Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Copper-Catalyzed Aerobic Oxidative Amidation of Tertiary Amines

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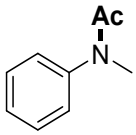
1. General Information

All manipulations were performed in air atmosphere. $Cu(OAc)_2$ was purchased from J&K Scientific Co. *N*,*N*-Dimethylaniline (**1a**) was purchased from Heowns Chemical, dried by distillation over CaH_2 and distilled prior to use. Anilines **1b**, **1f**, **1g**, **1h** and **1j** were purchased from Heowns Chemical, and used without further purification. Other tertiary amines were prepared according to reported procedures[1]. CH_3CN, DMA, DME, DMF, PhCl and DCE were dried by distillation over CaH_2. THF and toluene were dried by distillation over sodium/benzophenone. ^1H NMR and ^{13}C NMR were recorded on a Bruker AVANCE AV 400 (400 MHz for ^1H, 100 MHz for ^{13}C) instrument in $CDCl_3$ with tetramethylsilane as an internal standard. Data were reported as follows: chemical shift in ppm (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad signal), coupling constant (Hz), integration. TLC were performed on silica gel Huanghai HSGF254 plates and visualized by quenching of UV fluorescence (λ_{max}= 254 nm). Silica gel (200-300 mesh) was purchased from Qingdao Haiyang Chemical Co., China. Electron-impact-ionisation mass spectra (EI) were recorded with an Aligent 7890A/5975C GC–MS instrument. High resolution mass spectra (HRMS) were acquired on Varian 7.0T FTMS. FTIR spectra were obtained with a Bruker Tensor 27 instrument. All IR samples were prepared as thin films and reported in wave numbers (cm^{-1}).

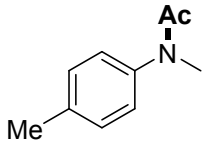
2. General Procedure for the Amides Synthesis

Typical procedure: A 25 mL Schlenk-type tube was equipped with a magnetic stir bar, and charged with $Cu(OAc)_2$ (4.6 mg, 0.05 mmol). The tube was sealed, and the atmosphere was changed to O_2 with an oxygen balloon. Tertiary amines **1a** (0.5 mmol), Ac_2O (2.5 mmol) and CH_3CN (1.0 mL) were added sequentially via syringes. The mixture was stirred at reflux for 36 h. The resulting solution was then cooled to room temperature, neutralized with a saturated solution of $NaHCO_3$, and extracted with EtOAc (3 × 25 mL). The combined organic layer was washed with brine, and dried over anhydrous Na_2SO_4. The volatiles were removed under vacuum, and the residue was purified by column chromatography to give the crude product **3a** in 90% yield (67 mg, white solid).

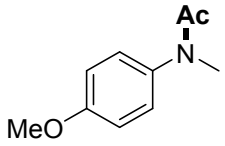
3. Characterization Data for Products 3



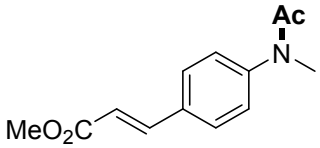
***N*-Methyl-*N*-phenylacetamide (3a)**: white solid (67 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.41 (t, *J* =7.4 Hz, 2H), 7.33 (t, *J* = 7.3 Hz, 1H), 7.18 (d, *J* = 7.4 Hz, 2H), 3.26 (s, 3H), 1.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.70, 144.72, 129.85, 127.83, 127.20, 37.28, 22.55. GC-MS: m/z = 149.



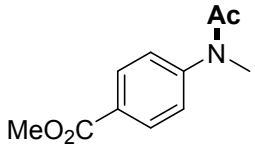
***N*-methyl-*N*-(p-tolyl)acetamide (3b)**: white solid (68 mg, 83%), ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.21 (d, *J* = 8.04 Hz, 2H), 7.07 (d, *J* = 8.16 Hz, 2H), 3.24 (s, 3H), 2.38 (s, 3H), 1.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.86, 142.16, 137.73, 130.41, 126.92, 37.31, 22.49, 21.18. GC-MS: m/z = 163.



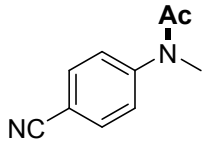
***N*-(4-methoxyphenyl)-*N*-methylacetamide (3c)**: white solid (80 mg, 89%), ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.10 (d, *J* = 8.08 Hz, 2H), 6.92 (d, *J* = 8.12 Hz, 2H), 3.83 (s, 3H), 3.23 (s, 3H), 1.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.01, 158.86, 137.52, 128.20, 114.87, 77.48, 77.16, 76.84, 55.55, 37.36, 22.41.GC-Ms: m/z = 179.



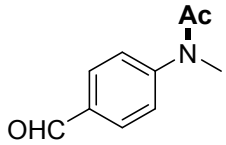
(E)-methyl 3-(4-(*N*-methylacetamido)phenyl)acrylate (3d): pale yellow solid (104 mg, 89%), ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm):7.67(d, *J* = 16.00 Hz, 2H), 7.56(d, *J* = 8.00 Hz, 2H), 7.21 (d, *J* = 8.00 Hz, 2H), 6.4(d, *J* = 16.00 Hz, 2H), 3.81(s, 3H), 3.26(s, 3H), 1.90(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.43, 167.26, 146.14, 133.83, 129.40, 127.59, 118.91, 51.95, 37.18, 22.61. IR (KBr, cm^{-1}): 1888, 1699, 1595, 1444, 1369, 935, 814, 736,695. GC-MS: m/z = 233.



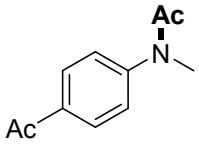
***N*-(4-Carbomethoxyphenyl)-*N*-methylacetamide (3e)**: white solid (85 mg, 82%); ^{1}H NMR (300 MHz, $CDCl_3$) : δ= 8.10 (d, *J* = 8.48 Hz, 2 H), 7.29 (d, *J* = 8.48 Hz, 2 H), 3.95 (s, 3 H), 3.31 (s, 3 H), 1.94 (br s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.30, 166.25, 148.52, 131.17, 129.13, 126.94, 52.43, 37.20, 22.59; IR (KBr, cm^{-1}): 1721, 1664, 1602,1509, 1275. GC-Ms: m/z = 207.



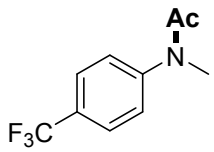
***N*-(4-Cyanophenyl)-*N*-methylacetamide (3f):** white solid (61 mg, 70%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.73 (d, *J* = 8.44 Hz, 2H), 7.34 (d, *J* = 8.44 Hz, 2H), 3.31 (s, 3H), 1.98(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.03, 148.45, 133.70, 127.68, 118.14, 37.37, 22.71. IR (KBr, cm^{-1}): 2228, 1657, 1601, 1508, 1380, 1359, 853. GC-Ms: m/z = 174.



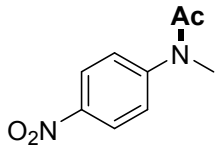
***N*-(4-Formylphenyl)-*N*-methylacetamide (3g)**: white solid (46 mg, 52%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 10.02 (s, 1H), 7.94 (d, *J* = 8.3 Hz, 2H), 7.38 (d, *J* = 8.2 Hz, 2H), 3.32 (s, 3H), 1.97(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 190.9, 170.0, 149.7, 135.0, 131.0, 127.4, 37.2, 22.6. IR (KBr, cm^{-1}): 2820, 2782, 1756, 1659, 1601, 1377, 1246, 1238, 971, 865. GC-Ms: m/z = 177.



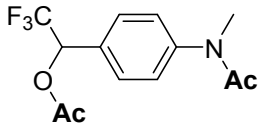
***N*-(4-acetylphenyl)-*N*-methylacetamide (3h)**: white solid (81 mg, 85%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.04(d, *J* = 8.44 Hz, 2H), 7.33(d, *J* = 8.44 Hz, 2H), 3.33(s, 3H), 2.65(s, 3H), 1.97(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 197.02, 170.25, 148.63, 129.92, 127.08, 119.23, 37.24, 26.76, 22.65. GC-MS : m/z = 191.



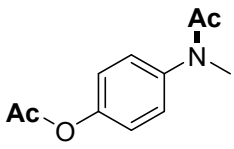
***N*-methyl-*N*-(4-(trifluoromethyl)phenyl)acetamide (3i)**: white solid (65 mg, 60%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.71(d, *J* = 8.24 Hz, 2H), 7.34(d, *J* = 8.24 Hz, 2H), 3.30(s, 3H), 1.93 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.10, 147.67, 129.82, 127.44, 126.87, 123.81(q, *J* = 273.70 Hz), 37.14, 22.49. ^{19}F NMR (400 MHz, $CDCl_3$) δ (ppm): -62.6 (s, 3F); IR (KBr, cm^{-1}): 1660, 1610, 1382, 1324, 1119, 1156, 1119, 1066, 859. GC-Ms: m/z = 217.



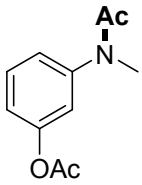
***N*-methyl-*N*-(4-nitrophenyl)acetamide (3j)**: yellow solid (49 mg, 50%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.30(d, *J* = 8.68 Hz, 2H), 7.40(d, *J* = 8.68 Hz, 2H), 3.35(s, 3H), 2.03(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.02, 154.36, 149.78, 127.49, 125.17, 37.52, 22.80. GC-MS : m/z = 194.



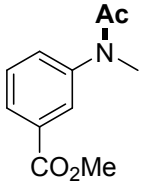
2,2,2-trifluoro-1-(4-(*N*-methylacetamido)phenyl)ethyl acetate (3k) : white solid (115 mg, 80%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.52 (d, *J* = 8.18 Hz, 2H), 7.25 (d, *J* = 8.18 Hz, 2H), 6.16 (q, *J* = 6.83 Hz, 1H), 3.27 (s, 3H), 2.22 (s, 3H), 1.90 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.39, 168.68, 145.99, 130.77, 129.55, 127.48, 123.04(q, *J* = 278.85 Hz), 71.35(q, *J* = 33.20 Hz), 37.15, 22.58, 20.66.IR (KBr, cm^{-1}): 1767, 1651, 1609, 1514, 1215, 1171, 1129, 1056, 866. GC-MS : m/z = 289. HRMS (ESI): Calcd. for $C_{13}H_{14}F_3NO_3$ $[M+Na]^+$: 312.0818; found: 312.0822.



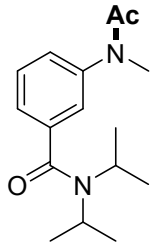
4-(*N*-methylacetamido)phenyl acetate (3l)： white solid (92 mg, 89%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.20 (d, *J* = 8.68Hz, 2H), 7.14 (d, *J* = 8.68 Hz, 2H), 3.25 (s, 3H), 2.32 (s, 3H), 1.88 (s,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.36, 168.95, 149.62, 141.82, 127.96, 122.74, 36.99, 22.23, 20.89; IR (KBr, cm^{-1}): 1760, 1658, 1638, 1509, 1378, 1198, 913, 861; GC-MS: m/z = 207.



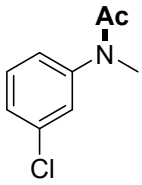
3-(*N*-methylacetamido)phenyl acetate (3m): white solid (99 mg, 96%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.41-7.44(m, 1H), 6.97-7.28(m, 3H), 3.27(s, 3H), 2.33(s, 3H), 1.91(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.60, 169.21, 151.54, 145.52, 130.48, 124.57, 121.16, 120.85, 37.22, 22.59, 21.23. GC-MS : m/z = 207.



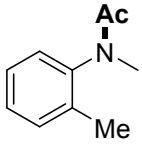
Methyl 3-(*N*-methylacetamido)benzoate (3n): white solid (88 mg, 85%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.03(d, *J* = 7.63 Hz, 1H), 8.02(s, 1H), 7.50-7.89(t, *J* = 7.78 Hz, 1H), 7.41(d, *J* = 7.72 Hz, 1H), 3.95(s, 3H), 3.29(s, 3H), 1.89(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.46, 166.16, 144.85, 132.03, 131.71, 130.01, 128.93, 128.31, 52.56, 37.25, 22.58. IR (KBr, cm^{-1}): 1726, 1670, 1415, 1381, 1314, 1248, 991, 758, 698. GC-MS : m/z = 207.



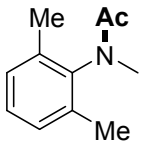
***N*,*N*-diisopropyl-3-(*N*-methylacetamido)benzamide (3o)**: white solid (110 mg, 80%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.45 (t, *J* = 7.72 Hz, 1H), 7.32-7.25 (m, 1H), 7.21 (d, *J* = 7.92 Hz, 1H), 7.17 (s, 1H), 3.79 (s, 1H), 3.55 (s, 1H), 3.27 (s, 3H), 1.90 (s, 3H), 1.54 (s, 6H), 1.16 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.48, 169.69, 144.81, 140.61, 130.14, 128.89, 127.45, 124.96, 124.53, 51.05, 46.03, 37.25, 22.53, 20.76. IR (KBr, cm^{-1}): 2967, 1672, 1630, 1453, 1378, 1343, 1213, 1041, 815, 716. GC-MS : m/z = 276.



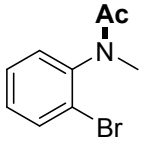
***N*-(3-chlorophenyl)-*N*-methylacetamide (3p)**: pale yellow solid (78 mg, 85%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.34-7.36(m, 2H), 7.22(s, 2H), 7.10(d, *J* = 7.92 Hz ，1H), 3.26(m, 3H), 1.90(m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.30, 145.78, 135.17, 130.77, 128.06, 127.55, 125.49, 37.18, 22.48. IR(KBr, cm^{-1}): 3051, 2930, 23591667, 1593, 1572, 1477, 1418, 1383, 1294, 1144, 1105, 1087, 974, 910, 797, 773, 707, 675, 411.GC-MS : m/z = 183.



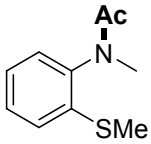
***N*-methyl-*N*-(o-tolyl)acetamide (3q)**: white solid (57 mg, 70%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.25-7.31(m, 3H), 7.11-7.13(m, 1H), 3.19(s, 3H), 2.24(s, 3H), 1.78(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.89, 143.16, 135.42, 131.55, 128.46, 127.94, 127.59, 35.95, 22.02, 17.39. IR (KBr, cm^{-1}): 1654, 1493, 1377, 1142, 1038, 776, 730. GC-MS : m/z = 163.



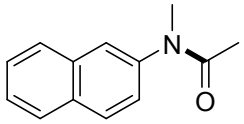
***N*-(2,6-dimethylphenyl)-*N*-methylacetamide (3r)**: white solid (74 mg, 84%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.11-7.29(m, 3H) 3.14(m, 3H), 2.22(m, 6H), 1.74(m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.90, 141.76, 135.62, 128.99, 128.17, 34.26, 21.31, 17.64. GC-MS : m/z = 177.



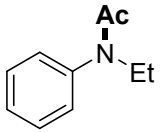
***N*-(2-bromophenyl)-*N*-methylacetamide (3s)**: white solid (102 mg, 90%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.69(d, *J* = 7.9 Hz, 1H), 7.40(t, *J* = 7.43 Hz, 1H), 7.24-7.31(m, 2H), 3.20(s,3H), 1.81(s,3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.54, 143.27, 134.00, 129.88, 129.76, 129.15, 123.45, 35.80, 22.23. IR (KBr, cm^{-1}): 1662, 1485, 1374, 1304, 1142, 1086, 1018, 841, 736, 723. GC-MS : m/z = 227.



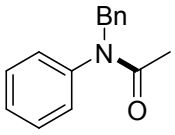
***N*-methyl-*N*-(2-(methylthio)phenyl)acetamide (3t)**: yellow solid (84 mg, 86%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.36(t, *J* = 7.42 Hz, 1H), 7.16-7.22 (m, 2H), 7.12-7.14(m, 1H), 3.18(s, 3H), 2.45(s, 3H), 1.81(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.07, 140.89, 138.59, 129.02, 128.25, 125.54, 124.91, 35.18, 21.92, 14.15. IR (KBr, cm^{-1}): 1659, 1470, 1421, 1375, 1300, 1142, 1060, 970, 778, 741. GC-MS : m/z = 195.



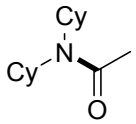
***N*-methyl-*N*-(naphthalen-2-yl)acetamide (4a)**: white solid (95 mg, 95%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.83-7.91(m, 3H), 7.66(s, 1H), 7.53-7.55(m,2H), 7.30(d, *J* = 8.54 Hz, 1H), 3.35(m,3H), 1.92(m,3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.79, 141.98, 133.71, 132.39, 129.96, 127.90, 127.86, 126.99, 126.76, 125.57, 125.20, 37.35, 22.66. GC-MS : m/z = 199.



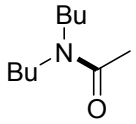
***N*-ethyl-*N*-phenylacetamide (4b)**: white solid (77 mg, 94%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.40 (t, *J* =7.52 Hz, 2H), 7.32 (t, *J* = 7.31 Hz, 1H), 7.13 (d, *J* = 7.31 Hz, 2H), 3.72 (q, *J* = 7.22 Hz, 2H), 1.79 (s, 3H), 1.08 (t, *J* = 7.22 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 169.9, 142.8, 129.6, 128.1, 127.8, 43.7, 22.8, 13.0. IR (KBr, cm^{-1}): 2983, 2938, 1654, 1597, 1496, 1401, 1298, 769, 711.GC-Ms: m/z = 163.



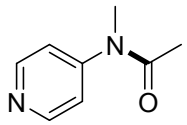
***N*-benzyl-*N*-phenylacetamide (4c)**: white solid (90 mg, 80%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.20-7.31(m, 8H), 6.98-6.99(m, 2H), 4.89(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.68, 144.59, 133.09, 130.03, 129.75, 128.35, 127.74, 127.09, 126.75, 37.20, 22.42. GC-MS: m/z = 225.



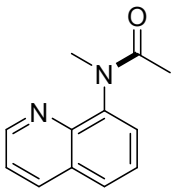
***N*,*N*-Dicyclohexylacetamid (4d)**: white solid (83 mg, 74%); ^{1}H NMR (400 MHz, DMSO) δ (ppm): 2.29(s, 2H), 1.97(s,3H), 1.76-1.03(m, 20H). ^{13}C NMR (100 MHz, DMSO) δ (ppm): 168.65, 57.91, 54.41, 30.70, 29.83, 25.95, 25.46, 25.16, 24.75, 23.74. GC-MS: m/z = 223.



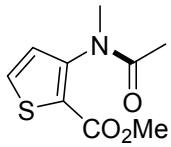
***N*,*N*-dibutylacetamide (4e)** : colorless liquid (79 mg, 92%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 3.30(t, *J* = 7.58 Hz, 2H), 3.21(t, *J* = 7.58 Hz, 2H), 2.07(s, 3H), 1.46-1.58(m, 4H), 1.26-1.38(m, 4H), 0.94(m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.16, 48.68, 45.58, 31.14, 29.98, 21.58, 20.33, 20.16, 13.96, 13.88. GC-MS: m/z = 171.



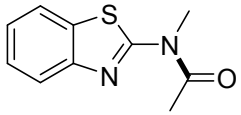
***N*-methyl-*N*-(pyridin-4-yl)acetamide (4f)**: white solid (39 mg, 51%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.61(d, *J* = 5.86 Hz, 2H), 7.16(d, *J* = 5.86 Hz, 2H), 3.29(s, 3H), 2.04(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.09, 151.70, 151.03, 120.95, 36.87, 22.80. GC-MS : m/z = 150.



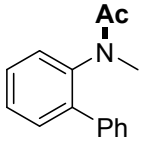
***N*-methyl-*N*-(quinolin-8-yl)acetamide (4g)**: white solid (65 mg, 65%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.99(d, *J* = 2.78 Hz, 1H), 8.24(dd, *J* = 1.27 Hz, 8.23Hz, 1H), 7.85(d, *J* = 7.84 Hz, 1H), 7.56-7.64(m, 2H), 7.48(q, *J* = 4.14 Hz, 1H), 3.40(s, 3H), 1.76(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.58, 151.16, 144.36, 142.09, 136.34, 129.61, 128.54, 128.39, 126.60, 121.99, 37.39, 22.33. IR (KBr, cm^{-1}): 1653, 1495, 1390, 1285, 1035, 970, 838, 801. GC-MS : m/z = 200. HRMS (ESI): Calcd. for $C_{12}H_{12}N_2O$ $[M+H]^+$: 201.1022; found: 201.1024.



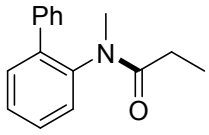
Methyl 3-(*N*-methylacetamido)thiophene-2-carboxylate (4h): white solid (68 mg, 64%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.56(d, *J* = 5.20 Hz, 1H), 6.98(d, *J* = 5.20 Hz, 1H), 3.88(s, 3H), 3.20(s, 3H), 1.85(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.41, 161.09, 147.00, 131.16, 128.30, 126.45, 52.51, 36.21, 21.96. IR (KBr, cm^{-1}): 1704, 1659, 1531, 1437, 1410, 1267, 794, 694. GC-MS : m/z = 213.



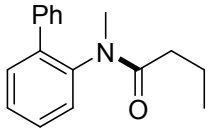
***N*-(benzo[d]thiazol-2-yl)-*N*-methylacetamide (4i)** : white solid (61 mg, 59%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.82(t, *J* = 9.61 Hz, 2H), 7.44(t, *J* = 8.00 Hz, 1H), 7.31(t, *J* = 7.48 Hz, 1H), 3.83, 2.48, 2.47. ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.90, 148.14, 133.50, 126.03, 123.95, 121.39, 121.20, 36.02, 23.71. IR (KBr, cm^{-1}):1674, 1499, 1375, 1277, 1001, 765, 693. GC-MS : m/z = 206. HRMS (ESI): Calcd. for $C_{10}H_{10}N_2OS$ $[M+H]^+$: 207.0587; found: 207.0589.



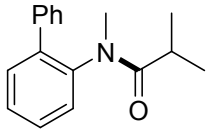
***N*-([1,1'-biphenyl]-2-yl)-*N*-methylacetamide (5a)**: white solid (107 mg, 95%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.36-7.44(m, 6H), 7.23-7.30(m, 3H), 3.00(s, 3H), 1.82(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.76, 141.99, 139.73, 138.75, 131.56, 128.91, 128.84, 128.56, 128.51, 128.43, 127.86, 37.07, 22.49. IR (KBr, cm^{-1}): 1663, 1479, 1431, 1372, 1077, 1074, 973, 781, 740, 701. GC-MS : m/z = 225.



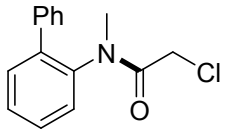
***N*-([1,1'-biphenyl]-2-yl)-*N*-methylpropionamide (5b)** : white solid (97 mg, 81%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.29-7.43(m, 6H), 7.22-7.29(m, 3H), 3.02(s, 3H), 2.07-2.17(m, 1H), 1.89-1.98(m, 1H), 0.96(t, *J* = 7.43 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 173.94, 141.64, 139.80, 138.72, 131.48, 128.84, 128.74, 128.59, 128.42, 128.39, 127.76, 37.15, 27.46, 9.60. IR (KBr, cm^{-1}): 1651, 1502, 1482, 1388, 1286, 1244, 1052, 776, 745, 698. GC-MS : m/z = 239.



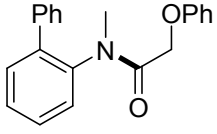
***N*-([1,1'-biphenyl]-2-yl)-*N*-methylbutyramide (5c)**: white solid (94 mg, 74%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.35-7.44(m, 6H), 7.21-7.29(m, 3H), 3.02(s, 3H), 2.04-2.10(m, 1H), 1.83-1.91(m, 1H), 1.40-1.63(m, 2H), 0.77(t, *J* = 7.33 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 173.13, 141.69, 139.80, 138.76, 131.48, 128.84, 128.74, 128.68, 128.47, 128.39, 127.78, 37.16, 36.07, 18.74, 13.95. IR (KBr, cm^{-1}): 2965, 2875, 1644, 1503, 1483, 1388, 1325, 1243, 1137, 1057, 808, 786, 748, 698. GC-MS : m/z = 253.



***N*-([1,1'-biphenyl]-2-yl)-*N*-methylisobutyramide (5d)**: white solid (58 mg, 46%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.34-7.44(m, 6H), 7.27-7.30(m, 3H), 3.11(s, 3H), 2.35-2.42(m, 1H), 0.96(d, *J* = 7.23 Hz, 3H), 0.67(d, *J* = 6.10 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 177.46, 141.76, 140.02, 138.67, 131.37, 128.89, 128.72, 128.67, 128.34, 128.31, 127.77, 37.72, 31.43, 20.33, 18.81. IR (KBr, cm^{-1}):1647, 1483, 1427, 1387, 789, 752, 705. GC-MS：m/z = 253.

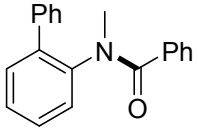


***N*-([1,1'-biphenyl]-2-yl)-2-chloro-*N*-methylacetamide (5e)**: white solid (83 mg, 64%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.37-7.46 (m, 6H), 7.29 (m, 3H), 3.88 (d, *J* = 12.37 Hz, 1H), 3.70 (d, *J* = 12.37 Hz, 1H), 3.09 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 166.35, 140.15, 139.77, 138.09, 131.86, 131.81, 129.25, 129.04, 128.58, 128.42, 128.19, 41.76, 38.03. IR (KBr, cm^{-1}): 1669, 1484, 1421, 1381, 1268, 1241, 782, 746, 701. GC-MS: m/z = 259.

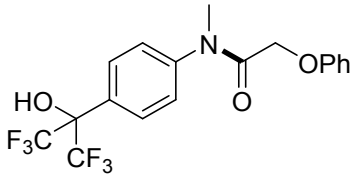


***N*-(biphenyl-2-yl)-*N*-methyl-2-phenoxyacetamide (5f)**: white solid (98 mg, 62%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.50-7.40 (m, 6H), 7.39-7.34 (m, 2H), 7.30 (s, 1H), 7.13 (t, *J* = 8.00 Hz, 2H), 6.88 (t, *J* = 7.32 Hz, 1H), 6.49 (d, *J*=7.20 Hz, 2H), 4.33 (d, *J* = 14.77 Hz, 1H), 4.18 (d, *J* = 14.77 Hz, 1H), 3.20 (s, 3H). ^{13}C NMR (100 MHz,

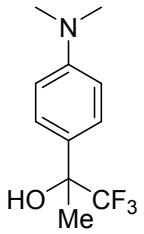
$CDCl_3$) δ (ppm): 167.70, 158.18, 139.89, 139.85, 138.46, 131.79, 129.39, 129.27, 129.14, 129.11, 128.65, 128.23, 128.15, 121.27, 114.69, 66.67, 38.06. IR (KBr, cm^{-1}): 3071, 2935, 1679, 1596, 1482, 1433, 1219, 1086, 778, 740, 702. GC-MS: m/z = 317. HRMS (ESI): Calcd. for $C_{21}H_{19}NO_2$ $[M+H]^+$: 318.1489; found: 318.1491.



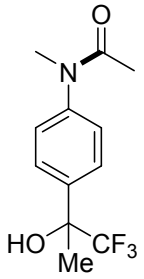
***N*-([1,1'-biphenyl]-2-yl)-*N*-methylbenzamide (5g)** : white solid (120 mg, 84%); ^1H NMR (400 MHz, DMSO) δ (ppm): 7.53(d, *J* = 7.76 Hz, 1H), 7.39-7.48(m, 2H), 7.29-7.34(m, 3H), 7.17-7.21(d, *J* = 7.52 Hz, 3H), 6.99-7.03(d, *J* = 7.57 Hz, 3H), 6.91-6.92(m, 2H), 6.70-6.72(d, *J* = 7.45Hz, 2H), 3.34(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 168.63, 141.87, 138.62, 138.30, 135.55, 130.79, 129.26, 128.69, 128.66, 128.38, 128.31, 128.00, 127.83, 127.28, 127.00, 38.60. IR (KBr, cm^{-1}): 1637, 1479, 1367, 1299, 1095, 776, 753, 693. GC-MS : m/z = 287. HRMS (ESI): Calcd. for $C_{20}H_{17}NO$ $[M+H]^+$: 288.1383; found: 288.1385.



***N*-(4-(1,1,1,3,3,3-hexafluoro-2-hydroxypropan-2-yl)phenyl)-*N*-methyl-2-phenoxyacetamide (5h)**: white solid (146 mg, 72%); ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.79(d, *J* = 8.38 Hz, 2H), 7.30(d, *J* = 8.67Hz, 2H), 7.21(t, *J* = 7.78 Hz, 2H), 6.94(t, *J* = 7.30 Hz, 1H), 6.70(s, 2H), 4.48(s, 2H), 4.14(s, 1H), 3.34(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 168.32, 157.81, 144.12, 130.15, 129.55, 129.42, 128.68, 126.81, 122.75(q, *J* = 285.79 Hz), 116.06, 114.72, 66.74, 37.84. ^{19}F NMR (376 MHz, $CDCl_3$) δ = -75.43. IR (KBr, cm^{-1}): 3227, 1663, 1605, 1511, 1254, 1171, 954, 934, 778, 750, 710, 688. GC-MS: m/z = 407. HRMS (ESI): Calcd. for $C_{18}H_{15}F_6NO_3$ $[M+H]^+$: 408.1029; found: 408.1034.



2-(4-(dimethylamino)phenyl)-1,1,1-trifluoropropan-2-ol (6): white solid (565 mg, 97%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.42(d, *J* = 8.32 Hz, 1H), 6.72(d, *J* = 8.32 Hz, 1H), 2.97(s, 6H), 2.31(br s, 1H), 1.75(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 150.59, 127.04, 126.07, 125.96(q, *J* = 283.53 Hz, 1H), 112.06, 74.63(q, *J* = 28.90Hz), 40.48, 23.63. IR (KBr, cm^{-1}): 3243, 1613, 1518, 1254, 1151, 1065, 935, 817. GC-MS: m/z = 233. HRMS (ESI): Calcd. for $C_{11}H_{14}F_3NO$ $[M+H]^+$: 234.1100; found: 234.1103.

