Angewandte Chemie
Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Supporting Information

for

Angew. Chem. Int. Ed. 200461327

69451 Weinheim, Germany

A Stereodivergent Synthesis of Virantmycin via an Enzyme-Mediated Diester Desymmetrization and a Highly Hindered Aryl Amination

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Dimethyl 2-(3,4-dimethyl-3-pentenyl)-2-methoxymethylmalonate (2). NaH (981 mg, 60% in mineral oil, 25 mmol) was washed with hexanes, then suspended in 20 mL of DMF. Dimethyl malonate (2.95 g, 22.3 mmol) was added via dropping funnel over 5 min. The reaction mixture was stirred for 5 min, during which time it became nearly clear. A solution of 5-iodo-2,3-dimethyl-2-pentene[1] (5.00 g, 22.3 mmol) in 10 mL of DMF was added via cannula. The resulting mixture was stirred for 3 d, then partitioned between ether and water. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo.

NaH (1.00 g, 60% in mineral oil, 25 mmol) was washed with hexanes, then suspended in 30 mL of THF. A solution of the above monoalkylation product in 10 mL of THF was added dropwise via cannula. The reaction mixture was stirred for 5 min, during which time it became nearly clear. Chloromethyl methyl ether (2.03 mL, 26.7 mmol) was added, and the resulting white heterogeneous mixture was stirred for 1 h, then partitioned between ether and water. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 20:1 to 9:1) afforded 3.92 g (65% over 2 steps) of **2**. Mp 61-63 ^{o}C (from pentane); IR (film) 1728 cm^{-1}; ^{1}H NMR (400 MHz) δ 3.80 (s, 2 H), 3.74 (s, 6 H), 3.36 (s, 3 H), 2.05-2.00 (m, 2 H), 1.92-1.88 (m, 2 H), 1.63 (s, 6 H), 1.62 (s, 3 H); ^{13}C NMR (100 MHz) δ 170.6 (C), 126.5 (C), 124.8 (C), 72.5 (CH_2), 59.4 (CH_3), 58.5 (C), 52.4 (CH_3), 29.3 (CH_2), 29.1 (CH_2), 20.5 (CH_3), 19.8 (CH_3), 18.2 (CH_3); MS (EI) *m/z* 272 (3), 240 (5), 209 (7), 145 (77), 143 (100); HRMS calcd for $C_{14}H_{24}O_5$: 272.1624. Found: 272.1632. Anal. calcd for $C_{14}H_{24}O_5$: C, 61.74; H, 8.88%. Found: C, 61.59; H, 9.06%.

(*S*)-2-(3,4-Dimethyl-3-pentenyl)-2-methoxymethylmalonic acid monomethyl ester (3). Diester **2** (26.4 g, 96.9 mmol) was dissolved in 1.32 L of DMSO, and 5.3 L of pH 8.0 phosphate buffer were added. To the resulting cloudy white suspension was added a solution of porcine liver esterase (1.3 g, 41 units/mg) dissolved in a minimum amount of pH 8.0 phosphate buffer. The mixture was stirred for 3 d, whereupon a second solution of PLE (1.3 g) in phosphate buffer was added. The mixture was stirred for another 2 d, whereupon a third and final solution of PLE (0.5 g) in phosphate buffer was added. The mixture was stirred another 2 d, during which time it became nearly homogeneous. The mixture was acidified with 10% HCl, and extracted four times with ether. The combined organic layers were washed with brine, dried, and concentrated in vacuo to afford 23.4 g of (+)-**3** as a colorless oil which solidified upon standing. NMR analysis revealed the presence of a small amount of DMSO (calculated yield: 22.2 g, 89%). NMR analysis in the presence of (*S*)-(-)-methylbenzylamine revealed the product to be 95% ee. $[\alpha]_D^{20}$ = +8.8 (*c* 0.26, $CHCl_3$); IR (film) 1746, 1717 cm^{-1}; ^1H NMR (400 MHz) δ 3.82 (s, 3 H), 3.81 (m, 2 H), 3.36 (s, 3 H), 2.02-1.88 (m, 4 H), 1.62 (s, 3 H), 1.61 (s, 3 H), 1.61 (s, 3 H); ^{13}C NMR (100 MHz) δ 173.6 (C), 173.2 (C), 125.8 (C), 125.5 (C), 74.6 (CH_2), 59.4 (CH_3), 58.5 (C), 53.0 (CH_3), 30.5 (CH_2), 29.4 (CH_2), 20.5 (CH_3), 19.8 (CH_3), 18.2 (CH_3); MS (EI) *m/z* 258 (0.6), 240 (4), 143 (28), 81 (73), 55 (100); HRMS calcd for $C_{13}H_{22}O_5$: 258.1467. Found: 258.1449. Anal. calcd for $C_{13}H_{22}O_5$: C, 60.45; H, 8.58%. Found: C, 60.31; H, 8.62%.

(*R*)-2-Fluorocarbonyl-2-methoxymethyl-5,6-dimethylhept-5-enoic acid methyl ester (4). Half ester (+)-**3** (4.14 g, 16.0 mmol) was dissolved in 150 mL of dichloromethane. The solution was cooled to 0 °C. Pyridine (1.3 mL, 16 mmol) was added, followed by cyanuric fluoride[2] (2.4 mL, 28 mmol). The reaction mixture was stirred at 0 °C for 1 h, then partitioned between saturated NH_4Cl solution and dichloromethane. The aqueous layer was washed with dichloromethane, and the combined organic fractions were dried and concentrated in vacuo. The crude product was adsorbed onto silica gel, transferred to the top of a chromatography column, and eluted (hexanes-ethyl acetate 20:1 to 9:1) to afford 2.98 g (71%) of **4** as a colorless oil. IR (film) 1849, 1747 cm^{-1}; ^1H NMR (300 MHz) δ 3.80 (br s, 5 H), 3.38 (s, 3 H), 2.13-1.92 (m, 4 H), 1.63 (s, 9 H); ^{13}C NMR (75 MHz) δ 168.2 (d, $^3J_{C\text{-}F}$ = 1.8 Hz, C), 159.9 (d, $^1J_{C\text{-}F}$ = 365.8 Hz, CF), 125.6 (C), 125.6 (C), 72.0 (CH_2), 59.4 (CH_3), 58.7 (d, $^2J_{C\text{-}F}$ = 43.7 Hz, C), 52.9 (CH_3), 29.7 (CH_2), 29.0 (CH_2), 20.5 (CH_3), 19.8 (CH_3), 18.2 (CH_3); MS (EI) *m/z* 260 (4), 121 (5), 96 (100); HRMS calcd for $C_{13}H_{21}FO_4$: 260.1424. Found: 260.1441.

(*S*)-2-Fluorocarbonyl-2-methoxymethyl-5,6-dimethylhept-5-enoic acid 2-trimethylsilylethyl ester (5). Acid (+)-**3** (2.00 g, 7.74 mmol), 1,3-dicyclohexylcarbodiimide (2.08 g, 10.1 mmol), and *N*,*N*-dimethylaminopyridine (946 mg, 7.74 mmol) were suspended in 40 mL of dichloromethane. 2-(Trimethylsilyl)ethanol (1.24 mL, 8.65 mmol) was added and the mixture was stirred for 3 d, then cooled to -78 °C. The reaction mixture was filtered, and the filtrate was concentrated in vacuo. Chromatography (hexanes-ethyl acetate 20:1 to 9:1) afforded 2.137 g (77%) of the corresponding mixed diester.

The diester was redissolved in 30 mL of methanol. Aqueous KOH (10%, 15 mL, 27 mmol) was added and the mixture was heated at 45 °C for 15 h. The reaction mixture was then partitioned between 40 mL of ether and 40 mL of 10% NaOH solution. The aqueous layer was washed with 20 mL of ether, and the combined organic fractions were washed with 10% HCl solution, dried, and concentrated in vacuo to afford 1.56 g (70%) of a 4 : 1 mixture of the corresponding trimethylsilyl half ester and 2-(trimethylsilyl)-ethanol. The basic aqueous layer was acidified with HCl, and extracted with two portions of dichloromethane to afford 386 mg of the crude half ester **3**.

The crude trimethylsilyl half ester was dissolved in 50 mL of dichloromethane. The solution was cooled to 0 °C, and pyridine (0.37 mL, 4.6 mmol) and cyanuric fluoride[2] (0.68 mL, 8.0 mmol) were added. The mixture was stirred for 1 h at 0 °C, then was partitioned between saturated NH_4Cl solution and dichloromethane. The aqueous layer was washed with dichloromethane, and the combined organic layers were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 20:1) afforded 1.08 g (75%) of **5** as a colorless oil. IR (film) 1848, 1738 cm^{-1}; ^{1}H NMR (300 MHz) δ 4.28 (br t, *J* = 8.7 Hz, 2 H), 3.82 (d, *J* = 9.2 Hz, 1 H), 3.78 (d, *J* = 9.7 Hz, 1 H), 3.39 (s, 3 H), 2.09-1.94 (m, 4 H), 1.64 (s, 9 H), 1.04 (br t, *J* = 8.7 Hz, 2 H), 0.06 (s, 9 H); ^{13}C NMR (75 MHz) δ 167.9 (d, $^3J_{C\text{-}F}$ = 2.4 Hz), 160.1 (d, $^1J_{C\text{-}F}$ = 365.8 Hz), 125.8, 125.5, 72.0, 64.7, 59.5, 58.8 (d, $^2J_{C\text{-}F}$ = 43.7 Hz), 29.6, 29.0, 20.5, 19.8, 18.3, 17.3, -1.6; MS (EI) *m/z* 299 (37), 261 (58), 155 (67), 141 (70), 96 (95); HRMS calcd for $C_{17}H_{31}FO_4Si$: 346.1976. Found: 346.1973.

(*R*)-4-(2-Bromo-5-methoxycarbonylphenyl)-2-(3,4-dimethylpent-3-enyl)-2-methoxymethyl-3-oxo-pentanedioic acid 5-methyl ester 1-(2-trimethylsilylethyl) ester (7). 1,1,1,3,3,3-Hexamethyldisilazane (5.32 mL, 25.1 mmol) was dissolved in 80 mL of ether.

The solution was cooled to 0 °C. *n*-Butyllithium (9.84 mL, 2.44 M, 24.0 mmol) was slowly added. The solution was removed from the ice bath, and allowed to warm to room temperature for 30 min.

Diester **6** (6.89 g, 24.0 mmol) was dissolved in 45 mL of ether, and cooled to 0 °C. The LiHMDS solution was added via cannula, resulting in the immediate precipitation of the lithium salt of **6** as a bright yellow solid. The mixture was stirred for 10 min at 0 °C, whereupon a solution of **5** (4.16 g, 12.0 mmol) in 35 mL of ether was added via cannula. The mixture was stirred for 1 h at 0 °C, then removed from the ice bath and stirred at room temperature for 20 h.

The reaction mixture was partitioned between ether and saturated NH_4Cl. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 6:1) afforded 4.62 g (63%) of **7** as a colorless oil. NMR analysis indicated the presence of a 1:1 mixture of diastereomers. IR (film) 1727 cm^{-1}; ^1H NMR (300 MHz) δ 8.32 (d, *J* = 2.0 Hz, 0.5 H) and 8.15 (d, *J* = 2.0 Hz, 0.5 H), 7.83 (dd, *J* = 8.7, 2.0 Hz, 1 H), 7.66 (d, *J* = 8.7 Hz, 1 H), 5.87 (s, 0.5 H) and 5.81 (s, 0.5 H), 4.12-3.63 (m, 4 H), 3.89 (s, 3 H), 3.72 (s, 1.5 H) and 3.71 (s, 1.5 H), 3.32 (s, 1.5 H) and 3.03 (s, 1.5 H), 2.08-1.66 (m, 4 H), 1.65-1.51 (m, 9 H), 1.00-0.62 (m, 2 H), -0.01 (s, 4.5 H) and -0.02 (s, 4.5 H); ^{13}C NMR (75 MHz; where separate signals for the respective carbon atoms of the two diastereomers were resolved, they are listed as δ of 1st signal/δ of 2nd signal) δ 199.0/198.4, 169.6/169.4, 167.5/167.4, 165.9, 132.9/132.9, 132.8/132.6, 131.8/131.7, 130.4, 130.2/130.2, 129.6/129.5, 126.3/126.3, 124.9/124.9, 71.4, 65.1/65.0, 64.1, 59.1/58.7, 59.0/58.6, 52.9, 52.3, 28.9, 28.7, 20.5/20.5, 19.8/19.7, 18.2/18.1, 17.0/16.9, -1.7/-1.7; MS (EI) *m/z* 586 (0.5), 584 (0.5), 555 (1), 553 (1), 459 (30), 457 (30), 427 (31), 425 (30), 360 (38), 358 (34), 345 (47), 96 (100); HRMS calcd for $C_{19}H_{26}BrO_6Si$ (M^+ - CH_3CO_2 - C_7H_{13} + H): 457.0682. Found: 457.0685.

