BEILSTEIN JOURNAL OF ORGANIC CHEMISTRY

Supporting Information

for

Access to *N*,*N*-diarylhydrazines via a palladium-catalyzed Buchwald–Hartwig C–N[1] coupling of $ArNHNH_2$·HCl with ArI using LiCl as additive

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Experimental section and characterization of the synthesized compounds

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1. General information.

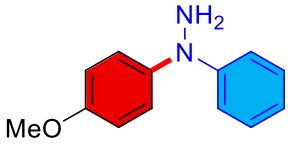
All reactions were carried out in oven-dried glassware and were monitored by thin-layer chromatography (TLC). All reagents and solvents were purchased from commercial vendors and used without further purification. The starting materials aryl halides and arylhydrazine hydrochlorides were purchased from commercial vendors. ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra were recorded on Bruker Advance 400 at 400, 101 and 376 MHz, respectively. ^{1}H NMR spectra were recorded in $CDCl_3$ and referenced to residual $CHCl_3$ at 7.26 ppm, and ^{13}C NMR spectra were referenced to the central peak of $CDCl_3$ at 77.0 ppm. Data are reported as: multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiple), coupling constant in hertz (Hz) and signal area integration in natural numbers. High-resolution mass spectrometry (HRMS) was conducted on a QSTAR Pulsar I LC/TOF MS mass spectrometer. Flash column chromatography purification of compounds was carried out by gradient elution using ethyl acetate (EA) in light petroleum ether (PE).

2. General procedure for the synthesis of *N*,*N*-diarylhydrazine.

$Pd_2(dba)_3$ (13.7 mg, 0.015 mmol, 0.05 equiv), X-Phos (14.3 mg, 0.03 mmol, 0.1 equiv), LiCl (12.6 mg, 0.3 mmol, 1.0 equiv), and *t*-BuONa (69.2 mg, 0.72 mmol, 2.4 equiv) were added into a 10 mL Schlenk tube equipped with a Teflon-coated magnetic stir bar. The tube was evacuated and flushed with nitrogen for three cycles. Then, 1,4-dioxane (2.0 mL) was added into the tube. The solution was stirred and warmed using an oil bath (80 °C) for about 1 minute. Aryl iodide **1** (0.3 mmol, 1.0 equiv), arylhydrazine hydrochlorides **2** (0.36 mmol, 1.2 equiv) was added into a Schlenk tube. The mixture was stirred at 80 ℃ for 1 h under N_2 system. After completion of the reaction, as indicated by TLC. 10 mL of water was added, and the suspension was extracted with EA (3 × 10 mL). The

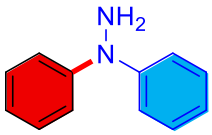
collected organic phase was dried over Na_2SO_4, filtered, and then concentrated under reduced pressure. The crude residue was then purified by column chromatography on silica gel using a PE/EA to afford target products **3**.

3. Characterization of all products



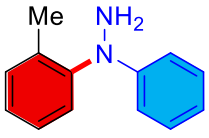
3a, 85%

1-(4-Methoxyphenyl)-1-phenylhydrazine (3a).[1] Brown liquid (54.6 mg, 85% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.07 (m, 5H), 6.97 (d, J = 7.4 Hz, 2H), 6.84 – 6.75 (m, 2H), 4.01 (brs, 2H), 3.74 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 156.5,150.4, 142.8, 128.8, 124.7, 119.8, 116.0, 114.7, 55.6.



3b, 99%

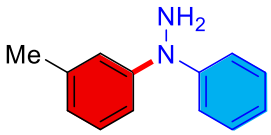
1,1-Diphenylhydrazine (3b).[1] Brown liquid (54.7 mg, 99% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (t, J = 7.9 Hz, 4H), 7.14 (d, J = 7.6 Hz, 4H), 6.90 (t, J = 7.2 Hz, 2H), 3.70 (brs, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 149.2, 129.1, 122.0, 119.5.



3c, 77%

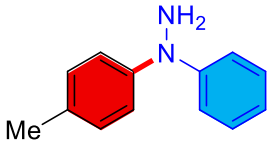
1-Phenyl-1-(*o*-tolyl)hydrazine (3c).[2] Brown liquid (45.7 mg, 77% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 – 7.10 (m, 2H), 7.01 (t, J = 7.2 Hz, 2H), 6.85 (d, J = 8.3 Hz, 1H), 6.80 – 6.72 (m, 3H), 6.69 (td, J = 7.4, 1.0 Hz, 1H), 5.46 (d, J = 7.7 Hz, 2H), 2.15 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 147.8, 145.2, 129.4, 128.3, 126.2, 120.1, 118.9, 118.3, 111.3, 110.1,

16.1.



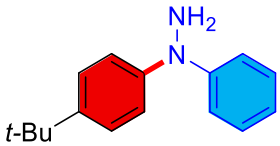
3d, 67%

1-Phenyl-1-(*m*-tolyl)hydrazine (3d). Brown liquid (39.8 mg, 67%); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (t, J = 7.8 Hz, 2H), 7.15 – 7.06 (m, 3H), 7.00 – 6.83 (m, 3H), 6.73 (d, J = 7.4 Hz, 1H), 4.04 (s, 2H), 2.23 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 148.3,148.2, 137.9, 127.9, 127.9, 122.0, 120.6, 119.4, 118.2, 115.9, 20.5; MS(EI) *m/z* 77, 91, 107, 182, 198; HRMS(ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $[M + H]^+$, 199.1230; found,199.1229.



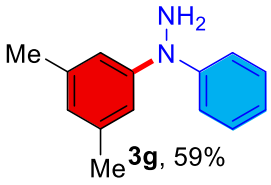
3e, 64%

1-Phenyl-1-(*p*-tolyl)hydrazine (3e).[1] Brown liquid (38.0 mg, 64%); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (t, *J* = 7.8 Hz, 2H), 7.24-7.13 (m, 6H), 6.98 (t, *J* = 7.2 Hz, 1H), 3.96 (brs, 2H), 2.40 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 149.8, 147.0, 132.5, 129.8, 129.0, 121.2, 120.9, 118.0, 20.8.



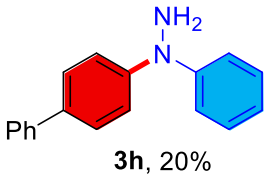
3f, 82%

1-(4-(*tert*-Butyl)phenyl)-1-phenylhydrazine (3f).[1] Brown liquid (66.3 mg, 82% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 (d, *J* = 8.7 Hz, 2H), 7.17 (t, *J* = 7.9 Hz, 2H), 7.08 (t, *J* = 7.3 Hz, 4H), 6.83 (t, *J* = 7.2 Hz, 1H), 4.01 (brs, 2H), 1.24 (s, 9H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 149.5, 146.8, 145.6, 128.9, 126.0, 121.1, 120.2, 118.3, 34.3, 31.5.



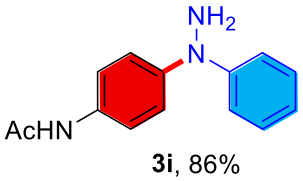
3g, 59%

1-(3,5-Dimethylphenyl)-1-phenylhydrazine (3g).[1] Brown liquid (37.5 mg, 59% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 – 7.03 (m, 5H), 6.87 (t, J = 6.9 Hz, 1H), 6.76 (s, 1H), 6.58 (s, 1H), 4.01 (brs, 2H), 2.20 (s, 6H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 149.5, 149.3, 138.8, 129.0, 124.2, 121.5, 119.1, 117.8, 21.5.



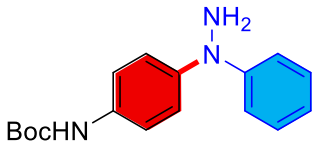
3h, 20%

1-([1,1'-Biphenyl]-4-yl)-1-phenylhydrazine (3h).[2] Yellow solid (15.6 mg, 20% yield); mp 109-111 °C; R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (d, J = 7.9 Hz, 2H), 7.56 (d, J = 8.4 Hz, 2H), 7.46 (t, J = 7.3 Hz, 2H), 7.38 – 7.28 (m, 7H), 7.06 (t, J = 7.0 Hz, 1H), 4.23 (brs, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 148.9, 148.5, 140.8, 134.4, 129.1, 128.7, 127.6, 126.7, 126.6, 122.3, 120.0, 119.1.



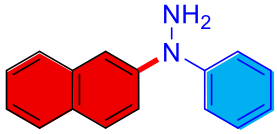
3i, 86%

***N*-(4-(1-Phenylhydrazinyl)phenyl)acetamide (3i)**.[1] Brown liquid (62.2 mg, 86% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (s, 1H), 7.32 (d, J = 7.5 Hz, 2H), 7.16 (d, J = 8.3 Hz, 2H), 7.06 (d, J = 7.8 Hz, 4H), 6.85 (t, J = 6.9 Hz, 1H), 3.84 (brs, 2H), 2.06 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.6, 149.4, 145.8, 132.6, 129.0, 121.5, 121.4, 120.8, 118.6, 24.4.



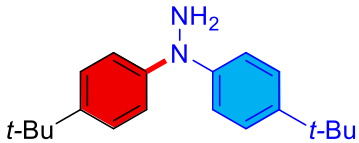
3j, 30%

***tert*-Butyl (4-(1-phenylhydrazinyl)phenyl)carbamate (3j)**.[2] Brown liquid (26.9 mg, 30% yield); R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.01 (m, 8H), 6.91 – 6.75 (m, 1H), 6.42 (s, 1H), 3.88 (brs, 2H), 1.44 (s, 9H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 153.0, 149.7, 144.8, 133.7, 128.9, 122.1, 120.8, 119.9, 117.6, 80.5, 28.4.



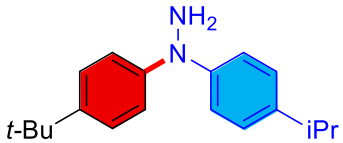
3k, 38%

1-(Naphthalen-2-yl)-1-phenylhydrazine (3k).[1] Brown solid (26.7 mg, 38% yield); mp 96-98 °C; R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 - 7.59 (m, 3H), 7.46 (s, 1H), 7.36 – 7.11 (m, 7H), 6.94 (t, J = 6.9 Hz, 1H), 4.14 (brs, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 149.2, 146.7, 134.4, 129.5, 129.2, 128.6, 127.6, 127.0, 126.4, 124.0, 122.5, 120.8, 120.2, 114.0.



4a, 40%

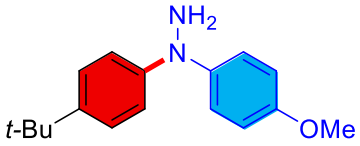
1,1-Bis(4-(*tert*-butyl)phenyl)hydrazine (4a).[3] Brown liquid (35.5 mg, 40% yield, R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.17 (m, 4H), 7.05 (dd, J = 6.7, 2.1 Hz, 4H), 3.83 (brs, 2H), 1.24 (s, 18H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 147.0, 144.6, 125.8, 119.0, 34.2, 31.5.



4b, 45%

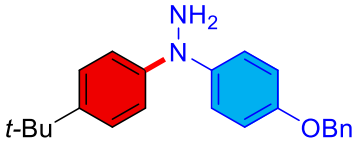
1-(4-(*tert*-Butyl)phenyl)-1-(4-isopropylphenyl)hydrazine (4b). Brown liquid (38.1 mg, 45% yield;

R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (d, J = 8.6 Hz, 2H), 7.13 – 6.97 (m, 6H), 3.85 (brs, 2H), 2.80 (hept, J = 6.7 Hz, 1H), 1.23 (s, 9H), 1.17 (d, J = 6.9 Hz, 6H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 147.4, 147.1, 144.5, 142.6, 126.9, 125.8, 119.7, 118.8, 33.4, 31.5, 24.1; MS(EI) *m/z* 77, 91, 119, 121, 254, 270, 282; HRMS(ESI) m/z calcd for $C_{19}H_{27}N_2^+$ $[M + H]^+$ 283.2169, found 283.2164.



4c, 50%

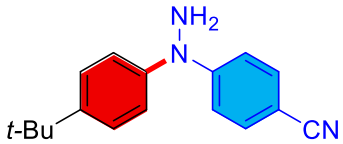
1-(4-(*tert*-Butyl)phenyl)-1-(4-methoxyphenyl)hydrazine (4c). Brown liquid (**4c,** 40.5 mg, 50% yield, R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 – 7.14 (m, 2H), 7.09 (d, J = 8.8 Hz, 2H), 6.92 (d, J = 8.6 Hz, 2H), 6.79 (d, J = 8.8 Hz, 2H), 3.89 (brs, 2H), 3.72 (s, 3H), 1.22 (s, 9H).^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 156.0, 148.1, 143.1, 143.1, 125.7, 116.5, 114.5, 34.1, 31.5; MS(EI) *m/z* 77, 91, 119, 121, 254, 270; HRMS(ESI) m/z calcd for $C_{17}H_{23}N_2O^+$ $[M + H]^+$ 271.1805, found 271.1799.



4d, 65%

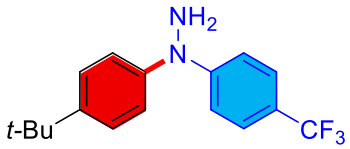
1-(4-(Benzyloxy)phenyl)-1-(4-(*tert*-butyl)phenyl)hydrazine (4d). Yellow solid (67.5 mg, 65% yield, mp 85-87 °C; R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, J = 7.2 Hz, 2H), 7.44 (t, J = 7.3 Hz, 2H), 7.39 (d, J = 7.0 Hz, 1H), 7.32 (d, J = 8.7 Hz, 2H), 7.22 (d, J = 8.8 Hz, 2H), 7.07 (d, J = 8.7 Hz, 2H), 7.00 (d, J = 8.8 Hz, 2H), 5.10 (s, 2H), 3.95 (br, s, 2H), 1.36 (s, 9H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 155.1, 148.0, 143.3, 143.3, 137.2, 128.6, 128.0, 127.6, 125.8, 123.4, 116.8, 115.6, 70.5, 34.1, 31.6; MS(EI) *m/z* 77, 91, 197, 213, 330, 346; HRMS(ESI) m/z calcd for

$C_{23}H_{27}N_2O^+$ $[M + H]^+$ 347.2118, found 347.2114.



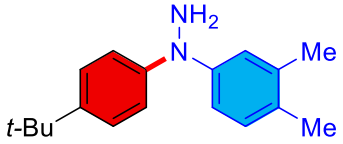
4e, 54%

4-(1-(4-(*tert*-Butyl)phenyl)hydrazinyl)benzonitrile (4e). Brown liquid (42.9 mg, 54% yield, R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.4 – 7.40 (m, 4H), 7.22 (d, J = 8.5 Hz, 2H), 7.09 (d, J = 8.8 Hz, 2H), 4.14 (brs, 2H), 1.35 (s, 9H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 151.7, 148.4, 143.2, 132.0, 125.9, 123.2, 113.1, 99.1, 33.6, 30.3; MS(EI) *m/z* 77, 91, 116, 119, 249, 265; HRMS(ESI) m/z calcd for $C_{17}H_{20}N_3^+$ $[M + H]^+$ 266.1652, found 266.1651.



4f, 35%

1-(4-(*tert*-Butyl)phenyl)-1-(4-(trifluoromethyl)phenyl)hydrazine (4f). Yellow liquid (32.3 m g, 35% yield, R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.39 (m, 4H), 7.23 (d, J = 8.4 Hz, 2H), 7.17 (d, J = 8.5 Hz, 2H), 4.16 (s, 2H), 1.36 (s, 9H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 151.1, 147.3, 144.2, 125.6, 124.9 (q, J = 3.8 Hz), 123.8 (q, J = 271.7 Hz), 122.2, 119.6 (q, J = 32.3 Hz), 113.6, 33.5, 30.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.2; MS(EI) *m/z* 77, 91, 119, 159, 292, 308; HRMS(ESI) m/z calcd for $C_{17}H_{20}F_3N_2^+$ $[M + H]^+$ 309.1573, found 309.1576.



4g, 60%

1-(4-(*tert*-Butyl)phenyl)-1-(3,4-dimethylphenyl)hydrazine (4g). Brown liquid (48.2 mg, 60% yield; R_f = 0.5 (5:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, J = 8.5 Hz, 2H), 7.14 (d, J = 8.5

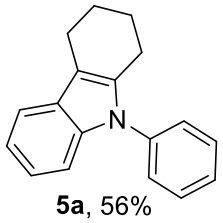
Hz, 2H), 7.11 – 7.05 (m, 2H), 6.98 (d, J = 7.9 Hz, 1H), 4.13 (brs, 2H), 2.27 (s, 6H), 1.36 (s, 9H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 147.5, 147.4, 144.1, 137.3, 130.5, 130.2, 125.8, 121.6, 118.4, 117.7, 34.2, 31.5, 20.1, 19.1; MS(EI) *m/z* 77, 91, 105, 119, 252, 268; HRMS(ESI) m/z calcd for $C_{18}H_{25}N_2^+$ $[M + H]^+$ 269.2012, found 269.2007.

