Supporting Information

Selective amination of aryl chlorides catalyzed by Ni(PMe$_3$)$_4$

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General information

All the reactions for C-N cross-coupling were carried out using standard Schlenk techniques under N$_2$ atmosphere. Toluene was dried by Na using benzophenone as indicator and distilled under N$_2$. CH$_3$CN, DMSO and DMF were refluxed with CaH$_2$ and distilled under N$_2$. Other chemicals obtained commercially were used as received without further purification. $^1$H NMR, $^{13}$C NMR and $^{19}$F NMR were recorded on 300 or 400 MHz Bruker instruments. Chemical shifts were referenced by external standard expressing in ppm (tetramethysilane, 0 ppm, CDCl$_3$).

General procedure for synthesis of the chloro-substituted Schiff bases (1a-1i)

The imines were prepared from 1:1 ratio of corresponding aldehyde and amine in ethanol. 1a-1f were recrystallized in pentane. 1g-1i are gained as yellow oil. The scope of the substrates is shown in Table S1.
Table S1. Substrates 1a-1i.

General procedure for C-N coupling reactions (Procedure A)
To a sealed tube was added 1 (1.5 mmol), amines, NaOH and nBu4NBr (0.075 mmol). Then the tube was evacuated and recharged by N2 for three times. Toluene (4 mL) and Ni(PMe3)4 (0.060 mmol in its toluene solution) was added under N2 atmosphere by syringe. The sealed tube was put in a 80°C oil bath. After reaction completed, the solvent was removed in vacuo completely and the product was extracted by pentane (15mL*3). Pure products were obtained by recrystallation from pentane, producing yellow powder or crystals.

General procedure for reducing of imines (Procedure B)
After the reaction of C-N coupling finished, solvent was removed and the crude products were extracted by pentane (15mL*3). After pentane was removed in vacuo, the imines were dissolved in 10mL of petroleum ether. Few drops of acetic acid was
added. Then NaBH₄ was added in a 30 mg amount over an interval of 2 minutes until the yellow color of imines faded into colorless. The precipitate was filtered off, and the solvent was concentrated. The products were obtained by silica gel column chromatography (petroleum ether : ethyl acetate 10:1).

**Analytical data for 2a-2q**

N-(4-methylphenyl)-2-[[4-(methylphenyl)imino]methyl]-3-chlorobenzenamine (2a).

Following procedure A, 1a (0.396 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH are both 1.5 mmol. After 12h heating, product 2a (0.477 g, 95%) is obtained.

**1H NMR (300 MHz, CDCl₃)** δ 11.76 (s, 1H), 9.26 (s, 1H), 7.25-7.15 (m, 8H), 7.12-7.05 (m, 2H), 6.76 (dd, 3J_HH = 5.7 Hz, 4J_HH = 2.7 Hz, 1H), 2.38 (s, 3H), 2.35 (s, 3H).

**13C NMR (75 MHz, CDCl₃)** δ 159.88, 149.53, 149.17, 138.89, 138.53, 136.74, 134.47, 132.70, 130.65, 130.55, 124.22, 121.81, 118.48, 114.82, 112.55, 21.68, 21.58.

**HRMS-ESI (m/z)** Calcd for C_{21}H_{19}ClN_{2} [M+H]: 335.1315; Found: 335.1260.


Following procedure A, 1b (0.427 g, 1.5 mmol) was used as substrate. The amount of 2-chloroaniline and NaOH are both 1.5 mmol. After 12h heating, product 2b (0.490 g, 87%) was obtained.

**1H NMR (300 MHz, CDCl₃)** δ 11.77 (s, 1H), 9.24 (s, 1H), 7.51-7.44 (m, 3H), 7.35-7.23 (m, 2H), 7.21-7.13 (m, 3H), 7.08 (td, 3J_HH = 7.8, 4J_HH = 1.5 Hz, 1H), 7.02 (d, 3J_HH = 8.4 Hz, 1H), 6.85 (dd, 3J_HH = 7.8, 4J_HH = 0.9 Hz, 1H). **13C NMR (75 MHz, CDCl₃)** δ 160.67, 148.10, 148.07, 138.46, 137.88, 132.63, 130.52, 130.04, 129.23, 129.00, 127.80, 127.26, 127.07, 125.24, 124.77, 119.94, 118.94, 115.19, 112.78.

