Supporting Information

Efficient synthesis of trisubstituted allenes via palladium-catalysed deaminative coupling of tertiary propargylamines with arylsiloxanes

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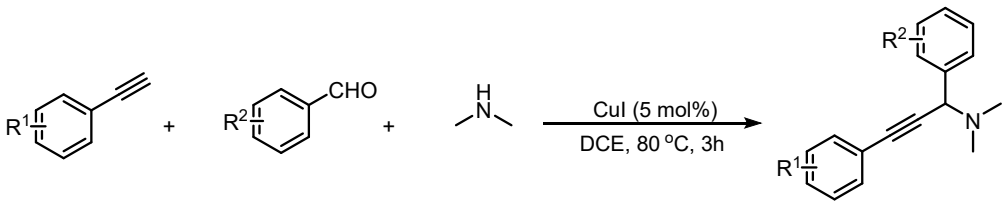
1. General information

All commercially available reagents were used without purification unless otherwise noted. All work-up and purification procedures were carried out with reagent-grade solvents that had not been pre-dried under ambient atmosphere. Chloroform was purified and dried according to standard methods prior to use. Thin-layer chromatography (TLC) was performed and Visualization of the compounds was accomplished with UV light (254 nm). The solvent was removed under reduced pressure, and the residue was purified by column chromatography on silica gel and eluted with petroleum/ethyl acetate to afford the desired product. All ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ operating at 400 MHz and 100 MHz, respectively. Chemical shifts (δ) are reported in ppm relative to the tetramethylsilane (TMS) signal or residual protio solvent signal. Data for ^{1}H NMR are recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, br = broad singlet, coupling constant(s) in Hz, integration). Data for ^{13}C NMR is reported in terms of chemical shift (δ, ppm). High resolution mass spectra were obtained on a Shimadzu LCMS-IT-TOF mass spectrometer with an electrospray ionization (ESI) probe.

2. General procedure for the preparation of propargylamine 1

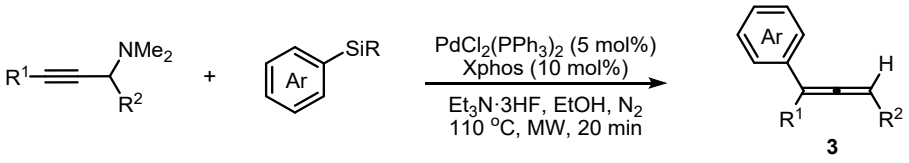


To a dried tube with a stirring bar were added CuI (1 mol%), toluene (5.0 mL), alkyne (10.0 mmol), aldehyde (11 mmol), and secondary amine (13 mmol). Then the reaction was stirred in a pre-heated oil bath at 100 ℃ stirring for 3 h. After cooling to room temperature, the solid was removed by filtration of the reaction mixture through a pad of celite. The filtrate was washed sequentially with ethyl acetate and dried over $MgSO_4$. The solvent was removed under reduced pressure, and the

residue was purified by column chromatography on silica gel and eluted with petroleum/ethyl acetate (20:1) to afford the desired product **1a-1p**

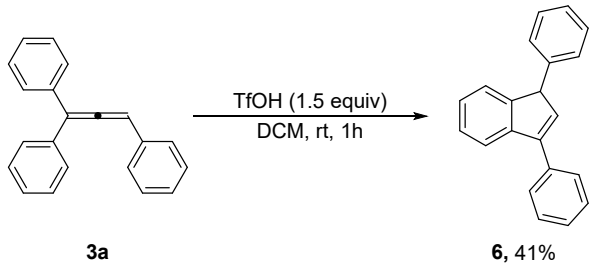
^{1}H NMR and ^{13}C NMR data were consistent with literature values.

3. General procedure for the synthesis of the desired product 3



Into a 2 mL biotage microwave vial was added 7.0 mg (5 mol%) $PdCl_2(PPh_3)_2$, 9.5 mg (10 mol%) X-Phos, 0.3 mmol aryl silane **2**, and 0.2 mmol propargylamine **1**. Subsequently 1.5 mL of anhydrous ethanol solution was added to the reaction flask and placed in a stirrer for 10 s at room temperature. At the end of stirring use a pipette gun to add and 0.6 mmol of $Et_3N{\cdot}3HF$ dropwise to the mixture. At this point the vial was sealed and placed in the microwave reactor. The contents of the vial were heated to 110 ℃ for a total time of 20 min (set time = 10 min; ramp and cool time = 5 min; power setting = normal). After cooling, the vial was opened and the contents were transferred to a round-bottom flask, washed with ethyl acetate and the solvent was removed in a rotary evaporator. The residue was purified by flash chromatography with petroleum ether to provide the desired product **3**.

4. General procedure for the synthesis of the desired product 6

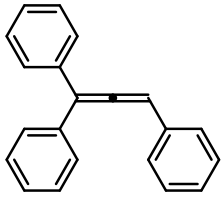


To a suspension of trifluoromethylated allene 3aa (53.7 mg, 0.2 mmol) in CH_2Cl_2 (2 mL) was added TfOH (18 μL, 0.15 mmol) at room temperature. The resulting mixture was stirred at room temperature for 1 h. Then the mixture was poured into ice water (20 mL) and extracted with

CH_2Cl_2. The combined organic layers were washed with saturated $NaHCO_3$ (aq.), dried over $MgSO_4$ and concentrated in vacuo. The residue was purified by column chromatography using n-hexane as eluent to afford the 1H-indene 6 (22.0 mg, 41% yield).

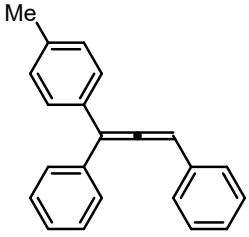
5. ^{1}H NMR, ^{13}C NMR and ^{19}F NMR data of the products

propa-1,2-diene-1,1,3-triyltribenzene(3a).[1] (46.8mg, 87% yield).



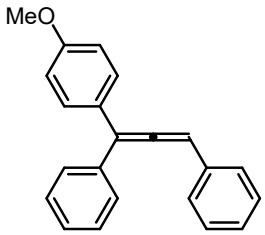
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.37 – 7.32 (m, 6H), 7.30 – 7.20 (m, 8H), 7.16 (d, J = 7.4 Hz, 1H), 6.63 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 208.3, 135.8, 132.9, 132.4, 128.9, 128.5, 128.4, 128.1, 127.7, 114.1, 96.8.

(1-(p-tolyl)propa-1,2-diene-1,3-diyl)dibenzene (3b).[2] (46.5mg, 82% yield).



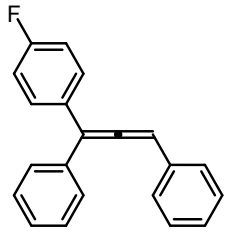
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.33 (m, 4H), 7.28 – 7.18 (m, 7H), 7.16 – 7.11 (m, 1H), 7.08 (d, J = 7.9 Hz, 2H), 6.61 (s, 1H), 2.28 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 207.1, 136.4, 135.3, 133.0, 132.1, 128.2, 127.8, 127.4, 127.3, 126.5, 126.3, 125.9, 112.5, 96.5, 20.2.

(1-(4-methoxyphenyl)propa-1,2-diene-1,3-diyl)dibenzene (3c).[3] (36.4mg, 61% yield).



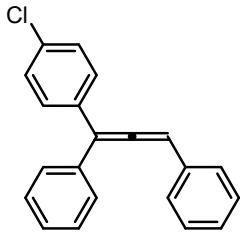
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.32 – 7.35 (m, 4H), 7.28 – 7.19 (m, 7H), 7.14 (s, 1H), 6.81 (m, 2H), 6.60 (s, 1H), 3.73 (s, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 207.0, 158.2, 135.4, 133.1, 128.6, 127.8, 127.4, 127.4, 127.3, 126.5, 126.3, 125.9, 113.1, 112.9, 112.3, 96.5, 54.3.

(1-(4-fluorophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3d). (49.9mg, 87% yield).



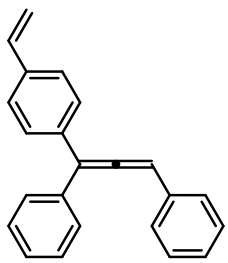
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.13 (m, 12H), 6.95 (t, J = 8.5 Hz, 2H), 6.63 (s, 1H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 207.1, 162.1, 160.5, 135.0, 132.7, 131.1, 131.1, 129.1, 129.0, 127.8, 127.6, 127.3, 126.7, 126.5, 126.0, 114.5, 114.3, 111.9, 96.8. HRMS m/z (ESI^+): Calculated for $C_{21}H_{15}F$ ($[M+H]^+$): 287.1231, found: 287.1235. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.49.

(1-(4-chlorophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3e). (47.8mg, 79% yield).



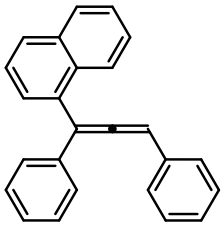
^{1}H NMR (600 MHz, $CDCl_3$) δ 7.32 (d, J = 7.3 Hz, 3H), 7.29 – 7.20 (m, 7H), 7.17 (d, J = 5.2 Hz, 1H), 6.64 (s, 1H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 207.2, 134.8, 133.7, 132.5, 132.4, 128.7, 127.9, 127.6, 127.6, 127.4, 126.8, 126.5, 126.5, 126.3, 126.0, 111.9, 97.0. HRMS m/z (ESI^+): Calculated for $C_{21}H_{15}Cl$ ($[M+H]^+$): 303.0935, found: 303.0930.

(1-(4-vinylphenyl)propa-1,2-diene-1,3-diyl)dibenzene (3f). (45.4mg, 77% yield).



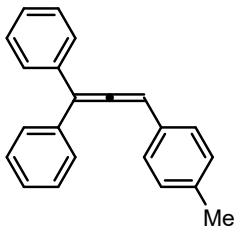
^{1}H NMR (400 MHz, $CDCl_3$) 7.47 – 7.18 (m, 14H), 6.77 – 6.66 (m, 2H), 5.75 (m, 1H), 5.24 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.5, 137.0, 136.4, 136.1, 135.6, 133.9, 128.9, 128.6, 128.5, 127.7, 127.4, 127.0, 126.4, 114.0, 113.6, 97.8. HRMS m/z (ESI^+): Calculated for $C_{17}H_{15}$ ($[M+H]^+$): 295.1481, found: 295.1474.

1-(1,3-diphenylpropa-1,2-dien-1-yl)naphthalene (3g). (41.3mg, 65% yield).



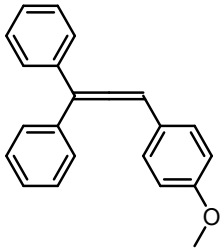
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, J = 8.5 Hz, 1H), 7.77 (m, 2H), 7.51 (m, 1H), 7.45 – 7.30 (m, 5H), 7.26 – 7.08 (m, 8H), 6.60 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 206.4, 135.4, 132.9, 132.8, 132.7, 131.0, 127.8, 127.5, 127.3, 127.3, 126.7, 126.3, 126.2, 126.1, 126.0, 125.2, 125.1, 124.8, 124.7, 110.0, 96.4. HRMS m/z (ESI^+): Calculated for $C_{17}H_{15}$ ($[M+H]^+$): 319.1481, found: 319.1477.

(3-(*p*-tolyl)propa-1,2-diene-1,1-diyl)dibenzene (3i).[4] (49.8mg, 65% yield).



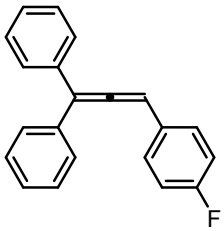
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.31 (m, 4H), 7.30 – 7.17 (m, 8H), 7.05 (d, J = 7.9 Hz, 2H), 6.61 (s, 1H), 2.26 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.2, 137.3, 136.4, 130.9, 129.6, 129.4, 128.8, 128.5, 127.5, 127.4, 127.3, 127.1, 126.9, 113.6, 97.6, 21.3.

(3-(4-methoxyphenyl)propa-1,2-diene-1,1-diyl)dibenzene (3j). (29.7mg, 50% yield).



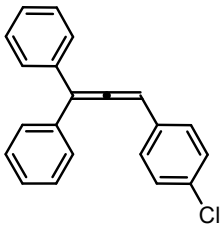
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.32 (m, 4H), 7.29 – 7.18 (m, 8H), 6.79 (d, J = 8.7 Hz, 2H), 6.60 (s, 1H), 3.72 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 206.8, 158.1, 135.4, 129.2, 128.4, 127.4, 127.2, 127.1, 126.4, 126.2, 125.1, 113.3, 112.6, 96.1, 54.3. HRMS m/z (ESI^+): Calculated for $C_{17}H_{17}$ ($[M+H]^+$): 299.1430, found: 299.1435.

(3-(4-fluorophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3k).[1] (32.0mg, 56% yield).



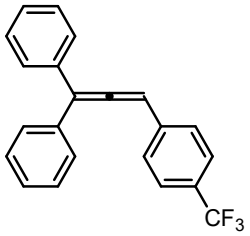
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.31 (m, 4H), 7.31 – 7.19 (m, 8H), 6.96 – 6.90 (m, 2H), 6.60 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.0, 163.4, 161.0, 136.1, 129.9, 129.9, 128.6, 128.5, 128.4, 127.7, 115.9, 115.7, 114.0, 96.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.62.

(3-(4-chlorophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3l).[1] (35.3mg, 58% yield).



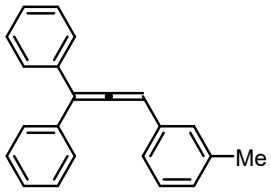
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 – 7.38 (m, 4H), 7.37 – 7.27 (m, 10H), 6.66 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.4, 135.9, 133.0, 132.5, 129.0, 128.6, 128.5, 128.2, 127.8, 114.2, 96.9.

(3-(4-(trifluoromethyl)phenyl)propa-1,2-diene-1,1-diyl)dibenzene (3m).[1] (47.1mg, 70% yield).



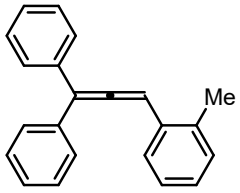
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 8.0 Hz, 2H), 7.41 (d, *J* = 8.1 Hz, 2H), 7.35 – 7.20 (m, 10H), 6.65 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.0, 136.9, 134.5, 129.2, 128.4, 128.3, 127.6, 127.4, 126.9, 126.0, 124.8, 124.8, 124.8, 124.7, 124.7, 113.3, 95.8. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.45.

(3-(*m*-tolyl)propa-1,2-diene-1,1-diyl)dibenzene (3n).[1] (32.2mg, 57% yield).



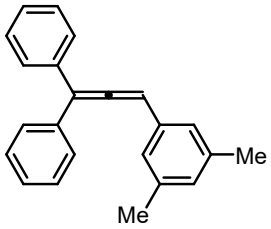
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.4 Hz, 4H), 7.37 (m, 6H), 7.27 (m, 3H), 7.13 – 7.07 (m, 1H), 6.73 (s, 1H), 2.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.4, 138.5, 136.3, 133.8, 128.7, 128.5, 128.3, 127.7, 127.6, 124.2, 113.6, 97.8, 21.4.

(3-(*o*-tolyl)propa-1,2-diene-1,1-diyl)dibenzene (3o).[5] (34.9mg, 62% yield).



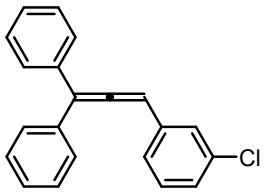
^{1}H NMR (400 MHz, $CDCl_3$) 7.49 (d, *J* = 7.5 Hz, 4H), 7.37 (m, 6H), 7.27 (d, *J* = 3.9 Hz, 3H), 7.14 – 7.06 (m, 1H), 6.74 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.4, 138.5, 136.3, 133.8, 128.7, 128.5, 128.3, 127.7, 127.6, 124.2, 113.6, 97.8, 21.4.

(3-(3,5-dimethylphenyl)propa-1,2-diene-1,1-diyl)dibenzene (3p). (32.1mg, 54% yield).



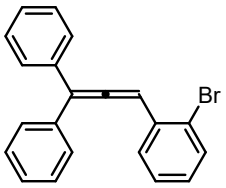
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 7.4 Hz, 4H), 7.38 (m, 6H), 7.08 (s, 2H), 6.93 (s, 1H), 6.71 (s, 1H), 2.35 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.4, 138.4, 136.4, 133.7, 129.3, 128.5, 127.5, 124.9, 113.5, 97.8, 21.3. HRMS m/z (ESI$^+$): Calculated for $C_{23}H_{20}$ ([M+H]$^+$): 297.1638, found: 297.1642.

(3-(3-chlorophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3q). (41.8mg, 69% yield).



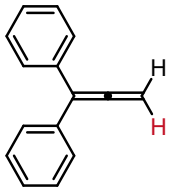
^{1}H NMR (400 MHz, $CDCl_3$) δ7.45 – 7.15 (m, 14H), 6.65 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.5, 136.0, 135.8, 134.8, 130.3, 130.0, 128.6, 128.5, 127.8, 127.4, 126.8, 125.1, 114.3, 96.8. HRMS m/z (ESI+): Calculated for $C_{21}H_{15}Cl$ ([M+H]$^+$): 303.0935, found: 303.0930.

(3-(2-bromophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3r). (28.3mg, 41% yield).