(*R*)-4-Bromo-3-[3-methoxymethyl-6,7-dimethyl-2-oxo-3-(2-trimethylsilyl-ethoxycarbonyl)oct-6-enyl]benzoic acid methyl ester (8). Triester **7** (4.62, 7.52 mmol) was dissolved in 70 mL of DMSO in a 100 mL round bottom flask. Aqueous NaCl (10%, 13 mL) was added, and a condenser was attached to the flask, which was then immersed in a 100 °C oil bath. The temperature was raised to 125 °C and the mixture was stirred for 20 h. The reaction mixture was cooled to room temperature, and partitioned between ether and water. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 9:1) afforded 3.71 g (78%) of **8** as a colorless oil which solidified upon standing. $[\alpha]_D^{20}$ = -8.0 (*c* 3.77, $CHCl_3$); IR (film) 1726 cm^{-1}; ^1H NMR (300 MHz) δ 7.82 (d, *J* = 1.5 Hz, 1 H), 7.79 (dd, *J* = 8.2, 1.5 Hz, 1 H), 7.65 (d, *J* = 8.2 Hz, 1 H), 4.29 (br t, *J* = 8.7 Hz, 2 H), 4.14 (m, 2 H), 3.95 (d, *J* = 9.7 Hz, 1 H), 3.90 (s, 3 H), 3.77 (d, *J* = 9.7 Hz, 1 H), 3.39 (s, 3 H), 2.19-1.87 (m, 4 H), 1.65 (s, 9 H), 1.06 (br t, *J* = 9.0 Hz, 2 H), 0.07 (s, 9 H); ^{13}C NMR (75 MHz) δ 202.1, 170.7, 166.3, 134.9, 132.9, 132.7, 130.8, 129.5, 129.4, 126.5, 125.0, 72.6, 64.1, 64.0, 59.4, 52.2, 46.5, 29.1, 29.1, 20.6, 19.9, 18.3, 17.5, -1.6; MS (EI) *m/z* 529 (4), 528 (4), 527 (4), 526 (4), 432 (13), 430 (12), 401 (48), 399 (48), 229 (50), 227 (50), 96 (100); HRMS calcd for $C_{17}H_{24}BrO_4Si$ (M^+ - CH_3CO_2 – C_7H_{13} + H): 399.0627. Found: 399.0606. Anal. calcd for $C_{26}H_{39}BrO_6Si$: C, 56.21; H, 7.08%. Found: C, 56.29; H, 7.13%.

4-Bromo-3-[(2*R*,3*R*)-2-hydroxy-3-methoxymethyl-6,7-dimethyl-3-(2-trimethylsilyl-ethoxycarbonyl)oct-6-enyl]benzoic acid methyl ester (9) and 4-bromo-3-[(2*S*,3*R*)-2-hydroxy-3-methoxymethyl-6,7-dimethyl-3-(2-trimethylsilyl-ethoxycarbonyl)oct-6-enyl]benzoic acid methyl ester (10). Ketone **8** (112 mg, 0.201 mmol) was dissolved in 10 mL of methanol. The solution was cooled to 0 °C, and $NaBH_4$ (152 mg, 4.02 mmol) was added. The mixture was stirred for 2.5 h at 0 °C, then partitioned between ether and saturated NH_4Cl. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 9:1 to 4:1) afforded 53.3 mg (47%) of **9** and 40.0 mg (36%) of **10**, both obtained as colorless oils which solidified upon standing. For **9**: $[\alpha]_D^{20}$ = +5.1 (*c* 6.14, $CHCl_3$); IR (film) 3503, 1725 cm^{-1}; ^1H NMR (400 MHz) δ 7.99 (d, *J* = 2.1 Hz, 1 H), 7.73 (dd, *J* = 8.3 Hz, 2.1 Hz, 1 H), 7.61 (d, *J* = 8.3 Hz, 1 H), 4.30-4.13 (m, 3 H), 3.98 (d, *J* = 9.9 Hz, 1 H), 3.91 (s, 3 H), 3.72 (d, *J* = 9.9 Hz, 1 H), 3.44 (s, 3 H), 3.29-3.18 (m, 1 H), 3.03 (dd, *J* = 13.7, 2.7 Hz, 1 H), 2.95 (dd, *J* = 13.8, 10.3 Hz, 1 H), 2.07-1.86 (m, 4 H), 1.65 (s, 6 H), 1.64 (s, 3 H), 1.06 (br t, *J* = 8.9 Hz, 1 H), 0.07 (s, 9 H); ^{13}C NMR (100 MHz) δ 173.7 (C), 166.6 (C), 139.2 (C), 132.8 (CH), 132.8 (CH), 130.4

(C), 129.3 (C), 128.8 (CH), 127.0 (C), 124.5 (C), 75.0 (CH), 73.1 (CH_2), 63.3 (CH_2), 59.6 (CH_3), 53.8 (C), 52.2 (CH_3), 39.5 (CH_2), 30.3 (CH_2), 29.3 (CH_2), 20.5 (CH_3), 19.9 (CH_3), 18.4 (CH_3), 17.6 (CH_2), -1.6 (CH_3); MS (EI) *m/z* 558 (0.1), 556 (0.1), 530 (0.7), 528 (0.7), 302 (8), 300 (8), 173 (50), 96 (52), 73 (100); HRMS calcd for $C_{24}H_{37}BrO_6Si$ (M^+ - C_2H_4): 528.1543. Found: 528.1576. Anal. calcd for $C_{26}H_{41}BrO_6Si$: C, 56.01; H, 7.41. Found: C, 56.16; H, 7.40. For **10**: $[\alpha]_D^{20}$ = -11.0 (*c* 6.61, $CHCl_3$); IR (film) 3503, 1725 cm^{-1}; ^1H NMR (400 MHz) δ 7.97 (d, *J* = 2.1 Hz, 1 H), 7.74 (dd, *J* = 8.3 Hz, 2.1 Hz, 1 H), 7.62 (d, *J* = 8.3 Hz, 1 H), 4.31-4.20 (m, 2 H), 4.19-4.11 (m, 1 H), 4.01 (d, *J* = 9.6 Hz, 1 H), 3.91 (s, 3 H), 3.67 (d, *J* = 9.6 Hz, 1 H), 3.46 (s, 3 H), 3.40-3.28 (m, 1 H), 3.16 (dd, *J* = 13.7, 2.0 Hz, 1 H), 2.86 (dd, *J* = 13.7, 11.1 Hz, 1 H), 2.00-1.66 (m, 4 H), 1.66 (s, 9 H), 1.09-1.02 (m, 2 H), 0.06 (s, 9 H); ^{13}C NMR (75 MHz) δ 173.9 (C), 166.6 (C), 139.1 (C), 133.0 (CH), 132.9 (CH), 130.3 (C), 129.3 (C), 128.8 (CH), 126.7 (C), 124.8 (C), 75.9 (CH), 73.9 (CH_2), 63.3 (CH_2), 59.5 (CH_3), 54.9 (C), 52.2 (CH_3), 38.8 (CH_2), 30.5 (CH_2), 29.6 (CH_2), 20.6 (CH_3), 19.9 (CH_3), 18.3 (CH_3), 17.6 (CH_2), -1.6 (CH_3); MS (EI) *m/z* 558 (0.1), 556 (0.1), 530 (0.7), 528 (0.7), 301 (8), 299 (8), 173 (50), 96 (52), 73 (100); HRMS calcd for $C_{24}H_{37}BrO_6Si$ (M^+ - C_2H_4): 528.1543. Found: 528.1576. Anal. calcd for $C_{26}H_{41}BrO_6Si$: C, 56.01; H, 7.41%. Found: C, 56.27; H, 7.44%.

Oxidation of Alcohol 10 to Ketone 8. Alcohol **10** (214.7 mg, 0.385 mmol) was dissolved in 15 mL of dichloromethane. Pyridinium chlorochromate (332 mg, 1.54 mmol) was added, and the mixture was stirred for 1 d. An additional 83 mg (0.39 mmol) of pyridinium chlorochromate was added, and the mixture was stirred for a further 2 d, then partitioned between ether and saturated NH_4Cl. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 4:1) afforded 164.8 mg (77%) of **8**, with physical and spectroscopic properties identical to those reported above.

3-[(2*R*,3*R*)-2-Acetoxy-3-formylamino-3-methoxymethyl-6,7-dimethyloct-6-enyl]-4-bromobenzoic acid methyl ester (11). Alcohol **9** (96.8 mg, 0.174 mmol) was dissolved in 3 mL of pyridine. *N*,*N*-Dimethylaminopyridine (89 mg, 0.73 mmol) and acetic anhydride (100 μL, 1.1 mmol) were added. The reaction mixture was stirred for

3 d, then partitioned between ether and saturated NH_4Cl solution. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo to provide the corresponding crude acetate.

The above product was dissolved in 15 mL of THF. Tetrabutylammonium fluoride (0.52 mL, 1.0 M in THF, 0.52 mmol) was added, and the mixture was stirred for 1 h, then partitioned between hexanes and saturated NH_4Cl solution. The aqueous layer was washed with hexanes, and the combined organic fractions were dried and concentrated in vacuo to provide the corresponding crude monocarboxylic acid.

The above acid was dissolved in 15 mL of toluene. *N*,*N*-Dimethylaminopyridine (40mg, 0.33 mmol), triethylamine (21 μL, 0.34 mmol), and diphenylphosphoryl azide (75 μL, 0.35 mmol) were added, and the mixture was refluxed for 2 h and 15 min, then partitioned between ether and saturated NH_4Cl solution. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo to provide the corresponding crude isocyanate. Although the isocyanate was generally used in the next step without further purification, it can be purified by chromatography (9:1 – 4:1 hexanes/ethyl acetate).

The above crude isocyanate was dissolved in 15 mL of THF. Sodium borohydride (131 mg, 3.46 mmol) was added and the mixture was stirred for 12.5 h. The reaction mixture was partitioned between ether and saturated NH_4Cl solution and the aqueous layer was washed with ether. The combined organic fractions were washed with saturated $NaHCO_3$ solution, dried, and concentrated in vacuo. Chromatography (chloroform-methanol 40:1) afforded 72.8 mg (84% from **9**) of **11** as a colorless oil. $[\alpha]_D^{20} = +33.9$ (*c* 0.71, $CHCl_3$); IR (film) 1746, 1725, 1688 cm^{-1}; ^1H NMR (300 MHz; the product was found to exist as a 1:1 mixture of rotamers in $CDCl_3$) δ 8.37 (d, *J* = 12.3 Hz, 0.5 H) and 8.21 (d, *J* = 1.4 Hz, 0.5 H), 7.87 (d, *J* = 2.0 Hz, 0.5 H) and 7.84 (d, *J* = 2.0 Hz, 0.5 H), 7.73 (dd, *J* = 8.7, 2.0 Hz, 0.5 H) and 7.70 (dd, *J* = 7.7, 2.0 Hz, 0.5 H), 7.60 (d, *J* = 8.7 Hz, 0.5 H) and 7.58 (d, *J* = 8.2 Hz, 0.5 H), 6.10 (d, *J* = 11.8 Hz, 0.5 H) and 5.99 (br s, 0.5 H), 5.67 (dd, *J* = 11.3, 2.6 Hz, 0.5 H) and 5.42 (dd, *J* = 11.3, 2.6 Hz, 0.5 H), 3.91 (s, 1.5 H) and 3.90 (s, 1.5 H), 3.67 (d, *J* = 9.2 Hz, 0.5 H) and 3.49 (d, *J* = 9.2 Hz, 0.5 H), 3.61 (d, *J* = 9.8 Hz, 0.5 H) and 3.44 (d, *J* = 9.8 Hz, 0.5 H), 3.41 (s, 1.5 H) and 3.36 (s, 1.5 H), 3.43-3.22 and 3.10-2.89 (m, total 2 H), 2.30-1.58 (m), 1.85 (s, 1.5 H) and 1.84 (s, 1.5 H); ^{13}C

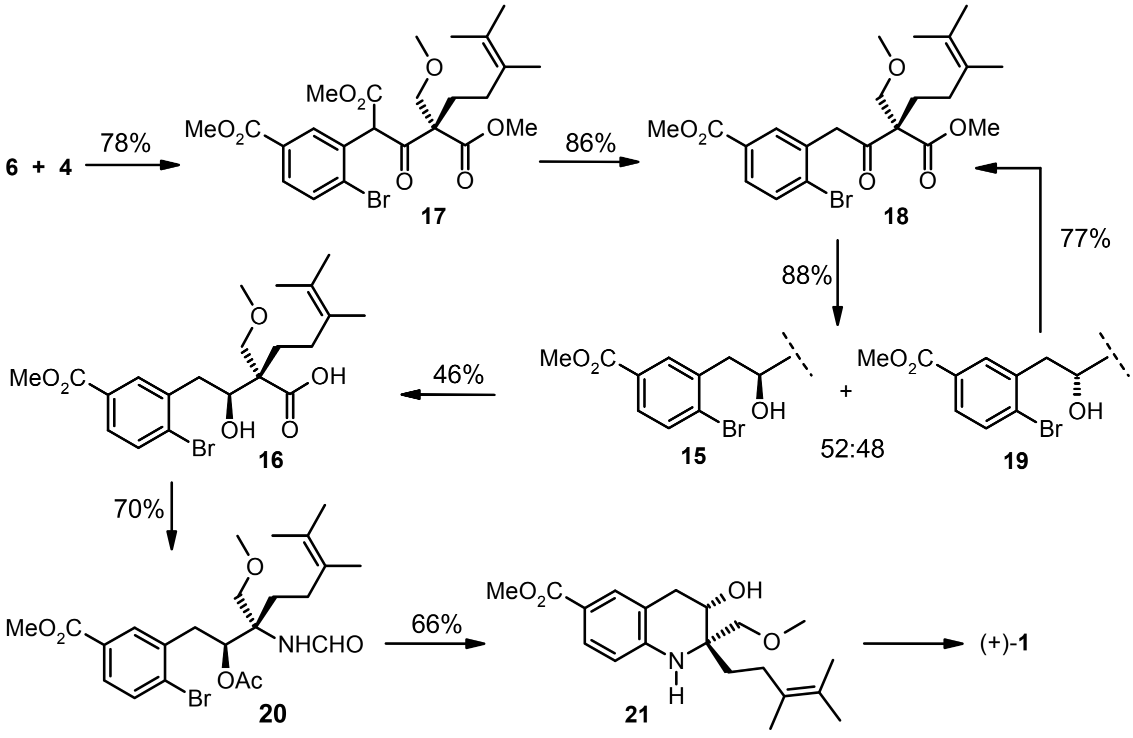
NMR (75 MHz; where separate signals for the respective carbon atoms of the two rotamers were resolved, they are listed as δ of 1st signal/δ of 2nd signal) δ 170.1/169.2 (C), 166.3/166.1 (C), 163.5/160.6 (CH), 137.6/136.7 (C), 133.1/133.0 (CH), 132.7/132.7 (CH), 130.4/130.3 (C), 129.4/129.1 (CH), 129.2/129.1 (C), 126.8/125.8 (C), 125.6/124.8 (C), 75.5/74.0 (CH), 73.8/73.2 (CH_2), 61.3/60.2 (C), 59.2/59.1 (CH_3), 52.3/52.2 (CH_3), 36.2/35.6 (CH_2), 30.0/29.7 (CH_2), 28.6/27.8 (CH_2), 20.6/20.6 (CH_3), 20.5/20.4 (CH_3), 20.1/20.0 (CH_3), 18.4/18.3 (CH_3); MS (EI) *m/z* 499 (1), 497 (1), 454 (20), 452 (21), 408 (13), 406 (13), 312 (8), 310 (9), 198 (43), 43(100); HRMS calcd for $C_{23}H_{32}BrNO_6$: 499.1393, 497.1413. Found: 499.1394, 497.1398. Anal. calcd for $C_{23}H_{32}BrNO_6$: C, 55.43; H, 6.47; N, 2.81%. Found: C, 55.84; H, 6.31; 2.63%.

