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Supporting Information

Aerobic Copper Catalyzed α-Oxyacylation of Ketones with Carboxylic Acids

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1 General Information

All reagents used in the experiments were obtained from commercial sources and used without further purification. Thin layer chromatography (TLC) employed glass 0.25 mm silica gel plates. All NMR spectra were recorded on Bruker AVANCE 400 for ^{1}H and ^{13}C NMR in $CDCl_3$. The NMR chemical shift was reported in ppm relative to 7.26 and 77.20 ppm of $CDCl_3$ solvent as the standards of ^{1}H and ^{13}C NMR. The HRMS of products were tested on LCMS-IT-TOF. Melting points were obtained on a X-4 digital melting point apparatus without correction. IR was tested on Bruker ALPHA.

2 Characterization data for the products

1-oxo-1-phenylpropan-2-yl benzoate (3aa)[1].

A white solid (94.2 mg, 74%). mp 98-99 ºC. Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, J = 8.0 Hz, 2H), 8.01 (d, J = 7.2 Hz, 2H), 7.60-7.55 (m, 2H), 7.50-7.42 (m, 4H), 6.21 (q, J = 7.2 Hz, 1H), 1.67 (d, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.9, 166.1, 134.5, 133.7, 133.4, 130.0, 129.6, 128.9, 128.6, 128.5, 72.0, 17.3. IR (KBr): υ = 2981, 1722, 1692, 1452, 1276, 1225, 1122, 968, 713. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{14}NaO_3$ $(M+Na)^+$ 277.0835, found 277.0837.

1-oxo-1-phenylpropan-2-yl 2-chlorobenzoate (3ab)[1].

A colorless oil (119.5 mg, 83%). Eluting with 8:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 6.8Hz, 2H), 7.96 (d, J = 7.2 Hz, 1H), 7.60 (t, J = 7.2 Hz, 1H), 7.52-7.41 (m, 4H), 7.33 (t, J = 7.2 Hz, 1H), 6.24 (q, J = 7.2 Hz, 1H),

1.66 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.6, 165.1, 134.5, 134.2, 133.9, 133.0, 132.0, 131.2, 129.4, 129.0, 128.7, 126.8, 72.5, 17.3. IR (KBr): υ = 3062, 2989, 1732, 1698, 1252, 1121, 969, 748, 700. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}ClNaO_3$ $(M+Na)^+$ 311.0445, found 311.0444.

1-oxo-1-phenylpropan-2-yl 2-bromobenzoate (**3ac**).

A light yellow oil (58.1 mg, 35%). Eluting with 8:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.2 Hz, 2H), 7.94 (d, *J* = 7.6 Hz, 1H), 7.65 (d, *J* = 8.0 Hz, 1H), 7.59 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.39-7.31 (m, 2H), 6.24 (q, *J* = 7.2 Hz, 1H), 1.66 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.5, 165.5, 134.5, 134.4, 133.8, 133.0, 131.9, 131.4, 128.9, 128.6, 127.3, 122.0, 72.5, 17.3. IR (KBr): υ = 3066, 2989, 1732, 1697, 1250, 1029, 968, 745, 699. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}BrNaO_3$ $(M+Na)^+$ 354.9940, found 354.9948.

1-oxo-1-phenylpropan-2-yl 2-iodobenzoate (**3ad**).

A colorless oil (140.6 mg, 74%). Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99-7.94 (m, 4H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.40 (t, *J* = 7.2 Hz, 1H), 7.15 (t, *J* = 7.6 Hz, 1H), 6.24 (q, *J* = 7.2 Hz, 1H), 1.66 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.4, 165.8, 141.4, 134.3, 134.2, 133.8, 133.1, 131.6, 128.9, 128.6, 128.1, 94.4, 72.6, 17.6. IR (KBr): υ = 3063, 2988, 1729, 1693, 1103, 1016, 742. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}INaO_3$ $(M+Na)^+$ 402.9802, found 402.9816.

1-oxo-1-phenylpropan-2-yl 3-iodobenzoate (**3ae**).

A white solid (171.1 mg, 90%). mp 117-119 ºC. Eluting with 10:1 petroleum ether/ethyl

acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.42 (s, 1H), 8.04 (d, *J* = 7.6 Hz, 1H), 7.99 (d, *J* = 7.2 Hz, 2H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.59 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.18 (t, *J* = 8.0 Hz, 1H), 6.19 (q, *J* = 7.2 Hz, 1H), 1.67 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.5, 164.6, 142.2, 138.7, 134.5, 133.8, 131.5, 130.2, 129.2, 129.0, 128.6, 94.0, 72.4, 17.4. IR (KBr): υ = 2983, 1719, 1702, 1306, 1126, 966, 744, 694. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}INaO_3$ $(M+Na)^+$ 402.9802, found 402.9816.

1-oxo-1-phenylpropan-2-yl 4-iodobenzoate (**3af**).

A white solid (153.9 mg, 81%). mp 109-111 ºC. Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.2 Hz, 2H), 7.83-7.78 (m, 4H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.49 (t, *J* = 7.6 Hz, 2H), 6.19 (q, *J* = 6.8 Hz, 1H), 1.66 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.7, 165.7, 138.0, 134.5, 133.9, 131.5, 129.1, 129.0, 128.7, 101.4, 72.3, 17.4. IR (KBr): υ = 3067, 2915, 1694, 1603, 1361, 1268, 1227, 1116. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}INaO_3$ $(M+Na)^+$ 402.9802, found 402.9819.

1-oxo-1-phenylpropan-2-yl 2-methylbenzoate (**3ag**)[1].

A colorless oil (101.9 mg, 76%). Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02-8.00 (m, 3H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.49 (t, *J* = 8.0 Hz, 2H), 7.41 (t, *J* = 7.2 Hz, 1H), 7.26 (t, *J* = 8.0 Hz, 2H), 6.20 (q, *J* = 7.2 Hz, 1H), 2.60 (s, 3H), 1.66 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.1, 167.1, 140.7, 134.6, 133.7, 132.4, 131.8, 131.0, 129.1, 129.0, 128.7, 125.9, 71.9, 17.3. IR (KBr): υ = 3064, 2987, 1720, 1698, 1257, 1228, 1076, 968, 739. HRMS (ESI, *m/z*) calcd.for $C_{17}H_{16}NaO_3$ $(M+Na)^+$ 291.0992, found 291.0988.

1-oxo-1-phenylpropan-2-yl 4-acetylbenzoate (**3ah**).

A white solid (59.2 mg, 40%). mp 85-87 ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.4 Hz, 2H), 8.01 (t, *J* = 7.2 Hz, 4H), 7.61 (t, *J* = 7.2 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 6.23 (q, *J* = 7.2 Hz, 1H), 2.65 (s, 3H), 1.69 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.7, 196.6, 165.3, 140.7, 134.5, 133.9, 133.4, 130.3, 129.1, 128.7, 128.4, 72.5, 27.1, 17.4. IR (KBr): υ = 2955, 1724, 1690, 1274, 1243, 1123, 911, 700. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{16}NaO_4$ $(M+Na)^+$ 319.0941, found 319.0946.

1-oxo-1-phenylpropan-2-yl 3-(dimethylamino)benzoate (**3ai**).

A light yellow solid (109.9 mg, 40%). mp 73-75 ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 (d, *J* = 7.2 Hz, 2H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.47 (t, *J* = 8.0 Hz, 3H), 7.42 (s, 1H), 7.29 (t, *J* = 8.0 Hz, 1H), 6.92 (d, *J* = 8.4 Hz, 1H), 6.18 (q, *J* = 6.8 Hz, 1H), 2.96 (s, 6H), 1.67 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.1, 166.8, 150.5, 134.7, 133.6, 130.2, 129.1, 128.9, 128.6, 117.9, 117.2, 113.5, 71.9, 40.6, 17.2. IR (KBr): υ = 3067, 2915, 1694, 1603, 1361, 1268, 1227, 1116. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{19}NaO_3$ $(M+Na)^+$ 320.1257, found 320.1254.

1-oxo-1-phenylpropan-2-yl 4-(dimethylamino)benzoate (**3aj**).

A white solid (95.1 mg, 64%). mp 125-127 ºC. Eluting with 3:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 (d, *J* = 7.2 Hz, 2H), 7.95 (d, *J* = 8.8 Hz, 2H), 7.57 (t, *J* = 8.0 Hz, 1H), 7.47 (t, *J* = 7.2 Hz, 2H), 6.66 (d, *J* = 8.8 Hz, 2H), 6.15 (q, *J* = 7.2 Hz, 1H), 3.04 (s, 6H), 1.63 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.7, 166.4, 153.6, 134.9, 133.5, 131.8, 128.9, 128.7, 116.6, 111.1, 71.3, 40.3, 17.3.

IR (KBr): υ = 3063, 1692, 1616, 1275, 1186, 1111, 966, 705. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{19}NaO_3$ $(M+Na)^+$ 320.1257, found 320.1263.

1-oxo-1-phenylpropan-2-yl 2,5-difluorobenzoate (**3ak**).

A white solid (89.9 mg, 62%). mp 54-56 ºC. Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.4 Hz, 2H), 7.68 (s, 1H),7.60 (t, *J* = 7.2 Hz, 1H), 7.49 (t, *J* = 8.0 Hz, 2H), 7.22-7.20 (m, 1H), 7.14-7.08 (m, 1H), 6.20 (q, *J* = 7.2 Hz, 1H), 1.66 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.3, 162.7, 159.7, 159.6, 159.3 159.2, 157.1, 157.0, 156.9, 156.8, 134.3, 133.9, 129.0, 128.7, 121.9, 121.8, 121.7, 121.6, 119.3, 119.2, 119.1, 119.0, 118.7, 118.6, 118.5, 118.4, 72.8, 17.3. IR (KBr): υ = 3088, 2995, 1732, 1697, 1494, 1265, 1189, 1094, 969, 769, 696. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{12}F_2NaO_3$ $(M+Na)^+$ 313.0647, found 313.0638.

1-oxo-1-phenylpropan-2-yl 2,6-difluorobenzoate (**3al**).

A colorless oil(87.0 mg, 60%). Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.2 Hz, 2H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.49 (t, *J* = 7.6 Hz, 2H), 7.43 (t, *J* = 8.4 Hz, 1H), 6.95 (t, *J* = 8.4 Hz, 2H), 6.25 (q, *J* = 6.8 Hz, 1H), 1.66 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.0, 162.4, 162.3, 161.1, 159.9, 159.8, 134.4, 133.9, 133.5, 133.4, 133.3, 129.0, 128.7, 112.4, 112.3, 112.1, 110.6, 110.5, 110.3, 73.1, 17.3. IR (KBr): υ = 3067, 2991, 1735, 1699, 1625, 1470, 1264, 1116, 1013, 699. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{12}F_2NaO_3$ $(M+Na)^+$ 313.0647, found 313.0646.

1-oxo-1-phenylpropan-2-yl 2,5-dichlorobenzoate (**3am**).

A white solid (140.1 mg, 87%). mp 78-80 ºC. Eluting with 10:1 petroleum ether/ethyl

acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99-7.93 (m, 3H), 7.61 (t, *J* = 7.2 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.42-7.37 (m, 2H), 6.23 (q, *J* = 7.2 Hz, 1H), 1.67 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.3, 163.8, 134.3, 134.0, 133.0, 132.8, 132.6, 132.4, 131.8, 130.6, 129.0, 128.7, 72.9, 17.3. IR (KBr): υ = 2990, 1737, 1698, 1251, 1148, 1127, 1047, 968, 696. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{12}Cl_2NaO_3$ $(M+Na)^+$ 345.0056, found 345.0059.

1-oxo-1-phenylpropan-2-yl cinnamate (**5aa**)[2].

A white solid (98.0 mg, 70%). mp 67-68 ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.6 Hz,2H), 7.75 (d, *J* = 16.0 Hz, 1H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.52-7.45 (m, 4H), 7.38-7.36 (m, 3H), 6.54 (d, *J* = 16.0 Hz, 1H), 6.12 (q, *J* = 7.2Hz, 1H), 1.61 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.9, 166.3, 145.9, 134.4, 134.4, 133.6, 130.5, 128.9, 128.8, 128.6, 128.2, 117.2, 71.5, 17.3. IR (KBr): υ = 3054, 3025, 1714, 1698, 1636, 1449, 1324, 1223, 1009, 770, 685. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{16}NaO_3$ $(M+Na)^+$ 303.0992, found 303.0993.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(4-chlorophenyl)acrylate (**5ab**).

A white solid (95.8 mg, 61%). mp104-106ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.2 Hz,2H), 7.69 (d, *J* = 16.0 Hz, 1H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.51-7.45 (m, 4H), 7.36 (d, *J* = 8.8 Hz, 2H), 6.51 (d, *J* = 16.0 Hz, 1H), 6.12 (q, *J* = 6.8Hz, 1H), 1.61 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.9, 166.2, 144.6, 136.6, 134.5, 133.8, 132.9, 129.5, 129.4, 129.0, 128.7, 118.0, 71.7, 17.4. IR (KBr): υ = 3066, 1710, 1695, 1635, 1324, 1191, 1178. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{15}ClNaO_3$ $(M+Na)^+$ 337.0602, found 337.0606.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(3-chlorophenyl)acrylate (**5ac**).

A white solid (80.1 mg, 51%). mp 103-105 ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.2 Hz,2H), 7.65 (d, *J* = 16.0 Hz, 1H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.50-7.46 (m, 3H), 7.39-7.28 (m, 3H), 6.52 (d, *J* = 16.0 Hz, 1H), 6.11 (q, *J* = 7.2Hz, 1H), 1.60 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.8, 165.9, 144.3, 136.1, 135.0, 134.4, 133.7, 130.4, 130.3, 128.9, 128.6, 128.3, 128.0, 126.4, 118.8, 71.7, 17.3. IR (KBr): υ = 3066, 1712, 1695, 1636, 1327, 1190, 1006, 796, 699. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{15}ClNaO_3$ $(M+Na)^+$ 337.0602, found 337.0605.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(4-nitrophenyl)acrylate (**5ad**).

A pale yellow solid (69.9 mg, 43%). mp 165-166 ºC. Eluting with 3:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (d, *J* = 8.4 Hz,2H), 7.98 (d, *J* = 7.6 Hz,2H),7.47 (d, *J* = 16.0 Hz, 1H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.68 (d, *J* = 8.8 Hz,2H),7.61 (t, *J* = 7.2 Hz, 1H), 7.50 (t, *J* = 7.6 Hz,2H),6.66 (d, *J* = 16.0 Hz, 1H), 6.14 (q, *J* = 7.2Hz, 1H), 1.62 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.7, 165.5, 148.8, 143.0, 140.5, 134.4, 133.9, 129.0, 128.9, 128.7, 124.4, 121.7, 72.0, 17.4. IR (KBr): υ = 3072, 1711, 1692, 1517, 1347, 1334, 1196, 1178, 1008, 850, 702. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{15}NNaO_5$ $(M+Na)^+$ 348.0842, found 348.0851.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(4-methoxyphenyl)acrylate (**5ae**).

A white solid (48.1 mg, 31%). mp 106-108 ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.6 Hz,2H), 7.69 (d, *J* = 16.0 Hz, 1H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.49-7.45 (m, 4H), 6.88 (d, *J* = 8.8 Hz, 2H), 6.40 (d, *J* = 16.0 Hz, 1H), 6.10 (q, *J* = 7.2 Hz, 1H), 3.80 (s, 3H), 1.59 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR

(100 MHz, $CDCl_3$) δ 197.1, 166.6, 161.6, 145.7, 134.6, 133.6, 130.0, 128.9, 128.6, 127.0, 114.7, 114.4, 71.3, 55.4, 17.3. IR (KBr): υ = 2961, 1712, 1695, 1633, 1513, 1286, 1175, 828, 702. HRMS (ESI, *m/z*) calcd.for $C_{19}H_{18}NaO_4$ $(M+Na)^+$ 333.1097, found 333.1103.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(3-methoxyphenyl)acrylate (**5af**).

A colorless oil (68.2 mg, 44%). Eluting with 10:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.0 Hz, 2H), 7.70 (d, *J* = 16.0 Hz, 1H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.27 (t, *J* = 8.0 Hz, 1H), 7.09 (d, *J* = 7.6 Hz, 1H), 7.03 (s, 1H), 6.91 (d, *J* = 8.4 Hz, 1H), 6.52 (d, *J* = 16.0 Hz, 1H), 6.10 (q, *J* = 7.2 Hz, 1H), 3.78 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.9, 166.1, 159.9, 145.8, 135.6, 134.4, 133.6, 129.9, 128.8, 128.5, 120.9, 117.5, 116.5, 112.9, 71.5, 55.3, 17.2. IR (KBr): υ = 3063, 2989, 2939, 2837, 1697, 1636, 1250, 1170, 700. HRMS (ESI, *m/z*) calcd.for $C_{19}H_{18}NaO_4$ $(M+Na)^+$ 333.1097, found 333.1102.

1-oxo-1-phenylpropan-2-yl(*E*)-3-(benzo[*d*][1,3]dioxol-5-yl)acrylate (**5ag**).

A pale grey solid (105.3 mg, 65%). mp 120-122ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 7.2 Hz, 2H), 7.64 (d, *J* = 16.0 Hz, 1H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.01 (t, *J* = 8.0 Hz, 2H), 6.79 (d, *J* = 8.0 Hz, 1H), 6.35 (d, *J* = 16.0 Hz, 1H), 6.10 (q, *J* = 6.8Hz, 1H), 5.99 (s, 2H), 1.59 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.1, 166.5, 149.9, 148.5, 145.8, 134.6, 133.7, 128.9, 128.8, 128.7, 124.9, 115.2, 108.7, 106.6, 101.7, 71.4, 17.3. IR (KBr): υ = 3066, 2901, 1717, 1700, 1633, 1503, 1451, 1265, 1175, 693. HRMS (ESI, *m/z*) calcd.for $C_{19}H_{16}NaO_5$ $(M+Na)^+$ 347.0890, found 347.0896.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(thiophen-2-yl)acrylate (**5ah**).

A white solid (65.8 mg, 46%). mp 93-95 ºC. Eluting with 5:1 petroleum ether/ethyl acetate.^1H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 7.2 Hz, 2H), 7.82 (d, *J* = 15.6 Hz,

1H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.46 (t, *J* = 8.0 Hz, 2H), 7.36 (d, *J* = 5.2 Hz, 1H), 7.23 (d, *J* = 3.2 Hz, 1H), 7.02 (t, *J* = 4.4 Hz, 1H), 6.32 (d, *J* = 16.0 Hz, 1H), 6.09 (q, *J* = 7.2 Hz, 1H), 1.58 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.9, 166.1, 139.4, 138.3, 134.4, 133.6, 131.4, 128.9, 128.8, 128.6, 128.2, 115.9, 71.5, 17.3. IR (KBr): υ = 3087, 1707, 1692, 1624, 1207, 1171, 702. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{14}NaO_3S$ $(M+Na)^+$ 309.0556, found 309.0557.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(furan-2-yl)acrylate (**5ai**).

A pale red solid (36.5 mg, 27%). mp 73-75 ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 7.2 Hz, 2H), 7.49 (t, *J* = 7.2 Hz, 1H), 7.46 (t, *J* = 8.0 Hz, 4H), 6.61 (d, *J* = 3.2 Hz, 1H), 6.45 (s, 1H), 6.39(d, *J* = 15.6 Hz, 1H), 6.07 (q, *J* = 7.2 Hz, 1H), 1.58 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.0, 166.4, 150.9, 145.1, 134.5, 133.7, 132.2, 128.9, 128.6, 115.4, 114.9, 112.5, 71.5, 17.3. IR (KBr): υ = 3122, 3038, 1712, 1699, 1634, 1320, 1282, 1213, 1170, 705. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{14}NaO_4$ $(M+Na)^+$ 293.0784, found 293.0788.

1-oxo-1-phenylpropan-2-yl (*E*)-3-(pyridin-3-yl)acrylate (**5aj**).

A pale yellow solid (16.9 mg, 12%). mp 74-76 ºC. Eluting with 1:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.62 (s, 1H), 8.00 (d, *J* = 7.2 Hz, 2H), 7.85 (d, *J* = 8.0 Hz, 1H), 7.74 (d, *J* = 16.0 Hz, 1H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.49 (t, *J* = 8.0 Hz, 2H), 7.33 (dd, *J* = 4.6, 3.2 Hz, 1H), 6.63 (d, *J* = 16.0 Hz, 1H), 6.15 (q, *J* = 6.8Hz, 1H), 1.63(d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.6, 165.4, 151.0, 149.7, 142.0, 134.3, 134.2, 133.6, 129.9, 128.8, 128.4, 123.8, 119.4, 71.7, 17.2. IR (KBr): υ = 3056, 2951, 1712, 1696, 1638, 1327, 1198, 1008, 962, 811, 700. HRMS (ESI, *m/z*) calcd.for $C_{17}H_{16}NO_3$ $(M+H)^+$ 282.1125, found 282.1125.

1-oxo-1-phenylpropan-2-yl acetate (**5ak**)[3].

A light yellow oil (49.0 mg, 51%). Eluting with 15:1 petroleum ether/ethyl acetate. ^{1}H

NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 5.94 (q, *J* = 7.2 Hz, 1H), 2.12 (s, 3H), 1.50 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.9, 170.5, 134.4, 133.7, 128.9, 128.5, 71.5, 20.8, 17.2. IR (KBr): υ = 2989, 2938, 1719, 1601, 1451, 1269, 1111, 1071, 712. HRMS (ESI, *m/z*) calcd.for $C_{11}H_{13}O_3$ $(M+H)^+$ 193.0859, found 193.0860.

1-oxo-1-phenylpropan-2-yl pivalate (**5al**).

A yellow oil (37.5 mg, 32%). Eluting with 20:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.4 Hz, 2H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 5.91 (q, *J* = 6.8 Hz, 1H), 1.52 (d, *J* = 7.2 Hz, 3H), 1.22 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.4, 178.1, 134.8, 133.6, 128.9, 128.6, 71.3, 33.7, 27.2, 17.0. IR (KBr): υ = 2975, 2936, 1731, 1699, 1450, 1280, 1229, 1158, 970, 700. HRMS (ESI, *m/z*) calcd.for $C_{14}H_{19}O_3$ $(M+H)^+$ 235.1329, found 235.1331.

(2-(methacryloyloxy)-1-phenylpropylidene)oxonium (**5am**).

A pale yellow oil (40.3 mg, 37%). Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.6 Hz, 2H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 6.22 (s, 1H), 6.01 (q, *J* = 7.2 Hz, 1H), 5.63 (s, 1H), 1.96 (s, 3H), 1.57 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.1, 166.9, 135.8, 134.6, 133.7, 128.9, 128.6, 126.7, 71.8, 18.4, 17.2. IR (KBr): υ = 2988, 1720, 1699, 1597, 1450, 1305, 1229, 1133, 1089, 971, 701. HRMS (ESI, *m/z*) calcd.for $C_{13}H_{15}O_3$ $(M+H)^+$ 219.1016, found 219.1014.

1-oxo-1-phenylpropan-2-yl 3-phenylpropanoate (**5an**).

A colorless oil (90.3 mg, 64%). Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.6 Hz, 2H), 7.59 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.30 (t, *J* = 7.2 Hz, 2H), 7.24-7.20 (m, 3H), 5.99 (q, *J* = 7.2 Hz, 1H), 3.00 (t, *J* = 8.0 Hz, 2H), 2.79-2.74 (m, 2H), 1.53 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100

MHz, $CDCl_3$) δ 196.9, 172.3, 140.4, 134.4, 133.6, 128.8, 128.6, 128.5, 128.4, 126.3, 71.5, 35.6, 30.8, 17.1. IR (KBr): υ = 3062, 2988, 2936, 1738, 1699, 1597, 1451, 1229, 1161, 699. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{18}NaO_3$ $(M+Na)^+$ 305.1148, found 305.1146.

1-(4-fluorophenyl)-1-oxopropan-2-yl benzoate (**3ba**)[1].

A white solid (119.7 mg, 88%). mp 87-88 ºC. Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 8.4 Hz, 2H), 8.05-8.01 (m, 2H), 7.55 (t, *J* = 7.6 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.13 (t, *J* = 8.4 Hz, 2H), 6.14 (q, *J* = 7.2 Hz, 1H), 1.65 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.3, 167.3, 166.0, 164.7, 133.4, 131.3, 131.2, 130.9, 130.8, 129.9, 129.4, 128.5, 116.2, 115.9, 71.8, 17.2. IR (KBr): υ = 3055, 2997, 1715, 1684, 1600, 1280, 1239, 1120, 966, 714. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}FNaO_3$ $(M+Na)^+$ 295.0741, found 295.0746.

1-(4-chlorophenyl)-1-oxopropan-2-yl benzoate (**3ca**)[1].

A white solid (49.0 mg, 34%). mp 94-95 ºC. Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 7.6 Hz, 2H), 7.94 (d, *J* = 8.4 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.45-7.41 (m, 4H), 6.12 (q, *J* = 7.2 Hz, 1H), 1.65 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.7, 166.0, 140.1, 133.5, 132.8, 130.0, 129.9, 129.4, 129.2, 128.5, 71.9, 17.1. IR (KBr): υ = 3069, 1717, 1693, 1270, 1116, 1092, 971, 720, 706. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}ClNaO_3$ $(M+Na)^+$ 311.0445, found 311.0442.

1-(3-chlorophenyl)-1-oxopropan-2-yl benzoate (**3da**).

