Synthesis of Azetidine and Pyrrolidine Derivatives through Selenium-Induced Cyclization of Secondary Homoallylamines − A ^{77}Se NMR Study

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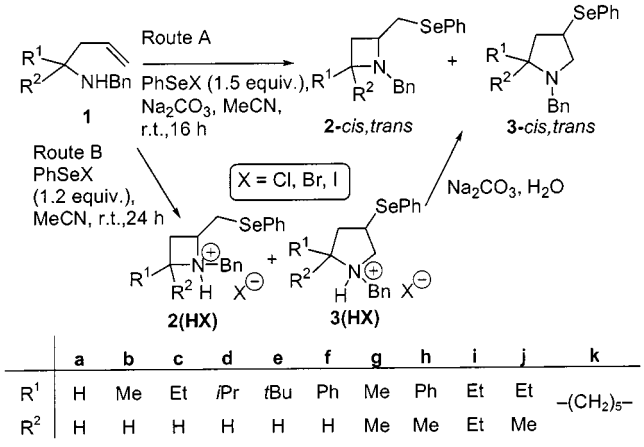
Treatment of α-alkyl and α,α-dialkyl homoallylic amines **1** with PhSeX (X = Cl, Br, I), in CH_3CN containing sodium carbonate produced mixtures of azetidines **2** and pyrrolidines **3**. The cyclization also occurred in the absence of Na_2CO_3, and the corresponding azetidinium and pyrrolidinium salts **2(HX)** and **3(HX)** were formed in $CDCl_3$ or CH_3CN. The crude reaction mixtures were analysed by ^{77}Se NMR. Each product – **2**, **3**, **2(HX)**, and **3(HX)** – was characterized by its ^{77}Se chemical shift, and the product ratios were determined for each reaction. The ratios of azetidine **2** to pyrrolidine **3** increased not only according to the steric hindrance around the α-carbon, but also with the nature of the counterion X^- (PhSeCl < PhSeBr < PhSeI). Use of PhSeI and amines **1g** to **1k** (R^1, $R^2 \neq H$), produced only the azetidinium salts **2(HI)**, allowing the isolation of the corresponding azetidines **2**, albeit in poor yield. Some reactions were monitored by ^{77}Se NMR at the beginning of the addition–cyclization process. No intermediates were observed when PhSeI was used, but the thermodynamic addition products **5(Br)**, **5(HBr)**, and some dibromoselenuranes **8** were detected.

Introduction

The electrophile-induced ring-closure of unsaturated carboxylic acids, alcohols, and amine derivatives is now an efficient method for the synthesis of lactones, cyclic ethers, and *N*-substituted aza-heterocycles, respectively.[1] Selenium methodology plays an important role in this field,[2,3] and various electrophilic selenium reagents such as benzeneselenenyl halides,[1,2,3] *N*-(phenylseleno)phthalimide,[4] and benzeneselenenyl triflate[5] and sulfate[6] are commonly used. A seleniranium intermediate is involved and the attack of the internal nucleophile occurs with stereospecific *anti*-addition. The *exo-trig* mode is favoured,[7] especially with a terminal olefinic bond. 1-Alkoxycarbonyl-2-(phenylselanylmethyl)pyrrolidines[1,2] and piperidines[8] have been prepared. Under acidic conditions, 1,2-dialkyl-5-(phenylselanylmethyl)pyrrolidines have been prepared, in modest yields, from secondary pent-4-en-1-ylamines through a 5-*exo-trig* process.[9]

Some years ago, we observed that mixtures of α-(phenylselanylmethyl)azetidines **2** and β-(phenylselanyl)pyrrolidines **3** were formed upon treatment of homoallyl benzylamines **1** with PhSeX (X = Cl, Br; 1.5 equiv.) in CH_2Cl_2 or CH_3CN at room temperature in the presence of sodium carbonate[10] (Scheme 1, route A).



	a	b	c	d	e	f	g	h	i	j	k
R^1	H	Me	Et	*i*Pr	*t*Bu	Ph	Me	Ph	Et	Et	–$(CH_2)_5$–
R^2	H	H	H	H	H	H	Me	Me	Et	Me	

Scheme 1

The formation of azetidines through a selenium-induced cyclization of homoallylamines by a 4-*exo-trig* process has now been observed for the first time. In the case of amines **1** (R^2 = H), the azetidines *cis*-**2** and the pyrrolidines *cis*-**3** and *trans*-**3** were separated, with some difficulties, by silica gel chromatography. In the course of this study, we found that the proportion of azetidine *cis*-**2** increased with the size of R^1 and that azetidines **2** were the major products of amines **1** bearing two α-substituents. It was also observed that the proportion of azetidines increased when PhSeBr was used instead of PhSeCl.[10] The geminal α-effect appears similar to that described for the electrophile-induced

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formation of small rings.[11,12] CH_3CN was a better solvent than CH_2Cl_2 for a more efficient 4-*exo*-*trig* cyclization process, affording azetidines derivatives.[10]

The synthesis of azetidines is at present an important objective and is usually carried out by cyclization of 4-haloalkylamines or δ-amino alcohols.[13] The azetidine skeleton appears in natural substances,[14] and so routes to optically active species are of great interest.[15]

We now report a complete study of this new reaction involving *N*-benzyl but-3-en-1-ylamines **1a** to **1k** and benzeneselenenyl halides PhSeX (X = Cl, Br, I) (Scheme 1). In the absence of Na_2CO_3, the corresponding azetidinium and pyrrolidinium halides **2(HX)** and **3(HX)** were formed (Scheme 1, route B).

The following paper describes the synthesis of β-halopyrrolidines when an excess of PhSeX (X = Cl, Br) was used. The stereocontrolled synthesis of 4-halo-1,2-dialkypyrrolidines from azetidines **2** and pyrrolidines **3** is also reported.[16]

Results and Discussion

The addition-cyclization process was first achieved at room temp. on amines **1**, in acetonitrile containing sodium carbonate (route A).[10] Either PhSeBr or PhSeI (1.5 equiv., preformed from diphenyldiselenide and iodine) was then added. Amines **1** were consumed more slowly with PhSeBr, but all reactions went to completion after stirring for 16 h. ^{77}Se NMR analysis of the crude reaction mixtures permitted the assignment of the chemical shift for each product: *cis*-**2**, *trans*-**2**, *cis*-**3**, and *trans*-**3**. The value δ_{Se}= 467.0 for PhSeSePh, often present beside the cyclized products, was adopted as internal reference. The δ_{Se} values and the compositions of the crude mixtures are collected in Table 1. The signal attributable to *trans*-**2** appeared very close to that of *cis*-**2** ($\Delta\delta \leq 1.5$ ppm) in the δ = 249.2−257.2 range. We were, however, able in most cases to determine the respective proportions. The peaks attributable to pyrrolidines **3** were found in the δ = 362−420 range for *cis*-**3** and 338−394 for *trans*-**3**. The stereochemistry of *cis*-**2d**, *trans*-**2d**, *cis*-**3d**, *trans*-**3d**, *cis*-**2e**, and *cis*-**2h** was secured by NOE experiments (Figure 1, Structures **A**, **B** for **2d** and **C**, **D** for **3d**).

The parent amine **1a** afforded a 18:82 mixture of azetidine **2a** and pyrrolidine **3a** whether PhSeBr or PhSeI was used (Table 1, entries 1, 2). In the other cases, the proportion of azetidines **2** was always greater when PhSeI was used. This reached 86% for **2e** (R^1 = *t*Bu, R^2 = H, entry 11) and 95% for **2i** ($R^1 = R^2$ = Et, entry 19). Proportions of 44, 48, and 57% of azetidines **2c** (R^1 = Et, R^2 = H) were found in the reaction mixtures obtained from **1c** treated with PhSeCl, PhSeBr, and PhSeI, respectively (entries 5, 6, 7).

Silica gel chromatography of the crude mixtures permitted the isolation of pure samples of *cis*-**3**, *trans*-**3**, *cis*-**2**, and *trans*-**2** (except for *trans*-**2b** and *trans*-**2c**) in that order of elution (heptane/CH_2Cl_2) for the mixtures obtained from **1b** to **1f** (R^2 = H). In some cases, the complete separation of the four isomers was not achieved; the isomerization of *trans*-**2b**- (R^1=Me) into *trans*-**3b** during chromatography prevented the isolation of *trans*-**2b**. Moreover, *trans*-**3c** and *cis*-**2c** were eluted together. The separation of the pyrrolidines **3** from the azetidines **2** was achieved without difficulty when R^1 and $R^2 \neq$ H.

In the absence of Na_2CO_3, mixtures of azetidinium and pyrrolidinium salts **2(HX)** and **3(HX)** were formed by treatment of amines **1** with PhSeBr or PhSeI (1.2 equiv.) in $CDCl_3$ or CH_3CN at room temperature (Scheme 1, route B). The δ_{Se} values of each salt *cis*-**2(HX)**, *trans*-**2(HX)**, *cis*-**3(HX)**, and *trans*-**3(HX)** were assigned for each crude salt product (Table 2). Basic aqueous treatment produced azetidines **2** and pyrrolidines **3** in ratios very close to those for the corresponding salts.

Cyclization occurred slowly for **1a**, **1b**, **1c**, **1d**, **1e**, and **1f**, especially in $CDCl_3$. Compounds **1b**, **1c** and **1f** needed more than 48 h of treatment to reach completion of reaction when PhSeBr was used (Table 2, entries 5, 6, 8, and 17). As described below, intermediate addition products could be characterized. The addition−cyclization process occurred more rapidly with PhSeI and when α,α-disubstituted amines **1g** to **1k** were used as substrates. The **2a(HX)/3a(HX)** ratios, given in Table 2 (entries 1−4), were modified, according to the excess of PhSeX, by a PhSe-induced isomerization of **2a(HX)**, also discussed below.

The ^{77}Se chemical shifts of *cis*-**2(HX)** and *trans*-**2(HX)** underwent a slight deshielding effect ($\Delta\delta_{Se} \approx 15-20$ ppm) compared to those of the corresponding azetidines *cis*-**2** and *trans*-**2**.

Examination of Tables 1 and 2 shows that the signals of *cis*-**3(HX)** (R^2 = H) were shifted upfield ($\Delta\delta_{Se}$ = −35 to −10 ppm). On going from *trans*-**3** to *trans*-**3(HX)**, an opposite effect took place ($\Delta\delta_{Se}$ = +10 to +35 ppm). The δ_{Se} values for *cis*-**3f** and *trans*-**3f** (R^1 = Ph, R^2 = H) could not be assigned and compared to those of other α-alkylpyrrolidines, as a consequence of the difficulty in gauging the direction of the phenyl group's anisotropic effect (Table 1, entries 12 and 13; Table 2, entry 17). It is interesting to note that only one stereoisomer of each azetidinium salt *cis*-**2(HX)** and *trans*-**2(HX)** was formed for R^1 = H, Me, Et, Ph (R^2 = H) and for the pyrrolidinium salts *cis*-**3(HX)** and *trans*-**3(HX)**. The spectrum of the **2d(HBr)/3d(HBr)** (R^1 = *i*Pr, R^2 = H) mixture deserves particular attention (Table 2, entries 11−13). The azetidinium salt area displays four peaks (Figure 2, spectra a). Surprisingly, trifluoroacetic acid treatment of a crude **2d** + **3d** mixture (spectrum b) resulted in the formation of the corresponding trifluoroacetic salts (spectrum c) with the same composition as observed for the HBr salts. Moreover, a pure sample of *cis*-**2d**, also treated with CF_3COOH, gave only the two major signals with very close δ_{Se} values ($\Delta\delta_{Se}$ = 0.2 ppm). The two external peaks ($\Delta\delta_{Se}$ = 13.5 ppm) must be attributable to the *trans*-**2d(HBr)** stereoisomers.