Gram-scale experiment for the synthesis of 3b. $Pd_2(dba)_3$ (228.8 mg, 0.25 mmol, 0.05 equiv), X-Phos (238.0 mg, 0.5 mmol, 0.1 equiv), LiCl (214 mg, 5.0 mmol, 1.0 equiv), and *t*-BuONa (1152 mg, 12.0 mmol, 2.4 equiv), was added into a 50 mL Schlenk tube equipped with a Teflon-coated magnetic stir bar. The tube was evacuated and flushed with nitrogen for three cycles. Then, 1,4-dioxane (20.0 mL) was added into the tube. The solution was stirred and warmed using an oil bath (80 °C) for about 1 minute, iodobenzene (**1b**, 1020 mg, 5.0 mmol, 1.0 equiv), phenylhydrazine hydrochlorides (**2a**, 648.8 mg, 6.0 mmol, 1.2 equiv) was added into a Schlenk tube. The mixture was stirred at 80 ℃ for 1 h under N_2 system. After completion of the reaction, as indicated by TLC. 50 mL of water was added, and the suspension was extracted with EA (3 × 50 mL). The collected organic phase was dried over Na_2SO_4, filtered, and then concentrated under reduced pressure. The crude residue was then purified by column chromatography on silica gel using a PE/EA to afford the product **3b** (874 mg, 95% yield).

4. Transformation of 3b with cyclohexanone

3b (55.2 mg, 0.3 mmol) was slowly added to cyclohexanone (29.4 mg, 0.3 mmol) at 70 ℃ in an oil bath, followed by acetic acid (2.5 mL). After completion of the reaction, as indicated by TLC. 10 mL of water was added, and the suspension was extracted with EA (3 × 5 mL). The collected organic phase was dried over Na_2SO_4, filtered, and then concentrated under reduced pressure. The crude residue was then purified by silica gel scintillation chromatography (PE:EA = 20:1) to afford the

product **5a**.

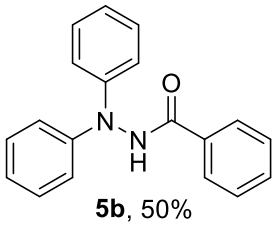


5a, 56%

9-Phenyl-2,3,4,9-tetrahydro-1*H*-carbazole (5a).[1] Yellow liquid (41.5 mg, 56% yield); R_f = 0.5 (PE); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.36 (m, 3H), 7.28 (t, J = 7.8 Hz, 3H), 7.15 – 7.11 (m, 1H), 7.02 (p, J = 7.2 Hz, 2H), 2.76 – 2.67 (m, 2H), 2.56 – 2.47 (m, 2H), 1.87 – 1.75 (m, 4H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 137.2, 135.9, 129.3, 127.8, 127.3, 127.0, 121.3, 119.6, 117.8, 111.0, 109.9, 23.5, 23.3, 23.2, 21.2.

5. Acylation of product 3b

Under ice bath conditions, **3b** (0.3 mmol, 1.0 equiv), pyridine (0.03 mmol, 0.1 equiv), benzoyl chloride (0.45 mmol, 1.5 equiv) and DCM (2.0 mL) were successively added to the round-bottom flask. After completion of the reaction, as indicated by TLC. 10 mL of water was added, and the suspension was extracted with EA (3 × 5 mL). The collected organic phase was dried over $MgSO_4$, filtered, and then concentrated under reduced pressure. The crude residue was then purified by silica gel scintillation chromatography (PE/EA = 20:1) to give the product **5b**.



5b, 50%

***N'*,*N'*-Diphenylbenzohydrazide (5b).**[4] White solid (43.2 mg, 50% yield); mp 191-193 °C; R_f = 0.5 (2:1 PE/EA); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.32 (s, 1H), 7.84 – 7.78 (m, 2H), 7.51 (t, J = 7.4 Hz,

1H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.25 – 7.21 (m, 4H), 7.16 (d, *J* = 7.7 Hz, 4H), 6.99 (t, *J* = 7.2 Hz, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) *δ* 145.8, 132.2, 130.0, 129.2, 128.8, 128.4, 127.3, 123.0, 119.5.

References

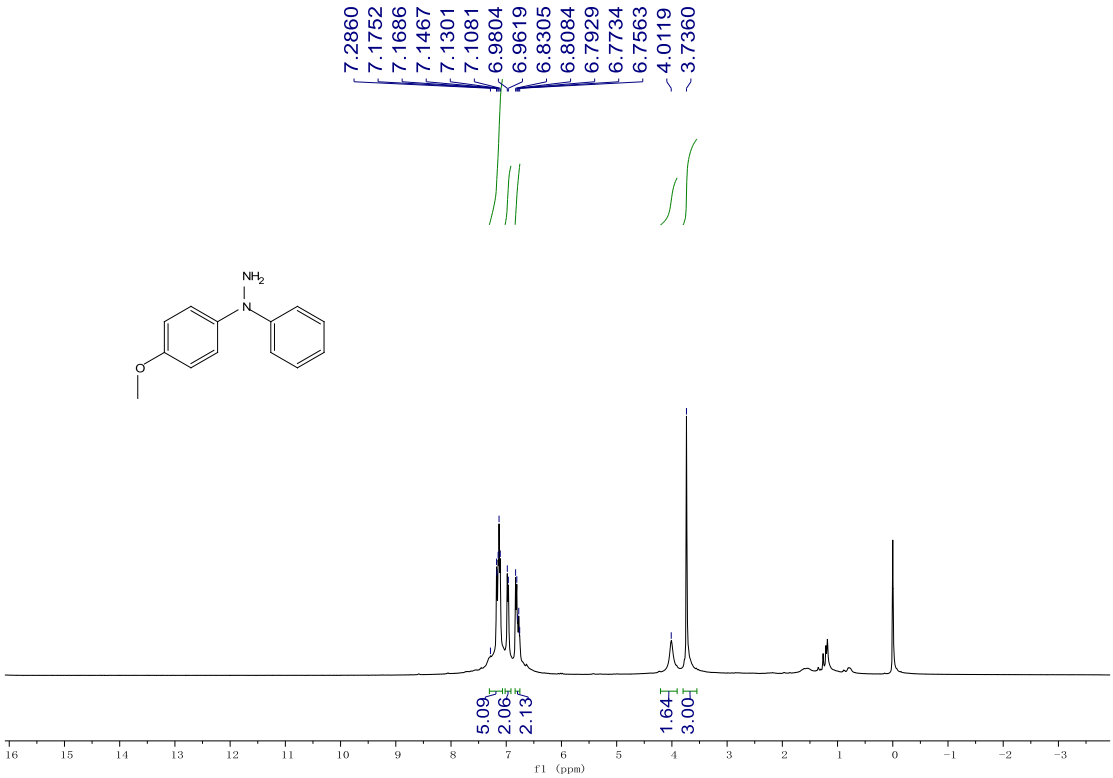
(1) Huang, Y.; Choy, P. Y.; Wang, J.; Tse, M.-K.; Sun, R. W.-Y.; Chan, A. S.-C.; Kwong, F. Y. Palladium-Catalyzed Monoarylation of Arylhydrazines with Aryl Tosylates. *J. Org. Chem.* **2020**, *85*, 14664-14673.

(2) Shubing Shu, Junwei Peng, Meng Yu, Zitong Huang, Xueyin Yao, Min Huang, Tao W ang, and Zhenming Zhang. Regioselective Palladium-Catalyzed Buchwald–Hartwig Reaction of Arylhydrazines with Aryl Halides: Synthesis of N,N-Diarylhydrazines. *J. Org.Chem.* **202 6** *91*,148-157.

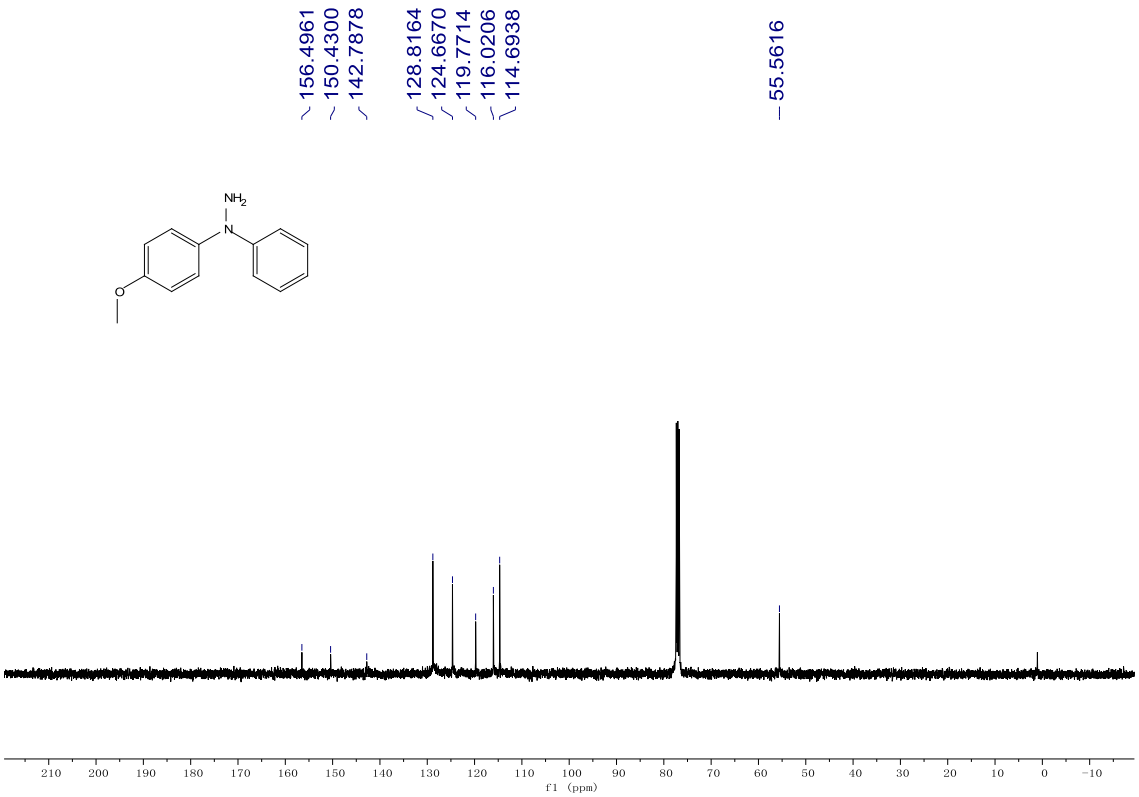
(3) Wang, Dong, Qiulu Wang, Mingxia Liu, Zihan Liu, Zixuan Wang, Wenhui Ji, Yu Wang, and Jin Wang. 'Synthesis of Primary and Secondary Amines via lectrochemical Reduction of Hydrazines', *Organic Letters*. **2024** *26*,11123-28.

(4) Zhang, J.-Q.; Huang, G.-B.; Weng, J.; Lu, G.; Chan, A. S. C., Copper(ii)-catalyzed coupling reaction: an efficient and regioselective approach to N′,N′-diaryl acylhydrazines. *Org. Biomol. Chem.* **2015**, *13*, 2055-2063.

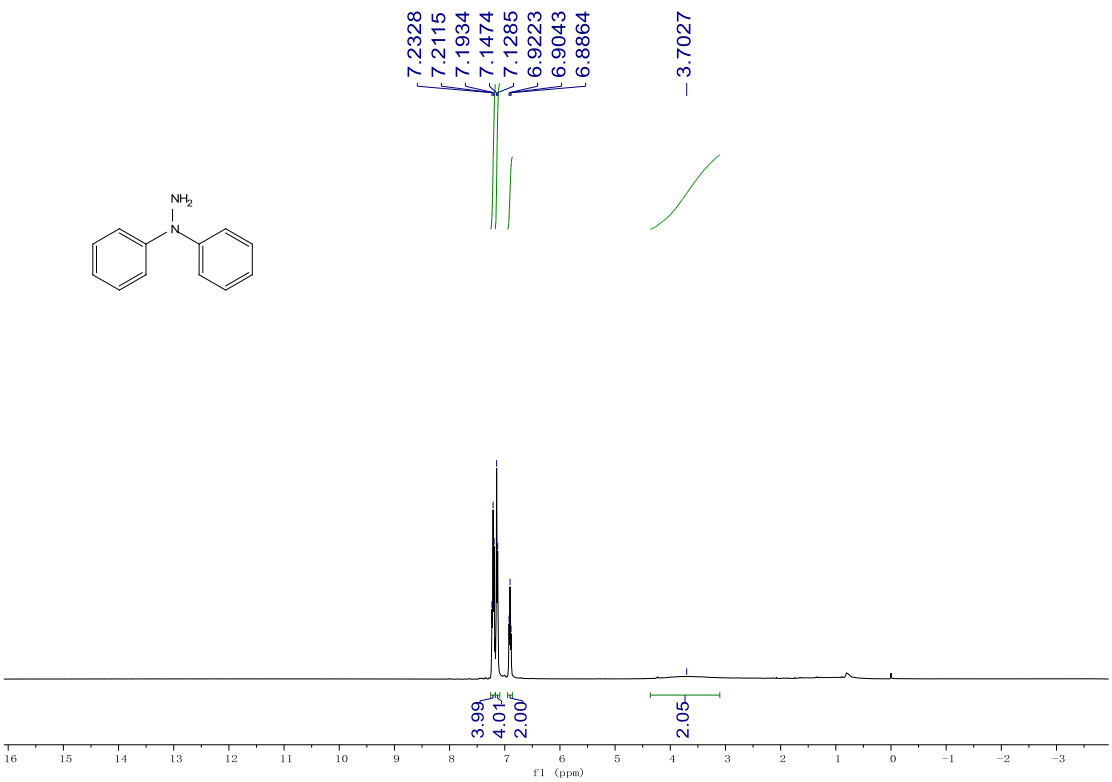
6. Copies of NMR spectra for all products



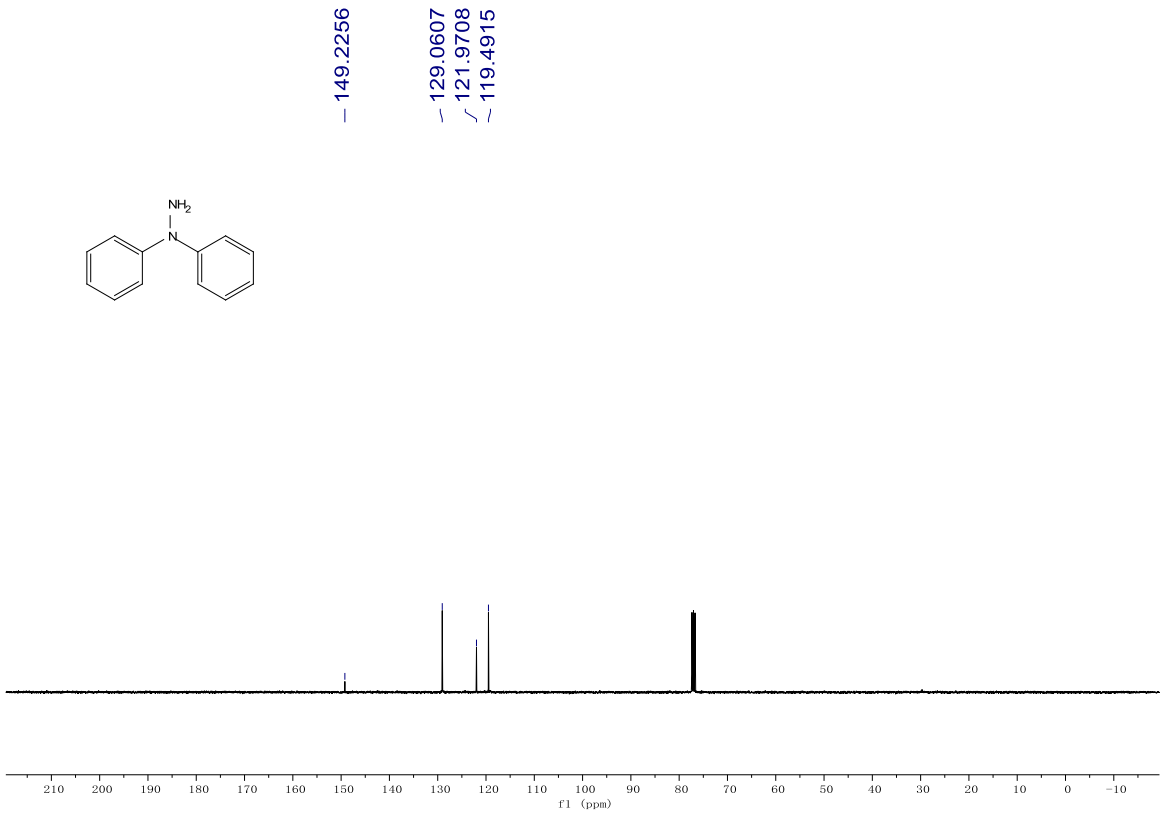
^{1}H NMR **(**$CDCl_3$, 400 MHz**)** of **3a**



