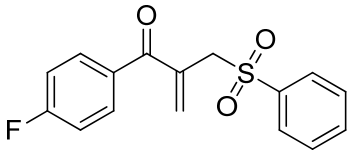
4-(2-((phenylsulfonyl)methyl)acryloyl)benzonitrile(3ga)



The reaction was conducted with 4-acetylbenzonitrile (**1g**, 33 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 6:1) to yield the desired product **3ga** as Yellow solid (36.1 mg, 54% yield), mp = 156-159 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 8.3 Hz, 2H), 7.80-7.73 (m, 4H), 7.68-7.63 (m, 1H), 7.56 (t, J = 7.8 Hz, 2H), 6.34 (s, 1H), 6.00 (s, 1H), 4.36 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 139.8, 138.8, 135.4, 134.7, 134.1, 132.1, 129.9, 129.3, 128.2, 117.8, 115.9, 57.5. HRMS calcd. for: $C_{17}H_{13}NO_3SNa^+$ $[M+Na]^+$ 334.05084, found 334.05081.

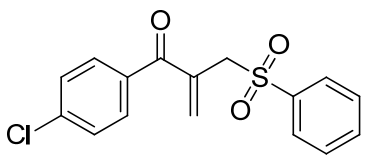
1-(4-fluorophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3ha)



The reaction was conducted with 1-(4-fluorophenyl)ethanone (**1h**, 24 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ha** as White solid (50 mg, 82% yield), mp = 108-111 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95-7.88 (m, 2H), 7.78-7.69 (m, 2H), 7.65-7.58 (m, 1H), 7.56-7.49 (m, 2H), 7.12 (dd, *J* = 9.5, 7.8 Hz, 2H), 6.24 (s, 1H), 5.99 (s, 1H), 4.36 (d, *J* = 0.7 Hz, 2H). ^{13}C NMR (100 MHz, CDCl3) δ 193.2, 165.4 (d, *J* = 253.09 Hz), 138.7, 135.5, 133.9, 133.4, 132.24365 (d, *J* = 9.13 Hz),132.2436, 129.2, 128.2, 115.5 (d, *J* = 21.81 Hz), 57.92. HRMS calcd. for: $C_{16}H_{14}FO_3S^+$ $[M+H]^+$ 305.06422, found 305.06445.

1-(4-chlorophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ia)

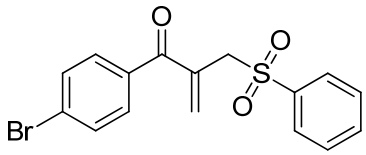


The reaction was conducted with 1-(4-chlorophenyl)ethanone (**1i**, 26 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel

(petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ia** as White solid (44.0 mg, 69% yield), mp = 124-127 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.89 (m, 2H), 7.66-7.61 (m, 3H), 7.53 (t, J = 7.6 Hz, 2H), 7.43-7.41 (m, 2H), 6.28 (s, 1H), 6.00 (s, 1H), 4.35 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.5, 139.2, 138.8, 135.5, 134.4, 134.0, 133.8, 131.0, 129.2, 128.7, 128.3, 57.8. HRMS calcd. for: for: $C_{16}H_{14}ClO_3S^+$ $[M+H]^+$ 321.03467, found 321.03497.

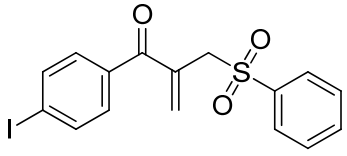
1-(4-bromophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ja)



The reaction was conducted with 1-(4-bromophenyl)ethanone (**1j**, 39.8 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ja** as White solid (56.9 mg, 78% yield), mp = 130 -132 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, J = 7.7 Hz, 2H), 7.64-7.51 (m, 7H), 6.28 (s, 1H), 6.00 (s, 1H), 4.35 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.7, 138.83, 138.79, 135.51, 135.48, 134.8, 134.02, 134.00, 133.9, 133.8, 131.7, 131.1, 129.3, 128.3, 127.8, 77.3, 77.0, 76.6, 57.8. HRMS calcd. for: $C_{16}H_{14}BrO_3S^+$ $[M+H]^+$ 364.98415, found 364.98410.

1-(4-iodophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ka)

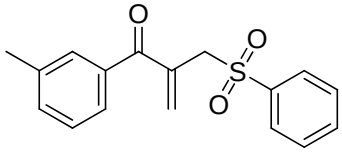


The reaction was conducted with 1-(4-iodophenyl)ethanone (**1k**, 49.2 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ka** as White solid (26.1 mg, 31% yield), mp = 103-106 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91-7.89 (m, 2H), 7.81 (d, J = 8.4 Hz, 2H), 7.62 (t, J = 7.5 Hz, 1H), 7.53 (t, J = 7.6 Hz, 2H), 7.40 (d, J = 8.4 Hz, 2H), 6.28 (s, 1H), 6.00 (s, 1H), 4.35 (s, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ

193.5, 139.2, 138.8, 135.5, 134.4, 134.0, 133.8, 131.1, 129.3, 128.7, 128.3, 57.8. HRMS calcd. for: $C_{16}H_{14}IO_3S^+$ $[M+H]^+$ 412.97028, found 412.97052.

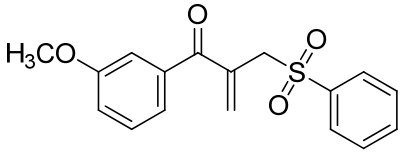
2-((phenylsulfonyl)methyl)-1-(m-tolyl)prop-2-en-1-one (3la)



The reaction was conducted with 1-(m-tolyl)ethanone (**1l**, 27 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3la** as Yellow oil. (50 mg, 83% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94-7.86 (m, 2H), 7.63-7.57 (m, 1H), 7.55-7.48 (m, 2H), 7.46-7.40 (m, 2H), 7.37-7.28 (m, 2H), 6.27 (s, 1H), 6.03 (s, 1H), 4.37 (d, J = 0.6 Hz, 2H), 2.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.8, 138.8, 138.1, 136.1, 135.7, 134.1, 133.9, 133.3, 129.9, 129.1, 128.3, 128.0, 126.8, 57.6, 21.2. HRMS calcd. for: $C_{17}H_{16}O_3SNa^+$ $[M+Na]^+$ 323.07124, found 323.07123.

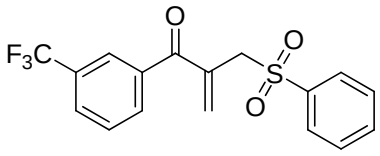
1-(3-methoxyphenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ma)



The reaction was conducted with 1-(3-methoxyphenyl)ethanone (**1m**, 27.5 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 9:1) to yield the desired product **3ma** as Yellow oil. (50 mg, 79% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.90 (m, 2H), 7.63-7.59 (m, 1H), 7.52 (t, J = 7.6 Hz, 2H), 7.33 (t, J = 7.9 Hz, 1H), 7.23-7.21 (m, 1H), 7.17-7.16 (m, 1H), 7.09-7.07 (m, 1H), 6.25 (s, 1H), 6.05 (s, 1H), 4.37 (s, 2H), 3.83 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.4, 159.4, 138.7, 137.4, 135.6, 134.2, 133.9, 129.18, 129.15, 128.31, 122.2, 118.9, 114.0, 57.6, 55.4. HRMS calcd. for: $C_{17}H_{17}O_4S^+$ $[M+H]^+$ 317.08421, found 317.08441.

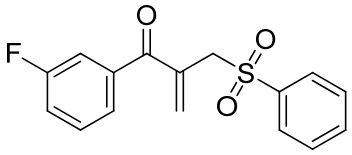
2-((phenylsulfonyl)methyl)-1-(3-(trifluoromethyl)phenyl)prop-2-en-1-one(3na)



The reaction was conducted with 1-(3-(trifluoromethyl)phenyl)ethanone (**1n**, 30.5 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 9:1) to yield the desired product **3na** as Yellow oil. (50 mg, 71% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93-7.91 (m, 2H), 7.88-7.87 (m, 2H), 7.81 (d, J = 7.6 Hz, 1H), 7.64-7.52 (m, 4H), 6.30 (s, 1H), 5.99 (s, 1H), 4.39 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 138.6, 136.8, 135.5, 134.4, 134.1, 132.7, 129.3, 129.1, 129.0, 128.3, 126.2 (q, J = 3.80 Hz), 124.9, 122.2, 57.6. HRMS calcd. for: $C_{17}H_{14}F_3O_3S^+$ $[M+H]^+$ 355.06103, found 355.06116.

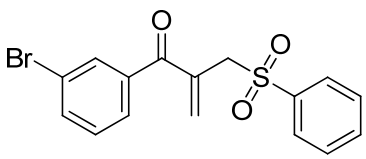
1-(3-fluorophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3oa)



The reaction was conducted with 1-(3-fluorophenyl)ethanone (**1o**, 24.5 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 9:1) to yield the desired product **3oa** as Yellow oil. (48 mg, 79% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.90 (m, 2H), 7.63 (t, J = 7.4 Hz, 1H), 7.54 (t, J = 7.6 Hz, 2H), 7.47-7.41 (m, 2H), 7.35-7.32 (m, 1H), 7.28-7.23 (m, 1H), 6.29 (s, 1H), 6.04 (s, 1H), 4.36 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 162.3 (d, J = 246.93 Hz), 138.7, 138.1 (d, J = 6.46 Hz), 135.1, 134.3, 134.0, 130.0 (d, J = 7.66 Hz), 129.2, 128.3, 125.3 (d, J = 2.95 Hz), 119.7 (d, J = 21.20 Hz), 116.3 (d, J = 22.59 Hz), 57.6. HRMS calcd. for: calcd for $C_{16}H_{13}FO_3SNa^+$ $[M+Na]^+$ 327.04616, found 327.04616.

1-(3-bromophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one(3pa)

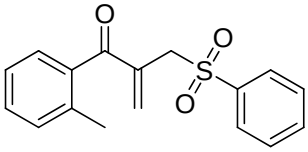


The reaction was conducted with 1-(3-bromophenyl)ethanone (**1p**, 26.5 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel

(petroleum ether/ethyl acetate = 9:1) to yield the desired product **3pa** as White oil. (51.7 mg, 71% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.90 (m, 2H), 7.74-7.73 (m, 1H), 7.69-7.52 (m, 5H), 7.32 (t, J = 7.8 Hz, 1H), 6.29 (s, 1H), 6.02 (s, 1H), 4.36 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.2, 138.6, 137.9, 135.5, 135.4, 134.4, 134.0, 132.2, 129.9, 129.2, 128.3, 128.1, 122.5, 57.5. HRMS calcd. for: $C_{16}H_{14}BrO_3S^+$ $[M+H]^+$ 364.98415, found 364.98428；

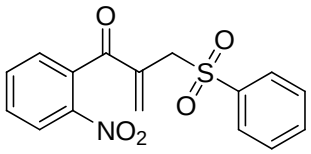
2-((phenylsulfonyl)methyl)-1-(o-tolyl)prop-2-en-1-one (3qa)



The reaction was conducted with 1-(o-tolyl)ethanone (**1q**, 26.1 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3qa** as White solid. (47.2 mg, 79% yield). mp = 148-151 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96-7.93 (m, 2H), 7.67-7.63 (m, 1H), 7.58-7.55 (m, 2H), 7.35-7.31 (m, 1H), 7.22-7.12 (m, 3H), 6.41 (s, 1H), 6.00 (s, 1H), 4.37 (s, 2H), 2.18 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.7, 138.9, 137.0, 136.8, 136.71, 136.68, 133.9, 131.0, 130.4, 129.2, 128.5, 128.2, 125.0, 55.5, 19.5. HRMS calcd. for: $C_{17}H_{17}O_3S^+$ $[M+H]^+$ 301.08929, found 301.08908.

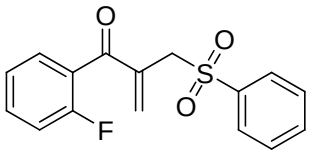
1-(2-nitrophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ra)



The reaction was conducted with 1-(2-nitrophenyl)ethanone (**1r**, 26.6 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **3ra** as White solid (43.1 mg, 65% yield). mp = 137-140 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18-8.16 (m, 1H), 7.98-7.96 (m, 2H), 7.75-7.58 (m, 5H), 7.28-7.26 (m, 1H), 6.45 (s, 1H), 5.87 (s, 1H), 4.37 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.06, 146.32, 138.72, 136.16, 135.78, 134.53, 134.10, 134.00, 130.78, 129.17, 128.76, 128.46, 124.49, 77.32, 77.00, 76.68, 55.10. HRMS calcd. for: $C_{16}H_{13}NO_5S^+$ $[M+H]^+$ 332.05872, found 332.05869.

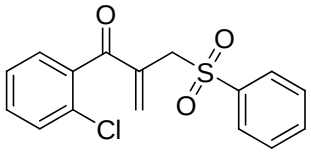
1-(2-fluorophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3sa)



The reaction was conducted with 1-(2-fluorophenyl)ethanone (**1s**, 24 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 9:1) to yield the desired product **3s** as yellow solid. (37.0 mg, 61% yield). mp = 92 - 96 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, J = 7.8 Hz, 2H), 7.64 (t, J = 7.4 Hz, 1H), 7.55 (t, J = 7.6 Hz, 2H), 7.50-7.45 (m, 1H), 7.31-7.27 (m, 1H), 7.19 (t, J = 7.5 Hz, 1H), 7.13-7.08 (m, 1H), 6.40 (s, 1H), 6.11-6.10 (m, 1H), 4.34 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.5, 159.6 (d, J = 251.18 Hz),136.6, 136.5 (d, J = 12.20 Hz), 136.4, 133.9, 133.1 (d, J = 8.28 Hz), 130.4 (d, J = 2.72 Hz), 129.1, 128.6, 125.3 (d, J = 14.76 Hz), 124.2 (d, J = 3.60 Hz), 116.2 (d, J = 21.44 Hz), 55.94. HRMS calcd. for: $C_{16}H_{14}FO_3S^+$ $[M+H]^+$ 305.06422, found 305.06430.

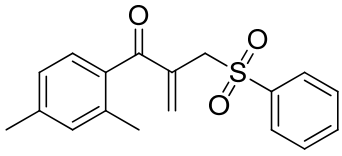
1-(2-chlorophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ta)



The reaction was conducted with 1-(2-chlorophenyl)ethanone (**1t**, 26 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ta** as white solid (53.7 mg, 84% yield). mp = 115-118 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95-7.92 (m, 2H), 7.68-7.64 (m, 1H), 7.59-7.55 (m, 2H), 7.38-7.37 (m, 2H), 7.31-7.27 (m, 1H), 7.12-7.10 (m, 1H), 6.50 (s, 1H), 6.03 (s, 1H), 4.36 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.5, 138.6, 137.8, 136.8, 136.1, 133.9, 131.2, 131.0, 130.0, 129.1, 128.9, 128.5, 126.45, 55.0. HRMS calcd. for: $C_{16}H_{14}ClO_3S^+$ $[M+H]^+$ 321.03467, found 321.03442.

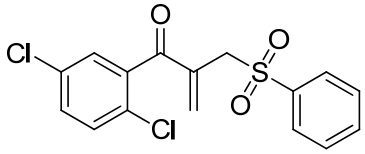
1-(2,4-dimethylphenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ua)



The reaction was conducted with 1-(2,4-dimethylphenyl)ethanone (**1u**, 30 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ua** as white solid (50.4 mg, 81% yield). mp = 146-149 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, J = 8.0 Hz, 2H), 7.63 (t, J = 7.4 Hz, 1H), 7.55 (t, J = 7.3 Hz, 2H), 7.07 (d, J = 7.7 Hz, 1H), 7.02-6.97 (m, 2H), 6.37-6.36 (s, 1H), 5.99 (s, 1H), 4.36 (s, 2H), 2.33 (s, 3H), 2.17 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.4, 140.8, 138.9, 137.1, 137.1, 136.0, 133.9, 133.8, 131.9, 129.1, 128.9, 128.5, 125.6, 55.8, 21.3, 19.6. HRMS calcd. for: $C_{18}H_{19}O_3S^+$ $[M+H]^+$ 315.10494, found 315.10519.

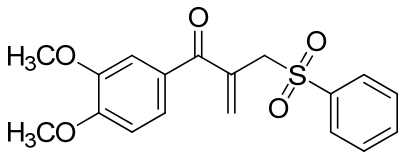
1-(2,5-dichlorophenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3va)



The reaction was conducted with 1-(2,5-dichlorophenyl)ethanone (**1v**, 37.8 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3va** as yellow solid. (53.0 mg, 75% yield). mp = 124-127 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94-7.92 (m, 2H), 7.68 (t, J = 7.4 Hz, 1H), 7.59 (t, J = 7.6 Hz, 2H), 7.34-7.33 (m, 2H), 7.01 (d, J = 2.2 Hz, 1H), 6.56 (s, 1H), 6.05 (s, 1H), 4.34 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.1, 138.6, 138.19, 138.17, 135.9, 134.1, 132.8, 131.3, 131.2, 129.3, 129.2, 128.7, 128.6, 54.94. HRMS calcd. for: $C_{16}H_{13}Cl_2O_3S^+$ $[M+H]^+$ 354.99570, found 354.99600.

1-(3,4-dimethoxyphenyl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3wa)

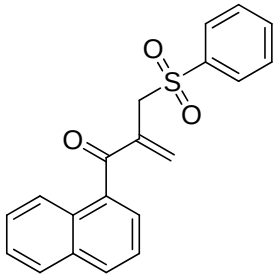


The reaction was conducted with 1-(3,4-dimethoxyphenyl)ethanone (**1w**, 30 μL, 0.2 mmol) and sodium

benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 6:1) to yield the desired product **3wa** as white solid (50.5 mg, 75% yield). mp = 135-138 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, J = 7.6 Hz, 2H), 7.60 (t, J = 7.3 Hz, 1H), 7.51 (t, J = 7.7 Hz, 2H), 7.40 (dd, J = 8.3, 1.0 Hz, 1H), 7.31 (s, 1H), 6.88 (d, J = 8.4 Hz, 1H), 6.15 (s, 1H), 5.98 (s, 1H), 4.37 (s, 2H), 3.95 (s, 3H), 3.91 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 153.2, 148.8, 138.7, 135.4, 133.8, 132.2, 129.1, 128.6, 128.2, 125.0, 111.6, 109.6, 58.4, 56.0, 55.9. HRMS calcd. for: $C_{18}H_{19}O_5S^+$ $[M+H]^+$ 347.09477, found 347.09488

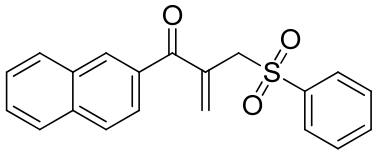
1-(naphthalen-1-yl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3xa)



The reaction was conducted with 1-(naphthalen-1-yl)ethanone (**1x**, 30.4 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3xa** as white solid. (55.8 mg, 84% yield). mp = 127-130 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99-7.93 (m, 3H), 7.88-7.85 (m, 1H), 7.77-7.75 (m, 1H), 7.69 -7.65 (m, 1H), 7.60-7.56 (m, 2H), 7.53-7.43 (m, 4H), 6.42 (s, 1H), 6.06 (s, 1H), 4.47 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.0, 138.8, 137.4, 137.0, 134.5, 133.9, 133.5, 131.4, 130.6, 129.2, 128.5, 128.3, 127.4, 127.3, 126.5, 125.1, 124.1, 55.78. HRMS calcd. for: $C_{20}H_{17}O_3S^+$ $[M+H]^+$ 337.08929, found 337.08929.

1-(naphthalen-2-yl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3ya)

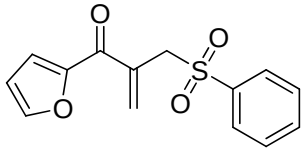


The reaction was conducted with 1-(naphthalen-2-yl)ethanone (**1y**, 34.0 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3ya** as white solid. (52.8 mg, 79% yield). mp

= 94-95 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.17 (s, 1H), 7.95-7.92 (m, 3H), 7.87 (d, J = 8.4 Hz, 2H), 7.75-7.72 (m, 1H), 7.62-7.54 (m, 3H), 7.50 (t, J = 7.5 Hz, 2H), 6.32 (s, 1H), 6.10 (s, 1H), 4.43 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.5, 138.7, 135.7, 135.2, 134.0, 133.9, 133.2, 132.0, 131.3, 129.3, 129.2, 128.4, 128.3, 128.3, 127.7, 126.9, 125.2, 57.80. HRMS calcd. for: $C_{20}H_{17}O_3S^+$ $[M+H]^+$ 337.08929, found 337.08929.

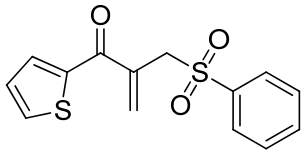
1-(furan-2-yl)-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3za)



The reaction was conducted with 1-(furan-2-yl)ethanone (**1z**, 20.0 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **3za** as white solid (36.5 mg, 66% yield). mp = 153-156 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86-7.84 (m, 2H), 7.63 (m, 1H), 7.60-7.56 (m, 1H), 7.49-7.45 (m, 2H), 7.14 (d, J = 3.6 Hz, 1H), 6.55-6.53 (m, 1H), 6.42 (s, 1H), 6.17 (s, 1H), 4.31 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.1, 151.1, 147.3, 138.4, 135.3, 133.9, 132.4, 129.0, 128.5, 120.5, 112.2, 57.87. HRMS calcd. for: $C_{14}H_{12}O_4SNa^+$ $[M+Na]^+$ 299.03485, found 299.03500.

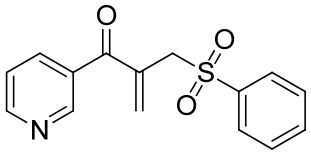
2-((phenylsulfonyl)methyl)-1-(thiophen-2-yl)prop-2-en-1-one (3aaa)



The reaction was conducted with 1-(thiophen-2-yl)ethanone (**1aa**, 21.6 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 9:1) to yield the desired product **3aaa** as white solid (45.7 mg, 78% yield). mp = 124-127 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, J = 8.0 Hz, 2H), 7.68 (d, J = 4.9 Hz, 1H), 7.63-7.62 (m, 1H), 7.58 (t, J = 7.4 Hz, 1H), 7.47 (t, J = 7.7 Hz, 2H), 7.13 (t, J = 4.3 Hz, 1H), 6.21 (m, 1H), 6.10 (m, 1H), 4.33 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 185.8, 141.7, 138.3, 135.9, 134.7, 134.6, 133.9, 131.5, 129.1, 128.4, 127.9, 58.3. HRMS calcd. for: calcd for $C_{14}H_{13}O_3S_2^+$ $[M+H]^+$ 293.03006, found 293.03040.

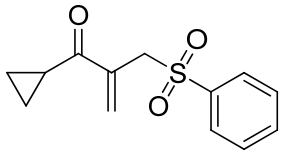
2-((phenylsulfonyl)methyl)-1-(pyridin-3-yl)prop-2-en-1-one (3aba)



The reaction was conducted with 1-(pyridin-3-yl)ethanone (**1ab**, 22.0 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to yield the desired product **3aba** as yellow oil (20.2 mg, 35% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.87 (s, 1H), 8.79-8.78 (m, 1H), 8.01-7.99 (m, 1H), 7.93-7.90 (m, 2H), 7.66-7.62 (m, 1H), 7.57-7.53 (m, 2H), 7.44-7.40 (m, 1H), 6.33 (s, 1H), 6.05 (s, 1H), 4.38 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.0, 153.1, 150.3, 138.5, 137.0, 135.7, 134.6, 134.1, 131.8, 129.3, 128.3, 123.3, 57.39. HRMS calcd. for: $C_{15}H_{14}NO_3S^+$ $[M+H]^+$ 288.06889, found 288.06894.

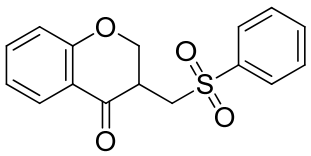
1-cyclopropyl-2-((phenylsulfonyl)methyl)prop-2-en-1-one (3aca)



The reaction was conducted with 1-cyclopropylethanone (**1ac**, 20.0 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **3aca** as white solid (41.9 mg, 35% yield), mp = 99-101 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85-7.83 (m, 2H), 7.63 (t, J = 7.4 Hz, 1H), 7.52 (t, J = 7.7 Hz, 2H), 6.52 (s, 1H), 6.27 (s, 1H), 4.20 (s, 2H), 2.32-2.26 (m, 1H), 0.87-0.82 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.4, 138.5, 137.3, 133.7, 131.5, 128.9, 128.6, 56.2, 15.8, 11.7. HRMS calcd. for: $C_{13}H_{14}O_3S^+$ $[M+H]^+$ 251.07364, found 251.07402.

3-((phenylsulfonyl)methyl)chroman-4-one (5aa)

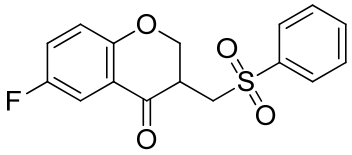


The reaction was conducted with 1-(2-hydroxyphenyl)ethanone (**4a**, 24.0 μL, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **5aa** as white solid. (42.7 mg, 71% yield), mp

= 108–111 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, J = 7.4 Hz, 2H), 7.84-7.82 (m, 1H), 7.69 (t, J = 7.4 Hz, 1H), 7.60 (t, J = 7.6 Hz, 2H), 7.52-7.48 (m, 1H), 7.04-6.99 (m, 2H), 5.02-4.09 (m, 1H), 4.35 (t, J = 11.8 Hz, 1H), 4.01-4.00 (m, 1H), 3.45-3.38 (m, 1H), 3.04-2.98 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.9, 161.6, 138.7, 136.5, 134.2, 129.5, 127.9, 127.5, 121.7, 119.9, 118.0, 69.5, 51.6, 40.7. HRMS calcd. for: $C_{16}H_{14}O_4SNa^+$ $[M+Na]^+$ 325.05050, found 325.05023.

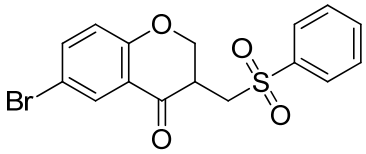
6-fluoro-3-((phenylsulfonyl)methyl)chroman-4-one (5ba)



The reaction was conducted with 1-(5-fluoro-2-hydroxyphenyl)ethanone (**4b**, 31.0 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **5ba** as white solid. (33.5 mg, 55% yield), mp = 141–144 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 - 7.96 (m, 2H), 7.72 - 7.70 (m, 1H), 7.63 – 7.60 (m, 2H), 7.49 – 7.46 (m, 1H), 7.26-7.21 (m, 1H), 7.01 - 6.98 (m, 1H), 5.03 - 4.99 (m, 1H), 4.34 (t, J = 11.9 Hz, 1H), 3.98 - 3.94 (m, 1H), 3.46 - 3.39 (m, 1H), 3.04- 2.98 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.8, 160.6, 139.2, 138.9, 134.3, 129.9, 129.6, 128.0, 121.2, 120.1, 114.5, 51.6, 40.6. HRMS calcd. for: $C_{16}H_{14}FO_4S^+$ $[M+H]^+$ 321.05913, found 321.05902.

6-bromo-3-((phenylsulfonyl)methyl)chroman-4-one (5ca)

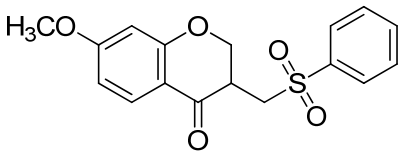


The reaction was conducted with 1-(5-bromo-2-hydroxyphenyl)ethanone (**4c**, 43.0 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **5ca** as white solid. (29.2 mg, 39% yield), mp = 178–181 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98-7.93 (m, 3H), 7.70 (t, J = 7.4 Hz, 1H), 7.63-7.56 (m, 3H), 6.91 (d, J = 8.9

Hz, 1H), 5.06-5.02 (m, 1H), 4.34 (t, J = 11.9 Hz, 1H), 3.98-3.93 (m, 1H), 3.47-3.39 (m, 1H), 3.03-2.97 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.8, 160.5, 139.2, 138.8, 134.3, 129.9, 129.6, 127.9, 121.1, 120.1, 114.4, 69.7, 51.6, 40.6. HRMS calcd. for: $C_{16}H_{14}BrO_4S^+$ $[M+H]^+$ 380.97907, found 380.97949.

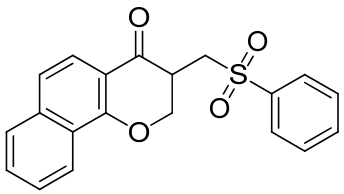
7-methoxy-3-((phenylsulfonyl)methyl)chroman-4-one (5da)



The reaction was conducted with 1-(2-hydroxy-4-methoxyphenyl)ethanone (**4d**, 33.2 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 6:1) to yield the desired product **5da** as white solid. (40.6 mg, 61% yield), mp = 241 - 244 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98-7.96 (m, 2H), 7.77 (d, J = 8.9 Hz, 1H), 7.71-7.67 (m, 1H), 7.60 (t, J = 7.6 Hz, 2H), 6.59-6.57 (m, 1H), 6.43 (d, J = 2.4 Hz, 1H), 5.02-4.98 (m, 1H), 4.35 (t, J = 11.6 Hz, 1H), 4.01-3.97 (m, 1H), 3.84 (s, 3H), 3.39-3.32 (m, 1H), 3.02-2.96 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 188.4, 166.4, 163.7, 138.9, 134.1, 129.5, 129.3, 128.0, 113.8, 110.6, 100.7, 69.9, 55.7, 51.9, 40.4. HRMS calcd. for: $C_{17}H_{17}O_5S^+$ $[M+H]^+$ 333.07912, found 333.07956.

3-((phenylsulfonyl)methyl)-2*H*-benzo[*h*]chromen-4(3*H*)-one (5ea)

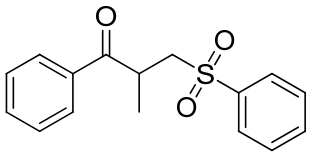


The reaction was conducted with 1-(1-hydroxynaphthalen-2-yl)ethanone (**4e**, 37.0 mg, 0.2 mmol) and sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol). The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to yield the desired product **5ea** as yellow solid. (24.9 mg, 61% yield), mp = 164–167 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31 (d, J = 8.3 Hz, 1H), 8.01-8.00 (m, 2H), 7.78 (d, J = 8.7 Hz, 2H), 7.72-7.54 (m, 5H), 7.40 (d, J = 8.7 Hz, 1H), 5.31-5.27 (m, 1H), 4.56 (t, J = 11.8 Hz, 1H), 4.07-4.03 (m, 1H), 3.55-3.48 (m, 1H), 3.11-3.04 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 189.4, 160.2, 138.9, 137.6, 134.2, 130.1, 129.6, 128.0,

127.8, 126.5, 124.6, 123.5, 121.8, 121.5, 114.5, 70.3, 52.0, 40.2. HRMS calcd. for: $C_{20}H_{16}O_4SNa$ $[M+Na]^+$ 375.06615, found 375.06622.

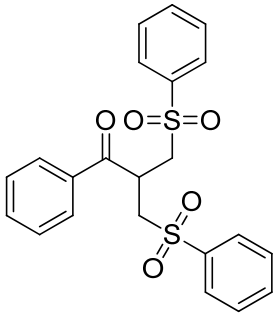
2-methyl-1-phenyl-3-(phenylsulfonyl)propan-1-one (7a)



A 10 mL oven-dried reaction vessel was charged with 1-phenyl-2-((phenylsulfonyl)methyl)prop-2-en-1-one (**3aa**) (57.2 mg, 0.2 mmol), Sodium borohydride (3.8 mg, 0.1 mmol), NMP (1.0 mL) and trifluoroacetic acid (14.9 μL, 0.2mmol) under air. The sealed reaction vessel was stirred at rt for 1.0 h. Then, the reaction was diluted with ethyl acetate (5 mL) and washed with saturated sodium chloride solution. The organic layer was separated, and the aqueous layer was extracted with ethyl acetate for three times. The combined organic layer was dried over magnesium sulfate and the volatiles were removed under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to yield the desired product **7a** as yellow solid (31.7 mg, 55% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92-7.86 (m, 4H), 7.92-7.86 (m, 2H), 7.52-7.46(m, 4H), 4.21-4.17(m, 1H), 3.94-3.87(m, 1H), 3.21-3.16(m, 1H), 1.35 (d, J = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.0, 139.4, 134.8, 133.8, 133.6, 129.3, 128.8, 128.5, 127.9, 58.5, 35.5, 18.7.

1-phenyl-3-(phenylsulfonyl)-2-((phenylsulfonyl)methyl)propan-1-one (8a)

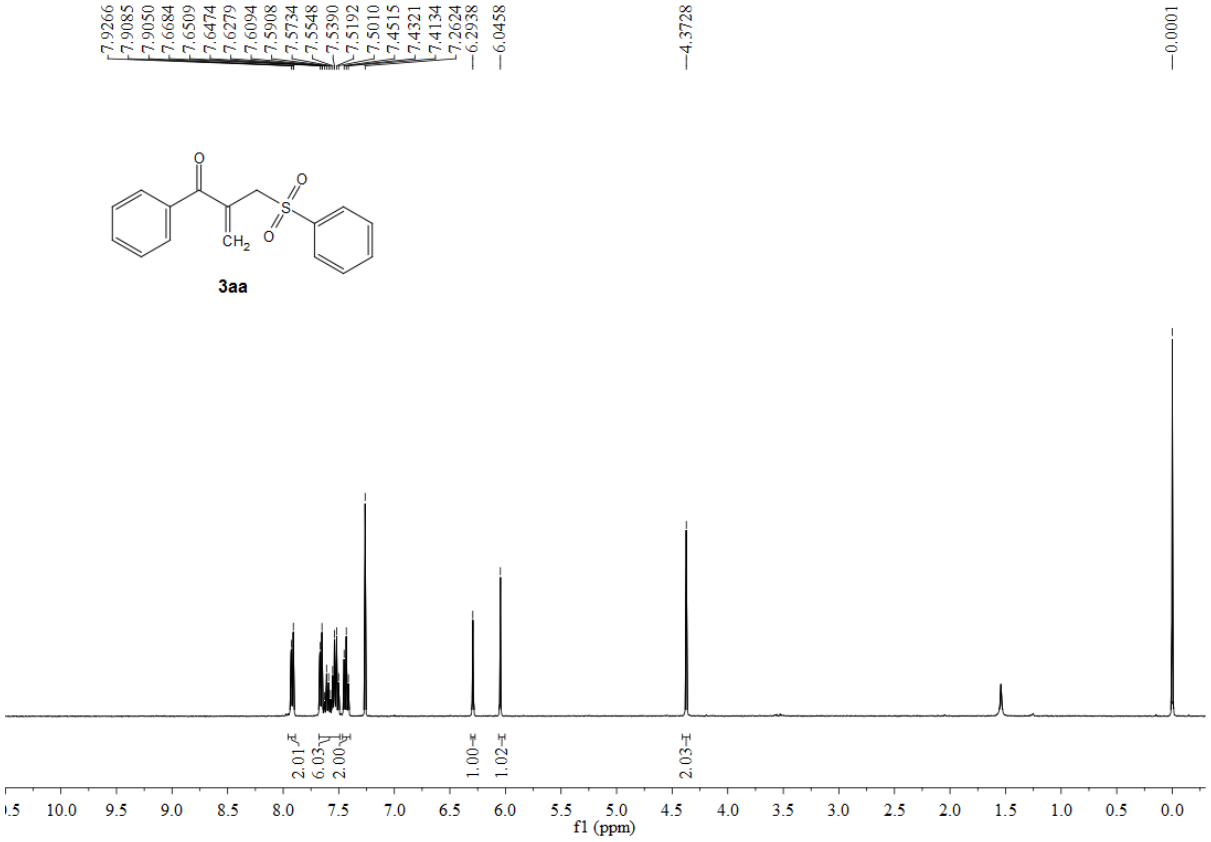


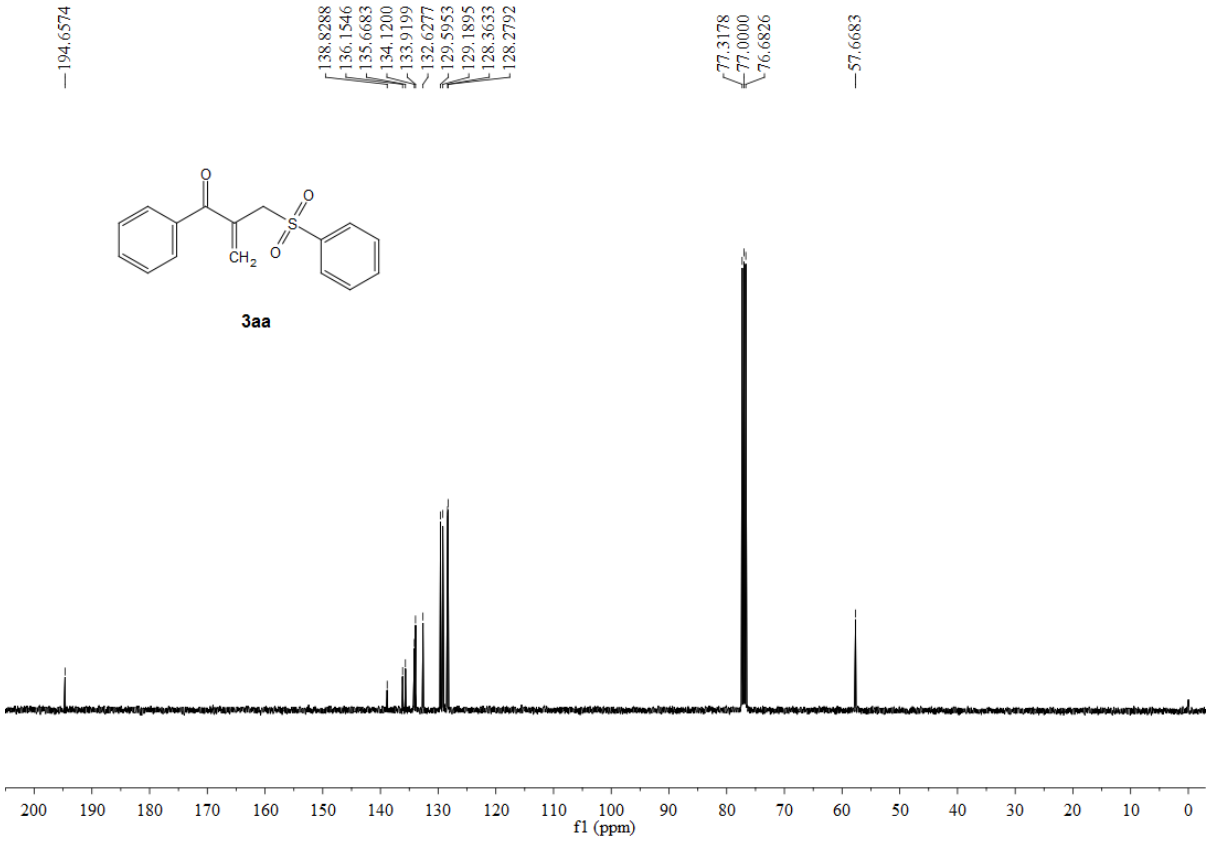
A 10 mL oven-dried reaction vessel was charged with 1-phenyl-2-((phenylsulfonyl)methyl)prop-2-en-1-one (**3aa**) (28.6 mg, 0.2 mmol), benzenesulfonohydrazide (17.2 mg, 0.1 mmol) and H_2O (0.5 mL) under air. The sealed reaction vessel was stirred at 65 ^{o}C for 10 h. After cooling to room temperature, the reaction was diluted with ethyl acetate (5 mL) and washed with saturated sodium chloride solution. The organic layer was separated, and the aqueous layer was extracted with ethyl acetate for three times. The combined organic layer was dried over

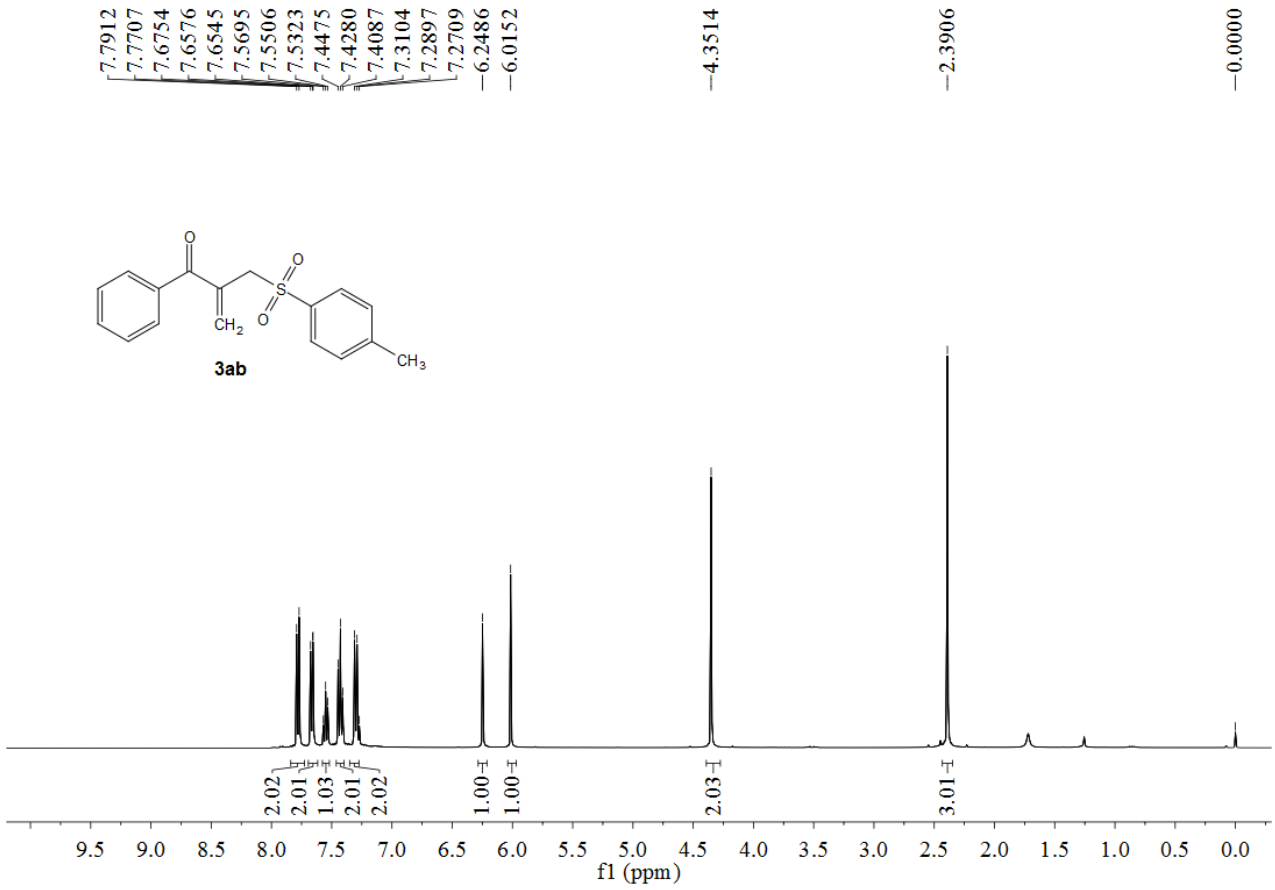
magnesium sulfate and the volatiles were removed under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 7.5:1) to yield the desired product **8a** as white solid (30.0 mg, 70% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86-7.83 (m, 4H), 7.73-7.70 (m, 2H), 7.60-7.55 (m, 7H), 7.38-7.34 (m, 2H), 4.38-4.35 (m, 1H), 3.70-3.65 (m, 2H), 3.56-3.51 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.0, 138.2, 134.23, 134.19, 133.8, 129.5, 129.0, 128.4, 128.3, 55.2, 35.2.

