Supporting Information

Copper-catalyzed 1,1-arylalkylation of terminal alkynes with diazo esters and organoboronic acids

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1. General Information

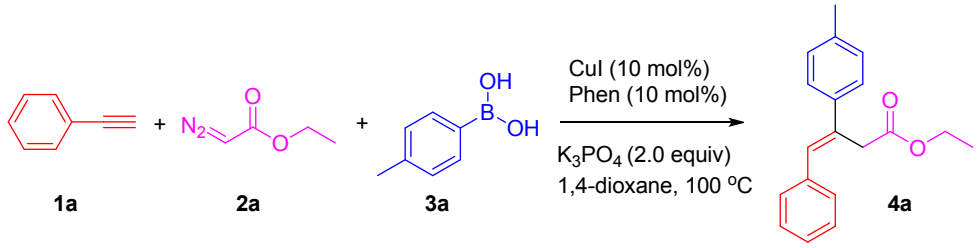
All deuterated solvents were purchased from Cambridge Isotope Laboratories. ^{1}H NMR and ^{13}C NMR spectra were recorded at 25 ºC on a Brüker Advance 400 spectrometer (^{1}H: 400 MHz and ^{13}C:100 MHz). ^{1}H NMR chemical shifts were determined relative to internal $(CH_3)_4Si$ (TMS) at δ 0.00 ppm or to the signal of the residual protonated solvent: $CDCl_3$ at δ 7.26 ppm. ^{13}C NMR chemical shifts were determined relative to the signal of the solvent: $CDCl_3$ at δ 77.00 ppm. Data for ^{1}H, ^{13}C NMR were recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet, q = quartet, dd = doublet of doublets), coupling constants (Hz) and integration. Melting points were obtained with a micro melting point XT4A Beijing Keyi electrooptic apparatus and are uncorrected. High-resolution mass data were recorded on a Waters LCT PremierxeTM (USA). Single-crystal X-ray crystallography was carried out on a Bruker Smart Apex II diffractometer system.

Materials and Methods:

Unless otherwise stated, starting materials were purchased from Aldrich or Energy-Chemical Limited and used as supplied without further purification. Solvents were used directly without further purification. The following starting materials were prepared according to the procedures described previously in the literature: **2b**,[1] **2c**,[2] **2d**,[2] **4a'**,[3] and **4a''**.[4] The 1,1-arylalkylation of alkynes were performed under a nitrogen atmosphere in flame dried flasks. All reactions were monitored by thin layer chromatography (TLC) with Taizhou GF254 silica gel coated plates. Flash column chromatography was carried out using 200-300 mesh silica gel at increased pressure.

2. General Procedure for 1,1-Arylalkylation of Terminal Alkynes

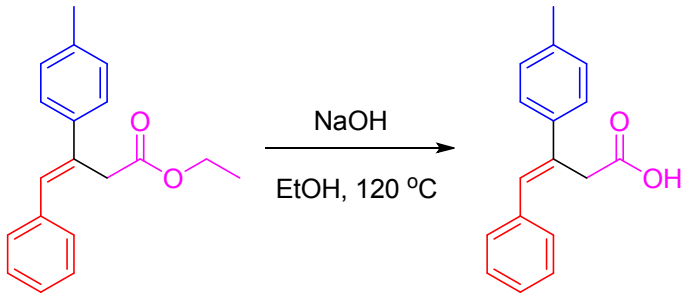
4a as an example



To a solution of the ethyl 2-diazoacetate **2a** (33 μL, 0.3 mmol) in 1,4-dioxane (1.0 mL) was added the ethynylbenzene **1a** (41 μL, 0.36 mmol), *p*-tolylboronic acid **3a** (124.9 mg, 0.9 mmol), Phen (5.4 mg, 0.03 mmol), CuI (5.7 mg, 0.03 mmol), and K_3PO_4 (130.0 mg, 0.6 mmol) under a N_2 atmosphere in a Schlenck tube. The reaction mixture was stirred at 100 °C for 1.5 h. After the reaction finished, the reaction mixture was cooled to room temperature and quenched by water. The mixture was extracted with EtOAc (3.0 mL×3), the combined organic phases were dried over anhydrous Na_2SO_4 and the solvent was evaporated under vacuum. The residue was purified by column chromatography to give the corresponding products **4a** (71.0 mg, 85%).

3. Synthetic Applications

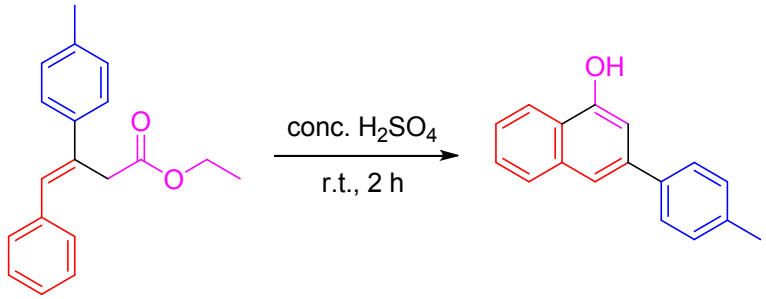
3.1 Hydrolysis of Product 4a



Compound **4a** (56.0 mg, 0.2 mmol) was taken in a Schlenck tube in EtOH (5 mL) with NaOH (0.4 g, 10 mmol). Schlenck tube was tightly closed with teflon cap and heated at 110 °C for 6 h. After completion of the reaction, the mixture was cooled to room temperature. Then 2N HCl was added to the aqueous layer until pH = 2. Next, the aqueous layer was extracted with EtOAc (2 x 20 mL). The organic layer was collected and dried over $MgSO_4$. After concentration in vacuum, the residue was purified by column chromatography to give the corresponding products **6** (45.0 mg, 89%).

3.2 Synthesis of 7

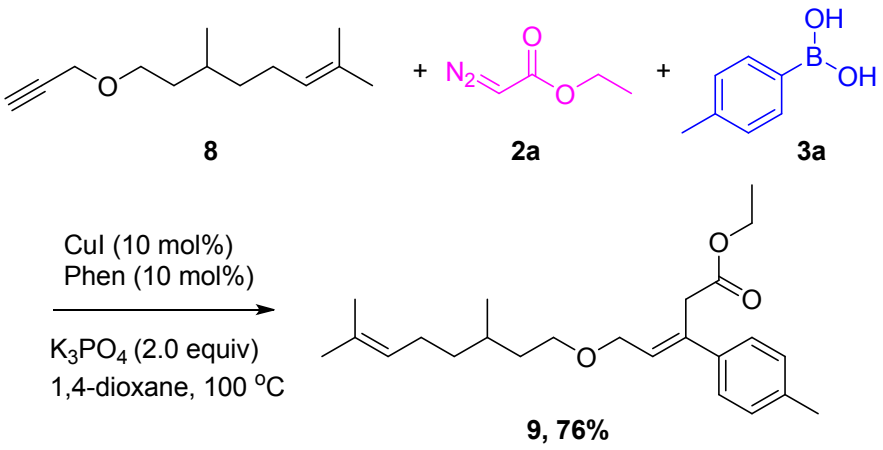
7a as an example



4a **7a, 74%**

Following the general procedure described previously in the literature,[5] (*E*)-ethyl 4-phenyl-3-(*p*-tolyl)but-3-enoate **4a** (84 mg, 0.3 mmol) was dissolved in conc. H_2SO_4 (300 mg) and stirred at room temperature for 2 h. The reaction mixture was carefully poured over cold water (2 mL). Next, the aqueous layer was extracted with EtOAc (3 x 5 mL), and the product **7a** (52 mg, 74%) was isolated by flash chromatography.

3.3 Synthesis of 9

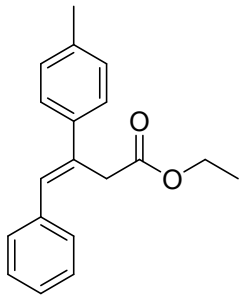


8 **2a** **3a**

9, 76%

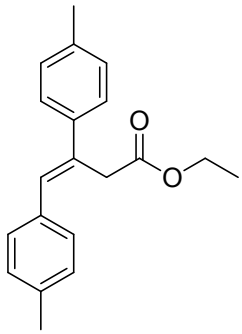
Following the abovementioned general procedure in S2, the reaction with **8** (70 mg, 0.36 mmol), **2a** (33 μL, 0.3 mmol), **3a** (124.9 mg, 0.9 mmol), Phen (5.4 mg, 0.03 mmol), CuI (5.7 mg, 0.03 mmol), and K_3PO_4 (130.0 mg, 0.6 mmol) under a N_2 atmosphere for 1.5 h at 100 °C afforded **9** as colorless oil (85 mg, 76% yield).

4. Analytical Data of Compounds 4-7 and 9



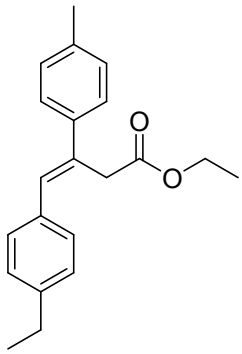
(*E*)-ethyl 4-phenyl-3-(*p*-tolyl)but-3-enoate 4a

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 2.38 (s, 3H), 3.71 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.19 (d, J = 7.6 Hz, 2H), 7.28-7.43 (m, 7H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 36.6, 60.7, 126.0, 127.0, 128.4, 128.7, 129.1, 130.4, 134.5, 137.3, 137.5, 138.7, 171.6. HRMS (ESI-TOF). Calcd for $C_{19}H_{21}O_2$, $[M+H]^+$ *m/z* 281.1542, Found 281.1537.



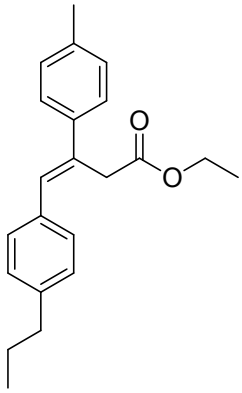
(*E*)-ethyl 3,4-di-*p*-tolylbut-3-enoate 4b

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.37 (s, 3H), 2.38 (s, 3H), 3.71 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 6.99 (s, 1H), 7.18 (d, J = 5.2 Hz, 2H), 7.20 (d, J = 5.2 Hz, 2H), 7.29 (d, J = 8.0 Hz, 2H), 7.41 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 21.2, 36.6, 60.7, 126.0, 128.6, 129.1, 129.1, 130.4, 133.8, 134.6, 136.8, 137.2, 138.9, 171.7. HRMS (ESI-TOF). Calcd for $C_{20}H_{23}O_2$, $[M+H]^+$ *m/z* 295.1698, Found 295.1688.



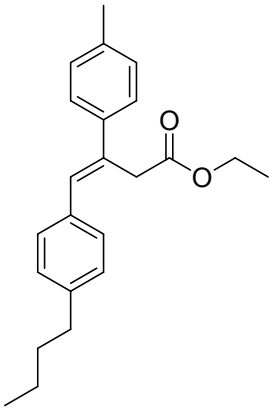
(*E*)-ethyl 4-(4-ethylphenyl)-3-(*p*-tolyl)but-3-enoate 4c

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 1.26 (t, J = 7.6 Hz, 3H), 2.37 (s, 3H), 2.67 (q, J = 7.6 Hz, 2H), 3.71 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 6.98 (s, 1H), 7.17 (d, J = 8.0 Hz, 2H), 7.21 (d, J = 8.0 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H), 7.40 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 15.5, 21.1, 28.6, 36.7, 60.7, 126.0, 127.9, 128.7, 129.1, 130.4, 133.9, 134.9, 137.2, 139.0, 143.2, 171.7. HRMS (ESI-TOF). Calcd for $C_{21}H_{24}NaO_2$, $[M+Na]^+$ *m/z* 331.1674, Found 331.1660.



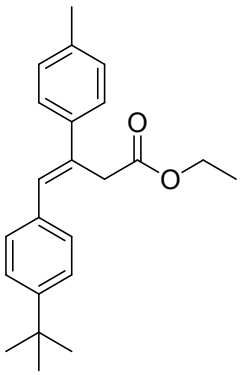
(*E*)-ethyl 4-(4-propylphenyl)-3-(*p*-tolyl)but-3-enoate 4d

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.98 (t, J = 7.2 Hz, 3H), 1.19 (t, J = 7.2 Hz, 3H), 1.65-1.70 (m, 2H), 2.37 (s, 3H), 2.62 (t, J = 7.6 Hz, 2H), 3.73 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 6.99 (s, 1H), 7.18 (d, J = 6.4 Hz, 2H), 7.20 (d, J = 6.4 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H), 7.41 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.8, 14.1, 21.1, 24.5, 36.6, 37.8, 60.7, 126.0, 128.5, 128.6, 129.1, 130.4, 133.8, 134.9, 137.2, 138.9, 141.6, 171.7. HRMS (ESI-TOF). Calcd for $C_{22}H_{27}O_2$, $[M+H]^+$ *m/z* 323.2011, Found 323.1998.



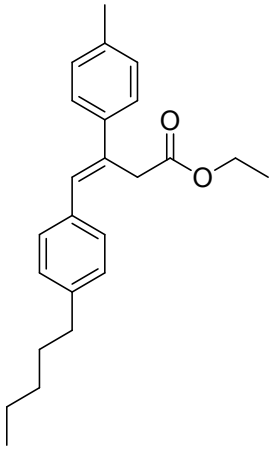
(*E*)-ethyl 4-(4-butylphenyl)-3-(*p*-tolyl)but-3-enoate 4e

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.95 (t, J = 7.2 Hz, 3H), 1.18 (t, J = 7.2 Hz, 3H), 1.34-1.43 (m, 2H), 1.58-1.66 (m, 2H), 2.37 (s, 3H), 2.63 (t, J = 7.6 Hz, 2H), 3.72 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 6.99 (s, 1H), 7.17-7.20 (m, 4H), 7.30 (d, J = 8.0 Hz, 2H), 7.40 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 14.1, 21.1, 22.4, 33.6, 35.4, 36.7, 60.7, 126.0, 128.4, 128.7, 129.1, 130.4, 133.8, 134.8, 137.2, 138.9, 141.9, 171.7. HRMS (ESI-TOF). Calcd for $C_{23}H_{29}O_2$, $[M+H]^+$ *m/z* 337.2168, Found 337.2168.



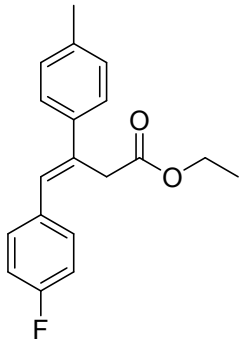
(*E*)-ethyl 4-(4-(*tert*-butyl)phenyl)-3-(*p*-tolyl)but-3-enoate 4f

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 1.35 (s, 9H), 2.37 (s, 3H), 3.73 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 6.99 (s, 1H), 7.18 (d, J = 8.0 Hz, 2H), 7.34 (d, J = 8.4 Hz, 2H), 7.39-7.42 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 31.3, 34.6, 36.7, 60.7, 125.3, 126.0, 128.5, 129.1, 130.3, 133.9, 134.6, 137.2, 138.9, 150.0, 171.7. HRMS (ESI-TOF). Calcd for $C_{23}H_{29}O_2$, $[M+H]^+$ *m/z* 337.2168, Found 337.2170.



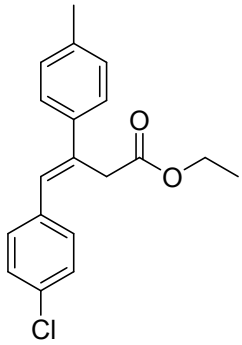
(*E*)-ethyl 4-(4-pentylphenyl)-3-(*p*-tolyl)but-3-enoate 4g

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.91 (t, J = 6.4 Hz, 3H), 1.18 (t, J = 7.2 Hz, 3H), 1.28-1.36 (m, 4H), 1.59-1.66 (m, 2H), 2.37 (s, 3H), 2.62 (t, J = 7.6 Hz, 2H), 3.72 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 6.99 (s, 1H), 7.15-7.20 (m, 4H), 7.30 (d, J = 7.6 Hz, 2H), 7.40 (d, J = 7.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 14.1, 21.1, 22.5, 31.1, 31.5, 35.7, 36.7, 60.7, 126.0, 128.4, 128.7, 129.1, 130.4, 133.8, 134.8, 137.2, 139.0, 141.9, 171.7. HRMS (ESI-TOF). Calcd for $C_{24}H_{30}NaO_2$, $[M+Na]^+$ *m/z* 373.2143, Found 373.2135.



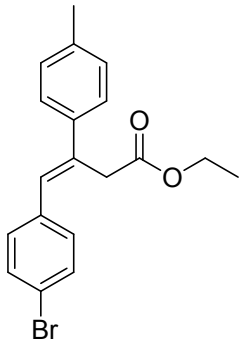
(*E*)-ethyl 4-(4-fluorophenyl)-3-(*p*-tolyl)but-3-enoate 4h

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 2.37 (s, 3H), 3.65 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 6.95 (s, 1H), 7.06 (t, J = 8.8 Hz, 2H), 7.18 (d, J = 8.0 Hz, 2H), 7.34-7.40 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 36.5, 60.8, 115.3 (d, J = 21.0 Hz), 126.0, 129.2, 129.3, 130.4 (d, J = 8.0 Hz), 133.6 (d, J = 4.0 Hz), 134.6, 137.5, 138.5, 161.9 (d, J = 245.0 Hz), 171.5. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}FO_2$, $[M+H]^+$ *m/z* 299.1447, Found 299.1438.



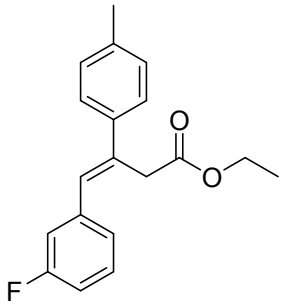
(*E*)-ethyl 4-(4-chlorophenyl)-3-(*p*-tolyl)but-3-enoate 4i

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 2.37 (s, 3H), 3.65 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 6.94 (s, 1H), 7.18 (d, J = 8.0 Hz, 2H), 7.31-7.36 (m, 4H), 7.39 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 36.6, 60.9, 126.1, 128.6, 129.1, 129.2, 130.1, 132.9, 135.2, 136.0, 137.6, 138.4, 171.4. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}ClO_2$, $[M+H]^+$ *m/z* 315.1152, Found 315.1148.



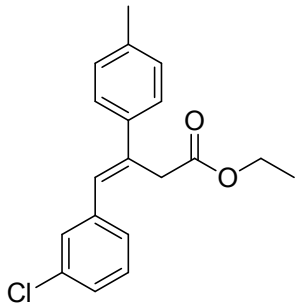
(*E*)-ethyl 4-(4-bromophenyl)-3-(*p*-tolyl)but-3-enoate 4j

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.2 Hz, 3H), 2.35 (s, 3H), 3.63 (s, 2H), 4.10 (q, J = 7.2 Hz, 2H), 6.90 (s, 1H), 7.17 (d, J = 8.0 Hz, 2H), 7.25 (d, J = 8.0 Hz, 2H), 7.37 (d, J = 8.0 Hz, 2H), 7.48 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 36.5, 60.8, 121.0, 126.0, 129.1, 129.2, 130.4, 131.5, 135.2, 136.4, 137.6, 138.3, 171.3. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}BrO_2$, $[M+H]^+$ *m/z* 359.0647, 361.0626, Found 359.0638, 361.0614.



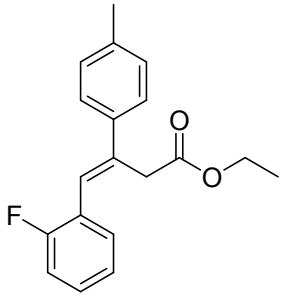
(*E*)-ethyl 4-(3-fluorophenyl)-3-(*p*-tolyl)but-3-enoate 4k

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.38 (s, 3H), 3.69 (s, 2H), 4.13 (q, J = 7.2 Hz, 2H), 6.96 (s, 1H), 6.98-7.01 (m, 1H), 7.11-7.16 (m, 2H), 7.19 (d, J = 8.0 Hz, 2H), 7.31-7.37 (m, 1H), 7.40 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 21.1, 36.6, 60.9, 113.9 (d, J = 21.0 Hz), 115.5 (d, J = 22.0 Hz), 124.5 (d, J = 3.0 Hz), 126.1, 129.1 (d, J = 2.0 Hz), 129.2, 129.8 (d, J = 8.0 Hz), 135.6, 137.7, 138.3, 139.7 (d, J = 7.0 Hz), 162.7 (d, J = 244.0 Hz), 171.3. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}FO_2$, $[M+H]^+$ *m/z* 299.1447, Found 299.1451.



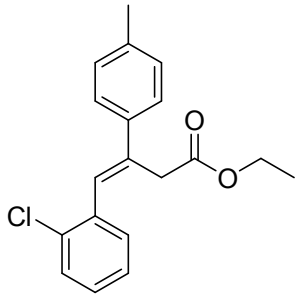
(*E*)-ethyl 4-(3-chlorophenyl)-3-(*p*-tolyl)but-3-enoate 4l

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.36 (s, 3H), 3.65 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 6.92 (s, 1H), 7.18 (d, J = 8.0 Hz, 2H), 7.24-7.32 (m, 3H), 7.37-7.39 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 36.7, 60.9, 126.1, 126.9, 127.1, 128.8, 128.9, 129.2, 129.6, 134.3, 135.8, 137.7, 138.3, 139.4, 171.2. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}ClO_2$, $[M+H]^+$ *m/z* 315.1152, Found 315.1141.



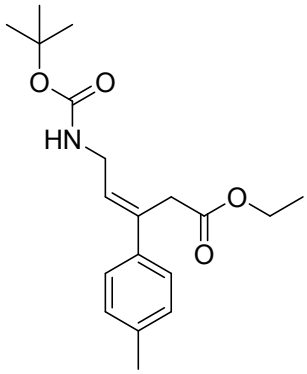
(*E*)-ethyl 4-(2-fluorophenyl)-3-(*p*-tolyl)but-3-enoate 4m

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.2 Hz, 3H), 2.37 (s, 3H), 3.65 (s, 2H), 4.09 (q, J = 7.2 Hz, 2H), 6.95 (s, 1H), 7.06-7.15 (m, 2H), 7.18 (d, J = 8.0 Hz, 2H), 7.26-7.30 (m, 1H), 7.41 (d, J = 8.0 Hz, 2H), 7.44-7.47 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 21.1, 36.8, 60.8, 115.4 (d, J = 22.0 Hz), 123.1 (d, J = 4.0 Hz), 123.9 (d, J = 4.0 Hz), 125.2 (d, J = 15.0 Hz), 126.1, 128.3, 129.0 (d, J = 8.0 Hz), 129.1, 130.3 (d, J = 3.0 Hz), 136.5, 137.9 (d, J = 65.0 Hz), 160.5 (d, J = 246.0 Hz), 171.3. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}FO_2$, $[M+H]^+$ *m/z* 299.1447, Found 299.1438.



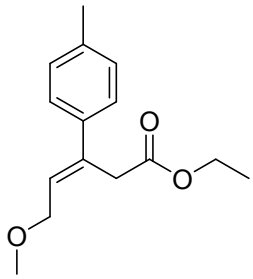
(*E*)-ethyl 4-(2-chlorophenyl)-3-(*p*-tolyl)but-3-enoate 4n

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.2 Hz, 3H), 2.37 (s, 3H), 3.60 (s, 2H), 4.09 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.19 (d, J = 8.0 Hz, 2H), 7.22-7.33 (m, 2H), 7.41-7.44 (m, 3H), 7.51 (dd, J_1 = 1.6 Hz, J_2 = 6.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 21.1, 36.7, 60.8, 126.2, 126.6, 127.6, 128.6, 129.2, 129.4, 130.3, 134.3, 135.7, 135.9, 137.7, 138.1, 171.4. HRMS (ESI-TOF). Calcd for $C_{19}H_{20}ClO_2$, $[M+H]^+$ *m/z* 315.1152, Found 315.1149.



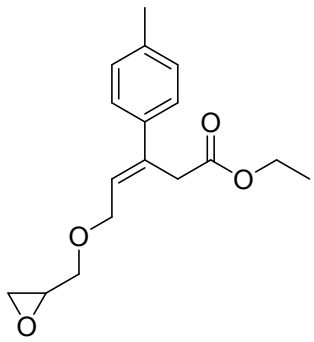
(*E*)-ethyl 5-((*tert*-butoxycarbonyl)amino)-3-(*p*-tolyl)pent-3-enoate 4o

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.22 (t, J = 7.2 Hz, 3H), 1.45 (s, 9H), 2.33 (s, 3H), 3.53 (s, 2H), 3.92 (t, J = 5.6 Hz, 2H), 4.12 (q, J = 7.2 Hz, 2H), 4.86 (s, 1H), 5.97 (t, J = 6.8 Hz, 1H), 7.12 (d, J = 8.0 Hz, 2H), 7.26 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.0, 28.4, 36.0, 38.9, 61.0, 79.3, 125.8, 127.2, 129.1, 135.3, 137.3, 138.4, 155.8, 171.1. HRMS (ESI-TOF). Calcd for $C_{19}H_{28}NO_4$, $[M+H]^+$ *m/z* 334.2018, Found 334.2032.



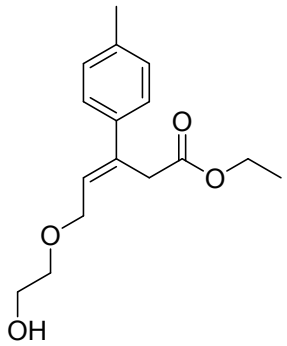
(*E*)-ethyl 5-methoxy-3-(*p*-tolyl)pent-3-enoate 4p

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.33 (s, 3H), 3.39 (s, 3H), 3.52 (s, 2H), 4.10 (q, J = 7.2 Hz, 2H), 4.16 (d, J = 6.4 Hz, 2H), 6.07 (t, J = 6.4 Hz, 1H), 7.13 (d, J = 8.0 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.0, 36.4, 58.2, 60.8, 69.4, 125.9, 127.5, 129.0, 135.4, 137.2, 138.5, 170.9. HRMS (ESI-TOF). Calcd for $C_{15}H_{20}NaO_3$, $[M+Na]^+$ *m/z* 271.1310, Found 271.1303.



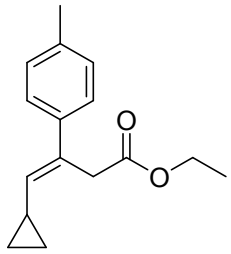
(*E*)-ethyl 5-(oxiran-2-ylmethoxy)-3-(*p*-tolyl)pent-3-enoate 4q

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.33 (s, 3H), 2.63 (dd, J_1 = 2.8 Hz, J_2 = 4.8 Hz, 1H), 2.81 (t, J = 3.6 Hz, 1H), 3.17-3.19 (m, 1H), 3.44 (dd, J_1 = 6.0 Hz, J_2 = 11.2 Hz, 1H), 3.53 (s, 2H), 3.79 (dd, J_1 = 2.8 Hz, J_2 = 11.2 Hz, 1H), 4.10 (q, J = 7.2 Hz, 2H), 4.27-4.30 (m, 2H), 6.08 (t, J = 6.4 Hz, 1H), 7.13 (d, J = 8.0 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.0, 36.4, 44.2, 50.8, 60.8, 68.1, 70.9, 125.9, 127.1, 129.0, 135.7, 137.3, 138.4, 170.8. HRMS (ESI-TOF). Calcd for $C_{17}H_{22}NaO_4$, $[M+Na]^+$ *m/z* 313.1416, Found 313.1418.



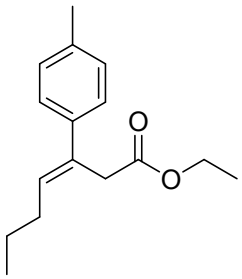
(*E*)-ethyl 5-(2-hydroxyethoxy)-3-(*p*-tolyl)pent-3-enoate 4r

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.27 (s, 1H), 2.34 (s, 3H), 3.53 (s, 2H), 3.62 (t, J = 4.4 Hz, 2H), 3.76 (t, J = 4.4 Hz, 2H), 4.10 (q, J = 7.2 Hz, 2H), 4.26 (d, J = 6.4 Hz, 2H), 6.09 (t, J = 6.4 Hz, 1H), 7.13 (d, J = 8.0 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.1, 36.5, 60.9, 61.9, 68.0, 71.6, 125.9, 127.1, 129.1, 136.0, 137.4, 138.4, 171.0. HRMS (ESI-TOF). Calcd for $C_{16}H_{23}O_4$, $[M+H]^+$ *m/z* 279.1596, Found 279.1589.



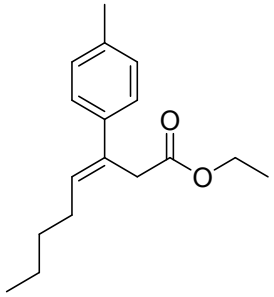
(*E*)-ethyl 4-cyclopropyl-3-(*p*-tolyl)but-3-enoate 4s

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.48-0.51 (m, 2H), 0.85-0.87 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H), 1.60-1.67 (m, 1H), 2.32 (s, 3H), 3.62 (s, 2H), 4.13 (q, *J* = 7.2 Hz, 2H), 5.32 (d, *J* = 9.6 Hz, 1H), 7.10 (d, *J* = 8.0 Hz, 2H), 7.25 (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 7.5, 11.3, 14.1, 21.0, 36.4, 60.6, 125.4, 128.9, 130.7, 135.7, 136.2, 139.2, 171.7. HRMS (ESI-TOF). Calcd for $C_{16}H_{21}O_2$, $[M+H]^+$ *m/z* 245.1542, Found 245.1538.



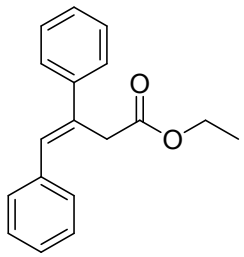
(*E*)-ethyl 3-(*p*-tolyl)hept-3-enoate 4t

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.96 (t, J = 7.2 Hz, 3H), 1.19 (t, *J* = 7.2 Hz, 3H), 1.47-1.52 (m, 2H), 2.19 (q, *J* = 7.2 Hz, 2H), 2.32 (s, 3H), 3.49 (s, 2H), 4.09 (q, *J* = 7.2 Hz, 2H), 5.91 (t, *J* = 7.2 Hz, 1H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.27 (d, *J* = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.9, 14.1, 21.0, 22.7, 31.0, 36.1, 60.6, 125.8, 128.9, 131.8, 132.3, 136.4, 139.6, 171.5. HRMS (ESI-TOF). Calcd for $C_{16}H_{23}O_2$, $[M+H]^+$ *m/z* 247.1698, Found 247.1690.



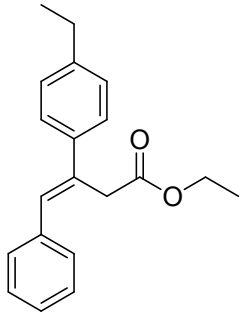
(*E*)-ethyl 3-(*p*-tolyl)oct-3-enoate 4u

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.92 (t, J = 7.2 Hz, 3H), 1.18 (t, J = 7.2 Hz, 3H), 1.35-1.47 (m, 4H), 2.21 (q, J = 7.2 Hz, 2H), 2.32 (s, 3H), 3.49 (s, 2H), 4.09 (q, J = 7.2 Hz, 2H), 5.91 (t, J = 7.2 Hz, 1H), 7.11 (d, J = 8.0 Hz, 2H), 7.26 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 14.1, 21.0, 22.4, 28.7, 31.6, 36.0, 60.6, 125.8, 128.9, 132.0, 132.0, 136.4, 139.5, 171.6. HRMS (ESI-TOF). Calcd for $C_{17}H_{25}O_2$, $[M+H]^+$ *m/z* 261.1855, Found 261.1846.



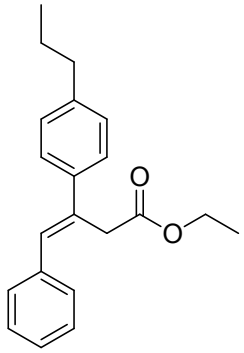
(*E*)-ethyl 3-(4-ethylphenyl)-4-phenylbut-3-enoate 5a

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 3.72 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 7.04 (s, 1H), 7.28-7.40 (m, 8H), 7.51-7.53 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 36.7, 60.7, 126.3, 127.2, 127.5, 128.4, 128.4, 128.7, 131.2, 134.7, 137.4, 141.7, 171.5. HRMS (ESI-TOF). Calcd for $C_{18}H_{19}O_2$, $[M+H]^+$ *m/z* 267.1385, Found 267.1378.



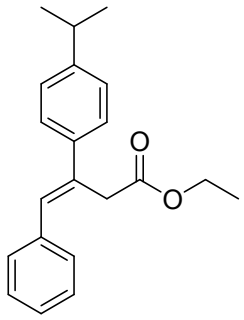
(*E*)-ethyl 3-(4-ethylphenyl)-4-phenylbut-3-enoate 5b

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 1.26 (t, J = 7.6 Hz, 3H), 2.67 (q, J = 7.6 Hz, 2H), 3.70 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.20 (d, J = 8.4 Hz, 2H), 7.27-7.39 (m, 5H), 7.43 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 15.5, 28.5, 36.7, 60.7, 126.1, 127.1, 127.9, 128.4, 128.7, 130.5, 134.5, 137.6, 139.0, 143.7, 171.6. HRMS (ESI-TOF). Calcd for $C_{20}H_{23}O_2$, $[M+H]^+$ *m/z* 295.1698, Found 295.1701.



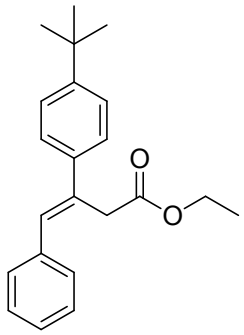
(*E*)-ethyl 4-phenyl-3-(4-propylphenyl)but-3-enoate 5c

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.96 (t, J = 7.2 Hz, 3H), 1.16 (t, J = 7.2 Hz, 3H), 1.63-1.69 (m, 2H), 2.60 (t, J = 7.6 Hz, 2H), 3.70 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 7.03 (s, 1H), 7.18 (d, J = 8.0 Hz, 2H), 7.27-7.39 (m, 5H), 7.42 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.8, 14.1, 24.5, 36.6, 37.7, 60.7, 126.0, 127.0, 128.4, 128.5, 128.7, 130.4, 134.5, 137.6, 139.0, 142.2, 171.6. HRMS (ESI-TOF). Calcd for $C_{21}H_{25}O_2$, $[M+H]^+$ *m/z* 309.1855, Found 309.1847.



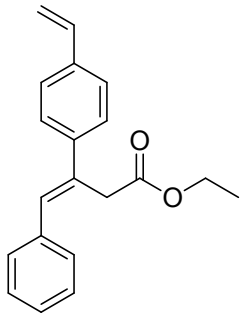
(*E*)-ethyl 3-(4-isopropylphenyl)-4-phenylbut-3-enoate 5d

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.15 (t, J = 7.2 Hz, 3H), 1.26 (d, J = 7.2 Hz, 6H), 2.85-2.95 (m, 1H), 3.69 (s, 2H), 4.10 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.22 (d, J = 8.4 Hz, 2H), 7.25-7.38 (m, 5H), 7.43 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.0, 23.9, 33.7, 36.6, 60.7, 126.1, 126.5, 127.0, 128.3, 128.7, 130.4, 134.4, 137.5, 139.0, 148.3, 171.6. HRMS (ESI-TOF). Calcd for $C_{21}H_{25}O_2$, $[M+H]^+$ *m/z* 309.1855, Found 309.1846.



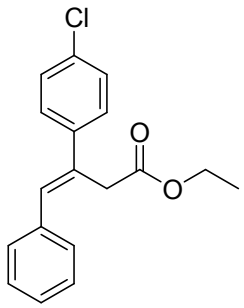
(*E*)-ethyl 3-(4-(*tert*-butyl)phenyl)-4-phenylbut-3-enoate 5e

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 1.34 (s, 9H), 3.70 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 7.04 (s, 1H), 7.27-7.40 (m, 7H), 7.45 (d, J = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 31.3, 34.5, 36.6, 60.7, 125.4, 125.8, 127.1, 128.4, 128.8, 130.5, 134.4, 137.6, 138.7, 150.6, 171.6. HRMS (ESI-TOF). Calcd for $C_{22}H_{27}O_2$, $[M+H]^+$ *m/z* 323.2011, Found 323.1996.



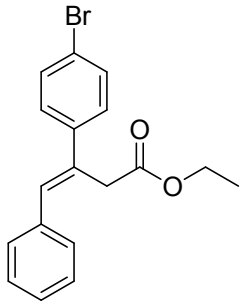
(*E*)-ethyl 4-phenyl-3-(4-vinylphenyl)but-3-enoate 5f

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 3.72 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 5.27 (d, J = 10.8 Hz, 1H), 5.78 (d, J = 17.6 Hz, 1H), 6.74 (dd, J_1 = 10.8 Hz, J_2 = 17.6 Hz, 1H), 7.07 (s, 1H), 7.29-7.32 (m, 1H), 7.37-7.43 (m, 6H), 7.48 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.5, 60.8, 113.8, 126.3, 127.2, 128.4, 128.8, 131.0, 134.2, 136.4, 136.9, 137.4, 141.0, 171.5. HRMS (ESI-TOF). Calcd for $C_{20}H_{21}O_2$, $[M+H]^+$ *m/z* 293.1542, Found 293.1530.



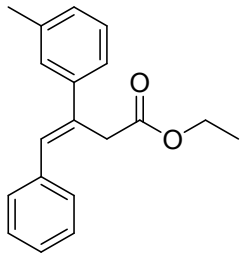
(*E*)-ethyl 3-(4-chlorophenyl)-4-phenylbut-3-enoate 5g

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 3.68 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 7.00 (s, 1H), 7.30-7.39 (m, 7H), 7.43 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.6, 60.9, 127.4, 127.6, 128.5, 128.6, 128.7, 131.7, 133.4, 133.6, 137.1, 140.2, 171.3. HRMS (ESI-TOF). Calcd for $C_{18}H_{18}ClO_2$, $[M+H]^+$ *m/z* 301.0995, Found 301.0992.



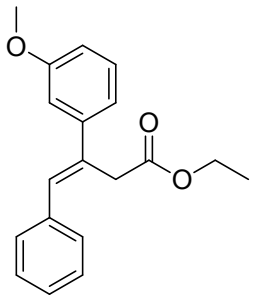
(*E*)-ethyl 3-(4-bromophenyl)-4-phenylbut-3-enoate 5h

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 3.68 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 7.01 (s, 1H), 7.29-7.41 (m, 7H), 7.50 (d, J = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.5, 60.9, 121.5, 127.4, 127.9, 128.4, 128.7, 131.5, 131.7, 133.6, 137.0, 140.6, 171.2. HRMS (ESI-TOF). Calcd for $C_{18}H_{18}BrO_2$, $[M+H]^+$ *m/z* 345.0490, 347.0470, Found 345.0486, 347.0462.