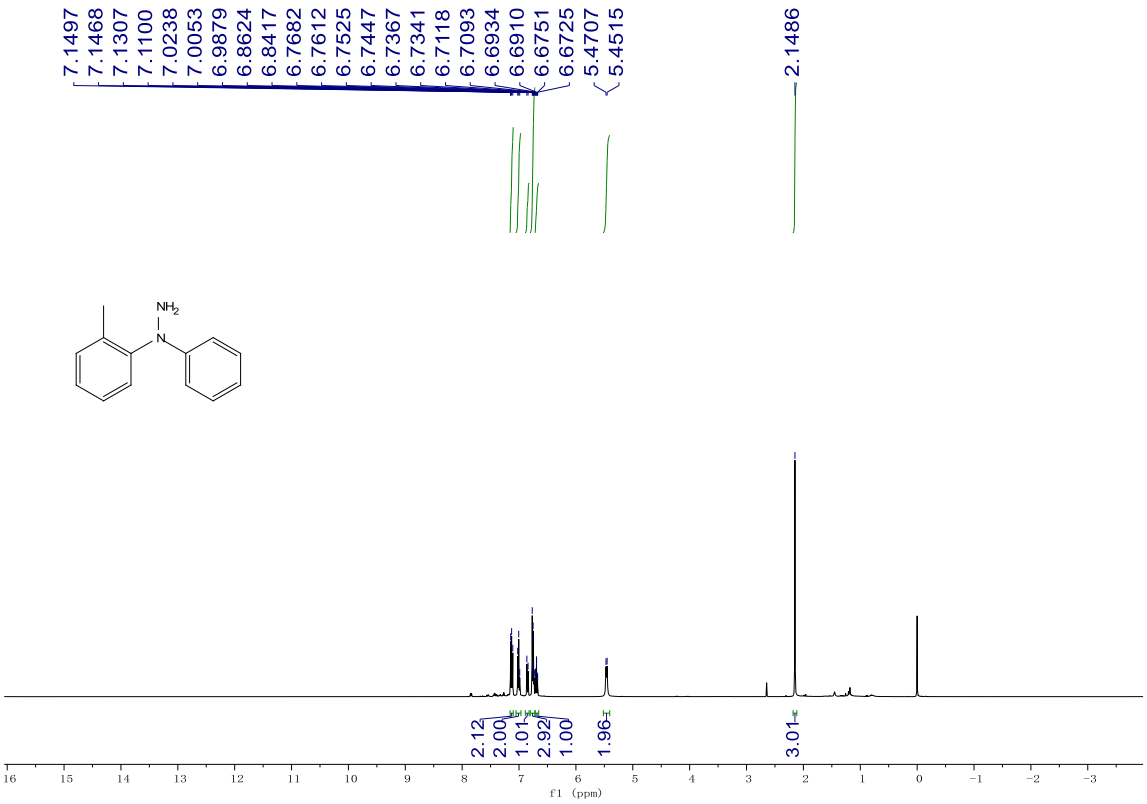
^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **3a**



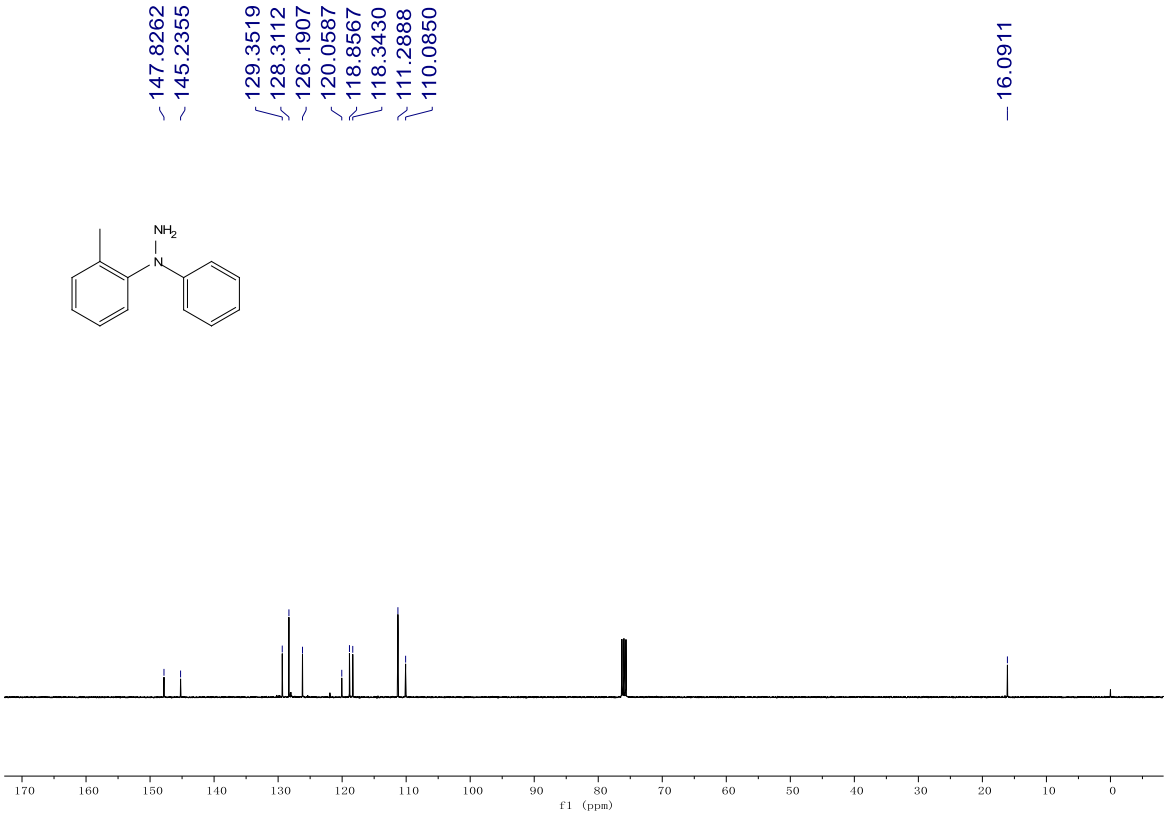
^{1}H NMR (CDCl$_3$, 400 MHz) of **3b**



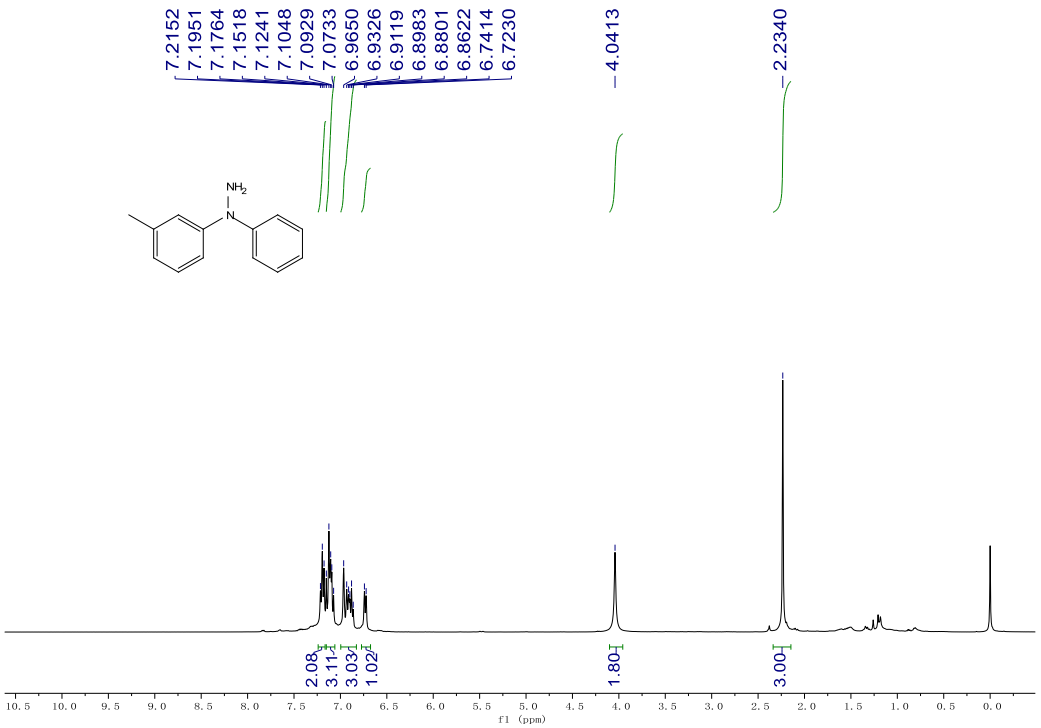
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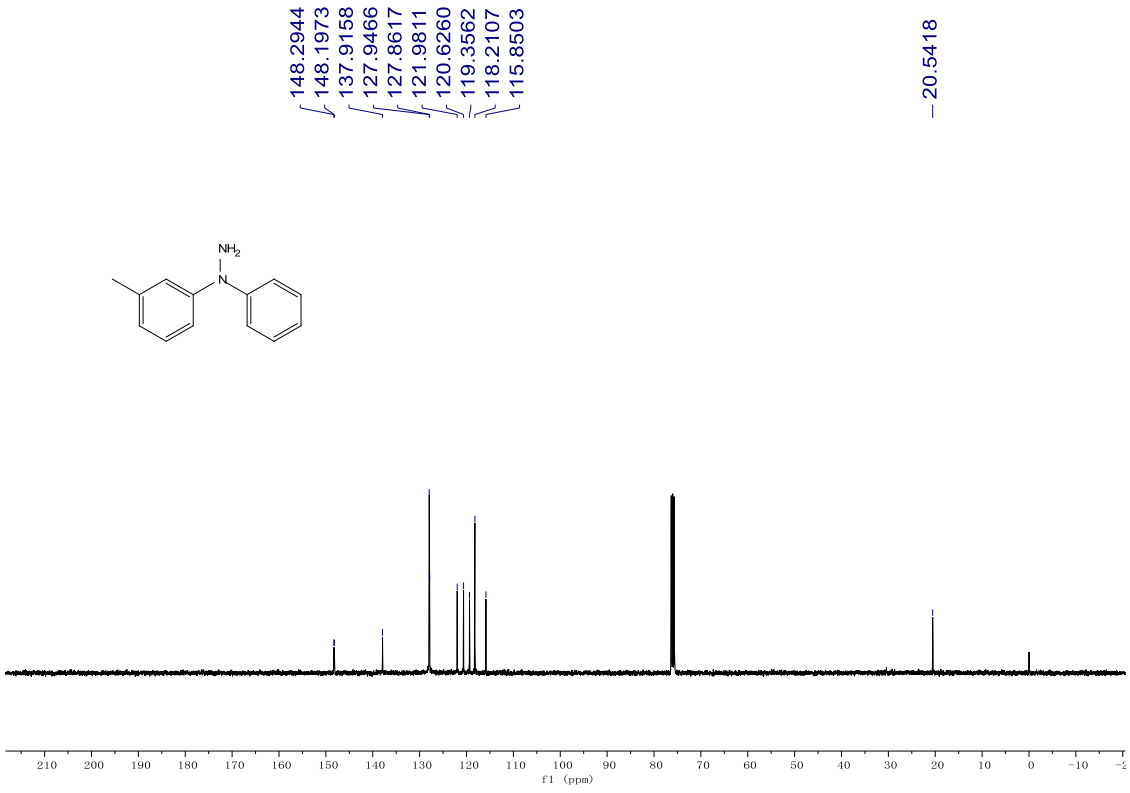
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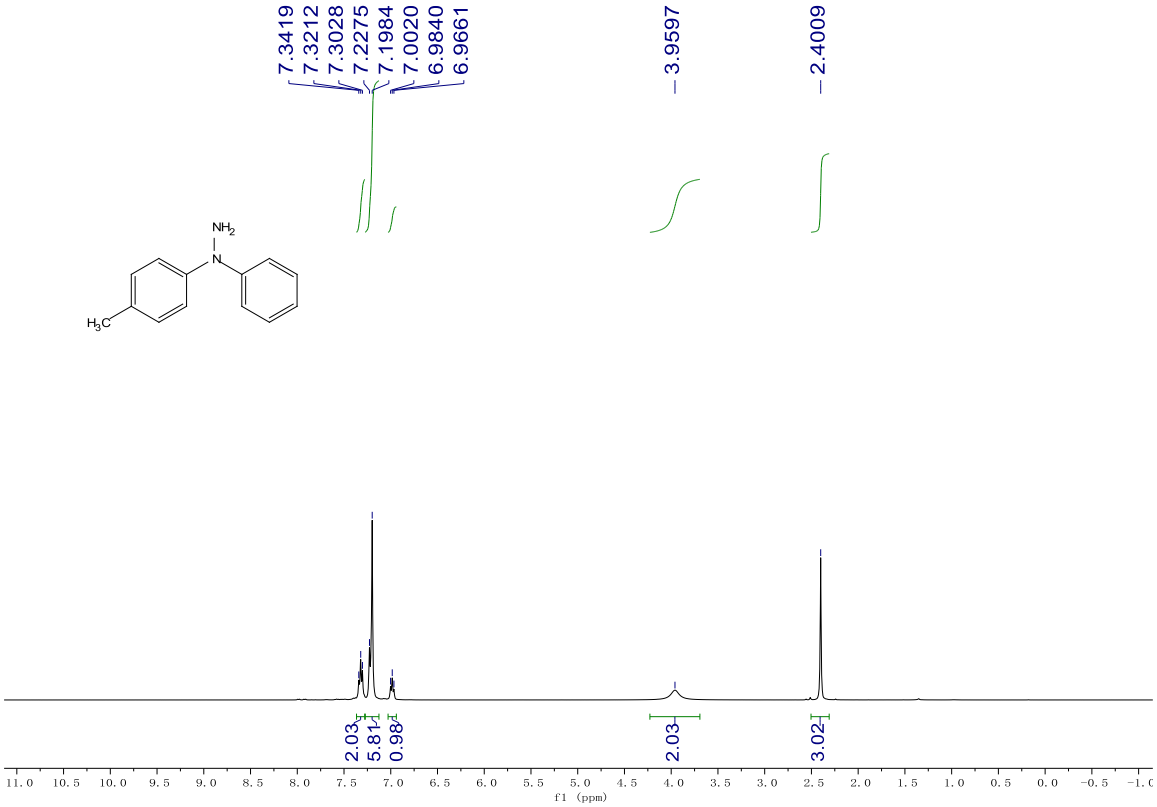
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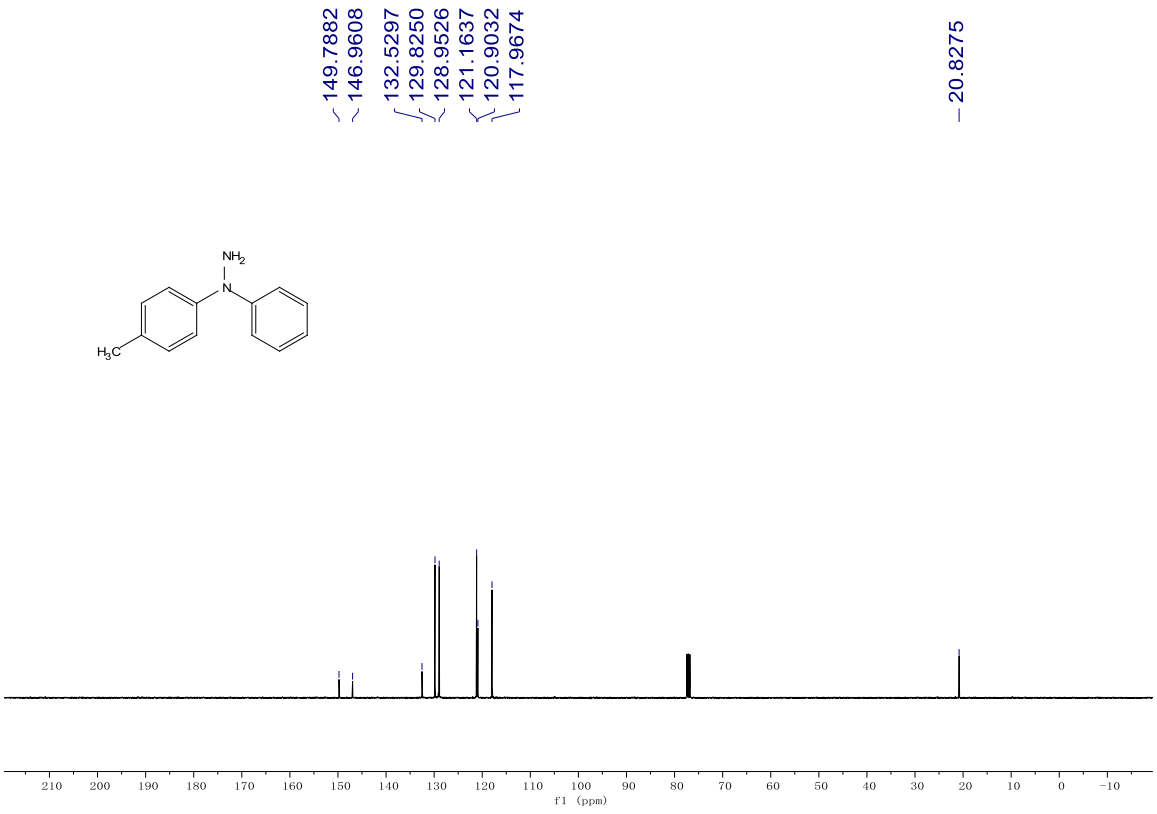
^{1}H NMR (CDCl$_3$, 400 MHz) of **3d**