NMR Spectra for the compounds prepared



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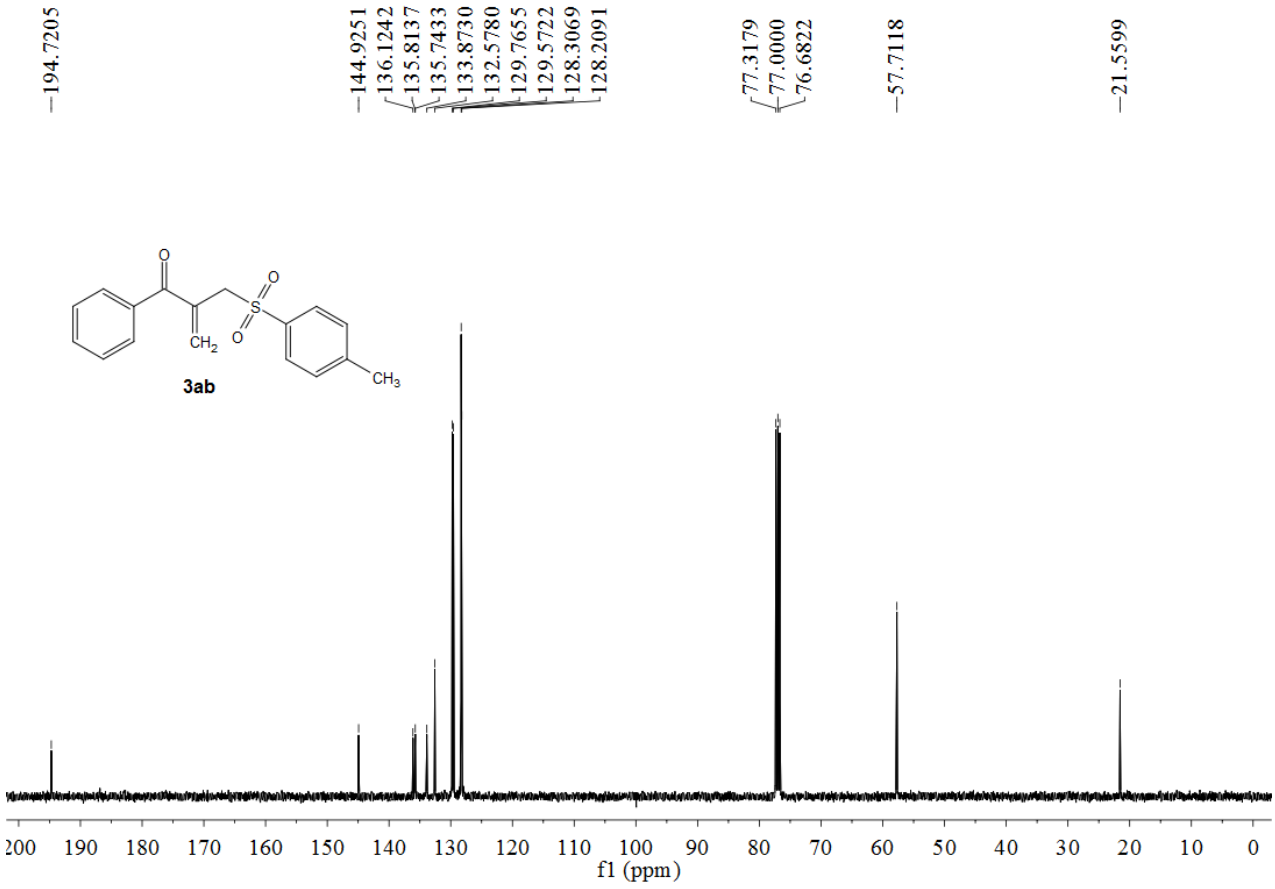
7.4087
7.3104
7.2897
7.2709
6.2486
6.0152
4.3514
2.3906
0.0000
O
O
S
O
CH2
CH3
3ab
2.02
2.01
1.03
2.01
2.02
1.00
1.00
2.03
3.01
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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O
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O
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CH3
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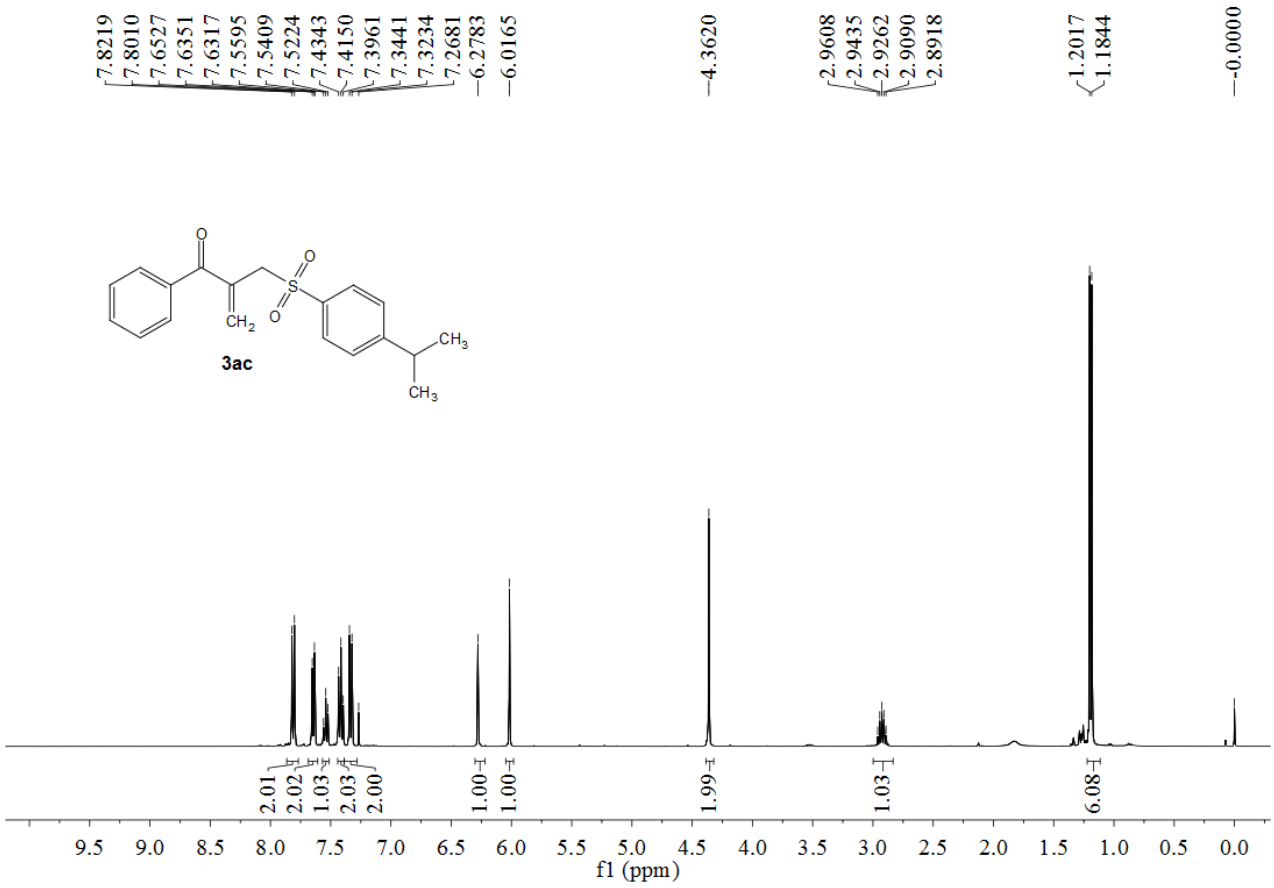
f1 (ppm)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7.2681
6.2783
6.0165
4.3620
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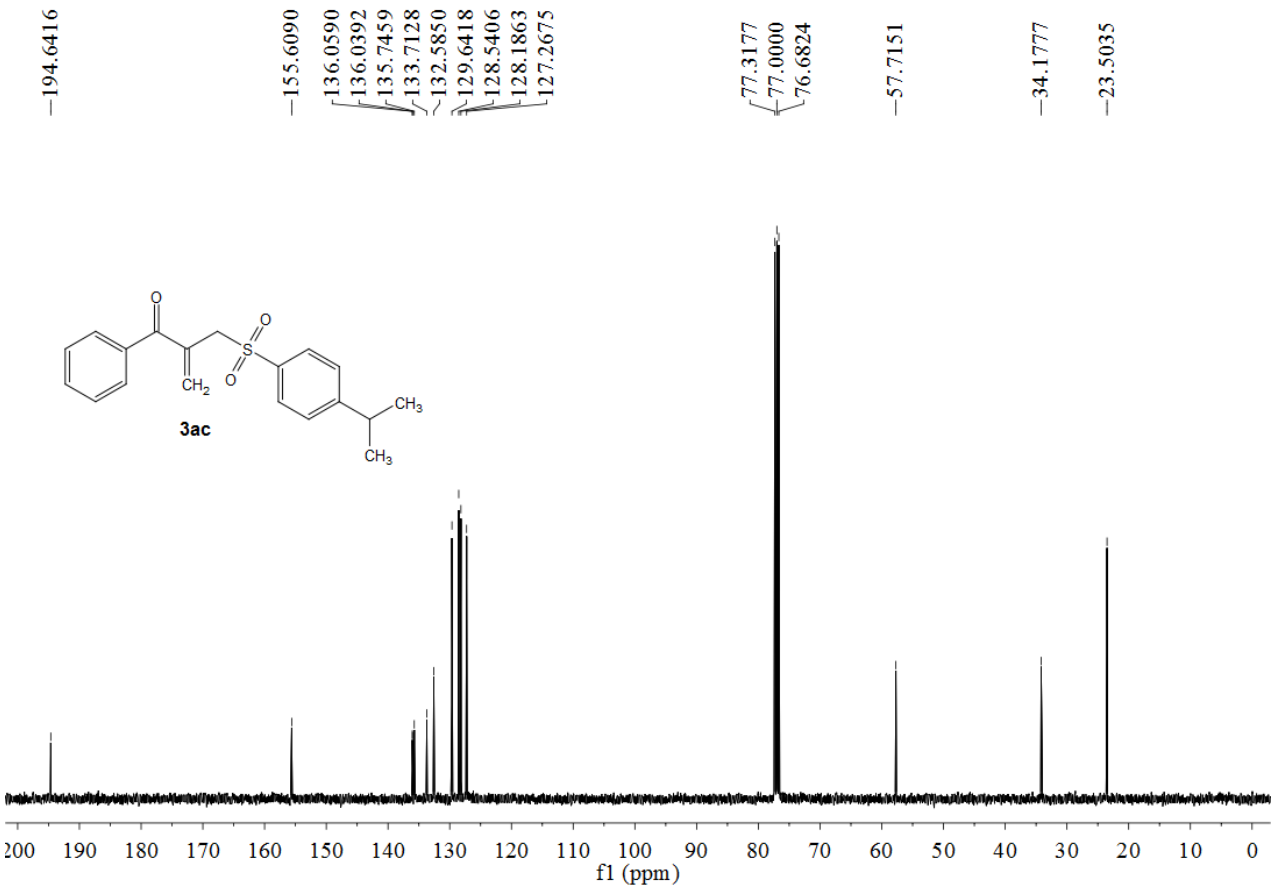
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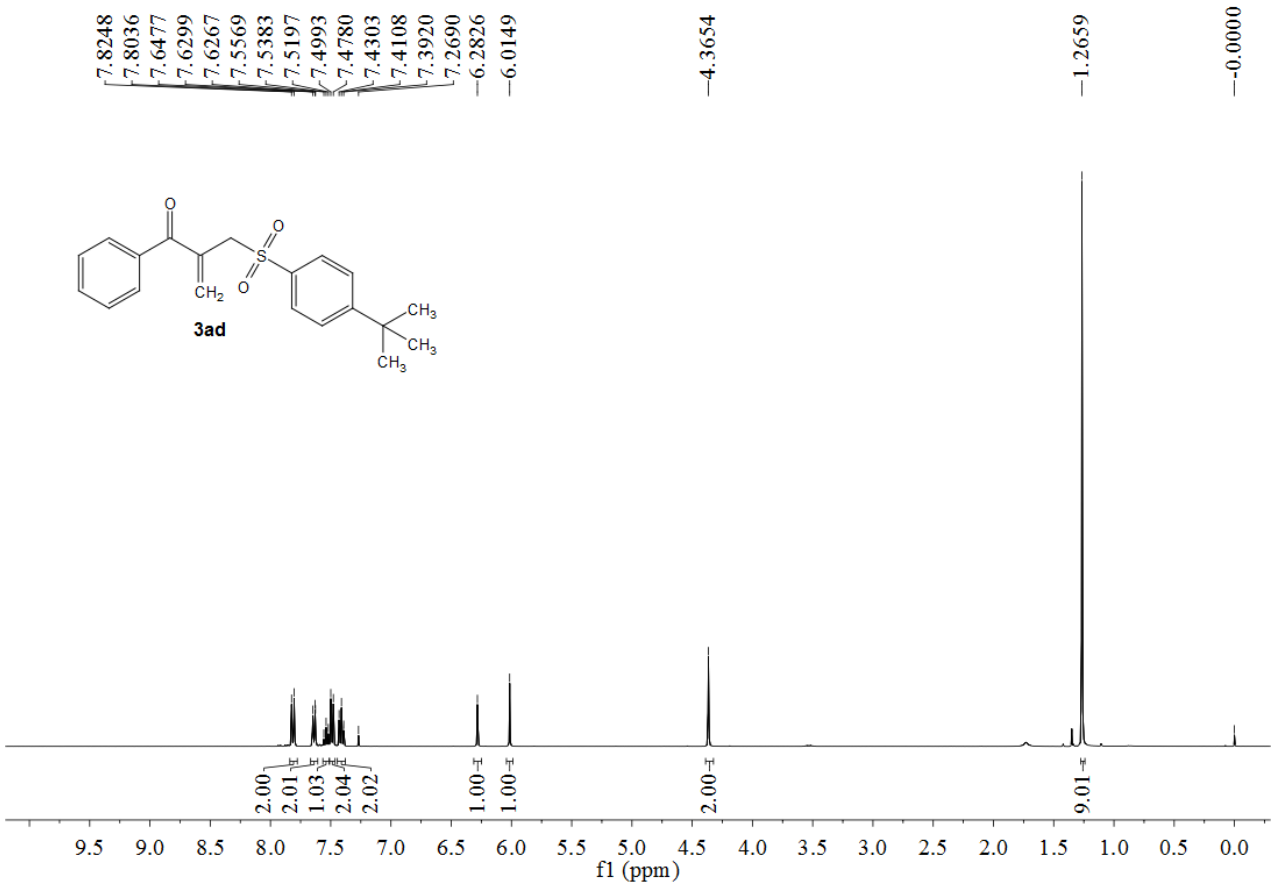
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4.3654
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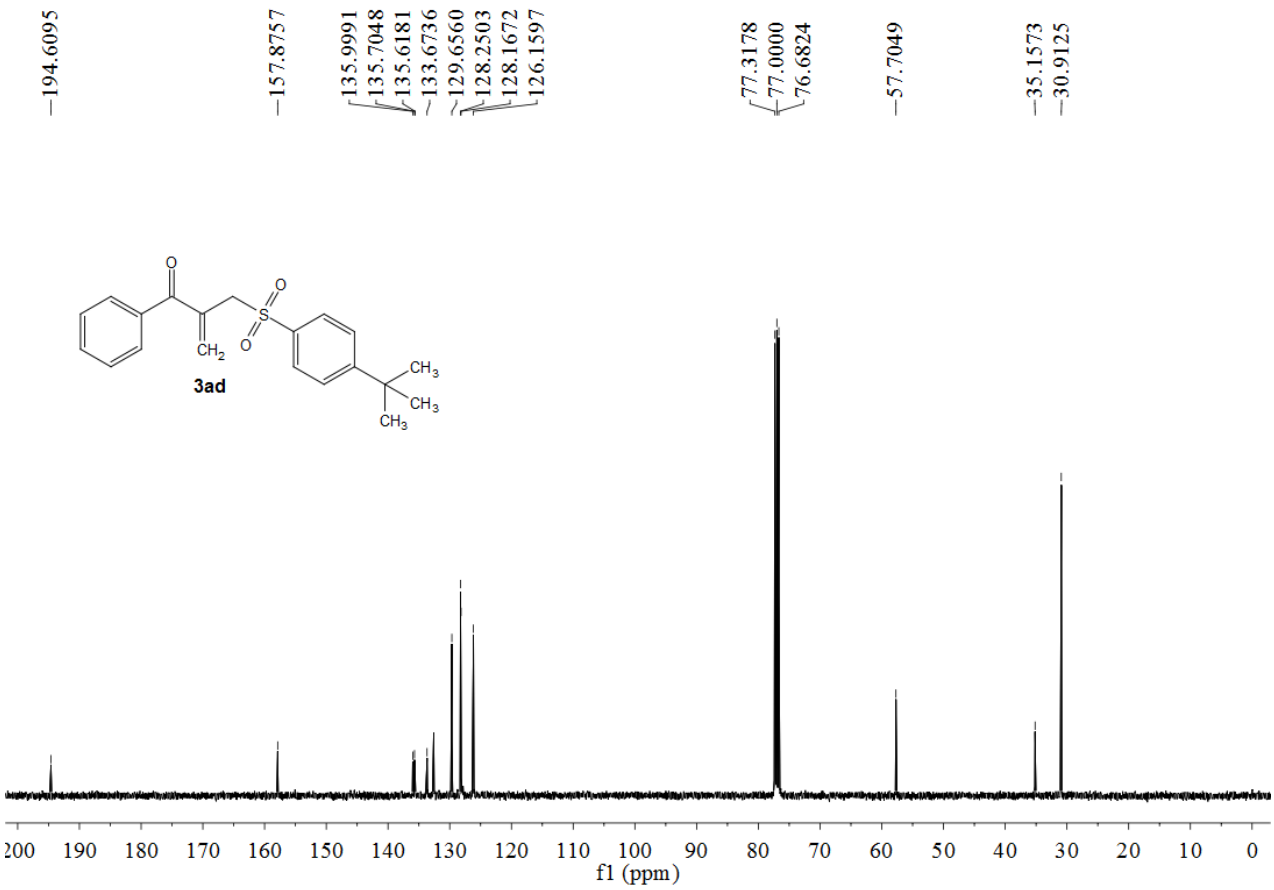
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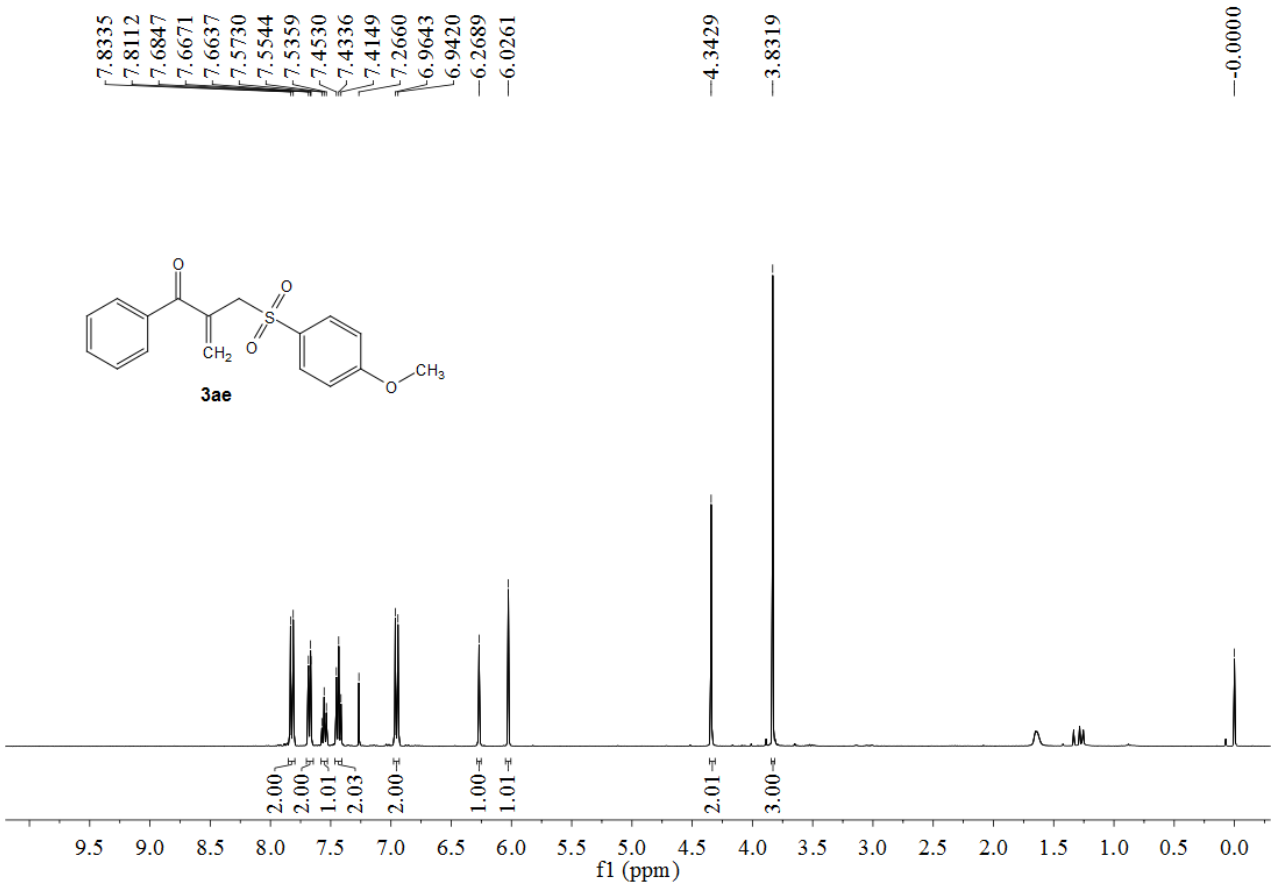
f1 (ppm)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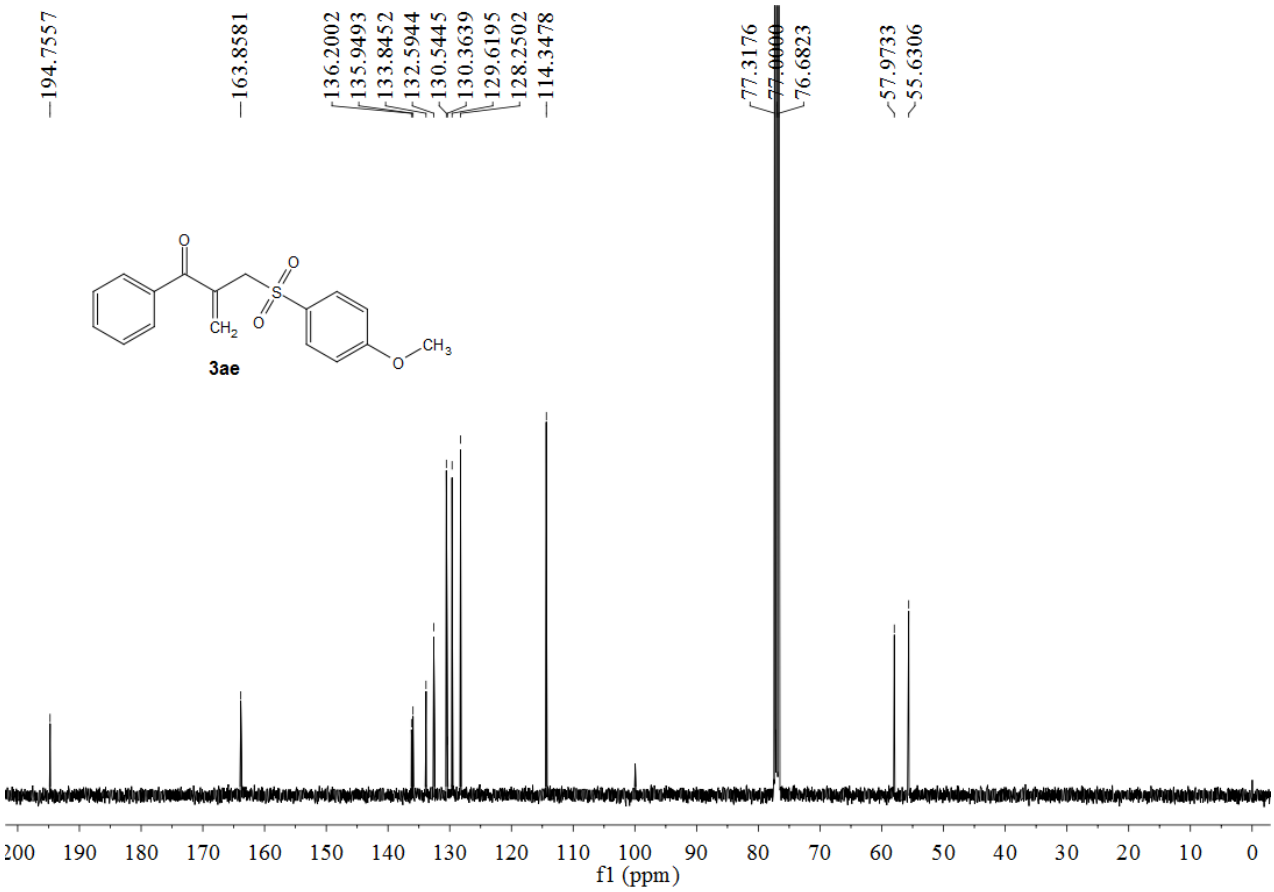
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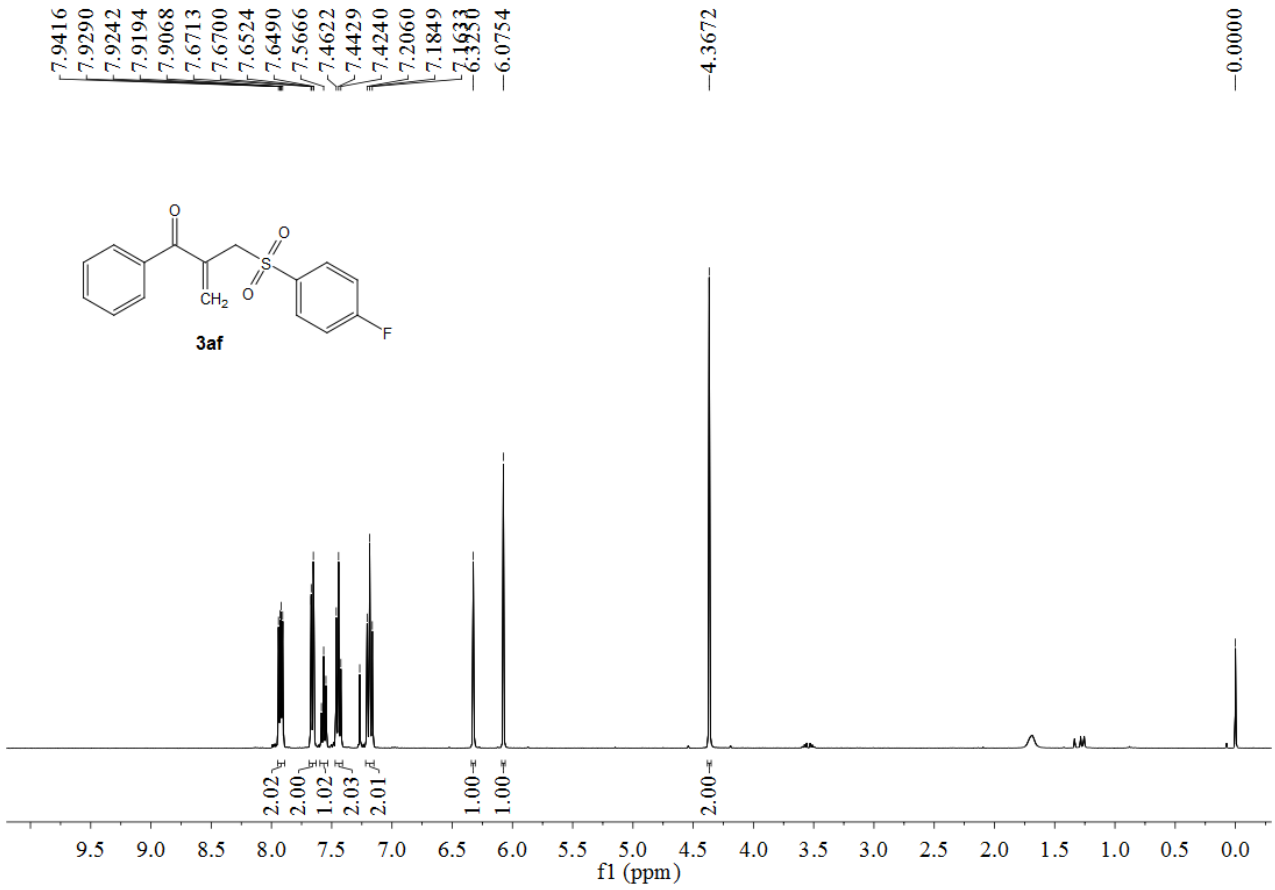
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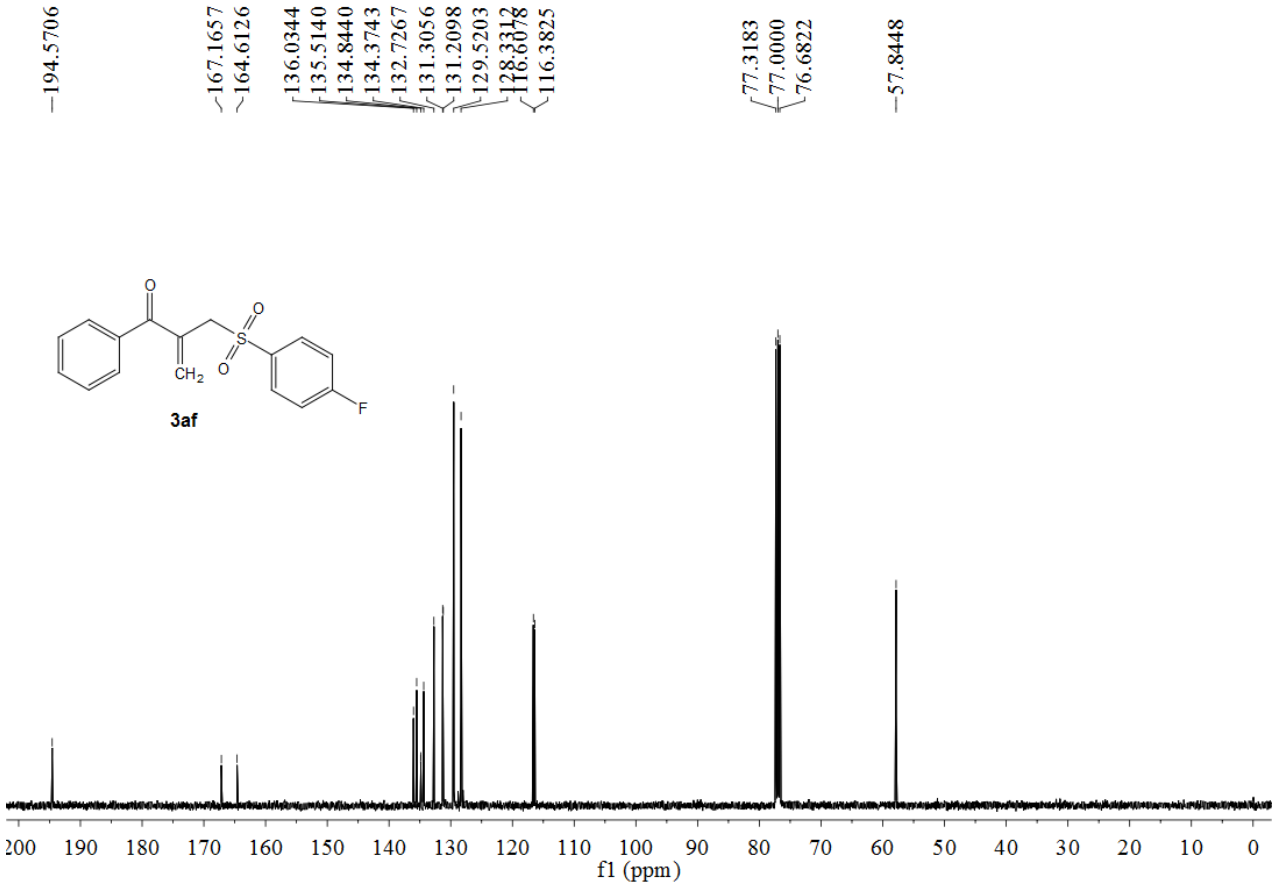
f1 (ppm)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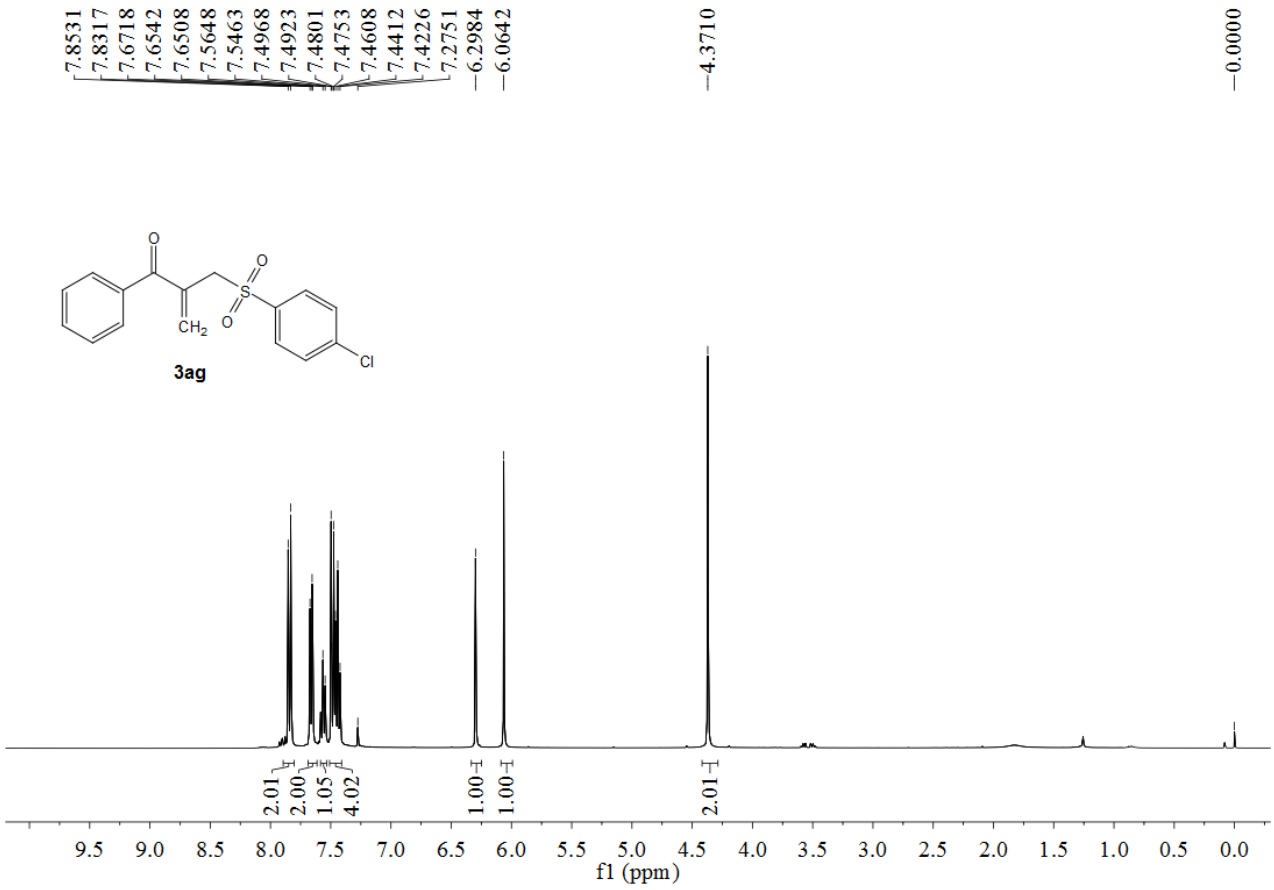
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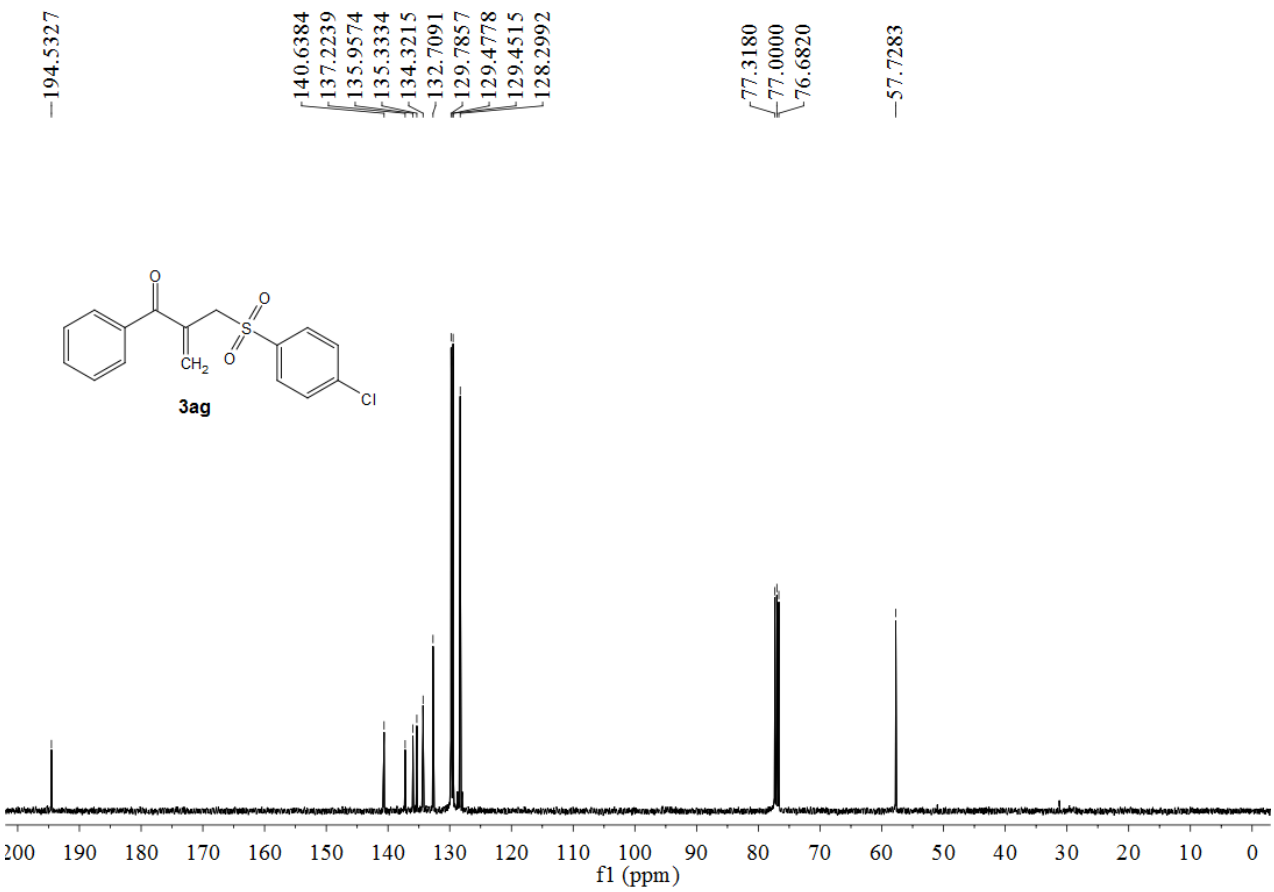
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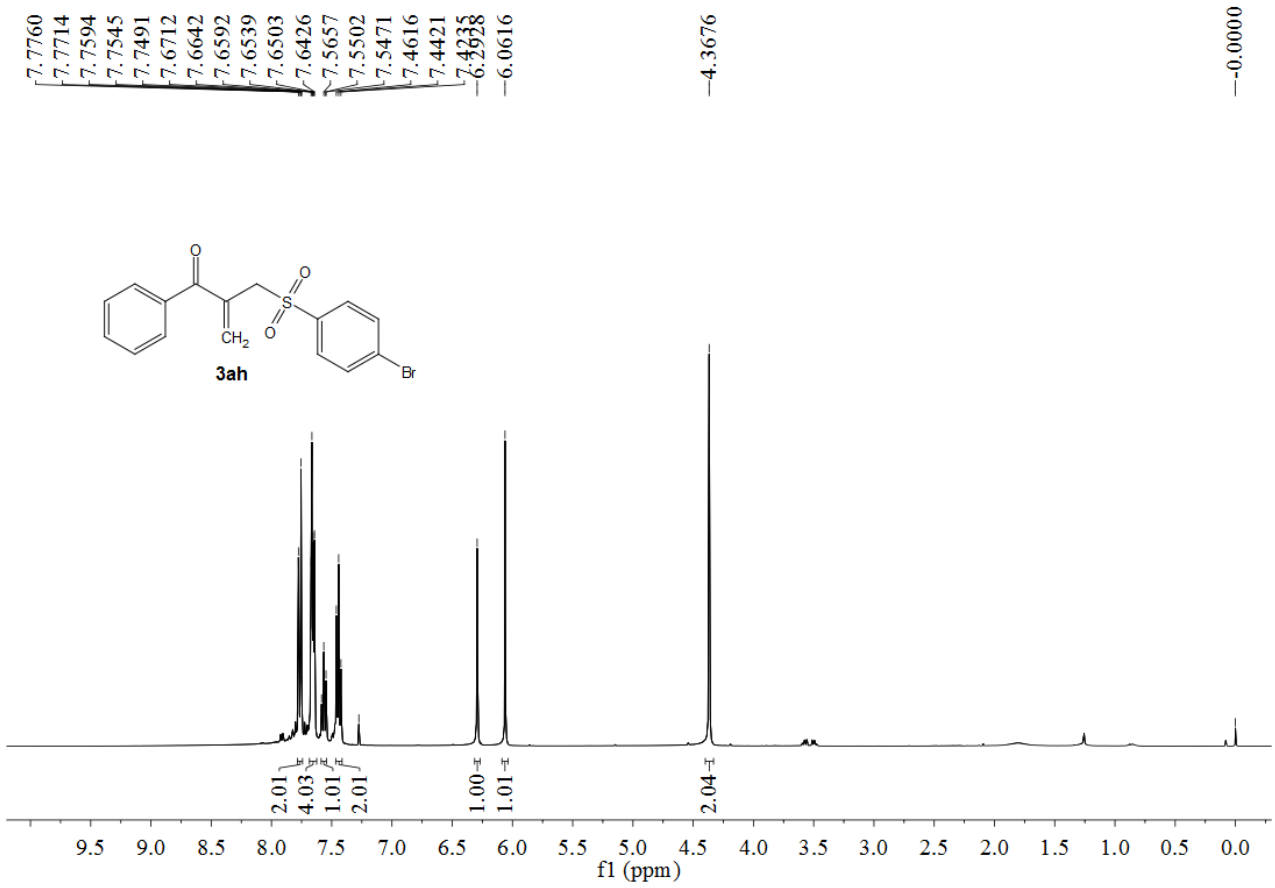
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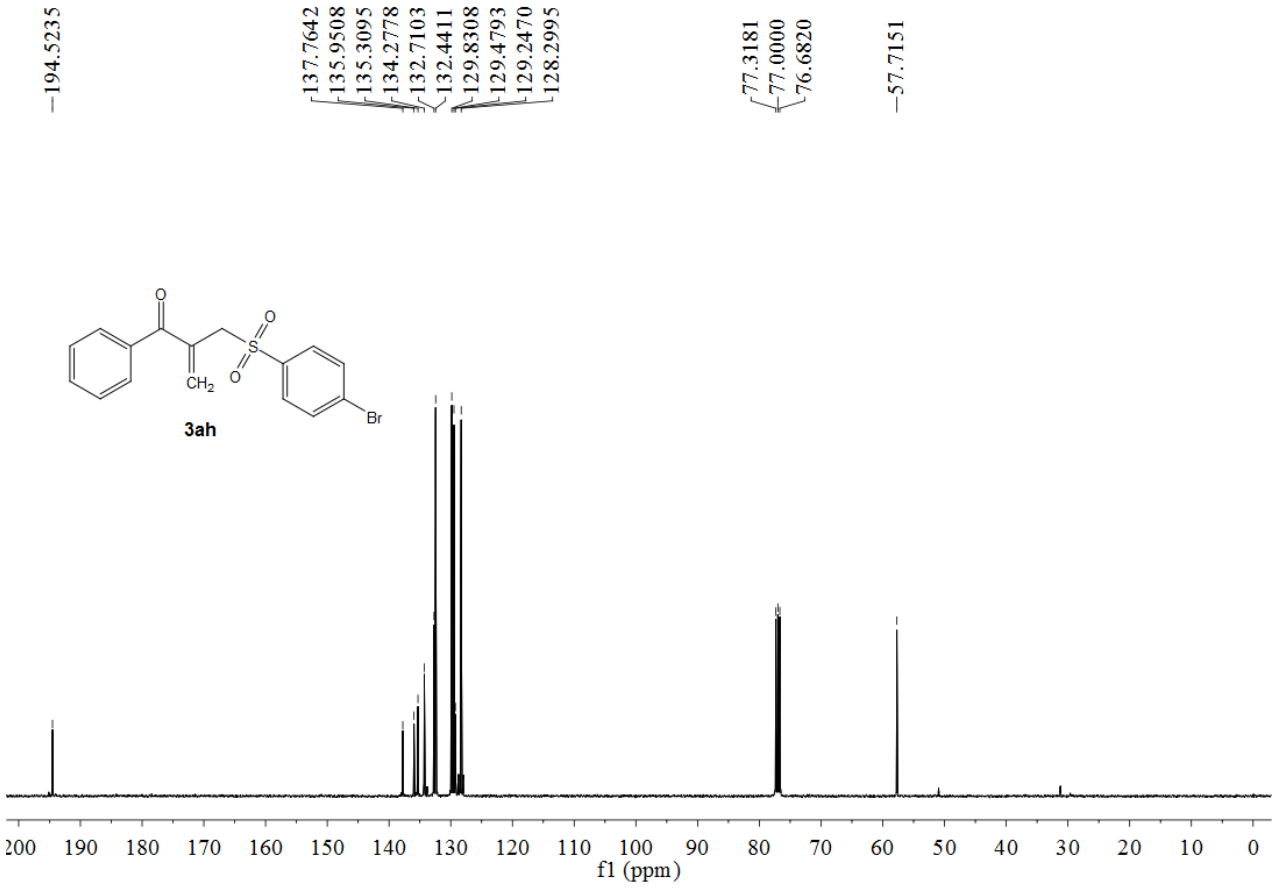
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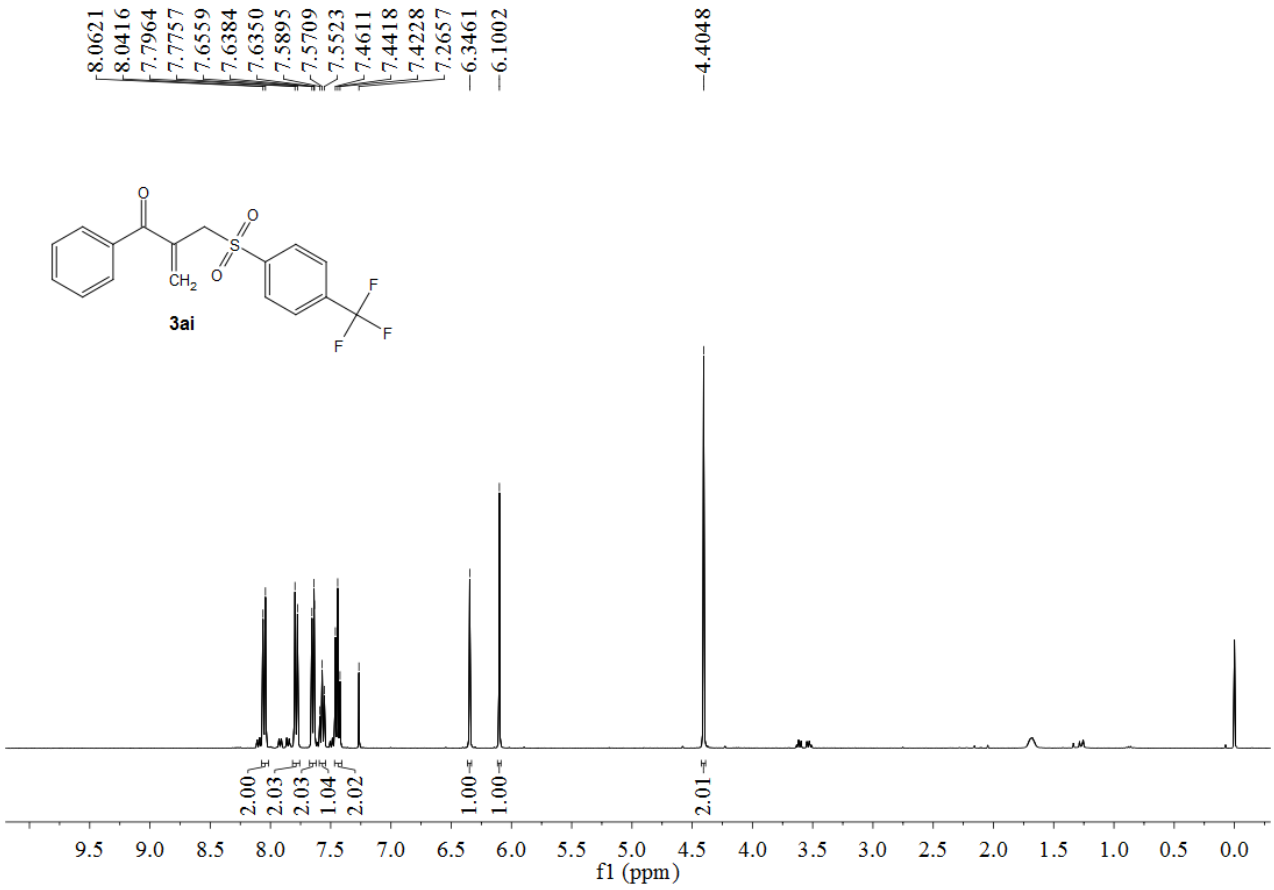
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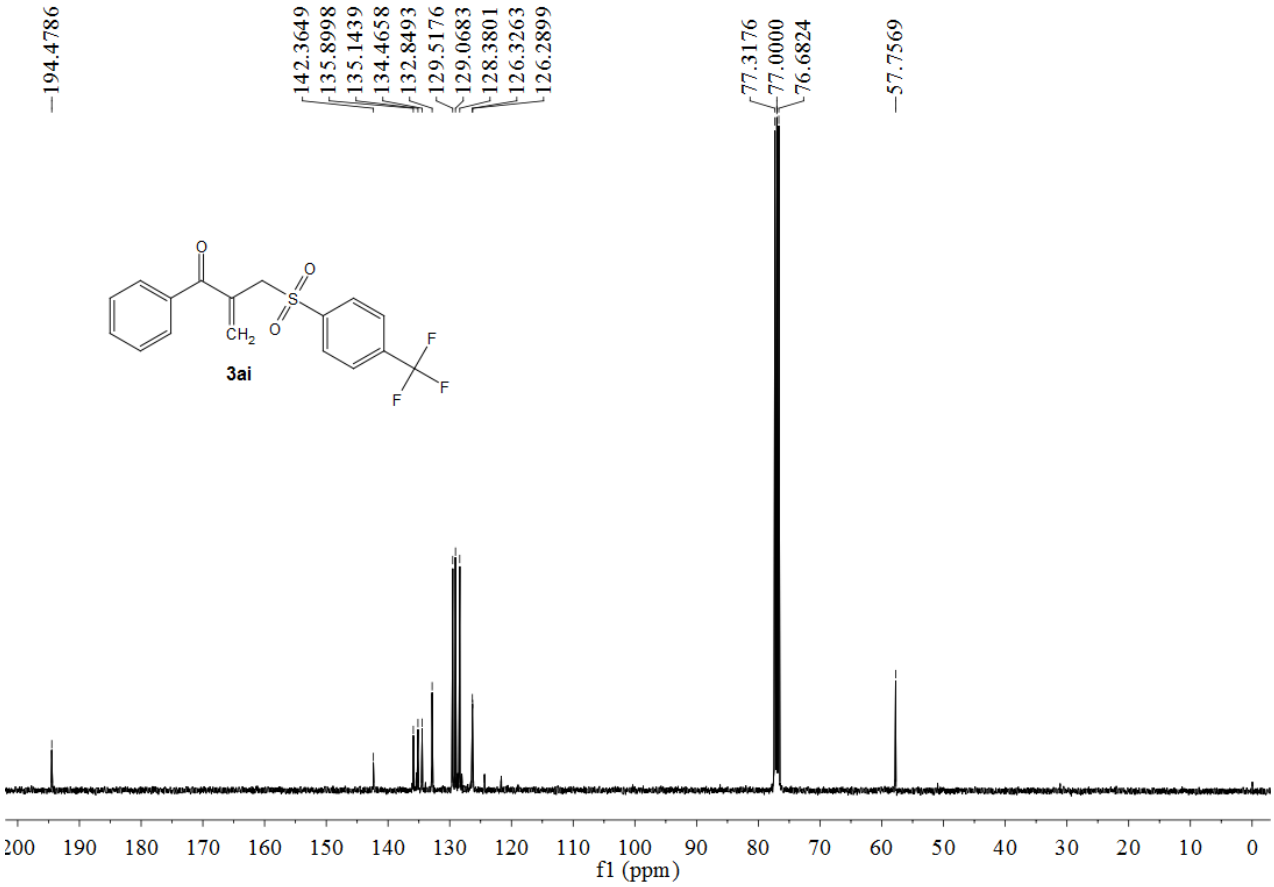
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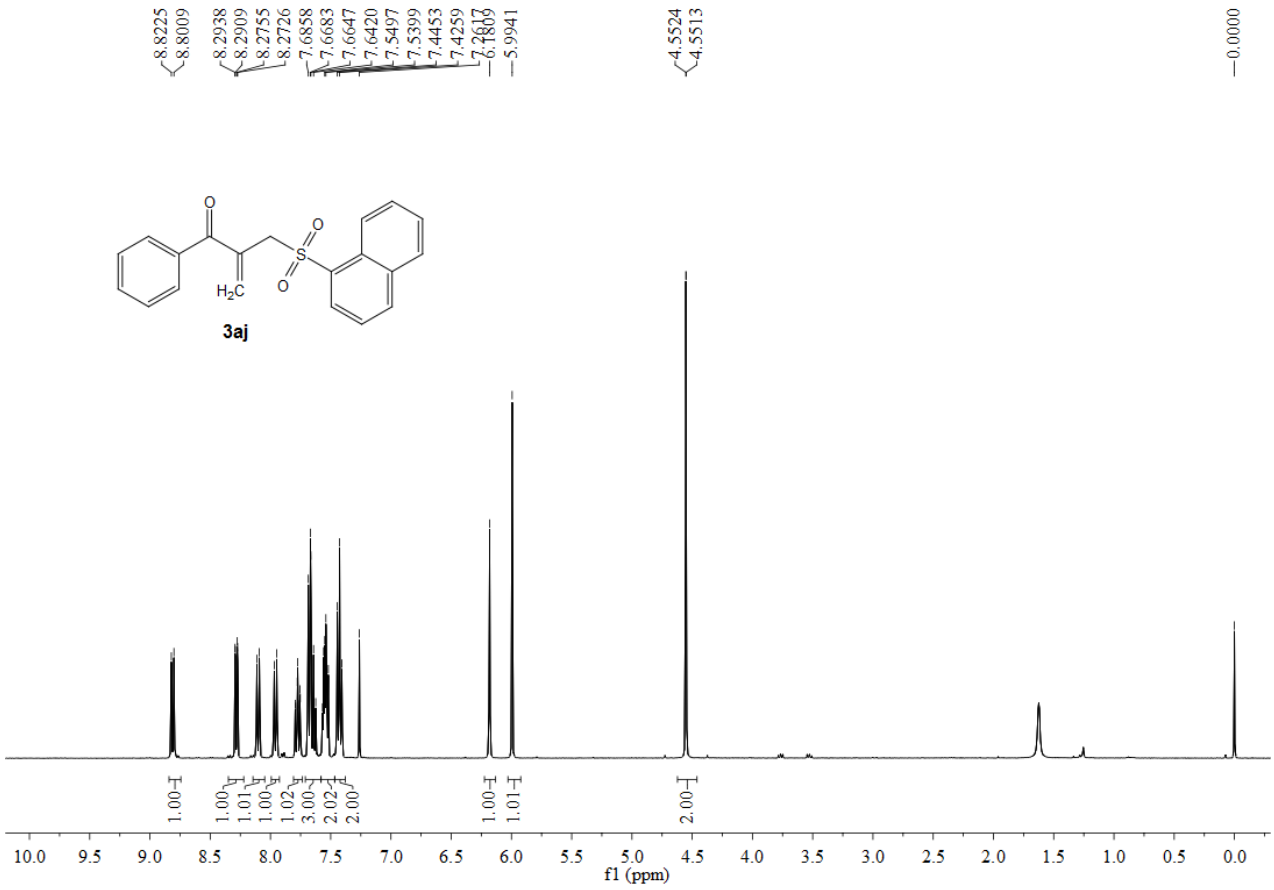
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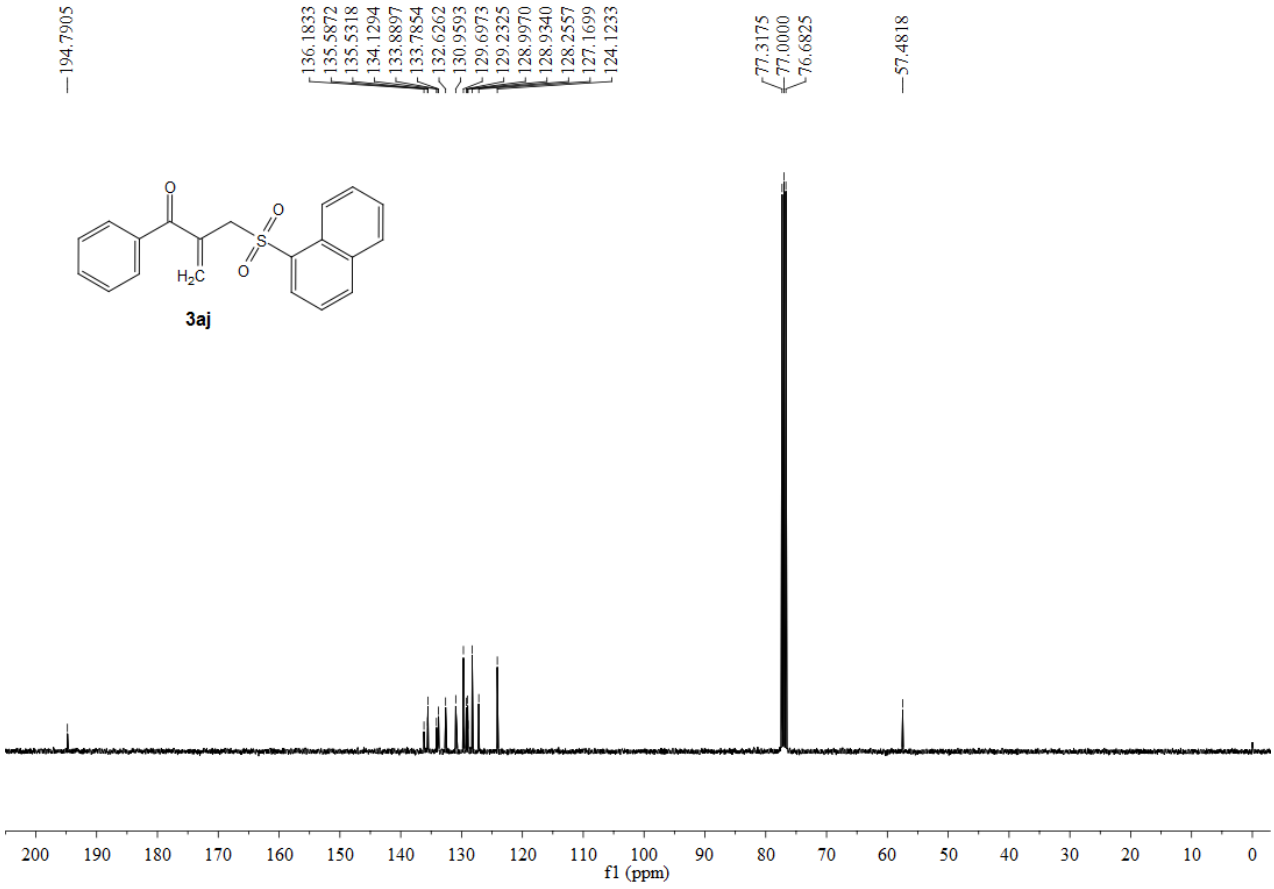
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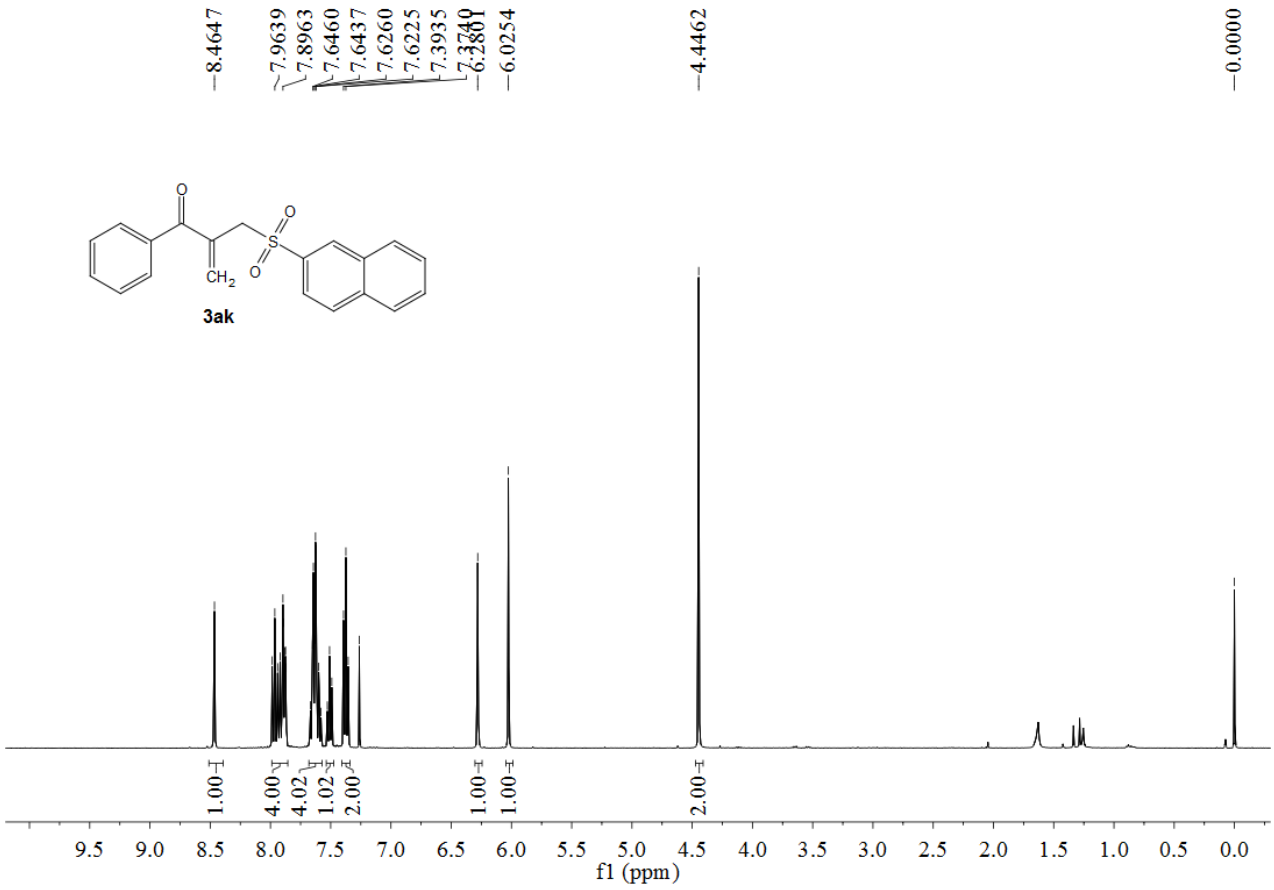
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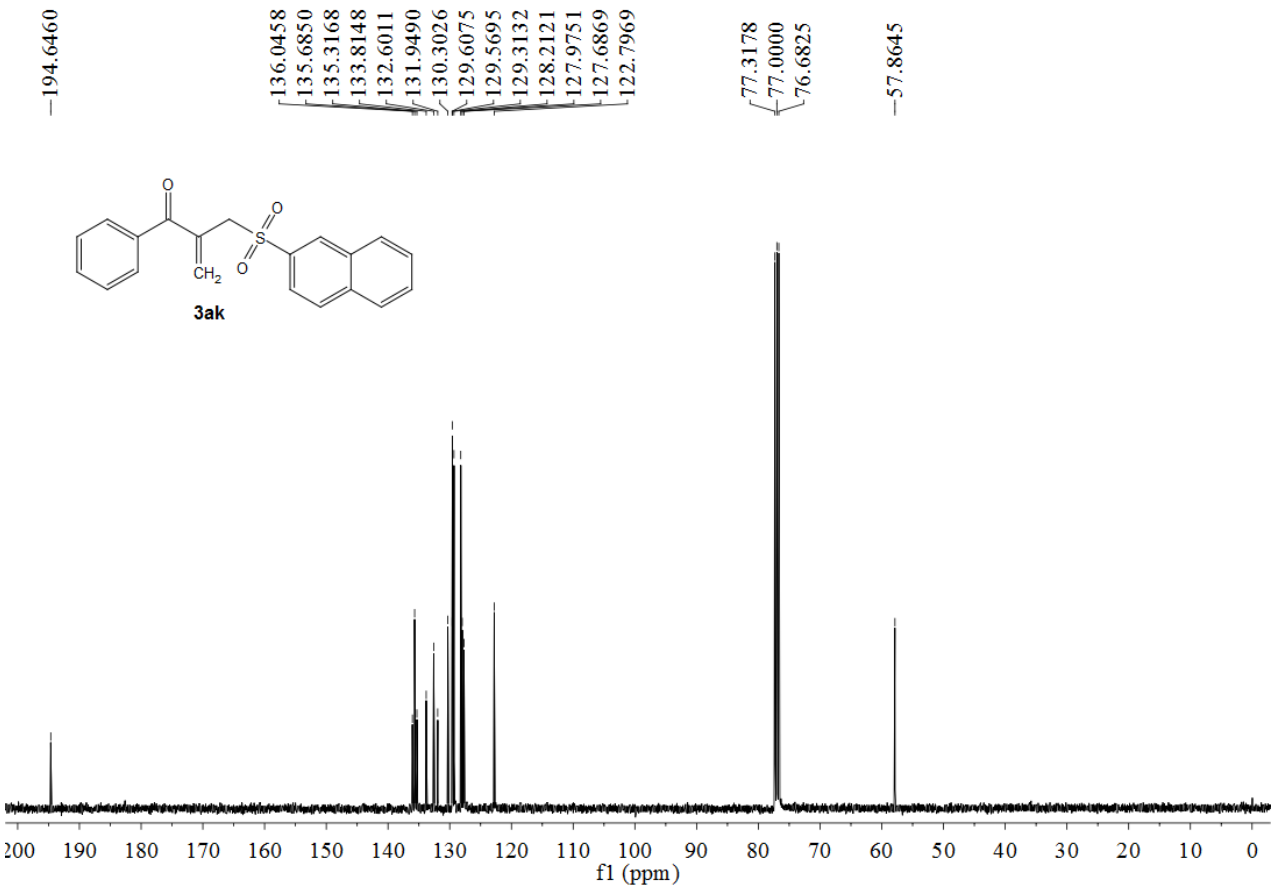
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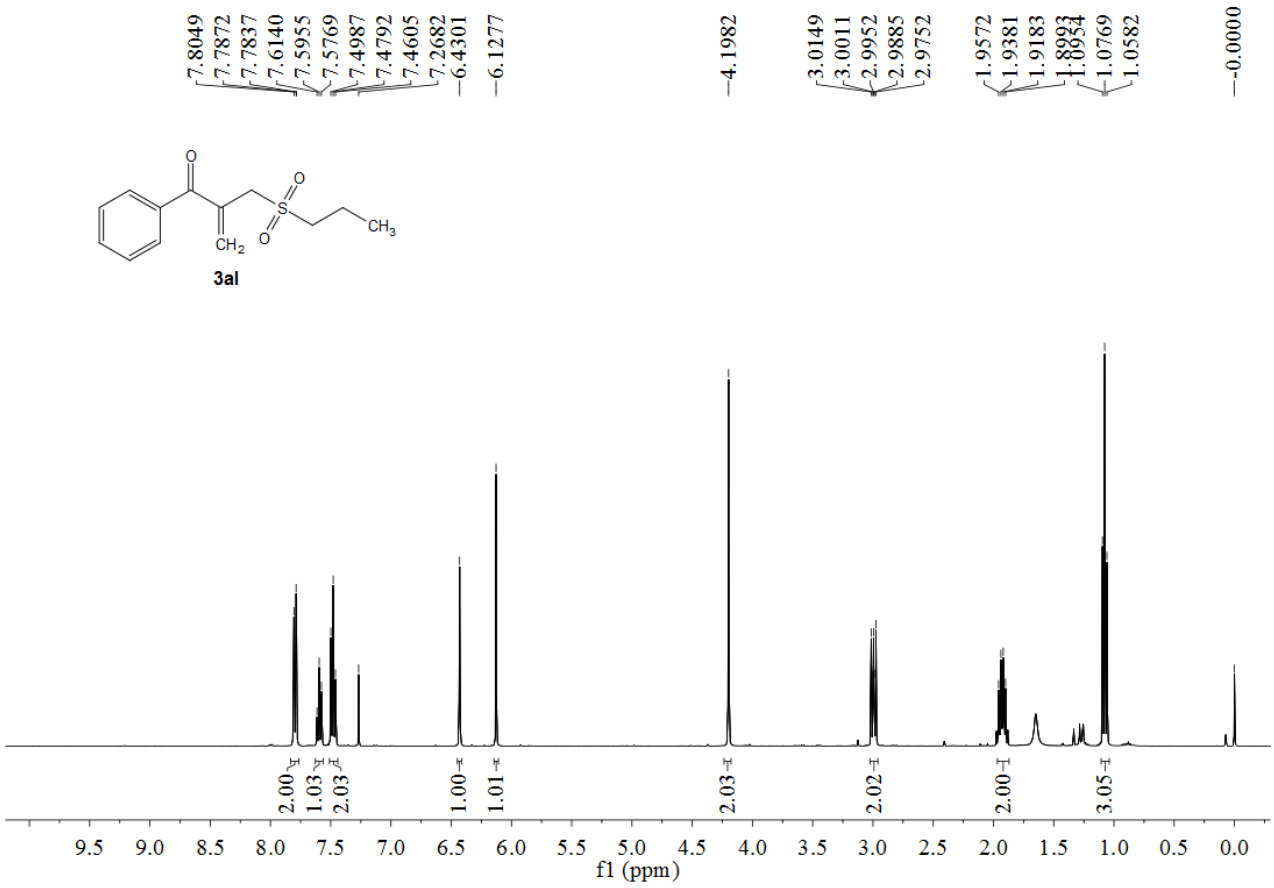
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CH3
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2.03
1.00
1.01
2.03
2.02
2.00
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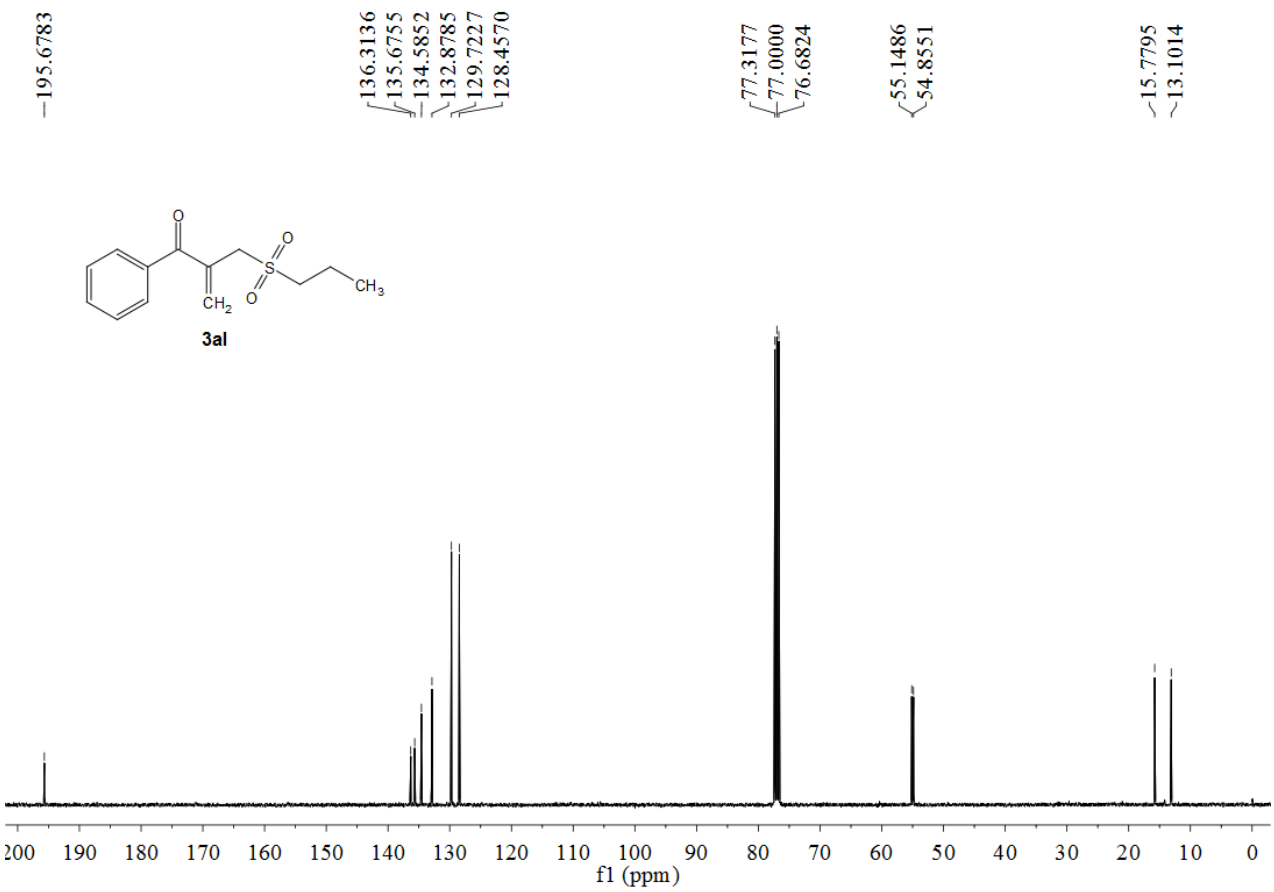
f1 (ppm)