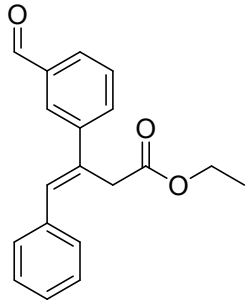
(*E*)-ethyl 4-phenyl-3-(*m*-tolyl)but-3-enoate 5i

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 2.39 (s, 3H), 3.70 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.12 (d, J = 7.2 Hz, 1H), 7.24-7.32 (m, 4H), 7.38 (d, J = 4.0 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.5, 36.7, 60.7, 123.3, 127.0, 127.1, 128.3, 128.3, 128.4, 128.7, 131.0, 134.8, 137.5, 138.0, 141.7, 171.6. HRMS (ESI-TOF). Calcd for $C_{19}H_{21}O_2$, $[M+H]^+$ *m/z* 281.1542, Found 281.1540.



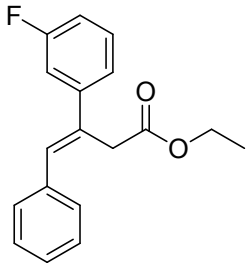
(*E*)-ethyl 3-(3-methoxyphenyl)-4-phenylbut-3-enoate 5j

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 3.69 (s, 2H), 3.84 (s, 3H), 4.11 (q, J = 7.2 Hz, 2H), 6.84-6.87 (m, 1H), 7.04-7.10 (m, 3H), 7.26-7.31 (m, 2H), 7.38 (d, J = 4.4 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.8, 55.3, 60.8, 112.1, 113.0, 118.7, 127.2, 128.4, 128.7, 129.4, 131.3, 134.6, 137.3, 143.3, 159.7, 171.5. HRMS (ESI-TOF). Calcd for $C_{19}H_{21}O_3$, $[M+H]^+$ *m/z* 297.1491, Found 297.1490.



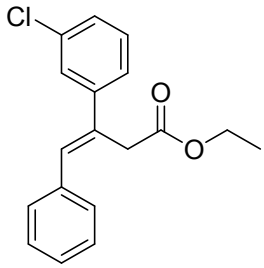
(*E*)-ethyl 3-(3-formylphenyl)-4-phenylbut-3-enoate 5k

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.2 Hz, 3H), 3.74 (s, 2H), 4.11 (q, J = 7.2 Hz, 2H), 7.09 (s, 1H), 7.30-7.40 (m, 5H), 7.55 (t, J = 7.6 Hz, 1H), 7.77 (d, J = 8.0 Hz, 1H), 7.82 (d, J = 7.2 Hz, 1H), 8.01 (s, 1H), 10.06 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.6, 60.9, 127.5, 127.6, 128.5, 128.7, 128.8, 129.2, 132.3, 132.7, 133.6, 136.6, 136.9, 142.8, 171.1, 192.2. HRMS (ESI-TOF). Calcd for $C_{19}H_{19}O_3$, $[M+H]^+$ *m/z* 295.1334, Found 295.1326.



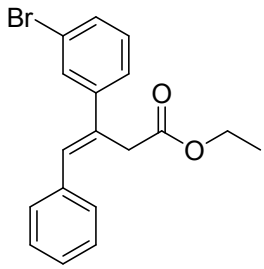
(*E*)-ethyl 3-(3-fluorophenyl)-4-phenylbut-3-enoate 5l

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17 (t, J = 7.2 Hz, 3H), 3.68 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 6.97-7.02 (m, 1H), 7.04 (s, 1H), 7.19-7.22 (m, 1H), 7.28-7.39 (m, 7H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.6, 60.9, 113.3 (d, J = 22.0 Hz), 114.4 (d, J = 21.0 Hz), 121.9 (d, J = 3.0 Hz), 127.5, 128.5, 128.8, 129.9 (d, J = 8.0 Hz), 132.1, 133.7 (d, J = 2.0 Hz), 137.0, 144.1 (d, J = 7.0 Hz), 163.0 (d, J = 244.0 Hz), 171.2. HRMS (ESI-TOF). Calcd for $C_{18}H_{18}FO_2$, $[M+H]^+$ *m/z* 285.1291, Found 285.1295.



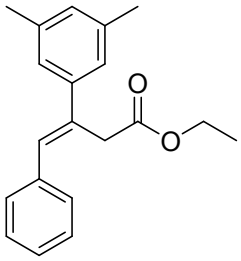
(*E*)-ethyl 3-(3-chlorophenyl)-4-phenylbut-3-enoate 5m

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 3.68 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.27-7.41 (m, 8H), 7.49 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.6, 60.9, 124.4, 126.5, 127.5, 127.6, 128.5, 128.7, 129.7, 132.3, 133.5, 134.4, 136.9, 143.6, 171.2. HRMS (ESI-TOF). Calcd for $C_{18}H_{18}ClO_2$, $[M+H]^+$ *m/z* 301.0995, Found 301.0992.



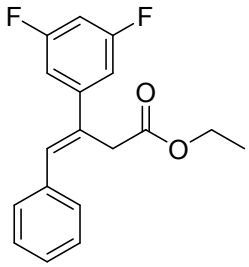
(*E*)-ethyl 3-(3-bromophenyl)-4-phenylbut-3-enoate 5n

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.18 (t, J = 7.2 Hz, 3H), 3.67 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 7.01 (s, 1H), 7.22-7.32 (m, 2H), 7.36-7.44 (m, 6H), 7.65 (t, J = 1.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.6, 60.9, 122.6, 124.9, 127.5, 128.5, 128.7, 129.5, 129.9, 130.5, 132.4, 133.5, 136.9, 144.0, 171.1. HRMS (ESI-TOF). Calcd for $C_{18}H_{18}BrO_2$, $[M+H]^+$ *m/z* 345.0490, 347.0470, Found 345.0479, 347.0460.



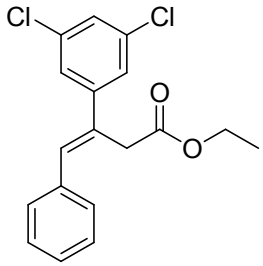
(*E*)-ethyl 3-(3,5-dimethylphenyl)-4-phenylbut-3-enoate 5o

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.35 (s, 6H), 3.70 (s, 2H), 4.13 (q, J = 7.2 Hz, 2H), 6.96 (s, 1H), 7.02 (s, 1H), 7.13 (s, 2H), 7.28-7.31 (s, 1H), 7.39 (d, J = 4.4 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 21.4, 36.7, 60.7, 124.1, 127.0, 128.4, 128.7, 129.3, 130.8, 134.8, 137.6, 137.8, 141.7, 171.6. HRMS (ESI-TOF). Calcd for $C_{20}H_{23}O_2$, $[M+H]^+$ *m/z* 295.1698, Found 295.1692.



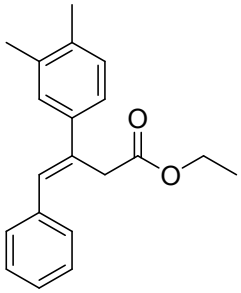
(*E*)-ethyl 3-(3,5-difluorophenyl)-4-phenylbut-3-enoate 5p

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.20 (t, J = 7.2 Hz, 3H), 3.65 (s, 2H), 4.14 (q, J = 7.2 Hz, 2H), 6.73-6.77 (s, 1H), 7.01-7.06 (s, 3H), 7.30-7.42 (s, 5H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.5, 61.0, 102.8 (t, J = 26.0 Hz), 109.2 (dd, J_1 = 8.0 Hz, J_2 = 19.0 Hz), 127.7, 128.5, 128.7, 132.8 (t, J = 3.0 Hz), 133.0, 136.6, 145.3 (t, J = 10.0 Hz), 163.1 (dd, J_1 = 13.0 Hz, J_2 = 246.0 Hz), 171.0. HRMS (ESI-TOF). Calcd for $C_{18}H_{17}F_2O_2$, $[M+H]^+$ *m/z* 303.1197, Found 303.1191.



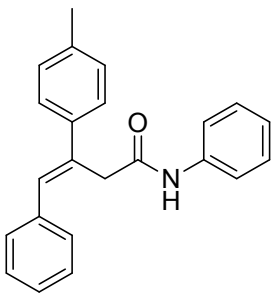
(*E*)-ethyl 3-(3,5-dichlorophenyl)-4-phenylbut-3-enoate 5q

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.20 (t, J = 7.2 Hz, 3H), 3.64 (s, 2H), 4.14 (q, J = 7.2 Hz, 2H), 7.02 (s, 1H), 7.29-7.41 (s, 8H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 36.5, 61.0, 124.9, 127.4, 127.7, 128.5, 128.7, 132.5, 133.3, 135.0, 136.5, 144.9, 170.9. HRMS (ESI-TOF). Calcd for $C_{18}H_{17}Cl_2O_2$, $[M+H]^+$ *m/z* 335.0606, Found 335.0601.



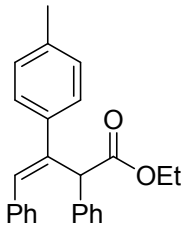
(*E*)-ethyl 3-(3,4-dimethylphenyl)-4-phenylbut-3-enoate 5r

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19 (t, J = 7.2 Hz, 3H), 2.28 (s, 3H), 2.30 (s, 3H), 3.69 (s, 2H), 4.12 (q, J = 7.2 Hz, 2H), 7.00 (s, 1H), 7.13 (d, J = 8.0 Hz, 1H), 7.22-7.29 (s, 3H), 7.38 (d, J = 4.8 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 19.4, 19.9, 36.6, 60.7, 123.6, 127.0, 127.5, 128.4, 128.7, 129.7, 130.3, 134.6, 136.1, 136.5, 137.6, 139.3, 171.6. HRMS (ESI-TOF). Calcd for $C_{20}H_{23}O_2$, $[M+H]^+$ *m/z* 295.1698, Found 295.1692.



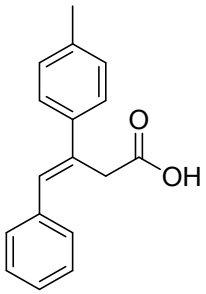
(*E*)-*N*,4-diphenyl-3-(*p*-tolyl)but-3-enamide 5s

White solid. mp: 178-179 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.38 (s, 3H), 3.83 (s, 2H), 7.07 (t, J = 7.2 Hz, 1H), 7.17 (s, 1H), 7.23 (d, J = 8.4 Hz, 2H), 7.28-7.42 (m, 10H), 7.49 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.1, 40.0, 119.8, 124.4, 126.0, 127.6, 128.7, 128.8, 128.9, 129.7, 131.7, 134.6, 136.8, 137.6, 138.2, 138.4, 168.5. HRMS (ESI-TOF). Calcd for $C_{23}H_{22}NO$, $[M+H]^+$ *m/z* 328.1701, Found 328.1697.



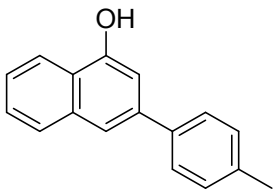
(*E*)-ethyl 2,4-diphenyl-3-(*p*-tolyl)but-3-enoate 5t

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.06 (t, J = 7.2 Hz, 3H), 2.31 (s, 3H), 4.03-4.09 (m, 2H), 5.35 (s, 1H), 7.01-7.06 (s, 3H), 7.20-7.36 (m, 12H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.9, 21.1, 52.5, 60.9, 126.9, 127.2, 128.0, 128.1, 128.4, 128.5, 128.7, 129.3, 132.0, 137.0, 137.1, 137.2, 138.1, 138.7, 172.2. HRMS (ESI-TOF). Calcd for $C_{25}H_{25}O_2$, $[M+H]^+$ *m/z* 357.1855, Found 357.1846.



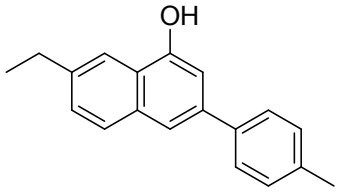
(*E*)-4-phenyl-3-(*p*-tolyl)but-3-enoic acid 6

White solid. mp: 154-155 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.39 (s, 3H), 3.75 (s, 2H), 7.06 (s, 1H), 7.20 (d, J = 8.0 Hz, 2H), 7.30-7.43 (m, 7H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.1, 36.1, 126.0, 127.2, 128.5, 128.7, 129.3, 131.0, 133.5, 137.3, 137.6, 138.3, 177.9. HRMS (ESI-TOF). Calcd for $C_{17}H_{17}O_2$, $[M+H]^+$ *m/z* 253.1229, Found 253.1225.



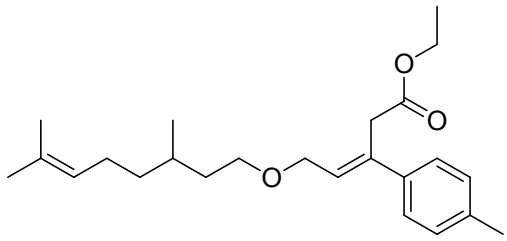
3-(*p*-tolyl)naphthalen-1-ol 7a

White solid. mp: 150-151 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.44 (s, 3H), 5.54 (s, 1H), 7.07 (s, 1H), 7.29 (d, J = 7.6 Hz, 2H), 7.48-7.60 (m, 4H), 7.67 (s, 1H), 7.88 (d, J = 7.6 Hz, 1H), 7.21 (d, J = 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.1, 108.3, 118.4, 121.4, 123.4, 125.2, 126.8, 127.1, 127.9, 129.5, 135.0, 137.2, 137.9, 138.8, 151.6. HRMS (ESI-TOF). Calcd for $C_{17}H_{15}O$, $[M+H]^+$ *m/z* 235.1123, Found 235.1115.



7-ethyl-3-(*p*-tolyl)naphthalen-1-ol 7b

White solid. mp: 132-134 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.32 (t, J = 7.6 Hz, 3H), 2.39 (s, 3H), 2.81 (q, J = 7.6 Hz, 2H), 5.42 (s, 1H), 7.00 (s, 1H), 7.23 (d, J = 7.6 Hz, 2H), 7.35 (d, J = 8.0 Hz, 1H), 7.53 (d, J = 8.0 Hz, 2H), 7.58 (s, 1H), 7.75 (d, J = 8.4 Hz, 1H), 7.93 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 15.6, 21.1, 29.2, 108.4, 118.2, 119.0, 123.5, 127.0, 128.0, 128.0, 129.5, 133.5, 137.0, 137.8, 138.1, 141.3, 151.3. HRMS (ESI-TOF). Calcd for $C_{19}H_{19}O$, $[M+H]^+$ *m/z* 263.1436, Found 263.1428.

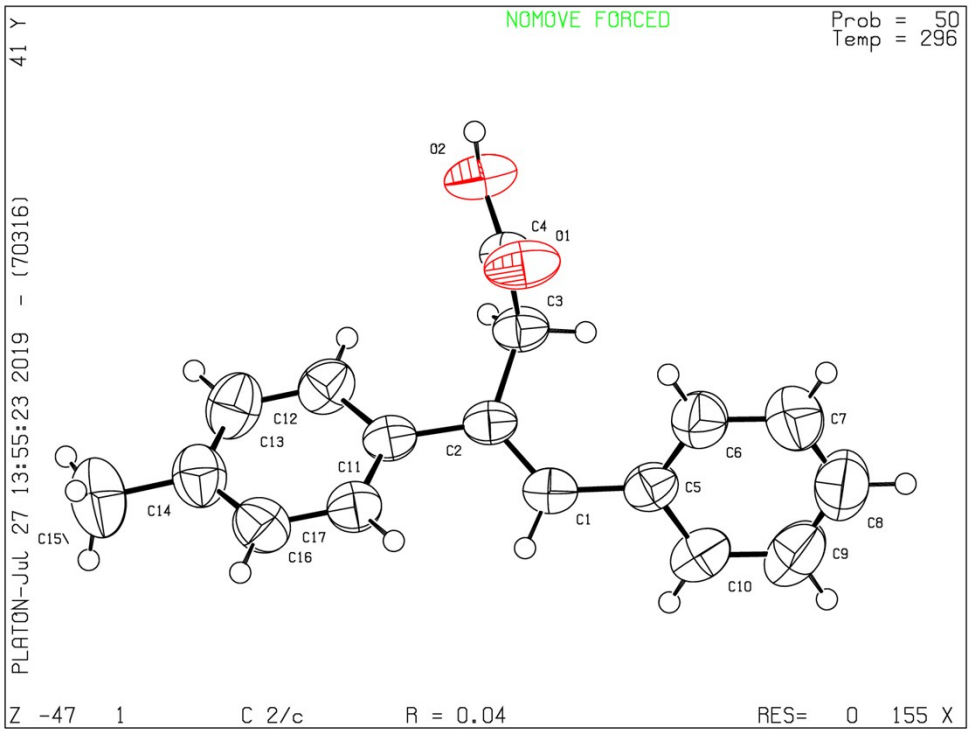


(*E*)-ethyl 5-((3,7-dimethyloct-6-en-1-yl)oxy)-3-(*p*-tolyl)pent-3-enoate 9

Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.91 (d, J = 6.4 Hz, 3H), 1.19 (t, J = 7.2 Hz, 3H), 1.35-1.44 (m, 3H), 1.56-1.68 (m, 8H), 1.95-2.03 (m, 2H), 2.33 (s, 3H), 3.49-3.53 (m, 4H), 4.10 (q, J = 7.2 Hz, 2H), 4.20 (d, J = 6.4 Hz, 2H), 5.10 (t, J = 6.4 Hz, 1H), 6.09 (t, J = 6.4 Hz, 1H), 7.13 (d,

J = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1, 17.6, 19.5, 21.0, 25.5, 25.7, 29.6, 36.4, 36.7, 37.2, 60.8, 67.8, 69.0, 124.8, 125.9, 128.0, 129.0, 131.1, 134.9, 137.1, 138.6, 171.0. HRMS (ESI-TOF). Calcd for $C_{24}H_{37}O_3$, $[M+H]^+$ *m/z* 373.2743, Found 373.2739.

5. Structure Analysis X-Ray Crystallography of 6



Compound	**6**
Empirical formula	$C_{17}H_{16}O_2$
Formula weight	252.30
Crystal system	Monoclinic
Space group	C2/c
a (Å)	18.085(4)
b (Å)	9.7655(19)
c (Å)	17.955(4)
α (°)	90
β (°)	115.852(15)
γ (°)	90
V (Å3)	2853.7(11)
Z	8
D/g cm-3	1.174
μ/mm-1	0.076
F(000)	1072.0
Reflns number	14941
R_{int}	0.0364
R_1	0.0440
GOF	1.012
wR^2(all data)	0.1346

6. References

[1] A. K. Gupta, X. Yin, M. Mukherjee, A. A. Desai, A. Mohammadlou, K. Jurewicz and W. D. Wulff, *Angew. Chem. Int. Ed.,* 2019, **58**, 3361.

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[3] A. Suárez and G. C. Fu, *Angew. Chem. Int. Ed.,* 2004, **43**, 3580.

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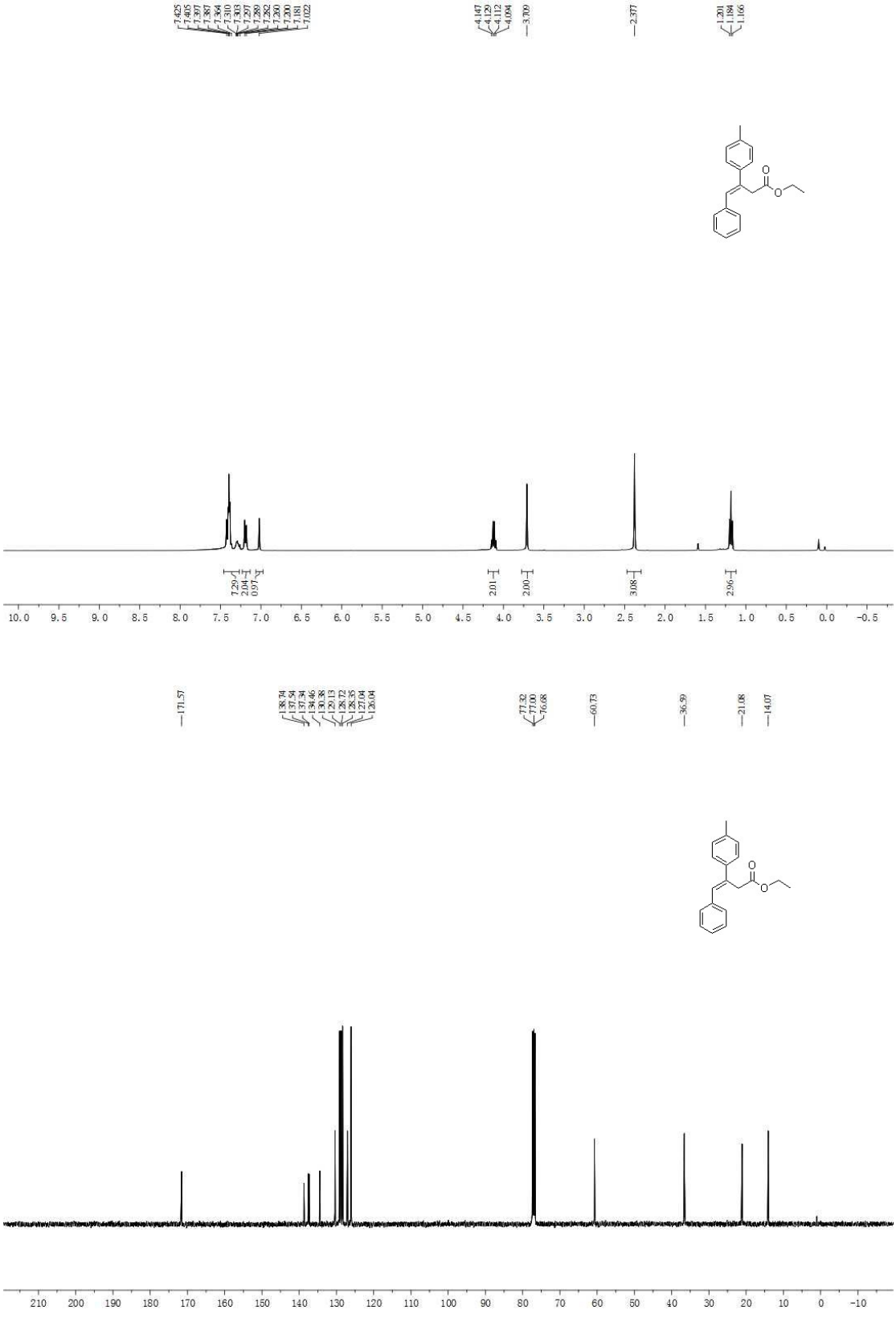
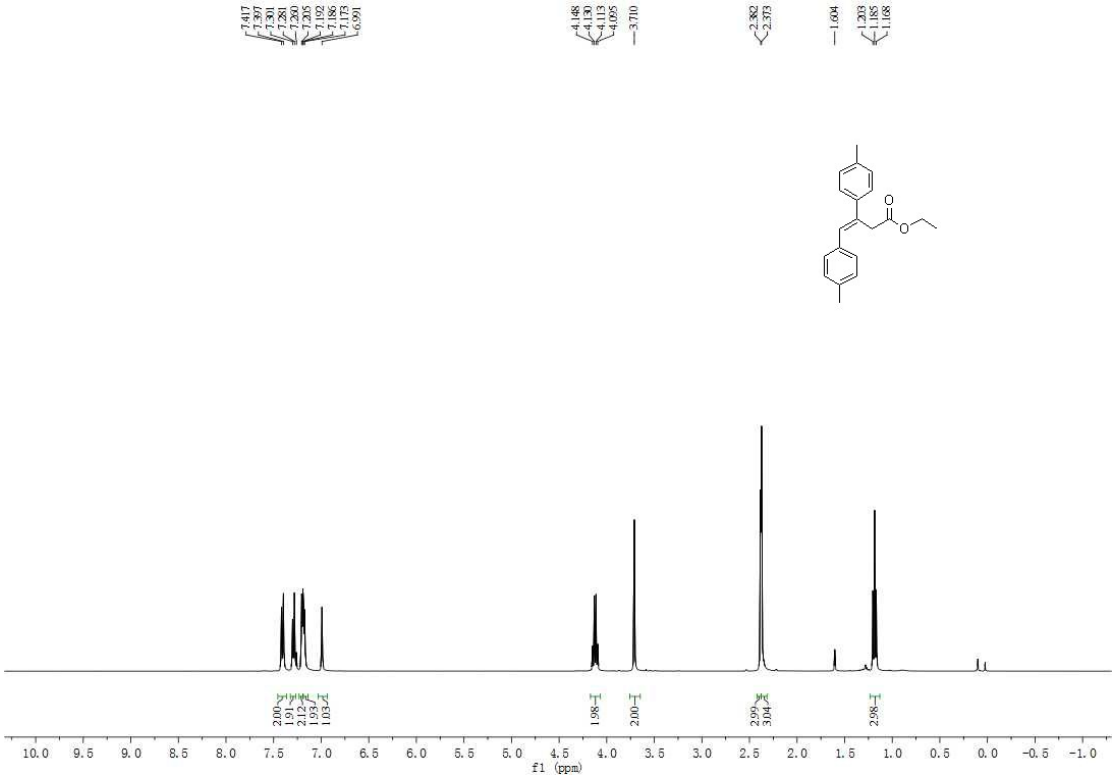
7. ^{1}H and ^{13}C NMR Spectra of Compounds 4-7 and 9

Product 4a



Product 4b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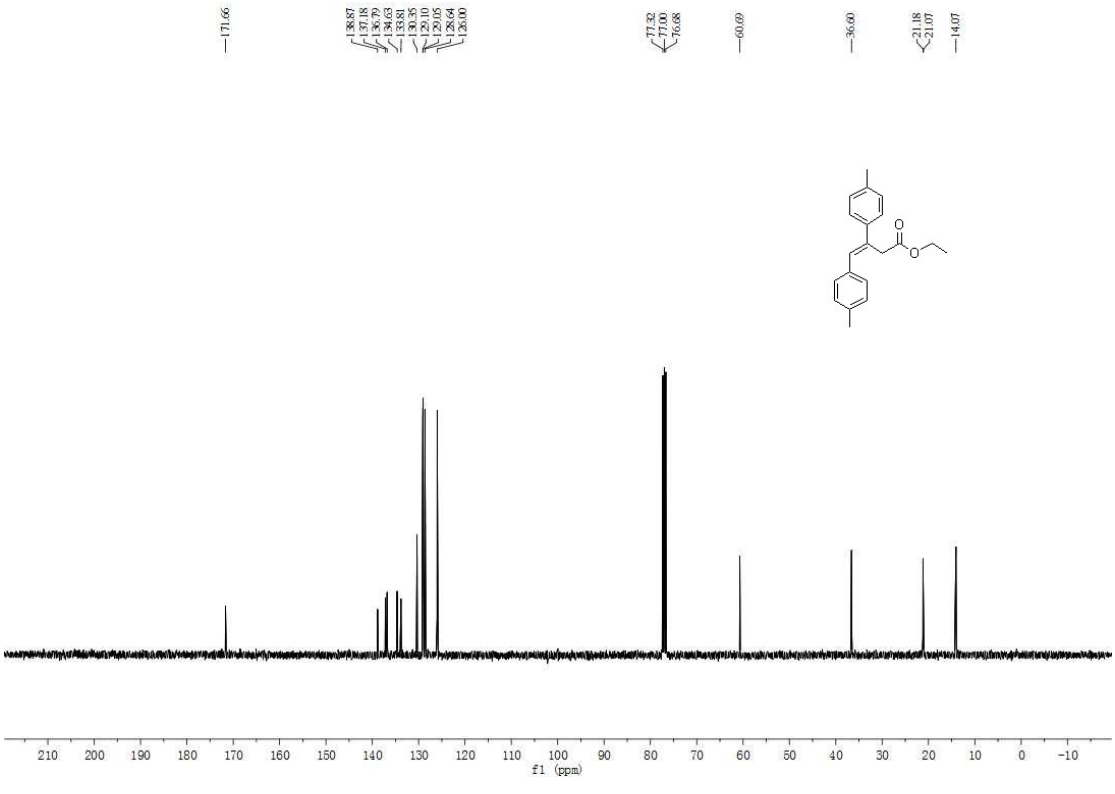
2.98
f1 (ppm)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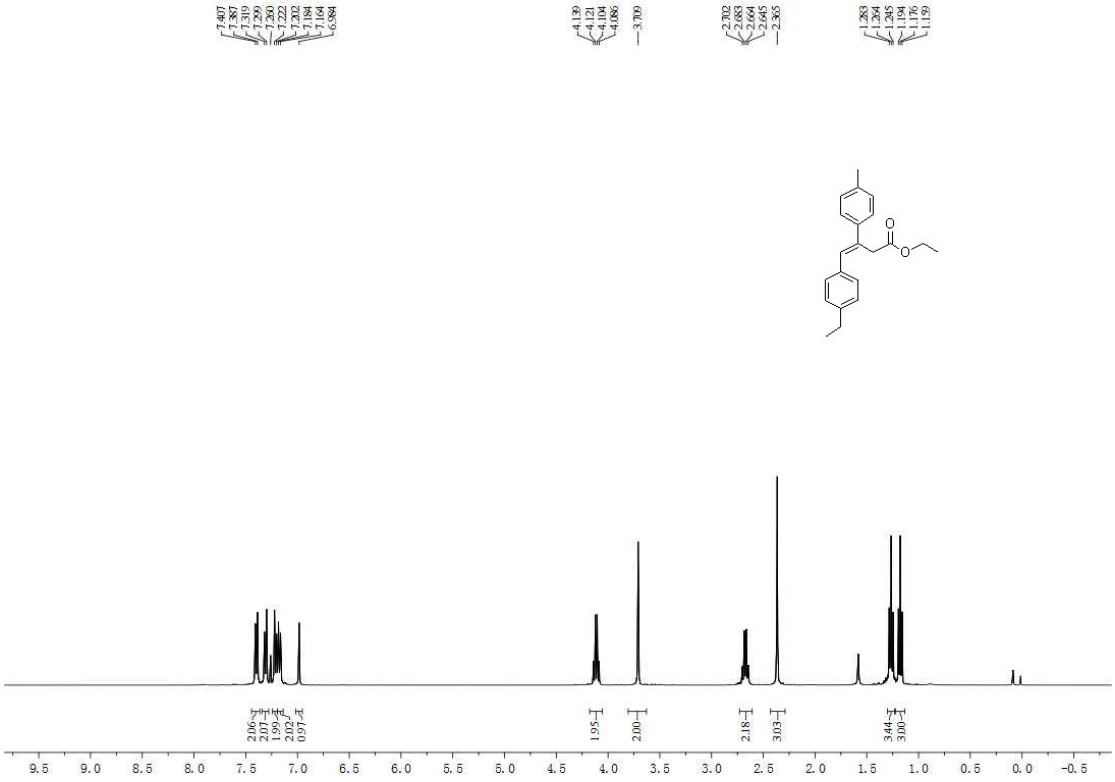
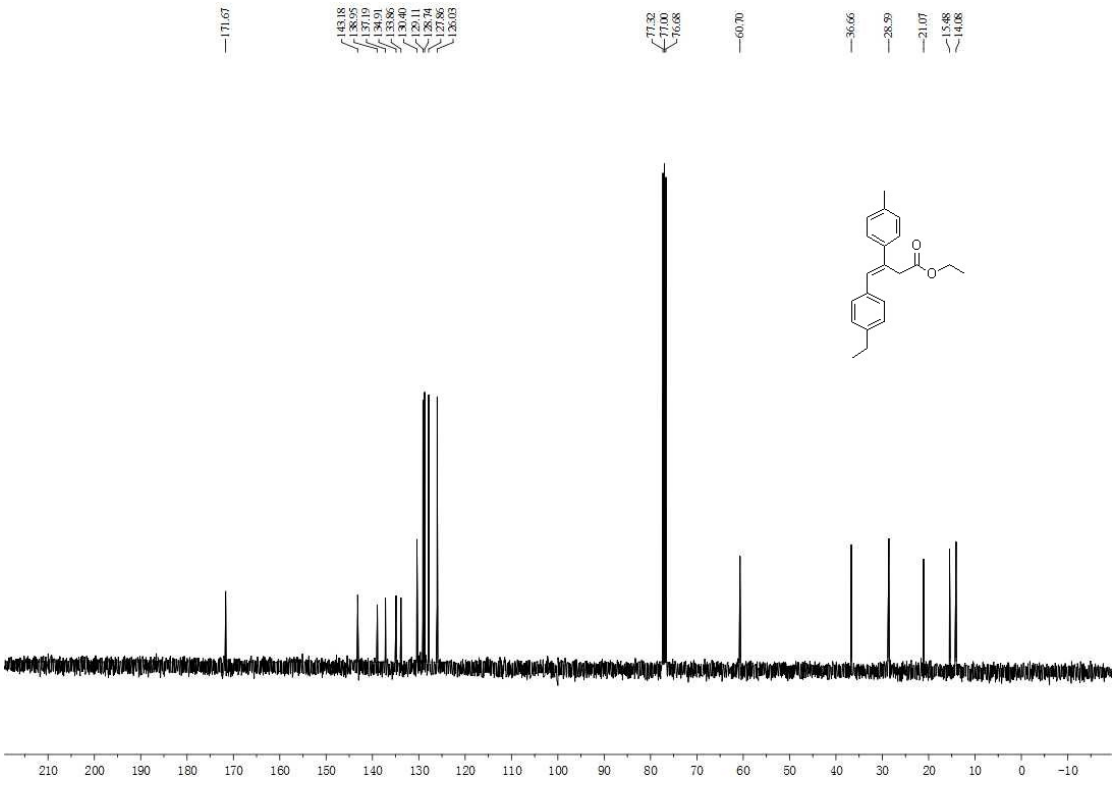
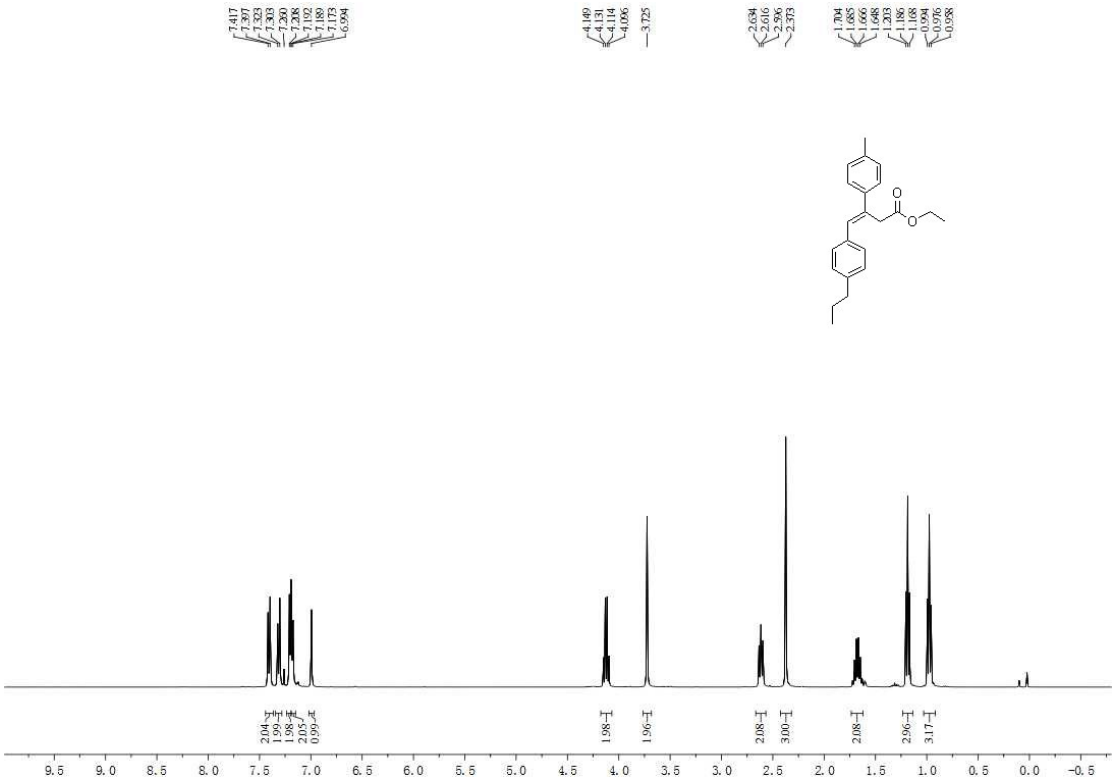
14.07
f1 (ppm)

