A Versatile Approach to Ullmann C–N Couplings at Room Temperature: New Families of Nucleophiles and Electrophiles for Photoinduced, Copper-Catalyzed Processes

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Supporting Information

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I. General Information

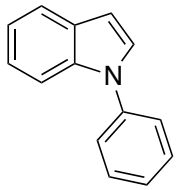
The following reagents were purchased and used as received unless otherwise specified: indole (Aldrich), 6-methoxyindole (AstaTech), 3-methylindole (Aldrich), 2-methylindole (Alfa Aesar), 7-methylindole (Aldrich), benzimidazole (Alfa Aesar), 5-methoxybenzimidazole (Aldrich), 2-methylbenzimidazole (Aldrich), imidazole (Alfa Aesar), 2-methylimidazole (Aldrich), carbazole (Aldrich; recrystallized), 3-methoxycarbazole (Matrix Scientific), iodobenzene (Aldrich), 4-iodotoluene (Aldrich), 2-iodotoluene (Aldrich), 4-iodoanisole (Aldrich), 4-iodobenzonitrile (Aldrich), 3-iodopyridine (Aldrich), bromobenzene (Avocado), 4-chlorobenzonitrile (Avocado), 1-ethyl-4-iodobenzene (Avocado), 4-bromotoluene (Aldrich), 4-chlorotoluene (Aldrich), methyl octanoate (Acros), 1-methyl-2-piperidone (Aldrich), benzylacetone (Aldrich), dicyclohexylamine (Aldrich), cyclohexylamine (Aldrich), chlorobenzene (Aldrich), *trans*-5-decene (Aldrich), *cis*-5-decene (TCI), 5-decyne (Lancaster), dibenzyl ether (Alfa Aesar), bromomethylenecyclohexane (Aldrich), CuI (Aldrich), LiO*t*-Bu (Alfa Aesar), and *t*-BuOH (Aldrich; anhydrous). CH_3CN was deoxygenated and dried by sparging with nitrogen followed by passage through an activated alumina column (S. G. Water) prior to use.

All coupling reactions were carried out using a Luzchem LZC–4V photoreactor at 254 nm (UVC). ^{1}H NMR data and ^{13}C NMR data were collected on a VARIAN 500 MHz spectrometer at ambient temperature. GC analyses were carried out on an Agilent 6890 series system with a DB-1 column (length 30 m, I.D. 0.25 mm) or an HP-5 column (length 30 m, I.D. 0.25 mm) or on an Agilent 6850 series system with a BETA DEX 120 column (length 30 m, I.D. 0.25 mm).

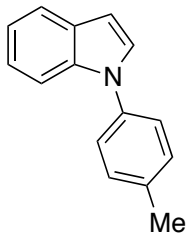
II. Photoinduced, Copper-Catalyzed N-Arylations (Tables 1–5)

General Procedure. The nitrogen heterocycle (1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), and CuI (19.0 mg, 0.10 mmol) were added to an oven-dried 10-mL quartz test tube that contained a stir bar. The test tube was fitted with a rubber septum, the joint was wrapped with electrical tape, and the test tube was evacuated and backfilled with nitrogen (three cycles). Then, CH_3CN (4.0 mL) and the aryl iodide (1.40 mmol; if the aryl iodide is a solid, then it was added immediately after the addition of CuI) were added in turn via syringe. The test tube was detached from the nitrogen manifold, and the puncture holes in the septum were covered with vacuum grease. The resulting mixture was stirred for 5 min, and then the test tube was transferred to a Luzchem LZC–4V photoreactor, where it was irradiated at 254 nm for 24 h (adequate stirring is important). Next, the mixture was passed through a long plug of silica gel (monitored by TLC), the solvent was removed, and the residue was purified by column chromatography.

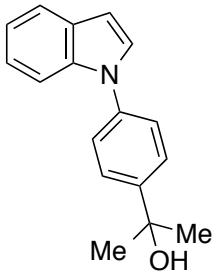
Notes: (a) A Honeywell ultraviolet air treatment system (model #RUVLAMP1), available for ~$110 from retail outlets such as Amazon or The Home Depot, furnishes a comparable result: indole and iodobenzene couple in 63% yield (calibrated GC analysis) after 48 h. (b) Use of a borosilicate, rather than a quartz, test tube leads to a low yield of the C–N coupling product.



1-Phenyl-1*H*-indole (Table 1, entry 1) [16096-33-6]. The title compound was synthesized according to the General Procedure from indole (117 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography (hexanes). Pale-yellow oil. First run: 142 mg (73% yield). Second run: 148 mg (77% yield).



1-(*p*-Tolyl)-1*H*-indole (Table 1, entry 2) [167283-32-1]. The title compound was synthesized according to the General Procedure from indole (117 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-iodotoluene (305 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). Colorless oil. First run: 140 mg (68%). Second run: 143 mg (69%).



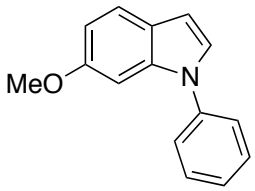
2-(4-(1*H*-Indol-1-yl)phenyl)propan-2-ol (Table 1, Entry 3). The title compound was synthesized according to the General Procedure from indole (117 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 2-(4-iodophenyl)propan-2-ol (367 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (20% EtOAc/hexanes) and purified by column chromatography on silica gel (7.5% EtOAc/hexanes→15% EtOAc/hexanes). Pale-orange solid. First run: 144 mg (57%). Second run: 143 mg (57%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.71−7.69 (m, 1H), 7.67−7.62 (m, 2H), 7.60−7.56 (m, 1H), 7.51−7.46 (m, 2H), 7.34 (d, 1H, *J* = 3.0 Hz), 7.23 (ddd, 1H, *J* = 8.0, 7.0, 1.0 Hz), 7.18 (ddd, 1H, *J* = 8.0, 7.0, 1.0 Hz), 6.69 (dd, 1H, *J* = 3.0, 1.0 Hz), 1.81 (br s, 1H), 1.66 (s, 6H).

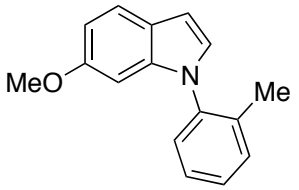
^{13}C NMR (126 MHz, $CDCl_3$) δ 147.5, 138.5, 136.0, 129.4, 128.1, 125.9, 124.2, 122.4, 121.2, 120.5, 110.7, 103.6, 72.6, 32.0.

FT-IR (neat) 3541, 3399, 3103, 3049, 2974, 2927, 2868, 1606, 1582, 1570, 1519, 1475, 1457, 1412, 1363, 1347, 1334, 1317, 1298, 1281, 1256, 1234, 1213, 1170, 1137, 1114, 1094, 1066, 1015, 955, 909, 883, 862, 840, 770, 762, 742, 720 cm^{-1}.

MS (ESI) *m*/*z* (M^++H) calcd for $C_{17}H_{18}NO$: 252, found: 252.



6-Methoxy-1-phenyl-1*H*-indole (Table 1, entry 4) [487058-34-4]. The title compound was synthesized according to the General Procedure from 6-methoxyindole (147 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by normal-phase column chromatography on silica gel (hexanes→1% Et_2O/hexanes) followed by reverse-phase column chromatography on C-18 silica gel (10%→100% CH_3CN/water). White solid. First run: 147 mg (66%). Second run: 150 mg (67%).



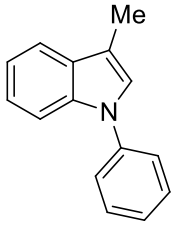
6-Methoxy-1-(*o*-tolyl)-1*H*-indole (Table 1, entry 5). The title compound was synthesized according to the General Procedure from 6-methoxyindole (147 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 2-iodotoluene (305 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by normal-phase column chromatography on silica gel (hexanes→1% Et_2O/hexanes) followed by reverse-phase column chromatography on C-18 silica gel (10%→100% CH_3CN/water). Yellow oil. First run: 154 mg (65% yield). Second run: 165 mg (70% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (d, 1H, *J* = 8.5 Hz), 7.40–7.36 (m, 2H), 7.35–7.31 (m, 2H), 7.06 (d, 1H, *J* = 3.2 Hz), 6.82 (dd, 1H, *J* = 8.5, 2.2 Hz), 6.59 (d, 1H, *J* = 3.2 Hz), 6.50 (s, 1H), 3.76 (s, 3H), 2.09 (s, 3H).

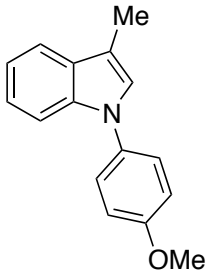
^{13}C NMR (126 MHz, $CDCl_3$) δ 156.8, 138.5, 137.8, 136.0, 131.4, 128.3, 128.2, 127.8, 127.0, 122.6, 121.5, 110.1, 102.5, 94.0, 55.8, 17.8.

FT-IR (neat) 3102, 3026, 2994, 2952, 2831, 1621, 1603, 1573, 1513, 1487, 1459, 1380, 1340, 1324, 1292, 1279, 1225, 1205, 1177, 1121, 1095, 1031, 927, 806, 769, 746, 720 cm^{-1}.

MS (ESI) *m*/*z* (M^++H) calcd for $C_{16}H_{16}NO$: 238, found: 238.

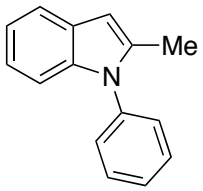


3-Methyl-1-phenyl-1*H*-indole (Table 1, entry 6) [112817-88-6]. The title compound was synthesized according to the General Procedure from 3-methylindole (131 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). Colorless oil. First run: 152 mg (73%). Second run: 145 mg (70%).

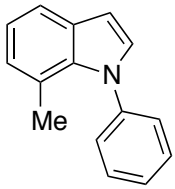


1-(4-Methoxyphenyl)-3-methyl-1*H*-indole (Table 1, entry 7) [876337-56-3]. The title compound was synthesized according to the General Procedure from 3-methylindole (131 mg, 1.00

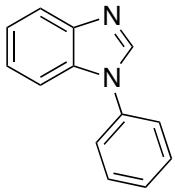
mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-iodoanisole (328 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→2% Et_2O/hexanes). Colorless oil. First run: 138 mg (58%). Second run: 138 mg (58%).



2-Methyl-1-phenyl-1*H*-indole (Table 1, entry 8) [16176-77-5]. The title compound was synthesized according to the General Procedure from 2-methylindole (131 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). Colorless oil. First run: 122 mg (59%). Second run: 124 mg (60%).



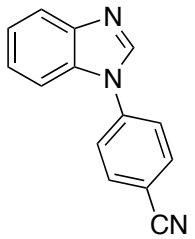
7-Methyl-1-phenyl-1*H*-indole (Table 1, entry 9) [473918-43-3]. The title compound was synthesized according to the General Procedure from 7-methylindole (131 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). White solid. First run: 139 mg (67%). Second run: 133 mg (64%).



1-Phenyl-1*H*-benzo[*d*]imidazole (Table 2, entry 1) [2622-60-8]. The title compound was synthesized according to the General Procedure from benzimidazole (118 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol), except that a mixture of *t*-BuOH (1.0 mL) and CH_3CN (3.0 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. The reaction mixture was filtered through a plug of silica gel (5% MeOH/CH_2Cl_2) and purified by

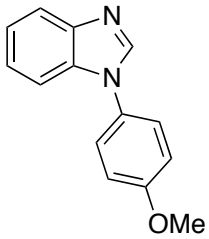
column chromatography on silica gel (0.75% MeOH/CH_2Cl_2, then 15%→25% EtOAc/hexanes). Yellow oil. First run: 158 mg (81%). Second run: 165 mg (85%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.



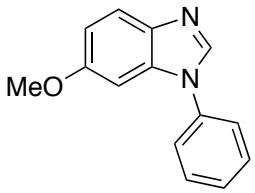
4-(1*H*-Benzo[*d*]imidazol-1-yl)benzonitrile (Table 2, entry 2) [25699-95-0]. The title compound was synthesized according to the General Procedure from benzimidazole (118 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-iodobenzonitrile (321 mg, 1.40 mmol), except that a mixture of *t*-BuOH (1.0 mL) and CH_3CN (3.0 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. The product was filtered through a plug of silica gel (5% MeOH/CH_2Cl_2) and purified by column chromatography on silica gel (1% MeOH/CH_2Cl_2, then 40%→55% EtOAc/hexanes). Yellow solid. First run: 185 mg (84%). Second run: 180 mg (82%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.

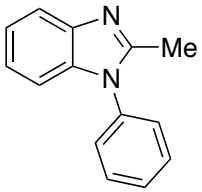


1-(4-Methoxyphenyl)-1*H*-benzo[*d*]imidazole (Table 2, entry 3) [2622-61-9]. The title compound was synthesized according to the General Procedure from benzimidazole (118 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-iodoanisole (328 mg, 1.40 mmol), except that a mixture of *t*-BuOH (1.0 mL) and CH_3CN (3.0 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. The reaction mixture was filtered through a plug of silica gel (5% MeOH/CH_2Cl_2) and purified by column chromatography on silica gel (1% MeOH/CH_2Cl_2, then 30%→50% EtOAc/hexanes). Yellow solid. First run: 177 mg (79%). Second run: 164 mg (73%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.

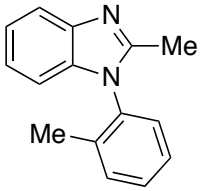


6-Methoxy-1-phenyl-1*H*-benzo[*d*]imidazole (Table 2, entry 4) [69445-55-2]. The title compound was synthesized according to the General Procedure from 5-methoxybenzimidazole (148 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% MeOH/CH_2Cl_2) and purified by column chromatography (1%→5% MeOH/CH_2Cl_2, then 20%→35% EtOAc/hexanes). Yellow solid. First run: 182 mg (81%, 6-methoxy-1-phenyl-1*H*-benzo[*d*]imidazole/5-methoxy-1-phenyl-1*H*-benzo[*d*]imidazole = 1.0:1). Second run: 190 mg (85%, 6-methoxy-1-phenyl-1*H*-benzo[*d*]imidazole/5-methoxy-1-phenyl-1*H*-benzo[*d*]imidazole = 1.1:1).



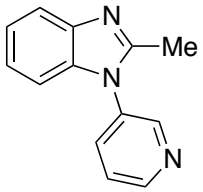
2-Methyl-1-phenyl-1*H*-benzo[*d*]imidazole (Table 2, entry 5) [1484-39-5]. The title compound was synthesized according to the General Procedure from 2-methylbenzimidazole (132 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (5% MeOH/ CH_2Cl_2) and purified by column chromatography on silica gel (1%→5% MeOH/CH_2Cl_2, then 20%→35% ethyl acetate/hexanes). Yellow solid. First run: 169 mg (81%). Second run: 175 mg (84%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.



2-Methyl-1-(*o*-tolyl)-1*H*-benzo[*d*]imidazole (Table 2, entry 6) [68874-09-9]. The title compound was synthesized according to the General Procedure from 2-methylbenzimidazole (132 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 2-iodotoluene (305 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica (10% MeOH/CH_2Cl_2) and purified by column chromatography (1% MeOH/CH_2Cl_2, then 20% EtOAc/hexanes). Yellow solid. First run: 170 mg (76%). Second run: 166 mg (75%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.



2-Methyl-1-(pyridin-3-yl)-1*H*-benzo[*d*]imidazole (Table 2, entry 7). The title compound was synthesized according to the General Procedure from 2-methylbenzimidazole (132 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 3-iodopyridine (287 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica (10% MeOH/CH_2Cl_2) and purified by column chromatography on silica gel (2% MeOH/CH_2Cl_2). Yellow solid. First run: 139 mg (66%). Second run: 140 mg (67%).

