

Supporting Information

Catalysis-Based Enantioselective Total Synthesis of Myxothiazole Z, (14S)-Melithiazole G and (14S)-Cystothiazole F

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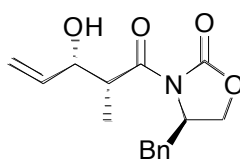
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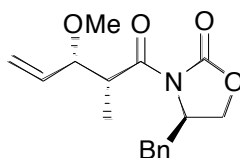
General: The reactions were run under argon atmosphere in oven-dried glassware unless otherwise specified. Dichloromethane was distilled from calcium hydride. THF and Et₂O were distilled from sodium/benzophenone. DMF was distilled under vacuum over MgSO₄, and pyridine was stored over NaOH pellets. Analytical thin layer chromatography (TLC) was performed on silica gel plates (Merck 60F₂₅₄) visualized either with a UV lamp (254 nm) or by using solutions of *p*-anisaldehyde/sulfuric acid/acetic acid in EtOH, phosphomolybdic acid in EtOH or KMnO₄/K₂CO₃/AcOH in water followed by heating. Flash chromatographies were performed on silica gel (60-230 mesh mesh). All the reactions were carried out under N₂ atmosphere. Organic extracts were dried over anhydrous Na₂SO₄. Infrared spectra (IR) were recorded on a Bruker TENSOR™ 27 (IRTF) and wave-numbers are indicated in cm⁻¹. ¹H NMR spectra were recorded on a Bruker AVANCE 400 at 400 MHz in CDCl₃ and data are reported as follows: chemical shift in parts per million from tetramethylsilane as an internal standard, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet or overlap of nonequivalent resonances), integration. ¹³C NMR spectra were recorded at 100 MHz in CDCl₃ (unless otherwise specified) and data were reported as follows: chemical shift in parts per million from tetramethylsilane with the solvent as an internal indicator (CDCl₃ δ 77.0 ppm), multiplicity with respect to proton (deduced from DEPT experiments, s = quaternary C, d = CH, t = CH₂, q = CH₃). Mass spectra (MS) were recorded using a Hewlett-Packard tandem 5890A/5971 GCMS (70 eV). High-Resolution Mass Spectra were performed by "Groupe de Spectrométrie de masse de l'Université Pierre et Marie Curie (Paris)". The enantiomeric excesses were determined by supercritical fluid chromatography (SFC) analysis on chiral phase.

(R)-4-Benzyl-3-[(2R,3S)-3-hydroxy-2-methyl-pent-4-enoyl]-oxazolidin-2-one (6)¹



To a solution of Evans' propionate **5** (4.67 g, 20 mmol) in CH₂Cl₂ (60 mL) were added *n*-Bu₂BOTf (24 mL, 1.0 M in CH₂Cl₂, 24 mmol) and *i*-Pr₂NEt (4.8 mL, 27.6 mmol) dropwise at 0 °C. After 10 min, the mixture was cooled to -78 °C and freshly distilled acrolein (7.0 mL, 105 mmol) was added dropwise over 5 min. The mixture was stirred at -78 °C for 45 min and allowed to warm to 0 °C over 30 min before a pH 7 aqueous buffer solution (30 mL) and MeOH (100 mL) were added. A MeOH/35% H₂O₂ mixture (2/1, 100 mL) was then added slowly over 20 min and the reaction mixture was stirred for a further 20 min at 0 °C before it was concentrated under reduced pressure. The residue was partitioned between Et₂O (200 mL) and H₂O (200 mL) and the aqueous phase was extracted with Et₂O (2 x 200 mL). The combined organic phases were washed with a saturated aqueous NaHCO₃ solution (150 mL) and brine (150 mL). Drying over MgSO₄, evaporation of the solvent and purification of the residue by flash column chromatography (SiO₂; hexane/EtOAc = 7:3) gave **6** (5.39 g, 93%) as a white solid.

(R)-4-Benzyl-3-[(2R,3S)-3-methoxy-2-methyl-pent-4-enoyl]-oxazolidin-2-one^{1b}



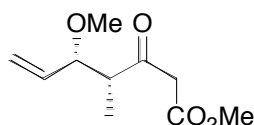
To a solution of alcohol **6** (1.8 g, 6.2 mmol) and 2,6-di-*tert*-butyl pyridine (11.5 g, 60 mmol) in CH₂Cl₂ (30 mL) was added methyl triflate (8.2 g, 50 mmol) dropwise and the reaction mixture was stirred for 40 h at rt. The reaction was quenched with a saturated aqueous NaHCO₃ solution (100 mL), extracted with CH₂Cl₂ (2 x 100 mL) and the combined organic phases were dried over anhydrous MgSO₄. Evaporation of the solvent and purification of the residue by flash column chromatography (SiO₂; hexane to Et₂O/hexane = 1:1) gave the desired product as a colourless viscous oil (1.6 g, 85%).

R_f = 0.28 (Et₂O/hexane = 1:1); [**α**]_D²⁰ -69.0 (*c* 1.0, CHCl₃); **IR** (neat): 2981, 2922, 1773, 1694, 1454, 1379, 1192, 1092, 980, 928, 745, 700 cm⁻¹; **¹H NMR** (CDCl₃, 400 MHz) δ 7.40-7.29 (m,

[1] (a) K. C. Nicolaou, W. E. Brenzovich, P. G. Bulger and T. M. Francis, *Org. Biomol. Chem.* 2006, **4**, 2119; (b) J. Gebauer, S. Arseniyadis and J. Cossy, *Org. Lett.*, 2007, **9**, 3425.

3H), 7.28-7.19 (m, 2H), 5.82 (m, 1H), 5.31-5.27 (m, 2H), 4.66 (m, 1H), 4.19 (quint, $J = 7$ Hz, 2H), 4.11 (m, 1H), 3.77 (t_{app}, $J = 7.0$ Hz, 1H), 3.31 (s, 3H), 3.30 (m, 1H), 2.78 (dd, $J = 9.8, 13.3$ Hz, 1H), 1.29 (d, $J = 7.0$ Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 174.6 (s), 153.2 (s), 136.0 (d), 135.3 (s), 129.5 (d, 2C), 128.9 (d, 2C), 127.3 (d), 119.0 (t), 84.1 (d), 66.0 (t), 56.8 (q), 55.5 (d), 42.3 (d), 37.8 (t), 13.3 (q); MS (EI, 70 eV): m/z (%): 303 (2), 272 (10), 256 (2), 156 (3), 127 (28), 117 (12), 99 (8), 91 (18), 71 (100); HRMS (ESI) m/z : calcd for C₁₇H₂₁NNaO₄ [M + Na]⁺: 326.1363, found: 326.1357.

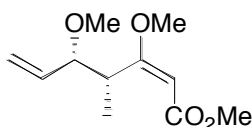
(4*R*,5*S*)-5-Methoxy-4-methyl-3-oxo-hept-6-enoic acid methyl ester (7)^{1b}



To a solution of the oxazolidinone derivative (607 mg, 2 mmol) in THF/H₂O (4/1, 5 mL) at 0 °C was added a 35% aqueous H₂O₂ solution (0.8 mL, 8 mmol) dropwise followed by LiOH·H₂O (168 mg, 4 mmol). After 1 h the mixture was treated with a saturated aqueous Na₂S₂O₅ solution (5 mL), diluted with H₂O (20 mL) and washed with CH₂Cl₂ (3 x 20 mL). The aqueous phase was then acidified with 3M HCl (8 mL) and extracted with EtOAc (4 x 30 mL). Drying of the combined organic phases over MgSO₄ and evaporation of the solvent gave the crude acid which was dissolved in THF (10 mL) and treated with carbonyl diimidazole (357 mg, 2.2 mmol) at 0 °C. After 2 h at rt the mixture was added dropwise to a solution of LiCH₂CO₂Me prepared from AcOMe (444 mg, 6 mmol), *i*-Pr₂NH (610 mg, 6 mmol) and *n*-BuLi (6 mmol, 2M in cyclohexane) at -78 °C and stirring was continued for 2 h at -78 °C. The reaction was quenched with 2N HCl (20 mL) and the aqueous phase was extracted with Et₂O (3 x 20 mL). The combined organic phases were then dried over MgSO₄, evaporated under reduced pressure and the residue was purified by flash column chromatography (SiO₂; Et₂O/hexane = 1:4) to give **7** (300 mg, 75%) as a colourless oil [keto-enol mixture in favor of the keto ester (9/1 ratio)].

R_f = 0.18 (Et₂O/hexane = 1:4); [α]_D²⁰ -41.8 (*c* 1.0, CHCl₃); IR (neat): 2983, 2939, 2825, 1747, 1713, 1629, 1437, 1311, 1238, 1160, 1087, 997, 930, 841, 656 cm⁻¹; ¹H NMR (CDCl₃, 400 MHz, keto-form) δ 5.64 (m, 1H), 5.33-5.24 (m, 2H), 3.77 (m, 1H), 3.75 (s, 3H), 3.61 (d, $J = 15.8$ Hz, 2H), 3.57 (d, $J = 15.8$ Hz, 2H), 3.28 (s, 3H), 2.94 (dq, $J = 5.5, 7.0$ Hz, 1H), 1.12 (d, $J = 7.0$ Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz, keto-form) δ 204.6 (s), 167.8 (s), 134.9 (d), 119.4 (t), 83.8 (d), 56.6 (q), 52.2 (d), 50.8 (q), 49.4 (t), 11.8 (q); MS (EI, 70 eV): m/z (%): 168 (2), 127 (4), 101 (12), 95 (6), 71 (100), 59 (8); HRMS (ESI) m/z : calcd for C₁₀H₁₆NaO₄ [M + Na]⁺: 223.0946, found: 223.0941.

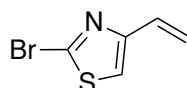
(E)-(4R,5S)-3,5-Dimethoxy-4-methyl-hepta-2,6-dienoic acid methyl ester (8)^{1b}



To a solution of keto ester **7** (200 mg, 1.0 mmol) and trimethyl orthoformate (424 mg, 4.0 mmol) in MeOH (5 mL) was added concentrated sulphuric acid (20 mg, 0.2 mmol) and the mixture was stirred for 48 h at rt. After dilution with Et₂O (80 mL), the organic phase was washed with a saturated aqueous NaHCO₃ solution (10 mL), dried over anhydrous MgSO₄ and concentrated under reduced pressure. Purification of the residue by flash column chromatography (SiO₂; Et₂O/hexane = 1:5) gave **8** (180 mg, 84%) as a colourless oil.

R_f = 0.25 (Et₂O/hexane = 1:5); [α]_D²⁰ +171.0 (*c* 1.0, CHCl₃); **IR** (neat): 2940, 2821, 1710, 1621, 1436, 1382, 1270, 1193, 1138, 1093, 1038, 993, 923, 824, 696 cm⁻¹; **¹H NMR** (C₆D₆, 400 MHz) δ 5.97 (ddd, *J* = 8.0, 10.3, 16.9 Hz, 1H), 5.22-5.13 (m, 2H), 5.11 (s, 1H), 4.79 (dq, *J* = 6.8, 8.5 Hz, 1H), 3.75 (t_{app}, *J* = 8.3 Hz, 1H), 3.58 (s, 3H), 3.27 (s, 3H), 3.03 (s, 3H), 1.53 (d, *J* = 6.8 Hz, 3H); **¹³C NMR** (C₆D₆, 100 MHz) δ 176.5 (s), 167.3 (s), 137.7 (d), 117.2 (t), 91.4 (d), 85.4 (d), 56.2 (q), 54.5 (q), 50.2 (q), 39.7 (d), 14.5 (q); **MS** (EI, 70 eV): *m/z* (%): 199 (2), 182 (14), 169 (8), 155 (7), 123 (12), 111 (3), 71 (100); **HRMS (ESI)** *m/z*: calcd for C₁₁H₁₈NaO₄ [M + Na]⁺: 237.1103, found: 237.1097.

2-Bromo-4-vinyl-thiazole (9)²



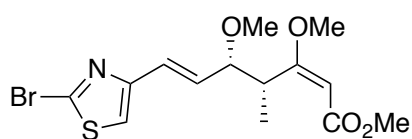
To a solution of 2-bromo-4-formylthiazole (472 mg, 2 mmol) in THF/CH₂Cl₂ (1:1, 30 mL) was added DIBAL-H (6 mL 1 M solution in CH₂Cl₂, 6 mmol) dropwise to maintain the temperature under -70 °C. After 5 h at -78 °C the reaction was quenched by addition of MeOH (5 mL) at the same temperature and the mixture was poured into cold 1 M HCl (20 mL). The aqueous phase was extracted with Et₂O (3 x 20 mL) and the combined organic phases were dried over MgSO₄. Evaporation of the solvent gave the crude aldehyde (330 mg), which was dissolved in THF (5 mL) and added dropwise to a cooled (0 °C) solution of methylenetriphenylphosphorane [prepared from Ph₃PCH₃Br (1.23 g, 3.4 mmol) and *t*-BuOK (390 mg, 3.4 mmol) at 0 °C in THF (10 mL)]. After 1 h at 0 °C, the reaction was quenched with a saturated aqueous NH₄Cl (20 mL) solution and the

[2] J. Gebauer, S. Arseniyadis and J. Cossy, *Eur. J. Org. Chem.*, 2008, **16**, 2701.

aqueous phase was extracted with Et₂O (3 x 20 mL). The combined organic phases were dried over anhydrous MgSO₄, evaporated under reduced pressure and the residue was purified by flash column chromatography (SiO₂; pentane to 5% Et₂O in pentane) gave **9** (200 mg, 53%) as a yellow oil.

IR (neat): 3100, 1629, 1489, 1435, 1396, 1309, 1005, 981, 917, 843, 763 cm⁻¹; **¹H NMR** (CDCl₃, 400 MHz) δ 6.96 (s, 1H), 6.56 (dd, *J* = 10.8, 17.5 Hz, 1H), 6.00 (dd, *J* = 1.2, 17.5 Hz, 1H), 5.32 (dd, *J* = 1.2, 10.8 Hz, 1H); **¹³C NMR** (CDCl₃, 100 MHz) δ 154.6 (s), 136.1 (s), 128.6 (d), 118.4 (d), 117.8 (t); **HRMS (ESI)** *m/z*: calcd for C₅H₅BrNS [M + H]⁺: 191.9299, found: 191.9297.

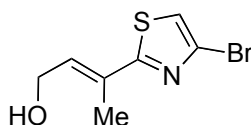
7-(2-Bromo-thiazol-4-yl)-3,5-dimethoxy-4-methyl-hepta-2,6-dienoic-acidmethylester (**10**)²



A solution of **9** (23 mg, 0.12 mmol) in CH₂Cl₂ (0.5 mL) was added in 5 portions (5 x 0.1 mL) to a solution of **8** (25 mg, 0.12 mmol) and **GII** (17 mg, 20%) in CH₂Cl₂ (0.6 mL) and the mixture was subjected to microwave irradiation for 1 h after each addition (400 W, 100 °C with cooling). Another portion of **GII** (9 mg, 10%) was then added and the mixture was irradiated for a further 30 min before the solvent was evaporated. Purification of the residue by flash column chromatography (SiO₂; Et₂O/hexane = 1:3) gave **10** (25 mg, 55%) as a colourless viscous oil.

[α]_D²⁰ +120.3 (*c* 0.8, CHCl₃); **IR** (neat): 2924, 1709, 1623, 1436, 1382, 1147, 1094, 1011 cm⁻¹; **¹H NMR** (CDCl₃, 400 MHz) δ 6.92 (s, 1H), 6.40 (d, *J* = 16.0 Hz, 1H), 6.31 (dd, *J* = 7.0, 16 Hz, 1H), 4.89 (s, 1H), 4.06 (dq, *J* = 7.0, 7.5 Hz, 1H), 3.73 (t_{app}, *J* = 7.5 Hz, 1H), 3.59 (s, 3H), 3.53 (s, 3H), 3.24 (s, 3H), 1.12 (d, *J* = 7.0 Hz, 3H). **¹³C NMR** (CDCl₃, 100 MHz) δ 176.5 (s), 167.6 (s), 154.0 (s), 135.7 (s), 132.9 (d), 124.0 (d), 117.7 (d), 91.1 (d), 84.0 (d), 57.1 (q), 55.5 (q), 50.8 (q), 39.9 (d), 14.1 (q); **HRMS (ESI)** *m/z*: calcd for C₁₄H₁₈BrNO₄NaS [M + Na]⁺: 398.0032, found: 398.0033.

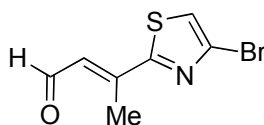
(*E*)-3-(4-Bromo-thiazol-2-yl)-but-2-en-1-ol.



2,4-dibromothiazole³ (972 mg, 4.0 mmol), (*E*)-3-tributylstannanyl-but-2-en-1-ol⁴ (1.60 g, 0.42 mmol), CuI (76 mg, 0.4 mmol) and PdCl₂(PPh₃)₂ (140 mg, 0.2 mmol) were heated in degassed DMF (20 mL, 0.2 M) at 90 °C for 20 h. After completion, the contents were cooled to rt and a saturated KF solution (25 mL) was added and stirred for 1 h. The reaction mixture was then extracted with EtOAc (3 x 50 mL), washed with brine, dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 99:1 to 9:1) to provide coupled product (*E*)-3-(4-bromo-thiazol-2-yl)-but-2-en-1-ol in 74% yield (690 mg) as an orangish amorphous solid.

R_f = 0.31 (*n*-pentane/EtOAc = 4:1); **IR** (neat): 3359, 3119, 1609, 1463, 1261, 1077, 1018, 883, 830, 799, 739 cm⁻¹; **¹H NMR** (400 MHz, CDCl₃) δ 7.26 (s, 1H), 6.58 (t, *J* = 6.5 Hz, 1H), 4.42 (dt, *J* = 6.5, 0.8 Hz, 2H), 2.15 (t, *J* = 1.3 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃) δ 171.1 (s), 131.5 (d), 130.9 (s), 125.2 (s), 116.0 (d), 59.4 (t), 14.8 (q); **MS** (EI, 70 eV): *m/z* (relative intensity) 233 ((Br⁸¹) M⁺, 20), 231 ((Br⁷⁹) M⁺, 20), 205 ((Br⁸¹) M-CHO⁺, 100), 203 ((Br⁷⁹) M-CHO⁺, 100), 190 ((Br⁸¹), 20), 188 ((Br⁷⁹), 20), 179 ((Br⁸¹), 15), 177 ((Br⁸¹), 15), 138 ((Br⁸¹), 30), 136 ((Br⁸¹), 30), 124 (80), 108 (18), 97 (20), 57 (35); **HRMS (ESI)** *m/z* calcd for C₇H₈BrNOS [M + Na]⁺: (Br⁸¹) 255.9225, (Br⁷⁹) 253.9246, found: (Br⁸¹) 255.9223, (Br⁷⁹) 253.9245.

(*E*)-3-(4-Bromo-thiazol-2-yl)-but-2-enal (13)⁵



To a solution of (*E*)-3-(4-bromo-thiazol-2-yl)-but-2-en-1-ol (1.20 g, 5.15 mmol) in CH₂Cl₂ (25 mL, 0.2 M) was added Dess-Martin periodinane (3.0 g, 7.21 mmol). After 45 min the reaction mixture was poured into a saturated NaHCO₃ solution (50 mL) and the layers were separated. The aqueous phase was extracted with CH₂Cl₂ (2 x 50 mL) and the combined organic fractions were washed with brine, dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified

[3] Commercially available from the Synthonix Corporation.

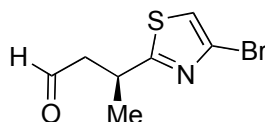
[4] J. F. Betzer, F. Delalogue, B. Muller, A. Pancrazi, J. Prunet, *J. Org. Chem.* **1997**, 62, 7768.

[5] T. J. Hoffman, J. Dash, J. H. Rigby, S. Arseniyadis and J. Cossy, *Org. Lett.*, 2009, **11**, 2756.

by flash column chromatography (8/2; *n*-pentane/EtOAc) to provide (*E*)-3-(4-bromo-thiazol-2-yl)-but-2-enal **1** in 90% yield (1.09 g) as a bright yellow solid (mp 123-124 °C).

R_f = 0.45 (*n*-pentane/EtOAc = 85:15); **IR** (neat): 3088, 2957, 1660, 1388, 1263 cm^{-1} ; **^1H NMR** (400 MHz, CDCl_3) δ 10.21 (d, J = 7.3 Hz, 1H), 7.36 (s, 1H), 6.76 (dq, J = 1.2, 7.3 Hz, 1H), 2.65 (d, J = 1.2 Hz, 3H); **^{13}C NMR** (100 MHz, CDCl_3) δ 191.8 (d), 169.0 (s), 147.8 (s), 128.2 (d), 127.7 (s), 120.0 (d), 15.3 (q); **MS** (EI, 70 eV): m/z (relative intensity) 233 ((Br^{81}) M^+ , 16), 231 ((Br^{79}) M^+ , 16), 205 ((Br^{81}) M-CHO^+ , 100), 203 ((Br^{79}) M-CHO^+ , 100), 190 ((Br^{81}), 20), 188 ((Br^{79}), 20), 179 ((Br^{81}), 15), 177 ((Br^{81}), 15), 138 ((Br^{81}), 30), 136 ((Br^{81}), 30), 124 (80), 108 (18), 97 (20), 57 (35); **HRMS (ESI)** m/z : calcd for $\text{C}_7\text{H}_6\text{BrNNaOS}$ [$\text{M} + \text{Na}$] $^+$: (Br^{81}) 255.9225, (Br^{79}) 253.9246, found: (Br^{81}) 255.9223, (Br^{79}) 253.9245.

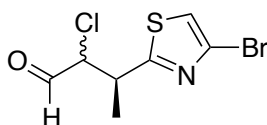
(*S*)-3-(4-Bromo-thiazol-2-yl)-butyraldehyde (**14**)



To a solution of (*E*)-3-(4-bromo-thiazol-2-yl)-but-2-enal **13** (250 mg, 1.1 mmol) in toluene (5.0 mL, 0.2 M) at -35 °C were added **II**·TFA (78 mg, 0.22 mmol) and Hantzsch ester **I** (400 mg, 1.30 mmol). Upon completion (reaction monitored by TLC; toluene/EtOAc = 7:3) the crude reaction mixture was diluted with pre-cooled Et_2O (5.0 mL), filtered through a small plug of silica and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 97:3) to afford (*S*)-3-(4-bromo-thiazol-2-yl)-butyraldehyde **14** in 84% yield (210 mg) as yellow oil.

