Supporting Information

A fluorenyl activating group enables addition of simple Grignard reagents to C=N electrophiles

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Table of Contents

I. General information.................................................................page S2
II. General procedures for preparation of azine substrates.......................page S2
III. Characterization of azine substrates.................................................page S3
IV. General procedure for reactions of azine substrates with Grignard reagents...page S7
V. Characterization of addition products ................................................page S7
VI. Procedures for derivatization of addition products..............................page S12
VII. Copies of $^1$H and $^{13}$C NMR spectra........................................page S14
I. General information

All reactions were carried out under nitrogen gas atmosphere unless otherwise indicated. All commercial reagents and anhydrous solvents (Drisolv, MilliporeSigma) were used as received from vendors. 9-fluorenone hydrazone was purchased from 1-Click Chemistry. Preparative column chromatography was performed on a Teledyne Isco CombiFlash Rf utilizing RedSep Rf Gold silica gel columns. Reactions were monitored using a Shimadzu LCMS/UV system with LC-30AD solvent pump, 2020 MS, Sil-30AC autosampler, SPD-M30A UV detector, CTO-20A column oven, using a 2-98% acetonitrile/0.1% formic acid (or 0.001% ammonia) gradient over 2.5 minutes. Analytical thin-layer chromatography (TLC) was carried out using 0.25 mm commercial silica gel plates (Dynamic Absorbents F) and visualizing with UV light. Nuclear magnetic resonance (1H NMR) spectra were recorded with a Bruker BioSpin GmbG (400 MHz 1H, 125 MHz 13C). Chemical shifts are reported in delta (δ) units, parts per million (ppm) downfield from tetramethylsilane. Data reported as multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet).

II. General procedures for preparation of azine substrates

Method A (no acid catalyst): to a solution of 9-fluorenone hydrazone (1.0 equiv) in anhydrous toluene (0.25 M) was added the appropriate aldehyde or ketone (1.0 to 1.2 equiv). The mixture was heated at 70 ºC with stirring for 16 h. After this time, the reaction mixture was allowed to cool to room temperature. The mixture was then concentrated, and the crude material was purified by column chromatography.

Method B (acid catalyst, room temp): to a solution of 9-fluorenone hydrazone (1.0 equiv) in anhydrous toluene (0.25 M) was added the appropriate aldehyde or ketone (1.0 to 1.2 equiv), followed by catalytic p-toluenesulfonic acid monohydrate (0.025 equiv). The mixture was stirred at 23 ºC for 16 h. After this time, the reaction mixture was concentrated, and the crude material was purified by column chromatography.

Method C (acid catalyst, heat): to a solution of 9-fluorenone hydrazone (1.0 equiv) in anhydrous toluene (0.25 M) was added the appropriate aldehyde or ketone (1.2 to 10 equiv), followed by catalytic p-toluenesulfonic acid monohydrate (0.025 equiv). The mixture was stirred at 70 ºC for 16 h. After this time, the reaction mixture was concentrated, and the crude material was purified by column chromatography.
III. Characterization of azine substrates

\[ \text{1a: 1-(Diphenylmethylene)-2-(1,4-dioxaspiro[4.5]decan-8-ylidene)hydrazine} \]
Prepared according to general method A on a 10 mmol scale using 1.0 equiv of 1,4-cyclohexanedione monoethylene acetal. Isolated 2.6 g (78\%) as a yellow oil. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta 7.68 - 7.61 \text{ (m, 2H)}, 7.44 - 7.30 \text{ (m, 6H)}, 7.23 - 7.14 \text{ (m, 2H)}, 3.98 \text{ (s, 4H)}, 2.67 \text{ (t, J = 6.8 Hz, 2H)}, 2.42 \text{ (dd, J = 7.6, 5.8 Hz, 2H)}, 1.80 \text{ (t, J = 6.8 Hz, 4H)}. \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta 162.88, 159.68, 138.20, 135.27, 129.68, 129.12, 128.68, 128.49, 128.14, 127.91, 126.45, 108.07, 64.67, 64.50, 38.19, 34.52, 33.90, 33.61, 31.90, 25.46. \text{LRMS [M+H]}^+ \text{ for } C_{21}H_{23}N_2O_2^+ \text{ calc'd 335, found 335.}

\[ \text{1b: 1-(9H-Fluoren-9-ylidene)-2-(1,4-dioxaspiro[4.5]decan-8-ylidene)hydrazine} \]
Prepared according to general method A on a 12 mmol scale using 1.1 equiv of 1,4-cyclohexanedione monoethylene acetal. Isolated 3.8 g (93\%) as an orange solid. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta 8.13 \text{ (d, J = 7.6 Hz, 1H)}, 7.86 \text{ (d, J = 7.4 Hz, 1H)}, 7.61 \text{ (dd, J = 11.1, 7.5 Hz, 2H)}, 7.39 \text{ (tt, J = 7.5, 1.3 Hz, 2H)}, 7.34 -7.21 \text{ (m, 2H)}, 4.05 - 3.93 \text{ (m, 4H)}, 2.81 - 2.69 \text{ (m, 4H)}, 2.04 - 1.95 \text{ (m, 2H)}, 1.87 - 1.78 \text{ (m, 2H)}. \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta 164.25, 155.11, 142.27, 141.01, 136.86, 131.54, 131.06, 130.55, 129.43, 128.01, 127.99, 122.48, 119.96, 119.75, 108.00, 64.56, 34.70, 33.73, 32.15, 25.06. \text{LRMS [M+H]}^+ \text{ for } C_{21}H_{21}N_2O_2^+ \text{ calc'd 333, found 333.}

\[ \text{S1: 1-(9H-Fluoren-9-ylidene)-2-(propan-2-ylidene)hydrazine} \]
Prepared according to general method C on a 10.3 mmol scale using 10 equiv of acetone. Isolated 1.95 g (81%) as an orange oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.14 (dt, $J = 7.6$, 1.0 Hz, 1H), 7.87 (dt, $J = 7.5$, 1.0 Hz, 1H), 7.66 – 7.56 (m, 2H), 7.38 (tt, $J = 7.5$, 1.3 Hz, 2H), 7.37 – 7.21 (m, 2H), 2.23 (s, 3H), 2.01 (s, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 161.25, 154.45, 142.24, 140.99, 136.98, 131.62, 130.47, 129.36, 127.99, 127.97, 122.43, 119.92, 119.73, 25.13, 18.55. LRMS $[M+H]^+$ for C$_{16}$H$_{13}$N$_2^+$ calc’d 235, found 235.