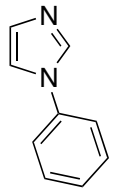
Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.78 (d, 1H, J = 3.2 Hz), 8.70 (s, 1H), 7.45 (apparent t, 2H, J = 3.2 Hz), 7.55 (dd, 1H, J = 7.9, 5.1 Hz), 7.28 (t, 1H, J = 7.8 Hz), 7.21 (t, 1H, J = 7.8 Hz), 7.10 (d, 1H, J = 8.0 Hz), 2.52 (s, 3H).

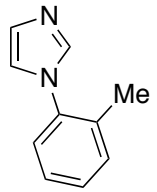
^{13}C NMR (126 MHz, $CDCl_3$) δ 151.4, 150.1, 148.3, 142.8, 136.3, 134.6, 133.0, 124.5, 123.2, 123.0, 119.4, 109.6, 14.6.

FT-IR (neat) 3391, 3053, 2927, 2851, 1615, 1587, 1575, 1524, 1486, 1456, 1427, 1393, 1372, 1314, 1287, 1249, 1187, 1149, 1105, 1050, 1029, 1015, 999, 929, 878, 810, 765, 745, 712 cm^{-1}.

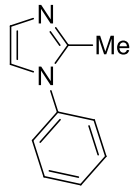
MS (ESI) m/z (M^++H) calcd for $C_{13}H_{12}N_3$: 210, found: 210.



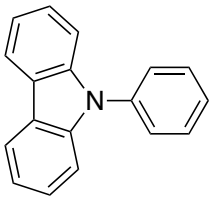
1-Phenyl-1*H*-imidazole (Table 3, entry 1) [7164-98-9]. The title compound was synthesized according to the General Procedure from imidazole (102 mg, 1.50 mmol), LiO*t*-Bu (168 mg, 2.10 mmol), CuI (28.6 mg, 0.15 mmol), and iodobenzene (428 mg, 2.10 mmol), except that a mixture of *t*-BuOH (1.5 mL) and CH_3CN (4.5 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. The reaction mixture was filtered through a plug of silica gel (1% MeOH/CH_2Cl_2) and purified by column chromatography (1% MeOH/CH_2Cl_2, then 40%→50% EtOAc/hexanes). Pale-yellow oil. First run: 150 mg (69%). Second run: 148 mg (68%).



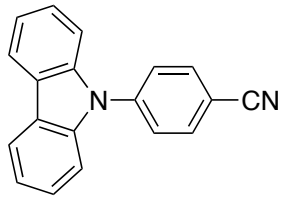
1-(*o*-Tolyl)-1*H*-imidazole (Table 3, entry 2) [25371-93-1]. The title compound was synthesized according to the General Procedure from imidazole (102 mg, 1.50 mmol), LiO*t*-Bu (168 mg, 2.10 mmol), CuI (28.6 mg, 0.15 mmol), and 2-iodotoluene (458 mg, 2.10 mmol), except that a mixture of *t*-BuOH (1.5 mL) and CH_3CN (4.5 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. The reaction mixture was filtered through a plug of silica gel (5% MeOH/CH_2Cl_2) and purified by column chromatography (1%→3% MeOH/CH_2Cl_2, then 30%→50% EtOAc/hexanes). Yellow oil. First run: 154 mg (65%). Second run: 161 mg (68%).



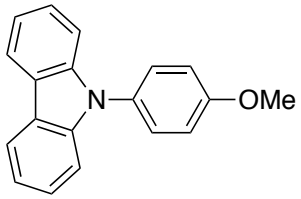
2-Methyl-1-phenyl-1*H*-imidazole (Table 3, entry 3) [60053-07-8]. The title compound was synthesized according to the General Procedure from 2-methylimidazole (123 mg, 1.50 mmol), LiO*t*-Bu (168 mg, 2.10 mmol), CuI (28.6 mg, 0.15 mmol), and iodobenzene (428 mg, 2.10 mmol). The reaction mixture was filtered through a plug of silica gel (10% MeOH/CH_2Cl_2) and purified by column chromatography (2% MeOH/CH_2Cl_2, then 40%→50% EtOAc/hexanes). Yellow oil. First run: 106 mg (45%). Second run: 109 mg (46%).



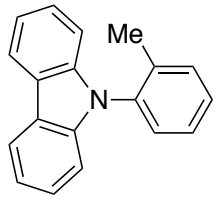
9-Phenyl-9*H*-carbazole (Table 4, entry 1) [1150-62-5]. The title compound was synthesized according to the General Procedure from carbazole (167 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and iodobenzene (286 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). White solid. First run: 212 mg (87%). Second run: 206 mg (85%).



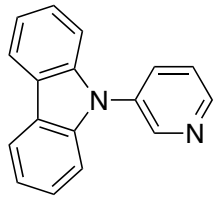
4-(9*H*-Carbazol-9-yl)benzonitrile (Table 4, entry 2) [57103-17-0]. The title compound was synthesized according to the General Procedure from carbazole (167 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-iodobenzonitrile (321 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→2% Et_2O/hexanes). Yellow solid. First run: 203 mg (76%). Second run: 209 mg (78%).



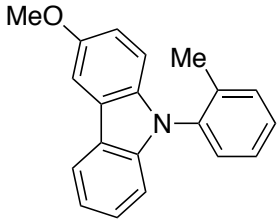
9-(4-Methoxyphenyl)-9*H*-carbazole (Table 4, entry 3) [19264-74-5]. The title compound was synthesized according to the General Procedure from carbazole (167 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-iodoanisole (328 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). White solid. First run: 215 mg (79%). Second run: 196 mg (72%).



9-(*o*-Tolyl)-9*H*-carbazole (Table 4, entry 4) [19155-50-1]. The title compound was synthesized according to the General Procedure from carbazole (167 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 2-iodotoluene (305 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). White solid. First run: 213 mg (83%). Second run: 204 mg (79%).



9-(Pyridin-3-yl)-9*H*-carbazole (Table 4, entry 5) [168127-56-8]. The title compound was synthesized according to the General Procedure from carbazole (167 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 3-iodopyridine (287 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (50% EtOAc/hexanes) and purified by column chromatography on silica gel (10% EtOAc/hexanes). White solid. First run: 154 mg (63%). Second run: 166 mg (68%).



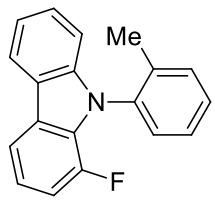
3-Methoxy-9-(*o*-tolyl)-9*H*-carbazole (Table 4, entry 6). The title compound was synthesized according to the General Procedure from 3-methoxycarbazole (100 mg, 0.51 mmol), LiO*t*-Bu (56.8 mg, 0.71 mmol), CuI (9.7 mg, 0.051 mmol), and 2-iodotoluene (155 mg, 0.71 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography on silica gel (hexanes→1% Et_2O/hexanes). Colorless oil. First run: 110 mg (76%). Second run: 110 mg (76%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12 (d, 1H, J = 7.5 Hz), 7.65 (d, 1H, J = 2.0 Hz), 7.50–7.33 (m, 5H), 7.27–7.23 (m, 1H), 7.06–7.01 (m, 2H), 6.96 (d, 1H, J = 9.0 Hz), 3.96 (s, 3H), 1.97 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 154.2, 141.8, 137.5, 136.4, 136.3, 131.6, 129.4, 128.8, 127.4, 126.0, 123.5, 123.0, 120.4, 119.2, 115.1, 110.7, 110.0, 103.4, 56.3, 17.7.

FT-IR (neat) 3050, 2993, 2932, 2830, 1627, 1600, 1580, 1498, 1485, 1462, 1438, 1381, 1359, 1329, 1285, 1254, 1236, 1206, 1179, 1167, 1149, 1119, 1098, 1035, 943, 912, 860, 847, 806, 764, 746, 720 cm^{-1}.

MS (ESI) m/z (M^+) calcd for $C_{20}H_{17}NO$: 287, found: 287.



1-Fluoro-9-(*o*-tolyl)-9*H*-carbazole (Table 4, entry 7). The title compound was synthesized according to the General Procedure from 1-fluorocarbazole (100 mg, 0.54 mmol), LiO*t*-Bu (60.5 mg, 0.76 mmol), CuI (10.3 mg, 0.054 mmol), and 2-iodotoluene (165 mg, 0.76 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column

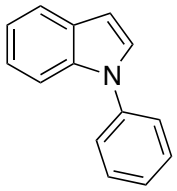
chromatography on silica gel (hexanes→1% Et_2O/hexanes). Pale-yellow oil. First run: 111 mg (75%). Second run: 110 mg (74%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (d, 1H, *J* = 8.0 Hz), 7.93 (d, 1H, *J* = 7.5 Hz), 7.47–7.34 (m, 5H), 7.30 (t, 1H, *J* = 7.5 Hz), 7.18 (td, 1H, *J* = 8.0, 4.0 Hz), 7.10 (dd, 1H, *J* = 12.0, 7.5 Hz), 7.01 (d, 1H, *J* = 8.5 Hz), 2.01 (s, 3H).

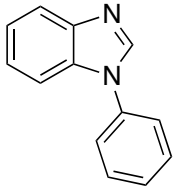
^{13}C NMR (126 MHz, $CDCl_3$) δ 149.6 (d, J_{CF} = 245.8 Hz), 141.9, 137.4, 137.3, 131.1, 129.0, 128.9, 128.7 (d, J_{CF} = 8.7 Hz), 127.0 (d, J_{CF} = 4.8 Hz), 126.9, 126.7, 123.0 (d, J_{CF} = 2.9 Hz), 120.5, 120.2, 119.8 (d, J_{CF} = 6.8 Hz), 116.2 (d, J_{CF} = 3.9 Hz), 112.1 (d, J_{CF} = 17.3 Hz), 110.3, 17.5.

FT-IR (neat) 3058, 2955, 2924, 1635, 1602, 1577, 1498, 1455, 1435, 1381, 1354, 1339, 1316, 1290, 1248, 1226, 1184, 1154, 1116, 1081, 1053, 1014, 951, 925, 884, 787, 745, 733, 722 cm^{-1}.

MS (EI) *m*/*z* (M^+) calcd for $C_{19}H_{14}FN$: 275, found: 275.

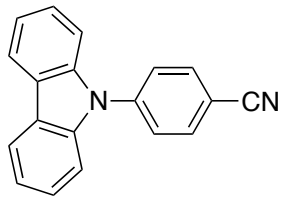


1-Phenyl-1*H*-indole (Table 5, entry 1) [16096-33-6]. The title compound was synthesized according to the General Procedure from indole (117 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and bromobenzene (220 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (10% EtOAc/hexanes) and purified by column chromatography (hexanes). Pale-yellow oil. First run: 115 mg (60% yield). Second run: 122 mg (63% yield).

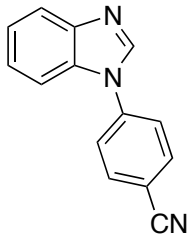


1-Phenyl-1*H*-benzo[*d*]imidazole (Table 5, entry 2) [2622-60-8]. The title compound was synthesized according to the General Procedure from benzimidazole (118 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and bromobenzene (220 mg, 1.40 mmol), except that a mixture of *t*-BuOH (1.0 mL) and CH_3CN (3.0 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. Reaction time: 48 h. The reaction mixture was filtered through a plug of silica gel (5% MeOH/CH_2Cl_2) and purified by normal-phase column chromatography on silica gel (0.75% MeOH/CH_2Cl_2) followed by reverse-phase column chromatography on C-18 silica gel (10%→100% CH_3CN/water). Yellow oil. First run: 118 mg (61%). Second run: 125 mg (64%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.



4-(9*H*-Carbazol-9-yl)benzonitrile (Table 5, entry 3) [57103-17-0]. The title compound was synthesized according to the General Procedure from carbazole (167 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-chlorobenzonitrile (193 mg, 1.40 mmol). The reaction mixture was filtered through a plug of silica gel (20% EtOAc/hexanes) and purified by normal-phase column chromatography on silica gel (hexanes→2% Et_2O/hexanes) followed by reverse-phase column chromatography on C-18 silica gel (10%→100% CH_3CN/water). Yellow solid. First run: 192 mg (72%). Second run: 194 mg (72%).



4-(1*H*-Benzo[*d*]imidazol-1-yl)benzonitrile (Table 5, entry 4) [25699-95-0]. The title compound was synthesized according to the General Procedure from benzimidazole (118 mg, 1.00 mmol), LiO*t*-Bu (112 mg, 1.40 mmol), CuI (19.0 mg, 0.10 mmol), and 4-chlorobenzonitrile (193 mg, 1.40 mmol), except that a mixture of *t*-BuOH (1.0 mL) and CH_3CN (3.0 mL) was used as the solvent (*t*-BuOH and CH_3CN were added in turn via syringe), due to the poor solubility of the heterocycle in neat CH_3CN. Reaction time: 48 h. The product was filtered through a plug of silica gel (5% MeOH/CH_2Cl_2) and purified by column chromatography on silica gel (1% MeOH/CH_2Cl_2, then 40%→55% EtOAc/hexanes). Yellow solid. First run: 131 mg (60%). Second run: 135 mg (62%).

Note: The reaction mixture was stirred until it became homogeneous, and then it was immediately transferred to the photoreactor before it turned to a white heterogeneous mixture. The reaction proceeded in poor yield when the white precipitate formed.

III. Nucleophile Competition Experiments (Table 6)

Procedure. Both of the nitrogen heterocycles (0.40 mmol each) and LiO*t*-Bu (32.0 mg, 0.40 mmol) were added to an oven-dried 10-mL quartz test tube that contained a stir bar. Next, the quartz tube was transferred to a glovebox, where *t*-BuOH (0.40 mL) and CH_3CN (0.40 mL) were added. The reaction mixture was stirred for 3 min, and then a solution of CuI in CH_3CN (0.80 mL, 0.050 M) was added, followed by iodobenzene (114 mg, 0.56 mmol) and dibenzyl ether (79.3 mg, 0.40 mmol; internal standard). The quartz test tube was capped with a rubber septum and transferred to a Luzchem LZC–4V photoreactor, where it was irradiated at 254 nm (adequate stirring is important). The ratio of products was determined by GC analysis after 2 h.

Note: Reactions with benzimidazole were quickly transferred to the photoreactor before they became heterogeneous.

IV. Electrophile Competition Experiments (eq 2)

Procedure. Indole (46.9 mg, 0.40 mmol) and LiO*t*-Bu (44.8 mg, 0.56 mmol) were added to an oven-dried 10-mL quartz test tube that contained a stir bar. Next, the quartz tube was transferred to a glovebox, where CH_3CN (0.80 mL), 1-ethyl-4-iodobenzene (130 mg, 0.56 mmol), and the aryl bromide or chloride (0.56 mmol) were added in turn. The reaction mixture was stirred for 3 min, and then a solution of CuI in CH_3CN (0.80 mL, 0.050 M) was added, followed by dibenzyl ether (79.3 mg, 0.40 mmol; internal standard). The quartz test tube was capped with a rubber septum and transferred to a Luzchem LZC–4V photoreactor, where it was irradiated at 254 nm (adequate stirring is important). The ratio of products was determined by GC analysis after 1 h.

