Copper-Mediated Efficient Three-component Synthesis of 1,2,4-Triazoles from Amines and Nitriles

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Supporting Information

Table of Contents

| 1. Experimental details and analytical data | S2-24 |
| 2. References | S24 |
| 3. $^1$H and $^{13}$C NMR spectra of all the products | S25-91 |
**General Information:** All reactions were carried out in oven-dried Schlenk tubes. PhCN was dried over calcium hydride before distillation. All the temperatures are referred to the bath temperature. All $^1$H NMR experiments were measured in relative to the signal of tetramethylsilane (0 ppm) in CDCl$_3$ and $^{13}$C NMR experiments were measured in relative to the signal of residual chloroform (77.00 ppm) in CDCl$_3$. $^{19}$F NMR experiments were measured with trifluoroacetic acid (-77.00 ppm) or CFCl$_3$ (0 ppm) as the external reference. IR spectra were recorded on the Bruker Tensor 27 infrared spectrometer with the major peaks listed. Melting points were measured without correction. Copper(II) acetate anhydrous (98.5%) was purchased from J&K, other common reagents were purchased from commercial sources and used without further purification unless noted otherwise. Column chromatography was performed using silica gel (H) eluting with ethyl acetate and petroleum ether. TLC was performed on glass-backed silica plates.

**Microwave irradiation experiments**

For reactions run in sealed microwave vials, oven-dried 5 mL vials containing a Teflon-coated stirring bar and sealed with a Teflon-lined septum were used. All microwave irradiation experiments were carried out with a MILESTONE S.r.l (MicroSYNTH 131718)® microwave reactor, operating at a frequency of 50 Hz with continuous irradiation power from 0 to 800 W utilizing the standard absorbance level of 800 W maximum power. The instrument was used in the standard configuration as delivered, including proprietary software. The temperature was measured with an IR
sensor on the outer surface of the process vial. After irradiation, reaction vessels were cooled rapidly to ambient temperature by gas jet cooling.

1. 1-Benzyl-3,5-diphenyl-1H-1,2,4-triazole (3a) (cb-5-117, 11-94, 9-112)

**Method A**: To a dried Schlenk tube were added Cu(OAc)₂ (367.9 mg, 2 mmol), BnNH₂ (108.6 mg, 1 mmol)/PhCN (2 mL) sequentially at room temperature. After stirring at 120 °C (oil bath) for 21 h, the resulting mixture was cooled to room temperature, diluted with 50 mL of Et₂O, filtered through a short pad of silica gel and concentrated under reduced pressure. The residue was purified by chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 40/1 to 10/1) to afford 3a (139.7 mg, 44%): solid; ¹H NMR (300 MHz, CDCl₃) δ 8.25-8.14 (m, 2 H, ArH), 7.66-7.57 (m, 2 H, ArH), 7.52-7.16 (m, 11 H, ArH), 5.40 (s, 2 H, CH₂).

**Gram-scale synthesis of 3a**:

To a dried three-necked flask were added Cu(OAc)₂ (3.6321 g, 20 mmol), BnNH₂ (1.0704 g, 10 mmol)/PhCN (20 mL) sequentially at room temperature. After stirring at 120 °C (oil bath) for 48 h, the resulting mixture was cooled to room temperature, diluted with 50 mL of Et₂O, filtered through a short pad of silica gel and concentrated under reduced pressure. The residue was purified by chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 30/1 to 15/1) to afford 3a (1.3062 g, 42%): solid; ¹H NMR (300 MHz, CDCl₃) δ 8.27-8.14 (m, 2 H, ArH), 7.64-7.57 (m, 2 H, ArH), 7.52-7.16 (m, 11 H, ArH), 7.25-7.16 (m, 2 H, ArH), 5.40 (s, 2 H, CH₂).
Method B: To a dried MW tube were added Cu(OAc)$_2$ (363.9 mg, 2 mmol), BnNH$_2$ (106.8 mg, 1 mmol)/PhCN (5 mL) sequentially at room temperature. The tube was sealed and irradiated in a microwave reactor (120 °C, 30 minutes, maximum power 800 W). Then, the resulting mixture was cooled to room temperature with a stream of air, diluted with 50 mL of Et$_2$O, filtered through a short pad of silica gel and concentrated under reduced pressure. The residue was purified by chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 10/1) to afford 3a$^1$ (127.0 mg, 41%): solid; m.p. 99-100 °C (hexane/Et$_2$O) (lit. m.p. 98.5-99.5 °C); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.21 (d, $J$ = 7.2 Hz, 2 H, ArH), 7.62-7.51 (m, 2 H, ArH), 7.48-7.13 (m, 11 H, ArH), 5.39 (s, 2 H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 161.4, 156.0, 135.9, 130.9, 130.0, 129.0, 128.70, 128.67, 128.6, 128.4, 127.9, 127.8, 126.6, 126.3, 52.6. IR (neat) 1519, 1497, 1476, 1463, 1443, 1406, 1353 cm$^{-1}$; MS (EI) (m/z) 312 ((M+1)$^+$, 5.71), 311 (M$^+$, 27.09), 91 (100).

The following compounds were prepared according to Method A or B in main text.

2. 1-(4-Fluorobenzyl)-3,5-diphenyl-1H-1,2,4-triazole (3b) (cb-9-144)

Method B: The reaction of Cu(OAc)$_2$ (362.4 mg, 2 mmol), 4-fluorobenzylamine (129.7 mg, 97% purity, 1 mmol), and PhCN (5 mL) afforded 3b (150.3 mg, 45%)
(eluent: petroleum ether/ethyl acetate = 10/1): oil; $^1$H NMR (300 MHz, CDCl$_3$) δ 8.24-8.16 (m, 2 H, ArH), 7.64-7.52 (m, 2 H, ArH), 7.50-7.33 (m, 6 H, ArH), 7.20-7.10 (m, 2 H, ArH), 7.05-6.92 (m, 2 H, ArH), 5.37 (s, 2 H, NCH$_2$); $^{13}$C NMR (CDCl$_3$, 75 MHz) δ 162.2 (d, $J$ = 245.9 Hz), 161.5, 155.9, 131.6 (d, $J$ = 3.5 Hz), 130.8, 130.2, 129.2, 128.8, 128.63, 128.61 (d, $J$ = 8.1 Hz), 128.45, 127.8, 126.3, 115.7 (d, $J$ = 20.9 Hz), 51.9; $^{19}$F NMR (CDCl$_3$, 282 MHz) -113.9; IR (neat) 1605, 1509, 1478, 1458, 1446, 1405, 1353, 1222, 1156, 1141, 1016 cm$^{-1}$; MS (EI) ($m/z$) 330 ((M+1)$^+$, 11.24), 329 (M$^+$, 49.41), 109 (100); HRMS calcd for C$_{21}$H$_{16}$N$_3$F (M$^+$): 329.1328, found: 329.1329.