**HRMS-ESI (m/z)** Calcd for C_{19}H_{13}Cl_{3}N_{2} [M+H]: 375.0223; Found: 375.0136.
N-phenyl-2-[(phenylimino)methyl]-3-chloro-benzenamine (2c).

Following procedure A, 1c (0.375 g, 1.5 mmol) was used as substrate. The amount of aniline and NaOH are both 1.5 mmol. After 12h heating, product 2c (0.405 g, 88%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 11.82 (s, 1H), 9.26 (s, 1H), 7.45-7.28 (m, 8H), 7.25-7.19(m, 2H), 7.15-7.10(m, 2H), 6.81 (dd, $^3J_{HH} = 7.5$, $^4J_{HH} = 1.2$Hz, 1H). $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 160.00, 150.94, 148.36, 140.51, 138.38, 132.26, 129.42, 129.29, 126.24, 123.96, 123.05, 121.28, 118.27, 114.37, 112.10. HRMS-ESI (m/z) Calcd for C$_{19}$H$_{15}$ClN$_2$ [M+H]: 307.1002; Found: 307.0953.

N-(4-chlorophenyl)-2-[[4-chlorophenyl]imino]methyl]-3-chloro-benzenamine (2d).

Following procedure A, 1d (0.427 g, 1.5 mmol) was used as substrate. The amount of 4-chloroaniline and NaOH are both 1.5 mmol. After 12h heating, product 2d (0.513 g, 91%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 11.66 (s, 1H), 9.22 (s, 1H), 7.40-7.31 (m, 4H), 7.24-7.11 (m, 6H), 6.83 (dd, $^3J_{HH} = 6.9$, $^4J_{HH} = 2.1$ Hz, 1H). $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 160.53, 149.54, 148.41, 139.28, 138.81, 132.91, 132.27, 129.82, 129.72, 129.40, 124.53, 122.82, 110.08, 114.71, 112.37. HRMS-ESI (m/z) Calcd for C$_{19}$H$_{13}$Cl$_3$N$_2$ [M+H]: 375.0223; Found: 375.0133.


Following procedure A, 1a (0.396 g, 1.5 mmol) was used as substrate. The amount of 2-chloroaniline and NaOH were both 1.5 mmol. After 12h heating, product 2e (0.426 g, 80%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 12.13 (s, 1H), 9.28 (s, 1H), 7.55 (dd, $^3J_{HH} = 8.1$, $^4J_{HH} = 8.1$ Hz, 1H).
1.5 Hz, 1H), 7.46 (dd, $^{3}J_{HH} = 7.8$, $^{4}J_{HH} = 1.2$ Hz, 1H), 7.24-7.12 (m, 7H), 7.00 (td, $^{3}J_{HH} = 7.8$, $^{4}J_{HH} = 1.2$ Hz, 1H), 6.87 (dd, $^{3}J_{HH} = 7.5$, $^{4}J_{HH} = 1.2$ Hz, 1H), 2.38 (s, 3H).

$^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 158.27, 147.89, 146.77, 138.25, 138.17, 136.48, 131.85, 130.35, 129.94, 127.13, 126.97, 123.81, 121.96, 121.29, 119.39, 116.06, 112.68, 21.09. HRMS-ESI (m/z) Calcd for C$_{20}$H$_{16}$Cl$_2$N$_2$ [M+H]: 355.0769; Found: 355.0767.

N-phenyl-2-[(4-methylphenyl)imino]methyl]-3-chloro-benzenamine (2f).

Following procedure A, 1a (0.396 g, 1.5 mmol) was used as substrate. The amount of aniline and NaOH were both 1.5 mmol. After 12h heating, product 2f (0.418g, 87%) was obtained.

