Enantioselective Synthesis of α-Ionone Derivatives using an Anti S_N2'-Substitution of Functionalized Zinc Organometallics

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Supporting Information

General considerations

Unless otherwise indicated, all reactions were carried out with magnetic stirring and, if air or moisture sensitive, in flame-dried glassware under argon. Syringes used to transfer reagents and solvent were purged with argon prior to use. Reactions were monitored by gas chromotography (GC and GC-MS) or thin layer chromotography (TLC). Enantiomeric purity was determined by chiral HPLC or capillary GC analysis. In all cases, the analysis was calibrated with a sample of the racemate.

Chiral HPLC:

column : Chiralcel OD-H, 0.46 cm x 25 cm

Chiral GC:

column : Chiraldex B-PH, 30.0 mm x 0.25 mm

method A: 40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min)

method B: 125 °C const.

method C: 100 °C const.

Starting materials

2-Iodo-4,4-dimethyl-2-cyclohexenone.[1]

To the flame dried round bottom flask 250 mL was charged with 4,4-dimethyl-2-cyclohexenone (2.64 mL, 20 mmol) and CH_2Cl_2 (130 mL). PDC (2.26 g, 6 mmol) and I_2 (5.08 g, 20 mmol) were added consecutively, and the reaction mixture was stirred at room temperature. After stirring for 26 h, I_2 (1 g, 3.9 mmol) was added, and the mixture was stirred for 25 h. The reaction mixture was filtered and washed with pentane (100 mL). The combined organic layer was washed with 2 M HCl (30 mL), saturated $NaHCO_3$ solution (30 mL), saturated $Na_2S_2O_3$ (30 mL), brine and dried over $MgSO_4$ anhydrous. The crude product was

purified by column chromatography (8% Et_2O:Pentane) afforded the desired product 4.644 g (93% yield).
^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.46 (s, 1H), 2.71-2.63 (m, 2H), 1.96-1.89 (m, 2H), 1.21-1.17 (m, 6H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 192.3, 168.5, 102.2, 38.4, 36.4, 33.7, 27.79, 27.76.
IR (film): 2960 (m), 2927 (m), 2865 (m), 1690 (s), 1584 (m), 1468 (m), 1320 (m), 1144 (m), 802 (m).
MS (EI, 70 ev), *m/z* (%): 250 (M^+, 55), 235 (6), 222 (9), 207 (6), 123 (100), 95 (13), 80 (20), 67 (23), 55 (9).

(*R*)-2-Iodo-4,4-dimethyl-2-cyclohexenol.[2]
The flame dried round bottom flask 100 mL under N_2 was charged with *L*-diphenylprolinol (167 mg, 0.66 mmol, 5 mol%), THF (14 mL) and $B(OMe)_3$ (78 μL, 0.66 mmol, 5 mol%). The mixture was stirred at room temperature for 1 h. Then borane-*N*,*N*-diethylaniline complex (2.35 mL, 13.2 mmol, 1 equiv) was added followed by addition of the solution of 2-iodo-4,4-dimethyl-2-cyclohexenone (3.3 g, 13.2 mmol) in THF (14 mL) by using syringe pump. The mixture was stirred for 1 h then carefully quenched with MeOH (6 mL). The solvent was removed with rotary evaporator. The remaining oil was dissolved with Et_2O, washed with Na_2CO_3 solution, 10% $KHSO_4$, brine and dried over Na_2SO_4. The crude product was purified by column chromatography (20% Et_2O:Pentane) afforded product as a colourless oil 3.01 g, (90% yield).
HPLC (heptane : *i*PrOH = 98:2, 0.3 mL/min): t_R/min = 27.61 (minor), 33.78 (major); 98% *ee*.
$[\alpha]_D^{20}$ +41.56 (c 0.9, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.17 (s, 1H), 4.06 (t, *J* = 5.2 Hz, 1H), 2.05-1.91 (m, 2H), 1.85-1.74 (m, 1H), 1.62-1.51 (m, 1H), 1.48-1.38 (m, 1H), 0.97 (s, 3H), 0.93 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 150.7, 102.9, 72.4, 37.8, 32.6, 29.23, 29.21, 28.4.
IR (film): 3370 (br), 2956 (s), 2935 (s), 2863 (s), 1043 (s).
MS (EI, 70 ev), *m/z* (%): 252 (M^+, 25), 125 (100), 110 (61), 107 (80), 95 (51), 79 (33), 69 (18), 55 (38).
HRMS (EI): calcd. for $C_8H_{13}IO$ [M^+]: 252.0011, found: 252.0038.

Phosphoric acid diethylester (*R*)-2-iodo-4,4-dimethylcyclohex-2-enyl ester (4).
The solution of (*R*)-2-iodo-4,4-dimethyl-2-cyclohexenol (1.26 g, 5 mmol) in dry Et_2O (9 mL) was added *N*-methylimidazole (0.95 mL, 12 mmol, 2.4 equiv). The mixture was cooled at 0 ^oC, chlorodiethylphosphate (1.74 mL, 12 mmol, 2.4 equiv) was added dropwise, then the mixture was stirred at room temperature overnight (16 h). The reaction mixture was quenched with saturated NaCl solution (20 mL) and extracted with Et_2O (3 x 20 mL). The combined organic phases was dried over Na_2SO_4 anhydrous. The crude product was purified by column chromatography (50% Et_2O:Pentane) afforded the product as a colourless oil 1.65 g (85% yield).
GC (column A, method A): t_R/min = 65.714 (major), 68.826 (minor); 98% *ee*.
$[\alpha]_D^{20}$ + 27.45 (c 1.1, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 6.21 (s, 1H), 4.70-4.65 (m, 1H), 4.17-4.05 (m, 2H), 4.05-3.91 (m, 2H), 2.00-1.86 (m, 2H), 1.57-1.47 (m, 1H), 1.40-1.30 (m, 1H), 1.28-1.17 (m, 6H), 0.90 (s, 3H), 0.85 (s, 3H).
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 153.5, 94.1, 78.2, 64.5, 64.1, 37.5, 31.3, 29.4, 28.5, 27.4, 16.5, 16.4.
IR (film): 2959 (m), 1275 (s), 1028 (s), 983 (s).
MS (EI, 70 ev), *m/z* (%): 261 (100), 155 (45), 127 (41), 107 (78), 99 (62), 91 (45), 79 (22).

HRMS (EI): calcd. for $C_{12}H_{22}IO_4P$ [M^+]: 388.0300, found: 388.0259.
Anal. calcd. for $C_{12}H_{22}IO_4P$ (388.18): C 37.13, H 5.71; found: C 37.14, H 5.73.

(*R*)-1-Iodo-5,5-dimethyl-6-pentylcyclohexene (5a).

The dipentylzinc reagent (4.8 M solution in THF, 1.12 mmol, 2.24 equiv) was added dropwise to a solution stirred at –30 °C , under argon atmosphere, of CuCN.2LiCl (1 M solution in THF, 0.56 mL, 0.56 mmol, 1.12 equiv) in NMP (sufficient to give an overall ratio of solvents THF:NMP = 3:1). The resulting mixture was stirred 1 h at –30 °C. Then **4** (194 mg, 0.5 mmol, 1 equiv) was added dropwise as a solution in THF (0.8 mL). The reaction mixture was stirred at –30 °C for 1 h and then slowly warmed up and continue stirred at –10 °C for 14 h. A saturated aqueous NH_4Cl solution (20 mL) was added followed by 25% aqueous ammonia solution (1 mL), and the reaction mixture was stirred at 25 °C until the copper salts had dissolved. The mixture was extracted with Et_2O (3 x 20 mL). The combined organic phases was washed with brine and dried over Na_2SO_4. After purification by column chromatography (pentane), **5a** was obtained as a colourless oil (122 mg, 80% yield).
GC (column A, method B): t_R/min = 19.079 (minor), 19.965 (major); 97% *ee*.
$[\alpha]_D^{20}$ +60.16 (c 1.25, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.12 (t, *J* = 3.8 Hz, 1H), 2.05-1.95 (m, 2H), 1.92-1.86 (m, 1H), 1.50-1.38 (m, 3H), 1.38-1.10 (m, 7H), 0.92 (s, 3H), 0.88 (s, 3H), 0.83 (t, *J* = 6.7 Hz, 3H)
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 136.3, 106. 0, 56.8, 35.5, 32.9, 32.3, 30.8, 29.6, 28.4, 28.0, 27.4, 22.9, 14.5.
IR (film): 2955 (s), 2929 (s), 2870 (s), 1466 (m), 1385 (w), 1365 (w), 924 (w), 828 (w), 742 (w).
MS (EI, 70 ev), *m/z* (%): 306 (M^+, 29), 251 (10), 250 (98), 236 (40), 180 (22), 179 (12), 123 (22), 109 (31), 93 (33), 81 (100), 67 (79), 55 (19).
HRMS (EI): calcd. for $C_{13}H_{23}I$ [M^+]: 306.0844, found: 306.0818.
Anal. calcd. for $C_{13}H_{23}I$ (306.23): C 50.99, H 7.57; found: C 51.19, H 7.68.

Typical procedure for the copper(I)-mediated addition of mixed dialkylzinc reagents to diethylphosphates.

The freshly prepared of alkylzinc halide reagent (solution in THF, 2.4 equiv) was cooled at –40 °C, then the solution of $TMSCH_2Li$ (1 M in pentane, 2.4 equiv) was added dropwise. The reaction mixture was stirred for 1 h at –40 °C then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 2.4 equiv) and NMP (sufficient to give an overall ratio of solvents THF:NMP = 3:1) was added successively. The resulting mixture was stirred at –30 °C for 30 min. Then **4** was added dropwise as a solution in THF. The reaction mixture was slowly warmed up to room temperature during the time stated for each compound. A saturated aqueous NH_4Cl solution (20 mL) was added followed by 25% aqueous ammonia solution (1 mL), and the reaction mixture was stirred at 25 °C until the copper salts had dissolved. The mixture was extracted with Et_2O (3 x 20 mL). The combined organic phases was washed with brine and dried over Na_2SO_4. Evaporation of the solvents and purification by column chromatography afforded the desired products.

(*R*)-6-But-3-enyl-1-iodo-5,5-dimethylcyclohexene (5b).

3-Butenylzinc iodide was freshly prepared by treatment of 4-iodobut-1-ene (791 mg, 4.3 mmol) with activated Zn foil (850 mg, 12.9 mmol, 3 equiv) in THF (2.5 mL) at 40 °C for 14 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots),

the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared 3-butenyl zinc iodide (1.59 M solution in THF, 2.3 mL, 3.6 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 3.6 mL, 3.6 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 3.6 mL, 3.6 mmol, 2.4 equiv) and NMP (2.2 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1.5 mL) solution of **4** (582 mg, 1.5 mmol, 1 equiv) was added, and the reaction mixture was stirred for 14 h while warmed up to 25 °C. The desired product **5b** was obtained, after purification by column chromatography (SiO_2, pentane), as a colourless oil (371 mg, 85% yield).
GC (column A, method B): t_R/min = 14.418 (minor), 15.151 (major); 98% *ee*.
$[\alpha]_D^{20}$ +81.17 (c 1.20, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.21 (t, *J* = 3.8 Hz, 1H), 5.84-5.70 (m, 1H), 5.02-4.86 (m, 2H), 2.14-1.90 (m, 4H), 1.66-1.36 (m, 3H), 1.22-1.10 (m, 2H), 0.93 (s, 3H), 0.90 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 139.2, 136.7, 114.9, 105.3, 56.0, 35.5, 34.1, 31.5, 30.7, 28.4, 27.9, 27.4.
IR (film): 2954 (s), 2921 (s), 2871 (s), 1640 (m), 1446 (m), 1386 (m), 1366 (m), 1327 (w), 992 (m), 911 (s).
MS (EI, 70 ev), *m/z* (%): 249 (3), 248 (32), 236 (20), 193 (8), 163 (43), 121 (11), 107 (46), 91 (47), 79 (100), 66 (47), 55 (16).
HRMS (EI): calcd. for $C_{12}H_{19}I$ [M^+]: 290.0531, found: 290.0561.
Anal. calcd. for $C_{12}H_{19}I$ (290.18): C 49.67, H 6.60; found: C 49.53, H 6.73.

(*R*)-3-(2-Iodo-6,6-dimethylcyclohex-2-enyl)-propionitrile (5c).

2-Cyanoethyzinc iodide[3] was freshly prepared by treatment of 3-iodopropionitrile (778 mg, 4.3 mmol) with activated Zn foil (850 mg, 12.9 mmol, 3 equiv) in THF (2.5 mL) at 25 °C for 3 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots), the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared 2-cyanoethyzinc iodide (1.15 M solution in THF, 2.1 mL, 2.4 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 2.4 mL, 2.4 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 2.4 mL, 2.4 mmol, 2.4 equiv) and NMP (1.8 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1 mL) solution of **4** (388 mg, 1 mmol, 1 equiv) was added, and the reaction mixture was stirred for 40 h while warmed up to 25 °C. The desired product **5c** was obtained, after purification by column chromatography (SiO_2, 25% Et_2O:Pentane), as a colourless oil (211 mg, 73% yield).
GC (column A, method A): t_R/min = 34.912 (minor), 35.911 (major); 95% *ee*.
$[\alpha]_D^{20}$ +70.40 (c 1.0, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.36 (t, *J* = 3.4 Hz, 1H), 2.53-2.44 (m, 2H), 2.14-1.78 (m, 5H), 1.50-1.20 (m, 2H), 1.01 (s, 3H), 0.96 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 140.0, 121.5, 102.9, 56.8, 37.0, 32.3, 29.5, 29.3, 29.2, 28.8, 18.9.
IR (film): 2958 (s), 2922 (s), 2873 (s), 2246 (m), 1732 (w), 1633 (m), 1445 (m), 1427 (m), 1388 (m), 919 (m).
MS (EI, 70 ev), *m/z* (%): 289 (M^+, 1), 261 (2), 233 (8), 162 (100), 146 (9), 132 (7), 121 (31), 106 (70), 91 (28), 79 (59), 65 (16), 53 (13).

HRMS (EI): calcd. for $C_{11}H_{16}IN$ [M^+]: 289.0327, found: 289.0304.
Anal. calcd. for $C_{11}H_{16}IN$ (289.16): C 45.96, H 5.58, N 4.84; found: C 45.97, H 5.63, N 4.68.

(*R*)-3-(2-Iodo-6,6-dimethylcyclohex-2-enyl)-propionic acid ethyl ester (5d).
2-Carboethoxyethyzinc iodide[4] was freshly prepared by treatment of 2-carboethoxyethyl iodide (1.32 g, 6 mmol) with activated Zn foil (1.18 g, 18 mmol, 3 equiv) in THF (3.5 mL) at 30 °C for 16 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots), the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared 2-carboethoxyethyzinc iodide (1.64 M solution in THF, 0.8 mL, 1.2 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 1.2 mL, 1.2 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 1.2 mL, 1.2 mmol, 2.4 equiv) and NMP (1 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1 mL) solution of **4** (194 mg, 0.5 mmol, 1 equiv) was added, and the reaction mixture was stirred for 45 h while warmed up to 25 °C. The desired product **5d** was obtained, after purification by column chromatography (SiO_2, 10% Et_2O:Pentane), as a colourless oil (134 mg, 81% yield).
GC (column A, method A): t_R/min = 28.641 (minor), 29.421 (major); 97% *ee*.
$[\alpha]_D^{20}$ +62.74 (c 0.95, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.17 (t, *J* = 3.8 Hz, 1H), 3.99 (q, *J* = 7.2 Hz, 2H), 2.32-2.22 (m, 2H), 1.98-1.76 (m, 4H), 1.74-1.60 (m, 1H), 1.40-1.26 (m, 1H), 1.16-1.04 (m, 1H), 1.12 (t, *J* = 7.2 Hz, 3H), 0.85 (s, 3H), 0.82 (s. 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 172.1, 135.8, 101.7, 59.0, 53.9, 33.8, 32.4, 28.9, 26.7, 26.2, 25.7, 25.3, 12.9.
IR (film): 2957 (m), 2922 (m), 2873 (m), 1737 (s), 1446 (m), 1367 (m), 1324 (m), 1253 (m), 1178 (m).
MS (EI, 70 ev), *m/z* (%): 291 (5), 248 (4), 209 (100), 163 (38), 121 (47), 107 (16), 93 (22), 79 (22), 55 (6).
HRMS (EI): calcd. for $C_{13}H_{21}IO_2$ [M^+]: 336.0586, found: 337.0644 [$M+H]^+$.

(*R*)-4-(2-Iodo-6,6-dimethylcyclohex-2-enyl)-butyric acid ethyl ester (5e).
3-Carboethoxypropylzinc iodide[4] was freshly prepared by treatment of 3-carboethoxypropyl iodide (1.45 g, 6 mmol) with activated Zn foil (1.18 g, 18 mmol, 3 equiv) in THF (3.5 mL) at 48 °C for 4 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots), the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared 3-carboethoxypropylzinc iodide (1.52 M solution in THF, 1.6 mL, 2.4 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 2.4 mL, 2.4 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 2.4 mL, 2.4 mmol, 2.4 equiv) and NMP (1.8 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1 mL) solution of **4** (388 mg, 1 mmol, 1 equiv) was added, and the reaction mixture was stirred for 48 h while warmed up to 25 °C. The desired product **5e** was obtained, after purification by column chromatography (SiO_2, 20% CH_2Cl_2:Pentane), as a colourless oil (286 mg, 82% yield).
GC (column A, method A): t_R/min = 38.837 (minor), 40.045 (major); 98% *ee*.
$[\alpha]_D^{20}$ +42.50 (c 0.80, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.19 (t, *J* = 3.8 Hz, 1H), 4.06 (q, *J* = 7.2 Hz, 2H), 2.23 (t, *J* = 7.4 Hz, 2H), 2.08-1.94 (m, 2H), 1.94-1.86 (m, 1H), 1.70-1.34 (m, 5H), 1.22-1.10 (m, 1H), 1.18 (t, *J* = 7.2 Hz, 3H), 0.91 (s, 3H), 0.89 (s, 3H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 172.5, 135.4, 103.7, 59.2, 55.1, 34.1, 33.8, 30.3, 29.3, 27.0, 26.5, 26.0, 23.7, 13.3.
IR (film): 2957 (m), 2921 (m), 2872 (m), 1735 (s), 1446 (m), 1368 (m), 1250 (m), 1179 (m), 856 (m).
MS (EI, 70 ev), *m/z* (%): 351 [$(M+H)^+$, 8], 305 (7), 223 (100), 193 (11), 177 (22), 167 (18), 121 (11), 93 (26), 41 (22).
Anal. calcd. for $C_{14}H_{23}IO_2$ (350.24): C 48.01, H 6.62; found: C 47.53, H 6.97.

(*R*)-Acetic acid 3-(2-iodo-6,6-dimethylcyclohex-2-enyl)-propyl ester (5f).
3-Acetoxypropylzinc iodide[4] was freshly prepared by treatment of 3-acetoxypropyl iodide (1.37 g, 6 mmol) with activated Zn foil (1.18 g, 18 mmol, 3 equiv) in THF (3.5 mL) at 40 °C for 4 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots), the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared 3-acetoxypropylzinc iodide (1.59 M solution in THF, 1.5 mL, 2.4 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 2.4 mL, 2.4 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 2.4 mL, 2.4 mmol, 2.4 equiv) and NMP (1.8 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1 mL) solution of **4** (388 mg, 1 mmol, 1 equiv) was added, and the reaction mixture was stirred for 46 h while warmed up to 25 °C. The desired product **5f** was obtained, after purification by column chromatography (SiO_2, 5% Et_2O:Pentane), as a colourless oil (218 mg, 65% yield).
GC (column A, method A): t_R/min = 32.538 (minor), 33.254 (major); 97% *ee*.
$[\alpha]_D^{20}$ +57.60 (c 0.75, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.23 (t, *J* = 3.8 Hz, 1H), 4.07-3.93 (m, 2H), 2.06-1.90 (m, 3H), 1.99 (s, 3H), 1.72-1.36 (m, 5H), 1.22-1.12 (m, 1H), 0.93 (s, 3H), 0.90 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 171.5, 137.0, 104.8, 65.1, 56.2, 35.5, 30.7, 28.6, 28.4, 28.3, 28.0, 27.3, 21.4.
IR (film): 2955 (m), 2920 (m), 2872 (m), 1741 (s), 1449 (w), 1365 (m), 1241 (s), 1043 (m).
MS (FAB), *m/z* (%): 337 [$(M+H)^+$, 8], 277 (100), 248 (46), 220 (29), 149 (89).
HRMS (EI): calcd. for $C_{13}H_{21}IO_2$ [M^+]: 336.0586, found: 336.0615.

(*R*)-2-[2-(2-Iodo-6,6-dimethylcyclohex-2-enyl)ethyl]-[1,3]dioxolane (5g).
[2-(1,3-dioxolan-2-yl)ethyl]zinc iodide[4] was freshly prepared by treatment of 2-(2-iodoethyl)-1,3-dioxolane (1.82 g, 8 mmol) with activated Zn foil (1.57 g, 24 mmol, 3 equiv) in THF (3.5 mL) at 45 °C for 3 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots), the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared [2-(1,3-dioxolan-2-yl)ethyl]zinc iodide (1.72 M solution in THF, 1.4 mL, 2.4 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 2.4 mL, 2.4 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 2.4 mL, 2.4 mmol, 2.4 equiv) and NMP (1.8 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1 mL) solution of **4** (388 mg, 1 mmol, 1 equiv) was added, and the reaction mixture was stirred for 41 h while warmed up to 25 °C. The desired product **5g** was obtained, after purification by column chromatography (SiO_2, 10% Et_2O:Pentane), as a colourless oil (303 mg, 90% yield).
GC (column A, method A): t_R/min = 42.135 (minor), 43.020 (major); 98% *ee*.
$[\alpha]_D^{20}$ +63.79 (c 0.95, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.23 (t, *J* = 3.8 Hz, 1H), 4.78 (t, *J* = 4.5 Hz, 1H), 3.94-3.88 (m, 2H), 3.82-3.76 (m, 2H), 2.08-1.94 (m, 3H), 1.74-1.62 (m, 3H), 1.61-1.54 (m, 1H), 1.47-1.40 (m, 1H), 1.18-1.14 (m, 1H), 0.93 (s, 3H), 0.91 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 137.1, 105.2, 104.6, 65.28, 65.22, 56.1, 35.5, 33.6, 30.7, 28.6, 28.1, 27.4, 26.2.
IR (film): 2955 (s), 2873 (s), 1142 (s), 1087 (m), 1038 (s), 943 (m).
MS (EI, 70 ev), *m/z* (%): 335 [$(M+H)^+$, 8], 330 (72), 248 (51), 204 (67), 99 (69), 73 (100).
HRMS (EI): calcd. for $C_{13}H_{21}IO_2$ [M^+]: 336.0586, found: 335.0519 [$M-H]^+$.
Anal. calcd. for $C_{13}H_{21}IO_2$ (336.21): C 46.44, H 6.30; found: C 46.75, H 6.39.