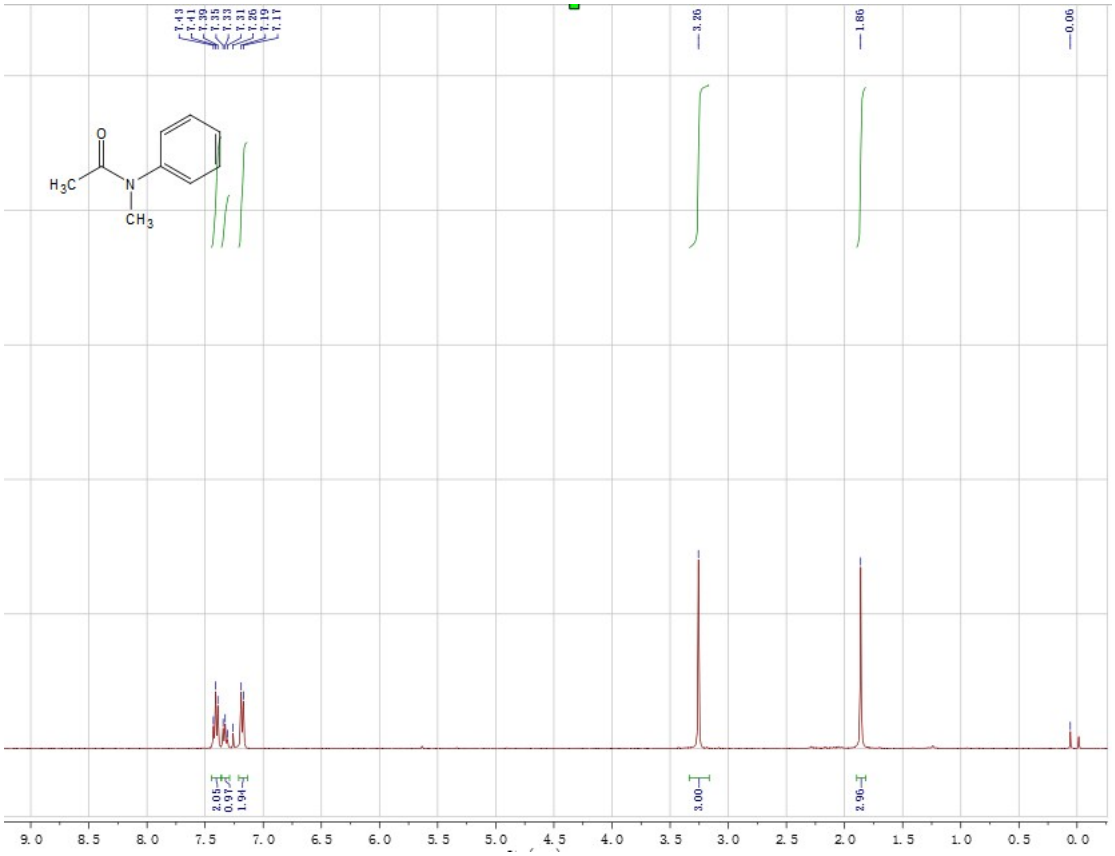


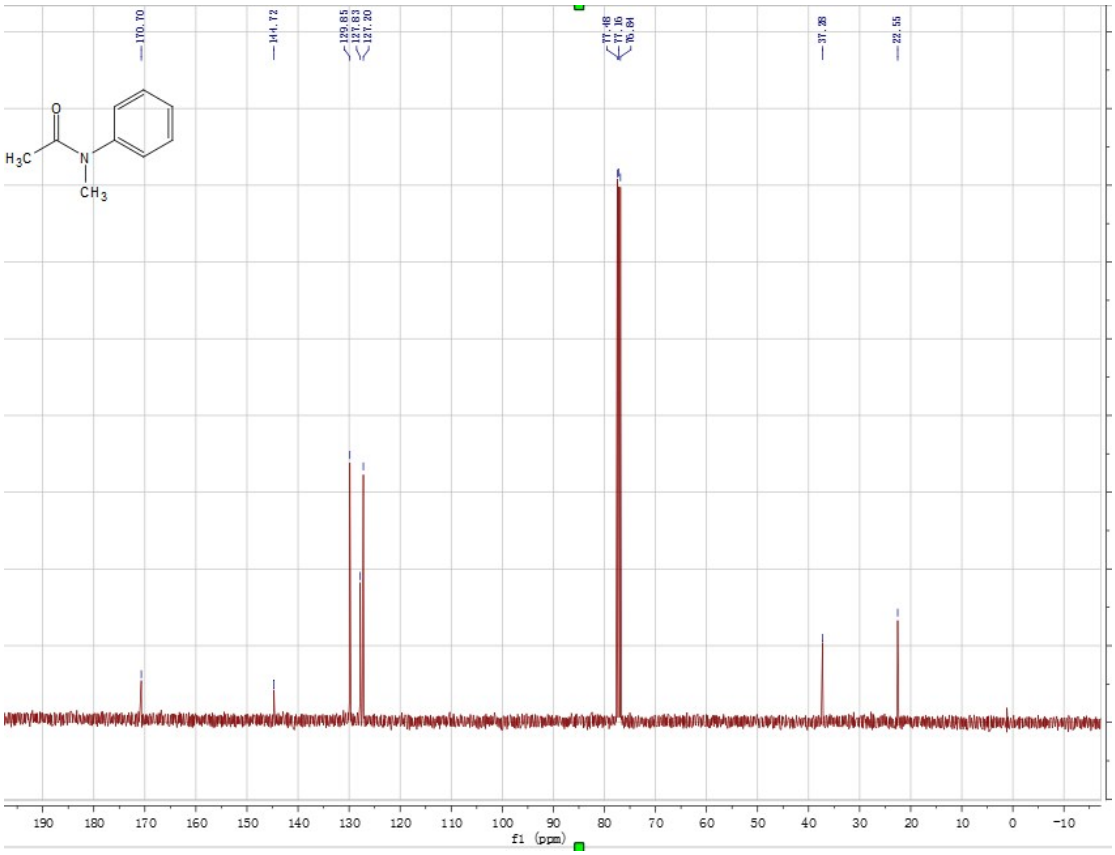
(***N*-methyl-*N*-(4-(1,1,1-trifluoro-2-hydroxypropan-2-yl)phenyl)acetamide (7)**: white solid (97 mg, 74%); ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.65(d, *J* = 8.01 Hz, 1H), 7.23(d, *J* = 8.01 Hz, 1H), 3.27(s, 3H), 2.80(br s, 1H), 1.89(s, 3H), 1.82(s, 3H). ^{13}C NMR (100 MHz, DMSO) δ (ppm): 169.01, 144.20, 138.82, 127.76, 126.58, 124.56(q, *J* = 284.45 Hz), 73.15(q, *J* = 28.07 Hz), 36.48, 22.83, 22.29. IR (KBr, cm^{-1}): 3346, 1646, 1511, 1379, 1292, 1152, 1061, 839. GC-MS: m/z = 261. HRMS (ESI): Calcd. for $C_{12}H_{14}F_3NO_2$ $[M+H]^+$: 262.1049; found: 262.1054.

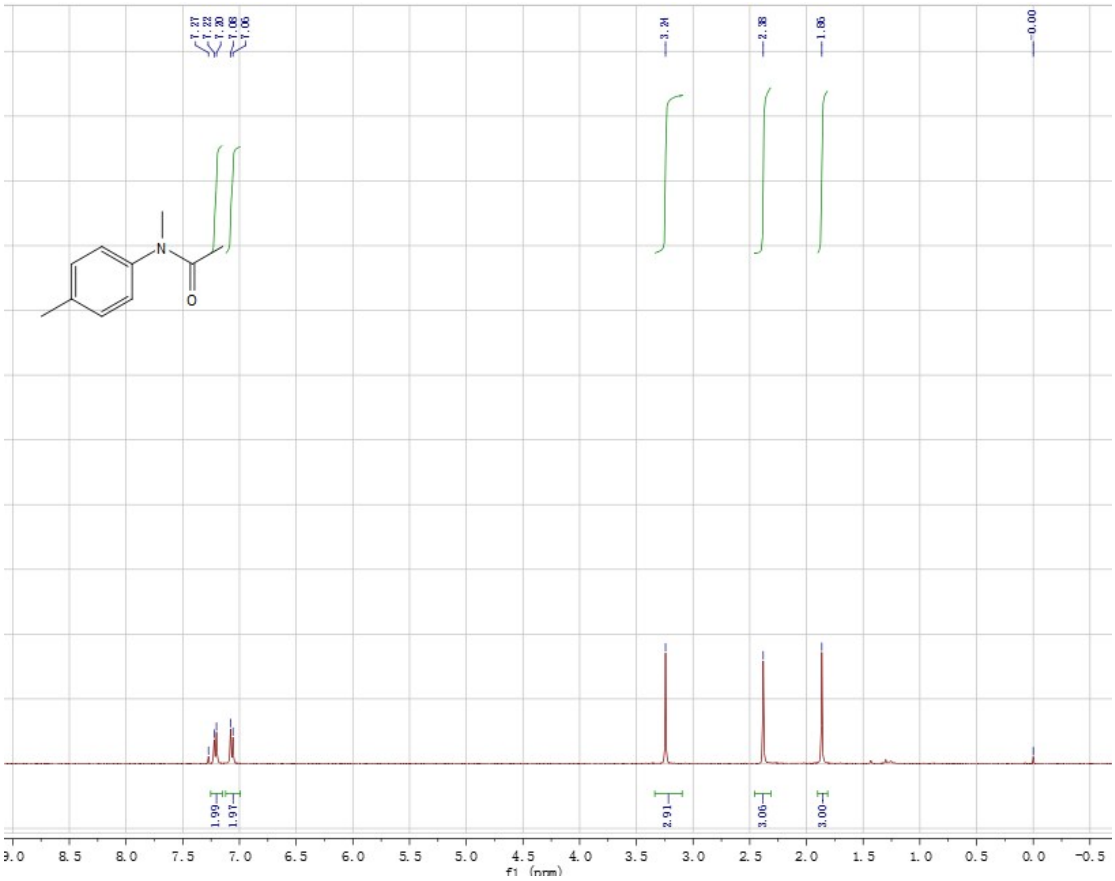
4. References

1. K. Kinashi, K.-P. Lee, S. Matsumoto, K. Ishida, Y. Ueda, Dyes and Pigments 2012, **92**, 783-788.

5. ^{1}H NMR and ^{13}C NMR Spectra of Products 3



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7.22
7.20
7.08
7.06
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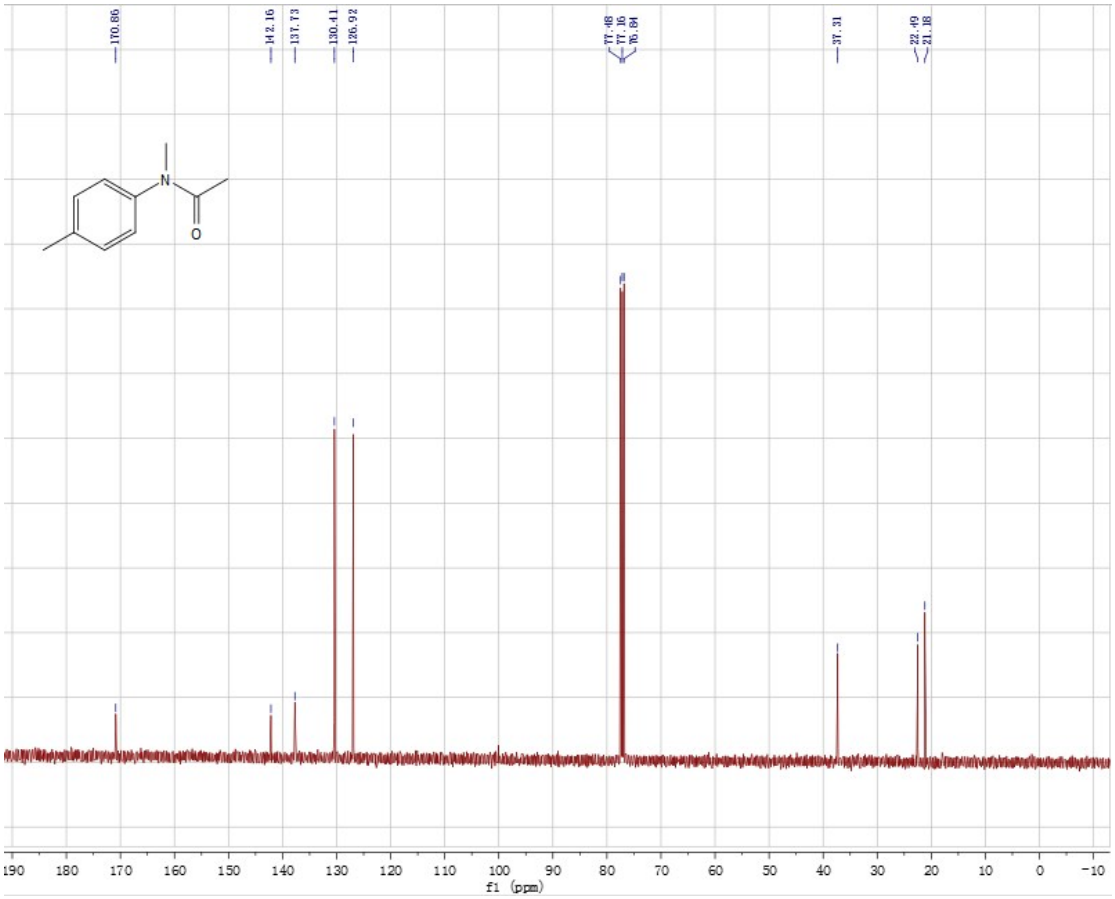
2.38
1.86
0.00
1.99
1.97
2.91
3.06
3.00
f1 (ppm)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77.16
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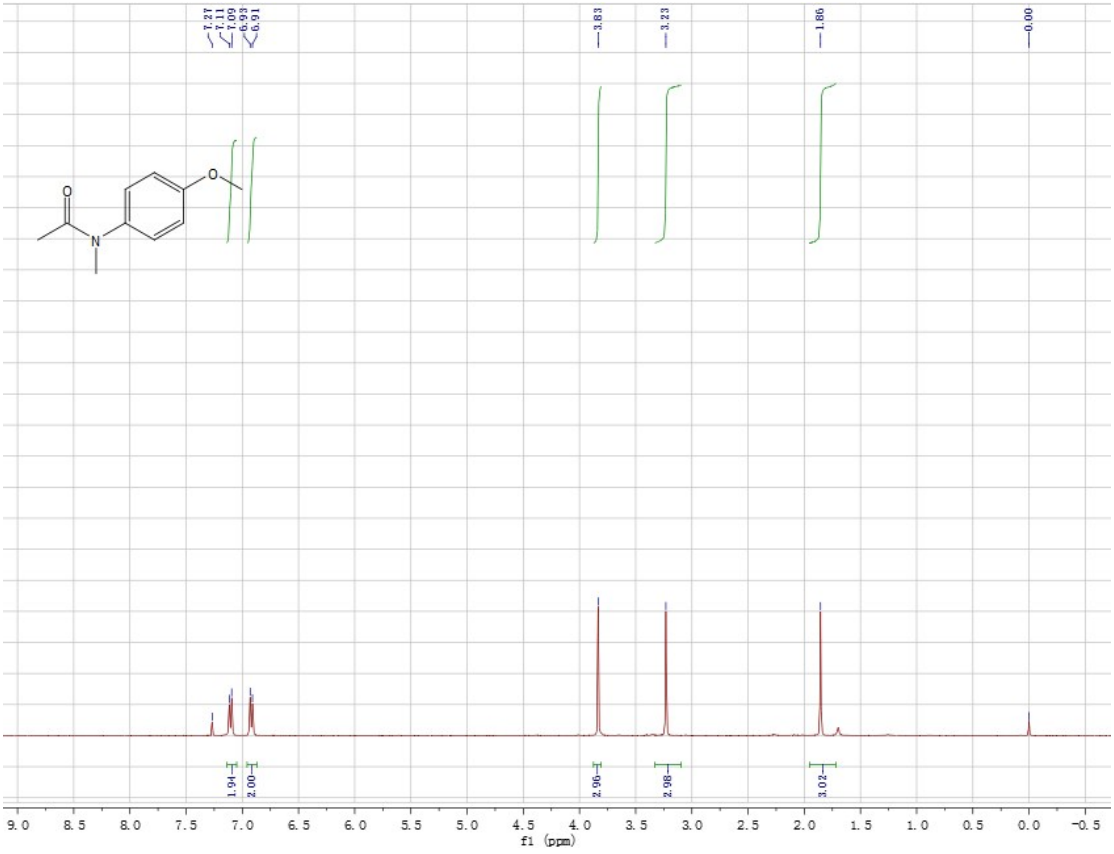
37.31
22.49
21.18
f1 (ppm)


7.27
7.11
7.09
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6.91
3.83
3.23
1.86
0.00
O
N
O
1.94
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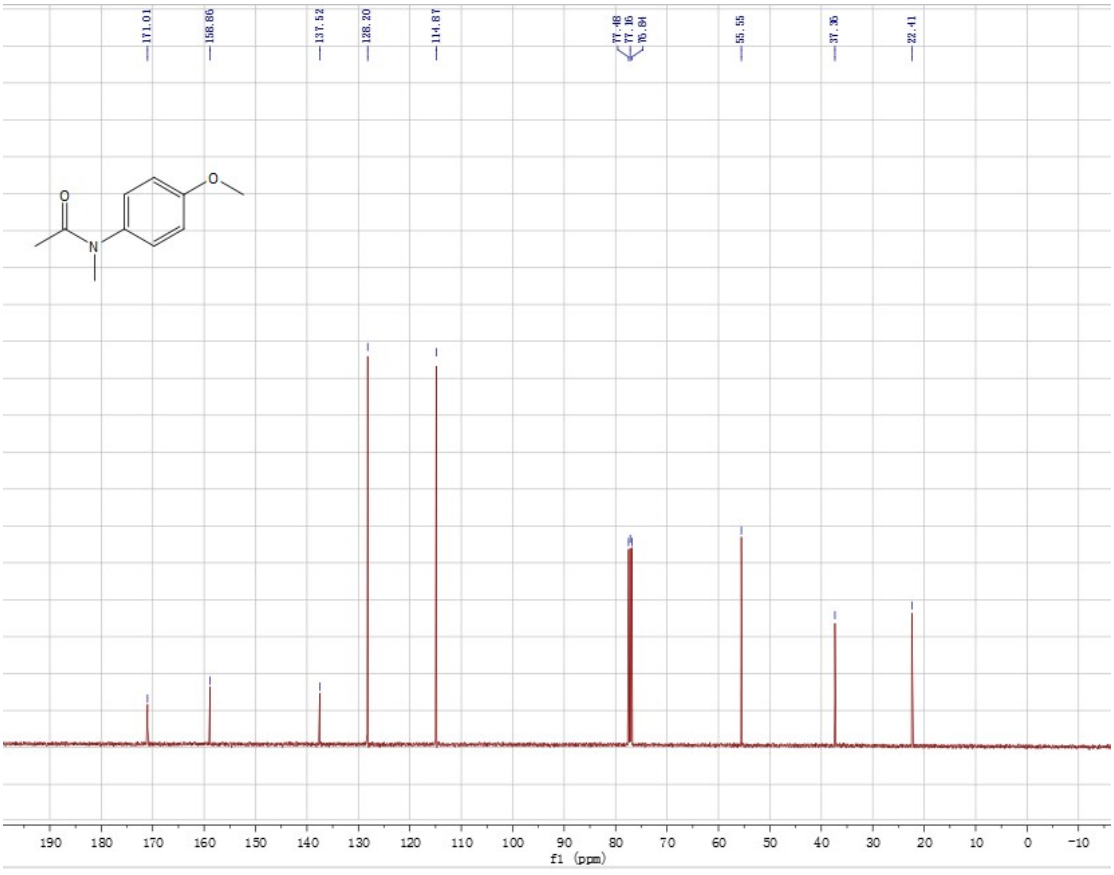
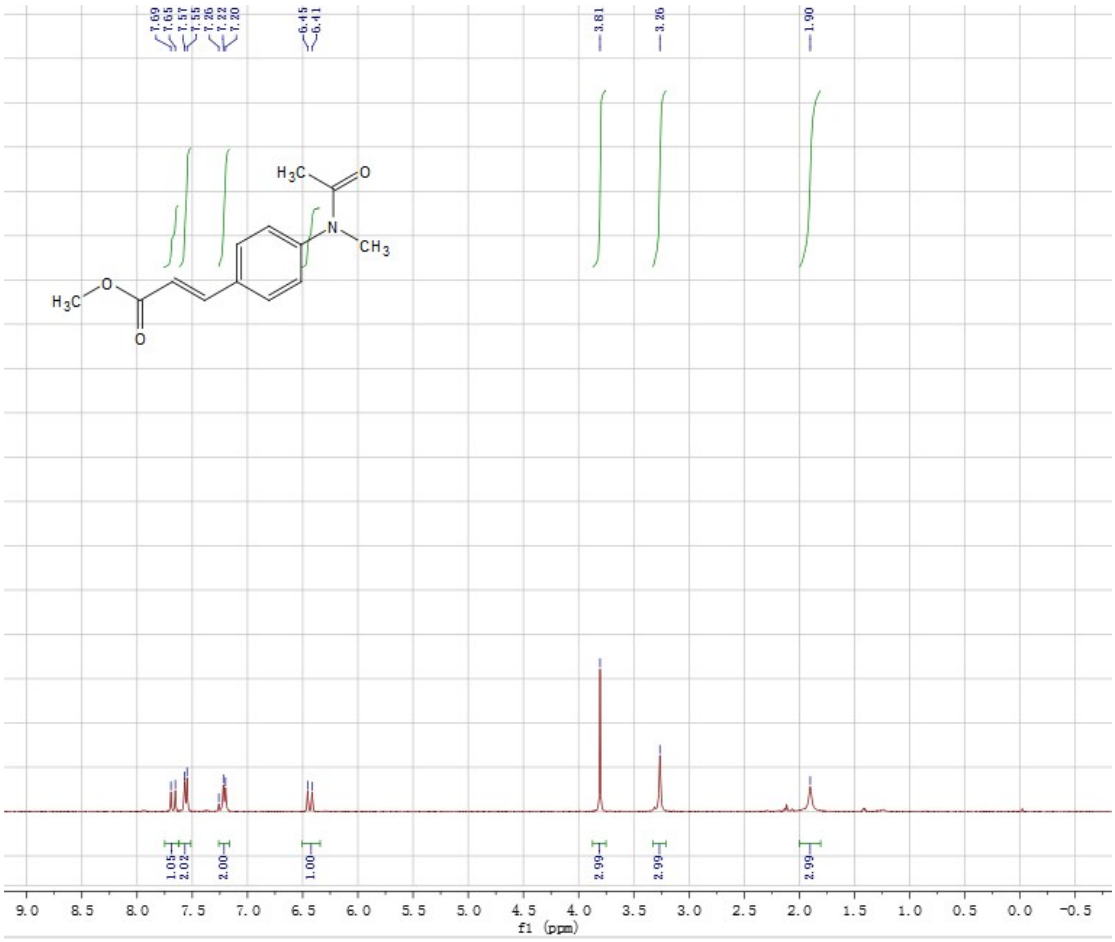
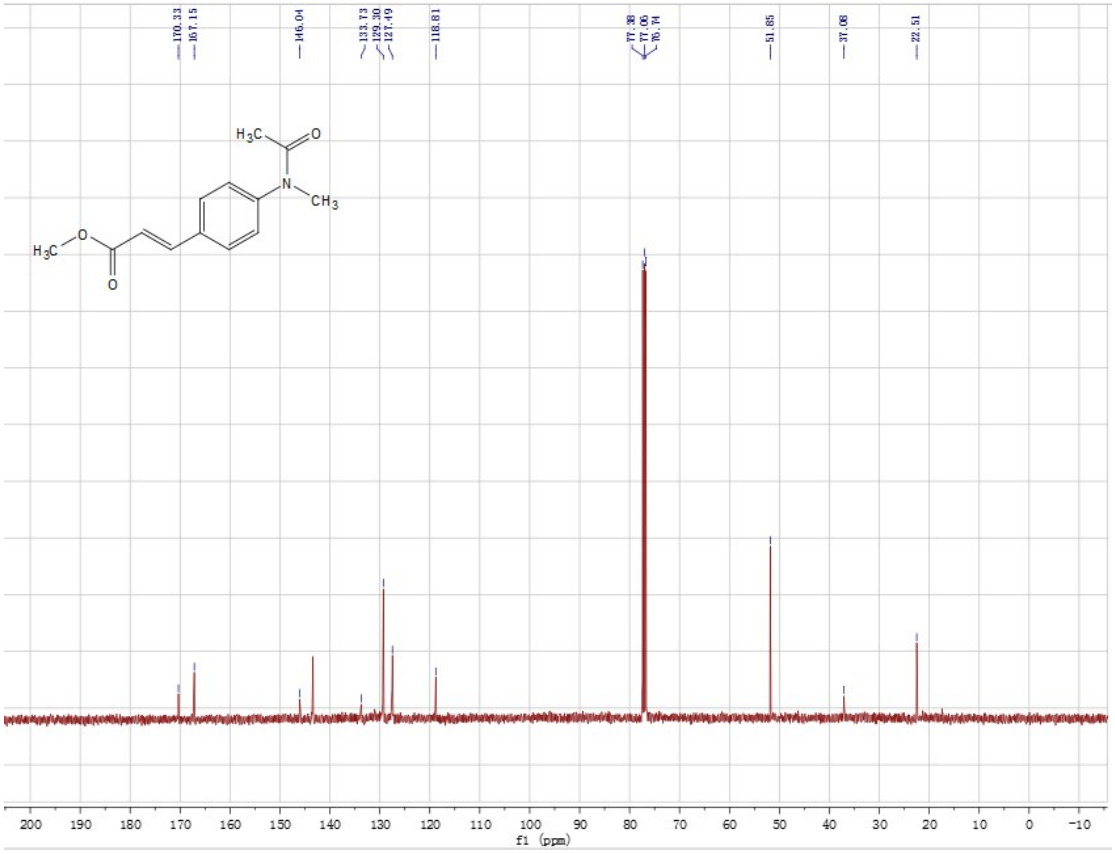
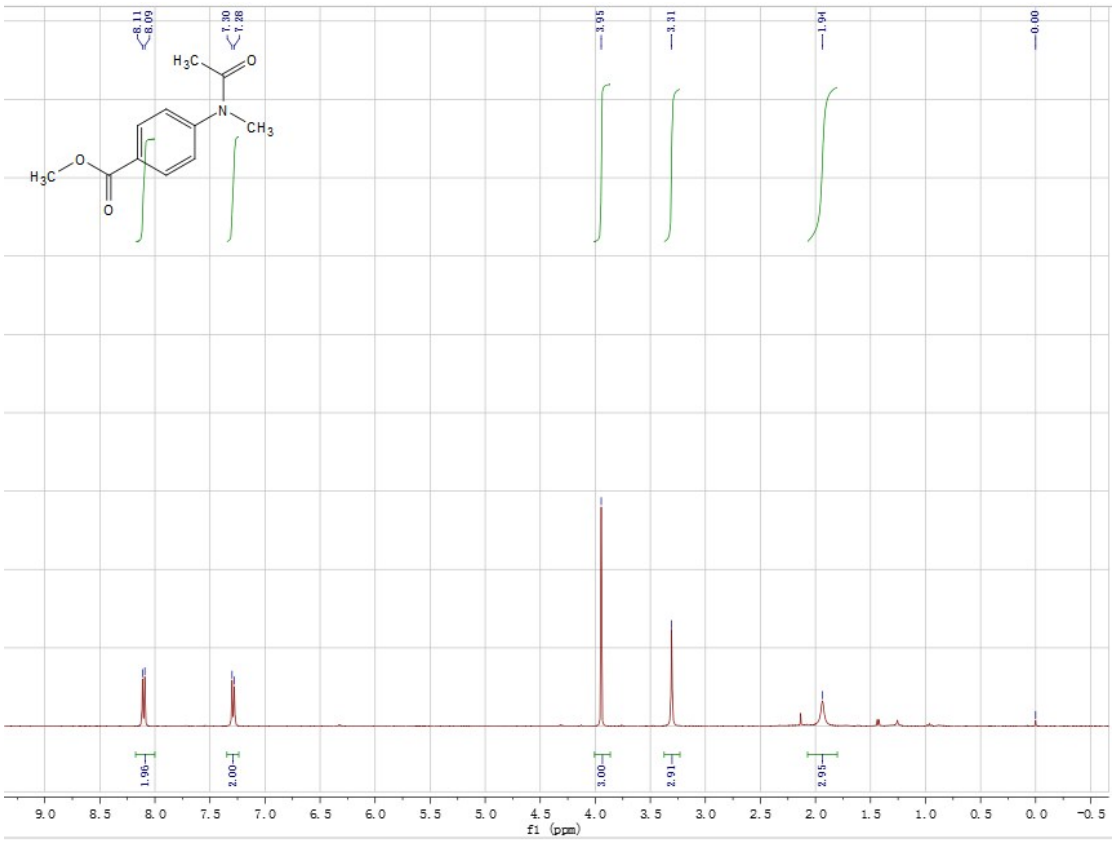
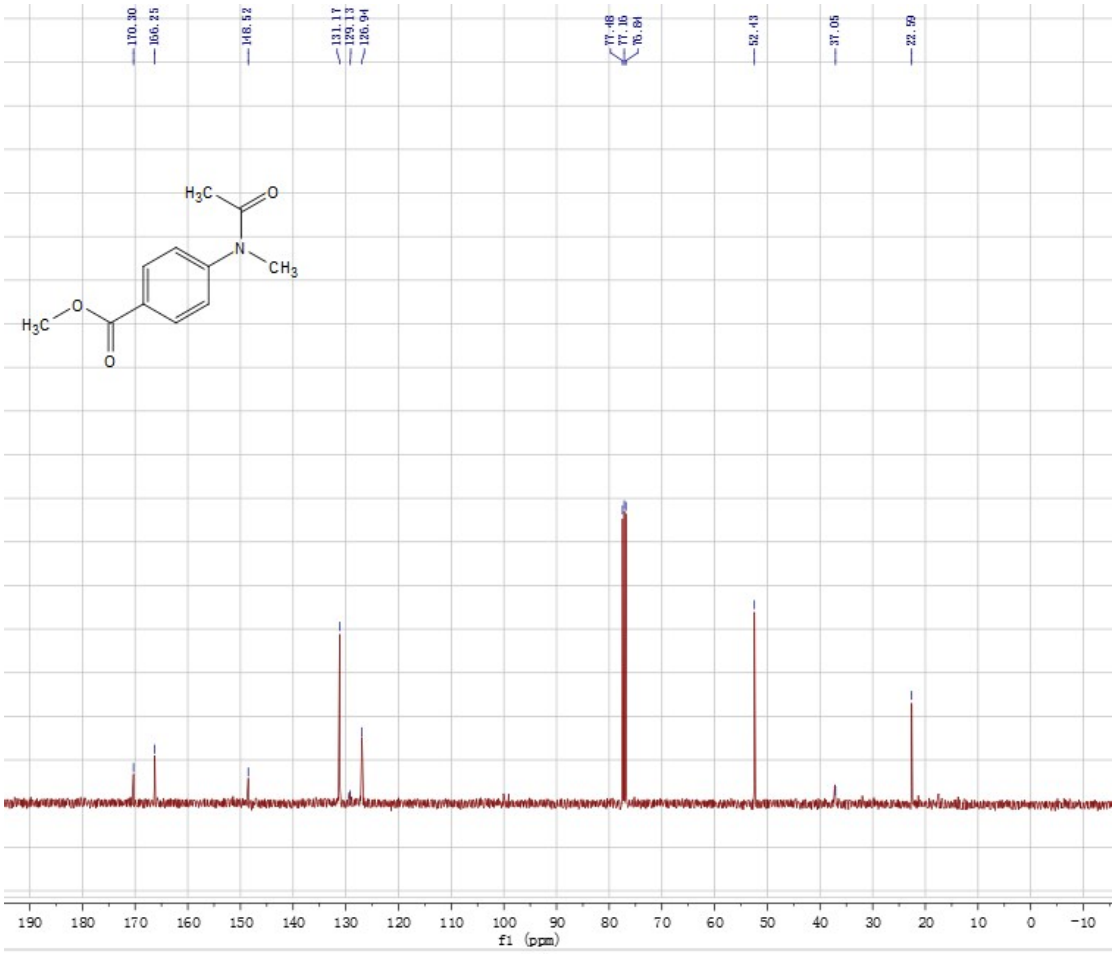
2.96
2.98
3.02
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

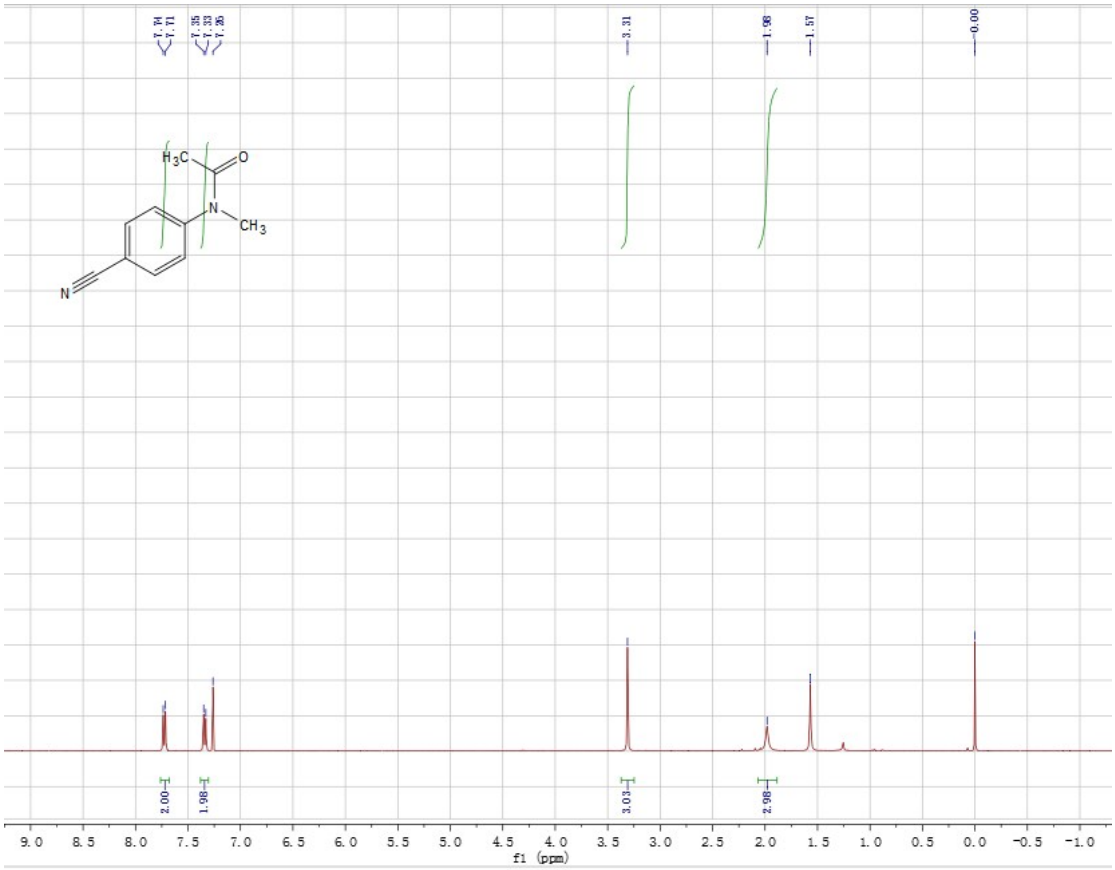

171.01
158.86
137.52
128.20
114.87
77.48
77.16
76.84
55.55
37.36
22.41
O
N
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