This observation allowed us to assign the structures **E** and **F** for *trans*-**2d(HBr)**, and **G** and **H** for *trans*-**2d(HBr)** (Figure 3). The difference of anisotropic effect of the benzyl

Table 1. Crude product composition of the selenium-induced cyclization of *N*-benzyl homoallylamines **1** (PhSeX, 1.5 equiv., Na_2CO_3, MeCN, room temp., 16 h)

Entry	X	Substrate			^{77}Se NMR (δ ppm)[a]				Composition (%)			
					Azetidine **2**		Pyrrolidine **3**		**2**		**3**	
		No.	R^1	R^2	*cis*	*trans*	*cis*	*trans*	*cis*	*trans*	*cis*	*trans*
1	Br	**1a**	H	H	256.8		396.1		18		82	
2	I	**1a**	H	H	256.8		396.1		18		82	
3	Br	**1b**	Me	H	257.1	256.0	419.8	386.2	29[b]	13	24[b]	34[b]
4	I	**1b**	Me	H	257.1	256.0	419.8	386.2	38	17	24	21
5	Cl	**1c**	Et	H	255.2	254.3	416.6	380.1	44		29	27
6	Br	**1c**	Et	H	255.2	254.3	416.6	380.1	35[b]	13	22	30
7	I	**1c**	Et	H	255.2	254.3	416.6	380.1	57		22	21
8	Br	**1d**	*i*Pr	H	252.0	251.2	407.3	372.7	46[b]	22[b]	19[b]	13[b]
9	I	**1d**	*i*Pr	H	252.0	251.2	407.3	372.7	80		12	8
10	Br	**1e**	*t*Bu	H	250.6[c]	249.2[c]	362.1	338.7	52[b]	31	5	12
11	I	**1e**	*t*Bu	H	250.6[c]	249.2[c]	362.1	338.7	86		5	9
12	Br	**1f**	Ph	H	253.4	254.4	425.3	388.2	34	12	24	30
13	I	**1f**	Ph	H	253.4	254.4	425.3	388.2	45	13	22	20
14	Br	**1g**	Me	Me	250.9		403.5		83		17	
15	I	**1g**	Me	Me	250.9		403.5		84		16	
16	Br	**1h**	Ph	Me	252.0	250.4	417.6	394.6	70[b]	14	12	4
17	I	**1h**	Ph	Me	252.0	250.4	417.6	394.6	66	25	6	3
18	Br	**1i**	Et	Et	252.2		392.7		88		12	
19	I	**1i**	Et	Et	252.2		392.7		95		5	
20	Br	**1j**	Et	Me	251.1	250.4	411.3	391.1	58	24	10	8
21	I	**1j**	Et	Me	251.1	250.4	411.3	391.1	88		7	5
22	Br	**1k**	$-(CH_2)_5-$		249.8		401.2		88		12	
23	I	**1k**	$-(CH_2)_5-$		249.8		401.2		93		7	

[a] PhSeSePh as internal reference. δ_{Se} = 467.0 ppm. [b] Stereochemistry assigned by NOE experiments. [c] Doublet ($\Delta\delta_{Se}$ = 0.2 ppm).

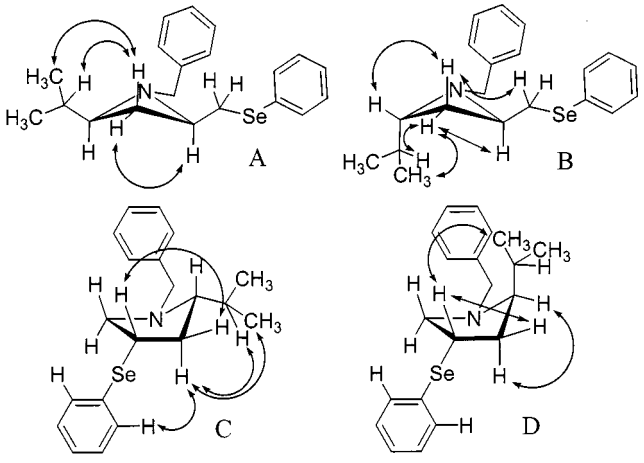


Figure 1. NOE correlations from NOESY spectra of **A**: *cis*-**2d**, **B**: *trans*-**2d**, **C**: *cis*-**3d**, and **D**: **3d**

group is negligible for the *cis* isomers but has some importance for the *trans* isomers. We cannot assign the stereochemistry of **G** and **H**, however. The pyrrolidinium salts *cis*-**3d(HBr)** and *trans*-**3d(HBr)** appeared only as one unattributable stereoisomer (Figure 3, structures **I** and **J**). As shown in Table 2 (entries 14, 15), a change of an isopropyl group for a *tert*-butyl substituent, resulted in two close signals ($\Delta\delta_{Se}$ = 0.2) observed for *cis*-**2e(HBr)**, with structures **E** and **F**. Compound *trans*-**2e(HBr)** appeared as an unique stereoisomer (δ_{Se} = 260.5) analogous to the major one (δ_{Se} = 262.7) observed for *trans*-**2d(HBr)**. We believe that this major stereoisomer could be represented by structure **G** (R^1 = *i*Pr).

It may also be observed that the spectra of azetidines *cis*-**2e** and *trans*-**2e** exhibit two doublets ($\Delta\delta_{Se}$ = 0.2 ppm) (Table 1, entries 10 and 11). As a consequence of severe steric hindrance, the high barrier of inversion around the nitrogen atom is probably responsible for the existence of the two conformers for each azetidine *cis*-**2e** and *trans*-**2e**.

From these observations, we deduced that the formation of the azetidinium and pyrrolidinium salts **2(HX)** and **3(HX)** is the result of protonation of **2** and **3** by the conjugated acids **1(HX)**, **4(HX)**, and **5(HX)**, affording the more stable isomeric salt.

The mechanistic aspects of this new multistep reaction were then investigated. It is generally accepted that selenirranium halide intermediates such as **6** (Scheme 2) are involved in competitive *exo*- and *endo*-*trigonal* ring-closure reactions of γ- or δ-unsaturated alcohols, phenols, carboxylic acids, amides and carbamates.[2,3]

To gain further insight into this reaction, we monitored the reactions between **1a-c** and PhSeBr, in both $CDCl_3$ and CD_3CN, by ^{77}Se NMR. As indicated in Scheme 2, the thermodynamic addition products **5a**, **5b**, and **5c**, their ammonium salts **5a(HBr)**, **5b(HBr)**, and **5c(HBr)** and the β-bromo dibromoselenuranes **8b** and **8c** were characterized by their ^{77}Se chemical shifts. The adducts **5d**, **5g**, **5i**, and **5k** were also detected at the beginning of the reaction when PhSeBr (1 equiv.) was added to the corresponding amine **1** (Figure 4). No iodo intermediates were observed when

Table 2. **2(HX)/3(HX)** salt composition of the selenium-induced cyclization of *N*-benzyl homoallylamines **1** in the absence of Na_2CO_3 (PhSeX, 1.2 equiv., $CDCl_3$ or MeCN, room temp., 24 h)

Entry	X	Substrate			Solvent	^{77}Se NMR (δ ppm)[a][b]				Composition (%)			
						2(HX)		**3(HX)**		**2(HX)**		**3(HX)**	
		No.	R^1	R^2		*cis*	*trans*	*cis*	*trans*	*cis*	*trans*	*cis*	*trans*
1	Br	**1a**	H	H	$CDCl_3$	270.7		385.3		12		88	
2	Br	**1a**	H	H	CH_3CN	270.7		385.3		16		84	
3	I	**1a**	H	H	$CDCl_3$	271.8		386.0		24		76	
4	I	**1a**	H	H	CH_3CN	271.8		386.0		16		84	
5	Br	**1b**	Me	H	$CDCl_3$[c][d]	274.6	271.1	384.9	396.7	24	6	19	51
6	Br	**1b**	Me	H	CH_3CN[c][d]	274.6	271.1	384.9	396.7	25	8	16	51
7	I	**1b**	Me	H	CH_3CN	275.5	274.0	386.2	395.9	45	17	17	21
8	Br	**1c**	Et	H	$CDCl_3$[c][e]	273.3	271.3	378.4	394.7	40		13	47
9	Br	**1c**	Et	H	CH_3CN	273.3	271.3	378.4	394.7	42		17	41
10	I	**1c**	Et	H	CH_3CN	275.2	273.8	380.2	390.3	58		24	18
11	Br	**1d**	*i*Pr	H	$CDCl_3$	270.1 270.3	262.7 275.8	359.7	382.6	38	15	16	31
12	Br	**1d**	*i*Pr	H	CH_3CN	270.1 270.3	262.7 275.8	359.7	382.6	46	20	13	21
13	I	**1d**	*i*Pr	H	CH_3CN	273.7 273.9	265.4 279.9	362.3	380.0	56	18	14	12
14	Br	**1e**	*t*Bu	H	$CDCl_3$	273.1 273.3	260.5	352.5	373.5	44	22	14	20
15	Br	**1e**	*t*Bu	H	CH_3CN	273.1 273.3	260.5	352.5	373.5	50	30	9	11
16	I	**1e**	*t*Bu	H	CH_3CN	273.5	265.6	354.1	372.9	55	29	5	11
17	Br	**1f**	Ph	H	$CDCl_3$[c]	277.5	276.2	396.1	416.9	45		17	48
18	I	**1f**	Ph	H	CH_3CN	Complex mixture of products							
19	Br	**1g**	Me	Me	$CDCl_3$	274.0		411.7; 417.9		77		6; 17	
20	Br	**1g**	Me	Me	CH_3CN	274.0		411.7; 417.9		80		6; 14	
21	I	**1g**	Me	Me	CH_3CN	274.1		/		100		0	
22	Br	**1h**	Ph	Me	CH_3CN	265.3; 265.3[f]		/		100		0	
23	Br	**1i**	Et	Et	$CDCl_3$[c]	269.3; 263.5		401.9		85		15	
24	Br	**1i**	Et	Et	CH_3CN	269.3; 263.5		401.9		93		7	
25	I	**1i**	Et	Et	CH_3CN	271.0; 271.2		/		100		0	
26	I	**1j**	Et	Me	CH_3CN	270.9; 271.5		/		100		0	
27	Br	**1k**	$-(CH_2)_5-$		CH_3CN	271.5; 271.7		408.7; 411.2		90		10	
28	I	**1k**	''		CH_3CN	270.9		/		100		0	

[a] PhSeSePh as internal reference. δ_{Se} = 467.0. [b] Spectra recorded in $CDCl_3$. [c] Incomplete reaction after 48 h. [d] Presence of the addition products **5b** and **5b(HBr)**. [e] Presence of the addition products **5c** and **5c(HBr)**. [f] Stereochemistry not assigned.