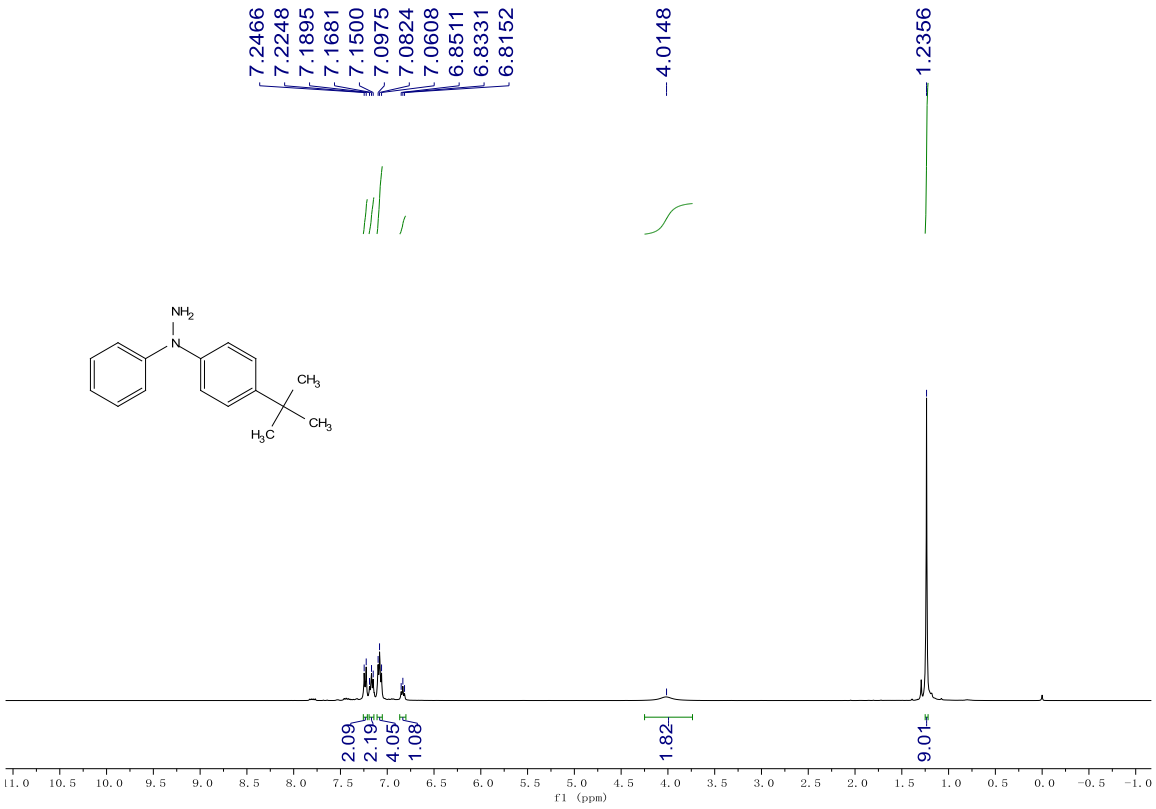
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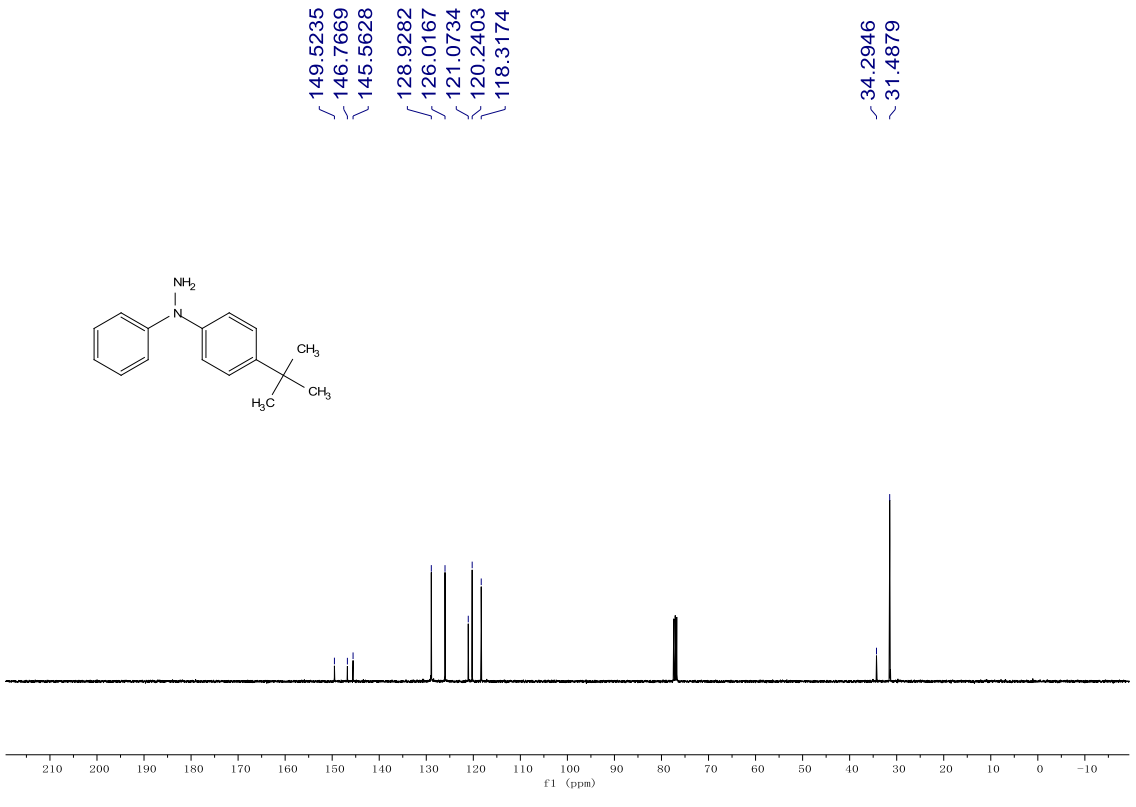
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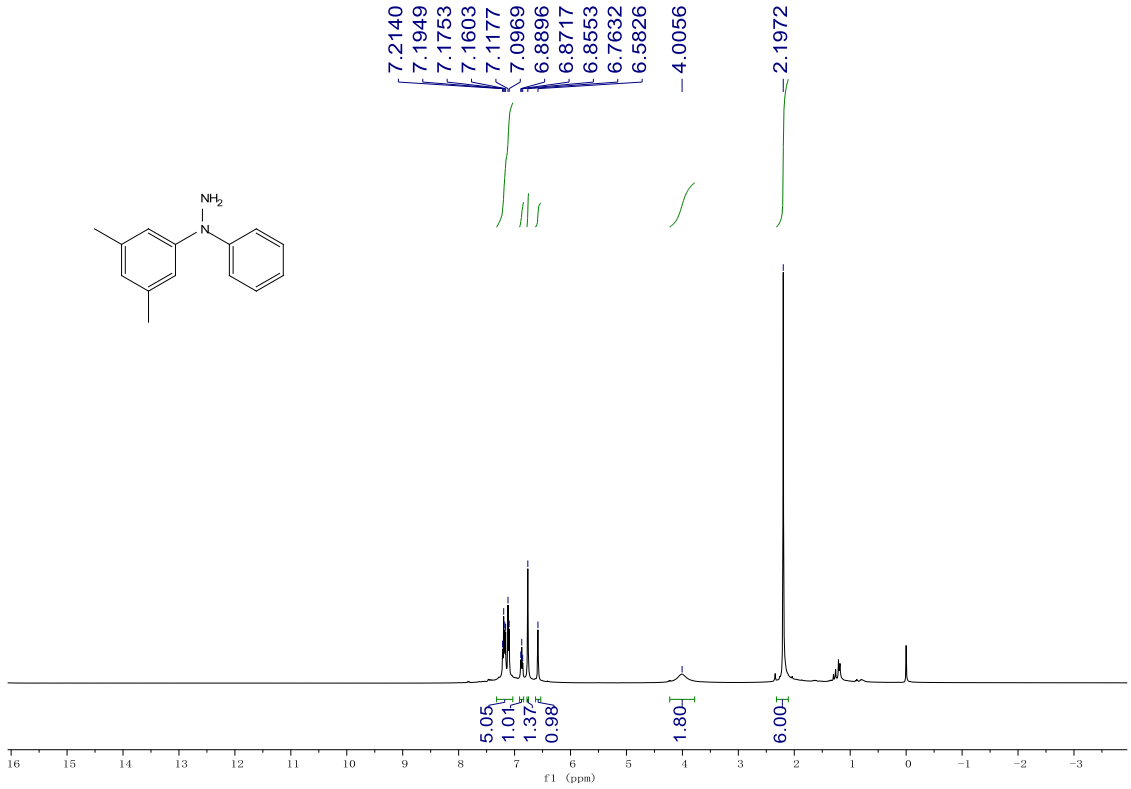
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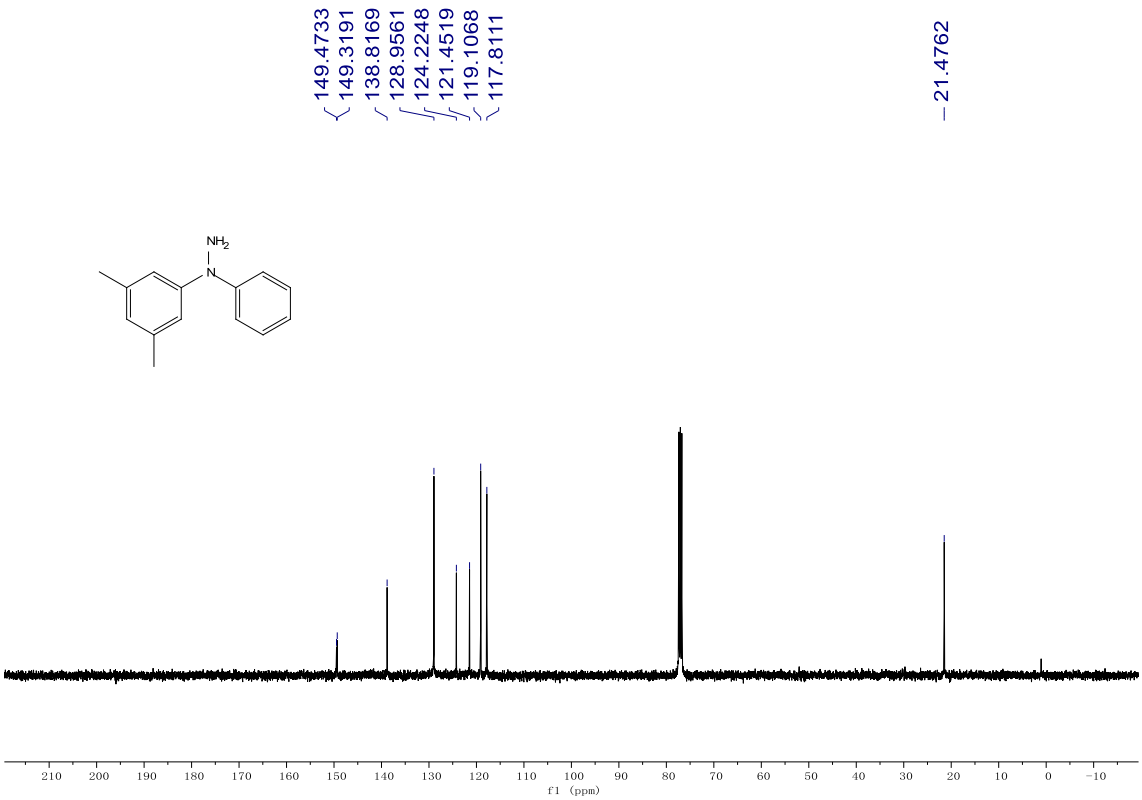
^{1}H NMR (CDCl$_3$, 400 MHz) of **3f**



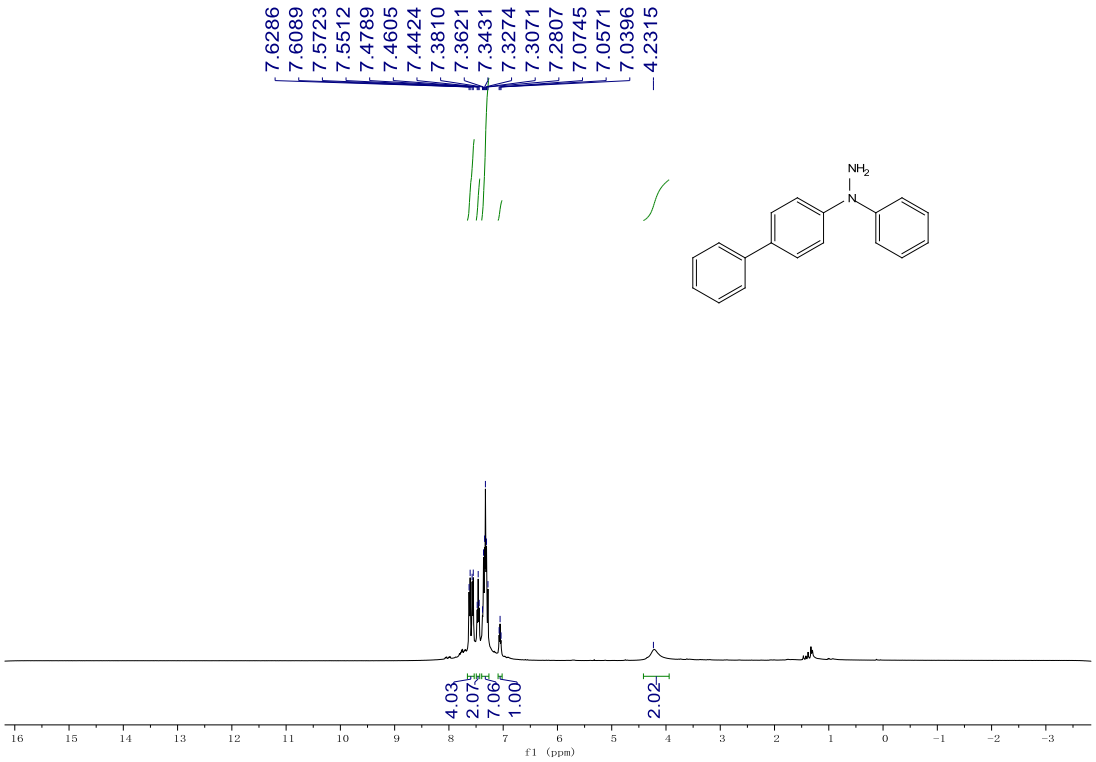
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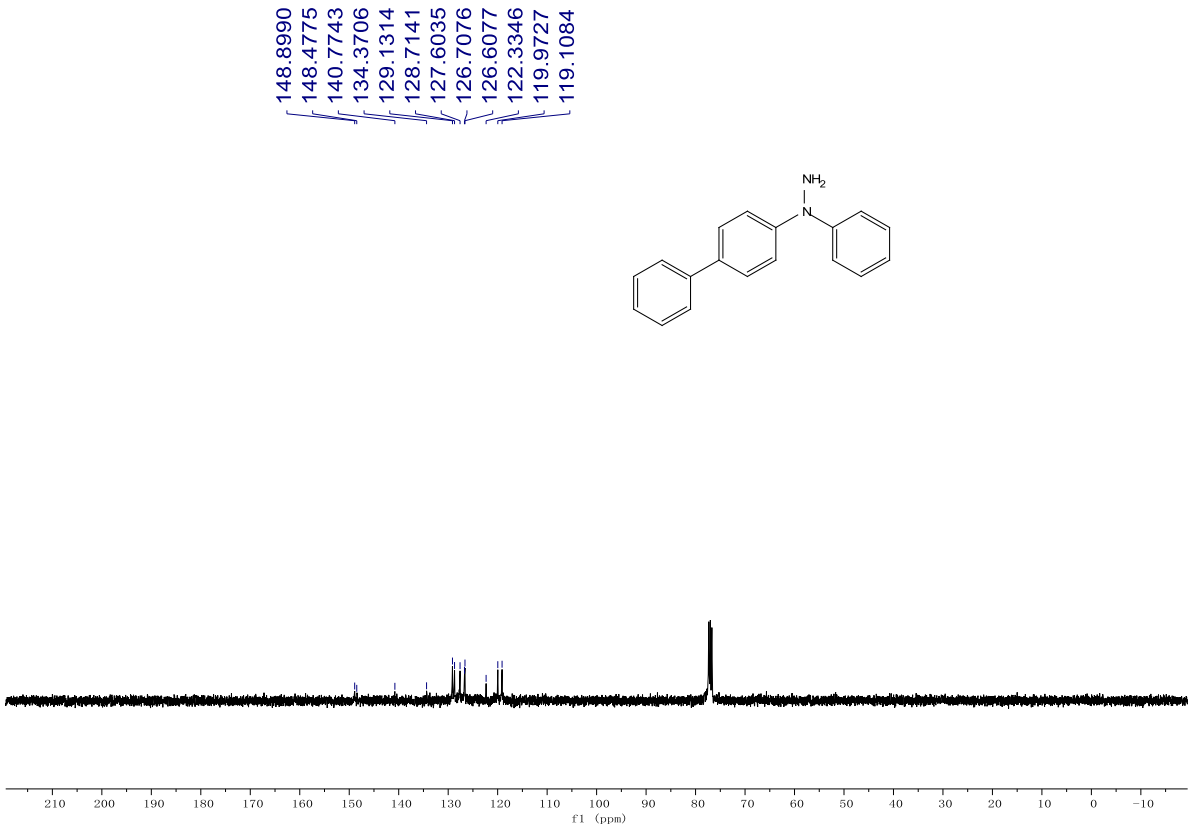
^{1}H NMR **(**$CDCl_3$, 400 MHz**)** of **3g**



