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Total Synthesis of Clerocidin via a Novel, Enantioselective Homoallenylboration Methodology

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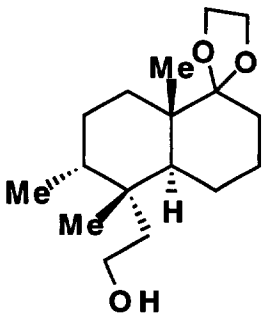
Supporting Information

General techniques. All reactions were carried out under an argon atmosphere in dry, freshly distilled solvents under anhydrous conditions, unless otherwise noted. Tetrahydrofuran (THF) and diethyl ether (Et_2O) were distilled from sodium/benzophenone; dichloromethane (CH_2Cl_2), HMPA and toluene from calcium hydride; DMF from calcium chloride. Yields refer to chromatographically and spectroscopically (^1H NMR) homogeneous materials, unless otherwise stated. Reagents were purchased at highest commercial quality and used without further purification unless otherwise stated. Reactions were monitored by thin-layer chromatography carried out on 0.25 mm E. Merck silica gel plates (60F-254) using UV light as visualizing agent and 7% ethanolic phosphomolybdic acid, or *p*-anisaldehyde solution and heat as developing agents. E. Merck silica gel (60, particle size 0.040-0.063 mm) was used for flash 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 a Varian 400 or 500 instrument 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, b = broad. IR spectra were recorded on a Perkin-Elmer

Model 781 spectrometer. Optical rotations were recorded on a Perkin-Elmer 241 polarimeter. High resolution mass spectra (HRMS) were recorded on a VG 7070 HS mass spectrometer under chemical ionization (CI) conditions or on a VG ZAB-ZSE mass spectrometer under fast atom bombardment (FAB) conditions.

Alcohol **11**

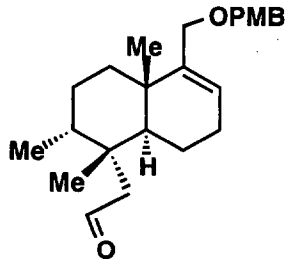
The higher homolog of the Wieland-Miescher ketone was obtained in enantiomerically pure form (>95%, HPLC) *via* a L-phenylalanine-mediated Robinson annulation, followed by two recrystallizations from ether/hexanes as described by: Brunner, S. D.; Radeke, H. S.; Tallarico, J. A.; Snapper, M. L. *J. Org. Chem.* **1995**, *60*, 1114. Uma, M. R.; Swaminathan, S.; Rajagopalan, K. *Tetrahedron Lett.* **1984**, *25*, 5825.



11

11: colorless liquid; R_f = 0.33 (silica, 70% ether in hexanes); $[a]^{25}_D$: -16.8 (c= 2.2, CH_2Cl_2); IR (film) ν_{max} 3355, 2952, 2878, 1454, 1381, 1186, 1031, 937; ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.94 (m, 3H), 3.81 (m, 1H), 3.68 (m, 2H), 1.89-1.22 (m, 14H), 1.07 (s, 3H), 0.98 (d, J= 7.0 Hz, 3H), 0.93 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 113.8, 65.5, 65.0, 59.3, 43.9, 43.1, 42.7, 37.5, 36.1, 30.4, 25.0, 23.7, 23.2, 21.3, 20.1, 17.7, 15.0; HRMS, calcd for $C_{17}H_{30}O_3$ (M+ H^+) 283.2275, found 283.2271.

Aldehyde **5**

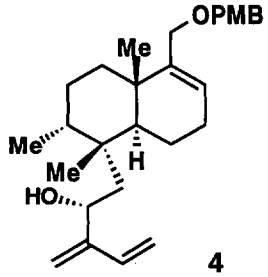


5

5: colorless liquid; R_f = 0.50 (silica, 50% ether in hexanes); $[\alpha]^{25}_D$: +16.3 (c= 5.1, CH_2Cl_2); IR (film) ν_{max} 2932, 2858, 1716, 1515, 1246, 1045, 823; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.91 (t, J= 3.0 Hz, 1H), 7.26 (d, J= 9.0 Hz, 2H), 6.87 (d, J= 8.5 Hz, 2H), 5.56 (bs, 1H), 4.40 (s, 2H), 3.96 (d, J= 12.5 Hz, 1H),

3.86 (d, J= 12.0 Hz, 1H), 3.79 (s, 3H), 2.37 (dd, J= 15.5, 2.5 Hz, 1H), 2.18 (dd, J= 15.0, 2.0 Hz, 2H), 2.08-1.95 (m, 2H), 1.86 (m, 1H), 1.63-1.24 (m, 6H), 1.19 (s, 3H), 1.14 (s, 3H), 1.01 (d, J= 6.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 204.9. 159.4, 144.4, 130.9, 129.6, 124.3, 114.0, 71.9, 70.7, 55.4, 54.0, 44.5, 39.5, 38.0, 36.6, 29.3, 26.4, 25.4, 22.4, 21.7, 18.4, 15.6; HRMS, calcd for $C_{24}H_{34}O_3$ (M+ Cs^+) 503.1561, found 503.1582.

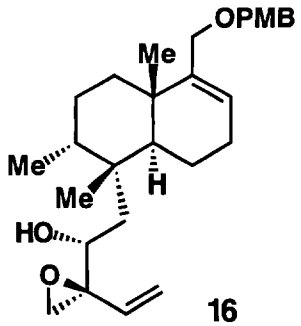
Alcohol **4**



4

To a mixture of L-DIPT (0.54 ml, 2.60 mmol), powdered molecular sieves (0.5 g), and toluene (5 ml) was added diisopropyl 2,3-butadien-1-ylboronate (0.27 ml, 1.30 mmol). The reaction mixture was stirred at 25°C for 1 h, and then connected to a vacuum (15 mmHg) for approximately 3 h under stirring. Argon was then allowed into the flask, followed by toluene (2 ml). The mixture was cooled to -78°C, and treated with a solution of aldehyde **5** (324 mg, 0.87 mmol) in toluene (5 ml). After stirring for 72 h at -78°C, the reaction mixture was quenched with water, allowed to warm to 25°C and extracted with Et_2O (3 X 10 ml). The combined ethereal solutions were concentrated, dried over $MgSO_4$, and the residue purified by flash chromatography (silica, 0-10% ether in hexanes) to afford alcohol **4** (0.30 g, 0.72 mmol, 83%, 71% de). **4**: colorless liquid; R_f = 0.5 (silica, 50% ether in hexanes); $[\alpha]^{25}_D$: +21.9 (c= 0.5, CH_2Cl_2); IR (film) ν_{max} 3442, 2927, 2860, 1611, 1514, 1247, 1035, 904, 823; ^1H NMR (500 MHz, $CDCl_3$) δ 7.26 (d, J= 10.5 Hz, 2H), 6.87 (d, J= 10.5 Hz, 2H), 6.32 (dd, J= 13.5, 22.0 Hz, 1H), 5.58-5.53 (m, 2H), 5.18-5.10 (m, 3H), 4.40 (s, 2H), 3.96 (d, J = 15.0 Hz, 1H), 3.86 (d, J= 15.0 H, 1H), 3.80 (s, 3H), 2.22-1.20 (m, 14H), 1.25 (s, 3H), 1.15 (s, J = 7.5 Hz, 3H), 0.86 (d, J= 8.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.4, 151.5, 144.8, 135.5, 131.1, 129.5, 124.2, 116.0, 114.0, 113.5, 71.8, 70.8, 70.5, 55.4, 45.6, 45.2, 38.5, 38.0, 35.6, 29.8, 29.4, 26.8, 26.7, 25.6, 22.1, 21.2, 18.0, 15.5; HRMS, calcd for $C_{28}H_{40}O_3$ (M+ Na^+) 447.2875, found 447.2890.

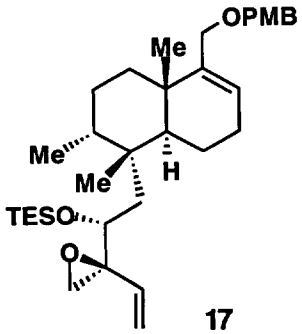
Epoxide **16**



16

To a stirring suspension of alcohol **4** (0.30 g, 0.72 mmol) and 4 A powdered, activated molecular sieves (0.10 g) in CH_2Cl_2 (3 ml) at -20°C, were added sequentially D-diethyl tartrate (38.2 µl, 0.18 mmol) and $(iPrO)_4Ti$ (47.6 µl, 0.16 mmol). The reaction mixture was allowed to stir at -20°C under argon for 30 min and then treated with *tert*-butyl hydroperoxide (0.26 ml, 5.0-6.0 M in decane, 1.44 mmol). After stirring at -20°C for 6 h, water (1 ml) was added and the reaction was allowed to warm to 25°C. The mixture was then treated with sodium hydroxide (0.2 ml of a 30% aqueous solution) and aqueous saturated sodium chloride (10 ml), stirred vigorously for 20 min. and then filtered through a small plug of celite. The organic phase was separated and the aqueous phase was washed with methylene chloride (2 X 10 ml). The organic layers were combined, dried over $MgSO_4$, concentrated, and the residue purified by flash chromotography (silica, 0-20% ether in hexanes), to furnish epoxide **16** (0.28 g, 0.63 mmol, 88%, 86% de). **16**: colorless liquid; R_f = 0.5 (silica, 50% ether in hexanes); $[\alpha]^{25}_D$: +37.40 (c= 0.5, CH_2Cl_2); IR (film) ν_{max} 3460, 2921, 1611, 1514, 1459, 1247, 1035; ^1H NMR (500 MHz, C_6D_6) δ 7.31 (d, J= 8.0 Hz, 2H), 6.82 (d, J= 8.5 Hz, 2H), 5.94 (dd, J= 17.0, 10.5 Hz, 1H), 5.66 (bs, 1H), 5.38 (dd, J= 17.0, 1.0 Hz, 1H), 5.05 (dd, J= 11.0, 1.0 Hz, 1H), 4.39 (s, 2H), 4.04 (d, J= 12.0 Hz, 1H), 3.91 (d, J= 12.5 Hz, 1H), 3.67 (d, J= 7.5 Hz, 1H), 3.30 (s, 3H), 2.60 (d, J= 5.5 Hz, 1H), 2.30 (d, J= 6.0 Hz, 1H), 2.13-1.27 (m, 12H), 1.25 (s, 3H), 1.17 (d, J= 6.5 Hz, 3H), 1.04 (s, 3H); ^{13}C NMR (125 MHz, C_6D_6) δ 160.0, 145.5, 134.6, 131.9, 129.7, 123.9, 117.6, 114.4, 72.1, 71.4, 68.9, 61.9, 55.0, 52.8, 45.1, 41.6, 38.8, 38.7, 37.3, 29.8, 27.1, 26.4, 23.0, 21.3, 19.1, 16.5; HRMS, calcd for $C_{28}H_{40}O_4$ (M+ Na^+) 463.2824, found 463.2806.

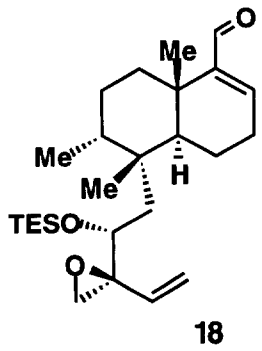
Silyl ether **17**



17

17: colorless liquid; R_f = 0.75 (silica, 25% ether in hexanes); $[\alpha]^{25}_D$: +18.48 (c= 4.6, CH_2Cl_2); IR (film) ν_{max} 2952, 2872, 1609, 1515, 1461, 1240, 1085, 743; ^{1}H NMR (500 MHz, C_6D_6) δ 7.30 (d, J= 8.5 Hz, 2H), 6.82 (d, J= 9.0 Hz, 2H), 6.32 (dd, J=17.5, 10.5 Hz, 1H), 5.60 (bs, 1H), 5.54 (dd, J= 17.0, 2.0 Hz, 1H), 5.13 (dd, J= 11.0, 2.0 Hz, 1H), 4.38 (s, 2H), 4.02 (d, J= 12.0 Hz, 1H), 3.89 (d, J= 12.0 Hz, 1H), 3.68 (dd, J= 8.5, 3.0 Hz, 1H), 3.29 (s, 3H), 2.66 (d, J= 6.0 Hz, 1H), 2.45 (d, J= 6.0 Hz, 1H), 2.04-0.91 (m, 12H), 1.24 (s, 3H), 1.19 (d, J= 7.0 Hz, 3H), 1.14 (s, 3H), 0.98 (t, J= 8.5 Hz, 9H), 0.61 (q, J= 8 Hz, 6H); ^{13}C NMR (125 MHz, C_6D_6) δ 160.0, 145.3, 134.2, 131.9, 129.7, 124.3, 116.5 114.4, 74.0, 72.0, 71.5, 61.2, 58.2, 55.0, 45.5, 42.9, 38.7, 38.6, 37.2, 29.7, 27.0, 26.2, 22.8, 20.9, 18.8, 16.6, 7.5, 5.9; HRMS, calcd for $C_{34}H_{54}O_4Si$ (M+ Cs^+) 687.2846, found 687.2825.

