Electronic Supplementary Material (ESI) for ChemComm.
This journal is © The Royal Society of Chemistry 2015

Electronic Supplementary Information

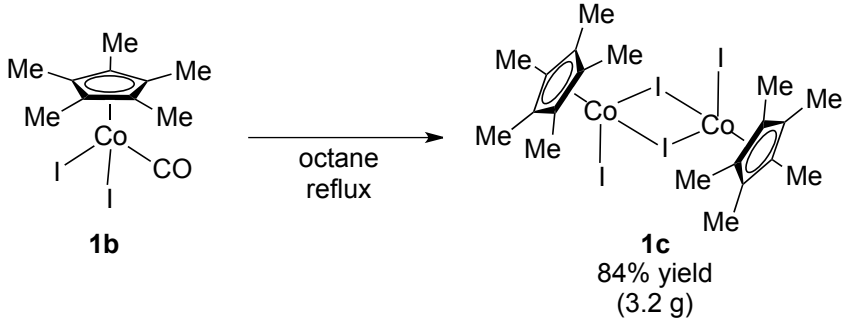
A Cp^*CoI_2-dimer as a precursor for cationic Co(III)-catalysis: application to C-H phosphoramidation of indoles

Bo Sun,[a] Tatsuhiko Yoshino,[a,b] Shigeki Matsunaga,[a,b]* and Motomu Kanai[a]*

[a] Graduate School of Pharmaceutical Sciences, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033 (Japan)
[Tel: (+81)3-5841-4830; Fax: (+81)3-5684-5206; kanai@mol.f.u-tokyo.ac.jp]
[b] ACT-C, JST, Hongo, Bunkyo-ku, Tokyo 113-0033 (Japan)
[Tel: (+81)3-5841-4836; Fax: (+81)3-5684-5206; smatsuna@mol.f.u-tokyo.ac.jp]

General: Infrared (IR) spectra were recorded on a JASCO FT/IR 410 Fourier transform infrared spectrophotometer. NMR spectra were recorded on JEOL JNM-ECX500 spectrometers, operating at 500 MHz for ^{1}H NMR and 125 MHz for ^{13}C NMR or JNM-ECS400 spectrometers, operating at 400 MHz for ^{1}H NMR, 100 MHz for ^{13}C NMR and 158 MHz for ^{31}P NMR. All spectra were obtained at ambient temperature. The chemical shifts (δ) were recorded in parts per million (ppm). The coupling constants (*J*) were shown in Hertz (Hz). Chemical shifts in $CDCl_3$ were reported the residual $CHCl_3$ (7.24 ppm for ^{1}H NMR, 77.0 ppm for ^{13}C NMR). ESI mass spectra for HRMS were measured on a JEOL JMS-T100LC AccuTOF spectrometer. 1,4-dioxane(Super Dehydrated) was purchased from Wako Ltd. and used without purification. 1-(Pyrimidin-2-yl)-1H-indole derivatives **2** were prepared by following the same procedure as described in the literature.[S1,S2] DPPA **3a** was purchased from Tokyo Chemical Industry Co., Ltd. and used without purification. Bis(4-methoxyphenyl)phosphoroazidate were prepared by following the same procedure as described in the literature.[S3]

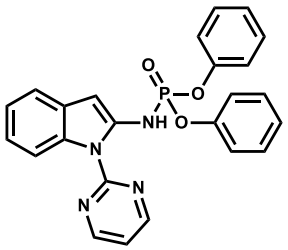
Preparation of $[Cp^*CoI_2]_2$ catalyst: [S4]



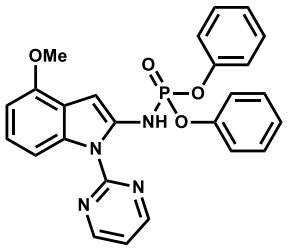
1b → **1c**
84% yield
(3.2 g)

To a round-bottomed flask was charged with *n*-octane (50 mL) and $[Cp^*Co(CO)I_2]$ (4.0 g). The mixture was heated to reflux under argon for 12 h. After cooling to room temperature, the solid precipitate was collected in a sintered- glass filtration funnel, washed with pentane, and dried under high vacuum to afford $[Cp^*CoI_2]_2$ (3.2 g, 84%) as a black powder. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.76 (s, 30H).

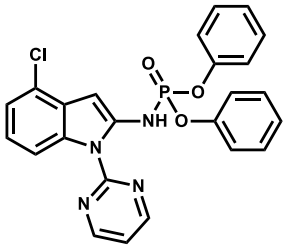
General Procedure of Co-catalyzed C-H Amidation of Indoles:
To a dried screw-capped vial were added indole **2** (0.80 mmol), phosphoryl azide **3** (0.40 mmol), $[Cp^*CoI_2]_2$ (17.6 mg, 20 μmol), $AgSbF_6$ (27.2 mg, 80 μmol), and 1,4-dioxane (0.20 mL) under Ar atmosphere. The vial was capped, and the mixture was heated at 60 °C for 36 h with stirring. The resulting mixture was cooled to room temperature, and directly purified by silica gel column chromatography (hexane:ethyl acetate = 1:1 for all compounds) to give product **4**.



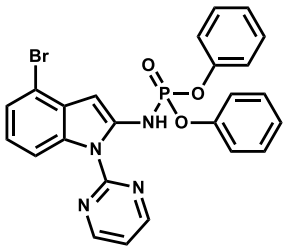
Diphenyl (1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4aa):
colorless solid; IR (KBr) ν 3052, 2917, 1615, 1423, 1283, 1185, 951, 781, 687 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 10.31 (d, J = 12.1 Hz, 1H), 8.55 -8.49 (m, 3H), 7.43 -7.39 (m, 1H), 7.22 -7.16 (m, 8H), 7.16 -7.09 (m, 2H), 7.09 -7.02 (m, 2H), 6.92 (t, J = 4.9 Hz, 1H), 6.45 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 157.5, 150.2 (d, J = 6.3 Hz), 136.4 (d, J = 7.2 Hz), 133.0, 129.7, 129.3, 125.4, 123.0, 121.8, 120.4 (d, J = 5.4 Hz), 119.0, 116.2, 115.9, 91.9; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.01; HRMS (ESI): m/z calculated for $C_{24}H_{19}N_4NaO_3P^+$ $[M+Na^+]$: 465.1087, found: 465.1089.



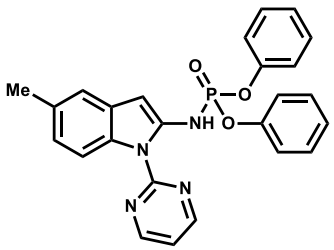
Diphenyl (4-methoxy-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ba):
colorless solid; IR (KBr) ν 3067, 2955, 1568, 1367, 1270, 1194, 1014, 963, 689 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 10.17 (d, *J* = 12.1 Hz, 1H), 8.58 (d, *J* = 4.9 Hz, 2H), 8.17 (d, *J* = 8.5 Hz, 1H), 7.26 -7.19 (m, 8H), 7.12 -7.07 (m, 3H), 6.97 (t, *J* = 4.9 Hz, 1H), 6.67 (d, *J* = 7.6 Hz, 1H), 6.62 (s, 1H), 3.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 157.5, 151.7, 150.2 (d, *J* = 6.3 Hz), 134.9 (d, *J* = 6.3 Hz), 134.0, 129.7, 125.3 (d, *J* = 1.8 Hz), 122.5, 120.5 (d, *J* = 5.4 Hz), 119.3, 116.3, 109.1, 103.7, 89.3, 55.4; ^{31}P NMR (158 MHz, $CDCl_3$) δ -8.80; HRMS (ESI): *m/z* calculated for $C_{25}H_{21}N_4NaO_4P^+$ $[M+Na^+]$: 495.1193, found: 495.1183.



Diphenyl (4-chloro-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ca): colorless solid; IR (KBr) ν 3081, 2909, 1567, 1428, 1279, 1193, 1024, 954, 765 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.47 (d, *J* = 12.1 Hz, 1H), 8.67 (d, *J* = 4.6 Hz, 2H), 8.54 (d, *J* = 8.6 Hz, 1H), 7.37 -7.29 (m, 8H), 7.28 -7.23 (m, 1H), 7.21 -7.16 (m, 2H), 7.15 -7.09 (m, 2H), 6.64 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.2, 157.6, 150.2 (d, *J* = 7.2 Hz), 137.3 (d, *J* = 7.2 Hz), 133.5, 129.8, 128.1, 125.5, 124.1, 122.9, 122.3, 120.4 (d, *J* = 4.8 Hz), 116.7, 114.5, 89.9; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.45; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}ClN_4NaO_3P^+$ $[M+Na^+]$: 499.0697, found: 499.0689.

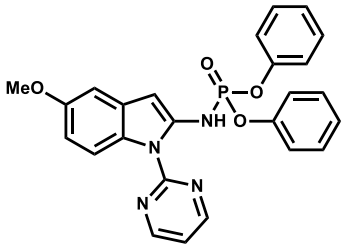


Diphenyl (4-bromo-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4da): colorless solid; IR (KBr) ν 3039, 2914, 1567, 1447, 1280, 1192, 1020, 902, 757 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.37 (d, *J* = 12.1 Hz, 1H), 8.57 (d, *J* = 4.9 Hz, 2H), 8.49 (d, *J* = 8.5 Hz, 1H), 7.31 (d, *J* = 8.1 Hz, 1H), 7.25 -7.17 (m, 8H), 7.11 -7.05 (m, 2H), 7.02 (t, *J* = 4.9 Hz, 1H), 6.97 (dd, *J* = 8.5, 8.1 Hz, 1H), 6.50 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 157.6, 150.2 (d, *J* = 7.2 Hz), 137.3 (d, *J* = 7.2 Hz), 133.1, 129.9, 129.8, 125.9, 125.5, 122.6, 120.4 (d, *J* = 4.5 Hz), 116.7, 115.1, 112.7, 91.7; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.51; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}BrN_4NaO_3P^+$ $[M+Na^+]$: 543.0192, found: 543.0198.

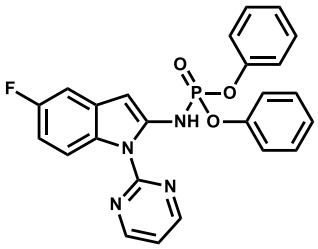


Diphenyl (5-methyl-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ea): colorless solid; IR (KBr) ν 3041, 2915, 1561, 1480, 1274, 1012, 957, 788, 615 cm^{-1};

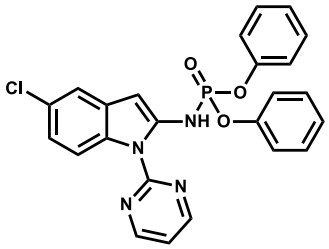
^{1}H NMR (400 MHz, $CDCl_3$) δ 10.36 (d, *J* = 12.6 Hz, 1H), 8.51 (d, *J* = 4.9 Hz, 2H), 8.41 (d, *J* = 8.5 Hz, 1H), 7.23 -7.14 (m, 9H), 7.09 -7.02 (m, 2H), 6.96 -6.89 (m, 2H), 6.37 (s, 1H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 157.4, 150.2 (d, *J* = 7.2 Hz), 136.5 (d, *J* = 7.2 Hz), 132.5, 131.1, 129.7, 129.5, 125.4, 123.0, 120.4 (d, *J* = 4.5 Hz), 119.1, 116.0, 115.7, 91.7, 21.3; ^{31}P NMR (158 MHz, $CDCl_3$) δ -8.98; HRMS (ESI): *m/z* calculated for $C_{25}H_{21}N_4NaO_3P^+$ [M+Na^+] : 479.1243, found: 479.1237.



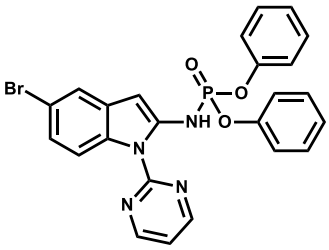
Diphenyl (5-methoxy-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4fa): yellow solid; IR (KBr) ν 3062, 2995, 1582, 1424, 1212, 1089, 936, 779, 691 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.44 (d, *J* = 12.1 Hz, 1H), 8.52 (d, *J* = 4.9 Hz, 2H), 8.45 (d, *J* = 9.0 Hz, 1H), 7.23 -7.15 (m, 8H), 7.09 -7.04 (m, 2H), 6.94 -6.89 (m, 2H), 6.73 -6.70 (m, 1H), 6.39 (s, 1H), 3.78 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 157.4, 156.1, 150.2 (d, *J* = 6.3 Hz), 137.2 (d, *J* = 7.2 Hz), 130.3, 129.7, 127.5, 125.4, 120.4 (d, *J* = 4.5 Hz), 117.0, 116.0, 109.7, 102.2, 91.8, 55.5; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.05; HRMS (ESI): *m/z* calculated for $C_{25}H_{21}N_4NaO_4P^+$ [M+Na^+] : 495.1193, found: 495.1197.



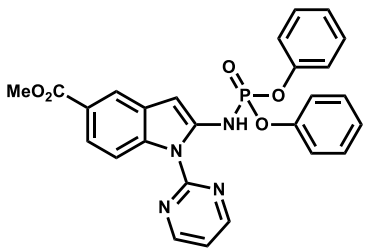
Diphenyl (5-fluoro-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ga): yellow solid; IR (KBr) ν 3063, 2923, 1597, 1495, 1285, 1200, 1024, 905, 767 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.45 (d, *J* = 12.1 Hz, 1H), 8.56 (d, *J* = 4.9 Hz, 2H), 8.51 (dd, *J* = 9.2, 4.5 Hz, 1H), 7.25 -7.16 (m, 8H), 7.10 -7.04 (m, 3H), 6.99 (t, *J* = 4.9 Hz, 1H), 6.82 (ddd, *J* = 9.2, 9.2, 2.7 Hz, 1H), 6.40 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6 (d, *J* = 237.4 Hz), 158.2, 157.5, 150.1 (d, *J* = 6.3 Hz), 138.0 (d, *J* = 7.2 Hz), 130.4 (d, *J* = 9.9 Hz), 129.8, 129.2, 125.4 (d, *J* = 1.8 Hz), 120.4 (d, *J* = 4.5 Hz), 117.1 (d, *J* = 9.0 Hz), 116.4, 109.0 (d, *J* = 24.3 Hz), 104.6 (d, *J* = 24.3 Hz), 91.6 (d, *J* = 3.6 Hz); ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.31; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}FN_4NaO_3P^+$ [M+Na^+] : 483.0993, found: 483.0987.



Diphenyl (5-chloro-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ha):
colorless solid; IR (KBr) ν 3062, 2927, 1565, 1498, 1256, 1071, 983, 764, 652 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.42 (d, *J* = 12.1 Hz, 1H), 8.55 (d, *J* = 4.6 Hz, 2H), 8.47 (d, *J* = 8.6 Hz, 1H), 7.36 (d, *J* = 2.3 Hz, 1H), 7.24 -7.16 (m, 8H), 7.10 -7.03 (m, 3H), 6.99 (t, *J* = 4.6 Hz, 1H), 6.37 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.2, 157.6, 150.1 (d, *J* = 6.0 Hz), 137.8 (d, *J* = 7.2 Hz), 131.3, 130.7, 129.8, 128.5, 125.5, 121.7, 120.4 (d, *J* = 4.8 Hz), 118.4, 117.2, 116.5, 91.1; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.36; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}ClN_4NaO_3P^+$ [M+Na^+] : 499.0697, found: 499.0710.

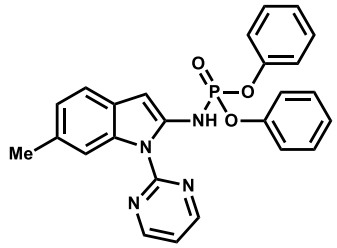


Diphenyl (5-bromo-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ia):
colorless solid; IR (KBr) ν 3042, 2924, 1582, 1492, 1276, 1163, 954, 771, 690 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.42 (d, *J* = 12.1 Hz, 1H), 8.55 (d, *J* = 4.9 Hz, 2H), 8.41 (d, *J* = 9.0 Hz, 1H), 7.51 (s, 1H), 7.25 -7.15 (m, 9H), 7.10 -7.04 (m, 2H), 6.99 (t, *J* = 4.9 Hz, 1H), 6.37 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 157.5, 150.1 (d, *J* = 6.3 Hz), 137.7 (d, *J* = 7.2 Hz), 131.6, 131.1, 129.8, 125.5 (d, *J* = 1.8 Hz), 124.4, 121.4, 120.3 (d, *J* = 4.5 Hz), 117.6, 116.5, 116.3, 90.9; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.39; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}BrN_4NaO_3P^+$ [M+Na^+] : 543.0192, found: 543.0199.

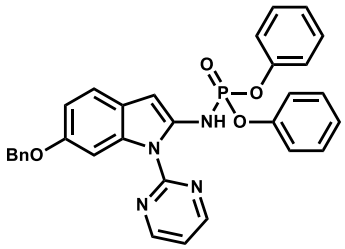


Methyl 2-((diphenoxyphosphoryl)amino)-1-(pyrimidin-2-yl)-1H-indole-5-carboxylate (4ja):
colorless solid; IR (KBr) ν 3057, 2953, 1704, 1564, 1491, 1292, 970, 767, 652cm^{-1};

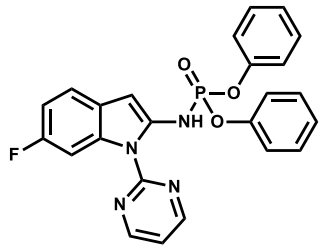
^{1}H NMR (400 MHz, $CDCl_3$) δ 10.28 (d, *J* = 12.1 Hz, 1H), 8.60 -8.53 (m, 3H), 8.13 (d, *J* = 1.8 Hz, 1H), 7.81 (dd, *J* = 9.0, 1.8 Hz, 1H), 7.25 -7.16 (m, 8H), 7.09 -7.05 (m, 2H), 7.03 (t, *J* = 4.9 Hz, 1H), 6.50 (s, 1H), 3.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.6, 158.1, 157.7, 150.1 (d, *J* = 7.2 Hz), 137.6 (d, *J* = 7.2 Hz), 135.7, 129.8, 129.0, 125.5, 124.8, 123.3, 120.9, 120.3 (d, *J* = 4.5 Hz), 116.9, 115.6, 92.0, 51.9; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.36; HRMS (ESI): *m/z* calculated for $C_{26}H_{21}N_4NaO_5P^+$ [M+Na^+] : 523.1142, found: 523.1125.



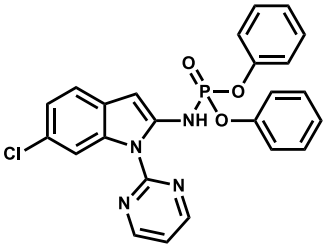
Diphenyl (6-methyl-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ka):
colorless solid; IR (KBr) ν 3063, 2915, 1577, 1428, 1284, 1185, 954, 813, 691 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.17 (d, *J* = 12.6 Hz, 1H), 8.55 (d, *J* = 4.9 Hz, 2H), 8.35 (s, 1H), 7.30 (d, *J* = 7.6 Hz, 1H), 7.22 -7.14 (m, 8H), 7.08 -7.03 (m, 2H), 7.00 -6.97 (m, 1H), 6.94 (t, *J* = 4.9 Hz, 1H), 6.41 (s, 1H), 2.41 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 157.5, 150.2 (d, *J* = 7.2 Hz), 135.7 (d, *J* = 7.2 Hz), 133.3, 131.7, 129.7, 126.9, 125.3, 124.3, 120.5 (d, *J* = 4.5 Hz), 118.7, 116.1, 116.0, 92.1, 22.0; ^{31}P NMR (158 MHz, $CDCl_3$) δ -8.80; HRMS (ESI): *m/z* calculated for $C_{25}H_{21}N_4NaO_3P^+$ [M+Na^+] : 479.1243, found: 479.1241.



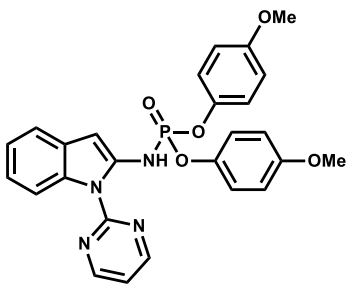
Diphenyl (6-(benzyloxy)-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate(4la):
yellow solid; IR (KBr) ν 3061, 2905, 1578, 1416, 1281, 1158, 953, 775, 695 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.12 (d, *J* = 14.1 Hz, 1H), 8.52 (d, *J* = 4.6 Hz, 2H), 8.30 (d, *J* = 2.3 Hz, 1H), 7.41 (brd, *J* = 7.5 Hz, 2H), 7.32 -7.27 (m, 3H), 7.25 -7.16 (m, 9H), 7.08 -7.02 (m, 2H), 6.94 (t, *J* = 4.6 Hz, 1H), 6.88 (dd, *J* = 8.6, 2.3 Hz, 1H), 6.38 (s, 1H), 5.05 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.3, 157.5, 155.2, 150.2 (d, *J* = 7.2 Hz), 137.5, 135.4 (d, *J* = 6.0 Hz), 133.8, 129.7, 128.5, 127.8, 127.6, 125.3, 123.3, 120.4 (d, *J* = 4.8 Hz), 119.2, 116.1, 111.5, 103.3, 92.1, 70.8; ^{31}P NMR (158 MHz, $CDCl_3$) δ -8.83; HRMS (ESI): *m/z* calculated for $C_{31}H_{25}N_4NaO_4P^+$[M+Na^+] : 571.1506, found: 571.1531.



Diphenyl (6-fluoro-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ma): colorless solid; IR (KBr) ν 3065, 2911, 1577, 1496, 1283, 1197, 969, 809, 687 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.22 (d, *J* = 12.1 Hz, 1H), 8.56 (d, *J* = 4.9 Hz, 2H), 8.35 (dd, *J* = 11.2, 2.2 Hz, 1H), 7.33 -7.28 (m, 1H), 7.24 -7.16 (m, 8H), 7.09 -7.04 (m, 2H), 6.99 (t, *J* = 4.9 Hz, 1H), 6.94 -6.88 (m, 1H), 6.41 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.3 (d, *J* = 234.7 Hz), 158.2, 157.6, 150.2 (d, *J* = 6.3 Hz), 136.7 (d, *J* = 3.6 Hz), 136.6 (d, *J* = 3.6 Hz), 132.9 (d, *J* = 12.6 Hz), 129.7, 125.4, 120.4 (d, *J* = 4.5 Hz), 119.2 (d, *J* = 9.9 Hz), 116.5, 110.8 (d, *J* = 23.4 Hz), 103.8 (d, *J* = 29.7 Hz), 91.7; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.11; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}FN_4NaO_3P^+[M+Na^+]$: 483.0993, found: 483.0976.

