Synthesis of Arylseleno-1,2,3-triazoles via Copper-Catalyzed 1,3-Dipolar Cycloaddition of Azido Arylselenides with Alkynes

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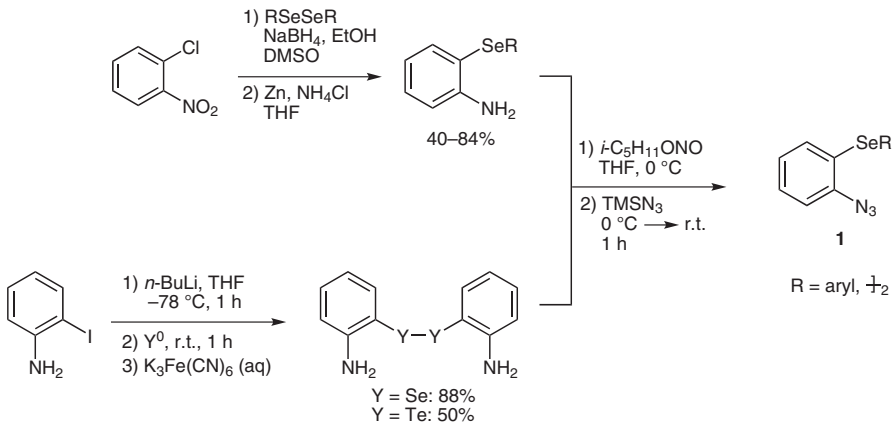
Abstract: The use of organoselenium compounds in the copper-catalyzed Huisgen 1,3-dipolar cycloaddition of azido arylselenides with various alkynes is described. Arylseleno-1,2,3-triazoles are prepared in excellent yields via reaction of amino arylselenides with *iso*-pentylnitrite and trimethylsilyl azide, and subsequent copper-catalyzed 1,3-dipolar cycloaddition of the resulting azido arylselenides with alkynes. The cycloaddition is also performed under mild conditions with several azido arylselenides and phenylacetylene to afford the corresponding arylseleno-1,2,3-triazoles in good to excellent yields. This click chemistry protocol represents an efficient method to produce new selenium–nitrogen compounds.

Key words: organoselenium compounds, azides, click chemistry, 1,2,3-triazoles

1,2,3-Triazoles, which are five-membered nitrogen-containing heterocycles, are an important class of compounds which display a wide spectrum of biological activity and are employed extensively as explosives and agrochemicals.[1] There are several methods available in the literature for the synthesis of 1,2,3-triazoles. One of the most attractive involves the thermal 1,3-dipolar cycloaddition of azides with alkynes, as pioneered by Huisgen.[2] The Huisgen 1,3-dipolar cycloaddition route toward the synthesis of 1,2,3-triazoles was popularized by Sharpless and co-workers, who discovered a copper-catalyzed reaction protocol.[3] The development of this copper-catalyzed process represented an important advance in triazole synthesis, and has become a paradigm of click chemistry.[4] The term click chemistry defines a chemical reaction which is versatile and clean, and which involves simple work-up and purification procedures.[4] The copper-catalyzed azide–alkyne cycloaddition represents a very effective example of click chemistry and has wide applications in various fields of chemistry, such as in the discovery and modulation of drug candidates,[5] the development of new materials,[6] the design of new catalysts,[7] supramolecular chemistry[8] and in biotechnology.[9]

Organoselenium compounds are attractive synthetic targets because of their chemo-, regio-, and stereoselective reactions,[10] and their association with biological activities.[11] Selenides or diselenides containing nitrogen atoms are a special class of these compounds which have been employed in various organic transformations, for example, in asymmetric synthesis.[10d,12] Consequently, the search for new and efficient methods for the preparation of highly-functionalized organoselenium compounds remains a challenge in organic chemistry. In a previous communication, we described the synthesis of azido arylselenides **1** starting from nitrogen-substituted benzenes to afford the corresponding products in good to excellent



Scheme 1 Syntheses of azido arylselenides and diselenides

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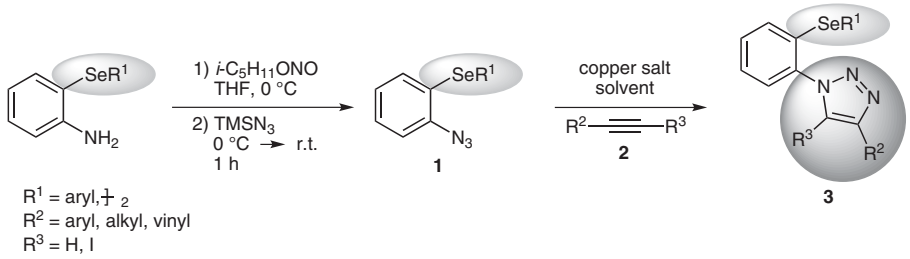


Scheme 2 Synthesis of arylseleno-1,2,3-triazoles **3**

yields under mild reaction conditions (Scheme 1).[13] This class of compounds has wider synthetic importance since they combine the well-known reactivity of the azido group[14] with that of a selenium-containing moiety.[15]

Azido arylselenides **1** appear to be highly promising substrates for copper-catalyzed 1,3-dipolar cycloadditions to give selenium–triazole derivatives. Although the synthesis of selenium-containing triazole compounds has been reported previously,[16] no procedure using a copper-catalyzed protocol has been described so far. This fact encouraged us to explore in detail the synthesis of azido arylselenides and diselenides **1**, and their subsequent use in the copper-catalyzed 1,3-dipolar cycloaddition with alkynes **2** to give arylseleno-1,2,3-triazoles **3** (Scheme 2).

Our initial studies were focused on the synthesis of azido arylselenides and diselenides **1**, as key intermediates for the preparation of the desired arylseleno-1,2,3-triazoles. Starting from nitrogen-substituted benzenes, and following incorporation of the arylselenium moiety on the aromatic ring, a number of amino arylselenides were obtained with satisfactory results (Scheme 1).[13] These compounds were converted into azido arylselenides **1** in good to excellent yields after reaction with *iso*-pentylnitrite and trimethylsilyl azide in tetrahydrofuran at 0 °C. Using optimized reaction conditions the corresponding azido arylchalcogenides and dichalcogenides were synthesized and the results are summarized in Table 1.

Analysis of these results indicated that the reactions were slightly sensitive to electronic effects. Examples with electron-neutral and electron-donating groups on the arylseleno moiety gave the best yields of products (Table 1, entries 1–3, 5 and 6). The presence of electron-withdrawing groups on the arylseleno moiety led to decreased yields of the desired products (Table 1, entries 4 and 7). Compound **1h**, a hindered azido arylselenide, was obtained in 75% yield (Table 1, entry 8). This method was extended to other amino arylchalcogenide and dichalcogenides to give azido arylsulfide **1j**, azido aryldiselenide **1k** and azido aryldittelluride **1l** in 99%, 71% and 50% yields, respectively (Table 1, entries 10–12).

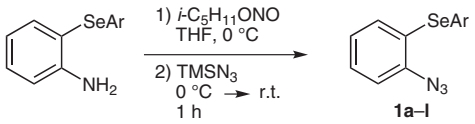
Next, we turned our attention to the application of azido arylselenides **1** for the synthesis of arylseleno-1,2,3-triazoles **3**, using a copper-catalyzed 1,3-dipolar cycloaddition protocol. The most common experimental procedure for this reaction involves the in situ generation of a copper(I) species by reduction of copper(II) sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$) with sodium ascorbate in aqueous medium.[3a] Thus, in a preliminary set of experiments, we studied the reaction of 2-azido arylselenide **1a** with phenylacetylene (**2a**) in the presence of copper(II) sulfate pentahydrate (5 mol%) and sodium ascorbate (10 mol%) in mixtures of different solvents (Table 2).