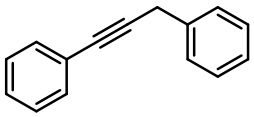
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (t, *J* = 1.8 Hz, 1H), 7.46 – 7.32 (m, 12H), 7.21 (t, *J* = 7.8 Hz, 1H), 6.67 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.5, 136.3, 135.8, 130.3, 130.3, 129.8, 128.6, 128.5, 127.8, 125.6, 123.0, 114.3, 96.7. HRMS m/z (ESI$^+$): Calculated for $C_{21}H_{15}Br$ ([M+H]$^+$): 347.0430, found: 347.0410.

propa-1,2-diene-1,1-diyldibenzene (3u).[6] (16.6mg, 43% yield).



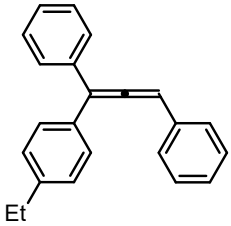
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.26 (m, 10H), 5.29 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 207.9, 136.3, 133.7, 128.8, 128.5, 128.5, 127.4, 127.1, 98.5.

prop-1-yne-1,3-diyldibenzene (4).[3] (7.8mg, 20% yield).



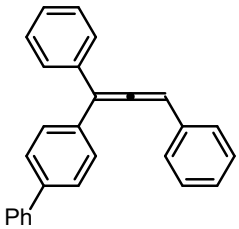
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.36 (m, 4H), 7.34 (m, 2H), 7.31 – 7.26 (m, 3H), 7.26 – 7.21 (m, 1H), 3.83 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 136.8, 131.7, 128.6, 128.3, 128.0, 127.8, 126.7, 123.7, 87.5, 82.7, 25.8.

(1-(4-ethylphenyl)propa-1,2-diene-1,3-diyl)dibenzene (3v). (37.9mg, 64% yield).



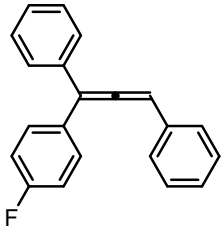
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.41 (m, 4H), 7.40 – 7.29 (m, 7H), 7.24 (m, 3H), 6.72 (s, 1H), 2.69 (q, J = 7.6 Hz, 2H), 1.30 – 1.27 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.2, 143.8, 136.4, 134.1, 133.4, 128.8, 128.5, 128.5, 128.4, 128.0, 127.5, 127.3, 127.0, 113.6, 97.6, 28.6, 15.6. HRMS m/z (ESI^+): Calculated for $C_{21}H_{20}$ ($[M+H]^+$): 297.1638, found: 297.1623.

4-(1,3-diphenylpropa-1,2-dien-1-yl)-1,1'-biphenyl (3w).[1] (33.3mg, 48% yield).



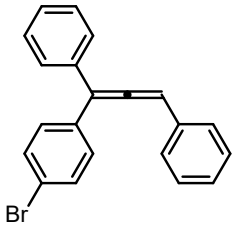
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 – 7.57 (m, 4H), 7.56 – 7.44 (m, 8H), 7.43 – 7.32 (m, 6H), 7.28 (d, J = 5.5 Hz, 1H), 6.78 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.5, 140.7, 140.5, 136.2, 135.1, 133.9, 128.9, 128.8, 128.6, 127.7, 127.5, 127.4, 127.3, 127.1, 113.5, 97.9.

(1-(4-fluorophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3x). (36.8mg, 62% yield).



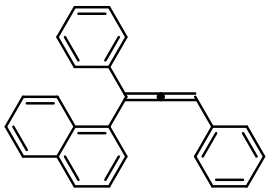
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.22 (m, 12H), 7.03 (t, *J* = 8.7 Hz, 2H), 6.70 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.1, 163.6, 161.1, 136.1, 133.8, 132.2, 132.1, 130.1, 130.1, 128.9, 128.6, 128.4, 127.7, 127.5, 127.0, 115.6, 115.4, 112.9, 97.9. HRMS m/z (ESI^+): Calculated for $C_{21}H_{15}F$ ($[M+H]^+$): 287.1231, found: 287.1235.^{19}F NMR (376 MHz, $CDCl_3$) δ -113.17.

(1-(4-bromophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3y).[7] (41.7mg, 60% yield).



^{1}H NMR (100 MHz, $CDCl_3$) δ 7.49 (d, *J* = 8.5 Hz, 2H), 7.44 – 7.40 (m, 4H), 7.39 – 7.25 (m, 8H), 6.74 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.2, 135.7, 135.3, 133.5, 131.7, 130.0, 128.9, 128.6, 128.4, 127.8, 127.6, 127.0, 121.6, 113.0, 98.1.

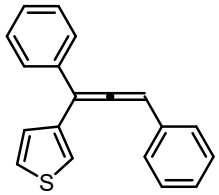
1-(1,3-diphenylpropa-1,2-dien-1-yl)naphthalene (3z). (36.5mg, 57% yield).



^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.3 Hz, 1H), 7.92 (d, *J* = 4.4 Hz, 2H), 7.66 (d, *J* = 6.9 Hz, 1H), 7.53 (m, 5H), 7.40 – 7.23 (m, 8H), 6.75 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 207.5,

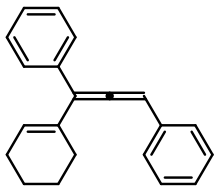
136.5, 134.0, 133.9, 133.8, 132.1, 128.8, 128.6, 128.4, 128.4, 127.8, 127.4, 127.3, 127.2, 127.0, 126.3, 126.2, 125.9, 125.7, 111.1, 97.4.

3-(1,3-diphenylpropa-1,2-dien-1-yl)thiophene (3aa). (23.1mg, 42% yield).



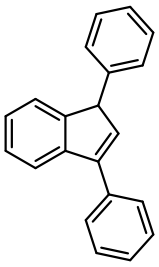
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 7.0 Hz, 2H), 7.45 – 7.33 (m, 8H), 7.28 – 7.22 (m, 2H), 7.20 (m, 1H), 6.71 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.3, 136.7, 136.3, 133.9, 128.8, 128.8, 128.6, 128.2, 128.0, 127.8, 127.4, 127.1, 125.6, 122.8, 109.3, 97.6. HRMS m/z (ESI$^+$): Calculated for $C_{19}H_{14}S$ ([M+H]$^+$): 275.0889, found:275.0886.

(1-(cyclohex-1-en-1-yl)propa-1,2-diene-1,3-diyl)dibenzene (3ab). (32.3mg, 59% yield).



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.33 (m, 8H), 7.32 – 7.23 (m, 2H), 6.55 (s, 1H), 5.74 (s, 1H), 2.24 (m, 4H), 1.72 (m, 4H).^{13}C NMR (100 MHz, $CDCl_3$) δ 206.8, 136.5, 134.9, 132.9, 129.1, 128.7, 128.2, 127.6, 127.2, 127.0, 126.8, 115.6, 97.0, 27.6, 26.0, 22.9, 22.3. HRMS m/z (ESI$^+$): Calculated for $C2_1H_{20}$ ([M+H]$^+$): 273.1638, found:273.1640.

1,3-diphenyl-1H-indene (6)[8] (22.0mg, 41% yield).



^{1}H NMR (600 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.2 Hz, 2H), 7.60 (d, *J* = 7.4 Hz, 1H), 7.47 (m, 2H), 7.42 – 7.37 (m, 1H), 7.30 (m, , 4H), 7.25 – 7.17 (m, 4H), 6.64 (m, 1H), 4.71 (s, 1H).

6. Reference

1.C. Wu, F. Hu, Z. Liu, G. Deng, F. Ye, Y. Zhang, J. Wang, Tetrahedron., 2015, 71,49, 9196-9201;

2.G. Zhao, Y. Wu, H-H. Wu, J. Yang, J. Zhang, J. Am. Chem. Soc. 2021, 143, 43, 17983-17988;

3.J. Su, C. Li, X. Hu, Y. Guo, Q. Song, Angew. Chem. Int. Ed., 2022, 61, e202212740;

4.Z. Liu, Dr. P, Liao, X. Bi, Chem. Eur. J., 2014, 20, 52, 17277-17281;

5.M. Yoshida, T. Gotou, M. Ihara, Tetrahedron Letters 2004, 45, 29, 5573-5575;

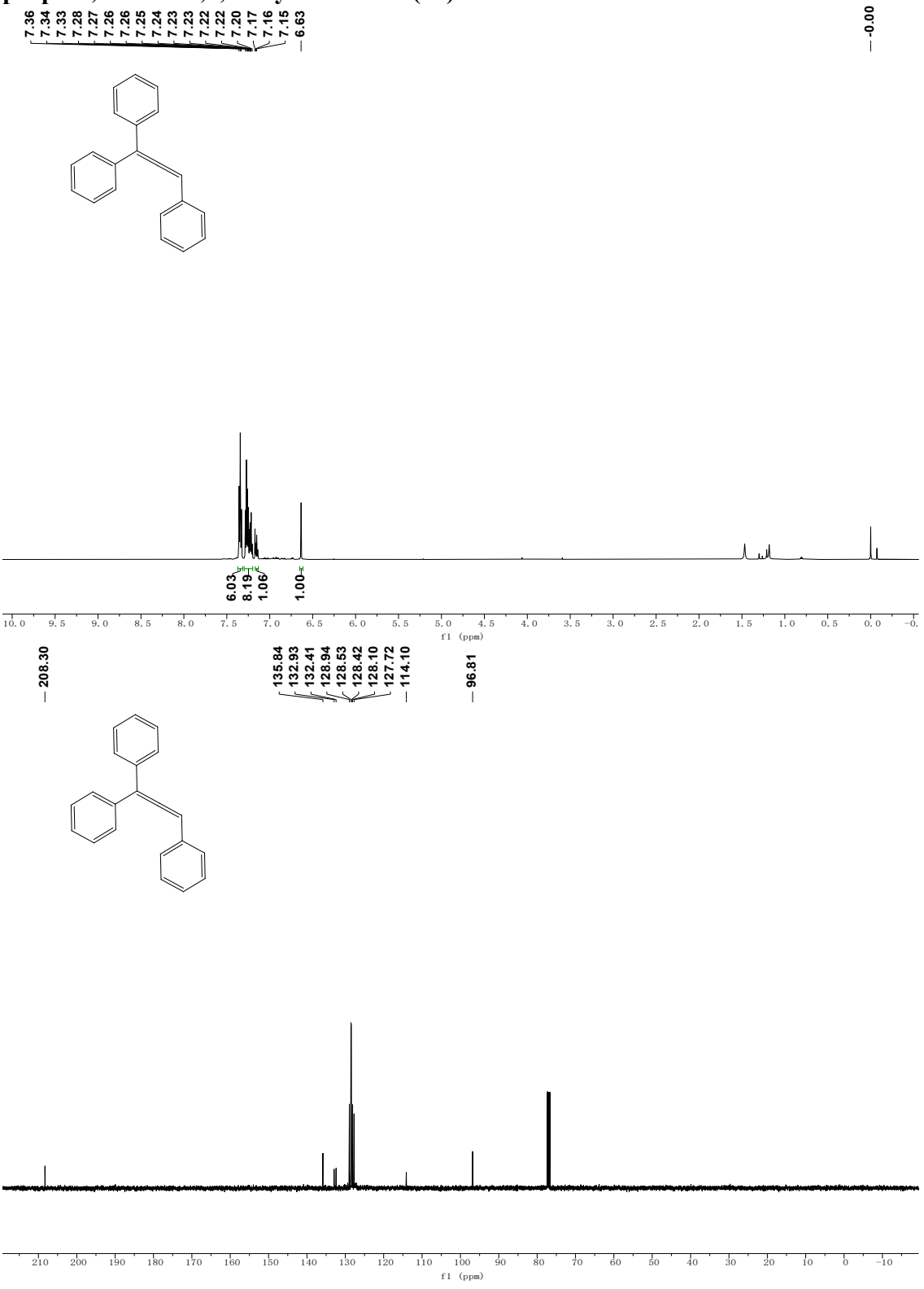
6.F. Ye, C. Wang, X. Ma, M-L Hossain, Y. Xia, Y. Zhang, J. Wang, J. Org. Chem. 2015, 80, 647-652;

7.Y. Yang, Z. Liu, A. Porta, G. Zanoni, X. Bi, Chem. Eur. J. 2017, 23, 9009.

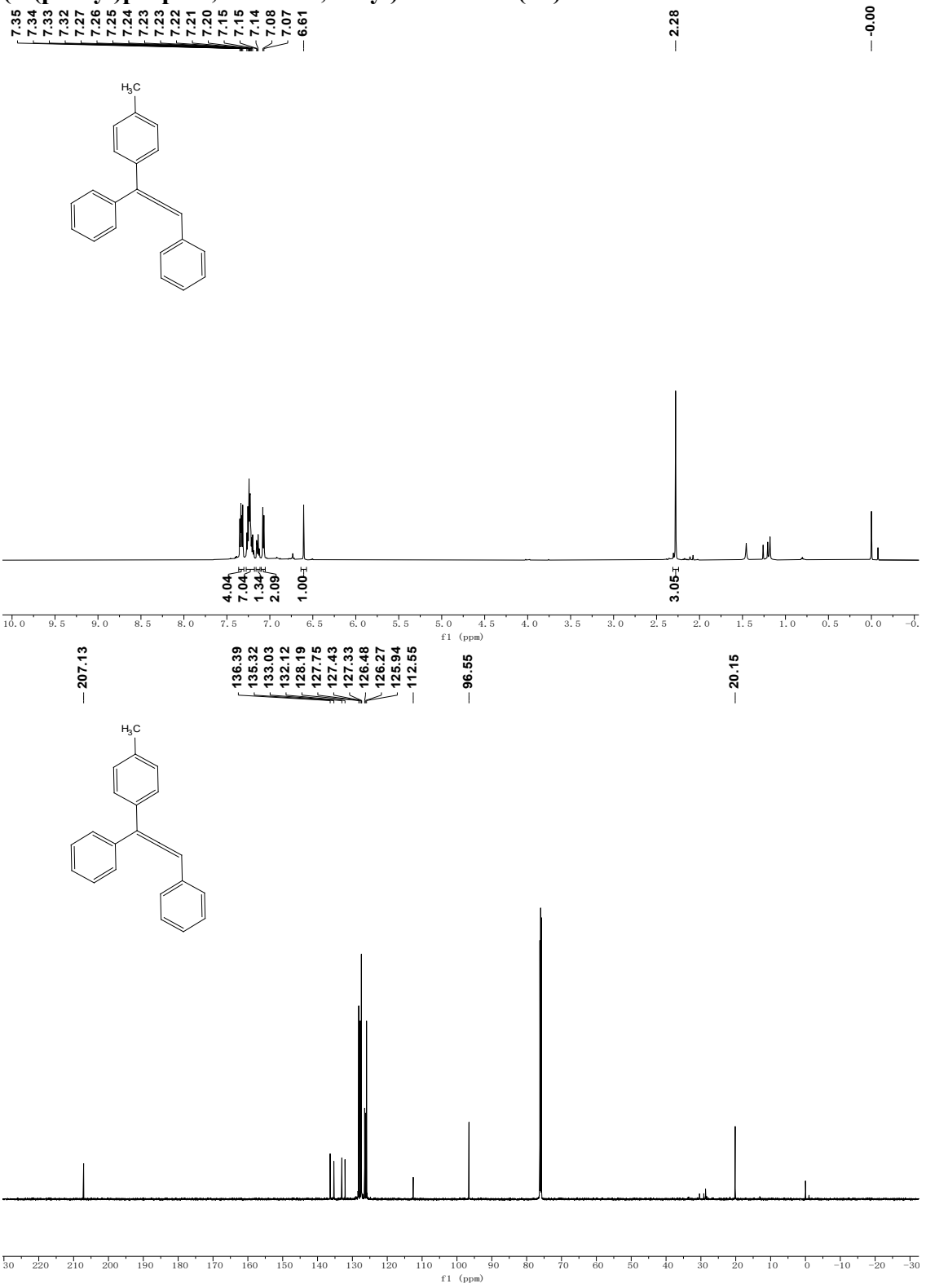
8. S. Jana, C. Pei, C. Empel, R. M. Koenigs, Angew. Chem.-Int. Edit., 2021, 60, 13271-13279.

7. ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra of the products

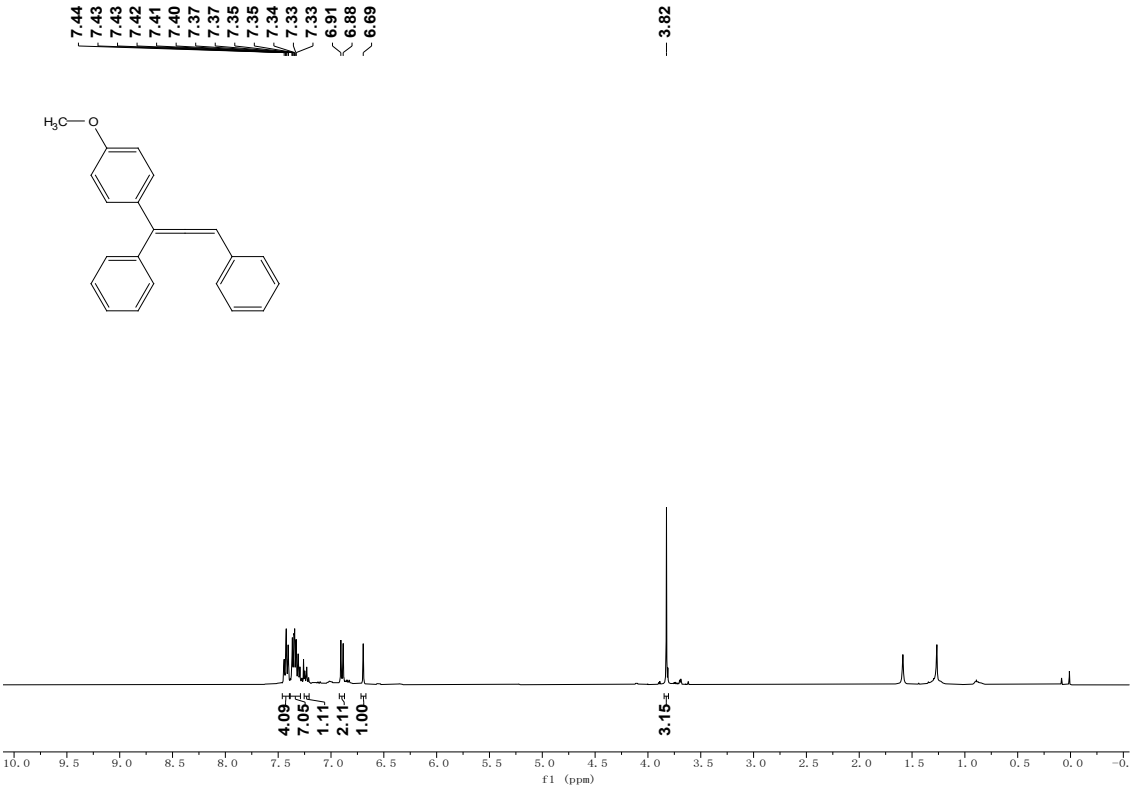
propa-1,2-diene-1,1,3-triyltribenzene(3a).

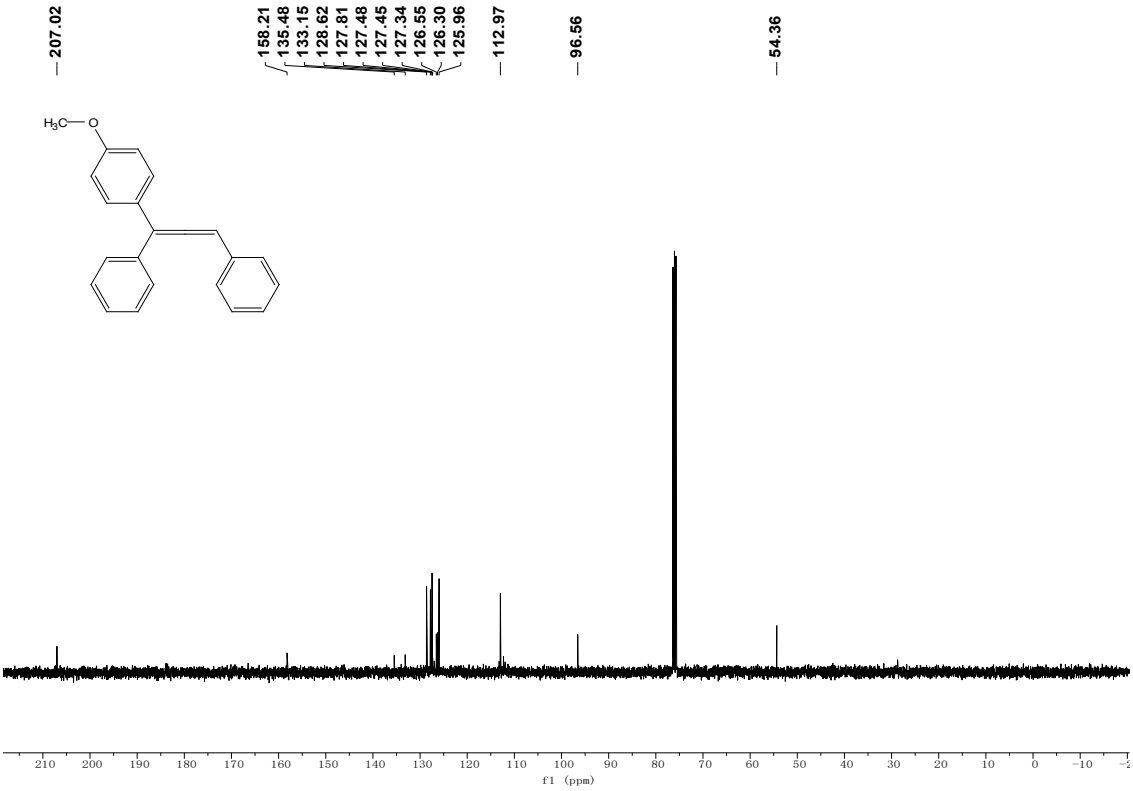


(1-(p-tolyl)propa-1,2-diene-1,3-diyl)dibenzene (3b).

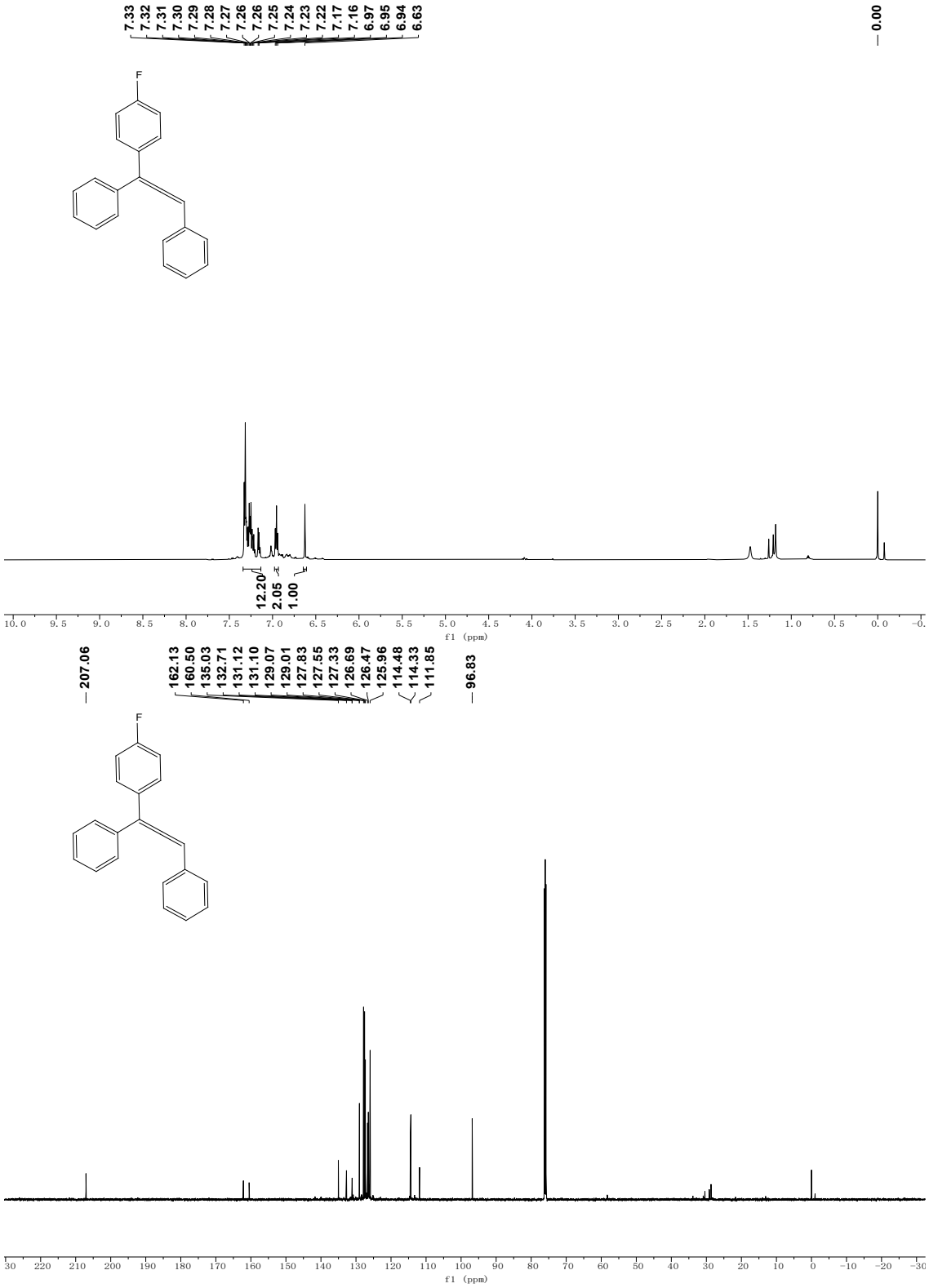


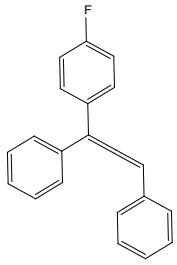
(1-(4-methoxyphenyl)propa-1,2-diene-1,3-diyl)dibenzene (3c).





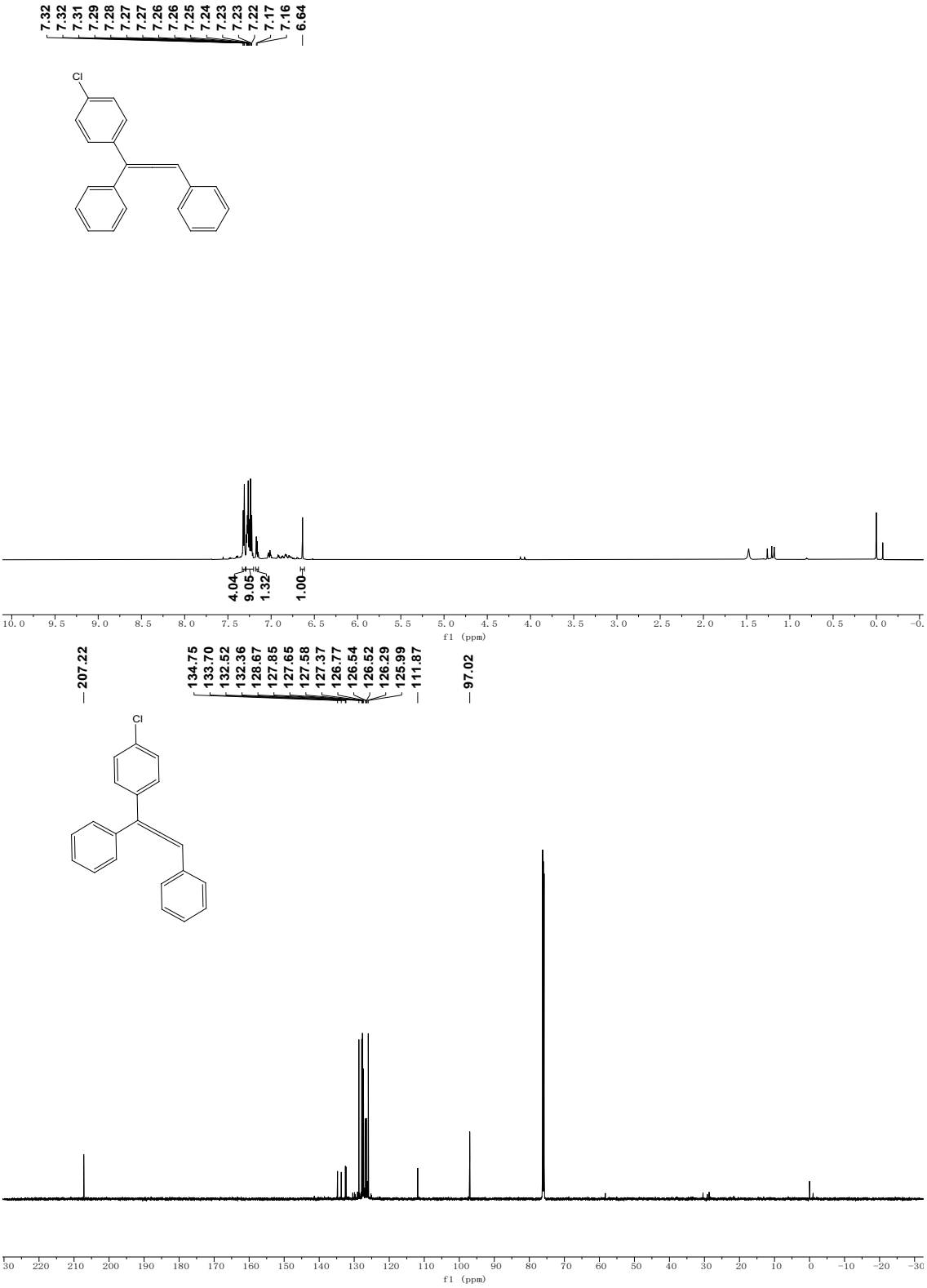
(1-(4-fluorophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3d).



