Selenium-Containing Heterocycles from Isoselenocyanates: 4-Methylselenazole Derivatives from the Reaction with Malononitrile and Propargyl Chloride

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Aryl isoselenocyanates **1** react with malononitrile (**6a**) and propargyl chloride (**8**) in DMF in the presence of Et_3N to give the corresponding 2-(3-aryl-2,3-dihydro-4-methyl-1,3-selenazol-2-ylidene)malononitriles **12** as major products. The analogous reaction takes place with benzoylacetonitrile (**6f**) instead of **6a**. In some cases, the corresponding noncyclic 2-[(arylamino)(prop-2-ynylselanyl)methylidene]malononitriles **9** were obtained as minor products. The structures of **9e** and **11a** have been established by X-ray crystallography.

1. Introduction. – The unique biochemical and pharmaceutical properties of organoselenium compounds make them very attractive, in particular for bioorganic and medicinal chemists. Such compounds, especially Se-containing heterocycles, have gradually gained importance over the last 25 years. Among the different possible heterocyclic systems are not least the 1,3-selenazoles. These heterocycles show remarkable reactivities and chemical properties, and they also find diverse pharmaceutical applications. Several reviews [1] describe their preparation [2] and pharmaceutical potential [3]. They have been studied widely, for example, as anticancer [4] and antiradiation agents [5], as protein kinase activators [6], and as superoxide anion scavengers [7], but they are also well-recognized in dye chemistry [8] and with respect to their physical properties [9].

Because of this broad spectrum of interest, we have focused our attention on the use of isoselenocyanates **1** as building blocks for the preparation of selenaheterocycles, in particular, 1,3-selenazole derivatives. Isoselenocyanates have proved to be useful starting materials, since they are easy to prepare, and safe to handle and to store. In addition, they typically react under mild conditions, which are compatible with the low stability of substrates and products in the preparation of complex molecules [10].

It has been shown that the reactions of bifunctional nucleophiles **2** with **1** yield five- to seven-membered heterocycles of type **4** and **5** [10c][11–16] (*Scheme 1*). The proposed reaction mechanism involves the formation of the adduct **3**, which undergoes ring closure by nucleophilic substitution of the leaving group X either by the Se- or the

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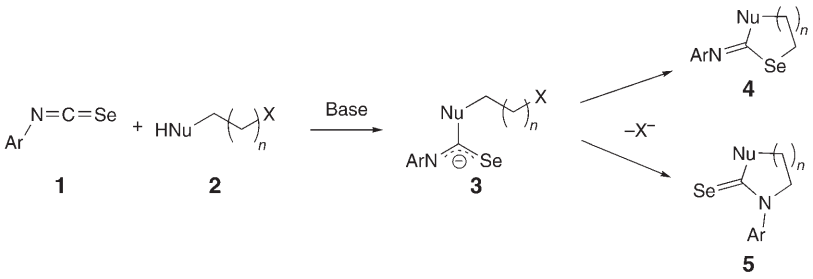
N-atom. Analogously, three-component reactions of **1** with a nucleophile and a bis-electrophile were carried out to yield selenaheterocycles [10c][17–20]. As a continuation of this work, we decided to investigate the addition of C-nucleophiles with **1** and to trap the intermediate by a suitably substituted electrophilic reagent, *i.e.*, propargyl chloride (3-chloroprop-2-yne).

Scheme 1



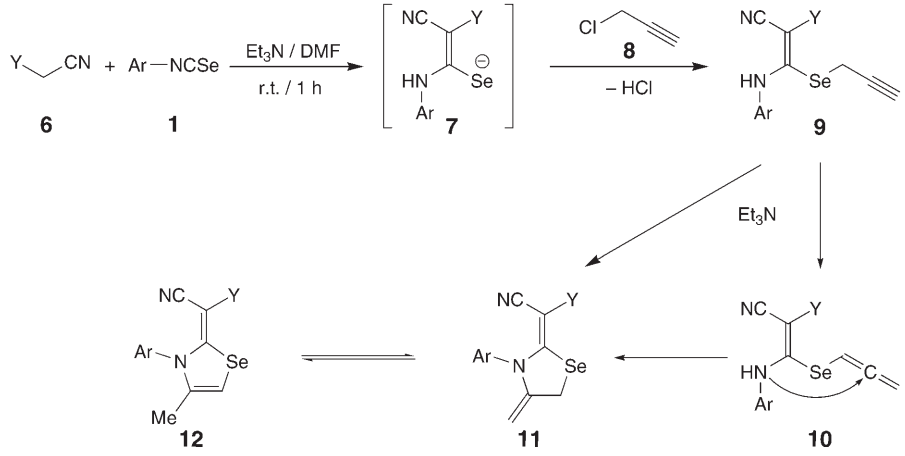
Several syntheses of heterocycles by using propargyl derivatives as acetylenic building blocks are described in the literature. For example, propargyl bromides were used for the preparation of fused bicyclic systems like selenazolo[2,3-*c*][1,2,4]triazines [21] and thiazolo[2,3-*c*][1,2,4]triazines [22], and thieno[3,2-*d*]pyrimidin-4-ones were prepared *via* a thio-*Claisen* rearrangement of 5-(propargylsulfanyl)pyrimidin-4(3*H*)-ones [23]. The reactions of isocyanates with propargyl amine and propargyl alcohol led to 4-methylidenimidazolidin-2-ones and 4-methyliden-1,3-oxazolidin-2-ones, respectively [24], whereas isothiocyanates and 3-methylbut-1-yn-3-ol, by treatment with NaH, yielded 5,5-dimethyl-4-methylidene-1,3-oxazolidine-2-thiones [25]. Whereas, in these cases, the ring closure of the intermediate occurs *via* nucleophilic attack of the N-atom at the inner C-atom of the acetylene unit, the reaction of isoselenocyanates and propargyl amines gave 2-amino-4,5-dihydro-5-methylidene-1,3-selenazoles by a cyclization *via* the Se-atom [26].

