电化学促进的 *N*-烯丙基硫代酰胺的硒化/环化合成 2-噻唑啉

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摘要 建立了一种电化学促进 *N*-烯丙基硫代酰胺的串联硒化/环化新方法, 用来制备含硒官能团的 2-噻唑啉衍生物。该方法反应条件温和, 底物范围广。初步的机理研究表明, 反应过程中有硒自由基的参与。该方法操作简单且无需使用催化剂、过渡金属和氧化剂。

关键词 电合成; 噻唑啉; 硫代酰胺; 硒化

Electrochemical-Promoted Synthesis of 2-Thiazolines via Selenylation/Cyclization of *N*-Allylthioamides

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Abstract An electrochemical selenylation/cyclization of *N*-allylthioamides has been developed for the synthesis of selenium-containing 2-thiazolines. This protocol provides an efficient approach to produce 2-thiazolines with broad substrate scope under mild reaction conditions. Preliminary mechanistic study indicates that selenium radical may be involved. The reaction is easy operated under catalyst- and oxidant-free conditions.

Keywords electrosynthesis; thiazolines; thioamides; selenation

1 Introduction

Thiazolines are privileged skeletons found in natural products and bioactive molecules,^[1] as well as widely used chiral ligands in asymmetric synthesis.^[2] Thus, a variety of synthetic approaches have been developed for the synthesis of thiazoline derivatives.^[3] Among these methods, cyclization of β -aminothiols was the most generally used approach.^[4] Recently, intramolecular cyclization of *N*-allylthioamides was also utilized for the synthesis of thiazoline derivatives.^[5] Despite the achieved progress, these protocols usually required toxic reagents, expensive metal catalysts and harsh conditions, which also accompanied by limited substrate scope and waste formation. Therefore, developing a green and efficient protocol for the construction of functionalized thiazolines is still in high demand.

Organoselenium compounds, as versatile synthetic intermediates, are widely used in organic synthesis.^[6] The selenium-containing heterocycles have attracted great attention in pharmaceutical agents.^[7] Therefore, continuous

efforts have been explored to develop efficient protocols for the synthesis of these derivatives.^[8] In the last decade, the intramolecular difunctionalization of readily available alkenes with easily accessible diselenides has received broad attention, generating various selenium-containing heterocycles, such as oxazolines,^[9] isoxazolines,^[10] dihydrofurans,^[11] and γ -lactams.^[12] However, to the best of our knowledge, a general synthetic method for the synthesis of selenium-containing thiazolines remains undeveloped.

Due to environmentally benign and mild conditions, electrochemical reactions have been widely developed in recent years.^[13] Electrochemical synthesis provides a direct approach to generate radical intermediates, which could avoid toxic oxidants and minimize waste formation.^[14-15] Very recently, the electrochemical difunctionalization of alkenes with diselenides has been reported.^[16]

Lei group^[17] explored a practical method for the synthesis of seleno oxazolines via electrochemical oxidative cyclization of *N*-allylamides (Scheme 1a). Sarkar group^[18]

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developed a tandem electrochemical cyclization process for the synthesis of isoxazolines (Scheme 1b). In view of the importance of seleno-containing heterocycles and our continued interest in thioamide chemistry,^[19] we herein developed a general electrochemical oxidative cyclization process for the synthesis of seleno-containing thiazolines using easily accessible *N*-allylthioamides under air at room temperature (Scheme 1c). A series of seleno-containing thiazoline derivatives, including the trifluoromethyl substituted derivatives, were obtained in catalyst- and oxidant-free conditions.

Scheme 1 Electrochemical reactions based on diselenides

2 Results and discussion

The readily available *N*-allylbenzothioamide (**1a**) and 1,2-diphenyldiselenane (**2a**) were chosen as the model substrates (Table 1). Utilizing the cheap carbon felt as both anode and cathode in an undivided cell under constant current of 2 mA, the reaction proceeded well in the presence of LiClO₄ (1.5 equiv.) and CH₃CN (4 mL) to provide the desired product **3a** in 68% yield (Entry 1). Encouraged by this result, a series of electrodes were tested and carbon felt was the best choice (Entries 1~4). Next, the electrolytes (Entries 5~8) and the solvents (Entries 9~12) were screened. The optimum electrolyte was LiClO₄ and the best solvent was CH₃CN. It was found that changing the reaction temperature did not improve the yields (Entries 13 and 14). A comparable yield was obtained under N₂ atmosphere (Entry 15). Notably, decreasing or increasing the constant current were found to be inferior for the reaction (Entries 16 and 17). No desired product was obtained in the absence of electricity (Entry 18). Finally, the optimized reaction conditions were defined as follows: carbon felt anode and cathode, 2 mA, **1a** (0.2 mmol), **2a** (0.6 equiv.), and LiClO₄ (1.5 equiv.) in CH₃CN (0.05 mol/L) at room temperature for 4 h.

