Supporting Information
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Supporting information

Fast assembly of 1H-imidazo[1,2-a]imidazol-5-amines via Groebke–Blackburn–Bienaymé reaction with 2-aminoimidazoles

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General experimental methods

$^1$H spectra and $^{13}$C NMR were recorded with 300 and 75 MHz respectively. The $^1$H and $^{13}$C chemical shifts are reported in parts per million relative to tetramethylsilane using the residual solvent signal as the internal reference. High-resolution mass spectra were recorded on a Kratos MS50TC system with a resolution of 10 000. The ion source temperature was 150-250 °C, as required.

The microwave irradiation experiments were carried out in a dedicated CEM-Discover monomode microwave apparatus, operating at a frequency of 2.45GHz with continuous irradiation power from 0 to 300 W and utilization of the standard absorbance level of 300 W. The reactions were carried out in 10-mL glass tubes, sealed with Teflon septum and placed in the microwave cavity. The reactions were irradiated at the required set temperature for the stipulated time and then cooled to the ambient temperature with air jet cooling.

Toluene for reactions was purchased from Sigma-Aldrich (34866-18L) and was dried and purified by MBRAUN SPS 800 solvent purification system.

For the synthesis of starting polysubstituted 2-aminimidazoles 1a-m see our previous reports.1

Representative Procedure for the Microwave-Assisted Groebke–Blackburn–Bienaymé Reaction Exemplified by the Synthesis of 1-Benzyl-N-tert-butyl-2,6-diphenyl-1H-imidazo[1,2-a]imidazol-5-amine (4a). To a microwave vial equipped with a magnetic stir bar containing 1-benzyl-5-phenyl-1H-imidazol-2-amine 1a (75 mg, 0.3 mmol) and p-toluenesulfonic acid hydrate (11 mg, 0.06 mmol), dry toluene (1 mL), benzaldehyde 2a (38 mg, 0.36 mmol) and tert-butyl isocyanide 3a (37 mg, 0.45 mmol) were consecutively added. The reaction vessel was sealed and irradiated in the cavity of a CEM-Discover microwave reactor at the set temperature of 110 °C for 30 min. Upon completion of the reaction, the vial was cooled with a stream of air. The resulting reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL)2 and saturated Na2CO3 (50 mL) aqueous solutions, dried over Na2SO4 and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 mL) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:7) as eluent to give pure 4a (87 mg, 69%).

2 CAUTION! The acidic work-up is necessary in most cases allowing to decompose imine 5 which otherwise is difficult to separate from the desired product 4.
1-Benzyl-\textit{N-}tert-butyl-2,6-diphenyl-1\textit{H}-imidazo[1,2-a]imidazol-5-amine (4a)

\textbf{1H NMR} (300 MHz, CDCl$_3$): $\delta$ = 8.07-7.95 (m, 2H), 7.41-7.26 (m, 7H), 7.25-7.10 (m, 6H), 6.94 (s, 1H), 5.22 (s, 2H), 2.90 (bs, 1H), 1.12 (s, 9H); $^{13}$C NMR (CDCl$_3$, 75 MHz): $\delta$ = 145.5, 137.4, 136.3, 136.2, 133.3, 129.5, 128.9, 128.7, 128.62, 128.56, 128.47, 128.0, 127.4, 127.3, 126.0, 120.1, 102.5, 55.6, 47.0, 30.3; HRMS (EI) for C$_{28}$H$_{28}$N$_4$ calcd. 420.2314, found 420.2281.

Work-up: The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 3M HCl (2×50 mL) and saturated Na$_2$CO$_3$ (50 mL) aqueous solutions, dried over Na$_2$SO$_4$ and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 mL) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:1) as eluent to give 4b (49 mg, 35%).