Product 4c





Product 4d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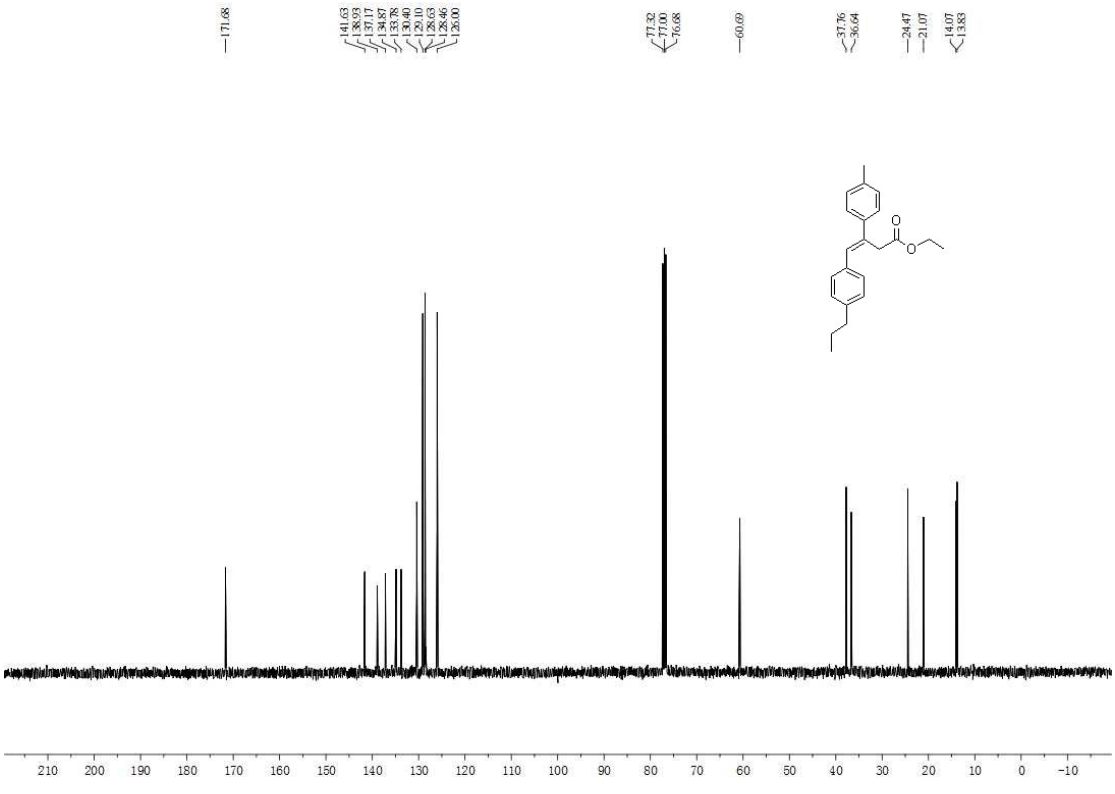
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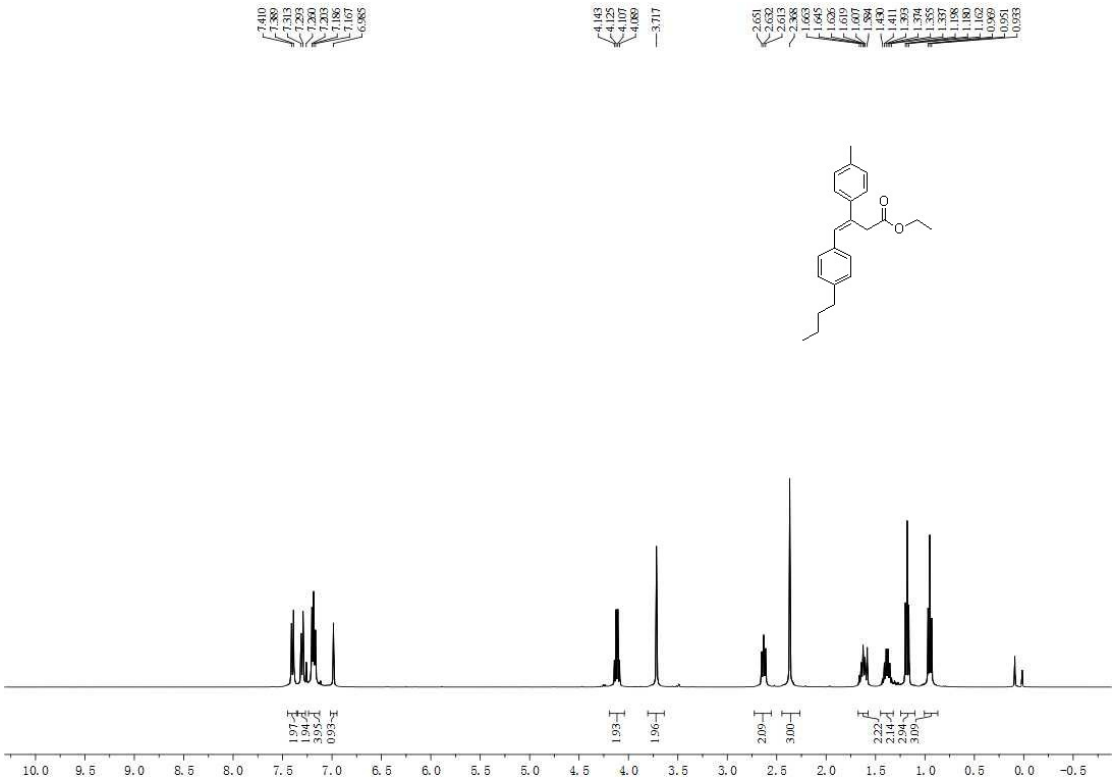
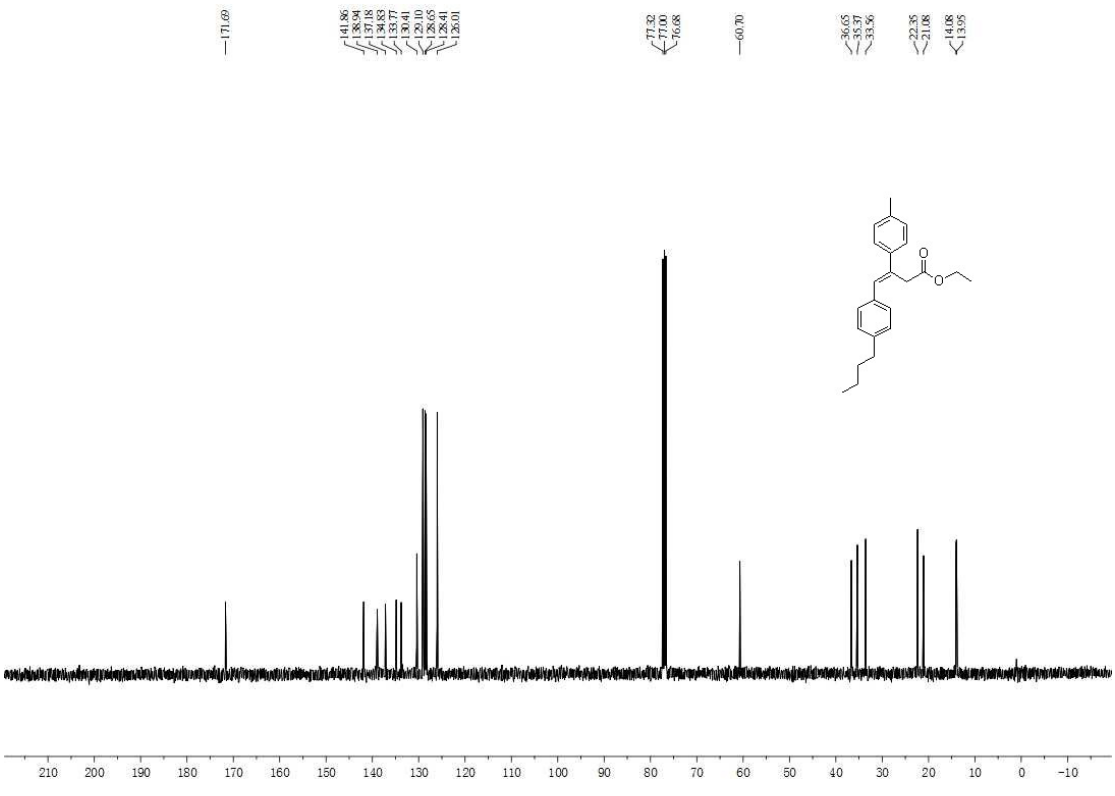
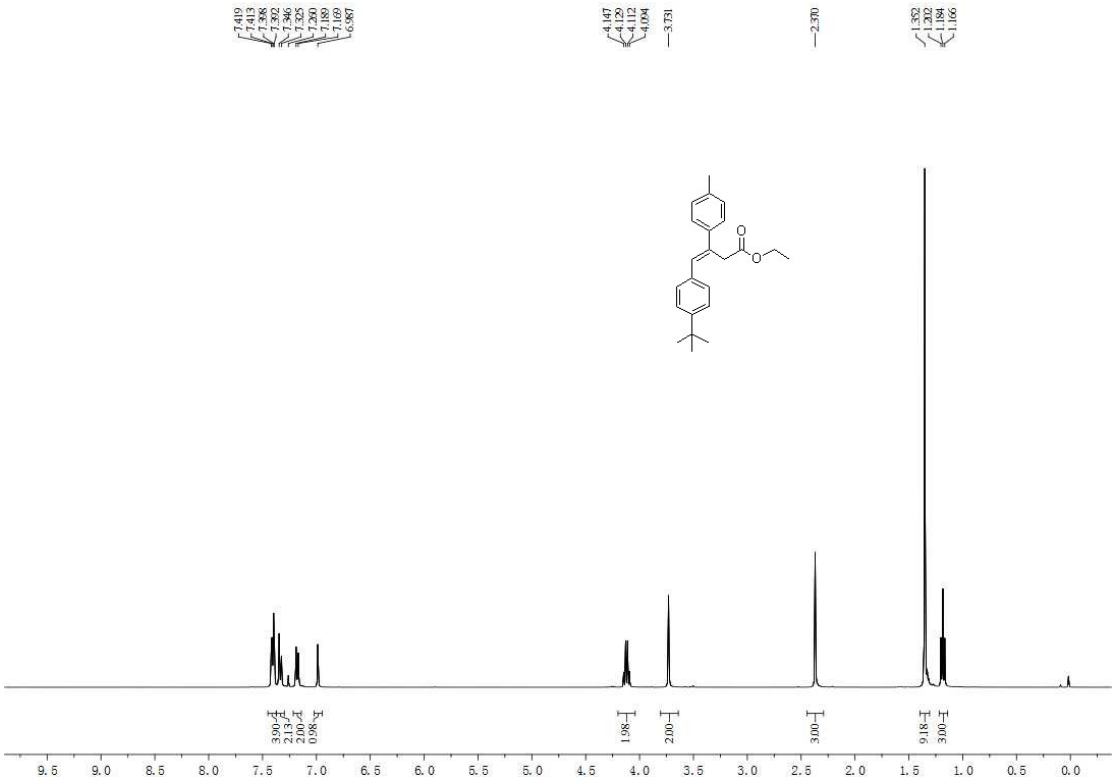
Product 4e





Product 4f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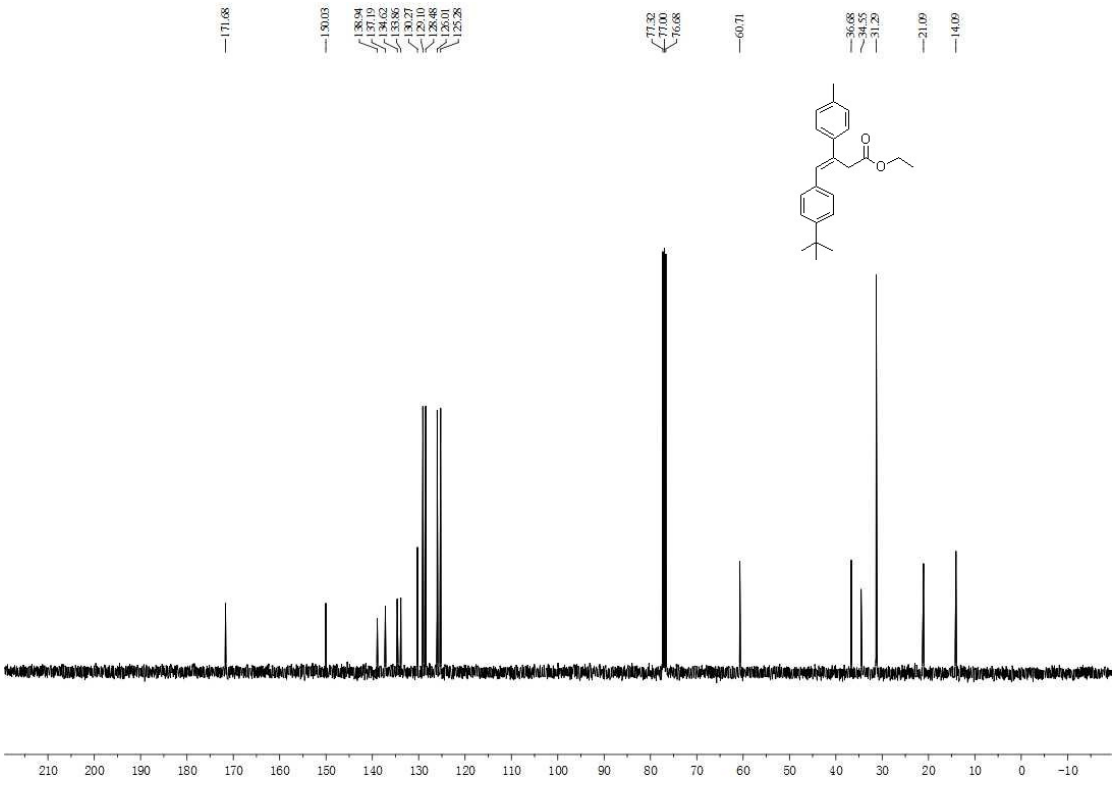
7.413
7.388
7.392
7.346
7.325
7.200
7.189
7.169
6.887
4.147
4.129
4.112
4.094
3.731
2.370
1.352
1.202
1.184
1.166
3.90
2.13
2.00
0.98
1.98
2.00
3.00
9.18
3.00


171.68
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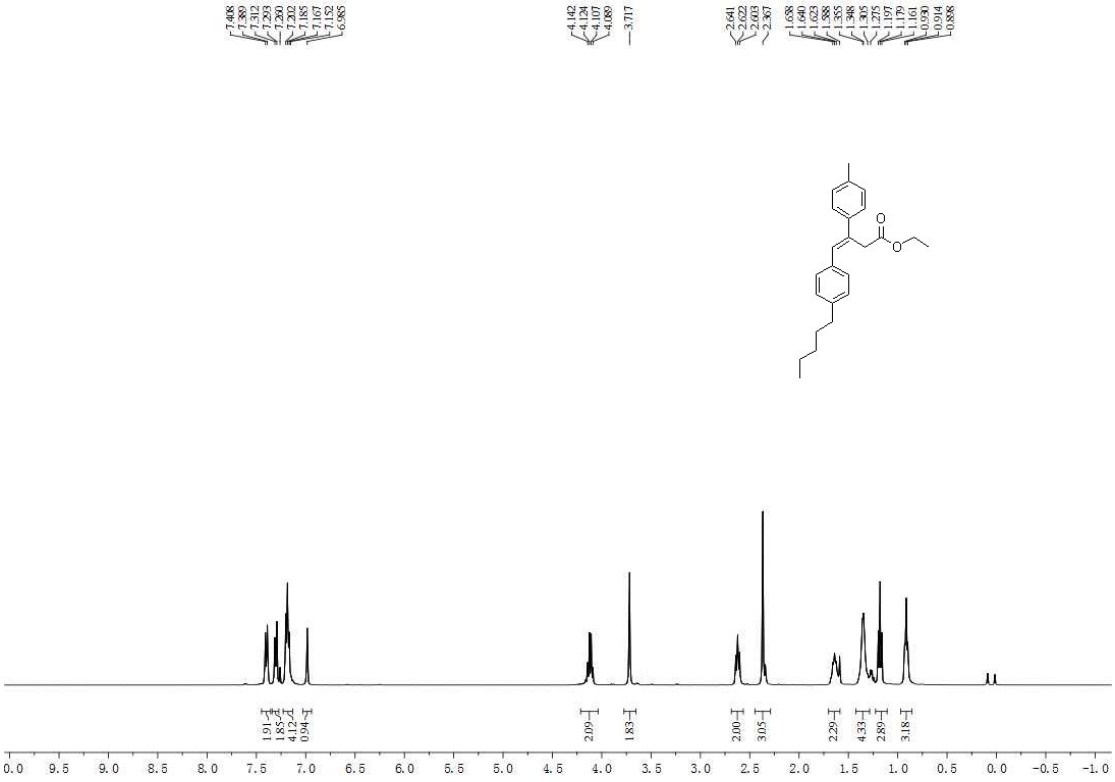
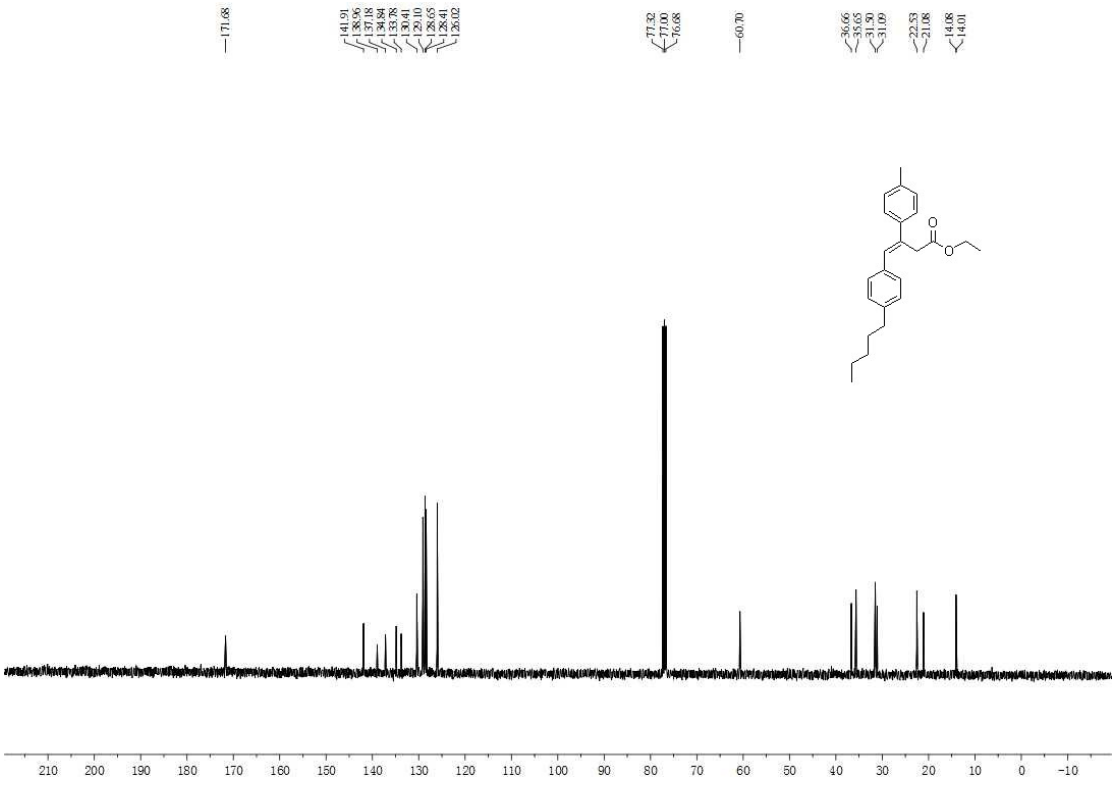
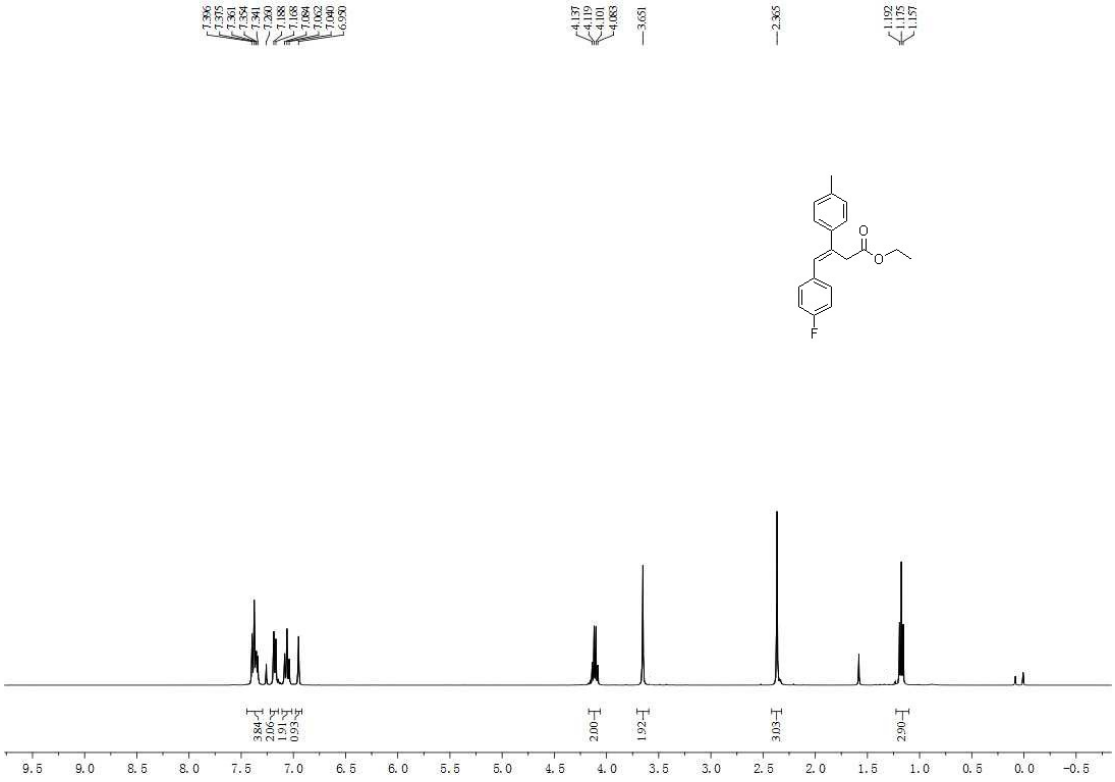
138.94
137.19
134.62
133.86
130.27
129.10
128.48
126.01
125.28
77.32
77.00
76.68
60.71
36.68
34.55
31.29
21.09
14.09

Product 4g





Product 4h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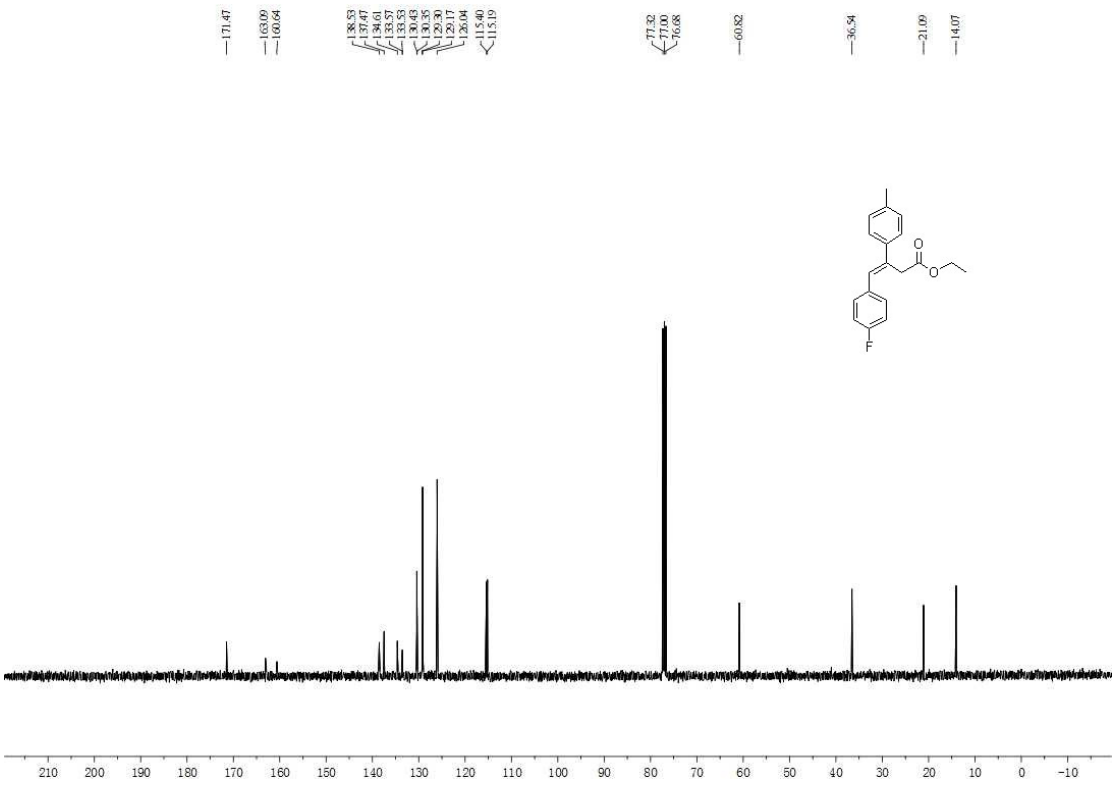
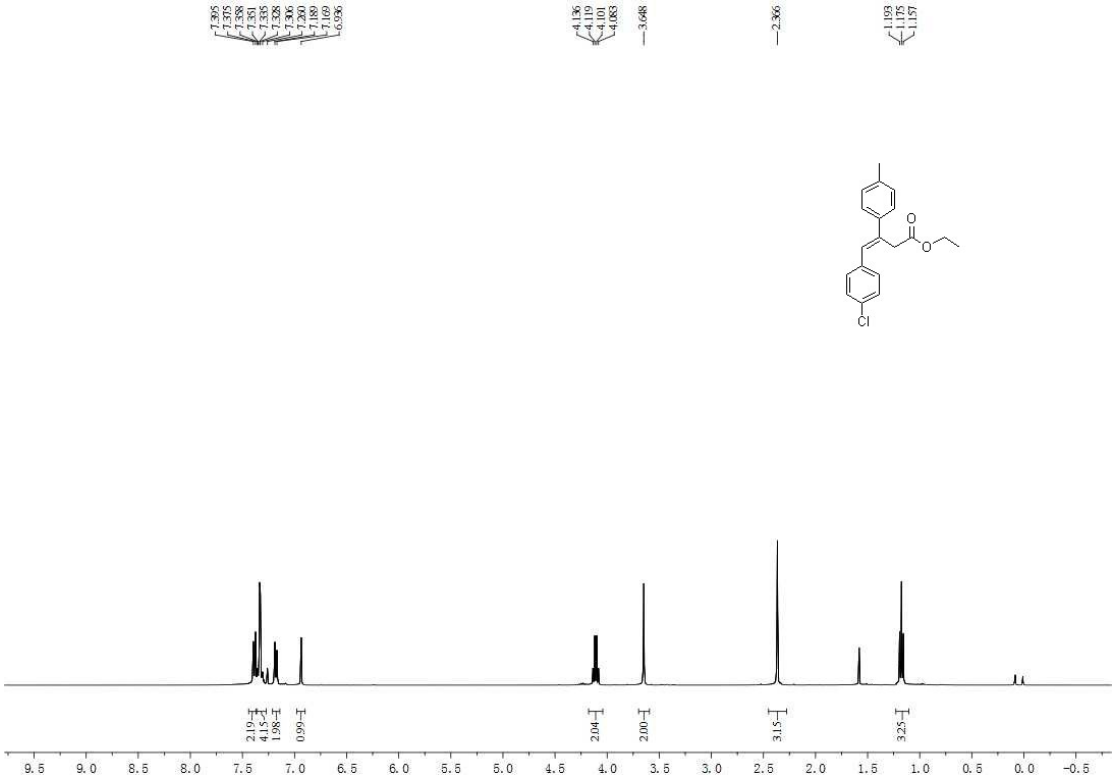
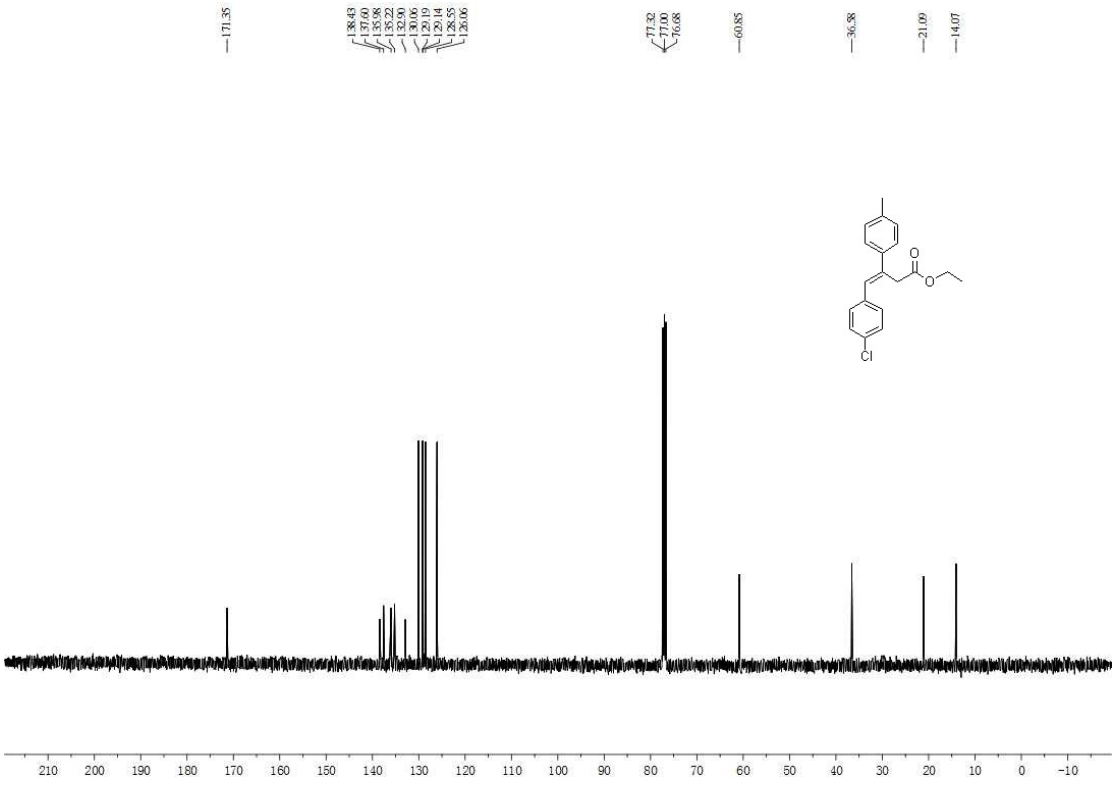
7.375
7.361
7.354
7.341
7.200
7.186
7.168
7.084
7.062
7.040
6.990
4.137
4.119
4.101
4.083
3.651
2.365
1.192
1.175
1.157
O
O
F
3.84
2.06
1.91
0.93
2.00
1.92
3.03
2.90
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5


171.47
163.09
160.64
138.53
137.47
134.61
133.57
133.53
130.43
130.35
129.30
129.17
126.04
115.40
115.19
77.32
77.00
76.68
60.82
36.54
21.09
14.07
O
O
F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

Product 4i


7.395
7.375
7.368
7.351
7.335
7.328
7.306
7.200
7.189
7.169
6.956
4.136
4.119
4.101
4.083
3.648
2.366
1.193
1.175
1.157
Cl
O
O
2.19
4.15
1.98
0.99
2.04
2.00
3.15
3.25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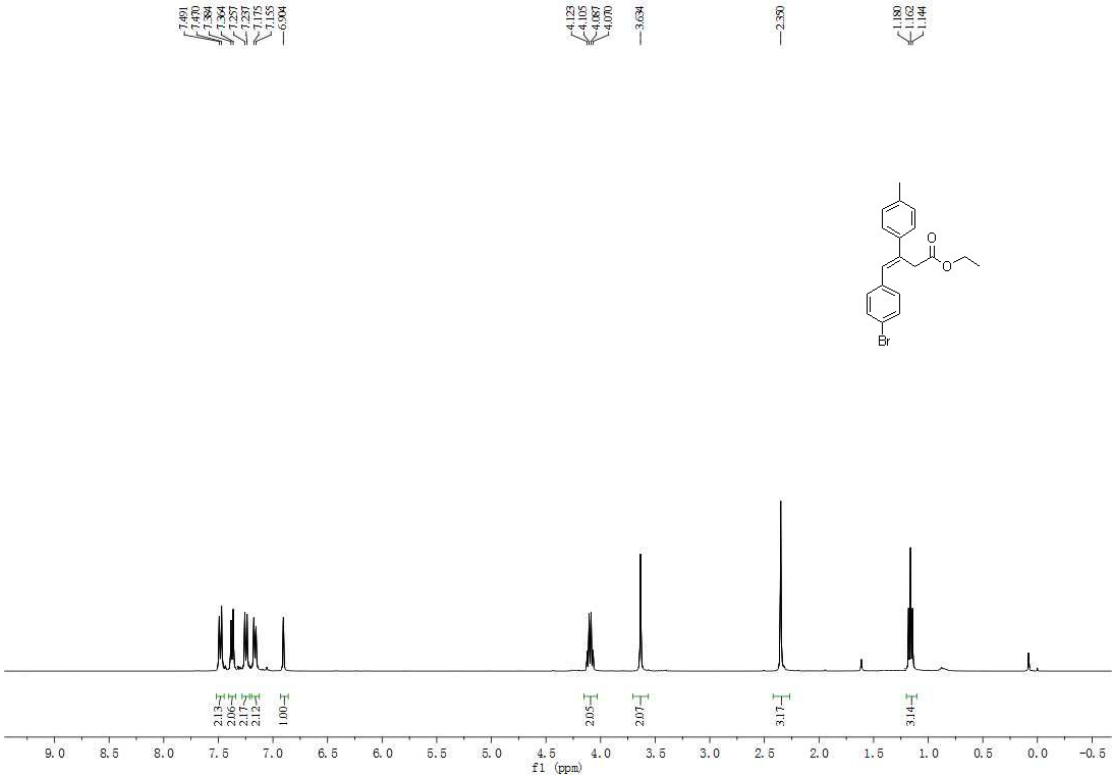
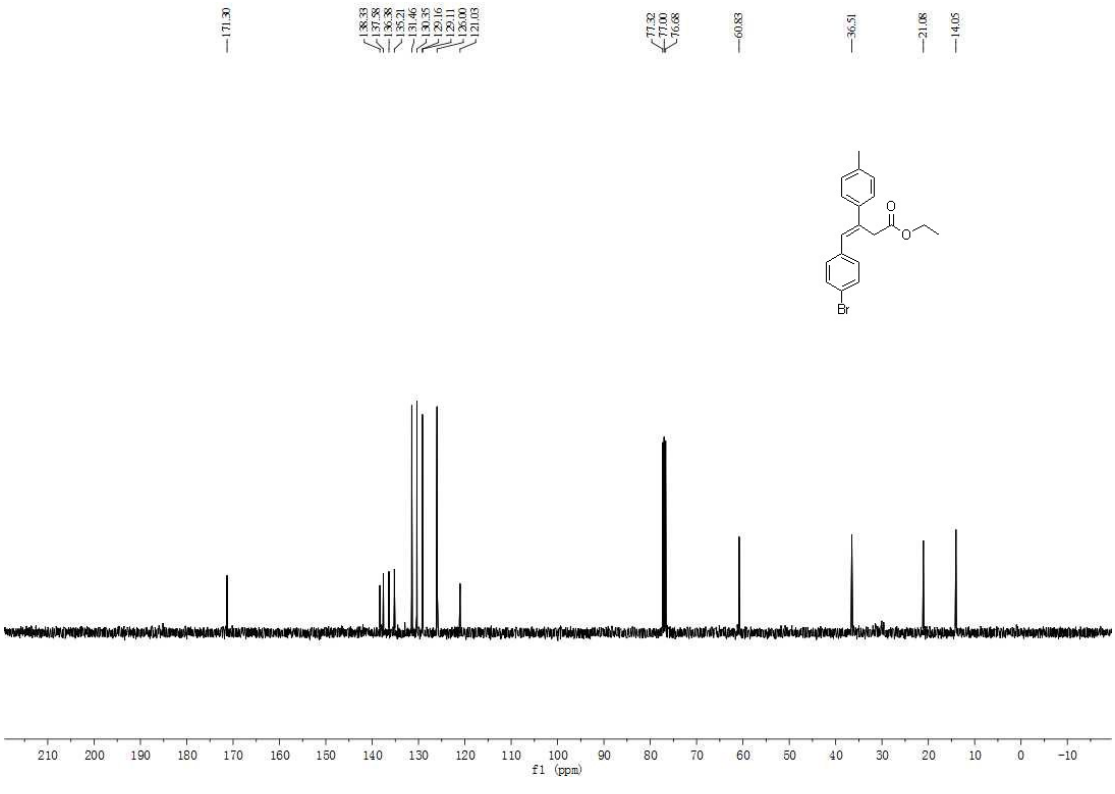
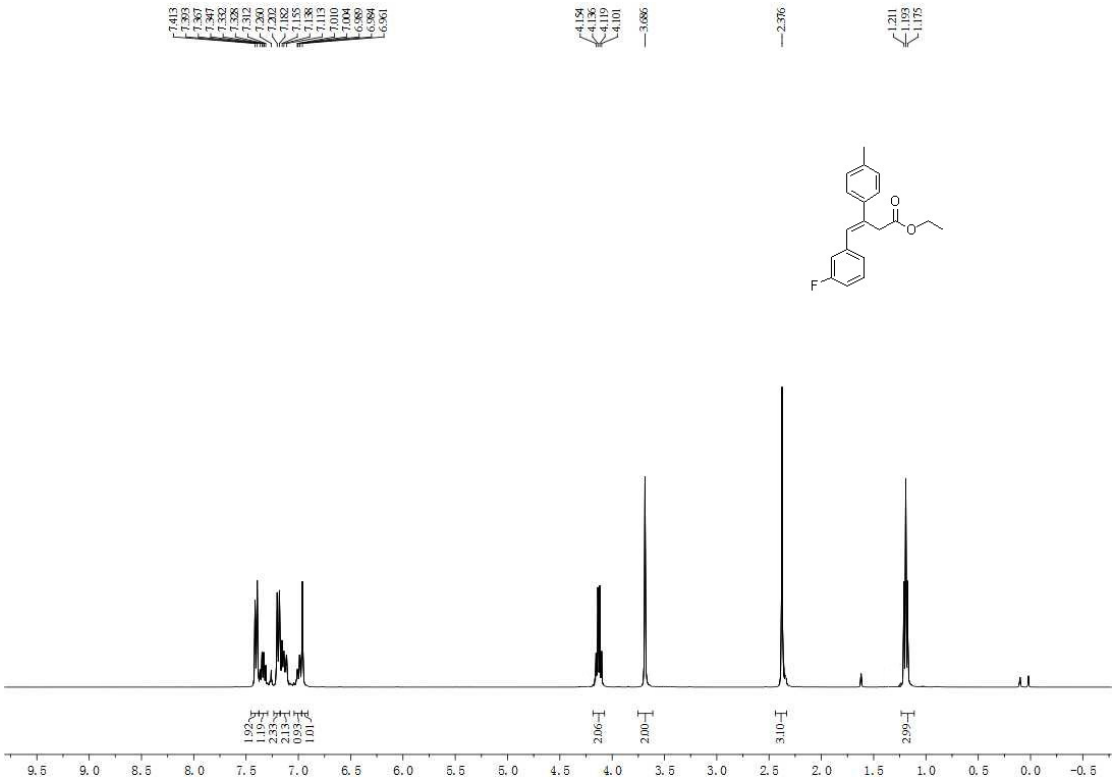
138.43
137.60
135.98
135.22
132.90
130.06
129.19
129.14
128.55
126.06
77.32
77.00
76.68
60.85
36.58
21.09
14.07
Cl
O
O