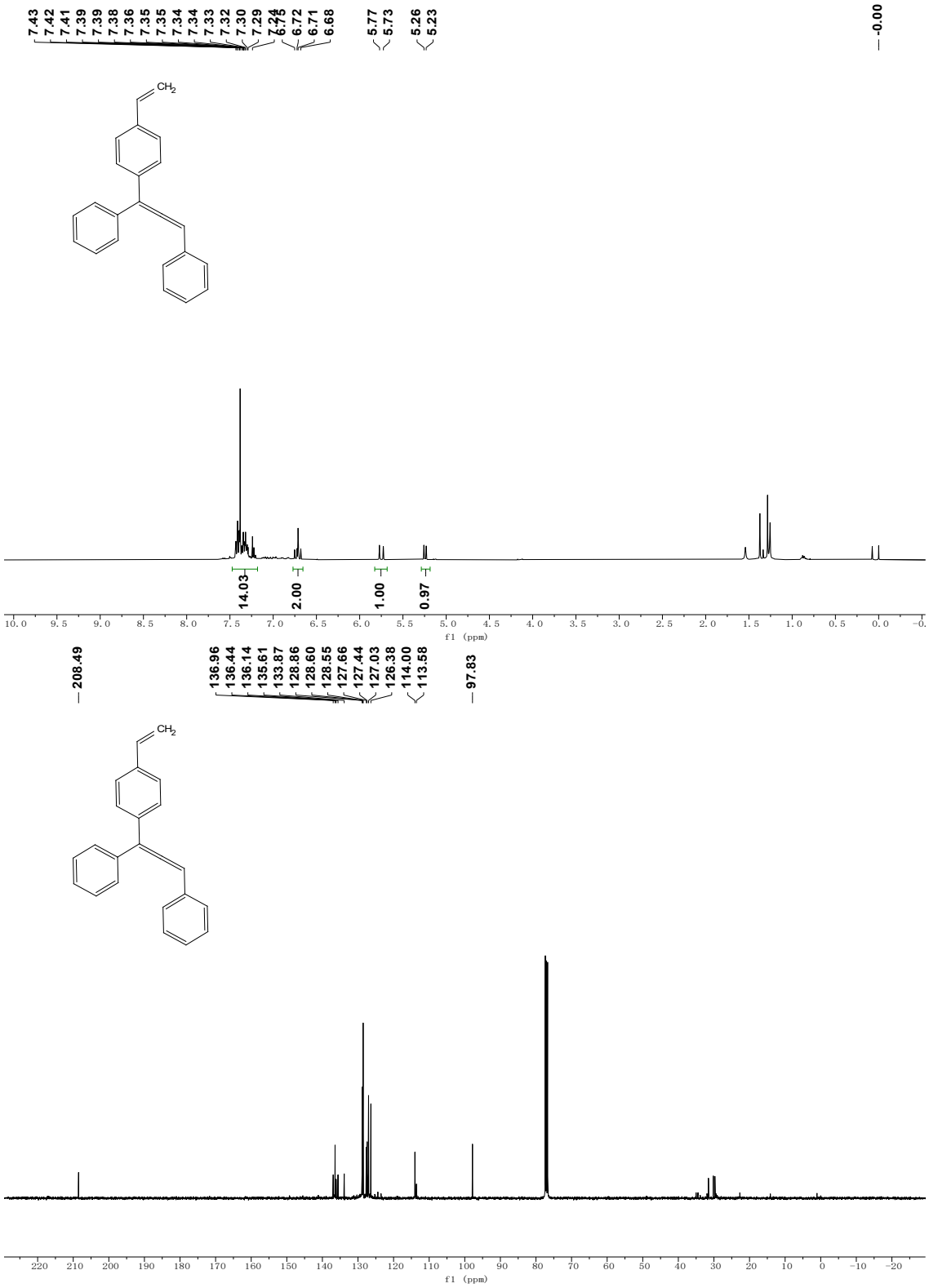

F

-114.49
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

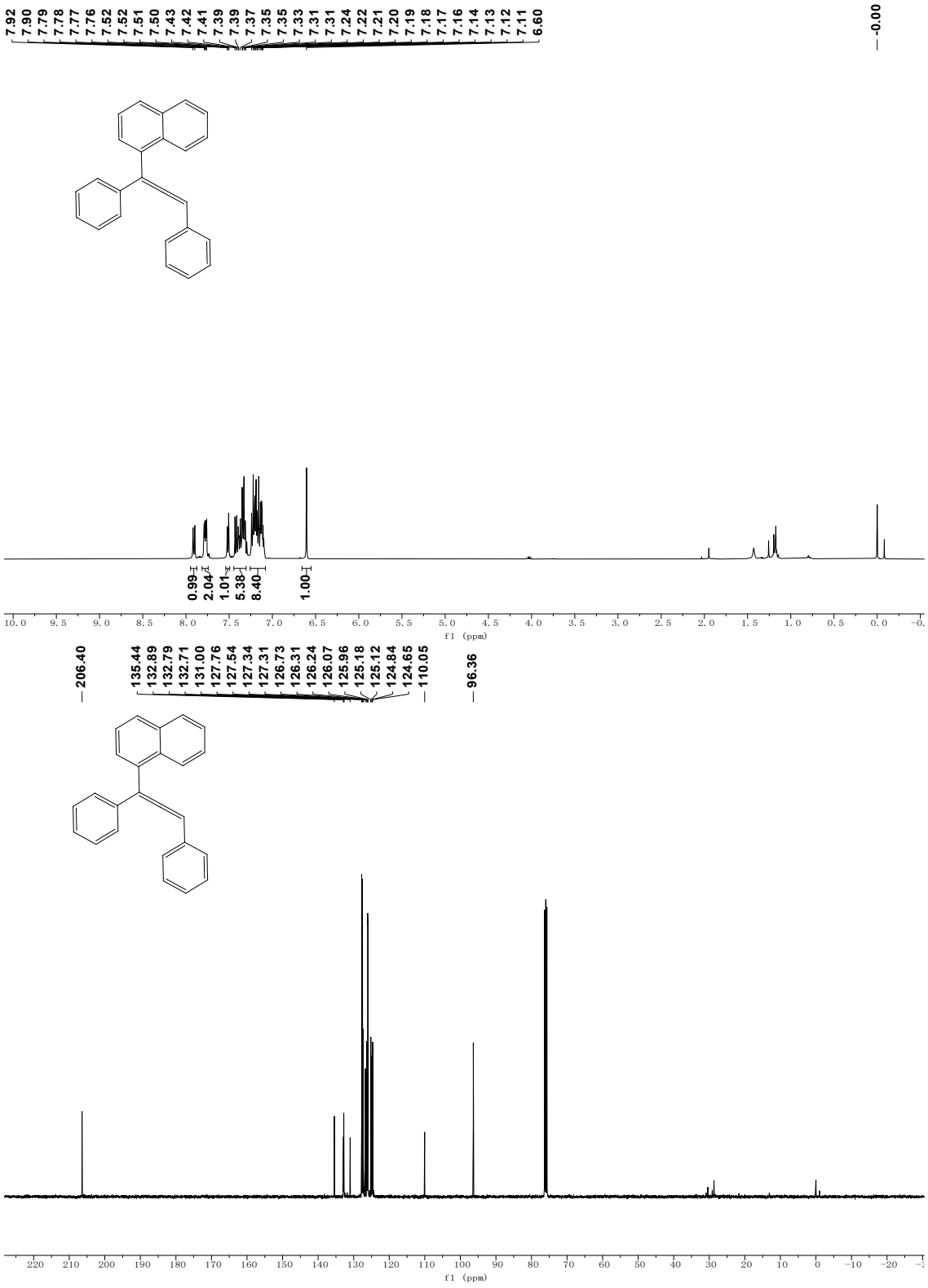
(1-(4-chlorophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3e).



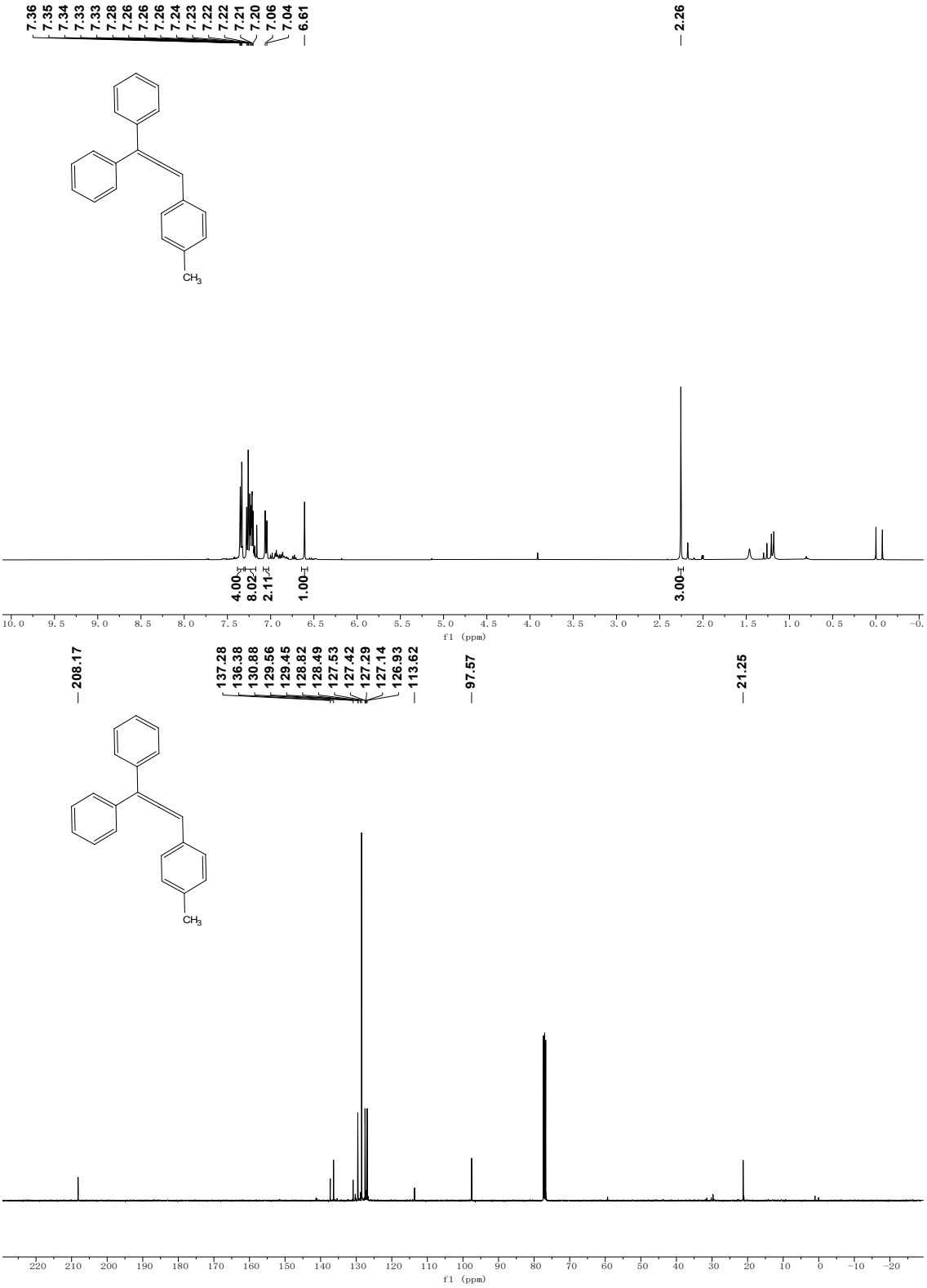
(1-(4-vinylphenyl)propa-1,2-diene-1,3-diyl)dibenzene (3f).



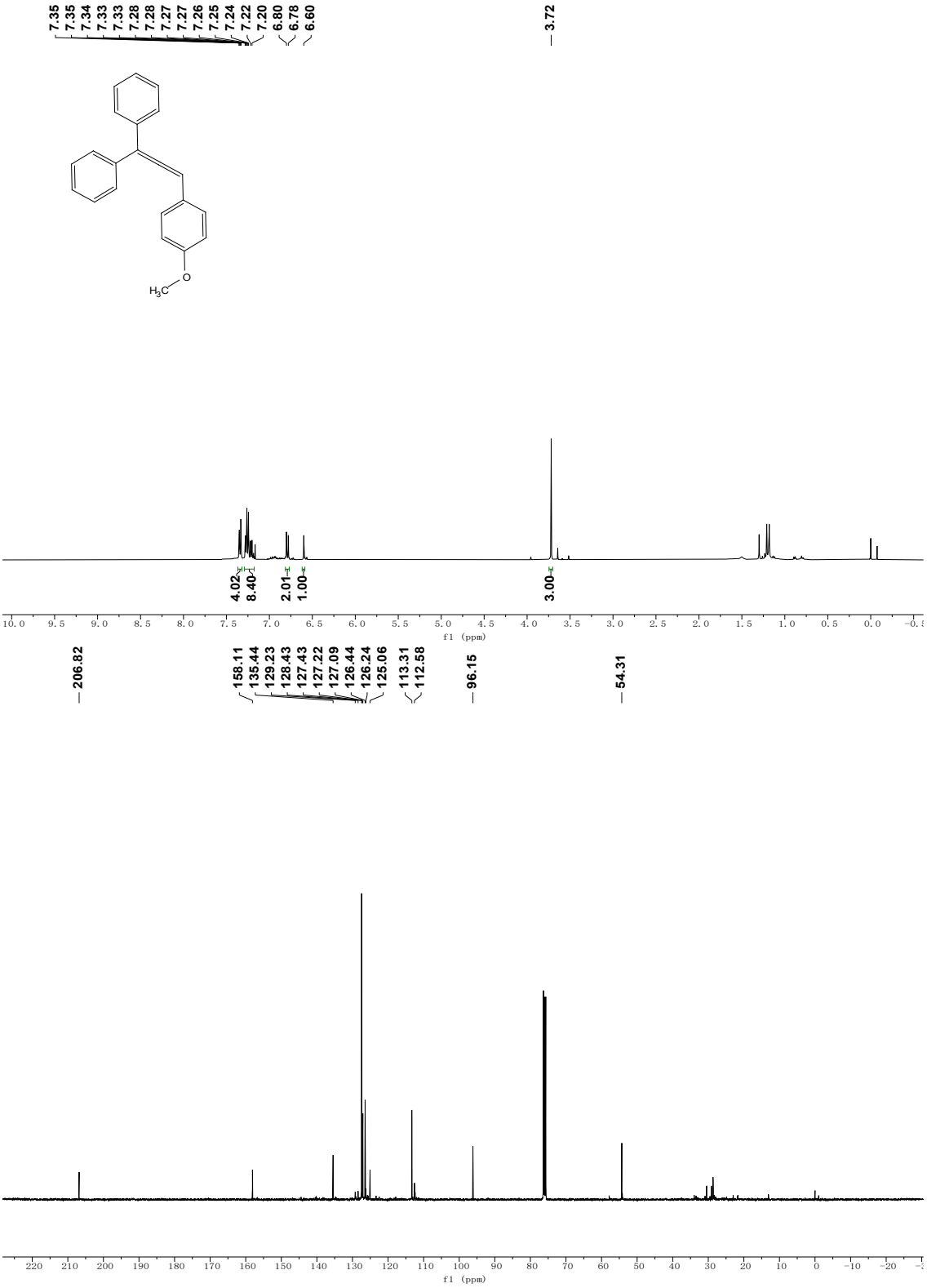
1-(1,3-diphenylpropa-1,2-dien-1-yl)naphthalene (3g).



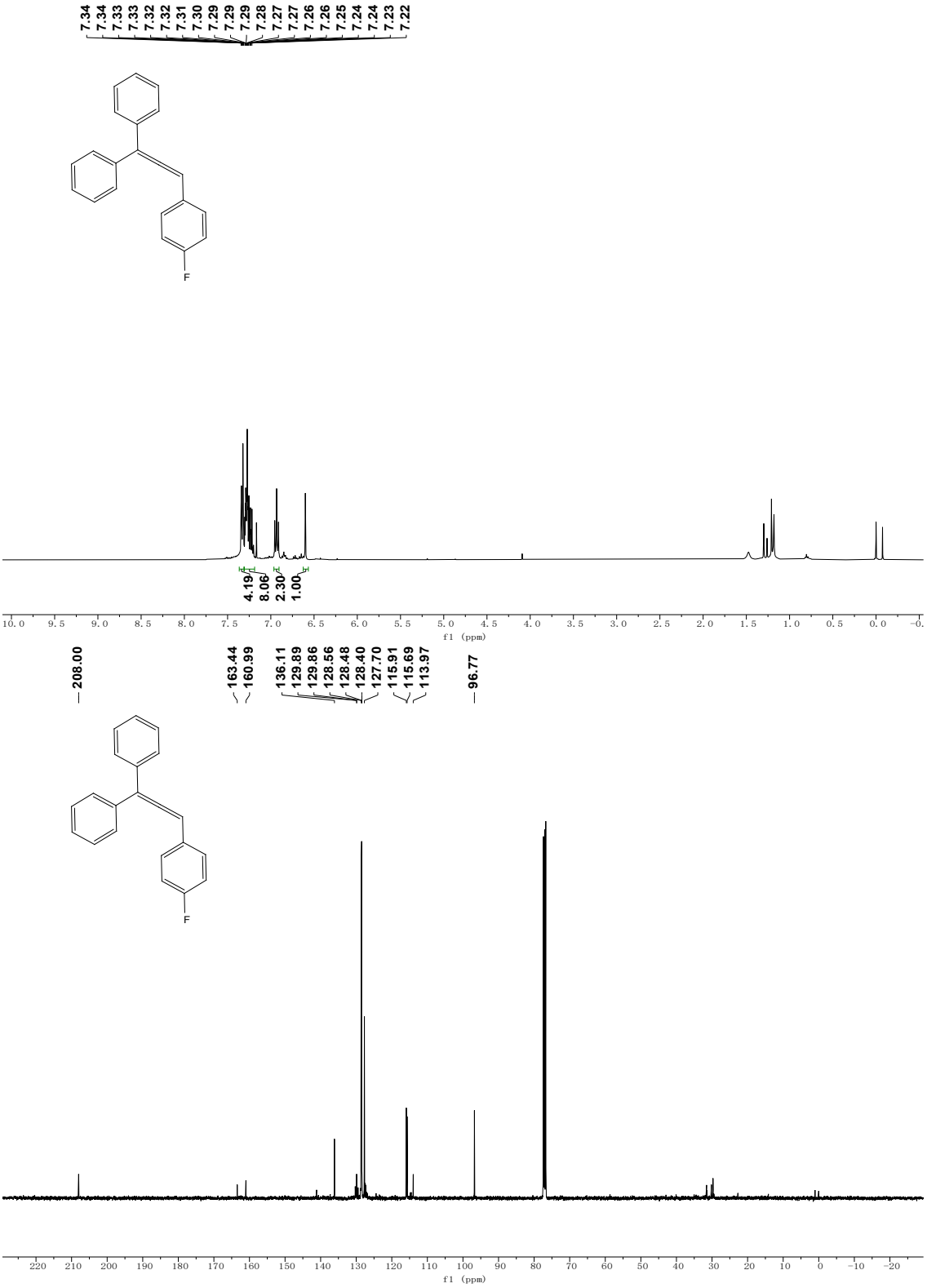
(3-(*p*-tolyl)propa-1,2-diene-1,1-diyl)dibenzene (3i).

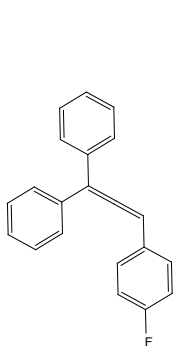


(3-(4-methoxyphenyl)propa-1,2-diene-1,1-diyl)dibenzene (3j).



(3-(4-fluorophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3k).




