Selenium-Containing Heterocycles from Isoselenocyanates: Synthesis of 1,3-Selenazinane and 1,3-Selenazinanone Derivatives

by **Geoffroy L. Sommen**[1]), **Anthony Linden**, and **Heinz Heimgartner***

Organisch-Chemisches Institut der Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich (phone: +41 44 635 42 82; fax: 01 635 6836; e-mail: heimgart@oci.unizh.ch)

The reaction of the intermediate ketene N,Se-hemiacetal **3**, prepared from cyanomethylene derivatives **1** by treatment with Et_3N and aryl isoselenocyanates **2**, with bis-electrophiles **6**, **7**, **9**, and **11** in DMF affords tetrahydro-1*H*-1,3-selenazine (=1,3-selenazinane) derivatives **8**, **10**, and **12** in good yield (*Scheme 2* and *Tables 1–3*). Chemical and spectroscopic evidence for the structures of the new compounds are described. The structures of **8d** and **12e** are established by X-ray crystallography (*Figs. 1* and *2*).

1. Introduction. – It is well established that selenium is an essential trace element, and selenium dietary supplements are commonly available, especially in countries such as France and New Zealand, where soils are selenium-deficient. The principal role of selenium *in vivo* is to prevent free-radical damage by incorporation into radical scavengers, or indirectly by reduction of the by-products of oxidative damage. In recent years, there has been a rapid increase of interest in organoselenium chemistry. There is no doubt that selenium-containing organic molecules have played and continue to play an important role in biology and medicine. The mythology surrounding the 'high toxicity' of organic selenides has largely been dispelled, and a wide range of them are now accepted as useful antioxidants [1–3], anticancer [4–7] and anti-inflammatory agents [8], antibiotics [9][10], and antiviral agents [11]. Therefore, organoselenium compounds are nowadays an important class of biologically active products [12–14]. The interest in selenium compounds may also be attributed to their specific chemical properties, which fit well into the requirements of modern organic synthesis. Most of them are well adapted to chemo-, regio-, and stereoselective reactions [15–18]. The remarkable increase in interest in selenium-containing heterocycles is not only a result of their reactivities and chemical properties [19–26], but also of their pharmaceutical applications [27–32].

For this reason, the use of isoselenocyanates in the synthesis of selenium-containing heterocycles became a focus of interest in our research group. Isoselenocyanates, with their special chemical properties [33–35] are very useful starting materials in heterocyclic chemistry [36] since they are easy to prepare and to store [37]. In addition, they undergo reactions under mild conditions, which are compatible with the

[1]) Postdoctoral stay at the University of Zürich (08.2004–08.2005). Present address: *Lonza AG*, Walliser Werke, CH-3930, Visp, Switzerland; e-mail: geoffroy.sommen@lonza.com

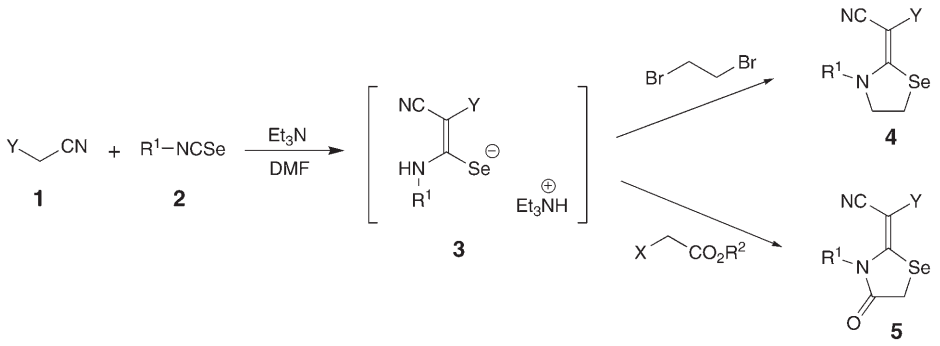
stability of a variety of unsaturated as well as multifunctional molecules in the preparation of natural products [38].

Within the family of selenium-containing heterocycles, selenazines have gained special importance. This heterocyclic system, with one Se- and one N-atom, is one of the most famous in the series of six-membered ring systems, and some syntheses have been reported [39][40]. Several similar structures were described and are of great pharmaceutical interest as antibacterial agents against *Escherichia coli* and *Staphylococcus aureus* [41]. Thiazines, the corresponding sulfur analogues, are also described extensively, and they are widely used as fungicides in pharmaceutical and agrochemical products [42].

As for the reaction of isoselenocyanates with nucleophiles, it is known that N-, O-, S-, and Se-nucleophiles add to the central C-atom [33], and that P-nucleophiles attack either the central C-atom or the Se-atom [34][43]. However, only a few examples have been reported for the reaction of C-nucleophiles with isoselenocyanates [44–46] and, recently, a reaction leading to 1,3-selenazoles was described [47].

As a continuation of previously published studies towards the synthesis of Se-containing heterocycles based on isoselenocyanate chemistry [48–53], we recently reported on the reaction of halogenated primary alkylamines to give selenazolidines [54] and selenazinanes [54], as well as the first selenazepanes [55] in good to excellent yields in a one-pot procedure. Following a similar strategy, *Koketsu et al.* have published the preparation of 2-imino-1,3-selenazolidine derivatives by the reaction of isoselenocyanates with prop-2-yn-1-amine [56]. Reactions *via* nucleophilic attack of mercapto acids led to 2-selenoxo-1,3-thiazolidin-4-ones and 2-selenoxo-1,3-thiazinan-4-ones in good yields [57]. Very recently, we published a study on the synthesis of 1,3-selenazolidines and 1,3-selenazolidinones from active methylene compounds **1** and isoselenocyanates **2**. Therein, the intermediate ketene N,Se-hemiacetal **3** reacted with 1,2-dibromoethane or 2-haloacetates to yield **4** and **5**, respectively [58] (*Scheme 1*). In the present paper, the results of the investigations aimed at extending this methodology to the synthesis of 1,3-selenazinane derivatives are reported.

Scheme 1



2. Results and Discussion. – In the synthesis of the 1,3-selenazolidine derivatives **4** and **5** [58], the intermediates of type **3** (*Scheme 1*) were treated with difunctionalized

reagents, which bear two leaving groups at C(1) and C(2), *i.e.*, in the α-position to each other (1,2-bis-electrophiles). Therefore, the concept for the preparation of analogous tetrahydro-1*H*-1,3-selenazine (=1,3-selenazinane) derivatives was to use 1,3-bis-electrophiles as partners in the reaction with **3**.

By treatment of **1a** with Et_3N in DMF and addition of **2**, the ketene N,Se-acetal of type **3** was generated *in situ* and intercepted by addition of prop-2-enoyl chloride (**6**) or 3-bromopropanoyl bromide (**7**) at room temperature. After stirring for 4 h, the solvent was evaporated and the solid residue was purified by column chromatography and recrystallization to give the products of type **8** in good yield (*Scheme 2*, *Table 1*).

The structures of the 2-(3-aryl-4-oxo-1,3-selenazinan-2-ylidene)propanedinitriles **8** were established on the basis of their spectroscopic data, which correspond reasonably well with those of the previously described 1,3-selenazolidines of type **5** [58]. Again, some data are quite unusual and need an explanation. For example, **8d** shows two C≡N absorptions in the IR spectrum (KBr) at 2209 and 2202 cm^{-1} and two signals in the ^{13}C-NMR spectrum ($CDCl_3$) at δ 110.8 and 115.4. Most remarkable are the IR absorption at 1714 cm^{-1} for C=O and the ^{13}C-NMR signal at δ 62.5 for C(2) of the propanedinitrile (=malononitrile) moiety (=$C(CN)_2$). The ^{13}C-NMR absorptions of C=O and C(2) of the heterocycle appear at δ 168.7 and 171.3. These data indicate that a highly dipolar character, *i.e.*, a zwitterion with the positive charge at the ring N-atom and the negative charge at $C(CN)_2$, has to be considered. Therefore, the structure of **8d** was determined by X-ray crystallography (*Fig. 1*).