As part of our program aiming at the development of simple procedures for the preparation of Se-containing heterocycles [10c][11–20][27], we report here on a novel and efficient synthesis of 4-methyl-1,3-selenazole derivatives.

2. Results and Discussion. – The carbanion generated from ethanenitrile derivatives **6** and Et_3N in DMF reacts with aromatic isoselenocyanates **1** to give intermediate ketene-N,Se-hemiacetals of type **7**. It was expected that the latter react with propargyl chloride (**8**) by substitution of Cl^- to give **9**. Subsequent ring closure *via* nucleophilic addition of the N-atom at the acetylene group could lead to selenazolidine derivatives of type **11** (*Scheme 2*). Alternatively, a base-catalyzed isomerization of **9** to give the allenyl derivative **10**, which could also be formed *via* a S_N2' reaction of **7** with **8**, followed by cyclization to give **11**, could be conceivable. Similar ring-closure reactions, which lead to 1,3-thiazole derivatives, were described by *Junjappa* and co-workers [28] and later by *Suma et al.* [29].

The necessary isoselenocyanates **1** were prepared easily by a slightly modified *Barton* procedure [30] from the corresponding *N*-arylformamides by treatment with

Scheme 2



For Ar and Y, see *Table 1*

$COCl_2$ and elemental Se. An equimolar mixture of malononitrile **6a**, phenyl isoselenocyanate **1a**, Et_3N, and propargyl chloride (**8**) in DMF was stirred at room temperature for 4 h. Then, the solvent was evaporated under reduced pressure, the solid residue was separated by column chromatography on SiO_2, and recrystallization of the major product from AcOEt gave 2-(2,3-dihydro-4-methyl-3-phenyl-1,3-selenazol-2-ylidene)malononitrile (**12a**) in 50% yield (*Scheme 3* and *Table 1*).

Scheme 3

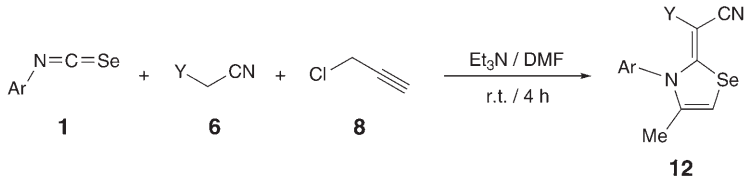


Table 1. *Preparation of Selenazole Derivatives* **12** *from Isoselenocyanates* **1**

	Ar	Y	Intermediate **9**[a])		**12**[a])	
			M.p. [°]	Yield [%]	M.p. [°]	Yield [%]
a	Ph	CN	–	–	235–237	50
b	4-MeO–C_6H_4	CN	133–135	28	247–249	45
c	4-Cl–C_6H_4	CN	–	–	174–176	45
d	4-Br–C_6H_4	CN	–	–	187–189	38
e	4-Me–C_6H_4	CN	154–156	24	135–137	56
f	Ph	COPh	–	–	197–199	50

[a]) For the *Formulae* of **9** and **12**, see *Scheme 2*.

The structure of **12a** has been deduced from the spectroscopic data and elemental analysis. Most indicative are the NMR spectra, which show signals for a Me (^{1}H: 1.84 ppm, ^{13}C: 16.8 ppm) and a =CH– group (^{1}H: 6.78 ppm, ^{13}C: 102.8 ppm). The ^{13}C signals for the malononitrile moiety ($C(CN)_2$ at 48.2 ppm) and SeC(2)N of the five-membered heterocycle (174.0 ppm) are characteristic for this structure (see [17][18][20]).

Single crystals of **12a**, suitable for an X-ray crystal-structure determination, were grown from AcOEt. Surprisingly, the structure in the crystal is the 4-methylidene derivative **11a**, *i.e.*, an isomer of **12a** (*Fig. 1*).