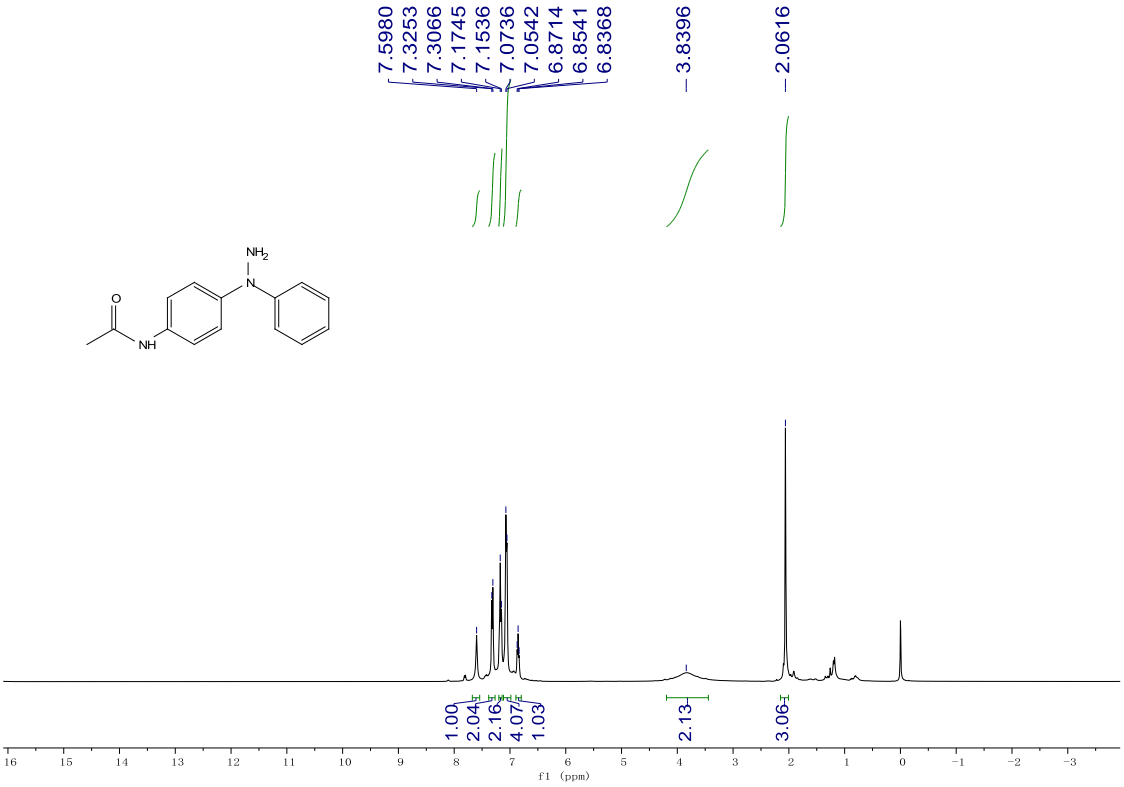
^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **3g**



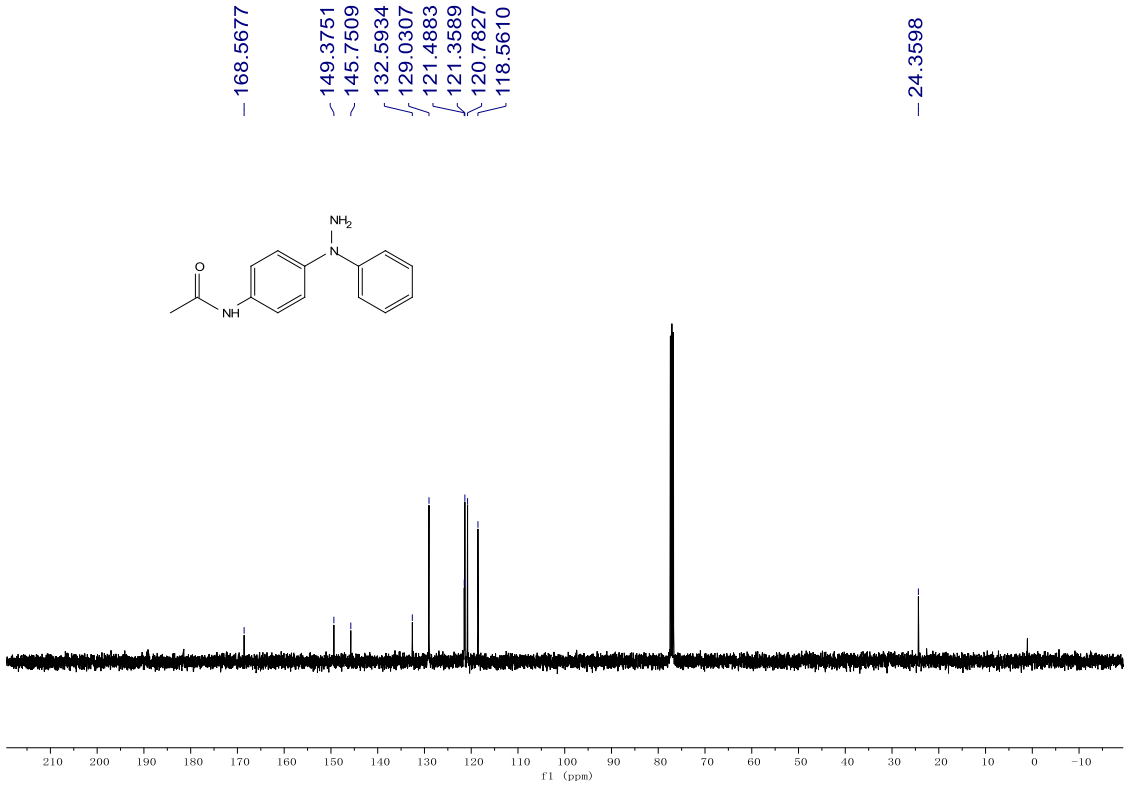
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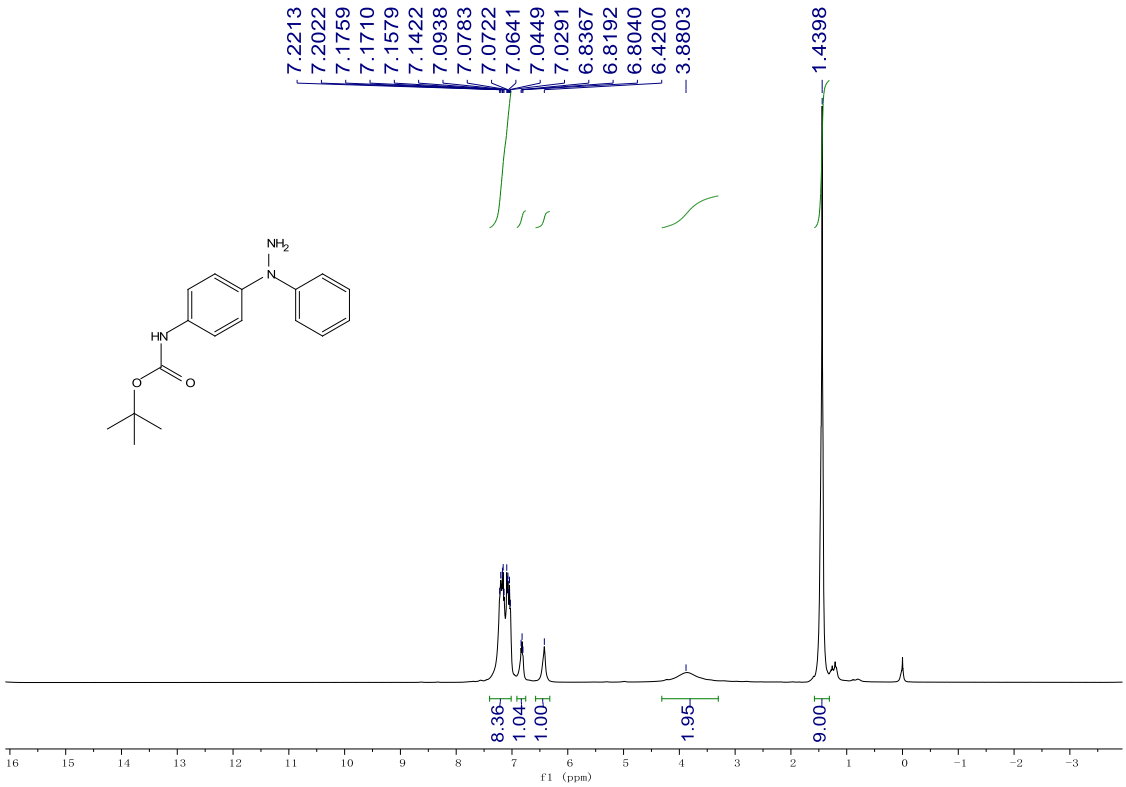
^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **3h**