Scheme 2

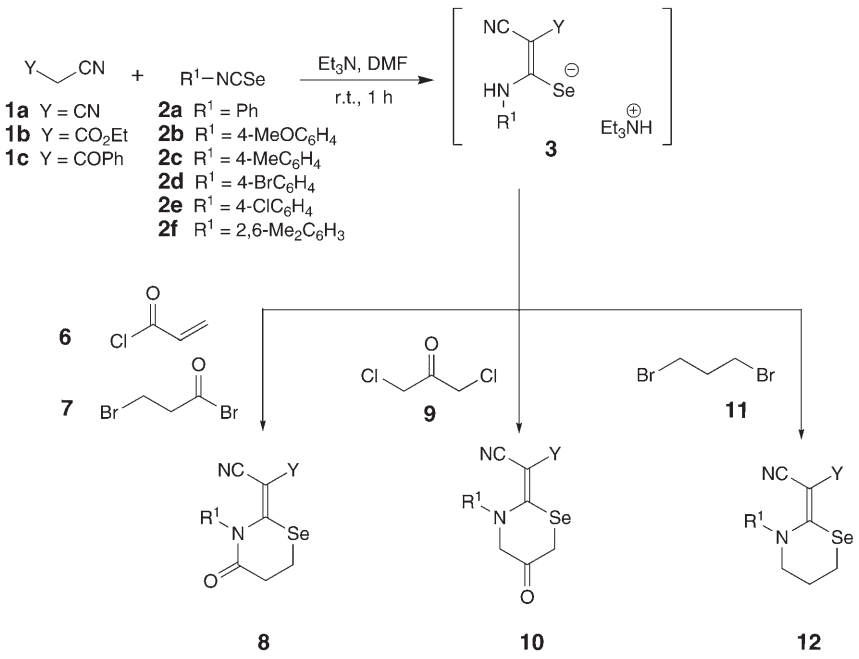
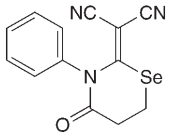
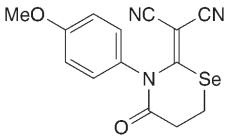
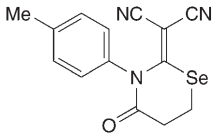
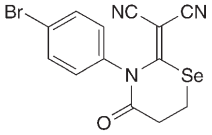
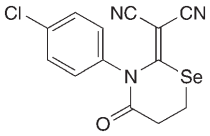


Table 1. *Preparation of Selenazinan-4-ones* **8a**–**e** *from Isoselenocyanates* **2a**–**e** *and* **1a**

Product		R^1	Y	Yield [%]
8a		Ph	CN	75[a]) 55[b])
8b		4-$MeOC_6H_4$	CN	65[a]) 45[b])
8c		4-MeC_6H_4	CN	62[a]) 50[b])
8d		4-BrC_6H_4	CN	71[a]) 44[b])
8e		4-ClC_6H_4	CN	78[a]) 57[b])

[a]) Use of 3-bromopropanoyl bromide. [b]) Use of prop-2-enoyl chloride.

In the crystal structure of **8d**, the heterocyclic ring has a screw-boat conformation. The two CN groups are coplanar with the atoms Se(1), C(2), N(3), and C(7). The bond angles within the $=C(CN)_2$ group are worth mentioning: whereas the angles C(2)–C(7)–C(9) and C(8)–C(7)–C(9) are small (117.8(3) and 113.7(3)°, resp.), the angle C(2)–C(7)–C(8) is 128.4(4)°, *i.e.*, the CN group is tilted away from the 4-bromophenyl residue. In turn, the latter is twisted out of the above mentioned plane by *ca.* 81°. In addition, the CN group pointing towards the aromatic residue is slightly bent away from this ring (N(8)–C(8)–C(7) = 172.9(4)°), whereas the other CN group is linear (N(9)–C(9)–C(7) = 178.8(5)°). The C(2)–C(7) bond is longer (1.380(5) Å) than a normal C=C bond and, on the other hand, the formal single bonds C(7)–C(8) and C(7)–C(9) are short (1.433(5) and 1.434(6) Å, resp.) as well as the N(3)–C(2) and Se(1)–C(2) bonds (1.376(5) and 1.900(4) Å, resp.). Furthermore, the C(4)–O(4) bond is short (1.202(5) Å), indicating that there is no 'amide conjugation' with the lone pair of the N(3) atom. This is in accordance with the IR absorption at 1714 cm^{-1}, which is typical for non conjugated carbonyl groups.

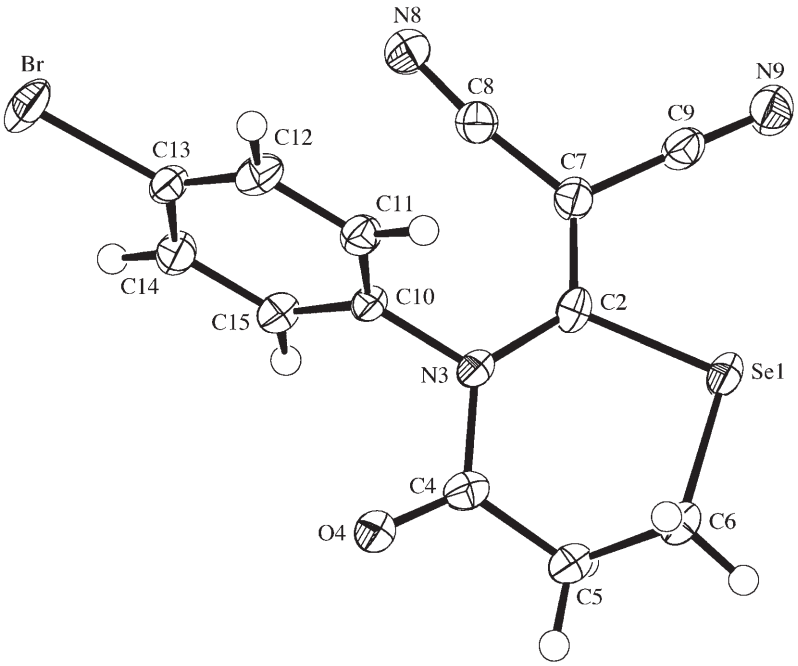


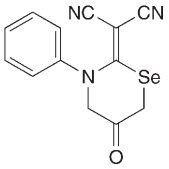
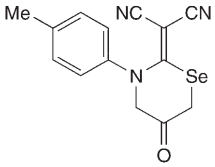
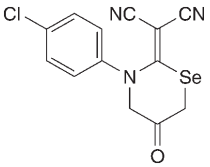
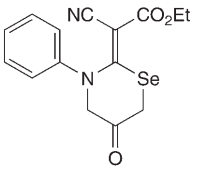
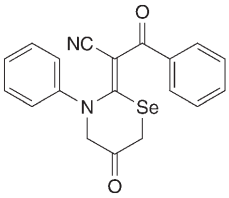
Fig. 1. *ORTEP Plot* [59] *of the molecular structure of* **8d**. Arbitrary atom numbering; 50% probability ellipsoids.

Under analogous reaction conditions, **1a**, **2**, and 1,3-dichloropropane-2-one (**9**) led to the 5-oxo-1,3-selenazinane derivatives **10a**–**c** (*Scheme 2*, *Table 2*). The characteristic spectroscopic data, *e.g.*, for **10a**, are the IR absorptions at 2211, 2196, and 1724 cm^{-1} for the two C≡N and the C=O groups. In the ^{13}C-NMR spectrum, the signals for the C≡N groups appear at δ 111.6 and 117.7, and for C(2) and C=O at δ 172.2 and 198.0, respectively. A similar reaction was observed by using ethyl cyanoacetate (**1b**) or 3-oxo-3-phenylpropanenitrile (**1c**) instead of **1a**. It is worth mentioning that in both cases, only one isomer was formed, **10d** and **10e**, respectively. In analogy to the results discussed in [58], we propose that the larger group, namely CO_2Et and COPh, respectively, is oriented *anti* to PhN(3), *i.e.*, the products being the (*Z*)-isomers.

The third bis-electrophile used was 1,3-dibromopropane (**11**). Under the usual conditions, the intermediate ketene N,Se-hemiacetal **3**, which was generated either with **1a** or **1b**, was trapped with **11** to yield 3-aryl-1,3-selenazinane derivatives of type **12** (*Scheme 2*, *Table 3*). Again, only one isomer was formed in the reactions with **1b**. The structure of **12e** was established by X-ray crystallography (*Fig. 2*).

In the crystal structure of **12e**, the heterocyclic ring is disordered over two differently puckered conformations, and the ester Et group is also disordered over two conformations. The overall structure of **12e** is rather similar to that of **8d**. Again, the Ph ring is twisted out of the plane defined by the atoms Se(1), C(2), N(3), and C(7) by *ca.* 69°. The C(2)–C(7) bond is longer (1.403(6) Å) than a normal C=C bond, whereas the formal single bond C(2)–N(3) is very short (1.357(5) Å). Furthermore, the

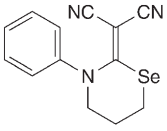
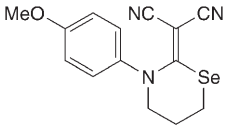
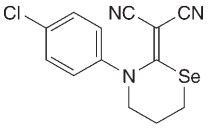
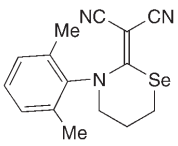
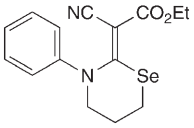
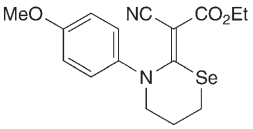
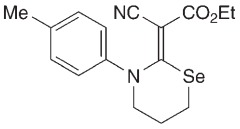
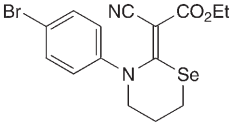
Table 2. *Preparation of Selenazinan-5-ones* **10a**–**e** *from Isoselenocyanates* **2a**,**c**,**e** *and* **1a**–**c**

Product		R^1	Y	Yield [%]
10a		Ph	CN	55
10b		4-MeC_6H_4	CN	61
10c		4-ClC_6H_4	CN	55
10d		Ph	CO_2Et	49
10e		Ph	COPh	48

C(7)–C(8) and the C(7)–C(10) bonds are significantly shorter (1.428(6) and 1.460(6) Å, resp.) than normal C–C single bonds. On the other hand, in contrast to **8d**, the bond angles at C(7) are much less different: C(2)–C(7)–C(8) 121.2(4)°, C(2)–C(7)–C(10) 121.3(4), and C(8)–C(7)–C(10) 117.3(4)°.