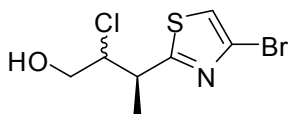
R_f = 0.40 (*n*-pentane/EtOAc = 85:15); $[\alpha]_D^{20}$ -9.5 (c 0.48, CHCl_3); **IR** (neat): 3120, 2969, 2829, 2727, 1723, 1478, 1456, 1383, 1375, 1310, 1253, 1095, 1077, 1060, 886, 831, 734 cm^{-1} ; **^1H NMR** (400 MHz, CDCl_3) δ 9.80 (s, 1H), 7.10 (s, 1H), 3.74 (hex_{app}, J = 7.0 Hz, 1H), 3.13 (ddd, J = 1.0, 6.5, 17.8 Hz, 1H), 2.77 (ddd, J = 1.3, 7.0, 17.8 Hz, 1H), 1.43 (d, J = 7.0 Hz, 3H); **^{13}C NMR** (100 MHz, CDCl_3) δ 199.8 (d), 175.6 (s), 124.3 (s), 116.0 (d), 49.9 (t), 32.6 (d), 21.0 (q); **MS** (EI, 70 eV): m/z (relative intensity) 235 ((Br^{81}) M^+ , 11), 233 ((Br^{79}) M^+ , 11), 206 ((Br^{81}) M-CHO^+ , 88), 204 ((Br^{79}) M-CHO^+ , 86), 192 ((Br^{81}), 100), 190 ((Br^{79}), 100), 178 ((Br^{81}), 7), 176 ((Br^{79}), 7), 166 ((Br^{81}), 7), 164 ((Br^{79}), 7), 139 ((Br^{81}), 13), 137 ((Br^{79}), 13), 138 ((Br^{81}), 13), 136 ((Br^{79}), 13), 57 (20); **HRMS (ESI)** m/z : calcd for $\text{C}_7\text{H}_8\text{BrNNaOS}$ [$\text{M} + \text{Na}$] $^+$: (Br^{81}) 257.9381, (Br^{79}) 255.9402, found: (Br^{81}) 257.9378, (Br^{79}) 255.9401.

(*R*)-3-(4-Bromothiazol-2-yl)-2-chlorobutan-1-al



To a solution of (*S*)-3-(4-bromothiazol-2-yl)-butyraldehyde (**14**) (50 mg, 0.217 mmol) in CH₂Cl₂ (1.0 mL) at 0 °C was added (*L*)-proline (2.5 mg, 0.022 mmol, 0.1 equiv) followed by *N*-chlorosuccimide (30 mg, 0.23 mmol, 1.05 equiv). The reaction mixture was warmed to rt and stirring was continued until complete conversion of the starting aldehyde (reaction monitored by GC/MS). After 3 h, the solution was diluted with *n*-pentane and filtered over Celite[®]. The crude residue was then concentrated under reduced pressure and passed over a small plug of silica gel (CH₂Cl₂) to afford (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutyraldehyde (**15**), which was used in the next step without further purification (85%, *dr* = 2:1). If one would want to stop at this stage, we recommend reducing the aldehyde to the corresponding chloro hydrine.

(*R*)-3-(4-Bromothiazol-2-yl)-2-chlorobutan-1-ol (Mixture of isomers)

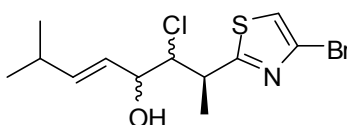


To a solution of (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutyraldehyde (10 mg, 0.037 mmol) in MeOH (0.5 mL) was added NaBH₄ (5 mg, 0.15 mmol, 4.0 equiv) and stirring was continued for 15 min. The reaction was then diluted with EtOAc (10 mL) and H₂O (5 mL). The layers were separated and the aqueous layer was extracted with EtOAc (10 mL). The combined organic fractions were finally dried over MgSO₄ and concentrated under reduced pressure to afford (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutan-1-ol (10 mg, 99% yield) as an orange oil as a mixture of isomers.

R_f = 0.24 (*n*-pentane/EtOAc = 4:1); **IR** (neat): 3360, 3122, 2974, 2934, 2879, 1776, 1475, 1454, 1254, 1080, 1032, 889, 735 cm⁻¹; **¹H NMR** (400 MHz, CDCl₃, *major isomer*) δ 7.17 (s, 1H), 4.37 (m, 1H), 3.92-3.62 (m, 3H), 2.64 (brs, 1H), 1.54 (d, *J* = 7.0 Hz, 3H); **¹H NMR** (400 MHz, CDCl₃, *minor isomer*) δ 7.20 (s, 1H), 4.30 (m, 1H), 3.92-3.62 (m, 3H), 2.64 (brs, 1H), 1.54 (d, *J* = 7.1 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃, *major isomer*) δ 173.4 (s), 124.8 (s), 116.7 (d), 67.0 (d), 65.0 (t), 41.1 (d), 16.7 (q); **¹³C NMR** (100 MHz, CDCl₃, *minor isomer*) δ 172.3 (s), 124.4 (s), 117.1 (d), 65.5 (d), 64.4 (t), 40.4 (d), 18.0 (q); **MS** (EI, 70 eV, *major isomer*) *m/z* (relative intensity) 271 (6), 269 (5), 236 (78), 234 (74), 218 (43), 216 (42), 206 (57), 204 (59), 192 (100), 190 (99), 139 (30), 138 (21), 137 (34), 136 (22), 123 (17), 111 (16), 83 (17), 71 (24), 58 (34), 57 (85), 53 (21); **MS** (EI,

70 eV, *minor isomer*): m/z (relative intensity) 271 (6), 269 (5), 236 (71), 234 (69), 218 (22), 216 (22), 206 (71), 204 (73), 192 (100), 190 (98), 139 (28), 138 (20), 137 (32), 136 (21), 123 (16), 111 (15), 83 (16), 71 (23), 58 (32), 57 (80), 53 (20); **HRMS (ESI)** m/z calcd for $C_7H_9BrNNaOS$ $[M + Na]^+$: (Br^{81}) 293.9149, (Br^{79}) 291.9169, found: (Br^{81}) 293.9154, (Br^{79}) 291.9179.

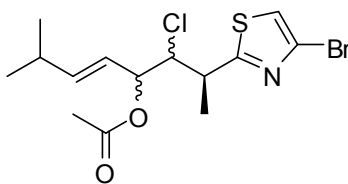
(*R,E*)-2-(4-Bromothiazol-2-yl)-3-chloro-7-methyloct-5-en-4-ol (Mixture of isomers)



To a solution of (*E*)-1-iodo-3-methylbut-1-ene (73 mg, 0.37 mmol, 2.0 equiv) and a crystal of 1,10-phenanthroline in THF (1.0 mL) at 0 °C was added MeLi (1.6 M solution in Et₂O) until a permanent color change was observed. The reaction mixture was then cooled to −78 °C and a freshly titrated 2.47 M solution of *n*-BuLi in hexanes (0.15 mL, 0.36 mmol, 1.95 equiv) was added dropwise. Stirring was continued for 30 min before the reaction mixture was added on to a solution of (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutyraldehyde (**15**) (49 mg, 0.18 mmol) in THF (1 mL) *via* cannula. After 10 min, MeOH (2 mL) was added slowly, the contents were brought to rt and diluted with CH₂Cl₂ (5 mL) and a saturated aqueous NH₄Cl solution (5 mL). The layers were separated and the aqueous layer was extracted with CH₂Cl₂ (2 x 10 mL). The combined organic fractions were dried over anhydrous MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (9/1; *n*-pentane/EtOAc) to afford (*E*)-(*R*)-2-(2-bromothiazol-4-yl)-3-chloro-7-methyloct-5-en-4-ol (46 mg, 73% yield, *dr* = 3:2) as a colorless oil.

R_f = 0.27 and 0.35 (*n*-pentane/EtOAc = 9:1); **IR** (neat): 3374, 3123, 2959, 2926, 2869, 1719, 1667, 1475, 1382, 1254, 1079, 1055, 972, 833, 731 cm^{−1}; **¹H NMR** (400 MHz, CDCl₃, *mixture of isomers*) δ 7.36–6.97 (2m, 1H), 5.74 (m, 1H), 5.51 (m, 1H), 4.43–3.60 (m, 3H), 2.31 (m, 1H), 1.57–1.49 (m, 3H), 1.01–0.96 (m, 6H); **¹³C NMR** (100 MHz, CDCl₃, *major isomers*) δ 174.3 (s), 172.6 (s), 143.1 (d), 141.9 (d), 125.0 (d), 124.8 (d), 124.7 (s), 124.2 (s), 117.3 (d), 116.4 (d), 73.9 (d), 73.7 (d), 69.3 (d), 69.1 (d), 40.4 (d), 39.7 (d), 31.0 (d), 30.9 (d), 22.2 (q, 2C), 22.2 (q, 2C), 18.4 (q), 15.9 (q); **¹³C NMR** (100 MHz, CDCl₃, *minor isomers*) δ 173.9 (s), 173.2 (s), 142.3 (d), 142.1 (d), 125.7 (d), 125.5 (d), 124.7 (s), 124.4 (s), 117.1 (d), 116.6 (d), 75.0 (d), 72.7 (d), 71.4 (d), 71.1 (d), 42.6 (d), 41.6 (d), 30.9 (d), 30.7 (d), 22.3 (q, 2C), 22.1 (q, 2C), 19.4 (q), 16.2 (q); **MS** (EI, 70 eV, *major isomer*): m/z (relative intensity) 304 (26), 302 (28), 206 (100), 204 (94), 192 (15), 190 (15), 139 (6), 137 (6), 123 (7), 99 (13), 97 (7), 95 (13), 81 (22), 79 (9), 77 (7), 71 (7), 69 (12), 57 (24), 55 (22), 53 (13); **HRMS (ESI)** m/z calcd for $C_{12}H_{17}BrClNNaOS$ $[M + Na]^+$: (Br^{81}) 361.9775, (Br^{79}) 359.9795, found: (Br^{81}) 361.9763, (Br^{79}) 359.9793.

Acetic acid (*E*)-1-[(*R*)-2-(2-bromothiazol-4-yl)-1-chloropropyl]-4-methylpent-2-enyl ester (17**)**

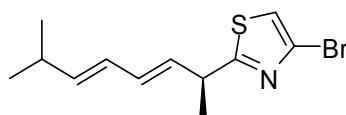


To a solution of (*E*)-(*R*)-2-(2-bromothiazol-4-yl)-3-chloro-7-methyloct-5-en-4-ol (44 mg, 0.13 mmol) in CH₂Cl₂ (2 mL) at 0 °C were added acetic anhydride (16 μL, 0.170 mmol, 1.3 equiv), NMM (22 μL, 0.195 mmol, 1.5 equiv) and DMAP (2.0 mg, 0.013 mmol, 0.1 equiv). The reaction contents were allowed to warm to rt and, after 2 h, were diluted with H₂O (5 mL) and CH₂Cl₂ (5 mL). The layers were separated and the aqueous layer was extracted with CH₂Cl₂ (2 x 10 mL). The combined organic fractions were dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 95:5) to afford acetic acid (*E*)-1-[(*R*)-2-(2-bromothiazol-4-yl)-1-chloropropyl]-4-methylpent-2-enyl ester (**17**) (46.5 mg, 94% yield) as a colorless oil.

R_f = 0.6 (PE/EtOAc = 9:1); **IR** (neat): 3121, 2961, 2870, 1740, 1475, 1370, 1227, 1019, 973, 832 cm⁻¹; **¹H NMR** (400 MHz, CDCl₃, *mixture of isomers*) δ 7.15 (m, 1H), 5.79 (m, 1H), 5.52-5.28 (m, 2H), 4.51-4.25 (3m, 1H), 3.65 (m, 1H), 2.29 (m, 1H), 2.11-2.00 (m, 3H), 1.50-1.44 (m, 3H), 1.02-0.94 (m, 6H); **¹³C NMR** (100 MHz, CDCl₃, *major isomers*) δ 173.7 (s), 172.3 (s), 169.6 (s), 169.6 (s), 145.7 (d), 145.4 (d), 124.8 (s), 124.4 (s), 121.1 (d), 120.4 (d), 116.8 (d), 116.6 (d), 74.7 (d), 74.7 (d), 66.5 (d), 66.2 (d), 42.3 (d), 40.4 (d), 31.0 (d, 2C), 22.0 (q), 22.0 (q, 2C), 21.9 (q), 21.3 (q, 2C), 19.3 (q), 15.5 (q); **¹³C NMR** (100 MHz, CDCl₃, *minor isomers*) δ 173.6 (s), 172.5 (s), 169.8 (s), 169.8 (s), 145.4 (d), 144.7 (d), 124.6 (s), 124.5 (s), 121.5 (d), 121.4 (d), 116.7 (d), 116.7 (d), 75.9 (d), 74.6 (d), 67.1 (d), 67.0 (d), 42.5 (d), 40.8 (d), 30.9 (d, 2C), 21.9 (q, 2C), 21.8 (q, 2C), 21.2 (q), 21.2 (q), 19.5 (q), 14.9 (q); **MS** (EI, 70 eV, *mixture of isomers*): *m/z* (relative intensity). 346 (66), 344 (66), 322 (27), 320 (19), 304 (15), 302 (23), 300 (16), 286 (62), 284 (58), 270 (10), 268 (10), 230 (19), 228 (15), 206 (98), 204 (100), 193 (39), 192 (38), 191 (39), 190 (38), 129 (28), 99 (87), 95 (32), 93 (38), 91 (21), 81 (53), 77 (28), 67 (18), 57 (32), 55 (29), 53 (21); **HRMS (ESI)** *m/z* calcd for C₉H₁₁BrNNaO₂S [M + Na]⁺: (Br⁸¹) 403.9880, (Br⁷⁹) 401.9901, found: (Br⁸¹) 403.9871, (Br⁷⁹) 401.9898.

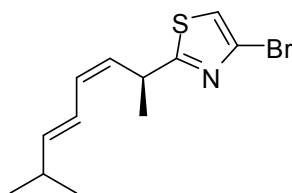
General method for the synthesis of (*E,E*)-18 and (*E,Z*)-18: To a solution of acetic acid (*E*)-1-[(*R*)-2-(2-bromo-thiazol-4-yl)-1-chloro-propyl]-4-methyl-pent-2-enyl ester (**17**) (43 mg, 0.113 mmol) in THF (0.9 mL) was added a SmI₂ solution (0.1 M solution in THF, 4.5 mL, 4 equiv), and the contents were refluxed in a sealed tube until complete conversion. After 4 h, the reaction mixture was allowed to cool to rt, the contents were diluted in Et₂O, added to a saturated aqueous Na₂S₂O₃ solution (20 mL) and stirred for 5 min. The layers were then separated and the aqueous phase was extracted with Et₂O (3 x 20 mL). The combined organic phases were washed with brine, dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified by preparative TLC (*n*-pentane/CH₂Cl₂ = 75:25) to afford (*E,E*)-**18** (11.9 mg) and (*E,Z*)-**18** (11.2 mg) in 42% and 39% yield respectively.

4-Bromo-2-[(*S,3E,5E*)-7-methylocta-3,5-dien-2-yl]thiazole [(*E,E*)-18 and (*E,Z*)-18]



R_f = 0.55 (*n*-pentane/CH₂Cl₂ = 75:25); $[\alpha]_D^{20}$ +27.1 (*c* 1.19, CHCl₃); **IR** (neat): 3123, 3120, 2961, 2928, 2868, 1733, 1656, 1476, 1251, 1079, 989, 830, 729 cm⁻¹; **¹H NMR** (400 MHz, C₆D₆) δ 6.40 (s, 1H), 5.98 (ddd, *J* = 0.8, 10.3, 14.8 Hz, 1H), 5.89 (ddd, *J* = 1.1, 10.3, 14.8 Hz, 1H), 5.54 (dd, *J* = 7.9, 14.8 Hz, 1H), 5.49 (dd, *J* = 6.7, 14.8 Hz, 1H), 3.53 (m, 1H), 2.16 (m, 1H), 1.31 (d, *J* = 7.0 Hz, 3H), 0.91 (d, *J* = 6.8 Hz, 6H); **¹³C NMR** (100 MHz, C₆D₆) δ 176.0 (s), 142.1 (d), 132.5 (d), 132.5 (d), 127.2 (d), 125.2 (s), 116.3 (d), 41.7 (d), 31.4 (d), 22.4 (q, 2C), 20.5 (q); **MS** (EI, 70 eV): *m/z* (relative intensity) 287 ((Br⁸¹), 8), 285 ((Br⁷⁹), 8), 244 ((Br⁸¹), 12), 242 ((Br⁷⁹), 12), 230 (26), 228 (20) 216 (13), 193 (17), 191 (17), 107 (13), 95 (100), 93 (16), 91 (19), 82 (21), 79 (19), 77 (22), 69 (14), 67 (28), 65 (11), 57 (12), 55 (16), 53 (13); **HRMS** (ESI) calcd for C₁₂H₁₇BrNS [M + H]⁺: (Br⁸¹) 288.0239, (Br⁷⁹) 286.0260, found: (Br⁸¹) 288.0240, (Br⁷⁹) 286.0262.

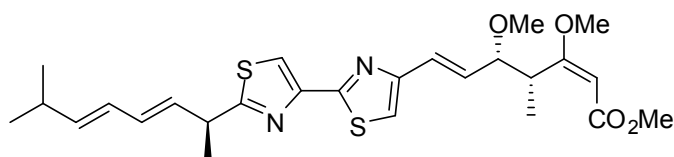
4-Bromo-2-[(*S,3Z,5E*)-7-methylocta-3,5-dien-2-yl]thiazole [(*E,Z*)-18]



R_f = 0.73 (*n*-pentane/CH₂Cl₂ = 75:25); $[\alpha]_D^{20}$ +133.1 (*c* 1.1, CHCl₃); **IR** (neat): 3123, 2961, 2928, 2869, 1732, 1651, 1476, 1252, 1081, 983, 947, 831, 729 cm⁻¹; **¹H NMR** (400 MHz, C₆D₆) δ 6.39 (s, 1H), 6.24 (ddt, *J* = 1.1, 11.0, 15.0 Hz, 1H), 5.99 (t_{app}, *J* = 10.8 Hz, 1H), 5.56 (dd, *J* = 7.2, 15.0 Hz,

1H), 5.28 (t, $J = 10.1$ Hz, 1H), 4.08 (m, 1H), 2.17 (m, 1H), 1.33 (d, $J = 6.9$ Hz, 3H), 0.91 (d, $J = 6.7$ Hz, 6H); ^{13}C NMR (100 MHz, C_6D_6) δ 175.9 (s), 144.7 (d), 131.2 (d), 130.4 (d), 125.1 (s), 122.3 (d), 116.3 (d), 37.2 (d), 31.7 (d), 22.4 (q, 2C), 21.1 (q); MS (EI, 70 eV): m/z (relative intensity) 287 ((Br 81), 3), 285 ((Br 79), 3), 244 ((Br 81), 17), 242 ((Br 79), 17), 230 (35), 228 (30) 216 (17), 214 (12), 193 (11), 191 (12), 109 (12), 107 (16), 95 (100), 91 (21), 82 (17), 79 (20), 77 (23), 67 (31), 65 (12), 57 (12), 55 (18), 53 (14); HRMS (ESI) m/z calcd for $\text{C}_{12}\text{H}_{17}\text{BrNS}$ $[\text{M} + \text{H}]^+$: (Br 81) 288.0239, (Br 79) 286.0260, found: (Br 81) 288.0240, (Br 79) 286.0262.

Myxothiazole Z (2)



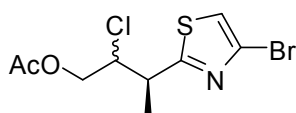
To a solution of 4-bromo-2-[(*S*,3*E*,5*E*)-7-methylocta-3,5-dien-2-yl]thiazole (*E,E*)-**18** (11.9 mg, 0.0416 mmol, 1 equiv) in degassed toluene (0.8 mL) were added hexamethylditin (86 μL , 0.416 mmol, 10 equiv) and $\text{Pd}(\text{PPh}_3)_4$ (5 mg, 0.00416 mmol, 0.1 equiv). The contents were then heated at 110 $^\circ\text{C}$ in a sealed tube until complete conversion. After 4 h, the contents were cooled to rt and concentrated under reduced pressure. The crude residue was filtered through a short plug of silica gel (pre-treated with Et_3N) eluting with hexane to remove the excess of hexamethylditin and provide 2-[(*S*,3*E*,5*E*)-7-methylocta-3,5-dien-2-yl]-4-(trimethylstannyl)thiazole which was used in the next step without further purification (89% yield).

2-[(*S*,3*E*,5*E*)-7-methylocta-3,5-dien-2-yl]-4-(trimethylstannyl)thiazole (0.03694 mmol, 2 equiv) was dissolved in degassed toluene (2 mL). Compound **10** (7 mg, 0.0185 mmol, 1 equiv) and $\text{Pd}(\text{PPh}_3)_4$ (2 mg, 0.00185 mmol, 0.1 equiv) were introduced, and the contents were heated again at 110 $^\circ\text{C}$. After complete conversion (overnight), the contents were cooled to rt and concentrated under reduced pressure. The crude residue was purified by column chromatography ($\text{CH}_2\text{Cl}_2/\text{acetone} = 98:2$) to provide myxothiazole Z (**2**) (7.5 mg, 82% yield) as a colorless oil.

$R_f = 0.29$ ($\text{CH}_2\text{Cl}_2/\text{Acetone} = 98:2$); $[\alpha]_D^{20} +111.5$ (c 0.75, MeOH); IR (neat): 3109, 2930, 1710, 1623, 1457, 1438, 1146, 1094, 972 cm^{-1} ; ^1H NMR (400 MHz, C_6D_6) δ 7.61 (s, 1H), 6.93 (dd, $J = 8.0$ 15.6 Hz, 1H), 6.64 (d, $J = 15.6$ Hz, 1H), 6.49 (s, 1H), 6.02 (dd, $J = 10.3$, 14.9 Hz, 1H), 5.91 (dd, $J = 10.3$, 15.0 Hz, 1H), 5.62 (dd, $J = 7.7$, 14.9 Hz, 1H), 5.49 (dd, $J = 6.9$, 15.0 Hz, 1H), 5.00 (s, 1H), 4.81 (m, 1H), 3.97 (t, $J = 8.0$ Hz, 1H), 3.65 (m, 1H), 3.45 (s, 3H), 3.24 (s, 3H), 2.96 (s, 3H), 2.16 (m, 1H), 1.49 (d, $J = 6.9$ Hz, 3H), 1.36 (d, $J = 6.9$ Hz, 3H), 0.91 (d, $J = 6.7$ Hz, 6H);

^{13}C NMR (100 MHz, C_6D_6) δ 177.0 (s), 175.8 (s), 167.6 (s), 162.90 (s), 154.9 (s), 149.8 (s), 141.9 (d), 133.1 (d), 132.4 (d), 132.2 (d), 127.3 (d), 126.3 (d), 115.8 (d), 115.7 (d), 91.7 (d), 85.0 (d), 56.8 (q), 54.9 (q), 50.5 (q), 41.6 (d), 40.6 (d), 31.4 (d), 22.4 (q, 2C), 20.7 (q), 14.6 (q); **HRMS (ESI)** m/z calcd for $\text{C}_{26}\text{H}_{34}\text{N}_2\text{NaO}_4\text{S}_2$ $[\text{M} + \text{Na}]^+$: 525.1852, found: 525.1844.