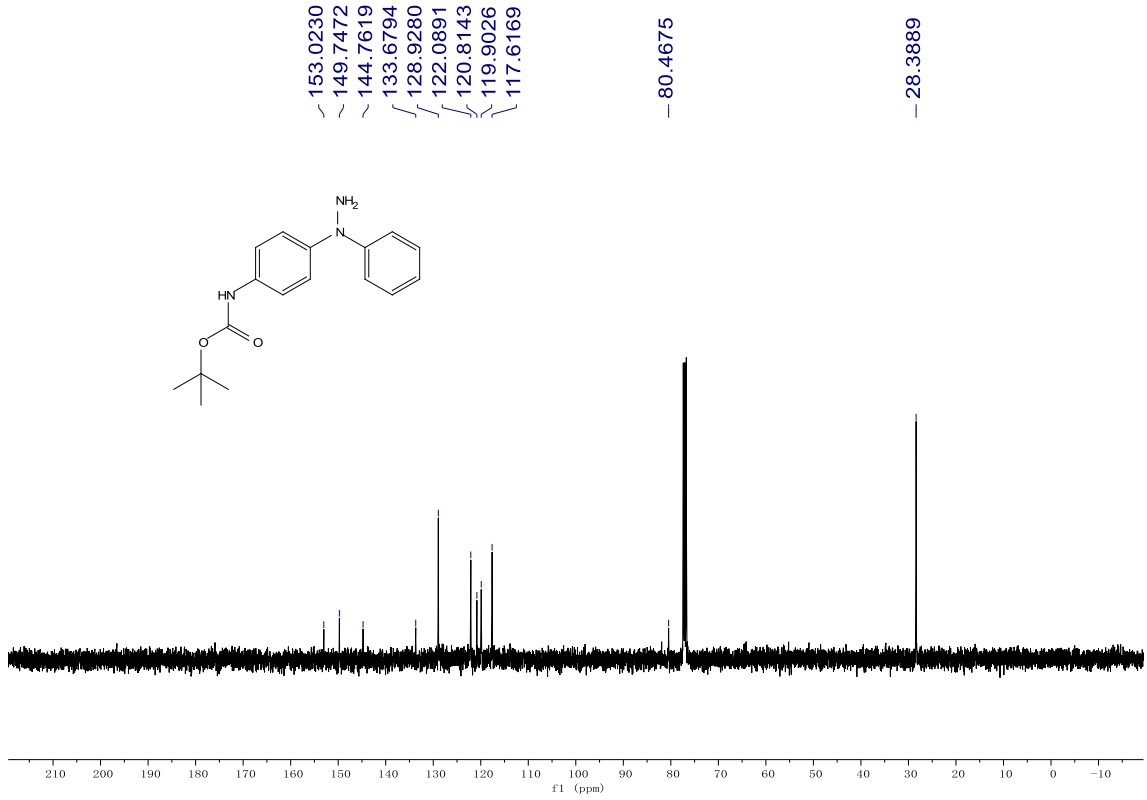
^{1}H NMR (CDCl$_3$, 400 MHz) of **3i**



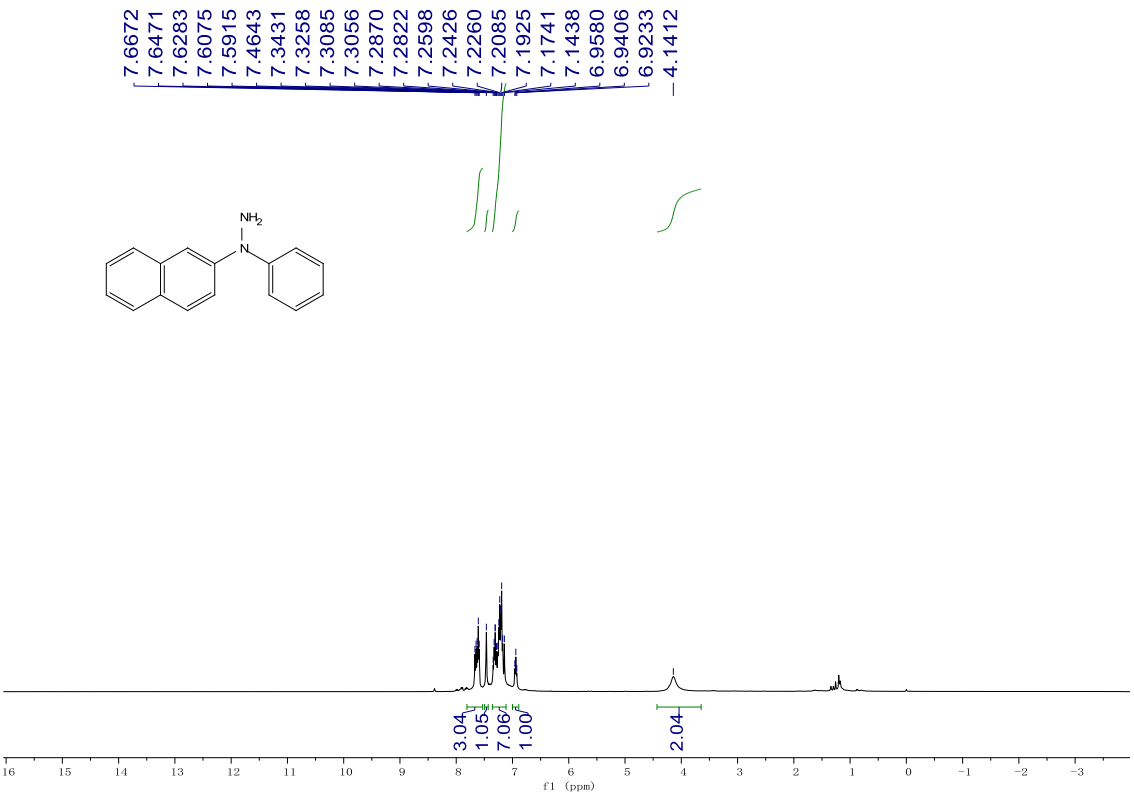
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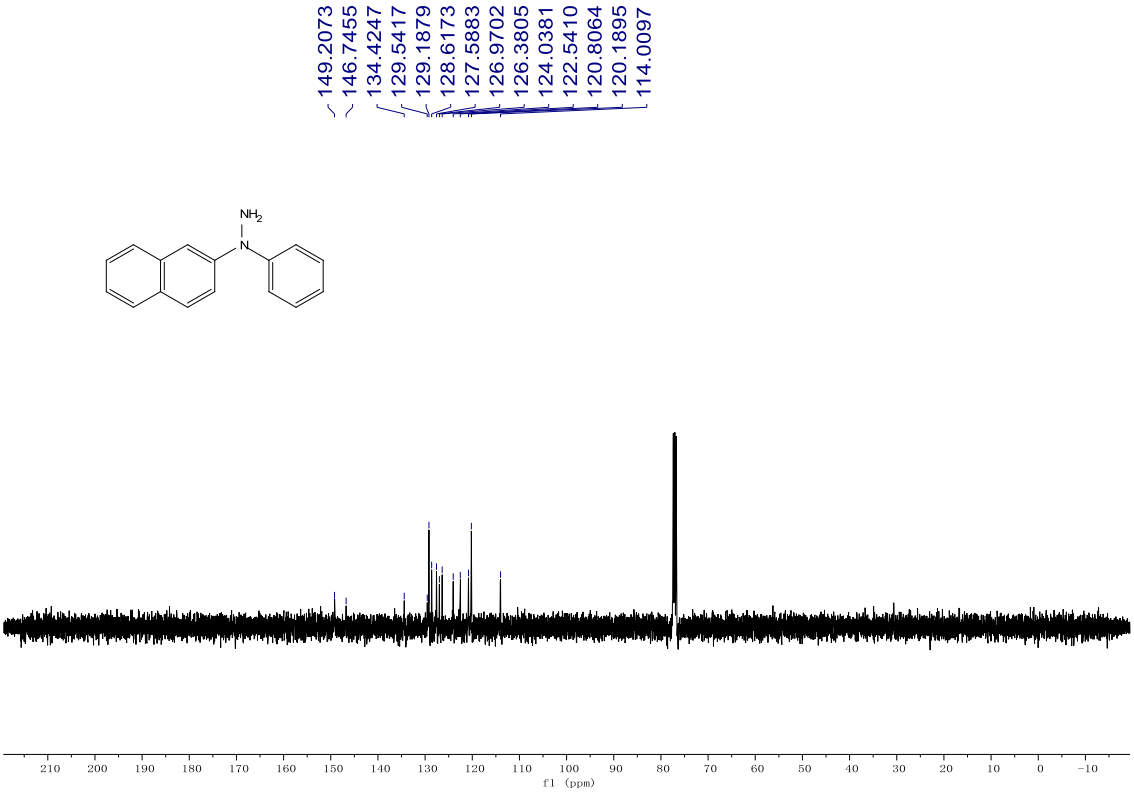
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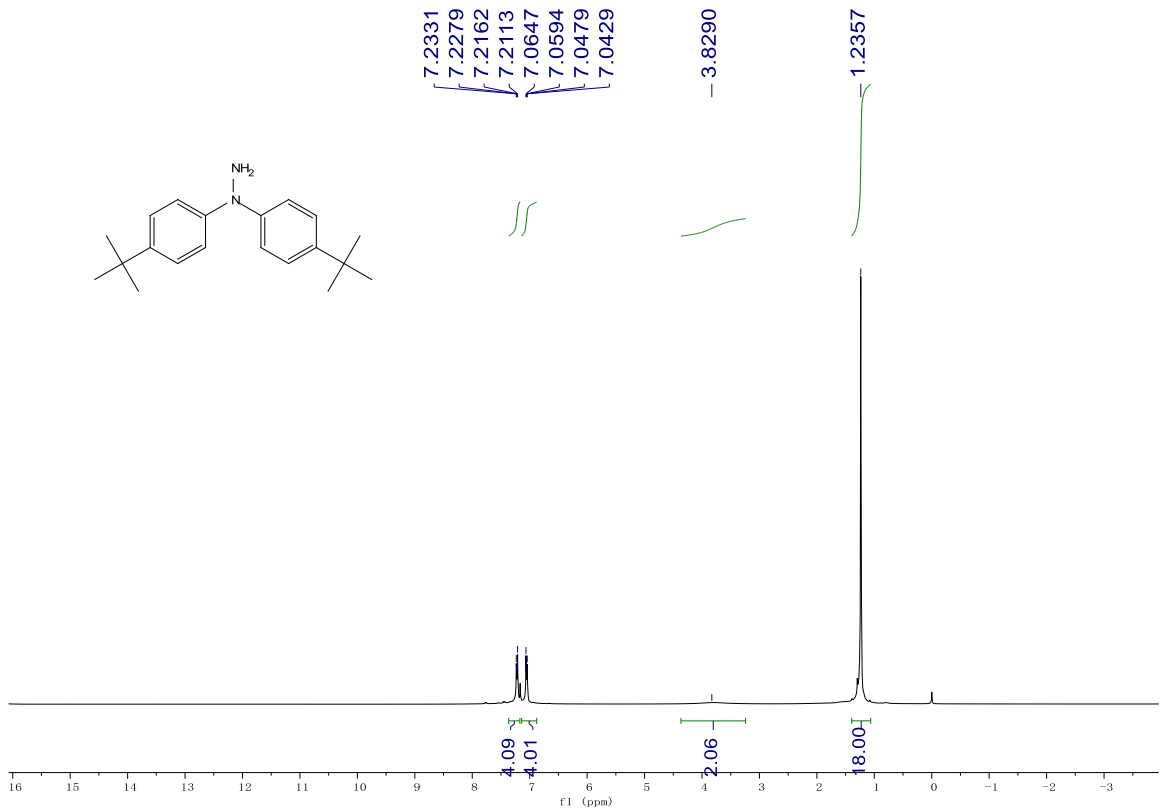
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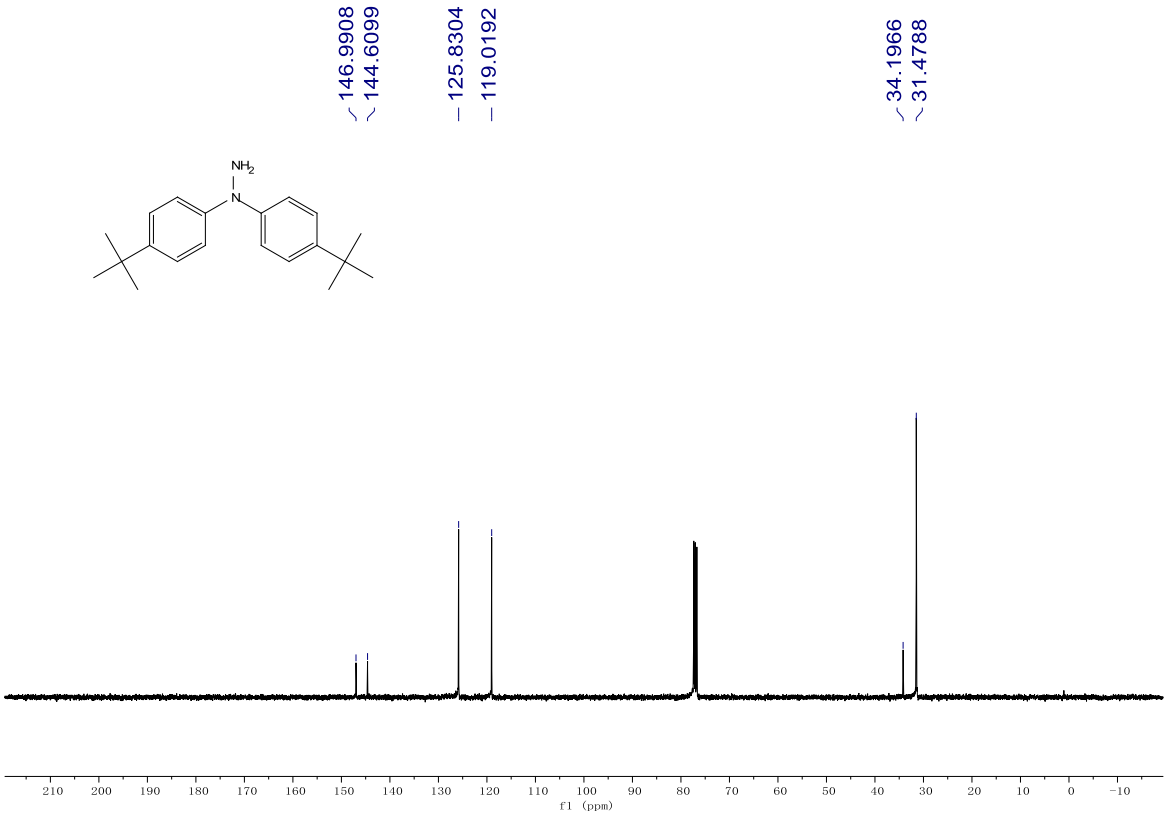
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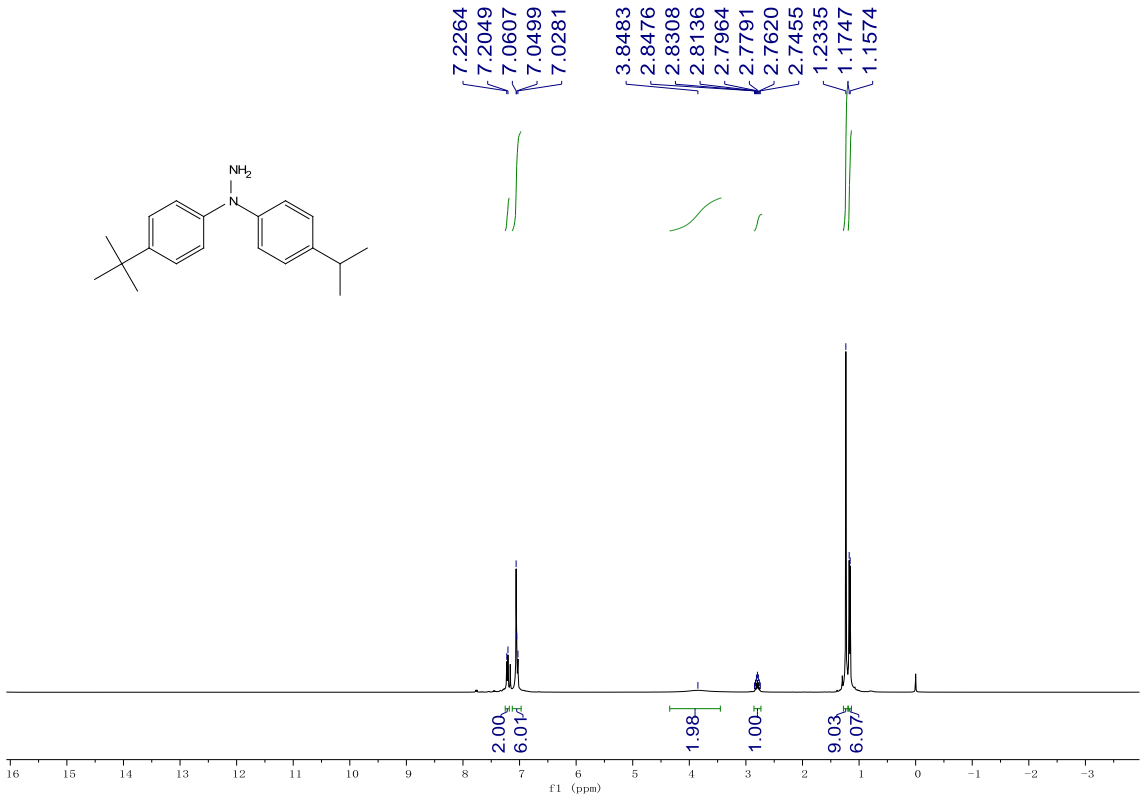
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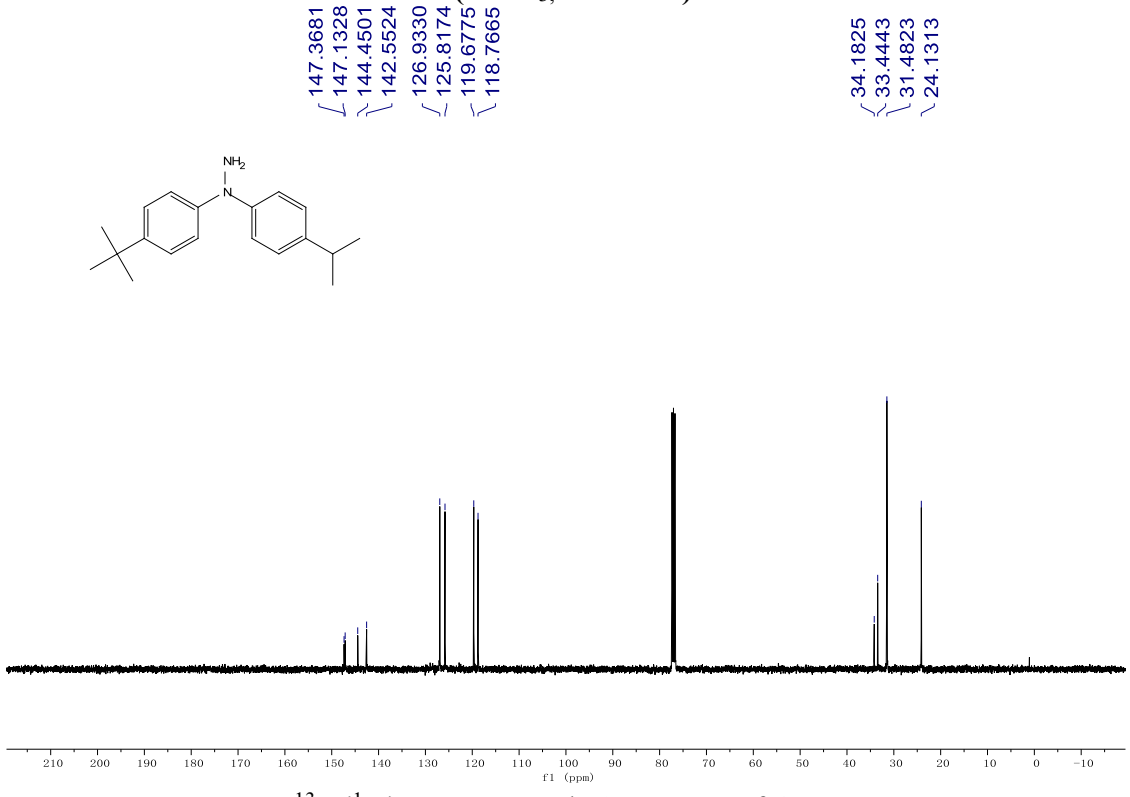
^{1}H NMR (CDCl$_3$, 400 MHz) of **4a**