The mechanistic interpretation of the formation of the 1,3-selenazinane derivatives **10** and **12** is depicted in *Scheme 3*: the carbanion generated from **1** and Et_3N in DMF reacts with isoselenocyanates **2** to give the intermediate ketene N,Se-hemiacetals **3**. The latter react with the halogenated compounds **9** or **11**, respectively, *via* an S_N2 substitution to give another intermediate of type **13**, which then undergoes the cyclization to give the 6-membered ring *via* a second S_N2 reaction or lactam formation.

Table 3. *Preparation of Selenazinanes* **12a**–**h** *from Isoselenocyanates* **2a**–**f** *and* **1a**,**b**

Product		R^1	Y	Yield [%]
12a		Ph	CN	66
12b		4-$MeOC_6H_4$	CN	63
12c		4-ClC_6H_4	CN	50
12d		2,6-$Me_2C_6H_3$	CN	50
12e		Ph	CO_2Et	35
12f		4-$MeOC_6H_4$	CO_2Et	35
12g		4-MeC_6H_4	CO_2Et	34
12h		4-BrC_6H_4	CO_2Et	69

We carried out the experiments with **6** and **7** with the aim of preparing 6-oxo-1,3-selenazinane derivatives **15** (*Scheme 4*), which are the third type of isomers in the series of compounds **8** and **10**. We expected that 3-bromopropanoyl bromide (**7**) would react

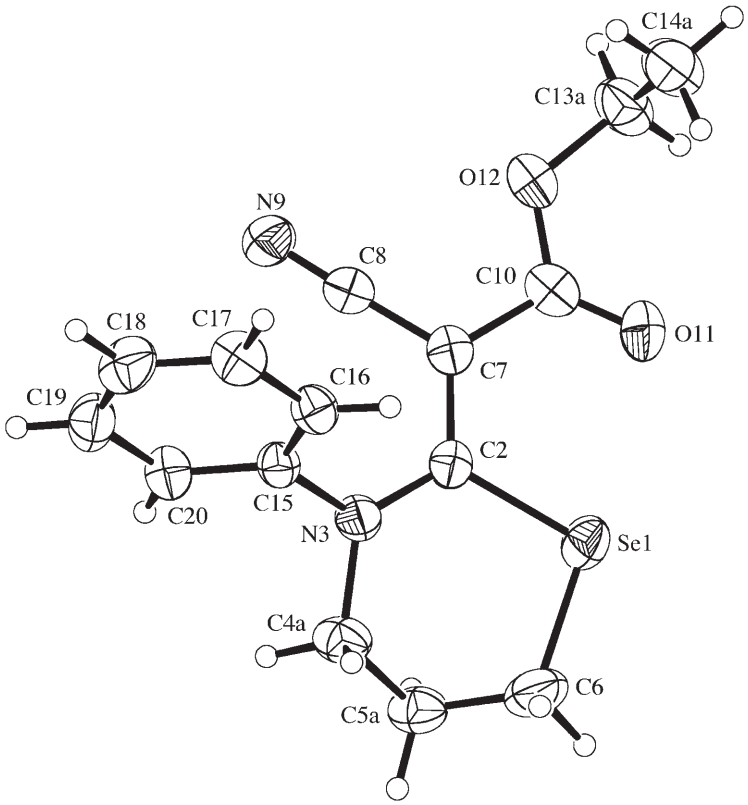
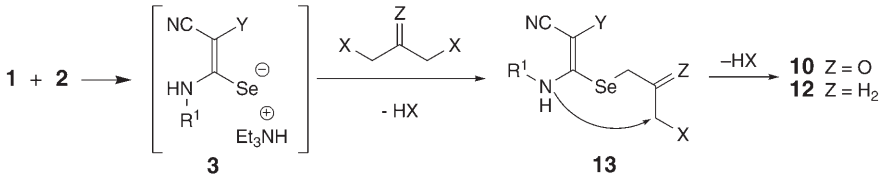


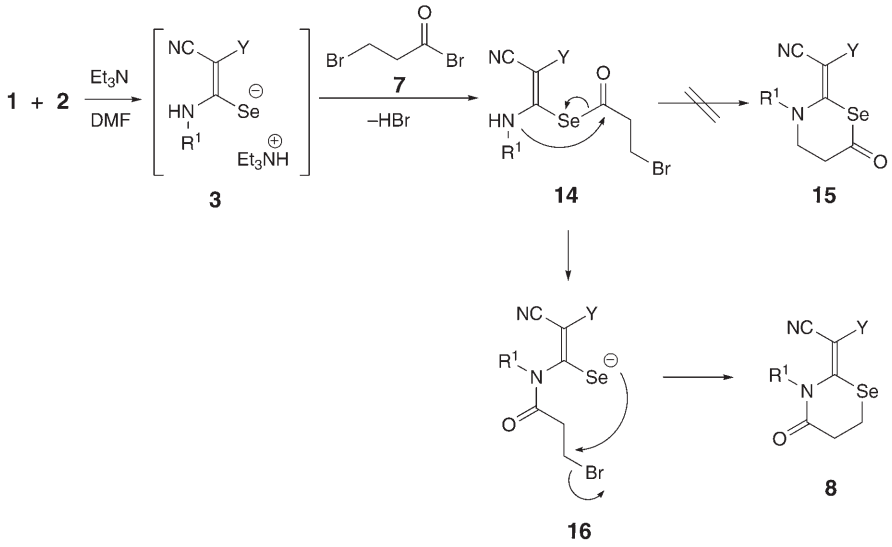
Fig. 2. *ORTEP Plot* [59] *of the molecular structure of one of the two disordered conformations of* **12e**. Arbitrary atom numbering; 50% probability ellipsoids.

Scheme 3



with intermediate **3** preferentially at the more electrophilic acid bromide group to give the second intermediate **14** (*Scheme 4*). The latter should undergo cyclization *via* an S_N2 reaction of the N-atom at the halogenated C-atom to give **15**. After several attempts, we never obtained these derivatives, but always the 4-oxo isomers **8**. Similar to the analogous reaction in the 5-membered ring series [58], we rationalize this observation by a 1,3-acyl shift in the intermediate **14** to give **16**. Cyclization of the latter then yields the isolated product **8**. An analogous reaction mechanism can be proposed

Scheme 4



for the reaction with prop-2-enoyl chloride (**6**), but an initial *Michael* addition by attack of the Se-atom followed by cyclization to give the lactam is also conceivable[2]).

Another goal of this study was the synthesis of analogous 1,3-selenazinane-4,5-diones. A literature search led to the idea of using propanedioyl dichloride in the reaction with **3**. Its use in the synthesis of 6-hydroxy-1,3-selenazin-4-ones from selenourea has been described by *Koketsu et al.* [60]. Furthermore, *Mironova et al.* have reported the preparation of 1,3-thiazine from thiourea and propanedioyl dichloride [61]. All attempts to use propanedioyl dichloride in the reaction with **3** were in vain. Furthermore, the experiments with diethyl propanedioate and a recently described propanedioic acid monoethyl ester were also unsuccessful.

In summary, we have shown that cyanomethylene derivatives **1** react with isoselenocyanates **2** in basic media to give an intermediate, which with some 1,3-bis-electrophiles undergo a ring formation to give 1,3-selenazinanes and 1,3-selenazinanones in good yields. Thus, variously substituted 5- [58] and 6-membered selenium-containing heterocycles can easily be synthesized in a one-pot procedure starting from cyanomethylene derivatives and isoselenocyanates.

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.

[2]) No cyclized products were obtained by using ethyl 3-bromopropanoate or ethyl prop-2-enoate as bis-electrophiles.

Experimental Part

1. *General*. See [51][52]. TLC: silica gel *60* F_{254} plates (0.25 mm; *Merck*). Column chromatography (CC): silica gel *60* (0.040–0.063 mesh; *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 $CDCl_3$ unless otherwise specified; chemical shifts in ppm, *J* in Hz. EI-MS and CI-MS: *Finnigan-SSQ-700* or *-MAT-90* instrument; EI mode: 70 eV; CI mode: NH_3 as carrier gas.

2. *Starting Materials*. Propanedinitrile (= malononitrile) and all halogenated compounds are commercially available (*Fluka*). Isoselenocyanates were prepared according to *Barton*'s procedure starting from formamides [37]. Formanilide is commercially available (*Fluka*, *Aldrich*), *N*-(4-chlorophenyl)-, *N*-(4-bromophenyl)-, *N*-(4-methylphenyl)-, *N*-(2,6-dimethylphenyl)-, and *N*-(4-methoxyphenyl)formamide were prepared from the corresponding commercial anilines and 95% HCOOH [62]. The soln. was heated to reflux for 30 min and concentrated. The residue was dissolved in Et_2O and washed with 5% AcOH soln., H_2O, and 5% $NaHCO_3$ soln. The aq. phase was extracted with Et_2O, and the combined org. extract dried ($MgSO_4$) and concentrated. The crude products were purified by recrystallization in H_2O.