F

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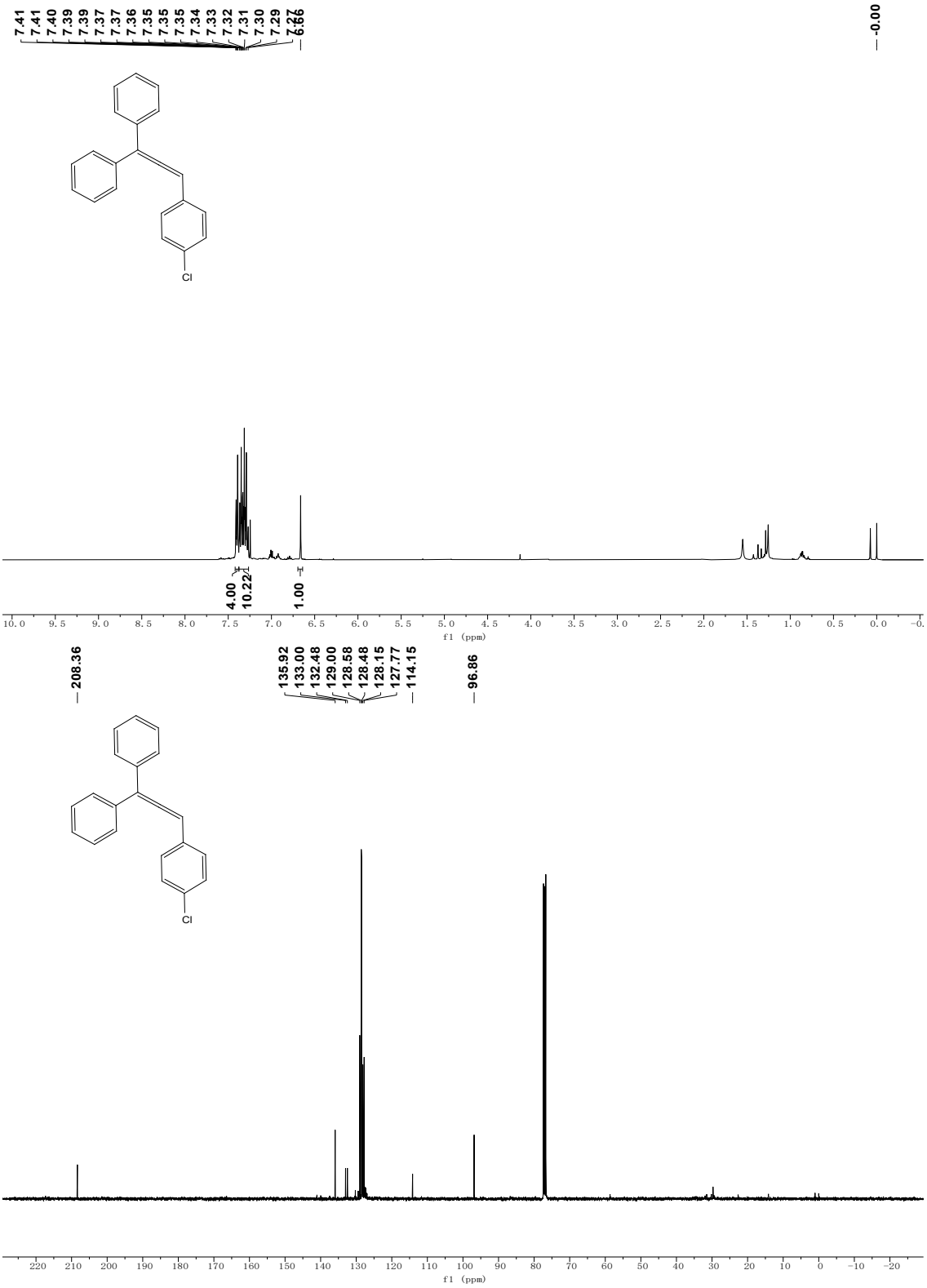
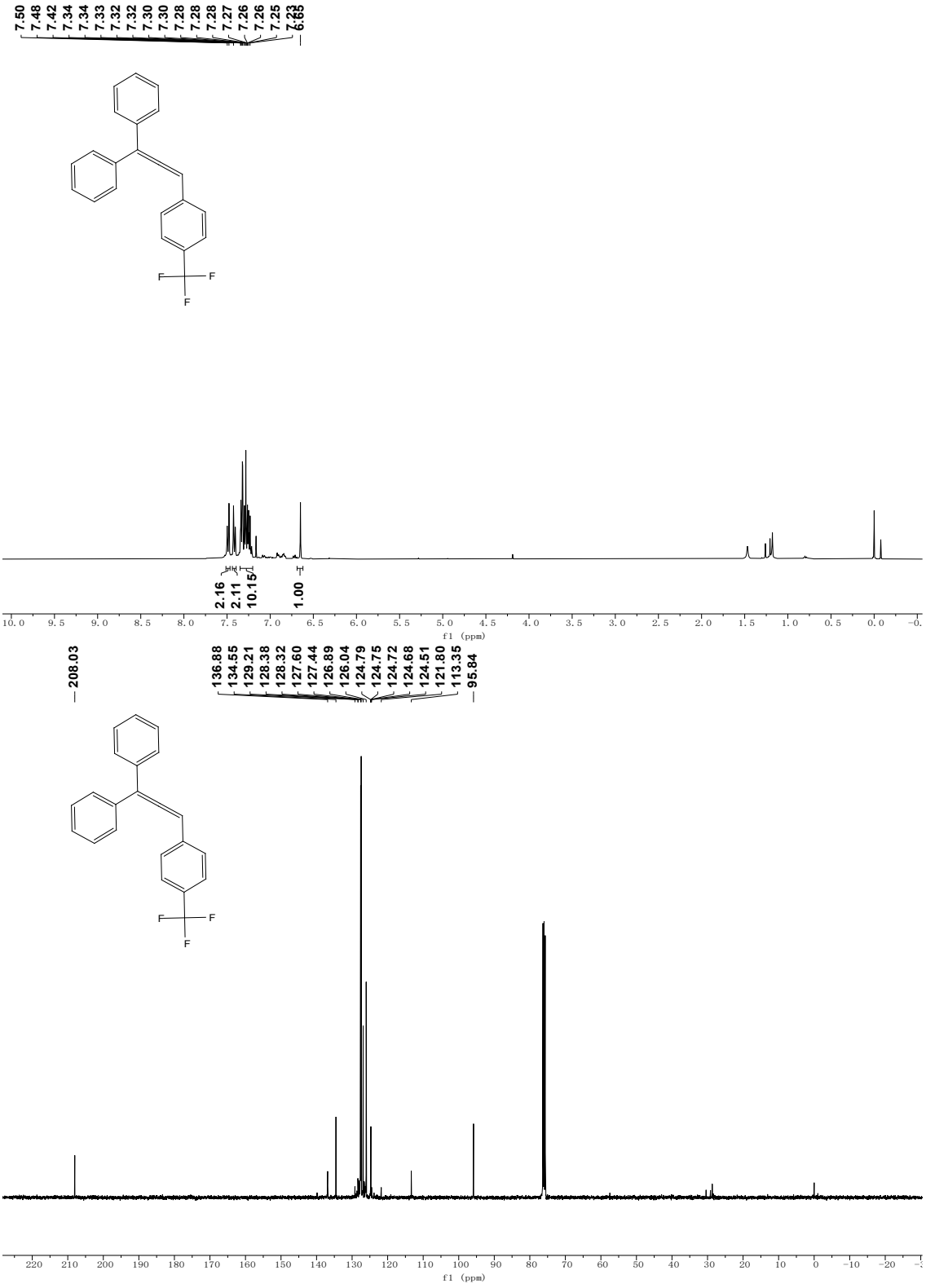
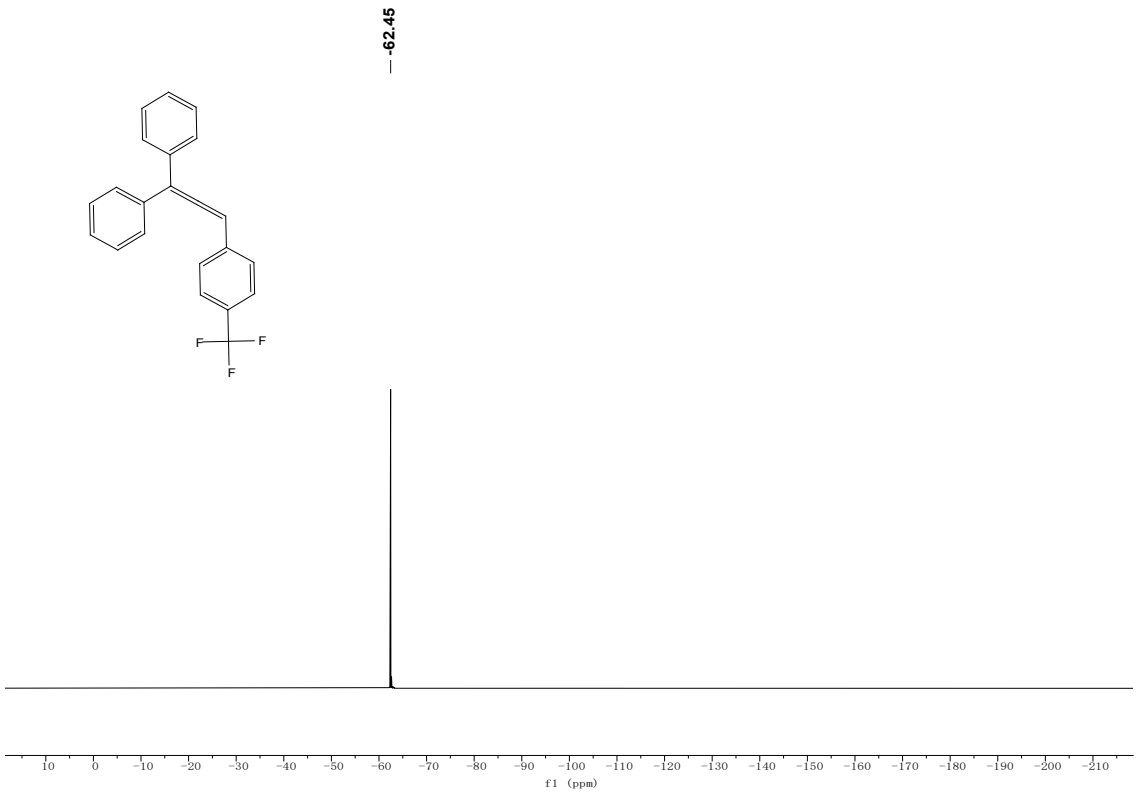
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

(3-(4-chlorophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3l).

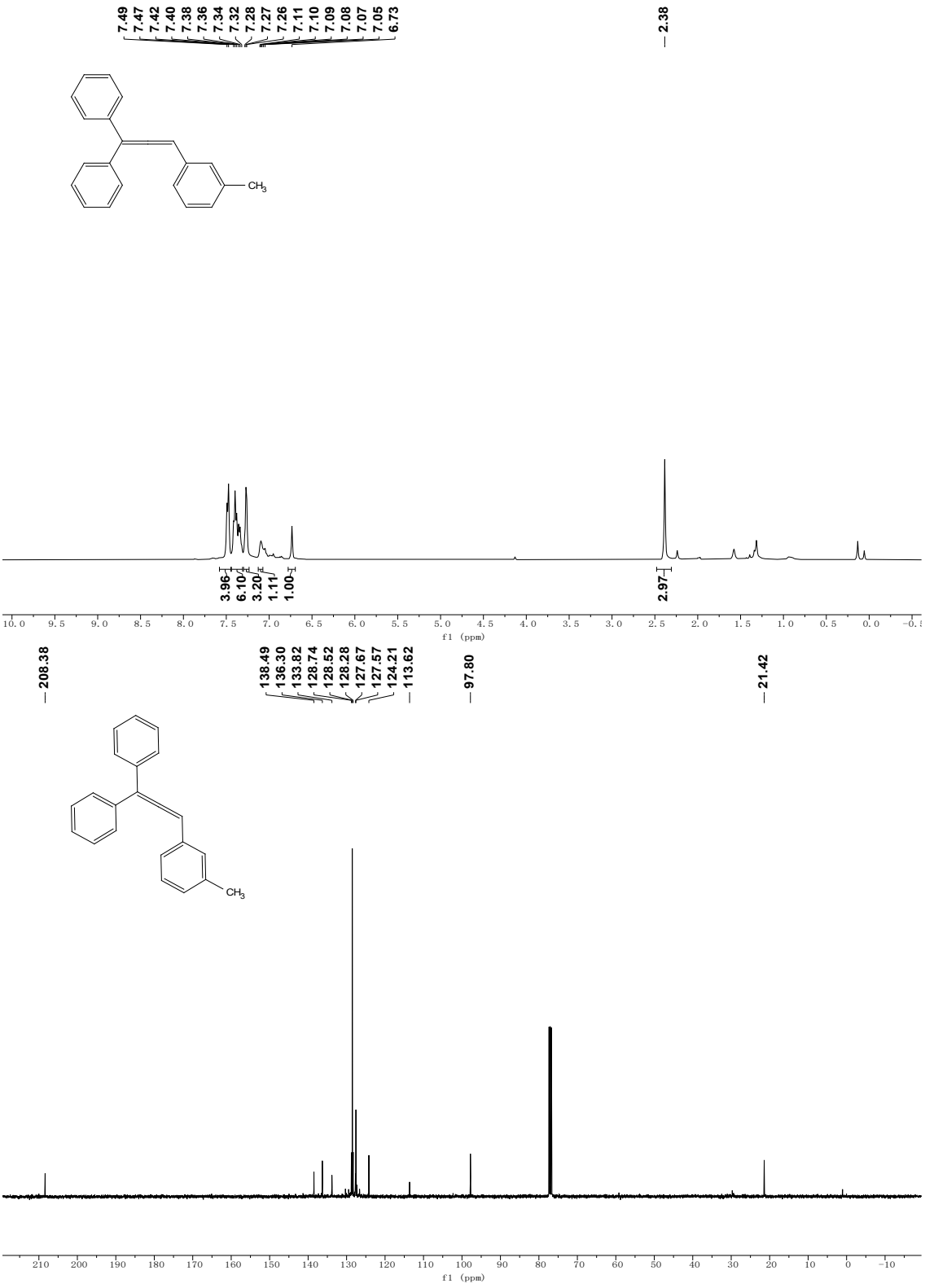


(3-(4-(trifluoromethyl)phenyl)propa-1,2-diene-1,1-diyl)dibenzene (3m).

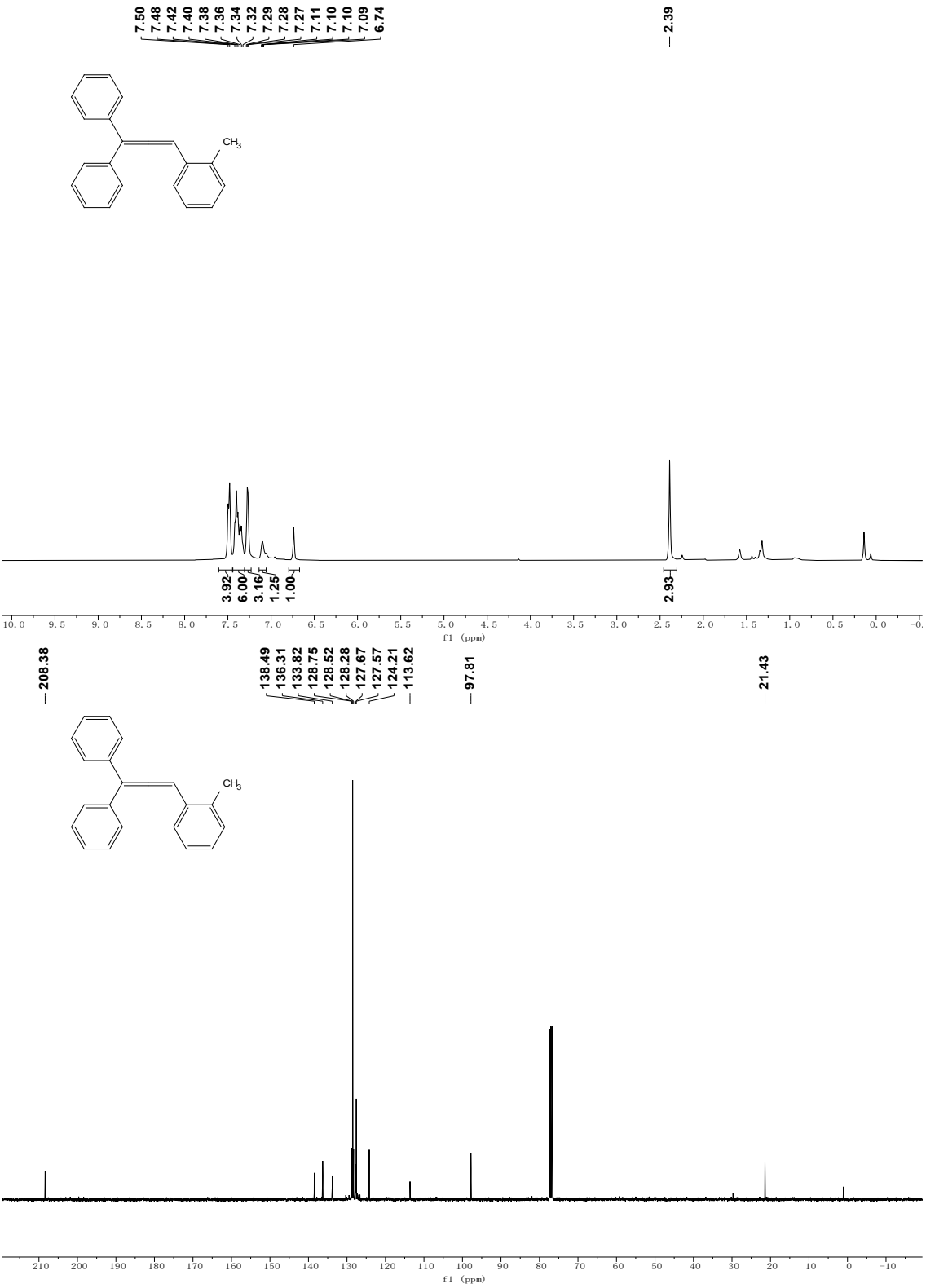



-62.45
F
F
F
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−180
−190
−200
−210
f1 (ppm)