PhSeI was added. The assignments were corroborated by a preliminary study of the addition of PhSeX (X = Cl, Br) to 1-hexene.

PhSeBr addition to terminal olefins in CH_3CN[17] or $CHCl_3$[18] produced mixtures of the two regioisomers. The thermodynamic adduct, bearing the PhSe group at the terminal CH_2 group, is the major component in equilibrium with the minor kinetic adduct at room temperature. The isomerization of the kinetic addition product of 1-butene with PhSeBr occurred in less than 5 min in CH_3CN but required 24 h for the corresponding PhSeCl adduct.[17] Acid catalysis is efficient for the isomerization of the reaction products of terminal olefins with sulfenyl chlorides.[19]

We characterized the two addition products derived from 1-hexene [**11** and **12** (PhSeCl)/**15** and **16** (PhSeBr)] by their ^{77}Se chemical shifts (Scheme 3, entries 1 and 3). It should be noted that the dichloroselenurane **14**, derived from the thermodynamic adduct **12**, was also formed (7.5%). The **11**/**12** and **15/16** ratios were similar to those previously observed.[17,18] The two β-chloro dichloroselenuranes **13** and **14** were also characterized after addition of SO_2Cl_2 to **11** and **12** (Scheme 3, entry 2). Bromine treatment of the **15/16** mixture resulted in the dibromoselenurane **18** derived from the thermodynamic adduct **16**, with only traces of the regioisomer **17** (entry 4). We were then surprised to find that introduction of a second equivalent of PhSeBr resulted partially in the dibromoselenurane **18**. No trace of the isomeric Se-dibromo complex **17** was detected (entry 5). β-Chloro dichloroselenuranes, analogous to **14**, were obtained by treatment of terminal olefins with a large excess of PhSeCl in CH_3CN[20] or CH_2Cl_2.[21]

It has also been shown that dihaloselenuranes are easily dehalogenated in the presence of PhSeSePh[20,22] and that $PhSeX_3$ (X = Cl, Br) adds irreversibly to terminal olefins to afford the anti-Markovnikov (kinetic) adducts, such as **14** (X = Cl) and **18** (X = Br), as the major products in ether at 0 °C.[23]

The reaction between PhSeBr and amine **1c** (R^1 = Et, R^2 = H) in CD_3CN containing Na_2CO_3 was then monitored by ^{77}Se NMR. Formation of PhSeSePh was immediately observed with 0.5 molar equiv. of selenium reagent. The pyrrolidine *trans*-**3c** and trace amounts of *cis*-**3c** ap-

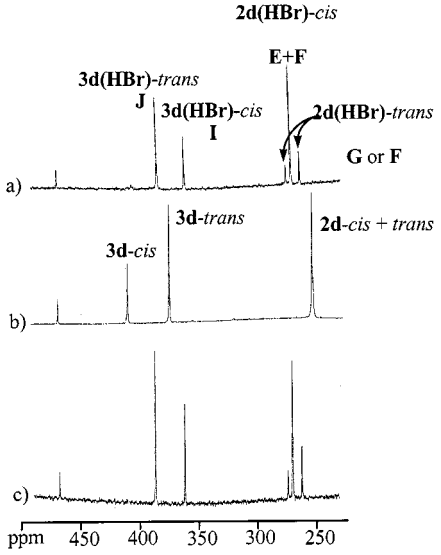


Figure 2. ^{77}Se NMR spectra in $CDCl_3$ of: a) **2d (HBr)**, *cis*/*trans*-**3d(HBr)** mixture (route B); b) **2d**, *cis*/*trans*-**3d** mixture (route A); c) CF_3COOH treatment of mixture b)

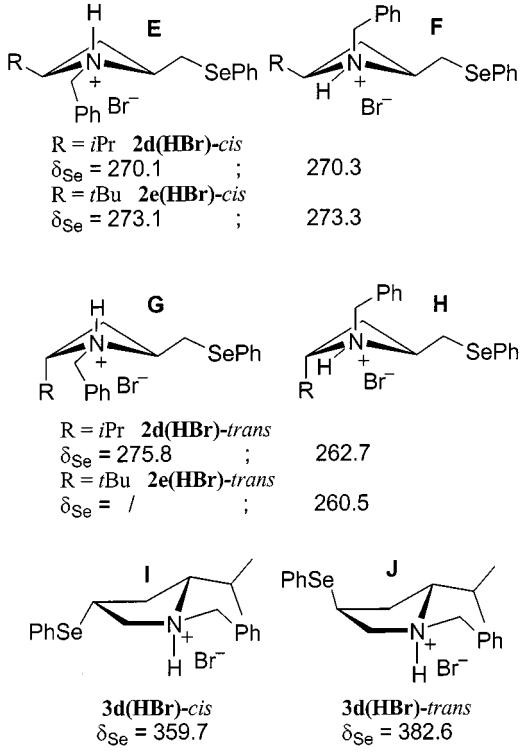


Figure 3. ^{77}Se NMR structure determination of salts *cis*/*trans*-**2d(HBr)**; *cis*/*trans*-**3d(HBr)**, and *cis*/*trans*-**2e(HBr)**

peared progressively. The azetidines *cis*-**2c** and *trans*-**2c** were then slowly formed after the introduction of 1.0 molar equiv. of PhSeBr. Azetidines *cis*-**2c**, *trans*-**2c** and pyrrolidine *cis*-**3c** were present, in similar ratios, after a 2 h reaction time at room temperature. Their proportions then increased, relative to that of pyrrolidine *trans*-**3c**, at the expense of PhSeSePh. The appearance of PhSeSePh in the early stage of the process is a result of the following equilibria:[2]

$$3\ PhSeBr \rightleftarrows PhSeSePh + PhSeBr_3 \quad (1)$$

$$2\ PhSeBr \rightleftarrows PhSeSePh + Br_2 \quad (2)$$

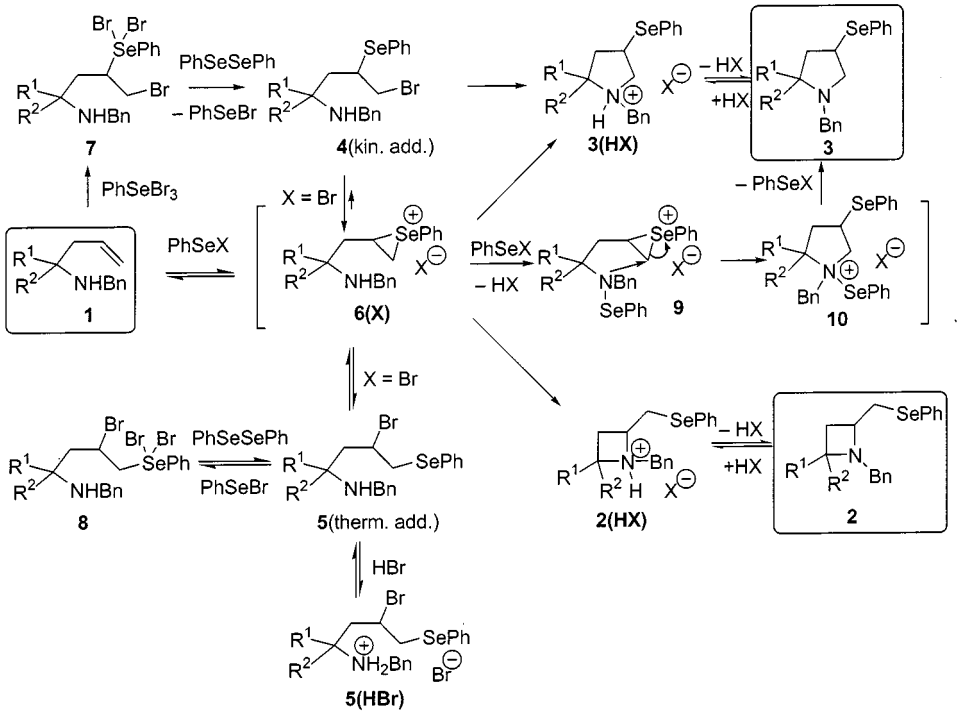
The presence of Na_2CO_3 probably favours the decomposition of PhSeBr.[24] Under these conditions, $PhSeBr_3$ adds to the olefinic double bond to produce the kinetic dibromoselenurane **7**, allowing the formation of the pyrrolidines **3(HBr)** at the beginning of the reaction through S_N2 substitution either before or after the PhSeSePh reduction of **7** (Scheme 2). The release of bromine explains the presence of **8**, derived from the thermal addition product **5**, easily reduced by PhSeSePh. In absence of Na_2CO_3, the ammonium bromides **5(HBr)** were detected for R^1 = H, Me, Et (R^2 = H). The formation of these salts probably results from a greater basicity of **5** than of **1**, and similarly that of the products **2** and **3**.

At this point, the question was: what is the nature of the nucleophilic centre involved in the cyclization? It is well known that PhSeX (X = Cl, Br) reacts instantaneously with dialkylamines to form unstable selenamides ($PhSeNR^1R^2$),[25,26] after capture of HX by a molar equivalent of amine or in the presence of another base. The ^{77}Se chemical shifts of some selenenamides were measured some years ago.[27] The signals of *N*-(phenylselanyl)morpholine **19**[27] and its stable Se−dichloro adduct **20**[28] appeared at δ = 931 for **19** and δ = 987 for **20** (Figure 5). In this range of ^{77}Se NMR chemical shifts, we never observed a characteristic signal attributable to a selenenamide **21** derived from **21(HX)**.[29]

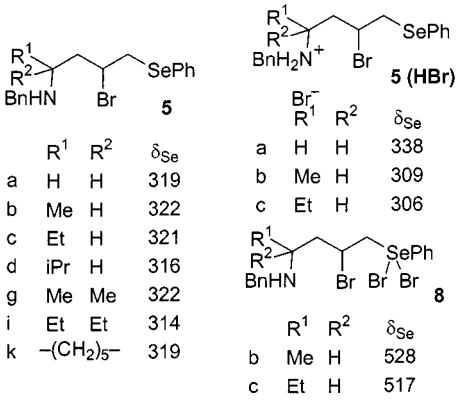
The acid-catalysed addition of sulfenamides or selenenamides to olefins has been described.[30,31] In the reaction between PhSeX and amines **1**, the very reactive intermediate **21(HX)** must be an efficient $PhSe^+$ donor to the olefinic double bond. The difference in bond strengths between the N−S and N−Se bonds must explain the lower reactivity of protonated sulfenamides.[30,31] Actually, to our surprise, only the PhSCl-induced cyclizations of *N*-(but-3-en-1-yl)aniline (Scheme 4) and of 2-allyl-3-benzylpyrrolidine have been studied.[32]

In this work, addition of PhSCl to the double bond was carried out after protonation of the amino group, to avoid the formation of the corresponding sulfenamide. The introduction of K_2CO_3, favouring the appearance of a thiiranium intermediate, allowed cyclization into 1-phenyl-3-(phenylsulfanyl)pyrrolidine without any trace of 1-phenyl-2-(phenylsulfanyl)methylazetidine. Under these experimental conditions, the amino group was the nucleophile in this case.