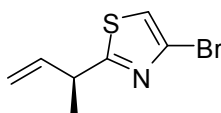
(*R*)-3-(4-Bromothiazol-2-yl)-2-chlorobutyl acetate (19) (Mixture of isomers)



To a solution of (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutan-1-ol (270 mg, 1 mmol) in CH_2Cl_2 (11 mL) at 0 °C were added acetic anhydride (123 μL mg, 1.3 mmol, 1.3 equiv), NMM (165 μL , 1.5 mmol, 1.5 equiv) and DMAP (12.2 mg, 0.1 mmol, 0.1 equiv). The reaction contents were allowed to warm to rt and, after 2 h, were diluted with H_2O (10 mL) and CH_2Cl_2 (10 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2 x 20 mL). The combined organic fractions were dried over MgSO_4 and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 9:1) to afford acetic acid (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutyl acetate (**19**) (297 mg, 95% yield) as a colorless oil.

R_f = 0.7 (*n*-pentane/EtOAc = 4:1); **IR** (neat): 3120, 2977, 1742, 1475, 1454, 1382, 1366, 1219, 1036, 889, 830, 733 cm^{-1} ; **^1H NMR** (400 MHz, CDCl_3 , *major isomer*) δ 7.18 (s, 1H), 4.54 (td, J = 4.9, 6.3 Hz, 1H), 4.36-4.21 (m, 2H), 3.64 (qd, J = 5.2, 6.9 Hz, 1H), 2.08 (s, 3H), 1.51 (d, J = 6.9 Hz, 3H); **^1H NMR** (400 MHz, CDCl_3 , *minor isomer*) δ 7.16 (s, 1H), 4.43 (dt, J = 5.0, 6.8 Hz, 1H), 4.36-4.21 (m, 2H), 3.73 (qd, J = 4.9, 7.1 Hz, 1H), 2.06 (s, 3H), 1.51 (d, J = 7.1 Hz, 3H); **^{13}C NMR** (100 MHz, CDCl_3 , *major isomer*) δ 172.9 (s), 170.5 (s), 124.7 (s), 117.0 (d), 65.4 (t), 61.8 (d), 41.0 (d), 20.8 (q), 15.4 (q); **^{13}C NMR** (100 MHz, CDCl_3 , *minor isomer*) δ 171.6 (s), 170.4 (s), 124.9 (s), 116.7 (d), 65.4 (t), 61.7 (d), 42.0 (d), 20.8 (q), 17.8 (q); **MS** (EI, 70 eV, *major isomer*): m/z (relative intensity) 278 (18), 276 (18), 236 (9), 234 (9), 218 (94), 216 (100), 206 (11), 204 (15), 192 (27), 190 (28), 137 (13), 136 (11), 58 (10), 57 (22); **MS** (EI, 70 eV, *minor isomer*): m/z (relative intensity) 278 (18), 276 (18), 236 (10), 234 (10), 218 (99), 216 (100), 206 (12), 204 (16), 192 (33), 190 (34), 137 (13), 136 (11), 58 (11), 57 (25); **HRMS (ESI)** m/z calcd for $\text{C}_9\text{H}_{11}\text{BrNNaO}_2\text{S}$ $[\text{M} + \text{Na}]^+$: (Br^{81}) 335.9254, (Br^{79}) 333.9275, found: (Br^{81}) 335.9249, (Br^{79}) 333.9277.

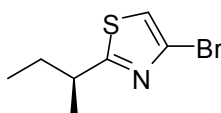
(*S*)-4-Bromo-2-(but-3-en-2-yl)thiazole (**20**)



To a solution of acetic acid (*R*)-3-(4-bromothiazol-2-yl)-2-chlorobutyl acetate (**19**) (278 mg, 0.89 mmol) in THF (6.7 mL) was added a SmI₂ solution (0.1 M solution in THF, 29.4 mL, 3.3 equiv), and the contents were refluxed in a sealed tube until complete conversion. After 4 h, the reaction mixture was allowed to cool to rt, the contents were diluted in Et₂O, added to a saturated aqueous Na₂S₂O₃ solution (40 mL) and stirred for 5 min. The layers were then separated and the aqueous phase was extracted with Et₂O (3x40 mL). The combined organic phases were washed with brine, dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/Et₂O = 98:2) to afford (*S*)-4-bromo-2-(but-3-en-2-yl)thiazole (**20**) (150 mg, 77% yield).

R_f = 0.7 (9/1; *n*-pentane/EtOAc); $[\alpha]_D^{20}$ +29.7 (*c* 0.95, CHCl₃); **IR** (neat): 3122, 3085, 2977, 2931, 1638, 1476, 1454, 1271, 1250, 1081, 923, 889, 828, 730 cm⁻¹; **¹H NMR** (400 MHz, CDCl₃) δ 7.11 (s, 1H), 6.02 (ddd, *J* = 7.2, 10.2, 17.2 Hz, 1H), 5.23 (dt, *J* = 1.2, 17.1 Hz, 1H), 5.19 (dt, *J* = 1.1, 10.2 Hz, 1H), 3.88 (m, 1H), 1.50 (d, *J* = 7.0 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃) δ 176.1 (s), 139.2 (d), 124.5 (s), 116.6 (t), 116.3 (d), 42.4 (d), 20.2 (q); **MS** (EI, 70 eV): *m/z* (relative intensity) 218 ((Br⁸¹), 21), 216 ((Br⁷⁹), 20), 204 ((Br⁸¹), 100), 202 ((Br⁷⁹), 98), 138 (22), 136 (20), 123 (50), 94 (17), 67 (15), 65 (14), 57 (53), 55 (33), 53 (18); **HRMS (ESI)** *m/z* calcd for C₇H₈BrNS [M + H]⁺: (Br⁸¹) 219.9613, (Br⁷⁹) 217.9634, found: (Br⁸¹) 219.9611, (Br⁷⁹) 217.9623.

(*S*)-4-Bromo-2-sec-butylthiazole (**21**)⁶



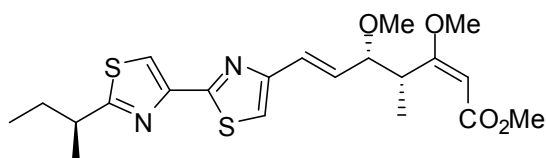
To a stirred solution of (*S*)-4-bromo-2-(but-3-en-2-yl)thiazole (**20**) (52 mg, 0.238 mmol, 1 equiv) in MeOH (2.2 mL) at rt under an argon atmosphere was added PtO₂ (9 mg, 0.036 mmol, 0.15 equiv). The resulting reaction mixture was stirred under a hydrogen atmosphere (1 atm) at rt until complete conversion of the starting material (reaction monitored by RM). After 4h, the crude reaction mixture was then filtered over Celite[®], the solvent was removed under reduced pressure to afford

[6] T. Bach, S. Heuser *J. Org. Chem.* 2002, **67**, 5789.

(*S*)-4-bromo-2-sec-butylthiazole (**21**) (52 mg, quantitative yield) as a colourless oil which was used in the next step without further purification.

R_f = 0.82 (*n*-pentane/EtOAc = 9:1); $[\alpha]_D^{20}$ +11.2 (*c* 1.7, CHCl₃); **IR** (neat): 3123, 2965, 2930, 2875, 1479, 1457, 1251, 1079, 1060, 886, 727 cm⁻¹; **¹H NMR** (400 MHz, MeOD) δ 7.39, (s, 1H), 3.11 (m, 1H), 1.86-1.64 (m, 2H), 1.36 (d, *J* = 6.9 Hz, 4H), 0.92 (t, *J* = 7.4 Hz, 3H); **¹³C NMR** (100 MHz, MeOD) δ 180.0 (s), 124.5 (s), 117.2 (d), 41.3 (d), 31.5 (t), 21.0 (q), 11.9 (q); **MS** (EI, 70 eV): *m/z* (relative intensity) 221 ((Br⁸¹), 12), 219 ((Br⁷⁹), 10), 206 ((Br⁸¹), 19), 204 ((Br⁷⁹), 19), 193 ((Br⁸¹), 79), 192 (68), 191 ((Br⁷⁹), 78), 190 (58), 139 (24), 138 (18), 137 (26), 136 (18), 111 (14), 84 (15), 71 (31), 57 (100), 54 (20), 52 (17).

(14*S*)-Melithiazole G (**3**)



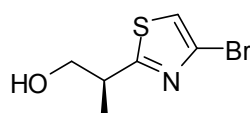
To a solution of (*S*)-4-bromo-2-sec-butylthiazole (**21**) (52 mg, 0.2384 mmol) in degassed toluene (2.3 mL) were added hexamethylditin (494 μ L, 2.384 mmol, 10 equiv) and Pd(PPh₃)₄ (19.5 mg, 0.02384 mmol, 0.1 equiv). The contents were then heated at 110 °C in a sealed tube until complete conversion. After 4 h, the contents were cooled to rt and concentrated under reduced pressure. The crude residue was filtered by column chromatography (silica gel pre-treated with NEt₃ and eluting with hexane) to remove excess of hexamethylditin and provide (*S*)-2-sec-butyl-4-(trimethylstannyl)thiazole (62% yield).

(*S*)-2-sec-Butyl-4-(trimethylstannyl)thiazole (0.1487 mmol, 4 equiv) was dissolved in degassed toluene (2 mL). 7-(2-Bromothiazol-4-yl)-3,5-dimethoxy-4-methylhepta-2,6-dienoic acid methyl ester (14 mg, 0.03718 mmol, 1 equiv) and Pd(PPh₃)₄ (5 mg, 0.00372 mmol, 0.1 equiv) were introduced, and the contents were heated again at 110 °C. After complete conversion (overnight), the contents were cooled to rt and concentrated under reduced pressure. The crude residue was purified by flash column chromatography over silica gel (CH₂Cl₂ to CH₂Cl₂/acetone = 98:2) to provide (14*S*)-melithiazole G (**3**) (13.5 mg, 83% yield) as a colorless oil.

R_f = 0.36 (CH₂Cl₂/Acetone = 95:5); $[\alpha]_D^{20}$ +106.6 (*c* 1.3, CHCl₃); **IR** (neat): 3112, 2965, 2931, 171, 1623, 1455, 1439, 1382, 1263, 1144, 1094, 971 cm⁻¹; **¹H NMR** (400 MHz, C₆D₆) δ 7.64 (s, 1H), 6.93 (dd, *J* = 8.0, 15.7 Hz, 1H), 6.64 (d, *J* = 15.7 Hz, 1H), 6.50 (s, 1H), 5.00 (s, 1H), 4.81 (dq,

$J = 6.9, 8.0$ Hz, 1H), 3.96 (t_{app}, $J = 8.0$ Hz, 1H), 3.46 (s, 3H), 3.25 (s, 3H), 2.97 (s, 3H), 2.83 (m, 1H), 1.66 (m, 1H), 1.49 (d, $J = 6.9$ Hz, 3H), 1.43 (m, 1H), 1.12 (d, $J = 6.9$ Hz, 3H), 0.73 (t, $J = 7.4$ Hz, 3H); ¹³C NMR (100 MHz, C₆D₆) δ 177.2 (s), 177.0 (s), 167.6 (s), 163.0 (s), 154.9 (s), 149.5 (s), 132.4 (d), 126.3 (d), 115.6 (d), 115.0 (d), 91.7 (d), 85.0 (d), 56.7 (q), 54.9 (q), 50.5 (q), 40.6 (d), 40.2 (d), 30.7 (t), 20.6 (q), 14.6 (q), 11.7 (q); HRMS (ESI) m/z calcd for C₂₁H₂₈N₂NaO₄S₂ [M + Na]⁺: 459.1383, found: 459.1385.

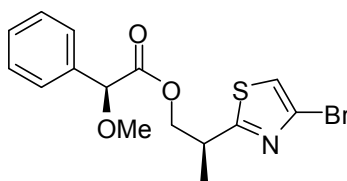
(S)-2-(4-Bromothiazol-2-yl)propan-1-ol



A solution (S)-4-bromo-2-(but-3-en-2-yl)thiazole (**20**) (59 mg, 0.271 mmol, 1 equiv) in a 1:1 mixture of MeOH/CH₂Cl₂ (5.4 mL) was exposed to ozone at -78 °C until the starting material was consumed (reaction monitored by TLC, 5 min). The resulting mixture was flushed with O₂ (10 min) and argon (5 min). NaBH₄ (102 mg, 2.71 mmol, 10 equiv) was then added portion-wise and the mixture was stirred for 30 min before a second portion of NaBH₄ was added (102 mg, 2.71 mmol, 10 equiv). The reaction mixture was allowed to reach 0 °C and stirred for an additional 30 min. The reaction mixture was diluted with CH₂Cl₂ (10 mL) and a saturated aqueous NH₄Cl solution (10 mL). The layers were separated and the aqueous layer was extracted with CH₂Cl₂ (2 x 10 mL). The combined organic fractions were washed with brine (10 mL), dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 4:1) to afford acetic acid (S)-2-(4-bromothiazol-2-yl)propan-1-ol (41 mg, 68% yield) as a colorless oil.

$R_f = 0.2$ (*n*-pentane/EtOAc = 4:1); $[\alpha]^{20}_D +3.53$ (c 0.98, CHCl₃); IR (neat): 3355, 3122, 2969, 2930, 2873, 1479, 1253, 1094, 1077, 1046, 1021, 891, 830, 732 cm⁻¹; ¹H NMR (400 MHz, C₆D₆): δ 6.43 (s, 1H), 3.53 (m, 1H), 2.93 (m, 1H), 2.80 (brs, 1H), 1.05 (d, $J = 7.1$ Hz, 1H); ¹³C NMR (100 MHz, C₆D₆) δ 175.5 (s), 124.6 (s), 116.1 (d), 66.7 (t), 41.0 (s), 17.0 (q); MS (EI, 70 eV): m/z (relative intensity) 193 ((Br⁸¹), 70), 192 ((Br⁷⁹), 62), 191 ((Br⁸¹), 71), 190 ((Br⁷⁹), 53), 139 ((Br⁸¹), 20), 137 ((Br⁷⁹), 22), 71 (34), 58 (46), 57 (100), 54 (23), 52(22); HRMS (ESI) m/z calcd for C₆H₉BrNOS [M + H]⁺: (Br⁸¹) 223.9562, (Br⁷⁹) 221.9583, found: (Br⁸¹) 223.9561, (Br⁷⁹) 221.9581.

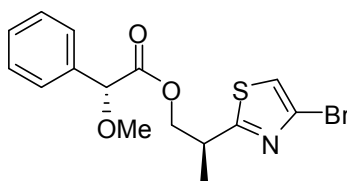
(S)-[*(S)*-2-(4-Bromothiazol-2-yl)propyl] 2-methoxy-2-phenylacetate



To a stirred solution of (*S*)-2-(4-bromothiazol-2-yl)propan-1-ol (4.2 mg, 0.0189 mmol, 1 equiv) in CH₂Cl₂, (1 mL) at 0 °C was added (*S*)-methoxyphenyl acetic acid (3.8 mg, 0.0227 mmol, 1.2 equiv), DCC (4.7 mg, 0.0227 mmol, 1.2 equiv) and DMAP (0.3 mg, 0.002 mmol, 0.1 equiv). The reaction mixture was allowed to stir at rt until complete conversion of the starting alcohol (reaction monitored by TLC). After 6 h, the reaction mixture was diluted with CH₂Cl₂ (5 mL) and a saturated aqueous NH₄Cl solution (5 mL) was added. The layers were separated and the aqueous layer was extracted with CH₂Cl₂ (2 x 10 mL) and the combined organic phases were washed with a saturated aqueous NaHCO₃ solution (5 mL) and with brine (5 mL), dried over anhydrous MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 9:1) to afford (*S*)-[*(S)*-2-(4-bromothiazol-2-yl)propyl] 2-methoxy-2-phenylacetate (4.6 mg, 66% yield) as a white solid.

R_f = 0.4 (*n*-pentane/EtOAc = 4:1); $[\alpha]_D^{20}$ +56.6 (*c* 0.46, CHCl₃); **IR** (neat): 3117, 2929, 2828, 1750, 1480, 1455, 1254, 1198, 1173, 1106, 1075; 1009, 732, 698 cm⁻¹; **¹H NMR** (400 MHz, CDCl₃) δ 7.39-7.31 (m, 5H), 7.06 (s, 1H), 4.74 (s, 1H), 4.39 (dd, *J* = 6.9, 10.9 Hz, 1H), 4.30 (dd, *J* = 5.8, 10.9 Hz, 1H), 3.49 (m, 1H), 3.39 (s, 3H), 1.28 (d, *J* = 7.0 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃) δ 173.1 (s), 170.5 (s), 136.1 (s), 128.9 (d), 128.8 (d, 2C), 127.3 (d, 2C), 124.6 (s), 116.3 (d), 82.5 (d), 68.2 (t), 57.5 (q), 38.0 (d), 17.3 (q); **MS** (EI, 70 eV): *m/z* (relative intensity) 371 ((Br⁸¹), 0.2), 369 ((Br⁷⁹), 0.2), 121 (100), 105 (3), 91 (7), 77 (10), 58 (1); **HRMS (ESI)** *m/z* calcd for C₁₅H₁₆BrNNaO₃S [M + Na]⁺: (Br⁸¹) 393.9906, (Br⁷⁹) 391.9927, found: (Br⁸¹) 393.9909, (Br⁷⁹) 391.9937.

(R)-((S)-2-(4-Bromothiazol-2-yl)propyl) 2-methoxy-2-phenylacetate

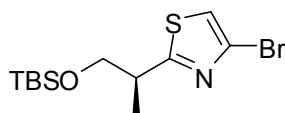


To a stirred solution of (*S*)-2-(4-bromothiazol-2-yl)propan-1-ol (4.2 mg, 0.0189 mmol, 1 equiv) in CH₂Cl₂, (1 mL) at 0 °C was added (*R*)-methoxyphenyl acetic acid (3.8 mg, 0.0227 mmol, 1.2 equiv), DCC (4.7 mg, 0.0227 mmol, 1.2 equiv) and DMAP (0.3 mg, 0.002 mmol, 0.1 equiv). The reaction mixture was allowed to stir at rt until complete conversion of the starting alcohol (reaction monitored by TLC). After 6 h, the reaction mixture was diluted with CH₂Cl₂ (5 mL) and a saturated aqueous NH₄Cl solution (5 mL) was added. The layers were separated and the aqueous layer was extracted with CH₂Cl₂ (2 x 10 mL) and the combined organic phases were washed with a saturated aqueous NaHCO₃ solution (5 mL) and with brine (5 mL), dried over anhydrous MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 9:1) to afford (*R*)-((*S*)-2-(4-bromothiazol-2-yl)propyl) 2-methoxy-2-phenylacetate (5.5 mg, 79% yield) as a white solid.

R_f = 0.4 (*n*-pentane/EtOAc = 4:1); $[\alpha]_D^{20}$ -39.3 (*c* 0.55, CHCl₃); **IR** (neat): 3117, 2931, 2828, 1751, 1480, 1455, 1255, 1198, 1173, 1106, 1075; 1010, 733, 698 cm⁻¹; **¹H NMR** (400 MHz, CDCl₃) δ 7.39-7.31 (m, 5H), 7.05 (s, 1H), 4.74 (s, 1H), 4.37 (dd, *J* = 6.9, 10.9 Hz, 1H), 4.33 (dd, *J* = 6.0, 10.9 Hz, 1H), 3.46 (m, 1H), 3.38 (s, 3H), 1.28 (d, *J* = 7.0 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃) δ 173.0 (s), 170.5 (s), 136.1 (s), 128.9 (d), 128.8 (d, 2C), 127.3 (d, 2C), 124.6 (s), 116.3 (d), 82.5 (d), 68.1 (t), 57.5 (q), 38.0 (d), 17.3 (q); **MS** (EI, 70 eV): *m/z* (relative intensity) 371 ((Br⁸¹), 0.1), 369 ((Br⁷⁹), 0.1), 121 (100), 105 (3), 91 (7), 77 (10), 57 (2); **HRMS (ESI)** *m/z* calcd for C₁₅H₁₆BrNNaO₃S [M + Na]⁺: (Br⁸¹) 393.9906, (Br⁷⁹) 391.9927, found: (Br⁸¹) 393.9908, (Br⁷⁹) 391.9936.

The examination of the crude ¹H NMR spectras of the corresponding (*R*)- and (*S*)-*O*-mandelates confirmed that no epimerisation occurred during the ozonolysis.

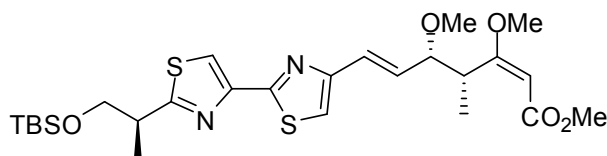
(*S*)-4-Bromo-2-(1-(*tert*-butyldimethylsilyloxy)propan-2-yl)thiazole (22)



To a solution of (*S*)-2-(4-bromothiazol-2-yl)propan-1-ol (31.3 mg, 0.141 mmol, 1 equiv) in CH₂Cl₂ (1.6 mL) at 0 °C were added 2,6-lutidine (55 μL, 0.473 mmol, 3 equiv) and TBSOTf (58 μL mg, 0.252 mmol, 1.6 equiv). The ice bath was then removed and the reaction mixture was slowly warmed to rt overnight. The next day, the contents were diluted with a saturated aqueous NH₄Cl solution (5 mL) and CH₂Cl₂ (10 mL) and the layers were separated. The aqueous fraction was extracted with CH₂Cl₂ (2 x 10 mL) and the combined organic phases were washed with brine (15 mL), dried over anhydrous MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (*n*-pentane/EtOAc = 99.5:0.5) to provide (*S*)-4-bromo-2-[1-(*tert*-butyldimethylsilyloxy)propan-2-yl]thiazole (**22**) (44.5 mg, 94% yield) as a colorless oil.

R_f = 0.82 (*n*-pentane/EtOAc = 4:1); $[\alpha]_D^{20}$ +9.2 (*c* 1.03, CHCl₃); **IR** (neat): 3124, 2955, 2929, 2885, 2857, 1471, 1255, 1112, 837, 777 cm⁻¹; **¹H NMR** (400 MHz, C₆D₆): δ 6.47 (s, 1H), 3.60 (dd, *J* = 6.2, 9.7 Hz, 1H), 3.55 (dd, *J* = 5.5, 9.7 Hz, 2H), 3.18-2.85 (m, 1H), 1.17 (d, *J* = 7.0 Hz, 3H), 0.90 (s, 10H), -0.07 (s, 3H), -0.07 (s, 3H); **¹³C NMR** (100 MHz, C₆D₆) δ 174.4(s), 124.9 (s), 116.0(d), 67.4(t), 41.5 (d), 26.0 (q, 3C), 18.4(s), 16.9(q), -5.5 (q, 2C); **MS** (EI, 70 eV): *m/z* (relative intensity) 280 ((Br⁸¹), 100), 278 ((Br⁷⁹), 95), 89 (26), 84 (19), 75 (88), 73 (89), 59 (37), 58 (27), 57 (31); **HRMS (ESI)** *m/z* calcd for C₁₂H₂₃BrNOSSi [M + H]⁺: (Br⁸¹) 338.0427, (Br⁷⁹) 336.0448, found: (Br⁸¹) 338.0424, (Br⁷⁹) 336.0450.