(2*R*,3*R*)-3-Acetoxy-2-(3,4-dimethylpent-3-enyl)-1-formyl-2-methoxymethyl-1,2,3,4-tetrahydroquinoline-6-carboxylic acid methyl ester (13). *N*-formyl amine **11** (72.8 mg, 0.146 mmol) was combined with $Pd_2(dba)_3$ (14 mg, 0.015 mmol), BINAPFu (30 mg, 0.043 mmol) and Cs_2CO_3 (95 mg, 0.29 mmol). The mixture was placed under Ar, and 10 mL of deoxygenated toluene was added via syringe. The reaction mixture was heated at 90 °C for 6.5 h, then cooled to room temperature and partitioned between ether and saturated NH_4Cl solution. The aqueous layer was washed with ether and the combined organic fractions were concentrated in vacuo. Chromatography (hexanes-ethyl acetate 4:1 to 2:1) afforded 64.6 mg of a yellow oil that consisted of **13** (quantitative), and a small amount (ca. 5%) of BINAPFu byproducts. The product was carried to the next step with no further purification. IR (film) 1743, 1721, 1684 cm^{-1}; ^1H NMR (400 MHz) δ 8.62 (br s, 1 H), 7.91 (dd, *J* = 8.5, 1.7 Hz, 1 H), 7.83 (s, 1 H), 5.31 (t, *J* = 4.5 Hz, 1 H), 4.12-3.88 (br s, 1 H), 3.91 (s, 3 H), 3.39 (s, 3 H), 3.30-2.85 (m, 2 H), 2.06 (s, 3 H), 2.09-1.91 (m, 2 H), 1.56 (s, 3 H), 1.49 (s, 3 H), 1.48 (s, 3 H); ^{13}C NMR (75 MHz) δ 170.1 (C), 166.4 (C), 162.4 (br CH), 130.7 (CH), 128.4 (br CH), 126.7 (C), 125.9 (C), 125.5 (CH), 125.1 (C), 70.7 (br CH_2), 69.3 (CH), 59.2 (CH_3), 52.1 (CH_3), 30.4 (CH_2), 30.1 (CH_2), 28.0 (CH_2), 21.0 (CH_3), 20.5 (CH_3), 19.7 (CH_3), 18.3 (CH_3); MS (EI) *m/z* 417 (1), 386 (3), 372 (100); HRMS calcd for $C_{23}H_{31}NO_6$: 417.2151. Found: 417.2119.

(2*R*,3*R*)-2-(3,4-Dimethylpent-3-enyl)-3-hydroxy-2-methoxymethyl-1,2,3,4-tetrahydroquinoline-6-carboxylic acid methyl ester (14). Acetate **13** (64.6 mg, containing ca. 5% of BINAPFu byproducts, 0.146 mmol) was dissolved in 10 mL of methanol. Sodium hydroxide (53 mg, 1.3 mmol) was added, and the resulting solution was stirred for 24 h. The mixture was then partitioned between ether and brine, the aqueous layer was washed with ether and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ethyl acetate 4:1 to 2:1) afforded 42.6 mg (84% from **11**) of **14** as a colorless oil. $[\alpha]_D^{20} = -49.2$ (*c* 0.59, $CHCl_3$) [lit.[3] for (*ent*)-**14** $[\alpha]_D^{26} = +36.2$ (*c* 0.250, $CHCl_3$)]; IR (film) 3362, 1699 (br), 1609 cm^{-1}; ^1H NMR (300 MHz), δ 7.73 (s, 1 H), 7.70 (d, *J* = 8.7 Hz, 1 H), 6.51 (d, *J* = 8.7 Hz, 1 H), 4.02-3.95 (m, 1 H), 3.85 (s, 3 H), 3.67 (d, *J* = 9.2 Hz, 1 H), 3.48 (d, *J* = 9.2 Hz, 1 H), 3.41 (s, 3 H), 3.10 (dd, *J* = 16.9, 4.1 Hz, 1 H), 2.85 (dd, *J* = 16.9, 5.6 Hz, 1 H), 2.15-1.96 (m, 2 H), 1.91-1.71 (m, 1 H), 1.65-1.46 (m, 10 H); ^{13}C NMR (75 MHz) δ 167.2, 146.6, 132.4, 129.3, 126.8, 124.5, 118.9, 117.0, 113.5, 75.0, 67.4, 59.5, 57.5, 51.5, 33.1, 32.6, 27.6, 20.5, 19.9, 18.4; MS (EI) *m/z* 347 (6), 316 (6), 302 (70), 284 (21), 220 (26), 144 (21), 83 (100); HRMS calcd for $C_{20}H_{29}NO_4$: 347.2097. Found: 347.2106. The spectroscopic properties were in accord with those reported in the literature.[3]

(-)-Virantmycin (1). The conversion of **14** into (-)-**1** was carried out by the procedure of Morimoto and Shirahama[3] to afford a product with mp 59.5 – 60.5 °C [lit.[3] mp 59 °C]; $[\alpha]_D^{20} = -11$ (*c* 0.13, $CHCl_3$) [lit.[3] $[\alpha]_D^{24} = -11.1$ (*c* 0.175, $CHCl_3$)]; IR (film) 1672, 1607 cm^{-1}; ^1H NMR (400 MHz) δ 7.78 (d, *J* = 8.2 Hz, 1 H), 7.77 (s, 1 H), 6.55 (d, *J* = 8.2 Hz, 1 H), 4.37 (t, *J* = 5.5 Hz, 1 H), 3.59 (d, *J* = 9.2 Hz, 1 H), 3.56 (d, *J* = 9.2 Hz, 1 H), 3.40 (s, 3 H), 3.38 (dd, *J* = 17.0 Hz, 4.5 Hz, 1 H), 3.12 (dd, *J* = 17.0 Hz, 6.1 Hz, 1 H), 2.10 (td, *J* = 12.2, 5.2 Hz, 1 H), 2.02 (td, *J* = 12.3, 4.4 Hz, 1 H), 1.87-1.67 (m, 2 H), 1.64 (s, 3 H), 1.62 (s, 6 H); ^{13}C NMR (100 MHz) δ 171.0, 147.1, 132.4, 130.4, 126.5, 124.8, 116.0, 113.6, 74.0, 59.4, 58.0, 56.2, 33.6, 33.5, 27.8, 20.6, 19.9, 18.4; MS (EI) *m/z* 353 (3), 351 (10), 338 (4), 336 (10), 308 (25), 306 (72), 254 (17), 224 (21), 149 (25), 83 (100); HRMS calcd for $C_{19}H_{26}ClNO_3$: 351.1601. Found: 351.1612. The spectroscopic properties were in accord with those reported in the literature.[3]

Procedures for the preparation of (+)-1.



(*S*)-4-(2-Bromo-5-methoxycarbonylphenyl)-2-(3,4-dimethylpent-3-enyl)-2-methoxymethyl-3-oxo-pentanedioic acid dimethyl ester (17). Diester **6** (6.63 g, 23.1 mmol) was acylated with acyl fluoride **4** by the same general procedure used for preparing **7**, to afford 4.73 g (78%) of the corresponding keto triester **17** as a colorless oil. NMR analysis indicated the presence of a 1:1 mixture of diastereomers. IR (film) 1726 cm^{-1}; ^{1}H NMR (400 MHz) δ 8.29 (d, *J* = 2.0 Hz, 0.5 H) and 8.15 (d, *J* = 2.0 Hz, 0.5 H), 7.83 (dd, *J* = 8.4, 2.1 Hz, 1 H), 7.67 (d, *J* = 8.4, 1 H), 5.86 (s, 0.5 H) and 5.79 (s, 0.5 H), 3.96-3.64 (m, 2 H), 3.90 (s, 1.5 H) and 3.90 (s, 1.5 H), 3.73 (s, 1.5 H) and 3.72 (s, 1.5 H), 3.58 (s, 1.5 H) and 3.55 (s, 1.5 H), 3.32 (s, 1.5 H) and 3.05 (s, 1.5 H), 2.06-1.67 (m, 4 H), 1.65-1.51 (m, 9 H); ^{13}C NMR (75 MHz, where separate signals for the respective carbon atoms of the two diastereomers were resolved, they are listed as δ of 1st signal/δ of 2nd signal) δ 198.8/198.3 (C), 169.9/169.8 (C), 167.5/167.4 (C), 165.9 (C), 132.9/132.9 (CH), 132.6/132.5 (C), 131.8/131.7 (CH), 130.4 (CH), 130.1/130.1 (C), 129.6/129.5 (C), 126.2/126.1 (C), 125.0/125.0 (C), 71.5/71.4 (CH_2), 65.1/64.9 (C), 59.1/58.8 (CH_3), 59.1/58.8 (CH), 52.9/52.9 (CH_3), 52.3 (br, CH_3), 29.0/28.8 (CH_2), 28.9/28.8 (CH_2), 20.5/20.5 (CH_3), 19.7/19.7 (CH_3), 18.2/18.1 (CH_3); MS (ESI) *m/z* 551, 549 (M^+ + Na), 567, 565 (M^+ + K); HRMS calcd for $C_{23}H_{28}BrO_7$ (M^+ - OCH_3): 495.1018. Found: 495.1011.

(*S*)-4-Bromo-3-(3-methoxycarbonyl-3-methoxymethyl-6,7-dimethyl-2-oxooct-6-enyl)benzoic acid methyl ester (18). Triester **17** (4.73 g, 8.96 mmol) was dissolved in 60 mL of DMSO. Aqueous NaCl (10%, 10 mL) was added, and the mixture was immersed in a 100 °C oil bath, then heated to 130 °C over 30 min. An additional 15 mL of 10% aqueous NaCl was added, in 3 portions, over the next 5.5 h, while the reaction mixture was maintained at 130 °C. The mixture was then partitioned between ether and water, the aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (hexanes-ether 5:1 to 3:1) afforded 3.63 g (86%) of **18** as a colorless oil. $[\alpha]_D^{20}$ = +11.9 (*c* 2.80, $CHCl_3$); IR (film) 1720 cm^{-1}; ^{1}H NMR (300 MHz) δ 7.82 (d, *J* = 1.5 Hz, 1 H), 7.78 (dd, *J* = 8.4, 1.8 Hz, 1 H), 7.64 (d, *J* = 8.2 Hz, 1 H), 4.16 (d, *J* = 17.9 Hz, 1 H), 4.09 (d, *J* = 18.4 Hz, 1 H), 3.95 (d, *J* = 9.2 Hz, 1 H), 3.90 (s, 3 H), 3.81 (s, 3 H), 3.78 (d, *J* = 9.2 Hz, 1 H), 3.40 (s, 3 H), 2.19-1.87 (m, 4

H), 1.64 (s, 9 H); ^{13}C NMR (75 MHz) δ 201.8, 171.0, 166.2, 134.8, 132.8, 132.7, 130.6, 129.5, 129.3, 126.3, 125.0, 72.5, 64.1, 59.3, 52.4, 52.2, 46.4, 29.1, 29.0, 20.5, 19.8, 18.2; MS (EI) *m/z* 470 (0.3), 468 (0.4), 438 (1), 436 (1), 343 (16), 341 (16), 229 (31), 227 (30), 96 (100) ; HRMS calcd for $C_{22}H_{29}BrO_6$: 468.1148. Found: 468.1175. Anal. calcd for $C_{22}H_{29}BrO_6$: C, 56.30; H, 6.23%. Found: C, 56.35; H, 6.12%.