Analysis of the results in Table 2 revealed that the cycloaddition reaction afforded the desired product in high yields using a variety of solvent systems (Table 2, entries 1–6). An interesting feature of this method was that water was required as a co-solvent for successful 1,2,3-triazole synthesis. This may be due to the increased solubility of sodium ascorbate and the copper salt in this solvent. Reactions using ultrasonic irradiation and ionic liquids proved to be less effective (Table 2, entries 9–11). Although most of the solvent systems investigated led to formation of the desired compound in high yield, the water–tetrahydrofuran (1:1) mixture proved to be the most effective for this transformation (Table 2, entry 6). It is important to note that the reaction was not air-sensitive.

The influence of the type and amount of copper salt on this reaction was also studied. Various copper catalysts including copper(II) sulfate pentahydrate, copper(II) bromide, copper(II) triflate [$Cu(OTf)_2$], copper(II) acetate monohydrate [$Cu(OAc)_2 \cdot H_2O$] and copper(II) oxide nanoparticles (CuO NPs) were tested, and found to display moderate to good catalytic activity (Table 3). Of the copper salts examined, copper(II) acetate monohydrate (5 mol%) gave the highest catalytic activity, affording compound **3a** in 92% yield (Table 3, entry 5). Good yields of product **3a** were also obtained when the amount of the copper catalyst was reduced (2.5 mol% and 1 mol%) (Table 3, entries 7 and 8). The reaction time had an influence on the yield of product **3a**, and the best yield (97%) was obtained after 12 hours at room temperature using 1 mol% of catalyst (Table 3, entry 10).

Under the optimized conditions, a variety of terminal alkynes reacted smoothly with 2-azido arylselenide **1a** to produce arylseleno-1,2,3-triazoles **3a–n** in good to excellent yields (Table 4). Alkynes possessing phenyl, substituted aryl, alkyl, vinyl and ester groups were tolerated in this 1,3-dipolar cycloaddition reaction, as were those with hydroxy and amine functional groups (Table 4, entries 1–12). Interesting results were obtained using (iodoethynyl)benzene and tetradeca-1,13-diyne. These alkynes

Table 1 Synthesis of Azido Arylchalcogenides **1a–l**

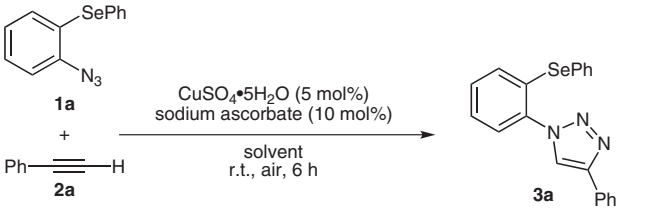


1a–l

Entry	Product	Yield (%)[a]
1	**1a**	99
2	**1b**	96
3	**1c**	95
4	**1d**	88
5	**1e**	99
6	**1f**	95
7	**1g**	80
8	**1h**	75
9	**1i**	75
10	**1j**	99
11	**1k**	71
12	**1l**	50

[a] Yield of isolated product.

Table 2 A Study of the Effect of Solvent on the Cycloaddition of 2-Azido Arylselenide **1a** and Phenylacetylene (**2a**)



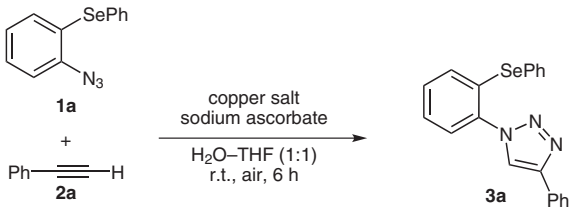
Entry	Solvent (ratio)	Yield of **3a** (%)[a]
1	H_2O–MeOH (1:1)	85
2	H_2O–MeOH (0.5:1)	83
3	H_2O–CH_2Cl_2 (1:1)	81
4	H_2O–Et_2O (1:1)	86
5	H_2O–acetone (1:1)	87
6	H_2O–THF (1:1)	89
7	H_2O–THF (0.5:1)	47
8	H_2O–THF (1:1)[b]	87
9	H_2O–THF (1:1)[c]	68
10	[bmim]BF_4[d]	–
11	H_2O–[bmim]BF_4 (1:1)	56

[a] Yield of isolated product.
[b] Reaction under an Ar atmosphere.
[c] Reaction under ultrasonic irradiation for 2 h.
[d] [bmim]BF_4 = 1-butyl-3-methylimidazolium tetrafluoroborate.

were cyclized efficiently to afford triazoles **3m** and **3n** in good yields (Table 4, entries 13 and 14).

To further extend the scope of this reaction, phenylacetylene (**2a**) was reacted with several azido arylselenides and the results are summarized in Table 5. 2-Azido arylselenides bearing electron-donating and electron-withdrawing groups on the arylselenium moiety produced the corresponding arylseleno-1,2,3-triazoles **3o–t** in good to excellent yields (Table 5, entries 1–6). Additionally, the use of a 4-azido arylselenide gave the desired product **3v** in 65% yield (Table 5, entry 8). The synthesis of triazoles using other 1-azido arylchalcogenides was studied next. When 2-azido arylsulfide was used, triazole **3w** was obtained in an excellent 99% yield (Table 5, entry 9). Notably, when azido aryldiselenide **1k** was used as the substrate, a satisfactory yield of diaryl-diseleno-1,2,3-triazole **3x** was obtained (Table 5, entry 10). These diselenide-1,2,3-triazoles have greater synthetic importance since they combine the well-known activity of the triazole group[1] with that of a diselenide moiety.[11] Extending this protocol to azido-tellurium analogue **1l**, we synthesized diaryl-ditelluro-1,2,3-triazole **3y** in 63% yield (Table 5, entry 11). Interestingly, these results show that the Se–Se and Te–Te bonds were not affected in this copper-catalyzed azide–alkyne cycloaddition; a similar situation was described by Theato and co-workers for S–S bonds.[17]

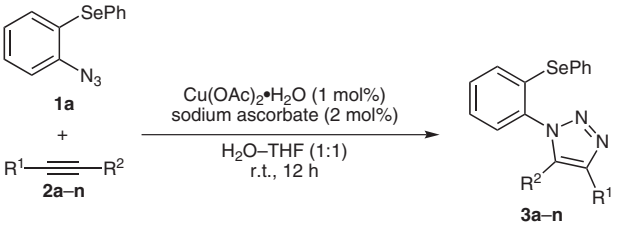
Table 3 The Effect of Various Copper Salts on the Cycloaddition of 2-Azido Arylselenide **1a** and Phenylacetylene (**2a**)



Entry	Copper salt (mol%)	Sodium ascorbate (mol%)	Yield of **3a** (%)[a]
1	$CuSO_4·5H_2O$ (5)	10	89
2	$CuBr_2$ (5)	10	71
3	$Cu(OTf)_2$ (5)	10	66
4	CuO NPs (5)	10	77
5	$Cu(OAc)_2·H_2O$ (5)	10	92
6	$Cu(OAc)_2·H_2O$ (5)[b]	10	93
7	$Cu(OAc)_2·H_2O$ (2.5)	5	90
8	$Cu(OAc)_2·H_2O$ (1)	2	89
9	$Cu(OAc)_2·H_2O$ (0.5)	1	20
10	$Cu(OAc)_2·H_2O$ (1)[c]	2	97

[a] Yield of isolated product.
[b] Reaction at 50 °C.
[c] Reaction was performed for 12 h at r.t.

