Total Synthesis of Kinamycins C, F, and J.

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Supporting Information Available

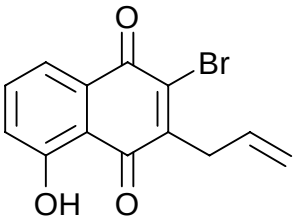
Experimental Data

Experimental Data for Compounds

General Procedures. All reactions were carried out under an argon atmosphere with dry solvents under anhydrous conditions, unless otherwise noted. Dry tetrahydrofuran (THF), toluene, diethyl ether (Et_2O), and methylene chloride (CH_2Cl_2), were obtained by passing commercially available pre-dried, oxygen-free formulations through activated alumina columns. Acetonitrile (CH_3CN), dimethylsulfoxide (DMSO), and *iso*-propanol (*i*-PrOH) were purchased in anhydrous form and used without further purification. Yields refer to chromatographically and spectroscopically (^{1}H NMR) homogeneous materials, unless otherwise stated. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. Reactions were monitored by thin-layer chromatography (TLC) carried out on 0.25 mm E. Merck silica gel plates (60F-254) using UV light as visualizing agent and an ethanolic solution of *p*-anisaldehyde and heat as a developing agent. E. Merck silica gel (60, particle size 0.040–0.063 mm) was used for flash column chromatography. Preparative thin-layer chromatography separations were carried out on 0.25 or 0.50 mm E. Merck silica gel plates (60F-254). NMR spectra were recorded on Bruker DRX-600 or DRX-500 instruments and calibrated using residual undeuterated solvent as an internal reference. The following

abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, pent = pentet, hex = hexet, br = broad. IR spectra were recorded on a Perkin-Elmer Spectrum 100 FT-IR spectrometer. LC/MS data were recorded on an Agilent 1100 series LC system coupled to an ESI Agilent MSD. Melting points (m.p.) are uncorrected and were recorded on a Thomas Hoover Uni-Melt melting point apparatus. High-resolution mass spectra (HRMS) were recorded on an Agilent ESI TOF (time of flight) mass spectrometer at 4000 V emitter voltage.

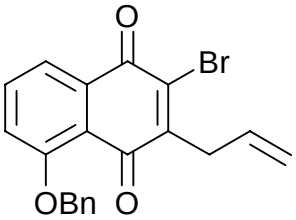
Napthoquinone 5



5

To a solution of bromo-nathoquinone **4** (4.0 g, 15.8 mmol, 1.0 equiv) in degassed MeCN (120 mL) at 25 °C, was added $AgNO_3$ (0.80 g, 4.74 mmol, 0.3 equiv) and vinylacetic acid (2.0 mL, 21.1 mmol, 1.3 equiv) and the reaction mixture was then heated to 65 °C. $(NH_4)_2S_2O_8$ (7.2 g, 31.6 mmol, 2.0 equiv) in degassed H_2O (60 mL) was then added dropwise to the reaction mixture at 65 °C over 30 min. After 3 h (starting material consumed by TLC), the reaction mixture was cooled to 25 °C, and the reaction mixture was extracted with EtOAc (3 × 150 mL), and the combined organic layers were washed with brine (150 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 6:1) provided bromo-napthoquinone **5** (3.5 g, 11.9 mmol, 75% yield) as a red-brown foam. **5**: R_f = 0.59 (silica gel, hexanes:EtOAc 4:1); IR (film) ν_{max} 3081, 1672, 1631, 1588, 1454, 1426, 1365, 1269, 1255, 1211, 1166, 1131, 1095, 1057, 998, 921, 834, 799, 777, 741, 709 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.70 (d, *J* = 7.8 Hz, 1 H), 7.61 (t, *J* = 7.8 Hz, 1 H), 7.28 (d, *J* = 7.8 Hz, 1 H), 5.85 (ddt, *J* = 16.8, 10.2, 6.6 Hz, 1 H), 5.26 (d, *J* = 16.8 Hz, 1 H), 5.16 (d, *J* = 10.2 Hz, 1 H), 3.61 ppm (d, *J* = 6.6 Hz, 2 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 186.5, 177.1, 161.8, 148.9, 140.2, 136.3, 131.1, 131.0, 124.8, 120.6, 118.4, 114.4, 34.8 ppm; HRMS (ESI-TOF): calcd for $C_{13}H_9BrO_3$ $[M+H^+]$: 292.9808, found 292.9801.

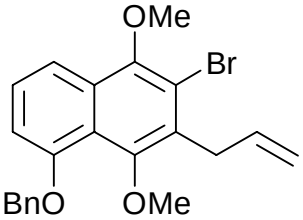
Benzyl-protected bromo-napthoquinone 5a



5a

To a solution of bromo-napthoquinone **5** (340 mg, 1.16 mmol, 1.0 equiv) in CH_2Cl_2 (12 mL) at 25 °C was added BnBr (0.28 mL, 2.32 mmol, 2.0 equiv), and freshly prepared Ag_2O (270 mg, 1.16 mmol, 1.0 equiv). The reaction mixture was stirred at 25 °C for 18 h, then filtered through a plug of Celite and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 4:1) provided benzyl-protected bromo-napthoquinone **5a** (410 mg, 1.10 mmol, 92% yield) as a colorless foam. **5a**: R_f = 0.53 (silica gel, hexanes:EtOAc 2:1); IR (film) ν_{max} 3065, 3017, 2921, 2860, 1670, 1604, 1583, 1498, 1447, 1383, 1273, 1257, 1220, 1161, 1096, 1050, 972, 913, 828, 772, 738, 696 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.82 (dd, *J* = 7.2, 0.6 Hz, 1 H), 7.60 (dd, *J* = 7.2, 0.6 Hz, 1 H), 7.55 (d, *J* = 7.2 Hz, 2 H), 7.42 (t, *J* = 7.2 Hz, 2 H), 7.33 (t, *J* = 7.2 Hz, 2 H), 5.88 (ddt, *J* = 16.8, 10.2, 6.6 Hz, 1 H), 5.31 (s, 2 H), 5.27 (dd, *J* = 16.8, 1.2 Hz, 1 H), 5.14 (dd, *J* = 10.2, 1.2 Hz, 1 H), 3.63 ppm (dt, *J* = 6.6, 1.2 Hz, 2 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 180.0, 178.1, 158.9, 150.7, 136.6, 135.9, 134.7, 133.3, 131.8, 128.7, 128.1, 126.7, 120.6, 119.9, 119.8, 118.1, 71.0, 35.7 ppm; HRMS (ESI-TOF): calcd for $C_{20}H_{16}BrO_3$ [M+H$^+$]: 383.0277, found 383.0282.

Methyl-protected hydroquinone 6

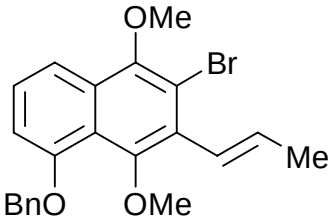


6

To a solution of benzyl-protected bromo-napthoquinone **5a** (200 mg, 0.52 mmol, 1.0 equiv) in EtOAc (1 mL), Et_2O (10 mL), and H_2O (10 mL) at 25 °C was added $Na_2S_2O_4$ (454 g, 2.61 mmol, 5.0 equiv) and the reaction mixture was stirred vigorously for 30 min. Upon consumption of starting material (TLC), the biphasic reaction mixture was extracted with EtOAc (3 × 10 mL), the combined organic layers washed with brine (15 mL), dried ($MgSO_4$), and concentrated. The resulting oil was then dissolved in DMF (5 mL) and cooled to –15 °C. NaH (44 mg, 1.10 mmol, 2.1 equiv) was added portionwise to the reaction mixture, and then MeI (71 μL, 1.15 mmol, 2.2 equiv) was added dropwise over 5 min, and the reaction

mixture was stirred at –15 °C for 1 h. The reaction mixture was then quenched with sat. aqueous NH_4Cl (10 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 10 mL), and the combined organic layers washed with brine (25 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 8:1) gave methyl-protected hydroquinone **6** (177 mg, 0.43 mmol, 82% yield) as a colorless foam. **6**: R_f = 0.64 (silica gel, hexanes:EtOAc 4:1); IR (film) ν_{max} 3068, 2931, 2840, 1637, 1611, 1561, 1497, 1453, 1440, 1385, 1365, 1324, 1264, 1160, 1120, 1081, 1051, 1030, 1015, 976, 911, 844, 812, 793, 750, 697 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.76 (d, *J* = 8.4 Hz, 1 H), 7.57 (d, *J* = 7.2 Hz, 2 H), 7.43 (t, *J* = 7.2 Hz, 2 H), 7.41 (t, *J* = 8.4 Hz, 1 H), 7.37 (t, *J* = 7.2 Hz, 1 H), 7.00 (d, *J* = 8.4 Hz, 1 H), 6.09 (ddt, *J* = 16.8, 10.2, 5.4 Hz, 1 H), 5.23 (s, 2 H), 5.10 (d, *J* = 10.2 Hz, 1 H), 5.05 (d, *J* = 16.8 Hz, 1 H), 3.96 (s, 3 H), 3.82 (d, *J* = 5.4 Hz, 2 H), 3.71 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 155.2, 151.4, 149.6, 136.8, 136.2, 130.5, 129.8, 128.5, 127.9, 127.6, 126.6, 120.4, 117.5, 115.7, 115.4, 108.7, 71.6, 63.1, 61.1, 34.3 ppm; HRMS (ESI-TOF): calcd for $C_{22}H_{22}BrO_3$ $[M+H^+]$: 413.0747, found 413.0737.

Double bond migrated napthoquinone 6a

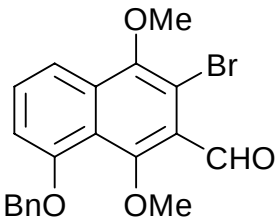


6a

To a cold (0 °C) solution of methyl-protected hydroquinone **6** (140 mg, 0.34 mmol, 1.0 equiv) in THF (4 mL) was added *t*-BuOK (680 μL, 1.0 M in THF, 0.68 mmol, 2.0 equiv) and the reaction mixture was stirred for 2 h at 0 °C. The reaction mixture was then quenched with H_2O (5 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 5 mL). The combined organic layers were dried ($MgSO_4$), concentrated, and double bond migrated napthoquinone **6a** (137 mg, 0.33 mmol, 98% yield) was used without further purification. **6a**: R_f = 0.59 (silica gel, hexanes:EtOAc 4:1); IR (film) ν_{max} 3027, 2929, 2835, 1609, 1553, 1498, 1449, 1380, 1361, 1324, 1262, 1205, 1176, 1159, 1125, 1080, 1053, 1030, 980, 912, 781, 760, 697 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.72 (d, *J* = 8.4 Hz, 1 H), 7.57 (d, *J* = 7.8 Hz, 2 H), 7.42 (t, *J* = 7.8 Hz, 2 H), 7.38 (t, *J* = 8.4 Hz, 1 H), 7.36 (t, *J* = 7.8 Hz, 1

H), 6.98 (d, J = 8.4 Hz, 1 H), 6.55 (d, J = 15.6 Hz, 1 H), 6.42 (dq, J = 15.6, 6.6 Hz, 1 H), 5.22, (s, 2 H), 3.95 (s, 3 H), 3.61 (s, 3 H), 1.99 ppm (d, J = 6.6 Hz, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 155.6, 151.3, 149.5, 136.9, 133.1, 130.2, 129.0, 128.5, 127.9, 127.6, 126.7, 125.6, 120.7, 116.3, 115.3, 108.7, 71.5, 61.3, 61.0, 19.3 ppm; HRMS (ESI-TOF): calcd for $C_{22}H_{22}BrO_3$ [M+H$^+$]: 413.0747, found 413.0728.

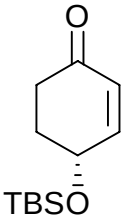
Bromo-aldehyde coupling partner 2



2

To a solution of double bond migrated napthoquinone **6a** (130 mg, 0.32 mmol, 1.0 equiv) in THF (2 mL) and H_2O (1 mL) at 25 °C was added OsO_4 (0.8 mg, 0.0032 mmol, 0.01 equiv) and $NaIO_4$ (162 mg, 0.76 mmol, 2.4 equiv). The reaction mixture was then heated to 70 °C and stirred for 18 h. The reaction mixture was then quenched with sat. aqueous $Na_2S_2O_3$ (5 mL) and stirred vigorously for 30 min. The biphasic reaction mixture was then extracted with EtOAc (3 × 10 mL) and the combined organic layers were washed with brine (15 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 6:1) provided bromo-aldehyde coupling partner **2** (108 mg, 0.27 mmol, 84% yield) as a colorless oil. **2**: R_f = 0.30 (silica gel, hexanes:EtOAc 4:1); IR (film) ν_{max} 2931, 2844, 1694, 1607, 1550, 1497, 1452, 1440, 1365, 1317, 1265, 1240, 1207, 1178, 1125, 1081, 1049, 1013, 970, 930, 843, 813, 756, 740, 697 cm^{-1}; ^{1}H NMR (600 MHz, $CDCl_3$): δ = 10.5 (s, 1 H), 7.76 (d, J = 8.4 Hz, 1 H), 7.58 (t, J = 8.4 Hz, 1 H), 7.55 (d, J = 7.8 Hz, 2 H), 7.43 (t, J = 7.8 Hz, 2 H), 7.38 (t, J = 7.8 Hz, 1 H), 7.07 (d, J = 8.4 Hz, 1 H), 5.24 (s, 2 H), 3.97 (s, 3 H), 3.78 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 190.7, 158.9, 156.8, 150.4, 136.1, 133.9, 130.3, 128.6, 128.2, 127.6, 125.1, 120.1, 115.4, 111.3, 109.1, 71.5, 65.3, 61.2 ppm; HRMS (ESI-TOF): calcd for $C_{20}H_{18}BrO_4$ [M+H$^+$]: 401.0383, found 401.0379.

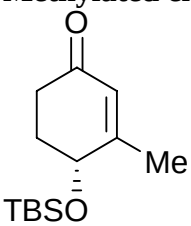
Enone 7



7

7: 80% *ee*, obtained according to ref 7. R_f = 0.48 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = +92.2 ($CDCl_3$, *c* = 2.33); IR (film) ν_{max} 2954, 2930, 2887, 2857, 1688, 1472, 1463, 1381, 1250, 1200, 1132, 1096, 1066, 997, 984, 971, 956, 857, 834, 774, 730, 667 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ = 6.80 (ddd, *J* = 10.5, 2.0, 1.5 Hz, 1 H), 5.89 (ddd, *J* = 10.5, 1.5, 1.0 Hz, 1 H), 4.50 (dddd, *J* = 9.0, 4.5, 2.5, 2.0 Hz, 1 H), 2.54 (dt, *J* = 17.0, 4.5 Hz, 1 H), 2.31 (ddd, *J* = 17.5, 13.0, 4.5 Hz, 1 H), 2.22–2.14 (m, 1 H), 2.01–1.92 (m, 1 H), 0.88 (s, 9 H), 0.10 (s, 3 H), 0.09 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 198.6, 153.7, 128.6, 66.9, 35.4, 32.9, 25.7, 18.0, –4.7, –4.8 ppm; HRMS (ESI-TOF): calcd for $C_{12}H_{23}O_2Si$ [M+H$^+$]: 227.1462, found 227.1470.

Methylated enone 8

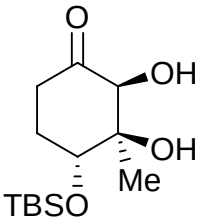


8

To a solution of MeMgBr (18.0 mL, 3.0 M in THF, 53.9 mmol, 2.0 equiv) in THF (80 mL) at –78 °C was added CuBr•DMS (553 mg, 2.7 mmol, 0.1 equiv) in HMPA (11 mL) dropwise over 10 min, and the reaction mixture was stirred at –78 °C for 30 min. A solution of enone **7** (6.1 g, 26.9 mmol, 1.0 equiv) in THF (30 mL) and TMSCl (8.6 mL, 67.3 mmol, 2.5 equiv) was then added dropwise to the reaction mixture over 45 min, and the reaction mixture was stirred at –78 °C for 30 min and then warmed to 25 °C over 30 min. The reaction mixture was then quenched with Et_3N (13 mL), hexanes (120 mL), and pH 7 buffer (120 mL), and the resulting slurry was filtered through a plug of Celite. The biphasic filtrate was then extracted with EtOAc (3 × 100 mL), the combined organic layers were washed with brine (2 × 100 mL), and then concentrated, without further drying. The resulting oil was dissolved in DMSO (250 mL), and $Pd(OAc)_2$ (1.8 g, 2.7 mmol, 0.1 equiv) was added in one portion to the reaction mixture at 25 °C, under an oxygen atmosphere (balloon, 1 atm). The reaction mixture was stirred at 25 °C for 18 h, and then quenched with H_2O (250 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 200 mL). The combined organic layers were dried ($MgSO_4$), and concentrated. Flash column

chromatography (silica gel, hexanes:EtOAc 10:1) afforded methylated enone **8** (5.8 g, 24.1 mmol, 90% yield over two steps) as a colorless oil. **8**: R_f = 0.44 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = +26.0 ($CDCl_3$, *c* =1.53); IR (film) ν_{max} 2954, 2929, 2887, 2857, 1673, 1472, 1463, 1440, 1374, 1360, 1324, 1252, 1195, 1096, 1098, 1066, 1004, 989, 972, 895, 879, 855, 835, 803, 774, 671 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ = 5.75 (d, *J* = 1.0 Hz, 1 H), 4.30 (dd, *J* = 8.5, 4.5 Hz, 1 H), 2.48 (dt, *J* = 17.0, 5.0 Hz, 1 H), 2.26 (ddd, *J* = 17.0, 12.0, 5.0 Hz, 1 H), 2.15–2.06 (m, 1 H), 1.97–1.88 (m, 1 H), 1.92 (s, 3 H), 0.86 (s, 9 H), 0.08 (s, 3 H), 0.07 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 198.4, 164.0, 126.4, 69.5, 34.9, 32.4, 25.6, 20.9, 17.9, –4.5, –5.1 ppm; HRMS (ESI-TOF): calcd for $C_{13}H_{25}O_2Si$ [M+H$^+$]: 241.1618, found 241.1622.

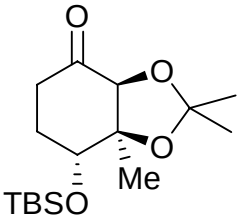
Diol 9



9

To a solution of methylated enone **8** (5.8 g, 24.1 mmol, 1.0 equiv) in acetone (45 mL) and H_2O (4.5 mL) at 25 °C, was added NMO (4.2 g, 36.2 mmol, 1.5 equiv), and OsO_4 (125 mg, 0.48 mmol, 0.02 equiv), and the reaction mixture was stirred at 25 °C for 45 min. The reaction mixture was then quenched with sat. aqueous $Na_2S_2O_4$ (50 mL), and the biphasic reaction mixture was stirred at 25 °C for 30 min, and then extracted with EtOAc (3 × 50 mL). The combined organic layers were then washed with brine (100 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 4:1) afforded diol **9** (5.0 g, 18.2 mmol, 76% yield) as a colorless oil after three recrystallizations (hexanes/EtOAc), which removed the minor wrong enantiomer. **9**: R_f = 0.16 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = –45.6 ($CDCl_3$, *c* =1.58); IR (film) ν_{max} 3468, 2951, 2931, 2858, 2886, 1722, 1463, 1390, 1361, 1254, 1086, 1041, 990, 963, 939, 885, 853, 837, 810, 776, 681 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 4.27 (s, 1 H), 3.89 (s, 1 H), 3.69 (s, 1 H), 2.74 (td, *J* = 13.8, 6.6 Hz, 1 H), 2.38–2.34 (m, 2 H), 2.32–2.26 (m, 1 H), 1.90–1.85 (m, 1 H), 1.40 (s, 3 H), 0.92 (s, 9 H), 0.13 (s, 3 H), 0.12 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 210.6, 79.6, 77.5, 73.4, 33.2, 29.2, 25.7, 23.7, 17.9, –4.5, –5.0 ppm; HRMS (ESI-TOF): calcd for $C_{13}H_{27}O_4Si$ [M+H$^+$]: 275.1673, found 275.1675.

