Synthesis of Pyridinylpyrrole Derivatives via the Palladium-Catalyzed Reaction of Acetylpyridines with Methyleneaziridines

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Alternative Mechanism.

One referee suggested the following mechanism. Alper has previously demonstrated[1] that N-butylmethyleneaziridine is transformed into 1-*n*-butyl-3-methyleneazetidin-2-one in the presence of catalytic Pd(0) under an atmosphere of CO via Pd-mediated insertion of CO into the sp^2 C-N bond. This transformation likely occurs via oxidative addition of the methyleneaziridine to Pd(0) to afford an exo-methylene azametallacyclobutane, which undergoes subsequent insertion of CO and reductive elimination to afford the product. The reaction described by the authors could therefore occur through a related mechanism involving initial oxidative addition of methyleneaziridine sp^2 C-N bond to Pd(0) [rather than C-H activation]. This would provide and azametallacyclobutane that could react with the acetophenone, undergoing a proton transfer/sigma bond metathesis between the C-H bond and the Pd-N bond to afford a vinylpalladium enolate species. Reductive elimination would lead to a 1-vinylacetophenone bearing a methyleneamino substituent. Intramolecular condensation of the nitrogen with the carbonyl followed by tautomerization would provide the observed product.

Accordingly, we carried out the NMR experiments. We have checked the reactions of acetophenone **9** and benzylaziridine **3a** with $Pd(PPh_3)_4$ in deuteriotoluene in an NMR tube separately. We have failed to observe any interaction between **3a** and palladium

even after prolonged heating at 110 °C. On the other hand, after overnight heating of the deuteriotoluene solution containing an equivalent amount of **9** and palladium, formation of some new product has been detected (approximately 1% yield). The reaction was accompanied with the decomposition of palladium yielding Pd mirror on the NMR tube. The ^{1}H and ^{13}C NMR spectra of this new product resembled closely those of **9** (the signal in the aliphatic region of the NMR spectra belonged to a CH_3 group as shown by DEPT experiments), but its extremely low concentration precluded the accurate structure elucidation. Thus, the NMR experiments suggested that **9** is more reactive towards the catalyst compared to **3a** that is consistent with the C–H activation mechanism of the whole transformation. Furthermore, as mentioned later in eq 3 of the text, we have obtained a strong support for the hydropalladation mechanism.

_d_-Content of the recovered 9-d_3

A reviewer pointed that some loss of deuterium would be observed in the recovered deuterated acetophenone. We investigated the d-content at methyl position of the recovered **9-d_3**, and found that it was 55%. This result supports that the equilibrium between **9-d_3** and **13** shown in eq 3 exists really in the addition reaction.

General. Spectroscopic measurements were carried out with the following instruments: JEOL JNM AL-400 and JEOL α-500 (^{1}H NMR, ^{13}C NMR), SHIMADZU FTIR-8200A (FT-IR), HITACHI M-2500s (HRMS). All Chemicals were purchased from Aldrich Chemical Company. All methyleneaziridines were prepared following the reported procedure.[2]

The Preparation of 1d as a representative procedure for the synthesis of pyridinylpyrroles. To the mixture of $Pd(PPh_3)_4$ (104.0 mg, 0.09 mmol) and acetylpyriidne **4a** (67 μl, 0.6 mmol) was added methyleneaziridine **3d** (49.5 mg, 0.3 mmol) under Ar atmosphere in a pressure vial and the mixture was stirred at 120 °C for 3 days. After completion of the reaction, which was monitored by GC, the mixture was filtered through a short Florisil column with ethyl acetate as eluent. Purification of the crude product with Florisil column chromatography (hexane : ethylacetate = 20 : 1) afforded the pyridinylpyrrole **1d** in 87% yield.

General experimental procedure for the preparation of 10 as an authentic sample.[3a] To a solution of LDA, prepared from diisopropylamine (0.588 g, 5 mmol) and *n*-butyllithium (1.6 M hexane solution, 3.1 ml, 5 mmol) in THF was added $TMSCHN_2$[3b] (1.56 M hexane solution, 3.2 ml, 5 mmol) at -78 °C under an Ar atmosphere. After

stirring for 30 min, a solution of 1-(dibenzylamino)-2-propanone[3c] (1.013 g, 4 mmol), prepared from 1-chloro-2-propanone (0.930 g, 10 mmol), dibenzylamine (0.977 g, 5 mmol), and Et_3N (0.611 g, 6 mmol) in THF, was added and the whole mixture was stirred at -78 °C for 3 h, then heated under reflux for 2 h. The reaction mixture was cooled to ambient temperature and 50 ml of cold water was added. The mixture was filtered off and the filtrate was extracted with benzene twice. The combined organic layer was dried over magnesium sulphate. The solvent was evaporated and the residue was used without further purification in the next step. The mixture of residue and manganese dioxide (3.476 g, 40 mmol) in dichloromethane (40 ml) was heated under reflux for 3 h to give **10**.

Reference

(1) Hamel, N.; Alper, H. *Tetrahedron Lett*. **1987**, *28*, 3237.

(2) Preparation of methyleneaziridines: (a) De Kimpe, N.; De Smaele, D.; Sakonyi, Z. *J. Org. Chem.* **1997**, *62*, 2448. (b) Ince, J.; Ross, T. M.; Slawin, A. M. Z.; Ennis, D. S. *Tetrahedron* **1996**, *52*, 7037.

(3) For authentic sample preparation, (a) Ogawa, H.; Aoyama, T.; Shioiri, T. *Heterocycles* **1996**, *42*, 75. (b) Miwa, K.; Aoyama, T.; Shioiri, T. *Synlett* **1994**, 109. (c) Stratford, E.; Curley, R. W. *J. Med. Chem.* **1983**, *26*, 1463.

2-Pyridinyl-(1-Benzyl-4-methyl)pyrrole (1a). IR (neat) 3384, 3063, 3030, 2925, 2868, 1947, 1589, 1560, 1501, 1477, 1402, 1348, 1284, 1259, 1216, 1178, 1152, 1136, 1090, 1076, 1027, 1001, 985, 777, 735 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ 2.11 (s, 3H), 5.68 (s, 2H), 6.44 (s, 1H), 6.55 (s, 1H), 6.99 (t, *J* = 6.2 Hz, 1H), 7.00 (d, *J* = 7.0 Hz, 2H), 7.16-7.24 (m, 3H), 7.42-7.46 (m, 1H), 7.54-7.60 (m, 1H), 8.47 (d, *J* = 4.5 Hz, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 11.80, 51.54, 112.42, 118.87, 120.09, 121.27, 124. 07, 126.89, 127.14, 127.22, 128.33, 128.72, 131.73, 136.18, 139.67, 148.44, 152.55; Anal. Calcd for $C_{17}H_{16}N_2$ (248.32): C, 82.22; H, 6.49; N, 11.28. Found: C, 82.08; H, 6.51; N, 11.10. HRMS (EI) Calcd for $C_{17}H_{16}N_2$: m/z 248.3224. Found: m/z 248.1308.

2-Pyridinyl-[4-Methyl-1-(1-phenyl-ethyl)]pyrrole (1b). IR (neat) 3864, 3842, 3817, 3748, 3689, 3670, 3633, 2918, 2848, 2355, 1719, 1696, 1653, 1590, 1501, 1437, 1390, 1187, 1152, 1090, 1019, 778, 738 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.79 (d, *J* = 6.8 Hz, 3H), 2.10 (s, 3H), 6.38 (s, 1H), 6.66 (s, 1H), 6.80 (q, *J* = 7.2 Hz, 1H), 6.99-7.02 (m, 1H), 7.09-7.25 (m, 5H), 7.40 (d, *J* = 8.0 Hz, 1H), 7.53-7.57 (m, 1H), 8.51 (d, *J* = 4.8 Hz, 1H); ^{13}C NMR ($CDCl_3$**,** 100 MHz) δ 12.05, 21.74, 54.22, 112.38, 112.39, 118.66, 119.79, 120.05, 121.80, 126.15, 126.68, 128.17, 136.05, 143.99, 148.42; Anal. Calcd for $C_{18}H_{18}N_2$ (262.35): C, 82.41; H, 6.92; N, 10.68. Found: C, 82.63; H, 7.09; N, 10.57. HRMS (EI) Calcd for $C_{18}H_{18}N_2$: m/z 262.3490. Found: m/z 262.1465.

2-Pyridinyl-(1-Hexyl-4-methyl)pyrrole (1c). IR (neat) 3876, 3845, 3828, 3810, 3774, 3696, 3682, 3660, 3348, 3070, 2955, 2925, 2855, 2361, 1726, 1589, 1501, 1452, 1433, 1312, 1261, 1201, 1153, 1119, 1089, 1027, 854, 778, 742, 720 cm^{-1}; ^1H NMR ($CDCl_3$,

400 MHz) δ0.84 (t, *J* = 7.1 Hz, 3H), 1.21-1.23 (m, 6H), 1.65-1.67 (m, 2H), 2.11 (s, 3H), 4.36 (t, *J* = 8.4 Hz, 2H), 6.37 (s, 1H), 6.55 (s, 1H), 7.00-7.03 (m, 1H), 7.46 (d, *J* = 6.2 Hz, 1H), 7.57-7.61 (m, 1H), 8.51 (d, *J* = 4.4 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ11.83, 14.07, 22.57, 26.42, 31.40, 31.82, 48.52, 111.91, 117.96, 119.83, 121.17, 123.55, 131.17, 135.94, 148.43, 152.76; Anal. Calcd for $C_{16}H_{22}N_2$ (242.36): C, 79.29; H, 9.15; N, 11.56. Found: C, 79.14; H, 9.44; N, 11.37. HRMS (EI) Calcd for $C_{16}H_{22}N_2$: m/z 242.3594. Found: m/z 242.1778.

2-Pyridinyl-[1-(1-Cyclohexyl-ethyl)-4-methyl]pyrrole (1d). IR (neat) 2956, 2925, 2855, 1621, 1538, 1506, 1455, 1375, 1322, 1272, 1219, 1145, 1118, 1031, 898, 860, 789, 754 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ0.63-0.73 (m, 1H), 0.84-0.88 (m, 1H), 0.90-1.07 (m, 2H), 1.15-1.20 (m, 2H), 1.44-1.54 (m, 6H), 1.67-1.75 (m, 2H), 2.12 (s, 3H), 4.97 (q, *J* = 6.8 Hz, 1H), 6.25 (s, 1H), 6.65 ((s, 1H), 7.03 (t, *J* = 7.2 Hz, 1H), 7.42 (d, *J* = 7.9 Hz, 1H), 7.60 (d, *J* = 7.6 Hz, 1H), 8.53 (d, *J* = 4.9 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 12.09, 19.25,26.22, 26.35, 29.60, 29.94, 45.50, 56.13, 111.13, 111.15, 118.46, 118.63, 119.92, 122.20, 135.95, 148.55; Anal. Calcd for $C_{18}H_{24}N_2$ (268.40): C, 80.55; H, 9.01 N, 10.44 Found: C, 80.32; H, 9.29; N, 10.39. HRMS (EI) Calcd for $C_{18}H_{24}N_2$: m/z 268.3966. Found: m/z 268.2934.

2-Pyridinyl-{1-[1-(4-Chloro-phenyl)-ethyl]-4-methyl}pyrrole (1e). IR (neat) 3388, 3047, 2925, 2856, 1709, 1589, 1561, 1502, 1447, 1408, 1350, 1284, 1259, 1177, 1153, 1135, 1091, 1015, 805, 778 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 2.04 (s, 3H), 5.59 (s, 2H), 6.46 (s, 1H), 6.47 (s, 1H), 6.92 (d, *J* = 7.8 Hz, 3H), 7.11 (d, *J* = 6.4 Hz, 2H), 7.38 (d, *J* = 7.9 Hz, 1H), 7.47-7.52 (m, 1H), 8.38 (d, *J* = 4.6 Hz, 1H), ; ^{13}C NMR ($CDCl_3$, 100 MHz) δ 11.86, 51.11, 112.47, 119.02, 120.09, 121.06, 123.94, 128.20, 128.39, 131.55, 132.53, 136.07, 138.24, 148.36, 152.38; Anal. Calcd for $C_{18}H_{15}ClN_2$ (282.77): C, 72.21; H, 5.35; Cl, 12.54; N, 9.91. Found: C, 72.49; H, 5.39; N, 9.75. HRMS (EI) Calcd for $C_{17}H_{15}ClN_2$: m/z 282.7672. Found: m/z 282.7918.

2-Pyridinyl-[1-(2,2-Dimethoxy-ethyl)-4-methyl]pyrrole (1f). IR (neat) 3348, 2930, 2834, 2360, 1707, 1590, 1560, 1502, 1447, 1387, 1316, 1284, 1262, 1193, 1125, 1076, 1027, 980, 921, 842, 779, 741 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ 2.11 (s, 3H), 3.35 (s, 6H), 4.46 (d, *J* = 5.3 Hz, 2H), 4.66 (t, *J* = 5.1 Hz, 1H), 6.42 (s, 1H), 6.61 (s, 1H), 7.03 (t, *J* = 4.2 Hz, 1H), 7.50 (d, *J* = 7.5 Hz, 1H), 7.60 (t, *J* = 7.3 Hz, 1H), 8.49 (d, *J* = 4.9 Hz, 1H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 11.72, 50.73, 55.06, 105.02, 112.27, 118.23, 119.93, 121.06, 125.32, 136.19, 148.26, 152.58; Anal. Calcd for $C_{14}H_{18}N_2O_2$ (246.30): C, 68.27;

H, 7.37; N, 11.37; O, 12.99. Found: C, 67.98; H, 7.53; N, 11.07. HRMS (EI) Calcd for $C_{14}H_{18}N_2O_2$: m/z 246.3050. Found: m/z 246.1363.

2-Pyridinyl[1-(3-Methoxy-propyl)-4-methyl]pyrrole (1g). IR (neat) 3336, 2925, 2872, 1699, 1588, 1572, 1501, 1437, 1407, 1290, 1200, 1117, 996, 904, 788, 759 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ1.92-1.98 (m, 2H), 2.11 (s, 3H), 3.27-3.30 (m, 5H), 4.47 (t, *J* = 7.2 Hz, 2H), 6.40 (s, 1H), 6.55 (s, 1H), 7.01 (t, *J* = 4.3 Hz, 1H), 7.47 (d, *J* = 7.1 Hz, 1H), 7.60 (t, *J* = 7.2 Hz, 1H), 8.51 (d, *J* = 4.4 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ11.79, 31.70, 45.51, 58.43, 69.63, 112.08, 118.00, 119.82, 120.97, 124.09, 131.12, 135.09, 148.47, 152.65; Anal. Calcd for $C_{14}H_{18}N_2$ (230.31): C, 73.01; H, 7.88; N, 12.16; O, 6.95. Found: C, 73.15; H, 7.59; N, 12.18. HRMS (EI) Calcd for $C_{14}H_{18}N_2O$: m/z 230.3056. Found: m/z 230.2414.