(*R*)-2-[2-(2-Iodo-6,6-dimethylcyclohex-2-enyl)ethyl]-2-methyl-[1,3]dioxolane (5h).
[2-(2-methyl-1,3-dioxolan-2-yl)ethyl]zinc iodide[4] was freshly prepared by treatment of 2-(2-iodoethyl)-2-methyl-1,3-dioxolane (1.94 g, 8 mmol) with activated Zn foil (1.57 g, 24 mmol, 3 equiv) in THF (3.5 mL) at 25 °C for 3 h. After insertion of Zn was completed (monitored by GC analysis of hydrolyzed aliquots), the concentration of the corresponding organozinc reagent was determined by performing an iodolysis and titrated with sodium thiosulfate solution.
According to typical procedure, the freshly prepared [2-(2-methyl-1,3-dioxolan-2-yl)ethyl]zinc iodide (1.35 M solution in THF, 0.9 mL, 1.2 mmol, 2.4 equiv) was treated with $TMSCH_2Li$ (1 M in pentane, 1.2 mL, 1.2 mmol, 2.4 equiv) at –40 °C for 1 h then allowed to warm up to –30 °C. To the resulting mixture, the solution of CuCN.2LiCl (1 M solution in THF, 1.2 mL, 1.2 mmol, 2.4 equiv) and NMP (1.0 mL) was added successively. The resulting mixture was stirred at –30 °C for 30 min. THF (1 mL) solution of **4** (194 mg, 0.5 mmol, 1 equiv) was added, and the reaction mixture was stirred for 48 h while warmed up to 25 °C. The desired product **5h** was obtained, after purification by column chromatography (SiO_2, 10% Et_2O:Pentane), as a colourless oil (125 mg, 71% yield).
GC (column A, method A): t_R/min = 42.098 (minor), 43.023 (major); 98% *ee*.
$[\alpha]_D^{20}$ +62.76 (c 0.58, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.31 (t, *J* = 3.8 Hz, 1H), 4.02-3.92 (m, 4H), 2.18-2.04 (m, 2H), 2.02-1.98 (m, 1H), 1.82-1.58 (m, 4H), 1.56-1.46 (m, 1H), 1.37 (s, 3H), 1.28-1.20 (m, 1H), 1.01 (s, 3H), 0.99 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 136.5, 110.0, 104.6, 64.60, 64.58, 55.9, 38.1, 35.1, 30.4, 28.2, 27.7, 27.0, 25.9, 23.6.
IR (film): 2955 (s), 2874 (s), 1448 (m), 1376 (m), 1253 (m), 1217 (m), 1138 (m), 1056 (s), 855 (s).
MS (EI, 70 ev), *m/z* (%): 350 (M^+, 4), 248 (10), 121 (4), 99 (7), 87 (100), 79 (7).
HRMS (EI): calcd. for $C_{14}H_{23}IO_2$ [M^+]: 350.0743, found: 350.0743.
Anal. calcd. for $C_{14}H_{23}IO_2$ (350.24): C 48.01, H 6.62; found: C 48.52, H 6.13.

4-[(1*R*)-2-Iodo-6,6-dimethyl-2-cyclohexen-1-yl]-2-butanone (7).
The mixture of (*R*)-6-but-3-enyl-1-iodo-5,5-dimethylcyclohexene (**5b**) (145 mg, 0.5 mmol), $PdCl_2$ (46 mg, 0.26 mmol), and $CuCl_2$ (67 mg, 0.5 mmol) in DMF (1.5 mL) and water (0.15 mL) was stirred under an oxygen atmosphere for 48 h at room temperature. It was diluted with Et_2O, washed with water, dried over anhydrous Na_2SO_4, and concentrated with a rotary evaporator. The residual oil was purified by column chromatography (SiO_2, 10% Et_2O:Pentane) afforded **7** as the pale yellow oil (126 mg, 82% yield).
GC (column A, method A): t_R/min = 23.303 (minor), 23.736 (major); 98% *ee*.
$[\alpha]_D^{20}$ +70.73 (c 0.57, CH_2Cl_2).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.26 (t, *J* = 3.9 Hz, 1H), 2.60-2.40 (m, 2H), 2.11 (s, 3H), 2.09-1.80 (m, 4H), 1.71-1.60 (m, 1H), 1.48-1.35 (m, 1H), 1.24-1.14 (m, 1H), 0.94 (s, 3H), 0.89 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 208.9, 137.6, 103.5, 55.5, 43.5, 35.6, 30.7, 30.3, 28.3, 28.0, 27.4, 25.8.
IR (film): 2956 (m), 2921 (m), 2872 (m), 1716 (s), 1429 (m), 1386 (m), 1161 (m).
MS (EI, 70 ev), *m/z* (%): 248 (20), 233 (8), 179 (100), 161 (10), 121 (45), 105 (16), 93 (34), 79 (23), 65 (8), 55 (8).
Anal. calcd. for $C_{12}H_{19}IO$ (306.18): C 47.07, H 6.25; found: C 47.16, H 6.42.

(*R*)-Dihydro-α-ionone (3).
$ZnCl_2$ (136 mg, 1 mmol) was dried by gentle heating under vacuum then, after cooling down to room temperature, dissolved in THF (0.5 mL). The resulting mixture was treated with MeLi (1.4 M in Et_2O, 0.7 mL, 1 mmol). After stirring at room temperature for 15 min, the resulting solution was transfered to the mixture of **7** (100 mg, 0.33 mmol), $Pd(dba)_2$ (9 mg, 0.017 mmol, 5 mol%), and dppf (9 mg, 0.017 mmol, 5 mol%) in THF (1 mL). The mixture was stirred at room temperature for 24 h. It was diluted with Et_2O, washed with water, dried over anhydrous Na_2SO_4, and concentrated with a rotary evaporator. The residual oil was purified by column chromatography (SiO_2, 10% Et_2O:Pentane) afforded **3** as the pale yellow oil (44 mg, 70% yield).
GC (column A, method C): t_R/min = 41.143 (minor), 45.071 (major); 98% *ee*.
$[\alpha]_D^{20}$ +149.45 (c 0.55, EtOH).

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 5.27 (br s, 1H), 2.44-2.34 (m, 2H), 2.06 (s, 3H), 1.94-1.84 (m, 2H), 1.76-1.62 (m, 1H), 1.62-1.45 (m, 4H), 1.43-1.27 (m, 2H), 1.12-1.01 (m, 1H), 0.84 (s, 3H), 0.89 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 209.5, 135.9, 121.4, 89.2, 48.8, 44.1, 32.9, 31.9, 30.3, 28.0, 24.8, 23.9, 23.3.
IR (film): 2957 (s), 2917 (s), 2870 (s), 1716 (s), 1449 (m), 1363 (s), 1160 (m).
MS (EI, 70 ev), *m/z* (%): 194 (M^+, 1), 176 (18), 161 (6), 136 (84), 121 (100), 107 (23), 95 (97), 81 (44), 67 (20), 55 (18).
HRMS (EI): calcd. for $C_{13}H_{22}O$ [M^+]: 194.1671, found: 194.1654.

3-[(1*R*)-2,6,6-trimethyl-2-cyclohexen-1-yl]propanal (8).
The Me_2Zn (2 M in toluene, 1.5 mL, 3.1 mmol, 3 equiv) was added dropwise to the mixture of **5d** (347 mg, 1.03 mmol), $Pd(dba)_2$ (30 mg, 0.05 mmol, 5 mol%), dppf (28 mg, 0.05 mmol, 5 mol%) in THF (2 mL). The resulting mixture was stirred at room temperature for 26 h. The reaction was quenched by carefully dropwise addition of saturated NH_4Cl solution, extracted with Et_2O, washed with water, dried over anhydrous Na_2SO_4, and concentrated with a rotary evaporator. The residual oil was purified by column chromatography (SiO_2, 5% Et_2O:Pentane) afforded ethyl 3-(2,6,6-trimethylcyclohex-2-en-1-yl)propanoate[5] as the pale yellow oil (186 mg, 81% yield).
^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 5.26 (br s, 1H), 4.04 (q, *J* = 7.2 Hz, 2H), 2.26 (t, *J* = 8.0 Hz, 2H), 1.94-1.84 (m, 2H), 1.80-1.66 (m, 1H), 1.65-1.43 (m, 4H), 1.44-1.26 (m, 2H), 1.18 (t, *J* = 7.2 Hz, 3H), 1.11-0.99 (m, 1H), 0.85 (s, 3H), 0.80 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 174.4, 136.0, 121.4, 60.6, 48.9, 34.9, 33.0, 31.9, 28.0, 27.9, 26.2, 23.8, 23.3, 14.6.
IR (film): 2959 (m), 2871 (m), 1737 (s), 1448 (m), 1375 (m), 1256 (m), 1180 (m), 1158 (m).
MS (EI, 70 ev), 224 (M^+, 38), 209 (61), 179 (17), 168 (100), 163 (26), 136 (21), 121 (61), 107 (19), 94 (84), 81 (45).
To the solution of ethyl 3-(2,6,6-trimethylcyclohex-2-en-1-yl)propanoate (160 mg, 0.71 mmol) in dry Et_2O (2.5 mL) at 0 °C was added dropwise of the solution of $LiAlH_4$ (1 M in

Et_2O, 1.41 mL, 1.41 mmol). The mixture was vigorously stirred for 10 min then quenched with aqeous solution of Na_2SO_4, filtered, and concentrated with a rotary evaporator afforded corresponding alcohol as a colourless oil.
A solution of DMSO (0.11 mL) in CH_2Cl_2 (0.4 mL) was added dropwise to a stirred solution of oxalylchloride (0.07 mL, 0.82 mmol) in CH_2Cl_2 (2.6 mL) under N_2 at –60 ^oC. After 5 min, a solution of the above alcohol in CH_2Cl_2-DMSO (3:1, 1 mL) was added dropwise. The reaction mixture was stirred for a further 20 min, Et_3N (0.5 mL, 3.56 mmol) was added at –60 ^oC and stirring was continued for a further 10 min. Then it was allowed to warm to room temperature, and water was added. The organic layer was separated, and the aqueous phase was extracted with Et_2O. The combined organic extracts was washed with water, dried over anhydrous Na_2SO_4, and concentrated with a rotary evaporator. The residual oil was purified by column chromatography (SiO_2, 5% Et_2O:Pentane) afforded **8**[5] as a colorless oil (117 mg, 91% yield).
^{1}H-NMR ($CDCl_3$, 200 MHz): δ = 9.74 (t, *J* = 1.8 Hz, 1H), 5.35 (br s, 1H), 2.53-2.41 (m, 2H), 2.04-1.90 (m, 2H), 1.90-1.30 (m, 7H), 1.22-1.06 (m, 1H), 0.92 (s, 3H), 0.87 (s, 3H).
IR (film): 2955 (s), 2917 (s), 2870 (m), 1727 (s), 1450 (w).
MS (EI, 70 ev), *m/z* (%): 180 (M^+, 4), 165 (2), 147 (8), 136 (100), 121 (62), 109 (19), 93 (48), 81 (90), 68 (42), 55 (31).
HRMS (EI): calcd. for $C_{12}H_{20}O$ [M^+]: 180.1514, found: 180.1519.

α-Ionone (2).
To the THF (5 mL) solution of **8** (75 mg, 0.42 mmol) was added phenylselenyl chloride (107 mg, 0.56 mmol, 1.3 equiv) and potassium *tert*-butoxide (71 mg, 0.63 mmol) at –78 ^oC. The resulting mixture was stirred at –78 ^oC under a nitrogen atmosphere for 1 h. Potassium *tert*-butoxide (71 mg, 0.63 mmol) was added at –78 ^oC, and the reaction mixture was stirred at –78 ^oC for 2 h. Additional potassium *tert*-butoxide (141 mg, 1.26 mmol) was added at –78 ^oC, and the mixture was stirred again at –78 ^oC for 2 h more. The reaction mixture was poured into a saturated ammonium chloride solution and extracted with Et_2O (3 x 20 mL). The combined organic layer was washed with brine, and dried over anhydrous Na_2SO_4, and concentrated with a rotary evaporator. The residual oil was purified by column chromatography (SiO_2, 5% Et_2O:Pentane) to give a selenylated compound as a pale yellow oil. To a dichloromethane (4 mL) sloution of the above selenylated compound was added a hydrogen peroxide solution (30% solution in water, 0.05 mL). The resulting mixture was stirred at room temperature for 20 min. The mixture was treated with a saturated $NaHCO_3$ solution, extracted with Et_2O, dried over anhydrous magnesium sulfate, filtered, and concentrated *in vacuo*. Purification by column chromatography (SiO_2, 15% Et_2O:Pentane) afforded (2*E*)-3-[(1*R*)-2,6,6-trimethylcyclohex-2-en-1-yl]acrylaldehyde as a pale yellow oil (51 mg, 70% yield).
^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 9.46 (d, *J* = 7.9 Hz, 1H), 6.61 (dd, *J* = 15.5, 9.7 Hz, 1H), 6.04 (dd, *J* = 15,5, 7.9 Hz, 1H), 5.47 (br s, 1H), 2.36 (d, *J* = 9.7 Hz, 1 H), 2.04-1.95 (m, 2H), 1.53-1.48 (m, 3H), 1.46-1.33 (m, 1H), 1.24-1.13 (m, 1H), 0.88 (s, 3H), 0.81 (s, 3H).
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 194.2, 159.8, 134.4, 131.9, 123.5, 54.9, 33.0, 31.5, 28.2, 27.1, 23.4, 23.1
IR (film): 2959 (m), 2918 (m), 1693 (s), 1450 (w), 1122 (m).
MS (EI, 70 ev), *m/z* (%): 178 (M^+, 22), 163 (13), 122 (70), 107 (100), 93 (64), 79 (51), 65 (9), 53 (10).
HRMS (EI): calcd. for $C_{12}H_{18}O$ [M^+]: 178.1358, found: 178.1377.
To a THF (3 mL) solution of the above aldehyde (51 mg, 0.29 mmol) was added MeMgCl (2.95 M in THF, 0.12 mL) at 0 ^oC. The resulting mixture was stirred at 0 ^oC for 15 min under a nitrogen atmosphere, poured into a saturated NH_4Cl, extracted with Et_2O (3 x 20 mL) to give the alcohol as a colourless oil.

To a DMF (3 mL) solution of above alcohol was added pyridinium dichromate (PDC) (219 mg, 0.58 mmol) and Celite (219 mg), which was stirred at room temperature for 16 h under a nitrogen atmosphere. PDC and Celite were filtered off then the crude meterial was purified by column chromatography (SiO_2, 15% Et_2O:Pentane) to give **2** as a colourless oil (48 mg, 87% yield).
GC (column A, method C): t_R/min = 46.128 (minor), 50.609 (major); 98% *ee*.
$[\alpha]_D^{20}$ +443 (c 0.75, $CHCl_3$).

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 6.61 (dd, *J* = 15.9, 6.1 Hz, 1H), 6.04 (d, *J* = 15.9 Hz, 1H), 5.49 (br s, 1H), 2.32-2.23 (m, 1H), 2.25 (s, 3H), 2.08-2.00 (m, 2H), 1.58-1.54 (m, 3H), 1.50-1.40 (m, 1H), 1.26-1.18 (m, 1H), 0.92 (s, 3H), 0.85 (s, 3H).
^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 198.4, 149.0, 132.3, 131.9, 122.7, 54.3, 32.5, 31.2, 27.8, 26.9, 26.8, 23.0, 22.8.
IR (film): 2958 (m), 2918 (m), 2867 (m), 1697 (m), 1676 (s), 1620 (m), 1436 (m), 1364 (m), 1252 (s), 988 (m).
MS (EI, 70 ev), *m/z* (%): 192 (M^+, 21), 177 (10), 136 (44), 121 (100), 109 (19), 93 (60), 77 (20).
HRMS (EI): calcd. for $C_{13}H_{20}O$ [M^+]: 192.1514, found: 192.1512.

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(4). (a) Knochel, P.; Millot, N.; Rodriguez, A. L. *Org. React*. **2001**, *58*, 417. (b) Knochel, P.; Singer, R. D. *Chem. Rev*. **1993**, *93*, 2117. (c) Knochel, P.; Jones, P. *Organozinc Reagents. A practical approach*, Oxford University Press, 1999. (d) Rao, S. A.; Knochel, P. *J. Am. Chem. Soc*. **1991**, *113*, 5735.
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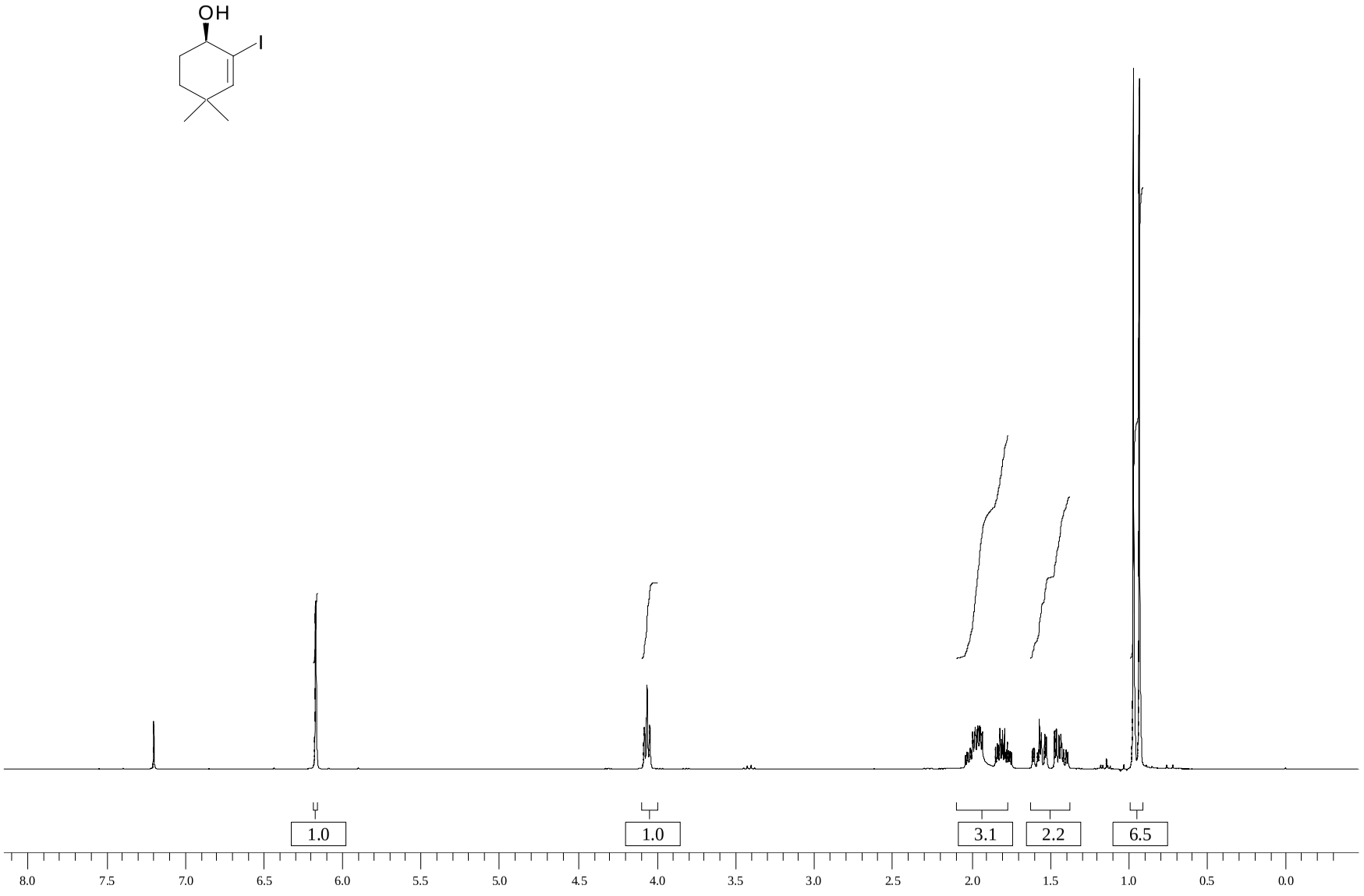
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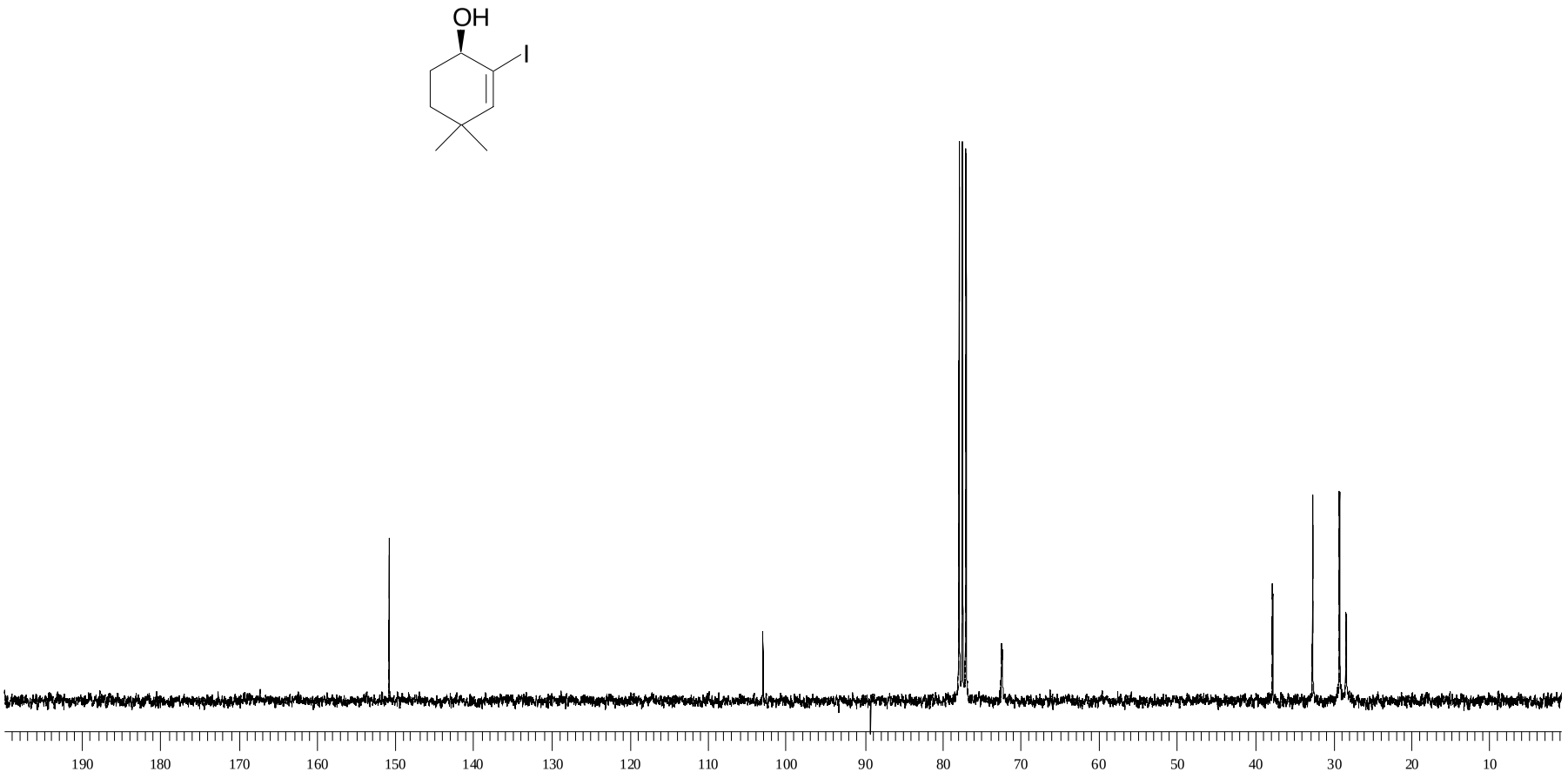
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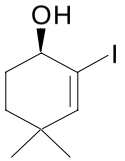
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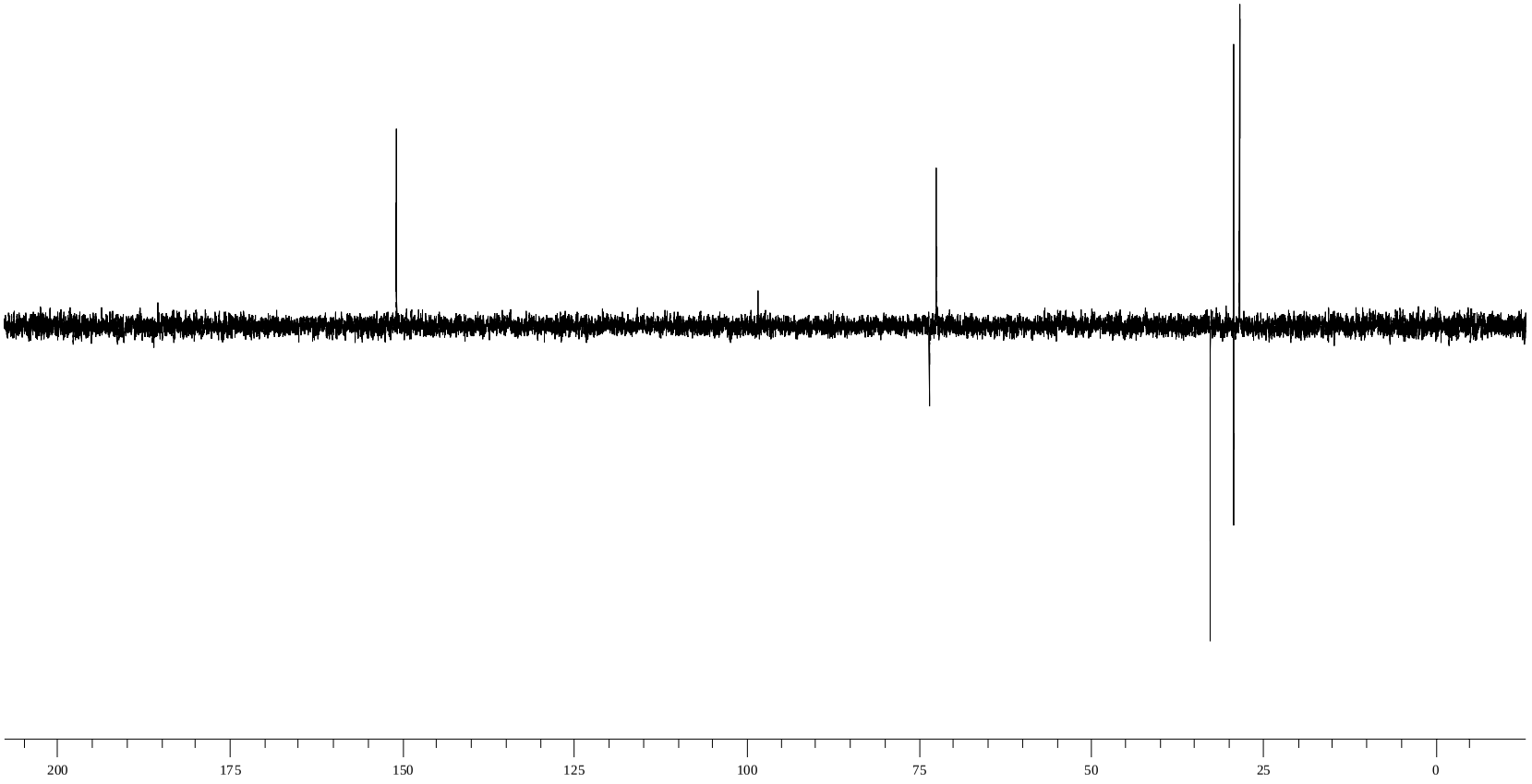
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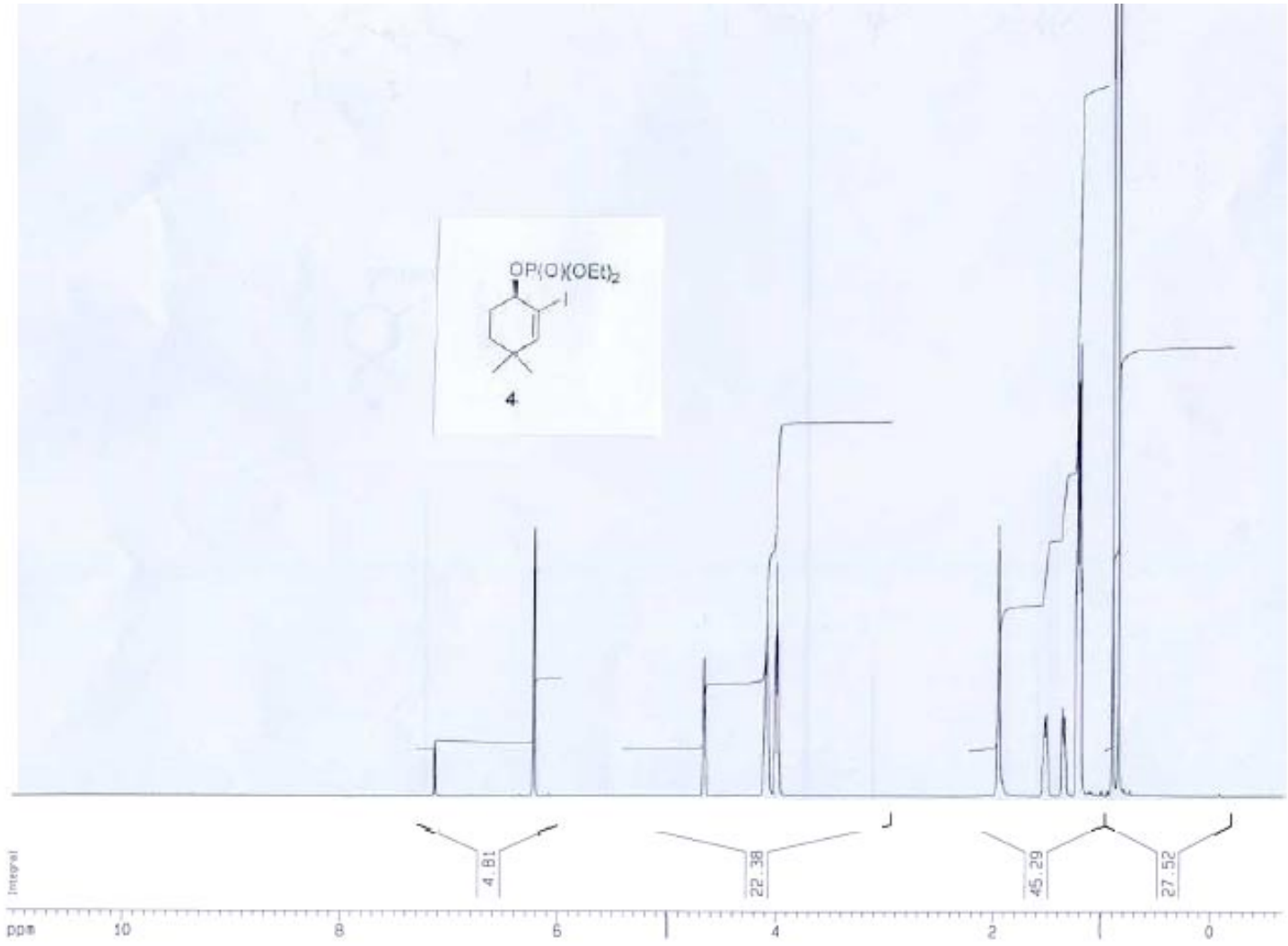