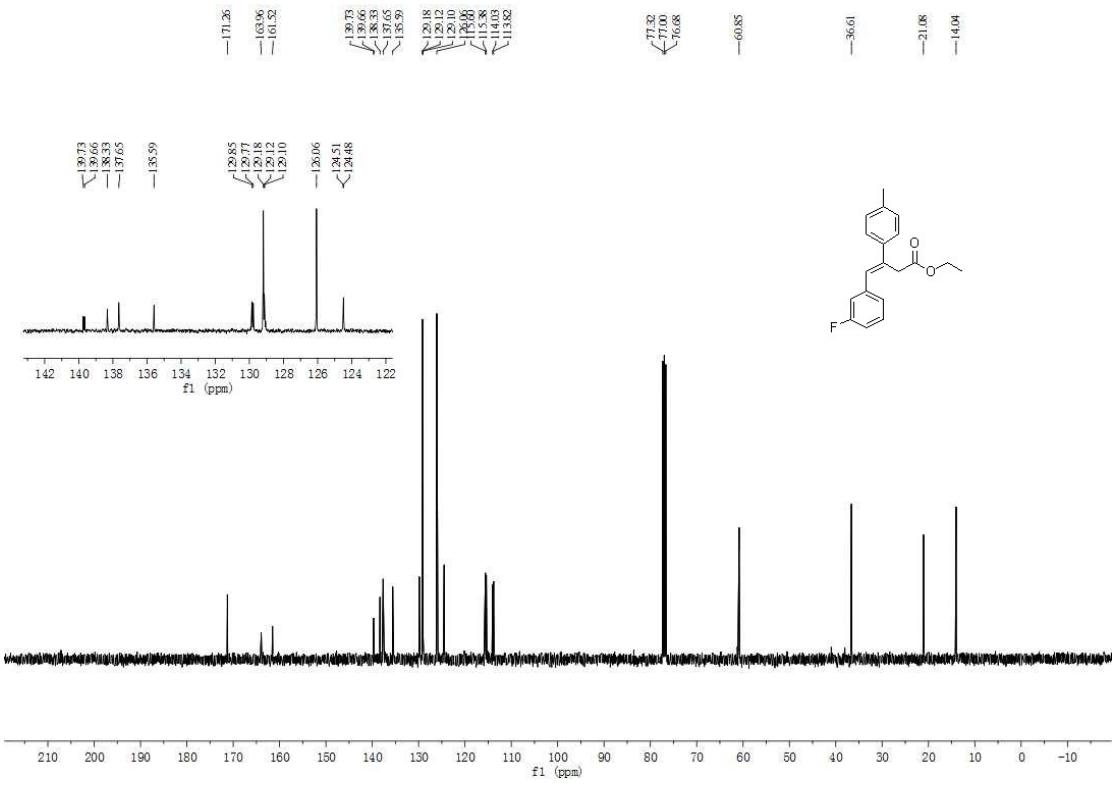
Product 4j


7.491
7.400
7.384
7.364
7.257
7.237
7.175
7.155
6.904
4.123
4.105
4.087
4.070
3.634
2.350
1.180
1.162
1.144
O
O
Br
2.13
2.06
2.17
2.12
1.00
2.05
2.07
3.17
3.14
f1 (ppm)

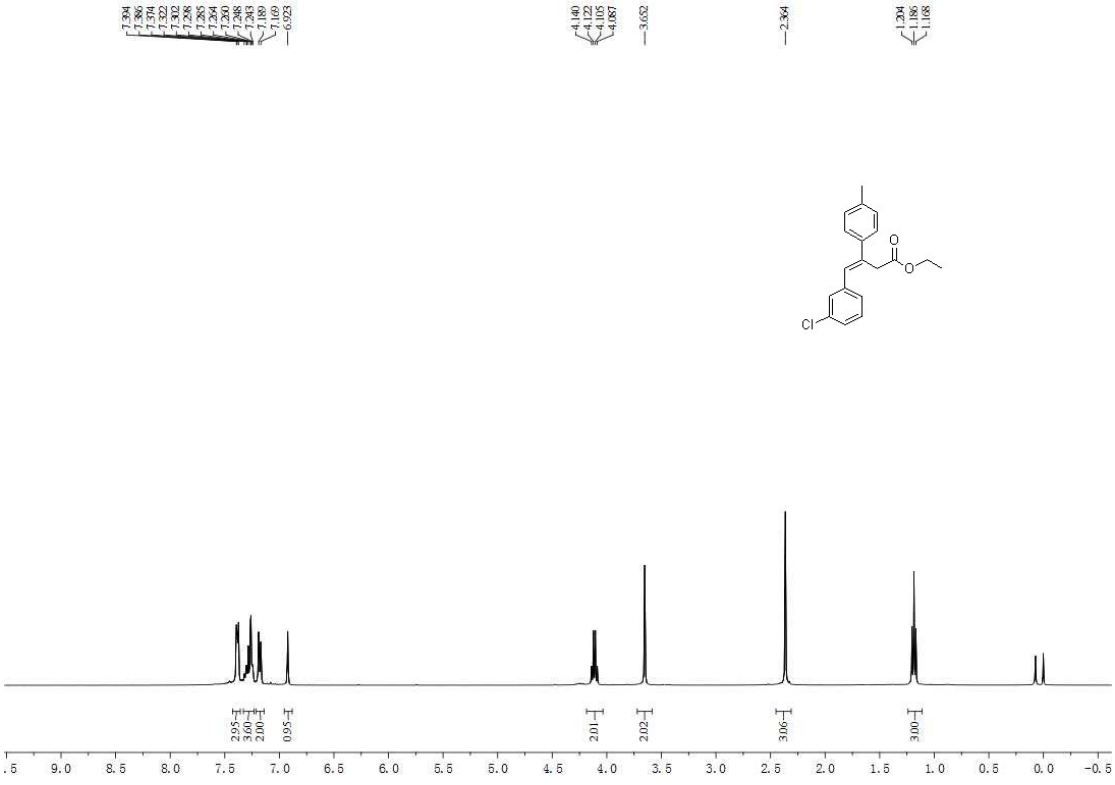

171.30
138.33
137.58
136.38
135.21
131.46
130.35
129.16
129.11
128.01
121.03
77.32
77.00
76.68
60.83
36.51
21.08
14.05
O
O
Br
f1 (ppm)

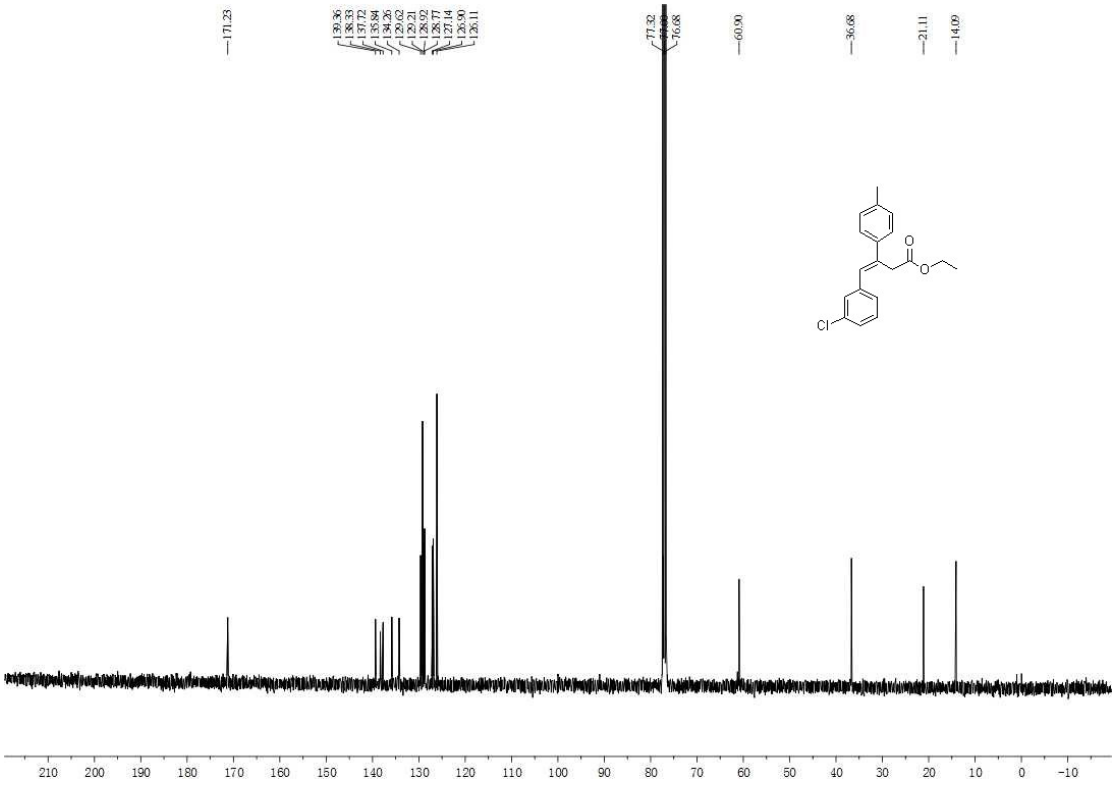
Product 4k





Product 4l


7.394
7.386
7.374
7.322
7.302
7.288
7.265
7.264
7.260
7.248
7.243
7.189
7.169
6.923
4.140
4.122
4.105
4.087
3.652
2.364
1.204
1.186
1.168
O
O
Cl
2.95
3.60
2.00
0.95
2.01
2.02
3.06
3.00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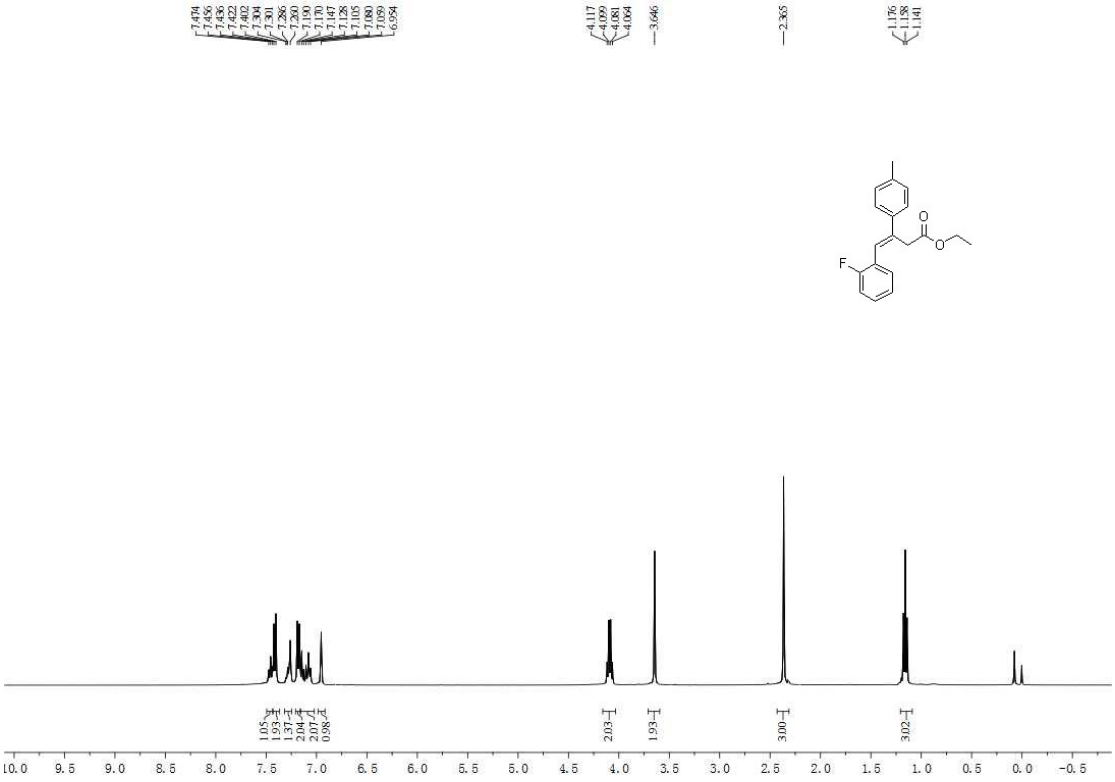
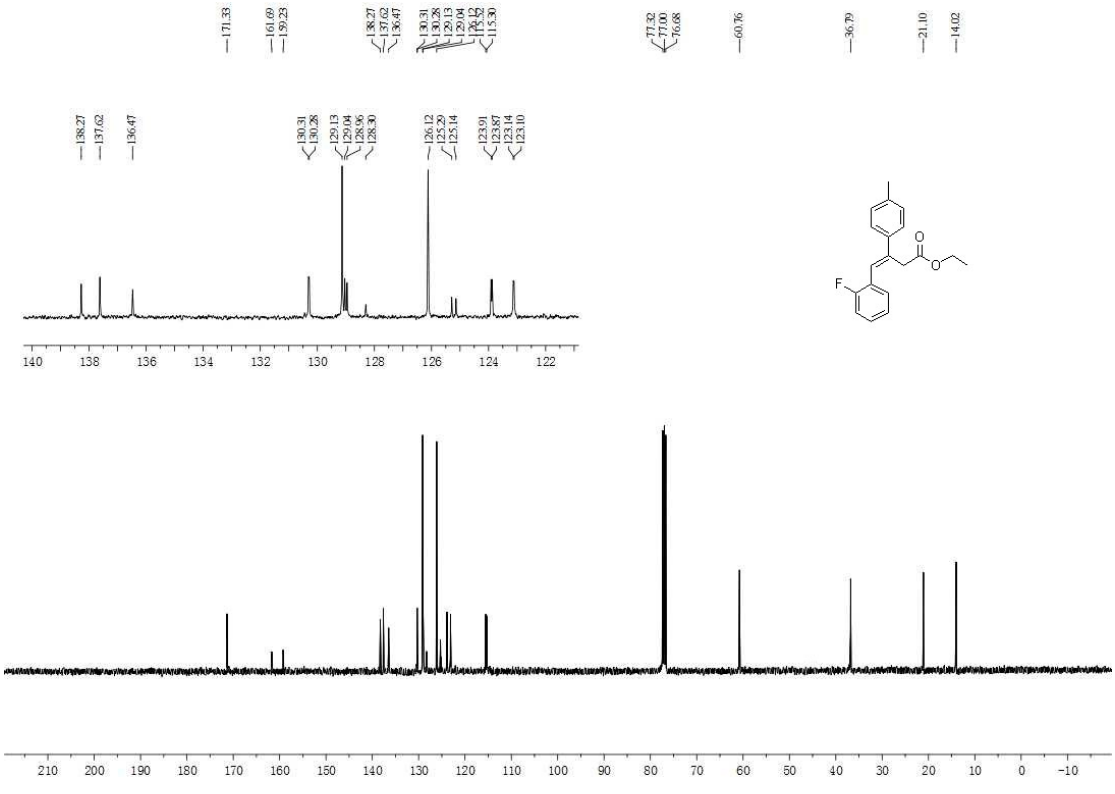
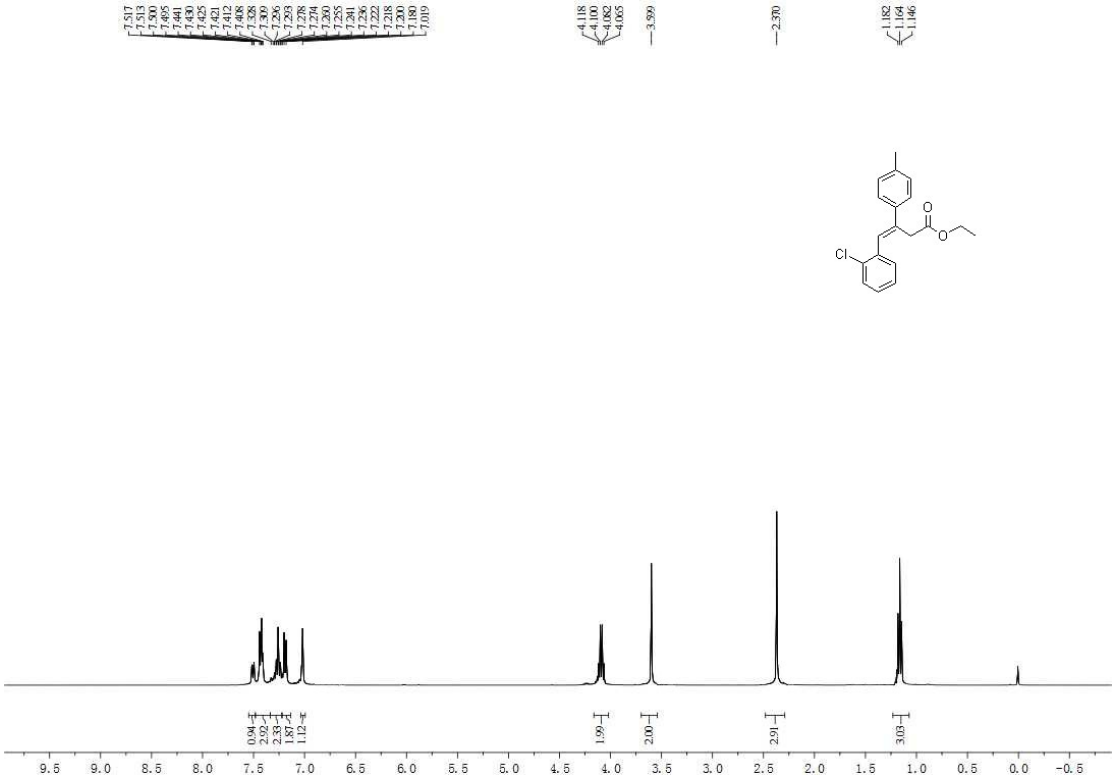
139.36
138.33
137.72
135.84
134.26
129.62
129.21
128.92
128.17
127.14
125.90
126.11
77.32
76.68
60.90
36.68
21.11
14.09
O
O
Cl

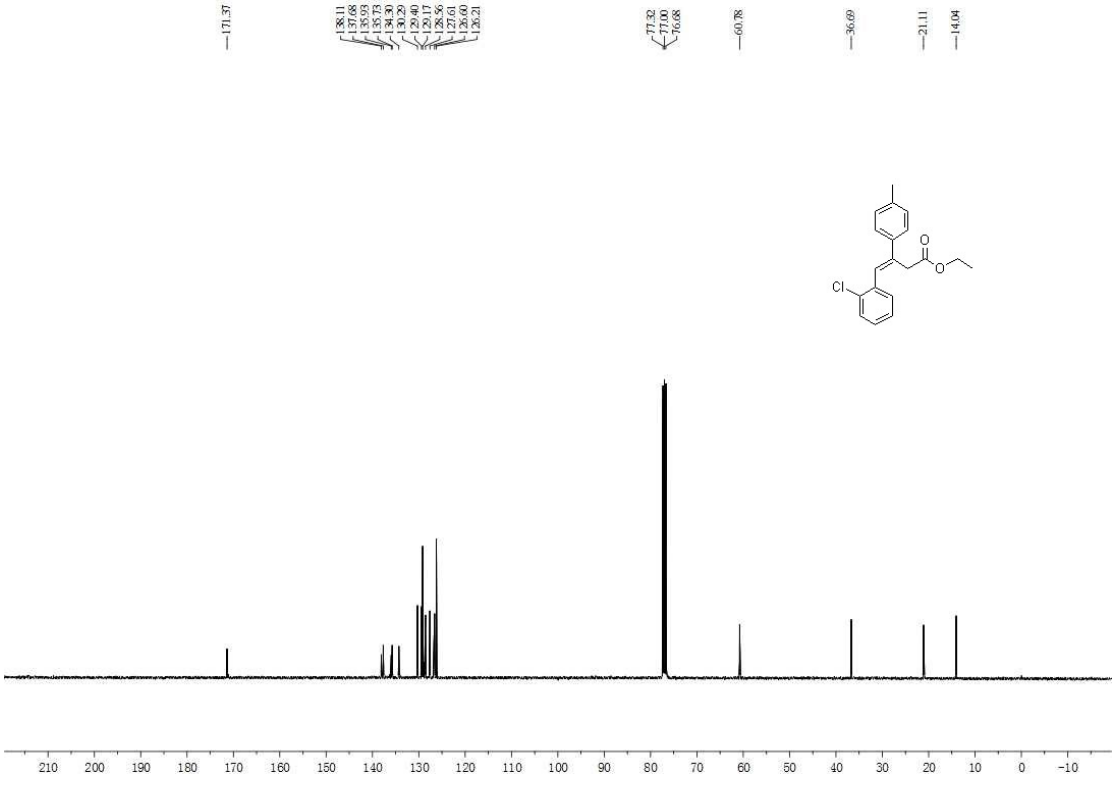
Product 4m



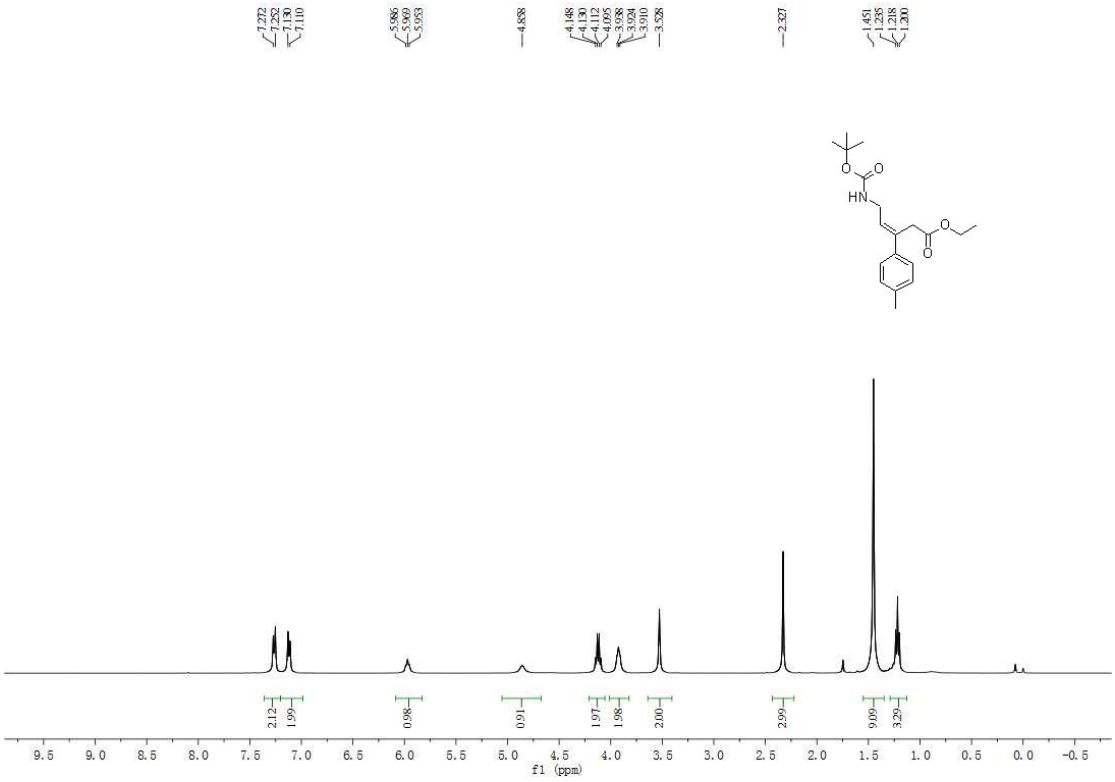


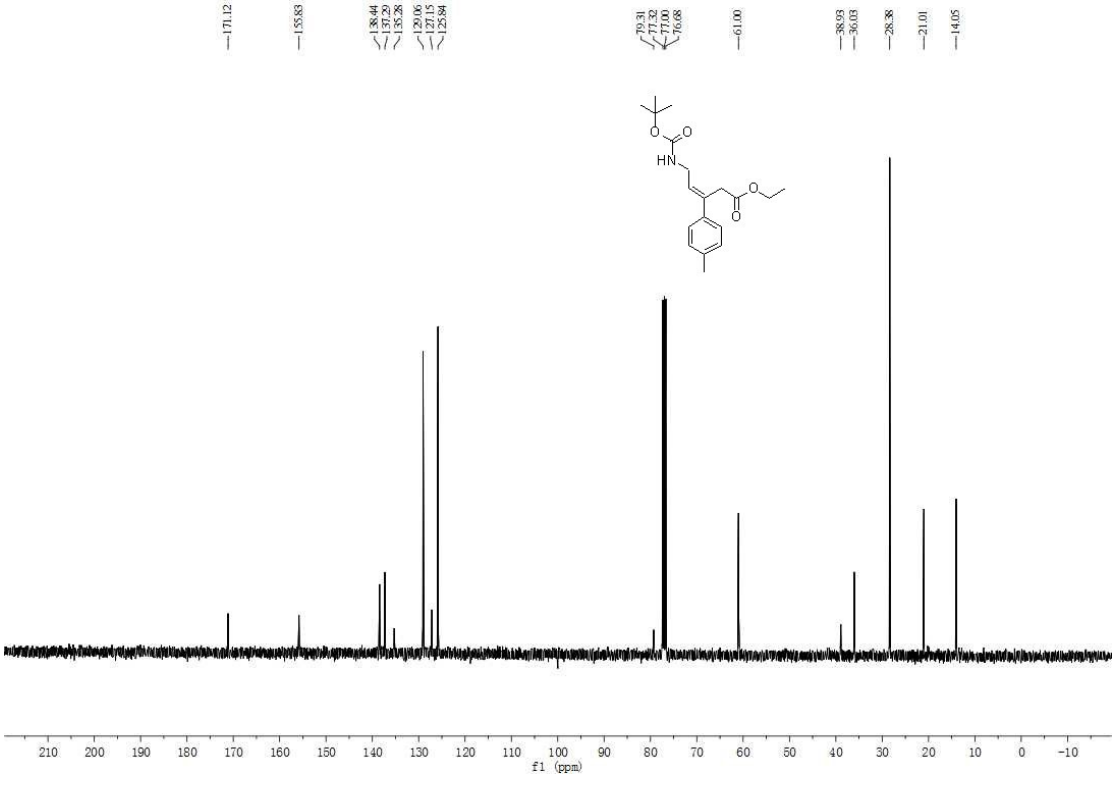
Product 4n





Product 4o


7.272
7.252
7.130
7.110
5.986
5.969
5.953
4.838
4.148
4.130
4.112
4.095
3.938
3.924
3.910
3.528
2.327
1.451
1.235
1.218
1.200
HN
O
O
O
O
2.12
1.99
0.98
0.91
1.97
1.98
2.00
2.99
9.09
3.29
f1 (ppm)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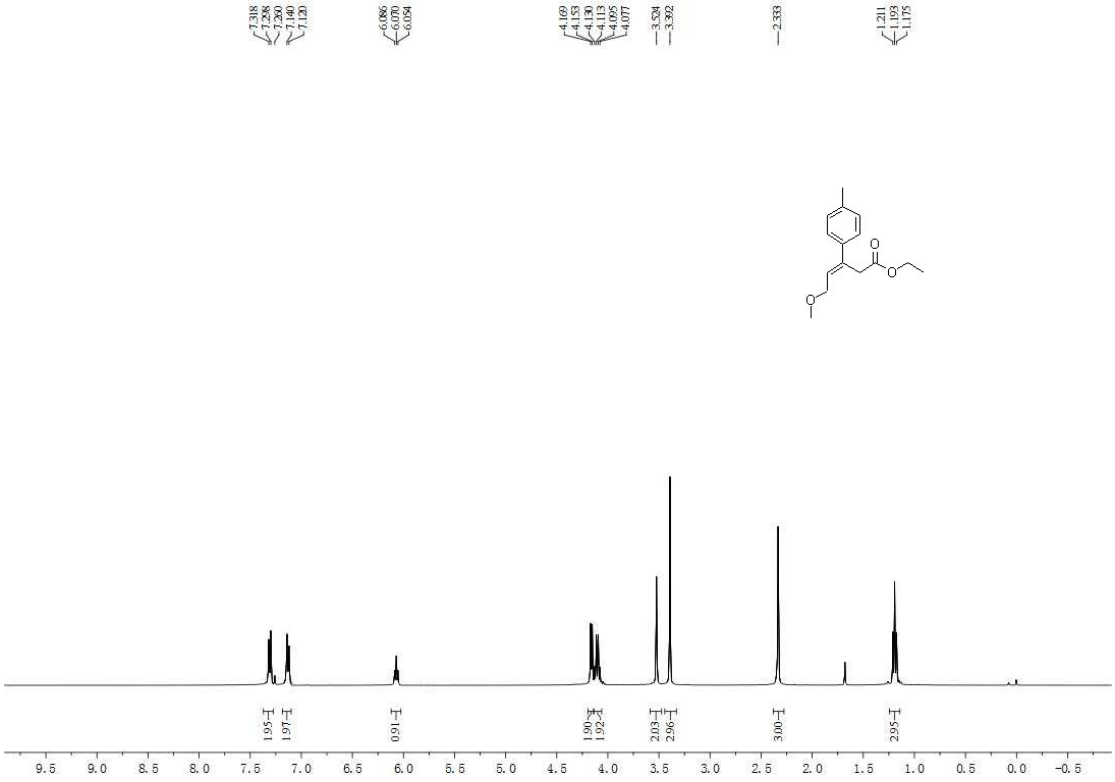
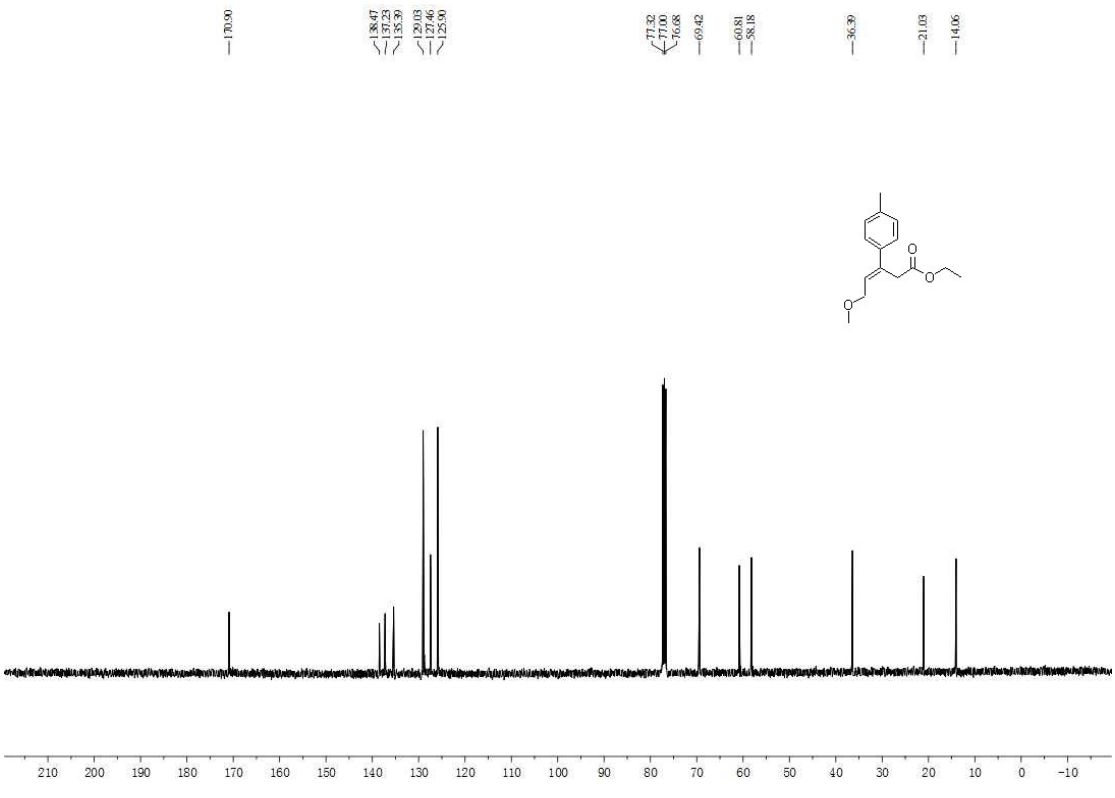
155.83
138.44
137.29
135.28
129.06
127.15
125.84
79.31
77.32
77.00
76.68
61.00
38.93
36.03
28.38
21.01
14.05
HN
O
O
O
O
f1 (ppm)

Product 4p


7.318
7.238
7.230
7.140
7.120
6.086
6.070
6.054
4.169
4.155
4.130
4.113
4.095
4.077
3.524
3.392
2.333
1.211
1.193
1.175
1.95
1.97
0.91
1.90
1.92
2.03
2.96
3.00
2.95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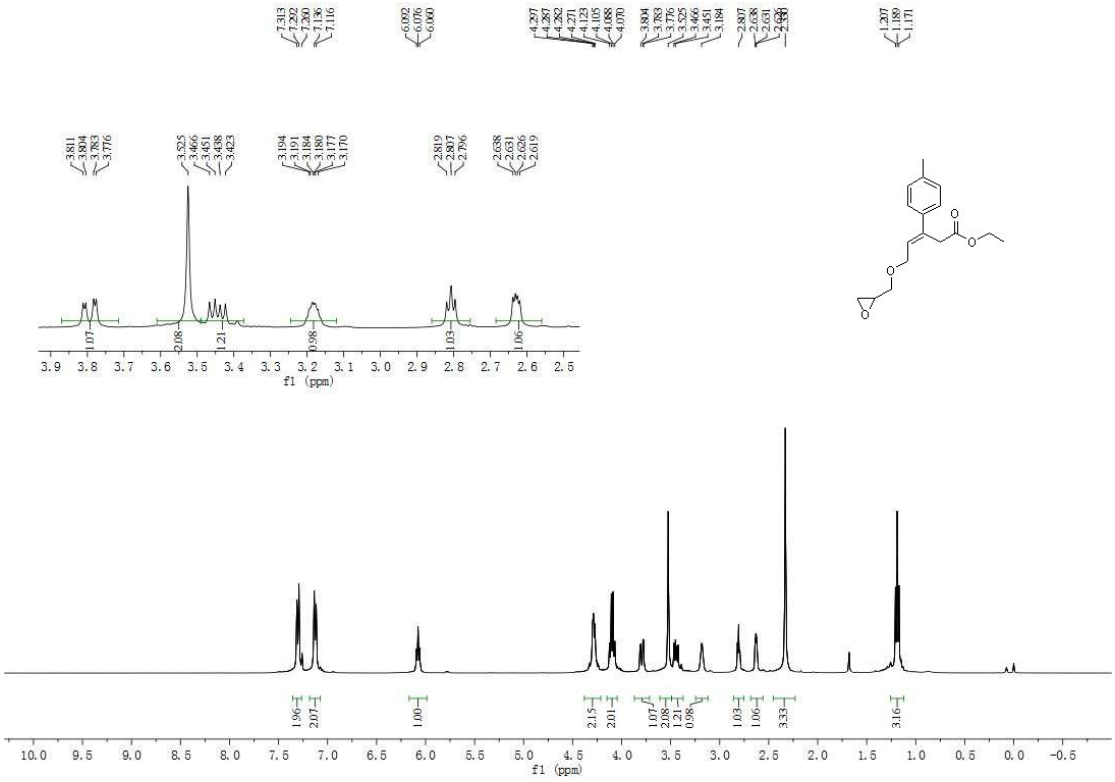
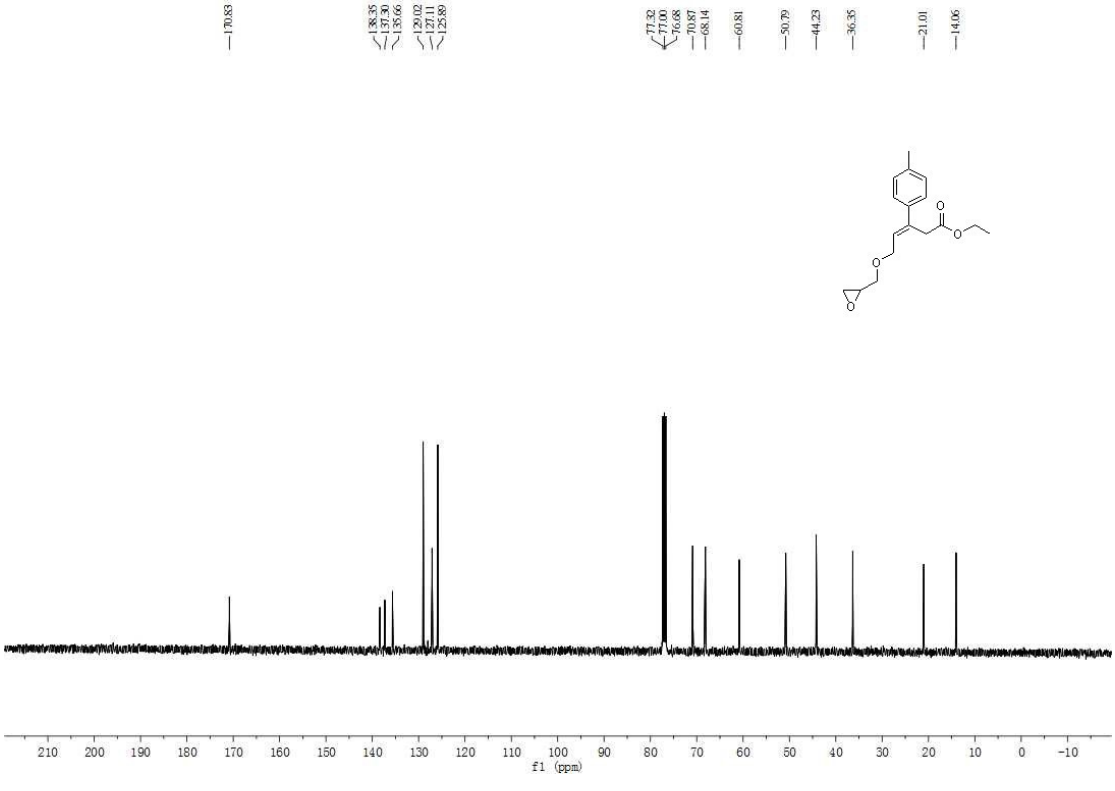
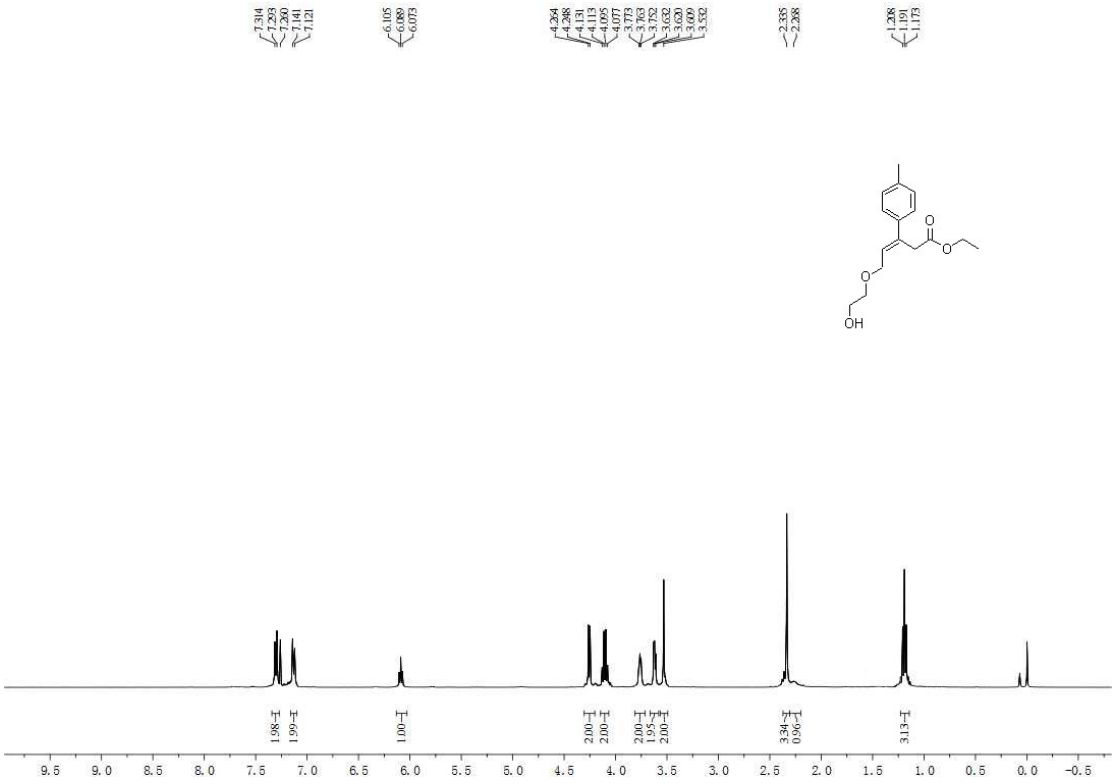
137.23
135.39
129.03
127.46
125.90
77.32
77.00
76.68
69.42
60.81
58.18
36.39
21.03
14.06