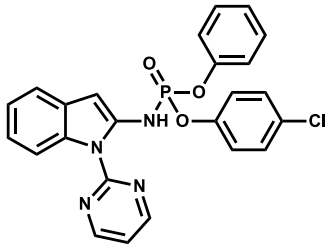


Diphenyl (6-chloro-1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4na): colorless solid; IR (KBr) ν 3054, 2919, 1577, 1496, 1281, 1194, 953, 770, 689 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.31 (d, *J* = 12.1 Hz, 1H), 8.61 (d, *J* = 1.8 Hz, 1H), 8.57 (d, *J* = 4.9 Hz, 2H), 7.31 (d, *J* = 8.5 Hz, 1H), 7.24 -7.16 (m, 8H), 7.14 -7.11 (m, 1H), 7.10 -7.05 (m, 2H), 7.01 (t, *J* = 4.9 Hz, 1H), 6.41 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 157.6, 150.1 (d, *J* = 7.2 Hz), 137.1 (d, *J* = 7.2 Hz), 133.2, 129.8, 127.8, 127.3, 125.4, 123.4, 120.4 (d, *J* = 4.5 Hz), 119.5, 116.6, 116.3, 91.6; ^{31}P NMR (158 MHz, $CDCl_3$) δ -9.22; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}ClN_4NaO_3P^+[M+Na^+]$: 499.0697, found: 499.0694.



Bis(4-methoxyphenyl) (1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ab):

colorless solid; IR (KBr) ν 3080, 2935, 1600, 1457, 1285, 1184, 955, 828, 743 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 10.18 (d, *J* = 12.1 Hz, 1H), 8.56 -8.52 (m, 3H), 7.42 (dd, *J* = 6.3, 1.8 Hz, 1H), 7.17 -7.07 (m, 6H), 6.95 (t, *J* = 4.9 Hz, 1H), 6.72 -6.67 (m, 4H), 6.43 (s, 1H), 3.64 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 157.5, 156.9, 143.7 (d, *J* = 6.3 Hz), 136.6 (d, *J* = 6.3 Hz), 133.0, 129.3, 123.0, 121.8, 121.3 (d, *J* = 4.5 Hz), 119.0, 116.2, 115.9, 114.6, 91.9, 55.5; ^{31}P NMR (158 MHz, $CDCl_3$) δ -7.80; HRMS (ESI): *m/z* calculated for $C_{26}H_{23}N_4NaO_5P^+$ $[M+Na^+]$: 525.1298, found: 525.1319.

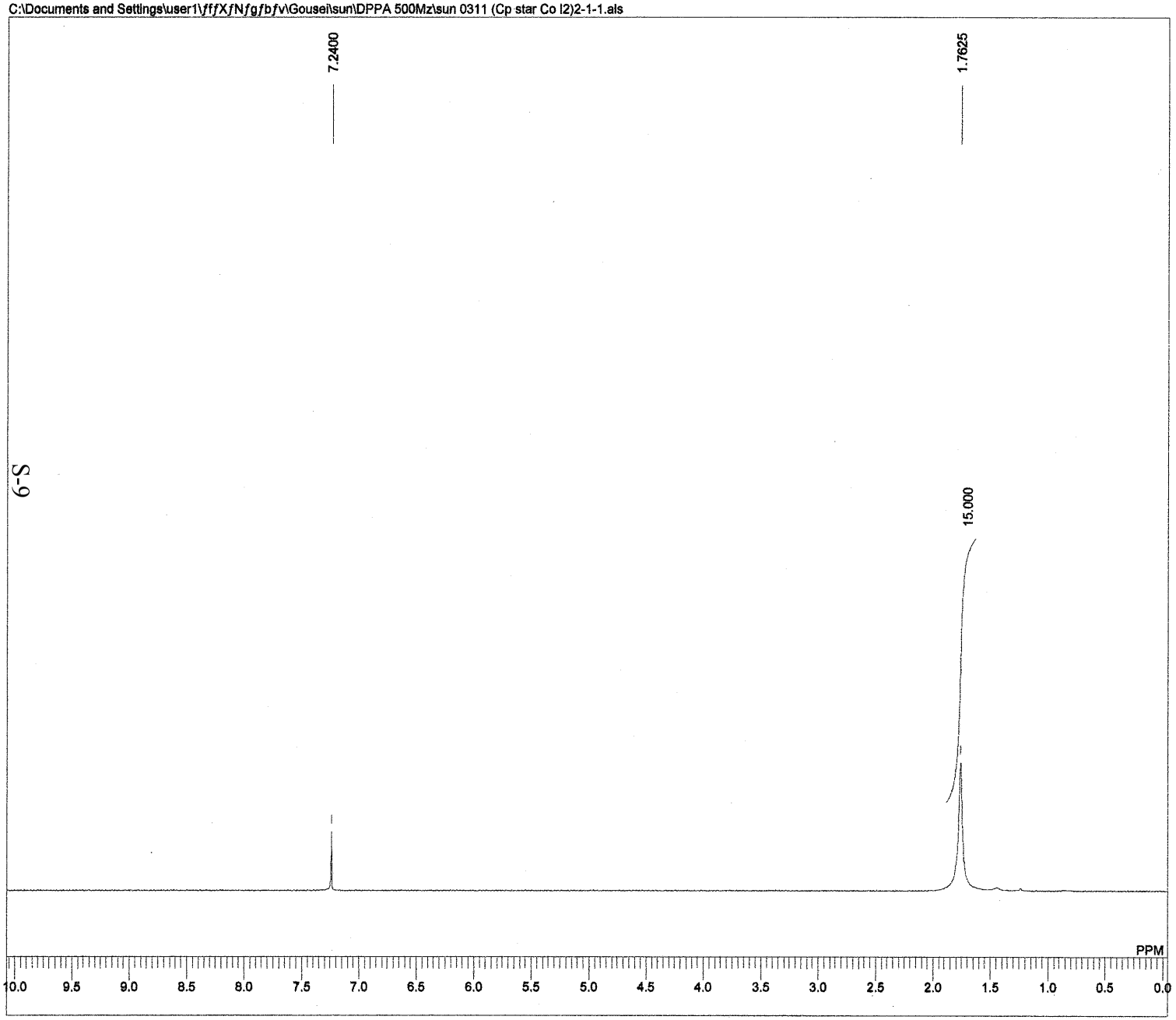


4-chlorophenyl phenyl (1-(pyrimidin-2-yl)-1H-indol-2-yl)phosphoramidate (4ac): yellow oil; IR (neat) ν 3057, 1583, 1485, 1427, 1352, 1190, 944, 747 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 10.32 (d, *J* = 12.1 Hz, 1H), 8.59 -8.45 (m, 3H), 7.45 -7.36 (m, 1H), 7.25 -7.01 (m, 11H)，6.90 (td, *J* = 4.9, 1.3 Hz, 1H), 6.41 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 158.3, 157.4, 150.0 (d, *J* = 7.2 Hz), 148.6 (d, *J* = 7.2 Hz), 136.1 (d, *J* = 7.2 Hz), 133.0, 130.7, 129.7, 129.7, 129.1, 125.5, 123.1, 122.0, 121.8 (d, *J* = 3.6 Hz), 120.3 (d, *J* = 4.8 Hz), 119.0, 116.2, 116.0, 92.1; ^{31}P NMR (158 MHz, $CDCl_3$) δ -8.87; HRMS (ESI): *m/z* calculated for $C_{24}H_{18}ClN_4NaO_3P^+$ $[M+Na^+]$: 499.0697, found: 499.0686.

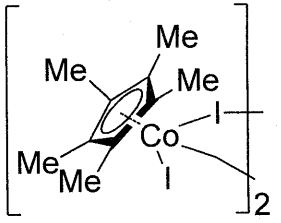
Reference:

[S1] L. Ackermann, A. V. Lygin. *Org. Lett.* **2011**, *13*, 3332.
[S2] J. Shi, B. Zhou, Y. Yang, Y. Li. Org. Biomol. Chem. 2012, 10, 8953.
[S3] S. H. Kim, D. Y. Jung, S. Chang. *J. Org. Chem*., **2007**, *72*, 9769.
[S4] S. A. Frith, J. Spencer. *Inorganic Syntheses*. **1990**, *28*, 273.
[S5] W. Li, L. Weng, G. Jin. *Inorg. Chem. Commun*. **2004**, *7*, 1174.

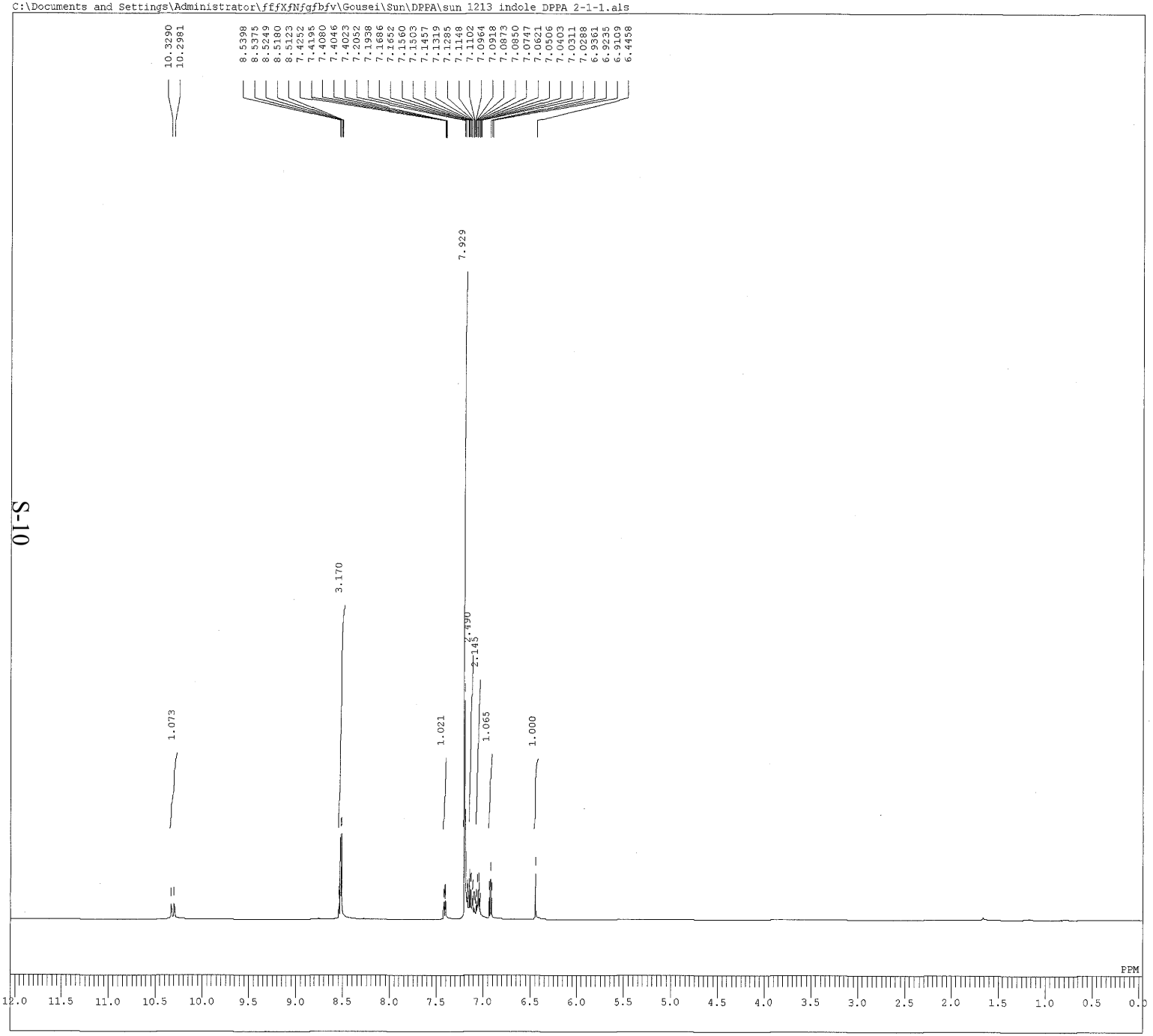
C:\Documents and Settings\user1\ƒƒXƒNƒgƒbƒv\Gousei\sun\DPPA 500Mz\sun 0311 (Cp star Co I2)2-1-1.als



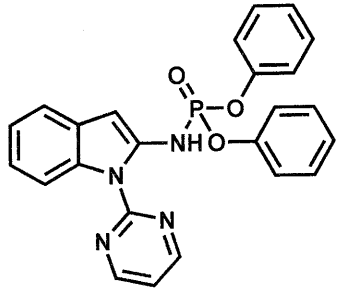
DFILE	sun 0311 (Cp star Co I2)2-1-1.als
COMNT	
DATIM	2014-03-11 22:08:28
OBNUC	1H
EXMOD	proton.jxp
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	13107
FREQU	7507.51 Hz
SCANS	7
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	5.55 usec
IRNUC	1H
CTEMP	21.3 c
SLVNT	CDCL3
EXREF	7.24 ppm
BF	0.12 Hz
RGAIN	40



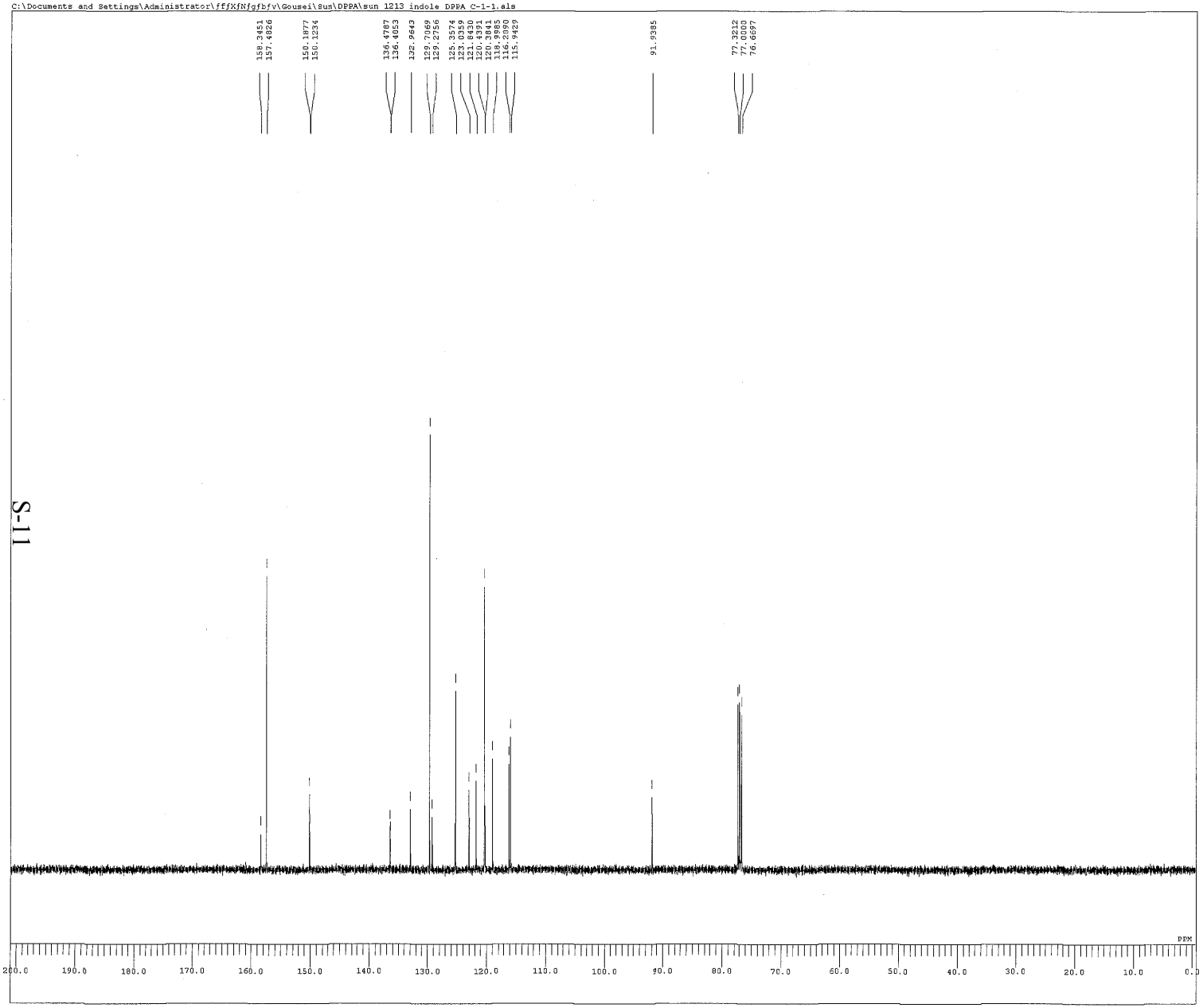
C:\Documents and Settings\Administrator\fffXfNfgfbfv\Gousei\Sun\DPPA\sun 1213 indole DPPA 2-1-1.als



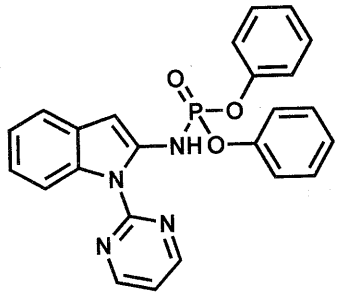

```
DFILE  sun 1213 indole DPPA 2-1-1.als
COMNT
DATIM  13-12-2013 22:46:44
OBNUC  1H
EXMOD  proton.jxp
OBFRQ        391.78 MHz
OBSET          8.51 KHz
OBFIN          3.34 Hz
POINT         13107
FREQU       5882.35 Hz
SCANS             9
ACQTM         2.2282 sec
PD            5.0000 sec
PW1             5.25 usec
IRNUC  1H
CTEMP          21.5 c
SLVNT  CDCL3
EXREF          0.00 ppm
BF             0.12 Hz
RGAIN            26
```



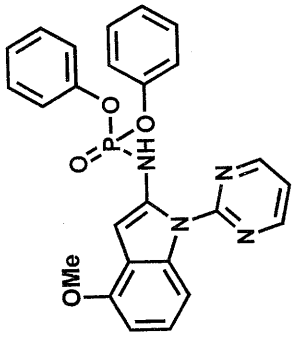
4aa



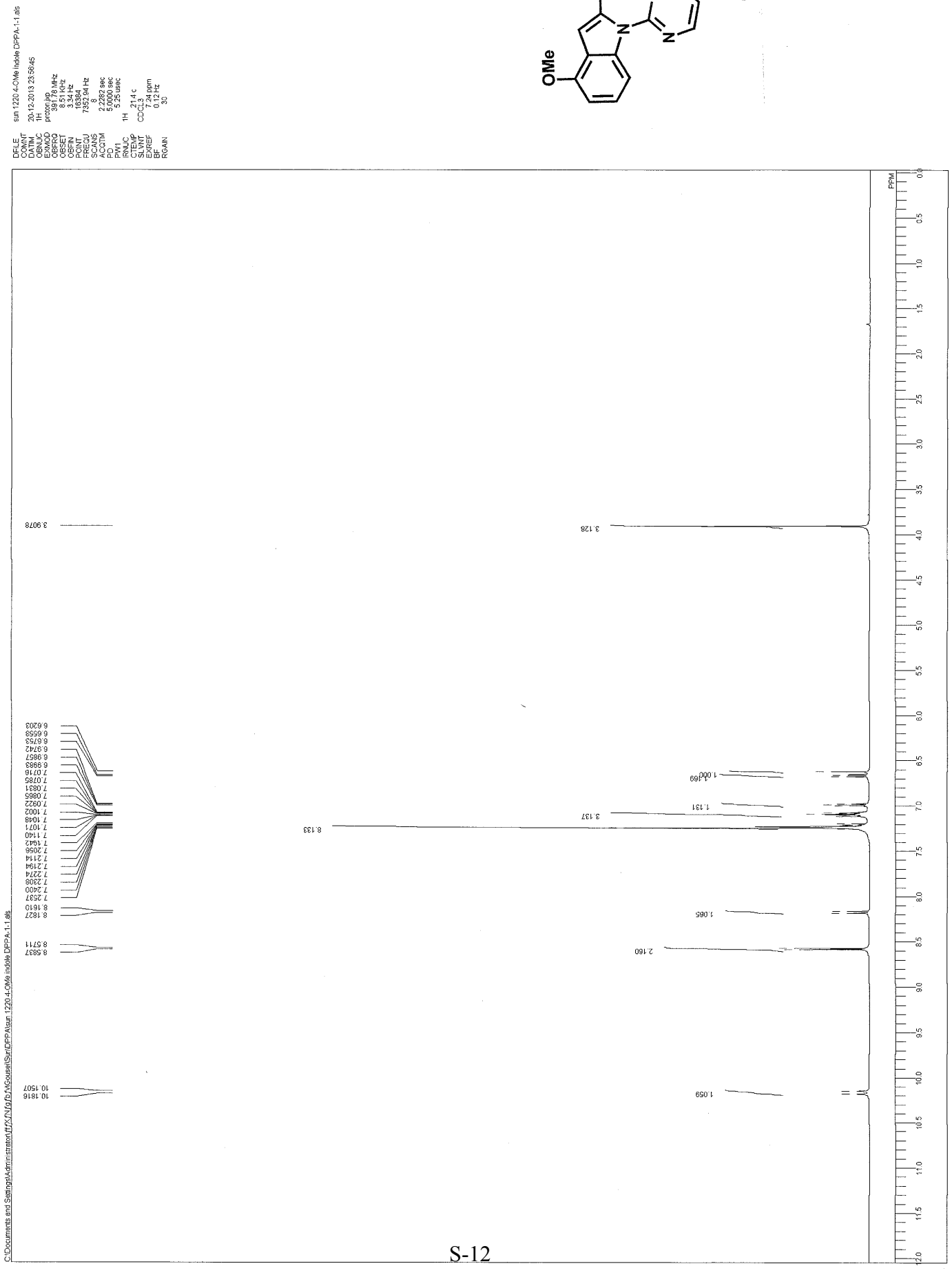

```
DFILE  sun 1213 indole DPPA C-1-1.als
COMNT
DATIM  13-12-2013 22:48:39
OBNUC  13C
EXMOD  carbon.jxp
OBFRQ        98.52 MHz
OBSET         4.64 KHz
OBFIN         8.74 Hz
POINT        26214
FREQU     23696.68 Hz
SCANS          132
ACQTM       1.1062 sec
PD          2.0000 sec
PW1           3.00 usec
IRNUC  1H
CTEMP        21.6 c
SLVNT  CDCL3
EXREF       77.00 ppm
BF           0.12 Hz
RGAIN          60
```

