SUPPORTING INFORMATION

Synthesis of 2-Imidazolines via Palladium-Catalyzed Cyclization Reaction of 2,3-Allenyl Amines and Aryl Iodides

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I. General Experimental Details

(1) Synthesis of substrates

Substrates were synthesized according to the literature methods with minor modifications.\(^1\)-\(^6\) A representative procedure (synthesis of \(N\)-(buta-2,3-dien-1-yl)-\(N\)\(^{\prime}\)-tosylbenzimidamide (1a)) is shown below.

\[
\text{TsNH}_2 + \text{DMAP (0.5 mol\%)} + \text{TEA (2.5 equiv)} + \text{EA/Tol, 55°C} 
\rightarrow \text{TsNH}_2 \text{Ph} 
\]

A round-bottom flask under \(N_2\) was filled with \(p\)-toluene sulfonamide (1 eq), ethyl acetate (2 mL/mmole), triethylamine (2.5 eq) and DMAP (0.5 mol %). A solution of acid chloride (1.1 eq) in toluene (0.8 mL/mmole) was added via a syringe over 15 minutes. The mixture was stirred for 1 hour at 55 °C under \(N_2\), cooled to room temperature and quenched with a solution of hydrochloric acid (0.5 M-3 mL/mmole). The resulting mixture was then extracted with EtOAc (3 times). The combined organic layers were dried on MgSO\(_4\), filtered and evaporated. The residue was purified by passing through a pad of silica gel eluting with DCM. This material was used without further purification.

(2) General procedure for the synthesis of products (3aa as example).

2,3-allenyl amine 1a (50 mg, 0.22 mmol) and iodobenzene 2a (38 mg, 0.26 mmol, 1.2...
equiv.) were added consecutively to a sealed tube charged with a mixture of potassium carbonate (64 mg, 0.66 mmol, 3.0 equiv.), [Pd(PPh$_3$)$_4$] (8.9 mg, 0.011 mmol, 5 mol%) in THF (3 mL) under an argon atmosphere. The resulting mixture was stirred at 85°C for 24 h and the completion of the reaction was monitored by TLC. After the reaction was finished, water (8 mL) was added and the solution was extracted with DCM. Then evaporation of the solvent, the crude product followed by purification on silica gel, the mixture was purified by silica gel column chromatography (PE/EA = 4:1) to afford the desired products 3aa.

\[
\begin{align*}
\text{(Ph)_N\text{Ts}} & \quad + \quad \text{PhI} \\
\text{1a} & \quad \text{[Pd(PPh}_3\text{)_4]} \ (5 \text{ mol%}) & \quad \text{K}_2\text{CO}_3 \ (3.0 \text{ equiv}) \quad \text{THF, 85°C, 24 h} & \quad \text{3aa}
\end{align*}
\]

II. Spectral Data of Products

2-phenyl-5-(1-phenylvinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3aa)
Yield: 65%, Light yellow solid, m.p. 80.2-81.3°C. $^1$H NMR (400 MHz, DMSO-$d_6$) $\delta$ (ppm) 7.82 – 7.26 (m, 13H), 5.59 (s, 2H), 5.43 (d, $J = 7.5$ Hz, 1H), 3.68 (dd, $J = 16.5, 9.4$ Hz, 1H), 3.46 (d, $J = 16.5$ Hz, 1H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-$d_6$) $\delta$ 158.72, 146.57, 145.31, 137.18, 135.20, 131.97, 131.57, 130.73, 130.55, 129.72, 129.26, 128.29, 127.63, 121.98, 113.72, 63.10, 60.76, 21.56. HRMS (ESI-Q-TOF, m/z) calcd for C$_{24}$H$_{22}$N$_2$O$_2$S [M+Na]$^+$: 425.1402, found [M+Na]$^+$: 425.1460.