3al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CH3
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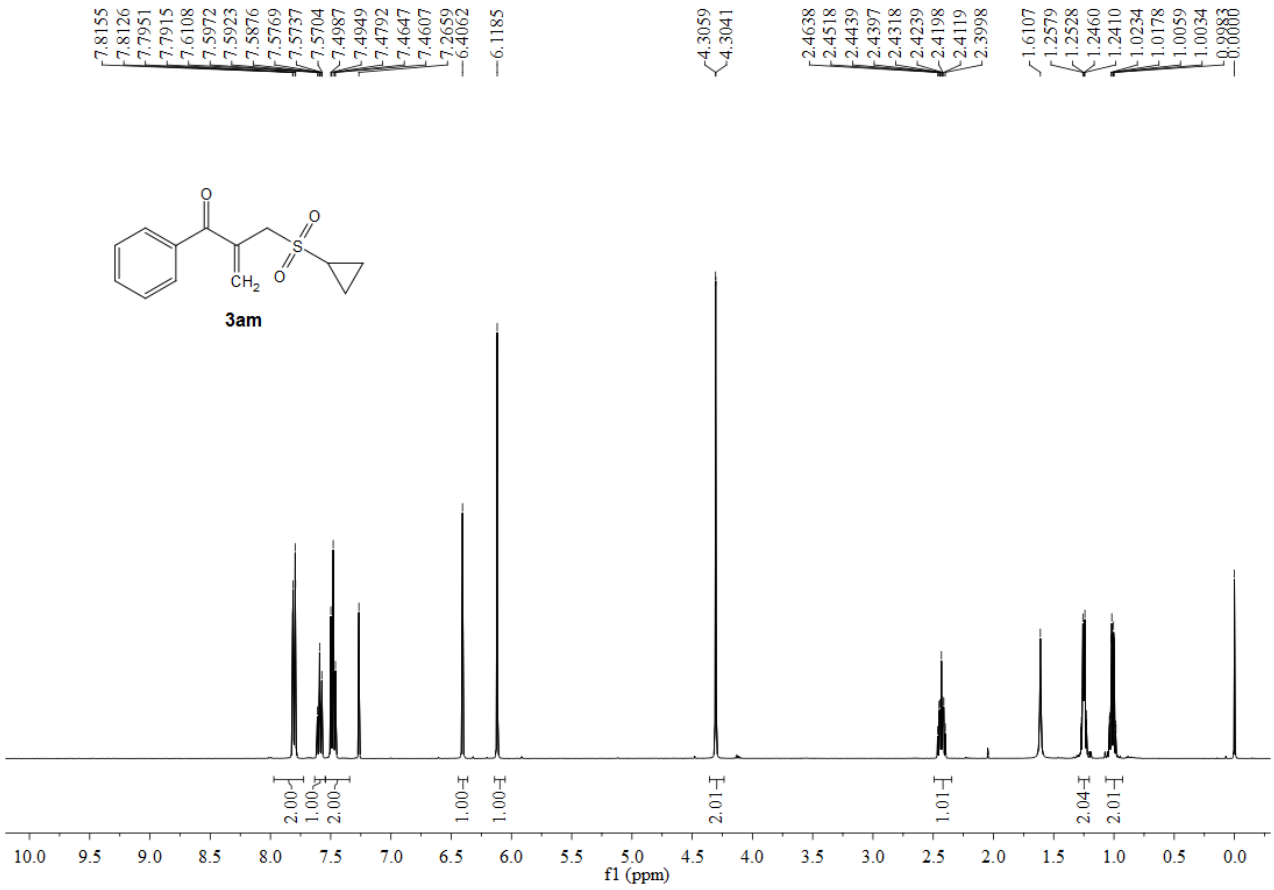
f1 (ppm)