4-Bromo-3-[(2*S*,3*S*)-2-hydroxy-3-methoxycarbonyl-3-methoxymethyl-6,7-dimethyl-oct-6-enyl]benzoic acid methyl ester (15) and 4-bromo-3-[(2*R*,3*S*)-2-hydroxy-3-methoxycarbonyl-3-methoxymethyl-6,7-dimethyl-oct-6-enyl]benzoic acid methyl ester (19). Ketone **18** (142.7 mg, 0.304 mmol) was reduced by the same procedure as in the case of **8** to afford a mixture of alcohols **15** and **19**. Chromatography (hexanes-ether 9:1 to 4:1) afforded 66.6 mg (46%) of **15** and 59.5 mg (42%) of **19** as colorless oils. For **15**: $[\alpha]_D^{20}$ = -7.7 (*c* 1.29, $CHCl_3$); IR (film) 3501, 1725 cm^{-1}; ^{1}H NMR (300 MHz) δ 7.97 (d, *J* = 2.1 Hz, 1 H), 7.72 (dd, *J* = 8.2 Hz, 2.1 Hz, 1 H), 7.60 (d, *J* = 8.2 Hz, 1 H), 4.19-4.08 (m, 1 H), 3.98 (d, *J* = 9.7 Hz, 1 H), 3.89 (s, 3 H), 3.75 (s, 3 H), 3.71 (d, *J* = 10.3 Hz, 1 H), 3.44 (s, 3 H), 3.20 (br d, *J* = 7.2 Hz, 1 H), 3.01 (dd, *J* = 13.8, 2.6 Hz, 1 H), 2.91 (dd, *J* = 13.6, 10.5 Hz, 1 H), 2.07-1.80 (m, 4 H), 1.63 (s, 9 H); ^{13}C NMR (75 MHz) δ 173.9 (C), 166.5 (C), 139.0 (C), 132.9 (CH), 132.8 (CH), 130.2 (C), 129.1 (C), 128.8 (CH), 126.8 (C), 124.5 (C), 74.8 (CH), 72.9 (CH_2), 59.5 (CH_3), 53.9 (C), 52.1 (CH_3), 51.8 (CH_3), 39.6 (CH_2), 30.3 (CH_2), 29.3 (CH_2), 20.5 (CH_3), 19.8 (CH_3), 18.3 (CH_3); MS (EI) *m/z* 472 (3), 470 (2), 147 (53), 96 (100); HRMS calcd for $C_{22}H_{31}BrO_6$: 472.1284, 470.1304. Found: 472.1262, 470.1294. Anal. calcd for $C_{22}H_{31}BrO_6$: C, 56.06; H, 6.63%. Found: C, 55.65; H, 6.79%. For **19**: $[\alpha]_D^{20}$ = +20.6 (*c* 1.19, $CHCl_3$); IR (film) 3501, 1724 cm^{-1}; ^{1}H NMR (300 MHz) δ 7.96 (d, *J* = 2.1 Hz, 1 H), 7.72 (dd, *J* = 8.2 Hz, 2.1 Hz, 1 H), 7.60 (d, *J* = 8.2 Hz, 1 H), 4.19-4.06 (m, 1 H), 4.02 (d, *J* = 9.7 Hz, 1 H), 3.89 (s, 3 H), 3.76 (s, 3 H), 3.67 (d, *J* = 9.7 Hz, 1 H), 3.46 (s, 3 H), 3.28-3.09 (m, 1 H), 3.15 (dd, *J* = 13.6, 1.8 Hz, 1 H), 2.85 (dd, *J* = 13.8, 11.3 Hz, 1 H), 2.06-1.66 (m, 4 H), 1.63 (s, 9 H); ^{13}C NMR (75 MHz) δ 174.1 (C), 166.5 (C), 138.9 (C), 132.9 (CH), 132.8 (CH), 130.2 (C), 129.2 (C), 128.8 (CH), 126.6 (C), 124.8 (C), 75.9 (CH), 73.8 (CH_2), 59.5 (CH_3), 55.1 (C), 52.2 (CH_3), 51.9 (CH_3), 38.7 (CH_2), 30.5 (CH_2), 29.6 (CH_2), 20.5 (CH_3), 19.8 (CH_3), 18.3

(CH_3); MS (EI) *m/z* 472 (2), 470 (2), 147 (47), 96 (100); HRMS calcd for $C_{22}H_{31}BrO_6$: 472.1284, 470.1304. Found: 472.1245, 470.1269.

The undesired epimer **19** was oxidized to ketone **18** in 77% yield, as in the case of alcohol **10**.

4-Bromo-3-[(2*S*,3*S*)-3-carboxy-2-hydroxy-3-methoxymethyl-6,7-dimethyloct-6-enyl]benzoic acid methyl ester (16). Diester **15** (28.7 mg, 0.0559 mmol) was dissolved in 2 mL of methanol. Aqueous KOH solution (10%, 1.0 mL, 1.8 mmol) was added, and the mixture was stirred for 20 h, then partitioned between ether and 10% HCl solution. The aqueous layer was washed with ether, and the combined organic layers were dried and concentrated in vacuo to afford 25.6 mg (100%) of the corresponding aryl monocarboxylic acid as a white solid. The product was dissolved in 0.5 mL of HMPA.

NaH (12 mg, 60% in mineral oil, 0.3 mmol) was suspended in 0.5 mL of HMPA. *n*-Propanethiol (30 μL, 0.57 mmol) was added, and the mixture was stirred for 2 h, to afford a homogeneous solution. The solution of **15** was slowly added via cannula. A further 0.5 mL of HMPA was used to rinse any remaining substrate into the reaction mixture. The light yellow solution was stirred for 4 h and 45 min, then partitioned between dichloromethane and 10% NaOH solution. The organic layer was washed three times with 10% NaOH solution and the combined aqueous layers were washed once with dichloromethane. The aqueous fraction was then acidified with HCl and extracted three times with ether. The combined ether layers were dried and evaporated to afford 23.8 mg of the corresponding crude dicarboxylic acid.

The above crude diacid was dissolved in 5 mL of methanol and cooled to -10 °C. Thionyl chloride (16 μL, 0.22 mmol) was added, and the solution was stirred for 1 h at -10 °C, 1 h at room temperature, 1 h at 45 °C, and 3 h at 65 °C. The reaction mixture was cooled to room temperature and partitioned between ether and 10% HCl solution. The aqueous layer was washed with ether, and the combined organic fractions were dried and concentrated in vacuo. Chromatography (chloroform-methanol 40:1) afforded 11.7 mg (46% overall from **15**) of **16** as a colorless oil. IR (film) 1723 (br) cm^{-1}; ^{1}H NMR (300 MHz) δ 7.99 (d, *J* = 2.0 Hz, 1 H), 7.73 (dd, *J* = 8.2, 2.0 Hz, 1 H), 7.61 (d, *J* = 8.2 Hz, 1 H), 4.19 (dd, *J* = 10.7, 2.1 Hz, 1 H), 3.97 (d, *J* = 9.7 Hz, 1 H), 3.90 (s, 3 H), 3.72 (d, *J* =

9.8 Hz, 1 H), 3.45 (s, 3 H), 3.12 (dd, *J* = 13.3, 1.6 Hz, 1 H), 2.99 (dd, *J* = 13.8, 10.8 Hz, 1 H), 2.11-1.82 (m, 4 H), 1.65 (s, 6 H), 1.63 (s, 3 H); ^{13}C NMR (75 MHz) δ 178.9 (C), 166.6 (C), 138.9 (C), 132.9 (CH), 132.8 (CH), 130.4 (C), 129.2 (C), 128.9 (CH), 126.7 (C), 124.7 (C), 74.5 (CH), 73.0 (CH_2), 59.5 (CH_3), 53.9 (C), 52.2 (CH_3), 39.3 (CH_2), 30.2 (CH_2), 29.2 (CH_2), 20.5 (CH_3), 19.9 (CH_3), 18.3 (CH_3); MS (EI) *m/z* 458 (0.6), 456 (0.6), 211 (7), 133 (26), 96 (71), 45 (100); HRMS calcd for $C_{21}H_{29}BrO_6$: 458.1127, 456.1148. Found: 458.1140, 456.1150.

3-[(2*S*,3*S*)-2-Acetoxy-3-formylamino-3-methoxymethyl-6,7-dimethyloct-6-enyl]-4-bromobenzoic acid methyl ester (20). Hydroxy acid **16** (27.8 mg, 0.0608 mmol) was dissolved in 2 mL of pyridine. *N*,*N*-Dimethylaminopyridine (17 mg, 0.14 mmol) was added, followed by acetic anhydride (100 μL, 1.1 mmol). The reaction mixture was stirred for 2 d, then partitioned between ether and saturated NH_4Cl. The aqueous layer was washed with ether, and the combined organic layers were dried and concentrated in vacuo to afford 28.5 mg (94%) of the corresponding acetate as a colorless oil. This was converted to *N*-formylamine **20** (27.4 mg, 70%) using an identical procedure to that employed for the preparation of **11**. Spectroscopic properties were identical to those of **11**.

(2*S*,3*S*)-2-(3,4-Dimethylpent-3-enyl)-3-hydroxy-2-methoxymethyl-1,2,3,4-tetrahydroquinoline-6-carboxylic acid methyl ester (21). *N*-Formylamine **20** (27.4 mg, 0.0550 mmol) was subjected to an intramolecular aryl amination using the same procedure as in the preparation of **13** to afford the corresponding tetrahydroquinoline (16.5 mg, 72%). The product was saponified to afford 12.7 mg (92%) of **21** via the same procedure used to obtain **14**. Compound **21** had identical spectroscopic properties to those of **14** and gave $[\alpha]_D^{20} = +47.9$ (*c* 0.32, $CHCl_3$).

(+)-Virantmycin. The conversion of **21** into (+)-**1** was carried out by the procedure of Morimoto and Shirahama[3] to afford a product with spectroscopic properties identical to those of (-)-**1** and $[\alpha]_D^{20} = +13$ (*c* 0.14, $CHCl_3$) [lit.[3] $[\alpha]_D^{24} = +11.2$ (*c* 0.125, $CHCl_3$)].

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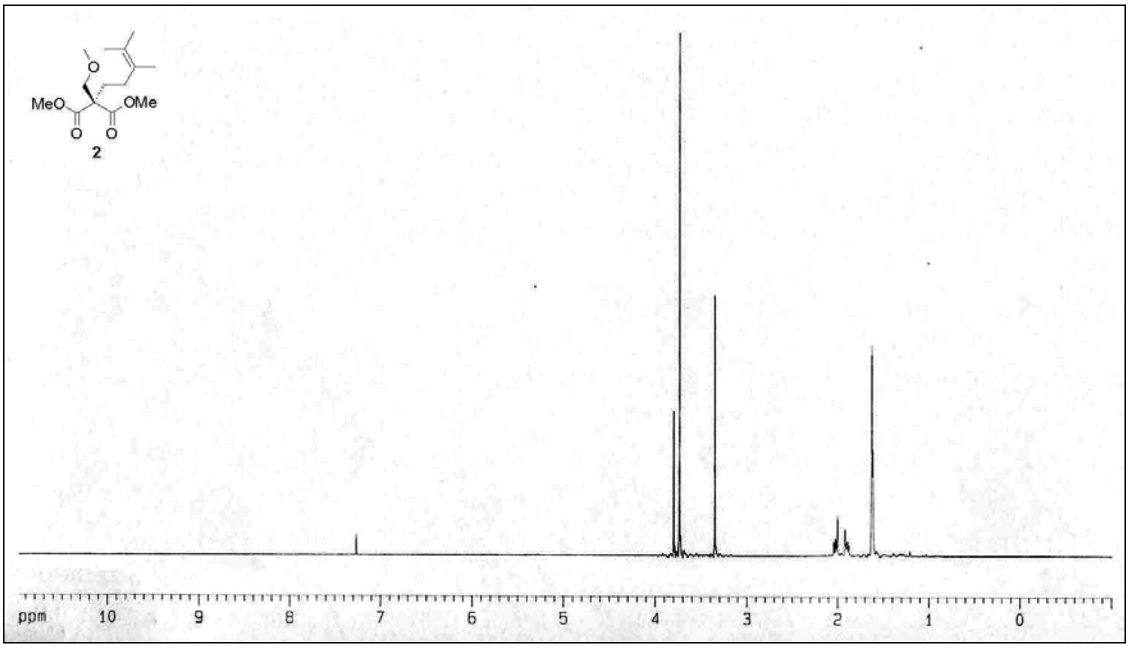
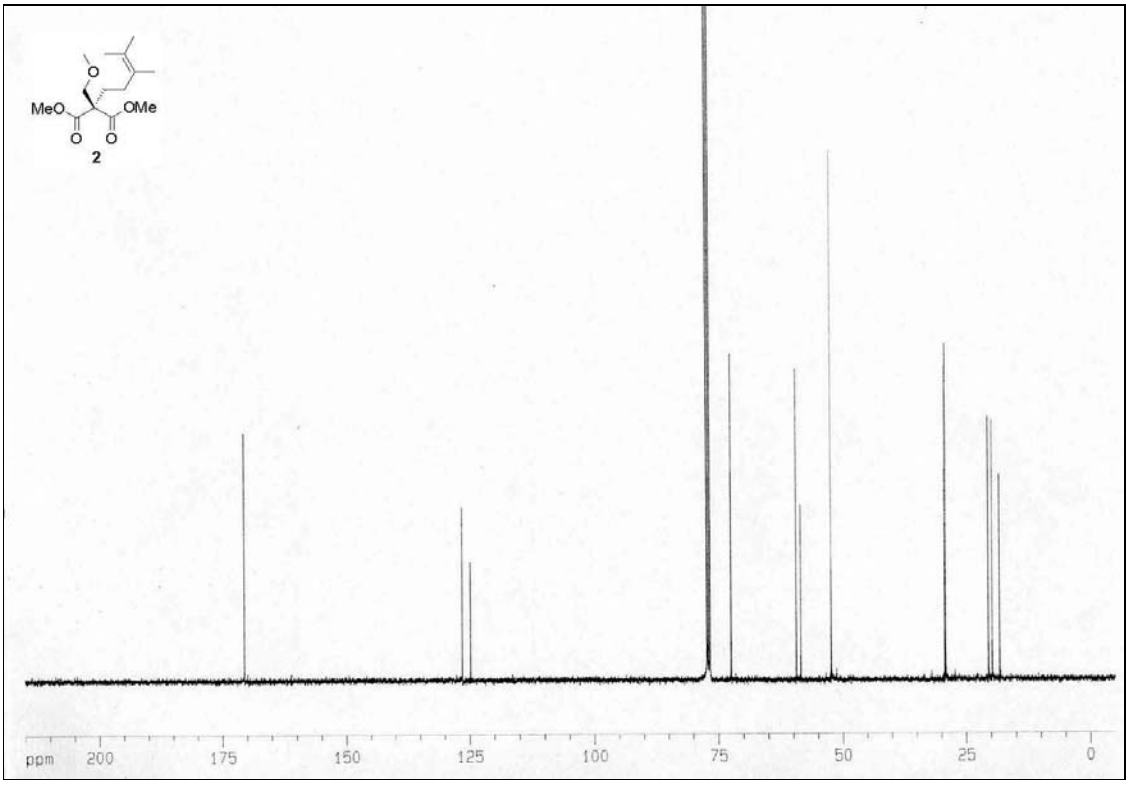
3. Y. Morimoto, H. Shirahama, *Tetrahedron* **1996**, *52*, 10631.

