Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

A $Sc(OTf)_3$ catalyzed Mukaiyama-Mannich reaction of difluoroenoxysilanes with unactivated ketimines

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General information: Reactions were monitored by thin layer chromatography using UV light to visualize the course of reaction. Purification of reaction products was carried out by flash chromatography on silica gel. Chemical yields refer to pure isolated substances. The infrared (IR) spectra were obtained using a Bruker tensor 27 infrared spectrometer. ^{1}H, ^{13}C, ^{19}F NMR spectra were obtained using a Bruker DPX-500, 400 or 300 MHz spectrometer. Chemical shifts are reported in ppm from $CDCl_3$ with the solvent resonance as the internal standard. The following abbreviations were used to designate chemical shift multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, h = heptet, m = multiplet, br = broad.

All reactions were carried out in an atmosphere of N_2 except noted. Anhydrous CH_2Cl_2 and $ClCH_2CH_2Cl$ were prepared by first distillation over P_2O_5 and then from CaH_2. Anhydrous Et_2O, THF and toluene were prepared by distillation over sodium-benzophenone ketyl prior to use. unactivated ketimines **1** and **4a-b**,[1] cyclic ketimines **4c-d**[2] were prepared following literature reports. The difluoroenoxysilanes **2** were prepared according to the literature reports.[3]

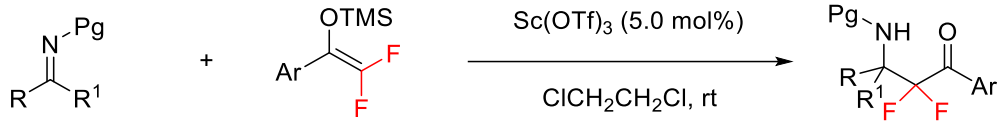
List of abbreviation:

Entry	Chemical name	Abbreviation
1	Petroleum ether	PE
2	1,2-Dichloroethane	DCE
3	Hexafluoroisopropyl alcohol	HFIP

[1] (*a*) J. L. García Ruano, J. Alemán, M. B. Cid and A. Parra, *Org. Lett.*, 2005, **7**, 179. (*b*) X. Huang, J. Huang, Y. Wen and X. Feng, *Adv. Synth. Catal.*, 2006, **348**, 2579.
[2] (a) H. Wang, T. Jiang and M.-H. Xu, *J. Am. Chem. Soc.*, 2013, **135**, 971; (b) S. Zhang, L. Li, Y. Hu, Z. Zha, Z. Wang and T.-P. Loh, *Org. Lett.*, 2015, **17**, 1050; (c) T. Kano, S. Song, Y. Kubota and K. Maruoka, *Angew. Chem., Int. Ed.*, 2012, **51**, 1191.
[3] (a) H. Amii, T. Kobayashi, Y. Hatamoto and K. Uneyama, *Chem. Commun.*, **1999**, 1323; (*b*) G. K. S. Prakash, J. Hu and G. A. Olah, *J. Fluorine Chem.*, 2001, **112**, 355.

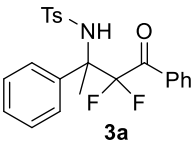
Part I General procedure for the Mukaiyama-Mannich reaction.

1) Mukaiyama-Mannich reaction of unactivated acyclic ketimines 1



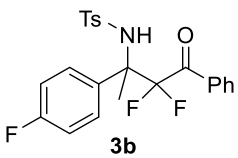
1 (0.25 mmol) **2** (0.375 mmol) **3**

General procedure A: an oven-dried 25 mL Schlenk tube were charged with $Sc(OTf)_3$ (6.2 mg, 0.0125 mmol, 5.0 mol%) and ketimines **1** (0.25 mmol, 1.0 equiv), followed by the addition of anhydrous DCE (2.5 mL, 0.1 M) and difluoroenoxysilanes **2** (0.375 mmol, 1.5 equivs) under an atmosphere of N_2, successively. The resulting solution was stirred at room temperature. After full consumption of ketimines **1** by TLC analysis, the reaction mixture was directly subjected to flash column chromatography to afford products **3** using indicated eluent.



3a

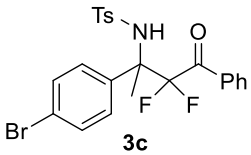
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3a** in 89% yield as white solid, Mp: 121-123 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73-7.71 (m, 2H), 7.65-7.63 (m, 2H), 7.56-7.52 (m, 1H), 7.50-7.47 (m, 2H), 7.36-7.32 (m, 2H), 7.26-7.23 (m, 5H), 6.45 (s, 1H), 2.41 (s, 3H), 1.89 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.14 (dd, *J* = 31.9, 28.7 Hz), 143.17, 139.73, 138.14 (d, *J* = 2.3 Hz), 134.41, 132.84, 129.88 (dd, *J* = 4.5, 2.7 Hz), 129.41, 128.38, 128.27, 128.24, 127.22, 126.98, 115.94 (t, *J* = 265.0 Hz), 65.35 (dd, *J* = 24.1, 23.2 Hz), 21.48, 18.67 (dd, *J* = 4.2, 3.4 Hz); ^{19}F NMR (376 MHz, $CDCl_3$): δ -105.35 (d, *J* = 275.2 Hz, 1F), -108.13 (d, *J* = 275.2 Hz, 1F); IR (ATR): 3305, 1696, 1598, 1421, 1323, 1152, 1136, 1094, 1051, 979, 903, 680, 703, 651, 551; HRMS (ESI): Exact mass calcd for $C_{23}H_{21}F_2NNaO_3S$ $[M+Na]^+$: 452.1102, Found: 452.1112.



3b

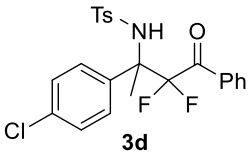
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3b** in 73% yield as white solid, Mp: 132-134 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.71-7.69 (m, 4H), 7.59-7.55 (m, 1H), 7.48-7.45 (m, 2H), 7.39-7.35 (m, 2H), 7.26-7.24 (m, 2H), 6.95-6.90 (m, 2H), 6.45 (s, 1H), 2.42 (s, 3H), 1.87 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.91 (dd, *J* = 31.8, 28.9 Hz), 162.47 (d, *J* = 247.0 Hz), 143.33, 139.63, 134.62, 133.86

(t, *J* = 2.7 Hz), 132.77, 129.93 (dd, *J* = 4.6, 2.9 Hz), 129.47, 129.35, 128.52, 126.98, 115.81 (t, *J* = 264.6 Hz), 115.07 (d, *J* = 21.3 Hz), 65.02 (t, *J* = 23.5 Hz), 21.48 (d, *J* = 2.0 Hz), 19.01; ^{19}F NMR (376 MHz, $CDCl_3$): δ -105.70 (d, *J* = 277.5 Hz, 1F), -108.19 (d, *J* = 277.1 Hz, 1F), -113.99 (s, 1F); IR (ATR): 3261, 1686, 1512, 1446, 1319, 1237, 1134, 1076, 972, 912, 813, 731, 688; HRMS (ESI): Exact mass calcd for $C_{23}H_{20}F_3NNaO_3S$ $[M+Na]^+$: 470.1008, Found: 470.1011.



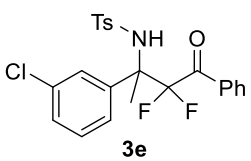
3c

Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **3c** in 77% yield as white solid, Mp: 115-117 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.75-7.67 (m, 4H), 7.61-7.56 (m, 1H), 7.41-7.36 (m, 6H), 7.26-7.23 (m, 2H), 6.41 (s, 1H), 2.42 (s, 3H), 1.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.53 (dd, *J* = 31.6, 29.5 Hz), 143.40, 139.53, 137.31 (d, *J* = 2.1 Hz), 134.69, 132.67 (t, *J* = 2.6 Hz), 131.28, 129.98 (t, *J* = 3.4 Hz), 129.47, 129.17, 128.56, 127.00, 122.67, 115.75 (t, *J* = 265.4 Hz), 65.12 (t, *J* = 23.5 Hz), 21.48, 18.92 (t, *J* = 3.5 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.50 (d, *J* = 280.3 Hz, 1F), -107.55 (d, *J* = 280.3 Hz, 1F); IR (ATR): 3252, 1685, 1594, 1432, 1319, 1154, 1084, 974, 911, 830, 715; HRMS (ESI): Exact mass calcd for $C_{23}H_{20}BrF_2NNaO_3S$ $[M+Na]^+$:530.0208, Found: 530.0214.



3d

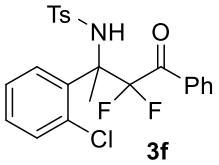
Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **3d** in 75% yield as white solid, Mp: 125-127 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.74-7.68 (m, 4H), 7.61-7.57 (m, 1H), 7.43-7.37 (m, 4H), 7.26-7.20 (m, 4H), 6.43 (s, 1H), 2.42 (s, 3H), 1.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.49 (dd, *J* = 31.3, 29.3 Hz), 143.35, 139.47, 136.73 (d, *J* = 2.1 Hz), 134.65, 134.33, 132.62, 129.92 (t, *J* = 3.4 Hz), 129.43, 128.84, 128.51, 128.25, 126.93, 115.78 (t, *J* = 265.0 Hz), 64.97 (t, *J* = 23.6 Hz), 21.42 (d, *J* = 2.4 Hz), 18.90 (t, *J* = 3.2 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.54 (d, *J* = 279.2 Hz, 1F), -107.56 (d, *J* = 279.5 Hz, 1F); IR (ATR): 3250, 1685, 1593, 1495, 1431, 1318, 1155, 1094, 973, 911, 812, 721, 680; HRMS (ESI): Exact mass calcd for $C_{23}H_{20}ClF_2NNaO_3S$ $[M+Na]^+$: 486.0713, Found: 486.0712.



3e

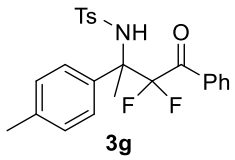
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3e** in 80% yield as white solid, Mp: 132-134 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76-7.74 (m, 2H), 7.69-7.67 (m, 2H), 7.60-7.57 (m, 1H), 7.42-7.37 (m, 4H), 7.26-7.19 (m, 4H), 6.40 (s, 1H), 2.42 (s, 3H), 1.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.37 (dd, *J* = 30.8, 29.4 Hz), 143.41, 140.10 (d, *J* = 2.0 Hz), 139.33, 134.71, 134.23, 132.59 (t, *J* = 2.8 Hz),

129.96 (t, *J* = 3.6 Hz), 129.49, 129.42, 128.54, 128.40, 127.76, 126.93, 125.61, 115.78 (t, *J* = 265.4 Hz), 65.02 (t, *J* = 23.5 Hz), 21.48, 19.03 (t, *J* = 3.1 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.57 (d, *J* = 280.0 Hz, 1F), -107.46 (d, *J* = 279.7 Hz, 1F); IR (ATR): 3280, 1703, 1596, 1434, 1324, 1286, 1151, 1095, 979, 810, 742; HRMS (ESI): Exact mass calcd for $C_{23}H_{20}ClF_2NNaO_3S$ $[M+Na]^+$: 486.0713, Found: 486.0715.



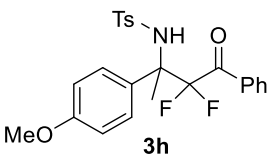
3f

Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3f** in 30% yield as white solid, Mp: 131-133 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76-7.74 (m, 2H), 7.69-7.67 (m, 2H), 7.59-7.55 (m, 1H), 7.42-7.36 (m, 4H), 7.25-7.16 (m, 4H), 6.40 (s, 1H), 2.41 (s, 3H), 1.89 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.44 (t, *J* = 30.1 Hz), 143.42, 140.13 (d, *J* = 2.1 Hz), 139.41, 134.70, 134.28, 132.67, 129.99 (t, *J* = 3.5 Hz), 129.51, 129.43, 128.56, 128.43, 127.81, 126.97, 125.64, 115.82 (t, *J* = 265.3 Hz), 65.08 (t, *J* = 23.6 Hz), 21.49, 19.07 (dd, *J* = 4.2, 3.6 Hz); ^{19}F NMR (376 MHz, $CDCl_3$): δ -105.65 (d, *J* = 279.7 Hz, 1F), -107.40 (d, *J* = 279.7 Hz, 1F); IR (ATR): 3281, 1703, 1596, 1434, 1325, 1151, 1095, 1059, 979, 909, 742; HRMS (ESI): Exact mass calcd for $C_{23}H_{20}ClF_2NNaO_3S$ $[M+Na]^+$: 486.0713, Found: 486.0715.



3g

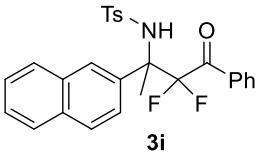
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3g** in 88% yield as white solid, Mp: 141-143 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.72-7.69 (m, 2H), 7.66-7.63 (m, 2H), 7.55-7.50 (m, 1H), 7.37-7.30 (m, 4H), 7.24-7.21 (m, 2H), 7.05-7.02 (m, 2H), 6.45 (s, 1H), 2.39 (s, 3H), 2.26 (s, 3H), 1.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.14 (dd, *J* = 31.9, 28.9 Hz), 143.08, 139.77, 138.03, 135.12 (d, *J* = 2.4 Hz), 134.31, 132.90, 129.89 (dd, *J* = 4.6 Hz, 2.7 Hz), 129.35, 128.92, 128.33, 127.12, 126.96, 115.97 (t, *J* = 264.8 Hz), 65.14 (dd, *J* = 24.0, 23.2 Hz), 21.44, 20.82, 18.69 (dd, *J* = 4.4 Hz, 3.1 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.35 (d, *J* = 274.7 Hz, 1F), -108.11 (d, *J* = 275.0 Hz , 1F); IR (ATR): 3270, 1691, 1596, 1447, 1320, 1273, 1152, 1094, 1047, 974, 725, 686; HRMS (ESI): Exact mass calcd for $C_{24}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 466.1259, Found: 466.1264.



3h

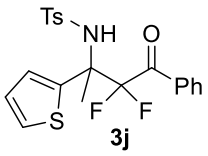
Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **3h** in 71% yield as white solid, Mp: 93-95 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.71-7.63 (m, 4H), 7.57-7.52 (m, 1H), 7.39-7.32 (m, 4H), 7.25-7.23 (m, 2H), 6.76-6.73 (m, 2H), 6.43 (s, 1H), 3.75 (s, 3H), 2.41 (s, 3H), 1.85 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.34

(dd, *J* = 31.8, 28.7 Hz), 159.33, 143.08, 139.76, 134.33, 132.95, 129.87 (dd, *J* = 4.6, 2.8 Hz), 129.72 (d, *J* = 2.2 Hz), 129.36, 128.67, 128.35, 126.95, 115.92 (t, *J* = 264.8 Hz), 113.49, 64.92 (dd, *J* = 24.0, 23.0 Hz), 55.15, 21.44, 18.79 (dd, *J* =4.5, 3.3 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.53 (d, *J* = 273.3 Hz, 1F), -108.63 (d, *J* = 273.5 Hz, 1F); IR (ATR): 3295, 1685, 1595, 1609, 1519, 1424, 1322, 1260, 1152, 1122, 977, 813, 713, 688; HRMS (ESI): Exact mass calcd for $C_{24}H_{23}F_2NNaO_4S$ $[M+Na]^+$: 482.1208, Found: 482.1213.



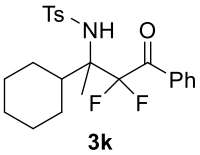
3i

Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **3i** in 84% yield as white solid, Mp: 123-125 ºC; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.87 (s, 1H), 7.76-7.66 (m, 7H), 7.59-7.56 (m, 1H), 7.50-7.43 (m, 3H), 7.29-7.24 (m, 2H), 7.18-7.16 (m, 2H), 6.52 (s, 1H), 2.35 (s, 3H), 2.01 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.85 (dd, *J* = 31.7, 29.3 Hz), 143.17, 139.65, 135.25 (d, *J* = 2.1 Hz), 134.36, 132.87, 132.70, 132.63, 129.88 (t, *J* = 3.2 Hz), 129.36, 128.43, 128.35, 127.92, 127.24, 127.20, 127.03, 126.59, 126.14, 124.59, 116.19 (t, *J* = 265.2 Hz), 65.52 (t, *J* = 23.3 Hz), 21.39, 19.21 (t, *J* = 2.8 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.09 (d, *J* = 277.8 Hz, 1F), -107.14 (d, *J* = 277.8 Hz, 1F); IR (ATR): 3263, 1686, 1593, 1420, 1314, 1125, 1092, 1043, 913, 811, 735; HRMS (ESI): Exact mass calcd for $C_{27}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 502.1259, Found: 502.1267.



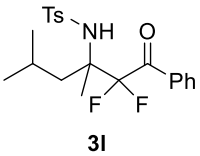
3j

Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **3j** in 55% yield as white solid, Mp: 124-126 ºC; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.80-7.70 (m, 4H), 7.61-7.55 (m, 1H), 7.42-7.37 (m, 2H), 7.26-7.22 (m, 2H), 7.19-7.17 (m, 1H), 7.00-6.99 (m, 1H), 6.84-6.82 (m, 1H), 6.51 (s, 1H), 2.40 (s, 3H), 1.93(s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.69 (dd, *J* = 31.9, 29.1 Hz), 143.26, 142.82 (d, *J* = 2.8 Hz), 139.39, 134.52, 132.84 (t, *J* = 2.7 Hz), 129.88 (dd, *J* = 4.6, 2.9 Hz), 129.40, 128.48, 127.09, 126.93, 126.00, 115.19 (t, *J* = 265.8 Hz), 63.59 (t, *J* = 24.9 Hz), 21.45, 19.85 (t, *J* = 2.8 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.80 (d, *J* = 278.3 Hz, 1F), -107.84 (d, *J* = 278.3 Hz, 1F); IR (ATR): 3273, 1696, 1596, 1425, 1325, 1278, 1154, 1123, 1092, 967, 899, 817, 687; HRMS (ESI): Exact mass calcd for $C_{21}H_{19}F_2NNaO_3S_2$ $[M+Na]^+$: 458.0667, Found: 458.0669.



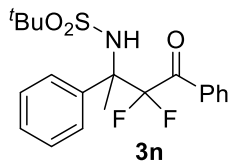
3k

Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3k** in 23% yield as white solid, Mp: 156-158 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97-7.95 (m, 2H), 7.71-7.69 (m, 2H), 7.65-7.61 (m, 1H), 7.48-7.45 (m, 2H), 7.22-7.20 (m, 2H), 5.55 (s, 1H), 2.38 (s, 3H), 1.93-1.90 (m, 1H), 1.83-1.76 (m, 2H), 1.69-1.57 (m, 3H), 1.44 (s, 3H), 1.24-1.01 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.50 (dd, *J* = 32.9, 30.7 Hz), 142.88, 139.45, 134.40, 132.94 (d, *J* = 3.5 Hz), 130.15 (dd, *J* = 5.0, 2.8 Hz), 129.23, 128.58, 127.26, 117.26 (t, *J* = 266.3 Hz), 66.40 (t, *J* = 20.2 Hz), 45.16, 27.58 (d, *J* = 5.0 Hz), 27.43, 26.58, 26.40, 26.06, 21.46, 12.38; ^{19}F NMR (376 MHz, $CDCl_3$): δ -100.27 (d, *J* = 293.3 Hz, 1F), -102.63 (d, *J* = 293.7 Hz, 1F); IR (ATR): 3232, 1691, 1596, 1446, 1318, 1152, 1106, 969, 902, 873, 810; HRMS (ESI): Exact mass calcd for $C_{23}H_{27}F_2NNaO_3S$ $[M+Na]^+$: 458.1572, Found: 458.1573.



3l

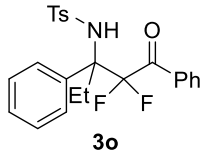
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3l** in 78% yield as white solid, Mp: 40-42 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97 (d, *J* = 7.6 Hz, 2H), 7.69 (d, *J* = 8.0 Hz, 2H), 7.61 (t, *J* = 7.6 Hz, 1H), 7.45 (t, *J* = 8.0 Hz, 2H), 7.18 (d, *J* = 8.0 Hz, 2H), 5.56 (s, 1H), 2.34 (s, 3H), 1.91 (h, *J* = 6.4 Hz, 1H), 1.78-1.73 (m, 1H), 1.58-1.57 (m, 1H), 1.53 (s, 3H), 1.01 (d, *J* = 6.4 Hz, 3H), 0.92 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 189.75 (t, *J* = 32.0 Hz), 142.93, 139.33, 134.47, 132.70 (t, *J* = 3.3 Hz), 130.22 (t, *J* = 3.9 Hz), 129.22, 128.51, 127.13, 116.64 (t, *J* = 263.6 Hz), 63.52 (t, *J* = 22.4 Hz), 44.76, 24.97, 24.73, 23.27, 21.37, 15.68 (t, *J* = 4.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$): δ -105.60 (d, *J* = 294.0 Hz, 1F), -106.50 (d, *J* = 294.0 Hz, 1F); IR (ATR): 2957, 1697, 1597, 1449, 1325, 1153, 1092, 912, 814, 716; HRMS (ESI): Exact mass calcd for $C_{21}H_{25}F_2NNaO_3S$ $[M+Na]^+$: 432.1415, Found: 432.1421.



3n

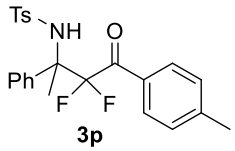
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3n** in 38% yield as colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.62-7.60 (m, 4H), 7.55-7.51 (m, 1H), 7.34-7.28 (m, 4H), 7.26-7.22 (m, 1H), 5.79 (s, 1H), 2.12 (s, 3H), 1.46 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 129.05 (dd, *J* = 32.1, 28.1 Hz), 138.92 (d, *J* = 2.2 Hz), 134.35, 133.28, 133.26, 129.87 (dd, *J* = 5.1, 2.6 Hz), 128.41, 128.37, 127.42, 116.20 (t, *J* = 264.8 Hz), 66.72 (dd, *J* = 24.1, 22.7 Hz), 60.68, 24.39, 19.19 (dd, *J* = 5.0, 2.4 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.30 (d, *J* = 269.3 Hz, 1F), -108.99 (d, *J* = 269.6 Hz, 1F); IR (ATR):

3315, 2921,1693, 1428, 1314, 1124, 1040, 946, 915, 858, 817,719, 694; HRMS (ESI): Exact mass calcd for $C_{20}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 418.1259, Found: 418.1263.



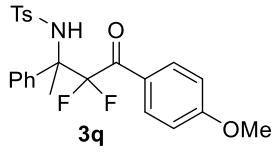
3o

Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3o** in 56% yield as white solid, Mp: 104-106 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69-7.67 (m, 2H), 7.61-7.59 (m, 2H), 7.53-7.49 (m, 1H), 7.41-7.38 (m, 2H), 7.32-7.26 (m, 2H), 7.20-7.17 (m, 5H), 5.98 (s, 1H), 2.78-2.69 (m, 1H), 2.48-2.39 (m, 1H), 2.34 (s, 3H), 0.87 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.31 (dd, *J* = 31.7, 29.5 Hz), 142.95, 139.58, 137.20 (d, *J* = 3.8 Hz), 134.13, 132.63 (t, *J* = 2.5 Hz), 129.83 (t, *J* = 3.3 Hz), 129.20, 128.22, 128.07, 127.26 (d, *J* = 3.4 Hz), 126.97, 116.98 (t, *J* = 266.6 Hz), 69.61 (t, *J* = 21.8 Hz), 25.26 (t, *J* = 2.5 Hz), 21.37, 8.82 (t, *J* = 2.1 Hz); ^{19}F NMR (376 MHz, $CDCl_3$): δ -100.45 (d, *J* = 283.5 Hz, 1F), -103.03 (d, *J* = 283.9 Hz, 1F). IR (ATR): 3273, 1702, 1597, 1596, 1434, 1330, 1149, 1060, 817, 764; HRMS (ESI): Exact mass calcd for $C_{24}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 466.1259, Found: 466.1264.



3p

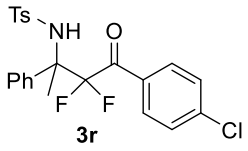
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3p** in 52% yield as white solid, Mp: 141-143 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.72-7.70 (m, 2H), 7.57-7.55 (m, 2H), 7.49-7.47 (m, 2H), 7.26-7.23 (m, 5H), 7.14-7.12 (m, 2H), 6.49 (s, 1H), 2.41 (s, 3H), 2.36 (s, 3H), 1.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 190.58 (dd, *J* = 31.7, 29.0 Hz), 145.75, 143.06, 139.83, 138.24 (d, *J* = 2.3 Hz), 130.34, 130.05 (dd, *J* = 4.8, 2.6 Hz), 129.34, 129.09, 128.16, 128.12, 127.24, 126.94, 116.01 (t, *J* = 265.2 Hz), 65.36 (t, *J* = 23.5 Hz), 21.66, 21.39, 18.70 (dd, *J* = 4.2, 3.1 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.17 (d, *J* = 274.1 Hz), -107.93 (d, *J* = 274.1 Hz); IR (ATR): 3287, 1691, 1604, 1425, 1324, 1154, 981, 904, 780, 740; HRMS (ESI): Exact mass calcd for $C_{24}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 466.1259, Found: 466.1259.



3q

Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **3q** in 42% yield as white solid, Mp: 167-169 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.73-7.66 (m, 4H), 7.50-7.48 (m, 2H), 7.26-7.22 (m, 5H), 6.79 (d, *J* = 9.0 Hz, 2H), 6.56 (s, 1H), 3.84 (s, 3H), 2.41 (s, 3H), 1.87 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 189.04 (dd, *J* = 31.0, 28.6 Hz), 164.57, 143.08, 139.85, 138.39 (d, *J* = 2.5 Hz), 132.71 (dd, *J* = 5.4, 2.8 Hz), 129.39, 128.16, 128.13, 127.25, 126.96, 125.61, 116.15 (t, *J* = 265.0 Hz), 113.72, 65.39 (t, *J* = 23.6 Hz), 55.52 (d, *J* = 2.5 Hz), 21.47 (d, *J* = 1.8 Hz), 18.68 (t, *J* = 3.1 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -104.96 (d, *J* = 274.1 Hz), -107.70 (d, *J* = 273.8 Hz); IR (ATR): 3297, 1684, 1596 1511, 1419,

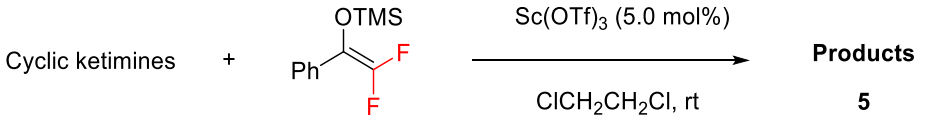
1322, 1265 1153, 1132, 1047, 905, 817, 787, 697; HRMS (ESI): Exact mass calcd for $C_{24}H_{23}F_2NNaO_4S$ $[M+Na]^+$: 482.1208, Found: 482.1217.



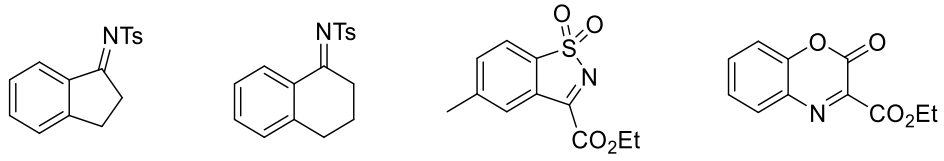
3r

Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **3r** in 63% yield as white solid, Mp: 150-152 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.73-7.70 (m, 2H), 7.55-7.53 (m, 2H), 7.47-7.44 (m, 2H), 7.31-7.30 (m, 1H), 7.28-7.23 (m, 6H), 6.36 (s, 1H), 2.42 (s, 3H), 1.89 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 189.98 (dd, *J* = 31.9, 28.7 Hz), 143.23, 141.15, 139.67, 137.89 (d, *J* = 2.1 Hz), 131.26 (dd, *J* = 5.0, 2.8 Hz), 131.15 (d, *J* = 3.1 Hz), 129.43, 128.74, 128.37, 128.33, 127.22, 126.95, 116.03 (t, *J* = 264.8 Hz), 65.28 (dd, *J* = 24.1, 22.9 Hz), 21.46, 18.59 (dd, *J* = 3.9, 2.7 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -105.50 (d, *J* = 273.5 Hz), -108.53 (d, *J* = 273.5 Hz); IR (ATR): 3286, 1698, 1587, 1426, 1324, 1155, 1092, 981, 902, 816, 704; HRMS (ESI): Exact mass calcd for $C_{23}H_{20}ClF_2NNaO_3S$ $[M+Na]^+$: 486.0713, Found: 486.0721.

2) Mukaiyama-Mannich reaction of cyclic ketimines 4

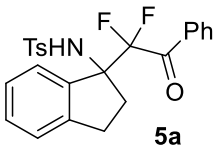


Structure of imine **4**



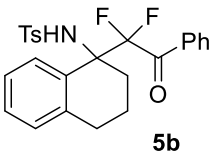
4a **4b** **4c** **4d**

General procedure B: an oven-dried 25 mL Schlenk tube were charged with $Sc(OTf)_3$ (6.2 mg, 0.0125 mmol, 5.0 mol%) and cyclic ketimines **4** (0.25 mmol, 1.0 equiv), followed by the addition of anhydrous DCE (2.5 mL, 0.1 M) and difluoroenoxysilane **2a** (0.375 mmol, 1.5 equivs) under an atmosphere of N_2, successively. The resulting solution was stirred at room temperature. After full consumption of ketimines **4** by TLC analysis, the reaction mixture was directly subjected to flash column chromatography to afford products **5** using indicated eluent.



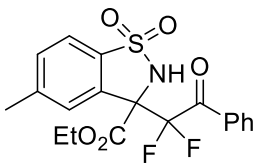
5a

Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **5a** in 80% yield as white solid, Mp: 119-121 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.02-7.99 (m, 2H), 7.65-7.60 (m, 1H), 7.49-7.43 (m, 2H), 7.30-7.19 (m, 4H), 7.09-7.04 (m, 3H), 7.00-6.95 (m, 1H), 6.04 (s, 1H), 2.86-2.81 (m, 2H), 2.77-2.68 (m, 1H), 2.55-2.45 (m, 1H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 189.79 (t, *J* = 32.1 Hz), 145.94, 142.70, 138.55, 135.28, 134.63, 132.27, 130.23 (t, *J* = 3.5 Hz), 129.38, 128.90, 128.53, 127.50 (d, *J* = 4.3 Hz), 126.89, 125.85, 124.43, 116.76 (t, *J* = 262.6 Hz), 72.34 (dd, *J* = 27.2, 21.6 Hz), 35.15, 30.08, 21.36; ^{19}F NMR (282 MHz, $CDCl_3$): δ -104.36 (d, *J* = 297.5 Hz, 1F), -106.85 (d, *J* = 297.8 Hz, 1F); IR (ATR): 3258, 1705, 1597, 1418, 1327, 1151, 1059, 874, 809, 769; HRMS (ESI): Exact mass calcd for $C_{24}H_{21}F_2NNaO_3S$ $[M+Na]^+$: 464.1102, Found: 464.1104.



5b

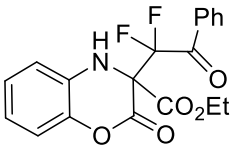
Column chromatography (PE/EtOAc = 10:1, v/v) afforded product **5b** in 21% yield as white solid, Mp: 105-107 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.75-7.72 (m, 2H), 7.59-7.54 (m, 1H), 7.49-7.47 (m, 2H), 7.40-7.26 (m, 2H), 7.21-7.06 (m, 5H), 6.84-6.79 (m, 1H), 5.98 (s, 1H), 2.75-2.71 (m, 2H), 2.63-2.57 (m, 1H), 2.39 (s, 3H), 2.29-2.19 (m, 1H), 1.92-1.84 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.13 (t, *J* = 30.8 Hz), 142.91, 139.79, 139.56, 134.23, 133.55, 130.41, 130.01 (t, *J* = 3.8 Hz), 129.31, 129.17, 129.12, 128.46, 128.36, 127.08, 125.60, 117.37 (t, *J* = 263.9 Hz), 63.84 (t, *J* = 22.7 Hz), 31.29, 29.38, 21.47, 19.00; ^{19}F NMR (282 MHz, $CDCl_3$): δ -101.82 (d, *J* = 279.7 Hz, 1F), -103.55 (d, *J* = 279.7 Hz, 1F); IR (ATR): 3246, 1705, 1597, 1435, 1332, 1287, 1168, 1071, 1031, 930, 814, 712; HRMS (ESI): Exact mass calcd for $C_{25}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 478.1259, Found: 478.1255.



5c

Column chromatography (PE/EtOAc = 6:1, v/v) afforded product **5c** in 60% yield as white solid;[4] ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.10-8.08 (m, 2H), 7.76-7.65 (m, 3H), 7.53-7.48 (m, 3H), 5.92 (s, 1H), 4.44-4.35 (m, 2H), 2.54 (s, 3H), 1.36 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 187.78 (t, *J* = 32.0 Hz), 165.60 (dd, *J* = 7.3, 2.0 Hz), 144.82, 135.15, 133.91, 132.69, 131.17 (t, *J* = 3.2 Hz), 130.59 (d, *J* = 1.8 Hz), 130.36 (dd, *J* = 4.0, 2.2 Hz), 128.78, 127.08 (d, *J* = 5.3 Hz), 121.59, 115.40 (t, *J* = 268.0 Hz), 68.32 (t, *J* = 24.9 Hz), 64.27, 21.88, 13.83. ^{19}F NMR (282 MHz, $CDCl_3$): δ -99.74 (dd, *J* = 297.5, 3.1 Hz, 1F), -106.00 (d, *J* = 297.5 Hz, 1F).

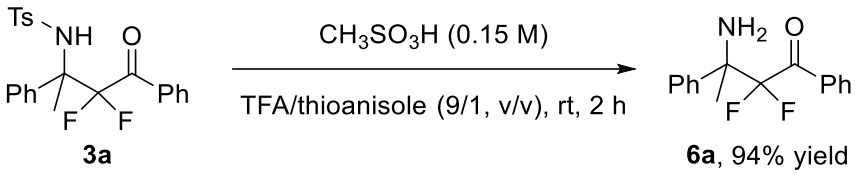
[4] J.-S. Yu and J. Zhou, *Org. Biomol. Chem*., 2015, **13**, 10968.



5d

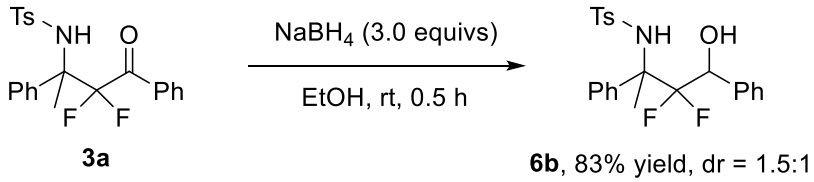
Column chromatography (PE/EtOAc = 6:1) afforded product **5d** in 100% yield as yellow solid;[4] ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.10-8.07 (m, 2H), 7.68-7.63 (m, 1H), 7.53-7.48 (m, 2H), 7.08-7.01 (m, 2H), 6.93-6.86 (m, 2H), 5.08 (s, 1H), 4.33-4.26 (q, *J* =7.2 Hz, 2H), 1.21 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 186.74 (dd, *J* = 30.7, 28.0 Hz), 164.89, 158.62 (t, *J* = 2.0 Hz), 139.91, 134.77, 131.47 (t, *J* = 3.2 Hz), 130.14 (dd, *J* = 4.1, 2.3 Hz), 128.69, 128.51, 125.53, 121.30, 116.77, 115.68, 115.08 (dd, *J* = 270.1, 265.8 Hz), 67.19 (t, *J* = 22.1 Hz), 63.67, 13.69; ^{19}F NMR (282 MHz, $CDCl_3$): δ -103.82 (d, *J* = 300.9 Hz, 1F), -106.13 (d, *J* = 301.2 Hz, 1F).

Part II. Transformations of products



3a **6a**, 94% yield

Compound **3a** (85.9 mg, 0.2 mmol) placed in 25 mL round-bottom flask was treated with a 0.15 M solution of methanesulfonicacid (28.8 mg, 0.3 mmol) in TFA/thioanisole (9/1, v/v, 2 mL) at room temperature. After being stirred at the same temperature for 2 h, the reaction mixture was concentrated under reduced pressure. To thus obtained residue were added sat. aq. $NaHCO_3$, and extracted with CH_2Cl_2 (10 mL×3). The organic layer was combined, dried over Na_2SO_4, and concentrated under reduced pressure to give the crude product, which was purified by silica gel column chromatography (petroleum ether/ethyl acetate = 6/1, v/v) to give primary amine **6a** as colorless oil (51.8 mg, 94% yield).[5] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.74-7.72 (m, 2H), 7.52-7.48 (m, 3H), 7.34-7.21 (m, 5H), 2.15 (br, 2H), 1.74 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 191.09 (t, *J* = 30.7 Hz), 140.59, 133.84, 133.65, 129.88 (t, *J* = 3.9 Hz), 128.20, 128.12, 127.67, 126.83 (t, *J* = 1.8 Hz), 118.62 (dd, *J* = 262.7, 259.5 Hz), 59.76 (t, *J* = 22.5 Hz), 24.39 (t, *J* = 3.4 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ - 106.05 (d, *J* = 272.7 Hz, 1F), -107.32 (d, *J* = 272.4 Hz, 1F); IR (ATR): 3314, 1693, 1597, 1447, 1313, 1124, 858, 759, 695; HRMS (ESI): Exact mass calcd for $C_{16}H_{16}F_2NO$ $[M+H]^+$: 276.1194, Found: 276.1191.

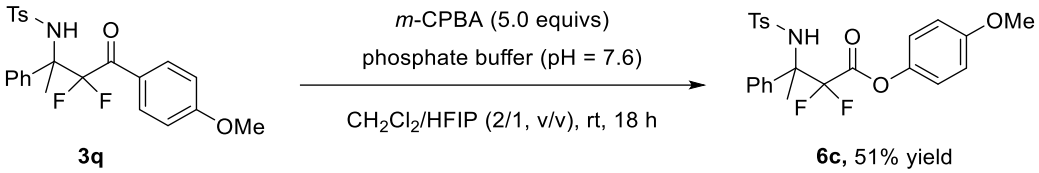


3a **6b**, 83% yield, dr = 1.5:1

Compound **3a** (85.9 mg, 0.2 mmol) was dissolved in 2.5 mL anhydrous EtOH, followed by the addition of $NaBH_4$ (23.4 mg, 0.6 mmol, 3.0 equivs) in one portion at room temperature. The resulting mixture was stirred until the complete consumption of **3a** as indicated by TLC analysis (about 0.5 h). Then the reaction was quenched by saturated NH_4Cl (aq.), and extracted with CH_2Cl_2 (5.0 mL × 3). The combined organic layer was washed with saturated brine (10 mL × 2), and dried over anhydrous Na_2SO_4, concentrated under reduced pressure to furnish the residue, which was purified

[5] S. Nakamura, M. Hayashi, Y. Hiramatsu, N. Shibata, Y. Funahashi and T. Toru, *J. Am. Chem. Soc*., 2009, **131**, 18240.

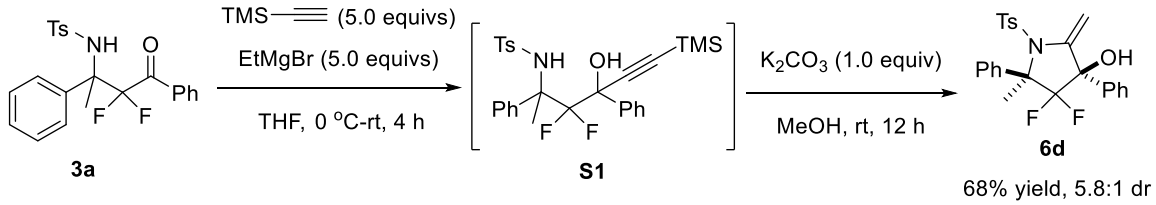
by flash column chromatography (petroleum ether/ethyl acetate = 6/1, v/v) to afford β-amino alcohol **6b** as white solid (71.6 mg, 83% yield). ^{1}H NMR of crude mixture revealed that the dr value was 1.5:1; ^{1}H NMR (300 MHz, $CDCl_3$) for the major isomer: δ 7.57-7.54 (m, 2H), 7.42-7.40 (m, 2H), 7.34-7.30 (m, 5H), 7.26-7.17 (m, 5H), 6.20 (s, 1H), 4.94-4.84 (m, 1H), 2.57 (d, *J* = 5.2 Hz, 1H), 2.40 (s, 3H), 2.06 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.00, 139.51, 137.37, 136.10, 129.24, 128.95, 128.18, 128.09, 127.97, 127.90, 127.59, 126.92, 119.02 (dd, *J* = 263.4, 248.3 Hz), 74.06 (dd, *J* = 35.0, 24.3 Hz), 65.72 (dd, *J* = 27.0, 21.7 Hz), 21.44, 21.22 (d, *J* = 1.7 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -110.33 (dd, *J* = 260.3, 3.1Hz, 1F), -123.12 (dd, *J* = 260.3, 16.1 Hz, 1F); Mp: 145-147 °C, IR (ATR): 3503, 3231, 2962, 1599, 1453, 1317, 1259, 1158, 1016, 978, 791, 700; HRMS (ESI): Exact mass calcd for $C_{23}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 454.1259, Found: 454.1262; ^{1}H NMR (400 MHz, $CDCl_3$) for the minor isomer: δ 7.77-7.74 (m, 4H), 7.55 (s, 1H), 7.46-7.42 (m, 2H), 7.40-7.36 (m, 1H), 7.31-7.23 (m, 6H), 4.50-4.43 (m, 1H), 3.25 (s, 1H), 2.40 (s, 3H), 1.70 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.90, 140.40, 135.90, 129.41, 129.00, 128.48, 128.16, 128.13, 128.02, 126.87 (d, *J* = 2.3 Hz), 126.82, 118.40 (dd, *J* = 266.8, 247.2 Hz), 74.12 (dd, *J* = 37.1, 23.4 Hz), 66.89 (dd, *J* = 27.5, 23.2 Hz), 21.48, 18.06 (d, *J* = 7.1 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -110.69 (d, *J* = 258.9 Hz, 1F), -126.77 (dd, *J* = 259.2, 19.2 Hz, 1F); Mp: 180-182 °C, IR (ATR): 3544, 3299, 1599, 1493, 1404, 1319, 1147, 1040, 873, 815, 703; HRMS (ESI): Exact mass calcd for $C_{23}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 454.1259, Found: 454.1262.



Compound **3q** (91.9 mg, 0.2 mmol) was dissolved in CH_2Cl_2/HFIP (2/1, v/v, 3.0 mL), followed by the addition of *m*-chloroperoxybenzoic acid (*m*-CPBA) (203.4 mg, 1.0 mmol, 85% wt, 5.0 equivs) and phosphate buffer (0.2 mL, pH = 7.6) at room temperature.[6] The resulting mixture was stirred until the complete consumption of **3q** as indicated by TLC analysis (about 18.0 h) before quenched by saturated $Na_2S_2O_3$ (aq.). The solution was extracted with CH_2Cl_2 (10 mL × 3). The combined organic layer was washed with saturated $NaHCO_3$ (aq.) and brine (10 mL × 2), sequentially. The

[6] S. Kobayashi, H. Tanaka, H. Amii and K. Uneyama, *Tetrahedron*, 2003, **59**, 1547.

solution was dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure to give the residue, which was purified by column chromatography (petroleum ether/ethyl acetate = 6/1, v/v) to afford β-amino ester **6c** as white solid (48.5 mg, 51% yield), Mp: 178-180 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.71-7.68 (m, 2H), 7.52-7.50 (m, 2H), 7.37-7.35 (m, 3H), 7.24-7.21 (m, 2H), 6.83-6.79 (m, 2H), 6.68-6.63 (m, 2H), 6.04 (s, 1H), 3.78 (s, 3H), 2.41 (s, 3H), 1.94 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 161.87 (t, *J* = 32.6 Hz), 157.94, 143.36, 142.60, 139.48, 137.05, 129.49, 128.70, 128.44, 127.26, 127.02, 121.41, 114.49, 114.44 (t, *J* = 262.8 Hz), 64.68 (t, *J* = 23.2 Hz), 55.56, 21.49, 18.36 (dd, *J* =5.2, 1.5 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -112.73 (d, *J* = 248.2 Hz, 1F), -115.03 (d, *J* = 248.2 Hz, 1F); IR (ATR): 3268, 2921, 1780, 1597, 1505, 1428, 1293, 1113, 1017, 971, 805, 712; HRMS (ESI): Exact mass calcd for $C_{24}H_{23}F_2NNaO_5S$ $[M+Na]^+$: 498.1157, Found: 498.1161.