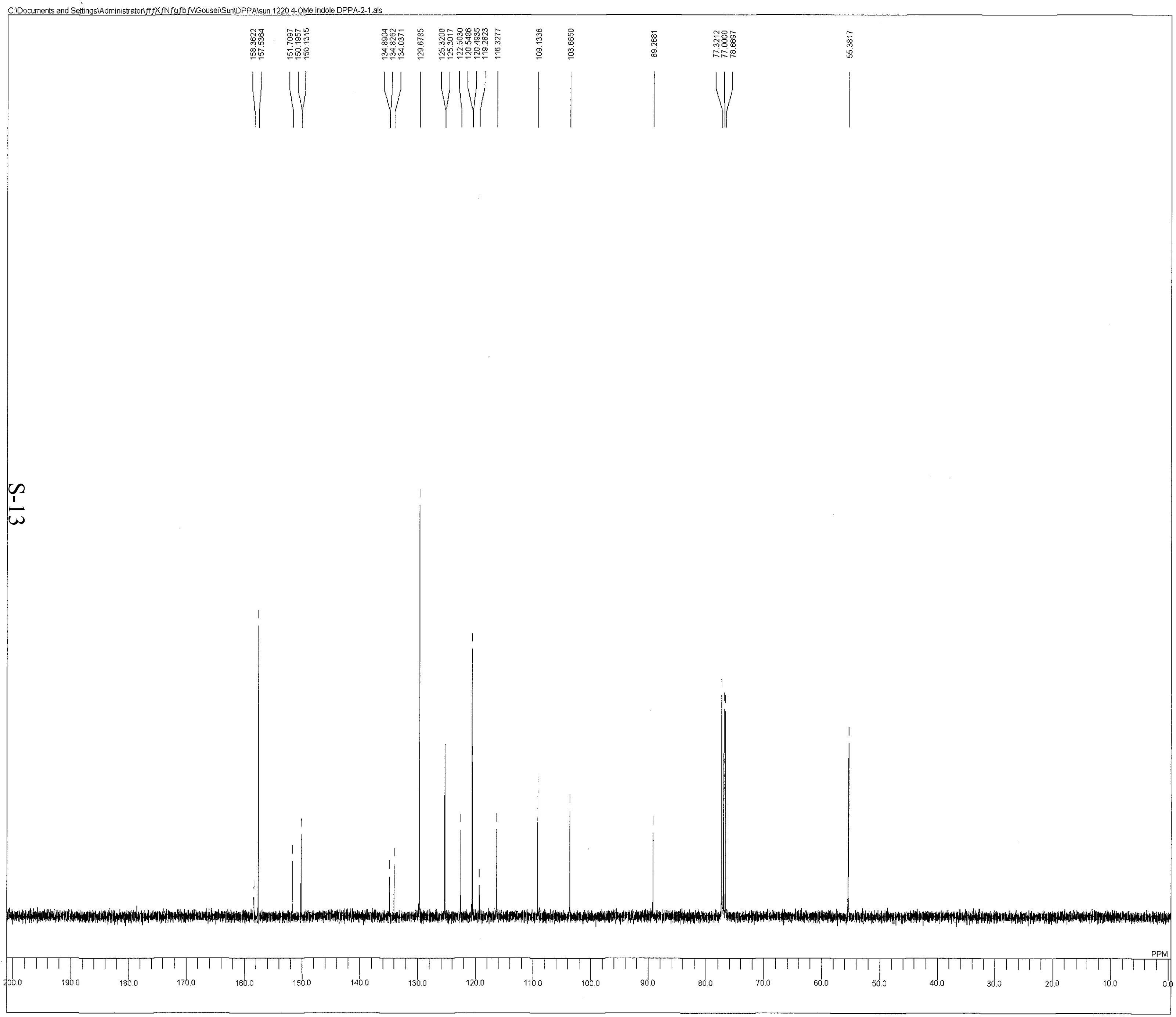


4aa

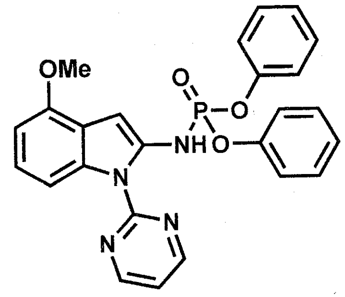

OMe
NH
O
P
O
O
N
N
N

4ba

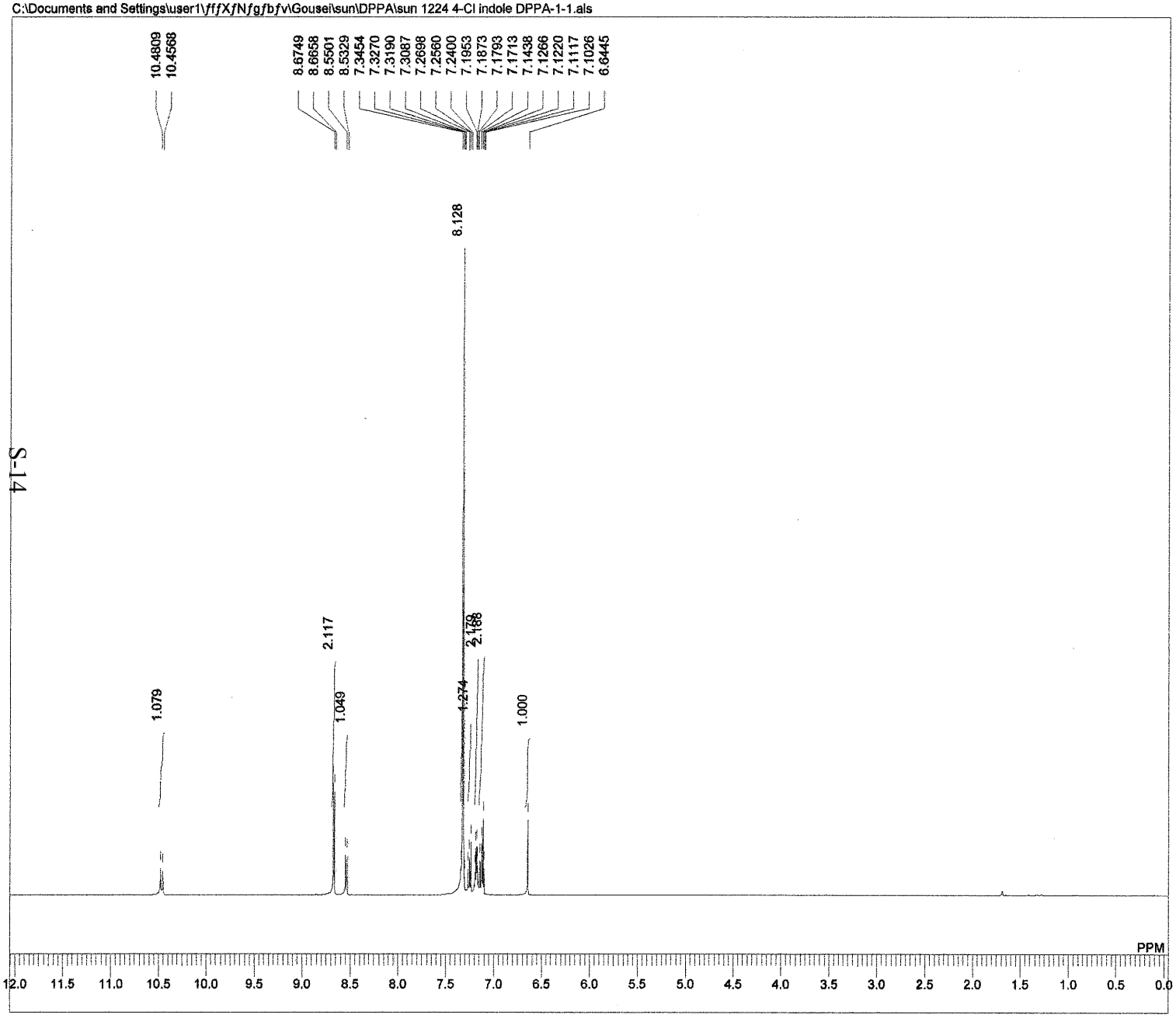

sun 1220 4-OMe Indole DPPA-1-1.als
20-12-2013 23:56:45
proton.jxp
391.78 MHz
8.51 kHz
3.34 Hz
65364
7352.94 Hz
8
2.2282 sec
5.0000 sec
5.25 usec
1H
21.4 c
CDCl3
7.24 ppm
0.12 Hz
30
PPM
3.9078
3.128
8.133
3.137
1.131
1.089
1.065
2.160
1.059
10.1816
10.1507
C:\Documents and Settings\Administrator\Desktop\MGoussel\Sun\DPPA\sun 1220 4-OMe indole DPPA-1-1.als



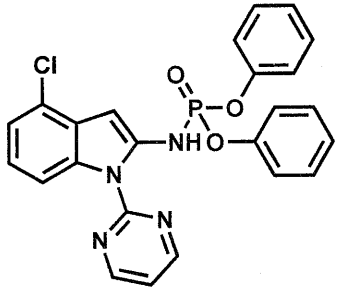
DFILE sun 1220 4-OMe indole DPPA-2-1.als
COMNT
DATIM 20-12-2013 23:59:27
OBNUC 13C
EXMOD carbon.jxp
OBFRQ 98.52 MHz
OBSET 4.64 KHz
OBFIN 8.74 Hz
POINT 32767
FREQU 29620.85 Hz
SCANS 112
ACQTM 1.1062 sec
PD 2.0000 sec
PW1 3.00 usec
IRNUC 1H
CTEMP 21.4 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 0.12 Hz
RGAIN 60



4ba

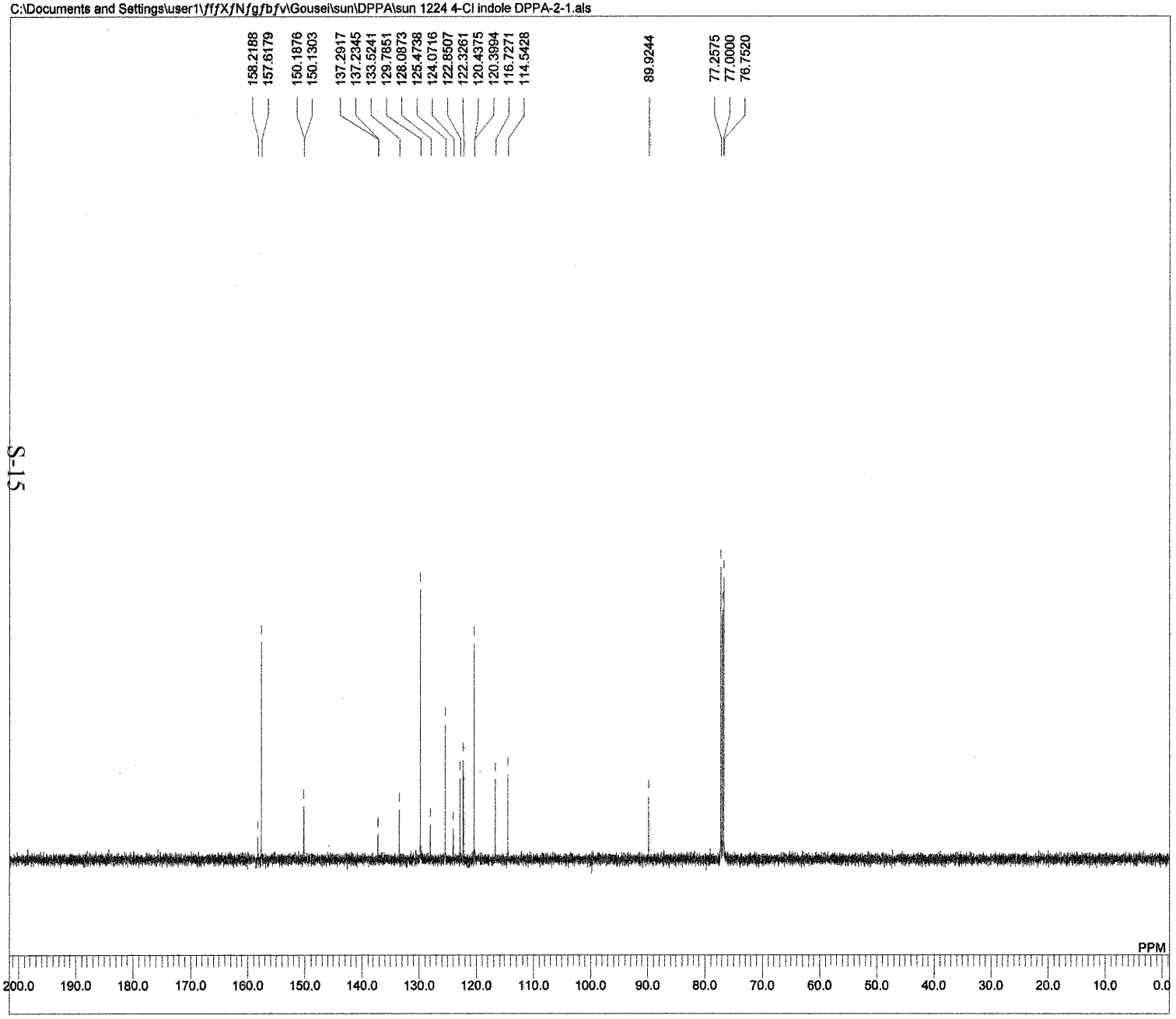


DFILE sun 1224 4-Cl indole DPPA-1-1.als
COMNT
DATIM 2013-12-24 23:36:54
OBNUC 1H
EXMOD proton.jxp
OBFRQ 500.16 MHz
OBSET 2.41 KHz
OBFIN 6.01 Hz
POINT 16384
FREQU 9384.38 Hz
SCANS 8
ACQTM 1.7459 sec
PD 5.0000 sec
PW1 5.55 usec
IRNUC 1H
CTEMP 21.2 c
SLVNT CDCL3
EXREF 7.24 ppm
BF 0.12 Hz
RGAIN 34

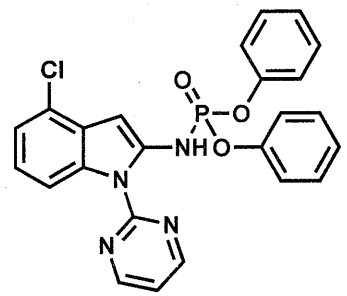


4ca

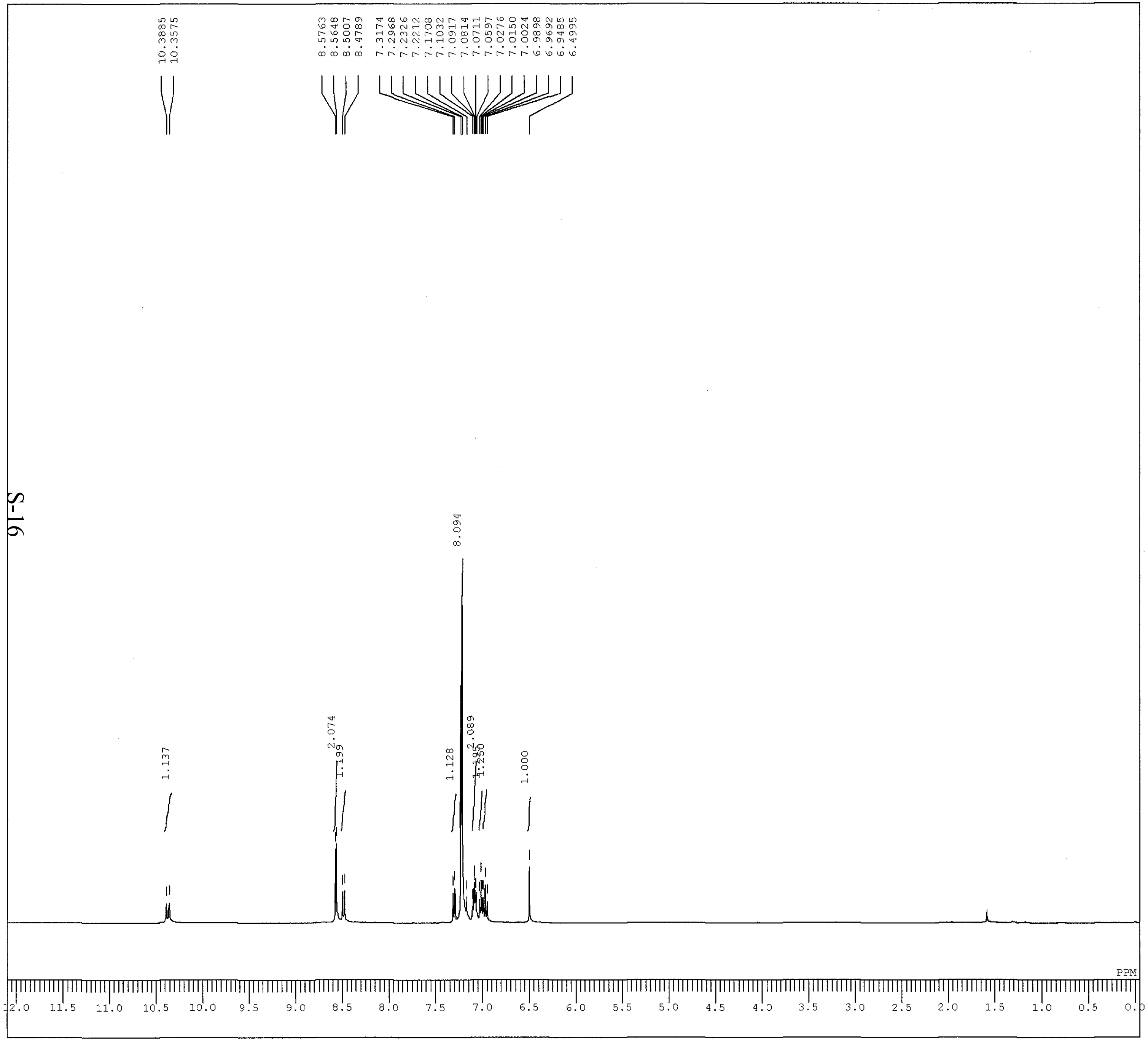
C:\Documents and Settings\user1\ƒƒXƒNƒgƒbƒv\Gousei\sun\DPPA\sun 1224 4-Cl indole DPPA-2-1.als



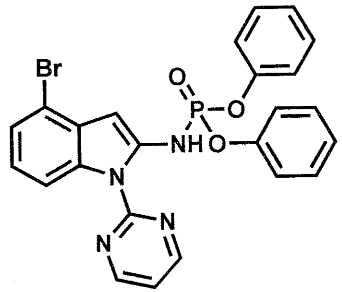
DFILE sun 1224 4-Cl indole DPPA-2-1.als
COMNT
DATIM 2013-12-24 23:38:33
OBNUC 13C
EXMOD carbon.jxp
OBFRQ 125.77 MHz
OBSET 7.87 KHz
OBFIN 4.21 Hz
POINT 32767
FREQU 39308.18 Hz
SCANS 81
ACQTM 0.8336 sec
PD 3.0000 sec
PW1 3.40 usec
IRNUC 1H
CTEMP 21.7 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 0.12 Hz
RGAIN 60