3. 1-Butyl-3,5-diphenyl-1$H$-1,2,4-triazole (3c) (cb-9-114, 9-117)

**Method B**: The reaction of Cu(OAc)$_2$ (363.9 mg, 2 mmol), n-BuNH$_2$ (73.1 mg, 1 mmol), and PhCN (5 mL) afforded 3c (147.8 mg, 53%) (eluent: petroleum ether/ethyl acetate = 10/1): oil; $^1$H NMR (300 MHz, CDCl$_3$) δ 8.19 (d, $J$ = 7.2 Hz, 2 H, ArH), 7.66-7.61 (m, 2 H, ArH), 7.60-7.24 (m, 6 H, ArH), 4.18 (t, $J$ = 7.2 Hz, 2 H, NCH$_2$), 2.00-1.83 (m, 2 H, CH$_2$), 1.40-1.21 (m, 2 H, CH$_2$), 0.86 (t, $J$ = 7.2 Hz, 3 H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 75 MHz) δ 161.0, 155.3, 131.1, 129.8, 128.8, 128.6, 128.3, 126.2, 48.8, 31.9, 19.5, 13.3; IR (neat) 3068, 2959, 2933, 2873, 1519, 1476, 1463, 1442, 1410, 1354, 1132, 1019 cm$^{-1}$; MS (EI) ($m/z$) 278 ((M+1)$^+$, 11.49), 277 (M$^+$, 55.63), 234 (100); HRMS calcd for C$_{18}$H$_{19}$N$_3$ (M$^+$): 277.1579, found: 277.1578.
Method A: The reaction of Cu(OAc)$_2$ (363.2 mg, 2 mmol), n-BuNH$_2$ (74.0 mg, 1 mmol), and PhCN (2 mL) afforded 3c (125.3 mg, 45%) (eluent: petroleum ether/ethyl acetate = 10/1): oil; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.18 (d, $J = 7.5$ Hz, 2 H, ArH), 7.66-7.60 (m, 2 H, ArH), 7.59-7.30 (m, 6 H, ArH), 4.20 (t, $J = 7.2$ Hz, 2 H, NCH$_2$), 2.00-1.80 (m, 2 H, CH$_2$), 1.40-1.21 (m, 2 H, CH$_2$), 0.87 (t, $J = 7.2$ Hz, 3 H, CH$_3$).

4. 1-Isobutyl-3,5-diphenyl-1H-1,2,4-triazole (3d) (cb-11-146)

Method B: The reaction of Cu(OAc)$_2$ (362.5 mg, 2 mmol), isobutylNH$_2$ (74.1 mg, 1 mmol), and PhCN (5 mL) afforded 3d (132.4 mg, 47%) (eluent: petroleum ether/ethyl acetate = 10/1): oil; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.19 (d, $J = 7.2$ Hz, 2 H, ArH), 7.68-7.57 (m, 2 H, ArH), 7.55-7.30 (m, 6 H, ArH), 4.02 (d, $J = 7.2$ Hz, 2 H, NCH$_2$), 2.45-2.25 (m, 1 H, CH), 0.86 (d, $J = 6.6$ Hz, 6 H, (CH$_3$)$_2$); $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 161.0, 156.0, 131.1, 129.8, 128.9, 128.7, 128.5, 128.4, 126.3, 56.2, 29.2, 19.7; IR (neat) 1519, 1476, 1462, 1441, 1409, 1390, 1354, 1284, 1193, 1173, 1132, 1098, 1070, 1040, 1027, 1018 cm$^{-1}$; MS (EI) ($m/z$) 278 ((M+1)$^+$, 14.65), 277 (M$^+$, 67.21), 104 (100); HRMS calcd for C$_{18}$H$_{19}$N$_3$ (M$^+$): 277.1579, found: 277.1577.

5. 1-Pentyl-3,5-diphenyl-1H-1,2,4-triazole (3e) (cb-9-140)
**Method B:** The reaction of Cu(OAc)$_2$ (363.3 mg, 2 mmol), $^6$C$_3$H$_{11}$NH$_2$ (88.1 mg, 1 mmol), and PhCN (5 mL) afforded 3e (135.1 mg, 46%) (eluent: petroleum ether/ethyl acetate = 15/1): oil; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.18 (d, $J$ = 7.5 Hz, 2 H, ArH), 7.72-7.60 (m, 2 H, ArH), 7.55-7.30 (m, 6 H, ArH), 4.19 (t, $J$ = 7.4 Hz, 2 H, NCH$_2$), 2.00-1.82 (m, 2 H, CH$_2$), 1.38-1.20 (m, 4 H, -(CH$_2$)$_2$-), 0.85 (t, $J$ = 5.9 Hz, 3 H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 161.1, 155.4, 131.1, 129.9, 128.9, 128.7, 128.4, 126.3, 49.2, 29.7, 28.5, 22.0, 13.8; IR (neat) 2958, 2926, 2856, 1476, 1463, 1441, 1408, 1355 cm$^{-1}$; MS (EI) ($m/z$) 292 ((M+1)$^+$, 12.96), 291 (M$^+$, 59.60), 234 (100); HRMS calcd for C$_{19}$H$_{21}$N$_3$ (M$^+$): 291.1735, found: 291.1734.

6. 1-Cyclohexyl-3,5-diphenyl-1H-1,2,4-triazole (3f) (cb-9-122)

**Method B:** The reaction of Cu(OAc)$_2$ (363.1 mg, 2 mmol), CyNH$_2$ (99.4 mg, 1 mmol), and PhCN (5 mL) afforded 3f (137.7 mg, 45%) (eluent: petroleum ether/ethyl acetate = 10/1): solid, 107-108 °C (petroleum ether /Et$_2$O) (lit. m.p. 106-107 °C); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.18 (d, $J$ = 7.8 Hz, 2 H, ArH), 7.68-7.57 (m, 2 H, ArH), 7.56-7.47 (m, 3 H, ArH), 7.46-7.30 (m, 3 H, ArH), 4.22 (tt, $J$ = 11.4, 4.1 Hz, 1 H, NCH$_2$), 2.23-2.02 (m, 2 H, CH$_2$), 2.02-1.80 (m, 4 H, -(CH$_2$)$_2$-), 1.78-1.61 (m, 1 H, one proton in CH$_2$), 1.40-1.20 (m, 3 H, three proton in (CH$_2$)$_2$); $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 160.9, 154.6, 131.4, 129.8, 128.9, 128.8, 128.7, 128.4, 126.3,
58.0, 33.1, 25.4, 24.9; IR (neat) 2955, 2941, 2853, 1515, 1476, 1455, 1438, 1402, 1380, 1350, 1326, 1300, 1263, 1174, 1131, 1071, 1025, 1019 cm⁻¹; MS (EI) (m/z) 304 (M⁺+ 1), 8.77, 303 (M⁺, 36.94), 221 (100).