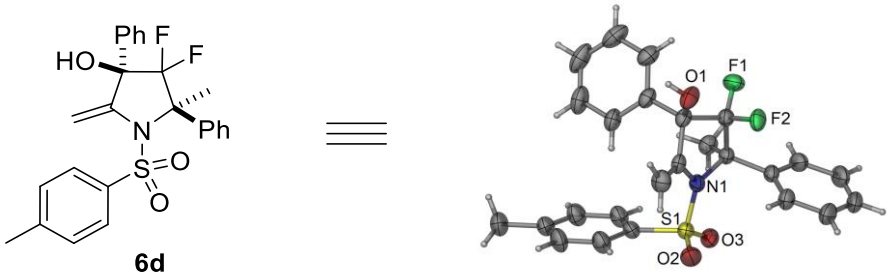


To a 25 mL oven-dried Schlenk tube were added trimethylsilylacetylene (147.0 μL, 1.0 mmol, 5.0 equivs) and 2.0 mL anhydrous THF, followed by the addition of EtMgBr (1.0 M in THF, 1.0 mL, 1.0 mmol, 5.0 equivs) at room temperature. The resulting solution was stirred for 3 h at room temperature. The reaction mixture was cooled to 0 °C, and then **3a** (85.9 mg, 0.2 mmol, 1.0 equiv) was added at 0 °C in one portion. The resulting mixture was stirred at room temperature. After full consumption of **3a** as indicated by TLC analysis (about 1.0 h), the reaction solution was quenched by saturated NH_4Cl (aq.), and then extracted with CH_2Cl_2 (10 mL × 3). The combined organic layer was washed with saturated brine (10 mL × 2). The solution was dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure to give the crude **S1**, which was used directly in the next step without further purification.

To above crude **S1** were added MeOH (1 mL, 0.2 M) and K_2CO_3 (27.6 mg, 0.2 mmol, 1.0 equiv). After being stirred at room temperature until complete conversion of **S1**, the reaction mixture was concentrated under vacuum. Then saturated NH_4Cl (aq.) was added to the residue, which was extracted with diethyl ether (10 mL × 3). The combined organic phases are washed with water, brine and dried over Na_2SO_4. After filtration, the solvent was evaporated and ^{1}H NMR of the crude residue

revealed that dr value was 5.8:1. The combined residue was purified by column chromatography (petroleum ether:ethyl acetate = 6/1, v/v) to afford **6d** as white solid (62.0 mg, 68% yield), Mp: 120-122 °C; For the major isomer: ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.88-7.86 (m, 2H), 7.60-7.57 (m, 2H), 7.46-7.36 (m, 5H), 7.27-7.16 (m, 1H), 7.06-7.00 (t, *J* = 7.8 Hz, 2H), 6.87-6.84 (m, 2H), 5.72 (s, 1H), 4.84 (d, *J* = 2.1 Hz, 1H), 2.64 (d, *J* = 4.5 Hz, 1H), 2.54 (s, 3H), 1.77 (d, *J* = 3.6 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 146.26 (d, *J* = 5.2 Hz), 144.76, 139.33 (d, *J* = 3.9 Hz), 136.24, 135.54, 129.55, 129.01, 128.92, 128.71, 128.29 (d, *J* = 2.9 Hz), 128.19, 127.77, 126.74 (d, *J* = 2.3 Hz), 121.62 (dd, *J* = 269.6, 256.7 Hz), 96.19, 80.06 (t, *J* = 22.2 Hz), 73.29 (dd, *J* = 26.1, 23.9 Hz), 21.66, 21.06 (d, *J* = 7.1 Hz); ^{19}F NMR (282 MHz, $CDCl_3$): δ -110.63 (dd, *J* = 225.6, 3.1 Hz, 1F), -120.37 (d, *J* = 225.6 Hz, 1F); IR (ATR): 3490, 1650, 1447, 1339, 1238, 1167, 1140, 1077, 979, 907, 878, 794; HRMS (ESI): Exact mass calcd for $C_{25}H_{23}F_2NNaO_3S$ $[M+Na]^+$: 478.1259, Found: 478.1285.

Part III. X-ray crystal data of 6d[7]



Data intensity of **6d** was collected using a XtaLAB PRO MM003 (Cu radiation) at 293 K in a nitrogen stream. Data collection and reduction were done by using the XtaLAB software package. The structures were solved by direct methods and refined by full-matrix least-squares on F^2 with anisotropic displacement parameters for non-H atoms using SHELX-97. Hydrogen atoms were added at their geometrically idea positions and refined isotropically. Crystal data for **6d**: $C_{25}H_{23}F_2NO_3S$, T = 293(2) K, triclinic, P-1, a = 8.0332(2) Å, b = 8.5272(2) Å, c = 16.9075(4) Å, α = 99.329(2)°, β = 99.436(2)°, γ = 101.204(2)°. V = 1097.99(5) Å^3. Z = 2, ρ_{calc} = 1.378 g/cm^3. Reflections collected 23454; independent reflections 4381 [R_{int} = 0.0586, R_{sigma} = 0.0344], R_1 = 0.0419, wR_2 = 0.1080 (all data), GOF = 1.073, and 293 parameter.

[7] Supplementary crystallographic data have been deposited at the Cambridge Crystallographic Data Center (CCDC 1884551).

Table 1. Crystal data and structure refinement for 6d.

Identification code	exp_588
Empirical formula	$C_{25}H_{23}F_2NO_3S$
Formula weight	455.50
Temperature/K	293(2)
Crystal system	triclinic
Space group	P-1
a/Å	8.0332(2)
b/Å	8.5272(2)
c/Å	16.9075(4)
α/°	99.329(2)
β/°	99.436(2)
γ/°	101.204(2)
Volume/Å^3	1097.99(5)
Z	2
ρ_{calc}g/cm^3	1.378
μ/mm^{-1}	1.696
F(000)	476.0
Crystal size/mm^3	0.48 × 0.46 × 0.42
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	10.796 to 149.18
Index ranges	-9 ⩽ h ⩽ 9, -10 ⩽ k ⩽ 10, -21 ⩽ l ⩽ 20
Reflections collected	23454
Independent reflections	4381 [R_{int} = 0.0586, R_{sigma} = 0.0344]
Data/restraints/parameters	4381/0/293
Goodness-of-fit on F^2	1.073
Final R indexes [I>=2σ (I)]	R_1 = 0.0391, wR_2 = 0.1060
Final R indexes [all data]	R_1 = 0.0419, wR_2 = 0.1080
Largest diff. peak/hole / e Å^{-3}	0.25/-0.39

Table 2 Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for exp_588. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	*x*	*y*	*z*	U(eq)
S1	4326.3(5)	2209.8(5)	6769.5(2)	42.55(13)
F1	1957.7(13)	3427.8(14)	9336.1(6)	56.6(3)
F2	1564.6(12)	889.0(12)	8779.9(6)	52.4(3)
O1	-1098.7(14)	1449.0(15)	7960.8(9)	53.7(3)
O2	3865.2(18)	657.8(16)	6232.6(8)	60.3(3)
O3	6051.0(14)	2787.0(16)	7242.6(7)	52.1(3)
N1	3032.7(15)	2215.6(16)	7430.0(7)	37.9(3)
C1	6042(2)	2348(2)	9414.2(10)	50.4(4)
C2	7025(3)	1350(3)	9752.2(12)	66.4(6)
C3	6859(3)	-212(3)	9372.1(13)	66.0(6)
C4	5692(3)	-825(2)	8650.7(13)	60.7(5)
C5	4669(2)	127(2)	8312.8(11)	48.3(4)
C6	4841.9(18)	1735.2(19)	8688.1(9)	37.7(3)
C7	3665.0(18)	2777.0(18)	8340.0(9)	35.6(3)
C8	1899.9(19)	2412.5(19)	8618.4(9)	39.8(3)
C9	459.4(18)	2479.6(19)	7903.2(10)	40.3(3)
C10	1194.0(19)	1746.1(18)	7192.6(9)	39.4(3)
C11	4487(2)	4598.3(19)	8563.4(11)	45.9(4)
C12	244(2)	810(2)	6503.3(11)	54.9(4)
C13	222.3(19)	4212.8(19)	7887.3(11)	44.0(4)
C14	-484(2)	4977(2)	8499.8(13)	56.3(4)
C15	-803(3)	6504(3)	8486.3(16)	69.8(6)
C16	-423(3)	7303(2)	7866.2(17)	74.6(7)
C17	293(3)	6559(2)	7263.3(15)	67.1(6)
C18	598(2)	5011(2)	7266.6(12)	52.2(4)

C19	3863(2)	3670(2)	6191.2(9)	44.0(4)
C20	2743(3)	3183(2)	5439.0(11)	56.4(4)
C21	2354(3)	4359(3)	5007.9(11)	63.2(5)
C22	3053(3)	5997(2)	5305.8(11)	55.0(4)
C23	4204(3)	6452(2)	6054.6(12)	59.3(5)
C24	4619(2)	5302(2)	6495.7(11)	53.7(4)
C25	2595(3)	7247(3)	4825.0(14)	74.4(6)

Table 3 Anisotropic Displacement Parameters ($Å^2×10^3$) for exp_588. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	46.4(2)	47.1(2)	39.7(2)	13.19(16)	9.93(15)	19.04(16)
F1	55.4(6)	73.7(7)	44.1(5)	7.1(5)	14.5(4)	22.8(5)
F2	44.7(5)	54.4(6)	67.0(6)	35.3(5)	12.2(4)	12.5(4)
O1	33.6(6)	47.1(7)	85.1(9)	27.5(6)	11.9(6)	8.6(5)
O2	81.4(9)	51.5(8)	53.1(7)	7.2(6)	17.3(6)	27.0(6)
O3	38.9(6)	71.7(8)	54.3(7)	24.8(6)	11.8(5)	21.0(5)
N1	35.7(6)	43.2(7)	35.1(6)	10.7(5)	2.7(5)	11.0(5)
C1	46.4(9)	65.1(11)	39.5(8)	8.1(7)	2.9(7)	18.8(8)
C2	54.0(11)	105.7(18)	45.7(10)	23.8(10)	-0.3(8)	34.4(11)
C3	69.4(12)	88.5(16)	63.0(12)	40.0(11)	19.1(10)	47.3(11)
C4	73.4(12)	52.4(11)	70.2(12)	27.5(9)	19.5(10)	30.5(9)
C5	52.3(9)	41.8(9)	51.6(9)	14.9(7)	3.1(7)	13.8(7)
C6	34.7(7)	43.5(8)	37.4(7)	13.4(6)	5.4(6)	11.9(6)
C7	35.5(7)	35.6(8)	35.7(7)	8.5(6)	3.5(5)	10.0(5)
C8	40.2(8)	40.4(8)	41.9(8)	13.8(6)	8.6(6)	11.6(6)
C9	32.5(7)	37.9(8)	52.0(9)	15.8(6)	5.5(6)	9.0(6)
C10	37.4(7)	34.9(8)	46.2(8)	14.5(6)	0.6(6)	10.1(6)
C11	44.3(8)	37.9(8)	53.3(9)	7.9(7)	6.4(7)	7.9(6)
C12	49.5(9)	53.6(11)	53.4(10)	8.1(8)	-3.9(7)	6.6(8)

C13	32.8(7)	38.8(8)	60.0(10)	13.2(7)	2.7(6)	9.8(6)
C14	44.5(9)	50.4(10)	75.4(12)	10.5(9)	12.4(8)	16.0(7)
C15	52.9(11)	49.2(11)	100.4(17)	-4.4(11)	4.8(10)	20.4(8)
C16	59.3(12)	36.6(10)	115.6(19)	8.7(11)	-15.3(12)	14.3(8)
C17	64.7(12)	45.0(11)	87.1(15)	25.4(10)	-7.9(10)	10.9(9)
C18	49.3(9)	44.4(9)	64.0(11)	19.2(8)	2.0(8)	13.6(7)
C19	48.6(8)	50.6(9)	37.5(8)	14.0(7)	10.7(6)	16.6(7)
C20	69.7(11)	54.6(11)	41.7(9)	12.2(8)	2.9(8)	11.5(9)
C21	73.5(12)	73.4(14)	42.6(9)	21.6(9)	-1.3(8)	19.1(10)
C22	64.2(11)	63.5(12)	48.7(9)	24.0(8)	17.7(8)	25.9(9)
C23	77.2(13)	50.8(11)	52.1(10)	18.6(8)	12.6(9)	13.7(9)
C24	62.6(11)	54.3(11)	42.9(9)	15.7(8)	4.8(7)	10.3(8)
C25	95.3(16)	81.1(16)	64.4(13)	37.1(11)	19.4(11)	40.6(13)

Table 4 Bond Lengths for exp_588.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
S1	O2	1.4221(13)	C8	C9	1.547(2)
S1	O3	1.4302(12)	C9	C10	1.522(2)
S1	N1	1.6455(13)	C9	C13	1.530(2)
S1	C19	1.7611(16)	C10	C12	1.322(2)
F1	C8	1.3599(18)	C13	C14	1.392(3)
F2	C8	1.3557(18)	C13	C18	1.383(2)
O1	C9	1.4102(18)	C14	C15	1.378(3)
N1	C7	1.5051(18)	C15	C16	1.383(4)
N1	C10	1.4236(18)	C16	C17	1.377(3)
C1	C2	1.394(3)	C17	C18	1.389(3)
C1	C6	1.385(2)	C19	C20	1.381(2)
C2	C3	1.353(3)	C19	C24	1.381(3)
C3	C4	1.367(3)	C20	C21	1.385(3)

C4	C5	1.385(2)	C21	C22	1.376(3)
C5	C6	1.384(2)	C22	C23	1.388(3)
C6	C7	1.5306(19)	C22	C25	1.506(3)
C7	C8	1.557(2)	C23	C24	1.383(3)
C7	C11	1.523(2)			

Table 5 Bond Angles for exp_588.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O2	S1	O3	119.46(8)	C9	C8	C7	107.96(12)
O2	S1	N1	108.66(8)	O1	C9	C8	108.54(12)
O2	S1	C19	107.91(8)	O1	C9	C10	111.16(13)
O3	S1	N1	106.12(7)	O1	C9	C13	110.78(12)
O3	S1	C19	108.44(8)	C10	C9	C8	98.91(11)
N1	S1	C19	105.42(7)	C10	C9	C13	113.99(13)
C7	N1	S1	123.59(9)	C13	C9	C8	112.84(13)
C10	N1	S1	123.13(10)	N1	C10	C9	107.28(12)
C10	N1	C7	113.24(12)	C12	C10	N1	128.27(16)
C6	C1	C2	120.13(18)	C12	C10	C9	124.42(15)
C3	C2	C1	121.06(18)	C14	C13	C9	118.46(16)
C2	C3	C4	119.34(17)	C18	C13	C9	122.57(16)
C3	C4	C5	120.71(19)	C18	C13	C14	118.89(16)
C6	C5	C4	120.62(17)	C15	C14	C13	120.4(2)
C1	C6	C7	120.76(14)	C14	C15	C16	120.6(2)
C5	C6	C1	118.10(15)	C17	C16	C15	119.20(19)
C5	C6	C7	121.04(13)	C16	C17	C18	120.6(2)
N1	C7	C6	111.62(12)	C13	C18	C17	120.3(2)
N1	C7	C8	99.27(11)	C20	C19	S1	120.04(14)
N1	C7	C11	111.24(12)	C24	C19	S1	119.64(12)
C6	C7	C8	109.97(12)	C24	C19	C20	120.32(16)

C11	C7	C6	113.25(12)	C19	C20	C21	118.97(18)
C11	C7	C8	110.65(12)	C22	C21	C20	121.96(17)
F1	C8	C7	110.78(12)	C21	C22	C23	117.95(17)
F1	C8	C9	114.71(12)	C21	C22	C25	120.71(18)
F2	C8	F1	105.09(12)	C23	C22	C25	121.33(19)
F2	C8	C7	110.44(12)	C24	C23	C22	121.20(18)
F2	C8	C9	107.79(12)	C19	C24	C23	119.56(16)

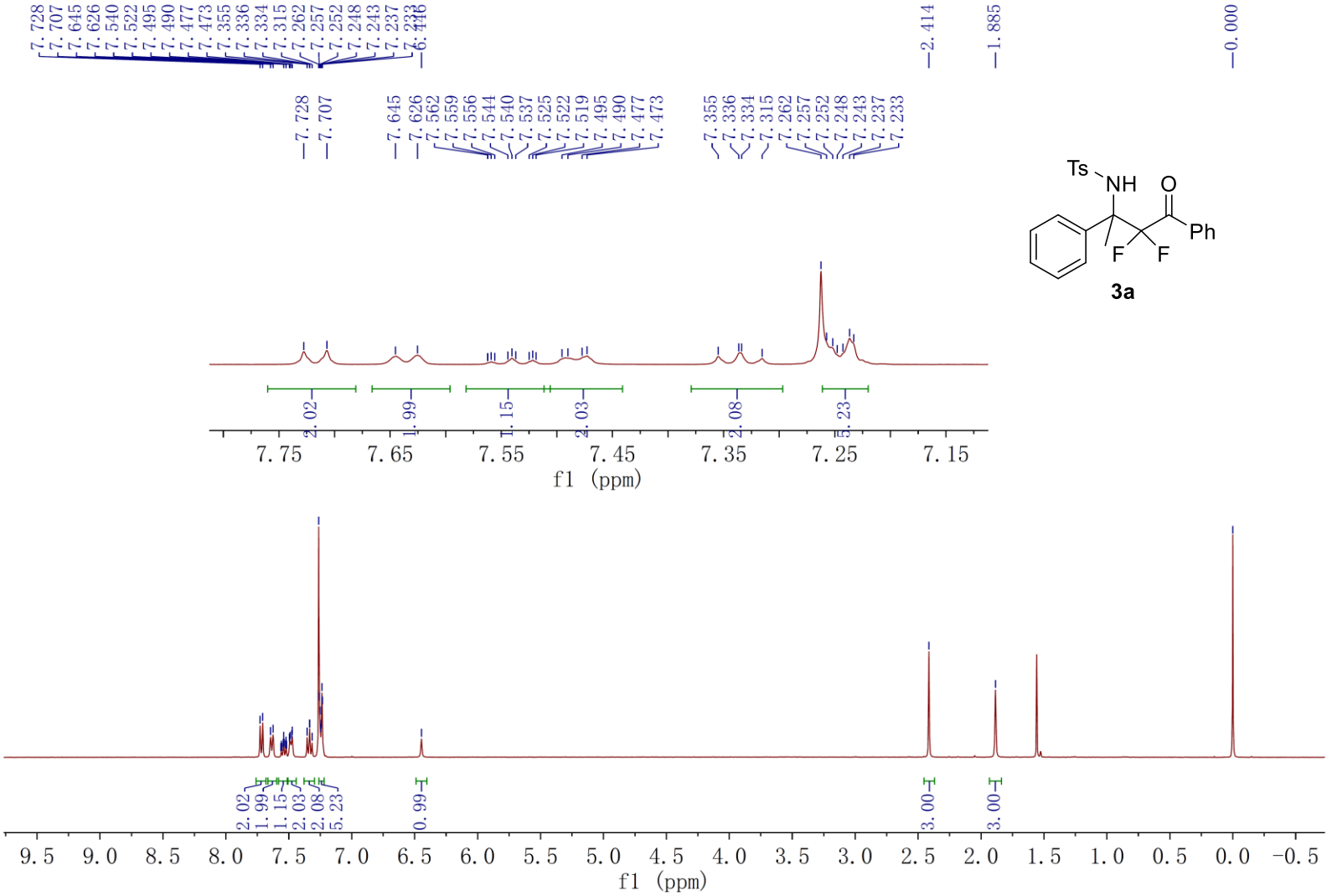
Table 6 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×10^3) for exp_588.

Atom	***x***	***y***	***z***	**U(eq)**
H1	-1912.06	1867.93	7829.87	81
H1A	6192.76	3426.62	9676.98	61
H2	7807.62	1765.51	10246.82	80
H3	7532.81	-861.79	9599.46	79
H4	5583.21	-1894.46	8383.89	73
H5	3859.06	-316.69	7829.28	58
H11A	5568.38	4800.41	8383.75	69
H11B	4689	4961.26	9145.99	69
H11C	3722.48	5181.11	8301.25	69
H12A	778.78	369.04	6100.61	66
H12B	-958.2	592.29	6421.16	66
H14	-742.79	4453.52	8920.89	68
H15	-1277.69	7002.44	8898.12	84
H16	-647.26	8329.86	7856.49	90
H17	573.89	7097.68	6850.28	81
H18	1056.35	4509.91	6849.37	63
H20	2258.32	2082.47	5225.32	68
H21	1596.97	4031.83	4502.1	76
H23	4705.68	7551.58	6263.65	71

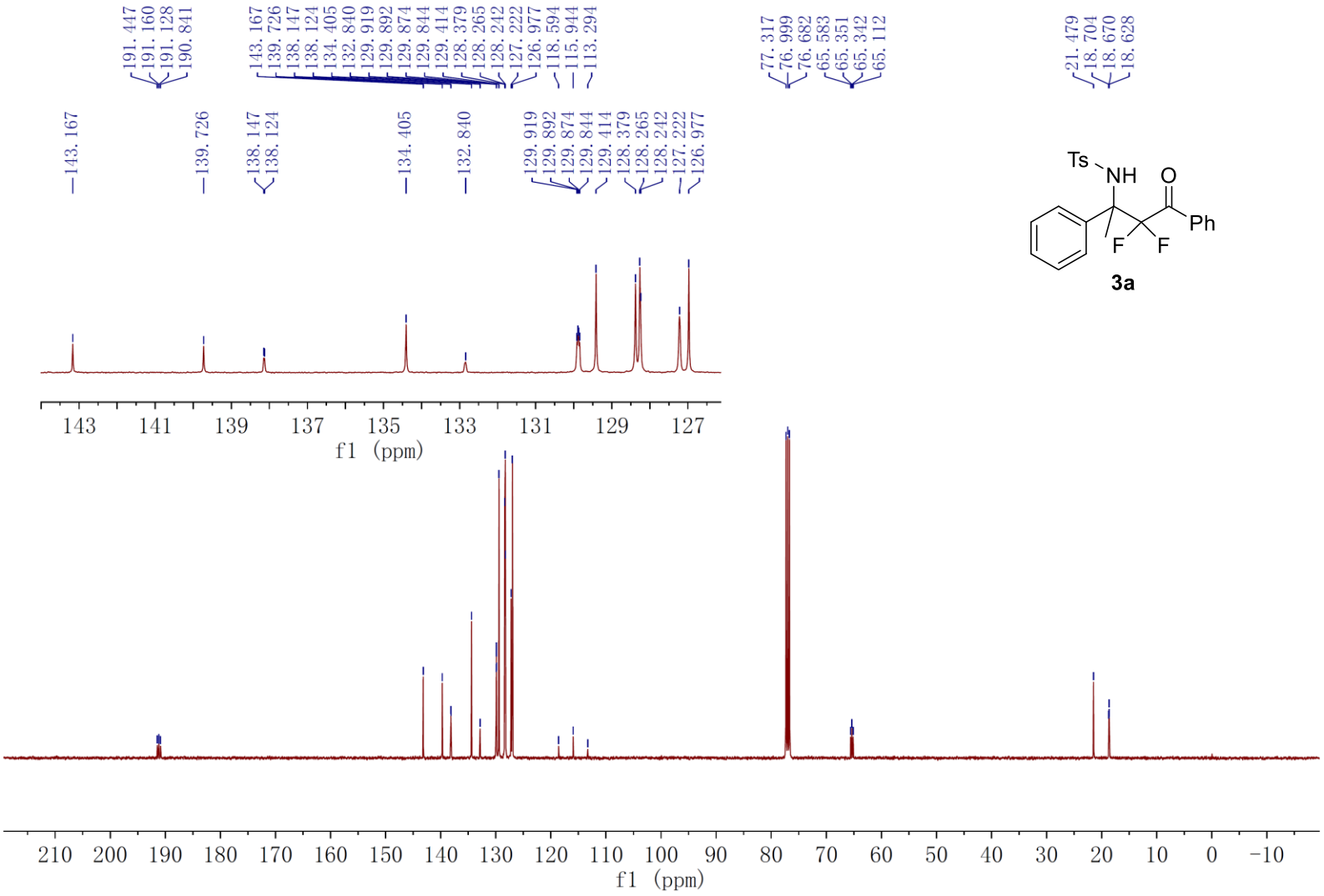
H24	5400.94	5624.82	6994.11	64
H25A	2276.89	6760.77	4252.54	112
H25B	3576.49	8148.1	4917.58	112
H25C	1639.29	7629.79	4998.29	112

Part IV. ^{1}H, ^{13}C, ^{19}F NMR spectra

HXS-HD-62-400M-H

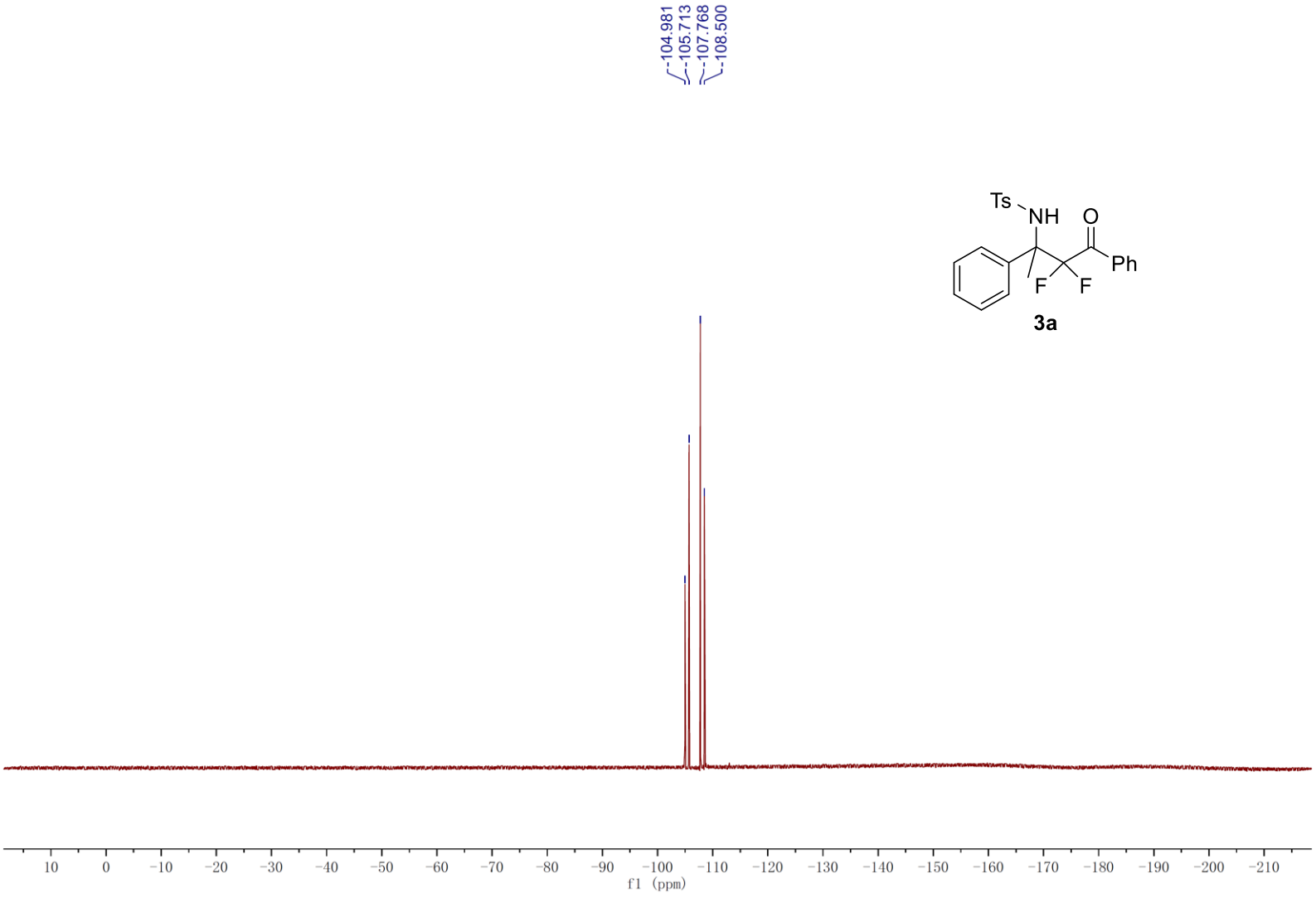


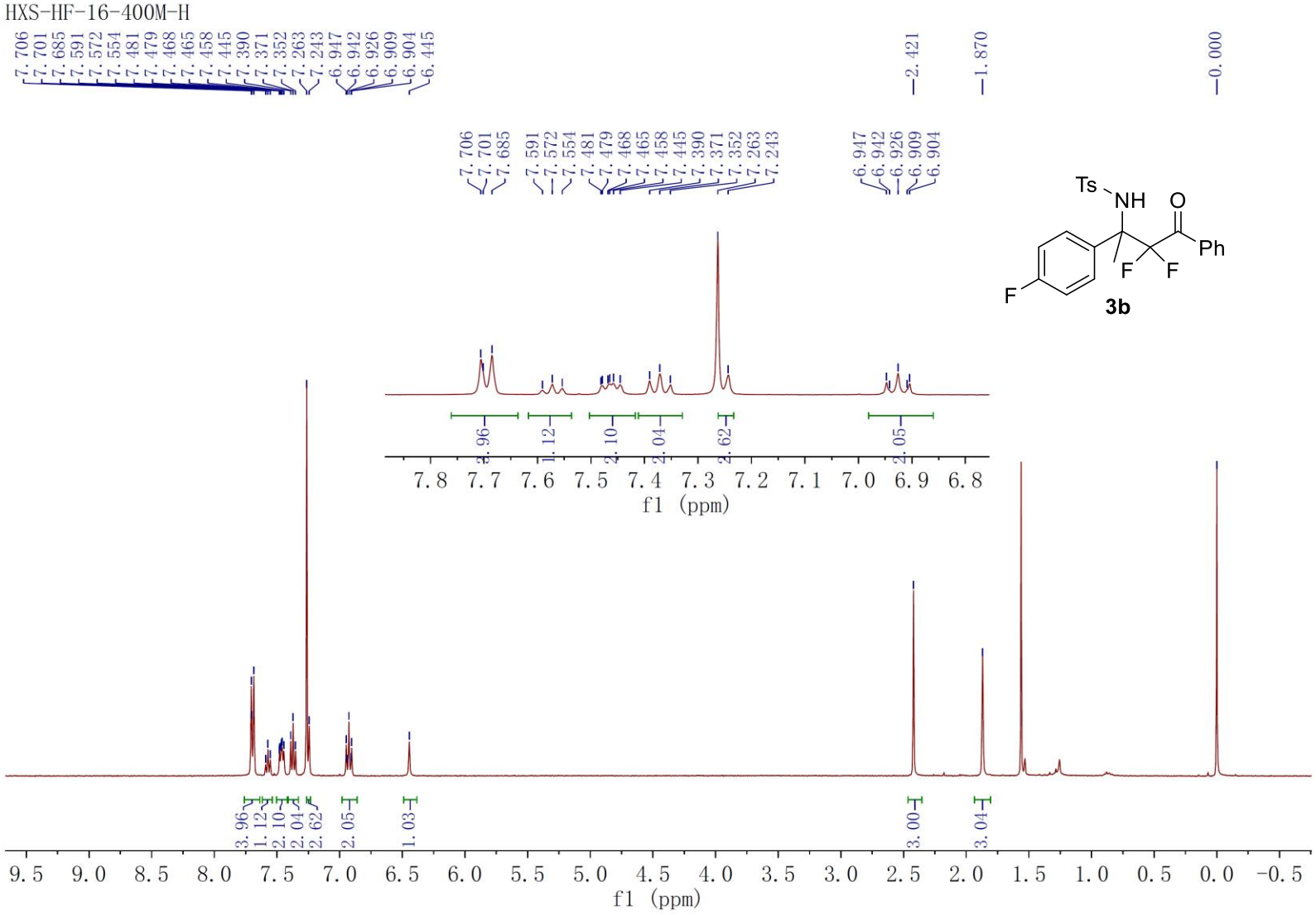
HXS-HD-62-400M-C

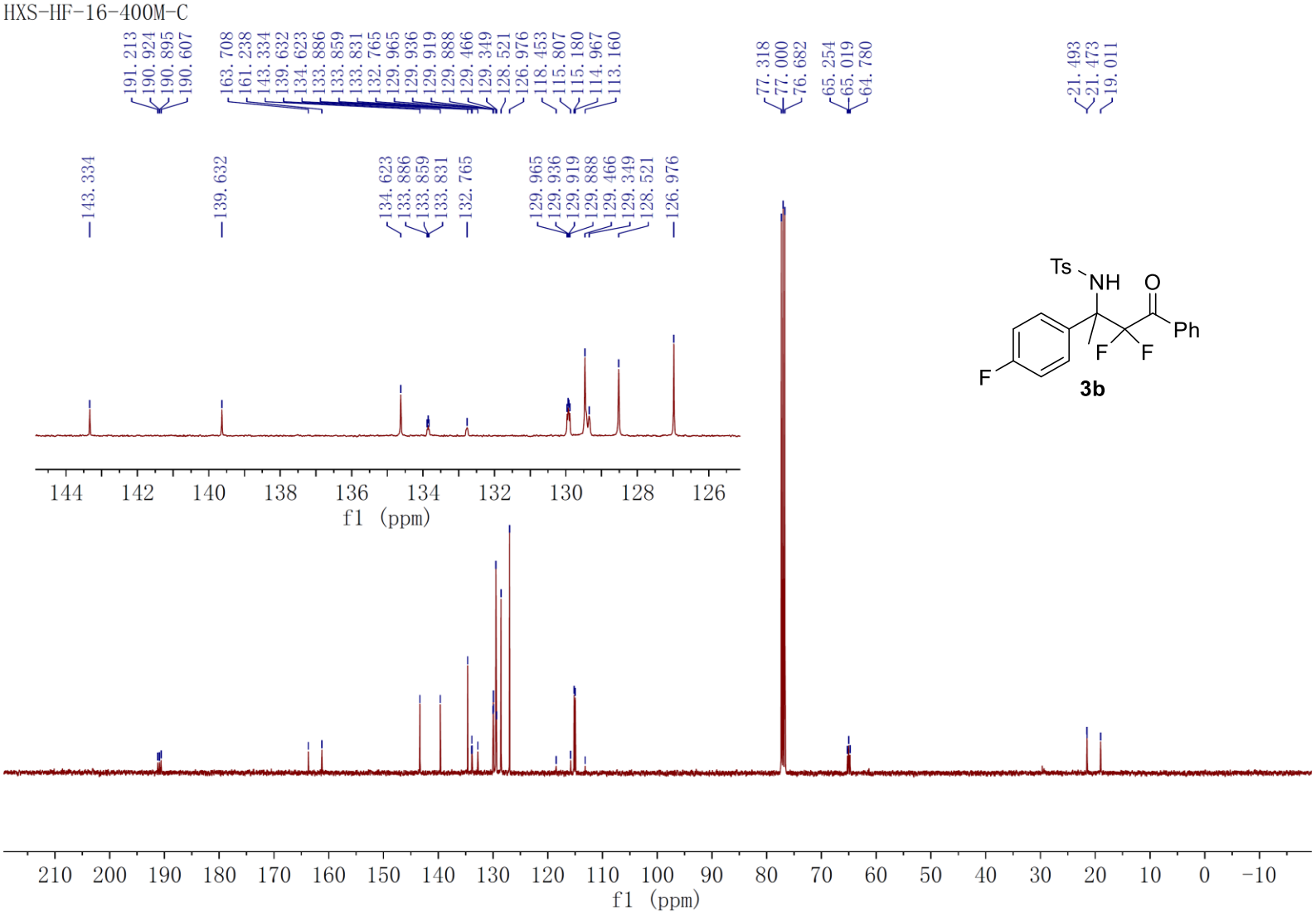


3a

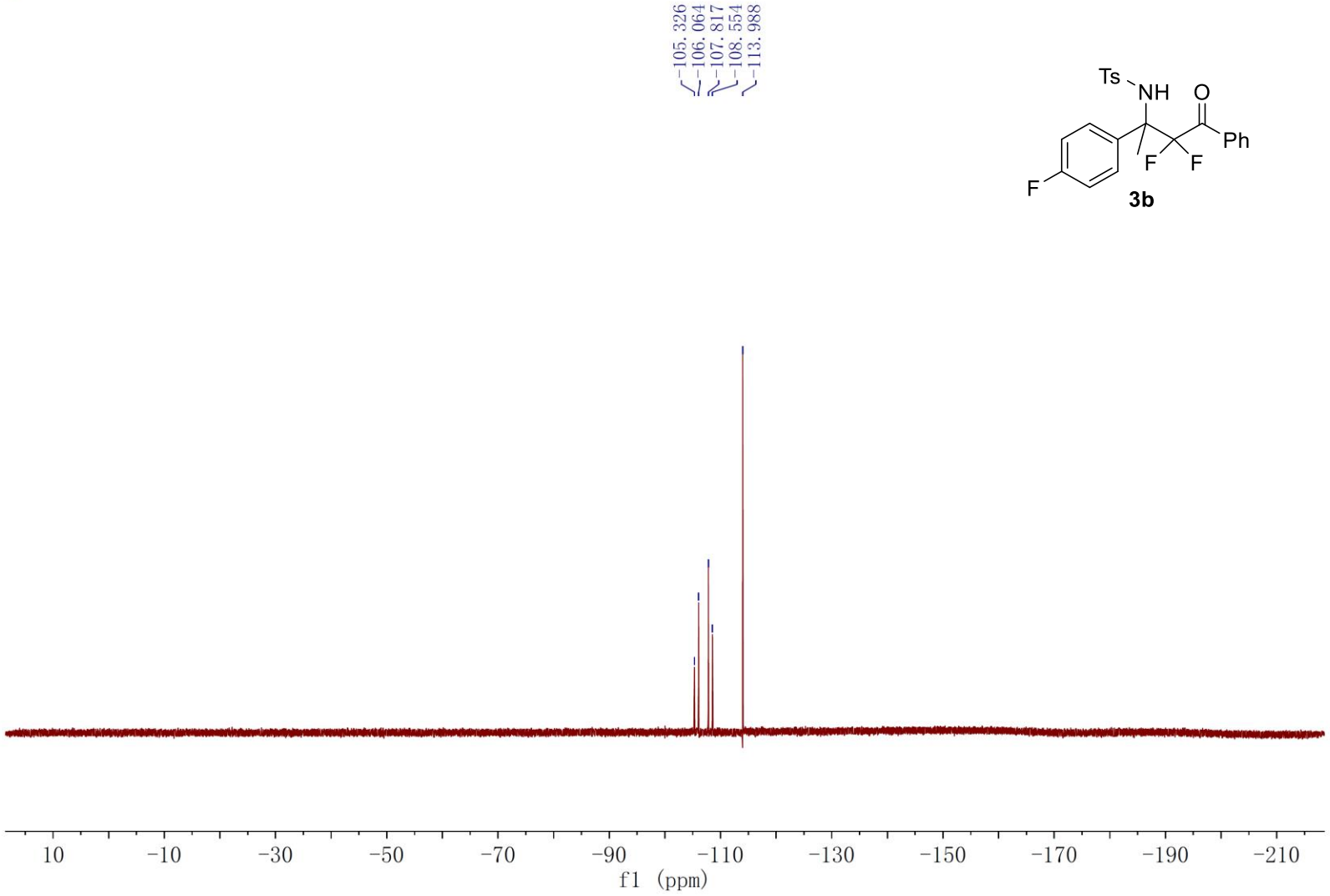
HXS-HD-62-400M-F



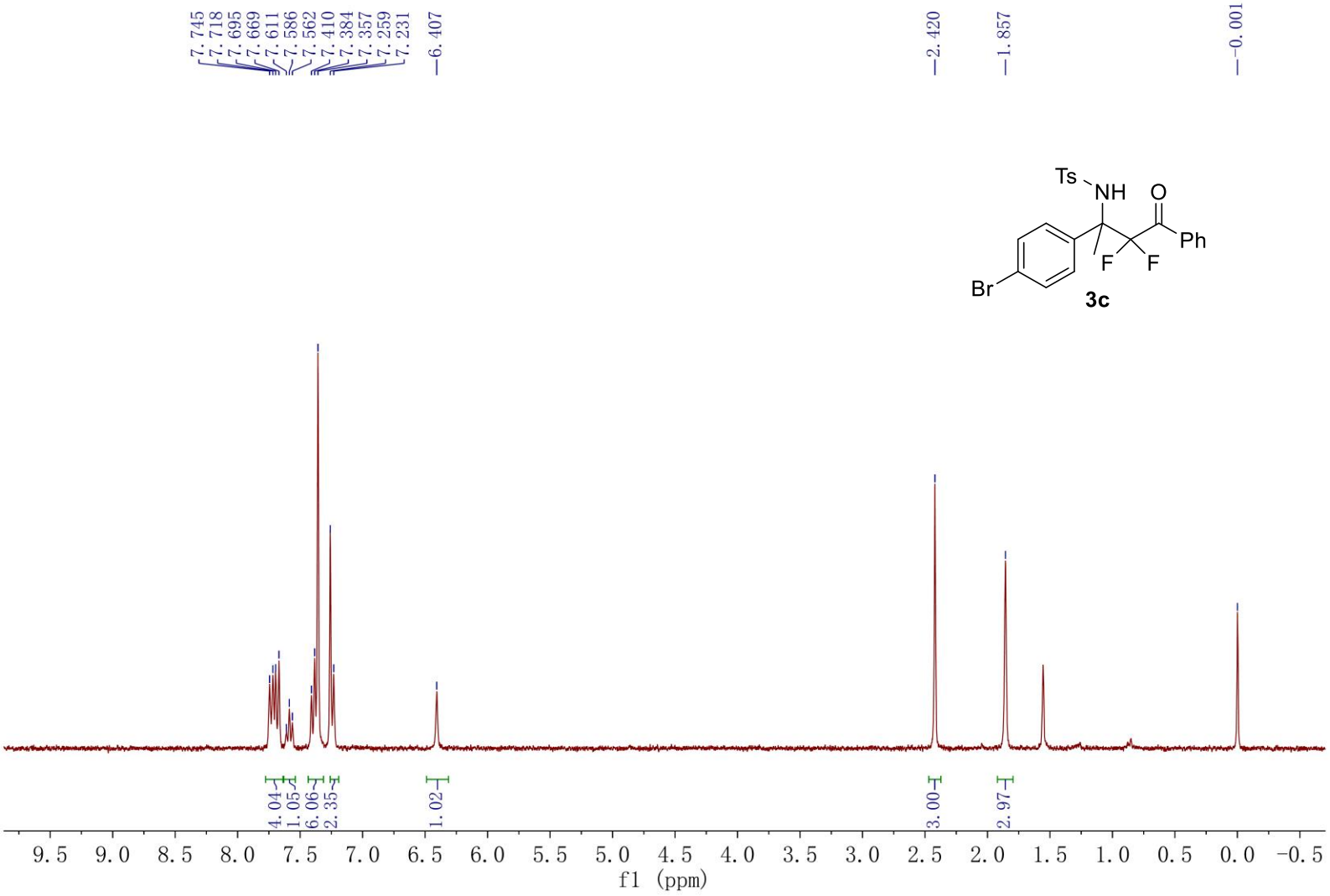

HXS-HF-16-400M-H
7.706
7.701
7.685
7.591
7.572
7.554
7.481
7.479
7.468
7.465
7.458
7.445
7.390
7.371
7.352
7.263
7.243
6.947
6.942
6.926
6.909
6.904
6.445
2.421
1.870
0.000
Ts
NH
O
Ph
F
F
F
3b
3.96
1.12
2.10
2.04
2.62
2.05
1.03
3.00
3.04
f1 (ppm)