^{1}H and ^{13}C NMR Spectra (CDCl$_3$) of 2





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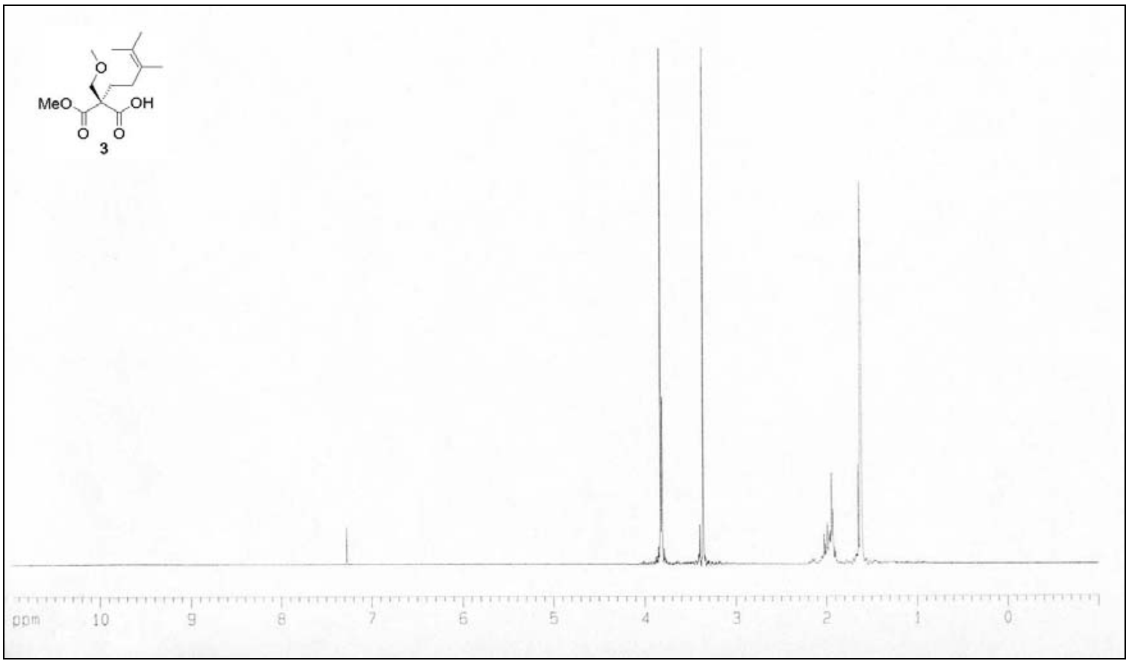

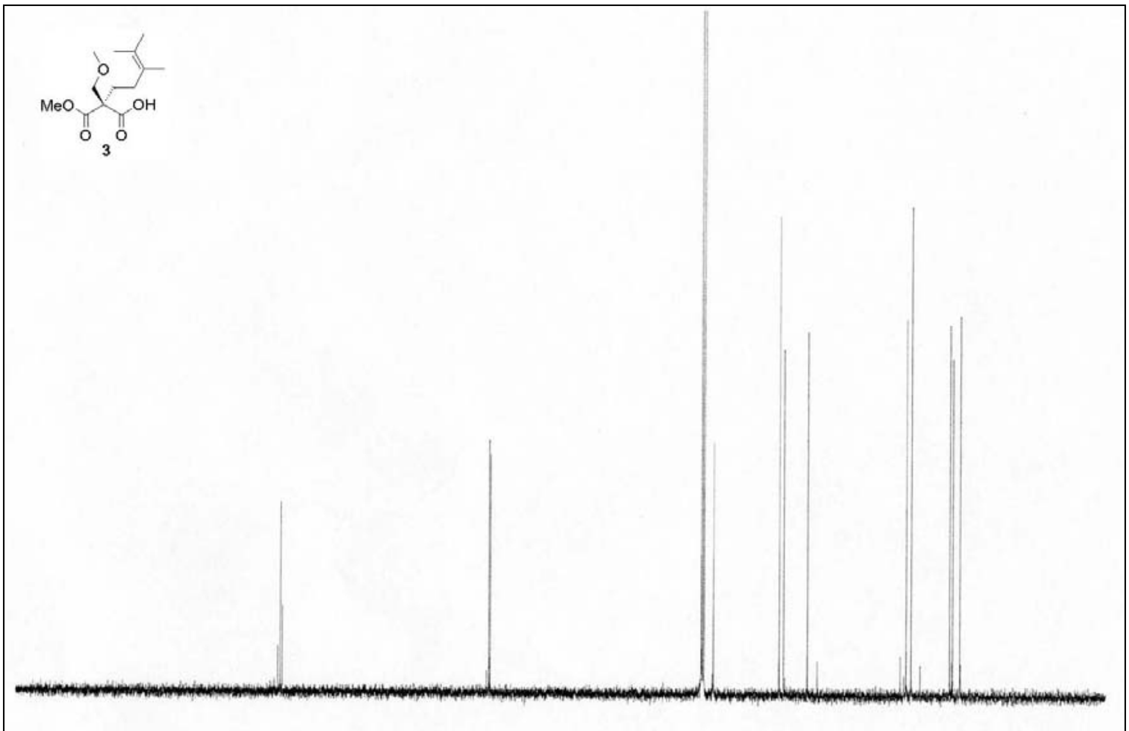

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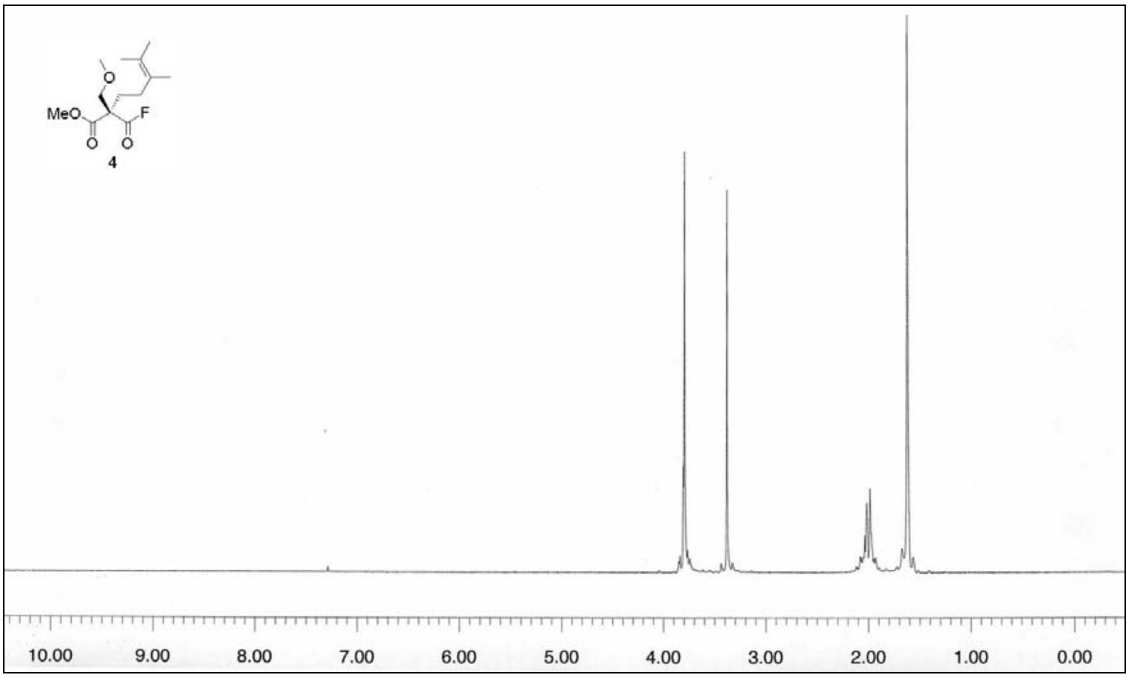
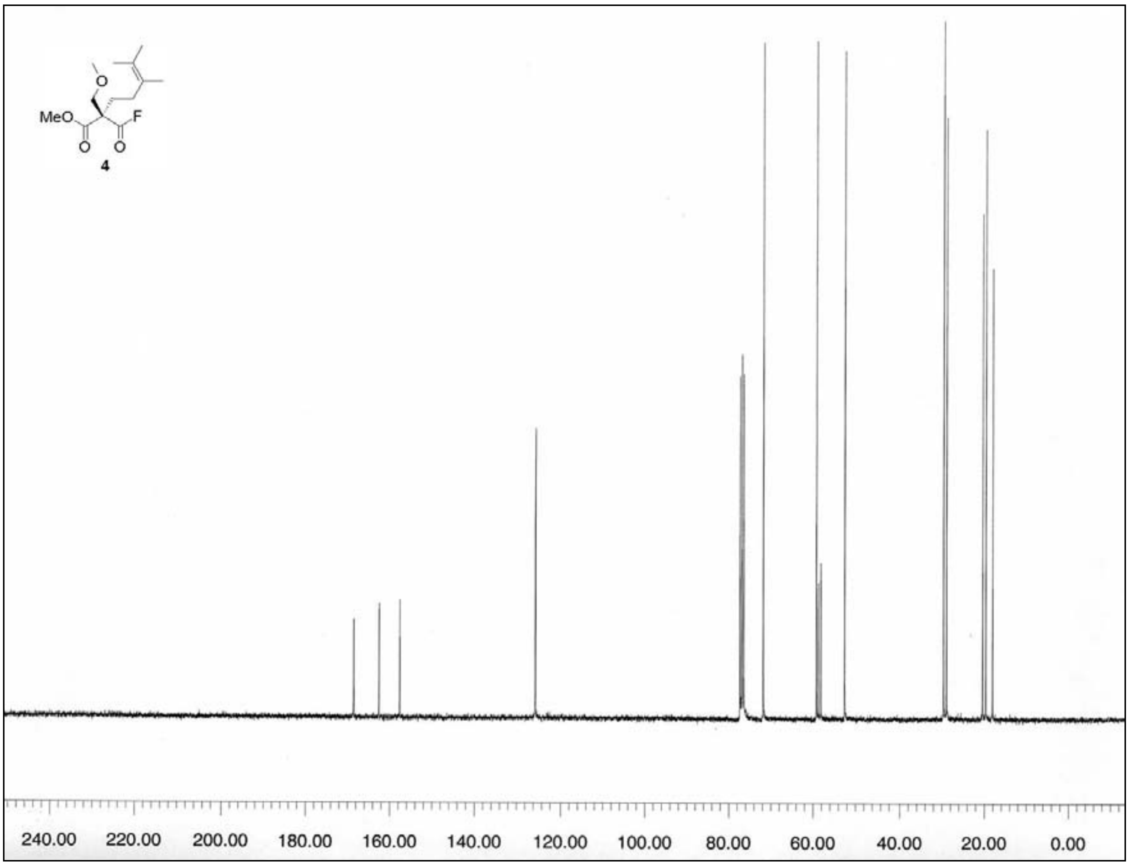
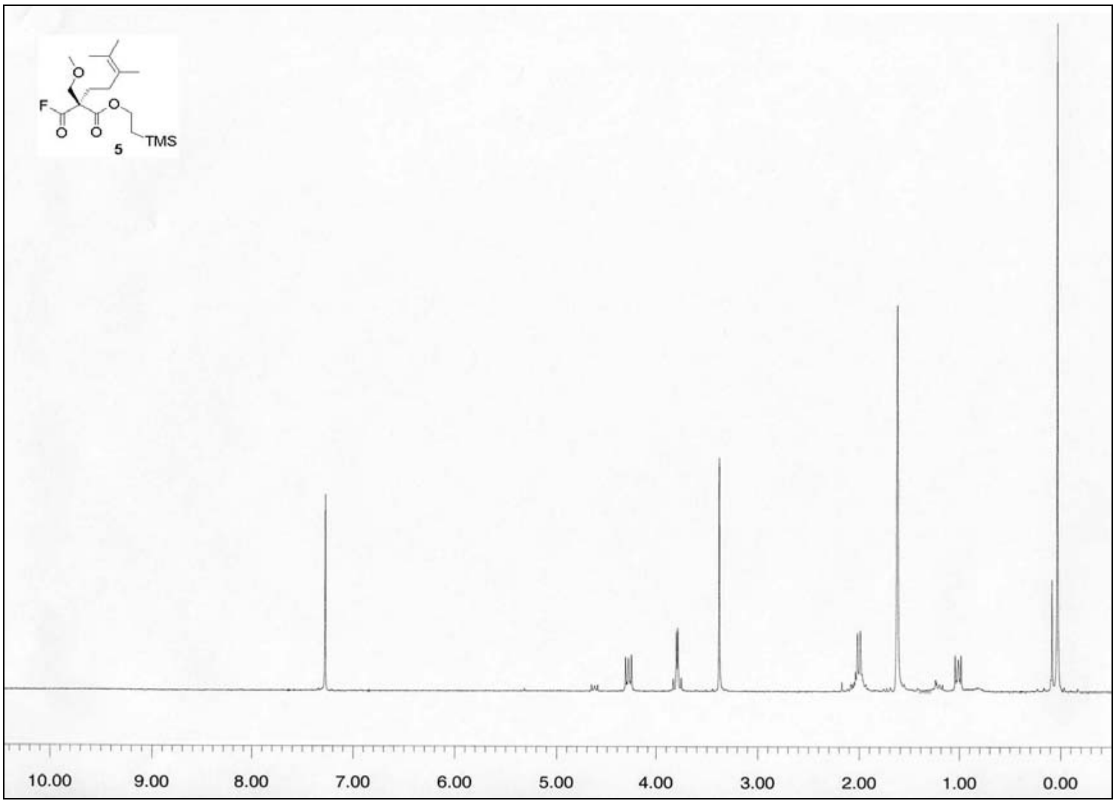
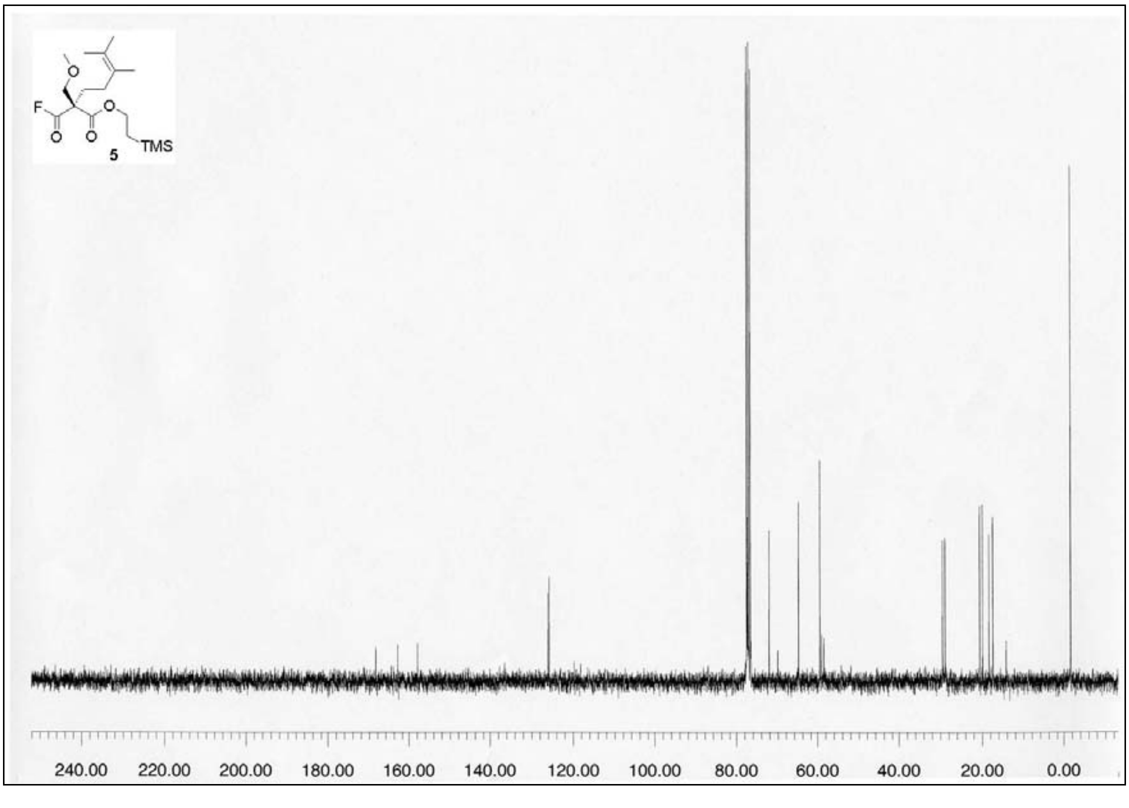