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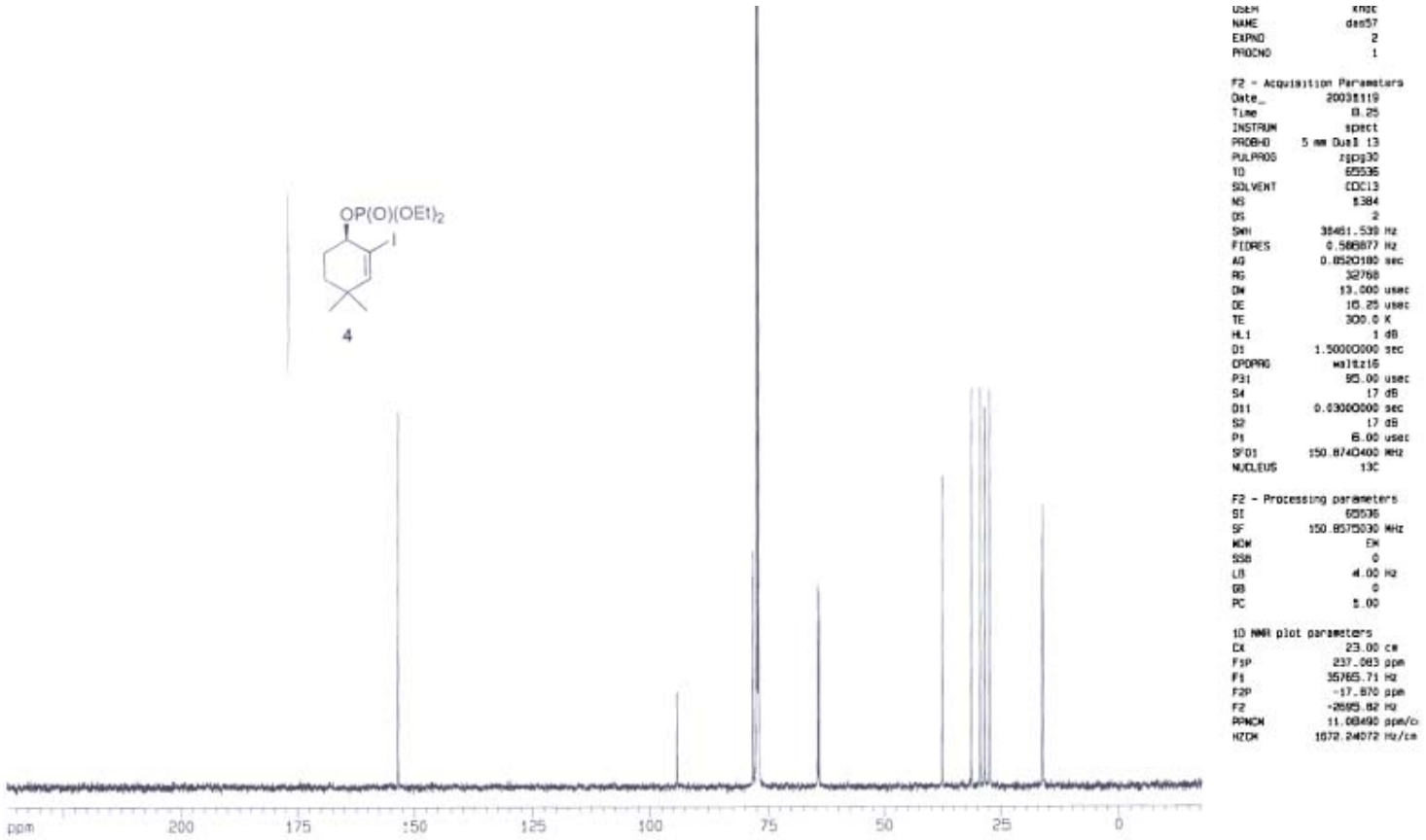


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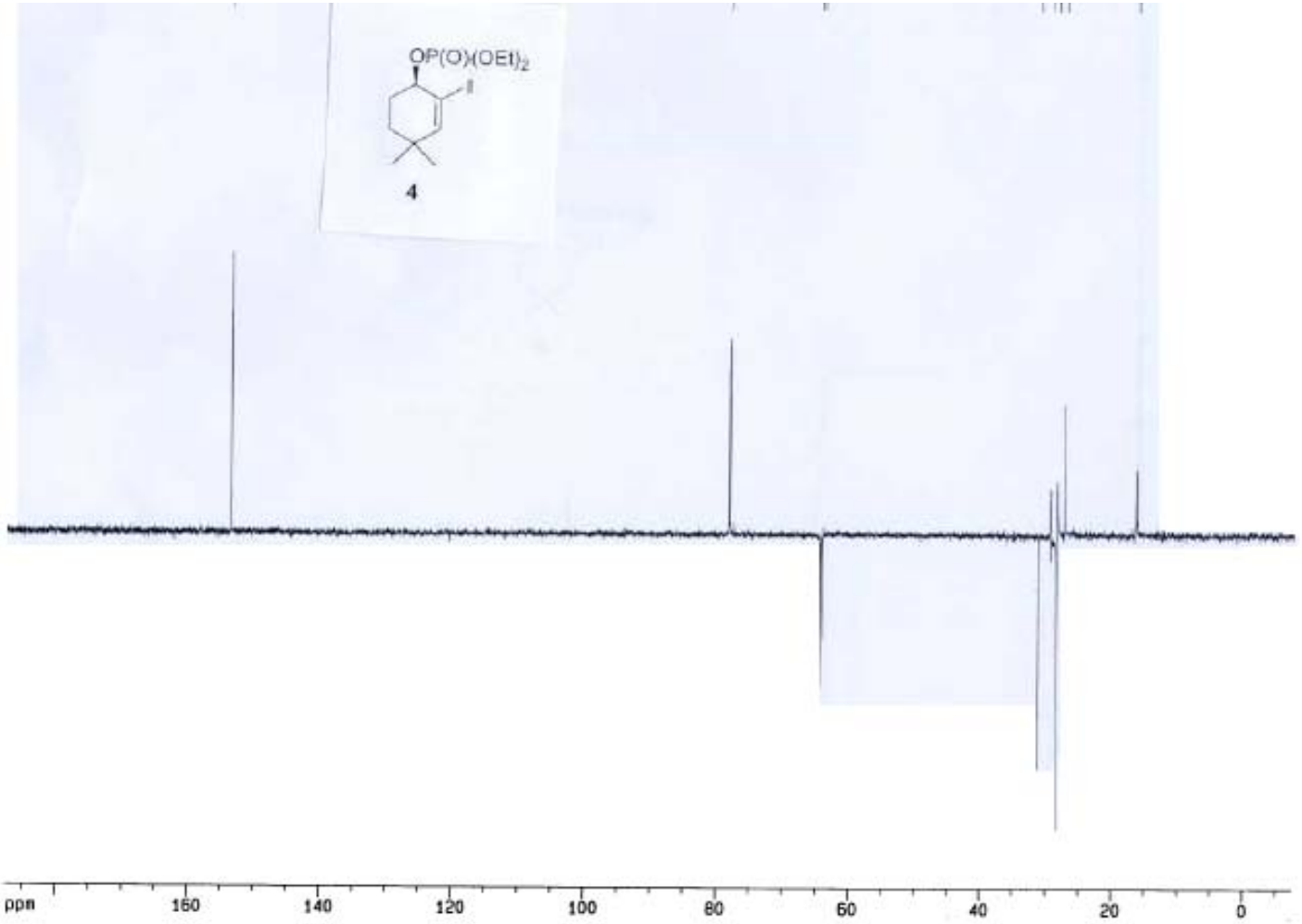

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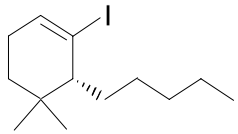

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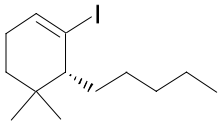

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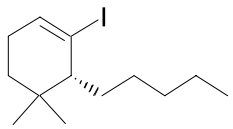

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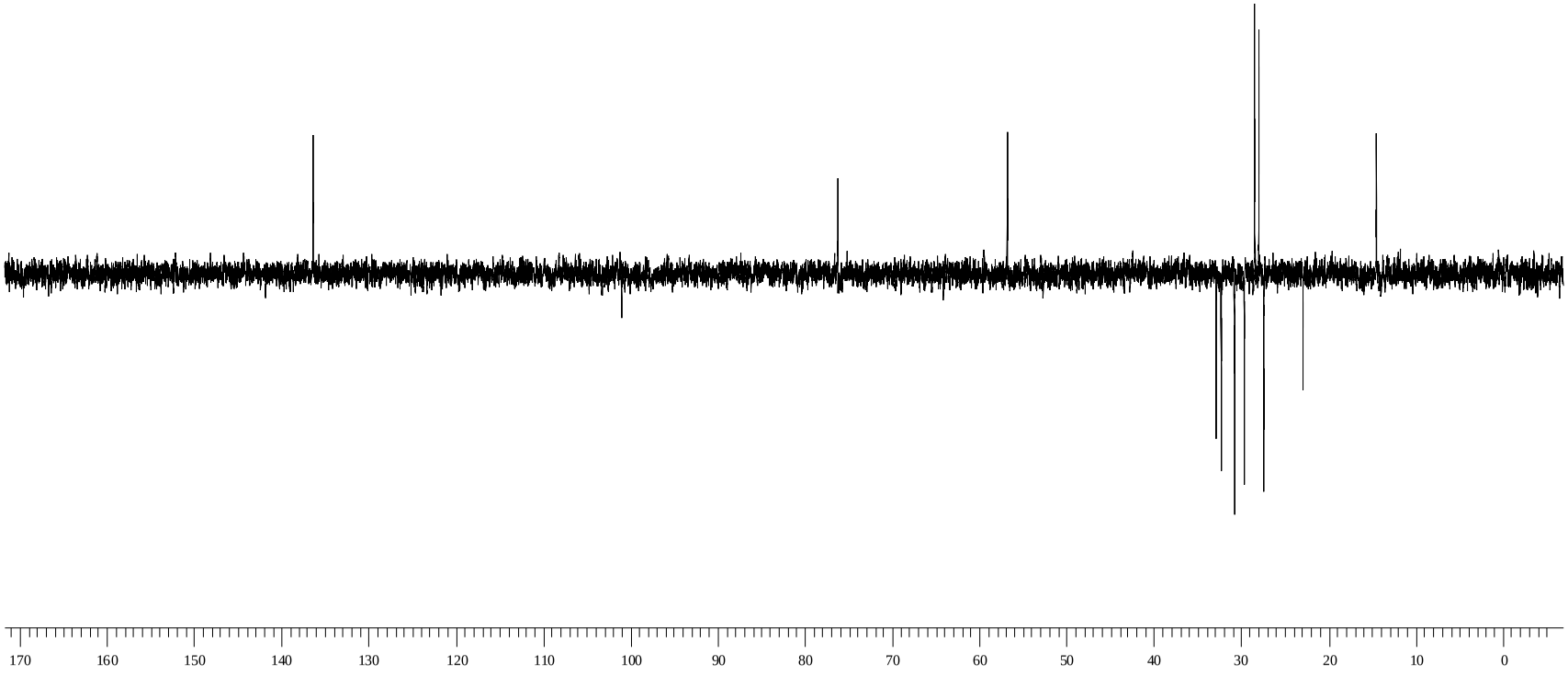

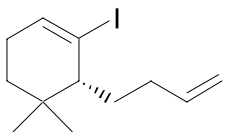

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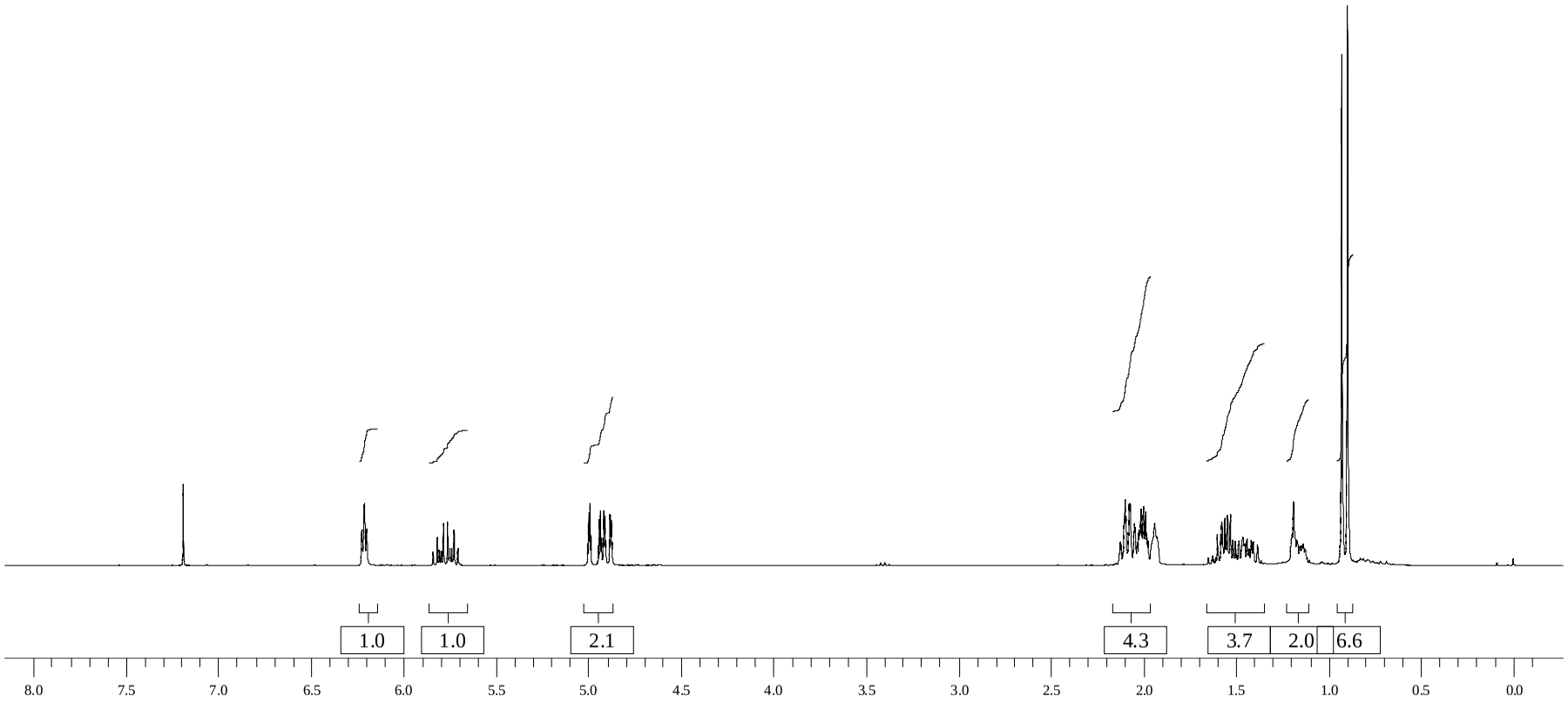