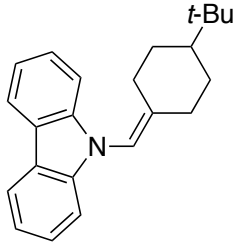
V. Functional-Group Tolerance Experiments (Table 7)

Procedure. Indole (46.9 mg, 0.40 mmol) and LiO*t*-Bu (44.8 mg, 0.56 mmol) were added to an oven-dried 10-mL quartz test tube that contained a stir bar. Next, the quartz test tube was transferred to a glovebox, where CH_3CN (0.80 mL) and the additive (0.40 mmol) were added in turn. The reaction mixture was stirred for 3 min, and then a solution of CuI in CH_3CN (0.80 mL, 0.050 M) was added, followed by iodobenzene (114 mg, 0.56 mmol) and dibenzyl ether (79.3 mg, 0.40 mmol; internal standard). The reaction mixture was stirred for 3 min, and then an aliquot was taken for a t = 0 time point. Next, the quartz test tube was capped with a rubber septum, the joint was wrapped with electrical tape, and the quartz tube was transferred to a Luzchem LZC–4V photoreactor, where it was irradiated at 254 nm for 24 h (adequate stirring is important). The yield of product and the percent recovery of the additive were determined by GC analysis.

VI. Photoinduced, Copper-Catalyzed N-Alkenylations/Alkynylations (Table 8)

General Procedure. The nitrogen heterocycle (0.50 mmol) and LiO*t*-Bu (83.0 mg, 1.04 mmol) were added to an oven-dried 10-mL quartz test tube that contained a stir bar. The quartz tube was fitted with a rubber septum, the joint was wrapped with electrical tape, and the quartz tube was evacuated and backfilled with nitrogen (3 cycles). Then, CH_3CN (4.0 mL) was added, and the mixture was stirred for 10 min. Next, a solution of CuI in CH_3CN (500 μL, 0.10 M) was added via syringe, and the mixture was stirred for 10 min. A 4-mL oven-dried vial was charged with the alkenyl iodide (0.85 mmol), closed with a septum cap, and evacuated and backfilled with nitrogen (3 cycles). The alkenyl iodide was transferred to the quartz tube via syringe. The vial was rinsed with CH_3CN (0.50 mL), and the washing was transferred to the quartz tube. The test tube was detached from the nitrogen manifold, and the puncture holes in the septum were covered with vacuum grease. The mixture was stirred for 10 min, and then the test tube was transferred to a Luzchem LZC–4V photoreactor, where it was irradiated at 254 nm for 12 h (adequate stirring is important). Next, the reaction mixture was passed through a plug of silica gel (10% EtOAc/hexanes; monitored by TLC), the solvent was removed, and the residue was purified by column chromatography.

Note: For the N-alkynylation process (Table 8, entry 5), the same procedure was employed, except that the reaction mixture was irradiated for 24 h.



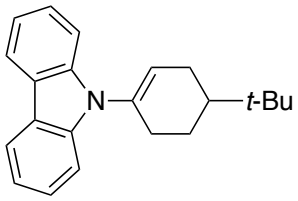
9-((4-(*tert*-Butyl)cyclohexylidene)methyl)-9*H*-carbazole (Table 8, entry 1). The title compound was synthesized according to the General Procedure from carbazole (84 mg, 0.50 mmol) and 1-(iodomethylidene)-4-*tert*-butyl-cyclohexane (237 mg, 0.85 mmol). The product was purified by column chromatography (hexanes). White solid. First run: 138 mg (87%). Second run: 131 mg (83%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.11 (d, 2H, J = 7.7 Hz), 7.46 (t, 2H, J = 7.7 Hz), 7.40–7.21 (m, 4H), 6.45 (s, 1H), 2.75–2.62 (m, 1H), 2.36–2.25 (m, 2H), 2.11–2.03 (m, 1H), 1.89–1.70 (m, 2H), 1.35–1.20 (m, 2H), 1.08–0.96 (m, 1H), 0.89 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 144.6, 140.9, 125.6, 122.9, 120.1, 119.3, 114.1, 110.0, 48.1, 33.2, 32.5, 29.2, 28.9, 28.1, 27.6.

FT-IR (neat) 3054, 2986, 2305, 1479, 1457, 1422, 1265, 896 cm^{-1}.

MS (EI) m/z (M^+) calcd for $C_{23}H_{27}N$: 317, found: 317.



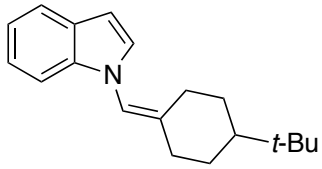
9-(4-(*tert*-Butyl)cyclohex-1-en-1-yl)-9*H*-carbazole (Table 8, entry 2). The title compound was synthesized according to the General Procedure from carbazole (84 mg, 0.50 mmol) and 4-*tert*-butyl-1-iodo-1-cyclohexene (225 mg, 0.85 mmol). The product was purified by column chromatography (hexanes). White solid. First run: 114 mg (75%). Second run: 114 mg (75%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.11 (d, 2H, J = 7.7 Hz), 7.46–7.36 (m, 4H), 7.28–7.19 (m, 2H), 6.10–6.06 (m, 1H), 2.50–2.36 (m, 3H), 2.24–2.12 (m, 1H), 2.10–2.00 (m, 1H), 1.65–1.50 (m, 2H), 1.00 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.4, 134.3, 128.3, 125.6, 122.9, 120.2, 119.1, 109.8, 44.0, 32.4, 28.5, 27.3, 26.6, 24.4.

FT-IR (neat) 3054, 2987, 2305, 1452, 1422, 1265, 896 cm^{-1}.

MS (EI) m/z (M^+) calcd for $C_{22}H_{25}N$: 303, found: 303.



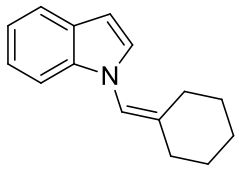
1-((4-(*tert*-Butyl)cyclohexylidene)methyl)-1*H*-indole (Table 8, entry 3). The title compound was synthesized according to the General Procedure from indole (59 mg, 0.50 mmol) and 1-(iodomethylidene)-4-*tert*-butyl-cyclohexane (237 mg, 0.85 mmol). The product was purified by column chromatography (hexanes). White solid. First run: 100 mg (75%). Second run: 99 mg (74%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.65 (d, 1H, J = 7.8 Hz), 7.32 (d, 1H, J = 8.3 Hz), 7.27–7.21 (m, 1H), 7.18–7.12 (m, 1H), 7.11–7.08 (m, 1H), 6.58–6.53 (m, 2H), 2.66–2.48 (m, 2H), 2.26–2.15 (m, 1H), 2.05–1.97 (m, 1H), 1.91–1.79 (m, 2H), 1.31–1.15 (m, 2H), 1.10–0.97 (m, 1H), 0.89 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 139.7, 136.6, 128.5, 128.1, 121.7, 120.7, 119.7, 116.4, 110.3, 101.8, 48.1, 33.4, 32.5, 29.0, 28.4, 28.2, 27.6.

FT-IR (neat) 3054, 2986, 2305, 1422, 1265, 896 cm^{-1}.

MS (EI) m/z (M^+) calcd for $C_{19}H_{25}N$: 267, found: 267.



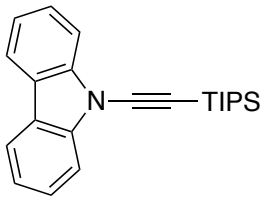
1-(Cyclohexylidenemethyl)-1*H*-indole (Table 8, entry 4). The title compound was synthesized according to the General Procedure from indole (59 mg, 0.50 mmol) and bromomethylenecyclohexane (155 mg, 0.85 mmol). Reaction time: 48 h. The product was purified by column chromatography (hexanes). Colorless oil. First run: 58 mg (55%). Second run: 60 mg (57%).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68 (d, 1H, *J* = 7.8 Hz), 7.34 (d, 1H, *J* = 8.2 Hz), 7.29–7.23 (m, 1H), 7.20–7.15 (m, 1H), 7.13–7.09 (m, 1H), 6.61–6.57 (m, 2H), 2.38–2.32 (m, 2H), 2.24–2.18 (m, 2H), 1.78–1.70 (m, 2H), 1.70–1.63 (m, 2H), 1.60–1.52 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.1, 136.6, 128.5, 128.1, 121.7, 120.7, 119.7, 116.8, 110.3, 101.8, 33.4, 28.5, 28.3, 27.4, 26.5.

FT-IR (neat) 2934, 2956, 2253, 1674, 1511, 1475, 1462, 1377, 1319, 1234, 1088, 907 cm^{-1}.

MS (EI) m/z (M^+) calcd for $C_{15}H_{17}N$: 211, found: 211.



9-((Triisopropylsilyl)ethynyl)-9*H*-carbazole (Table 8, entry 5). The title compound was synthesized according to the General Procedure from carbazole (84 mg, 0.50 mmol) and 2-bromo-1-triisopropylsilyl acetylene (222 mg, 0.85 mmol). The product was purified by column chromatography (hexanes). White solid. First run: 109 mg (63%). Second run: 107 mg (62%).

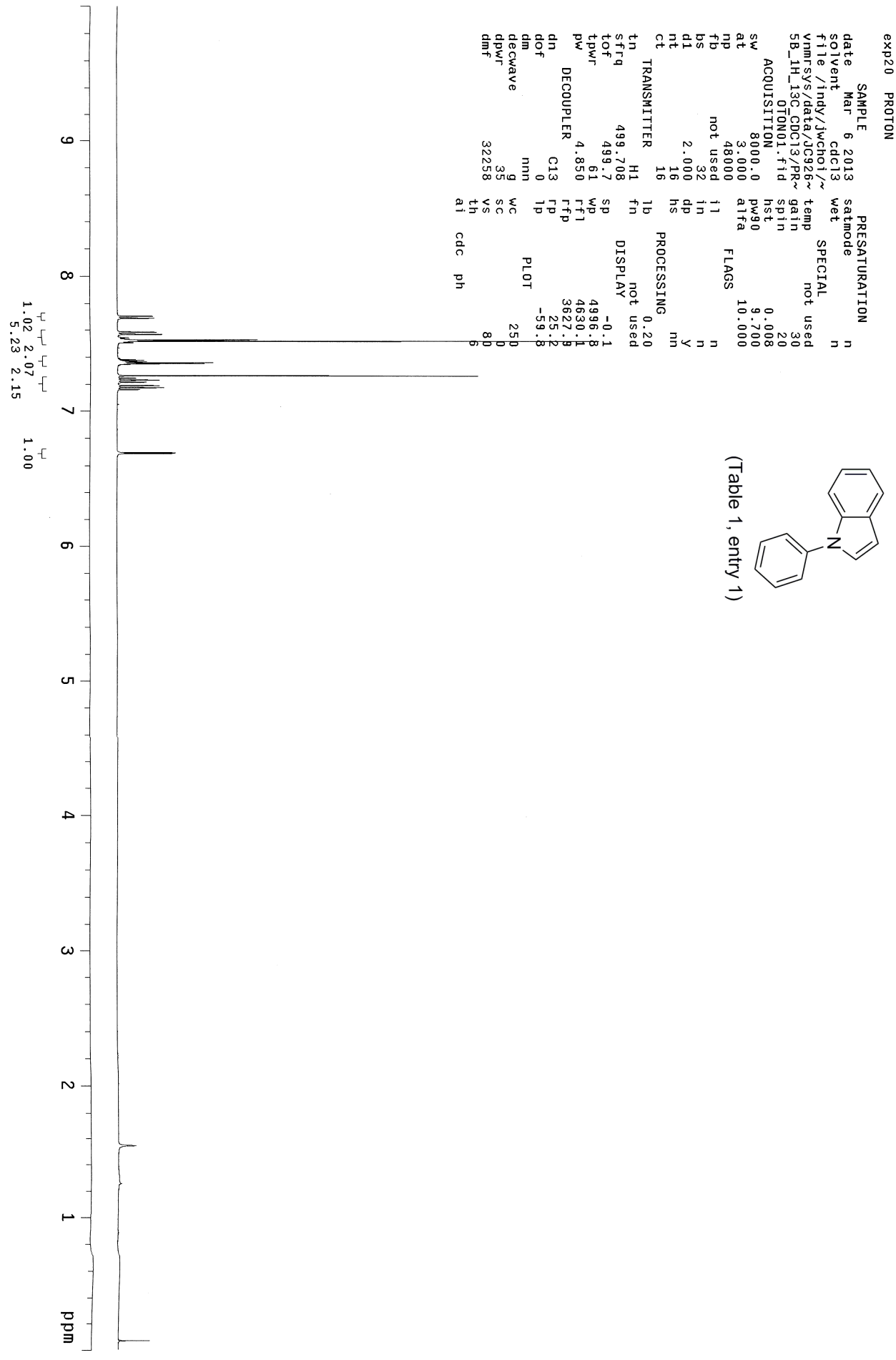
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.02 (d, 2H, *J* = 7.7 Hz), 7.64 (d, 2H, *J* = 8.1 Hz), 7.53 (t, 2H, *J* = 7.7 Hz), 7.34 (t, 2H, *J* = 7.7 Hz), 1.31–1.14 (m, 21H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.5, 126.7, 123.3, 122.0, 120.3, 111.4, 92.6, 72.8, 18.8, 11.4.

FT-IR (neat) 3054, 2986, 2305, 2178, 1422, 1265, 896 cm^{-1}.

MS (EI) m/z (M^+) calcd for $C_{23}H_{29}NSi$: 347, found: 347.

VII. 1H NMR Spectra



DZ-04-292-1-Purified

exp20 PROTON

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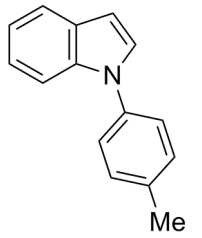
r/vnmrsys/data/DZ-~		temp	not used
04-292-1-Purified/~		gain	32
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	20.6
dof	0	lp	-73.7
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	40
dmf	32258	th	25
		ai cdc ph	

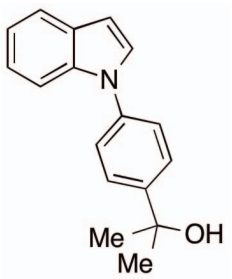


(Table 1, entry 2)

DZ-05-082-1-Purified

exp25 PROTON

SAMPLE		PRESATURATION	
date	Jul 26 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
05-082-1-Purified/~		gain	32
PROTON01.fid		spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	32	hs	nn
ct	32	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.698	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4632.1
DECOUPLER		rfp	3627.8
dn	C13	rp	-81.8
dof	0	lp	-72.7
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	11
dmf	32258	th	16
		ai cdc ph	

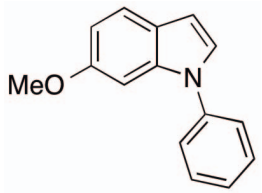


(Table 1, entry 3)

DZ-04-200-2-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 21 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-200-2-Purified/~		gain	30
	PROTON02.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.6
dof	0	lp	-72.6
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	48
		th	13
		ai cdc ph	

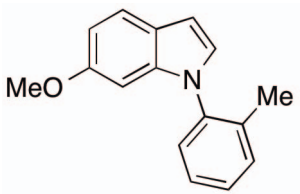


(Table 1, entry 4)