Coming back to the reaction between amines **1** and PhSeX (X = Cl, Br, I), we observed that a slight excess of selenium reagent was needed to obtain total disappearance



Scheme 2



	R^1	R^2	δ_{Se}
a	H	H	319
b	Me	H	322
c	Et	H	321
d	iPr	H	316
g	Me	Me	322
i	Et	Et	314
k	–$(CH_2)_5$–		319

	R^1	R^2	δ_{Se}
a	H	H	338
b	Me	H	309
c	Et	H	306

	R^1	R^2	δ_{Se}
b	Me	H	528
c	Et	H	517

Figure 4. ^{77}Se NMR characterization of the bromo intermediates **5**, **5 (HBr)**, and **8** ($CDCl_3$)

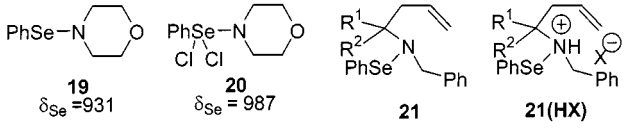
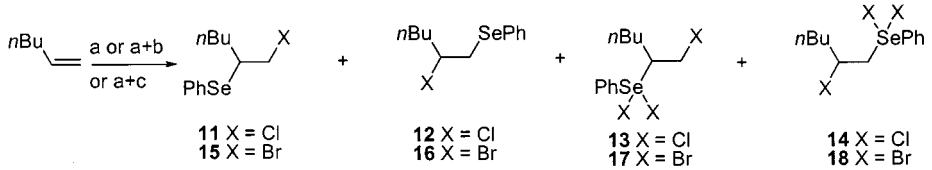


Figure 5. ^{77}Se NMR characterization of selenenamide derivatives

of the amine. From experiments described below, we supposed that the selenenamide-seleniranium intermediate **9** (Scheme 2) could be also involved in the cyclization process.

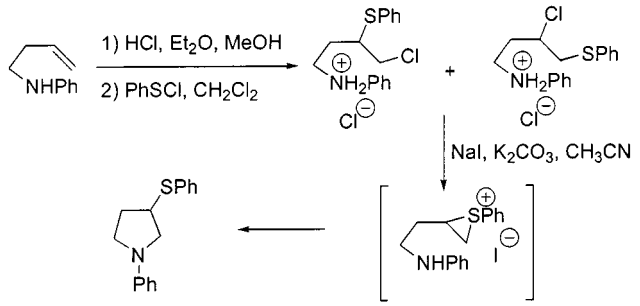
Addition of PhSeBr (2 equiv.) to the crude **2a(HBr)/3a(HBr)** salt mixture in CD_3CN was monitored by ^{77}Se NMR. The azetidinium salt **2a(HBr)** was completely isomerized into a pyrrolidinium salt **3a(HBr)**, characterized by a chemical shift (δ_{Se} = 379.8) different from that of the initial signal of **3a(HBr)** (δ_{Se} = 386.3). We also observed a



a) PhSeX (1equiv.), $CDCl_3$, r.t. 2 h. b) SO_2Cl_2 or Br_2. c) PhSeX (1equiv.).

Entry	Exp. conditions	X	kin. add. prod. Nr	δ_{Se}	Ratio (%)	therm. add prod. Nr	δ_{Se}	Ratio (%)	kin. $Se(X_2)$ prod. Nr	δ_{Se}	Ratio (%)	therm. $Se(X_2)$ prod Nr	δ_{Se}	Ratio (%)
1	a	Cl	**11**	377	74	**12**	300	18.5	–	–	–	**14**	535	7.5
2	a+b	Cl	–	–	–	--	–	–	**13**	639	67	**14**	535	33
3	a	Br	**15**	398	13	**16**	320	87	–	–	–	–	–	–
4	a+b	Br	–	–	–	–	–	–	**17**	615	4	**18**	491	96
5	a+c	Br	**15**	398	13	**16**	320	49	–	–	–	**18**	491	38

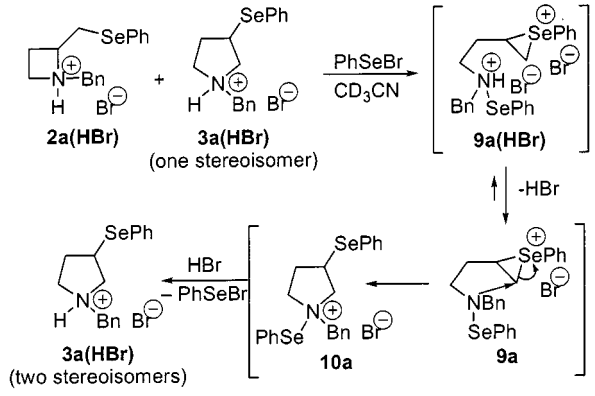
Scheme 3



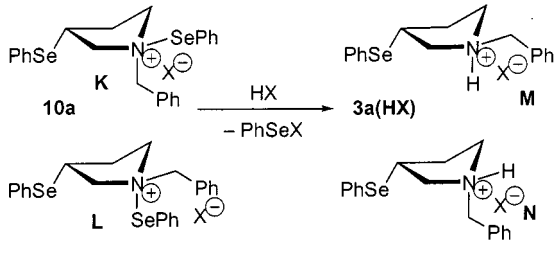
Scheme 4

slower decrease of this signal to the benefit of the new peak. This fact must be interpreted as a partial isomerization of the initially formed pyrrolidinium salt. At the end of the process, a 45:55 mixture of isomers was obtained.

The mechanism suggested for the PhSeBr-induced isomerization of **2a(HBr)** and **3a (HBr)** is depicted in Scheme 5. A second molar equivalent of PhSeBr must assist the opening of **2a(HBr)** and of **3a(HBr)** with formation of the (phenylselanyl)ammonium-seleniranium salt **9a(HBr)**. The selenenamide group of **9a** is suggested as the nucleophilic centre, affording the (phenylselanyl)pyrrolidinium bromide **10a** (mixture of the two stereoisomers **K** and **L**, Scheme 6). Under acidic conditions, the formation of the pyrrolidinium salt must occur stereoselectively, and the two isomers of **3a(HBr)** are obtained. As shown in Scheme 6,



Scheme 5



X^-	Solvent	δ_{Se}	(**M**, **N**)
Br^-	CD_3CN	386.3	379.8
Br^-	$CDCl_3$	385.3	384.4
I^-	$CDCl_3$	387.4	386.7

Scheme 6

the stereoisomers **K** and **L** of **10a** must afford **3a(HBr)** with the structures **M** and **N**, respectively.

This unexpected isomerization of **2a(HBr)** and **3a(HBr)** was also (in part) observed in $CDCl_3$ ($\Delta\delta_{Se}$ = 0.9 ppm) and upon treatment of **2a(HI)/3a(HI)** with PhSeI ($\Delta\delta_{Se}$ = 0.7 ppm). In another experiment, a 70:30 mixture of the two **M** and **N** isomers of **3a** (CF_3COOH) (δ_{Se} = 388.6 and 385.6) was formed by addition of trifluoroacetic acid (1.0 equiv.) to a pure sample of **3a**. In all cases, **3a** was regenerated after aqueous sodium carbonate treatment.

In the selenium-induced isomerization of **2a(HBr)** and **3a(HBr)**, we observed that the 4-*exo*-*trigonal* cyclization of **9a** to afford **2a(HBr)** was not efficient, unlike the direct formation of **2(HX)/3(HX)** mixtures from amines **1** (Table 2). From **1**, only one stereoisomer was formed for each pyrrolidinium salt *cis*-**3(HBr)** and *trans*-**3(HBr)**, while the isomerization of the **2a(HBr)/3a(HBr)** mixture provided the two stereoisomers of **3a(HBr)**. These results, coupled with observations from ^{77}Se NMR analysis of the salt mixtures **2d(HBr)/3d(HBr)** and **2e(HBr)/3e(HBr)** (Figure 3), prompted us to view the amino group of the seleniranium halide **6** (Br, I) as probably the nucleophile in the competitive 4-*exo*-*trig* and 5-*endo*-*trig* cyclization processes (Scheme 2). The selenenamide-seleniranium halide, such as **9**, could only be operative in the formation of the (phenylselanyl)pyrrolidiniuum halides **10**. The efficiency of the reaction in the absence of Na_2CO_3 must be the consequence of greater basicity in the cyclized products **2** and **3**, allowing the deprotonation of **1(HX)**.

The efficiency of the 4-*exo*-*trig* process, affording *cis* and *trans* azetidines **2**, increases progressively according to the size of R^1 (R^2 = H). This fact also agrees with the geminal α-effect governing the formation of small rings[11,12] when two α-substituents are present (Tables 1 and 2). The stereoisomer ratios of azetidines **2(HX)** were found to be slightly greater (Route B) than those of the corresponding azetidines **2** (Route A).

We were surprised to obtain only the azetidinium salts **2(HI)** when amines **1g** to **1k** (R^1, $R^2 \neq$ H) were treated with PhSeI (Table 2, entries 21, 22, 25, 26, 28). Regarding the *cis*/*trans* azetidine ratios, we observed that *cis*-**2** and *cis*-**2(HX)** were always the major isomers. This result could be explained by a greater stability of the *cis* isomers and a greater reactivity of the corresponding diastereoisomeric seleniranium intermediates **6**.

Conclusions

^{77}Se NMR analysis of the crude mixtures of products formed by PhSeX-induced cyclization of *N*-benzyl homoallylamines **1** in CH_3CN containing Na_2CO_3, has permitted the characterization of *cis* and *trans* azetidines **2** and *cis* and *trans* pyrrolidines **3** through their ^{77}Se chemical shifts. The relative proportions of each isomer were measured, as well as those of the corresponding HX salts (X = Br, I) when the reaction was carried out in the absence of Na_2CO_3. The structures of *cis*-**2d(HBr)**, *trans*-**2d(HBr)**, *cis*-

3d(HBr), and *trans*-**3d(HBr)** were studied and some reactions between PhSeBr and amines **1a**, **1b**, **1c** and **1d** were monitored by ^{77}Se NMR. The thermal addition products **5**, **5(HBr)**, and dibromoselenuranes **8** were characterized after a preliminary study involving the addition of PhSeX (X = Cl, Br) to 1-hexene. Compounds **2(HI)** and **3(HI)** were formed, without any traces of iodo intermediates, when PhSeI was used.

The proportions of **2** and **2(HX)** increased with the size of R^1 (R^2 = H) and when two substituents were present on the carbon linked to the nucleophilic centre. The same proportions also increased with the nature of the selenium reagent, in the order PhSeCl < PhSeBr < PhSeI. Azetidines **2** and their salts **2(HX)** resulted from a 4-*exo*-*trigonal* ring-closure involving the seleniranium intermediates **6(X)**, kinetically favoured by a geminal α-effect (R^1, $R^2 \neq$ H).[11,12]

PhSeI treatment of amines **1g** to **1k** allowed the isolation of 1-benzyl-2,2-dialkyl-4-(phenylselanylmethyl)azetidines **2g** to **2k** after neutralisation, without any traces of the corresponding pyrrolidines **3**. This fact is not very useful for synthetic purposes, the amine not being completely consumed.