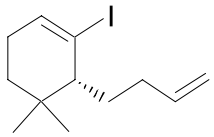

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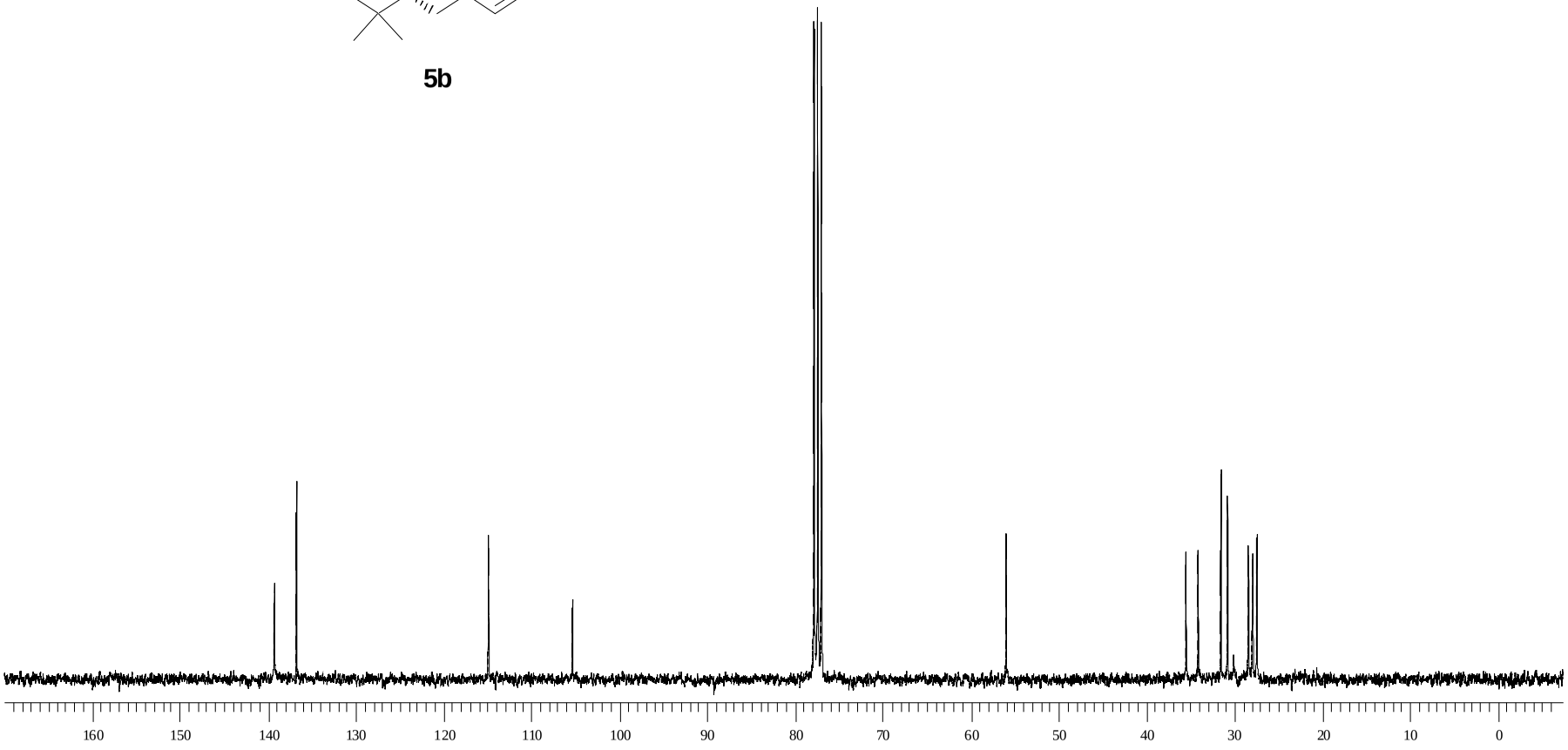

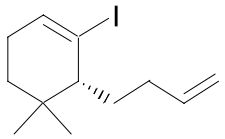

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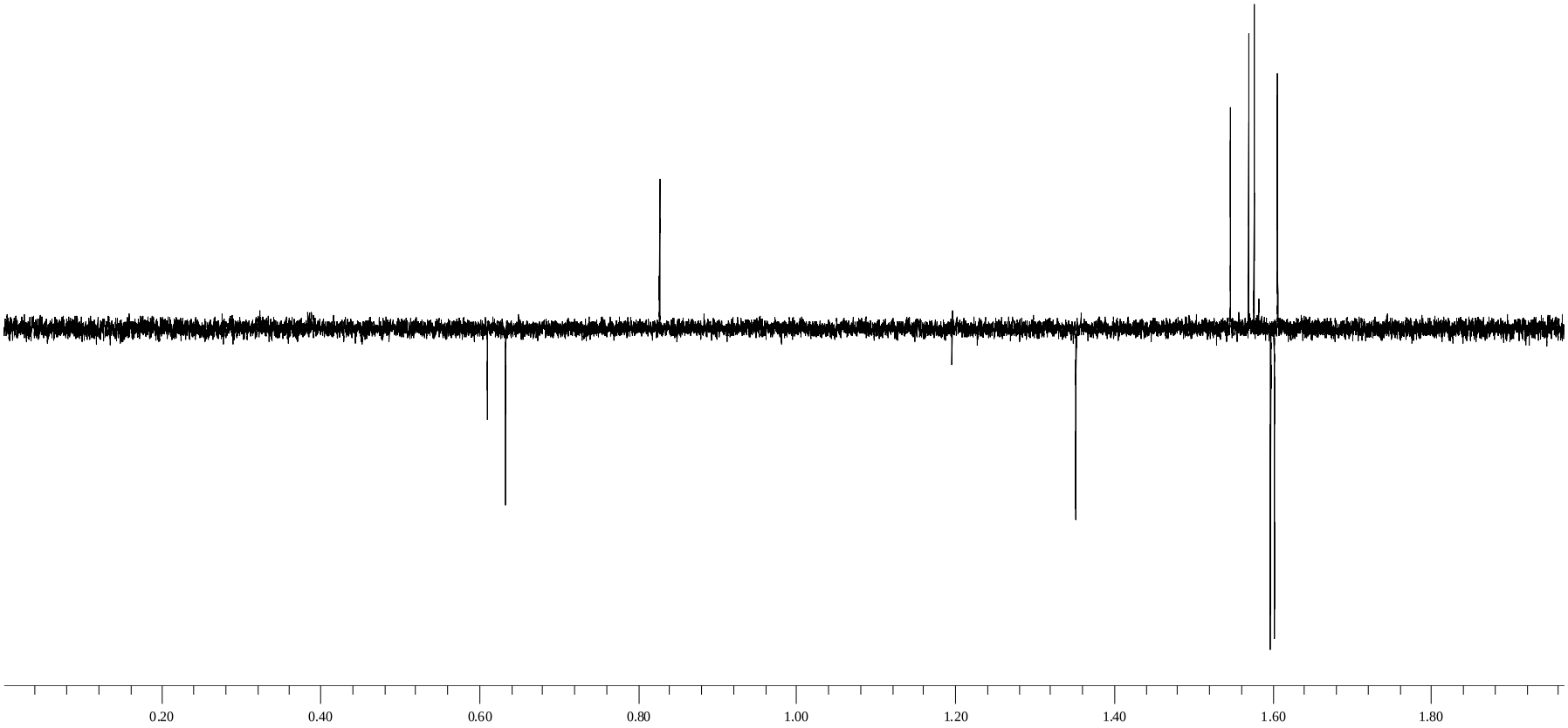

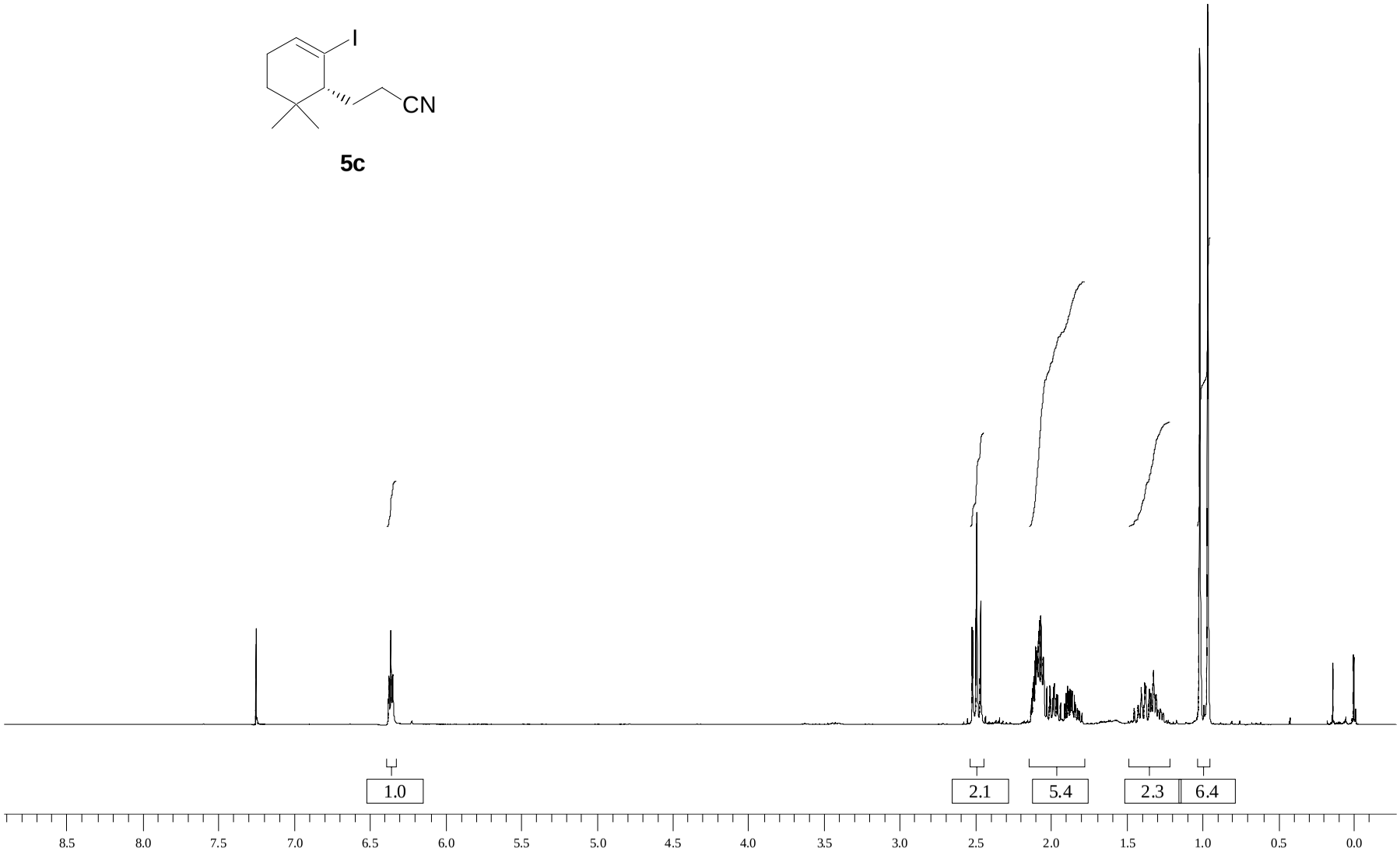
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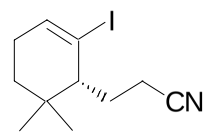

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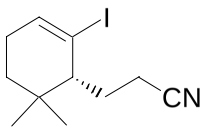

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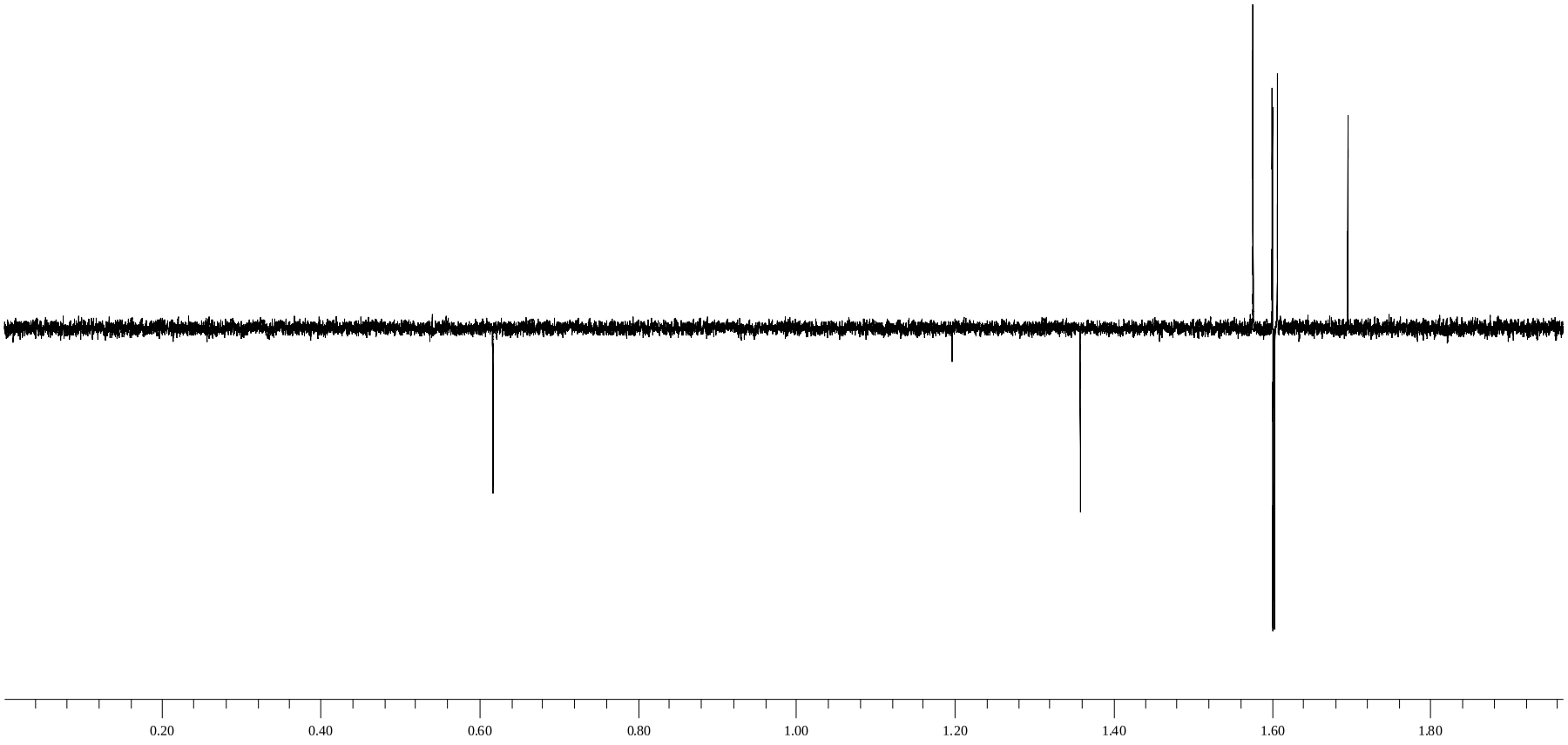

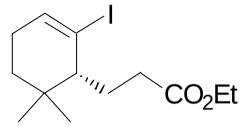
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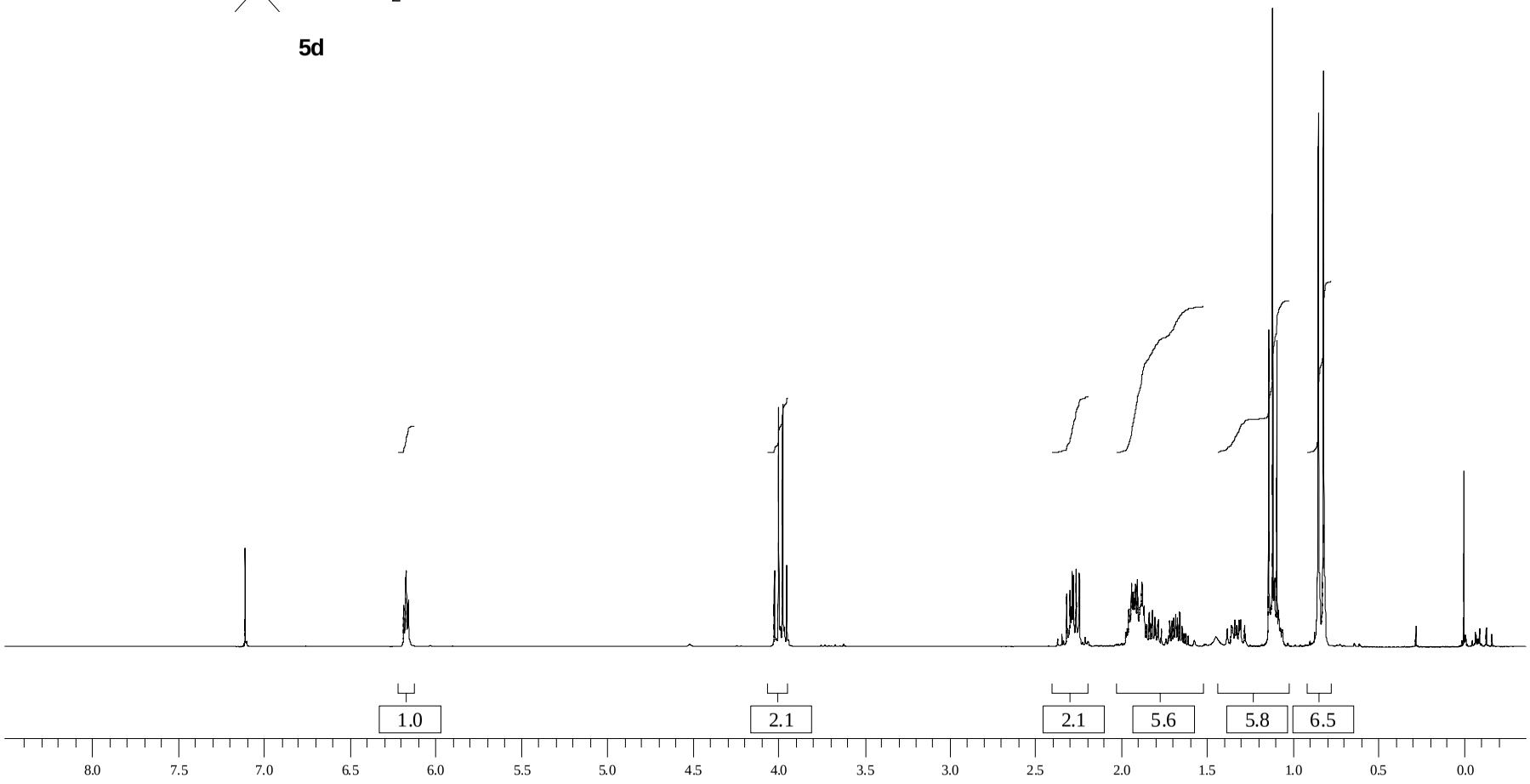
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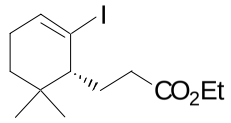

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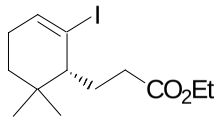

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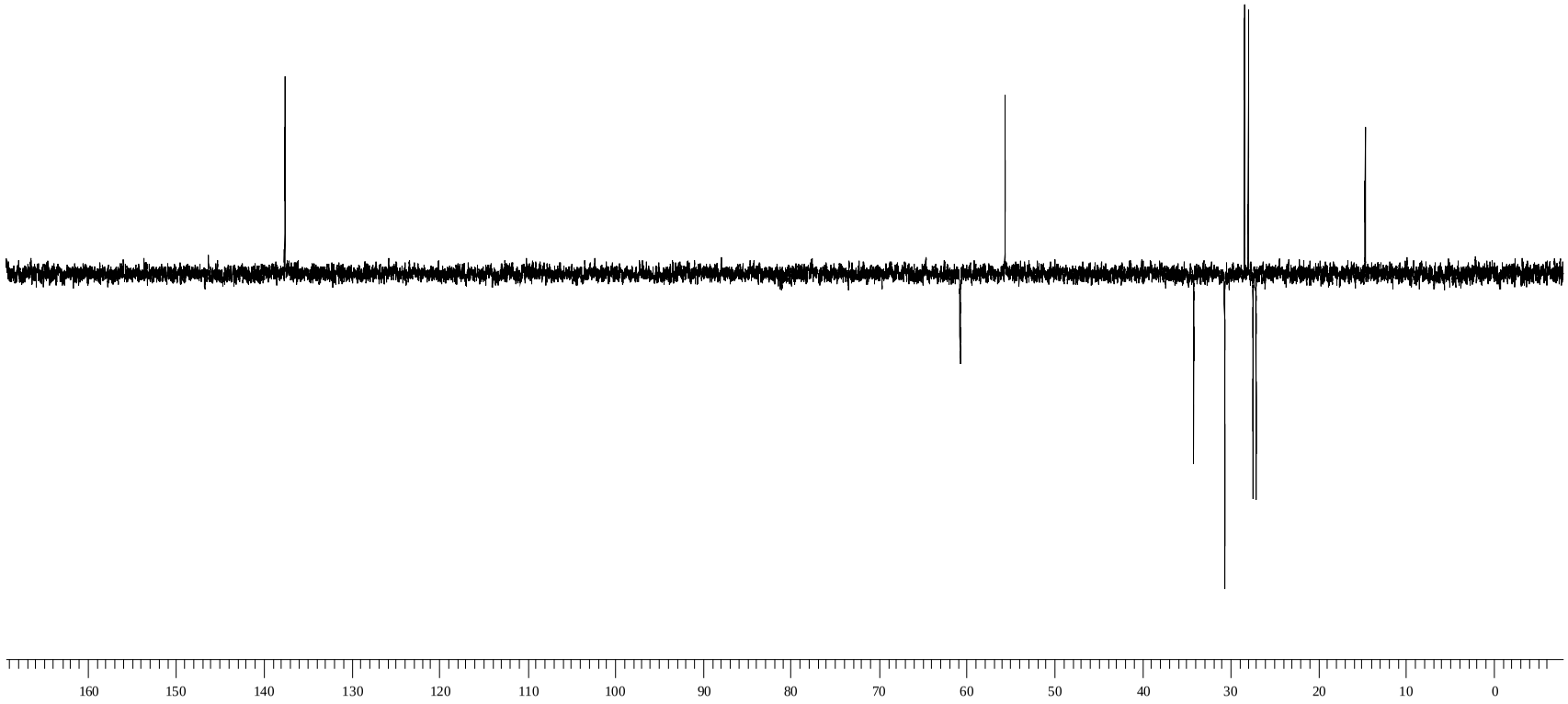

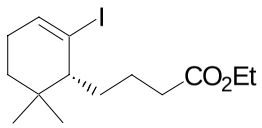
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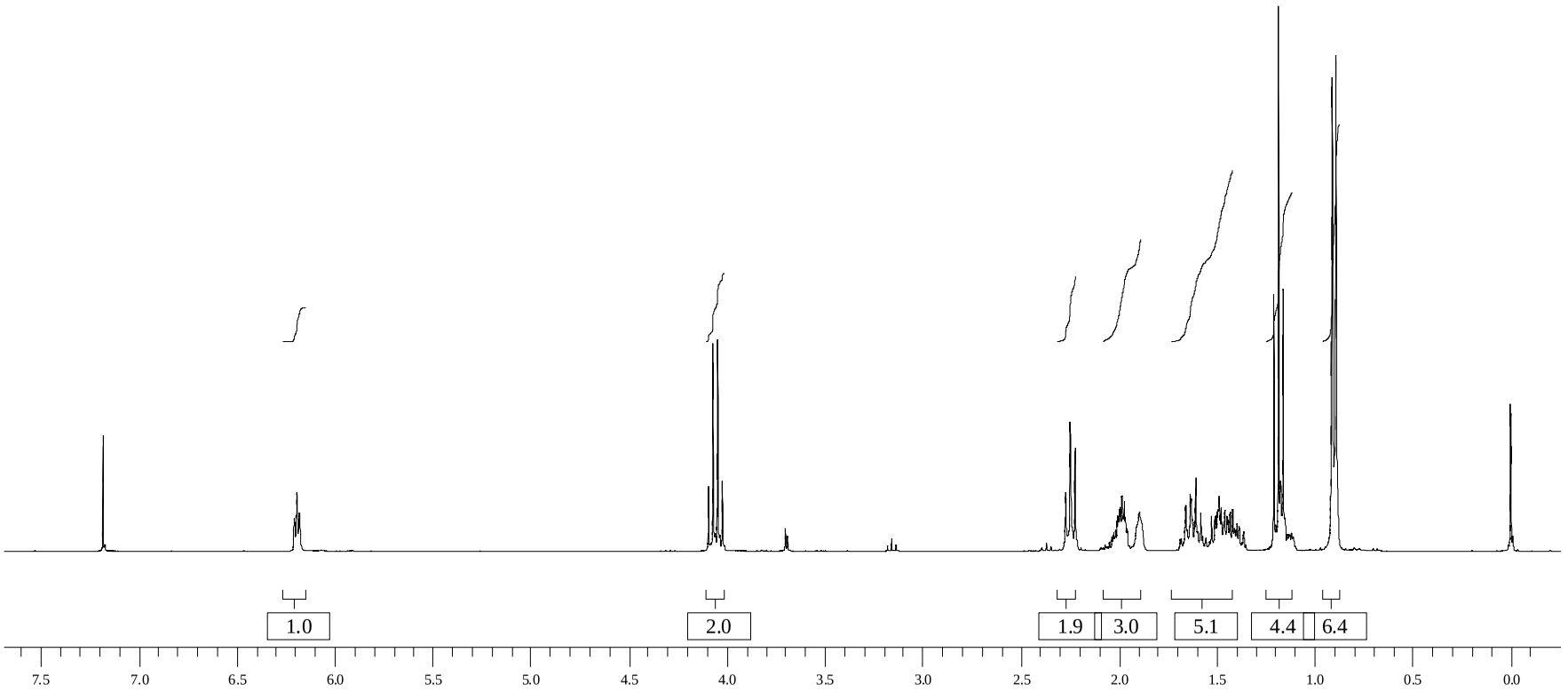
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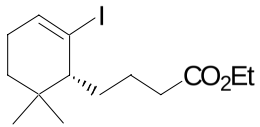
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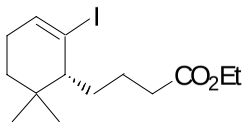

