Supplementary Information

Metal-free direct construction of sulfenylated pyrazoles via the NaOH promoted sulfenylation of pyrazolones with aryl thiols

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1. General information

All commercially available reagent grade chemicals were purchased from Aldrich, Acros, Alfa Aesar and Beijing Ouhe Chemical Company and used as received without further purification unless otherwise stated. All solvents were dried according to standard procedures. $^1$H NMR and $^{13}$C NMR spectra were recorded in CDCl$_3$ on a Bruker Avance III 500 spectrometer with TMS as internal standard (500 MHz $^1$H, 125 MHz $^{13}$C) at room temperature, the chemical shifts ($\delta$) were expressed in ppm and $J$ values were given in Hz. The following abbreviations are used to indicate the multiplicity: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet). All first order splitting patterns were assigned on the basis of the appearance of the multiplet. Splitting patterns that could not be easily interpreted were designated as multiplet (m). Mass analyses and HRMS were obtained on a Finnigan-LCQDECA mass spectrometer and a Bruker Daltonics Bio-TOF-Q mass spectrometer by the ESI method, respectively. Column chromatography was performed on silica gel (200 - 300 mesh).
2. General procedure for NaOH promoted sulfenylation of pyrazolones with aryl thiols for the synthesis of sulfenylated pyrazoles

\[
\begin{align*}
\text{R}^1-N \quad &\quad + \quad \text{Ar-SH} \quad \text{NaOH (1.2 equiv)} \quad \text{CH}_3\text{CN, 60°C} \quad \rightarrow \\
\text{R}^1-N \quad &\quad \text{S-Ar}
\end{align*}
\]

To a mixture of pyrazolone 1 (0.25 mmol, 43.6 mg), aryl thiol 2 (0.375 mmol, 46.6 mg), NaOH (0.3 mmol, 12.0 mg), and CH\(_3\)CN (2 mL) in a 25 mL round-bottomed flack at room temperature under air. The reaction vessel was allowed to stir at 60 °C for 2-5h. After the reaction, the resulting mixture was concentrated under vacuum and the residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired products.

3. The reaction of thiophenol 2b was conducted independently under the standard conditions

\[
\begin{align*}
\text{SH} \quad &\quad \text{standard conditions} \quad 1.5\text{h} \quad \rightarrow \\
\text{S-S} \quad &\quad \text{4b (95%)}
\end{align*}
\]

To a mixture of thiophenol 2b (0.5 mmol, 51.1 vl), NaOH (0.3 mmol, 12.0 mg), and CH\(_3\)CN (2 mL) in a 25 mL round-bottomed flack at room temperature under air. The reaction vessel was allowed to stir at 60 °C for 1.5h. After the reaction, the resulting mixture was concentrated under vacuum and the residue was purified by flash column chromatography using a mixture of petroleum ether to give the desired product 4b in 95% yield (52.1 mg, 0.238 mmol).

4. The reaction of pyrazolone 1a and diphenyl sulfide 4b was conducted under the standard conditions

\[
\begin{align*}
\text{Ph-N} \quad &\quad \text{Ph-S-S-Ph} \quad \text{standard conditions} \quad 2\text{h} \quad \rightarrow \\
\text{Ph-N} \quad &\quad \text{3ab (97%)}
\end{align*}
\]

To a mixture of pyrazolone 1a (0.25 mmol, 43.6 mg), diphenyl sulfide 4b (0.19 mmol, 46.6 mg), NaOH (0.3 mmol, 12.0 mg), and CH\(_3\)CN (2 mL) in a 25 mL round-bottomed flack at room temperature under air. The reaction vessel was allowed to stir at 60 °C for 2h. After the reaction, the resulting mixture was concentrated under vacuum and the residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired product 3ab in 97% yield (52.1 mg, 0.238 mmol).
mmol, 41.5 mg), NaOH (0.3 mmol, 12.0 mg), and CH₃CN (2 mL) in a 25 mL round-bottomed flask at room temperature under air. The reaction vessel was allowed to stir at 60 °C for 2h. After the reaction, the resulting mixture was concentrated under vacuum and the residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired product 3ab in 97% yield (71.6mg, 0.243 mmol).