A white solid (23.0 mg, 16%). mp 72-74 ºC. Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 7.6 Hz, 2H), 7.98 (s, 1H), 7.87 (d, *J* = 7.6 Hz, 1H), 7.61-7.55 (m, 2H), 7.47-7.41 (m, 3H), 6.11 (q, *J* = 7.2 Hz, 1H), 1.67 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.9, 166.2, 136.2, 135.4, 133.7, 133.6, 130.3, 130.1, 129.4, 128.8, 128.6, 126.7, 72.1, 17.2. IR (KBr): υ = 3064, 1720,

1696, 1273, 1220, 1114, 711. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}ClNaO_3$ $(M+Na)^+$ 311.0445, found 311.0443.

1-(4-bromophenyl)-1-oxopropan-2-yl benzoate (3ea)[1].

A pale yellow solid (76.4 mg, 46%). mp 90-92 ºC. Eluting with 10:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 7.2 Hz, 2H), 7.86 (d, *J* = 8.8 Hz, 2H), 7.62 (d, *J* = 8.8 Hz, 2H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.44 (t, *J* = 8.0 Hz, 2H), 6.12 (q, *J* = 6.8Hz, 1H), 1.65 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.0, 166.1, 133.6, 133.3, 132.3, 130.1, 130.0, 129.4, 129.0, 128.6, 71.9, 17.2. IR (KBr): υ = 2989, 1708, 1692, 1319, 1276, 969, 718. HRMS (ESI, *m/z*) calcd.for $C_{16}H_{13}BrNaO_3$ $(M+Na)^+$ 354.9940, found 354.9943.

1-oxo-1-(p-tolyl)propan-2-yl benzoate (3fa)[10a].

A white solid (85.8 mg, 64%). mp 77-79 ºC. Eluting with 15:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.0 Hz, 2H), 7.91 (d, *J* = 8.4 Hz, 2H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 6.20 (q, *J* = 7.2 Hz, 1H), 2.41 (s, 3H), 1.66 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.4, 166.1, 144.7, 133.4, 132.0, 130.0, 129.7, 129.6, 128.8, 128.5, 72.0, 21.8, 17.4. IR (KBr): υ = 3063, 2990, 1718, 1687, 1301, 1273, 1114, 710. HRMS (ESI, *m/z*) calcd.for $C_{17}H_{16}NaO_3$ $(M+Na)^+$ 291.0992, found 291.0984.

1-(4-methoxyphenyl)-1-oxopropan-2-yl benzoate (3ga)[1].

A white solid (45.5 mg, 32%). mp 96-97ºC. Eluting with 5:1 petroleum ether/ethyl acetate. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 6.8 Hz, 2H), 8.00 (d, *J* = 8.8 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.43 (t, *J* = 8.0 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 6.18 (q, *J* = 7.2 Hz, 1H), 3.84 (s, 3H), 1.66 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 195.2, 166.1, 164.0, 133.4, 131.0, 130.0, 129.7, 128.5, 127.3, 114.1, 71.8, 55.6, 17.5. IR (KBr): υ = 2964, 2840, 1709, 1684, 1600, 1280, 1239, 1120, 966, 714. HRMS (ESI,

m/z) calcd.for $C_{17}H_{16}NaO_4$ $(M+Na)^+$ 307.0941, found 307.0936.

1-oxo-1-phenylbutan-2-yl benzoate (**3ha**)[2].

A colorless oil (73.7 mg, 55%). Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, *J* = 7.6 Hz, 2H), 8.02 (d, *J* = 8.4 Hz, 2H), 7.58-7.56 (m, 2H), 7.50-7.43 (m, 4H), 6.07 (dd, *J* = 4.4, 3.6 Hz, 1H), 2.12-1.99 (m, 2H),1.12 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.5, 166.3, 135.0, 133.6, 133.4, 129.9, 129.7, 128.9, 128.5, 76.9, 25.0, 10.1. IR (KBr): υ = 2975, 2938, 1721, 1697, 1599, 1450, 1250, 1115, 712. HRMS (ESI, *m/z*) calcd.for $C_{17}H_{16}NaO_3$ $(M+Na)^+$ 291.0992, found 291.0983.

1-oxo-1-phenylpentan-2-yl benzoate (**3ia**).

A pale yellow oil (64.9 mg, 46%). Eluting with 15:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, *J* = 8.8 Hz, 2H), 8.02 (d, *J* = 8.4 Hz, 2H), 7.61-7.56 (m, 2H), 7.51-7.43 (m, 4H), 6.13 (dd, *J* = 5.2, 2.8Hz, 1H), 2.01-1.99 (m, 2H), 1.61-1.59 (m, 2H), 1.00 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.6, 166.3, 134.9, 133.6, 133.4, 129.9, 129.7, 128.9, 128.6, 128.5, 75.7, 33.6, 19.1, 13.9. IR (KBr): υ = 3064, 2962, 2874, 1721, 1697, 1599, 1310, 1115, 1071, 711. HRMS (ESI, *m/z*) calcd.for $C_{18}H_{18}NaO_3$ $(M+Na)^+$ 305.1148, found 305.1142.

3-oxobutan-2-yl benzoate (**3ma**).

A pale yellow oil (30.7 mg, 32%). The experiment was carried out in 80 ºC for 10 h. Eluting with 10:1 petroleum ether/ethyl acetate. ^1H NMR (400 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.0 Hz,2H), 7.60 (t, *J* = 7.6 Hz, 1H), 7.47 (t, *J* = 8.0 Hz, 2H), 5.32 (q, *J* = 7.2 Hz, 1H), 2.24 (s, 3H), 1.54 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 206.0, 166.1, 133.6, 130.0, 129.6, 128.7, 75.6, 25.9, 16.3. IR (KBr): υ = 2989, 2938, 1719, 1601, 1451, 1361, 1300, 1269, 1111, 1026, 712. HRMS (ESI, *m/z*) calcd.for $C_{11}H_{13}O_3$ $(M+H)^+$ 193.0859, found 193.0856.

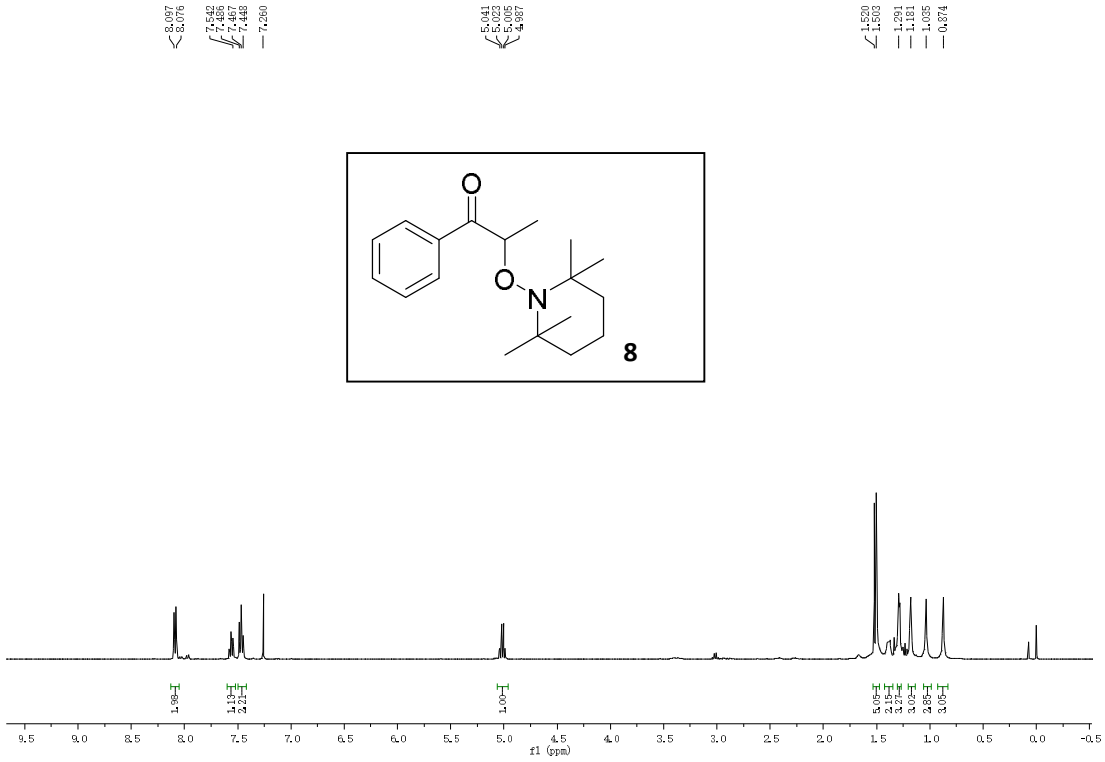
3 References

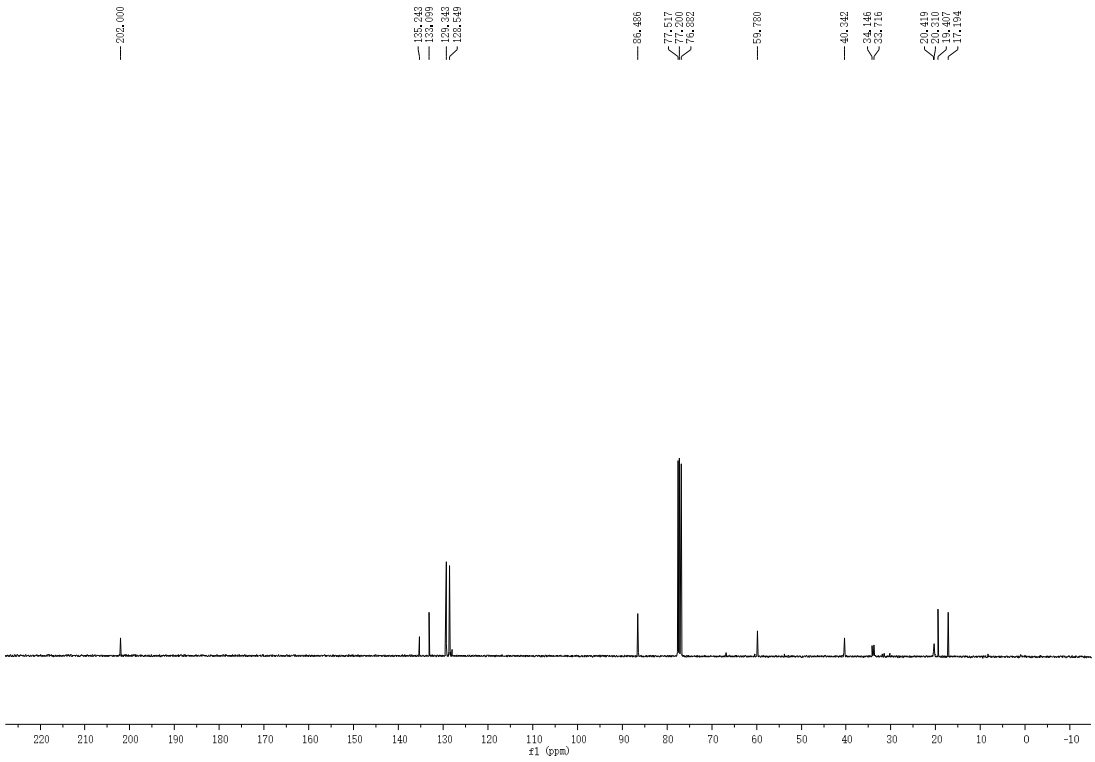
(1) C. Li, T. Jin, X. Zhang, C. Li, X. Jia and J. Li, *Org. Lett.* 2016, **18**, 1916.

(2) S. Guo, J.-T. Yu, Q. Dai, H. Yang and J. Cheng, *Chem. Commun.* 2014, **50**, 6240.

(9) M. Uyanik, D. Suzuki, T. Yasui and K. Ishihara, *Angew. Chem., Int. Ed*. 2011, **50**, 5331.

4 NMR Spectra of key intermediate 8

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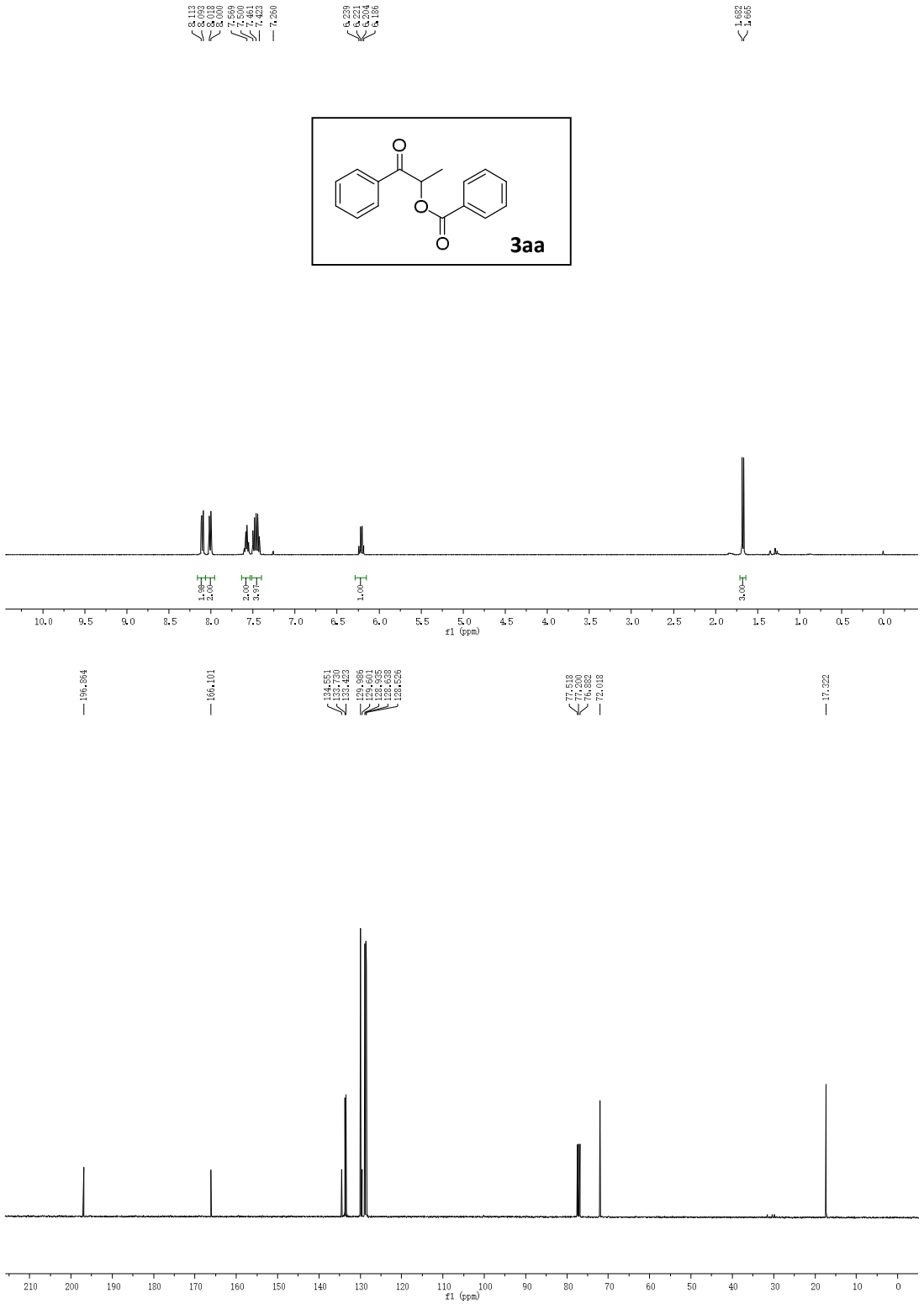
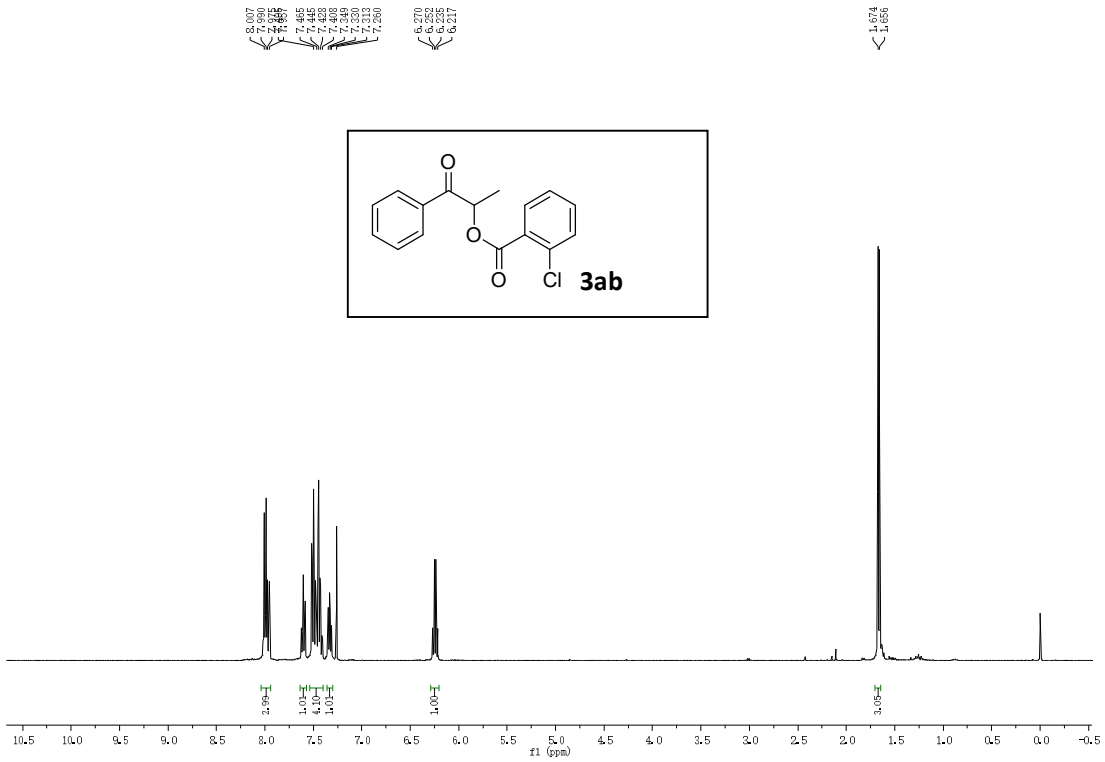
f1 (ppm)

5 NMR Spectra of product 3aa-3am

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6.217
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Cl
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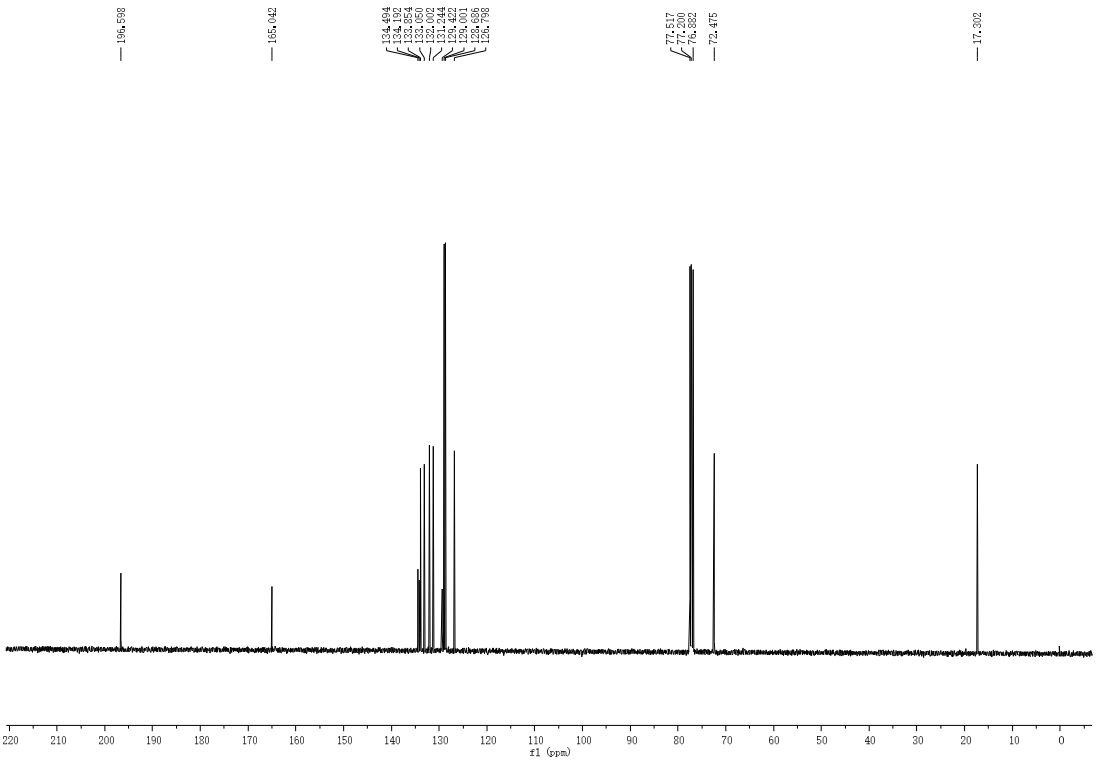
1.00
3.05
f1 (ppm)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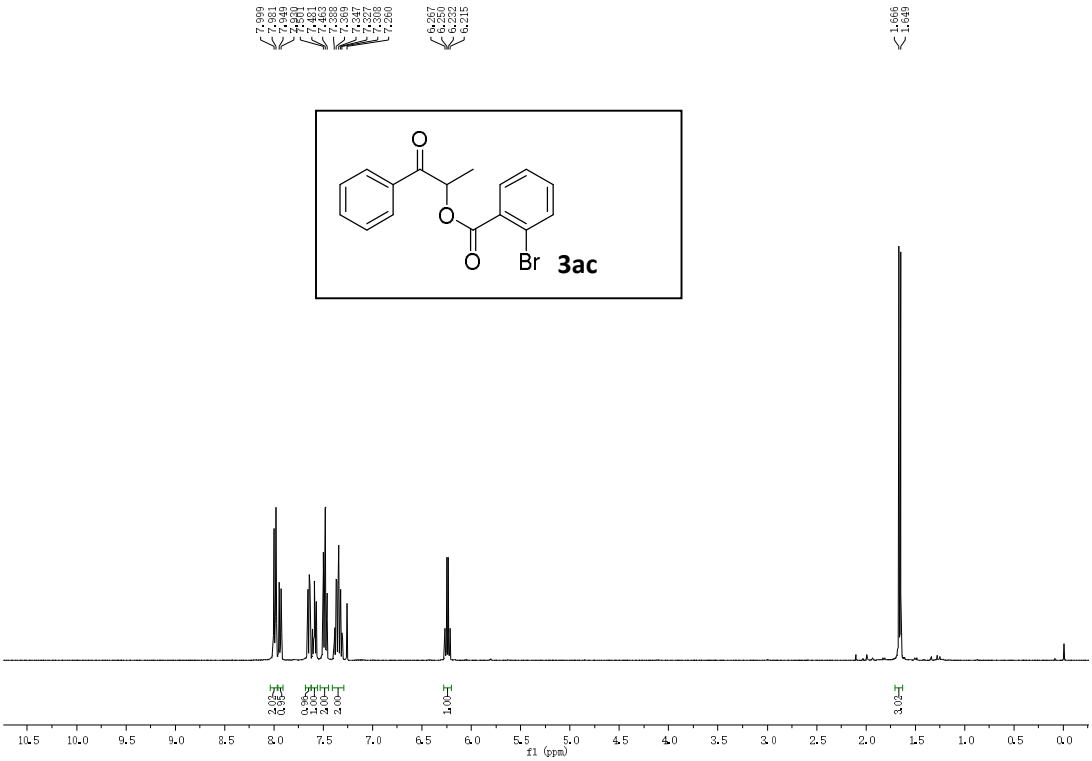
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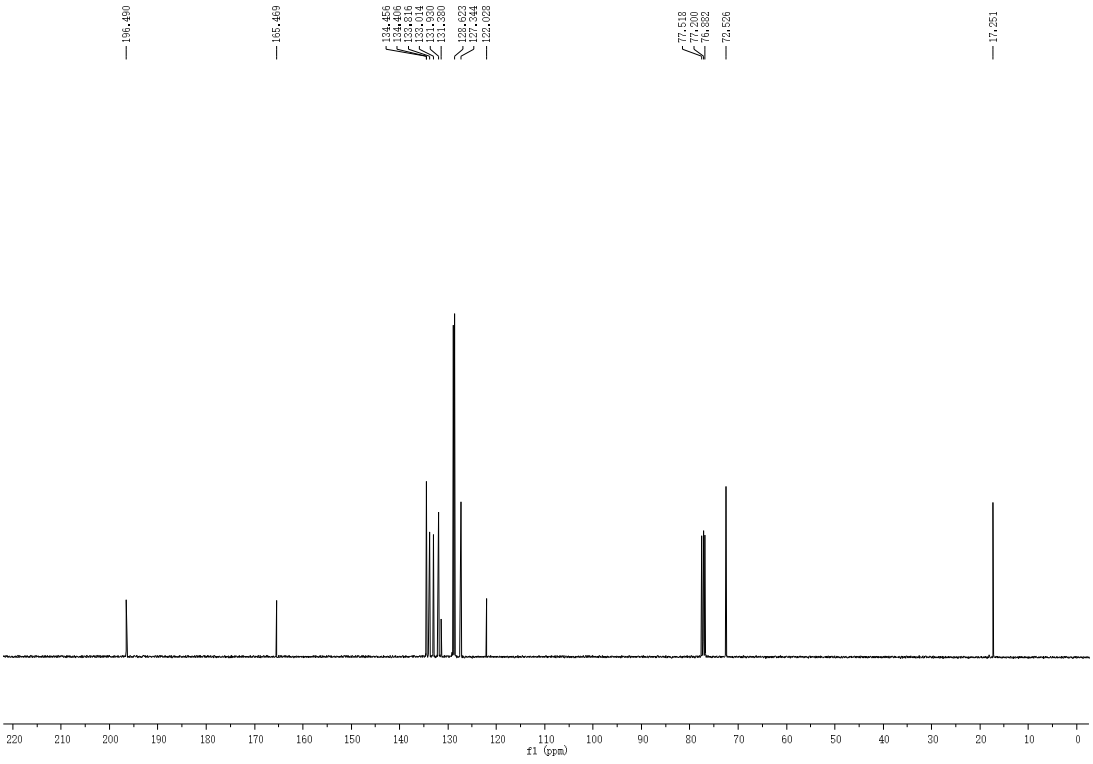
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f1 (ppm)