(2*E*,4*R*,5*S*,6*E*)-Methyl 7-[2'-(*S*)-1-(*tert*-butyldimethylsilyloxy)propan-2-yl]-2,4'-bithiazol-4-yl]-3,5-dimethoxy-4-methylhepta-2,6-dienoate



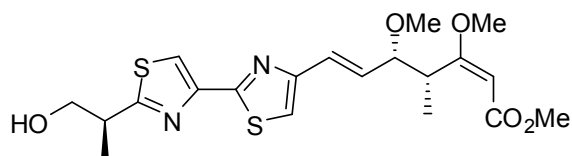
To a solution of (*S*)-4-bromo-2-(1-(*tert*-butyldimethylsilyloxy)propan-2-yl)thiazole (35 mg, 0.104 mmol) in degassed toluene (1 mL) were added hexamethylditin (216 μL, 1.04 mmol, 10 equiv) and Pd(PPh₃)₄ (12 mg, 0.0104 mmol, 0.1 equiv). The contents were then heated at 110 °C in a sealed tube until completion (reaction monitored by TLC). After 4 h, the contents were cooled to rt and concentrated under reduced pressure. The crude residue was filtered over a short plug of

silica gel (pre-treated with NEt₃) eluting with hexane to remove the excess of hexamethylditin and provide (*S*)-2-(1-(*tert*-butyldimethylsilyloxy)propan-2-yl)-4-(trimethylstannyl)thiazole (81% yield) which was used in the next step without further purification.

(*S*)-2-(1-(*tert*-butyldimethylsilyloxy)propan-2-yl)-4-(trimethylstannyl)thiazole (0.0843 mmol, 3 equiv) was dissolved in degassed toluene (2 mL). 7-(2-Bromothiazol-4-yl)-3,5-dimethoxy-4-methylhepta-2,6-dienoic acid methyl ester (10.6 mg, 0.0281 mmol, 1 equiv) and Pd(PPh₃)₄ (3.3 mg, 0.00281 mmol, 0.1 equiv) were introduced, and the contents were heated again at 110 °C. After complete conversion (overnight), the contents were cooled to rt and concentrated under reduced pressure. The crude residue was purified by column chromatography (CH₂Cl₂/acetone = 98:2) to provide (2*E*,4*R*,5*S*,6*E*)-methyl 7-[2'-(*S*)-1-(*tert*-butyldimethylsilyloxy)propan-2-yl]-2,4'-bithiazol-4-yl]-3,5-dimethoxy-4-methylhepta-2,6-dienoate (13.4 mg, 86% yield) as a colorless oil.

R_f = 0.76 (CH₂Cl₂/Acetone = 95:5); [α]_D²⁰ +78.0 (*c* 1.34, CHCl₃); **IR** (neat): 3105, 2931, 2857, 1712, 1625, 1462, 1383, 1259, 1146, 1095, 837, 777 cm⁻¹; **¹H NMR** (400 MHz, C₆D₆) δ 7.63 (s, 1H), 6.92 (dd, *J* = 8.0, 15.7 Hz, 1H), 6.64 (d, *J* = 15.6 Hz, 1H), 6.50 (s, 1H), 4.99 (s, 1H), 4.80 (dq, *J* = 6.9, 7.8 Hz, 1H), 3.96 (t_{app}, *J* = 8.0 Hz, 1H), 3.66 (dd, *J* = 6.0, 9.7 Hz, 1H), 3.62 (dd, *J* = 5.5, 9.7 Hz, 1H), 3.45 (s, 3H), 3.24 (s, 3H), 3.20-3.10 (m, 1H), 2.95 (s, 3H), 1.48 (d, *J* = 6.9 Hz, 3H), 1.23 (d, *J* = 7.0 Hz, 3H), 0.90 (s, 11H), -0.06 (s, 3H), -0.07 (s, 3H); **¹³C NMR** (100 MHz, C₆D₆) δ 177.0 (s), 174.1 (s), 167.6 (s), 163.0 (s), 155.0 (s), 149.4 (s), 132.4 (d), 126.3 (d), 115.6 (d), 115.6 (d), 91.7 (d), 85.0 (d), 67.5 (t), 56.7 (q), 54.9 (q), 50.5 (q), 41.4 (d), 40.6 (d), 26.0 (q, 3C), 18.4 (s), 17.1 (q), 14.6 (q), -5.4 (q, 2C); **HRMS (ESI)** *m/z* calcd for C₂₆H₄₁N₂O₅S₂Si [M + H]⁺: 553.2221, found: 553.2227.

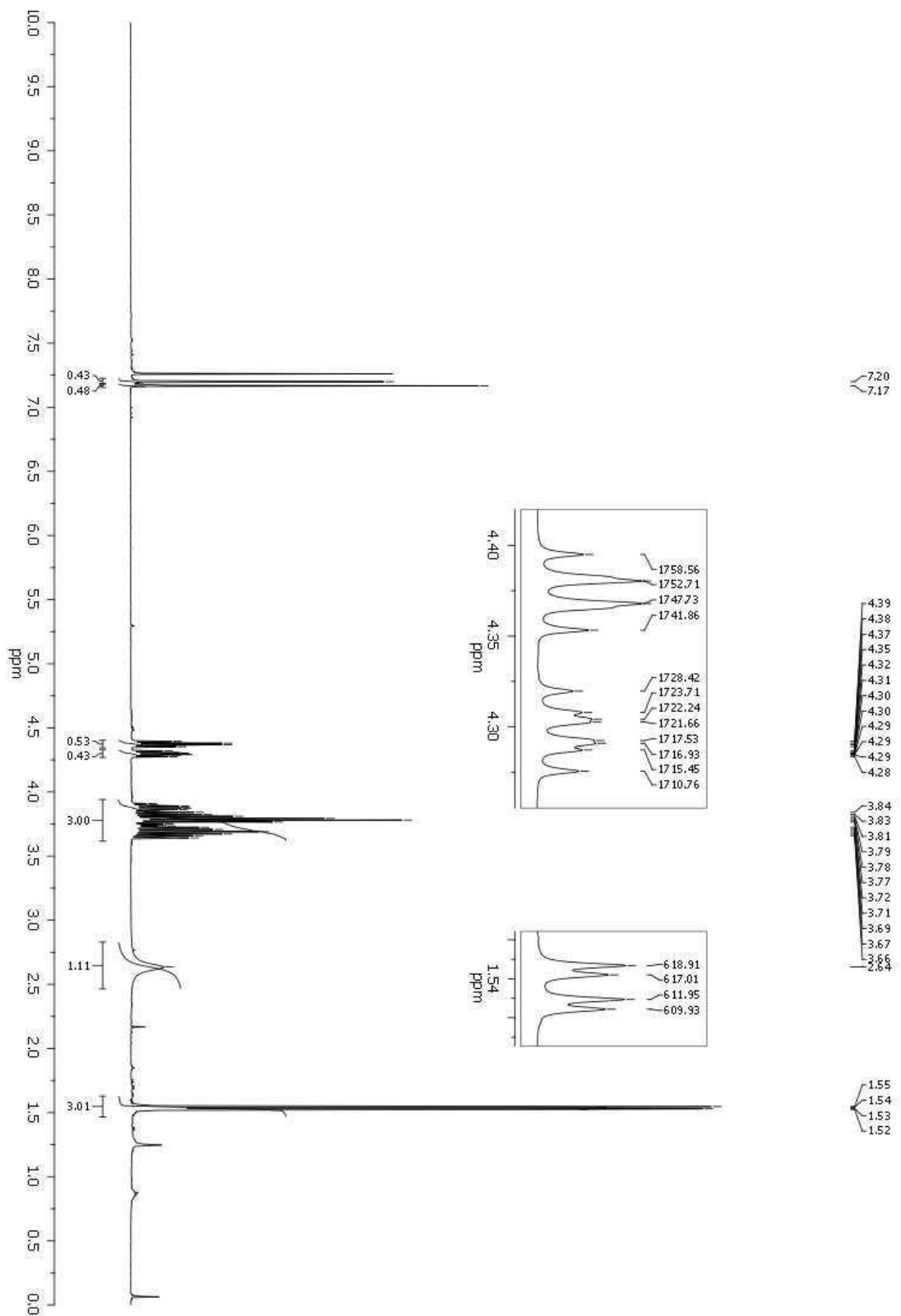
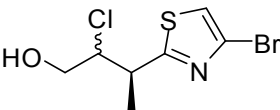
(14*S*)-Cystothiazole F (4)

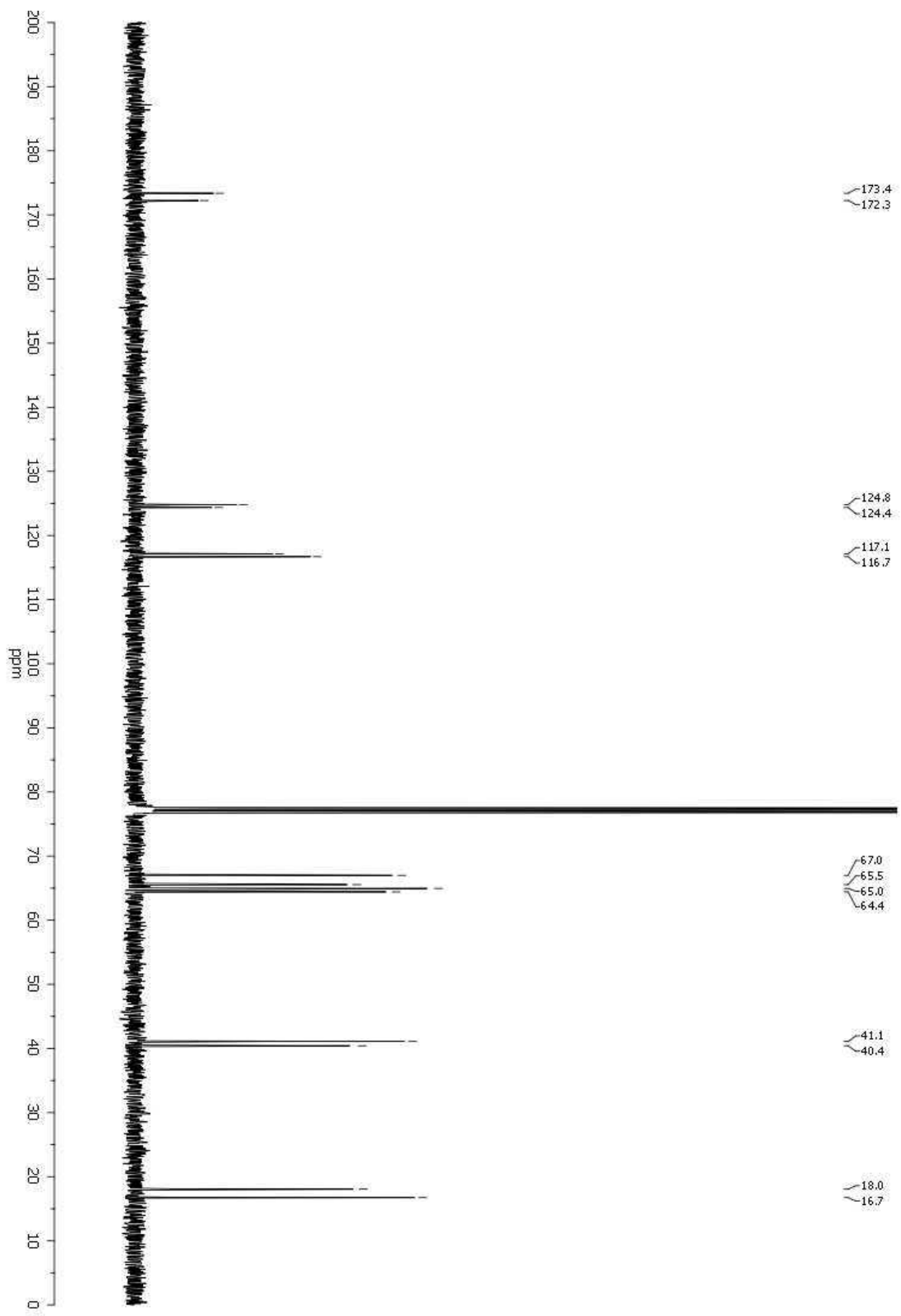
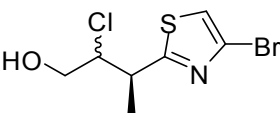


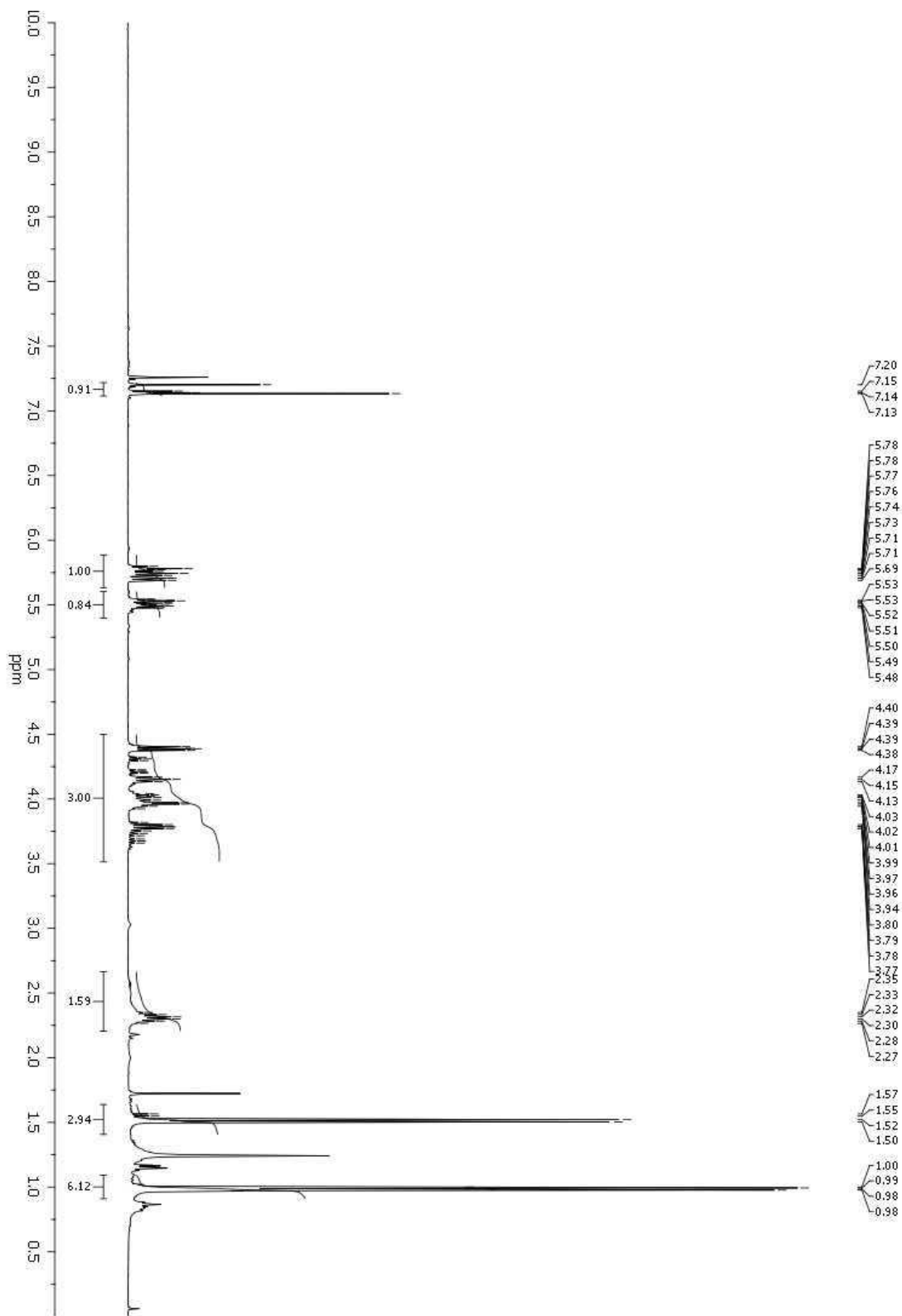
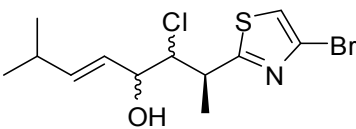
To a solution of (2*E*,4*R*,5*S*,6*E*)-methyl 7-[2'-(*S*)-1-(*tert*-butyldimethylsilyloxy)propan-2-yl]-2,4'-bithiazol-4-yl]-3,5-dimethoxy-4-methylhepta-2,6-dienoate (12.8 mg, 0.0232 mmol) in THF (2 mL) at 0 °C was added TBAF (1 M solution in THF, 13 μL, 1.1 equiv), and the resulting reaction mixture was stirred at the same temperature until complete conversion of the starting material (reaction monitored by TLC analysis). After 30 min, the reaction mixture was diluted with H₂O (5.0 mL) and AcOEt (5.0 mL). The layers were then separated and the aqueous phase was extracted

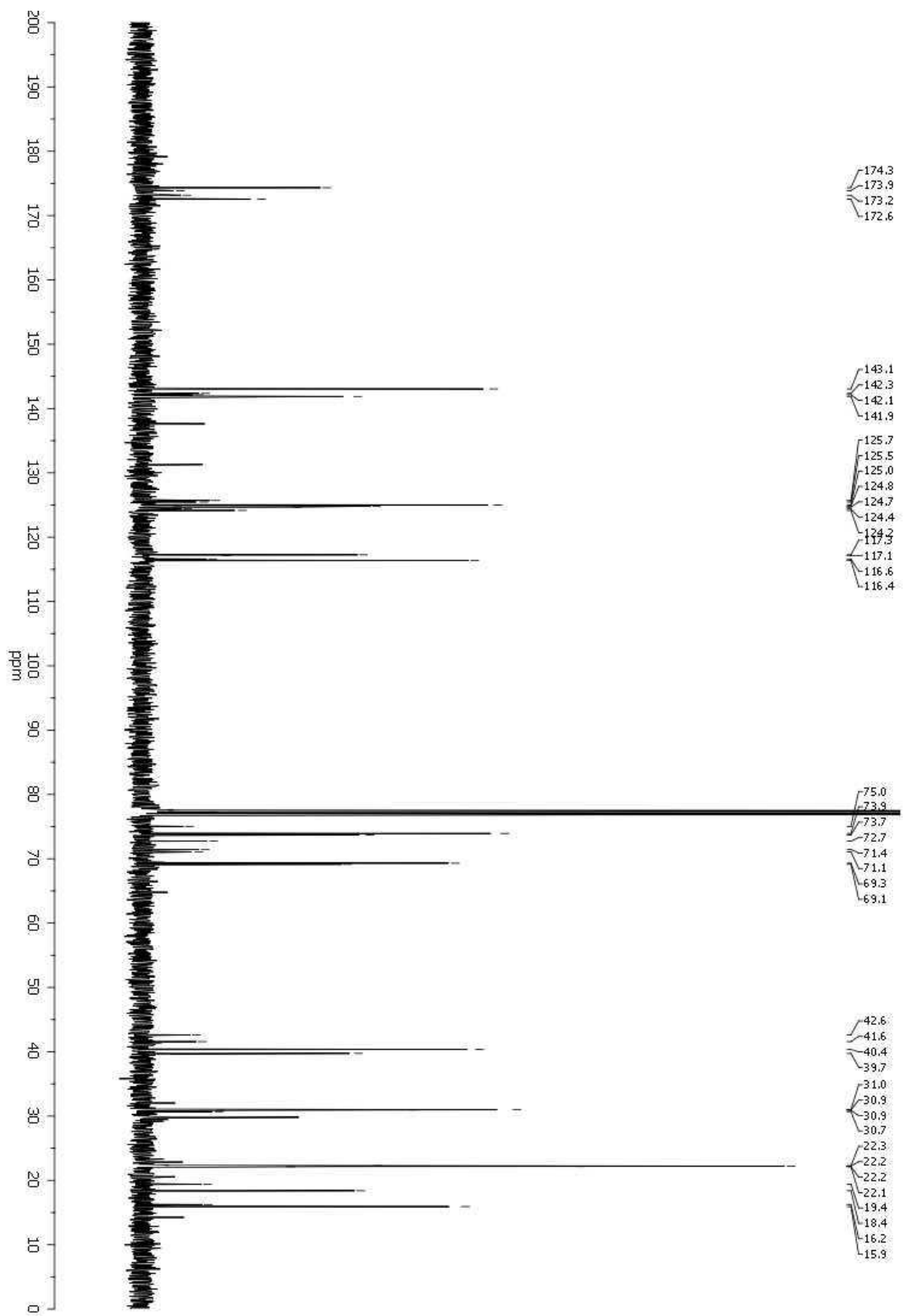
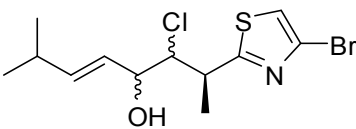
with AcOEt (3x10 mL). The combined organic phases were washed with brine (5 mL), dried over MgSO₄ and concentrated under reduced pressure. The crude residue was purified by column chromatography (CH₂Cl₂/acetone = 4:1) to afford (14*S*)-cystothiazole F (**4**) as a colorless solid (10 mg, 91%).