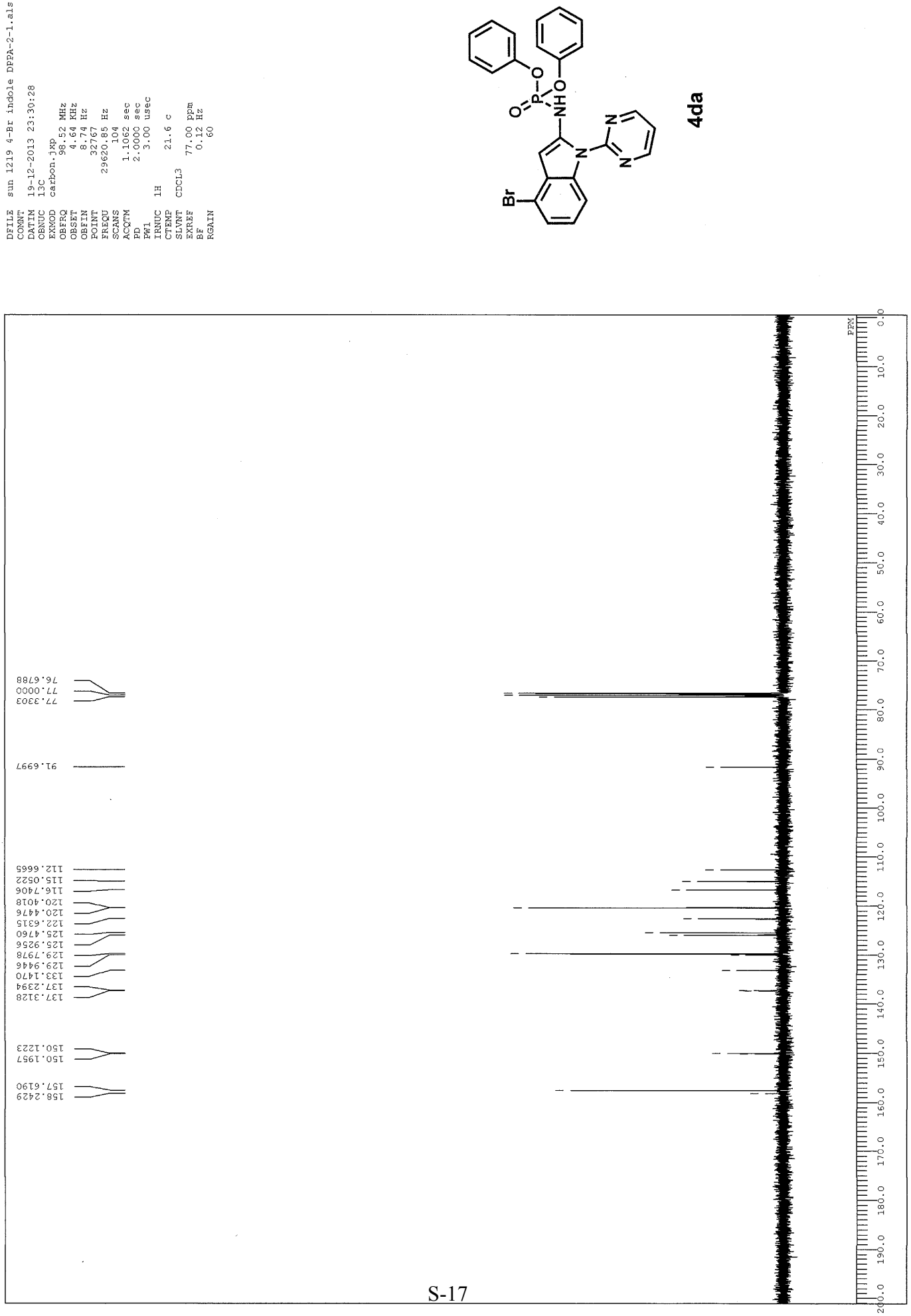
4ca

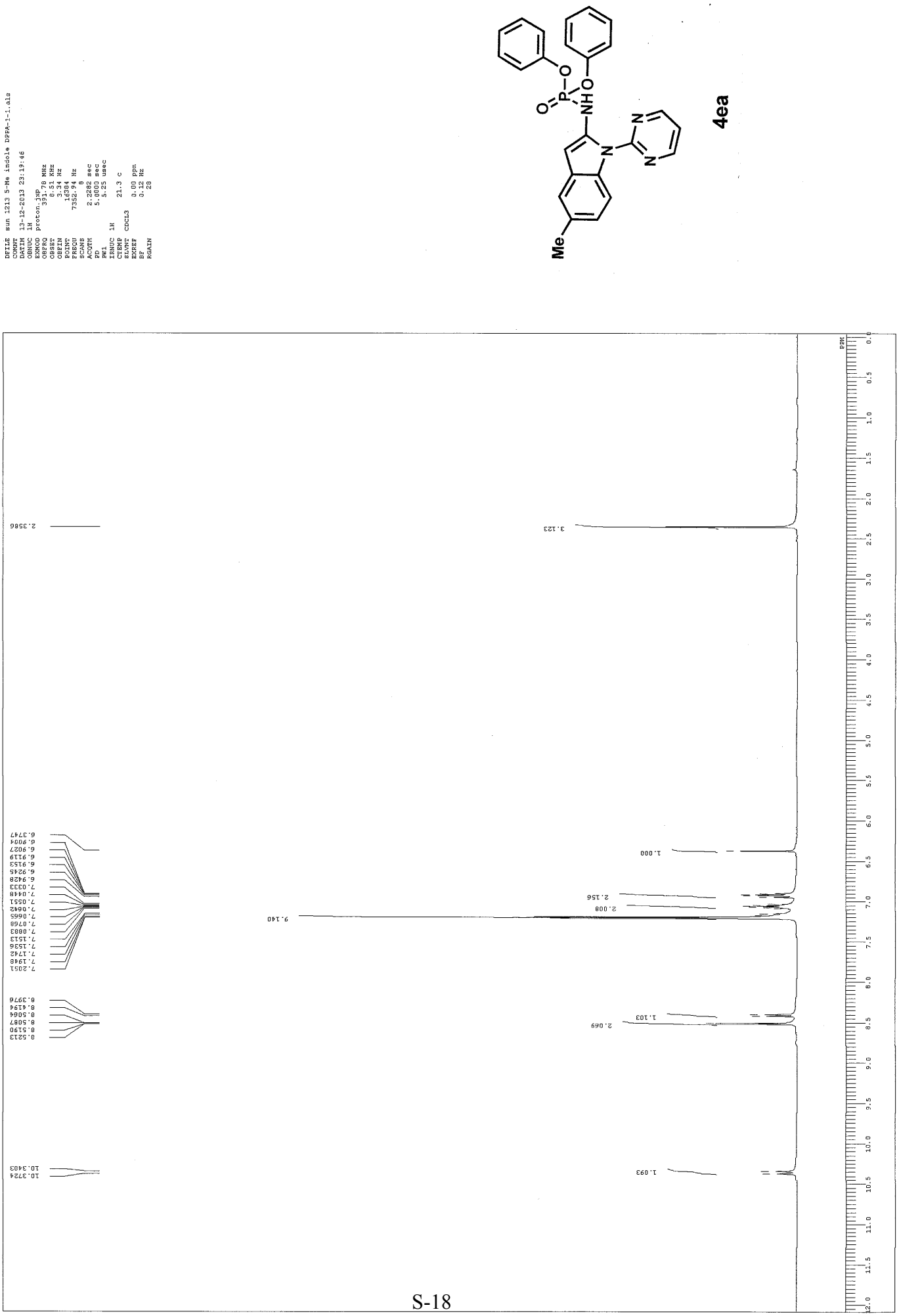



```
DFILE  sun 1219 4-Br indole DPPA-1-1.als
COMNT
DATIM  19-12-2013 23:27:56
OBNUC  1H
EXMOD  proton.jxp
OBFRQ        391.78 MHz
OBSET          8.51 KHz
OBFIN          3.34 Hz
POINT        16384
FREQU      7352.94 Hz
SCANS            7
ACQTM        2.2282 sec
PD           5.0000 sec
PW1            5.25 usec
IRNUC  1H
CTEMP          21.5 c
SLVNT  CDCL3
EXREF          0.00 ppm
BF             0.12 Hz
RGAIN           32
```

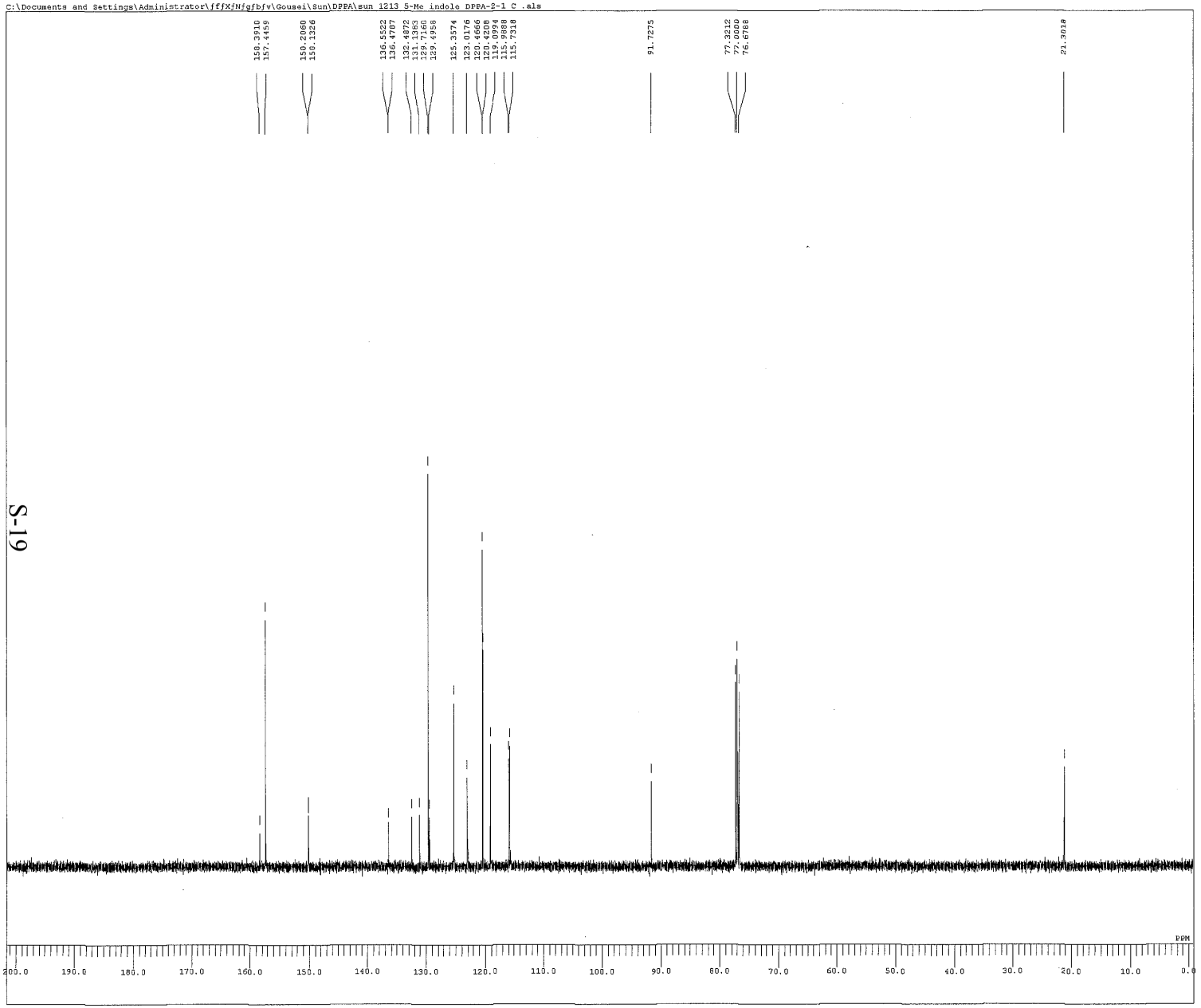


4da

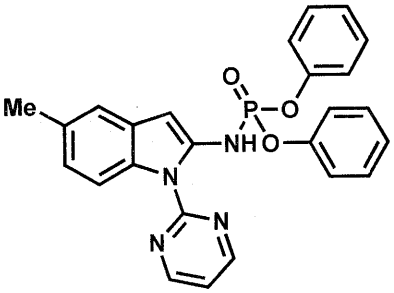

DFILE sun 1219 4-Br indole DPPA-2-1.als
COMNT
DATIM 19-12-2013 23:30:28
OBNUC 13C
EXMOD carbon.jxp
OBFRQ 98.52 MHz
OBSET 4.64 KHz
OBFIN 8.74 Hz
POINT 32767
FREQU 29620.85 Hz
SCANS 104
ACQTM 1.1062 sec
PD 2.0000 sec
PW1 3.00 usec
IRNUC 1H
CTEMP 21.6 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 0.12 Hz
RGAIN 60
4da
Br
158.2429
157.6190
150.1957
150.1223
137.3128
137.2394
133.1470
129.9446
129.7978
125.9256
125.4760
122.6315
120.4476
120.4018
116.7406
115.0522
112.6665
91.6997
77.3303
77.0000
76.6788
PPM
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0


DFILE sun 1213 5-Me indole DPFA-1-1.als
CONUT
DATIM 13-12-2013 23:19:46
OBNUC H1
EXMOD proton.jxp
OBFRQ 391.78 MHz
OBSET 0.51 KHz
OBFIN 3.34 Hz
POINT 12544
FREQU 7352.94 Hz
SCANS 8
ACQTM 2.2202 sec
PD 5.0000 sec
PW1 5.25 usec
INUNC 1H
CTEMP 21.3 c
SLVNT CDCl3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 28
4ea
Me
PPM
10.3724
10.3403
8.5213
8.5190
8.5087
8.5064
8.4194
8.3976
7.2051
7.1948
7.1742
7.1536
7.1513
7.0883
7.0758
7.0665
7.0642
7.0551
7.0448
7.0333
6.9428
6.9246
6.9153
6.9119
6.9027
6.9004
6.3747
2.3586
3.123
1.000
2.156
2.008
9.140
1.103
2.069
1.093

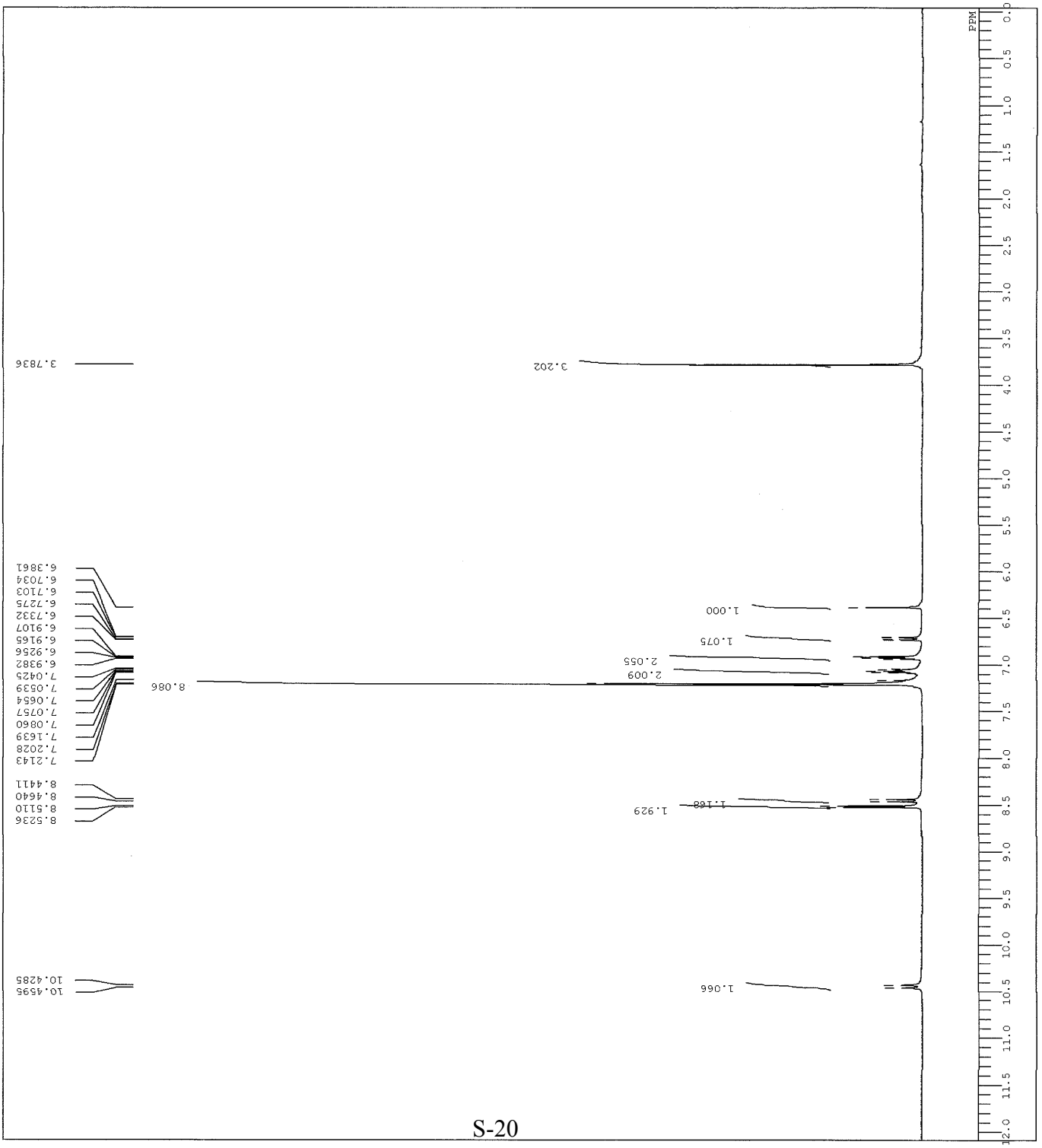
C:\Documents and Settings\Administrator\ffjXfNfgfbfv\Gousei\Sun\DPPA\sun 1213 5-Me indole DPPA-2-1 C .als

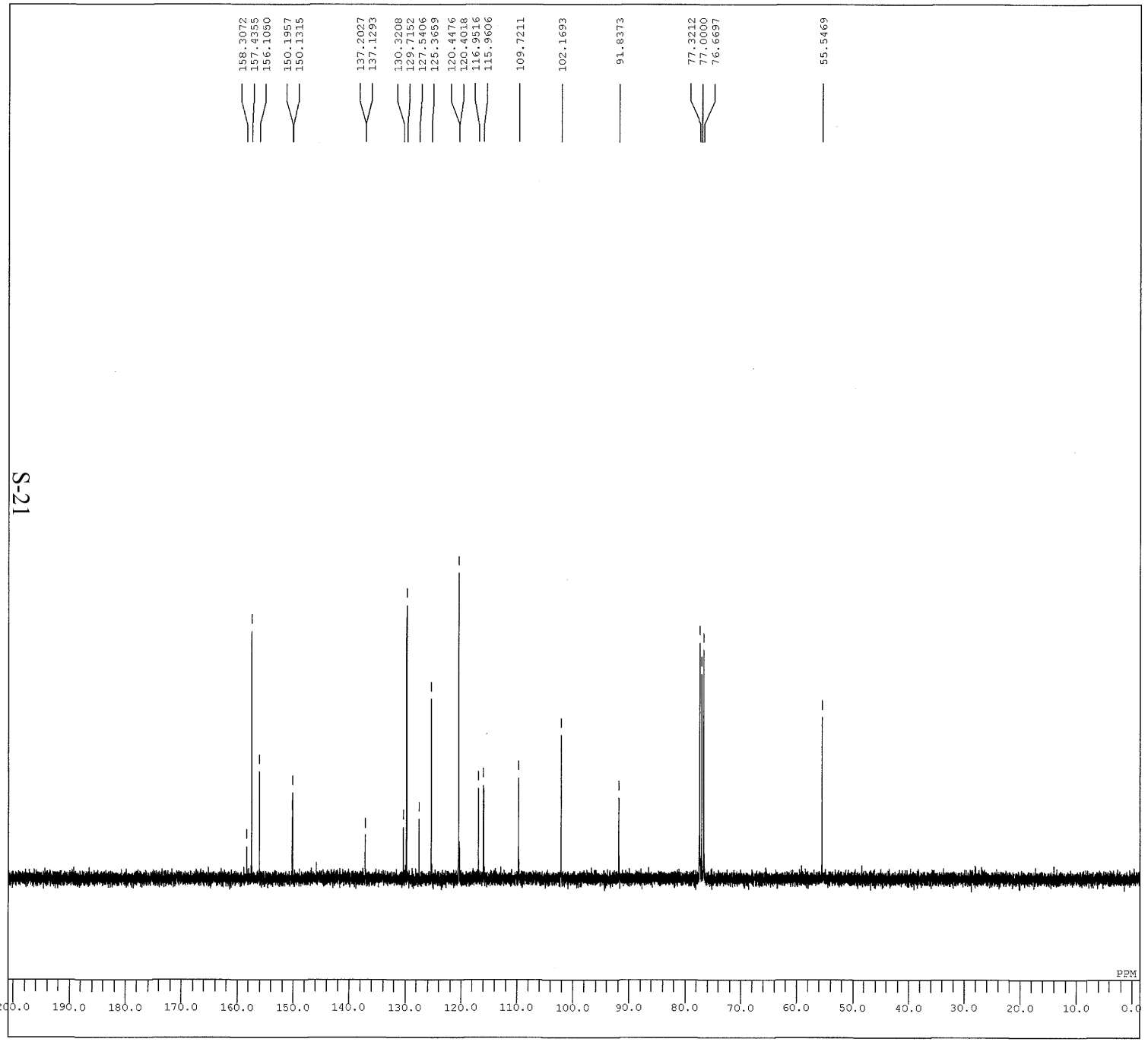



```
DFILE  sun 1213 5-Me indole DPPA-2-1 C .als
COMNT
DATIM  13-12-2013 23:22:00
OBNUC  13C
EXMOD  carbon.jxp
OBFRQ        98.52 MHz
OBSET         4.64 KHz
OBFIN         6.74 Hz
POINT        26214
FREQU     23696.68 Hz
SCANS          125
ACQTM       1.1062 sec
PD          2.0000 sec
PW1            3.00 usec
IRNUC  1H
CTEMP         21.7 c
SLVNT  CDCL3
EXREF        77.00 ppm
BF            0.12 Hz
RGAIN           60
```

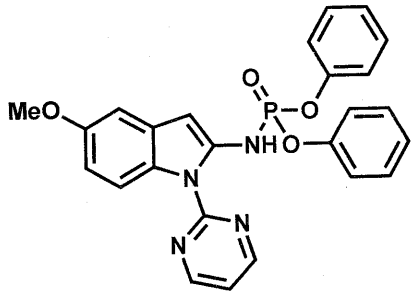


4ea

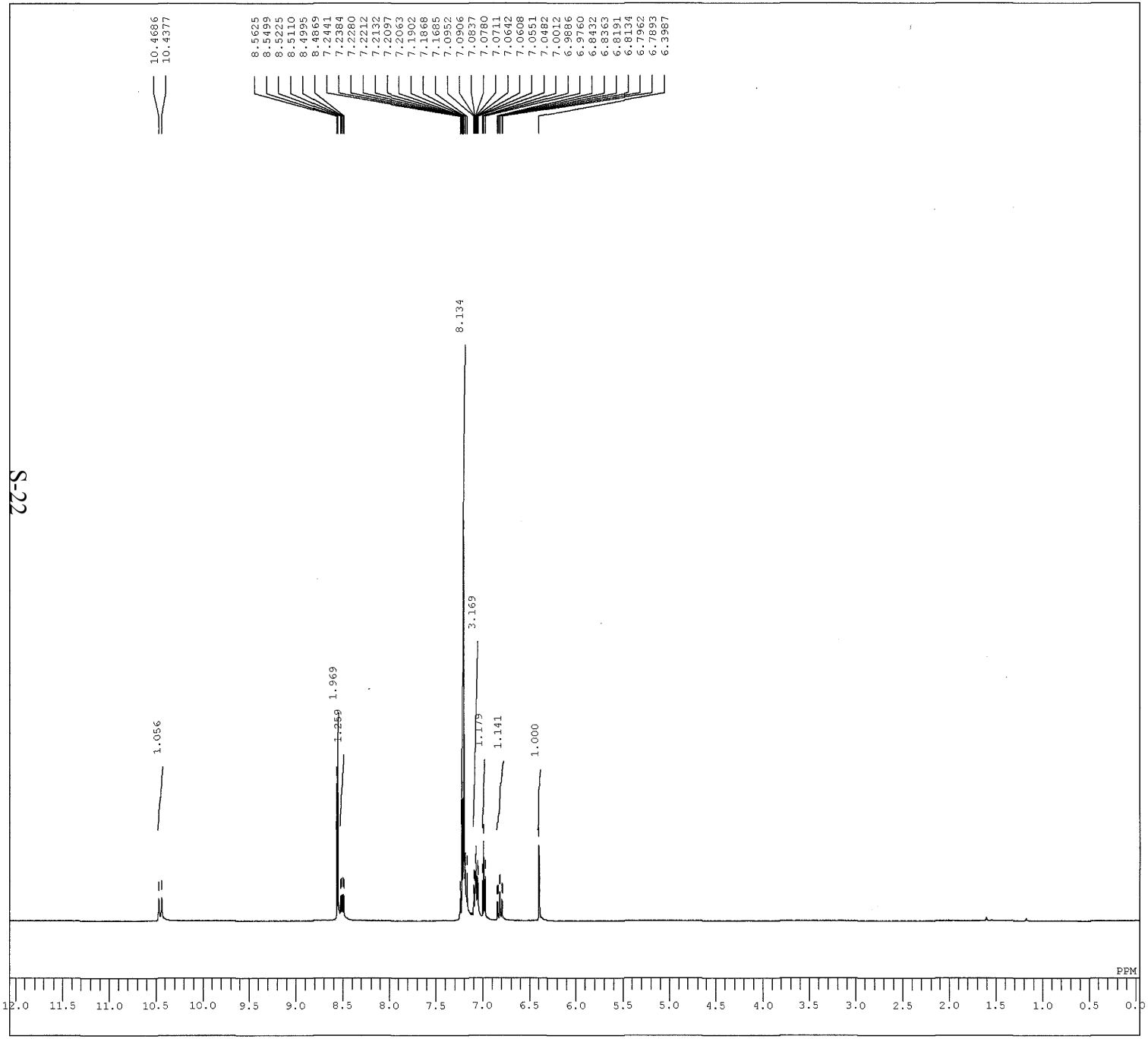

DFILE sun 1217 5-OMe indole DPPa-1-1.als
COMNT
DATIM 17-12-2013 23:42:16
OBNUC 1H
EXMOD proton.jxp
OBFRQ 391.78 MHz
OBSET 8.51 KHz
OBFIN 3.34 Hz
POINT 16384
FREQU 7352.94 Hz
SCANS 8
ACQTM 2.2282 sec
PD 5.0000 sec
PW1 5.25 usec
IRNUC 1H
CTEMP 21.3 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 28
MeO
4fa
PPM
10.4595
10.4285
8.5236
8.5110
8.4640
8.4411
7.2143
7.2028
7.1639
7.0860
7.0757
7.0654
7.0539
7.0425
6.9382
6.9256
6.9165
6.9107
6.7332
6.7275
6.7103
6.7034
6.3861
8.086
3.783
3.202
2.009
2.055
1.075
1.000
1.929
1.168
1.066