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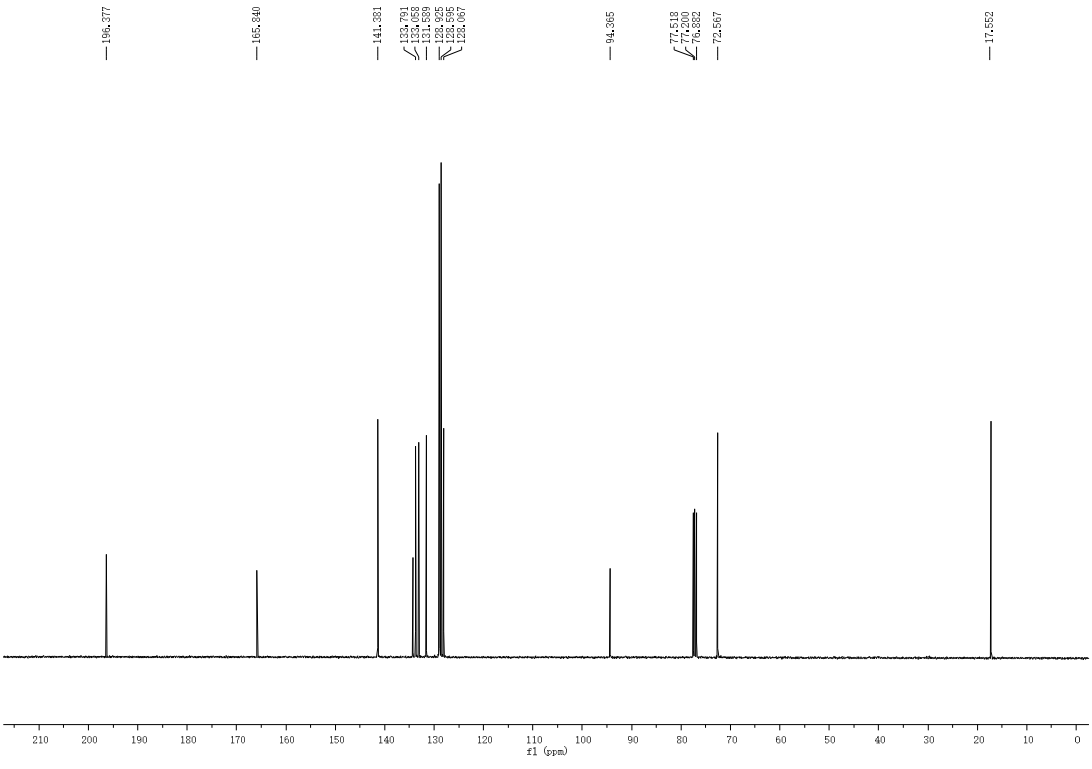
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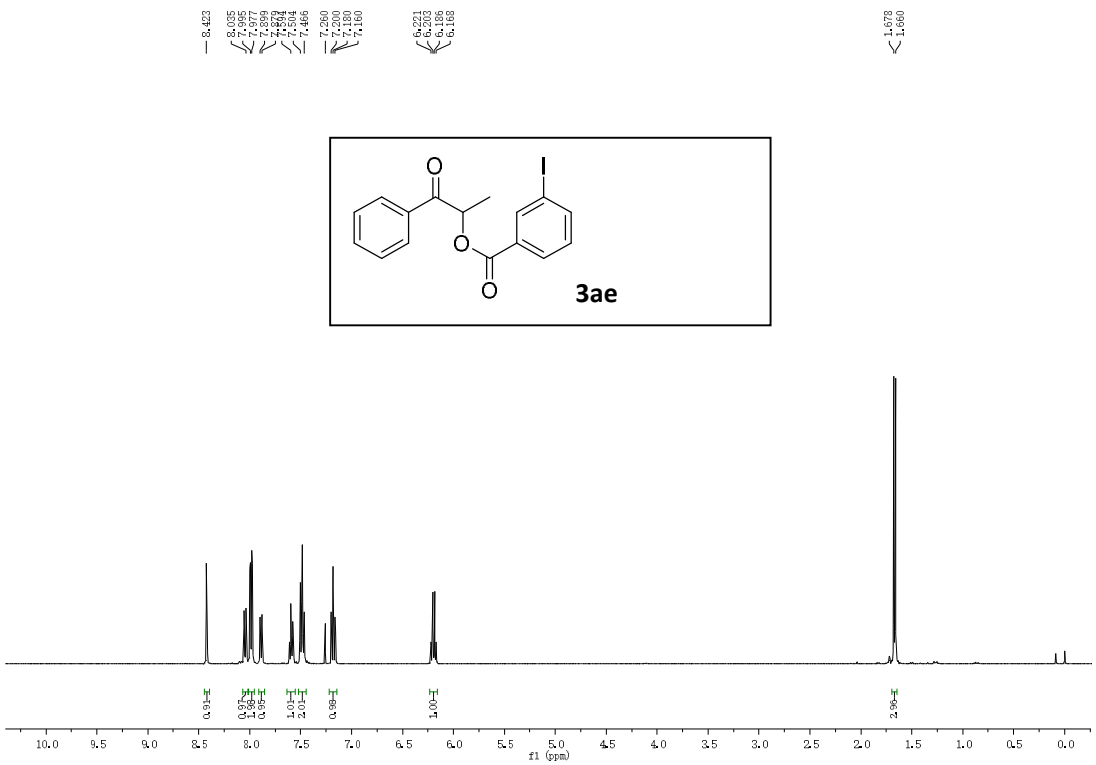
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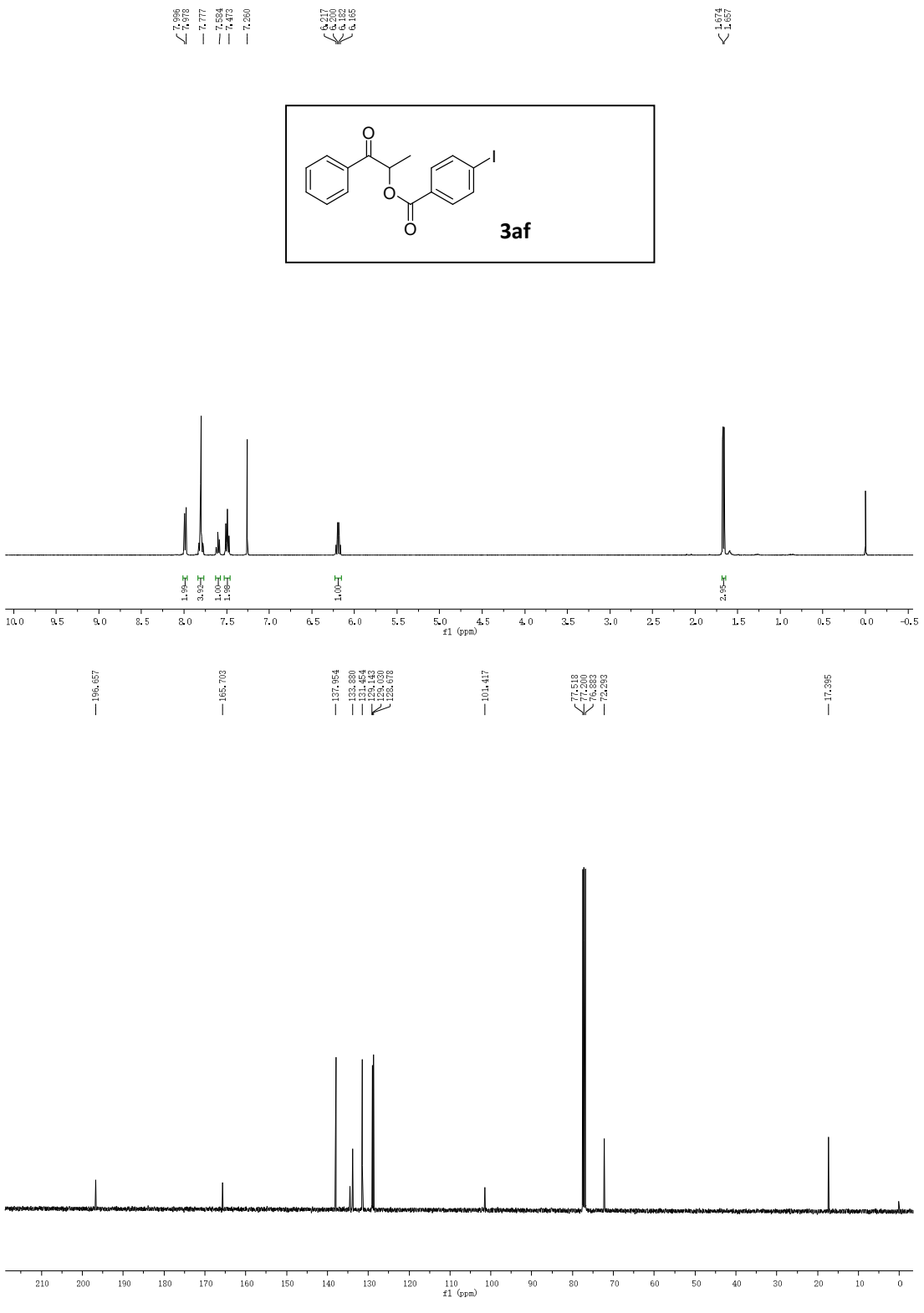
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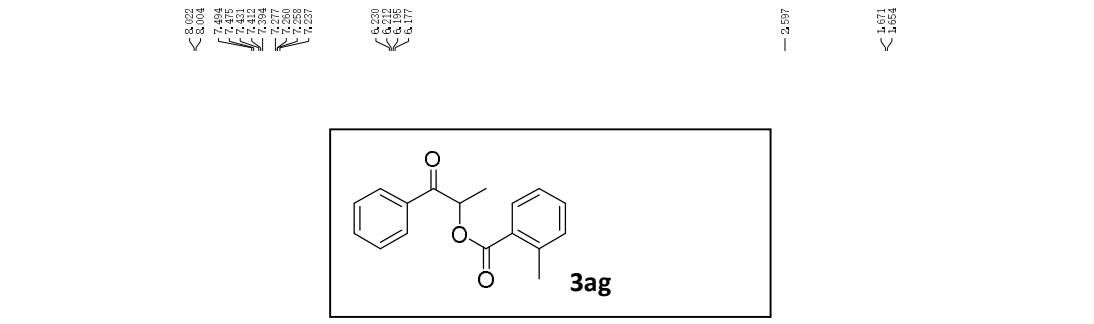
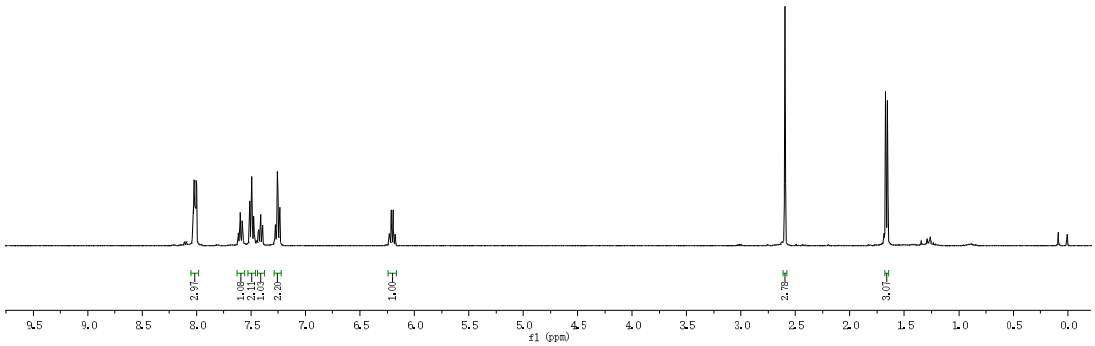
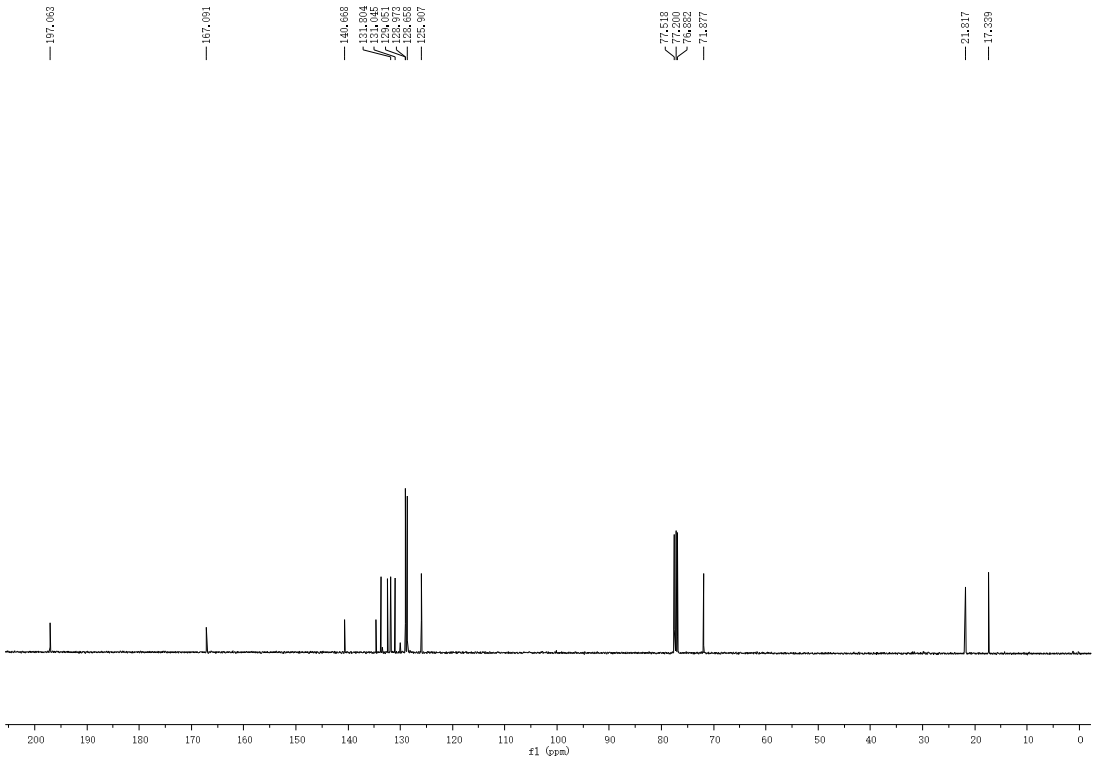
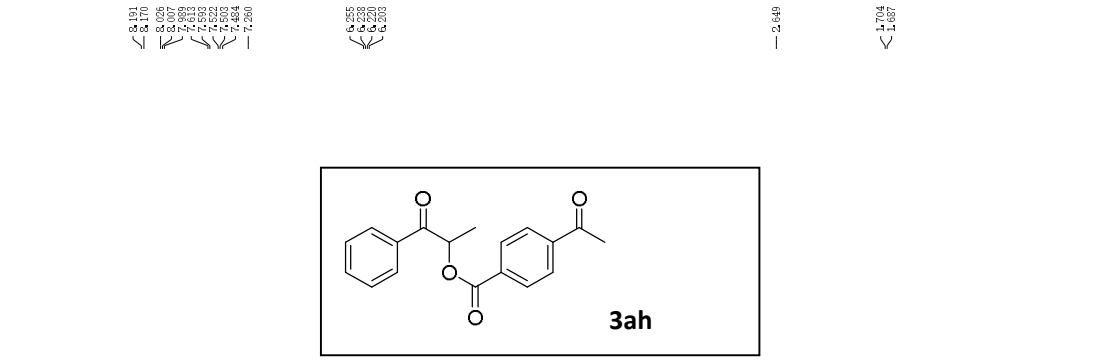
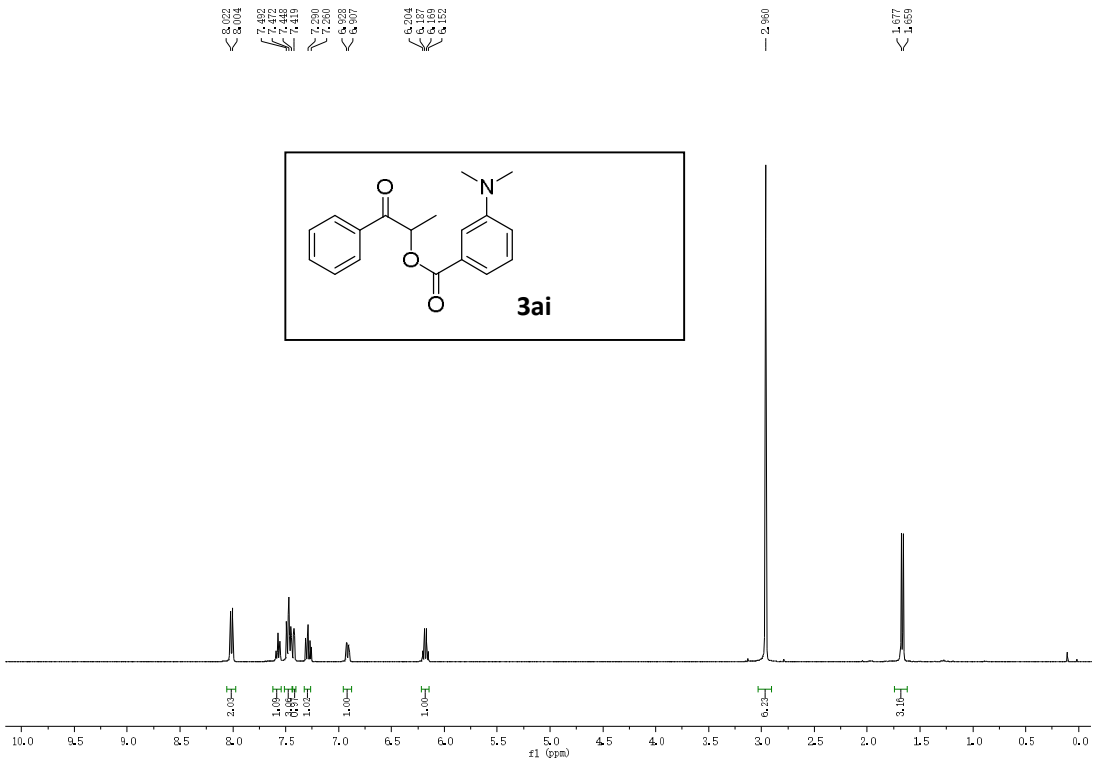
128.000
122.678
101.417
77.518
77.200
76.883
72.293
17.395
f1 (ppm)


8.002
8.004
7.494
7.475
7.431
7.412
7.394
7.277
7.269
7.258
7.237
6.230
6.213
6.195
6.177
2.597
1.671
1.654
3ag


2.97
1.08
2.11
1.03
2.00
1.00
2.78
3.07
f1 (ppm)


197.063
167.091
140.668
131.804
131.045
129.957
128.973
128.658
125.907
77.518
77.200
76.882
71.877
21.817
17.339
f1 (ppm)