7. 1-Hexyl-3,5-diphenyl-1H-1,2,4-triazole (3g) (cb-9-130)

![Chemical structure](image)

**Method B:** The reaction of Cu(OAc)₂ (363.5 mg, 2 mmol), n-C₆H₁₃NH₂ (102.0 mg, 1 mmol), and PhCN (5 mL) afforded 3g (146.1 mg, 48%) (eluent: petroleum ether/ethyl acetate = 10/1): oil; ¹H NMR (400 MHz, CDCl₃) δ 8.17 (d, J = 7.2 Hz, 2 H, ArH), 7.70-7.63 (m, 2 H, ArH), 7.59-7.50 (m, 3 H, ArH), 7.49-7.35 (m, 3 H, ArH), 4.21 (t, J = 7.4 Hz, 2 H, NCH₂), 2.00-1.87 (m, 2 H, CH₂), 1.36-1.20 (m, 6 H, -(CH₂)₃-), 0.85 (t, J = 6.8 Hz, 3 H, CH₃); ¹³C NMR (CDCl₃, 75 MHz) δ 161.1, 155.4, 131.2, 129.9, 128.9, 128.8, 128.4, 126.3, 49.2, 31.1, 30.0, 26.1, 22.4, 13.9; IR (neat) 3068, 2954, 2928, 2857, 1519, 1476, 1463, 1441, 1409, 1377, 1353, 1302, 1283, 1173, 1132, 1102, 1070, 1018 cm⁻¹; MS (EI) (m/z) 306 ((M⁺+ 1)⁺, 11.44), 305 (M⁺, 50.21), 234 (100); HRMS calcd for C₂₀H₂₃N₃ (M⁺): 305.1892, found: 305.1893.

8. 1-Octyl-3,5-diphenyl-1H-1,2,4-triazole (3h) (cb-9-141, cb-9-150)

![Chemical structure](image)

**Method B:** The reaction of Cu(OAc)₂ (363.8 mg, 2 mmol), n-C₈H₁₇NH₂ (128.5 mg, 1 mmol), and PhCN (5 mL) afforded 3h³ (166.9 mg, 50%) (eluent: petroleum ether/ethyl acetate = 15/1): oil; ¹H NMR (300 MHz, CDCl₃) δ 8.18 (d, J = 7.8 Hz, 2
H, ArH), 7.67-7.60 (m, 2 H, ArH), 7.53-7.30 (m, 6 H, ArH), 4.19 (t, J = 7.4 Hz, 2 H, NCH₂), 2.00-1.83 (m, 2 H, CH₂), 1.38-1.07 (m, 10 H, -(CH₂)₅-), 0.85 (t, J = 6.5 Hz, 3 H, CH₃); ¹³C NMR (CDCl₃, 75 MHz) δ 161.0, 155.4, 131.1, 129.8, 128.9, 128.7, 128.4, 126.2, 49.1, 31.6, 30.0, 28.9, 28.8, 26.3, 22.5, 13.9; IR (neat) 2926, 2855, 1519, 1476, 1442, 1354, 1133, 1071 cm⁻¹; MS (EI) (m/z) 334 ((M+1)⁺, 3.84), 333 (M⁺, 17.96), 221 (100).

**Method A:** The reaction of Cu(OAc)₂ (363.4 mg, 2 mmol), n-C₈H₁₇NH₂ (128.9 mg, 1 mmol), and PhCN (2 mL) afforded 3h (143.6 mg, 43%) (eluent: petroleum ether/ethyl acetate = 10/1): oil; ¹H NMR (300 MHz, CDCl₃) δ 8.22-8.14 (m, 2 H, ArH), 7.69-7.60 (m, 2 H, ArH), 7.55-7.30 (m, 6 H, ArH), 4.20 (t, J = 7.4 Hz, 2 H, NCH₂), 2.00-1.84 (m, 2 H, CH₂), 1.38-1.15 (m, 10 H, -(CH₂)₅-), 0.86 (t, J = 6.8 Hz, 3 H, CH₃).

9. 1-Dodecyl-3,5-diphenyl-1H-1,2,4-triazole (3i) (cb-9-131)

**Method B:** The reaction of Cu(OAc)₂ (363.4 mg, 2 mmol), n-C₁₂H₂₅NH₂ (185.7 mg, 1 mmol), and PhCN (5 mL) afforded 3i (214.7 mg, 55%) (eluent: petroleum ether/ethyl acetate = 10/1): oil; ¹H NMR (300 MHz, CDCl₃) δ 8.17 (d, J = 7.5 Hz, 2 H, ArH), 7.72-7.60 (m, 2 H, ArH), 7.58-7.30 (m, 6 H, ArH), 4.20 (t, J = 7.2 Hz, 2 H, NCH₂), 2.00-1.82 (m, 2 H, CH₂), 1.38-1.12 (m, 18 H, -(CH₂)₉-), 0.86 (t, J = 6.0 Hz, 3 H, CH₃).
H, CH₃); ¹³C NMR (CDCl₃, 75 MHz) δ 161.1, 155.5, 131.2, 129.9, 128.9, 128.81, 128.79, 128.4, 126.3, 49.2, 31.8, 30.1, 29.5, 29.4, 29.34, 29.27, 28.9, 26.4, 22.6, 14.1;
IR (neat) 2924, 2853, 1464, 1442, 1354, 1018 cm⁻¹; MS (EI) (m/z) 390 ([M+1]+, 5.76), 389 (M⁺, 19.41), 221 (100); HRMS calcd for C₂₆H₃₅N₃ (M⁺): 389.2831, found: 389.2832.

10. 1-Benzyl-3,5-di(m-tolyl)-1H-1,2,4-triazole (3j) (cb-11-68, kjq-2-55)

Method A: The reaction of Cu(OAc)₂ (363.4 mg, 2 mmol), BnNH₂ (107.1 mg, 1 mmol), and m-MeC₆H₄CN (2 mL) afforded 3j (163.8 mg, 48%) (eluent: petroleum ether/ethyl acetate = 15/1): oil; ¹H NMR (300 MHz, CDCl₃) δ 8.10-7.95 (m, 2 H, ArH), 7.46 (s, 1 H, ArH), 7.39-7.15 (m, 10 H, ArH), 5.40 (s, 2 H, NCH₂), 2.38 (s, 3 H, Me), 2.33 (s, 3 H, Me); ¹³C NMR (CDCl₃, 75 MHz) δ 161.4, 156.0, 138.5, 138.0, 136.0, 130.7, 129.8, 129.4, 128.6, 128.5, 128.3, 127.71, 127.67, 126.8, 126.6, 125.4, 123.4, 52.5, 21.19, 21.14; IR (neat) 1611, 1592, 1512, 1496, 1452, 1433, 1358, 1339, 1301, 1262, 1143 cm⁻¹; MS (EI) (m/z) 340 ([M+1]+, 23.42), 339 (M⁺, 94.69), 91 (100); HRMS calcd for C₂₃H₂₁N₃ (M⁺): 339.1735, found: 339.1736.
Method B: The reaction of Cu(OAc)$_2$ (362.7 mg, 2 mmol), BnNH$_2$ (107.4 mg, 1 mmol), and $m$-MeC$_6$H$_4$CN (5 mL) afforded 3j (126.9 mg, 37%) (eluent: petroleum ether/ethyl acetate = 15/1): oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.03 (s, 1 H, ArH), 7.99 (d, $J$ = 7.6 Hz, 1 H, ArH), 7.47 (s, 1 H, ArH), 7.39-7.27 (m, 7 H, ArH), 7.24-7.19 (m, 3 H, ArH), 5.45 (s, 2 H, NCH$_2$), 2.42 (s, 3 H, Me), 2.38 (s, 3 H, Me).