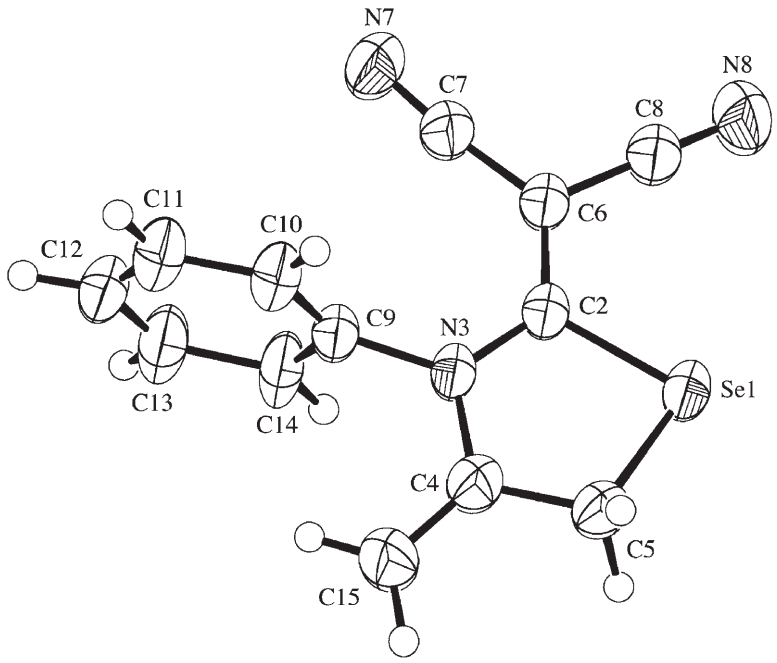


Fig. 1. *ORTEP Plot* [31] *of the molecular structure of* **11a** (arbitrary numbering of atoms; 50% probability ellipsoids)

The molecule **11a** sits on a crystallographic mirror plane and is partly disordered about this plane. The heterocyclic ring is not planar with the methylidene group within the ring being puckered out of the ring plane to form an envelope conformation. The mirror symmetry requires that this atom is disordered to both sides of the mirror plane. The exocyclic methylidene group also lies out of the plane, so is similarly disordered across both sides of the mirror plane. The Ph ring lies perpendicular to the mirror plane and is also tilted so that the *ipso*- and *para*-C-atoms do not lie on the mirror, which results in the entire Ph ring being disordered about the mirror plane as well. The geometric parameters of **11a** are very similar to those of analogous 2-(1,3-selenazolidin- and 1,3-selenazinan-2-ylidene)malononitriles described in [17][18][20], *i.e.*, the C(2)=C(6) bond is longer (1.389(3) Å) than a normal C=C bond, the formal single

bonds Se(1)–C(2), N(3)–C(2), C(6)–C(7), and C(6)–C(8) are short (1.883(2), 1.344(3), 1.422(4), and 1.425(4) Å, resp.), and the bond angle C(2)–C(6)–C(7) is widened (127.6(2)°), whereas the angles C(2)–C(6)–C(8) and C(7)–C(6)–C(8) are compressed (116.8(2)° and 115.6(2)°, resp.) with respect to the normally expected angles of 120°. These parameters indicate significant electron delocalization within the molecule.

The analogous reactions of 4-methoxyphenyl- (**1b**), 4-chlorophenyl- (**1c**), 4-bromophenyl- (**1d**), and 4-methylphenyl isoselenocyanate (**1e**) with **6a** and **8** yielded the correspondingly substituted products **12b**–**12e** (*Table 1*). In the cases of **1b** and **1e**, the proposed intermediates, *i.e.*, the noncyclic ketene-N,Se-hemiacetals **9b** and **9e**, respectively (*Scheme 2* and *Table 1*), were obtained as minor products after chromatographic workup. The cyclization to give the corresponding selenazolidine derivatives **12b** and **12e** has been achieved quantitatively by treatment with a stronger base like NaH.

The elucidation of the structures of **9a** and **9e** was based again on the analytical and spectroscopic data compared with those for similar compounds (*cf.* [20]). Finally, the structure of **9e** was established by X-ray crystallography (*Fig. 2*).