3. General Procedure for the Preparation of Selenazinane Derivatives. To a soln. of propanedinitrile (**1a**) or ethyl cyanoacetate (**1b**; 73 mg and 111 mg, resp., 1.1 mmol) in DMF (10 ml), Et_3N (0.15 ml, 1.1 mmol) was added, and the mixture was stirred for 30 min at r.t. The corresponding isoselenocyanate **2** (1.1 mmol) was added, and the mixture was stirred for 1 h at r.t. Then, the halogenated compound (1.1 mmol) was added dropwise, the mixture stirred for 4 h and then concentrated, and the crude product purified by CC (hexane/AcOEt 100:0 to 1:1).

2-(4-Oxo-3-phenyl-1,3-selenazinan-2-ylidene)propanedinitrile (**8a**). From **1a**, **2a**, and **6** or **7**: 183–250 mg (55–75%) of **8a**. Yellowish crystals. M.p. 188–190° (AcOEt). IR (KBr): 2209*s*, 2198*s*, 1714*s*, 1593*w*, 1476*s*, 1434*w*, 1344*m*, 1317*m*, 1249*s*, 1186*w*, 1169*w*, 1141*m*, 1030*w*, 1002*w*, 950*w*, 861*w*, 797*w*, 748*w*, 693*m*. ^{1}H-NMR: 3.32–3.42 (*m*, 2 CH_2); 7.21–7.27 (*m*, 2 arom. H); 7.47–7.55 (*m*, 3 arom. H). ^{13}C-NMR: 17.1 (CH_2); 35.8 (CH_2); 77.1 ($C(CN)_2$); 109.7, 114.1 (2 CN); 128.8 (2 arom. CH); 129.7 (2 arom. CH); 130.4 (1 arom. CH); 137.4 (1 arom. C); 167.4, 171.9 (CO, C(2)). CI-MS: 321 (100, $[M+NH_4]^+$), 304 (8, $[M+1]^+$). Anal. calc. for $C_{13}H_9N_3OSe$ (302.19): C 51.67, H 3.00, N 13.91; found: C 51.61, H 2.92; N 14.01.

2-[3-(4-Methoxyphenyl)-4-oxo-1,3-selenazinan-2-ylidene]propanedinitrile (**8b**). From **1a**, **2b**, and **6** or **7**: 165–238 mg (45–65%) of **8b**. Yellowish crystals. M.p. 185–187° (AcOEt). IR (KBr): 2211*s*, 2202*s*, 1725*s*, 1602*w*, 1587*w*, 1506*s*, 1475*s*, 1345*m*, 1317*w*, 1301*w*, 1252*s*, 1180*w*, 1168*w*, 1139*m*, 1108*w*, 1033*w*, 1019*w*, 969*w*, 825*w*, 764*w*, 672*w*. ^{1}H-NMR: 3.43–3.53 (*m*, 2 CH_2); 4.00 (*s*, MeO); 7.14, 7.29 (*AA′BB′*, *J* = 8.2, 4 arom. H). ^{13}C-NMR: 17.1 (CH_2); 35.7 (CH_2); 55.5 (MeO); 60.3 ($C(CN)_2$); 110.2, 114.6 (2 CN); 114.8 (2 arom. CH); 129.8 (1 arom. C); 130.1 (2 arom. CH); 160.9 (1 arom. C); 167.9, 168.0 (CO, C(2)). CI-MS: 351 (22, $[M+NH_4]^+$), 334 (100, $[M+1]^+$). Anal. calc. for $C_{14}H_{11}N_3O_2Se$ (332.22): C 50.61, H 3.34, N 12.65; found: C 50.87, H 3.48, N 12.46.

2-[3-(4-Methylphenyl)-4-oxo-1,3-selenazinan-2-ylidene]propanedinitrile (**8c**). From **1a**, **2c**, and **6** or **7**: 174–216 mg (50–62%) of **8c**. Yellowish crystals. M.p. 212–214° (AcOEt). IR (KBr): 2205*s*, 2198*s*, 1733*s*, 1717*s*, 1504*m*, 1475*s*, 1346*m*, 1315*w*, 1247*s*, 1183*w*, 1167*w*, 1126*s*, 1029*w*, 971*w*, 815*w*, 762*w*, 707*w*, 678*w*, 626*w*, 606*w*. ^{1}H-NMR: 2.35 (*s*, Me); 3.30–3.35 (*m*, 2 CH_2); 7.05, 7.22 (*AA′BB′*, *J* = 8.2, 4 arom. H). ^{13}C-NMR: 17.2 (CH_2); 21.2 (Me); 35.7 (CH_2); 67.5 ($C(CN)_2$); 110.0, 114.4 (2 CN); 128.5 (2 arom. CH); 130.1 (2 arom. CH); 134.8, 140.5 (2 arom. C); 167.8, 168.1 (CO, C(2)). CI-MS: 335 (10, $[M+NH_4]^+$), 318 (100, $[M+1]^+$). Anal. calc. for $C_{14}H_{11}N_3OSe$ (316.22): C 53.18, H 3.51, N 13.29; found: C 53.46, H 3.73, N 13.15.

2-[3-(4-Bromophenyl)-4-oxo-1,3-selenazinan-2-ylidene]propanedinitrile (**8d**). From **1a**, **2d**, and **6** or **7**: 184–298 mg (44–71%) of **8d**. Yellowish crystals. M.p. 208–210° (AcOEt). IR (KBr): 2209*s*, 2202*s*, 1714*s*, 1584*w*, 1476*s*, 1402*w*, 1344*m*, 1312*m*, 1253*s*, 1180*w*, 1168*w*, 1135*s*, 1069*w*, 1028*w*, 1011*w*, 868*w*, 822*w*, 806*w*, 793*m*, 708*w*, 659*w*, 600*w*. ^{1}H-NMR: 3.30 (*t*-like, *J* = 7.2, 2 H); 3.46 (*t*-like, *J* = 7.2, 2 H); 7.32, 7.65 (*AA′BB′*, *J* = 8.2, 4 arom. H). ^{13}C-NMR: 18.0 (CH_2); 35.0 (CH_2); 62.5 ($C(CN)_2$); 110.8, 115.4 (2 CN); 123.1 (1 arom. C); 131.7 (2 arom. CH); 132.0 (2 arom. CH); 136.9 (1 arom. C); 168.7, 171.3 (CO, C(2)). CI-MS: 399 (24, $[M+NH_4]^+$), 382 (100, $[M+1]^+$). Anal. calc. for $C_{13}H_8BrN_3OSe$ (381.09): C 40.97, H 2.12, N 11.03; found: C 41.03, H 1.98, N 11.07.

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

2-[3-(4-Chlorophenyl)-4-oxo-1,3-selenazinan-2-ylidene]propanedinitrile (**8e**). From **1a**, **2e**, and **6** or **7**: 211–289 mg (57–78%) of **8e**. Yellowish crystals. M.p. 191–193° (AcOEt). IR (KBr): 2209*s*, 2206*s*, 1716*s*, 1475*s*, 1407*w*, 1345*m*, 1314*m*, 1253*s*, 1182*w*, 1168*w*, 1136*s*, 1088*w*, 1027*w*, 1015*w*, 972*w*, 839*w*, 821*w*, 809*w*, 715*w*, 669*w*. ^{1}H-NMR: 3.25–3.31 (*m*, 2 CH_2); 7.12, 7.41 (*AA′BB′*, $J = 8.2$, 4 arom. H). ^{13}C-NMR: 17.2 (CH_2); 35.8 (CH_2); 61.8 ($C(CN)_2$); 110.0, 113.9 (2 CN); 129.9 (2 arom. CH); 130.1 (2 arom. CH); 135.8, 136.4 (2 arom. C); 167.5, 167.7 (CO, C(2)). CI-MS: 355 (18, $[M+NH_4]^+$), 338 (100, $[M+1]^+$). Anal. calc. for $C_{13}H_8ClN_3OSe$ (336.63): C 46.38, H 2.40, N 12.48; found: C 46.65, H 2.46, N 12.48.