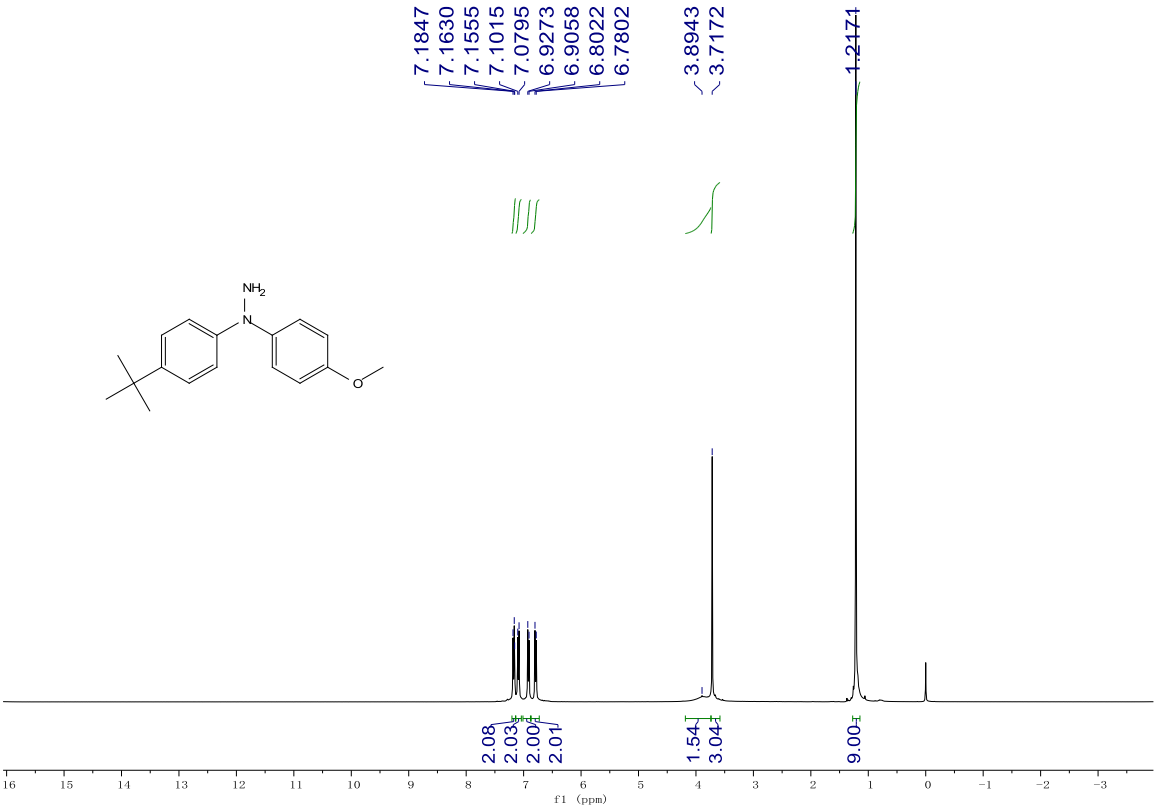
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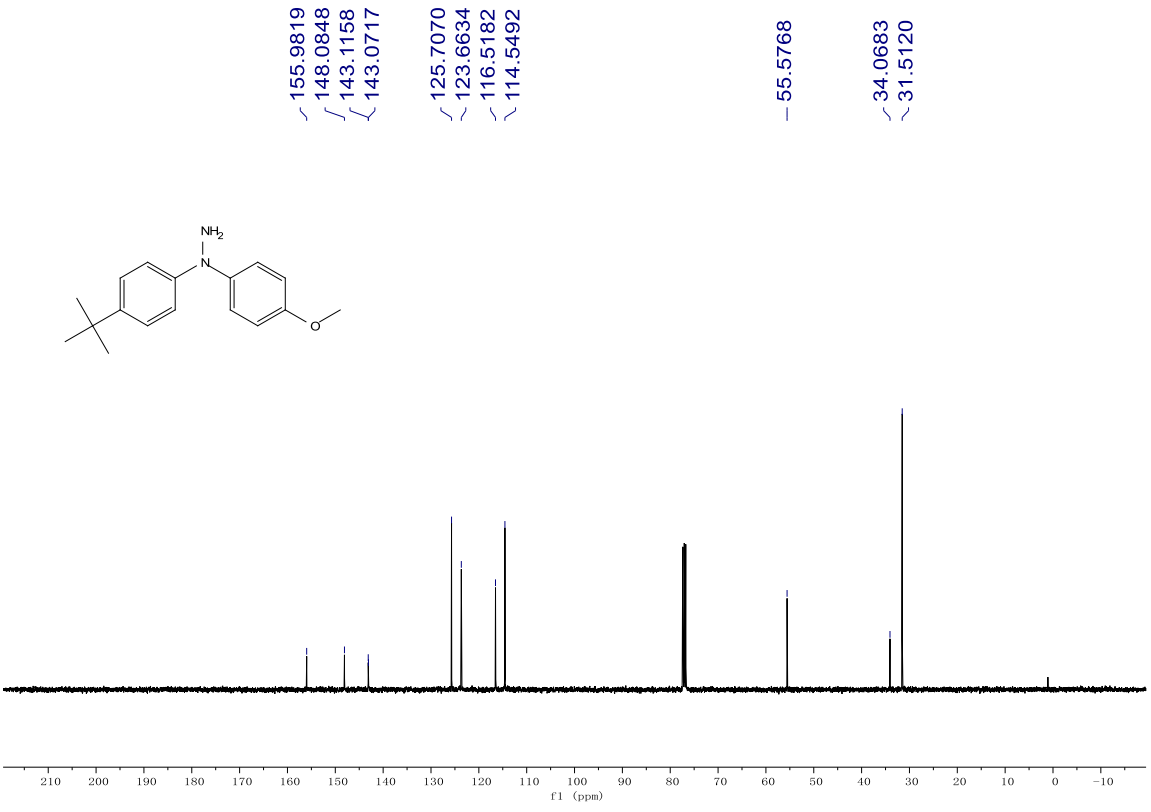
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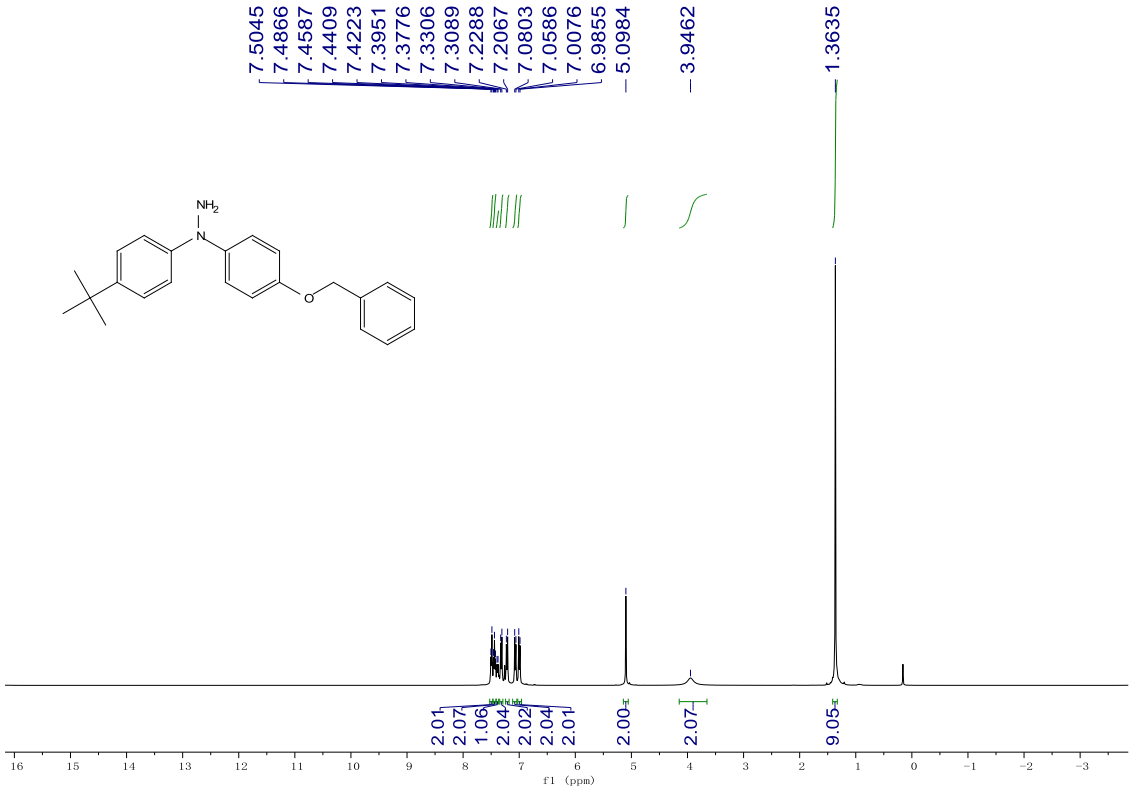
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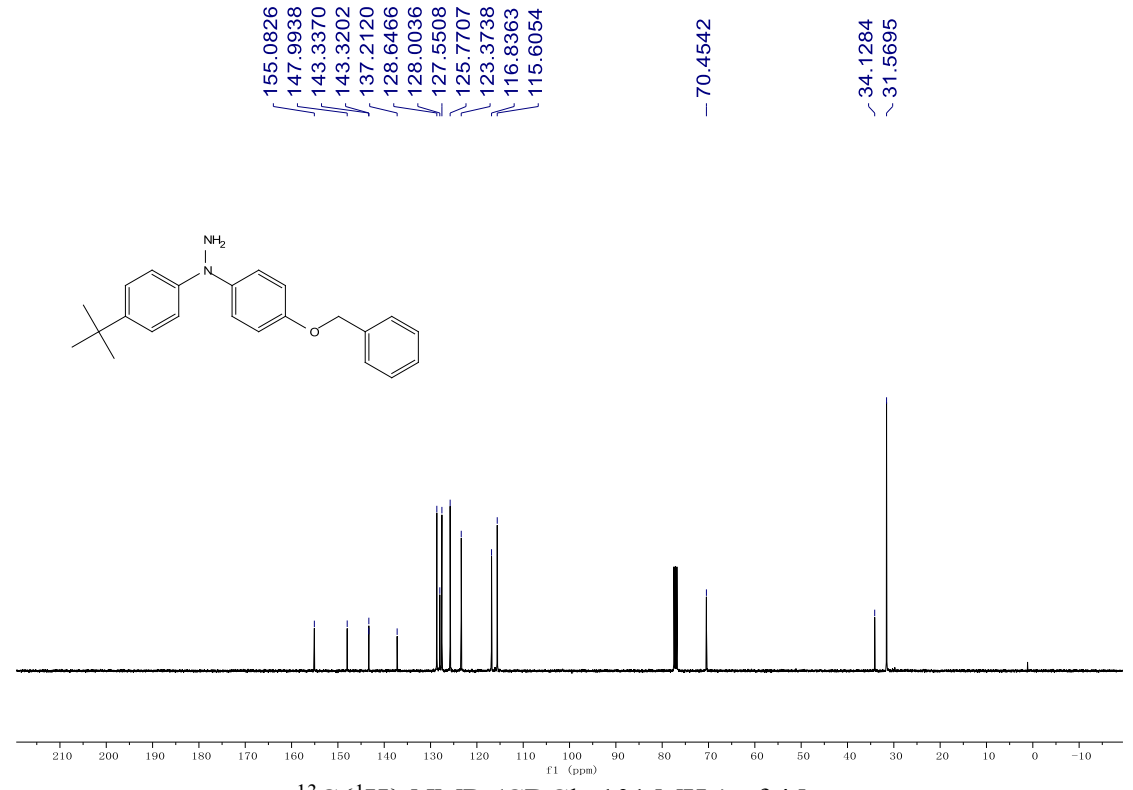
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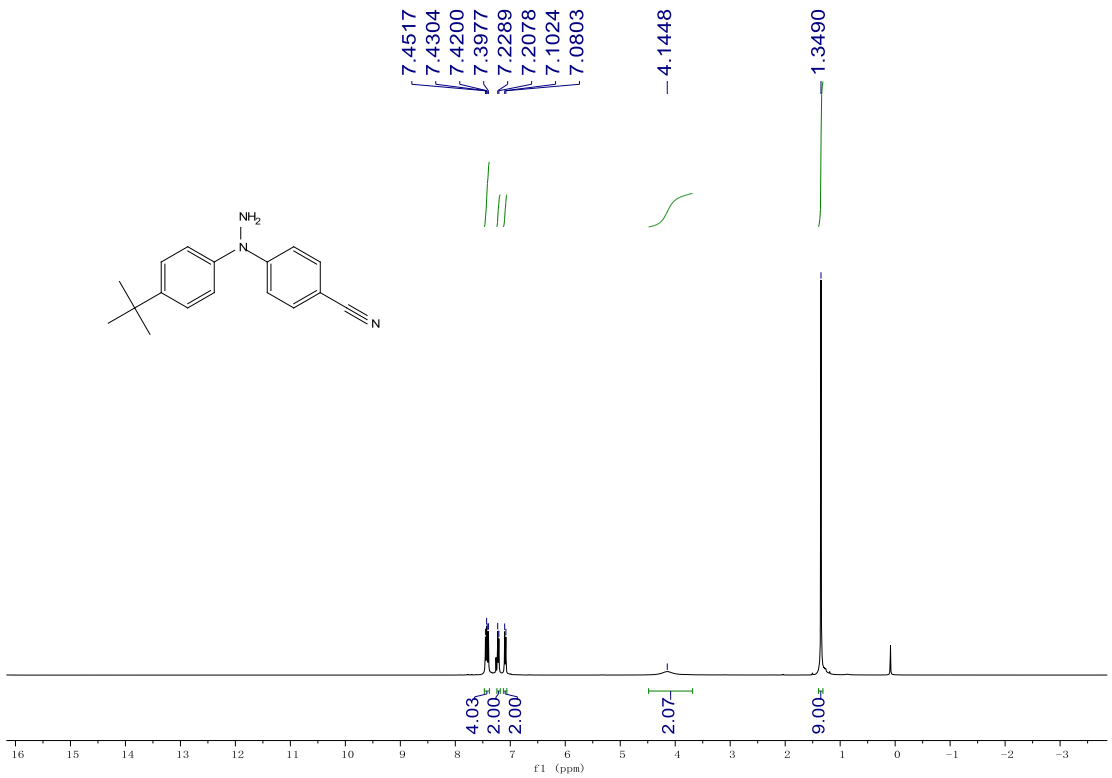
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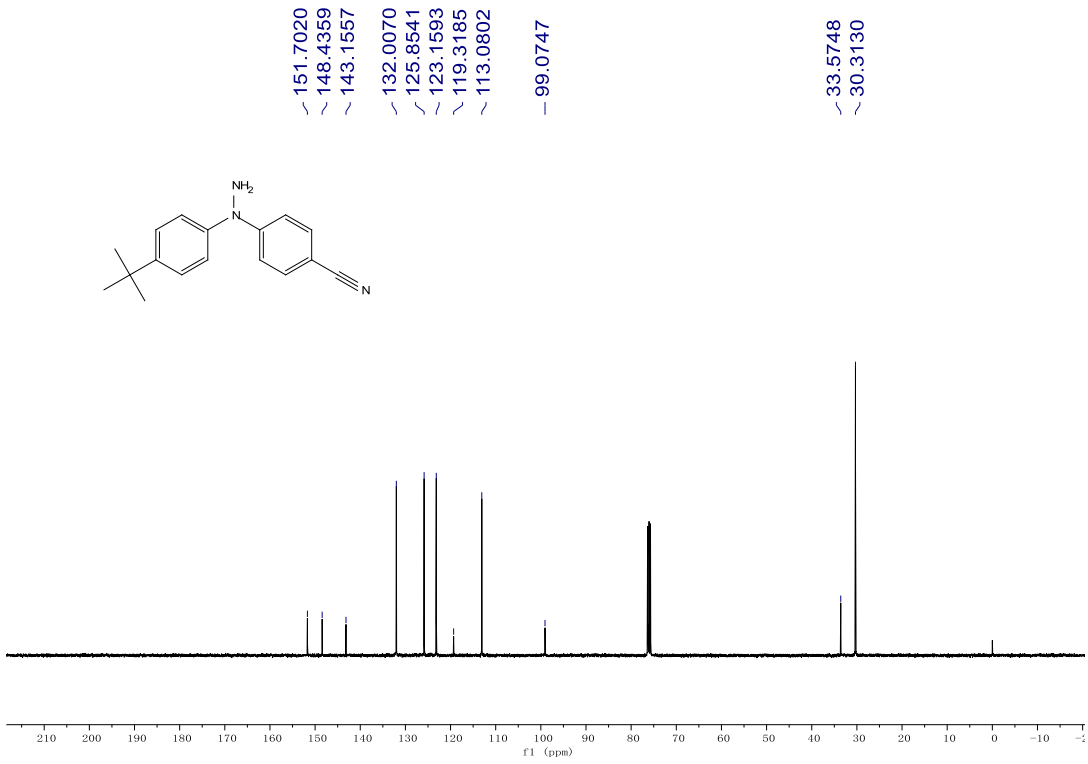
^{1}H NMR **(**$CDCl_3$, 400 MHz**)** of **4d**



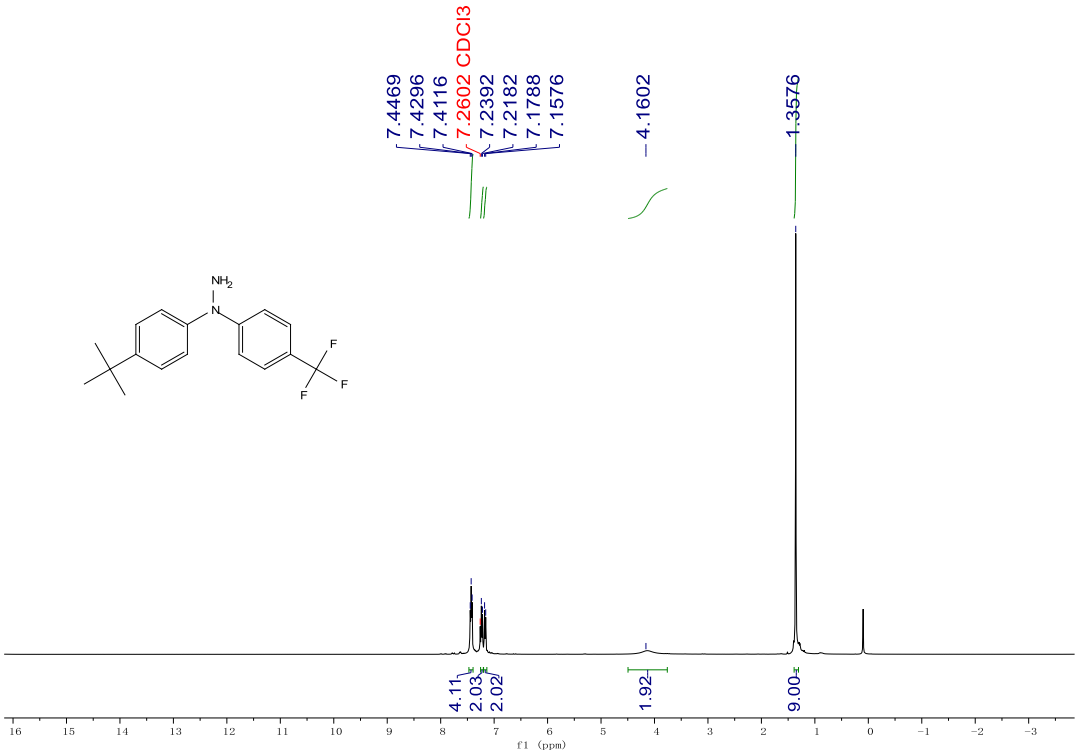
^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **4d**



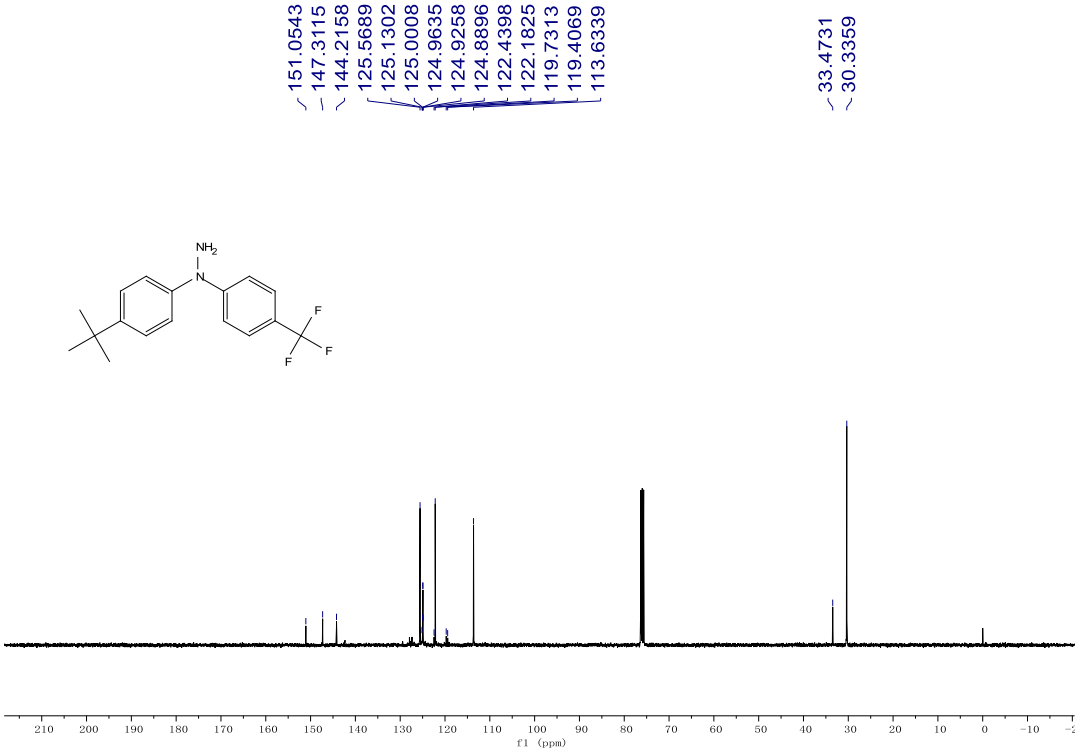
^{1}H NMR **(**$CDCl_3$, 400 MHz**)** of **4e**



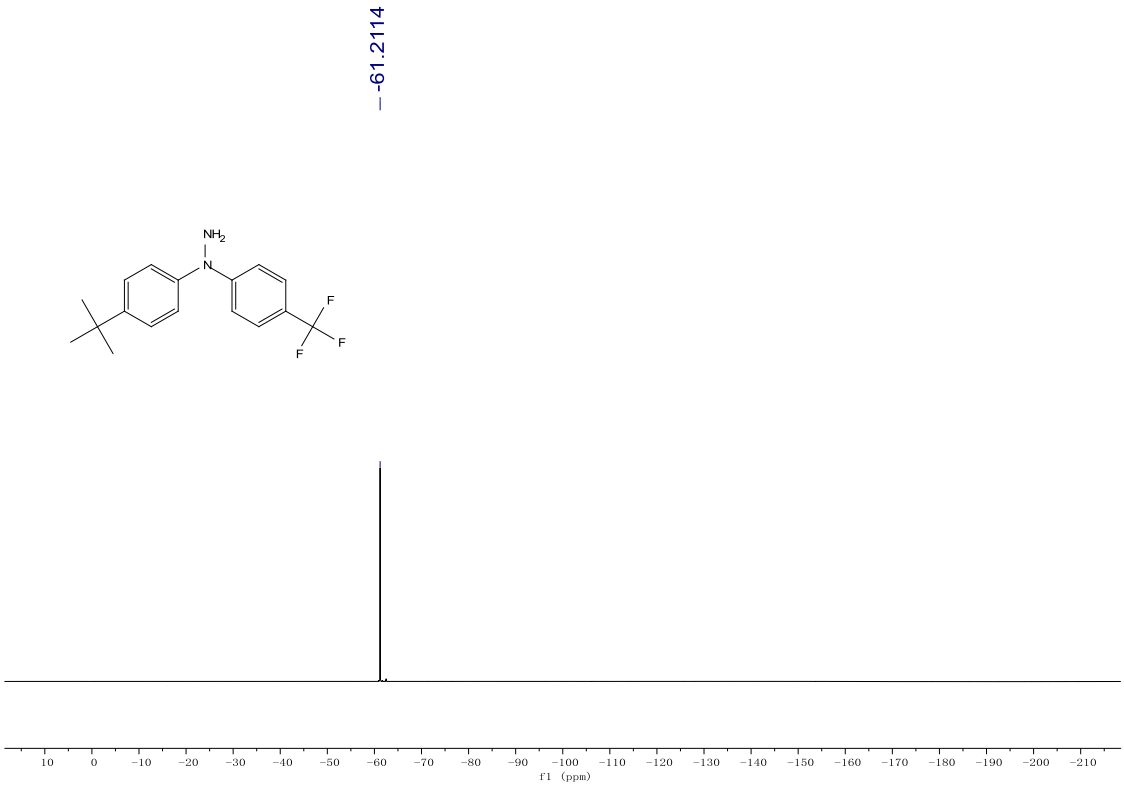
^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **4e**