\textbf{1H NMR} (300 MHz, CDCl$_3$): $\delta$ = 8.06-7.89 (m, 2H), 7.45-7.28 (m, 7H), 7.24-7.15 (m, 1H), 6.94 (d, J = 0.6 Hz, 1H), 6.72 (s, 1H), 6.67-6.61 (m, 1H), 6.61-6.54 (m, 1H), 5.88 (s, 2H), 5.12 (s, 2H), 2.81 (bs, 1H), 1.12 (s, 9H); $^{13}$C NMR (CDCl$_3$, 75 MHz): $\delta$ = 147.7, 146.9, 145.5, 136.4, 136.3, 133.2, 131.3, 129.5, 128.9, 128.8, 128.7, 128.0, 127.3, 126.0, 120.8, 120.1, 108.14, 108.12, 102.6, 101.0, 55.7, 46.8, 30.3; HRMS (EI) for C$_{29}$H$_{28}$N$_4$O$_2$ calcd. 464.2212, found 464.2232.

1-(2-Bromobenzyl)-\textit{N-}tert-butyl-2,6-diphenyl-1\textit{H}-imidazo[1,2-a]imidazol-5-amine (4c)

\textbf{Work-up:} The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na$_2$CO$_3$ (50 mL) aqueous solutions, dried over Na$_2$SO$_4$ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (2:3) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4c (46 mg, 31%).

\textbf{1H NMR} (300 MHz, CDCl$_3$): $\delta$ = 7.99-7.89 (m, 2H), 7.55-7.45 (m, 1H), 7.41-7.14 (m, 9H), 7.14-6.97 (m, 3H), 5.29 (s, 2H), 3.01 (bs, 1H), 1.14 (s, 9H); $^{13}$C NMR (CDCl$_3$, 75 MHz): $\delta$ = 145.3, 136.4, 136.1, 133.4, 132.6, 129.1, 128.9, 128.8, 128.7, 128.3, 128.0, 127.83, 127.77, 127.3, 126.0, 121.8, 120.3, 102.6, 55.7, 47.3, 30.3; HRMS (EI) for C$_{28}$H$_{27}$N$_4$Br calcd. 498.1419, found 498.1409.
Work-up: The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na2CO3 (50 mL) aqueous solutions, dried over Na2SO4 and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 ml) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:1) as eluent to give 4d (38 mg, 26%). ¹H NMR (300 MHz, CDCl₃): δ = 8.07-7.92 (m, 2H), 7.50-7.29 (m, 7H), 7.25-7.15 (m, 1H), 6.92 (s, 1H), 6.85 (s, 1H), 6.70 (s, 2H), 5.15 (s, 2H), 3.82 (s, 3H), 3.72 (s, 3H), 2.95 (bs, 1H), 1.12 (s, 9H); ¹³C NMR (CDCl₃, 75 MHz): δ = 148.7, 148.3, 133.2, 129.9, 129.7, 129.1, 128.8, 128.7, 128.0, 127.2, 126.0, 120.0, 111.2, 110.9, 102.7, 55.8, 55.7, 55.6, 46.9, 30.3; HRMS (EI) for C₃₀H₃₂N₄O₂ calcd. 480.2525, found 480.2536.

N-tert-butyl-1-cyclohexyl-2,6-diphenyl-1H-imidazo[1,2-a]imidazol-5-amine (4e)

Work-up: The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na2CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (1:1) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4e (22 mg, 18%). ¹H NMR (300 MHz, CDCl₃): δ = 8.08-7.96 (m, 2H), 7.53-7.29 (m, 7H), 7.23-7.12 (m, 1H), 6.83 (s, 1H), 3.89 (tt, J = 3.7 Hz, J = 12.1 Hz, 1H), 3.08-2.20 (m, 3H), 1.98-1.73 (m, 3H), 1.70-1.56 (m, 1H), 1.40-1.18 (m, 3H), 1.11 (s, 9H); ¹³C NMR (CDCl₃, 75 MHz): δ = 144.4, 136.6, 135.8, 132.8, 130.2, 129.2, 128.7, 128.5, 127.9, 127.3, 125.7, 119.3, 101.9, 55.6, 55.4, 30.9, 30.3, 25.9, 24.9; HRMS (EI) for C₂₇H₃₂N₄ calcd. 412.2627, found 412.2623.