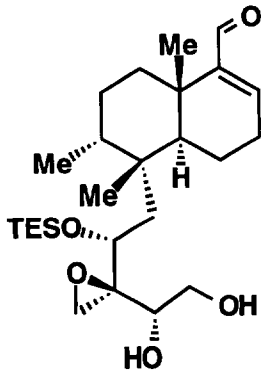
Olefin **18**



18

18: colorless liquid; R_f = 0.8 (silica, 50% ether in hexanes); $[\alpha]^{25}_D$: +22.33 (c= 2.7 , CH_2Cl_2); IR (film) ν_{max} 2959, 2878, 2704, 2361, 1690, 1468, 1085, 1011; ^{1}H NMR (500 MHz, C_6D_6) δ 9.19 (s, 1H), 6.32 (dd, J= 17.5, 11.0 Hz, 1H), 5.81 (bt, J= 3.5 Hz, 1H), 5.54 (dd, J= 17.0, 2.0 Hz, 1H), 5.13 (dd, J= 11.5, 2.0 Hz, 1H), 3.62 (dd, J= 8.0, 2.5 Hz, 1H), 2.76 (dt, J= 14.5, 4.0 Hz, 1H), 2.64 (d, J= 6.0 Hz, 1H), 2.45 (d, J= 6.5 Hz, 1H), 2.38 (q, J= 7.0 Hz, 1H), 2.01-1.28 (m, 10H), 1.24 (s, 3H), 1.11 (d, J= 7.0 Hz, 3H), 1.04 (s, 3H), 0.97 (t, J= 8.0 Hz, 9H), 0.58 (q, J= 8.5 Hz, 6H); ^{13}C NMR (125 MHz, C_6D_6) δ 193.4, 152.6, 151.1, 134.0, 116.4, 74.0, 61.1, 58.6, 45.5, 43.2, 38.55, 38.51, 37.0, 29.3, 28.7, 26.1, 21.9, 20.8, 18.0, 16.4, 7.4, 5.9; HRMS, calcd for $C_{26}H_{44}O_3Si$ (M+ Na^+) 455.2957, found 455.2971.

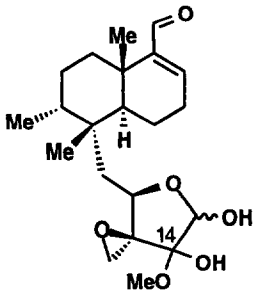
Diol **19**



19

To a solution of olefin **18** (25.1 mg, 0.058 mmol) in 50% *tert*-butyl alcohol/water (1 ml) at 0°C, was added a mixture of $(DHQD)_2PHAL$ (hydroquinidine1,4-phthalazinediyl diether) (0.5 mg, 0.58 μmol), $K_3Fe(CN)_6$ (0.057 g, 0.174 mmol), K_2CO_3 (0.024 g, 0.174 mmol), and $K_2OsO_4.2H_2O$ (0.2 mg, 0.58 μmol). The mixture was stirred at 0°C for 7 h, and then treated with $Na_2S_2O_5$. The reaction mixture was allowed to warm to 25°C while stirring vigorously, after which ethyl acetate (20 ml) was added, and the aqueous layer was further extracted with ethyl acetate (3 x 5 ml). The combined organic layers were dried over $MgSO_4$ and concentrated. Purification by flash chromatography (silica, 0-50% ether in hexanes) afforded diol **19** (0.020 g, 0.042 mmol, 72%, 75% de). **19**: white solid; *Rf* = 0.35 (silica, 60% ether in hexanes); $[\alpha]^{25}_D$: +35.0 (c= 0.2, CH_2Cl_2); IR (film) ν_{max} 3416, 2959, 2919, 2872, 1690, 1461, 1381, 1085, 1011; ^1H NMR (400 MHz, $CDCl_3$) δ 9.30 (s, 1H), 6.54 (bt, J= 2.8 Hz, 1H), 4.22 (t, J= 4.0 Hz, 1H), 3.77 (t, J= 4.8 Hz, 1H), 3.65 (m, 2H), 3.02 (d, J= 4.8 Hz, 1H), 2.71 (d, J= 4.4 Hz, 1H), 2.13-1.21 (m, 14H), 1.25 (s, 3H), 1.04 (s, 3H), 1.00 (d, J= 7.6 Hz, 3H), 0.96 (t, J= 8.0 Hz, 9H), 0.64 (q, J= 8.0 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.4, 152.1, 133.4, 79.3, 73.3, 68.3, 64.2, 50.2, 45.3, 42.6, 35.9, 29.8, 28.9, 28.7, 25.4, 21.7, 20.4, 17.7, 16.0, 7.1, 5.4; HRMS, calcd for $C_{26}H_{46}O_5Si$ (M+ Na^+) 489.3012, found 489.3028.

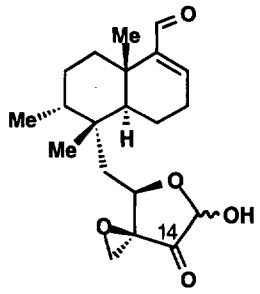
Clerocidin-C14 methanol adduct (**20**)



20

To a solution of oxalyl cloride (0.018 ml, 0.210 mmol) in CH_2Cl_2 (1 ml) at -78°C, was added slowly DMSO (0.024 ml, 0.336 mmol). The mixture was stirred at -78°C for 15 min and then treated with a solution of diol **19** (0.020 g, 0.042 mmol) in CH_2Cl_2 (1 ml) added dropwise over 5 min. After stirring for 30 min Et_3N (0.094 mmol, 0.672 mmol) was added slowly and the mixture was allowed to warm to 25°C. The crude reaction mixture was treated with TBAF•THF (0.046 ml, 1.0 M, 0.046 mmol), stirred for another 15 min, quenched with methanol (2 ml) and partitioned between water (10 ml) and ethyl acetate (10 ml). The organic layer was collected and the aqueous layer was further extracted with ethyl acetate (2 x 5 ml). The combined organic layers were dried over $MgSO_4$ and concentrated. Purification by preparative thin layer chromatography (silica, 0-50% ether in hexanes, 1% MeOH) afforded clerocidin as the C14-methanol adduct (**20**) (0.012g, 0.032 mmol, 76%). **20**: white solid; R_f = 0-0.4 (silica, 60% ether in hexanes); $[\alpha]^{25}_D$: +75.0 (c= 0.5, CD_3OD); IR (film) ν_{max} 3375, 2912, 1676, 1025; ^1H NMR (500 MHz, CD_3OD) δ 9.14 (s, 1H), 6.57 (s, 1H), 5.03 (s, 1H), 4.40 (m, 1H), 3.24, 3.23 (2 s, 3H), 3.03 (d, J= 5.5 Hz, 1H), 2.62 (d, J= 5.0 Hz, 1H), 2.4-2.23 (m, 3H), 1.82-1.72 (m, 3H), 1.42-1.15 (m, 6H), 1.11 (s, 3H), 0.92 (d, J= 7.0 Hz, 3H), 0.82 (s, 3H); ^{13}C NMR (125 MHz, CD_3OD) δ 194.7, 153.1, 152.3, 97.1, 96.6, 71.9, 71.2, 66.6, 48.6, 48.4, 47.7, 44.2, 38.2, 36.2, 29.3, 28.1, 25.5, 20.8, 20.6, 17.5, 14.8; HRMS, calcd for $C_{21}H_{32}O_6$ (M+ Na^+) 403.2097, found 403.2112.

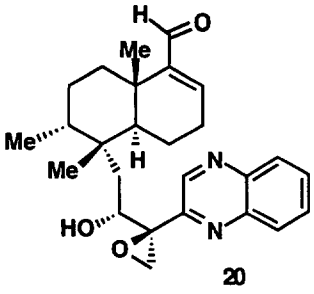
Clerocidin (**1**)



1

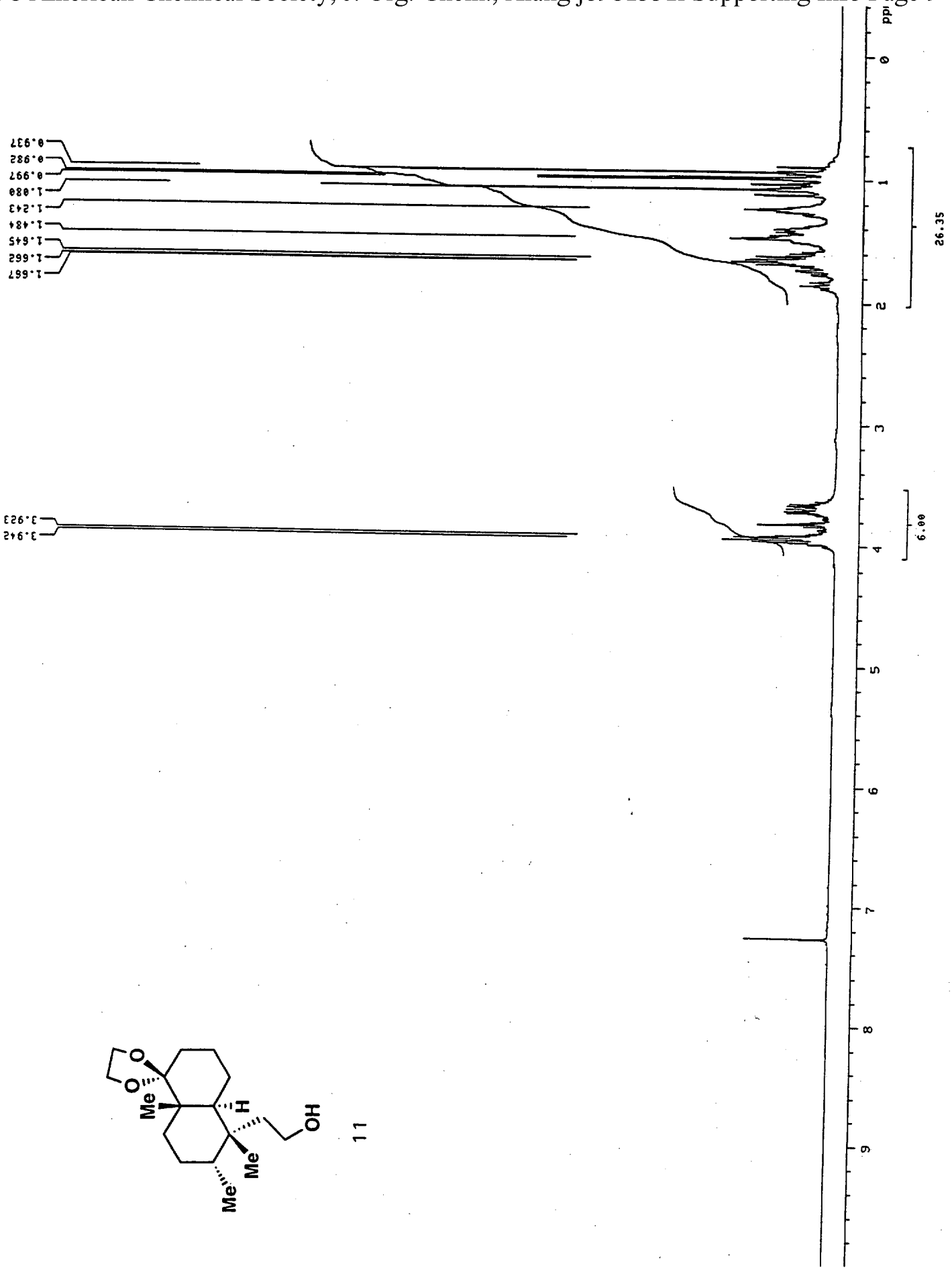
Conversion of compound **20** to **1** was accomplished by dissolving **20** in deuterated chloroform and evaporating the solvent under reduced pressure. This work-up afforded clerocidin (**1**) as a mixture of different forms (^{1}H NMR 500 MHz, $CDCl_3$). The interconversion of **20** to **1** was found to be solvent- and time-dependent.