With the optimized reaction conditions in hand, the scope with respect to thioamides **1** was first examined (Table 2). The reactions proceeded smoothly with arylthioamides bearing electron-donating groups (Me, OMe, Ph) and

Table 1 Optimization of reaction conditions^a

Entry	Anode/Cathode	Electrolyte	Solvent	Yield ^b /%
1	CF/CF	LiClO ₄	CH ₃ CN	68
2	Pt/C	LiClO ₄	CH ₃ CN	49
3	C/Pt	LiClO ₄	CH ₃ CN	46
4	C/C	LiClO ₄	CH ₃ CN	53
5	CF/CF	ⁿ Bu ₄ NBF ₄	CH ₃ CN	15
6	CF/CF	ⁿ Bu ₄ NI	CH ₃ CN	0
7	CF/CF	ⁿ Bu ₄ NPF ₆	CH ₃ CN	23
8	CF/CF	NH ₄ ClO ₄	CH ₃ CN	51
9	CF/CF	LiClO ₄	CH ₃ OH	60
10	CF/CF	LiClO ₄	CH ₃ CN/C ₂ H ₅ OH (V : V = 1 : 1)	58
11	CF/CF	LiClO ₄	DMF	0
12	CF/CF	LiClO ₄	CH ₃ CN/HFIP (V : V = 1 : 1)	16
13 ^c	CF/CF	LiClO ₄	CH ₃ CN	66
14 ^d	CF/CF	LiClO ₄	CH ₃ CN	40
15 ^e	CF/CF	LiClO ₄	CH ₃ CN	65
16 ^f	CF/CF	LiClO ₄	CH ₃ CN	56
17 ^g	CF/CF	LiClO ₄	CH ₃ CN	54
18 ^h	CF/CF	LiClO ₄	CH ₃ CN	0

^a Reaction conditions: CF anode, CF cathode, **1a** (0.2 mmol), **2a** (0.6 equiv.), electrolyte (1.5 equiv), solvent (4 mL), 2 mA, under air, 4 h. ^b Isolated yields. ^c T = 0 °C. ^d T = 50 °C. ^e Under N₂. ^f 1 mA, 10 h. ^g 3 mA. ^h No electric current.

electron-withdrawing groups (Cl, Br, COOMe, CF₃) at *para*-position, and the desired thiazolines **3a**~**3h** were afforded in 48%~68% yields. Substrates with *ortho*- and *meta*-chloro groups generated the desired products **3i** and **3j** in 63% and 61% yields, respectively. In addition, the reaction with disubstituted thioamide **1k** worked well to provide product **3k** in 50% yield. The reaction was compatible with naphthylthioamide to generate product **3l** in 60% yield. Heteroarylthioamides, such as furan and thiophene, were also tolerated to give the desired products **3m** and **3n** in 60% and 47% yields, respectively. It was noteworthy that cyclohexyl substrate was well tolerated to form product **3o** in 53% yield.

Next, the substrate scope of diselenides was tested under the optimized reaction conditions (Table 3). The reactions of diselenides bearing electron-donating groups at *para*-position run smoothly with thioamide **1a** to obtain the desired products **3p** and **3q** in good yields. Electron-withdrawing chloro group on the phenyl ring was also tolerated, although product **3r** was formed in low yield. For the reaction of diselenide with a naphthyl group, the desired product **3s** was afforded in 60% yield. Heterocyclic substituted diselenide such as thiophene was also compatible in the reaction to give product **3t** in 47% yield. Notably, the reaction was found to be tolerant for alkyl

Table 2 Scope of thioamides^{a,b}

^a Reaction conditions: CF anode, CF cathode, **1** (0.2 mmol), **2a** (0.6 equiv.), LiClO₄ (1.5 equiv.), CH₃CN (4 mL), 2 mA, 4 h. ^b Isolated yields.

Table 3 Scope of the diselenides^{a,b}

^a Reaction conditions: CF anode, CF cathode, **1a** (0.2 mmol), **2** (0.6 equiv.), LiClO₄ (1.5 equiv.), CH₃CN (4 mL), 2 mA, 4 h. ^b Isolated yields.

substituted diselenides (Me, Bn, Cy), the corresponding products **3u**~**3w** were isolated in moderate yields.

Incorporation of trifluoromethyl group into organic molecules is a broadly adopted strategy in drug design.^[20] The reactions of trifluoromethyl thioamides with different substituted diselenides such as phenyl, naphthyl and methyl proceeded smoothly to give products **4a**~**4c** in high yields (Table 4). In addition, thioamides bearing 1,1-disubstituted alkenes reacted successfully with diphenyl diselenide (**2a**) to produce the desired products **4d** and **4e** in 83% and 37% yields, respectively. Satisfyingly, substrate with trisubstituted alkene was also well tolerated, generating the desired product **4f** in 53% yield. It is noteworthy to obtain products **4a**~**4f**, and these trifluoromethyl substituted derivatives might show potential bioactivity.

Table 4 Scope of the trifluoromethyl thioamides^{a,b}

^a Reaction conditions: CF anode, CF cathode, **1** (0.2 mmol), **2** (0.6 equiv.), LiClO₄ (1.5 equiv.), CH₃CN (4 mL), 2 mA, 4 h. ^b Isolated yields. ^c Under N₂, 8 h.

Gram-scale reaction was performed in order to prove the practicality of this electrochemical process (Scheme 2, a). When **1a** reacted with **2a** under 10 mA constant current for 18 h, the desired product **3a** was obtained in 1.25 g. To gain insight into the mechanism, control experiments were performed. Only trace amount of **3a** was detected in the presence of 2,2,6,6-tetramethylpiperidin-1-yloxy (TEMPO), indicating the possibility of radical reaction pathway (Scheme 2, b). In addition, radical-clock experiment was explored using **1x** as reactant, producing **3x** in 54% yield with the cyclopropyl group retained (Scheme 2, c). This result excludes the intramolecular thiyl radical cyclization/selenylation mechanism.^[5b] Furthermore, cyclic voltammetry (CV) experiments were also carried out to study the redox potential of the reactants. An obvious reduction peak of **2a** is observed at -0.51 V, which implies that the reduction of **2a** is a readily pathway.

Based on the control experiments and literature reports,^[15] a plausible reaction mechanism has been proposed in Scheme 3. First, diselenide **2a** is reduced at the cathode to generate selenium radical **A** and selenium anion **B**.

Scheme 2 Gram-scale and control experiments

Intermediate **B** could be easily oxidized at the anode to form radical **A**. Subsequently, radical addition of intermediate **A** with **1a** generates alkyl radical **C**, which is further oxidized at the anode to give carbocation **D**. Finally, regioselective intramolecular 5-*exo*-trig cyclization accompanied by deprotonation affords the desired product **3a**.

Scheme 3 Possible mechanism

3 Conclusions

In conclusion, an efficient strategy for the construction of selenium-containing thiazolines by electrochemical selenylation/cyclization of *N*-allylthioamides has been developed. This green strategy is performed in catalyst- and oxidant-free conditions under air at room temperature. The reaction also features a broad substrate scope, easy operation and excellent selectivity. In addition, the selenyl thiazolines bearing trifluoromethyl group were also synthesized, which might exhibit potential biological activity.

4 Experimental section

4.1 General information

Column chromatography was performed on silica gel (200~300 mesh) using analytical pure ethyl acetate and petroleum ether. Melting points were recorded on a RY-1 microscopic melting apparatus and uncorrected. NMR spectra were recorded in DMSO-*d*₆ on 500 MHz spectrometers (500 MHz for ¹H NMR, 125 MHz for ¹³C NMR and 375 MHz for ¹⁹F NMR). Massspectra were obtained on an Ultima Global spectrometer with an ESI source. The electrochemical instrument is HONGSHENG FENG DPS-305BM. All the reactions were carried out under an air atmosphere using glassware without being predried. Unless noted, all commercial reagents and solvents were used without further purification.

4.2 General procedure

To a 10 mL two-necked flask was added thioamide **1** (0.2 mmol), diselenides **2** (0.12 mmol, 0.6 equiv.), LiClO₄ (0.3 mmol, 1.5 equiv.) and CH₃CN (4 mL). The flask was equipped with a carbon felt anode (1.5 cm×1 cm×0.5 cm) and a carbon felt cathode (1.5 cm×1 cm×0.5 cm). The whole cell was undivided cell. The reaction mixture was electrolyzed at a constant current of 2 mA at room temperature for 4 h. After completion of the reaction [monitored by thin-layer chromatography (TLC)], the solvent was removed under vacuum. The residue was purified by column chromatography on silica gel, eluting with ethyl acetate/petroleum ether to give compound **3**.

2-Phenyl-5-((phenylselenanyl)methyl)-4,5-dihydrothiazole (**3a**): 45 mg, 68% yield, light yellow oil. *R*_f=0.4 [*V*(petroleum ether) : *V*(ethyl acetate)=10 : 1]; ¹H NMR (DMSO-*d*₆, 500 MHz) δ: 7.74 (d, *J*=7.6 Hz, 2H), 7.48 (dt, *J*=28.3, 7.3 Hz, 5H), 7.33~7.22 (m, 3H), 4.42 (dd, *J*=16.3, 3.3 Hz, 1H), 4.30 (dd, *J*=16.3, 8.1 Hz, 1H), 4.22~4.14 (m, 1H), 3.18 (d, *J*=7.3 Hz, 2H); ¹³C NMR (DMSO-*d*₆, 125 MHz) δ: 165.5, 133.3, 132.4, 131.8, 129.8, 129.8, 129.2, 128.4, 127.5, 69.7, 51.3, 33.2; HRMS (ESI-TOF) calcd for C₁₆H₁₆NSSe [*M* + *H*]⁺ 334.0169, found 334.0170.

5-((Phenylselenanyl)methyl)-2-(*p*-tolyl)-4,5-dihydrothiazole (**3b**): 45 mg, 65% yield, light yellow oil. *R*_f=0.5 [*V*(petroleum ether) : *V*(ethyl acetate)=10 : 1]; ¹H NMR (DMSO-*d*₆, 500 MHz) δ: 7.64~7.60 (m, 2H), 7.54~7.48 (m, 2H), 7.32~7.23 (m, 5H), 4.39 (dd, *J*=16.3, 3.6 Hz, 1H), 4.28 (dd, *J*=16.3, 8.0 Hz, 1H), 4.20~4.13 (m, 1H), 3.17 (d, *J*=7.3 Hz, 2H), 2.33 (s, 3H); ¹³C NMR (DMSO-*d*₆, 125 MHz) δ: 165.3, 141.8, 132.4, 130.6, 129.8, 129.8, 128.4, 127.5, 69.6, 51.2, 33.2, 21.5; HRMS (ESI-TOF) calcd for C₁₇H₁₈NSSe [*M* + *H*]⁺ 348.0325, found 348.0330.

2-(4-Methoxyphenyl)-5-((phenylselenanyl)methyl)-4,5-dihydrothiazole (**3c**): 40 mg, 55% yield, light yellow oil. *R*_f=0.4 [*V*(petroleum ether) : *V*(ethyl acetate)=5 : 1]; ¹H NMR (DMSO-*d*₆, 500 MHz) δ: 7.68 (d, *J*=8.6 Hz, 2H), 7.51 (d, *J*=6.9 Hz, 2H), 7.33~7.23 (m, 3H), 6.99 (d, *J*=

8.6 Hz, 2H), 4.37 (dd, $J=16.1, 3.5$ Hz, 1H), 4.25 (dd, $J=16.1, 8.0$ Hz, 1H), 4.19~4.11 (m, 1H), 3.78 (s, 3H), 3.17 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 164.7, 162.1, 132.4, 130.1, 129.8, 127.5, 125.9, 114.5, 69.6, 55.9, 51.3, 33.2; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{18}\text{NOSse}$ $[\text{M}+\text{H}]^+$ 364.0274, found 364.0273.

2-([1,1'-Biphenyl]-4-yl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3d**): 39 mg, 48% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=5 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.86 (d, $J=7.8$ Hz, 2H), 7.80 (d, $J=8.0$ Hz, 2H), 7.74 (d, $J=7.3$ Hz, 2H), 7.57 (d, $J=6.9$ Hz, 2H), 7.51 (t, $J=7.4$ Hz, 2H), 7.44 (d, $J=7.2$ Hz, 1H), 7.37~7.26 (m, 3H), 4.48 (dd, $J=16.4, 3.1$ Hz, 1H), 4.36 (dd, $J=16.4, 8.1$ Hz, 1H), 4.28~4.21 (m, 1H), 3.24 (d, $J=7.2$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.1, 143.2, 139.4, 132.4, 132.2, 129.8, 129.5, 129.0, 128.6, 127.4, 127.2, 69.7, 51.4, 33.1; HRMS (ESI-TOF) calcd for $\text{C}_{22}\text{H}_{20}\text{Nssse}$ $[\text{M}+\text{H}]^+$ 410.0482, found 410.0483.

2-(4-Chlorophenyl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3e**): 46 mg, 63% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.76 (d, $J=8.4$ Hz, 2H), 7.55 (t, $J=7.6$ Hz, 4H), 7.35~7.25 (m, 3H), 4.44 (dd, $J=16.4, 3.5$ Hz, 1H), 4.32 (dd, $J=16.4, 8.1$ Hz, 1H), 4.27~4.21 (m, 1H), 3.22 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 164.0, 136.0, 131.9, 131.5, 129.6, 129.5, 129.3, 129.2, 128.8, 127.0, 69.2, 51.3, 32.6; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{15}\text{ClNssse}$ $[\text{M}+\text{H}]^+$ 367.9779, found 367.9780.

2-(4-Bromophenyl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3f**): 45 mg, 55% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.70 (s, 4H), 7.59~7.51 (m, 2H), 7.36~7.28 (m, 3H), 4.45 (dd, $J=16.4, 3.5$ Hz, 1H), 4.33 (dd, $J=16.3, 8.1$ Hz, 1H), 4.28~4.22 (m, 1H), 3.23 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 164.6, 132.4, 132.4, 132.3, 130.3, 129.8, 129.7, 127.5, 125.4, 69.7, 51.8, 33.1; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{13}\text{BrNssse}$ $[\text{M}+\text{H}]^+$ 411.9274, found 411.9270.

Methyl 4-(5-((phenylselanyl)methyl)-4,5-dihydrothiazol-2-yl)benzoate (**3g**): 38 mg, 49% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 8.02 (d, $J=8.2$ Hz, 2H), 7.86 (d, $J=8.2$ Hz, 2H), 7.52 (d, $J=6.8$ Hz, 2H), 7.32~7.24 (m, 3H), 4.46 (dd, $J=16.6, 3.6$ Hz, 1H), 4.33 (dd, $J=16.6, 8.1$ Hz, 1H), 4.27~4.20 (m, 1H), 3.85 (s, 3H), 3.20 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 166.0, 164.9, 137.1, 132.4, 132.3, 130.1, 129.8, 129.7, 128.7, 127.5, 69.8, 52.9, 51.7, 33.1; HRMS (ESI-TOF) calcd for $\text{C}_{18}\text{H}_{18}\text{NO}_2\text{Sse}$ $[\text{M}+\text{H}]^+$ 392.0223, found 392.0228.

5-((Phenylselanyl)methyl)-2-(4-(trifluoromethyl)phenyl)-4,5-dihydrothiazole (**3h**): 52 mg, 65% yield, white solid. $R_f=0.5$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; m.p. 49~51 °C; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.97 (d, $J=8.1$ Hz, 2H), 7.86 (d, $J=7.9$ Hz, 2H), 7.56

(d, $J=7.5$ Hz, 2H), 7.37~7.26 (m, 3H), 4.51 (dd, $J=16.6, 3.5$ Hz, 1H), 4.39 (dd, $J=16.5, 8.2$ Hz, 1H), 4.34~4.25 (m, 1H), 3.25 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 164.6, 136.8, 132.4, 131.7, 131.4, 131.2, 129.8, 129.7, 129.1, 127.5, 126.2, 126.2, 124.3 (d, $J=272.6$ Hz), 69.8, 51.9, 33.0; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -61.48; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{15}\text{F}_3\text{Nssse}$ $[\text{M}+\text{H}]^+$ 402.0043, found 402.0041.

2-(2-Chlorophenyl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3i**): 46 mg, 63% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.72 (d, $J=7.6$ Hz, 2H), 7.55~7.46 (m, 3H), 7.40 (t, $J=7.6$ Hz, 2H), 7.25 (q, $J=5.5$ Hz, 3H), 5.00~4.87 (m, 1H), 4.07 (dd, $J=15.0, 9.6$ Hz, 1H), 3.70 (dd, $J=15.0, 6.9$ Hz, 1H), 3.31~3.22 (m, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 155.0, 146.4, 142.9, 132.2, 129.9, 129.7, 127.3, 114.7, 112.2, 78.9, 59.9, 31.4; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{15}\text{ClNssse}$ $[\text{M}+\text{H}]^+$ 367.9779, found 367.9780.

2-(3-Chlorophenyl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3j**): 45 mg, 61% yield, light yellow oil. $R_f=0.5$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.78~7.47 (m, 6H), 7.41~7.16 (m, 3H), 4.46 (dt, $J=16.8, 8.4$ Hz, 1H), 4.38~4.18 (m, 2H), 3.22 (dd, $J=14.4, 8.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 164.3, 135.1, 134.0, 132.4, 131.7, 131.3, 129.8, 129.8, 127.5, 127.2, 69.7, 51.8, 33.0; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{15}\text{ClNssse}$ $[\text{M}+\text{H}]^+$ 367.9779, found 367.9777.

2-(2-Bromo-5-methoxyphenyl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3k**): 44 mg, 50% yield, light yellow oil. $R_f=0.2$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.61 (d, $J=8.8$ Hz, 1H), 7.56 (d, $J=7.3$ Hz, 2H), 7.33 (dt, $J=12.2, 6.7$ Hz, 3H), 7.09 (d, $J=3.0$ Hz, 1H), 7.02 (dd, $J=8.8, 3.0$ Hz, 1H), 4.50~4.43 (m, 1H), 4.26 (dd, $J=11.6, 3.8$ Hz, 2H), 3.79 (s, 3H), 3.28 (d, $J=6.8$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 164.5, 158.8, 136.1, 134.6, 132.3, 129.8, 129.7, 127.4, 118.1, 115.9, 110.9, 69.4, 56.1, 53.0, 32.8; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{17}\text{BrNssse}$ $[\text{M}+\text{H}]^+$ 441.9379, found 441.9374.

2-(Naphthalen-1-yl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3l**): 46 mg, 60% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 8.79 (d, $J=7.8$ Hz, 1H), 8.08 (d, $J=8.2$ Hz, 1H), 8.02 (d, $J=9.0$ Hz, 1H), 7.80 (d, $J=6.7$ Hz, 1H), 7.65~7.57 (m, 5H), 7.34 (dt, $J=12.1, 6.8$ Hz, 3H), 4.65 (dd, $J=16.3, 3.5$ Hz, 1H), 4.52 (dd, $J=16.3, 8.1$ Hz, 1H), 4.32~4.21 (m, 1H), 3.33 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.2, 133.8, 132.4, 131.6, 130.5, 130.2, 129.9, 129.1, 128.9, 127.8, 127.5, 126.9, 126.1, 126.0, 125.5, 70.9, 51.1, 33.3; HRMS (ESI-TOF) calcd for $\text{C}_{20}\text{H}_{18}\text{Nssse}$ $[\text{M}+\text{H}]^+$ 384.0325, found 384.0325.

2-(Furan-2-yl)-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3m**): 39 mg, 60% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=5 : 1$]; ^1H NMR

(DMSO- d_6 , 500 MHz) δ : 7.9 (s, 1H), 7.5 (d, $J=7.6$ Hz, 2H), 7.4~7.3 (m, 3H), 7.0 (d, $J=3.4$ Hz, 1H), 6.7 (d, $J=3.3$ Hz, 1H), 4.4 (dd, $J=16.2$, 3.2 Hz, 1H), 4.3~4.1 (m, 2H), 3.2 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 155.1, 147.9, 146.3, 132.4, 129.8, 129.7, 127.5, 114.1, 112.7, 69.4, 51.2, 32.9; HRMS (ESI-TOF) calcd for $\text{C}_{14}\text{H}_{14}\text{NOSse} [\text{M}+\text{H}]^+$ 323.9961, found 323.9963.

5-((Phenylselanyl)methyl)-2-(thiophen-2-yl)-4,5-dihydrothiazole (**3n**): 32 mg, 47% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.80 (d, $J=5.0$ Hz, 1H), 7.56 (d, $J=7.7$ Hz, 2H), 7.45 (d, $J=3.4$ Hz, 1H), 7.37~7.28 (m, 3H), 7.18~7.14 (m, 1H), 4.40~4.34 (m, 1H), 4.31~4.22 (m, 2H), 3.23 (d, $J=6.7$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 158.8, 136.9, 132.4, 131.4, 131.3, 129.8, 129.7, 128.5, 127.5, 69.1, 52.4, 33.0; HRMS (ESI-TOF) calcd for $\text{C}_{14}\text{H}_{14}\text{NS}_2\text{Se} [\text{M}+\text{H}]^+$ 339.9733, found 339.9734.

2-Cyclohexyl-5-((phenylselanyl)methyl)-4,5-dihydrothiazole (**3o**): 36 mg, 53% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.54~7.50 (m, 2H), 7.35~7.28 (m, 3H), 4.20~4.14 (m, 1H), 4.06 (dd, $J=8.0$, 1.4 Hz, 1H), 4.03~3.98 (m, 1H), 3.10 (d, $J=6.9$ Hz, 2H), 2.49~2.41 (m, 1H), 1.85 (t, $J=12.5$ Hz, 2H), 1.73~1.68 (m, 2H), 1.62 (d, $J=12.2$ Hz, 1H), 1.41~1.28 (m, 4H), 1.22~1.15 (m, 1H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 173.0, 132.4, 129.8, 127.4, 68.9, 50.5, 42.9, 33.4, 31.5, 31.4, 25.9, 25.6; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{22}\text{NSse} [\text{M}+\text{H}]^+$ 340.0638, found 340.0636.

2-Phenyl-5-((*p*-tolylselanyl)methyl)-4,5-dihydrothiazole (**3p**): 46 mg, 66% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.77 (d, $J=7.4$ Hz, 2H), 7.55 (t, $J=7.2$ Hz, 1H), 7.52~7.44 (m, 4H), 7.16 (d, $J=7.9$ Hz, 2H), 4.45 (dd, $J=16.4$, 3.7 Hz, 1H), 4.32 (dd, $J=16.4$, 8.1 Hz, 1H), 4.25~4.11 (m, 1H), 3.17 (d, $J=7.4$ Hz, 2H), 2.30 (s, 3H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.5, 137.2, 133.2, 133.1, 131.8, 130.5, 129.2, 128.4, 125.7, 69.6, 51.3, 33.5, 21.1; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{18}\text{NSse} [\text{M}+\text{H}]^+$ 348.0325, found 348.0324.

5-(((4-Methoxyphenyl)selanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3q**): 44 mg, 61% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.77 (d, $J=7.5$ Hz, 2H), 7.56~7.47 (m, 5H), 6.92 (d, $J=8.5$ Hz, 2H), 4.44 (dd, $J=16.4$, 3.7 Hz, 1H), 4.32 (dd, $J=16.4$, 8.1 Hz, 1H), 4.18~4.11 (m, 1H), 3.77 (s, 3H), 3.10 (d, $J=7.4$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.5, 159.6, 135.7, 133.3, 131.8, 129.2, 128.4, 119.0, 115.6, 69.6, 55.6, 51.4, 34.3; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{18}\text{NOSse} [\text{M}+\text{H}]^+$ 364.0274, found 364.0279.

5-(((4-Chlorophenyl)selanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3r**): 24 mg, 33% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.77 (d, $J=7.5$ Hz, 2H), 7.56 (dd, $J=14.2$, 7.8 Hz, 3H), 7.50 (t, $J=7.5$ Hz,

2H), 7.38 (d, $J=8.3$ Hz, 2H), 4.45 (dd, $J=16.3$, 3.5 Hz, 1H), 4.34 (dd, $J=16.3$, 8.0 Hz, 1H), 4.28~4.20 (m, 1H), 3.25 (d, $J=7.3$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.5, 134.1, 133.2, 132.4, 131.9, 129.7, 129.2, 128.6, 128.4, 69.7, 51.2, 33.4; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{15}\text{ClNSse} [\text{M}+\text{H}]^+$ 367.9779, found 367.9779.

5-((Naphthalen-1-ylselanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3s**): 46 mg, 60% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 8.28 (d, $J=8.3$ Hz, 1H), 7.99~7.86 (m, 3H), 7.76 (d, $J=7.7$ Hz, 2H), 7.65~7.46 (m, 6H), 4.47 (dd, $J=16.4$, 3.2 Hz, 1H), 4.35~4.27 (m, 1H), 4.22~4.14 (m, 1H), 3.29~3.22 (m, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.5, 134.1, 133.8, 133.2, 132.3, 131.8, 129.2, 128.7, 128.6, 128.4, 127.5, 127.1, 126.9, 126.6, 69.8, 51.3, 33.6; HRMS (ESI-TOF) calcd for $\text{C}_{20}\text{H}_{18}\text{NSse} [\text{M}+\text{H}]^+$ 384.0325, found 384.0325.

2-Phenyl-5-((thiophen-2-ylselanyl)methyl)-4,5-dihydrothiazole (**3t**): 32 mg, 47% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.78 (d, $J=7.2$ Hz, 2H), 7.71 (d, $J=5.2$ Hz, 1H), 7.52 (dt, $J=28.1$, 7.2 Hz, 3H), 7.34 (d, $J=3.3$ Hz, 1H), 7.09 (dd, $J=5.1$, 3.6 Hz, 1H), 4.47 (dd, $J=16.4$, 3.5 Hz, 1H), 4.35 (dd, $J=16.4$, 8.1 Hz, 1H), 4.21~4.13 (m, 1H), 3.13~3.03 (m, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.4, 136.6, 133.2, 132.4, 131.9, 129.2, 129.1, 128.4, 122.5, 69.5, 51.1, 37.2; HRMS (ESI-TOF) calcd for $\text{C}_{14}\text{H}_{14}\text{NS}_2\text{Se} [\text{M}+\text{H}]^+$ 339.9733, found 339.9731.

5-((Methylselanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3u**): 37 mg, 68% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.82~7.77 (m, 2H), 7.55 (t, $J=7.2$ Hz, 1H), 7.50 (t, $J=7.3$ Hz, 2H), 4.46~4.40 (m, 1H), 4.38~4.30 (m, 2H), 2.83~2.75 (m, 2H), 2.06 (s, 3H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.6, 133.4, 131.8, 129.2, 128.3, 69.8, 51.5, 31.0, 4.6; HRMS (ESI-TOF) calcd for $\text{C}_{11}\text{H}_{14}\text{N-SSe} [\text{M}+\text{H}]^+$ 272.0012, found 272.0014.

5-((Cyclohexylselanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3v**): 40 mg, 59% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.78 (d, $J=7.3$ Hz, 2H), 7.55 (t, $J=7.2$ Hz, 1H), 7.50 (t, $J=7.4$ Hz, 2H), 4.42 (dd, $J=16.0$, 3.7 Hz, 1H), 4.34 (dd, $J=16.0$, 7.8 Hz, 1H), 4.32~4.24 (m, 1H), 3.13~3.04 (m, 1H), 2.89~2.78 (m, 2H), 1.99 (d, $J=12.9$ Hz, 2H), 1.72~1.64 (m, 2H), 1.57 (dd, $J=10.3$, 4.2 Hz, 1H), 1.49~1.41 (m, 2H), 1.37~1.27 (m, 3H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.5, 133.3, 131.7, 129.2, 128.3, 69.9, 52.3, 39.1, 34.7, 28.3, 26.6, 25.7; HRMS (ESI-TOF) calcd for $\text{C}_{16}\text{H}_{22}\text{NSse} [\text{M}+\text{H}]^+$ 340.0638, found 340.0635.

5-((Benzylselanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3w**): 36 mg, 52% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.78 (d, $J=8.0$ Hz, 2H), 7.55 (t, $J=7.2$ Hz, 1H), 7.49 (t, $J=7.4$ Hz, 2H), 7.32 (q, $J=8.25$, 7.8 Hz, 4H), 7.23 (t, $J=6.9$ Hz, 1H), 4.38 (dd, $J=15.6$, 2.8

Hz, 1H), 4.30 (dd, $J=15.9, 7.8$ Hz, 1H), 4.25 (dt, $J=7.3, 3.6$ Hz, 1H), 3.94 (s, 2H), 2.75 (d, $J=7.0$ Hz, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 165.5, 139.9, 133.3, 131.8, 129.3, 129.2, 128.9, 128.3, 127.1, 69.9, 51.5, 29.7, 27.1; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{18}\text{NSe}$ $[\text{M} + \text{H}]^+$ 348.0325, found 348.0327.

5-(Cyclopropyl(phenylselanyl)methyl)-2-phenyl-4,5-dihydrothiazole (**3x**): 40 mg, 54% yield, light yellow oil. $R_f=0.3$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.77 (d, $J=7.6$ Hz, 2H), 7.69~7.63 (m, 2H), 7.50 (t, $J=7.3$ Hz, 1H), 7.44 (t, $J=7.4$ Hz, 2H), 7.41~7.33 (m, 3H), 4.23 (dd, $J=17.0, 3.4$ Hz, 1H), 3.94 (dd, $J=17.0, 7.9$ Hz, 1H), 3.81~3.73 (m, 1H), 3.05 (t, $J=8.8$ Hz, 1H), 1.18~1.09 (m, 1H), 0.70~0.63 (m, 1H), 0.63~0.56 (m, 1H), 0.48~0.42 (m, 1H), 0.38~0.30 (m, 1H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 157.8, 138.6, 134.5, 131.1, 129.8, 128.9, 128.2, 126.3, 53.7, 51.1, 41.4, 17.9, 7.1, 4.1; HRMS (ESI-TOF) calcd for $\text{C}_{19}\text{H}_{20}\text{NSe}$ $[\text{M} + \text{H}]^+$ 374.0482, found 374.0480.

5-((Phenylselanyl)methyl)-2-(trifluoromethyl)-4,5-dihydrothiazole (**4a**): 56 mg, 86% yield, light yellow oil. $R_f=0.5$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.59~7.52 (m, 2H), 7.37~7.29 (m, 3H), 4.52~4.43 (m, 2H), 4.42~4.34 (m, 1H), 3.30~3.22 (m, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 157.4 (q, $J=37.5$ Hz), 132.5, 129.9, 129.2, 127.6, 118.9 (q, $J=275.5$ Hz), 68.9, 53.8, 32.3; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -65.82; HRMS (ESI-TOF) calcd for $\text{C}_{11}\text{H}_{11}\text{F}_3\text{NSe}$ $[\text{M} + \text{H}]^+$ 325.9730, found 325.9728.

5-((Naphthalen-1-ylselanyl)methyl)-2-(trifluoromethyl)-4,5-dihydrothiazole (**4b**): 59 mg, 79% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 8.26 (d, $J=8.3$ Hz, 1H), 7.96 (dd, $J=18.4, 8.1$ Hz, 2H), 7.88 (d, $J=7.1$ Hz, 1H), 7.62 (dt, $J=25.9, 7.2$ Hz, 2H), 7.48 (t, $J=7.7$ Hz, 1H), 4.48 (d, $J=15.5$ Hz, 1H), 4.43~4.33 (m, 2H), 3.33~3.25 (m, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 156.4 (q, $J=37.4$ Hz), 133.1, 132.8, 131.5, 128.2, 127.9, 127.0, 126.5, 126.1, 125.9, 125.6, 117.9 (q, $J=275.6$ Hz), 68.0, 52.8, 31.6; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -65.78; HRMS (ESI-TOF) calcd for $\text{C}_{15}\text{H}_{13}\text{F}_3\text{NSe}$ $[\text{M} + \text{H}]^+$ 375.9886, found 375.9890.

5-((Methylselanyl)methyl)-2-(trifluoromethyl)-4,5-dihydrothiazole (**4c**): 46 mg, 88% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 4.60~4.50 (m, 1H), 4.45~4.30 (m, 2H), 2.78 (d, $J=7.4$ Hz, 2H), 2.01 (s, 3H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 157.5 (q, $J=37.8$ Hz), 118.9 (q, $J=275.7$ Hz), 69.0, 53.9, 30.1, 4.6; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -65.87; HRMS (ESI-TOF) calcd for $\text{C}_6\text{H}_9\text{F}_3\text{NSe}$ $[\text{M} + \text{H}]^+$ 263.9573, found 263.9575.

5-Methyl-5-((phenylselanyl)methyl)-2-(trifluoromethyl)-4,5-dihydrothiazole (**4d**): 56 mg, 83% yield, light yellow oil. $R_f=0.5$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.61~

7.54 (m, 2H), 7.37~7.27 (m, 3H), 4.35 (dd, $J=16.9, 2.3$ Hz, 1H), 4.22 (dd, $J=16.9, 2.3$ Hz, 1H), 3.59~3.45 (m, 2H), 1.60 (s, 3H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 157.5 (q, $J=37.8$ Hz), 132.4, 130.6, 129.8, 127.6, 118.7 (q, $J=275.9$ Hz), 74.2, 68.5, 38.7, 27.1; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -66.31; HRMS (ESI-TOF) calcd for $\text{C}_{12}\text{H}_{13}\text{F}_3\text{NSe}$ $[\text{M} + \text{H}]^+$ 339.9886, found 339.9885.

5-Phenyl-5-((phenylselanyl)methyl)-2-(trifluoromethyl)-4,5-dihydrothiazole (**4e**): 30 mg, 37% yield, light yellow oil. $R_f=0.4$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=10 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.45 (d, $J=7.5$ Hz, 2H), 7.41~7.35 (m, 4H), 7.33 (t, $J=7.2$ Hz, 1H), 7.25 (dd, $J=4.7, 1.6$ Hz, 3H), 4.91~4.85 (m, 1H), 4.65 (dd, $J=17.0, 2.4$ Hz, 1H), 3.84 (s, 2H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 157.6 (q, $J=37.8$ Hz), 141.0, 132.5, 130.5, 129.6, 129.1, 128.5, 127.6, 127.1, 118.7 (q, $J=275.6$ Hz), 74.3, 73.6, 29.5; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -66.15; HRMS (ESI-TOF) calcd for $\text{C}_{17}\text{H}_{15}\text{F}_3\text{NSe}$ $[\text{M} + \text{H}]^+$ 402.0043, found 402.0044.

5-(2-(Phenylselanyl)propan-2-yl)-2-(trifluoromethyl)-4,5-dihydrothiazole (**4f**): 37 mg, 53% yield, light yellow oil. $R_f=0.6$ [$V(\text{petroleum ether}) : V(\text{ethyl acetate})=20 : 1$]; ^1H NMR (DMSO- d_6 , 500 MHz) δ : 7.65 (d, $J=7.4$ Hz, 2H), 7.50 (t, $J=7.3$ Hz, 1H), 7.43 (t, $J=7.4$ Hz, 2H), 4.68~4.60 (m, 1H), 4.52~4.42 (m, 2H), 1.31 (d, $J=12.5$ Hz, 6H); ^{13}C NMR (DMSO- d_6 , 125 MHz) δ : 156.6 (q, $J=37.1$ Hz), 138.0, 129.4, 129.3, 125.6, 118.3 (q, $J=275.2$ Hz), 65.7, 64.0, 48.9, 26.1, 24.5; ^{19}F NMR (DMSO- d_6 , 375 MHz) δ : -65.89; HRMS (ESI-TOF) calcd for $\text{C}_{13}\text{H}_{15}\text{F}_3\text{NSe}$ $[\text{M} + \text{H}]^+$ 354.0043, found 345.0046.

Supporting Information Reaction equipment, cyclic voltammetry experiment and NMR spectra of new compounds. The Supporting Information is available free of charge via the Internet at <http://sioc-journal.cn/>.

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