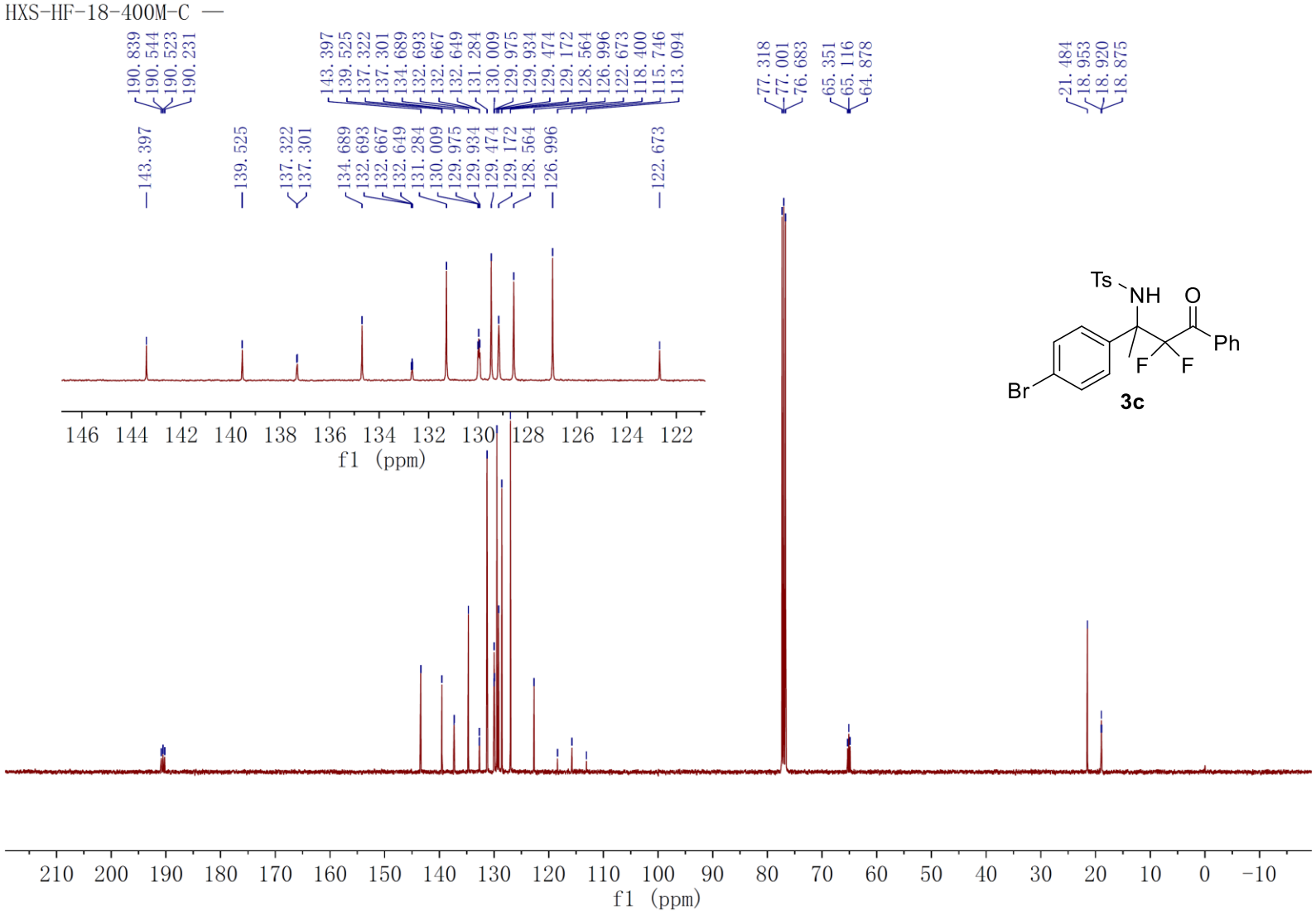

HXS-HF-16-400M-C
191.213
190.924
190.895
190.607
163.708
161.238
143.334
139.632
134.623
133.886
133.859
133.831
132.765
129.965
129.936
129.919
129.888
129.466
129.349
128.521
126.976
118.453
115.807
115.180
114.967
113.160
77.318
77.000
76.682
65.254
65.019
64.780
21.493
21.473
19.011
143.334
139.632
134.623
133.886
133.859
133.831
132.765
129.965
129.936
129.919
129.888
129.466
129.349
128.521
126.976
144 142 140 138 136 134 132 130 128 126
f1 (ppm)
Ts
NH
O
Ph
F
F
F
3b
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

HXS-HF-16-400M-F

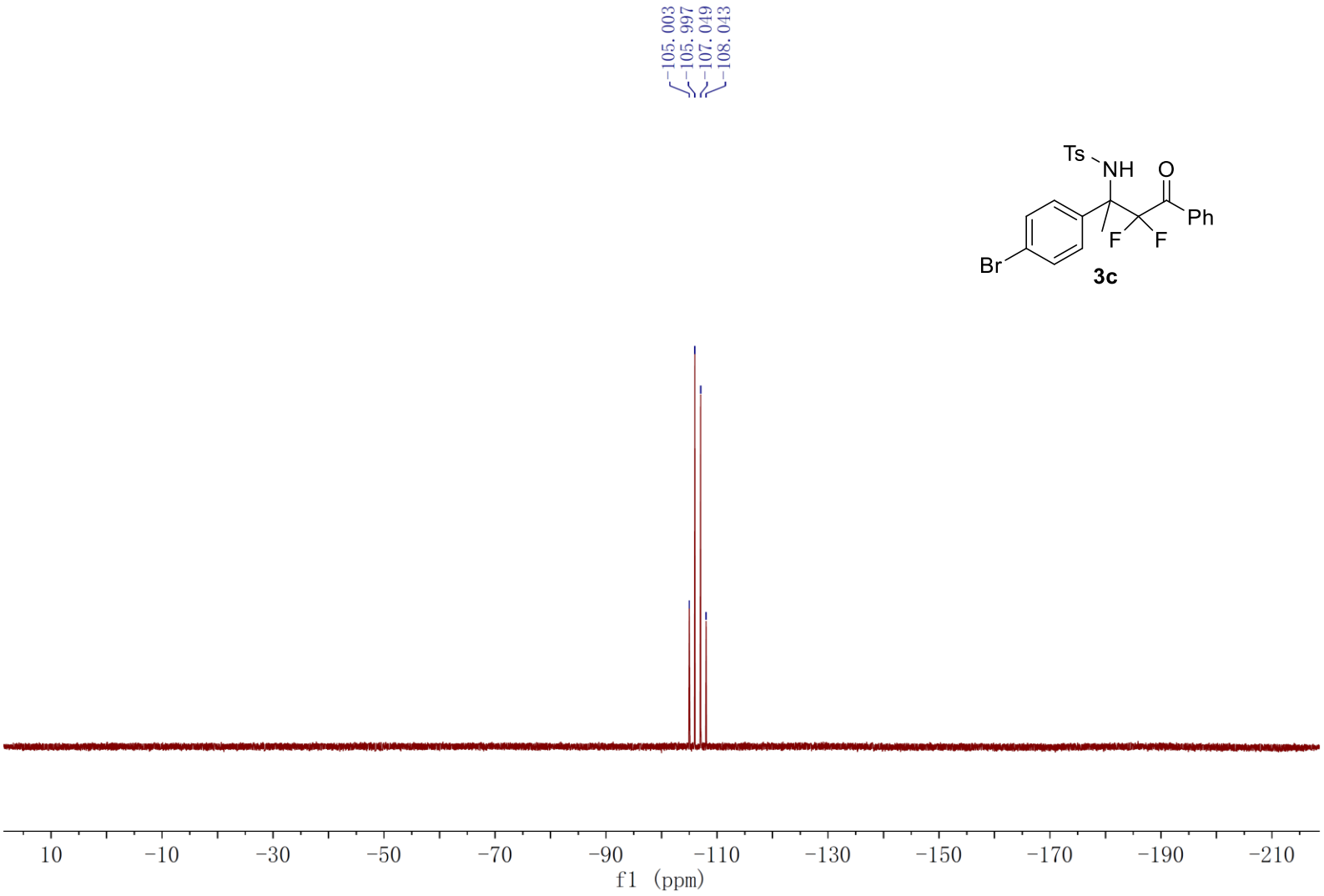


HXS-HF-18-300M-H

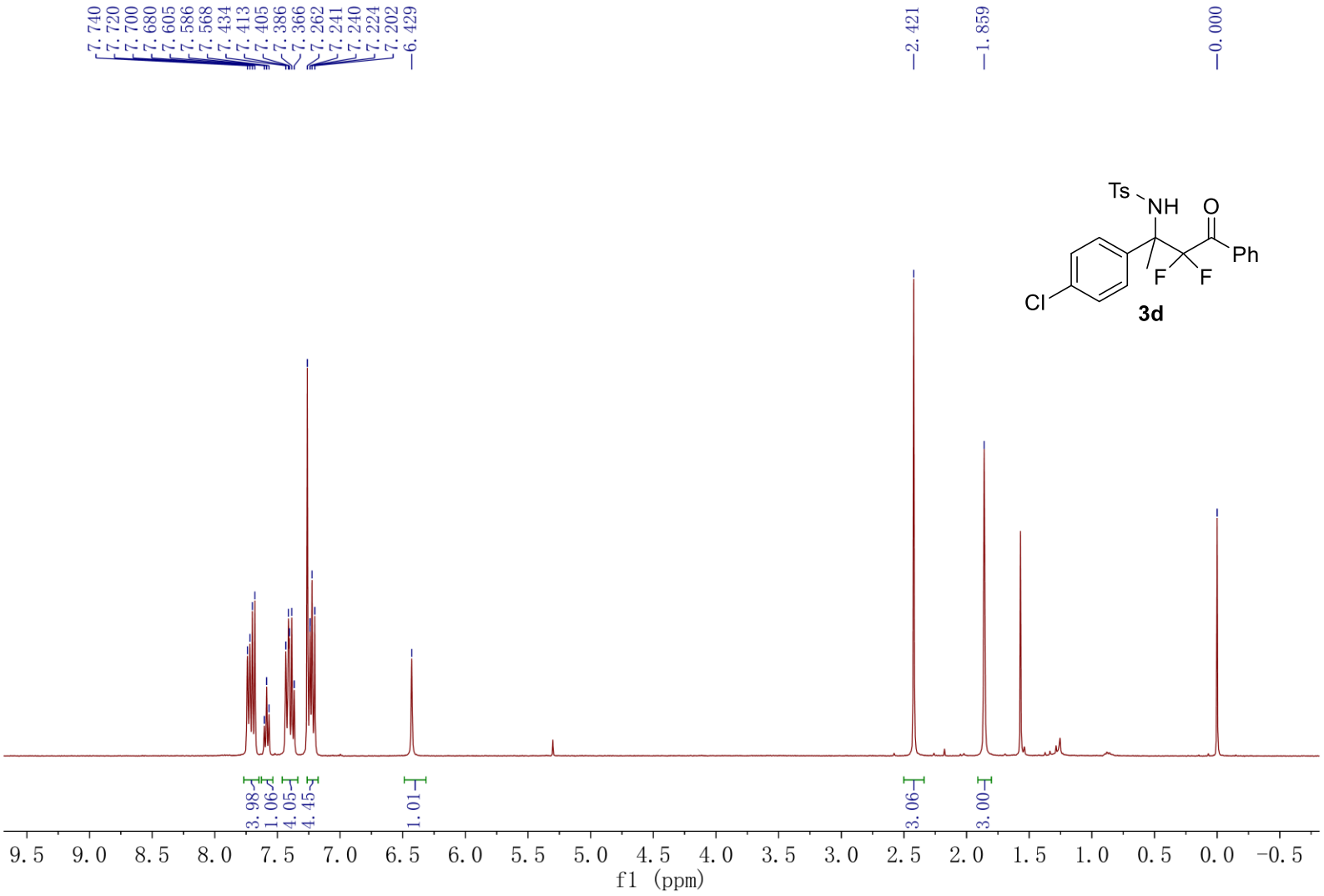


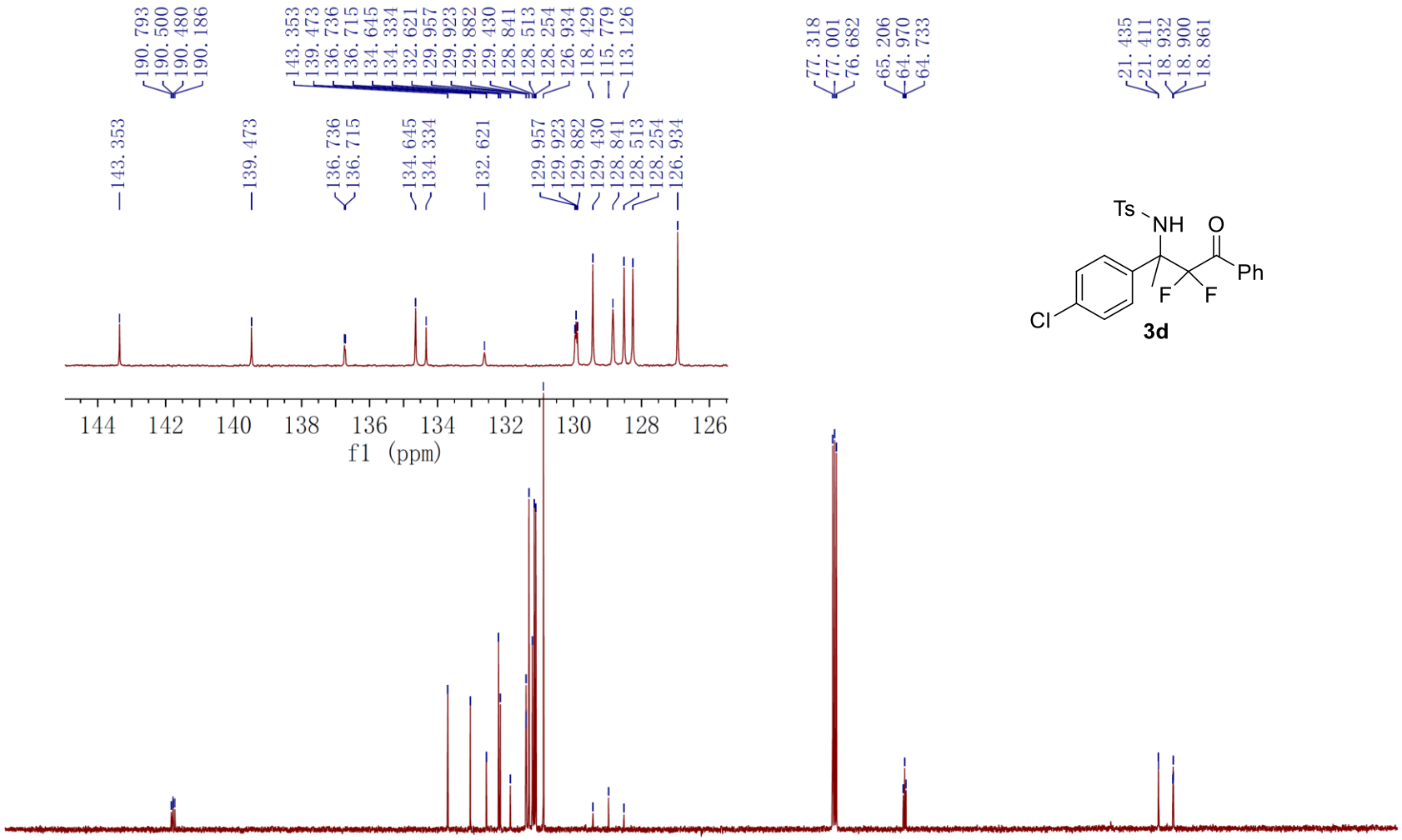

HXS-HF-18-400M-C
190.839
190.544
190.523
190.231
143.397
139.525
137.322
137.301
134.689
132.693
132.667
132.649
131.284
130.009
129.975
129.934
129.474
129.172
128.564
126.996
122.673
118.400
115.746
113.094
77.318
77.001
76.683
65.351
65.116
64.878
21.484
18.953
18.920
18.875
Ts
NH
O
Ph
F
F
Br
3c
f1 (ppm)
f1 (ppm)

HXS-HF-18-300M-F



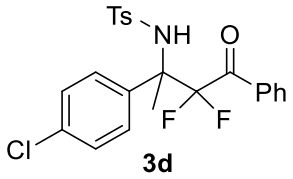
HXS-HF-17-H-400M



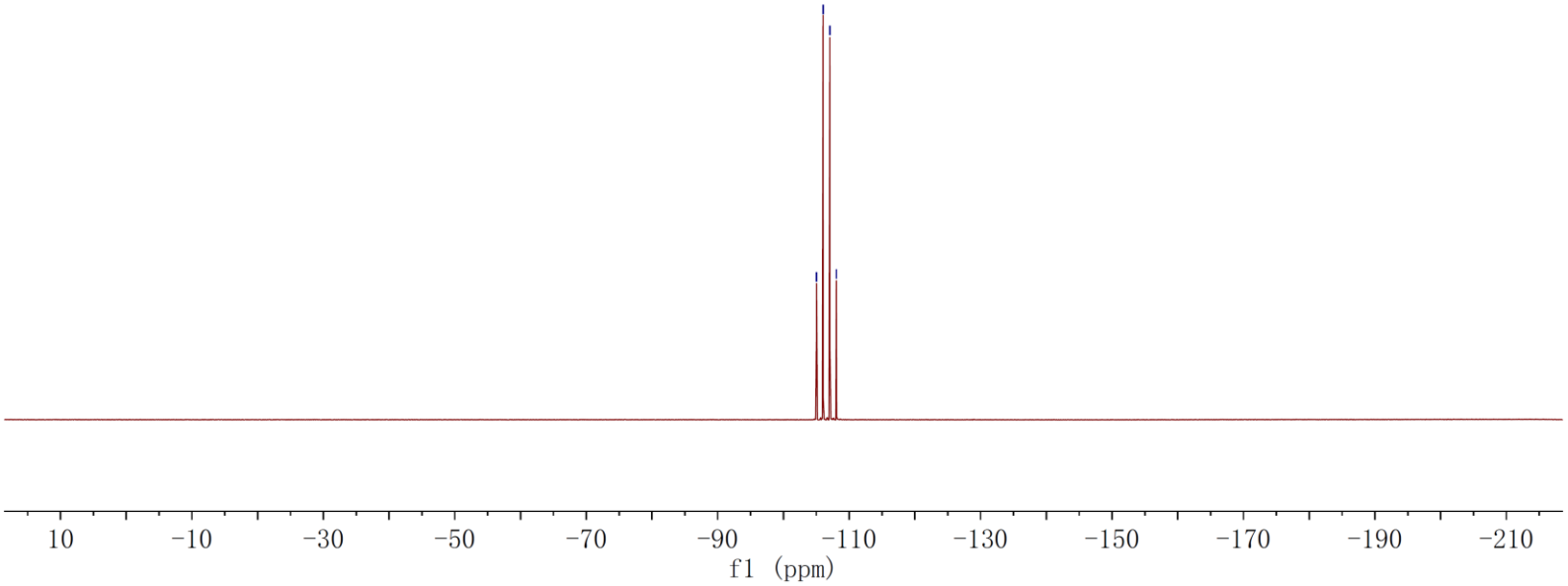

190.793
190.500
190.480
190.186
143.353
139.473
136.736
136.715
134.645
134.334
132.621
129.957
129.923
129.882
129.430
128.841
128.513
128.254
126.934
118.429
115.779
113.126
77.318
77.001
76.682
65.206
64.970
64.733
21.435
21.411
18.932
18.900
18.861
144
142
140
138
136
134
132
130
128
126
f1 (ppm)
Ts
NH
O
Ph
F
F
Cl
3d

HXS-HF-17-300M-F

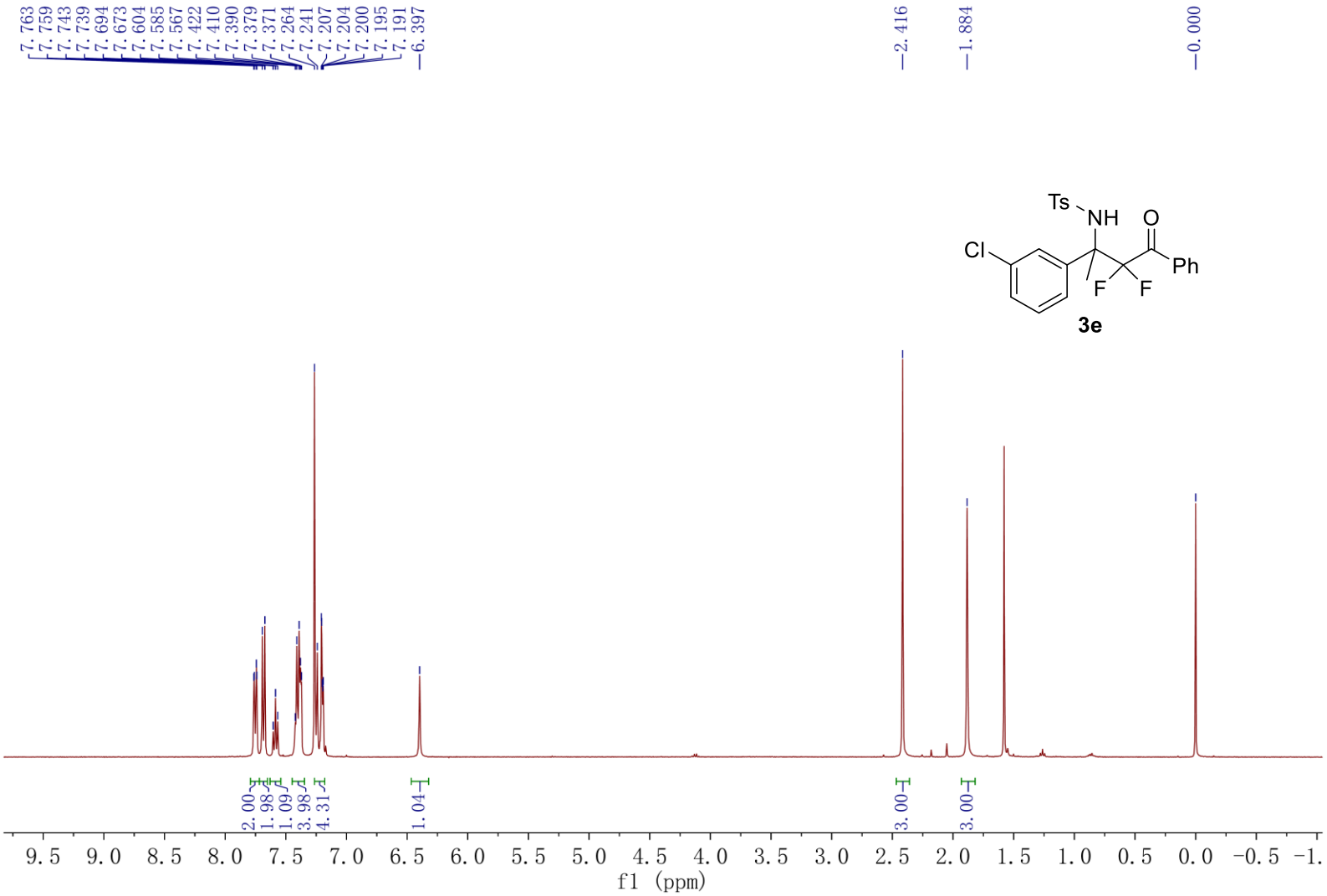
-105.040
-106.030
-107.060
-108.051



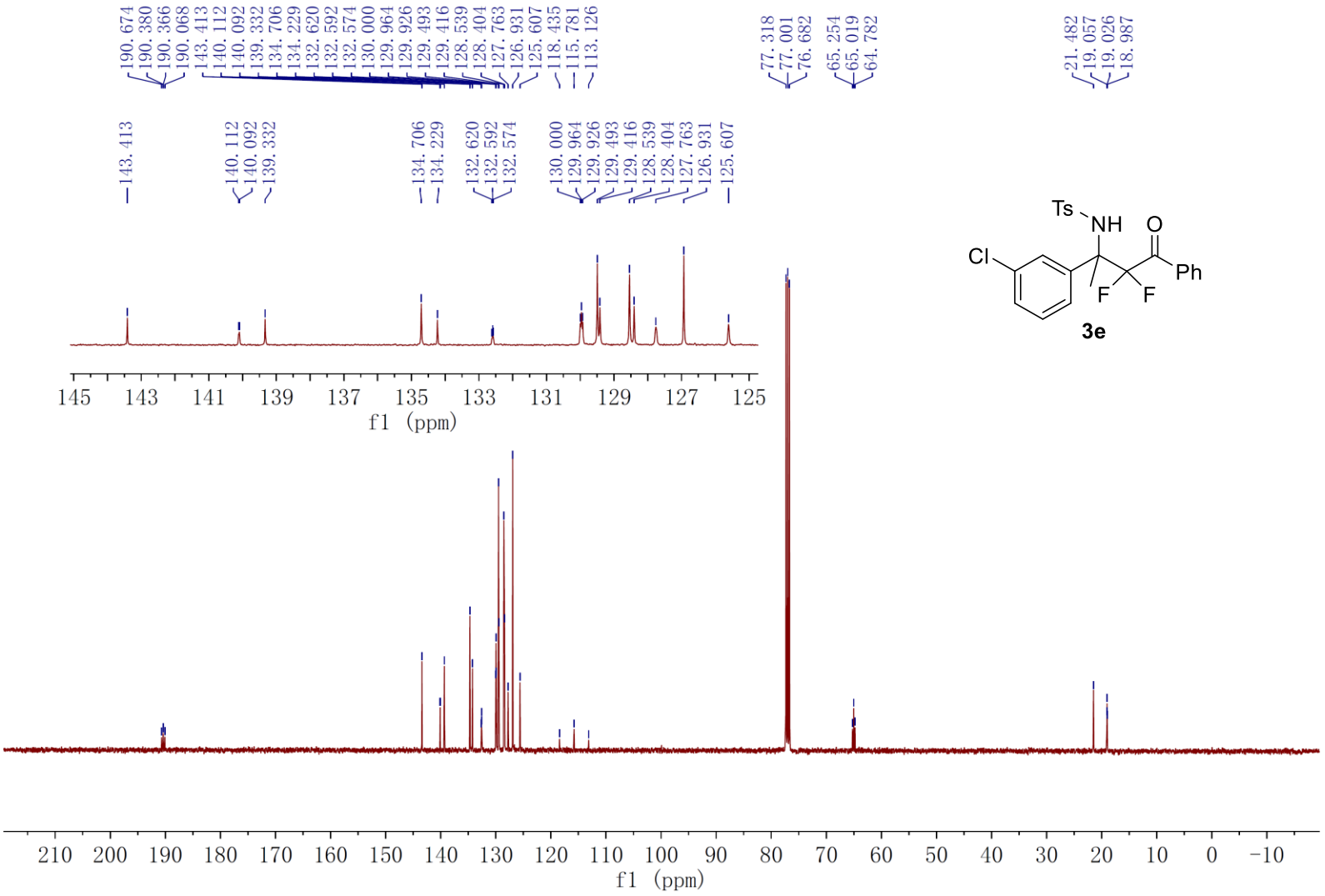
3d



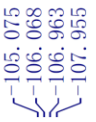
HXS-HF-34-400M-H

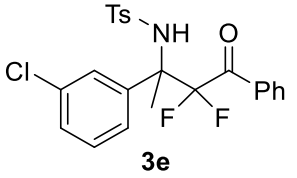


HXS-HF-34-400M-C

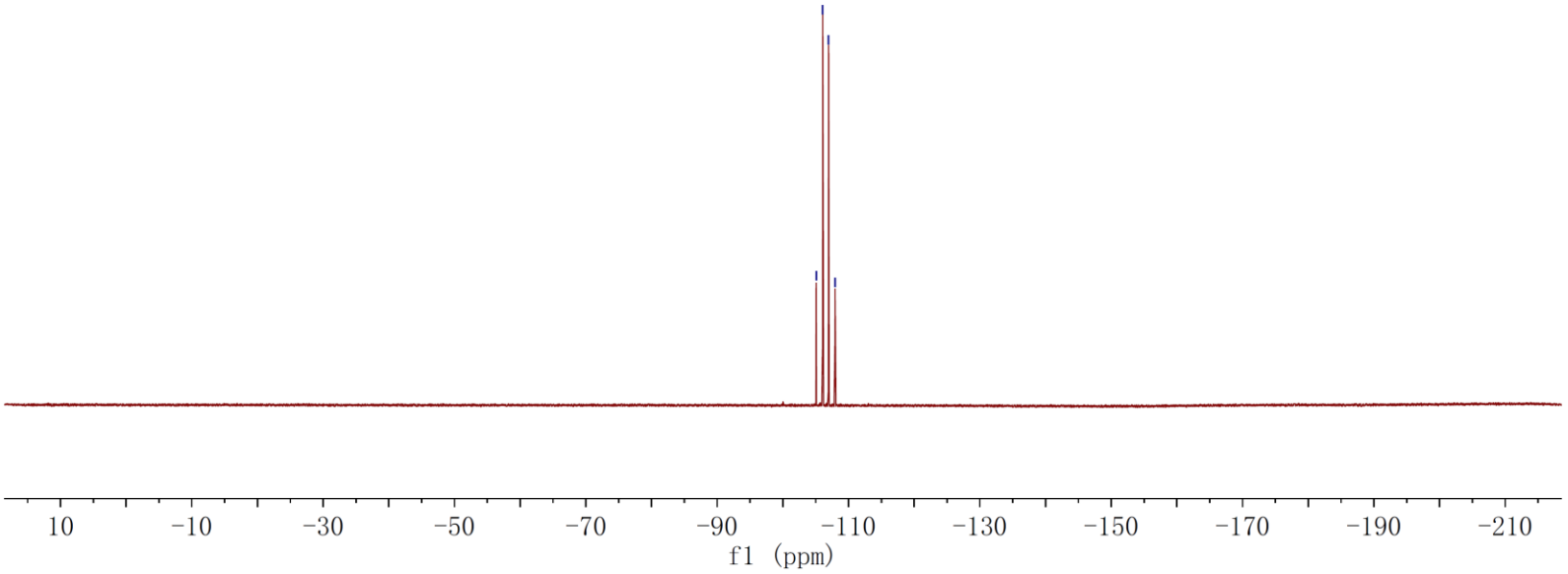


HXS-HF-34-300M-F

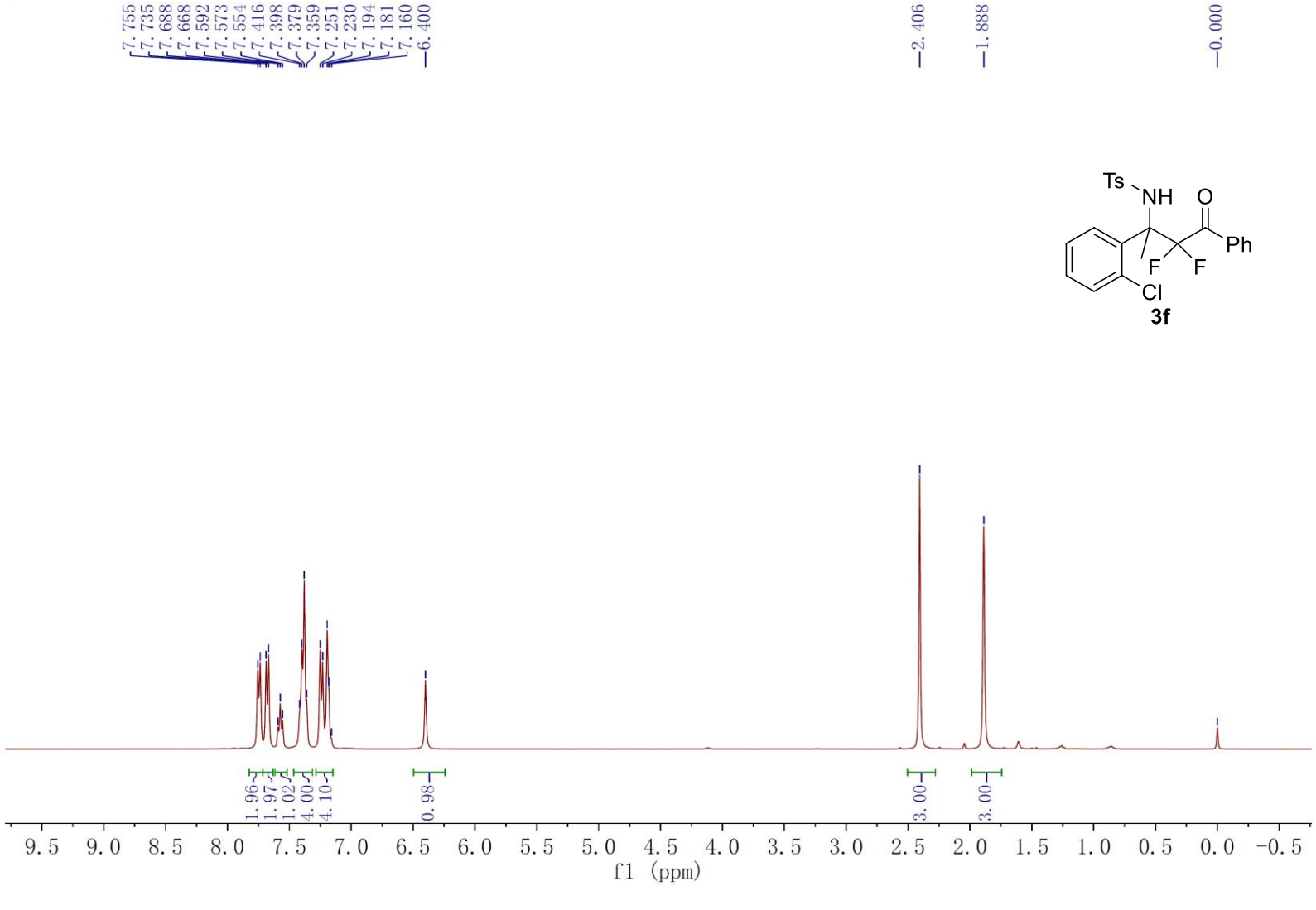


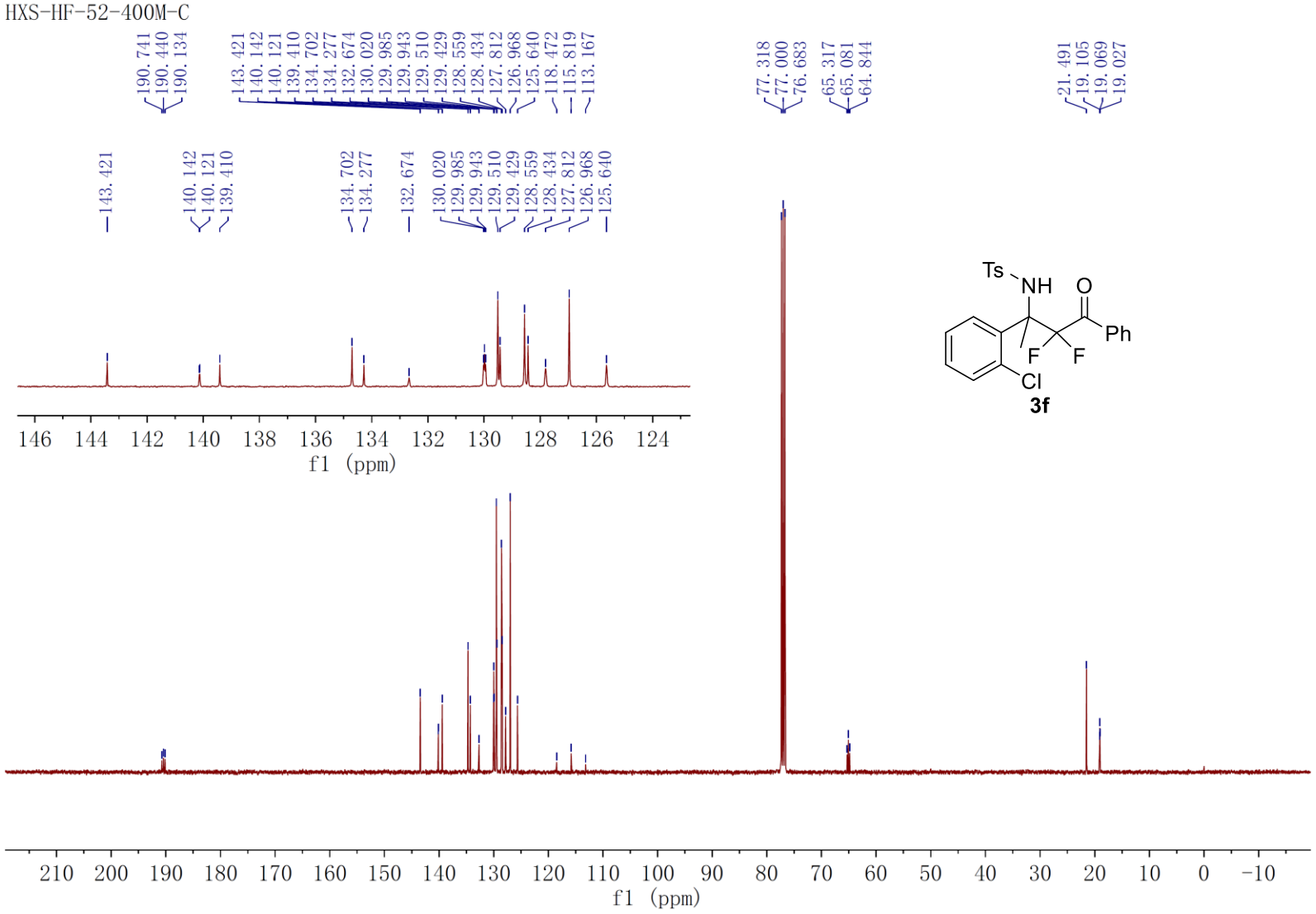


3e

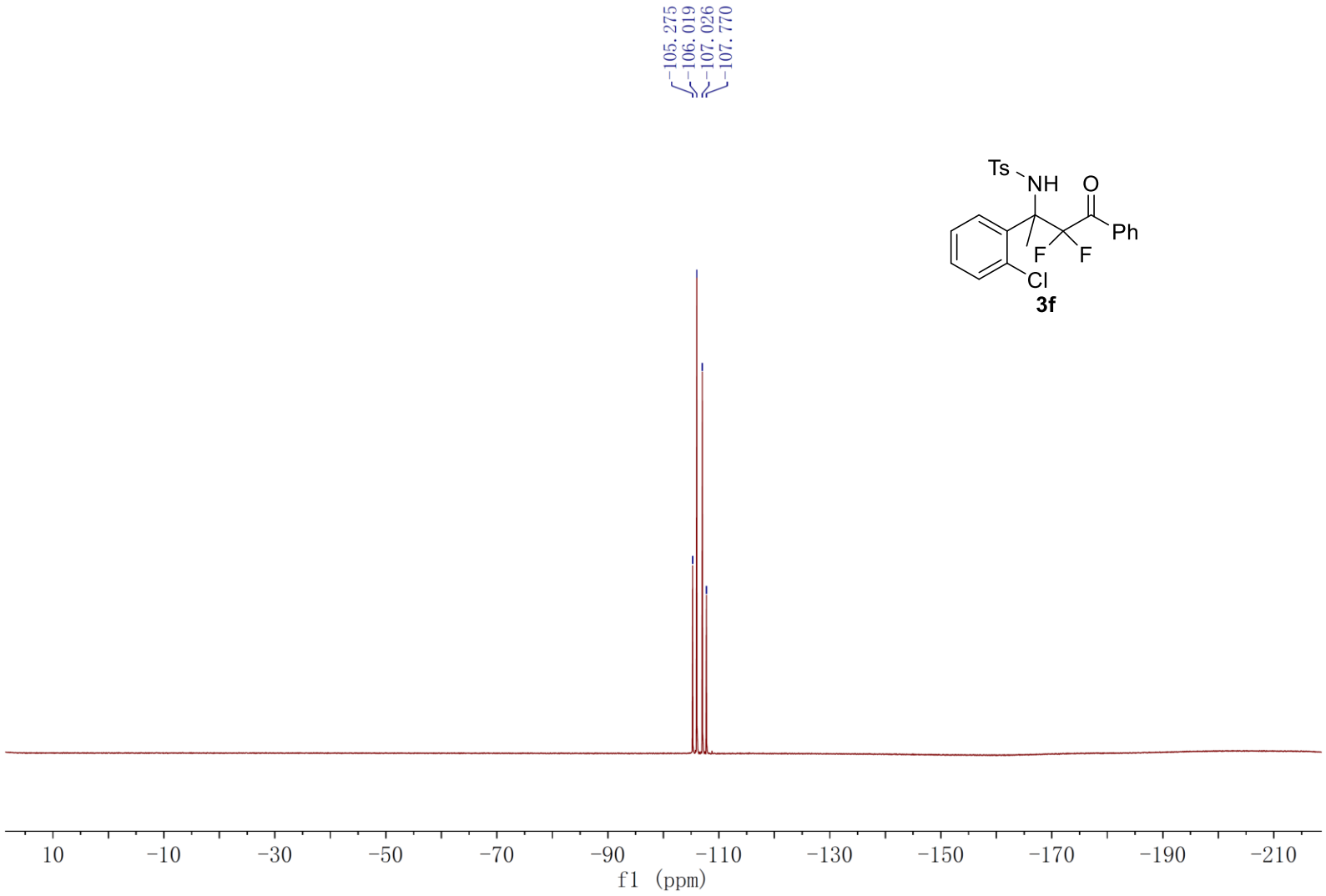


HXS-HF-52-400M-H

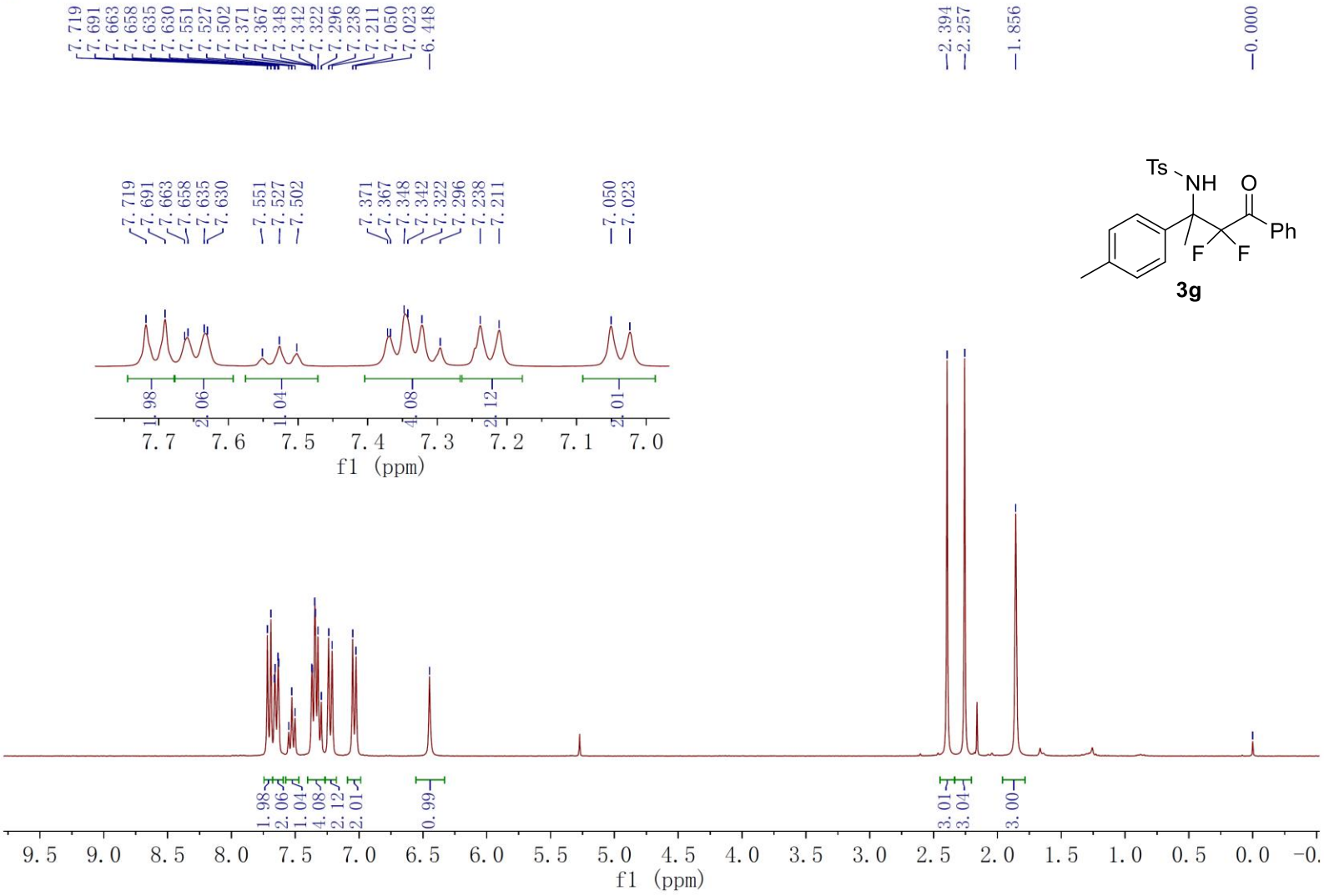



HXS-HF-52-400M-C
190.741
190.440
190.134
143.421
140.142
140.121
139.410
134.702
134.277
132.674
130.020
129.985
129.943
129.510
129.429
128.559
128.434
127.812
126.968
125.640
118.472
115.819
113.167
77.318
77.000
76.683
65.317
65.081
64.844
21.491
19.105
19.069
19.027
Ts
NH
O
Ph
F
F
Cl
3f
f1 (ppm)
f1 (ppm)