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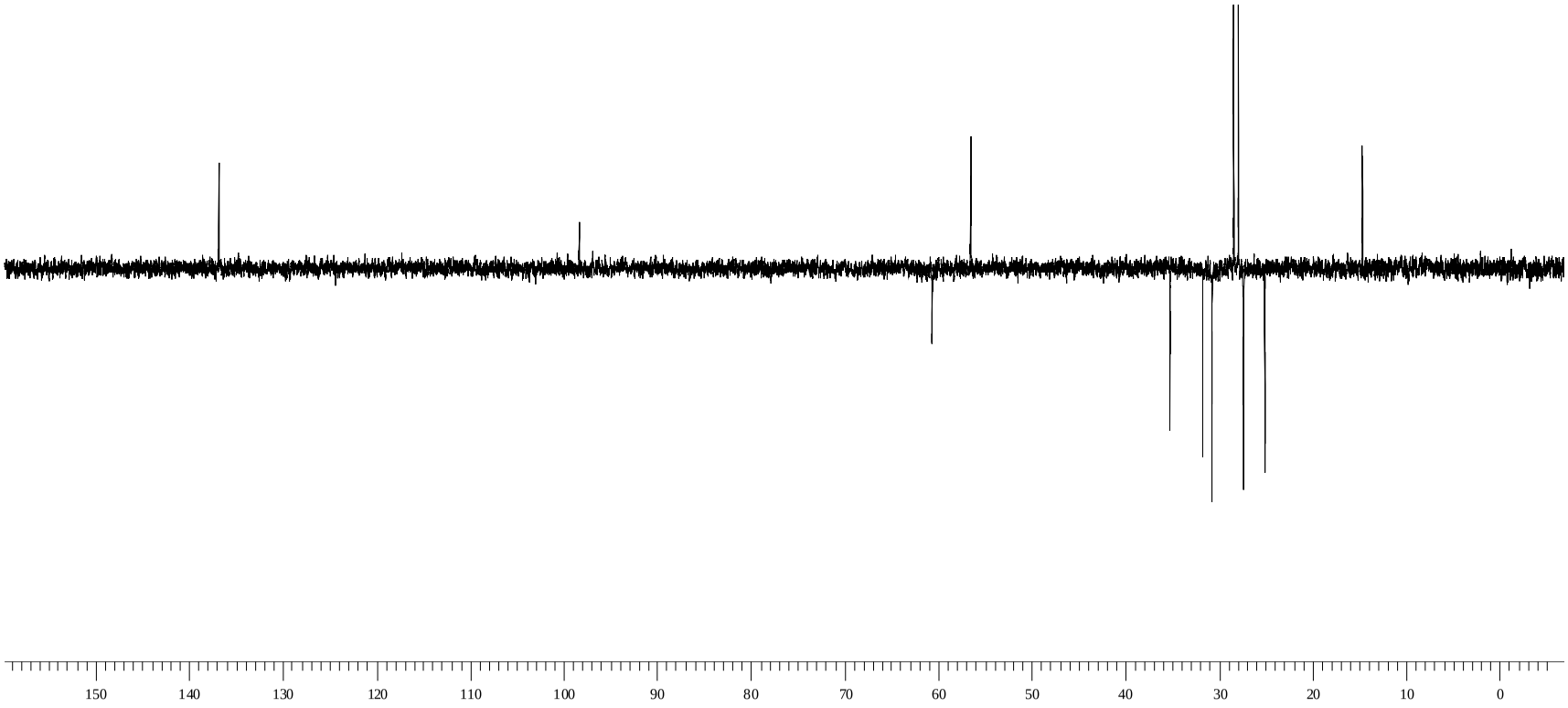

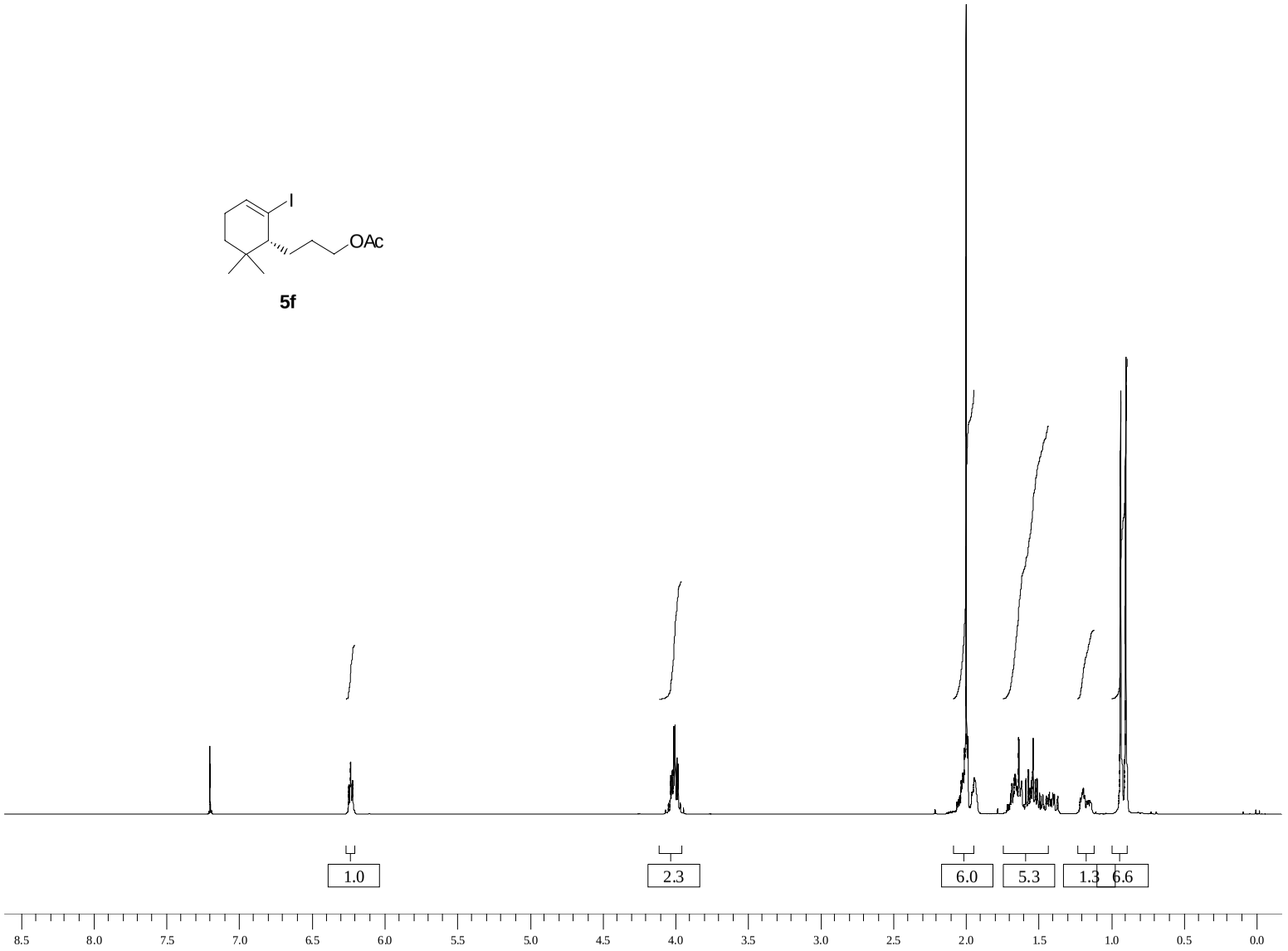
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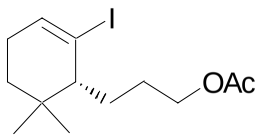
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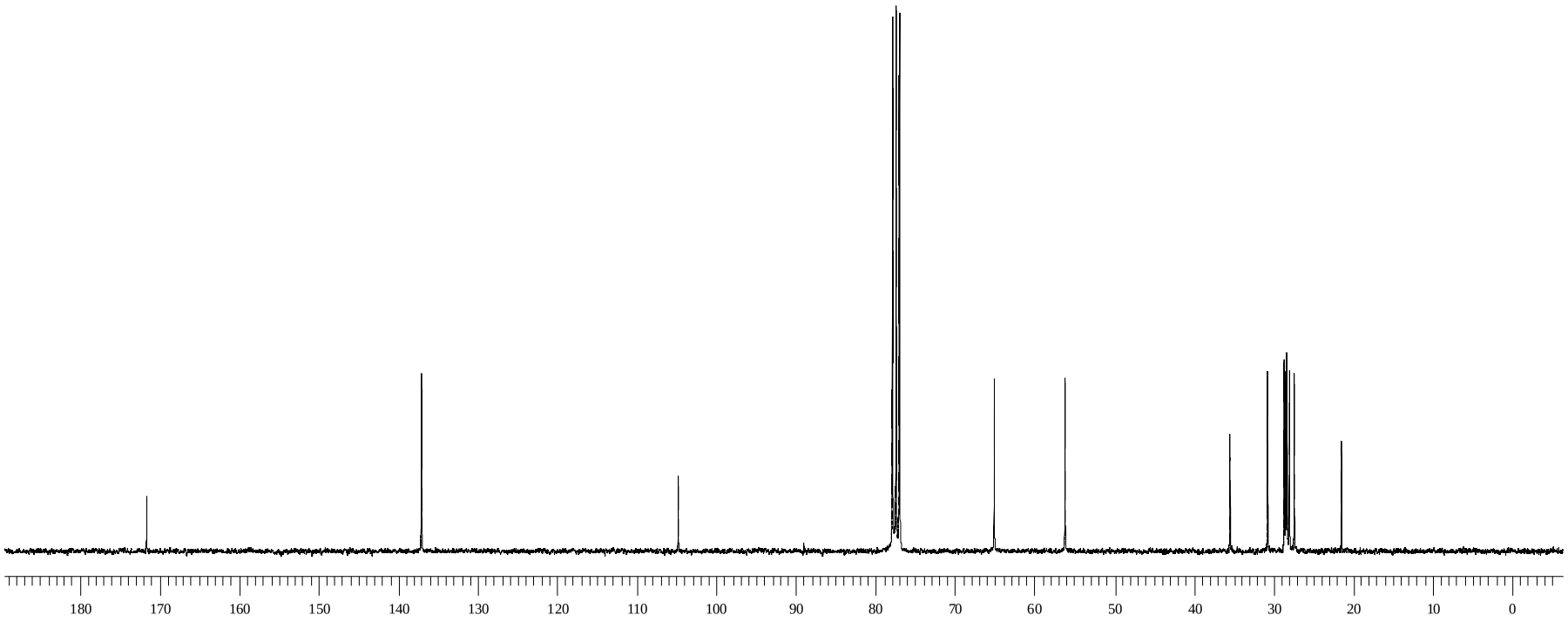
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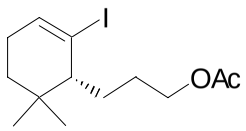

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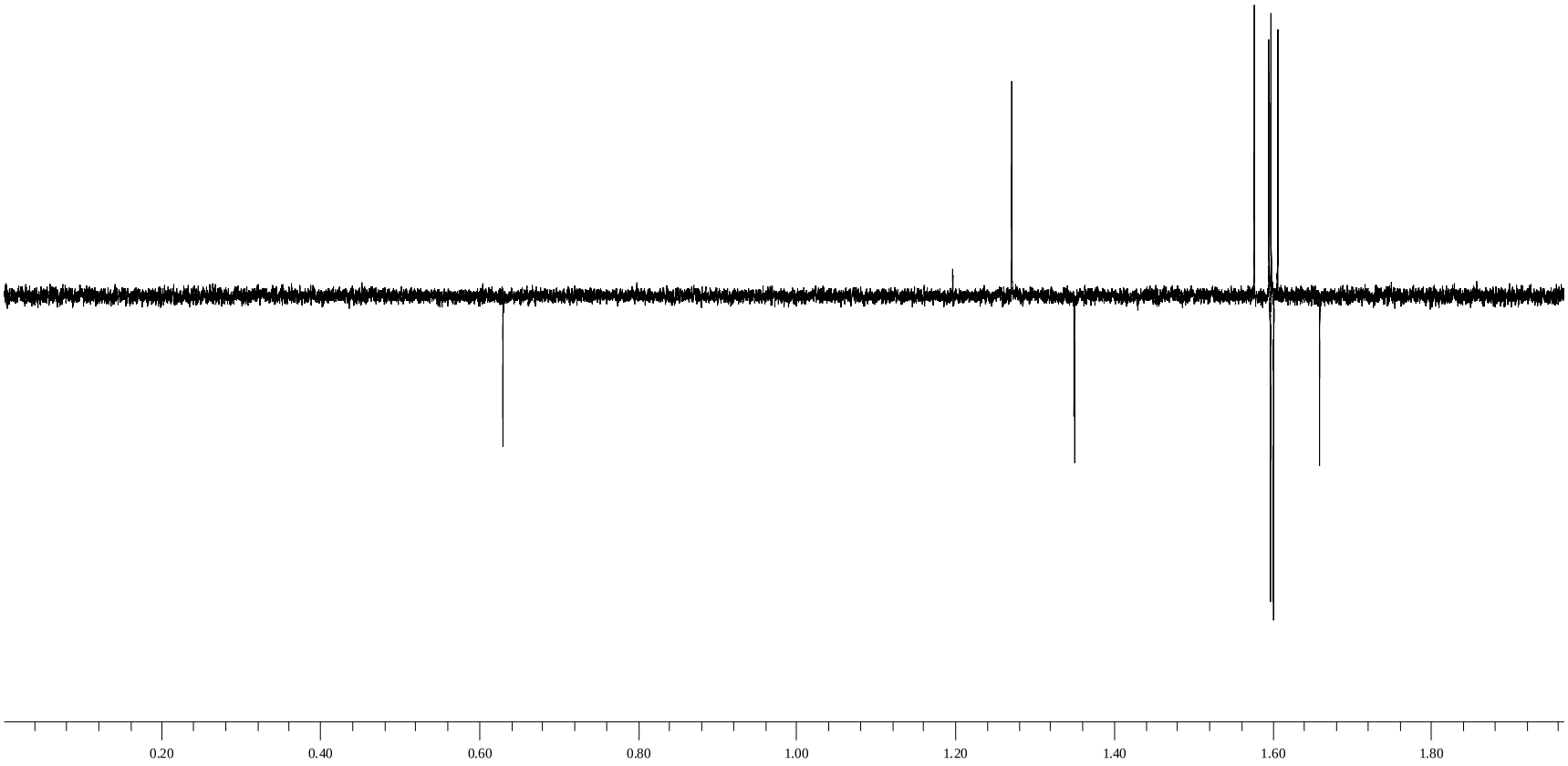

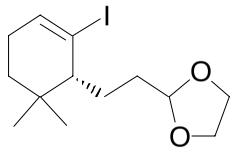
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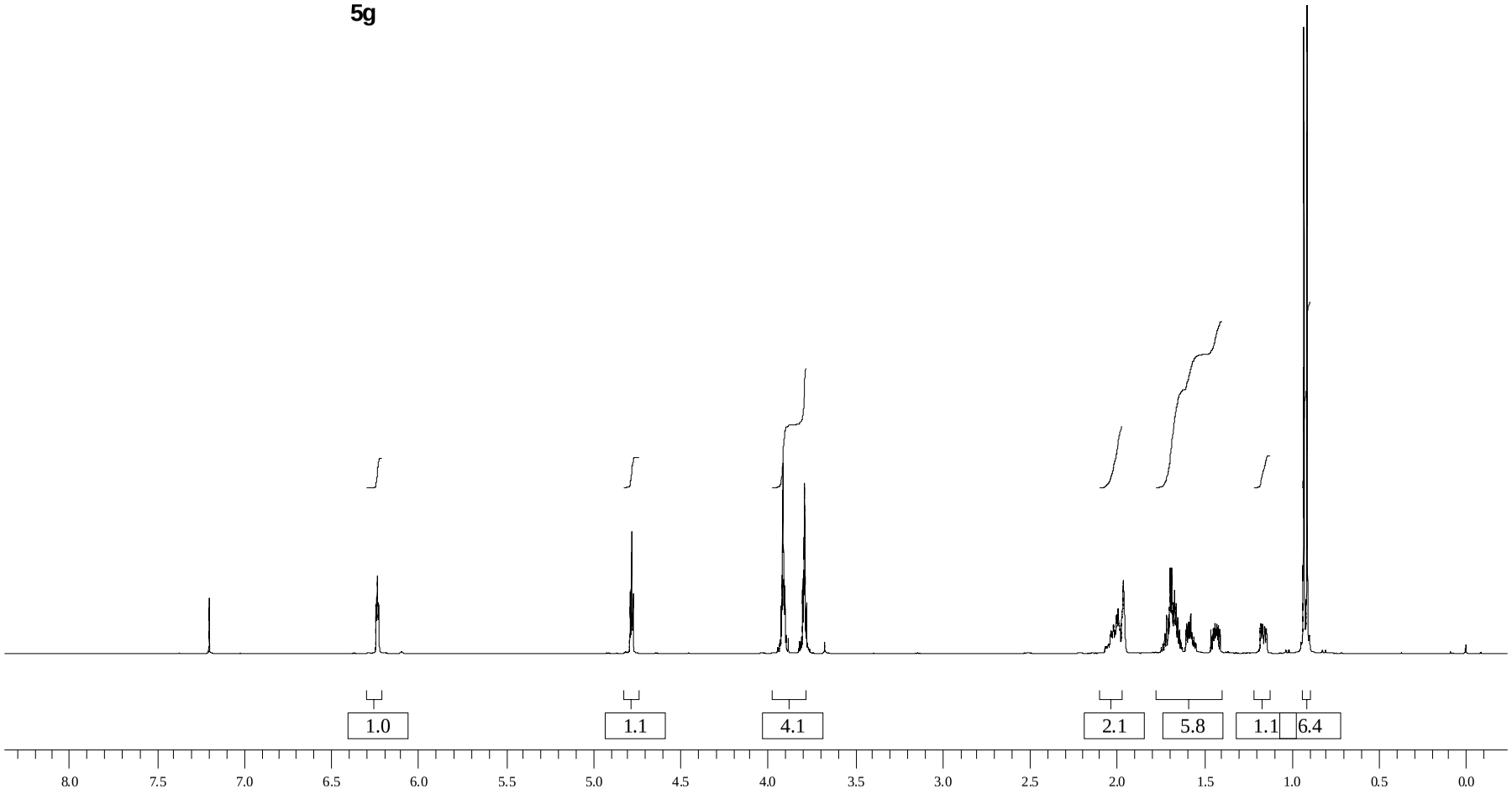
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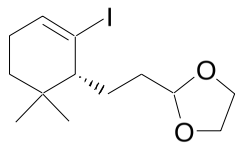

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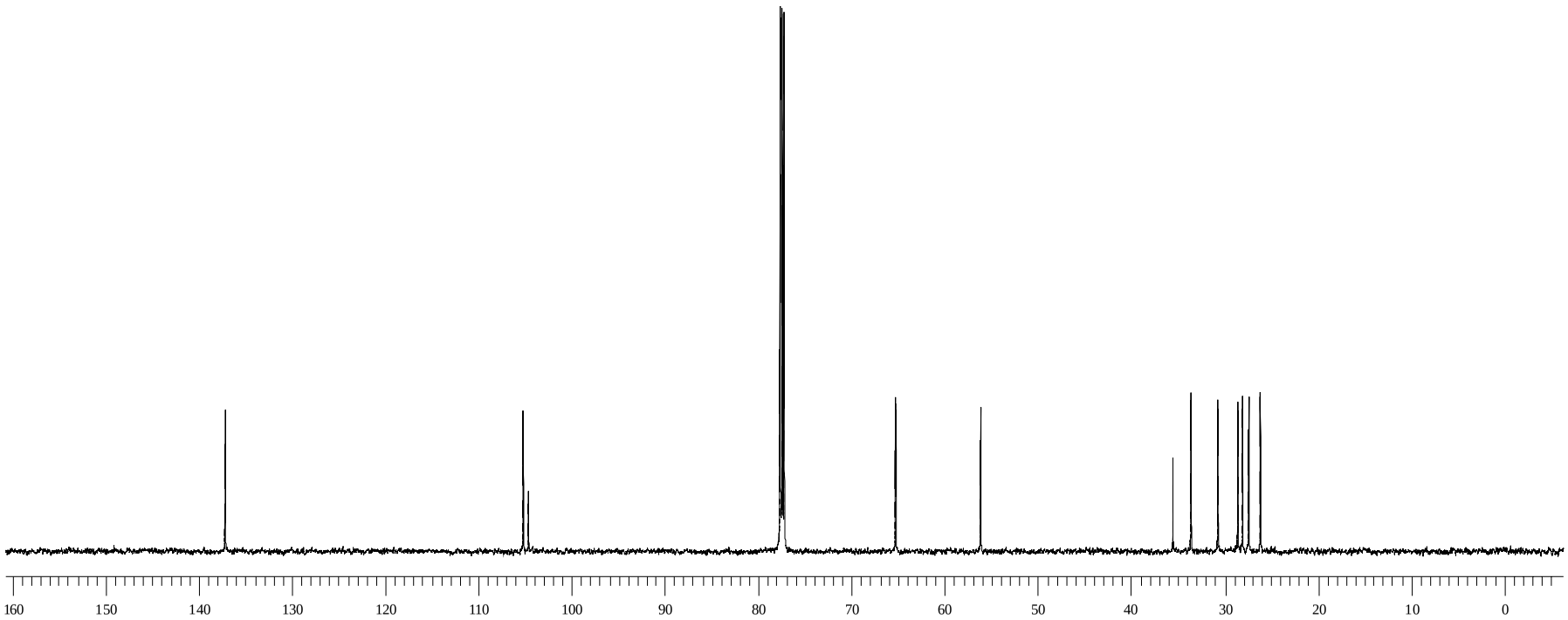