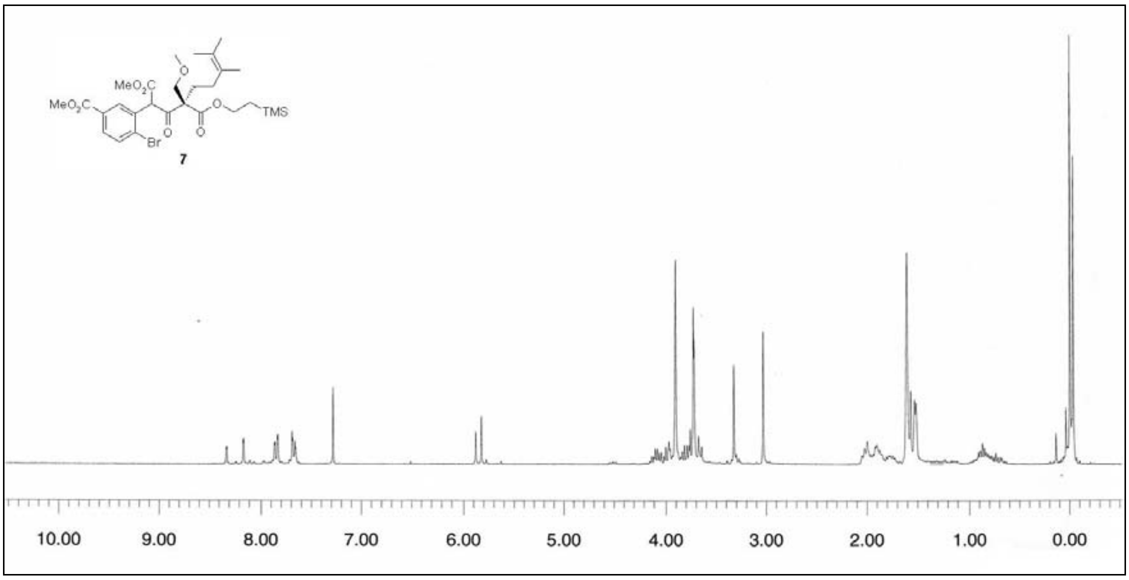


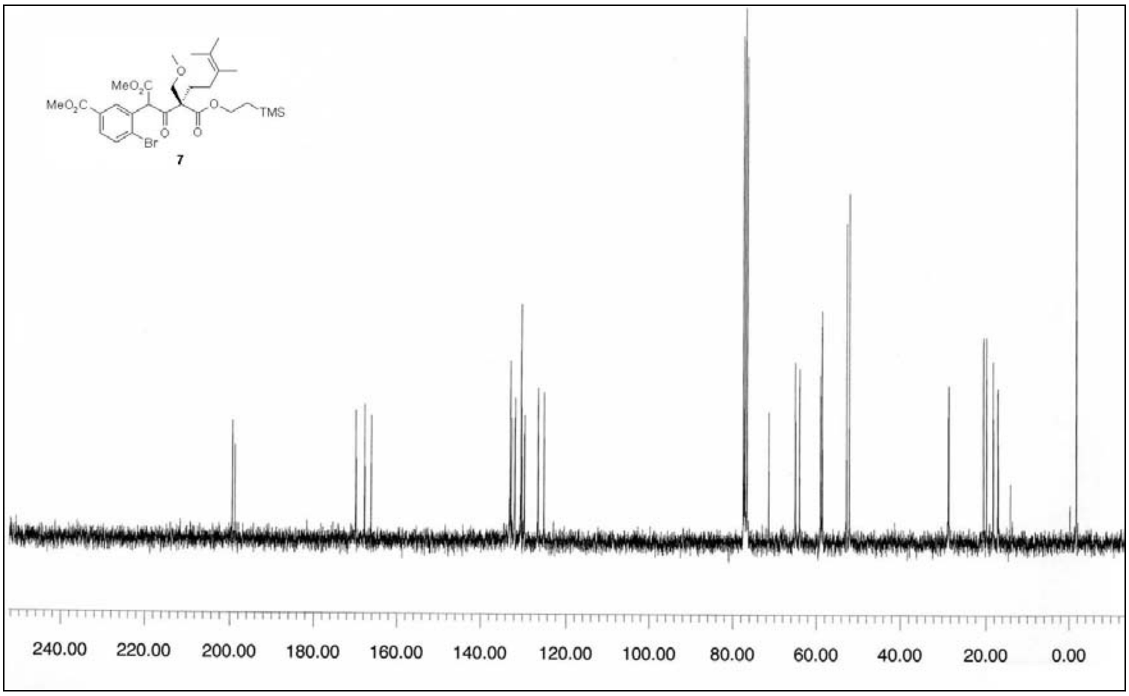
^{1}H and ^{13}C NMR Spectra (CDCl$_3$) of 5



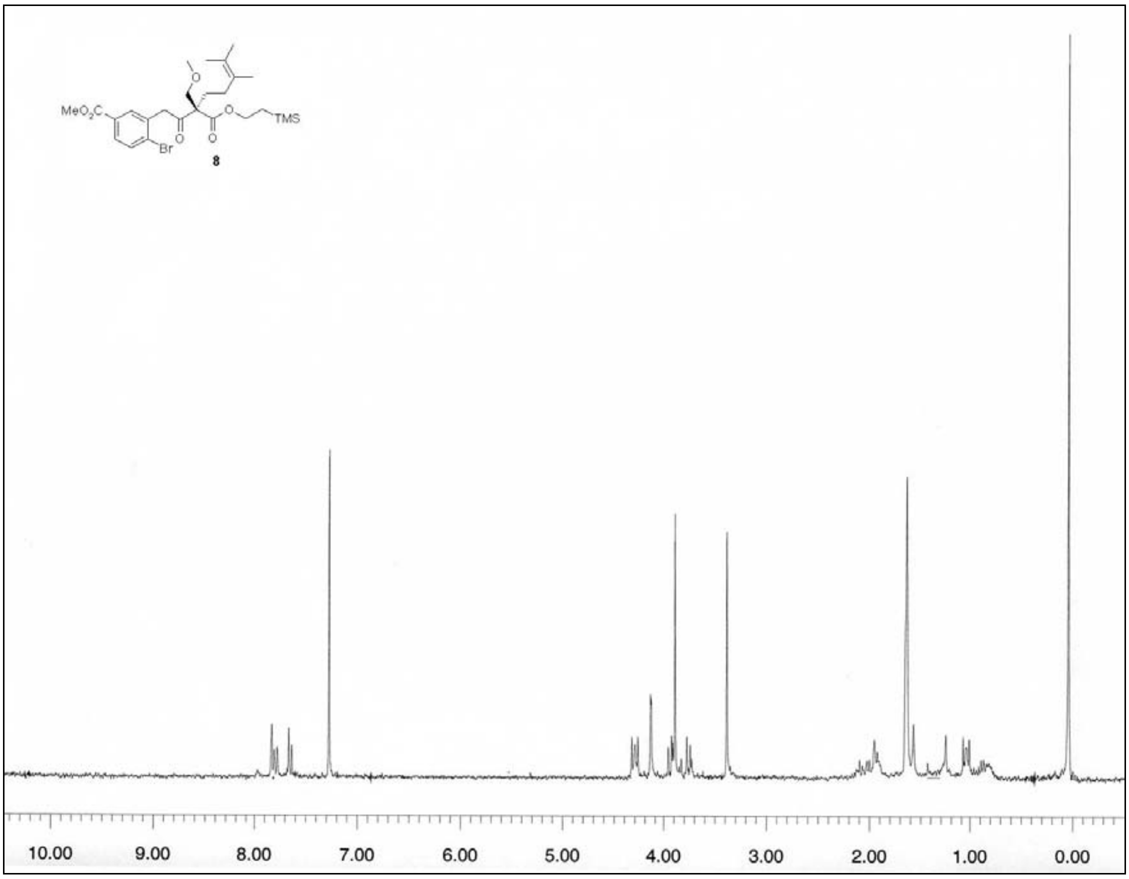


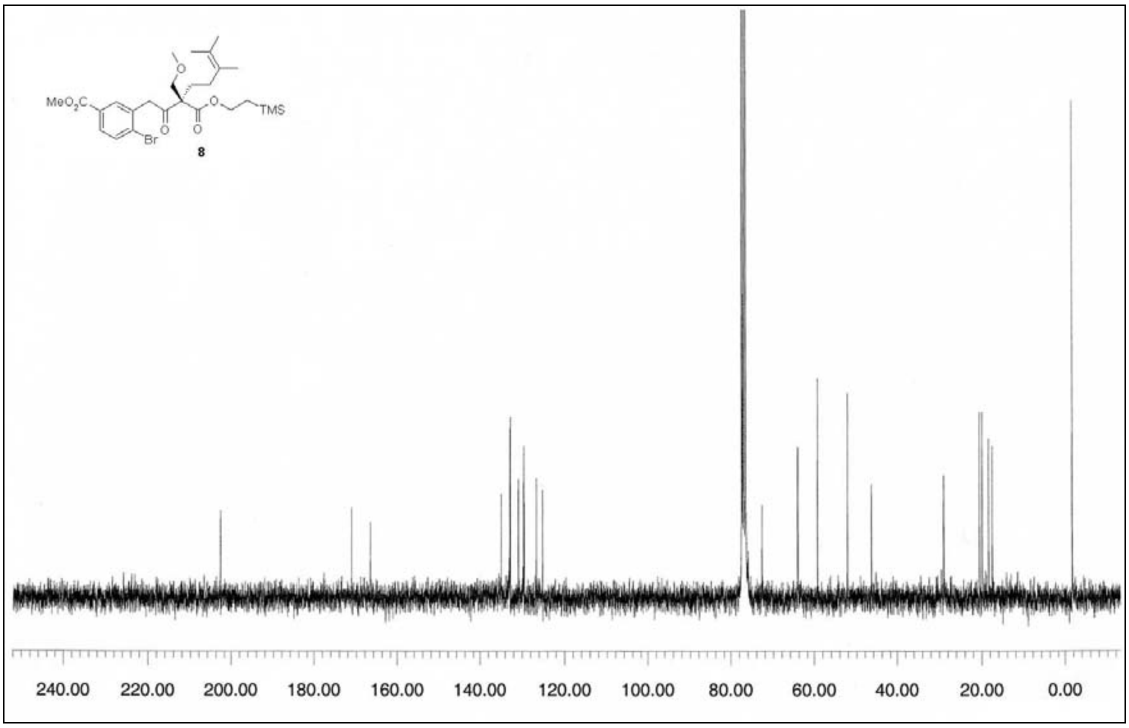
^{1}H and ^{13}C NMR Spectra ($CDCl_3$) of 7