5-(1-(4-methoxyphenyl)vinyl)-2-phenyl-1-tosyl-4,5-dihydro-1H-imidazole (3ab)
Yield: 73%, Light yellow solid, m.p. 155.3-156.1°C. $^1$H NMR (400 MHz, DMSO-$d_6$) $\delta$ 7.64 (d, $J = 7.4$ Hz, 2H), 7.55 (d, $J = 7.9$ Hz, 3H), 7.44 (m, 6H), 6.96 (d, $J = 8.5$ Hz, 2H), 5.46 (d, $J = 8.2$ Hz, 2H), 5.40 (d, $J = 8.0$ Hz, 1H), 3.78 (s, 3H), 3.67 (dd, $J = 16.3, 9.5$ Hz, 1H), 3.43 (dd, $J = 16.3, 2.2$ Hz, 1H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-$d_6$) $\delta$ 159.70, 158.78, 146.86, 145.27, 135.26, 131.56, 130.85, 130.57, 130.12, 129.72, 128.31, 128.22, 127.63, 114.50, 110.90, 63.21, 60.95, 55.64, 21.56. HRMS (ESI-Q-TOF, m/z) calcd for C$_{25}$H$_{24}$N$_2$O$_3$S [M+NA]$^+$: 455.1508, found [M+NA]$^+$: 455.1560.
5-(1-(2-methoxyphenyl)vinyl)-2-phenyl-1-tosyl-4,5-dihydro-1H-imidazole (3ac)

Yield: 70%. Light yellow solid, m.p. 154.9–155.6°C. 1H NMR (400 MHz, DMSO-d6) δ (ppm) 7.68 (d, J = 7.2 Hz, 2H), 7.58 – 7.41 (m, 7H), 7.33 (t, J = 7.4 Hz, 1H), 7.16 (d, J = 7.1 Hz, 1H), 7.06 – 6.92 (m, 2H), 5.55 (s, 1H), 5.43 – 5.34 (m, 1H), 5.18 (s, 1H), 3.81 (s, 3H), 3.51 – 3.44 (m, 1H), 3.30 – 3.20 (m, 1H), 2.41 (s, 3H). 13C NMR (100 MHz, DMSO-d6) δ (ppm) 156.68, 147.17, 145.25, 135.13, 131.52, 131.24, 131.05, 130.63, 129.64, 127.89, 127.48, 121.17, 114.53, 111.92, 63.13, 60.00, 55.99, 21.57. HRMS (ESI-Q-TOF, m/z) calcd for C25H24N2O3S [M+N]+: 455.1508, found [M+N]+: 455.1568.

2-phenyl-5-(1-(p-toly)vinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3ad)

Yield: 70%. Light yellow solid, m.p. 140.1–141.4°C. 1H NMR (400 MHz, DMSO-d6) δ (ppm) 7.64 (d, J = 6.9 Hz, 2H), 7.55 (d, J = 7.0 Hz, 3H), 7.51 – 7.30 (m, 7H), 7.21 (d, J = 7.0 Hz, 2H), 5.51 (d, J = 6.7 Hz, 2H), 5.41 (d, J = 7.7 Hz, 1H), 3.61 (dd, J = 17.6, 9.6 Hz, 1H), 3.42 (d, J = 15.6, 11.7 Hz, 1H), 2.41 (s, 3H), 2.32 (s, 3H). 13C NMR (100 MHz, DMSO-d6) δ (ppm) 158.76, 147.28, 145.27, 138.07, 135.25, 134.99, 131.57, 130.57, 129.70, 128.30, 127.62, 126.87, 111.82, 63.21, 60.89, 21.56, 21.17. HRMS (ESI-Q-TOF, m/z) calcd for C25H24N2O2S [M+N]+ : 439.1558, found [M+N]+: 439.1530.

2-phenyl-5-(1-(m-toly)vinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3ae)