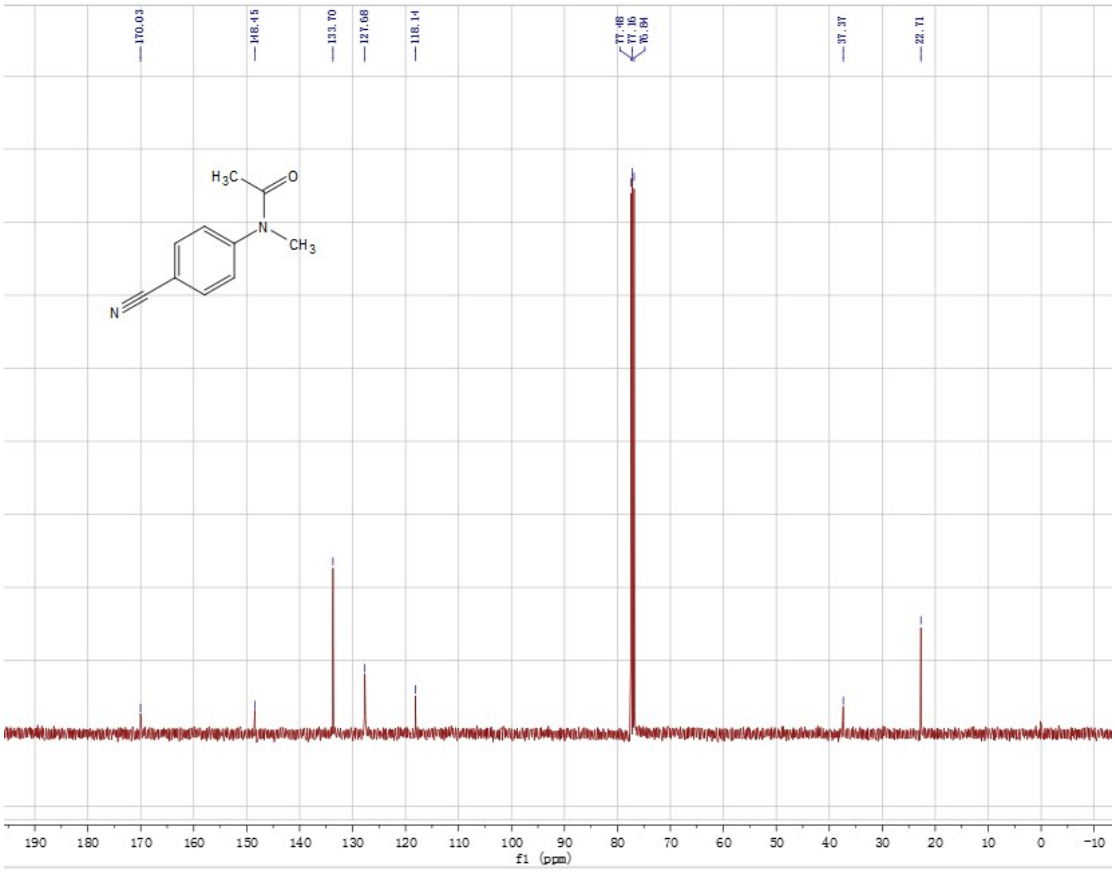

7.69
7.65
7.57
7.55
7.26
7.22
7.20
6.45
6.41
3.81
3.26
1.90
H3C
O
N
CH3
H3C
O
O
1.05
2.02
2.00
1.00
2.99
2.99
2.99
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

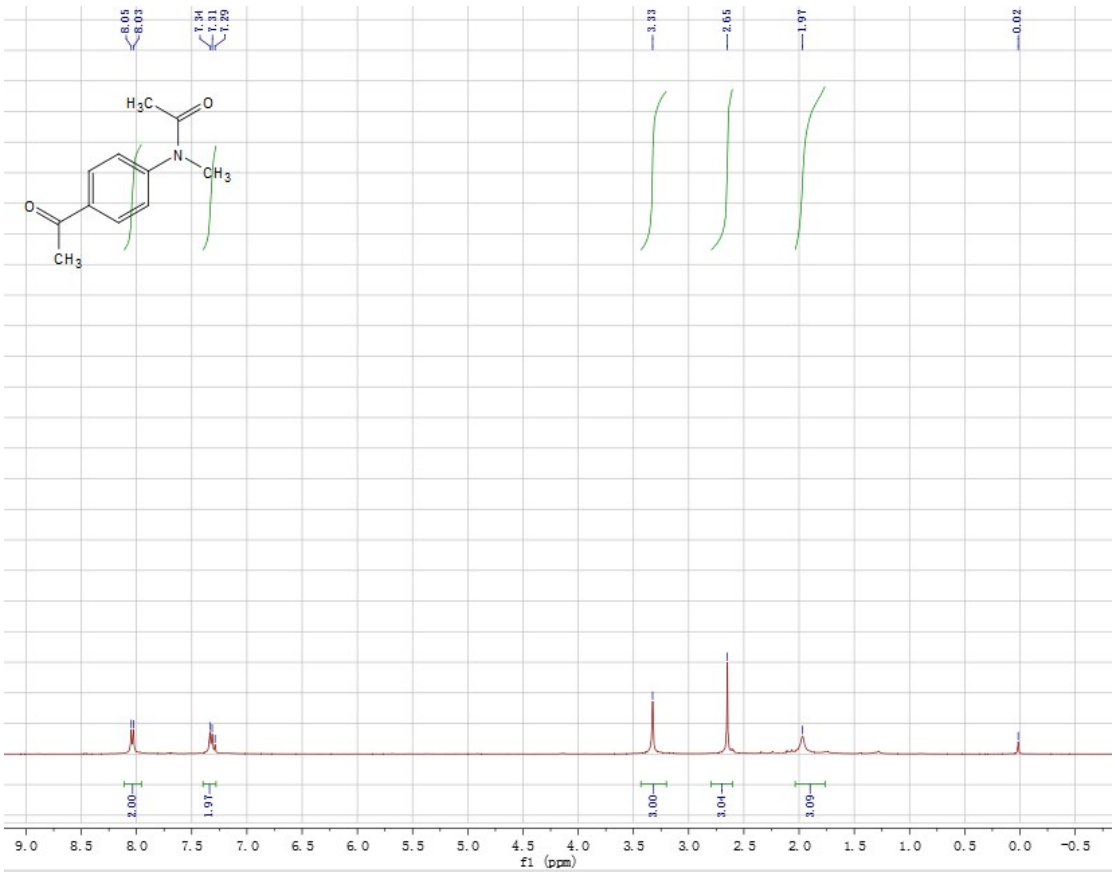

170.33
167.15
146.04
133.73
129.30
127.49
118.81
77.38
77.06
76.74
51.85
37.08
22.51
H3C
O
N
CH3
H3C
O
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

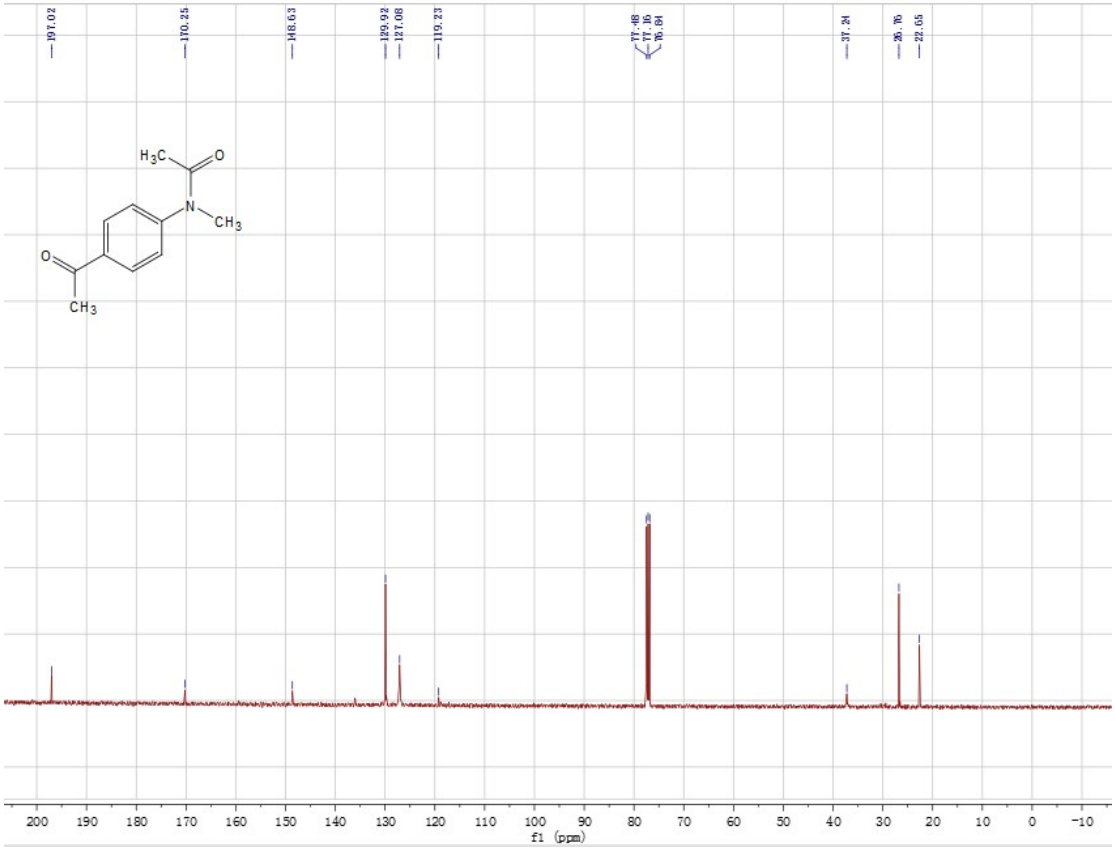

8.11
8.09
7.30
7.28
3.95
3.31
1.94
0.00
1.96
2.00
3.00
2.91
2.95
f1 (ppm)

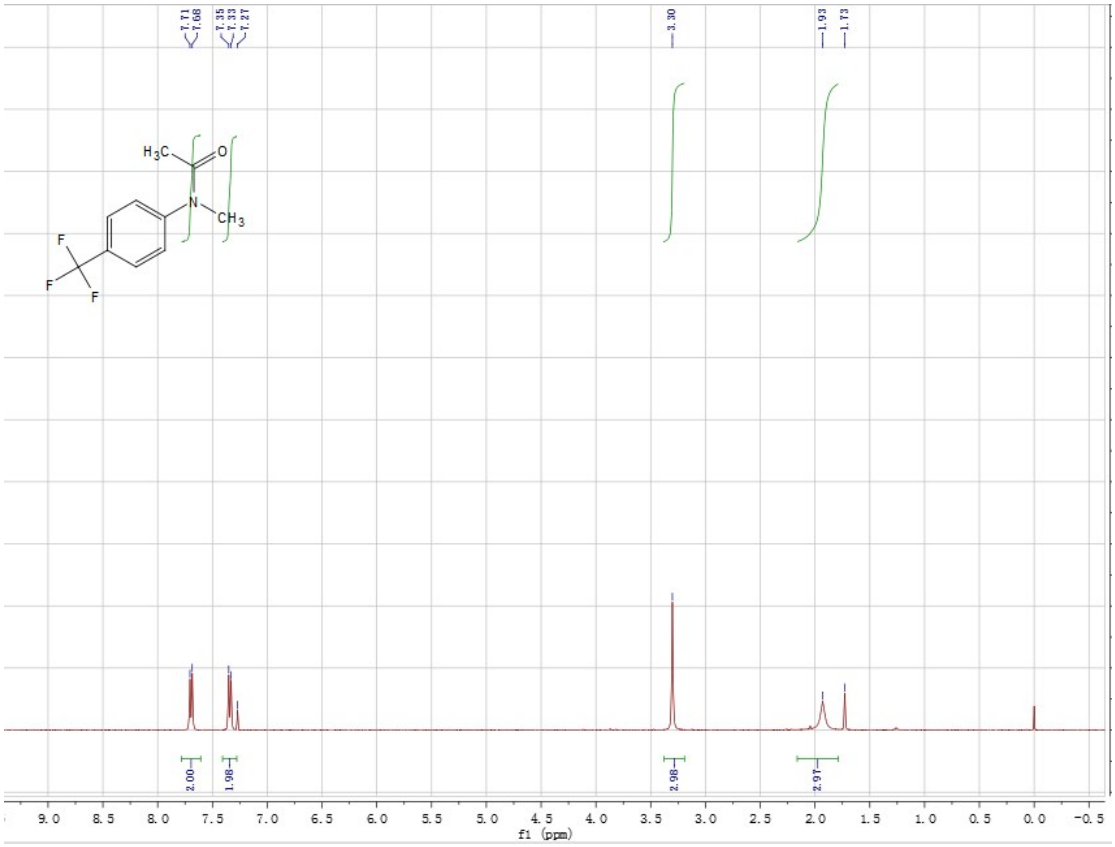

170.30
166.25
148.52
131.17
129.13
126.94
77.48
77.16
76.84
52.43
37.05
22.99
f1 (ppm)

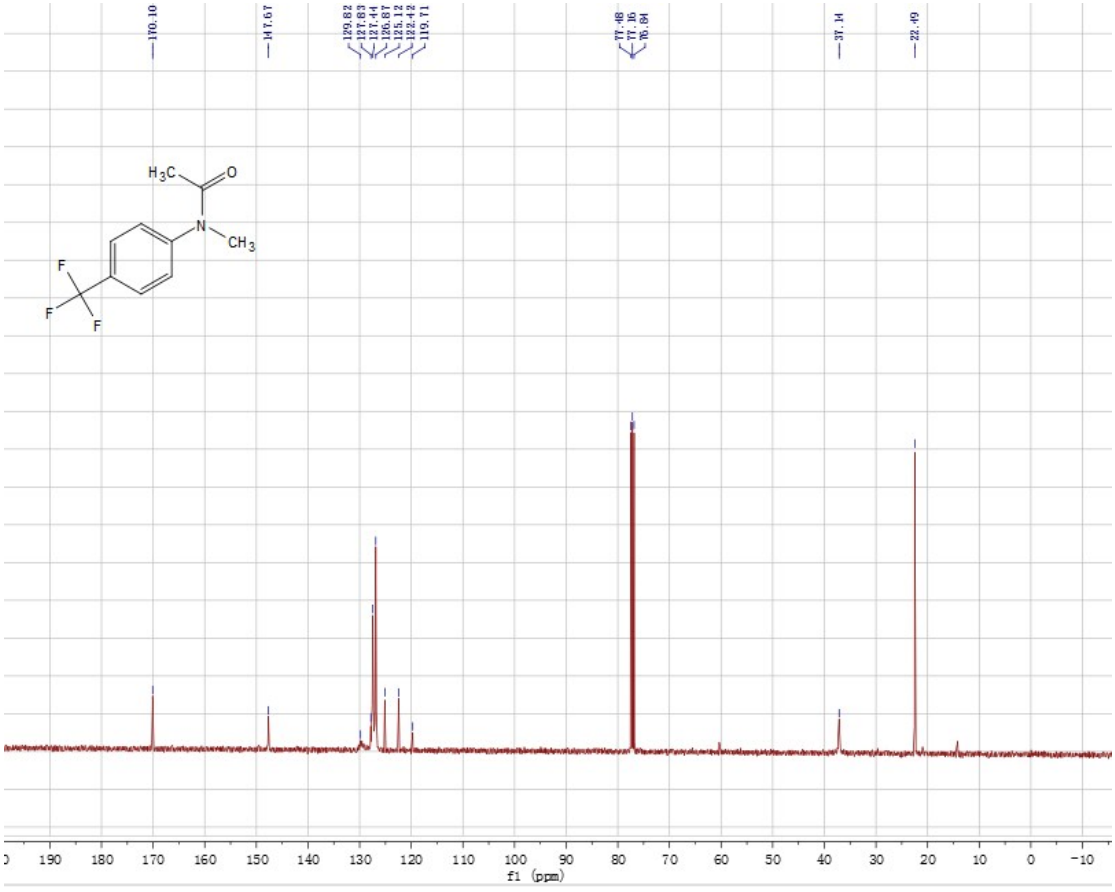

7.74
7.71
7.35
7.33
7.26
3.31
1.98
1.57
0.00
2.00
1.98
3.03
2.98
f1 (ppm)

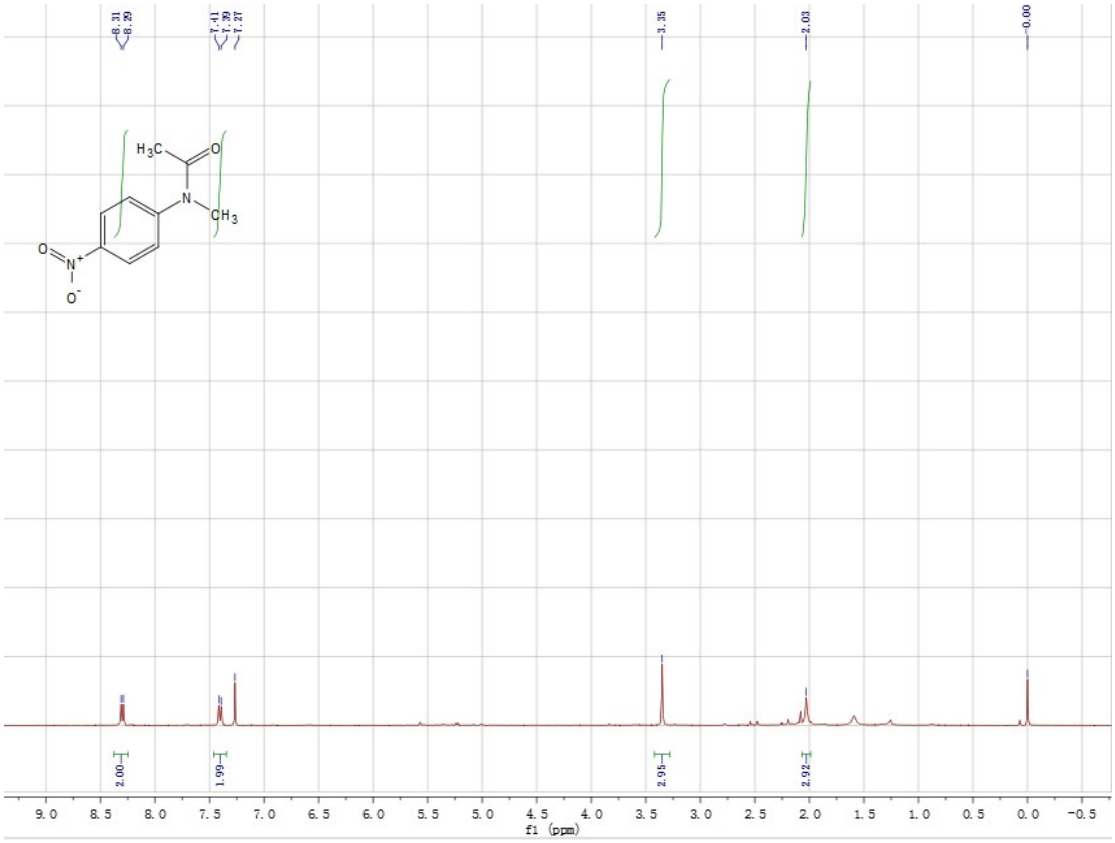

170.03
148.45
133.70
127.68
118.14
77.48
77.16
76.84
37.37
22.71
f1 (ppm)

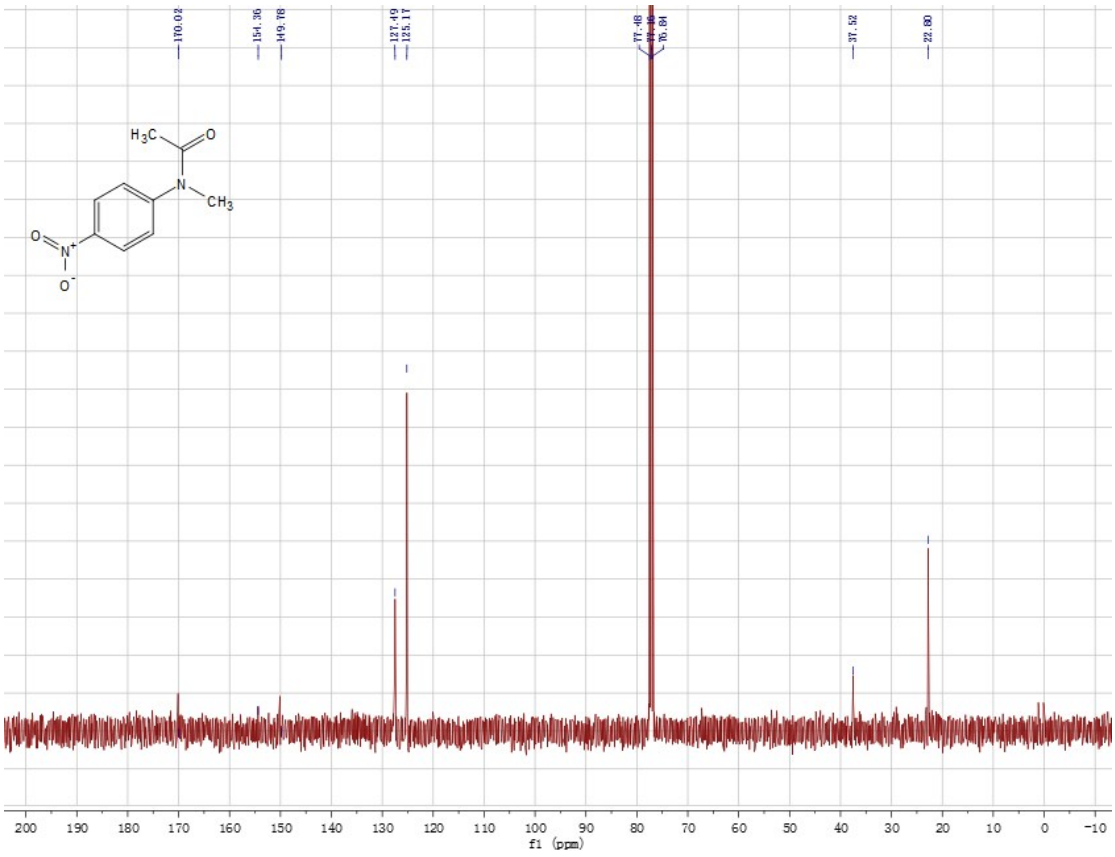

8.05
8.03
7.84
7.31
7.29
3.33
2.65
1.97
0.02
2.00
1.97
3.00
3.04
3.09
f1 (ppm)

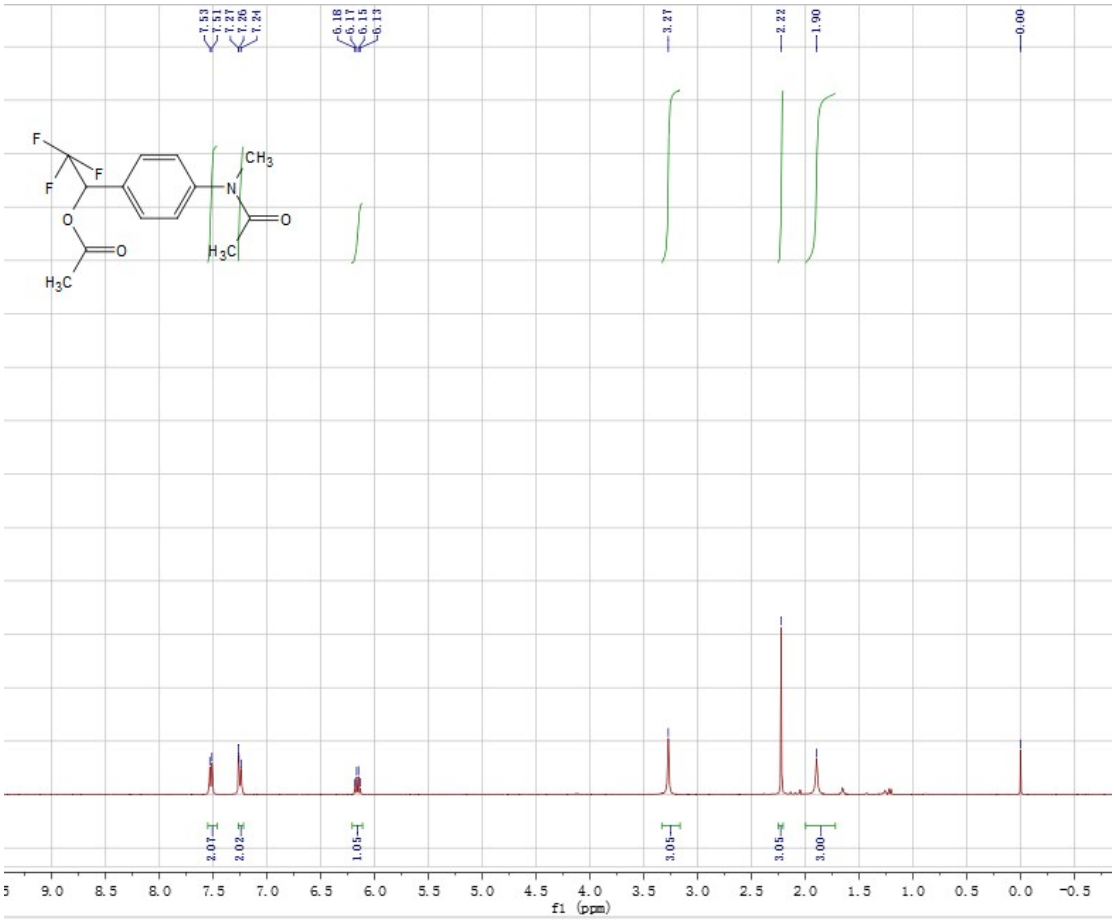

197.02
170.25
148.63
129.92
127.08
119.23
77.48
77.16
76.84
37.24
26.76
22.65
f1 (ppm)

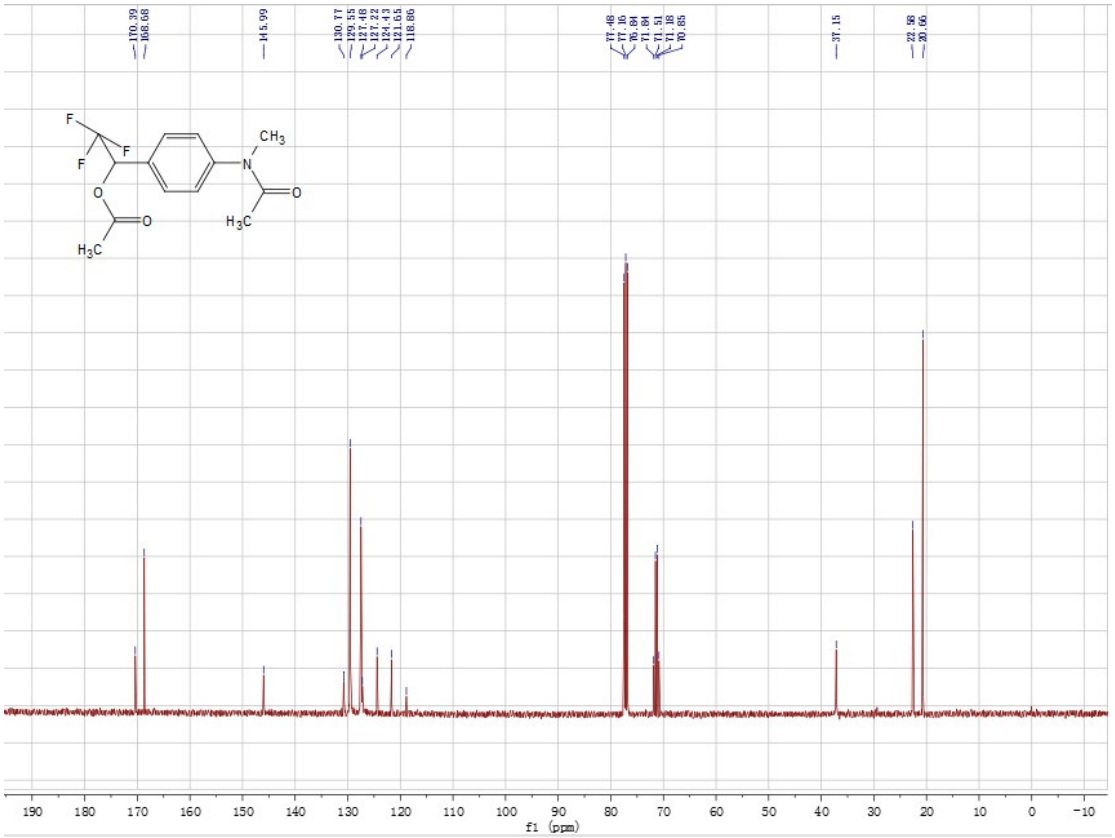

7.71
7.68
7.35
7.33
7.27
3.30
1.93
1.73
H3C
O
N
CH3
F
F
F
2.00
1.98
2.98
2.97
f1 (ppm)


170.10
147.67
129.82
127.83
127.44
126.87
125.12
122.42
119.71
77.48
77.16
76.84
37.14
22.49
H3C
O
N
CH3
F
F
F
f1 (ppm)


8.31
8.29
7.41
7.39
7.37
3.35
2.03
0.00
2.00
1.99
2.95
2.92
f1 (ppm)


170.02
154.36
149.78
127.49
125.17
77.48
37.52
22.80
f1 (ppm)


7.53
7.51
7.27
7.26
7.24
6.18
6.17
6.15
6.13
3.27
2.22
1.90
0.00
F
F
F
O
O
CH3
N
O
H3C
H3C
2.07
2.02
1.05
3.05
3.05
3.00
f1 (ppm)