Table 4 Reaction of **1a** with Various Alkynes



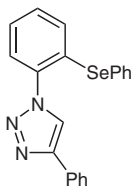
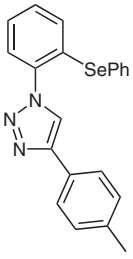
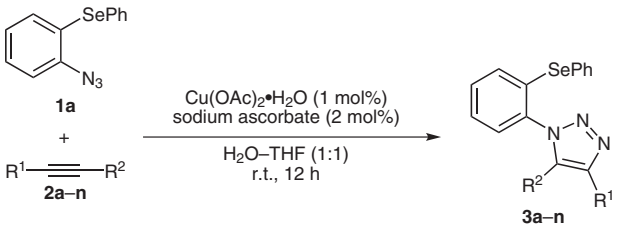
Entry	Product	Yield (%)[a]
1	**3a** (97%) 	97
2	**3b** (96%) 	96

Table 4 Reaction of **1a** with Various Alkynes (continued)



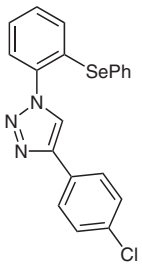
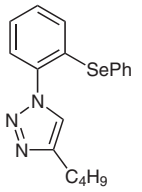
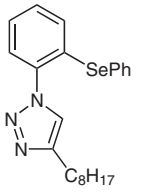
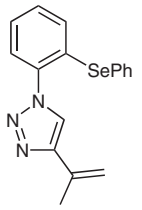
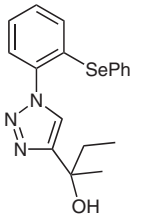
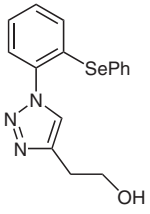
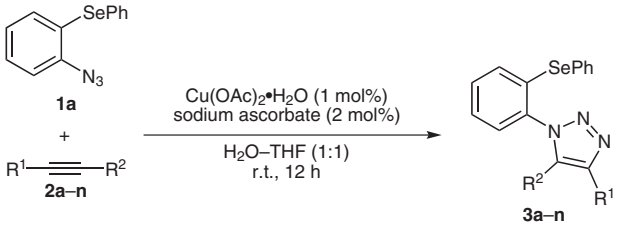
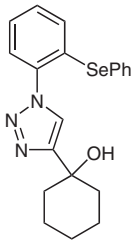
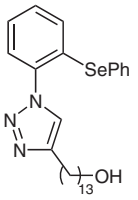
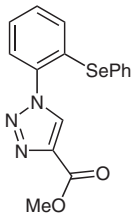
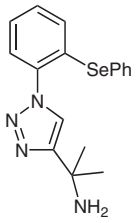
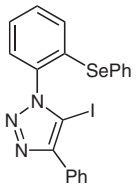
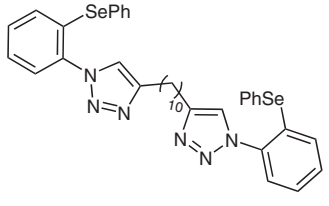
Entry	Product	Yield (%)[a]
3	**3c** (94%) 	94
4	**3d** (85%) 	85
5	**3e** (95%) 	95
6	**3f** (87%) 	87
7	**3g** (90%) 	90
8	**3h** (91%) 	91

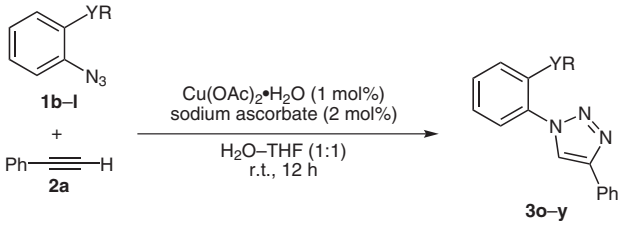
Table 4 Reaction of **1a** with Various Alkynes (continued)



Entry	Product	Yield (%)[a]
9	**3i** (97%) 	97
10	**3j** (75%) 	75
11	**3k** (87%) 	87
12	**3l** (86%) 	86
13	**3m** (83%) 	83
14	**3n** (92%) 	92

[a] Yield of isolated product.

Table 5 Reaction of Phenylacetylene (**2a**) with Various Azido Arylselenides



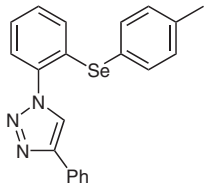
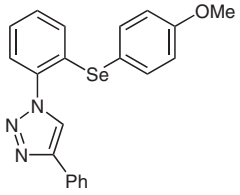
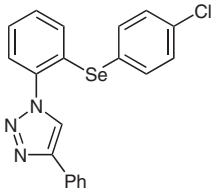
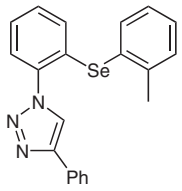
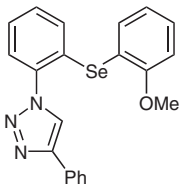
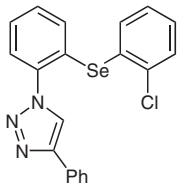
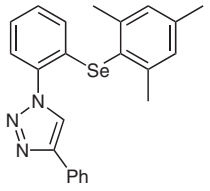
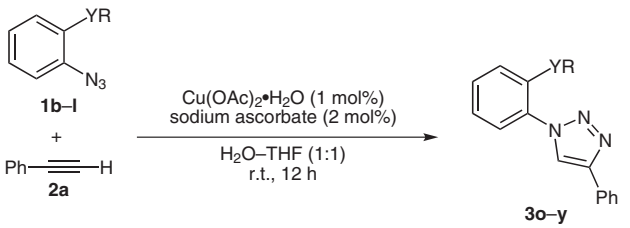
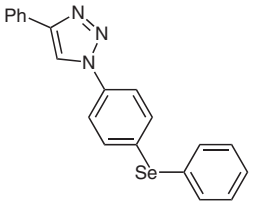
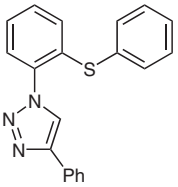
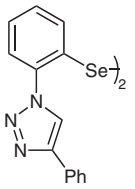
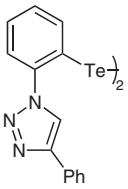
Entry	Product	Yield (%)[a]
1	**3o** 	98
2	**3p** 	94
3	**3q** 	88
4	**3r** 	90
5	**3s** 	91
6	**3t** 	87
7	**3u** 	75

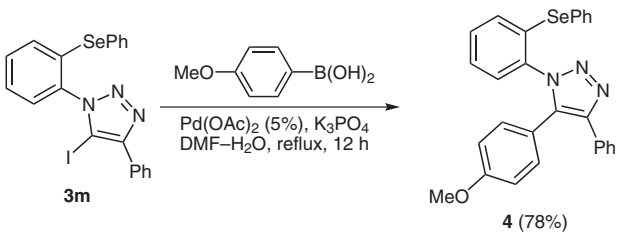
Table 5 Reaction of Phenylacetylene (**2a**) with Various Azido Arylselenides (continued)



Entry	Product	Yield (%)[a]
8	**3v** 	65
9	**3w** 	99
10	**3x** 	60
11	**3y** 	63

[a] Yield of isolated product.