N-tert-butyl-1-cyclododecyl-2,6-diphenyl-1H-imidazo[1,2-a]imidazol-5-amine (4f)

Work-up: The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na2CO3 (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (3:17) and subjected to the column chromatography with silica (25 g) and ethyl acetate / heptane (3:17) as eluent to give 4f (25 mg, 17%). ¹H NMR (300 MHz, CDCl₃): δ = 8.05-7.93 (m, 2H), 7.52-7.29 (m, 7H), 7.23-7.11 (m, 1H), 6.85 (s, 1H), 4.15 (pent, J = 6.7 Hz, 1H), 2.91 (bs, 1H), 2.36-2.19 (m, 2H), 2.18-2.00 (m, 2H), 1.38-0.74 (m, 27H); ¹³C NMR (CDCl₃, 75 MHz): δ = 144.2, 136.7, 136.0, 134.2, 130.1, 129.7, 128.6, 128.3, 127.3, 125.7, 119.3, 101.9, 55.6, 55.4, 30.9, 30.3, 25.9, 24.9; HRMS (EI) for C₃₁H₃₄N₄O₂ calcd. 484.2623, found 484.2625.
125.7, 119.5, 101.1, 55.6, 51.0, 30.3, 28.6, 24.1, 24.0, 22.7, 22.1, 21.8; HRMS (EI) for C\textsubscript{33}H\textsubscript{44}N\textsubscript{4} calcd. 496.3566, found 496.3569.

**N-tert-butyl-2-(4-chlorophenyl)-1-cyclopropyl-6-phenyl-1\textsubscript{H}-imidazo[1,2-a]imidazol-5-amine (4g)**

*Work-up:* The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na\textsubscript{2}CO\textsubscript{3} (50 mL) aqueous solutions, dried over Na\textsubscript{2}SO\textsubscript{4} and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 mL) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:7) as eluent to give 4g (60 mg, 49%). \textsuperscript{1}H NMR (300 MHz, CDCl\textsubscript{3}): \(\delta = 8.05-7.91\) (m, 2H), 7.50 (d, J = 8.5 Hz, 2H), 7.41 (d, J = 8.5 Hz, 2H), 7.39-7.30 (m, 2H), 7.24-7.14 (m, 1H), 6.90 (s, 1H), 3.33-3.21 (m, 1H), 2.86 (bs, 1H), 1.09 (s, 9H), 1.05-0.94 (m, 4H); \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 75 MHz): \(\delta = 145.1, 136.2, 134.2, 132.4, 132.1, 129.7, 129.2, 128.1, 127.9, 127.2, 126.1, 120.1, 102.1, 55.7, 30.4, 30.2;\) HRMS (EI) for C\textsubscript{24}H\textsubscript{25}N\textsubscript{4}Cl calcd. 404.1768, found 404.1774.

**N-tert-butyl-2-(4-chlorophenyl)-1-methyl-6-phenyl-1\textsubscript{H}-imidazo[1,2-a]imidazol-5-amine (4h)**

*Work-up:* The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na\textsubscript{2}CO\textsubscript{3} (50 mL) aqueous solutions, dried over Na\textsubscript{2}SO\textsubscript{4} and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 mL) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:2) as eluent to give 4h (41 mg, 36%). \textsuperscript{1}H NMR (300 MHz, CDCl\textsubscript{3}): \(\delta = 8.07-7.86\) (m, 2H), 7.52-7.29 (m, 6H), 7.26-7.16 (m, 1H), 6.94 (s, 1H), 2.96 (bs, 1H), 1.10 (s, 9H); \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 75 MHz): \(\delta = 145.6, 136.4, 136.2, 134.6, 132.1, 129.7, 129.2, 128.1, 127.9, 127.2, 126.1, 120.1, 102.1, 55.7, 30.4, 30.2;\) HRMS (EI) for C\textsubscript{22}H\textsubscript{23}N\textsubscript{4}Cl calcd. 378.1611, found 378.1614.