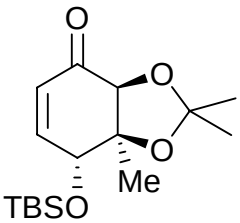
Acetonide 10



10

To a solution of diol **9** (5.0 g, 18.2 mmol, 1.0 equiv) in THF (625 mL) at 25 °C was added 2-methoxy-propene (17.4 mL, 182 mmol, 10.0 equiv), and CSA (85 mg, 0.37 mmol, 0.02 equiv), and the reaction mixture was stirred at 25 °C for 18 h. The reaction mixture was then quenched with H_2O (500 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 500 mL), the combined organic layers were dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 20:1) provided acetonide **10** (5.4 g, 17.2 mmol, 95% yield) as a colorless oil. **10**: R_f = 0.54 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = –36.8 ($CDCl_3$, *c* = 1.83); IR (film) ν_{max} 2982, 2932, 2888, 2858, 1729, 1472, 1463, 1408, 1374, 1330, 1250, 1210, 1177, 1137, 1087, 1063, 1042, 996, 969, 939, 912, 892, 856, 835, 809, 774, 750, 680, 656 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 3.93 (s, 1 H), 3.72 (d, *J* = 5.4 Hz, 1 H), 2.52–2.36 (m, 3 H), 1.84 (m, 1 H), 1.45 (s, 3 H), 1.40 (s, 3 H), 1.39 (s, 3 H), 0.85 (s, 9 H), 0.06 ppm (s, 6 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 207.4, 111.0, 87.0, 84.0, 71.6, 31.7, 27.1, 26.5, 25.6, 25.4, 23.8, 17.9, 17.9, –4.7, –5.0 ppm; HRMS (ESI-TOF): calcd for $C_{16}H_{31}O_4Si$ [M+H$^+$]: 315.1986, found 315.1987.

Enone 11

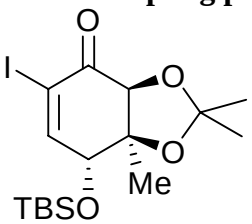


11

To a cold (0 °C) solution of acetonide **10** (4.4 g, 14.0 mmol, 1.0 equiv) in THF (140 mL) was added LiHMDS (42.0 mL, 1.0 M in THF, 42.0 mmol, 3.0 equiv) dropwise over 10 min, followed by TMSCl (5.4 mL, 42.0 mmol, 3.0 equiv) dropwise addition over 5 min. The reaction mixture was stirred for 20 min at 0 °C, and then warmed to 25 °C over 10 min. Upon disappearance of the starting material (TLC), the reaction mixture was quenched with H_2O (100 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 100 mL), and the combined organic layers were washed with brine (2 × 100 mL), and concentrated without further

drying. The residual oil was then dissolved in DMSO (140 mL), and $Pd(OAc)_2$ (940 mg, 1.4 mmol, 0.1 equiv) was added in one portion, and the reaction mixture was stirred under an oxygen atmosphere (balloon, 1 atm) at 25 °C for 18 h. The reaction mixture was then quenched with H_2O (150 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 150 mL), the combined organic layers were dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 10:1) gave enone **11** (3.7 g, 11.8 mmol, 84% yield over two steps). **11**: R_f = 0.57 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = –101.4 ($CDCl_3$, *c* = 2.0); IR (film) ν_{max} 2987, 2955, 2932, 2881, 2858, 1691, 1472, 1374, 1339, 1250, 1216, 1194, 1175, 1134, 1119, 1095, 1053, 1019, 992, 940, 889, 850, 836, 778, 696 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 6.77 (dd, *J* = 10.2, 1.8 Hz, 1 H), 6.05 (dd, *J* = 10.2, 2.1 Hz, 1 H), 4.58 (bt, *J* = 2.1 Hz, 1 H), 4.10 (s, 1 H), 1.49 (s, 3 H), 1.44 (s, 3 H), 1.32 (s, 3 H), 0.93 (s, 9 H), 0.16 (s, 3 H), 0.12 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 192.6, 154.6, 126.9, 110.4, 85.4, 81.0, 72.6, 27.8, 26.9, 25.7, 18.7, 18.0, –4.5, –4.9 ppm; HRMS (ESI-TOF): calcd for $C_{16}H_{29}O_4Si$ $[M+H^+]$: 313.1830, found 313.1822.

Iodide coupling partner 3

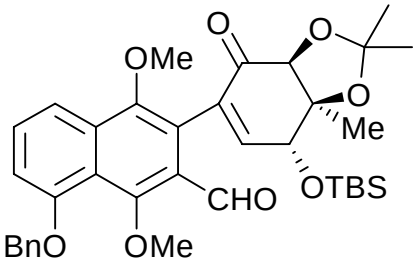


3

To a solution of enone **11** (1.4 g, 4.9 mmol, 1.0 equiv) in CH_2Cl_2 (7 mL) and pyridine (14 mL) at 25 °C was added I_2 (3.4 g, 13.4 mmol, 3.0 equiv) portionwise. After 30 min (starting material consumed by TLC), the reaction mixture was quenched with H_2O (50 mL) and $Na_2S_2O_3$ (5 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 50 mL), and the combined organic layers were washed with brine (50 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 20:1) yielded iodide **3** (1.8 g, 4.1 mmol, 92% yield) as a thick colorless oil. **3**: R_f = 0.62 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = –99.7 ($CDCl_3$, *c* = 5.25); IR (film) ν_{max} 2988, 2954, 2931, 2857, 1696, 1589, 1471, 1462, 1375, 1348, 1324, 1250, 1215, 1196, 1172, 1120, 1100, 1055, 1006, 991, 945, 911, 882, 860, 837, 813, 801, 779, 730 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.47 (d, *J* = 2.4 Hz, 1 H), 4.52 (d, *J* = 2.4

Hz, 1 H), 4.21 (s, 1 H), 1.44 (s, 3 H), 1.42 (s, 3 H), 1.33 (s, 3 H), 0.91 (s, 9 H), 0.13 (s, 3 H), 0.11 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 186.9, 161.9, 110.9, 99.2, 85.2, 79.4, 74.5, 27.7, 27.0, 25.6, 19.2, 18.0, –4.6, –4.9 ppm; HRMS (ESI-TOF): calcd for $C_{16}H_{28}IO_4Si$ [M+H$^+$]: 439.0796, found 439.0801.

Ullmann coupled product 12

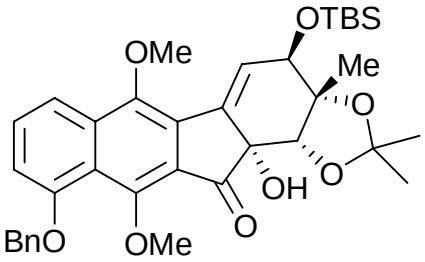


12

To a solution of bromo-aldehyde coupling partner **2** (110 mg, 0.27 mmol, 1.5 equiv) and iodide coupling partner **3** (80 mg, 0.18 mmol, 1.0 equiv) in DMSO (2 mL) at 25 °C was added Cu powder (116 mg, 1.82 mmol, 10.0 equiv), CuI (14 mg, 0.073 mmol, 0.4 equiv), and $Pd_2(dba)_3$ (17 mg, 0.018 mmol, 0.1 equiv), and the reaction mixture was heated to 65 °C for 2.5 h (iodide coupling partner **3** consumed by TLC), and then cooled to 25 °C. The reaction mixture was then quenched with H_2O (5 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 10 mL), the combined organic layers were washed with brine (10 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 20:1) provided Ullmann coupled product **12** (95 mg, 0.15 mmol, 83% yield) as a slightly yellow foam. **12**: R_f = 0.61 (silica gel, hexanes:EtOAc 2:1); $[\alpha]_D^{32}$ = +8.1 ($CDCl_3$, *c* = 1.25); IR (film) ν_{max} 2987, 2951, 2932, 2881, 2857, 1696, 1673, 1609, 1570, 1495, 1445, 1403, 1363, 1329, 1250, 1212, 1196, 1124, 1083, 1054, 993, 973, 936, 888, 837, 819, 776, 734, 698 cm^{-1}; ^{1}H NMR (600 MHz, $CDCl_3$): δ = 10.4 (s, 1 H), 7.82 (d, *J* = 8.4 Hz, 1 H), 7.59 (t, *J* = 8.4 Hz, 1 H), 7.56 (d, *J* = 7.2 Hz, 2 H), 7.44 (t, *J* = 7.2 Hz, 2 H), 7.38 (t, *J* = 7.2 Hz, 1 H), 7.08 (d, *J* = 8.4 Hz, 1 H), 6.1 (d, *J* = 1.8 Hz, 1 H), 5.27 (s, 2 H), 4.74 (s, 2 H), 3.80 (s, 3 H), 3.71 (s, 3 H), 1.62 (s, 3 H), 1.58 (s, 3 H), 1.52 (s, 3 H), 0.95 (s, 9 H), 0.20 (s, 3 H), 0.17 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 192.5, 191.1, 191.1, 161.5, 156.6, 151.7, 148.4, 136.3, 135.1, 133.6, 130.3, 128.7, 128.2, 127.6, 123.7, 122.5, 120.5, 116.0, 109.9, 109.5, 84.6, 82.1, 73.6, 71.6, 65.8, 61.8, 27.9, 26.5,

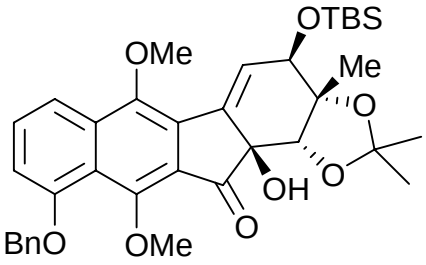
25.8, 19.6, 18.2, –4.5, –5.0 ppm; HRMS (ESI-TOF): calcd for $C_{36}H_{45}O_8Si$ [M+H$^+$]: 633.2878, found 633.2884.

Benzoin products 14 and 14a



14

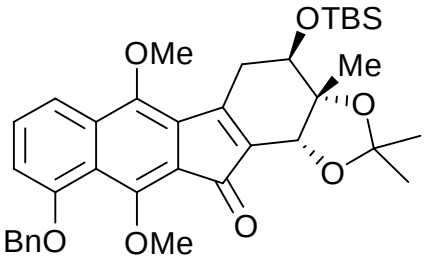
To a solution of Ullmann coupled product **12** (60 mg, 0.095 mmol, 1.0 equiv) in CH_2Cl_2 (1 mL) at 25 °C was added Rovis catalyst **13** (6.9 mg, 0.019 mmol, 0.2 equiv), followed by Et_3N (26.4 μL, 0.19 mmol, 2.0 equiv). The reaction mixture was then heated to 45 °C for 4 h (consumption of starting material by TLC), and cooled to 25 °C. The reaction mixture was quenched with H_2O (5 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 5 mL), the combined organic layers were washed with brine (5 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 10:1) yielded benzoin products **14** and **14a** (47 mg, 0.074 mmol, 78% yield, 3:1 mixture of inconsequential isomers) as a slightly yellow oil. **14**: R_f = 0.63 (silica gel, hexanes:EtOAc 2:1); $[\alpha]_D^{32}$ = –51.8 ($CDCl_3$, *c* = 1.48); IR (film) ν_{max} 3504, 2982, 2951, 2932, 2881, 2856, 1719, 1607, 1569, 1506, 1445, 1372, 1355, 1332, 1277, 1248, 1212, 1194, 1112, 1089, 1059, 1046, 1029, 1004, 982, 946, 910, 880, 867, 837, 820, 777, 734, 696 cm^{-1}; ^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.76 (d, *J* = 7.8 Hz, 1 H), 7.57 (d, *J* = 7.2 Hz, 1 H), 7.56 (d, *J* = 7.2 Hz, 1 H), 7.56 (t, *J* = 7.8 Hz, 1 H), 7.42 (t, *J* = 7.2 Hz, 2 H), 7.36 (t, *J* = 7.2 Hz, 1 H), 6.99 (d, *J* = 7.8 Hz, 1 H), 6.76 (d, *J* = 3.0 Hz, 1 H), 5.23 (s, 2 H), 5.02 (d, *J* = 3.0 Hz, 1 H), 4.10 (s, 1 H), 4.06 (s, 1 H), 3.94 (s, 3 H), 3.91 (s, 3 H), 1.60 (s, 3 H), 1.52 (s, 3 H), 1.32 (s, 3 H), 0.98 (s, 9 H), 0.18 (s, 3 H), 0.17 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 199.9, 158.5, 55.9, 147.6, 136.6, 136.5, 136.3, 131.4, 130.3, 130.1, 128.6, 128.0, 127.5, 122.3, 122.0, 115.0, 112.9, 108.7, 88.2, 81.1, 75.7, 73.7, 71.3, 63.0, 60.0, 60.1, 28.1, 27.8, 25.9, 22.9, 18.3, –4.6, –5.1 ppm; HRMS (ESI-TOF): calcd for $C_{36}H_{45}O_8Si$ [M+H$^+$]: 633.2878, found 633.2899.



14a

14a: R_f = 0.60 (silica gel, hexanes:EtOAc 2:1); $[\alpha]_D^{32}$ = +2.7 ($CDCl_3$, *c* = 0.98); IR (film) ν_{max} 3391, 2987, 2932, 2858, 1725, 1655, 1607, 1570, 1507, 1444, 1373, 1356, 1333, 1276, 1257, 1213, 1179, 1148, 1115, 1048, 1016, 1003, 977, 962, 934, 910, 875, 831, 809, 780, 758, 732, 697 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.78 (d, *J* = 8.4 Hz, 1 H), 7.58 (d, *J* = 7.2 Hz, 2 H), 7.56 (t, *J* = 8.4 Hz, 1 H), 7.42 (t, *J* = 7.2 Hz, 2 H), 7.35 (t, *J* = 7.2 Hz, 1 H), 7.15 (d, *J* = 6.0 Hz, 1 H), 7.00 (d, *J* = 8.4 Hz, 1 H), 5.23 (s, 2 H), 4.79 (s, 1 H), 4.68 (s, 1 H), 4.31 (d, *J* = 6.0 Hz, 1 H), 3.96 (s, 3 H), 3.93 (s, 3 H), 1.67 (s, 3 H), 1.32 (s, 3 H), 1.0 (s, 3 H), 0.90 (s, 9 H), 0.22 (s, 3 H), 0.21 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 196.8, 158.6, 155.5, 148.6, 141.0, 136.5, 136.2, 130.7, 129.9, 128.5, 128.0, 127.5, 127.5, 127.3, 124.0, 122.4, 115.1, 109.7, 108.9, 84.6, 84.5, 74.9, 72.0, 71.4, 63.1, 60.6, 27.4, 27.3, 26.7, 25.6, 17.8, –4.1, –5.0 ppm; HRMS (ESI-TOF): calcd for $C_{36}H_{45}O_8Si$ $[M+H^+]$: 633.2878, found 633.2874.

Indenone 14b



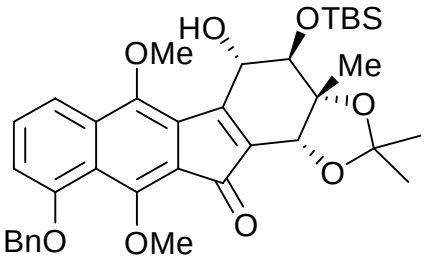
14b

To a solution of benzoin products **14** and **14a** (200 mg, 0.31 mmol, 1.0 equiv) in CH_2Cl_2 (4 mL) at 25 °C was added Ac_2O (322 mg, 3.1 mmol, 10.0 equiv), DMAP (38 mg, 0.31 mmol, 1.0 equiv) and Et_3N (319 mg, 3.1 mmol, 10.0 equiv). The reaction mixture was stirred at 25 °C for 20 h, and then diluted with ethyl acetate (50 mL). The biphasic reaction mixture was extracted with EtOAc (3 × 50 mL), and the combined organic layers were washed with sat. aqueous $NaHCO_3$ (100 mL) and brine (100 mL), then dried (Na_2SO_4), and concentrated. Flash chromatography (silica gel, hexanes:EtOAc 16:1) provided the corresponding acetate protected benzoin product (202 mg, 0.30 mmol, 95% yield) as a slightly yellow foam. To a solution of the acetate protected benzoin product (190 mg, 0.28 mmol, 1.0 equiv) in THF (5 mL) at –78 °C was added MeOH (57 μL, 1.4 mmol, 5.0 equiv), followed by SmI_2 (5.6 mL, 0.1 M in THF, 0.56

mmol, 2.0 equiv) added dropwise. The reaction mixture was stirred at –78 °C for 10 min (starting material consumed by TLC), then quenched with sat. aqueous NH_4Cl (10 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 10 mL). The combined organic layers were washed with sat. aqueous NH_4Cl (10 mL) and brine (10 mL), then dried (Na_2SO_4), and concentrated. The residual oil was dissolved in CH_2Cl_2 (8 mL), and Et_3N (77 μL, 0.56 mmol, 2.0 equiv) was added at 25 °C. The reaction mixture was stirred at 25 °C for 1 h and then concentrated. Flash chromatography (silica gel, hexanes:EtOAc 18:1) afforded indenone **14b** (141 mg, 0.23 mmol, 81% yield over two steps) as a slightly yellow foam. **14b**: R_f = 0.60 (silica gel, hexanes:EtOAc 4:1); $[\alpha]_D^{32}$ = +16.1 ($CDCl_3$, *c* = 1.02); IR (film) ν_{max} 2977, 2932, 2891, 2856, 1694, 1591, 1525, 1446, 1372, 1346, 1327, 1248, 1214, 1194, 1121, 1060, 1044, 1018, 980, 908, 864, 878, 837, 816, 778, 761, 733, 697 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.61 (d, *J* = 8.4 Hz, 1 H), 7.55 (d, *J* = 7.8 Hz, 2 H), 7.49 (t, *J* = 8.4 Hz, 1 H), 7.42 (t, *J* = 7.8 Hz, 2 H), 7.35 (t, *J* = 7.8 Hz, 1 H), 7.03 (d, *J* = 8.4 Hz, 1 H), 5.20 (q, *J* = 11.4 Hz, 2 H), 4.68 (s, 1 H), 4.14 (br dd, *J* = 9.6, 5.4 Hz, 1 H), 3.92 (s, 3 H), 3.91 (s, 3 H), 3.26 (dd, *J* = 19.2, 5.4 Hz, 1 H), 2.64 (dd, *J* = 19.2, 9.6 Hz, 1 H), 1.52 (s, 3 H), 1.49 (s, 3 H), 1.30 (s, 3 H), 0.95 (s, 9 H), 0.16 (s, 3 H), 0.14 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 190.9, 159.1, 156.7, 154.0, 147.1, 136.6, 135.8, 133.1, 129.9, 128.5, 128.0, 127.5, 127.4, 123.0, 119.3, 116.0, 111.1, 109.7, 82.1, 73.9, 72.3, 71.5, 63.2, 62.8, 33.3, 28.7, 27.2, 25.8, 18.1, 17.2, –4.4, –4.6 ppm; HRMS (ESI-TOF): calcd for $C_{36}H_{45}O_7Si$ [M+H$^+$]: 617.2929, found 617.2929.

Allylic alcohol 15

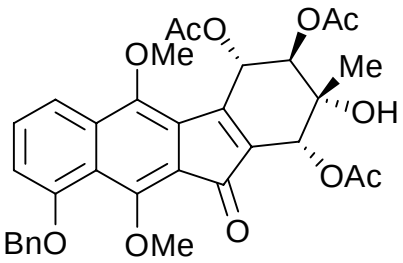
To a suspension of indenone **14b** (696 mg, 1.13 mmol, 1.0 eq) in 1,4-dioxane (40 mL) at 25 °C was added SeO_2 (145 mg, 1.30 mmol, 1.2 equiv), and the reaction mixture was heated at 110 °C for 9 h. Then reaction mixture was then cooled to 25 °C, and quenched with sat. aqueous Na_2SO_3 (50 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 50 mL). The combined organic layers were washed with brine (100 mL), dried ($MgSO_4$), and concentrated. Flash chromatography chromatography (silica gel, hexanes:EtOAc 18:1) gave allylic alcohol **15**



15

(515 mg, 0.81 mmol, 72% yield) as slightly yellow foam. **15**: R_f = 0.60 (silica gel, hexanes:EtOAc 2:1); $[\alpha]_D^{32}$ = +7.9 ($CDCl_3$, *c* = 0.67); IR (film) ν_{max} 3453, 2932, 2855, 1697, 1590, 1448, 1370, 1346, 1320, 1251, 1214, 1124, 1081, 1055, 1036, 1004, 878, 838, 779, 737, 698 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.59 (d, *J* = 8.4 Hz, 1 H), 7.55 (d, *J* = 7.2 Hz, 2 H), 7.52 (t, *J* = 8.4 Hz, 1 H), 7.42 (t, *J* = 7.2 Hz, 2 H), 7.36 (t, *J* = 7.2 Hz, 1 H), 7.05 (d, *J* = 8.4 Hz, 1 H), 5.21 (q, *J* = 11.4 Hz, 2 H), 4.66 (s, 1 H), 4.64 (d, *J* = 3.6 Hz, 1 H), 4.48–4.95 (brs, 1 H), 4.08 (d, *J* = 6.6 Hz, 1 H), 4.02 (s, 3 H), 3.93 (s, 3 H), 1.51 (s, 3 H), 1.49 (s, 3 H), 1.35 (s, 3 H), 0.95 (s, 9 H), 0.20 (s, 3 H), 0.18 ppm (s, 3 H); ^{13}C NMR (150 MHz, $CDCl_3$): δ = 190.9, 159.2, 155.8, 155.0, 145.2, 136.4, 135.0, 132.3, 128.7, 128.66, 128.0, 127.5, 127.1, 122.9, 119.0, 116.0, 111.2, 110.8, 83.0, 73.5, 71.5, 69.7, 63.8, 62.9, 28.6, 27.7, 25.9, 18.9, 18.4, –4.2, –4.9 ppm; HRMS (ESI-TOF): calcd for $C_{36}H_{45}O_8Si$ $[M+H^+]$: 633.2878, found 633.2872.