$^{1}$H NMR (300 MHz, CDCl$_3$) $\delta$ 11.88 (s, 1H), 9.26 (s, 1H), 7.40-7.28 (m, 4H), 7.24-7.09 (m, 7H), 6.80 (dd, $^{3}J_{HH} = 7.5$, $^{4}J_{HH} = 1.2$Hz, 1H), 2.38 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 159.18, 148.39, 148.28, 140.66, 138.29, 136.23, 132.08, 129.94, 129.45, 123.89, 122.99, 121.17, 118.31, 114.54, 112.10, 21.07. HRMS-ESI (m/z) Calcd for C$_{20}$H$_{17}$ClN$_2$ [M+H]: 321.1159; Found: 321.1164.

N-(4-chlorophenyl)-2-[(4-methylphenyl)imino]methyl]-3-chloro-benzenamine (2g).

Following procedure A, 1a (0.396 g, 1.5 mmol) was used as substrate. The amount of 4-chloroaniline and NaOH were both 1.5 mmol. After 12h heating, product 2g (0.437 g, 82%) was obtained.

$^{1}$H NMR (300 MHz, CDCl$_3$) $\delta$ 11.89 (s, 1H), 9.25 (s, 1H), 7.33-7.30 (m, 2H), 7.24-7.18 (m, 6H), 7.16-7.13 (m, 2H), 6.83 (dd, $^{3}J_{HH} = 5.4$, $^{4}J_{HH} = 3.3$ Hz, 1H), 2.38 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 159.12, 148.18, 147.85, 139.29, 138.36, 136.40, 132.15, 129.96, 129.48, 128.72, 123.96, 121.14, 118.76, 114.79, 112.00, 21.07. HRMS-ESI (m/z) Calcd for C$_{20}$H$_{16}$Cl$_2$N$_2$ [M+H]: 355.0769; Found: 355.0770.

N-naphthyl-2-[(4-methylphenyl)imino]methyl]-3-chloro-benzenamine (2h)
Following procedure A, 1a (0.396 g, 1.5 mmol) was used as substrate. The amount of naphthyl amine and NaOH were both 1.5 mmol. After 12h heating, product 2h (0.511g, 92%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) δ 12.31 (s, 1H), 9.38 (s, 1H), 8.20-8.17 (m, 1H), 8.91-8.88 (m, 1H), 7.70 (d, $^3$J$_{HH}$ = 7.8 Hz, 1H), 7.58 (d, $^3$J$_{HH}$ = 7.2 Hz, 1H), 7.53-7.48 (m, 3H), 7.21 (s, 4H), 7.10-7.00 (m, 2H), 6.80 (dd, $^3$J$_{HH}$ = 7.2, $^4$J$_{HH}$ = 1.5 Hz, 1H), 2.37 (s, 3H).

$^{13}$C NMR (100 MHz, CDCl$_3$) δ 159.21, 149.46, 148.24, 138.18, 136.73, 136.28, 134.82, 132.14, 129.95, 129.58, 128.39, 126.34, 126.32, 125.78, 124.96, 122.80, 121.23, 120.43, 118.08, 114.60, 112.43, 21.04. HRMS-ESI (m/z) Calcd for C$_{24}$H$_{19}$ClN$_2$ [M+H]: 371.1315; Found: 371.1286.

N-isopropyl-2-(4-fluorophenyl)amino-6-chloro-benzenemethanamine (2i).

Following procedure A, 1g (0.324 g, 1.5 mmol) was used as substrate. The amount of 4-fluoroaniline and NaOH were both 1.5 mmol. After 12h heating, it was handled following procedure B. Product 2i (0.351 g, 80%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) δ 8.83 (s, 1H), 7.09-7.04 (m, 2H), 7.01-6.97(m, 4H), 6.83(dd, $^3$J$_{HH}$ = 7.8, $^4$J$_{HH}$ = 1.5 Hz, 1H), 4.06 (s, 2H), 2.86(m, 1H), 1.15 (d, $^3$J$_{HH}$ = 6.3 Hz, 6H), 0.89 (m, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$) δ 157.81(d, $^1$J$_{CF}$ = 238.3Hz), 146.46, 138.88 (d, $^1$J$_{CF}$ = 2.3 Hz), 134.46, 128.42, 123.75, 120.55 (d, $^3$J$_{CF}$ = 7.7 Hz), 120.22, 115.92 (d, $^3$J$_{CF}$ = 22.3 Hz), 112.66, 48.43, 45.79, 23.09. $^{19}$F NMR (376 MHz, CDCl$_3$) δ 122.36-122.43(m, 1F). HRMS-ESI (m/z) Calcd for C$_{18}$H$_{18}$ClF$_2$N$_2$ [M+H]: 293.1221; Found: 293.2237.