5. Characterization data of products 3aa-3ha

![3aa](image)

3-methyl-1-phenyl-4-(p-tolylthio)-1H-pyrazol-5-ol,[1] Compound 3aa was obtained in 99% yield (73.3 mg, 0.248 mmol) according to the general procedure (2h). White solid, mp: 178.8-179.7 °C. ¹H NMR (⁶DMSO, 500 MHz, ppm): δ 12.16 (s, 1H), 7.75 (d, J = 8.2 Hz, 2H), 7.48 (t, J = 7.8 Hz, 2H), 7.28 (t, J = 7.4 Hz, 1H), 7.10 (d, J = 8.2 Hz, 2H), 7.00 (d, J = 8.1 Hz, 2H), 2.24 (s, 3H), 2.12 (s, 3H); ¹³C NMR (⁶DMSO, 125 MHz, ppm): 157.5, 152.5, 138.7, 135.3, 134.8, 130.1, 129.4, 126.1, 125.8, 121.2, 88.6, 20.9, 12.8. HRMS (ESI) calcd for C₁₇H₁₇N₂OS (M + H)⁺ 297.1062, found 297.1067.

![3ab](image)

3-methyl-1-phenyl-4-(phenylthio)-1H-pyrazol-5-ol,[2] Compound 3ab was obtained in 96% yield (67.9 mg, 0.241 mmol) according to the general procedure (3h). White solid, mp: 170.1-171.6 °C. ¹H NMR (⁶DMSO, 500 MHz, ppm): δ 12.16 (s, 1H), 7.75 (d, J = 7.7 Hz, 2H), 7.48 (t, J = 7.6 Hz, 2H), 7.29 (t, J = 7.9 Hz, 3H), 7.13 (t, J = 7.4 Hz, 1H), 7.09 (d, J = 7.6 Hz, 2H), 2.13 (s, 3H); ¹³C NMR (⁶DMSO, 125 MHz, ppm): 157.5, 152.6, 138.9, 138.6, 129.5, 129.4, 126.2, 125.4, 125.4, 121.2, 87.9, 12.8. HRMS (ESI) calcd for C₁₆H₁₅N₂OS (M + H)⁺ 283.0905, found 283.0907.
4-(4-methoxyphenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol\(^2\), Compound 3ac was obtained in 91% yield (70.7 mg, 0.227 mmol) according to the general procedure (4h). White solid, mp: 164.5-164.7 °C. \(^1\)H NMR (\(^{\text{d6}}\)DMSO, 500 MHz, ppm): \(\delta\) 12.11 (s, 1H), 7.73 (d, \(J = 7.7\) Hz, 2H), 7.49-7.45 (m, 2H), 7.27 (t, \(J = 7.4\) Hz, 1H), 7.09 (t, \(J = 8.8\) Hz, 2H), 6.90-6.87 (m, 2H), 3.71 (s, 3H), 2.14 (s, 3H); \(^{13}\)C NMR (\(^{\text{d6}}\)DMSO, 125 MHz, ppm): 158.0, 152.3, 138.7, 132.5, 129.4, 129.2, 128.2, 126.1, 121.1, 115.3, 89.7, 55.6, 12.8. HRMS (ESI) calcd for C\(_{17}\)H\(_{17}\)N\(_2\)O\(_2\)S (M + H\(^+\)) 313.1011, found 313.1015.

3-methyl-1-phenyl-4-(m-tolylthio)-1H-pyrazol-5-ol, Compound 3ad was obtained in 85% yield (63.3 mg, 0.214 mmol) according to the general procedure (4h). White solid, mp: 179.6-181.0 °C. \(^1\)H NMR (\(^{\text{d6}}\)DMSO, 500 MHz, ppm): \(\delta\) 12.16 (s, 1H), 7.76 (t, \(J = 1.1\) Hz, 2H), 7.49-7.46 (m, 2H), 7.28 (t, \(J = 7.4\) Hz, 1H), 7.17 (t, \(J = 7.6\) Hz, 1H), 6.94 (d, \(J = 8.2\) Hz, 2H), 6.85 (d, \(J = 8.0\) Hz, 1H), 2.25 (s, 3H), 2.13 (s, 3H); \(^{13}\)C NMR (\(^{\text{d6}}\)DMSO, 125 MHz, ppm): 157.5, 152.5, 138.8, 138.7, 138.7, 129.4, 129.4, 126.3, 126.1, 125.8, 122.5, 121.1, 88.2, 21.5, 12.8. HRMS (ESI) calcd for C\(_{17}\)H\(_{17}\)N\(_2\)OS (M + H\(^+\)) 297.1062, found 297.1061.