Product 4q





Product 4r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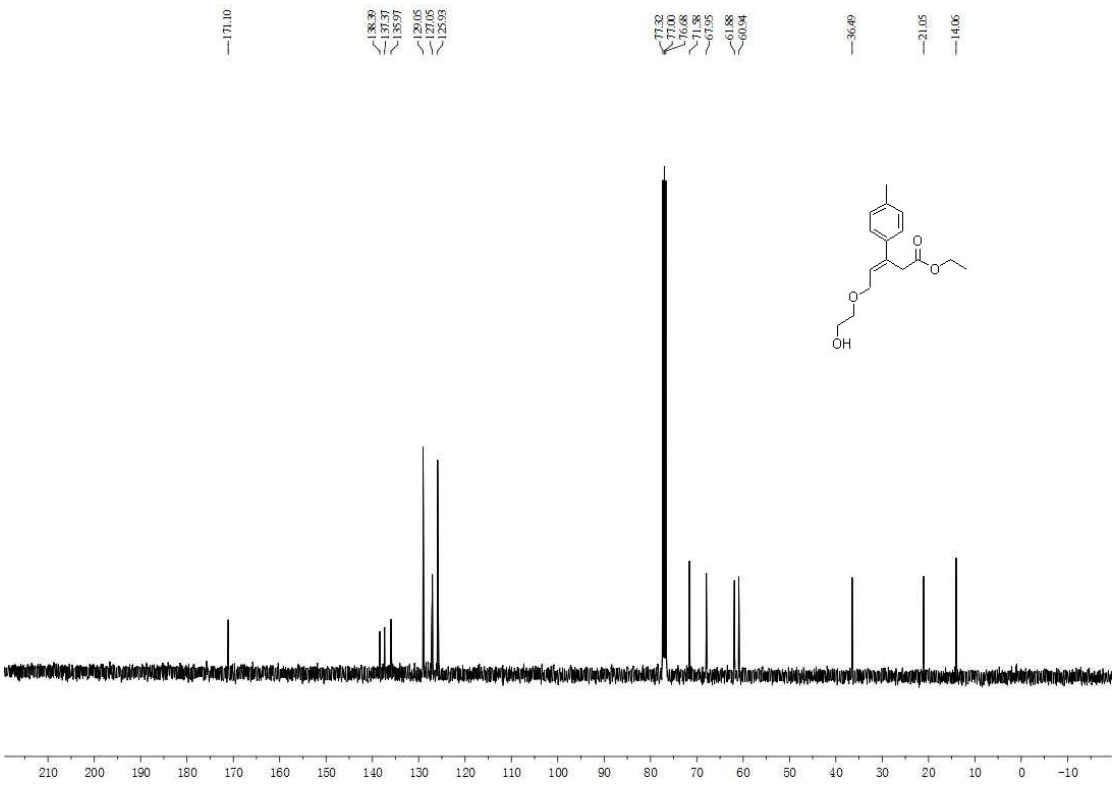
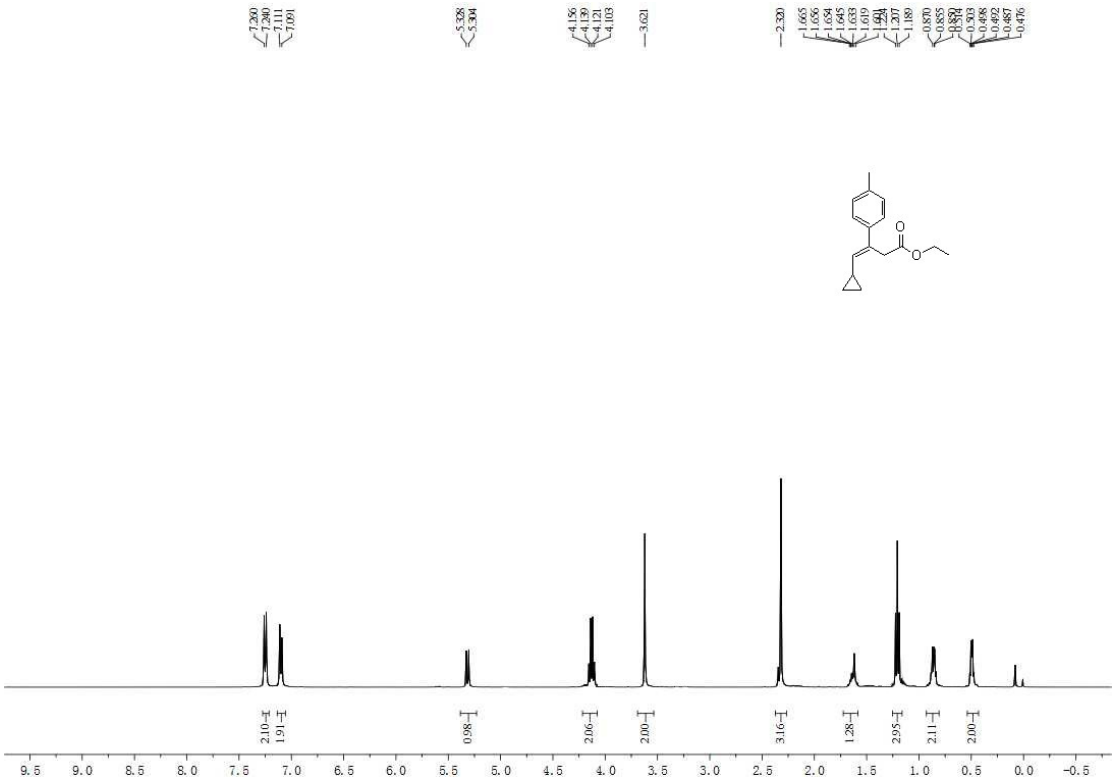
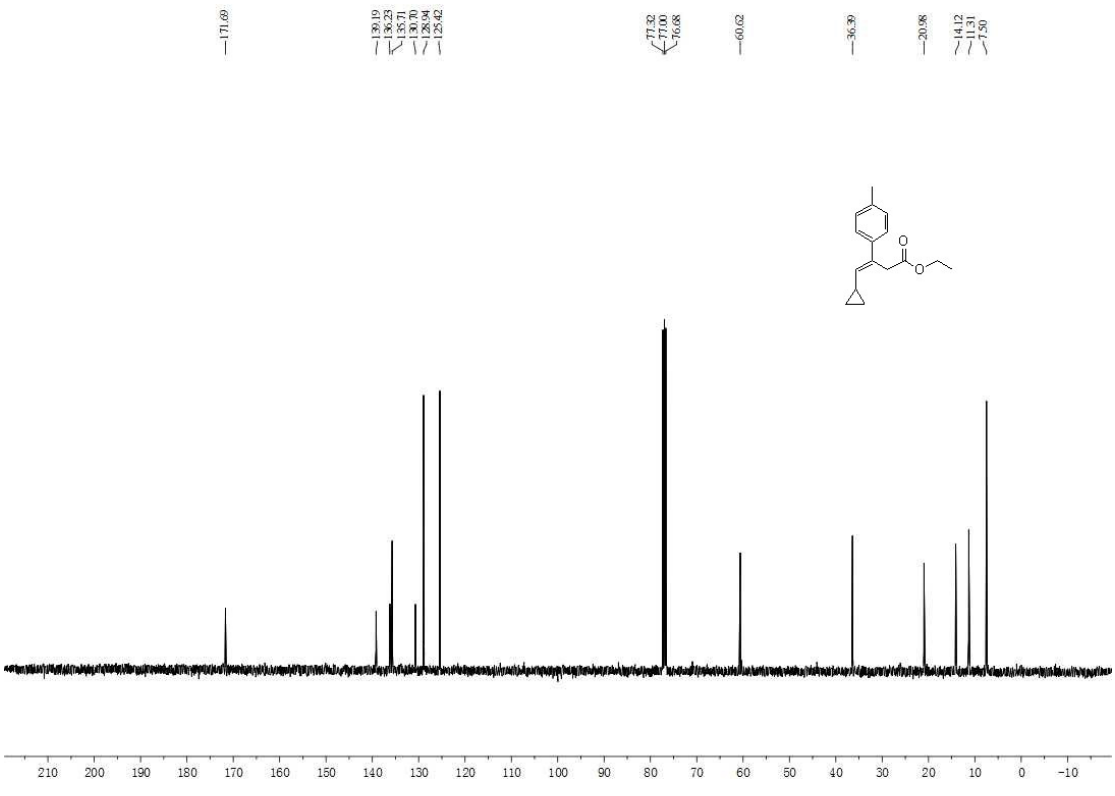
7.299
7.300
7.141
7.121
6.105
6.089
6.073
4.304
4.298
4.131
4.113
4.095
4.077
3.773
3.763
3.752
3.632
3.620
3.609
3.532
2.335
2.308
1.208
1.191
1.173
1.98
1.99
1.00
2.00
2.00
2.00
1.95
2.00
3.34
0.96
3.13

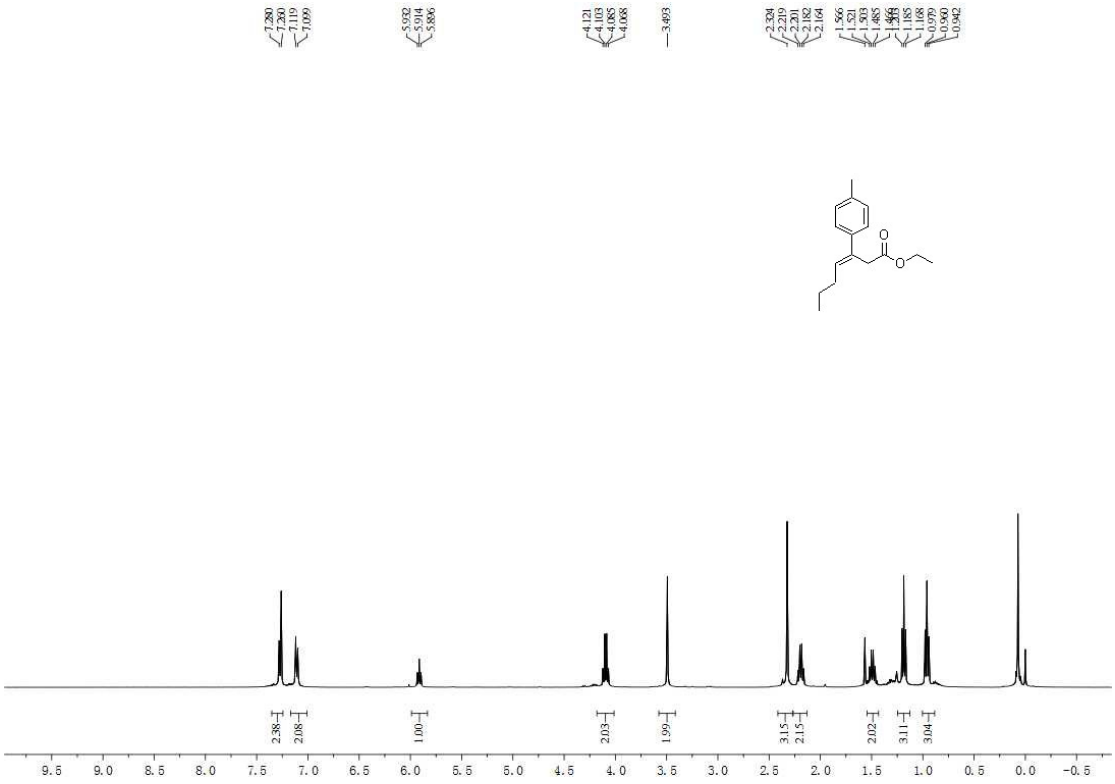

171.10
138.39
137.37
135.97
129.05
127.05
125.93
77.32
77.00
76.68
71.38
67.95
61.88
60.94
36.49
21.05
14.06

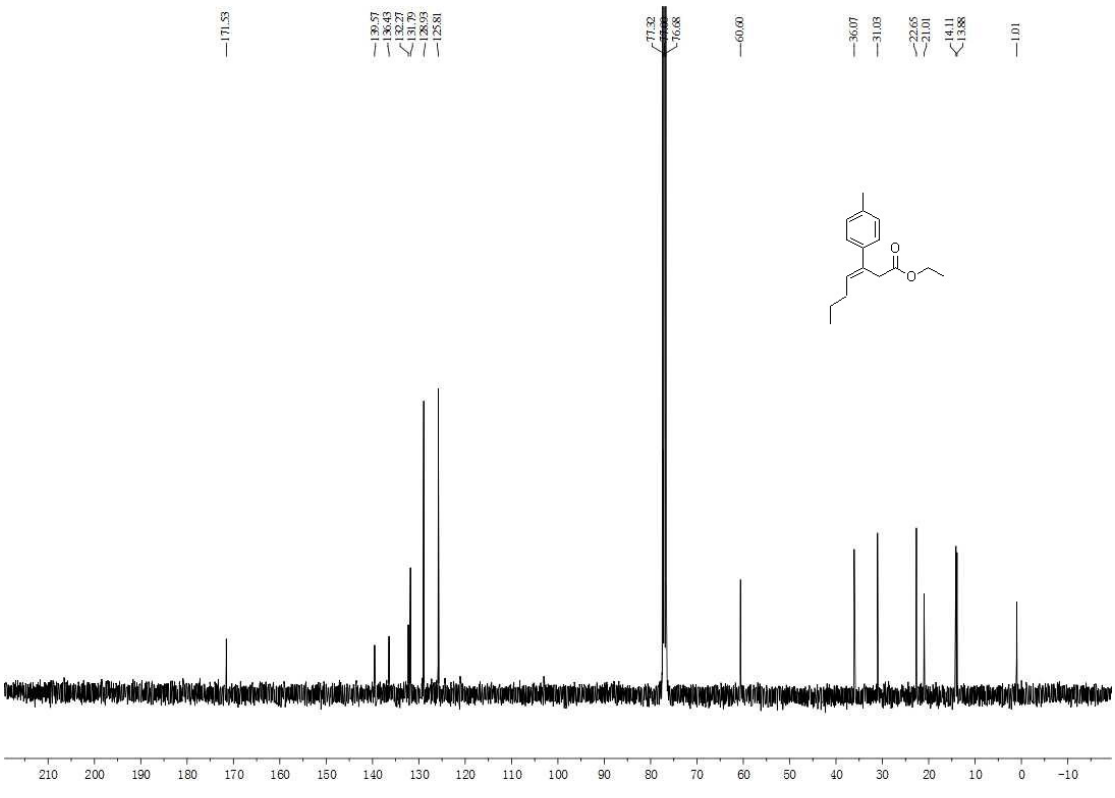
Product 4s



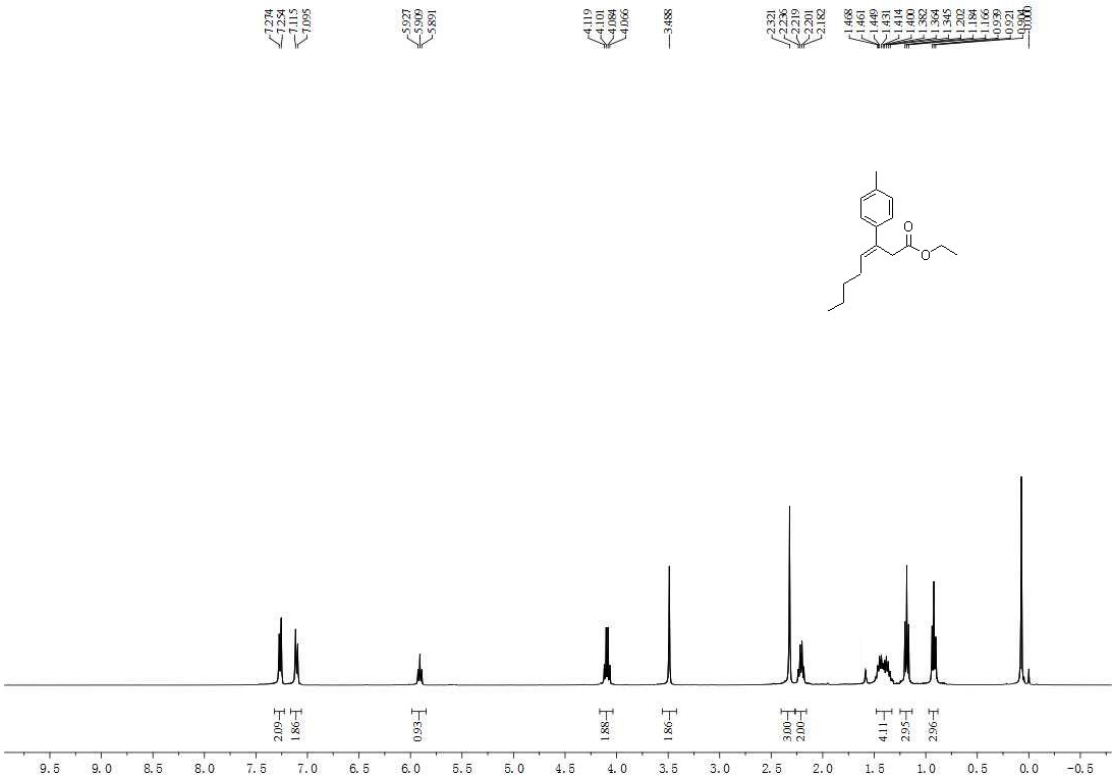


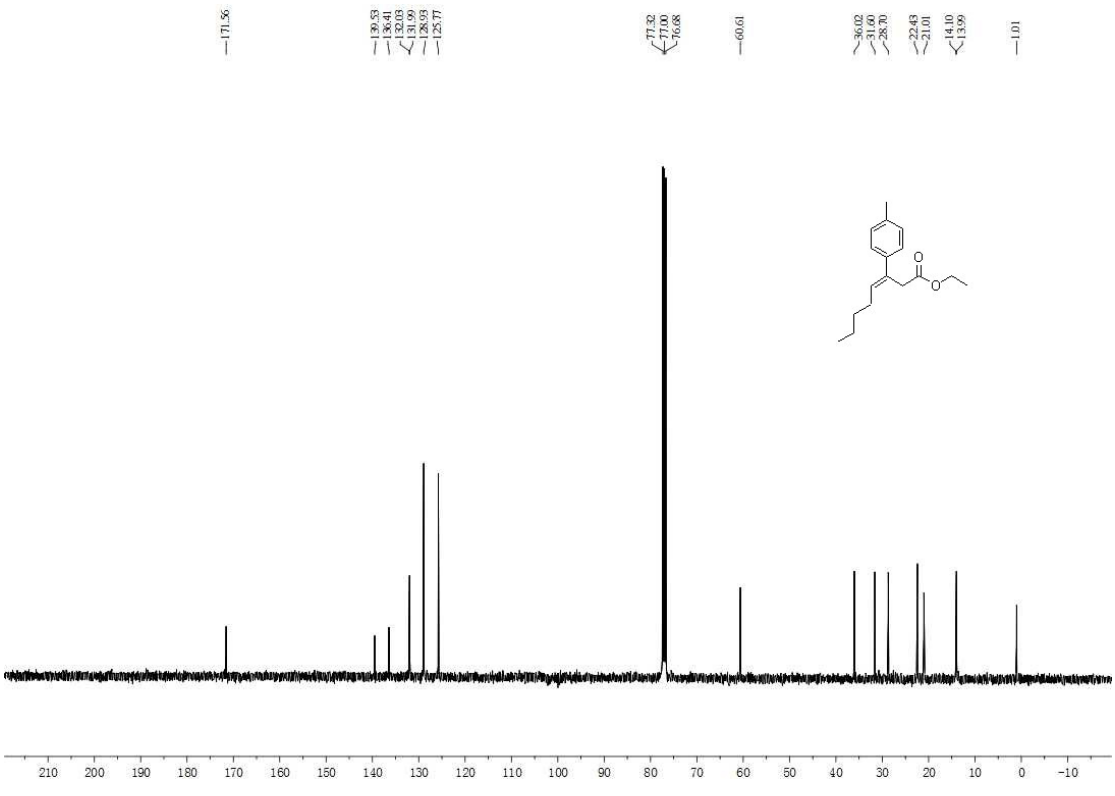
Product 4t



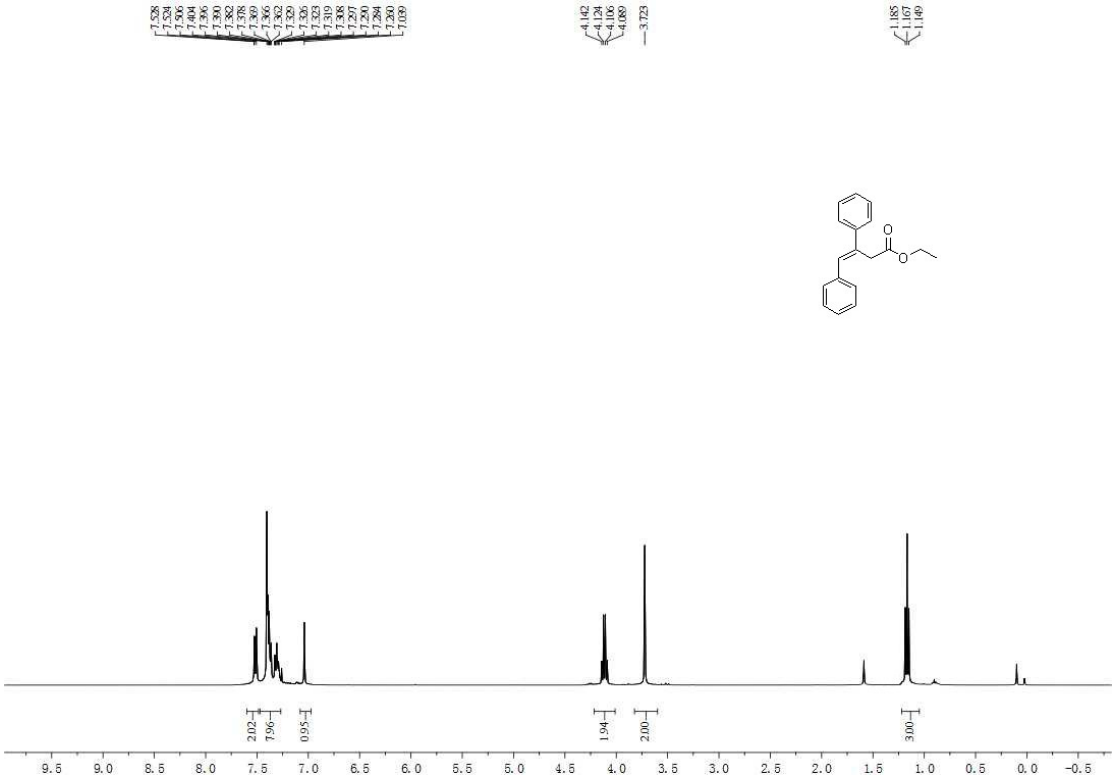


Product 4u





Product 5a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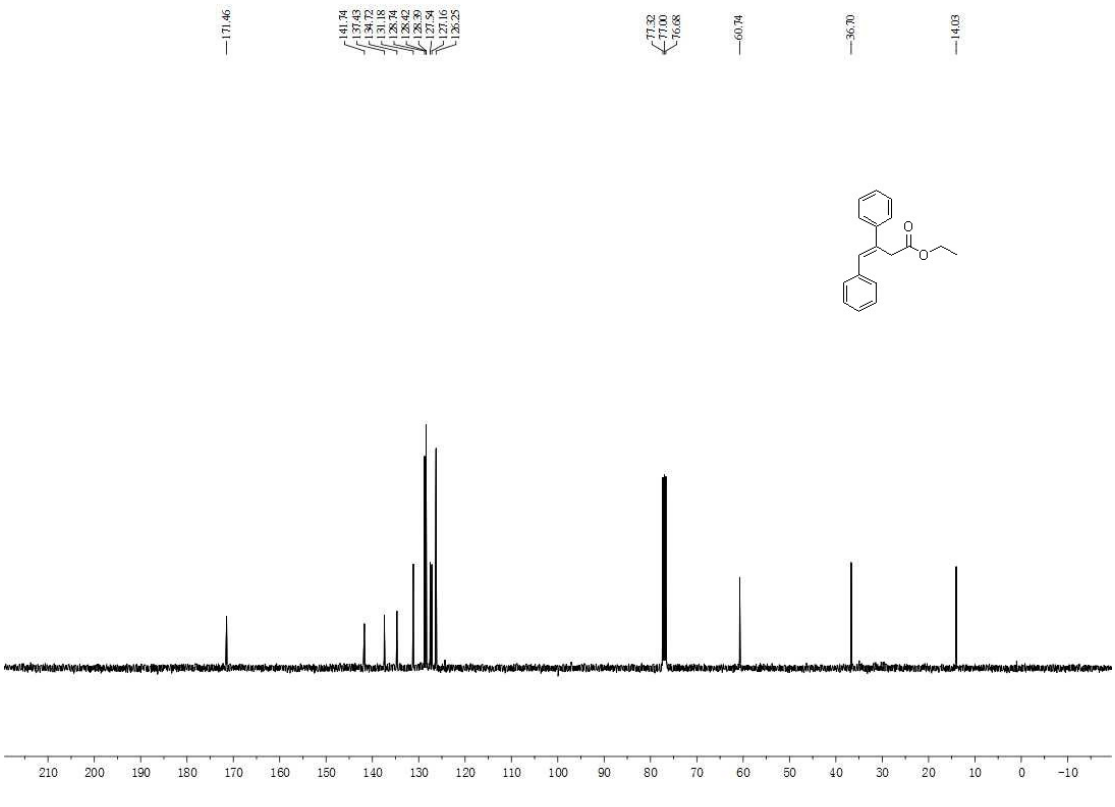
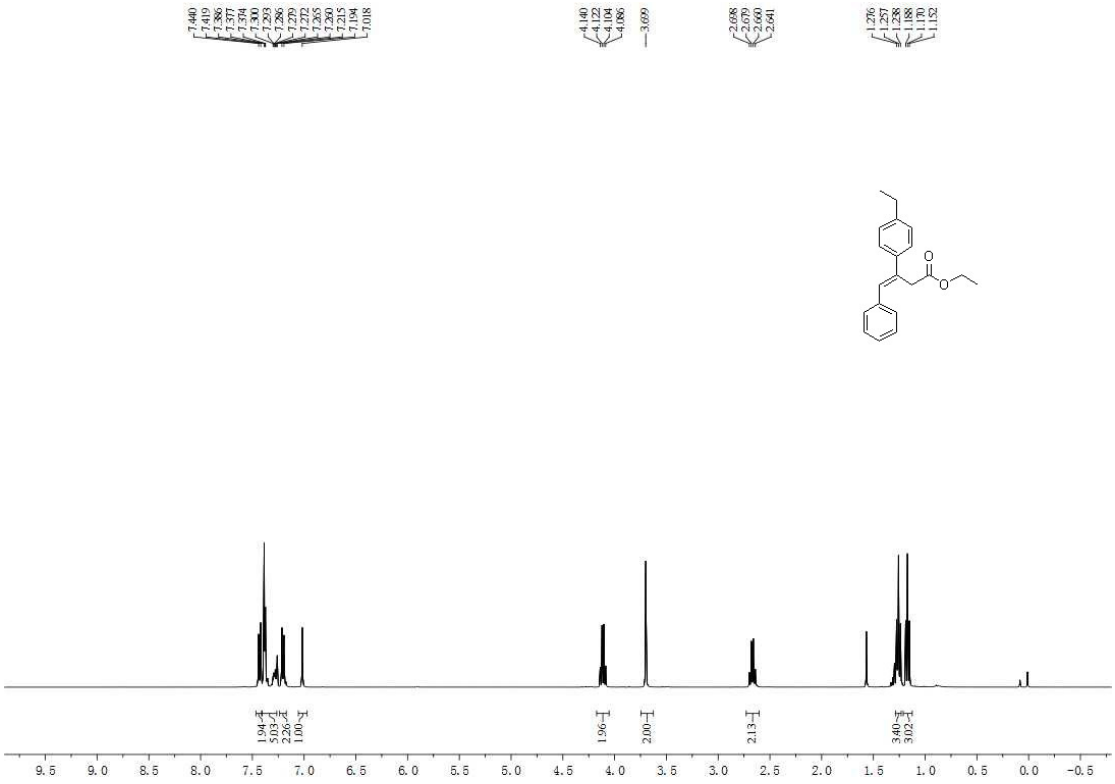
7.390
7.382
7.378
7.369
7.366
7.362
7.329
7.326
7.323
7.319
7.308
7.297
7.210
7.204
7.200
7.039
4.142
4.124
4.106
4.089
3.723
1.185
1.167
1.149
2.02
7.96
0.95
1.94
2.00
3.00


171.46
141.74
137.43
134.72
131.18
128.34
128.42
128.39
127.54
127.16
126.25
77.32
77.00
76.68
60.74
36.70
14.03

Product 5b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7.419
7.386
7.377
7.374
7.300
7.293
7.286
7.279
7.272
7.265
7.260
7.215
7.194
7.018
4.140
4.122
4.104
4.086
3.699
2.698
2.679
2.660
2.641
1.276
1.257
1.238
1.188
1.170
1.152
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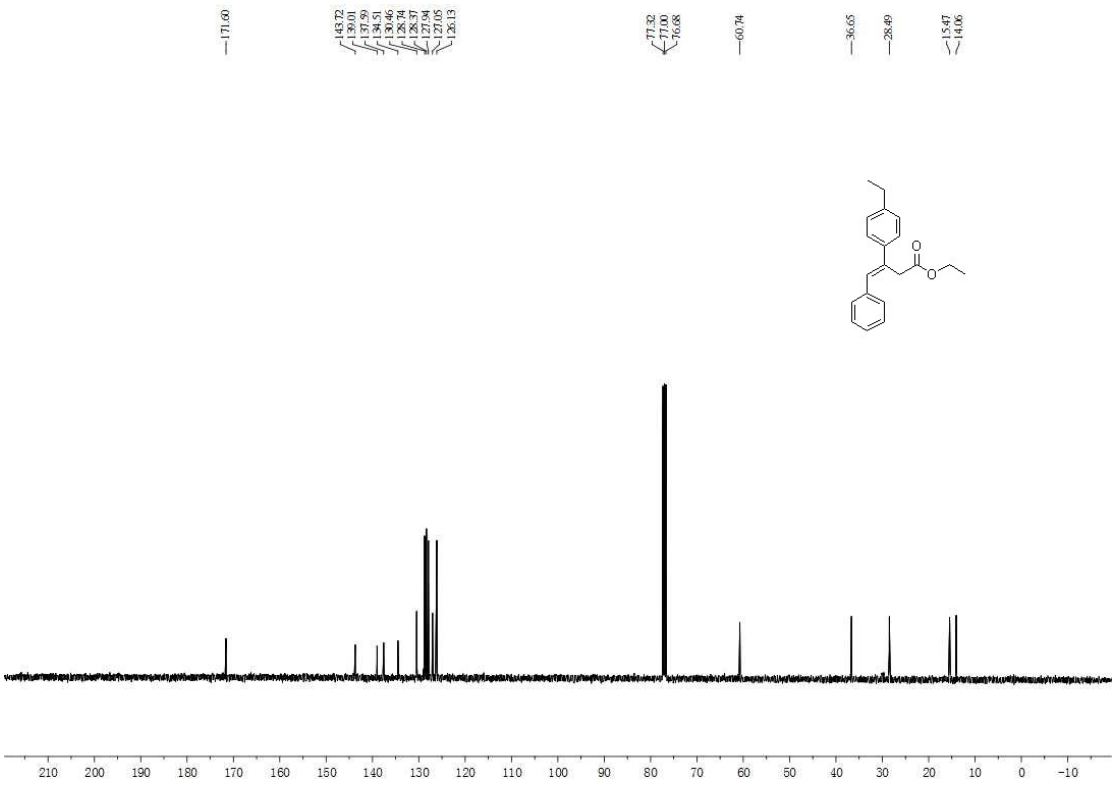
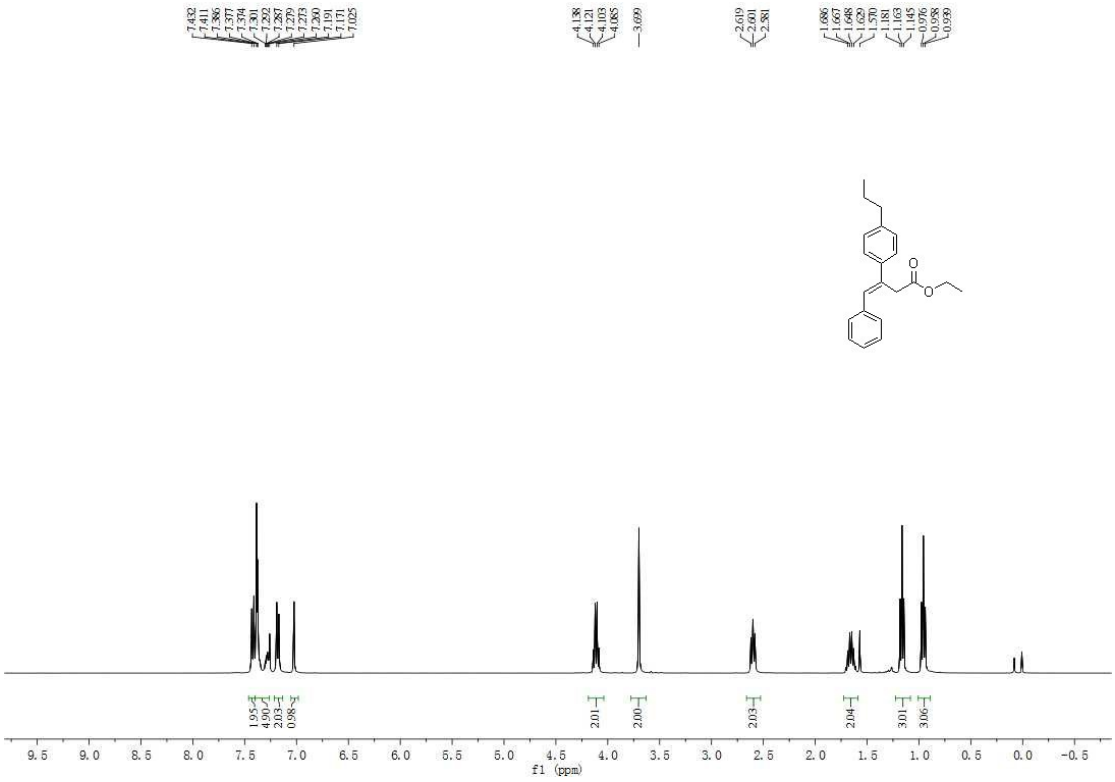
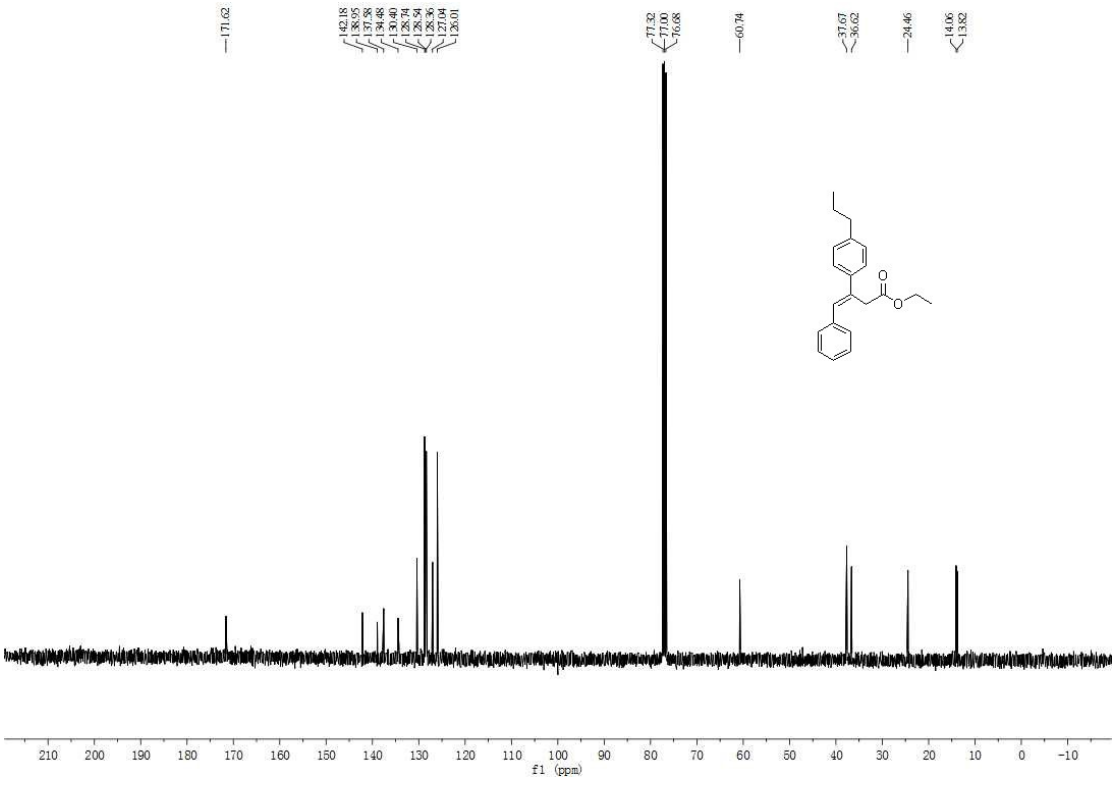
1.00
1.96
2.00
2.13
3.40
3.02