3al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7.4987
7.4949
7.4792
7.4647
7.4607
7.2659
6.4062
6.1185
4.3059
4.3041
2.4638
2.4518
2.4439
2.4397
2.4318
2.4239
2.4198
2.4119
2.3998
1.6107
1.2579
1.2528
1.2460
1.2410
1.0234
1.0178
1.0059
1.0034
0.9883
0.0000
O
O
O
S
CH2
3am
2.00
1.00
2.00
1.00
1.00
2.01
1.01
2.04
2.01
10.0 9.5 9.0 8.5 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
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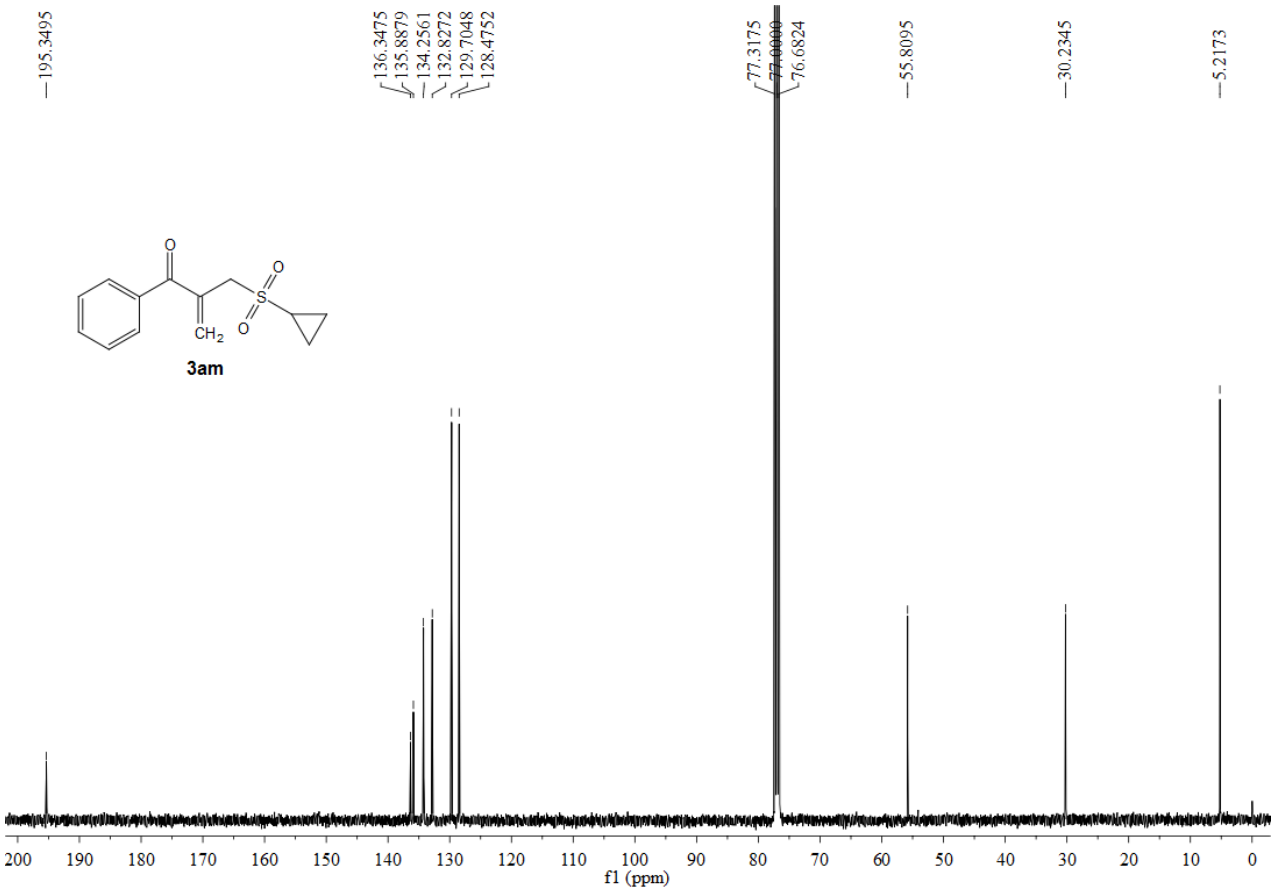
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55.8095
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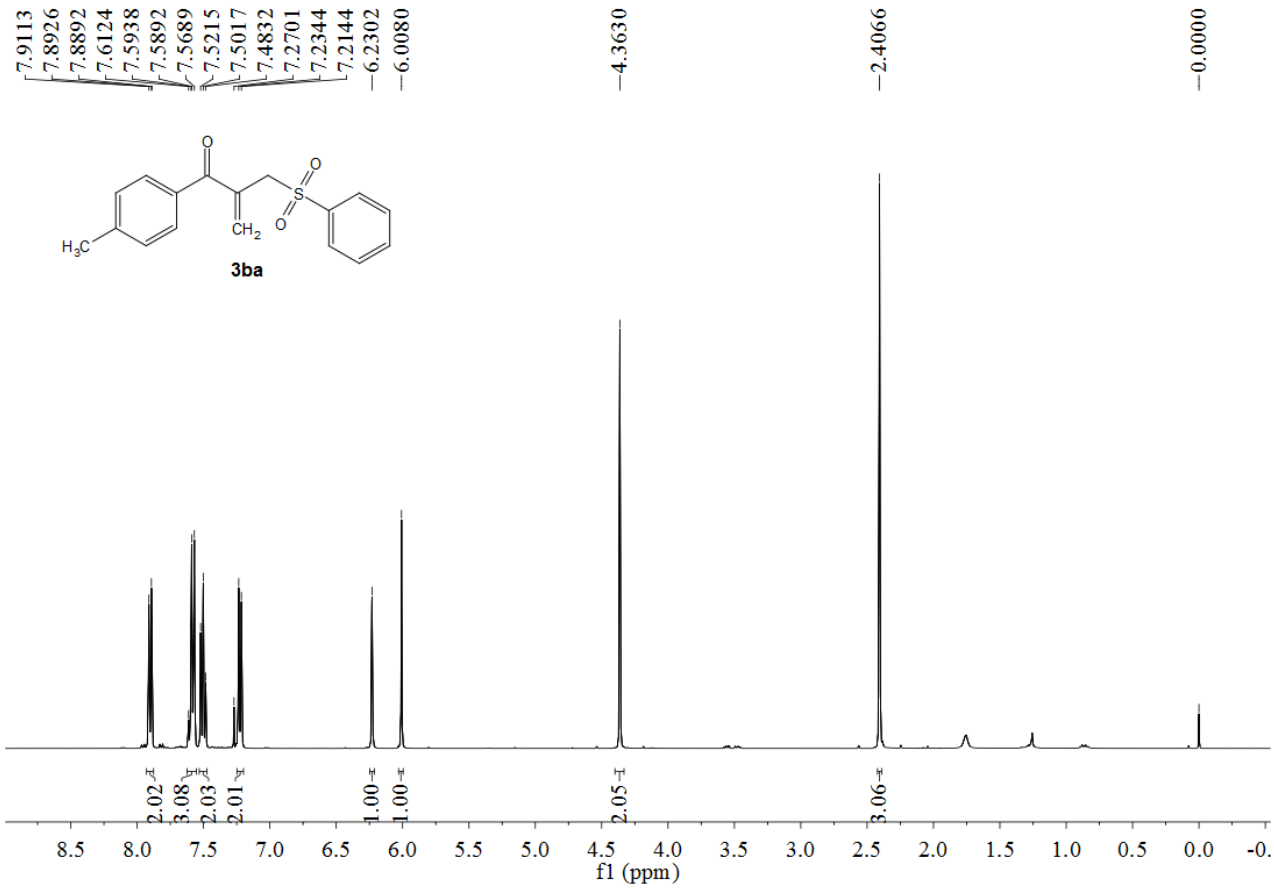
5.2173
O
O
O
S
CH2
3am
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.2701
7.2344
7.2144
6.2302
6.0080
4.3630
2.4066
0.0000
O
O
S
O
CH2
H3C
3ba
2.02
3.08
2.03
2.01
1.00
1.00
2.05
3.06
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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4.0
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3.0
2.5
2.0
1.5
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0.5
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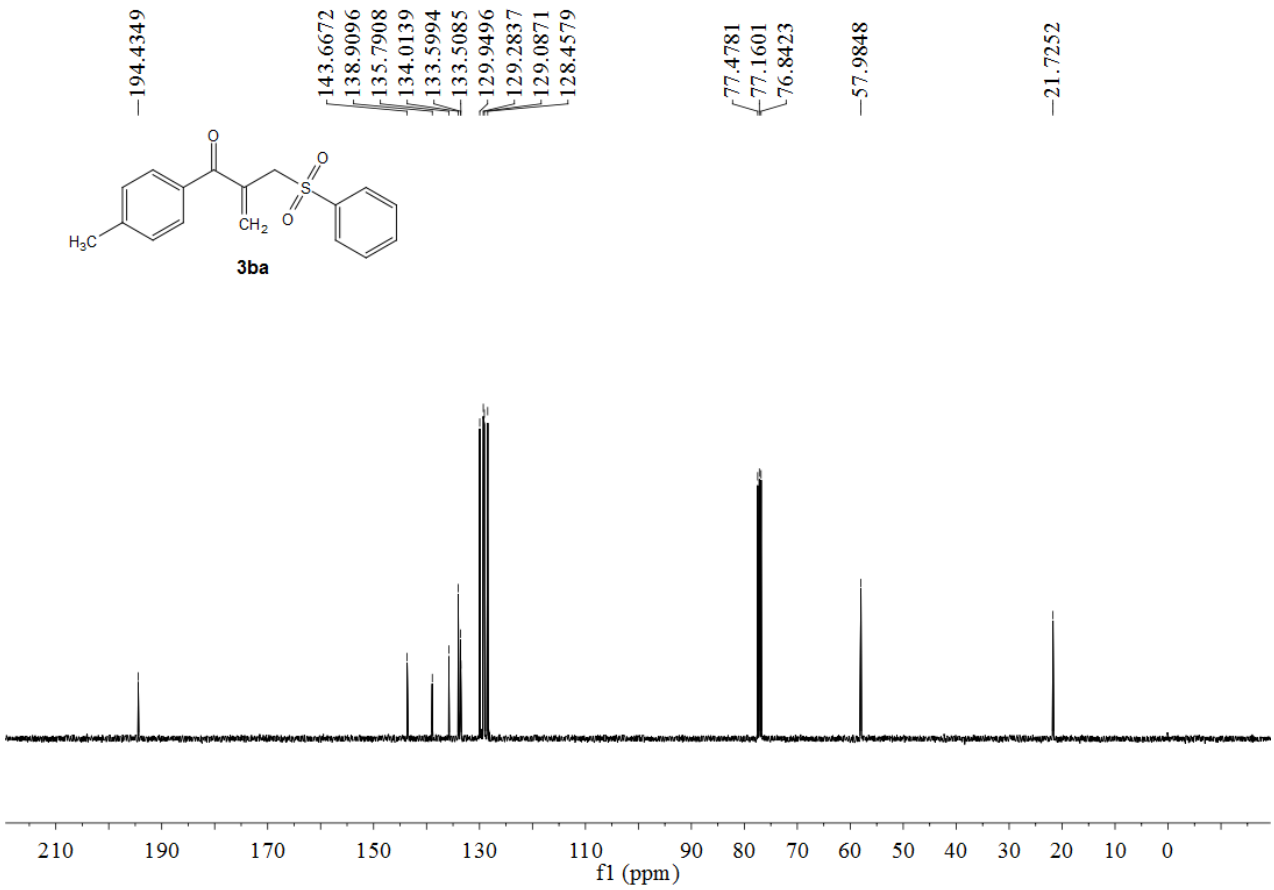
f1 (ppm)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128.4579
77.4781
77.1601
76.8423
57.9848
21.7252
O
O
S
O
CH2
H3C
3ba
210
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170
150
130
110
90
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70
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50
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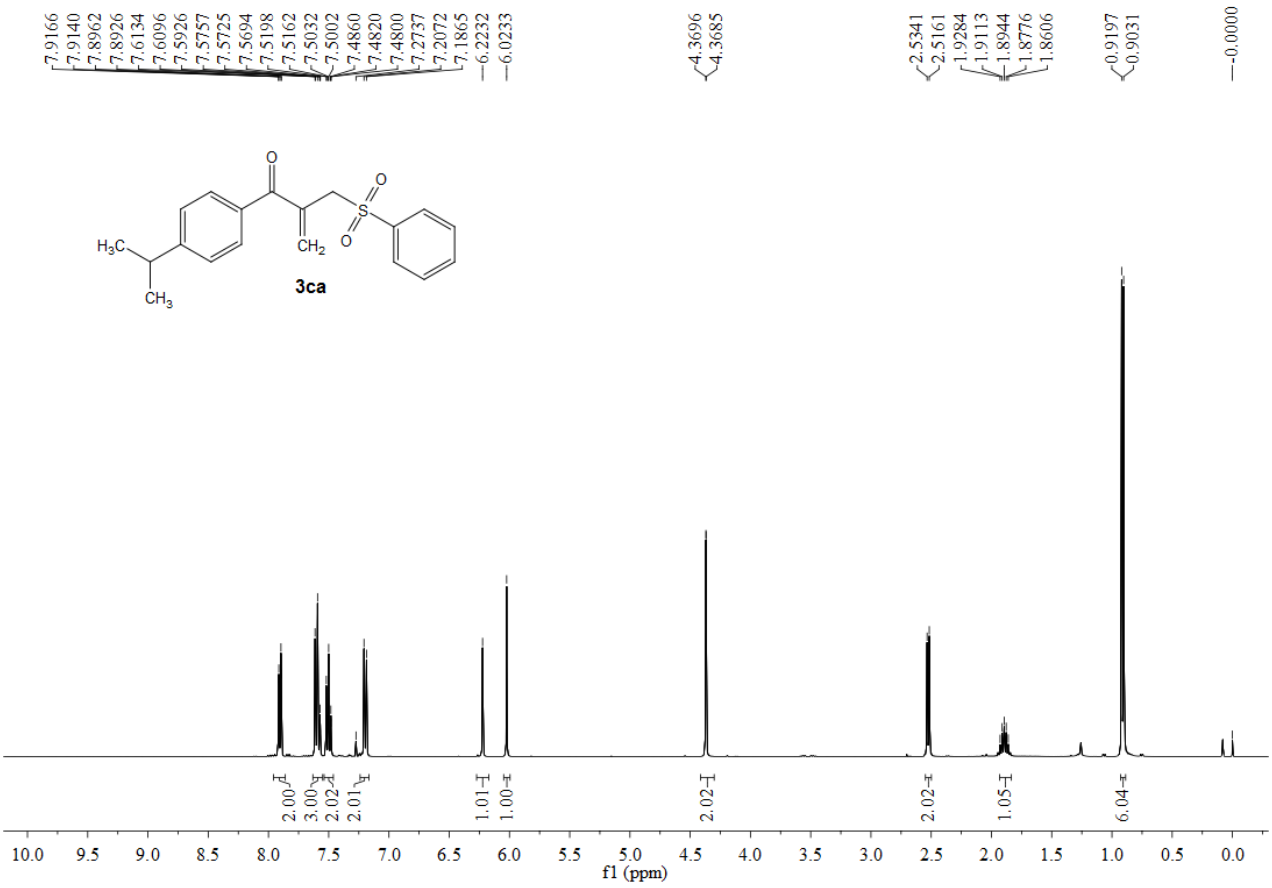
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7.5032
7.5002
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7.2737
7.2072
7.1865
6.2232
6.0233
4.3696
4.3685
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2.5161
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1.9113
1.8944
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1.8606
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0.0000
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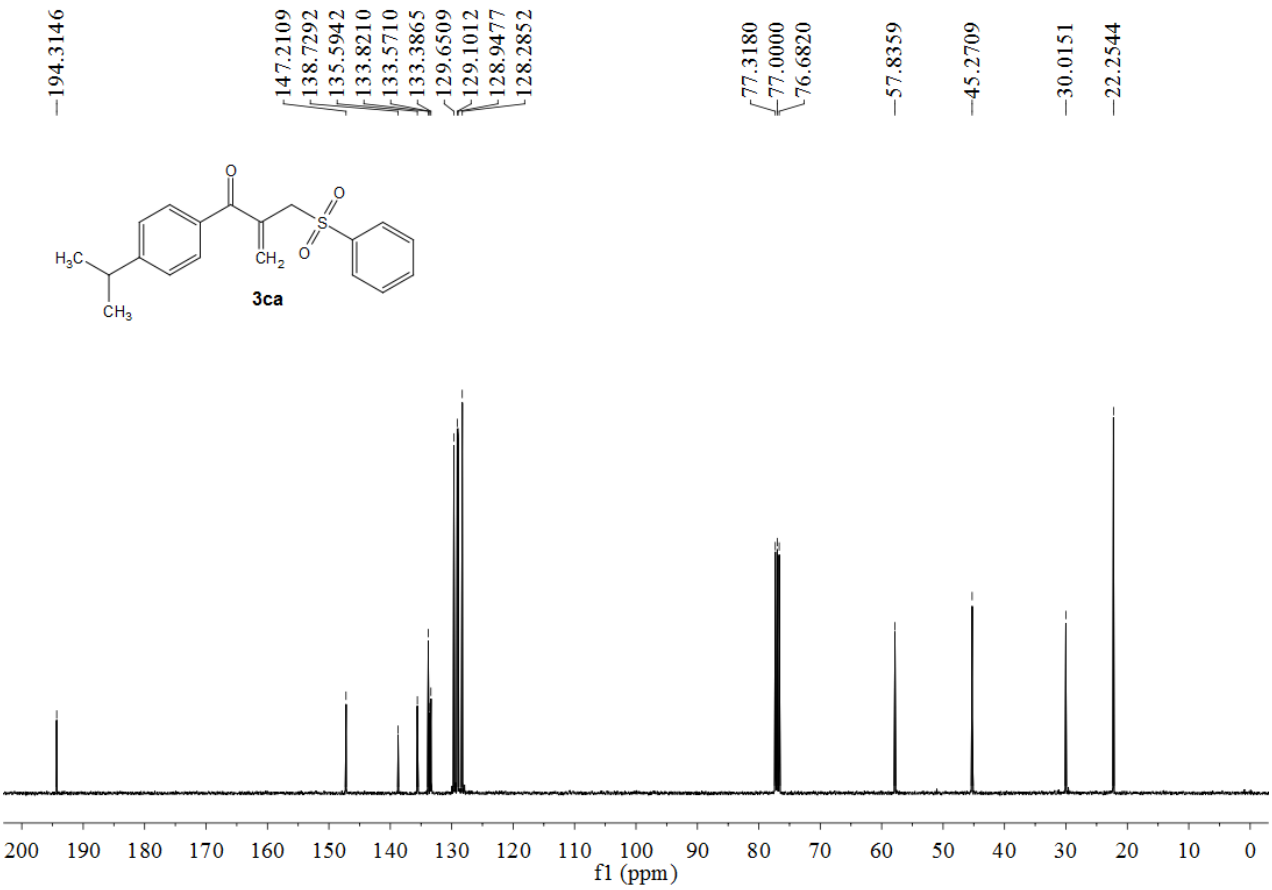
2.01
1.01
1.00
2.02
2.02
1.05
6.04
f1 (ppm)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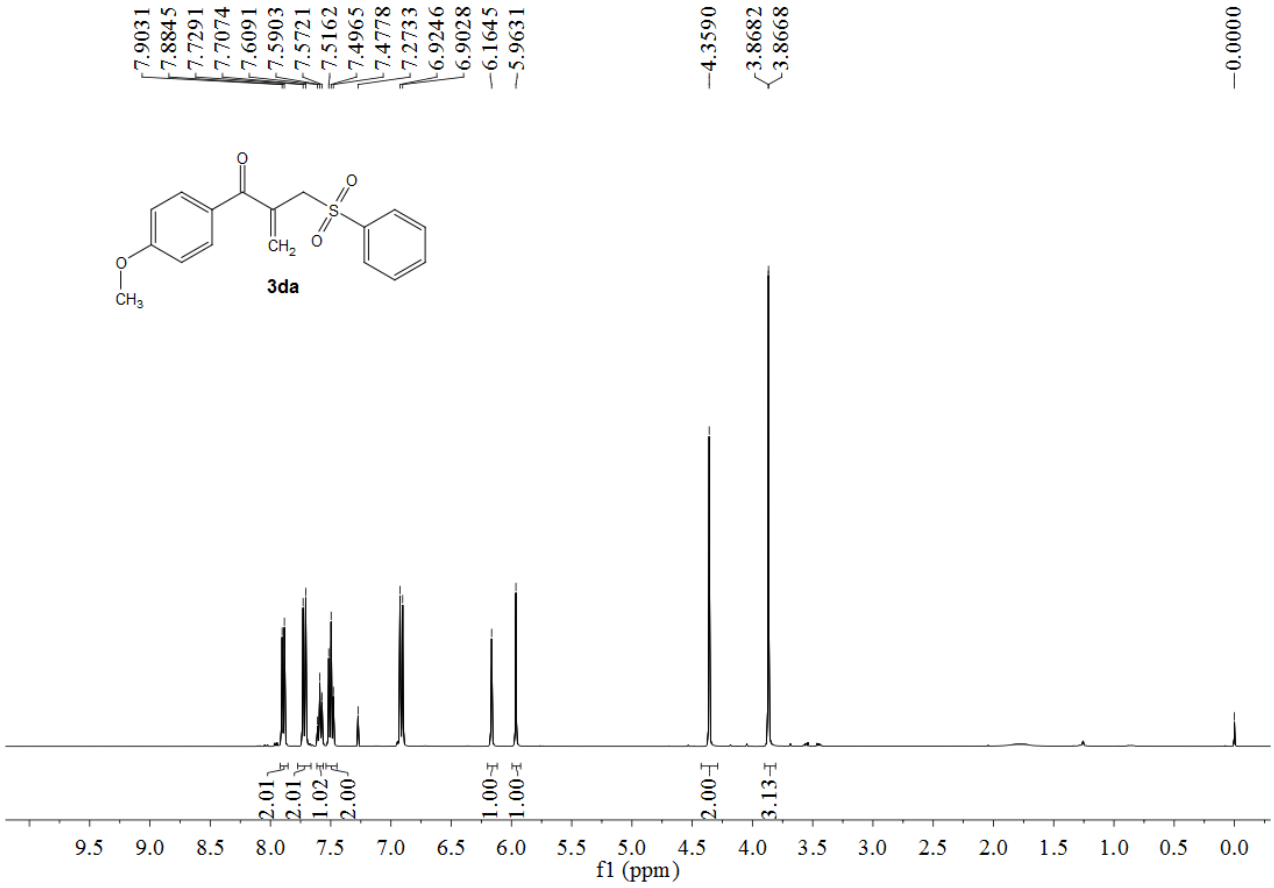
3ca
f1 (ppm)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7.5903
7.5721
7.5162
7.4965
7.4778
7.2733
6.9246
6.9028
6.1645
5.9631
4.3590
3.8682
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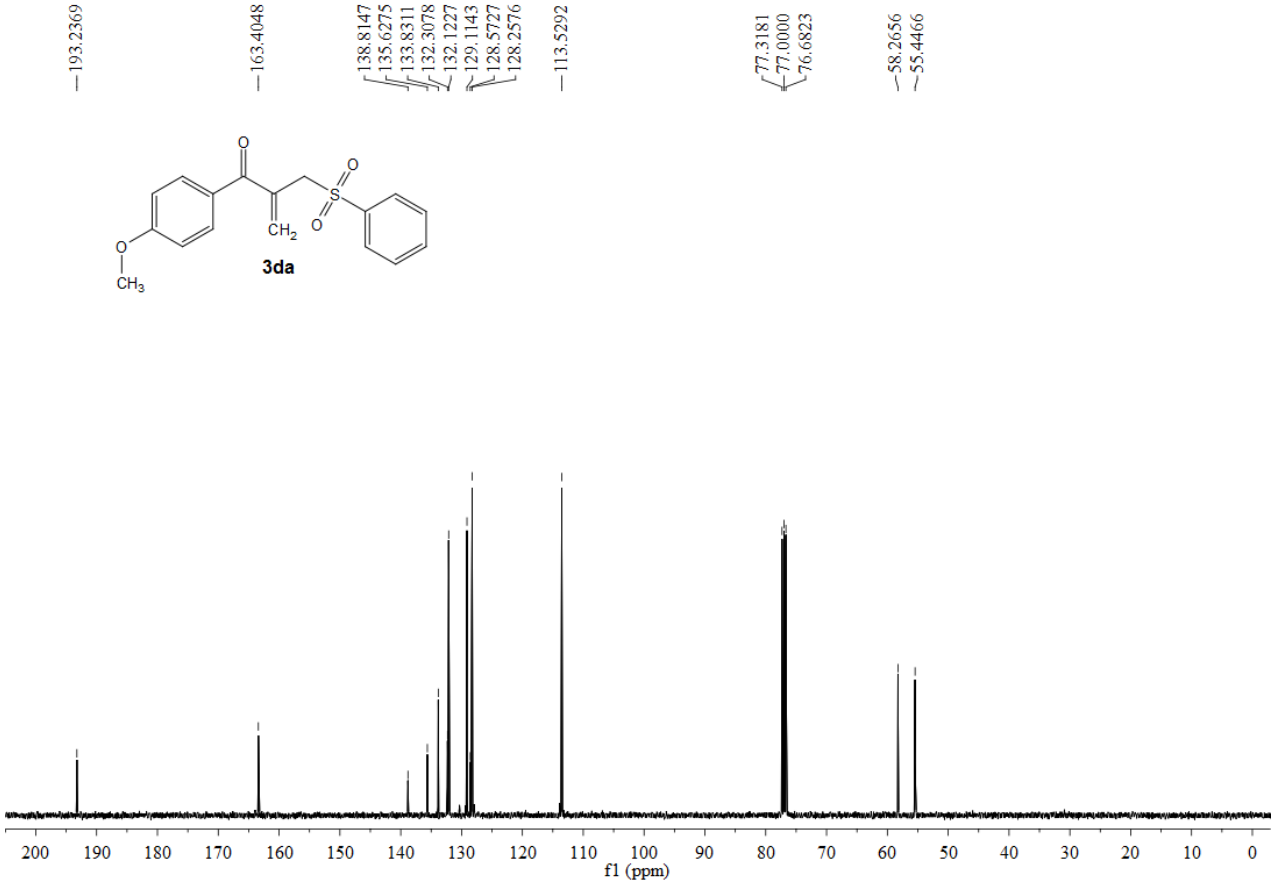
3da
2.01
2.01
1.02
2.00
1.00
1.00
2.00
3.13
f1 (ppm)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132.3078
132.1227
129.1143
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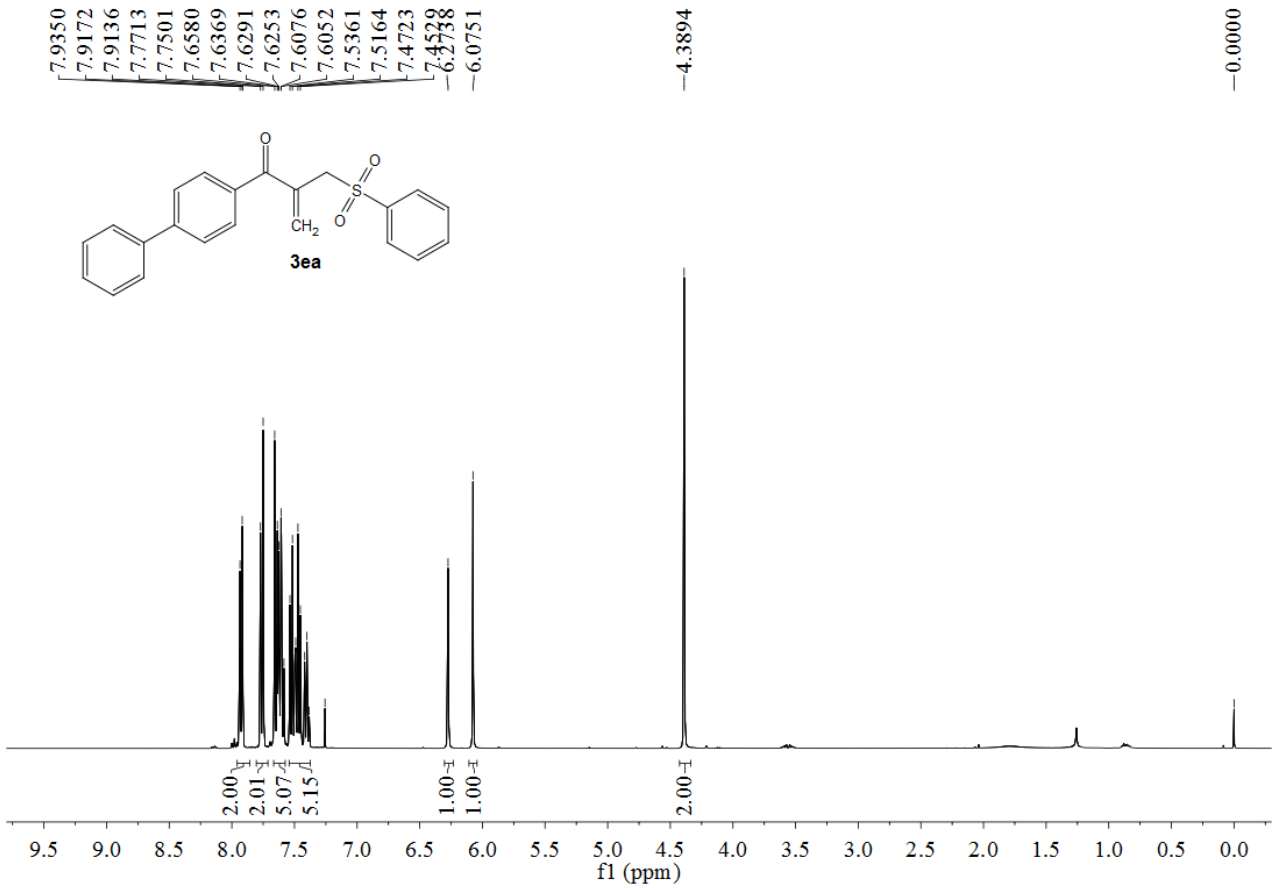
77.0000
76.6823
58.2656
55.4466
3da
f1 (ppm)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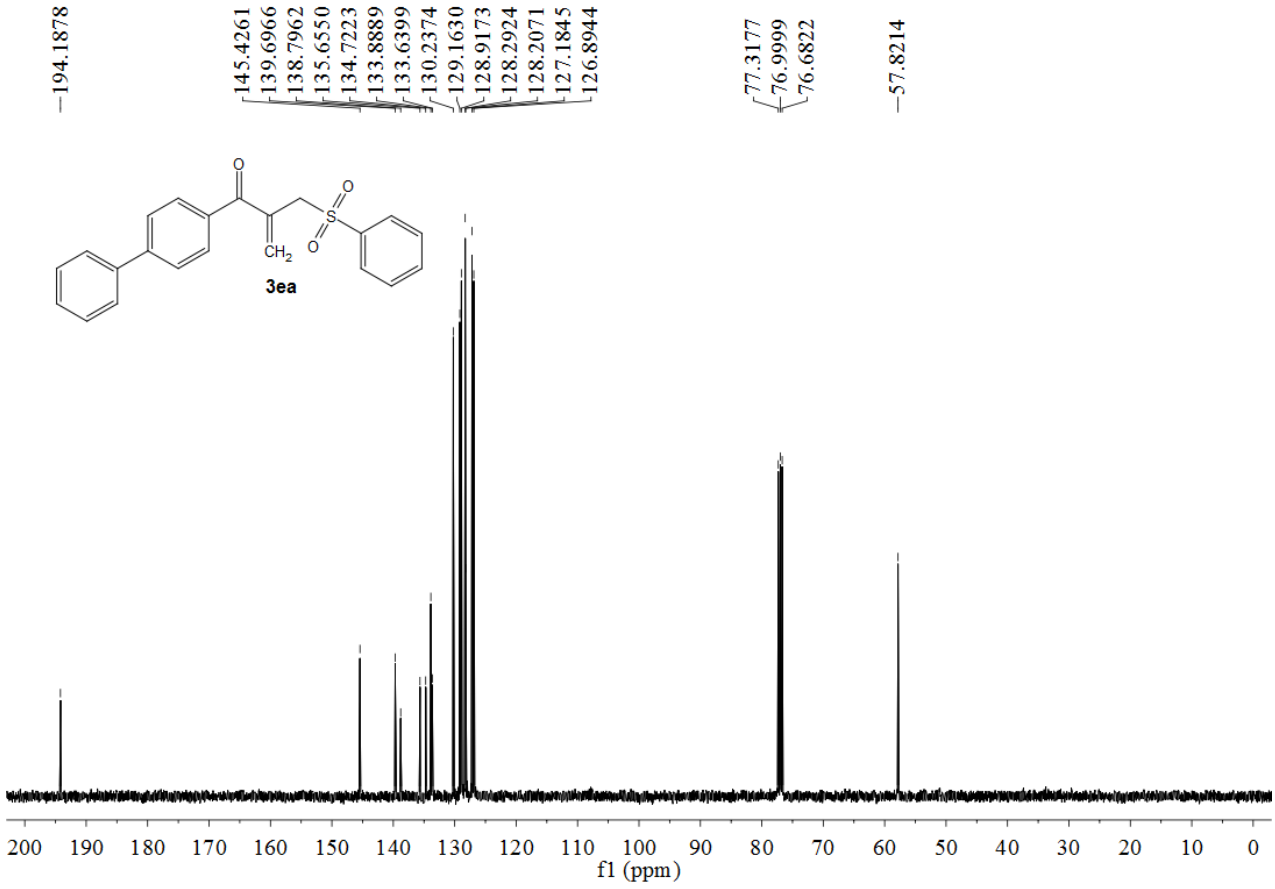
7.6369
7.6291
7.6253
7.6076
7.6052
7.5361
7.5164
7.4723
7.4529
6.2738
6.0751
4.3894
0.0000
O
O
S
O
O
CH2
3ea
2.00
2.01
5.07
5.15
1.00
1.00
2.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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128.2071
127.1845
126.8944
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76.9999
76.6822
57.8214
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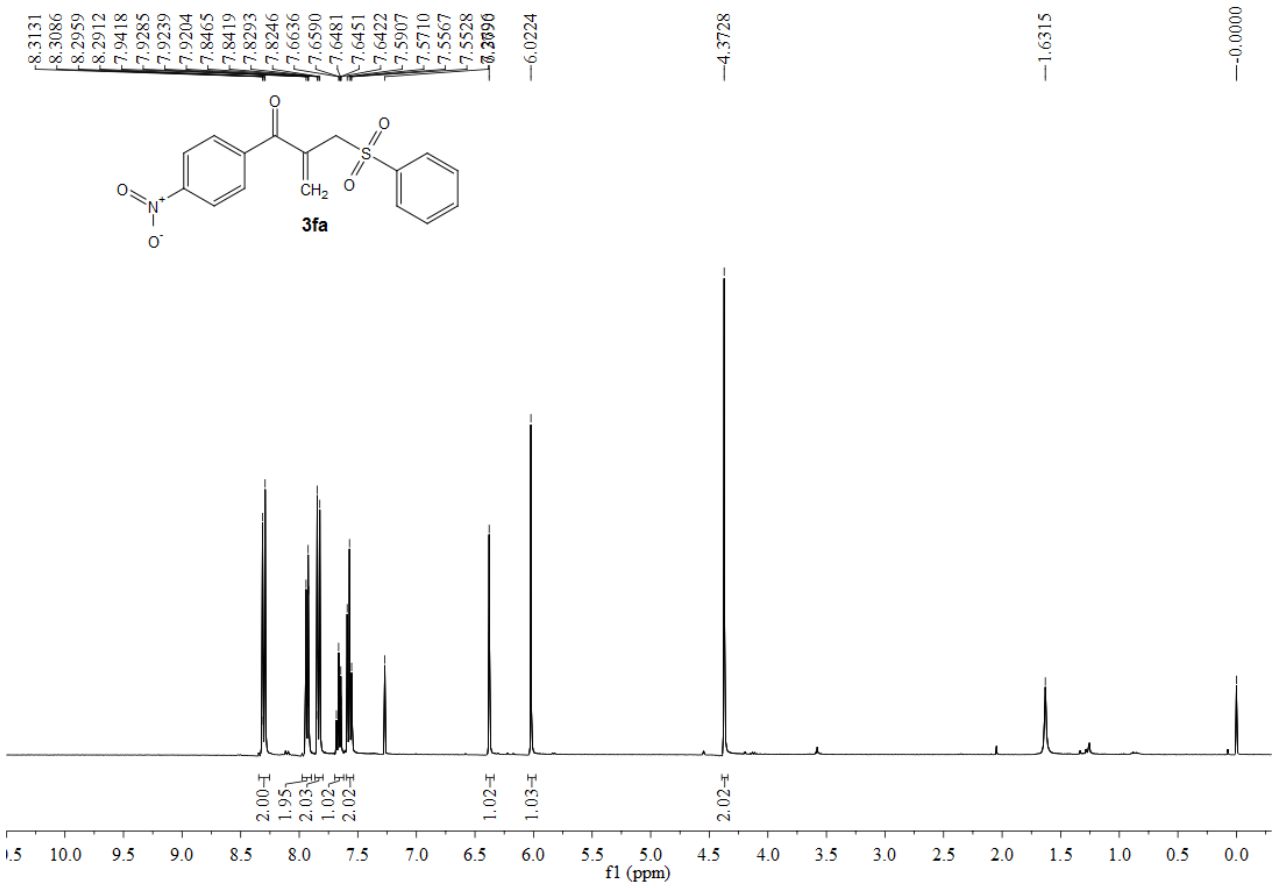
O
S
O
O
CH2
3ea
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.8419
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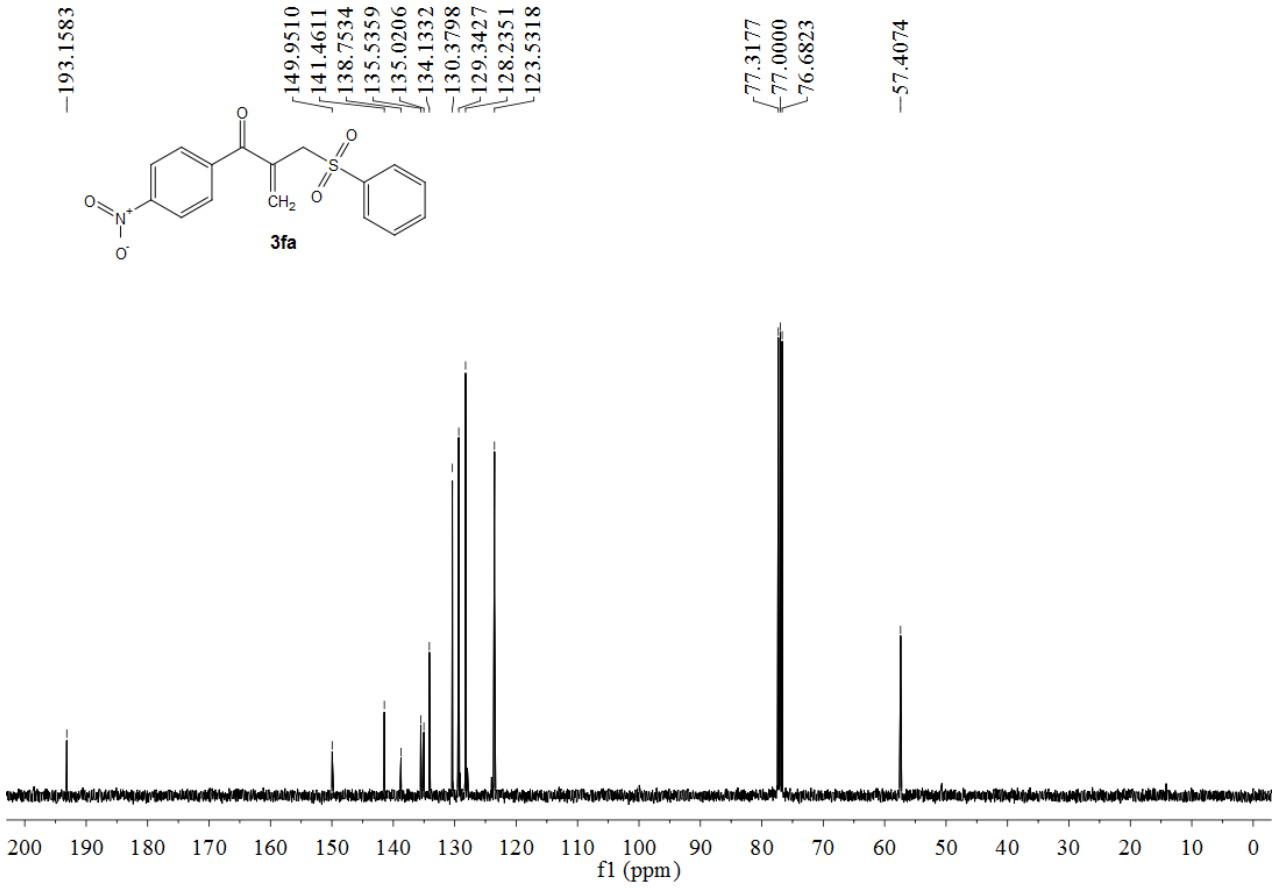
7.8246
7.6636
7.6590
7.6481
7.6451
7.6422
7.5907
7.5710
7.5567
7.5528
6.0224
4.3728
1.6315
0.0000
3fa
2.00
1.95
2.03
1.02
2.02
1.02
1.03
2.02
f1 (ppm)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77.0000
76.6823
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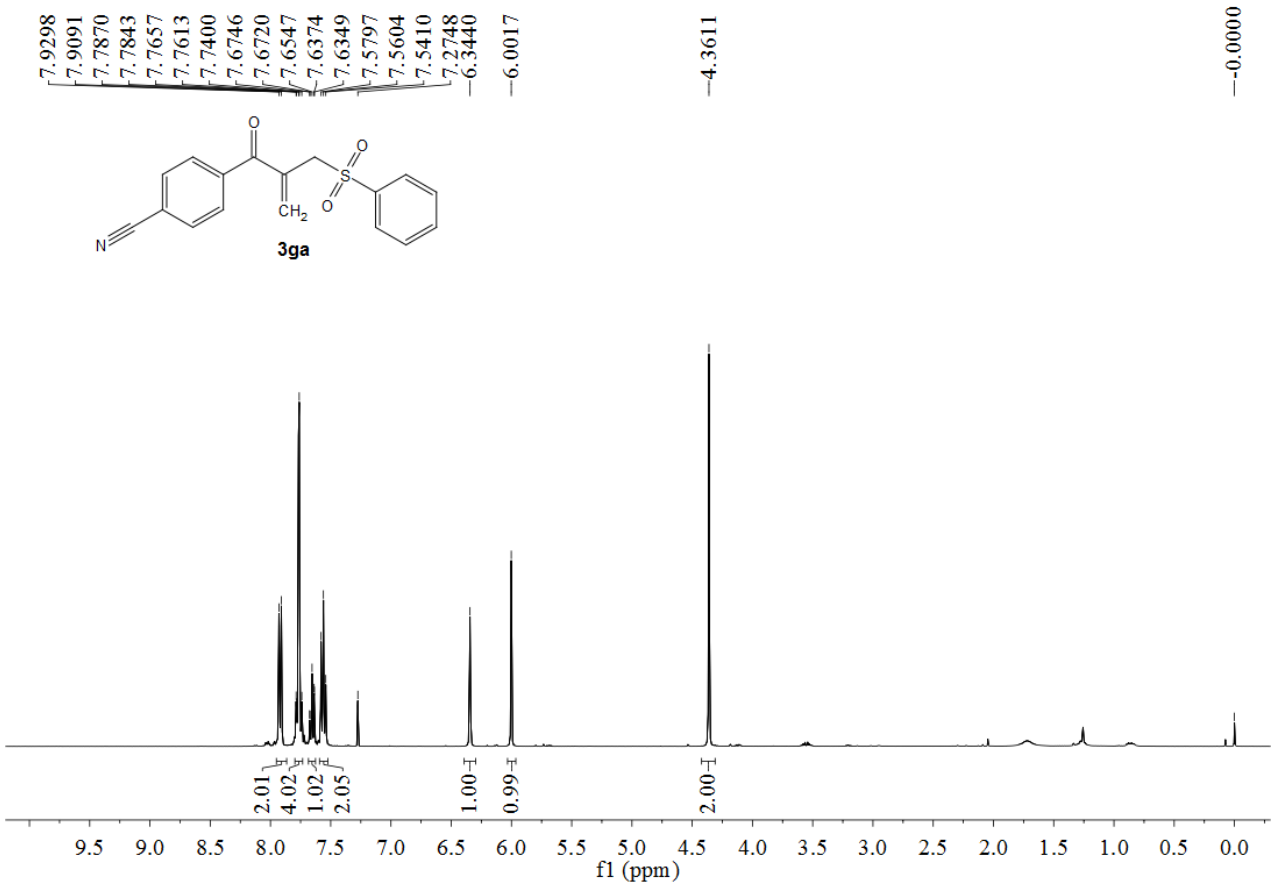
3fa
f1 (ppm)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7.7400
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7.6720
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7.6374
7.6349
7.5797
7.5604
7.5410
7.2748
6.3440
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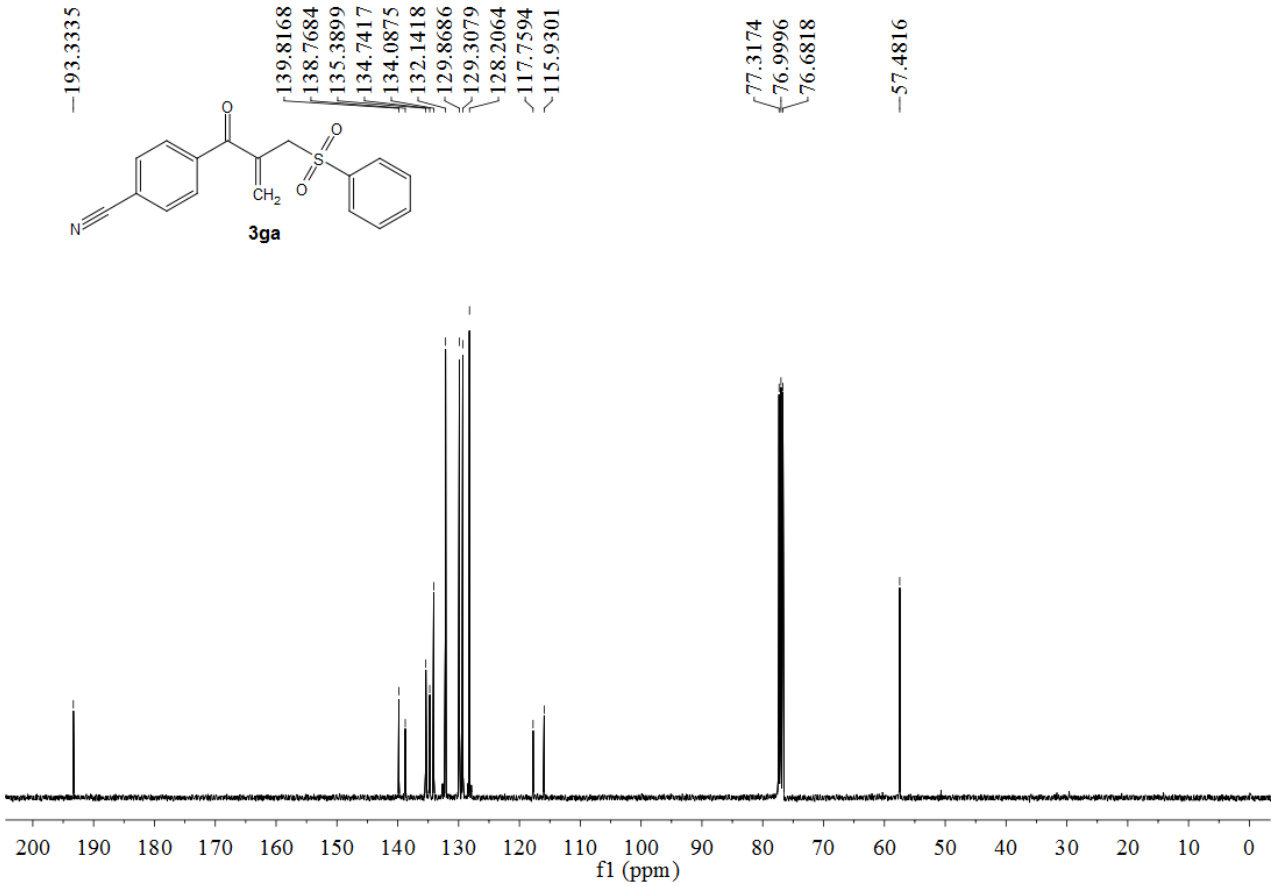
3ga
2.01
4.02
1.02
2.05
1.00
0.99
2.00
f1 (ppm)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76.6818
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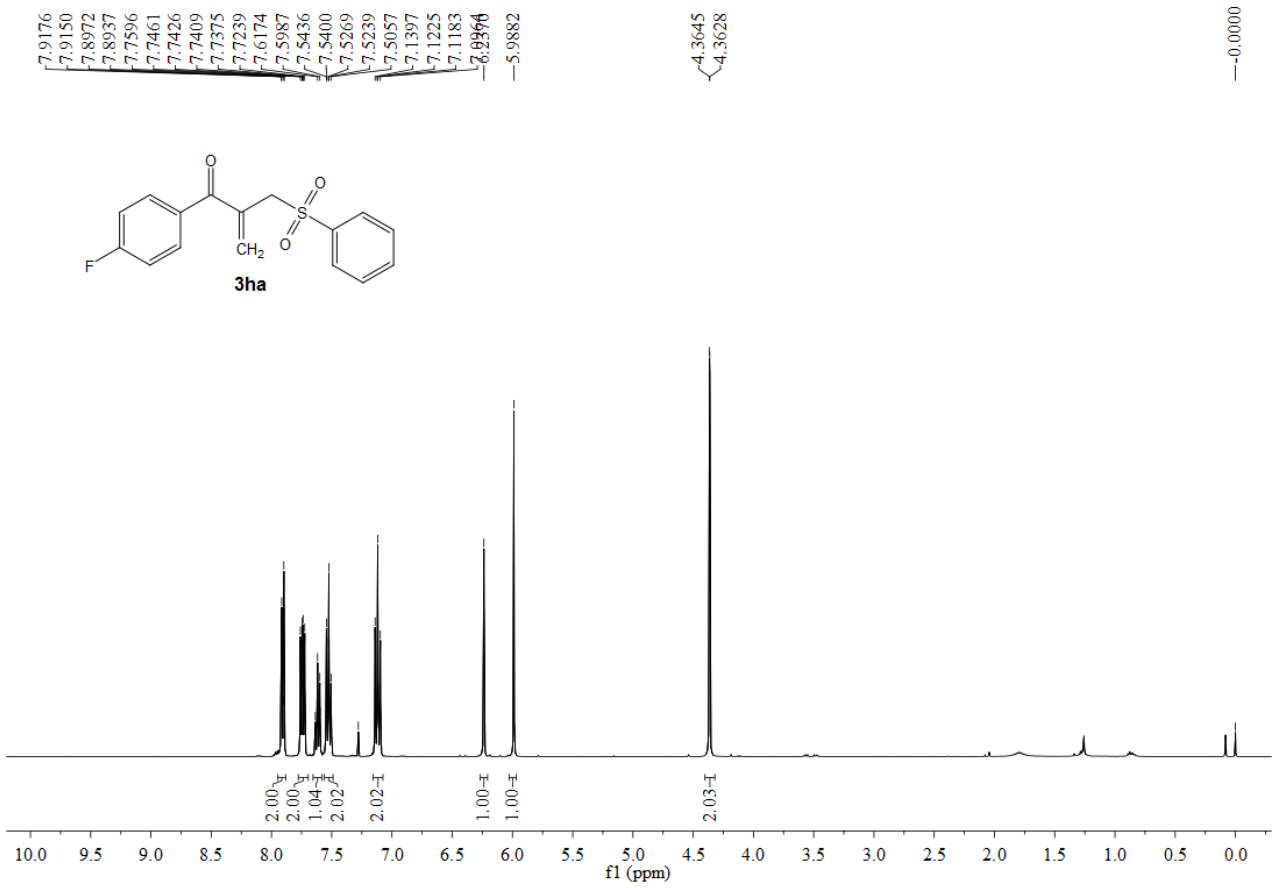
3ga
f1 (ppm)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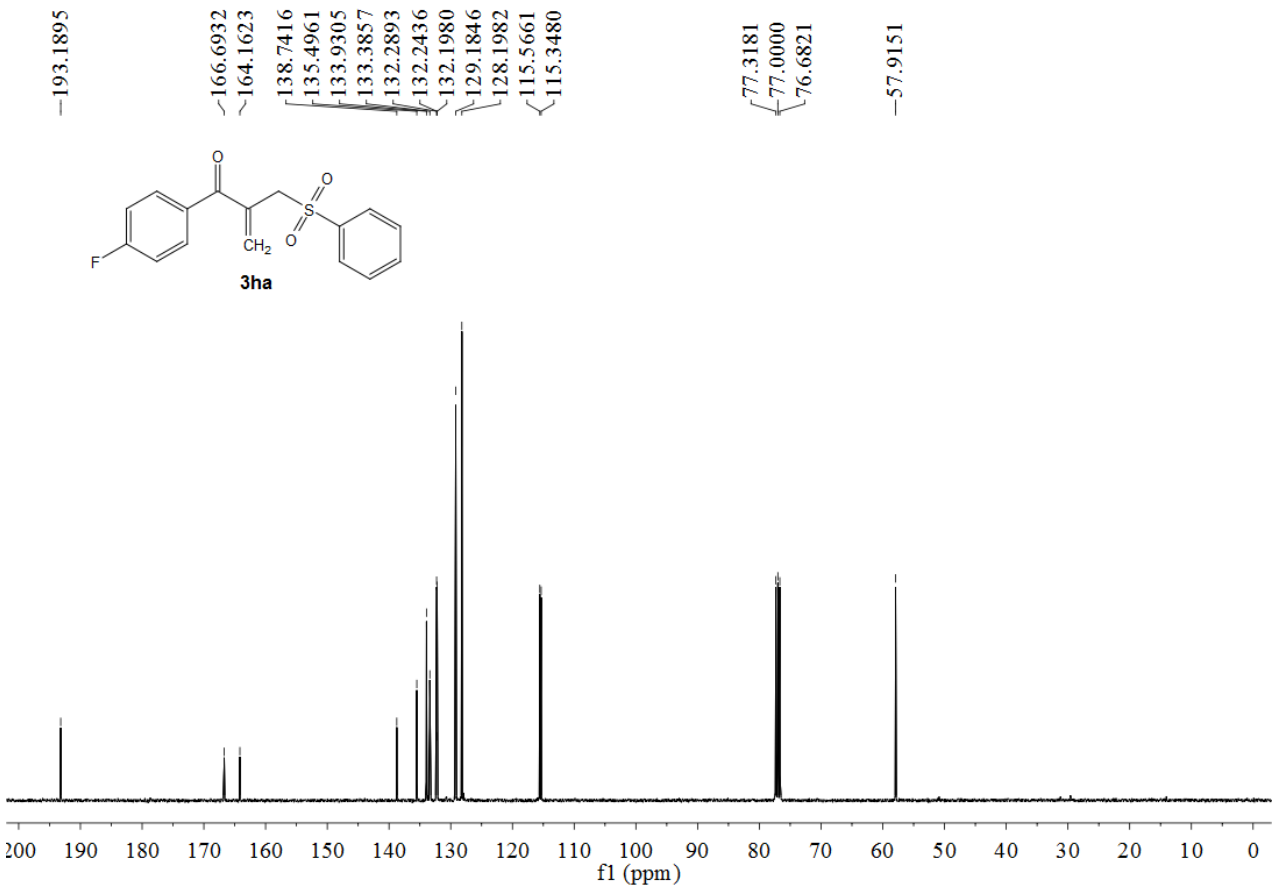
7.7375
7.7239
7.6174
7.5987
7.5436
7.5400
7.5269
7.5239
7.5057
7.1397
7.1225
7.1183
5.9882
4.3645
4.3628
0.0000
O
O
S
O
CH2
F
3ha
2.00
2.00
1.04
2.02
2.02
1.00
1.00
2.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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129.1846
128.1982
115.5661
115.3480
77.3181
77.0000
76.6821
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O
S
O
CH2
F
3ha
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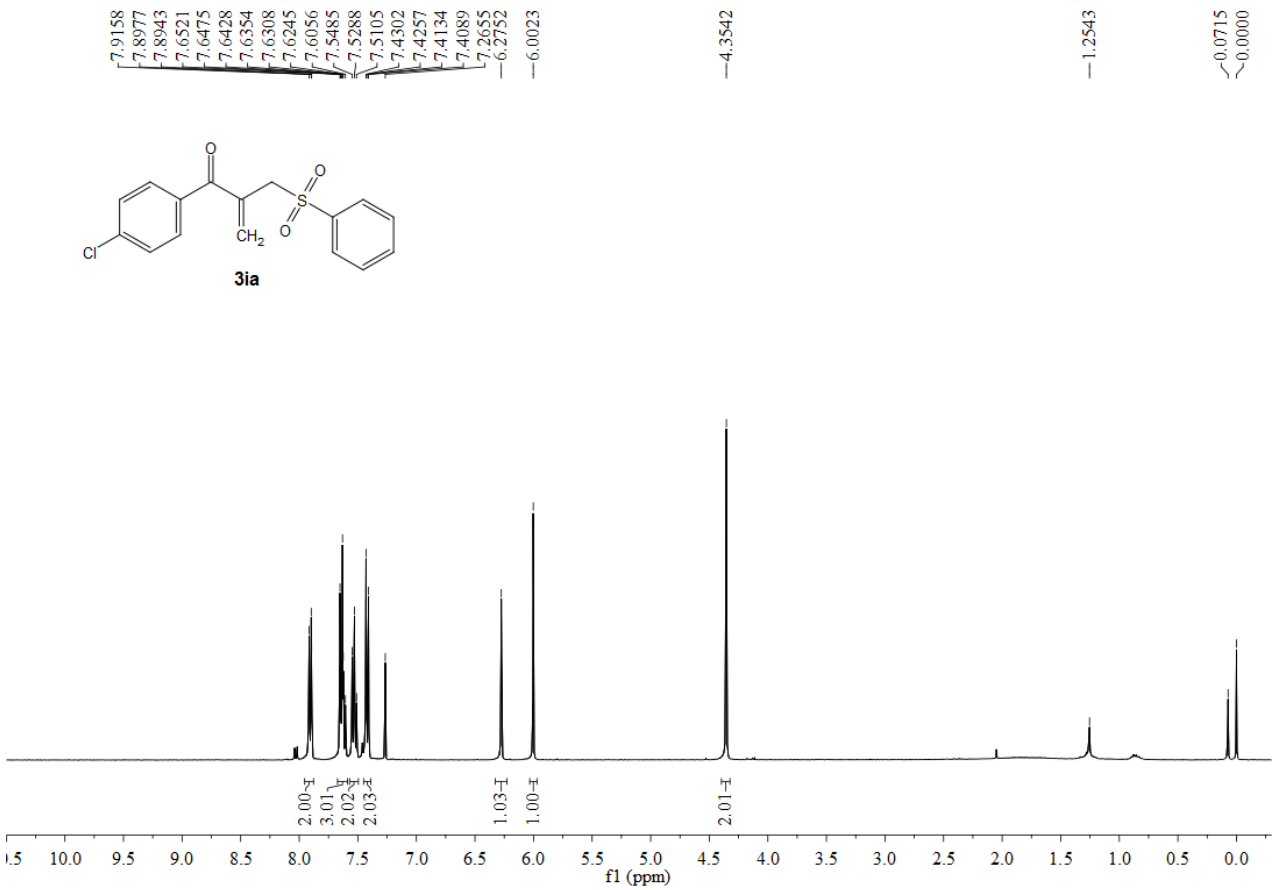
f1 (ppm)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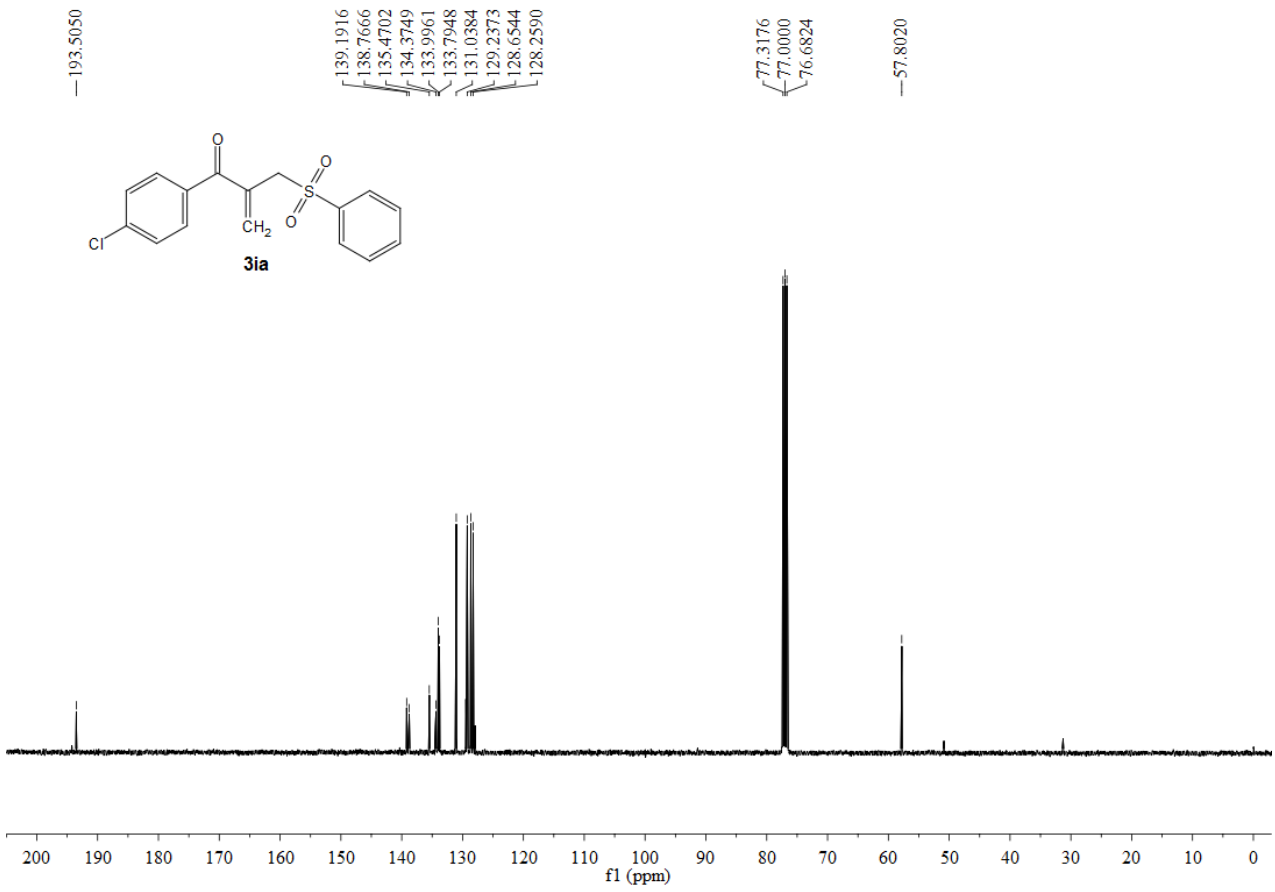
7.5288
7.5105
7.4302
7.4257
7.4134
7.4089
7.2655
6.2752
6.0023
4.3542
1.2543
0.0715
0.0000
O
O
S
O
CH2
Cl
3ia
2.00
3.01
2.02
2.03
1.03
1.00
2.01
f1 (ppm)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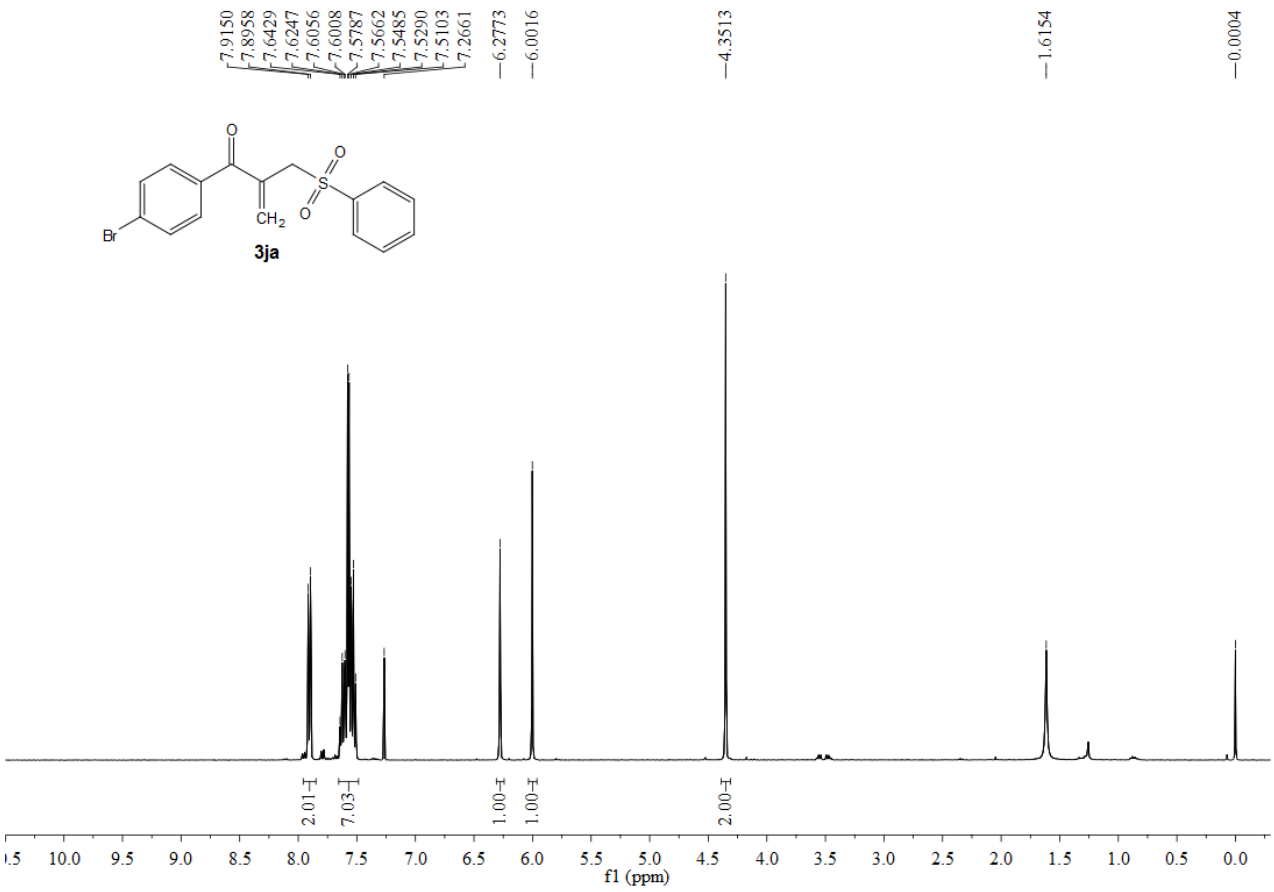
O
O
S
O
CH2
Cl
3ia
f1 (ppm)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7.5485
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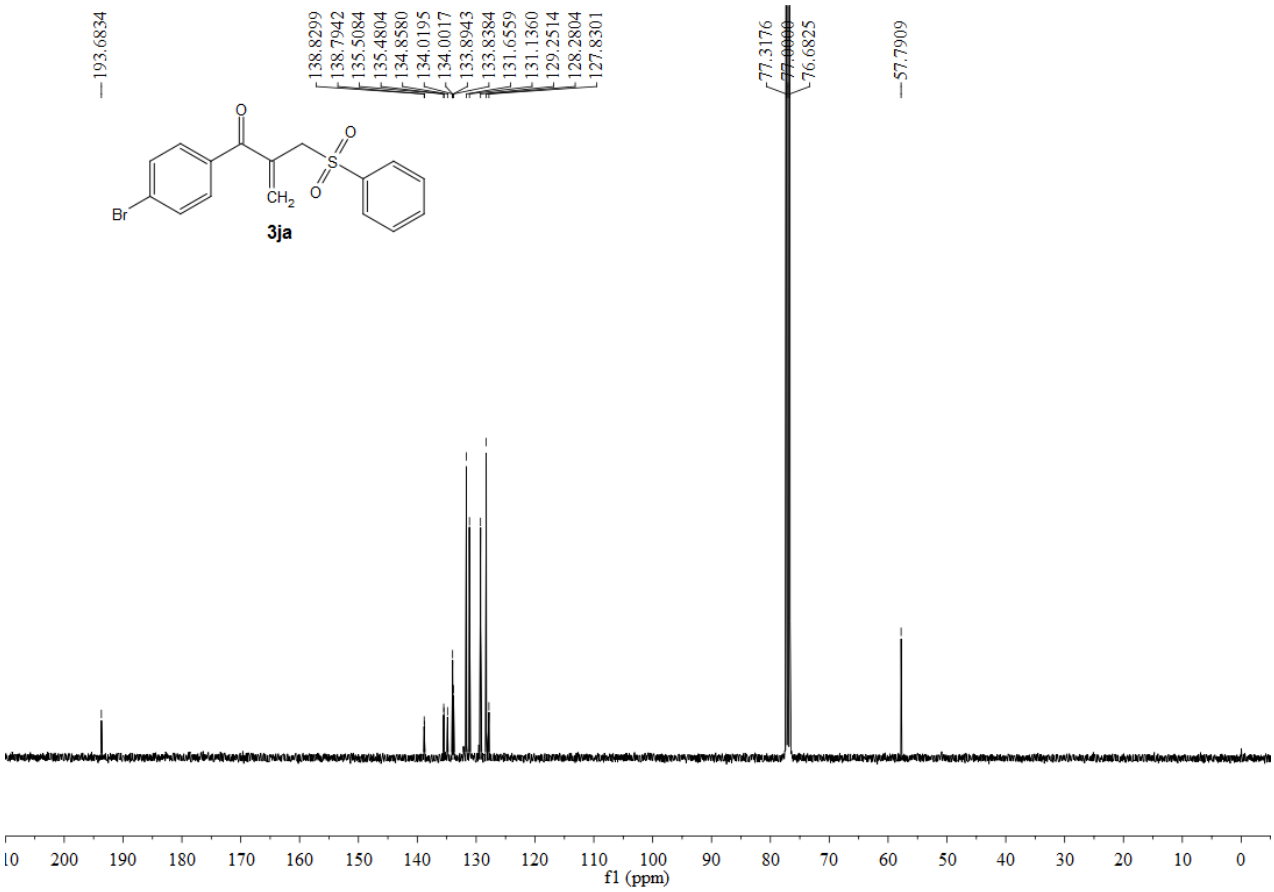
7.5103
7.2661
6.2773
6.0016
4.3513
1.6154
0.0004
O
O
S
O
CH2
Br
3ja
2.01
7.03
1.00
1.00
2.00
f1 (ppm)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131.6559
131.1360
129.2514
128.2804
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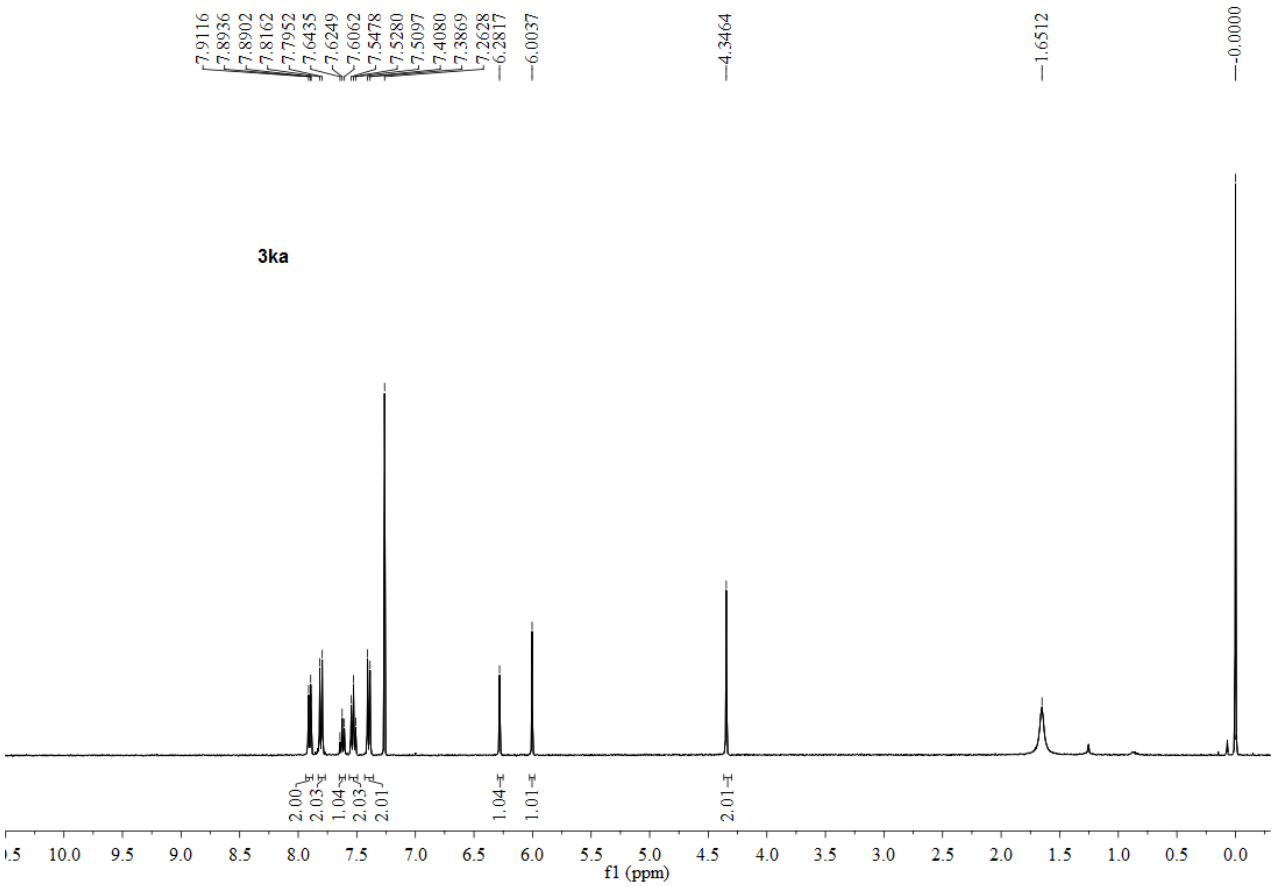
77.0000
76.6825
57.7909
O
O
S
O
CH2
Br
3ja
f1 (ppm)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7.5097
7.4080
7.3869
7.2628
6.2817
6.0037
4.3464
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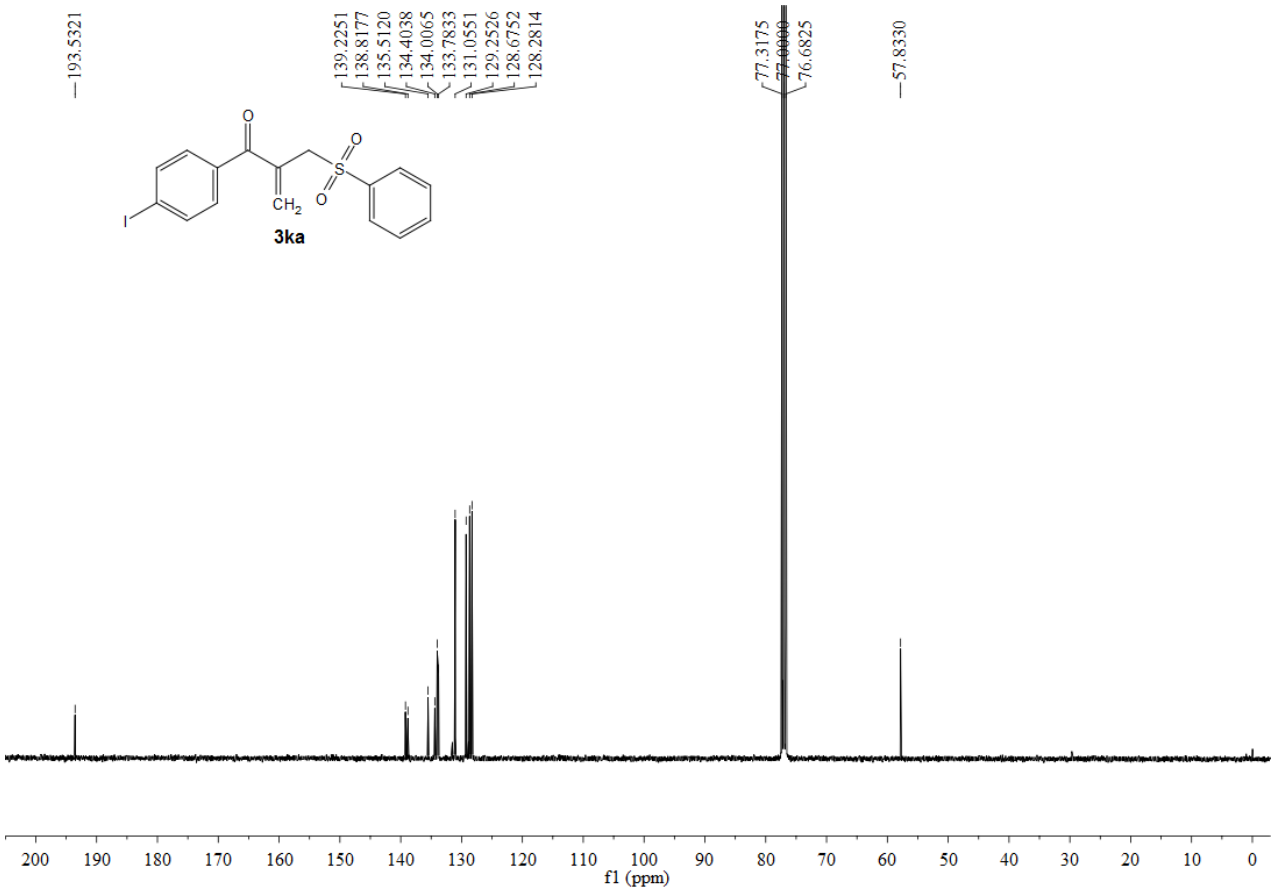
2.03
1.04
2.03
2.01
1.04
1.01
2.01
f1 (ppm)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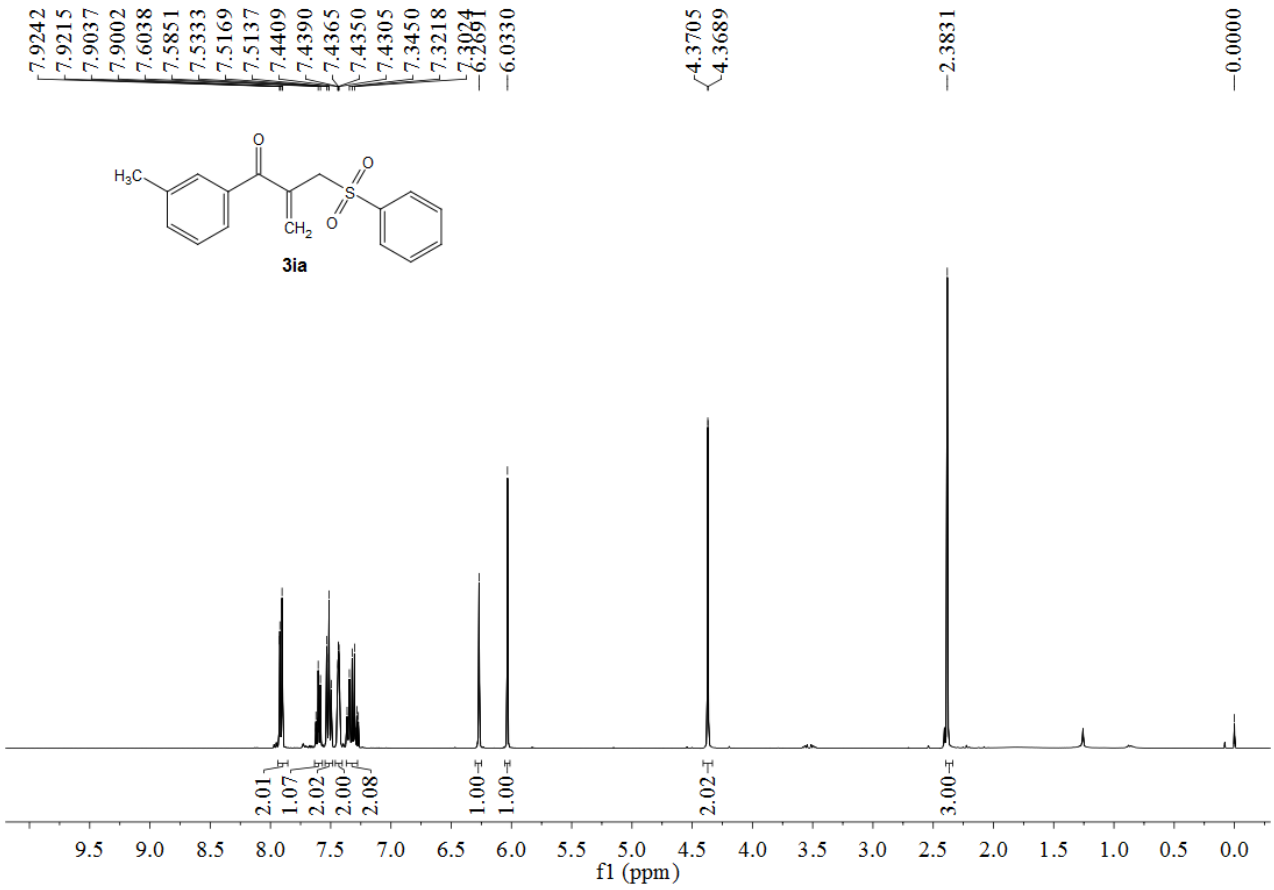
77.0000
76.6825
57.8330
O
O
S
O
CH2
O
I
3ka
f1 (ppm)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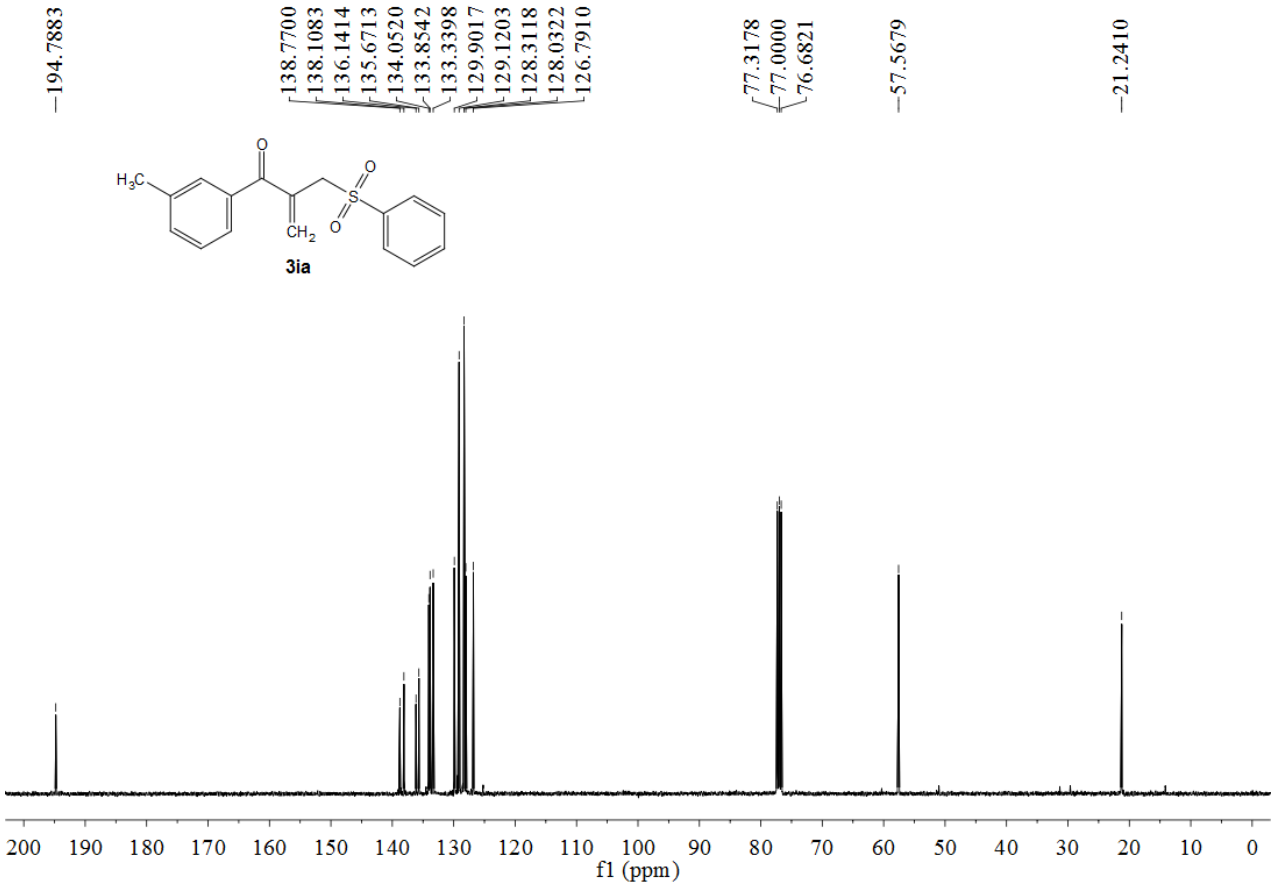
7.4390
7.4365
7.4350
7.4305
7.3450
7.3218
6.2691
6.0330
4.3705
4.3689
2.3831
0.0000
2.01
1.07
2.02
2.00
2.08
1.00
1.00
2.02
3.00
f1 (ppm)