As described in the following paper,[16] treatment of **1b** to **1f** (R^2 = H) with an excess of PhSeX (X = Cl, Br) afforded β-halopyrrolidines. Amines **1g** to **1k** ($R^2 \neq$ H), however, treated with an excess of PhSeBr in the presence of Na_2CO_3, afforded the corresponding azetidines **2**, in very good yields, after chromatographic elimination of the minor pyrrolidines **3**.

This work is now being extended to the PhSeX-induced cyclization of β-, γ-, or δ- substituted secondary homoallylamines. An asymmetric version of this reaction, using chiral substrates, is also being studied. For comparison, the PhSCl-induced cyclization of amines **1** is under investigation.

Experimental Section

General: Solvents were purified by conventional methods prior to use. TLC was performed on Merck 60F-250 silica gel plates and column chromatography over SI 60 silica gel (230−240 mesh). Mps were taken on a Kofler apparatus and were uncorrected. Elemental analyses were carried out on a Carlo−Erba EA 1100 analyser. NMR spectra were recorded on a Bruker DPX 300 spectrometer operating at 300 MHz for hydrogen and 75.4 MHz for carbon. This probe was equipped with pulsed-field (z) gradients. ^{77}Se NMR spectra were recorded at 21 °C on a Bruker DPX 400 spectrometer operating at 76.29 MHz for ^{77}Se, with a 19 μs pulse length (90° pulse = 19 μs) and an optimized relaxation delay of 2 s, which is rather low compared to T_1 observed for dialkylated selenide.[33] An average of 1500 scans for ^{77}Se NMR was necessary to provide reliable information. Chemical shifts (δ) are expressed in ppm relative to TMS for ^{1}H and ^{13}C nuclei and to Me_2Se for ^{77}Se nuclei; coupling constants (*J*) are given in Hertz; coupling multiplicities are reported using conventional abbreviations.

N-benzyl-but-3-en-1-ylamine **1a** was prepared by a known method.[34] The homoallylic amines **1b−1f** were synthesised by a Barbier-like reaction from the corresponding aldimines (Mg, allyl bromide, THF).[35] The α,α-disubstituted amines **1g−1k** were obtained by reductive allylation of the corresponding ketimines (allylmagnesium chloride in ether, THF, −20 °C). All amines were purified by distillation under reduced pressure or silica gel chromatography (CH_2Cl_2/hexane, 40:60). Some are known compounds: **1b**,[36,37] **1c**,[38] **1d**,[38] **1f**,[39] **1h**,[40] **1i**,[41] and **1k**.[40]

***N*-Benzyl-2,2-dimethylhex-5-en-3-ylamine (1e):** Oil, b.p.$_{0.02}$ 80 °C. 77% yield. ^{1}H NMR: δ = 0.97 (s, 9 H, *t*Bu), 1.20 (br, 1 H, NH), 1.88−2.08 (m, 1 H, 4-H), 2.20−2.30 (m, 1 H, 4-H), 2.40−2.55 (m, 1 H, 3-H), 3.72 (d, J_{AB} = 13.7 Hz, 1 H, Bn), 3.87 (d, J_{AB} = 13.7 Hz, 1 H, Bn), 5.02−5.16 (m, 2 H, 6-H), 5.92 (m, 1 H, 5-H), 7.22−7.45 (m, 5 H, Ph). ^{13}C NMR: δ = 27.1(Me), 35.8 (*C*-2), 36.4 (*C*-4), 55.3 (*C*H$_2$Ph), 66.4 (*C*-3), 116.3 (*C*-6), 126.8, 128.2, 128.3, 137.9 (*C*-5), 141.3. $C_{15}H_{23}N$: calcd. C 82.95, H 10.60, N 6.45; found C 82.84, H 10.54, N 6.53.

***N*-Benzyl-2-methylpent-4-en-2-ylamine (1g):** Oil, b.p.$_{0.02}$ 65 °C. 66% yield. ^{1}H NMR: δ = 1.07 (s, 6 H, Me), 1.33 (br, 1 H, NH), 2.17 (d, *J* = 7.4 Hz, 2 H, 3-H), 3.59 (s, 2 H, Bn), 4.98−5.08 (m, 2 H, 5-H), 5.80 (m, 1 H, 4-H), 7.18−7.30 (m, 5 H, Ph). ^{13}C NMR: δ = 27.0 (Me), 45.2 (*C*-3), 46.6 (*C*H$_2$Ph), 52.6 (*C*-2), 117.7 (*C*-5), 126.7, 128.2, 128.3, 134.8 (*C*-4), 141.2. $C_{13}H_{19}N$: calcd. C 82.54, H 10.05, N 7.41; found C 82.45, H 10.11, N 7.37.

***N*-Benzyl-3-methylhex-5-en-3-ylamine (1j):** Oil, b.p.$_{0.02}$ 79 °C. 63% yield. ^{1}H NMR: δ = 0.91 (t, *J* = 7.4 Hz, 3 H, Me), 1.07 (s, 3 H, Me), 1.30 (br, 1 H, NH), 1.46 (m, 2 H, MeC*H*$_2$), 2.22 (dd, *J* = 4.7, 5.9 Hz, 2 H, 4-H), 3.66 (s, 2 H, Bn), 5.05−5.15 (m, 2 H, 6-H), 5.85 (m, 1 H, 5-H), 7.22−7.38 (m, 5 H, Ph). ^{13}C NMR: δ = 7.9 (*C*-1), 24.3 (Me), 31.0 (*C*-2), 42.9 (*C*-4), 46.2 (*C*H$_2$Ph), 54.8 (*C*-3), 117.5 (*C*-6), 126.8, 128.3, 128.4, 134.9 (*C*-5), 141.5. $C_{14}H_{21}N$: calcd. C 82.76, H 10.34, N 6.89; found C 82.51, H 10.29, N 6.93.

PhSeBr-Induced Cyclization of Amines 1 in the Presence of Na_2CO_3. General Procedure: A solution of amine **1** (10 mmol) in freshly distilled acetonitrile (30 mL) containing anhydrous sodium carbonate (2 g) was treated dropwise at room temp., under inert atmosphere, with a solution of PhSeBr (15 mmol) in the same solvent (50 mL). The mixture was stirred for 16 h at room temp. and then treated with a saturated aq. NaCl solution. After separation, the aqueous phase was extracted with CH_2Cl_2 (3 × 20 mL) and the organic layers were dried and the solvents evaporated under reduced pressure. The residual oil was chromatographed on silica gel. Diphenyldiselenide was first eliminated by cyclohexane elution. The pyrrolidine *cis*-**3** (R^2 = H) was next eluted with a cyclohexane/CH_2Cl_2 mixture (90:10) followed by the pyrrolidine *trans*-**3** (R^2 = H) (80:20 mixture of the same solvents). The azetidine *cis*-**2** (R^2 = H) was then isolated (cyclohexane/CH_2Cl_2, 70:30). Azetidines *trans*-**2b** and *trans*-**2c** slowly isomerized during the chromatographic separation into *trans*-**3b** and *trans*-**3c**, respectively. Samples of *trans*-**2d**, *trans*-**2e** and *trans*-**2f** were obtained (cyclohexane/CH_2Cl_2, 60:40).

The azetidines **2g−2k** were synthesized, in better yield,[5] after separation from the minor pyrrolidine **3** (cyclohexane/CH_2Cl_2, 90:10) when an excess of PhSeBr (2.5 equiv.) was used in the same experimental conditions.

Cyclization of Amine 1a (85% overall yield)**:**

1-Benzyl-3-(phenylselanyl)pyrrolidine (3a): Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 2.050 g, 65% yield. ^{1}H NMR: δ = 1.93 (m, 1 H, 4-H), 2.38 (m, 1 H, 4-H), 2.51−2.74 (m, 3 H, 2-H and 5-H), 3.10 (dd, *J* = 7.2, 10.1 Hz, 1 H, 2-H), 3.59 (d, 1 H, J_{AB} = 12.9 Hz, Bn), 3.68 (d, 1 H, J_{AB} = 12.9 Hz, Bn), 3.77 (m, 1 H, 3-H), 7.20−7.35 (m, 8 H), 7.46−7.54 (m, 2 H). ^{13}C NMR: δ =

32.5 (*C*-4), 37.6 (*C*-3), 53.1 (*C*-5), 59.7 (*C*H_2Ph), 61.0 (*C*-2), 126.7, 128.0, 128.4, 128.7, 130.4, 132.9, 138.5. $C_{17}H_{19}NSe$: calcd. C 64.55, H 6.05, N 4.42; found C 64.42, H 6.18, N 4.75.

1-Benzyl-2-(phenylselanylmethyl)azetidine (2a): Flash chromatography (cyclohexane/CH_2Cl_2, 1:1). Oil. 0.140 g, < 5% yield. ^{1}H NMR: δ = 1.89 (m, 1 H, 3-H), 2.10 (m, 1 H, 3-H), 2.79 (dd, *J* = 1.5, 7.4 Hz, 1 H, 2-H), 2.86 (m, 2 H, C*H*$_2$SePh), 3.32 (m, 2 H, 4-H), 3.56 (d, 1 H, J_{AB} = 12.5 Hz, Bn), 3.73 (d, 1 H, J_{AB} = 12.5 Hz, Bn), 7.18−7.50 (m, 10 H, Ph). ^{13}C NMR: δ = 24.5 (*C*-3), 33.0 (*C*H$_2$SePh), 50.6 (*C*-4), 62.5 (*C*H$_2$Ph), 65.5 (*C*-2), 126.6, 127.1, 128.6, 128.9, 132.3, 137.6.

Cyclization of Amine 1b (82% overall yield)**:**

***cis*-1-Benzyl-2-methyl-4-(phenylselanyl)pyrrolidine (3b):** Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 0.230 g, 7% yield. ^{1}H NMR: δ = 1.27 (d, *J* = 5.7 Hz, 3 H, Me), 1.73 (m, 1 H, 3-H), 2.58 (m, 2 H, 2-H and 3-H), 2.73 (dd, *J* = 7.6, 10.7 Hz, 1 H, 5-H), 3.15 (dd, *J* = 3.1, 10.7 Hz, 1 H, 5-H), 3.31 (d, 1 H, J_{AB} = 13.5 Hz, Bn), 3.71 (m, 1 H, 4-H), 4.12 (d, 1 H, J_{AB} = 13.5 Hz, Bn), 7.20−7.38 (m, 8 H), 7.45−7.50 (m, 2 H). ^{13}C NMR: δ = 18.9 (Me), 36.6 (*C*-4), 41.8 (*C*-3), 57.0 (*C*-5), 57.1 (C-2), 61.0 (*C*H$_2$Ph), 126.9, 128.2, 128.8, 130.9, 133.2.