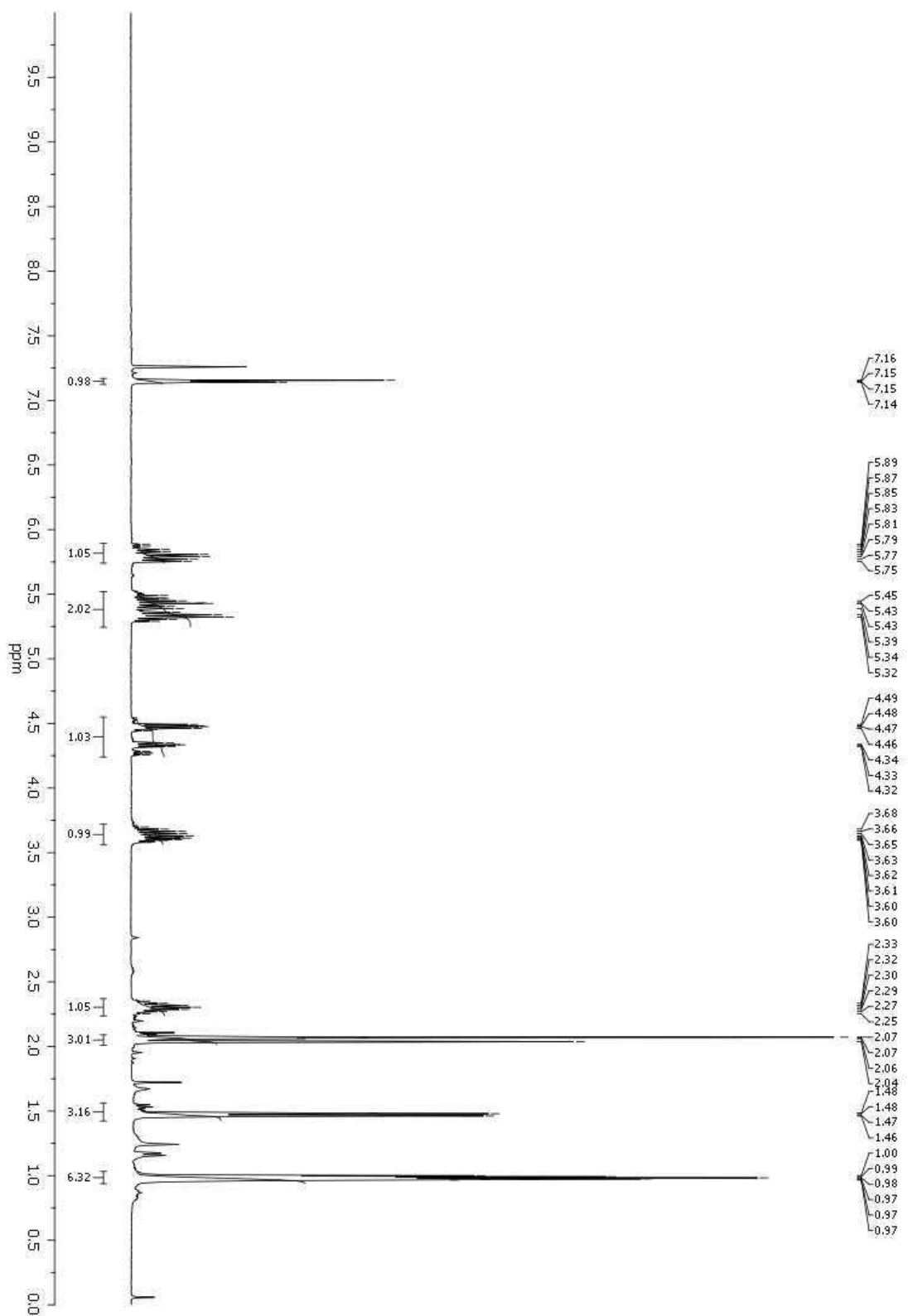
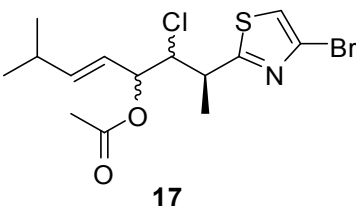
R_f = 0.09 (CH₂Cl₂/Acetone = 95:5); [**α**]²⁰_D +89.8 (*c* 0.85, CHCl₃); **IR** (neat): 3433, 3106, 2931, 1709, 1622, 1439, 1383, 1146, 1093, 1049, 972 cm⁻¹; **¹H NMR** (400 MHz, C₆D₆) δ 7.57 (s, 1H), 6.92 (dd, *J* = 7.9, 15.7 Hz, 1H), 6.64 (d, *J* = 15.7 Hz, 1H), 6.48 (s, 1H), 5.00 (s, 1H), 4.80 (dq, *J* = 6.9, 8.0 Hz, 1H), 3.97 (td, *J* = 0.8, 8.0 Hz, 1H), 3.55 (d, *J* = 5.9 Hz, 2H), 3.45 (s, 3H), 3.24 (s, 3H), 2.96 (s, 3H), 1.48 (d, *J* = 6.9 Hz, 3H), 1.04 (d, *J* = 7.1 Hz, 3H); **¹³C NMR** (100 MHz, C₆D₆) δ 177.0 (s), 175.1 (s), 167.7 (s), 162.6 (s), 155.0 (s), 149.4 (s), 132.6 (d), 126.3 (d), 115.7 (d), 115.4 (d), 91.7 (d), 84.9 (d), 66.8 (t), 56.8 (q), 54.9 (q), 50.5 (q), 40.7 (d), 40.6 (d), 17.1 (q), 14.6 (q); **HRMS (ESI)** *m/z* calcd for C₂₀H₂₆N₂NaO₅S₂ [M + Na]⁺: 461.1175, found: 461.1173.

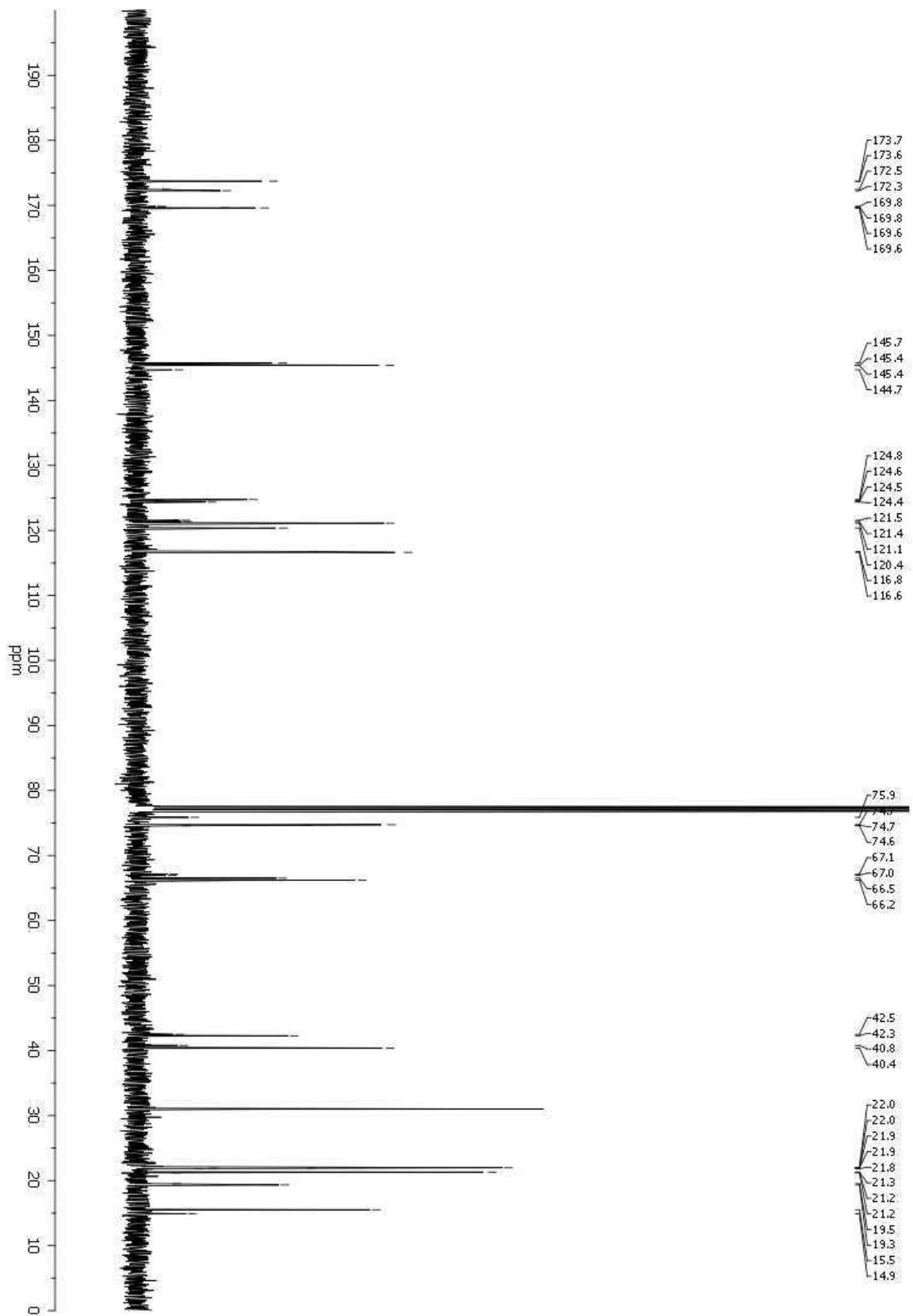
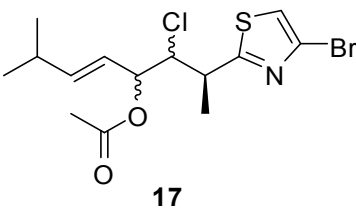


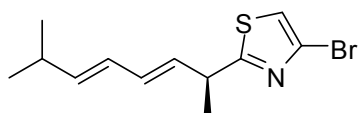




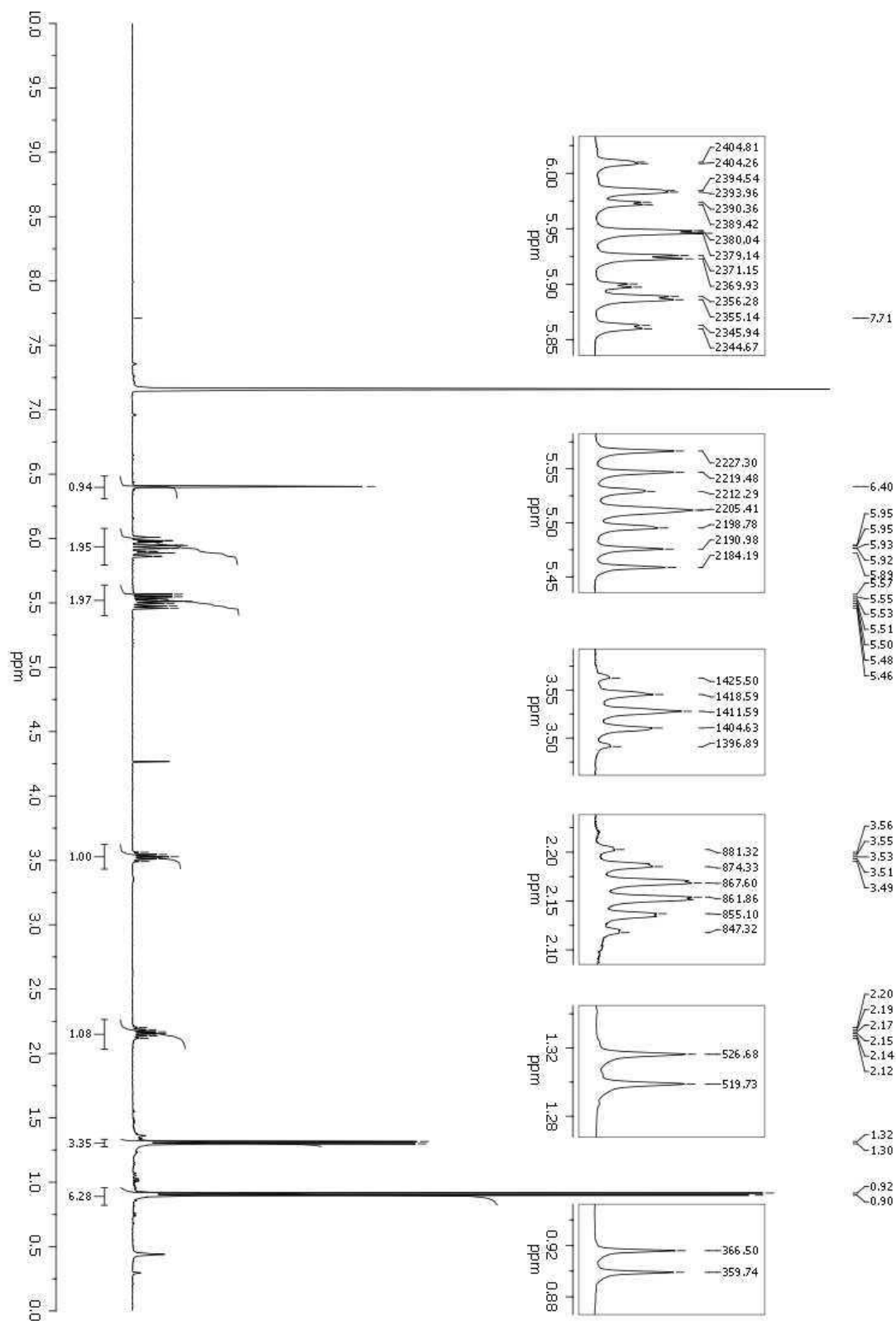


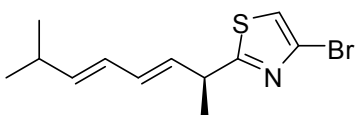




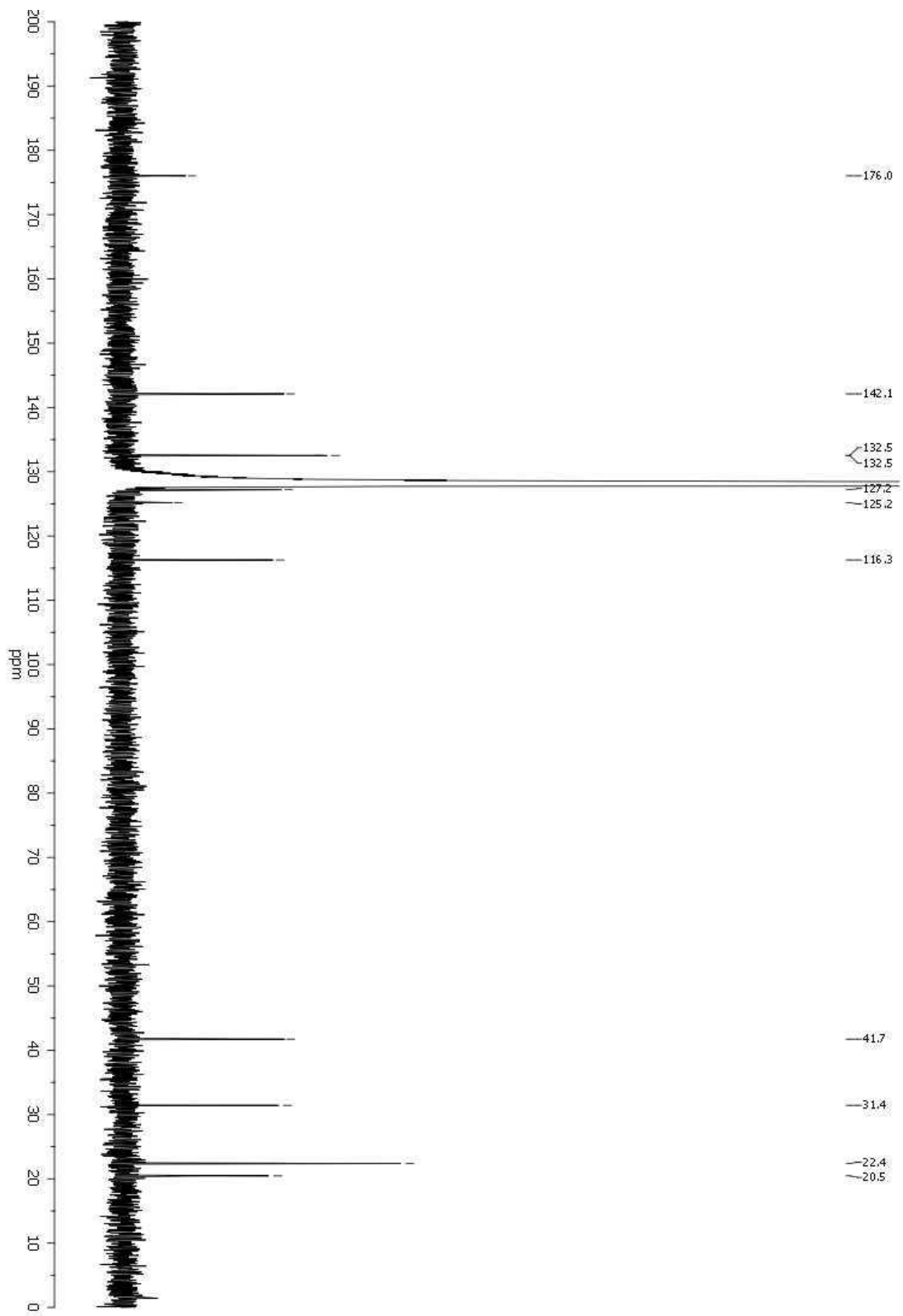


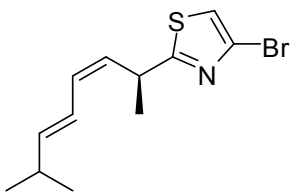
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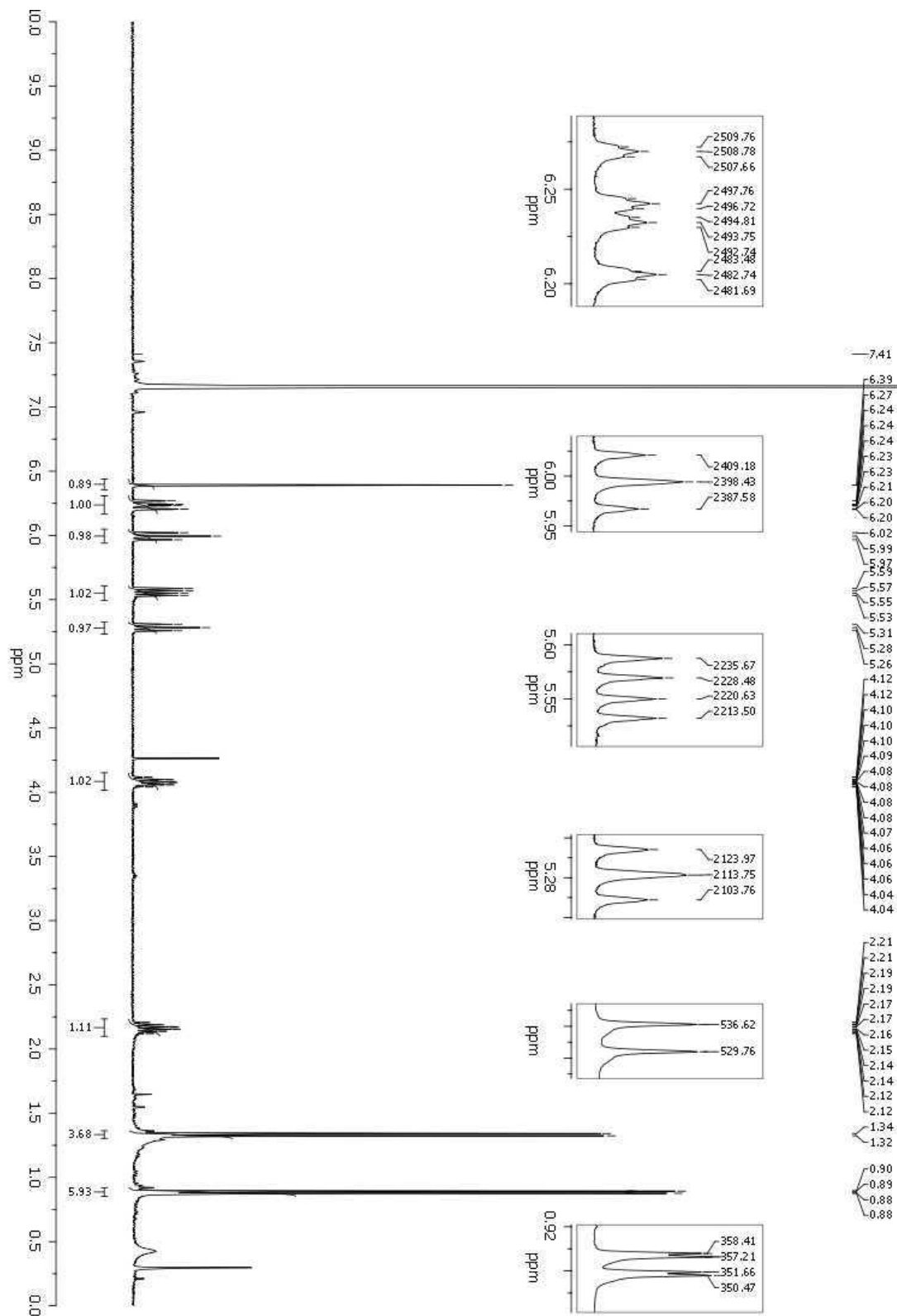


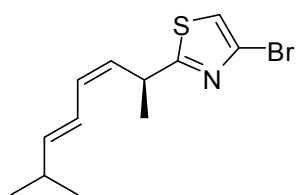
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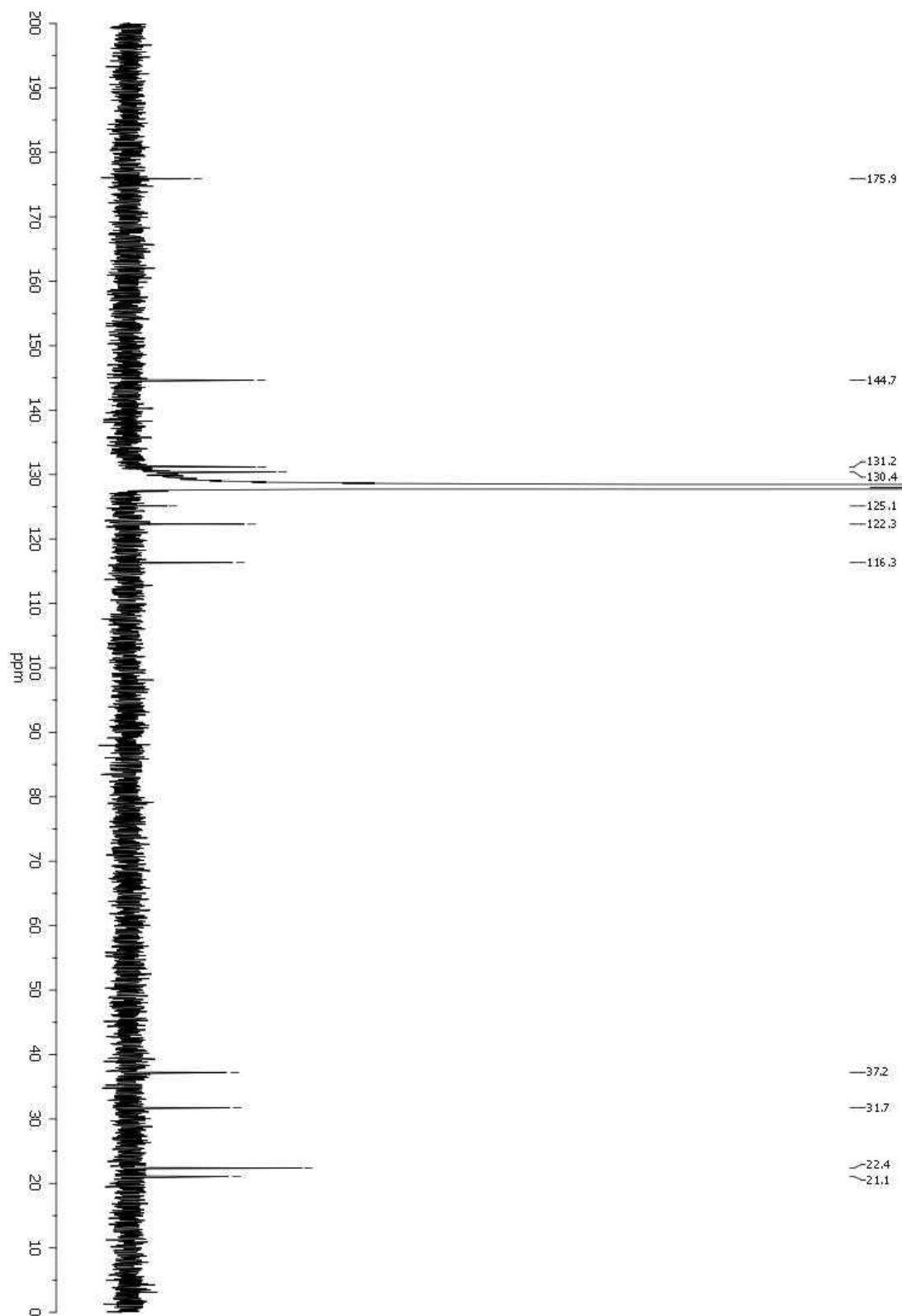