H3C
O
O
S
O
CH2

3ia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128.0322
126.7910
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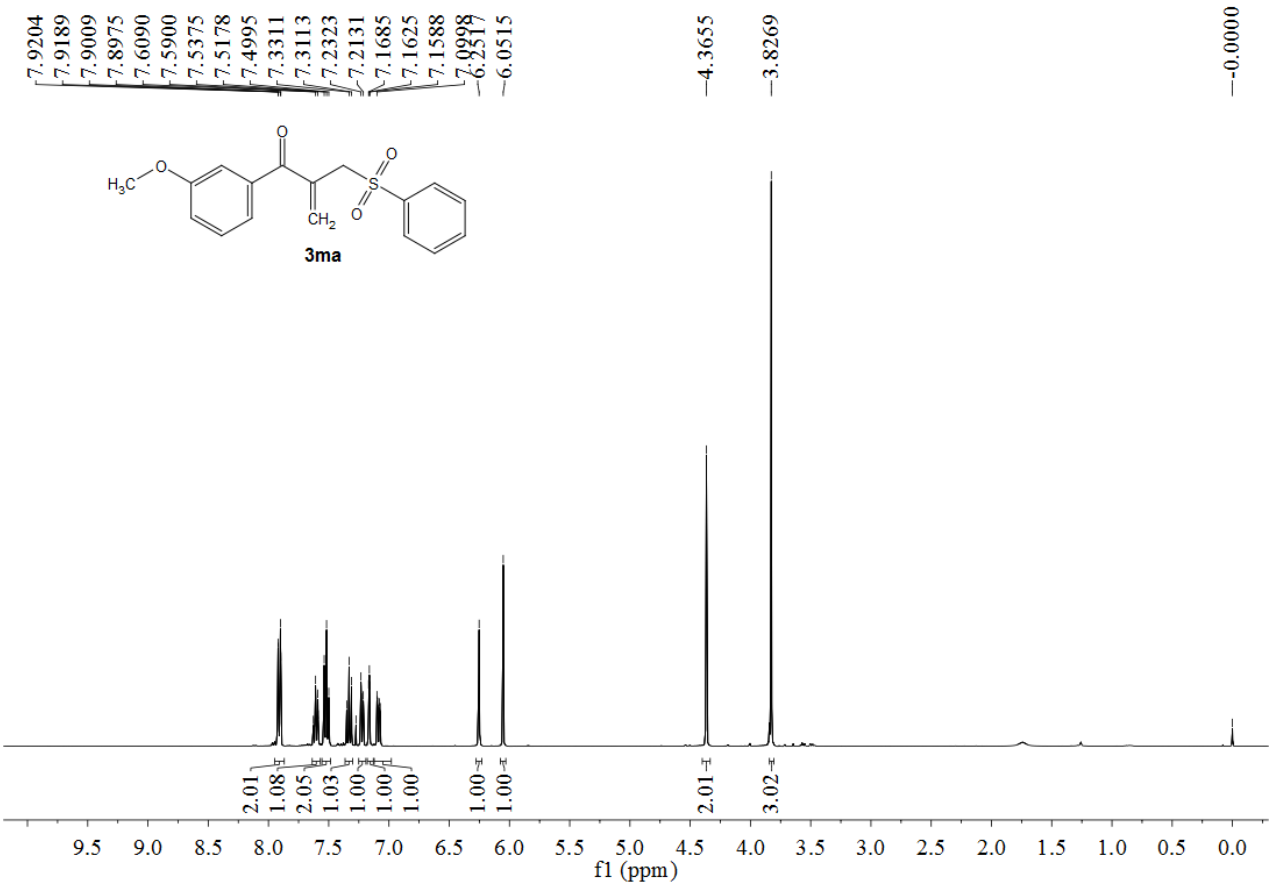
77.0000
76.6821
57.5679
21.2410
f1 (ppm)