8.191
8.170
8.026
8.007
7.989
7.633
7.613
7.522
7.503
7.484
7.260
6.255
6.238
6.220
6.203
2.649
1.704
1.687
3ah
1.92
3.99
1.02
1.96
1.00
2.94
3.19
f1 (ppm)
197.734
196.567
165.336
140.654
133.939
133.447
130.320
129.065
128.693
128.411
77.517
77.200
76.882
72.526
27.108
17.437
f1 (ppm)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8.004
7.492
7.472
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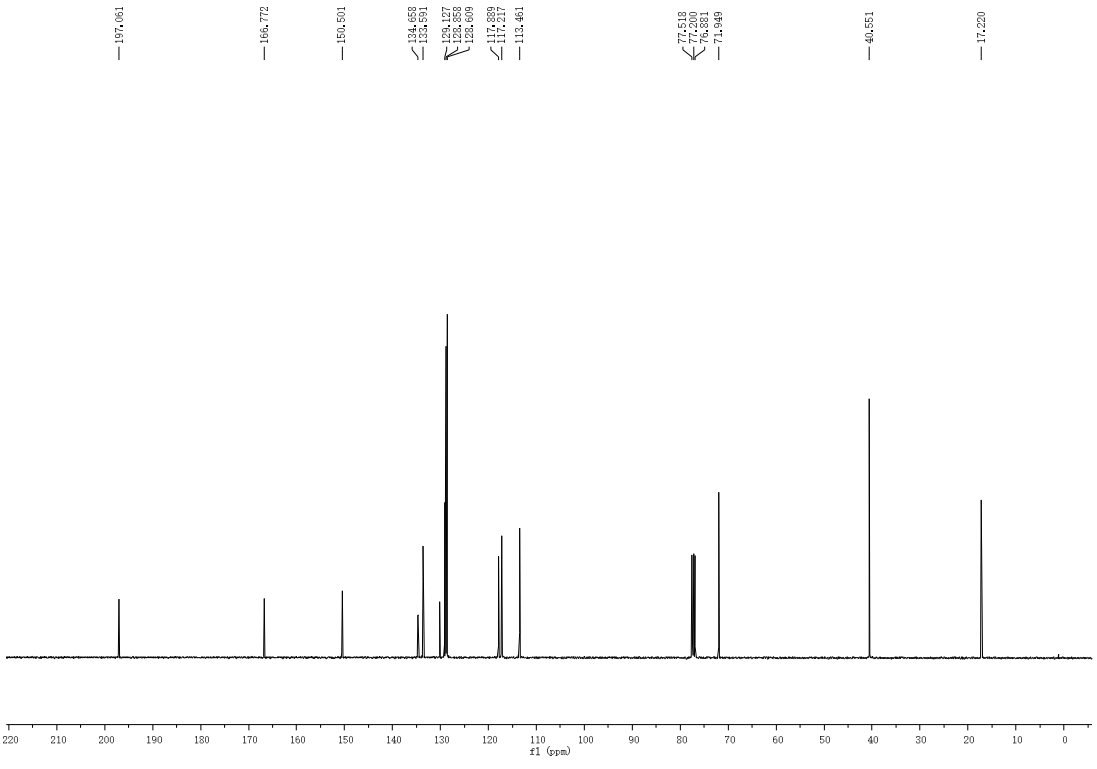
7.419
7.290
7.260
6.928
6.907
6.204
6.187
6.169
6.152
2.960
1.677
1.659
3ai
2.03
1.09
0.95
1.02
1.00
1.00
6.23
3.10
f1 (ppm)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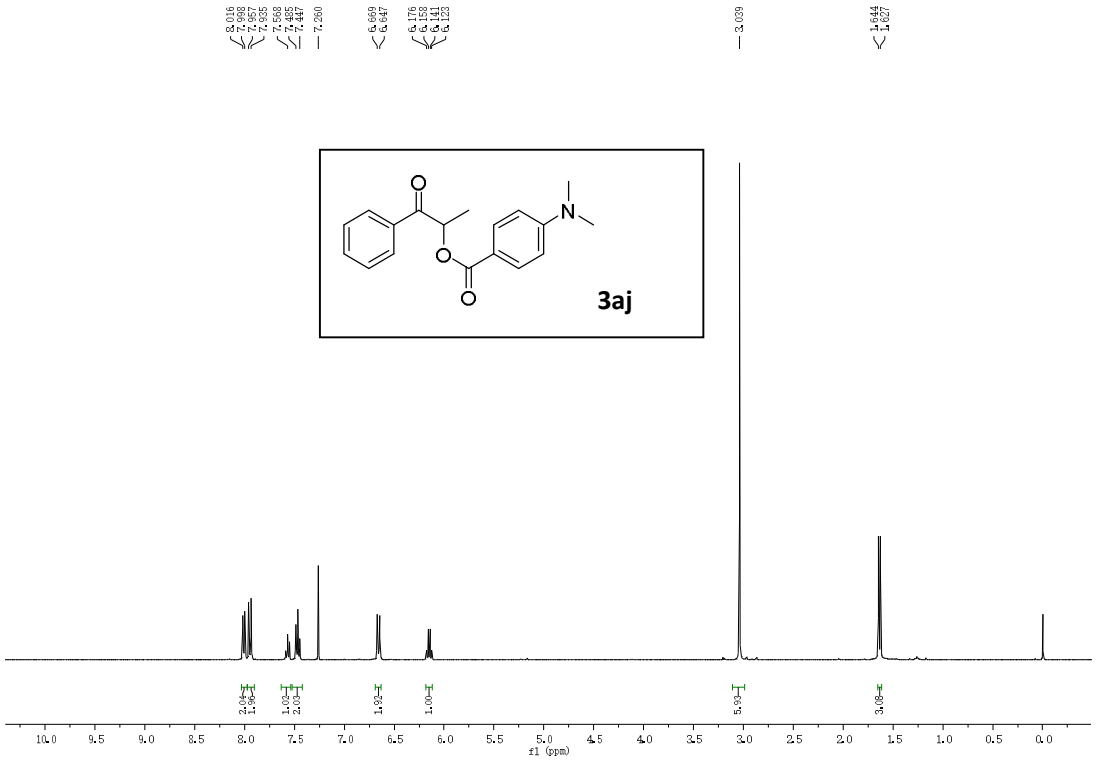
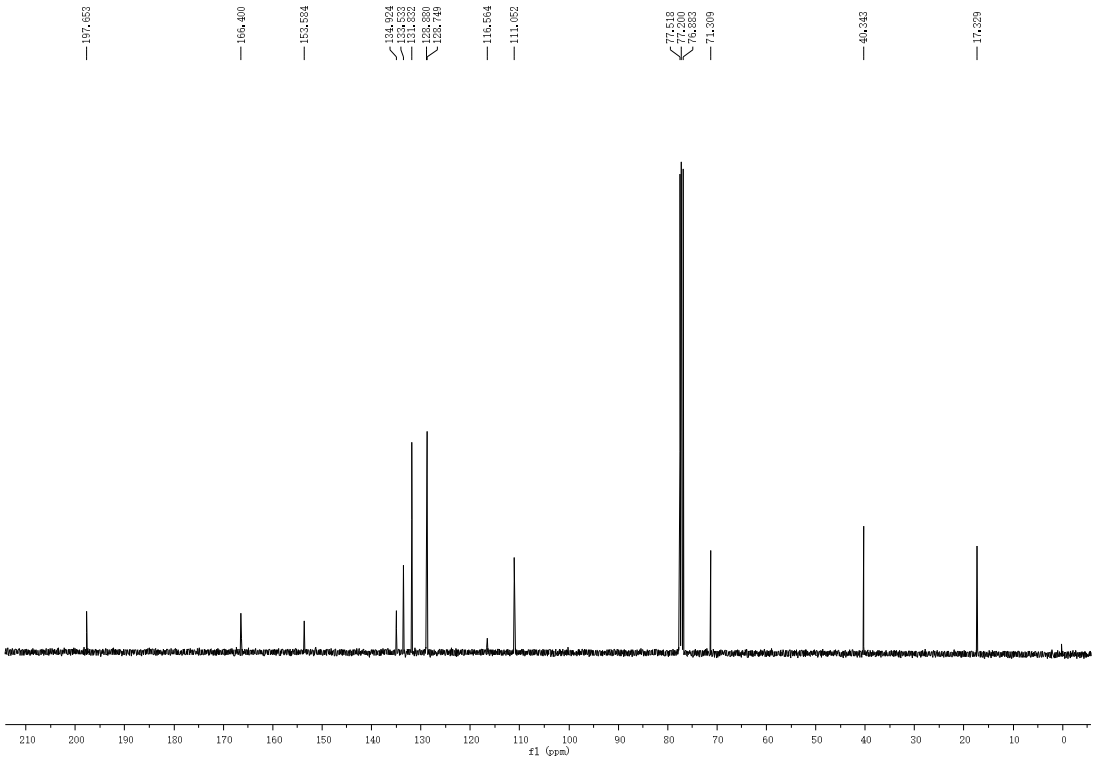
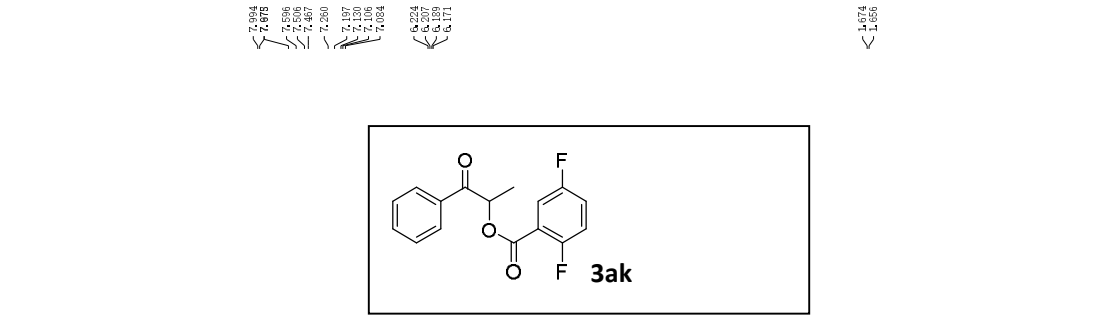
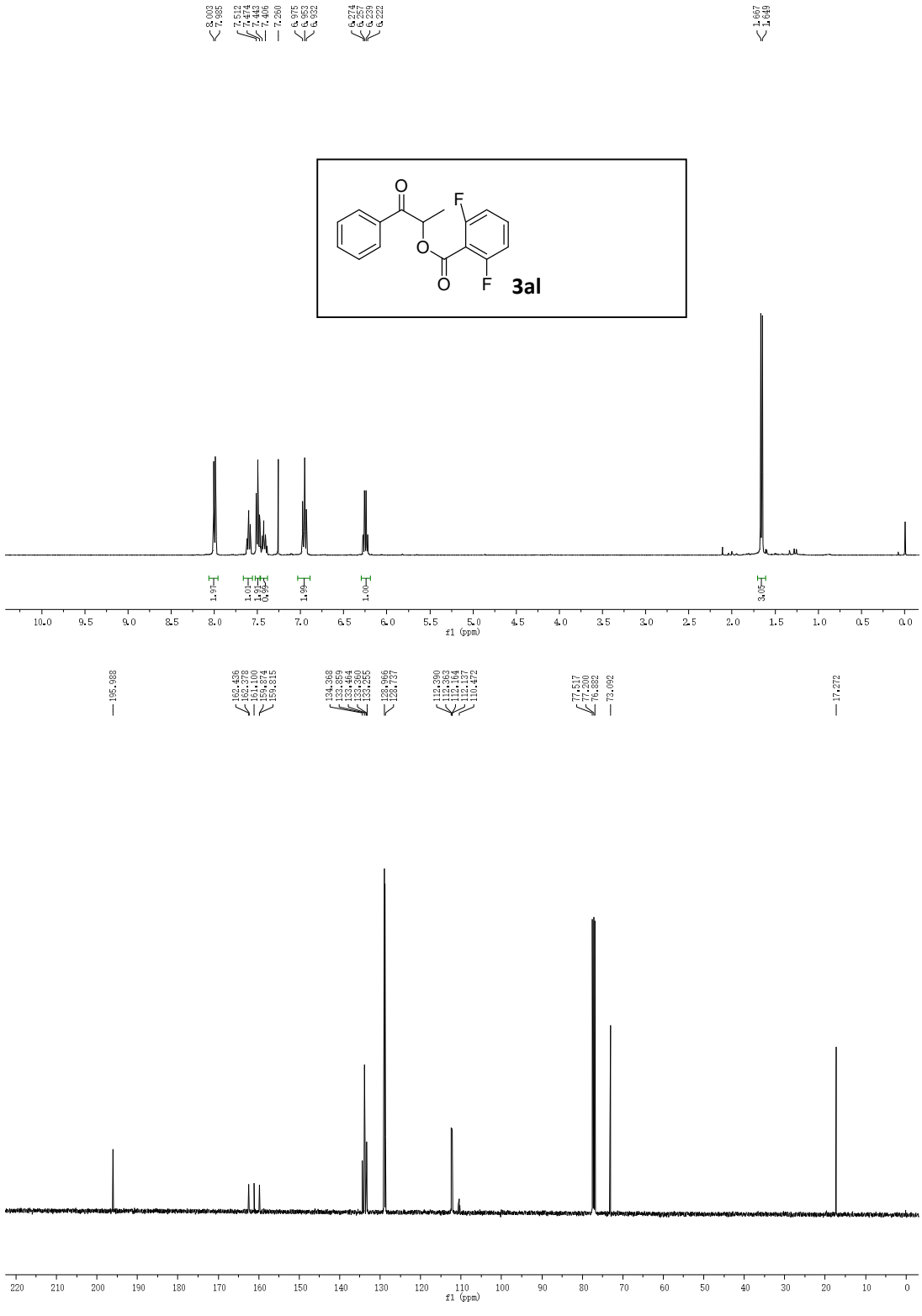
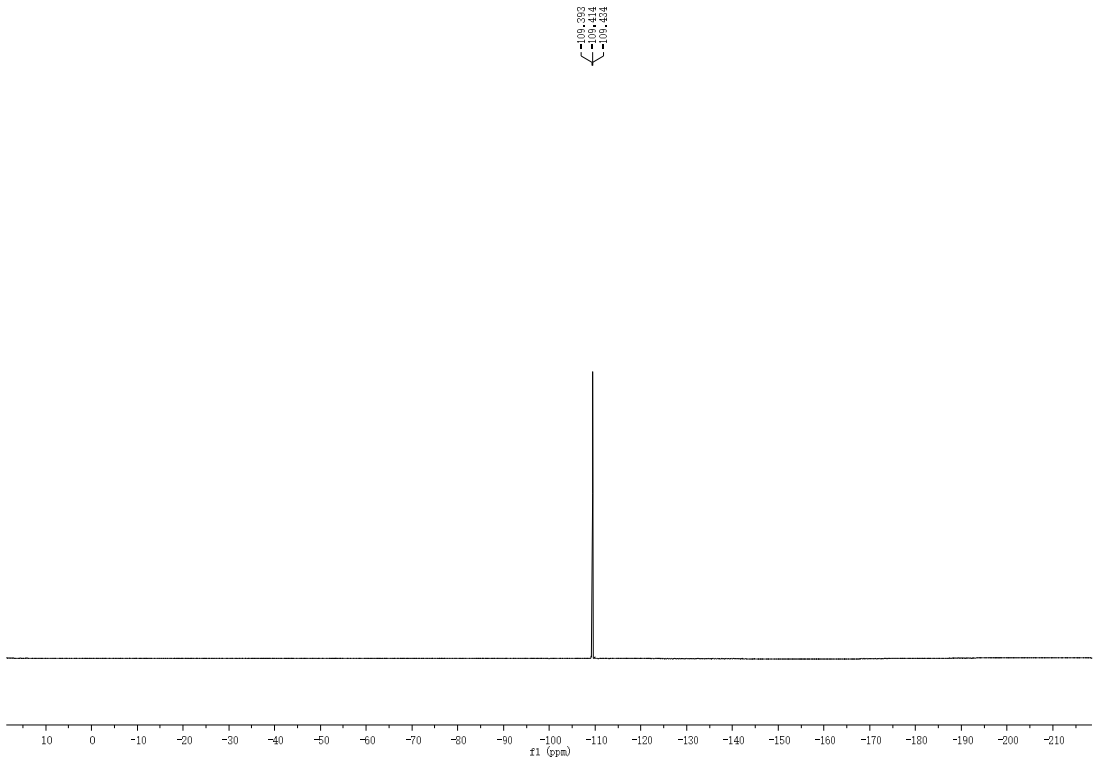
166.772
150.501
134.658
133.591
129.127
128.858
128.669
117.889
117.217
113.461
77.518
77.200
76.881
71.949
40.551
17.220
f1 (ppm)

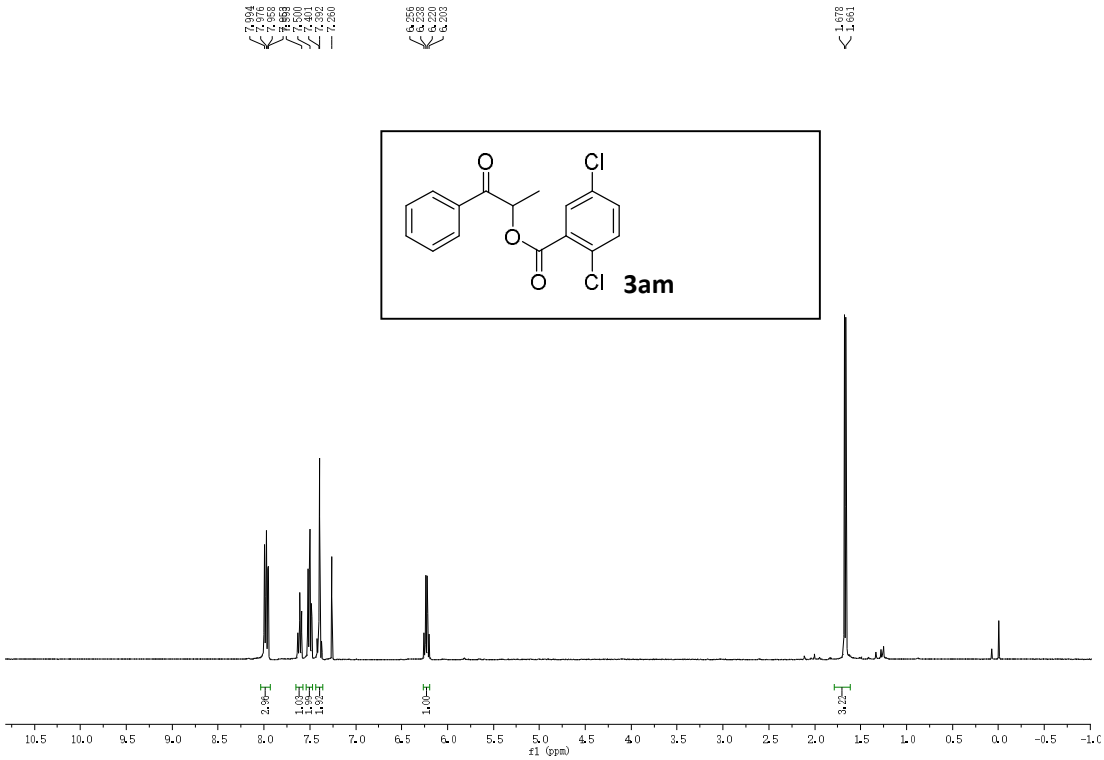

8.016
7.998
7.957
7.935
7.568
7.485
7.447
7.260
6.669
6.647
6.176
6.158
6.141
6.123
3.039
1.644
1.627
3aj
2.04
1.96
1.02
2.03
1.92
1.00
5.93
3.08
f1 (ppm)

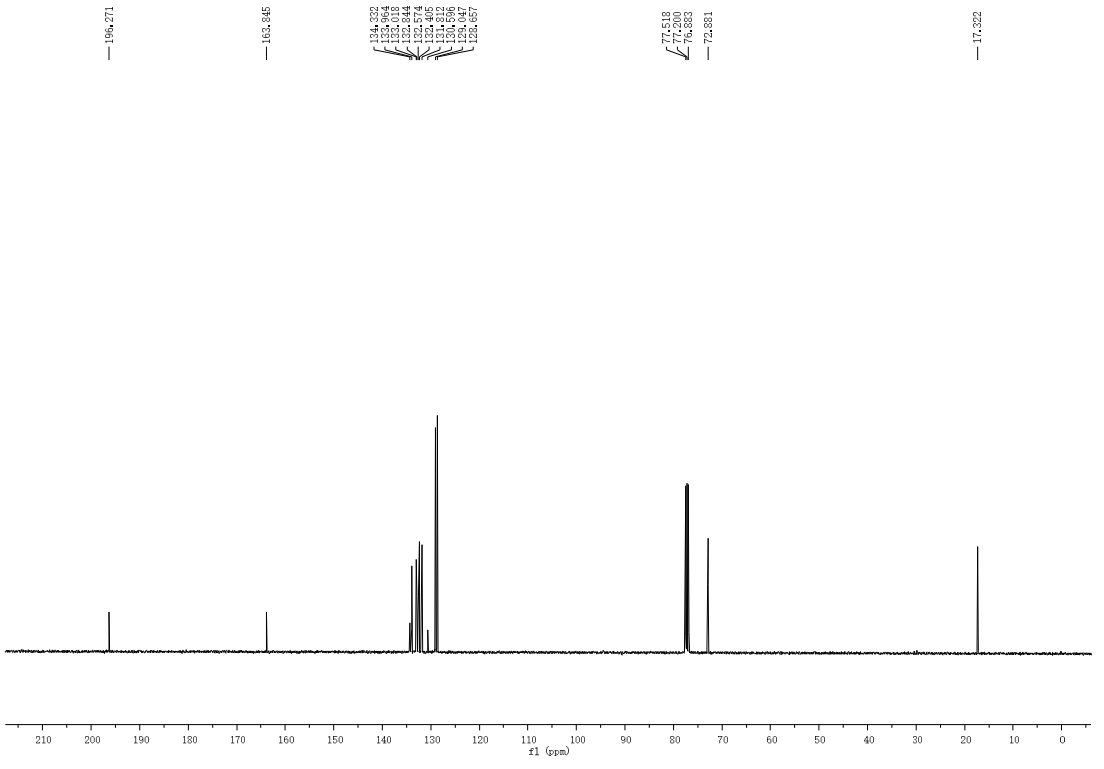

197.653
166.400
153.584
134.924
133.533
131.382
128.380
128.749
116.564
111.052
77.518
77.200
76.883
71.309
40.343
17.329
f1 (ppm)


3ak

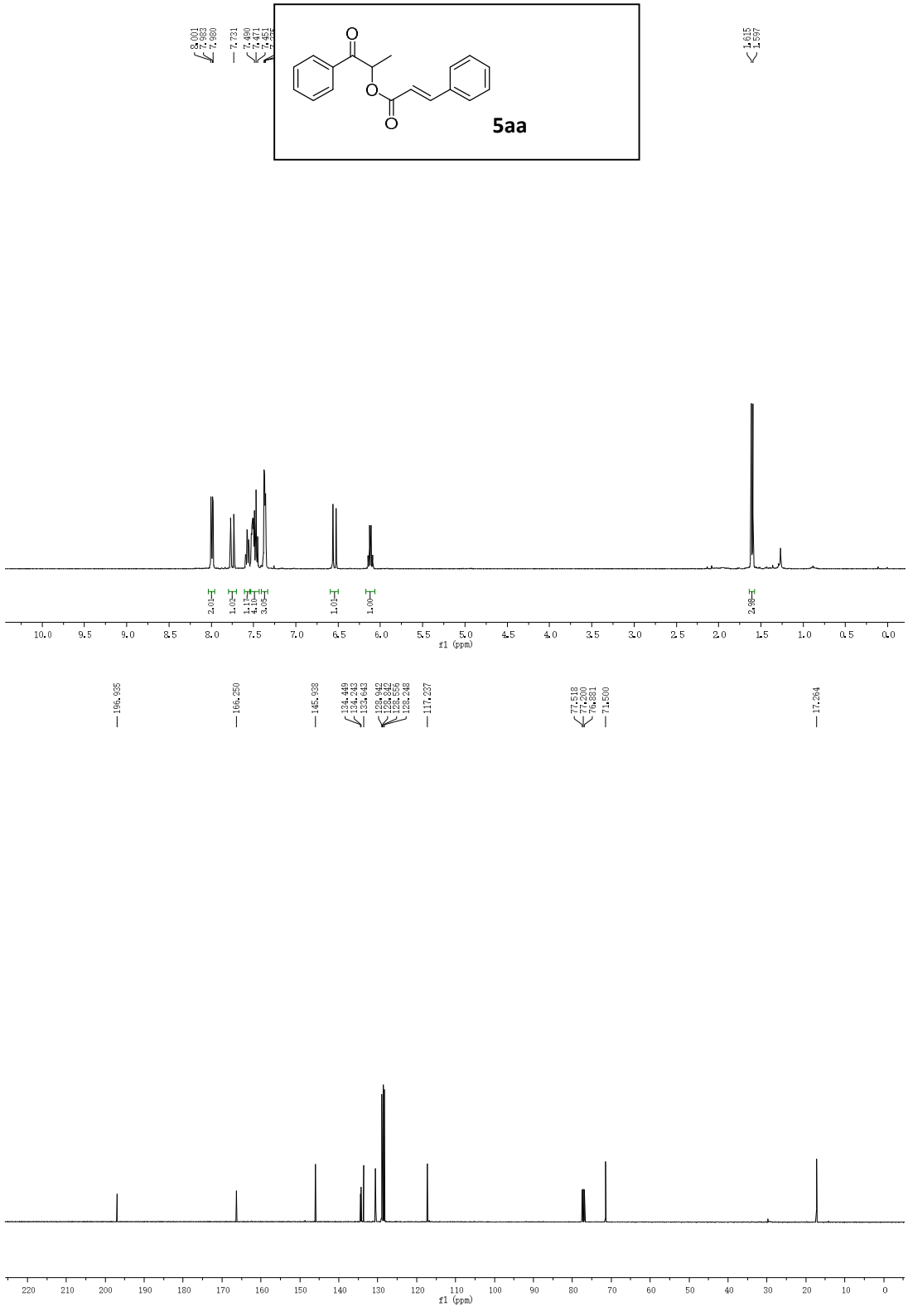

8.003
7.985
7.512
7.474
7.443
7.406
7.260
6.975
6.953
6.932
6.274
6.257
6.239
6.222
1.667
1.649
O
F
O
O
F
3al
1.97
1.01
1.91
0.89
1.98
1.00
3.05
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
195.988
162.436
162.378
161.010
159.874
159.815
134.368
133.859
133.464
133.360
133.255
128.966
128.787
112.390
112.363
112.164
112.137
110.472
77.517
77.200
76.882
73.092
17.272
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

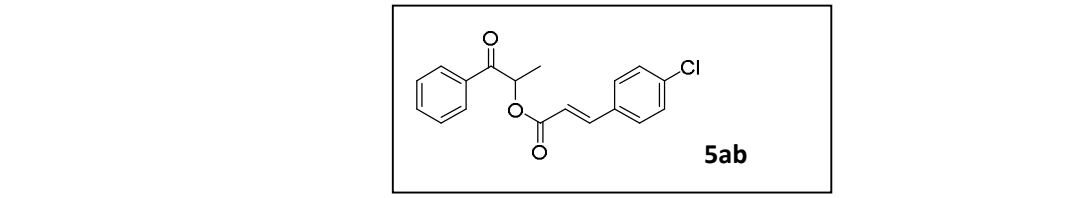

-109.393
-109.414
-109.434
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

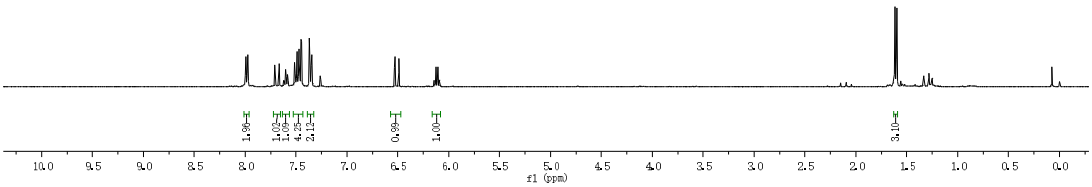

7.994
7.976
7.968
7.958
7.500
7.401
7.392
7.260
6.256
6.238
6.220
6.203
1.678
1.661
O
Cl
O
O
Cl
3am
2.90
1.03
1.94
1.92
1.00
3.22
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

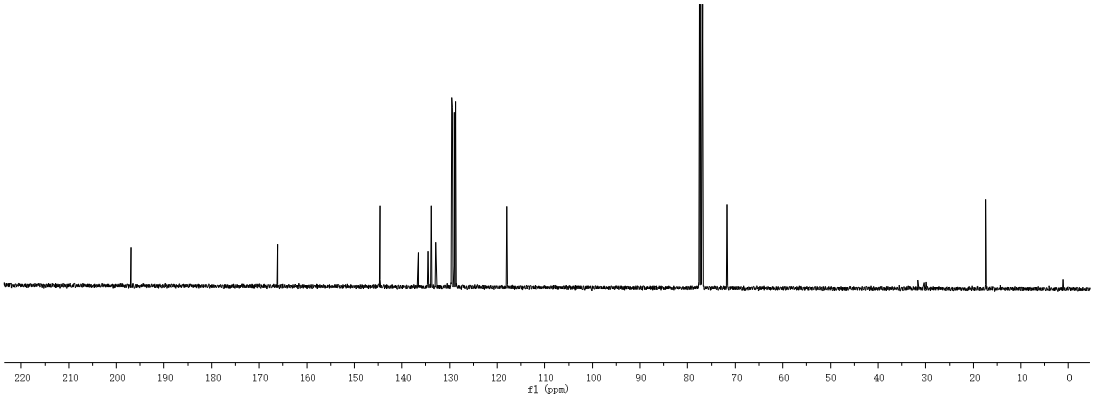

196.271
163.845
134.332
133.964
133.018
132.844
132.574
132.495
131.232
130.596
129.047
128.657
77.518
77.200
76.883
72.881
17.322
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