S2: 1-Cyclohexylidene-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to general method A on a 10.3 mmol scale using 1.1 equiv of cyclohexanone. Isolated 2.4 g (85%) as an orange oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.16 (d, $J = 7.6$ Hz, 1H), 7.86 (d, $J = 7.4$ Hz, 1H), 7.62 (dd, $J = 11.8$, 7.5 Hz, 2H), 7.43 – 7.34 (m, 2H), 7.34 – 7.21 (m, 2H), 2.60 – 2.51 (m, 4H), 1.91 – 1.80 (m, 2H), 1.71 – 1.61 (m, 4H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 166.33, 154.73, 142.23, 140.94, 136.98, 131.61, 130.88, 130.38, 129.44, 127.97, 127.92, 122.41, 119.90, 119.70, 35.55, 28.74, 27.46, 26.44, 25.84. LRMS $[M+H]^+$ for C$_{19}$H$_{19}$N$_2^+$ calc’d 275, found 275.

S3: 1-Cyclopentylidene-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to general method C on a 5.2 mmol scale using 2 equiv of cyclopentanone. Isolated 0.97 g (71%) as an orange oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.19 (d, $J = 7.7$ Hz, 1H), 7.86 (d, $J = 7.5$ Hz, 1H), 7.62 (dd, $J = 11.5$, 7.5 Hz, 2H), 7.39 (tt, $J = 7.7$, 1.8 Hz, 2H), 7.34 – 7.21 (m, 2H), 2.66 (t, $J = 7.0$ Hz, 2H), 2.46 (t, $J = 6.8$ Hz, 2H), 1.92 – 1.76 (m, 4H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 174.13, 154.50, 142.18, 141.00, 137.01, 131.58, 130.96, 130.45, 129.40, 127.97, 127.97, 122.44, 119.90, 119.71, 33.43, 29.56, 24.84, 24.78. LRMS $[M+H]^+$ for C$_{18}$H$_{17}$N$_2^+$ calc’d 261, found 261.
**S4**: 1-(9H-Fluoren-9-ylidene)-2-(1-methoxypropan-2-ylidene)hydrazine
Prepared according to general method A on a 5.2 mmol scale using 2 equiv of
cyclopentanone. Isolated 0.87 g (64%) as an orange oil. NMR shows a 3:1 mixture of E/Z
isomers. Chemical shifts are reported for the major isomer because most resonances of
the minor isomer were not well resolved. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.08 (dt, \(J = 7.5, 0.9\) Hz, 1H), 7.87 (dt, \(J = 7.5, 1.0\) Hz, 1H), 7.66 – 7.57 (m, 2H), 7.40 (tt, \(J = 7.3, 1.3\) Hz, 2H), 7.34 – 7.21 (m, 2H), 4.26 (s, 2H), 3.48 (s, 3H), 2.03 (s, 3H). \(^13\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 160.86, 142.34, 141.03, 136.73, 131.56, 131.18, 130.68, 129.38, 128.07, 128.03, 122.58, 119.99, 119.77, 75.88, 58.75, 14.67. LRMS [M+H]\(^+\) for C\(_{17}\)H\(_{17}\)N\(_2\)O\(^+\) calc’d 265, found 265.

![Structure](image)

**S5**: 4-((9H-Fluoren-9-ylidene)hydrazono)-1-benzylpiperidine
Prepared according to general method C on a 13 mmol scale using 1.2 equiv of 1-
benzylpiperidin-4-one. Isolated 3.8 g (81%) as an orange oil. \(^1\)H NMR (400 MHz,
CDCl\(_3\)) \(\delta\) 8.16 (dd, \(J = 7.6, 0.8\) Hz, 1H), 7.84 (d, \(J = 7.4\) Hz, 1H), 7.61 (dd, \(J = 12.2, 7.5\) Hz, 2H), 7.43 – 7.21 (m, 9H), 3.57 (s, 2H), 2.77 – 2.66 (m, 6H), 2.62 – 2.49 (m, 2H). \(^13\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 164.05, 155.34, 142.30, 141.03, 138.35, 136.90, 131.56, 131.05, 130.55, 129.58, 129.03, 128.33, 128.02, 127.98, 127.19, 122.49, 119.94, 119.75, 62.52, 53.72, 52.86, 34.81, 28.50. LRMS [M+H]\(^+\) for C\(_{25}\)H\(_{24}\)N\(_3\)\(^+\) calc’d 366, found 366.