2-(5-Oxo-3-phenyl-1,3-selenazinan-2-ylidene)propanedinitrile (**10a**). From **1a**, **2a**, and **9**: 183 mg (55%) of **10a**. Yellowish crystals. M.p. 181–183° (AcOEt). IR (KBr): 2211*s*, 2196*s*, 1724*m*, 1589*w*, 1505*s*, 1453*w*, 1421*w*, 1371*w*, 1345*w*, 1295*w*, 1256*w*, 1209*w*, 1144*w*, 1065*w*, 1029*w*, 1015*w*, 943*w*, 904*w*, 812*w*, 763*w*, 750*w*, 712*w*, 693*m*, 638*w*. ^{1}H-NMR: 3.69 (*s*, CH_2); 4.55 (*s*, CH_2); 7.33–7.49 (*m*, 5 arom. H). ^{13}C-NMR: 32.2 (CH_2); 47.0 ($C(CN)_2$); 63.4 (CH_2); 111.6, 117.7 (2 CN); 125.9 (1 arom. CH); 128.4 (2 arom. CH); 130.3 (2 arom. CH); 135.5 (1 arom. C); 172.7 (C(2)); 198.0 (CO). CI-MS: 321 (32, $[M+NH_4]^+$), 304 (100, $[M+1]^+$). Anal. calc. for $C_{13}H_9N_3OSe$ (302.19): C 51.67, H 3.00, N 13.91; found: C 51.55, H 2.76, N 14.10.

2-[3-(4-Methylphenyl)-5-oxo-1,3-selenazinan-2-ylidene)propanedinitrile (**10b**). From **1a**, **2c**, and **9**: 213 mg (61%) of **10b**. White crystals. M.p. 190–192° (AcOEt). IR (KBr): 2212*s*, 2192*s*, 1733*m*, 1516*s*, 1427*w*, 1408*w*, 1348*w*, 1285*w*, 1212*w*, 1167*w*, 1074*w*, 1026*w*, 1016*w*, 968*w*, 836*w*, 828*w*, 798w, 778w, 759*w*, 710*w*, 654*w*, 624*w*. ^{1}H-NMR: 2.38 (*s*, Me); 3.68 (*s*, CH_2); 4.54 (*s*, CH_2); 7.08, 7.23 (*AA′BB′*, $J = 8.1$, 4 arom. H). ^{13}C-NMR: 21.4 (Me); 31.6 (CH_2); 46.4 ($C(CN)_2$); 61.8 (CH_2); 111.3, 117.7 (2 CN); 125.0 (1 arom. C); 129.6 (2 arom. CH); 130.1 (2 arom. CH); 141.7 (2 arom. C); 172.8 (C(2)); 197.8 (CO). CI-MS: 335 (28, $[M+NH_4]^+$), 318 (100, $[M+1]^+$). Anal. calc. for $C_{14}H_{11}N_3OSe$ (316.22): C 53.18, H 3.51, N 13.29; found: C 53.08, H 3.46, N 13.60.

2-[3-(4-Chlorophenyl)-5-oxo-1,3-selenazinan-2-ylidene]propanedinitrile (**10c**). From **1a**, **2e**, and **9**: 204 mg (55%) **10c**. White crystals. M.p. 238–240° (AcOEt). IR (KBr): 2207*s*, 2198*s*, 1728*s*, 1502*s*, 1488*s*, 1415*m*, 1406*w*, 1372*w*, 1306*w*, 1297*w*, 1247*w*, 1199*w*, 1179*w*, 1108*w*, 1086*w*, 1058*w*, 1011*w*, 949*w*, 863*w*, 840*w*, 830*w*, 714*w*, 621*w*. ^{1}H-NMR: 3.70 (*s*, CH_2); 4.51 (*s*, CH_2); 7.12, 7.41 (*AA′BB′*, $J = 8.1$, 4 arom. H). ^{13}C-NMR: 32.1 (CH_2); 57.1 ($C(CN)_2$); 63.2 (CH_2); 112.5, 117.7 (2 CN); 128.0 (2 arom. CH); 129.4 (2 arom. CH); 132.8 (1 arom. C); 142.6 (1 arom. C); 172.5 (C(2)); 198.0 (CO). CI-MS: 355 (56, $[M+NH_4]^+$), 338 (100, $[M+1]^+$). Anal. calc. for $C_{13}H_8ClN_3OSe$ (336.63): C 46.38, H 2.40, N 12.48; found: C 46.20, H 2.46, N 12.60.

Ethyl 2-Cyano-2-(5-oxo-3-phenyl-1,3-selenazinan-2-ylidene)acetate (**10d**). From **1b**, **2a**, and **9**: 189 mg (49%) of **10d**. Yellow oil. IR (film): 2207*s*, 1747*m*, 1678*s*, 1583*w*, 1552*w*, 1485*s*, 1421*w*, 1397*w*, 1368*m*, 1284*s*, 1258*m*, 1176*w*, 1129*m*, 1118*m*, 1067*m*, 1012*m*, 967*w*, 844*w*, 781*w*, 767*w*, 726*w*, 697*w*, 646*w*. ^{1}H-NMR: 1.34 (*t*, $J = 7.2$, Me); 3.77 (*s*, CH_2); 4.26 (*q*, $J = 7.2$, CH_2O); 4.43 (*s*, CH_2); 7.15 (*d*-like, $J = 8.1$, 2 arom. H); 7.42–7.52 (*m*, 3 arom. H). ^{13}C-NMR: 14.2 (Me); 29.6 (CH_2); 46.5 (CH_2); 61.5 (CH_2); 61.6 ($C(CN)$); 114.0 (CN); 126.7 (1 arom. CH); 131.6 (2 arom. CH); 132.7 (2 arom. CH); 133.1 (1 arom. C); 162.4 (CO_2Et); 172.8 (C(2)); 198.1 (CO). CI-MS: 368 (44, $[M+NH_4]^+$), 351 (100, $[M+1]^+$). Anal. calc. for $C_{15}H_{14}N_2O_3Se$ (349.25): C 51.59, H 4.04, N 8.02; found: C 51.72, H 3.95, N 7.88.

3-Oxo-2-(5-oxo-3-phenyl-1,3-selenazinan-2-ylidene)-3-phenylpropanenitrile (**10e**). From **1c**, **2a**, and **9**: 202 mg (48%) of **10e**. White crystals. M.p. 222–224° (AcOEt). IR (KBr): 2200*s*, 1668*m*, 1600*s*, 1571*m*, 1485*m*, 1447*s*, 1399*w*, 1322*m*, 1305*m*, 1288*m*, 1214*w*, 1166*w*, 1102*w*, 1070*m*, 1011*m*, 961*m*, 937*w*, 912*w*, 841*w*, 826*w*, 778*w*, 725*m*, 698*m*, 646*w*. ^{1}H-NMR: 3.69 (*s*, CH_2); 4.45 (*s*, CH_2); 7.51 (*d*-like, $J = 8.1$, 2 arom. H); 7.62–7.95 (*m*, 8 arom. H). ^{13}C-NMR: 29.1 (CH_2); 60.4 (CH_2); 61.7 ($C(CN)$); 116.7 (CN); 124.7 (1 arom. CH); 128.0 (2 arom. CH); 131.5 (2 arom. CH); 131.9 (2 arom. CH); 132.3 (2 arom. CH); 133.1 (1 arom. CH); 136.0 (1 arom. C); 137.8 (1 arom. C); 176.0 (C(2)); 190.9, 193.2 (2 CO). CI-MS: 400 (54, $[M+NH_4]^+$), 383 (100, $[M+1]^+$). Anal. calc. for $C_{19}H_{14}N_2O_2Se$ (381.23): C 59.85, H 3.70, N 7.35; found: C 60.02, H 3.60, N 7.28.

2-(3-Phenyl-1,3-selenazinan-2-ylidene)propanedinitrile (**12a**). From **1a**, **2a**, and **11**: 210 mg (66%) of **12a**. Yellowish crystals. M.p. 182–184° (AcOEt). IR (KBr): 2200*s*, 2176*s*, 1593*w*, 1506*s*, 1447*m*, 1389*m*, 1326*m*, 1223*w*, 1179*w*, 1081*w*, 1034*w*, 760*m*, 693*m*, 613*w*. ^{1}H-NMR: 2.24–2.32 (*m*, 2 H); 3.28 (*t*-like, $J = 7.1$, 2 H); 3.84 (*t*-like, $J = 5.4$, 2 H); 7.25 (*d*-like, $J = 6.8$, 2 arom. H); 7.40–7.51 (*m*, 3 arom. H). ^{13}C-NMR:

14.3 (CH_2); 19.9 (CH_2); 61.2 (CH_2); 73.1 ($C(CN)_2$); 112.3, 114.5 (2 CN); 116.7 (2 arom. CH); 122.4 (1 arom. CH); 128.4 (2 arom. CH); 137.2 (1 arom. C); 171.9 (C(2)). CI-MS: 307 (100, $[M+NH_4]^+$), 290 (43, $[M+1]^+$). Anal. calc. for $C_{13}H_{11}N_3Se$ (288.13): C 54.18, H 3.85, N 14.58; found: C 54.53, H 4.03, N 14.59.