***trans*-1-Benzyl-2-methyl-4-(phenylselanyl)pyrrolidine (3b):** Flash chromatography (cyclohexane/CH_2Cl_2, 80:20). Oil. 0.525 g, 16% yield. ^{1}H NMR: δ = 1.15 (d, *J* = 6.0 Hz, 3 H, Me), 2.06 (m, 2 H, 3-H), 2.28 (dd, *J* = 8.4, 9.9 Hz, 1 H, 5-H), 2.64 (m, 1 H, 2-H), 3.17 (d, 1 H, J_{AB} = 12.9 Hz, Bn), 3.31 (dd, *J* = 7.3, 9.9 Hz, 1 H, 5-H), 3.68 (m, 1 H, 4-H), 4.00 (d, 1 H, J_{AB} = 12.9 Hz, Bn), 7.20−7.30 (m, 8 H), 7.42−7.48 (m, 2 H). ^{13}C NMR: δ = 18.7 (Me), 35.7 (*C*-4), 41.5 (*C*-3), 57.7 (*C*-5), 58.5 (*C*-2), 61.1 (*C*H$_2$Ph), 126.8, 128.1, 128.7, 133.0, 139.0. $C_{18}H_{21}NSe$: calcd. C 65.45, H 6.41, N 4.24; found C 65.15, H 6.34, N 4.54.

***cis*-1-Benzyl-2-methyl-4-(phenylselanylmethyl)azetidine (2b):** Flash chromatography (cyclohexane/CH_2Cl_2, 75:25). Oil. 0.395 g, 12% yield. ^{1}H NMR: δ = 1.03 (d,3 H, *J* = 6.0 Hz, Me), 1.42 (m,1 H, 3-H), 2.27 (m,1 H, 3-H), 2.82 (m,2 H, C*H*$_2$SePh), 2.99 (m,1 H, 2-H), 3.15 (m,1 H, 4-H), 3.65 (s,2 H, Bn), 7.18−7.30 (m, 8 H), 7.35−7.45 (m, 2 H). ^{13}C NMR: δ = 21.8 (Me), 32.6 (*C*-3), 33.5 (*C*H$_2$SePh), 58.0 (*C*-2), 61.6 (*C*H$_2$Ph), 62.0 (*C*-4), 126.5, 127.0, 128.1, 128.8, 129.4, 133.1, 138.1. $C_{18}H_{21}NSe$: calcd. C 65.45, H 6.41, N 4.24; found C 65.56, H 6.62, N 4.39.

Cyclization of Amine 1c (84% overall yield)**:**

***cis*-1-Benzyl-2-ethyl-4-(phenylselanyl)pyrrolidine (3c):** Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 0.308 g, 9% yield. ^{1}H NMR: δ = 0.90 (t, 3 H, *J* = 7.45 Hz, Me), 1.42 (m, 1 H, C*H*$_2$Me), 1.70 (dd, *J* = 5.0, 6.4 Hz, 1 H, 3-H), 1.76 (m, 1 H, C*H*$_2$Me), 2.42−2.51 (m, 2 H, 2-H and 3-H), 2.67 (dd, *J* = 7.4, 10.6 Hz, 1 H, 5-H), 3.07 (dd, *J* = 3.3, 10.6 Hz, 1 H, 5-H), 3.25 (d, 1 H, J_{AB} = 13.6 Hz, Bn), 3.63 (m, 1 H, 4-H), 4.03 (d, 1 H, J_{AB} = 13.6 Hz, Bn), 7.20−7.32 (m, 8 H), 7.45−7.47 (m, 2 H). ^{13}C NMR: δ = 10.2 (Me), 26.0 (*C*H$_2$Me), 36.9 (*C*-4), 38.7 (*C*-3), 57.3(*C*-5), 61.0 (*C*H$_2$Ph), 65.4 (*C*-2), 126.8, 128.1, 128.9, 131.0, 133.2. $C_{19}H_{23}NSe$: calcd. C 66.27, H 6.73, N 4.07; found C 66.56, H 6.52, N 4.21.

***trans*-1-Benzyl-2-ethyl-4-(phenylselanyl)pyrrolidine (3c):** Flash chromatography (cyclohexane/CH_2Cl_2, 80:20). Oil. 0.345 g, 10% yield. ^{1}H NMR: δ = 0.89 (t, *J* = 7.4 Hz, 3 H, Me), 1.37 (m, 1 H, C*H*$_2$Me), 1.73 (m,1 H, C*H*$_2$Me), 2.06 (m, 2 H, 3-H), 2.30 (t,1 H, *J* = 9.4 Hz, 5-H), 2.54 (m, 1 H, 2-H), 3.20 (d, 1 H, J_{AB} = 13 Hz, Bn), 3.31 (dd, *J* = 7.1, 9.8 Hz, 1 H, 5-H), 3.65 (m, 1 H, 4-H), 4.01 (d, 1 H, J_{AB} = 13.0 Hz, Bn), 7.20−7.30 (m, 8 H), 7.45−7.47 (m, 2 H). ^{13}C NMR: δ = 10.1 (Me), 26.1 (*C*H$_2$Me), 36.1 (*C*-4), 38.6 (*C*-3), 58.0 (*C*-5), 61.3 (*C*H$_2$Ph), 64.6 (*C*-2),126.8, 128.1, 128.7, 129.3, 132.2, 133.1, 139.0. $C_{19}H_{23}NSe$: calcd. C 66.27, H 6.73, N 4.07; found C 65.91, H 6.63, N 3.72.

***cis*-1-Benzyl-2-ethyl-4-(phenylselanylmethyl)azetidine (2c):** Flash chromatography (cyclohexane/CH_2Cl_2, 75:25). Oil. 0.512 g, 15% yield. ^{1}H NMR: δ = 0.75 (t, *J* = 7.4 Hz, 3 H, Me), 1.30−1.44 (m, 3 H, C*H*$_2$Me and 3-H), 2.23 (m, 1 H, 3-H), 2.73 (d, *J* = 6.4 Hz, 2 H, C*H*$_2$SePh), 2.81 (m, 1 H, 2-H), 3.10 (m, 1 H, 4-H), 3.57 (d, 1 H, J_{AB} = 12.5 Hz, Bn), 3.69 (d, 1 H, J_{AB} = 12.5 Hz, Bn), 7.15−7.40 (m, 10 H). ^{13}C NMR: δ = 9.4 (Me), 29.1 (*C*H$_2$Me), 30.2 (*C*-3), 33.6 (*C*H$_2$SePh), 61.6 (*C*-4), 62.0 (*C*H$_2$Ph), 63.2(*C*-2), 126.4, 126.9, 128.0, 128.8, 129.3, 132.1, 133.1, 138.5. $C_{19}H_{23}NSe$: calcd. C 66.27, H 6.73, N 4.07; found C 66.01, H 6.93, N 3.98.

Cyclization of Amine 1d (88% overall yield)**:**

***cis*-1-Benzyl-2-isopropyl-4-(phenylselanyl)pyrrolidine (3d):** Flash chromatography (cyclohexane/CH_2Cl_2, 90:10). m.p. 41 °C. 0.320 g, 9% yield. ^{1}H NMR: δ = 0.92 (d, *J* = 6.9 Hz, 3 H, Me), 0.96 (d, *J* = 6.9 Hz, 3 H, Me), 1.77 (m, 1 H, 3-H), 2.00 (m, 1 H, C*H*Me$_2$), 2.28 (m, 1 H, 3-H), 2.48 (m, 1 H, 2-H), 2.68 (dd, *J* = 7.4, 10.5 Hz, 1 H, 5-H), 3.07 (dd, *J* = 3.7, 10.5 Hz, 1 H, 5-H), 3.22 (d, 1 H, J_{AB} = 13.2 Hz, Bn), 3.62 (m, 1 H, 4-H), 4.05 (d, 1 H, J_{AB} = 13.2 Hz, Bn), 7.20−7.35 (m, 8 H), 7.43−7.50 (m, 2 H). ^{13}C NMR: δ = 15.5 (Me), 20.1 (Me), 28.3 (*C*HMe$_2$), 33.7 (*C*-3), 37.2 (*C*-4), 57.7 (*C*-5), 61.2 (*C*H$_2$Ph), 69.3 (*C*-2), 126.8, 128.1, 128.2, 128.8, 133.3. $C_{20}H_{25}NSe$: calcd. C 67.03, H 7.03, N 3.91; found C 66.98, H 7.24, N 3.97.

***trans*-1-Benzyl-2-isopropyl-4-(phenylselanyl)pyrrolidine (3d):** Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 0.135 g, < 5% yield. ^{1}H NMR: δ = 0.89 (d, *J* = 6.7 Hz, 3 H, Me), 0.91 (d, *J* = 6.7 Hz, 3 H, Me), 1.82 (m, 1 H, 3-H), 1.96 (m, 1 H, C*H*Me$_2$), 2.14 (m, 1 H, 3-H), 2.28 (dd, *J* = 6.7, 9.5 Hz, 1 H, 5-H), 2.58 (m, 1 H, 2-H), 3.17 (d, 1 H, J_{AB} = 13.1 Hz, Bn), 3.28 (dd, *J* = 9.2, 9.6 Hz, 1 H, 5-H), 3.57 (m, 1 H, 4-H), 4.02 (d, 1 H, J_{AB} = 13.1 Hz, Bn), 7.18−7.30 (m, 8 H), 7.43−7.50 (m, 2 H). ^{13}C NMR: δ = 15.3 (Me), 20.0 (Me), 28.4 (*C*HMe$_2$), 33.3 (*C*-3), 36.8 (*C*-4), 58.3 (*C*-5), 61.4 (*C*H$_2$Ph), 68.2 (*C*-2), 126.7, 126.9, 128.1, 128.5, 128.9, 133.3. $C_{20}H_{25}NSe$: calcd. C 67.03, H 7.03, N 3.91; found C 66.75, H 6.68, N 4.26.

***cis*-1-Benzyl-2-isopropyl-4-(phenylselanylmethyl)azetidine (2d):** Flash chromatography (cyclohexane/CH_2Cl_2, 75:25). Oil. 0.935 g, 26% yield. ^{1}H NMR: δ = 0.82 (d, *J* = 6.7 Hz, 3 H, Me), 0.89 (d, *J* = 6.7 Hz, 3 H, Me), 1.45 (m, 1 H, 3-H), 1.64 (m, 1 H, C*H*Me$_2$), 2.22 (m, 1 H, 3-H), 2.58−2.70 (m, 3 H, 2-H and C*H*$_2$SePh), 3.09 (m, 1 H, 4-H), 3.47 (d, 1 H, J_{AB} = 12.6 Hz, Bn), 3.89 (d, 1 H, J_{AB} = 12.6 Hz, Bn), 7.22−7.33 (m, 10 H). ^{13}C NMR: δ = 17.5 (Me), 18.9 (Me), 27.8 (*C*-3), 33.7 (*C*H$_2$SePh), 34.0 (*C*HMe$_2$), 61.1 (*C*-4), 62.9 (*C*H$_2$Ph), 68.0 (*C*-2), 126.3, 127.0, 128.0, 128.7, 129.3, 132.0. $C_{20}H_{25}NSe$: calcd. C 67.03, H 7.03, N 3.91; found C 67.13. H, 7.39, N 4.14.