Finally, compound **3m**, obtained via this cycloaddition protocol, proved to be promising as an intermediate in the preparation of more highly-substituted 1,2,3-triazoles. Triazole **3m** underwent Suzuki cross-coupling[18] with (4-methoxyphenyl)boronic acid to give the corresponding 4,5-disubstituted arylseleno-1,2,3-triazole **4** in good yield (Scheme 3).



Scheme 3 Suzuki cross-coupling of triazole **3m**

In summary, we have described the use of organoselenium compounds in copper-catalyzed Huisgen 1,3-dipolar cycloadditions. Arylseleno-1,2,3-triazoles **3** were prepared in good to excellent yields under mild conditions via reaction of amino arylselenides with *iso*-pentylnitrite and trimethylsilyl azide, and subsequent copper-catalyzed 1,3-dipolar cycloaddition of the resulting azido arylselenides **1** with various alkynes. In addition, we were able to convert compound **3m** into highly-substituted 1,2,3-triazole **4** in good yield using the Suzuki cross-coupling protocol. We have demonstrated that click chemistry is an efficient method to produce new selenium–nitrogen compounds with potential application for biological studies and as ligands for catalytic transformations.

All solvents were used as purchased unless otherwise noted. Alkynes were used as purchased or were prepared according to the literature.[19] Melting points were determined on an MQ APF–302 digital melting point apparatus. ^{1}H and ^{13}C NMR spectra were recorded at 400 MHz and 100 MHz, respectively, using Me_4Si as the internal standard. Hydrogen coupling patterns are described as singlet (s), doublet (d), triplet (t), quartet (q), quintet (quin), sextet (sext), multiplet (m), and broad (br). High resolution mass spectra were measured using a Bruker BioApex 70e FT-ICR (Bruker Daltonics, Billerica, USA) instrument in ESI mode. Column chromatography was performed using silica gel (Merck, 230–400 mesh). Thin layer chromatography (TLC) was performed using silica gel plates (Merck GF_{254}, 0.25 mm). For visualization, TLC plates were either placed under UV light, or stained with I_2 vapor, or acidic vanillin.

Azido Arylselenides; General Procedure

iso-Pentylnitrite (1.55 mmol, 0.21 mL) followed by trimethylsilyl azide (1.2 mmol, 0.16 mL) were added to a soln of amino arylselenide (1 mmol) or amino aryldiselenide (0.5 mmol) in THF (1.5 mL), in a dropwise manner at 0 °C under air. The mixture was stirred at 0 °C for 10 min after which the ice-bath was removed and the mixture stirred at r.t. for 1 h. The solvent was removed under vacuum and the product was isolated by column chromatography (eluent: hexane or hexane–EtOAc).

(2-Azidophenyl)(phenyl)selenide (1a)

Yield: 0.272 g (99%); yellow solid; mp 49–50 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.56–7.53 (m, 2 H), 7.35–7.30 (m, 3 H), 7.23 (td, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 7.12 (dd, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 7.02 (dd, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 6.94 (td, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 138.83, 135.10, 131.86, 129.56, 128.30, 128.25, 127.88, 125.52, 124.57, 118.17.

(2-Azidophenyl)(*p*-tolyl)selenide (1b)

Yield: 0.276 g (96%); red oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.45 (d, J = 8.0 Hz, 2 H), 7.19–7.06 (m, 4 H), 6.94–6.87 (m, 2 H), 2.34 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 138.61, 138.17, 135.75, 130.87, 130.39, 127.35, 125.42, 123.96, 119.55, 117.98, 21.15.

(2-Azidophenyl)(4-methoxyphenyl)selenide (1c)

Yield: 0.289 g (95%); pale-yellow solid; mp 63–64 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.54 (d, J = 8.8 Hz, 2 H), 7.19 (td, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 7.10 (dd, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 6.93–6.89 (m, 3 H), 6.84 (dd, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 3.84 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.14, 137.92, 137.42, 129.77, 126.86, 126.17, 125.30, 117.77, 117.10, 115.18, 55.02.

(2-Azidophenyl)(4-chlorophenyl)selenide (1d)
Yield: 0.271 g (88%); yellow solid; mp 36–37 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.45 (d, *J* = 8.4 Hz, 2 H), 7.29–7.24 (m, 3 H), 7.14 (d, *J* = 7.6 Hz, 1 H), 7.05 (d, *J* = 7.6 Hz, 1 H), 6.96 (t, *J* = 7.6 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 136.20, 134.67, 132.19, 129.78, 129.44, 128.30, 126.77, 125.64, 123.96, 118.32.

(2-Azidophenyl)(*o*-tolyl)selenide (1e)
Yield: 0.285 g (99%); red oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.48 (d, *J* = 8.0 Hz, 1 H), 7.31–7.28 (m, 2 H), 7.25–7.21 (m, 1 H), 7.14–7.11 (m, 2 H), 6.92 (td, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 6.84 (dd, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 2.40 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 141.80, 138.82, 136.24, 131.12, 130.45, 129.00, 128.81, 127.63, 126.95, 125.58, 124.05, 118.19, 22.52.

(2-Azidophenyl)(2-methoxyphenyl)selenide (1f)
Yield: 0.290 g (95%); pale-yellow solid; mp 58–60 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.33–7.22 (m, 3 H), 7.17 (d, *J* = 7.6 Hz, 1 H), 7.11 (d, *J* = 7.2 Hz, 1 H), 6.99 (t, *J* = 7.2 Hz, 1 H), 6.89 (d, *J* = 7.6 Hz, 1 H), 6.84 (t, *J* = 7.2 Hz, 1 H), 3.84 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 157.80, 140.74, 134.60, 133.24, 129.00, 128.87, 125.45, 121.61, 118.75, 118.33, 110.67, 99.98, 55.84.

(2-Azidophenyl)(2-chlorophenyl)selenide (1g)
Yield: 0.247 g (80%); pale-yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.42–7.38 (m, 2 H), 7.35 (dd, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 7.25–7.17 (m, 2 H), 7.12–7.05 (m, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 141.51, 135.77, 135.31, 132.66, 131.09, 129.88, 129.68, 128.33, 127.42, 125.72, 120.77, 118.65.

(2-Azidophenyl)(mesityl)selenide (1h)
Yield: 0.238 g (75%); yellow solid; mp 88–90 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.16–7.08 (m, 2 H), 7.02 (s, 2 H), 6.84 (td, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 6.47 (dd, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 2.41 (s, 6 H), 2.32 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 144.13, 139.54, 137.56, 128.99, 127.74, 126.28, 125.62, 125.37, 125.07, 118.00, 24.02, 21.05.

(4-Azidophenyl)(phenyl)selenide (1i)
Yield: 0.206 g (75%); orange oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.46–7.40 (m, 4 H), 7.26–7.24 (m, 3 H), 6.92 (d, *J* = 8.8 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 139.57, 134.92, 132.94, 132.49, 129.34, 127.30, 126.67, 119.95.

(2-Azidophenyl)(phenyl)sulfide (1j)
Yield: 0.228 g (99%); colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.33–7.22 (m, 7 H), 7.14–7.08 (m, 1 H), 7.02–6.97 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 139.02, 133.77, 131.99, 131.55, 129.24, 128.16, 127.42, 127.21, 125.24, 118.56.

1,2-Bis(2-azidophenyl)diselenide (1k)
Yield: 0.141 g (71%); brown oil.

^{1}H NMR (400 MHz, DMSO-d_6): δ = 8.02 (dd, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 2 H), 7.84–7.73 (m, 4 H), 7.60–7.56 (m, 2 H).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 148.93, 141.24, 139.27, 138.47, 136.21, 128.90.