170.39
168.68
145.99
130.77
129.55
127.48
127.22
124.43
121.65
118.86
77.48
77.16
76.84
71.84
71.51
71.18
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F
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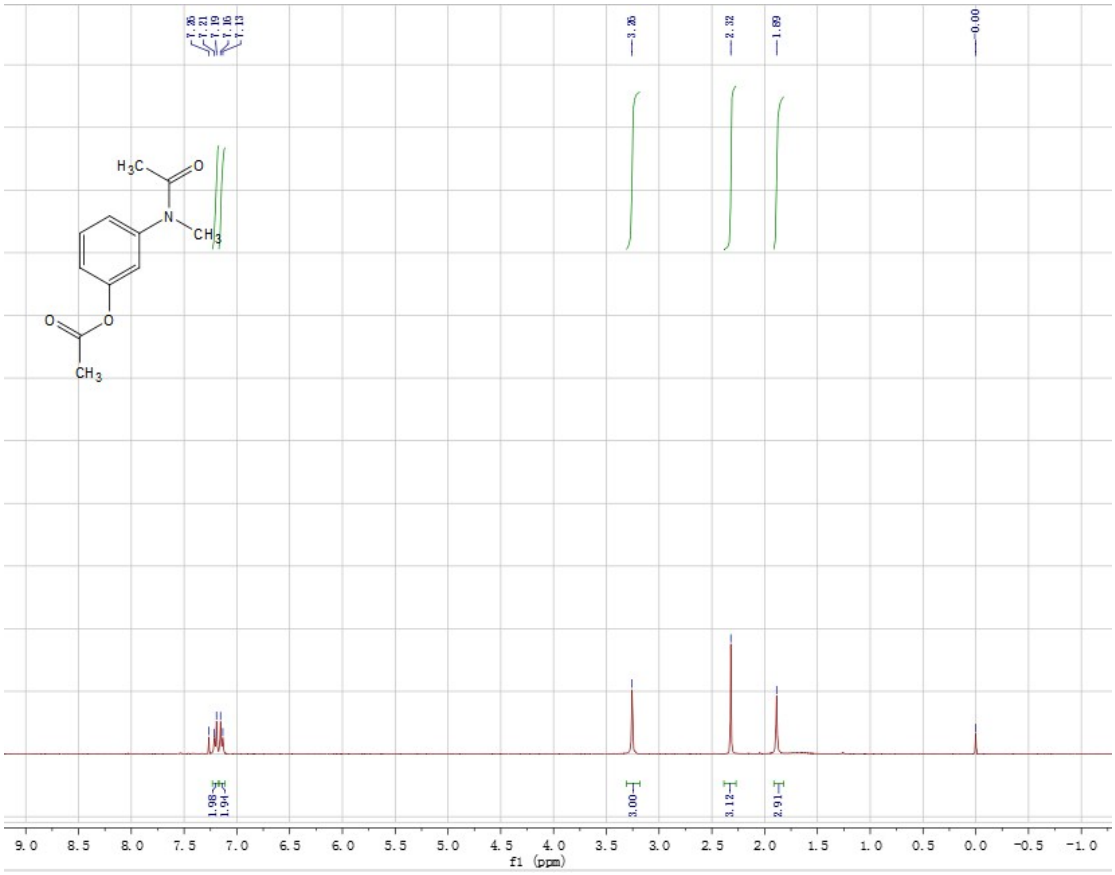
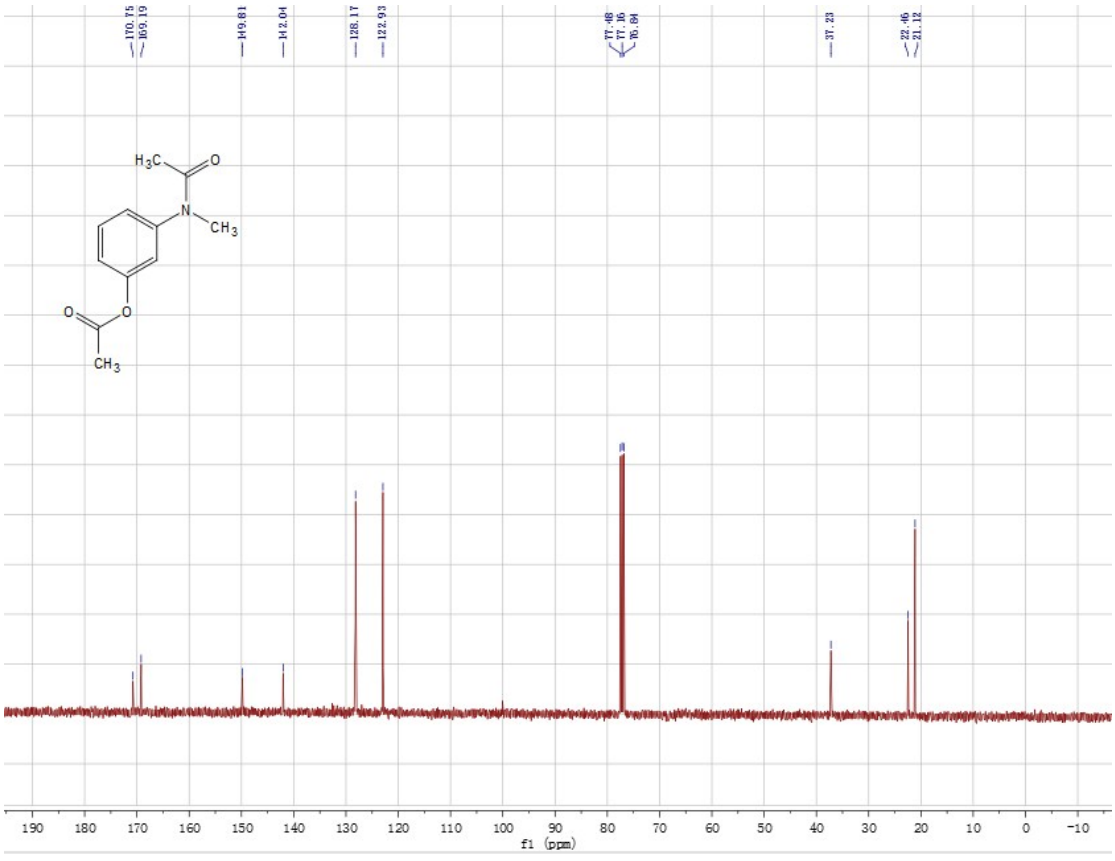
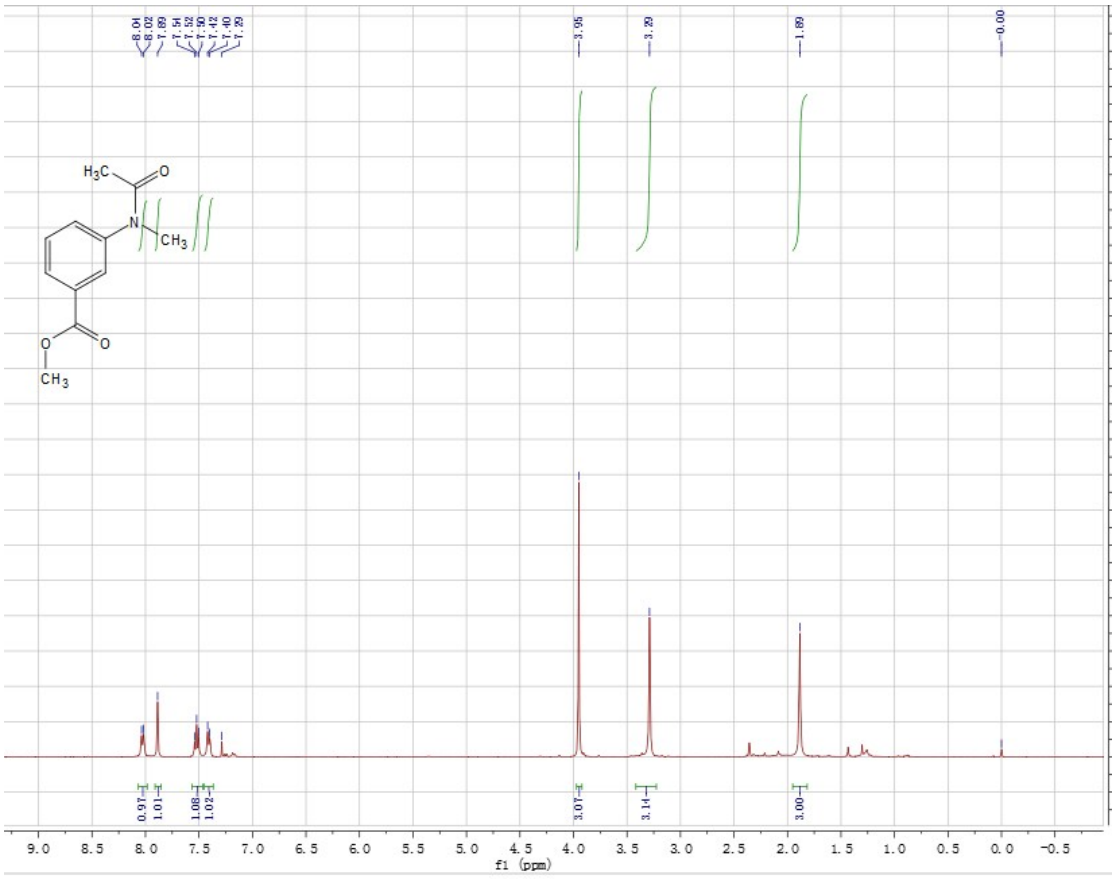
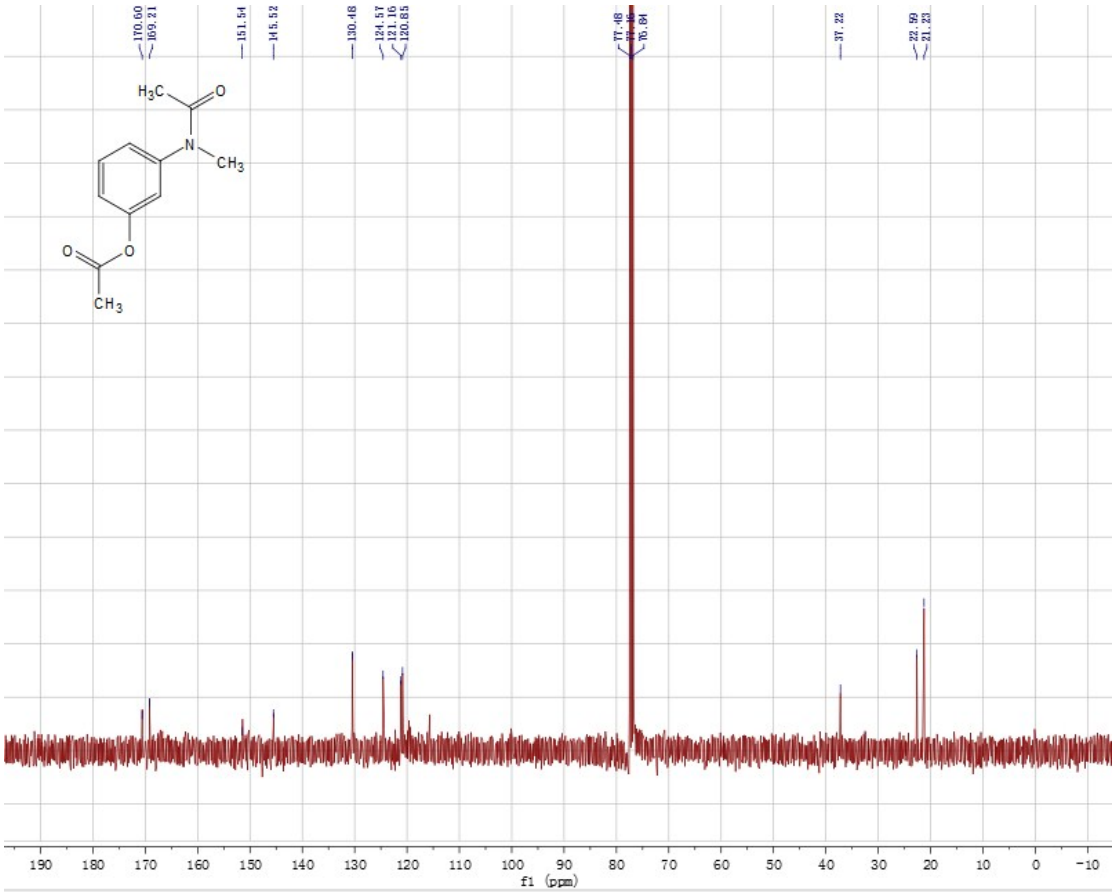
O
O
CH3
N
O
H3C
H3C
f1 (ppm)


7.25
7.21
7.19
7.16
7.13
3.25
2.32
1.89
0.00
1.98
1.94
3.00
3.12
2.91
f1 (ppm)


170.75
169.19
149.81
142.04
128.17
122.93
77.48
77.16
76.84
37.23
22.46
21.12
f1 (ppm)


8.04
8.02
7.89
7.54
7.52
7.50
7.42
7.40
7.29
3.96
3.29
1.89
0.00
0.97
1.01
1.08
1.02
3.07
3.14
3.00
f1 (ppm)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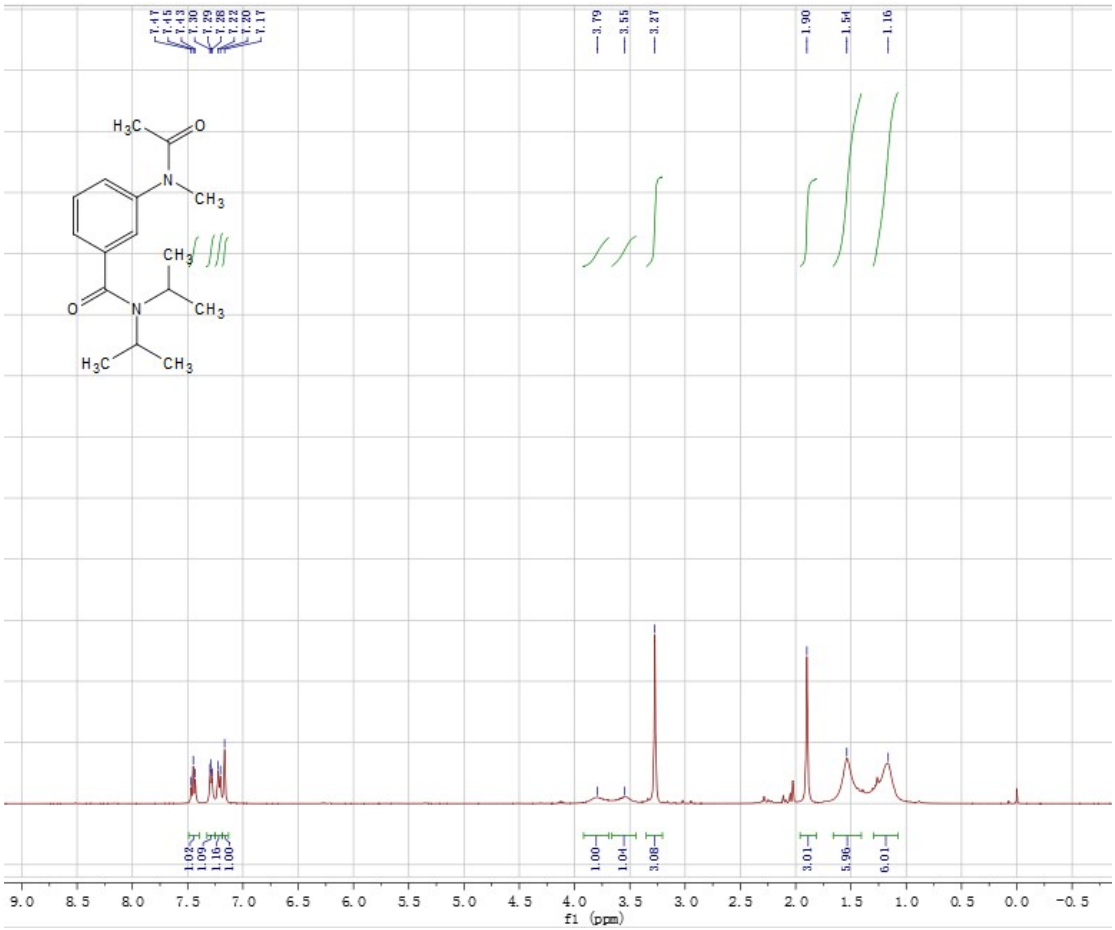
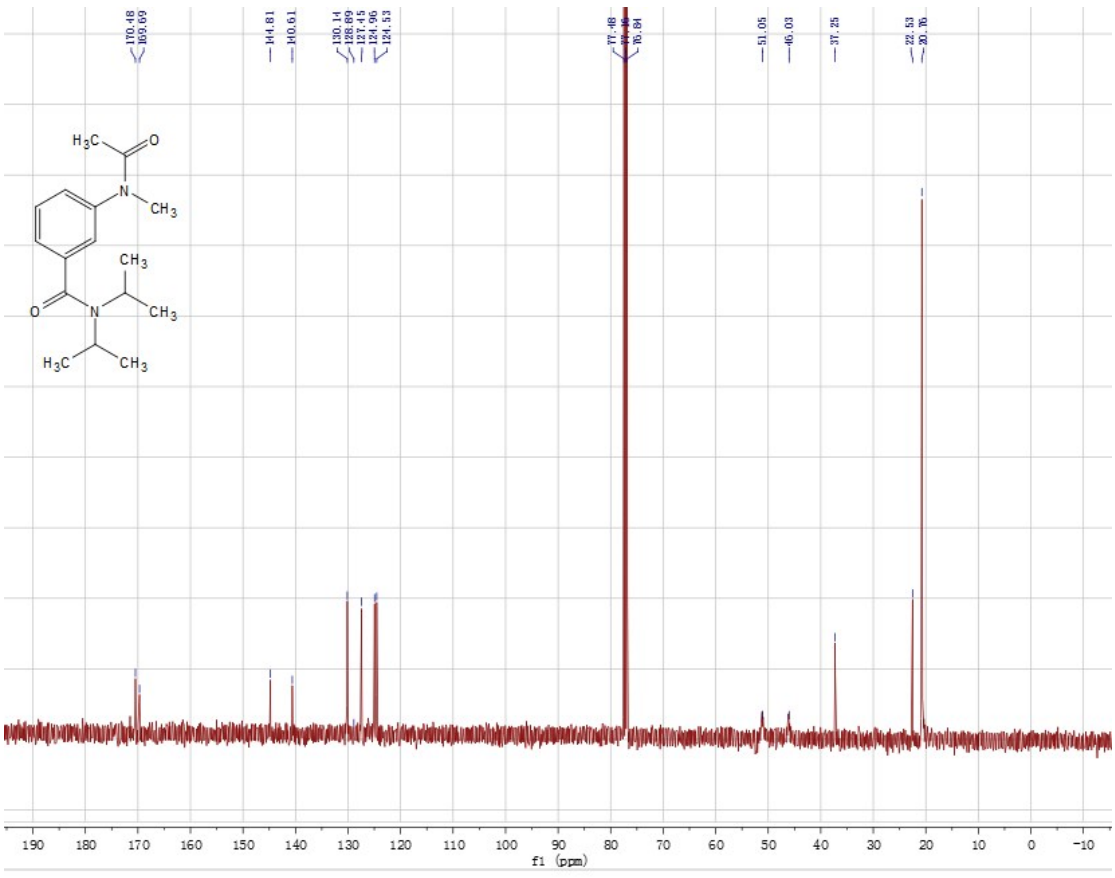
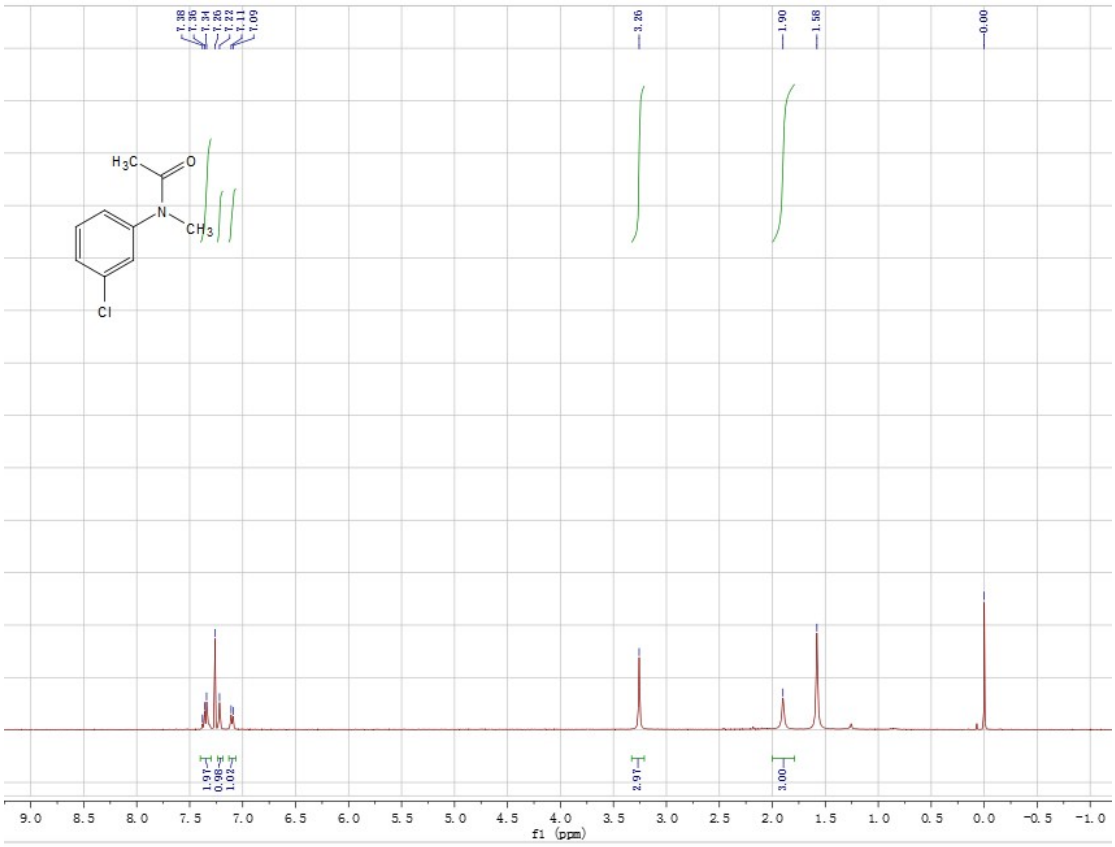
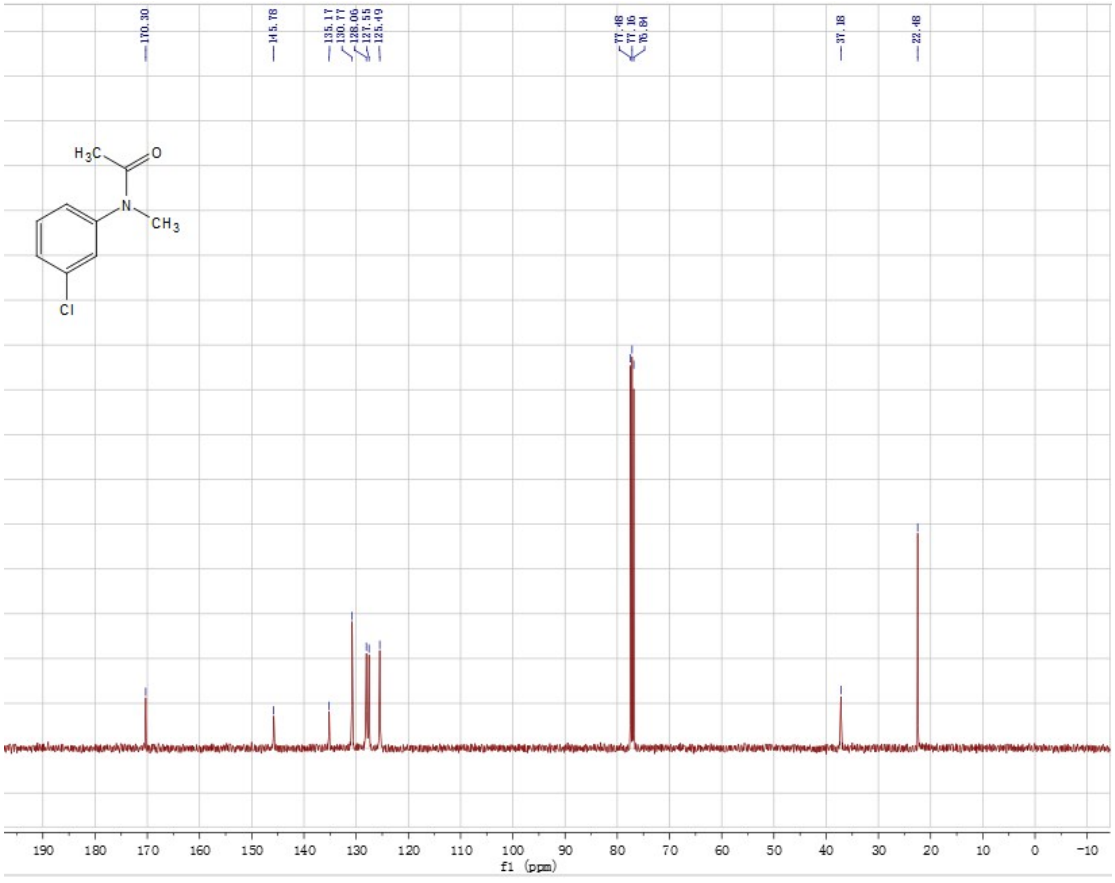
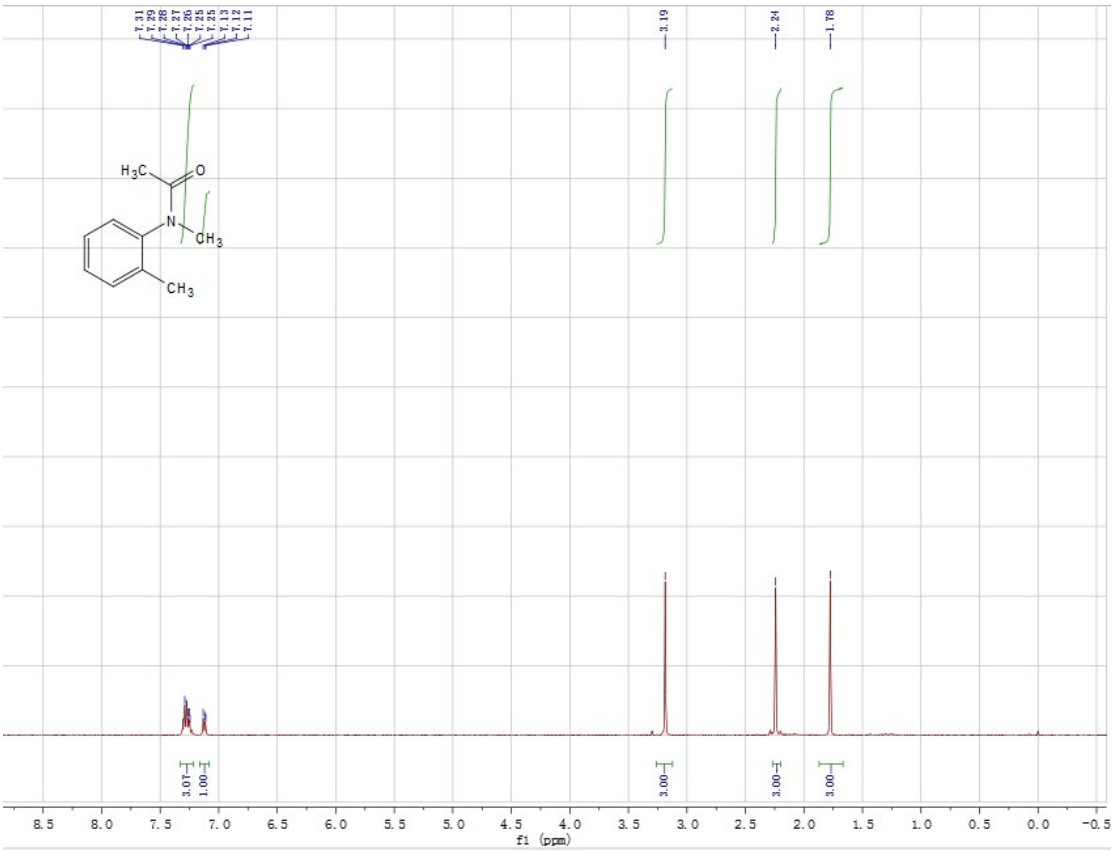
169.21
151.54
145.52
130.48
124.57
121.10
120.85
77.48
77.16
76.84
37.22
22.99
21.23
f1 (ppm)

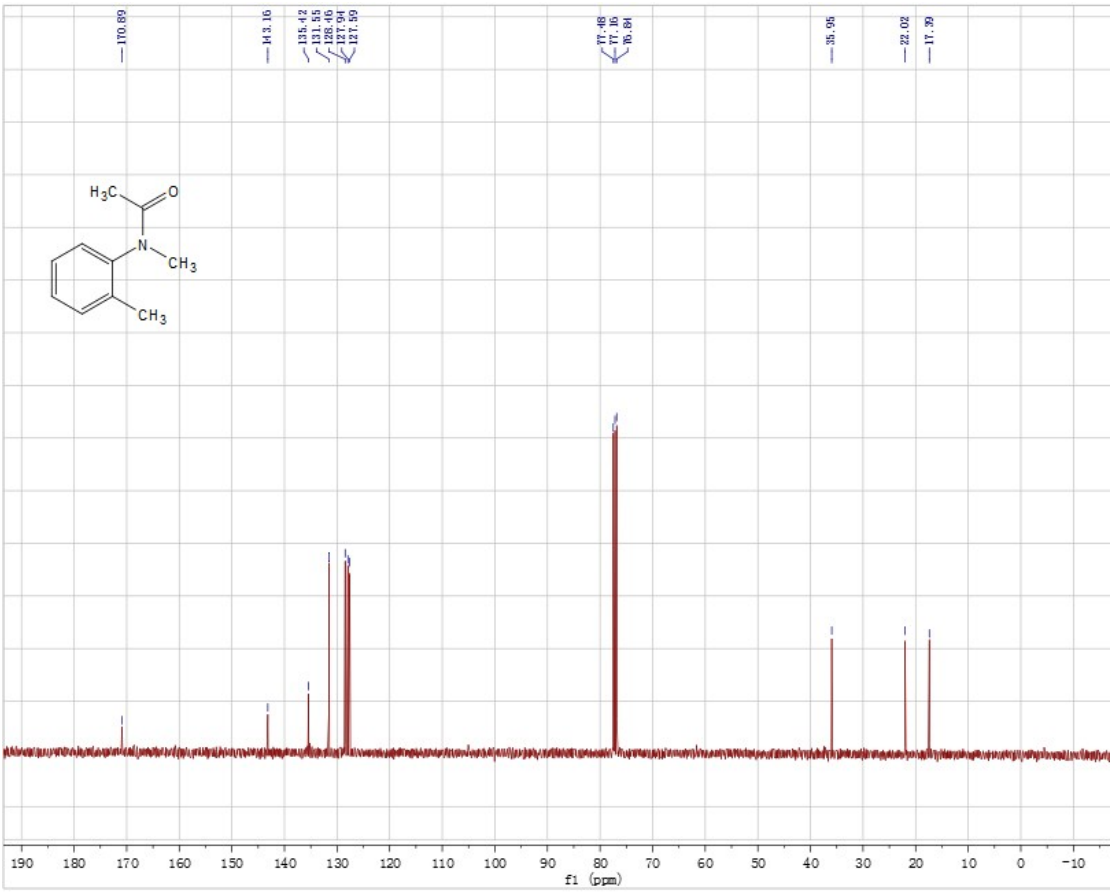

7.47
7.45
7.43
7.30
7.29
7.28
7.22
7.20
7.17
3.79
3.55
3.27
1.90
1.84
1.16
1.02
1.09
1.16
1.00
1.00
1.04
3.08
3.01
5.96
6.01
f1 (ppm)

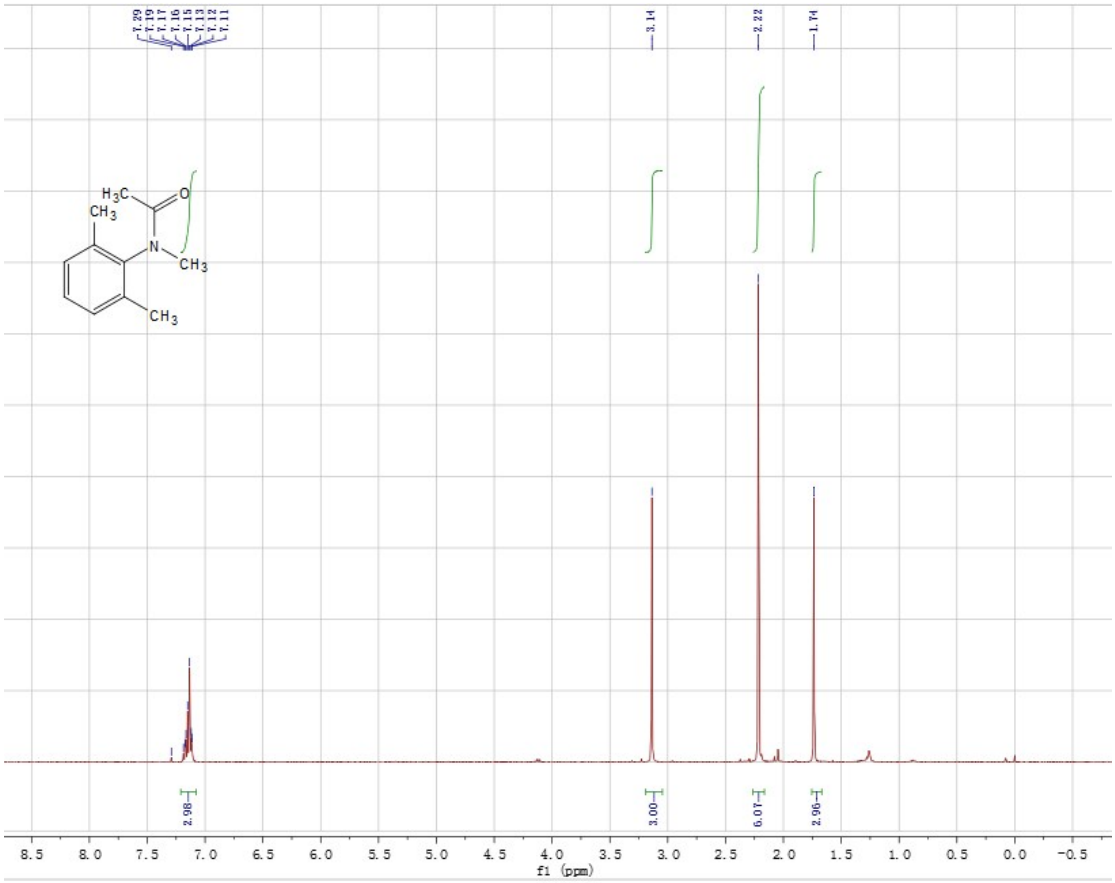

170.48
169.69
144.81
140.61
130.14
128.89
127.45
124.96
124.53
77.48
76.84
51.05
46.03
37.25
22.53
20.76
f1 (ppm)