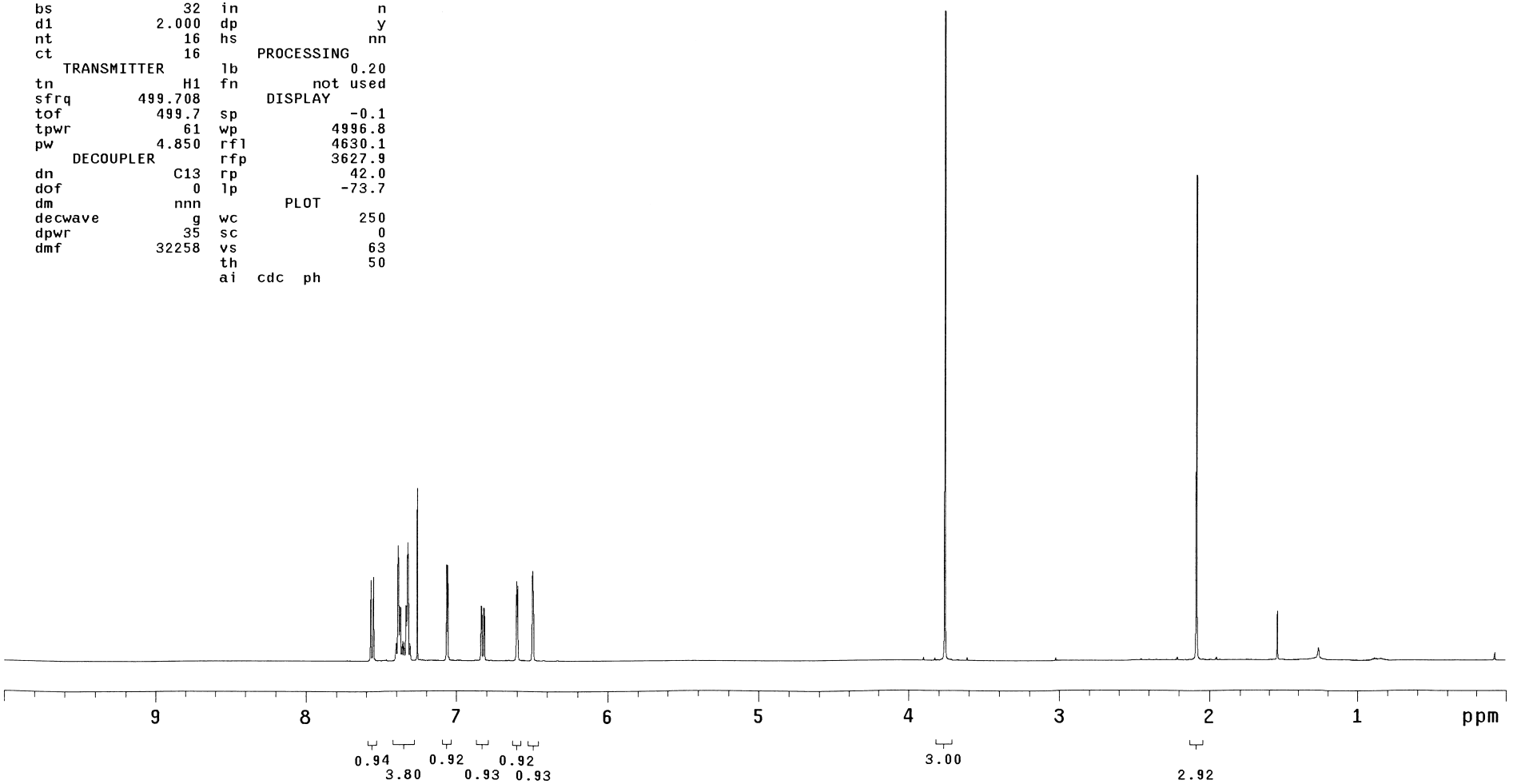
JC9267 1H CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 10 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC926~		temp	not used
7_1H_CDCl3/PROTON0~		gain	30
	1.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.0
dof	0	lp	-73.7
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	63
		th	50
		ai	cdc ph



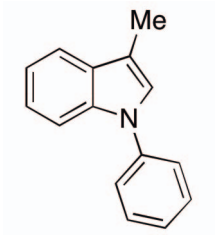
(Table 1, entry 5)



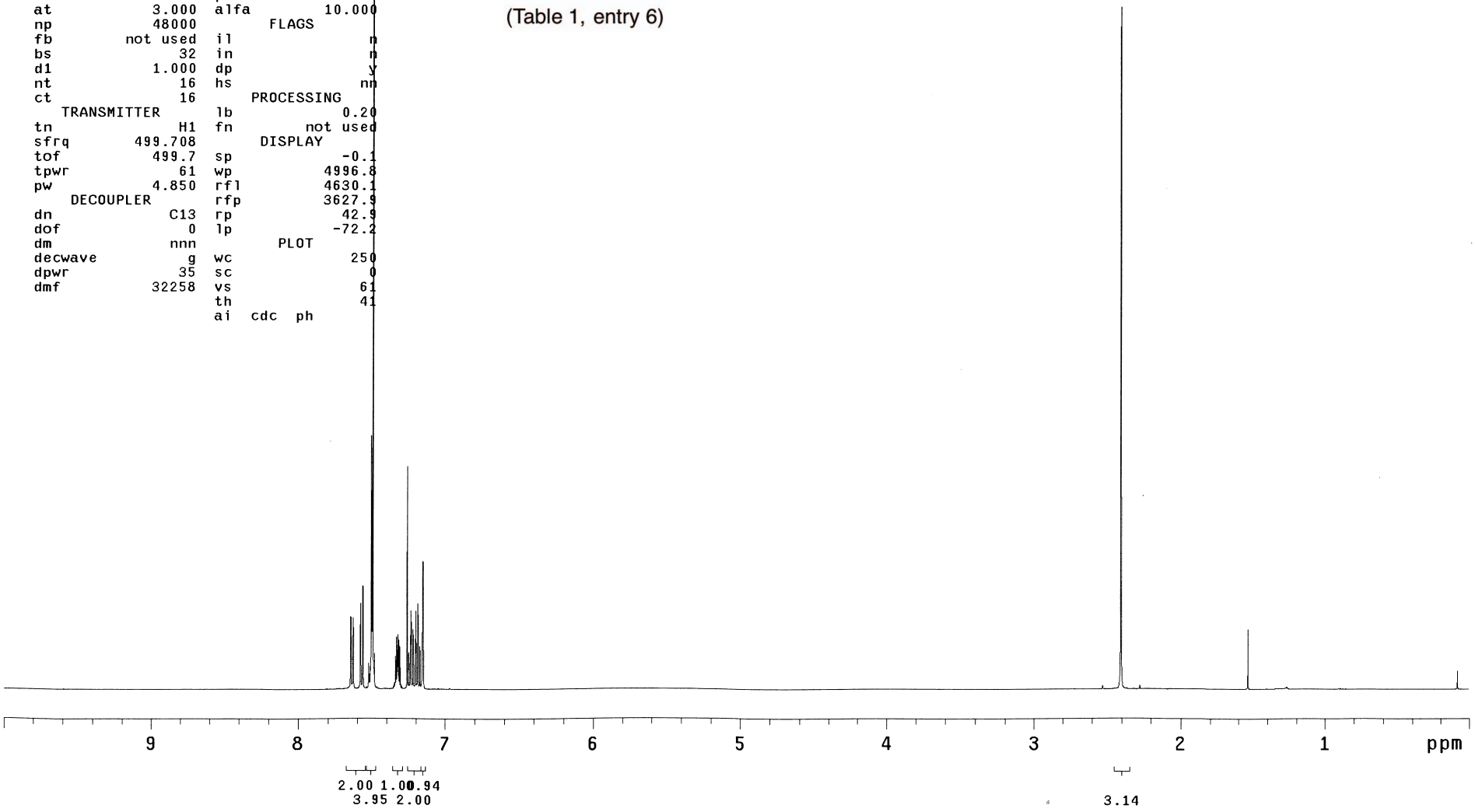
DZ-04-244-1-Purified

exp21 PROTON

SAMPLE		PRESATURATION	
date	Mar 16 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
	r/vnmrsys/data/DZ-~	temp	not used
	04-244-1-Purified/~	gain	30
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.9
dof	0	lp	-72.2
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	61
		th	41
		ai cdc ph	



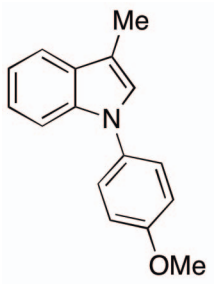
(Table 1, entry 6)



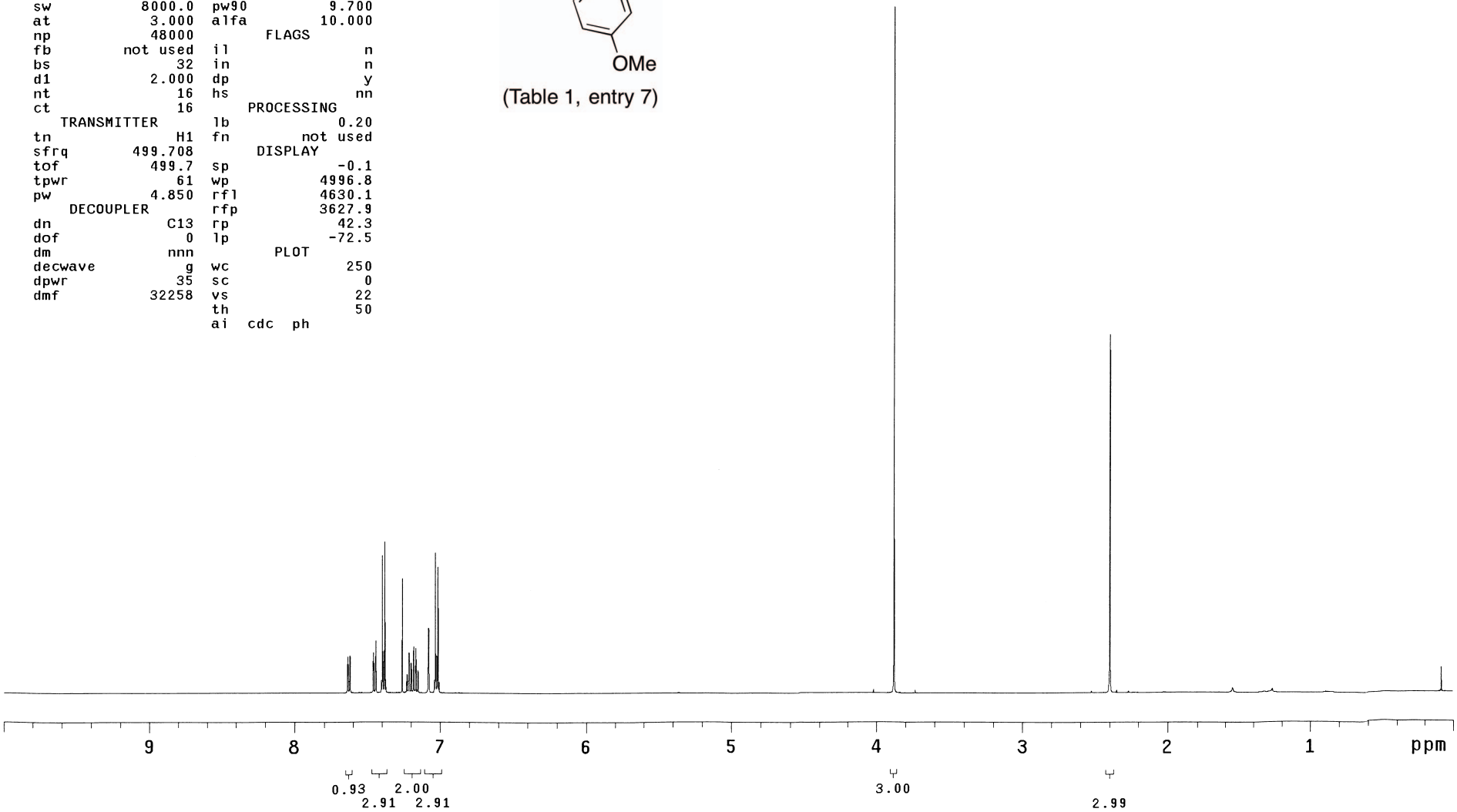
JC9299 CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 21 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC929~		temp	not used
9_1H_13C_CDCl3/PRO~		gain	30
	TON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.3
dof	0	lp	-72.5
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	22
		th	50
		ai cdc ph	



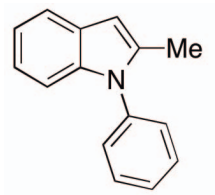
(Table 1, entry 7)



DZ-04-266-2-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 20 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-266-2-Purified/~		gain	30
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.7
dof	0	lp	-73.7
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	79
		th	25
		ai cdc ph	



(Table 1, entry 8)

DZ-04-246-1-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 16 2013	satmode	n
solvent	cdcl3	wet	n
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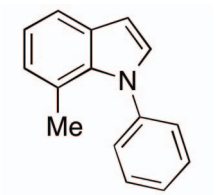
r/vnmrsys/data/DZ-~		temp	not used
04-246-1-Purified/~		gain	30
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	41.9
dof	0	lp	-70.9
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	85
		th	25
		ai	cdc ph

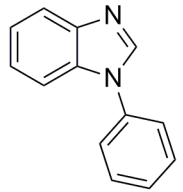


(Table 1, entry 9)

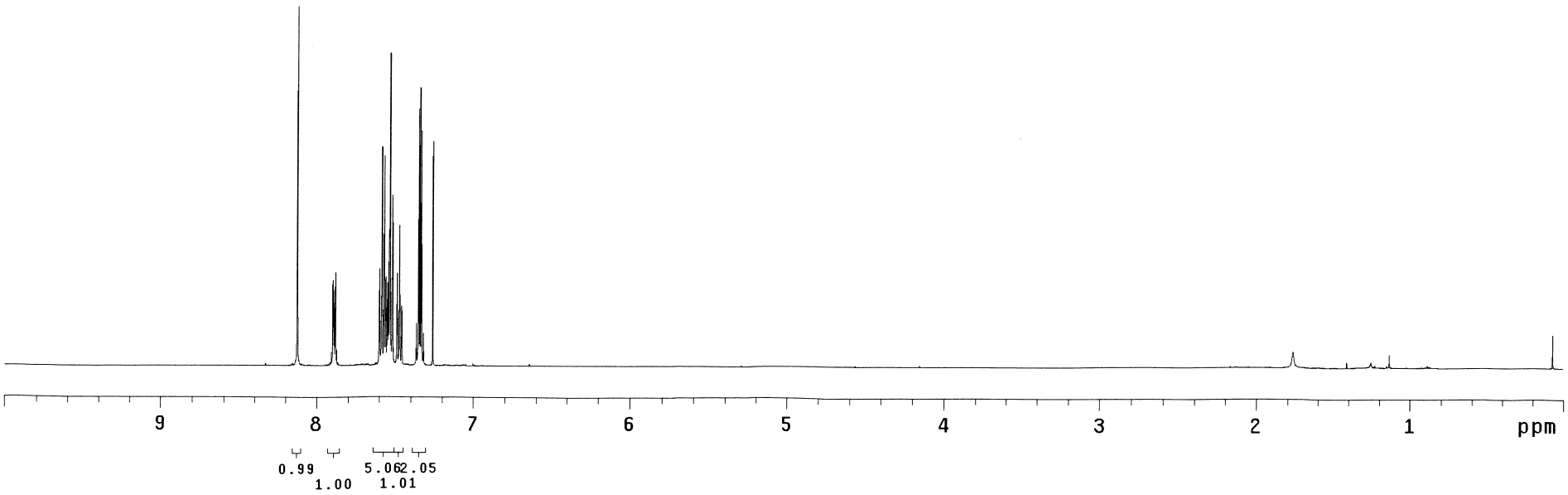
DZ-04-196-1-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 23 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-196-1-Purified/~		gain	30
	PROTON02.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	44.9
dof	0	lp	-72.3
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	65
		th	33
		ai cdc ph	



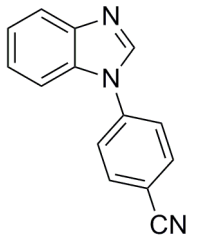
(Table 2, entry 1)