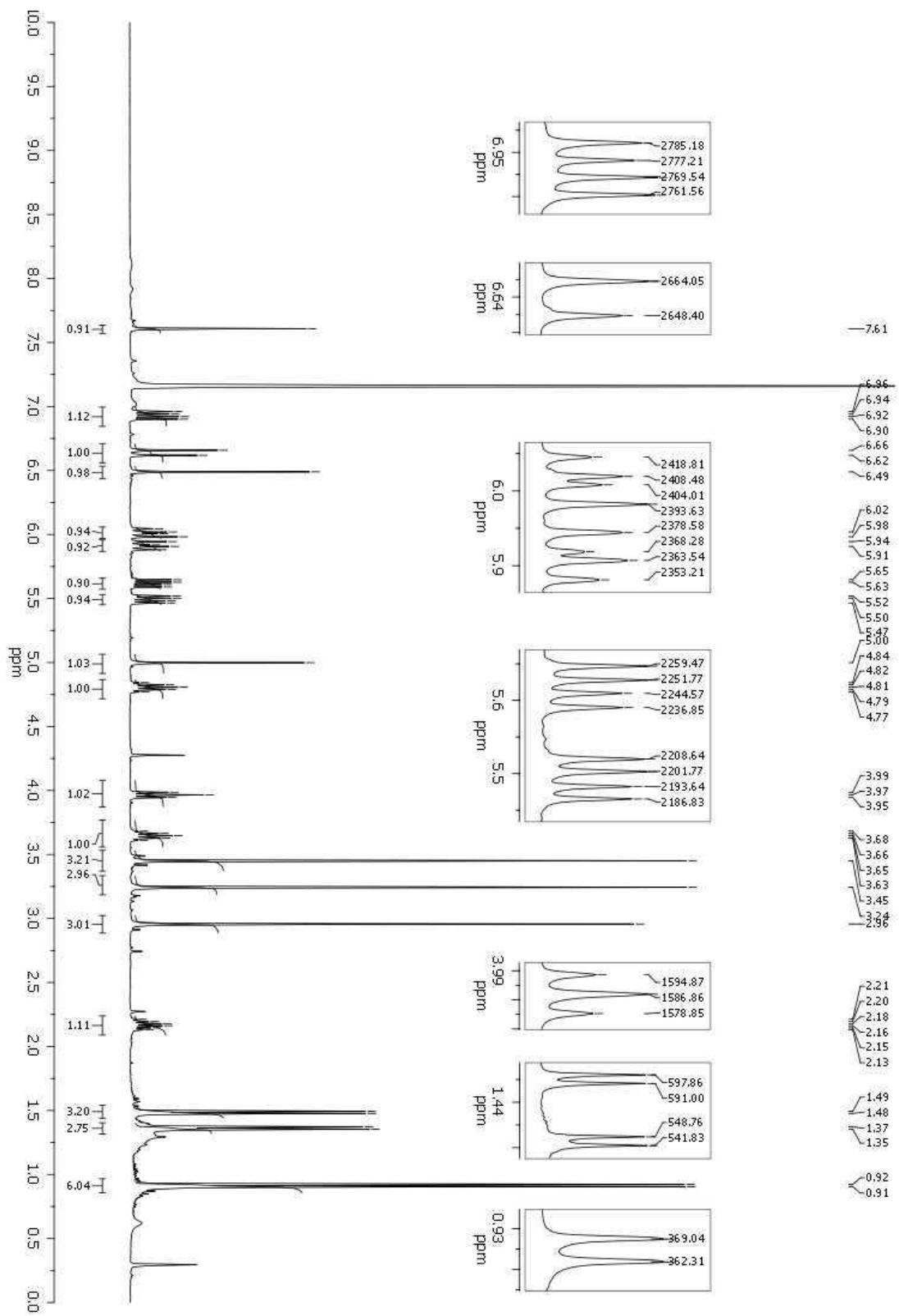
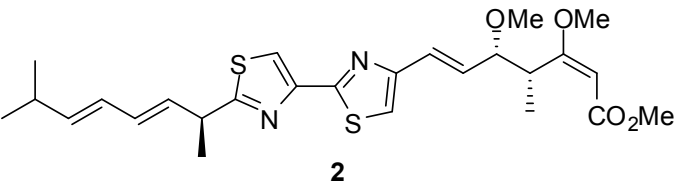
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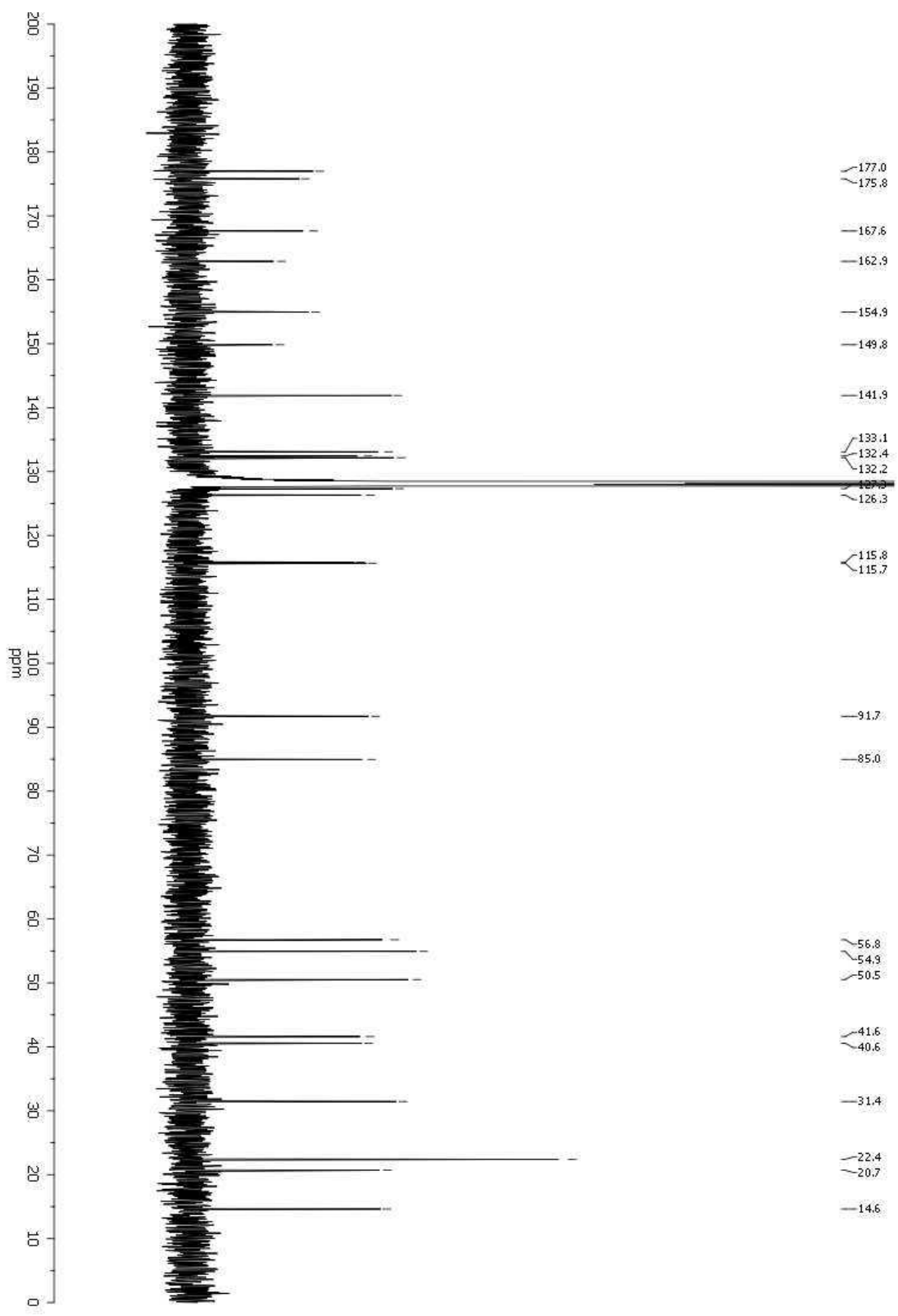
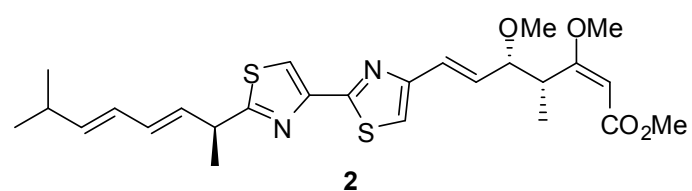


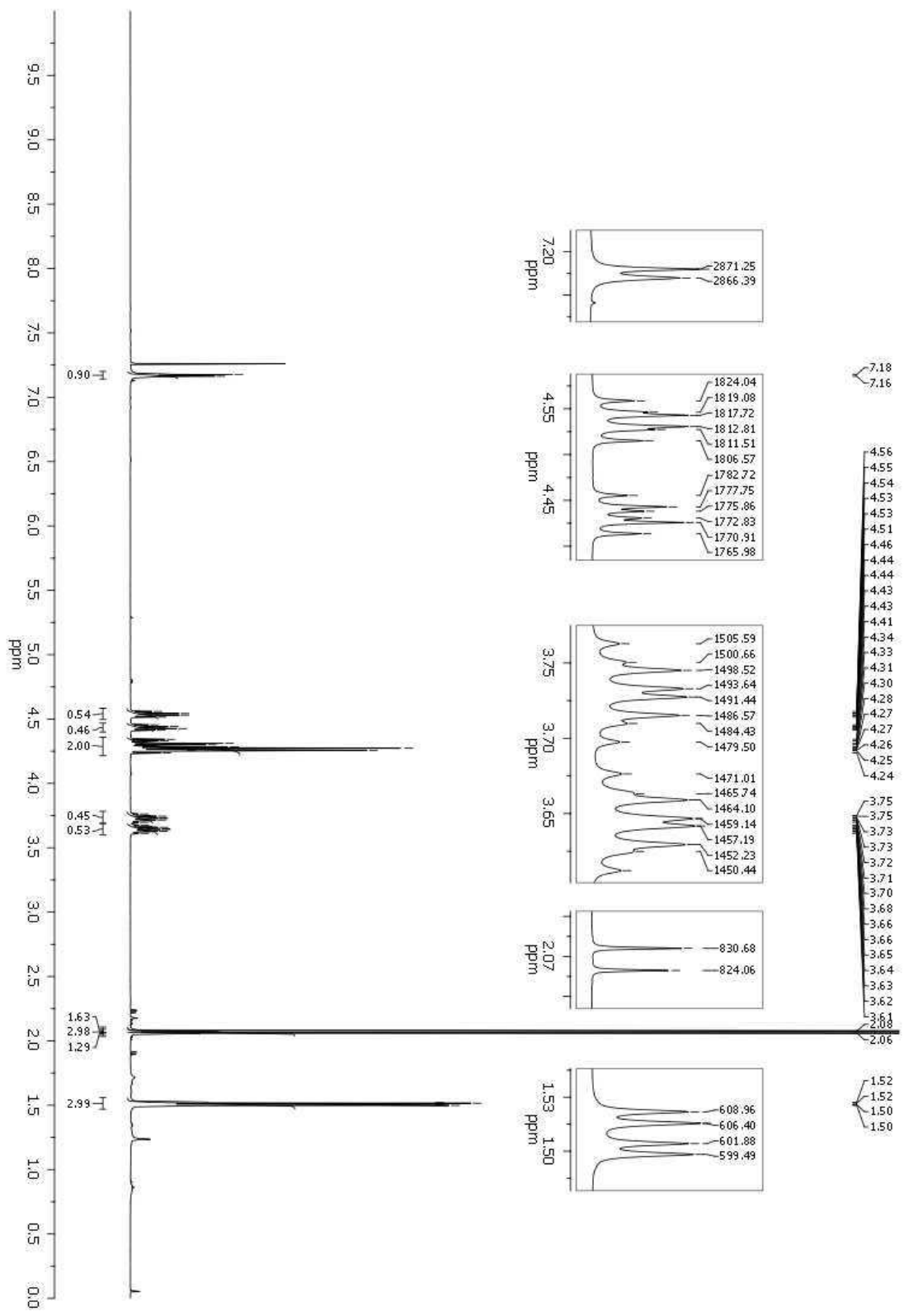
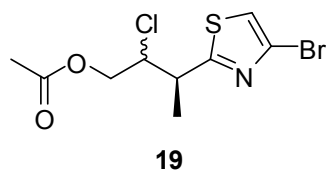


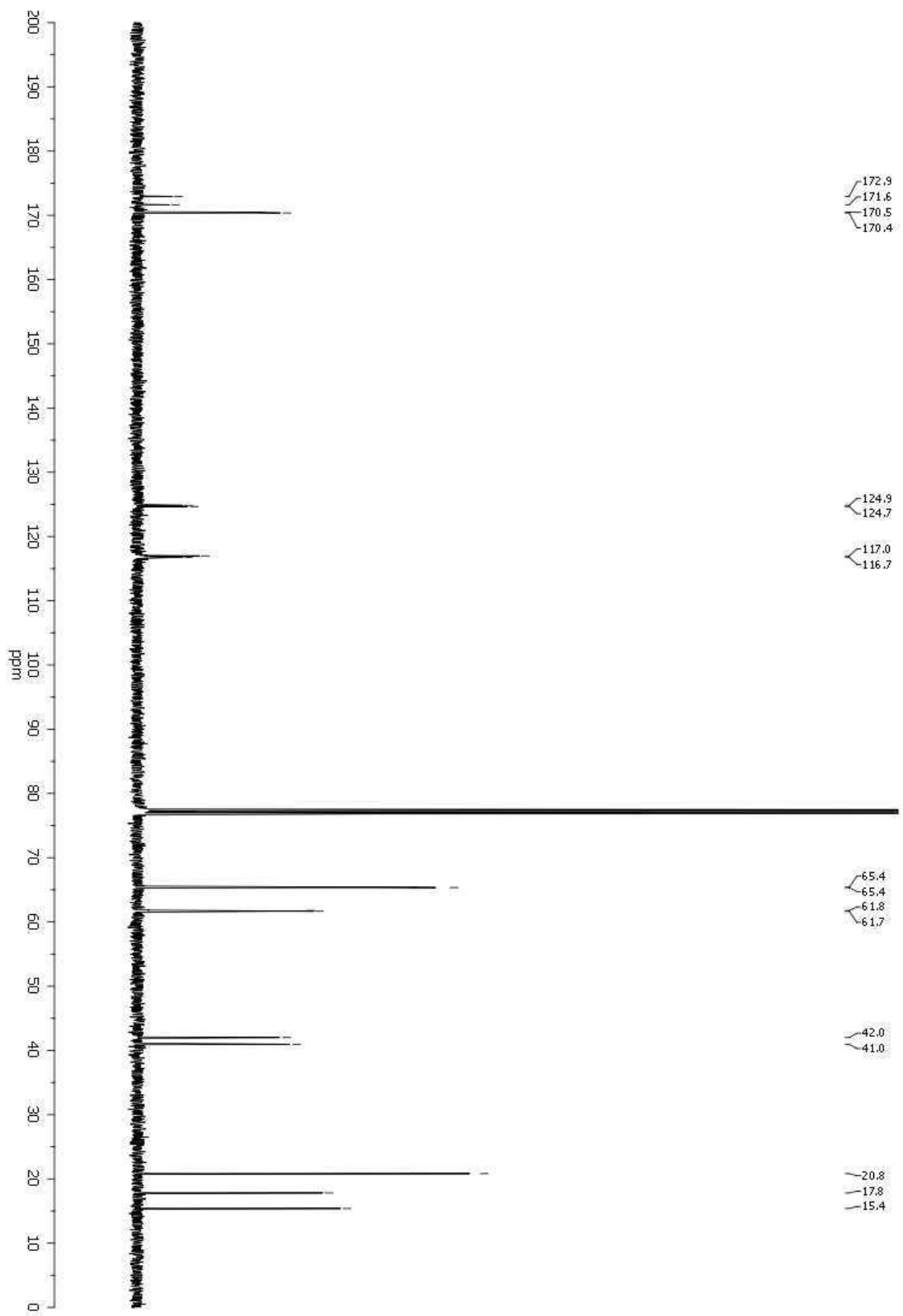
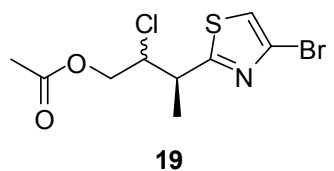
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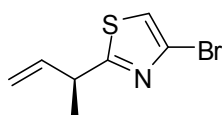