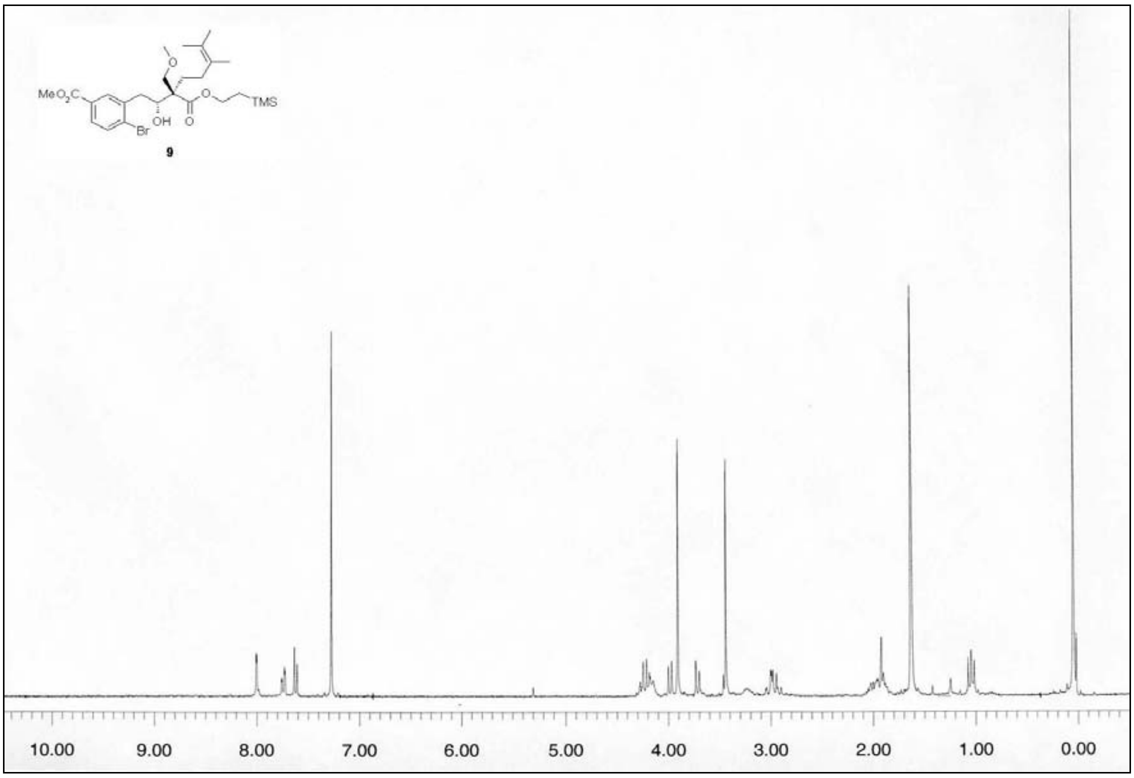


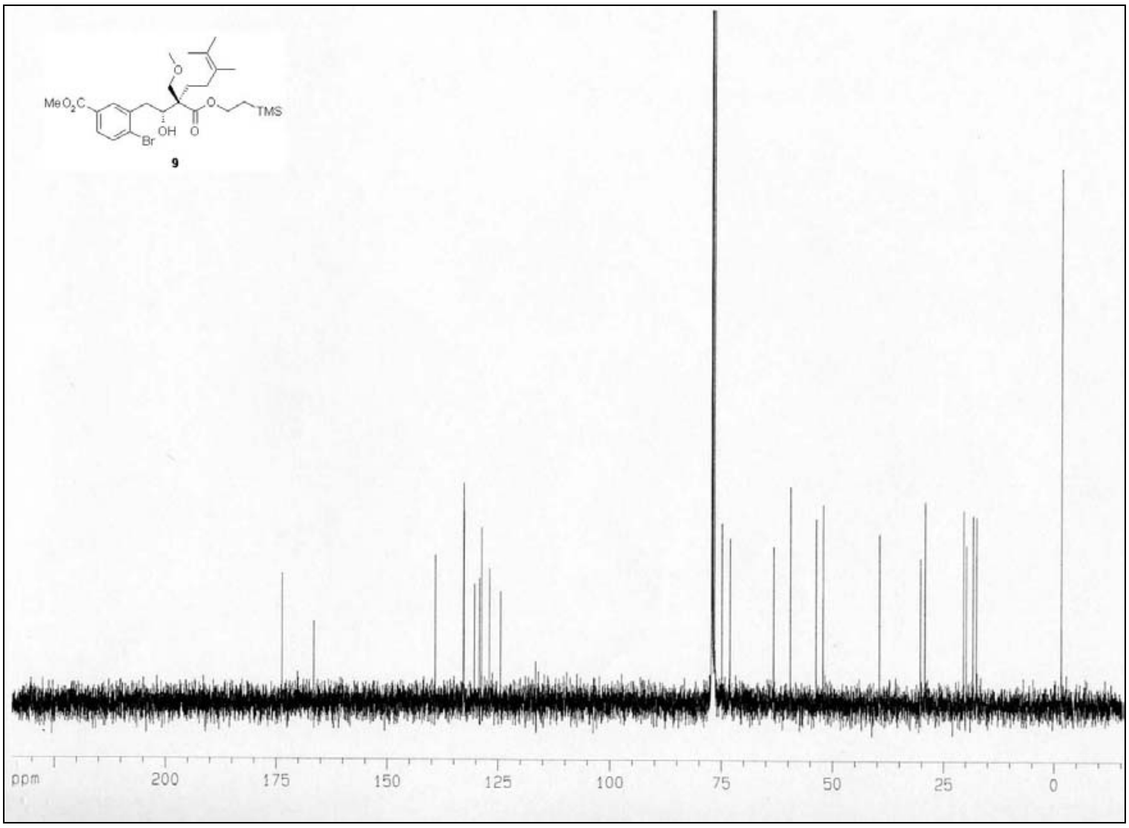
^{1}H and ^{13}C NMR Spectra ($CDCl_3$) of 8



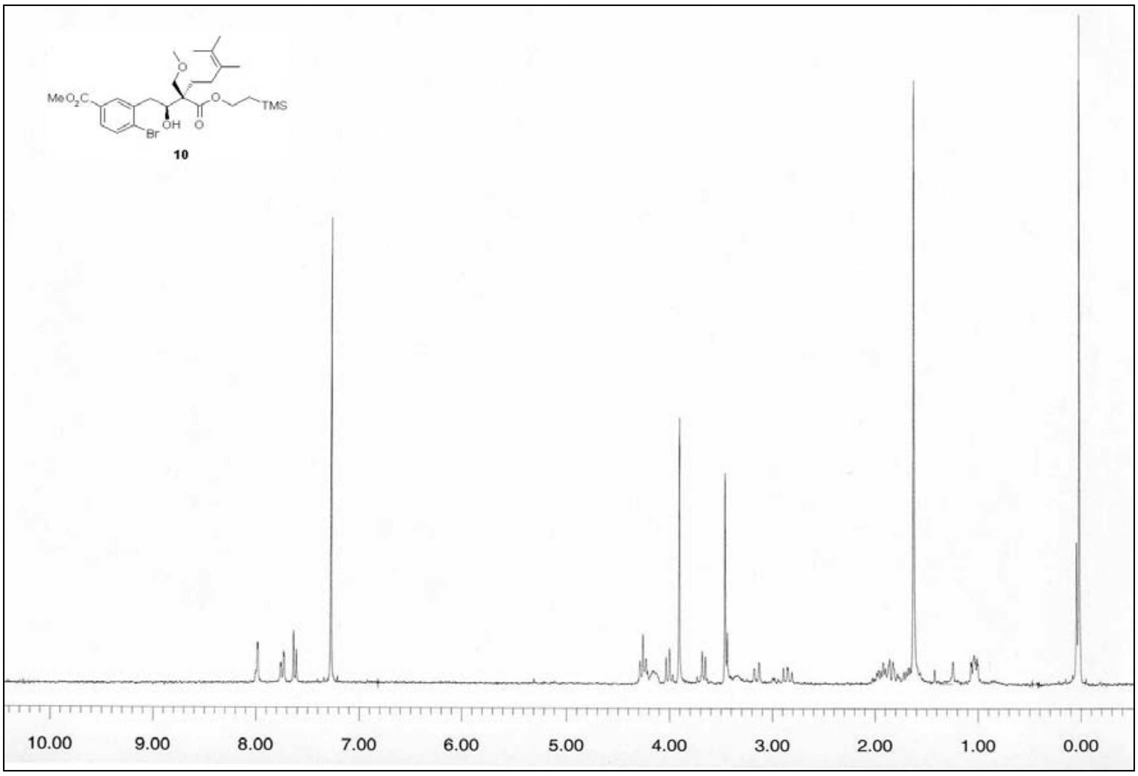


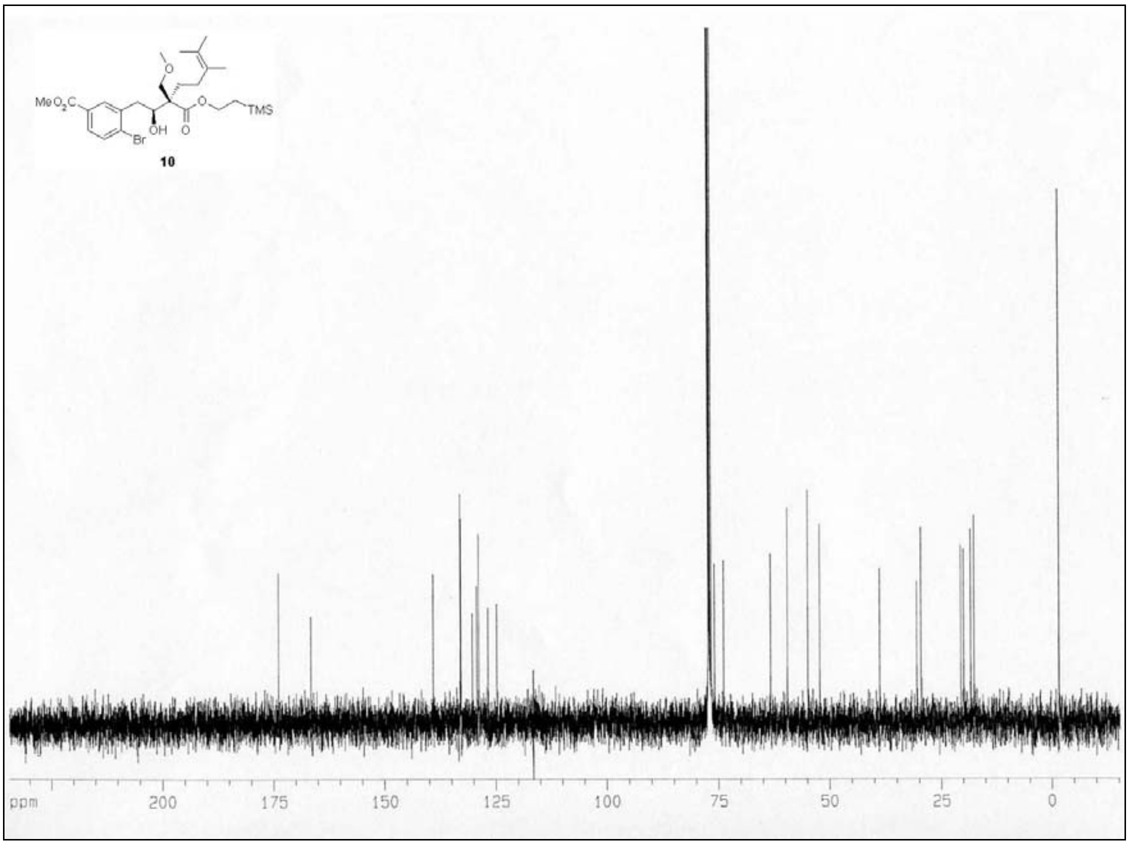
^{1}H and ^{13}C NMR Spectra (CDCl$_3$) of 9