1,2-Bis(2-azidophenyl)ditelluride (1l)
Yield: 0.124 g (50%); brown oil.

^{1}H NMR (400 MHz, DMSO-d_6): δ = 8.64–8.62 (m, 2 H), 8.22–8.15 (m, 4 H), 8.03–7.99 (m, 2 H).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 138.51, 130.89, 129.13, 128.08, 123.98, 118.53.

Aryseleno-1,2,3-Triazoles; General Procedure
To a soln of azido arylselenide (0.3 mmol) in THF (1.0 mL) were added the appropriate alkyne (0.33 mmol) and distilled H_2O (0.5 mL). Next, a fresh soln of sodium ascorbate (0.0012 g, 2 mol%) and $Cu(OAc)_2 \cdot H_2O$ (0.0006 g, 1 mol%) in distilled H_2O (0.5 mL) was added and the mixture stirred under air for 12 h. Brine (3 mL) was added and the mixture then extracted with CH_2Cl_2 (3 × 5 mL). The organic layers were combined, washed with brine (3 mL) and dried over $MgSO_4$. The solvent was removed under vacuum and the product isolated by column chromatography (eluent: hexane–EtOAc).

4-Phenyl-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (3a)
Yield: 0.110 g (97%); white solid; mp 149–150 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07 (s, 1 H), 7.91–7.89 (m, 2 H), 7.51–7.43 (m, 5 H), 7.38–7.27 (m, 7 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.67, 136.85, 135.02, 133.16, 130.25, 130.15, 130.12, 129.63, 128.84, 128.60, 128.29, 127.64, 126.05, 125.85, 120.96, 99.91.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{16}N_3Se$: 378.0509; found: 378.0506.

1-[2-(Phenylselanyl)phenyl]-4-(*p*-tolyl)-1*H*-1,2,3-triazole (3b)
Yield: 0.113 g (96%); pale-yellow solid; mp 135–137 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.03 (s, 1 H), 7.78 (d, *J* = 8.0 Hz, 2 H), 7.50–7.44 (m, 4 H), 7.36–7.24 (m, 7 H), 2.38 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.72, 138.12, 136.83, 135.03, 133.04, 130.09, 130.04, 129.59, 129.48, 128.81, 128.56, 127.55, 127.39, 125.95, 125.72, 120.56, 21.24.

HRMS: *m*/*z* calcd [M + Na]$^+$ for $C_{21}H_{17}N_3SeNa$: 414.0485; found: 414.0479.

4-(4-Chlorophenyl)-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (3c)
Yield: 0.115 g (94%); pale-yellow solid; mp 165–167 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.06 (s, 1 H), 7.83 (d, *J* = 8.8 Hz, 2 H), 7.49–7.46 (m, 4 H), 7.43–7.25 (m, 7 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 146.61, 136.78, 134.95, 134.06, 133.26, 130.28, 130.04, 129.66, 129.06, 128.79, 128.76, 128.63, 127.71, 127.09, 126.06, 121.05.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{15}ClN_3Se$: 412.0120; found: 412.0114.

4-Butyl-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (3d)
Yield: 0.091 g (85%); pale-yellow solid; mp 70–71 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.61 (s, 1 H), 7.49–7.47 (m, 2 H), 7.41–7.39 (m, 1 H), 7.34–7.22 (m, 6 H), 2.81 (t, *J* = 7.2 Hz, 2 H), 1.73 (quin, *J* = 7.2 Hz, 2 H), 1.43 (sext, *J* = 7.2 Hz, 2 H), 0.96 (t, *J* = 7.2 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.19, 136.86, 134.94, 132.68, 129.96, 129.75, 129.48, 128.73, 128.44, 127.31, 125.80, 121.88, 31.29, 25.16, 22.15, 13.71.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{18}H_{20}N_3Se$: 358.0822; found: 358.0816.

4-Octyl-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (3e)
Yield: 0.117 g (95%); yellowish solid; mp 66–68 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.61 (s, 1 H), 7.49–7.47 (m, 2 H), 7.40–7.38 (m, 1 H), 7.33–7.21 (m, 6 H), 2.79 (t, *J* = 7.2 Hz, 2 H), 1.74 (quin, *J* = 7.2 Hz, 2 H), 1.45–1.27 (m, 10 H), 0.87 (t, *J* = 7.2 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.19, 136.84, 134.92, 132.63, 129.94, 129.70, 129.45, 128.71, 128.41, 127.27, 125.76, 121.85, 31.67, 29.16, 29.13, 29.07, 29.04, 25.46, 22.47, 13.93.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{22}H_{28}N_3Se$: 414.1448; found: 414.1442.

1-[2-(Phenylselanyl)phenyl]-4-(prop-1-en-2-yl)-1*H*-1,2,3-triazole (3f)
Yield: 0.089 g (87%); pale-yellow solid; mp 90–92 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.79 (s, 1 H), 7.49–7.47 (m, 2 H), 7.42–7.39 (m, 1 H), 7.35–7.24 (m, 6 H), 5.82 (s, 1 H), 5.17–5.15 (m, 1 H), 2.17 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.53, 136.69, 134.94, 133.08, 132.95, 130.60, 130.01, 129.96, 129.53, 128.79, 127.50, 125.82, 120.86, 112.95, 20.55.

HRMS: *m*/*z* calcd [M + Na]$^+$ for $C_{17}H_{15}N_3SeNa$: 364.0329; found: 364.0323.

2-{1-[2-(Phenylselanyl)phenyl]-1*H*-1,2,3-triazol-4-yl}butan-2-ol (3g)
Yield: 0.101 g (90%); white solid; mp 131–133 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.79 (s, 1 H), 7.48–7.46 (m, 2 H), 7.43–7.40 (m, 1 H), 7.33–7.25 (m, 6 H), 2.89 (br s, 1 H), 1.98 (q, *J* = 7.6 Hz, 2 H), 1.66 (s, 3 H), 0.92 (t, *J* = 7.6 Hz, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 154.40, 136.79, 134.88, 132.89, 130.05, 129.98, 129.55, 128.72, 128.49, 127.45, 125.96, 121.42, 71.22, 35.83, 27.88, 8.27.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{18}H_{20}N_3OSe$: 374.0772; found: 374.0766.

2-{1-[2-(Phenylselanyl)phenyl]-1*H*-1,2,3-triazol-4-yl}ethanol (3h)
Yield: 0.094 g (91%); beige solid; mp 82–84 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.76 (s, 1 H), 7.48–7.45 (m, 2 H), 7.39 (dd, ^1J = 7.6 Hz, ^2J = 1.2 Hz, 1 H), 7.33–7.22 (m, 6 H), 3.99 (t, *J* = 6.0 Hz, 2 H), 3.14 (s, 1 H), 3.04 (t, *J* = 6.0 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 136.63, 134.92, 132.76, 129.97, 129.88, 129.50, 128.67, 128.48, 127.37, 125.77, 122.99, 61.28, 28.68.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{16}H_{16}N_3OSe$: 346.0459; found: 346.0453.

1-{1-[2-(Phenylselanyl)phenyl]-1*H*-1,2,3-triazol-4-yl}cyclohexanol (3i)
Yield: 0.116 g (97%); white solid; mp 154–156 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.79 (s, 1 H), 7.47–7.41 (m, 3 H), 7.35–7.25 (m, 6 H), 2.81 (s, 1 H), 2.10–2.04 (m, 2 H), 1.97–1.93 (m, 2 H), 1.83–1.74 (m, 2 H), 1.66–1.55 (m, 3 H), 1.45–1.38 (m, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 155.32, 136.92, 134.84, 133.06, 129.99, 129.93, 129.58, 128.82, 128.50, 127.56, 126.04, 121.19, 69.56, 38.06, 25.32, 21.98.