2-Pyridinyl[4-Methy-1-(1-phenyl-ethyl)]pyrrole (1h). IR (neat) 3864, 3842, 3817, 3748, 3689, 3670, 3633, 2918, 2848, 2354, 1719, 1696, 1653, 1590, 1501, 1437, 1390, 1187, 1152, 1090, 1019, 778, 738 cm^{-1}; ^1H NMR ($CDCl_3$, 300 MHz) δ1.78 (d, *J* = 9.5 Hz, 3H), 2.15 (s, 3H), 5.34 (q, *J* = 9.2 Hz, 1H), 6.11 (s, 1H), 6.71 (s, 1H), 6.99 (d, *J* = 9.0 Hz, 2H), 7.20-7.30 (m, 4H), 7.50 (d, *J* = 7.8 Hz, 1H), 8.47-8.53 (m, 2H); ^{13}C NMR

($CDCl_3$, 100 MHz) δ12.05, 21.73, 54.21, 112.38, 112.39, 118.66, 119.79, 120.06, 121.79, 126.15, 126.68, 128.17, 136.05, 143.98, 148.46; Anal. Calcd for $C_{18}H_{18}N_2$ (262.35): C, 82.41; H, 6.92; N, 10.68. Found: C, 82.17; H, 7.05; N, 10.54. HRMS (EI) Calcd for $C_{18}H_{18}N_2$: m/z 262.1465. Found: m/z 262.1464.

2-Pyridinyl[Methyl-1-(1-phenyl-ethyl)]pyrrole (1i). IR (neat) 3086, 3061, 3027, 2978, 2928, 2871, 1951, 1878, 1735, 1697, 1586, 1564, 1496, 1450, 1421, 1385, 1352, 1296, 1241, 1210, 1181, 1138, 1105, 1072, 1047, 1027, 1000, 969, 937, 913, 877, 845, 794, 743, 715 cm^{-1}; ^1H NMR ($CDCl_3$, 500 MHz) δ1.79 (d, J = 7.0 Hz, 3H), 2.14 (s, 3H), 5.49 (q, J = 7.0 Hz, 1H), 6.21 (s, 1H), 6.73 (s, 1H), 7.04 (d, J = 8.0 Hz, 2H), 7.15 (d, J = 4.5 Hz, 2H), 7.22-7.31 (m, 3H), 8.49 (d, J = 4.5 Hz, 2H). ^{13}C NMR ($CDCl_3$, 125 MHz) δ11.91, 22.48, 54.79, 112.14, 119.57, 119.65, 122.65, 125.60, 127.30, 128.67, 131.92, 140.90, 143.24, 149.70; Anal. Calcd for $C_{18}H_{18}N_2$ (262.35): C, 82.09; H, 7.27; N, 10.64. Found: C, 81.93; H, 6.99; N, 10.39. HRMS (EI) Calcd for $C_{18}H_{18}N_2$: m/z 262.3490. Found: m/z 262.2465.

2-etaneonyl-{6-[4-Methyl-1-(1-phenyl-ethyl)}pyrrole (1j). IR (neat) 3892, 3844, 3827, 3810, 3788, 3696, 3681, 3657, 3375, 2976, 2925, 2281, 1697, 1587, 1494, 1448, 1415, 1363, 1295, 1248, 1188, 1120, 1040, 1025, 954, 856, 796, 757 cm^{-1}; ^1H NMR ($CDCl_3$,

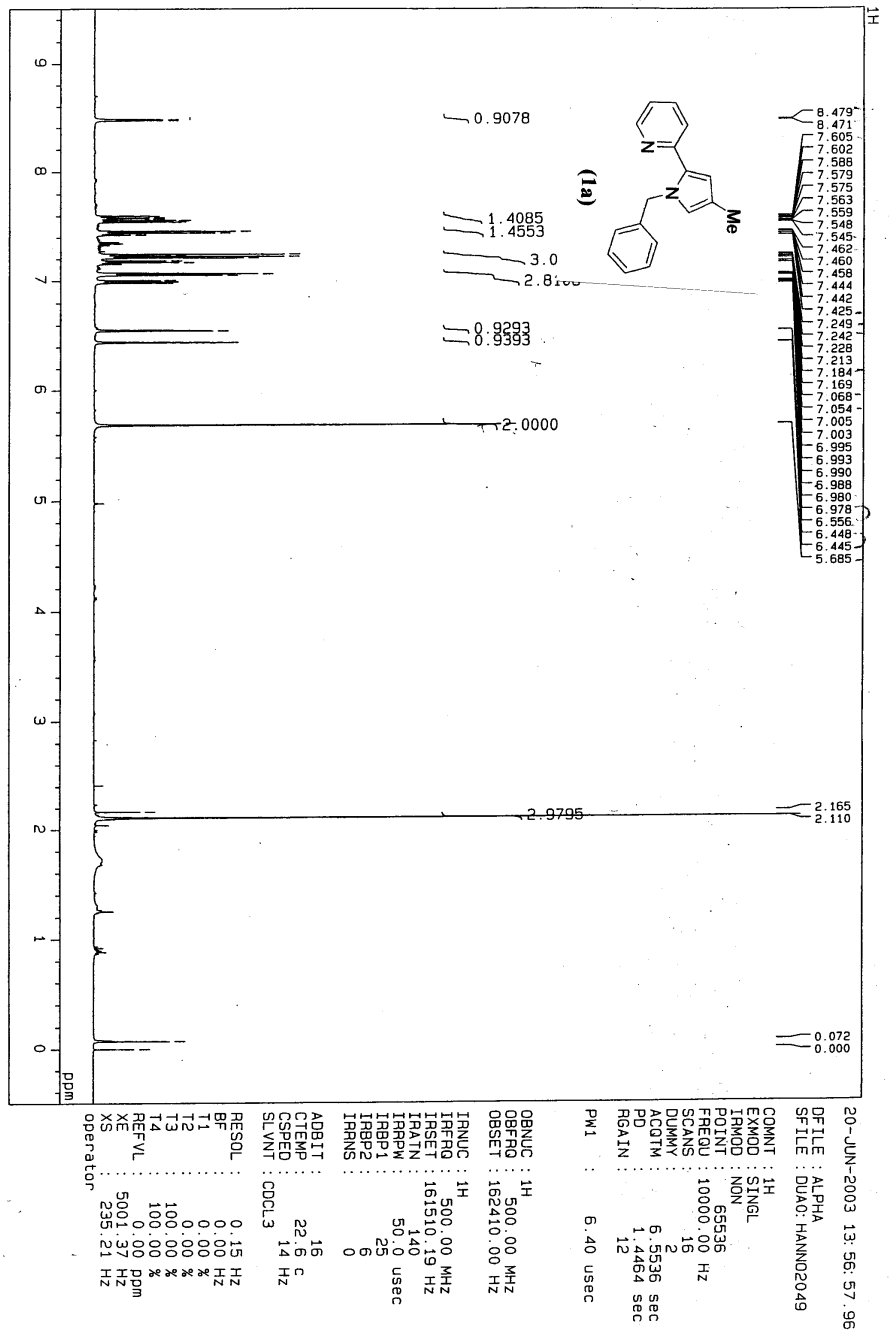
400 MHz) δ1.80 (d, J = 7.2 Hz, 3H), 2.04 (s, 3H), 2.48 (s, 3H), 6.41 (s, 1H), 6.56 (s, 1H), 6.82 (q, J = 5.1 Hz, 1H), 7.07 (d, J = 4.2 Hz, 2H), 7.13-7.22 (m, 3H), 7.57-7.71 (m, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ12.00, 14.20, 21.64, 22.72, 26.03, 54.41, 113.06, 117.95, 119.11, 120.76, 125.09, 126.19, 126.94, 128.32, 131.01, 137.09, 152.14, 152.28; Anal. Calcd for $C_{20}H_{20}N_2O$ (304.38): C, 78.92; H, 6.62; N, 9.20; O, 5.26. Found: C, 78.68; H, 6.87; N, 9.42. HRMS (EI) Calcd for $C_{20}H_{20}N_2O$: m/z 304.3854. Found: m/z 304.2570.

2-Pyrazinyl-[4-Methyl-1-(1-phenyl-ethyl)]pyrrole (1k). IR (neat) 3347, 3056, 2978, 2921, 1704, 1579, 1518, 1497, 1450, 1426, 1376, 1296, 1236, 1209, 1184, 1126, 1069, 1016, 973, 844, 785, 762, cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ1.80 (d, J = 7.2 Hz, 3H), 2.12 (s, 3H), 6.53 (s, 1H), 6.72-6.75 (m, 2H), 7.10 (d, J = 6.8Hz, 2H), 7.15-7.26 (m, 3H), 8.22 (s, 1H), 8.39 (s, 1H), 8.72 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ11.96, 21.89, 54.75, 113.58, 119.30, 121.65, 126.09,126.94,128.30, 139.90, 142.60, 143.18, 143.53; Anal. Calcd for $C_{17}H_{17}N_3$ (263.34): C, 77.54; H, 6.51 N, 15.96. Found: C, 77.27; H, 6.75; N, 15.92. HRMS (EI) Calcd for $C_{17}H_{17}N_3$: m/z 263.3371. Found: m/z 263.1417.

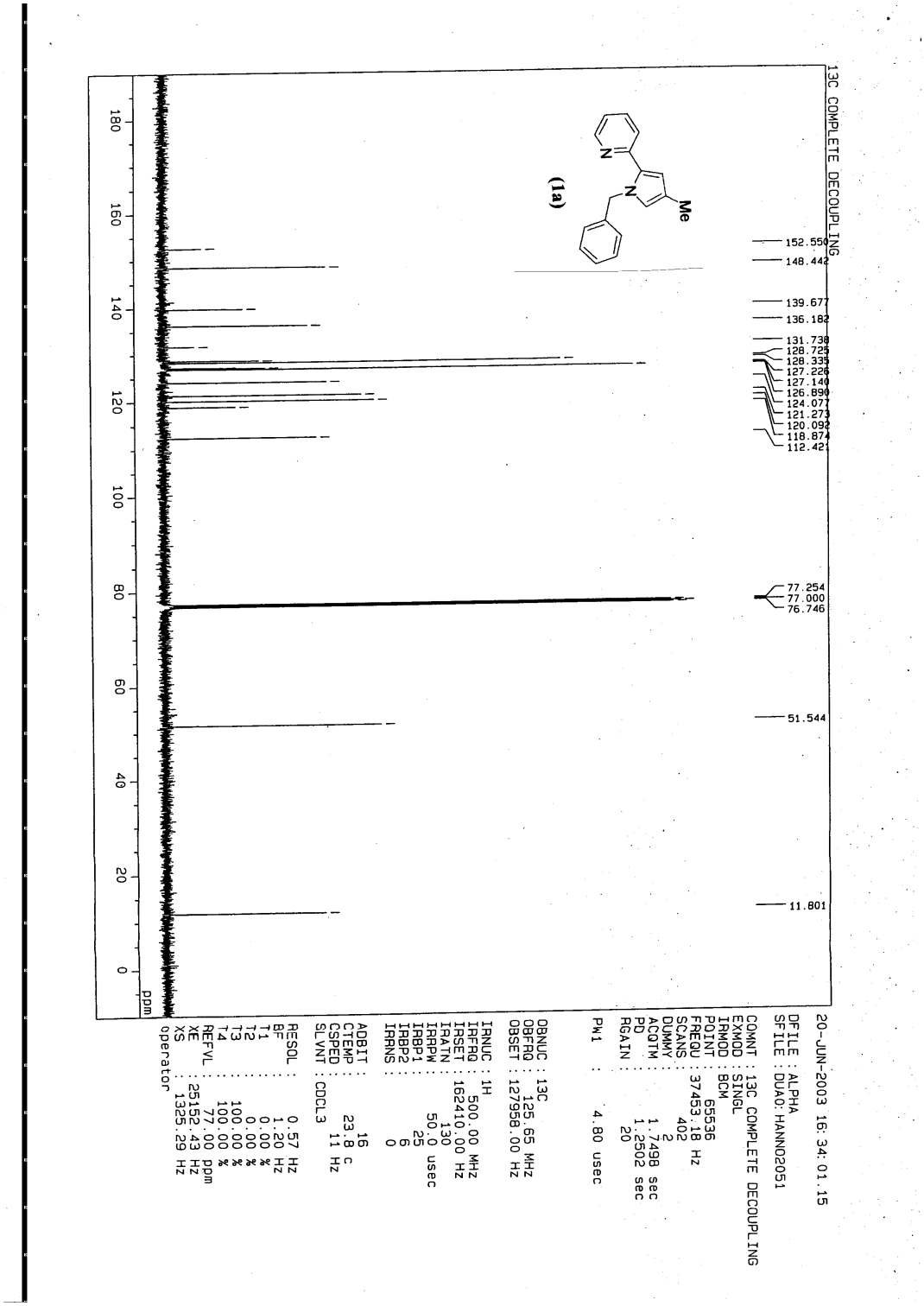
2-Arylyl-(4-methyl-2-benzyl)pyrrole (10). IR (neat) 3347, 3063, 3030, 2924, 2868, 1953, 1808, 1681, 1605, 1511, 1496, 1451, 1406, 1356, 1297, 1263, 1217, 1174, 1126,

1074, 1029, 972, 881, 785, 762, cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ2.06 (s, 3H), 4.99 (s, 2H), 6.03 (s, 1H), 6.43 (s, 1H), 7.16-7.24 (m, 10H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 11.98, 50.47, 110.18, 120.86, 126.46, 126.71, 127.15, 128.25, 128.54, 128.64, 133.29, 138.95; Anal. Calcd for $C_{18}H_{17}N$ (247.33): C, 87.41; H, 6.93; N, 5.66. Found: C, 87.57; H, 6.78; N, 5.51. HRMS (E1) Calcd for $C_{18}H_{17}N$: m/z 247.3343. Found: m/z 247.1356.