**1-Benzyl-N-tert-butyl-2-(4-chlorophenyl)-6-phenyl-1\textsubscript{H}-imidazo[1,2-a]imidazol-5-amine (4i)**

*Work-up:* The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 5M HCl (2×50 mL) and saturated Na\textsubscript{2}CO\textsubscript{3} (50 mL) aqueous solutions, dried over Na\textsubscript{2}SO\textsubscript{4} and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 mL) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:7) as eluent to give 4i (33 mg, 24%). \textsuperscript{1}H NMR (300 MHz, CDCl\textsubscript{3}): \(\delta = 8.03-7.90\) (m, 2H), 7.41-7.30 (m, 4H), 7.29-7.08 (m, 8H), 6.95 (s, 1H), 5.20 (s, 2H), 2.93 (bs, 1H), 1.12 (s, 9H); \textsuperscript{13}C NMR (CDCl\textsubscript{3}, 75 MHz): \(\delta = 145.4, 137.2, 136.3, 136.1, 134.8, 132.2, 130.1, 129.0, 128.6, 128.1, 127.9, 127.6, 127.3, 127.2, 126.1, 120.1, 102.9, 55.7, 47.1, 30.3;\) HRMS (EI) for C\textsubscript{28}H\textsubscript{27}N\textsubscript{4}Cl calcd. 454.1924, found 454.1933.
<table>
<thead>
<tr>
<th><strong>Compound</strong></th>
<th><strong>Work-up</strong></th>
<th><strong>NMR</strong></th>
<th><strong>HRMS</strong></th>
</tr>
</thead>
</table>
| 2-(Biphenyl-4-yl)-N-tert-butyl-1-cyclobutyl-6-phenyl-1H-imidazo[1,2-a]imidazol-5-amine (4j) | The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (2:3) and subjected to the column chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4j (50 mg, 36%). | \[
\begin{align*}
\text{\textit{1H NMR}} (300 MHz, CDCl}_3: \delta &= 8.12-7.97 (m, 2H), 7.74-7.58 (m, 4H), 7.52-7.42 (m, 4H), 7.42-7.31 (m, 3H), 7.24-7.15 (m, 1H), 6.88 (s, 1H), 4.62 (pent, J = 8.6 Hz, 1H), 3.52-3.27 (m, 2H), 2.91 (bs, 1H), 2.36-2.15 (m, 2H), 1.95 (q, J = 9.9 Hz, 1H), 1.77-1.56 (m, 1H), 1.12 (s, 9H); \\
\text{\textit{13C NMR}} (CDCl}_3, 75 MHz): \delta &= 144.6, 141.3, 140.3, 136.6, 135.9, 132.5, 129.3, 128.9, 128.8, 128.0, 127.7, 127.4, 127.3, 127.1, 125.9, 119.6, 101.6, 55.6, 49.9, 30.3, 28.8, 15.0; \\
\text{HRMS (EI)} \text{ for C}_{31}H_{32}N_4 \text{ calcd. 460.2627, found 460.2628.}
\end{align*}
\] | |
| N-tert-butyl-1-methyl-2-(4-(methylthio)phenyl)-6-phenyl-1H-imidazo[1,2-a]imidazol-5-amine (4k) | The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (1:1) and subjected to the column chromatography with silica (25 g) and ethyl acetate / heptane (1:1) as eluent to give 4k (32 mg, 27%). | \[
\begin{align*}
\text{\textit{1H NMR}} (300 MHz, CDCl}_3: \delta &= 8.02-7.91 (m, 2H), 7.42-7.28 (m, 6H), 7.25-7.16 (m, 1H), 6.92 (s, 1H), 3.65 (s, 3H), 2.94 (bs, 1H), 2.53 (s, 3H), 1.11 (s, 9H); \\
\text{\textit{13C NMR}} (CDCl}_3, 75 MHz): \delta &= 145.5, 139.6, 136.21, 136.18, 132.9, 128.8, 128.0, 127.7, 127.4, 127.3, 127.1, 125.9, 119.6, 101.7, 55.7, 30.4, 30.2, 15.5; \\
\text{HRMS (EI)} \text{ for C}_{23}H_{26}N_4S \text{ calcd. 390.1878, found 390.1887.}
\end{align*}
\] | |
| 1-Benzyl-N-tert-butyl-2-phenyl-6-p-tolyl-1H-imidazo[1,2-a]imidazol-5-amine (4l) | The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 ml) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:3) as eluent to give 4l (59 mg, 45%). | \[
\begin{align*}
\text{\textit{1H NMR}} (300 MHz, CDCl}_3): \delta &= 7.89 (d, J = 8.0 Hz, 2H), 7.40-7.26 (m, 5H), 7.26-7.09 (m, 7H), 6.93 (s, 1H), 5.21 (s, 2H), 2.87 (bs, 1H), 2.34 (s, 3H), 1.12 (s, 9H); \\
\text{\textit{13C NMR}} (CDCl}_3, 75 MHz): \delta &= 145.6, 137.5, 136.4, 135.4, 133.6, 133.2, 129.6, 128.9, 128.8, 128.7, 128.6, 128.5, 127.4, 127.3, 127.2, 119.8, 102.6, 55.6, 47.0, 30.4, 21.3; \\
\text{HRMS (EI)} \text{ for C}_{29}H_{30}N_4 \text{ calcd. 434.2470, found 434.2464.}
\end{align*}
\] | |
1-Benzyl-N-tert-butyl-6-(4-fluorophenyl)-2-phenyl-1H-imidazo[1,2-a]imidazol-5-amine (4m)