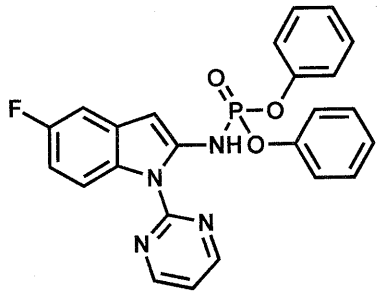

```
DFILE   sun 1217 5-OMe indole DPPA-2-1.als
COMNT
DATIM   17-12-2013 23:44:24
OBNUC   13C
EXMOD   carbon.jxp
OBFRQ         98.52 MHz
OBSET          4.64 KHz
OBFIN          8.74 Hz
POINT         32767
FREQU      29620.85 Hz
SCANS           100
ACQTM        1.1062 sec
PD           2.0000 sec
PW1             3.00 usec
IRNUC   1H
CTEMP          21.5 c
SLVNT   CDCL3
EXREF         77.00 ppm
BF             0.12 Hz
RGAIN            60
```



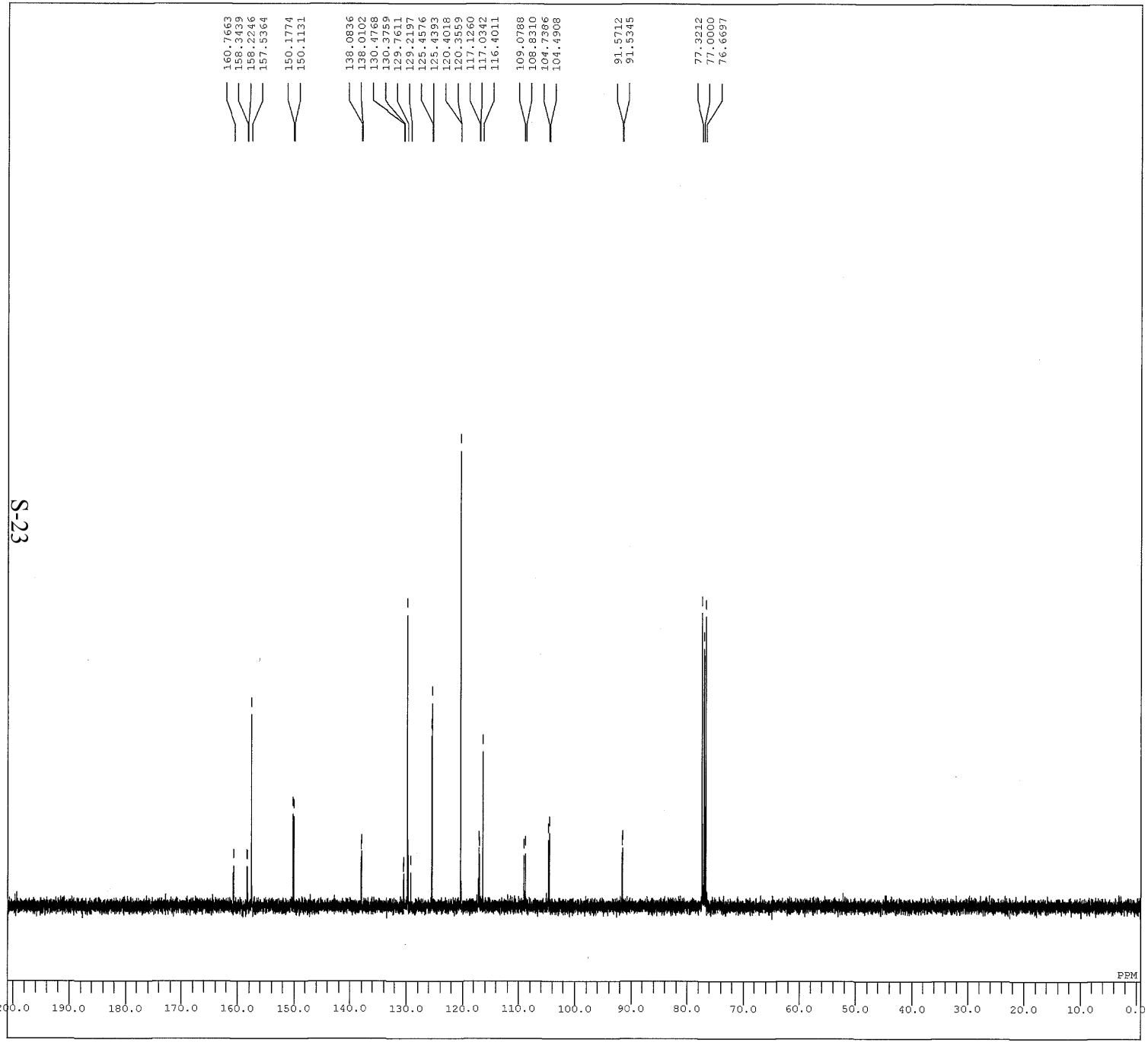
4fa



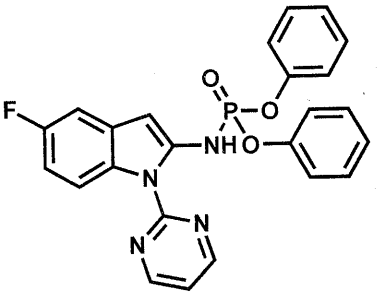

```
DFILE   sun 1217 5-F indole DPPa-1-1.als
COMNT
DATIM   18-12-2013 00:12:51
OBNUC   1H
EXMOD   proton.jxp
OBFRQ         391.78 MHz
OBSET           8.51 KHz
OBFIN           3.34 Hz
POINT          16384
FREQU        7352.94 Hz
SCANS                8
ACQTM         2.2282 sec
PD            5.0000 sec
PW1             5.25 usec
IRNUC   1H
CTEMP           21.2 c
SLVNT   CDCL3
EXREF           0.00 ppm
BF              0.12 Hz
RGAIN             30
```



4ga

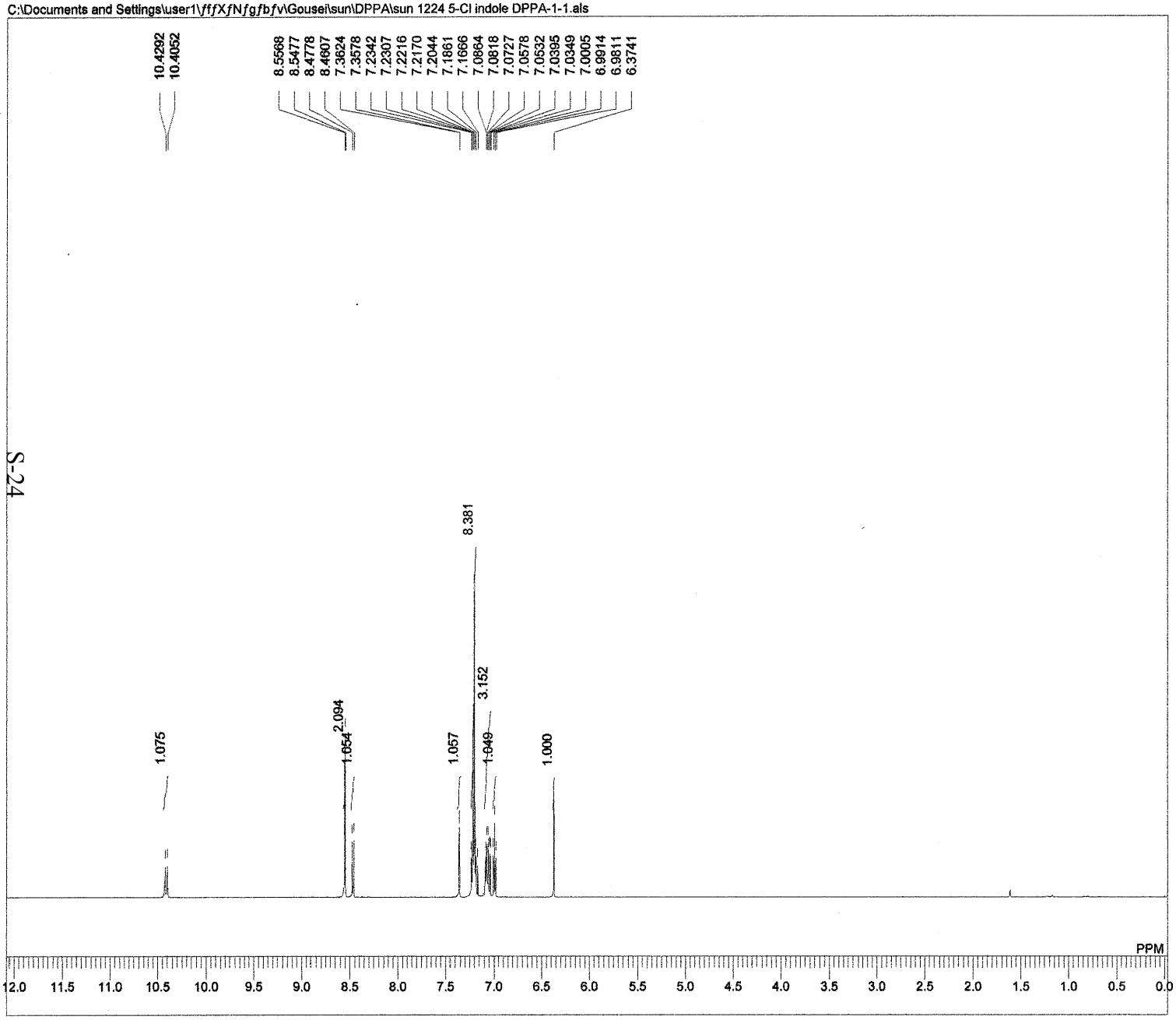



```
DFILE  sun 1217 5-F indole DPPA-2-1.als
COMNT
DATIM  18-12-2013 00:15:56
OBNUC  13C
EXMOD  carbon.jxp
OBFRQ          98.52 MHz
OBSET           4.64 KHz
OBFIN           8.74 Hz
POINT          32767
FREQU       29620.85 Hz
SCANS            150
ACQTM         1.1062 sec
PD            2.0000 sec
PW1              3.00 usec
IRNUC  1H
CTEMP           21.5 c
SLVNT  CDCL3
EXREF          77.00 ppm
BF              0.12 Hz
RGAIN             60
```

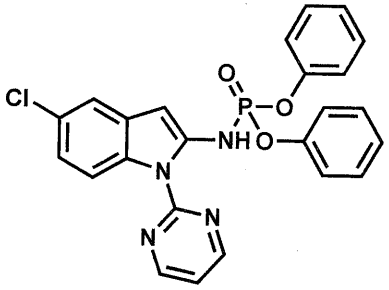


4ga

C:\Documents and Settings\user1\ƒƒXƒNƒgƒbƒv\Gousei\sun\DPPA\sun 1224 5-Cl indole DPPA-1-1.als

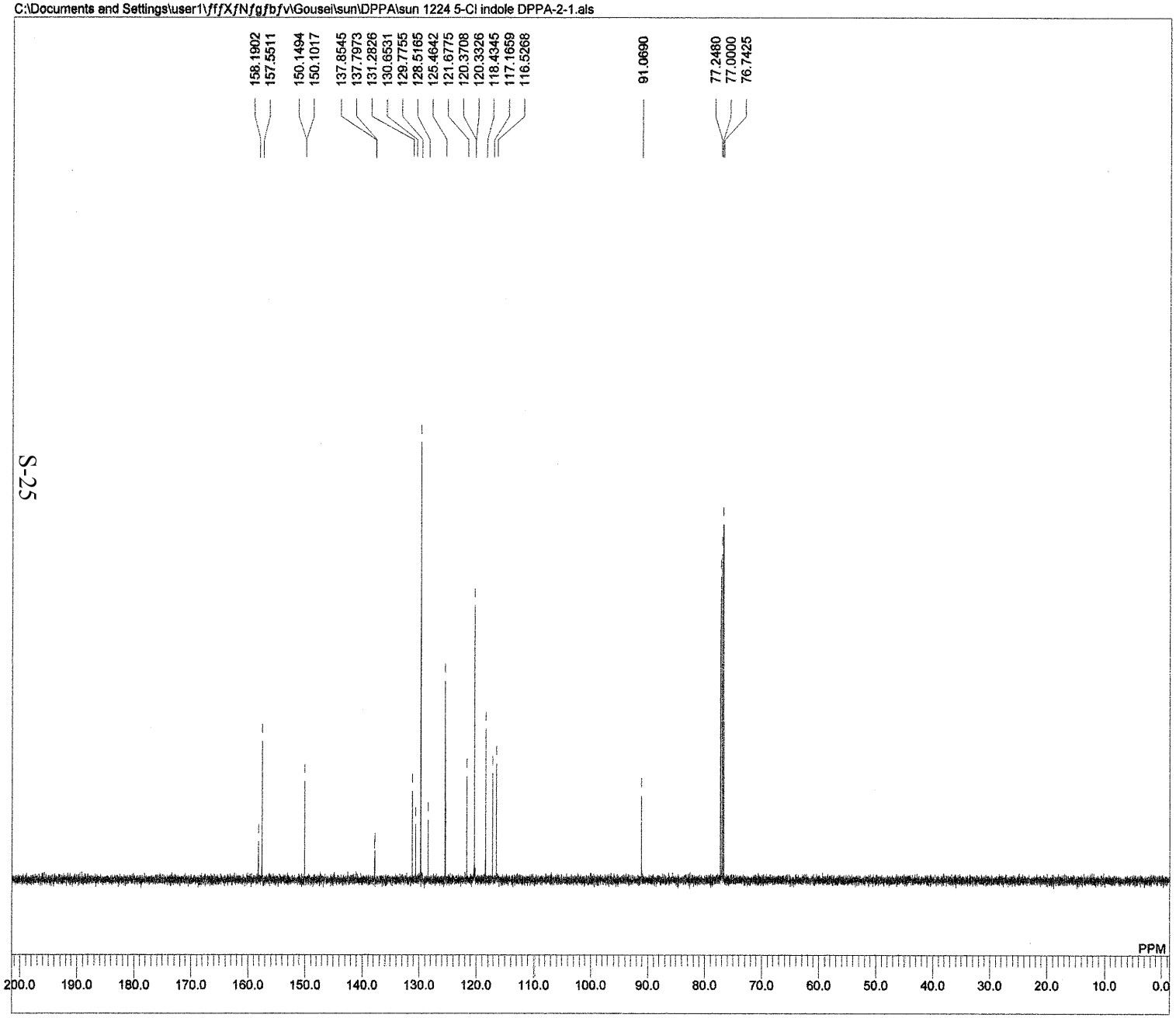


DFILE	sun 1224 5-Cl indole DPPA-1-1.als
COMNT	
DATIM	2013-12-24 23:22:24
OBNUC	1H
EXMOD	proton.jxp
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	16384
FREQU	9384.38 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	5.55 usec
IRNUC	1H
CTEMP	21.3 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	34

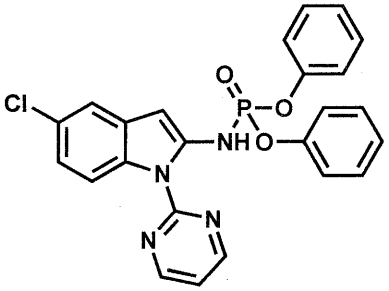


4ha

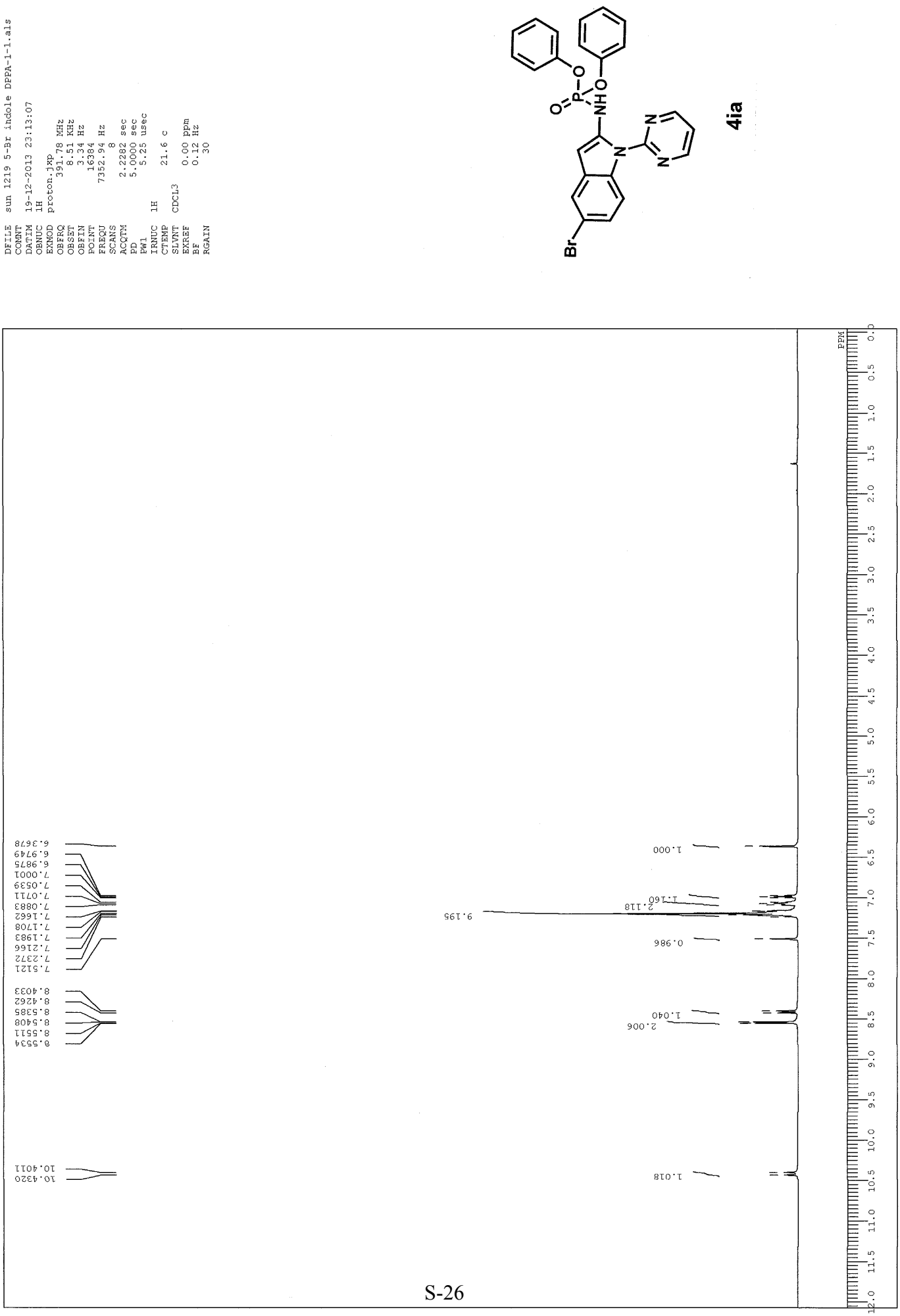
C:\Documents and Settings\user1\ffXfNfgfbfv\Gousei\sun\DPPA\sun 1224 5-Cl indole DPPA-2-1.als

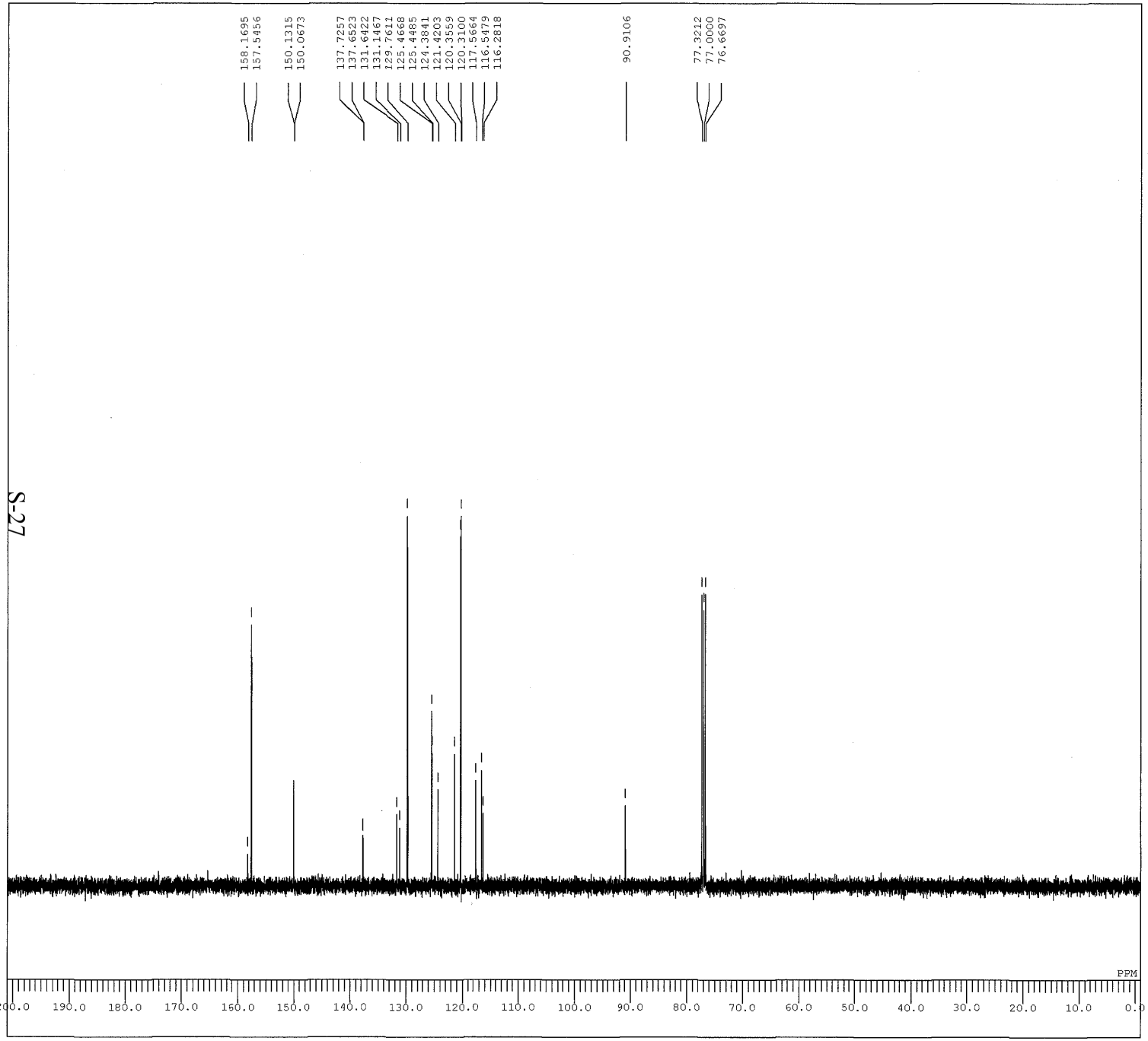


DFILE	sun 1224 5-Cl indole DPPA-2-1.als
COMNT	
DATIM	2013-12-24 23:24:22
OBNUC	13C
EXMOD	carbon.jxp
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	32767
FREQU	39308.18 Hz
SCANS	111
ACQTM	0.8336 sec
PD	3.0000 sec
PW1	3.40 usec
IRNUC	1H
CTEMP	21.7 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	0.12 Hz
RGAIN	60