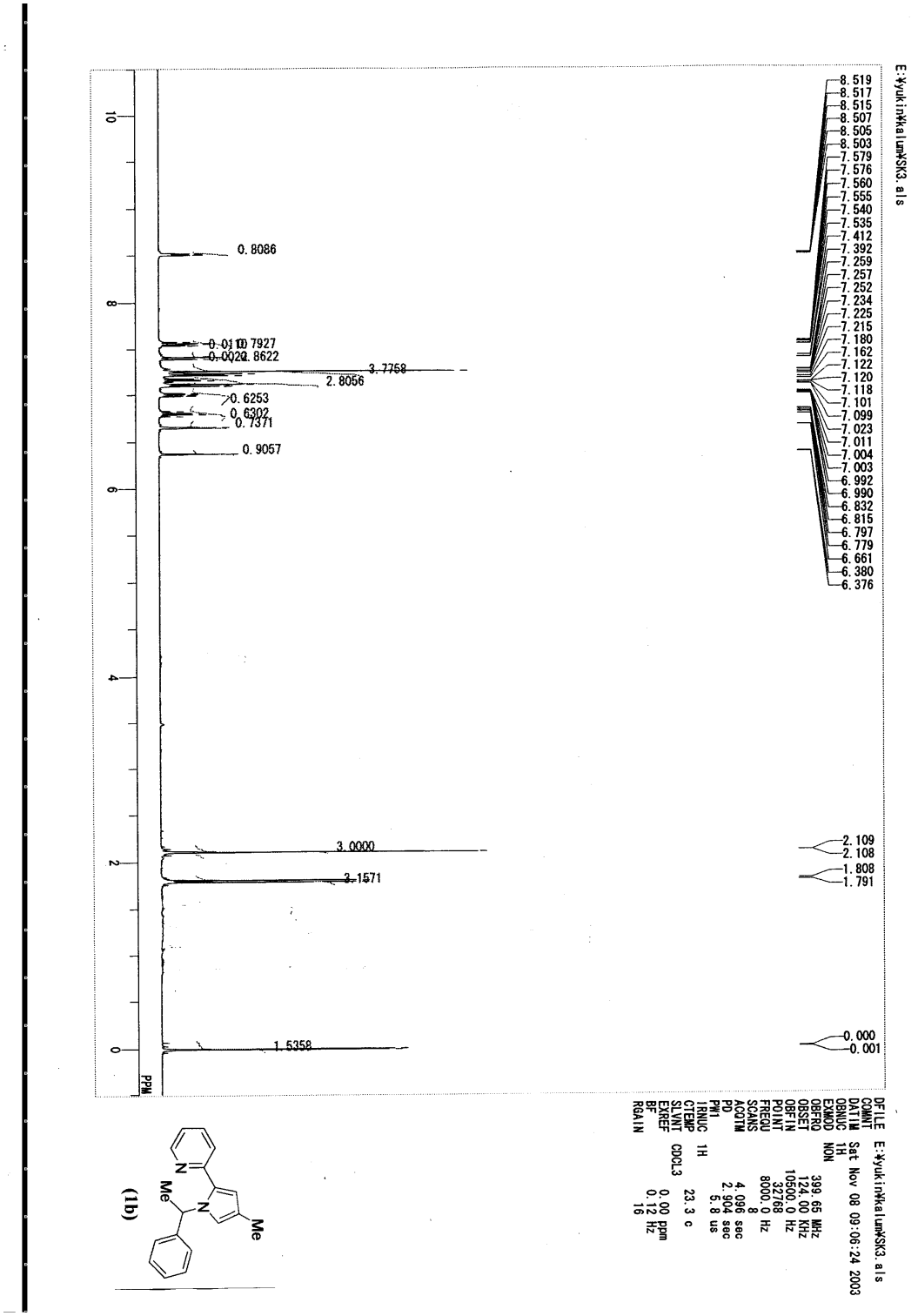
^{1}H-NMR of 2-Pyridinyl-(1-Benzyl-4-methyl)pyrrole (1a).



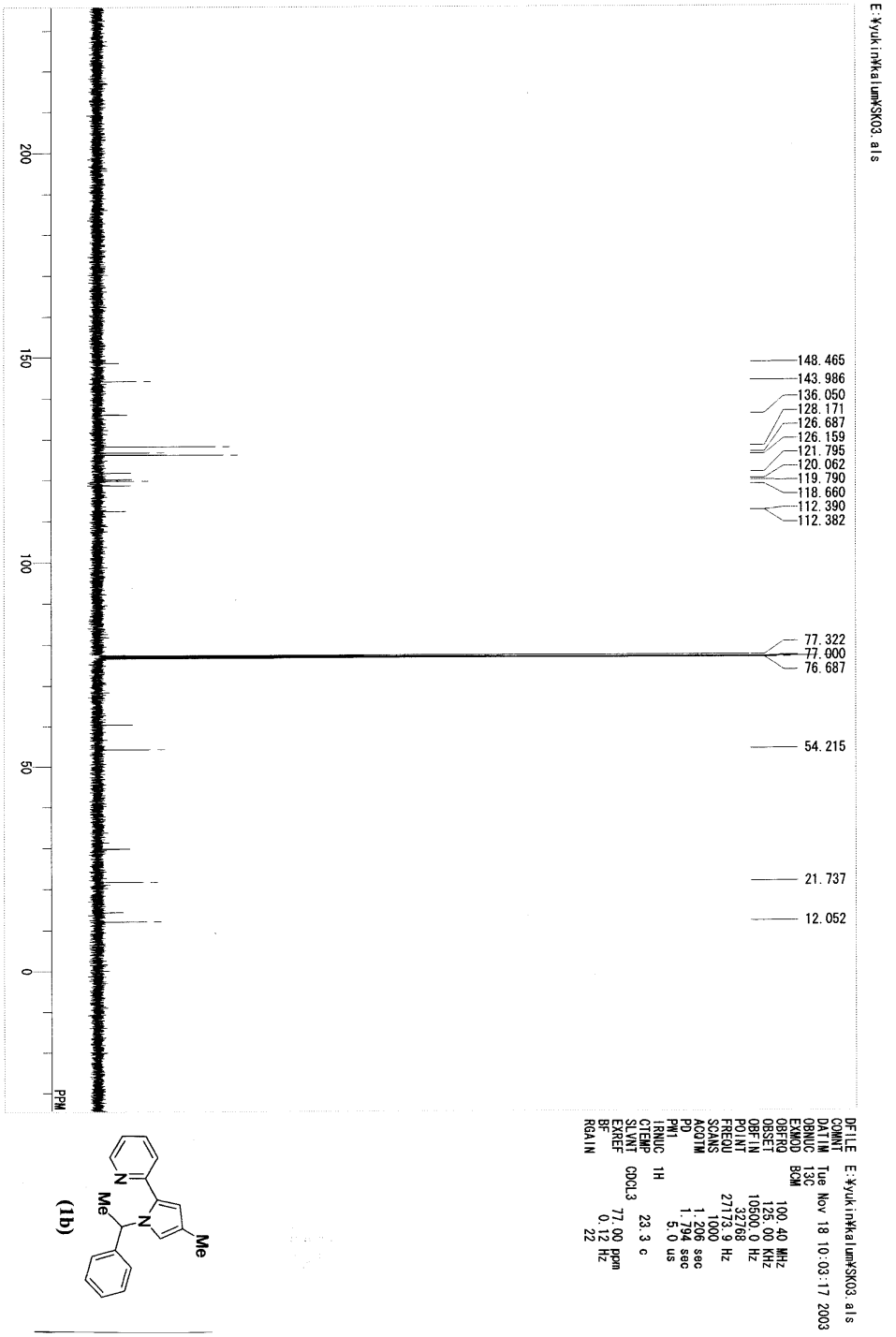
^{13}C-NMR of 2-Pyridinyl-(1-Benzyl-4-methyl)pyrrole (1a).



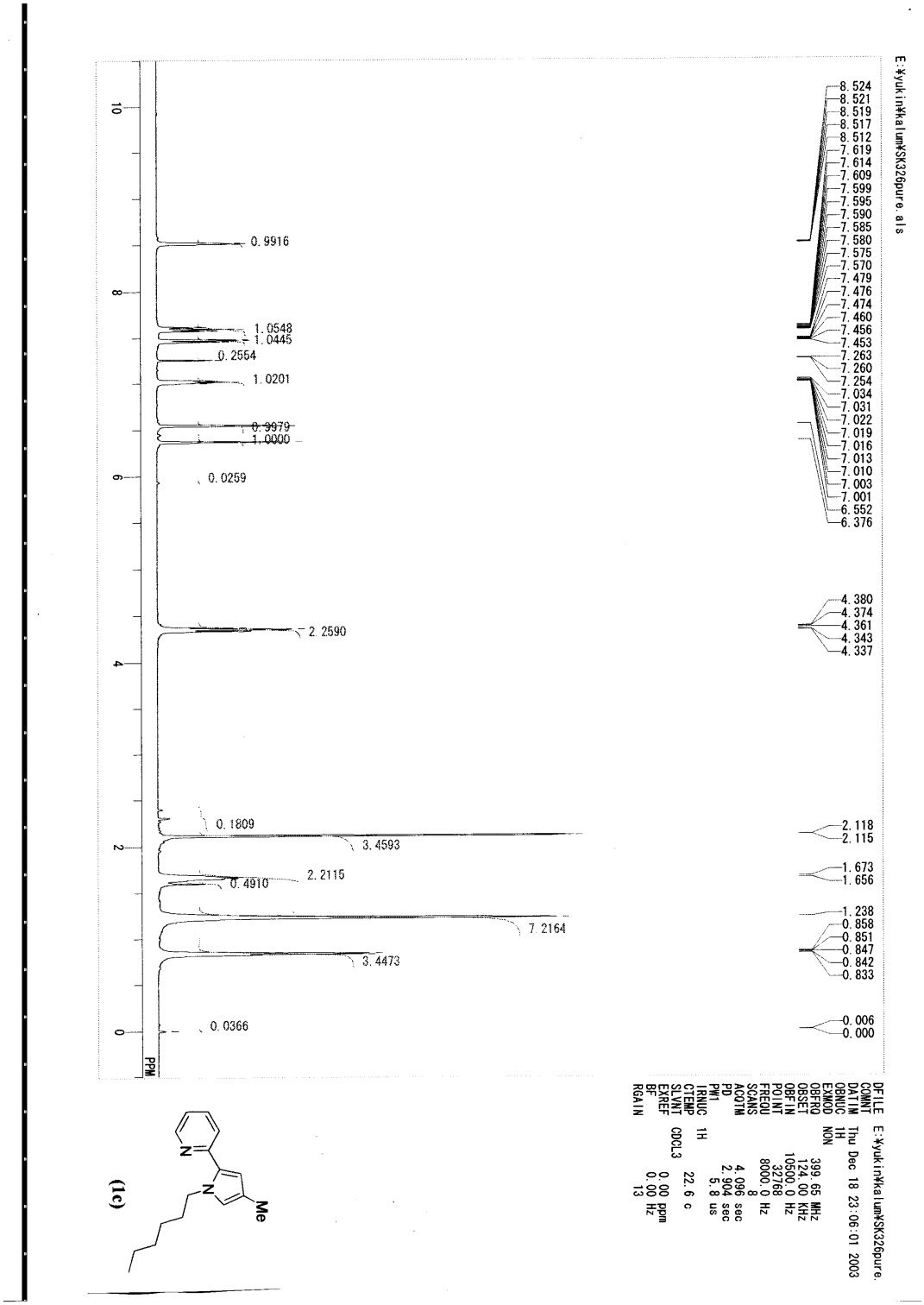
^{1}H-NMR of 2-Pyridinyl-[4-Methyl-1-(1-phenyl-ethyl)]pyrrole (1b).



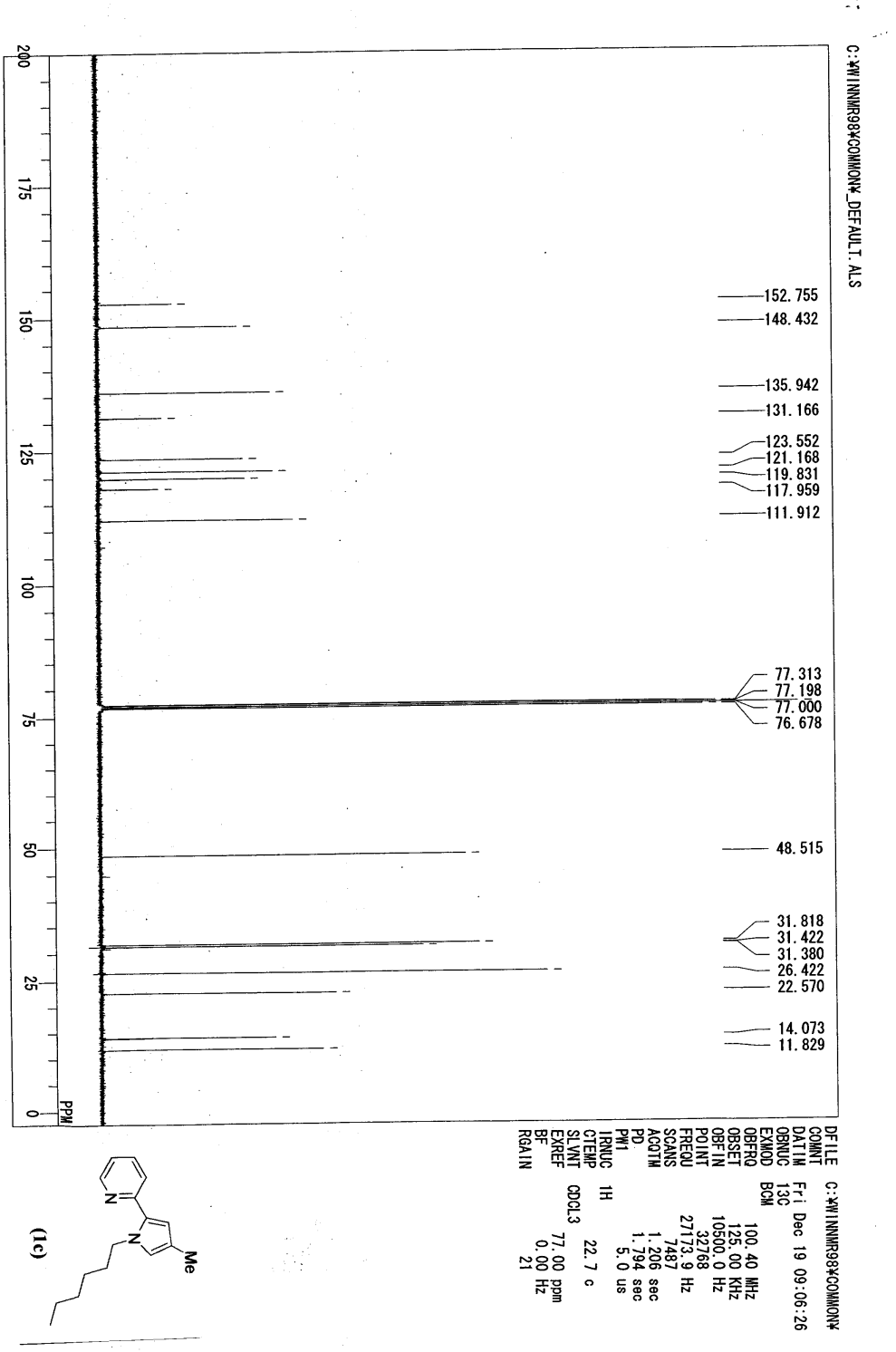
^{13}C-NMR of 2-Pyridinyl-[4-Methyl-1-(1-phenyl-ethyl)]pyrrole (1b).