N-nomalbutyl-2-(4-methylphenyl)amino-6-chloro-benzenemethanamine (2j).

Following procedure A, 1h (0.345 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h heating, it was handled
following procedure B. Product 2j (0.284 g, 63%) was obtained.

\[ \text{H NMR (300 MHz, CDCl}_3 \text{) } \delta 8.72 (s, 1H), 7.15 (dd, } \delta_{HH}^3 = 8.1, } \delta_{HH}^4 = 0.9 \text{ Hz, 1H}, 7.10-6.96 (m, 5H), 6.81 (dd, } \delta_{HH}^3 = 7.8, } \delta_{HH}^4 = 1.1 \text{ Hz, 1H}, 4.05 (s, 2H), 2.68 (t, } \delta_{HH}^3 = 6.9 \text{ Hz, 2H), 2.31 (s, 3H), 1.57-1.48 (m, 2H), 1.47-1.34 (m, 2H), 1.18 (s, 1H), 0.93 (t, } \delta_{HH}^3 = 7.2 \text{ Hz, 3H).} \]

\[ \text{C NMR (100 MHz, CDCl}_3 \text{) } \delta 146.54, 140.19, 134.50, 130.65, 129.85, 128.36, 123.57, 119.89, 119.25, 112.96, 48.71, 48.18, 32.23, 20.72, 20.48, 13.99. \]

HRMS-ESI (m/z) Calcd for C\textsubscript{18}H\textsubscript{23}ClN\textsubscript{2} [M+H]: 303.1628; Found: 303.3047.

N-cyclohexyl-2-(4-methylphenyl)amino-6-chloro-benzenemethanamine (2k).

Following procedure A, 1i (0.384 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h heating, it was handled following procedure B. Product 2k (0.402g, 82%) was obtained.

\[ \text{H NMR (300 MHz, CDCl}_3 \text{) } \delta 8.67 (s, 1H), 7.30 (dd, } \delta_{HH}^3 = 8.1, } \delta_{HH}^4 = 0.9 \text{ Hz, 1H), 7.17-7.06 (m, 3H), 7.00 (dt, } \delta_{HH}^3 = 8.4, } \delta_{HH}^4 = 2.1 \text{ Hz, 2H), 6.75 (td, } \delta_{HH}^3 = 7.5, } \delta_{HH}^4 = 1.2 \text{ Hz, 1H), 3.84 (s, 2H), 2.55-2.46 (m, 1H), 2.30 (s, 3H), 1.98-1.94 (m, 2H), 1.76-1.71 (m, 2H), 1.63-1.58 (m, 2H), 1.32-1.27 (m, 2H), 1.19-1.12 (m, 2H), 0.91 (s, 1H).} \]

\[ \text{C NMR (100 MHz, CDCl}_3 \text{) } \delta 144.43, 140.79, 129.91, 129.80, 129.75, 128.04, 126.85, 118.93, 118.38, 114.58, 56.09, 50.58, 33.59, 26.21, 24.88, 20.70. \]

HRMS-ESI (m/z) Calcd for C\textsubscript{20}H\textsubscript{25}ClN\textsubscript{2} [M+H]: 329.1785; Found: 329.1722.

N-\textit{iso}propyl-2-(4-methylphenyl)amino-6-chloro-benzenemethanamine (2l).