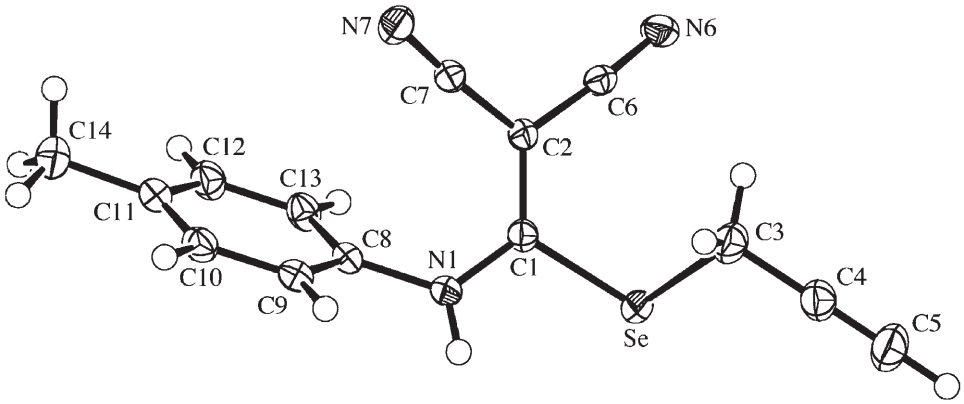


Fig. 2. *ORTEP Plot* [31] *of the molecular structure of* **9e** (arbitrary numbering of atoms; 50% probability ellipsoids)

The environment about the C(1)=C(2) bond is not planar with the plane defined by C(2), C(6), and C(7) making an angle of 14.2(2)° with the plane defined by N(1), C(1), and the Se-atom. Again, the C(1)=C(2) bond is relatively long (1.390(2) Å), and the single bonds Se–C(1), N(1)–C(1), C(2)–C(6), and C(2)–C(7) are relatively short (1.907(2), 1.335(2), 1.418(2), and 1.430(2) Å, resp.). The NH group forms an intermolecular H-bond with one of the cyano N-atoms of a neighboring molecule and thereby links the molecules into extended chains which run parallel to the [001] direction and have a graph set motif [32] of *C(6)*.

Similar to malononitrile (**6a**), the base-catalyzed reaction of benzoylacetonitrile (**6f**), phenyl isoselenocyanate (**1a**), and propargyl chloride (**8**) yielded a 1,3-selenazole derivative of type **12**, *i.e.*, the 2-(2,3-dihydro-1,3-selenazol-2-ylidene)-3-oxo-3-phenylpropanenitrile **12f** (*Table 1*). The NMR spectra established again the structure of the

2,3-dihydro-4-methyl-1,3-selenazole moiety, with ^{1}H- and ^{13}C-absorptions of the Me group at 1.95 and 16.9 ppm, respectively, and signals for H–C(5) at 7.02 and 109.8 ppm. The main differences with respect to the spectra of **12a**–**12e** are the presence of only one C≡N absorption (117.5 ppm) and a C=O signal at 187.7 ppm.

In conclusion, we have shown that the base-catalyzed three-component reaction with ethanenitrile derivatives **6**, isoselenocyanates **1**, and propargyl chloride (**8**) offers a convenient access to 1,3-selenazole derivatives of type **12**. This is of special importance, because the attempted preparation of those derivatives in the reaction of α-bromo ketones with **1** and **6** failed [20]. As proposed in *Scheme 2*, the reaction proceeds *via* addition of the carbanion of **6** onto the isoselenocyanate **1** to yield the acyclic intermediate **7**, which then reacts with **8** *via* the Se-atom to give the ketene-N,Se-hemiacetal **9**. This intermediate, which has been isolated in some cases, undergoes a base-catalyzed cyclization to lead, finally, to the products **12**. As described for several cyclization reactions with acetylenic compounds (see, *e.g.*, [21–25]), the ring closure of **9** occurs in a *5-exo-dig* fashion [33] to give the methylidene derivative **11**, the structure of which could be established by X-ray crystallography. The isomeric product **12** is then formed *via* a H-shift.

We thank the analytical units of our institute for spectra and analyses. Financial support of this work by the *Dr. Helmut Legerlotz-Foundation* and *F. Hoffmann-La Roche AG*, Basel, is gratefully acknowledged.

Experimental Part

1. *General.* See [27a,b]. TLC: silica gel *60* F_{254} plates (0.25 mm; *Merck*). Column chromatography (CC): silica gel *60* (0.040–0.063 mm; *Merck*). M.p.: *Büchi B-540* apparatus in capillaries; uncorrected. ^{1}H- (300 MHz) and ^{13}C-NMR (75.5 MHz) spectra: *Bruker ARX-300* instrument, in $CDCl_3$; chemical shifts in ppm. CI-MS: *Finnigan SSQ-700* or *MAT-90* instrument; NH_3 or isobutane as carrier gas.

2. *Starting Materials. Propanedinitrile* (=*malononitrile*; **6a**), *benzoylacetonitrile* (**6f**), and propargyl chloride (**8**) are commercially available (*Fluka*). Isoselenocyanates **1** were prepared according to *Barton*'s procedure starting from formamides [30]. Formanilide is commercially available (*Fluka*), *N*-(4-chlorophenyl)-, *N*-(4-bromophenyl)-, *N*-(4-methoxyphenyl)-, and *N*-(4-methylphenyl)formamides were prepared from the respective aniline and 95% HCOOH [34] (see also [19]).