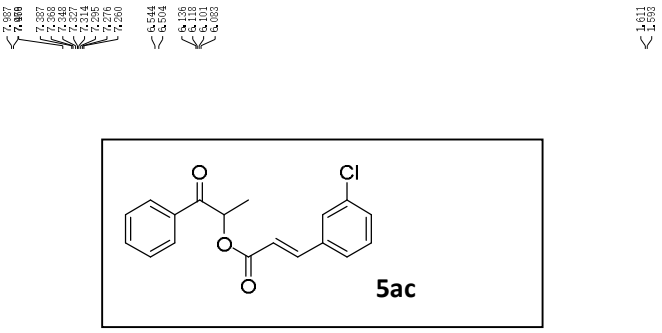
6 NMR Spectra of product 5aa-5an

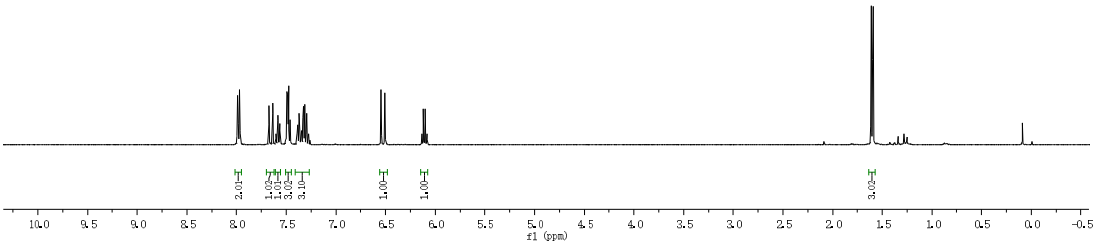


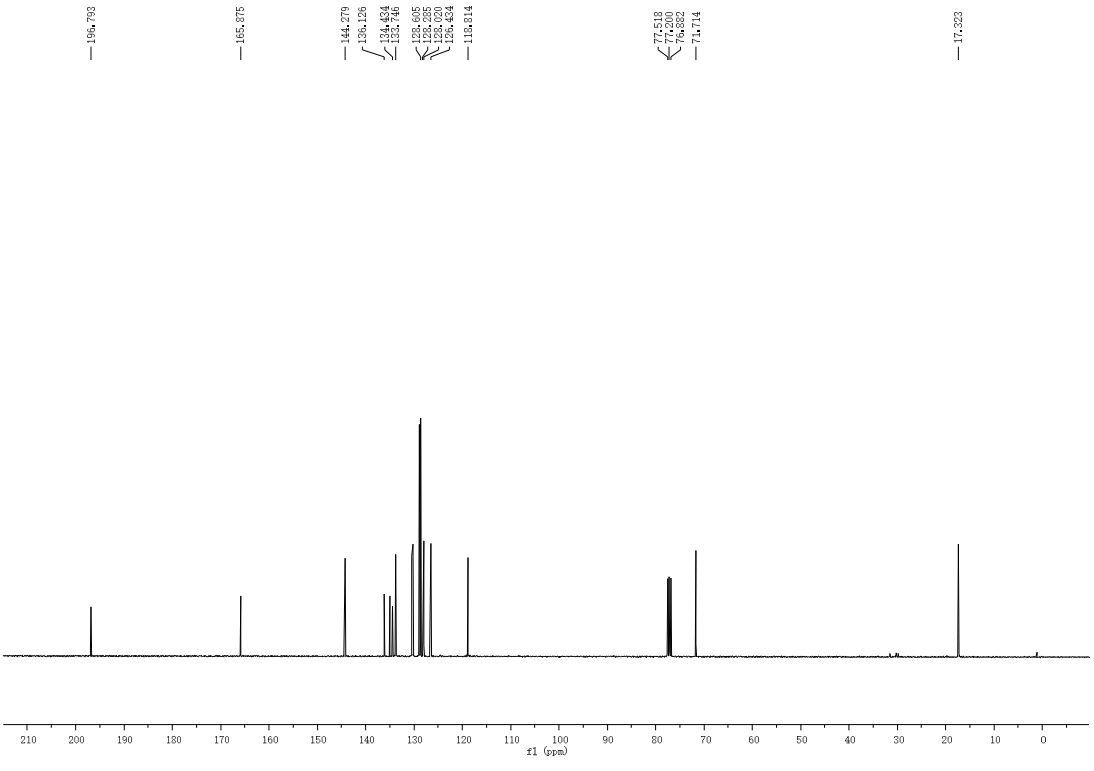

Cl
5ab

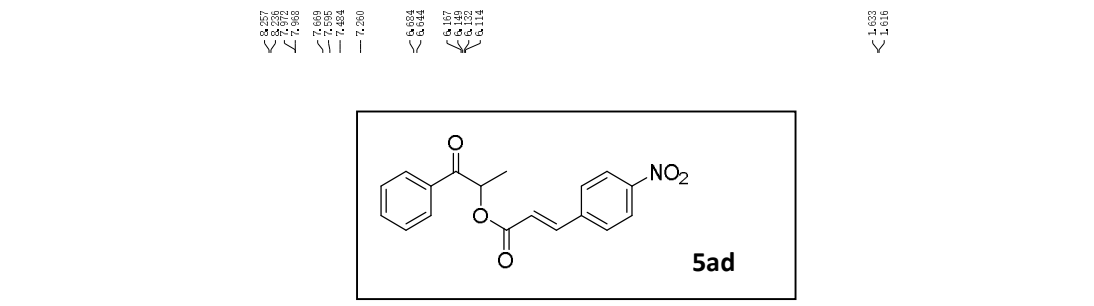


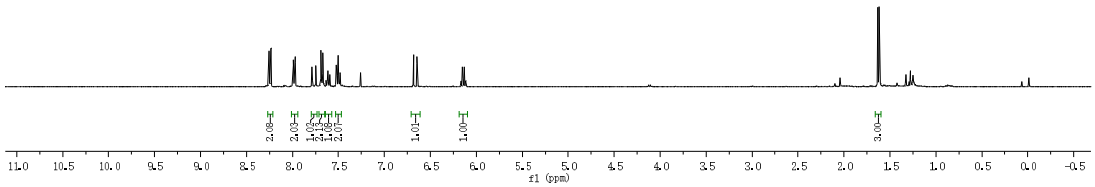


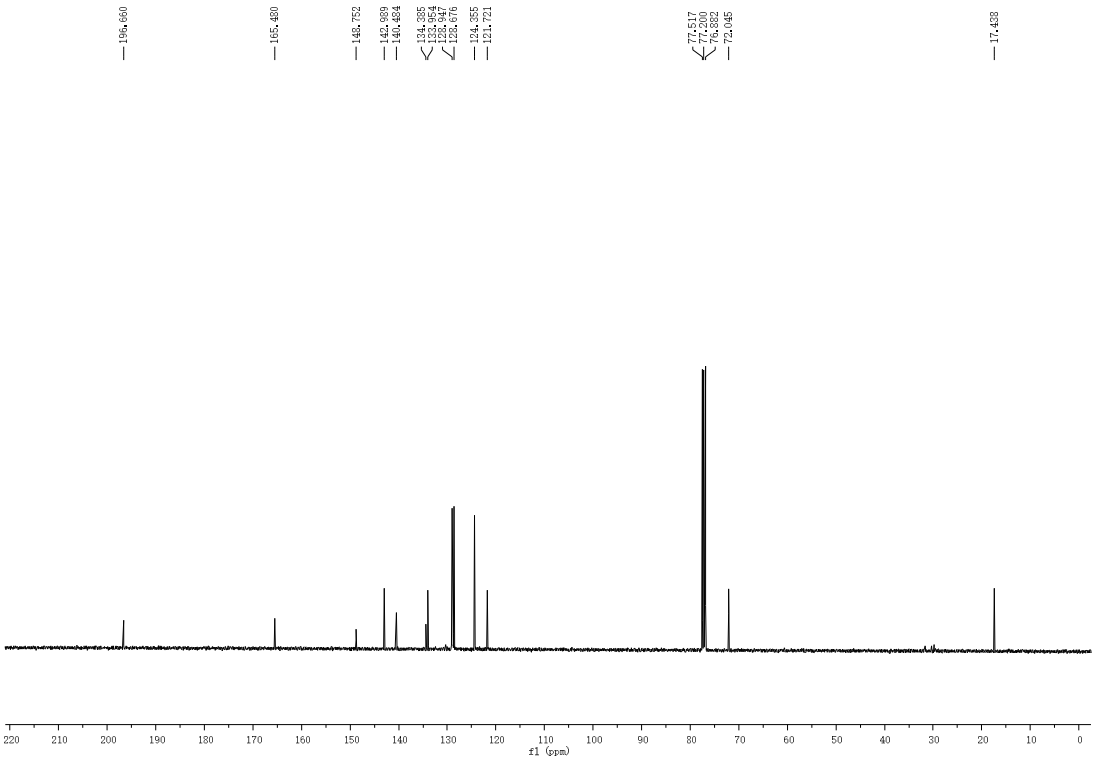

Cl
O
O
O
5ac

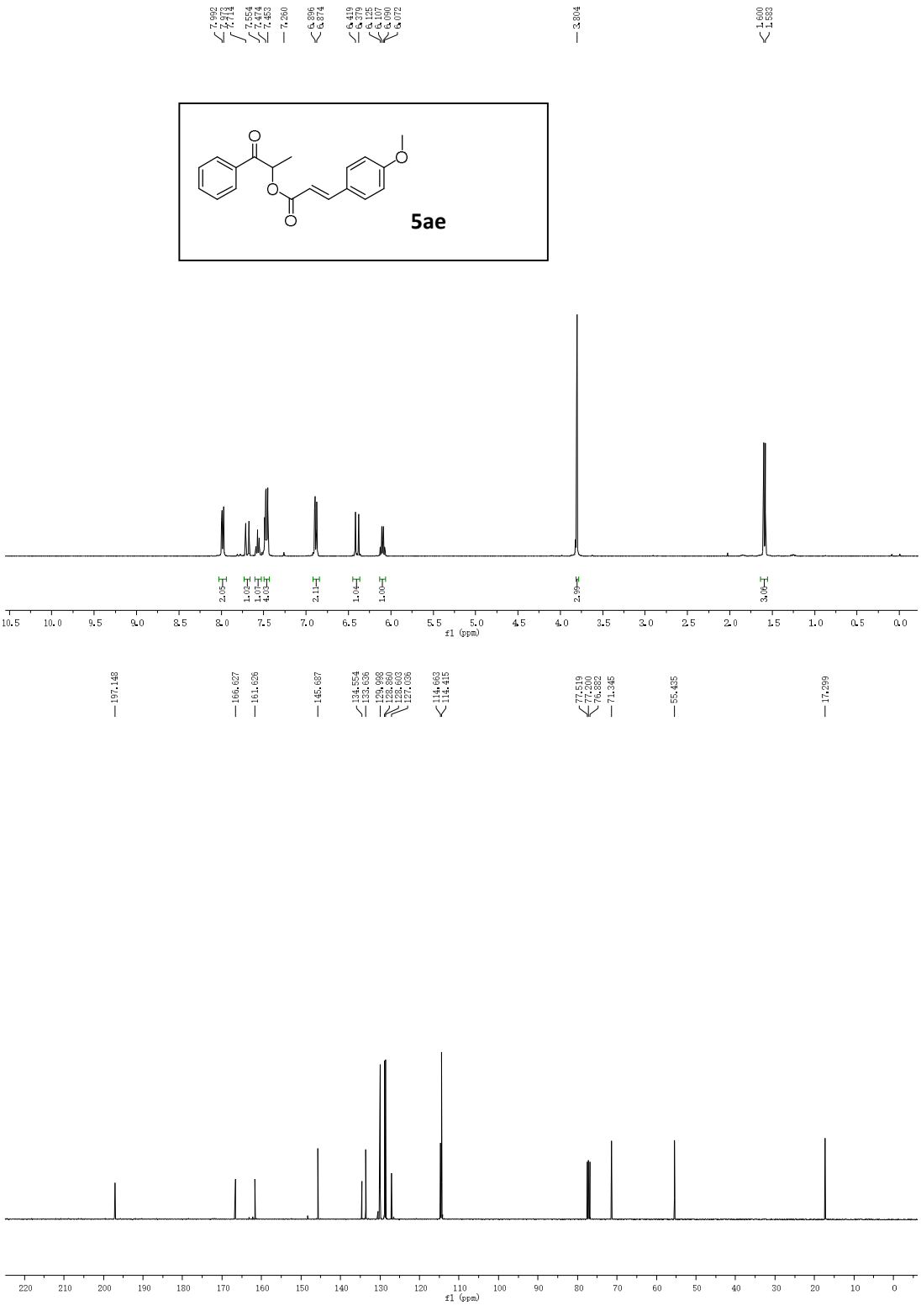





8.257
8.252
8.232
7.968
7.688
7.595
7.484
7.260
6.684
6.644
6.167
6.149
6.132
6.114
1.633
1.616
O
O
O
NO2
5ad


2.08
2.03
1.02
2.13
2.07
1.01
1.00
3.00
11.0 10.5 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 -0.5
f1 (ppm)


196.660
165.480
148.752
142.989
141.484
134.385
133.954
128.947
128.676
124.355
121.721
77.517
77.200
76.882
72.045
17.438
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.973
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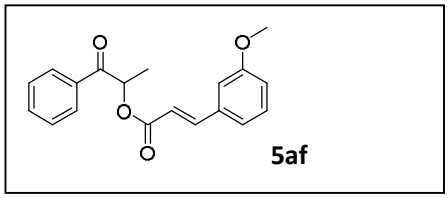
7.554
7.474
7.453
7.260
6.896
6.874
6.419
6.379
6.125
6.107
6.090
6.072
3.804
1.600
1.583
5ae
2.05
1.02
1.07
4.03
2.11
1.04
1.00
2.99
3.00
f1 (ppm)
197.148
166.627
161.626
145.687
134.554
133.636
129.998
128.860
128.603
127.036
114.663
114.415
77.519
77.200
76.882
71.345
55.435
17.299
f1 (ppm)


7.985
7.967
7.963
7.954
7.951
7.476
7.438
7.047
7.029
6.923
6.902
6.541
6.501
6.132
6.114
6.097
6.079
3.780
1.600
1.582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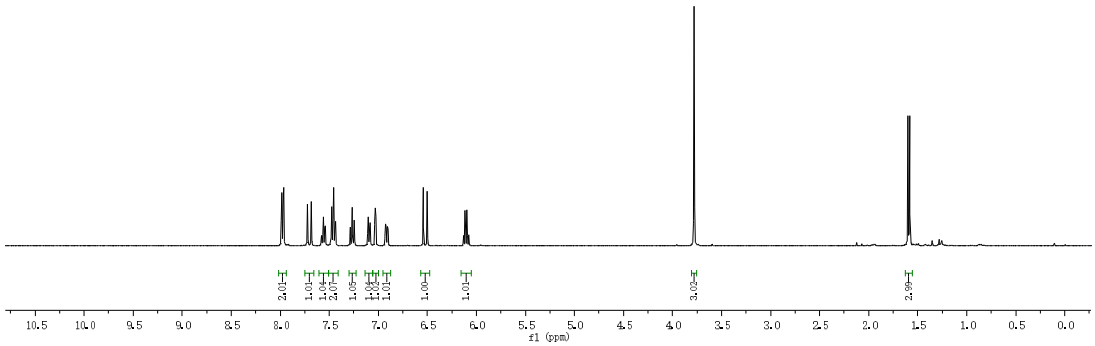
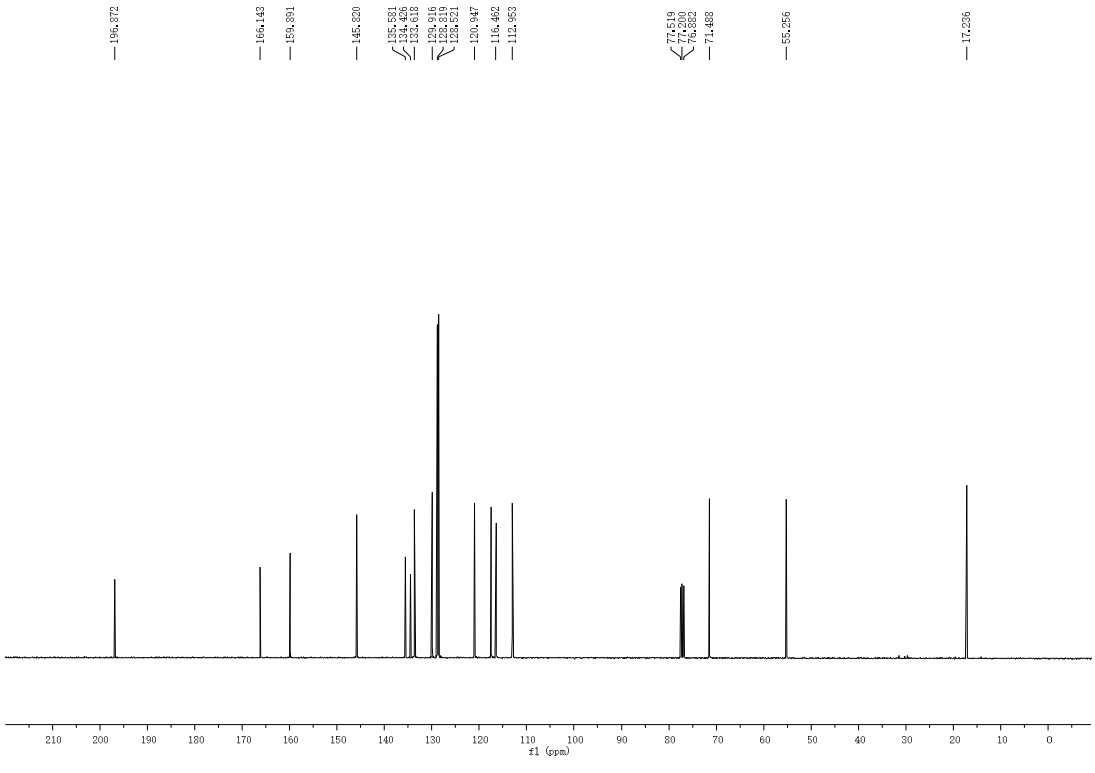

2.01
1.00
1.04
2.07
1.05
1.04
1.02
1.01
1.00
1.01
3.03
2.99
f1 (ppm)


196.872
166.143
159.891
145.820
135.581
134.426
133.618
129.916
128.819
128.521
120.947
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112.953
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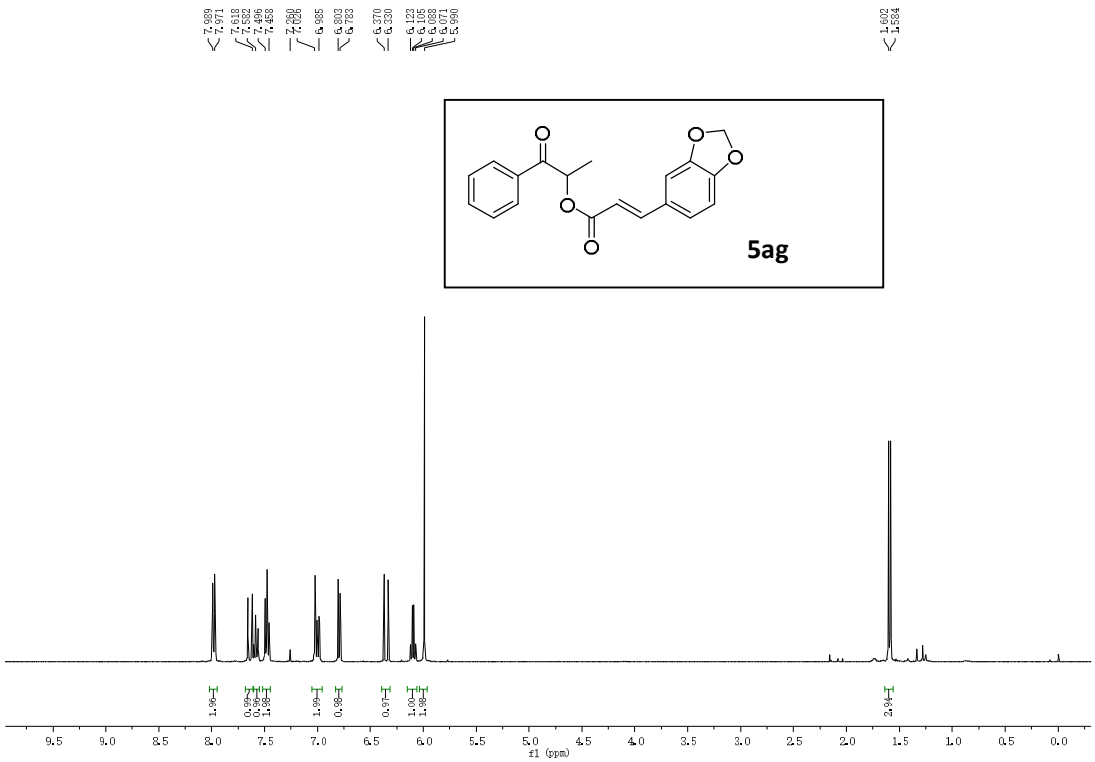
77.200
76.882
71.488
55.256
17.236
f1 (ppm)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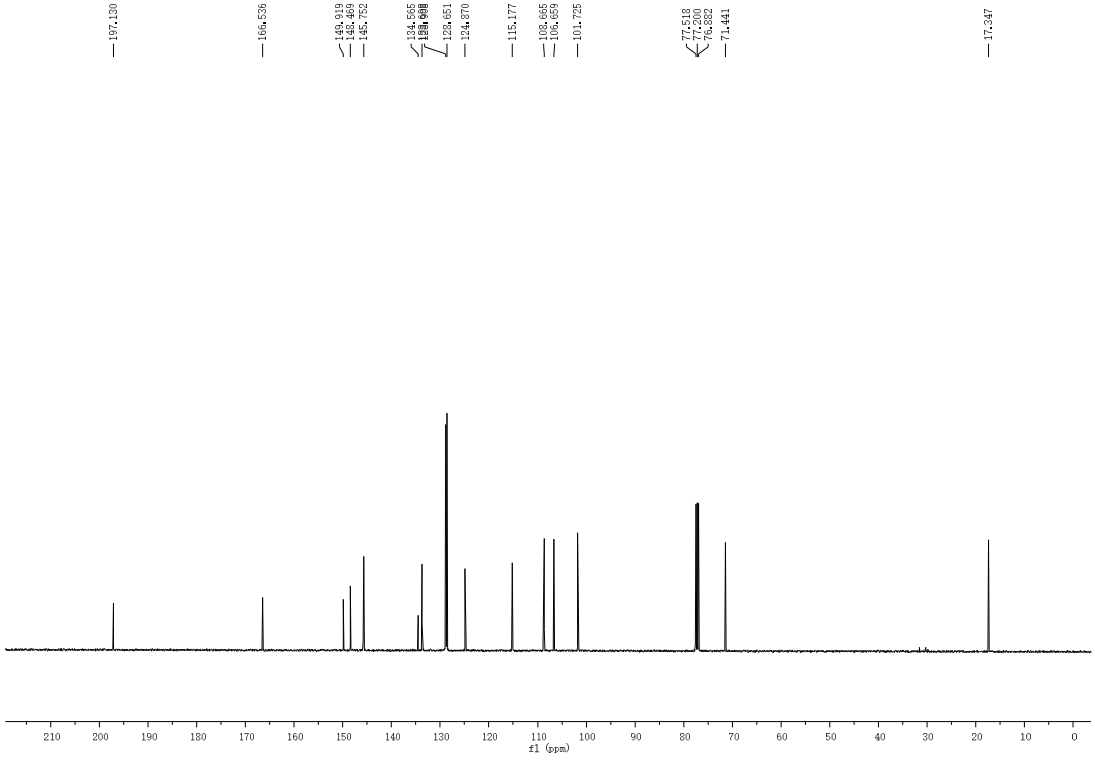
7.618
7.582
7.496
7.458
7.260
7.259
6.985
6.803
6.783
6.370
6.330
6.123
6.105
6.088
6.071
5.990
1.602
1.584
5ag
1.98
0.98
0.98
1.98
1.99
0.98
0.97
1.00
1.98
2.94
f1 (ppm)