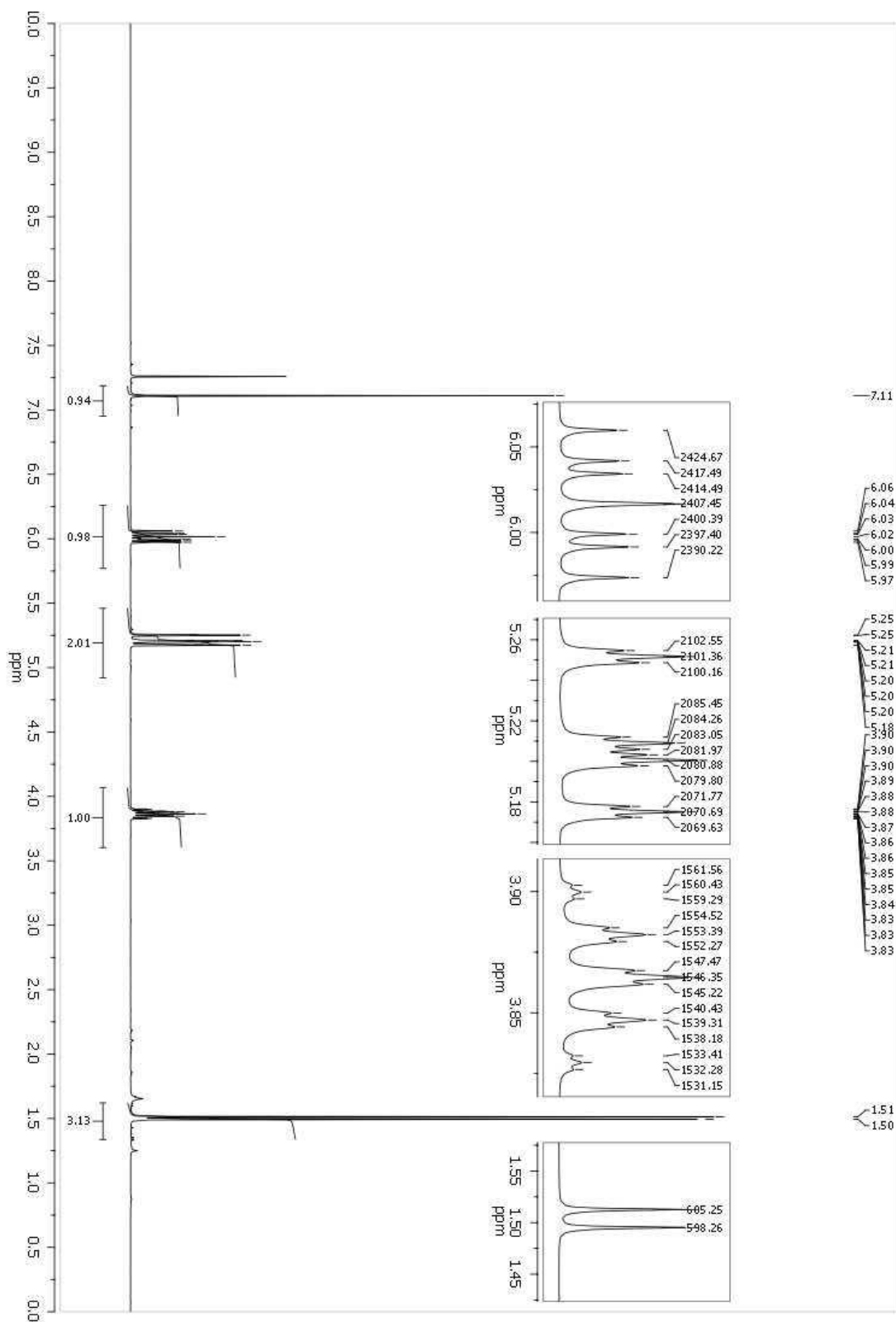


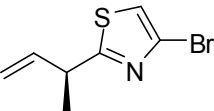




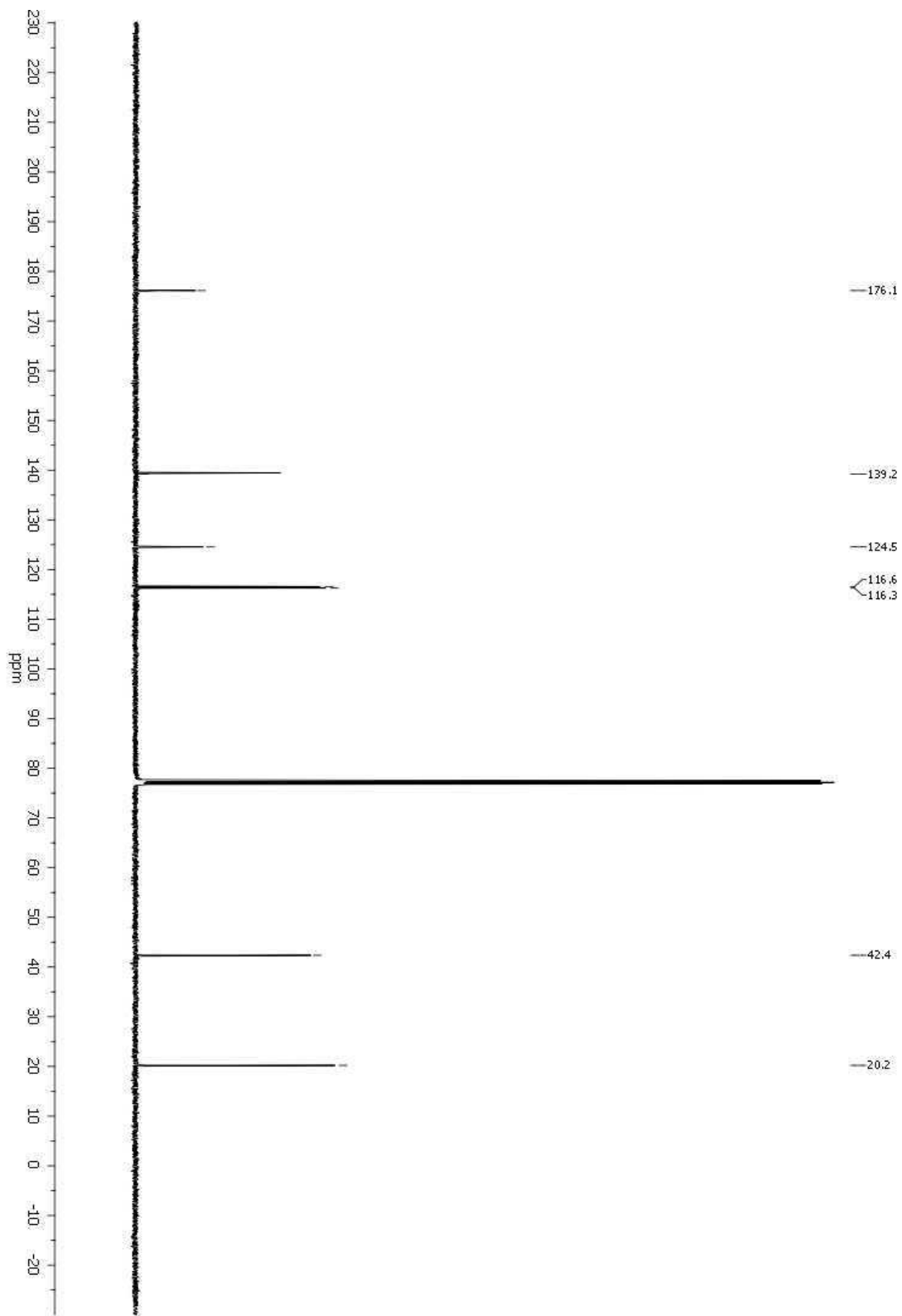


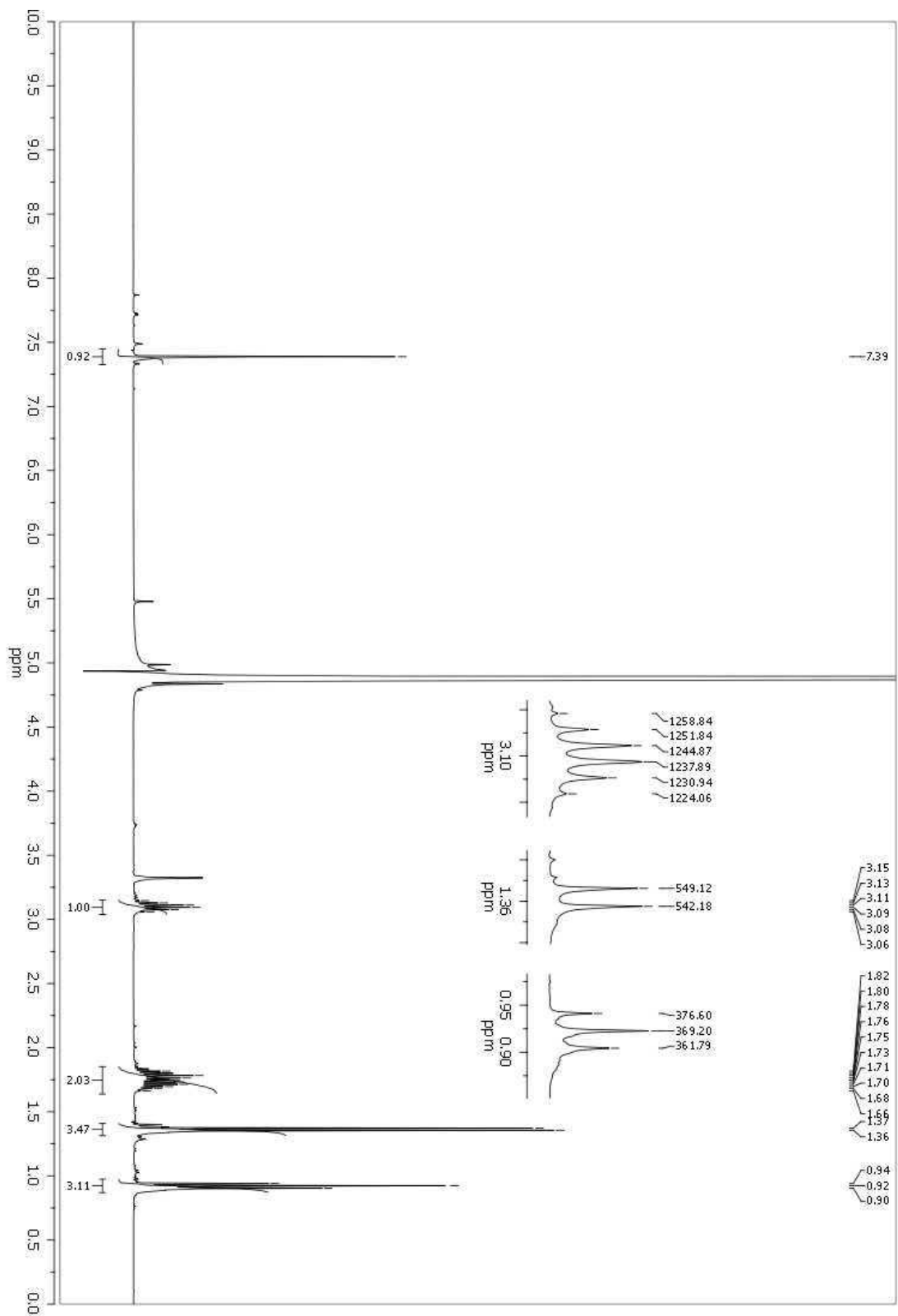
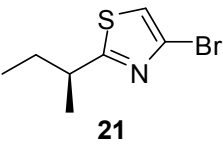
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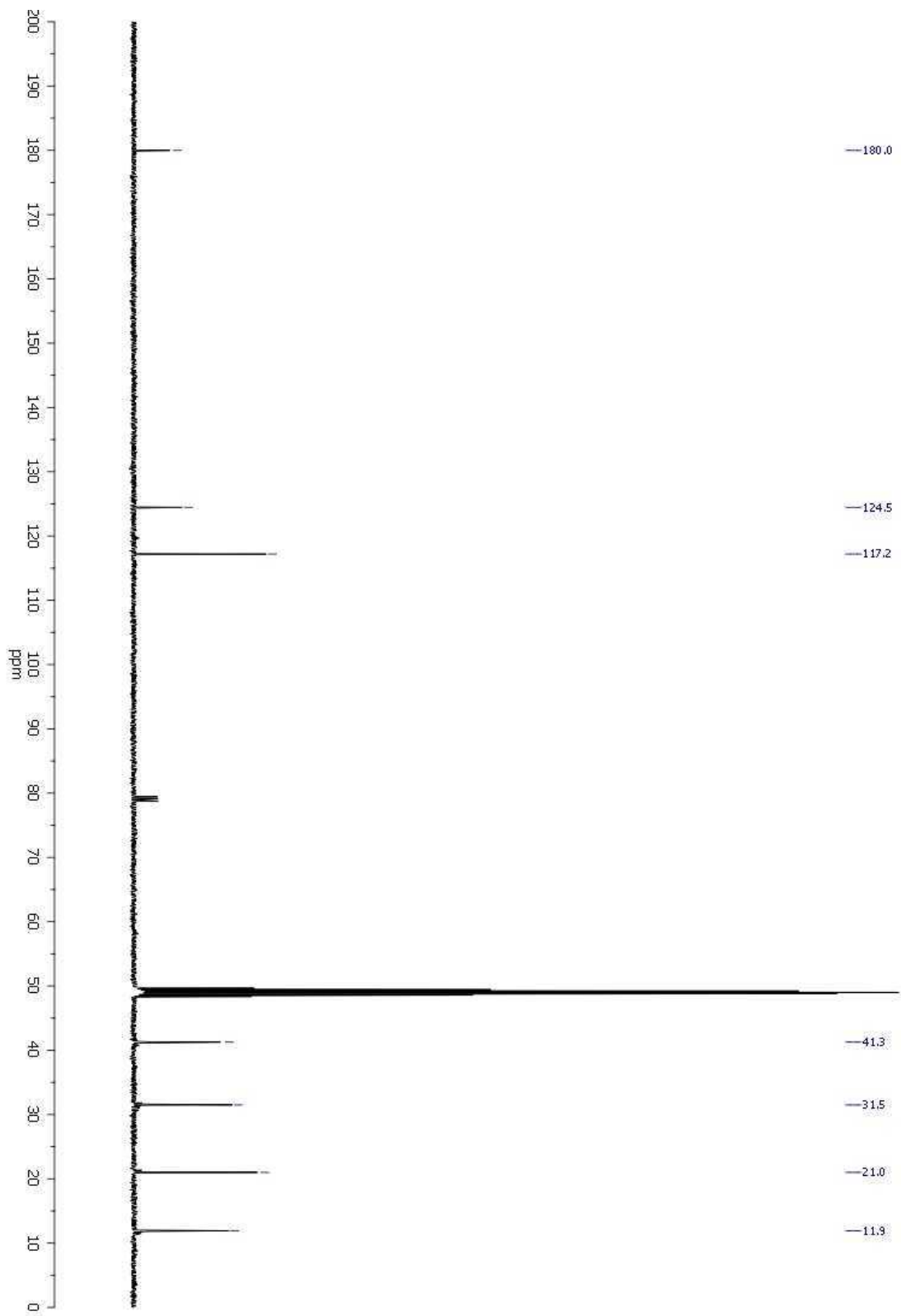
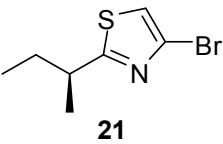


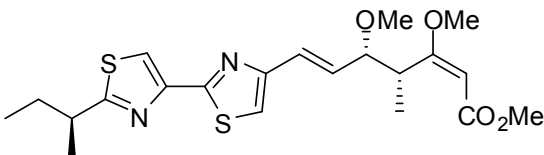


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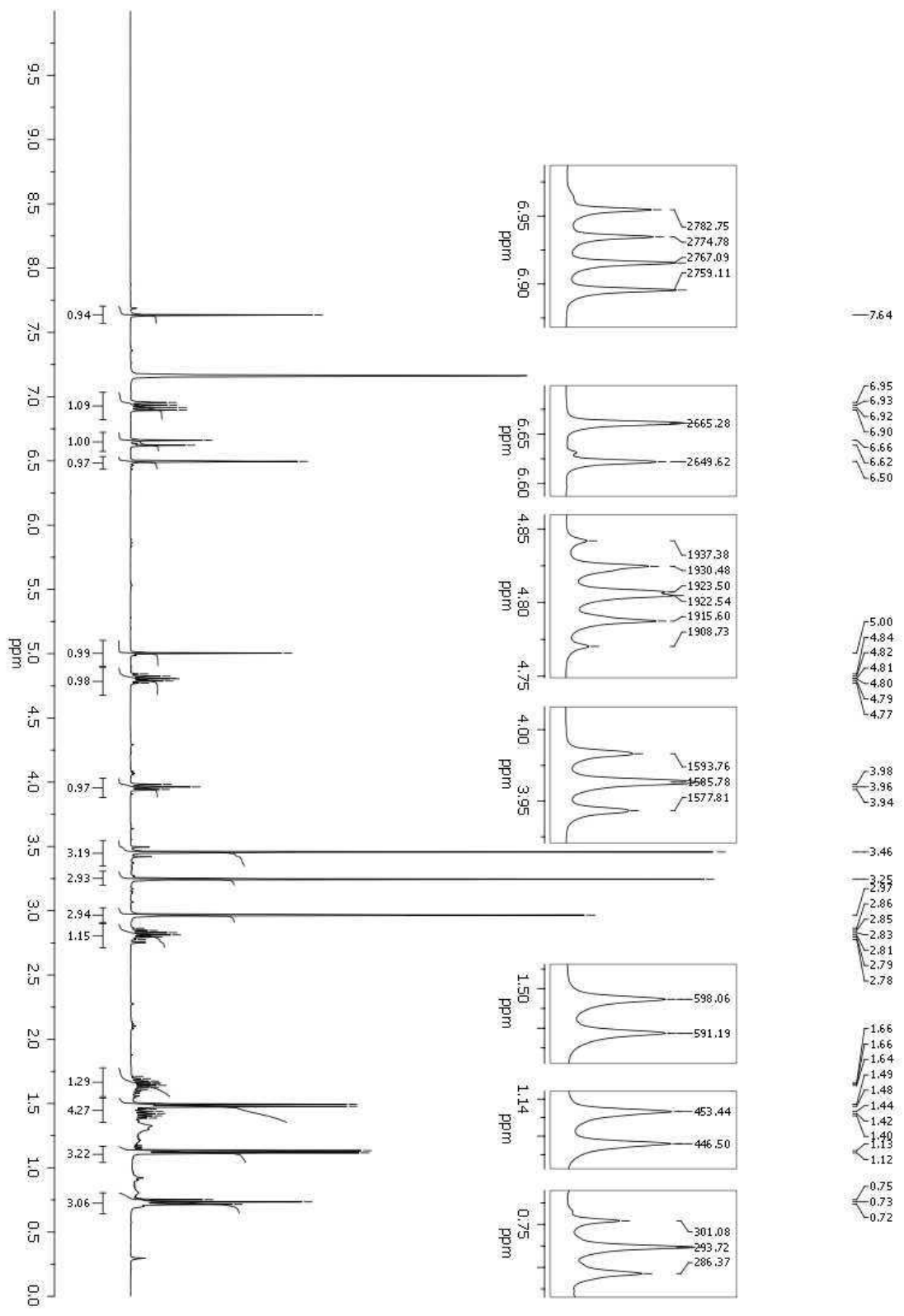


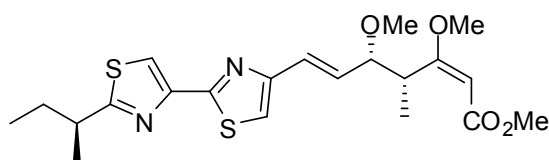




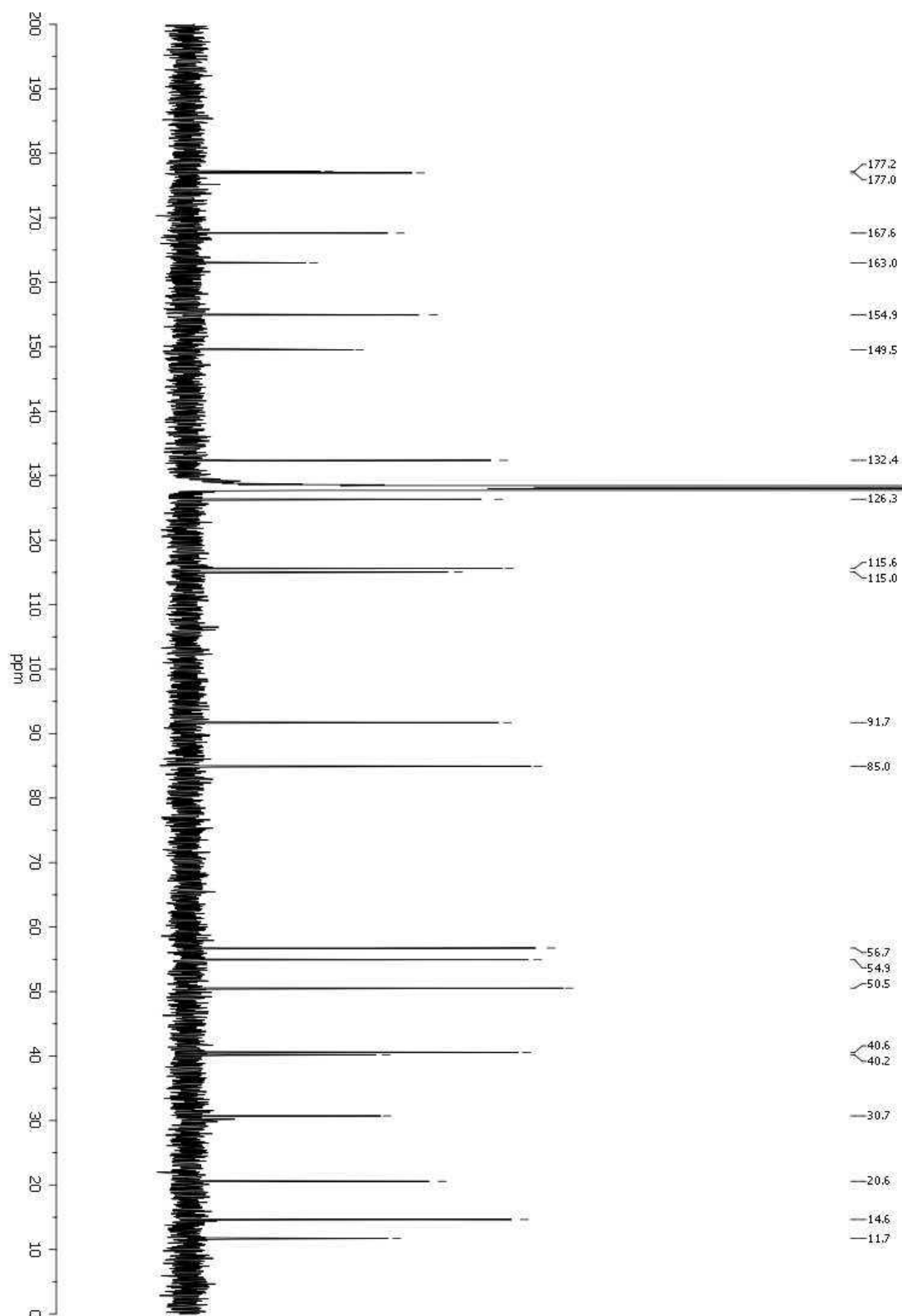


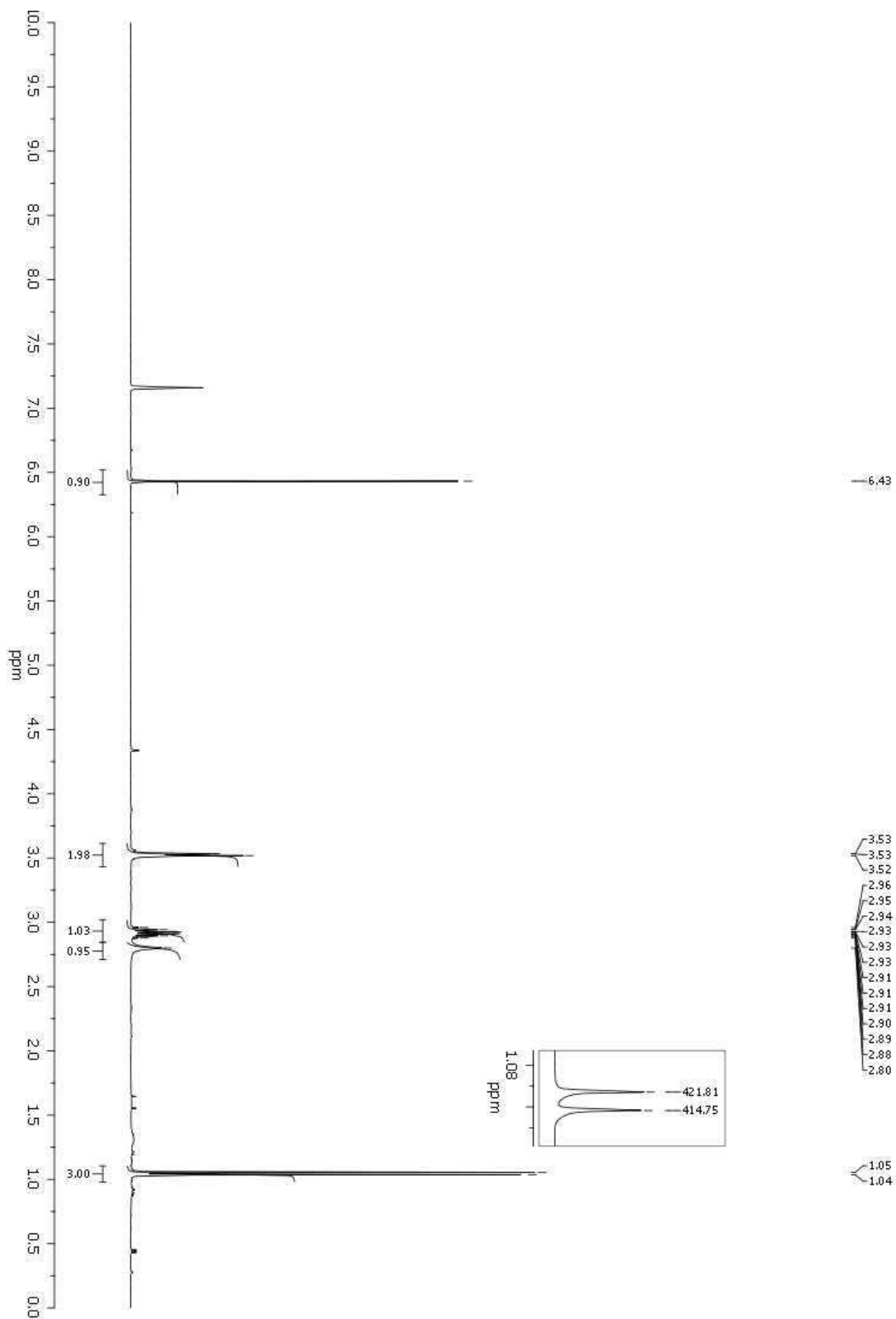
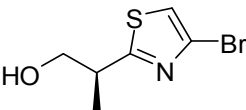
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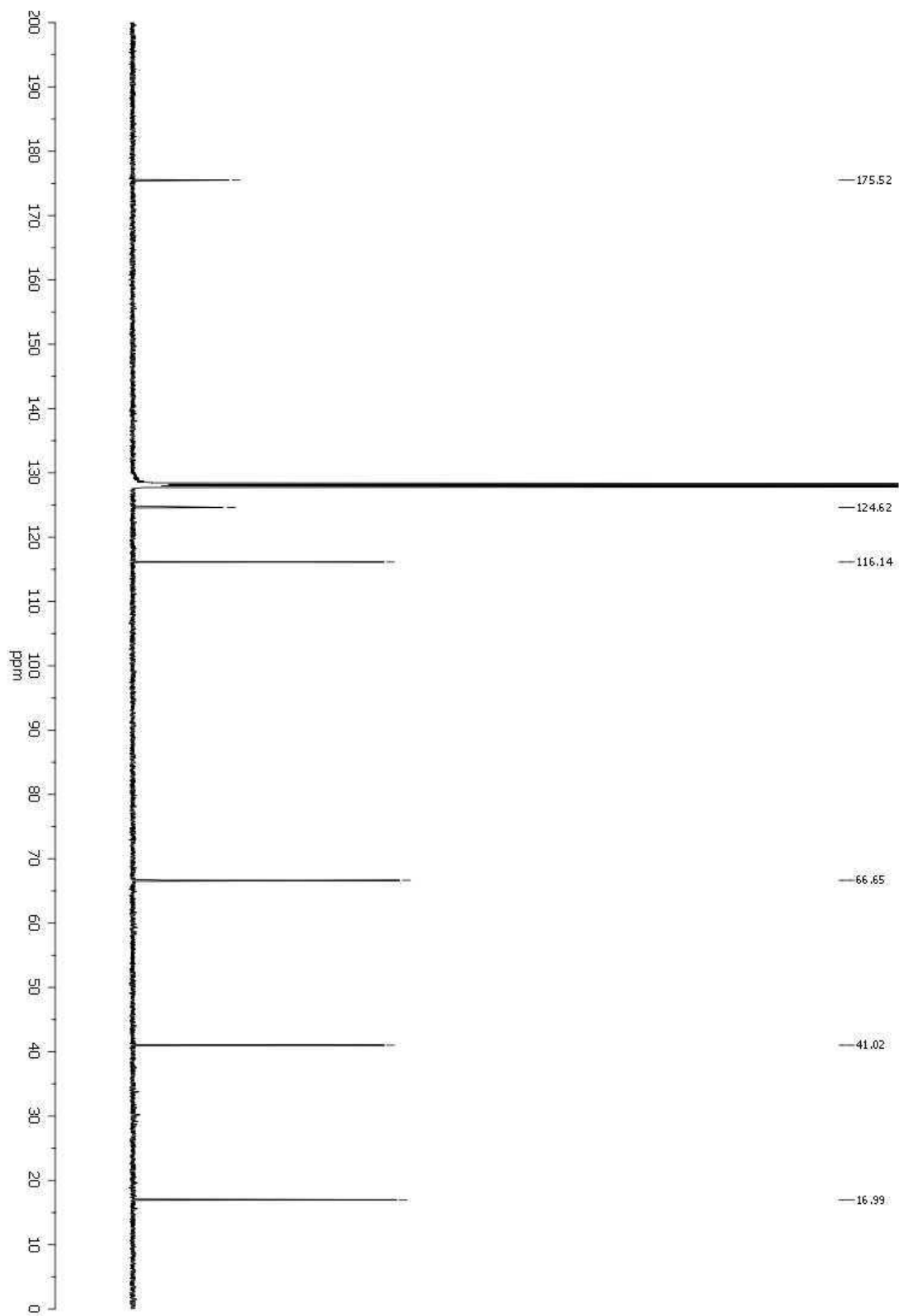
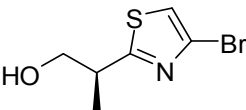