3. *General Procedure for the Preparation of 2,3-Dihydro-4-methyl-1,3-selenazole Derivatives* **12a**–**12f**. A 50-ml round-bottom flask equipped with magnetic stirrer and condenser was charged with a soln. of **6a** or **6f** (1.10 mmol) in DMF (25 ml). Then, Et_3N (0.15 ml, 1.10 mmol) was added, the mixture was stirred for 45 min at r.t., and isoselenocyanate (**1**, 1.10 mmol) was added. After stirring for 30 min at r.t., propargyl chloride (**8**, 0.08 ml, 1.10 mmol) was added, the mixture was stirred for 4 h at r.t., and then evaporated to dryness under reduced pressure. The crude product was purified by CC (SiO_2; hexane/AcOEt 100:0 to 1:1) and crystallized from AcOEt.

2-(2,3-Dihydro-4-methyl-3-phenyl-1,3-selenazol-2-ylidene)propanedinitrile (**12a**). Yield: 158.8 mg (50%). Yellowish crystals. M.p. 235–237°. IR (KBr): 3127*w*, 2925*w*, 2198*s*, 2185*s*, 1641*w*, 1595*w*, 1523*s*, 1493*s*, 1423*w*, 1363*m*, 1271*m*, 844*w*, 762*w*, 695*m*. IR (Nujol): 3022*w*, 2942*m*, 2916*m*, 2881*m*, 2842*s*, 2725*w*, 2197*s*, 2185*s*, 1639*m*, 1593*m*, 1523*m*, 1462*s*, 1377*s*, 1365*m*, 1270*m*, 1189*w*, 1160*w*, 1072*w*, 1028*w*, 1012*w*, 910*w*, 864*w*, 844*m*, 828*w*, 812*w*, 762*m*, 736*m*, 694*m*, 638*w*, 624*w*, 611*w*. ^{1}H-NMR: 1.84 (*s*, Me); 6.78 (*s*, H–C(5′)); 7.30 (*d*, *J* = 8.1, 2 arom. H); 7.55–7.64 (*m*, 3 arom. H). ^{13}C-NMR: 16.8 (Me); 48.2 (*C*(CN)$_2$); 102.8 (C(5′)); 112.5, 118.7 (2 CN); 128.7 (2 arom. CH); 130.2 (2 arom. CH); 131.5 (1 arom. CH); 136.0 (C(4′)); 141.1 (1 arom. C); 174.0 (C(2′)). CI-MS (NH_3): 592 (6), 590 (5, $[2M + NH_4]^+$), 307 (19), 306 (16), 305 (100, $[M(^{80}Se) + NH_4]^+$), 304 (8), 303 (51), 302 (19), 301 (19), 288 (7, $[M(^{80}Se) + 1]^+$). Anal. calc. for $C_{13}H_9N_3Se$ (286.19): C 54.46, H 3.17, N 14.68; found: C 54.46, H 3.24, N 14.78.

Suitable crystals for the X-ray crystal structure determination were grown from AcOEt by slow evaporation of the solvent. These crystals proved to be *2-(4-methylidene-3-phenyl-1,3-selenazolidin-2-ylidene)propanedinitrile* (**11a**).

2-[2,3-Dihydro-3-(4-methoxyphenyl)-4-methyl-1,3-selenazol-2-ylidene]propanedinitrile (**12b**). Yield: 156.5 mg (45%). Yellowish crystals. M.p. 247–249°. IR (KBr): 3116*w*, 2197*s*, 2181*s*, 1638*w*, 1604*w*, 1587*w*, 1510*s*, 1486*s*, 1465*m*, 1389*w*, 1366*w*, 1350*w*, 1299*m*, 1256*s*, 1171*m*, 1107*w*, 1020*m*, 873*w*, 844*m*, 773*w*, 754*w*, 736*w*, 718*w*, 615*w*, 602*w*. ^{1}H-NMR: 1.88 (*s*, Me); 3.93 (*s*, MeO); 6.82 (*s*, H–C(5′)); 7.09, 7.25 (*AA′BB′*, J_{AB} = 8.2, 4 arom. H). ^{13}C-NMR: 16.8 (Me); 48.2 (C(CN)$_2$); 55.5 (MeO); 102.4 (C(5′)); 112.8, 118.9 (2 CN); 115.2 (2 arom. CH); 128.5 (C(4′)); 129.8 (2 arom. CH); 141.6, 161.6 (2 arom. C); 174.5 (C(2′)). CI-MS (isobutane): 320 (19), 319 (16), 318 (100, [M(^{80}Se) + 1]$^+$), 317 (18), 316 (52), 315 (23), 314 (21). Anal. calc. for $C_{14}H_{11}N_3OSe$ (316.22): C 53.18, H 3.51, N 13.29; found: C 53.29, H 3.65, N 13.16.