11. 1-Benzyl-3,5-bis(4-fluorophenyl)-1H-1,2,4-triazole (3k) (cb-12-66, kjq-2-56)

Method A: The reaction of Cu(OAc)$_2$ (363.1 mg, 2 mmol), BnNH$_2$ (107.0 mg, 1 mmol), and $p$-FC$_6$H$_4$CN (2 mL) afforded 3k (150.1 mg, 43%) (eluent: petroleum ether/ethyl acetate = 30/1 to 15/1 for twice): solid, 165-166 $^\circ$C (Et$_2$O/petroleum ether); $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.20-8.11 (m, 2 H, ArH), 7.66-7.56 (m, 2 H, ArH), 7.40-7.28 (m, 3 H, ArH), 7.24-7.05 (m, 6 H, ArH), 5.42 (s, 2 H, NCH$_2$); $^{13}$C NMR (CDCl$_3$, 75 MHz) $\delta$ 163.8 (d, $J$ = 249.9 Hz), 163.5 (d, $J$ = 247.1 Hz), 160.8, 155.2, 135.8, 130.8 (d, $J$ = 9.2 Hz), 129.0, 128.3 (d, $J$ = 8.0 Hz), 128.1, 127.1 (d, $J$ = 3.0 Hz), 126.7, 124.0 (d, $J$ = 3.2 Hz), 116.1 (d, $J$ = 22.0 Hz), 115.5 (d, $J$ = 21.2 Hz), 52.8; $^{19}$F NMR (CDCl$_3$, 282 MHz) $\delta$-109.4, -112.1; IR (neat) 1600, 1543, 1527, 1494,
1474, 1456, 1439, 1426, 1363, 1339, 1318, 1290, 1215, 1157, 1126, 1096, 1077, 1030, 1014 cm\(^{-1}\); MS (EI) (\(m/z\)) 347 ((M\(^+\)), 41.56), 91 (100); elemental analysis calcd (%) for C\(_{21}\)H\(_{15}\)N\(_3\)F\(_2\): C 72.61, H 4.35, N 12.10; found: C 72.63, H 4.47, N 11.97.

**Method B:** The reaction of Cu(OAc)\(_2\) (363.5 mg, 2 mmol), BnNH\(_2\) (107.1 mg, 1 mmol), and \(p\)-FC\(_6\)H\(_4\)CN (5 mL) afforded 3k (142.4 mg, 41%) (eluent: petroleum ether to petroleum ether/ethyl acetate = 30/1): solid; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.23-8.10 (m, 2 H, ArH), 7.65-7.55 (m, 2 H, ArH), 7.41-7.29 (m, 3 H, ArH), 7.24-7.05 (m, 6 H, ArH), 5.43 (s, 2 H, NCH\(_2\)).

12. 1-Octyl-3,5-bis(4-fluorophenyl)-1H-1,2,4-triazole (3l) (cb-12-68, kjq-2-58)

**Method A:** The reaction of Cu(OAc)\(_2\) (363.2 mg, 2 mmol), \(n\)-C\(_8\)H\(_{17}\)NH\(_2\) (129.1 mg, 1 mmol), and \(p\)-FC\(_6\)H\(_4\)CN (2 mL) afforded 3l (186.4 mg, 50%) (eluent: petroleum ether/ethyl acetate = 30/1 to 15/1 for twice): solid, 56-58 °C (petroleum ether/Et\(_2\)O); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 8.20-8.10 (m, 2 H, ArH), 7.69-7.58 (m, 2 H, ArH), 7.41-7.29 (m, 3 H, ArH), 7.24-7.05 (m, 6 H, ArH), 4.16 (t, \(J = 7.5\) Hz, 2 H, NCH\(_2\) ), 2.00-1.85 (m, 2 H, CH\(_2\) ), 1.40-1.12 (m, 10 H, (CH\(_2\))\(_5\)), 0.86 (t, \(J = 6.9\) Hz, 3 H, CH\(_3\) ); \(^{13}\)C NMR (CDCl\(_3\),
75 MHz) δ 163.6 (d, \(J = 249.2\) Hz), 163.3 (d, \(J = 246.4\) Hz), 160.3, 154.5, 130.8 (d, \(J = 8.4\) Hz), 128.1 (d, \(J = 8.2\) Hz), 127.3 (d, \(J = 2.8\) Hz), 124.4 (d, \(J = 4.0\) Hz), 116.0 (d, \(J = 21.3\) Hz), 115.4 (d, \(J = 21.7\) Hz), 49.2, 31.6, 29.9, 28.9, 28.8, 26.3, 22.5, 13.9; \(^{19}\)F NMR (CDCl\(_3\), 282 MHz) –109.8, -112.4; IR (neat) 2948, 2922, 2869, 2851, 1603, 1543, 1529, 1479, 1467, 1428, 1416, 1377, 1347, 1311, 1224, 1211, 1163, 1151, 1130, 1099, 1090, 1033 cm\(^{-1}\); MS (EI) (m/z) 370 ((M+1)+, 9.85), 369 (M+, 41.03), 257 (100); elemental analysis calcd (%) for C\(_{22}\)H\(_{25}\)F\(_2\)N\(_3\): C 71.52, H 6.82, N 11.37; found: C 71.49, H 6.75, N 11.27.

**Method B:** The reaction of Cu(OAc)\(_2\) (362.6 mg, 2 mmol), \(n\)-C\(_8\)H\(_{17}\)NH\(_2\) (128.6 mg, 1 mmol), and \(p\)-FC\(_6\)H\(_4\)CN (5 mL) afforded 3l (168.4 mg, 46%) (eluent: petroleum ether/ethyl acetate = 100/1 to 20/1 for the first round, petroleum ether/ethyl acetate = 30/1 to 15/1 for the second round): solid; \(^1\)H NMR (400 MHz, CDCl\(_3\)) δ 8.18-8.09 (m, 2 H, ArH), 7.70-7.60 (m, 2 H, ArH), 7.22 (t, \(J = 8.6\) Hz, 2 H, ArH), 7.12 (t, \(J = 8.8\) Hz, 2 H, ArH), 4.18 (t, \(J = 7.4\) Hz, 2 H, NCH\(_2\)), 1.97-1.86 (m, 2 H, CH\(_2\)), 1.34-1.15 (m, 10 H, (CH\(_2\))\(_5\)), 0.86 (t, \(J = 7.0\) Hz, 3 H, CH\(_3\)).