Phthalazine-clerocidin adduct (**20**)



20

20: R_f = 0.6 (silica, 75% ether in hexanes); $[\alpha]^{25}_D$: -4.3 (c= 0.2, CH_2Cl_2); IR (film) ν_{max} 3444, 2917, 2860, 1722, 1687, 1455, 1265, 1131, 1082, 758; ^{1}H NMR (500 MHz, C_6D_6) δ 9.17 (s, 1H), 8.76 (s, 1H), 8.03 (m, 1H), 7.71 (m, 1H), 5.77 (t, J= 4.0 Hz, 1H), 4.19 (d, J= 8.0 Hz, 1H), 2.87 (d, J= 5.0 Hz, 1H), 2.36 (d, J= 5.0 Hz, 1H), 2.07 (m, 1H), 2.02 (dd, J= 3.0, 15.0 Hz, 1H), 1.89 (m, 2H), 1.70 (m, 3H), 1.52 (m, 2H), 1.36 (m, 4H), 1.26 (s, 3H), 1.14 (d, J= 7.0 Hz, 3H), 1.05 (s, 3H); ^{13}C NMR (125 MHz, C_6D_6) δ 192.9, 154.4, 152.3 150.5, 143.1, 142.6, 140.4, 130.6, 130.1, 129.9, 111.2, 72.4, 60.6, 57.5, 55.3, 44.7, 42.5, 38.6, 38.1, 36.8, 30.2, 29.8, 28.4, 26.2, 22.1, 21.3; HRMS, calcd for $C_{26}H_{31}O_3N_2$ (M+) 419.2335, found 419.2347.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O
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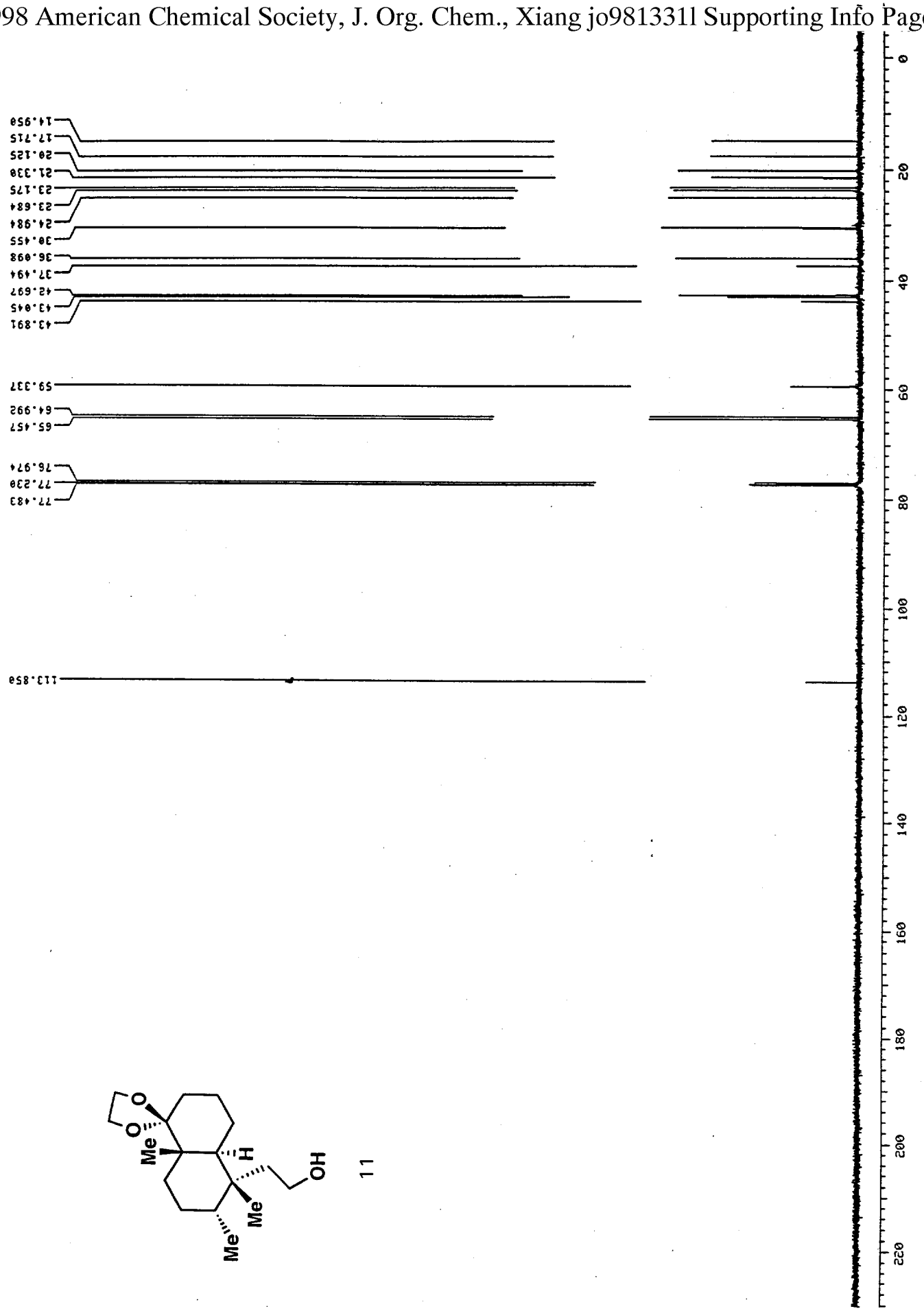
Me

11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59.337
64.992
65.457
76.974
77.230
77.483
113.858
0
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80
100
120
140
160
180
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O
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H
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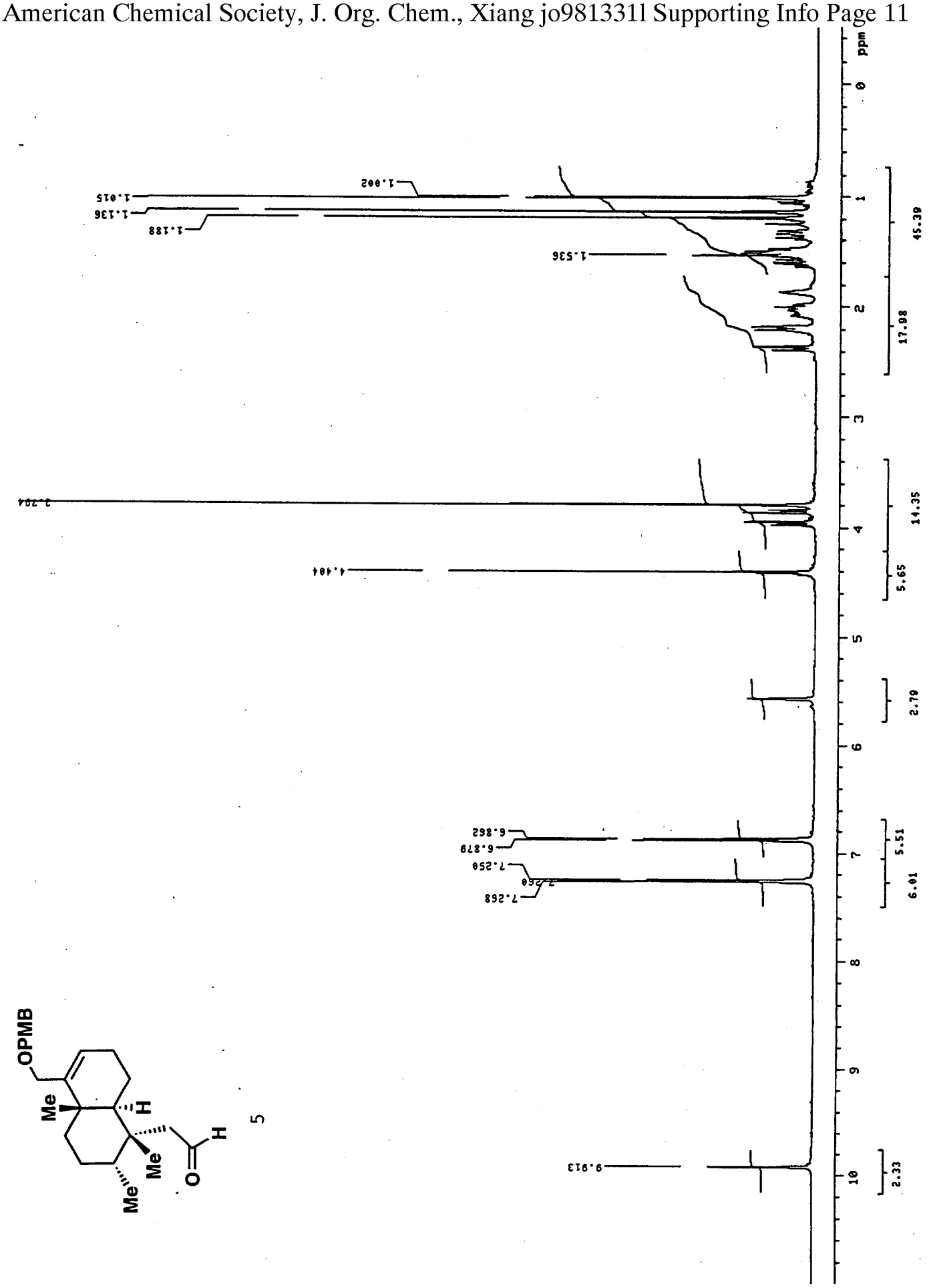
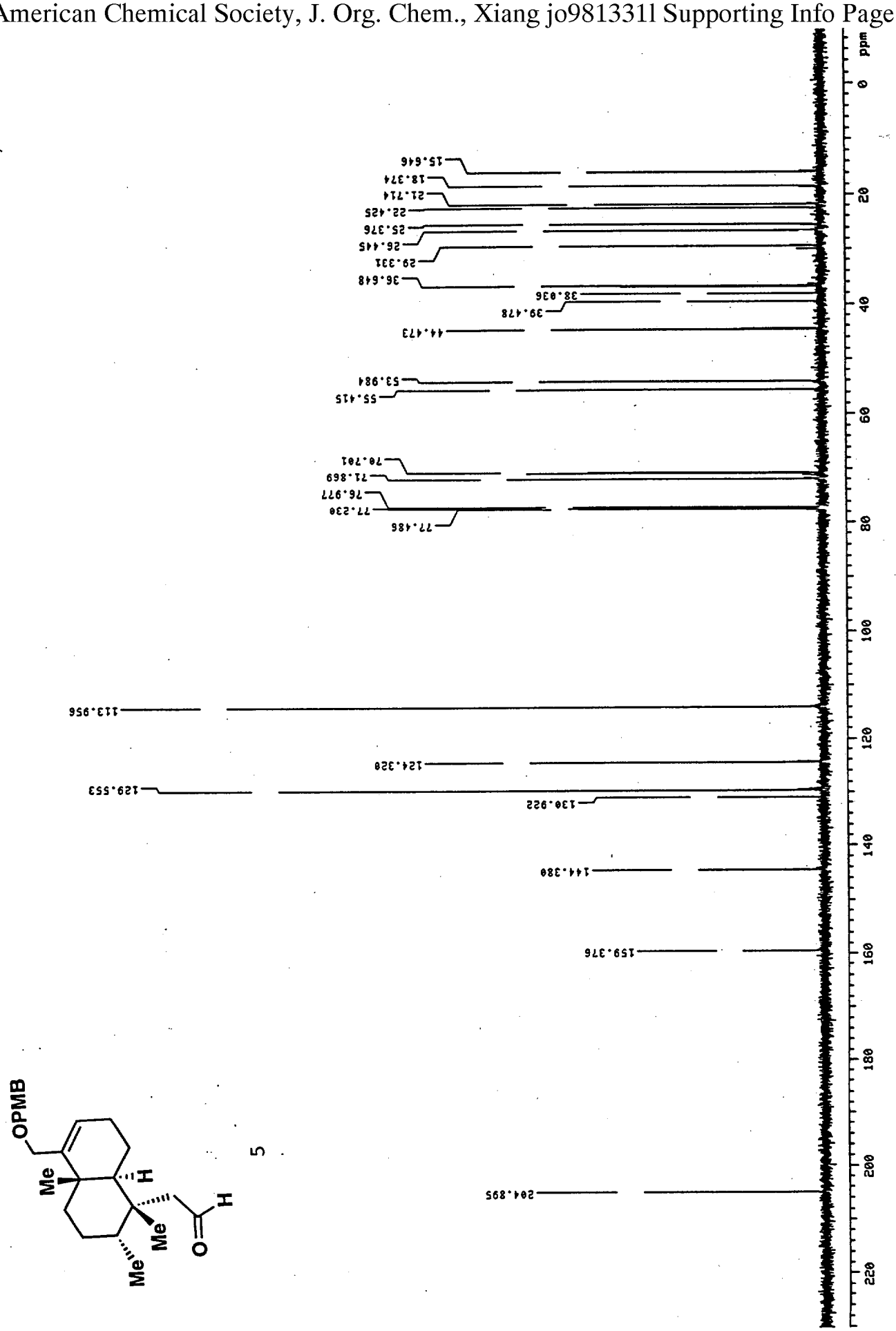
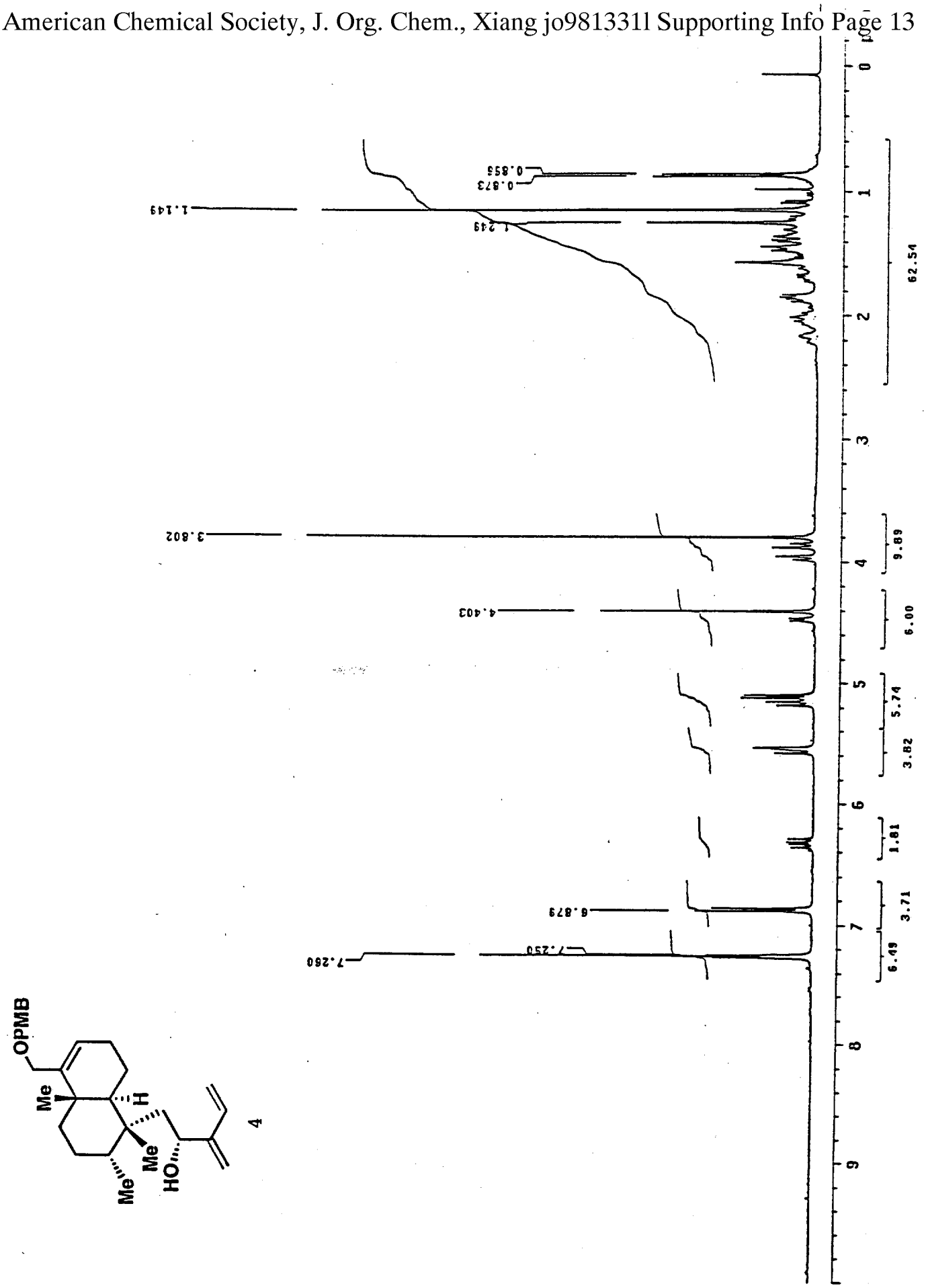
11