2-[3-(4-Methoxyphenyl)-1,3-selenazinan-2-ylidene]propanedinitrile (**12b**). From **1a**, **2b**, and **11**: 221 mg (63%) of **12b**. Yellowish crystals. M.p. 166–168° (AcOEt). IR (KBr): 2196*s*, 2175*s*, 1606*m*, 1584*w*, 1503*s*, 1462*m*, 1449*m*, 1385*m*, 1319*w*, 1258*s*, 1226*w*, 1179*w*, 1169*w*, 1106*w*, 1083*w*, 1033*m*, 968*w*, 901*w*, 835*m*, 811*w*, 746*w*, 720*w*, 642*w*, 618*w*. ^{1}H-NMR: 2.17–2.25 (*m*, 2 H); 3.19 (*t*-like, $J=7.1$, 2 H); 3.73 (*t*-like, $J=5.4$, 2 H); 3.76 (*s*, MeO); 6.88, 7.08 (*AA′BB′*, $J=8.0$, 4 arom. H). ^{13}C-NMR: 22.6 (CH_2); 23.8 (CH_2); 55.5 (CH_2); 57.4 (MeO); 74.8 ($C(CN)_2$); 112.0, 114.5 (2 CN); 115.2 (2 arom. CH); 127.5 (2 arom. CH); 137.3, 160.2 (2 arom. C); 172.3 (C(2)). CI-MS: 336 (100, $[M+NH_4]^+$), 320 (8, $[M+1]^+$). Anal. calc. for $C_{14}H_{13}N_3OSe$ (318.23): C 52.84, H 4.12, N 13.20; found: C 52.68, H 4.19, N 13.25.

2-[3-(4-Chlorophenyl)-1,3-selenazinan-2-ylidene]propanedinitrile (**12c**). From **1a**, **2e**, and **11**: 178 mg (50%) of **12c**. Yellowish crystals. M.p. 202–204° (AcOEt). IR (KBr): 2202*s*, 1591*w*, 1505*s*, 1487*s*, 1449*w*, 1439*m*, 1388*m*, 1353*w*, 1326*w*, 1267*w*, 1226*w*, 1174*w*, 1161*w*, 1091*m*, 1077*w*, 1014*m*, 963*w*, 898*w*, 840*m*, 791*w*, 715*w*, 674*w*, 615*w*. ^{1}H-NMR: 2.23–2.31 (*m*, 2 H); 3.28 (*t*-like, $J=7.2$, 2 H); 3.81 (*t*-like, $J=7.2$, 2 H); 7.20, 7.46 (*AA′BB′*, $J=8.1$, 4 arom. H). ^{13}C-NMR: 22.4 (CH_2); 24.0 (CH_2); 54.5 (CH_2); 77.2 ($C(CN)_2$); 112.2, 114.5 (2 CN); 128.2 (2 arom. CH); 128.7 (2 arom. CH); 133.1 (1 arom. C); 141.8 (1 arom. C); 170.2 (C(2)). CI-MS: 340 (100, $[M+NH_4]^+$), 324 (5, $[M+1]^+$). Anal. calc. for $C_{13}H_{10}ClN_3Se$ (322.65): C 48.39, H 3.12, N 13.02; found: C 48.67, H 3.21, N 12.93.

2-[3-(2,6-Dimethylphenyl)-1,3-selenazinan-2-ylidene]propanedinitrile (**12d**). From **1a**, **2f**, and **11**: 204 mg (50%) of **12d**. Yellowish crystals. M.p. 193–195° (AcOEt). IR (KBr): 2197*s*, 2176*s*, 1670*w*, 1593*w*, 1515*s*, 1455*w*, 1434*m*, 1383*s*, 1353*w*, 1318*m*, 1270*w*, 1222*w*, 1196*w*, 1183*w*, 1168*w*, 1101*w*, 1016*w*, 962*w*, 904*w*, 838*w*, 783*m*, 621*w*. ^{1}H-NMR: 2.57 (*s*, 2 Me); 2.64–2.72 (*m*, 2 H); 3.57 (*t*-like, $J=7.2$, 2 H); 3.95 (*t*-like, $J=5.5$, 2 H); 7.43 (*d*, $J=7.6$, 2 arom. H); 7.55–7.60 (*m*, 3 arom. H). ^{13}C-NMR: 17.8 (2 Me); 22.3 (CH_2); 24.2 (CH_2); 52.2 ($C(CN)_2$); 55.1 (CH_2); 112.3, 117.1 (2 CN); 129.0 (2 arom. CH); 130.2 (2 arom. C); 135.1 (1 arom. CH); 141.9 (1 arom. C); 170.9 (C(2)). CI-MS: 335 (100, $[M+NH_4]^+$), 318 (28, $[M+1]^+$). Anal. calc. for $C_{15}H_{15}N_3Se$ (316.27): C 56.97, H 4.78, N 13.29; found: C 57.14, H 4.56, N 13.19.

Ethyl 2-Cyano-2-(3-phenyl-1,3-selenazinan-2-ylidene)acetate (**12e**). From **1b**, **2a**, and **11**: 129 mg (35%) of **12e**. Yellowish crystals. M.p. 162–164° (AcOEt). IR (KBr): 2194*s*, 1671*s*, 1591*w*, 1484*s*, 1471*m*, 1449*m*, 1433*m*, 1385*m*, 1364*w*, 1284*s*, 1214*w*, 1168*w*, 1128*s*, 1021*w*, 1011*w*, 887*w*, 816*w*, 767*m*, 697*m*, 623*w*. ^{1}H-NMR: 1.23 (*t*, $J=7.2$, Me); 2.20–2.28 (*m*, 2 H); 3.04 (*t*-like, $J=7.2$, 2 H); 3.85 (*t*-like, $J=5.5$, 2 H); 4.14 (*q*, $J=7.2$, CH_2O); 7.21–7.30 (*m*, 3 arom. H); 7.43 (*d*-like, $J=8.1$, 2 arom. H). ^{13}C-NMR: 14.2 (Me); 22.1 (CH_2); 23.1 (CH_2); 55.9 (CH_2); 60.6 (CH_2); 78.4 (C(CN)); 114.3 (CN); 125.3 (2 arom. CH); 127.0 (1 arom. CH); 129.8 (2 arom. CH); 147.3 (1 arom. C); 171.2 (C(2)). CI-MS: 354 (100, $[M+NH_4]^+$), 337 (34, $[M+1]^+$). Anal. calc. for $C_{15}H_{16}N_2O_2Se$ (335.27): C 53.74, H 4.81, N 8.36; found: C 53.62, H 4.96, N 8.33.

Suitable crystals for an X-ray crystal-structure determination were obtained from AcOEt by slow evaporation of the solvent.

Ethyl 2-Cyano-2-[3-(4-methoxyphenyl)-1,3-selenazinan-2-ylidene]acetate (**12f**). From **1b**, **2b**, and **11**: 314 mg (35%) of **12f**. Yellowish crystals. M.p. 108–110° (AcOEt). IR (KBr): 2190*s*, 1666*w*, 1607*w*, 1585*w*, 1509*s*, 1479*m*, 1443*m*, 1377*m*, 1298*w*, 1270*s*, 1247*s*, 1212*w*, 1172*w*, 1128*s*, 1082*w*, 1028*m*, 911*w*, 831*w*, 763*w*, 723*w*. ^{1}H-NMR: 1.24 (*t*, $J=7.1$, Me); 2.20–2.28 (*m*, 2 H); 3.05 (*t*-like, $J=7.2$, 2 H); 3.78 (*t*-like, $J=7.1$, 2 H); 3.82 (*s*, MeO); 4.14 (*q*, $J=7.2$, CH_2O); 6.93, 7.16 (*AA′BB′*, $J=8.1$, 4 arom. H). ^{13}C-NMR: 14.2 (Me); 22.2 (CH_2); 23.1 (CH_2); 55.4 (MeO); 56.6 (CH_2); 60.4 (CH_2); 79.5 (C(CN)); 114.9 (2 arom. CH); 116.5 (CN); 126.8 (2 arom. CH); 140.4, 158.4 (2 arom. C); 167.1 (CO_2Et); 173.9 (C(2)). CI-MS: 384 (49, $[M+NH_4]^+$), 367 (100, $[M+1]^+$). Anal. calc. for $C_{16}H_{18}N_2O_3Se$ (365.29): C 52.61, H 4.97, N 7.67; found: C 52.78, H 4.90, N 7.76.

Ethyl 2-Cyano-2-[3-(4-methylphenyl)-1,3-selenazinan-2-ylidene)acetate (**12g**). From **1b**, **2c**, and **11**: 131 mg (34%) of **12g**. Yellowish crystals. M.p. 127–129° (AcOEt). IR (KBr): 2194*s*, 1671*s*, 1583*w*, 1509*w*, 1476*s*, 1437*s*, 1381*m*, 1322*w*, 1277*s*, 1171*w*, 1136*s*, 1029*w*, 886*w*, 818*w*, 764*w*, 712*w*, 618*w*. ^{1}H-NMR: 1.30 (*t*, $J=7.1$, *Me*CH_2); 2.25–2.33 (*m*, 2 H); 2.43 (*s*, Me); 3.11 (*t*-like, $J=7.2$, 2 H); 3.89 (*t*-like, $J=7.1$, 2 H); 4.21 (*q*, $J=7.2$, CH_2O); 7.19, 7.29 (*AA′BB′*, $J=8.1$, 4 arom. H). ^{13}C-NMR: 14.2 (*Me*CH_2); 21.0 (Me); 22.2 (CH_2); 23.0 (CH_2); 56.2 (CH_2); 60.5 (CH_2); 80.4 (C(CN)); 116.5 (CN); 125.2 (2 arom. CH); 130.4 (2

arom. CH); 137.0, 145.0 (2 arom. C); 167.2 (CO_2Et); 174.3 (C(2)). CI-MS: 368 (34, $[M+NH_4]^+$), 351 (100, $[M+1]^+$). Anal. calc. for $C_{16}H_{18}N_2O_2Se$ (349.29): C 55.02, H 5.19, N 8.02; found: C 55.00, H 5.01, N 8.06.