Yield: 75%. Light yellow solid, m.p. 96.1–97.2°C. 1H NMR (400 MHz, DMSO-d6) δ (ppm) 7.64 (d, J = 7.2 Hz, 2H), 7.56 (d, J = 8.1 Hz, 3H), 7.44 (m, 4H), 7.28 (dd, J = 15.3, 7.56 Hz, 3H), 7.17 (d, J = 6.8 Hz, 1H), 5.52 (d, J = 5.3 Hz, 2H), 5.43 (d, J = 8.0 Hz, 1H), 3.69 (dd, J = 16.2, 9.5 Hz, 1H), 3.45 (dd, J = 16.2, 2.6 Hz, 1H), 2.41 (s, 3H), 2.33 (s, 3H). 13C NMR (100 MHz, DMSO-d6) δ (ppm) 158.72, 147.72, 145.27, 138.28, 137.97, 135.29, 131.55, 130.82, 130.56, 129.70, 129.32, 128.98, 128.29, 127.67, 127.63, 124.18, 112.68, 63.35, 60.88, 21.56, 21.17. HRMS (ESI-Q-TOF, m/z) calcd for C25H24N2O2S [M+N]+ : 439.1558, found [M+N]+: 439.1522.
2-phenyl-5-(1-(o-tolyl)vinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3af)
Yield: 68%. Light yellow solid, m.p.151.2-152.1°C. 1H NMR (400 MHz, DMSO-d6) δ (ppm) 7.60 (d, J = 7.2 Hz, 2H), 7.53 (dd, J = 15.9, 7.9 Hz, 3H), 7.43 (dd, J = 19.7, 7.8 Hz, 4H), 7.20 (m, 4H), 5.66 (s, 1H), 5.12 (d, J = 8.7 Hz, 1H), 5.08 (s, 1H), 3.60 (dd, J = 16.2, 2.0 Hz, 1H), 3.33 (m, 1H), 2.39 (s, 3H), 2.33 (s, 3H). 13C NMR (100 MHz, DMSO-d6) δ (ppm) 158.80, 147.89, 145.28, 138.76, 135.99, 135.16, 131.57, 130.84, 130.70, 130.63, 129.72, 129.43, 128.26, 128.19, 127.48, 126.06, 115.16, 64.66, 59.54, 21.54, 20.01. HRMS (ESI-Q-TOF, m/z) calcd for C25H24N2O2S [M+Na]+: 439.1558, found [M+Na]+: 439.1577.

5-(1-(4-fluorophenyl)vinyl)-2-phenyl-1-tosyl-4,5-dihydro-1H-imidazole (3ag)
Yield: 60%. Light yellow solid, m.p.117.2-118.3°C. 1H NMR (400 MHz, DMSO-d6) δ (ppm) 7.63 (d, J = 7.2 Hz, 2H), 7.56 (d, J = 7.8 Hz, 5H), 7.44 (m, 4H), 7.24 (t, J = 8.6 Hz, 2H), 5.54 (d, J = 5.9 Hz, 2H), 5.43 (d, J = 8.0 Hz, 1H), 3.69 (dd, J = 16.1, 9.5 Hz, 1H), 3.46 (m, 1H), 2.41 (s, 3H). 13C NMR (100 MHz, DMSO-d6) δ (ppm) 163.70, 161.26, 158.73, 146.60, 145.30, 135.23, 134.38, 131.57, 130.77, 130.56, 129.72, 129.28, 129.20, 128.29, 127.65, 116.02, 115.81, 113.07, 63.28, 60.78, 21.55. HRMS (ESI-Q-TOF, m/z) calcd for C24H21FN2O2S [M+Na]+: 443.1308, found [M+Na]+: 443.1336.

5-(1-(4-chlorophenyl)vinyl)-2-phenyl-1-tosyl-4,5-dihydro-1H-imidazole (3ah)
Yield: 63%. Light yellow solid, m.p.130.1-131.2°C. 1H NMR (400 MHz, DMSO-d6) δ (ppm) 7.63 (d, J = 7.3 Hz, 2H), 7.54 (t, J = 7.0 Hz, 5H), 7.44 (m, 6H), 5.59 (s, 2H), 5.44 (d, J = 9.5 Hz, 1H), 3.69 (dd, J = 16.2, 9.5 Hz, 1H), 3.46 (d, J = 16.2 Hz, 1H), 2.41 (s, 3H). 13C NMR (100 MHz, DMSO-d6) δ (ppm) 158.72, 146.49, 145.32, 136.78, 135.20, 133.35, 131.59, 130.73, 130.56, 129.73, 129.06, 128.97, 128.30, 127.65, 113.68, 63.12, 60.76, 21.56. HRMS (ESI-Q-TOF, m/z) calcd for C24H21ClN2O2S[M+Na]+:459.1012, found [M+Na]+: 459.1055.
5-(1-(3-bromo-4-chlorophenyl)vinyl)-2-phenyl-1-tosyl-4,5-dihydro-1H-imidazole (3ai)

Yield: 53%, Light yellow solid, m.p. 114.2-115.1 °C. $^1$H NMR (400 MHz, DMSO-d$_6$) δ 7.74 (dd, J = 6.9, 1.5 Hz, 1H), 7.56 (m, 6H), 7.43 (m, 5H), 5.61 (s, 2H), 5.48 (d, J = 9.5 Hz, 1H), 3.71 (dd, J = 16.3, 2.6 Hz, 1H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ 158.61, 145.70, 145.32, 135.27, 131.60, 130.67, 130.52, 129.71, 129.28, 128.29, 128.69, 117.58, 117.37, 114.68, 63.18, 60.60, 40.39, 40.19, 39.98, 39.77, 39.56, 39.35, 21.56. HRMS (ESI-Q-TOF, m/z) calcd for C$_{24}$H$_{20}$ClFN$_2$O$_2$S [M+N$^+$]: 477.0918, found [M+N$^+$]: 477.0946.