HRMS: *m*/*z* calcd [M + Na]$^+$ for $C_{20}H_{21}N_3OSeNa$: 422.0748; found: 422.0742.

13-{1-[2-(Phenylselanyl)phenyl]-1*H*-1,2,3-triazol-4-yl}tridecan-1-ol (3j)
Yield: 0.106 g (75%); white solid; mp 80–82 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.61 (s, 1 H), 7.49–7.47 (m, 2 H), 7.41–7.39 (m, 1 H), 7.35–7.24 (m, 6 H), 3.62 (t, *J* = 7.6 Hz, 2 H), 2.79 (t, *J* = 7.6 Hz, 2 H), 2.24 (s, 1 H), 1.74 (quin, *J* = 7.6 Hz, 2 H), 1.56 (quin, *J* = 7.6 Hz, 2 H), 1.42–1.26 (m, 18 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.23, 136.84, 134.95, 132.69, 129.98, 129.78, 129.49, 128.71, 128.46, 127.32, 125.82, 121.94, 67.95, 62.67, 32.63, 29.45, 29.42, 29.38, 29.29, 29.21, 29.17, 29.07, 25.62, 25.45.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{27}H_{38}N_3OSe$: 500.2180; found: 500.2174.

Methyl 1-[2-(Phenylselanyl)phenyl]-1*H*-1,2,3-triazole-4-carboxylate (3k)
Yield: 0.094 g (87%); yellow solid; mp 81–82 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.41 (s, 1 H), 7.46–7.26 (m, 9 H), 3.98 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.76, 139.56, 136.11, 134.52, 133.48, 130.65, 129.73, 129.53, 128.85, 128.52, 128.25, 127.85, 126.13, 52.07.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{16}H_{14}N_3O_2Se$: 360.0251; found: 360.0245.

2-{1-[2-(Phenylselanyl)phenyl]-1*H*-1,2,3-triazol-4-yl}propan-2-amine (3l)
Yield: 0.092 g (86%); white solid; mp 82–83 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.84 (s, 1 H), 7.50–7.47 (m, 2 H), 7.42 (d, *J* = 7.6 Hz, 1 H), 7.35–7.26 (m, 6 H), 3.72 (s, 2 H), 2.33 (s, 6 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 144.87, 136.73, 134.92, 132.75, 130.09, 129.96, 129.52, 128.61, 128.48, 127.38, 125.86, 123.79, 54.13, 44.99.

HRMS: *m*/*z* calcd [M + Na]$^+$ for $C_{17}H_{18}N_4SeNa$: 381.0594; found: 381.0588.

5-Iodo-4-phenyl-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (3m)
Yield: 0.125 g (83%); yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08–8.06 (m, 2 H), 7.52–7.47 (m, 4 H), 7.43–7.34 (m, 5 H), 7.31–7.25 (m, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 149.49, 136.77, 135.14, 133.48, 133.24, 131.23, 129.96, 129.51, 128.60, 128.57, 128.55, 128.49, 128.39, 127.61, 127.42.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{15}IN_3Se$: 503.9476; found: 503.9470.

1,10-Bis{1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazol-4-yl}decane (3n)
Yield: 0.204 g (92%); white solid; mp 143–144 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.58 (s, 2 H), 7.48–7.46 (m, 4 H), 7.41 (d, *J* = 7.6 Hz, 2 H), 7.34–7.22 (m, 12 H), 2.79 (t, *J* = 7.2 Hz, 4 H), 1.74 (quin, *J* = 7.2 Hz, 4 H), 1.41–1.25 (m, 12 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.32, 137.33, 134.95, 133.10, 130.03, 129.83, 129.58, 129.08, 128.49, 127.51, 126.08, 122.01, 29.46, 29.31, 29.29, 29.18, 25.62.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{38}H_{41}N_6Se_2$: 741.1723; found: 741.1717.

4-Phenyl-1-[2-(*p*-tolylselanyl)phenyl]-1*H*-1,2,3-triazole (3o)
Yield: 0.105 g (98%); pale-yellow solid; mp 107–108 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07 (s, 1 H), 7.90 (d, *J* = 8.0 Hz, 2 H), 7.44–7.22 (m, 9 H), 7.09 (d, *J* = 8.0 Hz, 2 H), 2.31 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 138.87, 136.29, 135.48, 132.25, 130.71, 130.40, 129.95, 128.76, 128.72, 128.16, 127.80, 127.11, 125.74, 125.74, 124.62, 120.89, 21.08.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{21}H_{18}N_3Se$: 392.0666; found: 392.0666.

1-{2-[(4-Methoxyphenyl)selanyl]phenyl}-4-phenyl-1*H*-1,2,3-triazole (3p)
Yield: 0.115 g (94%); yellow solid; mp 138–140 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08 (s, 1 H), 7.92 (d, *J* = 7.6 Hz, 2 H), 7.47–7.41 (m, 5 H), 7.37–7.17 (m, 4 H), 6.85 (d, *J* = 7.6 Hz, 2 H), 3.78 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.38, 147.66, 137.77, 135.99, 131.61, 131.56, 130.42, 130.00, 128.81, 128.27, 126.89, 125.82, 125.76, 120.83, 118.09, 115.36, 55.22.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{21}H_{18}N_3OSe$: 408.0615; found: 408.0609.

1-{2-[(4-Chlorophenyl)selanyl]phenyl}-4-phenyl-1*H*-1,2,3-triazole (3q)
Yield: 0.108 g (88%); beige solid; mp 105–107 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.06 (s, 1 H), 7.89 (d, *J* = 7.6 Hz, 2 H), 7.47–7.29 (m, 9 H), 7.24 (d, *J* = 7.6 Hz, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.74, 136.82, 136.28, 134.95, 133.10, 130.20, 130.09, 129.77, 129.70, 128.82, 128.32, 127.84, 127.13, 125.88, 125.80, 120.78.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{15}ClN_3Se$: 412.0120; found: 412.0114.

4-Phenyl-1-[2-(*o*-tolylselanyl)phenyl]-1*H*-1,2,3-triazole (3r)
Yield: 0.105 g (90%); white solid; mp 150–152 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.03 (s, 1 H), 7.88 (d, *J* = 7.2 Hz, 2 H), 7.48–7.41 (m, 4 H), 7.36–7.32 (m, 2 H), 7.28–7.20 (m, 4 H), 7.08 (td, ^1J = 7.6 Hz, ^2J = 2.4 Hz, 1 H), 2.30 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.68, 141.59, 137.27, 136.17, 132.78, 130.60, 130.49, 130.15, 129.77, 129.67, 129.22, 128.83, 128.25, 127.49, 127.03, 126.28, 125.95, 120.89, 22.46.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{21}H_{18}N_3Se$: 392.0666; found: 392.0665.

1-{2-[(2-Methoxyphenyl)selanyl]phenyl}-4-phenyl-1*H*-1,2,3-triazole (3s)
Yield: 0.111 g (91%); yellow solid; mp 123–124 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.09 (s, 1 H), 7.84 (d, *J* = 7.2 Hz, 2 H), 7.51 (t, *J* = 7.6 Hz, 2 H), 7.41–7.37 (m, 3 H), 7.29 (t, *J* = 7.6 Hz, 2 H), 7.24–7.19 (m, 2 H), 6.82–6.78 (m, 2 H), 3.69 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.10, 147.29, 138.34, 135.16, 134.10, 130.52, 129.90, 129.59, 128.68, 128.26, 128.04, 127.57, 126.33, 125.81, 121.67, 121.20, 119.11, 111.17, 55.79.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{21}H_{18}N_3OSe$: 408.0615; found: 408.0609.