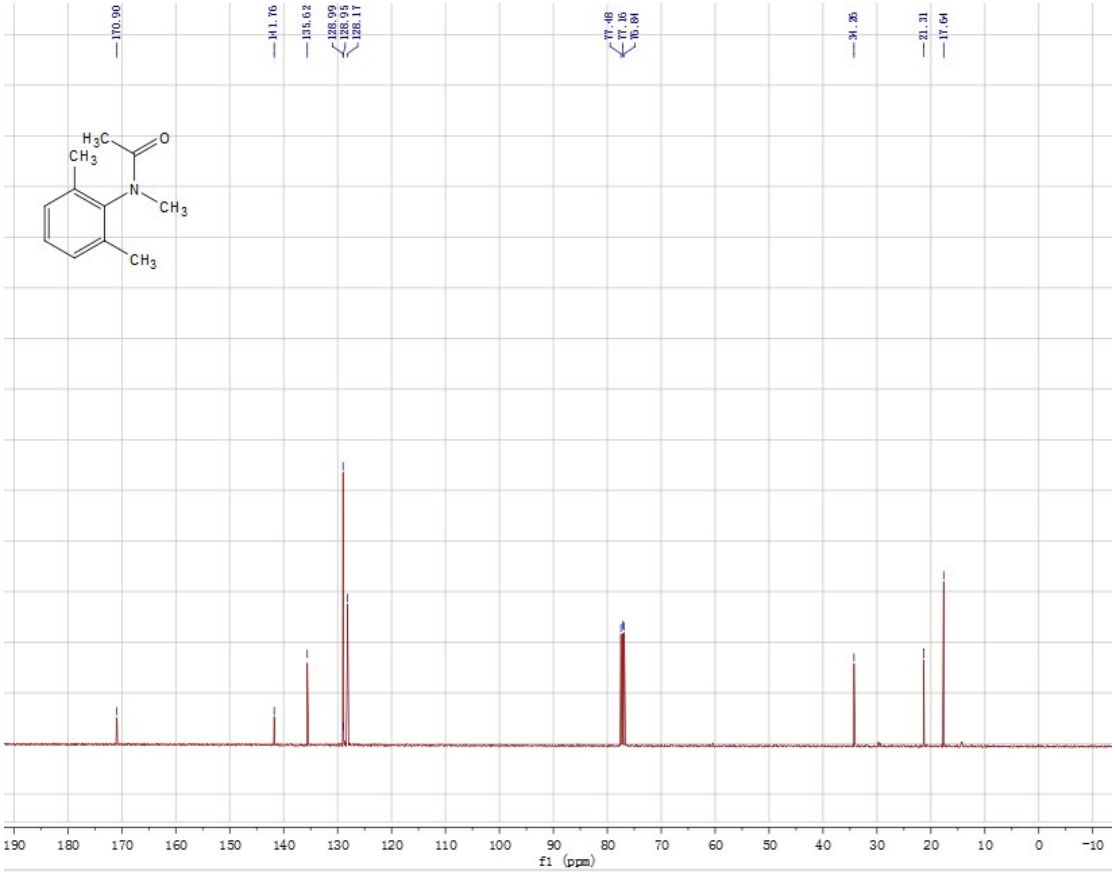

7.38
7.35
7.34
7.26
7.22
7.11
7.09
3.26
1.90
1.58
0.00
H3C
O
N
CH3
Cl
1.97
0.98
1.02
2.97
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

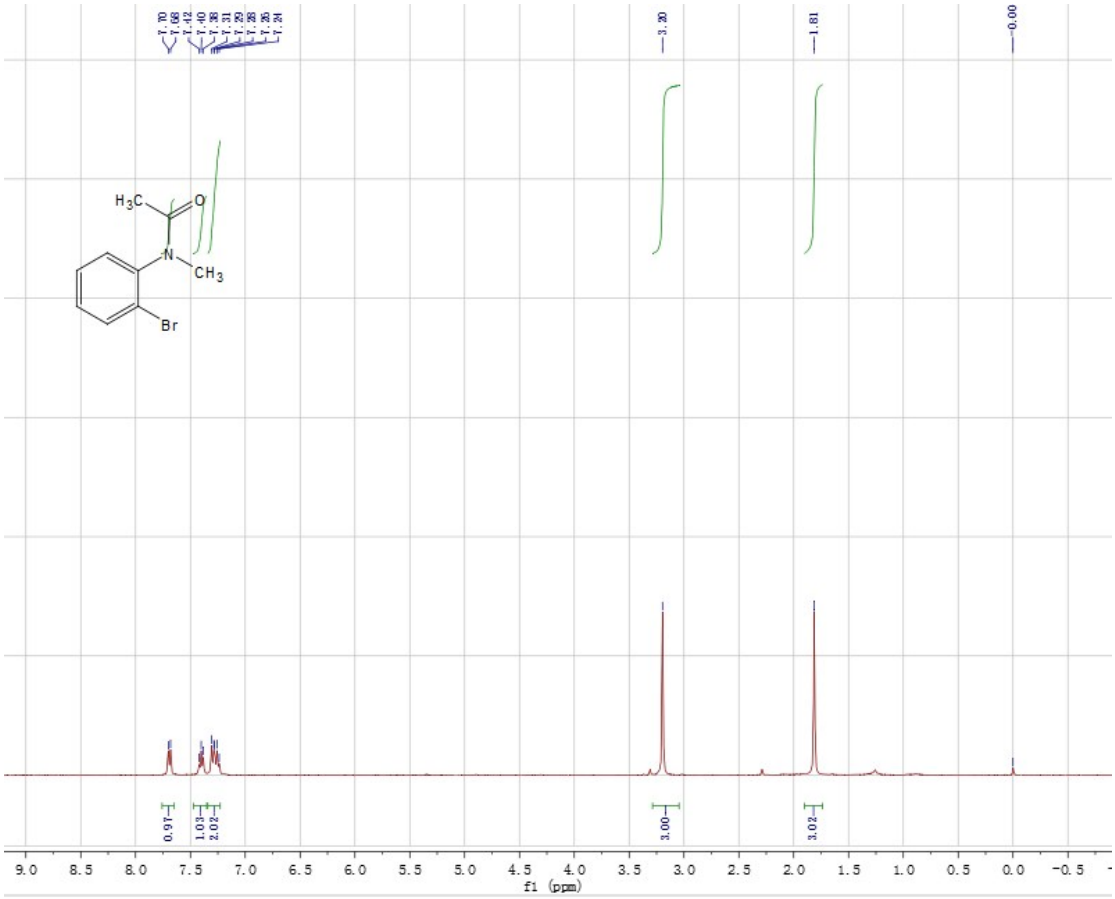

170.30
145.78
135.17
130.77
128.06
127.15
125.49
77.48
77.16
76.84
37.18
22.48
H3C
O
N
CH3
Cl
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

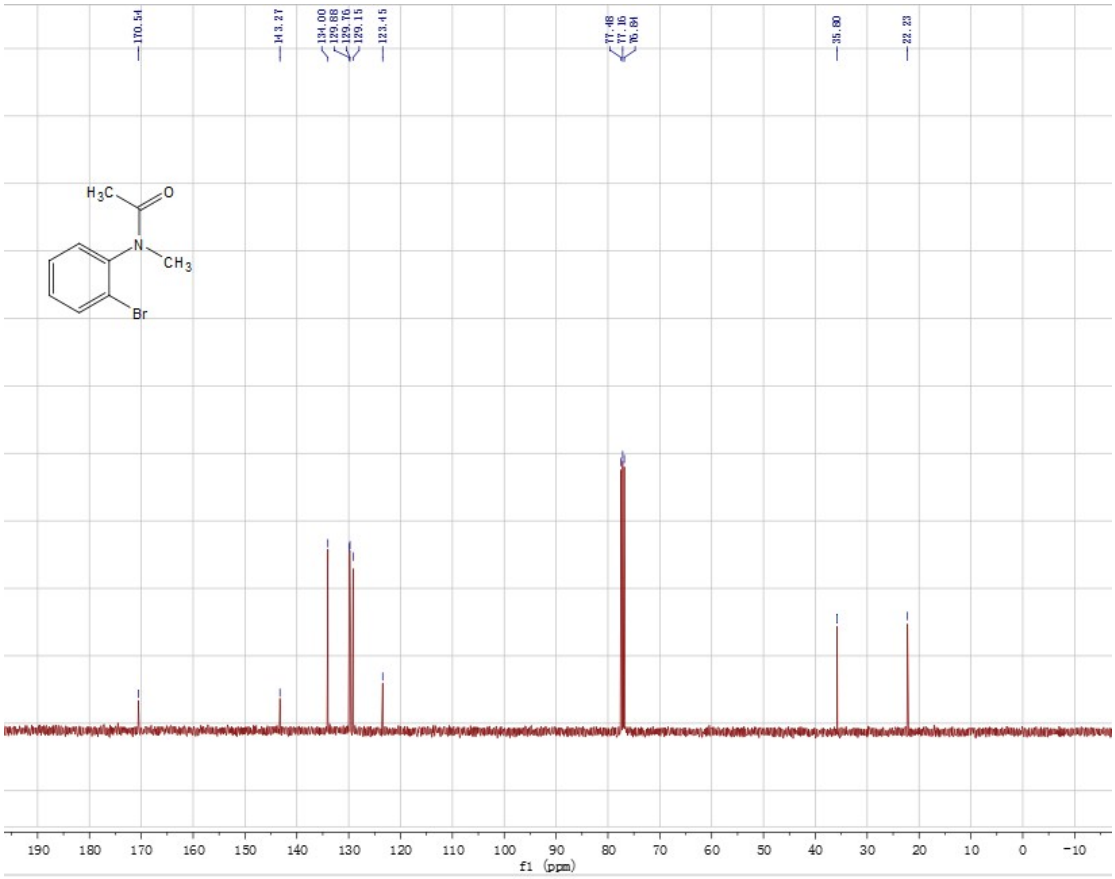

7.31
7.29
7.28
7.27
7.26
7.25
7.25
7.13
7.12
7.11
3.19
2.24
1.78
H3C
O
N
CH3
CH3
3.07
1.00
3.00
3.00
3.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

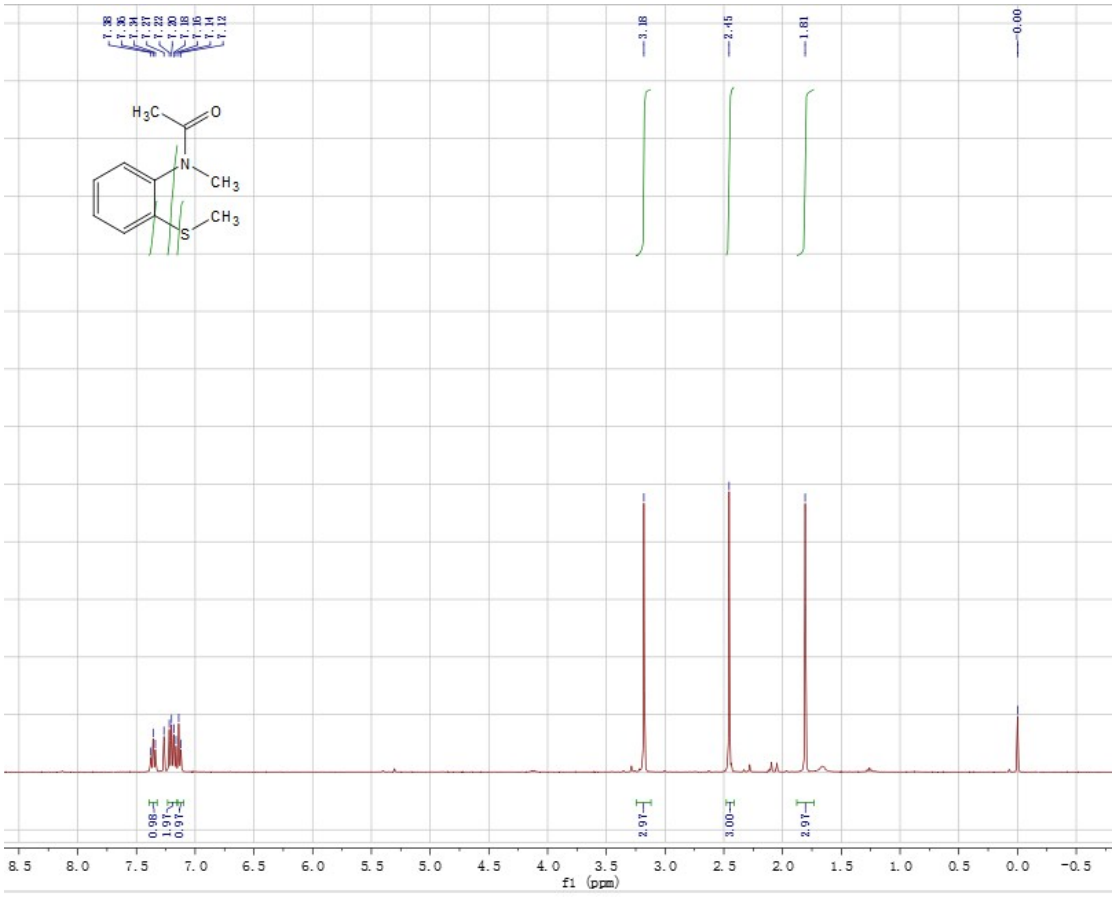

170.89
143.16
135.42
131.55
128.46
127.94
127.59
77.48
77.16
76.84
35.95
22.02
17.39
H3C
O
N
CH3
CH3
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

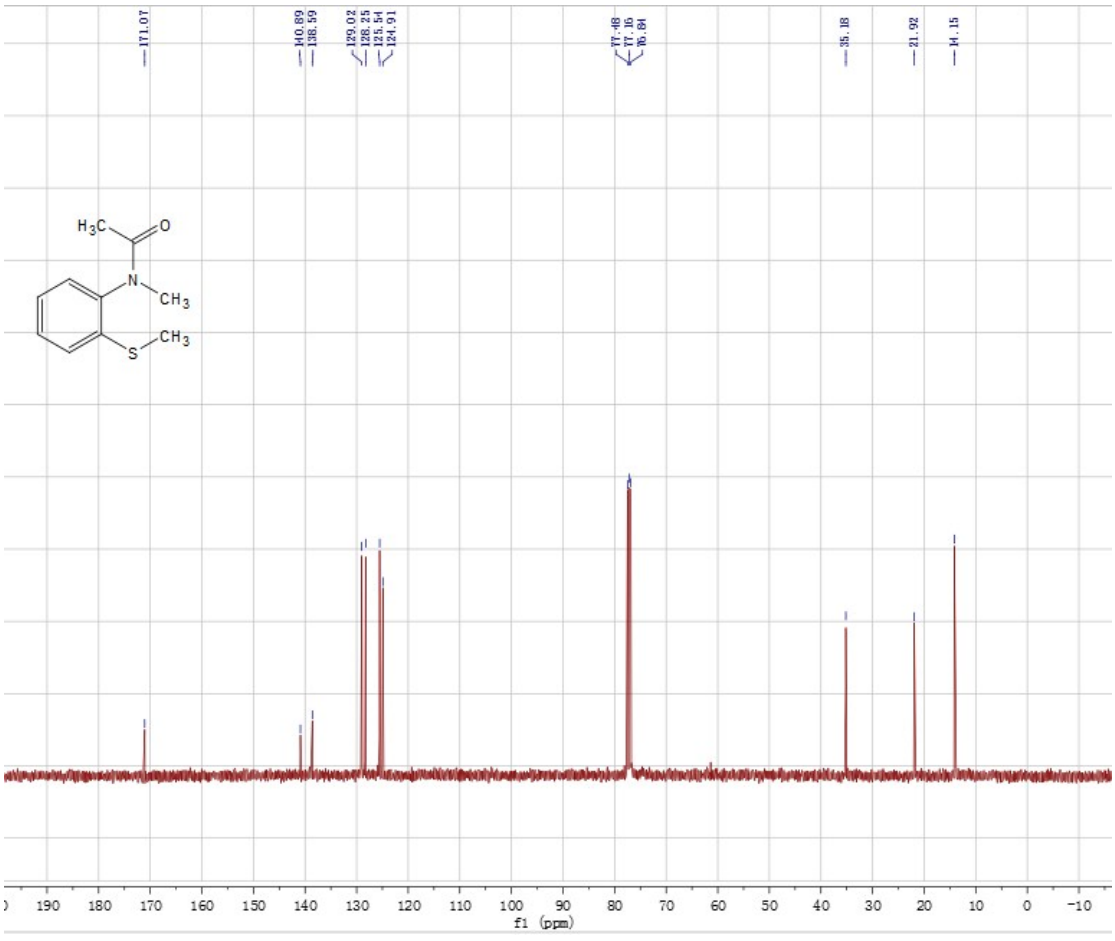

7.29
7.19
7.17
7.16
7.15
7.13
7.12
7.11
3.14
2.22
1.74
2.98
3.00
6.07
2.96
f1 (ppm)

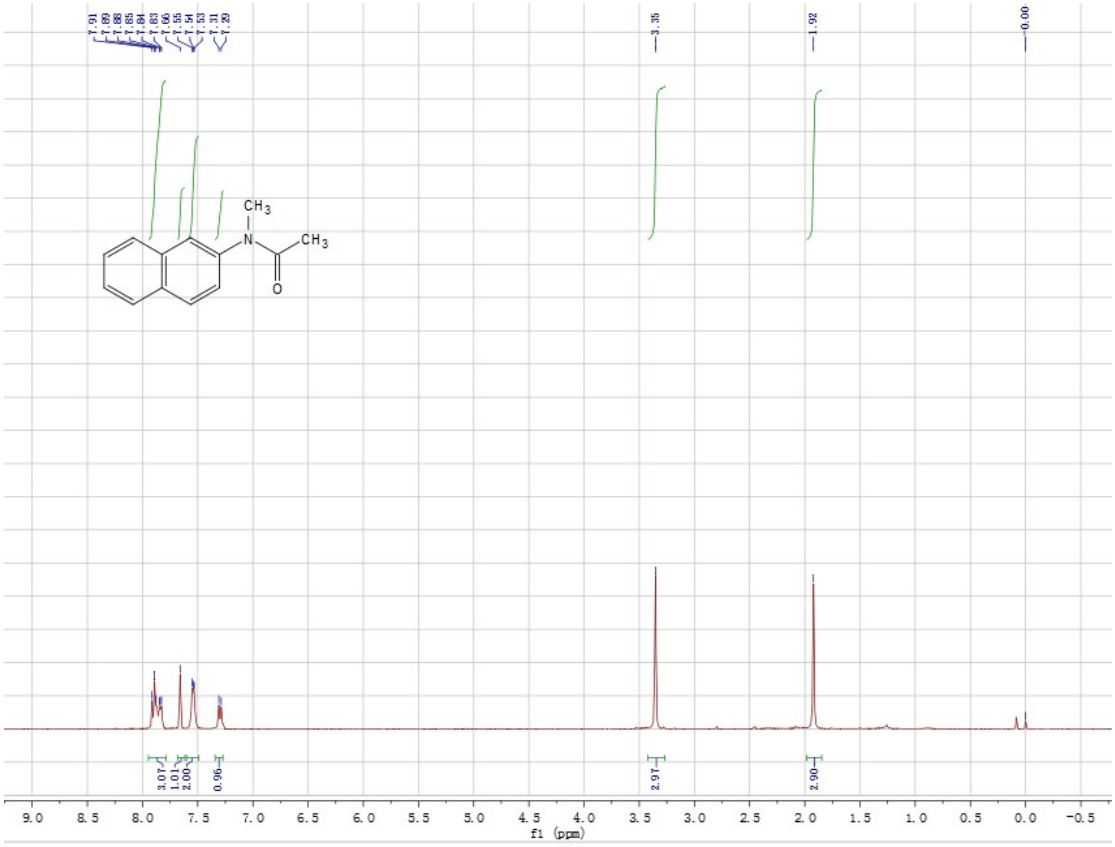

170.90
141.76
135.62
128.99
128.95
128.17
77.48
77.16
76.84
31.26
21.31
17.64
f1 (ppm)


7.70
7.68
7.42
7.40
7.38
7.31
7.29
7.25
7.24
3.20
1.81
0.00
H3C
O
N
CH3
Br
0.97
1.03
2.02
3.00
3.02
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)


170.54
143.27
134.00
129.88
129.76
129.15
123.45
77.48
77.16
76.84
35.80
22.23
H3C
O
N
CH3
Br
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.38
7.35
7.34
7.27
7.22
7.20
7.18
7.15
7.14
7.12
3.18
2.45
1.81
0.00
H3C
O
N
CH3
S
CH3
0.98
1.97
0.97
2.97
3.00
2.97
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)