197.130
166.536
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148.469
145.752
134.565
129.651
124.870
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108.665
106.659
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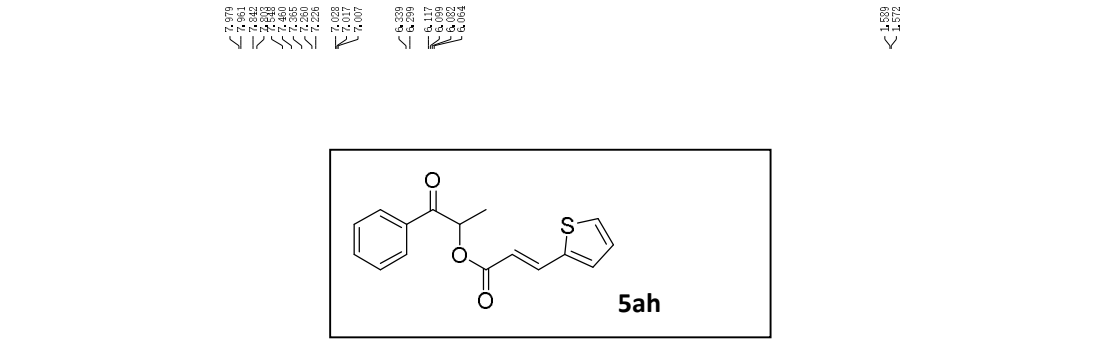
77.200
76.882
71.441
17.347
f1 (ppm)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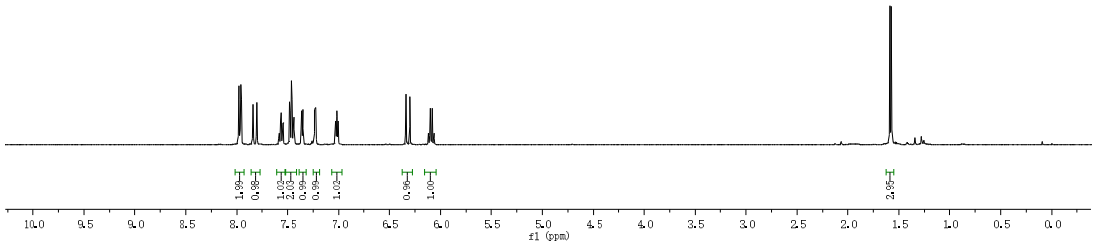
7.961
7.842
7.828
7.460
7.365
7.260
7.226
7.028
7.017
7.007
6.339
6.299
6.117
6.099
6.082
6.064
1.589
1.572
O
O
O
S
5ah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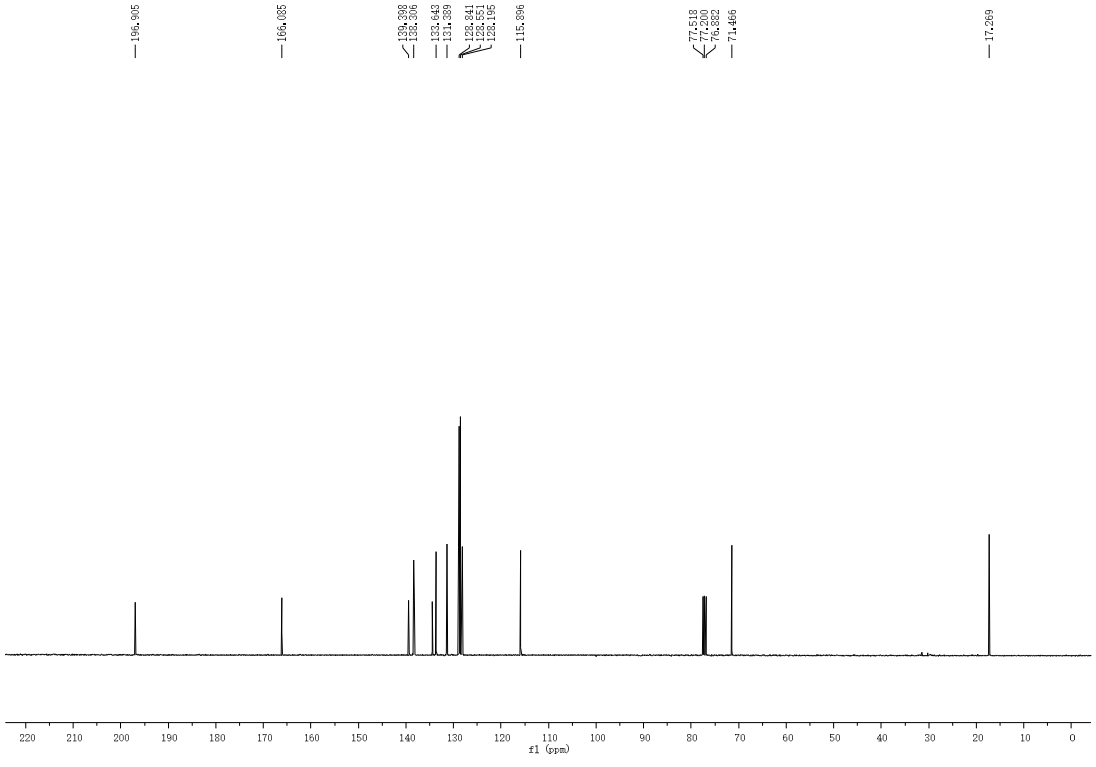
0.98
1.02
2.03
0.99
0.99
1.02
0.99
1.00
2.95
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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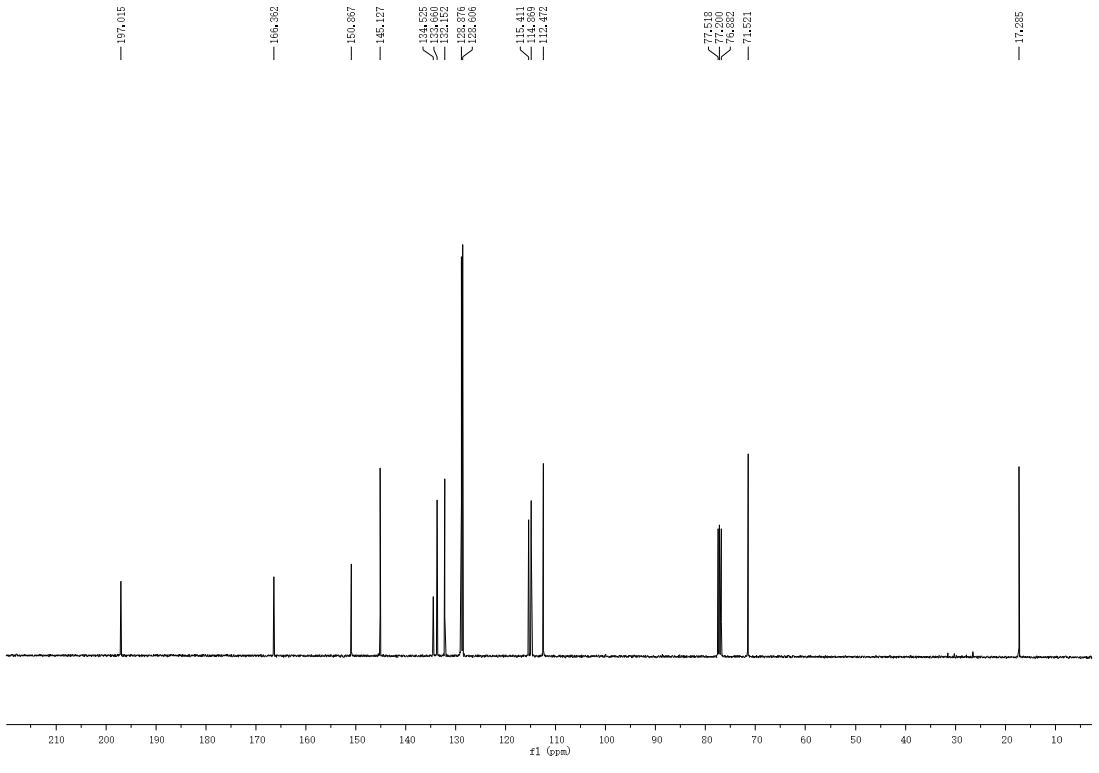
139.398
138.306
133.643
131.389
129.841
128.651
128.195
115.896
77.518
77.200
76.882
71.466
17.269
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.976
7.958
7.569
7.486
7.447
7.260
6.611
6.603
6.372
6.101
6.093
6.066
6.048
1.587
1.570
5ai
2.08
1.10
3.97
1.03
1.02
0.97
1.00
3.02
f1 (ppm)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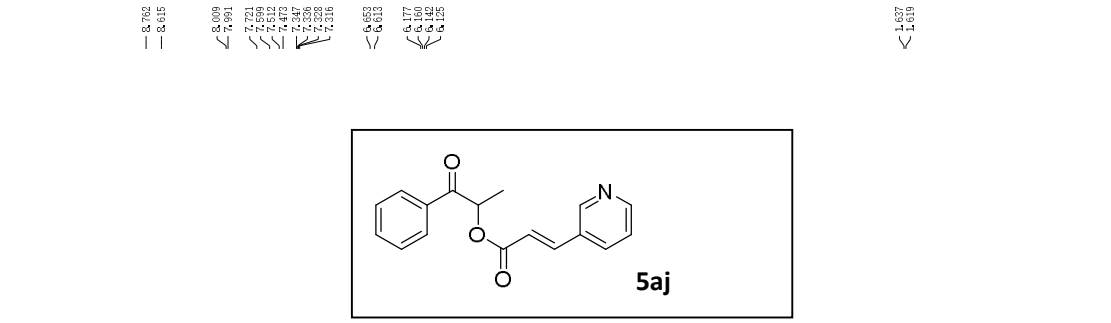
77.518
77.200
76.882
71.521
17.285
f1 (ppm)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7.991
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7.599
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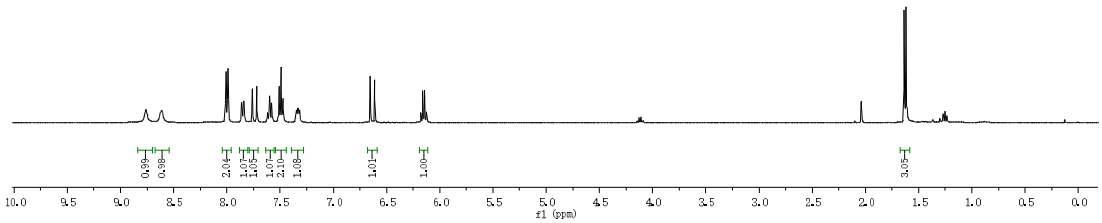
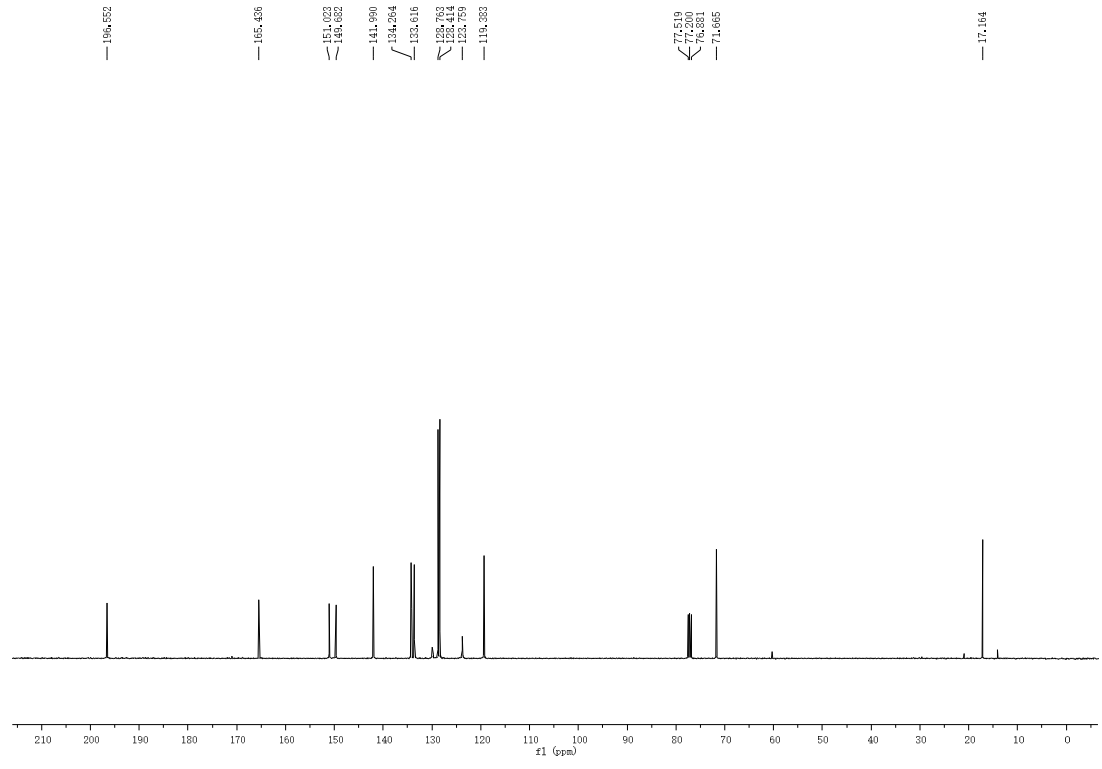
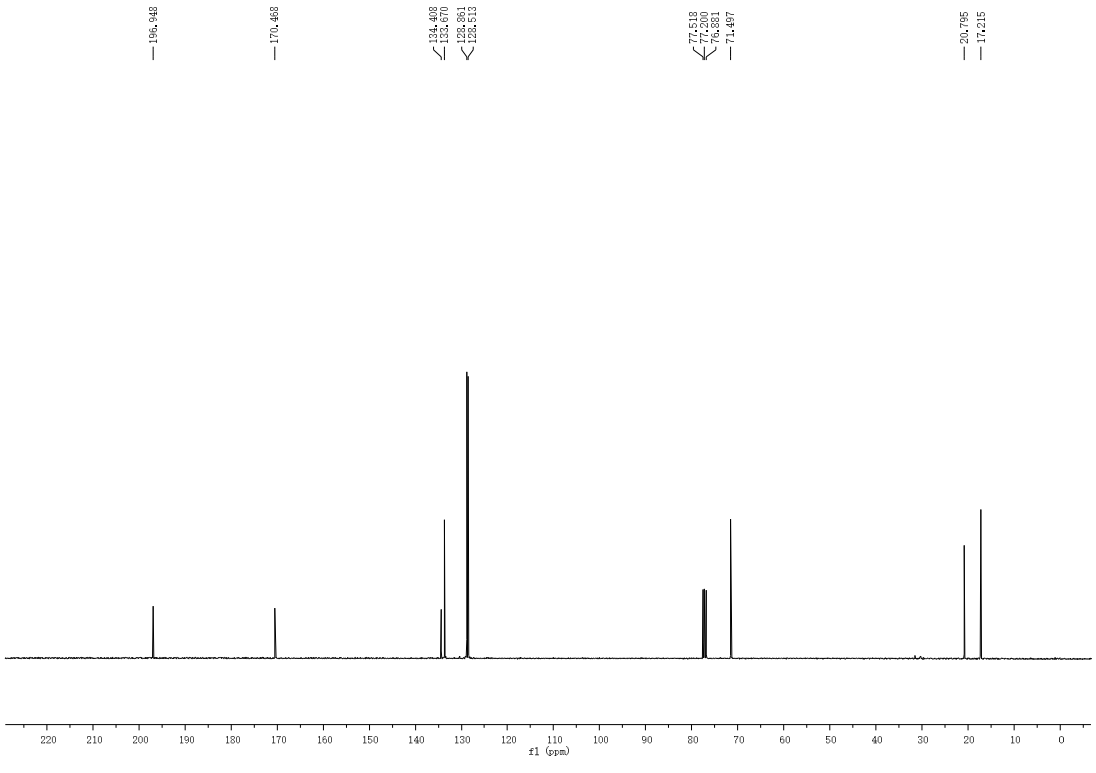
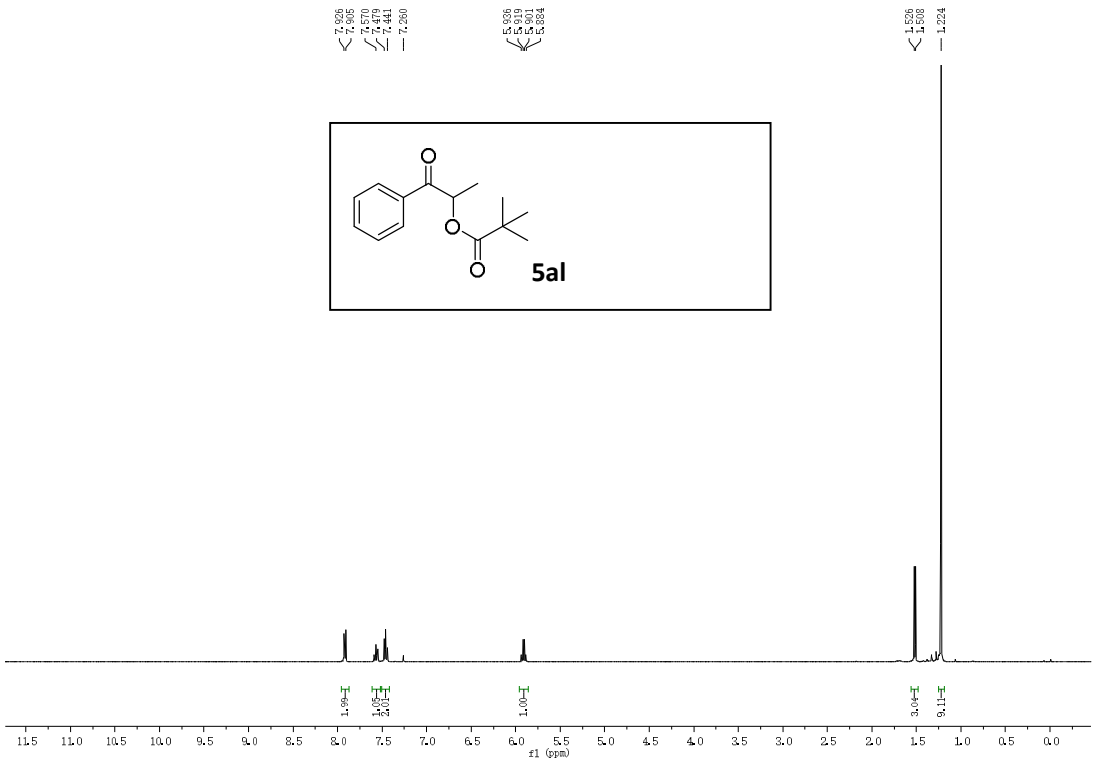
7.473
7.347
7.326
7.238
7.316
6.653
6.613
6.177
6.160
6.142
6.125
1.637
1.619
O
N
O
O
5aj

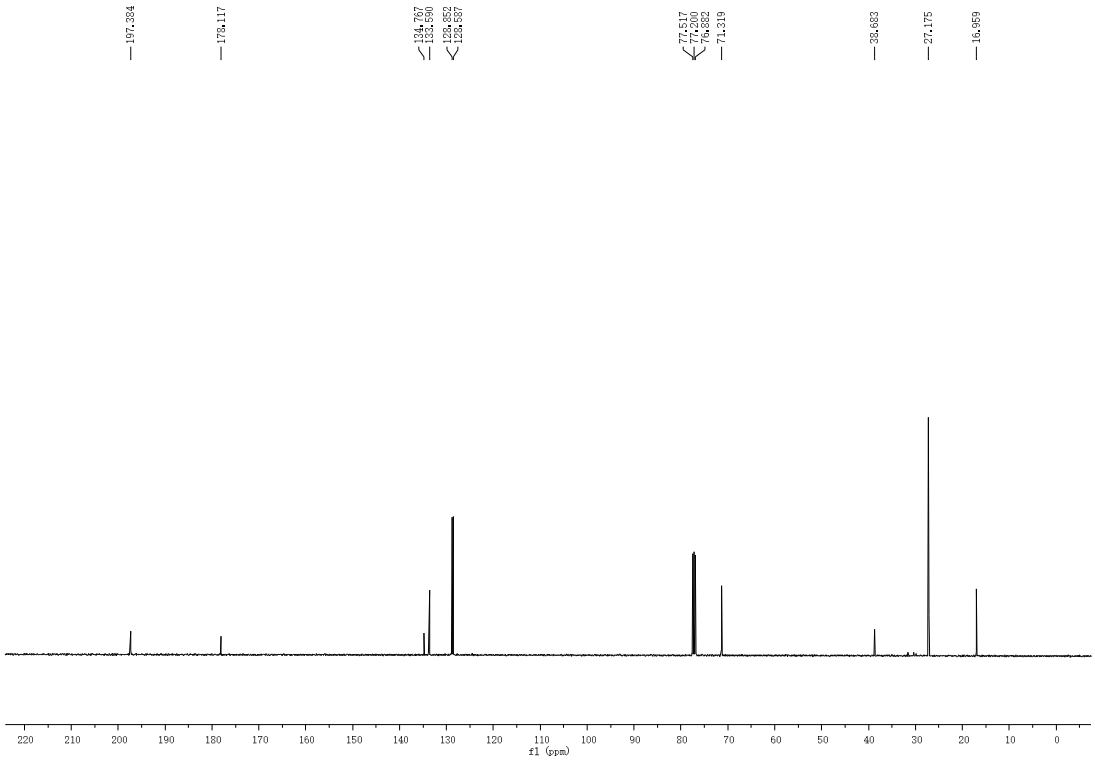

0.99
0.98
2.04
1.07
1.05
1.07
2.10
1.08
1.01
1.00
3.05
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

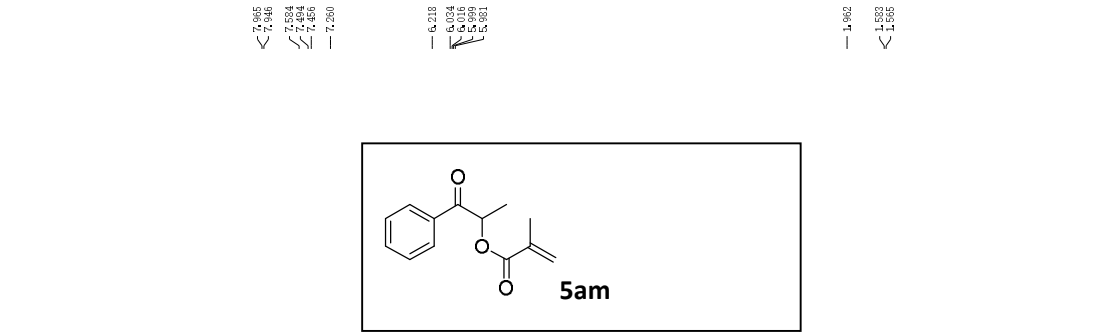

196.552
165.436
151.023
149.682
141.990
134.264
133.616
128.763
128.414
123.759
119.383
77.519
77.200
76.881
71.665
17.164
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

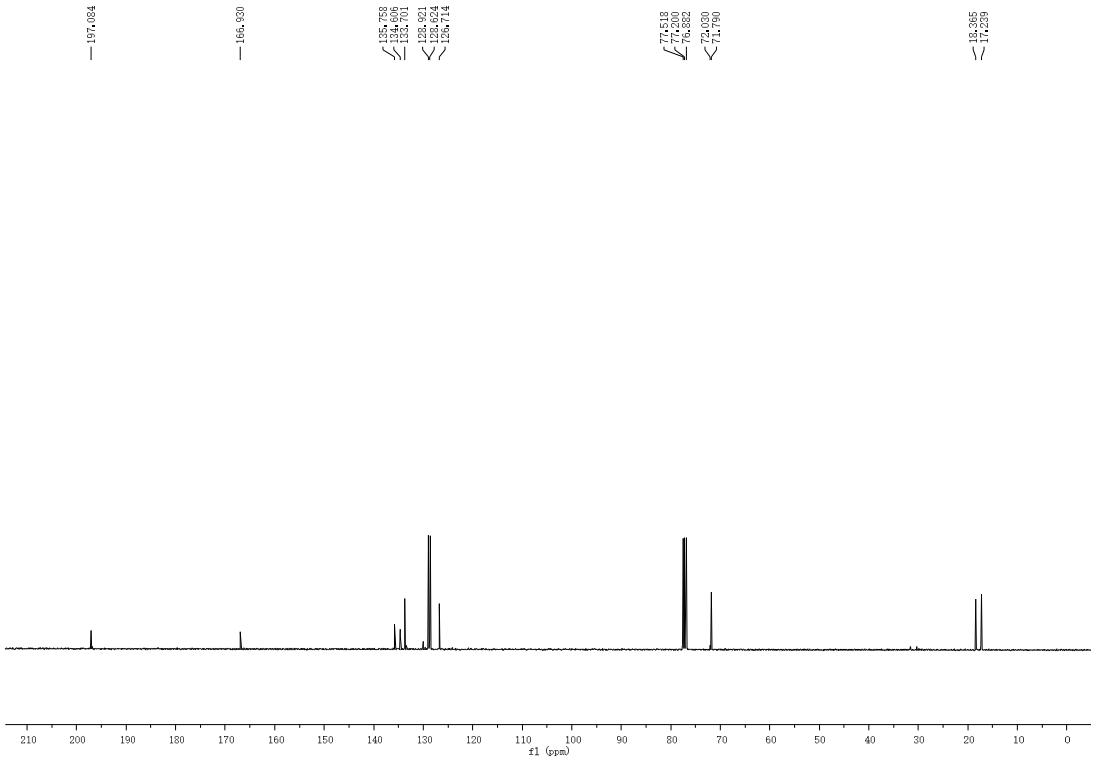

7.925
7.907
7.904
7.558
7.466
7.448
7.260
5.969
5.951
5.934
5.916
2.117
1.509
1.491
O
O
O
5ak
1.98
1.00
1.99
1.00
3.03
3.05
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

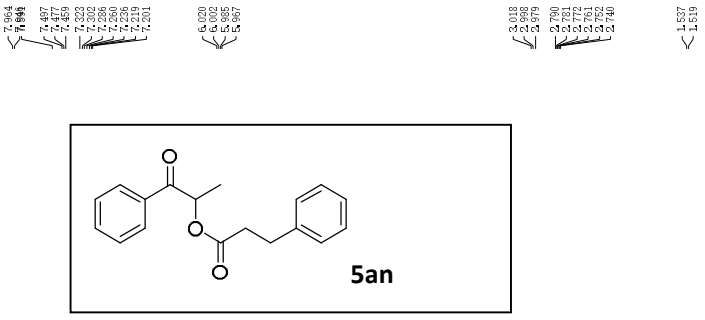

196.948
170.468
134.408
133.670
128.861
128.513
77.518
77.200
76.881
71.497
20.795
17.215
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.926
7.905
7.570
7.479
7.441
7.260
5.936
5.919
5.901
5.884
1.526
1.508
1.224
5al
1.99
1.08
2.01
1.00
3.04
9.11
f1 (ppm)


197.384
178.117
134.767
133.590
128.852
128.587
77.517
77.200
76.882
71.319
38.683
27.175
16.959
f1 (ppm)


7.965
7.946
7.584
7.564
7.456
7.260
6.218
6.034
6.016
5.999
5.981
1.962
1.583
1.565
5am
1.96
1.15
2.08
1.04
1.00
0.99
2.98
2.99
f1 (ppm)