Acetate protected compound 15a

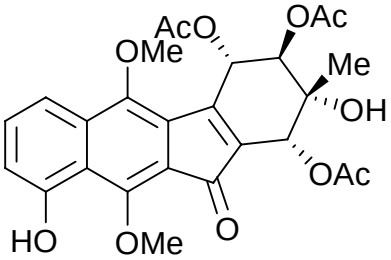


15a

To a solution of allylic alcohol **15** (70 mg, 0.11 mmol, 1.0 equiv) in MeCN (7 mL) at 25 °C was added aq. HF (2.1 mL) and the reaction mixture was stirred at 25 °C for 3 h. The reaction mixture was then quenched with brine (20 mL) and extracted with EtOAc (3 × 25 mL). The combined organic layers were washed with sat. aq. $NaHCO_3$ (2 × 25 mL) and brine (25 mL), dried ($MgSO_4$), and concentrated. The resulting oil was dissolved in CH_2Cl_2 (3 mL), and Ac_2O (105 μL, 1.11 mmol, 10.0 equiv) was added at 25 °C, followed by DMAP (14 mg, 0.11 mmol, 1.0 equiv), and Et_3N (155 μL, 1.11 mmol, 10.0 equiv). The reaction mixture was stirred for 30 min at 25 °C, and then quenched with brine (10 mL) and extracted with EtOAc (3 × 10 mL). The combined organic layers were washed with brine (10 mL), dried ($MgSO_4$), and concentrated. Flash column chromatography (silica gel, hexanes:EtOAc 2:1) provided acetate

protected **15a** (60 mg, 0.099 mmol, 89% yield over two steps) as a yellow-orange foam. **15a**: R_f = 0.20 (silica gel, hexanes:EtOAc 1:1); $[\alpha]_D^{32}$ = –65.0 ($CDCl_3$, *c* = 0.93); IR (film) ν_{max} 3476, 2931, 2850, 1747, 1695, 1590, 1525, 1446, 1371, 1345, 1321, 1224, 1046, 1026, 976, 911, 844, 810, 758, 732, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ = 7.47 (d, *J* = 8.0 Hz, 1 H), 7.54 (d, *J* = 7.5 Hz, 2 H), 7.50 (t, *J* = 8.0 Hz, 1 H), 7.40 (t, *J* = 7.5 Hz, 2 H), 7.34 (t, *J* = 7.5 Hz, 1 H), 7.04 (d, *J* = 8.0 Hz, 1 H), 6.05 (d, *J* = 6.0 Hz, 1 H), 5.90 (s, 1 H), 5.49 (d, *J* = 6.0 Hz, 1 H), 5.20 (s, 2 H), 3.88 (s, 3 H), 3.79 (s, 3 H), 2.17 (s, 3 H), 2.16 (s, 3 H), 2.13 (s, 3 H), 1.36 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 189.0, 170.7, 170.3, 170.2, 159.1, 155.0, 147.3, 136.4, 135.6, 130.3, 128.5, 128.0, 127.4, 125.2, 122.9, 118.9, 116.6, 111.5, 75.1, 72.4, 71.5, 67.9, 67.5, 63.9, 62.7, 31.5, 22.6, 20.9, 20.2, 14.1 ppm; HRMS (ESI-TOF): calcd for $C_{33}H_{33}O_{11}$ $[M+H^+]$: 605.2017, found 605.1999.

Free-phenol 16

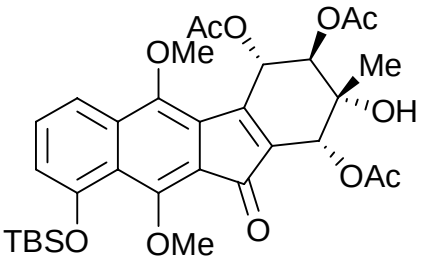


16

To a solution of acetate protected **15a** (57 mg, 0.094 mmol, 1.0 equiv) in EtOAc (3 mL) and AcOH (10 μL) at 25 °C was added Pd/C (5.7 mg, 10% w/w), and the reaction mixture was stirred at 25 °C under a hydrogen atmosphere (balloon, 1 atm) for 3 h (checking each hour by ^1H NMR). Upon consumption of starting material (^1H NMR), the reaction mixture was filtered through a plug of Celite, and concentrated. The resulting free-phenol **16** (48 mg, 0.093 mmol, 99% yield) was used without further purification. **16**: R_f = 0.24 (silica gel, hexanes:EtOAc 1:1); $[\alpha]_D^{32}$ = –96.6 ($CDCl_3$, *c* = 0.5); IR (film) ν_{max} 3473, 3362, 2941, 1748, 1693, 1590, 1532, 1444, 1371, 1346, 1225, 1165, 1036, 1019, 930, 907, 816, 730 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 9.74 (s, 1 H), 7.49 (t, *J* = 7.8 Hz, 1 H), 7.44 (d, *J* = 7.8 Hz, 1 H), 6.97 (d, *J* = 7.8 Hz, 1 H), 6.04 (d, *J* = 6.6 Hz, 1 H), 5.89 (s, 1 H), 5.49 (d, *J* = 6.6 Hz, 1 H), 4.34 (s, 3 H), 3.80 (s, 3 H), 2.19 (s, 3 H), 2.17 (s, 3 H), 2.12 (s, 3 H), 1.35 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 189.0, 170.7, 170.3, 170.2, 159.1, 155.0, 147.3, 136.4, 135.6, 188.1, 170.3, 170.2, 158.7, 153.9, 147.9, 135.4, 134.2, 131.7, 124.7,

118.1, 115.4, 115.2, 75.1, 72.4, 67.8, 67.4, 64.4, 63.9, 21.0, 20.9, 20.2 ppm; HRMS (ESI-TOF): calcd for $C_{26}H_{26}O_{11}Na$ [M+Na$^+$]: 537.1367, found 537.1375.

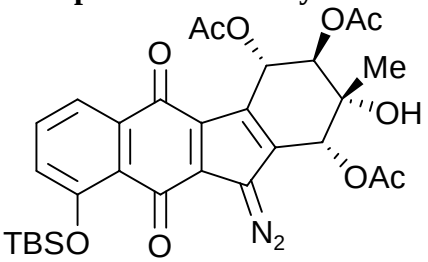
TBS-protected phenol 16a



16a

To a solution of free-phenol **16** (257 mg, 0.50 mmol, 1.0 equiv) in DMF (9 mL) at 25 °C was added TBSCl (375 mg, 2.5 mmol, 5.0 equiv) and imid. (204 mg, 3.0 mmol, 6.0 equiv) and the reaction mixture was stirred at 25 °C for 3 h. The reaction mixture was quenched with H_2O (20 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 20 mL), and the combined organic layers were washed with sat. aqueous $NaHCO_3$ (20 mL) and brine (20 mL), then dried (Na_2SO_4), and concentrated. Flash chromatography (silica gel, hexanes:EtOAc 2:1) afforded TBS-protected phenol **16a** (296 mg, 0.47 mmol, 94% yield) as yellow foam. **16a**: R_f = 0.30 (silica gel, hexanes:EtOAc 1:1); $[\alpha]_D^{32}$ = –108.3 ($CDCl_3$, c = 0.65); IR (film) ν_{max} 3484, 2932, 2857, 1747, 1695, 1590, 1524, 1447, 1370, 1344, 1220, 1038, 1022, 977, 956, 938, 910, 840, 821, 804, 760, 730 cm^{-1}; ^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.56 (d, J = 7.8 Hz, 1 H), 7.43 (t, J = 7.8 Hz, 1 H), 6.93 (d, J = 7.8 Hz, 1 H), 6.04 (d, J = 6.0 Hz, 1 H), 5.89 (s, 1 H), 5.48 (d, J = 6.0 Hz, 1 H), 4.00 (s, 3 H), 3.79 (s, 3 H), 2.17 (s, 3 H), 2.16 (s, 3 H), 2.12 (s, 3 H), 1.35 (s, 3 H), 1.02 (s, 9 H), 0.25 (s, 3 H), 0.23 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 188.9, 170.8, 170.3, 170.3, 156.1, 155.6, 147.2, 135.5, 135.4, 130.1, 124.8, 124.6, 119.9, 117.6, 117.0, 75.2, 72.4, 67.9, 67.5, 63.9, 62.9, 26.1, 21.0, 21.0, 21.0, 20.2, 18.8, –4.1, –4.2 ppm; HRMS (ESI-TOF): calcd for $C_{32}H_{41}O_{11}Si$ [M+H$^+$]: 629.2413, found 629.2412.

TBS-protected kinamycin C 17

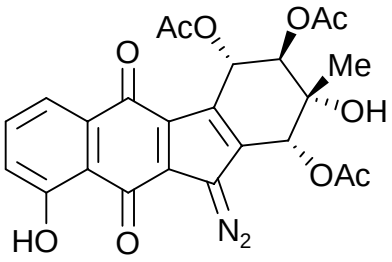


17

To a solution of TBS-protected phenol **16a** (25 mg, 0.040 mmol, 1.0 equiv) in *i*-PrOH (2.0 mL) at 25 °C was added $TsHNNH_2$ (37 mg, 0.20 mmol, 5.0 equiv), and aq. 1 M HCl

(0.05 mL), and the reaction mixture was stirred at that temperature for 18 h. The reaction mixture was quenched with H_2O (2 mL) and the biphasic reaction mixture was extracted with EtOAc (3 × 2 mL), and the combined organic layers were dried ($MgSO_4$), filtered, and concentrated. Preparative plate chromatography (silica gel, benzene:acetone 5:1) provided the corresponding tosyl-hydrazone (30 mg, 0.038 mmol, 95% yield, *ca*. 4:1 mixture of isomers) as a yellow-orange foam. To a cold (0 °C) solution of the tosyl-hydrazone (27 mg, 0.034 mmol, 1.0 equiv) in MeCN (1.0 mL) was added CAN (56 mg, 0.102 mmol, 3.0 equiv) in pH 7 buffer (0.1 mL). The reaction mixture was stirred at 0 °C for about 1 h (consumption of starting material by TLC), and then put directly on a prep-plate (silica gel, hexanes:EtOAc 1:1), which yielded TBS-protected kinamycin C (**17**, 8.7 mg, 0.014 mmol, 42% yield) as a yellow foam. **17**: R_f = 0.30 (silica gel, hexanes:EtOAc 1:1); $[\alpha]_D^{32}$ = –37.8 ($CDCl_3$, *c* = 0.33); IR (film) ν_{max} 3463, 2951, 2931, 2860, 2144, 1744, 1651, 1582, 1486, 1462, 1433, 1371, 1319, 1297, 1226, 1165, 1085, 1046, 968, 881, 843, 821, 806, 789, 732 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 7.83 (d, *J* = 7.8 Hz, 1 H), 7.50 (t, *J* = 7.8 Hz, 1 H), 7.12 (d, *J* = 7.8 Hz, 1 H), 6.23 (d, *J* = 7.2 Hz, 1 H), 5.60 (d, *J* = 7.2 Hz, 1 H), 5.50 (s, 1 H), 2.19 (s, 6 H), 2.12 (s, 3 H), 1.28 (s, 3 H), 1.05 (s, 9 H), 0.26 ppm (s, 6 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 178.6, 178.5, 172.0, 170.9, 170.3, 156.4, 136.5, 136.0, 134.1, 128.4, 127.7, 127.3, 125.4, 122.8, 121.2, 78.0, 75.6, 73.6, 71.1, 68.2, 25.9, 21.1, 21.0, 20.8, 18.6, 18.6, –4.1, –4.1 ppm; HRMS (ESI-TOF): calcd for $C_{30}H_{35}N_2O_{10}Si$ $[M+H^+]$: 611.2056, found 611.2039.

Kinamycin C (1c)

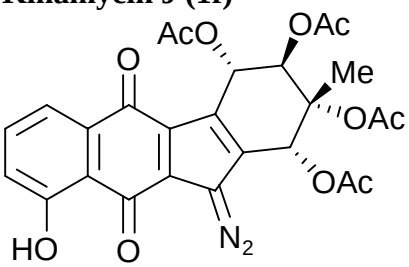


1c

To a solution of TBS-protected kinamycin C (**17**, 8.0 mg, 0.013 mmol, 1.0 equiv) in MeCN (0.2 mL) at 25 °C was added aq. 1 M HCl (0.1 mL), and the reaction mixture was stirred at 25 °C for 3 h. The reaction mixture was then quenched with H_2O (0.5 mL), the biphasic reaction mixture was extracted with EtOAc (3 × 0.5 mL), and the combined organic layers were dried ($MgSO_4$), and

concentrated. Preparative-plate chromatography (silica gel, hexanes:EtOAc 1:1) gave kinamycin C (**1c**, 6.1 mg, 0.012 mmol, 95% yield) as a yellow foam. **1c**: R_f = 0.23 (silica gel, hexanes:EtOAc 1:1); $[\alpha]_D^{32}$ = –23.8 ($CHCl_3$, *c* = 0.34); IR (film) ν_{max} 3470, 2927, 2850, 2148, 1741, 1659, 1623, 1597, 1484, 1457, 1370, 1331, 1301, 1229, 1157, 1075, 1039, 1019, 953, 908, 833, 765, 753, 734, 701 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 12.12 (s, 1 H), 7.67 (d, *J* = 8.4 Hz, 1 H), 7.56 (t, *J* = 8.4 Hz, 1 H), 7.18 (d, *J* = 8.4 Hz, 1 H), 6.23 (d, *J* = 7.2 Hz, 1 H), 5.60 (d, *J* = 7.2 Hz, 1 H), 5.49 (s, 1 H), 2.66 (br s, 1 H), 2.21 (s, 3 H), 2.20 (s, 3 H), 2.11 (s, 3 H), 1.27 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 184.0, 178.1, 171.9, 171.0, 162.0, 136.3, 134.3, 132.6, 130.0, 129.1, 126.7, 123.8, 119.9, 115.6, 77.9, 75.5, 73.6, 71.0, 68.0, 21.1, 21.0, 20.8, 18.6 ppm; HRMS (ESI-TOF): calcd for $C_{24}H_{21}N_2O_{10}$ $[M+H^+]$: 497.1196, found 497.1195.

Kinamycin J (1f)

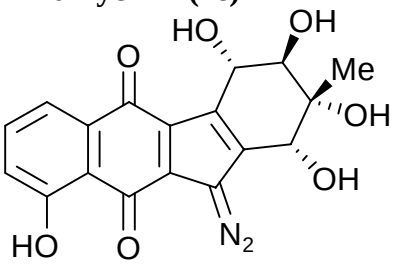


kinamycin J (1f)

To a solution of TBS-protected kinamycin C **17** (3.2 mg, 0.0052 mmol, 1.0 equiv) in CH_2Cl_2 (0.2 mL) at 25 °C was added Ac_2O (5.3 μL, 0.052 mmol, 10.0 equiv), DMAP (0.64 mg, 0.0052 mmol, 1.0 equiv), and Et_3N (7.2 μL, 0.052 mmol, 10.0 equiv). The reaction mixture was stirred at 25 °C for 2 h, and then put directly onto a prep-plate (silica gel, hexanes:EtOAc 1:1), which afforded the corresponding tetraacetate as a yellow foam. This foam was then dissolved in MeCN (0.2 mL), and aq. 1 M HCl (0.1 mL) was added to the reaction mixture at 25 °C. The reaction mixture was then stirred for 3 h at 25 °C and then quenched with H_2O (0.5 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 0.5 mL), and the combined organic layers were dried ($MgSO_4$), and concentrated. Preparative plate chromatography (silica gel, CH_2Cl_2:MeOH 9:1) provided kinamycin J (**1f**, 2.2 mg, 0.0041 mmol, 80% yield) as a yellow foam. **1f**: R_f = 0.52 (silica gel, hexanes:EtOAc 1:1); $[\alpha]_D^{32}$ = –75.0 ($CDCl_3$, *c* = 0.06); IR (film) ν_{max} 2950, 2924, 2852, 2156, 1743, 1660, 1624, 1456, 1370, 1258, 1229, 1166, 1077, 1036, 1021, 909, 801, 762, 733, 701 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$): δ = 12.14 (s, 1 H), 7.67 (d, *J* = 7.8 Hz, 1 H), 7.55 (t,

J = 7.8 Hz, 1 H), 7.18 (d, J = 7.8 Hz, 1 H), 6.56 (s, 1 H), 6.21 (d, J = 6.6 Hz, 1 H), 5.87 (d, J = 6.6 Hz, 1 H), 2.16 (s, 3 H), 2.14 (s, 3 H), 2.10 (s, 3 H), 2.03 (s, 3 H), 1.59 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 184.1, 178.2, 170.7, 170.4, 170.1, 169.8, 162.1, 136.2, 134.2, 132.5, 129.4, 128.9, 126.0, 123.8, 119.9, 115.6, 96.1, 81.1, 73.3, 68.0, 66.9, 21.8, 21.0, 20.7, 20.7, 16.2 ppm; HRMS (ESI-TOF): calcd for $C_{26}H_{22}N_2O_{11}Na$ [M+Na$^+$]: 561.1116, found 561.1119.

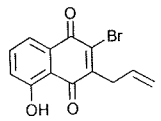
Kinamycin F (1e)



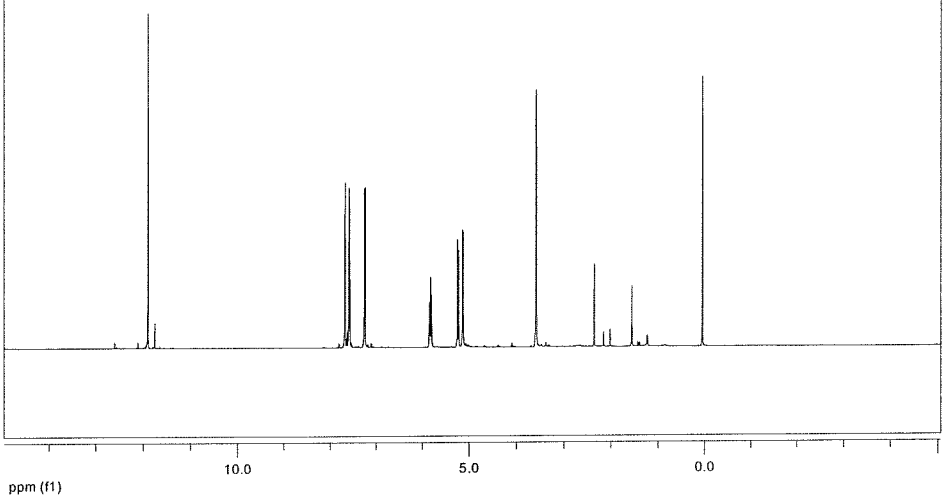
kinamycin F (1e)

To a solution of TBS-protected kinamycin C **17** (3.2 mg, 0.0052 mmol, 1.0 equiv) in THF (0.2 mL) at 25 °C was added aq. 0.2 M LiOH (0.1 mL), and the reaction mixture was stirred at 25 °C for 1 h. The reaction mixture was then quenched with H_2O (0.5 mL), and the biphasic reaction mixture was extracted with EtOAc (3 × 0.5 mL), and the combined organic layers were dried ($MgSO_4$), and concentrated. Preparative plate chromatography (silica gel, CH_2Cl_2:MeOH 9:1) provided kinamycin F (**1e**, 1.8 mg, 0.0048 mmol, 92% yield) as an orange foam. **1e**: R_f = 0.16 (silica gel, CH_2Cl_2:MeOH 9:1); $[\alpha]_D^{32}$ = –103.7 (MeCN, c = 0.08); IR (film) ν_{max} 3369, 2925, 2855, 2138, 1618, 1481, 1455, 1333, 1233, 1157, 1085, 1044, 1016, 971, 915, 882, 832, 771, 753, 743, 699 cm^{-1}; ^{1}H NMR (600 MHz, $CDCl_3$): δ = 12.07 (br s, 1 H), 7.45 (t, J = 7.2 Hz, 1 H), 7.42 (d, J = 7.2 Hz, 1 H), 7.02 (d, J = 7.2 Hz, 1 H), 4.47 (s, 2 H), 4.30 (s, 1 H), 3.69 (s, 1 H), 3.52 (br s, 2 H), 3.72 (br s, 1 H), 1.07 ppm (s, 3 H); ^{13}C NMR (125 MHz, $CDCl_3$): δ = 184.5, 181.3, 162.8, 138.8, 136.9, 135.3, 131.9, 130.6, 130.1, 124.7, 120.2, 116.8, 75.9, 74.9, 74.3, 69.6, 69.1, 21.5 ppm; HRMS (ESI-TOF): calcd for $C_{18}H_{14}N_2O_7Na$ [M+Na$^+$]: 393.0693, found 393.0689.