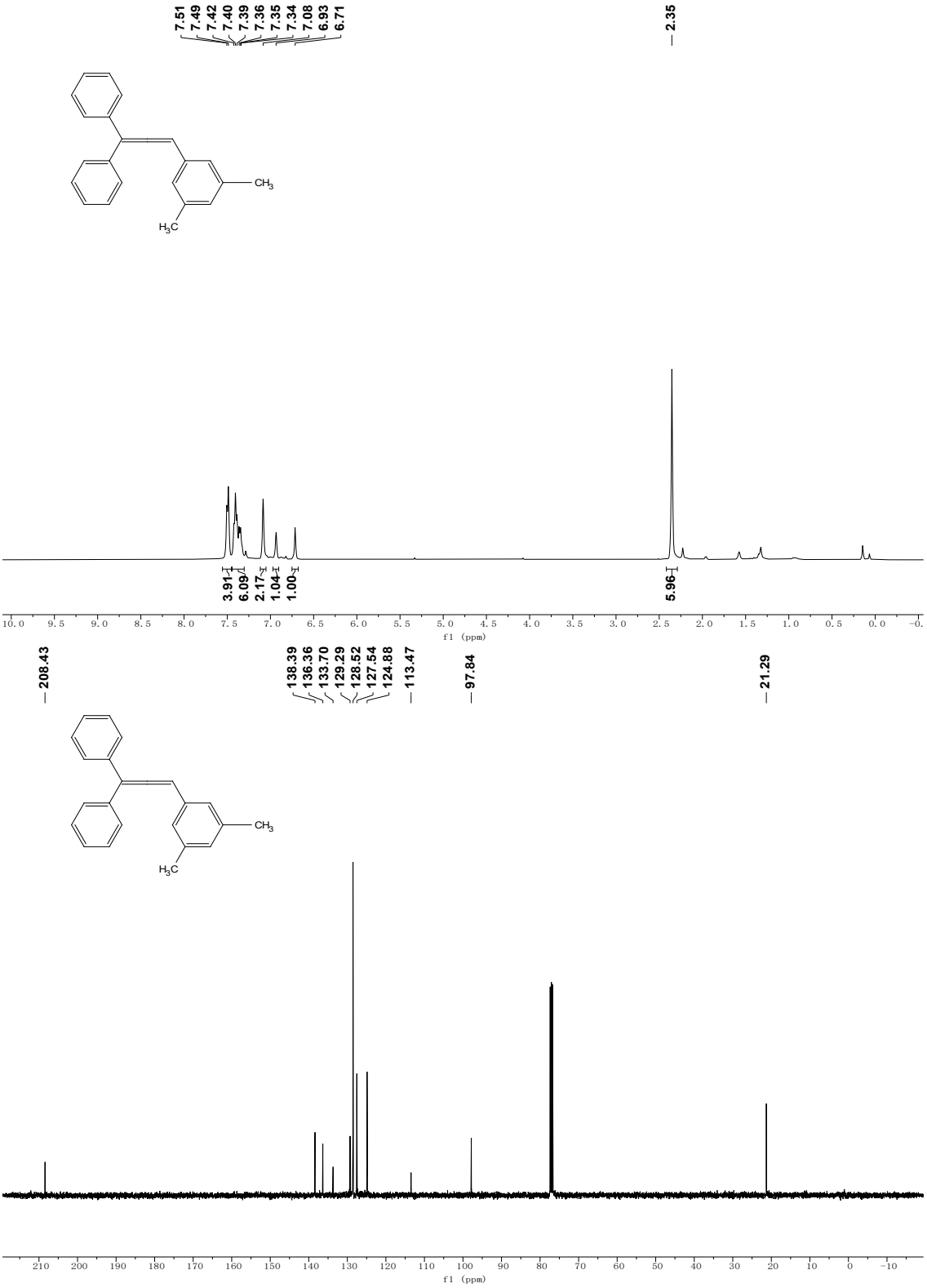
(3-(*m*-tolyl)propa-1,2-diene-1,1-diyl)dibenzene (3n).



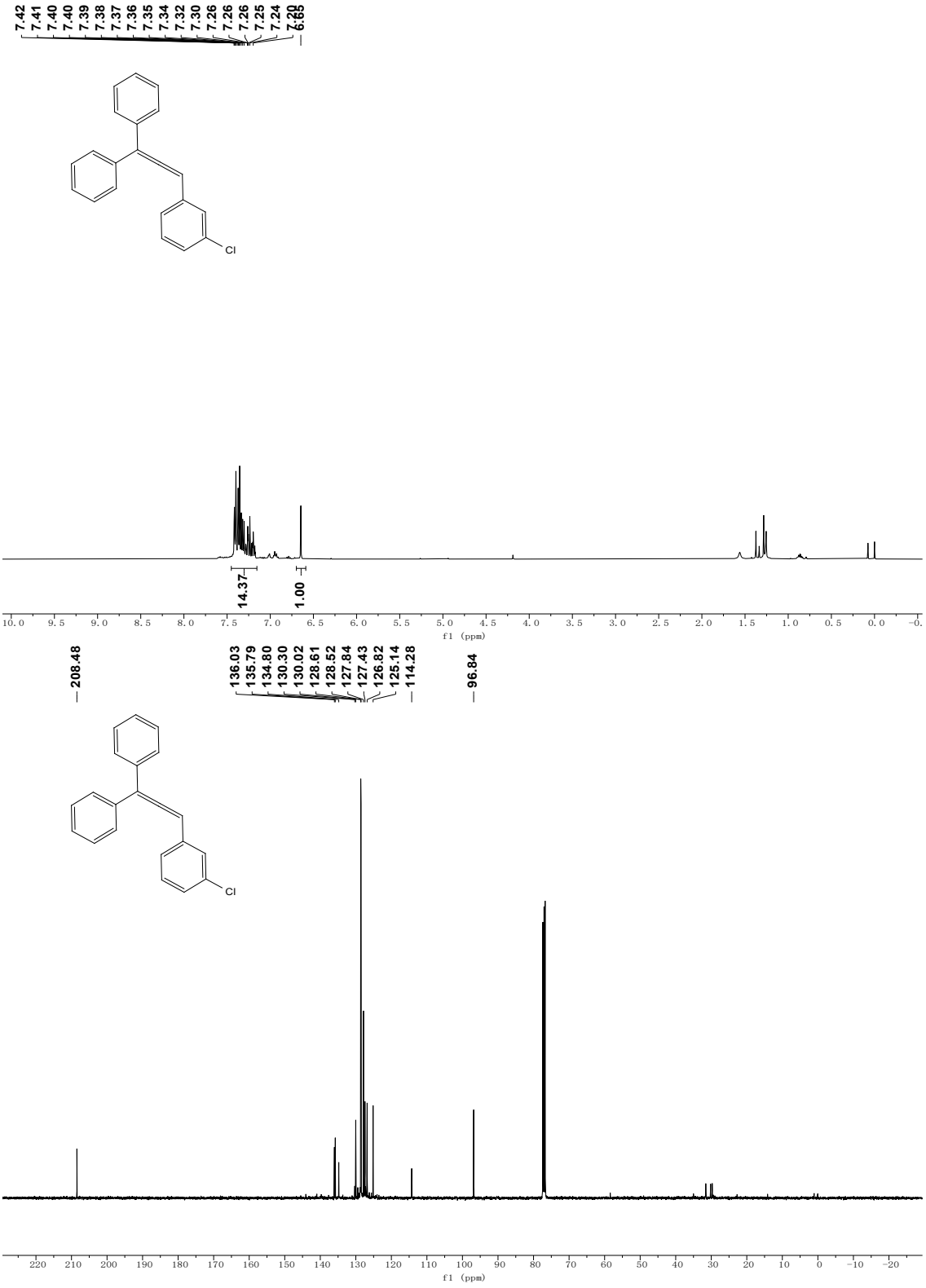
(3-(*o*-tolyl)propa-1,2-diene-1,1-diyl)dibenzene (3o).



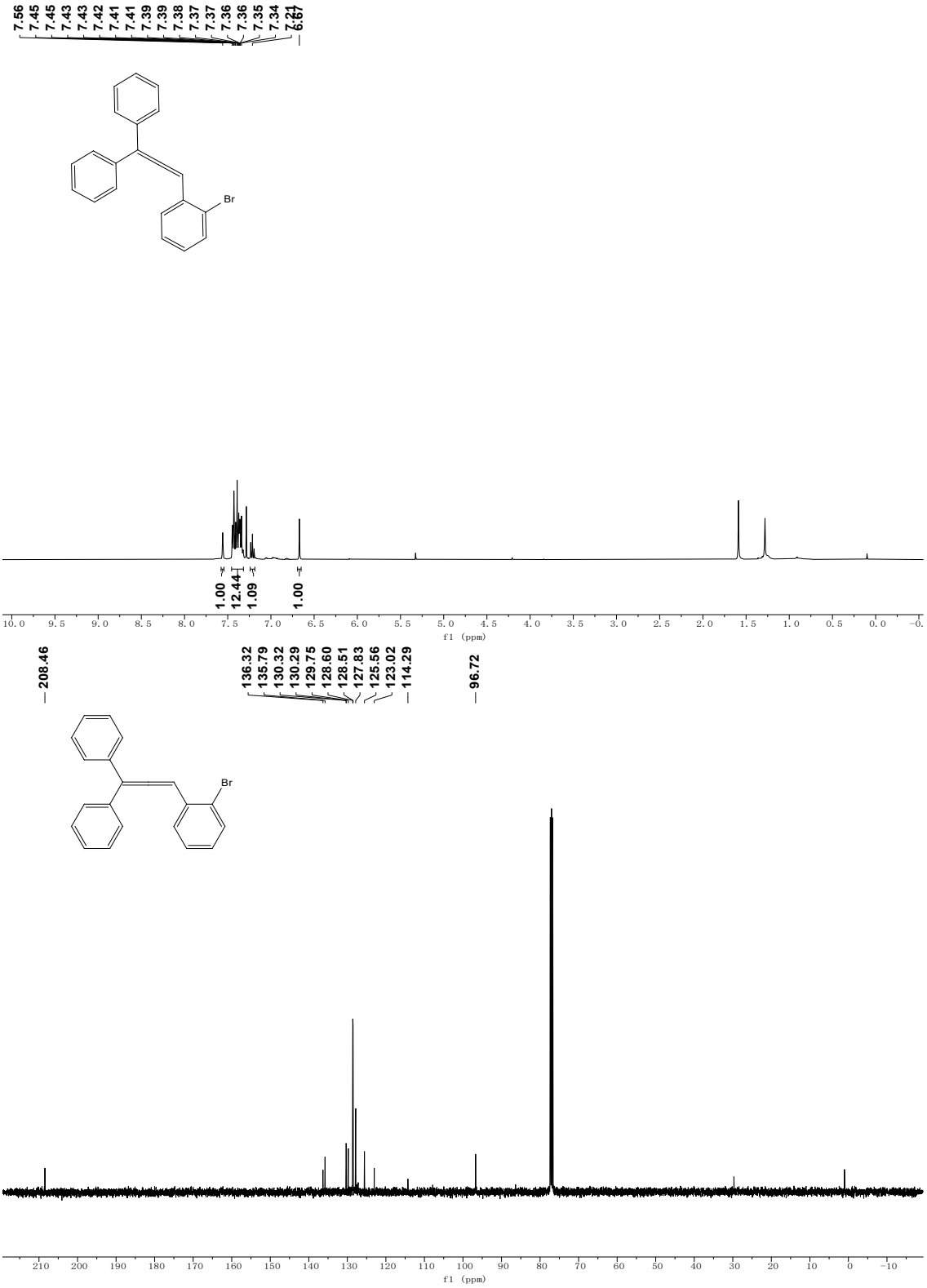
(3-(3,5-dimethylphenyl)propa-1,2-diene-1,1-diyl)dibenzene (3p).



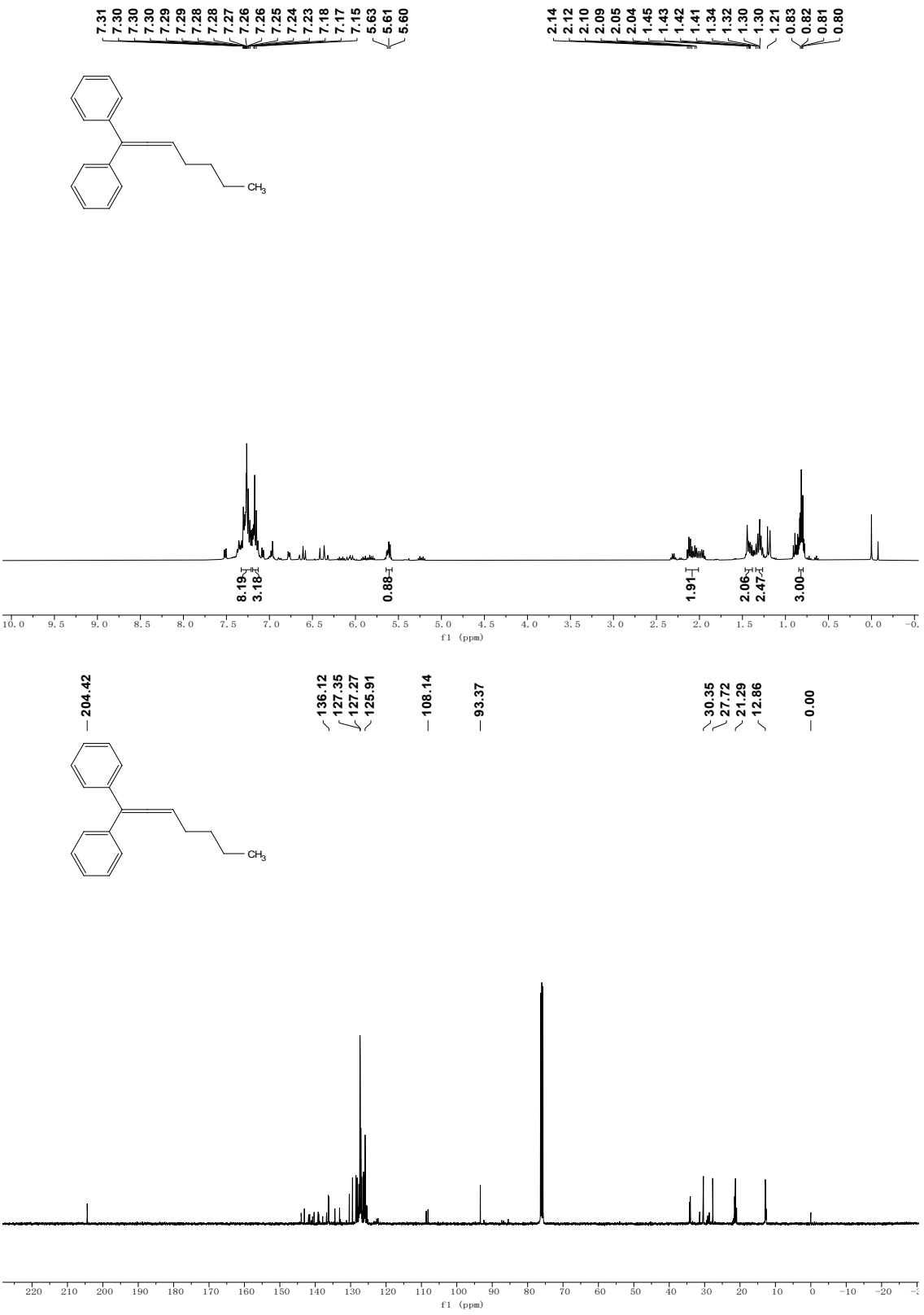
(3-(3-chlorophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3q).



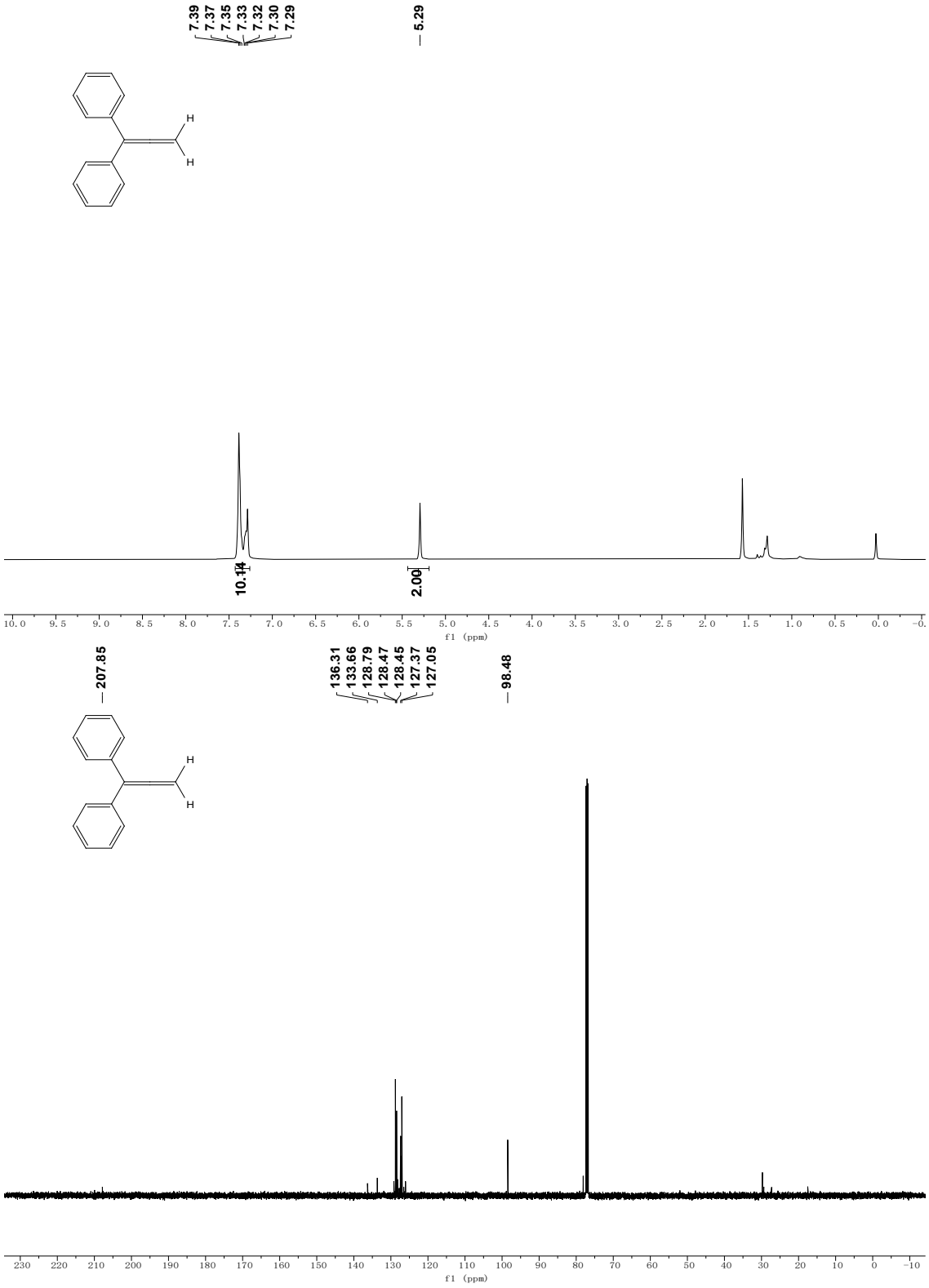
(3-(2-bromophenyl)propa-1,2-diene-1,1-diyl)dibenzene (3r).