1-(4-(1-(2-phenyl-1-tosyl-4,5-dihydro-1H-imidazol-5-yl)vinyl)phenyl)ethan-1-one (3aj)

Yield: 61%, Light yellow solid, m.p. 157.1-158.3 °C. $^1$H NMR (400 MHz, DMSO-d$_6$) δ (ppm) 7.97 (d, J = 8.1 Hz, 2H), 7.65 (m, 4H), 7.56 (d, J = 8.0 Hz, 3H), 7.44 (dd, J = 21.1, 7.7 Hz, 4H), 5.71 (s, 1H), 5.67 (s, 1H), 5.50 (d, J = 7.1 Hz, 1H), 3.72 (dd, J = 16.3, 9.6 Hz, 1H), 3.46 (dd, J = 16.3, 2.3 Hz, 1H), 2.60 (s, 3H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ (ppm) 197.95, 158.75, 146.89, 154.35, 142.45, 136.73, 135.18, 130.71, 130.58, 129.74, 129.30, 129.28, 128.99, 128.32, 127.67, 127.37, 114.89, 63.07, 60.83, 27.26, 21.57. HRMS (ESI-Q-TOF, m/z) calcd for C$_{26}$H$_{24}$N$_2$O$_3$S [M+N$^+$]: 467.1508, found [M+N$^+$]: 467.1562.

2-phenyl-1-tosyl-5-(1-(4-(trifluoromethyl)phenyl)vinyl)-4,5-dihydro-1H-imidazole (3ak)

Yield: 46%, Light yellow solid, m.p. 110.5-111.3 °C. $^1$H NMR (400 MHz, DMSO-d$_6$) δ (ppm) 7.75 (q, J = 8.4 Hz, 4H), 7.58 (m, 6H), 7.44 (dd, J = 19.9, 7.8 Hz, 4H), 5.68 (d, J = 5.6 Hz, 2H), 5.48 (m, 1H), 3.71 (dd, J = 16.3, 9.5 Hz, 1H), 3.49 (dd, J = 16.3, 2.6 Hz, 1H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-d$_6$) δ 157.47, 145.51, 140.86, 137.03, 136.03, 134.88, 130.76, 130.33, 129.68, 129.48, 129.30, 128.86, 128.55, 127.69, 126.96, 125.15, 67.60, 60.31, 21.56. HRMS (ESI-Q-TOF, m/z) calcd for C$_{25}$H$_{23}$F$_3$N$_2$O$_3$S [M+N$^+$]: 493.1276, found [M+N$^+$]: 493.1210.
**2-phenyl-5-(1-(thiophen-2-yl)vinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3al)**

Yield: 78%, Light yellow solid, m.p.131.2-132.1°C. ¹H NMR (400 MHz, DMSO-d₆) δ (ppm) 7.67 – 7.60 (m, 2H), 7.58 – 7.49 (m, 4H), 7.48 – 7.37 (m, 4H), 7.28 – 7.23 (m, 1H), 7.10 (dd, J = 5.0, 3.7 Hz, 1H), 5.56 (s, 1H), 5.43 (s, 1H), 5.37 (dd, J = 9.6, 3.3 Hz, 1H), 3.89 (dd, J = 16.3, 9.7 Hz, 1H), 3.58 (dd, J = 16.3, 3.6 Hz, 1H), 2.41 (s, 3H).

**13C NMR (100 MHz, DMSO-d₆) δ (ppm) 149.29, 146.93, 146.51, 145.33, 143.97, 137.69, 135.38, 130.60, 129.14, 128.71, 127.66, 126.97, 116.96, 112.70, 112.23, 63.15, 60.48, 21.55.**


**2-(4-methoxyphenyl)-5-(1-phenylvinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3ba)**

Yield: 59%, Light yellow solid, m.p.59.2-60.5°C. ¹H NMR (400 MHz, DMSO-d₆) δ (ppm) 7.63 (d, J = 8.7 Hz, 2H), 7.56 (d, J = 8.2 Hz, 2H), 7.48 (d, J = 7.1 Hz, 2H), 7.39 (m, 5H), 7.01 (d, J = 8.7 Hz, 2H), 5.53 (d, J = 7.9 Hz, 2H), 5.41 (d, J = 8.1 Hz, 1H), 3.84 (s, 3H), 3.56 (dd, J = 16.0, 9.3 Hz, 1H), 3.41 (d, J = 2.4 Hz, 1H), 2.41 (s, 3H).