3-methyl-1-phenyl-4-(o-tolylthio)-1H-pyrazol-5-ol, Compound 3ae was obtained in 97% yield (71.8 mg, 0.242 mmol) according to the general procedure (2h). White solid, mp: 190.7-190.8 °C. \(^1\)H NMR (\(^{\text{d6}}\)DMSO, 500 MHz, ppm): \(\delta\) 12.16 (s, 1H), 7.76 (d, \(J = 7.6\) Hz, 2H), 7.48 (t, \(J = 7.6\) Hz, 2H), 7.29 (t, \(J = 7.4\) Hz, 1H), 7.18 (d, \(J = 7.3\) Hz, 2H), 6.90-6.87 (m, 2H), 3.71 (s, 3H), 2.14 (s, 3H); \(^{13}\)C NMR (\(^{\text{d6}}\)DMSO, 125 MHz, ppm): 157.5, 152.5, 138.8, 138.7, 138.7, 129.4, 129.4, 126.3, 126.1, 125.8, 122.5, 121.1, 88.2, 21.5, 12.8. HRMS (ESI) calcd for C\(_{17}\)H\(_{17}\)N\(_2\)OS (M + H\(^+\)) 297.1062, found 297.1061.
Hz, 1H), 7.10 (t, \(J = 6.7\) Hz, 1H), 7.05-7.01 (m, 1H), 6.74 (d, \(J = 7.6\) Hz, 1H), 2.37 (s, 3H), 2.11 (s, 3H); \(^{13}\)C NMR (\(\text{d}^6\text{DMSO}, 125\) MHz, ppm): 157.8, 152.7, 138.6, 137.7, 134.0, 130.5, 129.4, 127.0, 126.2, 125.0, 124.1, 121.2, 87.0, 19.7, 12.8. HRMS (ESI) calcd for C\(_{17}\)H\(_{17}\)N\(_2\)OS (M + H)\(^+\) 297.1062, found 297.1063.

![Compound 3af](image)

**4-(2,4-dimethylphenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol.** Compound 3af was obtained in 90% yield (69.8 mg, 0.225 mmol) according to the general procedure (4h). White solid, mp: 190.0-190.4 °C. \(^1\)H NMR (\(\text{d}^6\text{DMSO}, 500\) MHz, ppm): \(\delta\) 12.11 (s, 1H), 7.75 (d, \(J = 7.9\) Hz, 2H), 7.48 (t, \(J = 7.7\) Hz, 2H), 7.28 (t, \(J = 7.4\) Hz, 1H), 7.01 (s, 1H), 6.91 (d, \(J = 8.0\) Hz, 1H), 6.65 (d, \(J = 7.8\) Hz, 1H), 2.34 (s, 3H), 2.21 (s, 3H), 2.09 (s, 3H); \(^{13}\)C NMR (\(\text{d}^6\text{DMSO}, 125\) MHz, ppm): 157.5, 152.6, 138.6, 134.3, 134.1, 134.1, 131.3, 129.4, 127.6, 126.1, 124.7, 121.1, 87.6, 20.7, 19.7, 12.7. HRMS (ESI) calcd for C\(_{18}\)H\(_{19}\)N\(_2\)OS (M + H)\(^+\) 311.1218, found 311.1214.