13. 1-Octyl-3,5-di\((p\)-toyl\))-1\(H\)-1,2,4-triazole (3m) (cb-12-67, kjq-2-59)
Method A: The reaction of Cu(OAc)₂ (363.4 mg, 2 mmol), \( n-C₈H₁₇NH₂ \) (128.7 mg, 1 mmol), and \( p-\text{MeC}_₆H₄CN \) (2 mL) afforded \( 3m \) (193.2 mg, 54%) (eluent: petroleum ether/ethyl acetate = 15/1): solid, 81-82 °C (n-hexane/Et₂O); \(^1\)H NMR (300 MHz, CDCl₃) δ 8.05 (d, \( J = 8.1 \) Hz, 2 H, ArH), 7.54 (d, \( J = 8.4 \) Hz, 2 H, ArH), 7.30 (d, \( J = 7.8 \) Hz, 2 H, ArH), 7.23 (d, \( J = 8.1 \) Hz, 2 H, ArH), 4.17 (t, \( J = 7.4 \) Hz, 2 H, NCH₂), 2.41 (s, 3 H, ArCH₃), 2.37 (s, 3 H, ArCH₃), 2.00-1.84 (m, 2 H, CH₂), 1.35-1.11 (m, 10 H, \((\text{CH₂})₅\)), 0.86 (t, \( J = 6.9 \) Hz, 3 H, CH₃); \(^{13}\)C NMR (CDCl₃, 75 MHz) δ 161.0, 155.4, 139.9, 138.7, 129.4, 129.1, 128.6, 128.4, 126.2, 125.5, 49.1, 31.6, 30.0, 29.0, 28.9, 26.3, 22.5, 21.3, 14.0; IR (neat) 2953, 2929, 2867, 2851, 1615, 1467, 1426, 1413, 1393, 1373, 1346, 1316, 1299, 1280, 1237, 1207, 1178, 1130, 1110, 1034, 1017 cm⁻¹; MS (EI) \((m/z) 362 \) ([M⁺], 17.39), \( 361 \) (M⁺, 68.22), 262 (100); elemental analysis calcd (%) for \( C₂₄H₃₁N₃ \): C 79.73, H 8.64, N 11.62 ; found: C 79.40, H 8.61, N 11.49.

Method B: The reaction of Cu(OAc)₂ (364.4 mg, 2 mmol), \( n-C₈H₁₇NH₂ \) (128.8 mg, 1 mmol), and \( p-\text{MeC}_₆H₄CN \) (5 mL) afforded \( 3m \) (141.1 mg, 39%) (eluent: petroleum ether/ethyl acetate = 15/1): solid; \(^1\)H NMR (400 MHz, CDCl₃) δ 8.05 (d, \( J \)
= 8.0 Hz, 2 H, ArH), 7.55 (d, J = 8.4 Hz, 2 H, ArH), 7.31 (d, J = 8.4 Hz, 2 H, ArH),
7.24 (d, J = 8.0 Hz, 2 H, ArH), 4.19 (t, J = 7.4 Hz, 2 H, NCH2), 2.43 (s, 3 H, ArCH3),
2.39 (s, 3 H, ArCH3), 1.96-1.86 (m, 2 H, CH2), 1.34-1.15 (m, 10 H, (CH2)5), 0.86 (t, J
= 7.0 Hz, 3 H, CH3).

14. 1-Octyl-3,5-bis(2-fluorophenyl)-1H-1,2,4-triazole (3n) (kjq-2-103)

Method B: The reaction of Cu(OAc)2 (363.1 mg, 2 mmol), n-C8H17NH2 (128.6
mg, 1 mmol), and o-FC6H4CN (5 mL) afforded 3n (154.0 mg, 42%) (eluent:
petroleum ether/ethyl acetate = 30/1 to 15/1): oil; 1H NMR (400 MHz, CDCl3) δ
8.13 (td, J = 7.6, 1.9 Hz, 1 H, ArH), 7.61 (td, J = 7.2, 1.5 Hz, 1 H, ArH), 7.56-7.49 (m,
1 H, ArH), 7.41-7.27 (m, 2 H, ArH), 7.27-7.15 (m, 3 H, ArH), 4.13 (t, J = 7.4 Hz, 2 H,
NCH2), 1.95-1.85 (m, 2 H, CH2), 1.32-1.13 (m, 10 H, (CH2)5), 0.85 (t, J = 7.0 Hz, 3 H,
CH3); 13C NMR (CDCl3, 150 MHz) δ 160.3 (d, J = 251.9 Hz), 159.7 (d, J = 248.9 Hz),
158.2 (d, J = 4.7 Hz), 150.4 (d, J = 0.9 Hz), 132.4 (d, J = 9.0 Hz), 132.0 (d, J = 2.1
Hz), 130.5 (d, J = 8.7 Hz), 130.2 (d, J = 2.9 Hz), 124.7 (d, J = 3.8 Hz), 124.0 (d, J =
3.2 Hz), 119.1 (d, J = 11.7 Hz), 116.6 (d, J = 15.0 Hz), 116.4 (d, J = 21.6 Hz), 116.2
(d, J = 21.1 Hz), 49.4 (d, J = 3.3 Hz), 31.6, 29.7, 29.0, 28.9, 26.4, 22.5, 14.0; 19F
NMR (CDCl3, 376 MHz) -113.1, -113.3; IR (neat) 2927, 2856, 1622, 1585, 1517,
1483, 1471, 1413, 1344, 1263, 1226, 1157, 1135, 1094, 1034, 1020 cm⁻¹; MS (EI)
(m/z) 370 ((M+1)+, 6.02), 369 (M+, 19.67), 257 (100); HRMS calcd for C22H25F2N3

15. 1-Benzyl-3,5-bis(3-methoxyphenyl)-1H-1,2,4-triazole (3o) (kJq-2-67)

\[
\begin{align*}
\text{BnNH}_2 & \quad \text{Cu(OAc)}_2 \text{ (2 equiv)} \\
1a & \quad m-\text{MeOC}_6\text{H}_4\text{CN} \\
\text{120 °C (MW)} & \quad 0.5 \text{ h, 30%}
\end{align*}
\]

Method B: The reaction of Cu(OAc)_2 (363.4 mg, 2 mmol), BnNH_2 (107.9 mg, 1 mmol), and m-\text{MeOC}_6\text{H}_4\text{CN} (5 mL) afforded 3o (112.8 mg, 30%) (eluent: petroleum ether/ethyl acetate = 50/1 to 10/1 to 5/1): oil; \(^1\)H NMR (400 MHz, CDCl_3) \(\delta\) 7.80 (d, \(J = 7.6\) Hz, 1 H, ArH), 7.75 (s, 1 H, ArH), 7.38-7.26 (m, 5 H, ArH), 7.24-7.15 (m, 3 H, ArH), 7.15-7.12 (m, 1 H, ArH), 7.01 (dd, \(J = 8.2, 2.2\) Hz, 1 H, ArH), 6.96 (dd, \(J = 8.4, 2.4\) Hz, 1 H, ArH), 5.46 (s, 2 H, NCH_2), 3.87 (s, 3 H, OMe), 3.74 (s, 3 H, OMe); \(^{13}\)C NMR (CDCl_3, 100 MHz) \(\delta\) 161.4, 159.8, 159.7, 155.9, 136.1, 132.3, 129.9, 129.6, 129.1, 128.8, 127.9, 126.7, 120.9, 118.9, 116.6, 115.8, 113.7, 110.9, 55.4, 55.3, 52.7; IR (neat) 1584, 1514, 1465, 1433, 1339, 1317, 1283, 1262, 1242, 1222, 1182, 1142, 1113, 1077, 1030 cm\(^{-1}\); MS (EI) (m/z) 372 ((M+1)+, 25.21), 371 (M+, 100); HRMS calcd for C_{23}H_{21}N_3O_2 (M\(^+\)): 371.1634, found: 371.1638.