***trans*-1-Benzyl-2-isopropyl-4-(phenylselanylmethyl)azetidine (2d):** Flash chromatography (cyclohexane/CH_2Cl_2, 60:40). Oil. 0.165 g, < 5% yield. ^{1}H NMR: δ = 0.77 (dd, 6 H, *J* = 2.6, 6.7 Hz, Me), 1.64 (m, 1 H, C*H*Me$_2$), 1.72 (m, 1 H, 3-H), 2.00 (m, 1 H, 3-H), 2.92−3.08 (m, 2 H, C*H*$_2$SePh), 3.19 (m, 1 H, 2-H), 3.57 (m, 1 H, 4-H), 3.69 (d, 1 H, J_{AB} = 14.2 Hz, Bn), 3.81 (d, 1 H, J_{AB} = 14.2 Hz, Bn), 7.05−7.26 (m, 10 H).

Cyclization of Amine 1e (87% overall yield)**:**

***trans*-1-Benzyl-2-*tert*-butyl-4-(phenylselanyl)pyrrolidine (3e):** Flash chromatography (cyclohexane/CH_2Cl_2, 90:10). Oil. 0.180 g, < 5% yield. ^{1}H NMR: δ = 0.92 (s, 9 H, *t*Bu), 1.98 (m, 1 H, 3-H), 2.15 (m, 1 H, 3-H), 2.45 (dd, *J* = 8.6, 10.1 Hz, 1 H, 5-H), 2.73 (dd, *J* = 4.0, 9.4 Hz, 1 H, 2-H), 3.27 (dd, *J* = 5.8, 10.1 Hz, 1 H, 5-H), 3.62 (m, 1 H, 4-H), 3.62 (d, 1 H, J_{AB} = 13.9 Hz, Bn), 4.15 (d, 1 H, J_{AB} = 13.9 Hz, Bn), 7.15−7.37 (m, 8 H), 7.45−7.50 (m, 2 H). ^{13}C NMR: δ = 26.8 (Me), 35.6 (*C*-3), 39.5 (*C*-4), 62.0 (*C*-5), 63.2 (*C*H_2Ph), 72.7 (*C*-2), 126.5, 127.0, 127.8, 128.1, 128.9, 133.6.

***cis*-1-Benzyl-2-*tert*-butyl-4-(phenylselanylmethyl)azetidine (2e):** Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). m.p. 32 °C. 0.860 g, 23% yield. ^{1}H NMR: δ = 0.88 (s, 9 H, *t*Bu), 1.47 (m, 1 H, 3-H), 2.09 (m, 1 H, 3-H), 2.54 (m, 2 H, C*H*$_2$SePh), 2.72 (m, 1 H, 2-H), 3.01 (m, 1 H, 4-H), 3.38 (d, 1 H, J_{AB} = 12.8 Hz, Bn), 3.94 (d, 1 H, J_{AB} = 12.8 Hz, Bn), 7.15−7.35 (m, 10 H). ^{13}C NMR: δ = 25.1 (*C*-3), 25.8 (Me), 33.4 (*C*H_2SePh), 48.0 (*C*Me$_3$), 60.9 (*C*-4), 63.5 (*C*H_2Ph), 70.8 (*C*-2), 126.2, 126.4, 127.9, 128.7, 129.1, 131.7. $C_{21}H_{27}$NSe: calcd. C 67.73, H 7.31, N 3.76; found C 67.64, H 7.37, N 4.02.

***trans*-1-Benzyl-2-*tert*-butyl-4-(phenylselanylmethyl)azetidine (2e):** Flash chromatography (cyclohexane/CH_2Cl_2, 70:30). m.p. 46 °C. 0.253 g, 7% yield. ^{1}H NMR: δ = 0.90 (s, 9 H, *t*Bu), 1.66 (m, 1 H, 3-H), 2.14 (m, 1 H, 3-H), 3.06 (q, *J* = 11.6 Hz, 1 H, 5-H), 3.16 (m, 1 H, 5-H), 3.27 (t, *J* = 8.0 Hz, 1 H, 2-H), 3.57 (m, 1 H, 4-H), 3.78 (d, 1 H, J_{AB} = 14.5 Hz, Bn), 3.91 (d, 1 H, J_{AB} = 14.5 Hz, Bn), 7.05−7.15 (m, 4 H), 7.22−7.35 (m, 6 H). ^{13}C NMR: δ = 26.0 (*C*-3), 26.4 (Me), 28.7 (*C*H_2SePh), 34.2 (*C*Me$_3$), 55.5 (*C*H_2Ph), 56.7 (*C*-4), 72.2 (*C*-2), 126.6, 127.0, 127.9, 128.2, 128.8, 129.4, 131.4, 140.4. $C_{21}H_{27}$NSe: calcd. C 67.73, H 7.31, N 3.76; found C 67.34, H 7.35, N 4.10.

Cyclization of Amine 1f (82% overall yield)**:**

***cis*-1-Benzyl-2-phenyl-4-(phenylselanyl)pyrrolidine(3f):** Flash chromatography (cyclohexane/CH_2Cl_2, 90:10). m.p. 35 °C. 0.387 g, 10% yield. ^{1}H NMR: δ = 1.97 (m, 1 H, 3-H), 2.70 (m, 1 H, 3-H), 2.75 (dd, *J* = 2.7, 10.5 Hz, 1 H, 5-H), 3.09 (d, 1 H, J_{AB} = 13.6 Hz, Bn), 3.28 (dd, *J* = 2.6, 10.5 Hz, 1 H, 5-H), 3.48 (dd, *J* = 7.1, 9.1 Hz, 1 H, 2-H), 3.75 (m, 1 H, 4-H), 3.86 (d, 1 H, J_{AB} = 13.6 Hz, Bn), 7.15−7.40 (m, 11 H), 7.45−7.55 (m, 4 H). ^{13}C NMR: δ = 37.1 (*C*-4), 43.8 (*C*-3), 56.9 (*C*H_2Ph), 60.3 (*C*-5), 69.4 (*C*-2), 126.6, 127.0, 127.6, 128.0, 128.2, 128.4, 128.9, 133.7, 139.1. $C_{23}H_{23}$NSe: calcd. C 70.40, H 5.91, N 3.57; found C 70.25, H 5.85, N 3.81.

***trans*-1-Benzyl-2-phenyl-4-(phenylselanyl)pyrrolidine (3f):** Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 0.308 g, 8% yield. ^{1}H NMR: δ = 2.37 (m, 1 H, 5-H), 2.40 (m, 2 H, 3-H), 3.13 (d, 1 H, J_{AB} = 13.6 Hz, Bn), 3.60 (m, 1 H, 5-H), 3.65 (m, 1 H, 2-H), 3.87 (m, 1 H, 4-H), 3.87 (d, 1 H, J_{AB} = 13.6 Hz, Bn), 7.15−7.55 (m, 15 H). ^{13}C NMR: δ = 36.4 (*C*-4), 43.9 (*C*-3), 57.6 (*C*-5), 60.4 (*C*H_2Ph), 68.1 (*C*-2), 126.8, 127.1, 127.2, 127.4, 128.1, 128.5, 129.0, 129.5, 132.2, 133.3. $C_{23}H_{23}$NSe: calcd. C 70.40, H 5.91, N 3.57; found C 70.19, H 5.76, N 3.68.

***cis*-1-Benzyl-2-phenyl-4-(phenylselanylmethyl)azetidine (2f):** Flash chromatography (cyclohexane/CH_2Cl_2, 75:25). Oil. 0.475 g, 12% yield. ^{1}H NMR: δ = 1.72 (m, 1 H, 3-H), 2.52 (m, 1 H, 3-H), 2.76 (m, 2 H, C*H*$_2$SePh), 3. 28 (m, 1 H, 4-H), 3.90 (m, 1 H, 2-H), 3.52 (d, 1 H, J_{AB} = 12.8 Hz, Bn), 3.86 (d, 1 H, J_{AB} = 12.8 Hz, Bn), 7.15−7.45 (m, 15 H). ^{13}C NMR: δ = 34.2 (*C*H_2SePh), 34.9 (*C*-3), 61.4 (*C*H_2Ph), 62.0 (*C*-4), 64.8 (*C*-2), 126.2, 126.4, 127.9, 128.7, 129.1, 131.7, 138.8, 141.7. $C_{23}H_{23}$NSe: calcd. C 70.40, H 5.91, N 3.57; found C 70.53, H 5.88, N 3.90.

***trans*-1-Benzyl-2-phenyl-4-(phenylselanylmethyl)azetidine (2f):** Flash chromatography (cyclohexane/CH_2Cl_2, 60:40). Oil. 0.161 g, < 5% yield. ^{1}H NMR: δ = 2.30 (m, 2 H, 3-H), 3.10 (m, 2 H, C*H*$_2$SePh), 3.53 (d, 1 H, J_{AB} = 13.8 Hz, Bn), 3.64 (d, 1 H, J_{AB} = 13.8 Hz, Bn), 3.84 (m, 1 H, 4-H), 4.58 (dd, *J* = 6.0, 7.7 Hz, 1 H, 2-H), 7.10−7.40 (m, 15 H). ^{13}C NMR: δ = 30.0 (*C*-3), 33.0 (*C*H_2SePh), 54.0 (*C*H_2Ph), 60.2 (*C*-4), 64.6 (*C*-2), 126.5, 126.7, 127.3, 127.5, 128.1, 128.3, 128.9, 129.9, 131.7, 138.9, 141.6.

Cyclization of Amine 1g (90% overall yield)**:**

1-Benzyl-2,2-dimethyl-4-(phenylselanyl)pyrrolidine (3g): Flash chromatography (cyclohexane/CH_2Cl_2, 75:25). Oil; 0.150 g, < 5% yield. ^{1}H NMR: δ = 1.10 (s, 3 H, Me), 1.16 (s, 3 H, Me), 1.89 (dd, *J* = 6.7, 13.2 Hz, 1 H, 3-H), 2.26 (dd, *J* = 9.3, 13.2 Hz, 1 H, 3-H), 2.81 (dd, *J* = 6.5, 10.2 Hz, 1 H, 5-H), 3.07 (dd, *J* = 8.0, 10.2 Hz, 1 H, 5-H), 3.49 (d, 1 H, J_{AB} = 13.4 Hz, Bn), 3.58 (d, 1 H, J_{AB} = 13.4 Hz, Bn), 3.70 (m, 1 H, 4-H), 7.18−7.50 (m, 10 H). ^{13}C NMR: δ = 23.2 (Me), 23.7 (Me), 35.1 (*C*-4), 48.0 (*C*-3), 52;0 (*C*-5), 58.4 (*C*H_2Ph), 60.5 (*C*-2), 126.5, 126.7, 128.0, 128.1, 129.8, 131.7, 132.9. $C_{19}H_{23}$NSe: calcd. C 66.26, H 6.73, N 4.06; found C 65.92, H 6.58, N 4.18.