171.07
140.89
136.59
129.02
128.26
125.54
124.91
77.48
77.15
76.84
35.18
21.92
14.15
H3C
O
N
CH3
S
CH3
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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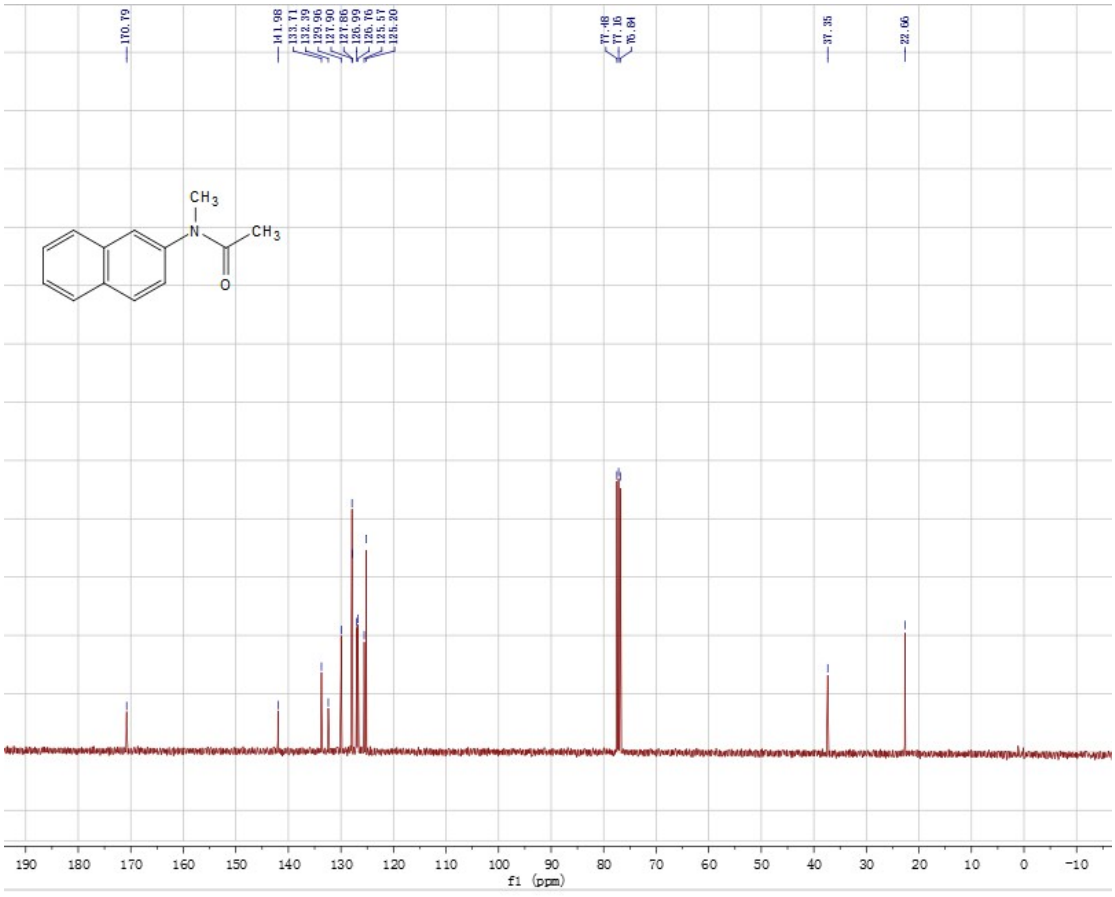
7.89
7.88
7.85
7.84
7.83
7.66
7.55
7.54
7.53
7.31
7.29
3.35
1.92
0.00
CH3
N
CH3
O
3.07
1.01
2.00
0.96
2.97
2.90
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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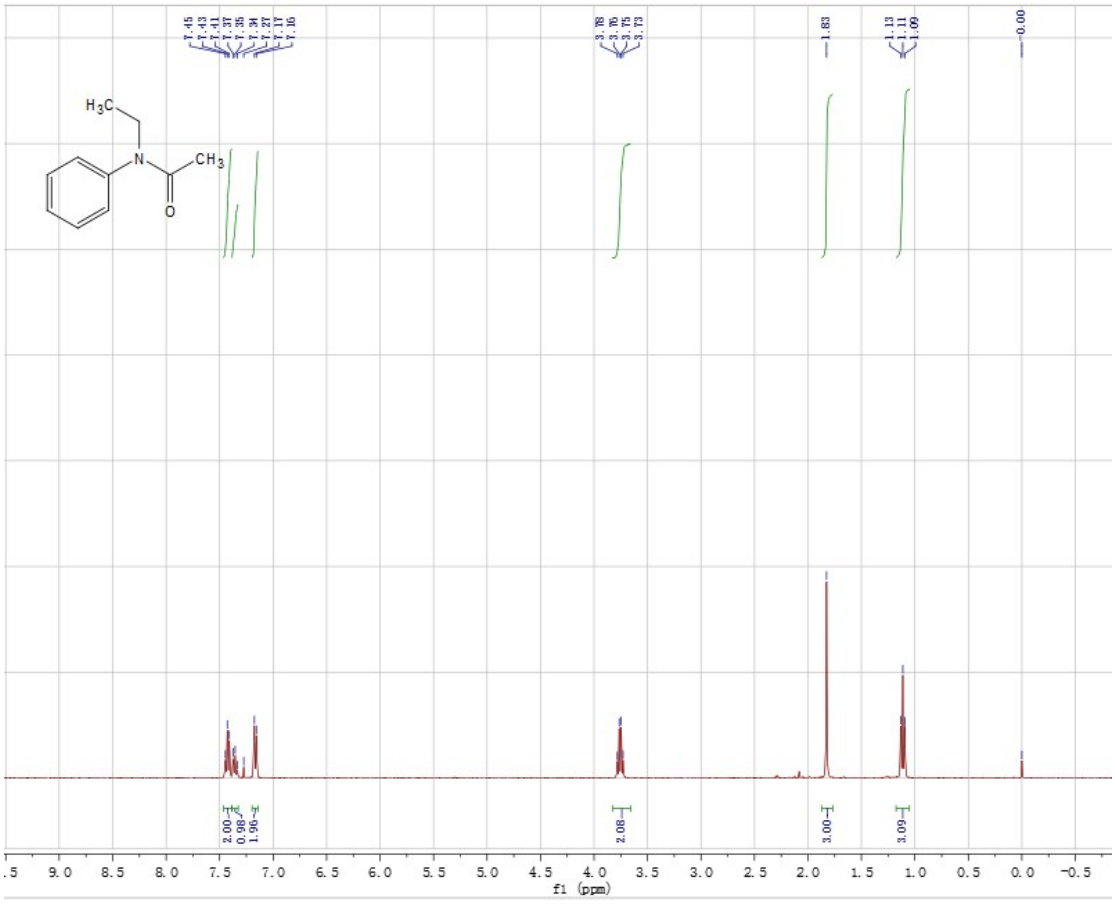
132.39
129.96
127.90
127.86
126.99
126.76
125.57
125.20
77.48
77.16
76.84
37.35
22.66
CH3
N
CH3
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.45
7.43
7.41
7.37
7.35
7.34
7.27
7.17
7.16
3.78
3.76
3.75
3.73
1.83
1.13
1.11
1.09
0.00
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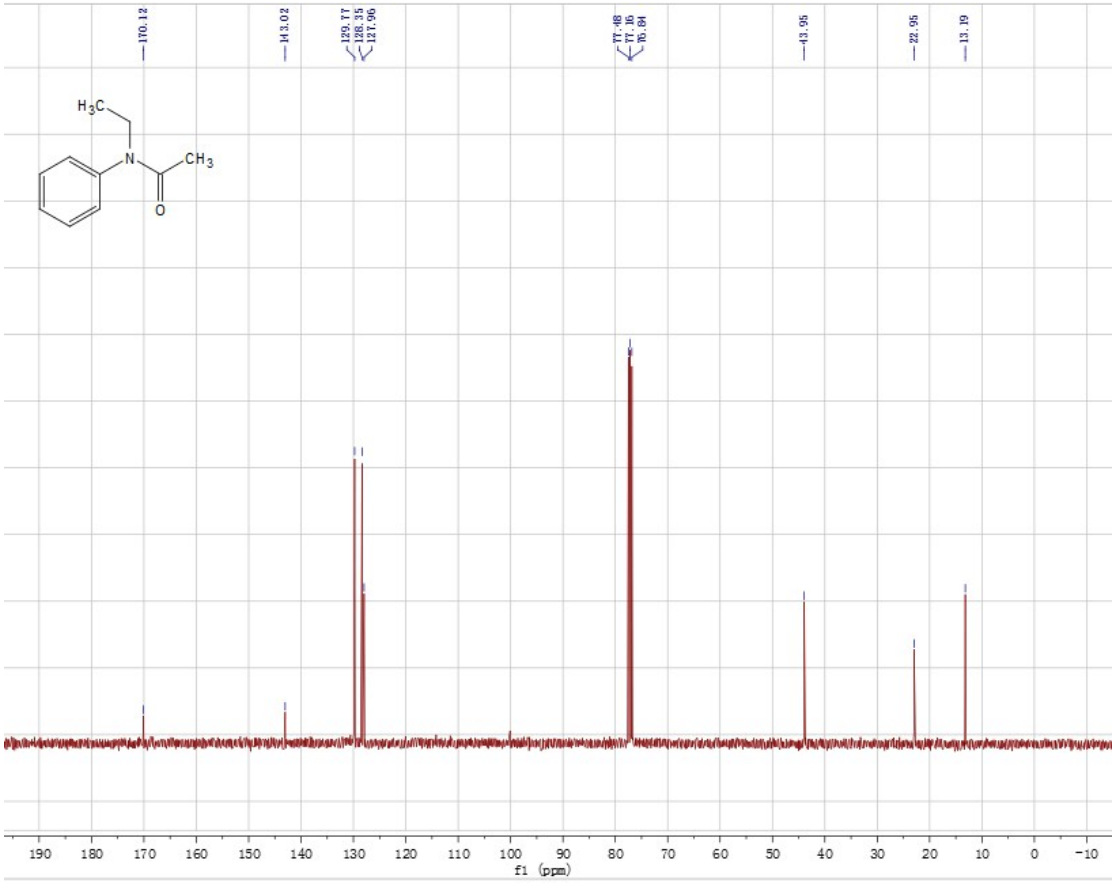
N
CH3
O
2.00
0.98
1.96
2.08
3.00
3.09
f1 (ppm)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143.02
129.77
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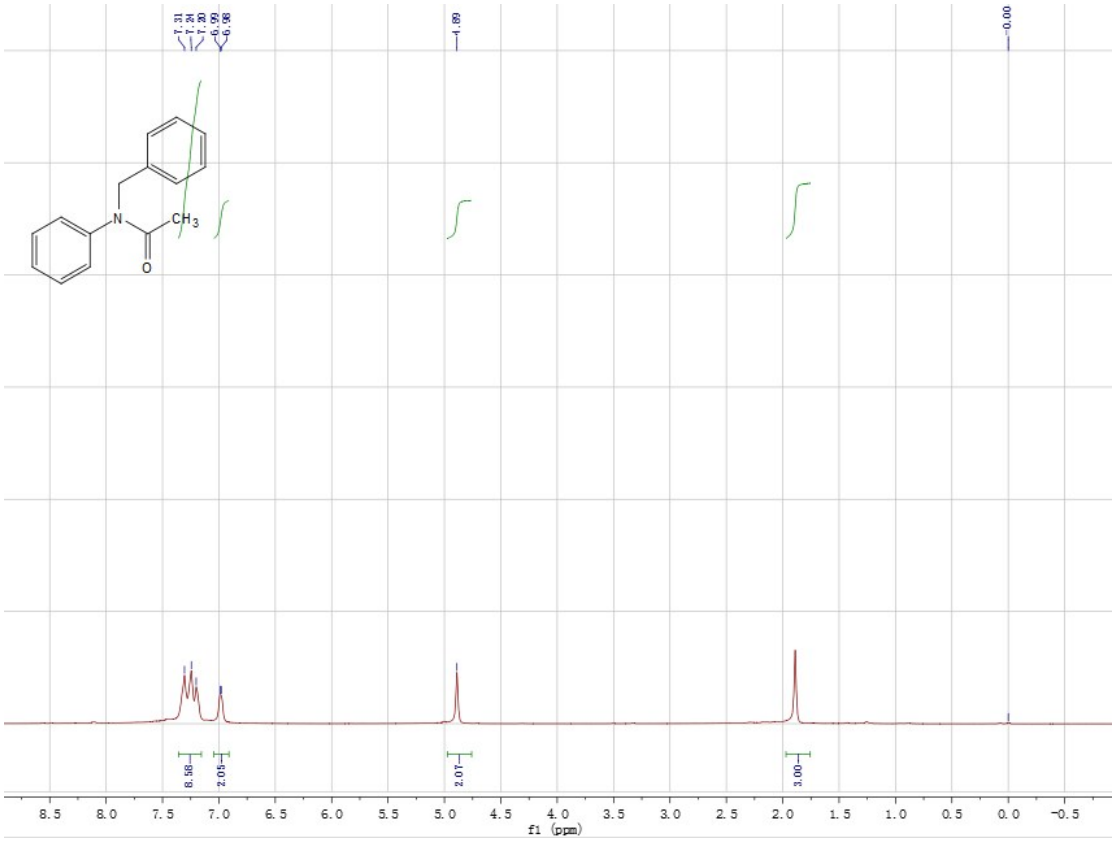
77.16
76.84
43.95
22.95
13.19
H3C
N
CH3
O
f1 (ppm)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7.24
7.20
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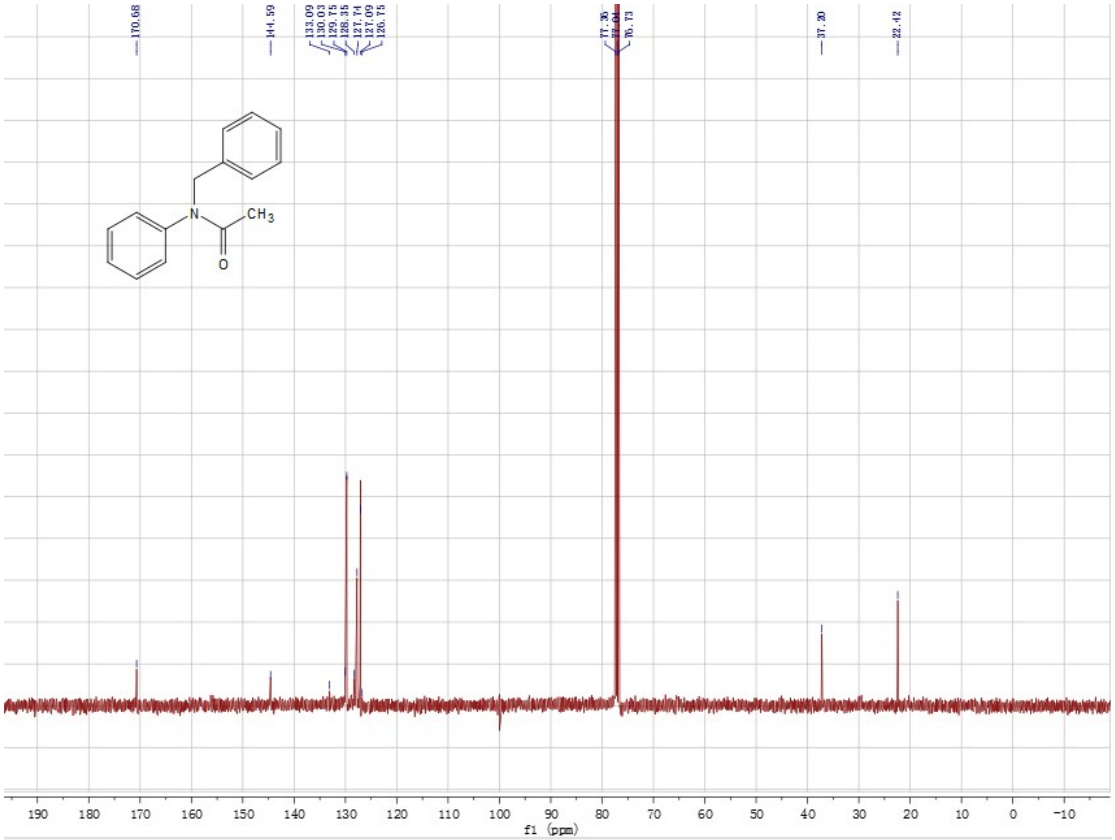
6.98
4.89
0.00
N
CH3
O
8.58
2.05
2.07
3.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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144.59
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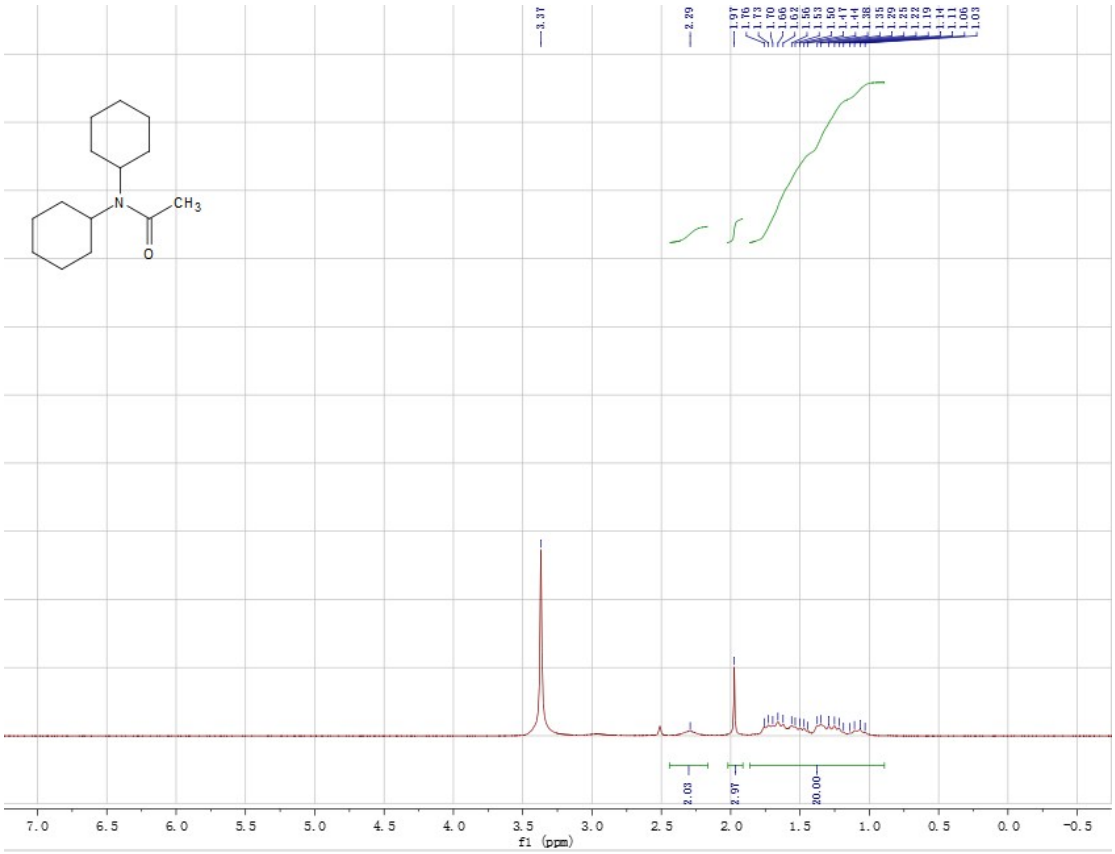
130.03
129.75
128.35
127.74
127.09
126.75
77.26
77.04
76.73
37.20
22.42
N
CH3
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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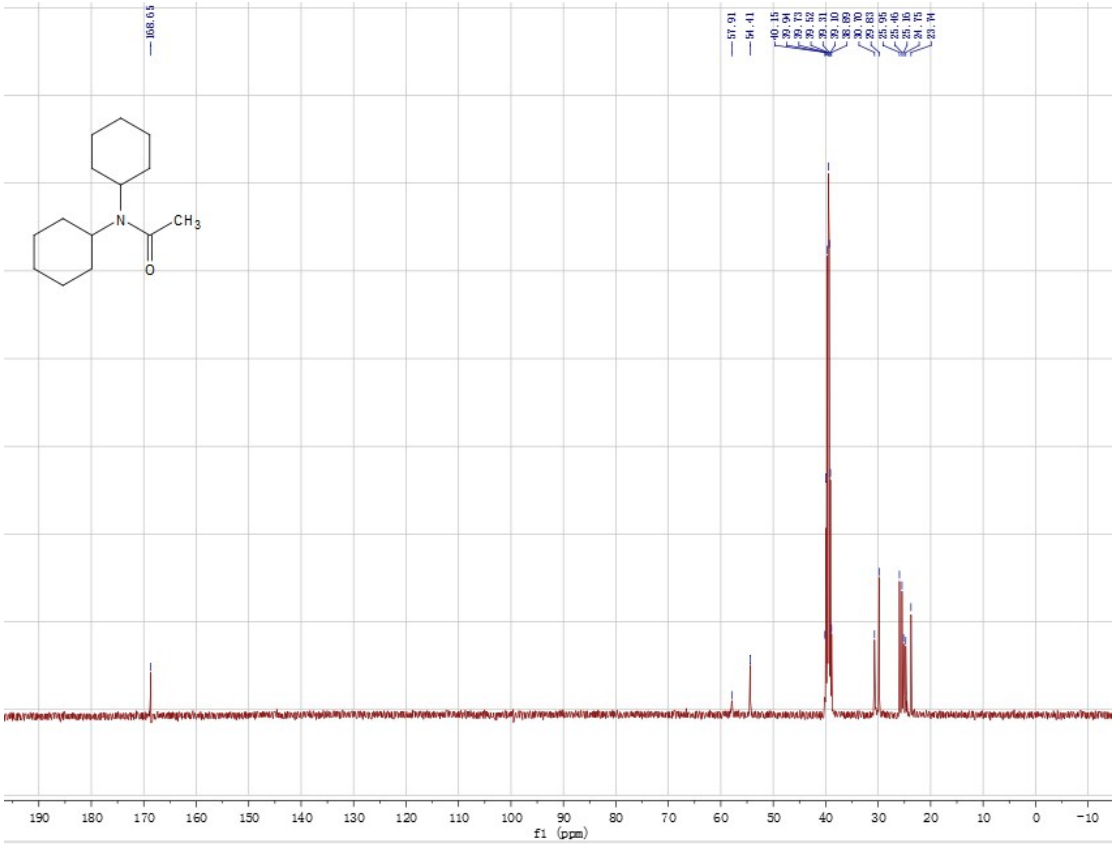
1.70
1.66
1.62
1.56
1.53
1.50
1.47
1.44
1.38
1.35
1.29
1.25
1.22
1.19
1.14
1.11
1.06
1.03
N
CH3
O
2.03
2.97
20.00
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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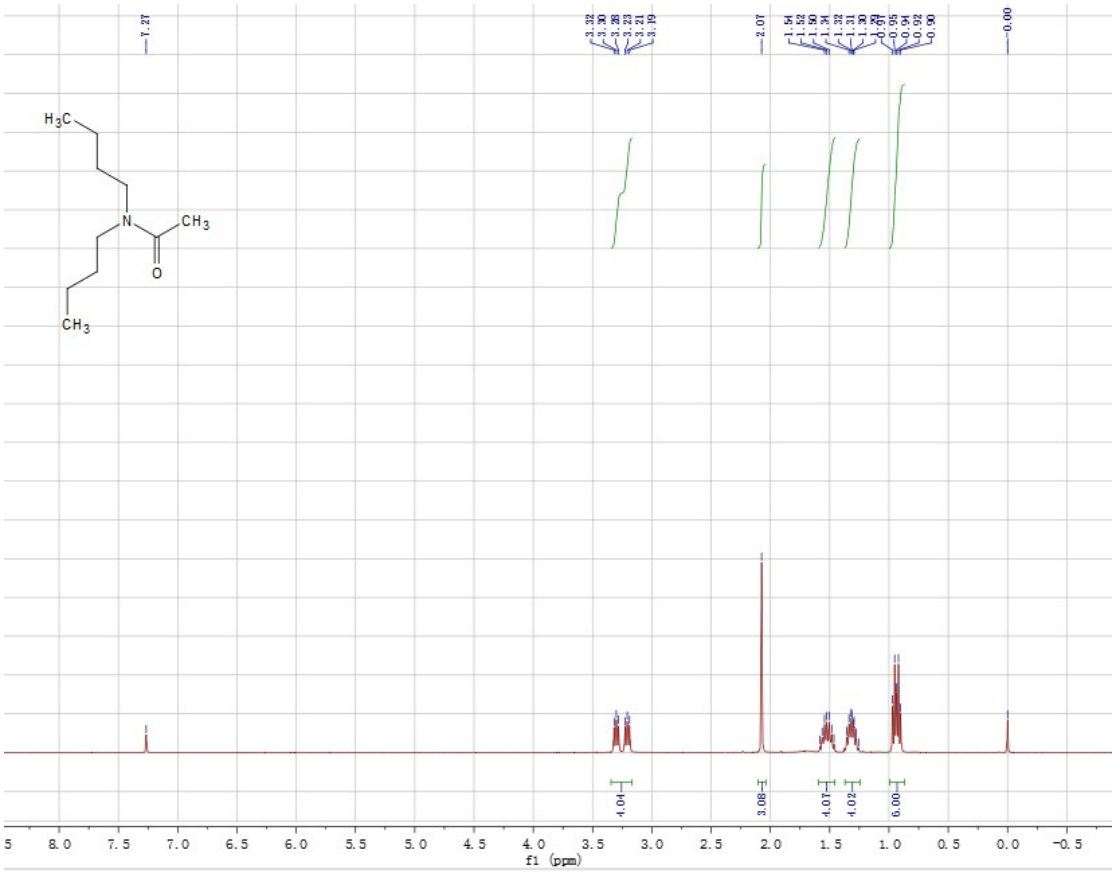
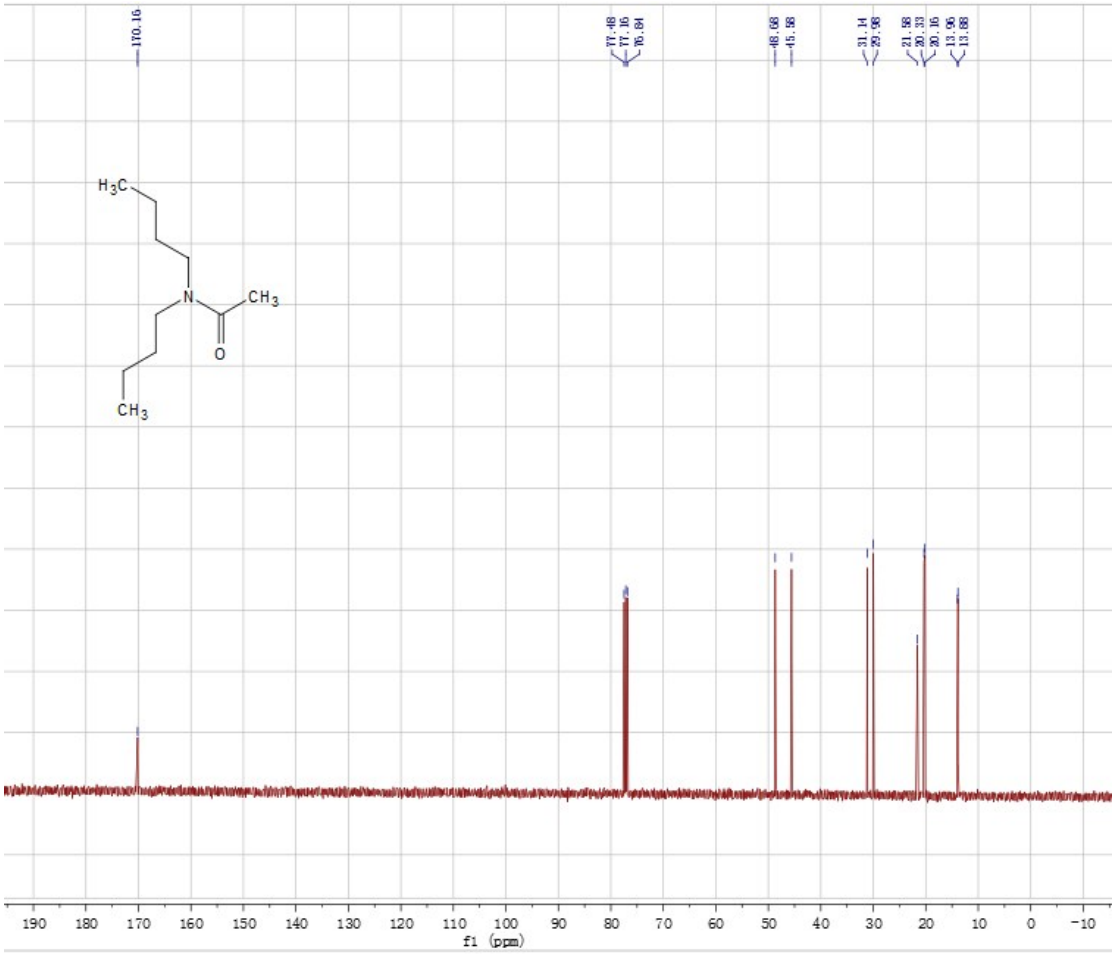
39.73
39.52
39.31
39.10
38.89
30.70
29.53
25.95
25.40
25.16
24.75
23.94
N
CH3
O
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


1.27
3.32
3.30
3.28
3.23
3.21
3.19
2.07
1.54
1.52
1.50
1.34
1.32
1.31
1.30
0.97
0.95
0.94
0.92
0.90
0.00
H3C
N
CH3
O
CH3
4.04
3.08
4.07
4.02
6.00
f1 (ppm)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77.48
77.16
76.84
48.68
45.98
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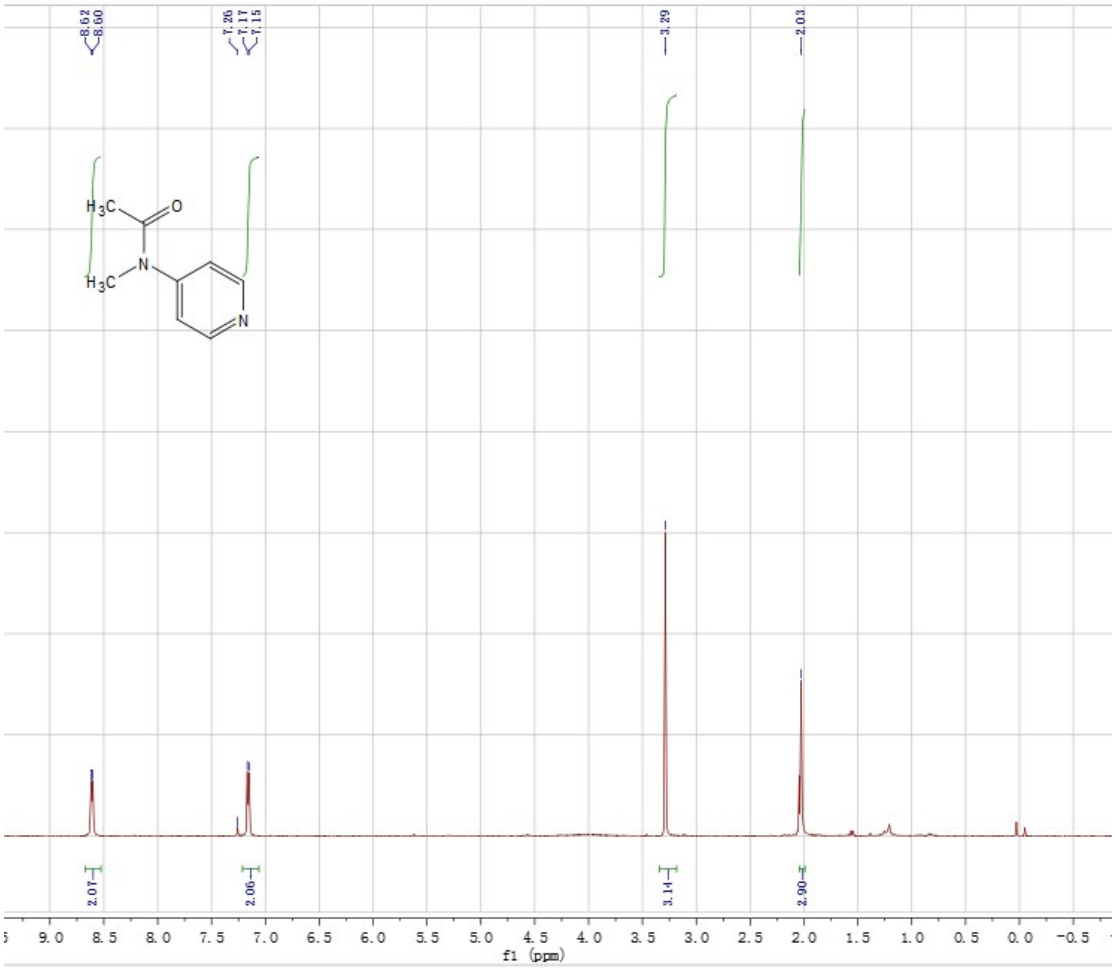
29.98
21.88
20.33
20.16
13.96
13.88
H3C
N
CH3
O
CH3
f1 (ppm)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8.60
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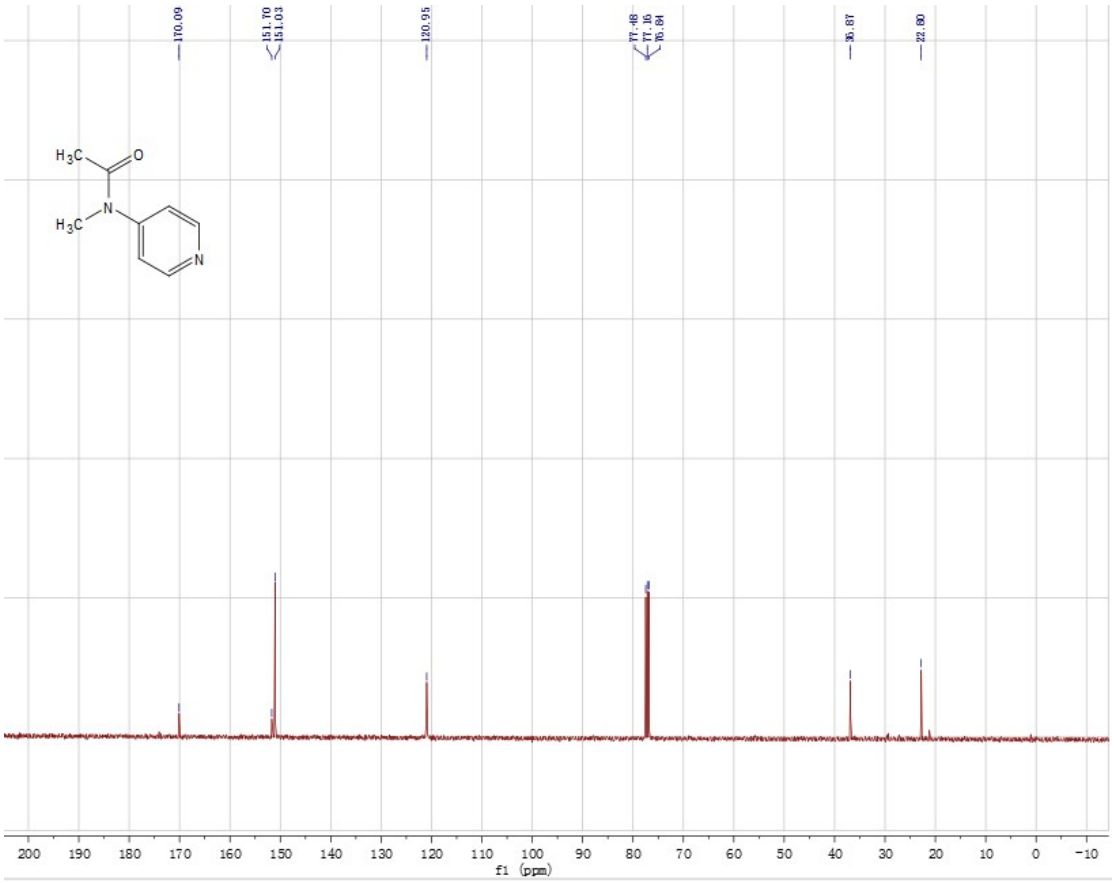
3.29
2.03
2.07
2.06
3.14
2.90
f1 (ppm)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151.70
151.03
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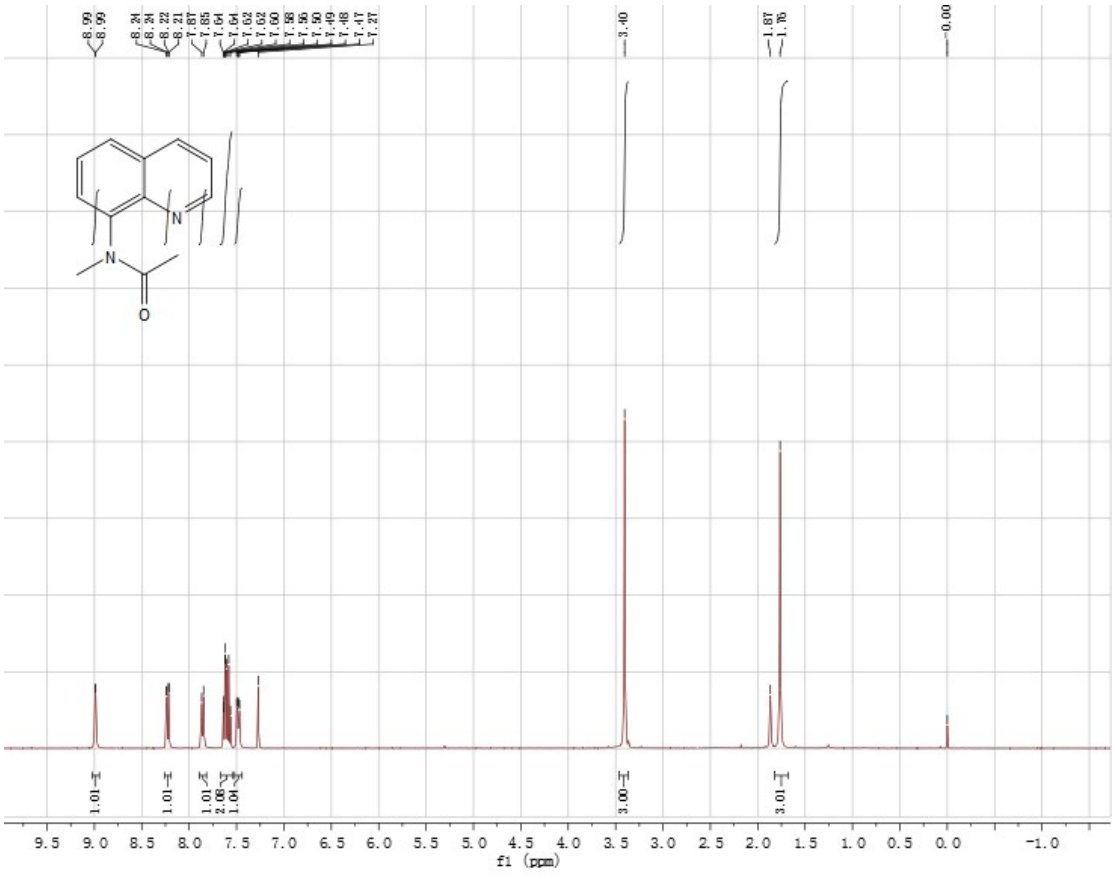
77.48
77.16
76.84
36.87
22.80
f1 (ppm)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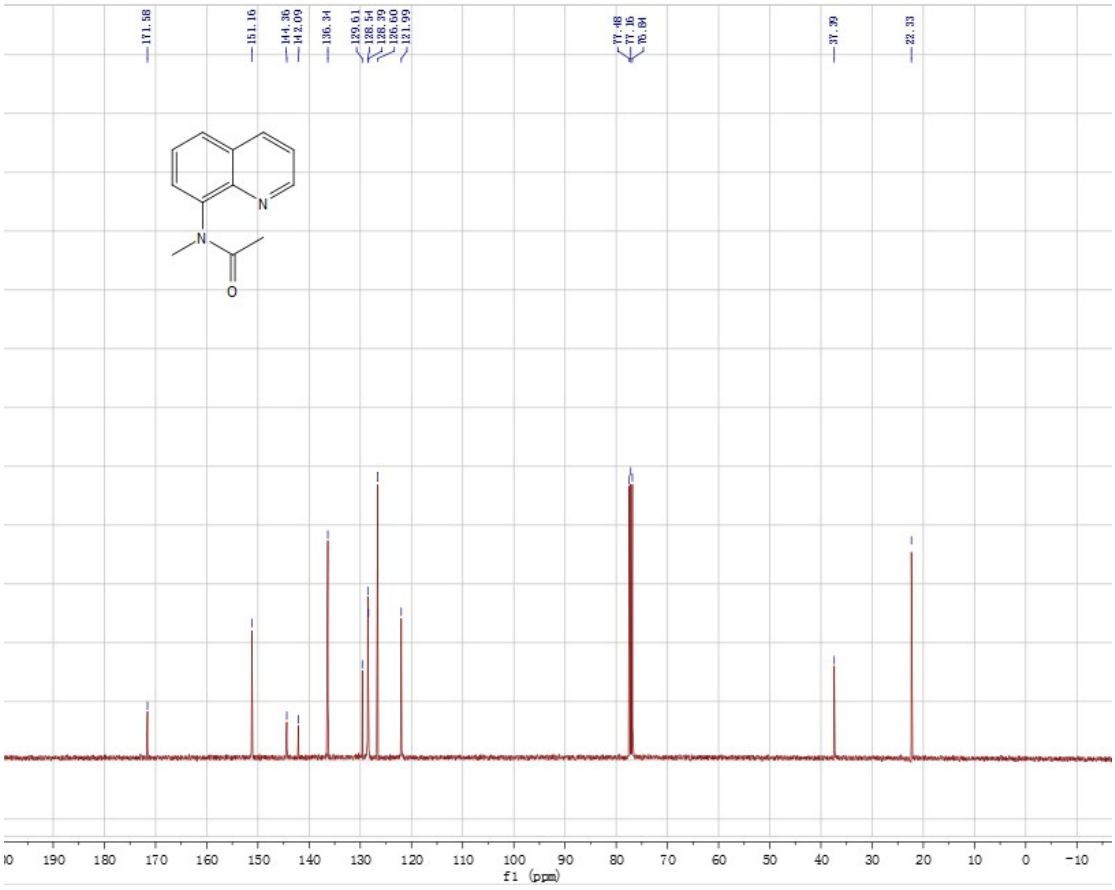
8.99
8.24
8.24
8.22
8.21
7.87
7.85
7.64
7.64
7.62
7.62
7.60
7.58
7.56
7.50
7.49
7.48
7.47
7.27
3.40
1.87
1.76
0.00
1.01
1.01
1.01
2.08
1.04
3.00
3.01
f1 (ppm)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144.36
142.09
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129.61
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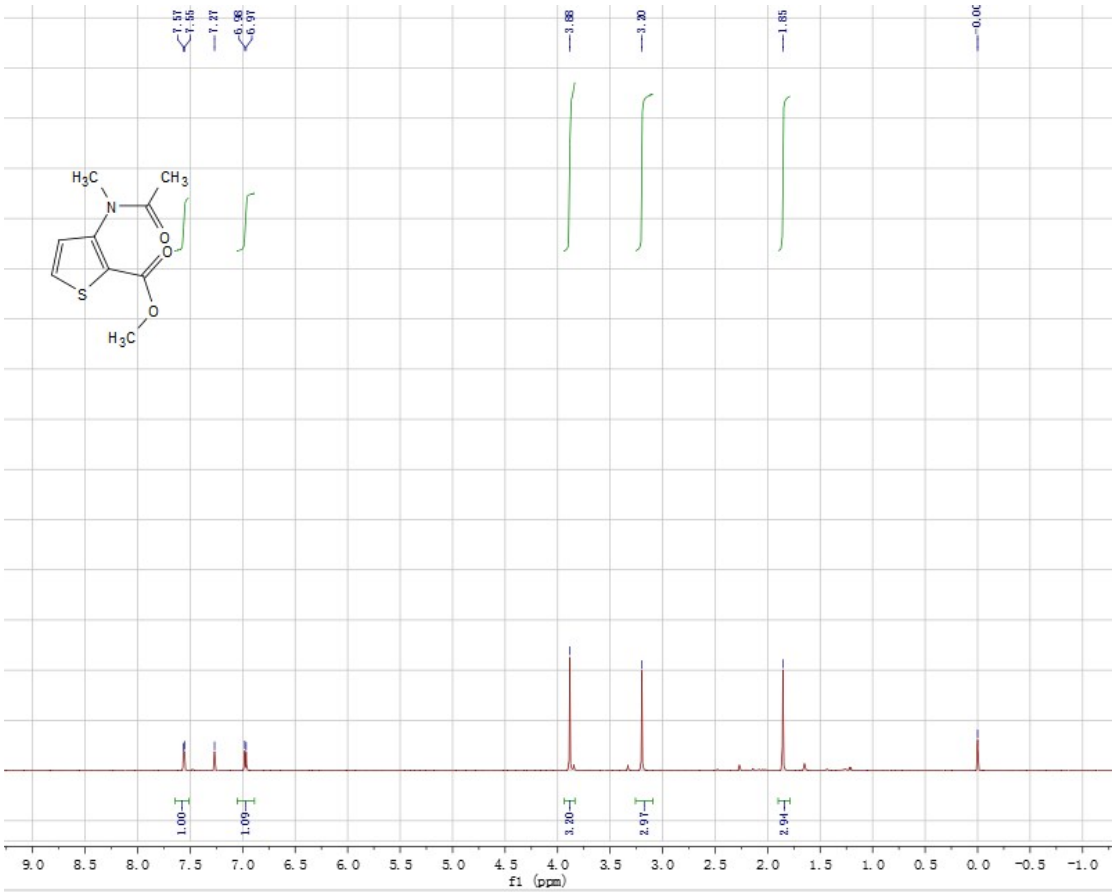
128.39
126.60
121.99
77.48
77.16
76.84
37.39
22.33
f1 (ppm)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7.55
7.27
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6.97
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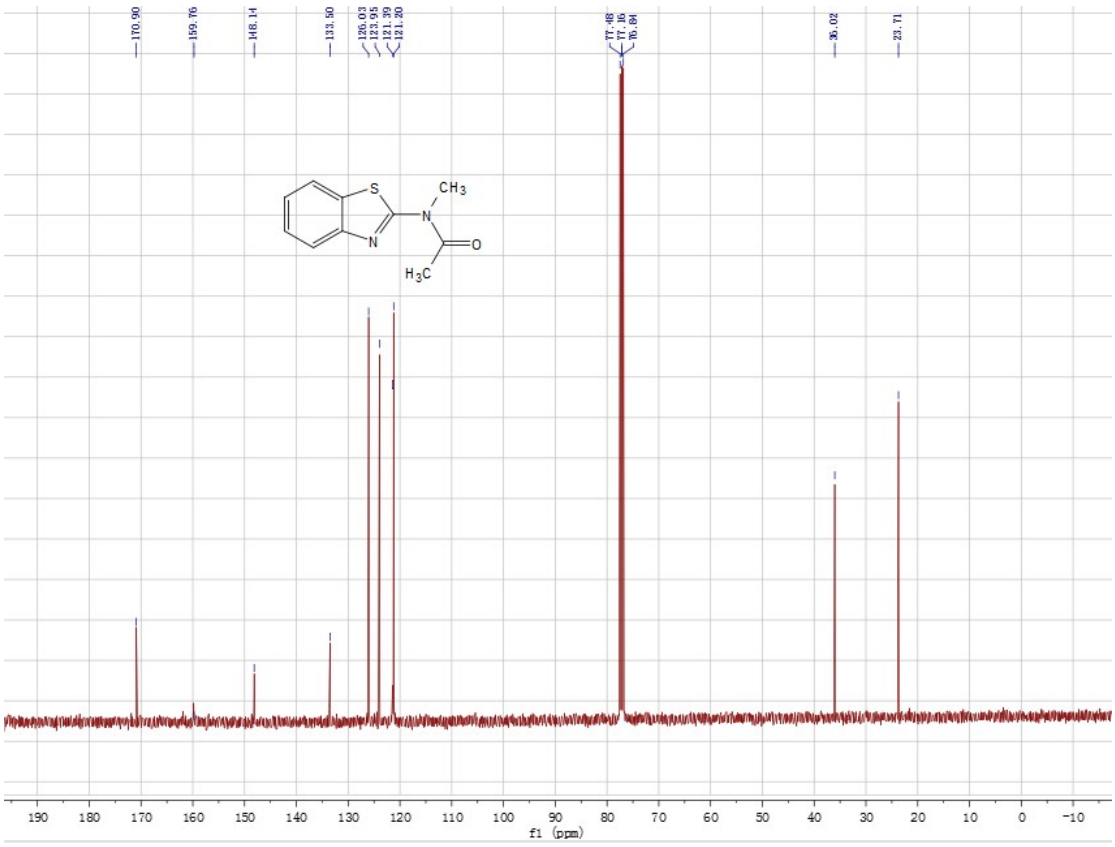
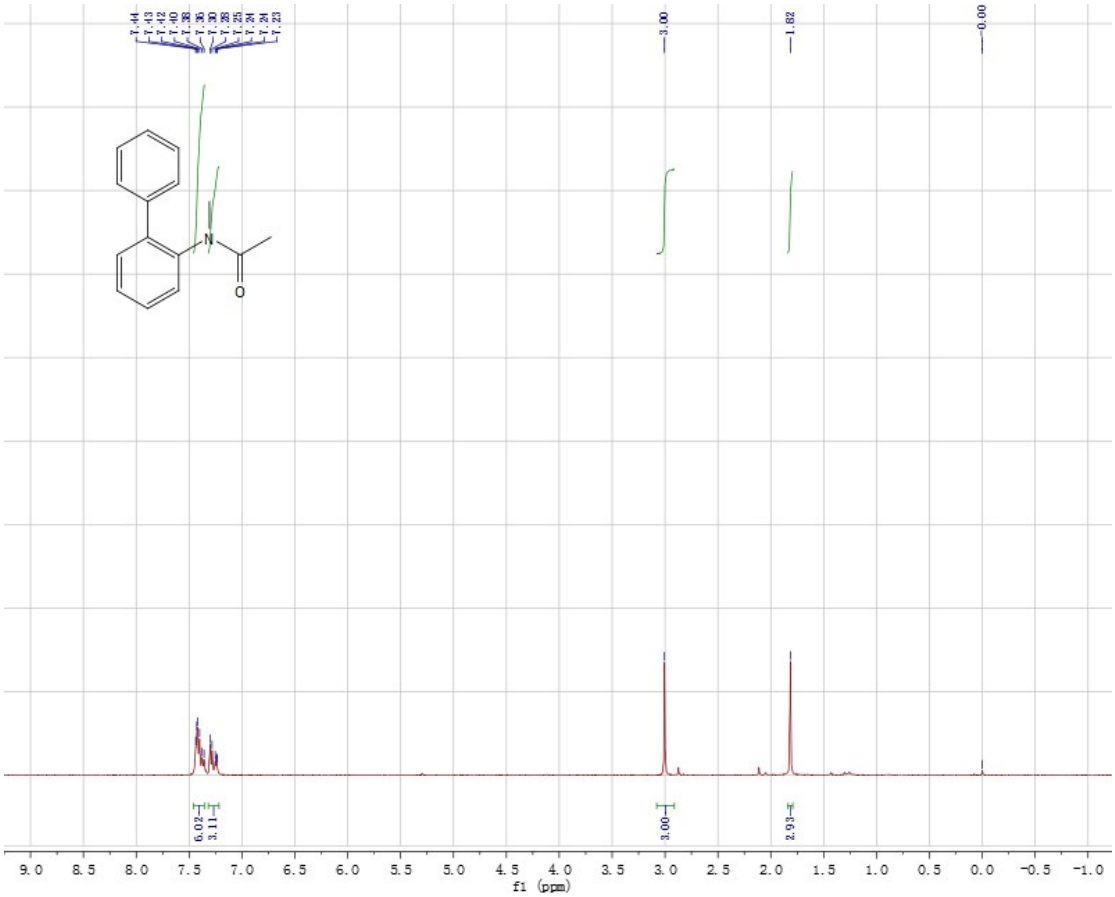
3.20
1.85
0.00
1.00
1.09
3.20
2.97
2.94
f1 (ppm)


