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FACILE PREPARATION OF 5-ALKYL-1-ARYLTETRAZOLES WITH ARENES, ACYL CHLORIDES, HYDROXYLAMINE, AND DIPHENYLPHOSPHORYL AZIDE

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Abstract – Successive treatment of arenes with acyl chlorides and $AlCl_3$, the addition of water and removal of solvent, the reaction with $NH_2OH•HCl$ and K_2CO_3, and the reaction with diphenylphosphoryl azide and DBU under warming conditions gave the corresponding 5-alkyl-1-aryltetrazoles efficiently in good to moderate yields. The present method is one-pot transformation of arenes into 5-alkyl-1-aryltetrazoles using the Friedel-Crafts acylation and the Beckmann rearrangement under transition-metal-free conditions.

INTRODUCTION

Nitrogen-containing heteroaromatics are very attractive in view of their potent biological activities.[1] In particular, tetrazoles are one of the most important nitrogen-containing five-membered heteroaromatics and the core of some pharmaceuticals.[2] Losartan is a 5-substituted tetrazole bearing antihypertensive activity,[2b-2f] and 1,5-disubstituted tetrazoles also have potent biological activities, as shown in Figure 1.

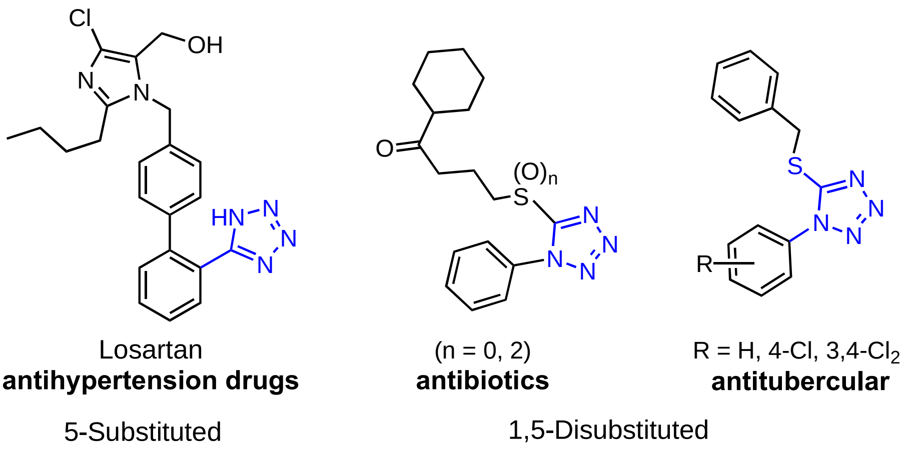
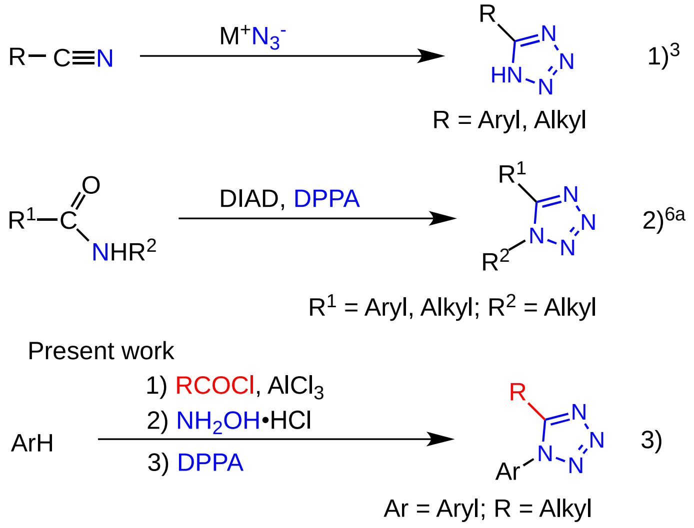


Figure 1. Examples of Biologically Active Substances Bearing Tetrazole Core

Comprehensive synthetic studies of tetrazoles have been carried out.[2a] Most of the 5-substituted tetrazoles are prepared by the reactions of nitriles with metal azides in the presence of acids or transition metals [N_1+N_3], as shown in Scheme 1 (eq. 1), and recent reports of this approach are as follows:[3] the preparation of 5-aryltetrazoles from aromatic nitriles and NaN_3 under microwave irradiation;[3a] the preparation of 5-aryl- and 5-alkyltetrazoles from nitriles and NaN_3 in the presence of $ZnBr_2$,[3b] Cu-Zn alloy nanopowder,[3c] or $Yb(OTf)_3$;[3d] the preparation of 5-aryl- and 5-alkyltetrazoles from nitriles, NaN_3, and AcOH with a high-temperature microreactor;[3e] the preparation of 5-arylsulfanyl- and 5-alkylsulfanyltetrazoles from thiocyanates and NaN_3 in the presence of $ZnCl_2$;[3f] the preparation of 5-aryl- and 5-alkyltetrazoles from nitriles and NaN_3 in the presence of L-proline;[3g] and the preparation of 5-aryl- and 5-alkyltetrazoles from nitriles and Me_3SiN_3 in the presence of Bu_3SnOMe.[3h] The preparation of 5-alkyl- and 5-aryltetrazoles from aldoximes and NaN_3 in the presence of $InCl_3$;[4a] from aldoximes and diphenylphosphoryl azide (DPPA);[4b,4c] and from arylboronic acids and NaN_3 in the presence of pincer-type Pd(II) complex[4d] was also reported. Moreover, the preparation of 5-alkenyltetrazoles from cinnamyl alcohols, Me_3SiN_3, and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) in the presence of $Cu(ClO_4)_2$;[4e] and from allyl ethyl carbonates, *tert*-butyl isocyanide, and Me_3SiN_3 in the presence of $Pd(OAc)_2$[4f] was also reported. The Ugi reaction could also be used for the preparation of 5-(α-amino)alkyltetrazoles from amines, aldehydes, β-cyanoethyl isocyanide, and Me_3SiN_3.[4g] The preparation of 2,5-disubstituted tetrazoles with [N_2+N_2] approach using the sequential reactions of aryldiazonium salts, amidines, and K_2CO_3, followed by the reaction with I_2 and KI;[5a] the sequential reactions of aromatic aldehydes and alkylhydrazines, followed by the reaction with di-*tert*-butyl azodicarboxylate and [bis(trifluoroacetoxy)iodo]benzene;[5b] and the reaction of aryldiazonium salts and α-diazocarbonyl compounds in the presence of $AgNO_3$[5c] was reported.



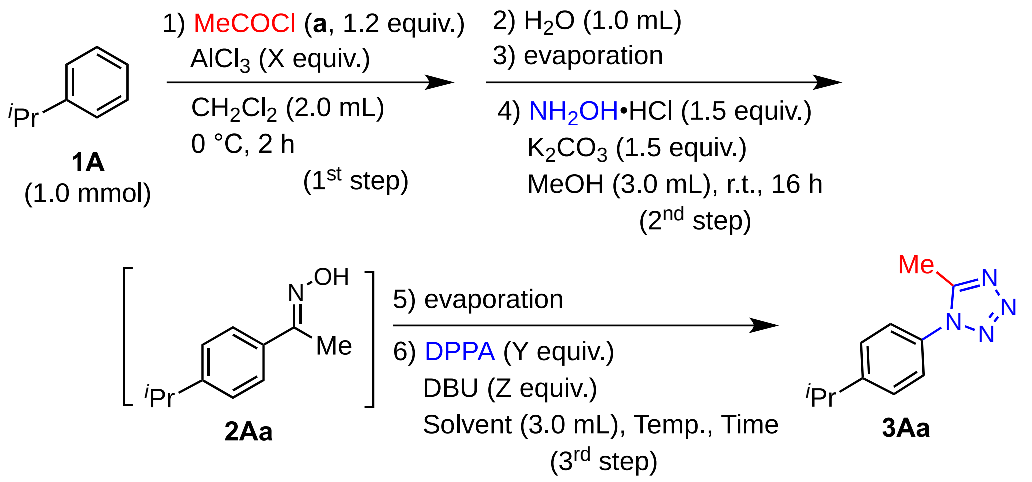
Scheme 1. Preparation of 5-Substituted, and 1,5-Disubstituted Tetrazoles

On the other hand, synthetic studies of 1,5-disubstituted tetrazoles are limited, and recent reports are as follows:[6] the preparation of 1-alkyl-5-aryltetrazoles from secondary amides, diisopropyl azodicarboxylate (DIAD), DPPA, and 2-$PyPh_2P$ (eq. 2 in Scheme 1);[6a] the preparation of 1-aryl-5-(*N*-arylamino)tetrazoles from 1,3-diarylthioureas, I_2, and NaN_3;[6b] the preparation of 1-amino-5-aryltetrazoles from arylhydrazones, Me_3SiN_3, and $PhI(OAc)_2$ in the presence of $Cu(OAc)_2$;[6c] the electrochemical preparation of 1-amino-5-aryltetrazoles from arylhydrazones and Me_3SiN_3;[6d] the preparation of 1,5-dialkyl- and 5-alkyl-1-aryltetrazoles from aldehydes, primary amines, isocyanides, and Me_3SiN_3 under ultrasonic irradiation;[6e,6f] the preparation of 1-alkyl- and 1-aryl-5-aroyltetrazoles from aldehydes, aniline, isocyanides, Me_3SiN_3, and ^{t}BuOOH in the presence of CuBr;[6g] the preparation of oxime forms of 5-acyl-1-alkyltetrazoles from (*Z*)-chlorooximes, isocyanides, and Me_3SiN_3;[6h] the preparation of 1-(2',4'-dimethoxyphenyl)-5-phenyltetrazole from 5-phenyltetrazole and 1,3-dimethoxybenzene in the presence of $[Ru(bpy)_3]Cl_2$ and Selectfluor under blue LED irradiation;[6i] the preparation of 5-alkyl-1-aryltetrazoles from dimethyl alkylidenemalonate, isocyanides, and Me_3SiN_3 in the presence of $Mg(OTf)_2$ and L-$RaPr_2$;[6j] and the preparation of 1,5-dialkyl- and 5-alkyl-1-aryltetrazoles from ketoximes and DPPA.[6k] As mentioned above, various methods for the preparation of 5-substituted tetrazoles are well known (eq. 1). However, methods for the preparation of 5-substituted 1-arytetrazoles, which are one of the 1,5-disubstituted tetrazoles, are quite limited. To the best of our knowledge, the one-pot preparation of 5-substituted 1-aryltetrazoles with arenes through the intermolecular C-C bond formation has not been studied. Here, as part of our synthetic studies of the efficient preparation of heteroaromatics from arenes,[7] we would like to report the preparation of 5-alkyl-1-aryltetrazoles by the reaction of arenes with acyl chloride in the presence of $AlCl_3$ using the Friedel-Crafts acylation, followed by the reaction with $NH_2OH•HCl$, and then DPPA in one pot under transition-metal-free conditions (eq. 3 in Scheme 1).

RESULTS AND DISCUSSION

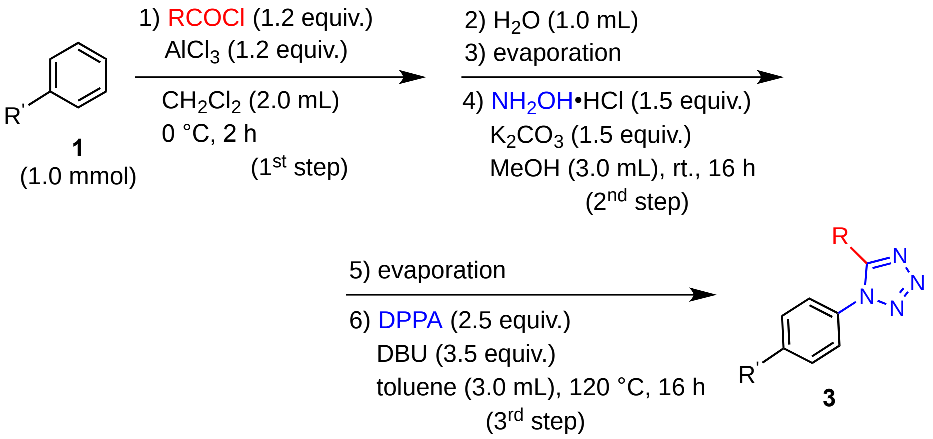
First, treatment of cumene **1A** (1.0 mmol) with acetyl chloride (**a**, 1.2 equiv.) and $AlCl_3$ (1.2 equiv.) in CH_2Cl_2 (2.0 mL) in a 30 mL sealed tube for 2 h at 0 °C (1st step), followed by the addition of cooled water (1.0 mL) and removal of the solvent gave 4-isopropylphenyl methyl ketone. Further reaction of formed 4-isopropylphenyl methyl ketone with $NH_2OH•HCl$ (1.5 equiv.) and K_2CO_3 (1.5 equiv.) in MeOH (3.0 mL) for 16 h at room temperature (2nd step) gave (*E*)-4-isopropylphenyl methyl ketoxime **2Aa** in 78% yield. Based on this result, after the 2nd reaction step starting from cumene **1A** under the same procedure and conditions, removal of the solvent and the reactions of oxime **2Aa** with DPPA (2.5 equiv.) and 1,8-diazabicyclo[5.4.0]-7-undecene (DBU, 3.5 equiv.) in acetonitrile (3.0 mL) and toluene (3.0 mL) for 16 h at 90 °C (3rd step) gave 1-(4'-isopropylphenyl)-5-methyltetrazole **3Aa** in 54% and 57% yields, respectively, as shown in Table 1 (entries 1, 2).

Table 1. Transformation of Cumene **1A** to 1-(4'-Isopropylphenyl)-5-methyltetrazole **3Aa**



Entry	X (equiv.)	Y (equiv.)	Z (equiv.)	Solvent	Temp. (°C)	Time (h)	Yield (%)
1	1.2	2.5	3.5	MeCN	90	16	54
2	1.2	2.5	3.5	toluene	90	16	57
3	**1.2**	**2.5**	**3.5**	**toluene**	**120**	**16**	**60**
4	1.2	2.5	3.5	toluene	130	16	39
5	1.2	2.5	3.5	toluene	120	24	48
6	1.2	1.2	1.2	toluene	120	16	31
7	1.2	4.0	3.5	toluene	120	16	44
8	1.05	2.5	3.5	toluene	120	16	53
9	1.4	2.5	3.5	toluene	120	16	53
10	1.6	2.5	3.5	toluene	120	16	42

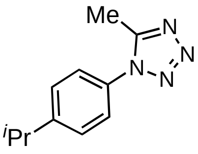
When the 3rd reaction step was carried out in toluene for 16 h at 120 °C, **3Aa** was obtained in 60% yield (entry 3). When the 3rd reaction step was carried out at 130 °C for 16 h, the yield of **3Aa** was decreased to 39% (entry 4). When the reaction time of the 3rd reaction step was prolonged to 24 h, the yield of **3Aa** was decreased to 48% (entry 5). In addition, when the amounts of DPPA and DBU were reduced or increased, the yield of **3Aa** was decreased (entries 6, 7). When the amount of acetyl chloride was changed to 1.05 equiv., 1.4 equiv., and 1.6 equiv. under the same procedure and conditions as those of entry 3, the yield of **3Aa** was again decreased, respectively (entries 8~10). Thus, treatment of cumene **1A** with acetyl chloride (**a**, 1.2 equiv.) and $AlCl_3$ (1.2 equiv.) in CH_2Cl_2 (2.0 mL) for 2 h at 0 °C (1st step), followed by the addition of cooled water (1.0 mL), removal of the solvent, the reaction of the residue with NH_2OH•HCl (1.5 equiv.) and K_2CO_3 (1.5 equiv.) in MeOH (3.0 mL) for 16 h at room temperature (2nd step), removal of the solvent, and finally the reaction with DPPA (2.5 equiv.) and DBU (3.5 equiv.) in toluene (3.0 mL) for 16 h at 120 °C (3rd step) gave 1-(4’-isopropylphenyl)-5-methyltetrazole **3Aa** in the highest yield.



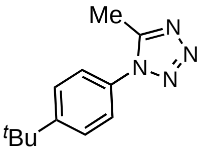
Arene 1 **1A**: ^{i}PrC$_6$H$_5$, **1B**: ^{t}BuC$_6$H$_5$, **1C**: MeOC$_6$H$_5$, **1D**: EtOC$_6$H$_5$, **1E**: PhOC$_6$H$_5$, **1F**: *o*-MeC$_6$H$_4$OMe, **1G**: *p*-MeC$_6$H$_4$OMe, **1H**: 1,2-Methylenedioxybenzene, **1I**: 2,3-Dihydrobenzofuran, **1J**: ClC$_6$H$_5$, **1K**: BrC$_6$H$_5$, **1L**: IC$_6$H$_5$, **1M**: 1-Methylnaphthalene, **1N**: 1-Methoxynaphthalene, **1O**: 2-Ethylthiophene, **1P**: 3-Methylbenzothiophene, **1Q**: MeC$_6$H$_5$

RCOCl **a**: MeCOCl, **b**: EtCOCl, **c**: ^{n}PrCOCl, **d**: ^{i}PrCOCl, **e:** *c*-C$_5$H$_9$COCl, **f**: *c*-C$_6$H$_{11}$COCl, **g**: PhCOCl, **h**: *p*-ClC$_6$H$_4$COCl

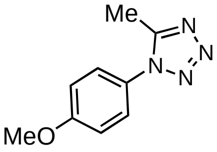
Products, Yields



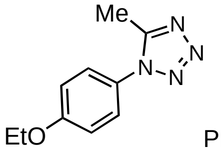
3Aa
60%



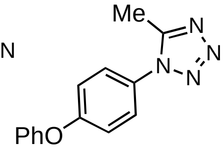
3Ba
64%[a]



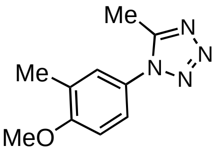
3Ca
72% (64%)[b]



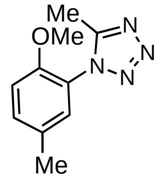
3Da
79%



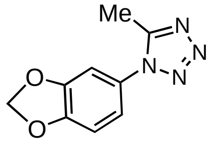
3Ea
71%



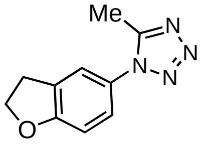
3Fa
57%



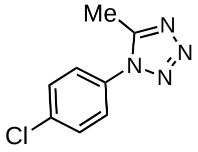
3Ga
55%



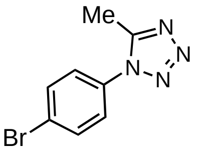
3Ha
47%[c]



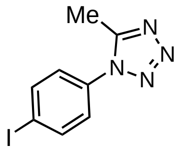
3Ia
68%[d]



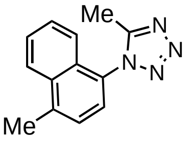
3Ja
38%[e,f1]



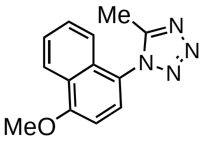
3Ka
48%[e]



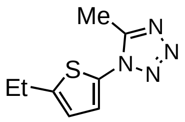
3La
43%[e]



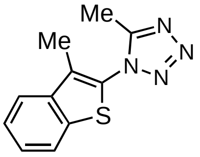
3Ma
60%



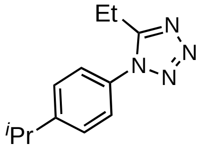
3Na
58%[g]



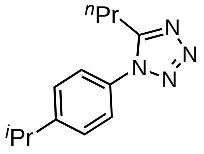
3Oa
67%[h]



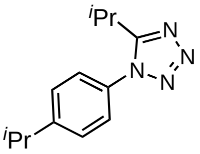
3Pa
46%[a,h]



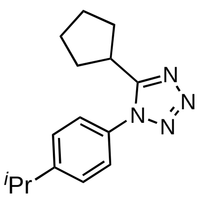
3Ab
72%



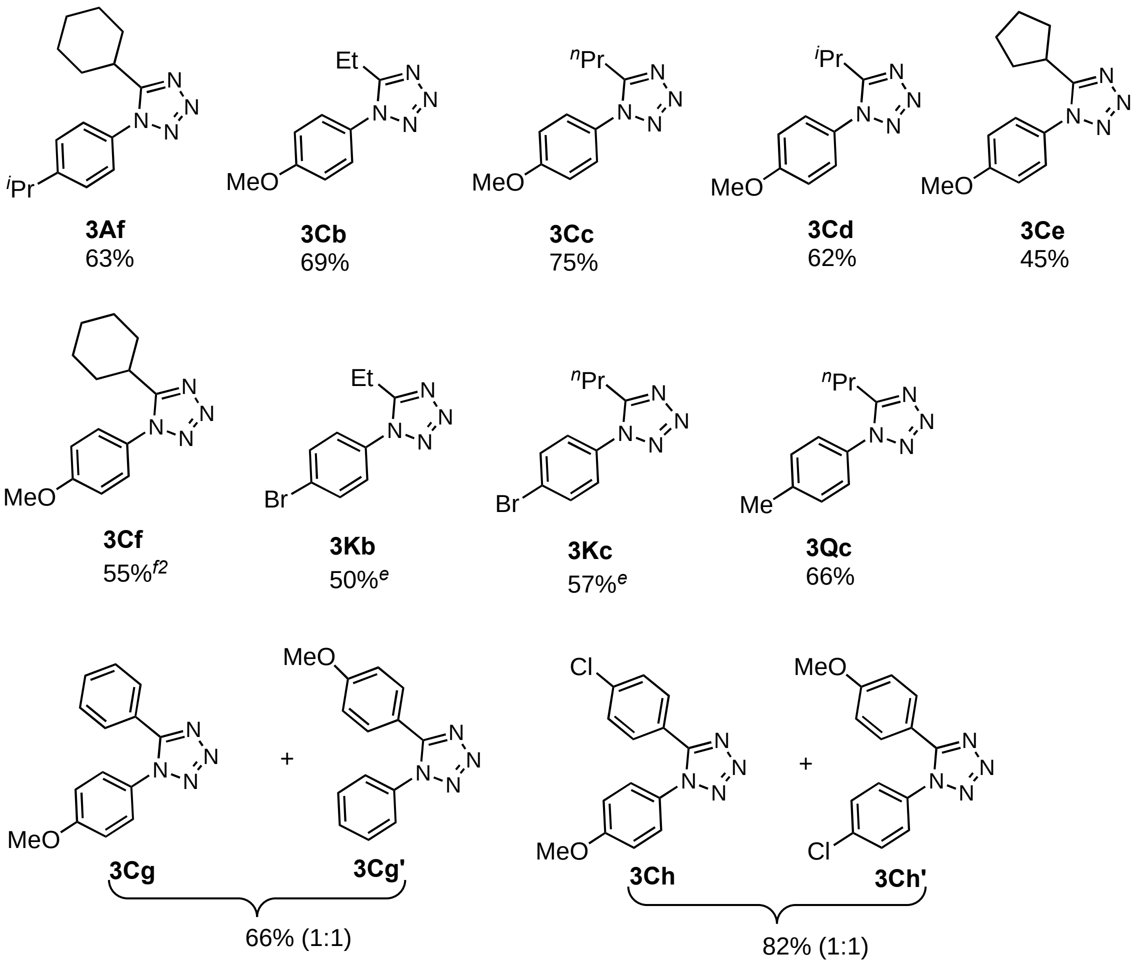
3Ac
85%



3Ad
69%



3Ae
58%



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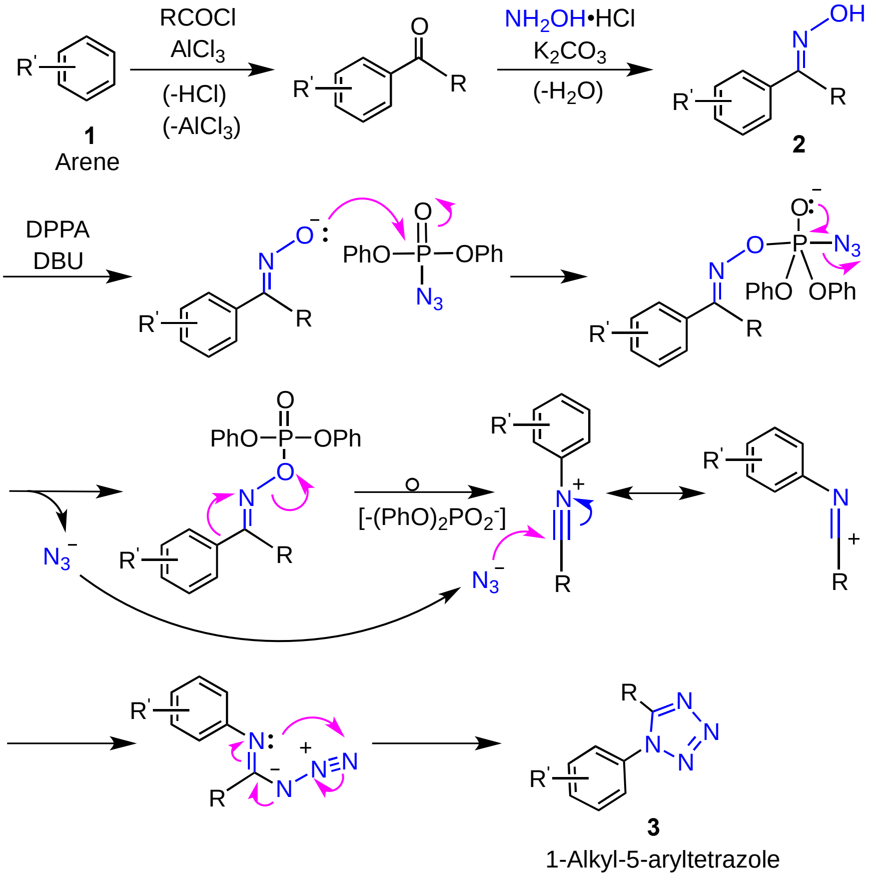
[a] Reaction time for 3rd step was 12 h.
[b] Reaction was carried out with **1C** (10.0 mmol).
[c] 1st step was carried out at -50 °C.
[d] 1st step was carried out at -10 °C.
[e] 1st step was carried out for 24 h at 40 °C.
[f] 2nd step was carried out for ^{1}16 h or ^{2}24 h at 60 °C.
[g] 1st step was carried out for 3 h at room temperature.
[h] 2nd step was carried out at 80 °C.

Scheme 2. Transformation of Arenes **1** into 5-Alkyl-1-aryltetrazoles **3**

Based on those results, the successive treatment of arenes **1** (1.0 mmol), such as *tert*-butylbenzene (**1B**), anisole (**1C**), phenetole (**1D**), diphenyl ether (**1E**), *o*-methylanisole (**1F**), *p*-methylanisole (**1G**), 1,2-methylenedioxybenzene (**1H**), and 2,3-dihydrobenzofuran (**1I**), with acetyl chloride (**a**, 1.2 equiv.) and $AlCl_3$ (1.2 equiv.) in CH_2Cl_2 (2.0 mL) for 2 h at 0 °C (-50 °C for **1H** and -10 °C for **1I**) (1st step), followed by the addition of cooled water, removal of the solvent, and the reaction with NH_2OH•HCl (1.5 equiv.) and K_2CO_3 (1.5 equiv.) for 16 h at room temperature (2nd step), and finally the removal of the solvent and the reaction with DPPA (2.5 equiv.) and DBU (3.5 equiv.) for 16 h at 120 °C (3rd step) gave the corresponding 1-aryl-5-methyltetrazoles **3Ba**~**3Ia** as a single isomer in good to moderate yields, respectively, as shown in Scheme 2. As a gram-scale experiment, anisole (**1C**, 10.0 mmol) was treated in a 100 mL screw-capped flask under the same procedure and conditions to generate

1-(4’-methoxyphenyl)-5-methyltetrazole (**3Ca**) in 64% yield. Treatment of halobenzenes, such as chlorobenzene (**1J**), bromobenzene (**1K**), and iodobenzene (**1L**), which have an electron-deficient aromatic ring, under the same procedure and conditions also generated 1-aryl-5-methyltetrazoles **3Ja**~**3La** bearing halogens at the *para*-position of the aromatic ring in moderate yields, respectively, although the 1st reaction step was carried out for 24 h at 40 °C. 1-Methylnaphthalene (**1M**), 1-methoxynaphthalene (**1N**), 2-ethylthiophene (**1O**), and 3-methylbenzothiophene (**1P**) also reacted under the same procedure and conditions to provide 1-aryl-5-methyltetrazoles **3Ma**~**3Pa** in moderate yields, respectively. On the other hand, the same treatment of cumene (**1A**) and anisole (**1C**) with acyl chlorides, such as propionyl chloride (**b**), butyryl chloride (**c**), isobutyryl chloride (**d**), cyclopentanecarbonyl chloride (**e**), and cyclohexanecarbonyl chloride (**f**), instead of acetyl chloride (**a**) under the same procedure and conditions gave 5-alkyl-1-(4’-isopropylphenyl)tetrazoles **3Ab**~**3Af** and 5-alkyl-1-(4’-methoxyphenyl)tetrazoles **3Cb**~**3Cf** in good to moderate yields, respectively. However, the reaction of cumene (**1A**) with pivaloyl chloride, which has a tertiary alkyl group, under the same procedure and conditions did not generate 5-*tert*-butyl-1-(4’-isopropylphenyl)tetrazole at all because decarbonylation of the formed pivaloyl cation occurred in the 1st reaction step.



Scheme 3. Possible Reaction Pathway

Less reactive bromobenzene (**1K**) could also be transformed into 1-(4'-bromophenyl)-5-ethyltetrazole (**3Kb**) and 1-(4'-bromophenyl)-5-propyltetrazole (**3Kc**) with propionyl chloride (**b**) and butyryl chloride (**c**), respectively, under the same procedure and conditions.

On the other hand, the same treatment of anisole (**1C**) with aroyl chlorides, such as benzoyl chloride (**g**) and *p*-chlorobenzoyl chloride (**h**), instead of acyl chloride generated 1:1 mixtures of two regioisomers **3Cg** / **3Cg'**, and **3Ch** / **3Ch'** in good yields, respectively. This reason comes from that the formed oximes after the 2nd reaction step are a 1:1 mixture of *E*-form and *Z*-form. Therefore, the 1,2-rearrangement reaction occurred in both aryl groups derived from anisole and aroyl chloride in the 2nd reaction step. Thus the present method is suitable for the preparation of 5-alkyl-1-aryltetrazoles.

A possible reaction pathway is shown in Scheme 3. The reaction would proceed through the C-C bond formation of arenes with acyl chlorides by the Friedel-Crafts acylation, the formation of oximes, and the reaction of the oximes with DPPA via the 1,2-aryl rearrangement to generate 5-alkyl-1-aryltetrazoles.

CONCLUSION

Arenes could be successfully transformed into 5-alkyl-1-aryltetrazoles in one pot in good to moderate yields by the treatment with acyl chlorides and $AlCl_3$, followed by the reaction with water, $NH_2OH \cdot HCl$, and K_2CO_3, and then with DPPA under warming conditions. We believe the present method would be useful and efficient because a variety of 5-alkyl-1-aryltetrazoles can be prepared in one pot with easily available arenes and other reagents under transition-metal-free conditions.

EXPERIMENTAL

^{1}H-NMR and ^{13}C-NMR spectra were obtained with JEOL-JNM-ECX400 and JEOL-JNM-ECS400 spectrometers. Chemical shifts were recorded as follows: chemical shift in ppm from internal tetramethylsilane (TMS) on the δ□scale, multiplicity (s = singlet; d = doublet; t = triplet; q = quartet; m = multiplet; br = broad), coupling constant (Hz) and integration. High-resolution mass spectra (HRMS) were recorded by a Thermo Fisher Scientific Exactive Orbitrap mass spectrometer. IR spectra were measured with a JASCO FT/IR-4100 spectrometer. Melting points were determined with a Yamato Melting Point Apparatus Model MP-21. Silica gel 60F_{254} (Merck) was used for TLC and Silica gel 60N (63~210 mesh, Kanto Kagaku Co.) was used for short column chromatography.

Transformation of Cumene 1A into Oxime 2Aa: To a solution of cumene **1A** (1.0 mmol, 120.0 mg) in CH_2Cl_2 (2.0 mL) in a 30 mL sealed tube was added acetyl chloride (1.2 mmol, 85.4 μL) at 0 °C. After flash with argon gas, the mixture was stirred for a few minutes. Anhydrous $AlCl_3$ (1.2 mmol, 161.0 mg) was added and the obtained mixture was stirred for 2 h at 0 °C. Then, the reaction mixture was quenched with cooled water (1.0 mL) and stirred for 0.5 h. After removal of the solvent under reduced pressure, MeOH (3.0 mL), $NH_2OH \cdot HCl$ (1.5 mmol, 107.0 mg), and K_2CO_3 (1.5 mmol, 207.0 mg) were added. After flash with argon gas, the obtained mixture was stirred for 16 h at rt. The reaction mixture was quenched with water (15.0 mL), and the mixture was filtered. The filtrate was extracted with $CHCl_3$ (20.0 mL × 3). Then, the organic layer was dried over Na_2SO_4. After removal of the solvent under reduced pressure, the residue was purified by short column chromatography on silica gel (*n*-hexane/AcOEt (5:1)) to afford (*E*)-4-isopropylphenyl methyl ketoxime **2Aa** in 78% yield (137.5 mg).

(*E*)-4-Isopropylphenyl Methyl Ketoxime (2Aa): Yield: 137.5 mg (78%); white solid; mp 72-73 °C; IR(neat): 3246, 2961, 1608, 1510, 1299, 920, 830 cm^{-1}; ^1H-NMR (400 MHz, $CDCl_3$): δ = 1.26 (d, 6H, *J* = 7.0 Hz), 2.28 (s, 3H), 2.92 (sept, 1H, *J* = 7.0 Hz), 7.24 (d, 2H, *J* = 8.2 Hz), 7.56 (d, 2H, *J* = 8.4 Hz), 8.07 (s, 1H); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 12.3, 23.8, 33.9, 126.0, 126.6, 134.0, 150.2, 155.8; HRMS (ESI): Calcd for $C_{11}H_{16}ON$ $[M+H]^+$ = 178.1226, Found = 178.1226.

Typical Procedure for Transformation of Arenes 1 into 5-Alkyl-1-aryltetrazoles 3: To a solution of cumene **1A** (1.0 mmol, 120.0 mg) in CH_2Cl_2 (2.0 mL) in a 30 mL sealed tube was added acetyl chloride (1.2 mmol, 85.4 µL) at 0 °C. After flash with argon gas, the mixture was stirred for a few minutes. Anhydrous $AlCl_3$ (1.2 mmol, 161.0 mg) was added and the obtained mixture was stirred for 2 h at 0 °C. Then, the reaction mixture was quenched with cooled water (1.0 mL) and stirred for 0.5 h. After removal of the solvent under reduced pressure, MeOH (3.0 mL), $NH_2OH \cdot HCl$ (1.5 mmol, 107.0 mg), and K_2CO_3 (1.5 mmol, 207.0 mg) were added. After flash with argon gas, the obtained mixture was stirred for 16 h at rt. After removal of the solvent under reduced pressure, toluene (3.0 mL), DPPA (2.5 mmol, 0.54 mL), and DBU (3.5 mmol, 0.53 mL) were added to the residue. After flash with argon gas, the mixture was warmed at 120 °C for 16 h. The mixture was cooled to rt and then, sat. $NaHCO_3$ aq. (15.0 mL) was added. The mixture was filtered through Celite, and the filtrate was extracted with AcOEt (20.0 mL ×3). The organic layer was dried over Na_2SO_4. After removal of the solvent under reduced pressure, the residue was purified by short column chromatography on silica gel (*n*-hexane/AcOEt, 3:1-1:3) to afford 1-(4'-isopropylphenyl)-5-methyl-*1H*-tetrazole **3Aa** in 60% yield (121.1 mg).

1-(4'-Isopropylphenyl)-5-methyl-1*H*-tetrazole (3Aa): Yield: 121.1 mg (60%); colorless oil; IR (neat): 2960, 2865, 1507, 1410, 1107, 1084, 839 cm^{-1}; ^1H-NMR (400 MHz, $CDCl_3$): δ = 1.31 (d, 6H, *J* = 7.0 Hz), 2.61 (s, 3H), 3.03 (sept, 1H, *J* = 6.8 Hz), 7.37 (d, 2H, *J* = 8.6 Hz), 7.44 (d, 2H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.6, 23.7, 33.8, 124.4, 127.8, 131.3, 151.4, 151.5; HRMS (ESI): Calcd for $C_{11}H_{15}N_4$ $[M+H]^+$ = 203.1291, Found = 203.1291.

1-(4'-*tert*-Butylphenyl)-5-methyl-1*H*-tetrazole (3Ba): Yield: 137.7 mg (64%); white solid; mp 82-83 °C; IR (neat): 2964, 2867, 1508, 1109, 1083, 837 cm^{-1}; ^1H-NMR (400 MHz, $CDCl_3$): δ = 1.39 (s, 9H), 2.62 (s, 3H), 7.39 (d, 2H, *J* = 8.6 Hz), 7.59 (d, 2H, *J* = 8.6 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.8, 31.2, 34.9, 124.1, 126.8, 131.2, 151.5, 153.8; HRMS (ESI): Calcd for $C_{12}H_{17}N_4$ $[M+H]^+$ = 217.1448, Found = 217.1446.

1-(4'-Methoxyphenyl)-5-methyl-1*H*-tetrazole (3Ca): Yield: 136.8 mg (72%); white solid; mp 82-83 °C (lit.[6k] mp 82-83 °C); IR (neat): 2983, 2856, 1523, 1509, 1254, 1102, 1021, 830 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.58 (s, 3H), 3.90 (s, 3H), 7.07 (d, 2H, *J* = 8.8 Hz), 7.37 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.6, 55.7, 115.0, 126.1, 126.5, 151.7, 160.8; HRMS (ESI): Calcd for $C_9H_{11}ON_4$ $[M+H]^+$ = 191.0927, Found = 191.0929.

1-(4'-Ethoxyphenyl)-5-methyl-1*H*-tetrazole (3Da): Yield: 160.4 mg (79%); white solid; mp 88-89 °C; IR (neat): 2985, 2883, 1509, 1257, 1180, 1102, 1047, 828 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.47 (t, 3H, *J* = 7.0 Hz), 2.58 (s, 3H), 4.11 (q, 2H, *J* = 7.0 Hz), 7.05 (d, 2H, *J* = 9.1 Hz), 7.35 (d, 2H, *J* = 9.1 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.6, 14.6, 64.0, 115.4, 126.0, 126.3, 151.6, 160.2; HRMS (ESI): Calcd for $C_{10}H_{13}ON_4$ $[M+H]^+$ = 205.1084, Found = 205.1086.

5-Methyl-1-(4'-phenoxyphenyl)-1*H*-tetrazole (3Ea): Yield: 178.1 mg (71%); white solid; mp 96-97 °C; IR (neat): 2983, 2878, 1507, 1254, 1164, 1115, 1050, 791 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.61 (s, 3H), 7.10 (d, 2H, *J* = 8.6 Hz), 7.15 (d, 2H, *J* = 8.6 Hz), 7.22 (t, 1H, *J* = 6.8 Hz), 7.38-7.44 (m, 4H); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.6, 118.8, 119.9, 124.7, 126.2, 128.1, 130.1, 151.6, 155.5, 159.3; HRMS (ESI): Calcd for $C_{14}H_{13}ON_4$ $[M+H]^+$ = 253.1084, Found = 253.1084.

1-(4'-Methoxy-3'-methylphenyl)-5-methyl-1*H*-tetrazole (3Fa): Yield: 117.1 mg (57%); white solid; mp 123-124 °C; IR (neat): 2975, 2841, 1505, 1247, 1134, 1090, 1026, 817 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.29 (s, 3H), 2.57 (s, 3H), 3.92 (s, 3H), 6.96 (d, 1H, *J* = 8.2 Hz), 7.21 (s, 1H), 7.22 (d, 1H, *J* = 8.2 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.6, 16.2, 55.7, 110.2, 123.3, 125.9, 126.8, 128.7, 151.6, 159.0; HRMS (ESI): Calcd for $C_{10}H_{13}ON_4$ $[M+H]^+$ = 205.1084, Found = 205.1083.

1-(2'-Methoxy-5'-methylphenyl)-5-methyl-1*H*-tetrazole (3Ga): Yield: 111.5 mg (55%); yellow solid; mp 79-80 °C; IR (neat): 2963, 2849, 1512, 1248, 1118, 1082, 1021, 816 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.37 (s, 3H), 2.45 (s, 3H), 3.79 (s, 3H), 7.00 (d, 1H, *J* = 8.4 Hz), 7.17 (s, 1H), 7.34 (d, 1H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 8.9, 20.1, 55.8, 112.1, 121.8, 128.2, 130.8, 132.6, 151.3, 153.2; HRMS (ESI): Calcd for $C_{10}H_{13}ON_4$ $[M+H]^+$ = 205.1084, Found = 205.1082.

1-(Benzo[*d*][1',3']dioxol-5'-yl)-5-methyl-1*H*-tetrazole (3Ha): Yield: 96.8 mg (47%); white solid; mp 152-153 °C; IR (neat): 2907, 2781, 1489, 1254, 1112, 1028, 931, 819, 730 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.58 (s, 3H), 6.12 (s, 2H), 6.88 (d, 1H, *J* = 7.9 Hz) 6.89 (s, 1H), 6.95 (d, 1H, *J* = 7.9 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.6, 102.4, 106.0, 108.6, 118.7, 127.3, 148.7, 149.2, 151.7; HRMS (ESI): Calcd for $C_9H_9O_2N_4$ $[M+H]^+$ = 205.0720, Found = 205.0721.

1-(2',3'-Dihydrobenzofuran-5'-yl)-5-methyl-1*H*-tetrazole (3Ia): Yield: 137.9 mg (68%); orange oil; IR (neat): 2961, 1490, 1235, 1111, 1084, 822 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.57 (s, 3H), 3.32 (t, 2H, *J* = 8.8 Hz), 4.71 (t, 2H, *J* = 8.8 Hz), 6.92 (d, 1H, *J* = 8.6 Hz), 7.15 (d, 1H, *J* =8.4 Hz), 7.27 (s, 1H);

^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.6, 29.4, 72.1, 109.9, 121.9, 125.0, 126.2, 129.1, 151.7, 161.6; HRMS (ESI): Calcd for $C_{10}H_{11}ON_4$ [M+H]$^+$ = 203.0927, Found = 203.0928.

1-(4’-Chlorophenyl)-5-methyl-1*H*-tetrazole (3Ja): Yield: 73.8 mg (38%); yellow solid; mp 81-82 °C (lit.[6k] mp 86-87 °C); IR (neat): 3068, 1496, 1096, 1042, 831, 809 cm^{-1}; ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 2.63 (s, 3H), 7.44 (d, 2H, *J* = 8.6 Hz), 7.59 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.8, 125.8, 130.2, 132.2, 136.5, 151.5; HRMS (ESI): Calcd for $C_8H_8N_4{}^{35}Cl$ [M+H]$^+$ = 195.0432, Found = 195.0434.

1-(4’-Bromophenyl)-5-methyl-1*H*-tetrazole (3Ka): Yield: 114.8 mg (48%); yellow solid; mp 108-109 °C; IR (neat): 3056, 1489, 1118, 1074, 821, 690 cm^{-1}; ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 2.63 (s, 3H), 7.37 (d, 2H, *J* = 8.8 Hz), 7.74 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.8, 124.5, 125.9, 132.7, 133.2, 151.4; HRMS (ESI): HRMS (ESI): Calcd for $C_8H_8N_4{}^{79}Br$ [M+H]$^+$ = 238.9927, Found = 238.9928, $C_8H_8N_4{}^{81}Br$ [M+H]$^+$ = 240.9906, Found = 240.9907.

1-(4’-Iodophenyl)-5-methyl-1*H*-tetrazole (3La): Yield: 123.0 mg (48%); white solid; mp 146-147 °C; IR (neat): 3051, 1491, 1398, 1083, 1006, 819 cm^{-1}; ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 2.63 (s, 3H), 7.23 (d, 2H, *J* = 8.6 Hz), 7.94 (d, 2H, *J* = 8.6 Hz); ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.8, 96.0, 126.0, 133.4, 139.1, 151.4; HRMS (ESI): Calcd for $C_8H_8N_4I$ [M+H]$^+$ = 286.9788, Found = 286.9787.

5-Methyl-1-(4’-methylnaphthalen-1’-yl)-1*H*-tetrazole (3Ma): Yield: 133.8 mg (60%); yellow solid; mp 109-110 °C; IR (neat): 2925, 2854, 1600, 1514, 1113, 1075, 761 cm^{-1}; ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 2.42 (s, 3H), 2.82 (s, 3H), 7.13 (d, 1H, *J* = 8.4 Hz), 7.39 (d, 1H, *J* = 7.5 Hz), 7.48 (d, 1H, *J* = 7.3 Hz), 7.56 (t, 1H, *J* = 7.6 Hz) , 7.66 (t, 1H, *J* = 7.5 Hz), 8.14 (d, 1H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.0, 19.7, 121.9, 124.6, 124.9, 125.7, 127.2, 127.9, 128.0, 128.9, 133.2, 138.7, 153.5; HRMS (ESI): Calcd for $C_{13}H_{13}N_4$ [M+H]$^+$ = 225.1135, Found = 225.1134.

1-(4’-Methoxynaphthalen-1’-yl)-5-methyl-1*H*-tetrazole (3Na): Yield: 139.1 mg (58%); yellow solid; mp 116-117 °C; IR (neat): 3007, 2939, 2844, 1579, 1516, 1246, 1100, 1087, 634 cm^{-1}; ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 2.41 (s, 3H), 4.10 (s, 3H), 6.92 (d, 1H, *J* = 8.4 Hz), 7.04 (d, 1H, *J* = 7.3 Hz), 7.42 (d, 1H, *J* = 8.2 Hz), 7.54-7.61 (m, 2H), 8.40 (d, 1H, *J* = 7.5 Hz); ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.0, 56.0, 102.6, 121.1, 122.2, 122.9, 125.6, 126.0, 126.6, 128.8, 129.9, 153.5, 157.7; HRMS (ESI): Calcd for $C_{13}H_{13}ON_4$ [M+H]$^+$ = 241.1084, Found = 241.1083.

1-(5’-Ethylthiophen-2’-yl)-5-methyl-1*H*-tetrazole (3Oa): Yield: 129.8 mg (67%); orange oil; IR (neat): 3090, 2970, 1522, 1495, 1102, 1073, 1034, 808, 754 cm^{-1}; ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 1.37 (t, 3H, *J* = 7.7 Hz), 2.63 (s, 3H), 2.90 (q, 2H, *J* = 7.5 Hz), 6.80 (d, 1H, *J* = 3.6 Hz), 7.03 (d, 1H, *J* = 3.9 Hz); ^{13}C-NMR (100 MHz, CDCl$_3$): δ = 9.5, 15.6, 23.6, 122.5, 124.1, 129.7, 148.8, 152.4; HRMS (ESI): Calcd for $C_8H_{11}N_4S$ [M+H]$^+$ = 195.0699, Found = 195.0701.

5-Methyl-1-(3’-methylbenzo[*b*]thiophen-2’-yl)-1*H*-tetrazole (3Pa): Yield: 106.1 mg (46%); brown solid; mp 126-127 °C; IR (neat): 3055, 1599, 1520, 1104, 1067, 761, 726 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 2.26 (s, 3H), 2.57 (s, 3H), 7.52-7.54 (m, 2H), 7.82-7.89 (m, 2H); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 9.2, 11.2, 122.6, 123.2, 125.4, 126.2, 126.8, 131.9, 137.5, 137.6, 154.0; HRMS (ESI): Calcd for $C_{11}H_{11}N_4S$ $[M+H]^+$ = 231.0699, Found = 231.0698.

5-Ethyl-1-(4'-isopropylphenyl)-1*H*-tetrazole (3Ab): Yield: 155.5 mg (72%); colorless oil; IR (neat): 2962, 2867, 1505, 1421, 1084, 1060, 840 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.31 (d, 6H, *J* = 6.8 Hz), 1.39 (t, 3H, *J* = 7.5 Hz), 2.91 (q, 2H, *J* = 7.5 Hz), 3.03 (sep, 1H, *J* = 6.8 Hz), 7.35 (d, 2H, *J* = 8.6 Hz), 7.43 (d, 2H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.6, 17.4, 23.8, 33.9, 124.7, 127.8, 131.4, 151.5, 156.0; HRMS (ESI): Calcd for $C_{12}H_{17}N_4$ $[M+H]^+$ = 217.1448, Found = 217.1448.

1-(4'-Isopropylphenyl)-5-propyl-1*H*-tetrazole (3Ac): Yield: 195.2 mg (85%); colorless oil; IR (neat): 2963, 2871, 1518, 1420, 1081, 839 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.98 (t, 3H, *J* = 7.5 Hz), 1.32 (d, 6H, *J* = 6.8 Hz), 1.83 (sext, 2H, *J* = 7.5 Hz), 2.85 (t, 2H, *J* = 7.5 Hz), 3.03 (sep, 1H, *J* = 7.0 Hz), 7.34 (d, 2H, *J* = 8.4 Hz), 7.43 (d, 2H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 13.6, 20.6, 23.8, 25.4, 33.9, 124.8, 127.8, 131.4, 151.5, 155.0; HRMS (ESI): Calcd for $C_{13}H_{19}N_4$ $[M+H]^+$ = 231.1604, Found = 231.1602.

5-Isopropyl-1-(4'-isopropylphenyl)-1*H*-tetrazole (3Ad): Yield: 158.5 mg (69%); colorless oil; IR (neat): 2964, 2876, 1489, 1187, 1101, 1010, 958, 754 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.31 (d, 6H, *J* = 7.0 Hz), 1.64 (d, 6H, *J* = 6.6 Hz), 3.01 (sep, 1H, *J* = 7.0 Hz), 4.79 (sept, 1H, *J* = 6.6 Hz), 7.42 (d, 2H, *J* = 8.4 Hz), 7.55 (d, 2H, *J* = 8.2 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 23.0, 23.7, 34.1, 51.0, 121.6, 127.4, 128.8, 152.5, 153.8; HRMS (ESI): Calcd for $C_{13}H_{19}N_4$ $[M+H]^+$ = 231.1604, Found = 231.1604.

5-Cyclopentyl-1-(4'-isopropylphenyl)-1*H*-tetrazole (3Ae): Yield: 148.6 mg (58%); white solid; mp 77-78 °C; IR (neat): 3051, 2960, 1488, 1186, 1058, 955, 840 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.31 (d, 6H, *J* = 6.8 Hz), 1.72-1.78 (m, 2H), 2.07-2.13 (m, 2H), 2.15-2.24 (m, 4H), 3.00 (sept, 1H, *J* = 6.8 Hz), 4.88 (q, 1H, *J* = 6.3 Hz), 7.42 (d, 2H, *J* = 8.2 Hz), 7.58 (d, 2H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 23.7, 24.7, 33.9, 34.1, 59.3, 121.7, 127.3, 129.0, 152.2, 154.1; HRMS (ESI): Calcd for $C_{15}H_{21}N_4$ $[M+H]^+$ = 257.1761, Found = 257.1759.

5-Cyclohexyl-1-(4'-isopropylphenyl)-1*H*-tetrazole (3Af): Yield: 169.0 mg (63%); white solid; mp 78-79 °C; IR (neat): 2958, 1488, 1185, 1160, 956, 773, 687 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.32 (d, 6H, *J* = 6.8 Hz), 1.35-1.39 (m, 3H), 1.75-1.76 (m, 1H), 1.95-1.97 (m, 2H), 2.02-2.18 (m, 4H), 3.02 (sept, 1H, *J* = 7.0 Hz), 4.35 (tt, *J* = 11.6, 4.1 Hz), 7.43 (d, 2H, *J* = 8.2 Hz), 7.54 (d, 2H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 23.7, 24.8, 25.3, 33.3, 34.1, 58.1, 121.7, 127.4, 128.8, 152.2, 153.7; HRMS (ESI): Calcd for $C_{16}H_{23}N_4$ $[M+H]^+$ = 271.1917, Found = 271.1912.

5-Ethyl-1-(4'-methoxyphenyl)-1*H*-tetrazole (3Cb): Yield: 140.0 mg (69%); orange oil; IR (neat): 2979, 2843, 1506, 1255, 1105, 1082, 1022, 832 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.37 (t, 3H, *J* = 7.7 Hz), 2.88 (q, 2H, *J* = 7.7 Hz), 3.90 (s, 3H), 7.06 (d, 2H, *J* = 9.1 Hz), 7.35 (d, 2H, *J* = 9.1 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.4, 17.1, 55.5, 114.8, 126.2 (2C), 156.1, 160.7; HRMS (ESI): Calcd for $C_{10}H_{13}ON_4$ $[M+H]^+$ = 205.1084, Found = 205.1085.

1-(4'-Methoxyphenyl)-5-propyl-1*H*-tetrazole (3Cc): Yield: 163.6 mg (75%); orange oil; IR (neat): 2966, 2838, 1518, 1253, 1172, 1106, 1023, 835 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.97 (t, 3H, *J* = 7.5 Hz), 1.80 (sext, 2H, *J* = 7.5 Hz), 2.82 (t, 2H, *J* = 7.7 Hz), 3.90 (s, 3H), 7.07 (d, 2H, *J* = 8.8 Hz), 7.34 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 13.5, 20.5, 25.2, 55.6, 114.8, 126.3 (2H), 155.1, 160.8; HRMS (ESI): Calcd for $C_{11}H_{15}ON_4$ $[M+H]^+$ = 219.1240, Found = 219.1239.

5-Isopropyl-1-(4'-methoxyphenyl)-1*H*-tetrazole (3Cd): Yield: 135.9 mg (62%); colorless oil; IR (neat): 2840, 1517, 1248, 1189, 1021, 830 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.64 (d, 6H, *J* = 6.6 Hz), 3.90 (s, 3H), 4.77 (sept, 1H, *J* = 6.6 Hz), 7.07 (d, 2H, *J* = 8.6 Hz), 7.57 (d, 2H, *J* = 8.6 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ =22.9, 51.0, 55.5, 114.7, 116.0, 130.3, 153.4, 161.7; HRMS (ESI): Calcd for $C_{11}H_{15}ON_4$ $[M+H]^+$ = 219.1240, Found = 219.1237.

5-Cyclopentyl-1-(4'-methoxyphenyl)-1*H*-tetrazole (3Ce): Yield: 110.9 mg (45%); colorless oil; IR (neat): 2874, 1613, 1474, 1254, 1022, 836 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.73-1.80 (m, 2H), 2.06-2.12 (m, 2H), 2.17-2.24 (m, 4H), 3.89 (s, 3H), 4.86 (quint, 1H, *J* = 6.8 Hz), 7.07 (d, 2H, *J* = 8.4 Hz), 7.60 (d, 2H, *J* = 8.4 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 24.7, 33.9, 55.5, 59.3, 114.7, 116.4, 130.5, 154.0, 161.7; HRMS (ESI): Calcd for $C_{13}H_{17}ON_4$ $[M+H]^+$ = 245.1397, Found = 245.1393.

5-Cyclohexyl-1-(4'-methoxyphenyl)-1*H*-tetrazole (3Cf): Yield: 143.1 mg (55%); white solid; mp 110-111 °C; IR (neat): 2857, 1613, 1479, 1260, 1027, 837 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.32-1.42 (m, 3H), 1.74-1.79 (m, 1H), 1.94-1.97 (m, 2H), 2.01-2.17 (m, 4H), 3.90 (s, 3H), 4.32 (tt, 1H, *J* = 11.3, 4.3 Hz), 7.08 (d, 2H, *J* = 8.8 Hz), 7.56 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 24.7, 25.2, 33.1, 55.4, 58.0, 114.7, 116.2, 130.2, 153.4, 161.6; HRMS (ESI): Calcd for $C_{14}H_{19}ON_4$ $[M+H]^+$ = 259.1553, Found = 259.1549.

1-(4'-Bromophenyl)-5-ethyl-1*H*-tetrazole (3Kb): Yield: 126.6 mg (50%); yellow solid; mp 86-87 °C; IR (neat): 3068, 2981, 1488, 1070, 1009, 828, 551 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 1.40 (t, 3H, *J* = 7.5 Hz), 2.92 (q, 2H, *J* = 7.5 Hz), 7.35 (d, 2H, *J* = 8.8 Hz), 7.74 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 11.5, 17.5, 124.6, 126.3, 132.7, 133.2, 156.0; HRMS (ESI): Calcd for $C_9H_{10}N_4{}^{79}Br$ $[M+H]^+$ = 253.0083, Found = 253.0085, $C_9H_{10}N_4{}^{81}Br$ $[M+H]^+$ = 255.0063, Found = 255.0063.

1-(4'-Bromophenyl)-5-propyl-1*H*-tetrazole (3Kc): Yield: 152.2 mg (57%); yellow oil; IR (neat): 2965, 2874, 1489, 1069, 1010, 828 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.98 (t, 3H, *J* = 7.5 Hz), 1.83 (sext, 2H, *J* = 7.5 Hz), 2.85 (t, 2H, *J* = 7.5 Hz), 7.34 (d, 2H, *J* = 8.8 Hz), 7.74 (d, 2H, *J* = 8.8 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 13.6, 20.6, 25.5, 124.6, 126.4, 132.7, 133.1, 155.0; HRMS (ESI): Calcd for $C_{10}H_{12}N_4{}^{79}Br$ $[M+H]^+$ = 267.0240, Found = 267.0240, $C_{10}H_{12}N_4{}^{81}Br$ $[M+H]^+$ = 269.0219, Found =

269.0219.

1-(4’-Methylphenyl)-5-propyl-1*H*-tetrazole (3Qc): Yield: 132.5 mg (66%); colorless oil; IR (neat): 2966, 2875, 1519, 1107, 1081, 820 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 0.97 (t, 3H, *J* = 7.5 Hz), 1.81 (sext, 2H, *J* = 7.5 Hz), 2.47 (s, 3H), 2.84 (t, 2H, *J* = 7.5 Hz), 7.31 (d, 2H, *J* = 8.4 Hz), 7.38 (d, 2H, *J* = 8.2 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 13.7, 20.7, 21.3, 25.5, 124.8, 130.4, 131.3, 140.8, 155.1; HRMS (ESI): Calcd for $C_{11}H_{15}N_4$ $[M+H]^+$ = 203.1291, Found = 203.1290.

1-(4’-Methoxyphenyl)-5-phenyl-1*H*-tetrazole (3Cg) and 5-(4’-Methoxyphenyl)-1-phenyl-1*H*-tetrazole (3Cg’): It could not be separated. Yield: 165.8 mg (66%); white solid; mp 102-103 °C; IR (neat): 3068, 2841, 1513, 1249, 1103, 1023, 840, 764, 690 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.84 (s, 3H), 3.89 (s, 3H), 6.91 (d, 2H, *J* = 9.1 Hz), 7.01 (d, 2H, *J* = 9.1 Hz), 7.31 (d, 2H, *J* = 9.1 Hz), 7.39-7.43 (m, 4H), 7.47-7.59 (m, 8H); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 55.4, 55.6, 114.4, 114.9, 115.5, 123.6, 125.3, 126.7, 127.2, 128.8, 128.9, 129.8, 130.3, 130.4, 131.1, 134.7, 153.4, 153.5, 160.8, 161.8; HRMS (ESI): Calcd for $C_{14}H_{13}ON_4$ $[M+H]^+$ = 253.1084, Found = 253.1082.

5-(4’-Chlorophenyl)-1-(4”-methoxyphenyl)-1*H*-tetrazole (3Ch): Yield: 116.1 mg (40%); white solid; mp 121-122 °C; IR (neat): 2961, 2846, 1496, 1255, 1092, 1015, 834 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.85 (s, 3H), 6.93 (d, 2H, *J* = 9.1 Hz), 7.37 (d, 2H, *J* = 8.8 Hz), 7.48-7.52 (m, 4H); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 55.4, 114.5, 115.2, 126.5, 130.1, 130.5, 133.1, 136.4, 153.4, 162.0; HRMS (ESI): Calcd for $C_{14}H_{12}ON_4{}^{35}Cl$ $[M+H]^+$ = 287.0694, Found = 287.0692.

1-(4’-Chlorophenyl)-5-(4”-methoxyphenyl)-1*H*-tetrazole (3Ch’): Yield: 119.0 mg (41%); white solid; mp 124-125 °C; IR (neat): 3017, 2836, 1508, 1250, 1172, 1024, 837, 745 cm^{-1}; ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 3.90 (s, 3H), 7.03 (d, 2H, *J* = 9.1 Hz), 7.30 (d, 2H, *J* = 8.8 Hz), 7.39 (d, 2H, *J* = 8.8 Hz), 7.53 (d, 2H, *J* = 8.6 Hz); ^{13}C-NMR (100 MHz, $CDCl_3$): δ = 55.7, 115.1, 122.1, 126.7, 126.9, 129.3, 130.1, 137.6, 152.7, 161.0; HRMS (ESI): Calcd for $C_{14}H_{12}ON_4{}^{35}Cl$ $[M+H]^+$ = 287.0694, Found = 287.0692.

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