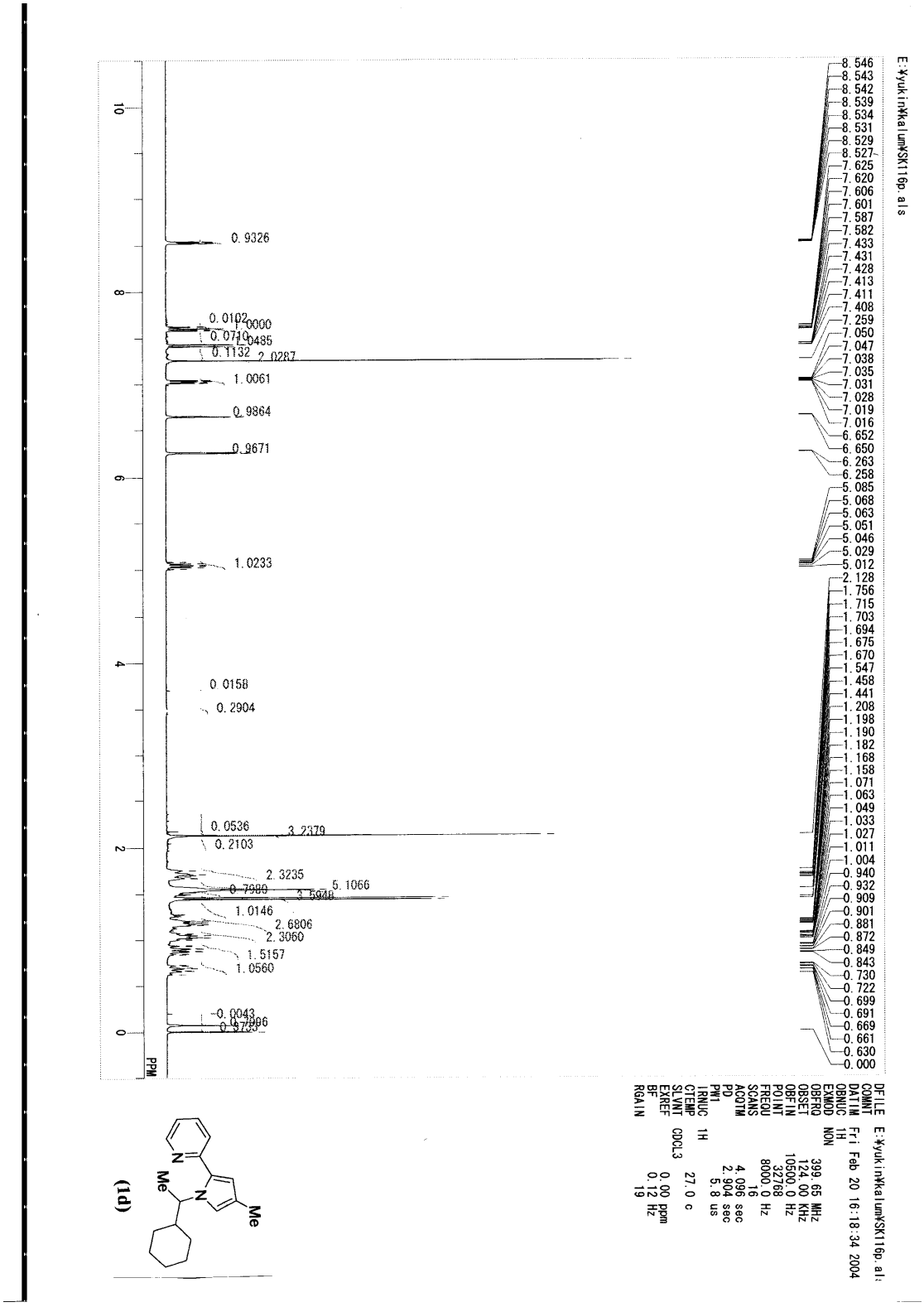
^{1}H-NMR of 2-Pyridinyl-(1-Hexyl-4-methyl)pyrrole (1c).



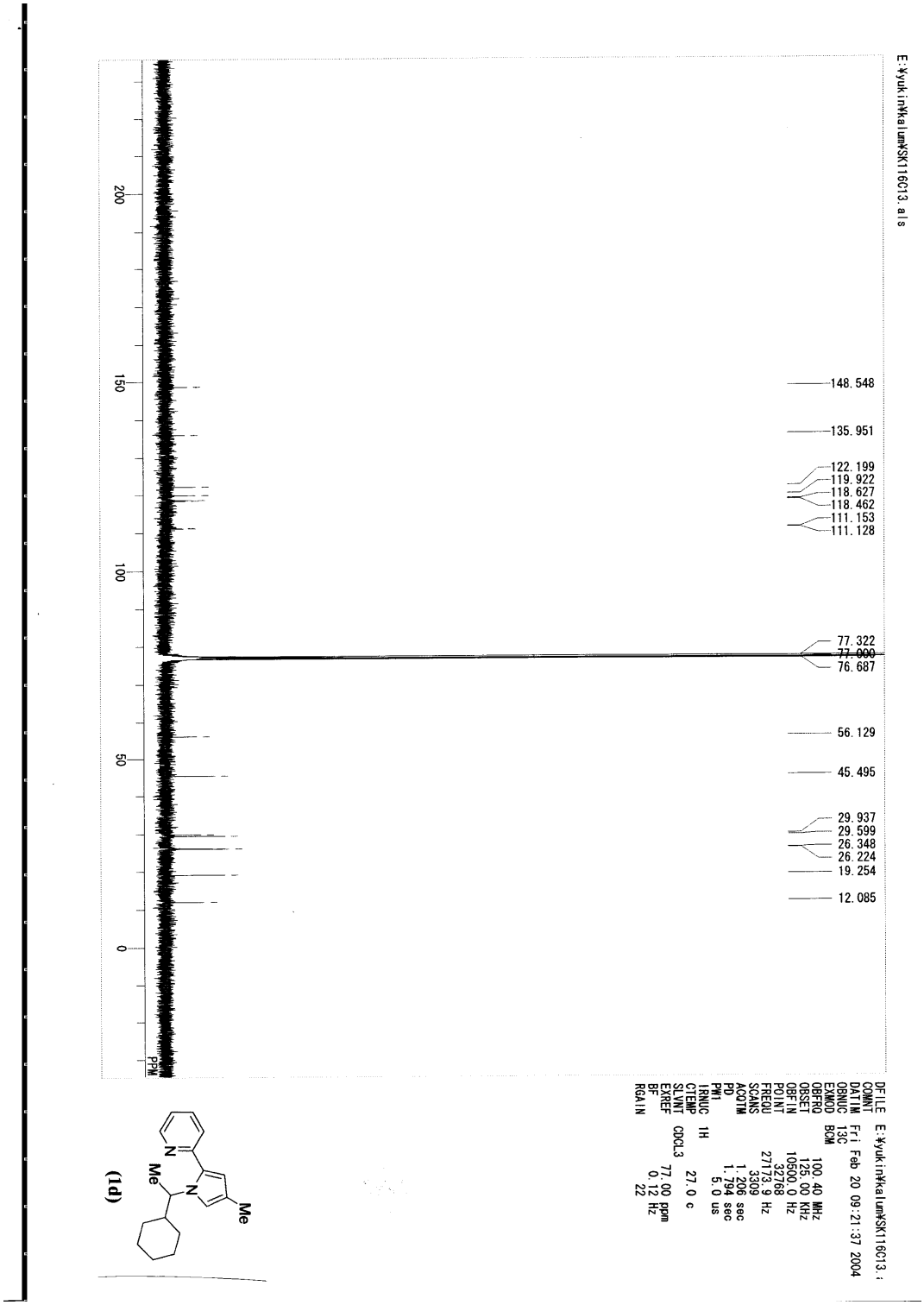
^{13}C-NMR of 2-Pyridinyl-(1-Hexyl-4-methyl)pyrrole (1c).



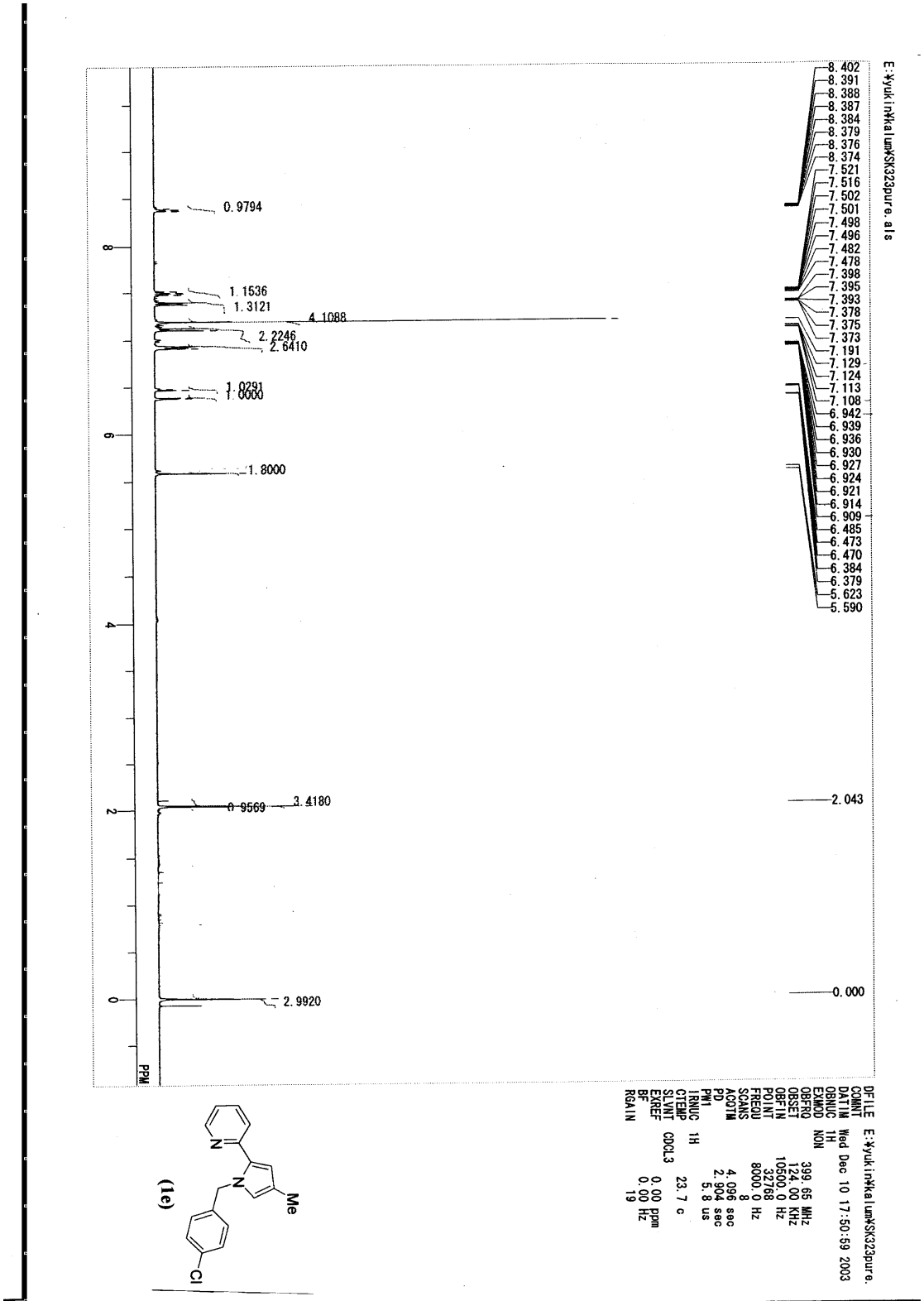
^{1}H-NMR of 2-Pyridinyl-[1-(1-Cyclohexyl-ethyl)-4-methyl]pyrrole (1d).



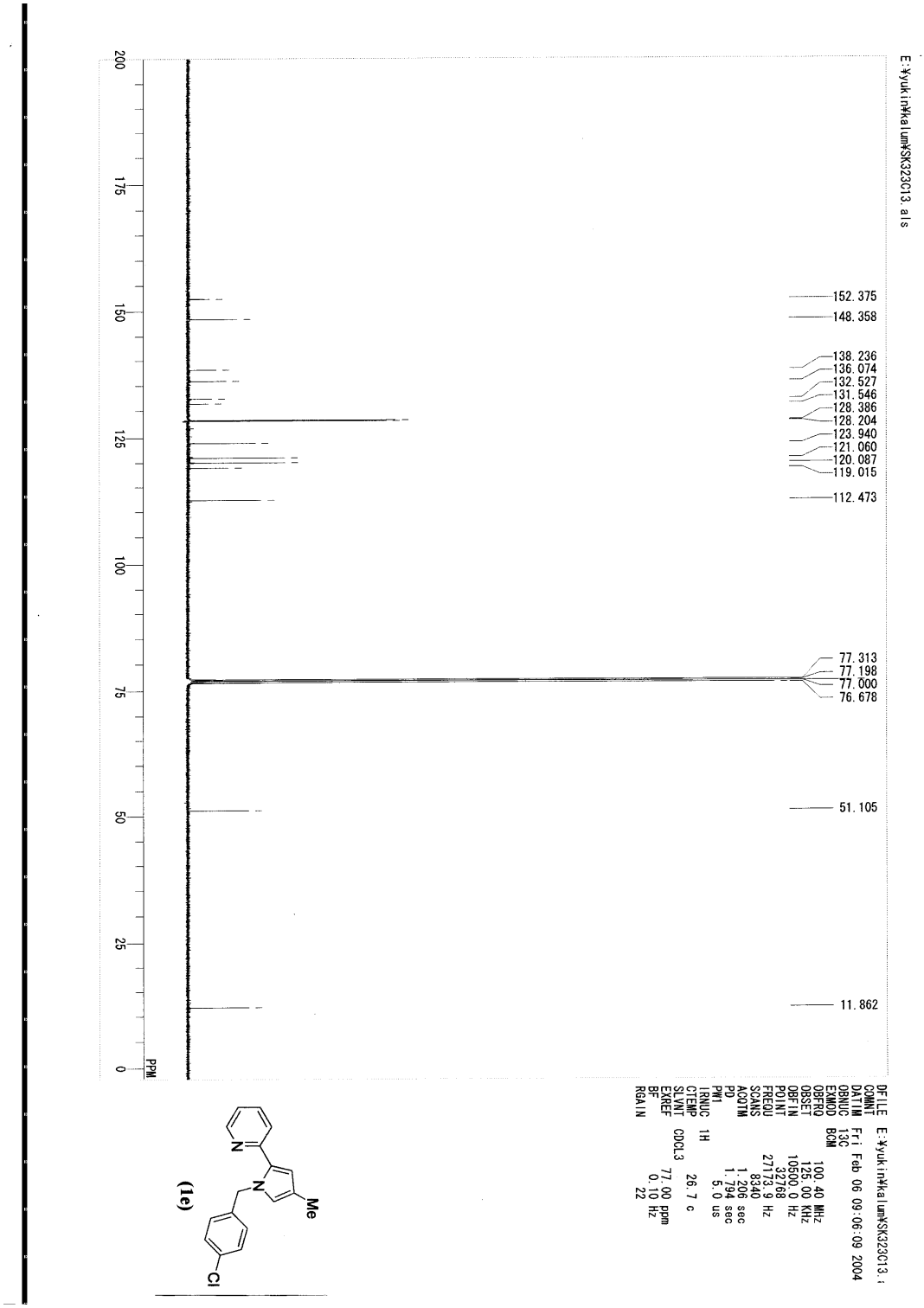
^{13}C-NMR of 2-Pyridinyl-[1-(1-Cyclohexyl-ethyl)-4-methyl]pyrrole (1d).