**13C NMR (100 MHz, DMSO-d₆) δ (ppm) 163.27, 160.79, 145.76, 145.03, 144.97, 138.97, 134.65, 134.55, 134.34, 134.30, 132.92, 132.88, 132.79, 131.59, 130.50, 130.37, 129.00, 128.63, 128.13, 127.67, 117.91, 116.84, 116.59, 115.27, 115.05, 72.99, 61.88, 51.90, 21.65, 21.62.**


**2-(4-bromophenyl)-5-(1-phenylvinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3ca)**

Yield: 71%, Light yellow solid, m.p.131.7-132.6°C. ¹H NMR (400 MHz, DMSO-d₆) δ (ppm) 7.59 (m, 7H), 7.44 (m, 6H), 5.59 (d, J = 3.1 Hz, 2H), 5.42 (d, J = 7.7 Hz, 1H), 3.68 (dd, J = 16.2, 9.5 Hz, 1H), 3.46 (dd, J = 16.2, 2.6 Hz, 1H), 2.41 (s, 3H). ¹³C NMR (100 MHz, DMSO-d₆) δ (ppm) 144.93, 144.85, 144.79, 143.47, 138.75, 134.19, 133.66, 130.52, 130.41, 128.96, 128.53, 128.22, 127.99, 127.90, 127.80, 127.08, 116.71, 73.56, 62.45, 52.59, 21.60, 21.58. HRMS (ESI-Q-TOF, m/z) calcd for C₂₅H₂₁BrN₂O₂S [M+Na]⁺: 503.0507, 505.0487 found [M+Na]⁺: 503.0545, 505.0495.
Yield: 68%, colorless oil. $^1$H NMR (400 MHz, DMSO-$d_6$) δ (ppm) 7.74 (dd, $J = 7.0, 1.6$ Hz, 1H), 7.55 (ddd, $J = 10.6, 9.7, 4.9$ Hz, 6H), 7.43 (m, 5H), 5.60 (s, 2H), 5.48 (d, $J = 8.1$ Hz, 1H), 3.71 (dd, $J = 16.3, 9.5$ Hz, 1H), 3.50 (dd, $J = 16.3, 2.6$ Hz, 1H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-$d_6$) δ (ppm) 158.61, 156.25, 145.70, 145.31, 135.91, 135.28, 131.58, 130.68, 130.52, 129.70, 129.28, 128.10, 128.03, 127.69, 120.33, 120.15, 117.57, 117.36, 114.67, 63.18, 60.60, 21.56. HRMS (ESI-Q-TOF, m/z) calcld for $C_{24}H_{20}ClFN_2O_2S$ [M+N$^+$]: 477.0918, found [M+N$^+$]: 477.0978.

Yield: 65%, Light yellow solid, m.p. 117.1-118.0°C. $^1$H NMR (400 MHz, DMSO-$d_6$) δ (ppm) 7.97 (d, $J = 8.3$ Hz, 2H), 7.65 (dd, $J = 13.7, 7.8$ Hz, 4H), 7.56 (d, $J = 8.1$ Hz, 3H), 7.44 (m, 4H), 5.54 (s, 2H), 5.49 (dd, $J = 9.6, 3.4$ Hz, 1H), 3.85 (dd, $J = 16.4, 9.6$ Hz, 1H), 3.57 (dd, $J = 16.4, 3.4$ Hz, 1H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, DMSO-$d_6$) δ (ppm) 157.49, 147.63, 145.58, 137.91, 135.07, 133.68, 131.61, 130.66, 129.79, 129.09, 128.70, 127.61, 127.47, 115.00, 67.26, 63.08, 52.69, 21.56. HRMS (ESI-Q-TOF, m/z) calcld for $C_{26}H_{24}N_2O_4S$ [M+N$^+$]: 483.1457, found [M+N$^+$]: 483.1413.
5-(1-phenylvinyl)-2-(thiophen-2-yl)-1-tosyl-4,5-dihydro-1H-imidazole (3ga)
Yield: 56%. Light yellow solid, m.p.105.8-106.6°C. ^1H NMR (400 MHz, DMSO-d_6) δ (ppm) 7.63 (m, 2H), 7.54 (m, 4H), 7.44 (m, 4H), 7.26 (dd, J = 3.6, 1.0 Hz, 1H), 7.10 (dd, J = 5.1, 3.7 Hz, 1H), 5.56 (s, 1H), 5.43 (s, 1H), 5.37 (dd, J = 9.7, 3.4 Hz, 1H), 3.89 (dd, J = 16.3, 9.7 Hz, 1H), 3.57 (dd, J = 16.3, 3.4 Hz, 1H), 2.41 (s, 3H).