170.90
159.76
148.14
133.50
126.03
123.95
121.39
121.20
77.48
77.16
76.84
36.02
23.71
S
N
CH3
N
O
H3C
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.28
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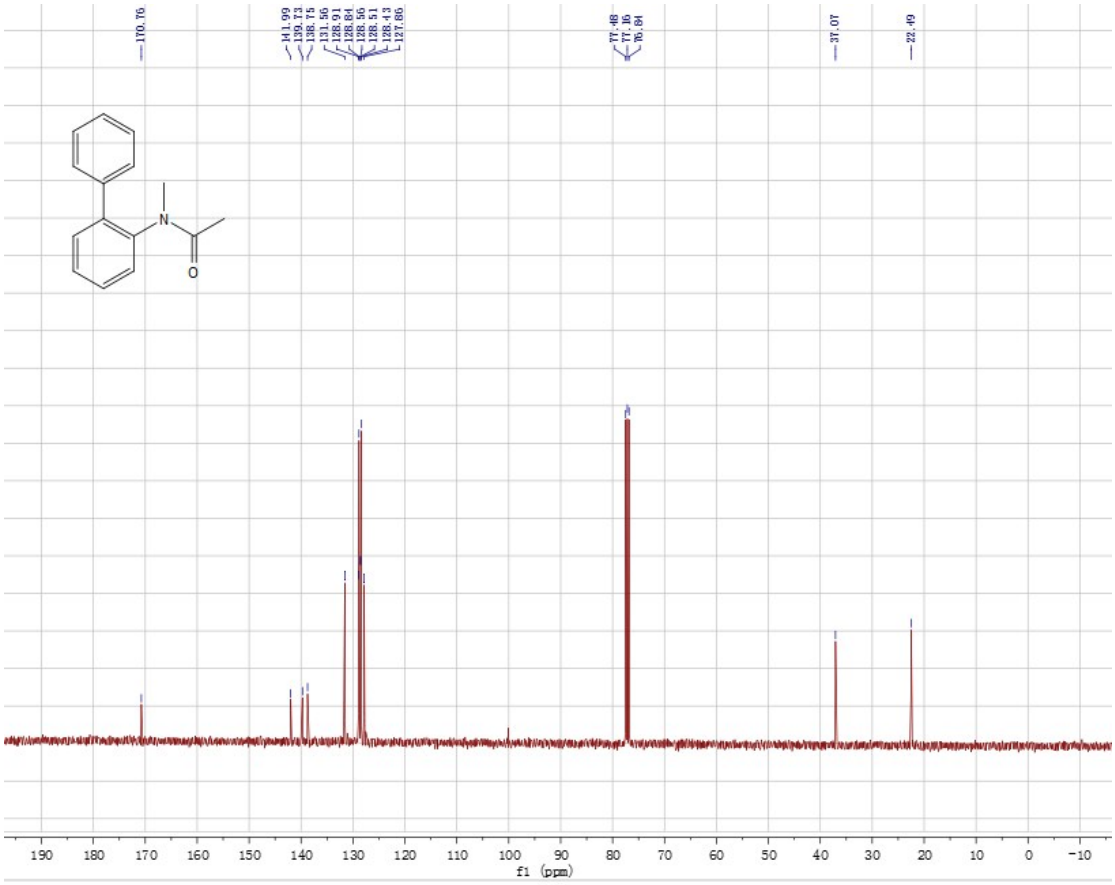
7.24
7.24
7.23
3.00
1.82
0.00
N
O
6.02
3.11
3.00
2.93
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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128.56
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128.43
127.86
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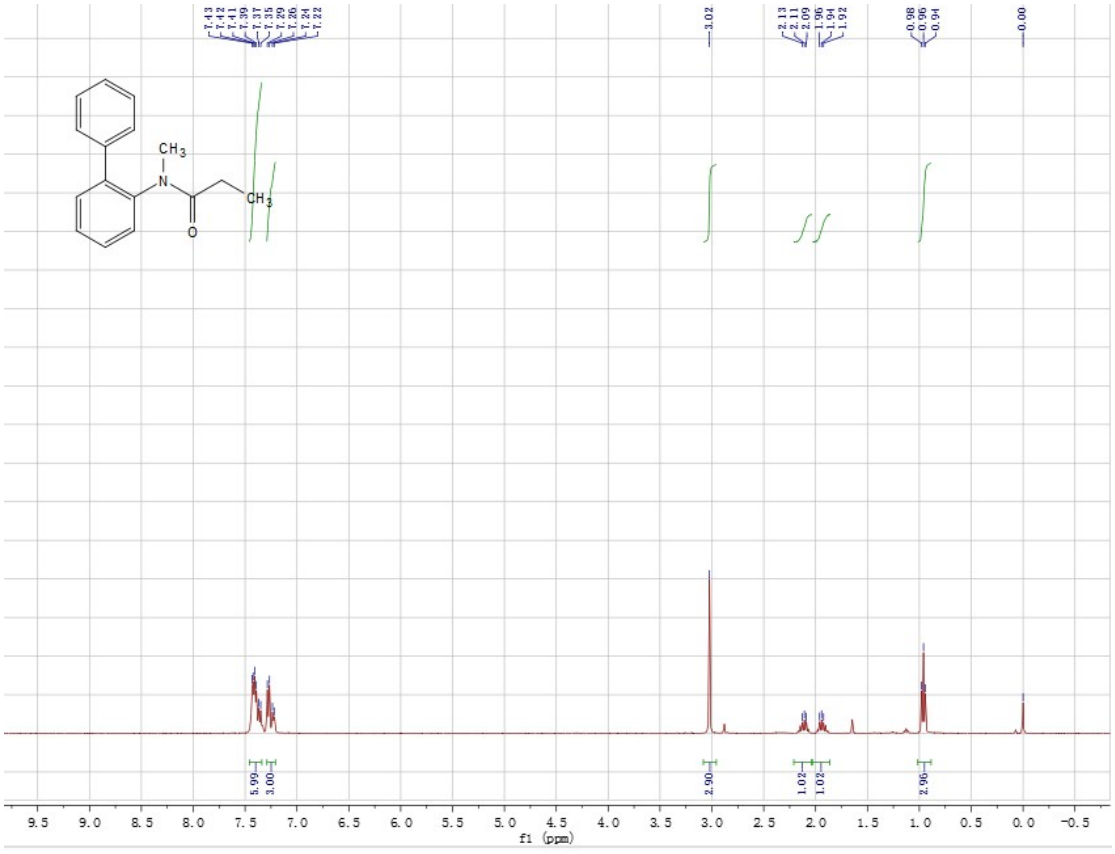
77.15
76.84
37.07
22.49
N
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)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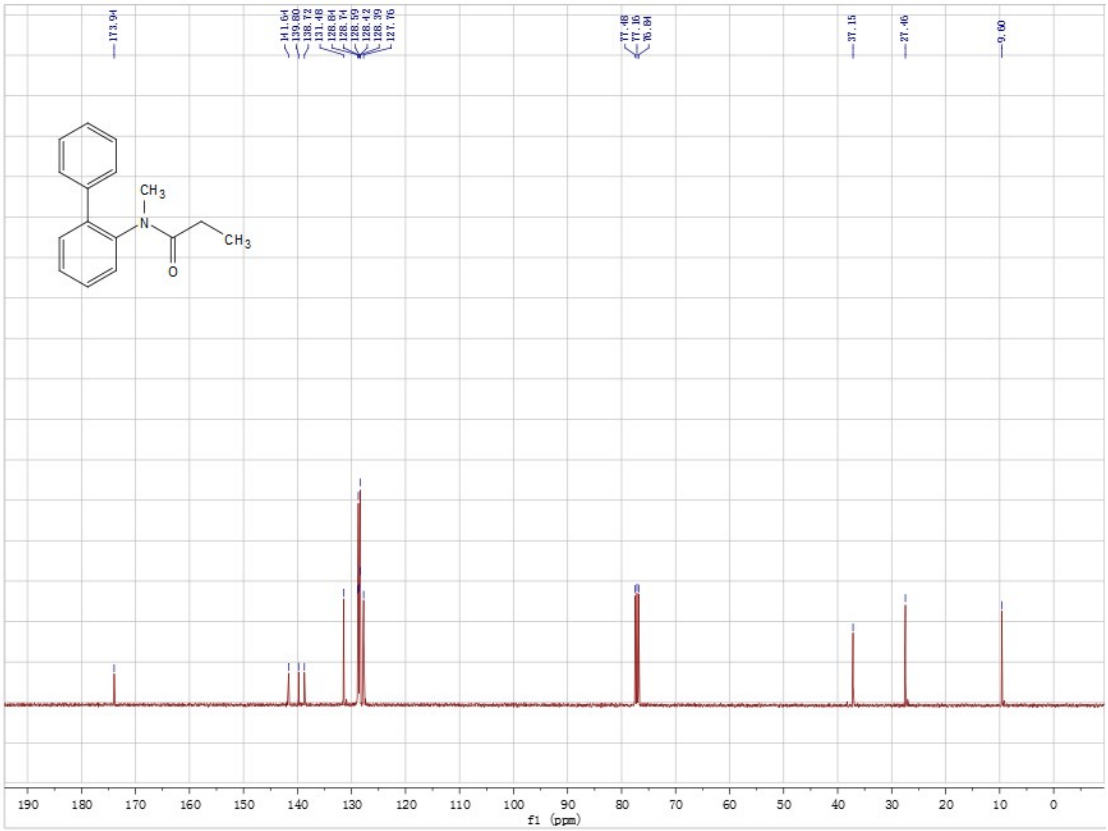
7.41
7.39
7.37
7.35
7.29
7.26
7.24
7.22
3.02
2.13
2.11
2.09
1.96
1.94
1.92
0.98
0.96
0.94
0.00
CH3
N
CH3
O
5.99
3.00
2.90
1.02
1.02
2.96
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)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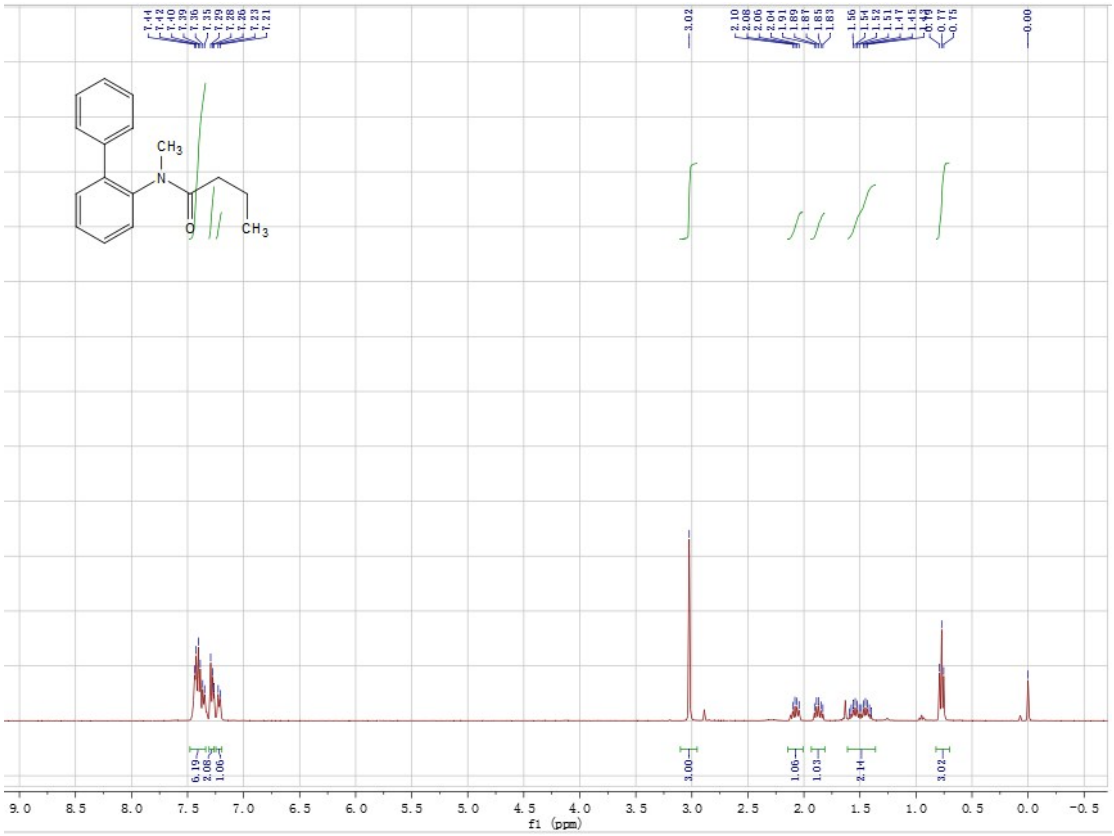
77.16
76.84
37.15
27.46
9.60
CH3
N
CH3
O
f1 (ppm)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7.42
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7.36
7.35
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7.26
7.23
7.21
3.02
2.10
2.08
2.06
2.04
1.91
1.89
1.87
1.85
1.83
1.56
1.54
1.52
1.51
1.47
1.45
0.77
0.75
0.00
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N
O
CH3
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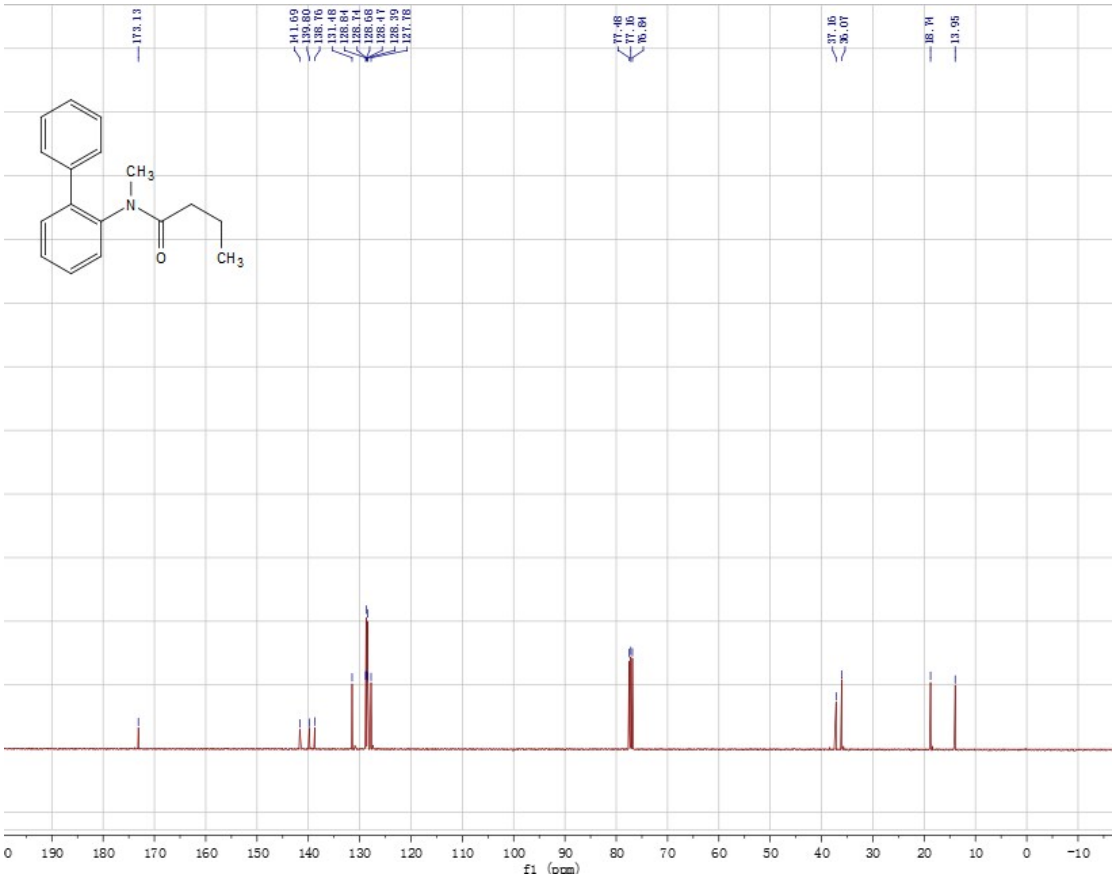
2.08
1.06
3.00
1.06
1.03
2.14
3.02
f1 (ppm)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128.29
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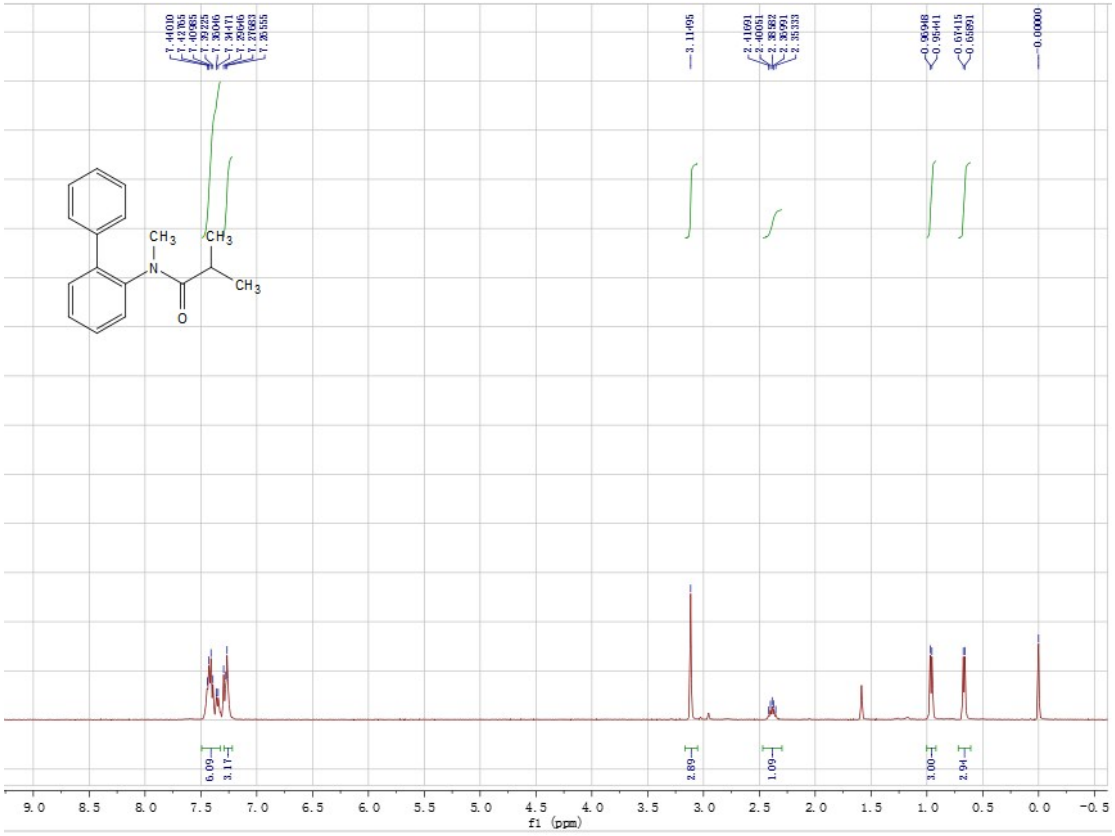
76.84
37.15
36.07
18.74
13.95
CH3
N
O
CH3
f1 (ppm)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7.36046
7.34471
7.29566
7.27683
7.26555
3.11495
2.41691
2.40061
2.38382
2.36991
2.35333
0.95948
0.95441
0.67415
0.65891
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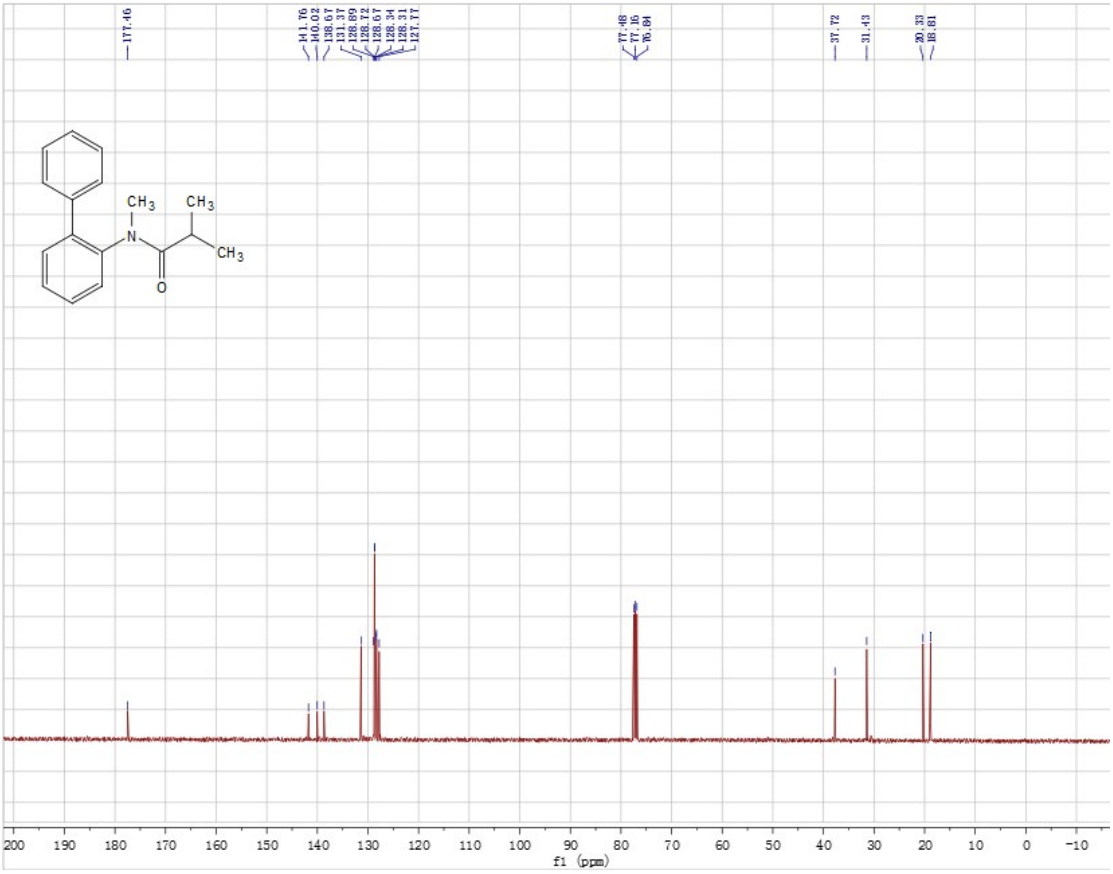
CH3
CH3
N
CH3
O
6.09
3.11
2.89
1.09
3.00
2.94
f1 (ppm)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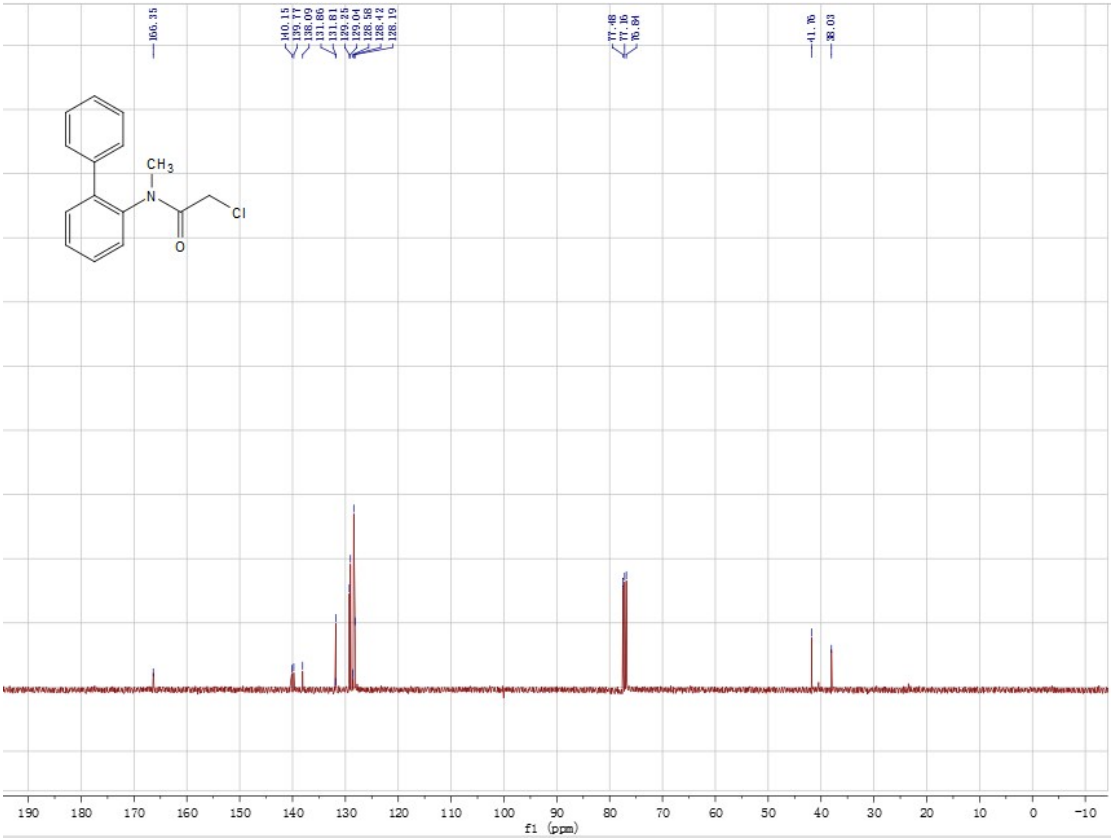
127.77
77.48
77.16
76.84
37.72
31.43
20.33
18.81
CH3
CH3
N
CH3
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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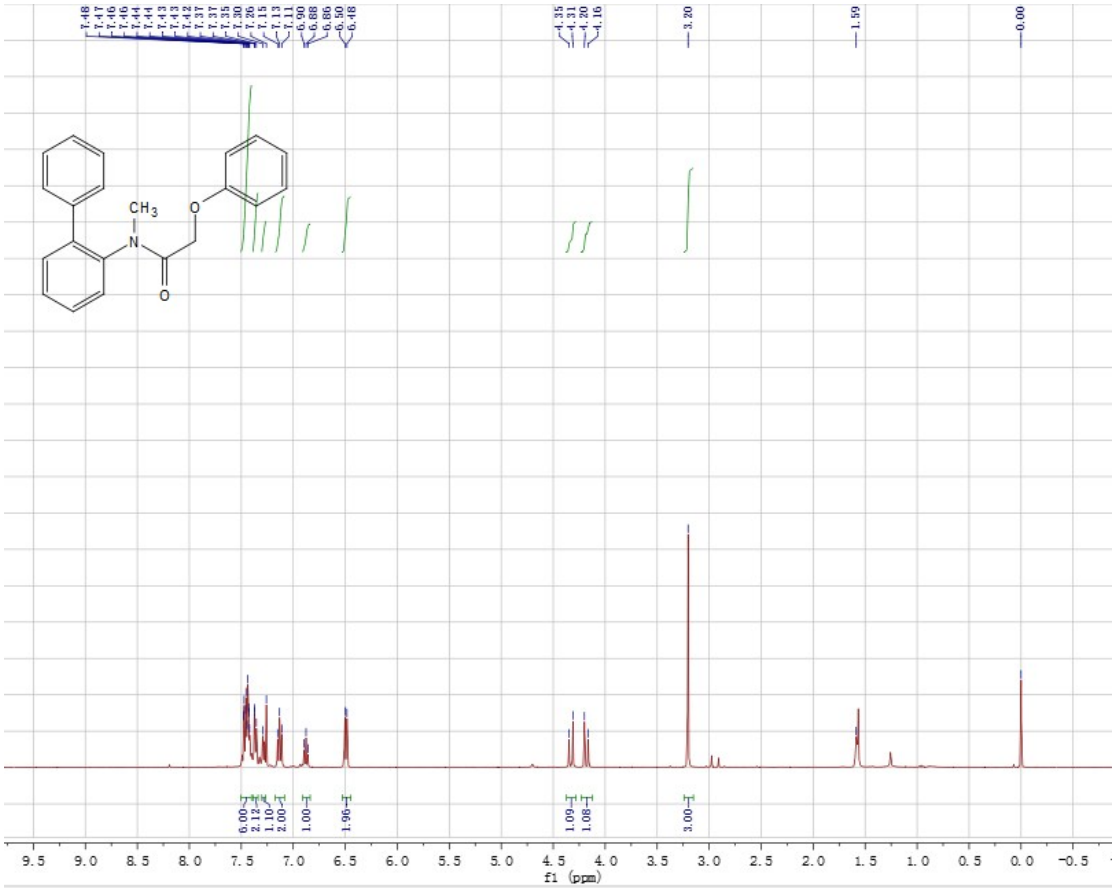
128.19
77.48
77.16
76.84
41.76
38.03
CH3
N
Cl