![Structure](image)

**S6**: 2-(1-((9H-Fluoren-9-ylidene)hydrazono)ethyl)pyrimidine
Prepared according to general method B on a 5.16 mmol scale using 1.0 equiv of 2-
acetylpyrimidine. Isolated 1.0 g (65%) as an orange solid. \(^1\)H NMR (400 MHz, CDCl\(_3\))
\(\delta\) 8.93 (d, \(J = 4.8\) Hz, 2H), 8.10 – 8.04 (m, 1H), 7.95 (dt, \(J = 7.5, 1.0\) Hz, 1H), 7.66 –
7.59 (m, 2H), 7.47 – 7.30 (m, 4H), 7.20 (td, \(J = 7.6, 1.1\) Hz, 1H), 2.49 (s, 3H). \(^13\)C NMR
(101 MHz, CDCl\(_3\)) \(\delta\) 162.83, 157.40, 156.04, 152.63, 142.24, 141.12, 136.45, 131.47,
131.17, 130.76, 129.64, 128.21, 128.09, 122.84, 120.65, 119.98, 119.83, 14.81. LRMS
[M+H]\(^+\) for C\(_{19}\)H\(_{15}\)N\(_4\)\(^+\) calc’d 299, found 299.
S7: 1-Benzylidene-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to general method A on a 10.3 mmol scale using 1.2 equiv of benzaldehyde. Isolated 2.6 g (89%) as an orange oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.57 (s, 1H), 8.46 (d, J = 7.6 Hz, 1H), 7.98 – 7.88 (m, 3H), 7.62 (t, J = 8.1 Hz, 2H), 7.51 (dd, J = 4.9, 1.9 Hz, 3H), 7.47 – 7.39 (m, 2H), 7.34 – 7.27 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 162.05, 160.35, 159.49, 142.47, 141.60, 136.86, 134.44, 131.70, 131.43, 131.27, 131.13, 130.68, 128.95, 128.72, 128.18, 128.11, 122.90, 119.91, 119.84. LRMS [M+H]$^+$ for C$_{20}$H$_{15}$N$_2$ $^+$ calc'd 283, found 283.

S8: (R)-1-(3,7-Dimethylct-6-en-1-ylidene)-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to general method B on a 5.15 mmol scale using 1.2 equiv of (R)-citronellal. Isolated 1.23 g (72%) as an orange oil. NMR shows a 5:1 mixture of E/Z isomers. Chemical shifts are reported for the major isomer because most resonances of the minor isomer were not well resolved. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.41 (d, J = 7.5 Hz, 1H), 7.94 (t, J = 5.9 Hz, 1H), 7.89 – 7.82 (m, 1H), 7.67 – 7.55 (m, 2H), 7.44 – 7.35 (m, 2H), 7.35 – 7.19 (m, 2H), 5.16 – 5.07 (m, 1H), 2.57 (d, J = 14.5, 5.7 Hz, 1H), 2.47 – 2.32 (m, 1H), 2.17 – 1.88 (m, 3H), 1.69 (s, 3H), 1.62 (s, 3H), 1.56 – 1.44 (m, 1H), 1.41 – 1.28 (m, 1H), 1.05 (d, J = 6.6 Hz, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 163.33, 155.74, 142.36, 141.58, 136.89, 136.67, 131.68, 131.31, 130.99, 130.56, 128.07, 128.05, 124.38, 122.70, 119.81, 119.77, 40.38, 37.01, 31.03, 25.74, 25.55, 19.90, 17.72. LRMS [M+H]$^+$ for C$_{23}$H$_{27}$N$_2$ $^+$ calc'd 331, found 331.

S9: 1-(2,2-Dimethylpropylidene)-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to general method B on a 7.7 mmol scale using 1.25 equiv of 2,2,2-trimethylacetaldehyde. Isolated 1.67 g (82%) as an orange oil. $^1$H NMR (400 MHz,
CDCl$_3$ $\delta$ 8.45 (d, J = 7.6 Hz, 1H), 7.88 − 7.82 (m, 2H), 7.60 (dd, J = 10.9, 7.5 Hz, 2H), 7.45 − 7.36 (m, 2H), 7.33 − 7.23 (m, 2H), 1.29 (s, 9H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 170.76, 159.96, 142.39, 141.53, 136.87, 131.71, 131.31, 130.97, 130.46, 128.06, 128.06, 122.66, 119.83, 119.75, 35.61, 27.32. LRMS [M+H]$^+$ for C$_{18}$H$_{19}$N$_2$ calc’d 263, found 263.

IV. General procedure for reactions of azine substrates with Grignard reagents

To a solution of azine substrate in anhydrous THF (~0.2 M) cooled to 0 °C was added slowly a solution of Grignard reagent (1 to 5 equiv). After addition, the reaction mixture was allowed to warm to room temperature and stir for 16 h. After this time, the reaction was quenched with 5% aqueous citric acid, and the mixture was extracted with isopropyl acetate (3x). The combined organics were washed with water and brine, dried over sodium sulfate, and concentrated. The resulting crude material was purified by column chromatography. NOTE: the azine substrates were generally found to be hygroscopic. Therefore, best yields were obtained when the azines were dried overnight in a vacuum desiccator over anhydrous calcium sulfate prior to use.

IV. Characterization of addition products

2a: 1-(Diphenylmethene)−2-(8-ethyl-1,4-dioxaspiro[4.5]decan-8-yl) hydrazine
Prepared according to the general procedure from 1a (220 mg, 0.66 mmol) using ethylmagnesium bromide (3M solution in ethyl ether, 5 equiv). Isolated 67 mg (28%) as a pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.55 − 7.38 (m, 5H), 7.30 − 7.16 (m, 5H), 5.14 (s, 1H), 3.93 (s, 4H), 1.92 − 1.81 (m, 2H), 1.79 − 1.67 (m, 2H), 1.63 − 1.48 (m, 6H), 0.71 (t, J = 7.5 Hz, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 142.59, 139.36, 133.88, 129.36, 129.18, 128.57, 128.00, 127.06, 125.88, 109.22, 64.21, 64.18, 56.49, 32.60, 31.60, 30.47, 7.42. LRMS [M+H]$^+$ for C$_{23}$H$_{29}$N$_2$O$_2$ calc’d 365, found 365.
2b: 1-(8-Ethyl-1,4-dioxaspiro[4.5]decan-8-yl)-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to the general procedure from 1b (3.8 g, 11 mmol) using ethylmagnesium bromide (3 M solution in ethyl ether, 5 equiv). Isolated 2.4 g (58%) as an orange solid. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.83 – 7.73 (m, 3H), 7.71 – 7.62 (m, 1H), 7.40 (td, J = 7.5, 1.1 Hz, 1H), 7.34 (td, J = 7.5, 1.3 Hz, 1H), 7.33 – 7.23 (m, 2H), 6.68 (s, 1H), 3.96 (s, 3H), 2.16 – 2.06 (m, 2H), 1.96 – 1.85 (m, 2H), 1.82 – 1.72 (m, 3H), 1.72 – 1.62 (m, 4H), 0.84 (t, J = 7.5 Hz, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 140.63, 138.76, 138.47, 137.30, 130.35, 128.47, 127.46, 127.37, 127.10, 123.87, 120.48, 120.25, 119.35, 108.96, 64.28, 64.28, 57.78, 32.77, 31.55, 30.61, 7.55. LRMS [M+H]$^+$ for C$_{23}$H$_{27}$N$_2$O$_2$ $^+$ calc’d 363, found 363.