16. 1-Benzyl-3,5-bis(4-(trifluoromethyl)phenyl)-1H-1,2,4-triazole (3p) (kJq-2-65)

\[
\begin{align*}
\text{BnNH}_2 & \quad \text{Cu(OAc)}_2 \text{ (2 equiv)} \\
1a & \quad \rho-\text{CF}_3\text{C}_6\text{H}_4\text{CN} \\
\text{120 °C (MW)} & \quad 0.5 \text{ h, 28%}
\end{align*}
\]

Method B: The reaction of Cu(OAc)_2 (363.1 mg, 2 mmol), BnNH_2 (107.5 mg, 1
mmol), and \( p\)-CF\(_2\)C\(_6\)H\(_4\)CN (6.3962 g) afforded \( 3\) (126.5 mg, 28%) (elu: petroleum ether/ethyl acetate = 100/1 to 20/1): white solid, 151-153 °C (petroleum ether & ethyl acetate); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.31 (d, \( J = 8.4 \) Hz, 2 H, ArH), 7.79-7.69 (m, 6 H, ArH), 7.41-7.31 (m, 3 H, ArH), 7.24-7.19 (m, 2 H, ArH), 5.49 (s, 2 H, NCH\(_2\)); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz) \( \delta \) 160.6, 155.0, 135.4, 134.1, 132.3 (q, \( J = 32.7 \) Hz), 131.2, 131.1 (q, \( J = 32.0 \) Hz), 129.2, 129.1, 128.3, 126.68, 126.65, 125.9 (q, \( J = 3.7 \) Hz), 125.6 (q, \( J = 3.8 \) Hz), 124.1 (q, \( J = 270.7 \) Hz), 123.6 (q, \( J = 271.2 \) Hz), 53.1; \(^{19}\)F NMR (CDCl\(_3\), 376 MHz) -63.1, -63.4; IR (neat) 1620, 1535, 1466, 1424, 1359, 1324, 1165, 1064, 1015 cm\(^{-1}\); MS (EI) (m/z) 448 ((M+1)+, 5.15), 447 (M+, 21.33), 91 (100); elemental analysis calcd (%) for C\(_{23}\)H\(_{15}\)N\(_3\)F\(_6\): C 61.75, H 3.38, N 9.39; found: C 61.38, H 3.44, N 9.18.

17. 1-Benzyl-3,5-bis(4-chlorophenyl)-1H-1,2,4-triazole (3q) (kJq-2-69)

![Diagram](image)

**Method B**: The reaction of Cu(OAc)\(_2\) (364.2 mg, 2 mmol), BnNH\(_2\) (106.0 mg, 1 mmol), and \( p\)-ClC\(_6\)H\(_4\)CN (5.5560 g) afforded 3q (170.6 mg, 45%) (elu: petroleum ether/ethyl acetate = 100/1 to 20/1): white solid, 172-174 °C (petroleum ether & ethyl acetate); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.11 (d, \( J = 8.4 \) Hz, 2 H, ArH), 7.55 (d, \( J = 8.0 \) Hz, 2 H, ArH), 7.50-7.26 (m, 7 H, ArH), 7.20 (d, \( J = 7.2 \) Hz, 2 H, ArH), 5.44 (s, 2 H, NCH\(_2\)); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz) \( \delta \) 160.7, 155.1, 136.5, 135.6, 135.1, 130.0, 129.3, 129.1, 129.0, 128.7, 128.1, 127.7, 126.6, 126.2, 52.8; IR (neat) 1601,
1495, 1470, 1455, 1422, 1409, 1361, 1342, 1316, 1295, 1275, 1240, 1203, 1172, 1126, 1090, 1033, 1014 cm⁻¹; MS (EI) (m/z) 383 (M⁺(37Cl37Cl), 4.33), 381 (M⁺(37Cl35Cl), 23.84), 379 (M⁺(35Cl35Cl), 36.56), 91 (100); elemental analysis calcd (%) for C21H15N3Cl2: C 66.33, H 3.98, N 11.05; found: C 66.27, H 3.95, N 10.92.

18. Dimethyl 4,4′-(1-benzyl-1H-1,2,4-triazole-3,5-diyl)dibenzoate (3r) (kjq-2-70)

\[
\begin{align*}
&\text{BnNH}_2 \quad \text{Cu(OAc)}_2 (2 \text{ equiv}) \\
&\quad \text{Cu(OAc)}_2(2 \text{ equiv}) \\
&\quad \text{120 °C (MW)} \\
&\quad 0.5 \text{h, 12%} \\
&\quad \text{petroleum ether/ethyl acetate = 50/1 to 5/1 for the first round, petroleum ether/ethyl acetate = 20/1 to 5/1 for the second round): white solid, 157-159 °C (petroleum ether & ethyl acetate); } \\
&\text{1H NMR (400 MHz, CDCl}_3\text{)} \delta 8.27 (d, J = 8.8 Hz, 2 H, ArH), 8.16-8.10 (m, 4 H, ArH), 7.72 (d, J = 8.4 Hz, 2 H, ArH), 7.39-7.29 (m, 3 H, ArH), 7.24-7.18 (m, 2 H, ArH), 5.49 (s, 2 H, NCH2), 3.95 (s, 3 H, Me), 3.94 (s, 3 H, Me); \text{13C NMR (CDCl}_3\text{, 100 MHz)} \delta 166.8, 166.2, 160.8, 155.3, 135.4, 134.9, 131.8, 131.7, 130.6, 130.0, 129.9, 129.0, 128.8, 128.2, 126.7, 126.3, 53.1, 52.4, 52.1; \text{IR (neat) 1713, 1611, 1577, 1532, 1494, 1476, 1455, 1431, 1362, 1272, 1190, 1135, 1110, 1016 cm}^{-1}; \text{MS (EI) (m/z) 428 ((M+1)^{\text{+}}, 20.76), 427 (M^{\text{+}}, 69.87), 91 (100); elemental analysis calcd (% for C}_{25}H_{21}N_{3}O_{4}: C 70.25, H 4.95, N 9.83; found: C 70.00, H 5.05, N 9.65.}
\end{align*}
\]