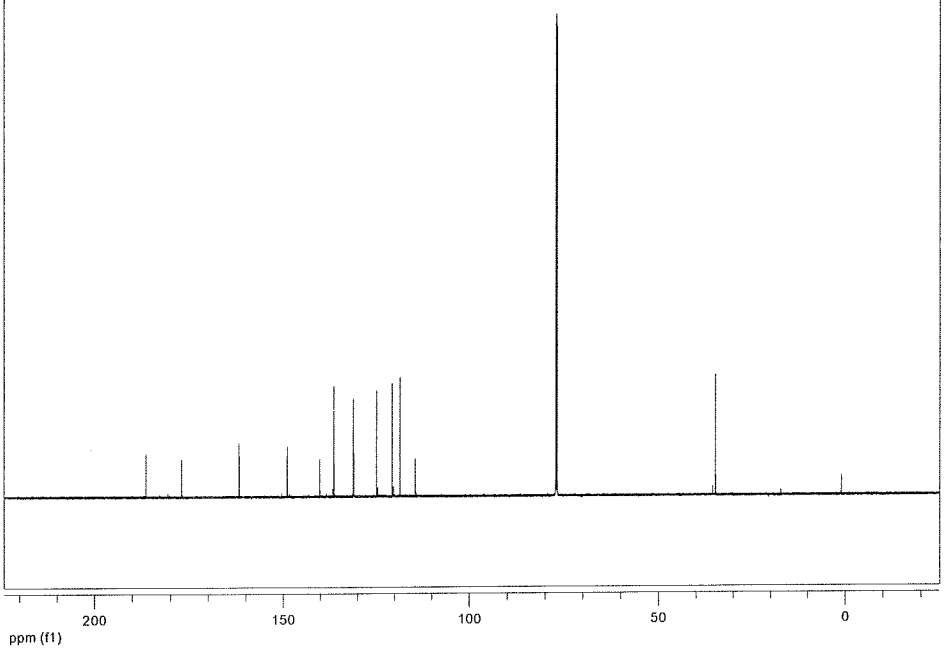
^{1}H NMR spectrum of **5** (600 MHz, $CDCl_3$)



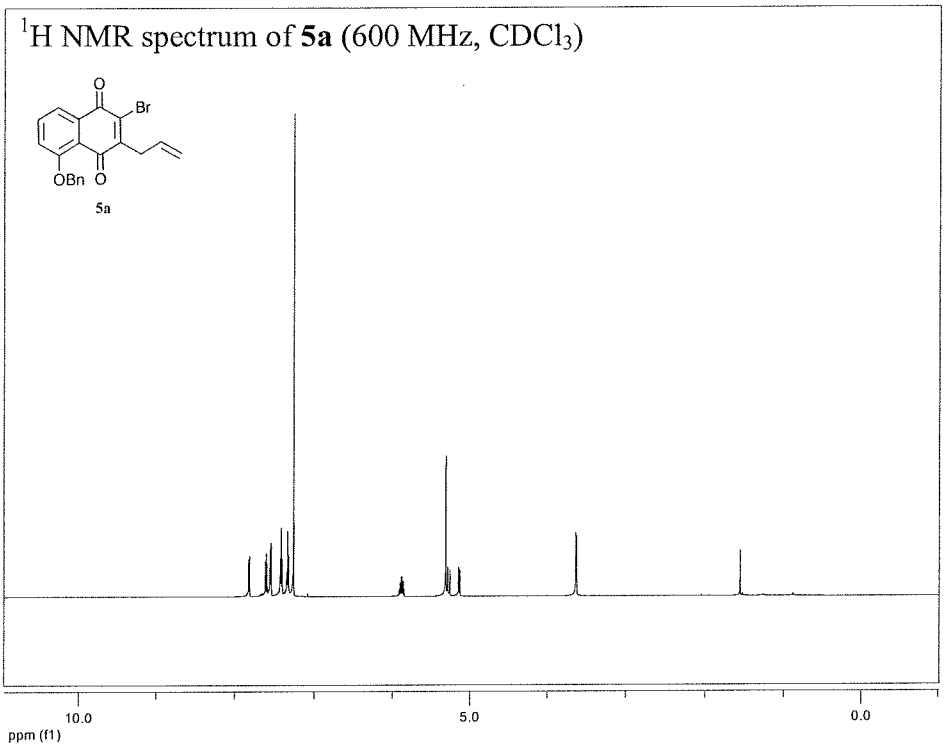
5



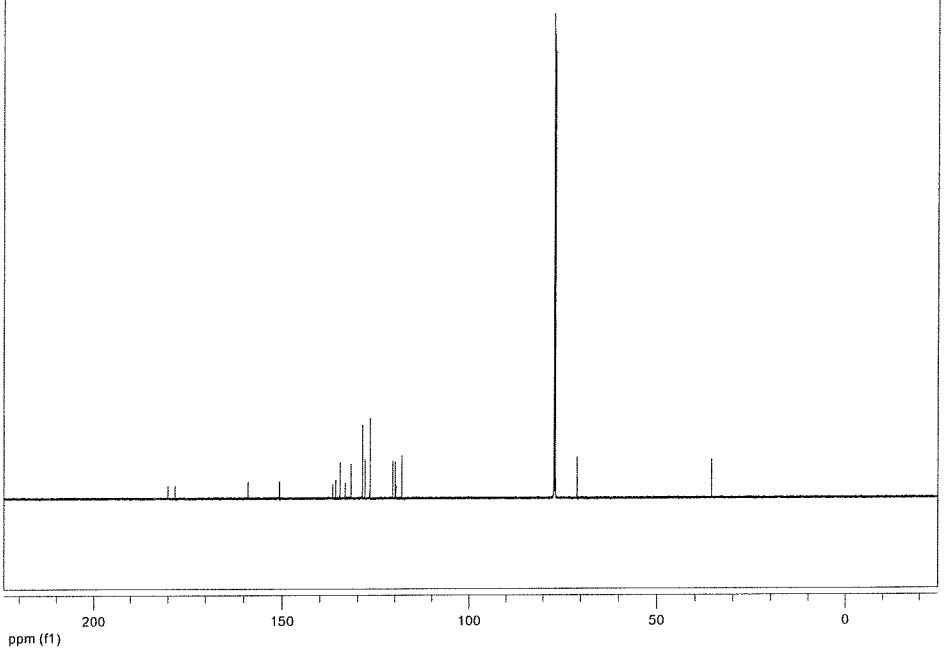
^{13}C NMR spectrum of **5** (150 MHz, $CDCl_3$)



^{1}H NMR spectrum of **5a** (600 MHz, $CDCl_3$)

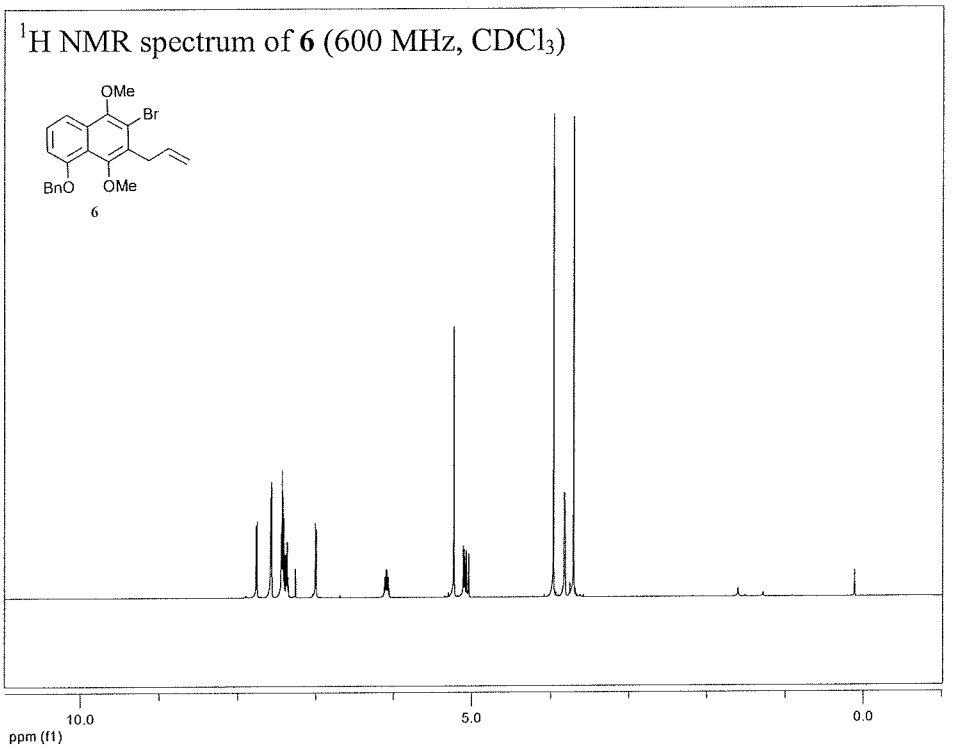


^{13}C NMR spectrum of **5a** (150 MHz, $CDCl_3$)

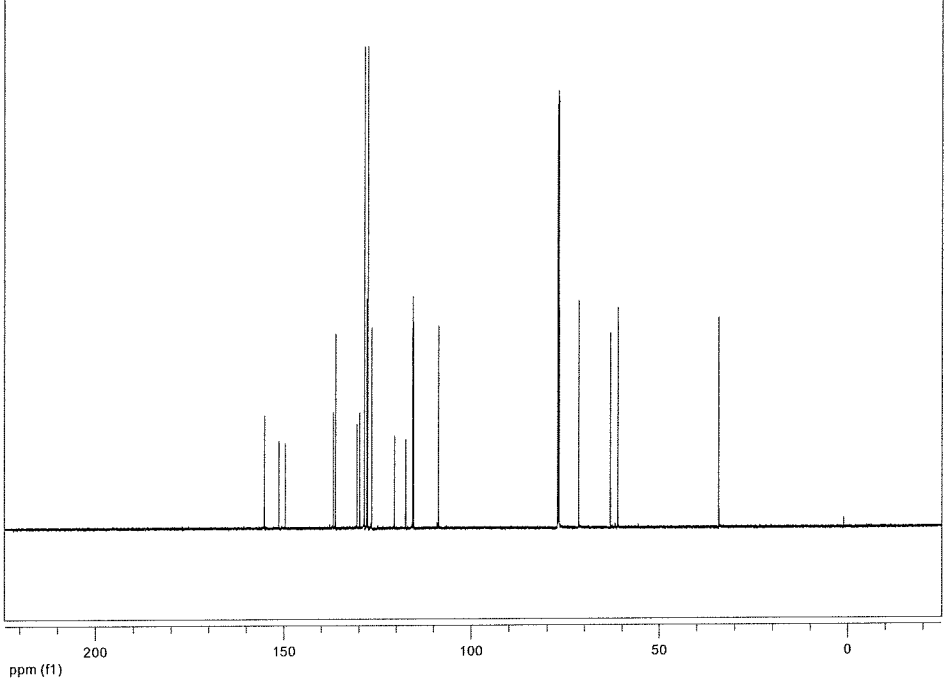


^{1}H NMR spectrum of **6** (600 MHz, $CDCl_3$)

6

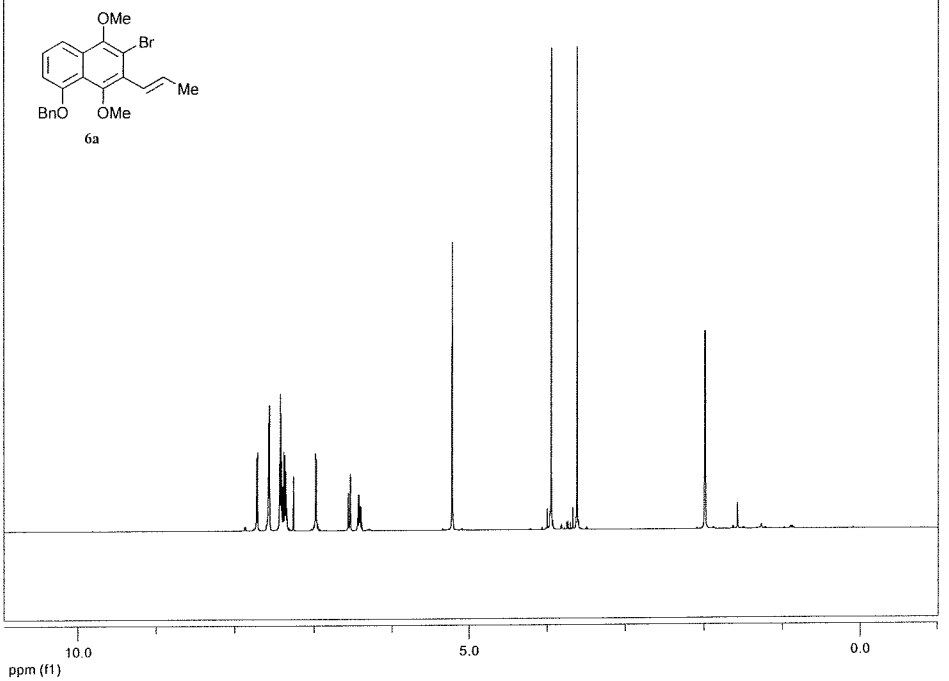


^{13}C NMR spectrum of **6** (150 MHz, $CDCl_3$)

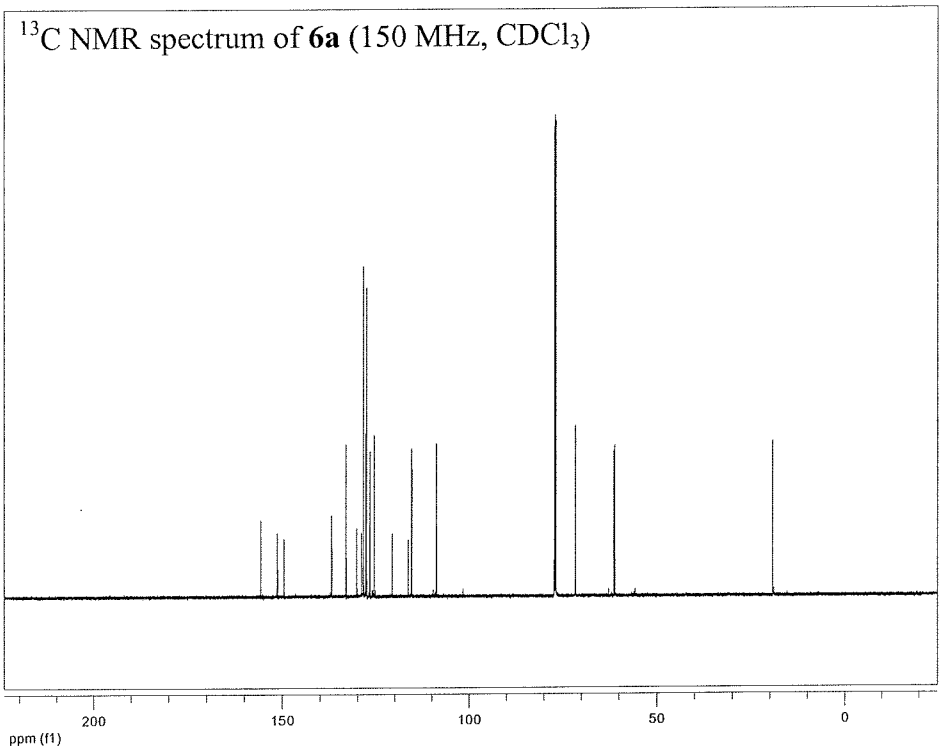


^{1}H NMR spectrum of **6a** (600 MHz, $CDCl_3$)

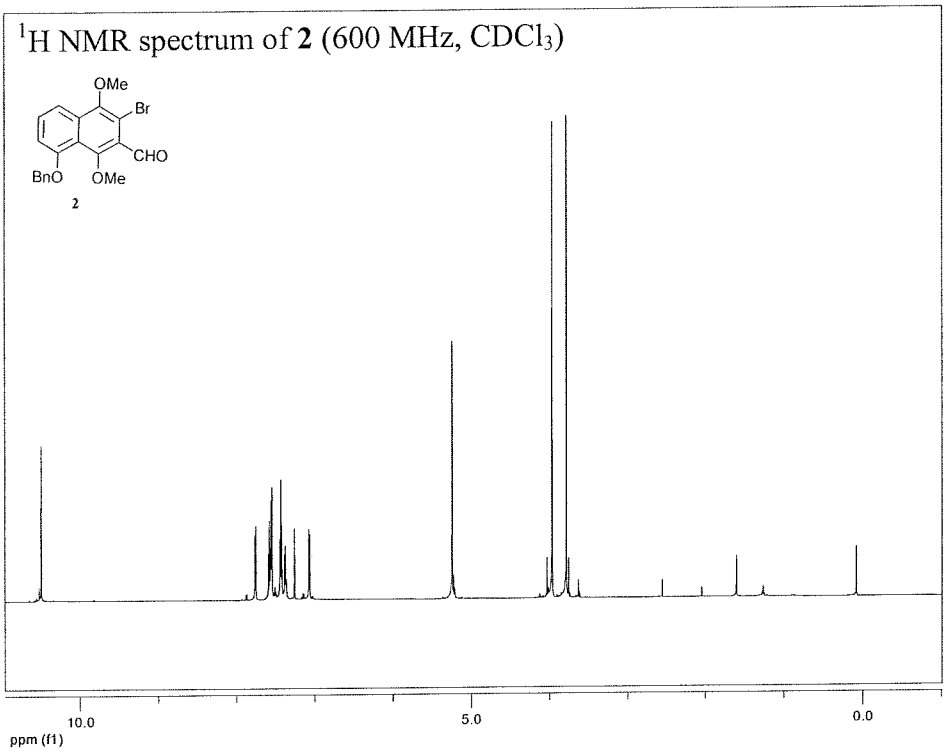
6a



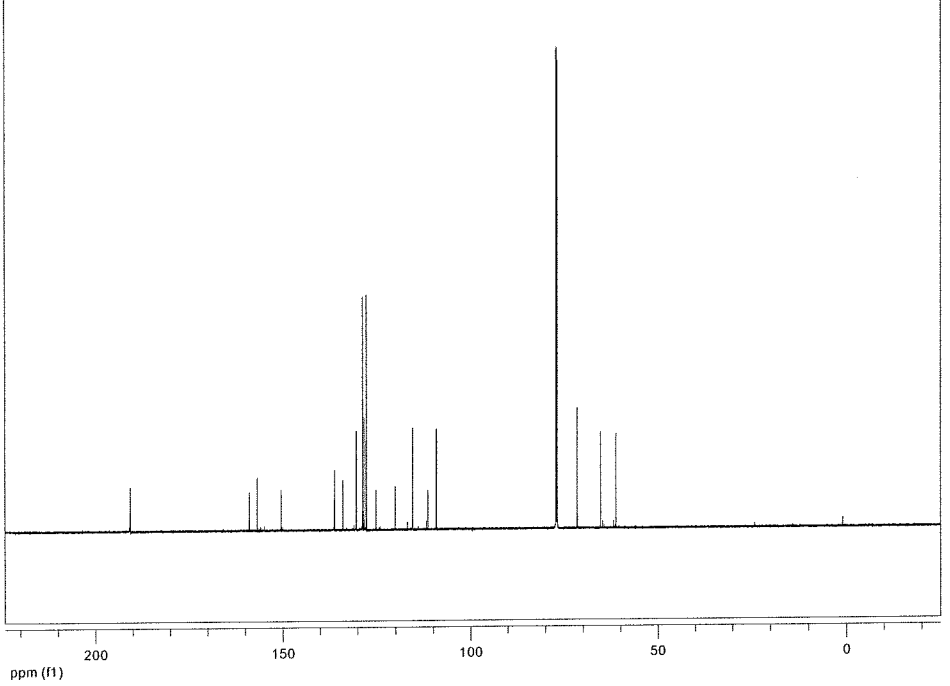
^{13}C NMR spectrum of **6a** (150 MHz, $CDCl_3$)