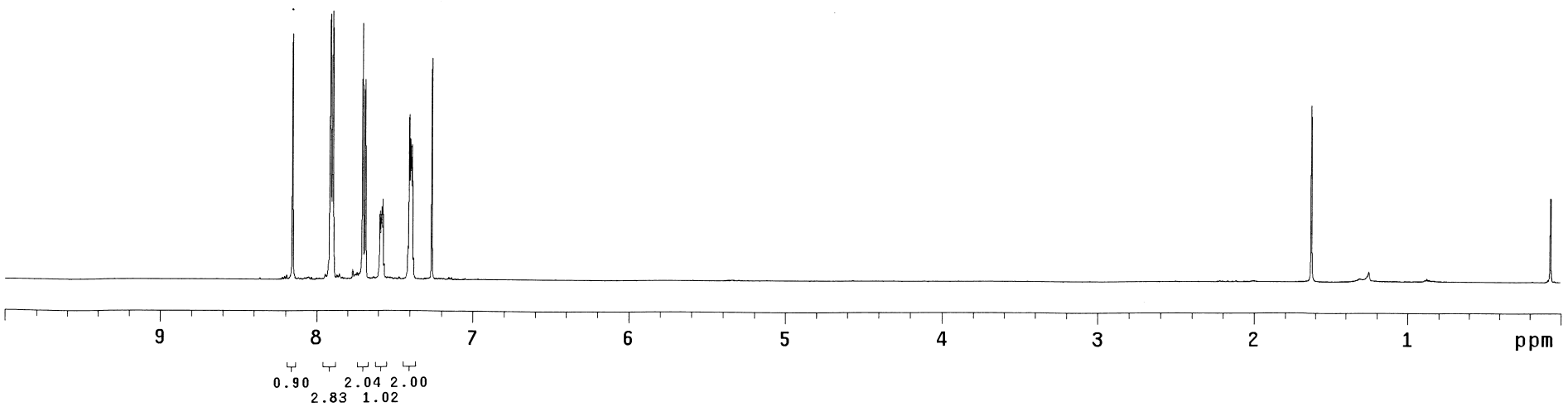
DZ-04-270-1-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 26 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-270-1-Purified/~		gain	32
	PROTON01.fid	spin	0
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4629.9
DECOUPLER		rfp	3627.9
dn	C13	rp	24.7
dof	0	lp	-72.1
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	135
dmf	32258	th	4
		ai cdc ph	



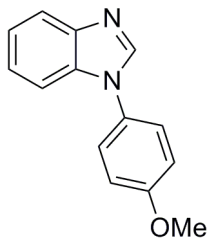
(Table 2, entry 2)



DZ-04-268-3-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Apr 2 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-268-3-Purified/~		gain	32
	PROTON02.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	21.6
dof	0	lp	-79.4
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	25
dmf	32258	th	13
		ai cdc ph	



(Table 2, entry 3)

JC9273A 1H 13C CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
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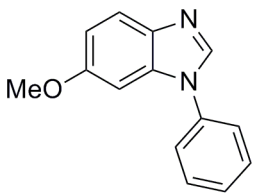
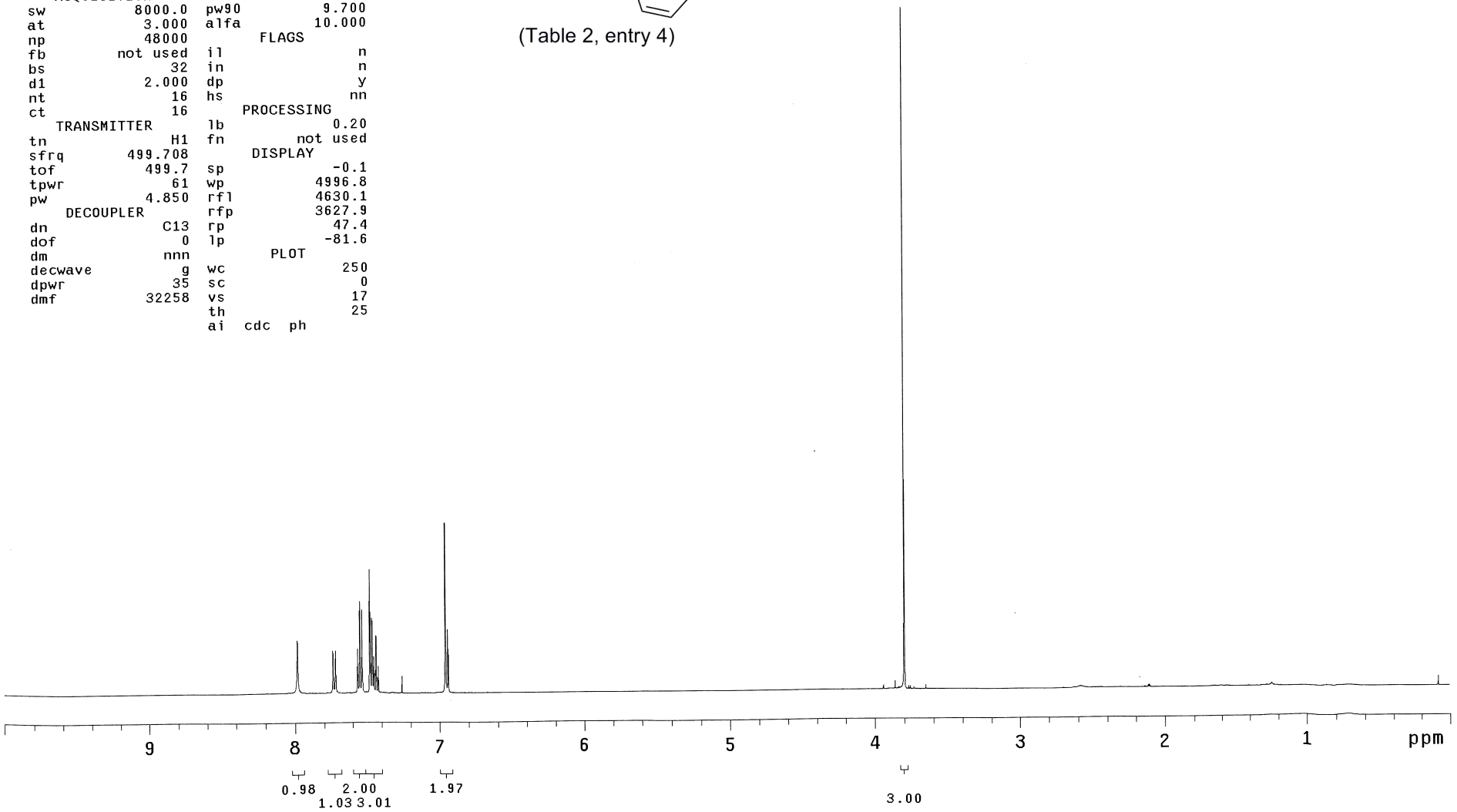
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC927~		temp	not used
3A_1H_13C_CDCl3/PR~		gain	18
OTON02.fid		spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	47.4
dof	0	lp	-81.6
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	17
		th	25
		ai cdc ph	



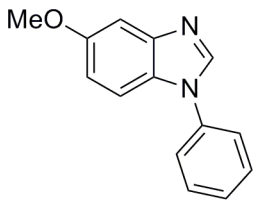
(Table 2, entry 4)



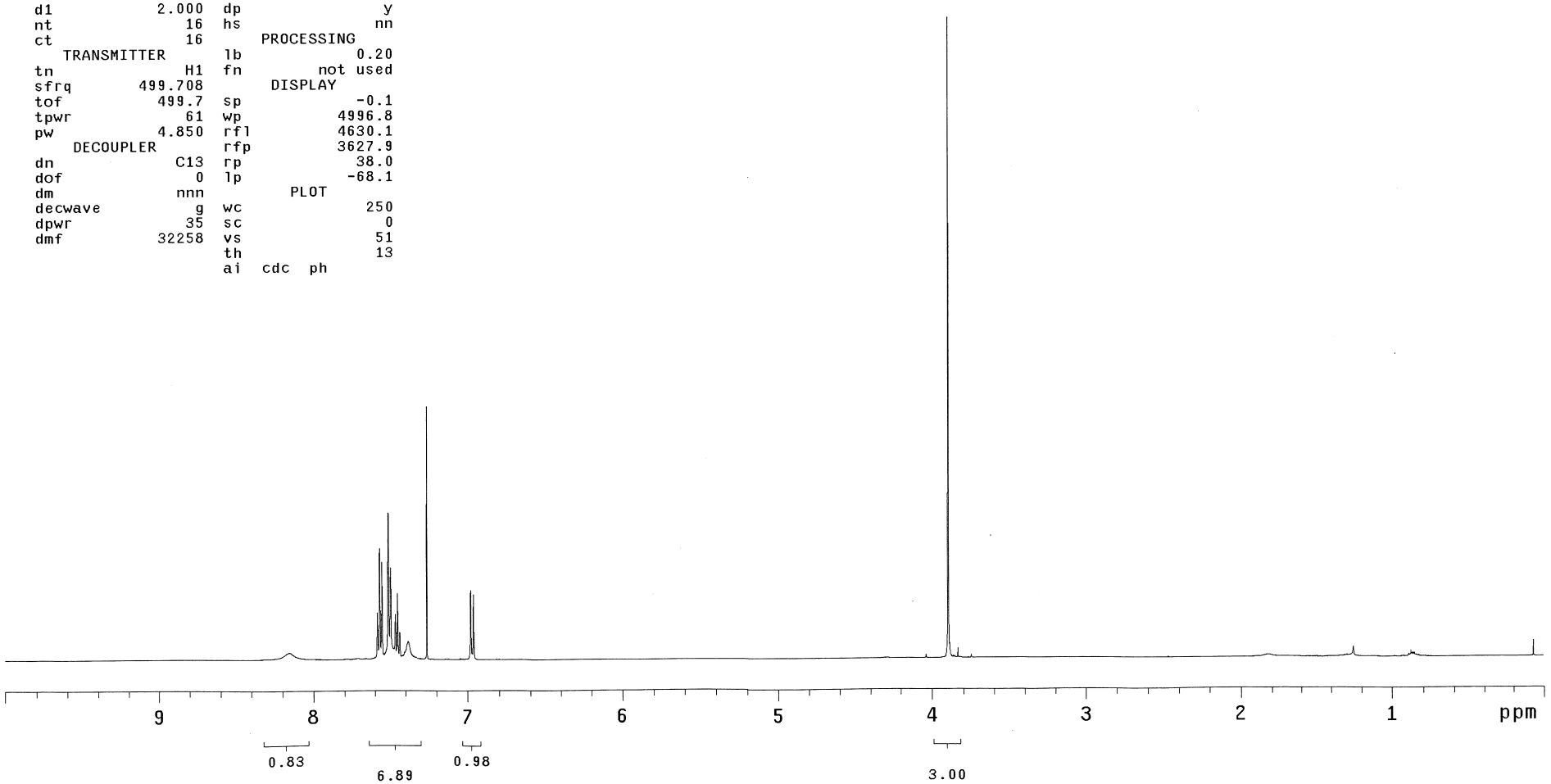
JC9273 Lower-spot 1H CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 10 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC927~		temp	not used
3_Lower-spot_1H_CD~		gain	30
C13/PROTON02.fid		spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	38.0
dof	0	lp	-68.1
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	51
		th	13
		ai cdc ph	



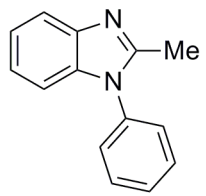
(Table 2, entry 4)



JC9291 1H CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 21 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC929~		temp	not used
1_1H_CDCl3/PROTON0~		gain	30
	2.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	41.9
dof	0	lp	-68.8
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	43
		th	6
		ai cdc ph	

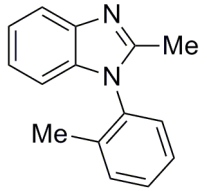


(Table 2, entry 5)

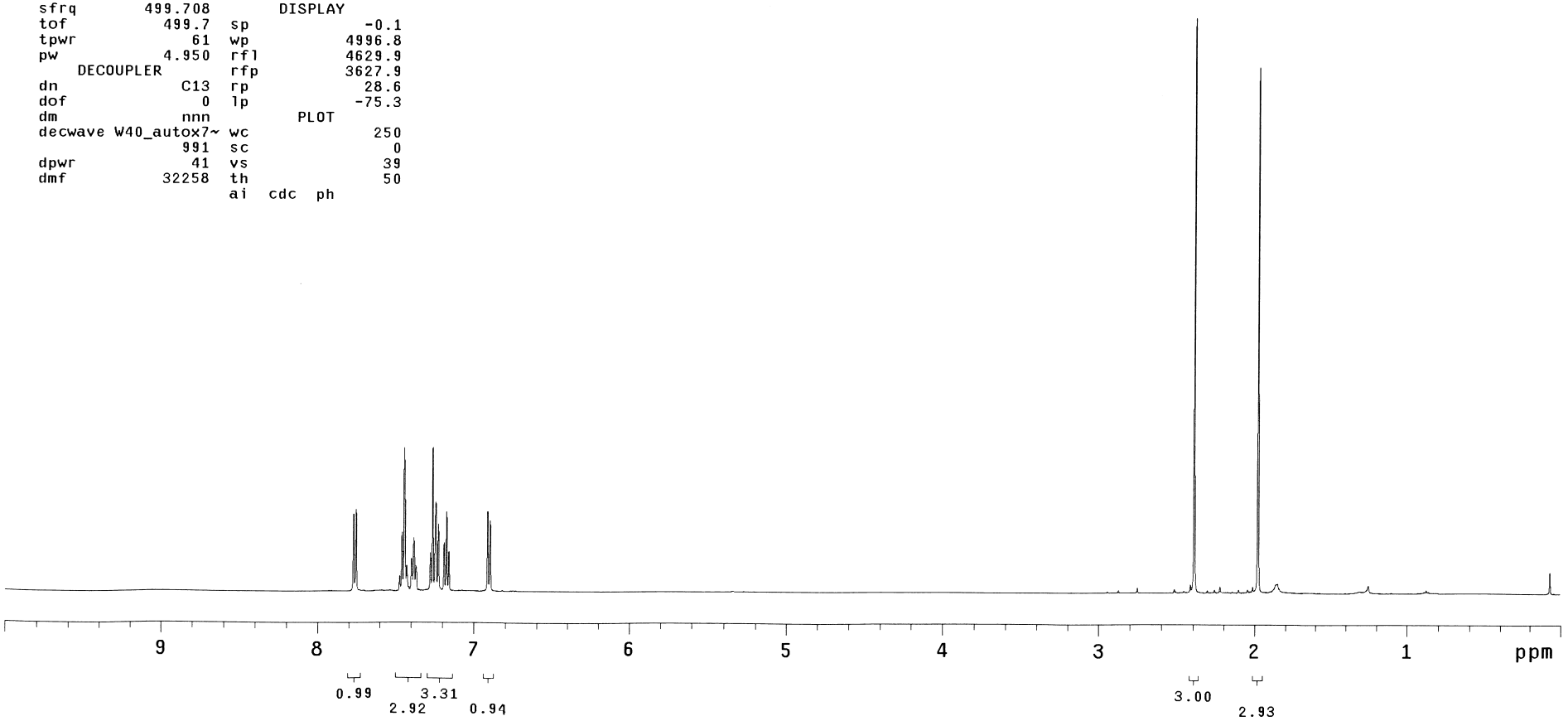
JC9303B CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 25 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC930~		temp	not used
3B_1H_13C_CDCl3/PR~		gain	32
	OTON01.fid	spin	0
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4629.9
DECOUPLER		rfp	3627.9
dn	C13	rp	28.6
dof	0	lp	-75.3
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	39
dmf	32258	th	50
		ai cdc ph	



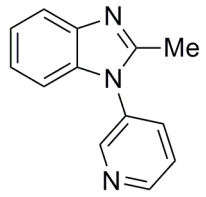
(Table 2, entry 6)