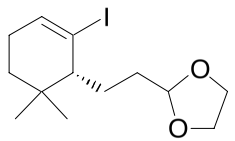

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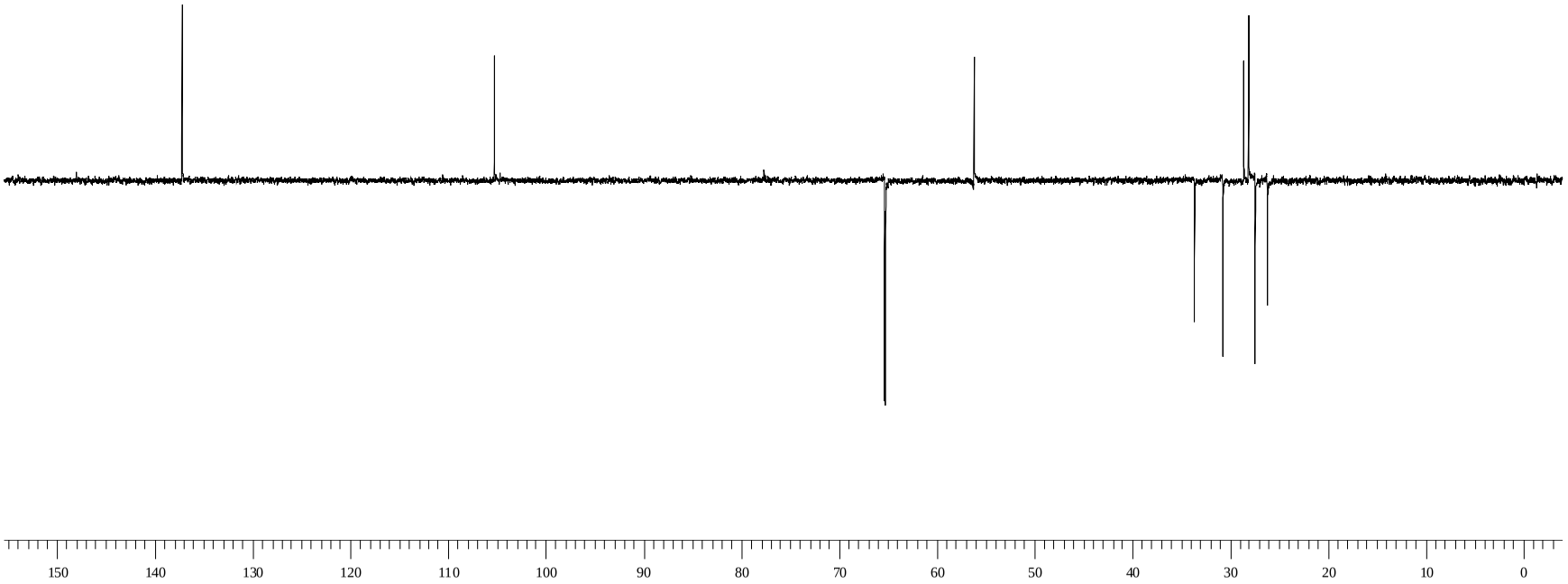

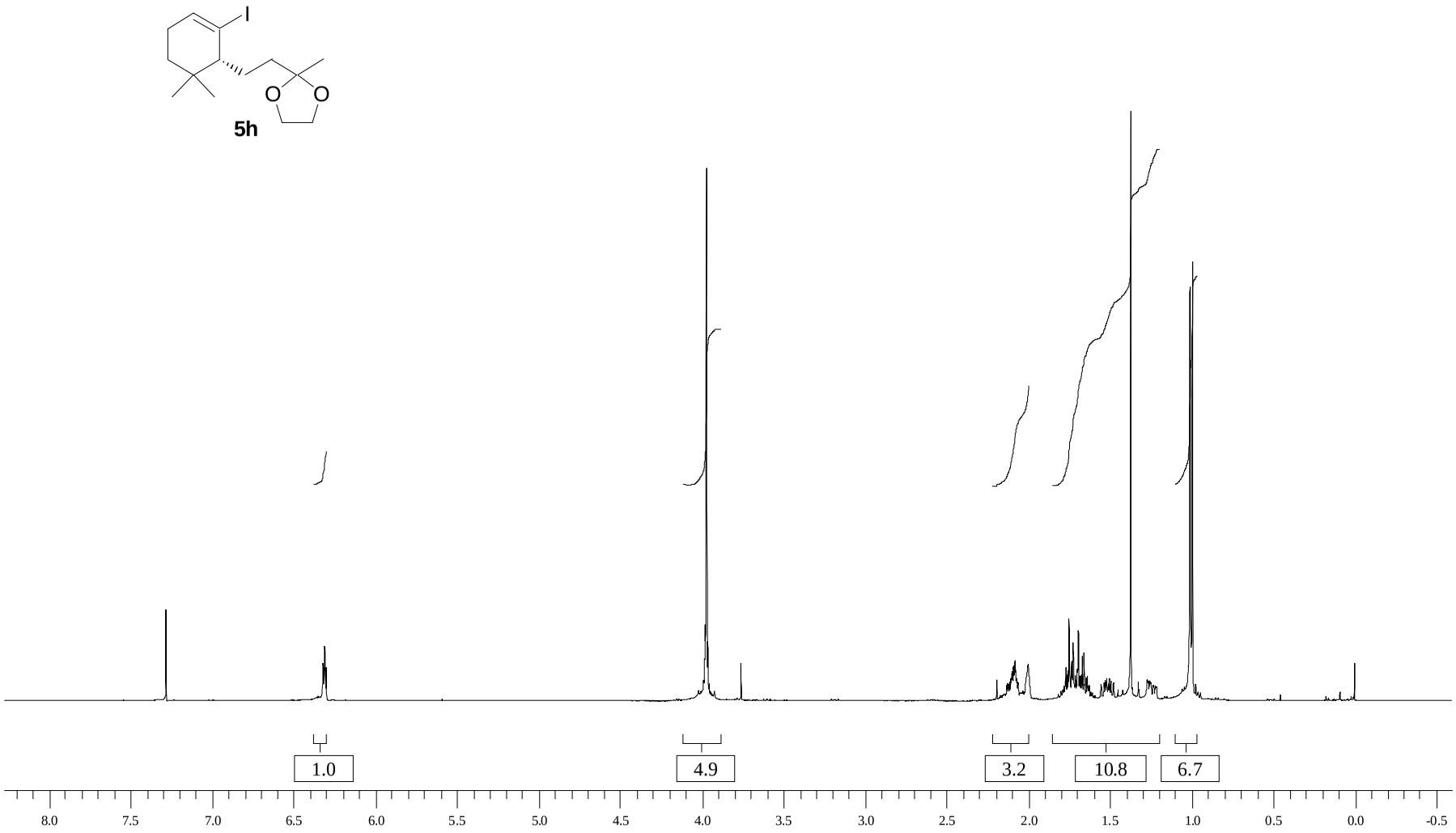
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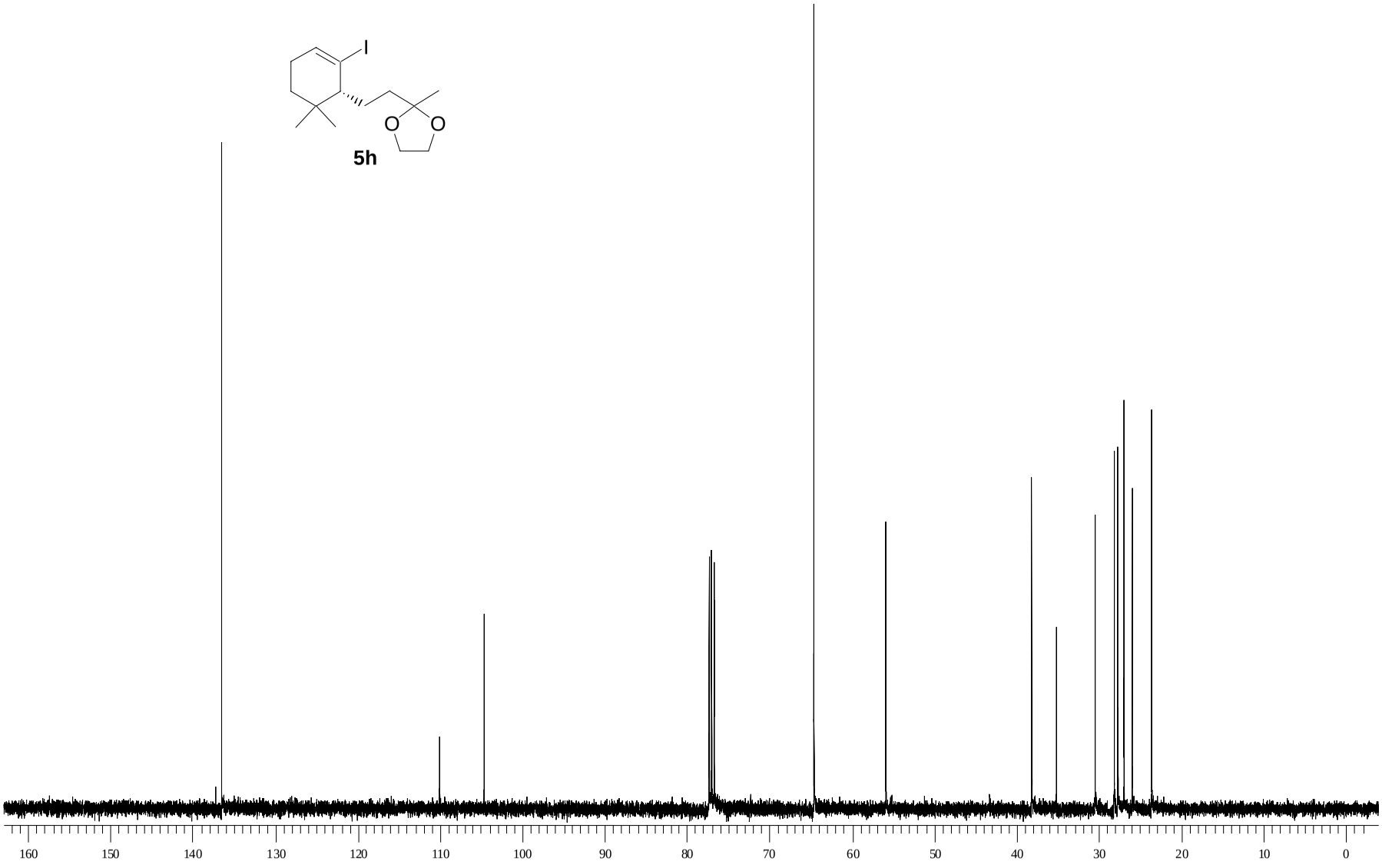
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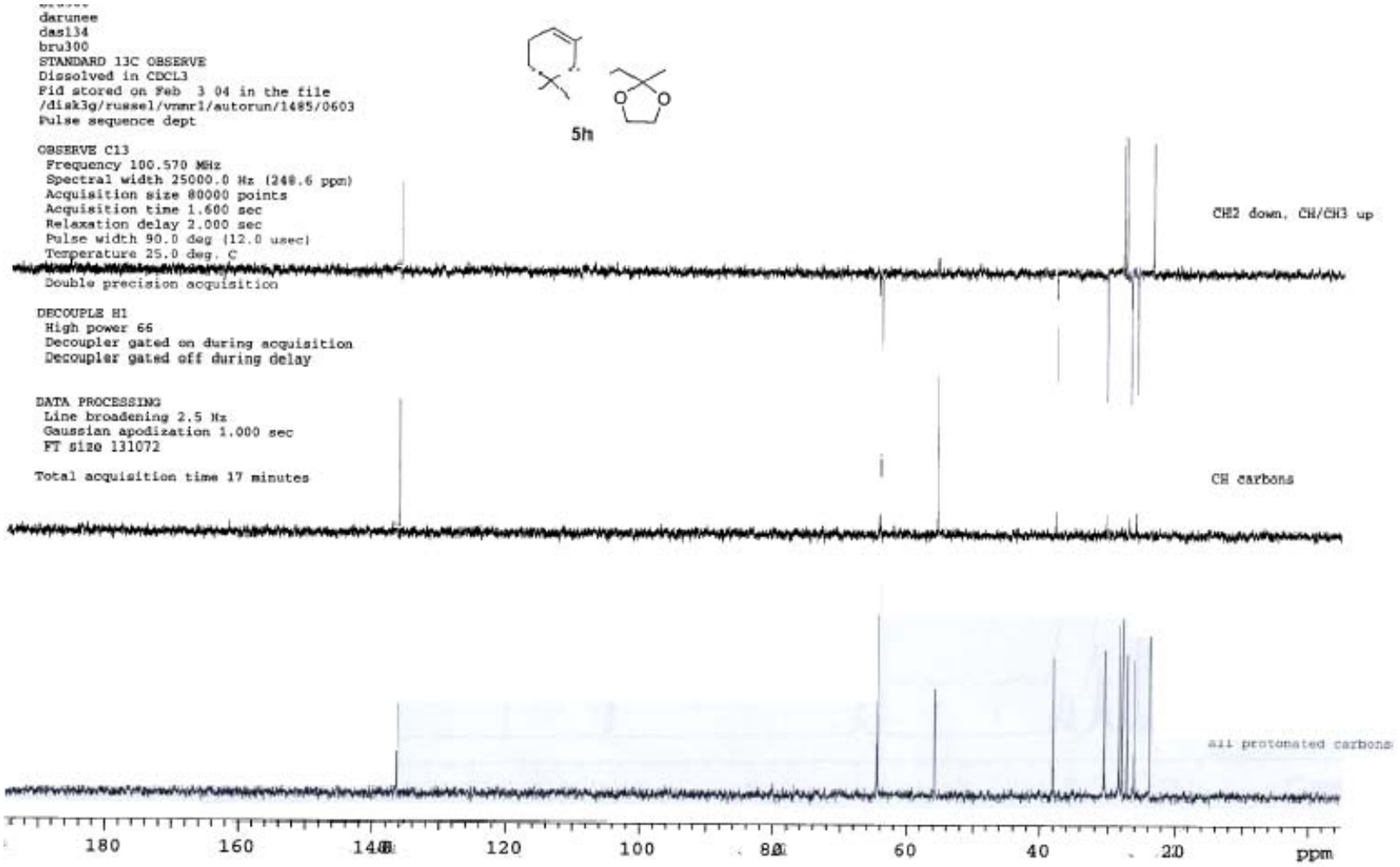
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das134
bru300
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Spectral width 25000.0 Hz (248.6 ppm)
Acquisition size 80000 points
Acquisition time 1.600 sec
Relaxation delay 2.000 sec
Pulse width 90.0 deg (12.0 usec)
Temperature 25.0 deg. C
Double precision acquisition
DECOUPLE H1
High power 66
Decoupler gated on during acquisition
Decoupler gated off during delay
DATA PROCESSING
Line broadening 2.5 Hz
Gaussian apodization 1.000 sec
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CH carbons
all protonated carbons
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60
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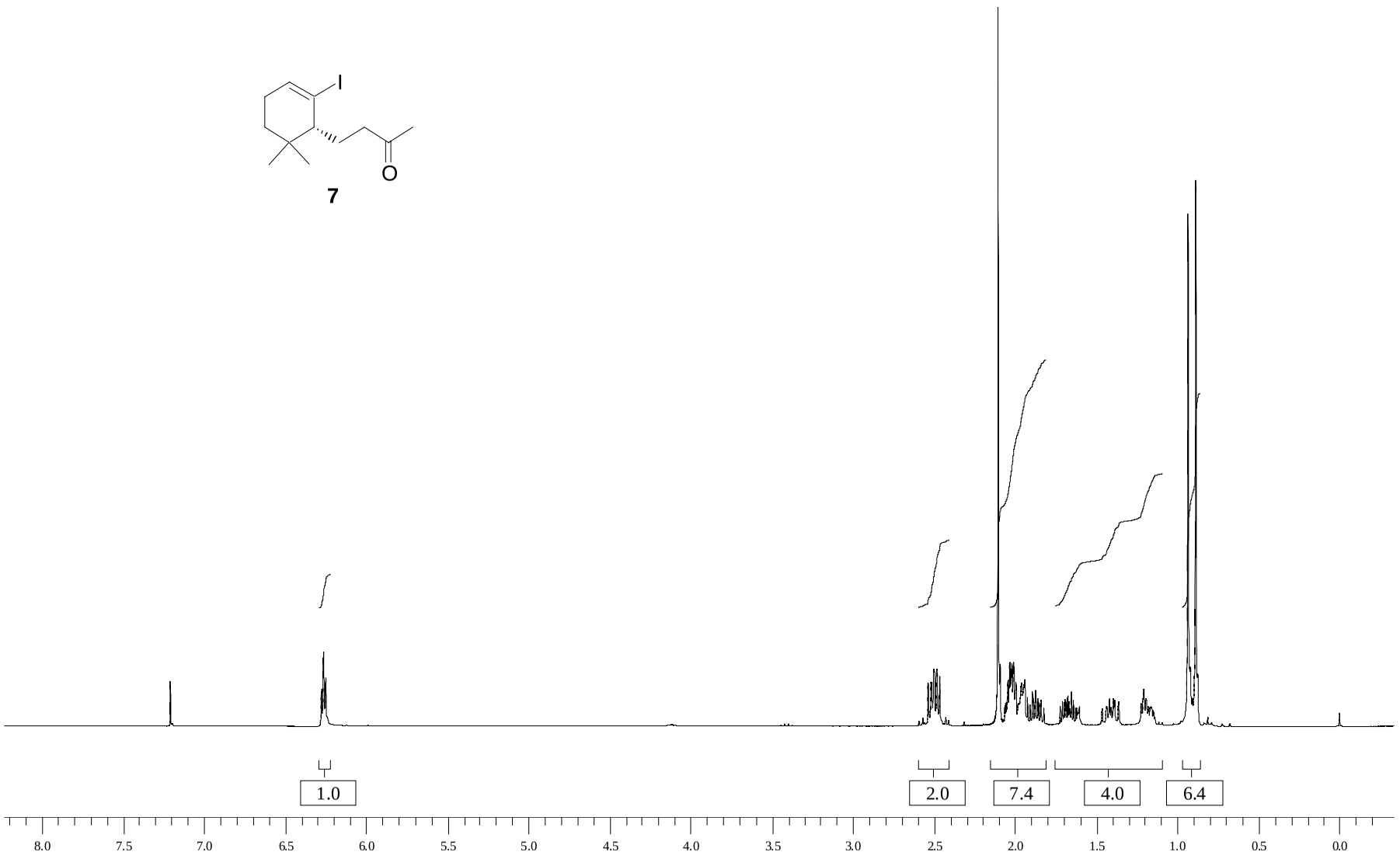
ppm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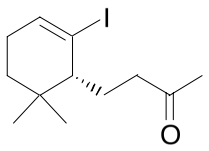

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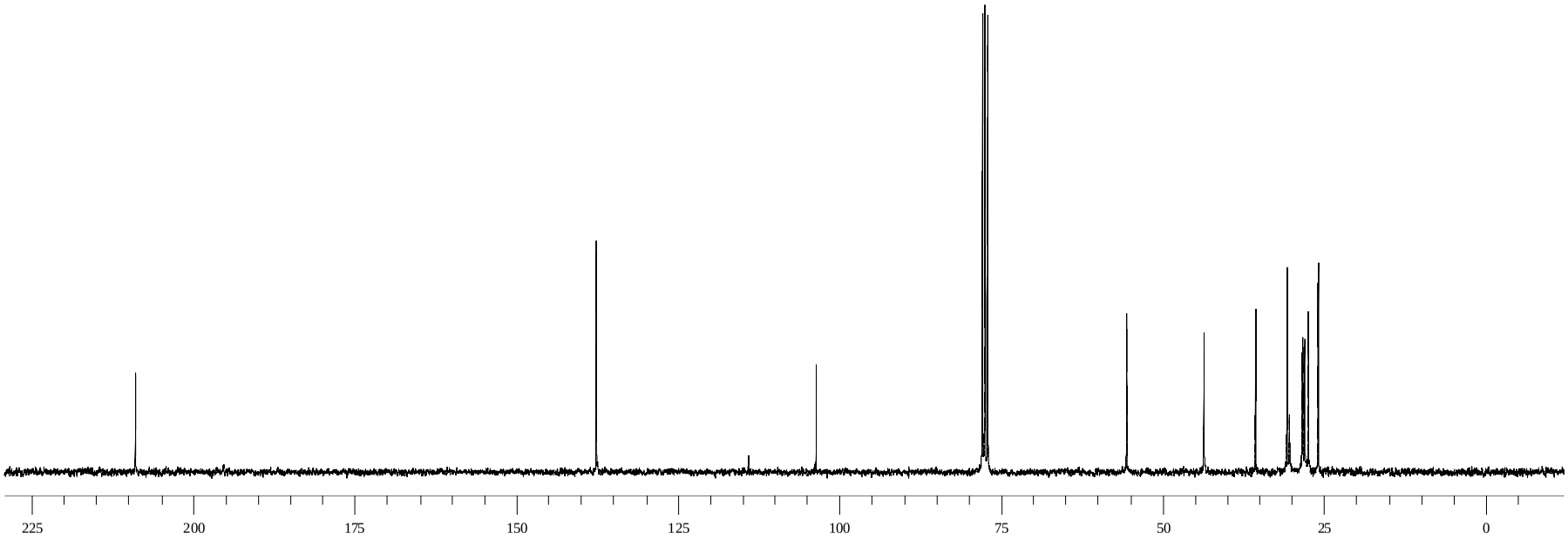

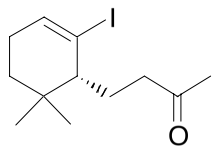

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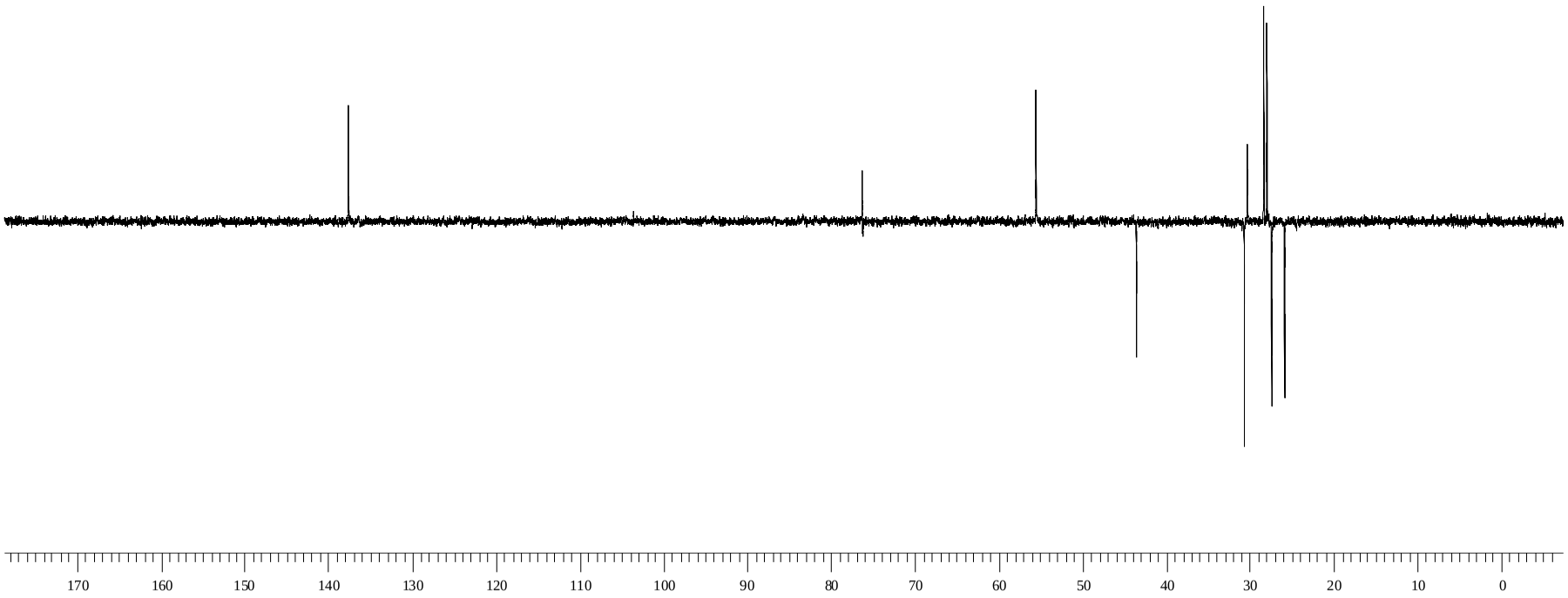