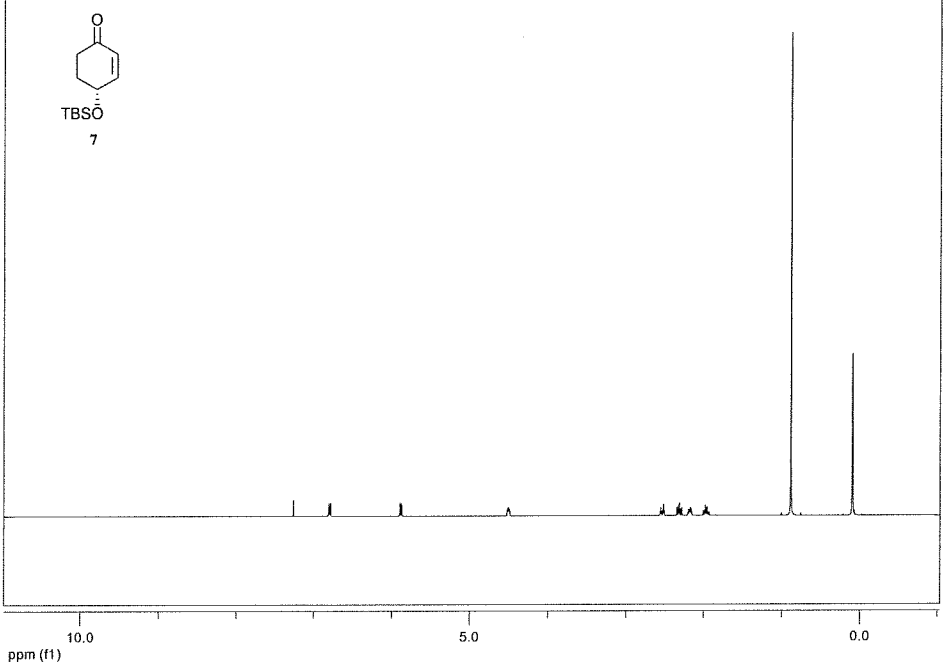
^{1}H NMR spectrum of **2** (600 MHz, $CDCl_3$)



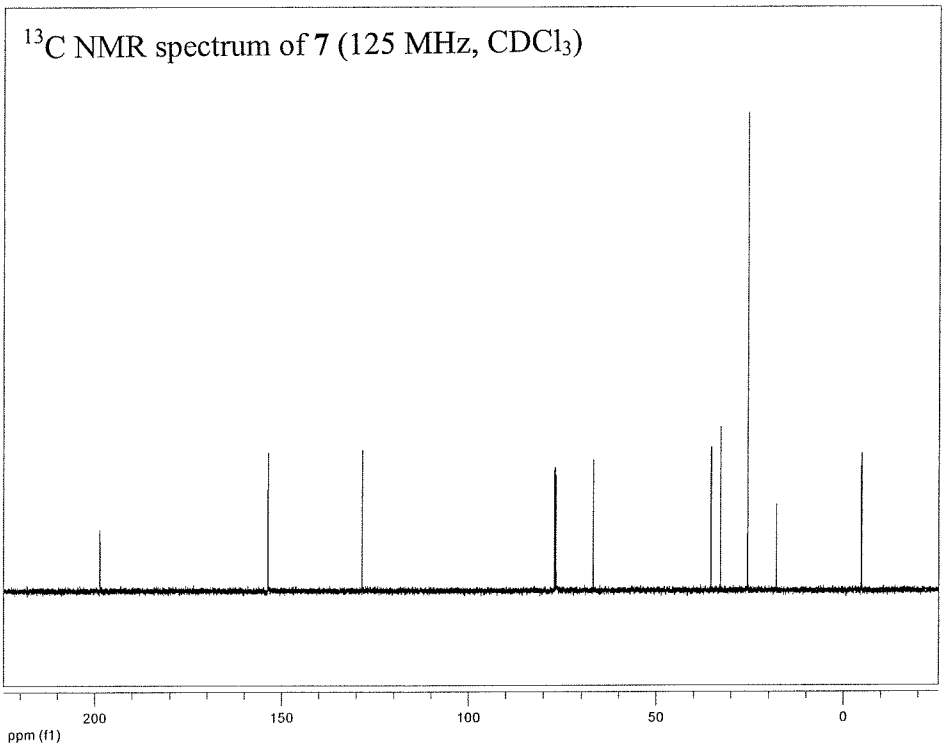
^{13}C NMR spectrum of **2** (150 MHz, $CDCl_3$)



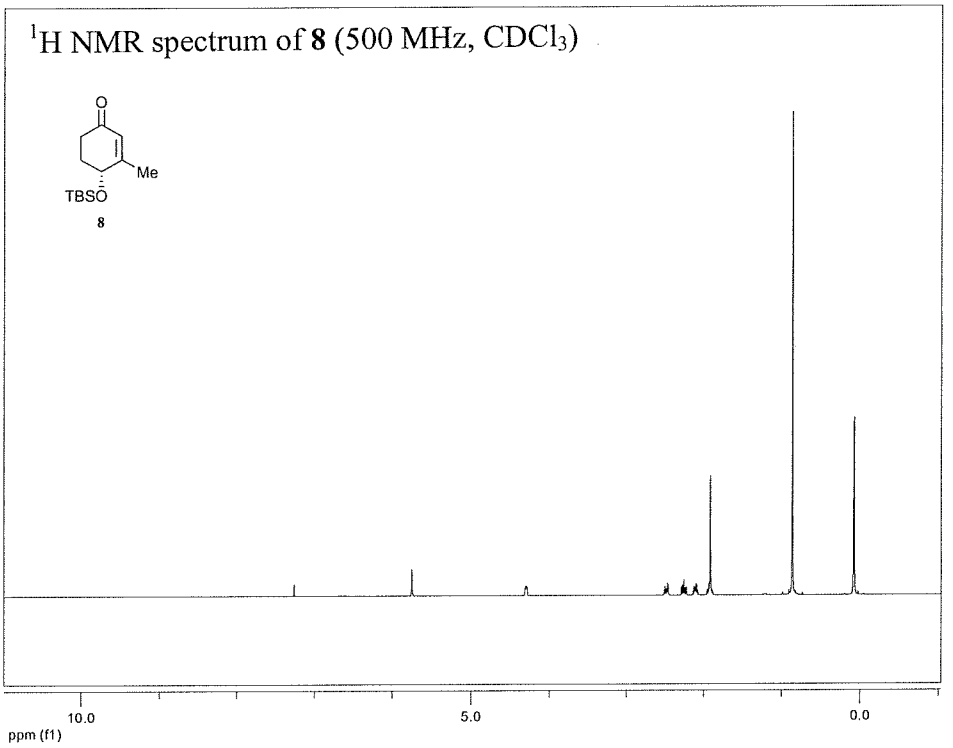
^{1}H NMR spectrum of **7** (500 MHz, $CDCl_3$)



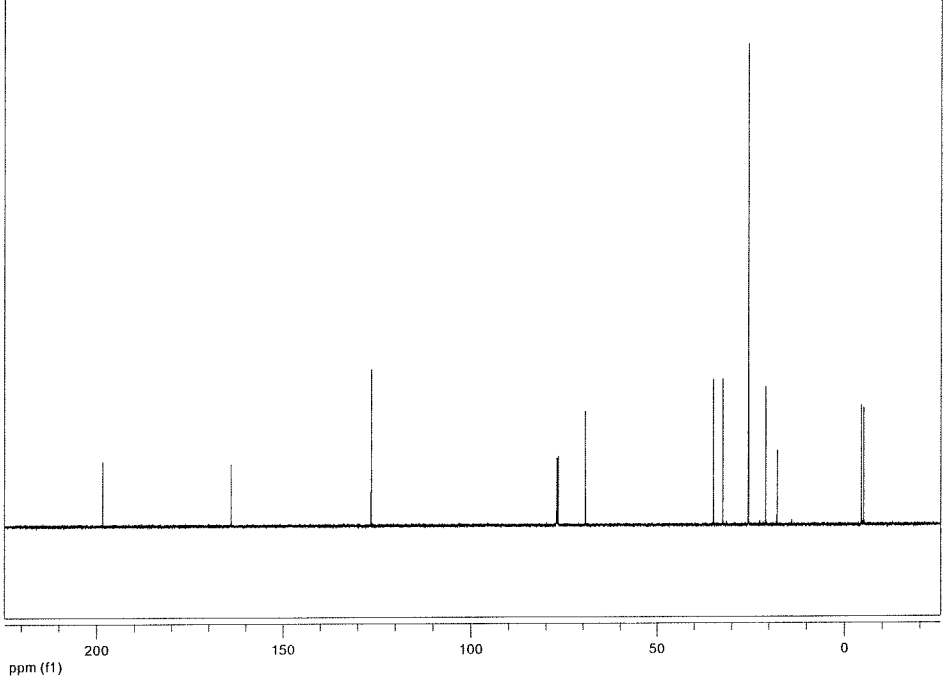
^{13}C NMR spectrum of **7** (125 MHz, $CDCl_3$)



^{1}H NMR spectrum of **8** (500 MHz, $CDCl_3$)

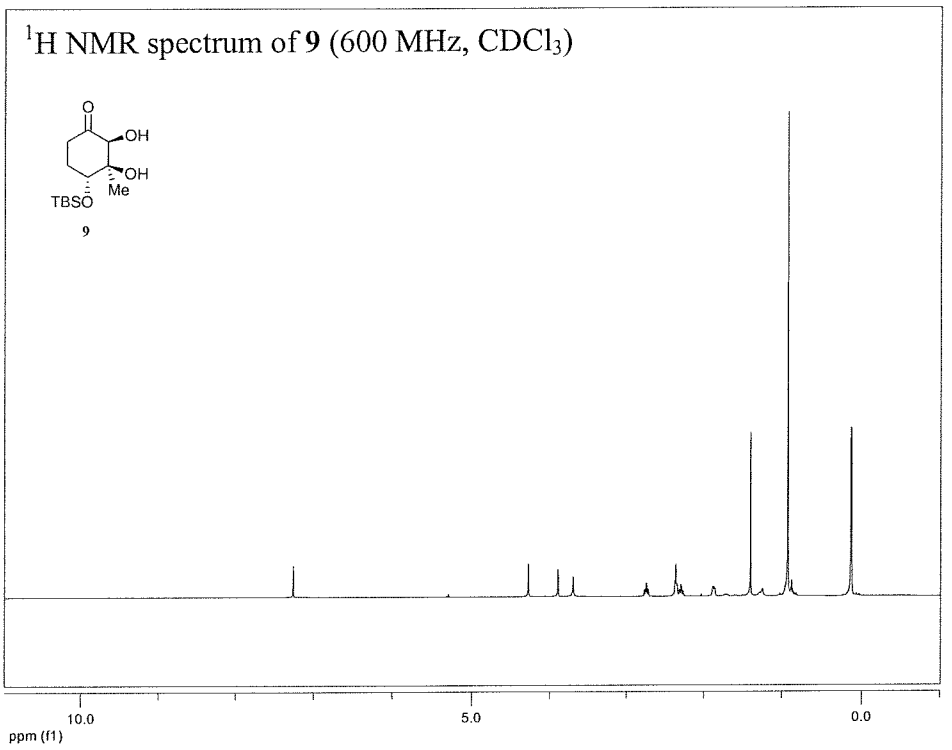


^{13}C NMR spectrum of **8** (125 MHz, $CDCl_3$)

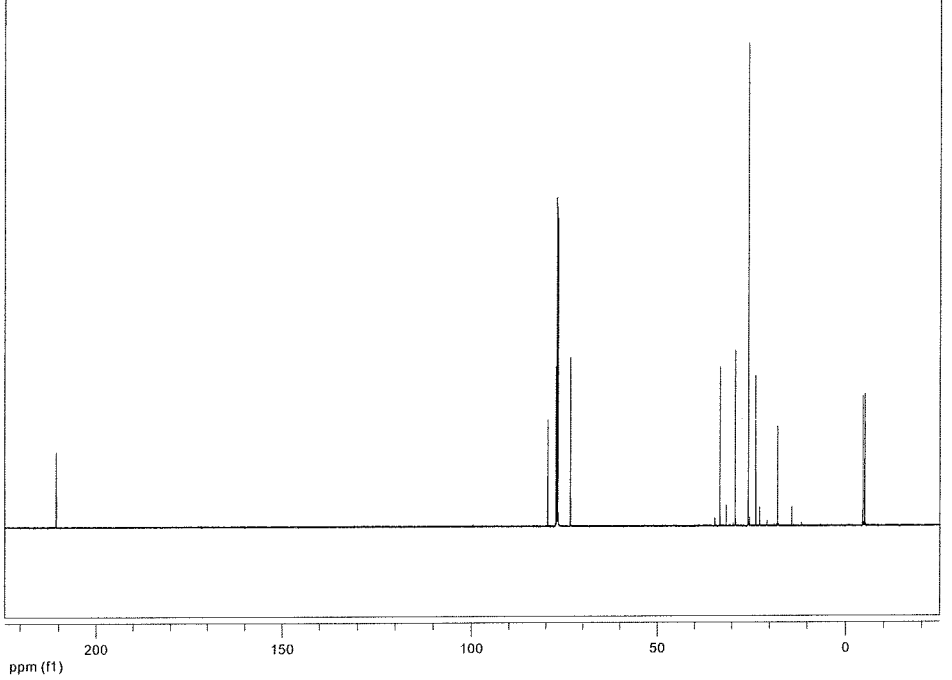


^{1}H NMR spectrum of **9** (600 MHz, $CDCl_3$)

9

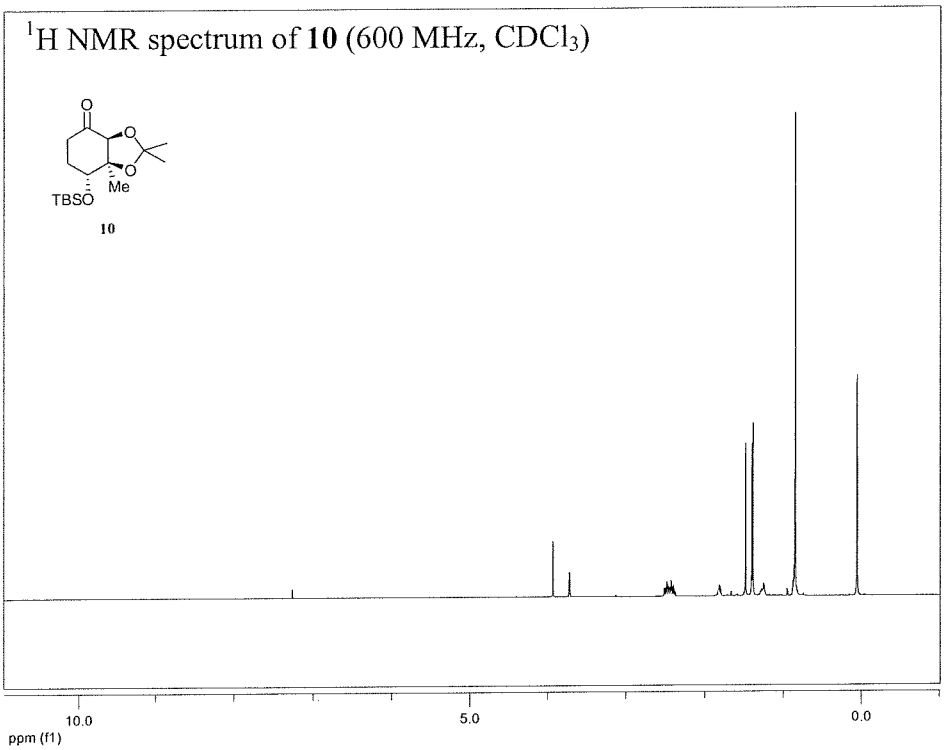


^{13}C NMR spectrum of **9** (150 MHz, $CDCl_3$)

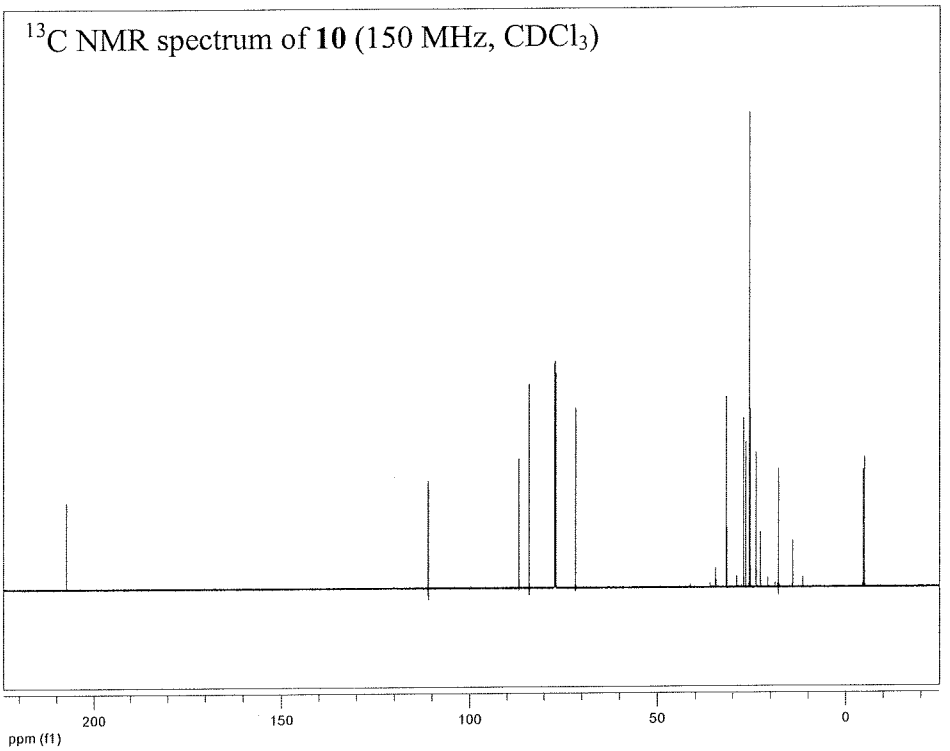


^{1}H NMR spectrum of **10** (600 MHz, $CDCl_3$)

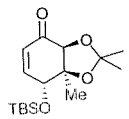
10



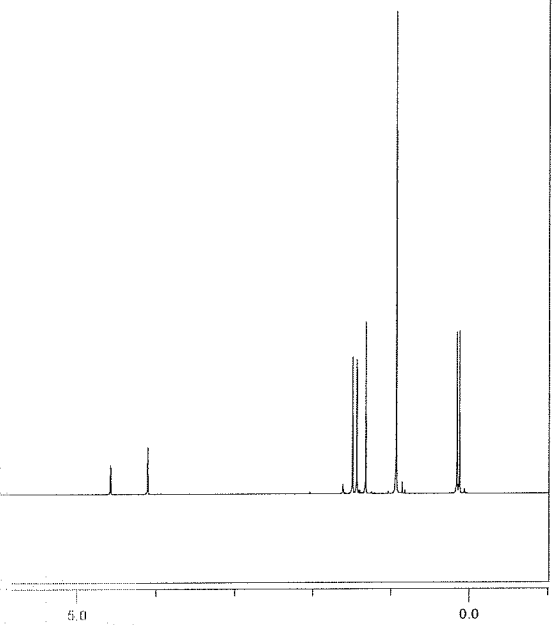
^{13}C NMR spectrum of **10** (150 MHz, $CDCl_3$)



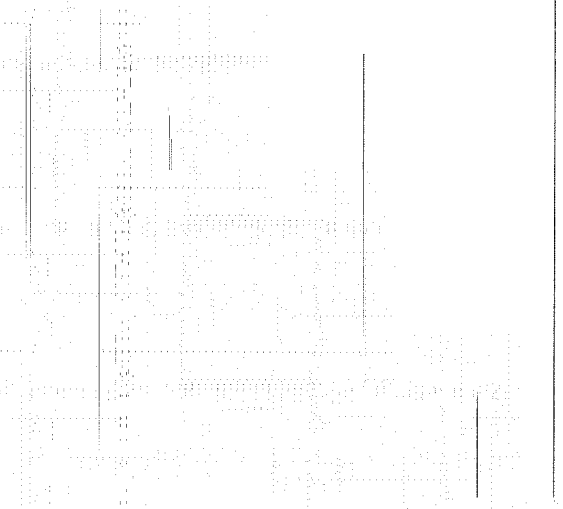
^{1}H NMR spectrum of **11** (600 MHz, $CDCl_3$)