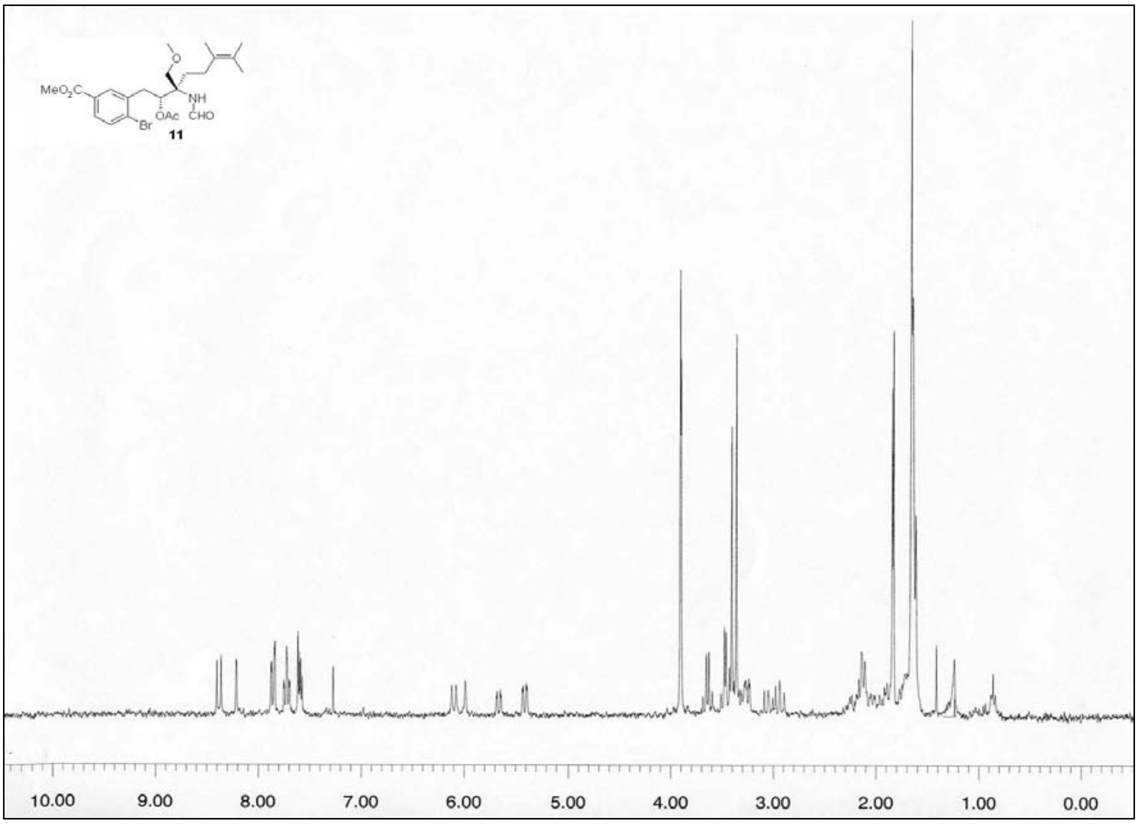


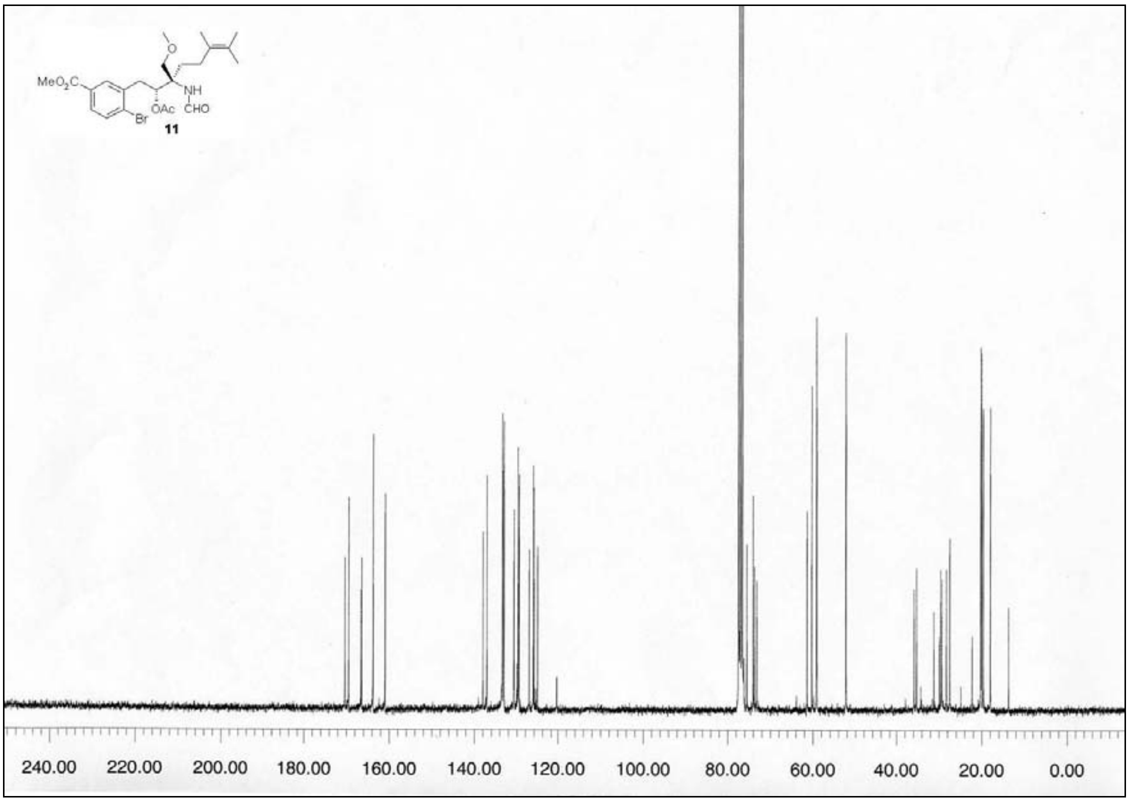
^{1}H and ^{13}C NMR Spectra (CDCl$_3$) of 10



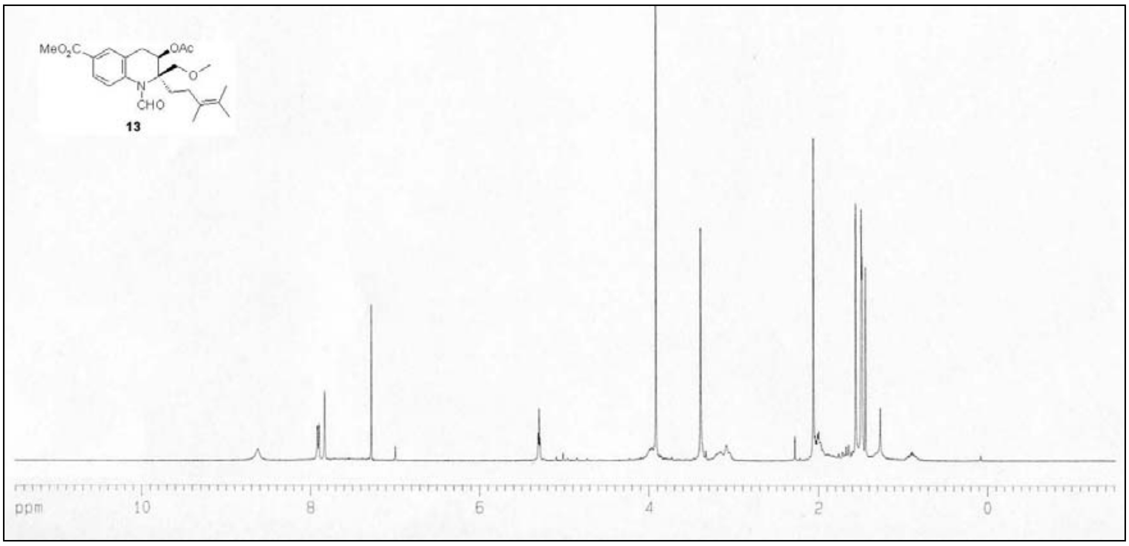


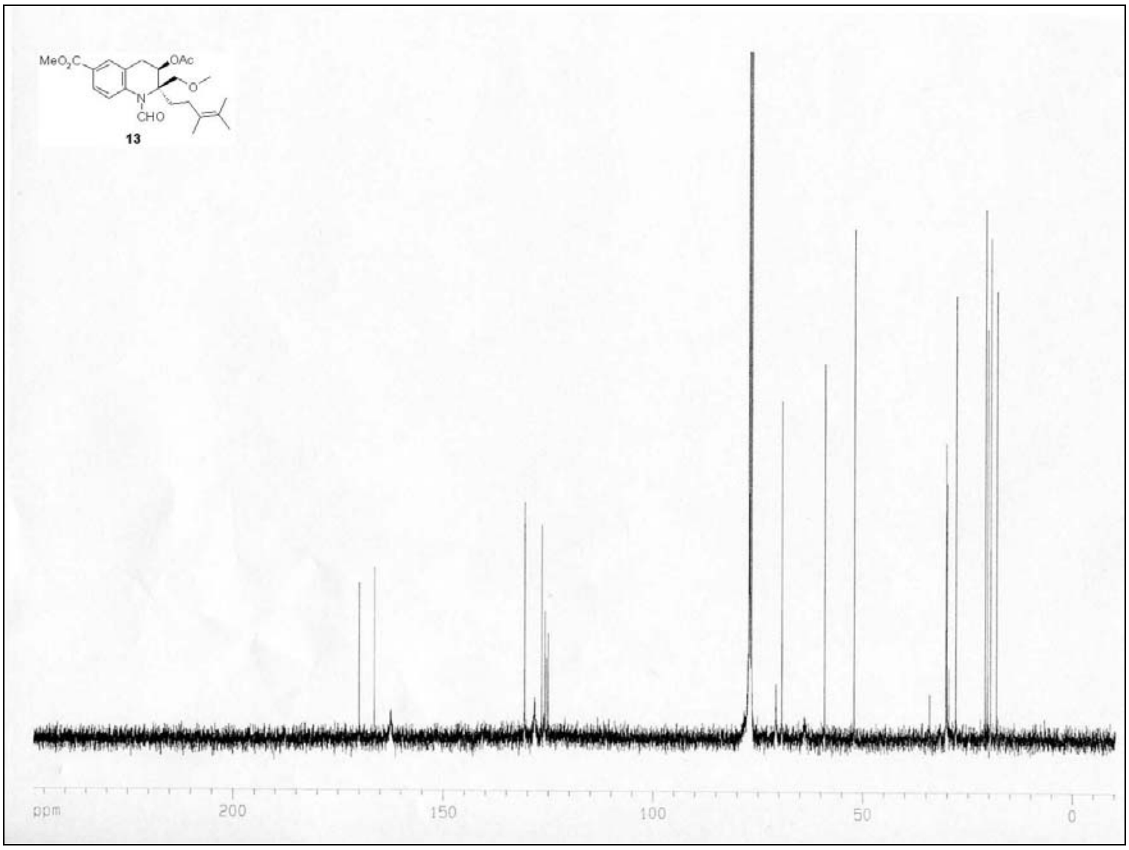
^{1}H and ^{13}C NMR Spectra ($CDCl_3$) of 11



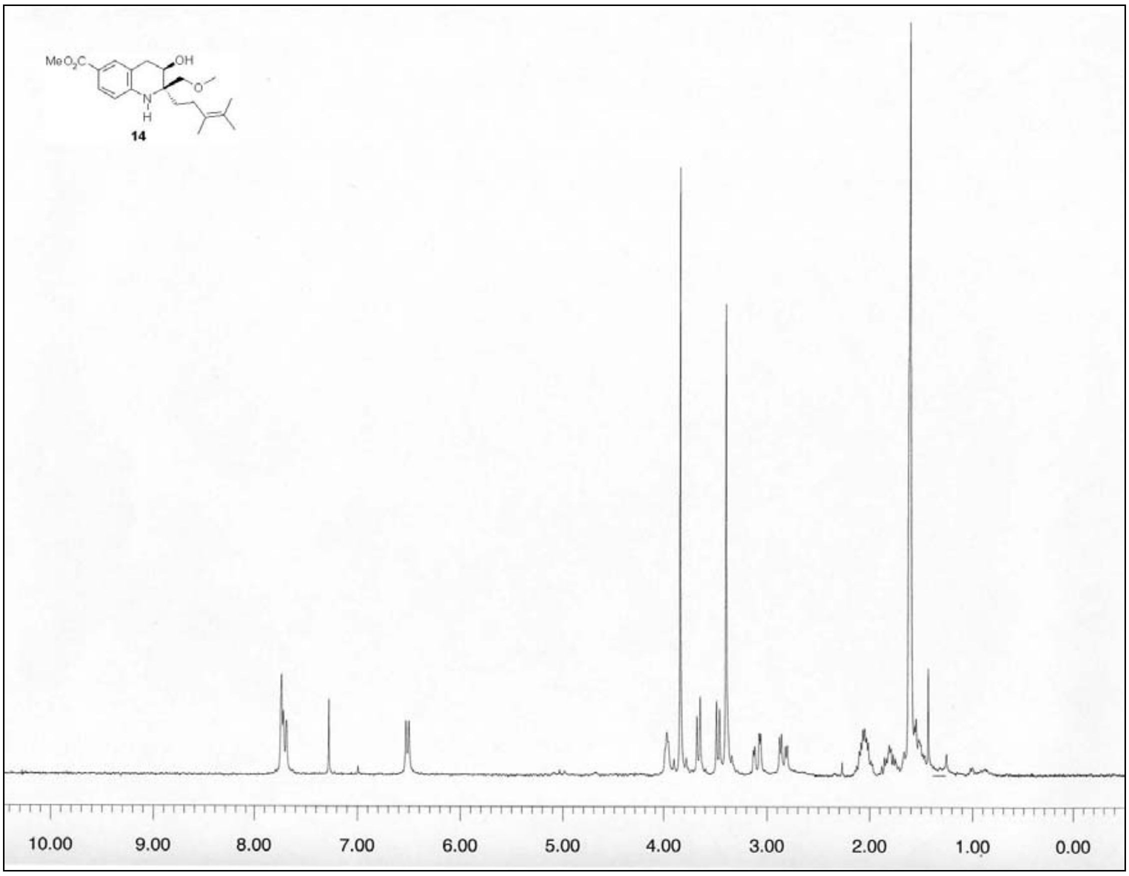


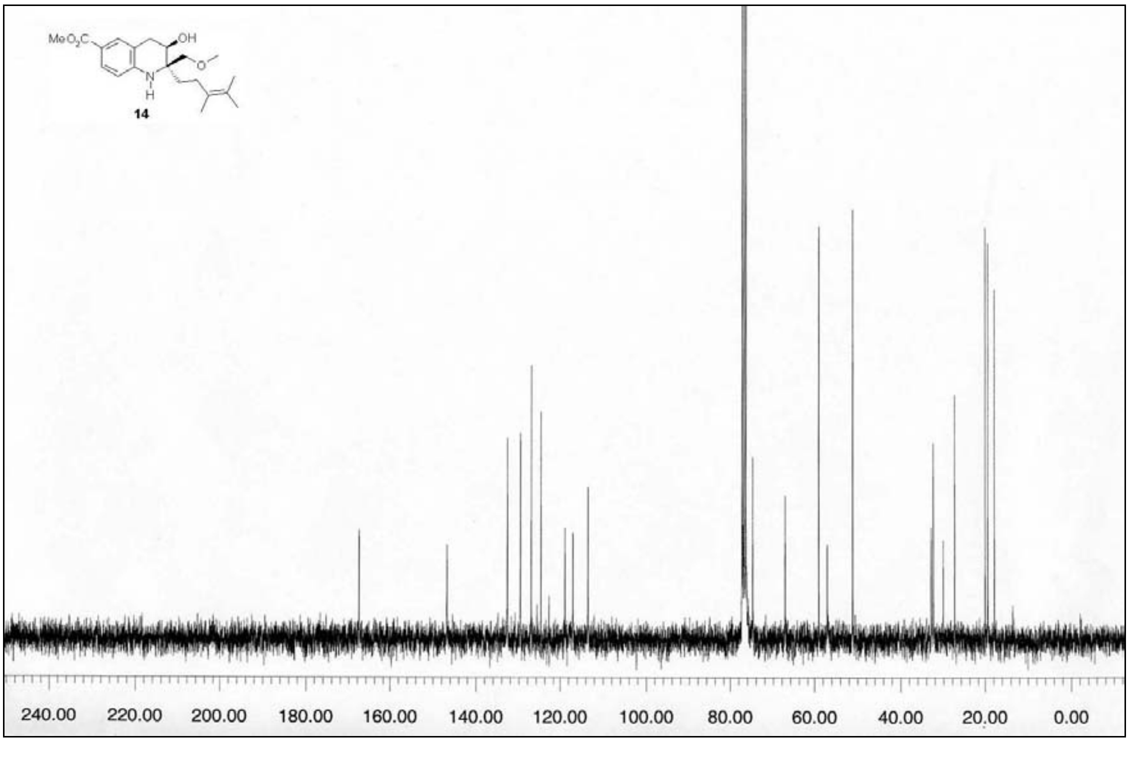
^{1}H and ^{13}C NMR Spectra ($CDCl_3$) of 13





^{1}H and ^{13}C NMR Spectra ($CDCl_3$) of 14





^{1}H and ^{13}C NMR Spectra ($CDCl_3$) of (-)-1