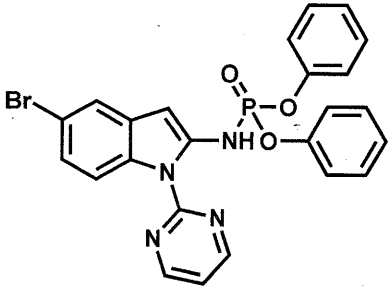


4ha

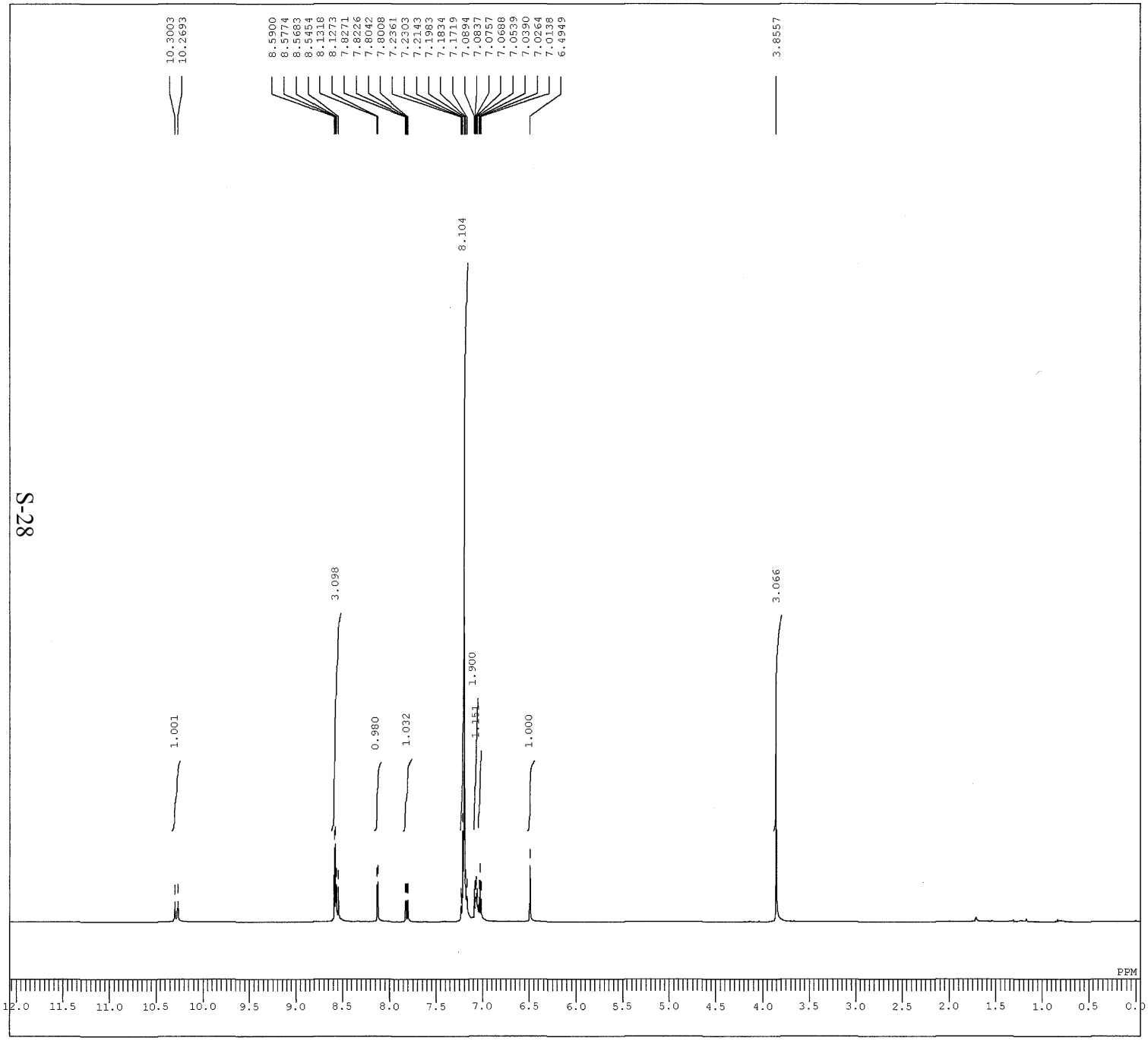

DFILE sun 1219 5-Br indole DPPA-1-1.als
COMNT
DATIM 19-12-2013 23:13:07
OBNUC 1H
EXMOD proton.jxp
OBFRQ 391.78 MHz
OBSET 8.51 KHz
OBFIN 3.34 Hz
POINT 16384
FREQU 7352.94 Hz
SCANS 8
ACQTM 2.2282 sec
PD 5.0000 sec
PW1 5.25 usec
IRNUC 1H
CTEMP 21.6 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 30
4ia
Br
PPM
10.4320
10.4011
8.5534
8.5511
8.5408
8.5385
8.4262
8.4033
7.5121
7.2372
7.2166
7.1983
7.1708
7.1662
7.0883
7.0711
7.0539
7.0001
6.9875
6.9749
6.3678
1.018
2.006
1.040
0.986
9.195
2.118
1.160
1.000



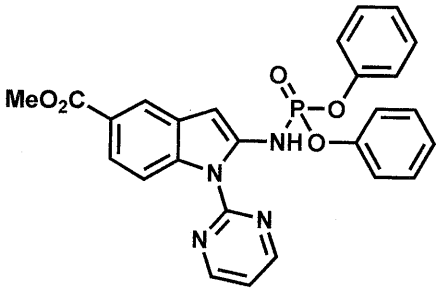

```
DFILE   sun 1219 5-Br indole DPPA-2-1.als
COMNT
DATIM   19-12-2013 23:15:01
OBNUC   13C
EXMOD   carbon.jxp
OBFRQ         98.52 MHz
OBSET          4.64 KHz
OBFIN          8.74 Hz
POINT         32767
FREQU      29620.85 Hz
SCANS            96
ACQTM         1.1062 sec
PD            2.0000 sec
PW1             3.00 usec
IRNUC   1H
CTEMP           21.6 c
SLVNT   CDCL3
EXREF         77.00 ppm
BF             0.12 Hz
RGAIN            60
```



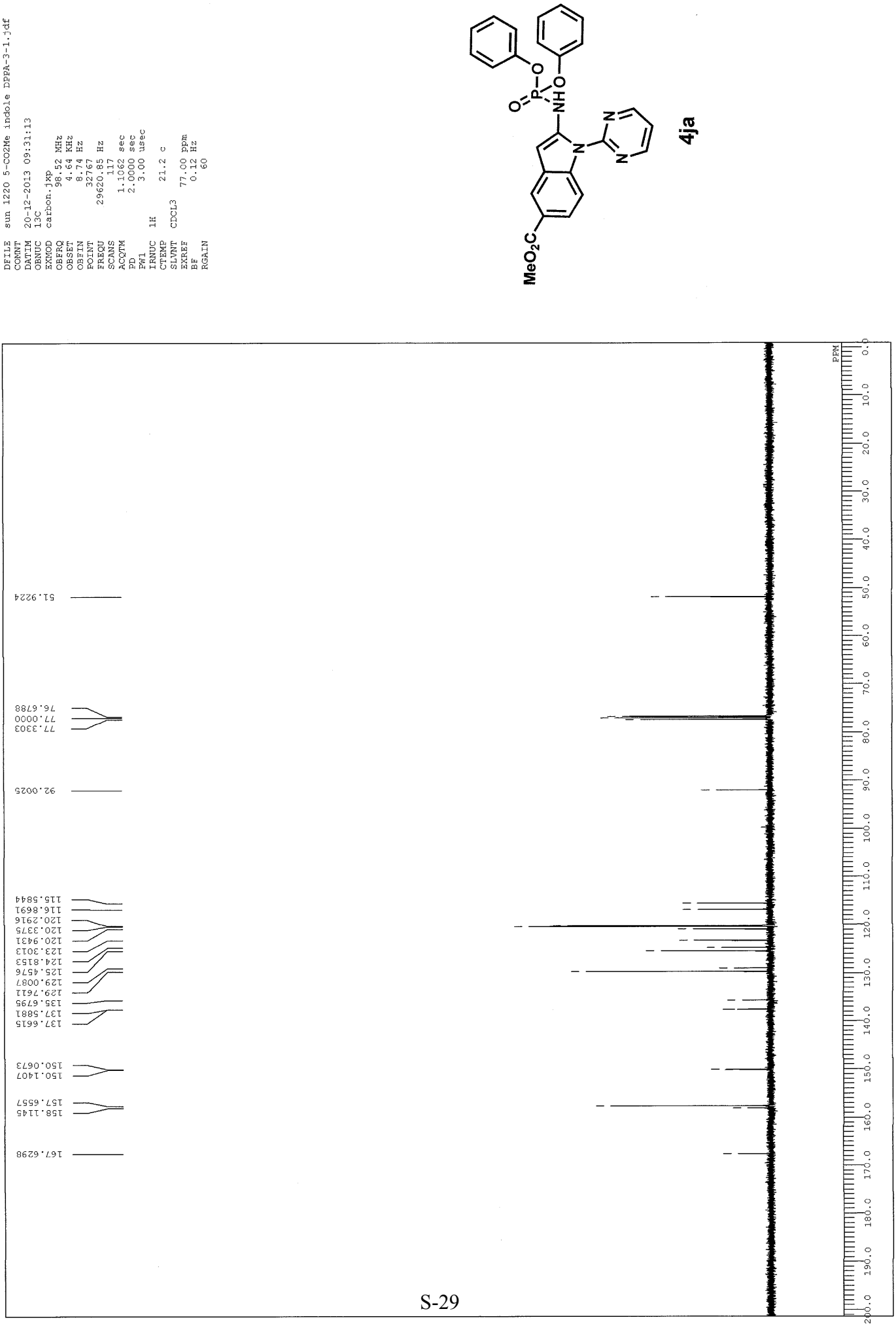
4ia

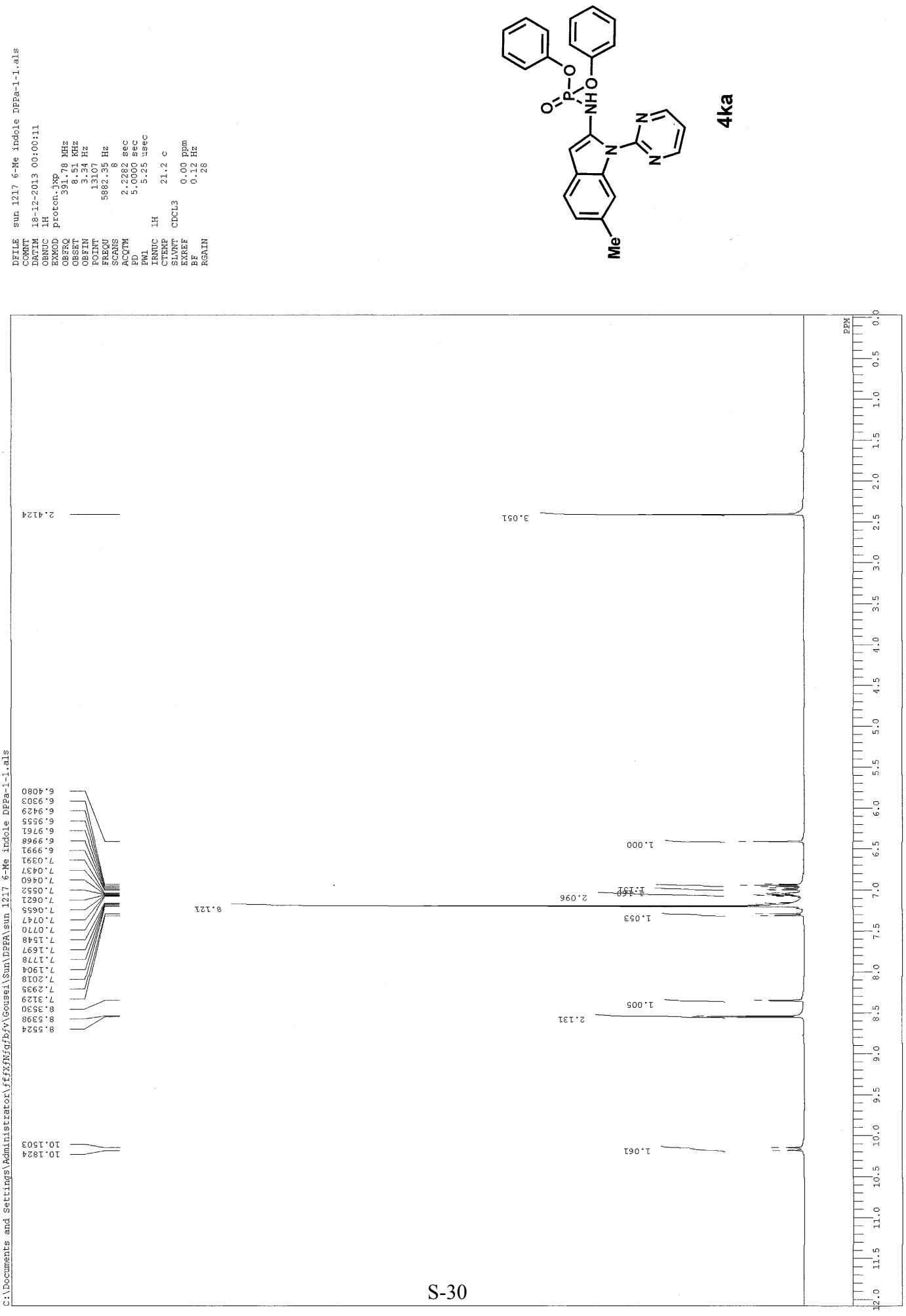


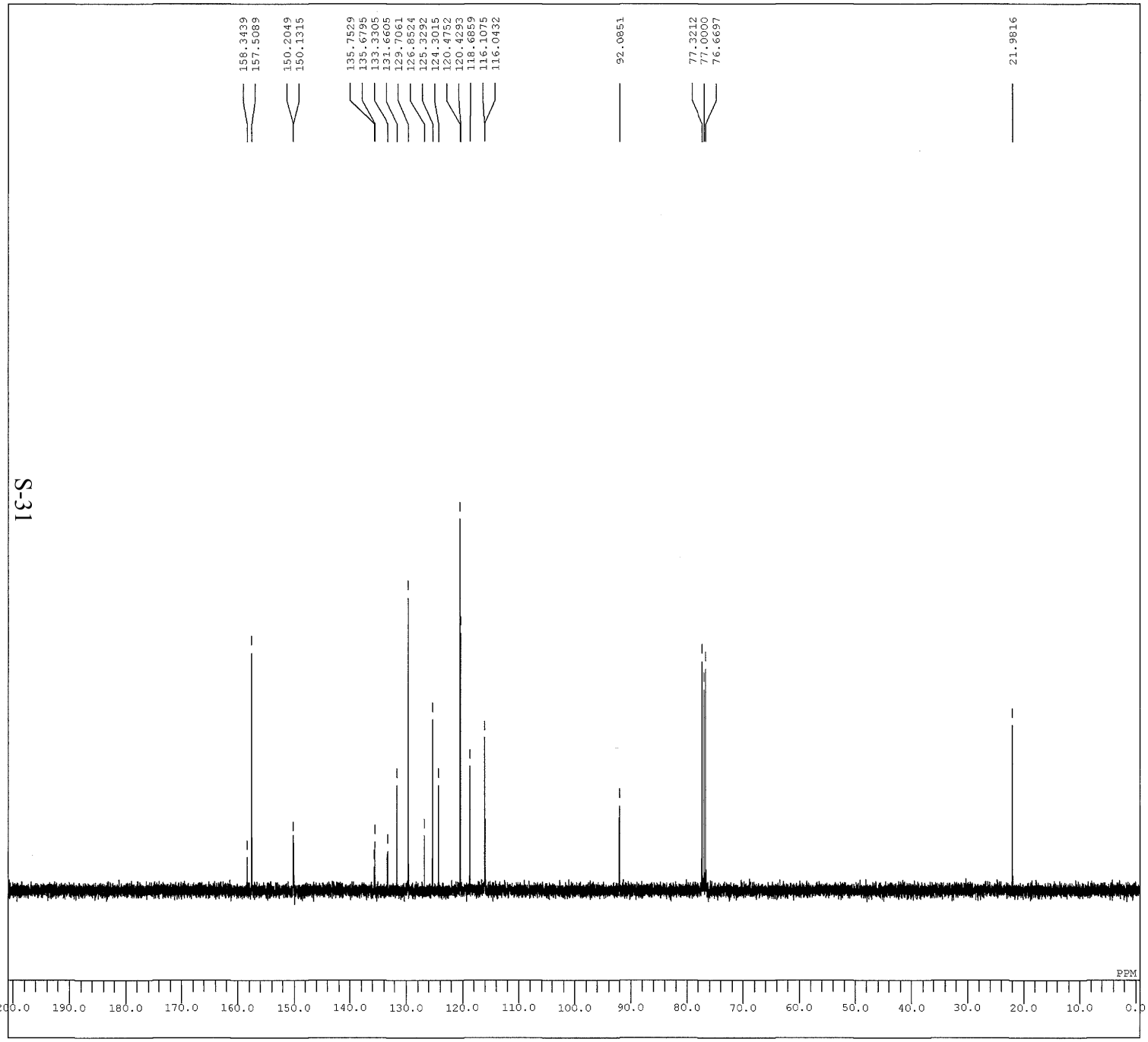

```
DFILE  sun 1220 5-CO2Me indole DPPA-2-1.als
COMNT
DATIM  20-12-2013 09:28:30
OBNUC  1H
EXMOD  proton.jxp
OBFRQ        391.78 MHz
OBSET          8.51 KHz
OBFIN          3.34 Hz
POINT         16384
FREQU       7352.94 Hz
SCANS             8
ACQTM         2.2282 sec
PD            5.0000 sec
PW1             5.25 usec
IRNUC  1H
CTEMP          21.2 c
SLVNT  CDCL3
EXREF          0.00 ppm
BF             0.12 Hz
RGAIN            28
```



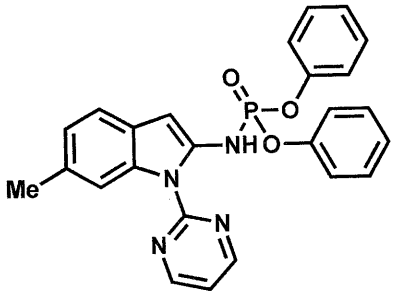
4ja


DFILE sun 1220 5-CO2Me indole DPPA-3-1.jdf
COMNT
DATIM 20-12-2013 09:31:13
OBNUC 13C
EXMOD carbon.jxp
OBFRQ 98.52 MHz
OBSET 4.64 KHz
OBFIN 8.74 Hz
POINT 32767
FREQU 29620.85 Hz
SCANS 117
ACQTM 1.1062 sec
PD 2.0000 sec
PW1 3.00 usec
IRNUC 1H
CTEMP 21.2 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 0.12 Hz
RGAIN 60
MeO2C
4ja
51.9224
76.6788
77.0000
77.3303
92.0025
115.5844
116.8691
120.2916
120.3375
120.9431
123.3013
124.8153
125.4576
129.0087
129.7611
135.6795
137.5881
137.6615
150.0673
150.1407
157.6557
158.1145
167.6298
PPM


DFILE sun 1217 6-Me indole DPPa-1-1.als
COMNT
DATIM 18-12-2013 00:00:11
OBNUC 1H
EXMOD proton.jxp
OBFRQ 391.78 MHz
OBSET 8.51 KHz
OBFIN 3.34 Hz
POINT 13107
FREQU 5882.35 Hz
SCANS 8
ACQTM 2.2282 sec
PD 5.0000 sec
PW1 5.25 usec
IRNUC 1H
CTEMP 21.2 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 28
4ka
Me
C:\Documents and Settings\Administrator\ffFXfNfgfbfv\Gousei\Sun\DPPA\sun 1217 6-Me indole DPPa-1-1.als
10.1824
10.1503
8.5524
8.5398
8.3530
7.3129
7.2935
7.2018
7.1904
7.1778
7.1697
7.1548
7.0770
7.0747
7.0655
7.0621
7.0552
7.0460
7.0437
7.0391
6.9968
6.9761
6.9555
6.9429
6.9303
6.4080
8.121
2.4124
3.051
2.096
1.000
1.053
1.005
2.131
1.061
PPM



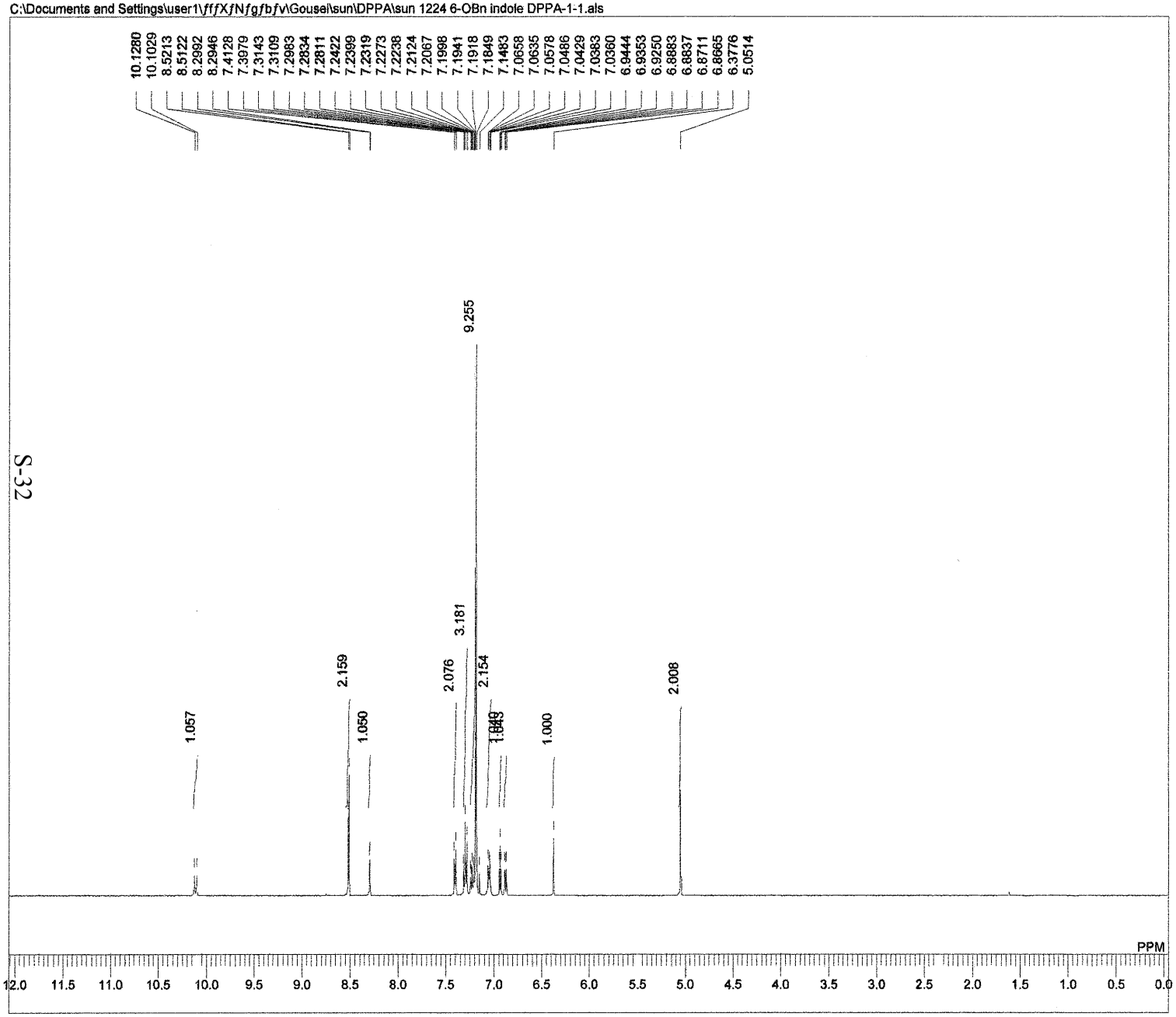

```
DFILE   sun 1217 6-Me indole DPPA-2-1.als
COMNT
DATIM   18-12-2013 00:01:53
OBNUC   13C
EXMOD   carbon.jxp
OBFRQ          98.52 MHz
OBSET           4.64 KHz
OBFIN           8.74 Hz
POINT          32767
FREQU       29620.85 Hz
SCANS             69
ACQTM          1.1062 sec
PD             2.0000 sec
PW1               3.00 usec
IRNUC   1H
CTEMP            21.4 c
SLVNT   CDCL3
EXREF           77.00 ppm
BF               0.12 Hz
RGAIN              60
```