3: 1-(9H-Fluoren-9-ylidene)-2-(2-methyl-1-(p-tolyl)propan-2-yl)hydrazine
Prepared according to the general procedure from S1 (1.7 g, 7.3 mmol) using 4-methylbenzylmagnesium chloride (0.5 M solution in THF, 3 equiv). Isolated 1.24 g (50%) as an orange oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.91 – 7.82 (m, 1H), 7.77 (dd, J = 7.5, 1.0 Hz, 1H), 7.71 – 7.62 (m, 1H), 7.55 (d, J = 7.6 Hz, 1H), 7.41 – 7.16 (m, 4H), 7.00 (s, 4H), 6.57 (s, 1H), 2.94 (s, 2H), 2.27 (s, 3H), 1.38 (s, 6H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 140.80, 139.70, 138.55, 137.66, 135.85, 134.68, 130.47, 130.42, 128.99, 128.61, 127.58, 127.40, 127.31, 124.45, 120.46, 120.37, 119.42, 57.62, 47.02, 26.72, 21.06. LRMS [M+H]$^+$ for C$_{24}$H$_{25}$N$_2$ $^+$ calc’d 341, found 341.

4: 1-(9H-Fluoren-9-ylidene)-2-(1-(3-methoxyphenyl)cyclohexyl)hydrazine
Prepared according to the general procedure from S2 (400 mg, 1.46 mmol) using 3-methoxyphenylmagnesium bromide (1.0 M solution in THF, 3 equiv). Isolated 380 mg (68%) as an orange solid. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.82 – 7.76 (m, 1H), 7.80 – 7.69 (m, 2H), 7.69 – 7.60 (m, 1H), 7.44 – 7.26 (m, 2H), 7.30 – 7.17 (m, 3H), 7.12 – 7.04 (m, 2H), 7.00 (s, 1H), 6.74 (ddd, \(J = 8.2, 2.4, 1.1\) Hz, 1H), 3.73 (s, 3H), 2.38 (dt, \(J = 13.4, 4.6\) Hz, 2H), 2.07 (ddd, \(J = 14.0, 10.7, 3.7\) Hz, 2H), 1.84 – 1.60 (m, 5H), 1.50 – 1.36 (m, 1H).

\(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 159.60, 149.52, 140.73, 138.75, 138.53, 137.32, 130.46, 129.25, 128.53, 127.49, 127.39, 127.15, 124.01, 120.50, 120.44, 119.34, 118.42, 112.60, 111.47, 61.85, 55.17, 35.85, 25.72, 22.40. LRMS [M+H]\(^+\) for C\(_{26}\)H\(_{27}\)N\(_2\)O\(^+\) calc’d 383, found 383.

5: 1-(1-Benzylcyclopentyl)-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to the general procedure from S3 (102 mg, 0.39 mmol) using benzylmagnesium chloride (2.0 M solution in THF, 3 equiv). Isolated 114 mg (83%) as an orange oil. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.92 – 7.83 (m, 1H), 7.79 (d, \(J = 7.5\) Hz, 1H), 7.74 – 7.65 (m, 1H), 7.47 (d, \(J = 7.7\) Hz, 1H), 7.40 – 7.35 (m, 1H), 7.35 – 7.16 (m, 3H), 7.16 – 7.11 (m, 3H), 7.11 – 7.05 (m, 2H), 6.62 (s, 1H), 3.06 (s, 2H), 2.10 – 1.97 (m, 3H), 1.91 – 1.71 (m, 5H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 140.65, 139.48, 138.52, 138.42, 137.51, 130.44, 128.48, 128.33, 128.16, 127.52, 127.26, 126.17, 124.15, 120.37, 120.30, 119.36, 69.78, 45.52, 36.71, 23.84. LRMS [M+H]\(^+\) for C\(_{25}\)H\(_{25}\)N\(_2\) calc’d 353, found 353.