Ethyl 2-[3-(4-Bromophenyl)-1,3-selenazinan-2-ylidene]-2-cyanoacetate (**12h**). From **1b**, **2d**, and **11**: 314 mg (69%) of **12h**. Yellowish crystals. M.p. 138–140° (AcOEt). IR (KBr): 2200*s*, 1663*s*, 1481*s*, 1447*m*, 1428*s*, 1386*m*, 1326*w*, 1277*s*, 1218*w*, 1181*w*, 1135*m*, 1068*m*, 1028*m*, 1005*m*, 907*w*, 889*w*, 837*m*, 767*m*, 710*w*, 629*w*, 609*w*. ^{1}H-NMR: 1.40 (*t*, *J* = 7.1, Me); 2.35–2.43 (*m*, 2 H); 3.21 (*t*-like, *J* = 7.2, 2 H); 3.98 (*t*-like, *J* = 7.1, 2 H); 4.30 (*q*, *J* = 7.2, 2 H); 7.28, 7.68 (*AA′BB′*, *J* = 8.9, 4 arom. H). ^{13}C-NMR: 14.2 (Me); 22.2 (CH_2); 22.9 (CH_2); 55.6 (CH_2); 60.7 (CH_2); 82.0 (*C*(CN)); 116.3 (CN); 120.1 (1 arom. C); 126.7 (2 arom. CH); 132.9 (2 arom. CH); 146.3 (1 arom. C); 162.4 (CO_2Et); 175.0 (C(2)). CI-MS: 432 (82, $[M+NH_4]^+$), 415 (100, $[M+1]^+$). Anal. calc. for $C_{15}H_{15}BrN_2O_2Se$ (414.17): C 43.50, H 3.65, N 6.76; found: C 43.57, H 3.51, N 6.75.

Table 4. *Crystallographic Data for Compounds* **8d** *and* **12e**

	8d	**12e**
Crystallized from	CH_2Cl_2	AcOEt
Empirical formula	$C_{13}H_8BrN_3OSe$	$C_{15}H_{16}N_2O_2Se$
M_r	381.03	335.20
Crystal color, habit	colorless, needle	orange, prism
Crystal dimensions [mm]	0.05 × 0.10 × 0.30	0.10 × 0.12 × 0.17
Temperature [K]	160(1)	273(1)
Crystal system	monoclinic	orthorhombic
Space group	$P2_1/c$	$P2_12_12_1$
Z	4	4
Reflections for cell determination	28461	13769
2θ range for cell determination [°]	4–50	4–50
Unit cell parameters:		
a [Å]	10.9085(4)	9.2368(5)
b [Å]	18.3762(8)	10.6208(6)
c [Å]	6.7674(2)	14.916(1)
β [°]	100.272(3)	90
V [Å^3]	1334.83(9)	1463.3(2)
D_x [g cm^{-3}]	1.896	1.521
$\mu(\mathrm{Mo}K_\alpha)$ [mm^{-1}]	5.808	2.567
Scan type	ω	ω
$2\theta_{(\max)}$ [°]	50	50
Transmission factors [min; max]	0.517; 0.755	0.623; 0.779
Total reflections measured	16260	13994
Symmetry-independent reflections	2341	2578
Reflections with $I > 2\sigma(I)$	2039	1937
Reflections used in refinement	2341	2578
Parameters refined; restraints	173; 0	222; 77
Final $R(F)$ ($I > 2\sigma(I)$ reflections)	0.0345	0.0371
$wR(F^2)$ (all data)	0.0838	0.0829
Weighting parameters [a; b][a]	0.0315; 3.7663	0.0347; 0.1447
Goodness of fit	1.072	1.050
Secondary extinction coefficient	0.0035(5)	0.007(1)
Final $\Delta_{\max}/\sigma$	0.002	0.001
$\Delta\rho$ (max; min) [e Å^{-3}]	0.79; −0.55	0.25; −0.32

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

X-Ray Crystal-Structure Determination of **8d** *and* **12e** (see *Table 4* and *Figs. 1* and *2*)[3]). All measurements were made with a *Nonius-KappaCCD* diffractometer [63], 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 [64]. The intensities were corrected for *Lorentz* and polarization effects, and absorption corrections based on the multiscan method [65] were applied. Equivalent reflections, other than the *Friedel* pairs of **12e**, were merged. Data collection and refinement parameters are given in *Table 4*, and views of the molecules are shown in the *Figs. 1* and *2*. The structures were solved by direct methods with SIR92 [66], which revealed the positions of all non-H-atoms. In the case of **12e**, the heterocyclic ring and the ester Et group are disordered. Two sets of positions were defined for two CH_2 groups in the heterocyclic ring and for the atoms of the ester Et group. The site-occupation factors of the major conformations of these disordered groups refined to 0.557(8) and 0.67(2), resp. Similarity restraints were applied to the chemically equivalent bond lengths and angles involving all disordered C-atoms, while neighboring atoms within and between each conformation of the disordered groups were restrained to have similar atomic displacement parameters. For both structures, the non-H-atoms were refined anisotropically. All of the H-atoms were placed in geometrically calculated positions and refined by using a riding model where each H-atom was assigned a fixed isotropic displacement parameter with a value equal to 1.2 U_{eq} of its parent C-atom (1.5 U_{eq} for the Me groups of **12e**). The refinement of each structure was carried out on F^2 using by full-matrix least-squares procedures, which minimized the function $\Sigma w(F_o^2 - F_c^2)^2$. Corrections for secondary extinction were applied. Although **12e** is achiral, it crystallized in a non-centrosymmetric space group. Refinement of the absolute structure parameter [67] yielded a value of $-0.01(1)$, which confidently confirms that the refined coordinates, represent the true absolute structure. Neutral-atom scattering factors for non-H-atoms were taken from [68a], and the scattering factors for H-atoms were taken from [69]. Anomalous dispersion effects were included in F_c [70]; the values for f' and f'' were those of [68b]. The values of the mass attenuation coefficients are those of [68c]. All calculations were performed with the SHELXL97 [71] program.

REFERENCES

[1] T. Fenner, C. H. Schiesser, *Molecules* **2004**, *9*, 472.
[2] G. Mugesh, H. B. Singh, *Chem. Soc. Rev.* **2000**, *29*, 347.
[3] L.-O. Klotz, K.-D. Kröncke, D. P. Buchczyk, H. Sies, *J. Nutrition* **2003**, 1448S.
[4] M. Soriano-Garcia, *Curr. Med. Chem.* **2004**, *11*, 1657.
[5] C. Shi, L. Yu, F. Yang, J. Yan, H. Zeng, *Biochem. Biophys. Res. Commun.* **2003**, *309*, 578.
[6] E. Unni, F. S. Kittrell, U. Singh, R. Sinha, *Breast Cancer Res.* **2004**, *6*, R586.
[7] K. El-Bayoumy, R. Sinha, *Mutat. Res.* **2004**, *551*, 181.
[8] D. Seiyaku, *Drugs Future* **1995**, *20*, 1057.
[9] E. V. Ratushnaya, Y. I. Kirova, M. A. Suchkov, B. I. Drevko, V. B. Borodulin, *Pharm. Chem. J.* **2002**, *36*, 652.
[10] K. Kloc, I. Maliszewska, J. Mlochowski, *Synth. Commun.* **2003**, *33*, 3815.
[11] H. Wójtowicz, M. Chojnacka, J. Mlochowski, J. Palus, L. Syper, D. Hudecova, M. Uher, E. Piasecki, M. Rybka, *Farmaco* **2003**, *58*, 1235.
[12] G. Mugesh, W.-W. Du Mont, H. Sies, *Chem. Rev.* **2001**, *101*, 2125.
[13] S. W. May, *Exp. Opin. Invest. Drugs* **2002**, *11*, 1261.
[14] Z. J. Witczak, S. Czernecki, *Adv. Carbohydr. Chem. Biochem.* **1998**, *53*, 143.
[15] D. Liotta, *Acc. Chem. Res.* **1984**, *17*, 28.
[16] T. Wirth, *Liebigs Ann. Recl.* **1997**, 2189.
[17] T. Wirth, *Tetrahedron* **1999**, *55*, 1.

---

[3]) CCDC-619816 and 619817 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.ac.uk/data_request/cif.