1-Benzyl-2,2-dimethyl-4-(phenylselanylmethyl)azetidine (2g): Flash chromatography (cyclohexane/CH_2Cl_2, 65:35). Oil. 2.465 g, 72% yield. ^{1}H NMR: δ = 1.08 (s, 3 H, Me), 1.19 (s, 3 H, Me), 1.65 (dd, *J* = 7.9, 10.3 Hz, 1 H, 3-H), 1.92 (dd, *J* = 7.4, 10.3 Hz, 1 H, 3-H), 2.66−2.86 (m, 2 H, C*H*$_2$SePh), 3.34 (m, 1 H, 4-H), 3.51 (d, 1 H, J_{AB} = 13.1 Hz, Bn), 3.69 (d, 1 H, J_{AB} = 13.1 Hz, Bn), 7.10−7.30 (m, 10 H). ^{13}C NMR: δ = 20.7 (Me), 30.5 (Me), 34.2 (*C*H_2SePh), 38.8 (*C*-3), 54.0 (*C*H_2Ph), 59.2 (*C*-2), 60.2 (*C*-4), 126.2, 126.6, 127.8, 128.6, 128.9, 131.9, 139.9. $C_{19}H_{23}$NSe: calcd. C 66.26, H 6.73, N 4.06; found C 66.58, H 6.78, N 3.98.

Cyclization of Amine 1h (92% overall yield)**:**

***cis*-1-Benzyl-2-methyl-2-phenyl-4-(phenylselanyl)pyrrolidine (3h):** Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 0.180 g, < 5% yield. ^{1}H NMR: δ = 1.44 (s, 3 H, Me), 2.19 (dd, *J* = 8.0, 13.3 Hz, 1 H, 3-H), 2.38 (dd, *J* = 10.4, 13.3 Hz, 1 H, 3-H), 3.04 (dd, *J* = 8.3, 10.7 Hz, 1 H, 5-H), 3.17 (d, 1 H, J_{AB} = 13.5 Hz, Bn), 3.27 (dd, *J* = 3.6, 10.7 Hz, 1 H, 5-H), 3.59 (d, 1 H, J_{AB} = 13.5 Hz, Bn), 3.83 (m, 1 H, 4-H), 7.15−7.66 (m, 15 H). ^{13}C NMR: δ = 16.9 (Me), 37.1 (*C*-4), 52.0 (*C*-3), 53.0 (*C*-5), 58.0 (*C*H_2Ph), 62.6 (*C*-2), 126.8, 128.1, 128.7, 129.3, 132.2, 133.1, 139.0.

***cis*-1-Benzyl-2-methyl-2-phenyl-4-(phenylselanylmethyl)azetidine (2h):** Flash chromatography (cyclohexane/CH_2Cl_2, 70:30). Oil. 2.280 g, 56% yield. ^{1}H NMR: δ = 1.62 (s, 3 H, Me), 1.89 (dd, *J* = 7.9, 10.3 Hz, 1 H, 3-H), 2.33 (dd, *J* = 7.4, 10.3 Hz, 1 H, 3-H), 2.57 (m, 2 H, C*H*$_2$SePh), 3.49 (m, 1 H, 4-H), 3.58 (d, 1 H, J_{AB} = 12.7 Hz, Bn), 3.93 (d, 1 H, J_{AB} = 12.7 Hz, Bn), 7.15−7.50 (m, 10 H). ^{13}C NMR: δ = 21.8 (Me), 34.2 (*C*H_2SePh), 41.0 (*C*-3), 55.2 (*C*H_2Ph), 61.2 (*C*-4), 63.6 (*C*-2), 126.2, 126.4, 127.9, 128.7, 129.1, 131.7, 138.8, 141.7. $C_{24}H_{25}$NSe: calcd. C 70.92, H 6.20, N 3.45; found C 70.64, H 6.08, N 3.58.

Cyclization of Amine 1i (87% overall yield)**:**

1-Benzyl-2,2-diethyl-4-(phenylselanyl)pyrrolidine (3i): Flash chromatography (cyclohexane/CH_2Cl_2, 85:15). Oil. 0.164 g, < 5% yield. ^{1}H NMR: δ = 0.90 (m, 6 H, Me), 1.25−1.50 (m, 4 H, C*H*$_2$Me), 1.85 (dd, *J* = 6.6, 13.1 Hz, 1 H, 3-H), 2.21 (dd, *J* = 9.1, 13.1 Hz, 1 H, 3-H), 2.81 (dd, *J* = 6.5, 10.2 Hz, 1 H, 5-H), 3.09 (dd, *J* = 8.0, 10.2 Hz, 1 H, 5-H), 3.60 (m, 3 H, 4-H and Bn), 7.15−7.40 (m, 10 H).

1-Benzyl-2,2-diethyl-4-(phenylselanylmethyl)azetidine (2i): Flash chromatography (cyclohexane/CH_2Cl_2, 70:30). Oil. 2.60 g, 70% yield. ^{1}H NMR: δ = 0.77 (t, *J* = 7.4 Hz, 3 H, Me), 0.80 (t, *J* = 7.4 Hz, 3 H, Me), 1.23−1.72 (m, 5 H, 3-H and C*H*$_2$Me), 1.88 (dd, *J* = 7.8, 10.7 Hz, 1 H, 3-H), 2.50−2.61 (m, 2 H, C*H*$_2$SePh), 3.23 (m, 1 H, 4-H), 3.41 (d, 1 H, J_{AB} = 13.05 Hz, Bn), 3.74 (d, 1 H, J_{AB} = 13.05 Hz, Bn), 7.08−7.30 (m, 10 H). ^{13}C NMR: δ = 8.4 (Me), 9.1 (Me), 24.8 (*C*H$_2$Me), 31.6 (*C*H$_2$Me), 33.7 (*C*-3), 34.8 (*C*H$_2$SePh), 54.9 (*C*H$_2$Ph), 61.0 (*C*-4), 65.5 (*C*-2), 126.7, 127.2, 128.5, 129.3, 129.5, 131.0, 132.3, 141.2. $C_{21}H_{27}NSe$: calcd. C 67.73, H 7.31, N 3.76; found C 67.93, H 7.13, N 3.98.

Cyclization of Amine 1j (91% overall yield)**:**

***cis*-1-Benzyl-2-ethyl-2-methyl-4-(phenylselanylmethyl)azetidine (2j):** Flash chromatography (cyclohexane/CH_2Cl_2, 70:30). Oil. 1.246 g, 35% yield. ^{1}H NMR: δ = 0.80 (t, *J* = 7.5 Hz, 3 H, C*H*$_3$CH$_2$), 1.17 (s, 3 H, Me), 1.33 (m, 2 H, CH$_3$C*H*$_2$), 1.64 (dd, *J* = 7.8, 10.4 Hz, 1 H, 3-H), 1.81 (dd, *J* = 7.6, 10.4 Hz, 1 H, 3-H), 2.62−2.79 (m, 2 H, C*H*$_2$SePh), 3.31 (m,1 H, 4-H), 3.48 (d, 1 H, J_{AB} = 13.0 Hz, Bn), 3.70 (d, 1 H, J_{AB} = 13.0 Hz, Bn), 7.15−7.37 (m, 10 H). ^{13}C NMR: δ = 8.1 (*C*H$_3$CH$_2$), 18.6 (Me), 34.1 (*C*-3), 35.5 (*C*H$_2$Me), 36.0 (*C*H$_2$SePh), 54.6 (*C*H$_2$Ph), 60.3 (*C*-4), 126.3, 126.7, 128.0, 128.8, 129.0, 132.9. $C_{20}H_{25}NSe$: calcd. C 67.03, H 7.03, N 3.91; found C 66.88, H 6.93, N 3.87.

***trans*-1-Benzyl-2-ethyl-2-methyl-4-(phenylselanylmethyl)azetidine (2j):** Flash chromatography (cyclohexane/CH_2Cl_2, 60:40). Oil. 0.155 g, < 5% yield. ^{1}H NMR: δ = 0.83 (t, *J* = 7.5 Hz, 3 H, C*H*$_3$CH$_2$), 1.07 (s, 3 H, Me), 1.50 (m, 2 H, CH$_3$C*H*$_2$), 1.77 (dd, *J* = 7.5, 10.5 Hz, 1 H, 3-H), 2.05 (dd, *J* = 7.8, 10.5 Hz, 1 H, 3-H), 2.65−2.83 (m, 2 H, C*H*$_2$SePh), 3.36 (m,1 H, 4-H), 3.52 (d, 1 H, J_{AB} = 13.0 Hz, Bn), 3.78 (d, 1 H, J_{AB} = 13.0 Hz, Bn), 7.15−7.38 (m, 10 H). ^{13}C NMR: δ = 8.8 (*C*H$_3$CH$_2$), 13.4 (Me), 29.8 (*C*H$_2$Me), 34.5 (*C*-3), 35.7 (*C*H$_2$SePh), 53.1 (*C*H$_2$Ph), 60.1 (*C*-4), 126.3, 126.8, 127.3, 127.9, 128.7, 128.9, 131.9.

Cyclization of Amine 1k (88% overall yield)**:**

Spiro Compound 3k: Flash chromatography (cyclohexane/CH_2Cl_2, 70:30). Oil. 0.160 g, < 5% yield. ^{1}H NMR: δ = 1.35−1.76 (m, 10 H, (CH$_2$)$_5$], 1.94 (dd, *J* = 6.5, 13.4 Hz, 1 H, 3-H), 2.35 (dd, *J* = 10.0, 13.4 Hz, 1 H, 3-H), 2.85 (dd, *J* = 6.4, 10.0 Hz, 1 H, 5-H), 3.12 (dd, *J* = 6.5, 10.0 Hz, 1 H, 5-H), 3.62 (d, 1 H, J_{AB} = 13.7 Hz, Bn), 3.67 (d, 1 H, J_{AB} = 13.7 Hz, Bn), 3.65 (m, 1 H, 4-H), 7.16−7.34 (m, 8 H), 7.46−7.49 (m, 2 H). ^{13}C NMR: δ = 23.0, 23.3, 25.0, 29.7, 33.4 (*C*H$_2$)$_5$, 34.6 (*C*-4), 50.6 (*C*-3), 52.3 (*C*-5), 56.9 (*C*H$_2$Ph), 60.2 (*C*-2), 126.6, 127.1, 127.8, 127.9, 128.1, 129.0, 130.4, 132.3.

Spiro Compound 2k: Flash chromatography (cyclohexane/CH_2Cl_2, 60:40). Oil. 2.650 g, 69% yield. ^{1}H NMR: δ = 1.17−1.66 (m, 10 H, (CH$_2$)$_5$], 1.92 (dd, *J* = 2.5, 10.4 Hz, 1 H, 3-H), 2.06 (dd, *J* = 7.7, 10.4 Hz, 1 H, 3-H), 2.68−2.78 (m, 2 H, C*H*$_2$SePh), 3.37 (m, 1 H, 4-H), 3.46 (d, 1 H, J_{AB} = 13.1 Hz, Bn), 3.80 (d, 1 H, J_{AB} = 13.1 Hz, Bn), 7.10−7.35 (m, 10 H). ^{13}C NMR: δ = 22.9, 23.1, 25.7, 30.3, 34.5 (*C*H$_2$)$_5$, 35.8 (*C*-3), 40.4 (*C*H$_2$SePh), 53.2 (*C*H$_2$Ph), 60.0 (*C*-4), 62.8 (*C*-2), 126.0, 126.5, 128.1, 128.4, 129.0, 132.1, 133.1. $C_{22}H_{27}NSe$: calcd. C 68.73, H 7.08, N 3.64; found C 68.95, H 7.41, N 3.78.

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