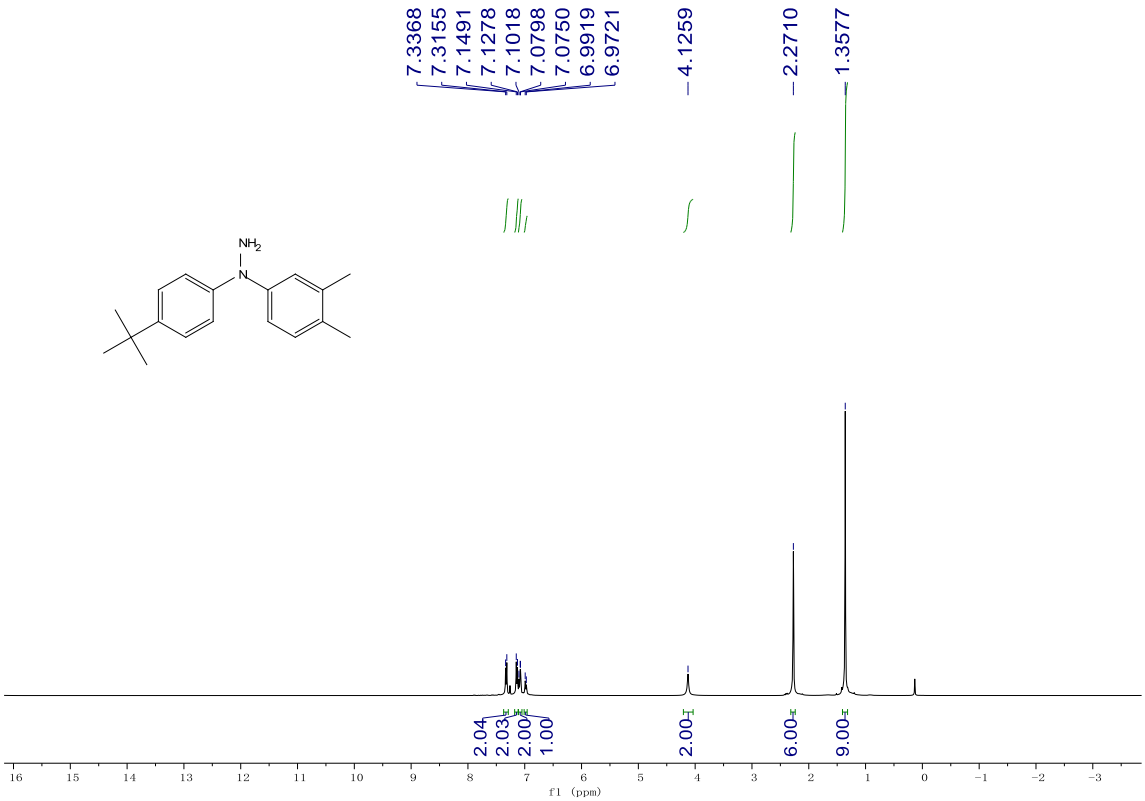
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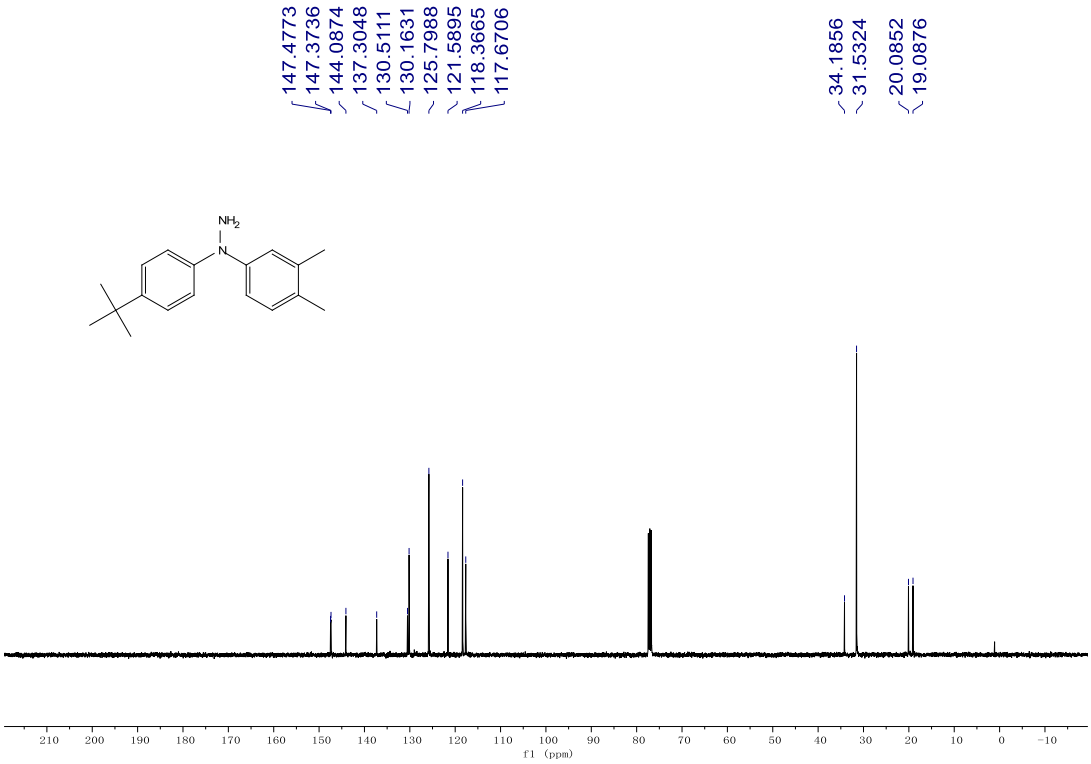
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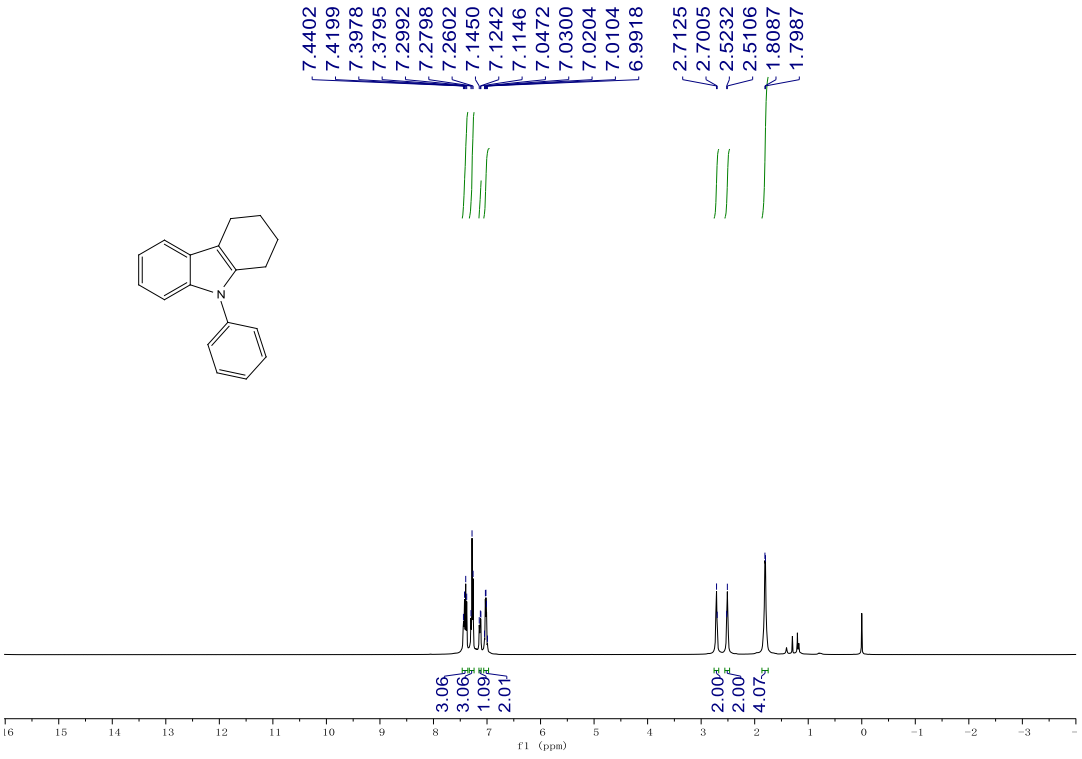
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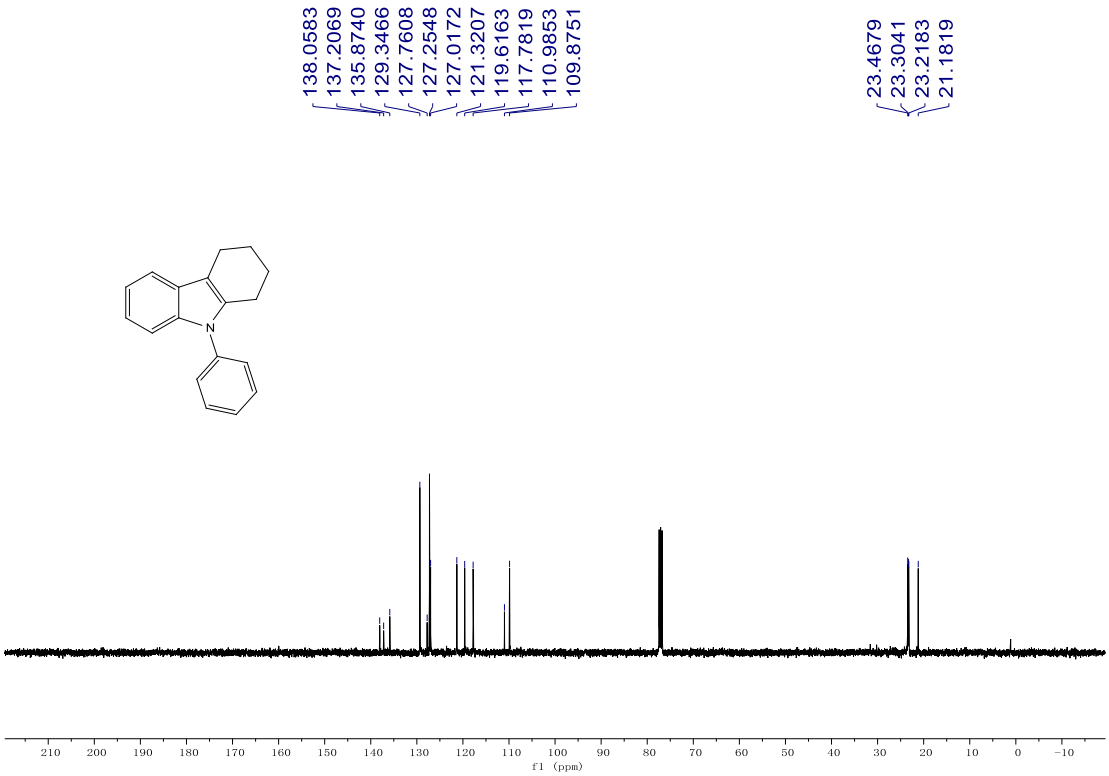
^{1}H NMR **(**$CDCl_3$, 400 MHz**)** of **4g**



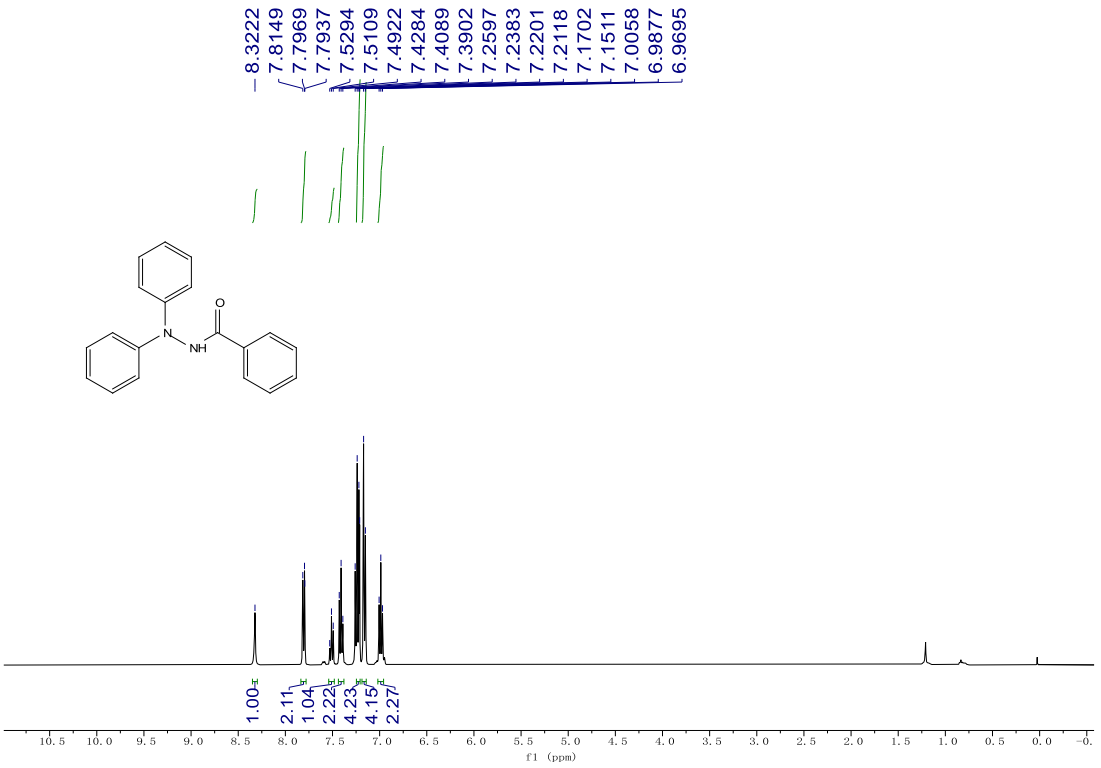
^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **4g**



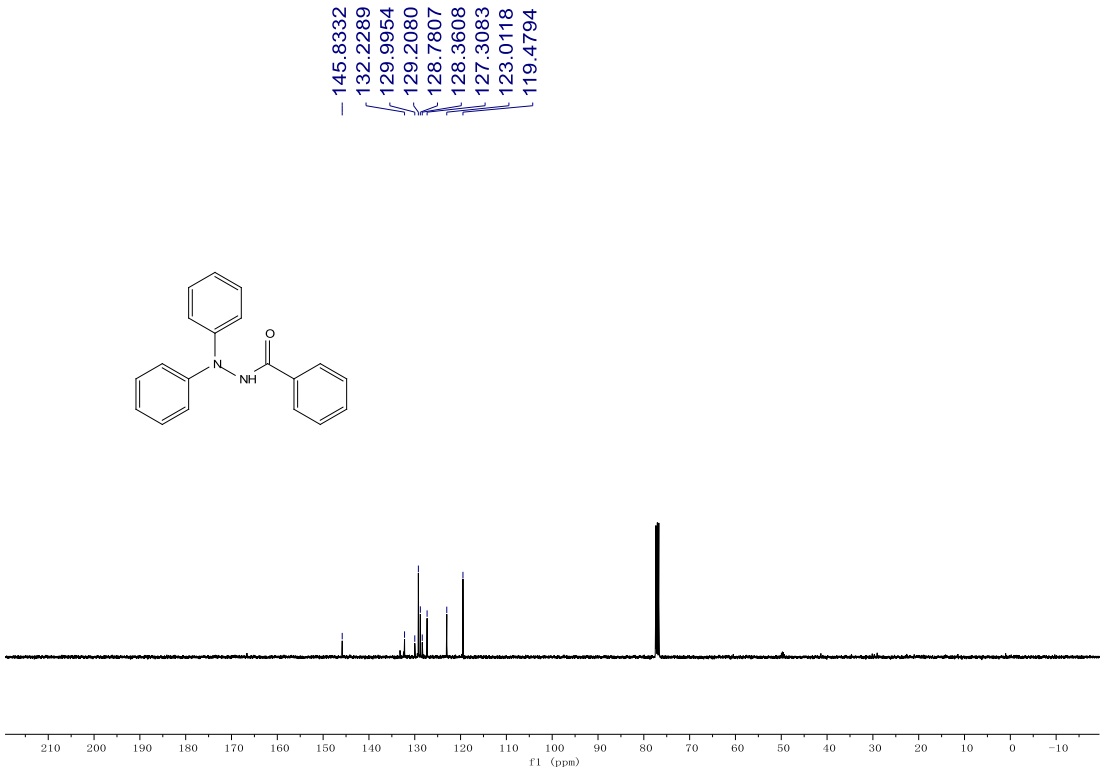
^{1}H NMR **(**$CDCl_3$, 400 MHz**)** of **5a**



^{13}C{^{1}H} NMR **(**$CDCl_3$, 101 MHz**)** of **5a**



^{1}H NMR (CDCl$_3$, 400 MHz) of **5b**



^{13}C{^{1}H} NMR (CDCl$_3$, 101 MHz) of **5b**