![Compound 3ag](image)

**4-(2-aminophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol.** Compound 3ag was obtained in 97% yield (72.1 mg, 0.243 mmol) according to the general procedure (2h). Gray solid, mp: 182.9-183.1 °C. \(^1\)H NMR (\(\text{d}^6\text{DMSO}, 500\) MHz, ppm): \(\delta\) 7.71 (d, \(J = 8.0\) Hz, 2H), 7.46 (t, \(J = 7.8\) Hz, 2H), 7.26 (t, \(J = 7.4\) Hz, 1H), 7.14 (d, \(J = 6.7\) Hz, 1H), 6.99-6.96 (m, 1H), 6.68 (d, \(J = 7.8\) Hz, 1H), 6.50 (t, \(J = 7.4\) Hz, 1H), 3.85 (s, 2H), 2.20 (s, 3H); \(^{13}\)C NMR (\(\text{d}^6\text{DMSO}, 125\) MHz, ppm): 159.2, 152.6, 148.4, 138.1, 132.7, 129.4, 128.9, 125.9, 120.6, 119.1, 117.1, 115.4, 92.3, 12.6. HRMS (ESI) calcd for C\(_{16}\)H\(_{16}\)N\(_3\)OS (M + H)\(^+\) 298.1014, found 298.1013.
4-(2-chlorophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol, Compound 3ah was obtained in 87% yield (68.6 mg, 0.217 mmol) according to the general procedure (2h). White solid, mp: 182.0-182.3 °C. ¹H NMR (d⁶DMSO, 500 MHz, ppm): δ 12.32 (s, 1H), 7.77 (t, J = 1.0 Hz, 2H), 7.49 (t, J = 7.6 Hz, 2H), 7.46-7.44 (m, 1H), 7.30 (t, J = 7.4 Hz, 1H), 7.28-7.24 (m, 1H), 7.17-7.14 (m, 1H), 6.78 (d, J = 7.7 Hz, 1H), 2.11 (s, 3H); ¹³C NMR (d⁶DMSO, 125 MHz, ppm): 157.3, 152.6, 138.5, 137.7, 129.9, 129.4, 129.4, 128.2, 126.5, 126.3, 125.7, 121.4, 85.8, 12.7. HRMS (ESI) calcd for C₁₆H₁₄ClN₂O (M + H)⁺ 317.0515, found 317.0517.

4-(4-fluorophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol[¹], Compound 3ai was obtained in 98% yield (73.9 mg, 0.246 mmol) according to the general procedure (3h). White solid, mp: 170.8-171.1 °C. ¹H NMR (d⁶DMSO, 500 MHz, ppm): δ 12.26 (s, 1H), 7.74 (d, J = 7.7 Hz, 2H), 7.48 (t, J = 7.6 Hz, 2H), 7.28 (t, J = 7.4 Hz, 1H), 7.15 (t, J = 9.2 Hz, 4H), 2.14 (s, 3H); ¹³C NMR (d⁶DMSO, 125 MHz, ppm): 160.9 (d, J = 240.4 Hz), 157.4, 152.4, 138.6, 134.3 (d, J = 2.8 Hz), 129.4, 127.7 (d, J = 7.9 Hz), 126.2, 121.2, 116.5 (d, J = 21.9 Hz), 88.5, 12.5. HRMS (ESI) calcd for C₁₆H₁₄F₅N₄OS (M + H)⁺ 301.0811, found 301.0815.

4-(4-chlorophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol[²], Compound 3aj was obtained in 91% yield (71.8 mg, 0.227 mmol) according to the general procedure (2h). White solid, mp: 179.1-181.1 °C. ¹H NMR (d⁶DMSO, 500 MHz, ppm): δ 12.26 (s,
1H), 7.75 (d, J = 8.0 Hz, 2H), 7.48 (t, J = 7.8 Hz, 2H), 7.35 (d, J = 8.6 Hz, 2H), 7.29 (t, J = 7.4 Hz, 1H), 7.10 (d, J = 8.6 Hz, 2H), 2.13 (s, 3H); $^{13}$C NMR (d$_6$DMSO, 125 MHz, ppm): 157.2, 152.4, 138.5, 138.1, 130.0, 129.4, 127.0, 126.2, 121.2, 87.3, 12.7. HRMS (ESI) calcd for C$_{16}$H$_{14}$ClN$_2$OS (M + H)$^+$ 317.0515, found 317.0513.