[18] T. Wirth, *Chimia* **2001**, *55*, 65.
[19] N. Sonoda, *Pure Appl. Chem*. **1993**, *65*, 699.
[20] V. P. Litvinov, V. D. Dyachenko, *Russ. Chem. Rev*. **1997**, *66*, 923.
[21] D. L. Klayman, W. H. H. Günther, 'Organic Selenium Compounds: Their Chemistry and Biology', J. Wiley & Sons, New York, 1973, p. 579 and 629.
[22] H. J. Reich, 'Topics in Current Chemistry: Organoselenium Chemistry, Modern Development in Organic Synthesis', Vol. 208, Ed. T. Wirth, Springer Verlag, Berlin, 2000.
[23] C. Paulmier, 'Selenium Reagents and Intermediates in Organic Synthesis', Pergamon Press, Oxford, 1986, p. 70.
[24] M. Renson, 'The Chemistry of Organic Selenium and Tellurium Compounds', Vol. 1, Eds. S. Patai, Z. Rappoport, J. Wiley & Sons, New York, 1986, p. 399.
[25] 'Organoselenium Chemistry, A Practical Approach', Ed. T. G. Back, Oxford University Press, Oxford, 1999.
[26] H. J. Reich, *Acc. Chem. Res.* **1979**, *12*, 22.
[27] 'Selenium in Biology and Medicine', Ed. A. Wengel, Springer Verlag, Berlin, 1989.
[28] R. F. Burk, 'Selenium in Biology and Human Health', Springer Verlag, New York, 1994.
[29] Y. Ogasawara, G. Lacourciere, T. C. Stadtman, *Proc. Natl. Acad. Sci. U.S.A.* **2001**, *98*, 9494.
[30] Y. Xu, E. T. Kool, *J. Am. Chem. Soc*. **2000**, *122*, 9040.
[31] S. Janzsu, G. Hoppert, J. Shodiere, J.-C. Yerdon, *Jpn. Kokai Tokkyo Koho*, Jap. Pat. 11140067, 1999; *Chem. Abstr.* **1999**, *131*, 32054.
[32] H. E. Ganther, *Bioorg. Med. Chem*. **2001**, *9*, 1459.
[33] Z. J. Witczak, *Tetrahedron* **1985**, *41*, 4781.
[34] W. J. Stec, K. Lesiak, M. Sudol, *Synthesis* **1975**, *12*, 785.
[35] K. Sukata, *J. Org. Chem*. **1989**, *54*, 2015.
[36] M. L. Petrov, N. I. Zmitrovich, *Russ. J. Gen. Chem*. **1999**, *69*, 245.
[37] D. H. R. Barton, S. I. Parekh, M. Tajbakhsh, E. A. Theodorakis, C.-L. Tse, *Tetrahedron* **1994**, *50*, 639; M. T. Bakhsh, Y. S. Behshtiha, M. M. Heravi, *J. Chem. Soc. Pakistan* **1996**, *18*, 159.
[38] K. C. Nicolaou, N. A. Petasis, 'Selenium in Natural Products Synthesis', CIS Inc., Philadelphia PA, 1984.
[39] M. Koketsu, T. Senda, K. Yoshimura, H. Ishihara, *J. Chem. Soc., Perkin Trans. 1* **1999**, 453; M. Koketsu, Y. Tanaka, S. Hiramatsu, H. Ishihara, *Heterocycles* **2001**, *55*, 1181; M. Koketsu, H. Ishihara, *Curr. Org. Chem*. **2003**, *7*, 175.
[40] M. Sainsbury, in 'Rodd's Chemistry of Carbon Compounds', 2nd edn., Vol. IV (G/H), Elsevier, Amsterdam, 1998, p. 609.
[41] M. Koketsu, H. Ishihara, M. Hatsu, *Res. Commun. Mol. Pathol. Pharmacol*. **1998**, *101*, 179; M. Koketsu, H. Ishihara, W. Wu, K. Murakami, I. Saiki, *Eur. J. Pharm. Sci.* **1999**, *9*, 157; W. Wu, K. Murakami, M. Koketsu, Y. Yamada, I. Saiki, *Anticancer Res.* **1999**, *19*, 5375; S. I. Cho, M. Koketsu, H. Ishihara, M. Matsushita, A. C. Nairn, H. Fukazawa, Y. Uehara, *Biochim. Biophys. Acta* **2000**, *1475*, 207.
[42] A. W. Raut, A. G. Doshi, *Orient. J. Chem*. **1995**, *11*, 205.
[43] L. J. Stangeland, T. Austad, J. Songstad, *Acta Chem. Scand*. **1973**, *27*, 3919.
[44] L. Henriksen, C. Dreier, *Chem. Scr.* **1975**, *8*, 112.
[45] J. Becher, E. G. Frandsen, C. Dreier, L. Henricksen, *Acta Chem. Scand., Ser. B* **1977**, *31*, 843.
[46] L. Henricksen, *Int. J. Sulfur Chem.* **1973**, *8*, 389.
[47] H. Maeda, N. Kambe, N. Sonoda, S. Fuyjiwara, T. Shin-Ike, *Tetrahedron* **1997**, *53*, 13667.
[48] P. K. Atanassov, A. Linden, H. Heimgartner, *Helv. Chim. Acta* **2004**, *87*, 1873.
[49] P. K. Atanassov, A. Linden, H. Heimgartner, *Helv. Chim. Acta* **2004**, *87*, 1452.
[50] P. K. Atanassov, A. Linden, H. Heimgartner, *Heterocycles* **2004**, *621*, 521.
[51] P. K. Atanassov, Y. Zhou, A. Linden, H. Heimgartner, *Helv. Chim. Acta* **2002**, *85*, 1102.
[52] Y. Zhou, H. Heimgartner, *Helv. Chim. Acta* **2000**, *83*, 539.
[53] Y. Zhou, A. Linden, H. Heimgartner, *Helv. Chim. Acta* **2000**, *83*, 1576.
[54] G. L. Sommen, A. Linden, H. Heimgartner, *Eur. J. Org. Chem*. **2005**, *14*, 3128.
[55] G. L. Sommen, A. Linden, H. Heimgartner, *Tetrahedron Lett.* **2005**, *46*, 6723.

[56] M. Koketsu, T. Sakai, T. Kiyokuni, D. R. Garud, H. Ando, H. Ishihara, *Heterocycles* **2006**, *68*, 1607.
[57] G. L. Sommen, A. Linden, H. Heimgartner, *Heterocycles* **2005**, *65*, 1903.
[58] G. L. Sommen, A. Linden, H. Heimgartner, *Tetrahedron* **2006**, *62*, 3344.
[59] C. K. Johnson, 'ORTEP II', Report ORNL-5138, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1976.
[60] M. Koketsu, S. Hiramatsu, H. Ishihara, *Chem. Lett.* **1999**, 485; M. Koketsu, Y. Takenaka, H. Ishihara, *Heteroatom Chem.* **2003**, *14*, 106.
[61] G. A. Mironova, E. N. Kirillova, V. N. Kuklin, N. A. Smorygo, B. A. Ivin, *Khim. Geterosikl. Soedin.* **1984**, *10*, 1328.
[62] A. R. Katritzky, R. L. Parris, E. S. Ignatchenko, S. M. Allin, M. Siskin, *J. Prakt. Chem.* **1997**, *339*, 59.
[63] R. Hooft, KappaCCD Collect Software, Nonius BV, Delft, 1999.
[64] Z. Otwinowski, W. Minor, in 'Methods in Enzymology', Vol. 276, 'Macromolecular Crystallography', Part A, Eds. C. W. Carter Jr., and R. M. Sweet, Academic Press, New York, 1997, p. 307.
[65] R. H. Blessing, *Acta Crystallogr., Sect A* **1995**, *51*, 33.
[66] A. Altomare, G. Cascarano, C. Giacovazzo, A. Guagliardi, M. C. Burla, G. Polidori, M. Camalli, SIR92, *J. Appl. Crystallogr.* **1994**, *27*, 435.
[67] H. D. Flack, G. Bernardinelli, *Acta Crystallogr., Sect. A* **1999**, *55*, 908; H. D. Flack, G. Bernardinelli, *J. Appl. Crystallogr.* **2000**, *33*, 1143.
[68] a) E. N. Maslen, A. G. Fox, M. A. O'Keefe, in 'International Tables for Crystallography', Ed. A. J. C. Wilson, Kluwer Academic Publishers, Dordrecht, 1992, Vol. C, Table 6.1.1.1, p. 477; b) D. C. Creagh, W. J. McAuley, in 'International Tables for Crystallography', Ed. A. J. C. Wilson, Kluwer Academic Publishers, Dordrecht, 1992, Vol. C, Table 4.2.6.8, p. 219; c) D. C. Creagh, J. H. Hubbell, in 'International Tables for Crystallography', Ed. A. J. C. Wilson, Kluwer Academic Publishers, Dordrecht, 1992, Vol. C, Table 4.2.4.3, p. 200.
[69] R. F. Stewart, E. R. Davidson, W. T. Simpson, *J. Chem. Phys.* **1965**, *42*, 3175.
[70] J. A. Ibers, W. C. Hamilton, *Acta Crystallogr.* **1964**, *17*, 781.
[71] G. M. Sheldrick, SHELXL97, Program for the Refinement of Crystal Structures, University of Göttingen, Göttingen, 1997.

Received September 8, 2006