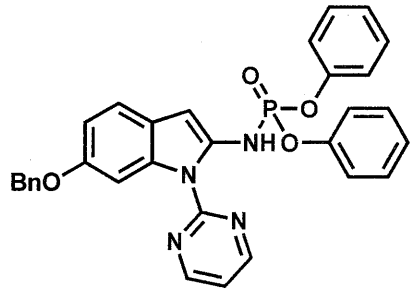


4ka

C:\Documents and Settings\user1\ffXfNfgfbfv\Gousei\sun\DPPA\sun 1224 6-OBn indole DPPA-1-1.als

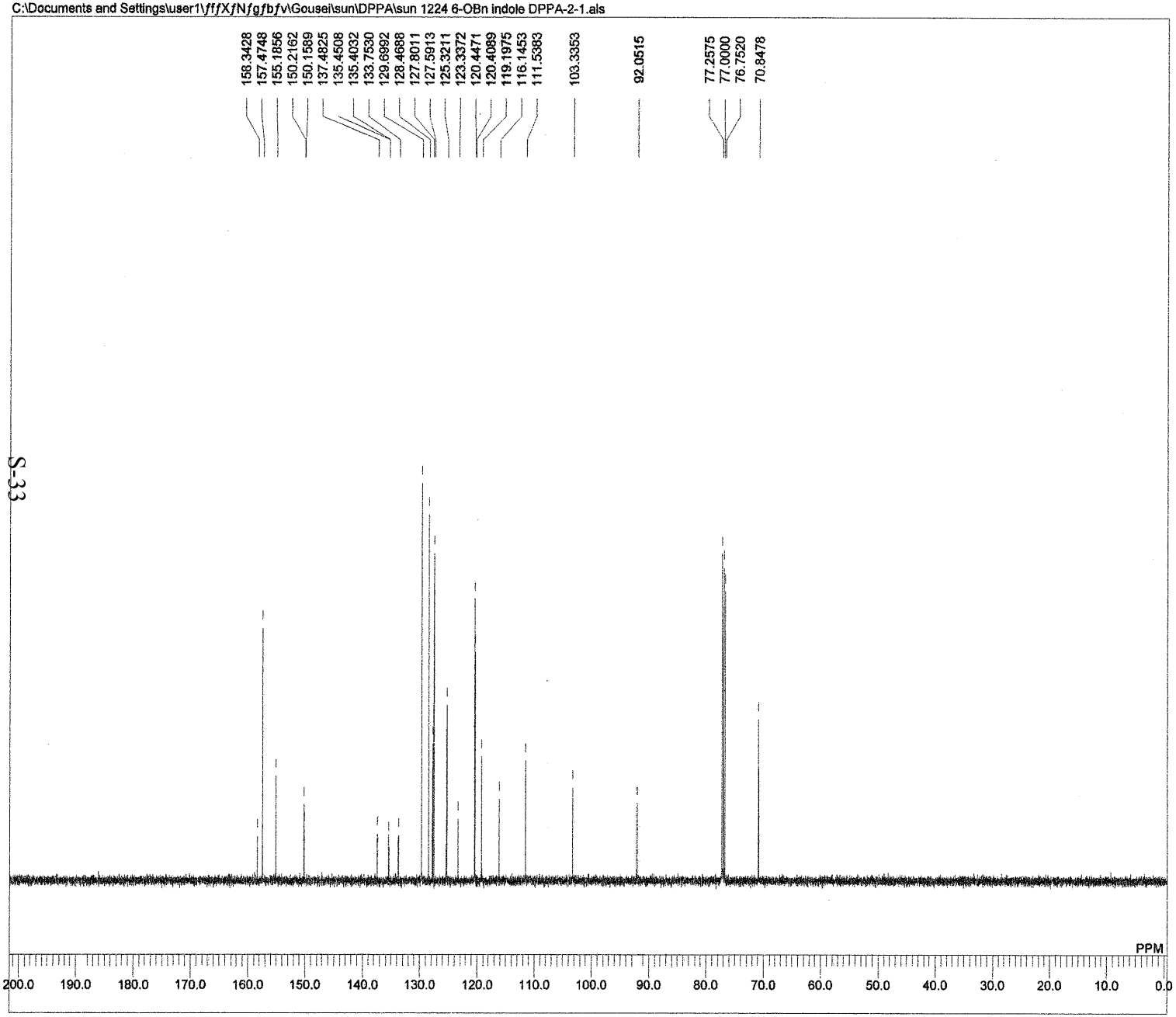
DFILE	sun 1224 6-OBn indole DPPA-1-1.als
COMNT	
DATIM	2013-12-24 23:49:46
OBNUC	1H
EXMOD	proton.jxp
OBFRQ	500.16 MHz
OBSET	2.41 KHz
OBFIN	6.01 Hz
POINT	16384
FREQU	9384.38 Hz
SCANS	8
ACQTM	1.7459 sec
PD	5.0000 sec
PW1	5.55 usec
IRNUC	1H
CTEMP	21.3 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	30



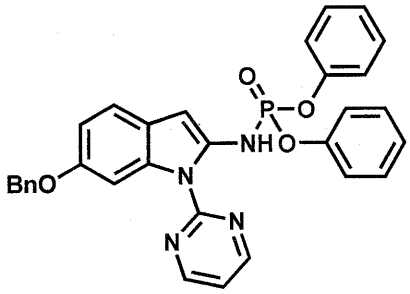


4la

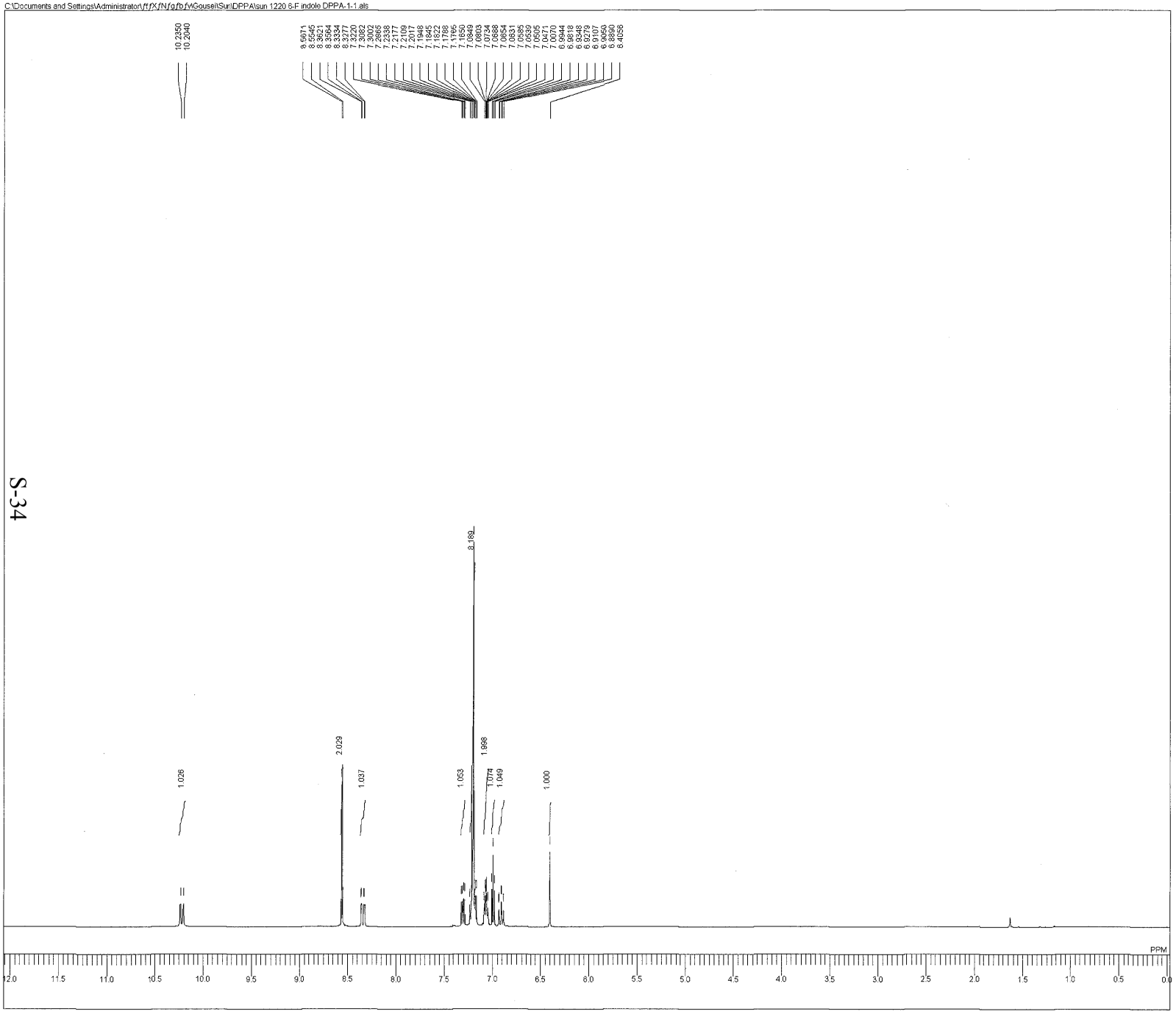
C:\Documents and Settings\user1\ƒƒXƒNƒgƒbƒv\Gousei\sun\DPPA\sun 1224 6-OBn indole DPPA-2-1.als



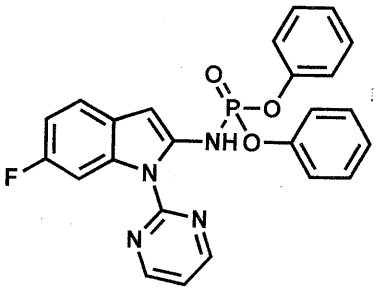
DFILE	sun 1224 6-OBn indole DPPA-2-1.als
COMNT	
DATIM	2013-12-24 23:51:26
OBNUC	13C
EXMOD	carbon.jxp
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	32767
FREQU	39308.18 Hz
SCANS	111
ACQTM	0.8336 sec
PD	3.0000 sec
PW1	3.40 usec
IRNUC	1H
CTEMP	21.7 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	0.12 Hz
RGAIN	60



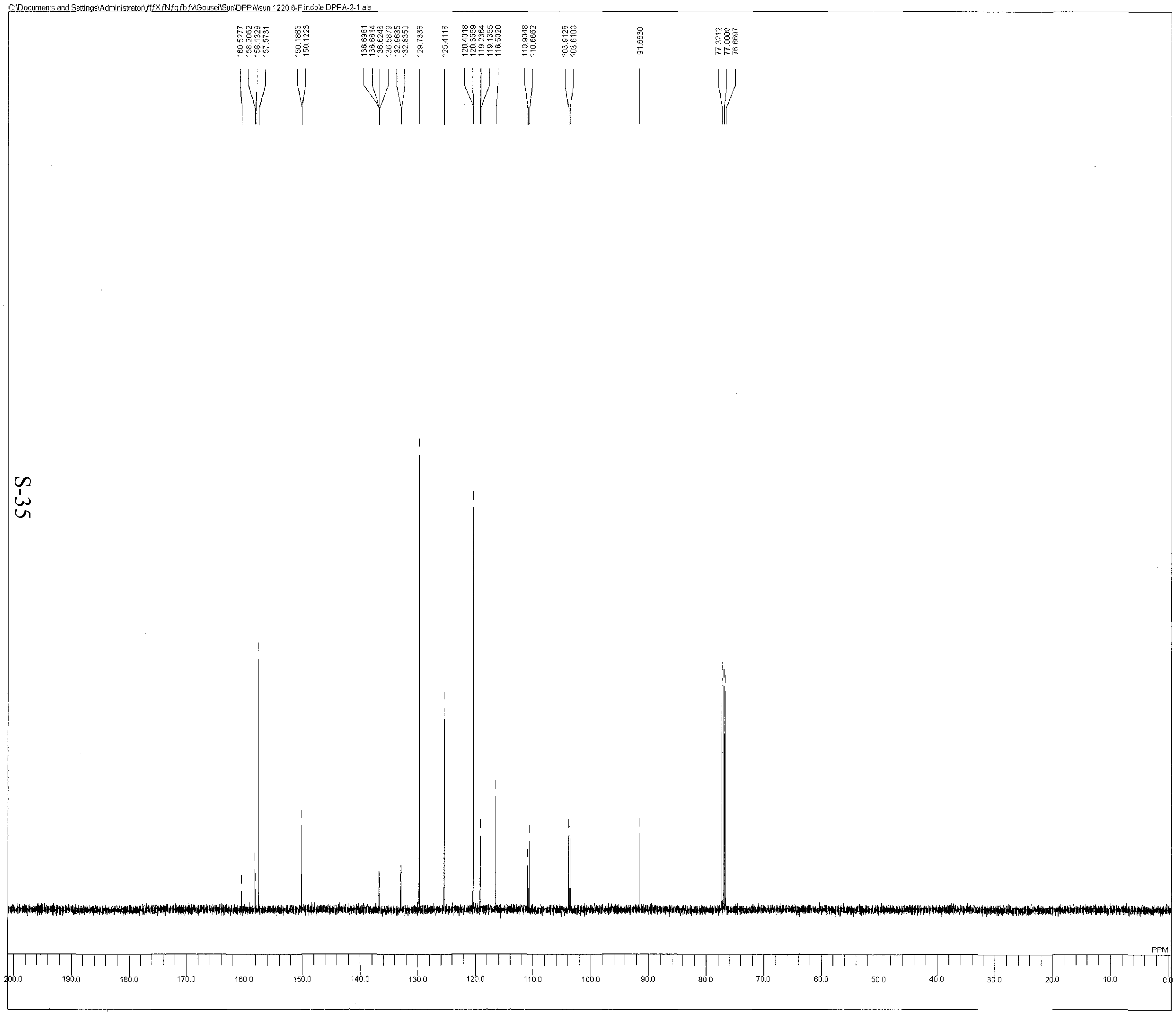
4la



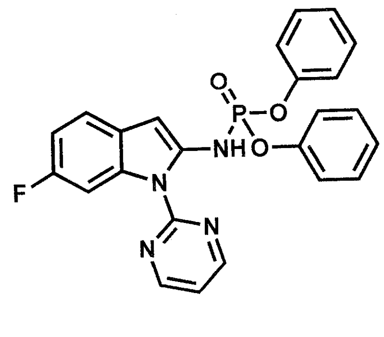
DFILE sun 1220 6-F indole DPPA-1-1.als
COMNT
DATIM 20-12-2013 23:38:37
OBNUC 1H
EXMOD proton.jxp
OBFRQ 391.78 MHz
OBSET 8.51 KHz
OBFIN 3.34 Hz
POINT 16384
FREQU 7352.94 Hz
SCANS 8
ACQTM 2.2282 sec
PD 5.0000 sec
PW1 5.25 usec
IRNUC 1H
CTEMP 21.5 c
SLVNT CDCL3
EXREF 0.00 ppm
BF 0.12 Hz
RGAIN 30



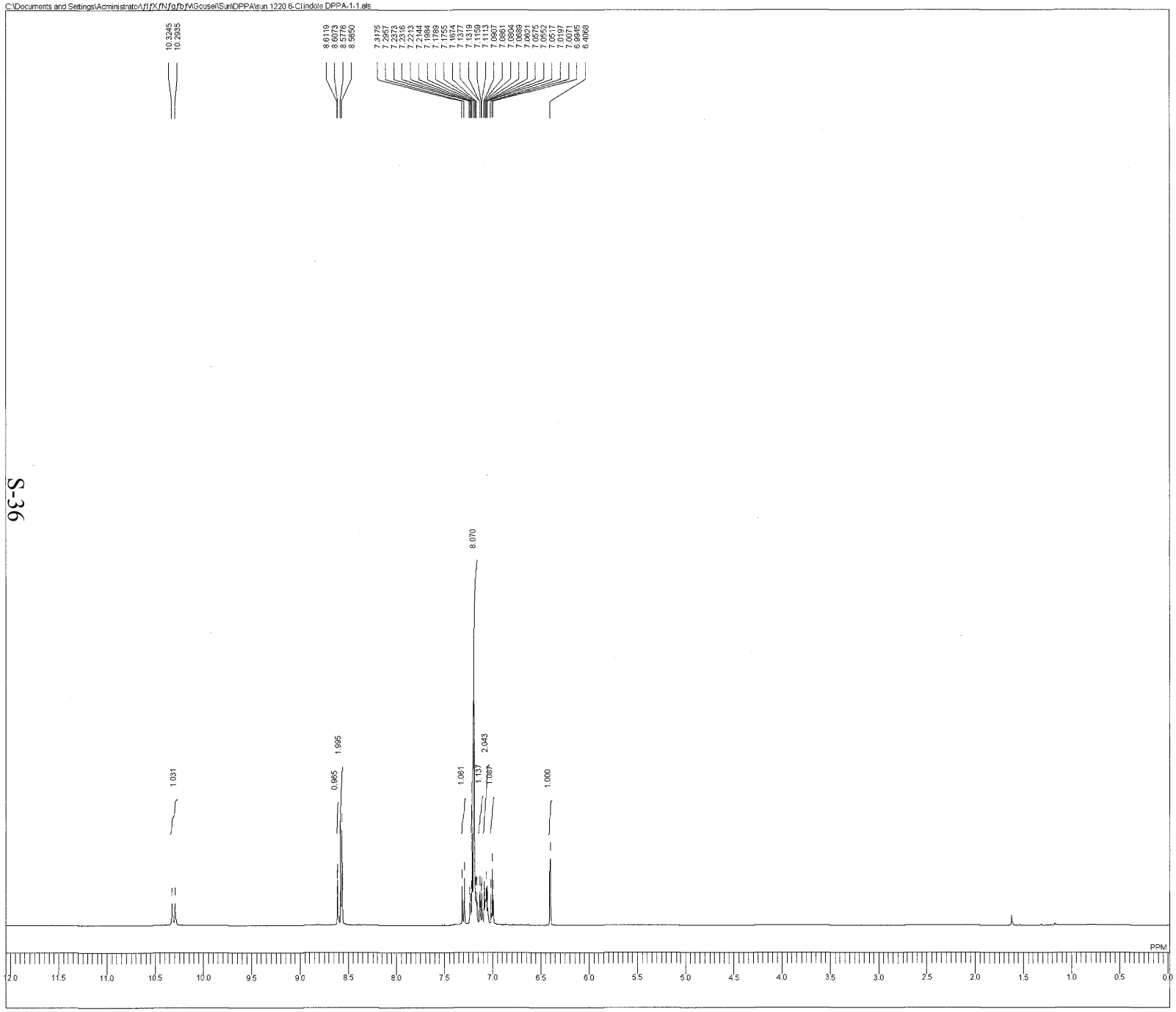
4ma



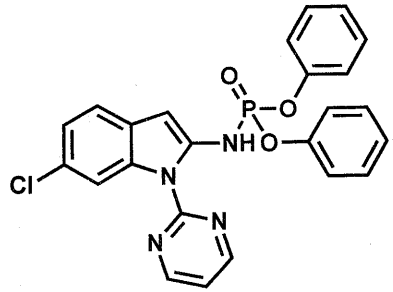
DFILE sun 1220 6-F indole DPPA-2-1.als
COMNT
DATIM 20-12-2013 23:41:13
OBNUC 13C
EXMOD carbon.jxp
OBFRQ 98.52 MHz
OBSET 4.64 KHz
OBFIN 8.74 Hz
POINT 32767
FREQU 29620.85 Hz
SCANS 121
ACQTM 1.1062 sec
PD 2.0000 sec
PW1 3.00 usec
IRNUC 1H
CTEMP 21.6 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 0.12 Hz
RGAIN 60