13C NMR (100 MHz, DMSO-d_6) δ (ppm) 158.66, 145.36, 141.58, 140.90, 135.09, 131.57, 130.57, 129.74, 128.42, 128.30, 127.67, 126.65, 125.59, 111.11, 63.26, 61.33, 21.57. HRMS (ESI-Q-TOF, m/z) calcd for C_{22}H_{10}N_2O_2S_2 [M+N]^+: 431.0966, found [M+N]^+: 431.0910.

2-(napthalen-1-yl)-5-(1-phenylvinyl)-1-tosyl-4,5-dihydro-1H-imidazole (3ha)
Yield: 48%. Light yellow solid, m.p.159.3-160.2°C. ^1H NMR (400 MHz, DMSO-d_6) δ (ppm) 8.09 (d, J = 8.1 Hz, 1H), 7.97 (d, J = 7.9 Hz, 1H), 7.90 (d, J = 8.2 Hz, 1H), 7.59 (p, J = 6.7 Hz, 2H), 7.50 (t, J = 7.2 Hz, 6H), 7.44 - 7.35 (m, 5H), 5.88 (s, 1H), 5.25 (d, J = 14.1 Hz, 2H), 3.68 (dd, J = 16.3, 1.8 Hz, 1H ), 3.38 (d, J = 16.3 Hz, 1H), 2.37 (s, 3H). ^13C NMR (100 MHz, DMSO-d_6) δ (ppm) 158.69, 146.76, 145.34, 135.05, 133.73, 131.51, 130.78, 130.66, 129.68, 128.80, 128.60, 128.19, 127.45, 126.96, 126.53, 125.80, 125.67, 116.79, 65.24, 59.56, 21.54. HRMS (ESI-Q-TOF, m/z) calcd for C_{28}H_{24}N_2O_2S [M+N]^+: 475.1558, found [M+N]^+: 475.1510.
III. Copies of $^1$H NMR and $^{13}$C NMR Spectra

$^1$H NMR spectrum of compound 3aa (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3aa (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ab (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ab (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ac (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ac (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound $3\text{ad}$ (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound $3\text{ad}$ (100 MHz, DMSO-$d_6$)
$^{1}H$ NMR spectrum of compound 3ae (400 MHz, DMSO-$d_6$)

$^{13}C$ NMR spectrum of compound 3ae (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3af (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3af (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ag (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ag (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ah (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ah (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ai (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ai (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3aj (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3aj (100 MHz, DMSO-$d_6$)
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^{1}H\text{ NMR spectrum of compound 3ak (400 MHz, DMSO-}d_6)\
\]

\[
^{13}C\text{ NMR spectrum of compound 3ak (100 MHz, DMSO-}d_6)\
\]
${}^1$H NMR spectrum of compound 3al (400 MHz, DMSO-$d_6$)

${}^{13}$C NMR spectrum of compound 3al (100 MHz, DMSO-$d_6$)
$^{1}$H NMR spectrum of compound 3ba (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ba (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ea (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ea (100 MHz, DMSO-$d_6$)
$^{1}$H NMR spectrum of compound 3da (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3da (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ea (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ea (100 MHz, DMSO-$d_6$)
$^{1}H$ NMR spectrum of compound 3fa (400 MHz, DMSO-$d_6$)

$^{13}C$ NMR spectrum of compound 3fa (100 MHz, DMSO-$d_6$)
$^{1}$H NMR spectrum of compound 3ga (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ga (100 MHz, DMSO-$d_6$)
$^1$H NMR spectrum of compound 3ha (400 MHz, DMSO-$d_6$)

$^{13}$C NMR spectrum of compound 3ha (100 MHz, DMSO-$d_6$)
IV. Reference:


