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Synthesis and Reactivity of *N*-Selenoacylamidines Precursors of Selenoheterocycles

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Abstract : A new synthesis and the reactivity of stable selenaazadienes are discussed. Their dienic, electrophilic and nucleophilic character are used to prepare five and six membered selenoheterocycles. The easy access to selenazine, selenazinone, selenopyran, selenazoline, selenazole and selenophene heterocycles from *N*-selenoacylamidines is described. An interpretation of the reactivity of the selenaazadiene systems, experimentaly compared to their thia analogues, is based on their physico-chemical parameters and correlated to the theoretical calculations of their frontier molecular orbital energy levels. © 1998 Elsevier Science Ltd. All rights reserved.

The interest in hetero azabutadienes, particularly *N*-acyl and *N*-thioacylamines, as participants in hetero Diels-Alder reactions is well established.[1-3] In this context, stabilized *N*-phenylacylimines **1** and *N*-thioacylamidines **2** have been widely studied to produce amino heterocycles including an oxygen or a sulphur atom in the ring.[4] Some examples have demonstrated that *N*-acylimines **1** participate as electron-deficient partners in cycloaddition reactions with electron rich dienophiles,[2a] whereas *N*-thioacylamidines **2** have been shown to undergo normal Diels-Alder reactions under HOMO diene/LUMO dienophile control with typical electron-deficient dienophiles.[5] According to the literature, only a few cycloaddition reactions from selenodienic systems have been reported.[6] In recent years, the synthesis of six membered ring heterocycles containing a selenium atom has been performed mainly using a carbon-selenium double bond as the 2π dienophile partner

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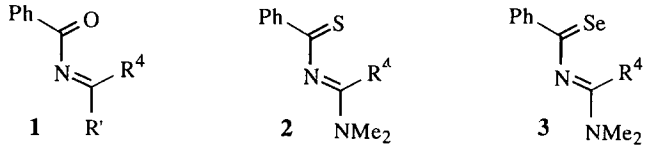
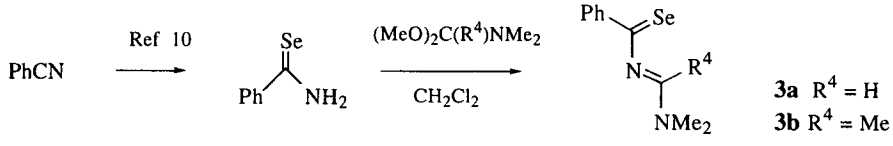
for [4+2] cycloadditions.[7] With these considerations in mind, we have focused our attention on the synthesis of *N*-selenoacylamidines **3** and studied their reactivity in cycloaddition reactions. In a preliminary note we have proposed an original access to selenoheterocycles from isolated *N*-selenoacylamidines.[8] The present paper reports an extension of this work and a discussion on its potential for the synthesis of five and six membered selenoheterocycles.



Our investigation includes an evaluation of the influence of the group VIa selenium atom on diene behaviour and the easy access to various selenoheterocycles of interest both for their biological activity[9] and for their potential as organic conductor precursors.[10] The reactivity of the *N*-selenoacylamidines **3** was compared to their corresponding thiaazabutadiene analogues **2** and interpreted on the basis of their spectroscopic properties and frontier molecular orbital calculations.

RESULTS AND DISCUSSION

N-selenoacylamidines **3a**[11] and **3b** were synthesized in two steps from benzonitrile (**Scheme 1**). Sodium hydrogen selenide heated in the presence of benzonitrile at 80°C in pyridine solution gave selenobenzamide in 90 % yield.[12] An alternative approach involved the use of a modified Takikawa procedure:[13] bis-trimethylsilyl selenide reacted in a sealed tube at 80° C in the absence of solvent with benzonitrile leading to selenobenzamide in 80% yield.

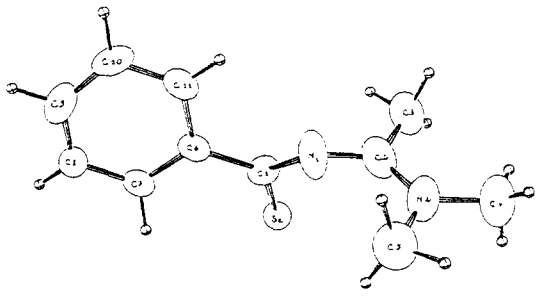


Scheme 1

The condensation of *N,N*-dimethylformamide dimethyl acetal and *N,N*-dimethylacetamide dimethylacetal with selenobenzamide, as previously achieved with thiobenzamide,[14] led to the *N*-selenoacylamidines **3a** and **3b** in 30% and 90% yields respectively after purification by flash chromatography. Compound **3a** appeared less stable on silica gel than its homologue **3b** which was isolated in crystallized form. Nevertheless, the ^{1}H NMR analysis of the crude reaction product indicated the presence of **3a** in 85% yield in the mixture. Consequently, **3a** should be generated and used *in situ* in the next experiments in order to improve the overall yield of the reactions.

The stereochemistry of *N*-selenoacylamidines was fully established by X-ray crystallography of **3b** (**Fig 1**).[15] The *s*-cis conformation of the dienic system and the *E* configuration of the imine function (*N*-dialkylamino and *N*-selenoacyl group in anti position) were confirmed in the solid state. An electronic delocalization from the *N*-dimethylamino group to the selenocarbonyl function along the dienic skeleton was also suggested by the values of the bond lengths. Thus, the observed C(Se)-N value of 129 pm was comparable

with a theoretical double bond distance [C=N 128 pm], whereas a significant percentage of single bond character [C-Se 198 pm][16] seems to participate in the selenocarbonyl bond measured at 186 pm. Similar observations were made previously regarding the corresponding *N*-thioacylamidine analogues **2**.[5a,17]



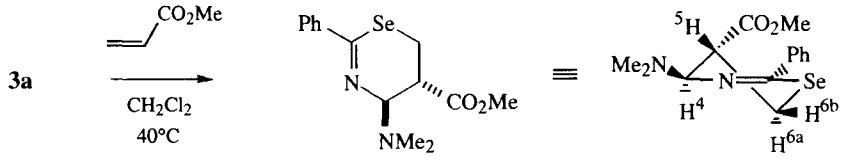
Atom 1	Atom 2	Atom 3	Angles in degrees
C1	N1	C2	125.(1)
SE	C1	N1	123.6 (9)
SE	C1	C6	118.4 (8)
N1	C1	C6	118.(1)
N1	C2	N2	118.(1)
N1	C2	C3	122.(2)
N2	C2	C3	120.(1)

Atom 1	Atom 2	Distance in picometre
SE	C1	186 (1)
N1	C1	129 (1)
N1	C2	132 (2)
N2	C2	134 (2)
C1	C6	147 (2)
C2	C3	148 (2)

Figure 1. O. R. T. E. P. Drawing of **3b**

N-Selenoacylamidines as 1-selena-3-aza-1,3-diene systems

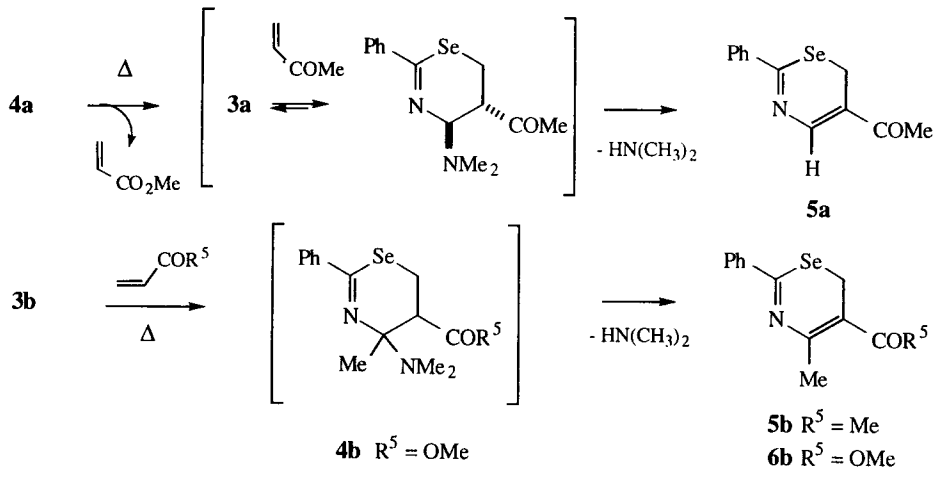
One of the main interests of our study concerned the reactivity of *N*-selenoacylamidines **3** as 4π heterodienic systems in [4+2] cycloaddition reactions with electrophilic dienophiles. Thus, **3a**, generated *in situ* from selenobenzamide, was quenched with an excess of methyl acrylate at 40°C affording the 5,6-dihydro-4*H*-1,3-selenazine **4a** in 91% overall yield (**Scheme 2**).



4a

Scheme 2

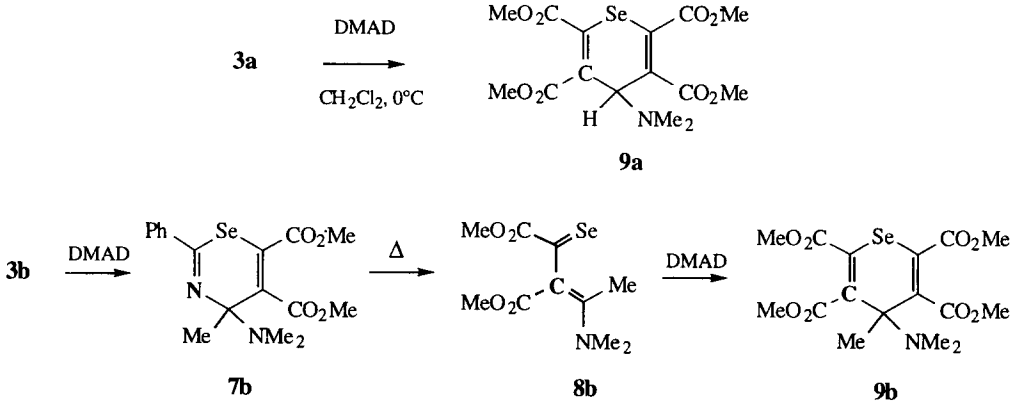
The cycloadduct **4a**, resulting from the exocyclic approach of the dienophile, adopts an half-chair conformation in solution according to the ^{1}H NMR data (400MHz, $CDCl_3$: $J_H{}^4\text{-}H^5$ = 9.9 Hz, $J_H{}^5\text{-}H^{6a}$ = 12.3 Hz, $J_H{}^5\text{-}H^{6b}$ = 4.3 Hz). The main fragment peak observed by mass spectrometry of **4a** (m/z 240 M+1) revealed the occurrence of a retro Diels-Alder process under electron impact. The corresponding thermal cycloreversion was clearly established by the treatment of the selenazine **4a** at 60°C in the presence of methyl vinyl ketone (MVK) used as solvent (**Scheme 3**). Under the latter conditions the heterodiene **3a**, released from **4a**, was trapped by Diels-Alder reaction with the excess MVK. Consequently, the 6*H*-1,3-selenazine **5a**, resulting from a subsequent *in-situ* elimination of the dimethylamino group from the cycloadduct intermediate, was isolated in 70% overall yield. This procedure, using the dienophile as solvent, accelerated the cycloaddition sequence and avoided the nucleophilic addition of the dimethylamine released in the reaction as previously observed in the case of 6*H*-1,3-thiazine analogues.[18]



Scheme 3

Following a similar cycloaddition-elimination process as that discussed above, the 6*H*-1,3-selenazines **5b** and **6b** were obtained by treatment of **3b** with methyl vinyl ketone in tetrahydrofuran at room temperature (80% yield) and at reflux of methyl acrylate (50% yield), respectively (**Scheme 3**).

We have extended the scope of our investigations by examining the cycloaddition reactions in the presence of acetylenic dienophiles. The addition of dimethyl acetylenedicarboxylate (DMAD) to **3a** at 0°C afforded the 4*H*-selenopyran **9a** in 48% yield (**Scheme 4**).



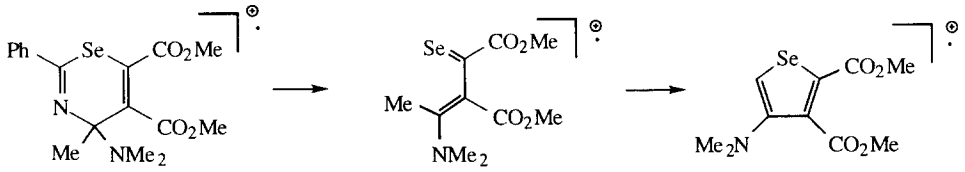
Scheme 4

The process pathway leading to the formation of **9a** from **3a** was clearly established by the analysis of the reaction intermediates derived from the *N*-selenoacylamidine **3b**. At room temperature, the 4*H*-1,3-selenazine **7b** (70% yield) was the first cycloadduct produced by treatment of **3b** with DMAD. The thermolysis of **7b** occurred at reflux of methylene chloride under a nitrogen atmosphere to yield the selenoamide vinylogue **8b** in 90% yield. Finally, access to the substituted 4*H*-selenopyran **9b** was achieved from **8b** in 60% yield by a [4+2] cycloaddition with an excess of DMAD in the same solvent under an inert atmosphere. The synthesis of

9b was also performed in a one pot procedure from **3b** in refluxing methylene chloride solution with DMAD added in excess. The structures of compounds **7** to **9** were supported by ^{1}H and ^{13}C NMR analysis.

Substituted 4*H*-1,3-selenazines, selenoamide vinylogues and 4*H*-selenopyrans can be obtained from *N*-selenoacylamidines according to the experimental conditions. An attraction of this methodology is the opportunity to convert efficiently the *N*-selenoacylamidines, used as 1-selena-3-aza-1,3-dienes, into selenoamide vinylogues, assimilated as 1-selena-1,3-butadienes, by a cycloaddition-cycloreversion process. In this reaction sequence, the nitrogen atom in the heterodiene skeleton was formally replaced by a functionalized carbon atom.[5b,c] This conversion can be transposed to the heterocycle series following a cycloreversion-cycloaddition sequence which effects the transformation of 4*H*-1,3-selenazines into tetra-substituted 4*H*-selenopyran derivatives.

The cycloreversion process from the 4*H*-1,3-selenazine **7b** was previously emphazised by the mass spectrometry data (**Scheme 5**). The analysis of the CID-MIKE fragmentation of **7b** has shown the presence of the selenazinium ion (m/z = 352) resulting from the loss of the dimethylamino group from the molecular ion, but the main fragment peak [m/z = 291 (100)] revealed the appearence of a selenophene ion. The formation of this five membered heterocycle under 4*H*-1,3-selenazine **7b** electron impact could result from a selenoamide vinylogue intermediate (m/z = 293, not observed) released from the cycloreversion of **7b**.

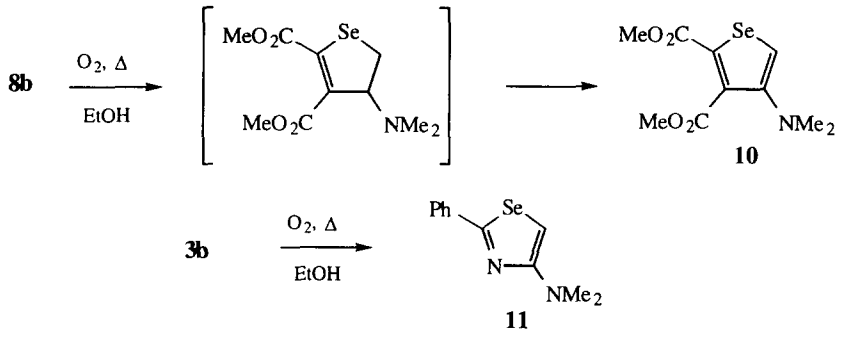


m/z = 395 **m/z = 293** **m/z = 291**

Scheme 5

This hypothesis was confirmed by the behaviour of the selenoamide vinylogue **8b** under thermal conditions. Thus, in a refluxing solution of ethanol saturated with oxygen, the selenophene **10** resulting from the oxidative cyclisation of **8b** was readily formed in 75% yield (**Scheme 6**). The cyclisation process should occur *via* an aromatic transition state following the Dewar-Zimmerman rules[19] leading to a dihydroselenophene intermediate. The access to the selenophene heterocycles from selenoamide vinylogue precursors was also proposed by Liebscher J. using electrophilic reagents.[20] Nevertheless, the intramolecular ring closure process appeared to be an original alternative to produce functionalized selenophene derivatives. The formation of **10** seemed predominant at the expense of the selenopyran **9b** as it was produced in a 4/1 ratio when the vinylogue **8b** was treated in the presence of one equivalent of DMAD in oxygenated methylene chloride solution. The production of the selenophene **10** could be performed in a one pot procedure at reflux of ethanol from the *N*-selenoacylamidine **3b** or from the 4*H*-1,3-selenazine **9b** in the presence of two or one equivalent of the corresponding dienophile, respectively.

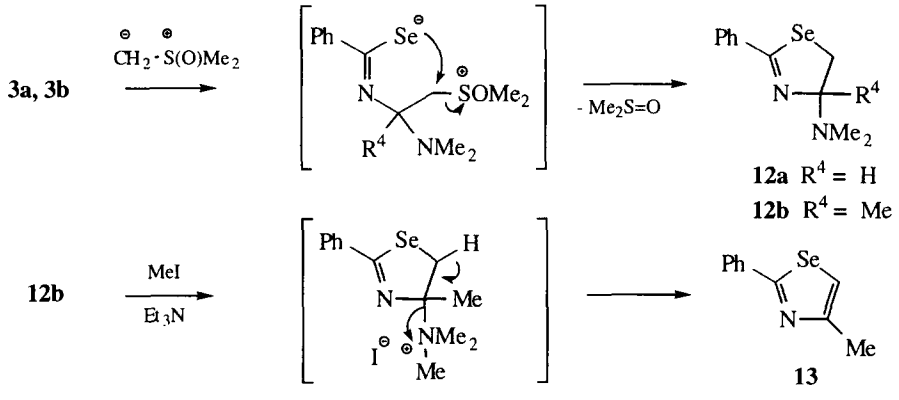
Similar oxidation conditions applied to the *N*-selenoacylamidine **3b** led to the 4-dialkylamino-selenazole **11** although isolated in a low yield of 35%.[21]



Scheme 6

N-Selenoacylamidines : nucleophilic and electrophilic properties

In order to extend our investigation of the synthesis of five membered selenoheterocycles, the *N*-selenoacylamidines have been considered as nucleophilic and electrophilic reagents. We first examined the nucleophilic addition of a sulphur ylide on **3a** and **3b** (**Scheme 7**). The sulfoxonium ylide, generated *in situ* by treatment of the trimethylsulfoxonium iodide with sodium hydride in dimethylsulfoxide,[22] reacted with the *N*-selenoacylamidines **3a** and **3b** to give the selenazol-2-ines **12a** and **12b** in 63% and 71% yield respectively. The reaction pathway involved the addition of the sulphur ylide on the imine bond of the heterodienes, which was confirmed as the main electrophilic centre of the systems.[23] The resulting intermediates underwent cyclisation by a subsequent intramolecular substitution of the dimethylsulfoxonium leaving group. The aromatization of **12b** into the selenazole **13** was achieved by the addition of methyl iodide at 0°C in methylene chloride or in the presence of phenylisocyanate in refluxing toluene (**Scheme 7**). Surprisingly, the elimination of dimethylamine from the selenazol-2-ine **12a** was not observed under the latter conditions.

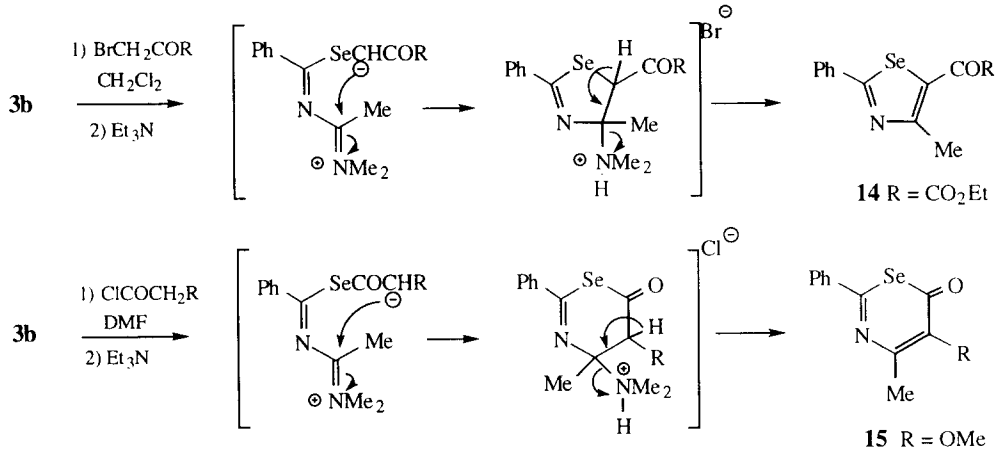


Scheme 7

Access to the selenazol-2-ine **12a** was also envisaged by the reaction of **3a** with diazomethane.[24] The reaction, carried out in dry tetrahydrofuran, was not fully optimised as the heterocycle was produced in a low yield of 30% after 3 days reaction time. Nevertheless, the 1,3-dipolarophile character of the

N-selenoacylamidine emphasized in this experiment has been exploited and will be discussed in another context.[25]

The versatile reactivity of the *N*-selenoacylamidine **3b** was illustrated in the presence of electrophiles (**Scheme 8**). Thus, the treatment of **3b** with ethyl bromopyruvate in the presence of triethylamine afforded the selenazole **14**. The substitution, giving rise to an acyclic iminium bromide salt, led to the selenazol-2-ine intermediate by nucleophilic addition of the α-keto ester enolate on the resulting iminium function of the salt. After *in-situ* β-elimination of dimethylamine, the aromatic heterocycle **14** was isolated from the reaction in 55% overall yield. Also, the 6*H*-selenazin-6-one **15** was obtained in 33 % yield by the reaction of **3b** with methoxyacetyl chloride in the presence of triethylamine following a similar mechanistic pathway.

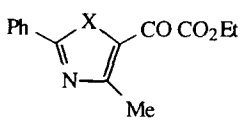


Scheme 8

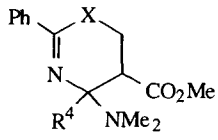
N-thio and N-selenoacylamidines : Comparison of reactivity

The comparison between the reactivity of *N*-selenoacylamidines **3a** and **3b** and that of their *N*-thioacylamidine analogues[3a,5b] **2a** (R^4 = H) and **2b** (R^4 = Me) seemed attractive from a theoretical point of view. The enhanced polarization of the selenabutadiene systems, suspected in a solid state (see bond lengh **Fig 1**), was confirmed in solution by the comparison of the experimental dipole moment measured in benzene or 1,4-dioxane.[26] In solution, an increase in the dipole value of the 1-hetero-3-aza-1,3-dienes (R^4 = Me) was observed: **1b** (μ_{exp}= 4.59 D), **2b** (μ_{exp}= 5.78 D) and **3b** (μ_{exp}= 6.60 D). These observations were correlated with the ability of the *N*-thio and *N*-selenoacylamidines **2b** and **3b** to react as nucleophiles. The high nucleophilic character of the selenodiene **3b** was experimentally confirmed by a competitive reaction in the presence of ethyl bromopyruvate. The addition of an equimolar amount of the electrophile, at room temperature, to a solution containing one equivalent of each heterodiene afforded a 3/1 ratio of the corresponding selenazole **14** and thiazole **16** (**Fig. 2**). 80% of unreacted initial thiadiene **2b** and 30% of selenadiene **3b** were recovered by flash chromatography on silica gel.

The comparative study was then continued with [4+2] cycloaddition reactions. The choice of the appropriate dienophile in the cycloaddition experiments was dictated by the yield of the reaction or the stability of the resulting cycloadducts. In the presence of methyl acrylate, the formation of dihydrothiazine **17b** from the *N*-thioacylamidine **2b** did not exceed 20% yield after twenty hours under usual thermal conditions (**Fig. 2**).

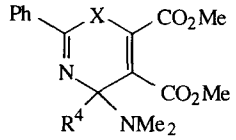


14 X = Se
16 X = S

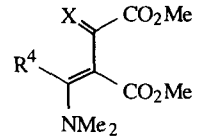


4a X = Se, R^4 = H
4b X = Se, R^4 = Me
17b X = S, R^4 = Me

Figure 2



7a X = Se, R^4 = H
7b X = Se, R^4 = Me
18a X = S, R^4 = H
18b X = S, R^4 = Me



8a X = Se, R^4 = H
8b X = Se, R^4 = Me
19a X = S, R^4 = H

Figure 3

We have previously observed that under a similar activation, in the presence of the same dienophile, the dihydroselenazine **4b** was produced from **3b** in a better yield, but an undesirable elimination of dimethylamine leading to the 6*H*-1,3-selenazine **6b** occured *in-situ* (**Scheme 3**). Acidic catalysis was envisaged as an alternative activating method to promote the hetero Diels-Alder reaction with methyl acrylate,[3c,27] since using magnesium bromide as a Lewis acid, at 0°C in methylene chloride, the dihydrothiazine **17b** was obtained in 80% yield from **2b** without any elimination of dimethylamine occuring. Unfortunately, no satisfactory result has been obtained with the *N*-selenoacylamidine **3b**. Nevertheless, it is interesting to note that the Diels-Alder reaction with methyl acrylate and the *N*-selenoacylamidine **3a** was efficiently catalysed by aluminium trichloride. The reaction, leading to the corresponding 4*H*-1,3-selenazine **4a** in 63% yield, occurred at -30°C in methylene chloride solution. The inhibition of the cycloaddition of **3b** could eventually be correlated to the presence of a donor methyl group which could increase the ability of the Lewis acid to chelate the selenadiene instead of inducing the expected activation of the dienophile.

However, the experimental evaluation was continued with dimethyl acetylenedicarboxylate (DMAD) as the dienophile. In the presence of DMAD, the *N*-thio and *N*-selenoacylamidines **2b** and **3b** reacted readely, affording the 4*H*-1,3-thiazine **18b**[5c] and 4*H*-1,3-selenazine **7b**, respectively, in good yields (**Fig. 3**). Furthermore, after 2 hours at room temperature in tetrahydrofuran, the 4*H*-1,3-selenazine **7b** was the only cycloadduct produced after the addition of 1 equivalent of the dienophile in a 1/1 equimolar solution of both heterodienes. These results, supporting the idea that the selenium atom enhances the reactivity of the heteroazadiene in [4+2] cycloaddition reactions, prompted us to evaluate the cycloreversion process providing the formation of the heteroamide vinylogues from the 4*H*-thiazine or 4*H*-selenazine heterocycles. We have previously studied the effect of the substituents upon the cycloreversion process of 4-dialkylamino-4*H*-1,3-thiazines.[5b,c] In particular, the presence of a donor group such as a methyl at C-4 of the 4*H*-1,3-thiazines appeared unfavourable to the cycloreversion, contrary to the effect of an hydrogen or an electron withdrawing substituent.[28] In fact, the 4-methyl-2-phenyl-4*H*-1,3-thiazine **18b** remains unchanged at reflux of methylene chloride for several days, whereas the thioamide vinylogue **19a** was released in 70% yield from the 2-phenyl-4*H*-1,3-thiazine **18a** under the same conditions (**Fig. 3**). Comparatively the selenium derivatives were more reactive: the selenoamide vinylogue **8b** was isolated in 85% yield from the 4-methyl-2-phenyl-4*H*-1,3-selenazine **7b** after 12 hours at reflux of methylene chloride, whereas the cycloreversion of the 2-phenyl-4*H*-1,3-selenazine **7a**, proceeded at 0°C in the same solvent. In this case, due to its high reactivity, the selenoamide vinylogue **8a** had to be trapped as soon as it was released from **7a** (for example with an acetylenic dienophile, as performed for the synthesis of the selenopyran **9a: Scheme 4**).

As a result of these experiments, it seems obvious that the nature of the heterocarbonyl function strongly influenced the diene reactivity of the *N*-heteroacylamidines as well as the stability of the cycloadducts. The cycloaddition experiments carried out with *N*-thio and *N*-selenoacylamidines have the characteristics for pericyclic reactions.[29] Thus, no formation of a reactive intermediate has been detected during the [4+2] cycloaddition reactions discussed above, which are sensitive to acid catalysis and thermal and high pressure activations. However, the experiments remained limited due to the retro Diels-Alder or the cycloreversion events which can occur from the resulting cycloadducts.

The reactivity of the *N*-thio and *N*-selenoacylamidines **2b** and **3b** was then interpreted on the basis of the frontier molecular orbital (FMO) theory.[30] It has been admitted that frontier orbital interactions involving the highest occupied molecular orbital (HOMO) of the diene and the lowest unoccupied molecular orbital (LUMO) of the dienophile have a direct effect upon the kinetic product distribution of the [4+2] cycloaddition. The frontier orbital energies of the *N*-heteroacylamidines **1b**, **2b**, **3b** and those of the heteroamide vinylogues **19b**[5c] and **8b** were calculated using the PM3 semi empirical method (**Fig.4**).[31] The change of the heteroatom at the heterocarbonyl position of the azadiene systems, following the group VIa column, leads to the narrowing of their HOMO-LUMO energy gaps.

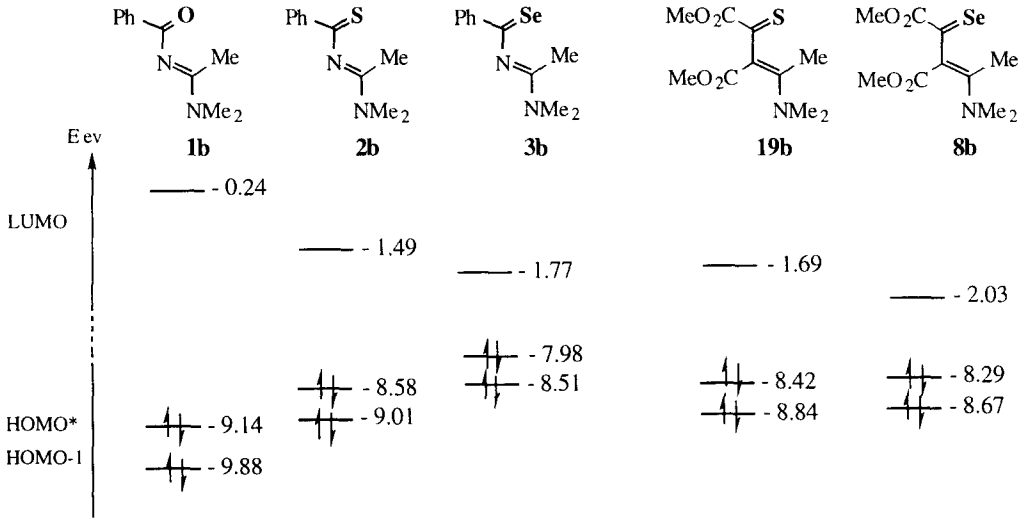


Figure 4 : Frontier Molecular Orbital energy levels by PM3 calculation ; * Lone pair

These observations could explain the trend of the selenoamide vinylogues to generate aromatic selenophenes under mild thermal conditions when a methyl group is present at the C-4 centre (**Scheme 6**),[32a] whereas, their thioamide analogues required an higher temperature to lead to the corresponding thiophene heterocycles.[32b]

The PM3 calculation data for minimum eigenvectors on the Pz direction involved in the Diels-Alder reactions have shown that these coefficients are not significant in the HOMO of the *N*-heteroacylamidines **2b** and **3b** (**Fig. 5**). Consequently, the eigenvectors on the Pz direction of their respective HOMO-1 must be taken into account in the interpretation of the reactivity of these heterodienes under HOMO-1 diene / LUMO dienophile interactions. Consequently, the greater reactivity of 1-selena-1,3-dienes towards cycloaddition reactions seems to be justified in both the *N*-heteroacylamidine and the heteroamide vinylogue series. We

believe that, in the case of the selenoamide vinylogue **8b**, the methoxycarbonyl substitution of the butadiene does not participate in the conjugation of the dienic system (if we referred to the X-ray structure of the thio analogues **19b**).[5c]

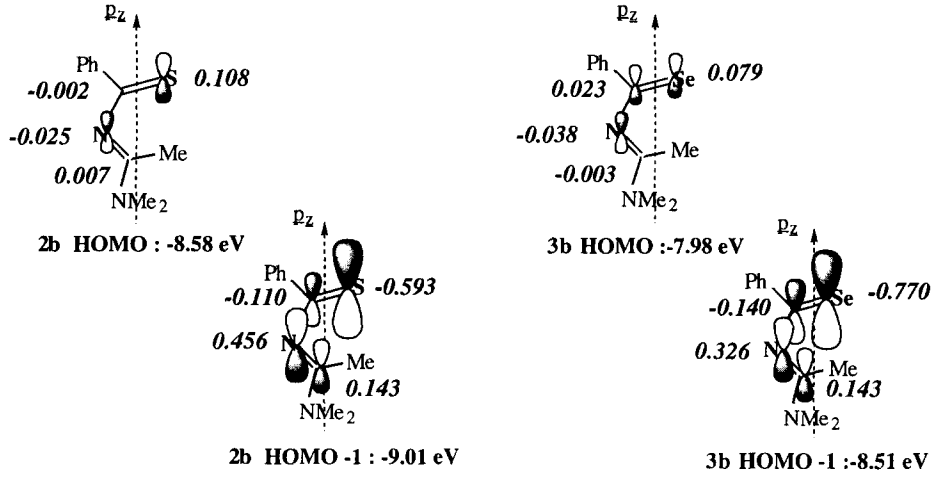


Figure 5 : PM3 calculation data for minimum eigenvectors on the Pz direction for HOMO (Lone pair) and HOMO-1 of the *N*-heteroacylamidines **2b** and **3b**.

The total regioselectivity of the cycloaddition reactions observed in all experiments can be correlated to the HOMO-1 and LUMO eigenvectors.[33] [4+2] cycloaddition reactions achieved from *N*-thio and *N*-selenoacylamidines as well as from thio and selenoamide vinylogues should be considered as a limit model of asynchronous hetero Diels-Alder reactions.[34]

CONCLUSION

As a results of this study, the *N*-selenoacylamidines can be regarded as potential heterodienic, electrophilic or nucleophilic reagents. Their reactivity has been explored to produce a number of five and six membered ring selenoheterocycles which are of interest as precursors of biological derivatives incorporating a selenoheteroatom. Thus, further thio and selenoheterocycles are under biological evaluation as chemotherapeutic or antiviral agents. Furthermore, the easy access from *N*-selenoacylamidine, *via* the selenoamide vinylogues, to the selenophene heterocycles of which the substitution depends upon the nature of the starting acetylenic reagent, allowed us to propose these compounds as new precursors in the elaboration of original π-conjugated organic materials.[32a]

The reactivity of the selenoheterodienes, highlighted experimentally by comparing it to that of their *N*-thioacylamidine analogues, was interpreted on the basis of the frontier molecular orbital (FMO) theory. We observed that the narrowing of their corresponding HOMO, HOMO-1 and LUMO energy levels is related to the the group VIa substituent on the 1,3-butadiene systems.

The *N*-selenoacylamidines as well as the selenoamide vinylogues appear to be a new class of building blocks in the field of heterochemistry. The opportunity to extend their reactivity as usefulness precursors of original oxo and aza dienic systems is currently being studied in our laboratory.

Aknowledges : The authors would like to thank Dr. NGuyên Trong Anh for fruitful discussions.

X-RAY CRYSTALLOGRAPHY[35]

$C_{11}H_{14}N_2Se$: Mr = 235.2, trigonal, P31, a = 7.832 (2), c = 16.378 (9) A, V = 870 (1) A^{-3}, Z = 3, D_x = 1.450 $Mg.m^{-3}$, λ (MoKα) = 0.70926A, μ = 31.67 cm^{-1}, F(000) 384, T = 293 K, final R = 0.047 for 887 observations. The sample (0.35*0.45*0.45 mm) is studied on an automatic diffractometer CAD4 ENRAF-NONIUS with graphite monochromatized MoKα radiation. The cell parameters are obtained by fitting a set of 25 high-theta reflection. The data collection ($2\theta_{max}$ = 50°, scan $\omega/2\theta$ = 1, t_{max} = 60 s, range HKL : H 0,10 K 0,10 L -20,20, intensity controls without appreciable decay (0.2%) gives 2101 reflections from which 887 were independent (R_{int} = 0.029) with $I>3\sigma(I)$.

After Lorenz and polarization corrections the structure was solved with a Patterson map which reveals the selenium atom. The remaining non hydrogen atoms of the structure are found after several scale factor and Fourier difference calculations. After isotopic (R = 0.080) an absorption correction was made with the program DIfabs (Walker and Stuart, 1993). After anisotropic refinement (R = 0.060) many hydrogen atoms may be found with a Fourier Difference (between 0.79 and 0.25 eA^{-3}) the remaining ones being set in theoritical position. The whole structure was refined by the full-matrix least-square techniques (use of F magnitude ; x, y, z, β_{ij} for Se, C and N atoms and x, y, z for H atoms ; 127 variables and 887 observations ; $w = 1/\sigma(F_o)^2 = [\sigma^2(I) + (0.04F_o^2)^2]^{-1/2}$ with the resulting R = 0.053, R_w = 0.047 and S_w = 1.46 (residual $\Delta\rho < 0.78$ eA^{-3}).

Atomic scattering factors from International Tables for X-Ray Crystallography (1974). All the calculations were performed on a Digital Micro VAX 3100 computer with the MolEN package (Enraf-Nonius, 1990).

EXPERIMENTAL SECTION

^1H NMR and ^{13}C NMR spectra were recorded on a Bruker spectrometer AC 200 ; chemical shifts are expressed in parts per million (ppm) referenced to residual chloroform (7.27 ppm). Coupling constants (*J*) are given in hertz (Hz). Multiplicities are recorded as s (singlet), d (doublet), t (triplet), q (quartet), and m (multiplet). Mass spectra m/z (% base peak) were recorded on a HP 5889A spectrometer EI (70 eV). Infra-Red spectra were carried out on a Bruker IFS 45WHR Fourier transform i. r. spectrophotometer. Melting points were determined on a C. REICHERT microscope apparatus and are uncorrected. Elemental analyses were carried out on a Perkin-Elmer 2400 C, H, N elemental analyser. Tetrahydrofuran (THF) was prepared by pre-drying with KOH followed by distillation from Na/benzophenone. Diethyl ether was distilled from Na/benzophenone. Methylene chloride and ethyl acetate were dried by distillation over P_2O_5 and toluene was distilled from sodium. All solvents were freshly distilled by standard methods prior to use.[36] Flash chromatography was performed on silica-gel Merck 60 230-400 mesh. Thin layer chromatography was performed on precoated plates of silica gel $60F_{254}$ (Merck, Art 7735).

Selenobenzamide. To a mixture of selenium pellets (15.8 g, 200 mmol) in dry ethanol (200 mL) was added, at 0°C under N_2, sodium borohydride (8.36 g, 220 mmol) and the reaction was stirred at r.t. for 0.5 h. A solution of benzonitrile (5.15 mL, 50 mmol) in distilled pyridine (32.4 mL) was then added. The resulting mixture was refluxed and acidified by dropwise addition of 2N HCl (100 mL) over 1h. The solution was then cooled to r.t. and extracted with methylene chloride. The organic phase was dried over magnesium sulfate, filtered and the solvent was removed under reduced pressure. Flash column chromatography on silica gel using

80/20 petroleum ether/ethyl acetate afforded the title compound in 98% yield: yellow powder; mp 123-125 °C; R_f 0.2 (petroleum ether/ethyl acetate, 70/30); IR (KBr) 3329, 3268 and 3146 (NH); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 7.34 to 7.91 (m, 6H, C_6H_5, N*H*), 8.53 (br s, 1H, N*H*); ^{13}C-NMR ($CDCl_3$, 75MHz) δ 126.8, 128.6, 132.1 and 142.1 (C_6H_5), 208.0 (*C*=Se); *m/z* 185 (M+1, 17), 183 (100), 103 (76), 77 (22), 76 (32), 42 (59).

4-Dimethylamino-2-phenyl-1-selena-3-aza-1,3-butadiene 3a. To a solution of selenobenzamide (0.38 g, 2.06 mmol) in anhydrous methylene chloride (5 mL), under N_2, was added *N,N*-dimethylformamide dimethyl acetal (0.54 mL, 4.1 mmol). The mixture was stirred at 0°C for 0.75 h. Then, the solvent was removed to dryness. The crude residue was purified by flash column chromatography on silica gel using 70/30 petroleum ether/ethyl acetate to give the selenabutadiene **3a** isolated in 30% yield. This product is unstable on silica gel and sensitive to freezing and inert storage conditions. Thus, it is judicious to use it without any purification (^{1}H NMR of the crude product of the reaction before purification showed it to be present in 85% yield in the mixture): green oil; R_f 0.30 (petroleum ether/ethyl acetate, 70/30); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 3.19 and 3.22 [2s, 6H, N(CH_3)$_2$], 7.36 to 7.50 (m, 5H, C_6H_5), 8.25 to 8.30 (m, 2H, C_6H_5), 8.64 (s, 1H, =C*H*).

4-Dimethylamino-4-methyl-2-phenyl-1-selena-3-aza-1,3-butadiene 3b. A mixture of selenobenzamide (1 g, 5.4 mmol) and *N,N*-dimethylacetamide dimethyl acetal (1 mL, 8.15 mmol) dissolved in dry methylene chloride (20 mL) was stirred at 0°C under N_2 for 1 h. The solution was concentrated to dryness and the residue was chromatographed under nitrogen pressure on silica gel using 70/30 petroleum ether/ethyl acetate. The selenabutadiene **3b** was isolated and crystallized in petroleum ether in 92% yield: orange powder; mp 123-125°C; R_f 0.16 (petroleum ether/ethyl acetate, 30/70); ^{1}H-NMR ($CDCl_3$, 400MHz) δ 2.50 (s, 3H, CH_3), 3.22 and 3.29 [2s, 6H, N(CH_3)$_2$], 7.27 to 7.44 (m, 3H, C_6H_5); 8.23 to 8.26 (m, 2H, C_6H_5); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 19.5 (CH_3), 39.9 and 40.2 [N(CH_3)$_2$], 127.7, 128.8, 130.9 and 144.6 (C_6H_5), 171.4 (*C*=N), 196.9 (*C*=Se); *m/z* 254 (M+1 <1), 189 (34), 175 (100), 104 (37), 77 (21), 72 (25), 44 (24); Anal.Calcd for $C_{11}H_{14}N_2Se$: C, 52.18; H, 5.57; N, 11.06; Se, 31.19. Found C, 52.36; H, 5.40; N, 10.95; Se, 31.28

4-Dimethylamino-5,6-dihydro-5-methoxycarbonyl-2-phenyl-4*H*-1,3-selenazine 4a.

Method A : To a solution of *N*-selenoacylamidine **3a** (0.5 g, 2.1 mmol) dissolved in dry methylene chloride (15 mL) under N_2 atmosphere was added at 40°C methyl acrylate (1.88 mL, 20.9 mmol). The mixture was stirred for 6 h. Concentration of the solvent under reduced pressure and subsequent purification of the residue by flash chromatography on silica gel using 70/30 petroleum ether/ethyl acetate afforded the dehydro-1,3-selenazine **4a** crystallized from petroleum ether/ethyl acetate in 91% yield.

Method B : To a solution of diethylaluminium chloride (0.63 mL, 1M in hexane; 3.7 mmol.) in dry methylene chloride (2.50 mL) was added, under N_2 atmosphere methyl acrylate (0.56 mL, 6.2 mmol). The solution was cooled at -30°C before the introduction of the *N*-selenoacylamidine **3a** (0.1 g, 0.42 mmol) dissolved in dry methylene chloride (1 mL). The mixture was stirred for 3 h. at -30°C before the hydrolysis of the Lewis acid by a solution of potassium hydrogenocarbonate 10%. The organic layer was successively washed by an aqueous solution of sodium chloride and of potassium hydrogenocarbonate and then dried under magnesium sulfate. After filtration the filtrate was concentrated under reduced pressure and the residue was chromatographed on

silica gel as before. The dihydro-1,3-selenazine **4a** was isolated in 63% yield : grey powder ; mp 62°C; R_f0.4 (petroleum ether/ethyl acetate, 70/30); IR (KBr) 1725 (C=O); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.41 [2s, 6H, N(CH_3)$_2$], 2.68 (m, 1H, $J_{H^{6ax}\text{-}H^5}$=12.3 Hz, $J_{H^4\text{-}H^5}$=9.9 Hz, $J_{H^{6eq}\text{-}H^5}$=4.3 Hz, $CHCO_2CH_3$), 3.07 (dd, 1H, $J_{H^{6ax}\text{-}H^{6eq}}$=11 Hz, $J_{H^5\text{-}H^{6eq}}$=4.3 Hz, $SeCH_{ax}H_{eq}$), 3.61 (dd, 1H, $J_{H^{6eq}\text{-}H^{6ax}}$=11.0 Hz, $J_{H^5\text{-}H^{6ax}}$=12.3 Hz, $SeCH_{ax}H_{eq}$), 3.77 (s, 3H, CO_2CH_3), 4.22 [d, 1H, $J_{H^4\text{-}H^5}$=9.9 Hz, $CHN(CH_3)_2$], 7.41 to 7.70 (2m, 5H, C_6H_5); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 21.0 ($SeCH_2$), 40.2 [N(CH_3)$_2$], 41.0 ($CHCO_2CH_3$), 52.1 (CO_2CH_3), 81.8 [$CHN(CH_3)_2$], 126.6, 128.4, 130.7 and 139.7 (C_6H_5), 156.8 (SeC=N), 173.8 (CO_2CH_3); *m/z* 326 (M+1, <1), 240 (63), 223 (47), 142 (64), 137 (88), 84 (38), 42 (100), 15 (26); Anal.Calcd for $C_{14}H_{18}N_2O_2Se$: C, 51.53; H, 5.56; N, 8.59; O, 9.81; Se, 24.51. Found C, 51.65; H, 5.45; N, 8.47; Se, 23.92.

5-Acetyl-2-phenyl-6*H*-1,3-selenazine 5a. A mixture containing *N*-selenoacylamidine **3a** (0.3 g, 1.25 mmol) and methyl vinyl ketone (10 mL, 12.55 mmol) was refluxed for 12 h under N_2. The resulting solution was filtered and the organic phase was concentrated. The residue was chromatographed on silica gel using 80/20 petroleum ether/ethyl acetate leading to the selenazine **5a** crystallized in petroleum ether in 65% yield: brown powder ; mp 58-60°C; R_f0.35 (petroleum ether/ethyl acetate, 80/20); IR (KBr) 1651 (C=O); ^{1}H-NMR (CD_3COCD_3, 300MHz) δ 2.45 (s, 3H, $COCH_3$) 3.66 (s, 2H, $SeCH_2$), 7.53 to 7.63 (m, 3H, C_6H_5); 8.04 to 8.07 (m, 2H, C_6H_5), 8.13 (s, 1H, NC*H*); ^{13}C-NMR (CD_3COCD_3, 75MHz) δ 15.0 ($SeCH_2$), 26.0 ($COCH_3$), 117.3 (=$CCOCH_3$), 129.7, 130.0, 133.5 and 139.8 (C_6H_5), 149.9 (N-*C*H=, $J_{^{13}C\text{-}H}$ = 179 Hz), 169.2 (SeC=N), 196.1 (*C*=O); *m/z* 265 (M+1, 29), 223 (32), 184 (38), 143 (19), 104 (20), 43 (100); Anal.Calcd for $C_{12}H_{11}NOSe$: C, 54.56; H, 4.20; N, 5.30. Found: C, 54.09; H, 4.08; N, 5.09.

5-Acetyl-4-methyl-2-phenyl-6*H*-1,3-selenazine 5b. A solution of *N*-selenoacylamidine **3b** (0.3 g, 1.18 mmol) and methyl vinyl ketone (1 mL, 11.85 mmol) was refluxed for 2 days under N_2 atmosphere. After filtration, the organic solvent was evaporated and the residue was purified by flash chromatography on silica gel using 70/30 petroleum ether/ethyl acetate to give the selenazine **5b** in 80% yield : brown powder; mp 66-68 °C; R_f0.7 (petroleum ether/ethyl acetate, 70/30); IR (KBr) 1663 (C=O); ^{1}H-NMR (CD_3COCD_3, 300MHz) δ 2.41 (s, 3H, CH_3), 2.47 (s, 3H, $COCH_3$) 3.69 (s, 2H, $SeCH_2$), 7.53 to 7.59 (m, 3H, C_6H_5); 8.04 to 8.07 (m, 2H, C_6H_5); ^{13}C-NMR (CD_3COCD_3, 75MHz) δ 19.8 ($SeCH_2$), 22.4 (CH_3), 31.0 ($COCH_3$), 114.6 (=$CCOCH_3$), 129.6, 130.2, 133.1 and 139.6 (C_6H_5), 154.7 (N*C*CH_3), 164.6 (SeC=N), 198.9 ($COCH_3$); *m/z* 279 (M+1, 7); 236 (35); 133 (28), 104 (21); 77 (13), 43 (100); Anal.Calcd for $C_{13}H_{13}NOSe$: C, 55.91; H, 4.69; N, 5.01. Found C, 55.79; H 4.53; N, 4.83.

5-Methoxycarbonyl-4-methyl-2-phenyl-6*H*-1,3-selenazine 6b. A solution of *N*-selenoacylamidine **3b** (0.3 g, 1.18 mmol) and methyl acrylate (1 mL, 11.85 mmol) was refluxed for 20 h. under N_2 atmosphere. The mixture was concentrated and the residue was chromatographed on silica gel using 60/40 petroleum ether/ethyl acetate affording the selenazine **6b** in 50% yield: brown powder; mp 70 °C; R_f 0.85 (petroleum ether/ethyl acetate 40/60); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.35 (s, 3H, CH_3), 3.53 (1q, 2H, $SeCH_2$), 3.66 (s, 3H, CO_2CH_3), 7.35 to 7.97 (2m, 5H, C_6H_5); *m/z* 295 (M+1, 29),264 (21), 263 (94), 261 (47), 236 (32), 215 (20), 214 (100), 160 (36), 133 (26), 104 (48), 83 (26), 77 (37). Anal.Calcd for $C_{13}H_{13}NO_2Se$: C, 53.07; H, 4.45; N, 4.76. Found: C, 53.09; H, 4.50; N, 4.69.

4-Dimethylamino-5,6-bis-methoxycarbonyl-4-methyl-2-phenyl-4*H*-1,3-selenazine 7b. A mixture of *N*-selenoacylamidine **3b** (0.77 g, 3.04 mmol) and dimethyl acetylenedicarboxylate (0.6 mL, 4.6 mmol) dissolved in dry methylene chloride (10 mL) was stirred at r.t. under N_2 for 1.5 h. The solvent was evaporated and the residue was chromatographed on silica gel using 60/40 petroleum ether/ethyl acetate to give the title compound **7b** cristallized in petroleum ether in 70% yield: orange powder; mp 78-81 °C; R_f0.5 (petroleum ether/ethyl acetate, 60 / 40); IR (KBr) 1735 and 1727 (C=O); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 1.57 (s, 3H, CH_3), 2.39 [s, 6H, $N(CH_3)_2$], 3.82 and 3.86 (2s, 6H, CO_2CH_3), 7.36 to 7.92 (2m, 5H, C_6H_5); mass spectrum appears as the result of the fragmentation of the selenophene **10** generated by a cycloreversion-oxydation process under electronic impact; Anal.Calcd for $C_{17}H_{20}N_2O_4Se$: C, 51.65; H, 5.10; N, 7.09 .Found C, 51.89; H, 5.05; N, 7.12.

4-Dimethylamino-2,3-bis-methoxycarbonyl-4-methyl-1-selena-1,3-butadiene 8b. A solution of 4*H*-1,3-selenazine **7b** (0.25 g, 0.63 mmol) in freshly distilled methylene chloride (10 mL) was refluxed under N_2 for 15 h. The organic solvent was evaporated and the residue was purified by flash chromatography on silica gel using 10% methanol in ethyl acetate as eluent affording the selenoamide vinylogue **8b** crystallized in 90% yield in petroleum ether : red powder; mp 122°C; R_f0.2 (methanol/ethyl acetate, 10/90); IR (KBr) 1692 and 1715 (C=O); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.71 (s, 3H, CH_3), 3.50 and 3.62 [2s, 6H, $N(CH_3)_2$], 3.67 and 3.87 (2s, 6H, 2 CO_2CH_3); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 24.0 (CH_3), 43.7 and 45.5 [$N(CH_3)_2$], 52.0 and 52.6 (CO_2CH_3), 120.7 [C=C(CH_3)$N(CH_3)_2$], 160.3 [C=C(CH_3)$N(CH_3)_2$], 172.0 and 176.7 (CO_2CH_3), 187.1 (C=Se); mass spectrum appears as the result of the fragmentation of the selenophene **10** generated by a oxydation process under electronic impact; Anal.Calcd for $C_{10}H_{15}NO_4Se$: C, 41.08; H, 5.17; N, 4.79; Se, 27.04. Found C, 41.26; H 5.69; N, 4.79; Se, 27.04.

4-Dimethylamino-2,3,5,6-tetra-*kis*-methoxycarbonyl-4*H*-selenopyran 9a. To a solution of *N*-selenoacylamidine **3a** (1.6 g, 6.69 mmol) dissolved in dry methylene chloride (10 mL) was added dimethyl acetylenedicarboxylate (2.47 mL, 20 mmol) and the mixture was stirred at 0°C for 1h under N_2. The solution was concentrated under reduced pressure and the residue was chromatographed on silica gel using 80/20 petroleum ether/ethyl acetate yielding 48% the selenopyran **9a**: yellow powder; mp 78°C; R_f0.3 (petroleum ether/ethyl acetate, 70/30); IR (KBr) 1713 and 1737 (C=O); ^{1}H-NMR (CD_3COCD_3, 300MHz) δ 2.26 [s, 6H, $N(CH_3)_2$], 3.79 and 3.83 (2s, 12H, CO_2CH_3), 4.99 [s, 1H, $CHN(CH_3)_2$]; ^{13}C-NMR (CD_3COCD_3, 75MHz) δ 41.3 [$N(CH_3)_2$], 53.2 and 53.8 (CO_2CH_3), 64.1 [$CHN(CH_3)_2$, $J_{^{13}C-H}$ = 142Hz], 131.2 and 132.3 (=C-CO_2Me), 165.3 and 167.6 (C=O); Anal.Calcd for $C_{15}H_{19}NO_8Se$: C, 42.87; H, 4.56; N, 3.33; O, 30.45; Se, 18.79. Found C, 42.58 ; H, 4.52 ; Se, 18.73.

4-Dimethylamino-2,3,5,6-tetra-*kis*-methoxycarbonyl-4-methyl-4*H*-selenopyran 9b.

from 8b: Argon gas was bubbled into a solution of selenoamide vinylogue **8b** (0.9 g, 3.1 mmol) dissolved in dry methylene chloride (20 mL) before addition under N_2 at 0° C of dimethyl acetylenedicarboxylate (0.56 mL, 4.6 mmol). The mixture was stirred for 2 h at 0° C and concentrated under reduced pressure. The residue was chromatographed on silica gel using 80/20 petroleum ether/ ethyl acetate affording the selenopyran **9b** in 60% yield.

from 3b: Argon gas was bubbled into a solution of *N*-selenoacylamidine **3b** (0.5 g, 2 mmol) dissolved in dry methylene chloride (10 mL). Under argon dimethyl acetylenedicarboxylate (2.43 mL, 19.7 mmol) was

added and the mixture was refluxed for 1.5 h. The organic solvent was then evaporated and the residue was chromatographed on silica gel using 80/20 petroleum ether/ethyl acetate affording **9b** in 40% overall yield from **3b** : yellow oil; R_f 0.32 (petroleum ether/ethyl acetate, 60/40); ^{1}H-NMR (CD_3COCD_3, 300MHz) δ 1.94 (s, 3H, CH_3), 2.22 [s, 6H, $N(CH_3)_2$], 3.78 to 3.81 (4s, 12H, CO_2CH_3); Anal.Calcd for $C_{16}H_{21}NO_8Se$: C, 44.25; H, 4.87; N, 3.23; Se, 18.18 .Found C, 43.87 ; H, 4.87 ; Se, 18.20.

4-Dimethylamino-2,3-bis-methoxycarbonyl-selenophene 10. A solution saturated with oxygen containing the selenoamide vinylogue **8b** (0.15 g, 0.51 mmol) dissolved in ethyl alcohol (20 mL) was refluxed for 12 h. Concentration under reduced pressure of the solution followed by purification of the residue by flash chromatography on silica gel using 80/20 petroleum ether/ethyl acetate afforded the selenophene **10** crystallized in petroleum ether in 75% yield : yellow powder; mp 95-97° C; R_f 0.62 (petroleum ether/ethyl acetate, 60/40); IR (KBr) 1740 and 1745 (C=O); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.71 [s, 6H, $N(CH_3)_2$], 3.83 and 3.95 (2s, 6H, CO_2CH_3), 7.20 (s, 1H, SeC*H*=); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 45.4 [$N(CH_3)_2$], 53.5 and 54.0 (CO_2CH_3), 116.6 (SeCH=, $J_{^{13}C\text{-}H}$ = 183 Hz), 134.9, 139.1, 154.5, 163.4 and 168.5 [SeC=C-CO_2CH_3, SeC=C-CO_2CH_3,C-$N(CH_3)_2$,CO_2CH_3]; *m/z* 291 (M+1, 100), 289 (49), 276 (26), 260 (37), 244 (41), 228 (21), 201 (20), 173 (38), 45 (35); Anal.Calcd for $C_{10}H_{13}NO_4Se$: C, 41.39; H, 4.51; N, 4.83. Found C, 42.34; H 4.92; N, 4.59.