![3ak]

4-(4-bromophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol$^{[2]}$, Compound 3ak was obtained in 84% yield (76.2 mg, 0.212 mmol) according to the general procedure (3h). White solid, mp: 194.1-194.3 °C. $^1$H NMR (d$_6$DMSO, 500 MHz, ppm): $\delta$ 12.34 (s, 1H), 7.75 (d, J = 7.6 Hz, 2H), 7.48 (t, J = 8.4 Hz, 4H), 7.29 (t, J = 7.4 Hz, 1H), 7.04 (d, J = 8.6 Hz, 2H), 2.13 (s, 3H); $^{13}$C NMR (d$_6$DMSO, 125 MHz, ppm): 157.7, 152.4, 138.7, 138.6, 132.3, 129.4, 127.4, 126.2, 121.2, 118.1, 87.3, 12.8. HRMS (ESI) calcd for C$_{16}$H$_{14}$BrN$_2$OS (M + H)$^+$ 361.0010, found 361.0011.

![3al]

4-(3-chlorophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol$^{[1]}$, Compound 3al was obtained in 92% yield (72.9 mg, 0.231 mmol) according to the general procedure (2h). White solid, mp: 182.1-182.9 °C. $^1$H NMR (d$_6$DMSO, 500 MHz, ppm): $\delta$ 12.33 (s, 1H), 7.75 (d, J = 7.9 Hz, 2H), 7.49 (t, J = 7.7 Hz, 2H), 7.33-7.28 (m, 2H), 7.20-7.18 (m, 1H), 7.07-7.05 (m, 2H), 2.14 (s, 3H); $^{13}$C NMR (d$_6$DMSO, 125 MHz, ppm): 157.7, 152.4, 141.8, 138.5, 134.3, 131.2, 129.4, 126.3, 125.4, 124.5, 124.0, 121.3, 87.0, 12.7. HRMS (ESI) calcd for C$_{16}$H$_{14}$ClN$_2$OS (M + H)$^+$ 317.0515, found 317.0517.

![3am]

4-(3,4-dichlorophenylthio)-3-methyl-1-phenyl-1H-pyrazol-5-ol, Compound 3am
was obtained in 89% yield (77.7 mg, 0.222 mmol) according to the general procedure (2h). White solid, mp: 89.2-90.3 °C. \(^1\)H NMR (\(^{1}\)DMSO, 500 MHz, ppm): \(\delta 7.75\) (d, \(J = 7.6\) Hz, 2H), 7.53 (d, \(J = 8.5\) Hz, 1H), 7.48 (t, \(J = 7.6\) Hz, 2H), 7.30-7.27 (m, 2H), 7.06-7.04 (m, 1H), 2.14 (s, 3H); \(^{13}\)C NMR (\(^{1}\)DMSO, 125 MHz, ppm): 157.5, 152.4, 140.5, 138.4, 132.2, 131.4, 129.4, 127.8, 126.5, 126.3, 125.5, 121.2, 87.0, 12.7. HRMS (ESI) calcd for C\(_{16}\)H\(_{13}\)Cl\(_2\)N\(_2\)O\(_5\) (M + H\(^+\)) 351.0126, found 351.0121.

![Structure of 3an](image)

**3-methyl-1-phenyl-4-(4-(trifluoromethyl)phenylthio)-1H-pyrazol-5-ol.** Compound 3an was obtained in 97% yield (84.8 mg, 0.242 mmol) according to the general procedure (4h). White solid, mp: 198.9-199.3 °C. \(^1\)H NMR (\(^{1}\)DMSO, 500 MHz, ppm): \(\delta 12.40\) (s, 1H), 7.76 (d, \(J = 7.6\) Hz, 2H), 7.63 (d, \(J = 8.4\) Hz, 2H), 7.49 (t, \(J = 7.6\) Hz, 2H), 7.30 (t, \(J = 7.4\) Hz, 1H), 7.27 (d, \(J = 8.3\) Hz, 2H), 2.14 (s, 3H); \(^{13}\)C NMR (\(^{1}\)DMSO, 125 MHz, ppm): 157.5, 152.4, 145.0, 138.5, 129.4, 128.8 (d, \(J = 132.5\)Hz), 126.2 (q, \(J = 3.8\) Hz), 125.8 (d, \(J = 31.7\) Hz), 125.4, 124.8 (d, \(J = 269.9\) Hz), 121.3, 88.3, 12.7. HRMS (ESI) calcd for C\(_{17}\)H\(_{14}\)F\(_3\)N\(_2\)O\(_5\) (M + H\(^+\)) 351.0779, found 351.0781.