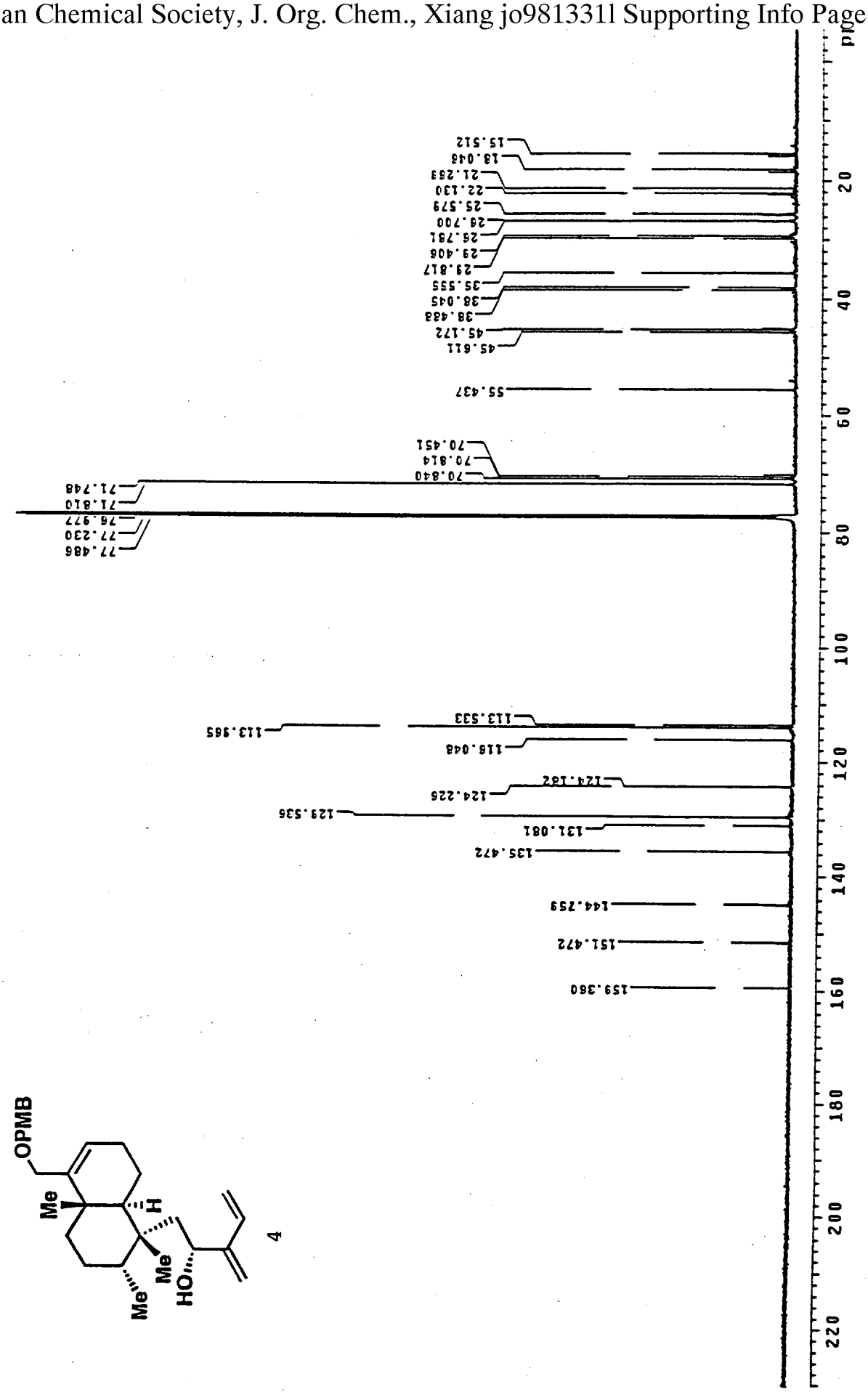


5



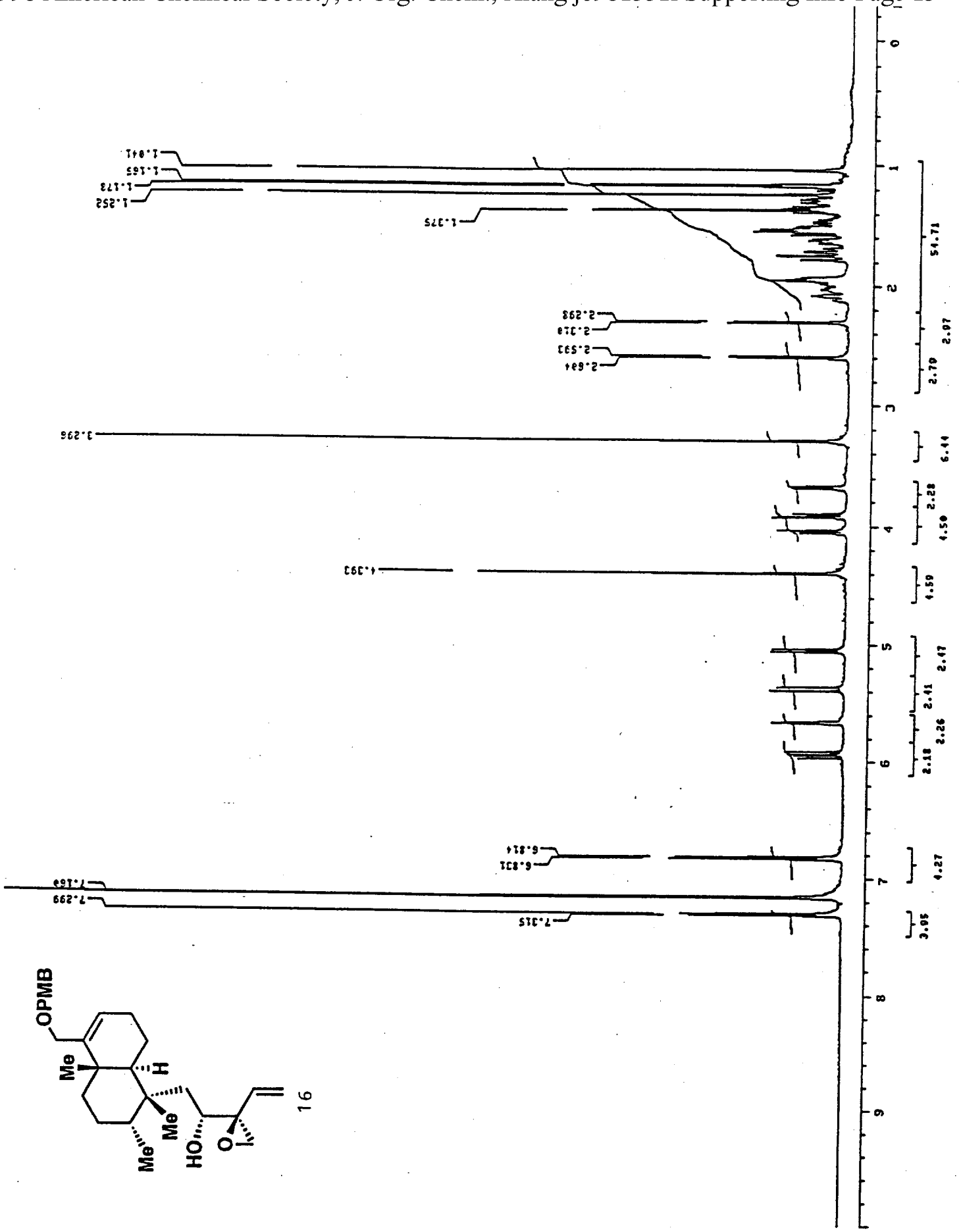
5

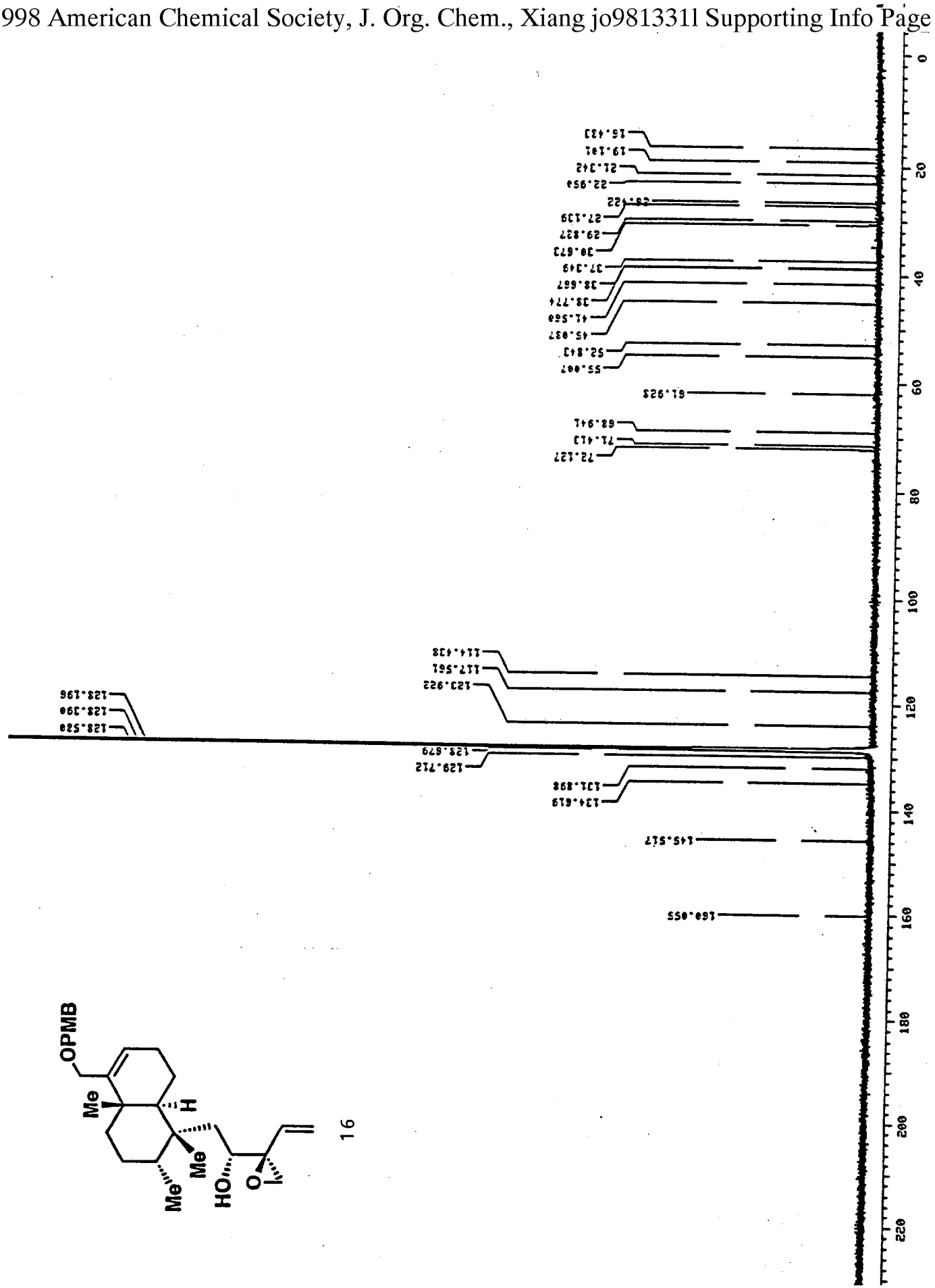

OPMB
Me
H
Me
Me
HO
4
7.260
7.250
6.879
4.403
3.802
1.249
1.149
0.873
0.855
62.54
9.89
6.00
5.74
3.82
1.81
3.71
6.49