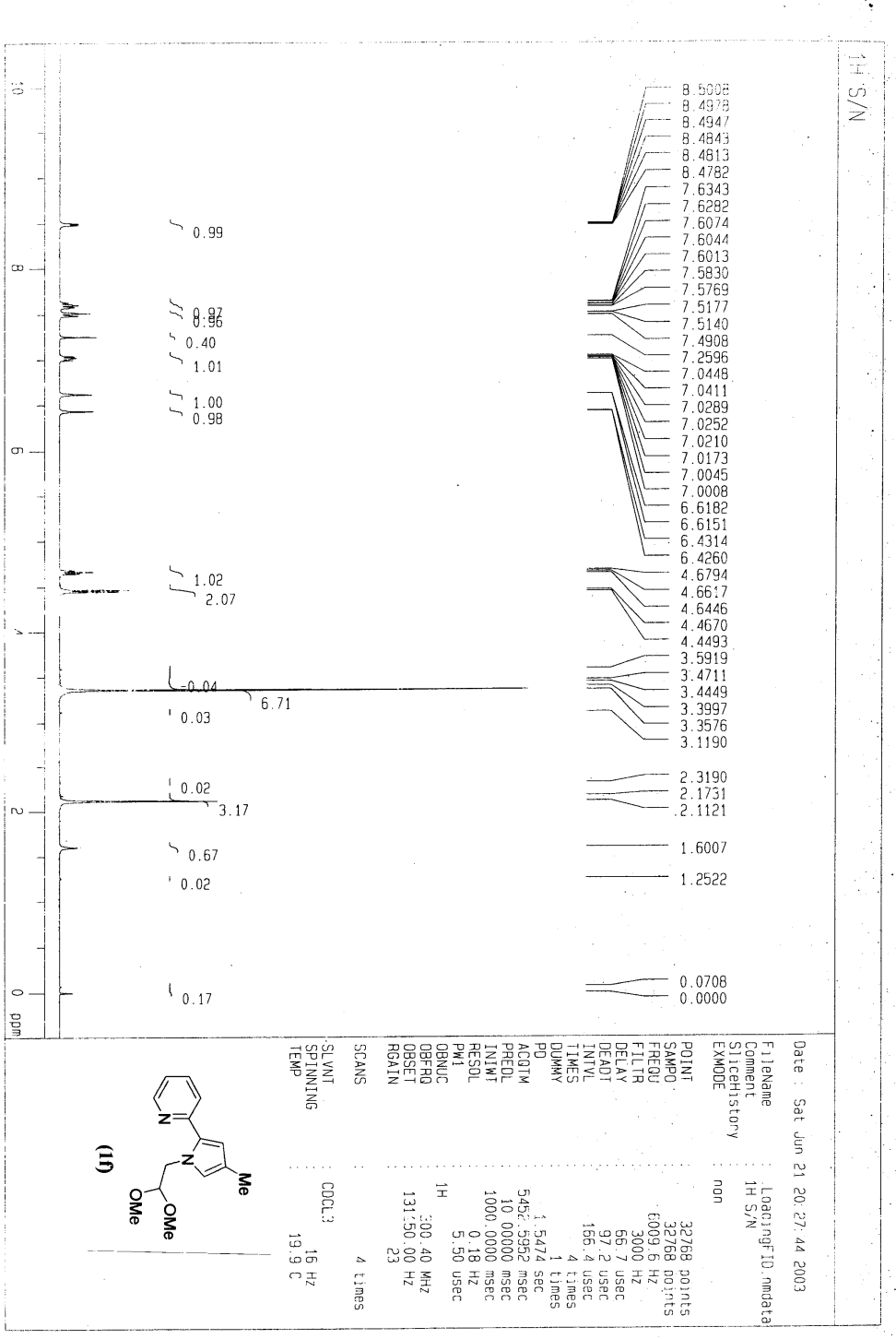
^{1}H-NMR of 2-Pyridinyl-{1-[1-(4-Chloro-phenyl)-ethyl]-4-methyl}pyrrole (1e).



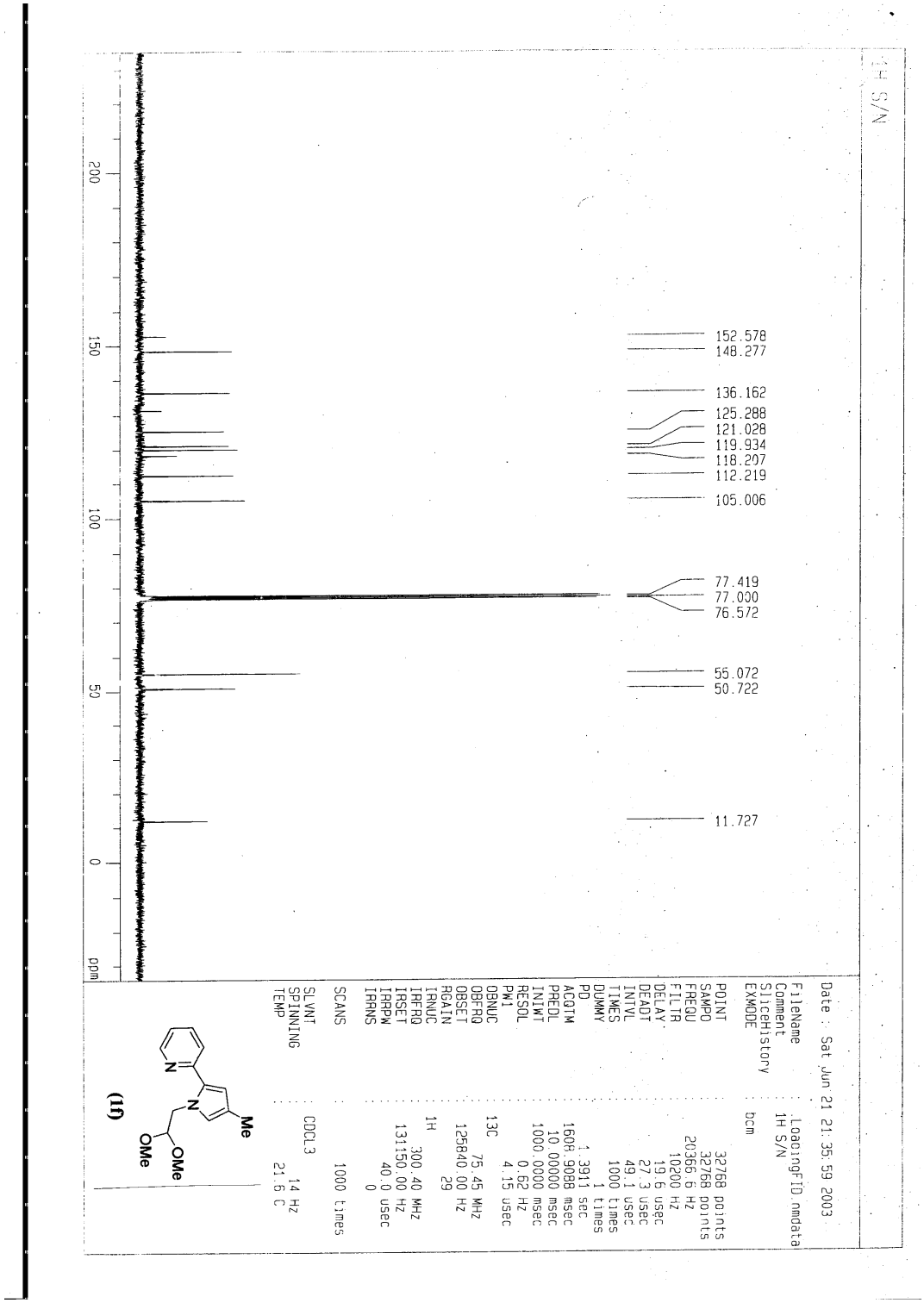
^{13}C-NMR of 2-Pyridinyl-{1-[1-(4-Chloro-phenyl)-ethyl]-4-methyl}pyrrole (1e).



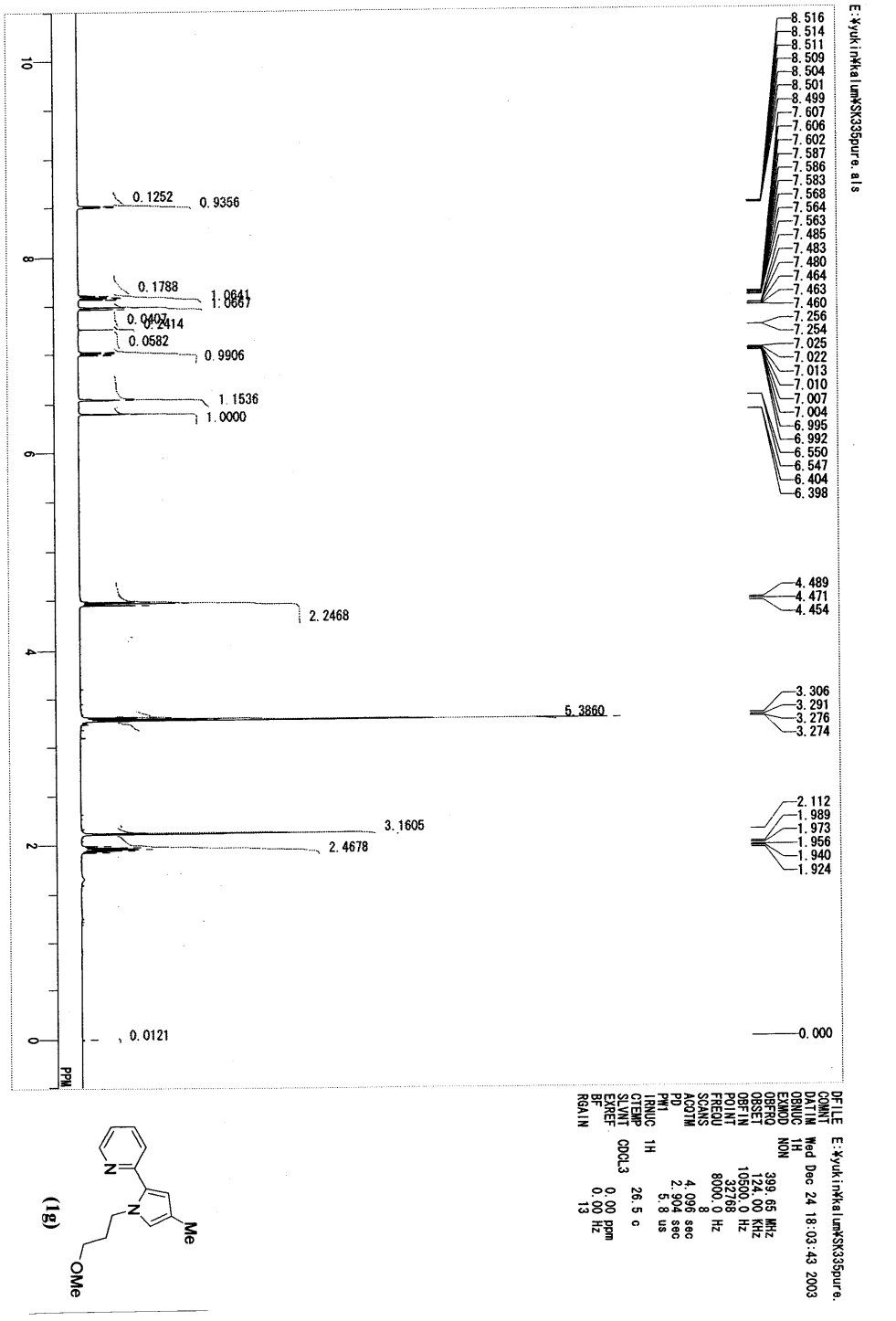
^{1}H-NMR of 2-Pyridinyl-[1-(2,2-Dimethoxy-ethyl)-4-methyl]pyrrole (1f).



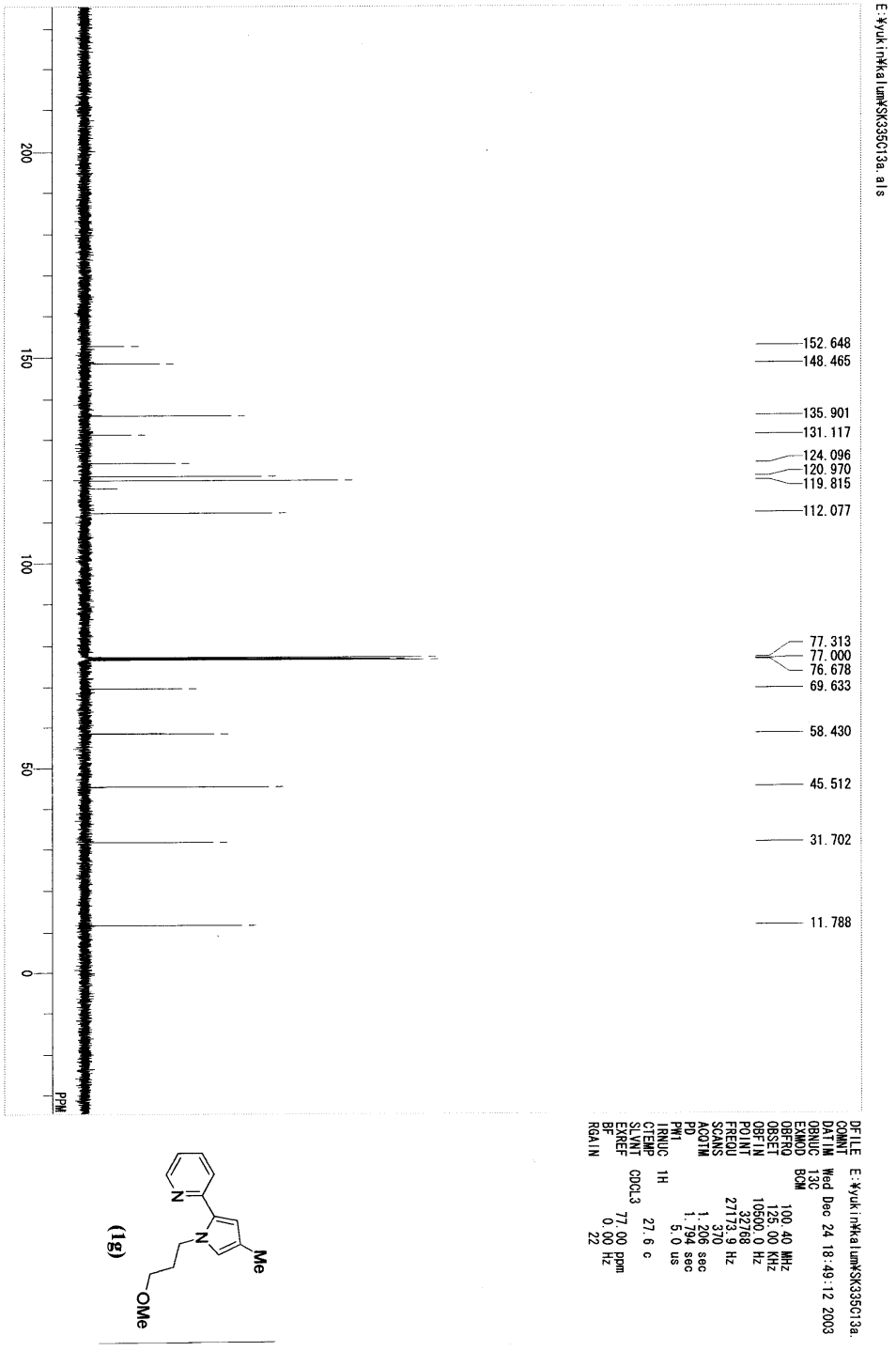
^{13}C-NMR of 2-Pyridinyl-[1-(2,2-Dimethoxy-ethyl)-4-methyl]pyrrole (1f).