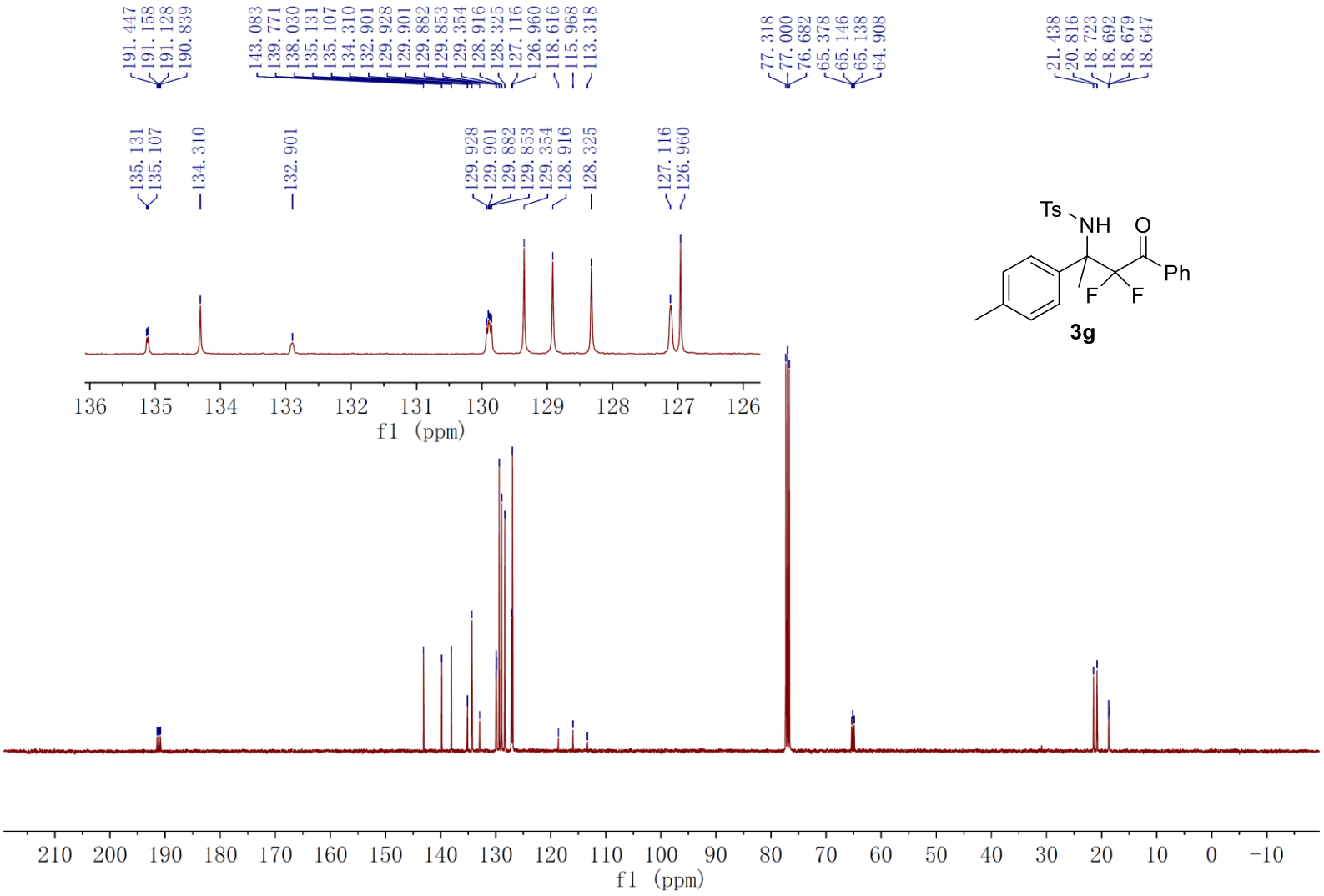
HXS-HF-52-400M-F



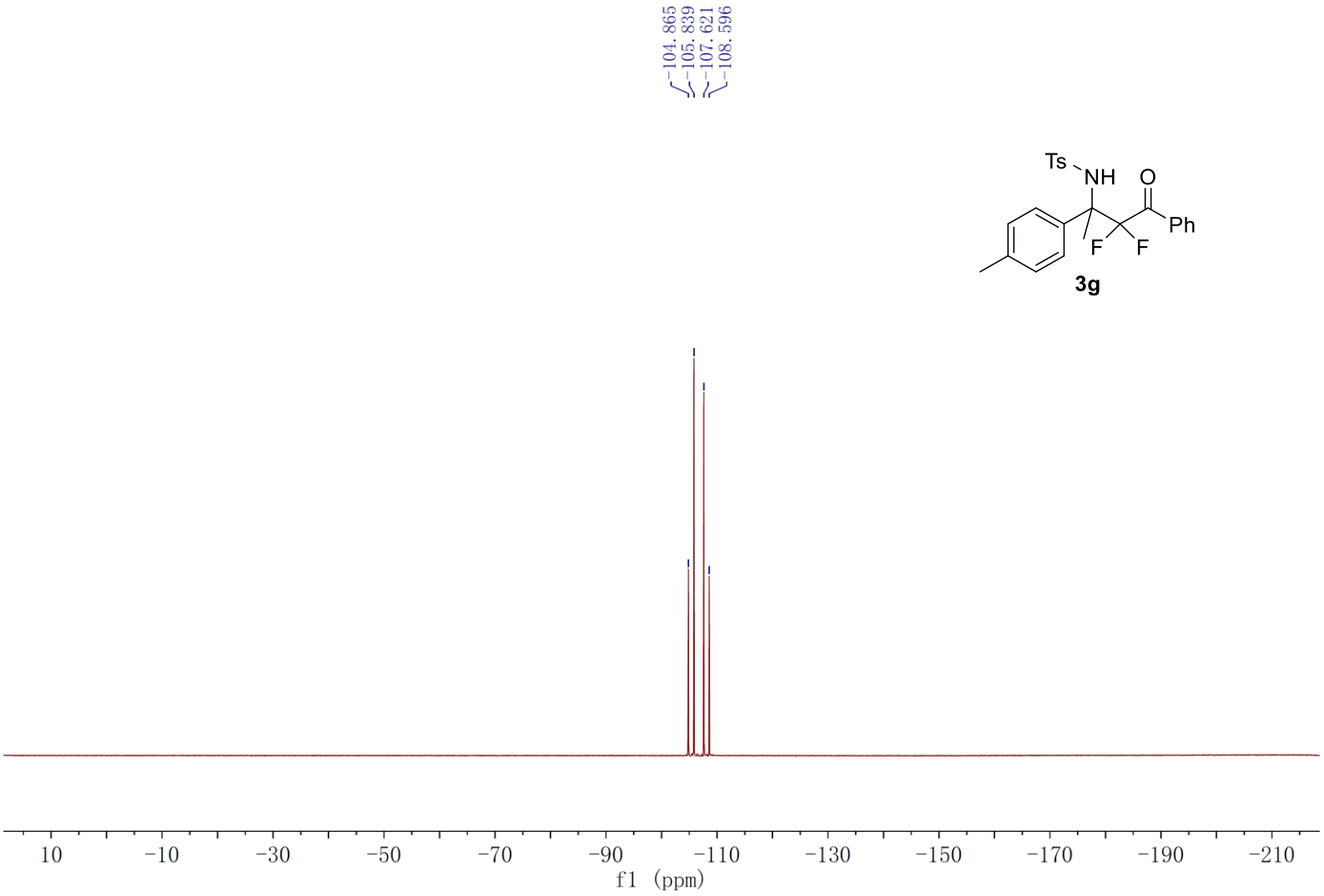
HXS-HE-146-300M-H



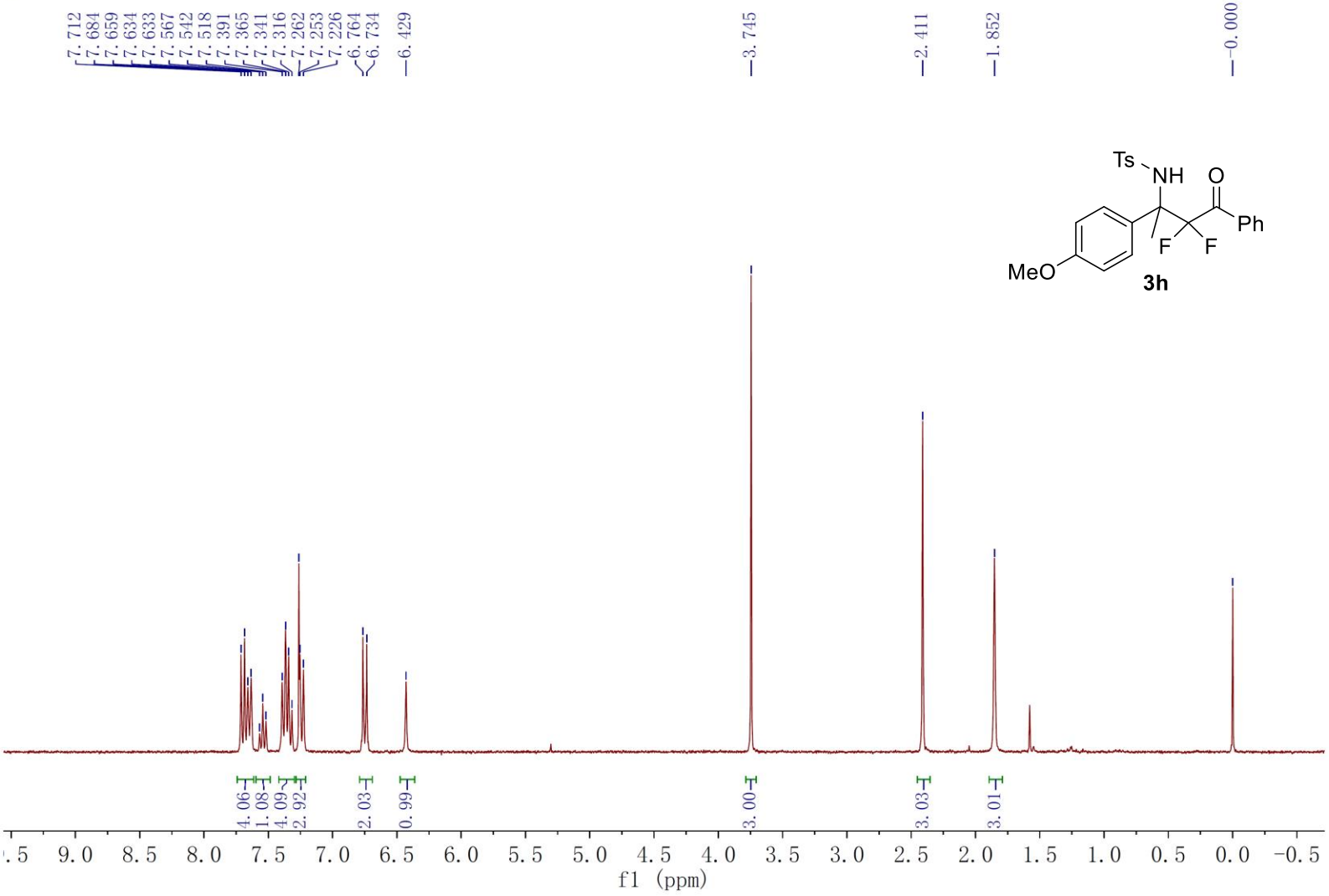
HXS-HE-146-400M-C

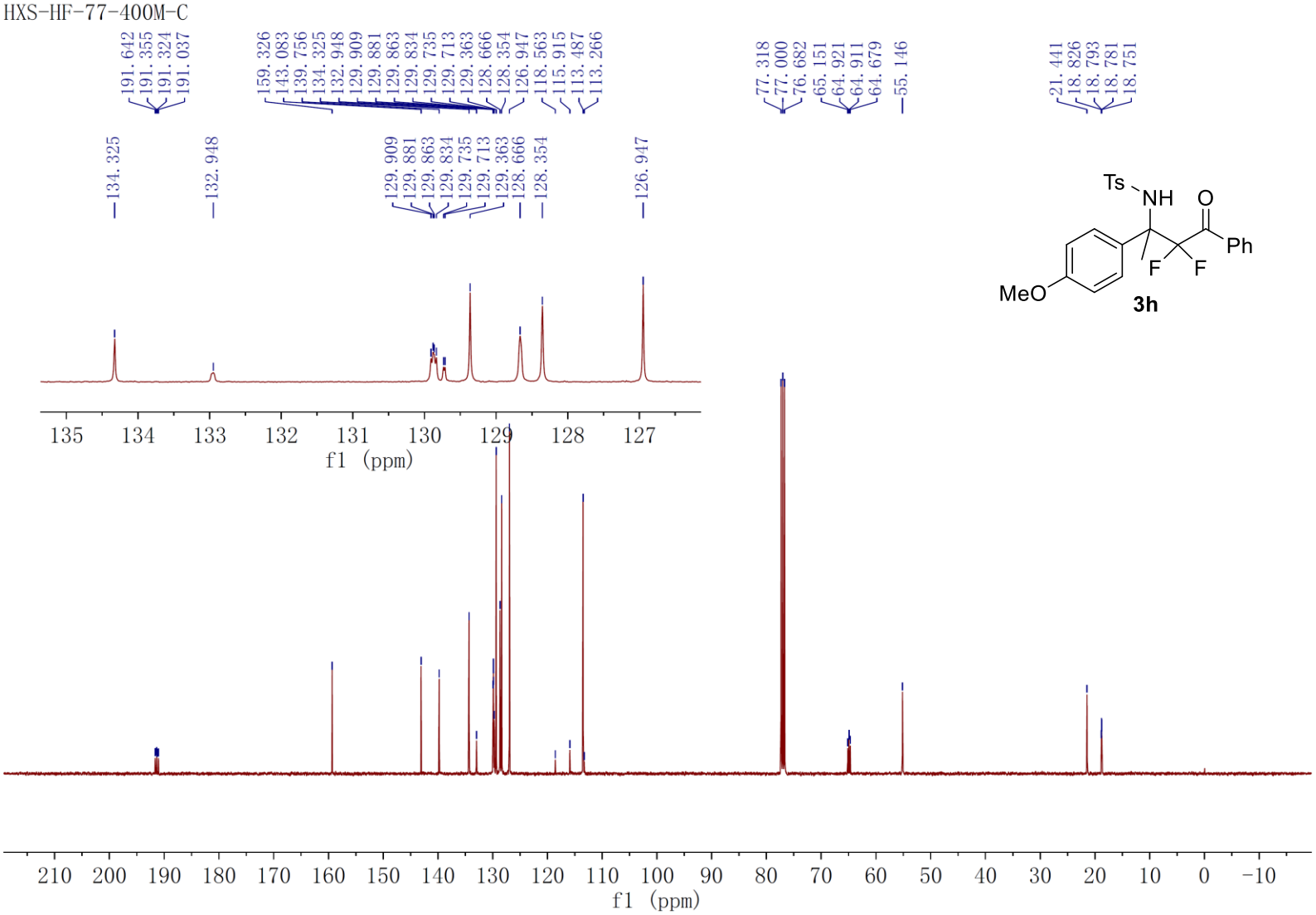


HXS-HE-146-300M-F

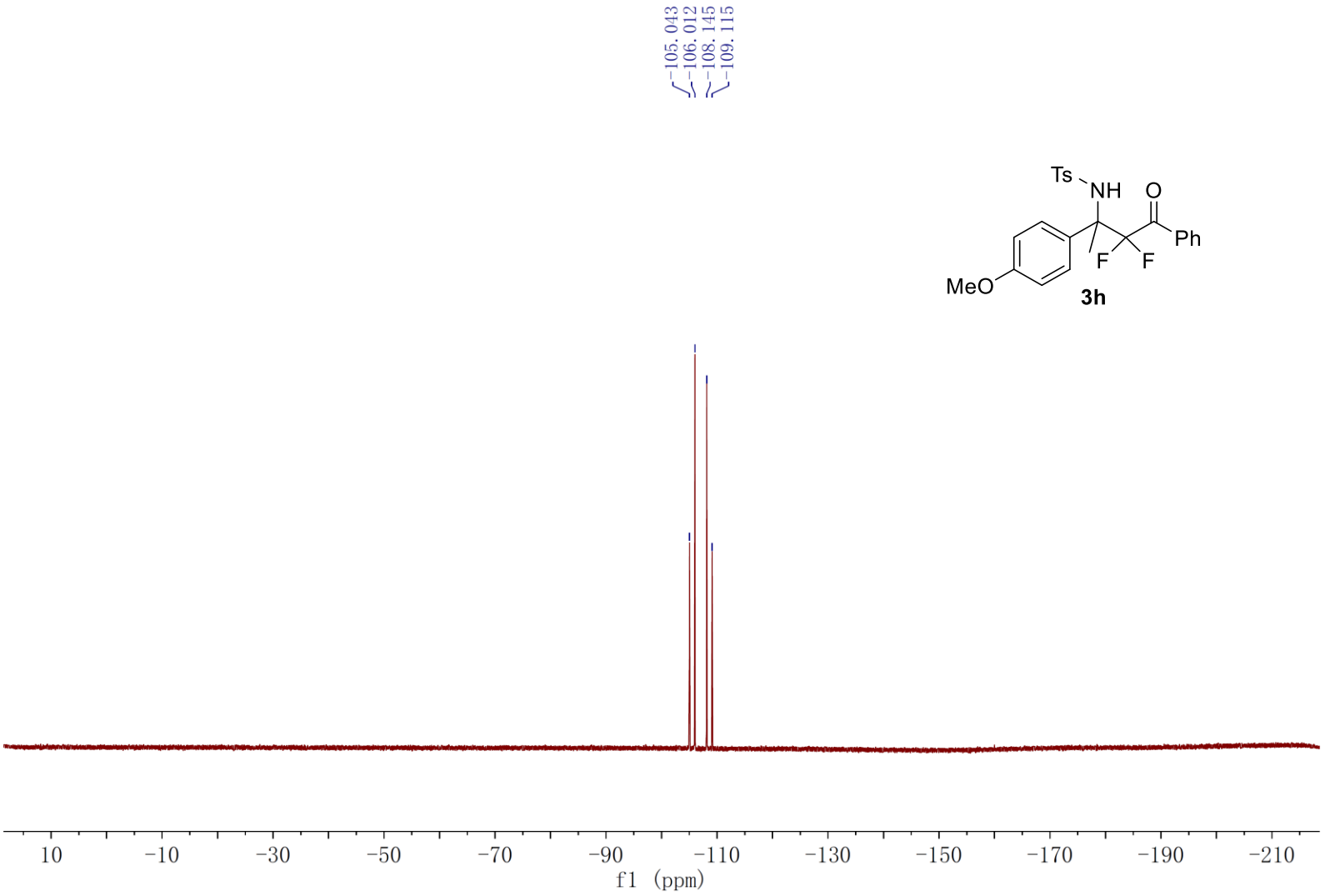


HXS-HF-77-300M-H

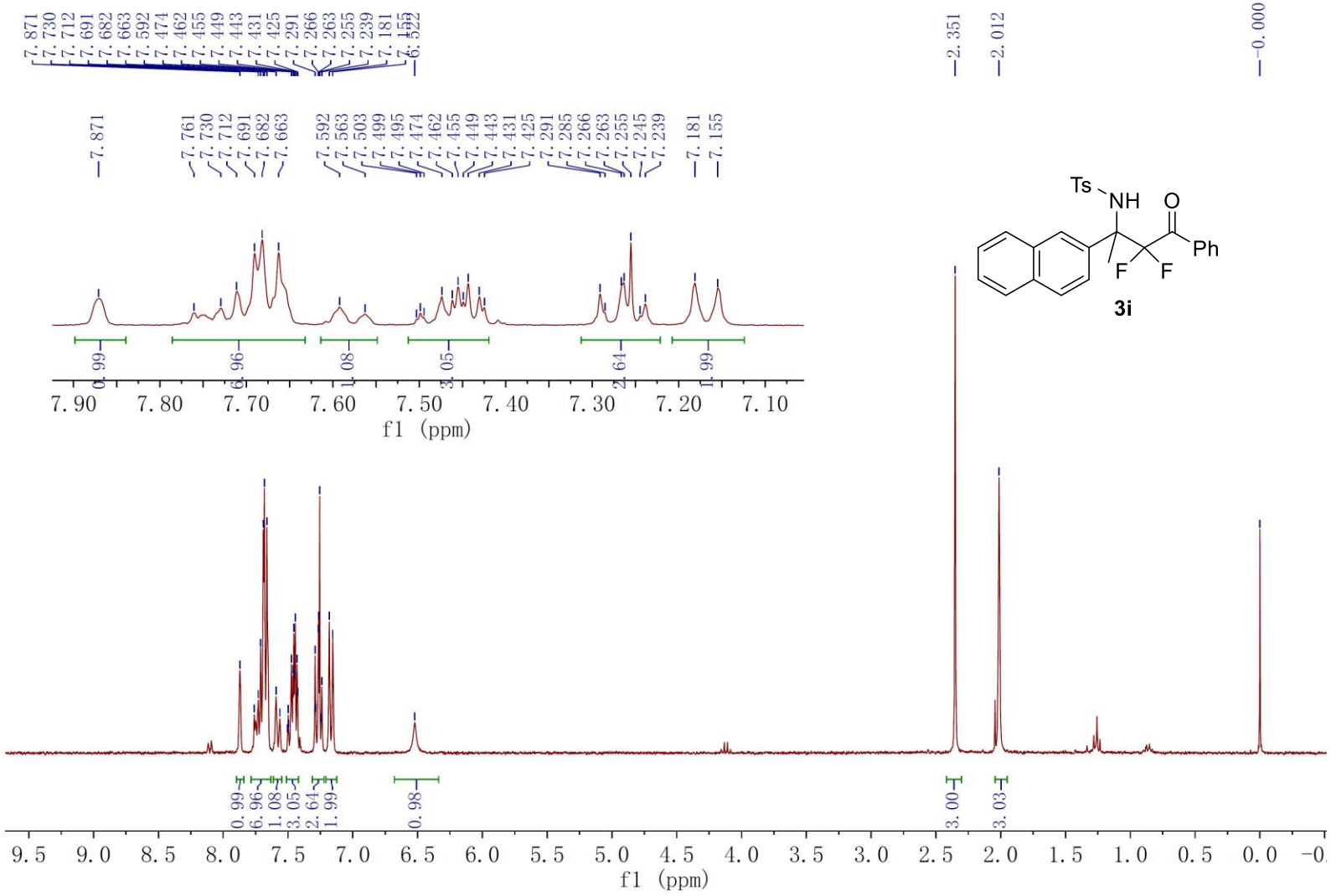


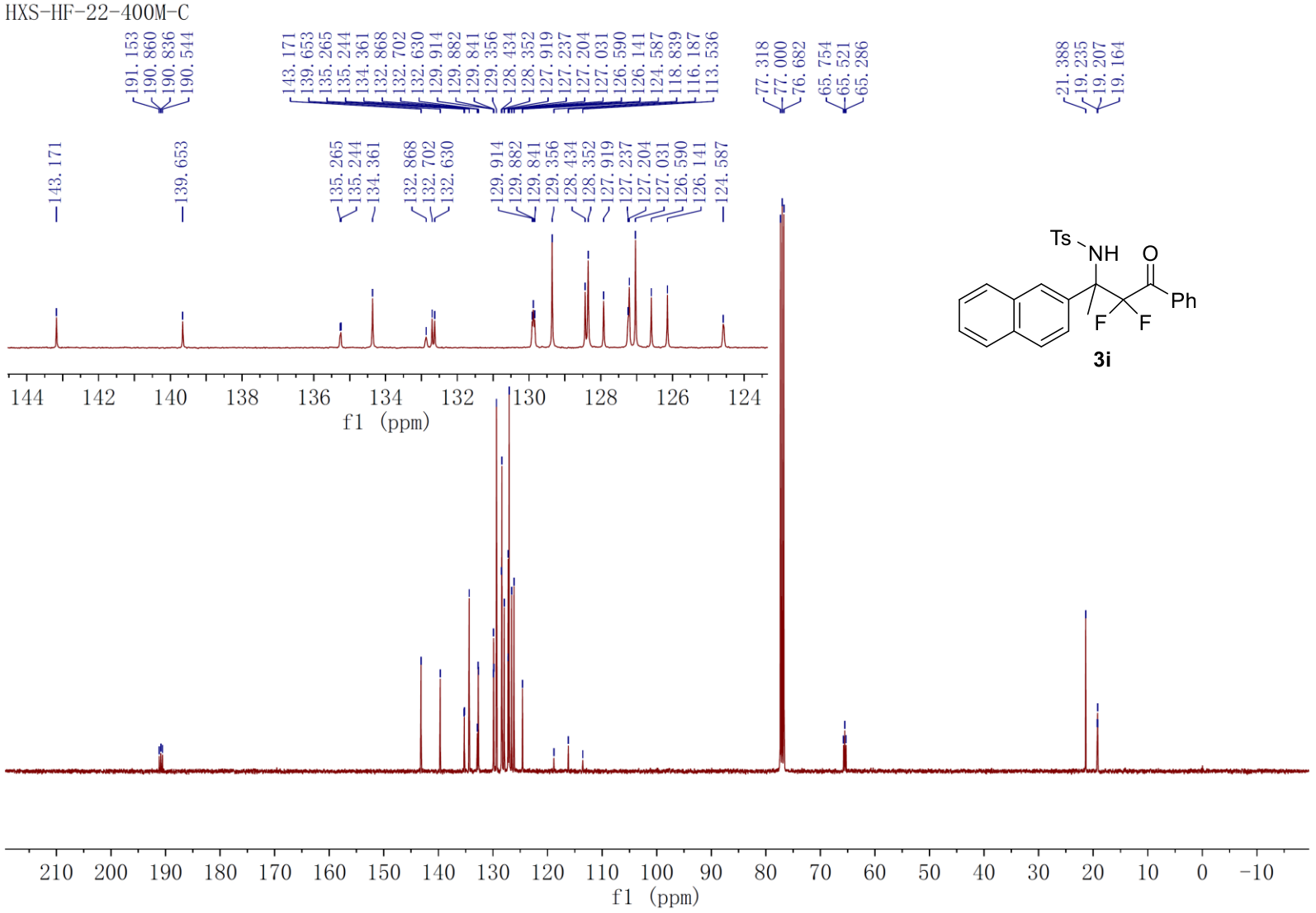

HXS-HF-77-400M-C
191.642
191.355
191.324
191.037
159.326
143.083
139.756
134.325
132.948
129.909
129.881
129.863
129.834
129.735
129.713
129.363
128.666
128.354
126.947
118.563
115.915
113.487
113.266
77.318
77.000
76.682
65.151
64.921
64.911
64.679
55.146
21.441
18.826
18.793
18.781
18.751
134.325
132.948
129.909
129.881
129.863
129.834
129.735
129.713
129.363
128.666
128.354
126.947
Ts
NH
O
Ph
F
F
MeO
3h
135
134
133
132
131
130
129
128
127
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

HXS-HF-77-300M-F

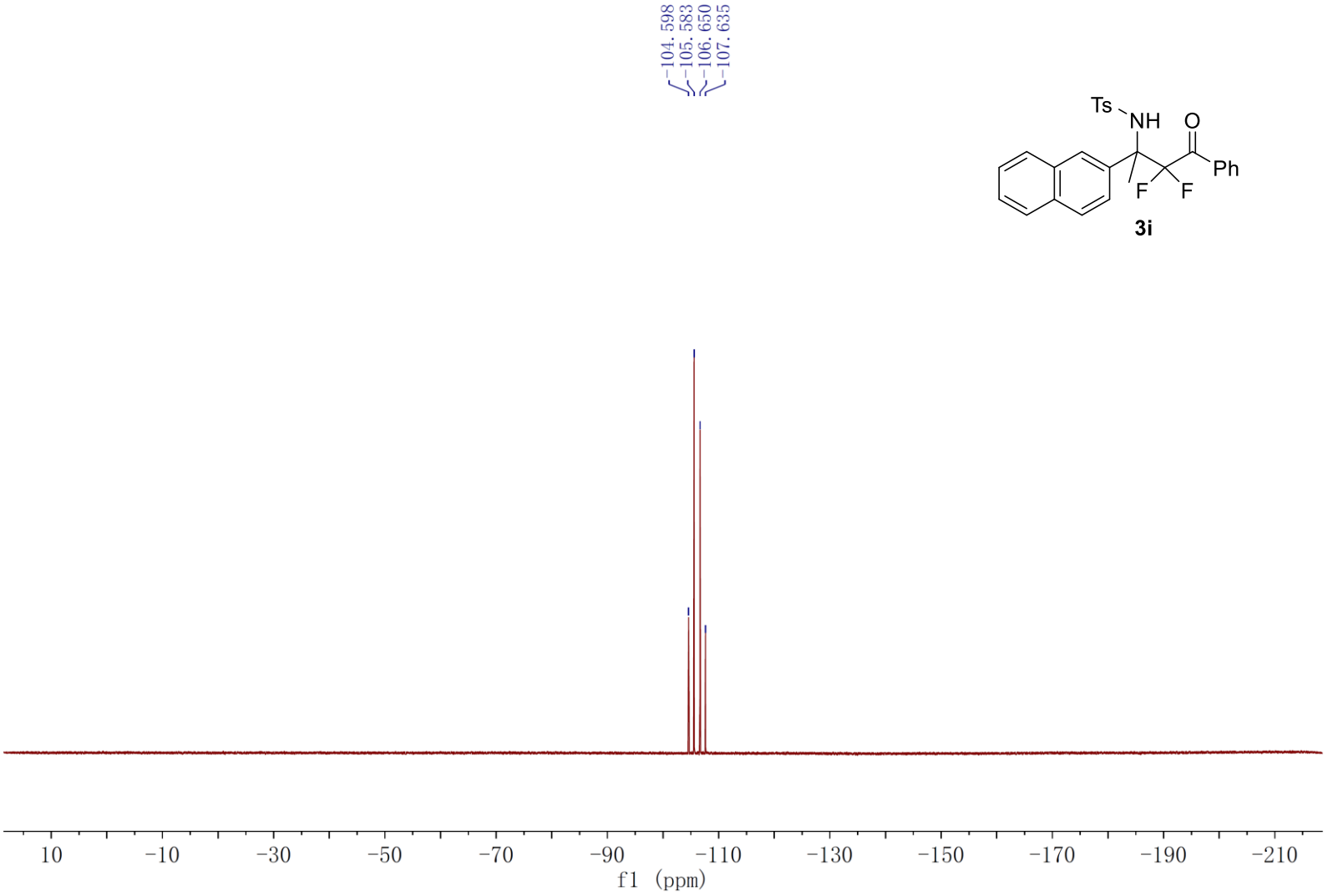


HXS-HF-22-300M-H



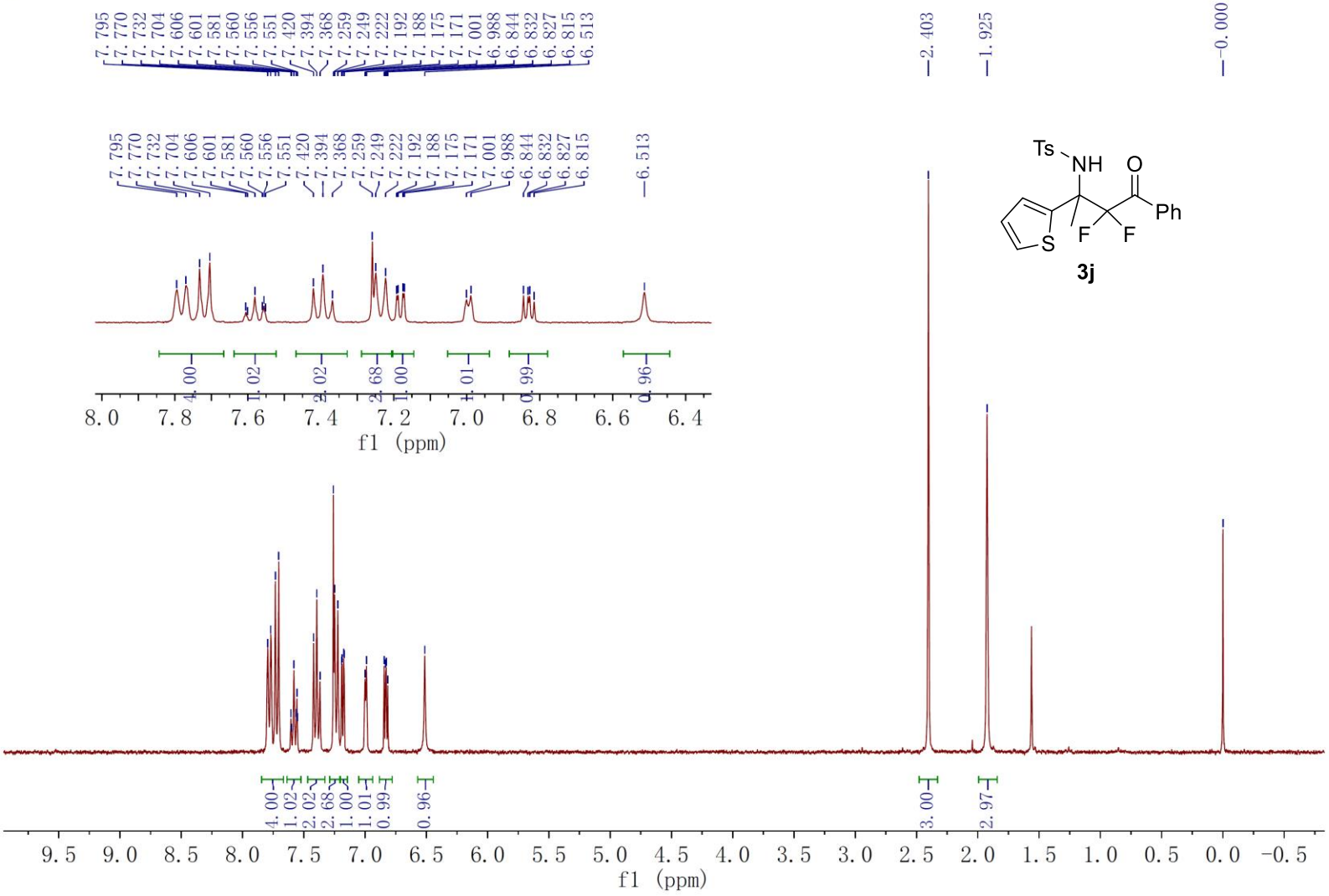

HXS-HF-22-400M-C
191.153
190.860
190.836
190.544
143.171
139.653
135.265
135.244
134.361
132.868
132.702
132.630
129.914
129.882
129.841
129.356
128.434
128.352
127.919
127.237
127.204
127.031
126.590
126.141
124.587
118.839
116.187
113.536
77.318
77.000
76.682
65.754
65.521
65.286
21.388
19.235
19.207
19.164
Ts
NH
O
Ph
F
F
3i
f1 (ppm)
f1 (ppm)

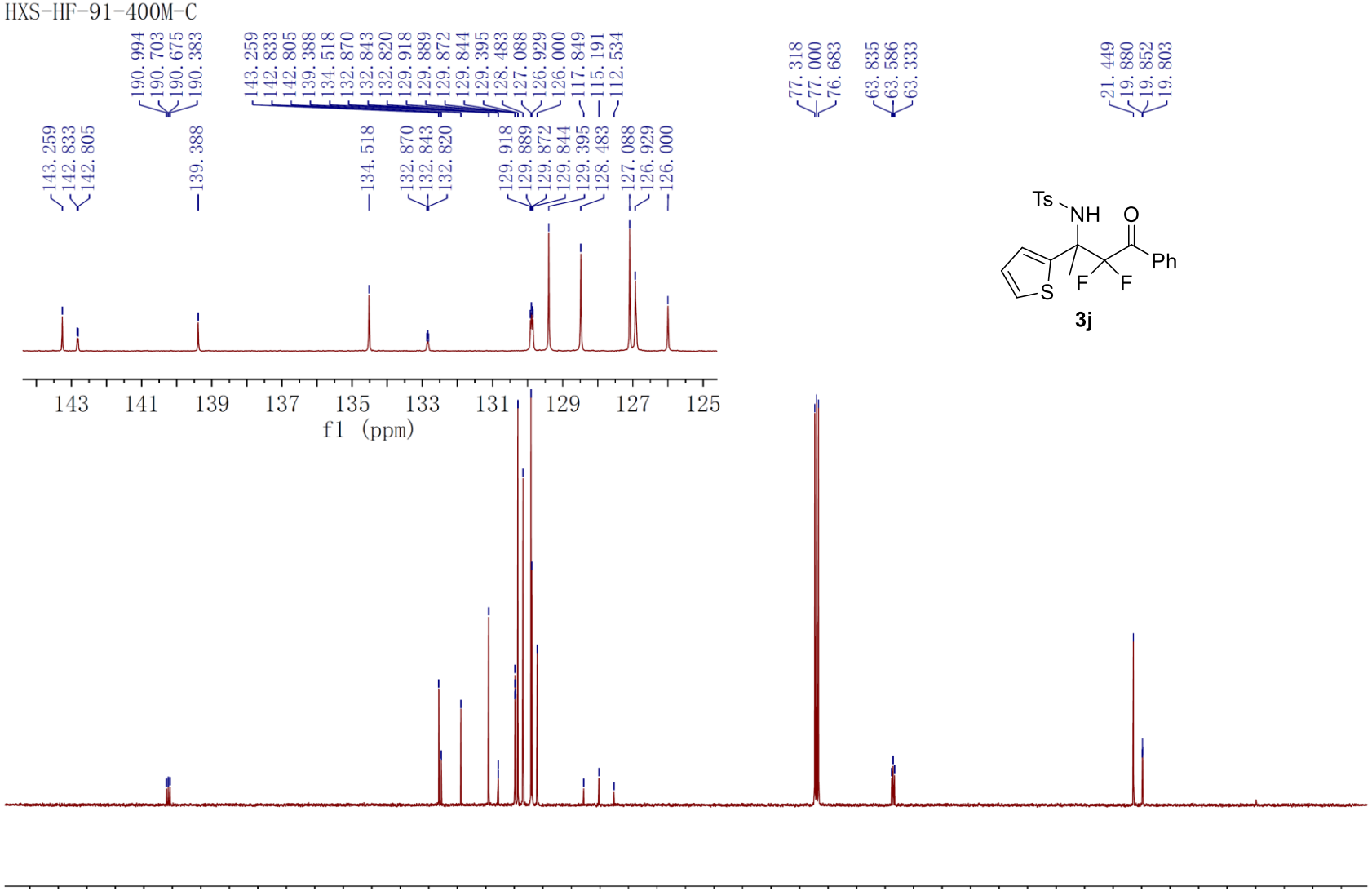
HXS-HF-22-300M-F



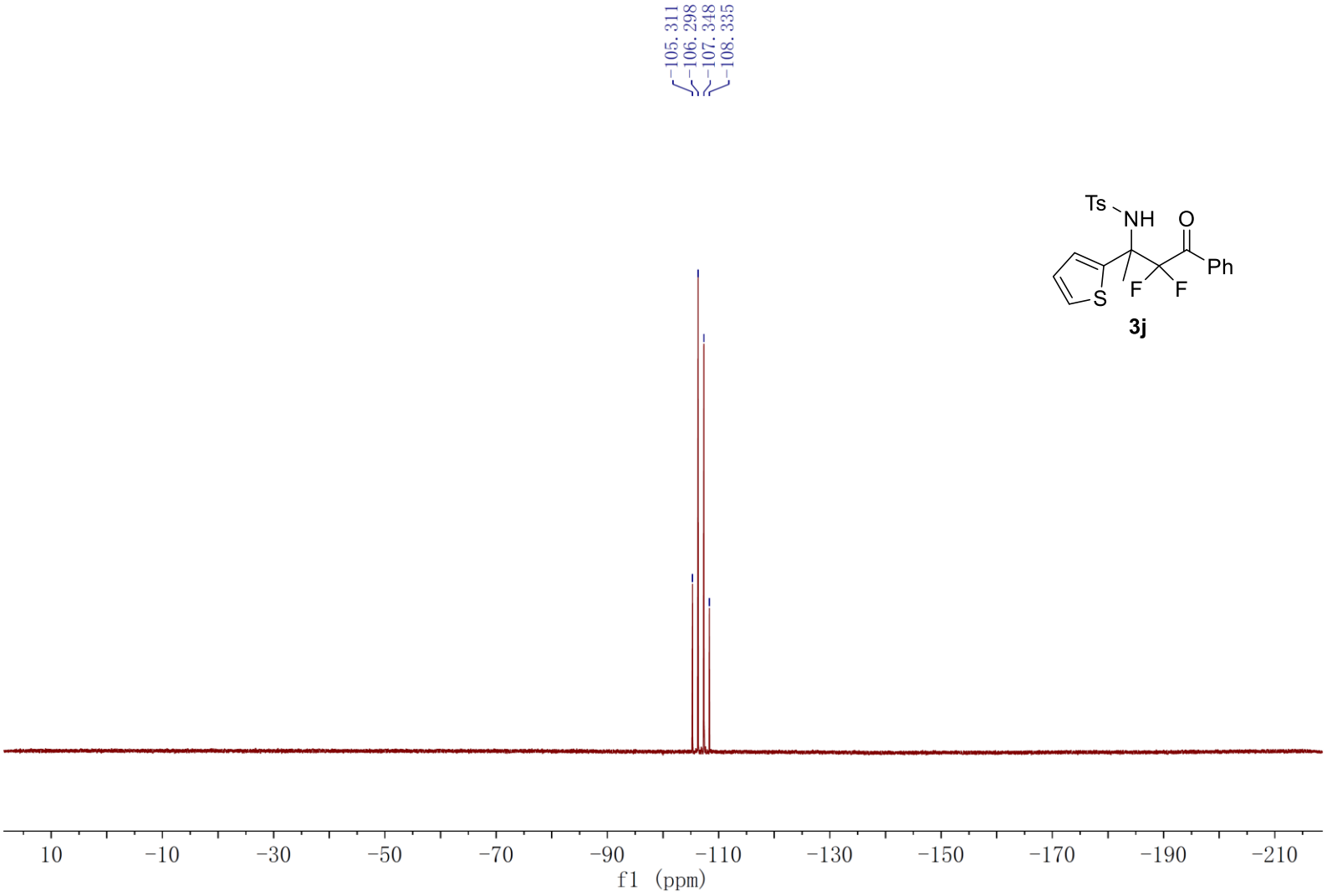
3i

HXS-HF-91-300M-H



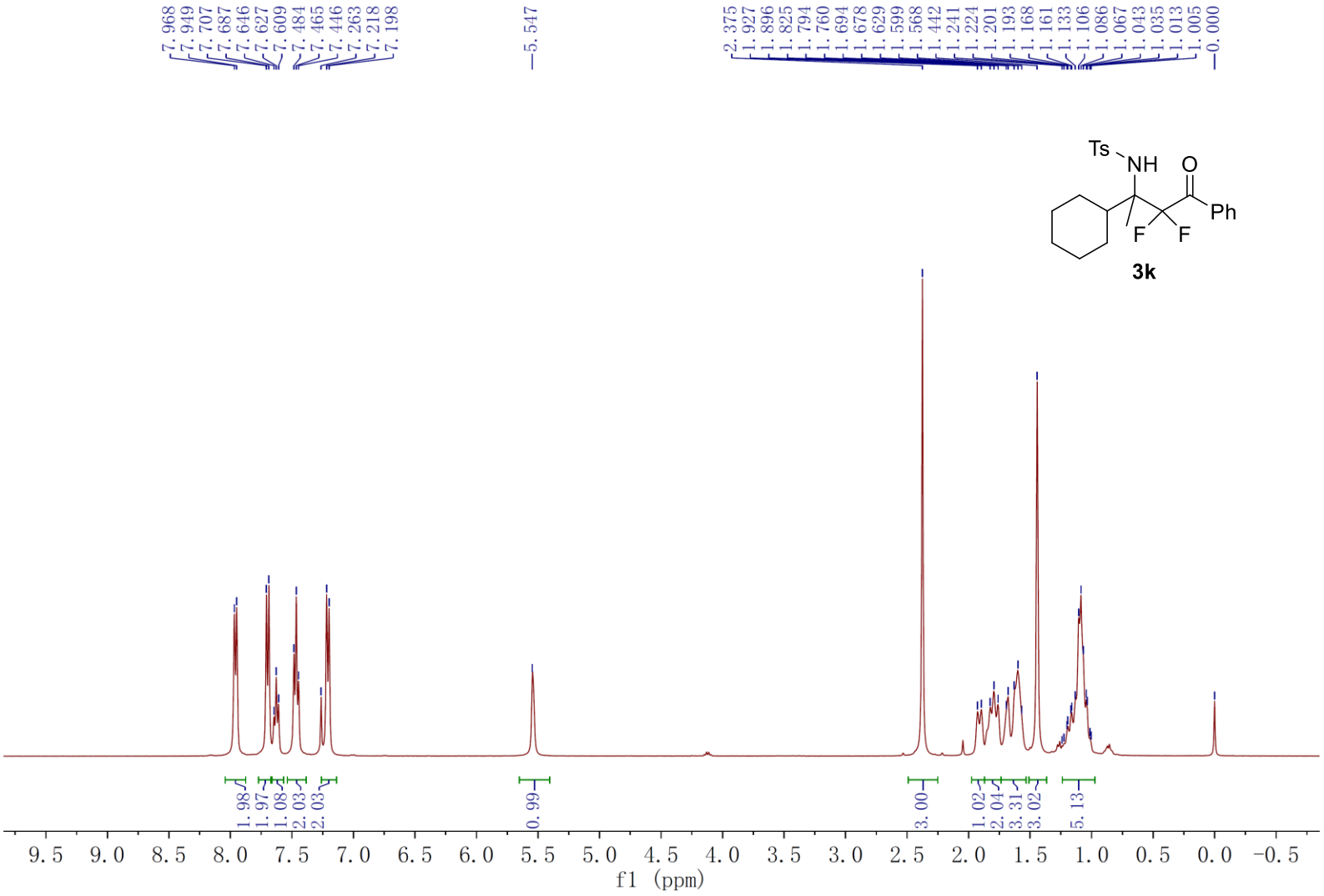

HXS-HF-91-400M-C
190.994
190.703
190.675
190.383
143.259
142.833
142.805
139.388
134.518
132.870
132.843
132.820
129.918
129.889
129.872
129.844
129.395
128.483
127.088
126.929
126.000
117.849
115.191
112.534
77.318
77.000
76.683
63.835
63.586
63.333
21.449
19.880
19.852
19.803
143.259
142.833
142.805
139.388
134.518
132.870
132.843
132.820
129.918
129.889
129.872
129.844
129.395
128.483
127.088
126.929
126.000
143
141
139
137
135
133
131
129
127
125
f1 (ppm)
Ts
NH
O
Ph
F
F
S
3j