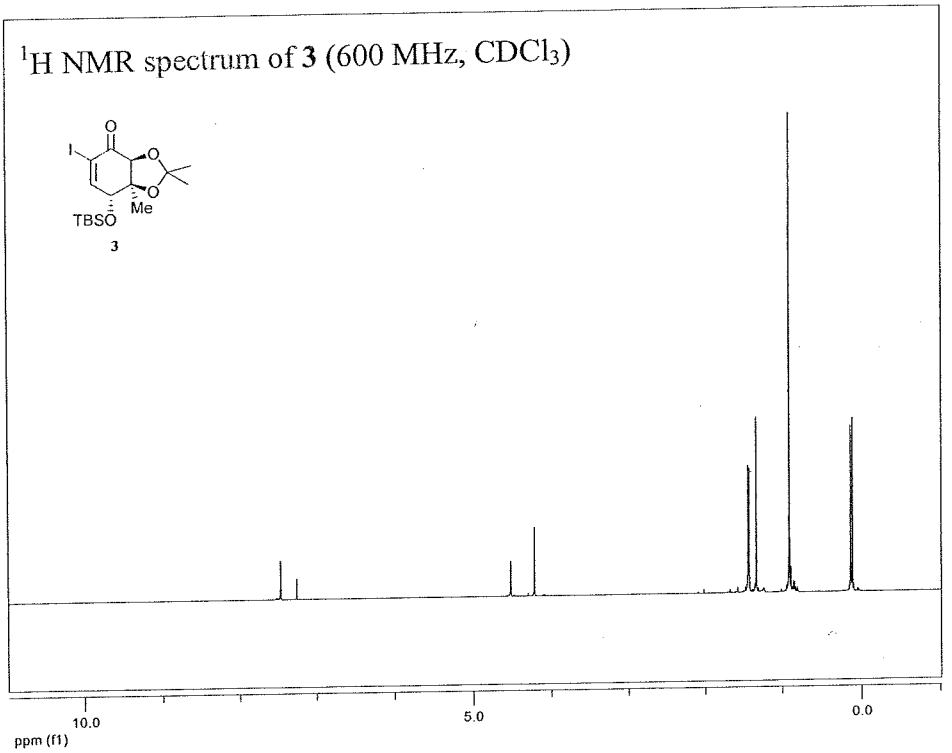
11



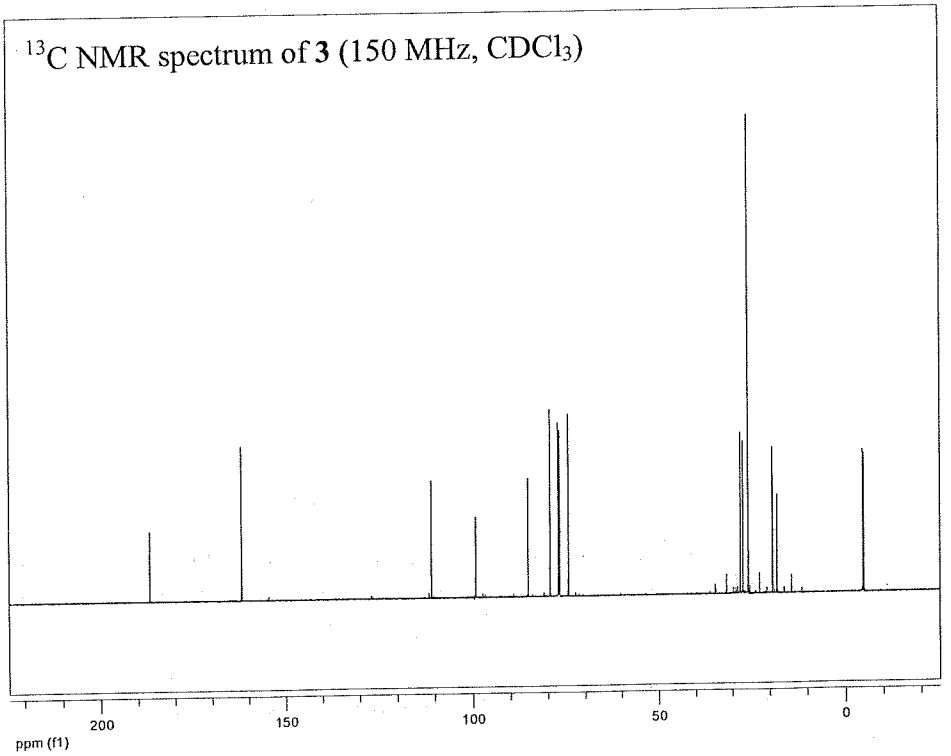
MHz, $CDCl_3$)



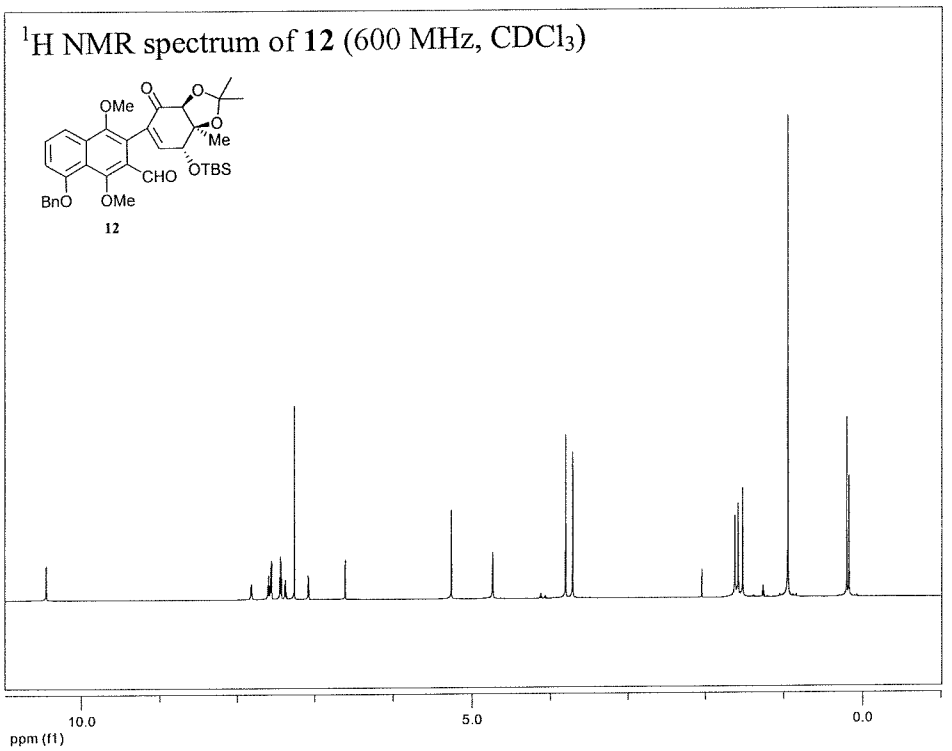
^{1}H NMR spectrum of **3** (600 MHz, $CDCl_3$)



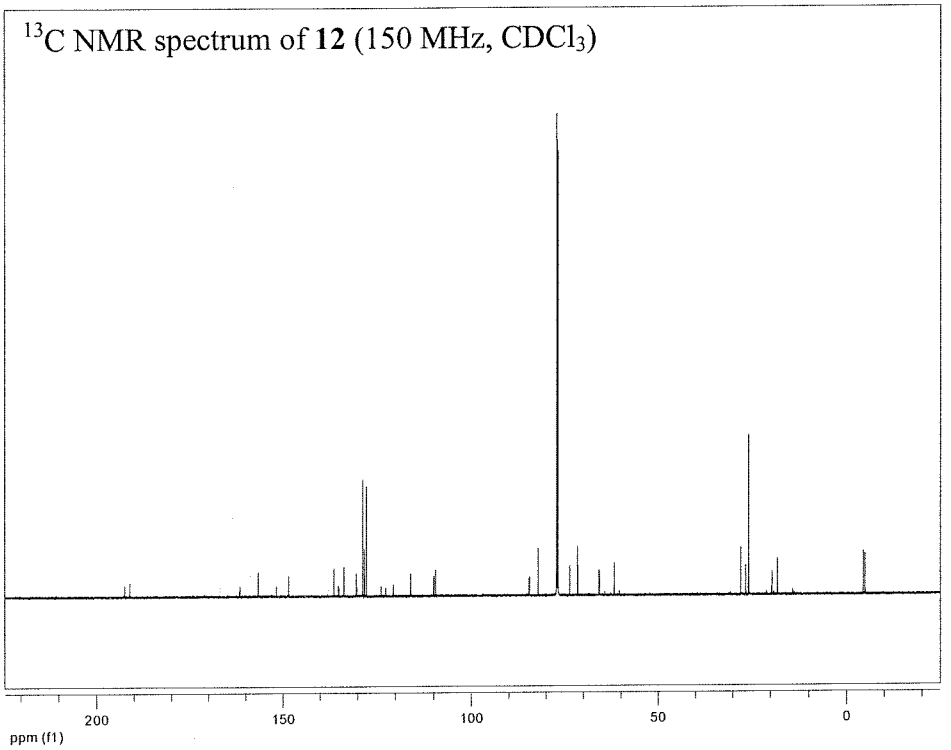
^{13}C NMR spectrum of **3** (150 MHz, $CDCl_3$)



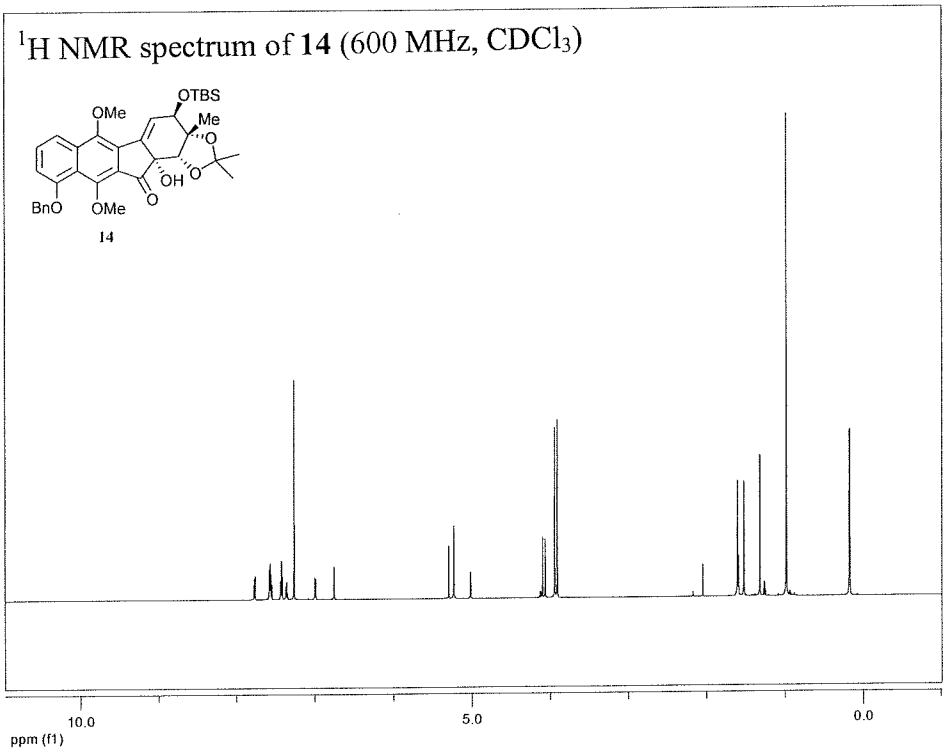
^{1}H NMR spectrum of **12** (600 MHz, $CDCl_3$)



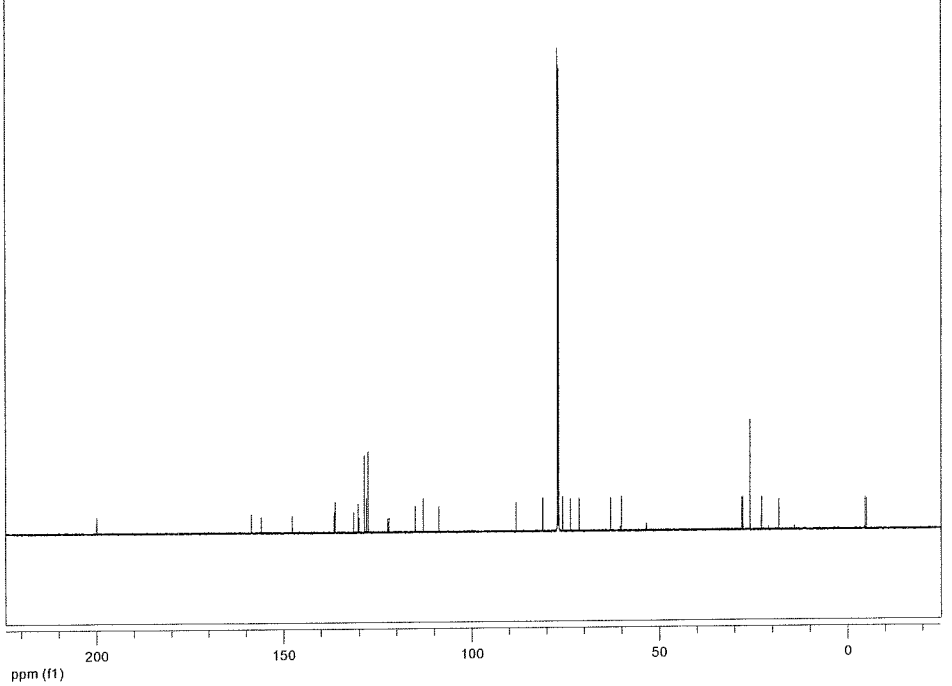
^{13}C NMR spectrum of **12** (150 MHz, $CDCl_3$)



^{1}H NMR spectrum of **14** (600 MHz, $CDCl_3$)

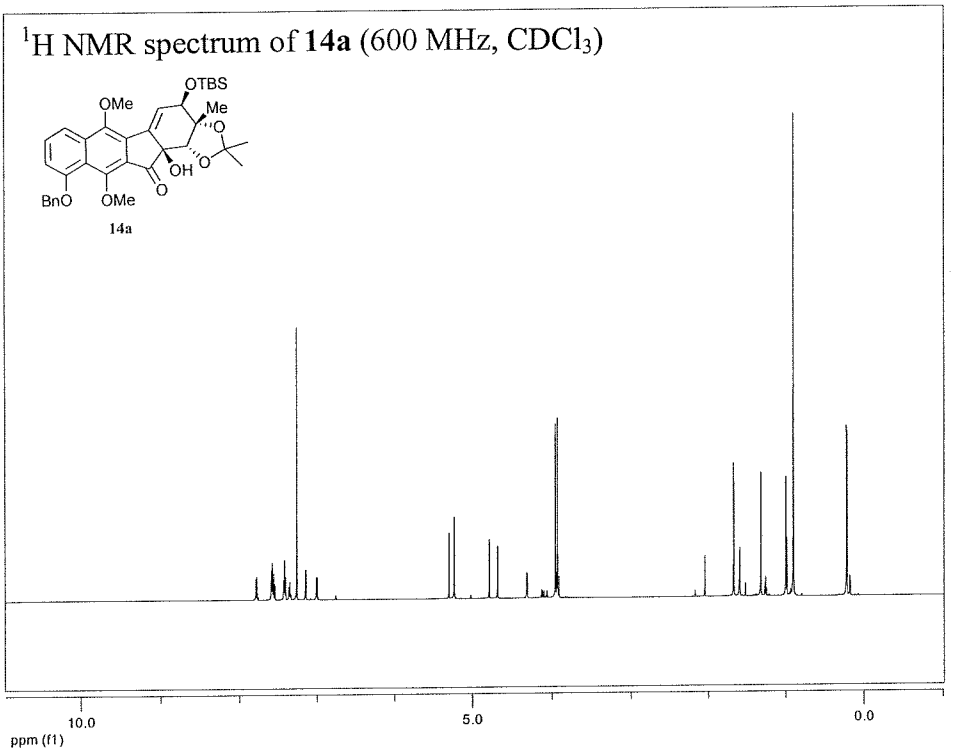


^{13}C NMR spectrum of **14** (150 MHz, $CDCl_3$)

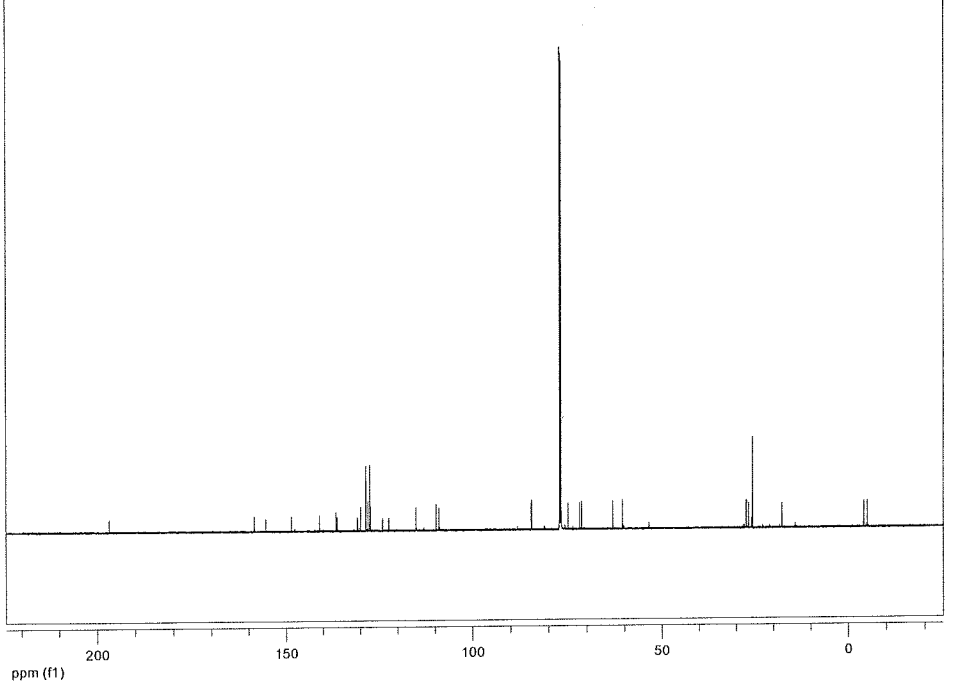


^{1}H NMR spectrum of **14a** (600 MHz, $CDCl_3$)

14a

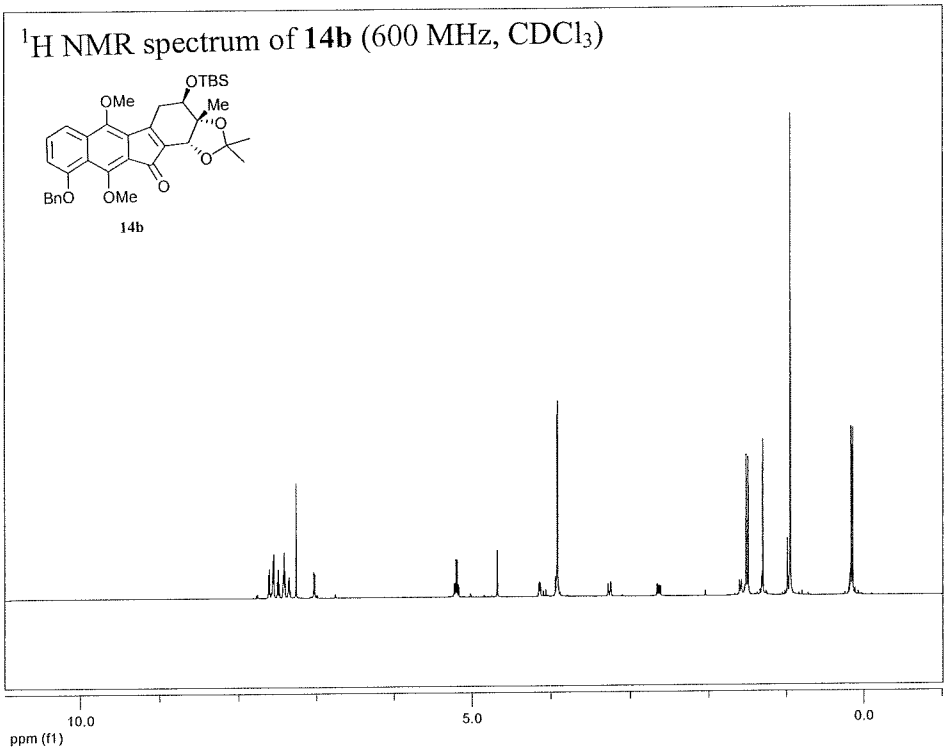


^{13}C NMR spectrum of **14a** (150 MHz, $CDCl_3$)