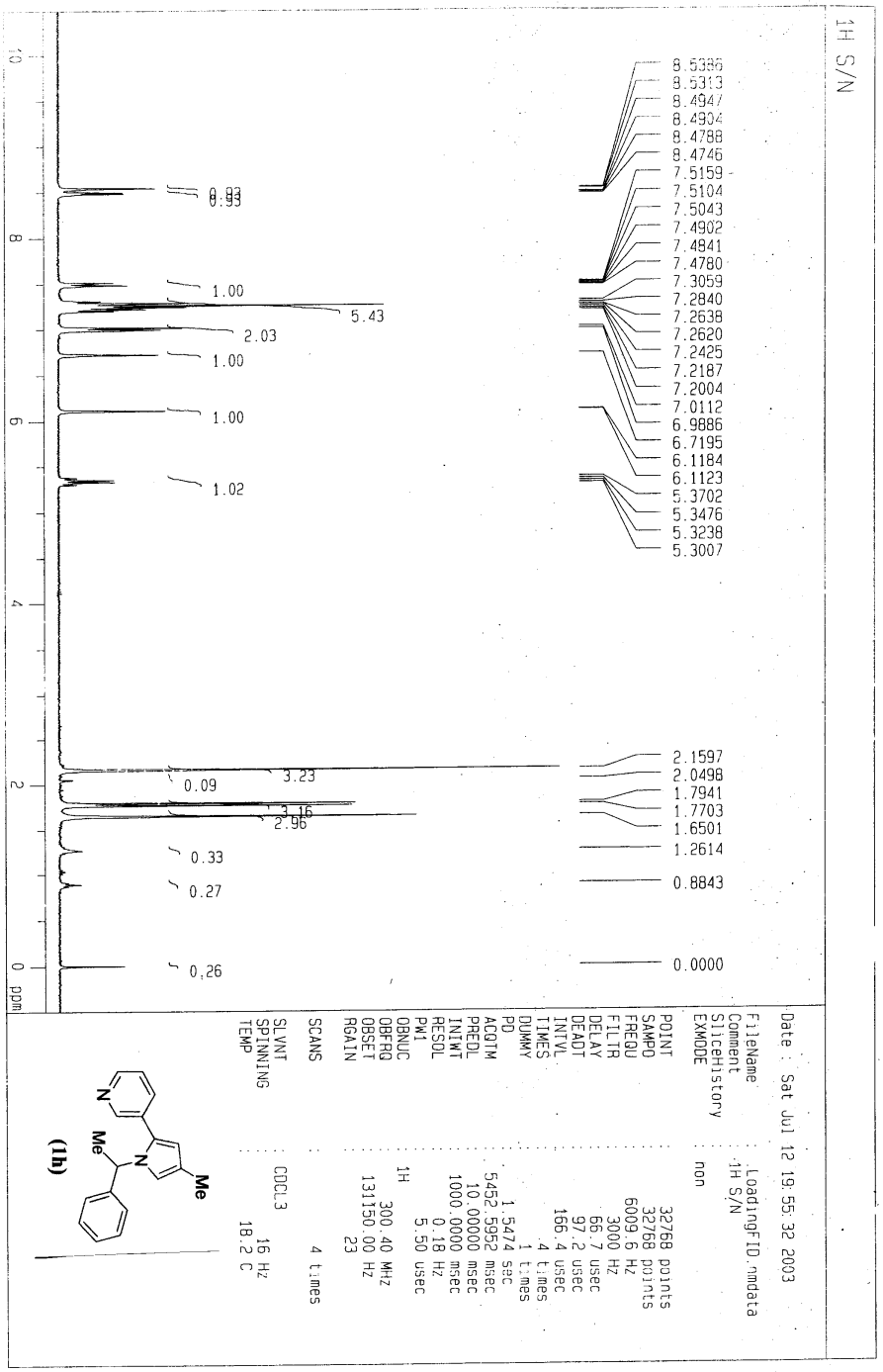
^{1}H-NMR of 2-Pyridinyl[1-(3-Methoxy-propyl)-4-methyl]pyrrole (1g).



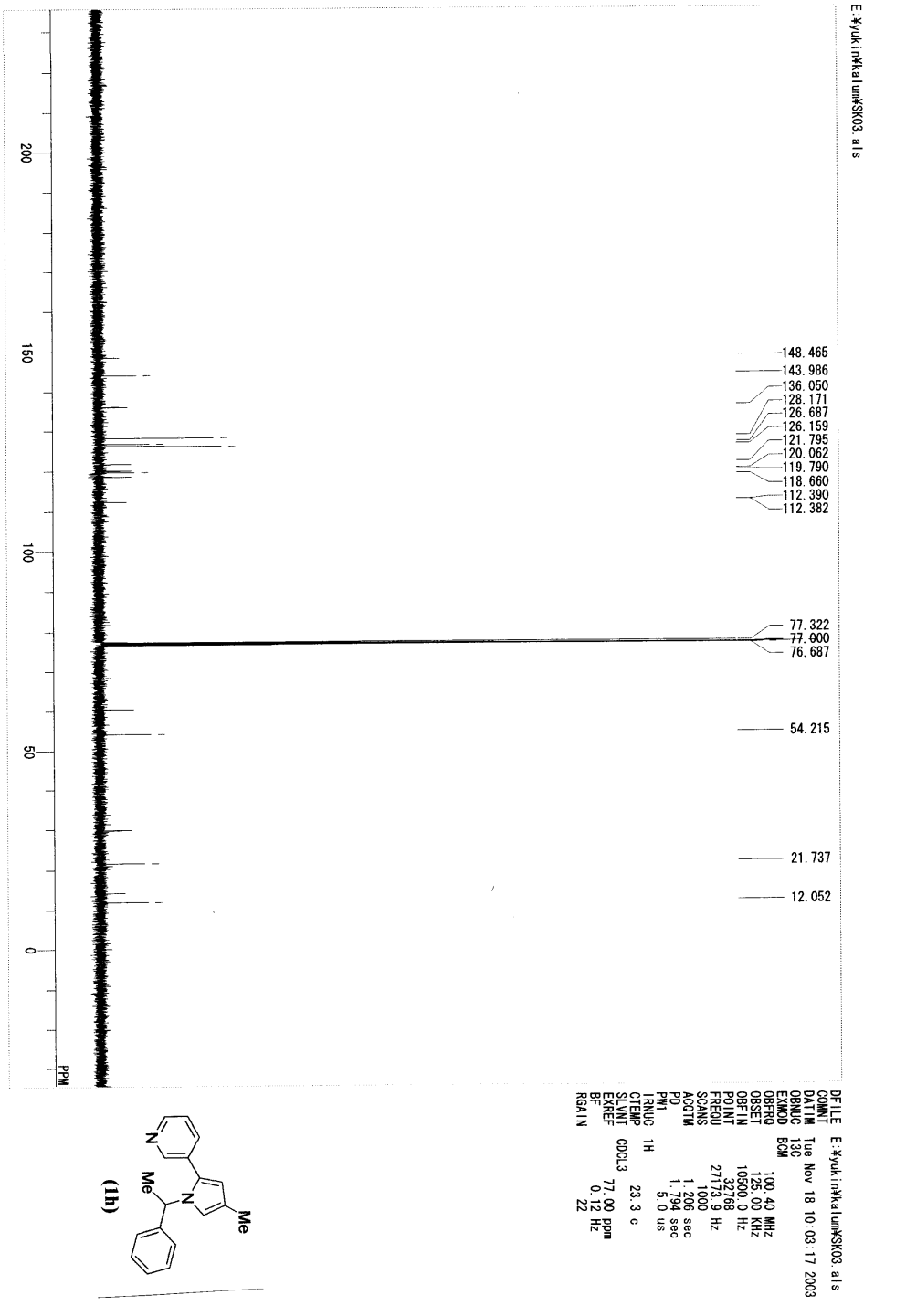
^{13}C-NMR of 2-Pyridinyl[1-(3-Methoxy-propyl)-4-methyl]pyrrole (1g).



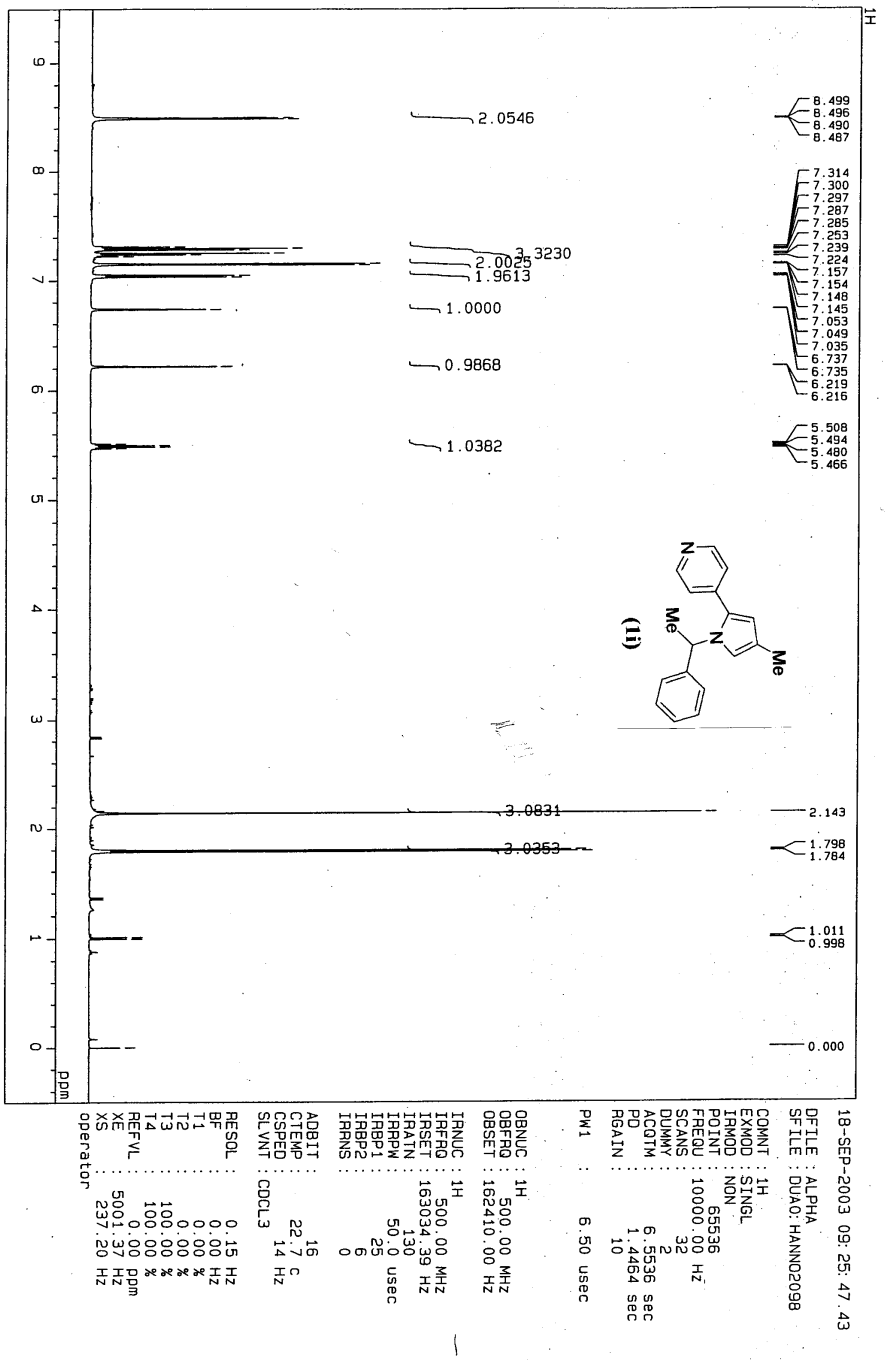
^{1}H-NMR of 2-Pyridinyl[4-Methy-1-(1-phenyl-ethyl)]pyrrole (1h).