6: 1-(2-Cyclopropyl-1-methoxypropan-2-yl)-2-(9H-fluoren-9-ylidene)hydrazine
Prepared according to the general procedure from S4 (100 mg, 0.38 mmol) using cyclopropylmagnesium bromide (0.5 M solution in THF, 5 equiv). Isolated 95 mg (82%) as an orange oil. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.84 – 7.73 (m, 3H), 7.70 – 7.61 (m, 1H), 7.44 – 7.29 (m, 2H), 7.33 – 7.22 (m, 2H), 7.01 (s, 1H), 3.59 (d, \(J = 9.2\) Hz, 1H), 3.53 (d, \(J = 9.1\) Hz, 1H), 3.38 (s, 3H), 1.30 – 1.19 (m, 1H), 1.18 (s, 3H), 0.63 – 0.51 (m, 1H), 0.55 – 0.39 (m, 3H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 140.09, 139.24, 137.90, 137.00, 134.08, 129.79, 127.96, 126.85, 126.81, 126.66, 123.79, 119.72, 118.74, 78.35, 58.97, 58.64, 18.20, 16.92. LRMS [M+H]\(^+\) for C\(_{20}\)H\(_{23}\)N\(_2\)O\(^+\) calc’d 307, found 307.
7: 4-((2-(9H-Fluoren-9-ylidene)hydrazinyl)-1-benzyl-4-ethylpiperidinyl)-1-benzyl-4-ethylpiperidine
Prepared according to the general procedure from S5 (3.4 g, 9.3 mmol) using ethylmagnesium bromide (3 M solution in ethyl ether, 5 equiv). Isolated 2.6 g (71%) as an orange oil. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta \) 7.84 – 7.73 (m, 3H), 7.71 – 7.64 (m, 1H), 7.45 – 7.34 (m, 2H), 7.34 – 7.19 (m, 7H), 6.71 (s, 1H), 3.51 (s, 2H), 2.68 (dt, J = 11.9, 4.0 Hz, 2H), 2.41 (td, J = 11.4, 2.8 Hz, 2H), 2.05 (dt, J = 13.8, 2.8 Hz, 2H), 1.88 – 1.67 (m, 4H), 0.84 (t, J = 7.4 Hz, 3H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta \) 140.65, 138.61, 138.57, 138.46, 137.23, 130.36, 129.22, 128.41, 128.20, 127.49, 127.37, 127.08, 126.97, 123.82, 120.49, 120.22, 119.35, 63.39, 56.90, 49.62, 34.00, 32.96, 7.16. LRMS [M+H]\(^+\) for C\(_{27}\)H\(_{30}\)N\(_3\)\(^+\) calc’d 396, found 396.

8: 2-((1-(2-(9H-Fluoren-9-ylidene)hydrazinyl)-1-cyclopentylyethyl)pyrimidinyl)-1-cyclopentylyethyl)pyrimidine
Prepared according to the general procedure from S6 (100 mg, 0.34 mmol) using cyclopentylmagnesium bromide (2 M solution in ethyl ether, 1 equiv). Isolated 50 mg (41%) as an orange oil. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta \) 8.75 (d, J = 4.8 Hz, 2H), 8.74 (s, 1H), 8.15 – 8.06 (m, 1H), 7.86 – 7.73 (m, 2H), 7.72 – 7.62 (m, 1H), 7.47 – 7.35 (m, 2H), 7.32 – 7.23 (m, 2H), 7.16 (t, J = 4.9 Hz, 1H), 2.69 (p, J = 8.6 Hz, 1H), 2.00 (s, 3H), 1.72 – 1.56 (m, 2H), 1.55 – 1.36 (m, 6H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta \) 172.60, 156.46, 140.44, 138.93, 138.75, 137.32, 130.41, 128.18, 127.50, 127.36, 126.88, 124.18, 120.25, 120.23, 119.29, 118.85, 66.08, 50.98, 27.38, 26.82, 25.58, 25.32, 22.39. LRMS [M+H]\(^+\) for C\(_{24}\)H\(_{25}\)N\(_4\)\(^+\) calc’d 369, found 369.
9: 1-(9H-Fluoren-9-ylidene)-2-(phenyl(σ-tolyl)methyl)hydrazine
Prepared according to the general procedure from S7 (100 mg, 0.35 mmol) using \( \sigma \)-tolylmagnesium bromide (1 M solution in THF, 3 equiv). Isolated 66 mg (41%) as an orange solid. \(^1H\) NMR (400 MHz, \( C_6D_6 \)) \( \delta \) 7.89 – 7.82 (m, 1H), 7.62 (d, \( J = 7.6 \) Hz, 1H), 7.44 – 7.33 (m, 4H), 7.26 (d, \( J = 7.9 \) Hz, 2H), 7.14 – 6.88 (m, 9H), 6.84 (t, \( J = 7.5 \) Hz, 1H), 5.88 (d, \( J = 3.9 \) Hz, 1H), 2.02 (s, 3H). \(^13C\) NMR (101 MHz, \( C_6D_6 \)) \( \delta \) 142.69, 142.03, 141.29, 139.52, 138.33, 138.07, 136.82, 130.61, 129.33, 129.03, 128.88, 128.55, 128.31, 127.92, 127.81, 127.77, 127.68, 127.44, 127.33, 127.23, 124.82, 121.13, 120.33, 119.35, 68.88, 20.67. LRMS [M+H]\(^+\) for \( C_{27}H_{23}N_2 \) cale’d 375, found 375.