**Work-up:** The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2x50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in ethyl acetate (5 mL) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:7) as eluent to give 4m (71 mg, 54%).

**1H NMR** (300 MHz, CDCl₃): δ = 8.07-7.95 (m, 2H), 7.43-7.28 (m, 5H), 7.04 (t, J = 8.8 Hz, 2H), 6.93 (s, 1H), 5.21 (s, 2H), 2.82 (bs, 1H), 1.12 (s, 9H);

**13C NMR** (CDCl₃, 75 MHz): δ = 161.4 (d, J = 244.5 Hz), 145.5, 137.3, 135.7, 133.3, 132.5 (d, J = 3 Hz), 129.4, 128.9, 128.77, 128.75, 128.67, 128.5, 127.4, 127.2, 119.6, 114.7 (d, J = 21.1 Hz), 102.5, 55.6, 47.0, 30.3; **HRMS** (EI) for C₂₈H₂₇N₄F calcd. 438.2220, found 438.2243.

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1-Benzyl-N-tert-butyl-2-phenyl-6-(4-(trifluoromethyl)phenyl)-1H-imidazo[1,2-a]imidazol-5-amine (4n)

**Work-up:** The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2x50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (1:1) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4n (107 mg, 73%).

**1H NMR** (300 MHz, CDCl₃): δ = 8.26 (d, J = 8.2 Hz, 2H), 7.59 (d, J = 8.2 Hz, 2H), 7.43-7.28 (m, 5H), 7.27-7.10 (m, 5H), 6.93 (s, 1H), 5.21 (s, 2H), 2.82 (bs, 1H), 1.12 (s, 9H);

**13C NMR** (CDCl₃, 75 MHz): δ = 145.5, 139.7, 137.1, 134.9, 133.9, 129.1, 128.9, 128.8, 128.6, 127.55, 127.48 (q, J = 32.1 Hz), 127.3, 127.0, 124.8 (q, J = 3.8 Hz), 124.6 (q, J = 271.7 Hz), 120.9, 102.6, 55.8, 47.1, 30.4; **HRMS** (EI) for C₂₉H₂₇N₄F₃ calcd. 488.2188, found 488.2192.

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4-(1-Benzyl-5-(tert-butylamino)-2-phenyl-1H-imidazo[1,2-a]imidazol-6-yl)benzonitrile (4o)

**Work-up:** The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2x50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (1:1) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4→2:3) as eluent to give 4o (100 mg, 75%).