H3C
O
O
S
O
CH2

3ia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7.3113
7.2323
7.2131
7.1685
7.1625
7.1588
7.0998
6.2517
6.0515
4.3655
3.8269
0.0000
3ma
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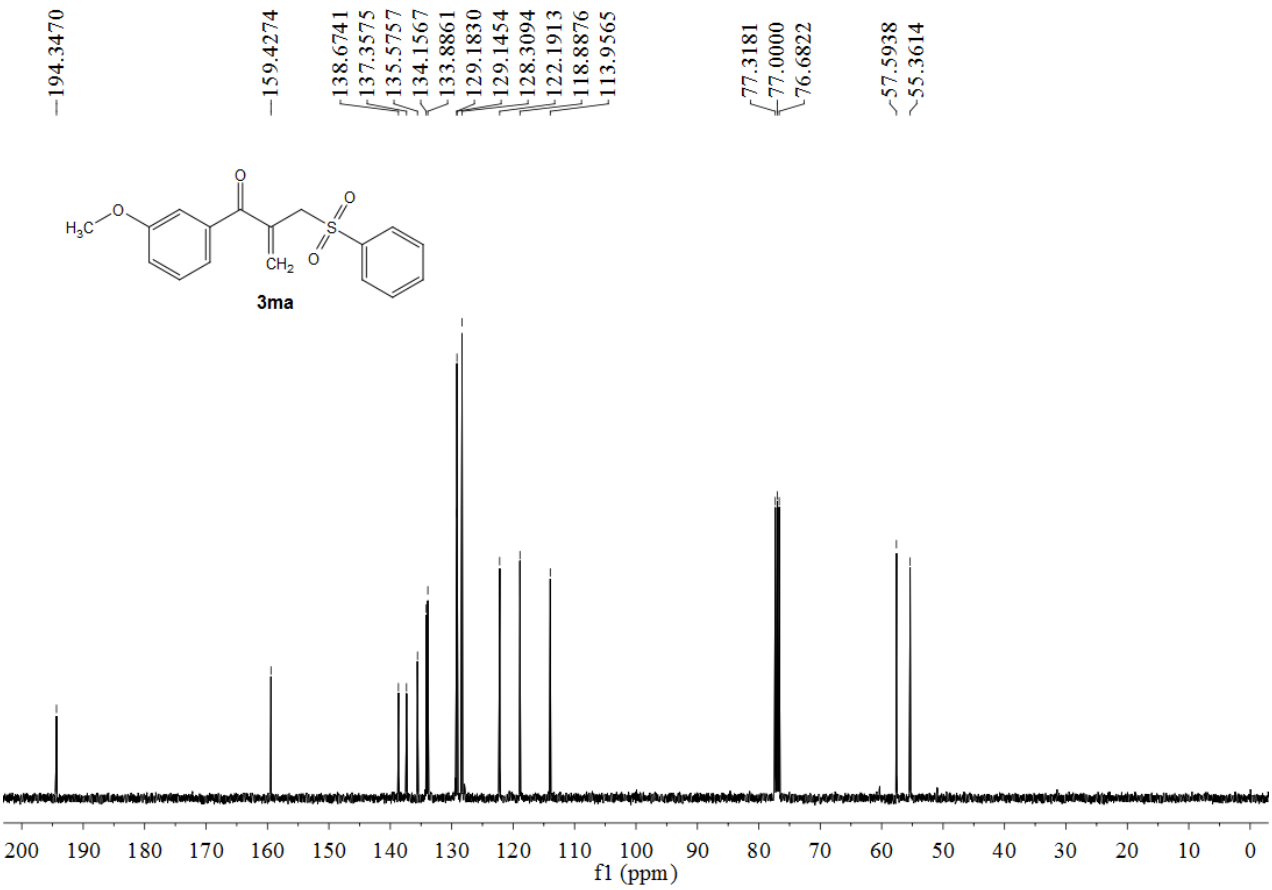
1.08
2.05
1.03
1.00
1.00
1.00
1.00
1.00
2.01
3.02
f1 (ppm)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128.3094
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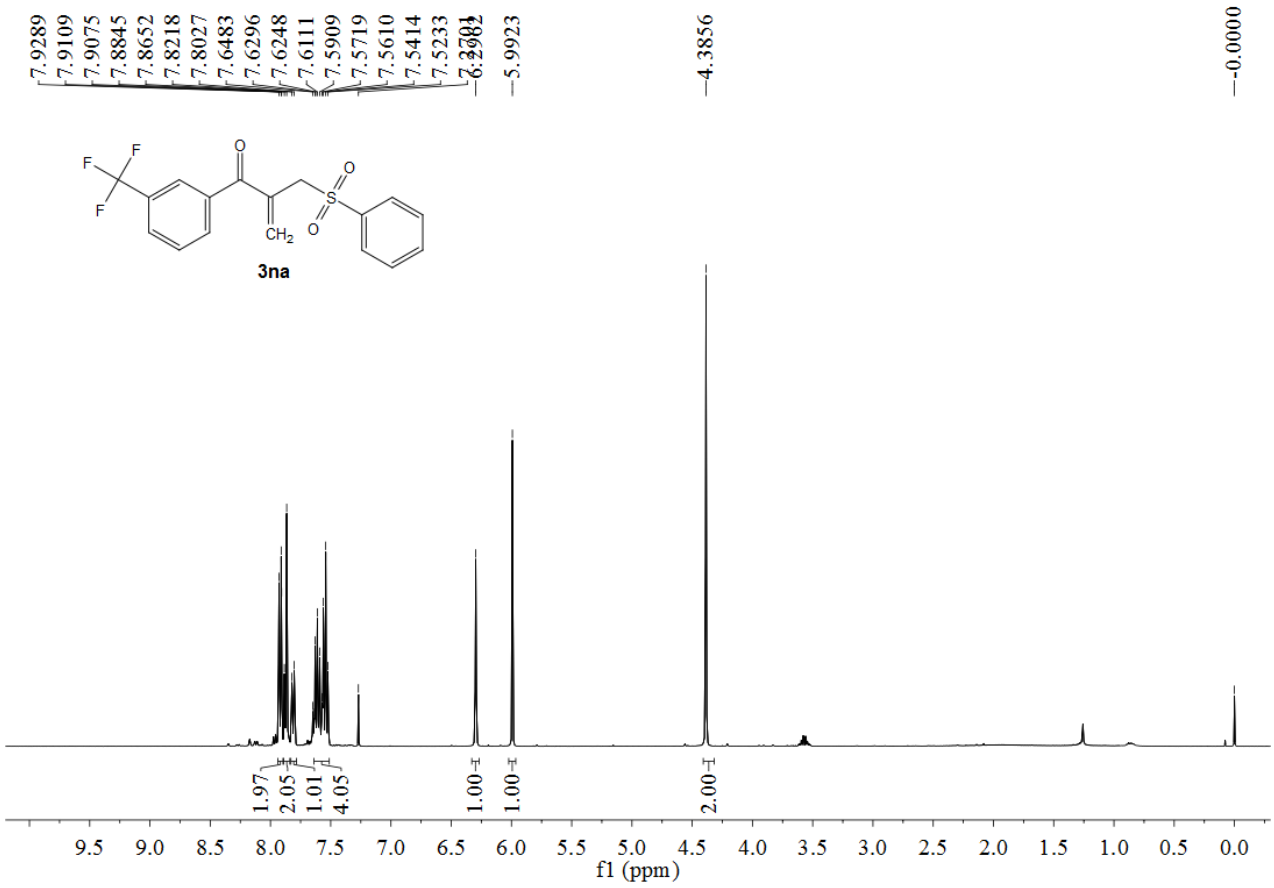
3ma
f1 (ppm)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7.9109
7.9075
7.8845
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7.8218
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7.6296
7.6248
7.6111
7.5909
7.5719
7.5610
7.5414
7.5233
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2.00
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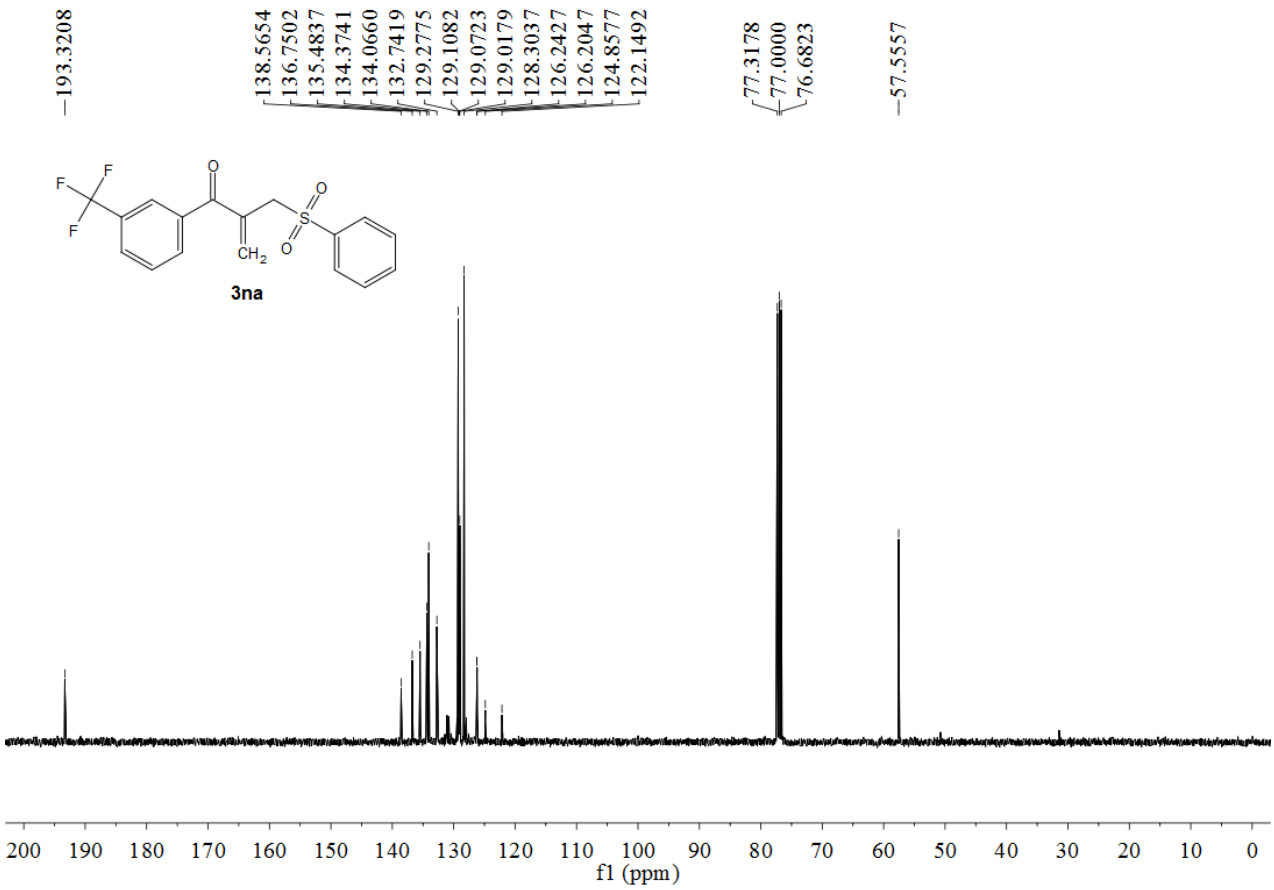
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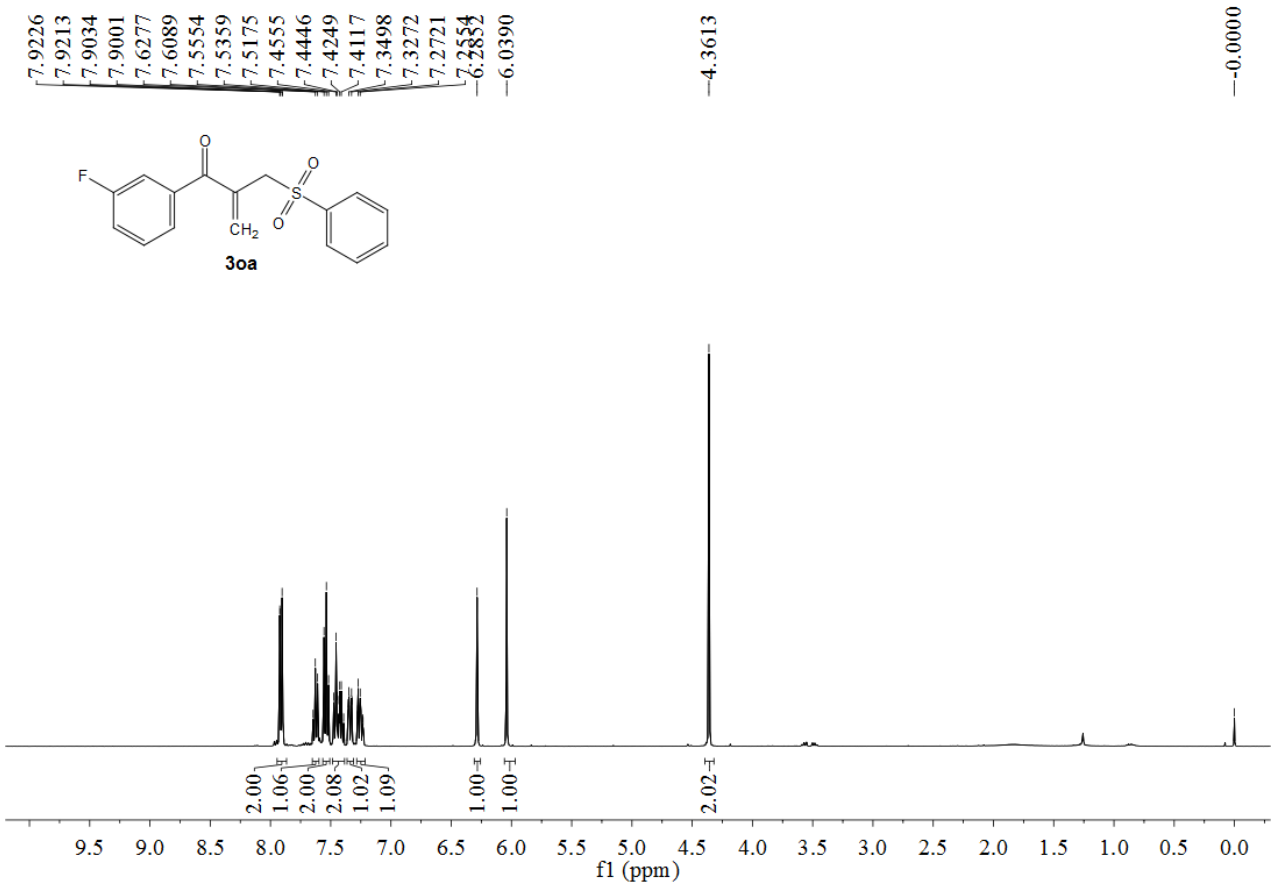
f1 (ppm)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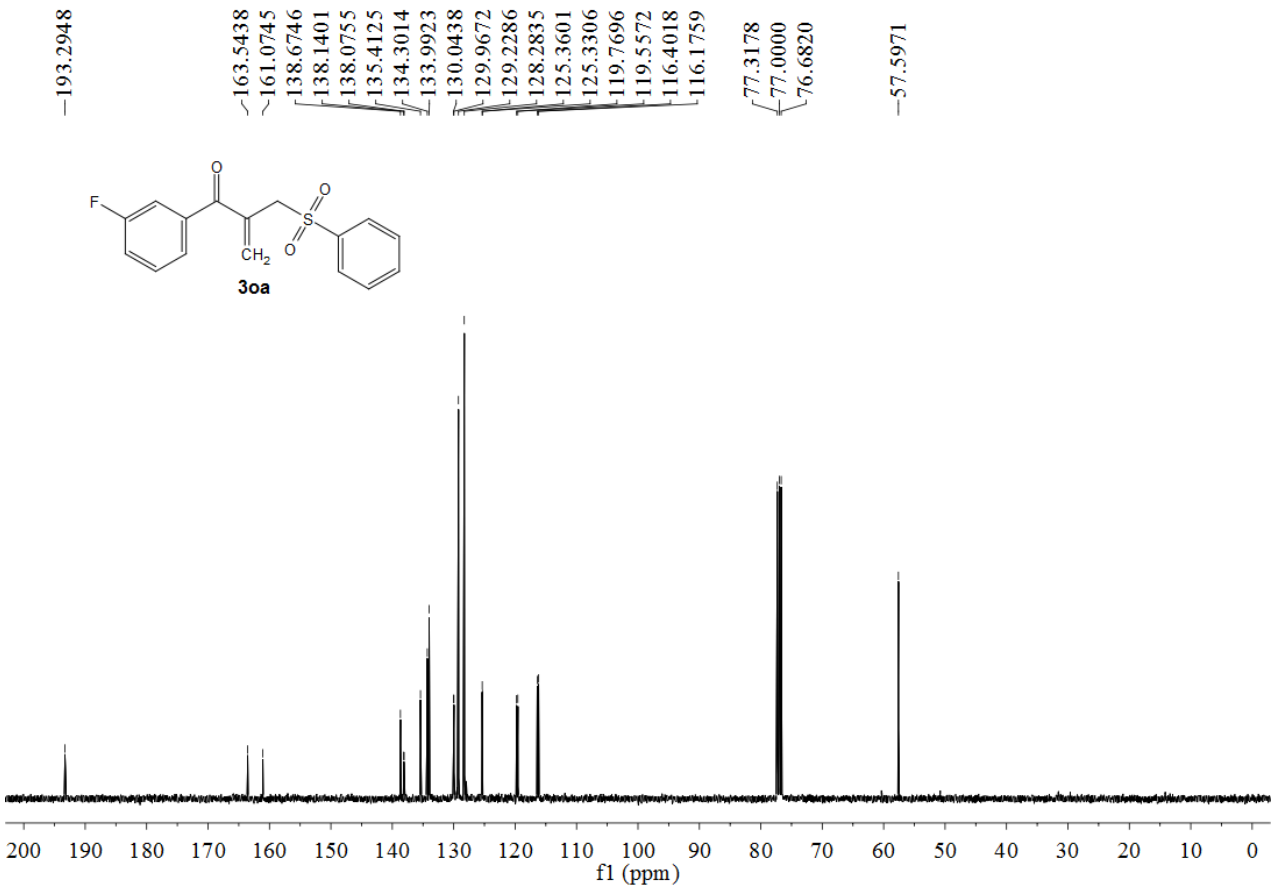
7.4446
7.4249
7.4117
7.3498
7.3272
7.2721
7.2554
7.2852
6.0390
4.3613
0.0000
F
O
O
S
O
CH2
3oa
2.00
1.06
2.00
2.08
1.02
1.09
1.00
1.00
2.02
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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128.2835
125.3601
125.3306
119.7696
119.5572
116.4018
116.1759
77.3178
77.0000
76.6820
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O
O
S
O
CH2
3oa
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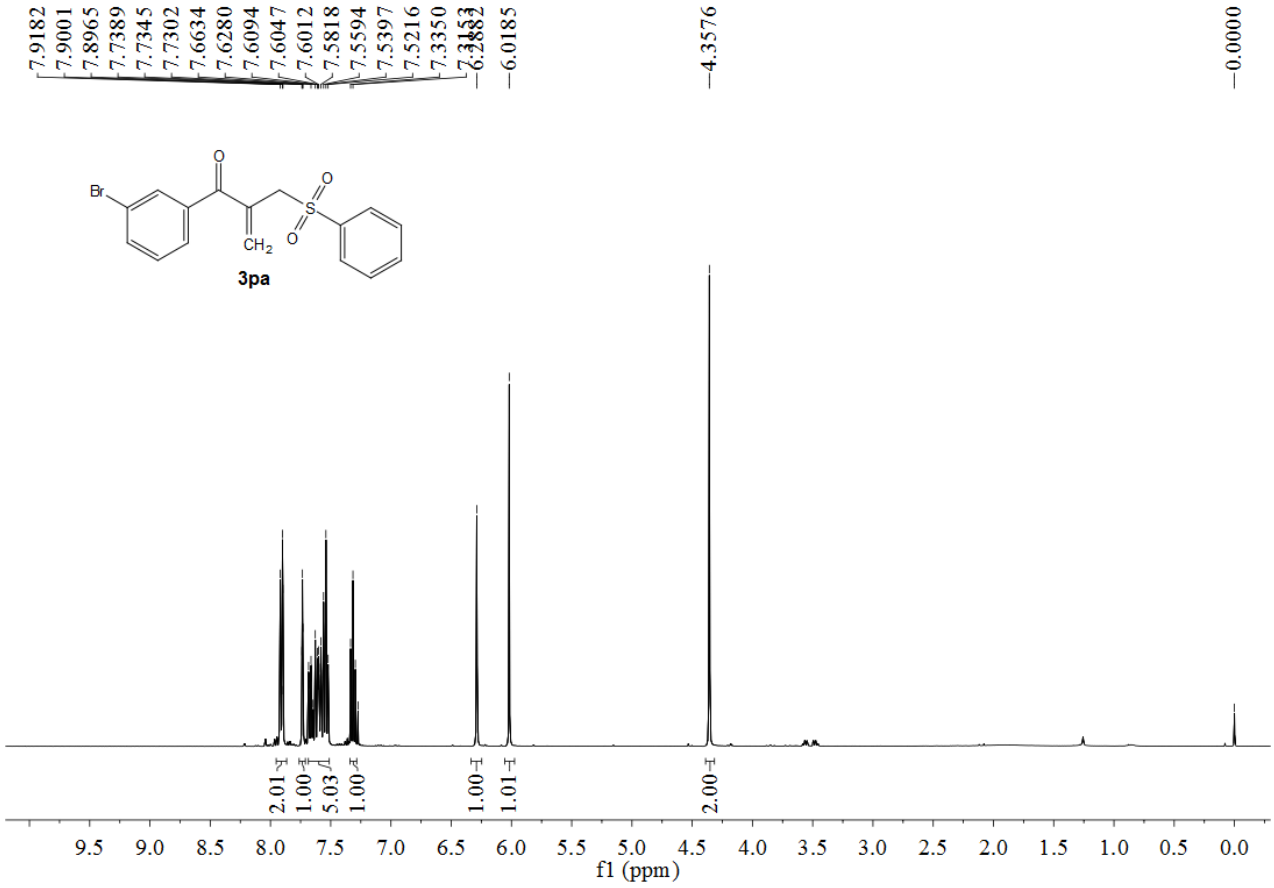
f1 (ppm)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7.5397
7.5216
7.3350
6.2882
6.0185
4.3576
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Br
O
O
S
O
CH2
3pa
2.01
1.00
5.03
1.00
1.00
1.01
2.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
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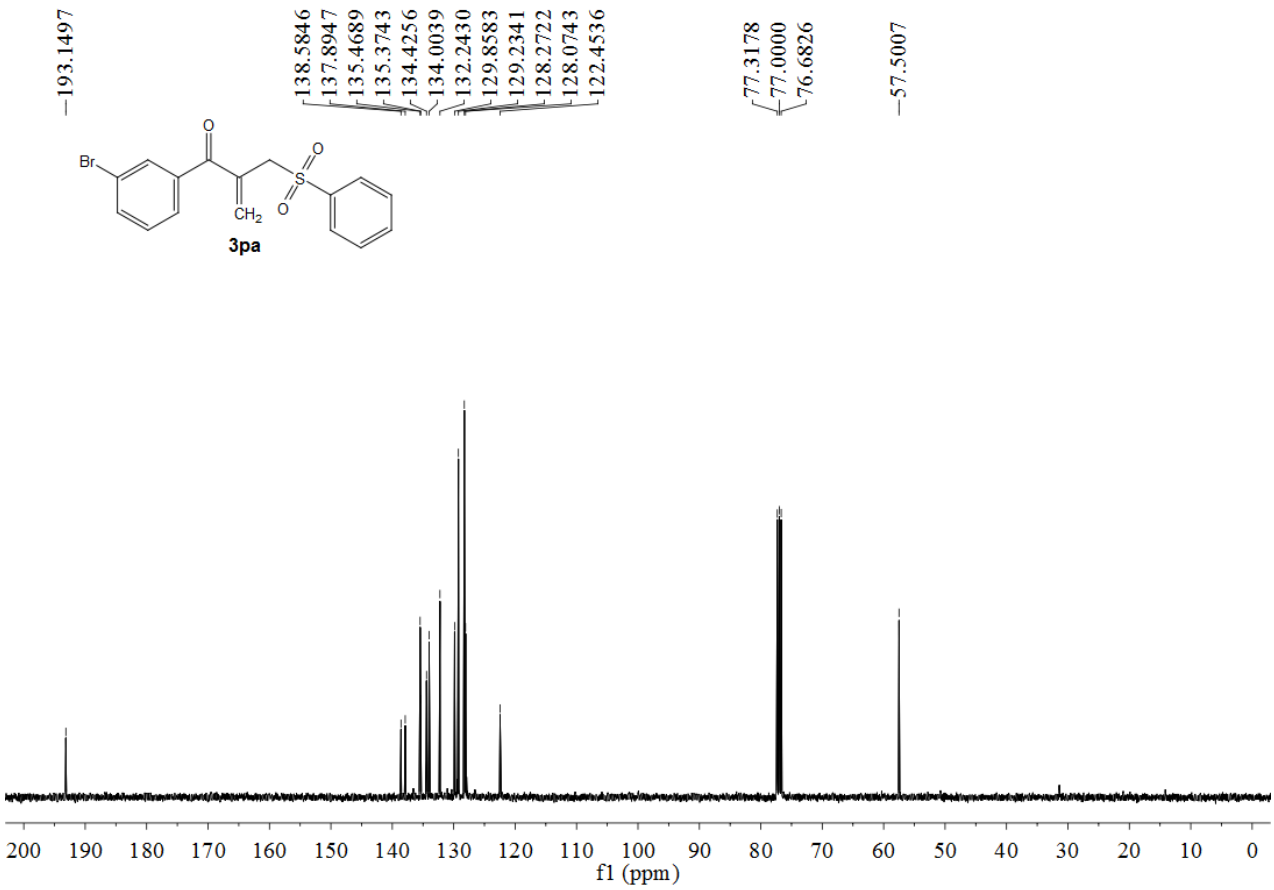
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77.0000
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O
S
O
CH2
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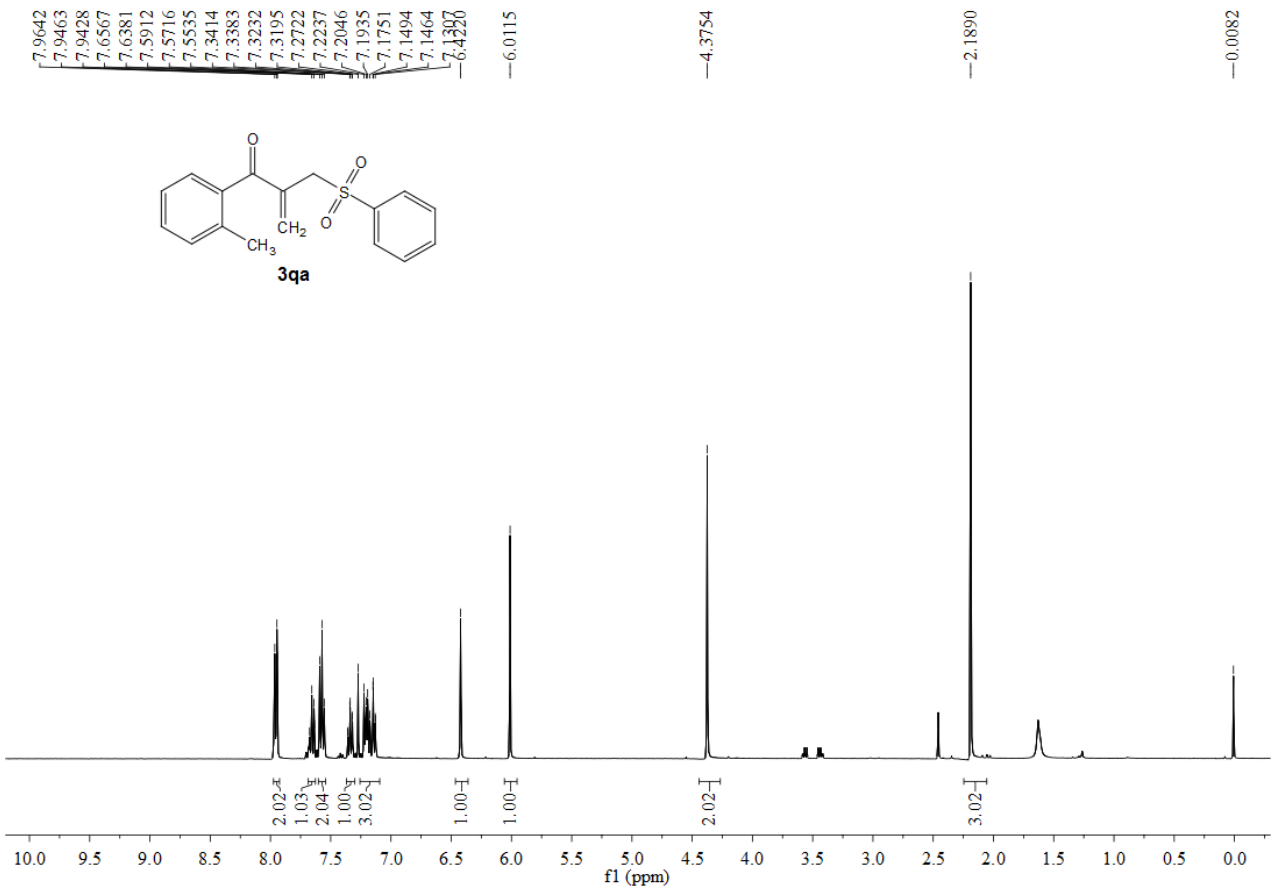
f1 (ppm)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7.2722
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7.2046
7.1935
7.1751
7.1494
7.1464
7.1307
6.4220
6.0115
4.3754
2.1890
0.0082
O
O
S
O
CH2
CH3
3qa
2.02
1.03
2.04
1.00
3.02
1.00
1.00
2.02
3.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
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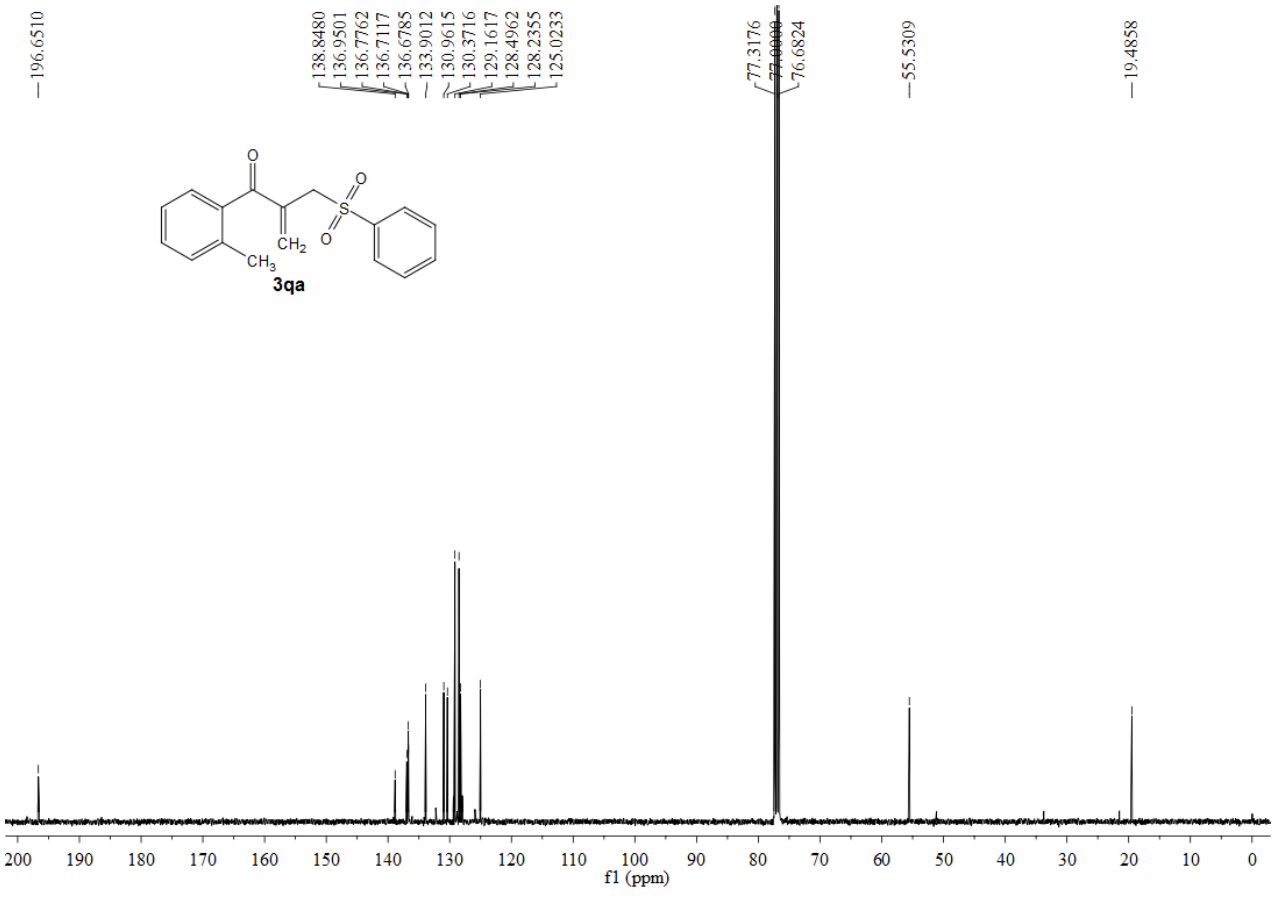
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128.2355
125.0233
77.3176
77.0000
76.6824
55.5309
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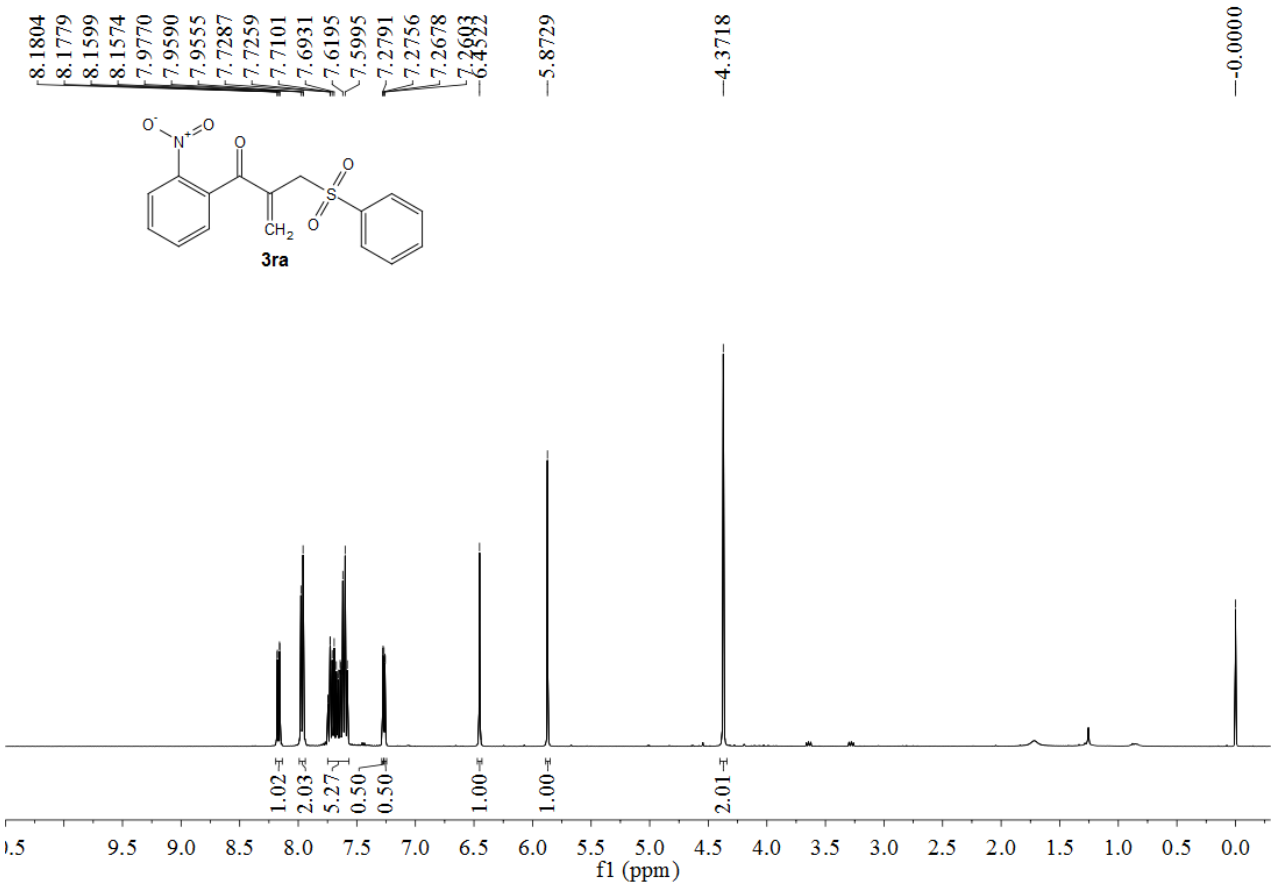
O
O
S
O
CH2
CH3
3qa
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.6931
7.6195
7.5995
7.2791
7.2756
7.2678
7.2603
6.4322
5.8729
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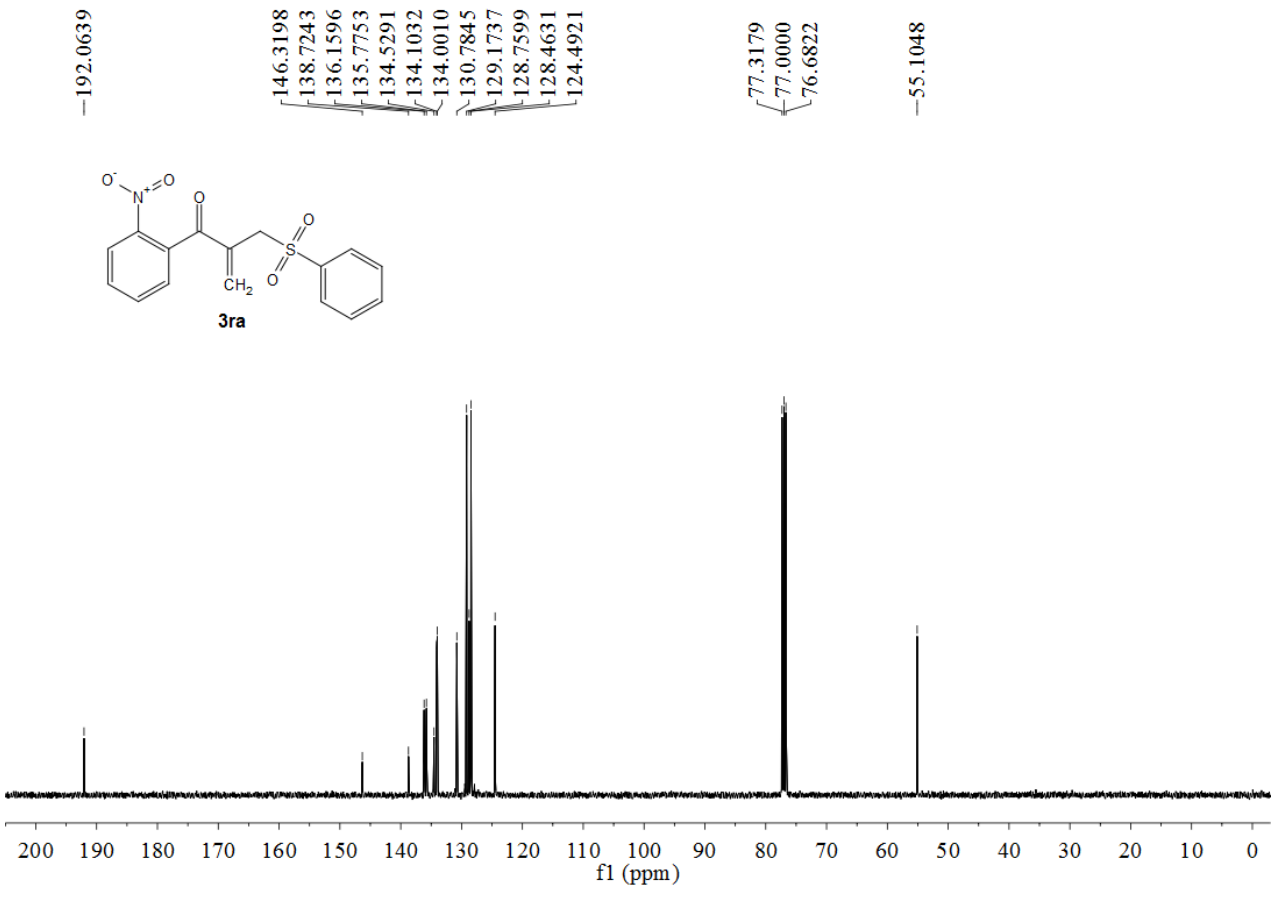
1.02
2.03
5.27
0.50
0.50
1.00
1.00
2.01
f1 (ppm)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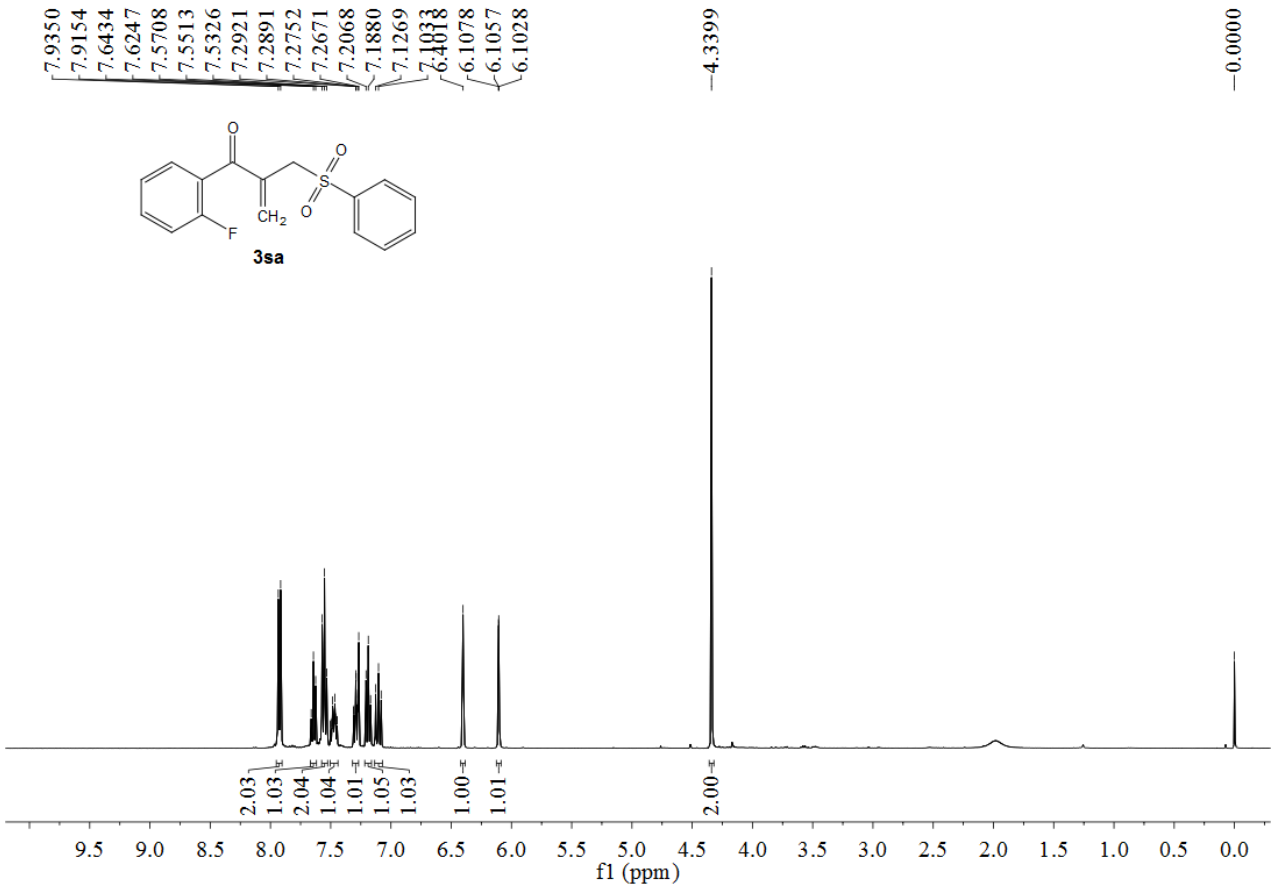
f1 (ppm)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7.2671
7.2068
7.1880
7.1269
6.4018
6.1078
6.1057
6.1028
4.3399
0.0000
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2.04
1.04
1.01
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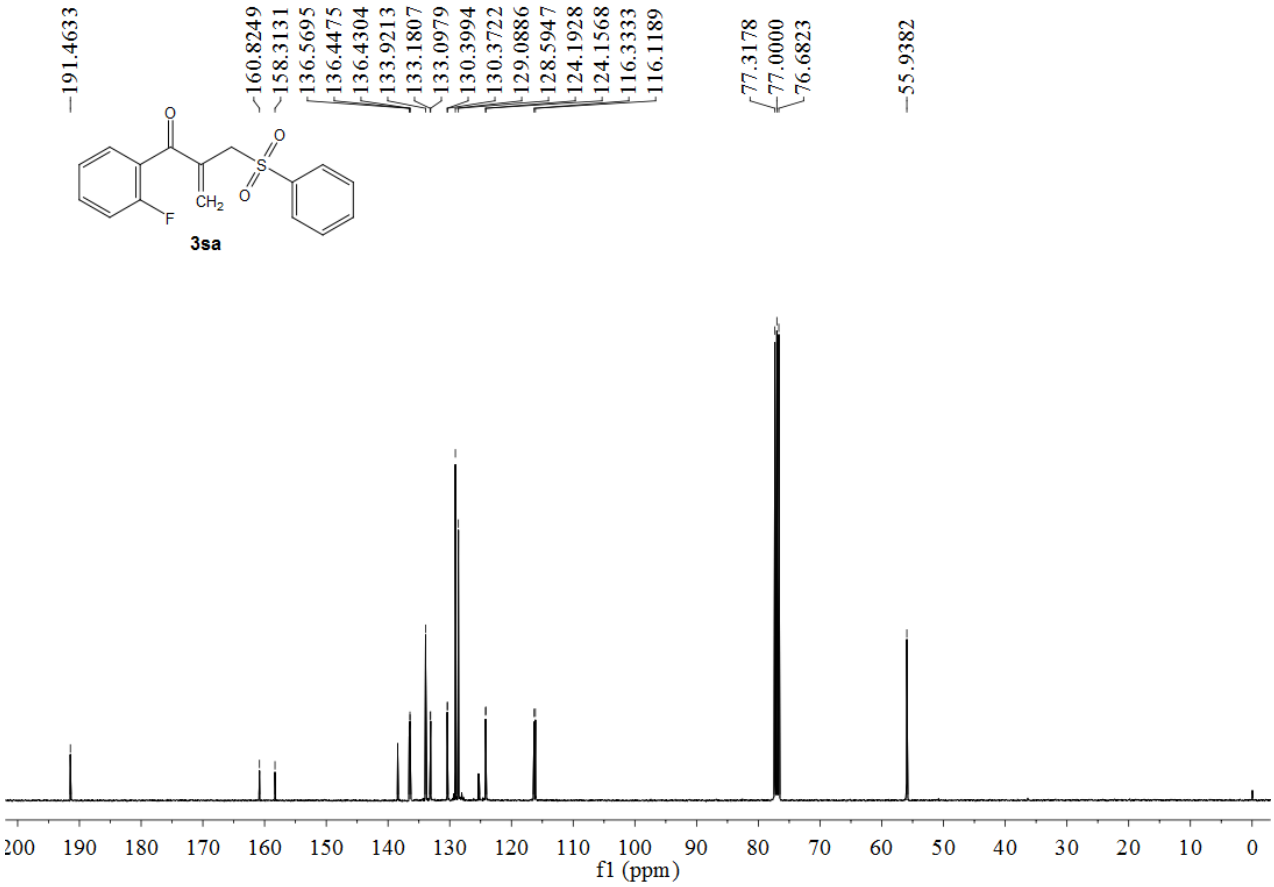
1.03
1.00
1.01
2.00
f1 (ppm)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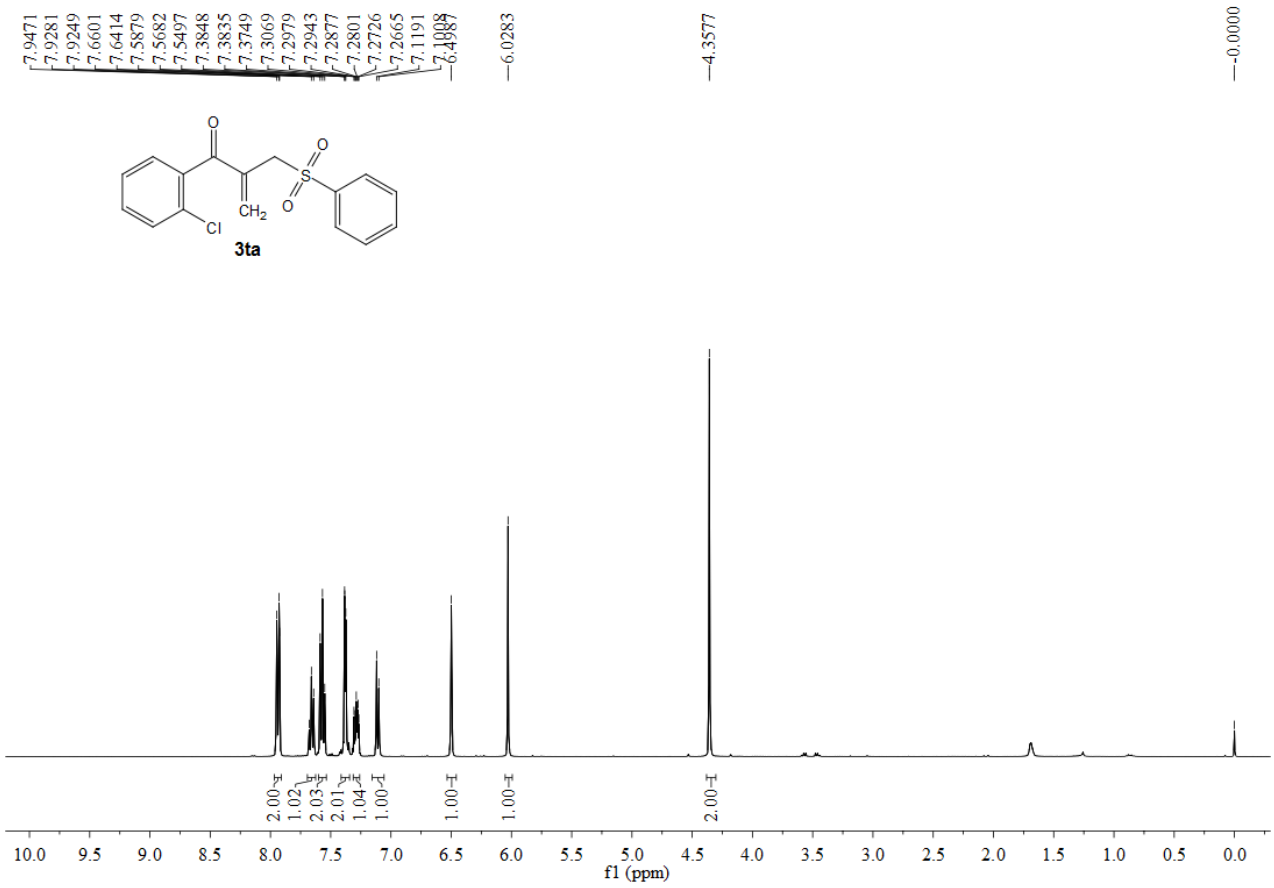
f1 (ppm)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7.3069
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7.2877
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7.2665
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1.04
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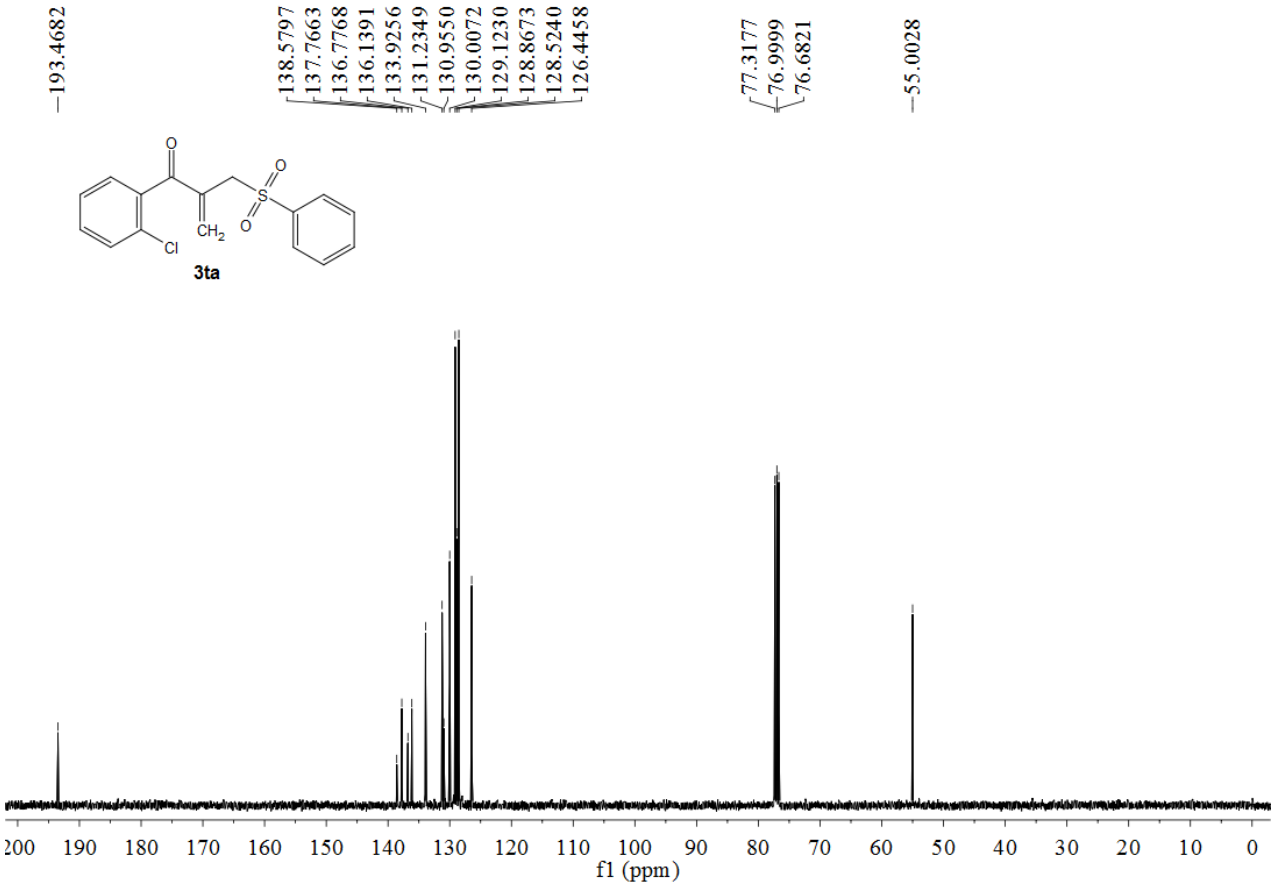
1.00
1.00
2.00
f1 (ppm)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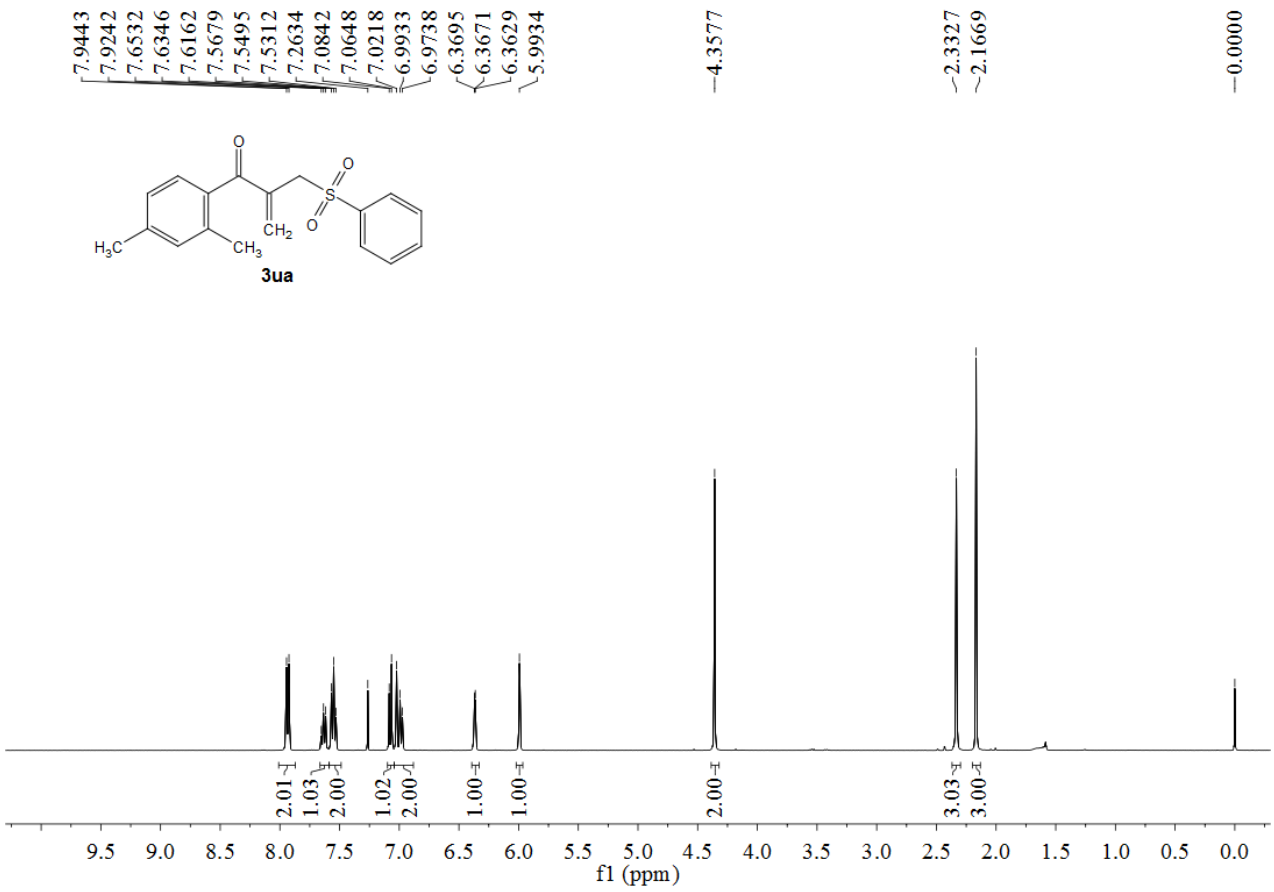
f1 (ppm)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7.0218
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6.3629
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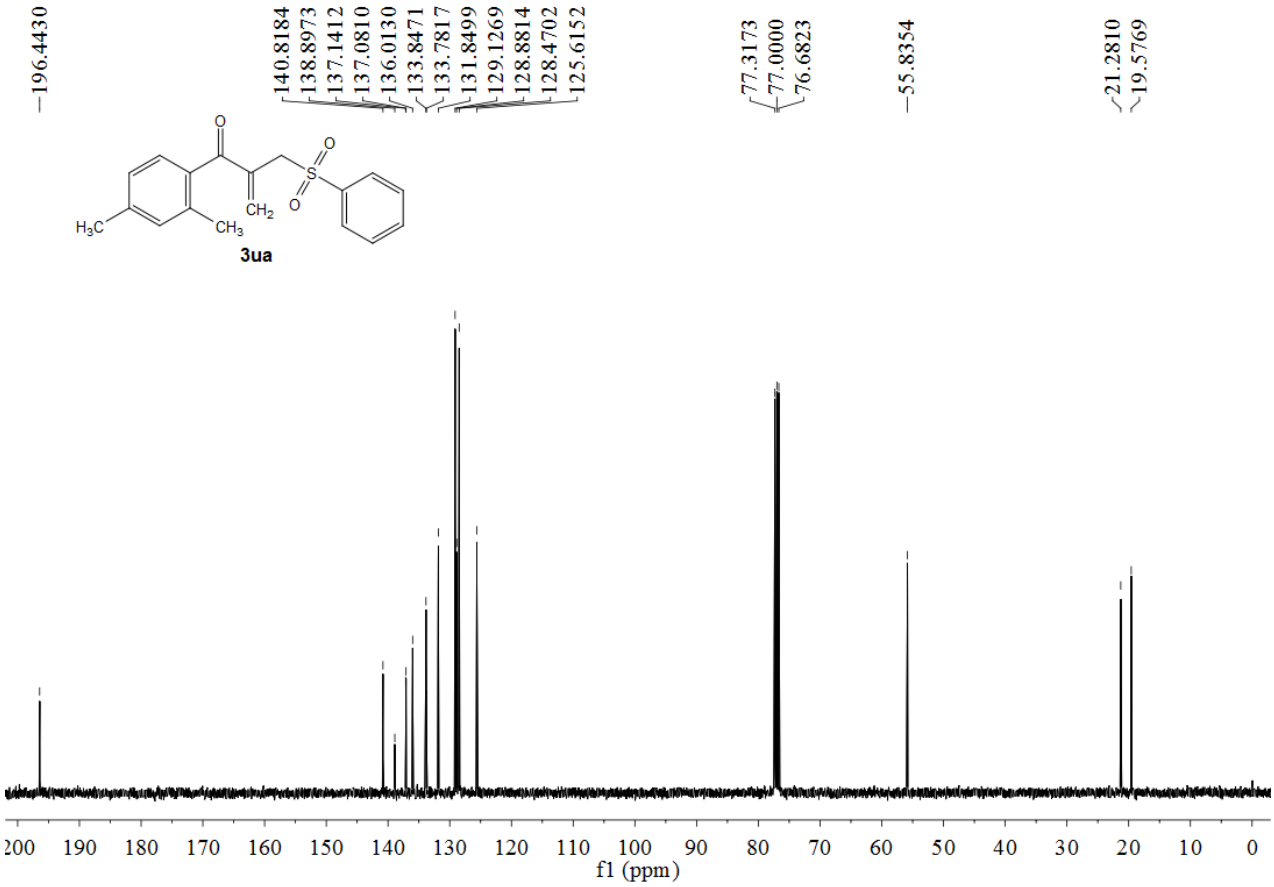
3.00
f1 (ppm)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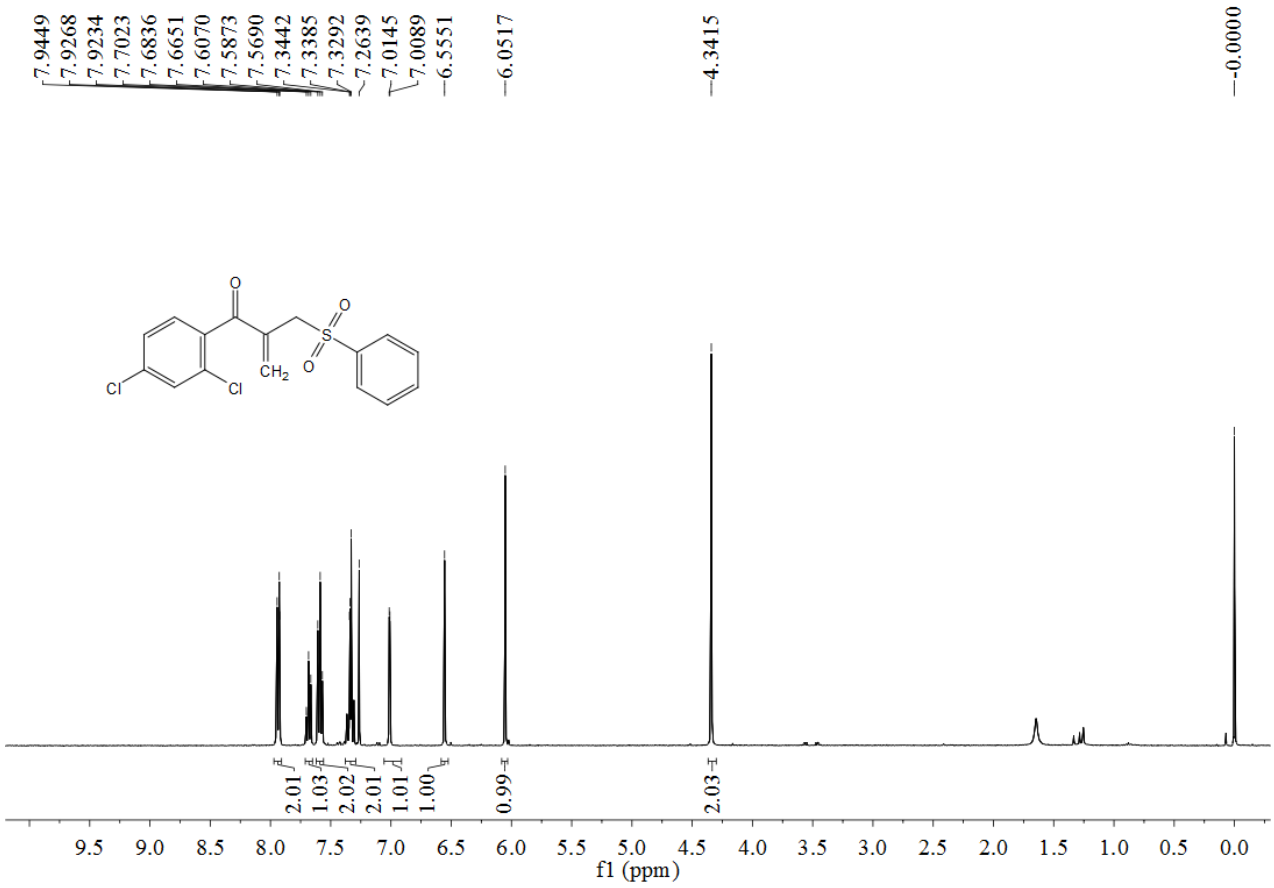
f1 (ppm)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7.3292
7.2639
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7.0089
6.5551
6.0517
4.3415
0.0000
O
O
S
O
CH2
Cl
Cl
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1.03
2.02
2.01
1.01
1.00
0.99
2.03
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
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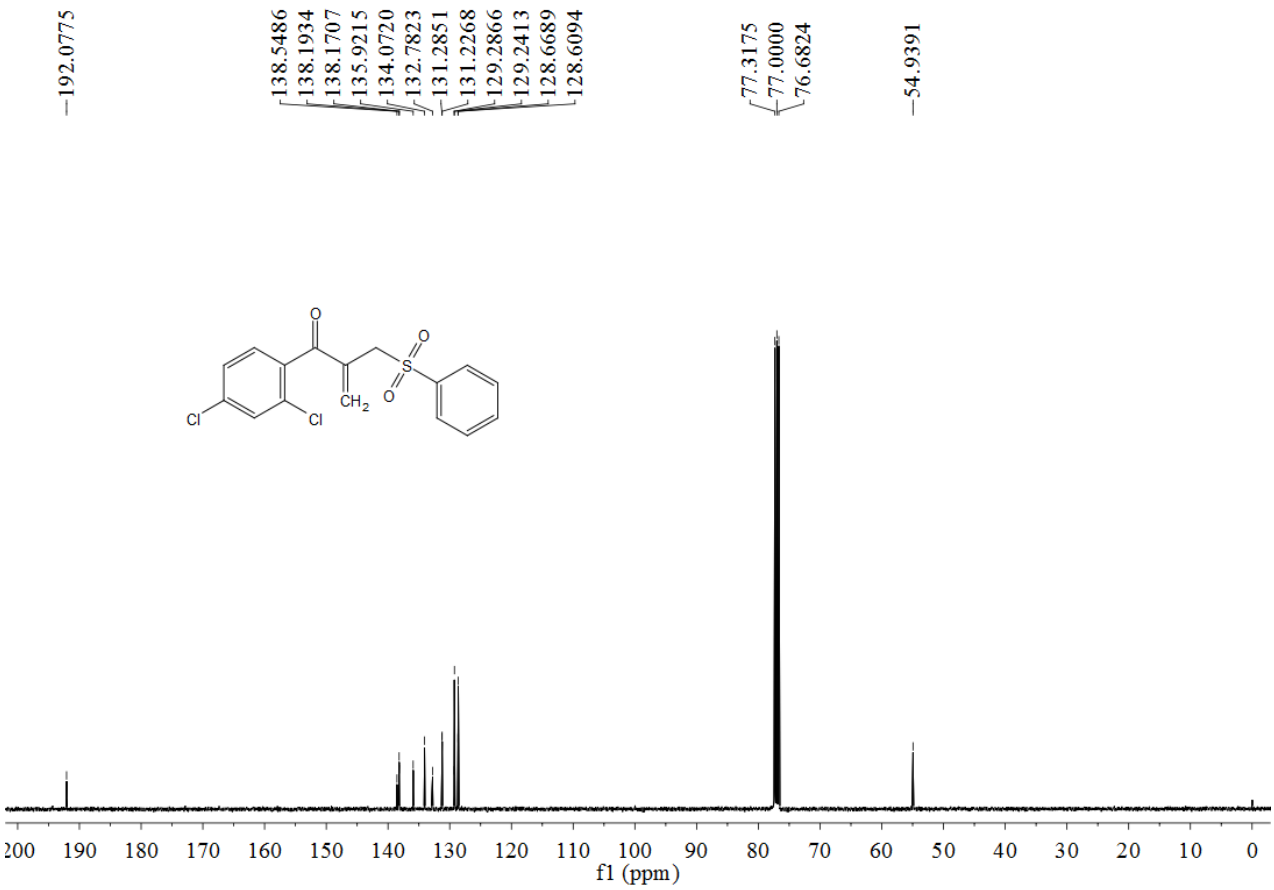
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O
S
O
CH2
Cl
Cl
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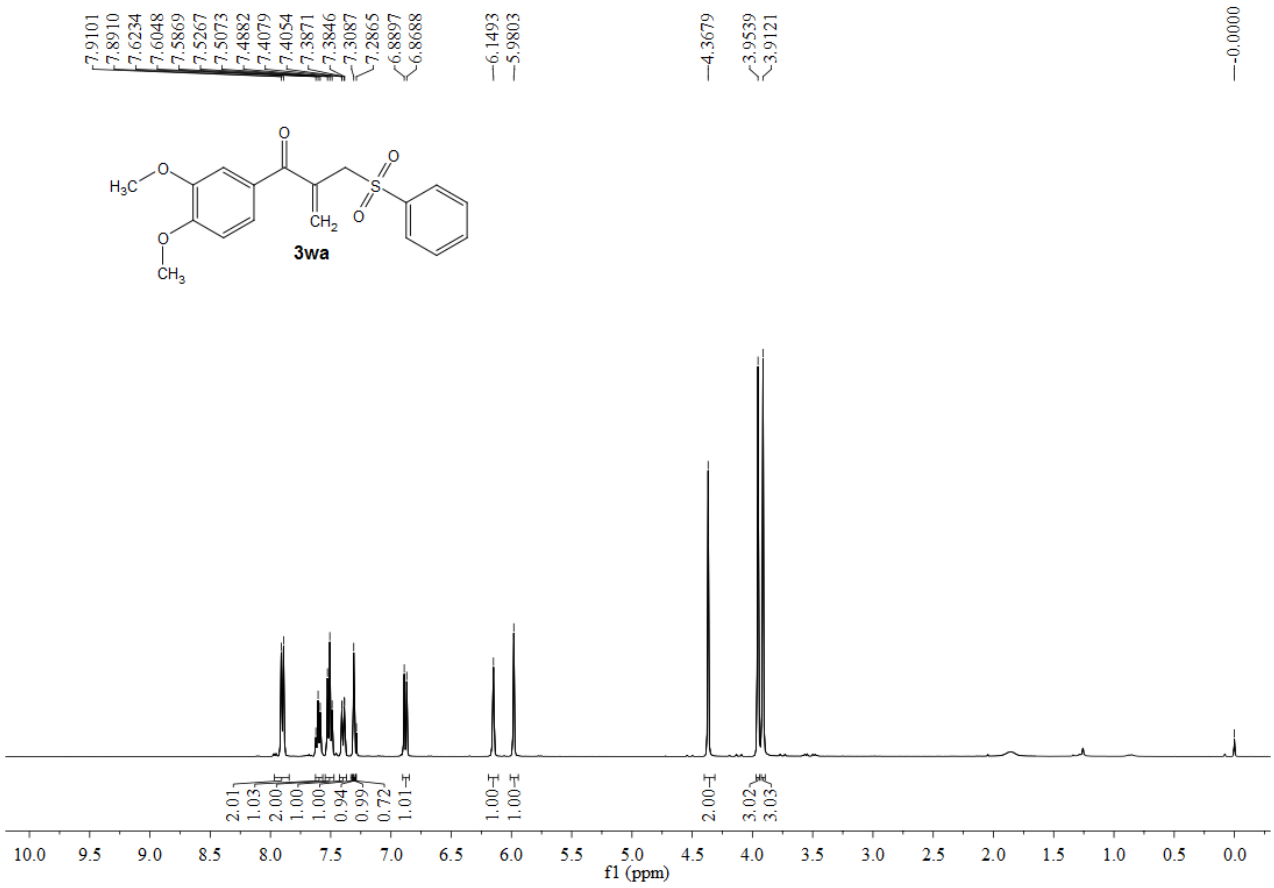
f1 (ppm)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1.00
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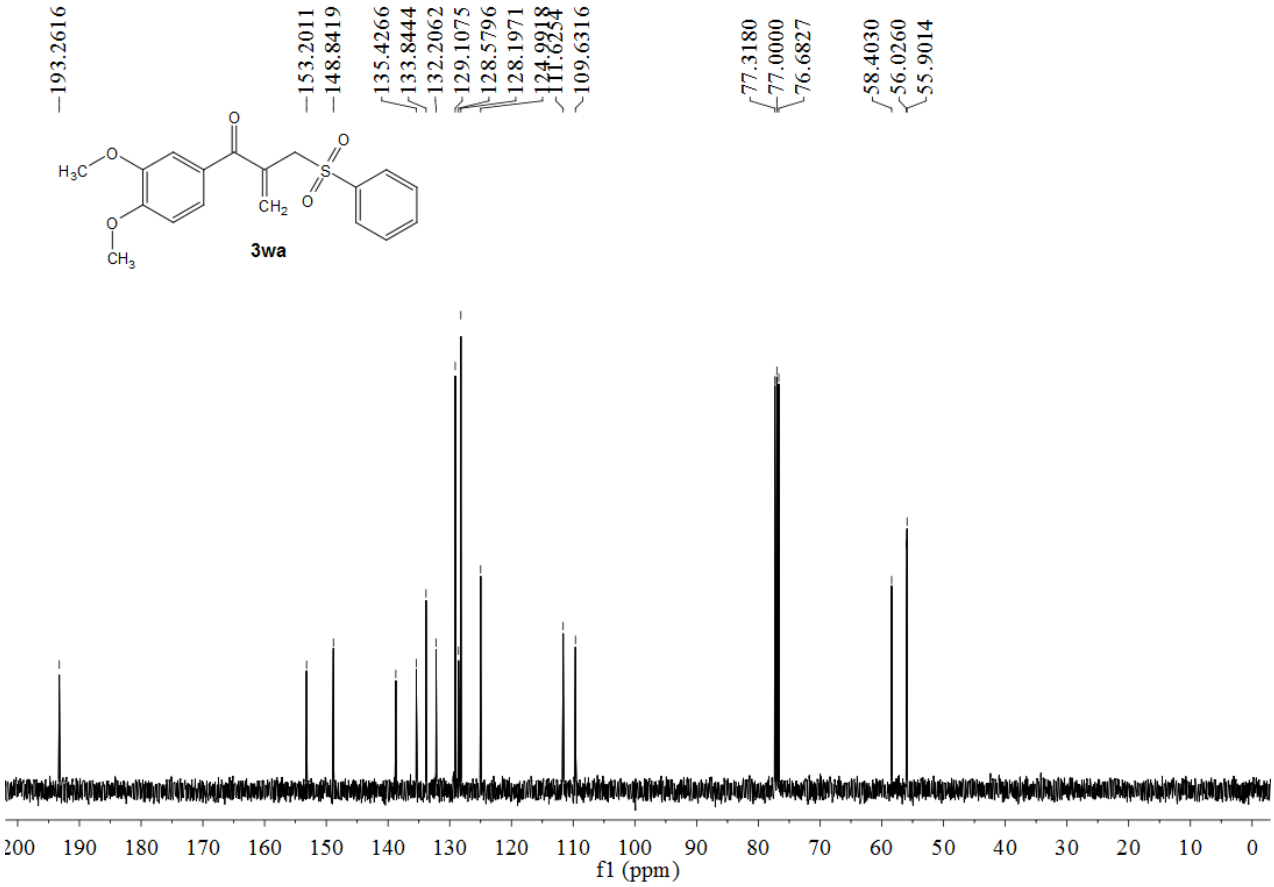
3.03
f1 (ppm)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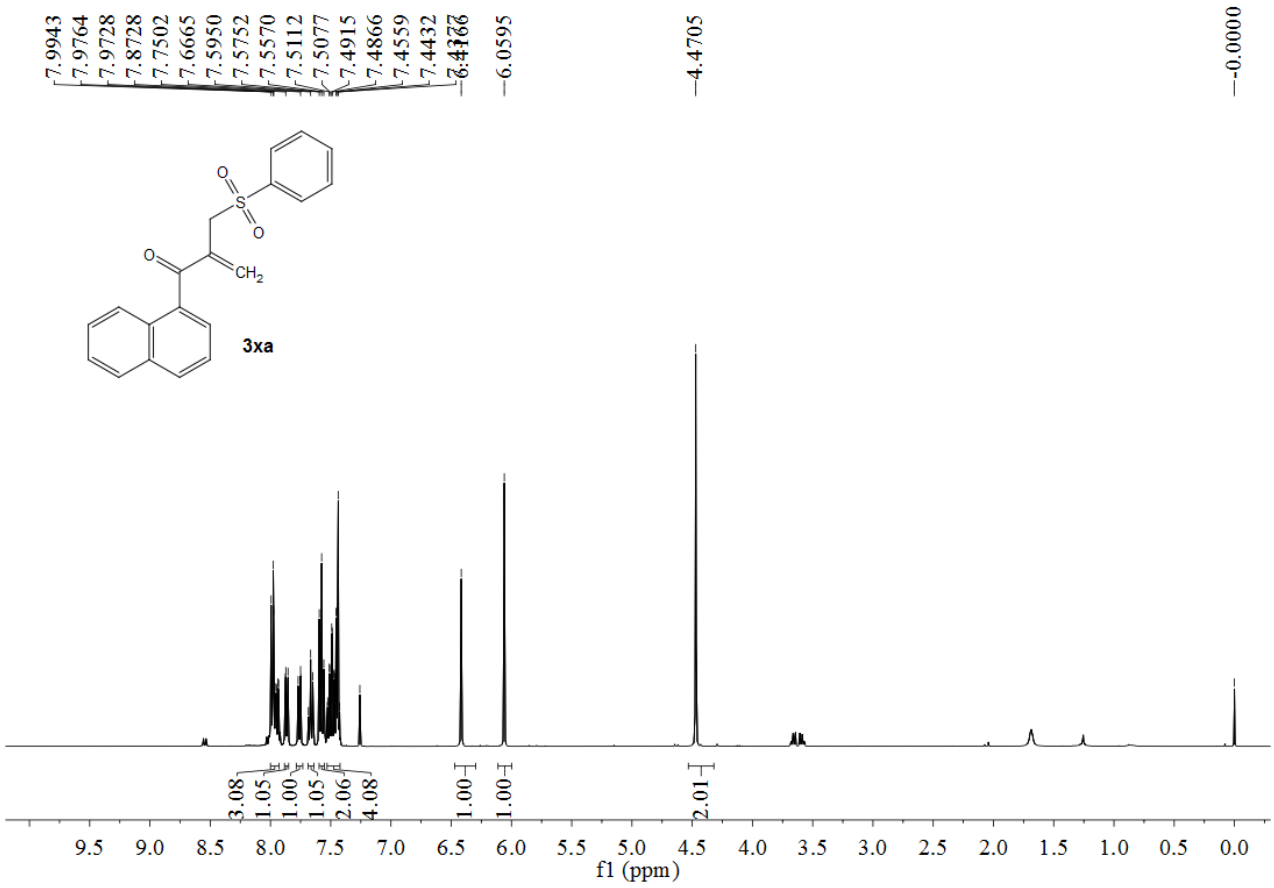
3wa
f1 (ppm)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1.05
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1.00
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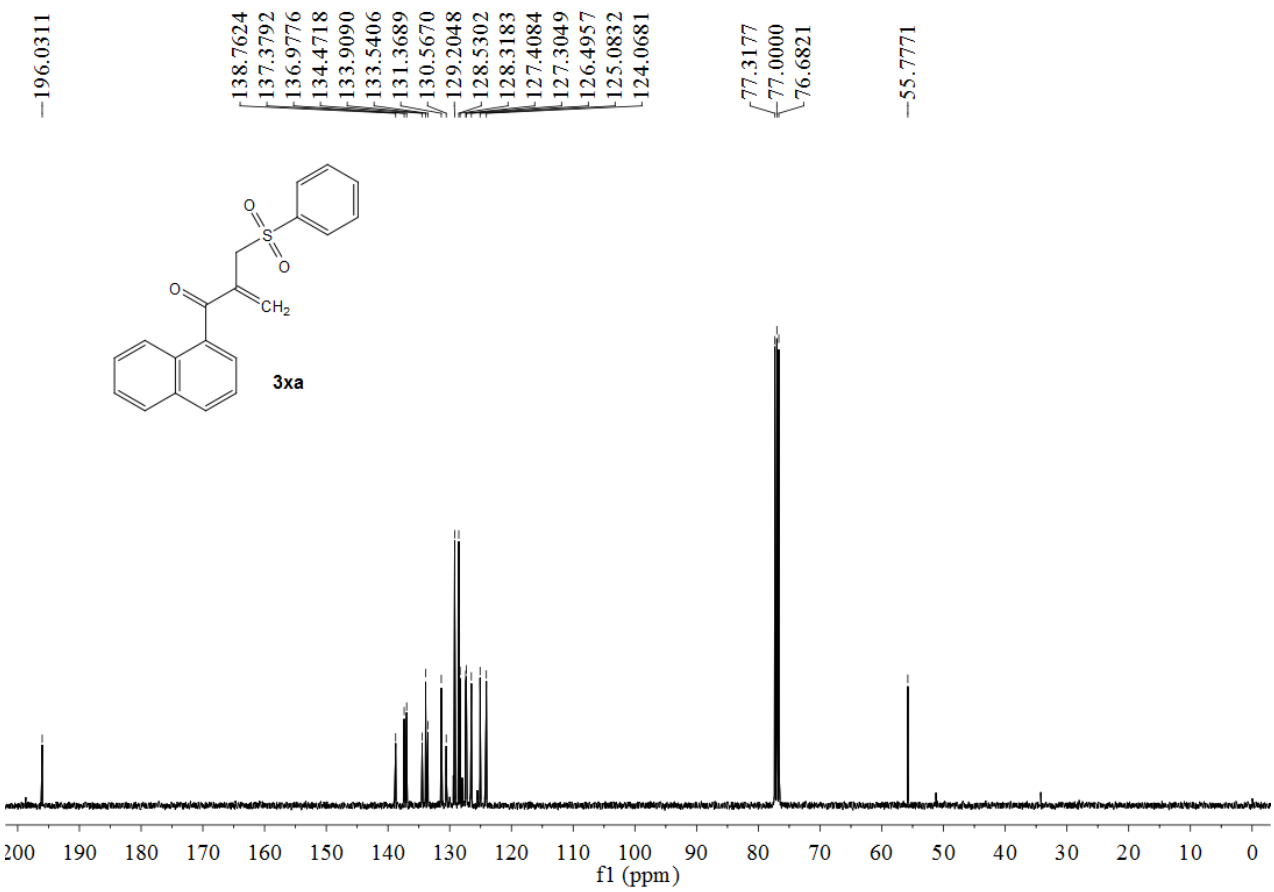
2.01
f1 (ppm)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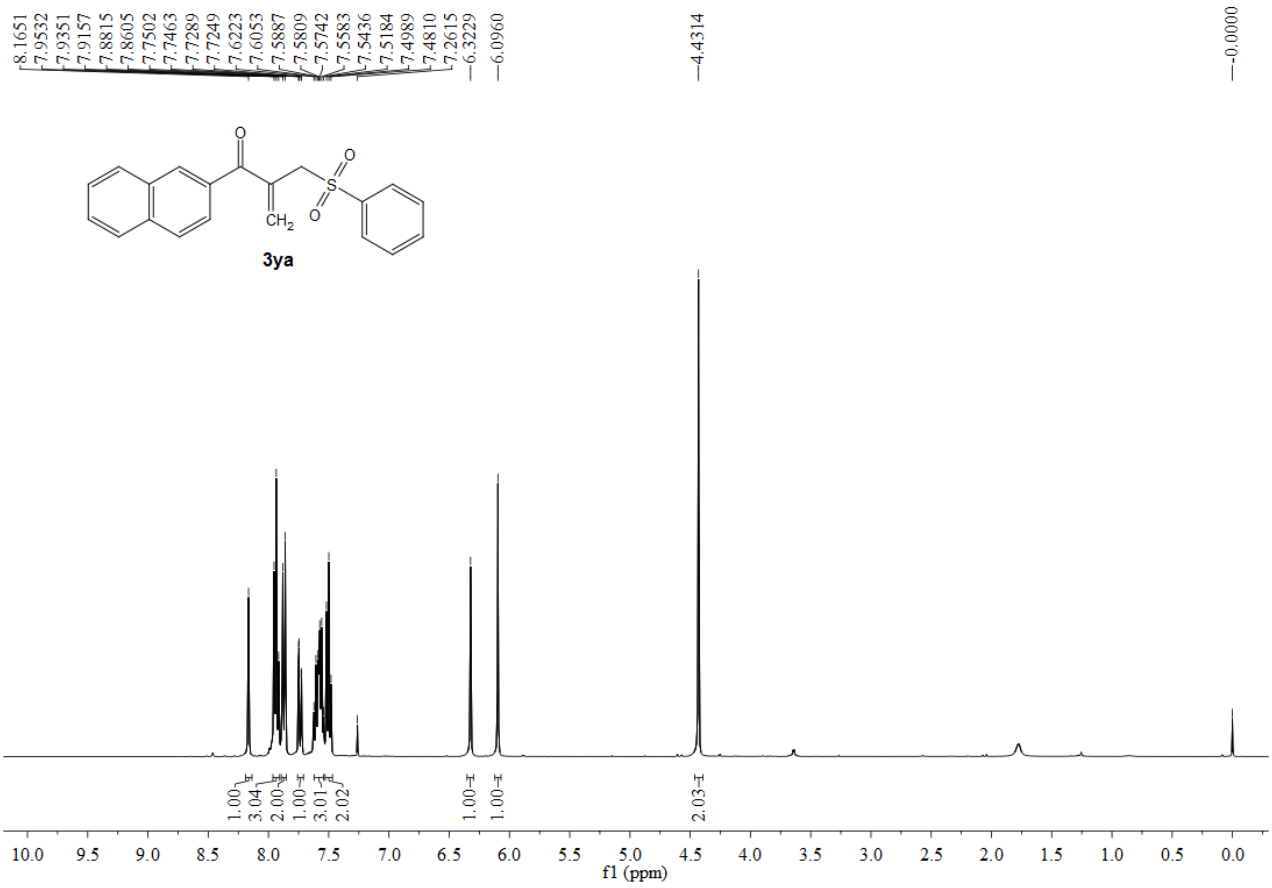
3xa
f1 (ppm)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6.0960
4.4314
0.0000
O
O
S
O
CH2
3ya
1.00
3.04
2.00
1.00
3.01
2.02
1.00
1.00
2.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
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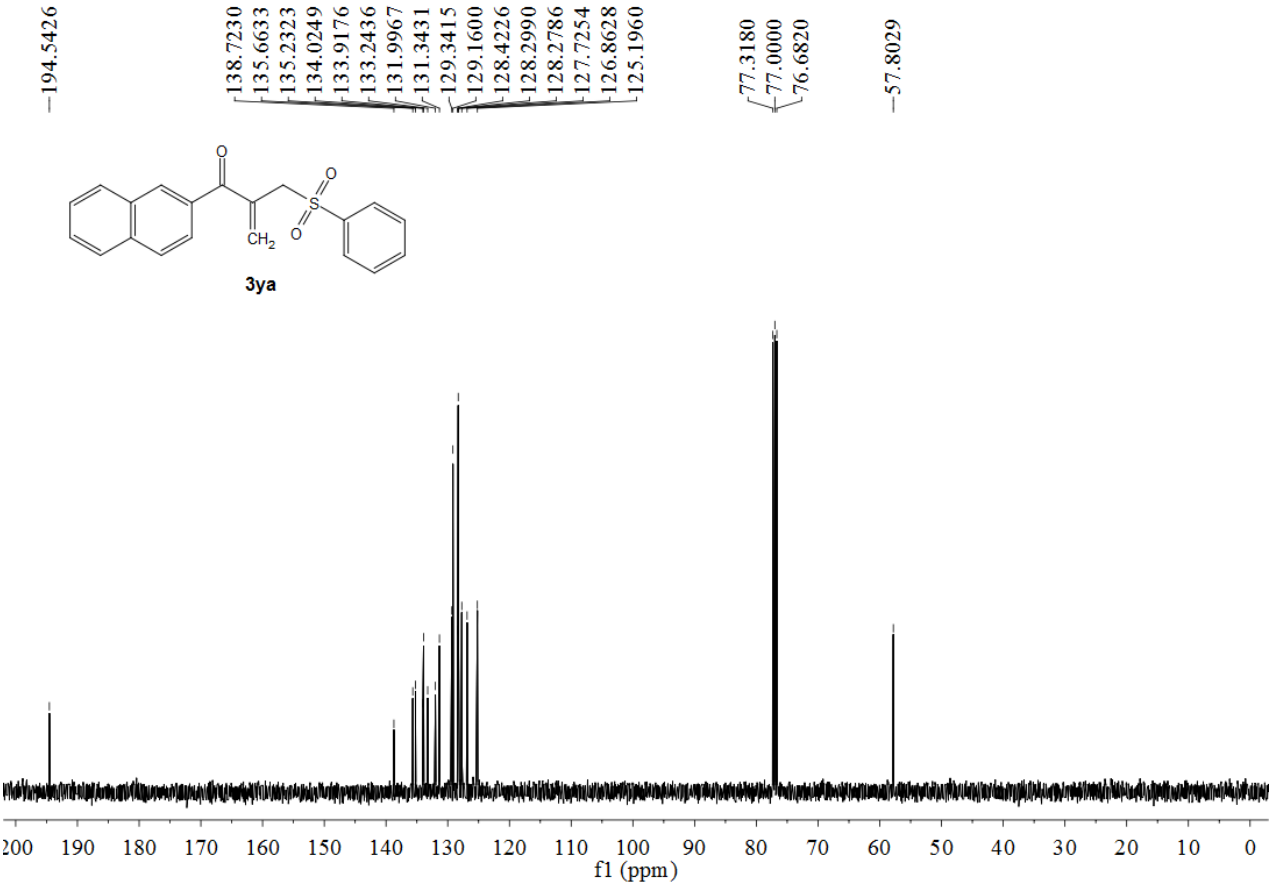
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O
O
S
O
CH2
3ya
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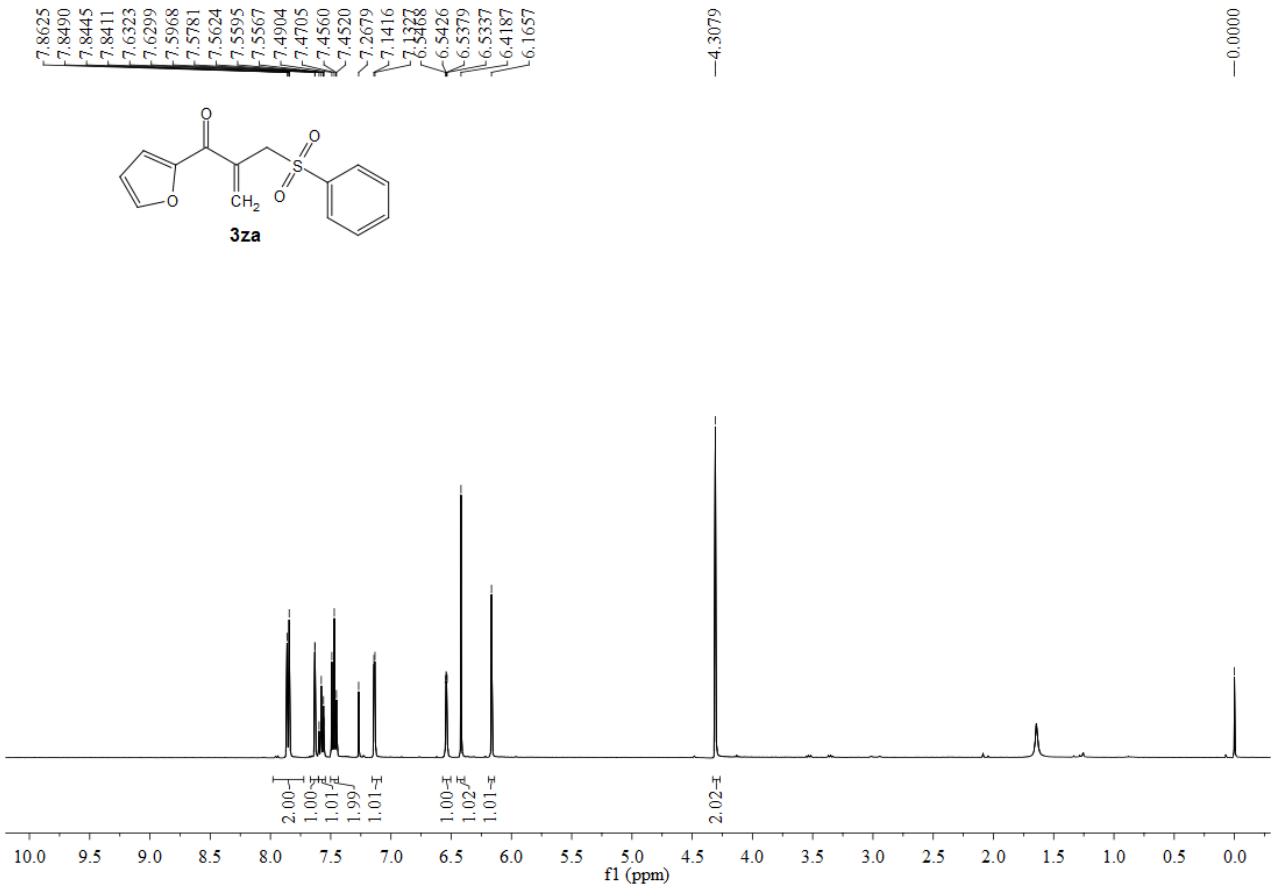
f1 (ppm)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0.0000
O
O
S
O
O
CH2
3za
2.00
1.00
1.01
1.99
1.01
1.00
1.02
1.01
2.02
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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1.0
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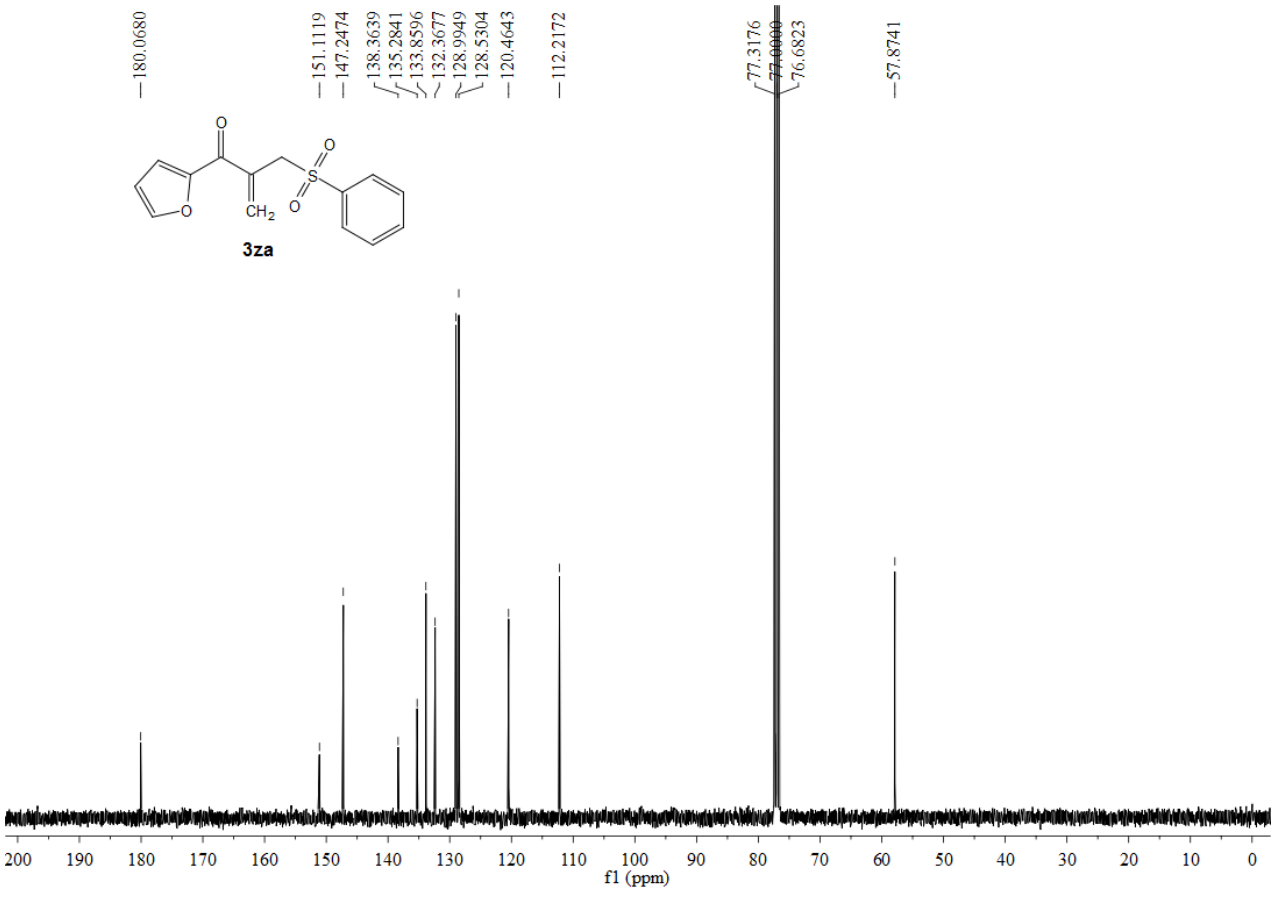
f1 (ppm)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O
O
S
O
O
CH2
3za
200
190
180
170
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150
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100
90
80
70
60
50
40
30
20
10
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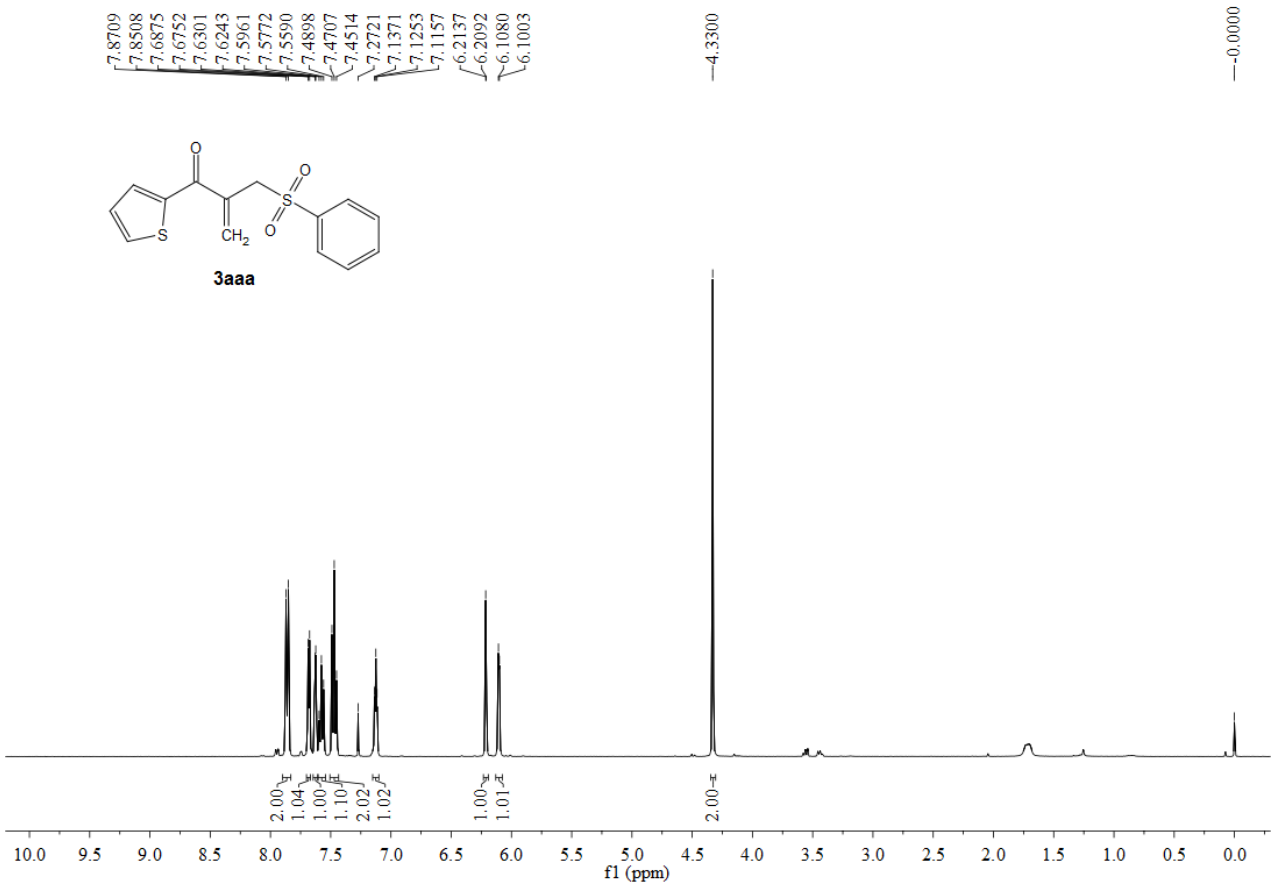
f1 (ppm)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7.4514
7.2721
7.1371
7.1253
7.1157
6.2137
6.2092
6.1080
6.1003
4.3300
0.0000
2.00
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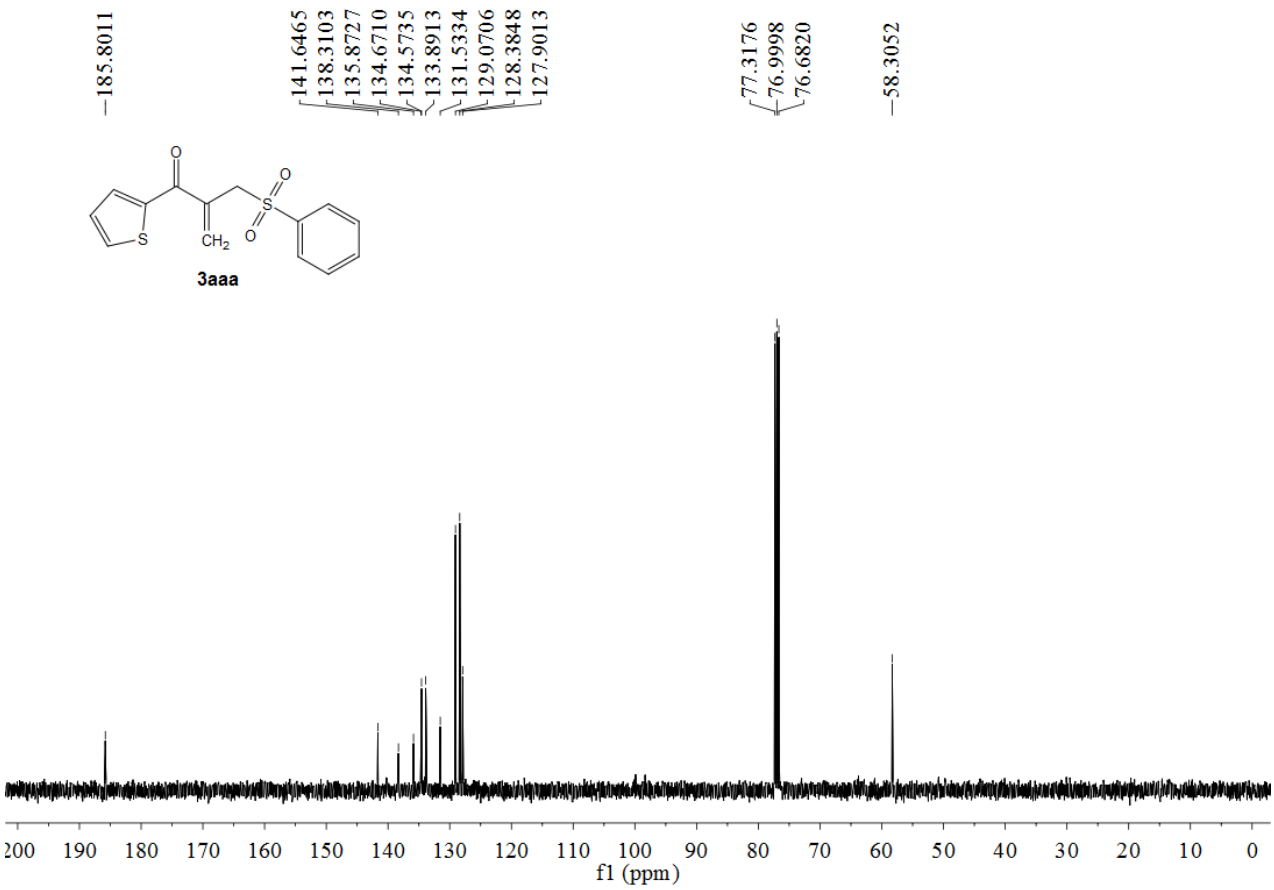
1.00
1.10
2.02
1.02
1.00
1.01
2.00
f1 (ppm)