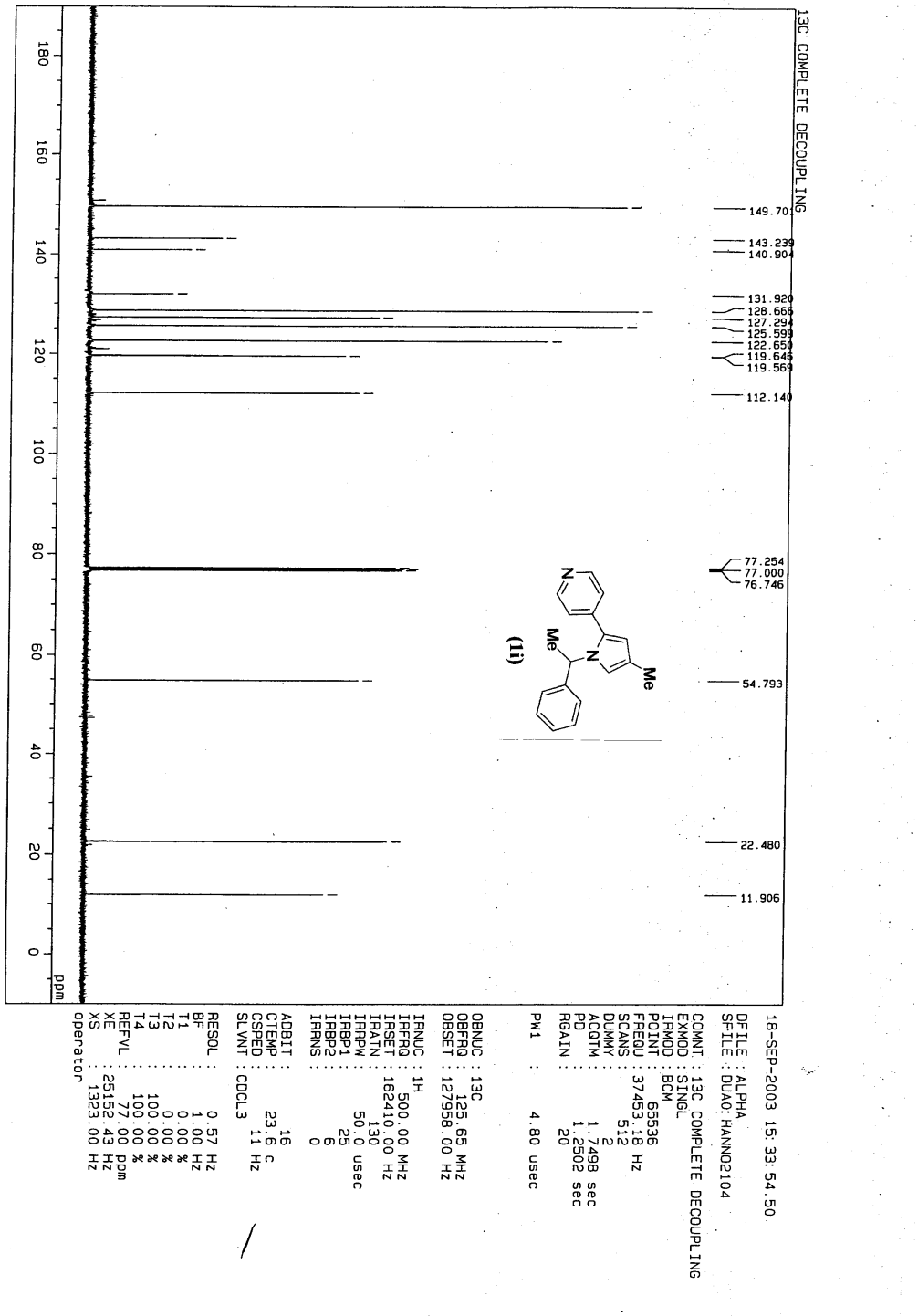
^{13}C-NMR of 2-Pyridinyl[4-Methy-1-(1-phenyl-ethyl)]pyrrole (1h).



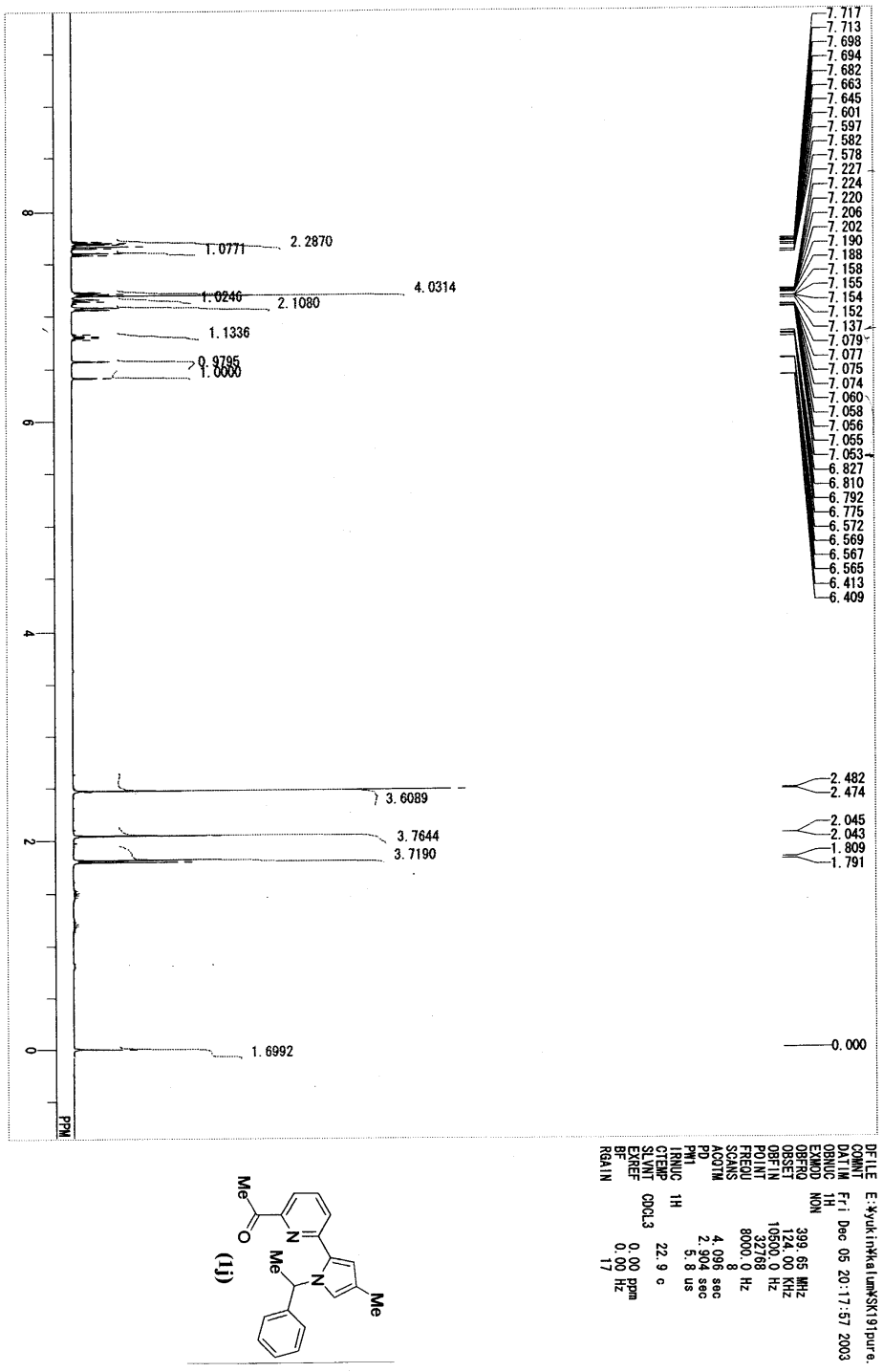
^{1}H-NMR of 2-Pyridinyl[Methyl-1-(1-phenyl-ethyl)]pyrrole (1i).



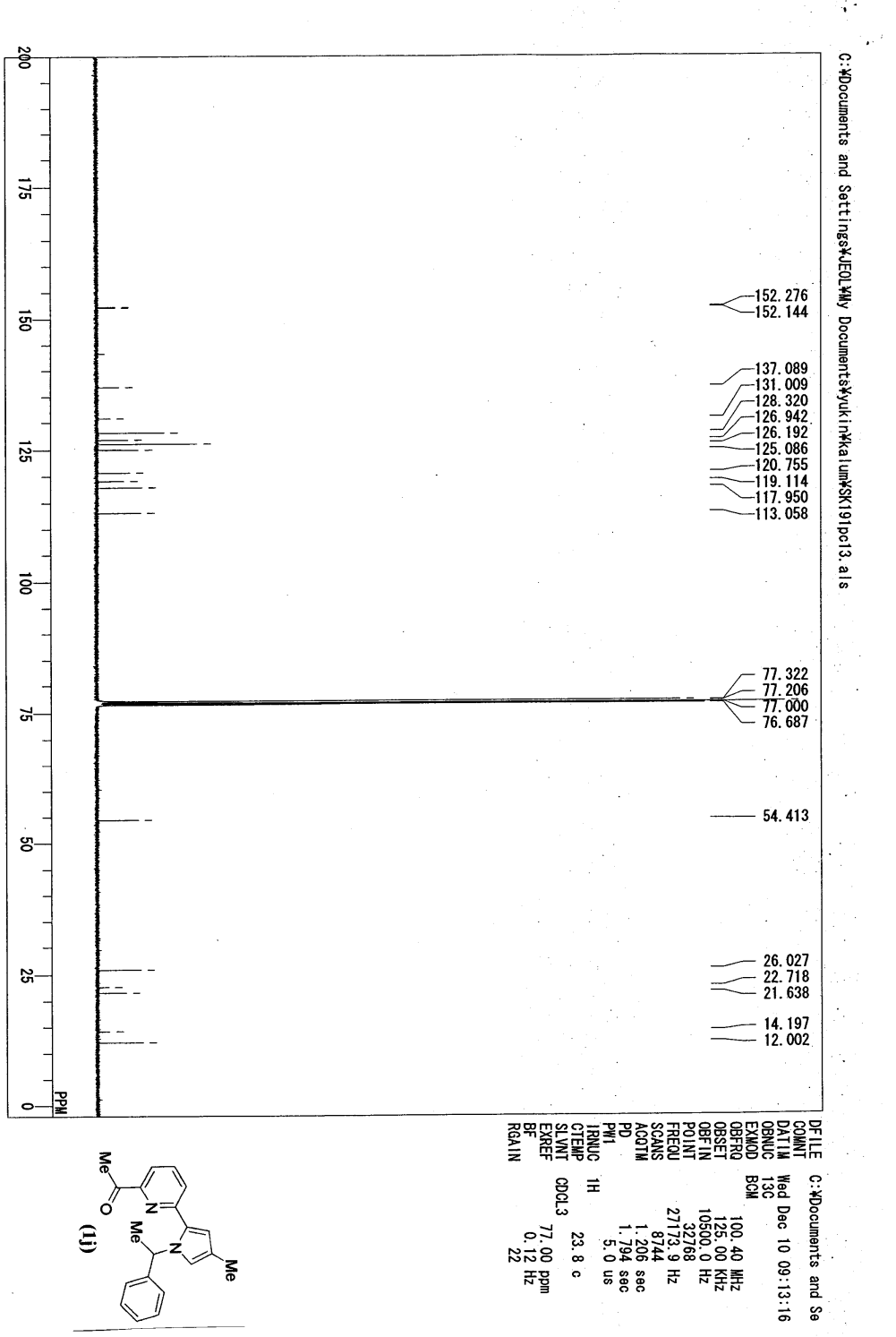
^{13}C-NMR of 2-Pyridinyl[Methyl-1-(1-phenyl-ethyl)]pyrrole (1i).



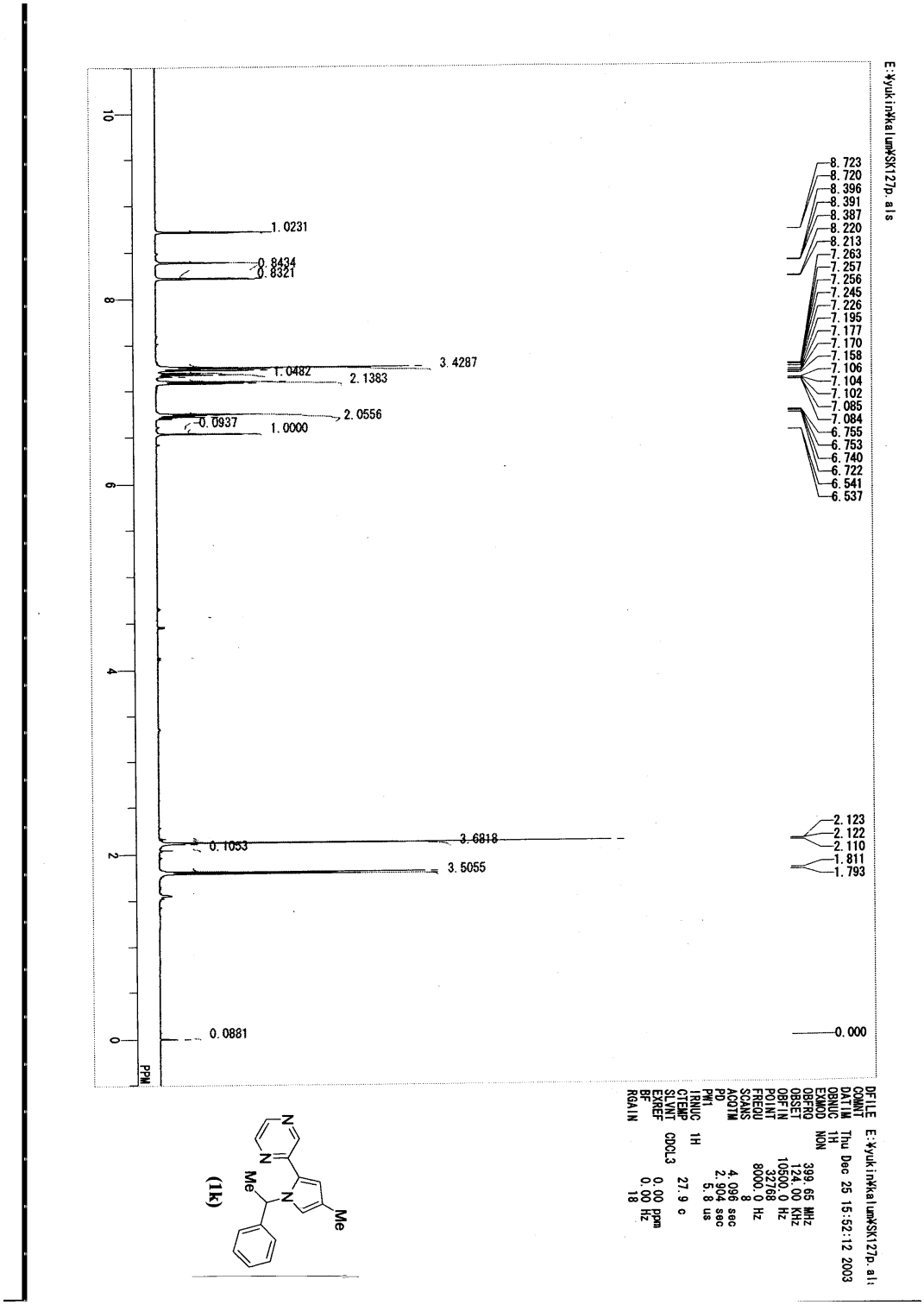
^{1}H-NMR of 2-etaneonyl-{6-[4-Methyl-1-(1-phenyl-ethyl)}pyrrole (1j).