10: 1-(9H-Fluoren-9-ylidene)-2-((5R)-2,5,9-trimethyldeca-1,8-dien-3-yl)hydrazine
Prepared according to the general procedure from S8 (100 mg, 0.30 mmol) using isopropenylmagnesium bromide (1 M solution in 2-methyltetrahydrofuran, 3 equiv). Isolated 93 mg (83%) as a yellow oil. NMR indicates a ~1:1 dr. Resonances for both diastereomers are reported together because they could not be clearly assigned to one isomer. \(^1H\) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.78 (tt, \( J = 7.9, 2.5 \) Hz, 3H), 7.70 – 7.62 (m, 1H), 7.41 (td, \( J = 7.5, 1.1 \) Hz, 1H), 7.37 – 7.22 (m, 4H), 6.68 (s, 1H), 5.15 – 5.07 (m, 1H), 5.04 – 4.88 (m, 2H), 4.20 – 4.10 (m, 1H), 2.10 – 1.82 (m, 3H), 1.80 – 1.76 (m, 3H), 1.68 – 1.64 (m, 3H), 1.60 (s, 3H), 1.58 – 1.40 (m, 3H), 1.00 (t, \( J = 6.8 \) Hz, 3H). \(^13C\) NMR (101 MHz, CDCl\(_3\)) \( \delta \) 146.72, 145.79, 140.81, 140.77, 139.61, 139.39, 138.30, 138.27, 137.49, 137.43, 134.70, 131.33, 130.41, 129.16, 129.10, 128.71, 128.66, 127.58, 127.37, 127.32, 126.87, 126.74, 124.74, 124.35, 124.19, 124.10, 120.47, 120.32, 119.90, 119.34, 113.03, 112.14, 64.91, 64.48, 39.96, 39.52, 37.36, 37.25, 29.52, 29.35, 25.69, 25.46, 25.41, 19.89, 19.85, 18.87, 18.30, 17.70. LRMS [M+H]\(^+\) for \( C_{26}H_{33}N_2^+ \) cale’d 373, found 373.
11: 1-(9\(H\)-Fluoren-9-ylidene)-2-(1-mesityl-2,2-dimethylpropyl)hydrazine
Prepared according to the general procedure from S9 (100 mg, 0.38 mmol) using 2,4,6-trimethylphenylmagnesium bromide (1 M solution in THF, 5 equiv). Isolated 114 mg (78\%) as a yellow oil. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.86 – 7.76 (m, 2H), 7.73 – 7.59 (m, 2H), 7.43 – 7.31 (m, 3H), 7.29 – 7.18 (m, 2H), 6.91 – 6.85 (m, 1H), 6.81 – 6.76 (m, 1H), 5.18 (d, J = 6.1 Hz, 1H), 2.53 (s, 3H), 2.51 (s, 3H), 2.23 (s, 3H), 1.15 (s, 9H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 140.63, 138.37, 138.29, 137.96, 137.12, 135.79, 135.51, 134.76, 131.42, 130.37, 129.58, 128.39, 127.41, 127.37, 127.02, 123.42, 120.51, 120.42, 119.25, 70.93, 37.60, 28.88, 23.24, 22.85, 20.62. LRMS [M+H]\(^+\) for C\(_{27}\)H\(_{31}\)N\(_2\)\(^+\) calc’d 383, found 383.

VI. Procedures for derivatization of addition products

12: 1-(2-Methyl-1-(\(p\)-tolyl)propan-2-yl)-3-phenyl-1\(H\)-pyrazol-5-ol
To a solution of compound 3 (100 mg, 0.29 mmol) in pyridine (2 mL) was added hydroxylamine hydrochloride (61 mg, 0.88 mmol, 3 equiv). The resulting mixture was heated to 65 \(^\circ\)C with stirring for 16 h. After this time, ethyl benzoylacetate (0.25 mL, 1.47 mmol, 5 equiv) was added, and heating was continued at 70 \(^\circ\)C for 4 hours. The crude reaction mixture was filtered and directly purified by reverse phase HPLC (Gemini-NX C18, 50 x 30 mm column; solvent A: 0.1% formic acid in water; solvent B: acetonitrile; gradient of 40-80% B) to afford 36 mg (40\%) of product 12 as a white solid. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.65 – 7.55 (m, 2H), 7.45 – 7.35 (m, 3H), 7.03 (s, 4H), 3.59 (s, 2H), 3.15 (s, 2H), 2.28 (s, 3H), 1.58 (s, 6H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 172.39, 152.12, 135.85, 134.53, 131.62, 130.30, 129.85, 128.73, 128.68, 125.52, 61.31, 45.09, 40.02, 26.42, 21.01. LRMS [M+H]\(^+\) for C\(_{20}\)H\(_{23}\)N\(_2\)O\(^-\) calc’d 307, found 307.
**13: tert-Butyl 2-(8-ethyl-1,4-dioxaspiro[4.5]decan-8-yl)hydrazine-1-carboxylate**

To a solution of compound 2b (100 mg, 0.28 mmol) in pyridine (2 mL) was added hydroxylamine hydrochloride (58 mg, 0.83 mmol, 3 equiv). The resulting mixture was heated to 65 °C with stirring for 16 h. After cooling the mixture to room temperature, di-tert-butyl dicarbonate (261 mg, 1.16 mmol, 4.2 equiv) was added. The resulting mixture was stirred at room temperature for 3 h. The crude reaction mixture was filtered and directly purified by reverse phase HPLC (Gemini-NX C18, 50 x 30 mm column; solvent A: 0.1% formic acid in water; solvent B: acetonitrile; gradient of 5-85% B) to afford 50 mg (60%) of product 13 as a pale yellow oil. NMR showed a mixture of Boc rotamers. 

$^1$H NMR (400 MHz, CDCl$_3$) δ 5.64 (s, 1H), 3.98 – 3.87 (m, 4H), 1.92 – 1.80 (m, 2H), 1.58 – 1.49 (m, 5H), 1.45 (s, 9H), 1.53 – 1.37 (m, 4H), 0.87 (t, J = 7.5 Hz, 3H). 

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 157.06, 108.92, 64.20, 64.17, 56.94, 36.98, 32.50, 30.47, 30.29, 28.34, 28.31, 7.66, 7.55. LRMS [M+H]$^+$ for C$_{15}$H$_{29}$N$_2$O$_4$+ calc’d 301, found 301.