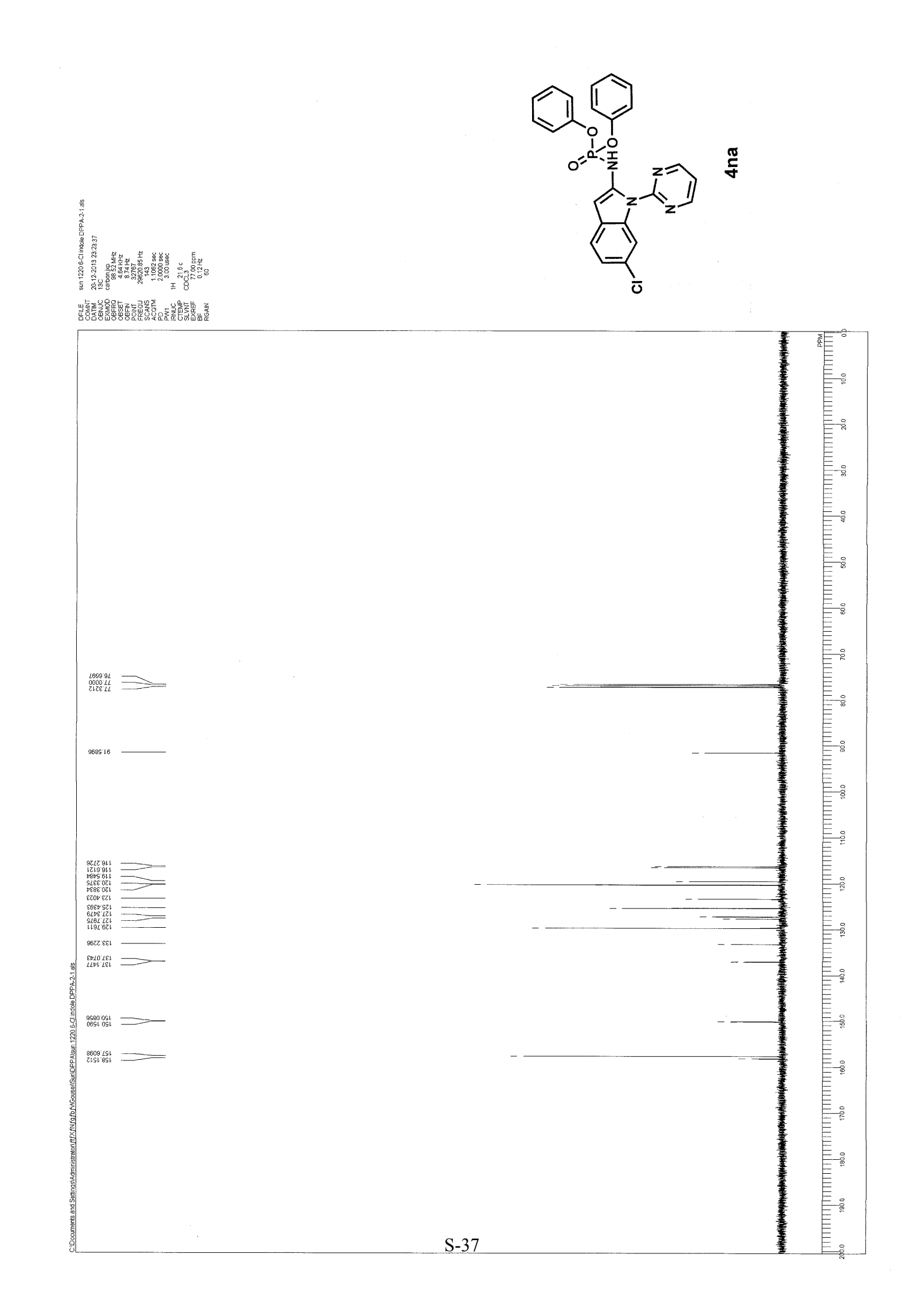
4ma

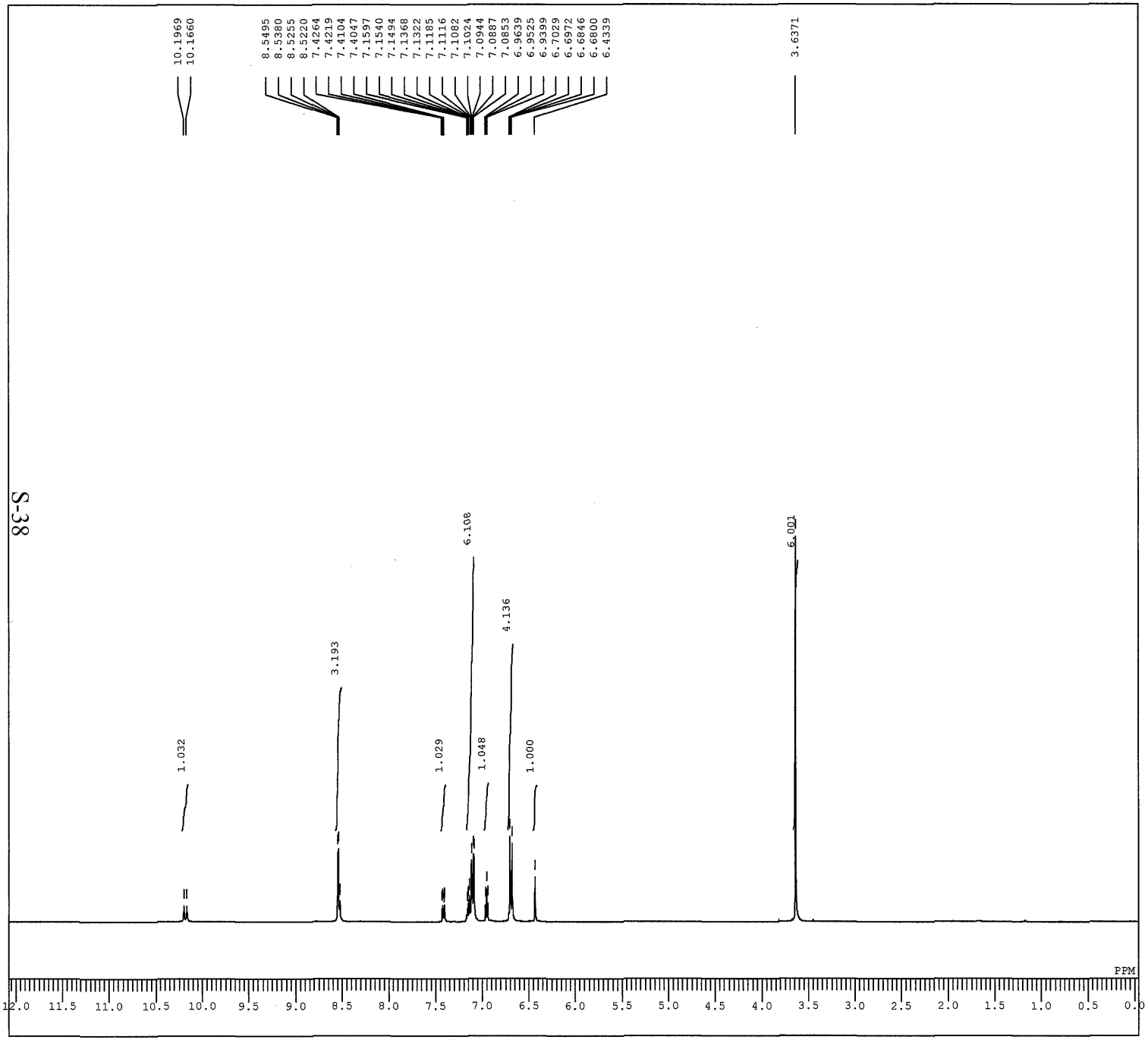



```
DFILE   sun 1220 6-Cl indole DPPA-1-1.als
COMNT
DATIM   20-12-2013 23:21:31
OBNUC   1H
EXMOD   proton.jxp
OBFRQ     391.78 MHz
OBSET       8.51 KHz
OBFIN       3.34 Hz
POINT      13107
FREQU    5882.35 Hz
SCANS          8
ACQTM      2.2282 sec
PD         5.0000 sec
PW1          5.25 usec
IRNUC   1H
CTEMP     21.3 c
SLVNT   CDCL3
EXREF      0.00 ppm
BF          0.12 Hz
RGAIN         30
```

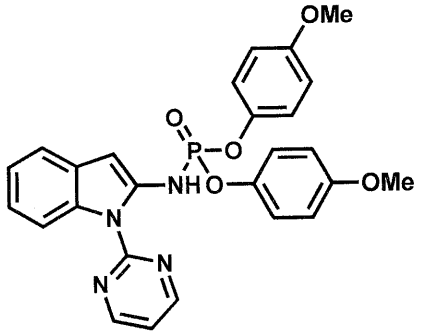



4na

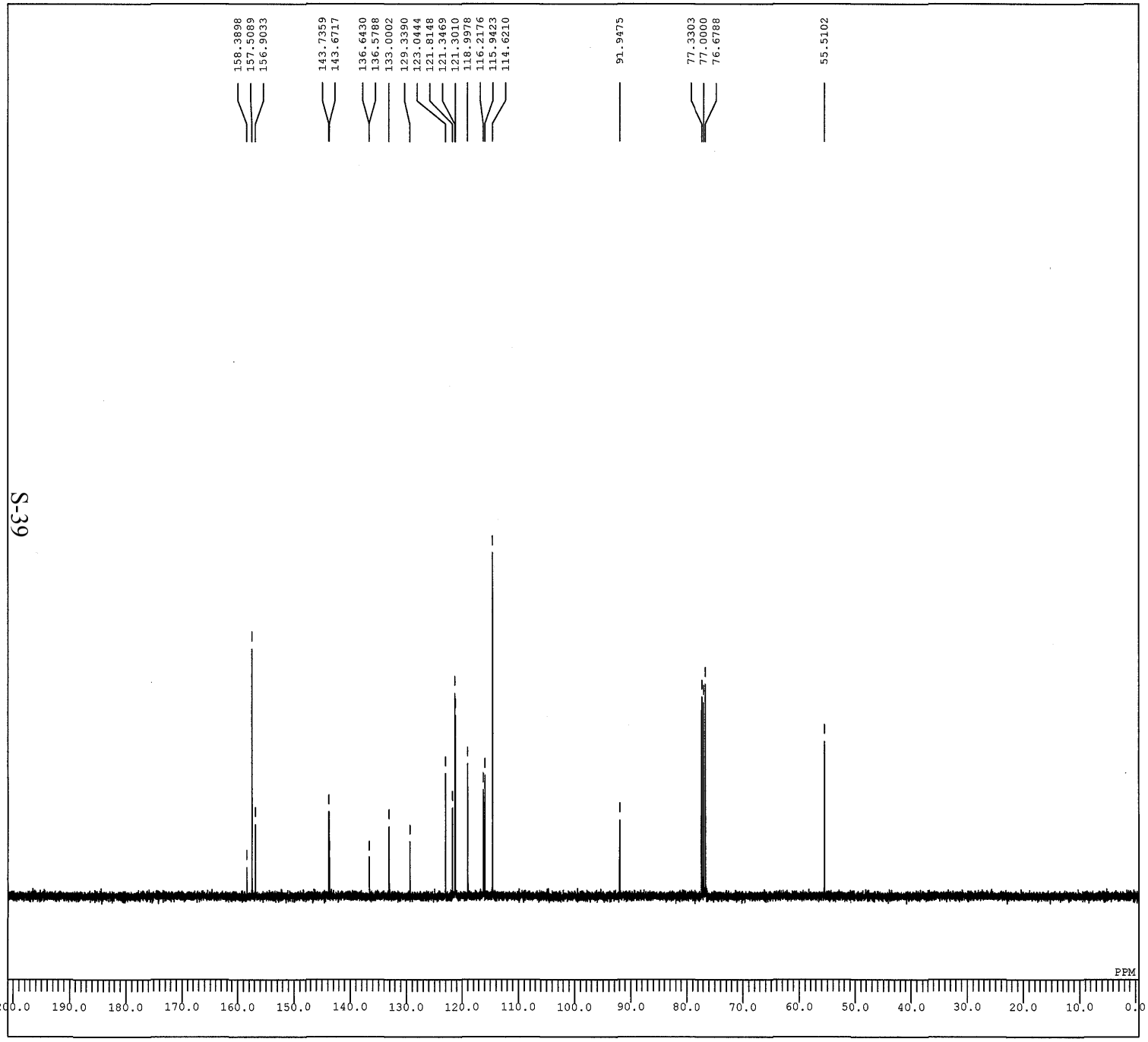

4na
sun 1220 6-Cl indole DPPA-2-1.als
20-12-2013 23:23:37
13C
carbon.jxp
100.71 MHz
41.64 kHz
8.74 Hz
32767
29620.85 Hz
1.1063 sec
2.0000 sec
3.00 usec
1H
21.0 c
CDCl3
77.00 ppm
0.12 Hz
60
C:\Documents and Settings\Administrator\ffjfXfNfgfbf\MGoussi\Sun\DPPA\sun 1220 6-Cl indole DPPA-2-1.als
PPM



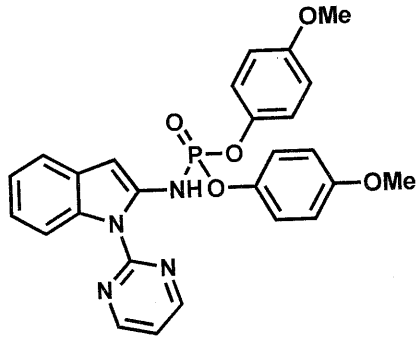

```
DFILE  sun 0113 indole (4-OMeO)2P(O)-1-1.als
COMNT
DATIM  13-01-2014 21:57:18
OBNUC  1H
EXMOD  proton.jxp
OBFRQ        391.78 MHz
OBSET          8.51 KHz
OBFIN          3.34 Hz
POINT         16384
FREQU       7348.62 Hz
SCANS            12
ACQTM         2.2295 sec
PD            5.0000 sec
PW1             5.25 usec
IRNUC  1H
CTEMP          25.0 c
SLVNT  CDCL3
EXREF          0.00 ppm
BF             0.12 Hz
RGAIN            30
```



4ab

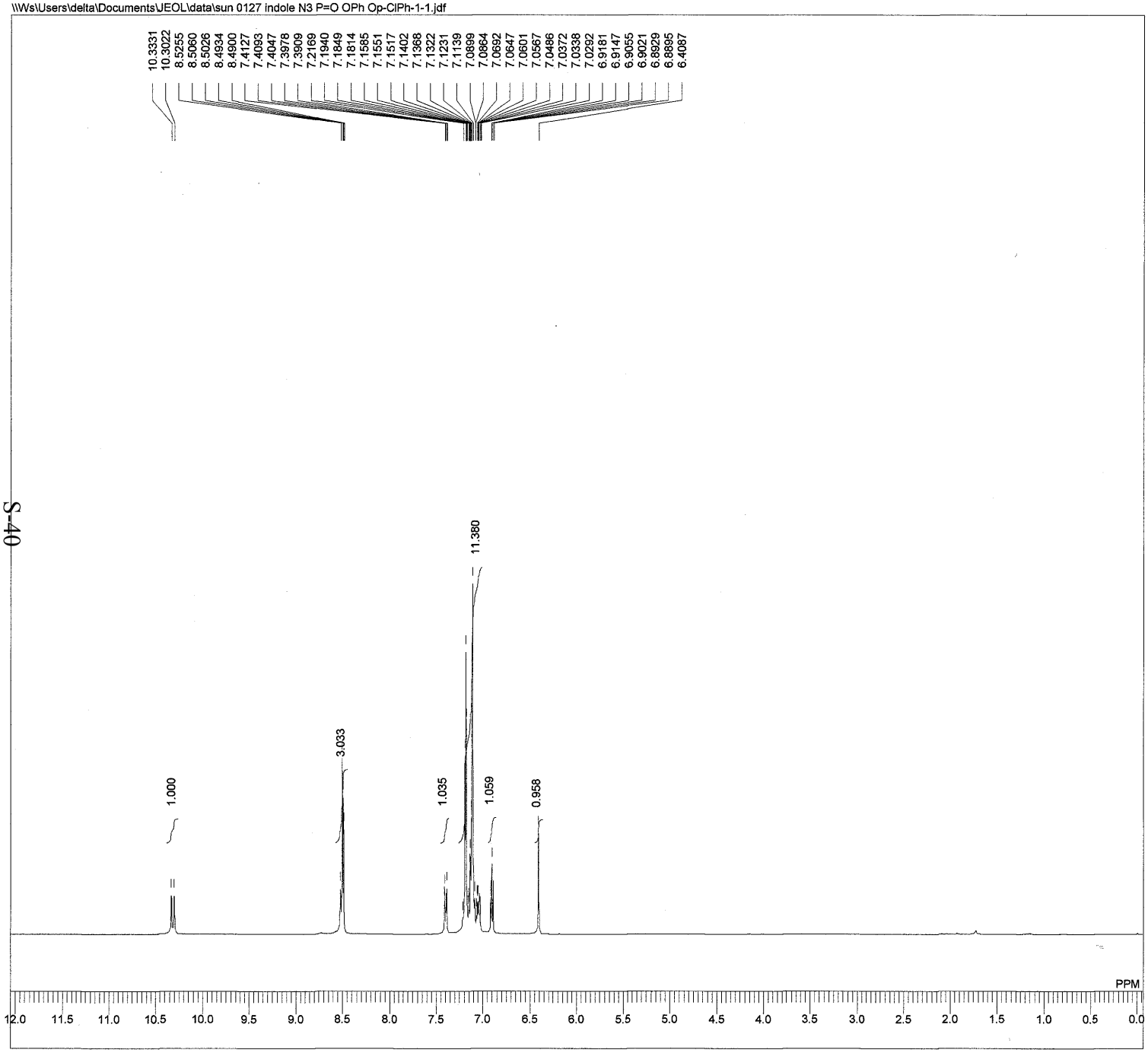



```
DFILE  sun 0113 indole (4-OMeO)2P(O)-2-1.als
COMNT
DATIM  13-01-2014 21:59:58
OBNUC  13C
EXMOD  carbon.jxp
OBFRQ         98.52 MHz
OBSET          4.64 KHz
OBFIN          8.74 Hz
POINT         32767
FREQU      29620.85 Hz
SCANS           155
ACQTM         1.1062 sec
PD            2.0000 sec
PW1             3.00 usec
IRNUC  1H
CTEMP          25.0 c
SLVNT  CDCL3
EXREF          77.00 ppm
BF              0.12 Hz
RGAIN             60
```

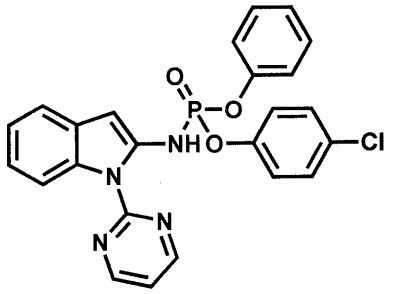


4ab

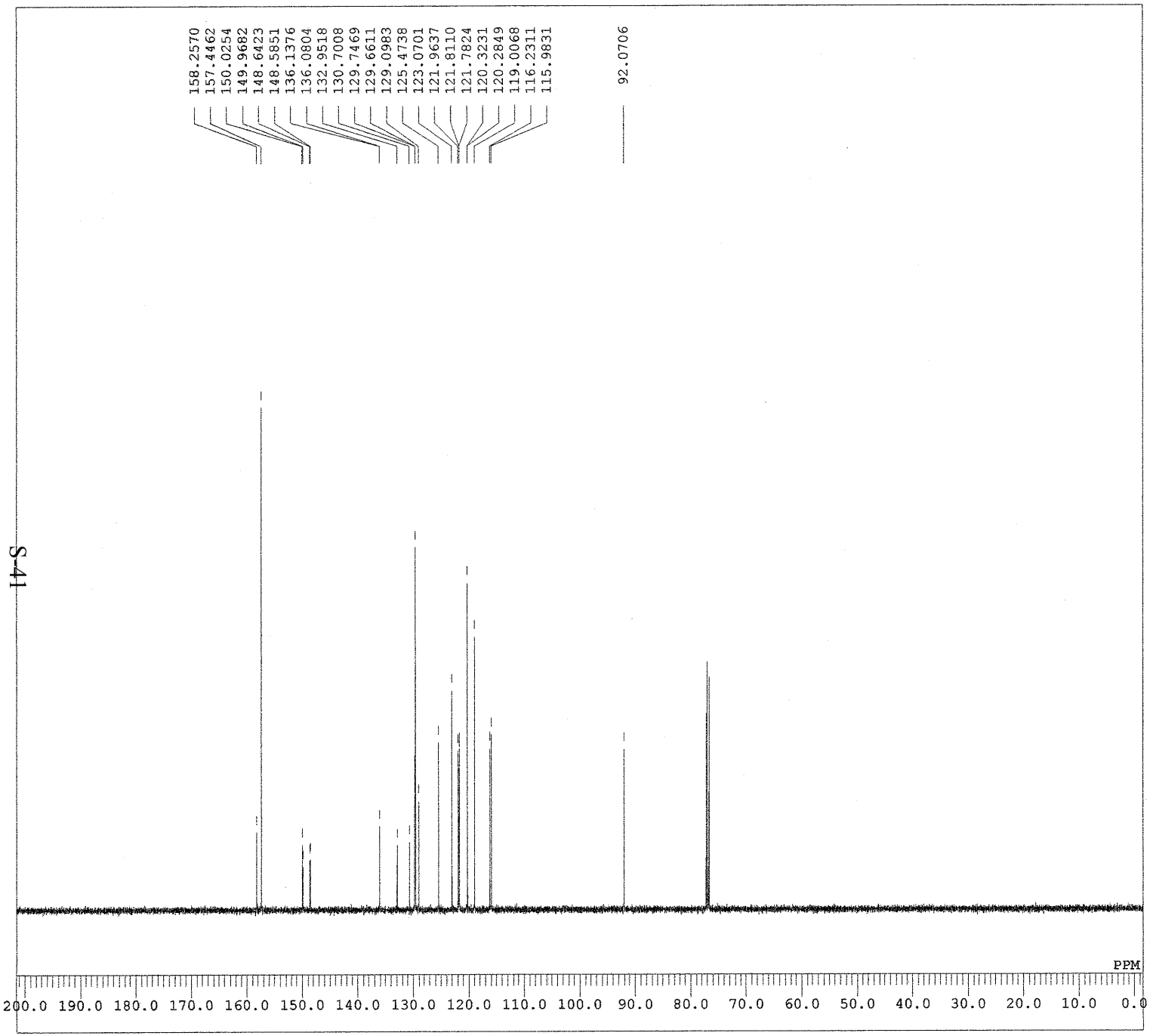
\\Ws\Users\delta\Documents\JEOL\data\sun 0127 indole N3 P=O OPh Op-ClPh-1-1.jdf



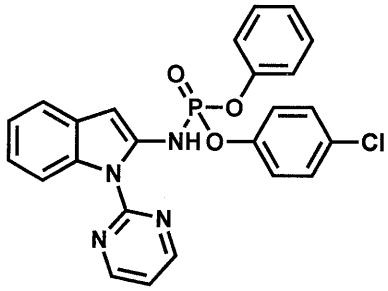
DFILE	sun 0127 indole N3 P=O OPh Op-ClPh-1-1.jdf
COMNT	
DATIM	27-01-2015 18:13:29
OBNUC	1H
EXMOD	proton.jxp
OBFRQ	391.78 MHz
OBSET	8.51 KHz
OBFIN	3.34 Hz
POINT	16384
FREQU	7348.62 Hz
SCANS	8
ACQTM	2.2295 sec
PD	5.0000 sec
PW1	6.50 usec
IRNUC	1H
CTEMP	460.0 c
SLVNT	CDCL3
EXREF	0.00 ppm
BF	0.12 Hz
RGAIN	26



4ac



DFILE	sun 0127 indole N3 P=O OPh Op-ClPh-1-
COMNT	
DATIM	2015-01-27 18:09:19
OBNUC	13C
EXMOD	carbon.jxp
OBFRQ	125.77 MHz
OBSET	7.87 KHz
OBFIN	4.21 Hz
POINT	32767
FREQU	39308.18 Hz
SCANS	216
ACQTM	0.8336 sec
PD	2.0000 sec
PW1	3.40 usec
IRNUC	1H
CTEMP	23.7 c
SLVNT	CDCL3
EXREF	77.00 ppm
BF	0.12 Hz
RGAIN	60



4ac