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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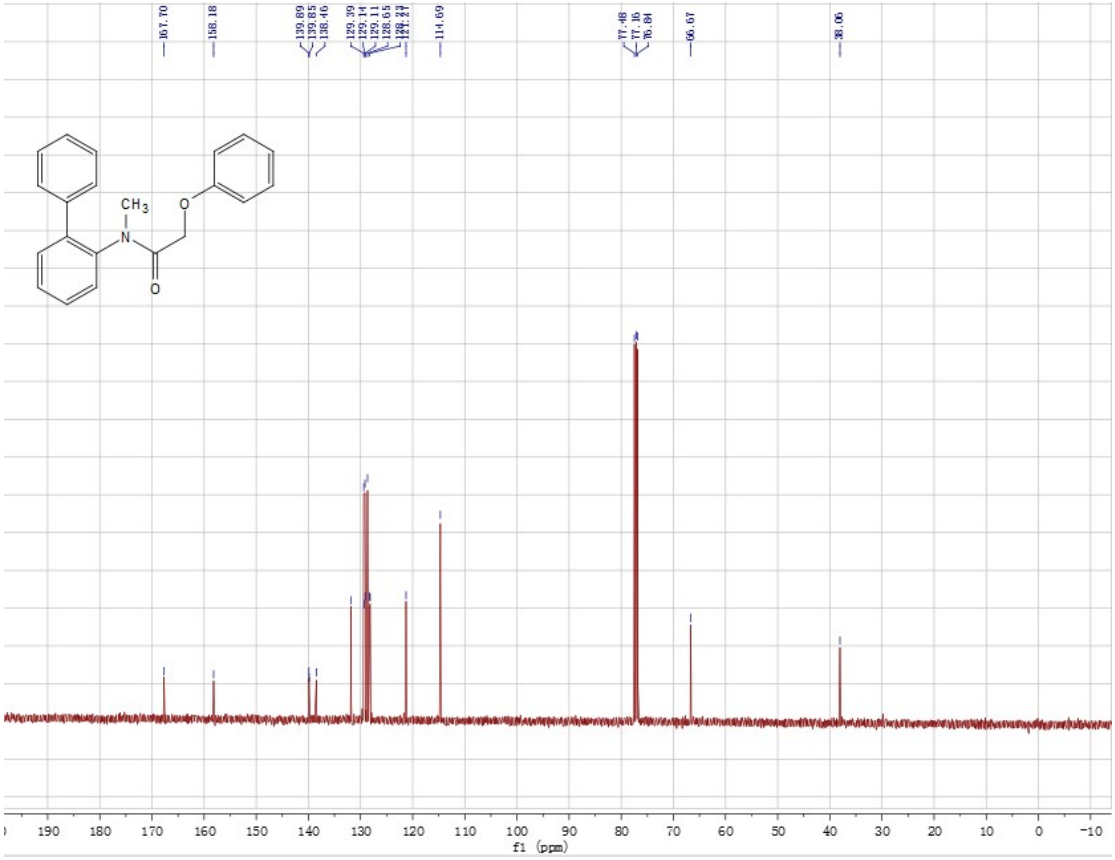
7.35
7.30
7.26
7.15
7.13
7.11
6.90
6.88
6.86
6.90
6.48
4.35
4.31
4.20
4.16
3.20
1.59
0.00
CH3
N
O
O
6.00
2.12
1.10
2.00
1.00
1.96
1.09
1.08
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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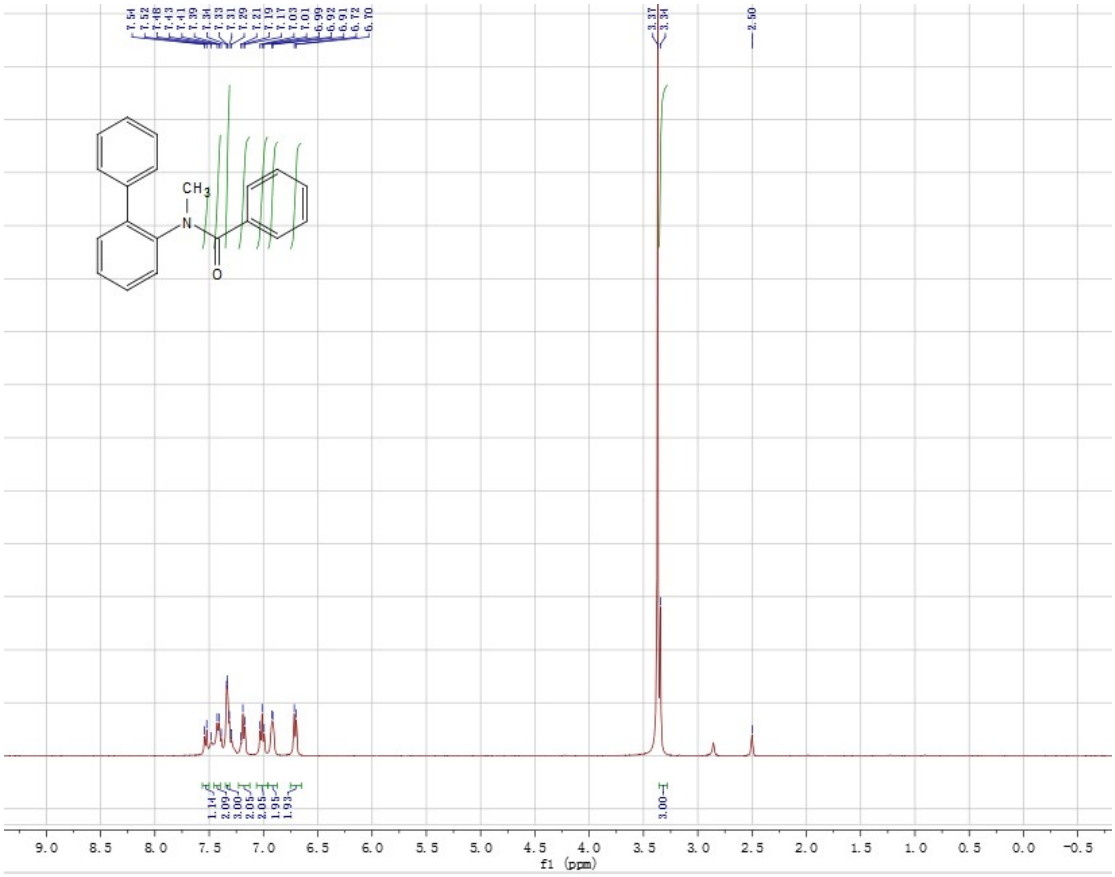
129.39
129.14
129.11
128.65
114.69
77.48
77.16
76.84
66.67
38.06
CH3
N
O
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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7.39
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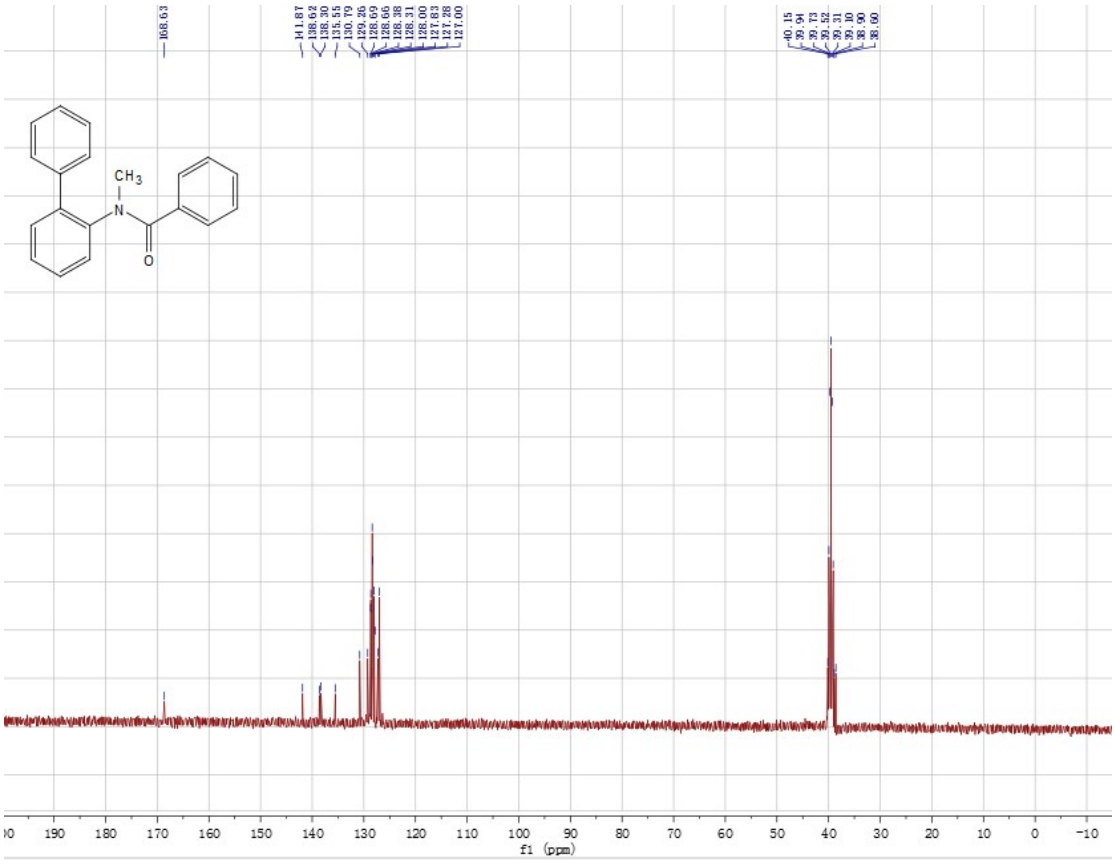
7.31
7.29
7.21
7.19
7.17
7.03
7.01
6.99
6.92
6.91
6.72
6.70
3.37
3.34
2.50
CH3
N
O
1.14
2.09
3.00
2.05
2.05
1.95
1.93
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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141.87
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138.30
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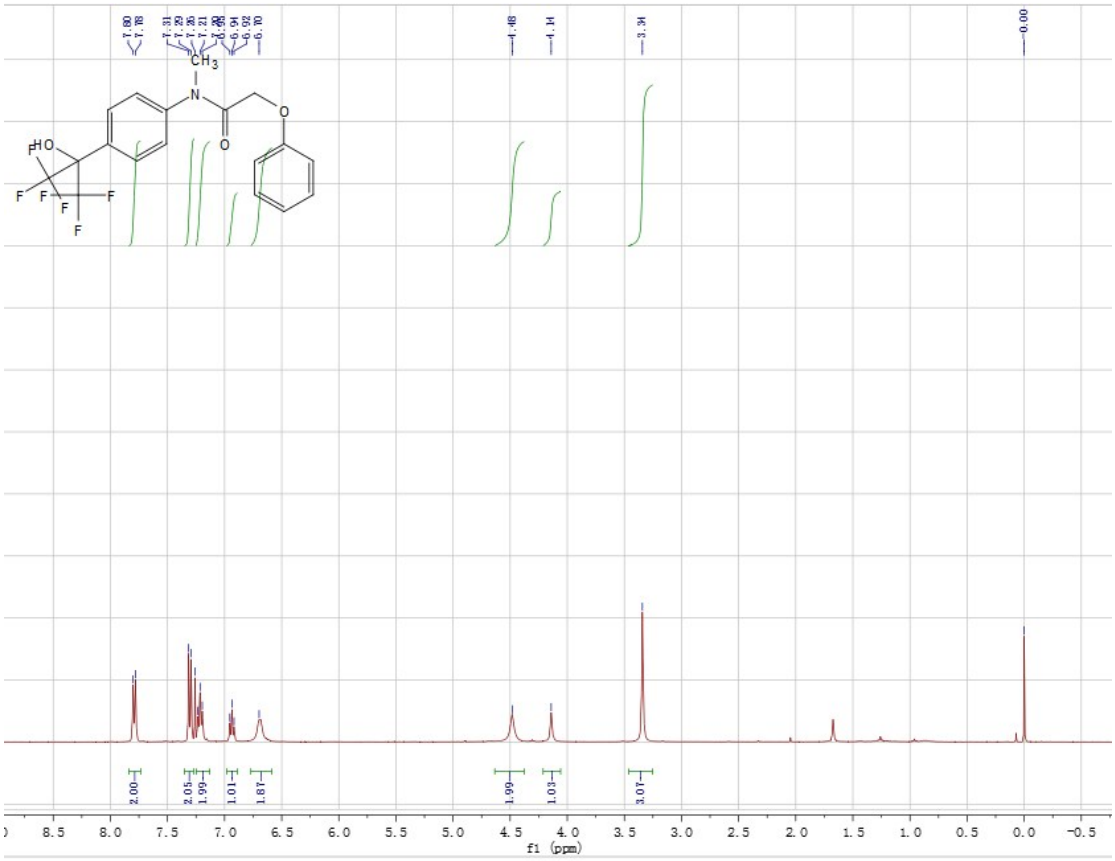
130.79
129.26
128.69
128.66
128.38
128.31
128.00
127.85
127.28
127.00
40.15
39.94
39.73
39.52
39.31
39.10
38.90
38.69
CH3
N
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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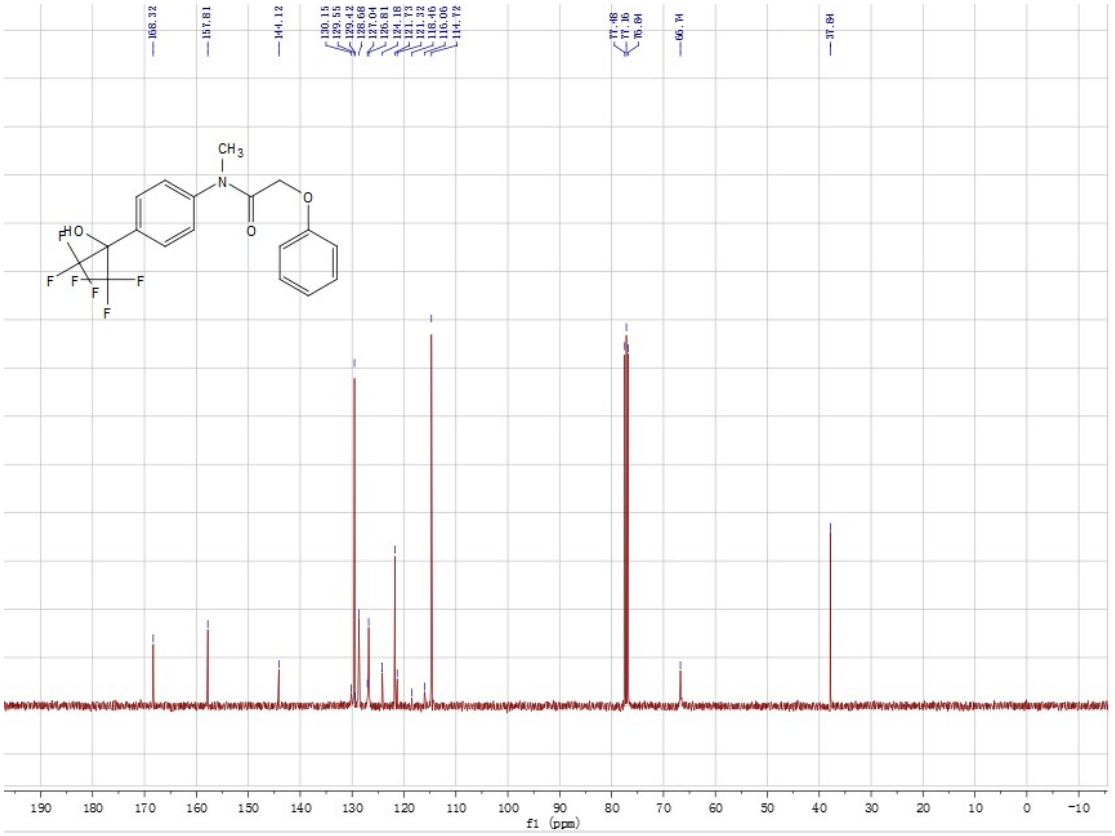
7.26
7.21
6.94
6.92
6.70
4.48
4.14
3.34
0.00
CH3
N
O
O
HO
F
F
F
F
F
2.00
2.05
1.99
1.01
1.87
1.99
1.03
3.07
f1 (ppm)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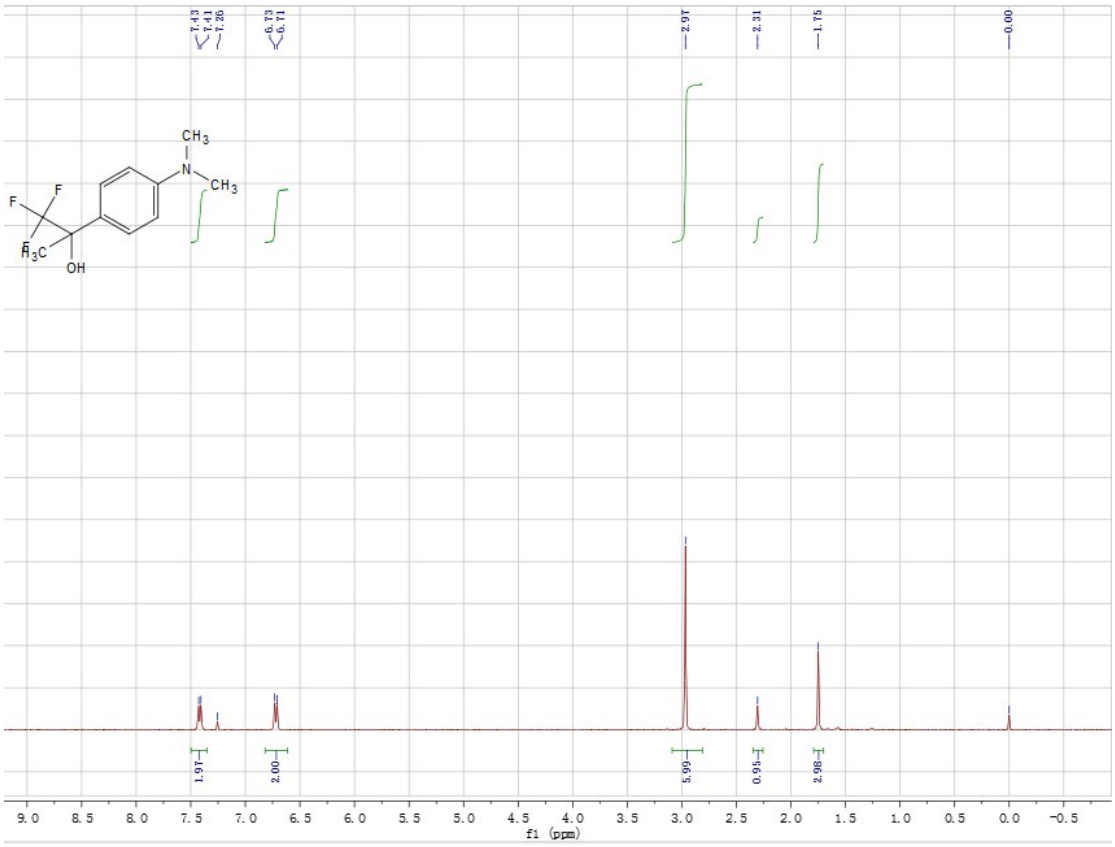
124.18
121.73
121.32
118.46
116.06
114.72
77.48
77.16
76.84
66.74
37.84
CH3
N
O
O
HO
F
F
F
F
F
f1 (ppm)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7.41
7.26
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6.71
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2.31
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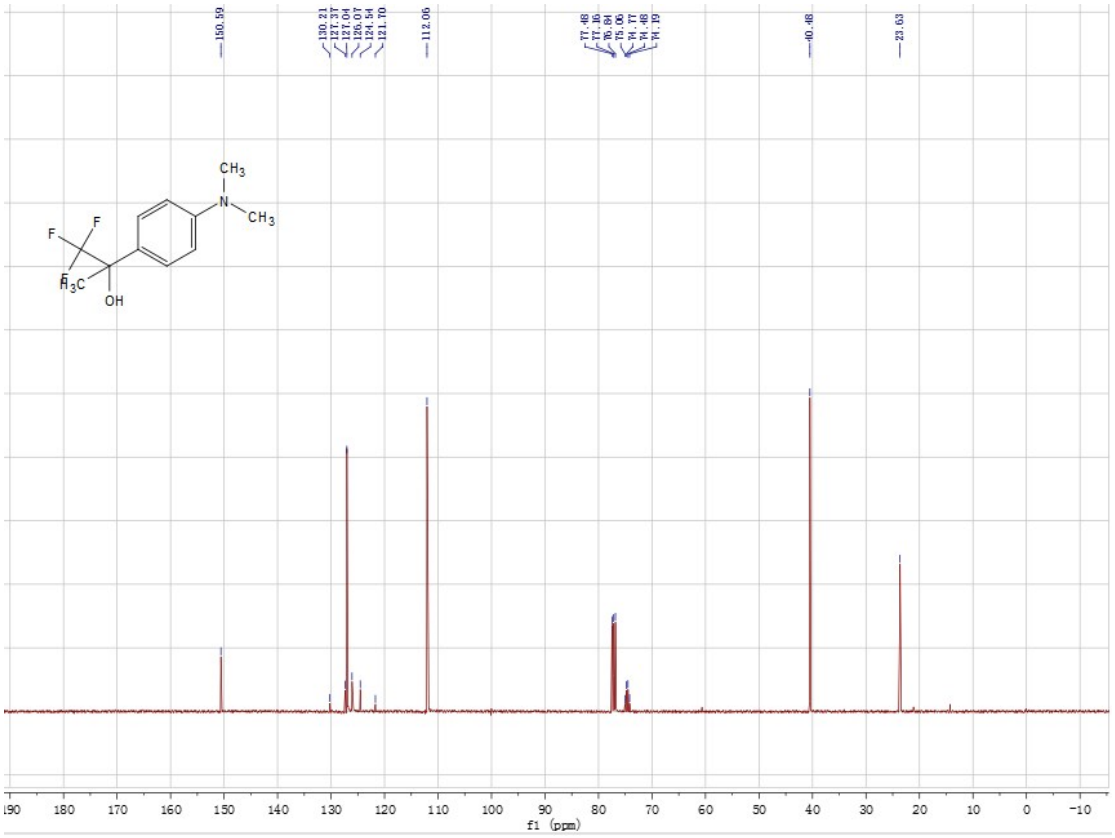
0.00
1.97
2.00
5.99
0.95
2.98
f1 (ppm)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130.21
127.37
127.04
126.07
124.54
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77.16
76.84
75.06
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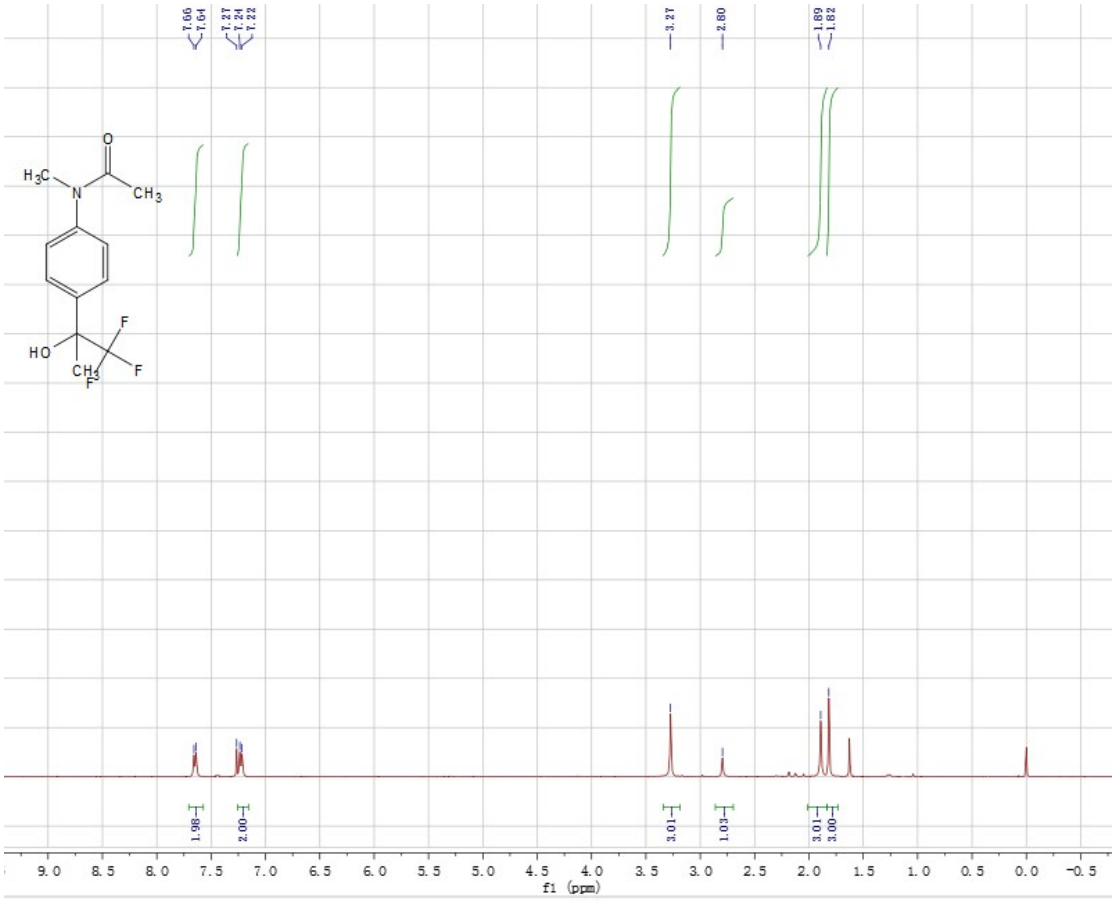
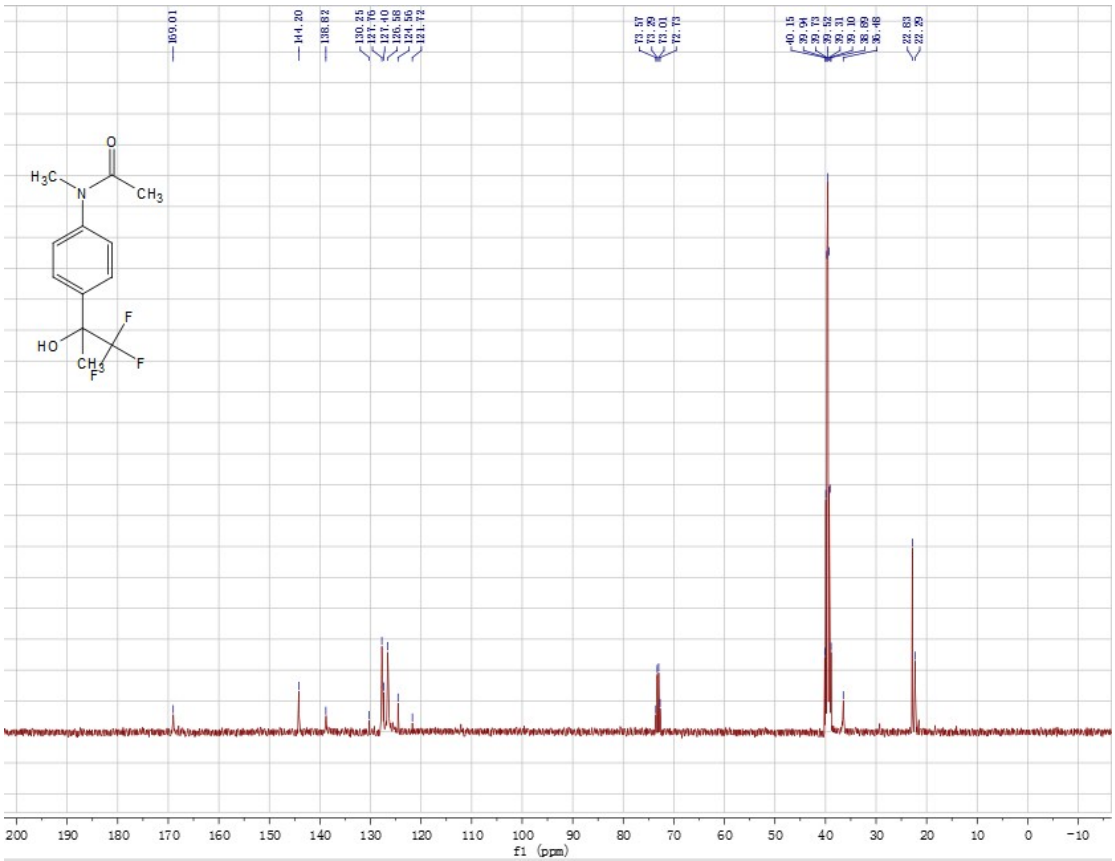
74.48
74.19
40.48
23.63
f1 (ppm)


7.66
7.64
7.27
7.24
7.22
3.27
2.80
1.89
1.82
1.98
2.00
3.01
1.03
3.01
3.00
f1 (ppm)


169.01
144.20
138.82
130.25
127.76
127.40
126.58
124.95
121.72
73.57
73.29
73.01
72.73
40.15
39.94
39.73
39.52
39.31
39.10
38.89
38.68
22.83
22.29
f1 (ppm)