**14: 2-Methyl-1-(p-tolyl)propan-2-amine**

To a solution of compound 3 (540 mg, 1.59 mmol) in THF (4 mL) and ethanol (4 mL) was added 10% palladium on carbon (338 mg, 0.32 mmol, 0.2 equiv). The reaction vessel was fitted with a balloon of hydrogen gas and stirred at room temperature for 24 h. After this time, the reaction mixture was filtered through Celite. It was possible at this point to isolate the product amine free base by distillation, however a yield is not reported for this method due to the volatility of the product as a free base. Instead, the filtrate was treated with 1M hydrogen chloride in ethyl ether (8 mL, 5 equiv). The resulting mixture was concentrated, then the crude material was purified by reverse phase HPLC (Gemini-NX C18, 50 x 30 mm column; solvent A: 0.05% trifluoroacetic acid in water; solvent B: acetonitrile; gradient of 5-50% B) to afford 272 mg (62%) of product 14 trifluoroacetate salt as a colorless oil. NMR for the TFA salt: $^1$H NMR (400 MHz, CD$_3$OD) δ 7.17 (d, J = 7.9 Hz, 2H), 7.12 (d, J = 8.0 Hz, 2H), 2.87 (s, 2H), 2.32 (s, 3H), 1.31 (s, 6H). $^{13}$C NMR (101 MHz, CD$_3$OD) δ 136.96, 131.53, 130.13, 128.91, 54.14, 45.11, 24.15, 19.70. NMR for the free base: $^1$H NMR (400 MHz, CDCl$_3$) δ 7.11 (d, J = 8.0 Hz, 2H), 7.07 (d, J = 8.1 Hz, 2H), 2.62 (s, 2H), 2.33 (s, 3H), 1.11 (s, 6H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 135.74, 135.38, 130.35, 128.70, 50.73, 50.01, 30.35, 21.02. LRMS [M+H]$^+$ for C$_{11}$H$_{18}$N$^+$ calc’d 164, found 164.
VII. Copies of $^1$H and $^{13}$C NMR spectra

NMR spectra of 1a:

$^1$H NMR (400 MHz, Chloroform-d): δ 7.68 – 7.64 (m, 2H), 7.53 – 7.44 (m, 4H), 7.33 – 7.14 (m, 2H), 3.48 (t, 4H, J = 6.5 Hz, 2H), 2.42 (s, 6H, J = 6.5 Hz, 2H), 1.80 (s, J = 6.5 Hz, 4H).

$^{13}$C NMR (100 MHz, CDCl$_3$): δ 162.88, 159.66, 138.26, 135.27, 129.68, 129.12, 128.82, 128.68, 128.49, 128.14, 127.51, 126.41, 108.67, 84.87, 64.79, 39.39, 34.52, 33.46, 31.96, 25.46.
NMR spectra of 1b:

$^1$H NMR (400 MHz, Chloroform-$d$): 8.13 (d, $J = 7.5$ Hz, 1H), 7.86 (d, $J = 7.4$ Hz, 1H), 7.44 (d, $J = 11.1$ Hz, 2H), 7.39 (d, $J = 7.5$ Hz, 2H), 7.23 (t, 2H), 4.05 - 3.95 (m, 4H), 2.91 - 2.69 (m, 4H), 2.85 - 1.95 (m, 2H), 1.87 - 1.81 (m, 2H).

$^{13}$C NMR (100 MHz, CDCl$_3$): 164.25, 155.11, 142.72, 141.05, 136.86, 131.54, 131.06, 130.55, 129.03, 126.01, 127.98, 122.46, 119.96, 119.75, 118.08, 64.36, 34.70, 33.73, 32.35, 25.06.
NMR spectra of S1:
NMR spectra of S2:
NMR spectra of S3:
NMR spectra of S4:
NMR spectra of S5:

**1H NMR (400 MHz, Chloroform-d) δ 8.16 (dd, J = 7.6, 6.8 Hz, 1H), 7.84 (dd, J = 7.4 Hz, 1H), 7.61 (dd, J = 12.2, 7.5 Hz, 2H), 7.40 – 7.21 (m, 9H), 3.77 (m, 2H), 2.77 – 2.66 (m, 2H), 2.52 – 2.40 (m, 2H).**

**13C NMR (100 MHz, CDCl3) δ 144.05, 155.34, 142.30, 141.03, 138.35, 136.98, 131.57, 131.06, 130.55, 129.58, 129.05, 128.23, 128.02, 127.98, 127.19, 122.48, 119.94, 119.75, 62.52, 53.72, 52.86, 34.81, 28.59.**
NMR spectra of S6:

$^1$H NMR (400 MHz, Chloroform-$d$): $\delta$ 8.95 (d, $J = 8.9$ Hz, 2H), 8.38 – 8.30 (m, 1H), 7.45 (d, $J = 7.5$, 1H), 7.36 – 7.31 (m, 4H), 7.07 – 7.00 (m, 4H), 7.01 (t, $J = 7.6$, 1H), 1.14 (t, 3H), 2.09 (s, 3H).

$^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 162.83, 157.40, 156.64, 152.65, 142.24, 141.12, 136.45, 131.47, 131.17, 130.79, 129.64, 128.21, 128.09, 122.84, 120.65, 119.98, 119.83, 14.81.
NMR spectra of S7:
NMR spectra of S8:

$^1$H NMR (400 MHz, Chloroform-d) δ 5.41 (d, J = 7.5 Hz, 1H), 3.96 (t, J = 5.9 Hz, 1H), 7.89 – 7.92 (m, 1H), 7.67 – 7.69 (m, 1H), 7.44 – 7.35 (m, 2H), 7.35 – 7.30 (m, 2H), 5.66 – 5.67 (m, 2H), 2.57 (dd, J = 14.5, 5.7 Hz, 1H), 2.49 (s, 3H), 2.35 (s, 3H), 3.16 (s, 3H), 1.26 (d, J = 6.6 Hz, 3H).

$^1$C NMR (100 MHz, CDCl3) δ 163.33, 155.74, 142.36, 141.58, 136.89, 136.67, 131.48, 131.31, 130.99, 130.70, 129.07, 128.05, 124.36, 122.70, 119.11, 119.77, 40.31, 37.01, 31.03, 25.74, 25.65, 19.00, 17.72.