3aaa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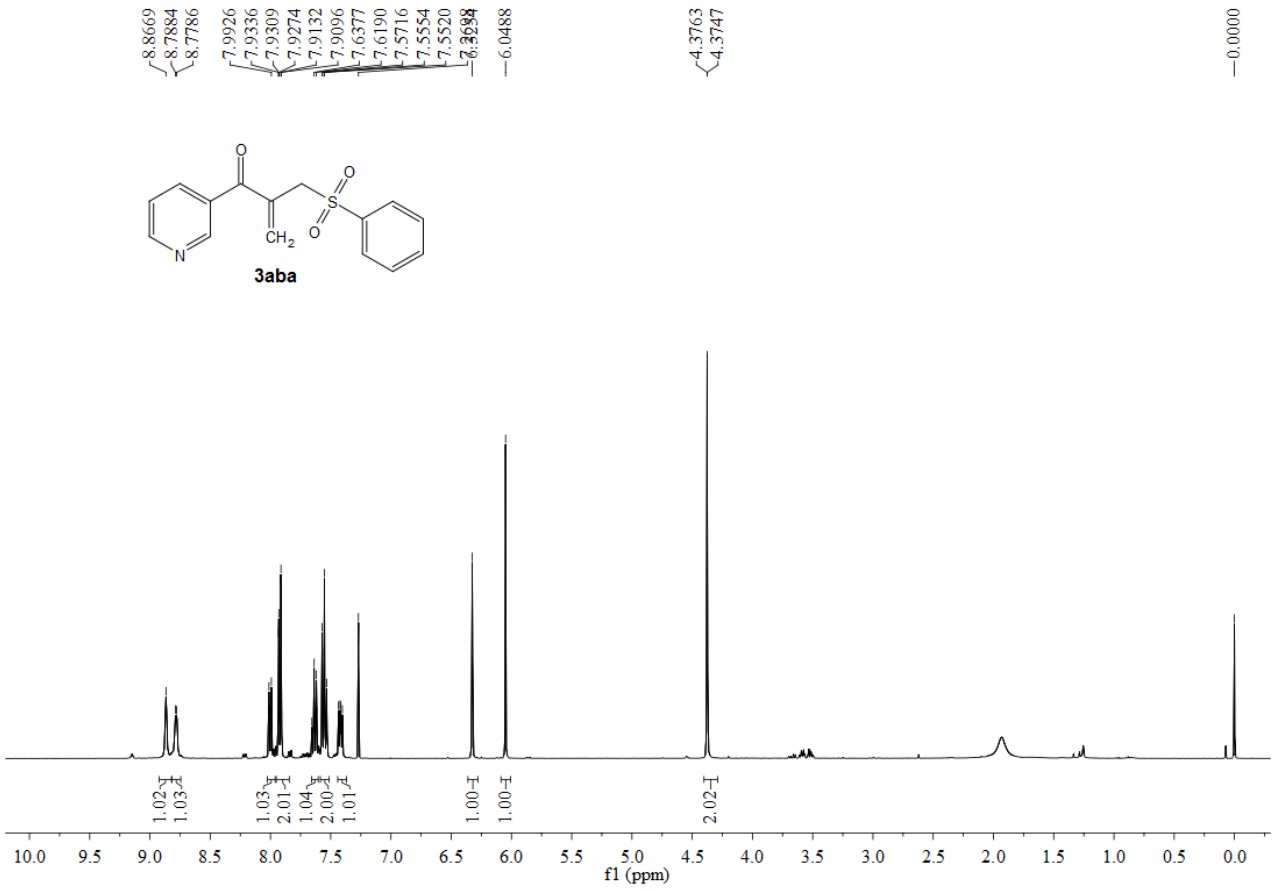
127.9013
77.3176
76.9998
76.6820
58.3052
f1 (ppm)

3aaa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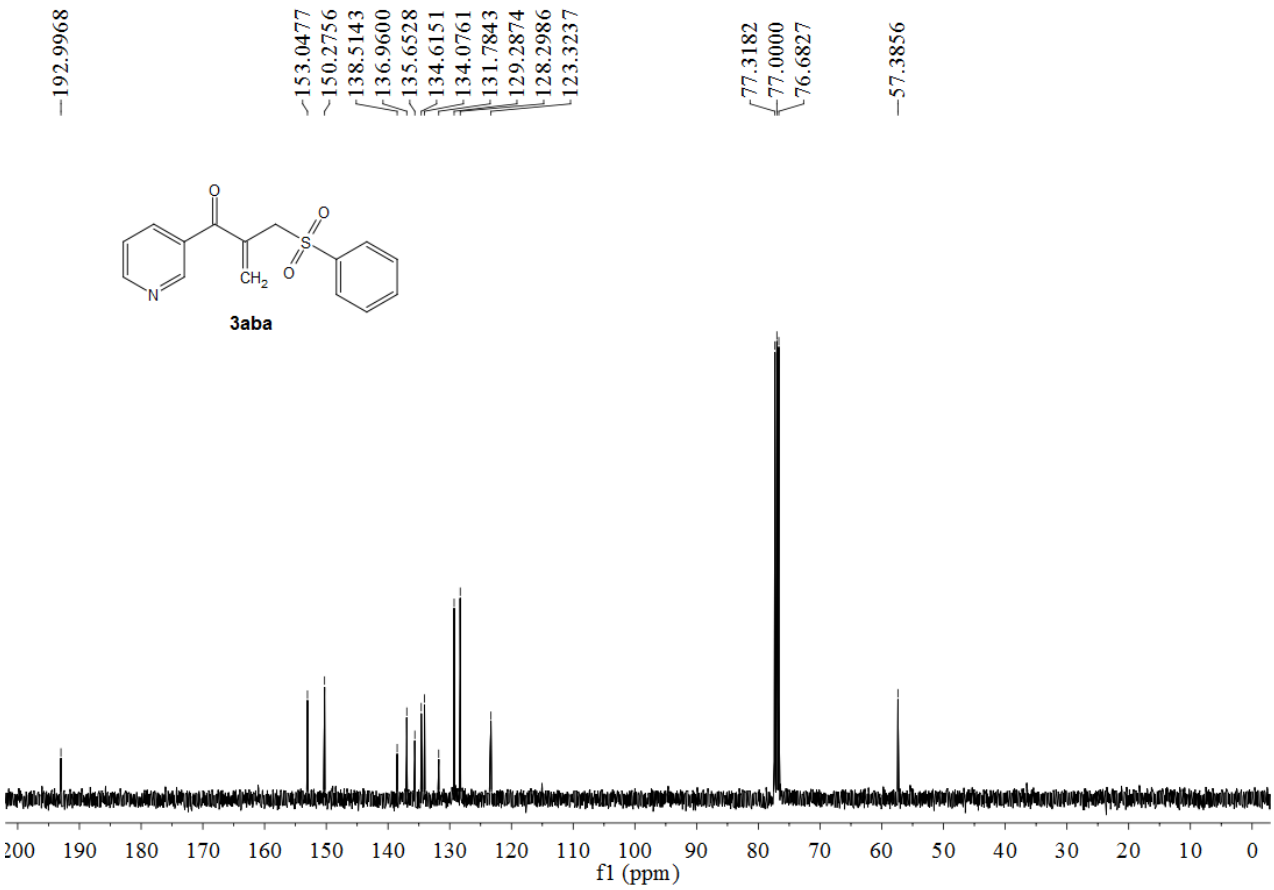
7.9274
7.9132
7.9096
7.6377
7.6190
7.5716
7.5554
7.5520
6.0488
4.3763
4.3747
0.0000
O
O
S
O
CH2
N
3aba
1.02
1.03
1.03
2.01
1.04
2.00
1.01
1.00
1.00
2.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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123.3237
77.3182
77.0000
76.6827
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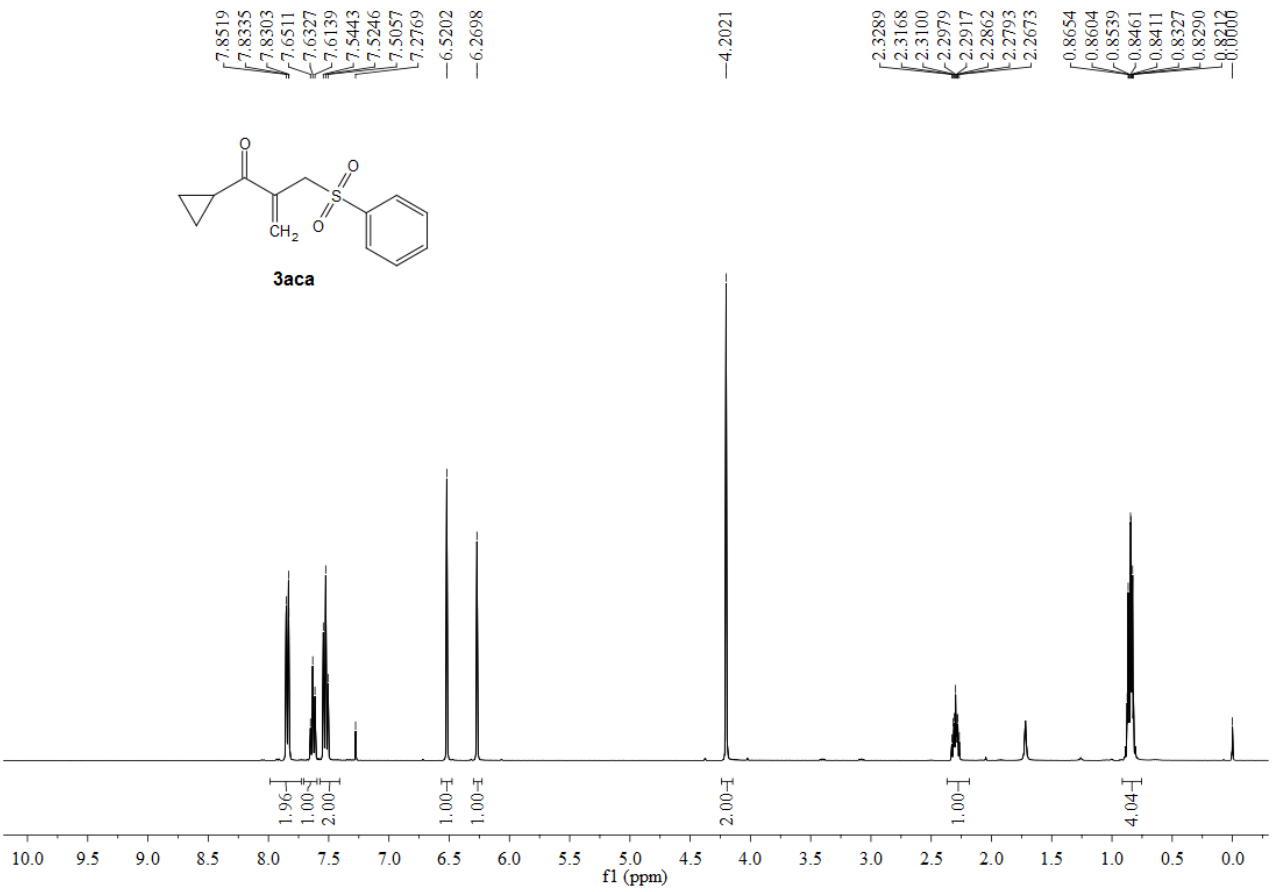
O
S
O
CH2
N
3aba
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.5057
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6.5202
6.2698
4.2021
2.3289
2.3168
2.3100
2.2979
2.2917
2.2862
2.2793
2.2673
0.8654
0.8604
0.8539
0.8461
0.8411
0.8327
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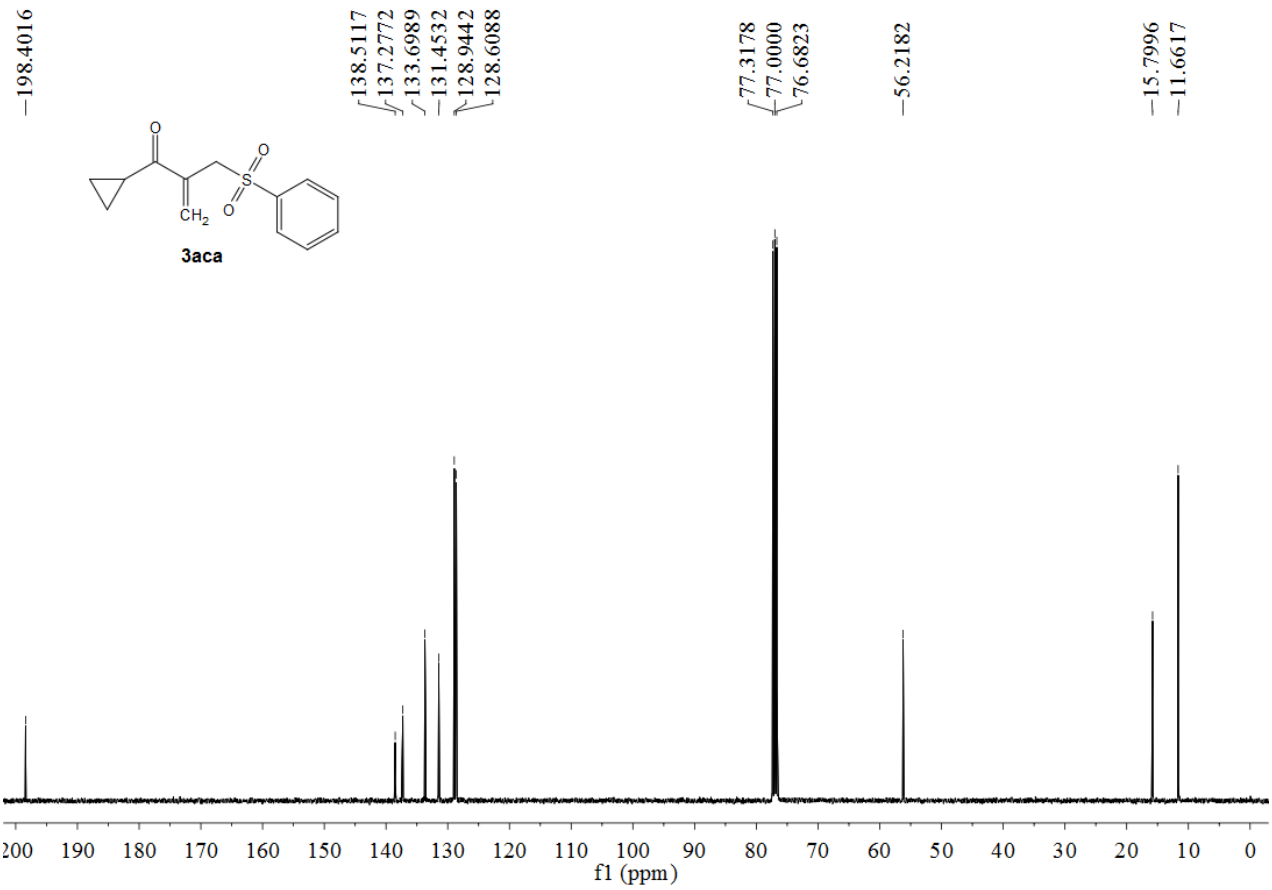
f1 (ppm)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56.2182
15.7996
11.6617
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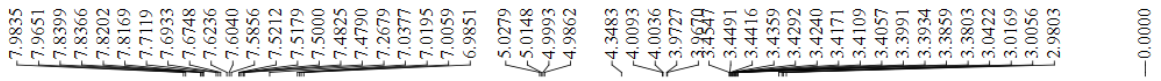
f1 (ppm)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7.6040
7.5856
7.5212
7.5179
7.5000
7.4825
7.4790
7.2679
7.0377
7.0195
7.0059
6.9851
5.0279
5.0148
4.9993
4.9862
4.3483
4.0093
4.0036
3.9727
3.9670
3.4547
3.4491
3.4416
3.4359
3.4292
3.4240
3.4171
3.4109
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3.3934
3.3859
3.3803
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3.0169
3.0056
2.9803
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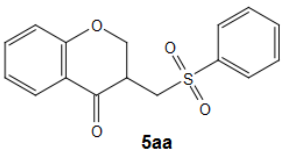
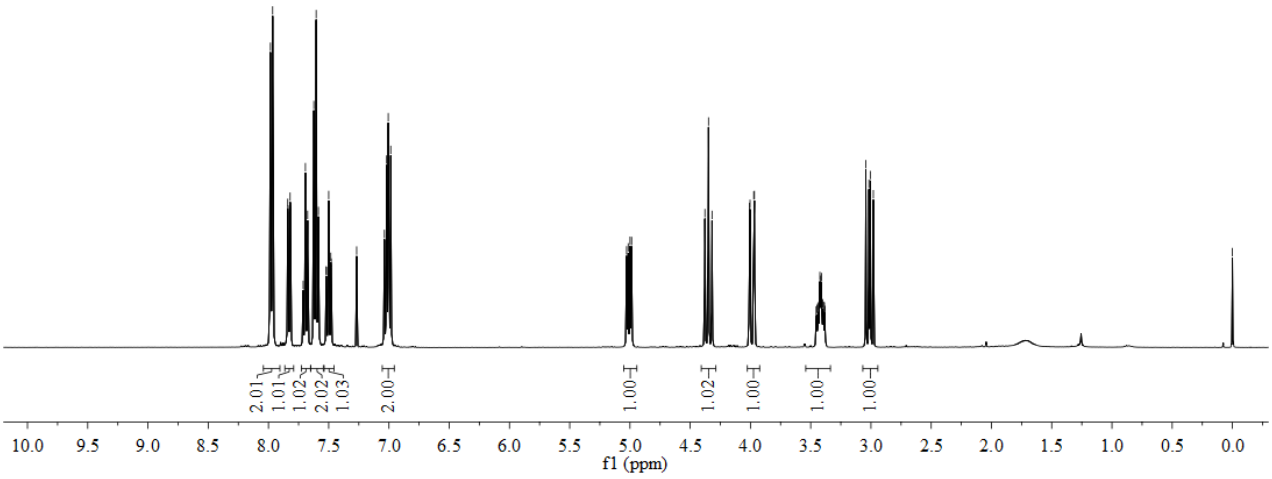