1-{2-[(2-Chlorophenyl)selanyl]phenyl}-4-phenyl-1*H*-1,2,3-triazole (3t)
Yield: 0.107 g (87%); yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10 (s, 1 H), 7.87–7.83 (m, 2 H), 7.55 (dd, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 7.50 (dd, ^1J = 7.6 Hz, ^2J = 1.2 Hz, 1 H), 7.45–7.32 (m, 4 H), 7.26–7.23 (m, 2 H), 7.20 (dt, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 7.16 (dd, ^1J = 7.6 Hz, ^2J = 1.2 Hz, 1 H), 7.06 (dd, ^1J = 7.6 Hz, ^2J = 1.2 Hz, 1 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.52, 142.59, 138.14, 136.15, 135.25, 134.23, 130.56, 130.30, 129.72, 129.18, 128.91, 128.73, 128.20, 127.52, 126.31, 125.77, 125.70, 120.90.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{15}ClN_3Se$: 412.0120; found: 412.0116.

1-[2-(Mesitylselanyl)phenyl]-4-phenyl-1*H*-1,2,3-triazole (3u)
Yield: 0.094 g (75%); brown solid; mp 162–163 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.13 (s, 1 H), 7.95 (d, *J* = 7.2 Hz, 2 H), 7.47 (t, *J* = 7.2 Hz, 2 H), 7.43 (dd, ^1J = 8.0 Hz, ^2J = 1.6 Hz, 1 H), 7.37 (t, *J* = 7.6 Hz, 1 H), 7.27 (dd, ^1J = 7.2 Hz, ^2J = 1.6 Hz, 1 H), 7.18 (td, ^1J = 7.6 Hz, ^2J = 1.2 Hz, 1 H), 6.98 (s, 2 H), 6.83 (dd, ^1J = 8.0 Hz, ^2J = 1.2 Hz, 1 H), 2.37 (s, 6 H), 2.29 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.70, 143.76, 139.72, 136.04, 131.03, 130.31, 130.17, 129.40, 129.08, 128.86, 128.31, 126.17, 125.98, 125.91, 125.89, 120.69, 24.01, 21.02.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{23}H_{22}N_3Se$: 420.0979; found: 420.0973.

4-Phenyl-1-[4-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (3v)
Yield: 0.073 g (65%); white solid; mp 180–182 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.15 (s, 1 H), 7.89 (d, *J* = 8.4 Hz, 2 H), 7.67 (d, *J* = 8.4 Hz, 2 H), 7.57–7.54 (m, 4 H), 7.45 (t, *J* = 7.2 Hz, 2 H), 7.38–7.32 (m, 4 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.48, 135.88, 133.90, 133.28, 132.90, 130.09, 129.82, 129.62, 128.92, 128.48, 128.11, 125.84, 121.13, 117.34.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{16}N_3Se$: 378.0509; found: 378.0503.

4-Phenyl-1-[2-(phenylthio)phenyl]-1*H*-1,2,3-triazole (3w)
Yield: 0.098 g (99%); white solid; mp 128–130 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.09 (s, 1 H), 7.88–7.85 (m, 2 H), 7.53–7.51 (m, 1 H), 7.42 (t, *J* = 7.6 Hz, 2 H), 7.37–7.24 (m, 9 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 147.30, 136.34, 132.89, 132.84, 132.19, 132.02, 130.23, 130.11, 129.40, 128.72, 128.12, 128.09, 127.68, 126.84, 125.73, 121.58.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{20}H_{16}N_3S$: 330.1065; found: 330.1059.

1,2-Bis[2-(4-phenyl-1*H*-1,2,3-triazol-1-yl)phenyl]diselenide (3x)
Yield: 0.108 g (60%); brown solid; mp 136–138 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.33 (d, *J* = 8.4 Hz, 2 H), 7.93 (d, *J* = 8.4 Hz, 2 H), 7.86–7.83 (m, 4 H), 7.63–7.59 (m, 2 H), 7.53–7.46 (m, 6 H), 7.39–7.35 (m, 2 H), 7.26 (s, 2 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 130.22, 130.17, 129.05, 128.87, 127.92, 127.55, 127.43, 127.40, 126.57, 125.88, 125.42, 115.97.

HRMS: *m*/*z* calcd [M – $C_{14}H_{10}N_3Se$]$^+$ for $C_{14}H_{10}N_3Se$: 300.0040; found: 300.0035.

1,2-Bis[2-(4-phenyl-1*H*-1,2,3-triazol-1-yl)phenyl]ditelluride (3y)
Yield: 0.132 g (63%); brown solid; mp 131–133 °C.

^{1}H NMR (400 MHz, DMSO-d_6): δ = 7.36–7.20 (m, 16 H), 7.12–7.08 (m, 4 H).

^{13}C NMR (100 MHz, DMSO-d_6): δ = 141.42, 134.02, 129.08, 129.00, 128.45, 127.93, 127.14, 125.40, 125.04, 121.20, 117.32, 116.22.

HRMS: *m*/*z* calcd [M – $C_{14}H_{10}N_3Te$]$^+$ for $C_{14}H_{10}N_3Te$: 349.9937; found: 349.9931.

5-(4-Methoxyphenyl)-4-phenyl-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (4)

To a soln of 5-iodo-4-phenyl-1-[2-(phenylselanyl)phenyl]-1*H*-1,2,3-triazole (**3m**) (0.126 g, 0.25 mmol) in DMF (2.5 mL) was added $Pd(OAc)_2$ (0.003 g, 5 mol%) and (4-methoxyphenyl)boronic acid (0.053 g, 0.35 mmol) under Ar. The resulting soln was stirred for 30 min at r.t., after which a soln of K_3PO_4 (1.2 mmol, 0.254 g) in H_2O (0.6 mL) was added. The mixture was then heated at reflux temperature for 12 h, cooled to r.t., diluted with CH_2Cl_2 (20 mL) and washed with brine (2 × 20 mL). The organic phase was separated, dried over $MgSO_4$, and concentrated under vacuum. The residue was purified by flash chromatography (eluent: hexane–EtOAc, 80:20).

Yield: 0.094 g (78%); yellowish solid; mp 117–119 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.44 (d, *J* = 8.4 Hz, 1 H), 7.71 (dd, ^1J = 7.6 Hz, ^2J = 1.2 Hz, 1 H), 7.44–7.39 (m, 1 H), 7.28–7.05 (m, 15 H), 5.03 (s, 3 H).

^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.25, 139.17, 139.06, 138.65, 137.93, 130.97, 130.68, 129.83, 129.46, 128.87, 128.74, 126.85, 126.75, 124.98, 120.38, 118.62, 74.94.

HRMS: *m*/*z* calcd [M + H]$^+$ for $C_{27}H_{22}N_3OSe$: 484.0928; found: 484.0922.

Supporting Information for this article is available online at http://www.thieme-connect.com/ejournals/toc/synthesis.