15.512
18.046
21.263
22.130
25.579
28.700
28.781
29.408
29.817
35.535
38.045
38.488
45.172
45.611
55.437
70.451
70.814
70.840
71.748
71.810
76.977
77.230
77.486
113.533
113.965
118.048
124.182
124.226
129.536
131.081
135.472
144.259
151.472
159.360
ppm
20
40
60
80
100
120
140
160
180
200
220

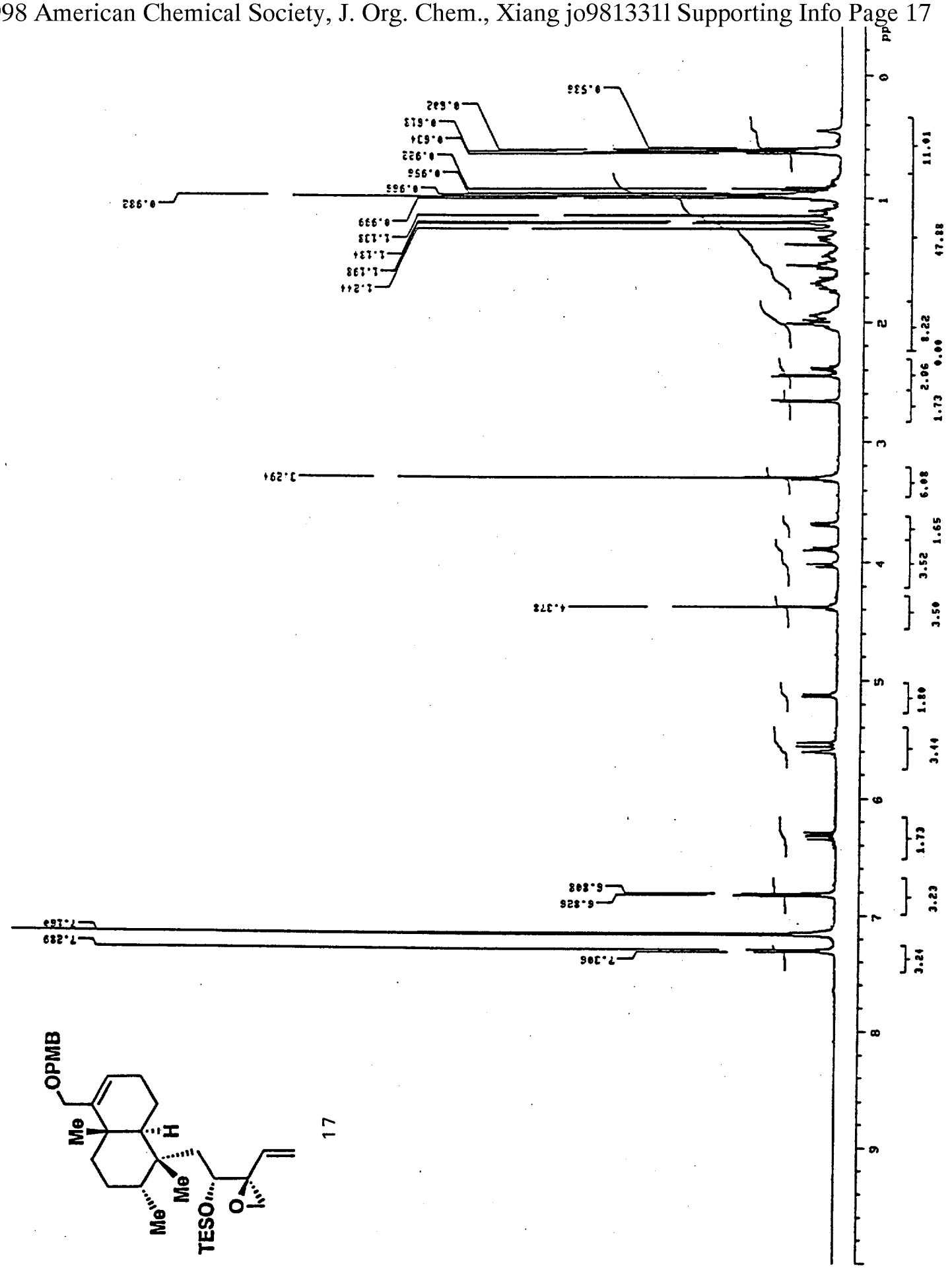
OPMB
Me
H
Me
HO
Me

4

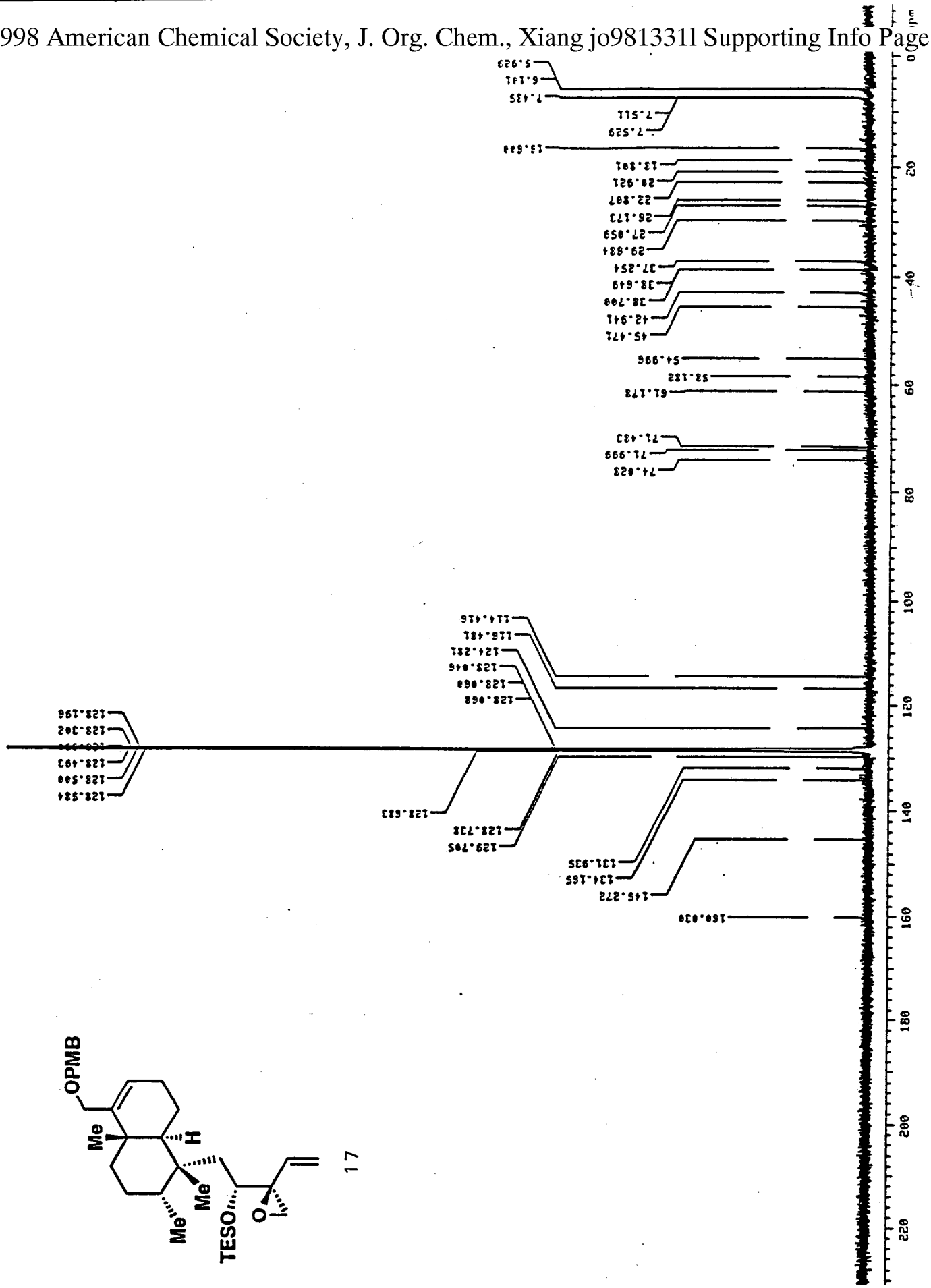

1.841
1.665
1.473
1.252
1.375
2.298
2.318
2.533
2.684
3.296
4.393
6.814
6.831
7.159
7.299
7.315
OPMB
Me
H
Me
Me
HO
O
16