O
O
S
O
O

5aa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1.01
1.02
2.02
1.03
2.00
1.00
1.02
1.00
1.00
1.00
10.0 9.5 9.0 8.5 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)


189.8739
161.5907
138.7337
136.5307
134.1500
129.5153
127.9154
127.4642
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119.8499
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77.0000
76.6822
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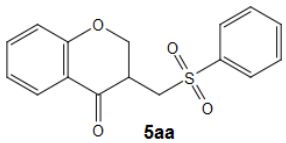
51.6148
40.7302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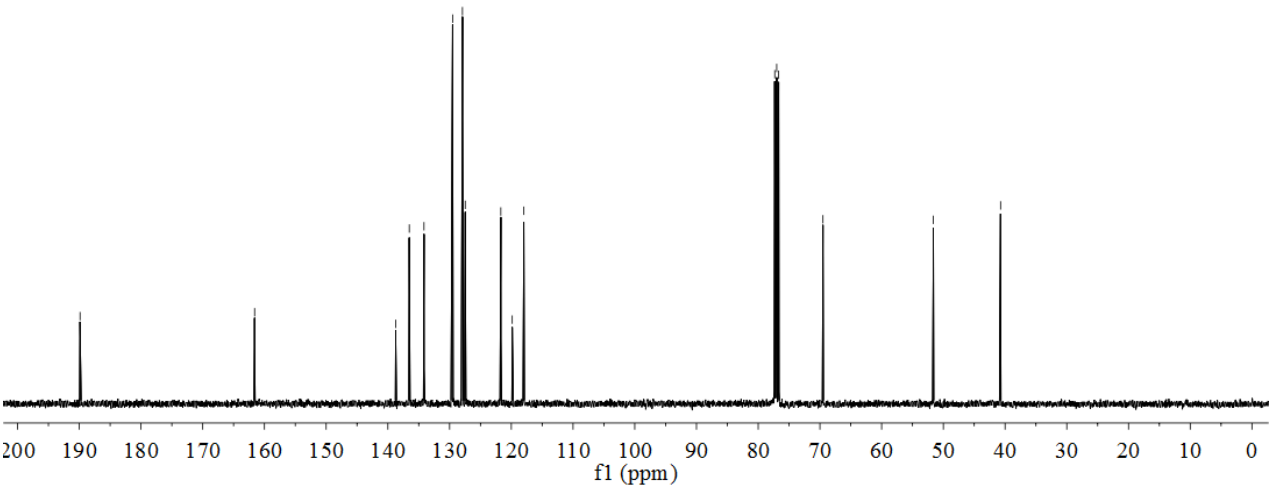
O
S
O
O

5aa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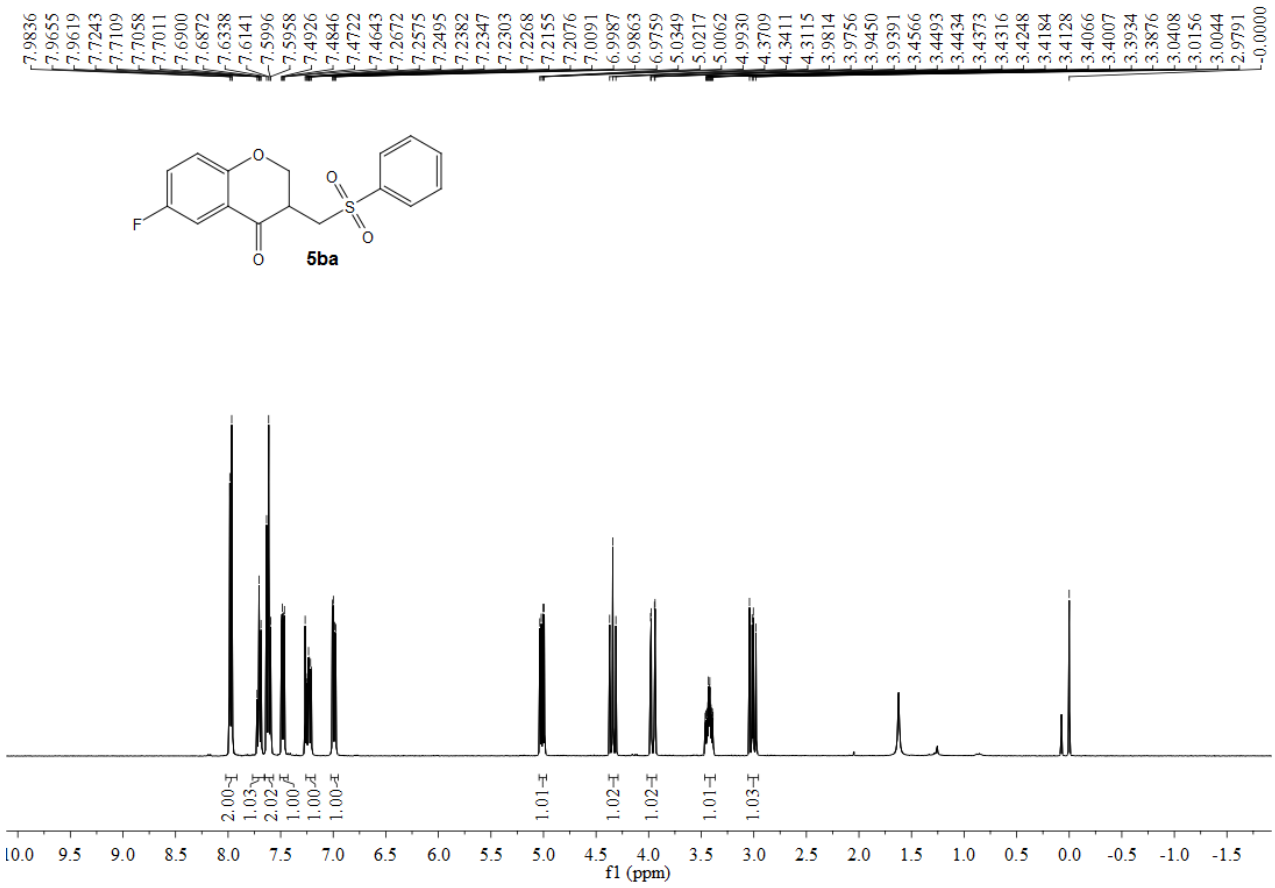
f1 (ppm)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7.5958
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7.4643
7.2672
7.2575
7.2495
7.2382
7.2347
7.2303
7.2268
7.2155
7.2076
7.0091
6.9987
6.9863
6.9759
5.0349
5.0217
5.0062
4.9930
4.3709
4.3411
4.3115
3.9814
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3.9450
3.9391
3.4566
3.4493
3.4434
3.4373
3.4316
3.4248
3.4184
3.4128
3.4066
3.4007
3.3934
3.3876
3.0408
3.0156
3.0044
2.9791
0.0000
O
O
S
O
F
O
5ba
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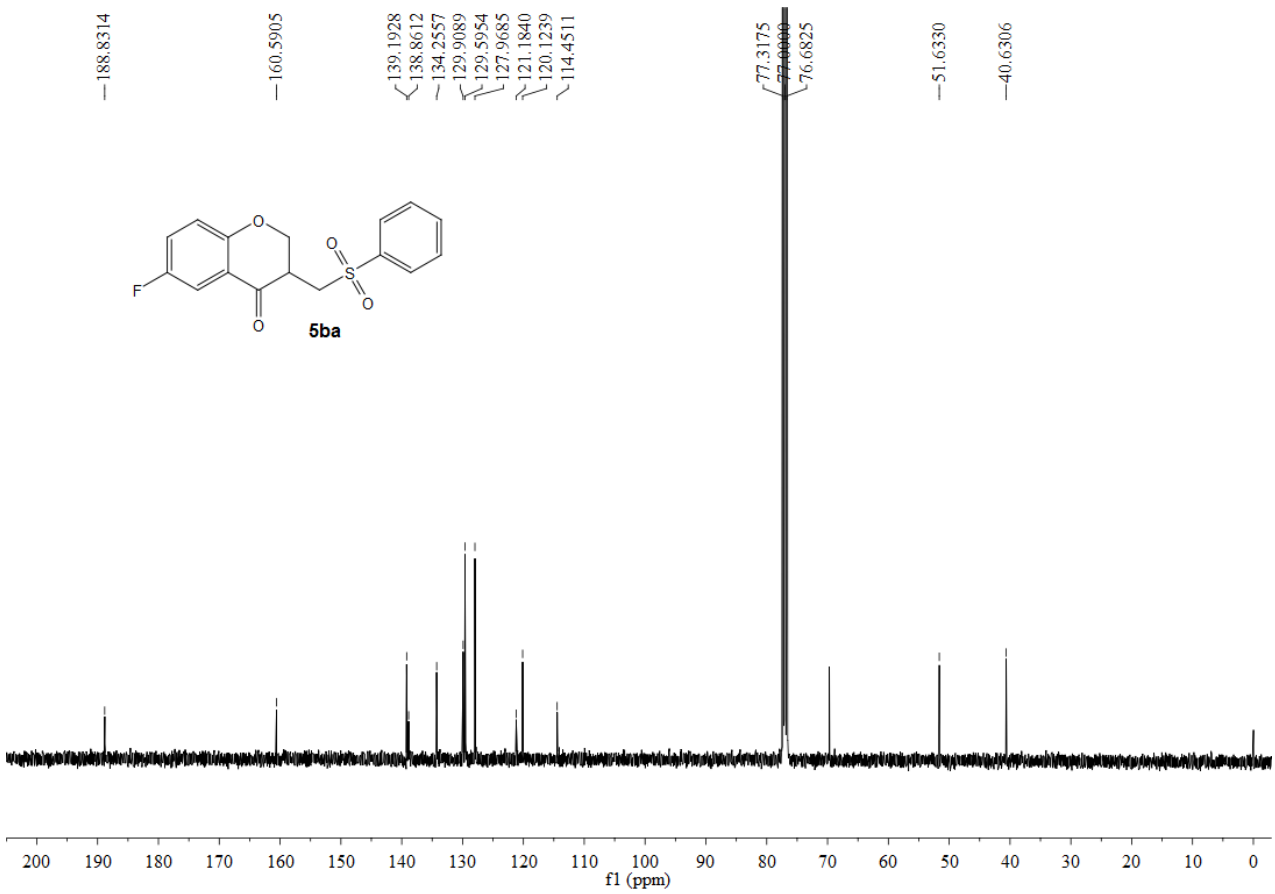
2.02
1.00
1.00
1.00
1.01
1.02
1.02
1.01
1.03
f1 (ppm)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129.5954
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121.1840
120.1239
114.4511
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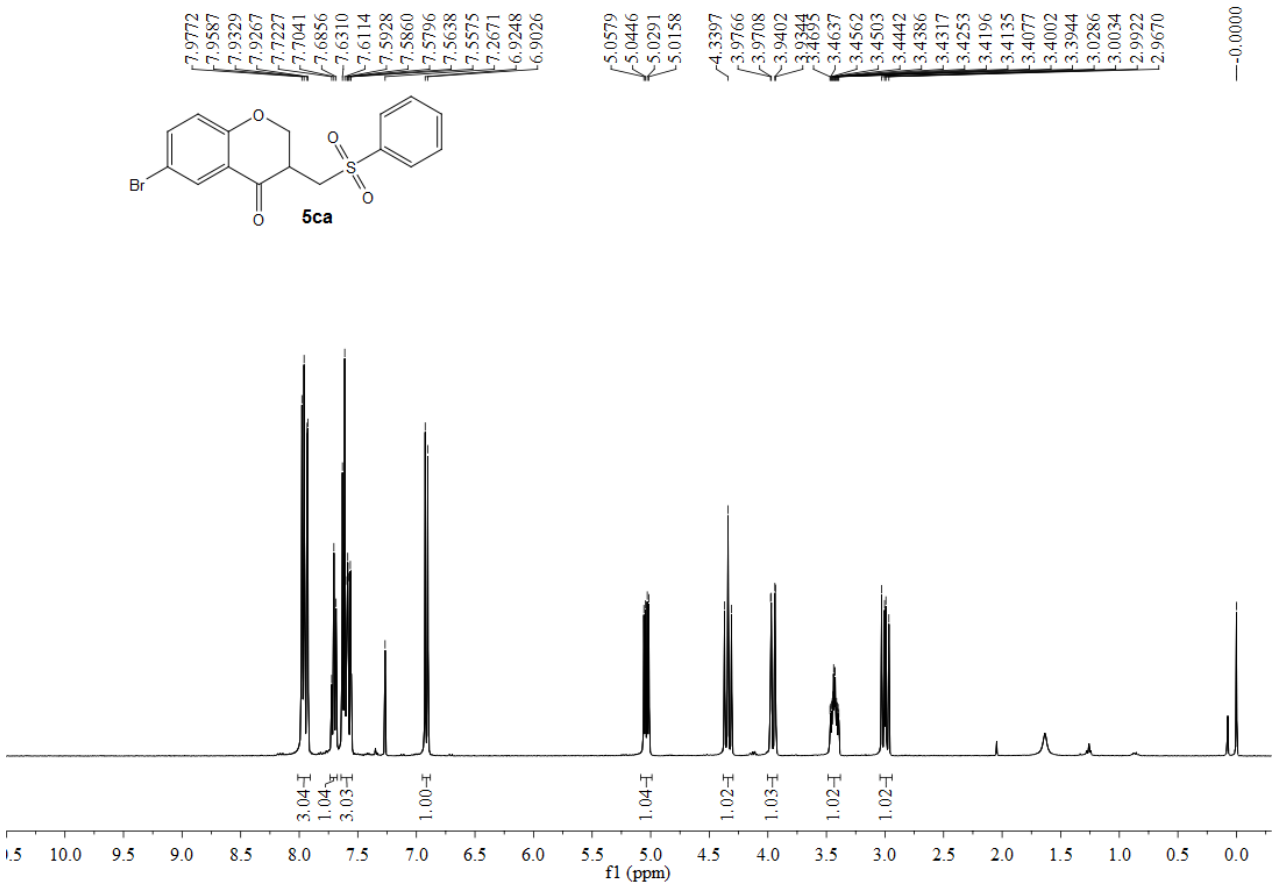
76.6825
51.6330
40.6306
O
O
S
O
F
O
5ba
f1 (ppm)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7.5796
7.5638
7.5575
7.2671
6.9248
6.9026
5.0579
5.0446
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4.3397
3.9766
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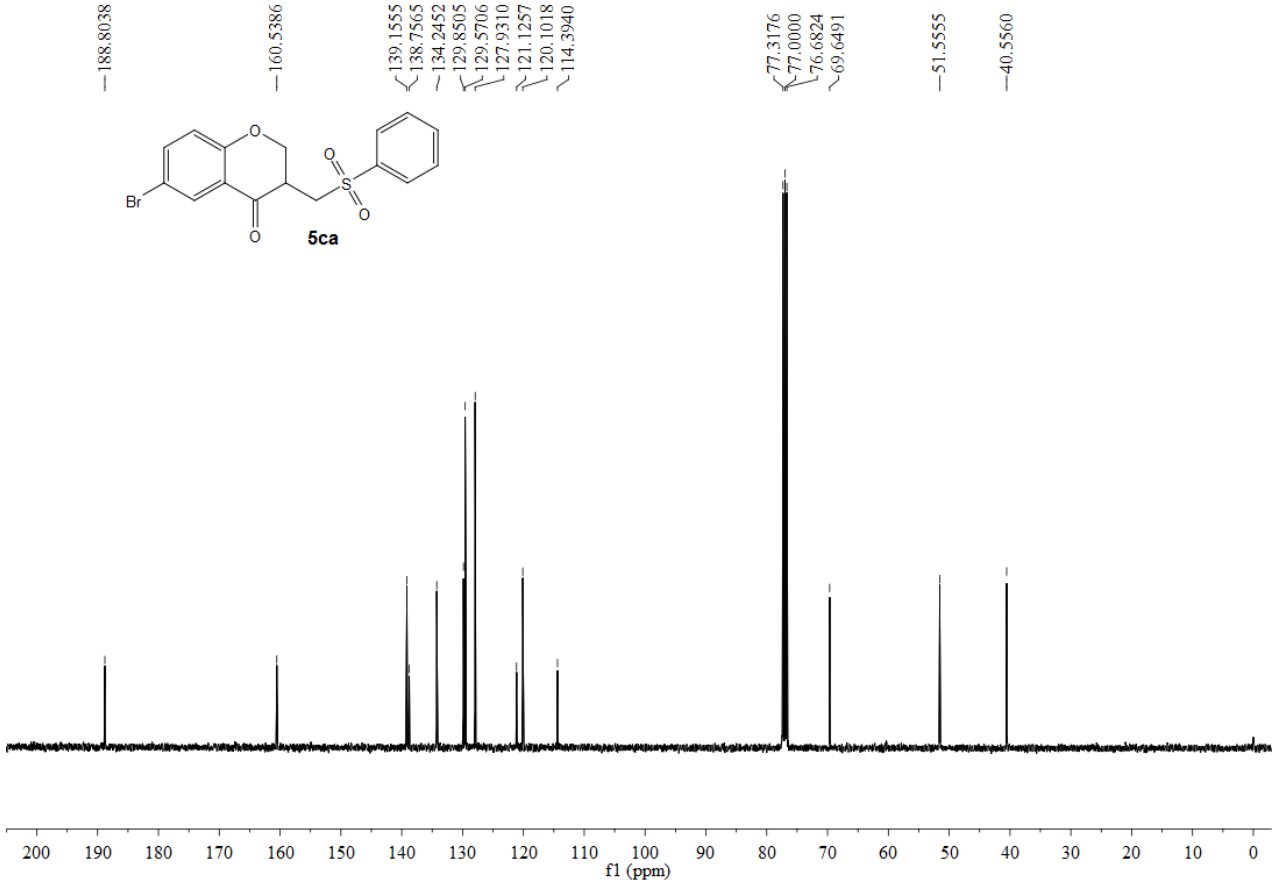
3.9402
3.4637
3.4562
3.4503
3.4442
3.4386
3.4317
3.4253
3.4196
3.4135
3.4077
3.4002
3.3944
3.0286
3.0034
2.9922
2.9670
0.0000
Br
O
O
S
O
O
5ca
3.04
1.04
3.03
1.00
1.04
1.02
1.03
1.02
1.02
f1 (ppm)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121.1257
120.1018
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77.0000
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69.6491
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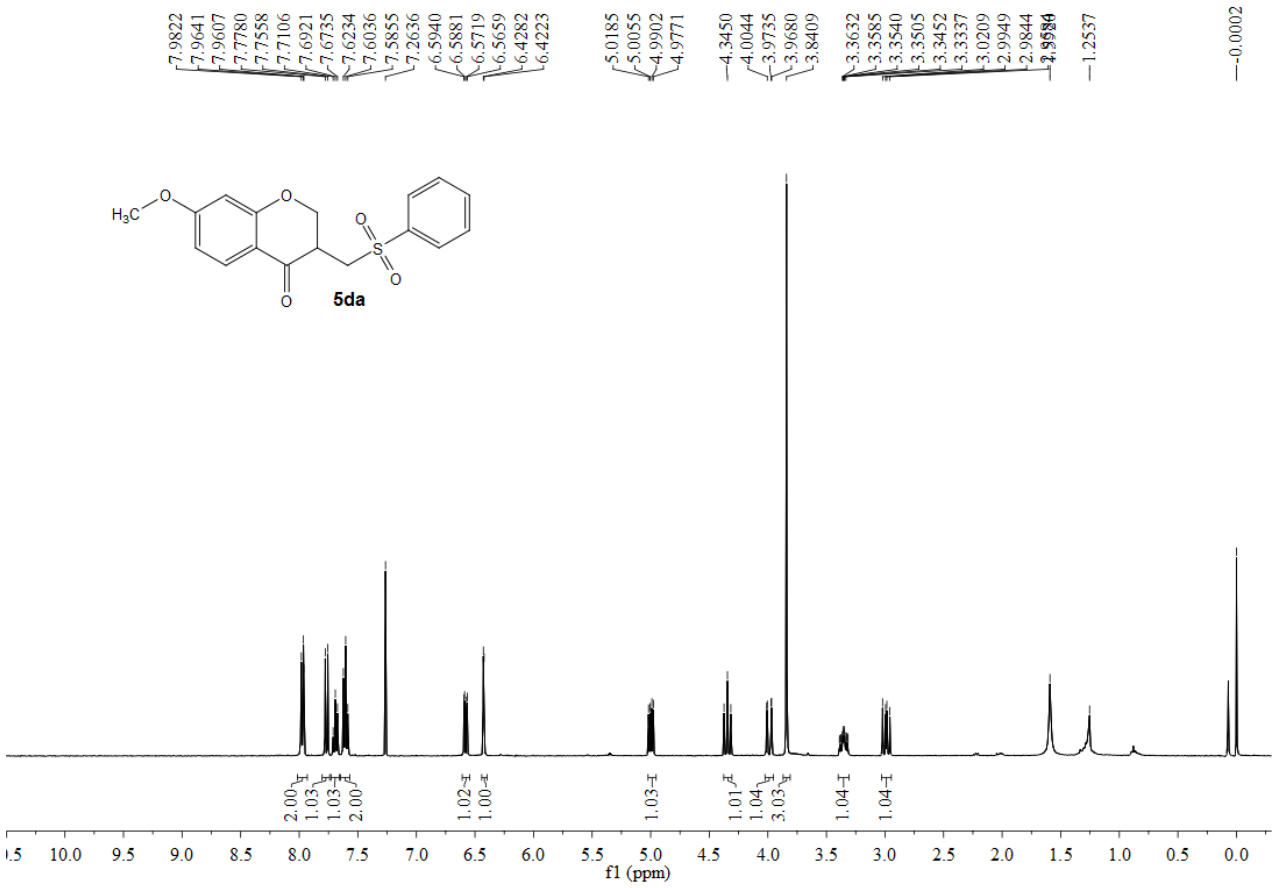
40.5560
Br
O
O
S
O
O
5ca
f1 (ppm)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6.5719
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6.4282
6.4223
5.0185
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4.9771
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3.9680
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5da
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1.03
1.01
1.04
3.03
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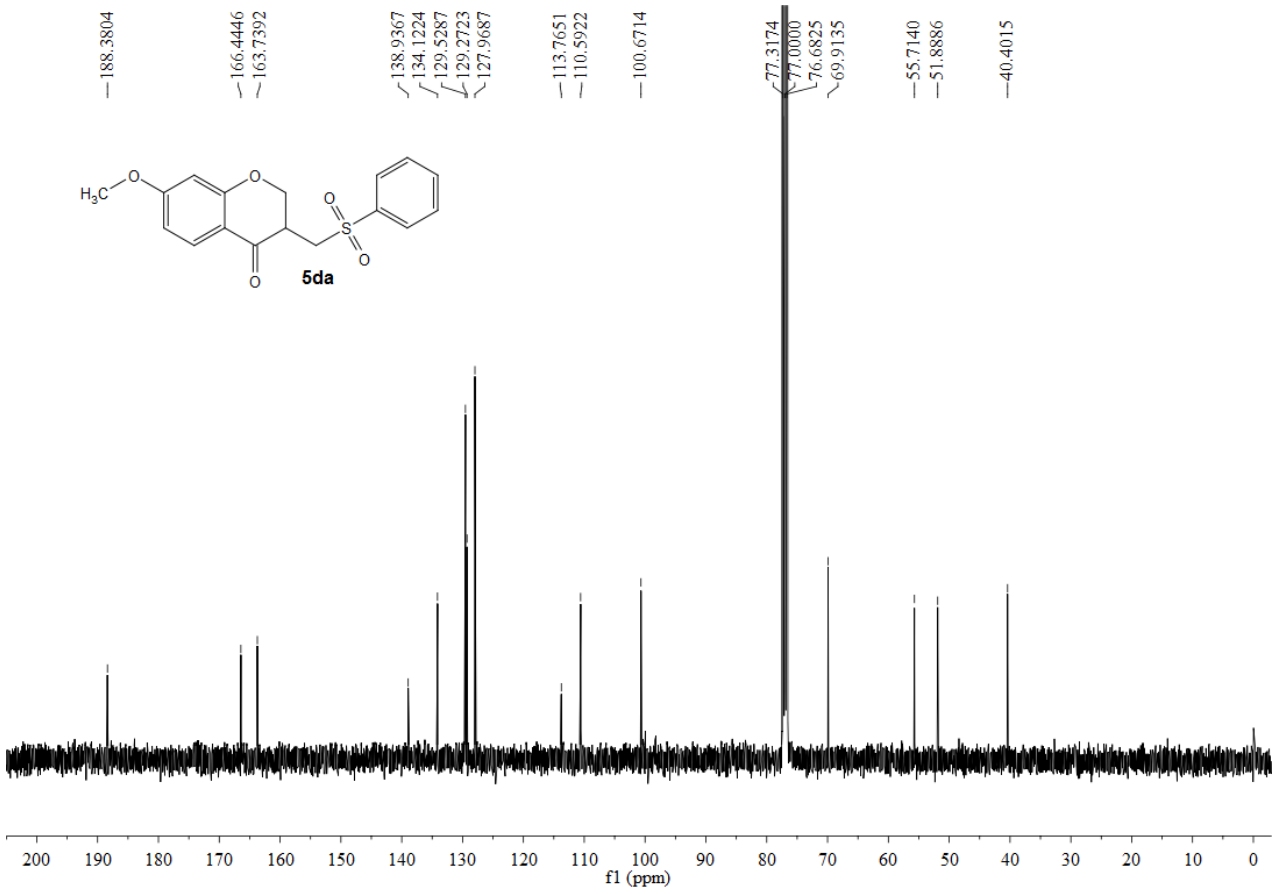
1.04
f1 (ppm)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110.5922
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77.0000
76.6825
69.9135
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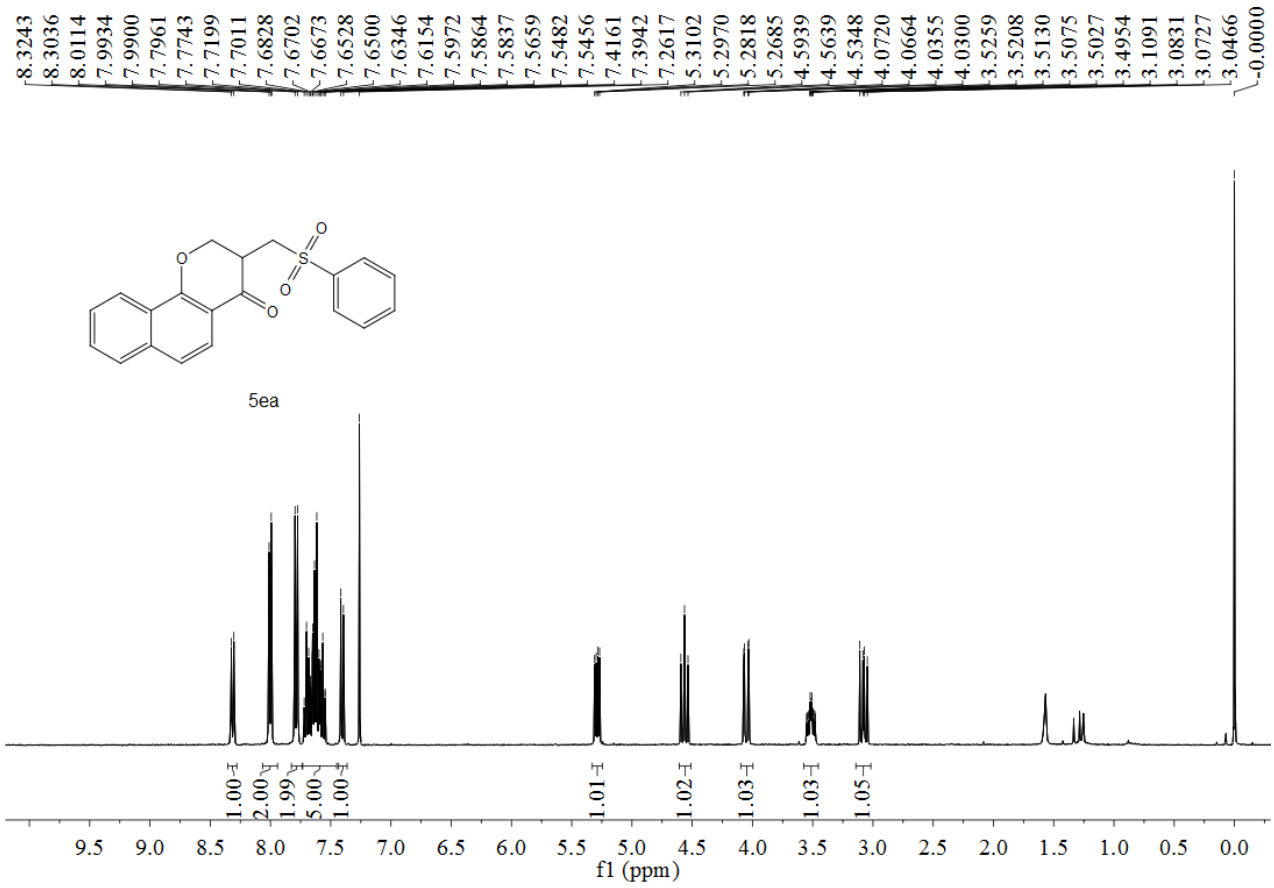
51.8886
40.4015
5da
f1 (ppm)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7.6673
7.6528
7.6500
7.6346
7.6154
7.5972
7.5864
7.5837
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7.5482
7.5456
7.4161
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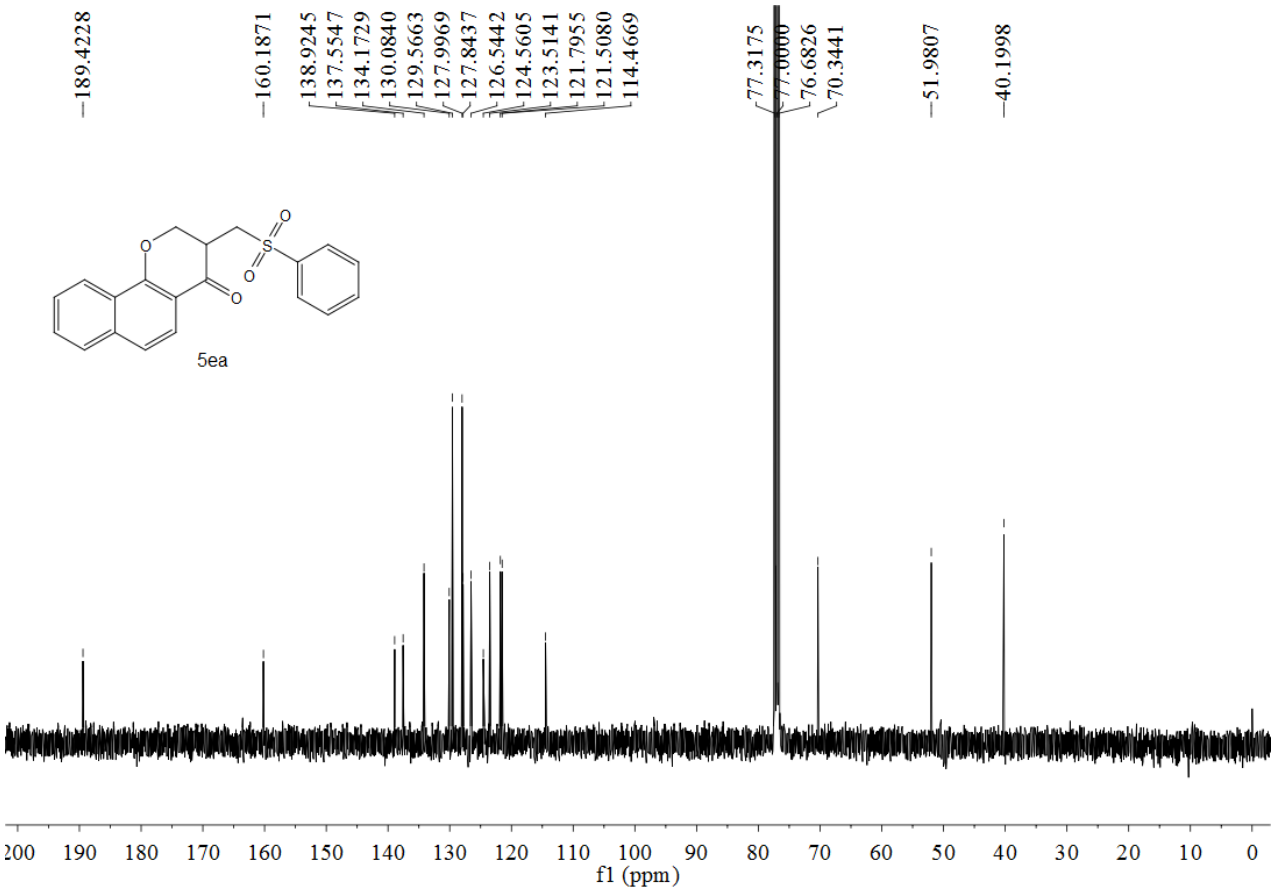
7.2617
5.3102
5.2970
5.2818
5.2685
4.5939
4.5639
4.5348
4.0720
4.0664
4.0355
4.0300
3.5259
3.5208
3.5130
3.5075
3.5027
3.4954
3.1091
3.0831
3.0727
3.0466
-0.0000
5ea
1.00
2.00
1.99
5.00
1.00
1.01
1.02
1.03
1.03
1.05
f1 (ppm)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129.5663
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127.8437
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124.5605
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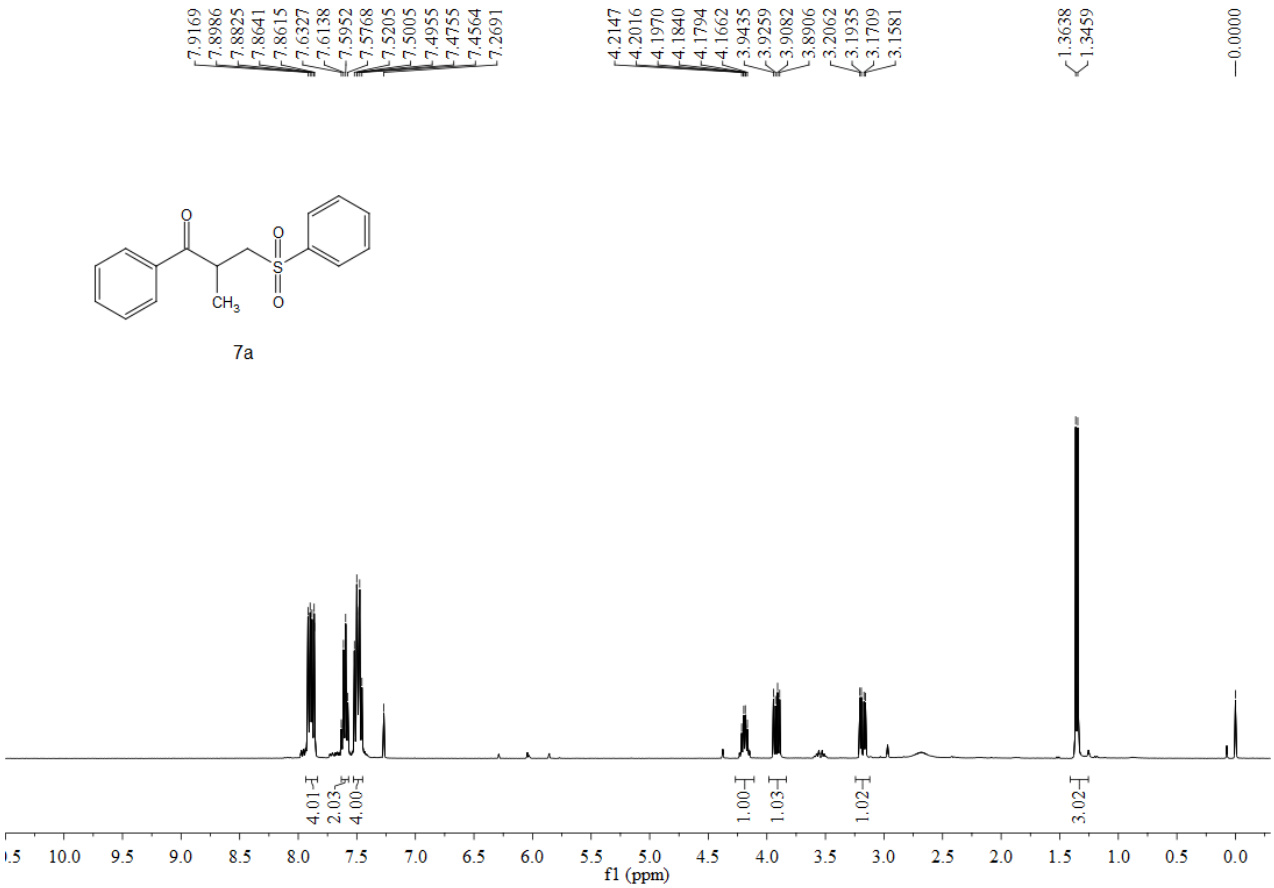
5ea
f1 (ppm)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7.4755
7.4564
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4.1794
4.1662
3.9435
3.9259
3.9082
3.8906
3.2062
3.1935
3.1709
3.1581
1.3638
1.3459
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O
O
S
O
O
CH3
7a
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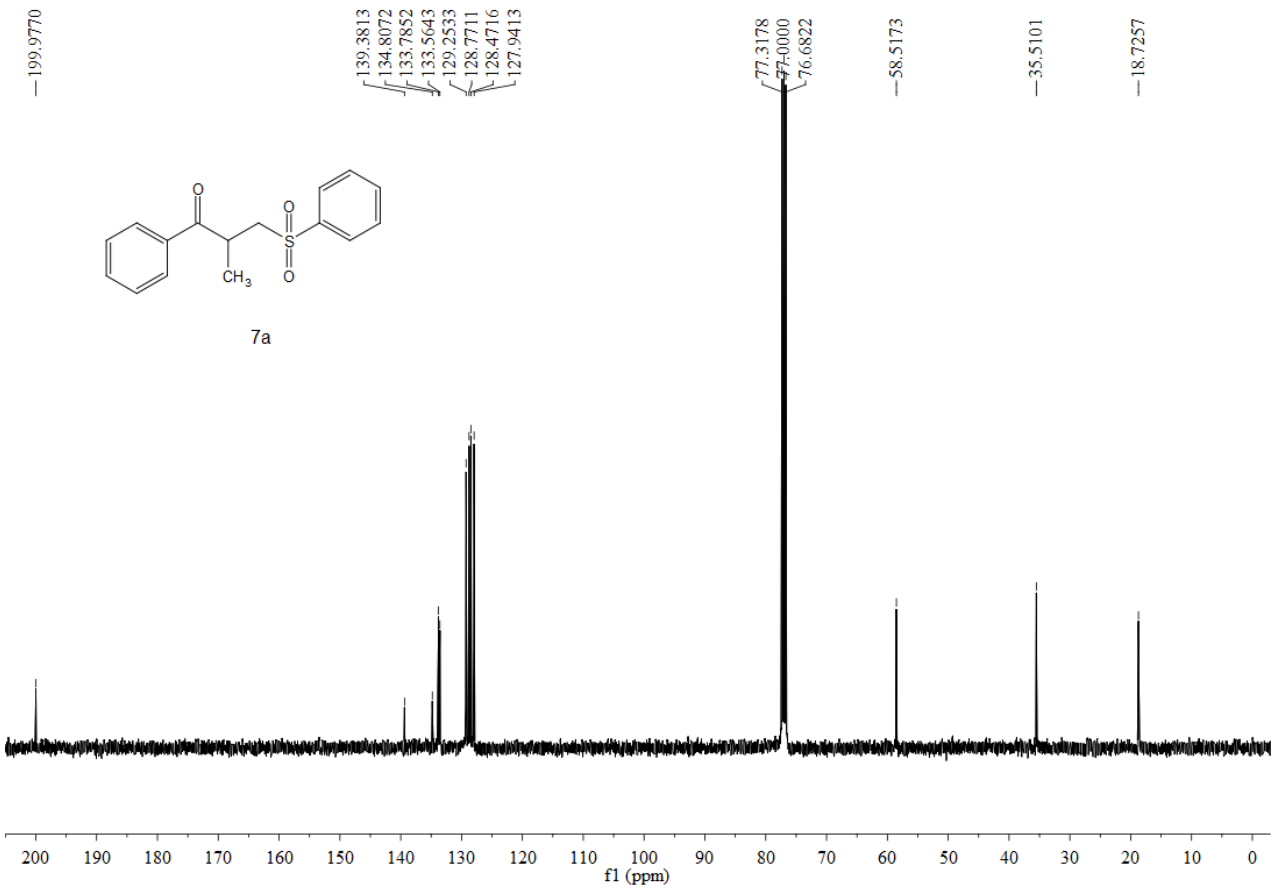
4.00
1.00
1.03
1.02
3.02
f1 (ppm)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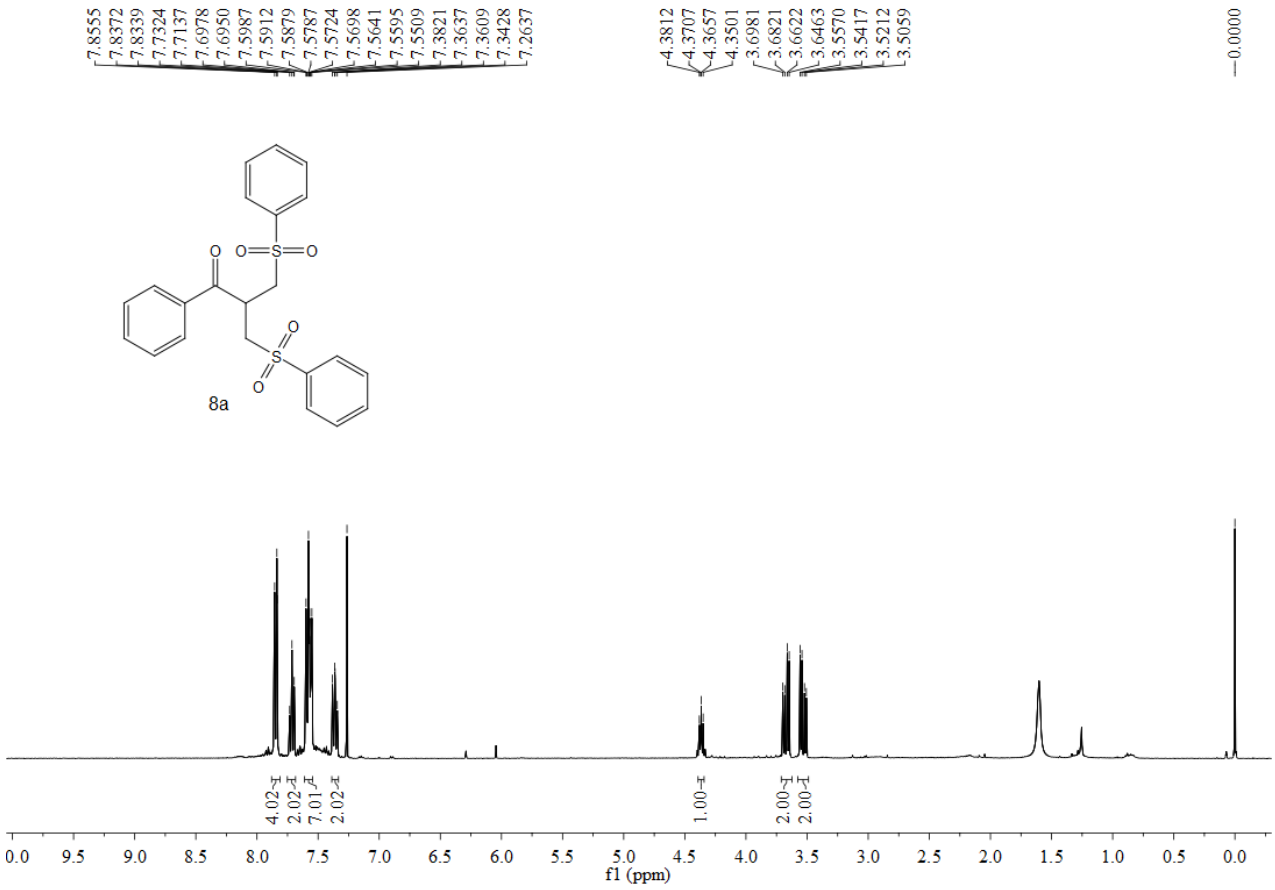
18.7257
O
O
S
O
O
CH3
7a
f1 (ppm)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7.5724
7.5698
7.5641
7.5595
7.5509
7.3821
7.3637
7.3609
7.3428
7.2637
4.3812
4.3707
4.3657
4.3501
3.6981
3.6821
3.6622
3.6463
3.5570
3.5417
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8a
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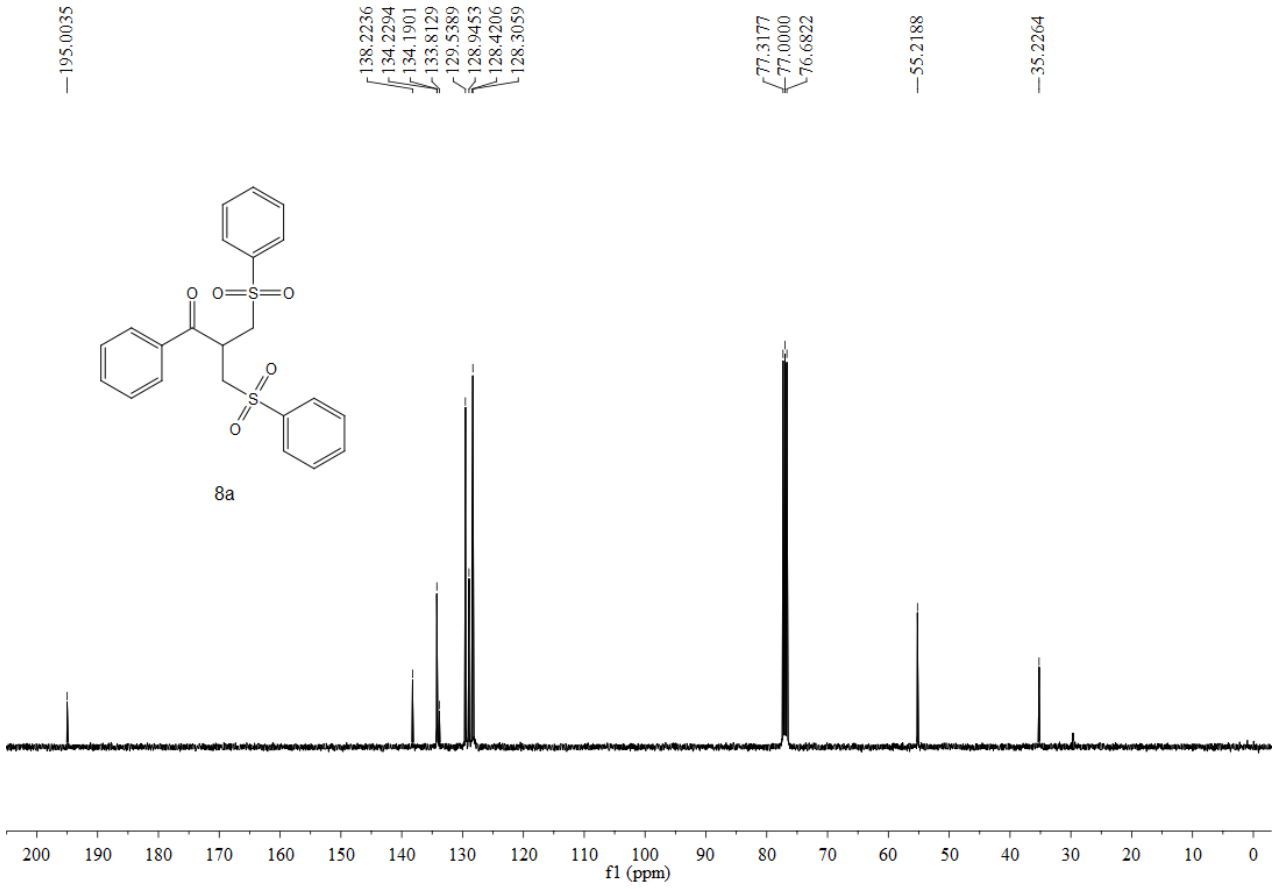
2.02
7.01
2.02
1.00
2.00
2.00
f1 (ppm)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55.2188
35.2264
8a
f1 (ppm)