197.084
166.930
135.758
134.606
133.701
128.921
128.624
126.714
77.518
77.200
76.882
72.030
71.790
18.365
17.239
f1 (ppm)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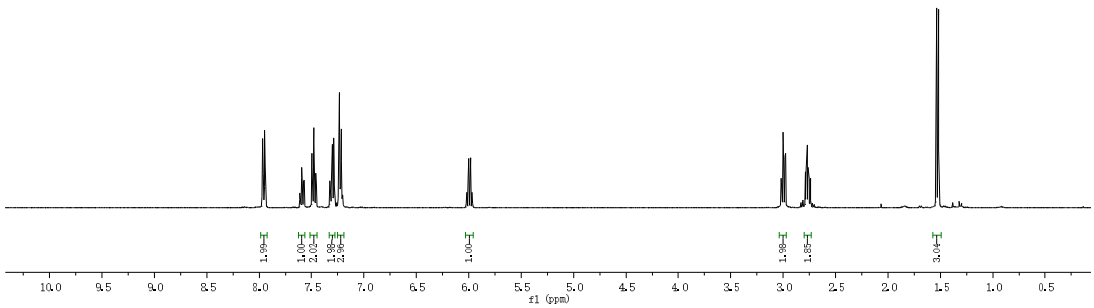
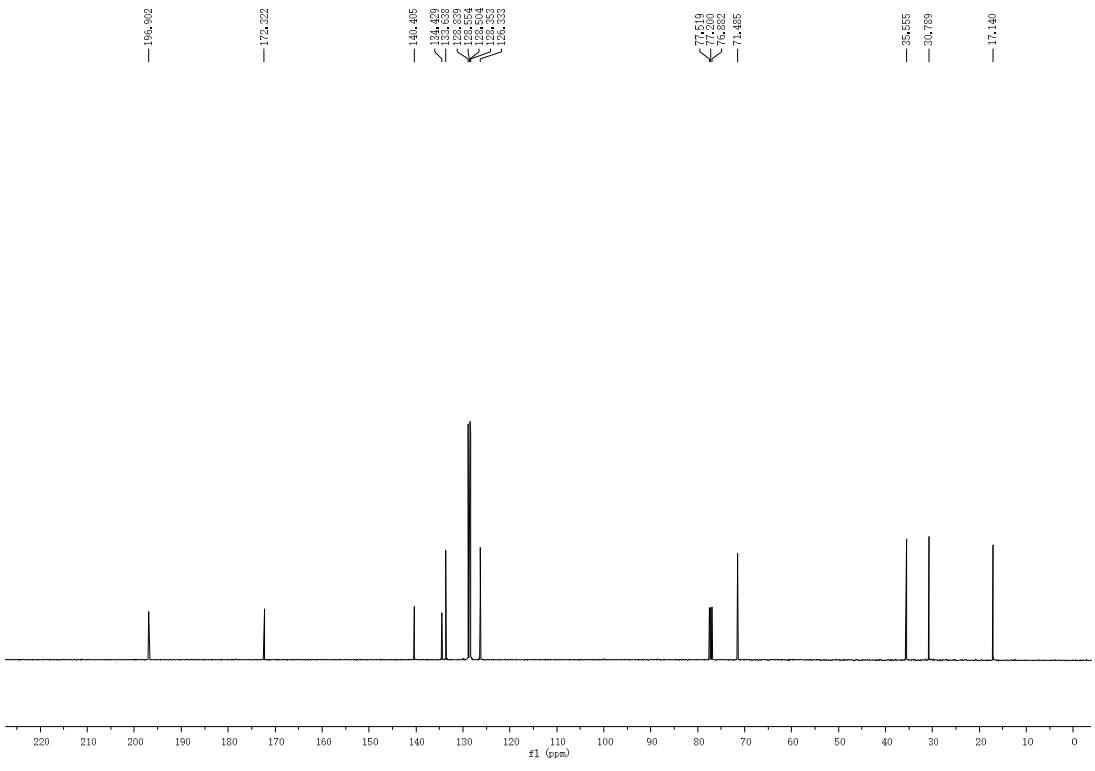
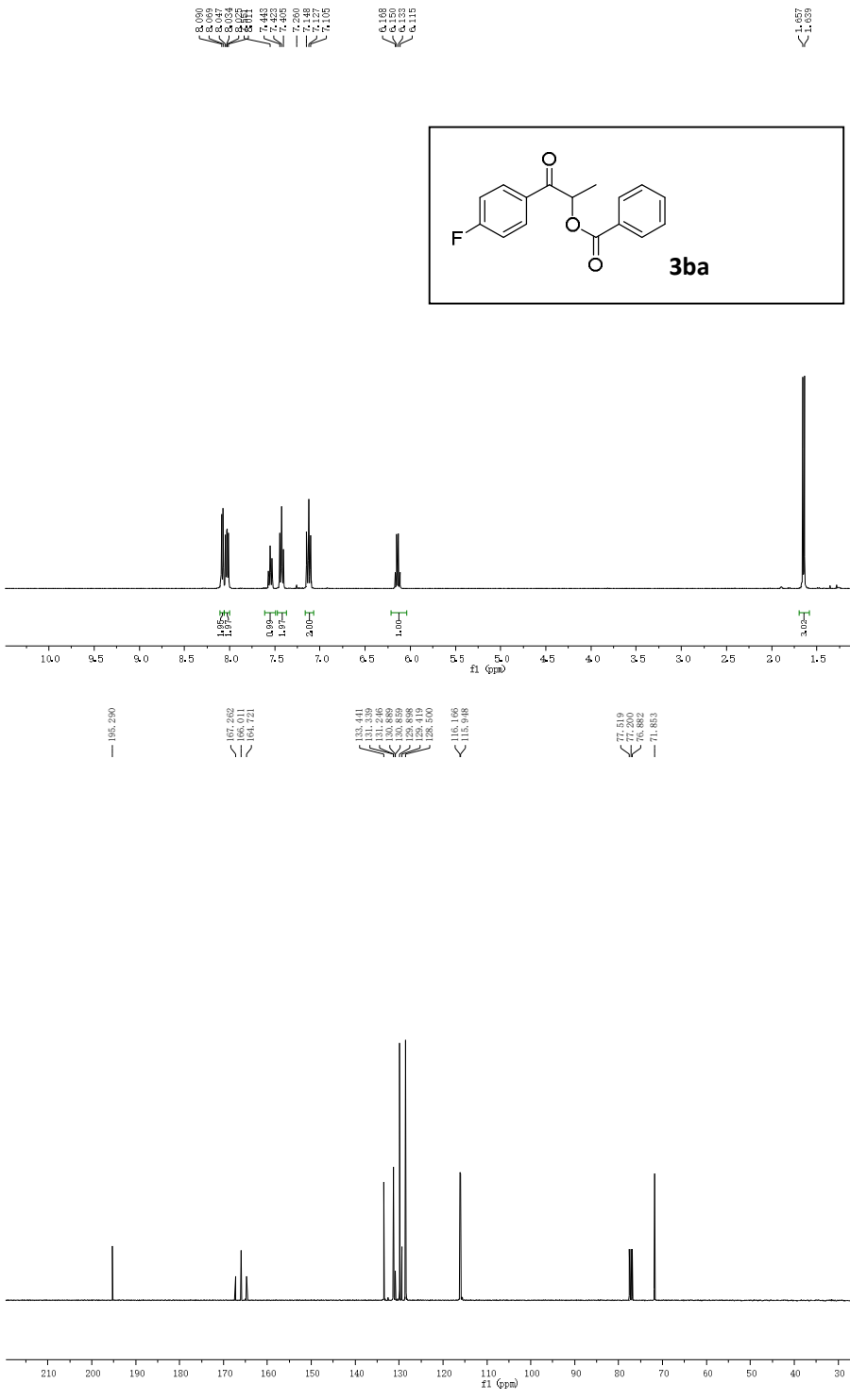
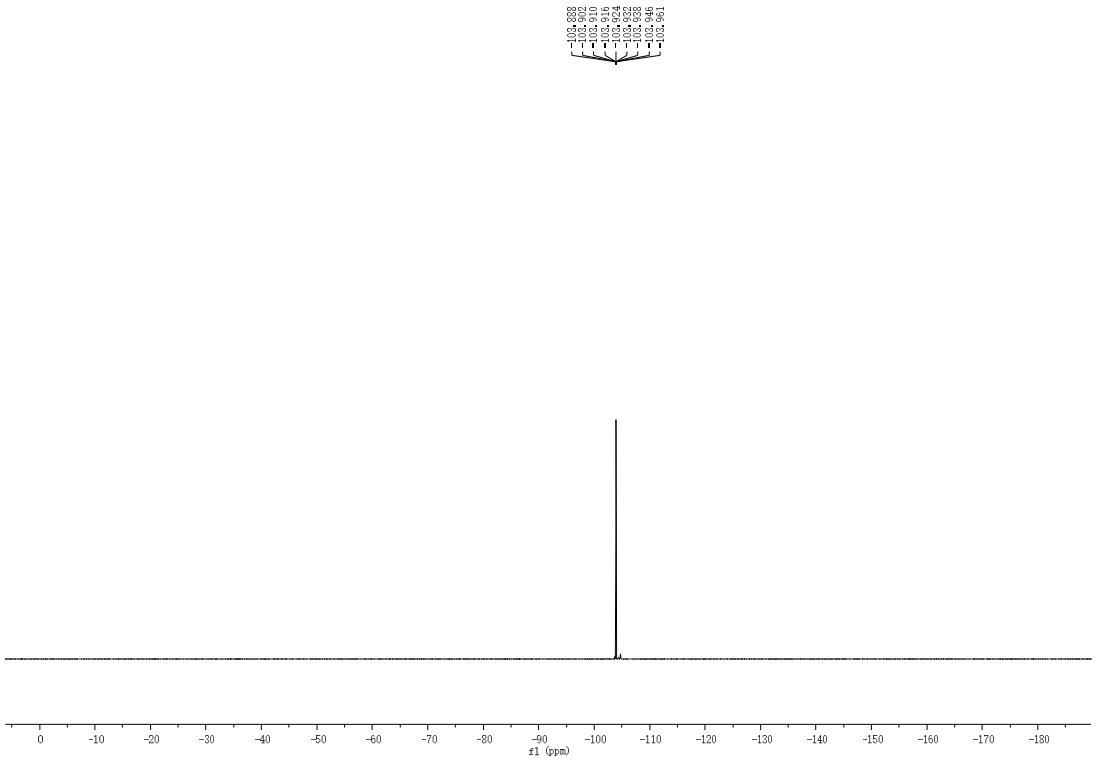
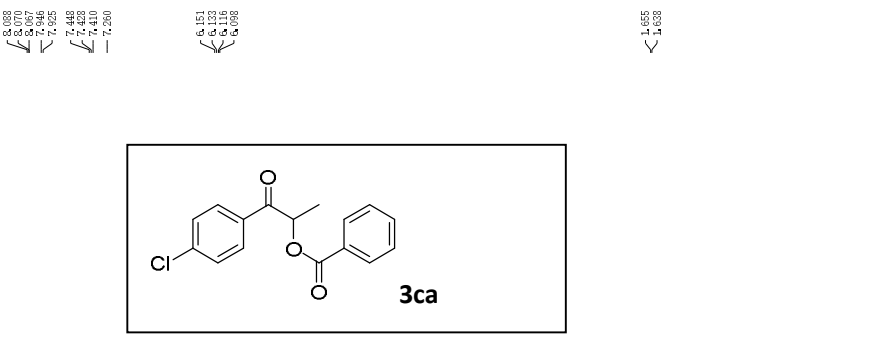

f1 (ppm)

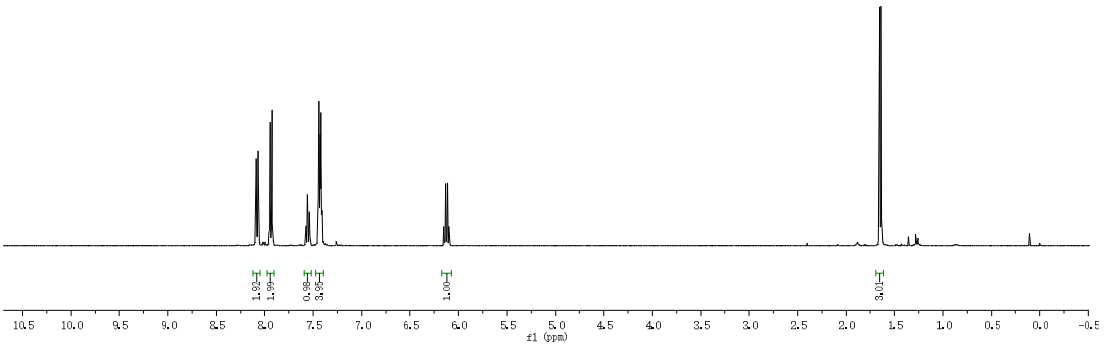

f1 (ppm)

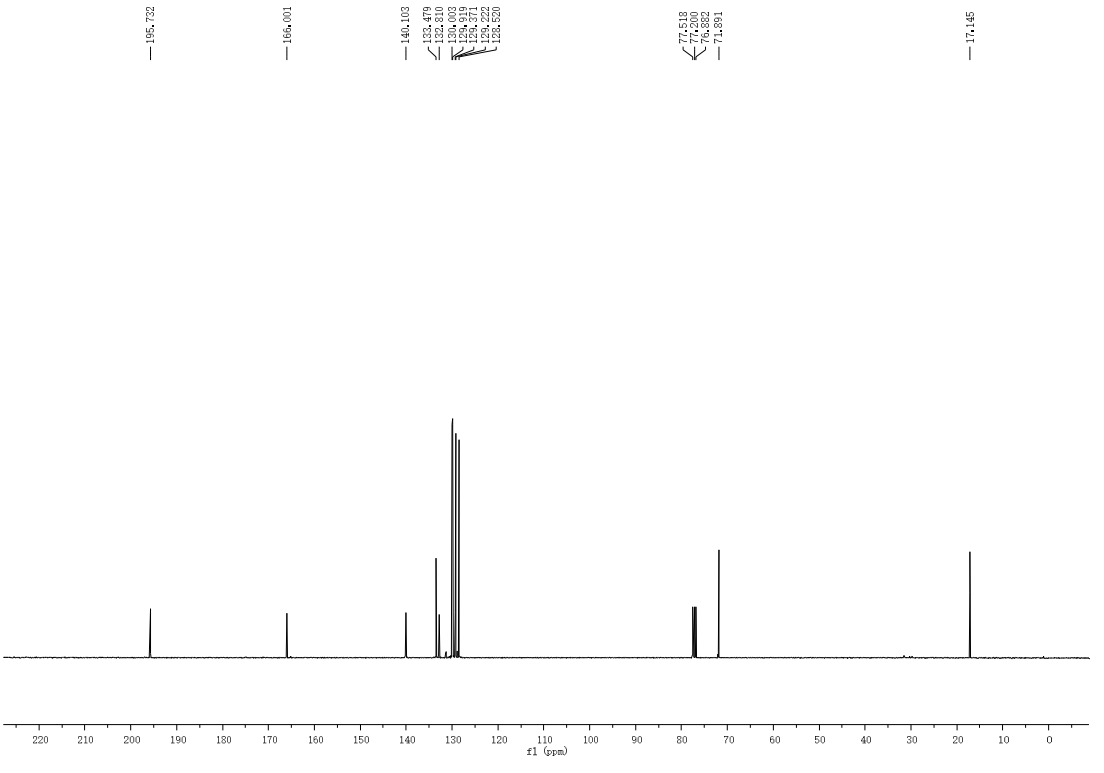
7 NMR Spectra of product 3ba-3ma

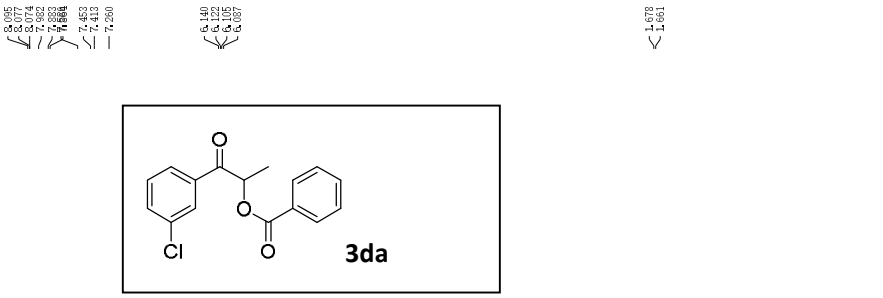


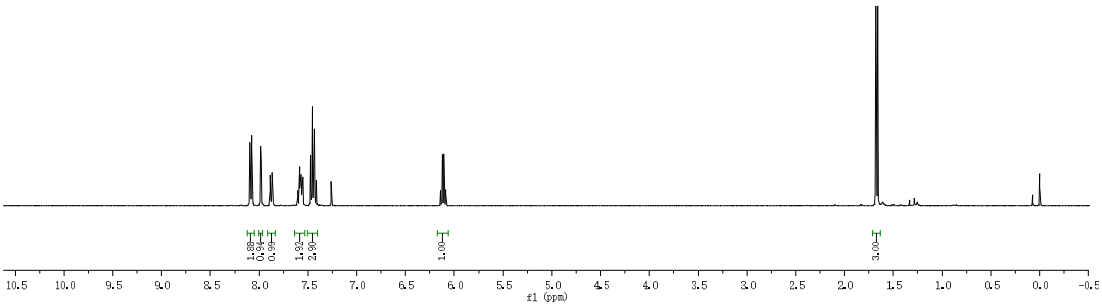

-102.888
-102.902
-102.910
-102.916
-102.924
-102.932
-102.938
-102.946
-102.961
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
f1 (ppm)

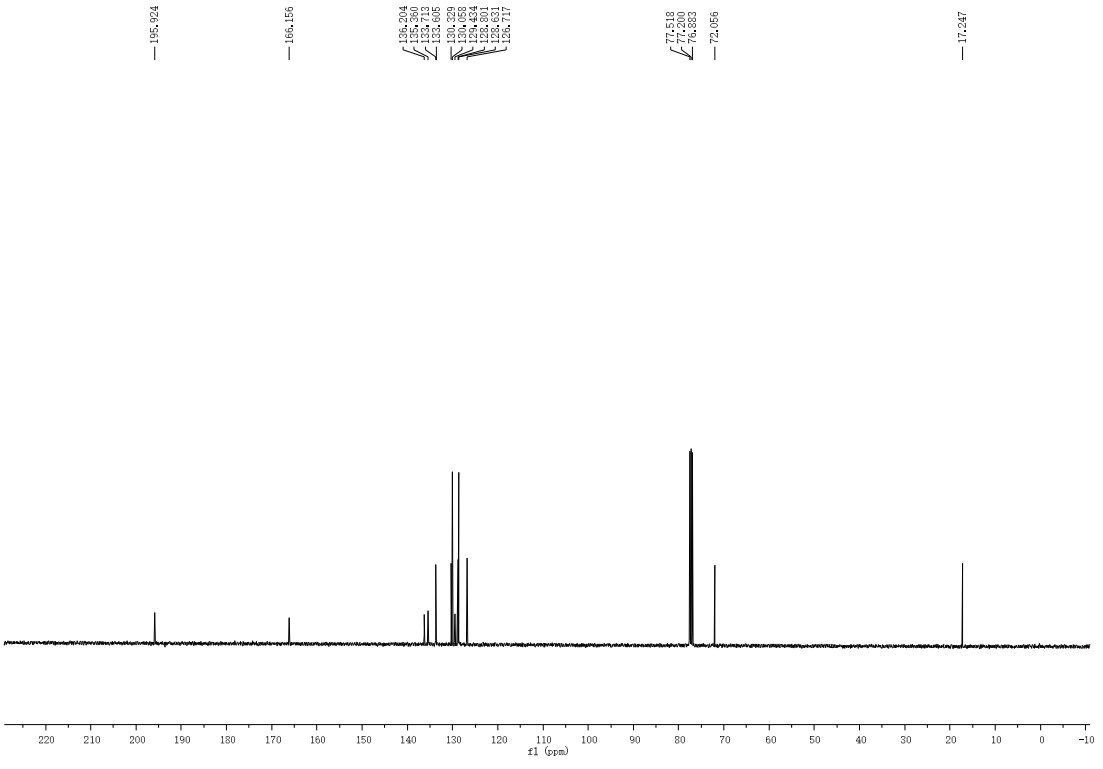

8.088
8.070
8.067
7.946
7.925
7.448
7.430
7.410
7.260
6.151
6.133
6.115
6.098
1.655
1.638
Cl
O
O
O
3ca

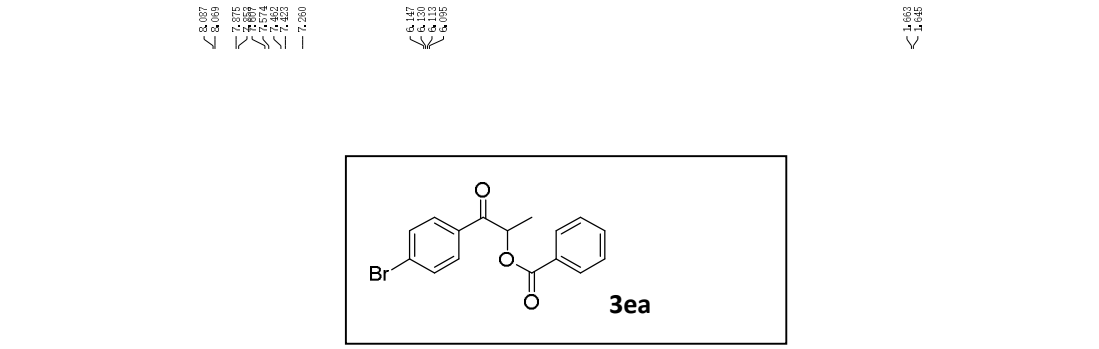

1.92
1.99
0.98
3.95
1.00
3.01
f1 (ppm)

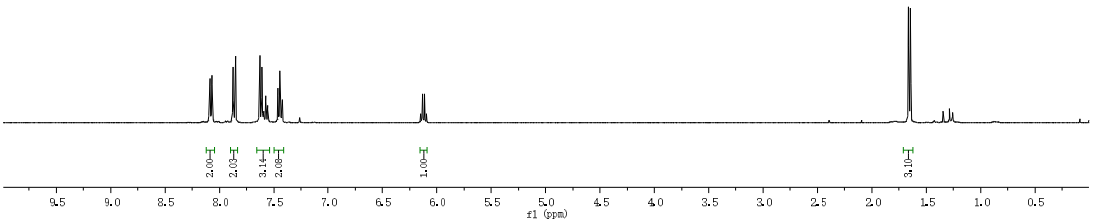

195.732
166.001
140.103
133.479
132.810
130.000
129.919
129.371
129.222
128.520
77.518
77.200
76.882
71.891
17.145
f1 (ppm)

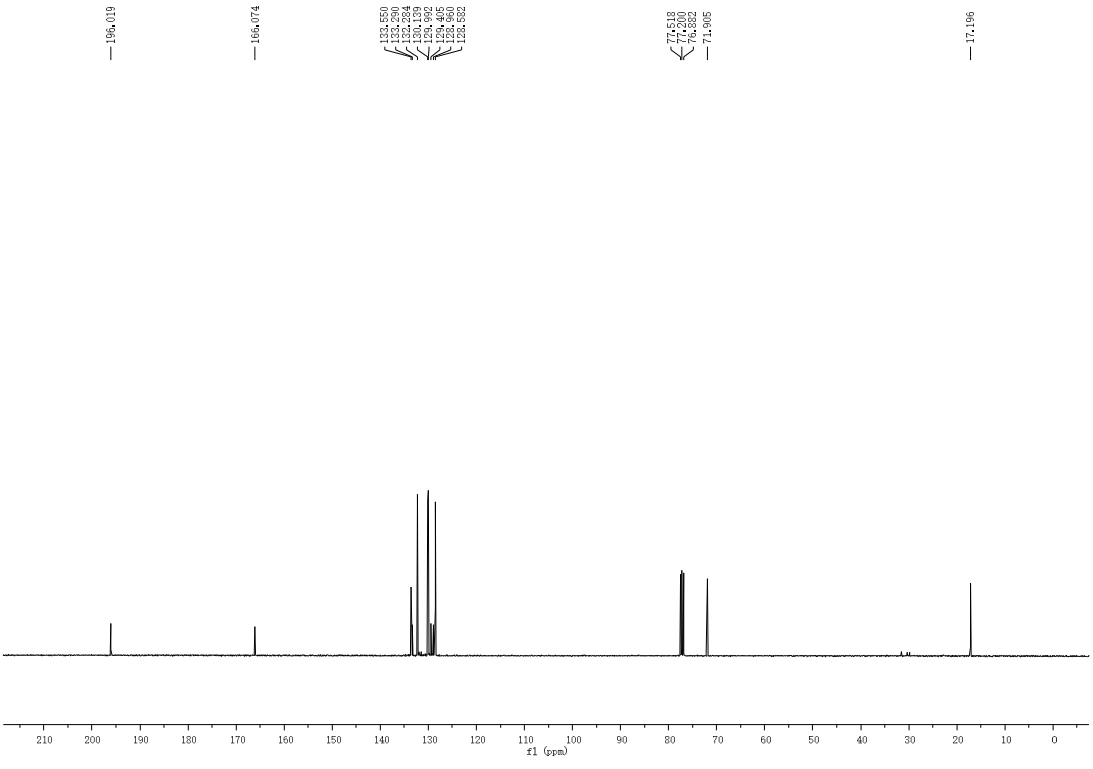

8.095
8.077
8.074
7.982
7.963
7.683
7.664
7.453
7.413
7.260
6.140
6.122
6.105
6.087
1.678
1.661
Cl
O
O
O
3da