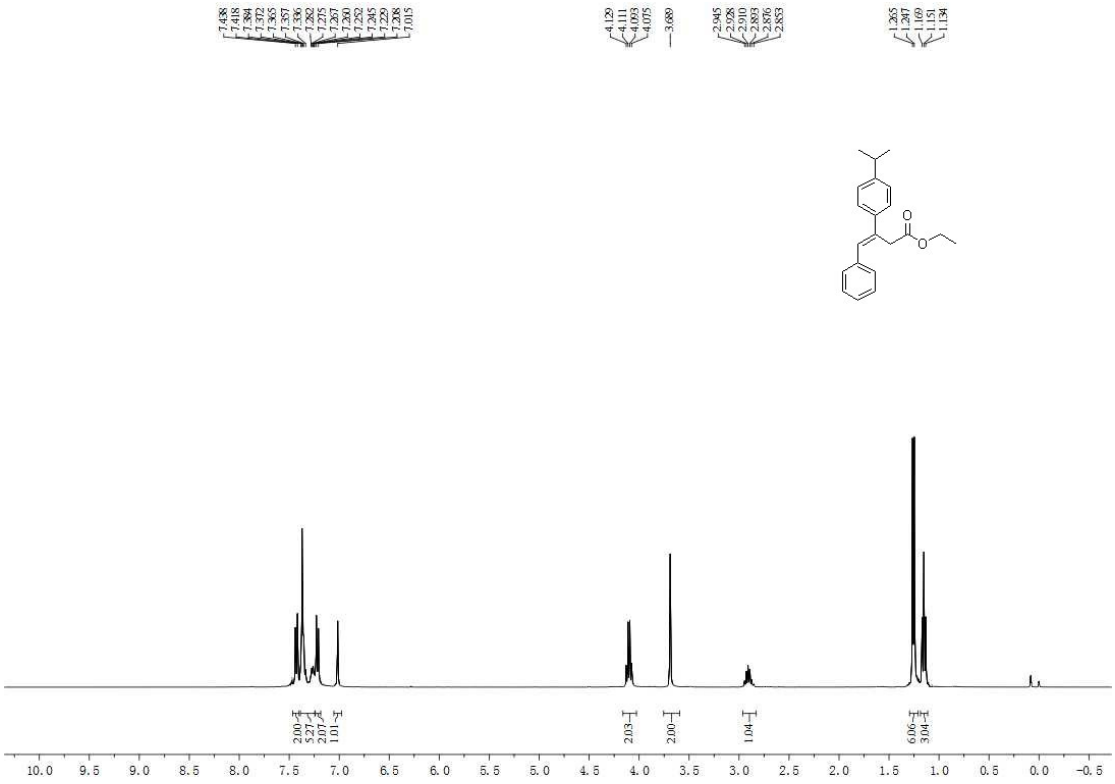

171.60
143.72
140.01
137.59
134.51
130.46
128.74
128.37
127.94
127.05
126.13
77.32
77.00
76.68
60.74
36.65
28.49
15.47
14.06

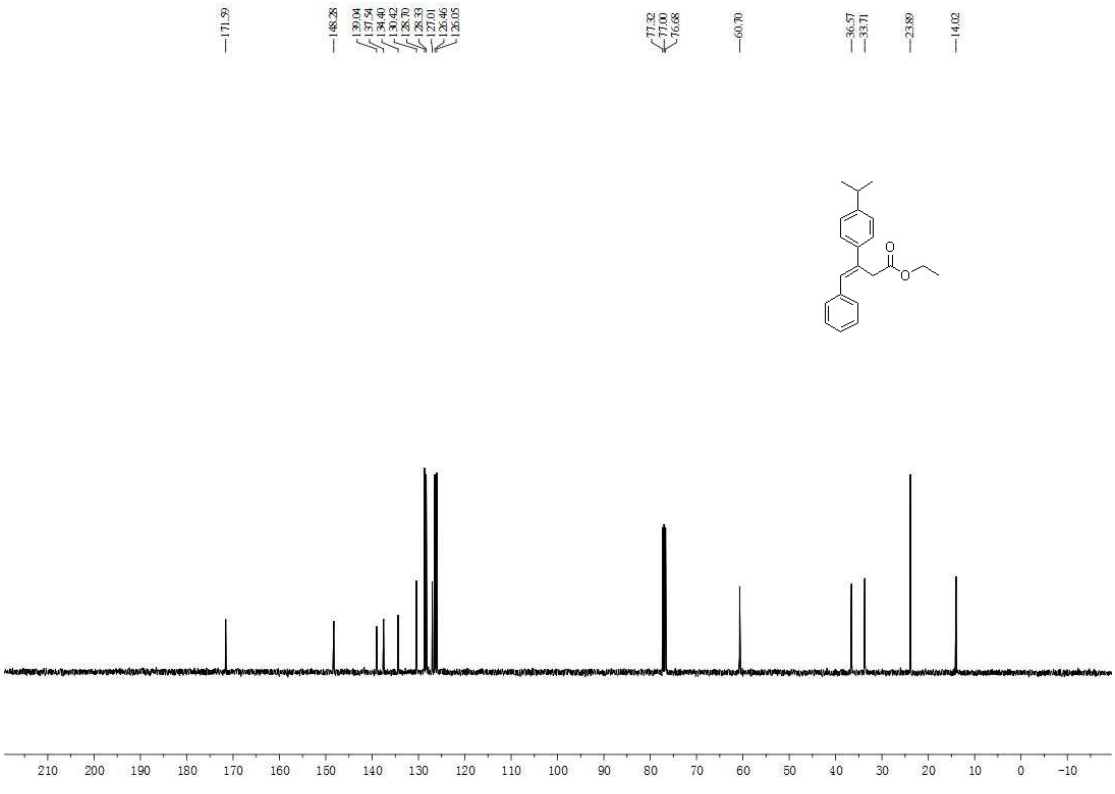
Product 5c


7.432
7.411
7.386
7.377
7.374
7.301
7.292
7.287
7.279
7.273
7.200
7.191
7.171
7.025
4.138
4.121
4.103
4.085
3.699
2.619
2.601
2.581
1.686
1.667
1.648
1.629
1.570
1.161
1.145
0.976
0.958
0.939
1.95
4.90
2.03
0.98
2.01
2.00
2.03
2.04
3.01
3.06
f1 (ppm)

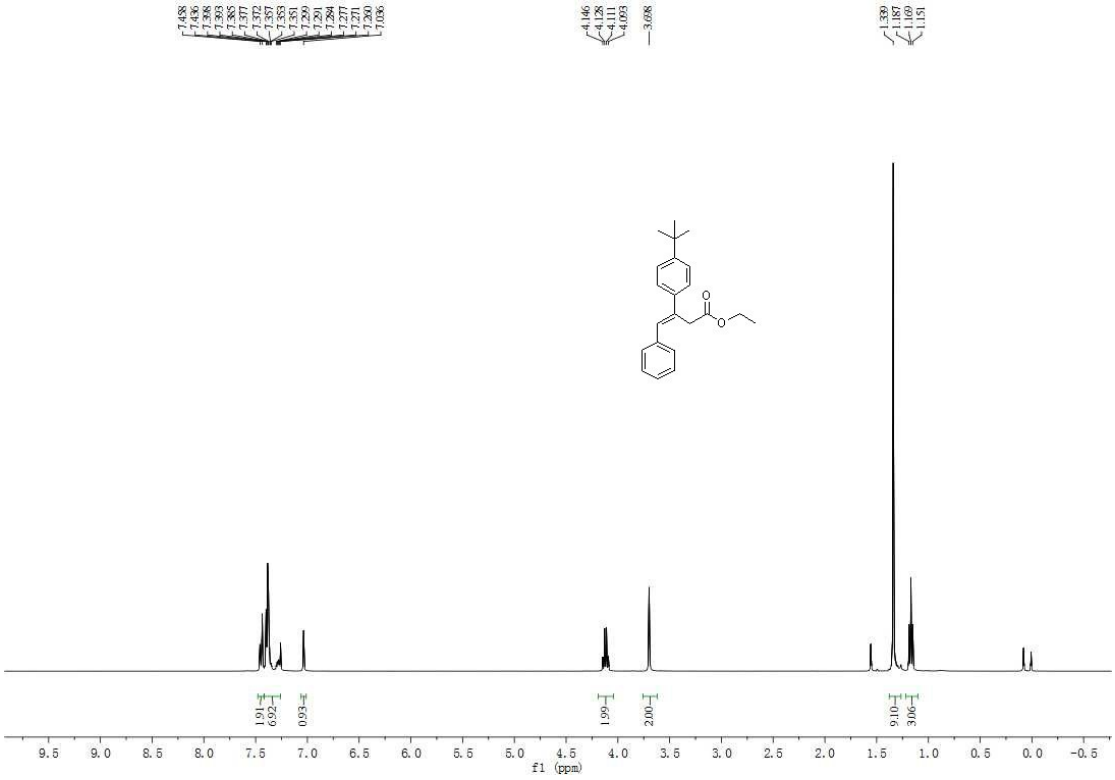

171.62
142.18
138.95
137.38
134.48
130.40
128.74
128.54
128.36
127.04
126.01
77.32
77.00
76.68
60.74
37.67
36.62
24.46
14.06
13.82
f1 (ppm)

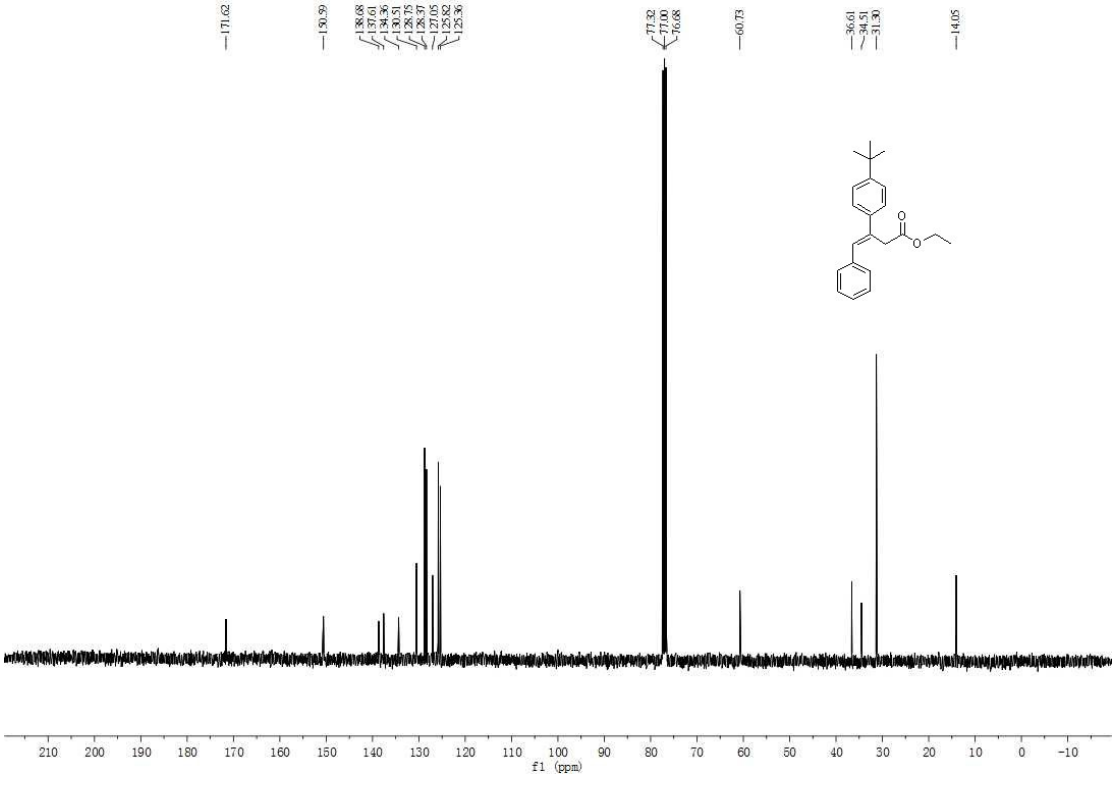
Product 5d



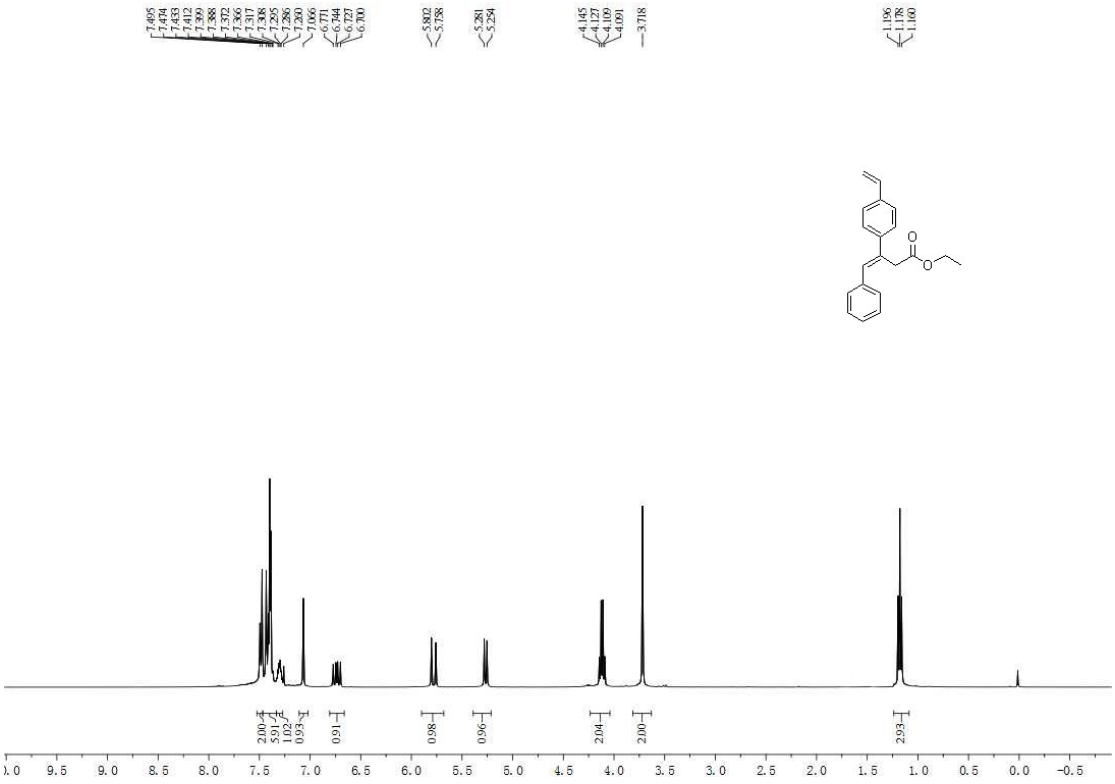


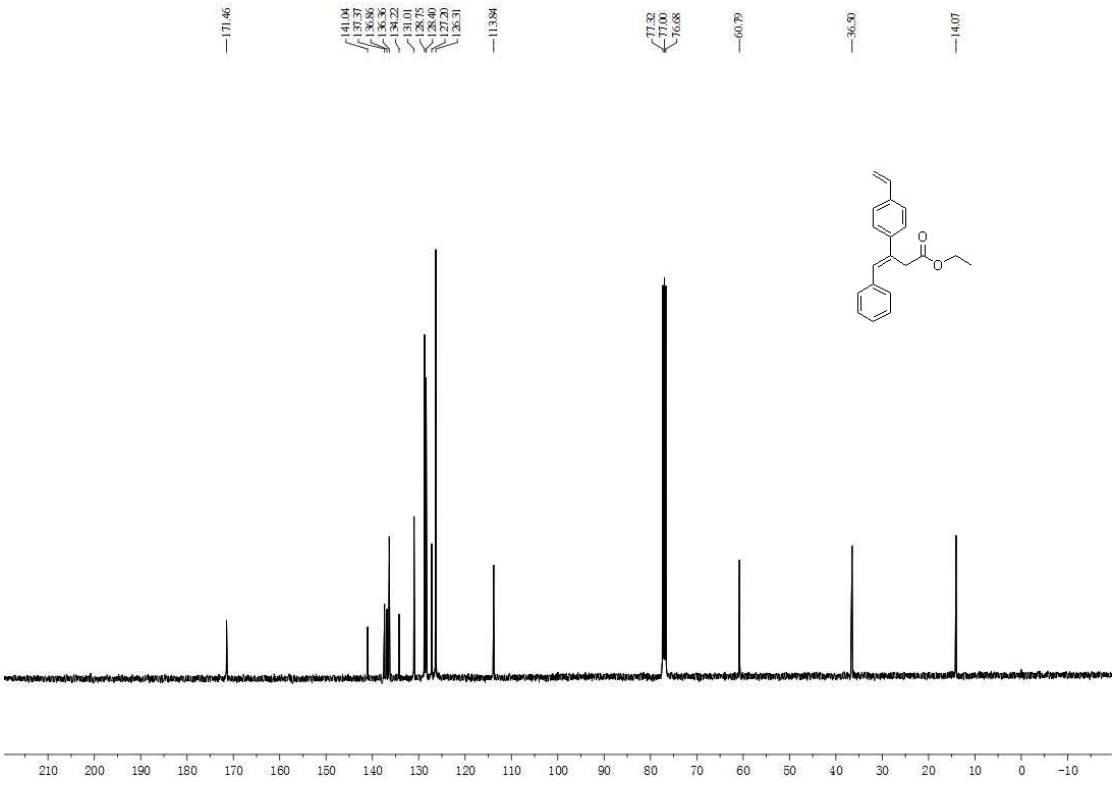
Product 5e


7.438
7.436
7.388
7.393
7.385
7.377
7.372
7.357
7.353
7.351
7.299
7.291
7.284
7.277
7.271
7.200
7.036
4.146
4.128
4.111
4.093
3.698
1.200
1.187
1.169
1.151
1.91
6.92
0.93
1.99
2.00
9.10
3.06
f1 (ppm)

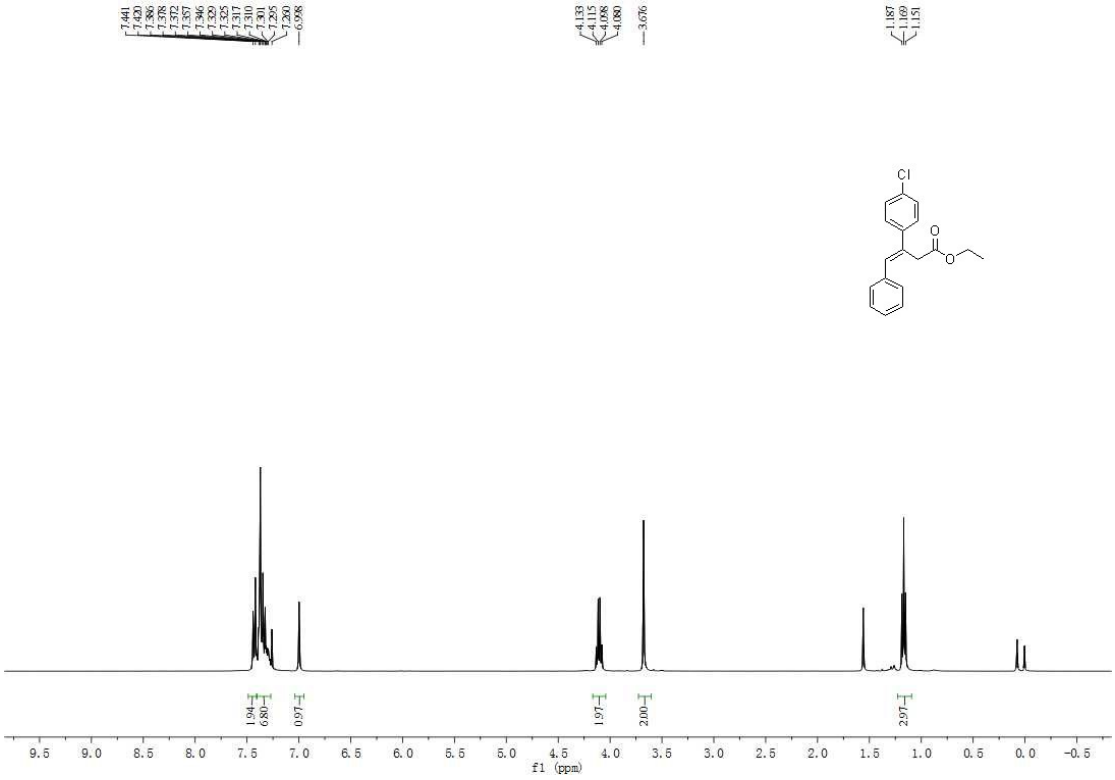

171.62
150.59
138.68
137.61
134.36
130.51
128.55
128.37
127.05
125.82
125.36
77.32
77.00
76.68
60.73
36.61
34.51
31.30
14.05
f1 (ppm)

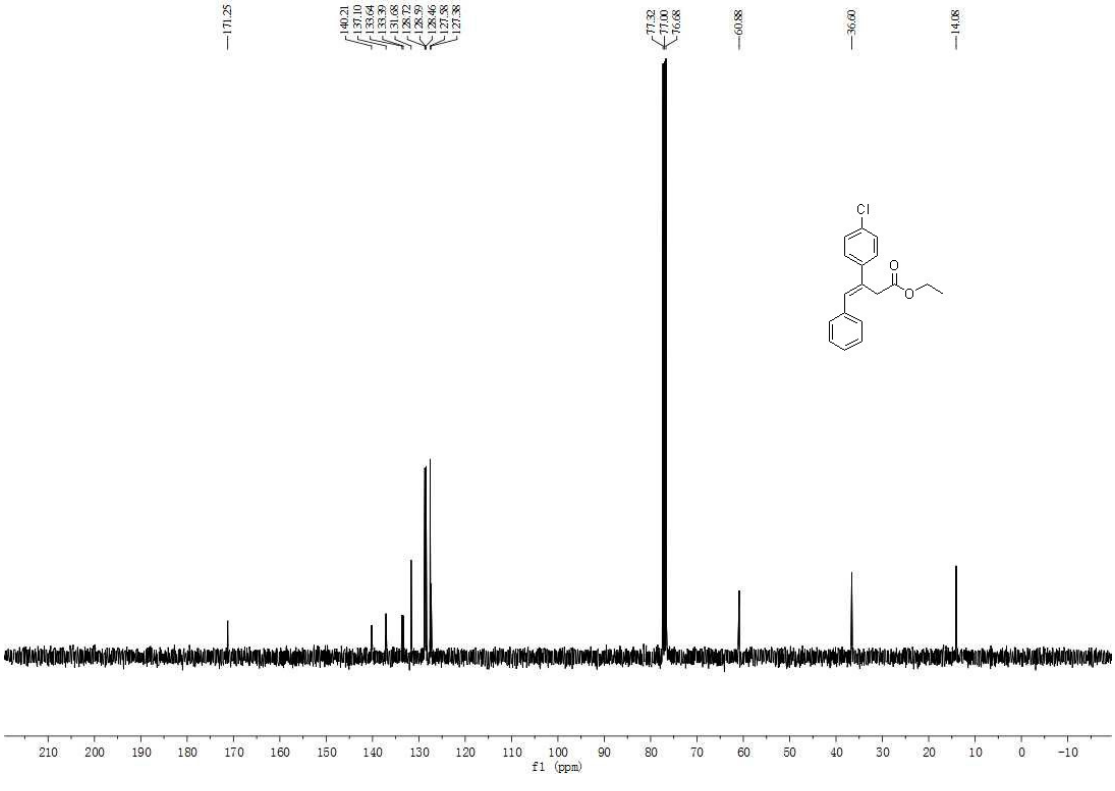
Product 5f


7.495
7.434
7.433
7.412
7.399
7.398
7.372
7.366
7.317
7.308
7.295
7.286
7.200
7.066
6.771
6.744
6.727
6.700
5.802
5.758
5.281
5.254
4.145
4.127
4.109
4.091
3.718
1.196
1.178
1.160
2.00
5.91
1.02
0.93
0.91
0.98
0.96
2.04
2.00
2.93

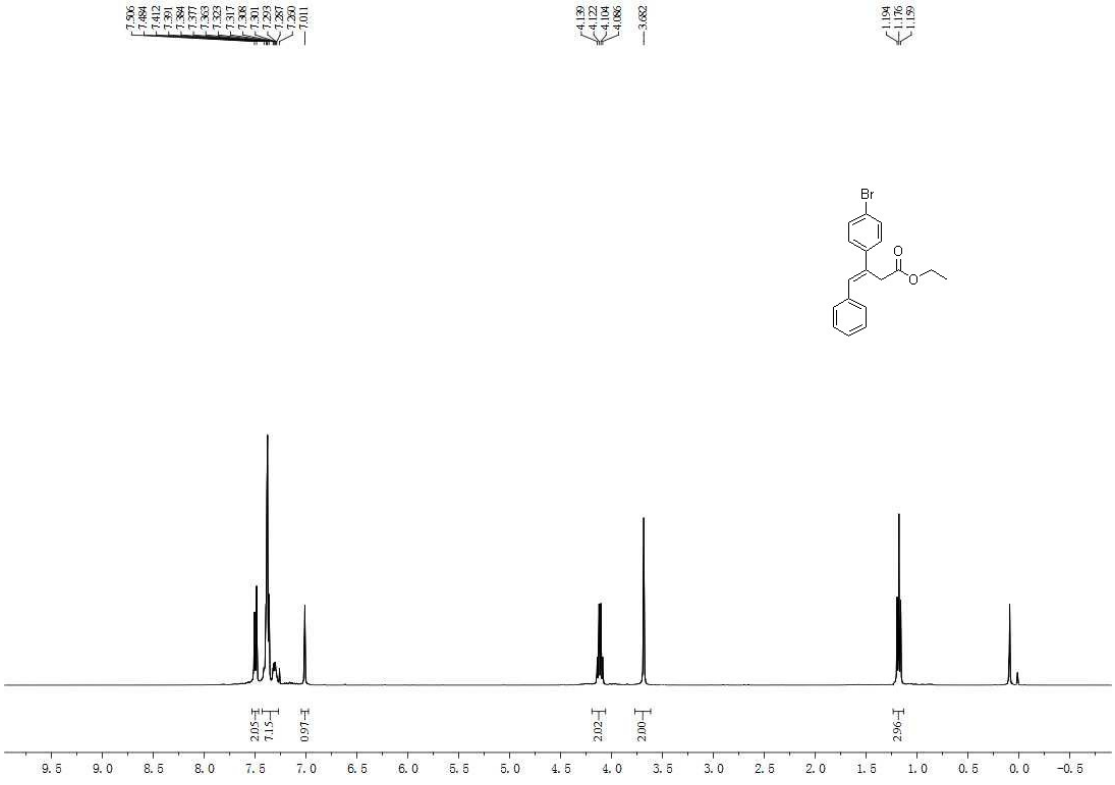

171.46
141.04
137.37
136.86
136.35
134.22
131.01
128.75
128.40
127.20
126.31
113.84
77.32
77.00
76.68
60.79
36.30
14.07

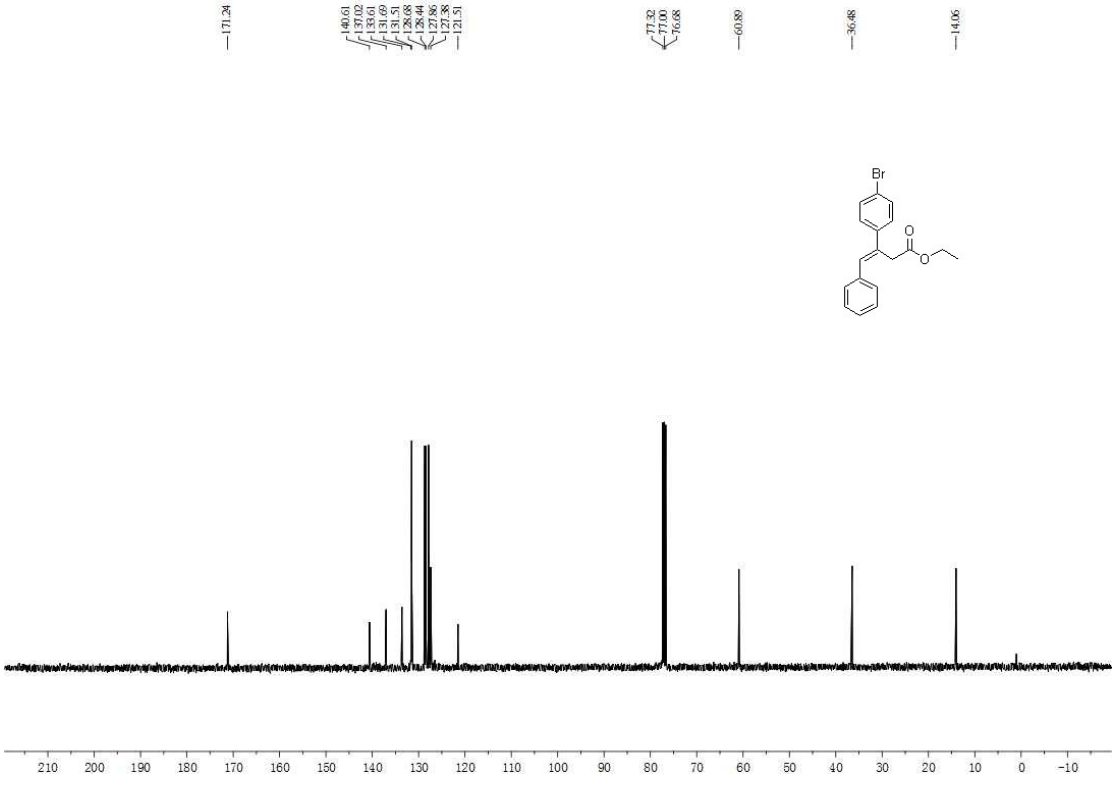
Product 5g


7.441
7.400
7.386
7.378
7.372
7.357
7.346
7.329
7.325
7.317
7.310
7.301
7.295
7.290
6.998
4.133
4.115
4.098
4.080
3.676
1.187
1.169
1.151
Cl
O
O
1.94
6.80
0.97
1.97
2.00
2.97
f1 (ppm)


171.25
140.21
137.10
133.64
131.39
131.08
128.72
128.59
128.46
127.58
127.38
77.32
77.00
76.68
60.88
36.60
14.08
Cl
O
O
f1 (ppm)

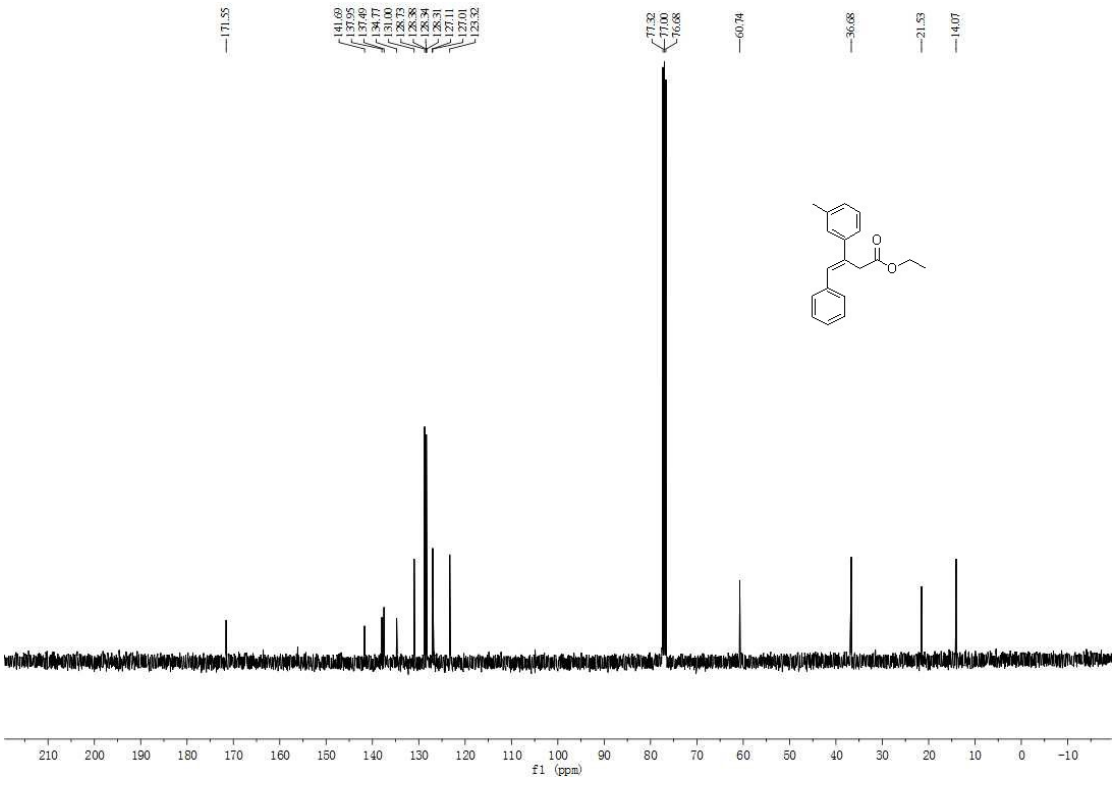
Product 5h


7.506
7.494
7.412
7.391
7.384
7.377
7.363
7.323
7.317
7.308
7.301
7.293
7.287
7.280
7.011
4.139
4.122
4.104
4.086
3.682
1.194
1.176
1.159
Br
O
O
2.05
7.15
0.97
2.02
2.00
2.96

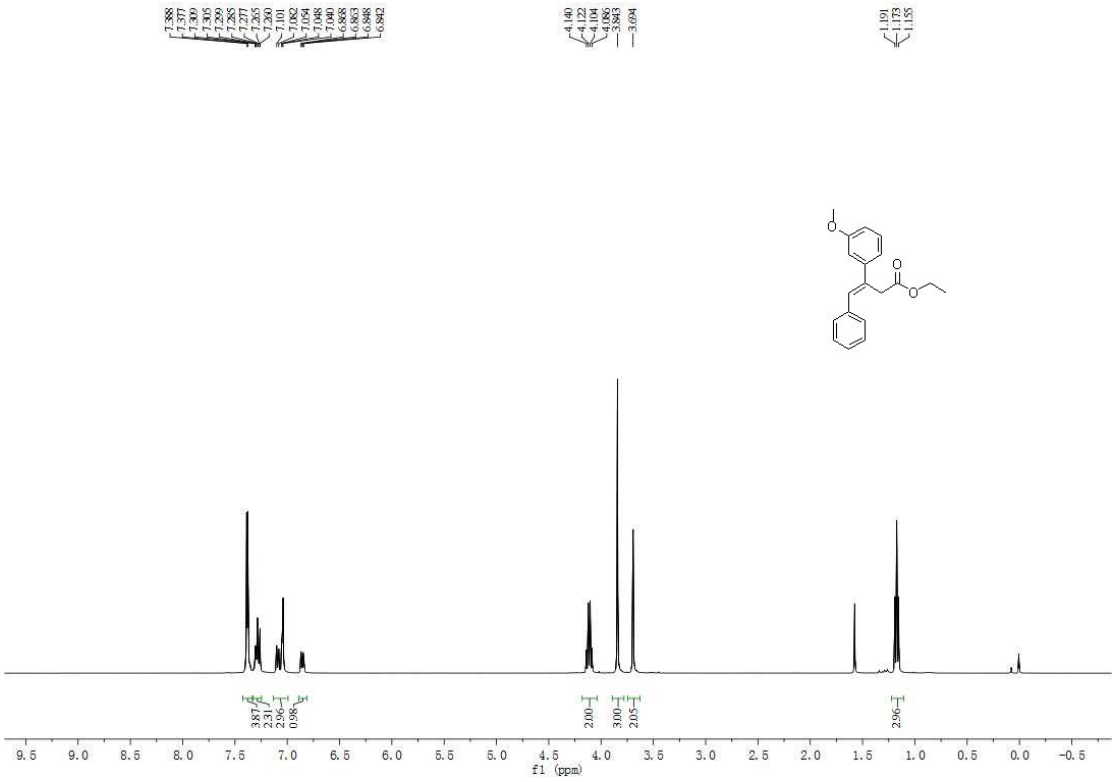

171.24
140.61
137.02
133.61
131.69
131.53
128.68
128.44
127.86
127.38
121.51
77.32
77.00
76.68
60.89
36.48
14.06
Br
O
O

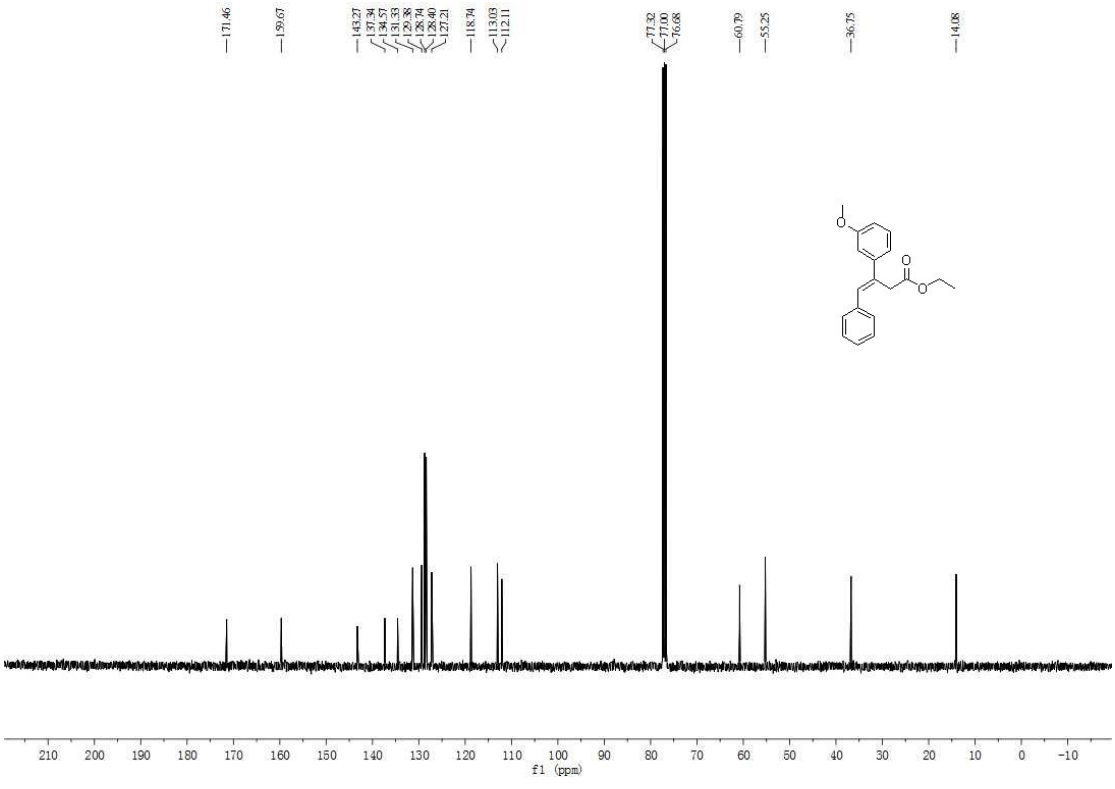
Product 5i


7.388
7.378
7.324
7.308
7.294
7.289
7.286
7.278
7.260
7.241
7.130
7.112
7.018
4.140
4.122
4.104
4.086
3.703
2.387
1.189
1.171
1.153
3.90
4.48
1.03
1.00
2.01
2.00
3.03
3.02
f1 (ppm)