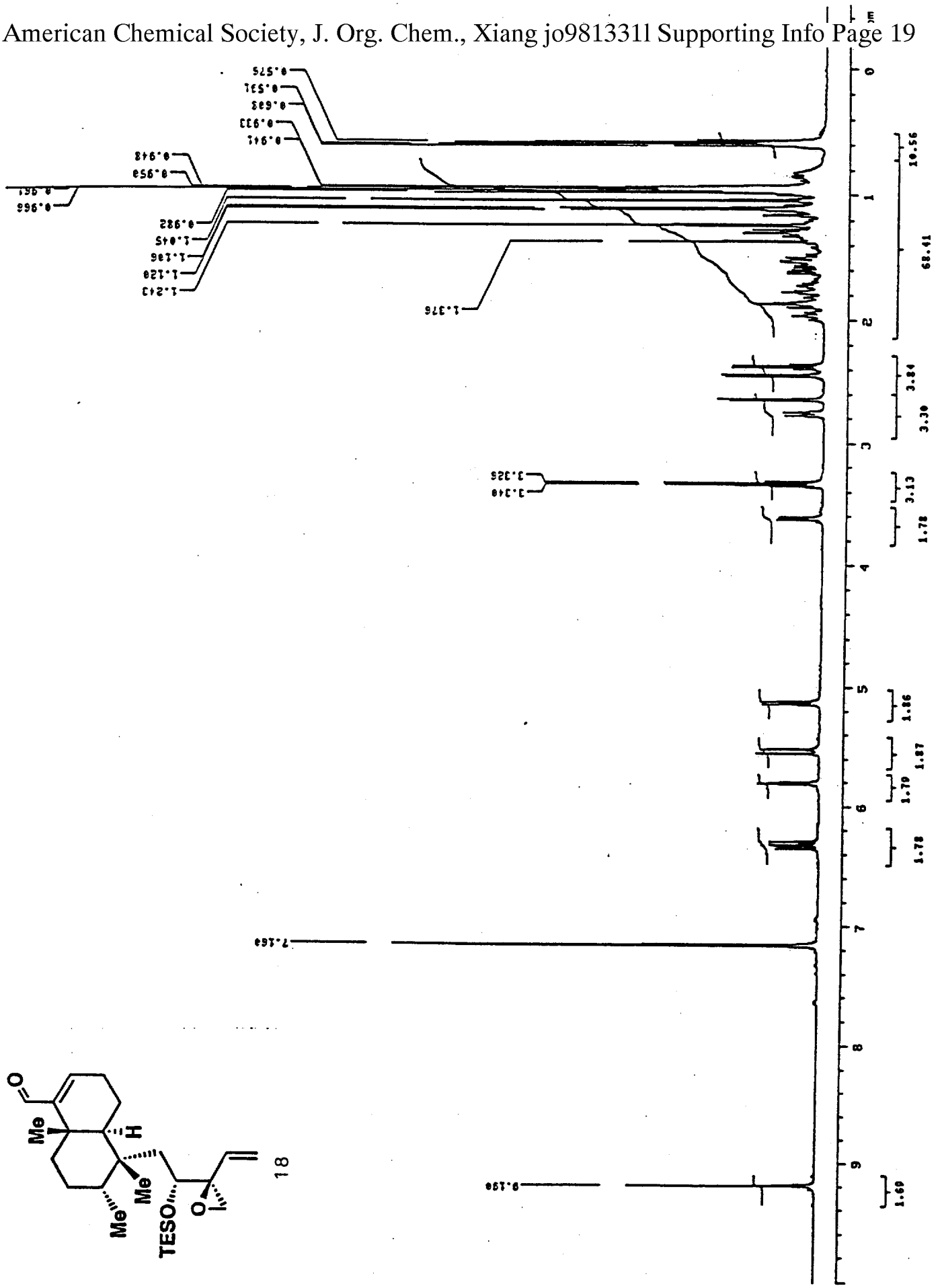
16



17

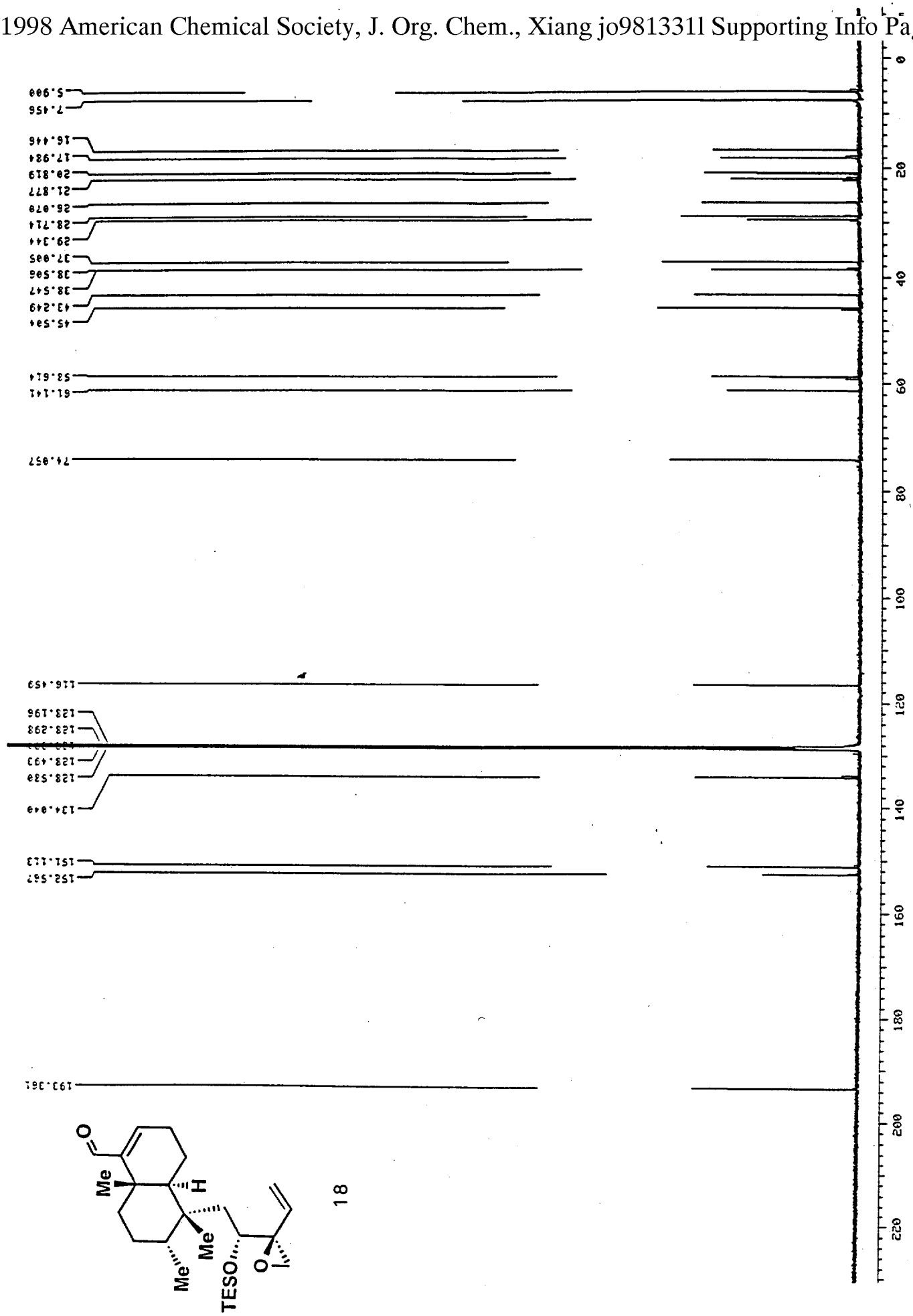


17


0.575
0.531
0.683
0.933
0.941
0.948
0.958
0.961
0.966
0.982
1.045
1.136
1.220
1.243
1.376
3.325
3.349
7.169
9.139
10.56
68.41
3.84
3.30
3.13
1.78
1.86
1.87
1.70
1.78
1.60
ppm

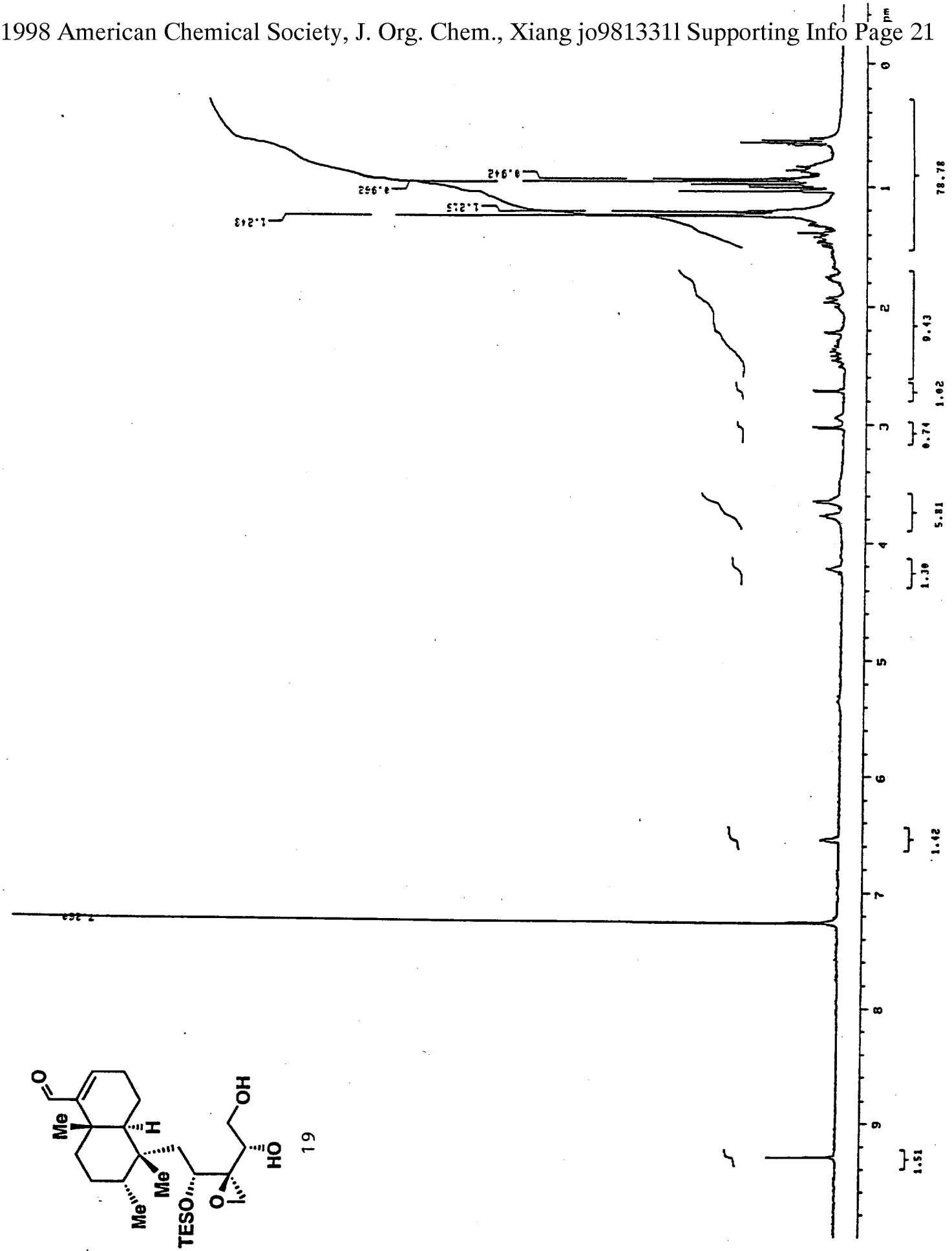
O
Me
H
Me
Me
TESO
O

18


5.900
7.456
16.446
17.984
20.819
21.877
26.078
28.714
29.344
37.005
38.506
38.547
43.249
45.584
52.614
61.141
74.057
116.459
128.196
128.298
128.493
128.538
134.049
151.113
152.567
193.361
0
20
40
60
80
100
120
140
160
180
200
220