19. 1-Benzyl-3,5-bis(4-methoxyphenyl)-1H-1,2,4-triazole (3s) (kjq-2-71)
Method B: The reaction of Cu(OAc)$_2$ (364.0 mg, 2 mmol), BnNH$_2$ (107.0 mg, 1 mmol), and $p$-MeOC$_6$H$_4$CN (5.3978 g) afforded 3s (47.3 mg, 13%) (eluent: petroleum ether/ethyl acetate = 50/1 to 5/1 for the first round, petroleum ether/ethyl acetate = 20/1 to 5/1 for the second round): white solid, 130-132 °C (petroleum ether & ethyl acetate); $^1$H NMR (400 MHz, CDCl$_3$) δ 8.12 (d, $J = 8.8$ Hz, 2 H, ArH), 7.55 (d, $J = 8.8$ Hz, 2 H, ArH), 7.37-7.25 (m, 3 H, ArH), 7.23-7.16 (m, 2 H, ArH), 7.00-6.91 (m, 4 H, ArH), 5.42 (s, 2 H, NCH$_2$), 3.83 (s, 3 H, Me), 3.82 (s, 3 H, Me); $^{13}$C NMR (CDCl$_3$, 150 MHz) δ 161.3, 160.9, 160.4, 155.9, 136.3, 130.2, 128.8, 127.82, 127.81, 126.7, 123.9, 120.4, 114.2, 113.8, 55.3, 55.2, 52.5; IR (neat) 1611, 1580, 1531, 1478, 1466, 1418, 1345, 1298, 1260, 1246, 1175, 1167, 1144, 1133, 1103, 1026, 1006 cm$^{-1}$; MS (EI) ($m/z$) 372 ((M+1)$^+$, 24.29), 371 (M$^+$, 100); elemental analysis calcd (%) for C$_{23}$H$_{21}$N$_3$O$_2$: C 74.37, H 5.70, N 11.31; found: C 74.10, H 5.55, N 11.11.

20. 1-Benzyl-3,5-bis(3-iodophenyl)-1$H$-1,2,4-triazole (3t) (kjq-2-73)

Method B: The reaction of Cu(OAc)$_2$ (363.4 mg, 2 mmol), BnNH$_2$ (107.0 mg, 1 mmol), and $m$-IC$_6$H$_4$CN (5.3978 g) afforded 3t (85.1 mg, 20%) (eluent: petroleum ether/ethyl acetate = 50/1 to 5/1): white solid, 120-122 °C (petroleum ether & ethyl acetate); $^1$H NMR (400 MHz, CDCl$_3$) δ 8.11 (d, $J = 8.8$ Hz, 2 H, ArH), 7.55 (d, $J = 8.8$ Hz, 2 H, ArH), 7.37-7.25 (m, 3 H, ArH), 7.23-7.16 (m, 2 H, ArH), 7.00-6.91 (m, 4 H, ArH), 5.42 (s, 2 H, NCH$_2$), 3.83 (s, 3 H, Me), 3.82 (s, 3 H, Me); $^{13}$C NMR (CDCl$_3$, 150 MHz) δ 161.3, 160.9, 160.4, 155.9, 136.3, 130.2, 128.8, 127.82, 127.81, 126.7, 123.9, 120.4, 114.2, 113.8, 55.3, 55.2, 52.5; IR (neat) 1611, 1580, 1531, 1478, 1466, 1418, 1345, 1298, 1260, 1246, 1175, 1167, 1144, 1133, 1103, 1026, 1006 cm$^{-1}$; MS (EI) ($m/z$) 372 ((M+1)$^+$, 24.29), 371 (M$^+$, 100); elemental analysis calcd (%) for C$_{23}$H$_{21}$I$_2$N$_3$: C 67.61, H 5.07, N 11.31; found: C 67.34, H 4.97, N 11.01.
mmol), and $m$-IC$_6$H$_4$CN (6.0035 g) afforded 3t (115.0 mg, 20%) (eluent: petroleum ether/ethyl acetate = 100/1 to 20/1): white solid, 117-119 °C (petroleum ether & ethyl ether); $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.55 (s, 1 H, ArH), 8.14 (d, $J = 7.6$ Hz, 1 H, ArH), 7.98 (s, 1 H, ArH), 7.83 (d, $J = 8.0$ Hz, 1 H, ArH), 7.74 (d, $J = 8.0$ Hz, 1 H, ArH), 7.54 (d, $J = 8.0$ Hz, 1 H, ArH), 7.43-7.29 (m, 3 H, ArH), 7.28-7.14 (m, 4 H, ArH), 5.43 (s, 2 H, NCH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 160.1, 154.5, 139.3, 138.2, 137.6, 135.5, 135.1, 132.7, 130.4, 130.3, 129.6, 129.0, 128.3, 127.7, 126.9, 125.6, 94.43, 94.42, 53.0; IR (neat) 1595, 1565, 1505, 1451, 1439, 1425, 1359, 1329, 1306, 1243, 1150, 1132, 1061, 1032 cm$^{-1}$; MS (EI) ($m$/z) 564 ((M+1)$^+$, 3.92), 563 (M$,^+$, 17.18), 91 (100); elemental analysis calcld (%) for C$_{21}$H$_{15}$N$_3$I$_2$: C 44.79, H 2.68, N 7.46; found: C 44.71, H 2.73, N 7.36.

**Synthesis of N-benzylbenzimidamide 4$^4$(kjq-2-90)**

\[
\begin{align*}
\text{BnNH}_2 + \text{CuCl (1.2 equiv)} & \xrightarrow{\text{PhCN, 80 °C, 19 h, 50%}} \text{Bn}^+\text{HNPh} \\
\end{align*}
\]

To a dried Schlenk tube were added CuCl (1.1911 g, 12 mmol), BnNH$_2$ (1.0724 g, 10 mmol), and PhCN (10 mL) sequentially under Ar atmosphere at room temperature. After being stirred at 80 °C (oil bath) for 19 h, the resulting mixture was cooled to room temperature and poured in 80 mL of Et$_2$O, followed by the addition of 50 mL of NaOH (2 M, aqueous). The resulting mixture was stirred vigorously for 5 min, filtered, extracted with Et$_2$O (2 x 80 mL), and dried over anhydrous Na$_2$SO$_4$. After filtration, a stream of HCl gas was bubbled through the solution forming a solid. The solid was collected by filtration and then dissolved in an aqueous solution of NaOH (1 M). The
resulting mixture was extracted with 3 x 30 mL of Et₂O. Drying over anhydrous Na₂SO₄, filtration, evaporation and column chromatography on silica gel afforded N-benzylbenzimidamide 4 (1.0474 g, 50%) (eluent: petroleum ether/ethyl acetate = 3/1 to ethyl acetate/ triethylamine = 30/1): white solid, 79-81 °C (petroleum ether & ethyl acetate); ¹H NMR (400 MHz, CDCl₃) δ 7.60-7.53 (m, 2 H, ArH), 7.43-7.29 (m, 7 H, ArH), 7.29-7.22 (m, 1 H, ArH), 5.94-5.20 (brs, 2 H, 2 x NH), 4.50 (s, 2 H, CH₂); ¹³C NMR (CDCl₃, 100 MHz) δ 163.0, 138.9, 137.4, 129.8, 128.4, 127.5, 126.9, 125.9, 46.6; IR (neat) 3461, 3307, 3175, 3030, 2849, 2813, 1634, 1597, 1563, 1494, 1454, 1443, 1374, 1346, 1155, 1071, 1026 cm⁻¹; MS (EI) (m/z) 211 ((M+1)+, 7.10), 210 (M+, 51.43), 209 (100); elemental analysis calcd (%) for C₁₄H₁₄N₂: C 79.97, H 6.71, N 13.32; found: C 79.88, H 6.67, N 13.30.