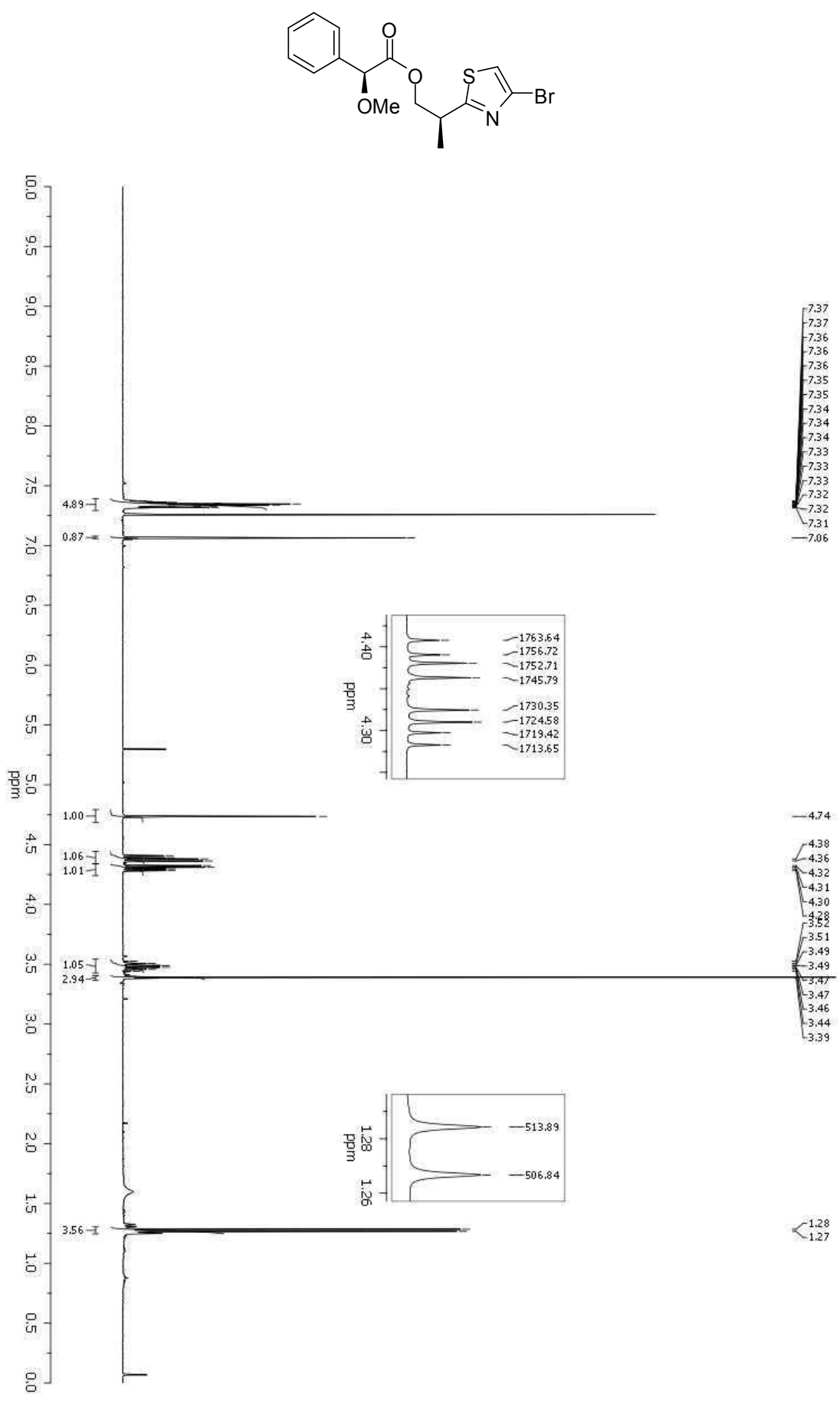


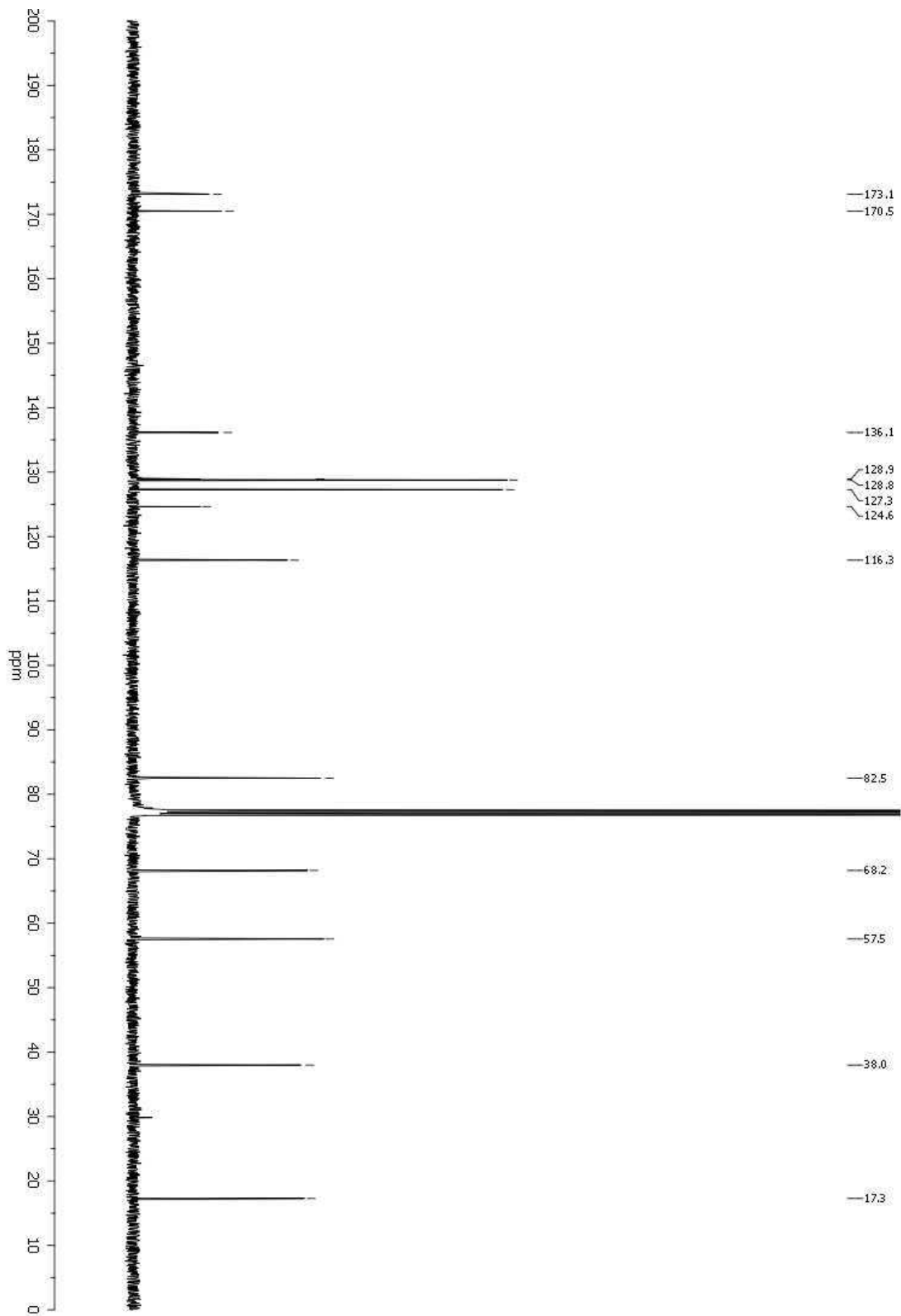
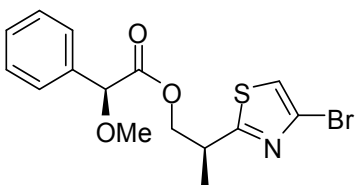
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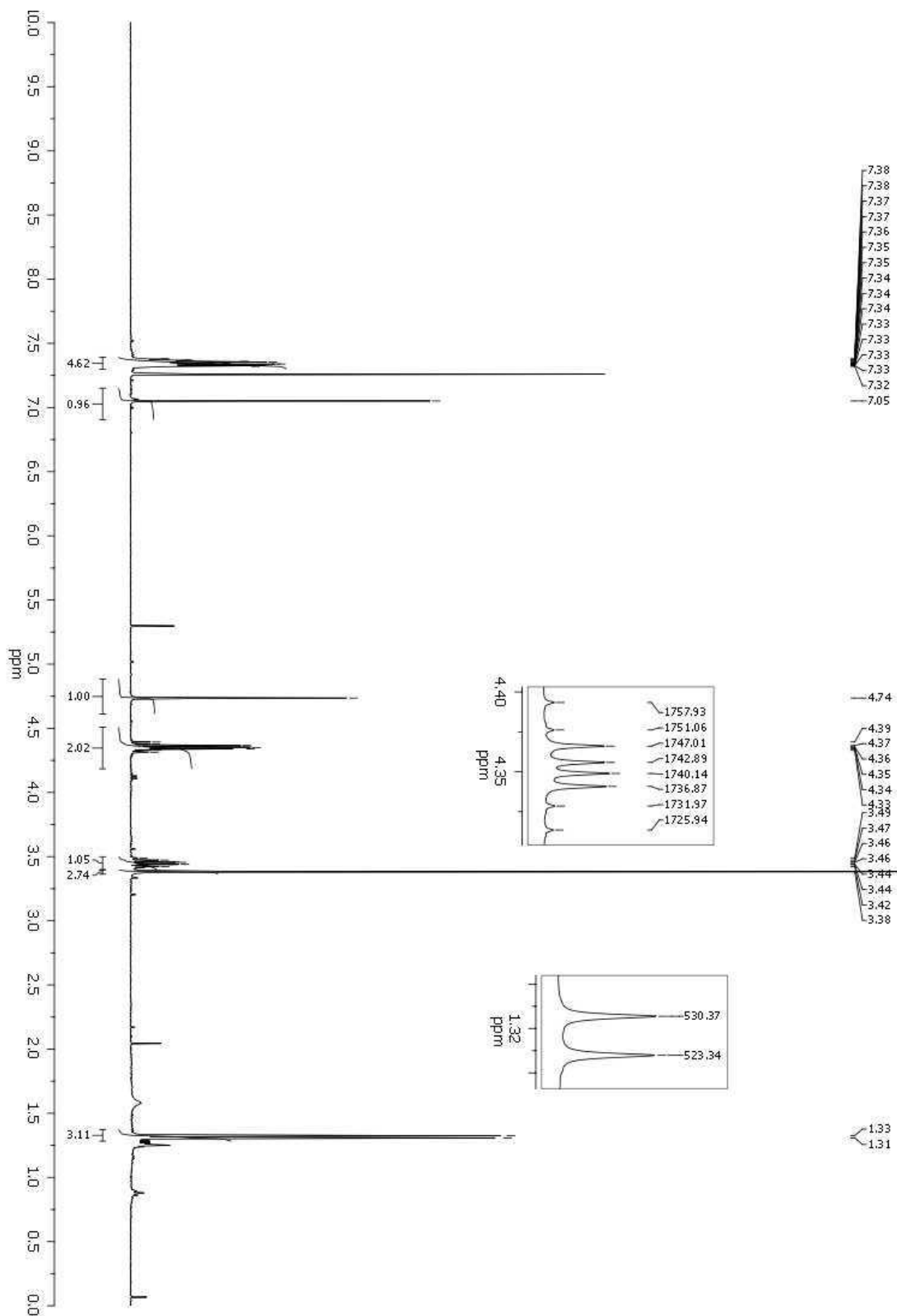
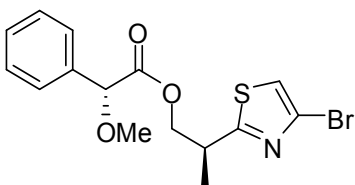


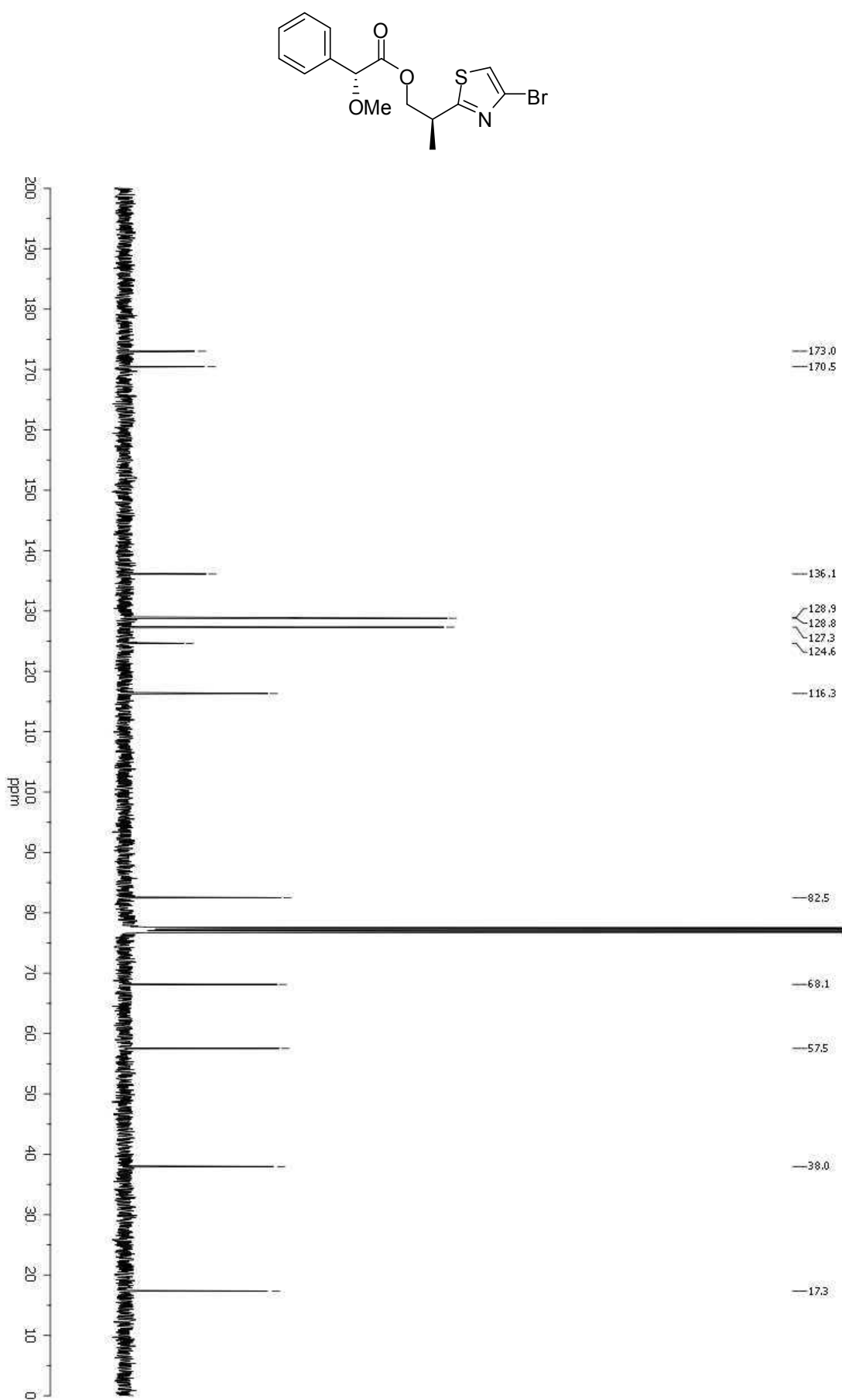


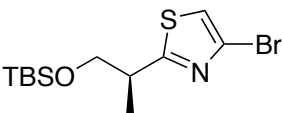




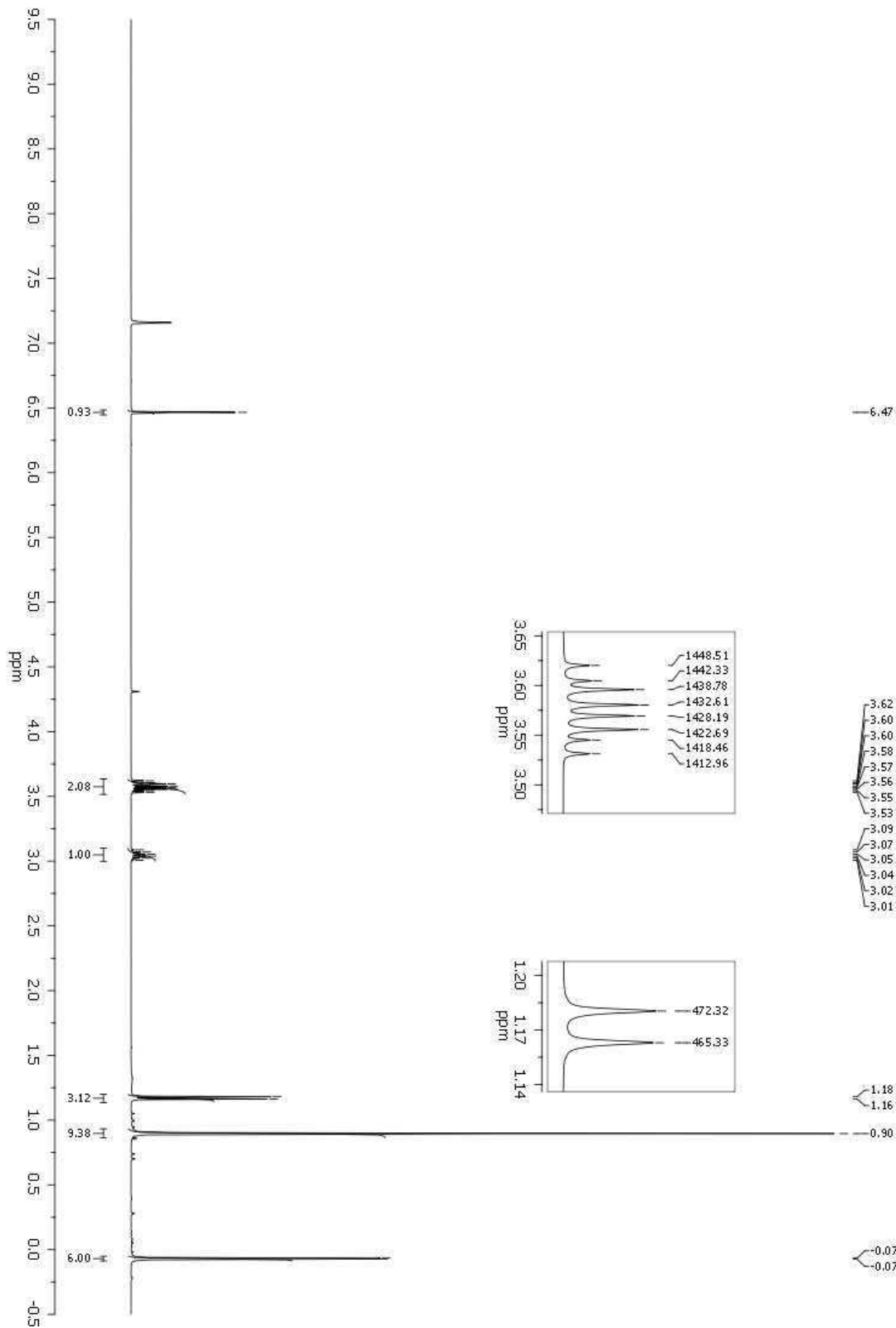


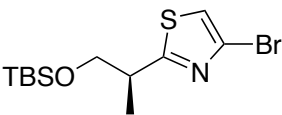






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