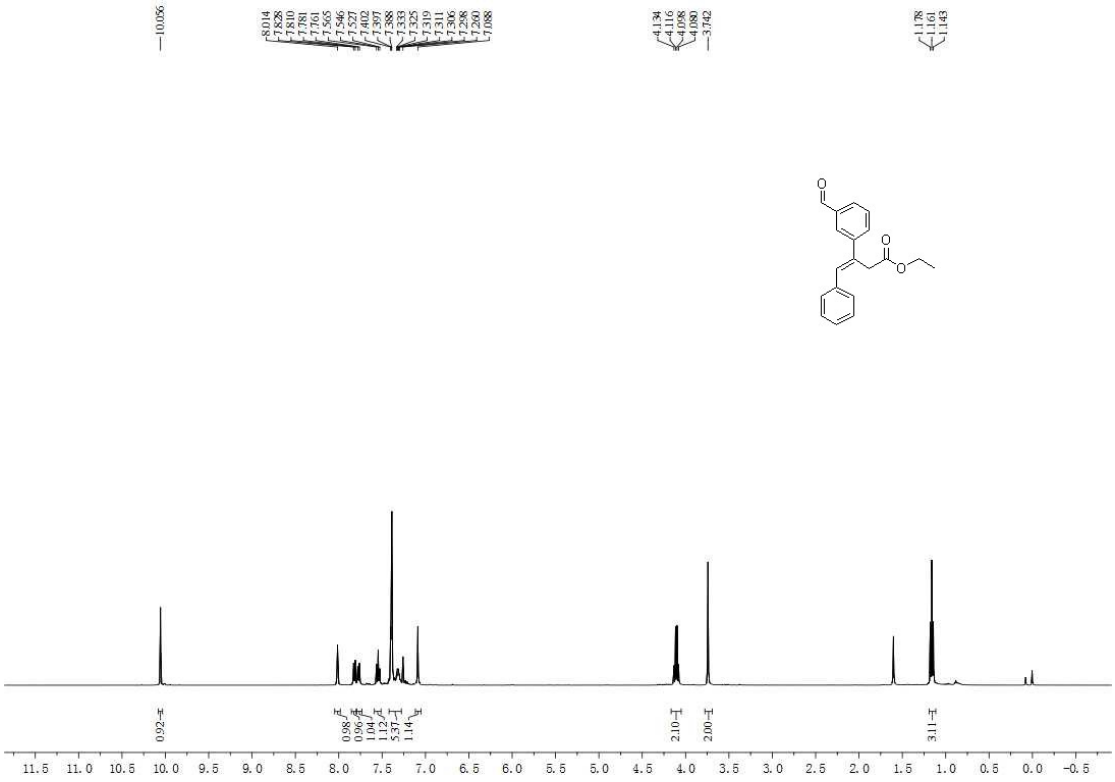

171.55
141.69
137.95
137.49
134.77
131.00
128.73
128.38
128.34
128.31
127.11
127.01
125.32
77.32
77.00
76.68
60.74
36.68
21.53
14.07
f1 (ppm)

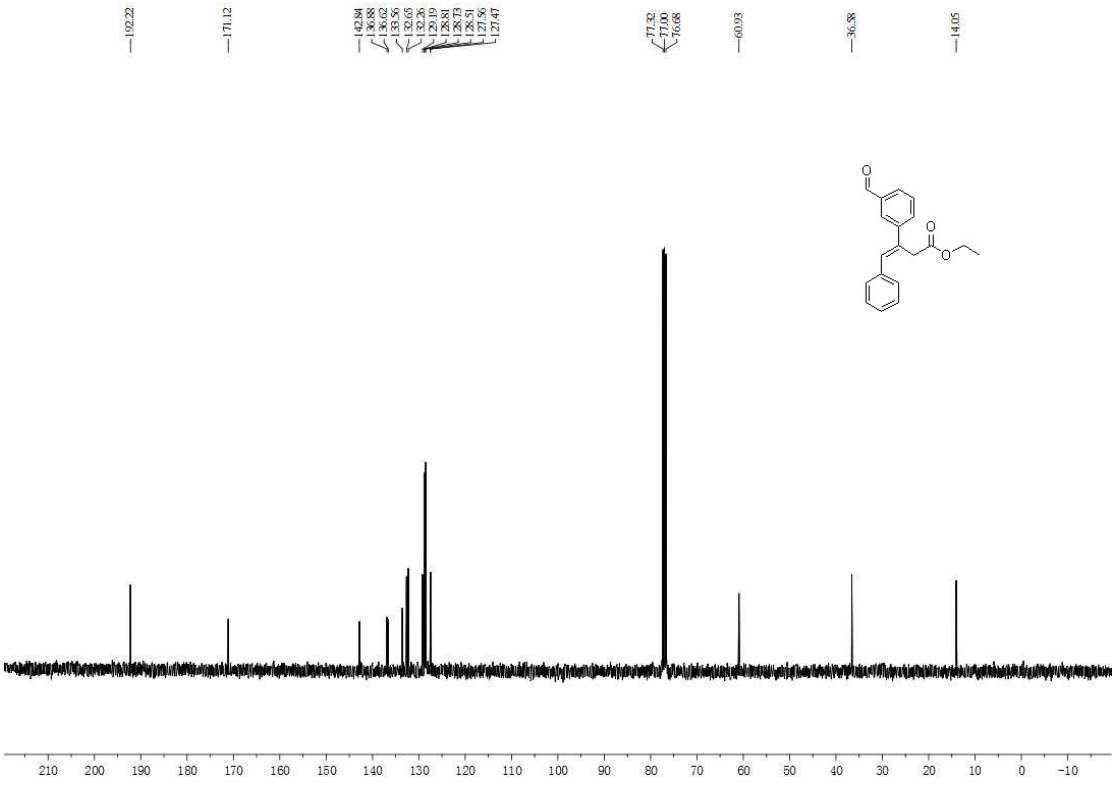
Product 5j


7.388
7.377
7.309
7.305
7.299
7.285
7.277
7.265
7.260
7.101
7.082
7.054
7.048
7.040
6.888
6.883
6.846
6.842
4.140
4.122
4.104
4.086
3.695
3.694
1.191
1.173
1.155
3.67
2.31
2.96
0.98
2.00
3.00
2.05
2.96
f1 (ppm)

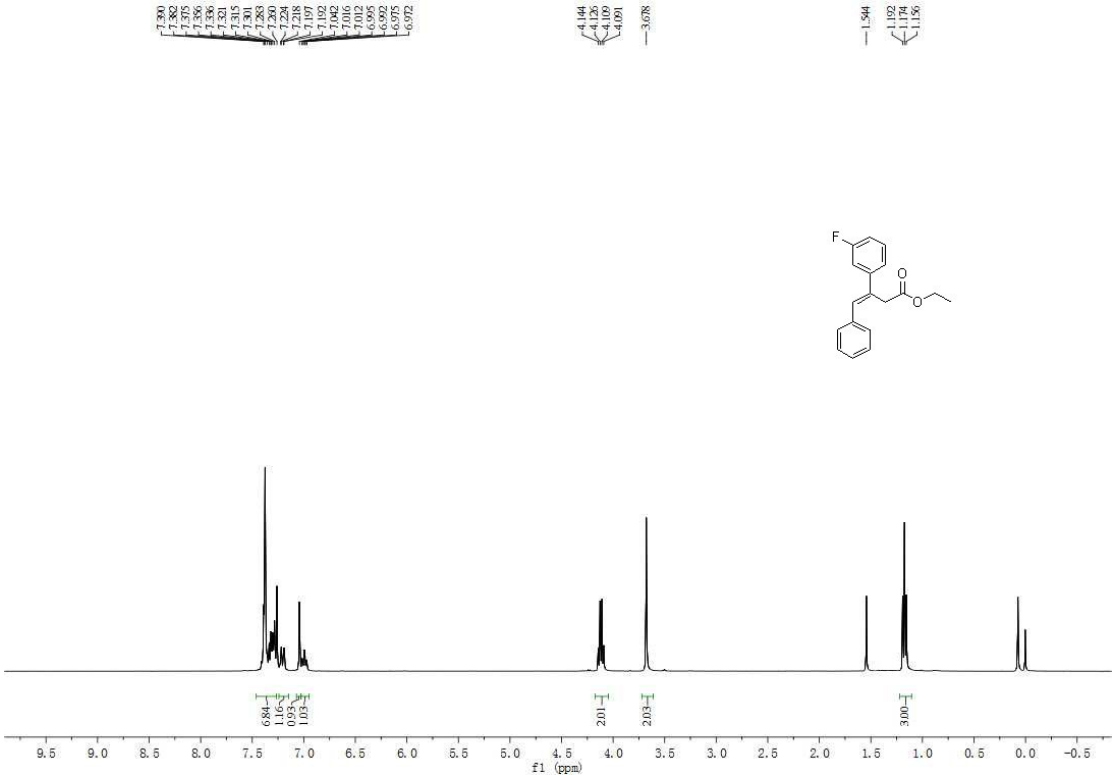

171.46
159.67
143.27
137.34
134.57
131.33
129.38
128.74
128.40
127.21
118.74
113.03
112.11
77.32
77.00
76.68
60.79
55.25
36.75
14.08
f1 (ppm)

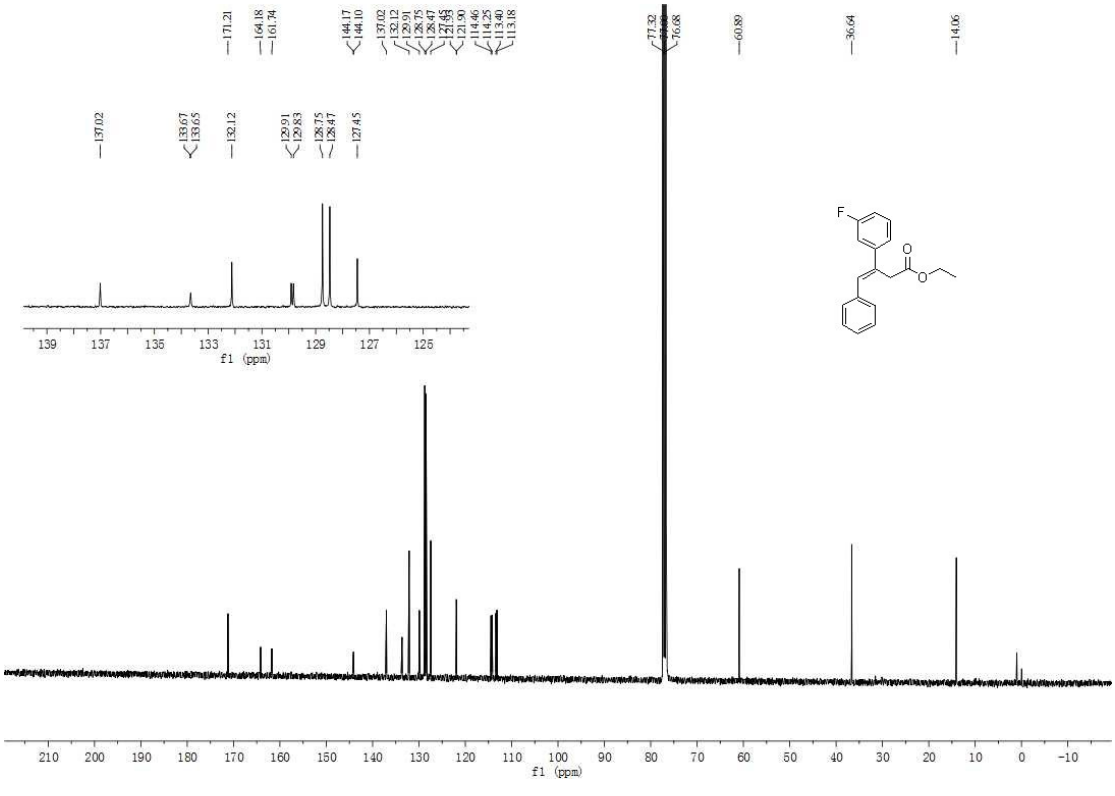
Product 5k


10.056
8.014
7.828
7.810
7.781
7.761
7.565
7.546
7.527
7.402
7.397
7.388
7.333
7.325
7.319
7.311
7.306
7.298
7.260
7.088
4.134
4.116
4.098
4.080
3.742
1.178
1.161
1.143
0.92
0.98
0.96
1.04
1.12
5.37
1.14
2.10
2.00
3.11
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5

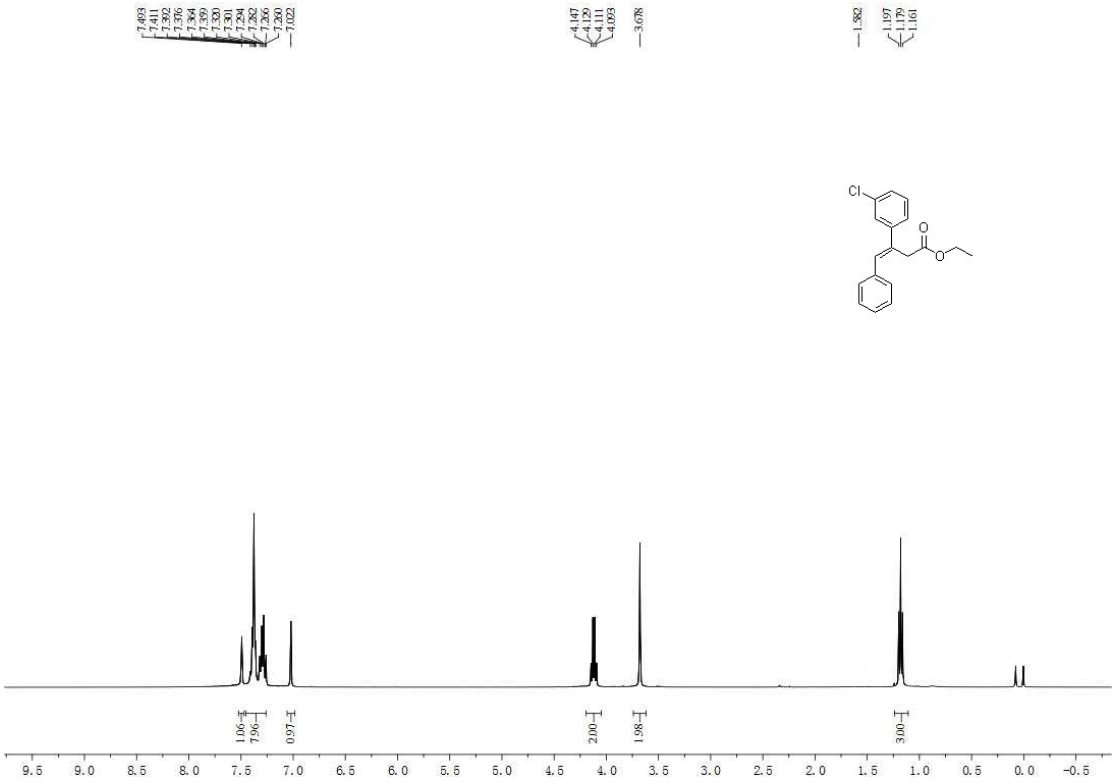

192.22
171.12
142.84
136.88
136.62
133.56
132.65
132.26
129.19
128.81
128.73
128.51
127.56
127.47
77.32
77.00
76.68
60.93
36.58
14.05
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

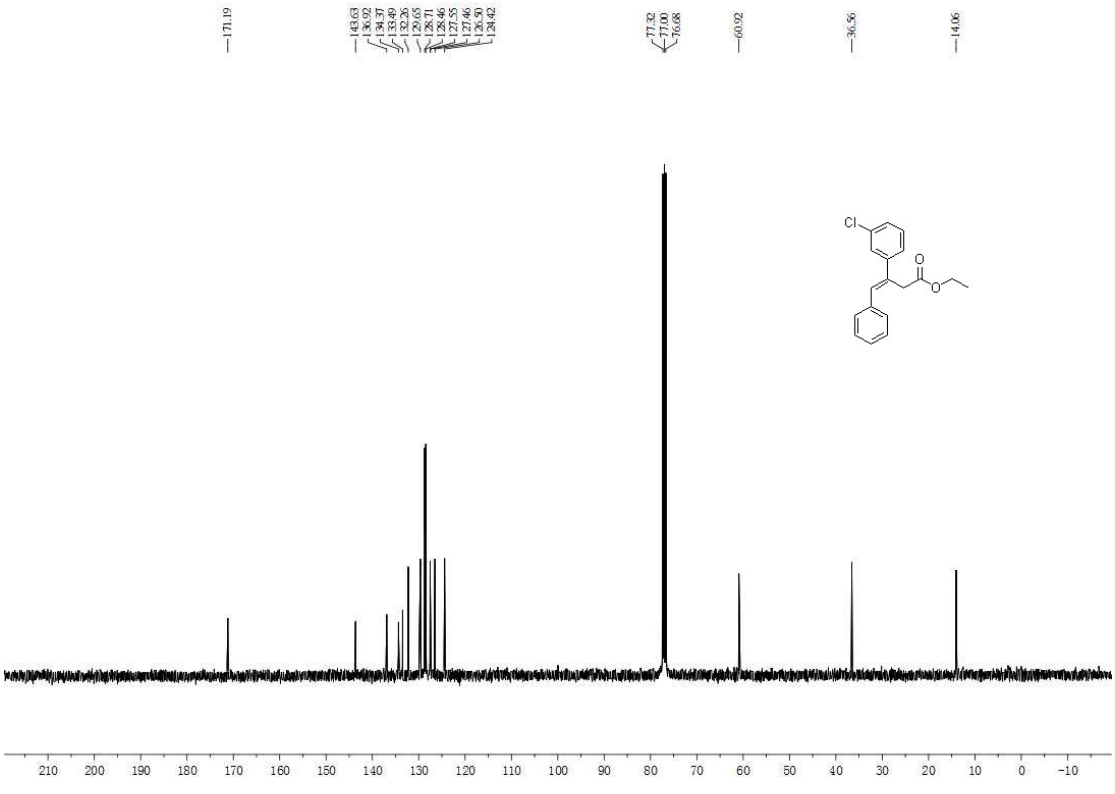
Product 5l


7.300
7.382
7.375
7.366
7.306
7.321
7.315
7.301
7.283
7.280
7.224
7.218
7.197
7.192
7.042
7.016
7.012
6.995
6.992
6.975
6.972
4.144
4.126
4.109
4.091
3.678
1.594
1.192
1.174
1.156
F
O
O
6.84
1.16
0.93
1.03
2.01
2.03
3.00
f1 (ppm)

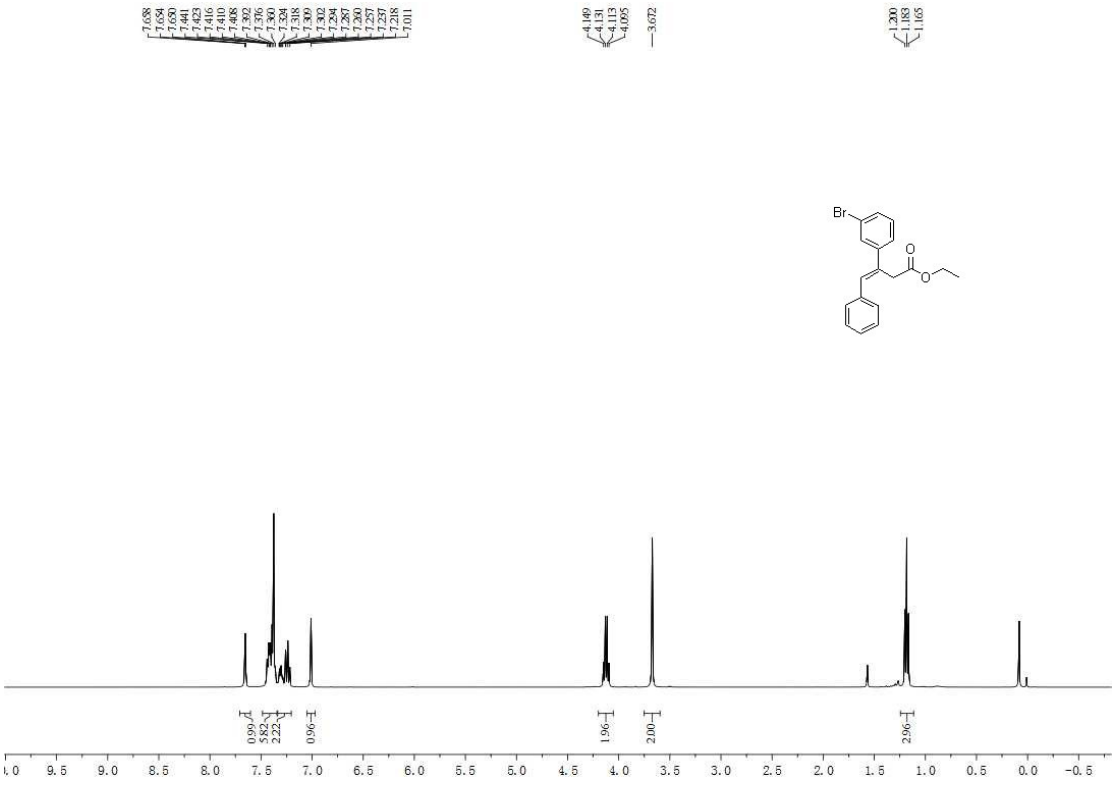

171.21
164.18
161.74
144.17
144.10
137.02
133.67
133.65
132.12
129.91
129.83
128.75
128.47
127.45
121.90
114.46
114.25
113.40
113.18
77.32
76.68
60.89
36.64
14.06
F
O
O
f1 (ppm)

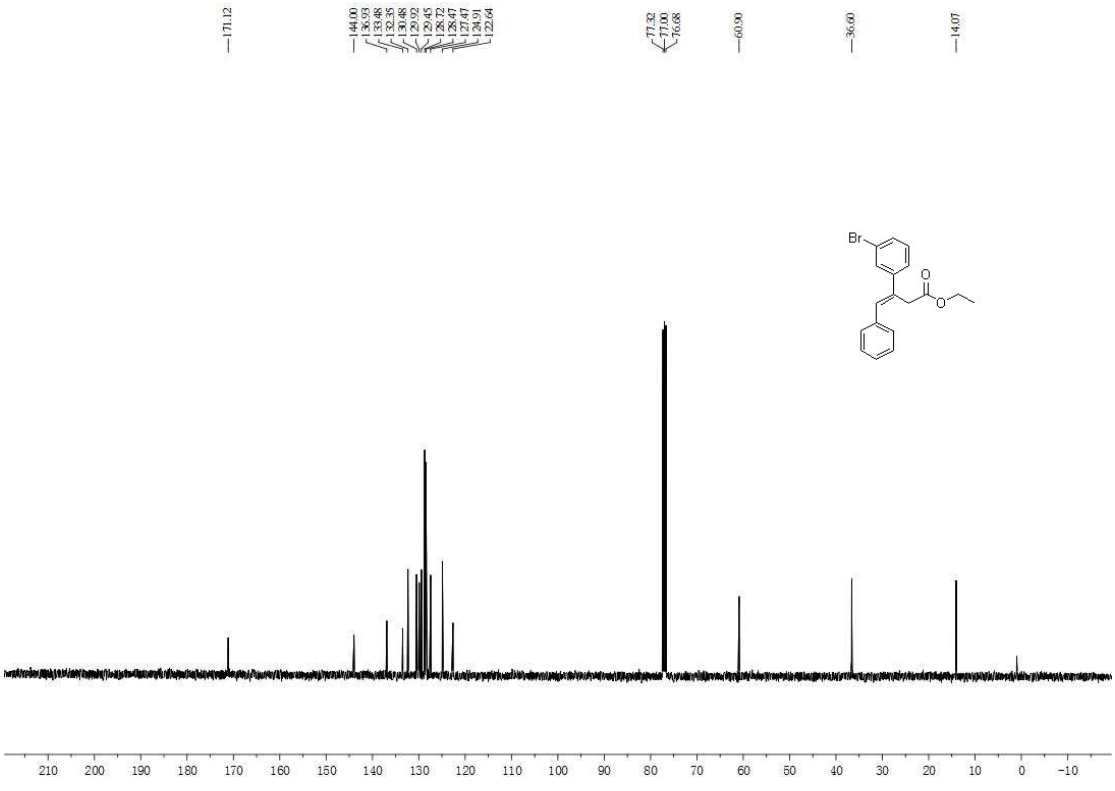
Product 5m


7.403
7.411
7.392
7.376
7.364
7.339
7.320
7.301
7.284
7.282
7.266
7.260
7.022
4.147
4.129
4.111
4.093
3.678
1.582
1.197
1.179
1.161
Cl
O
O
1.06
7.96
0.97
2.00
1.98
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

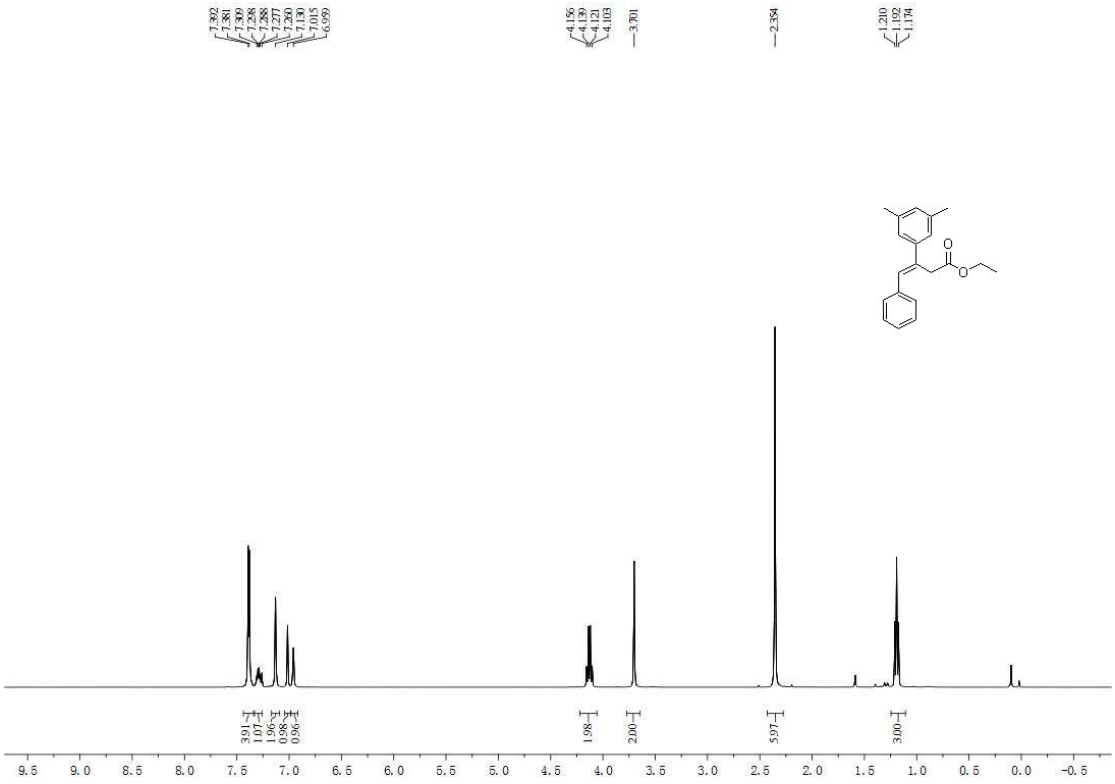

171.19
143.63
136.92
134.37
133.49
132.26
129.65
128.71
128.46
127.55
127.46
126.50
124.42
77.32
77.00
76.68
60.92
36.56
14.06
Cl
O
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

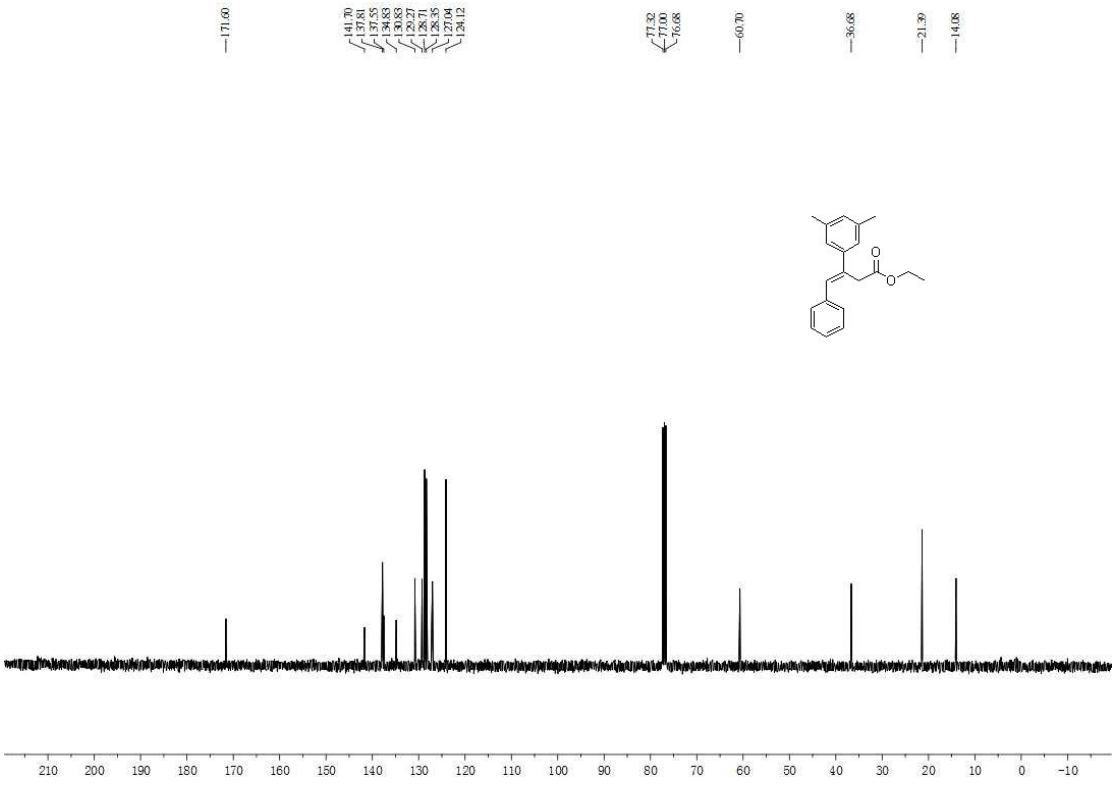
Product 5n


7.658
7.654
7.650
7.644
7.421
7.416
7.410
7.408
7.392
7.376
7.300
7.324
7.318
7.309
7.302
7.294
7.287
7.300
7.257
7.237
7.218
7.011
4.149
4.131
4.113
4.095
3.672
1.200
1.183
1.165
Br
O
O
0.99
5.82
2.22
0.96
1.96
2.00
2.96

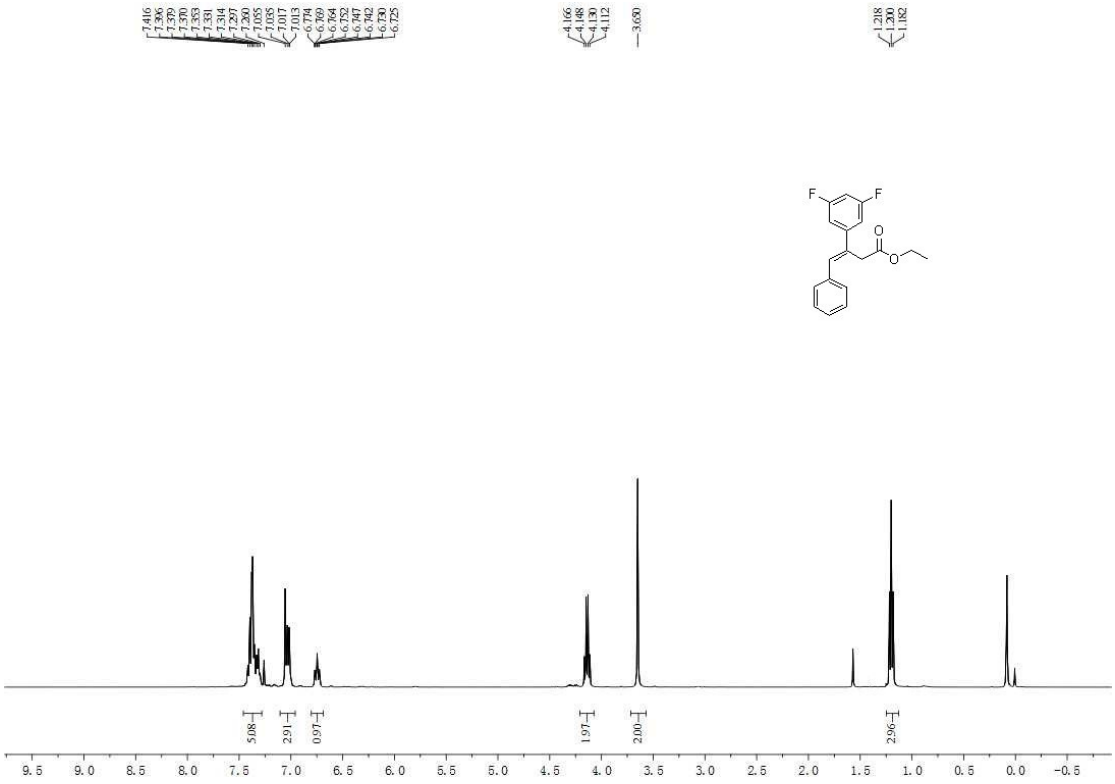

171.12
144.00
136.68
133.48
132.35
130.48
129.92
129.45
128.72
128.47
127.67
127.01
122.64
77.32
77.00
76.68
60.90
36.60
14.07
Br
O
O

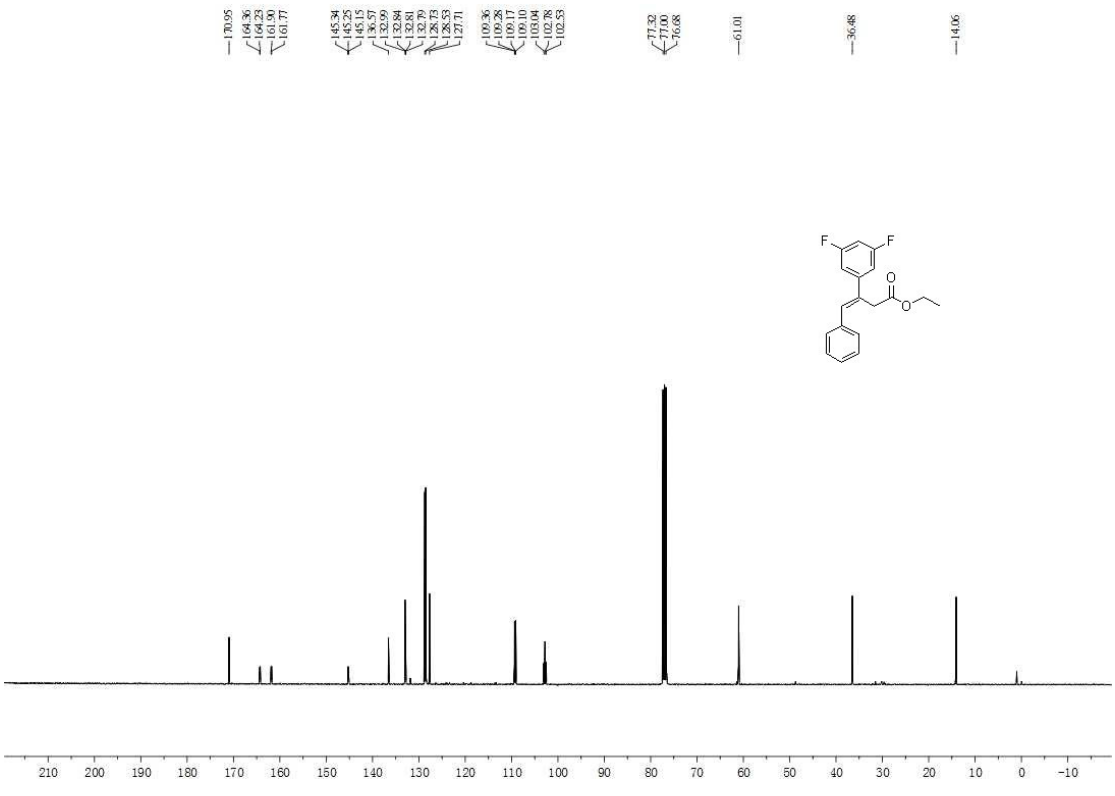
Product 5o


7.392
7.381
7.369
7.288
7.288
7.277
7.260
7.130
7.015
6.999
4.156
4.139
4.121
4.103
3.701
2.394
1.210
1.192
1.174
3.91
1.07
1.96
0.98
0.96
1.98
2.00
5.97
3.00

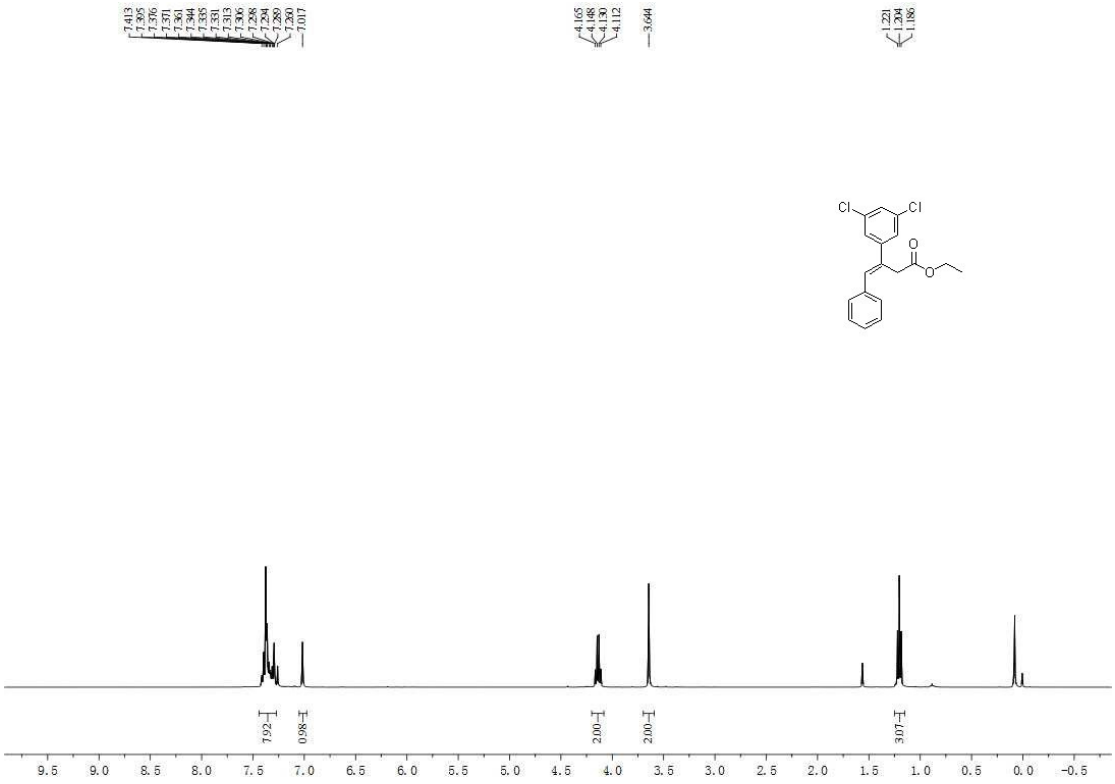

171.60
141.70
137.81
137.55
134.83
130.83
129.27
128.71
128.35
127.04
124.12
77.32
77.00
76.68
60.70
36.68
21.39
14.08