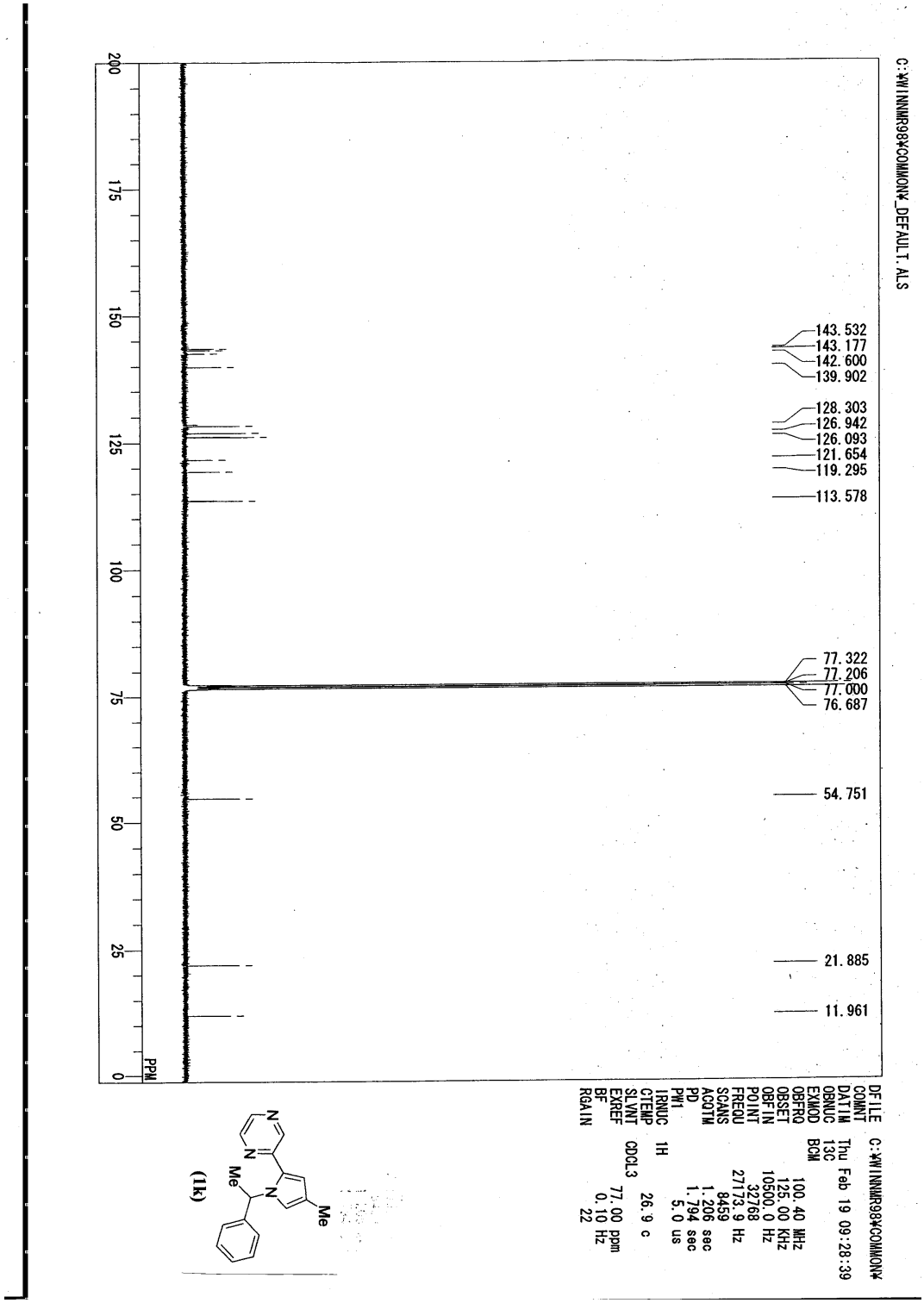
^{13}C-NMR of 2-etaneonyl-{6-[4-Methyl-1-(1-phenyl-ethyl)}pyrrole (1j).



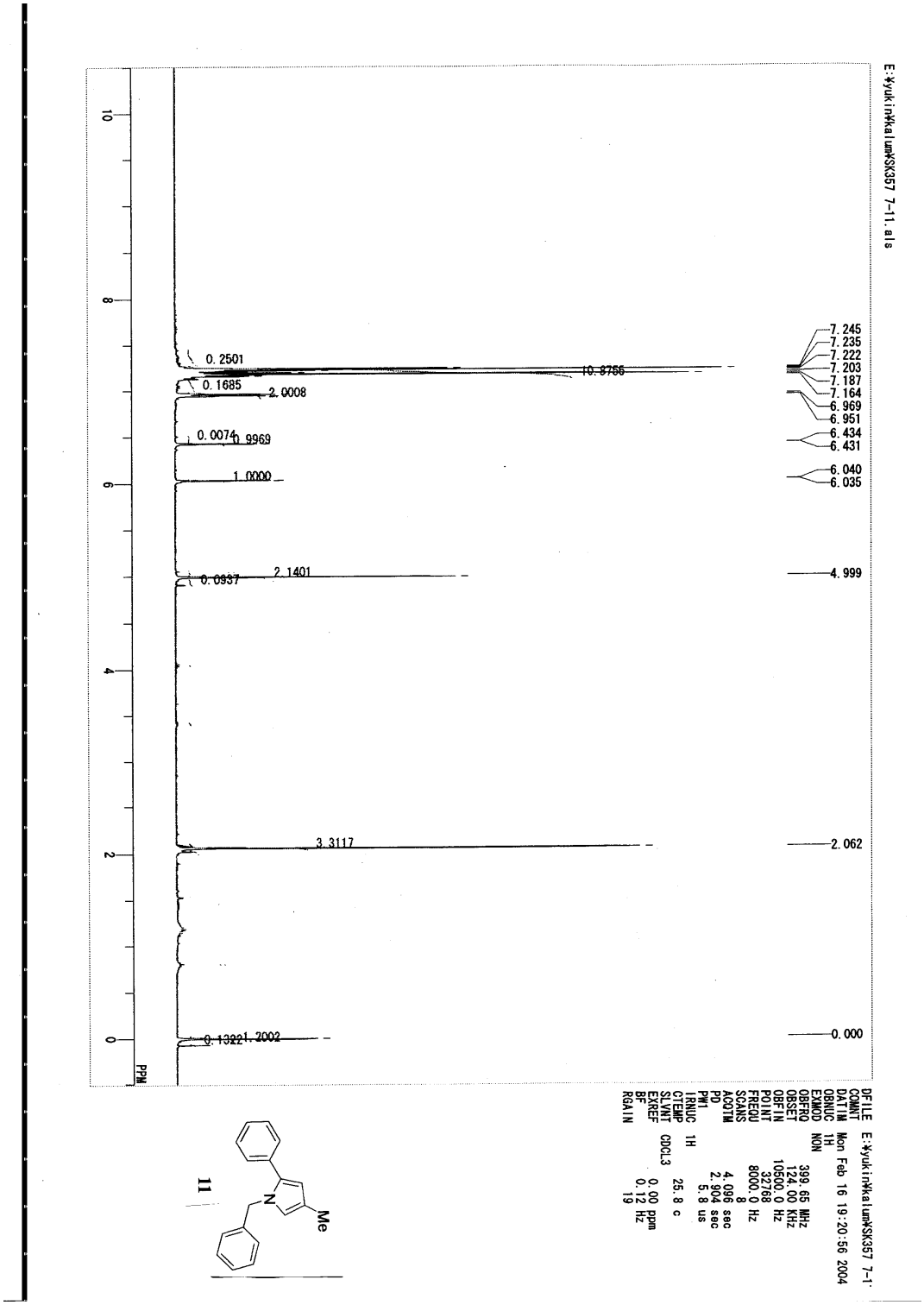
^{1}H-NMR of 2-Pyrazinyl-[4-Methyl-1-(1-phenyl-ethyl)]pyrrole (1k).



^{13}C-NMR of 2-Pyrazinyl-[4-Methyl-1-(1-phenyl-ethyl)]pyrrole (1k).



^{1}H-NMR of 2-Arylyl-(4-methyl-2-benzyl)pyrrole (10).



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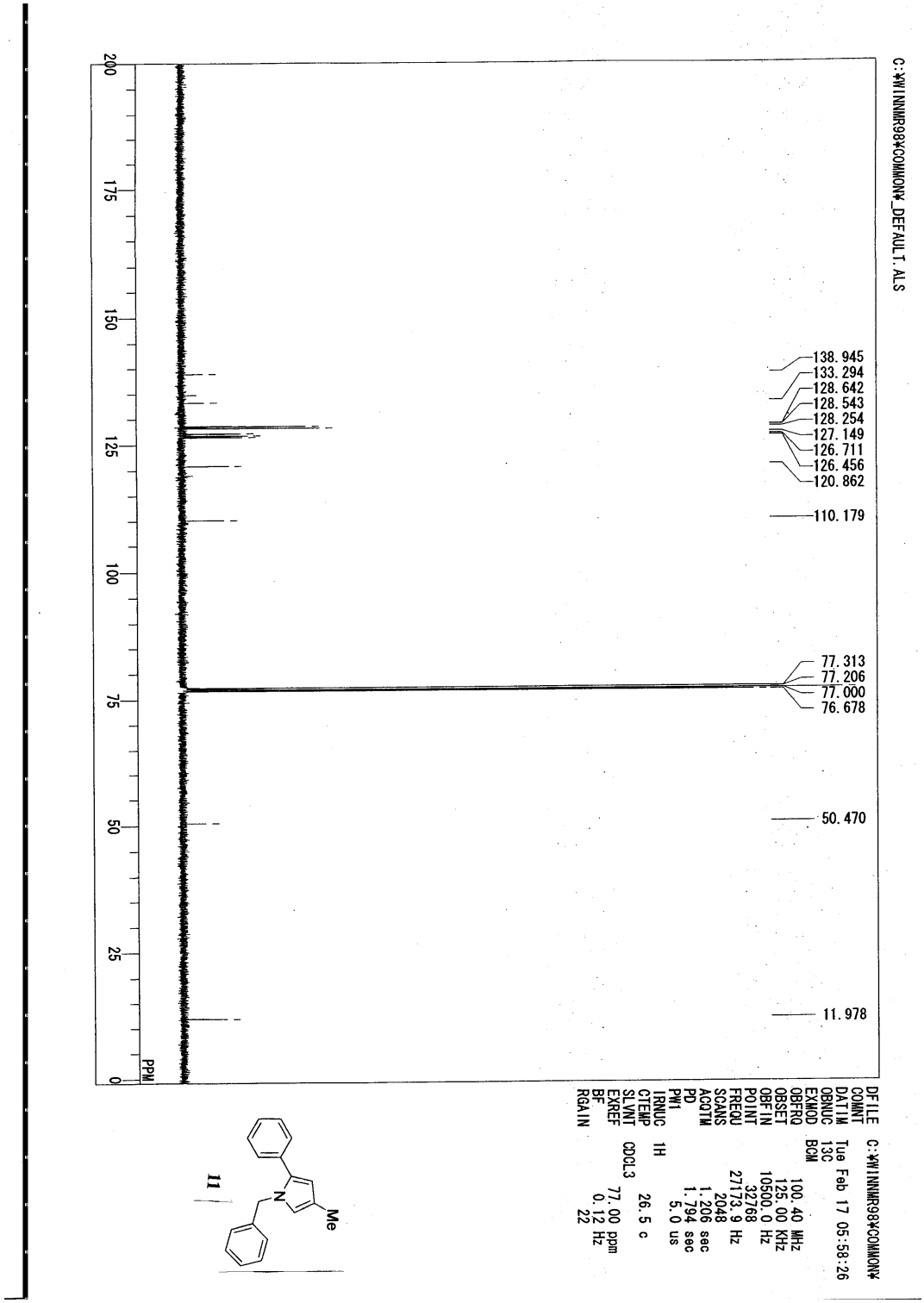
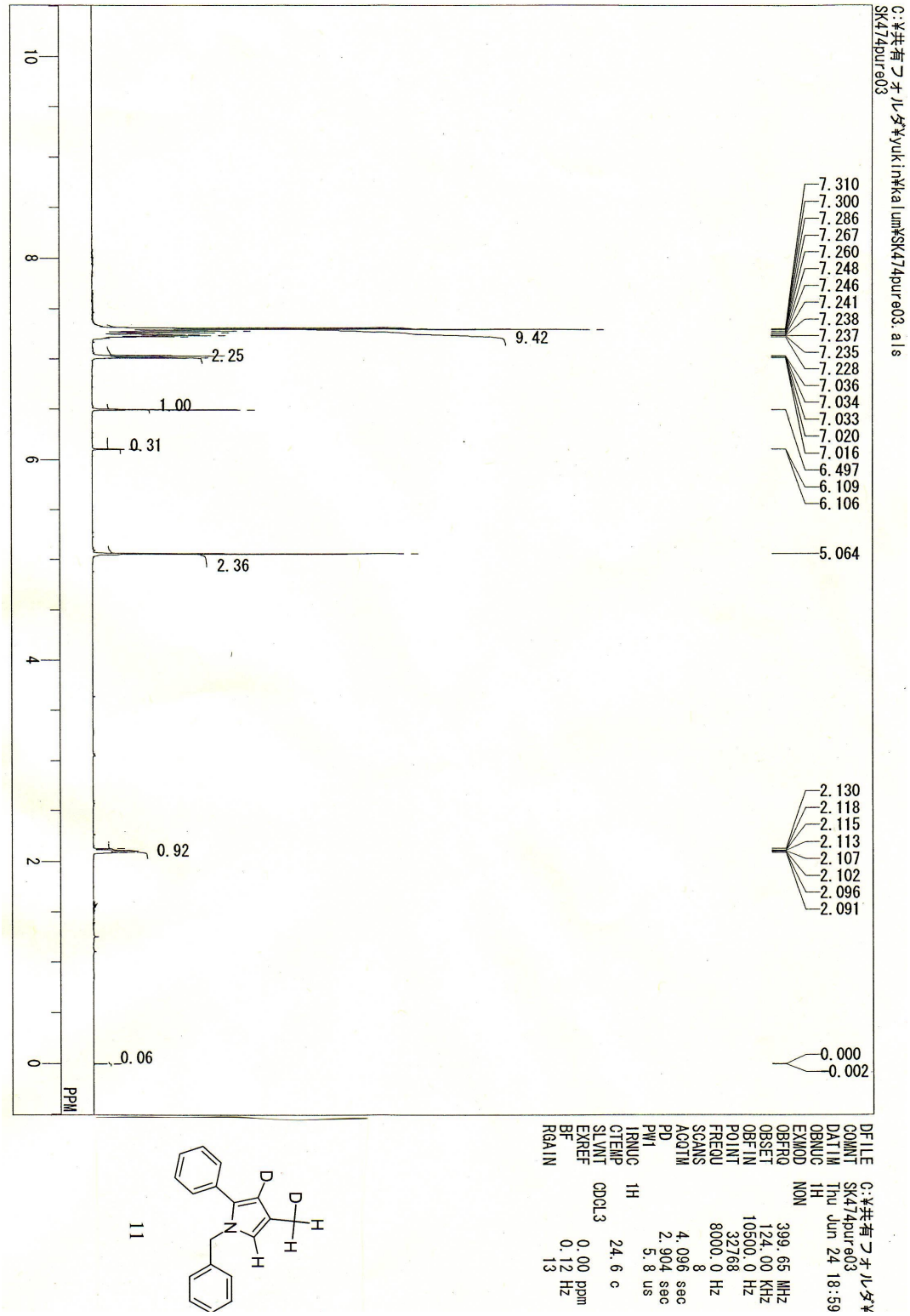
^{13}C-NMR of 2-Arylyl-(4-methyl-2-benzyl)pyrrole (10).



^{1}H-NMR of 11.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11

^{1}H NMR of the recovered deuterated acetophenone (9-d_3)