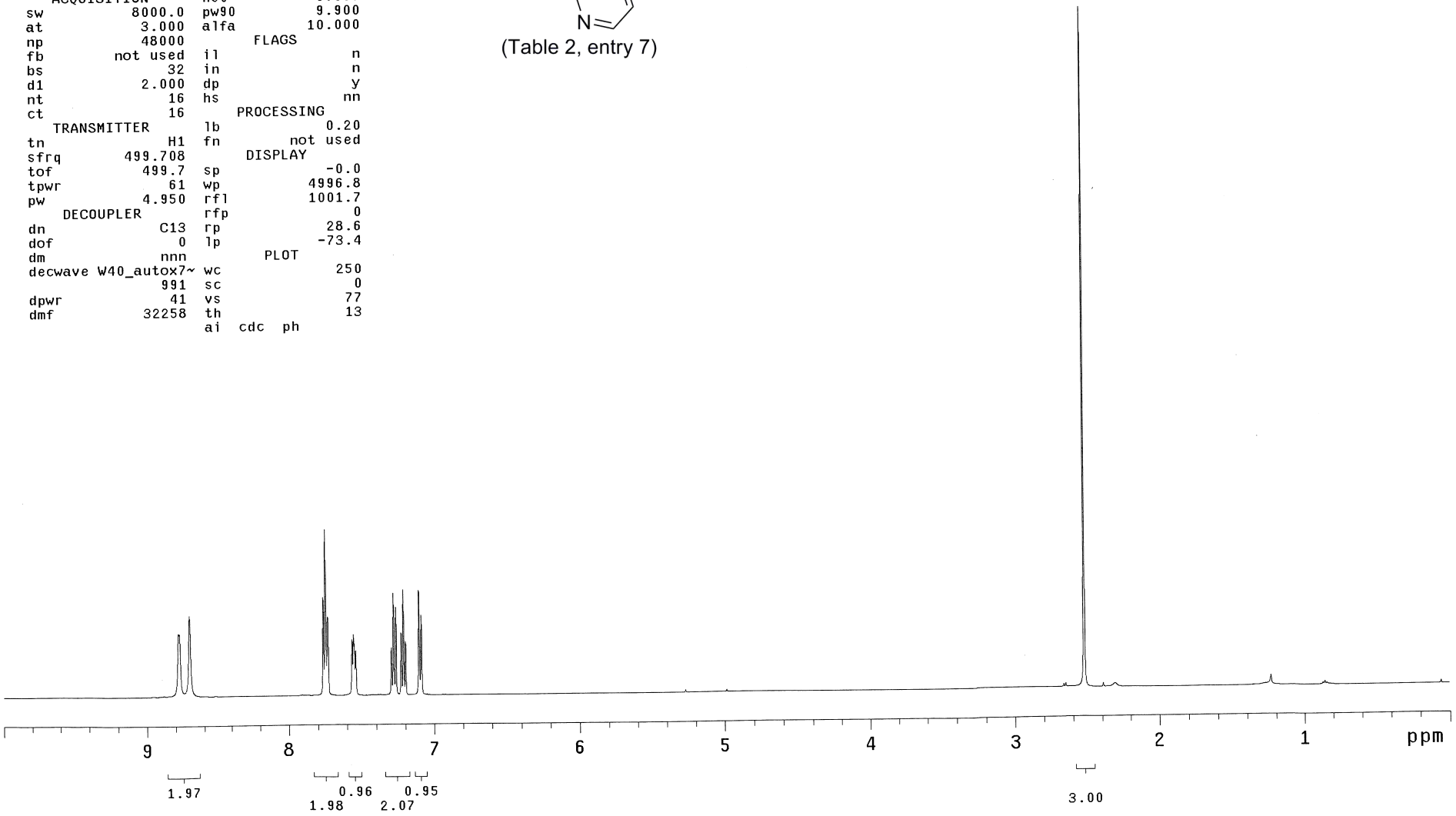
JC10009 CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 29 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC100~		temp	not used
09_1H_13C_CDCl3/PR~		gain	20
	OTON01.fid	spin	0
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.0
tpwr	61	wp	4996.8
pw	4.950	rfl	1001.7
DECOUPLER		rfp	0
dn	C13	rp	28.6
dof	0	lp	-73.4
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	77
dmf	32258	th	13
		ai cdc ph	



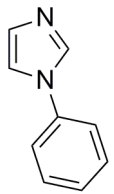
(Table 2, entry 7)



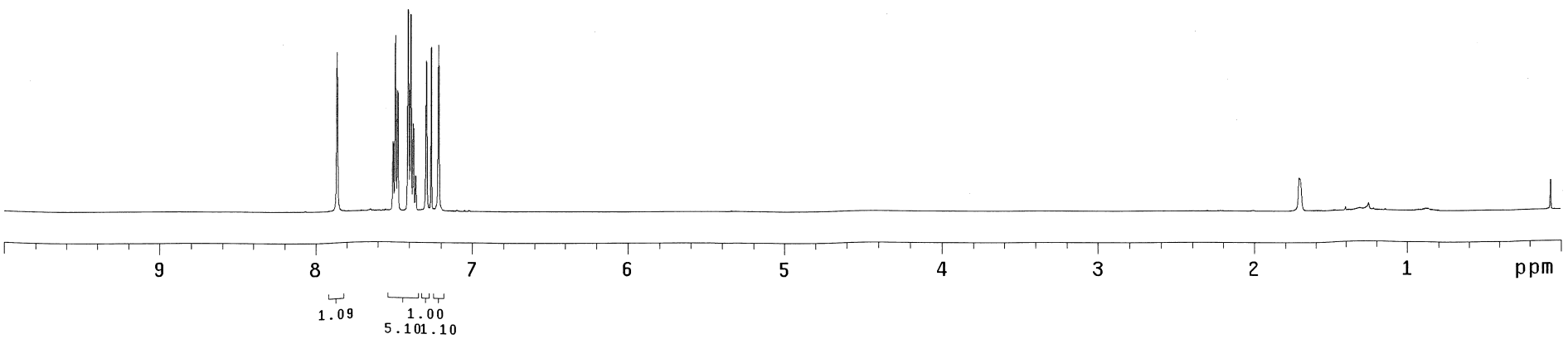
DZ-Ph-imidazole 1H CDCl3

exp10 PROTON

SAMPLE		PRESATURATION	
date	Mar 29 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~vnmrsys/data/DZ-Ph~-imidazole_1H_CDCl~3/PROTON01.fid	SPECIAL	
		temp	not used
		gain	32
		spin	0
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4629.9
DECOUPLER		rfp	3627.9
dn	C13	rp	27.6
dof	0	lp	-76.2
dm	nnn	PLOT	
decwave	W40_autox7~991	wc	250
		sc	0
dpwr	41	vs	100
dmf	32258	th	49
		ai cdc ph	



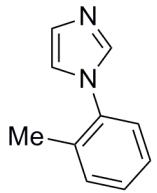
(Table 3, entry 1)



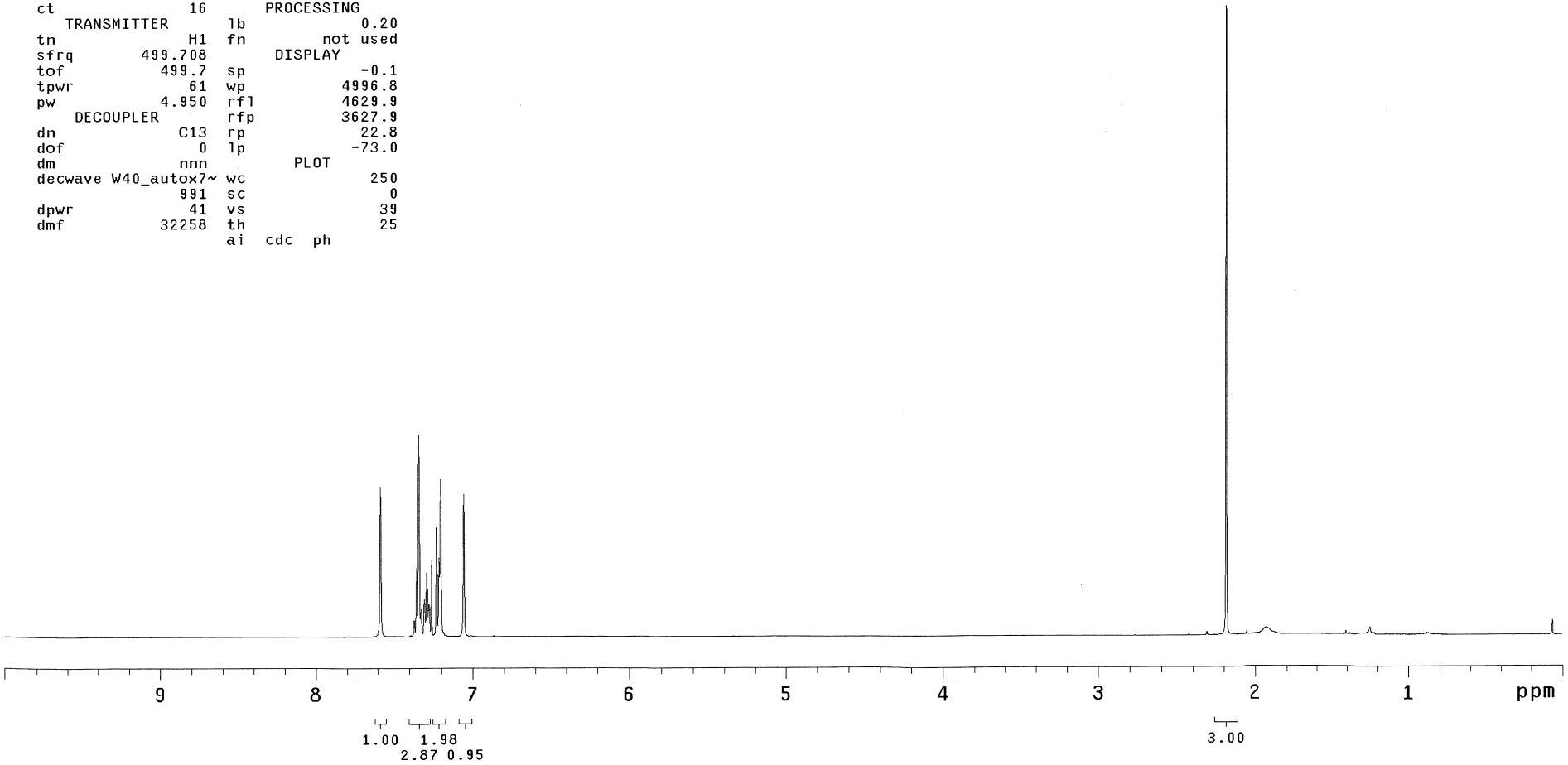
JC10013 CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 31 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC100~		temp	not used
13_1H_13C_CDCl3/PR~		gain	32
OTON01.fid		spin	0
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4629.9
DECOUPLER		rfp	3627.9
dn	C13	rp	22.8
dof	0	lp	-73.0
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	39
dmf	32258	th	25
		ai cdc ph	



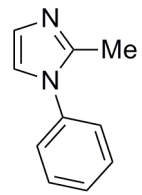
(Table 3, entry 2)



DZ-04-254-1-Purified

exp10 PROTON

SAMPLE		PRESATURATION	
date	Mar 16 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-254-1-Purified/~		gain	30
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.5
dof	0	lp	-73.7
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	23
		th	13
		ai cdc ph	

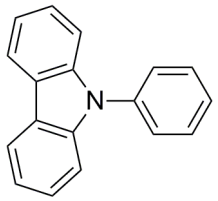


(Table 3, entry 3)

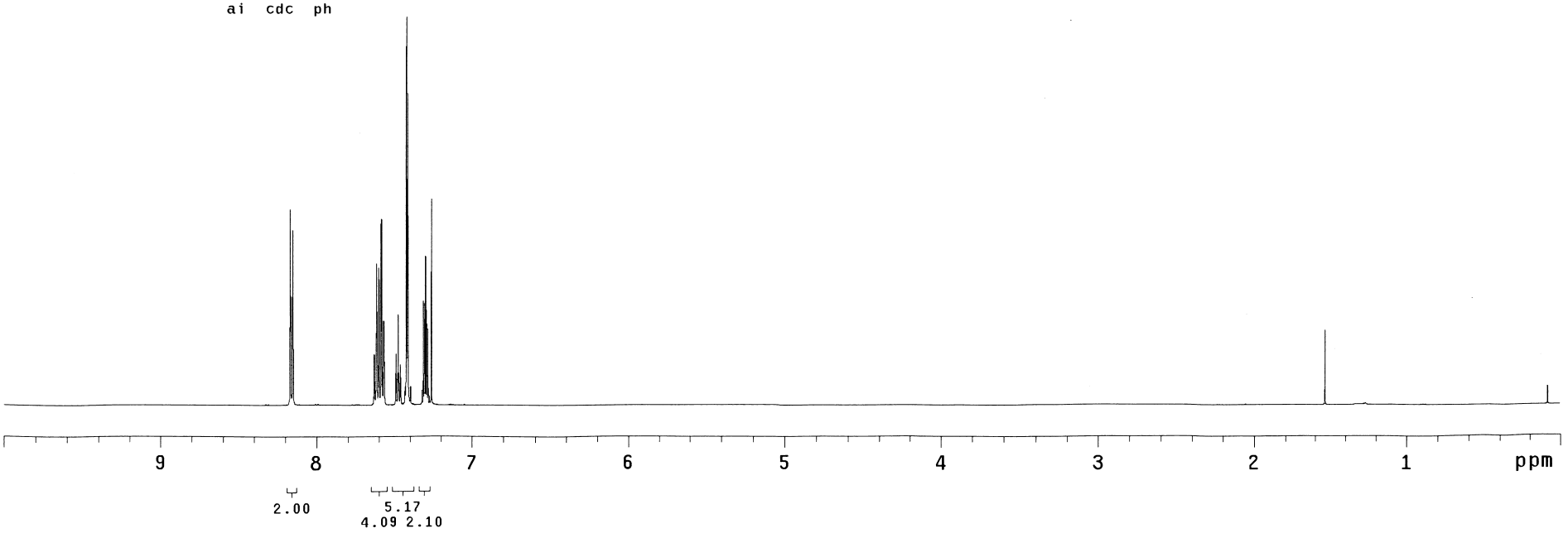
DZ-04-230-3-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 18 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-230-3-Purified/~		gain	30
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	40.0
dof	0	lp	-71.1
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	50
		th	38
		ai cdc ph	



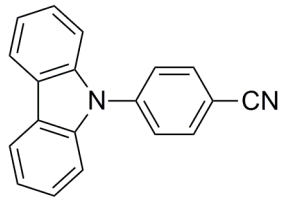
(Table 4, entry 1)