2-[3-(4-Chlorophenyl)-2,3-dihydro-4-methyl-1,3-selenazol-2-ylidene]propanedinitrile (**12c**). Yield: 158.7 mg (45%). Yellowish crystals. M.p. 174–176°. IR (KBr): 2197*s*, 2189*s*, 1639*m*, 1591*w*, 1509*s*, 1486*s*, 1406*w*, 1360*m*, 1264*m*, 1185*w*, 1089*m*, 1021*w*, 1013*w*, 863*w*, 849*w*, 809*w*, 721*w*, 616*w*. ^{1}H-NMR: 1.80 (*s*, Me); 6.75 (*s*, H–C(5′)); 7.23, 7.52 (*AA′BB′*, J_{AB} = 8.2, 4 arom. H). ^{13}C-NMR: 16.8 (Me); 48.4 (C(CN)$_2$); 103.0 (C(5′)); 112.5, 118.4 (2 CN); 130.0 (2 arom. CH); 130.5 (2 arom. CH); 134.4 (C(4′)); 137.8, 140.8 (2 arom. C); 174.0 (C(2′)). CI-MS (NH_3): 342 (7), 341 (43), 340 (15), 339 (100, [M(^{80}Se) + NH_4]$^+$), 338 (11), 337 (48), 336 (16), 335 (17). Anal. calc. for $C_{13}H_8N_3SeCl$ (320.64): C 48.70, H 2.51, N 13.11; found: C 48.69, H 2.67, N 13.13.

2-[3-(4-Bromophenyl)-2,3-dihydro-4-methyl-1,3-selenazol-2-ylidene]propanedinitrile (**12d**). Yield: 152.6 mg (38%). Yellowish crystals. M.p. 187–189°. IR (KBr): 2199*s*, 2183*s*, 1637*w*, 1606*w*, 15012*s*, 1481*s*, 1400*m*, 1347*m*, 1268*m*, 1070*m*, 1012*m*, 880*w*, 842*m*, 805*w*, 756 *w*, 716*w*, 613*w*. ^{1}H-NMR: 1.79 (*s*, Me); 6.75 (*s*, H–C(5′)); 7.15, 7.66 (*AA′BB′*, J_{AB} = 8.7, 4 arom. H). ^{13}C-NMR: 16.9 (Me); 48.5 (C(CN)$_2$); 103.2 (C(5′)); 112.6, 118.5 (2 CN); 125.8 (1 arom. C); 130.2 (2 arom. CH); 132.6 (C(4′)); 133.5 (2 arom. CH); 134.5, 140.8 (2 arom. C); 173.9 (C(2′)). CI-MS (isobutane): 370 (12), 369 (12), 368 (77), 367 (22), 366 (100, [M(^{80}Se,^{78}Br) + 1]$^+$), 365 (27), 364 (48), 363 (17), 362 (15). Anal. calc. for $C_{13}H_8N_3SeBr$ (365.10): C 42.77, H 2.21, N 11.51; found: C 42.60, H 2.05, N 11.50.

2-[2,3-Dihydro-4-methyl-3-(4-methylphenyl)-1,3-selenazol-2-ylidene]propanedinitrile (**12e**). Yield: 184.9 mg (56%). Yellowish crystals. M.p. 135–137°. IR (KBr): 3251*w*, 2202*s*, 2192*s*, 1639*m*, 1586*w*, 1509*s*, 1362*m*, 1267*m*, 1109*w*, 1024*w*, 1013*w*, 852*w*, 809*w*, 772*w*, 712*w*, 619*w*. ^{1}H-NMR: 2.08, 2.53 (2*s*, 2 Me); 6.80 (*s*, H–C(5′)); 7.35, 7.48 (*AA′BB′*, J_{AB} = 8.2, 4 arom. H). ^{13}C-NMR: 20.8, 27.2 (2 Me); 50.1 (C(CN)$_2$); 95.4 (C(5′)); 111.4, 117.5 (2 CN); 128.5 (2 arom. CH); 129.4 (C(4′)); 130.4 (2 arom. CH); 140.4, 151.9 (2 arom. C); 173.2 (C(2′)). CI-MS (NH_3): 322 (5), 321 (44), 320 (22), 319 (100, [M(^{80}Se) + NH_4]$^+$), 318 (19), 317 (54), 316 (12), 315 (18). Anal. calc. for $C_{14}H_{11}N_3Se$ (300.22): C 56.01, H 3.69, N 14.00; found: C 56.07, H 3.65, N 13.78.