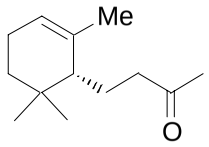

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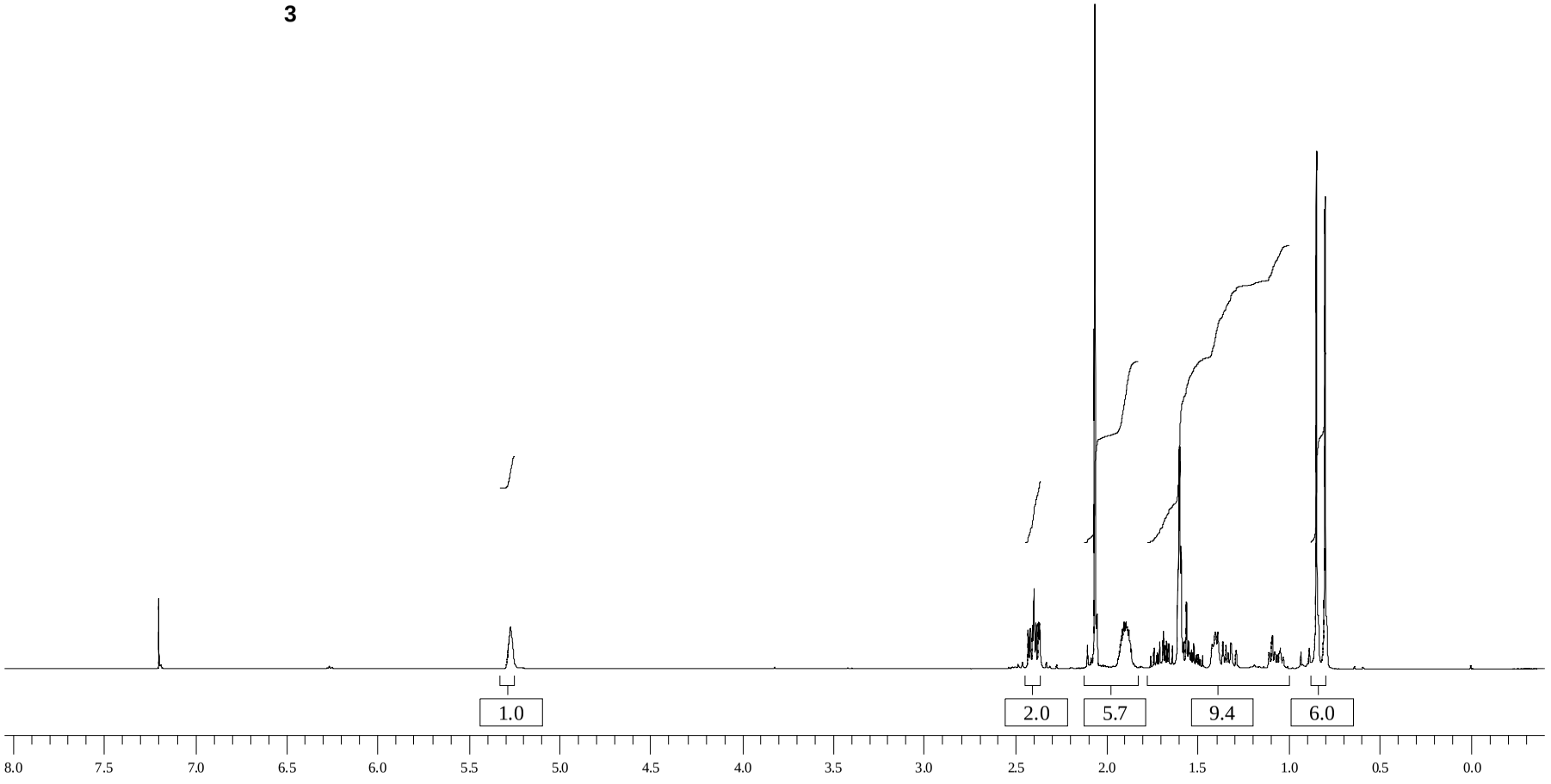

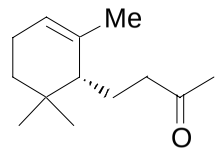

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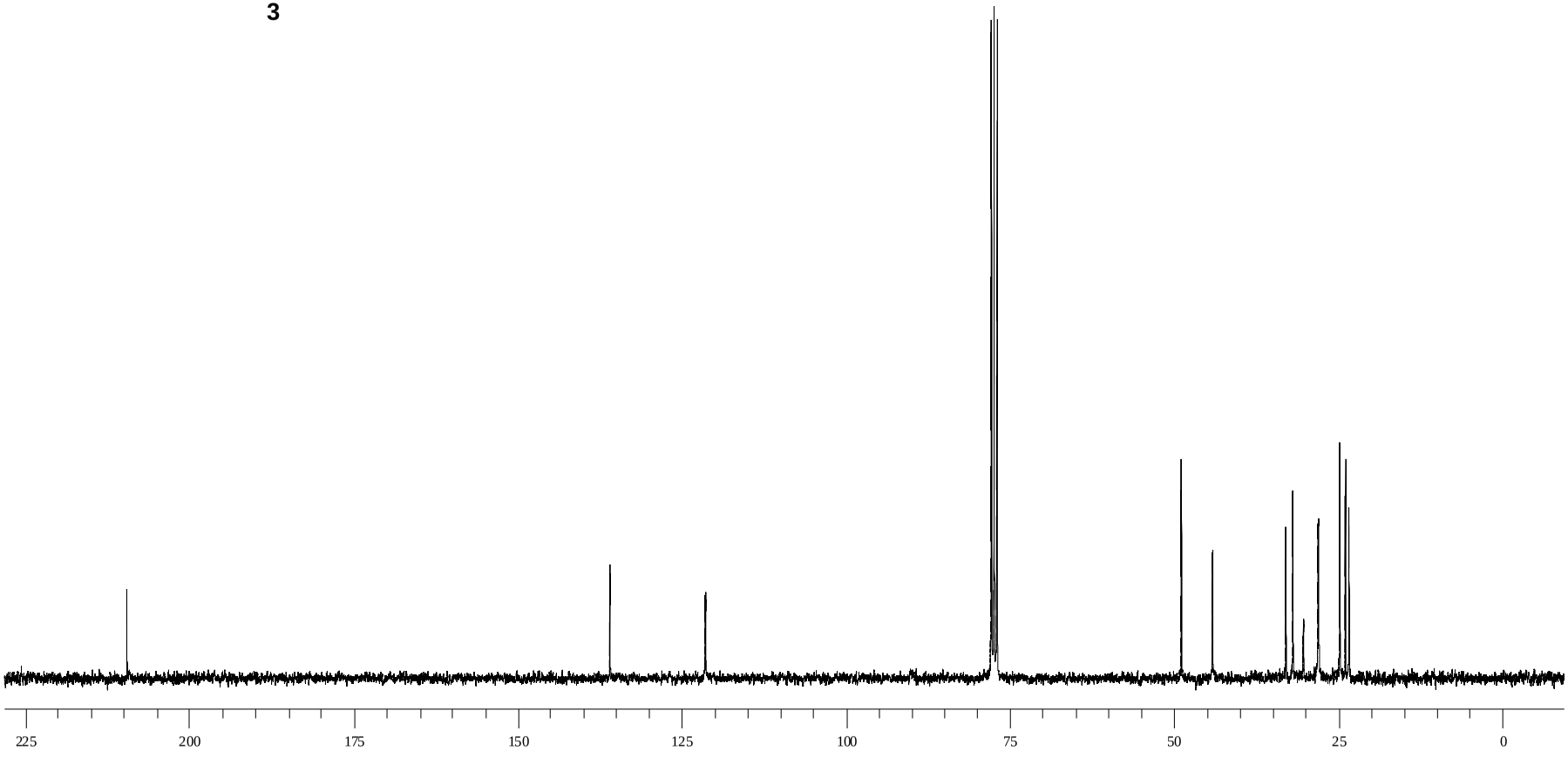

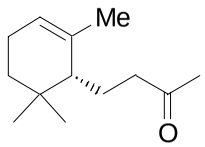

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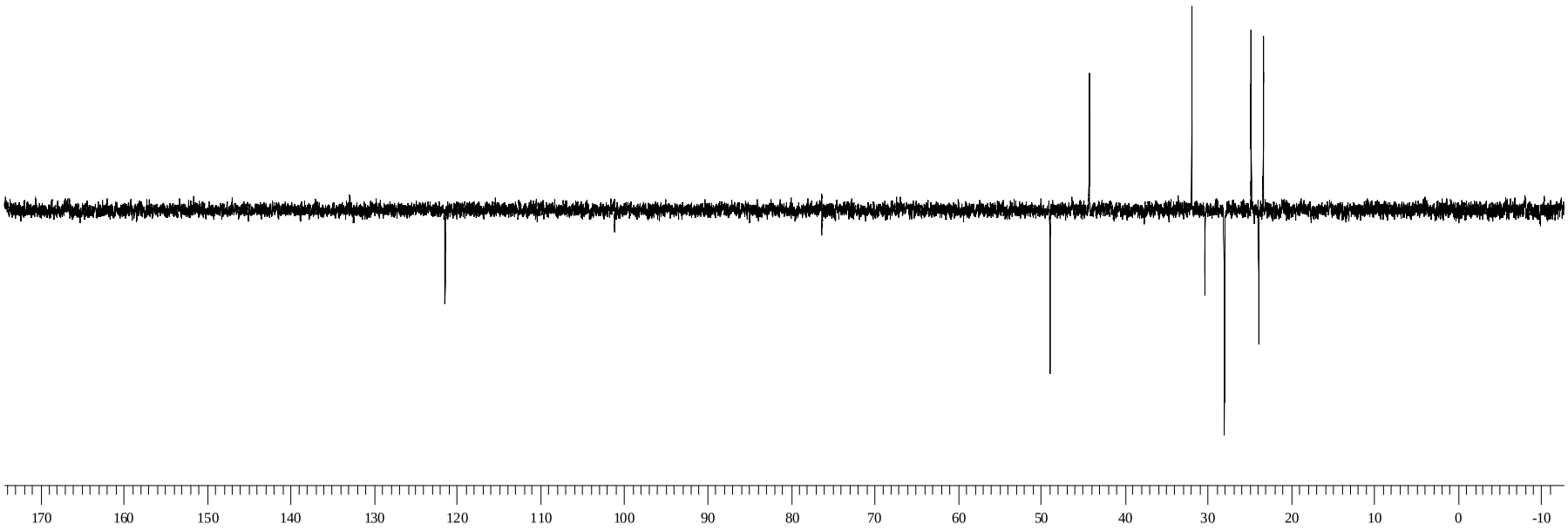

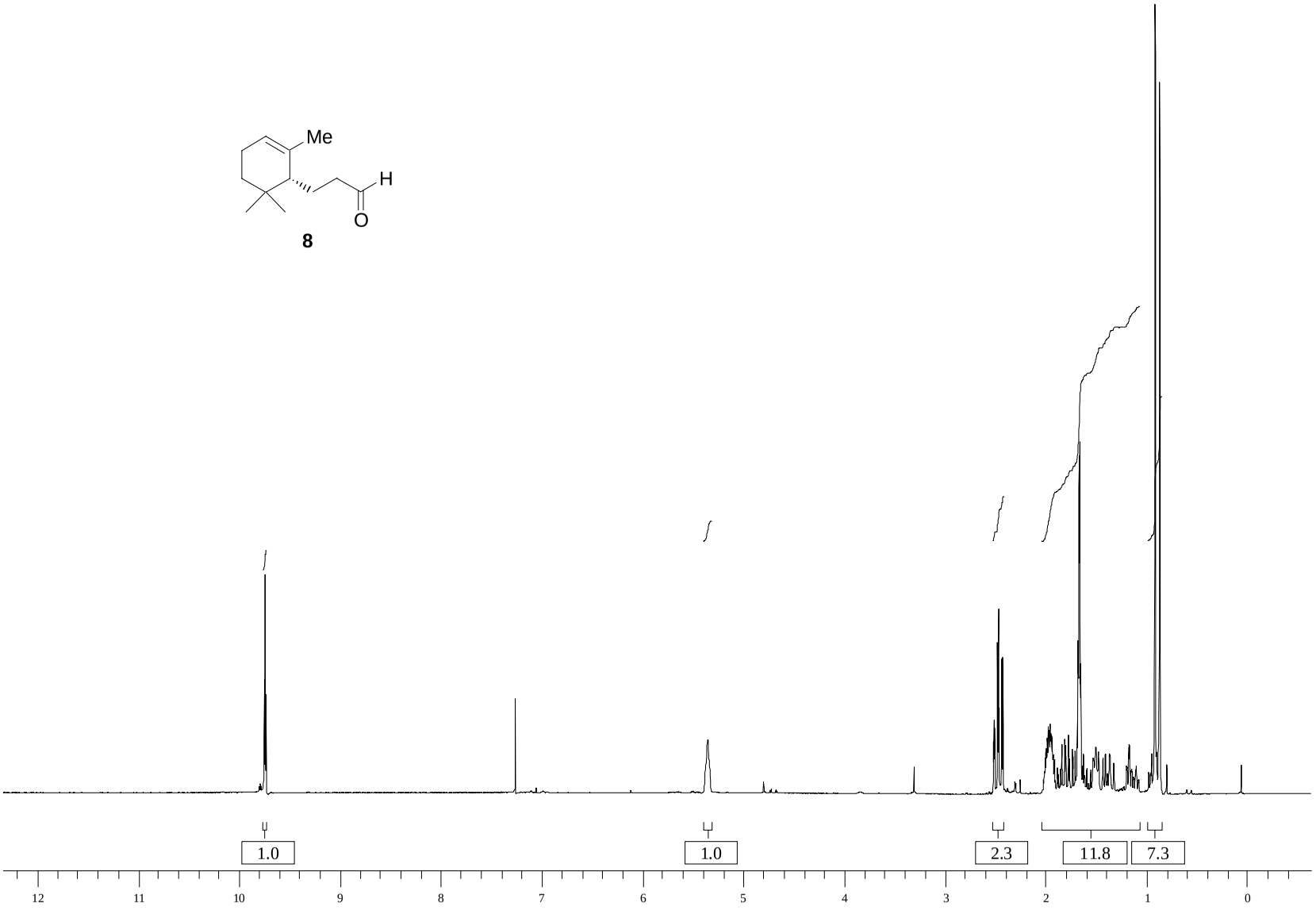
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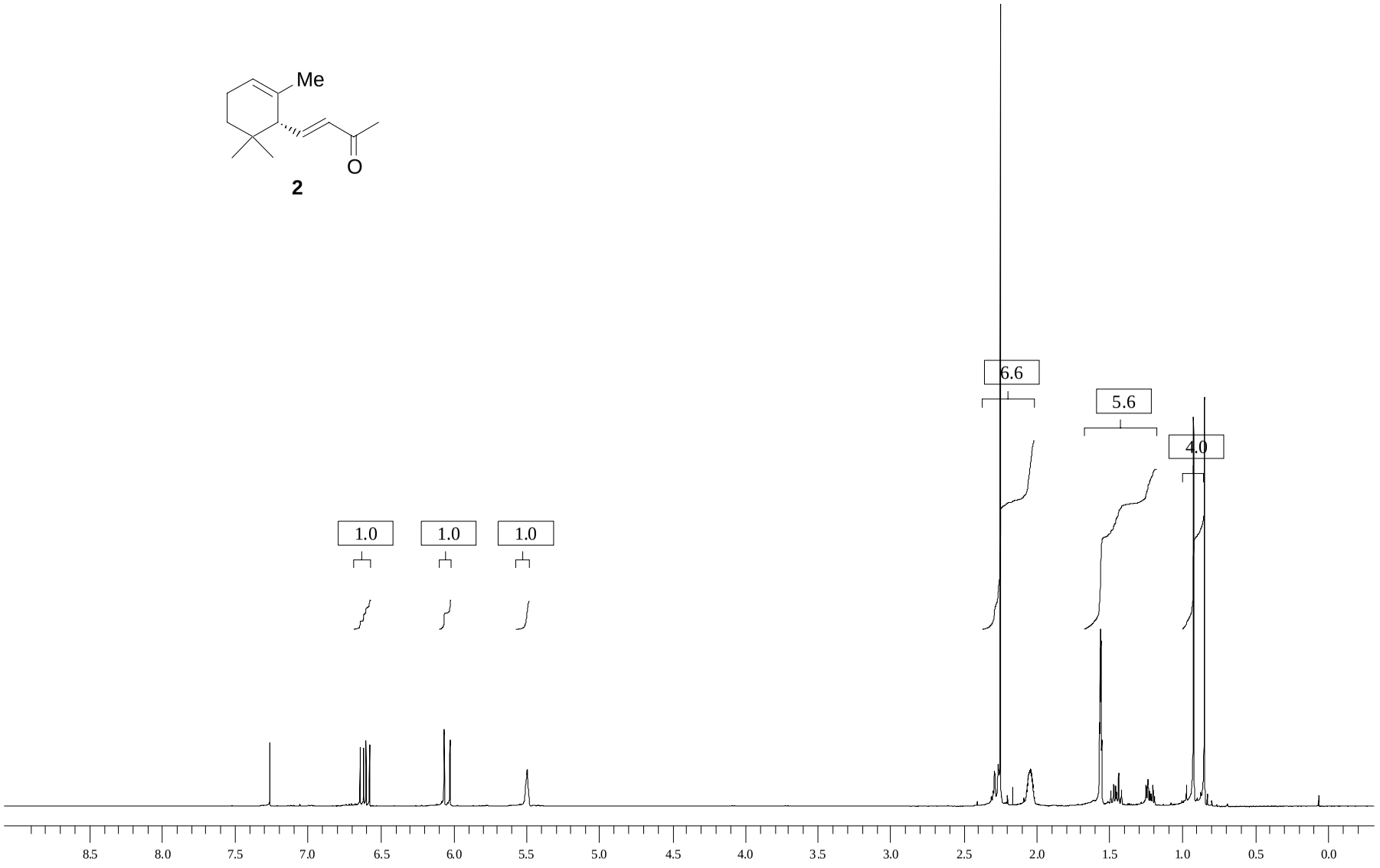
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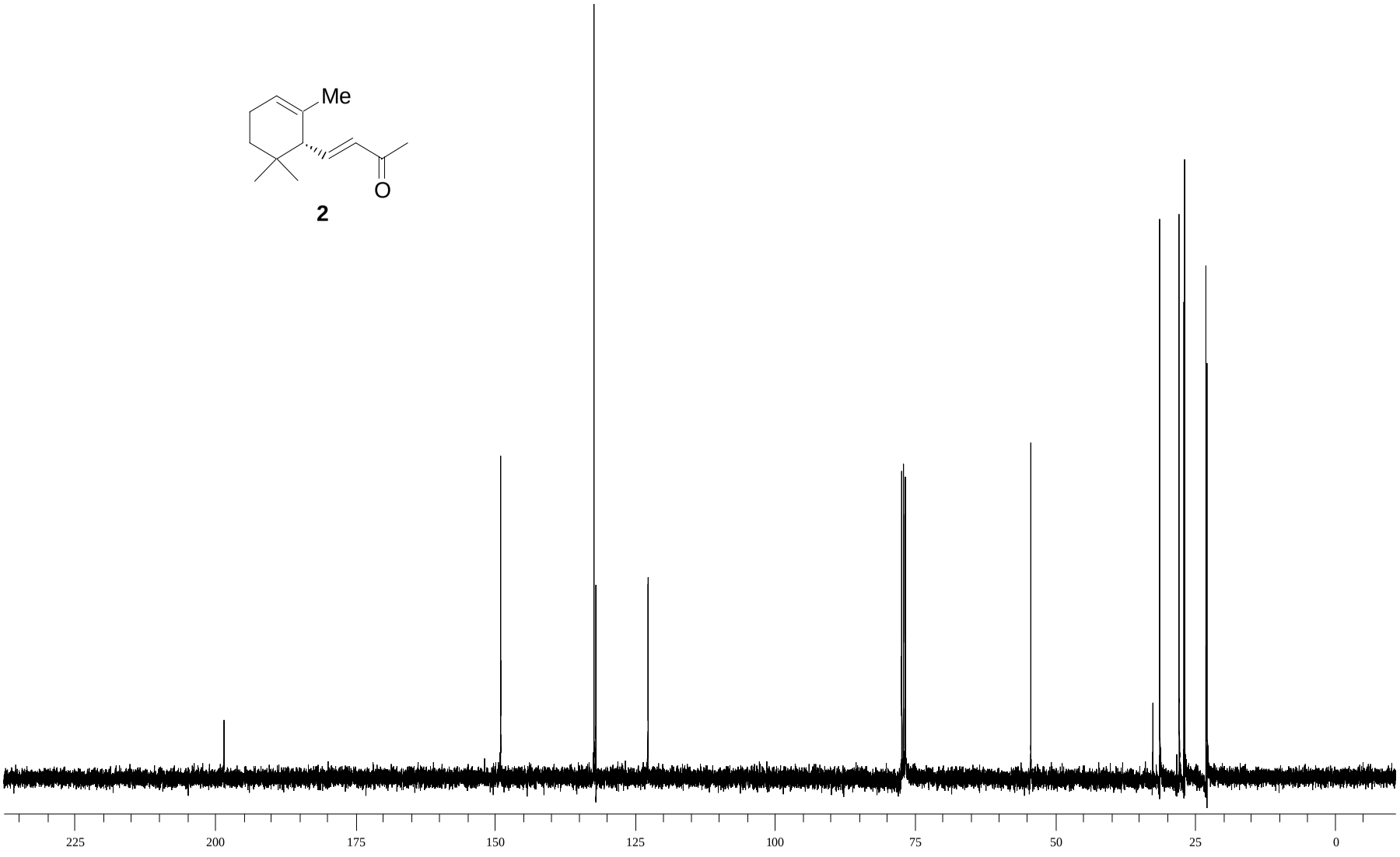
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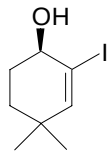
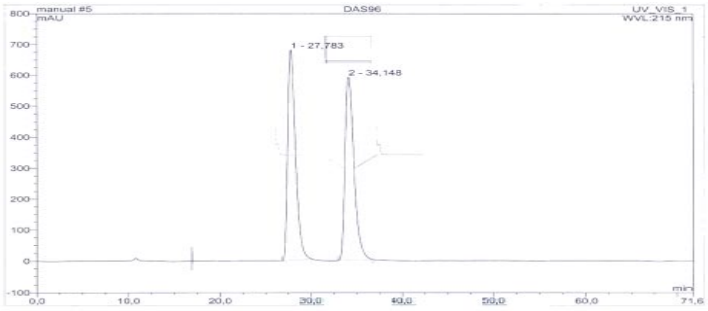
Appendix:

Determination of the enantiomeric excess by chiral GC and chiral HPLC

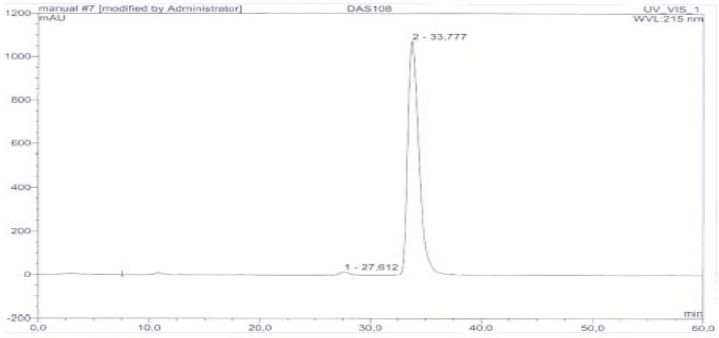
(*R*)-2-Iodo-4,4-dimethyl-2-cyclohexenol
HPLC (Chiralcel OD-H, 0.46 cm x 25 cm, heptane : *i*PrOH = 98:2, 0.3 mL/min): t_R/min = 27.61 (minor), 33.78 (major); 98% *ee*.