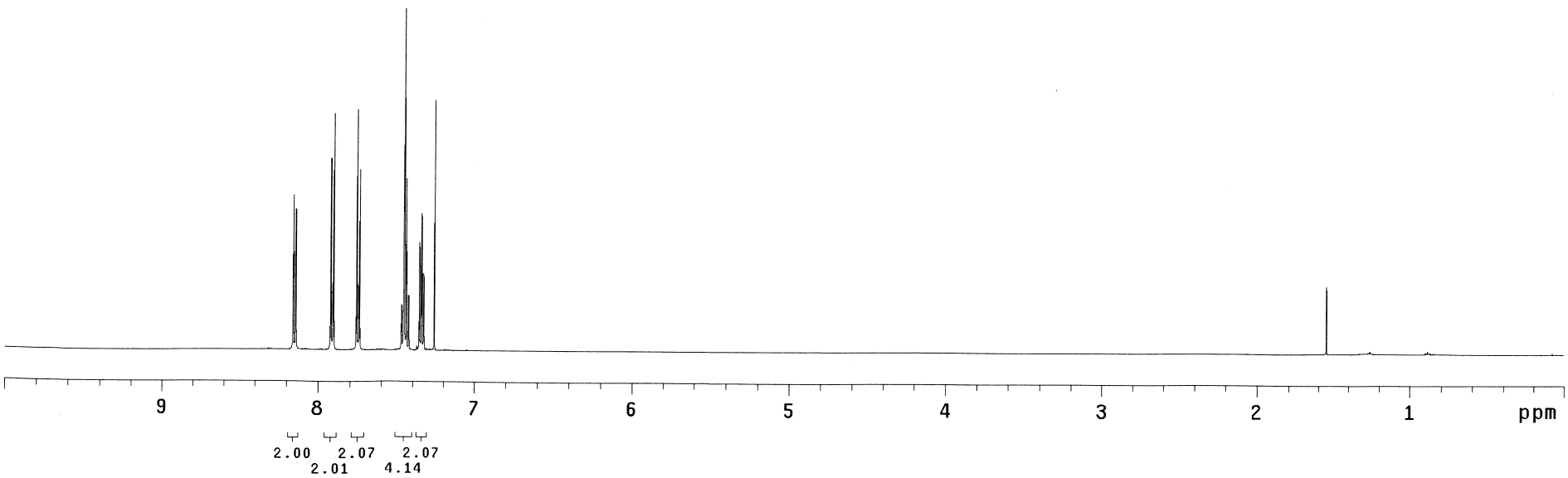
JC9283 1H CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 17 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC928~		temp	not used
3_1H_CDCl3/PROTON0~		gain	30
	1.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	43.3
dof	0	lp	-75.9
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	49
		th	37
		ai cdc ph	



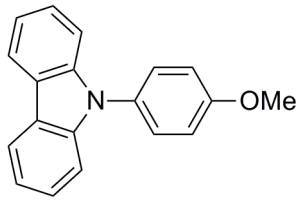
(Table 4, entry 2)



JC9281 CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 16 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC928~		temp	not used
1_1H_13C_CDCl3/PRO~		gain	30
TON01.fid		spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	41.5
dof	0	lp	-74.5
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	42
		th	25
		ai	cdc ph

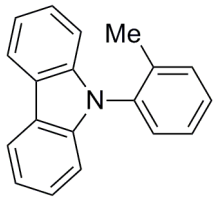


(Table 4, entry 3)

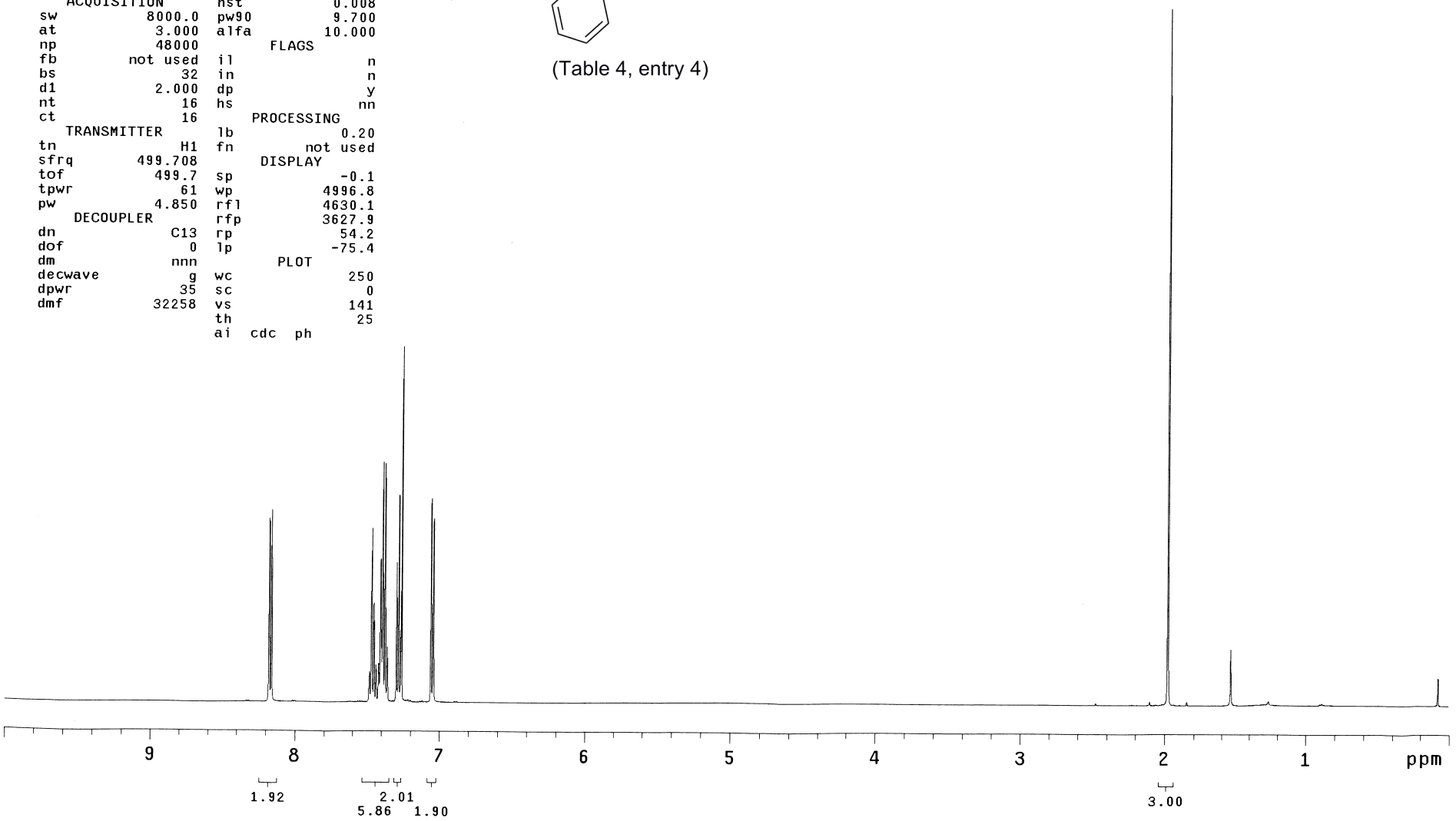
JC9275B CDCl3

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 13 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC927~		temp	not used
5B_CDCl3/PROTON01.~		gain	30
	fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	54.2
dof	0	lp	-75.4
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	141
		th	25
		ai	cdc ph



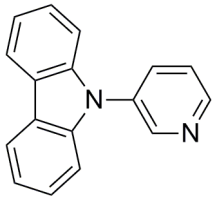
(Table 4, entry 4)



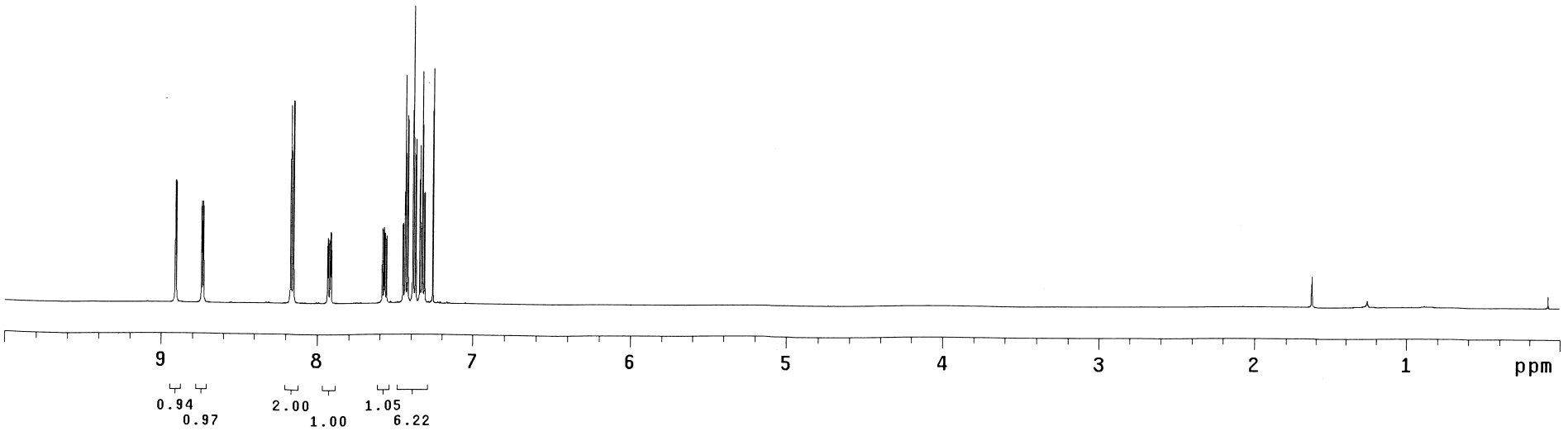
DZ-04-252-1-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 18 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-252-1-Purified/~		gain	30
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	41.0
dof	0	lp	-73.0
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	75
		th	40
		ai cdc ph	



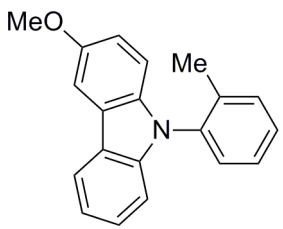
(Table 4, entry 5)



DZ-04-262-1-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 18 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-262-1-Purified/~		gain	30
	PROTON02.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	40.0
dof	0	lp	-70.0
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	44
		th	50
		ai cdc ph	

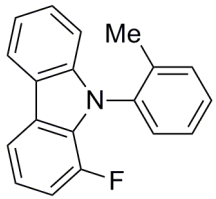


(Table 4, entry 6)

DZ-04-264-1-Purified

exp20 PROTON

SAMPLE		PRESATURATION	
date	Mar 18 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
04-264-1-Purified/~		gain	30
	PROTON02.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.700
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.850	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	42.2
dof	0	lp	-74.1
dm	nnn	PLOT	
decwave	g	wc	250
dpwr	35	sc	0
dmf	32258	vs	97
		th	25
		ai cdc ph	

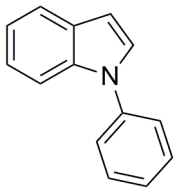


(Table 4, entry 7)

DZ-05-030-1-Purified

exp10 PROTON

SAMPLE		PRESATURATION	
date	Apr 19 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
05-030-1-Purified/~		gain	32
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	13.3
dof	0	lp	-67.9
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	27
dmf	32258	th	7
		ai cdc ph	



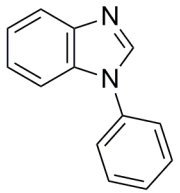
(Table 5, entry 1)

JMM1250

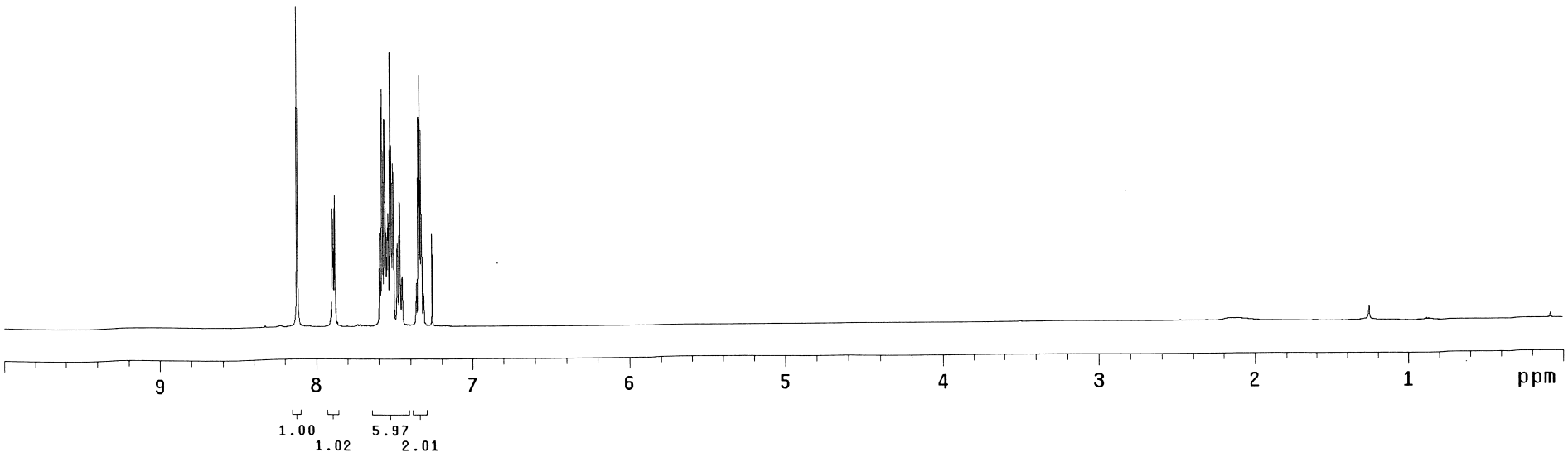
exp10 PROTON

SAMPLE	
date	Apr 27 2013
solvent	cdcl3
file	/indy/jmmolin~a/vnmrsys/data/JMM~1250/PROTON01.fid
ACQUISITION	
sw	8000.0
at	3.000
np	48000
fb	not used
bs	32
d1	2.000
nt	16
ct	16
TRANSMITTER	
tn	H1
sfrq	499.708
tof	499.7
tpwr	61
pw	4.950
DECOUPLER	
dn	C13
dof	0
dm	nnn
decwave	W40_autox7~991
dpwr	41
dmf	32258

PRESATURATION	
satmode	n
wet	n
SPECIAL	
temp	not used
gain	20
spin	20
hst	0.008
pw90	9.900
alfa	10.000
FLAGS	
il	n
in	n
dp	y
hs	nn
PROCESSING	
lb	0.20
fn	not used
DISPLAY	
sp	-0.0
wp	4996.8
rfl	1001.7
rfp	0
rp	24.3
lp	-68.3
PLOT	
wc	250
sc	0
vs	101
th	31
ai	cdc ph



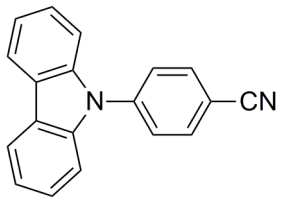
(Table 5, entry 2)