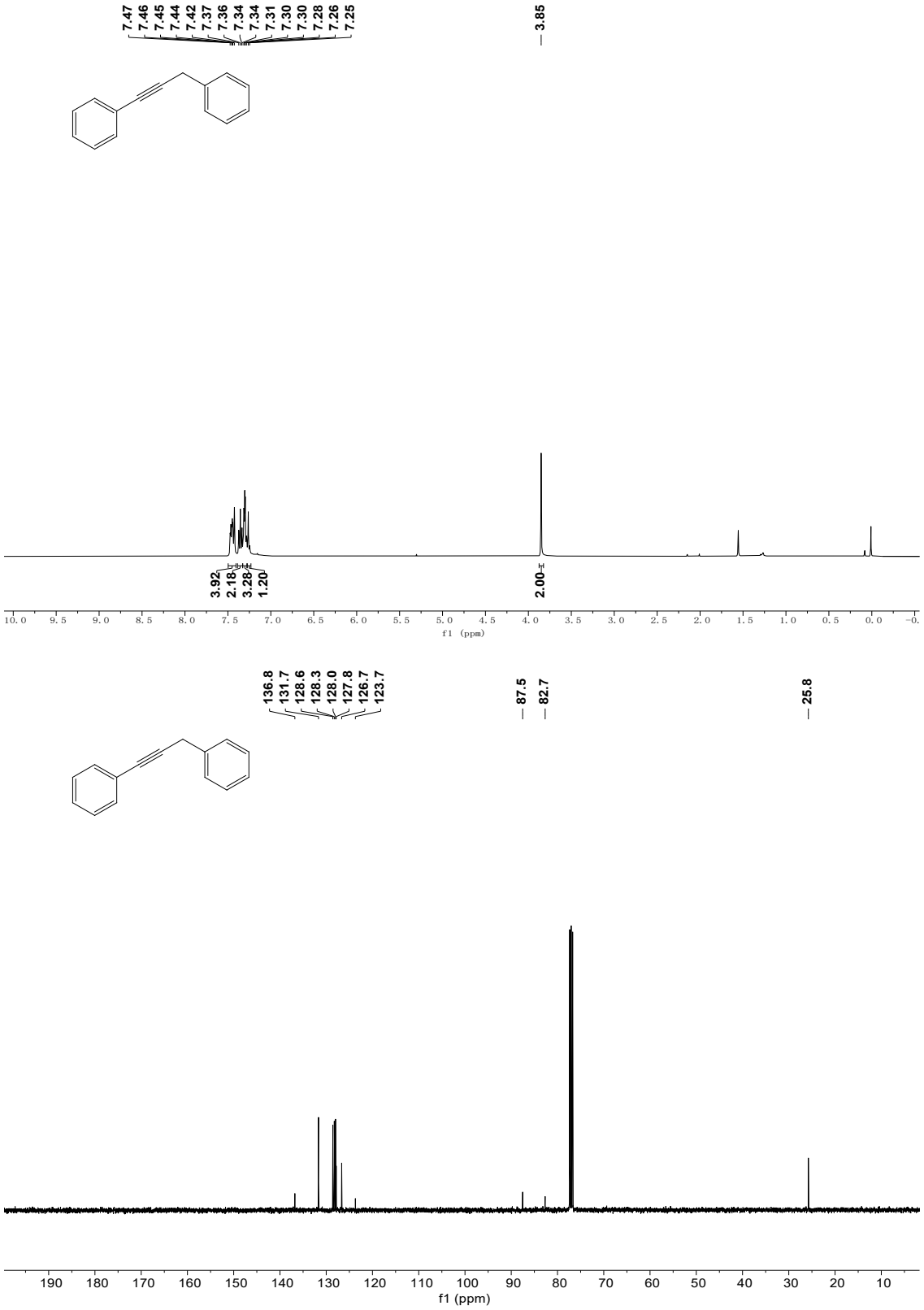
3t crude product



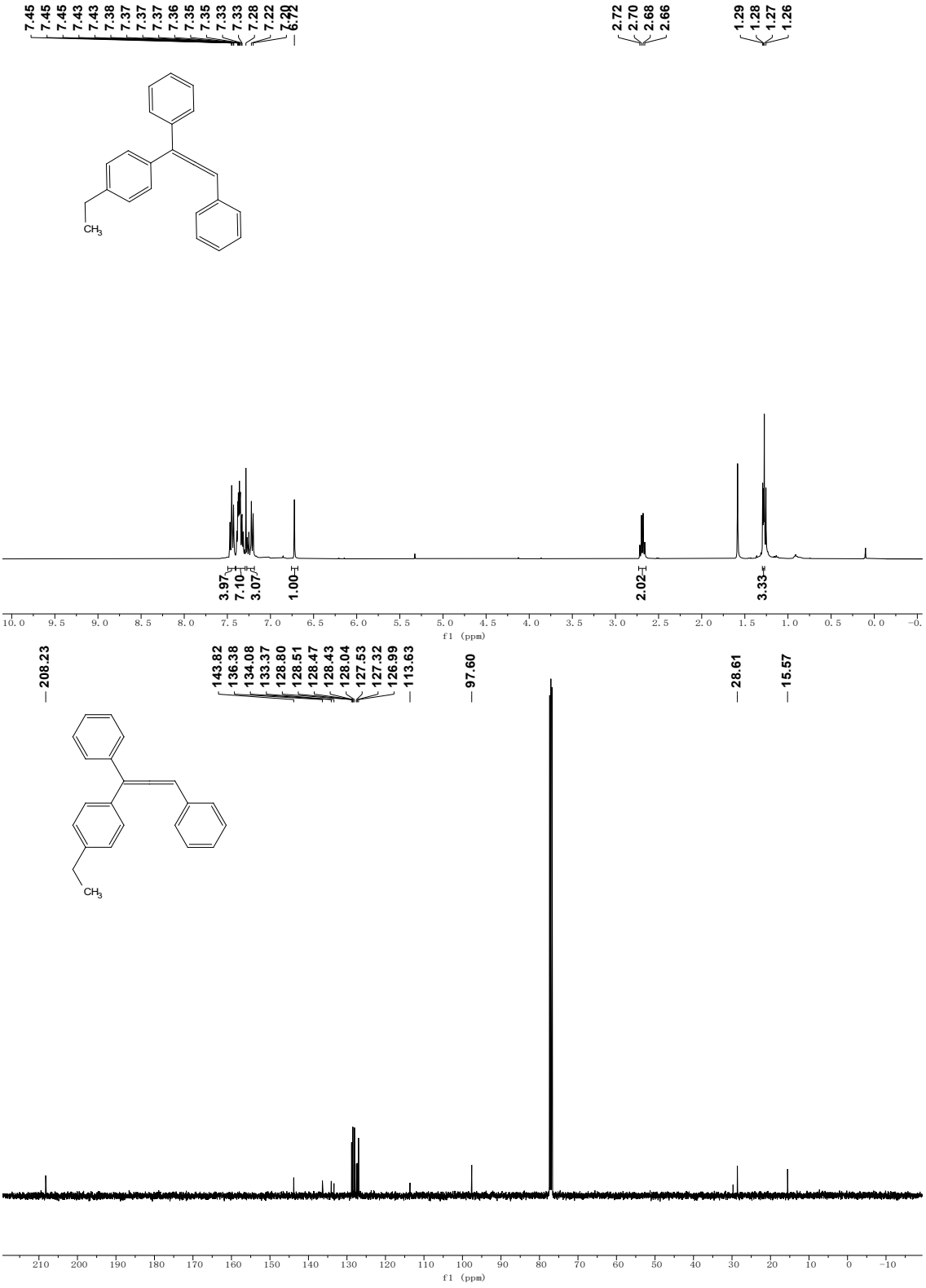
propa-1,2-diene-1,1-diyldibenzene (3u).



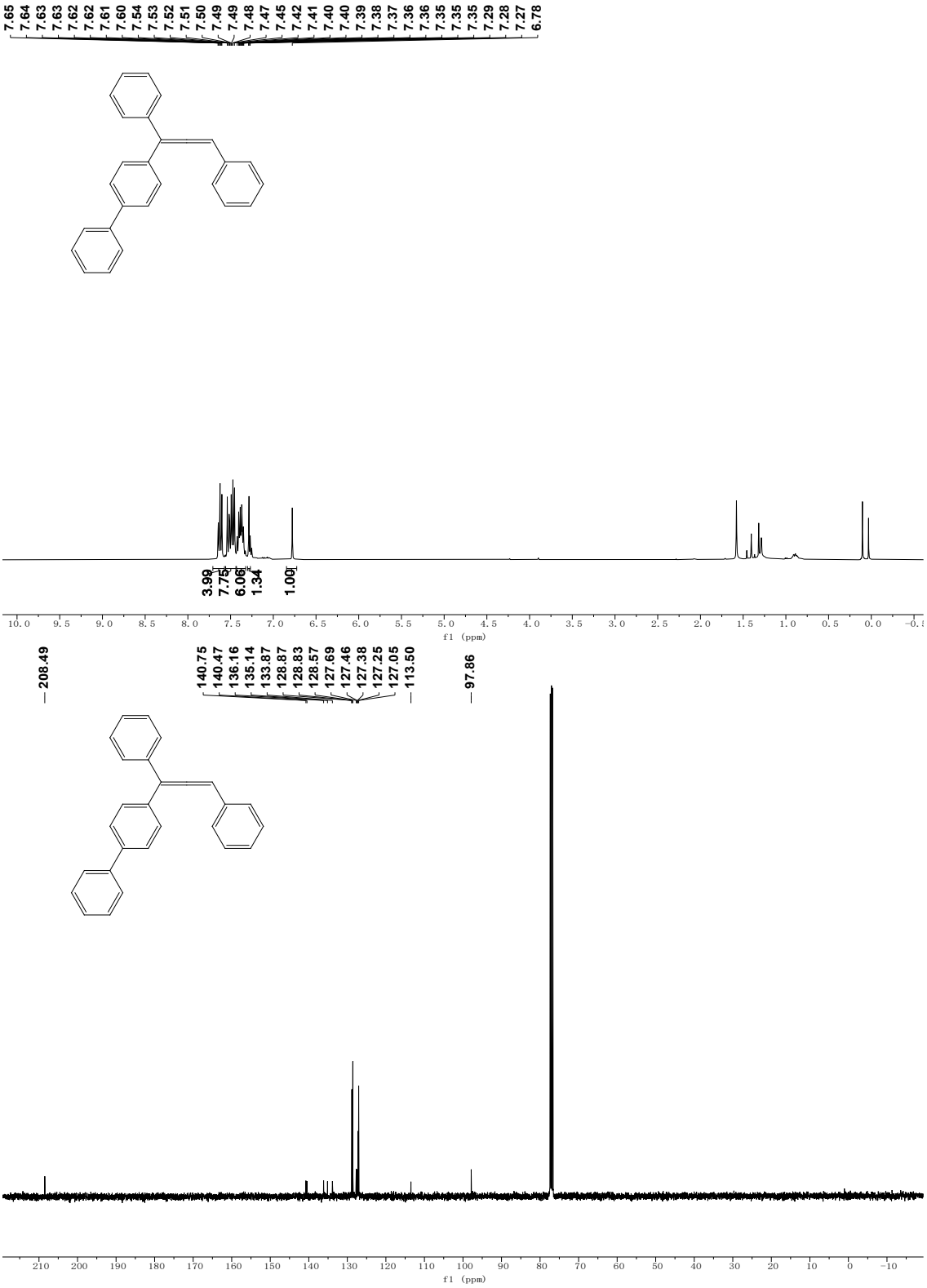
prop-1-yne-1,3-diyldibenzene (4).



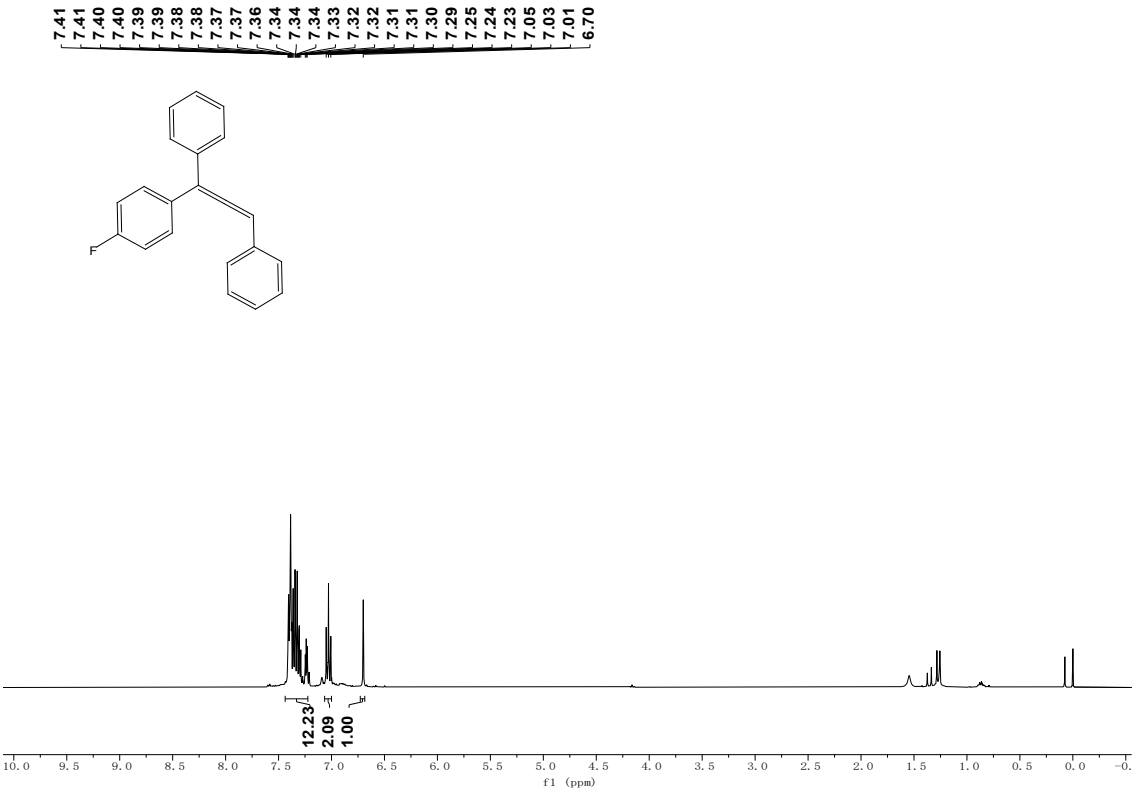
(1-(4-ethylphenyl)propa-1,2-diene-1,3-diyl)dibenzene (3v).