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References

(1) Grimett, M. R. In *Comprehensive Organic Chemistry*; Barton, D.; Ollis, W. D., Eds.; Pergamon Press: Oxford, **1979**.
(2) Huisgen, R. *Angew. Chem.* **1963**, *75*, 604.
(3) (a) Rostovtsev, V. V.; Green, L. G.; Fokin, V. V.; Sharpless, K. B. *Angew. Chem. Int. Ed.* **2002**, *41*, 2596. (b) Krasinski, A.; Radic, Z.; Manetsch, R.; Raushel, J.; Taylor, P.; Sharpless, K. B.; Kolb, H. C. *J. Am. Chem. Soc.* **2005**, *127*, 6686. (c) Lee, L. V.; Mitchell, M. L.; Huang, S.; Fokin, V. V.; Sharpless, K. B.; Wong, C. *J. Am. Chem. Soc.* **2003**, *125*, 9588. (d) Hein, J. E.; Tripp, J. P.; Krasnova, L. B.; Sharpless, K. B.; Fokin, V. V. *Angew. Chem. Int. Ed.* **2009**, *48*, 1. (e) Tornøe, C. W.; Christensen, C.; Meldal, M. *J. Org. Chem.* **2002**, *67*, 3057. (f) Shao, C.; Cheng, G.; Su, D.; Xu, J.; Wang, X.; Hu, Y. *Adv. Synth. Catal.* **2010**, *352*, 1587.
(4) Kolb, H. C.; Finn, M. G.; Sharpless, K. B. *Angew. Chem. Int. Ed.* **2001**, *40*, 2004.
(5) (a) Tron, G. C.; Pirali, T.; Billington, R. A.; Canonico, P. L.; Sorba, G.; Genazzani, A. A. *Med. Res. Rev.* **2008**, *28*, 278. (b) Hein, C. D.; Liu, X.-M.; Wang, D. *Pharm. Res.* **2008**, *25*, 2216. (c) Xie, J.; Seto, C. T. *Bioorg. Med. Chem.* **2007**, *15*, 458. (d) Lee, T.; Cho, M.; Ko, S. Y.; Youn, H. J.; Baek, D. J.; Cho, W. J.; Kang, C. Y.; Kirn, S. *J. Med. Chem.* **2007**, *50*, 585. (e) Parrish, B.; Emrick, T. *Bioconjugate Chem.* **2007**, *18*, 263.
(6) (a) Nandivada, H.; Jiang, X.; Lahann, J. *Adv. Mater.* **2007**, *19*, 2197. (b) Lee, B. S.; Lee, J. K.; Kim, W. J.; Jung, Y. H.; Sim, S. J.; Lee, J.; Choi, I. S. *Biomacromolecules* **2007**, *8*, 744.
(7) (a) Bastero, A.; Font, D.; Pericàs, M. A. *J. Org. Chem.* **2007**, *72*, 2460. (b) Chassaing, S.; Kumarraja, M.; Sido, A. S. S.; Paie, P.; Sommer, J. *Org. Lett.* **2007**, *9*, 883.
(8) Carlqvist, P.; Maseras, F. *Chem. Commun.* **2007**, 748.
(9) Nepogodiev, S. A.; Dedola, S.; Marmuse, L.; Oliveira, M. T.; Field, R. A. *Carbohydr. Res.* **2007**, *342*, 529.
(10) (a) Wirth, T. *Organoselenium Chemistry,* In *Topics in Current Chemistry*; Springer-Verlag: Heidelberg, **2000**, 208. (b) Paulmier, C. *Selenium Reagents and Intermediates in Organic Synthesis,* In *Organic Chemistry Series*, Vol. 4; Baldwin, J. E., Ed.; Pergamon Press: Oxford, **1986**. (c) Perin, G.; Lenardão, E. J.; Jacob, R. G.; Panatieri, R. B. *Chem. Rev.* **2009**, *109*, 1277. (d) Freudendahl, D. M.; Shahzad, S. A.; Wirth, T. *Eur. J. Org. Chem.* **2009**, 1649. (e) Freudendahl, D. M.; Santoro, S.; Shahzad, S. A.; Santi, C.; Wirth, T. *Angew. Chem. Int. Ed.* **2009**, *48*, 8409. (f) Braga, A. L.; Lüdtke, D. S.; Vargas, F. *Curr. Org. Chem.* **2006**, *10*, 1921.
(11) (a) Parnham, M. J.; Graf, E. *Prog. Drug Res.* **1991**, *36*, 9. (b) Mugesh, G.; du Mont, W. W.; Sies, H. *Chem. Rev.* **2001**, *101*, 2125. (c) Nogueira, C. W.; Zeni, G.; Rocha, J. B. T. *Chem. Rev.* **2004**, *104*, 6255. (d) Alberto, E. E.; Nascimento, V.; Braga, A. L. *J. Braz. Chem. Soc.* **2010**, *21*, 2032.
(12) (a) Braga, A. L.; Ludtke, D. S.; Vargas, F.; Braga, R. C. *Synlett* **2006**, 1453. (b) Braga, A. L.; Vargas, F.; Sehnem, J. A.; Braga, R. C. *J. Org. Chem.* **2005**, *70*, 9021. (c) Braga, A. L.; Paixao, M. W.; Ludtke, D. S.; Silveira, C. C.; Rodrigues, O. E. D. *Org. Lett.* **2003**, *5*, 2635. (d) Braga, A. L.; Paixao, M. W.; Marin, G. *Synlett* **2005**, 1975. (e) Braga, A. L.; Ludtke, D. S.; Sehnem, J. A.; Alberto, E. E. *Tetrahedron* **2005**, *61*, 11664. (f) Braga, A. L.; Rodrigues, O. E. D.; Paixão, M. W.; Appelt, H. R.; Silveira, C. C.; Bottega, D. P. *Synthesis* **2002**, 2338.
(13) For a previous communication, see: Deobald, A. M.; Camargo, L. R. S.; Tabarelli, G.; Hörner, M.; Rodrigues, O. E. D.; Alves, D.; Braga, A. L. *Tetrahedron Lett.* **2010**, *51*, 3364.
(14) (a) Bräse, S.; Gil, C.; Knepper, K.; Zimmermann, V. *Angew. Chem. Int. Ed.* **2005**, *44*, 5188. (b) Scriven, E. F. V.; Turnbull, K. *Chem. Rev.* **1988**, *88*, 297. (c) L'Abbé, G. *Chem. Rev.* **1969**, *69*, 345.
(15) (a) Riela, S.; Aprile, C.; Gruttadauria, M.; Lo Melo, P.; Noto, R. *Molecules* **2005**, *10*, 383. (b) Ward, V. R.; Cooper, N. A.; Ward, A. P. *J. Chem. Soc., Perkin Trans. 1* **2001**, 944. (c) Broggini, G.; Molteni, G.; Zucchi, G. *Synthesis* **1995**, 647.
(16) (a) Back, T. G.; Bethell, R. J.; Parvez, M.; Taylor, J. A.; Wehrli, D. *J. Org. Chem.* **1999**, *64*, 7426. (b) Tiecco, M.; Testaferri, L.; Santi, C.; Tomassini, C.; Marini, F.; Bagnoli, L.; Temperini, A. *Angew Chem. Int. Ed.* **2003**, *42*, 3131.
(17) Roth, P. J.; Kessler, D.; Zentel, R.; Theato, P. *J. Polym. Sci., Part A: Polym. Chem.* **2009**, *47*, 3118.
(18) (a) Miyaura, N.; Suzuki, A. *Chem. Rev.* **1995**, *95*, 2457. (b) Barancelli, D. A.; Alves, D.; Prediger, P.; Stangherlin, E. C.; Nogueira, C. W.; Zeni, G. *Synlett* **2008**, 119.
(19) Brandsma, L. *Preparative Acetylene Chemistry*, 3rd ed.; Elsevier: Amsterdam, **1988**.