The reaction of 4 with different nitriles:

1. 1-Benzyl-5-phenyl-3-(m-tolyl)-1H-1,2,4-triazole (3u) (kjq-2-89)

![Diagram of reaction](image)

Method B: The reaction of Cu(OAc)₂ (365.0 mg, 2 mmol), 4 (210.9 mg, 1 mmol), and m-MeC₆H₄CN (5 mL) afforded 3j (8.3 mg, 2%) and 3u (117.6 mg, 36%) (eluent: petroleum ether/ethyl acetate = 100/1 to 30/1).

3j: oil; ¹H NMR (400 MHz, CDCl₃) δ 8.03 (s, 1 H, ArH), 7.99 (d, J = 8.0 Hz, 1 H, ArH), 7.47 (s, 1 H, ArH), 7.39-7.27 (m, 7 H, ArH), 7.24-7.19 (m, 3 H, ArH), 5.45 (s, 2 H, NCH₂), 2.42 (s, 3 H, Me), 2.38 (s, 3 H, Me).
3u: white solid; 86-88 °C (petroleum ether & ethyl acetate); \(^1\)H NMR (400 MHz, CDCl\(_3\)) δ 8.03 (s, 1 H, ArH), 7.99 (d, \(J = 7.6\) Hz, 1 H, ArH), 7.65-7.60 (m, 2 H, ArH), 7.52-7.43 (m, 3 H, ArH), 7.38-7.29 (m, 4 H, ArH), 7.24-7.18 (m, 3 H, ArH), 5.46 (s, 2 H, NCH\(_2\)), 2.42 (s, 3 H, Me); \(^13\)C NMR (CDCl\(_3\), 100 MHz) δ 161.6, 156.0, 138.1, 136.0, 130.8, 130.1, 129.9, 128.80, 128.75, 128.7, 128.4, 127.94, 127.85, 127.0, 126.7, 123.5, 52.6, 21.3; IR (neat) 1605, 1510, 1487, 1451, 1406, 1346, 1241, 1214, 1179, 1144, 1121, 1077, 1018 cm\(^{-1}\); MS (EI) (m/z) 326 ((M+1)\(^{+}\), 26.00), 325 (M\(^{+}\), 100); elemental analysis calcd (%) for C\(_{22}\)H\(_{19}\)N\(_3\): C 81.20, H 5.89, N 12.91; found: C 81.01, H 6.01, N 12.65.

2. 1-Benzyl-3-(4-chlorophenyl)-5-phenyl-1\(^H\)-1,2,4-triazole (3v) (kjq-2-94)

![Chemical structure of 3q and 3v](image)

**Method B:** The reaction of Cu(OAc)\(_2\) (362.6 mg, 2 mmol), 4 (211.1 mg, 1 mmol), and p-ClC\(_6\)H\(_4\)CN (5.5022 g) afforded 3q (30.6 mg, 8%) and 3v (163.5 mg, 47%) (eluent: petroleum ether/ethyl acetate = 100/1 to 30/1 for the first round, petroleum ether/ethyl acetate = 30/1 for the second round).

3q: white solid; \(^1\)H NMR (400 MHz, CDCl\(_3\)) δ 8.11 (d, \(J = 8.0\) Hz, 2 H, ArH), 7.55 (d, \(J = 8.4\) Hz, 2 H, ArH), 7.48-7.28 (m, 7 H, ArH), 7.19 (d, \(J = 7.2\) Hz, 2 H, ArH), 5.43 (s, 2 H, NCH\(_2\)).

3v: white solid; 145-147 °C (petroleum ether & ethyl acetate); \(^1\)H NMR (400 MHz, CDCl\(_3\)) δ 8.13 (d, \(J = 8.4\) Hz, 2 H, ArH), 7.65-7.59 (m, 2 H, ArH), 7.53-7.39 (m, 5 H, ArH), 7.39-7.28 (m, 3 H, ArH), 7.24-7.18 (m, 2 H, ArH), 5.45 (s, 2 H, NCH\(_2\)); \(^13\)C
NMR (CDCl$_3$, 100 MHz) $\delta$ 160.5, 156.1, 135.8, 134.9, 130.2, 129.5, 128.80, 128.78, 128.6, 127.9, 127.70, 127.66, 126.7, 52.6; IR (neat) 1601, 1533, 1495, 1467, 1455, 1429, 1417, 1363, 1343, 1318, 1296, 1240, 1203, 1173, 1157, 1126, 1087, 1074, 1018 cm$^{-1}$; MS (El) ($m/z$) 347 (M$^+$(37Cl), 24.67), 345 (M$^+$(35Cl), 70.06), 91 (100); elemental analysis calcd (%) for C$_{21}$H$_{16}$ClN$_3$: C 72.93, H 4.66, N 12.15; found: C 73.08, H 4.99, N 12.00.

3. 1-Benzyl-3-(3-iodophenyl)-5-phenyl-1$H$-1,2,4-triazole (3w) (kjq-2-92)

**Method B:** The reaction of Cu(OAc)$_2$ (364.3 mg, 2 mmol), 4 (209.5 mg, 1 mmol), and $m$-IC$_6$H$_4$CN (5.9982 g) afforded 3t (28.8 mg, 5%) and 3w (203.2 mg, 47%) (eluent: petroleum ether/ethyl acetate = 100/1 to 30/1).

3t: white solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.55 (t, $J$ = 1.6 Hz, 1 H, ArH), 8.14 (dt, $J$ = 7.6, 1.1 Hz, 1 H, ArH), 7.98 (t, $J$ = 1.6 Hz, 1 H, ArH), 7.83 (dt, $J$ = 7.8, 1.3 Hz, 1 H, ArH), 7.74 (dt, $J$ = 8.0, 1.4 Hz, 1 H, ArH), 7.54 (dt, $J$ = 7.8, 1.3 Hz, 1 H, ArH), 7.41-7.30 (m, 3 H, ArH), 7.25-7.15 (m, 4 H, ArH), 5.43 (s, 2 H, NCH$_2$).

3w: white solid; 142-144 °C (petroleum ether & ethyl acetate); $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.56 (s, 1 H, ArH), 8.16 (d, $J$ = 8.0 Hz, 1 H, ArH), 7.73 (d, $J$ = 8.0 Hz, 1 H, ArH), 7.65-7.59 (m, 2 H, ArH), 7.54-7.44 (m, 3 H, ArH), 7.39-7.28 (m, 3 H, ArH), 7.23-7.14 (m, 3 H, ArH), 5.46 (s, 2 H, NCH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 160.0, 156.2, 138.0, 135.8, 135.1, 133.0, 130.3, 130.2, 128.9, 128.8, 128.7, 128.0,
127.7, 126.7, 125.5, 94.4, 52.7; IR (neat) 1594, 1565, 1499, 1467, 1452, 1434, 1394, 1358, 1346, 1286, 1261, 1242, 1145, 1061, 1018 cm⁻¹; MS (EI) (m/z) 438 ((M+1)⁺, 23.93), 437 (M⁺, 98.71), 91 (100); elemental analysis calcd (%) for C₂₁H₁₆I₃N₃: C 57.68, H 3.69, N 9.61; found: C 57.73, H 3.92, N 9.45.

References

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