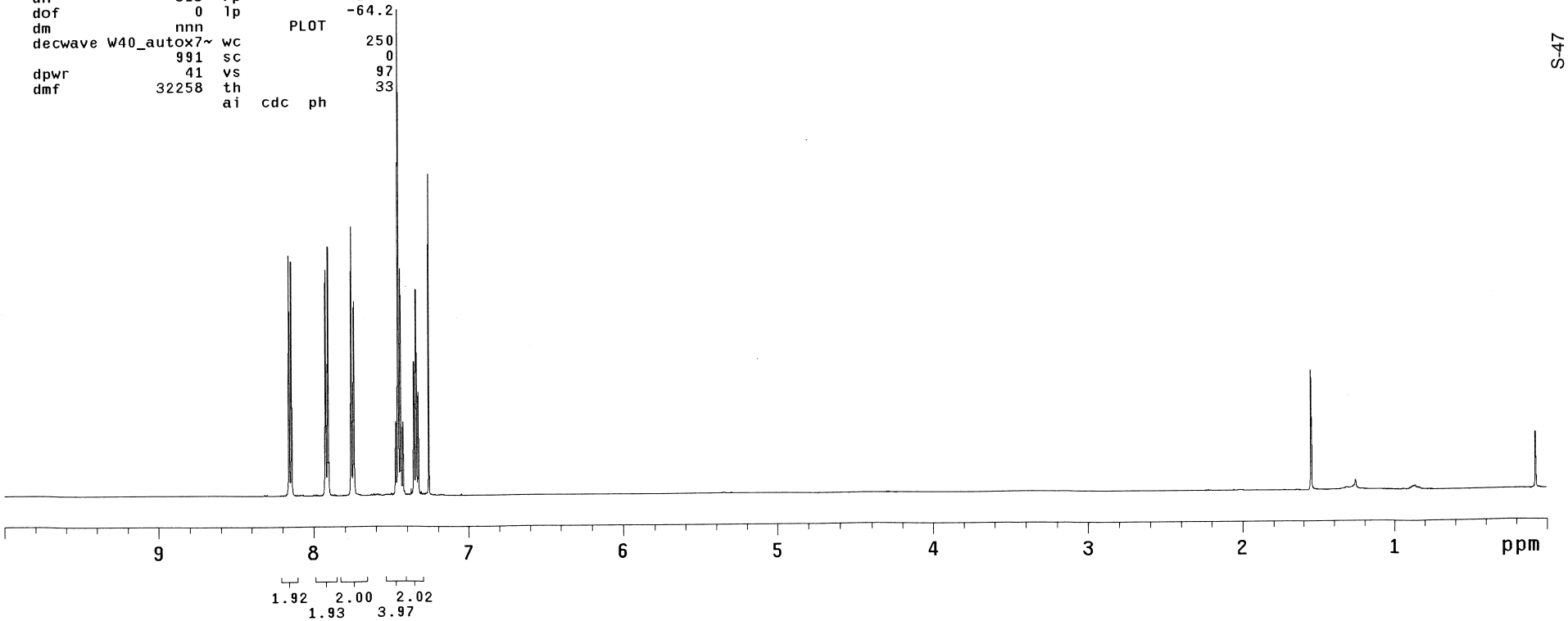
JC10065 1H CDCl3

exp10 PROTON

SAMPLE		PRESATURATION	
date	Apr 27 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jwchoi/~	SPECIAL	
vnmrsys/data/JC100~		temp	not used
65_1H_CDCl3/PROTON~		gain	32
	02.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	2.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	17.3
dof	0	lp	-64.2
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	97
dmf	32258	th	33
		ai cdc ph	



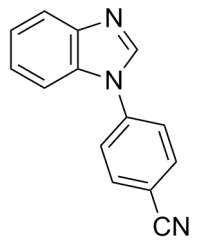
(Table 5, entry 3)



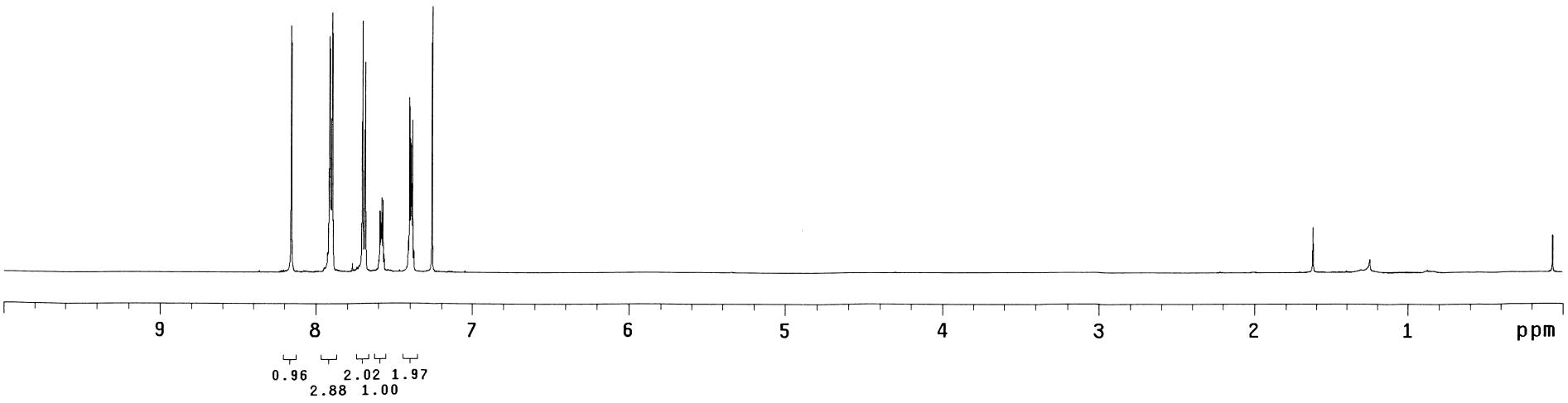
DZ-05-034-1-Purified

exp10 PROTON

SAMPLE		PRESATURATION	
date	Apr 19 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/dziegle~	SPECIAL	
r/vnmrsys/data/DZ-~		temp	not used
05-034-1-Purified/~		gain	32
	PROTON01.fid	spin	20
ACQUISITION		hst	0.008
sw	8000.0	pw90	9.900
at	3.000	alfa	10.000
np	48000	FLAGS	
fb	not used	il	n
bs	32	in	n
d1	1.000	dp	y
nt	16	hs	nn
ct	16	PROCESSING	
TRANSMITTER		lb	0.20
tn	H1	fn	not used
sfrq	499.708	DISPLAY	
tof	499.7	sp	-0.1
tpwr	61	wp	4996.8
pw	4.950	rfl	4630.1
DECOUPLER		rfp	3627.9
dn	C13	rp	15.6
dof	0	lp	-72.5
dm	nnn	PLOT	
decwave	W40_autox7~	wc	250
	991	sc	0
dpwr	41	vs	100
dmf	32258	th	4
		ai cdc ph	



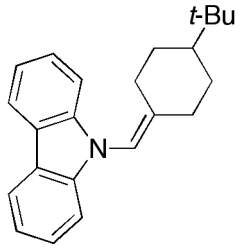
(Table 5, entry 4)



JMM1180

exp10 PROTON

SAMPLE		PRESATURATION	
date	Mar 29 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jmmolin~a/vnmrsys/data/JMM~1180/PROTON03.fid	SPECIAL	
		temp	not used
ACQUISITION		gain	20
		spin	0
sw	8000.0	hst	0.008
at	3.000	pw90	9.900
np	48000	alfa	10.000
fb	not used	FLAGS	
bs	32	il	n
d1	1.000	in	n
nt	16	dp	y
ct	16	hs	nn
TRANSMITTER		PROCESSING	
tn	H1	lb	0.20
sfrq	499.708	fn	not used
tof	499.7	DISPLAY	
tpwr	61	sp	-0.0
pw	4.950	wp	4996.8
DECOUPLER		rfl	1001.7
dn	C13	rfp	0
dof	0	rp	30.8
dm	nnn	lp	-73.2
decwave	W40_autox7~991	PLOT	
		wc	250
dpwr	41	sc	0
dmf	32258	vs	81
		th	6
		ai	cdc ph

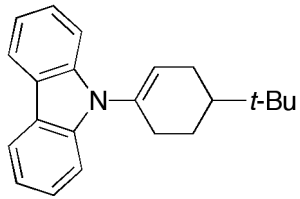


(Table 8, entry 1)

JMM1200

exp10 PROTON

SAMPLE		PRESATURATION	
date	Mar 29 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jmmolin~	SPECIAL	
a/vnmrsys/data/JMM~		temp	not used
1200/PROTON03.fid		gain	32
ACQUISITION		spin	0
sw	8000.0	hst	0.008
at	3.000	pw90	9.900
np	48000	alfa	10.000
fb	not used	FLAGS	
bs	32	il	n
d1	1.000	in	n
nt	32	dp	y
ct	32	hs	nn
TRANSMITTER		PROCESSING	
tn	H1	lb	0.20
sfrq	499.708	fn	not used
tof	499.7	DISPLAY	
tpwr	61	sp	-0.0
pw	4.950	wp	4996.8
DECOUPLER		rfl	1001.7
dn	C13	rfp	0
dof	0	rp	29.1
dm	nnn	lp	-72.6
decwave	W40_autox7~	PLOT	
	991	wc	250
dpwr	41	sc	0
dmf	32258	vs	40
		th	13
		ai cdc ph	

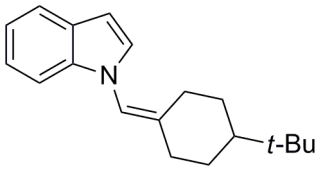


(Table 8, entry 2)

JMM1193

exp10 PROTON

SAMPLE		PRESATURATION	
date	Mar 26 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jmmolin~	SPECIAL	
a/vnmrsys/data/JMM~		temp	not used
1193/PROTON01.fid		gain	20
ACQUISITION		spin	0
sw	8000.0	hst	0.008
at	3.000	pw90	9.900
np	48000	alfa	10.000
fb	not used	FLAGS	
bs	32	il	n
d1	1.000	in	n
nt	16	dp	y
ct	16	hs	nn
TRANSMITTER		PROCESSING	
tn	H1	lb	0.20
sfrq	499.708	fn	not used
tof	499.7	DISPLAY	
tpwr	61	sp	-0.0
pw	4.950	wp	4996.8
DECOUPLER		rfl	1001.7
dn	C13	rfp	0
dof	0	rp	26.0
dm	nnn	lp	-70.8
decwave	W40_autox7~	PLOT	
	991	wc	250
dpwr	41	sc	0
dmf	32258	vs	45
		th	13
		ai cdc ph	

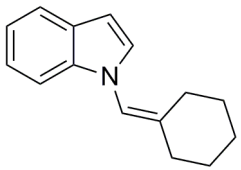


(Table 8, entry 3)

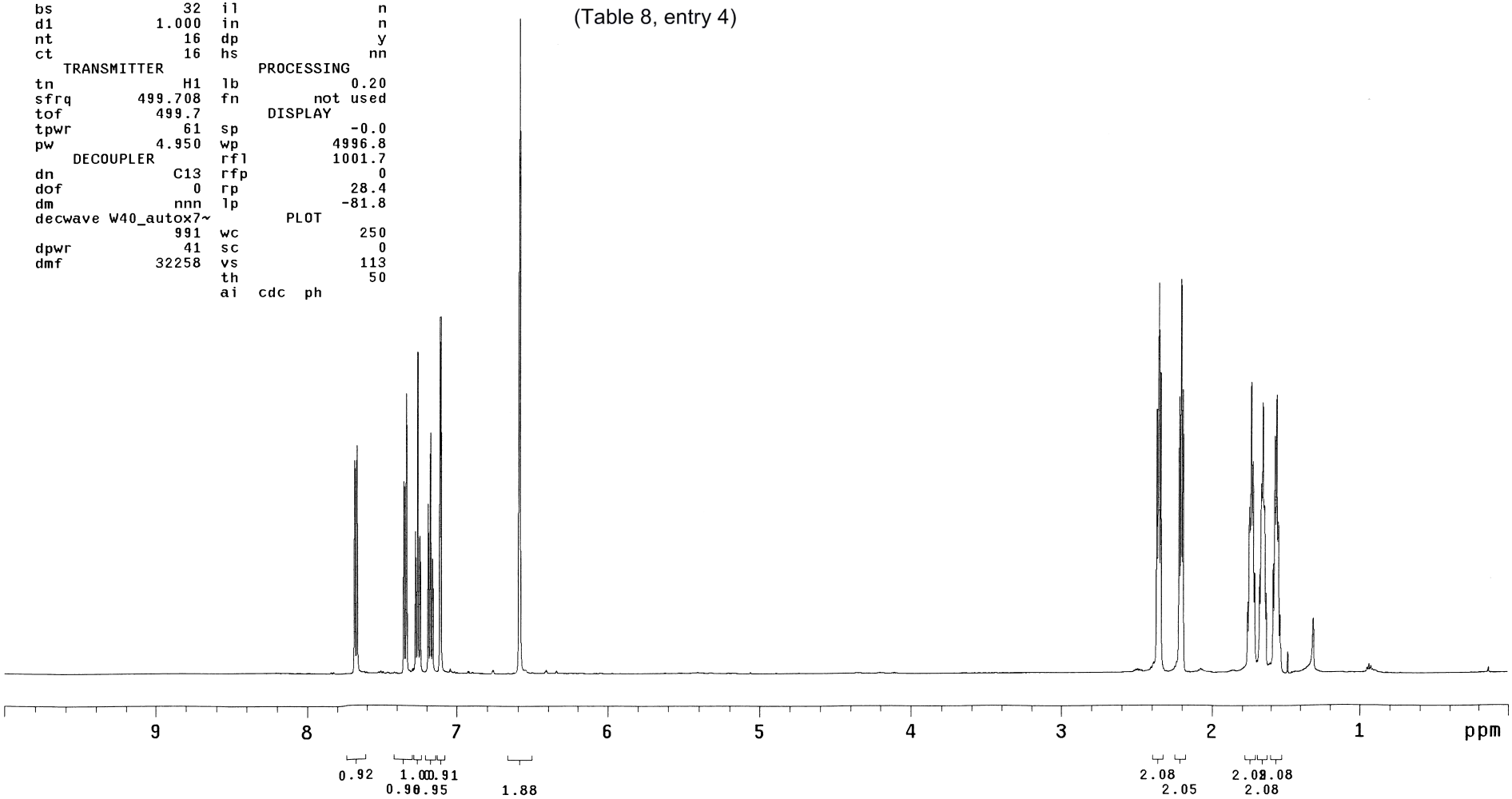
JMM1234

exp10 PROTON

SAMPLE		PRESATURATION	
date	Apr 26 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jmmolin~a/vnmrsys/data/JMM~1234/PROTON01.fid	SPECIAL	
		temp	not used
ACQUISITION		gain	20
sw	8000.0	spin	20
at	3.000	hst	0.008
np	48000	pw90	9.900
fb	not used	alfa	10.000
bs	32	FLAGS	
d1	1.000	il	n
nt	16	in	n
ct	16	dp	y
TRANSMITTER		hs	nn
tn	H1	PROCESSING	
sfrq	499.708	lb	0.20
tof	499.7	fn	not used
tpwr	61	DISPLAY	
pw	4.950	sp	-0.0
DECOUPLER		wp	4996.8
dn	C13	rfl	1001.7
dof	0	rfp	0
dm	nnn	rp	28.4
decwave	W40_autox7~991	lp	-81.8
		PLOT	
dpwr	41	wc	250
dmf	32258	sc	0
		vs	113
		th	50
		ai	cdc ph



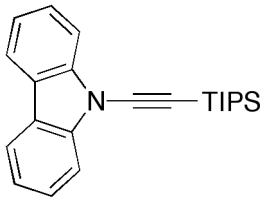
(Table 8, entry 4)



JMM1202

exp10 PROTON

SAMPLE		PRESATURATION	
date	Mar 26 2013	satmode	n
solvent	cdcl3	wet	n
file	/indy/jmmolin~	SPECIAL	
a/vnmrsys/data/JMM~		temp	not used
1202/PROTON01.fid		gain	20
ACQUISITION		spin	0
sw	8000.0	hst	0.008
at	3.000	pw90	9.900
np	48000	alfa	10.000
fb	not used	FLAGS	
bs	32	il	n
d1	1.000	in	n
nt	16	dp	y
ct	16	hs	nn
TRANSMITTER		PROCESSING	
tn	H1	lb	0.20
sfrq	499.708	fn	not used
tof	499.7	DISPLAY	
tpwr	61	sp	-0.0
pw	4.950	wp	4996.8
DECOUPLER		rfl	1001.7
dn	C13	rfp	0
dof	0	rp	25.5
dm	nnn	lp	-71.9
decwave	W40_autox7~	PLOT	
	991	wc	250
dpwr	41	sc	0
dmf	32258	vs	47
		th	3
		ai cdc ph	



(Table 8, entry 5)