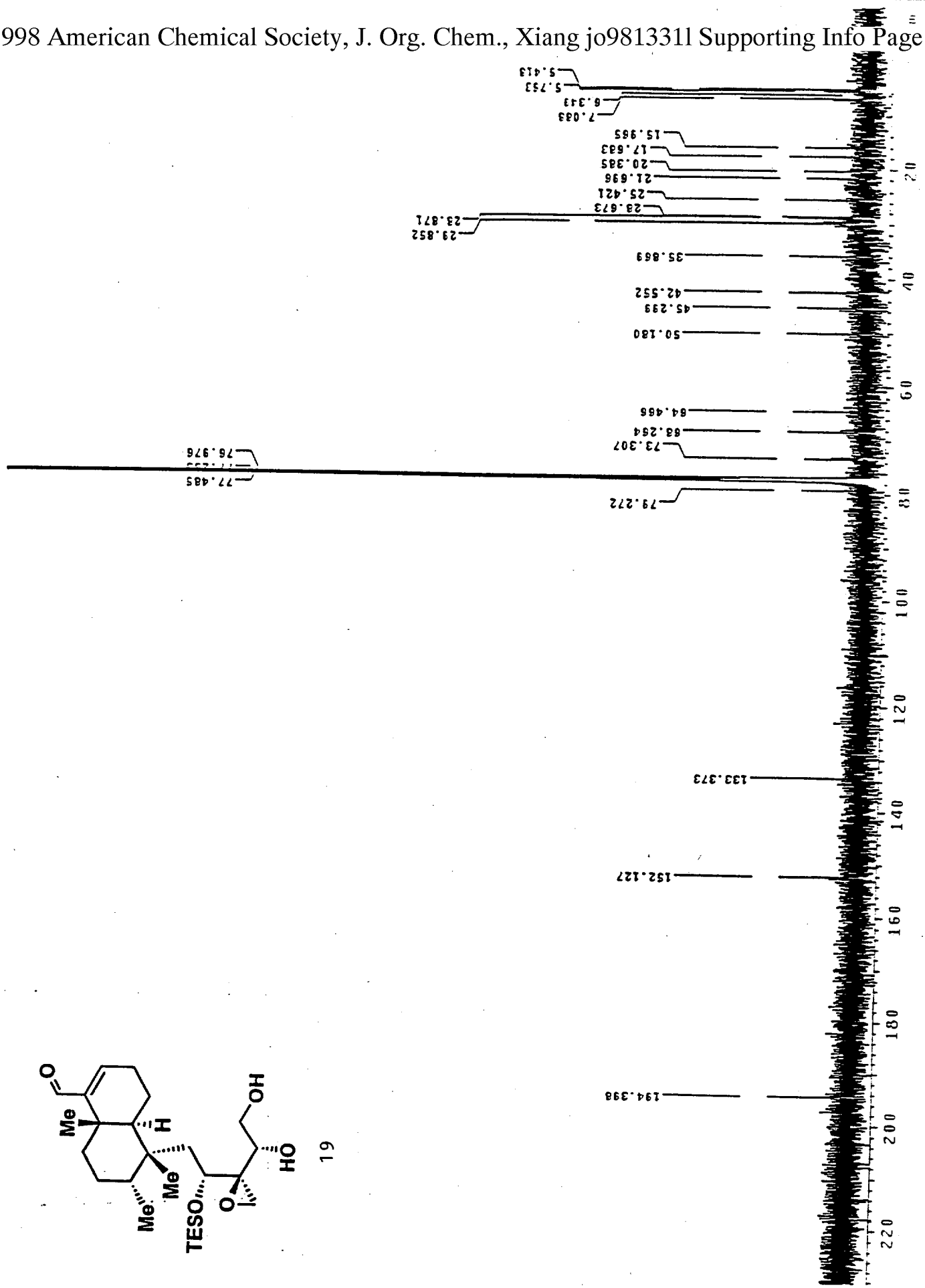
O
Me
H
Me
Me
TESO
O

18

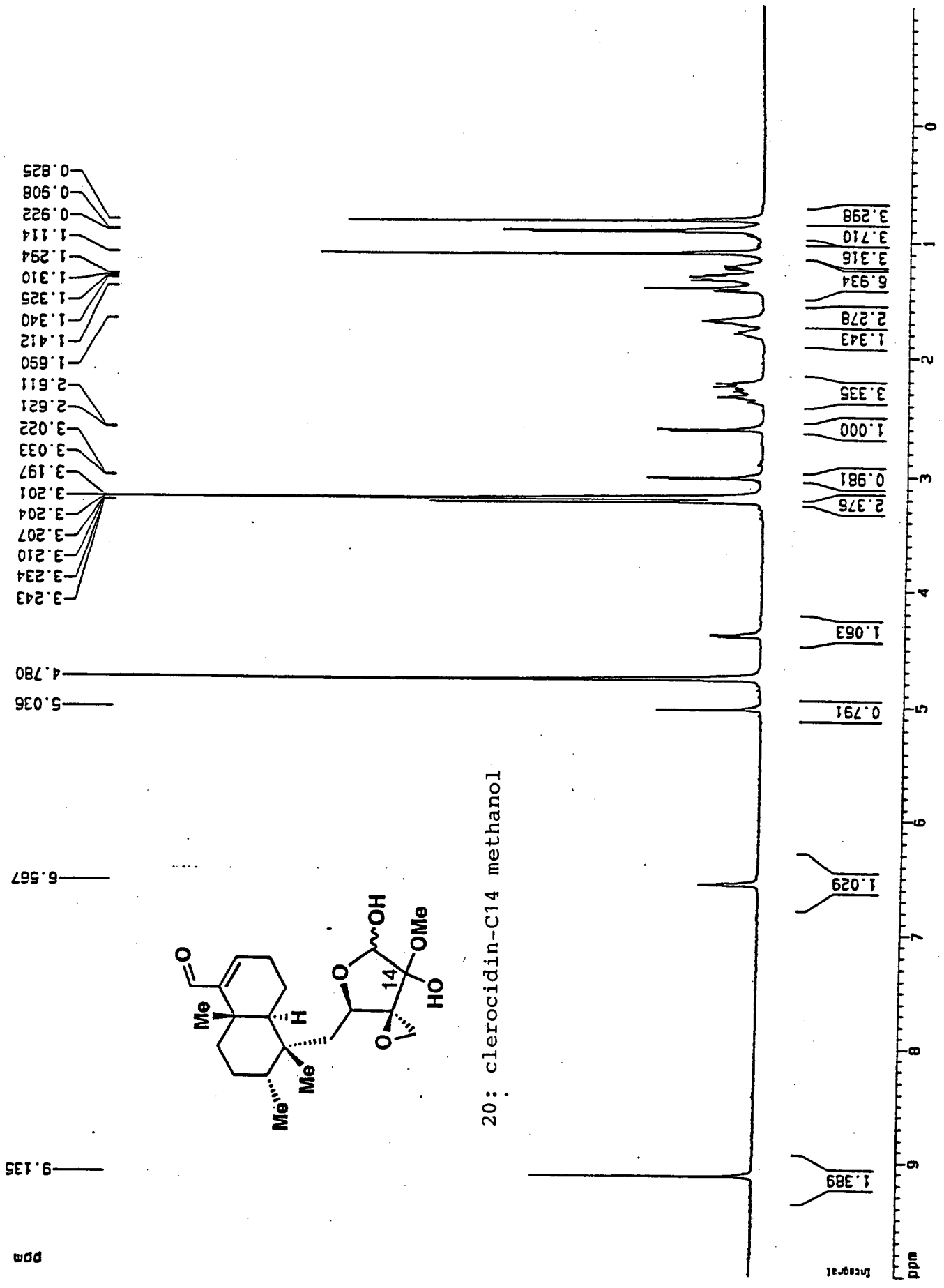

ppm
0.942
0.952
1.215
1.243
2.269
78.78
9.43
1.02
0.74
5.81
1.30
1.42
1.51

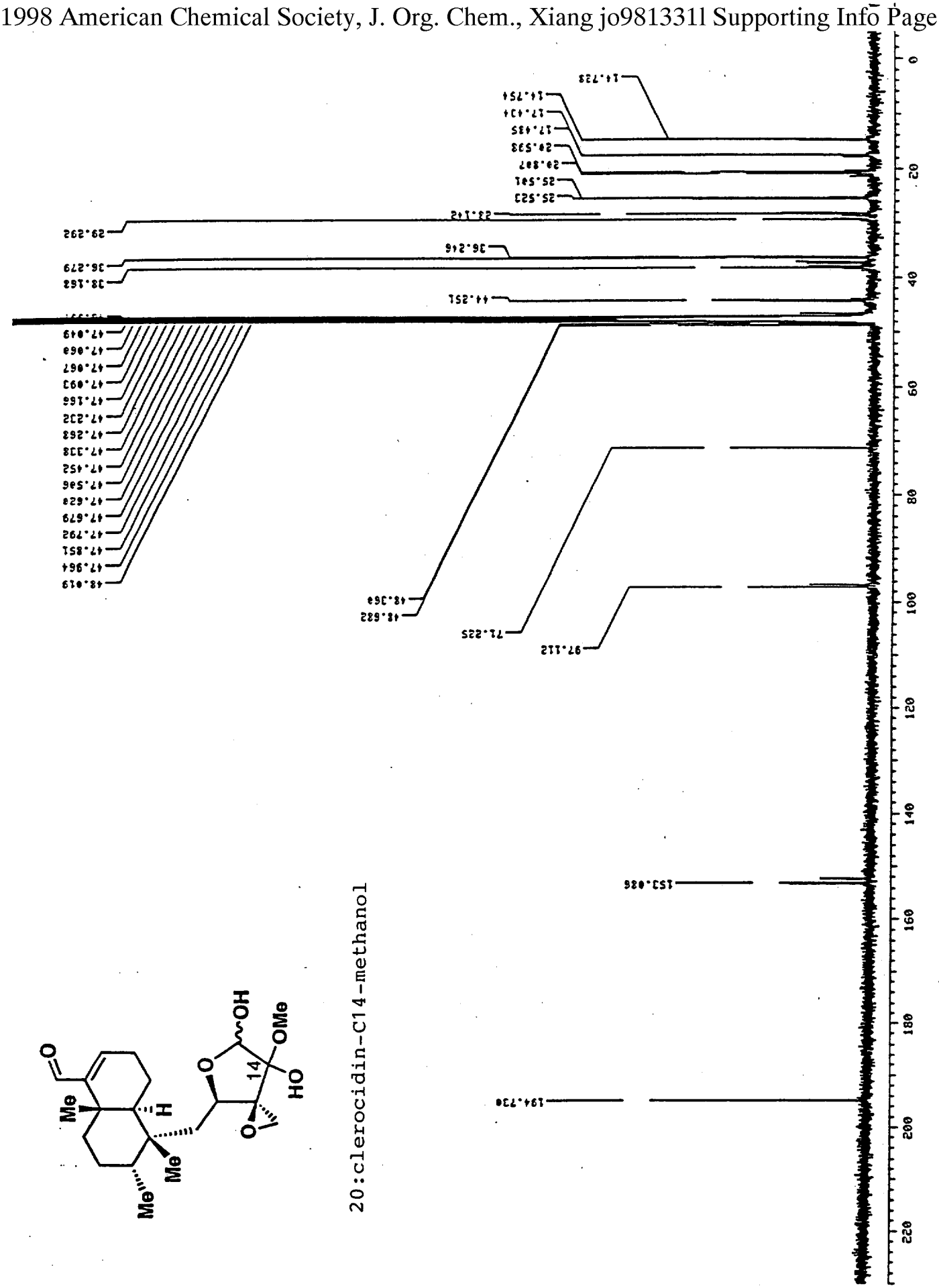
O
Me
H
Me
Me
TESO
O
OH
HO

19



19



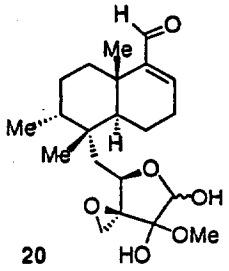


20:clerocidin-C14-methanol

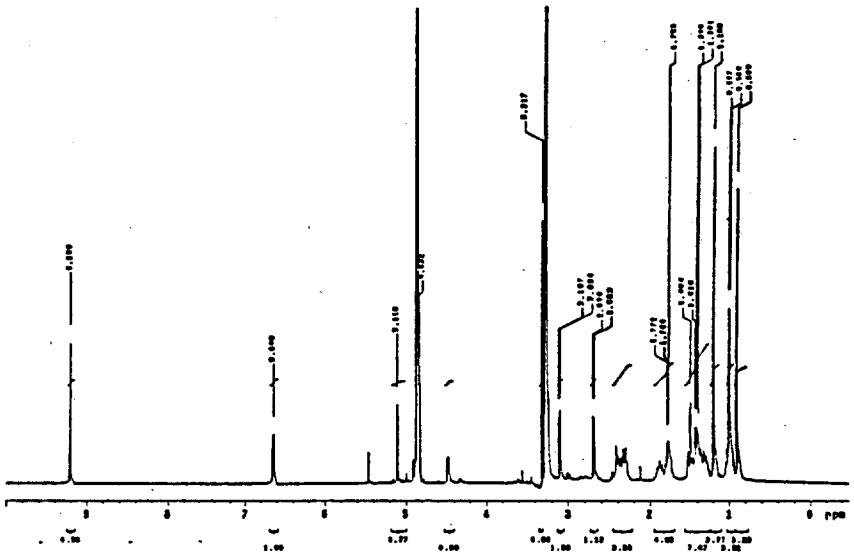
Exper. 1

^{1}H NMR spectrum of clerocidin in CD_3OD

(Shown as the clerocidin-C14 methanol adduct (**20**)).



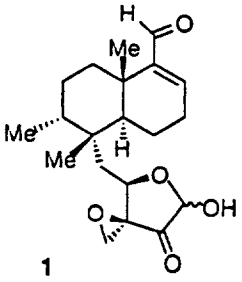
20



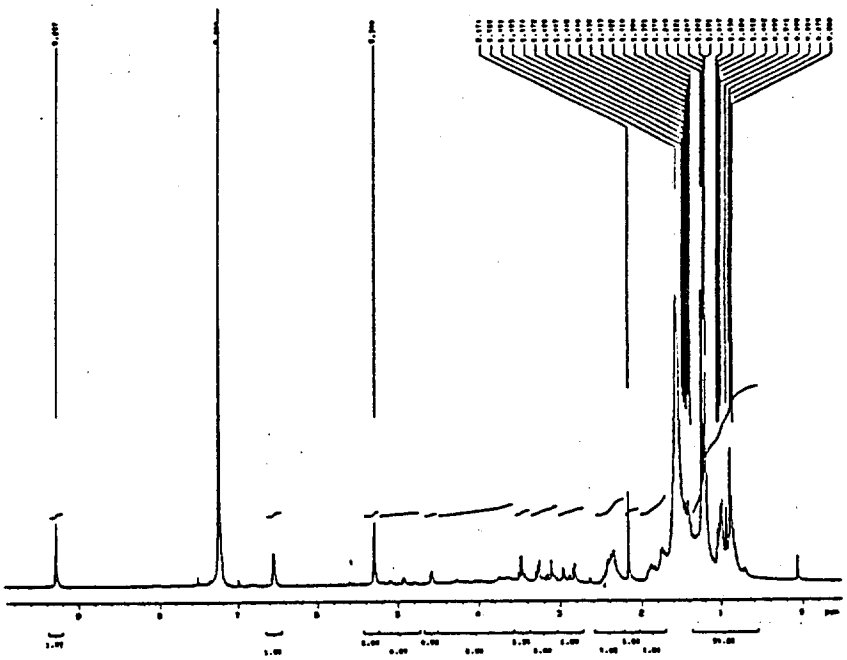
Exper. 2

^{1}H NMR spectrum of clerocidin in $CDCl_3$

(Recorded after evaporation of the CD_3OD from Exper. 1,
and shown as the free clerocidin (**1**)).



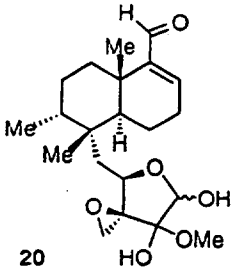
1



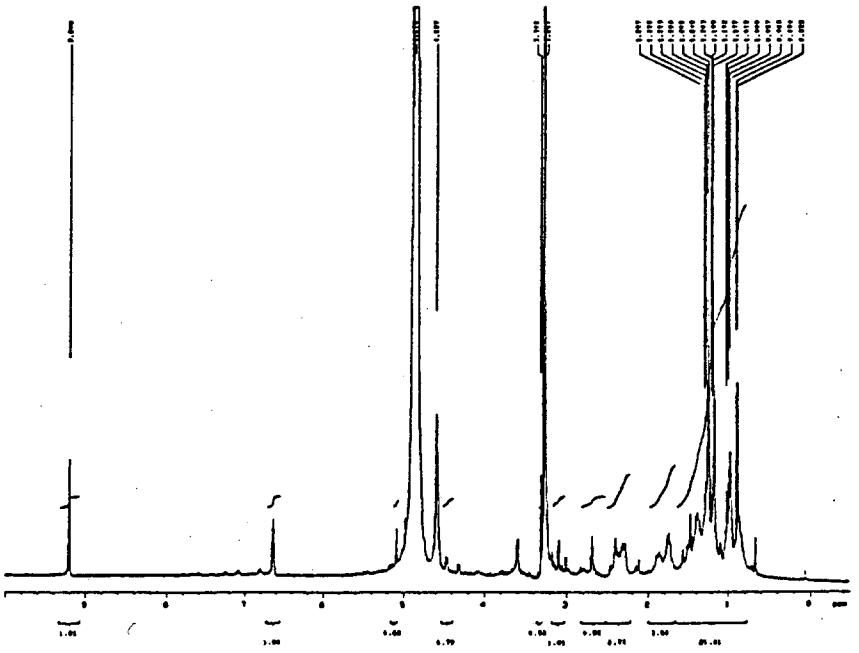
Exper. 3

^{1}H NMR spectrum of clerocidin in CD_3OD

(Recorded after evaporation of the $CDCl_3$ from Exper. 2,
and shown as the clerocidin-C14 methanol adduct (**20**)).