2-(2,3-Dihydro-4-methyl-3-phenyl-1,3-selenazol-2-ylidene)-3-oxo-3-phenylpropanenitrile (**12f**). Yield: 200.9 mg (50%). Yellowish crystals. M.p. 197–199°. IR (KBr): 3089*w*, 2918*w*, 2192*s*, 1590*m*, 1566*m*, 1491*m*, 1445*m*, 1430*s*, 1332*s*, 1310*m*, 1272*w*, 1212*w*, 1175*w*, 1154*w*, 1107*w*, 1071*w*, 1018*w*, 956*w*, 858*m*, 794*w*, 775*w*, 721*m*, 697*m*, 670*m*. ^{1}H-NMR: 1.95 (*s*, Me); 7.02 (*s*, H–C(5′)); 7.31–7.42 (*m*, 5 arom. H); 7.55–7.65 (*m*, 3 arom. H); 7.74 (*d*-like, J = 8.2, 2 arom. H). ^{13}C-NMR: 16.9 (Me); 60.3 (C(CN)); 109.8 (C(5′)); 117.5 (CN); 127.7 (2 arom. CH); 128.1 (2 arom. CH); 128.7 (2 arom. CH); 129.8 (2 arom. CH); 130.6, 130.9 (2 arom. CH); 138.1, 138.5, 139.2 (C(4′), 2 arom. C); 171.4 (C(2′)); 187.7 (CO). CI-MS (isobutane): 369 (20), 368 (22), 367 (100, [M(^{80}Se) + 1]$^+$), 366 (12), 365 (51), 364 (20), 363 (19). Anal. calc. for $C_{19}H_{14}N_2OSe$ (365.29): C 62.47, H 3.86, N 7.67; found: C 62.45, H 3.79, N 7.51.

2-{[(4-Methoxyphenyl)amino][(prop-2-ynyl)selanyl]methylidene}propanedinitrile (**9b**). Yield: 156.5 mg (45%). Yellowish crystals. M.p. 133–135°. IR (KBr): 3256*m* (br.), 2211*s*, 2195*s*, 1607*m*, 1518*s*, 1509*s*, 1440*w*, 1414*w*, 1299*w*, 1252*m*, 1190*w*, 1107*w*, 1031*w*, 946*w*, 837*w*, 718*w*, 686*w*, 636*w*, 607*w*. ^{1}H-NMR: 2.59 (*t*, J = 2.7, ≡CH); 3.64 (*d*, J = 2.7, CH_2); 4.03 (*s*, MeO); 7.12, 7.38 (*AA′BB′*, J_{AB} = 8.1, 4 arom. H); 8.48 (br. *s*, NH). ^{13}C-NMR: 14.4 (CH_2); 55.5 (MeO); 59.8 (C(CN)$_2$); 74.2 (≡CH); 77.7 (C≡CH); 113.8 (CN); 114.6 (2 arom. CH); 115.3 (CN); 126.9 (2 arom. CH); 130.0, 159.4 (2 arom. C); 166.9 (NCSe). CI-MS (isobutane): 320 (18), 319 (17), 318 (100, [M(^{80}Se) + 1]$^+$), 317 (19), 316 (51), 315 (25), 314 (22). Anal. calc. for $C_{14}H_{11}N_3OSe$ (316.22): C 53.18, H 3.51, N 13.29; found: C 53.31, H 3.68, N 13.20.

2-{[(4-Methylphenyl)amino][(prop-2-ynyl)selanyl]methylidene}propanedinitrile (**9e**). Yield: 79.3 mg (24%). Yellowish crystals. M.p. 154–156°. IR (KBr): 3256*s*, 3218*s*, 2974*w*, 2213*s*, 2198*s*, 1586*m*, 1518*s*, 1507*s*, 1419*w*, 1404*w*, 1307*w*, 1291*w*, 1266*w*, 1190*w*, 1108*w*, 1015*w*, 951*w*, 821*m*, 713*m*, 688*m*, 637*w*, 606*m*. ^{1}H-NMR: 2.36 (*s*, Me); 2.42 (*t*, $J = 2.7$, ≡CH); 3.53 (*d*, $J = 2.7$, CH_2); 7.14–7.21 (*m*, 4 arom. H); 10.08 (br. *s*, NH). ^{13}C-NMR: 14.0 (Me); 20.9 (CH_2); 58.6 ($C(CN)_2$); 73.8 (≡CH); 78.0 (C≡CH); 113.8, 116.3 (2 CN); 124.4 (2 arom. CH); 129.7 (1 arom. C); 130.6 (2 arom. CH); 135.8 (1 arom. C); 165.6 (NCSe). CI-MS (NH_3): 321 (18), 320 (17), 319 (100, $[M(^{80}Se) + NH_4]^+$), 318 (19), 317 (51), 316 (25), 315 (22). Anal. calc. for $C_{14}H_{11}N_3Se$ (300.22): C 56.01, H 3.69, N 14.00; found: C 55.89, H 3.55, N 13.90.

Suitable crystals for the X-ray crystal-structure determination were grown from CH_2Cl_2 by slow evaporation of the solvent.