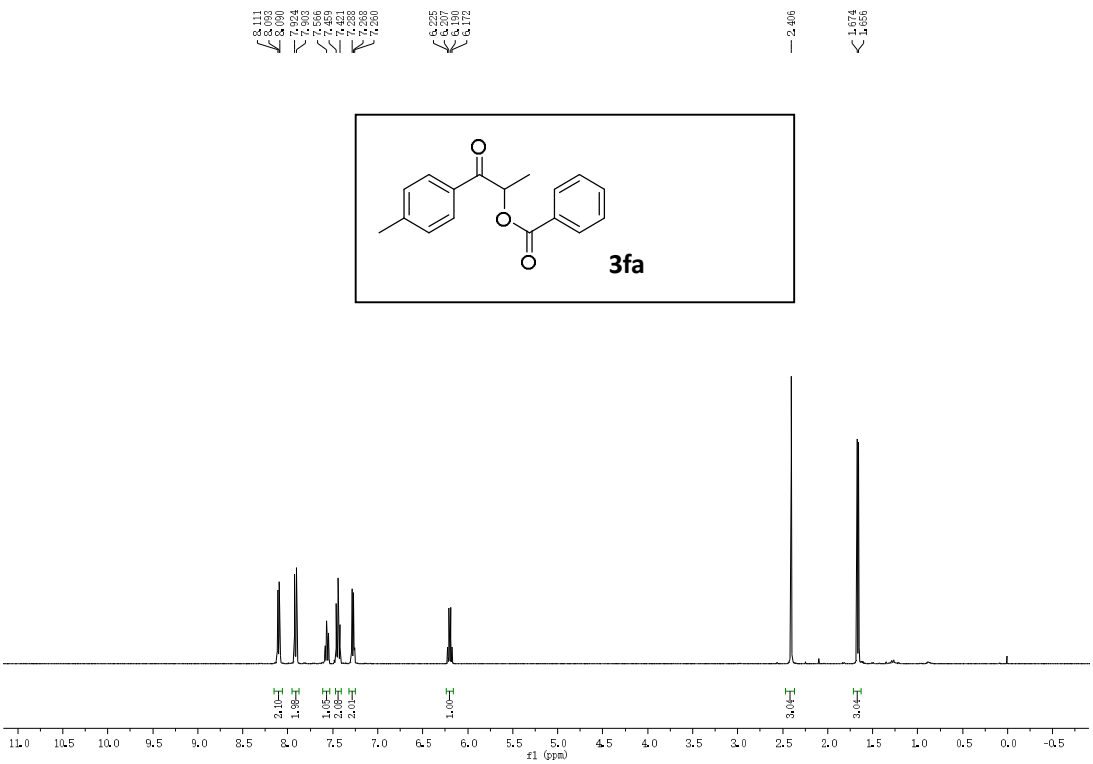

1.88
0.94
0.89
1.92
2.80
1.00
3.00
f1 (ppm)

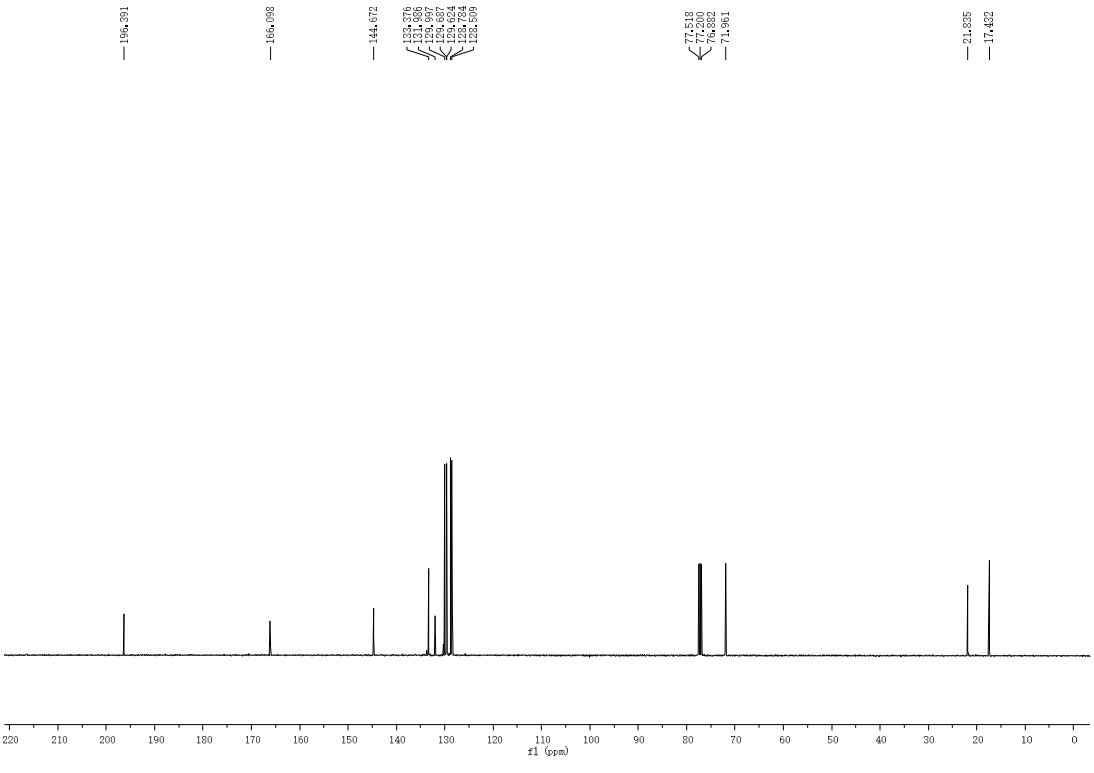

195.924
166.156
136.204
135.360
133.772
132.665
130.229
130.058
129.434
128.801
128.697
126.717
77.518
77.200
76.883
72.056
17.247
f1 (ppm)


8.087
8.069
7.875
7.859
7.574
7.423
7.260
6.147
6.130
6.113
6.095
1.663
1.645
Br
O
O
O
3ea


2.00
2.03
3.14
2.08
1.00
3.10
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
f1 (ppm)


196.019
166.074
133.550
132.590
132.284
130.139
129.992
129.465
128.960
128.582
77.518
77.200
76.882
71.905
17.196
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.111
8.093
8.090
7.924
7.903
7.566
7.459
7.451
7.288
7.268
7.260
6.225
6.207
6.190
6.172
2.406
1.674
1.656
3fa
2.10
1.98
1.05
2.09
2.01
1.00
3.04
3.04
f1 (ppm)


196.391
166.098
144.672
133.376
131.986
129.997
129.697
129.624
128.784
128.509
77.518
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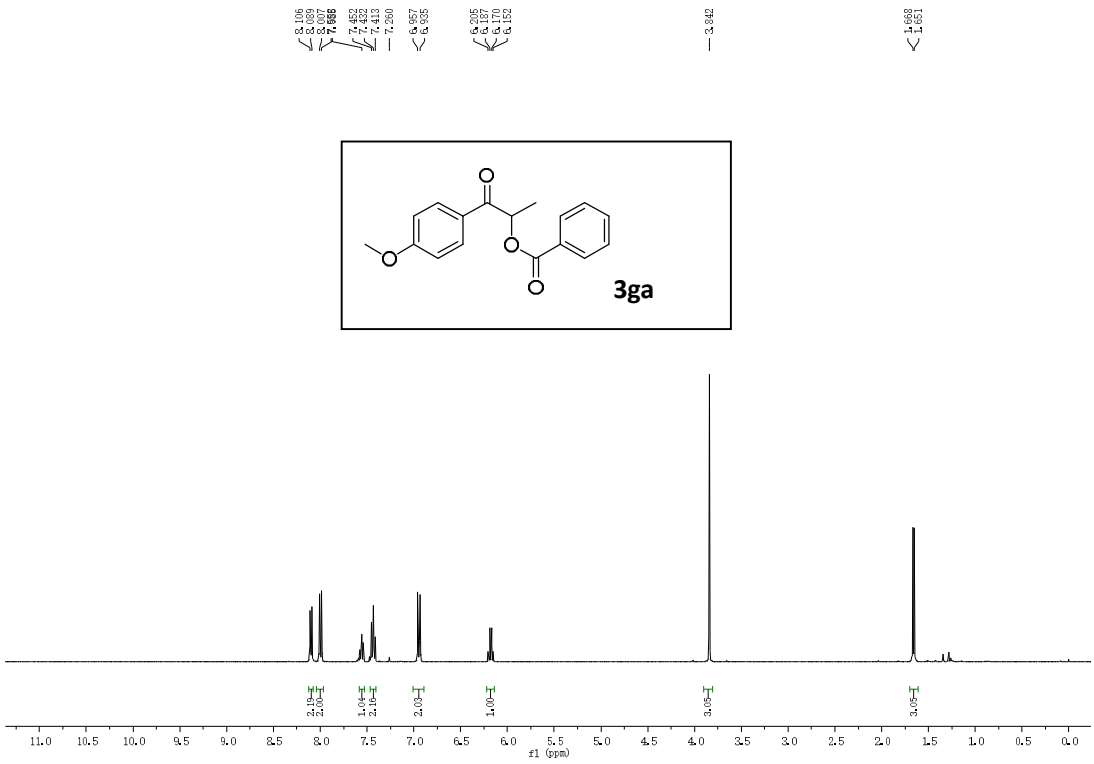
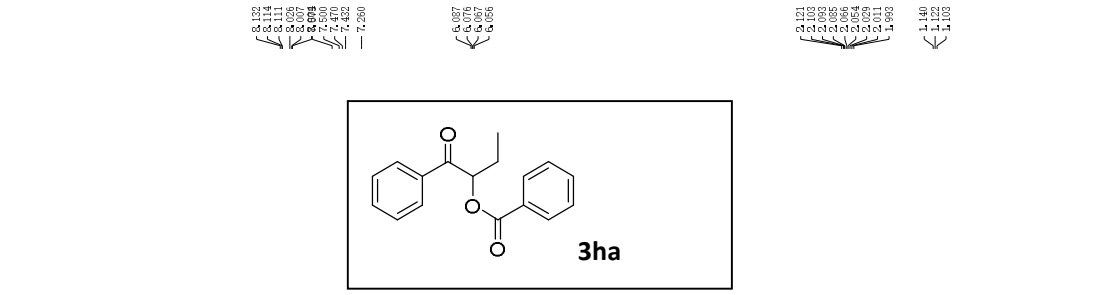
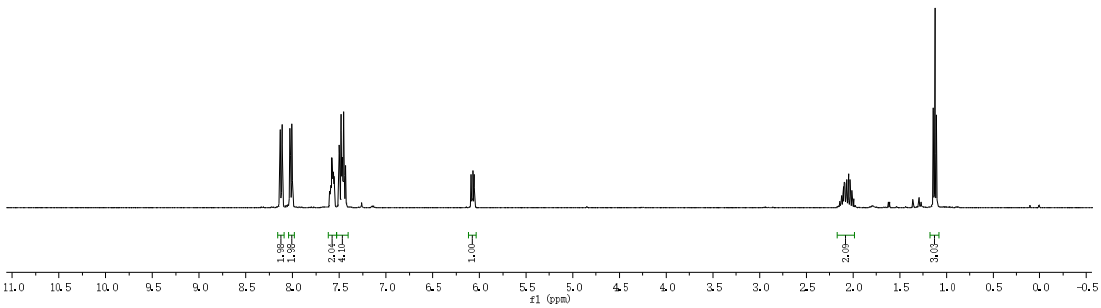
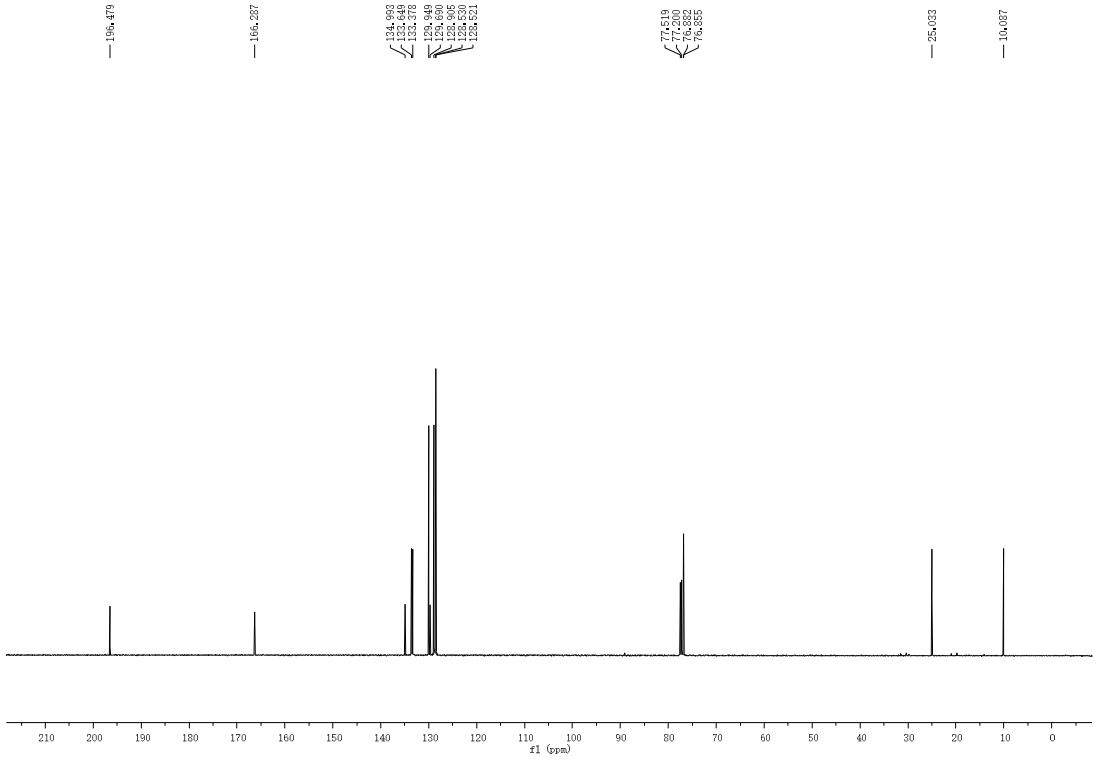
76.882
71.961
21.835
17.432
f1 (ppm)


8.106
8.089
8.007
7.452
7.432
7.413
7.260
6.957
6.935
6.205
6.187
6.170
6.152
3.842
1.668
1.651
3ga
2.19
2.00
1.04
2.16
2.03
1.00
3.05
3.05
f1 (ppm)
195.213
166.093
163.993
133.851
130.992
129.966
129.685
128.488
127.346
114.128
77.518
77.200
76.881
74.777
55.599
17.497
f1 (ppm)


8.132
8.114
8.111
8.028
8.026
8.007
8.004
7.500
7.470
7.432
7.260
6.087
6.076
6.067
6.056
2.121
2.103
2.098
2.085
2.066
2.054
2.029
2.011
1.998
1.140
1.122
1.103
3ha


1.98
1.98
2.04
4.11
1.00
2.09
3.03
f1 (ppm)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166.287
134.993
133.649
133.378
129.949
129.690
128.905
128.530
128.521
77.519
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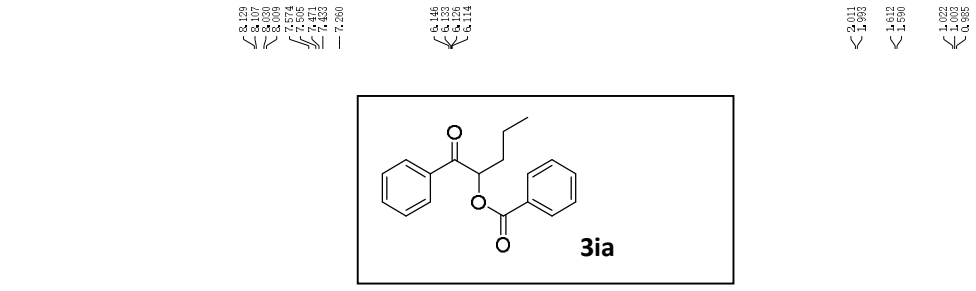
76.882
76.855
25.033
10.087
f1 (ppm)


8.129
8.107
8.100
8.009
7.574
7.505
7.471
7.453
7.260
6.146
6.133
6.126
6.114
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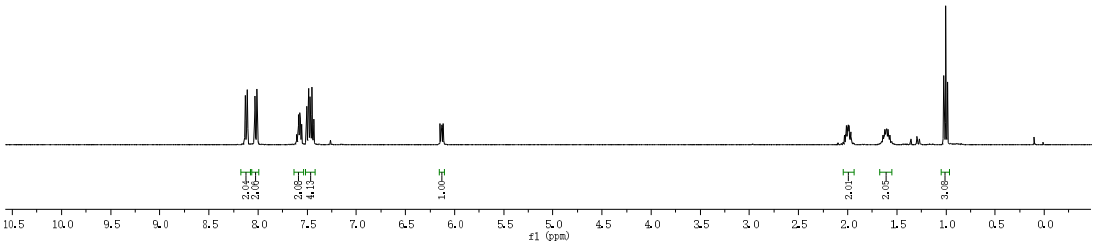
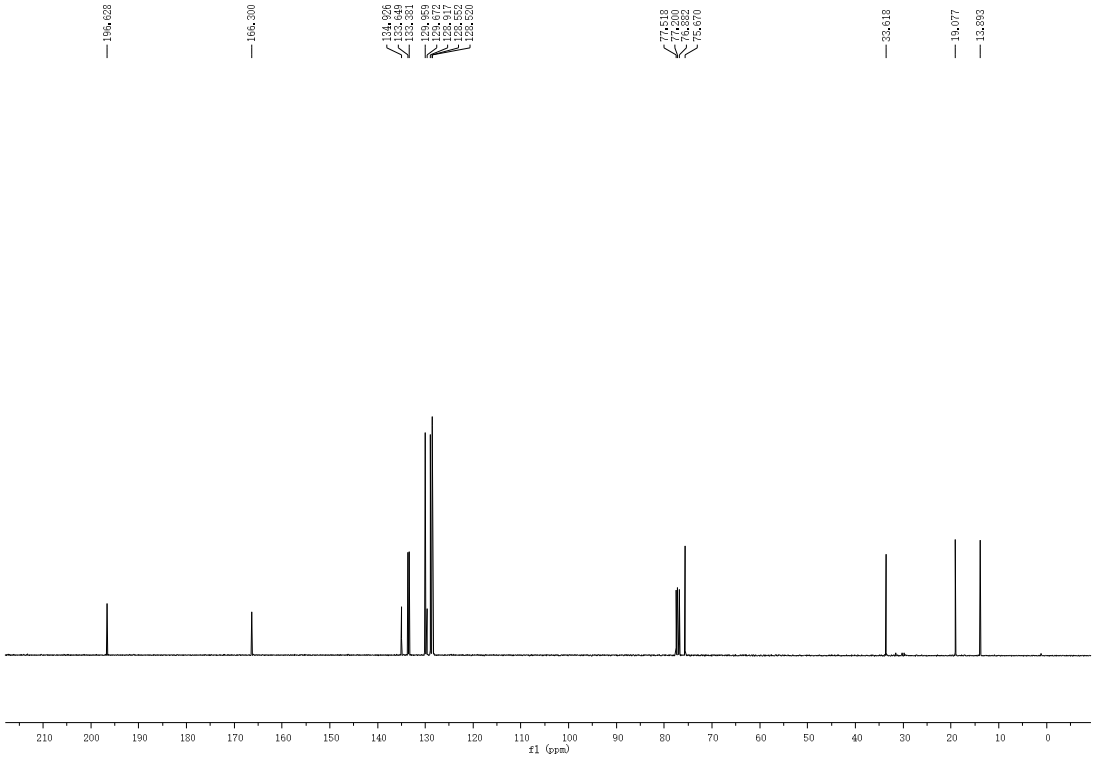
1.612
1.590
1.022
1.003
0.985
3ia


2.04
2.00
2.08
4.13
1.00
2.01
2.05
3.08
f1 (ppm)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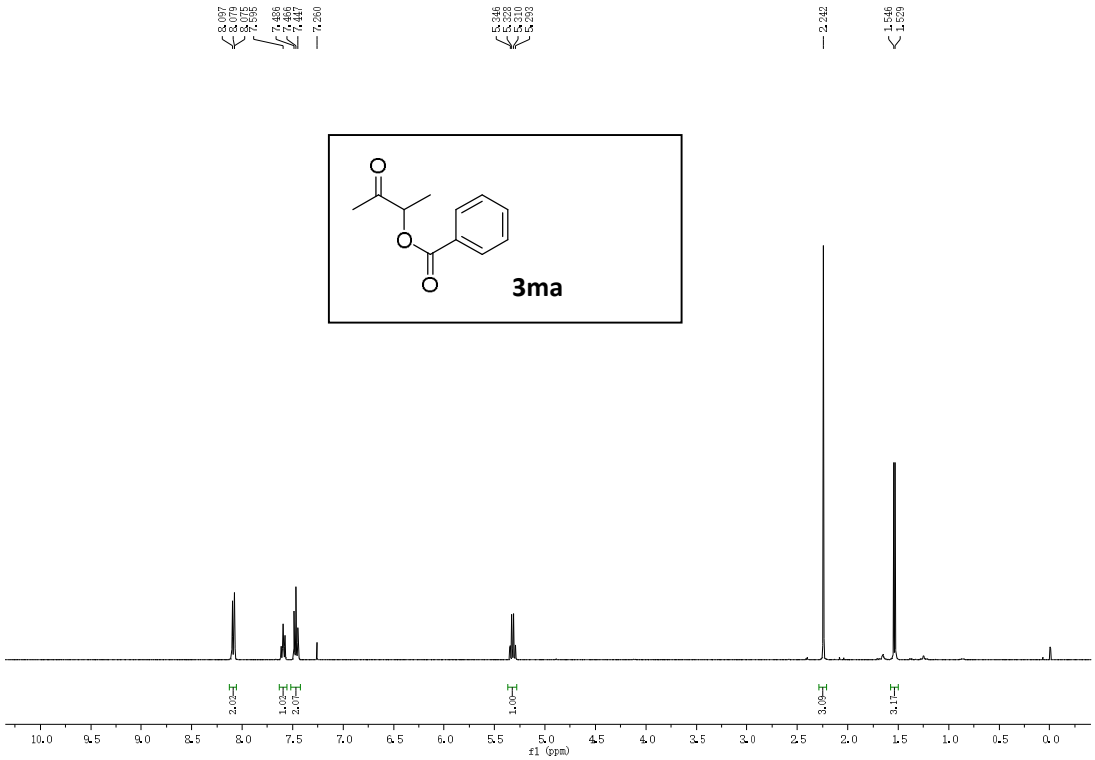
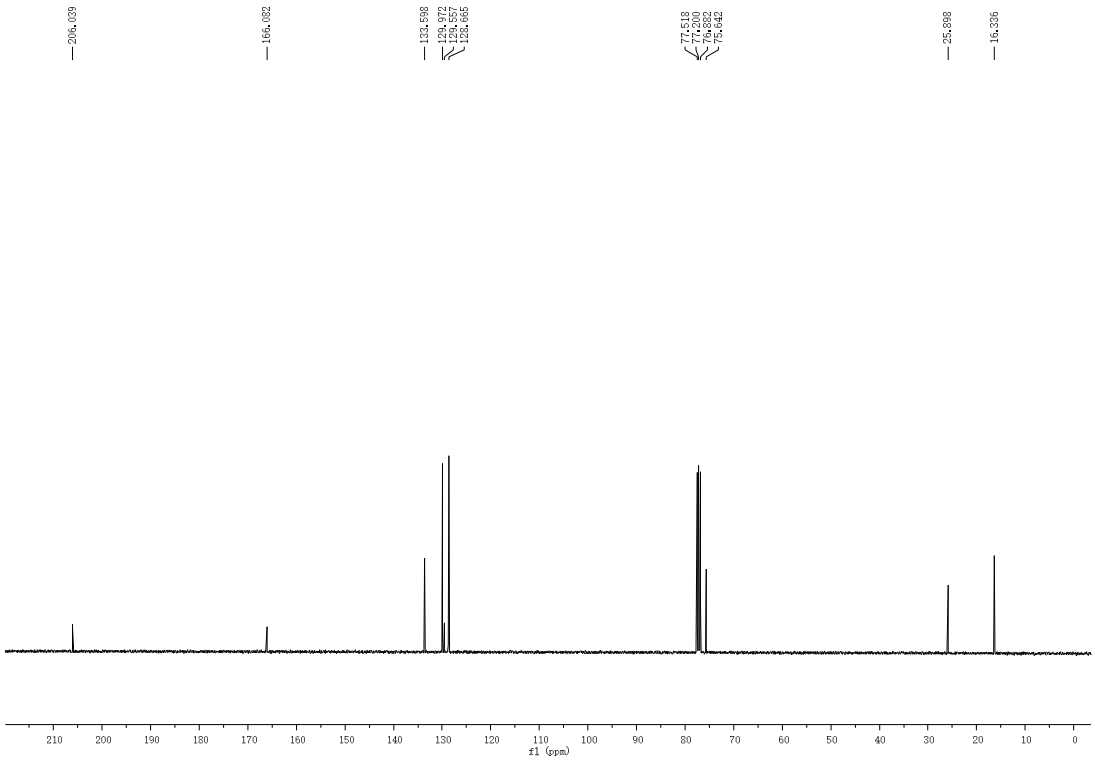
134.926
133.949
133.381
129.959
129.672
128.917
128.552
128.320
77.518
77.200
76.882
75.670
33.618
19.077
13.893
f1 (ppm)


8.097
8.079
8.075
7.595
7.486
7.466
7.447
7.260
5.346
5.328
5.310
5.293
2.242
1.546
1.529
3ma
2.02
1.03
2.07
1.00
3.09
3.17
f1 (ppm)


206.039
166.082
133.598
129.972
129.557
128.665
77.518
77.200
76.883
76.542
25.898
16.336
f1 (ppm)