![Structure of 3ba](image)

**3-methyl-1-p-tolyl-4-(p-tolylthio)-1H-pyrazol-5-ol.** Compound 3ba was obtained in 93% yield (72.2 mg, 0.233 mmol) according to the general procedure (4h). White solid, mp: 98.9-100.7 °C. \(^1\)H NMR (\(^{1}\)DMSO, 500 MHz, ppm): \(\delta 12.07\) (s, 1H), 7.61 (d, \(J = 8.5\) Hz, 2H), 7.27 (d, \(J = 8.4\) Hz, 2H), 7.10 (d, \(J = 8.2\) Hz, 2H), 6.99 (d, \(J = 8.2\) Hz, 2H), 2.33 (s, 3H), 2.24 (s, 3H), 2.11 (s, 3H); \(^{13}\)C NMR (\(^{1}\)DMSO, 125 MHz, ppm): 156.3, 152.0, 136.3, 135.4, 135.3, 134.7, 130.1, 129.8, 125.7, 121.2, 88.2, 21.0, 20.9, 12.8. HRMS (ESI) calcd for C\(_{18}\)H\(_{19}\)N\(_2\)OS (M + H\(^+\)) 311.1218, found 311.1215.
1-(4-chlorophenyl)-3-methyl-4-(p-tolylthio)-1H-pyrazol-5-ol, Compound 3ca was obtained in 98% yield (81.2 mg, 0.246 mmol) according to the general procedure (2h). White solid, mp: 89.7-90.1 °C. ¹H NMR (d6 DMSO, 500 MHz, ppm): δ 12.38 (s, 1H), 7.80-7.79 (m, 2H), 7.54-7.53 (m, 2H), 7.10 (d, J = 8.2 Hz, 2H), 6.99 (d, J = 8.2 Hz, 2H), 2.24 (s, 3H), 2.12 (s, 3H); ¹³C NMR (d6 DMSO, 125 MHz, ppm): 157.5, 152.9, 137.5, 135.1, 134.8, 130.1, 130.1, 129.4, 125.8, 122.4, 88.8, 20.9, 12.8. HRMS (ESI) calcd for C17H16ClN2OS (M + H)+ 331.0672, found 331.0677.

1-(4-fluorophenyl)-3-methyl-4-(p-tolylthio)-1H-pyrazol-5-ol, Compound 3da was obtained in 81% yield (64.0 mg, 0.204 mmol) according to the general procedure (2h). White solid, mp: 151.8-152.4 °C. ¹H NMR (d6 DMSO, 500 MHz, ppm): δ 12.21 (s, 1H), 7.78-7.75 (m, 2H), 7.32 (t, J = 8.9 Hz, 2H), 7.10 (d, J = 8.1 Hz, 2H), 6.99 (d, J = 8.2 Hz, 2H), 2.24 (s, 3H), 2.11 (s, 3H); ¹³C NMR (d6 DMSO, 125 MHz, ppm): 160.2 (d, J = 241.4 Hz), 156.9, 152.4, 135.2, 135.1, 134.8, 130.1, 125.8, 123.3 (d, J = 8.0 Hz), 116.1 (d, J = 22.6 Hz), 88.5, 20.9, 12.8. HRMS (ESI) calcd for C17H16FN2OS (M + H)+ 315.0967, found 315.0969.

4-(5-hydroxy-3-methyl-4-(p-tolylthio)-1H-pyrazol-1-yl)benzonitrile[1], Compound 3ea was obtained in 77% yield (61.7 mg, 0.192 mmol) according to the general procedure (2h). White solid, mp: 184.2-184.6 °C. ¹H NMR (d6 DMSO, 500 MHz, ppm): δ 12.67 (s, 1H), 8.02 (d, J = 8.9 Hz, 2H), 7.93 (d, J = 8.8 Hz, 2H), 7.10 (d, J = 8.2 Hz, 2H), 7.00 (d, J = 8.2 Hz, 2H), 2.23 (s, 3H), 2.14 (s, 3H); ¹³C NMR (d6 DMSO, 125
MHz, ppm): 158.7, 154.2, 142.0, 135.0, 133.9, 130.2, 125.9, 120.2, 119.2, 107.6, 89.4, 20.9, 12.8. HRMS (ESI) calcd for C\textsubscript{18}H\textsubscript{16}N\textsubscript{3}OS (M + H)\textsuperscript{+} 322.1014, found 322.1016.