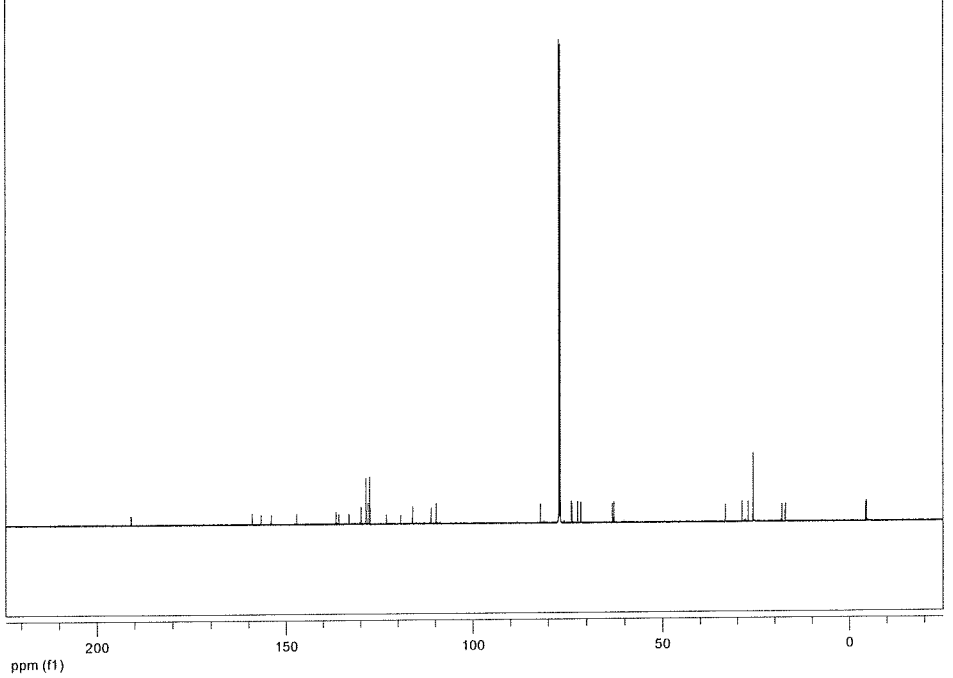


^{1}H NMR spectrum of **14b** (600 MHz, $CDCl_3$)

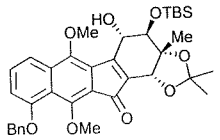
14b



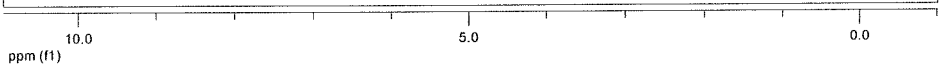
^{13}C NMR spectrum of **14b** (150 MHz, $CDCl_3$)



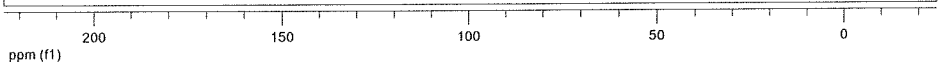
^{1}H NMR spectrum of **15** (600 MHz, $CDCl_3$)



15

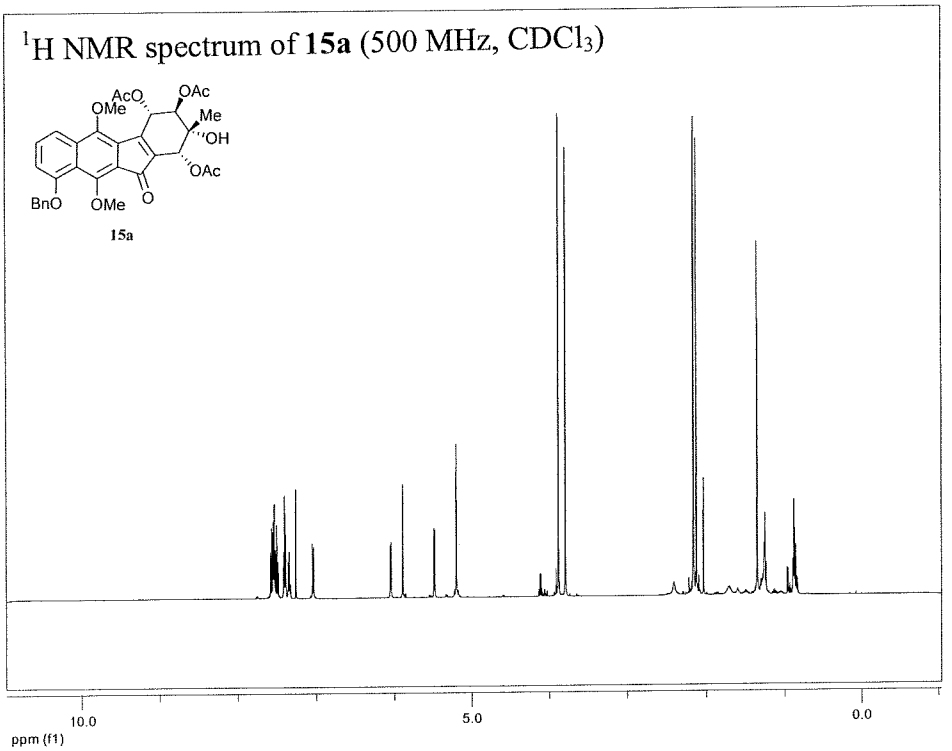


^{13}C NMR spectrum of **15** (150 MHz, $CDCl_3$)

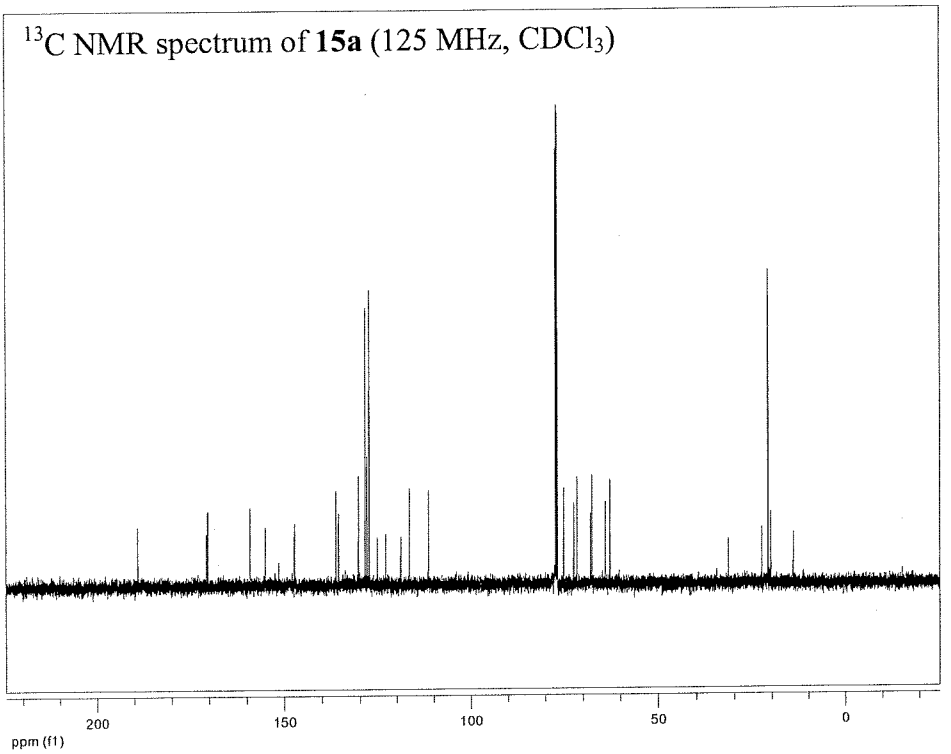


^{1}H NMR spectrum of **15a** (500 MHz, $CDCl_3$)

15a

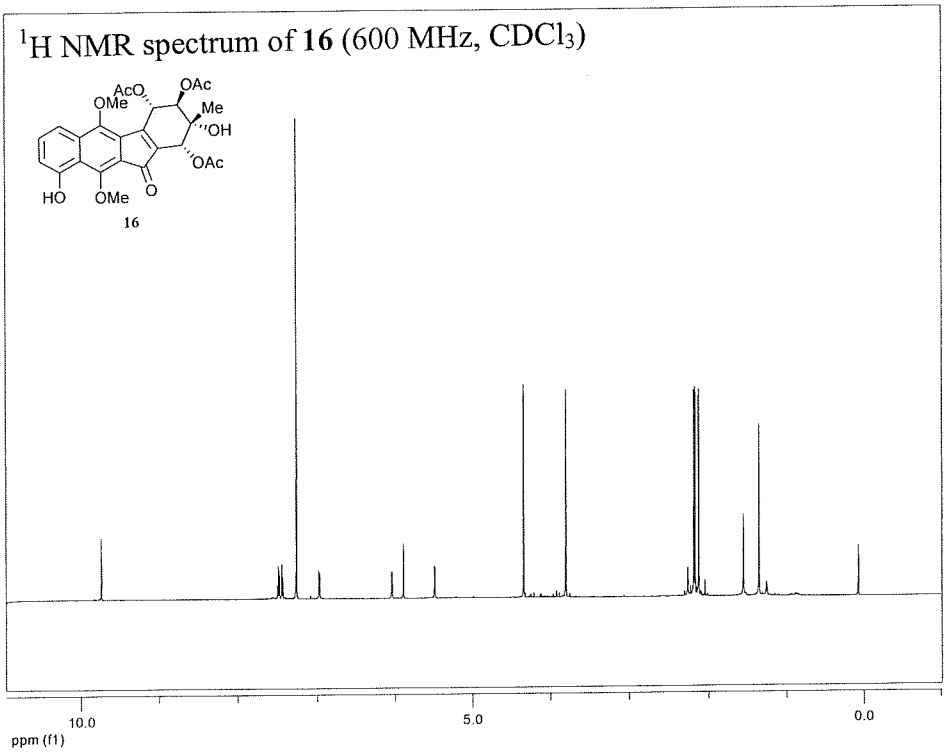


^{13}C NMR spectrum of **15a** (125 MHz, $CDCl_3$)

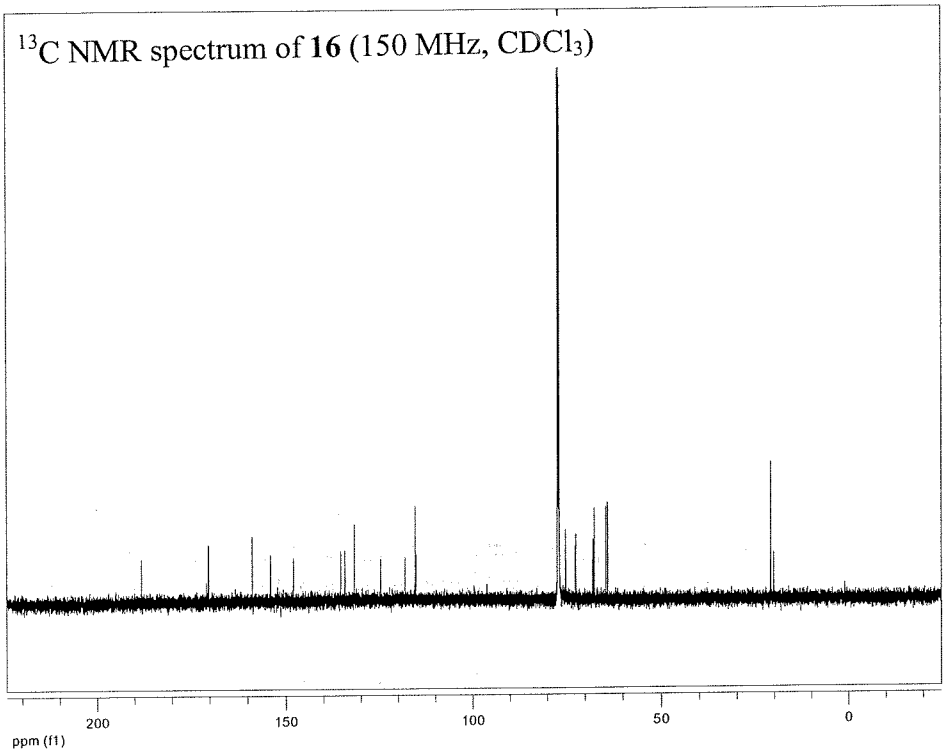


^{1}H NMR spectrum of **16** (600 MHz, $CDCl_3$)

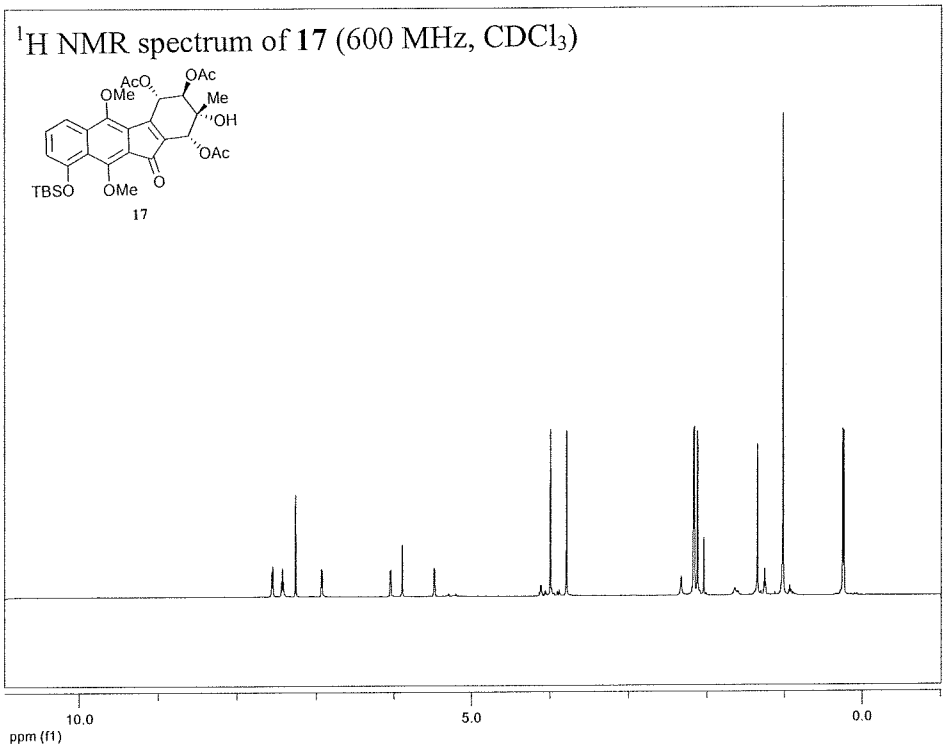
16



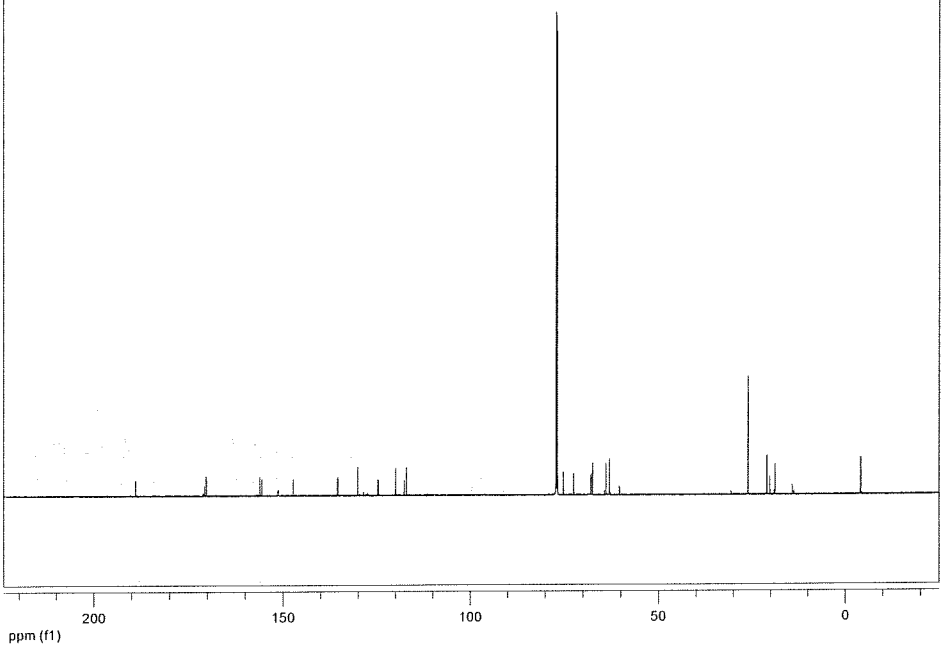
^{13}C NMR spectrum of **16** (150 MHz, $CDCl_3$)



^{1}H NMR spectrum of **17** (600 MHz, $CDCl_3$)

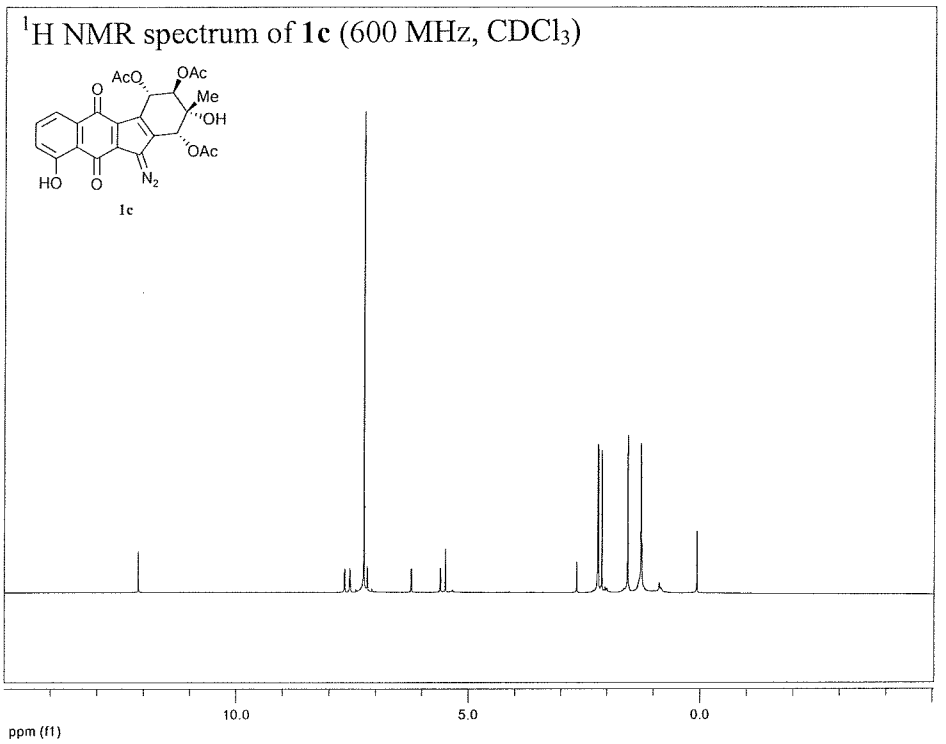


^{13}C NMR spectrum of **17** (150 MHz, $CDCl_3$)

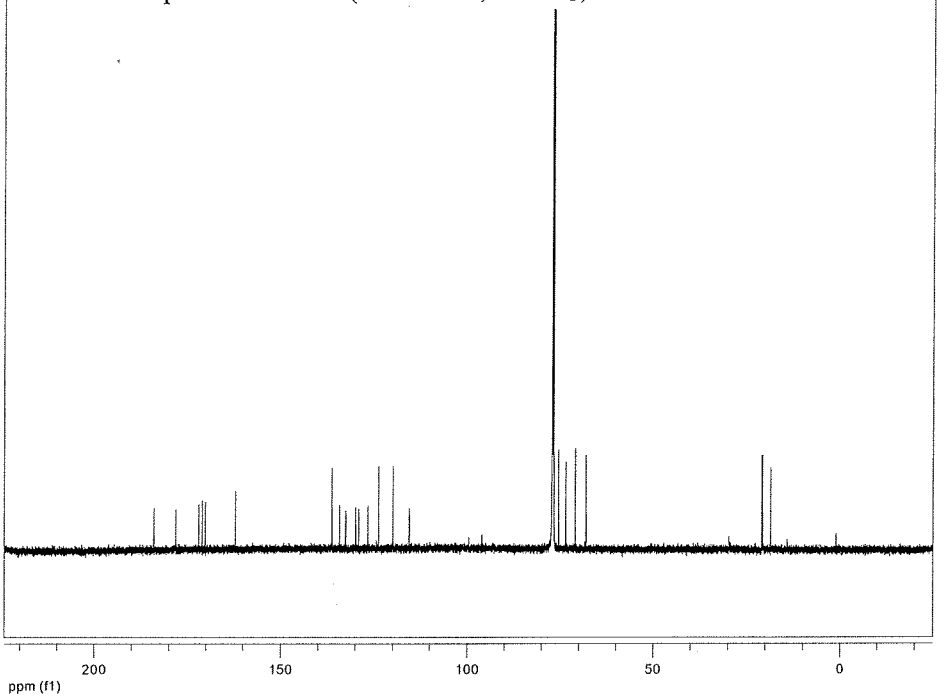


^{1}H NMR spectrum of **1c** (600 MHz, $CDCl_3$)

1c



^{13}C NMR spectrum of **1c** (150 MHz, $CDCl_3$)