**1H NMR** (300 MHz, CDCl₃): δ = 8.31 (d, J = 8.5 Hz, 2H), 7.60 (d, J = 8.5 Hz, 2H), 7.45-7.28 (m, 5H), 7.27-7.10 (m, 5H), 6.93 (s, 1H), 5.19 (s, 2H), 2.77 (bs, 1H), 1.17 (s, 9H);

**13C NMR** (CDCl₃, 75 MHz): δ = 146.0, 141.2, 137.1, 134.8, 134.2, 131.7, 129.1, 128.9, 128.8, 128.6, 127.6, 127.2, 127.1, 121.5, 119.8, 108.4, 102.4, 56.0, 47.0, 30.4; **HRMS** (EI) for C₂₉H₂₇N₅ calcd.
1-Benzyl-\(N\)-tert-butyl-6-(4-nitrophenyl)-2-phenyl-\(1\H\)-imidazo[1,2-a]imidazol-5-amine (4p)

**Work-up:** The reaction mixture was directly subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:17) as eluent to give 4p (108 mg, 77%).

\[ ^1H \text{NMR} \] (300 MHz, CDCl\(_3\)): \( \delta = 8.39 \text{ (d, J = 9.0 Hz, 2H)}, 8.18 \text{ (d, J = 9.0 Hz, 2H)}, 7.44-7.29 \text{ (m, 5H)}, 7.29-7.20 \text{ (m, 3H)}, 7.20-7.11 \text{ (m, 2H)}, 6.94 \text{ (s, 1H)}, 5.20 \text{ (s, 2H)}, 2.79 \text{ (bs, 1H)}, 1.18 \text{ (s, 9H)}; \] 

\[ ^{13}C \text{NMR} \] (CDCl\(_3\), 75 MHz): \( \delta = 146.1, 145.3, 143.3, 137.0, 134.7, 134.4, 129.0, 128.9, 128.8, 128.6, 127.6, 127.2, 126.9, 123.4, 122.1, 102.4, 56.1, 47.0, 30.4; \]

HRMS (EI) for C\(_{28}\)H\(_{27}\)N\(_5\)O\(_2\) calcd. 465.2165, found 465.2152.

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1-Benzyl-\(N\)-tert-butyl-2-phenyl-6-(pyridin-2-yl)-\(1\H\)-imidazo[1,2-a]imidazol-5-amine (4q)

**Work-up:** The reaction mixture was directly subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4q (52 mg, 41%).

\[ ^1H \text{NMR} \] (300 MHz, CDCl\(_3\)): \( \delta = 8.51-8.40 \text{ (m, 1H)}, 7.97 \text{ (d, J = 8.1 Hz, 1H)}, 7.63 \text{ (dt, J = 1.8 Hz, J = 7.8 Hz, 1H)}, 7.41-7.28 \text{ (m, 5H)}, 7.28-7.18 \text{ (m, 3H)}, 7.18-7.11 \text{ (m, 2H)}, 7.04 \text{ (s, 1H)}, 7.02-6.94 \text{ (m, 1H)}, 5.20 \text{ (s, 2H)}, 1.24 \text{ (s, 9H)}; \] 

\[ ^{13}C \text{NMR} \] (CDCl\(_3\), 75 MHz): \( \delta = 156.3, 147.9, 145.7, 137.4, 136.1, 133.9, 130.4, 129.3, 128.9, 128.3, 128.2, 127.5, 127.1, 126.8, 119.84, 119.75, 103.2, 56.0, 47.1, 30.0; \]

HRMS (EI) for C\(_{27}\)H\(_{27}\)N\(_5\) calcd. 421.2266, found 421.2276.

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1-Benzyl-\(N\)-tert-butyl-2-phenyl-6-propyl-\(1\H\)-imidazo[1,2-a]imidazol-5-amine (4q)

**Work-up:** The reaction mixture was directly subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (3:7) as eluent to give 4q (63 mg, 54%).

\[ ^1H \text{NMR} \] (300 MHz, CDCl\(_3\)): \( \delta = 7.39-7.14 \text{ (m, 8H)}, 7.11-7.02 \text{ (m, 2H)}, 6.88 \text{ (s, 1H)}, 5.18 \text{ (s, 2H)}, 3.00-2.37 \text{ (m, 3H)}, 1.83-1.64 \text{ (m, 2H)}, 1.20 \text{ (s, 9H)}, 0.98 \text{ (t, J = 7.3 Hz, 3H)}; \] 

\[ ^{13}C \text{NMR} \] (CDCl\(_3\), 75 MHz): \( \delta = 145.2, 137.8, 137.5, 132.4, 129.7, 128.8, 128.7, 128.4, 127.9, 127.3, 127.1, 119.3, 102.5, 54.6, 46.9, 30.2, 29.9, 23.4, 14.3; \]

HRMS (EI) for C\(_{25}\)H\(_{30}\)N\(_4\) calcd. 386.2470, found 386.2458.