3-methyl-4-(p-tolylthio)-1-(4-(trifluoromethyl)phenyl)-1H-pyrazol-5-ol, Compound 3fa was obtained in 87% yield (79.2 mg, 0.218 mmol) according to the general procedure (2h). White solid, mp: 173.6-174.2 °C. \textsuperscript{1}H NMR (\textsuperscript{d}\textsubscript{6}DMSO, 500 MHz, ppm): δ 12.49 (s, 1H), 8.03 (d, J = 8.7 Hz, 2H), 7.85 (d, J = 8.8 Hz, 2H), 7.10 (d, J = 8.2 Hz, 2H), 7.01 (d, J = 8.2 Hz, 2H), 2.24 (s, 3H), 2.14 (s, 3H); \textsuperscript{13}C NMR (\textsuperscript{d}\textsubscript{6}DMSO, 125 MHz, ppm): 158.3, 153.9, 141.7, 134.9 (d, J = 16.0 Hz), 130.2, 127.9, 126.7 (q, J = 3.3 Hz), 125.9, 124.7 (d, J = 270.2 Hz), 121.4, 120.5, 89.3, 20.9, 12.8. HRMS (ESI) calcd for C\textsubscript{18}H\textsubscript{16}F\textsubscript{3}N\textsubscript{2}OS (M + H)\textsuperscript{+} 365.0935, found 365.0933.

1-(2-chlorophenyl)-3-methyl-4-(p-tolylthio)-1H-pyrazol-5-ol, Compound 3ga was obtained in 90% yield (74.6 mg, 0.226 mmol) according to the general procedure (5h). White solid, mp: 98.7-100.1 °C. \textsuperscript{1}H NMR (\textsuperscript{d}\textsubscript{6}DMSO, 500 MHz, ppm): δ 11.86 (s, 1H), 7.67-7.65 (m, 1H), 7.56-7.48 (m, 3H), 7.11 (d, J = 8.1 Hz, 2H), 7.00 (d, J = 8.0 Hz, 2H), 2.25 (s, 3H), 2.08 (s, 3H); \textsuperscript{13}C NMR (\textsuperscript{d}\textsubscript{6}DMSO, 125 MHz, ppm): 158.4, 152.4, 153.8, 135.6, 134.6, 131.9, 131.0, 130.6, 130.5, 130.1, 128.4, 125.5, 86.4, 20.9, 12.8. HRMS (ESI) calcd for C\textsubscript{17}H\textsubscript{16}ClN\textsubscript{2}OS (M + H)\textsuperscript{+} 331.0672, found 331.0677.

3-tert-butyl-1-methyl-4-(p-tolylthio)-1H-pyrazol-5-ol, Compound 3ha was
obtained in 90% yield (62.3 mg, 0.226 mmol) according to the general procedure (4h). White solid, mp: 211.4-211.6 °C. $^1$H NMR (d$_6$DMSO, 500 MHz, ppm): $\delta$ 11.14 (s, 1H), 7.06 (d, $J = 8.2$ Hz, 2H), 6.86 (d, $J = 8.2$ Hz, 2H), 3.52 (s, 3H), 2.22 (s, 3H), 1.22 (s, 9H); $^{13}$C NMR (d$_6$DMSO, 125 MHz, ppm): 159.1, 157.2, 136.7, 134.0, 129.8, 124.9, 82.4, 33.9, 33.8, 29.6, 20.9. HRMS (ESI) calcd for C$_{15}$H$_{21}$N$_2$OS (M + H)$^+$ 277.1375, found 277.1371.

6. Reference


7. Copies of NMR spectra for compounds 3aa-3ha
3ah

\[ \text{Structure Image} \]

\[ \text{Graph Image} \]
3an
3ba
3fa

![Diagram of a molecule](image)

![Graph of spectra](image)
3ha