4-Dimethylamino-2-phenyl-1,3-selenazol 11. A solution of *N*-selenoacylamidine **3b** (0.13 g, 0.51 mmol) in oxygenated ethanol (15 mL) was refluxed for 18 h. The organic solvent was removed and the residue was purified by flash chromatography on silica gel using 80/20 petroleum ether/ethyl acetate to give the title compound **11** in 35% yield: brown oil; R_f 0.8 (petroleum ether/ethyl acetate, 80/20); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.92 (s, 6H, $N(CH_3)_2$), 6.10 (s, 1H, SeC*H*=), 7.27 to 7.82 (2m, 5H, C_6H_5); *m/z* 252 (M+1, 80), 148 (100); 134 (31), 93 (21), 42 (90);

4-Dimethylamino-2-phenyl-1,3-selenazol-2-ine 12a. A mixture of iodotrimethylsulfoxonium (0.91 g, 4.16 mmol) dissolved in freshly distilled dimethylsulfoxide (15 mL) and sodium hydride (0.2 g, 8.33 mmol) was stirred at r.t. under N_2 for 0.30 h. *N*-selenoacylamidine **3a** resulting from the condensation of selenobenzamide and *N,N*-dimethylformamide dimethyl acetal (estimated by NMR in crude mixture at 0.96 g, 4 mmol), was added to the mixture and the solution stirred for 0.5 h. The solution was extracted with ethyl acetate and washed with water (100mL). The organic layer was dried under magnesium sulfate, filtrated and evaporated to dryness. The residue was chromatographed on silica gel using 70/30 petroleum ether/ethyl acetate to give the selenazol-2-ine **12a** in 63% yield: orange oil; R_f 0.54 (petroleum ether/ethyl acetate, 60/40); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.42 (s, 6H, $N(CH_3)_2$), 3.39 (dd, 1H, $J_{H^5\text{-}H^4}$=8.3 Hz,$J_{H^5\text{-}H^{5'}}$=10.7 Hz, $SeCH_2$), 3.57 (dd, $J_{H^{5'}\text{-}H^4}$=8.2 Hz,$J_{H^5\text{-}H^{5'}}$=10.7 Hz, 1H, $SeCH_2$), 5.38 (dd, $J_{H^4\text{-}H^5}$=8.3 Hz,$J_{H^4\text{-}H^{5'}}$=8.2 Hz, 1H, $CHN(CH_3)_2$), 7.36 to 7.76 (2m, 5H, C_6H_5); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 32.1 ($SeCH_2$), 41.9 ($N(CH_3)_2$), 102.9 [$CHN(CH_3)_2$, $J_{^{13}C\text{-}H}$ = 148 Hz], 129.4, 129.6, 132.1 and 136.3 (C_6H_5), 164.8 (SeC=N); *m/z* (CI^+NH_3) 255 (M+2, 100%); Anal.Calcd for $C_{11}H_{14}N_2Se$: C, 52.18; H, 5.57; N, 11.06 .Found C, 52.32; H, 5.69; N, 11.04 .

4-Dimethylamino-4-methyl-2-phenyl-1,3-selenazol-2-ine 12b A mixture of iodotrimethylsulfoxonium (1.46 g, 6.67 mmol) dissolved in freshly distilled dimethylsulfoxide (15 mL) and

sodium hydride (0.33 g, 13.4 mmol) was stirred at r.t. under N_2 for 0.5 h. *N*-selenoacylamidine **3b** (1.7 g, 6.7 mmol) was added to the mixture and the solution was stirred for 0.75 h. The residue was extracted with ethyl acetate and the organic layer was dried under magnesium sulfate, filtrated and evaporated to dryness. The residue was chromatographed on silica gel using 70/30 petroleum ether/ethyl acetate to give the selenazol-2-ine **12b** in 71% yield: brown oil; R_f 0.11 (petroleum ether/ethyl acetate, 60/40); IR (film) 1619 (C=N); ^{1}H-NMR ($CDCl_3$, 400MHz) δ 1.52 (s, 3H, CH_3), 2.41 [s, 6H, $N(CH_3)_2$], 3.24 and 3.67 (2d, $J_{H^5\text{-}H^{5'}}$ = 10.7 Hz, 2H, $SeCH_2$), 7.36 to 7.75 (2m, 5H, C_6H_5); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 24.3 (CH_3), 36.0 (CH_2), 39.5 ($N(CH_3)_2$), 102.9 [$CHN(CH_3)_2$], 128.3, 128.6, 130.9 and 135.4 (C_6H_5), 160.3 (Se*C*=N); *m/z* (CI^+NH_3) 269 (M+2, 21%), 224 (100%); Anal.Calcd for $C_{12}H_{16}N_2Se$: C, 53.93; H, 6.02; N, 10.45 .Found C, 54.10; H 6.14; N, 10.22

4-Methyl-2-phenyl-1,3-selenazol 13. A solution of selenazol-2-ine **12b** (0.12 g, 0.45 mmol.) dissolved in dry methylene chloride (20 mL) and methyl iodide (0.11mL, 1.76 mmol.) was stirred for 6 h at 0°C. After extraction of the mixture using ethyl acetate, the organic layer was dried under magnesium sulfate, filtrated and evaporated to dryness. The residue was chromatographed on silica gel using 70/30 petroleum ether/ethyl acetate leading to the selenazol **13** in 70% yield: brown oil; R_f0.84 (petroleum ether/ethyl acetate, 60/40); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.49 (s, 3H, CH_3), 7.37 to 7.89 (2m, 5H, C_6H_5); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 19.3 (CH_3), 119.2 (Se*C*H=, $J_{^{13}C\text{-}H}$ = 186 Hz), 127.8, 129.9, 130.9 and 137.4 (C_6H_5), 155.2 (CCH_3), 176.7 (Se*C*=N); *m/z* (CI^+NH_3) 224 (M+2, 100%); Anal.Calcd for $C_{10}H_9NSe$: C, 54.07; H, 4.08; N, 6.31 .Found C, 54.23; H, 3.94; N, 6.40.

5-(ethoxycarbonyl)Acetyl-4-methyl-2-phenyl-1,3-selenazole 14. To a solution of *N*-selenoacylamidine **3b** (0.5 g, 2 mmol.) dissolved in dry methylene chloride (20 mL) was added dropwise ethyl bromopyruvate (0.29 mL, 2.4 mmol.). The mixture was stirred at r.t. as the formation of salt was observed. Triethylamine (0.54 mL, 3.94 mmol.) was then added and the stirring maintained for another 1h. The precipitate was removed by filtration and the filtrate was concentrated. The residue was chromatographed on silica gel using 70/30 petroleum ether/ethyl acetate leading to the selenazol **14** crystallized in petroleum ether in 55% yield.mp 56-58°C; R_f0.82 (petroleum ether/ethyl acetate, 80/20); IR (KBr) 1729; 1670 (C=O) ^{1}H-NMR ($CDCl_3$, 200MHz) δ 1.45 (t, 3H, CH_2CH_3) ; 2.80 (s, 3H, CH_3) ; 4.43 (q, 2H, CH_2CH_3) ; 7.45 to 7.97 (2m, 5H, C_6H_5).^{13}C-NMR ($CDCl_3$, 50MHz) δ 14.9 (CH_2CH_3) ; 21.2 (CH_3) ; 64.1 (CH_2CH_3) ; 128.2, 130.1, 132.6 et 136.6 (C_6H_5) ; 127.9, 163.5, 167.7, 178.2 and 183.3 [Se-*C*=C, N-*C*(CH_3)=, Se-*C*=N, *C*=O]; *m/z* 323 (M+1, 12), 250 (100), 222 (15), 119 (39), 117 (20), 71 (34); Anal.Calcd for $C_{14}H_{13}NO_3Se$: C, 52.19 ; H, 4.07; N, 4.35 ; O, 14.90 ; Se, 24.50. Found: C, 51.87 ; H, 4.20 ; N, 4.38.

5-Methoxy-4-methyl-2-phenyl-6*H*-1,3-selenazin-6-one 15. *N*-selenoacylamidine **3b** (0.5 g, 2 mmol) was dissolved in a solution of dry *N,N*-dimethylformamide and ether (1/2, 15 mL) at r.t. under N_2 atmosphere. Methoxyacetyl chloride (0.54 mL, 6 mmol) and triethylamine (1.1 mL, 8 mmol) was added and the resulting mixture was stirred for 5 h. The solution was extracted with ethyl acetate and the organic layer was washed twice with water (100mL), dried on magnesium sulfate, filtered and concentrated. The residue was chromatographed on silica gel using 60/40 petroleum ether/ethyl acetate, to give the selenazinone **15** crystallized in petroleum ether in 33% yield: yellow powder; mp 73-75°C; R_f0.58 (petroleum ether/ethyl acetate, 80/20); IR (KBr) 1648 (C=O); ^{1}H-NMR ($CDCl_3$, 200MHz) δ 2.39 (s, 3H, CH_3), 3.77 (s, 3H, OCH_3), 7.35 to 7.79

(2m, 5H, C_6H_5); ^{13}C-NMR ($CDCl_3$, 50MHz) δ 22.2 (CH_3), 61.0 (OCH_3), 127.9, 128.1, 129.3, 132.9 and 140.1 (C_6H_5, =$COCH_3$), 154.3 [N-C(CH_3)=], 170.3 (Se-C=N), 181.5 (Se-C=O); *m/z* 281 (M+1, 40), 253 (94), 251 (47), 169 (100), 167 (50), 107 (23), 104 (25), 89 (25), 77 (31), 70 (87), 55 (46); Anal.Calcd for $C_{12}H_{11}NO_2Se$: C, 51.44; H, 3.96; N, 5.00. Found C, 51.78; H, 3.90; N, 5.10.

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