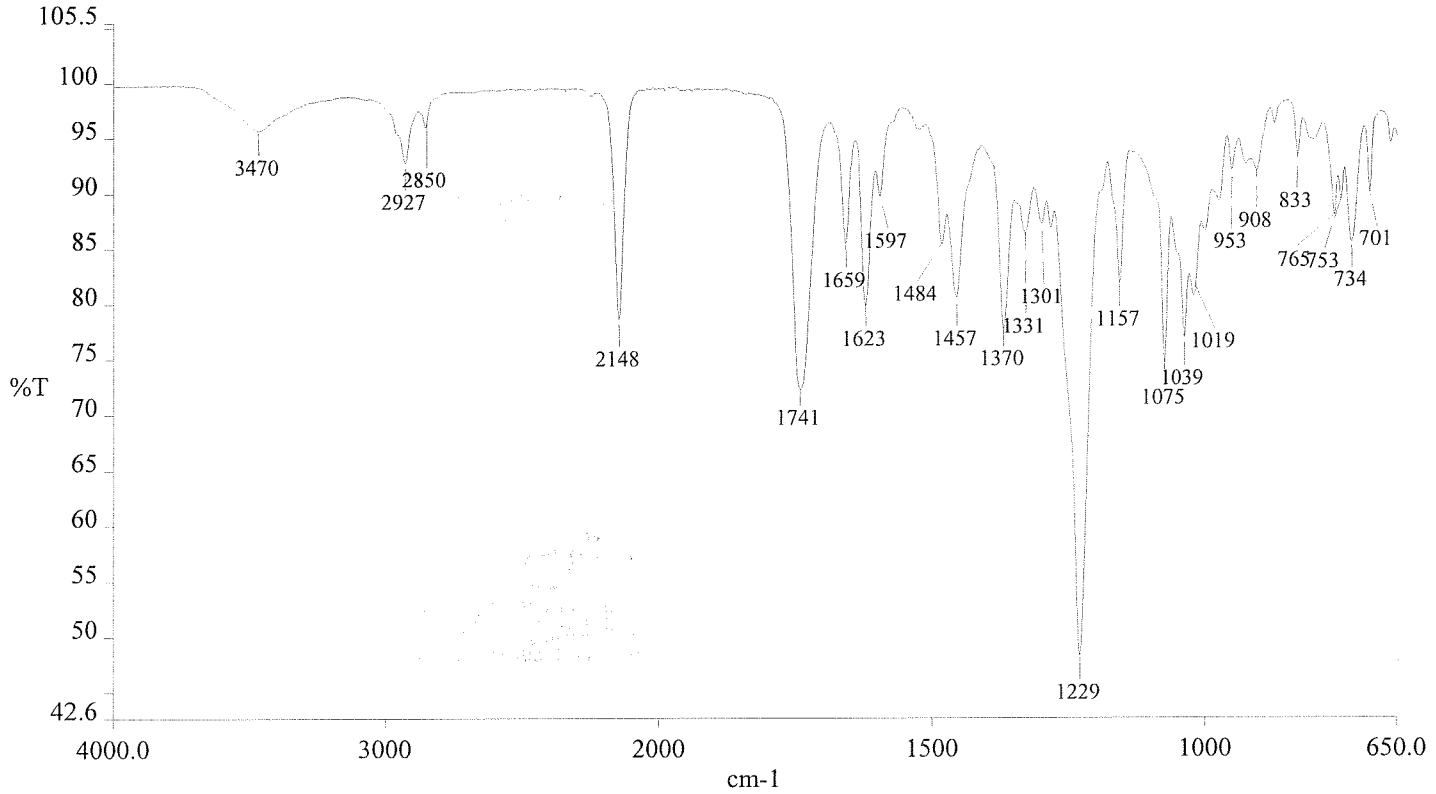
Analyst: Andrea N

Date Created: Friday, June 08, 2007 9:49 AM Pacific Daylight Time

Spectrum Name: aln-11-C20.sp

Description:

Comments:



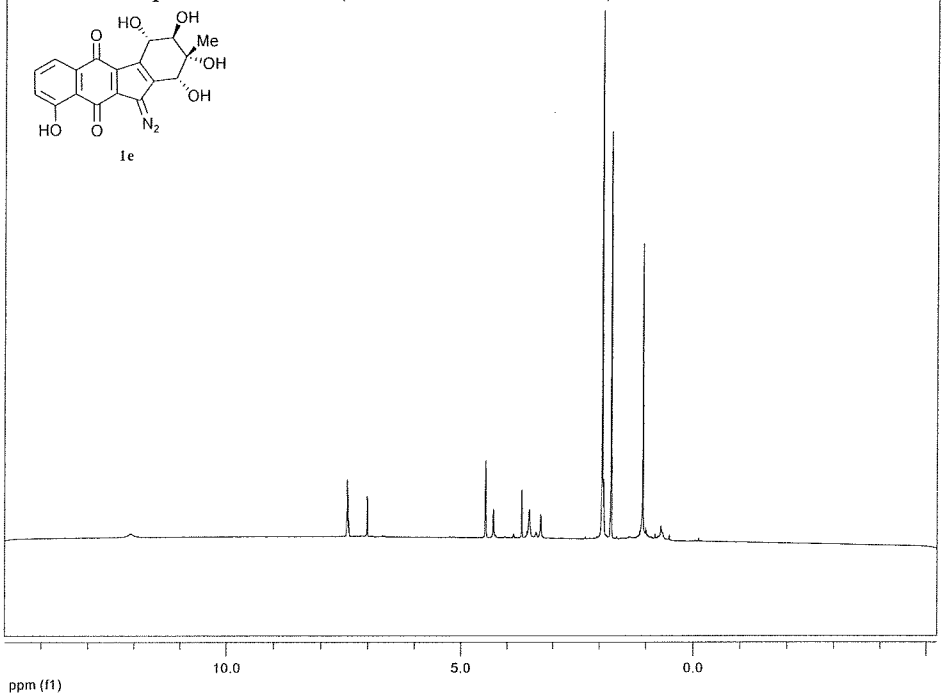
aln-11-C20.sp
aln-11-C20.pk

aln-11-C20.sp 3351 4000 650 48 99 4 %T 4 2

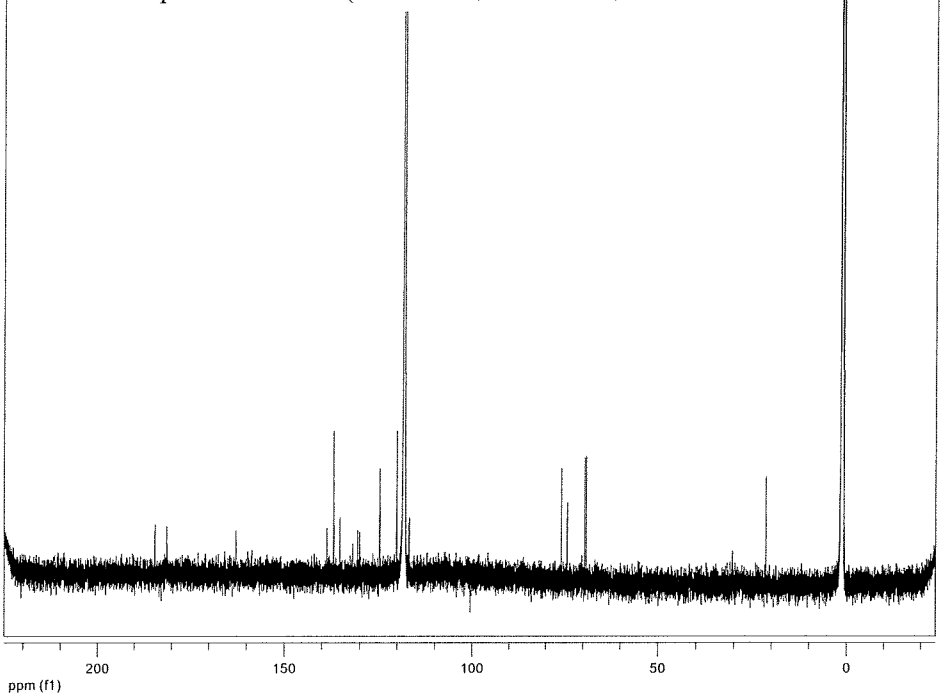
REF 4000 99 2000 99 600
3470 95 2927 92 2148 78 1741 72 1659 85
1623 79 1597 89 1484 85 1457 80 1370 77
1331 86 1301 87 1229 48 1157 81 1075 74
1039 76 953 92 908 91 833 93 765 87
753 89 734 85 701 90

^{1}H NMR spectrum of **1e** (600 MHz, MeCN-d_3)

1e



^{13}C NMR spectrum of **1e** (150 MHz, MeCN-d_3)



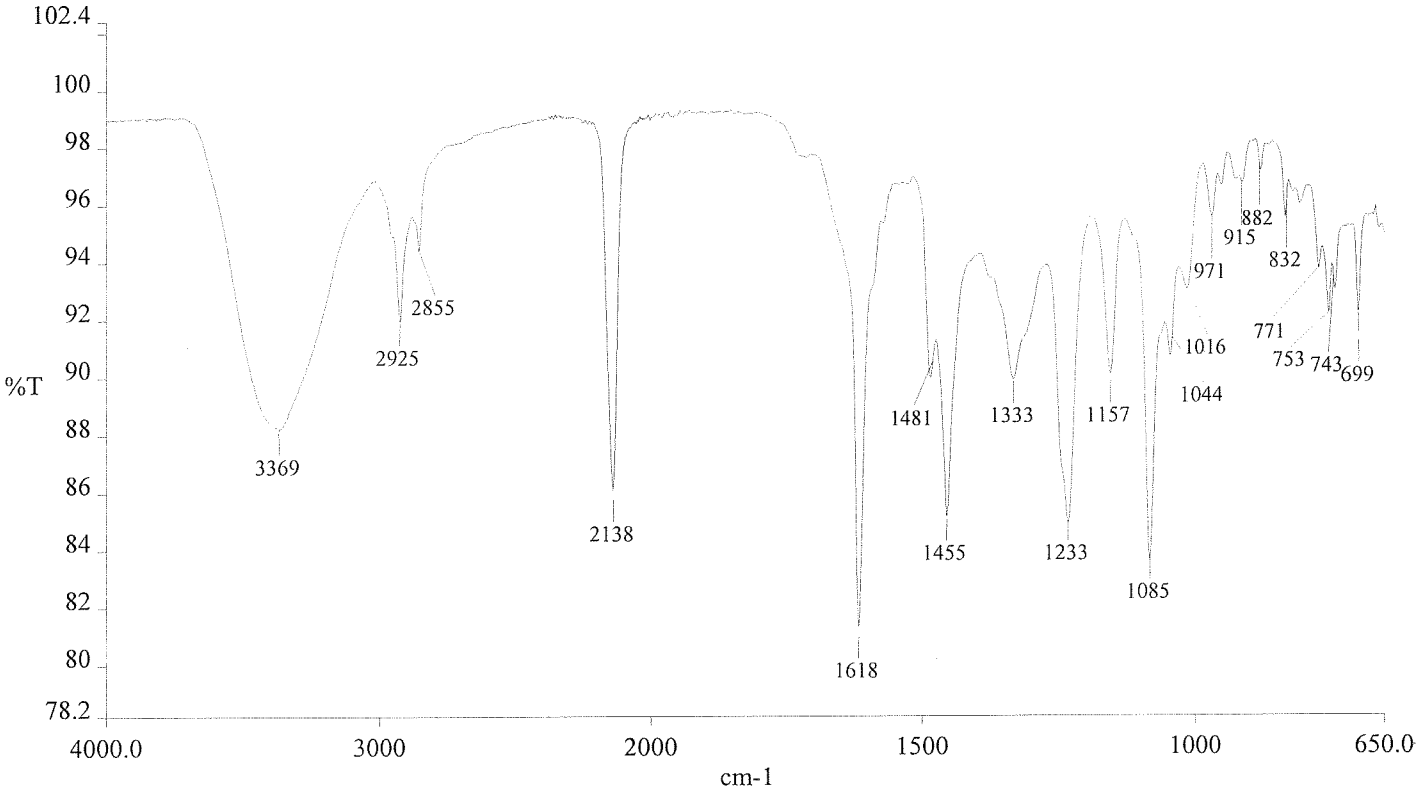
Analyst: Andrea N

Date Created: Tuesday, June 12, 2007 10:42 AM Pacific Daylight Time

Spectrum Name: aln-11-C21.sp

Description: Kinamycin F

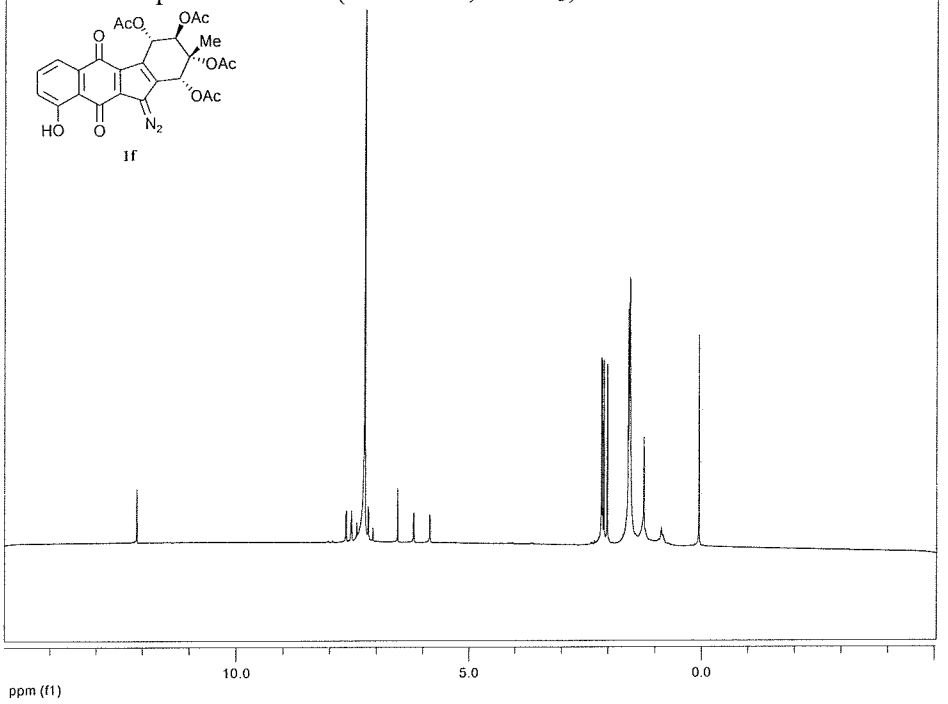
Comments:



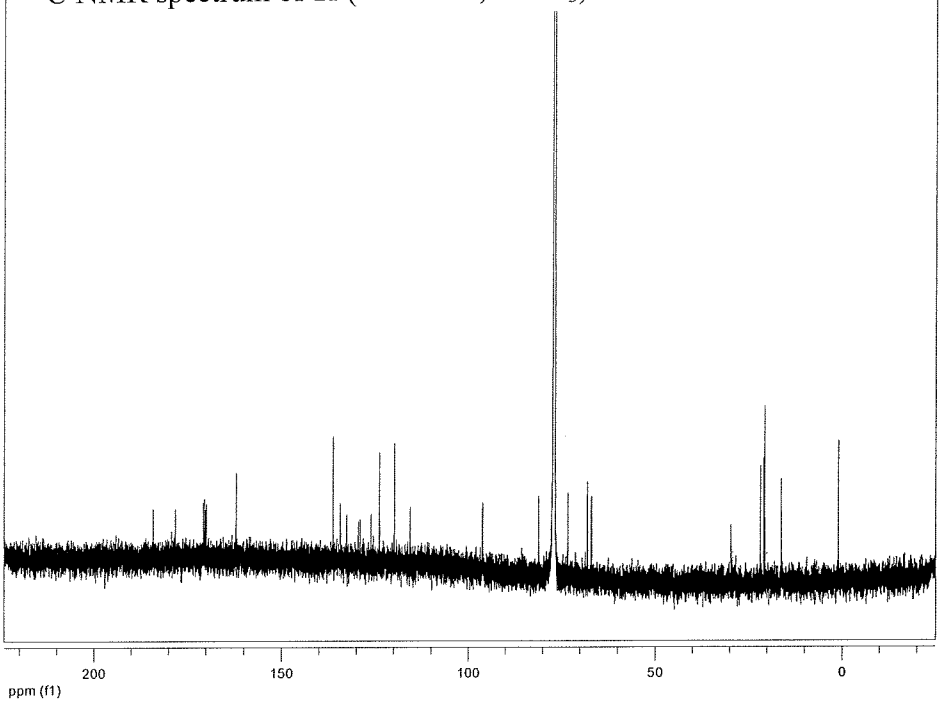
aln-11-C21.sp
aln-11-C21.pk

AL879D~1.SP 3351 4000 650 81 99 4 %T 4 2
Kinamycin F
REF 4000 99 2000 99 600
3369 88 2925 91 2138 86 1618 81 1455 85
1333 89 1233 84 1157 90 1085 83 753 92
699 92

^{1}H NMR spectrum of **1f** (600 MHz, $CDCl_3$)



^{13}C NMR spectrum of **1f** (150 MHz, $CDCl_3$)



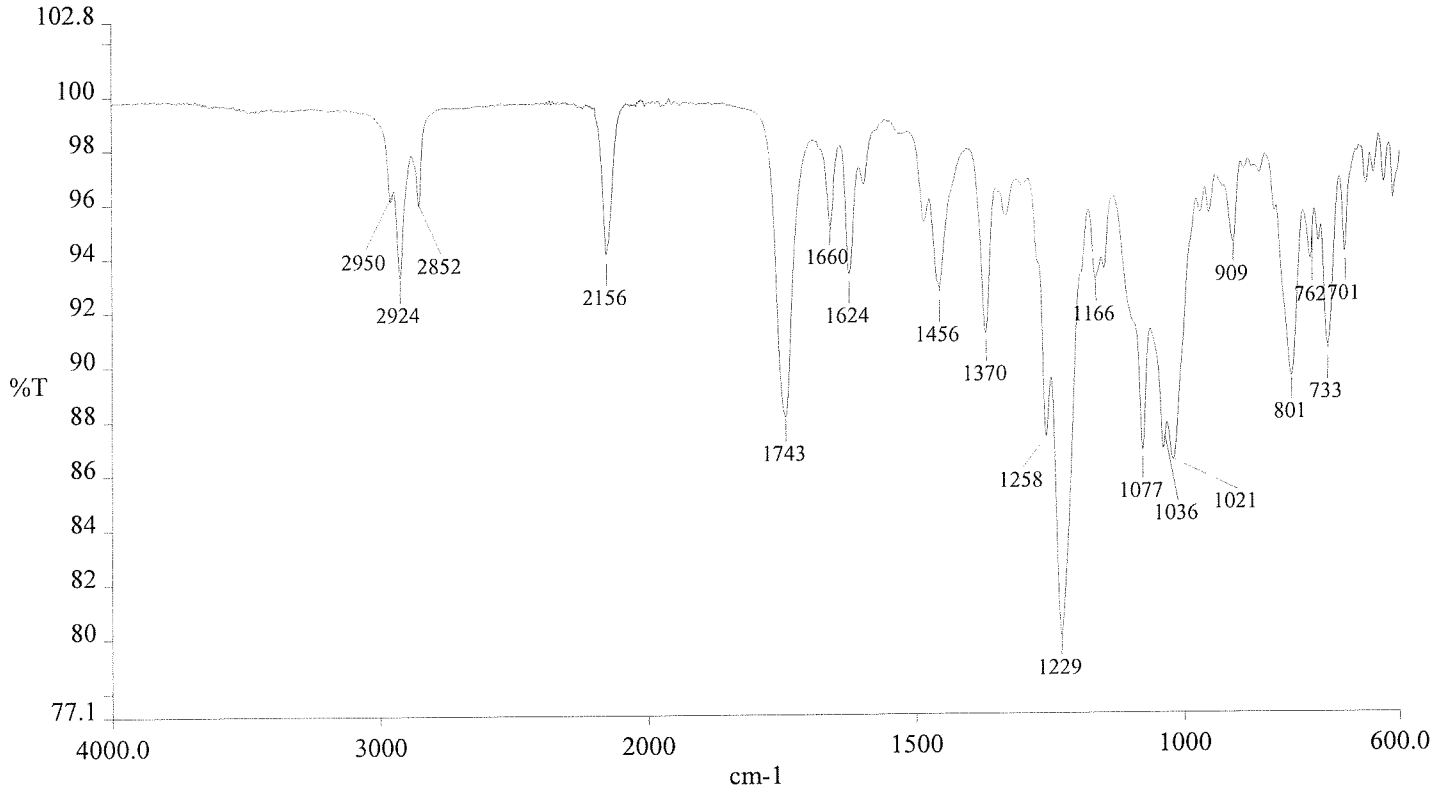
Analyst: Andrea N

Date Created: Tuesday, June 12, 2007 7:18 PM Pacific Daylight Time

Spectrum Name: aln-11-C22-2.sp

Description: Kinamycin J

Comments:



aln-11-C22-2.sp
aln-11-C22-2.pk

aln-11-C22-2.sp 3401 4000 600 80 99 4 %T 4 2
Kinamycin J
REF 4000 99 2000 99 600
2924 93 2156 94 1743 88 1660 95 1624 93
1456 92 1370 91 1258 87 1229 80 1166 93
1077 86 1021 86 909 94 801 89 733 90
701 94