NMR spectra in the figure show the chemical shifts and coupling constants for the protons and carbons of S8.
NMR spectra of S9:

^1H NMR (400 MHz, Chloroform-d): δ 8.45 (d, J = 7.6 Hz, 1H), 7.88 - 7.92 (m, 2H), 7.60 (dd, J = 10.9, 7.5 Hz, 2H), 7.45 - 7.36 (m, 2H), 7.33 - 7.23 (m, 2H), 1.29 (s, 9H).

^13C NMR (100 MHz, CDCl3): δ 170.76, 154.94, 144.38, 141.55, 136.87, 131.71, 131.31, 130.47, 130.46, 120.06, 120.66, 122.65, 19.85, 115.75, 35.61, 27.32.
NMR spectra of 1b:

\[ \text{\textsuperscript{1}H NMR (400 MHz, Chloroform-d)}: 6.75 - 7.01 (m, 3H), 7.30 - 7.61 (m, 5H), 5.14 - 1.88, 3.35 - 1.4 - 1.07 (m, 2H), 1.03 - 1.46 (m, 6H), 0.71 (t, \text{J = 7.5 Hz, 3H}) \]

\[ \text{\textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3})}: 120.32, 120.28, 120.36, 125.39, 125.78, 126.65, 128.88, 130.68, 131.76, 132.21, 141.29, 143.88, 151.88, 159.22, 64.31, 64.48, 65.49, 66.30, 74.94, 74.95, 75.47, 7.42 \]
NMR spectra of 2b:

$^1$H NMR (400 MHz, Chloroform-d): 7.63 – 7.73 (m, 3H), 7.5 – 7.62 (m, 1H), 7.4 (d, 2H), 7.36 (d, 2H), 7.34 (d, 2H), 7.29 (m, 2H), 6.89 (s, 1H), 1.96 – 2.06 (m, 2H), 1.96 – 1.85 (m, 2H), 1.82 – 1.72 (m, 3H), 1.72 – 1.62 (m, 4H), 0.84 (t, J = 7.5 Hz, 3H).

$^{13}$C NMR (100 MHz, CDCl3): 140.63, 138.78, 138.47, 137.38, 130.35, 128.47, 127.46, 127.37, 127.30, 123.87, 120.48, 120.25, 119.35, 108.96, 64.28, 64.24, 57.78, 32.77, 31.25, 30.61, 7.55.
NMR spectra of 3:
NMR spectra of 4:

\[ \text{S28} \]
NMR spectra of 5:

\[ \text{[Diagram of NMR spectra]} \]

\[ ^{1}H\text{NMR (400 MHz, CDCl}_{3}\text{)}: 8.72 - 7.63 (m, 1H), 7.42 (d, J = 7.5 Hz, 1H), 7.34 - 7.05 (m, 2H), 7.14 - 7.05 (m, 2H), 7.04 - 7.03 (m, 1H), 7.01 - 6.98 (m, 1H), 6.62 - 6.42 (m, 1H), 5.08 (s, 2H), 2.18 - 1.97 (m, 3H), 1.91 - 1.71 (m, 5H). \]
NMR spectra of 6:

H-NMR 1H (500 MHz, CDCl3): 8.74 – 7.75 (m, 3H), 7.59 – 7.51 (m, 3H), 7.12 – 7.22 (m, 3H), 7.10 (s, 1H), 5.59 (s, 2H), 5.53 (s, 2H), 4.94 (m, 1H), 3.88 (p, 2H), 1.30 – 1.19 (m, 6H), 1.18 (s, 3H), 0.83 – 0.51 (m, 1H), 0.55 – 0.39 (m, 3H).

C-NMR (100 MHz, CDCl3): 186.09, 139.24, 137.96, 137.06, 134.08, 129.79, 127.96, 126.85, 126.81, 126.46, 123.79, 119.72, 118.74, 78.35, 56.97, 58.64, 58.20, 16.92.
NMR spectra of 7:
NMR spectra of 8:

$^1$H NMR (100 MHz, CDCl$_3$): δ 172.60, 156.46, 140.44, 138.88, 138.75, 137.32, 130.41, 128.18, 127.36, 127.31, 126.88, 124.18, 120.25, 120.23, 119.29, 118.83, 66.08, 59.98, 27.38, 20.82, 25.58, 23.32, 22.30.

$^13$C NMR (100 MHz, CDCl$_3$): δ 172.60, 156.46, 140.44, 138.88, 138.75, 137.32, 130.41, 128.18, 127.36, 127.31, 126.88, 124.18, 120.25, 120.23, 119.29, 118.83, 66.08, 59.98, 27.38, 20.82, 25.58, 23.32, 22.30.
NMR spectra of 9:
NMR spectra of 10:

\[ ^1H\text{NMR (400 MHz, Chloroform-d)}: 8.7.74 (t, J = 7.5 Hz, 2H), 7.68 (d, J = 7.5 Hz, 1H), 7.37 - 7.22 (m, 3H), 6.66 (t, J = 4.8 Hz, 1H), 4.20 - 4.10 (m, 1H), 2.00 - 1.82 (m, 3H), 1.80 - 1.76 (m, 3H), 1.68 - 1.64 (m, 3H), 1.53 - 1.40 (m, 3H), 0.90 (d, J = 6.9 Hz, 3H). \]
NMR spectra of 11:
NMR spectra of 12:

1H NMR (400 MHz, Chloroform-d): 7.05 - 7.55 (m, 2H), 7.45 - 7.35 (m, 3H), 7.03 (s, 4H), 3.59 (s, 2H), 2.58 (s, 3H), 1.58 (s, 6H).

13C NMR (100 MHz, CDCl3): 172.30, 152.12, 135.85, 134.53, 131.62, 130.30, 129.65, 128.73, 126.68, 125.52, 61.71, 43.09, 40.02, 26.42, 21.01.
NMR spectra of 13:
NMR spectra of 14: