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On the utility of the azido transfer protocol: synthesis of 2- and 5-azido *N*-methylimidazoles, 1,3-thiazoles and *N*-methylpyrazole and their conversion to triazole–azole bisheteroaryls†

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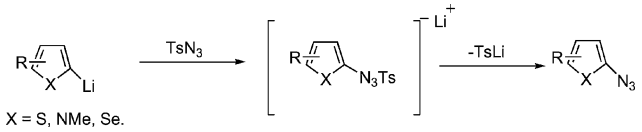
The azido transfer procedure of heteroaryllithium and tosyl azide was used to synthesize selected 2- and 5-azidoazoles. This procedure, which is based on the fragmentation of the appropriate lithium triazene salts **1a**–**7a**, successfully afforded 2-azido-*N*-methylimidazole **1**, 2-azido-1,3-thiazole **2**, 2-azidobenzo-1,3-thiazole **3**, 5-azido-*N*-methylpyrazole **4**, 5-azido-*N*-methylimidazole **6** [*via* 2-(trimethylsilyl)-5-azido-*N*-methylimidazole **5**], and 5-azido-1,3-thiazole **7** (*via* 5-lithio-1,3-thiazole), but attempts to prepare 5-azido-2-(trimethylsilyl)-1,3-thiazole **8** from the corresponding triazene **7a** failed, affording only the desilylated azide **7** in poor yield. Azides **1**–**7** underwent 1,3-dipolar cycloaddition when mixed with neat (trimethylsilyl)acetylene, giving 1-heteroaryl-4-trimethylsilyl-1,2,3-triazoles **1b–7b** generally in very high yields.

Introduction

Azides derived from five-membered heteroarenes play an ever-increasing role in chemistry, and their synthesis and various applications have stimulated overwhelming interest in these nitrogen-linked heteroarenes.[1] A number of five-membered azido heteroarenes with one heteroatom[2] and some benzo-derivatives[3] have been produced in our laboratory *via* tosyl azide reaction with heteroaryllithiums (azido transfer) (Scheme 1).



Scheme 1

Kinetic studies of these azido systems[4] have suggested that the 3-derivatives have a chemical reactivity not dissimilar from that of arylnitrenes, whereas the corresponding 2-azido analogues undergo low-temperature dissociation to a 'nitrene', followed by ring cleavage. In some instances, the dissociation and ring cleavage occur *via* a concerted mechanism without intervention of a 'free' nitrene.[5] Furthermore, the ring cleavage is not general; in some cases it competes with either an intramolecular cyclization (with the participation of an *ortho*-neighboring group[1b,6]) or with an intermolecular 1,3-cycloaddition[2,4–7] (in the presence of activated dipolarophiles), affording fused- or bisheteroaryls, respectively. These chemical behaviors are similar to those reported in the literature for analogous systems.[8]

To date, the great majority of known heteroaryl azides have been obtained by nucleophilic displacement of various nucleofuge groups with an azido ion[8a,9] or by diazotization of heteroaryl amines followed by addition of sodium azide.[8a,10] The latter procedure has largely been applied starting from commercially available amino heteroarenes with two or more heteroatoms, allowing studies on the thermal and chemical behavior of the resulting azides as precursors (or otherwise) of 'stabilized nitrenes'. Most work on the simple molecules 2-azido-1,3-thiazole, 2-azido-benzo-1,3-thiazole and 2-azido-1-methyl-1*H*-imidazole has focused on azido–tetrazole isomerism, which has been extensively studied from chemical[11] and theoretical viewpoints.[12] Of these compounds, 2-azido-1-methyl-1*H*-imidazole does not isomerize and undergoes a photochemical ring-cleavage reaction[13] that provides a facile route to small molecules such as heterodienes that are useful building-blocks in hetero Diels–Alder reactions.[14]

Our long term interest in this field prompted us to study the versatility of the azido transfer procedure by an extension to azidoazoles, some of them as yet unknown. In line with the strong-base–proton exchange process, preparative butyllithium deprotonation of azoles, such as *N*-methylimidazole, 1,3-thiazole and *N*-methyl pyrazole, takes place selectively at C-2 (or at C-5 when C-2 is blocked) and the resulting lithioheteroarenes[15] can potentially be employed for the azido transfer reaction. In this paper, we report the reactions of some 2-lithiated azoles (*N*-methylimidazole, 1,3-thiazole and benzo-1,3-thiazole) and 5-lithiated azoles (*N*-methyl pyrazole, 2-(trimethylsilyl)-*N*-methylimidazole, 2-(trimethylsilyl)-1,3-thiazole and 1,3-thiazole) with tosyl azide to afford the corresponding lithium triazene salts **1a**–**7a**, and **7a**′. The subsequent fragmentation of these salts produces the desired azides **1–7** in different yields (Scheme 2).

This study was carried out in view of the chemical, biological and theoretical importance of the nitrogen-linked azole systems.[16] Additional impetus was given to this work by the fact that previously only one of the azidoazoles (*i.e.*, 2-azido-1-methyl-1*H*-1,3-benzimidazole), whose biological activities[17a] have been reported, has been prepared *via* azido transfer.[17b]

In this study, we were also interested to compare the 1,3-dipolar cycloaddition (1,3-DC) reactivities of the recovered azidoazoles **1–7** with our previously reported data on the analogous reaction to bisheteroaryls,[18] which were determined by reaction of azido heteroaryl systems with one heteroatom and (trimethyl)silylacetylene.[2,4–7]

† Electronic supplementary information (ESI) available: NMR spectra of 4b and 7b and Table 1. See http://www.rsc.org/suppdata/ob/b5/b500634a/

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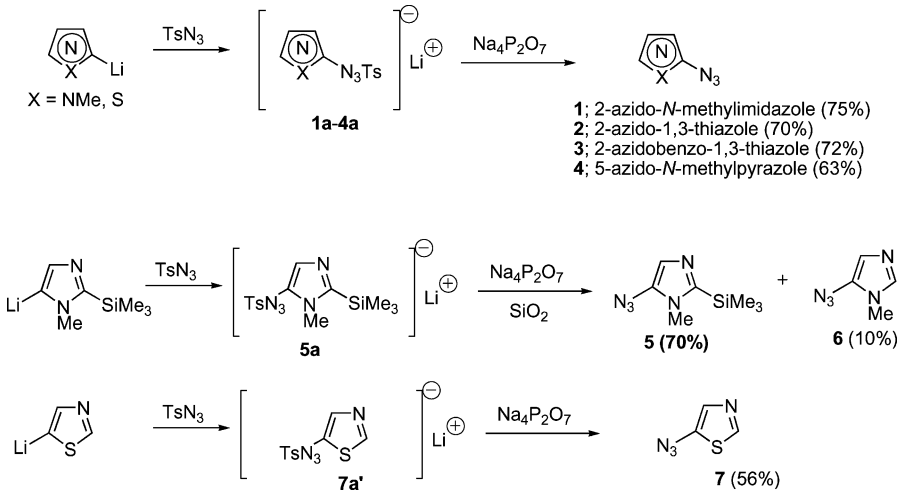


Scheme 2

Results and discussion

Following the standard azido transfer procedure, 2-lithiated *N*-methylimidazole,[19] 2-lithiated 1,3-thiazole,[20] 2-lithiated benzo-1,3-thiazole,[21] 5-lithiated *N*-methylpyrazole,[22] 5-lithiated 2-(trimethylsilyl)-1-methyl-1*H*-imidazole,[23] 5-lithiated 2-(trimethylsilyl)-1,3-thiazole[24] and 5-lithiated 1,3-thiazole[25] that had been prepared according to the literature procedure, were converted into solid tosyl triazene lithium salts **1a**–**7a** and **7a**' by reaction with tosyl azide. For the optimization experiments, selected triazene lithium salts **1a, 2a, 5a** and **7a**' were monitored by recording ^{1}H NMR spectra in DMSO, which displayed structures congruent with the single anionic form.

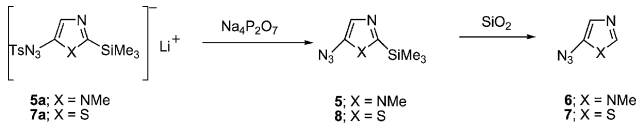
Fragmentation of the triazene salts **1a** and **4a** with aqueous tetrasodium pyrophosphate ($Na_4P_2O_7$) gave rise to the desired 2-azido-1-methyl-1*H*-imidazole **1**, 2-azido-1,3-thiazole **2**, 2-azidobenzo-1,3-thiazole **3** and 5-azido-1-methyl-1*H*-pyrazole **4** in fairly good yields (63–75%).

Structural assignments of azides **1–3** were made by comparison of the ^{1}H- and ^{13}C-NMR spectra with those reported previously.[26] In particular, integration of the ^{1}H NMR signals of azides **1** in $CDCl_3$ and **3** in DMSO solutions at room temperature indicated the occurrence of azido–tetrazole isomerism (*ca.* 5 : 1 and 1 : 11, respectively). In addition, in IR spectra obtained from samples deposited on flat sodium chloride plates, the N_3 ν_{as}-band was lacking for azide **2** but was strong for azide **1**[11c] (2142 cm^{-1}) and weak for **2** (2122 cm^{-1}). 2-Azidoazoles **1–3** at room temperature appear more stable (but require storage in the dark at 4 °C) compared to 5-azidoazole **4** that requires storage at −20 °C. This compound was characterized spectroscopically (IR, ESI, ^{1}H- and ^{13}C-NMR).

The successful outcome of the azido transfer reaction in these instances prompted us to study the preparation of two novel simple azidoazoles, 5-azido-1-methyl-1*H*-imidazole (**6**) and 5-azido-1,3-thiazole (**7**).

A potential two-stage route to the 5-azidoazoles **6** and **7** is to use silylation to protect the readily lithiated 2-position by reacting 2-lithio-*N*-methylimidazole and 2-lithio-1,3-thiazole with trimethylsilyl chloride. The resulting 2-silylated *N*-methylimidazole[19] and 1,3-thiazole[20] can then potentially be lithiated at the 5-position to obtain the corresponding triazene lithium salts **6a** and **7a** *via* tosyl azide. Then, by fragmentation of **6a** and **7a**, it may be possible to prepare our target azides **5** and **8** containing the removable trimethylsilyl group at C-2, which can be regarded as precursors of the simple azidoazoles **6** and **7** (Scheme 3).

In our experiments, this synthetic route provided high yields only for azide **5**, and as a consequence for azide **6**. In fact, the fragmentation of the 1-methyl-5-{3-[(4-methylphenyl)sulfonyl]-1-triazenyl}-2-(trimethylsilyl)-1*H*-imidazole lithium salt **5a** gave the hitherto unknown 2-silylated 5-azido imidazole **5** in high yield (crude 81%).



Scheme 3

Chromatographic purification of the resulting crude oil on a silica column led to the separation of azide **5** (70%) together with about 10% of the desilylated compound 5-azido-1-methyl-1*H*-imidazole **6**.

By similar routes, various simple 5-substituted azoles have been prepared previously *via* acidic or neutral desilylation of 5-substituted 1-methyl-2-(trimethylsilyl)-1*H*-imidazole[23] or 1,3-thiadiazole.[24] We found it more convenient to recover azide **6** from **5** using tetrabutylammonium fluoride on silica gel in THF solution, an approach characterized by a shorter reaction time (3–4 h) and facile work-up.[27] When this method was applied to 0.01 mol of **5**, we succeeded in isolating the desired azide **6** in quantitative yield.

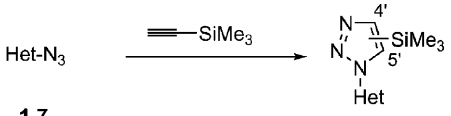
The solvent and temperature dependencies of the NMR spectra of *N*-methylimidazole and -pyrazole with various substitutions have been reported.[28] Our ^{1}H and ^{13}C NMR spectra for both unambiguously obtained azides **1** and **6** were comparable: the ^{1}H NMR spectrum of azide **1** shows two distinct although closely spaced proton signals (δ 6.78 and 6.63) that are at similar positions to those of azide **6** (δ 6.85 and 6.68). Similarly, in the ^{13}C NMR spectra, the carbon signals corresponding to C-4 and C-5 in **1** (δ 127.2 and 119.9) are at similar chemical shifts to the C-4 and C-2 signals of **6** (δ 127.5 and 120.0).

As for the thiazole system, the synthetic route to azide **7** *via* the 2-silylated azide **8** proved to be unreliable owing to the facile desilylation of the starting C-2-silylated compound during the basic aqueous fragmentation of **7a**. Furthermore, in the course of the work-up, azide **7** decomposed, affording tar-like material. We also attempted an acidic fragmentation using a universal buffer solution at pH 4.0 (Britton–Robinson). In this case, the fragmentation occurred slightly faster, giving only small amounts of 5-azido-1,3-thiazole **7** *via* concurrent desilylation of the uncovered **8**.

There is a literature report[29] of 5-lithio-1,3-thiazole being selectively obtained by bromine–lithium exchange with methyllithium from 5-bromo-1,3-thiazole. Application of this procedure to the azido transfer reaction gave 5-{3-[(4-methylphenyl)sulfonyl]triazenyl}-1,3-thiazole lithium salt **7a**′ in

a high yield (87%). Azide **7** could be isolated (56%) as the only identifiable product by careful fragmentation of **7a′** in aqueous sodium pyrophosphate.

As in previous reports on 2-azido heteroaryls,[1b,8] azides **6, 4** and **7** were found to be more unstable with respect to azides **1, 2** and **3**, which are probably stabilized by the sp^2 nitrogen at the 3-position, and **5**, whose stability is assisted by the *p*-like trimethylsilyl group.[5] All the azidoazoles are potential key intermediates for the synthesis of novel heterocyclic systems by ring transformation or intermolecular cycloaddition. In the present study, we examined the chemistry of the 1,3-dipolar cycloaddition (1,3-DC) of azidoazoles **1–7** with (trimethysilyl)acetylene (TMSAc) as a route to silylated bisheteroaryls such as triazole–azoles **1b–7b** (Scheme 4).



1-7 **1b-7b** (76-98%)

1; Het = *N*-methylimidazol-2-yl
2, Het = thiazol-2-yl
3, Het = benzothiazol-2-yl
4, Het = *N*-methylpyrazol-5-yl
5, Het = 2-(trimethylsilyl)-*N*-methylimidazol-5-yl
6, Het = *N*-methylimidazol-5-yl
7; Het = thiazol-5-yl

Scheme 4

The solvent sensitivity of the azido–tetrazole isomerism manifested in the ^{1}H NMR spectra recorded in TMSAc solution, where azides **2** and (the poorly soluble) **3** exist predominantly in the open-chain form. The 1,3-DC in neat TMSAc may thus be a suitable chemical system for examining the solvent contribution to the equilibrium between the open-chain and cyclized forms. To explore this possibility, we allowed solutions (or a suspension of **3**) of azides **1, 2**, and **4–7** in neat TMSAc to react in plug-seal screw-cap tubes under standard laboratory conditions (until TLC showed the disappearance of the starting azide). Longer reaction times were required for the reactions of **1** (26 days), **2** (30 days), **3** (40 days), **5** (35 days) and **6** (20 days) compared to those of the analogous cycloaddition of five-membered 2-azido heteroarenes with one heteroatom,[7] whereas the 5-azido derivatives **4** (10 days) and **7** (6 days) showed comparable reactivities. The lower reactivity of the 2-azidoazoles can be attributed to the azides having a lesser degree of 1,3-dipolar character due to the relatively lower energy level of the π-orbitals on the 2-position (compared to the 5-position) of the azole ring.[30] Structural assignments of novel azole–triazoles **1b–7b** were made on the basis of IR, ESI, ^{1}H- and ^{13}C-NMR spectra.

As expected from previous findings,[2,4–7] the 1,3-DC occurs with high regioselectivity, affording mostly C-4′ silylated triazoles. Only in the cases of **2b** and **3b** were evidence of trace amounts (less than 5%) of the C-5′ silylated isomers (**2b′** and **3b′** respectively) detected in the ^{1}H NMR spectra of the residue obtained after the elimination of the excess TMSAc; the C-5′ silylated isomers were characterized by H-4′ signals (δ 7.75 and 7.80 for **2b′** and **3b′**, respectively) at higher field than the H-5′ signals of the C-4′ silylated isomers (δ 8.39 and 8.54, respectively) (Scheme 5).

2b, **3b**, **4b**, **7b** **2b'**, **3b'**, **4b'**, **7b'**

Scheme 5

In light of these findings, cycloadducts **4b** and **7b**, whose triazole-proton signals were observed at higher field (δ 7.75 and 7.48) with respect to the H-5′ signals of **1b–3b, 5b** and **6b**, might be C-5′ silylated isomers.

As a quick attempt to confirm the regiochemistry of **4b** and **7b**, we performed time-inexpensive theoretical calculations using the set of programs in Spartan '04 Windows,[31] at the RHF/6-31G* level of theory to obtain optimized-geometries, energies and NMR spectra. The calculated and experimental carbon and proton-shifts for the C-4′- (**b**) and C-5′-silylated isomers (**b′**) of **4b** and **7b** are available as ESI supplementary material†.

Comparing the experimental and theoretical data, we see that the H-4′ signals of the C-5′ silylated isomers resonate at higher field than the H-5′ signals of the C-4′ ones, however on the whole, further calculations on a larger number of examples are required to confirm this matter.

In conclusion, we have shown the advantages that may be gained from adopting the azido transfer protocol by which a series of azidoazoles could be prepared starting from regioselectively lithiated azoles. We successfully prepared simple 2- (**1–3**) and 5-azidoazoles (**4, 6** and **7**) together with 2-silylated 5-azido *N*-methylimidazole **5**, whose stabilities and reactivities towards TMSAc varied considerably. Given the biological importance of molecules incorporating the imidazole ring, the current inability to easily differentiate 1,2-(**1** or **1b**) from 1,5-(**6** or **6b**) disubstituted imidazoles is an issue that needs to be resolved. Although questions have previously been raised regarding the need for a method of distinguishing between the 1,4- and 1,5-isomers,[32] to our knowledge there has been no report on the NMR spectroscopic similarity of the 1,2- and 1,5-isomers.

Experimental

Materials

Heteroaryl azides **1–7** were prepared from the corresponding lithio-derivatives and *p*-tosylazide according to the heteroaryl–azido transfer procedure.[2] All the starting heteroaryllithio derivatives were prepared according to literature methods (see text), either *via* a base–proton exchange process applied to *N*-methylimidazole, 1,3-thiazole, benzo-1,3-thiazole, *N*-methylpyrazole, or 2-trimethylsilyl-1,3-thiazole, purchased from Aldrich Chimica Italiana, or by halogen–metal exchange from 5-bromo-1,3-thiazole. The general techniques, compound authentication and/or characterization were performed using standard methods. (Trimethylsilyl)acetylene, butyllithium (1.6 M in hexane), methyllithium (1.6 M in diethyl ether), chlorotrimethylsilane and tetrabutylammonium fluoride on silica gel (1.0–1.5 F^-/g resin) (Aldrich Chimica Italiana) were used as received. 2-(Trimethylsilyl)-1-methyl-1*H*-imidazole,[19] tosylazide[33] and 5-bromo-1,3-thiazole[25] were prepared according to the literature methods.

Instrumentation

Melting points were determined on a Kofler hot-stage apparatus and are uncorrected. IR spectra were measured from films on a Perkin-Elmer Spectrum 2000 FT-IR spectrometer. ^{1}H- and ^{13}C-NMR spectra were recorded on a Varian Gemini 300 or 400. *J*-values are given in Hz. Mass spectra were recorded using ESI Water ZQ-4000 instruments.

Preparation of azides 1–7 by fragmentation of the lithium triazene salts 1–7a and 7a′

Following a standard azido transfer procedure,[2] solutions in anhydrous diethyl ether (100 cm^3) of 2-lithiated 1,3-thiazole, benzo-1,3-thiazole and 5-lithiated 2-trimethylsilyl-1,3-thiazole and 1,3-thiazole (0.016 mol) or in THF (100 cm^3) for 2-lithiated *N*-methylimidazole and 5-lithiated 2-trimethylsilyl *N*-methylimidazole and *N*-methylpyrazole, were treated drop-wise with tosyl azide (0.017 mol in 20 ml of anhydrous diethyl ether or THF) at −78 °C. The suspension was stirred for 4 hours

at the same temperature and was then allowed to reach room temperature and stirred overnight. The resulting solid triazene lithium salts **1a–7a, 7a′** were filtered off, washed with anhydrous pentane, and dried under vacuum.

The ^{1}H NMR spectra (in DMSO) of significant lithium triazene salts **1a, 2a, 4a** and **7a′** display single congruent structures:

1-Methyl-2-{3-[(4-methylphenyl)sulfonyl]triazenyl}-1*H*-imidazole lithium salt **1a**, δ_H (300 MHz) 7.81 (2H, d, *J* 8.0, Ts), 7.38 (2H, d, *J* 8.0, Ts), 7.15 (1H, bs, H-4), 6.90 (1H, bs, H-5), 3.48 (3H, s, NMe) and 2.43 (3H, s, Me).

2-{3-[(4-Methylphenyl)sulfonyl]triazenyl}-1,3-thiazole lithium salt **2a**, δ_H (300 MHz) 8.76 (1H, d, *J* 4.2, H-4), 7.98 (1H, d, *J* 4.2, H-5), 7.46 (2H, d, *J* 7.5, Ph), 7.20 (2H, d, *J* 7.5, Ph) and 2.37 (3H, s, Me).

1-Methyl-5-{3-[(4-methylphenyl)sulfonyl]triazenyl}-1*H*-pyrazole lithium salt **4a**, δ_H (300 MHz) 7.57 (2H, d, *J* 7.8, Ts), 7.45 (2H, d, *J* 7.8, Ts), 6.83 (1H, bs, H-3), 6.78 (1H, bs, H-4), 3.92 (3H, s, N–Me) and 2.40 (3H, s, Me).

5-{3-[(4-Methylphenyl)sulfonyl]triazenyl}-1,3-thiazole lithium salt **7a′**, δ_H (300 MHz) 8.72 (1H, bs, H-4), 8.14 (1H, bs, H-2), 7.73 (2H, d, *J* 8.2, Ts), 7.33 (2H, d, *J* 8.2, Ts) and 2.41 (3H, s, Me). This compound was obtained by treatment of 5-lithium-1,3-thiazole with *p*-tosylazide in THF.

The resulting solid lithium triazene salts **1a**–**6a**, and **7a′** were decomposed by treatment with aqueous $Na_4P_2O_7$ (0.016 mol in 50 cm^3) at 0 to 4 °C in the presence of 30 cm^3 of *n*-pentane for the release of azides **1–7**. The resulting cold organic–aqueous suspensions were extracted daily with *n*-pentane (5–8 × 30 cm^3) and the combined organic layers dried over $MgSO_4$. After the solvent excess was eliminated *in vacuo*, the resulting crude residue was purified by flash chromatography on a silica column (or Florisil for **7**) by elution with petroleum ether (bp 40 to 60 °C) with increased diethyl ether content. The following azides were obtained:

2-Azido-1-methyl-1*H*-imidazole 1. (0.012 mol, 75%) as a light yellow oil;[10a] ν_{max}/cm^{-1} 2954, 2142 (N_3, ν_{as}), 1505, 1477, 1265 (N_3, ν_{ps}), 1142, 731 and 688; δ_H (400 MHz; $CDCl_3$) 6.78 (1H, d, *J* 1.6, H-4), 6.63 (1H, d, *J* 1.6, H-5) and 3.35 (3H, s, Me); δ_C (100.6 MHz; $CDCl_3$) 141.1 (s, C-2), 127.2 (d, $^1J_{C-H}$ 191.1, $^2J_{C-H}$ 8.9, C-4), 119.9 (d, $^1J_{C-H}$ 189.3, $^2J_{C-H}$ 15.4, $^3J_{Me}$ 3.2, C-5) and 32.1 (q, $^1J_{C-H}$ 140.5); *m*/*z* 124 (M + H), 146 (M + Na).

2-Azido-1,3-thiazole 2. Recovered according to the literature[26] as a grey solid thiazole[3,2-*d*]tetrazole **2t** (0.011 mol, 70%); mp 94–96 °C (lit.[34] 97 °C); ν_{max}/cm^{-1} 1467, 1378, 721.

The following ^{13}C NMR spectra of compound **2** (**2 : 2t**, *ca.* 5 : 1) δ_C (75.4 MHz; $CDCl_3$) 163.0 (s), 140.3 (d) and 115.9 (d), and **2t** 170.8 (s), 133.8 (d) and 106.7 (d) were obtained; *m*/*z* 127 (M + H), 149 (M + Na).

2-Azidobenzo-1,3-thiazole 3. Recovered mostly as cyclized [1,2,3,4]tetrazole[5,1-*b*][1,3]benzothiazole isomer **3t** (0.0115 mol, 72%); mp 110–112 °C (lit.[33] 110–112 °C); ν_{max}/cm^{-1} (weak) 2122 (N_3, ν_{as}), 1464, 1252, 1212; *m*/*z* 177 (M + H), 199 (M + Na). ^{1}H- and ^{13}C-NMR spectra in DMSO (**3 : 3t**, *ca.* 1 : 11) were identical to those reported previously.[11b]

5-Azido-1-methyl-1*H*-pyrazole 4. (0.01 mol, 63%) as a pale yellow oil; ν_{max}/cm^{-1} 2918, 2126 (N_3, ν_{as}), 1595, 1165, 1090 and 745; δ_H (300 MHz; $CDCl_3$) 7.40 (1H, d, *J* 2.25, H-3), 6.08 (1H, d, *J* 2.25, H-4) and 3.74 (3H, s, Me); δ_C (75.4 MHz; $CDCl_3$) 139.2 ($^1J_{C-H}$ 187.3, $^2J_{C-H}$ 4.3, C-3), 138.3 (s, C-5), 94.5 ($^1J_{C-H}$ 177.8, $^2J_{C-H}$ 10.7, C-4) and 35.1 ($^1J_{C-H}$ 140.3, Me); *m*/*z* 124 (M + H), 146 (M + Na).

5-Azido-1-methyl-2-(trimethylsilyl)-1*H*-imidazole 5. (0.013 mol, 81%, see text) as a light yellow oil; ν_{max}/cm^{-1} 2958, 2144 (N_3, ν_{as}), 1492, 1445, 1252 (N_3, ν_{ps}) and 842 ($SiMe_3$); δ_H (400 MHz; $CDCl_3$) 6.87 (1H, s, H-4), 3.93 (3H, s, Me) and 0.24 (9H, s, $SiMe_3$); δ_C (100.6 MHz; $CDCl_3$) 144.3 (s, C-5), 136.3 (d, J_{C-H} 188.5 Hz), 130.2 (s, C-2), 32.1 (q) and −0.75 (q); *m*/*z* 196 (M + H), 218 (M + Na).

5-Azido-1-methyl-1*H*-imidazole 6. Obtained *via* quantitative desilylation of 0.01 mol of **5** (see text), as a yellow oil; ν_{max}/cm^{-1} 2954, 2142 (N_3, ν_{as}), 1505, 1477, 1280, 1265 (N_3, ν_{ps}), 1169 and 744; δ_H (400 MHz; $CDCl_3$) 6.85 (1H, d, *J* 1.4, H-4), 6.68 (1H, d, *J* 1.4, H-5) and 3.41 (3H, s, Me); δ_C (100.6 MHz; $CDCl_3$) 136.7 (s, C-5), 127.5 ($^1J_{C-H}$ 191.2, $^2J_{C-H}$ 8.9, C-4), 120.0 ($^1J_{C-H}$ 190.5, $^2J_{C-H}$ 15.3, C-2) and 32.2 ($^1J_{C-H}$ 140.8, Me); *m*/*z* 124 (M + H), 146 (M + Na).

5-Azido-1,3-thiadiazole **7** was obtained in small yields by fragmentation and simultaneous desilylation of **7a** using a universal buffered solution at pH 4.0 (Britton–Robinson). The suspension was extracted every two days with *n*-pentane (5 × 30 cm^3) and the combined organic layers were dried over $MgSO_4$.

An alternative procedure that gave better yields entailed treatment of 5-lithio-1,3-thiazole with *p*-tosylazide following the general protocol and normal fragmentation of the resulting triazene salt **7a′** (see text).

After the elimination of excess solvent *in vacuo*, chromatography of both resulting crude reaction residues on a Florisil column (using petroleum ether with increased diethyl ether content) gave:

5-Azido-1,3-thiazole 7. (0.009 mol, 56%) as a pale yellow oil; ν_{max}/cm^{-1} 2918, 2127 (N_3, ν_{as}), 1505, 1165, 1089 and 865; δ_H (300 MHz; $CDCl_3$) 8.48 (1H, bs, H-2), 7.50 (1H, bs, H-4); δ_C (75.4 MHz; $CDCl_3$) 147.7 (d, C-2), 137.8 (s, C-5), 127.0 (d, C-4); *m*/*z* 149 (M + Na).

Reactions of heteroaryl azides 1–7 with (trimethylsilyl)acetylene at 25 °C. General procedure. A solution of the azide (1 mmol for **1, 2** and **7**, and 2 mmol for **3**–**6**) in neat (trimethylsilyl)acetylene (1 and 2 cm^3) was allowed to react in a screw-cap tube for the appropriate time following the reactions by TLC. The solvent–reagent was removed under vacuum and the residue purified on a silica column using pentane with increasing amounts of diethyl ether (up to 100%) and then characterized.

The following new triazoles were obtained:

1-(1-Methyl-1*H*-imidazol-2-yl)-4′-(trimethylsilyl)-1*H*-1,2,3-triazole 1b. (26 days, 0.76 mmol, 76%) as an oil; ν_{max}/cm^{-1} 2958, 1252 and 842 ($SiMe_3$); δ_H (400 MHz; $CDCl_3$) 8.18 (1H, s, H-5′), 7.02 (1H, d, *J* 1.0, H-4), 6.93 (1H, d, *J* 1.0, H-5), 3.90 (3H, s, Me) and 0.37 (9H, s, $SiMe_3$); δ_C (100.6 MHz; $CDCl_3$) 147.0 (s, C′-4), 141.3 (s, C-2), 130.5 (d, $^1J_{C-H}$ 196.0), 127.5 ($^1J_{C-H}$ 192.0, $^2J_{C-H}$ 8.0), 122.7 (bq, $^1J_{C-H}$ 190.0, $^2J_{C-H}$ 12.5), 35.0 (q) and −0.94 (q); *m*/*z* 222 (M + H), 244 (M + Na).

1-(1,3-Thiazol-2-yl)-4′-(trimethylsilyl)-1*H*-1,2,3-triazole 2b. (30 days, 0.90 mmol, 90%) as an oil; ν_{max}/cm^{-1} 3123, 2959, 1725, 1528, 1251 and 844 ($SiMe_3$); δ_H (300 MHz; $CDCl_3$) 8.39 (1H, s, H-5′), 7.67 (1H, d, *J* 3.6, H-4), 7.25 (1H, d, *J* 3.6, H-5) and 0.38 (9H, s, $SiMe_3$); δ_C (75.4 MHz; $CDCl_3$) 157.8 (s, C-2), 148.2 (s, C-4′), 140.7 (d, C-4), 126.8 (d, C-5′), 118.2 (d, C-5) and −0.68 (q); *m*/*z* 225 (M + H), 247 (M + Na).

This compound undergoes spontaneous desilylation that is completed after standing for 3 months at room temperature, affording 1-(1,3-thiazol-2-yl)-1*H*-1,2,3-triazole **2c**; mp 86–88 °C; ν_{max}/cm^{-1} 3103, 1529, 1475, 1024 and 778; δ_H (400 MHz; $CDCl_3$) 8.44 (1H, d, *J* 1.0, H-5′), 7.83 (1H, d, *J* 1.0, H-4′), 7.67 (1H, d, *J* 3.6, H-4) and 7.25 (1H, d, *J* 3.6, H-5); δ_C (100.6 MHz; $CDCl_3$) 158.1 (s, C-2), 141.1 (d, C-4), 135.2 (d, C-4′), 122.1 (d, C-5′) and 118.6 (d, C-5); *m*/*z* 153 (M + H), 175 (M + Na).

1-(Benzo-1,3-thiazol-2-yl)-4′-(trimethylsilyl)-1*H*-1,2,3-triazole 3b. (40 days, 1.80 mmol, 90%); 116–118 °C; ν_{max}/cm^{-1} 3131, 2954, 1540, 1249 and 844 ($SiMe_3$); δ_H (300 MHz; $CDCl_3$) 8.54 (1H, s, H-5′), 7.97 (1H, d, *J* 8.1, H-4), 7.89 (1H, d, *J* 7.8, H-7), 7.53 (1H, m, H-5), 7.44 (1H, m, H-6) and 0.40 (9H, s, $SiMe_3$); δ_C (75.4 MHz; $CDCl_3$) 156.8 (s, C-2), 150.5 (s, C-3a), 148.7

(s, C-4′), 133.0 (s, C-7a), 127.3 (d, C-5), 127.1 (d, C-6), 125.8 (d, C-5′), 123.4 (d, C-4), 122.2 (d, C-7) and −0.68 (q); *m/z* 275 (M + H), 297 (M + Na) and 313 (M + K).

1-(1-Methyl-1*H*-pyrazol-5-yl)-4′(or 5′)-(trimethylsilyl)-1*H*-1,2,3-triazole 4b. (10 days, 1.96 mol, 98%) as a colorless oil; ν_{max}/cm^{-1} 2958, 1547, 1516, 1252 and 843 ($SiMe_3$); δ_H (300 MHz; $CDCl_3$) 7.75 (1H, s, H-5′), 7.54 (1H, d, *J* 1.9, H-3), 6.37 (1H, d, *J* 1.9, H-4), 3.86 (3H, s, Me) and 0.36 (9H, s, $SiMe_3$); δ_C (75.4 MHz; $CDCl_3$) 141.3 (s, C-5), 138.9 ($^1J_{C-H}$ 188.5, $^2J_{C-H}$ 4.3, C-3), 131.2 ($^1J_{C-H}$ 193.2, C-4′ or C-5′), 130.0 (s, C-5′ or C-4′), 101.7 ($^1J_{C-H}$ 180.0, $^2J_{C-H}$ 10.3, C-4), 37.4 (q) and −0.90 (q); *m/z* 222 (M + H), 244 (M + Na).

1-[(1-Methyl-2-(trimethylsilyl)-1*H*-imidazol-5-yl]-4′-(trimethylsilyl)-1*H*-1,2,3-triazole 5b. (35 days, 1.36 mmol, 68%)* pale yellow oil; ν_{max}/cm^{-1} 2958, 1252 and 842 ($SiMe_3$); δ_H (300 MHz; $CDCl_3$) 8.12 (1H, s, H-5′), 7.05 (1H, s, H-4), 3.86 (3H, s, Me), 0.37 (9H, s, $SiMe_3$) and 0.36 (9H, s, $SiMe_3$); δ_C (75.4 MHz; $CDCl_3$) 146.6 (s), 141.6 (s), 136.2 ($^1J_{C-H}$ 187.2, $^2J_{C-H}$ 5.5, C-4), 133.7 (s), 130.7 ($^1J_{C-H}$ 195.8, C-4′), 35.1 (q), −0.39 (q) and −0.60 (q); *m/z* 294 (M + H), 316 (M + Na).

*About 20% of **5b** undergoes desilylation at the 2-position in the silica column affording the triazole-azole identical to **6b**, obtained by reaction of azide **6** and (trimethylsilyl)acetylene.

1-(1-Methyl-1*H*-imidazol-5-yl)-4′-(trimethylsilyl)-1*H*-1,2,3-triazole 6b. (20 days, 1.76 mmol, 88%) as a colorless oil; ν_{max}/cm^{-1} 2958, 1547, 1516, 1252 and 843 ($SiMe_3$); δ_H (400 MHz; $CDCl_3$) 8.17 (1H, s, H-5′), 7.00 (1H, bs, H-4), 6.92 (1H, d, *J* 1.4, H-2), 3.88 (3H, s, Me) and 0.36 (9H, s, $SiMe_3$); δ_C (100.6 MHz; $CDCl_3$) 146.9 (s, C′-4), 138.6 (s, C-5), 130.5 ($^1J_{C-H}$ 196.0), 127.5 ($^1J_{C-H}$ 192.7, $^2J_{C-H}$ 8.8), 122.7 ($^1J_{C-H}$ 191.1, $^2J_{C-H}$ 16.0, $^3J_{C-H}$ 3.5), 35.3 (q) and −0.60 (q); *m/z* 222 (M + H), 244 (M + Na) and 260 (M + K).

1-(1,3-Thiazol-5-yl)-4′(or 5′)-(trimethylsilyl)-1*H*-1,2,3-triazole 7b. (6 days, 0.90 mmol, 90%) as a pale yellow oil; ν_{max}/cm^{-1} 3085, 2959, 1549, 1251 and 847 ($SiMe_3$); δ_H (300 MHz; $CDCl_3$) 8.75 (1H, d, *J* 0.6, H-2), 8.06 (1H, d, *J* 0.6, H-4), 7.84 (1H, s, H-4′ or 5′) and 0.32 (9H, s, $SiMe_3$); δ_C (75.4 MHz; $CDCl_3$) 150.8 (d, $^1J_{C-H}$ 215.5 and $^2J_{C-H}$ 16.0, C-2), 141.6 (s, C-5), 138.1 (s, C-5′ or C-4′), 133.8 (d, $^1J_{C-H}$ 190.3 and $^2J_{C-H}$ 13.4, C-4), 129.1 (d, $^1J_{C-H}$ 194.0, C-4′ or C-5′) and −0.92 (q); *m/z* 225 (M + H), 247 (M + Na).

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