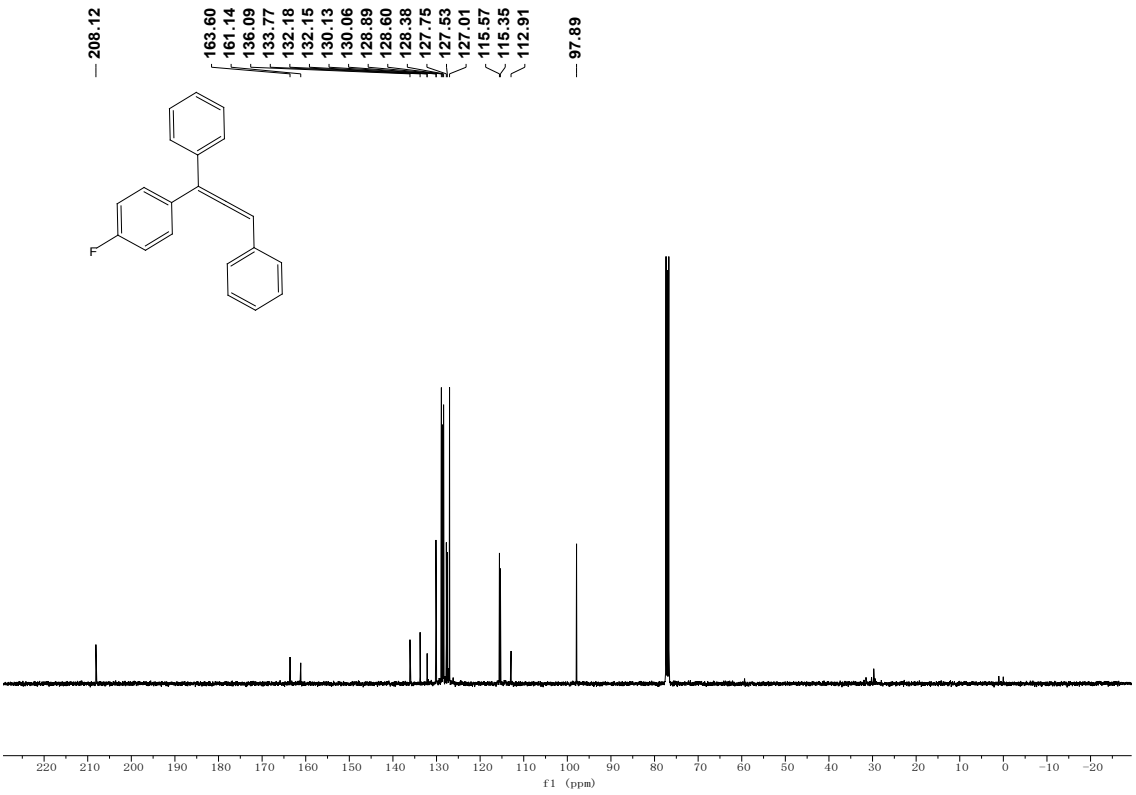


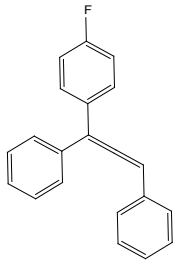
4-(1,3-diphenylpropa-1,2-dien-1-yl)-1,1'-biphenyl (3w).



(1-(4-fluorophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3x).

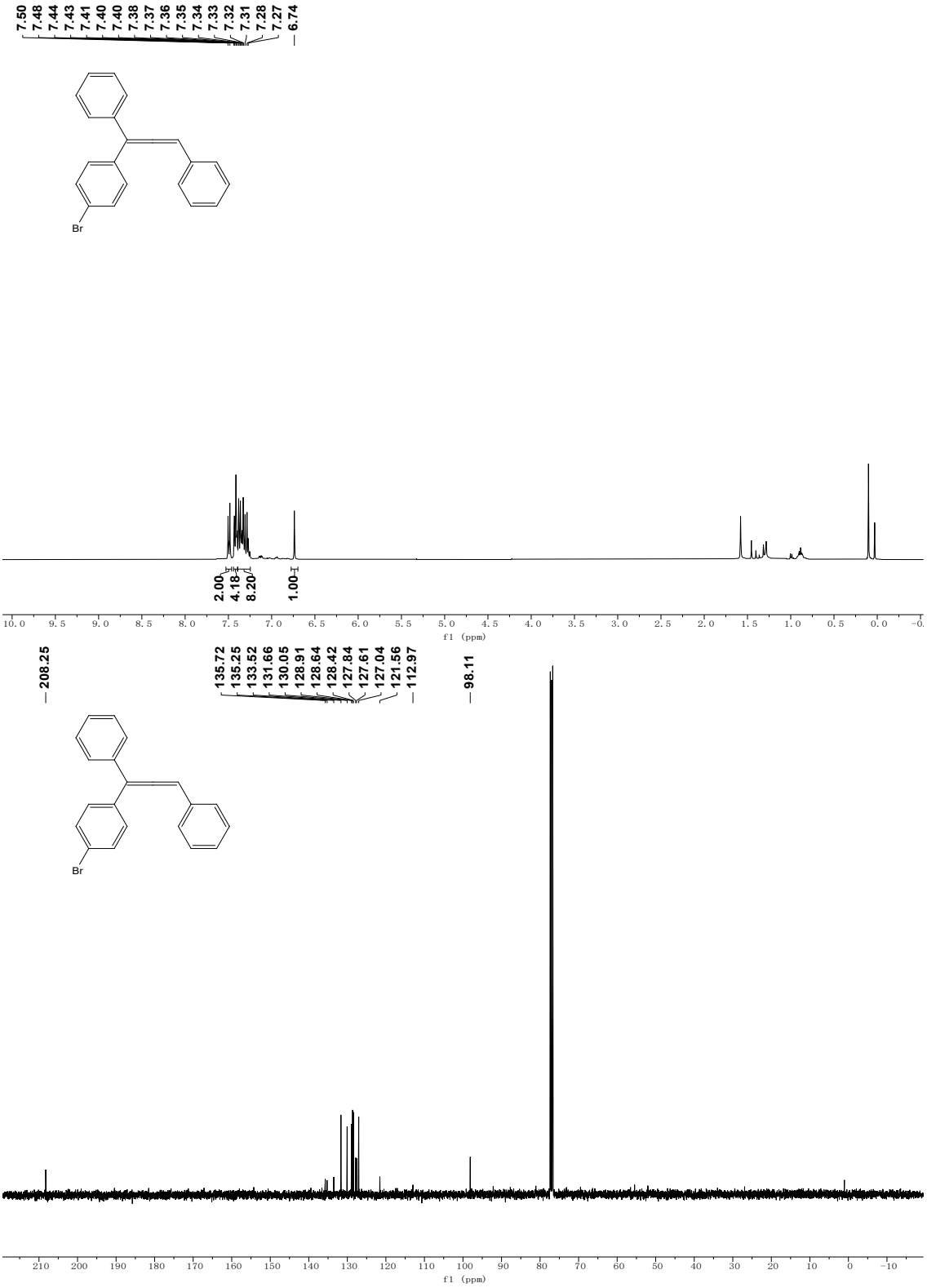




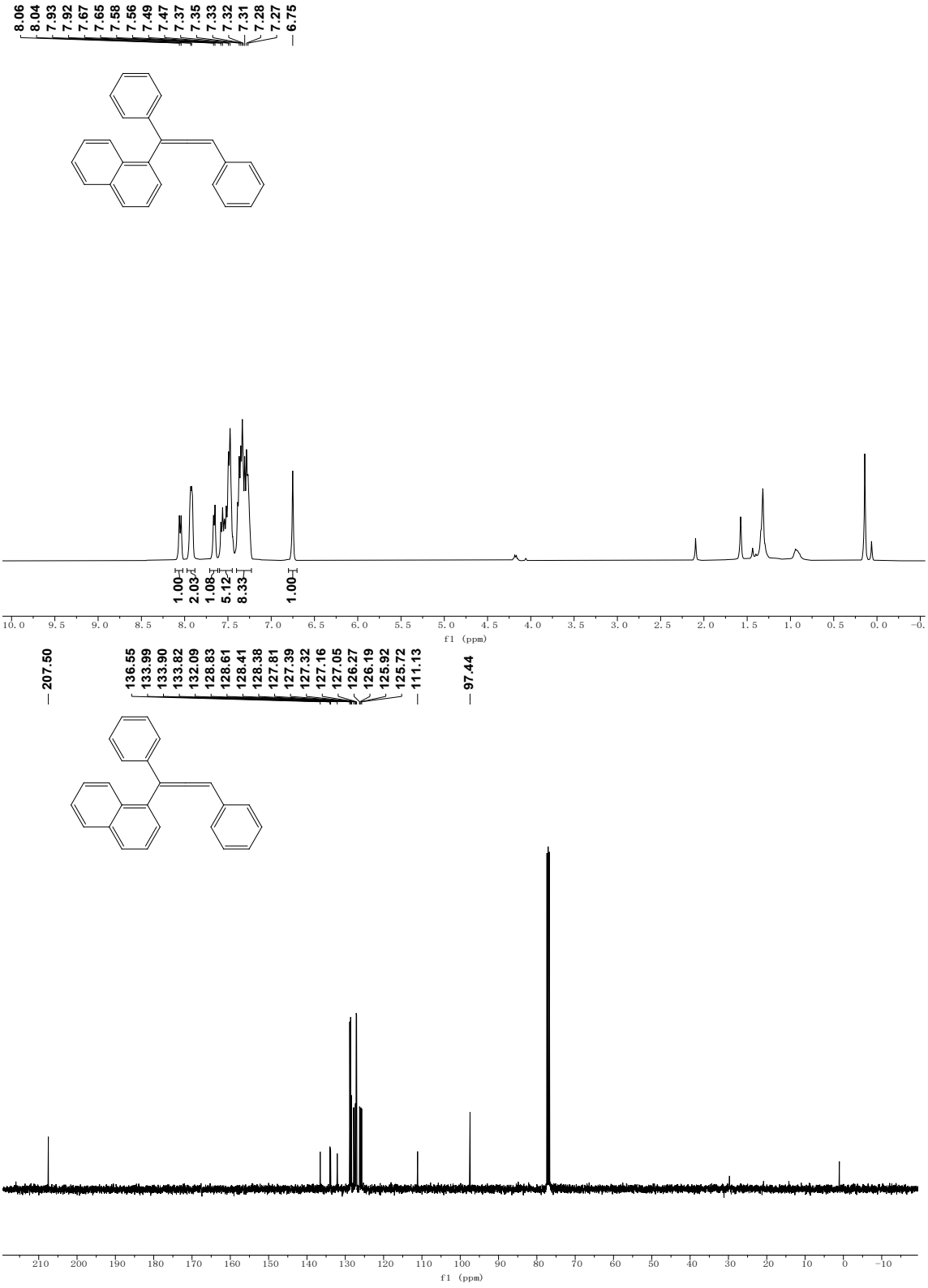

F

-113.17
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

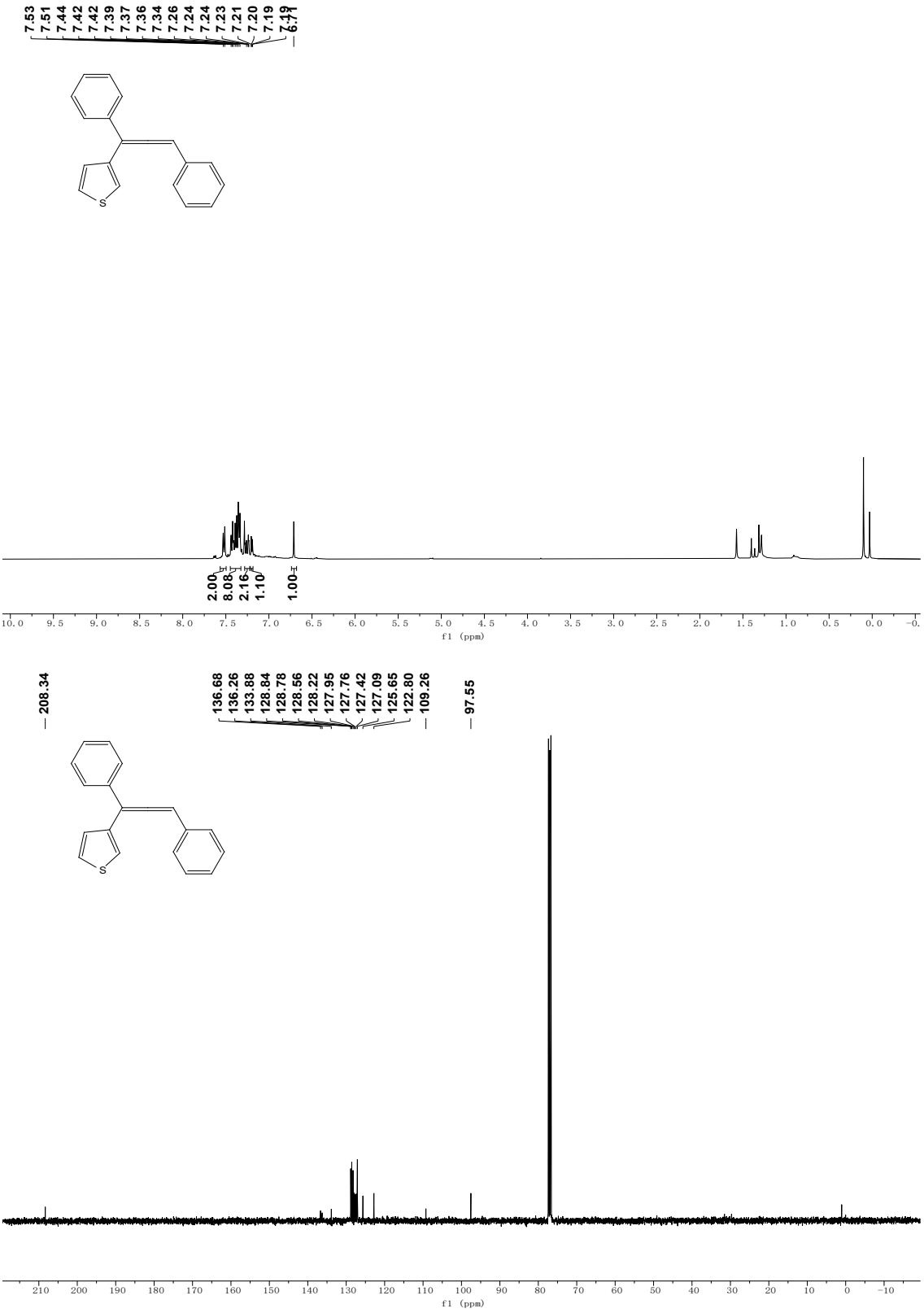
(1-(4-bromophenyl)propa-1,2-diene-1,3-diyl)dibenzene (3y).



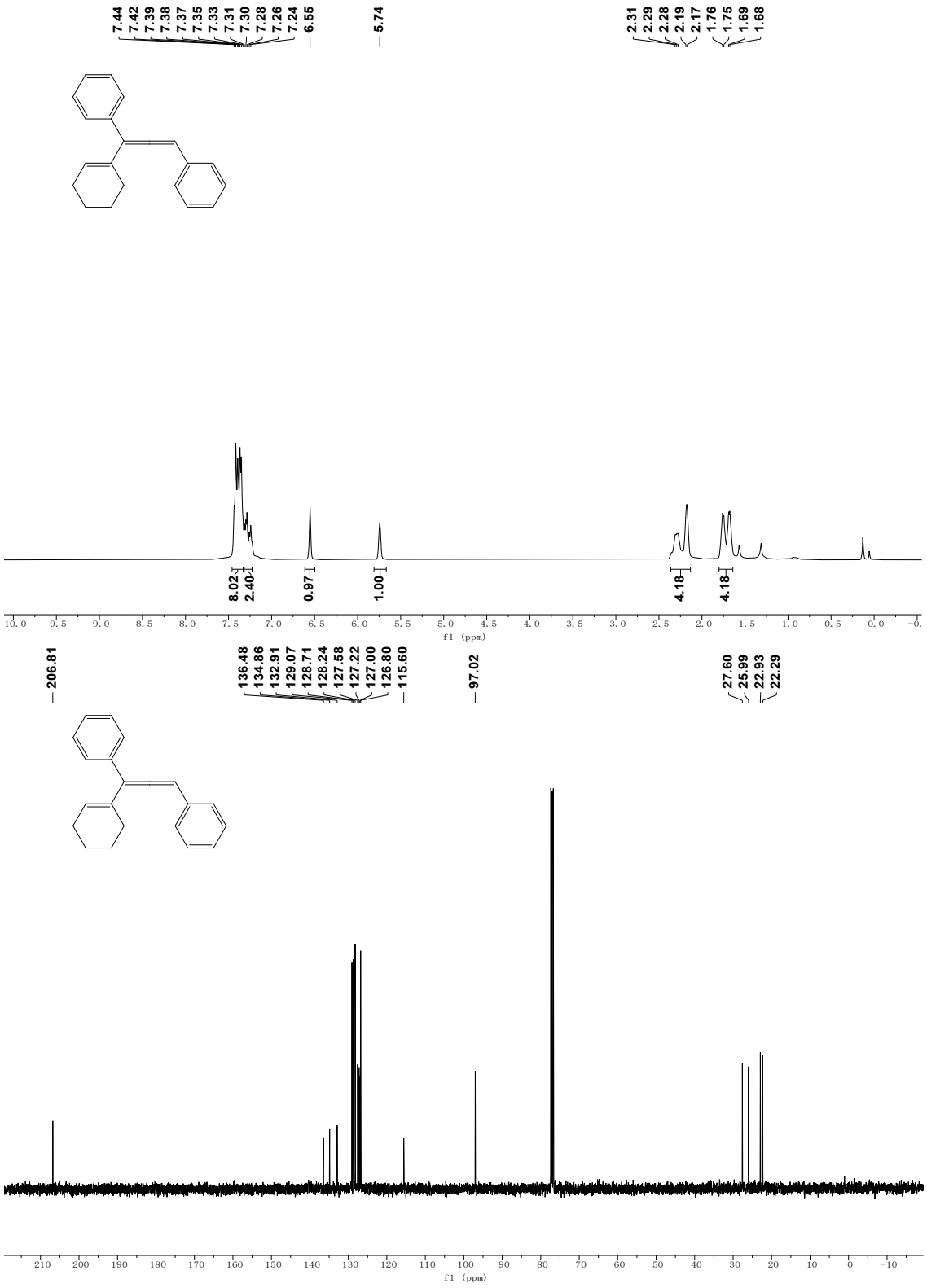
1-(1,3-diphenylpropa-1,2-dien-1-yl)naphthalene (3z).



3-(1,3-diphenylpropa-1,2-dien-1-yl)thiophene (3aa).



(1-(cyclohex-1-en-1-yl)propa-1,2-diene-1,3-diyl)dibenzene (3ab).



1,3-diphenyl-1H-indene (6)