X-Ray Crystal-Structure Determination of **9e** *and* **11a** (see *Table 2* and *Figs. 1* and *2*)[2]). All measurements were conducted on a *Nonius KappaCCD* diffractometer [35] using graphite-monochromated MoK_α radiation (λ 0.71073 Å) and an *Oxford Cryosystems Cryostream 700* cooler. Data reduction was performed with *HKL Denzo* and *Scalepack* [36]. The intensities were corrected for *Lorentz* and polarization effects, and absorption corrections based on the multi-scan method [37] were applied. Equivalent reflections were merged. The data collection and refinement parameters are given in *Table 2*, and views of the molecules are shown in *Figs. 1* and *2*. The structures were solved by direct methods using SIR92 [38] in the case of **9e** and SHELXS97 [39] in the case of **11a**, which revealed the positions of all non-H-atoms. The non-H-atoms were refined anisotropically. The molecule of **11a** sits across a crystallographic mirror plane, but the heterocyclic ring and exocyclic CH_2= groups do not lie in the plane, so are necessarily disordered across the mirror. The Ph ring lies perpendicular to the mirror plane and is also tilted so that the *ipso*- and *para*-C-atoms do not lie on the mirror, which results in the entire Ph ring being disordered about the mirror plane as well. In reality, the *ipso*-C-atom, C(9), must lie slightly off the mirror plane if the Ph group is disordered in this way, but the refinement became unstable if C(9) was forced to remain off the mirror. The final model has C(9) on the mirror plane, which leads to a slight distortion of the proper geometry of the Ph ring. Neighboring atoms within and between each conformation of the disordered Ph group were restrained to have similar atomic displacement parameters. The amine H-atom of **9e** and the H-atoms of the exocyclic CH_2= group of **11a** were placed in the positions indicated by a difference electron-density map, and their positions were allowed to refine. All remaining H-atoms were placed in geometrically calculated positions and refined using a riding model, where each H-atom was assigned a fixed isotropic displacement parameter with a value equal to 1.2U_{eq} of its parent atom (1.5U_{eq} for the Me group of **9e**). The refinement of each structure was carried out on F^2 using full-matrix least-squares procedures, which minimized the function $\Sigma w(F_o^2 - F_c^2)^2$. A correction for secondary extinction was applied in the case of **9e**. For **11a**, one reflection, whose intensity was considered to be an extreme outlier, was omitted from the final refinement. Neutral atom scattering factors for non-H-atoms were taken from [40a], and the scattering factors for H-atoms were taken from [41]. Anomalous dispersion effects were included in F_c [42]; the values for f' and f'' were those of [40b]. The values of the mass attenuation coefficients are those of [40c]. All calculations were performed using the SHELXL97 [43] program.

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[2]) CCDC-665411 and CCDC-665412 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from the *Cambridge Crystallographic Data Centre via* http://www.ccdc.cam.ac.uk/data_request/cif.

Table 2. *Crystallographic Data for Compounds* **9e** *and* **11a**

	9e	**11a**
Crystallized from	CH_2Cl_2	AcOEt
Empirical formula	$C_{14}H_{11}N_3Se$	$C_{13}H_9N_3Se$
Formula weight	300.16	286.13
Crystal color, habit	pale-orange, prism	colorless, plate
Crystal dimensions [mm]	$0.20 \times 0.25 \times 0.45$	$0.02 \times 0.22 \times 0.27$
Temp. [K]	160(1)	273(1)
Crystal system	monoclinic	monoclinic
Space group	$P2_1/c$	$P2_1/m$
Z	4	2
Reflections for cell determination	22421	38309
2θ Range for cell determination [°]	4–60	4–60
Unit cell parameters a [Å]	11.2096(2)	8.5520(2)
b [Å]	15.8370(3)	7.4215(2)
c [Å]	7.4753(1)	10.3021(3)
β [°]	94.561(1)	107.579(2)
V [Å^3]	1322.86(4)	623.33(3)
D_x [g cm^{-3}]	1.507	1.524
$\mu(\mathrm{Mo}K_\alpha)$ [mm^{-1}]	2.822	2.990
Scan type	ϕ and ω	ω
$2\theta_{(\max)}$ [°]	60	60
Transmission factors [min; max]	0.484; 0.580	0.660; 0.945
Total reflections measured	35475	17600
Symmetry independent reflections	3880	1936
Reflections with $I > 2\sigma(I)$	3429	1565
Reflections used in refinement	3880	1935
Parameters refined; restraints	169; 0	130; 36
Final $R(F)$ [$I > 2\sigma(I)$ reflections]	0.0263	0.0304
$wR(F^2)$ (all data)	0.0680	0.0676
Weighting parameters [a; b][a])	0.0331; 0.6712	0.0258; 0.1683
Goodness-of-fit	1.052	1.073
Secondary extinction coefficient	0.0051(8)	–
Final $\Delta_{\max}/\sigma$	0.001	0.001
$\Delta\rho$ (max; min) [e · Å^{-3}]	0.48; −0.71	0.27; −0.38

[a]) $w^{-1} = \sigma^2(F_o^2) + (aP)^2 + bP$ where $P = (F_o^2 + 2F_c^2)/3$.

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