20

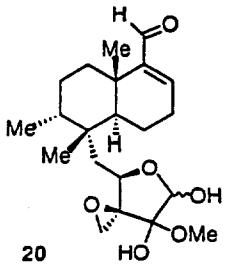


Time-dependent interconversion studies of clerocidin methanol adduct 20 to clerocidin (1)

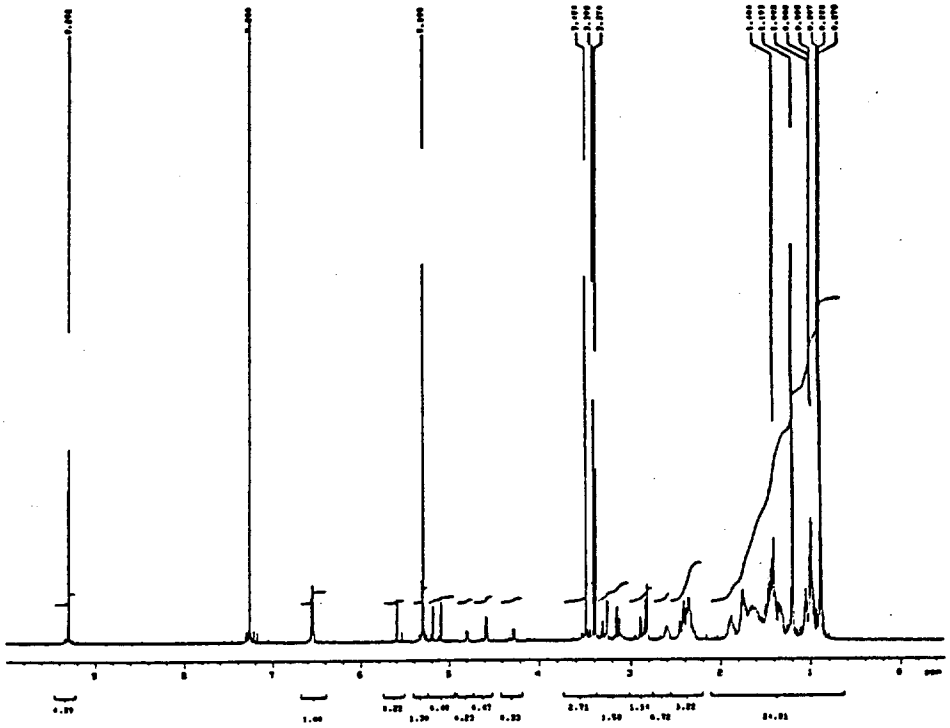
Exper. 1

^{1}H NMR spectrum of clerocidin--C14 methanol adduct (**20**) in $CDCl_3$.

Spectrum was recorded immediately after dissolving **20** in $CDCl_3$.



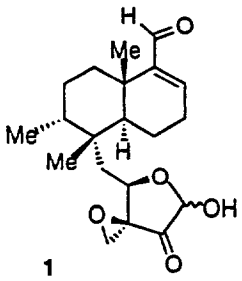
20



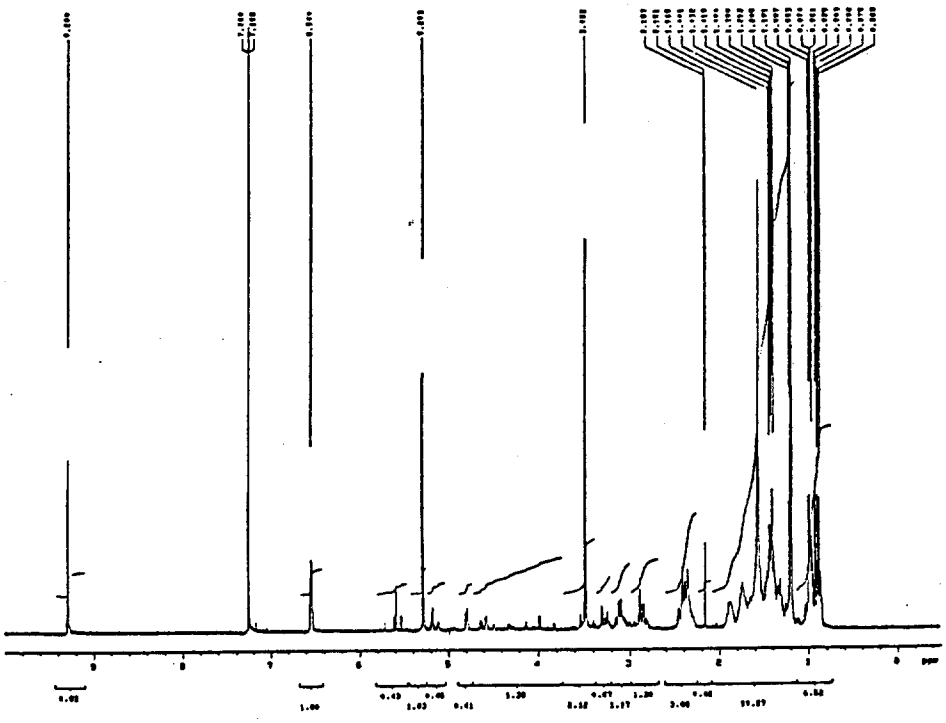
Exper. 2

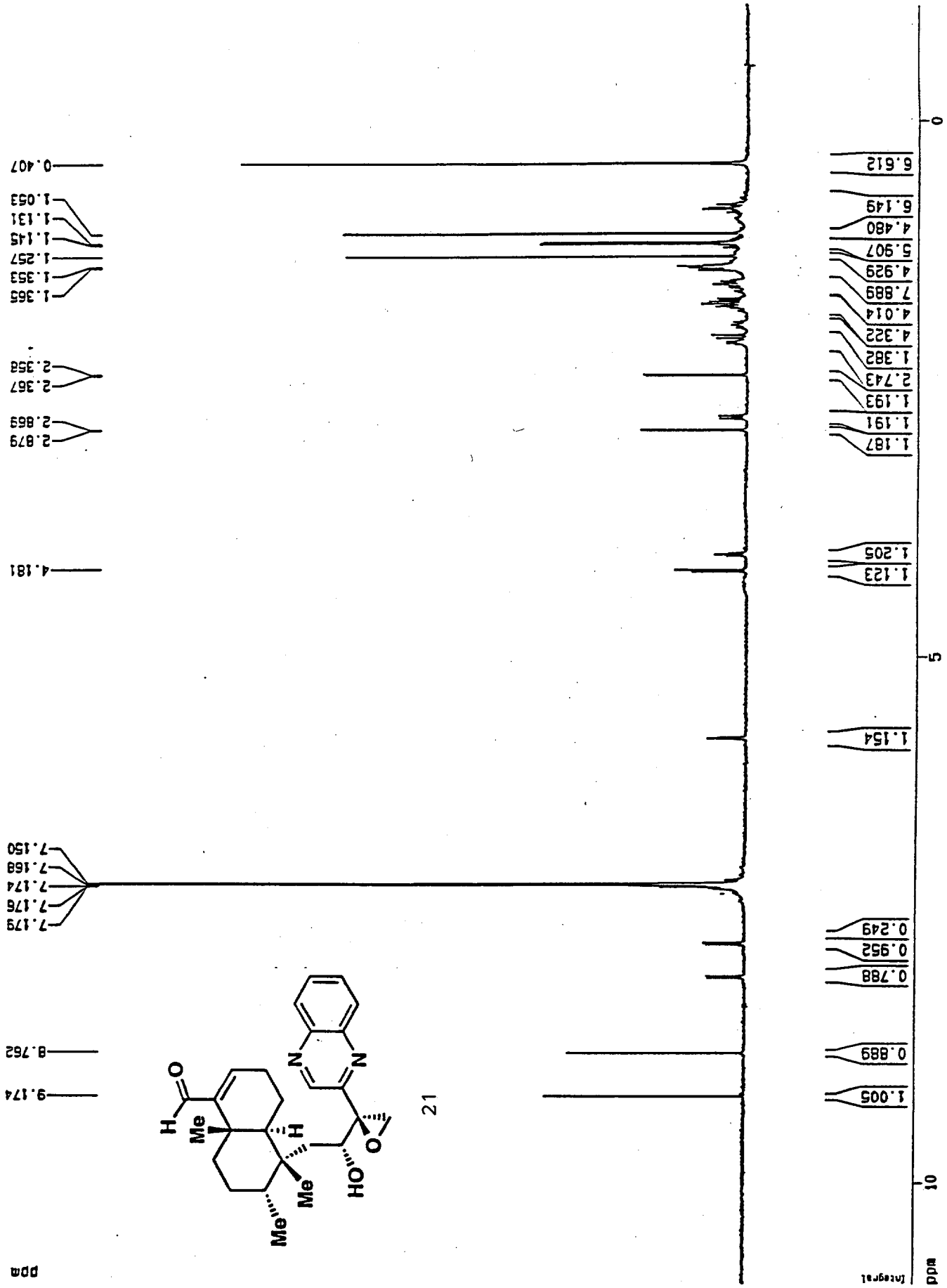
^{1}H NMR spectrum of clerocidin--C14 methanol adduct (**20**) in $CDCl_3$.

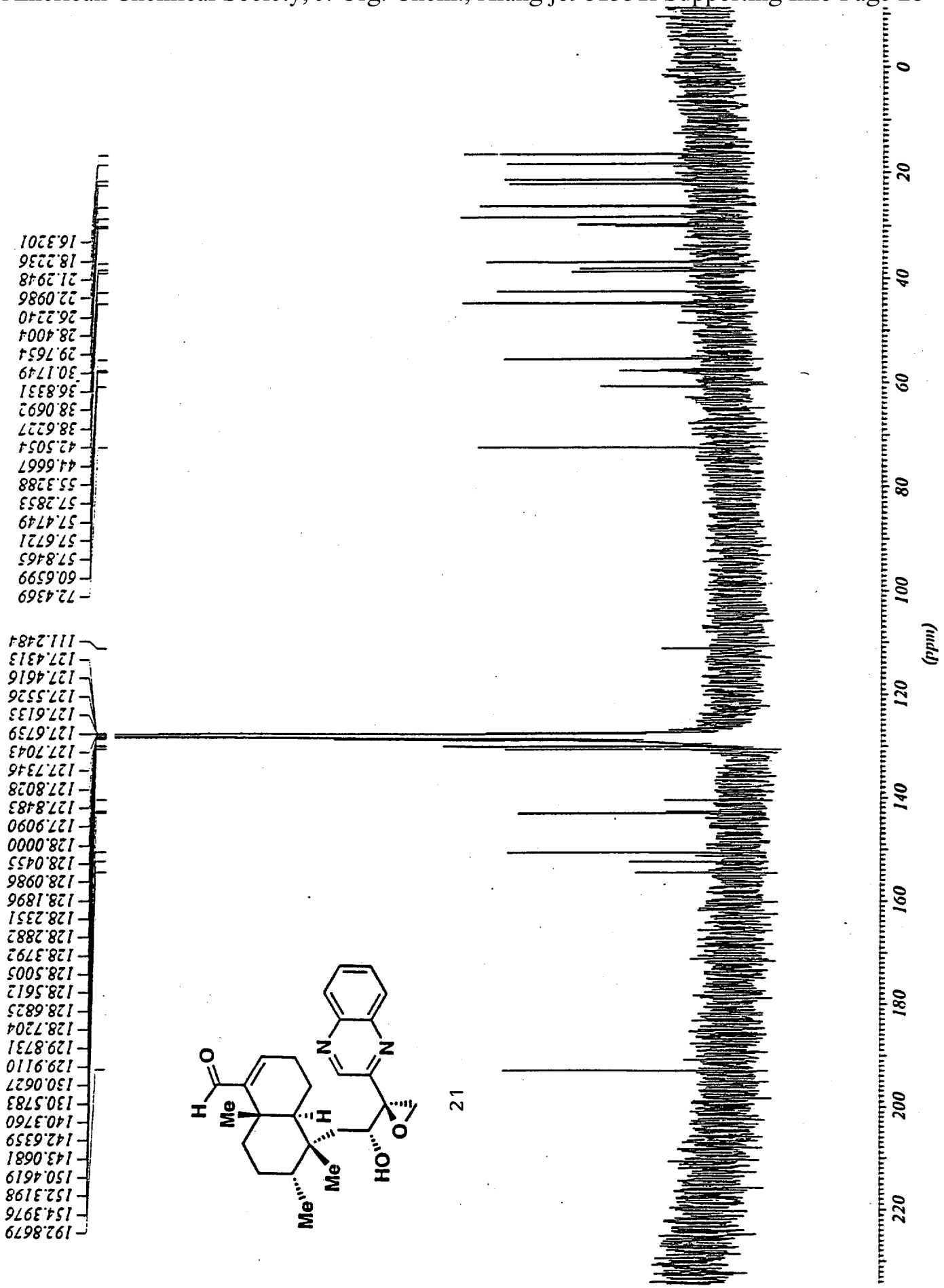
Spectrum was recorded 24 hrs after dissolving **20** in $CDCl_3$.
(The peak at 3.48 ppm is free methanol).



1






16.3201
18.2236
21.2948
22.0986
26.2240
28.4004
29.7654
30.1749
36.8331
38.0692
38.6227
42.5054
44.6667
55.3288
57.2853
57.4749
57.6721
57.8465
60.6599
72.4369
111.2484
127.4313
127.4616
127.5526
127.6133
127.6739
127.7043
127.7346
127.8028
127.8483
127.9090
128.0000
128.0455
128.0986
128.1896
128.2351
128.2882
128.3792
128.5005
128.5612
128.6835
128.7204
129.8731
129.9110
130.0627
130.5783
140.3760
142.6359
143.0681
150.4619
152.3198
154.3976
192.8679
O
H
Me
Me
Me
H
N
N
O
HO
21
0
20
40
60
80
100
120
140
160
180
200
220
(ppm)