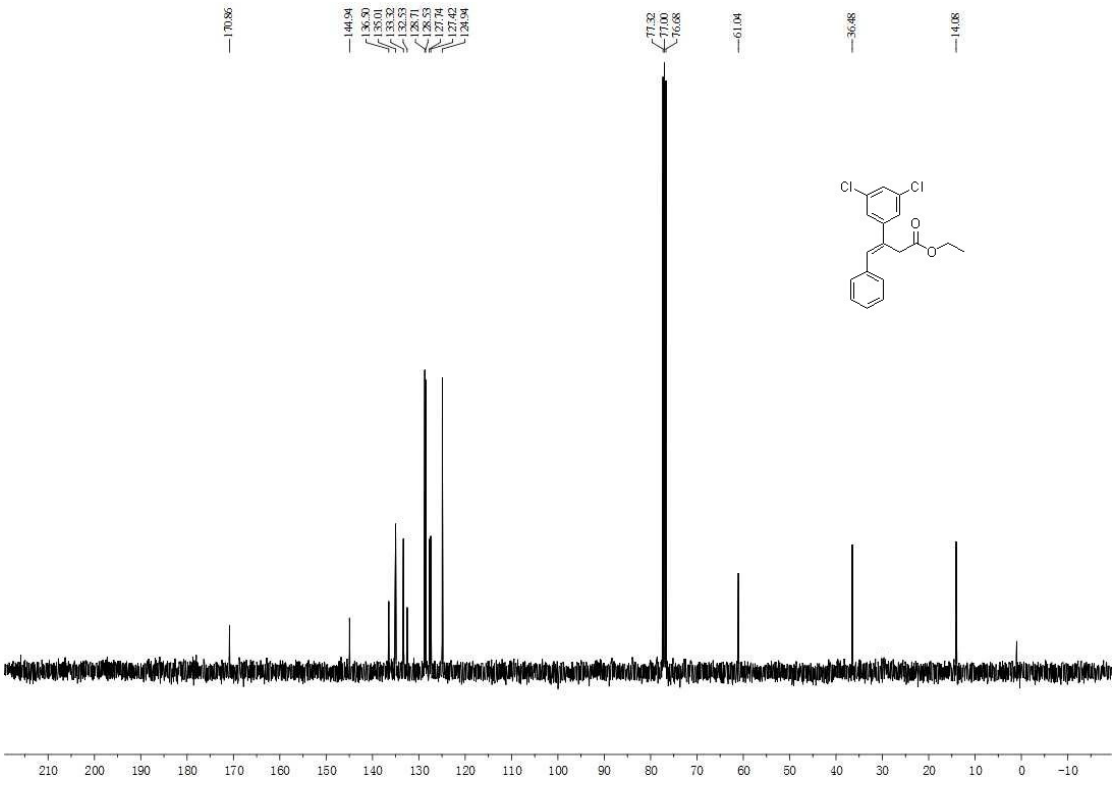
Product 5p


7.416
7.406
7.399
7.390
7.383
7.331
7.314
7.297
7.200
7.055
7.035
7.017
7.013
6.774
6.769
6.764
6.752
6.747
6.742
6.730
6.725
4.166
4.148
4.130
4.112
3.690
1.218
1.200
1.182
F
F
O
O
5.08
2.91
0.97
1.97
2.00
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

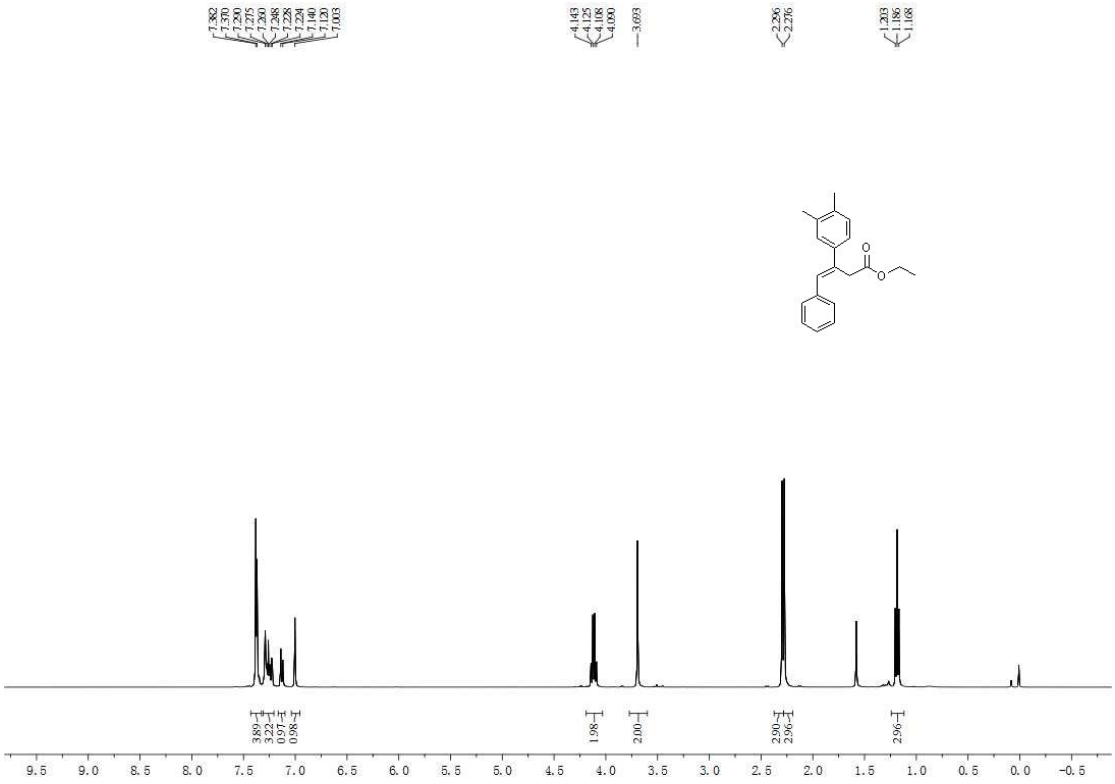

170.95
164.36
164.23
161.90
161.77
145.34
145.25
145.15
136.57
132.99
132.84
132.81
132.79
128.73
128.53
127.71
109.36
109.28
109.17
109.10
103.04
102.98
102.93
77.32
77.00
76.68
61.01
36.48
14.06
F
F
O
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

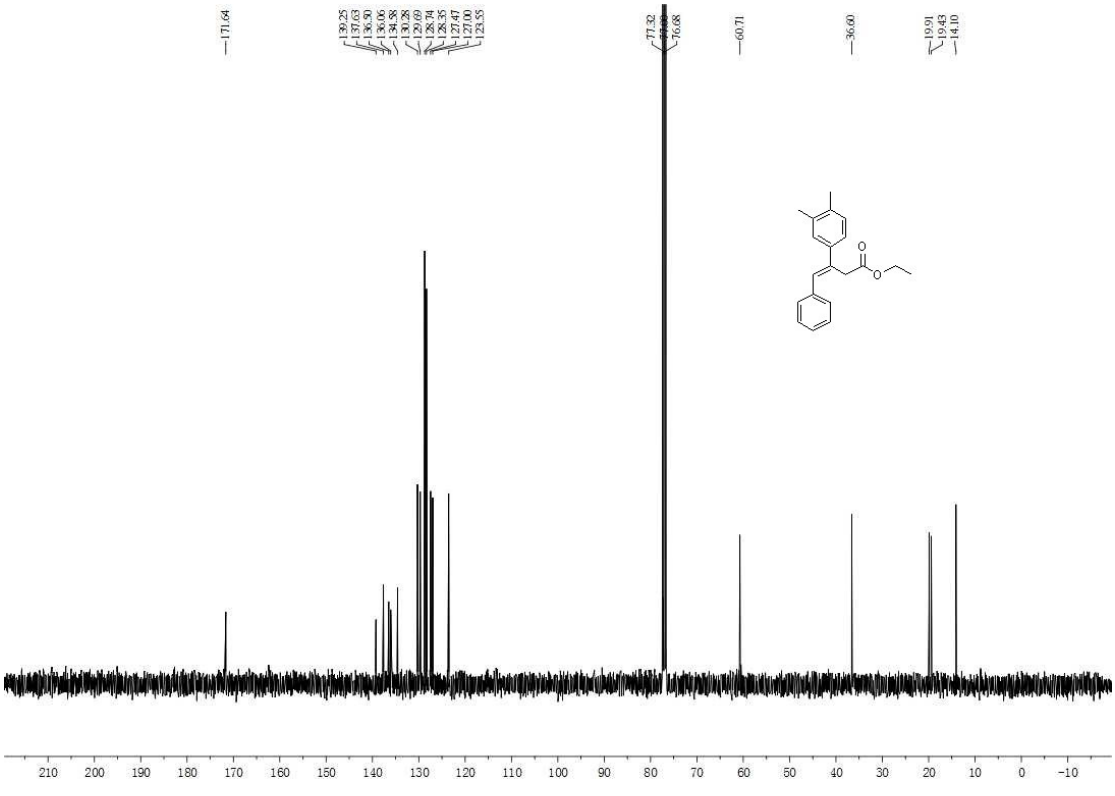
Product 5q


7.413
7.395
7.376
7.371
7.361
7.344
7.335
7.331
7.313
7.306
7.286
7.274
7.259
7.250
7.017
4.165
4.146
4.131
4.112
3.644
1.221
1.204
1.186
Cl
Cl
O
O
7.92
0.98
2.00
2.00
3.07
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

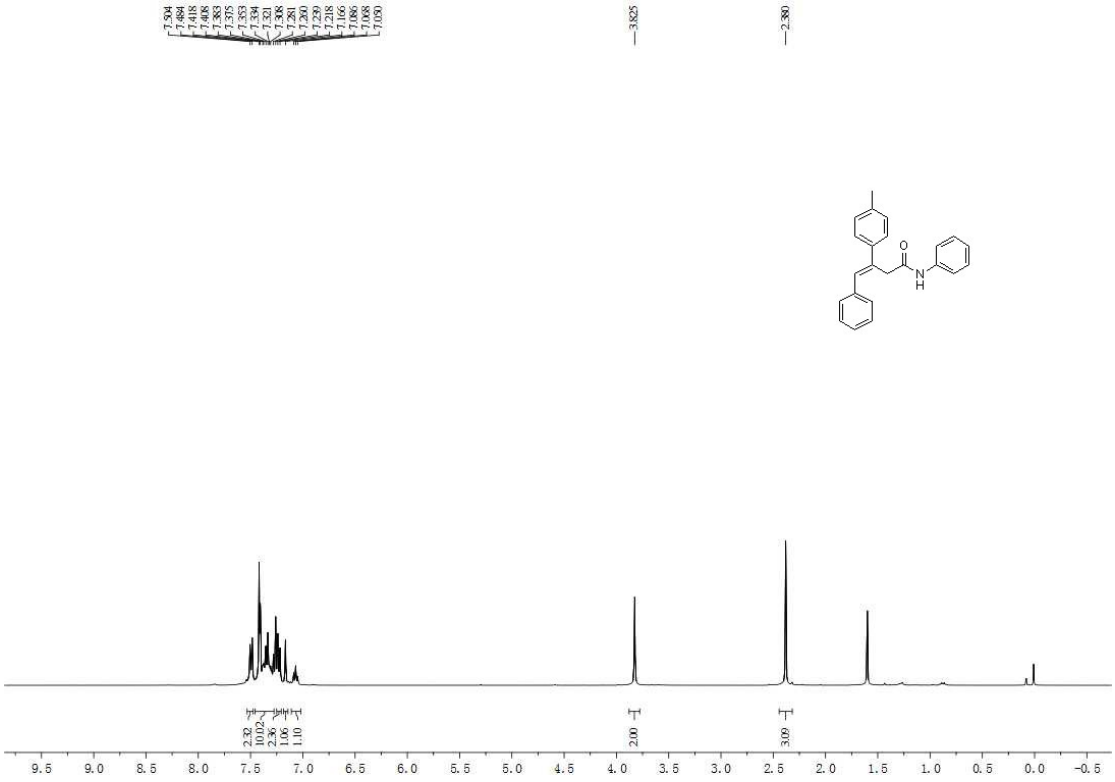

170.86
144.94
136.50
135.01
133.32
132.53
128.71
128.53
127.74
127.42
124.94
77.32
77.00
76.68
61.04
36.48
14.08
Cl
Cl
O
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

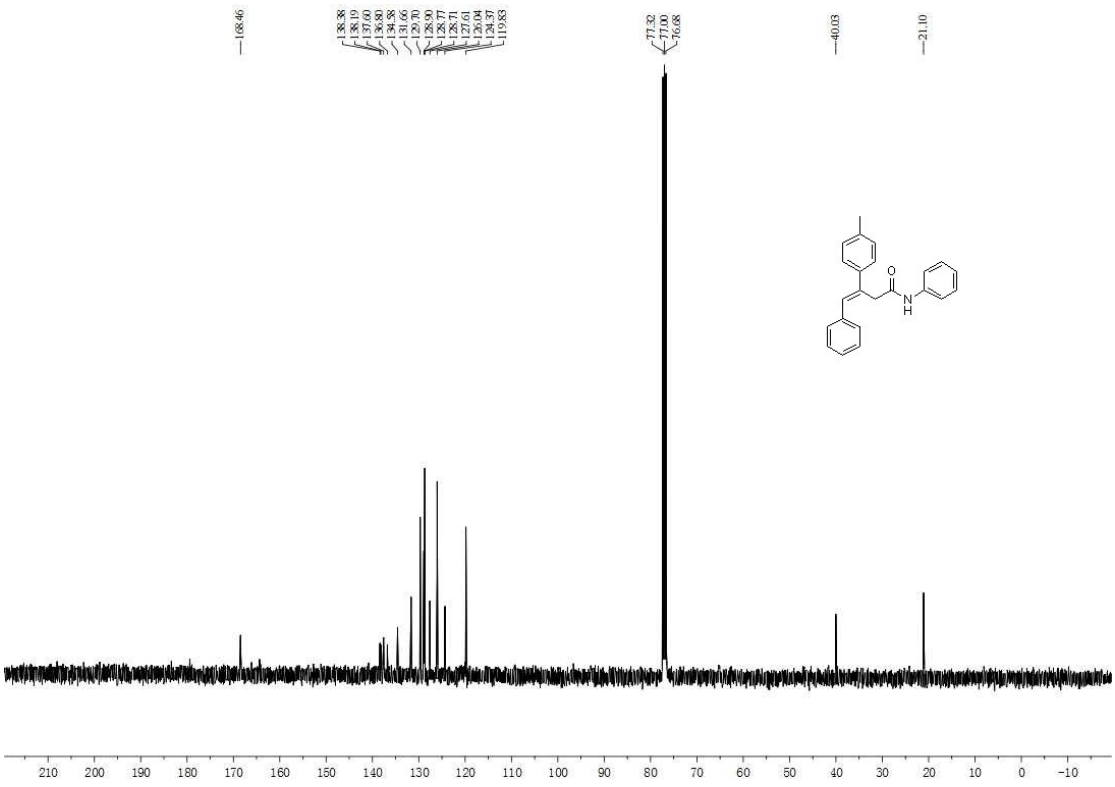
Product 5r


7.382
7.370
7.230
7.275
7.260
7.248
7.228
7.224
7.140
7.120
7.083
4.143
4.125
4.108
4.090
3.693
2.296
2.276
1.203
1.186
1.168
3.89
3.22
0.57
0.58
1.98
2.00
2.90
2.96
2.96

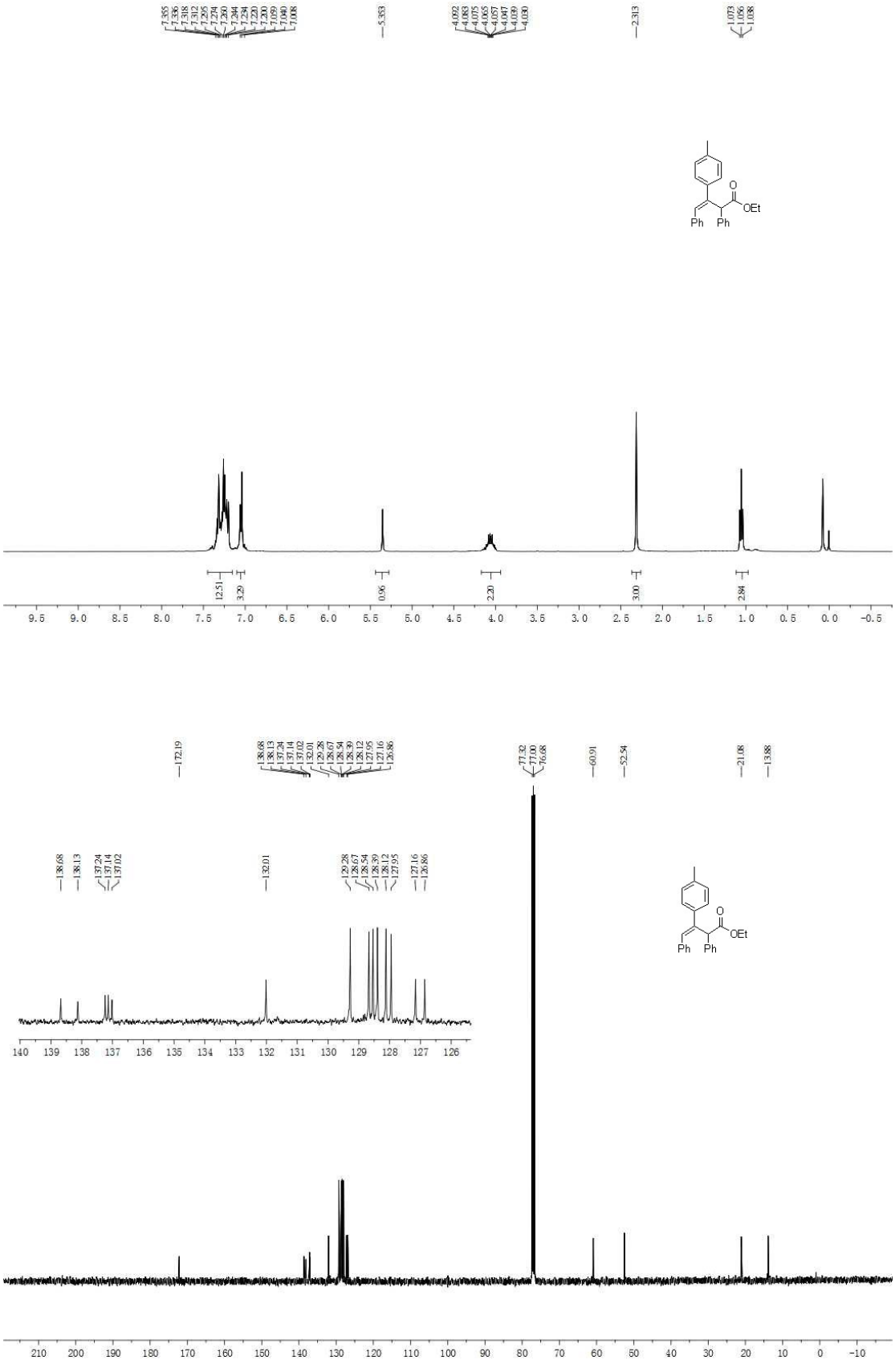

171.64
139.25
137.63
136.50
134.06
134.38
130.38
129.69
128.74
128.35
127.47
127.00
125.55
77.32
77.00
76.68
60.71
36.60
19.91
19.43
14.10

Product 5s

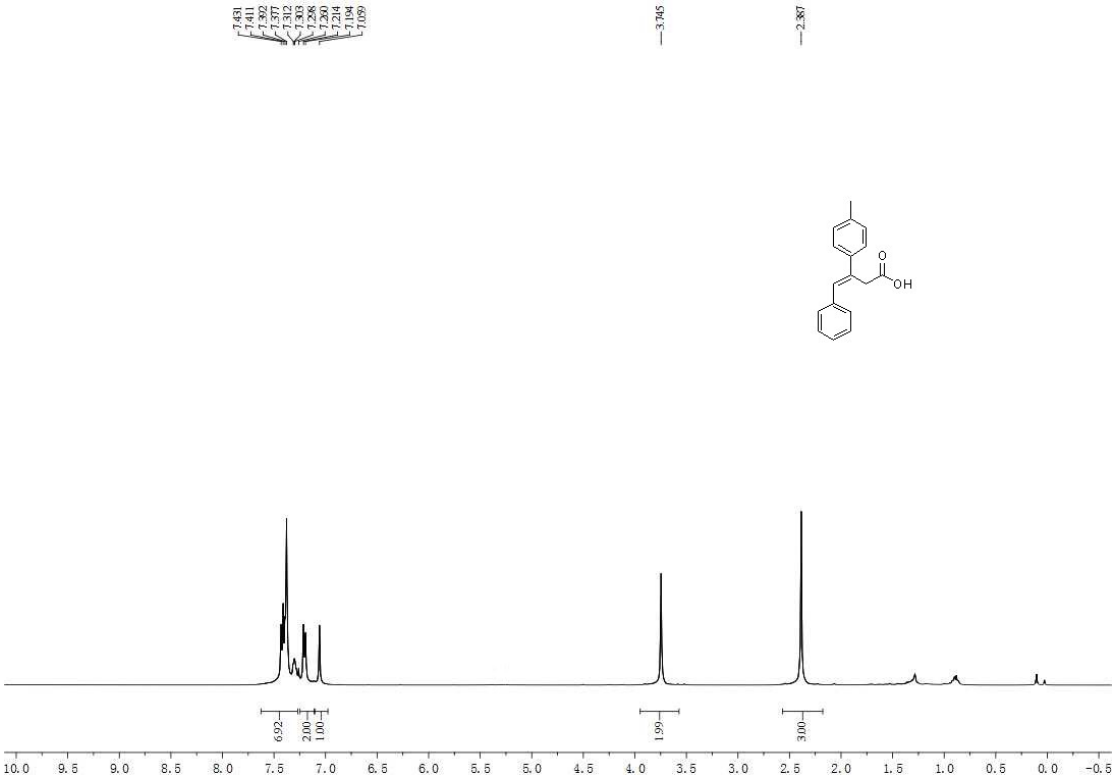

7.504
7.494
7.418
7.408
7.383
7.375
7.353
7.334
7.321
7.306
7.281
7.260
7.239
7.218
7.166
7.086
7.066
7.050
3.825
2.380
2.32
10.02
2.36
1.06
1.10
2.00
3.09

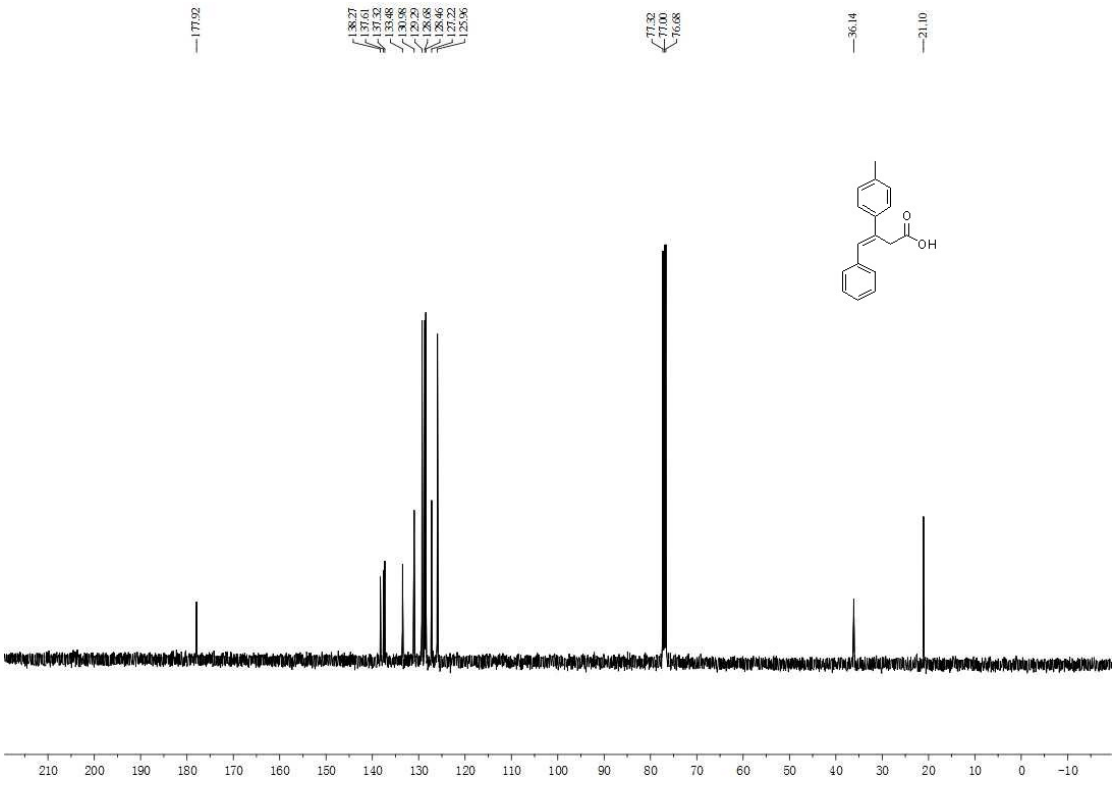

168.46
138.38
138.19
137.60
136.98
134.58
131.66
129.70
128.90
128.77
128.71
127.61
126.04
124.37
119.83
77.32
77.00
76.68
40.03
21.10

Product 5t

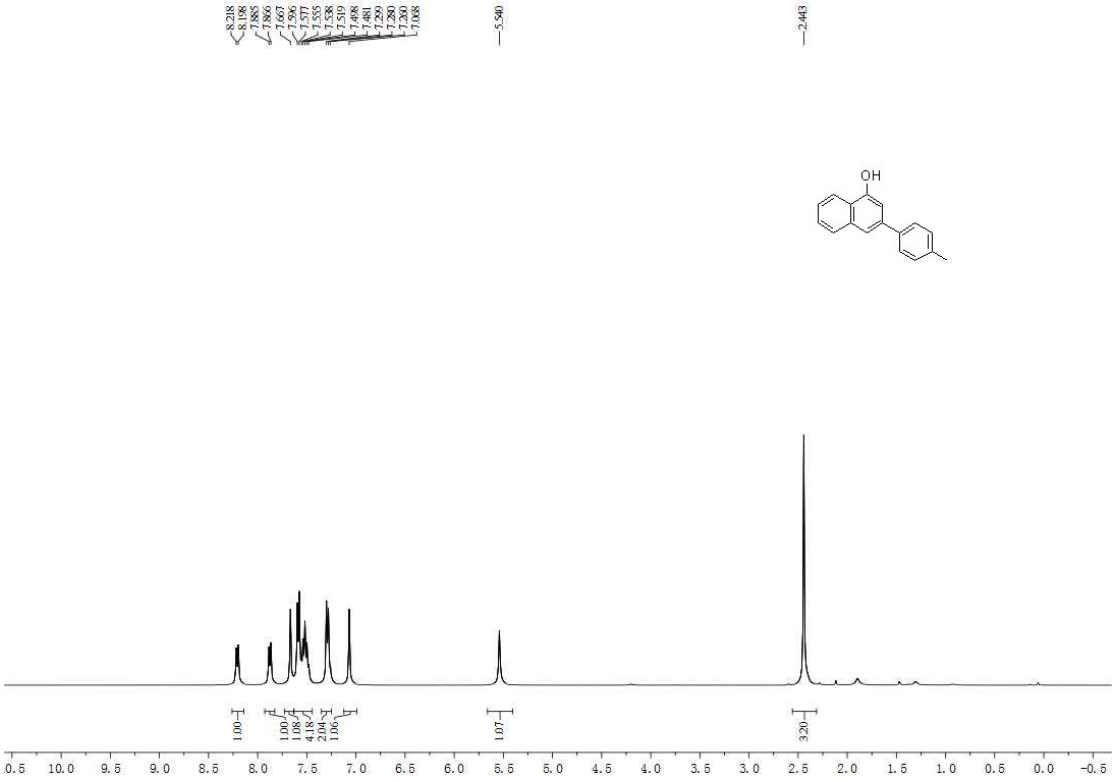


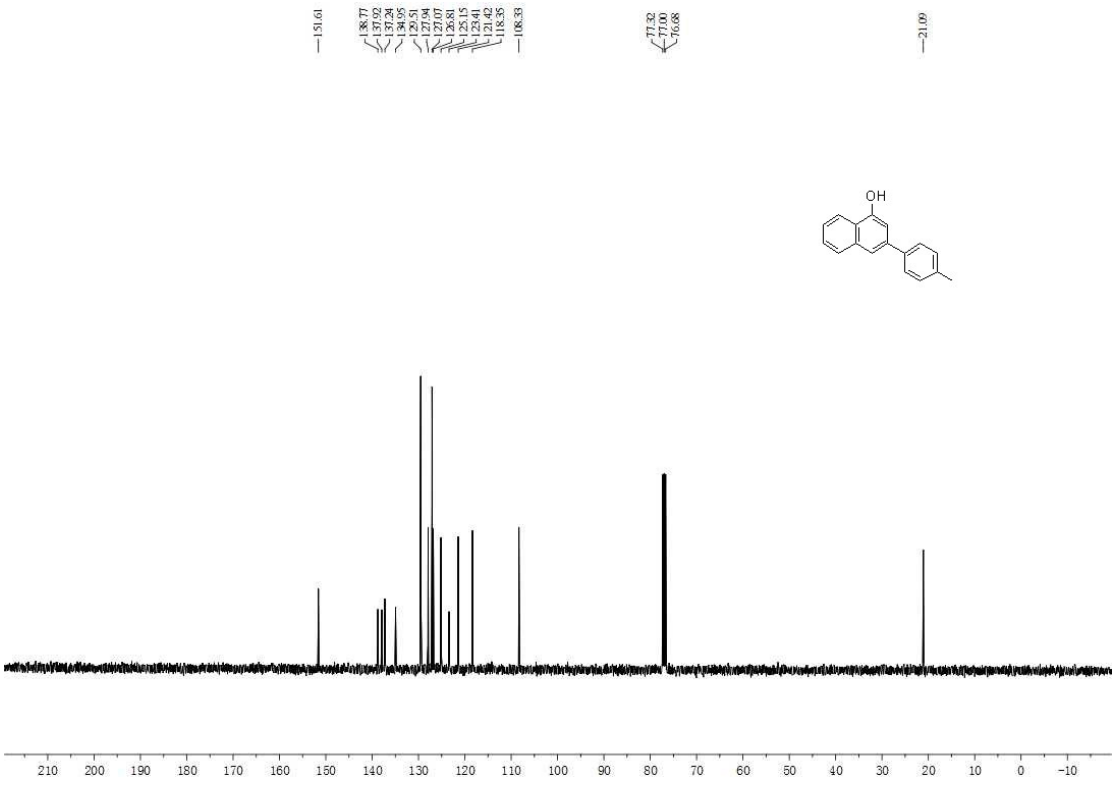
Product 6


7.431
7.411
7.392
7.377
7.312
7.303
7.286
7.260
7.234
7.194
7.059
3.745
2.387
O
OH
6.92
2.00
1.00
1.99
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5

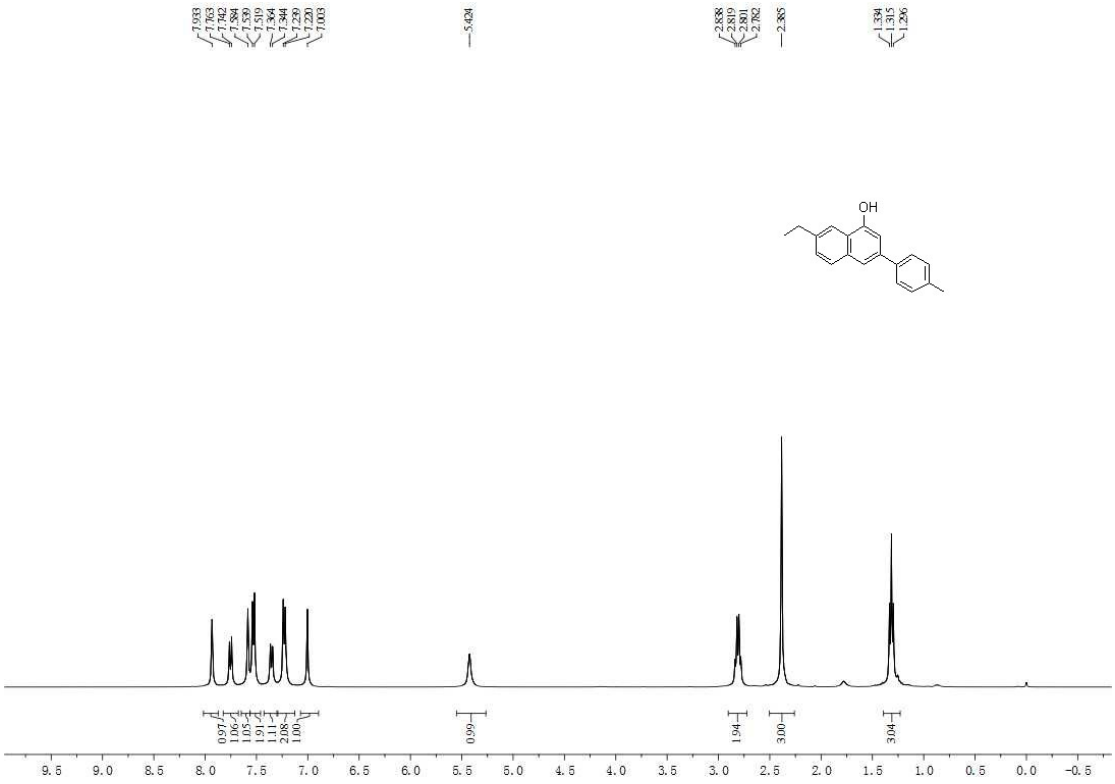

177.92
138.27
137.61
137.32
133.48
130.98
129.29
128.68
128.46
127.22
125.96
77.32
77.00
76.68
36.14
21.10
O
OH
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

Product 7a


8.218
8.198
7.885
7.866
7.667
7.596
7.577
7.555
7.538
7.519
7.498
7.481
7.260
7.240
7.220
7.200
7.008
5.540
2.443
OH
1.00
1.00
1.08
4.14
2.04
1.06
1.07
3.20
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5


151.61
138.77
137.92
137.24
134.95
129.51
127.94
127.07
126.83
125.15
123.41
121.42
118.35
108.33
77.32
77.00
76.68
21.09
OH
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

Product 7b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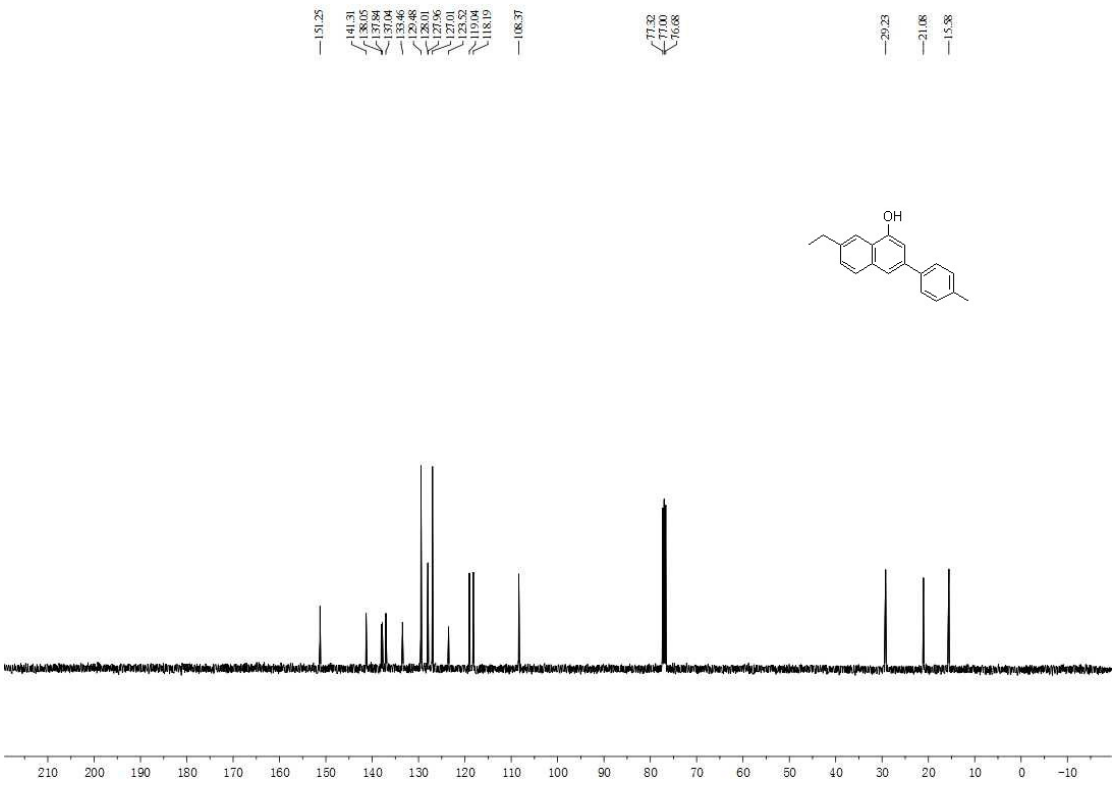
7.763
7.742
7.584
7.539
7.519
7.364
7.344
7.229
7.220
7.003
5.424
2.858
2.819
2.801
2.782
2.385
1.334
1.315
1.296
OH
0.97
1.06
1.05
1.91
1.11
2.08
1.00
0.99
1.94
3.00
3.04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141.31
138.05
137.84
137.04
133.46
129.48
128.01
127.96
127.01
123.52
119.04
118.19
108.37
77.32
77.00
76.68
29.23
21.08
15.58
OH

Product 9