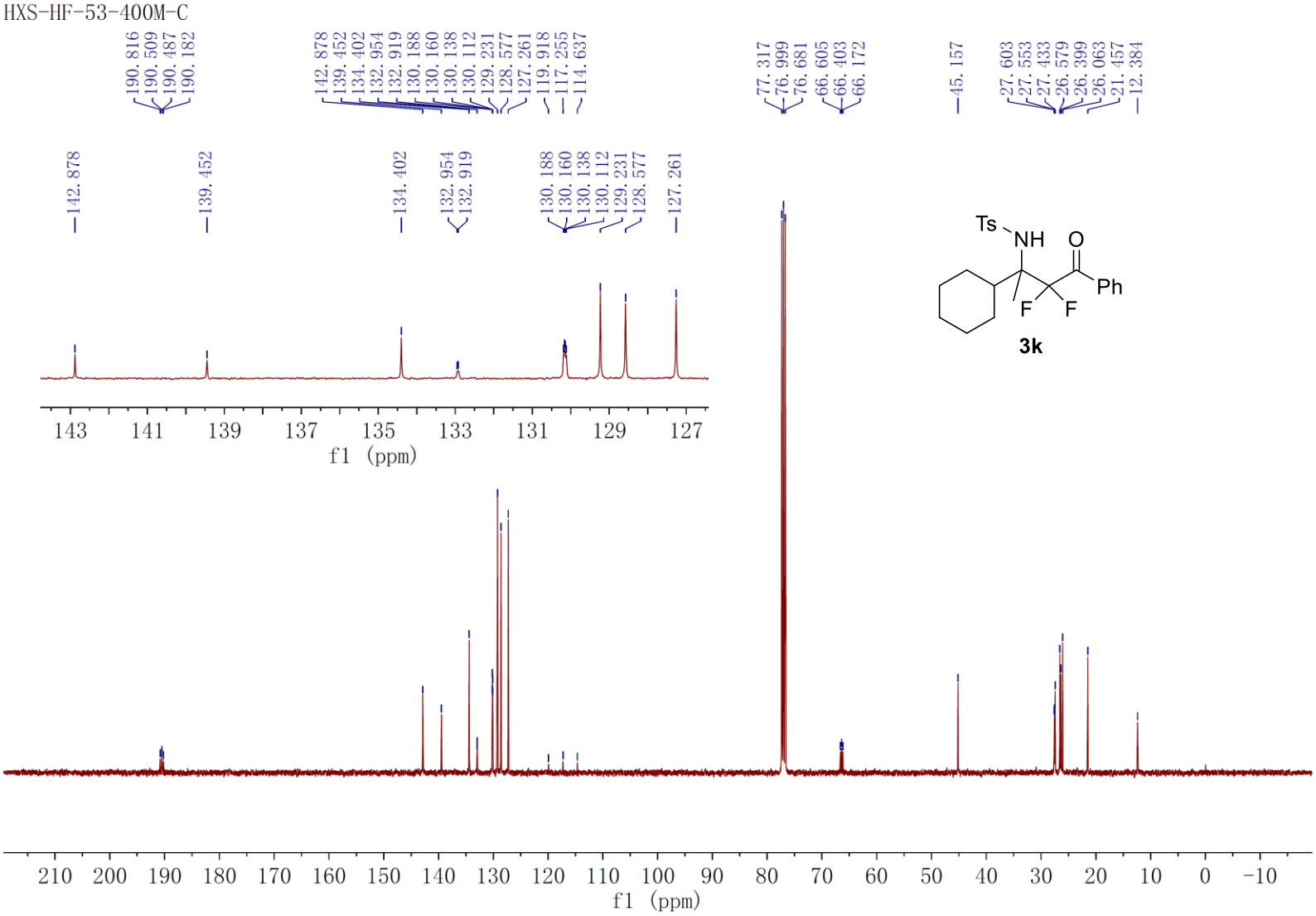
HXS-HF-91-300M-F



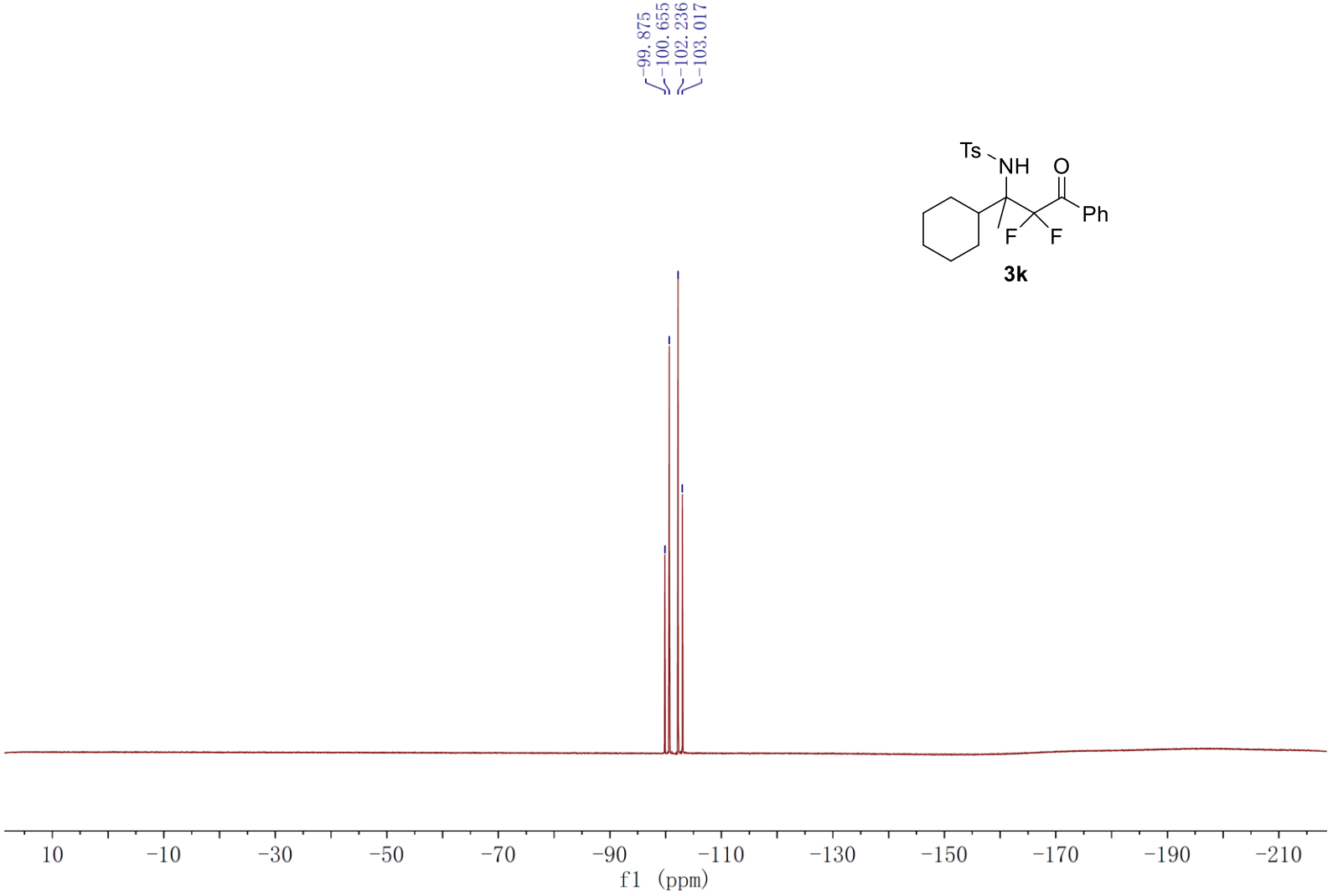
3j

HXS-HF-53-400M-H

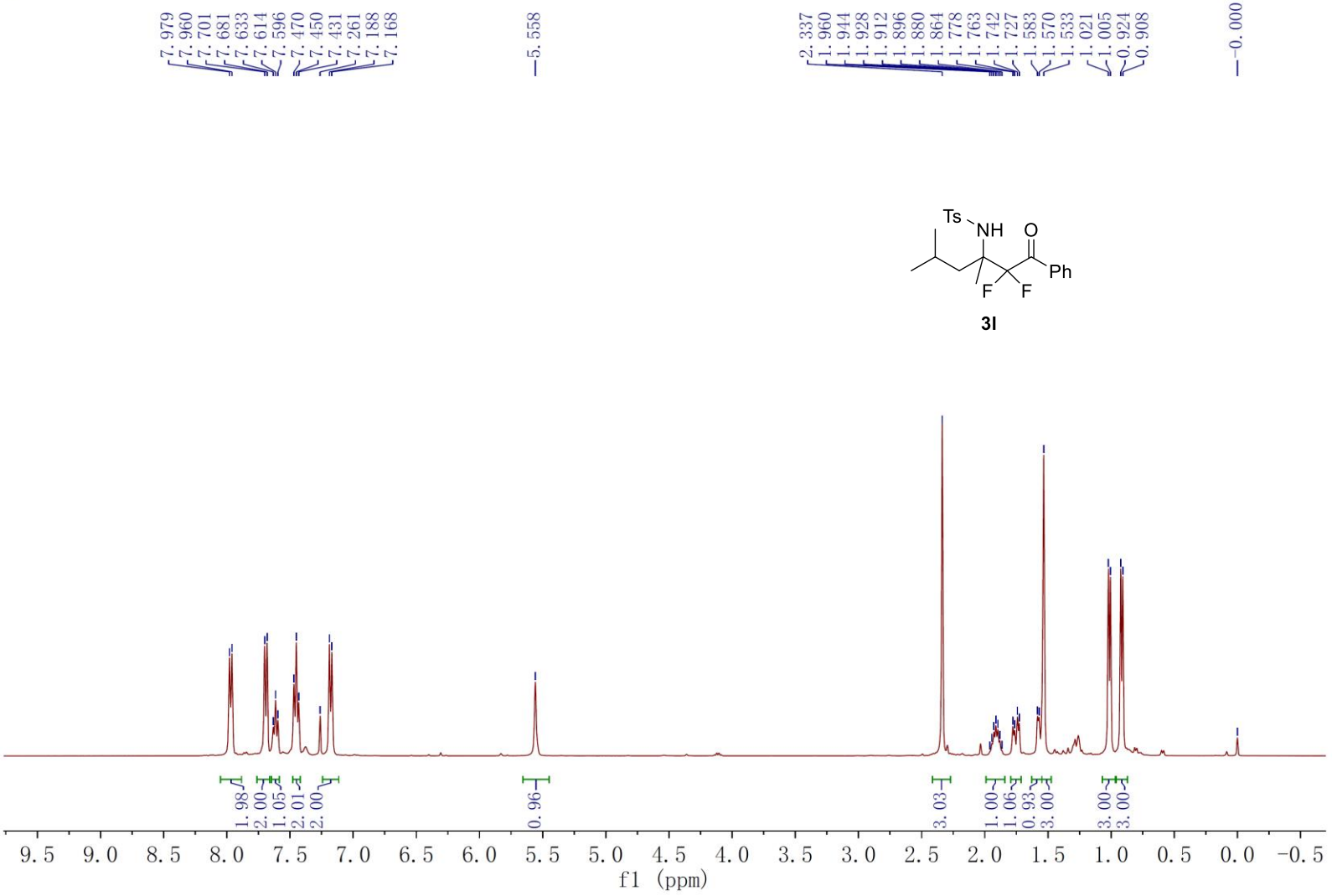



HXS-HF-53-400M-C
190.816
190.509
190.487
190.182
142.878
139.452
134.402
132.954
132.919
130.188
130.160
130.138
130.112
129.231
128.577
127.261
119.918
117.255
114.637
77.317
76.999
76.681
66.605
66.403
66.172
45.157
27.603
27.553
27.433
26.579
26.399
26.063
21.457
12.384
Ts
NH
O
Ph
F
F
3k
f1 (ppm)
f1 (ppm)

HXS-HF-53-400M-F

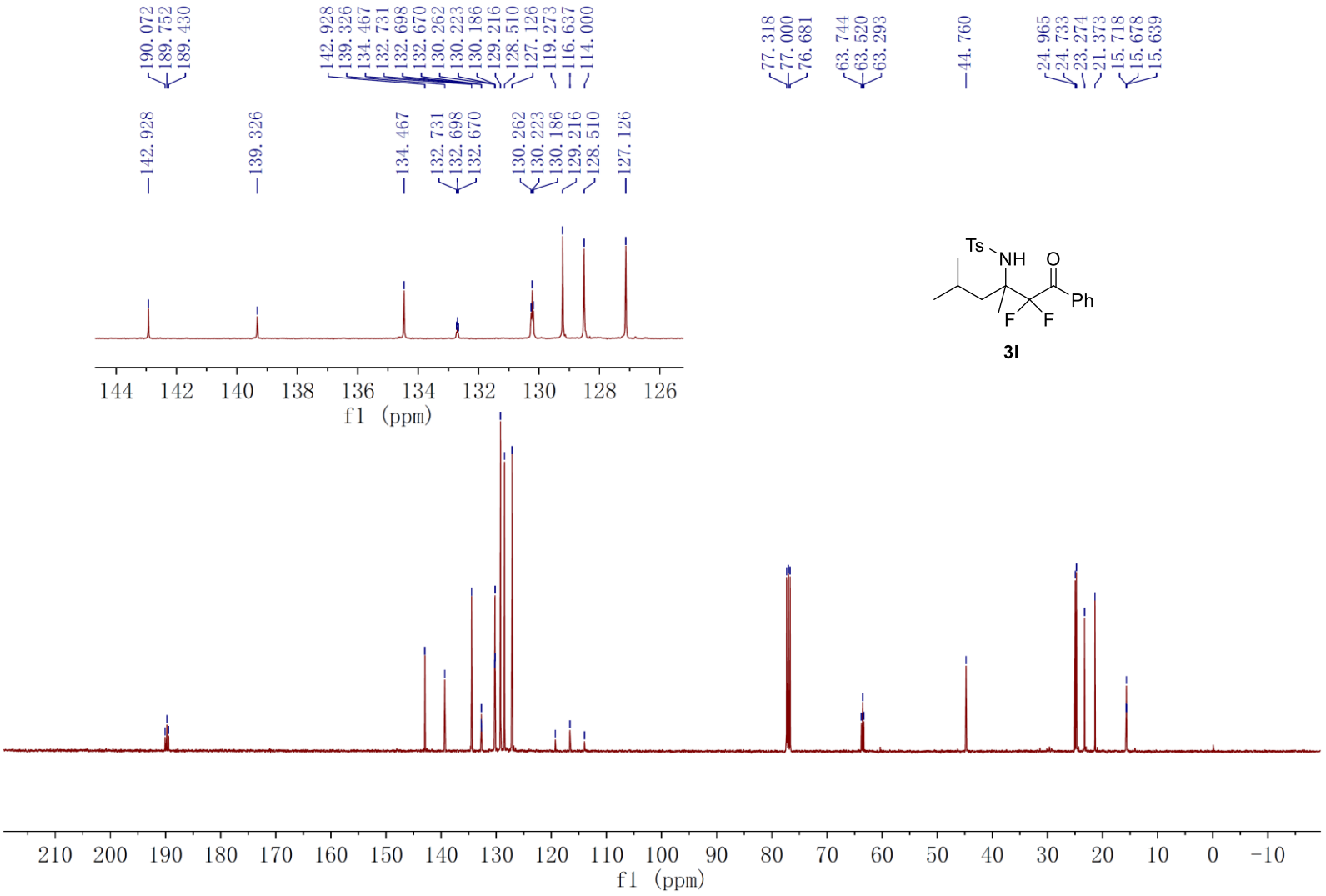


HXS-HJ-90-400M-H

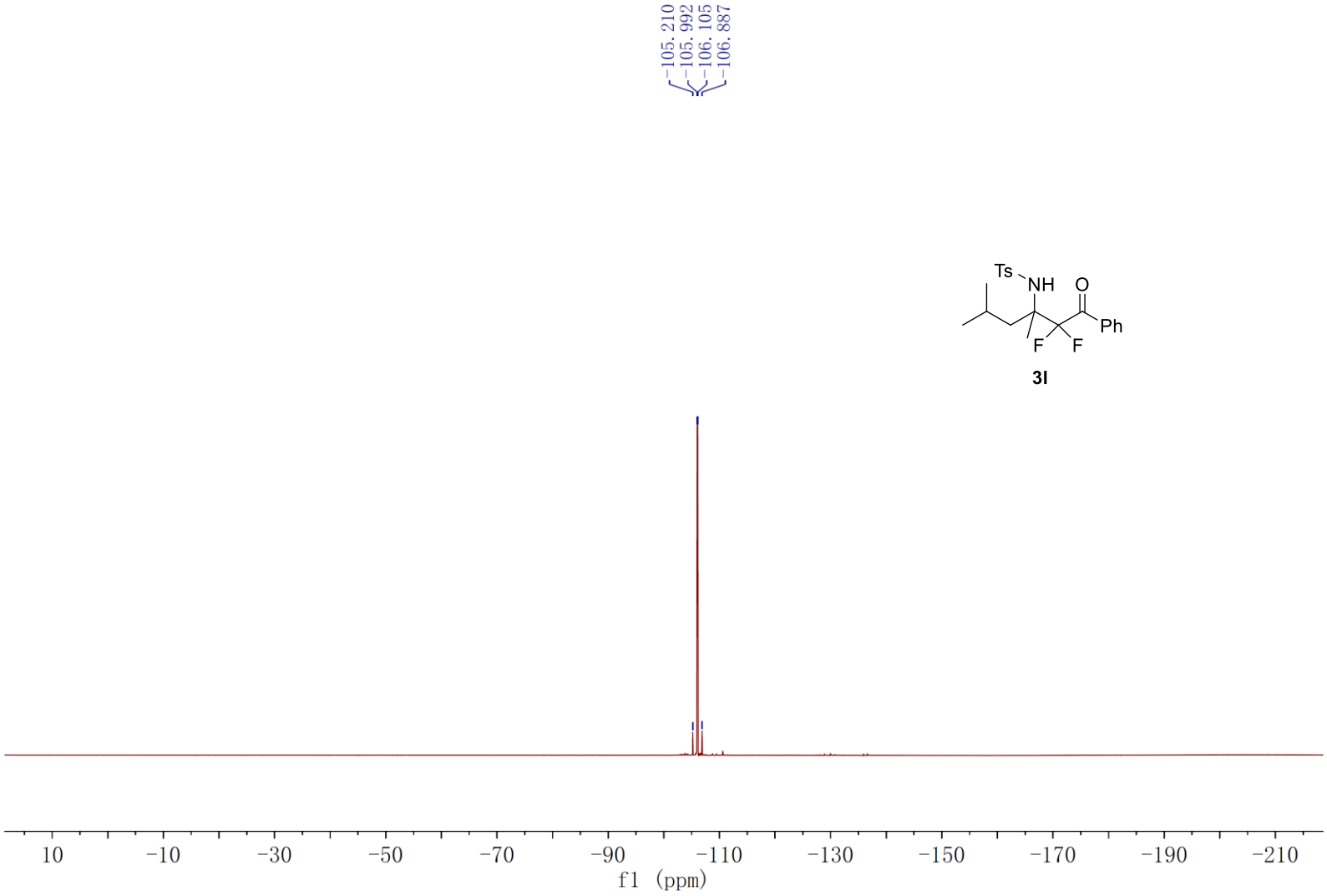


3l

HXS-HJ-90-400M-C

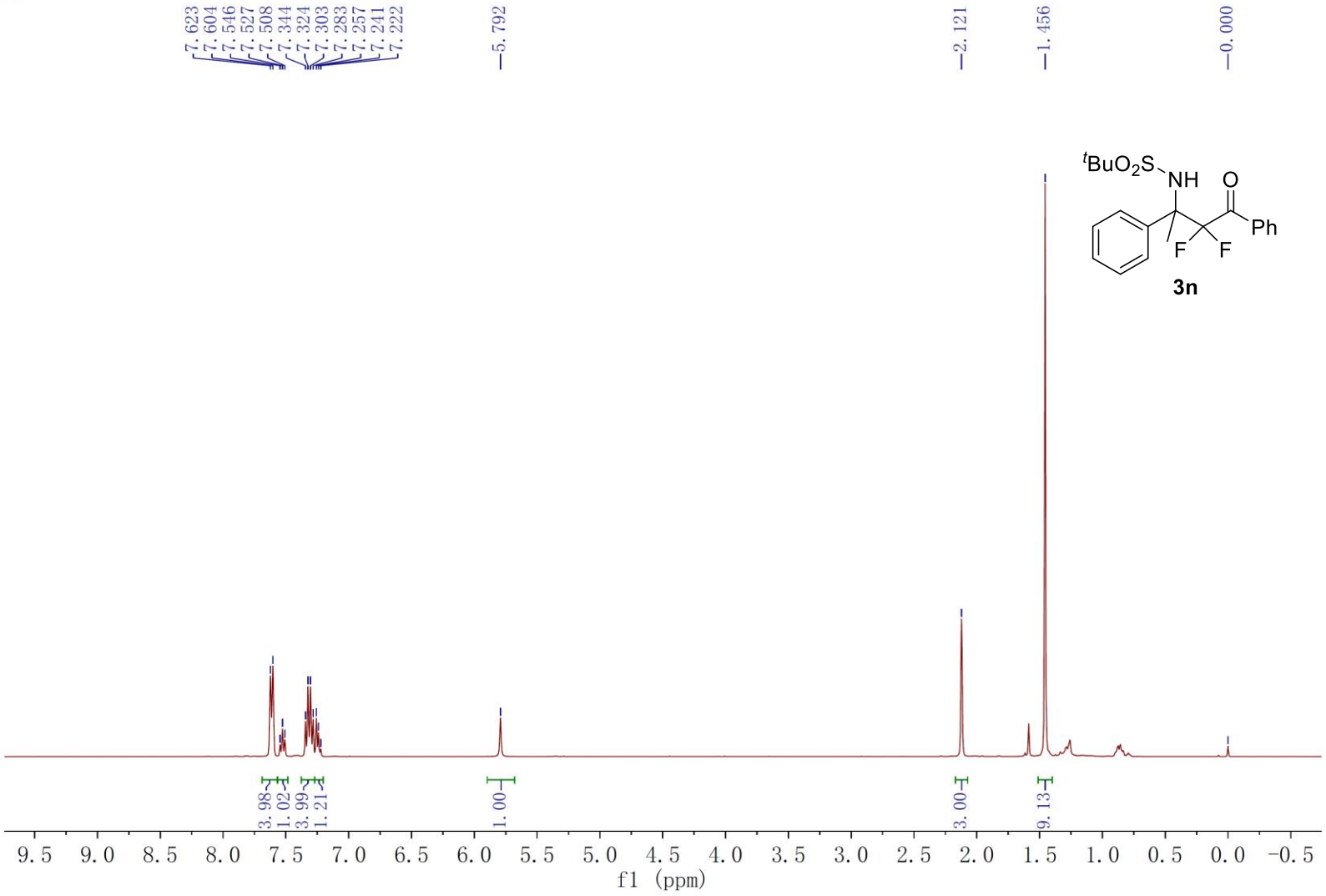


HXS-HJ-90-400M-F

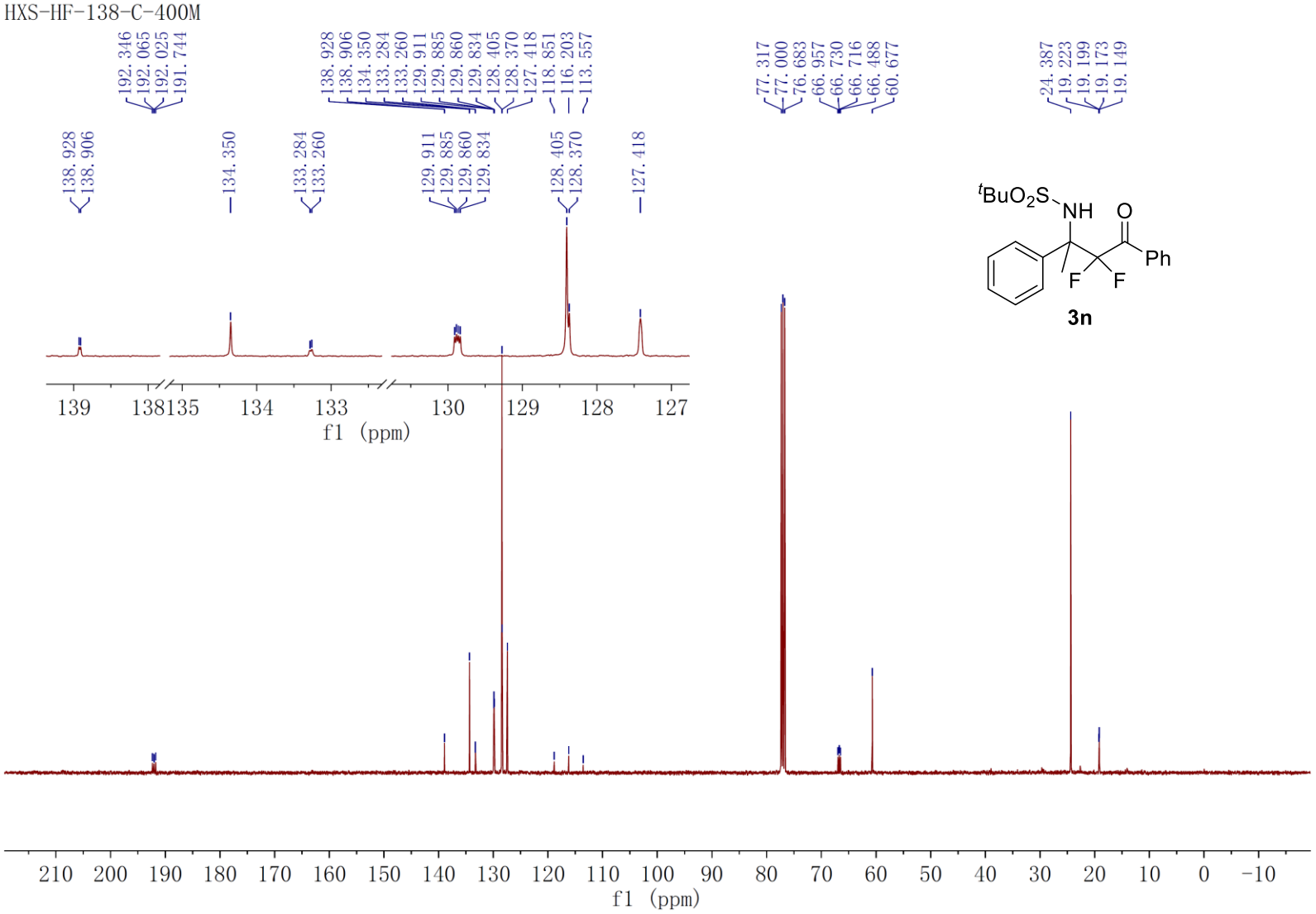


3l

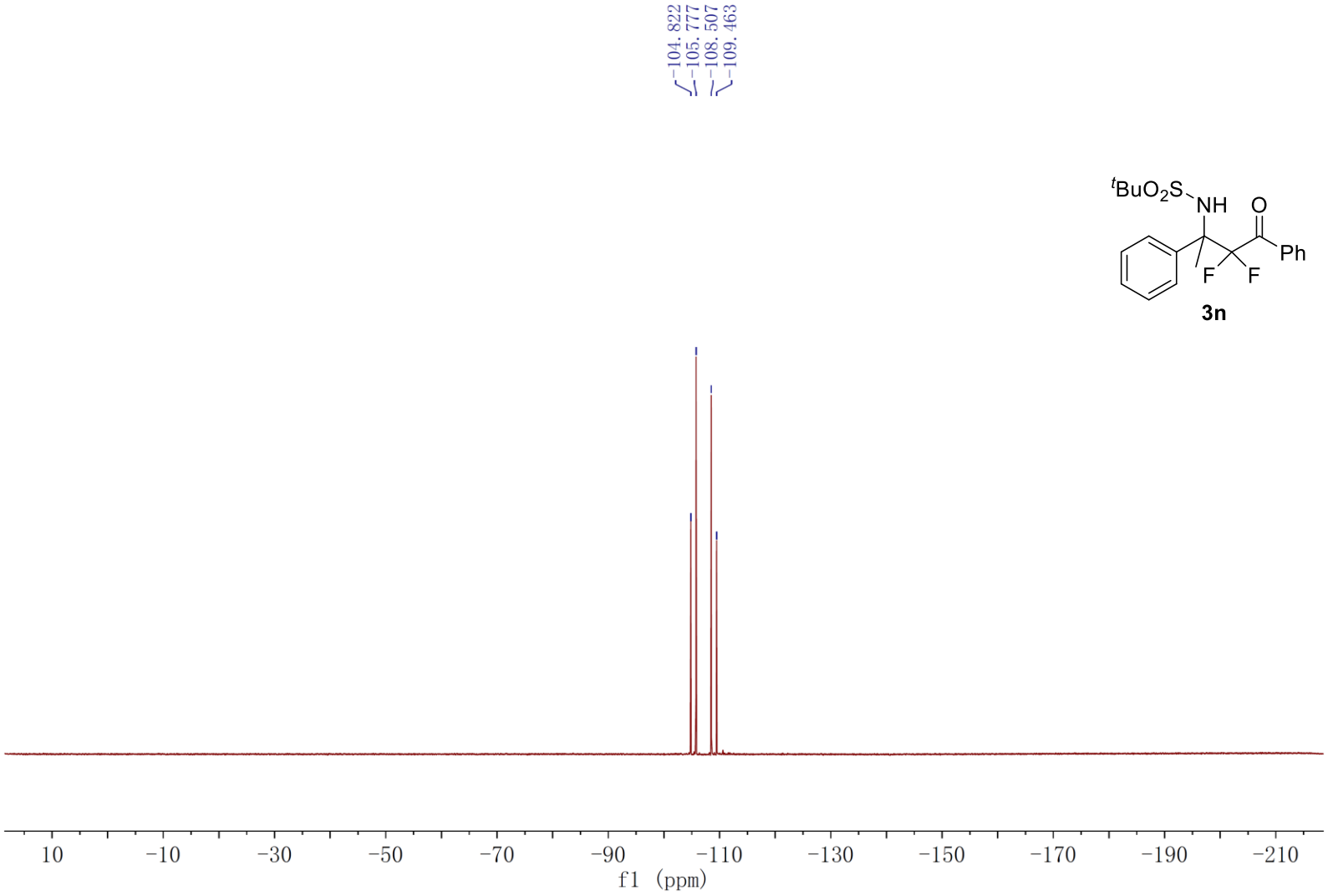
HXS-HF-138-H-400M



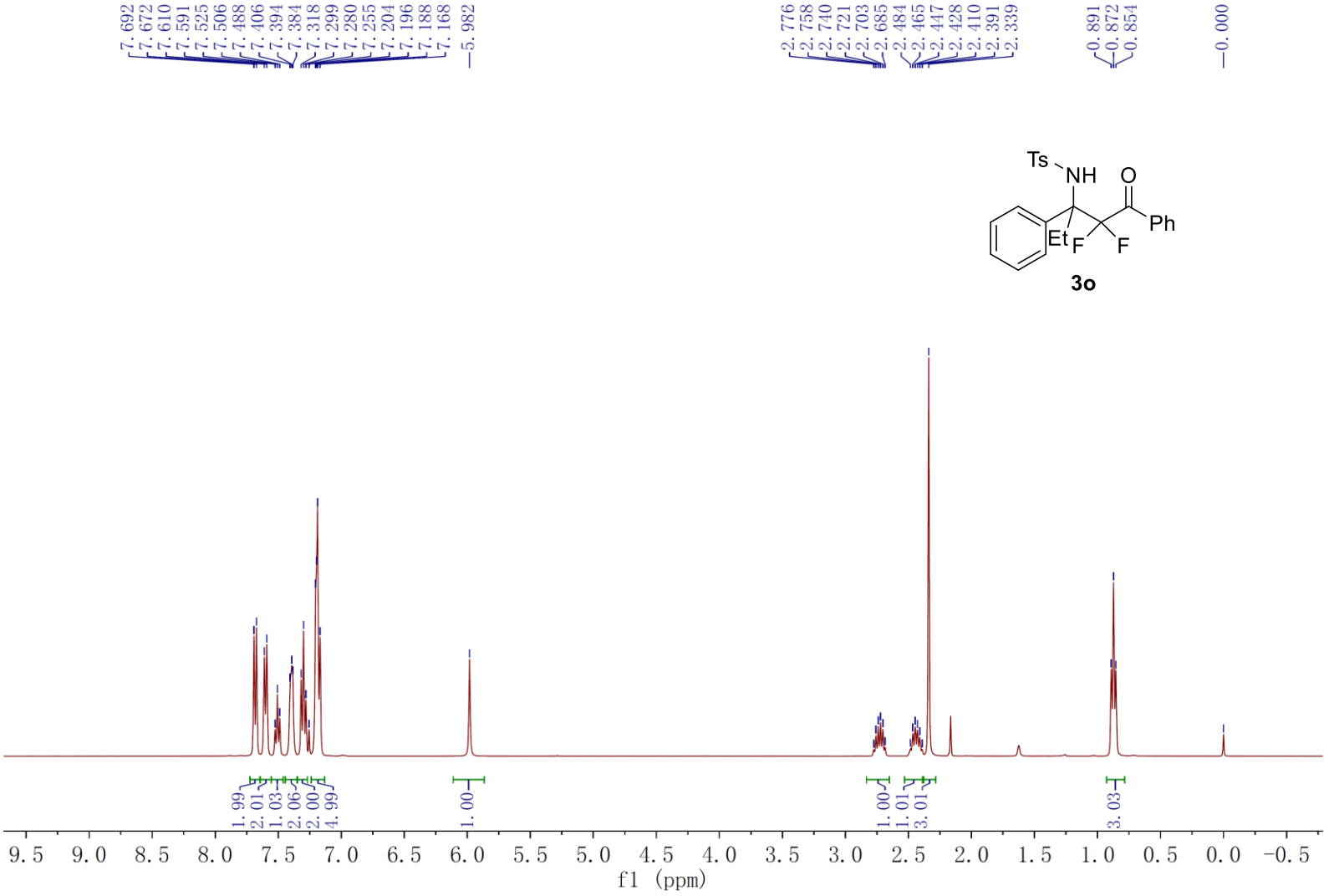
3n


HXS-HF-138-C-400M
192.346
192.065
192.025
191.744
138.928
138.906
134.350
133.284
133.260
129.911
129.885
129.860
129.834
128.405
128.370
127.418
118.851
116.203
113.557
77.317
77.000
76.683
66.957
66.730
66.716
66.488
60.677
24.387
19.223
19.199
19.173
19.149
tBuO2S
NH
O
Ph
F
F
3n
f1 (ppm)
f1 (ppm)

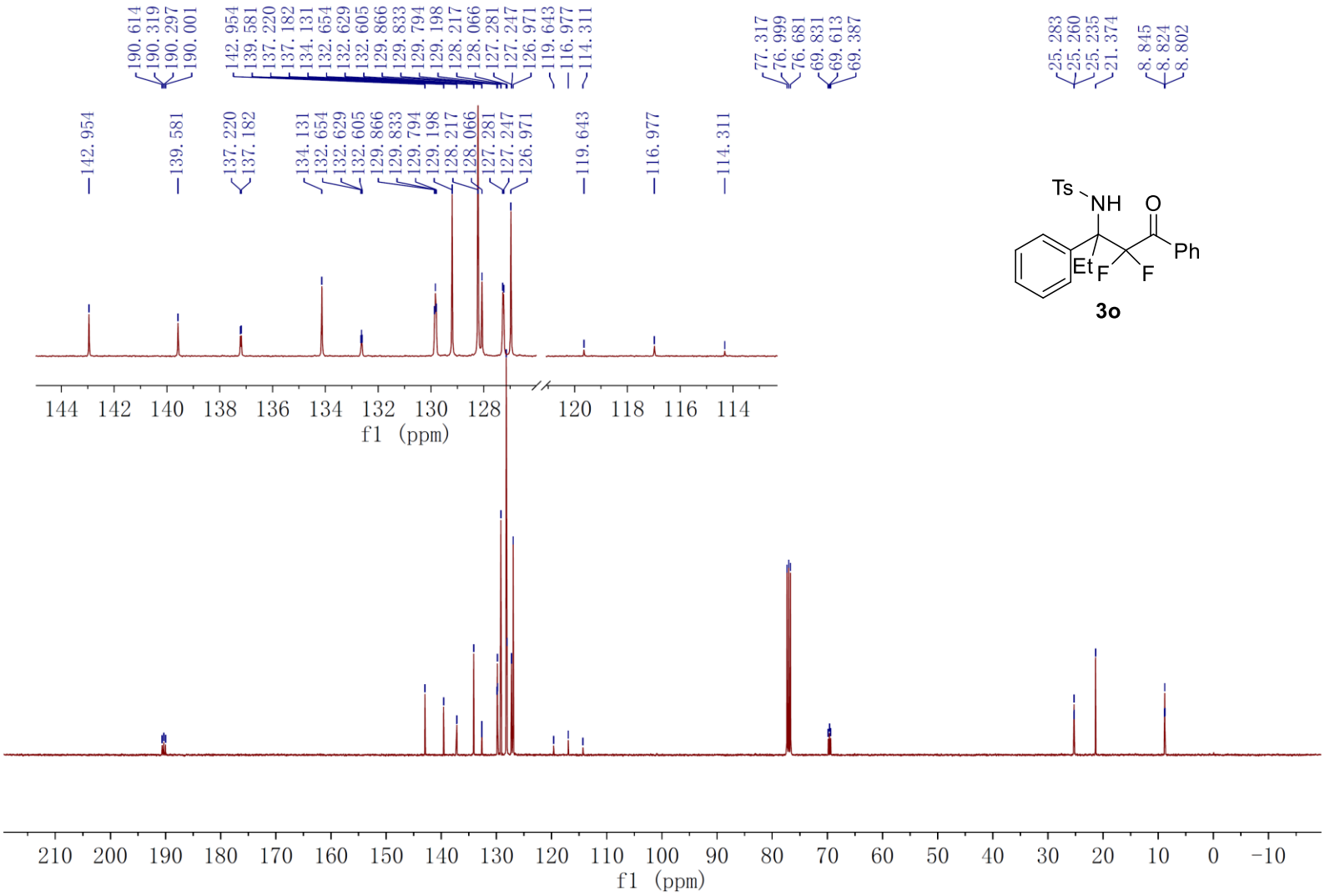
HXS-HF-138-300M-F



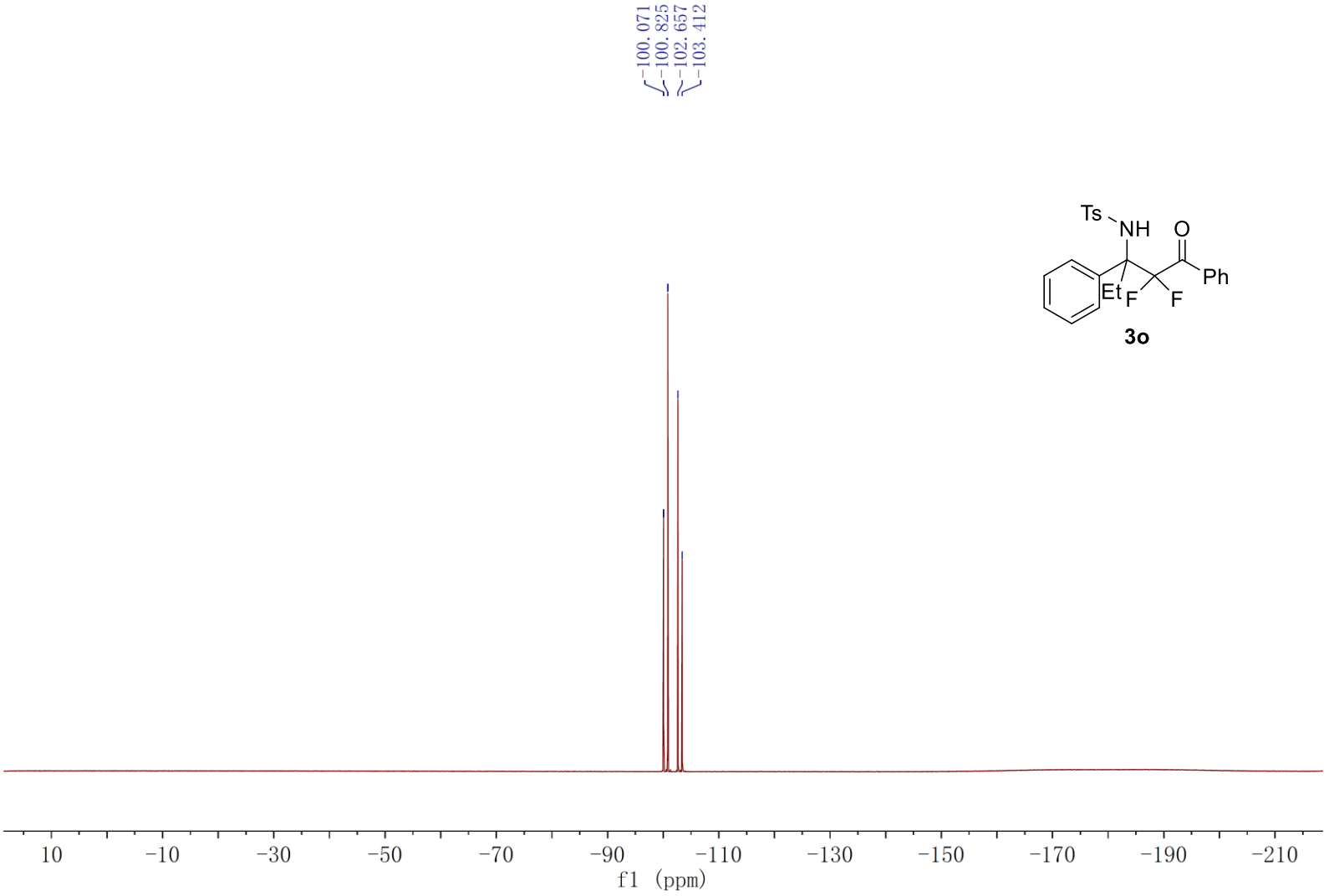
HXS-HF-33-400M



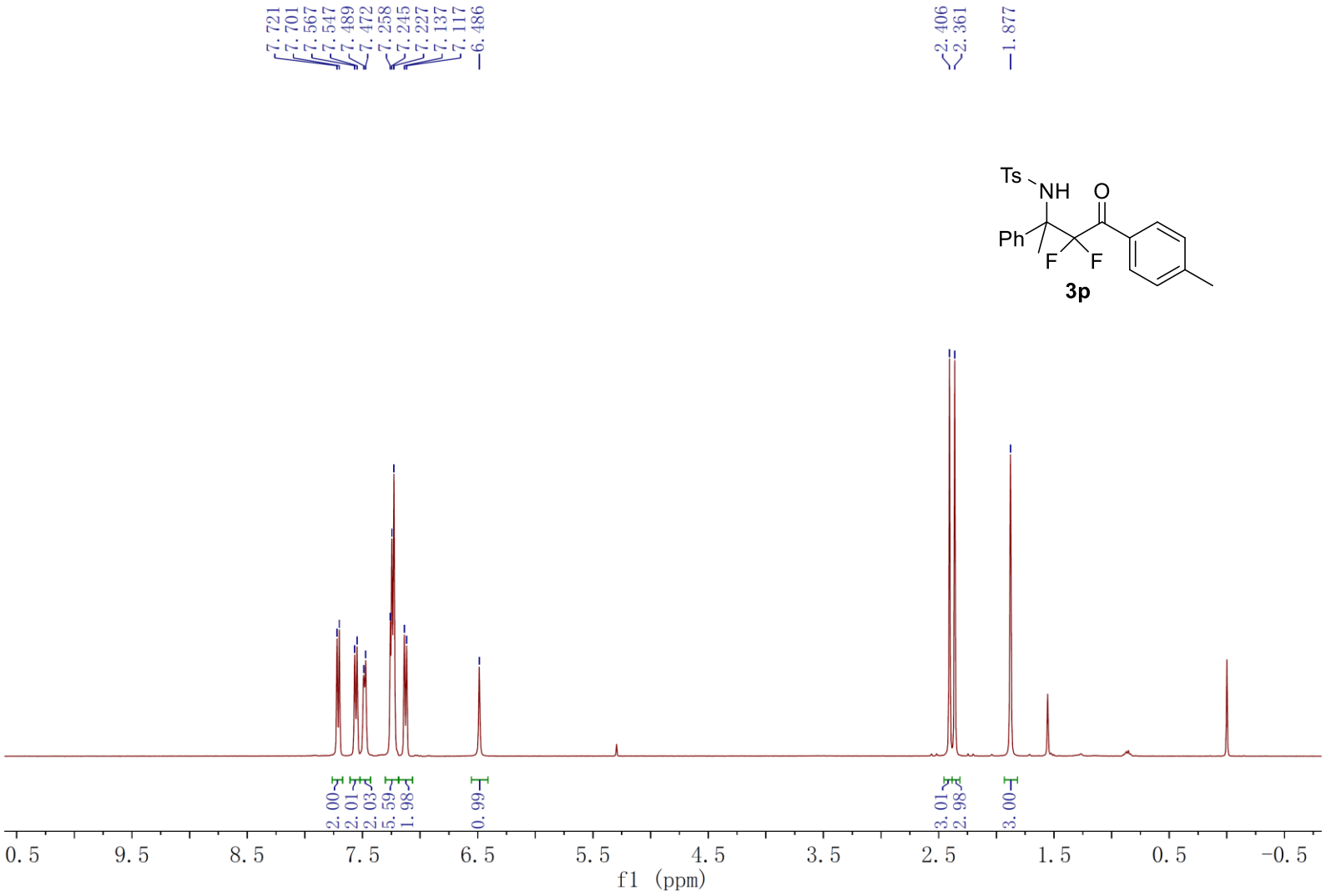
HXS-HF-33-400M-C

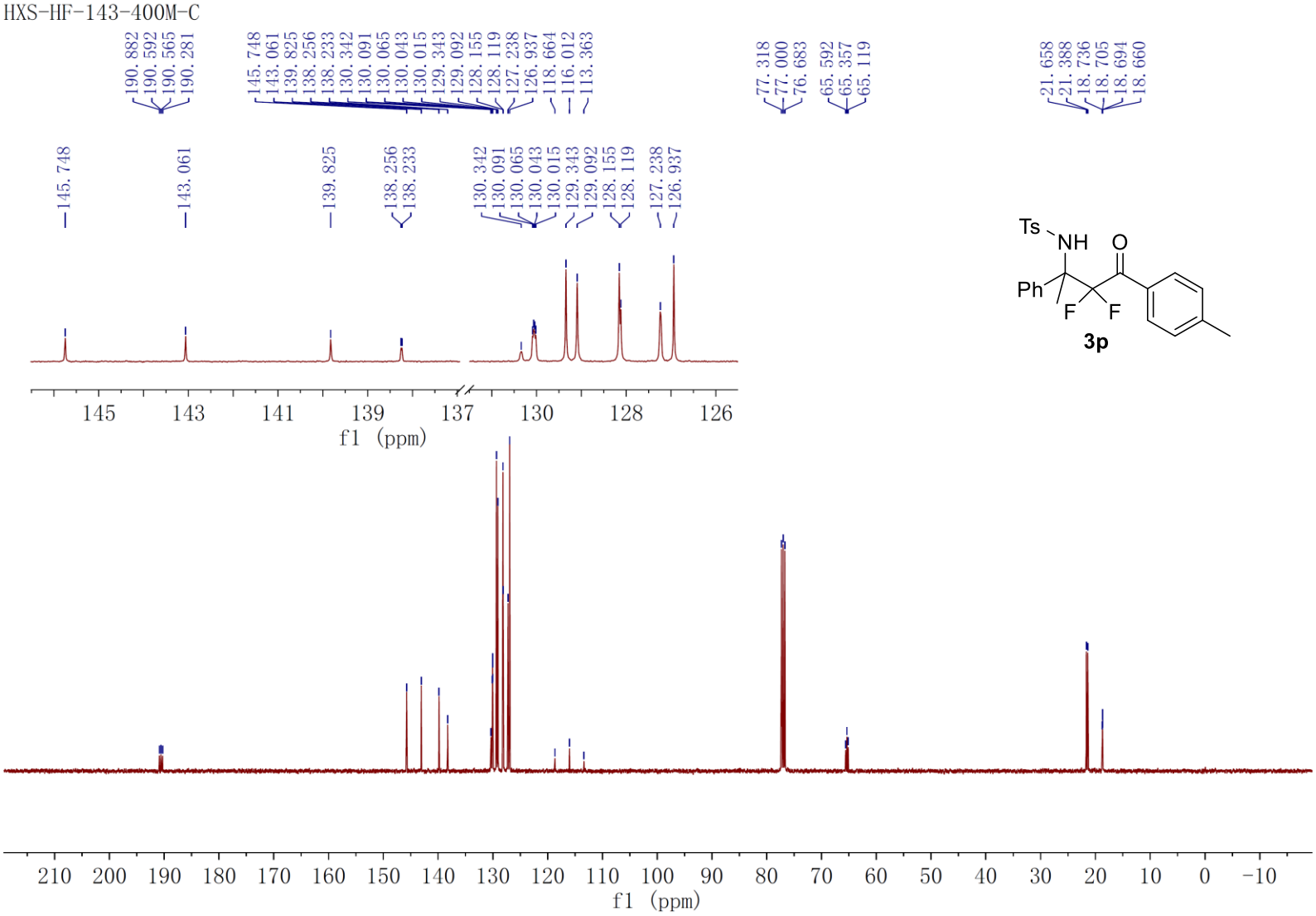


HXS-HF-33-400M-F

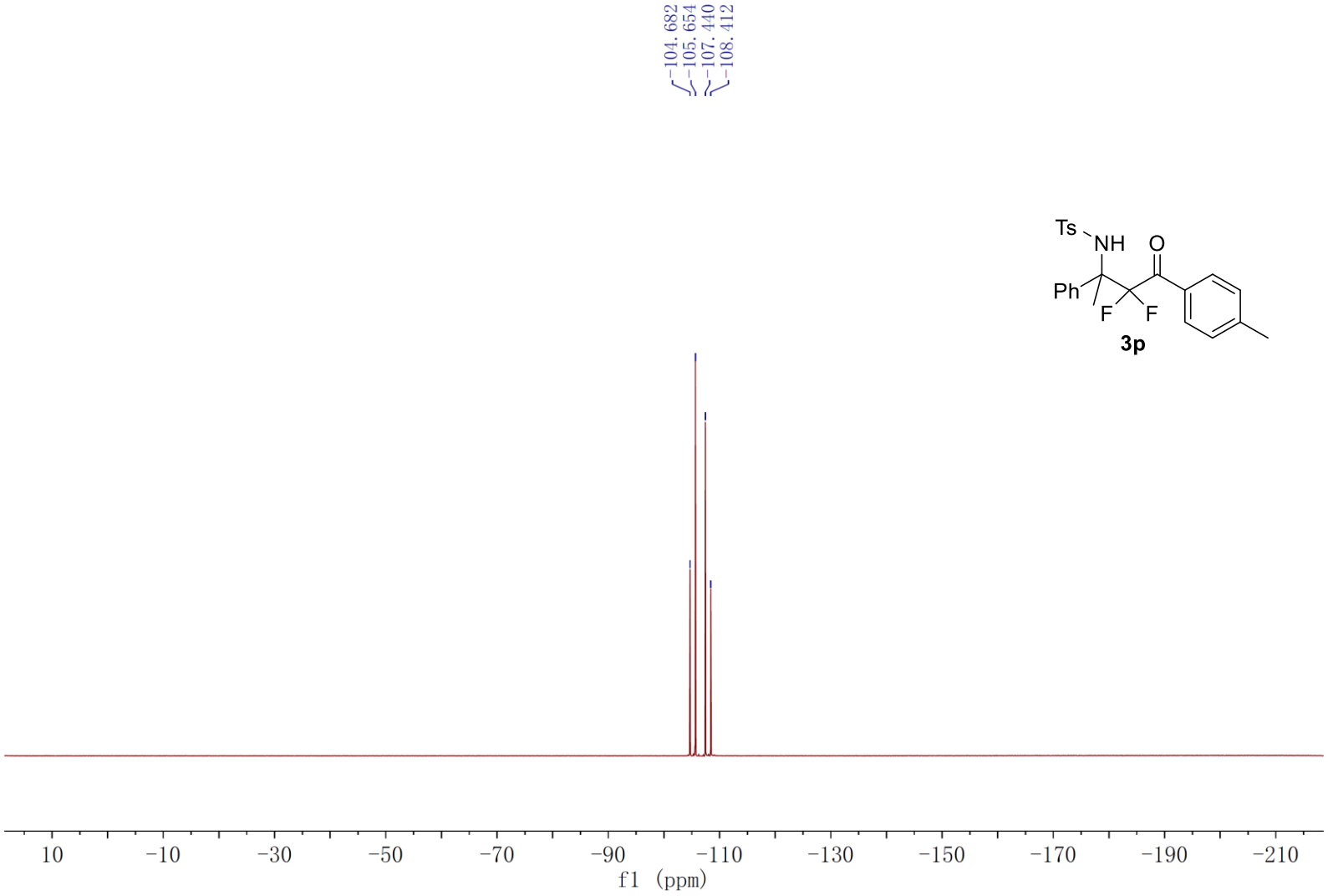


HXS-HF-143-400M-H

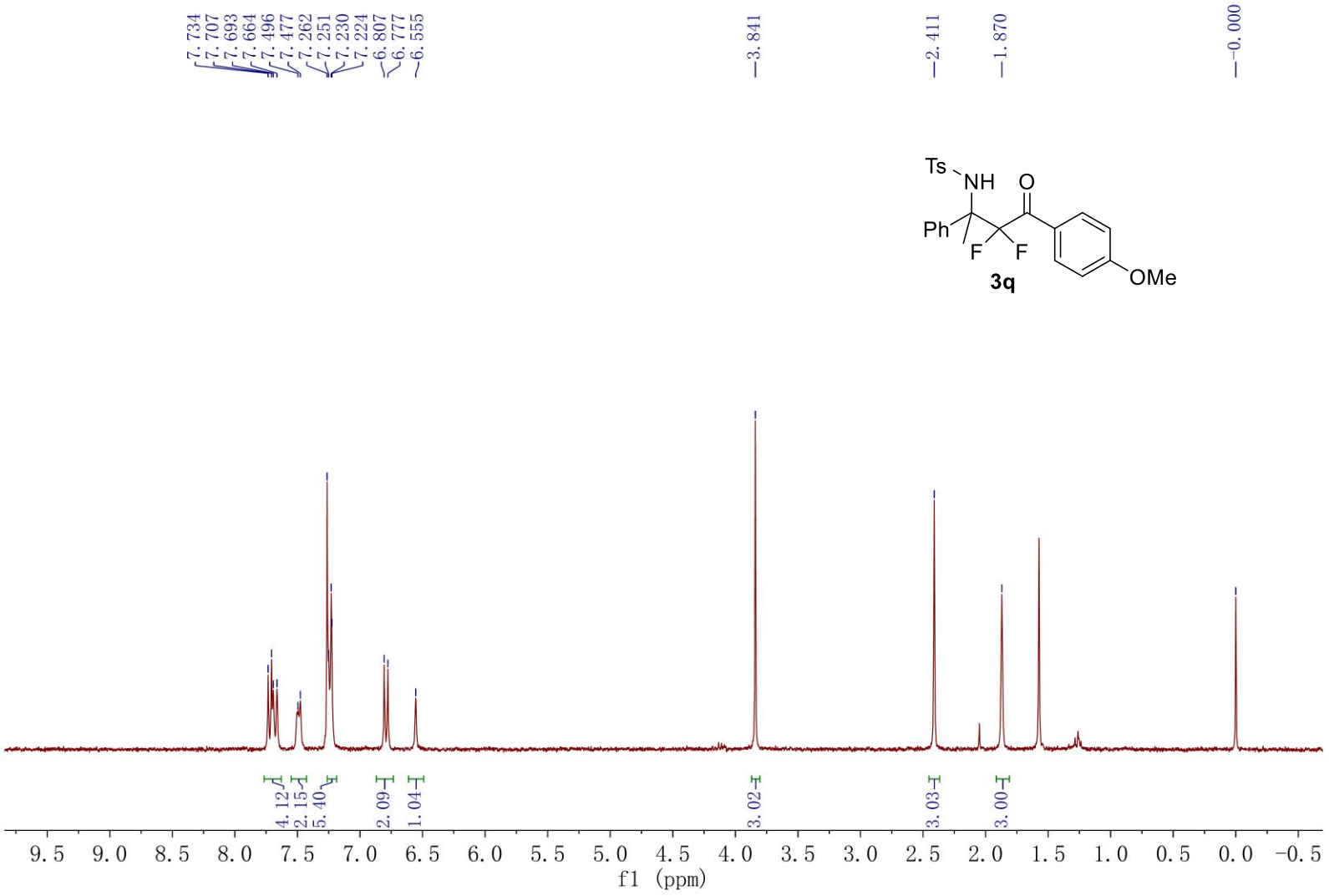


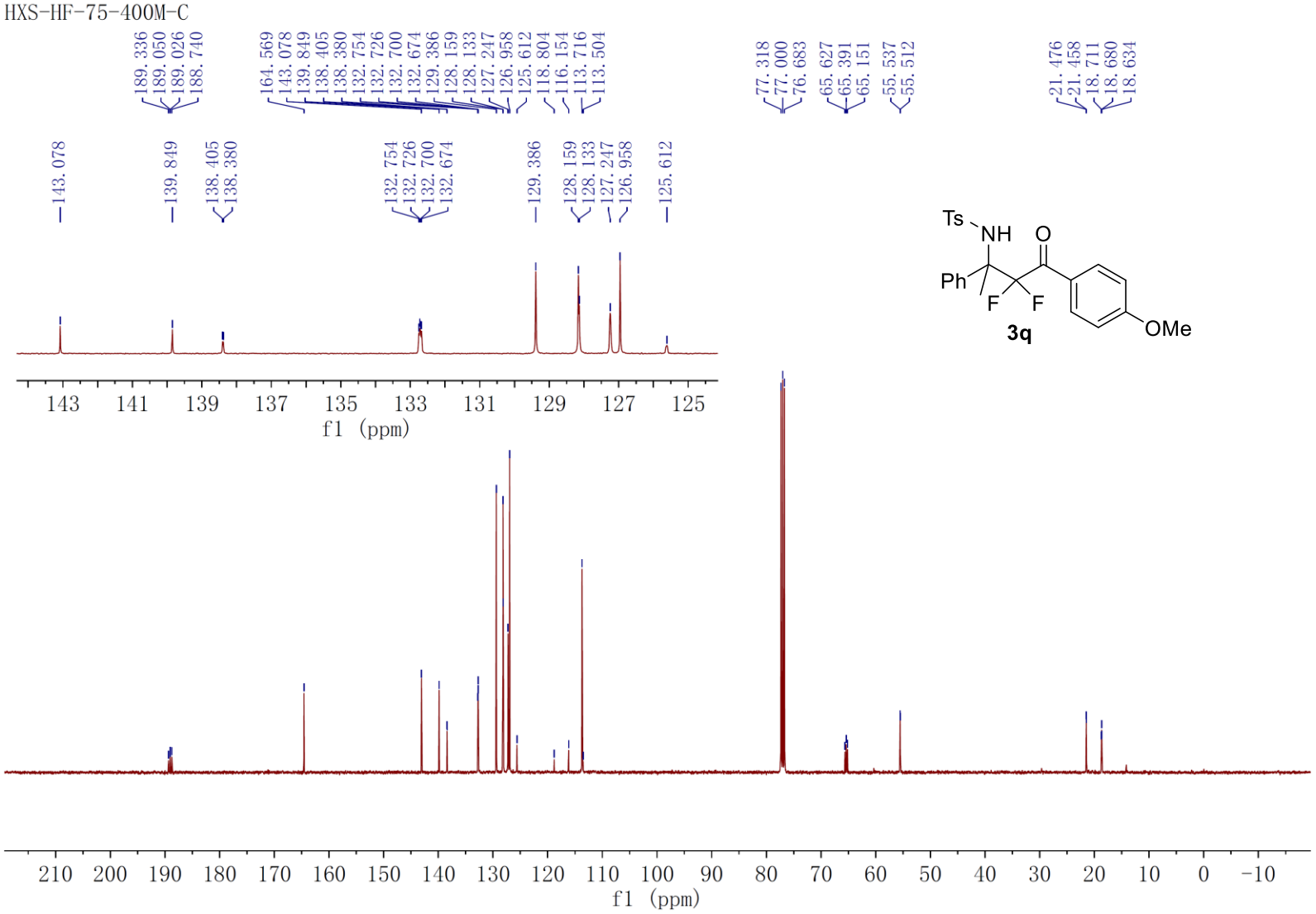

HXS-HF-143-400M-C
190.882
190.592
190.565
190.281
145.748
143.061
139.825
138.256
138.233
130.342
130.091
130.065
130.043
130.015
129.343
129.092
128.155
128.119
127.238
126.937
118.664
116.012
113.363
77.318
77.000
76.683
65.592
65.357
65.119
21.658
21.388
18.736
18.705
18.694
18.660
Ts
NH
O
Ph
F
F
3p
f1 (ppm)
f1 (ppm)

HXS-HF-143-300M-F

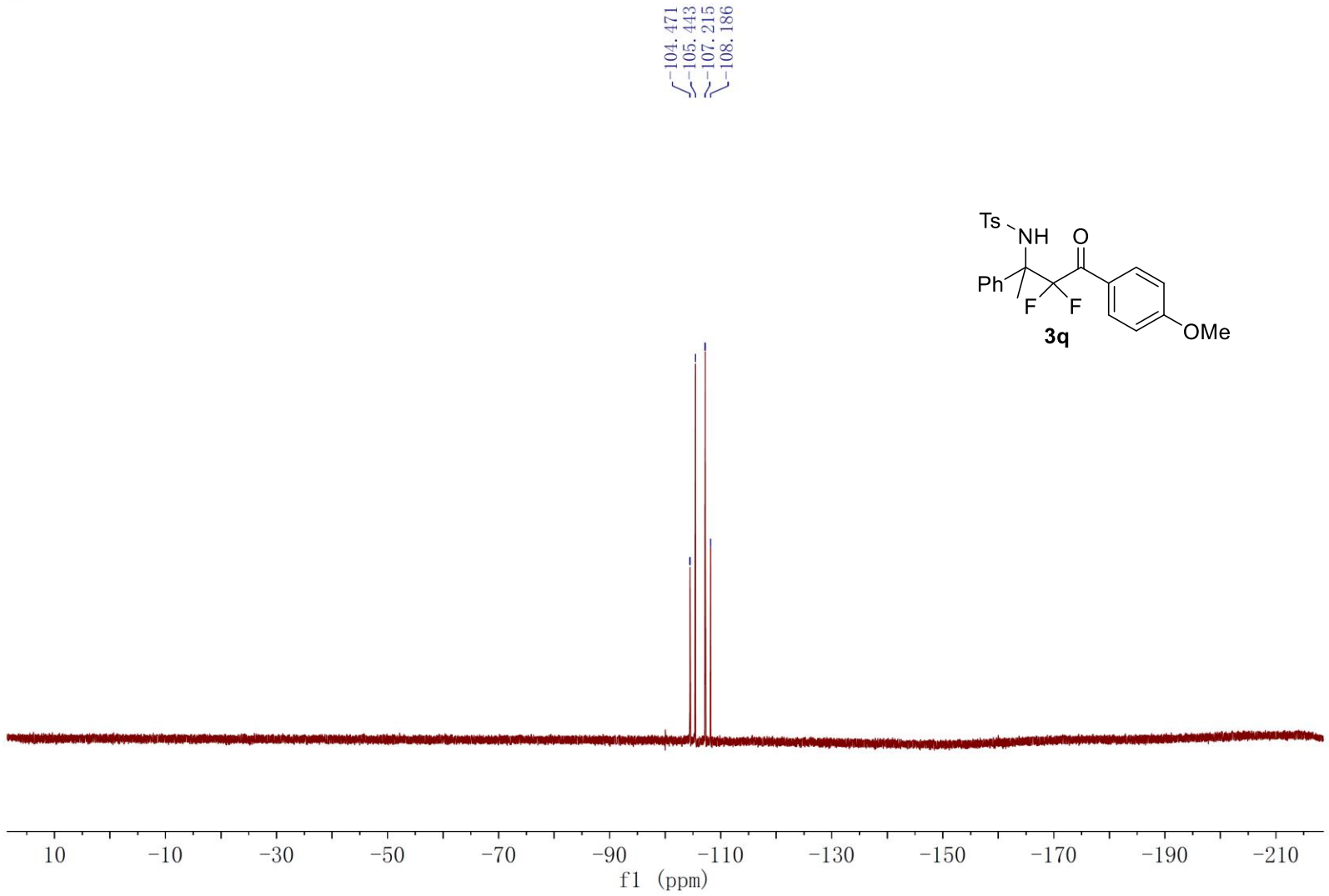


HXS-HF-75-300M-H

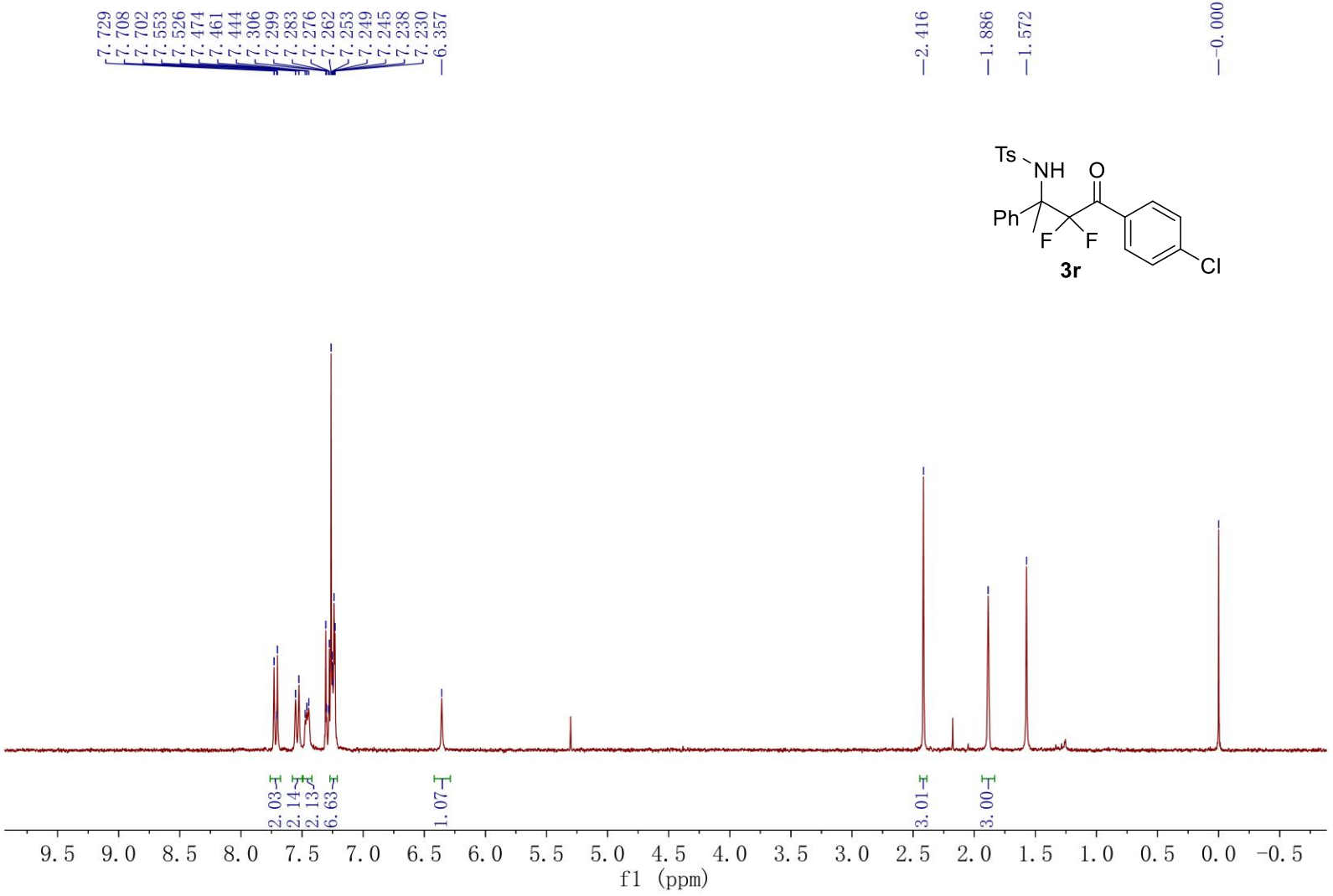


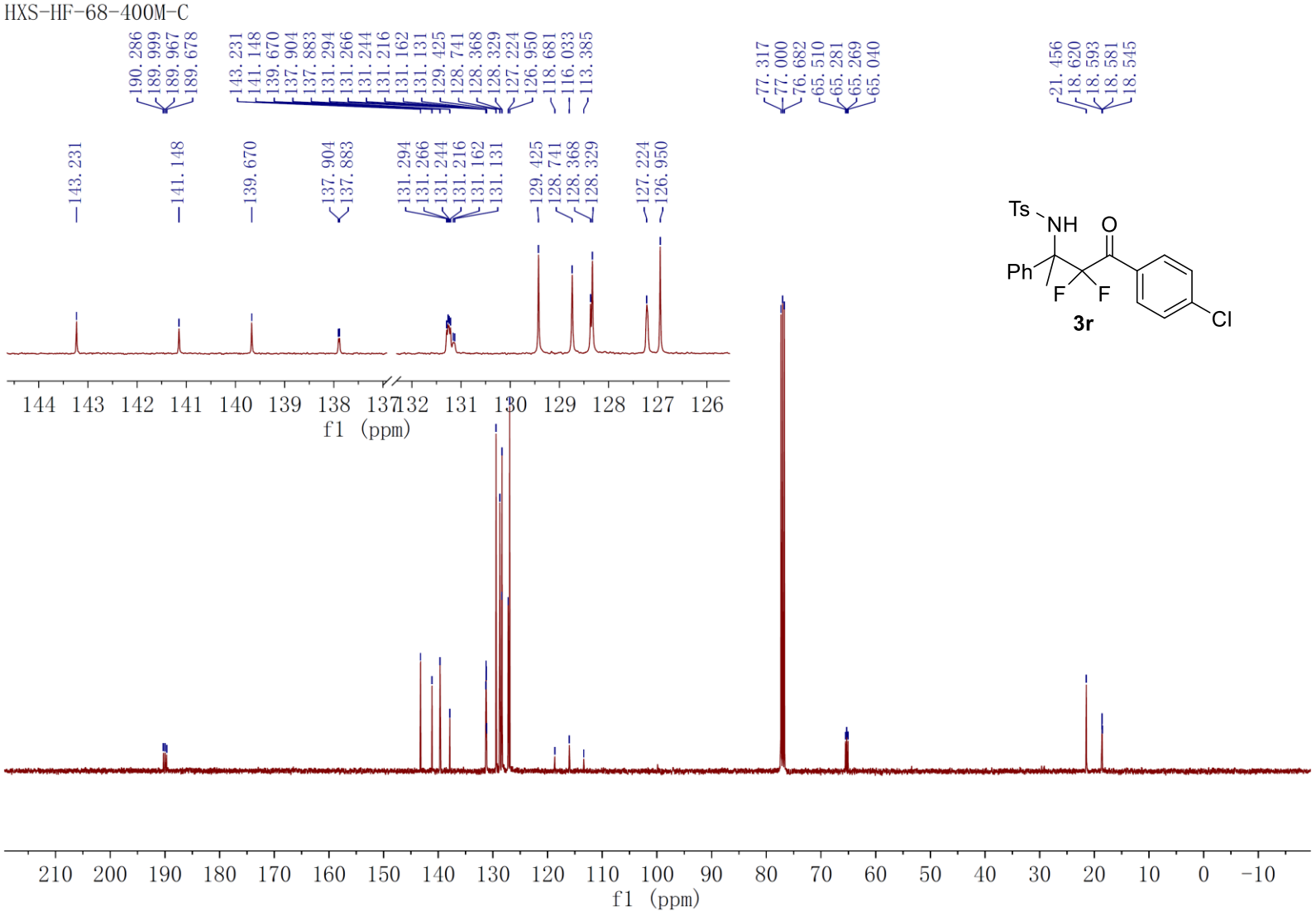

HXS-HF-75-400M-C
189.336
189.050
189.026
188.740
164.569
143.078
139.849
138.405
138.380
132.754
132.726
132.700
132.674
129.386
128.159
128.133
127.247
126.958
125.612
118.804
116.154
113.716
113.504
77.318
77.000
76.683
65.627
65.391
65.151
55.537
55.512
21.476
21.458
18.711
18.680
18.634
143.078
139.849
138.405
138.380
132.754
132.726
132.700
132.674
129.386
128.159
128.133
127.247
126.958
125.612
Ts
NH
O
Ph
F
F
OMe
3q
143 141 139 137 135 133 131 129 127 125
f1 (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

HXS-HF-75-300M-F

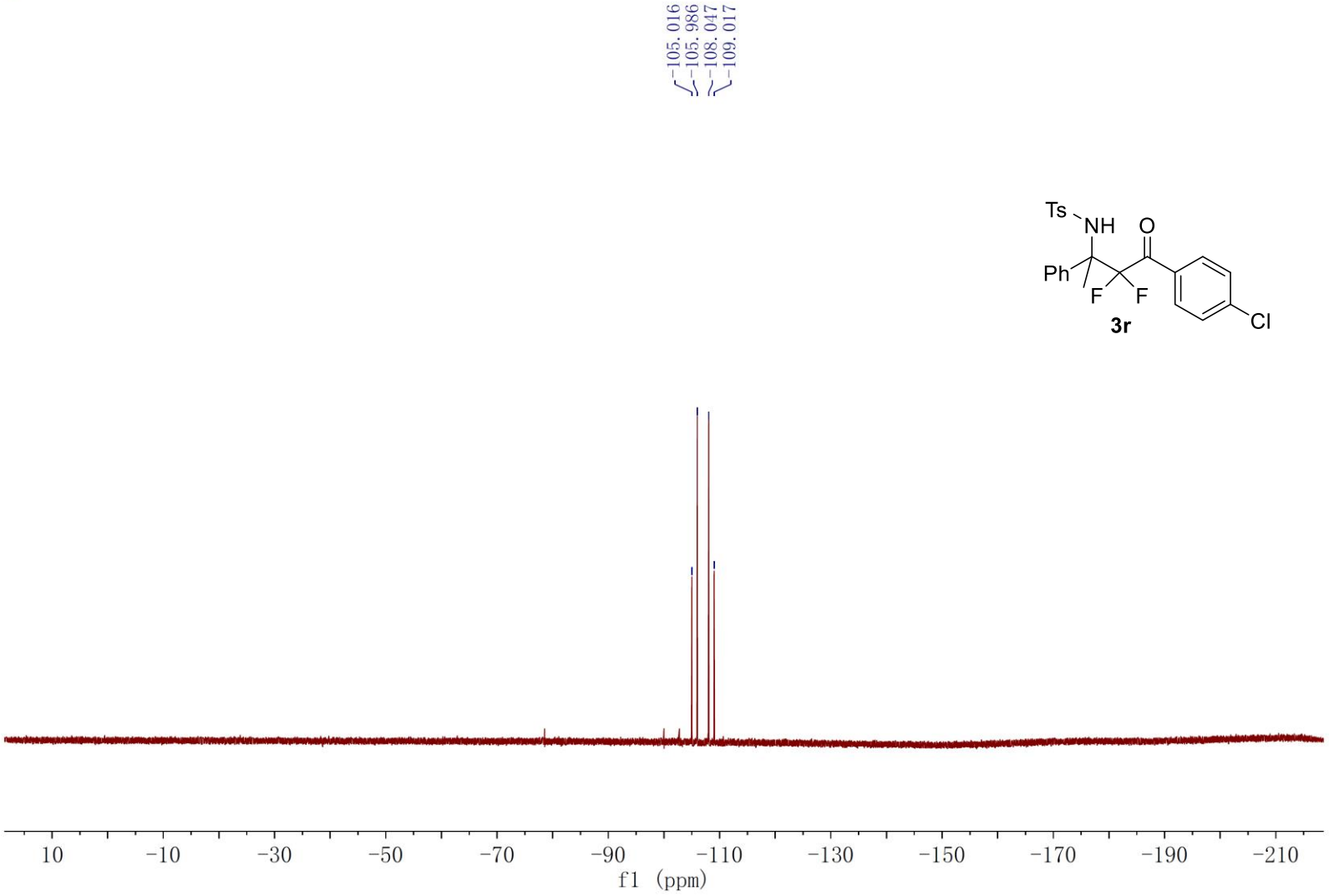


HXS-HF-68-300M-H

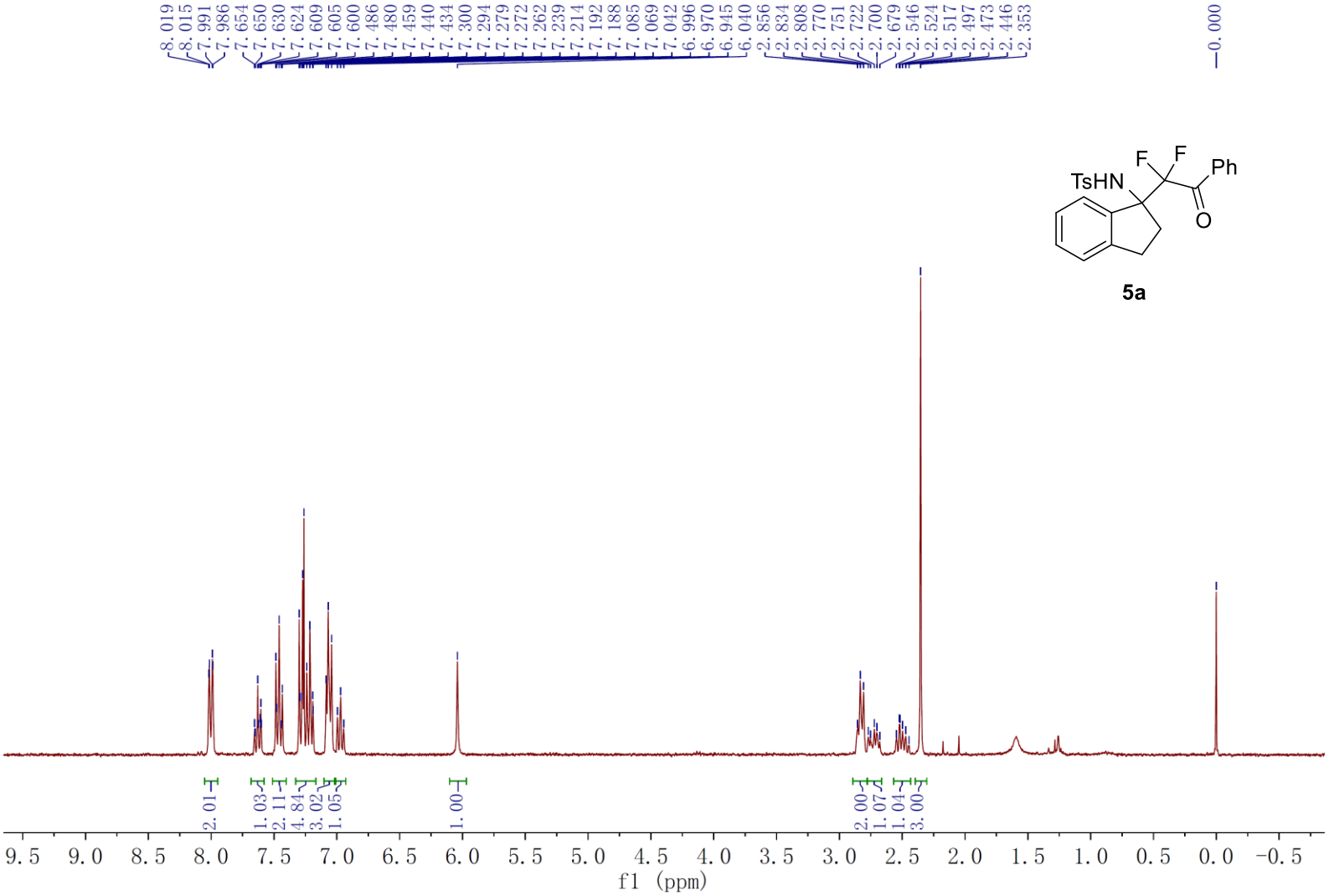



HXS-HF-68-400M-C
190.286
189.999
189.967
189.678
143.231
141.148
139.670
137.904
137.883
131.294
131.266
131.244
131.216
131.162
131.131
129.425
128.741
128.368
128.329
127.224
126.950
118.681
116.033
113.385
77.317
77.000
76.682
65.510
65.281
65.269
65.040
21.456
18.620
18.593
18.581
18.545
143.231
141.148
139.670
137.904
137.883
131.294
131.266
131.244
131.216
131.162
131.131
129.425
128.741
128.368
128.329
127.224
126.950
144 143 142 141 140 139 138 137 132 131 130 129 128 127 126
f1 (ppm)
Ts
NH
O
Ph
F
F
Cl
3r
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

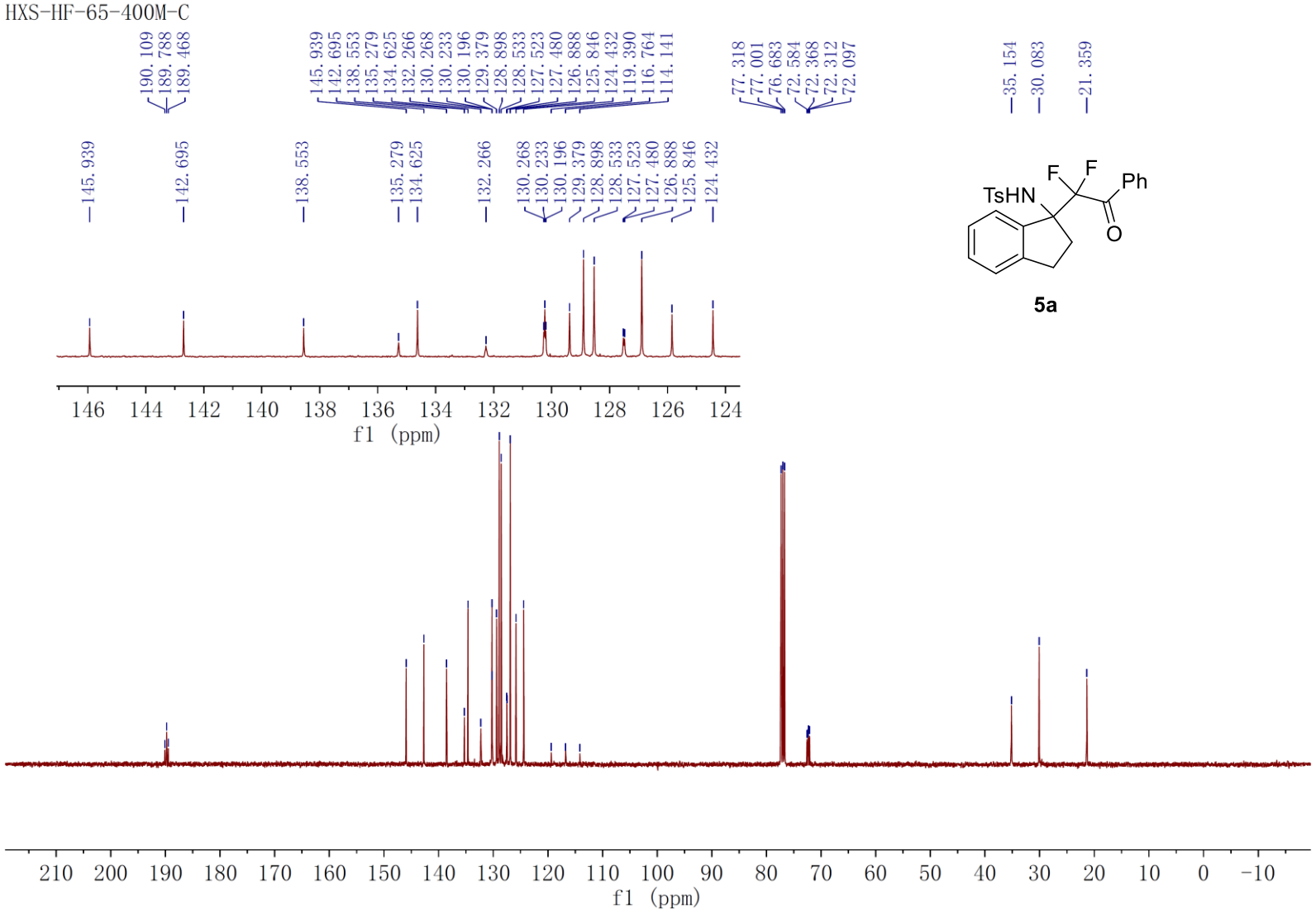
HXS-HF-68-300M-F



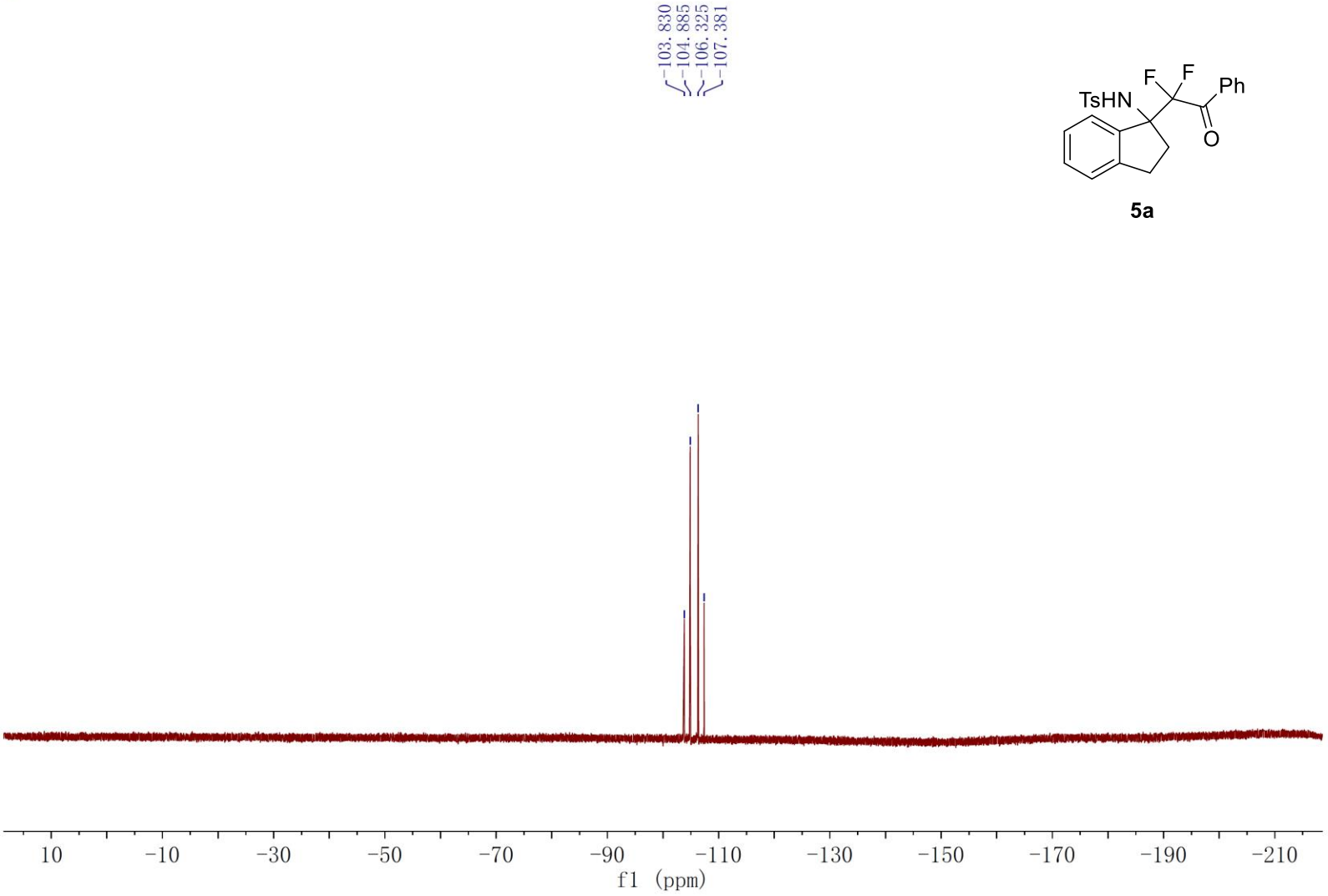
HXS-HF-65-300M-H



5a

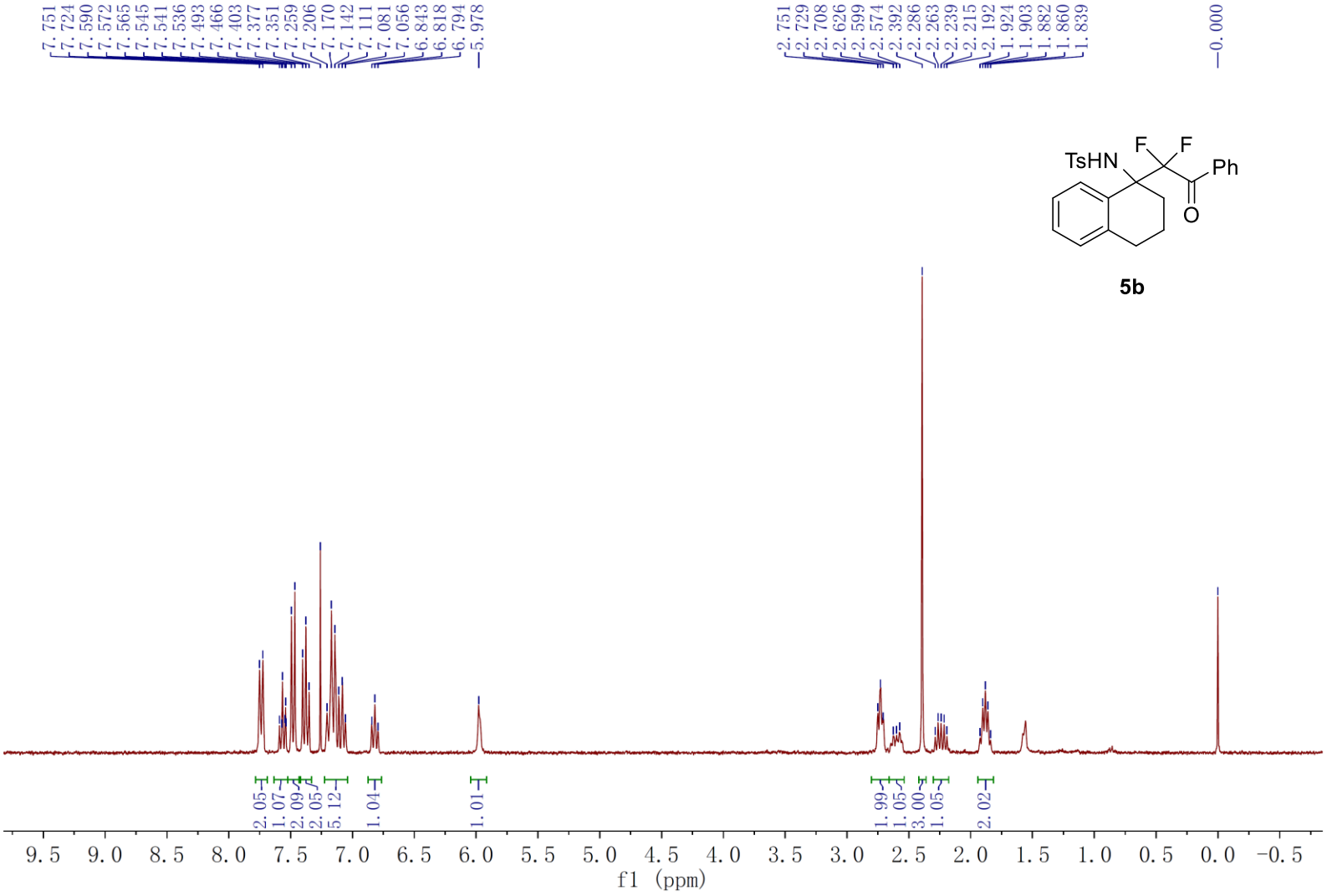

HXS-HF-65-400M-C
190.109
189.788
189.468
145.939
142.695
138.553
135.279
134.625
132.266
130.268
130.233
130.196
129.379
128.898
128.533
127.523
127.480
126.888
125.846
124.432
119.390
116.764
114.141
77.318
77.001
76.683
72.584
72.368
72.312
72.097
35.154
30.083
21.359
TsHN
F
F
Ph
O
5a
f1 (ppm)
f1 (ppm)

HXS-HF-65-300M-F

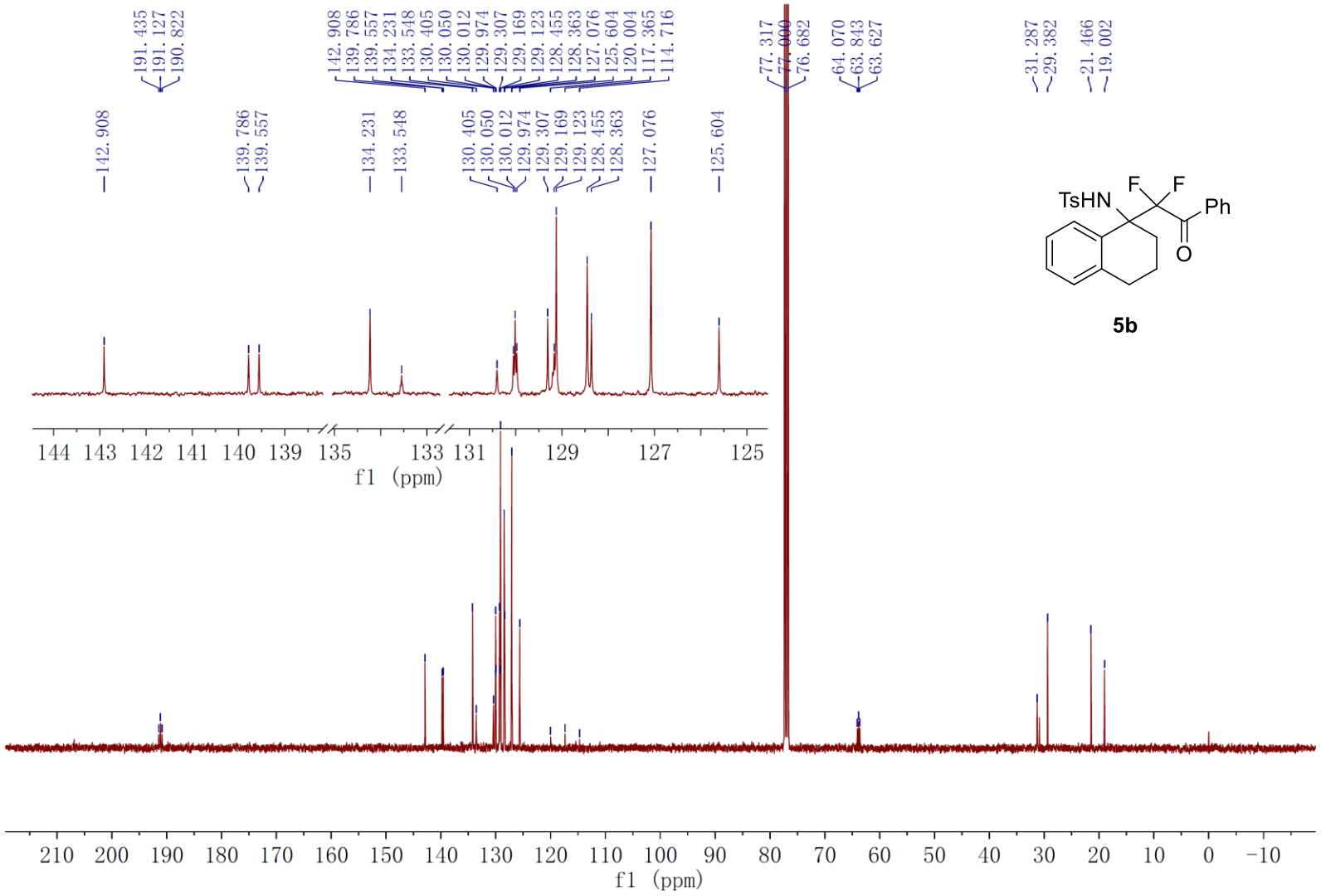


5a

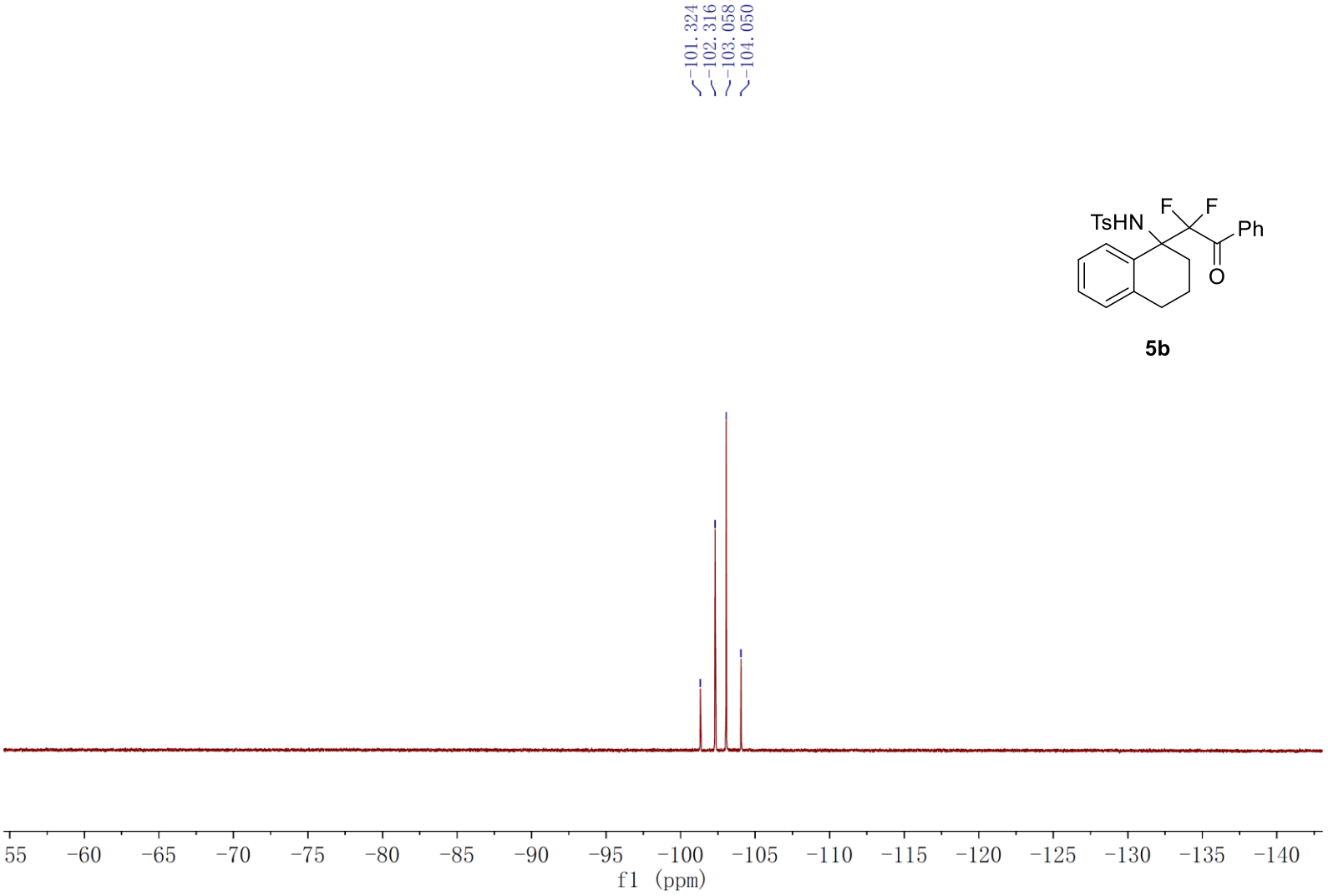
HXS-HG-33-300M-H



5b


HXS-HG-33-C-400M
191.435
191.127
190.822
142.908
139.786
139.557
134.231
133.548
130.405
130.050
130.012
129.974
129.307
129.169
129.123
128.455
128.363
127.076
125.604
120.004
117.365
114.716
77.317
77.000
76.682
64.070
63.843
63.627
31.287
29.382
21.466
19.002
TsHN
F
F
Ph
O
5b
f1 (ppm)
f1 (ppm)

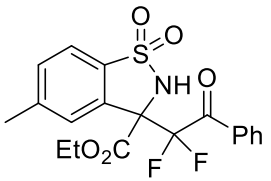
HXS-HG-33-300M-F



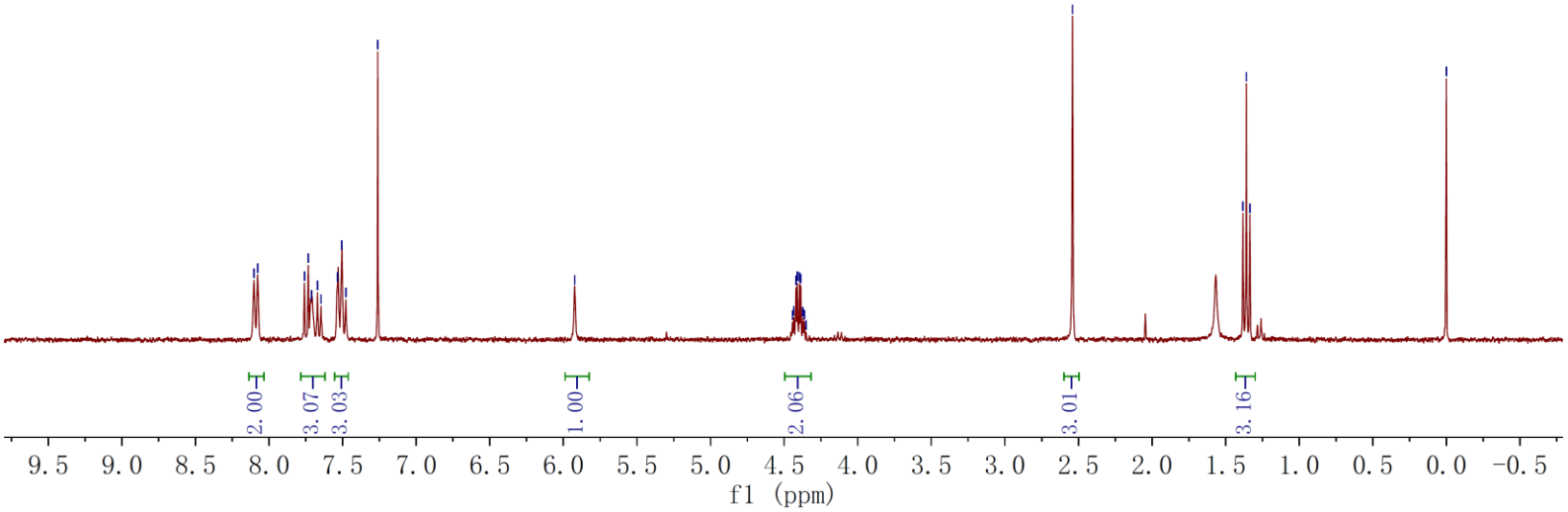
5b

HXS-HG-73-300M-H

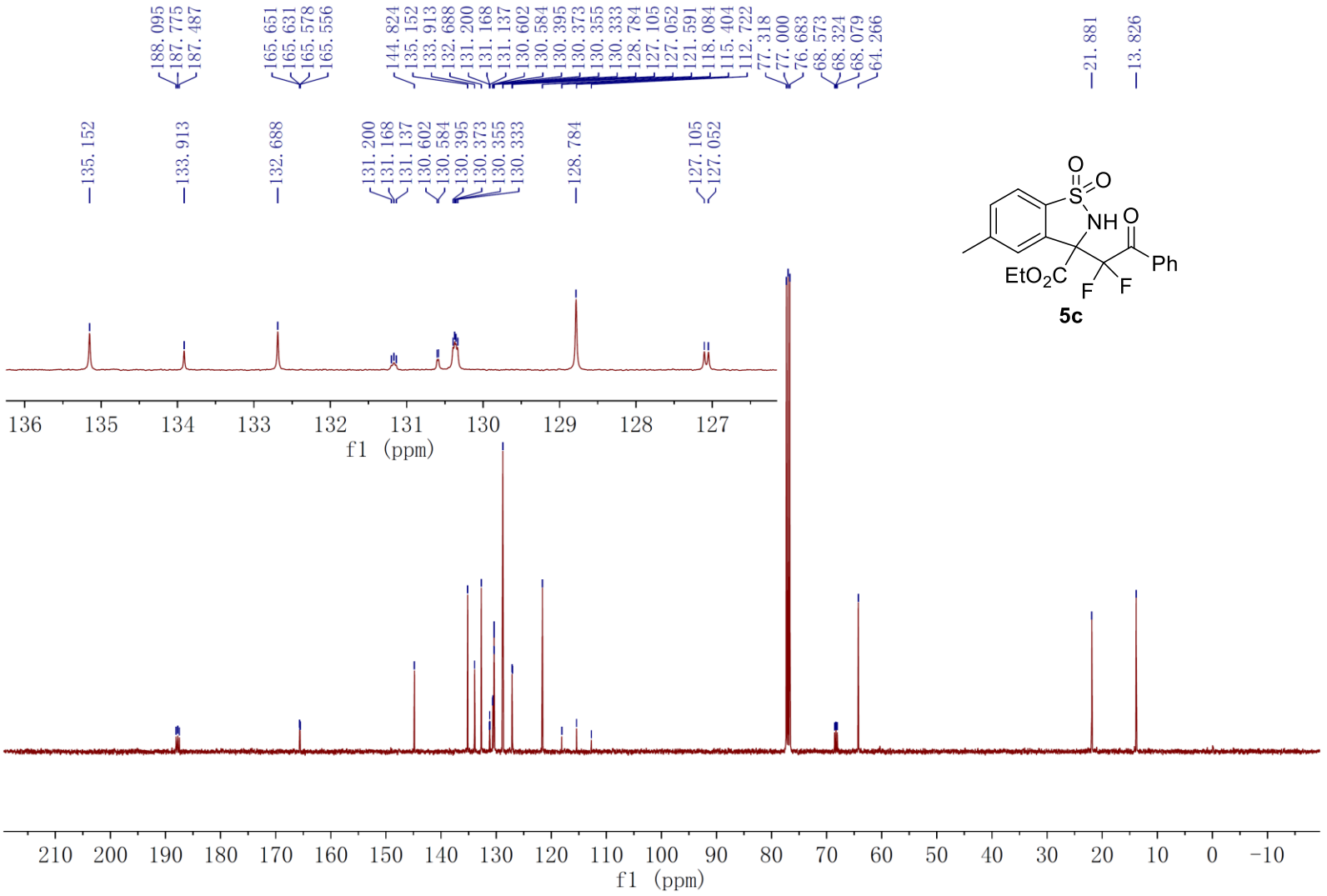
8.103
8.077
7.760
7.733
7.711
7.672
7.647
7.534
7.506
7.478
7.261
5.923
4.443
4.434
4.420
4.411
4.396
4.387
4.373
4.363
4.351
2.540
1.382
1.359
1.335
0.000



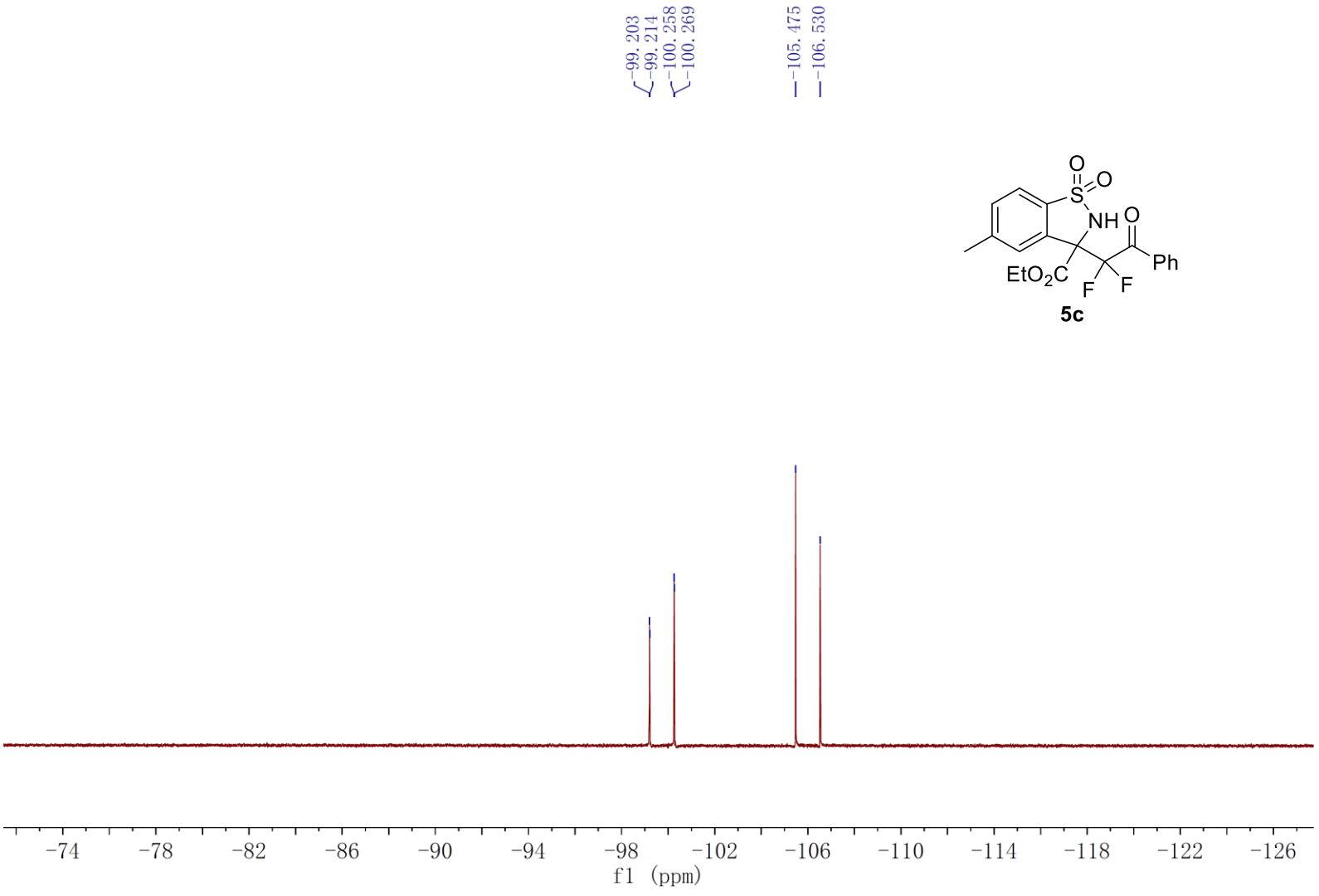
5c



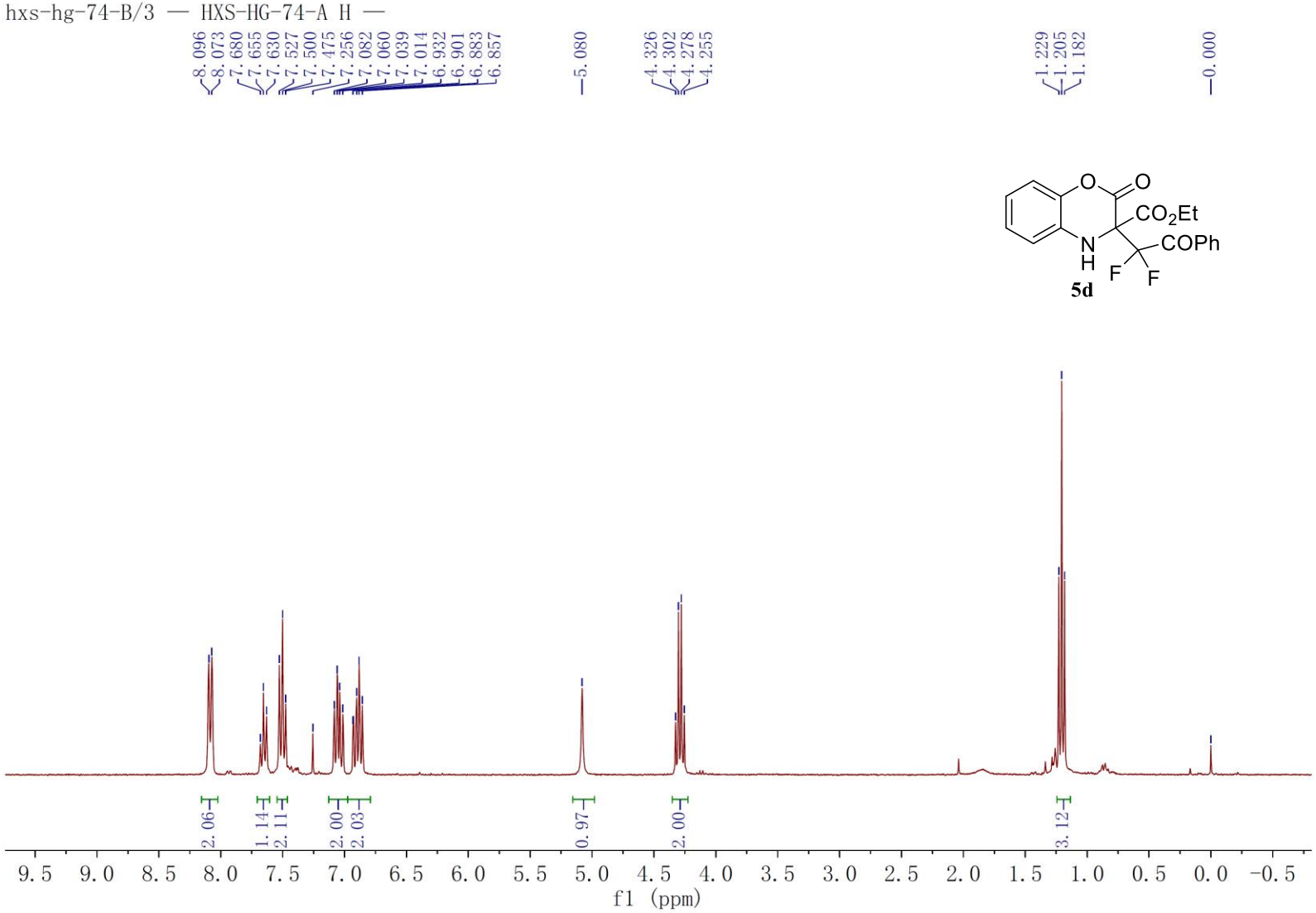
HXS-HG-73-400M-C



HXS-HG-73-300M-F

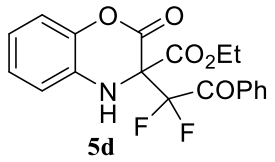


5c

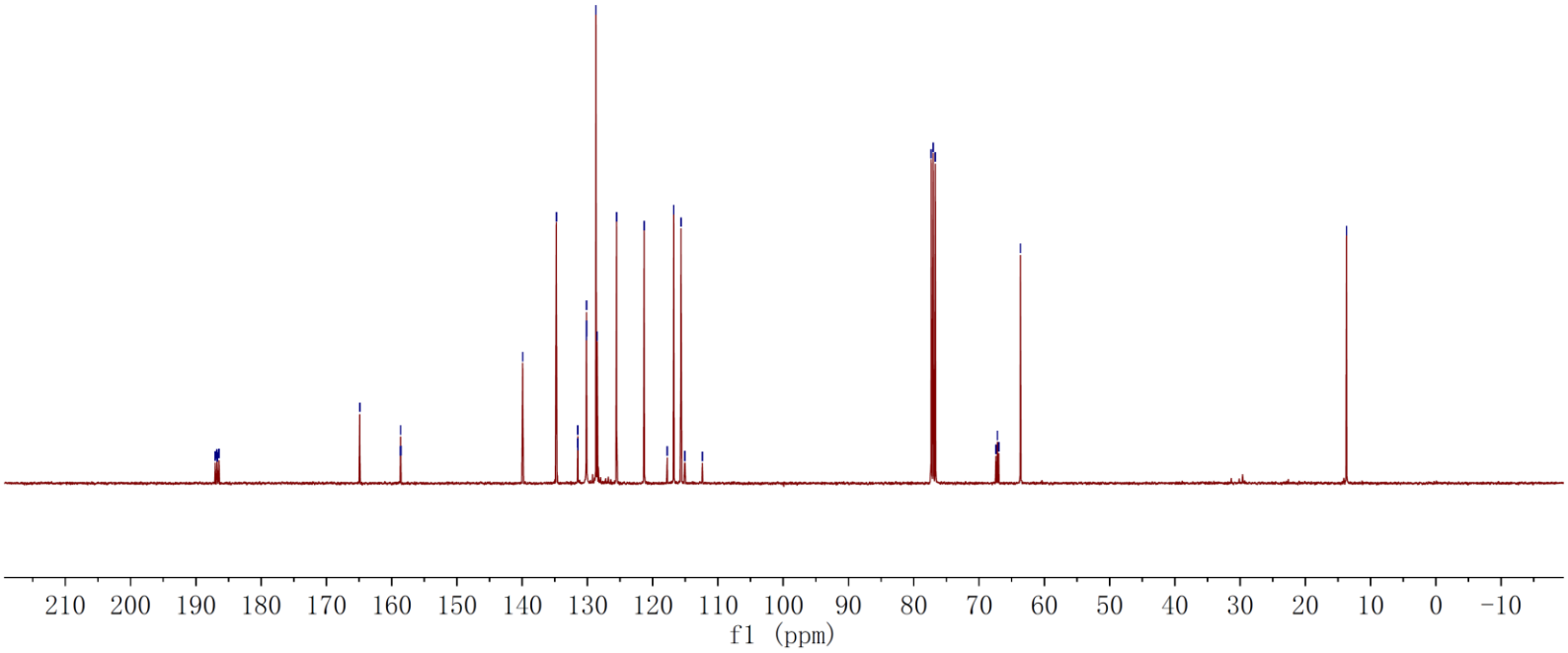

hxs-hg-74-B/3 — HXS-HG-74-A H —
8.096
8.073
7.680
7.655
7.630
7.527
7.500
7.475
7.256
7.082
7.060
7.039
7.014
6.932
6.901
6.883
6.857
5.080
4.326
4.302
4.278
4.255
1.229
1.205
1.182
0.000
O
O
CO2Et
N
H
COPh
F
F
5d
2.06
1.14
2.11
2.00
2.03
0.97
2.00
3.12
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

HXS-HG-74-400M-C

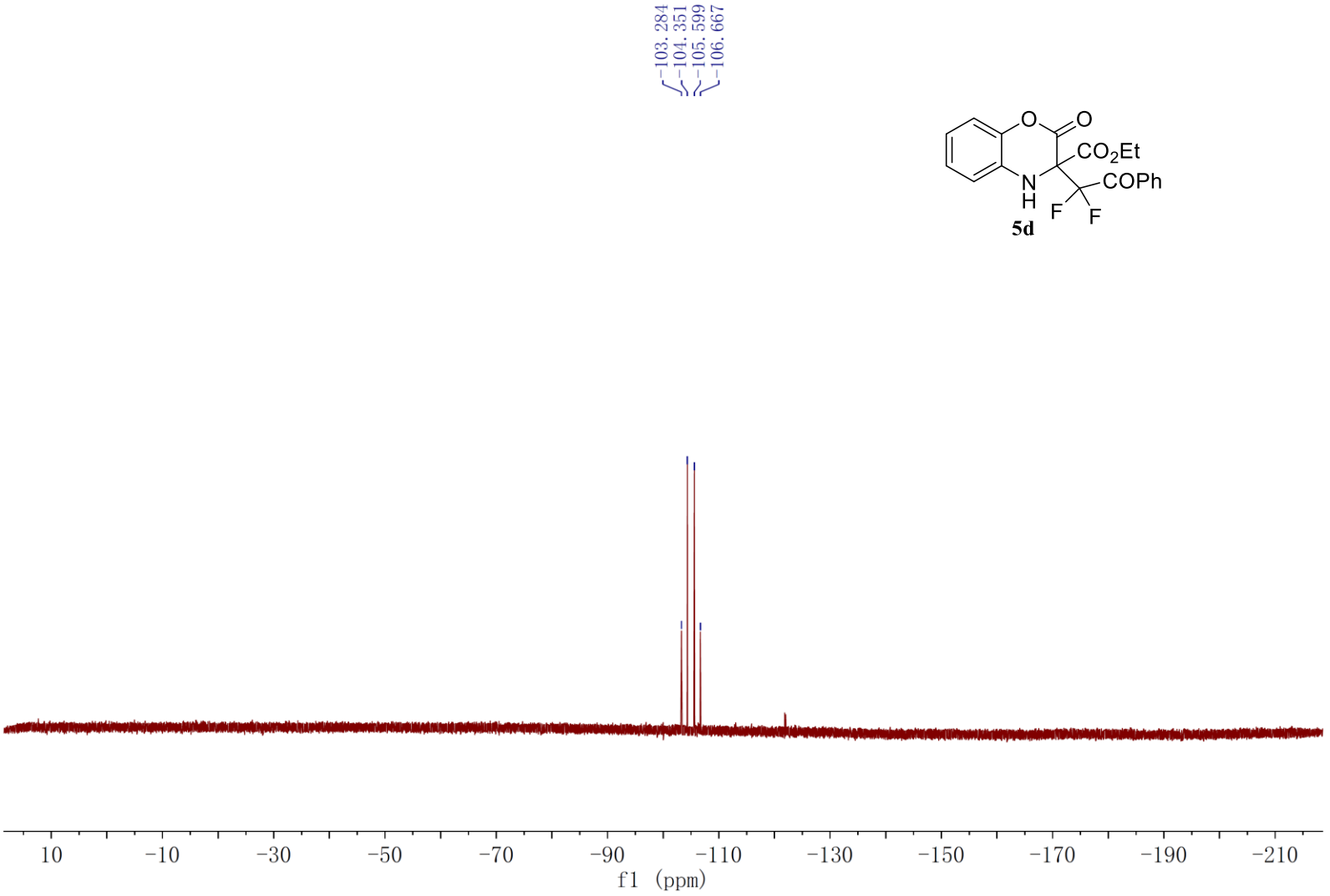
187.035
186.755
186.728
186.448
164.885
158.643
158.623
158.601
139.914
134.771
131.504
131.472
131.441
130.176
130.153
130.135
130.112
128.687
128.505
125.531
121.304
117.759
116.770
115.676
115.101
115.058
112.397
77.318
77.001
76.682
67.413
67.192
66.972
63.667
13.692



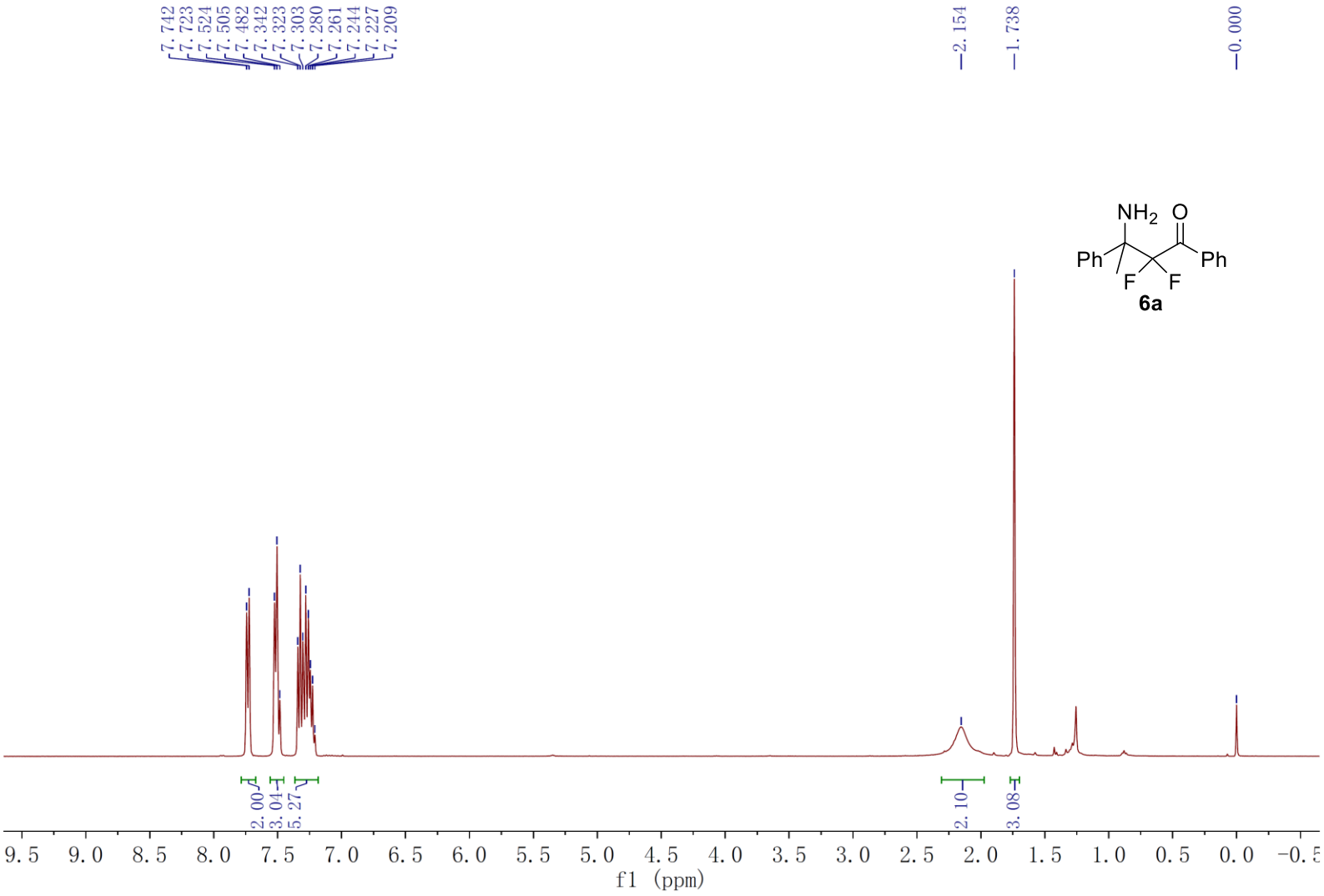
5d



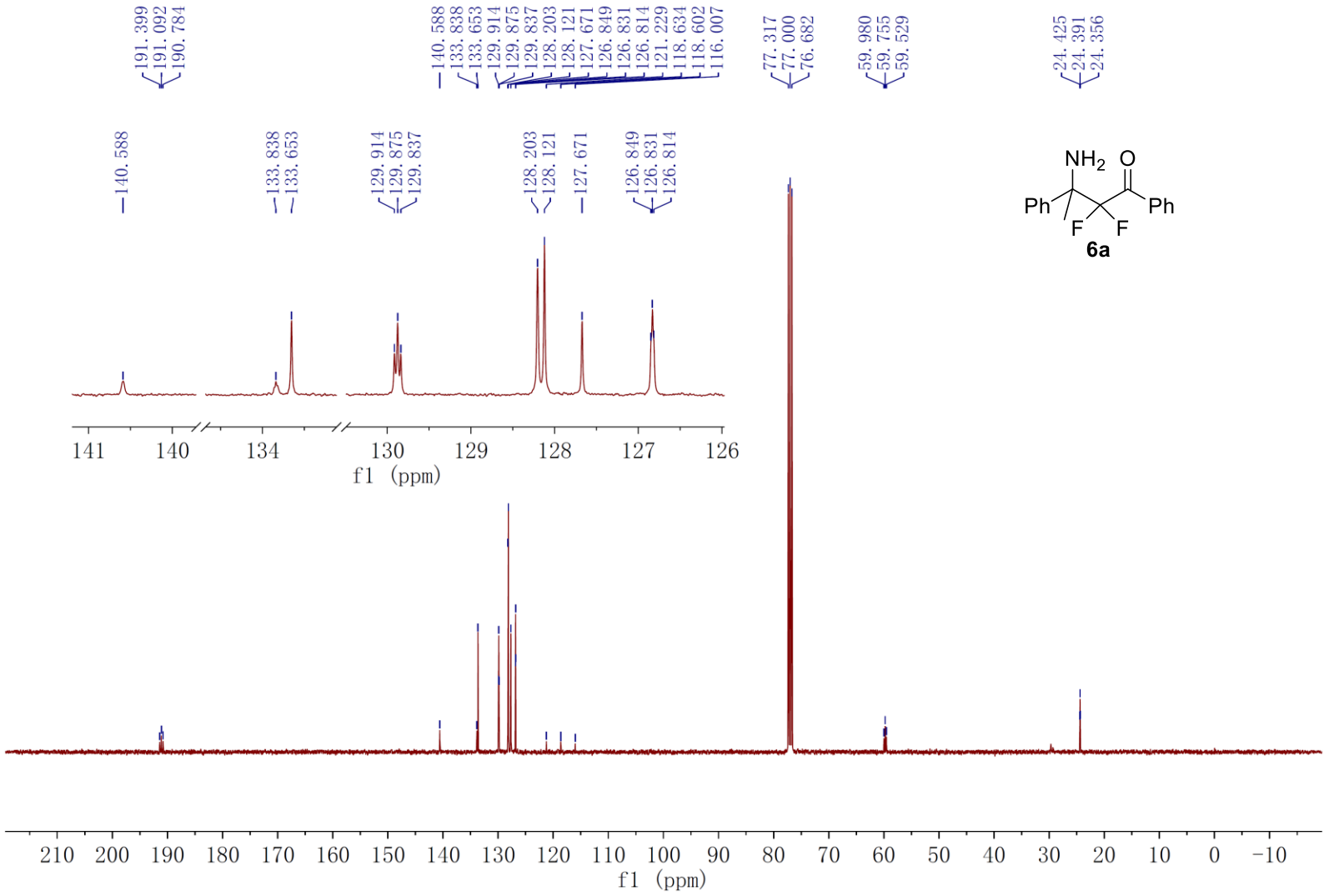
HXS-HG-74-300M-F



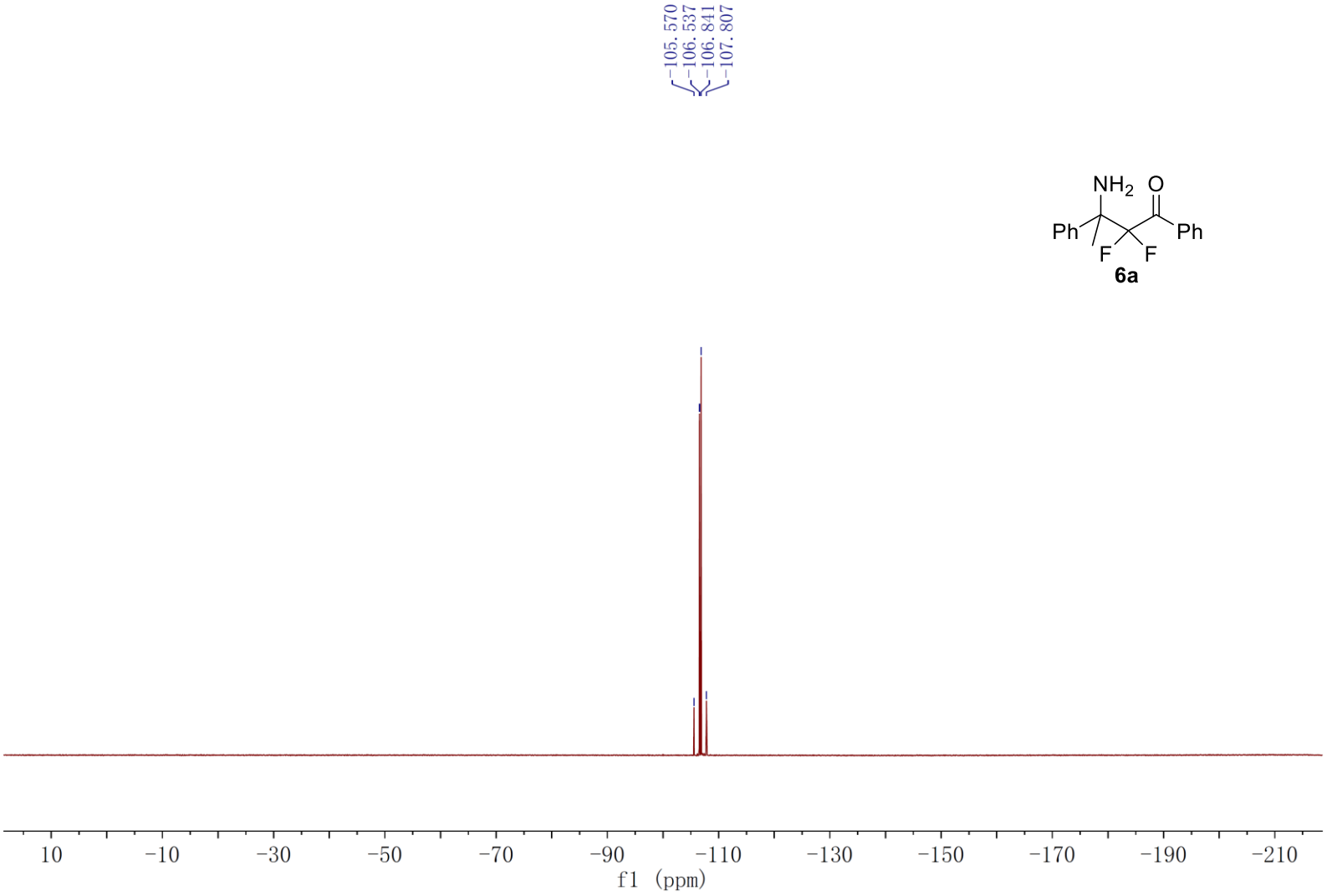
HXS-HF-133-400M-H



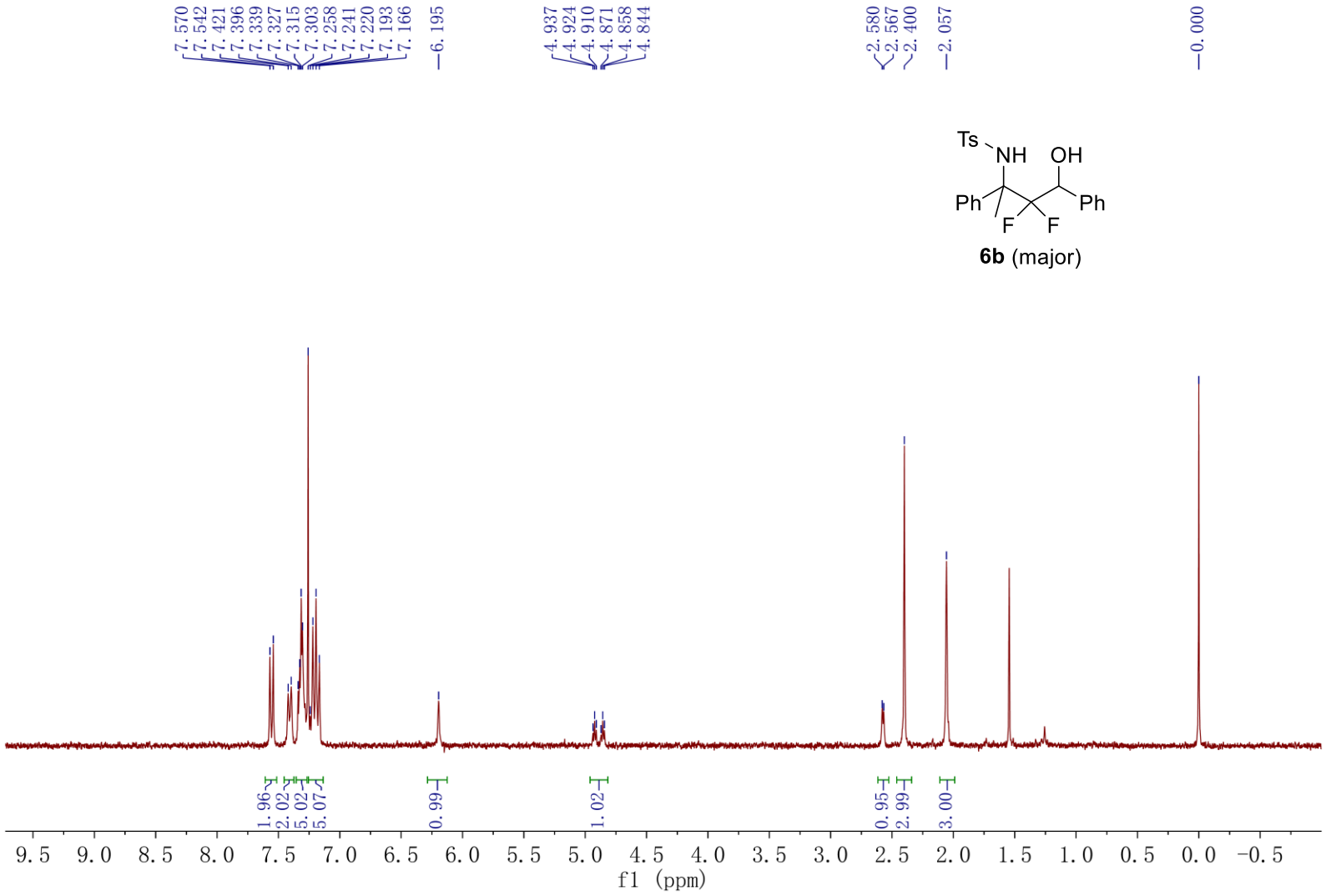
HXS-HF-133-400M-C



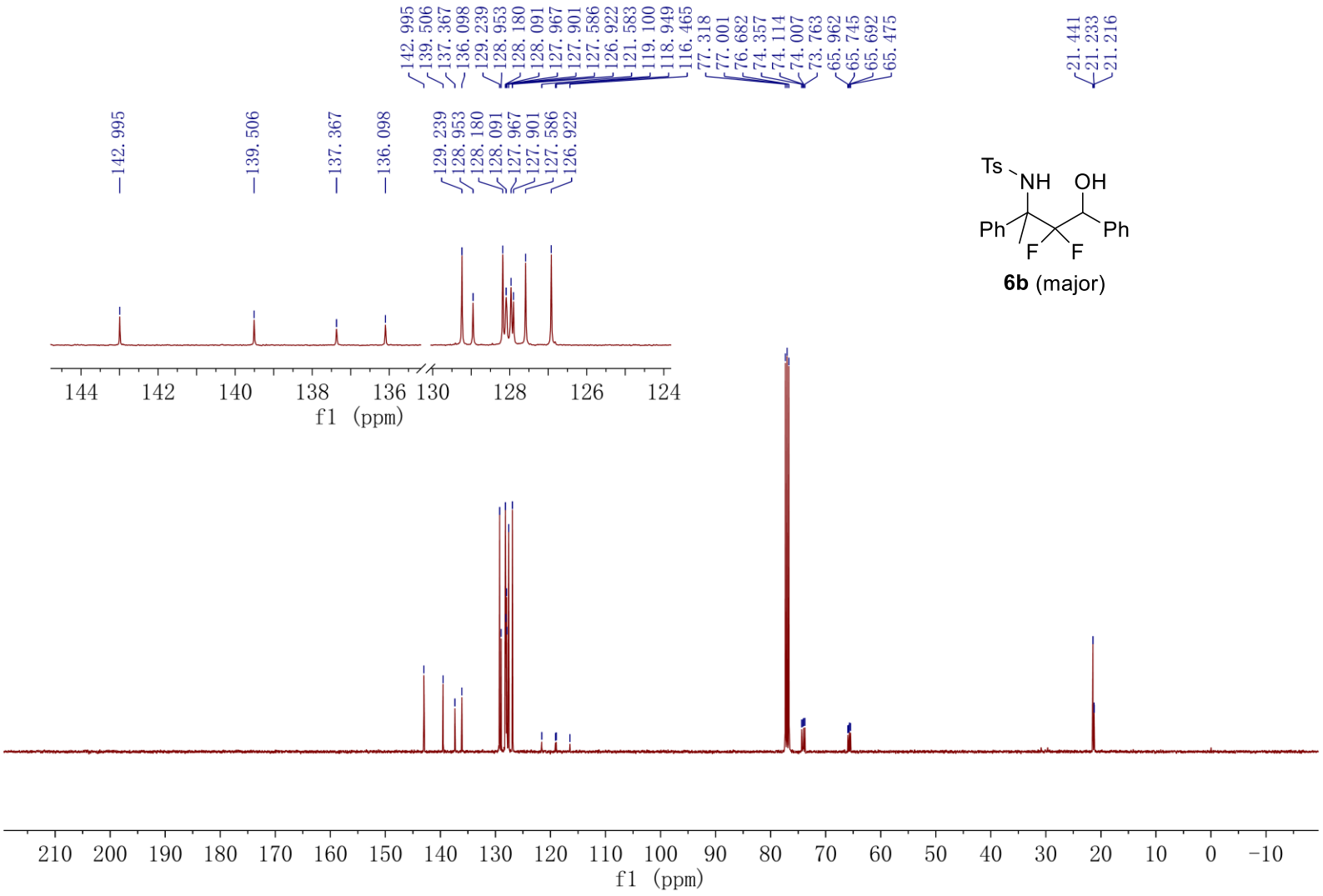
HXS-HF-133-300M-F



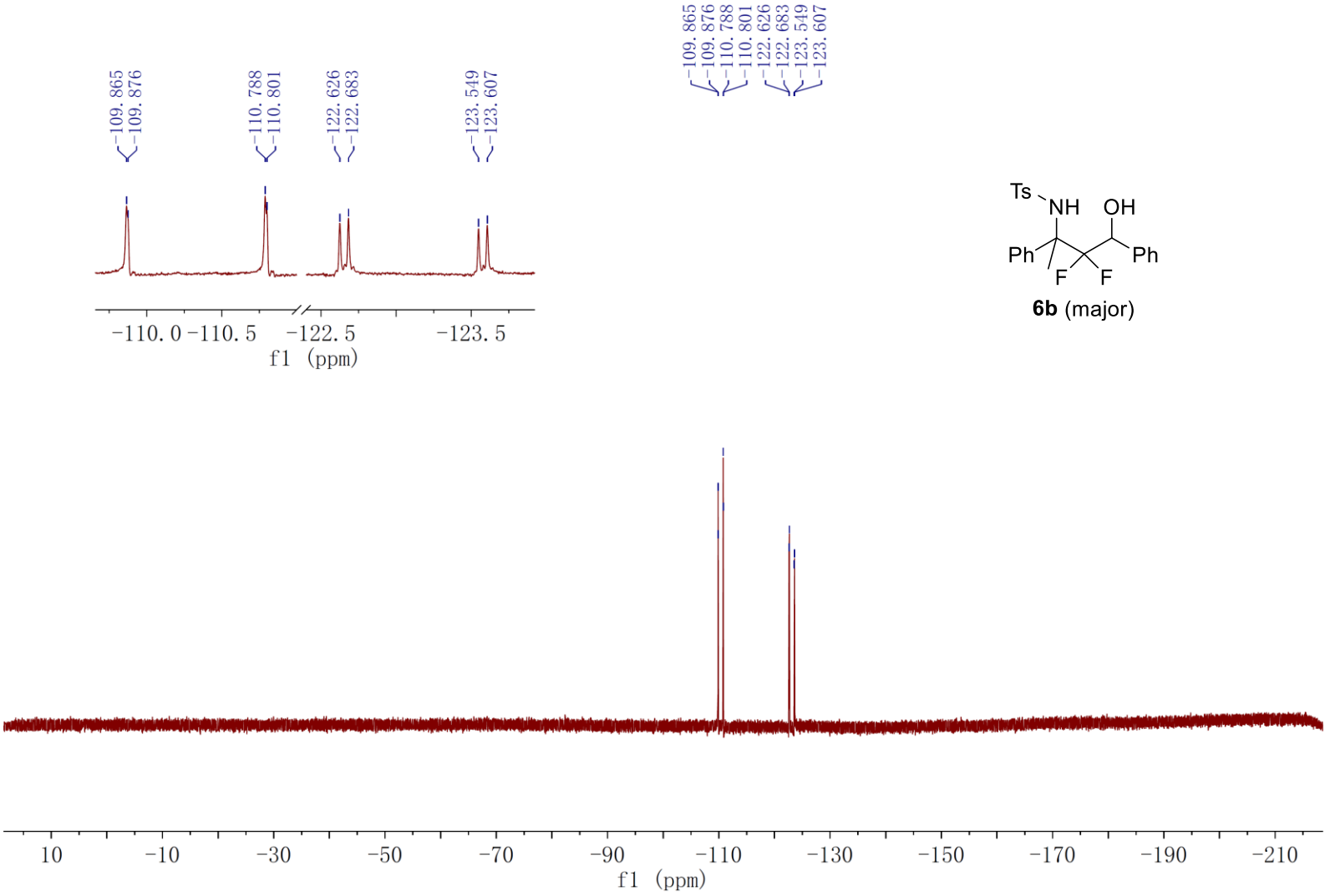
HXS-HF-108-L-300M-H



HXS-HF-108-L-400M-C

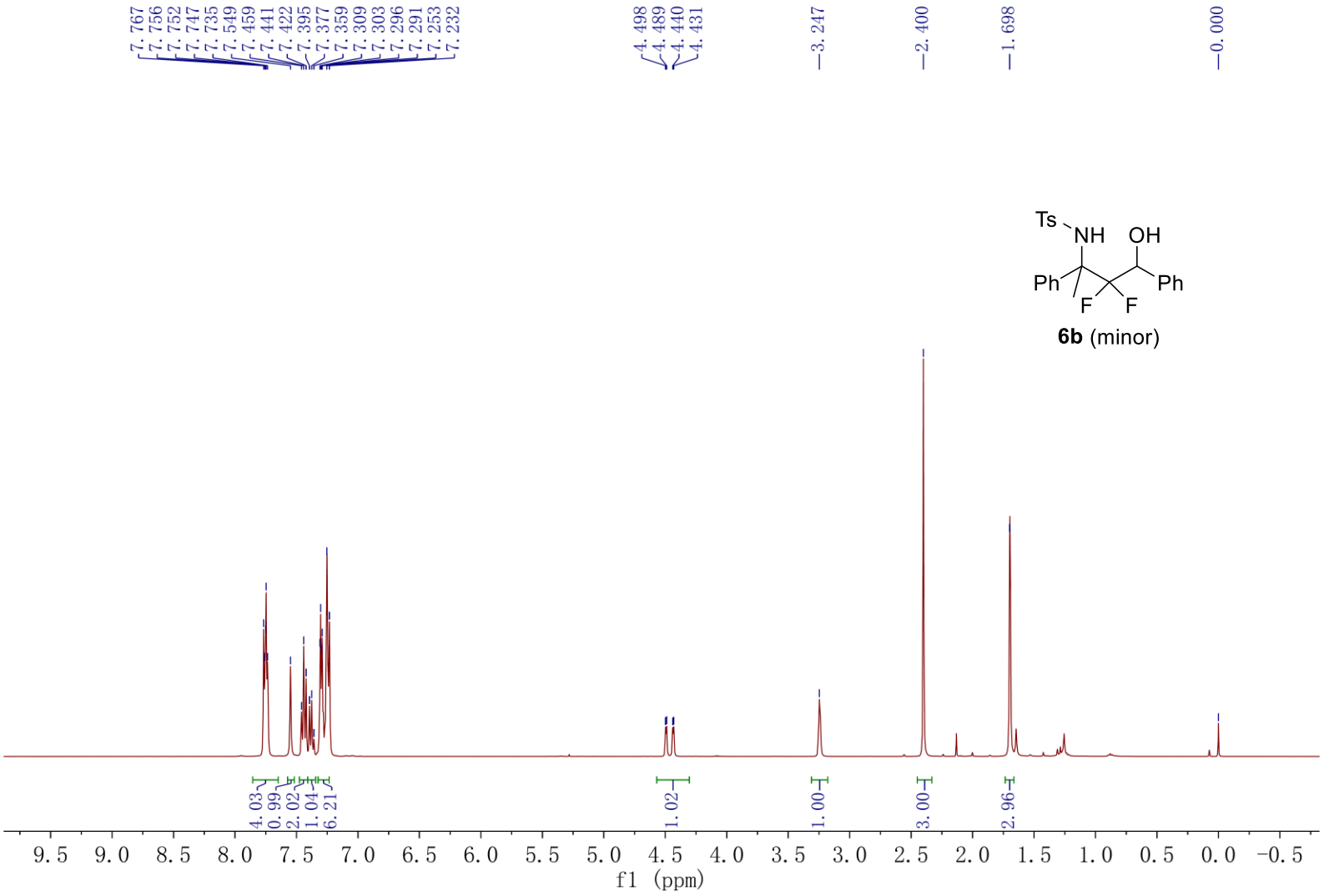


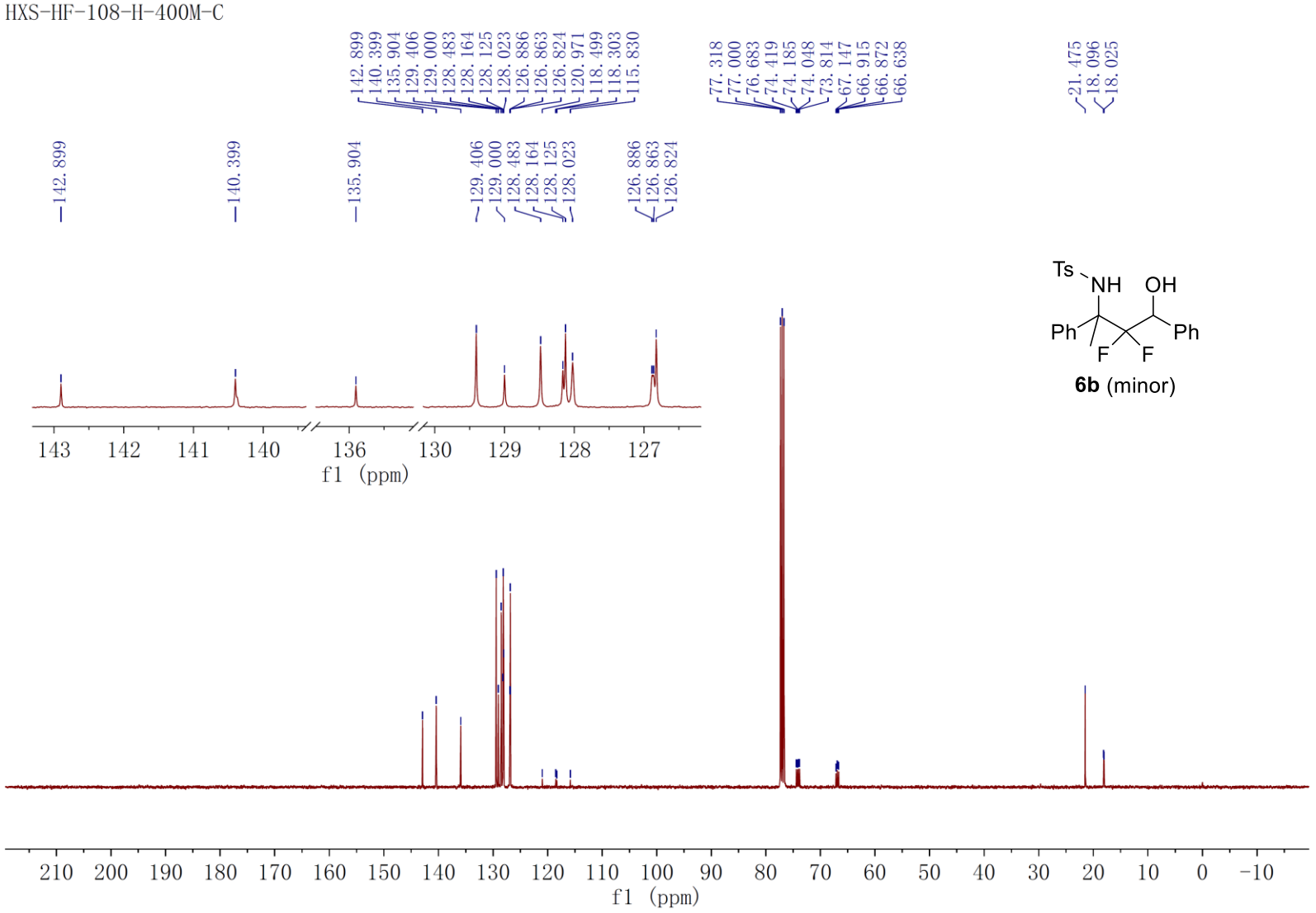
HXS-HF-108-L-300M-F



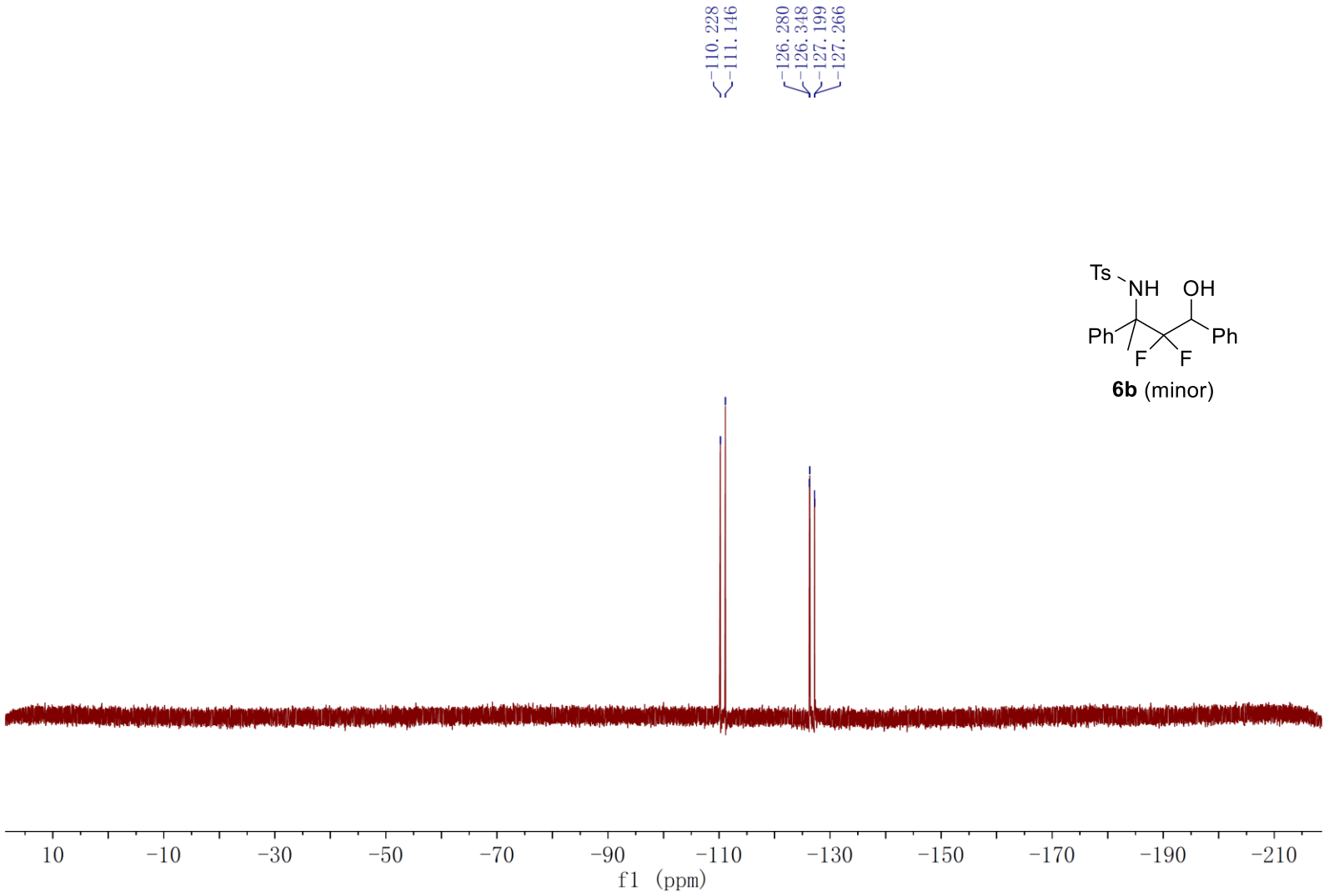
6b (major)

HXS-HF-108-H-400M-H



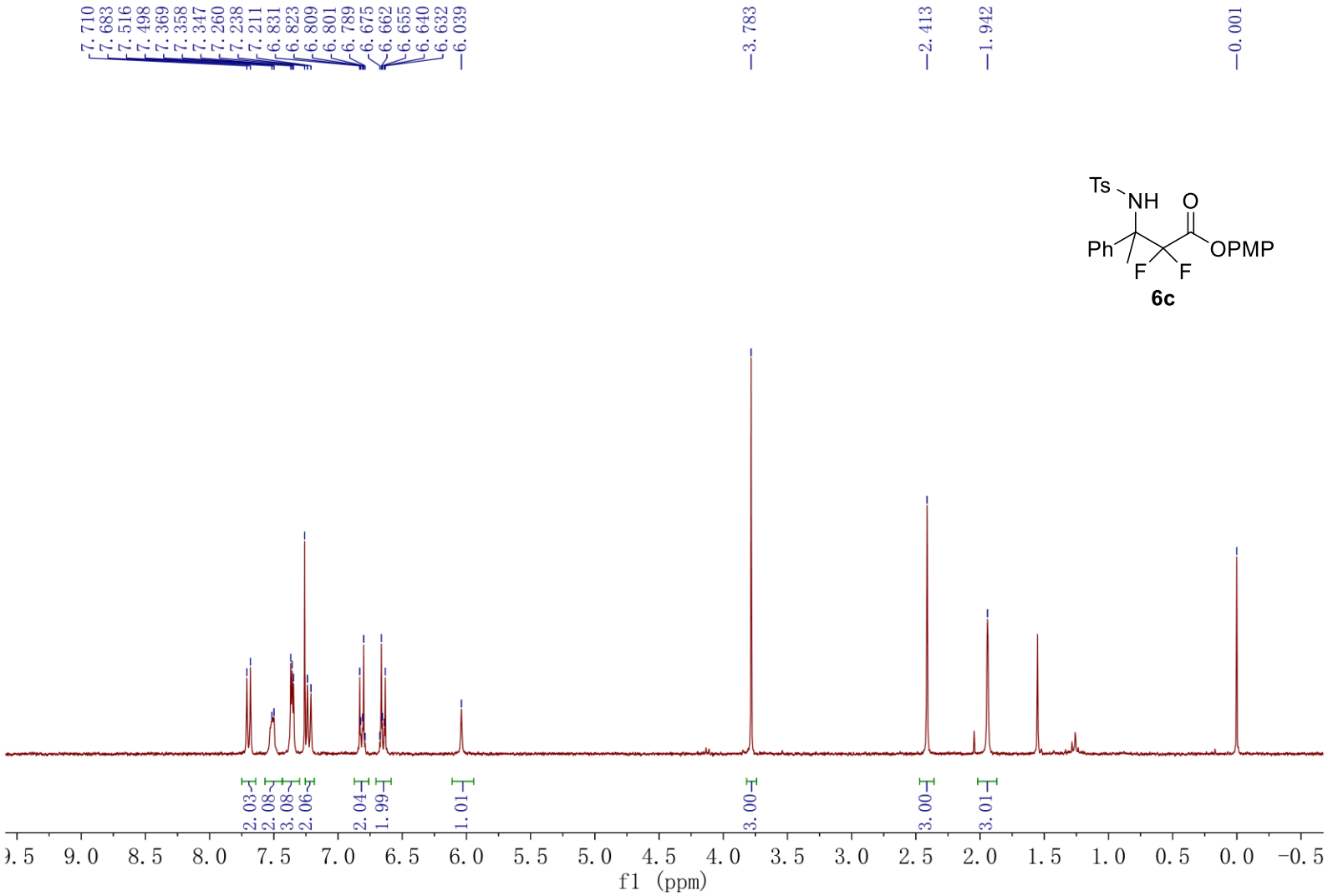

HXS-HF-108-H-400M-C
142.899
140.399
135.904
129.406
129.000
128.483
128.164
128.125
128.023
126.886
126.863
126.824
120.971
118.499
118.303
115.830
77.318
77.000
76.683
74.419
74.185
74.048
73.814
67.147
66.915
66.872
66.638
21.475
18.096
18.025
Ts
NH
OH
Ph
Ph
F
F
6b (minor)
f1 (ppm)
f1 (ppm)

HXS-HF-108-H-300M-F

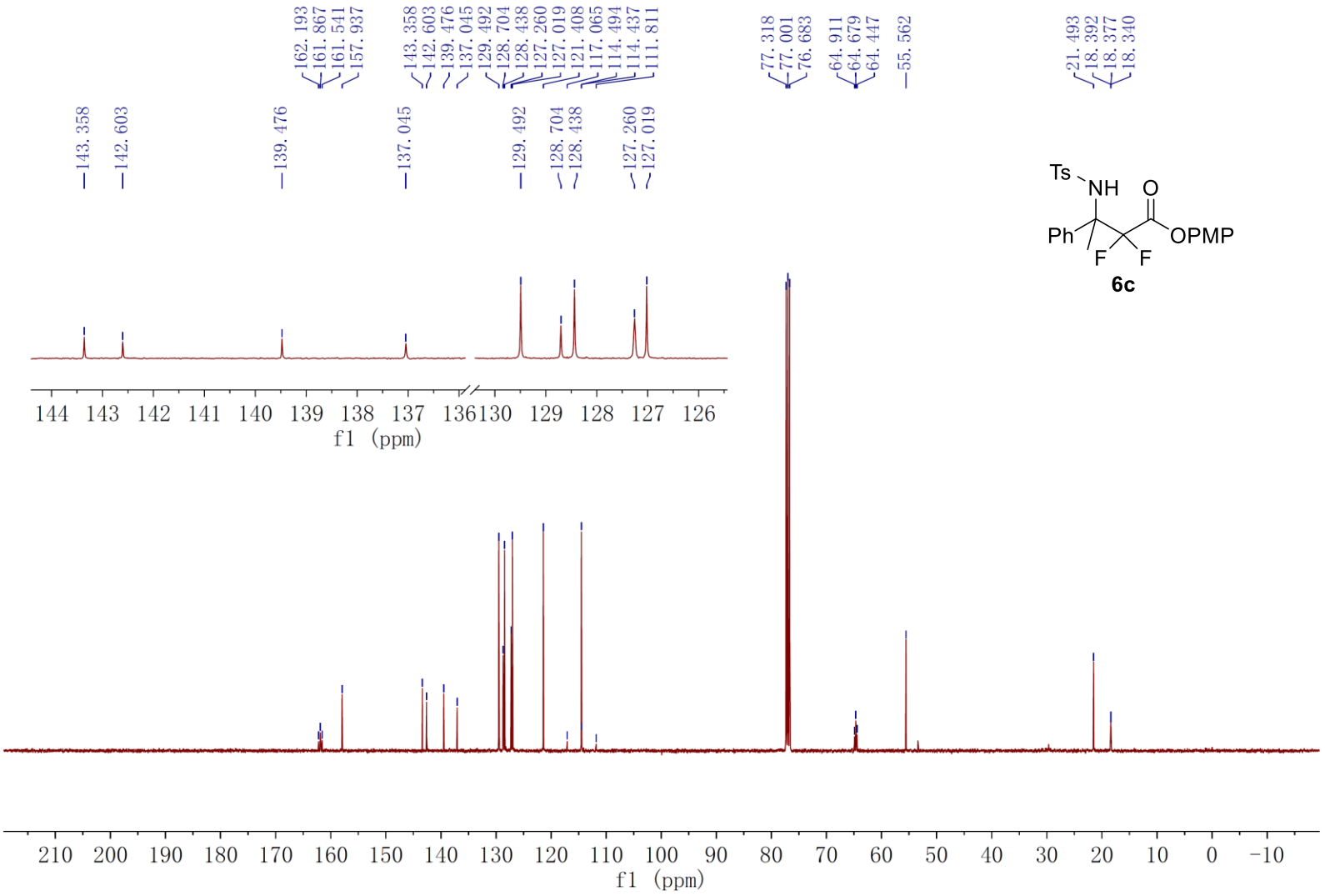


6b (minor)

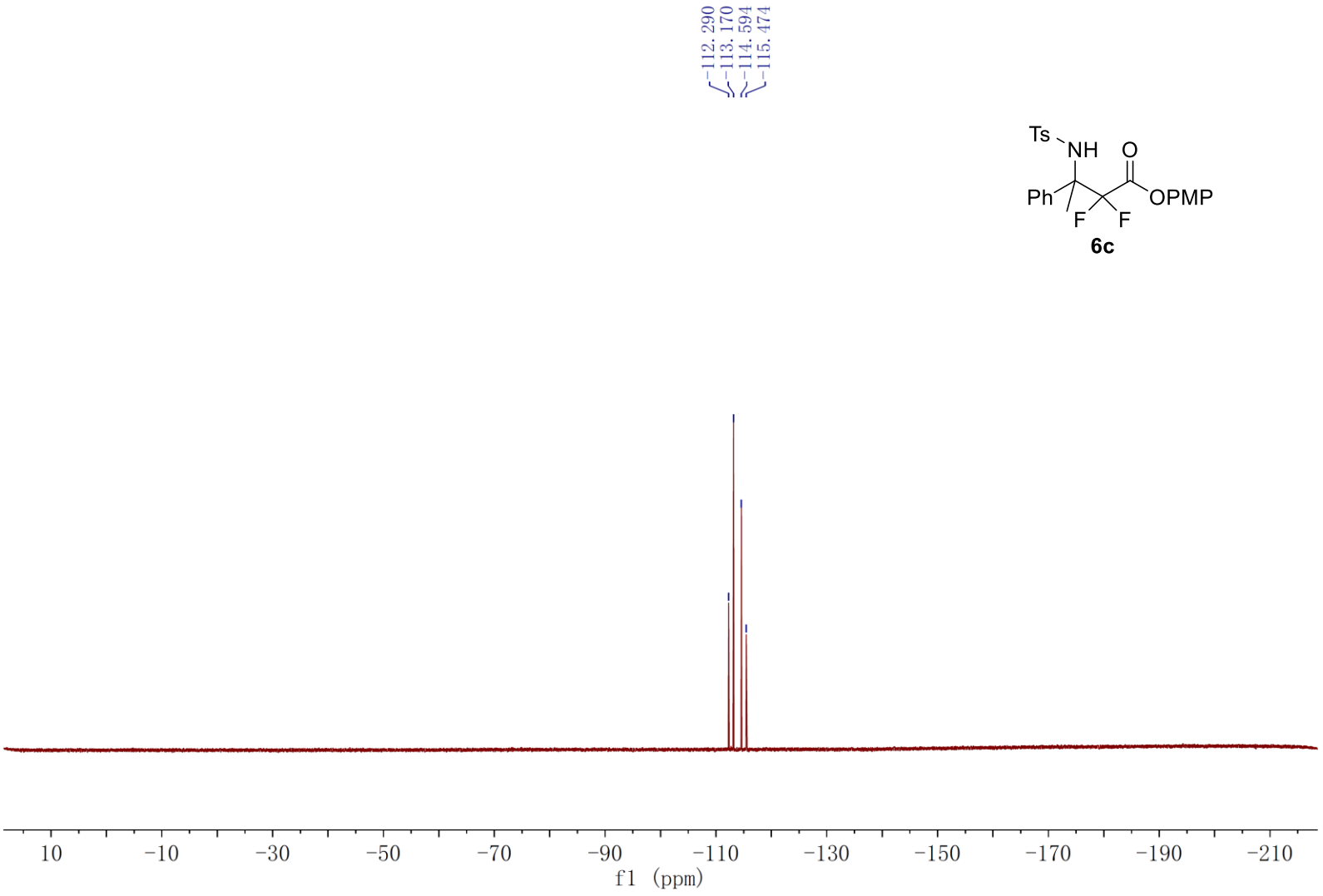
HXS-HF-122-300M-H



HXS-HF-122-400M-C

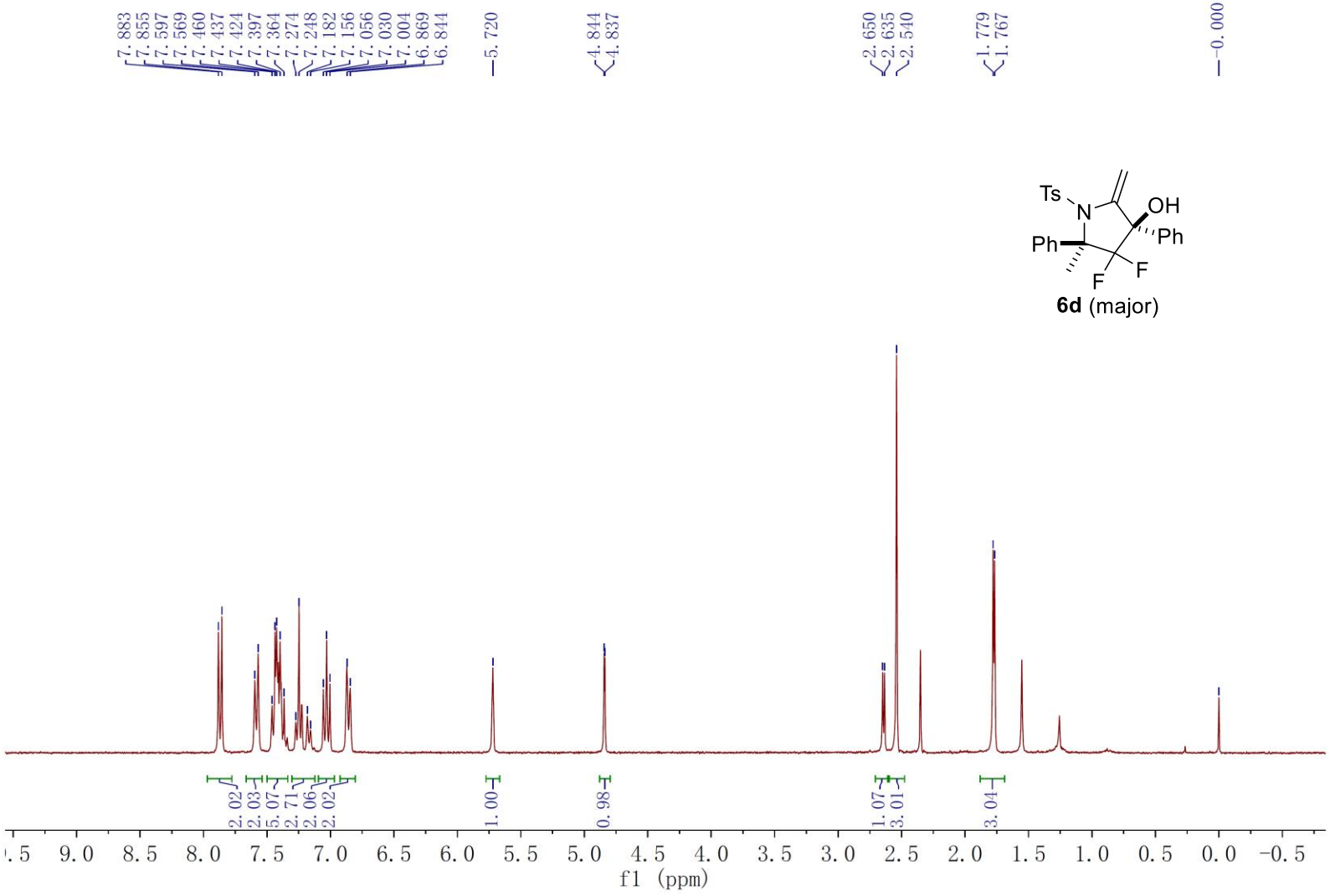


HXS-HF-122-300M-F

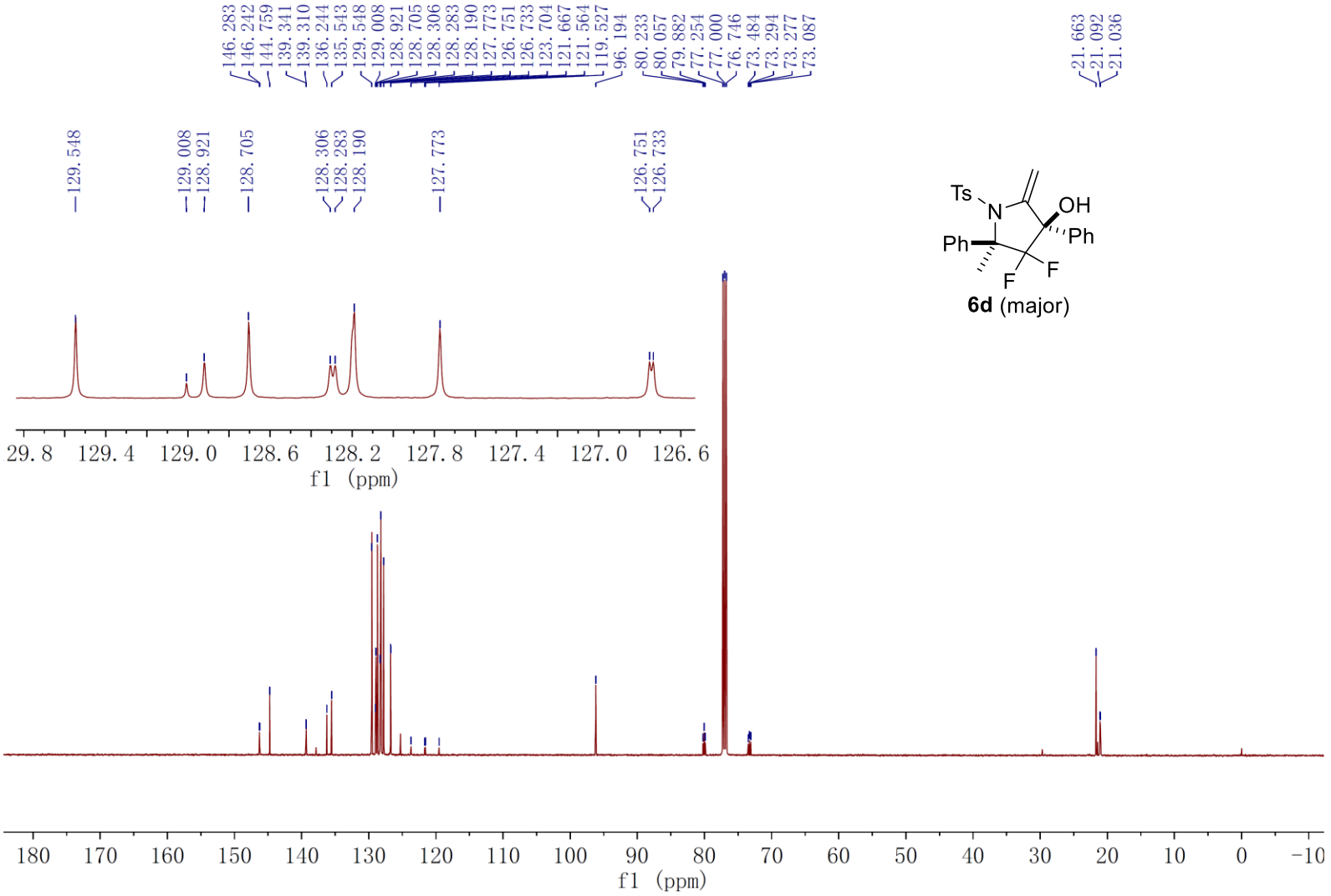


6c

HXS-HG-66-300M-H



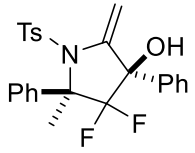
HXS-HG-66-500M-C



6d (major)

HXS-HG-66-300M-F

-110.224
-110.235
-111.024
-111.035
-119.971
-120.771



6d (major)