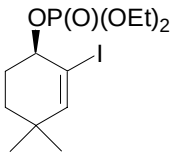
a) racemic



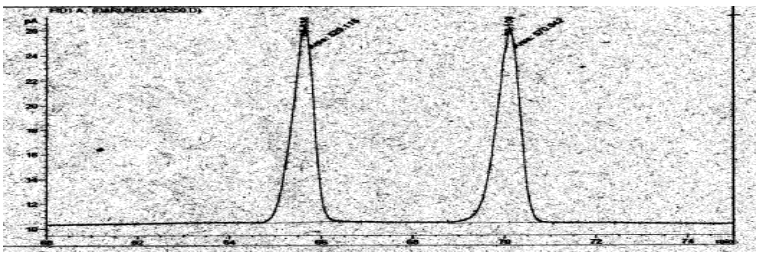
b) chiral



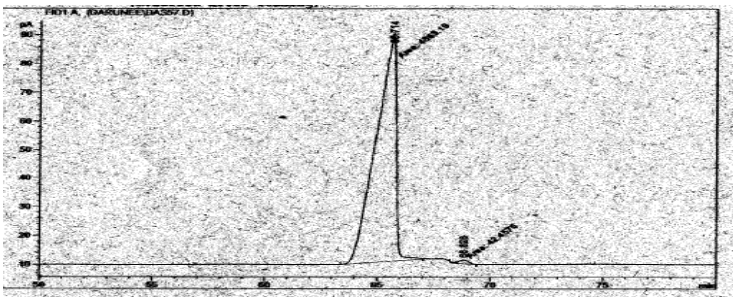
Phosphoric acid diethylester (*R*)-2-iodo-4,4-dimethylcyclohex-2-enyl ester (4).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 65.714 (major), 68.826 (minor); 98% *ee*.



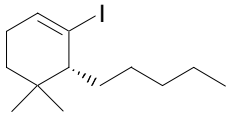
a) racemic



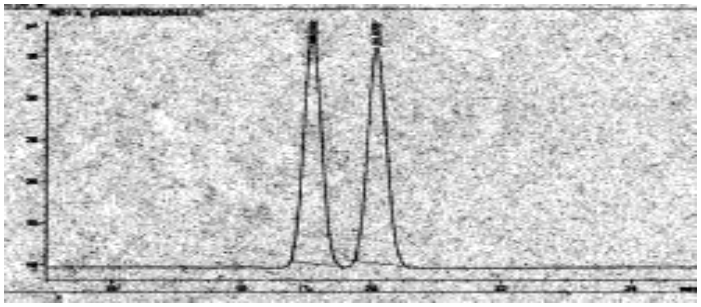
b)chiral



(*R*)-1-Iodo-5,5-dimethyl-6-pentylcyclohexene (5a).
GC (125 ^{o}C; Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 19.079 (minor), 19.965 (major); 97 % *ee*.



a) racemic



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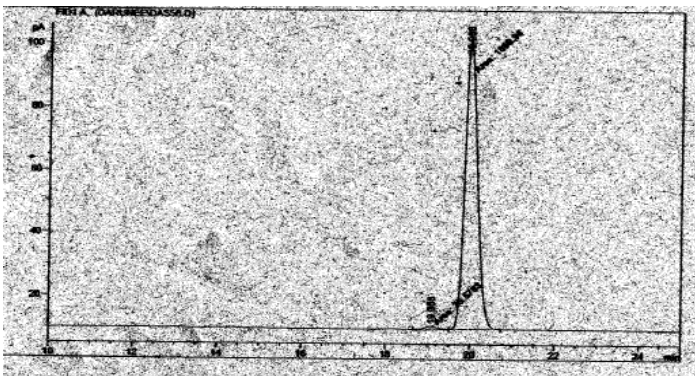
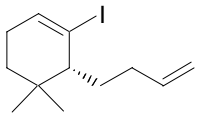


(*R*)-6-But-3-enyl-1-iodo-5,5-dimethylcyclohexene (5b).
GC (125 °C; Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 14.418 (minor), 15.151 (major); 98 % *ee*.



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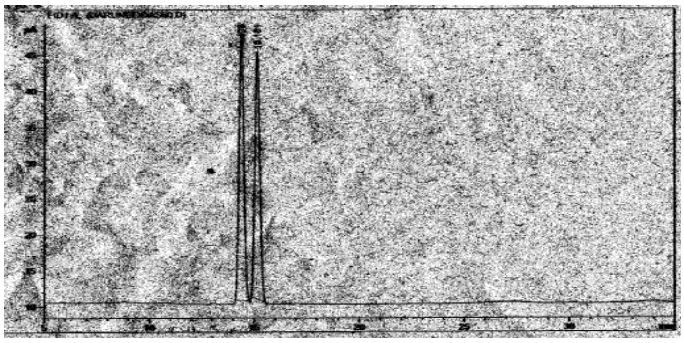
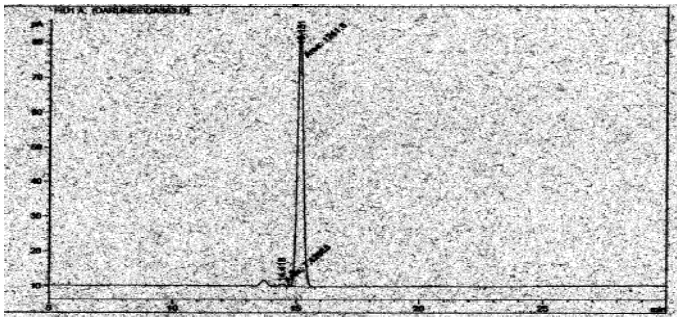
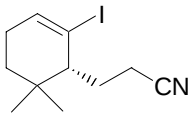


b) chiral



(*R*)-3-(2-Iodo-6,6-dimethylcyclohex-2-enyl)-propionitrile (5c).

GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 34.912 (minor), 35.911 (major); 95 % *ee*.



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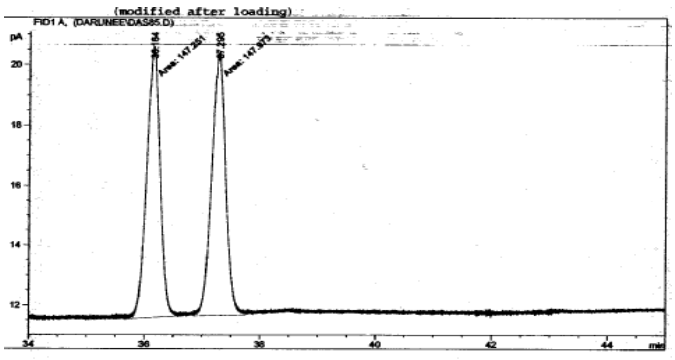
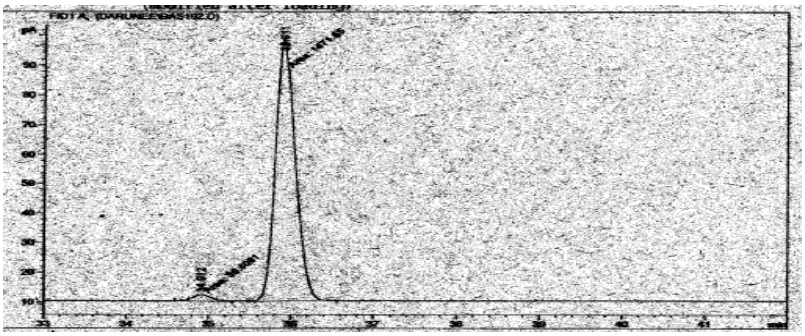
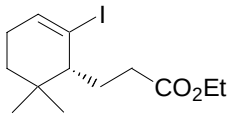


b) chiral



(*R*)-3-(2-Iodo-6,6-dimethylcyclohex-2-enyl)-propionic acid ethyl ester (5d).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 28.641 (minor), 29.421 (major); 97 % *ee*.



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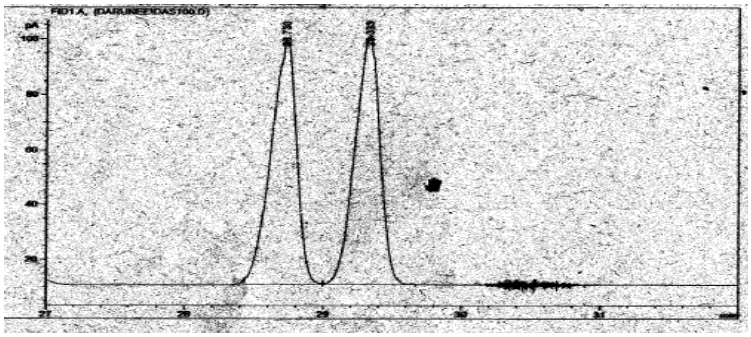

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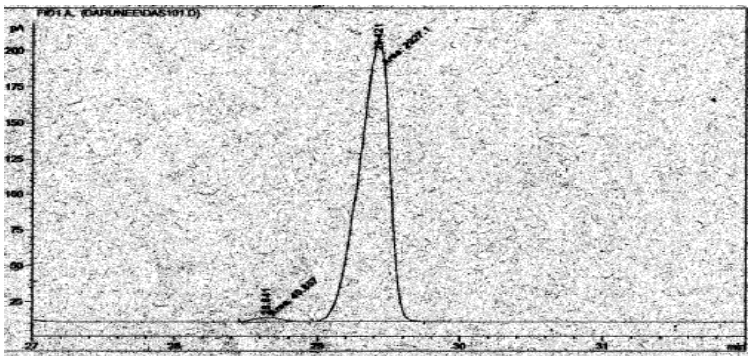
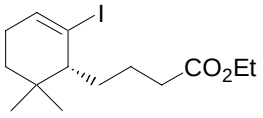
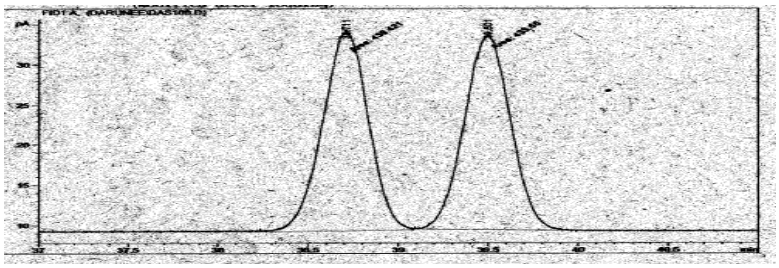


(*R*)-4-(2-Iodo-6,6-dimethylcyclohex-2-enyl)-butyric acid ethyl ester (5e).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 38.837 (minor), 40.045 (major); 98% *ee*.



a) racemic



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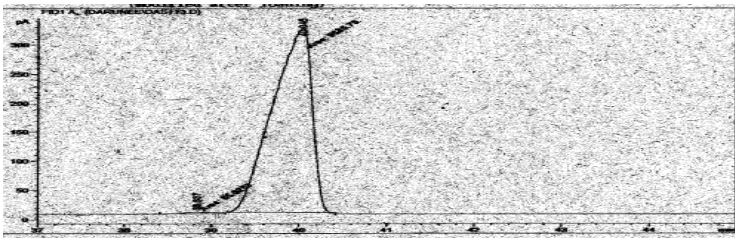
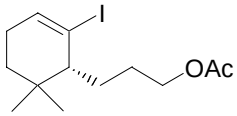


(*R*)-Acetic acid 3-(2-iodo-6,6-dimethylcyclohex-2-enyl)-propyl ester (5f).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 32.538 (minor), 33.254 (major); 97% *ee*.



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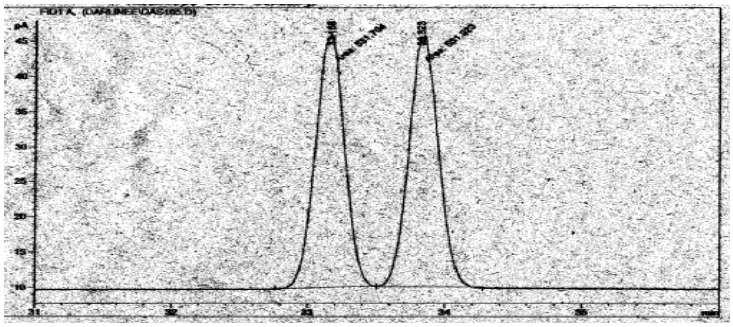
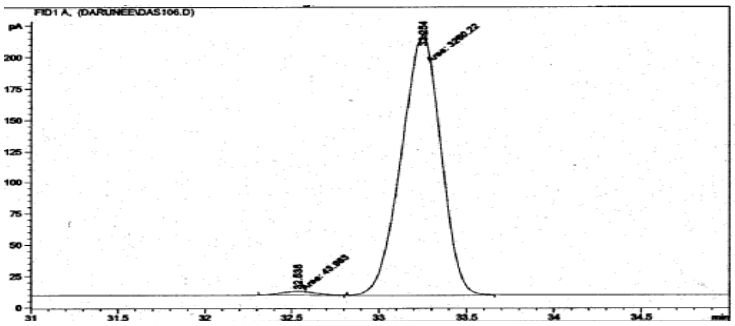
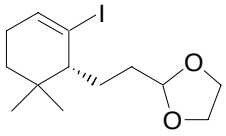


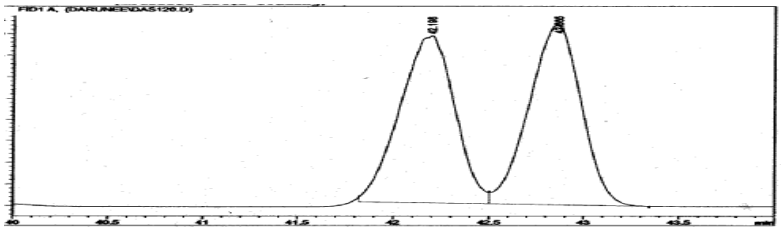
b) chiral



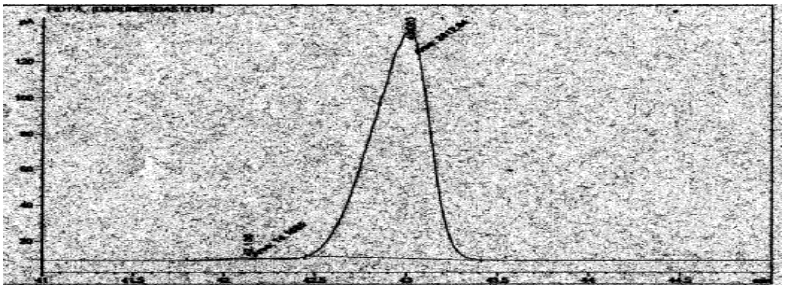
(*R*)-2-[2-(2-Iodo-6,6-dimethylcyclohex-2-enyl)ethyl]-[1,3]dioxolane (5g).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 42.135 (minor), 43.020 (major); 98% *ee*.



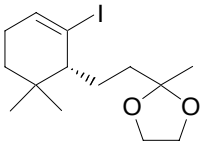
a) racemic



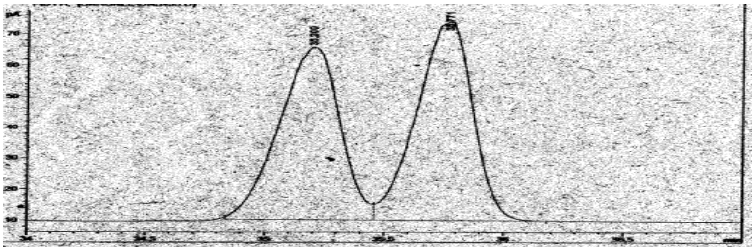
b) chiral



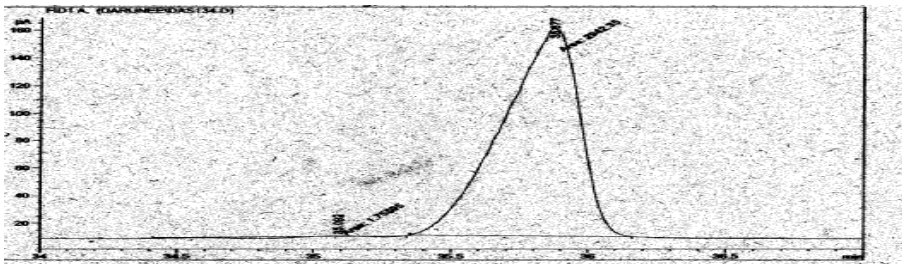
(*R*)-2-[2-(2-Iodo-6,6-dimethylcyclohex-2-enyl)ethyl]-2-methyl-[1,3]dioxolane (5h).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 42.098 (minor), 43.023 (major); 98% *ee*.



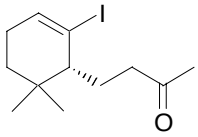
a) racemic



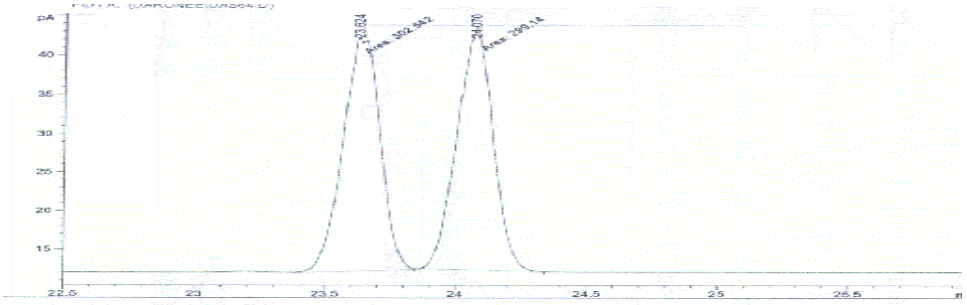
b) chiral



4-[(1*R*)-2-iodo-6,6-dimethyl-2-cyclohexen-1-yl]-2-butanone (7).
GC (40 °C (2 min), ramp of 20 °C/min to 160 °C (90 min); Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 23.303 (minor), 23.736 (major); 98% *ee*.



a) racemic



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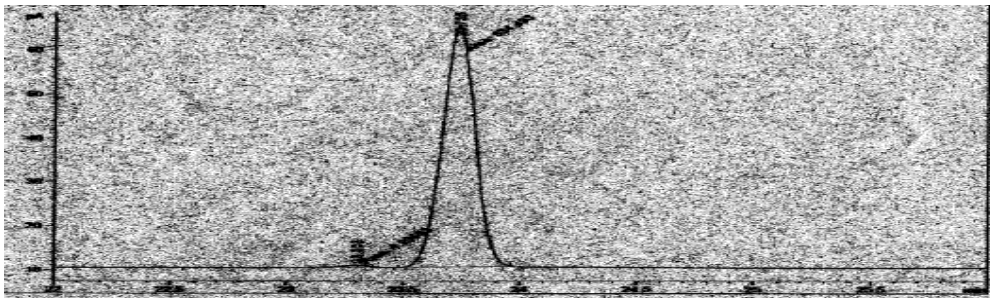
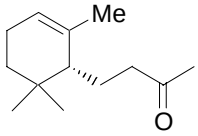
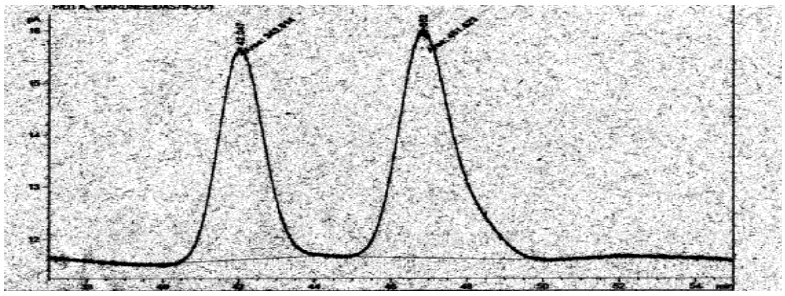


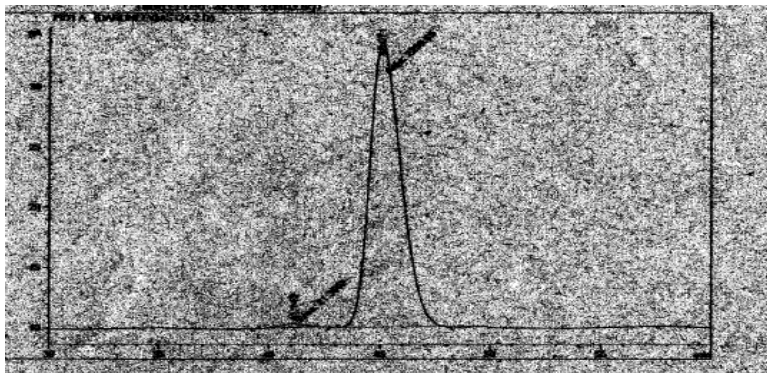
(*R*)-Dihydro-α-ionone (3).
GC (100 °C; Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 41.143 (minor), 45.071 (major); 98% *ee*.



a) racemic

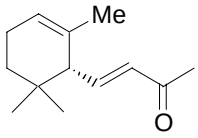


b) chiral

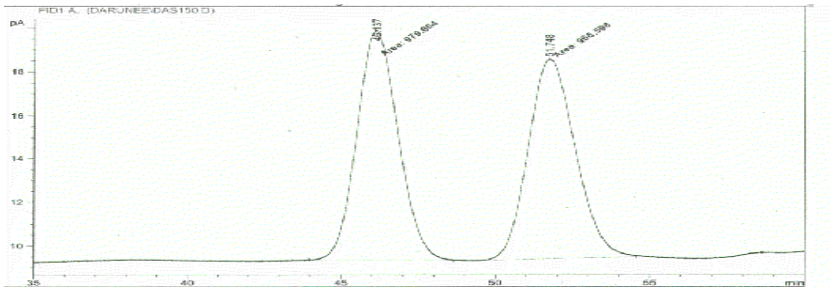


α-Ionone (2).

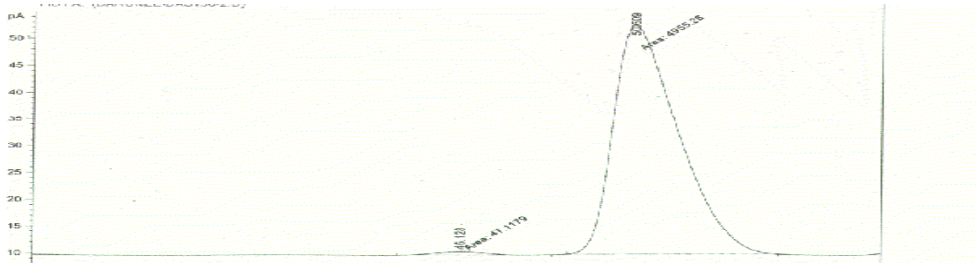
GC (100 °C; Chiraldex B-PH, 30.0 mm x 0.25 mm): t_R/min = 46.128 (minor), 50.609 (major); 98 % *ee*.



a) racemic



b) chiral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