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1-Benzyl-2,6-diphenyl-\(N\)-(2,4,4-trimethylpentan-2-yl)-\(1\H\)-imidazo[1,2-a]imidazol-5-amine (4s)

The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na\(_2\)CO\(_3\) (50 mL) aqueous solutions, dried over Na\(_2\)SO\(_4\) and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (1:4) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4r (64 mg, 45%).

\[ ^1H \text{NMR} \] (300 MHz, CDCl\(_3\)): \( \delta = 7.99-7.84 \text{ (m, 2H)}, 7.44-7.27 \text{ (m, 7H)}, 7.27-7.09 \text{ (m, 6H)}, 6.95 \text{ (s, 1H)}, 5.22 \text{ (s, 2H)}, 3.06 \text{ (bs, 1H)}, 1.57 \text{ (s, 9H)}; \]
2-(4-Chlorophenyl)-1-cyclopropyl-6-phenyl-N-(2,4,4-trimethylpentan-2-yl)-1H-imidazo[1,2-a]imidazol-5-amine (4s)
The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (2×50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (2:3) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (2:3) as eluent to give 4s (54 mg, 39%).

^1H NMR (300 MHz, CDCl₃): δ = 7.95-7.84 (m, 2H), 7.51 (d, J = 8.1 Hz, 2H), 7.42 (d, J = 8.1 Hz, 2H), 7.41-7.31 (m, 2H), 7.25-7.16 (m, 1H), 6.91 (s, 1H), 3.35-3.20 (m, 1H), 2.85 (bs, 1H), 1.54 (s, 2H), 1.11-0.93 (m, 19H);

^13C NMR (CDCl₃, 75 MHz): δ = 145.0, 137.4, 136.0, 133.5, 129.5, 128.9, 128.7, 128.6, 128.3, 127.4, 127.3, 126.3, 125.8, 121.9, 101.9, 57.5, 47.0, 34.2, 25.9, 24.8;

HRMS (EI) for C₂₈H₃₃N₄Cl calcd. 460.2394, found 460.2384.

1-Benzyl-N-cyclohexyl-2,6-diphenyl-1H-imidazo[1,2-a]imidazol-5-amine (4t)
Work-up: The reaction mixture was diluted with ethyl acetate (50 mL), thoroughly washed with 1M HCl (imine) (2×50 mL) and saturated Na₂CO₃ (50 mL) aqueous solutions, dried over Na₂SO₄ and concentrated under reduced pressure. The crude product was dissolved in 5 ml of ethyl acetate / heptane (1:1) and subjected to the flash chromatography with silica (25 g) and ethyl acetate / heptane (1:4) as eluent to give 4t (39 mg, 29%).

^1H NMR (300 MHz, CDCl₃): δ = 8.04-7.94 (m, 2H), 7.43-7.29 (m, 7H), 7.28-7.12 (m, 6H), 6.92 (s, 1H), 5.22 (s, 2H), 3.17-2.48 (m, 2H), 2.01-1.84 (m, 2H), 1.80-1.65 (m, 2H), 1.65-1.52 (m, 1H), 1.35-1.11 (m, 5H);

^13C NMR (CDCl₃, 75 MHz): δ = 145.3, 137.4, 136.0, 133.5, 129.5, 128.9, 128.7, 128.6, 128.5, 128.3, 127.4, 127.3, 126.3, 125.8, 121.9, 101.9, 57.5, 47.0, 34.2, 25.9, 24.8;
Integral

N

NH

O

4b
Integral ppm

4h

Chemical shifts and integrals are shown for different peaks in the spectrum.
Integral

4j
Integral

(8.4507 7.9611 7.6360 7.3567 7.2148 7.0441 6.9901 5.2044 1.2439)

N

N

4q

(ppm)
Key NOESY correlations for 1H-imidazo[1,2-a]imidazol-5-amine 4o

$^{1}$H NMR, CDCl$_3$, 400 MHz