Following procedure A, 1g (0.324 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h heating, it was handled following procedure B. Product 2l (0.370 g, 86%) was obtained.

\[ \text{H NMR (300 MHz, CDCl}_3 \text{) } \delta 8.76 (s, 1H), 7.18-6.96 (m, 6H), 6.82 (d, } \delta_{HH}^3 = 7.8 \text{ Hz, 1H), 4.05 (s, 2H), 2.91-2.83 (m, 1H), 2.31 (s, 3H), 1.15 (d, } \delta_{HH}^3 = 6.3 \text{ Hz, 6H), 1.02 (s, 1H).} \]

\[ \text{C NMR (75 MHz, CDCl}_3 \text{) } \delta 146.44, 140.29, 134.42, 130.55, 129.93, 128.40, 123.85, 120.01, 119.03, 113.05, 48.50, 45.87, 23.17, 20.78. \]

HRMS-ESI (m/z) Calcd
N-(4-methylphenyl)-2-[(naphthylimino)methyl]-3-chloro-benzenamine (2m).

Following procedure A, 1e (0.450 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h heating, product 2m (0.550 g, 99%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) δ 11.91 (s, 1H), 9.35 (s, 1H), 8.28 (dd, $^3$J$_{HH}$ = 6.9, $^4$J$_{HH}$ = 2.7 Hz, 1H), 7.87, (dd, $^3$J$_{HH}$ = 7.2, $^4$J$_{HH}$ = 2.4 Hz, 1H), 7.75 (d, $^3$J$_{HH}$ = 8.4 Hz, 1H), 7.55-7.48 (m, 3H), 7.25-7.12 (m, 7H), 6.81 (dd, $^3$J$_{HH}$ = 7.2, $^4$J$_{HH}$ = 1.5 Hz, 1H), 2.36 (s, 3H).

$^{13}$C NMR (75 MHz, CDCl$_3$) δ 160.39, 149.05, 148.55, 138.44, 137.72, 133.97, 133.89, 132.47, 130.05, 128.54, 127.88, 126.44, 126.21, 126.17, 123.43, 117.95, 114.51, 113.86, 112.02, 20.93. HRMS-ESI (m/z) Calcd for C$_{24}$H$_{19}$ClN$_2$ [M+H]:371.1315; Found: 371.1286.

N-(4-methylphenyl)-2-[(2-chlorophenyl)imino]methyl]-3-chloro-benzenamine (2n).

Following procedure A, 1b (0.427 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h heating, product 2n (0.368 g, 69%) was obtained.

$^1$H NMR (300 MHz, CDCl$_3$) δ 11.94 (s, 1H), 9.29 (s, 1H), 7.47 (dd, $^3$J$_{HH}$ = 7.8, $^4$J$_{HH}$ = 1.4 Hz, 1H), 7.36-7.28 (m, 2H), 7.24-7.09 (m, 7H), 6.77 (dd, $^3$J$_{HH}$ = 7.2, $^4$J$_{HH}$ = 1.4 Hz, 1H), 2.35 (s, 3H). $^{13}$C NMR (75 MHz, CDCl$_3$) δ 159.97, 149.14, 147.48, 138.40, 137.73, 133.78, 132.67, 129.96, 129.94, 129.83, 127.81, 127.05, 123.44, 119.21, 117.71, 114.05, 112.07, 20.93. HRMS-ESI (m/z) Calcd for C$_{20}$H$_{16}$Cl$_2$N$_2$ [M+H]:355.0769; Found: 355.0770.

N-(4-methylphenyl)-2-[[4-methylphenyl]imino]methyl]-3-(4-methylphenyl)amino -benzenamine (2o).

Following procedure A, 1a (0.396 g, 1.5 mmol) was used
as substrate. The amount of 4-methylaniline and NaOH were both 3.0 mmol. After 24h heating, product 2o (0.395 g, 65%) is obtained.

\[ ^1\text{H NMR (300 MHz, CDCl}_3 \delta 8.95 (s, 1H), 8.54 (s, 2H), 7.15-7.09 (m, 7H), 7.04-6.98 (m, 6H), 6.74 (d, \text{ }^3J_{HH} = 8.1 \text{ Hz, } 2H), 2.33 (s, 3H), 2.31 (s, 6H). \]

\[ ^{13}\text{C NMR (75 MHz, CDCl}_3 \delta 158.63, 149.58, 147.42, 141.01, 135.88, 133.19, 132.02, 130.30, 130.18, 121.47, 120.84, 111.52, 109.27, 21.38, 21.18. \]

HRMS-ESI (m/z) Calcd for C\(_{28}\)H\(_{27}\)N\(_3\) [M+H]: 406.2283; Found: 406.2242.

N-(4-methylphenyl)-2-(4-methylphenyl)amino-benzenemethanamine (2p).

Following procedure A, 1f (0.344 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h/24h heating, it was handled following procedure B. Product 2p [0.076 g, 17% (12h) / 0.315 g, 70% (24h)] was obtained.

\[ ^1\text{H NMR (300 MHz, CDCl}_3 \delta 7.33 (s, 1H), 7.29 (d, \text{ }^3J_{HH} = 5.7 \text{ Hz, } 1H), 7.22 (t, \text{ }^3J_{HH} = 7.8 \text{ Hz, } 1H), 7.07 (dd, \text{ }^3J_{HH} = 8.4, \text{ }^4J_{HH} = 2.7 \text{ Hz, } 4H), 6.96 (d, \text{ }^3J_{HH} = 8.4 \text{ Hz, } 2H), 6.89-6.85 (m, 2H), 6.72 (d, \text{ }^3J_{HH} = 8.4 \text{ Hz, } 2H), 4.26 (s, 2H), 3.59 (s, 1H), 2.30 (s, 3H), 2.29 (s, 3H). \]

\[ ^{13}\text{C NMR (100 MHz, CDCl}_3 \delta 145.98, 143.79, 140.38, 130.67, 130.44, 129.88, 129.86, 128.75, 128.29, 126.26, 120.00, 119.13, 116.09, 114.41, 48.25, 20.72, 20.50. \]

HRMS-ESI (m/z) Calcd for C\(_{21}\)H\(_{22}\)N\(_2\) [M+H]: 303.1861; Found: 303.1867.

N-(4-methylphenyl)-perchloroaniline (2q).

Following procedure A, hexachlorobenzene (0.428 g, 1.5 mmol) was used as substrate. The amount of 4-methylaniline and NaOH were both 1.5 mmol. After 12h heating, the crude product was purified by column chromatography using petroleum ether as eluent. Pure product 2q (0.304 g, 57%) is obtained.

\[ ^1\text{H NMR (300 MHz, CDCl}_3 \delta 7.07 (d, \text{ }^3J_{HH} = 8.1 \text{ Hz, } 2H), 6.65 (d, \text{ }^3J_{HH} = 8.1 \text{ Hz, } 2H), 5.95 (s, 1H), 2.30 (s, 3H). \]

\[ ^{13}\text{C NMR (100 MHz, CDCl}_3 \delta 139.61, 138.05, 132.06, 131.93, 129.69, 127.86, 127.58, 117.84, 20.69. \]

HRMS-ESI (m/z) Calcd for
C_{13}H_8Cl_3N [M+H]: 355.9148; Found: 355.9078.

{H NMR of 2a}
\[ \text{\(^{13}\text{C NMR of 2a}\)} \]

\[ \text{\(^{1}\text{H NMR of 2b}\)} \]
$^{13}$C NMR of 2b

$^1$H NMR of 2c
$^{13}$C NMR of 2c

$^1$H NMR of 2d
$\text{C NMR of 2d}$

$\text{H NMR of 2e}$
$^{13}$C NMR of $2e$

$^1$H NMR of $2f$
$\text{C NMR of } 2f$

$\text{H NMR of } 2g$
$^{13}$C NMR of 2h

$^1$H NMR of 2i
$^{13}$C NMR of 2i

$^{19}$F NMR of 2i
$^1$H NMR of 2j

$^{13}$C NMR of 2j
$^1$H NMR of 2k

$^{13}$C NMR of 2k
$^1$H NMR of 2l

$^{13}$C NMR of 2l
$^1$H NMR of 2m

$^{13}$C NMR of 2m
$^{1}H$ NMR of 2n

$^{13}C$ NMR of 2n
$^{1}H$ NMR of 2o

$^{13}C$ NMR of 2o
$^1$H NMR of 2p

$^{13}$C NMR of 2p
$\text{H NMR of } 2q$

$\text{C NMR of } 2q$

$\text{H NMR of } 2q$

$\text{C NMR of } 2q$