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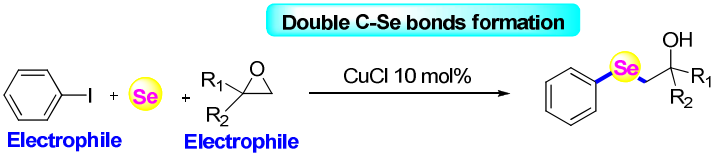


Abstract: Using Se powder as the selenating reagent, the copper-catalyzed double C-Se cross-coupling of aryl iodides, epoxides and elemental selenium has been developed. This strategy provides a straightforward approach to synthesis β -hydroxy phenylselenides with excellent regioselectivity of ring opening reaction. This process proceeds in generally good yields and compatible with a broad range of functional groups.

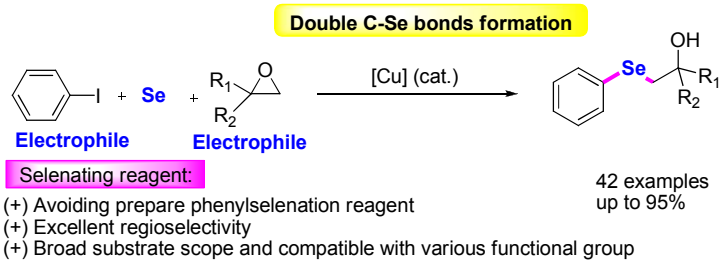
Introduction

Organoselenium chemistry has gained increasingly attention, because selenium-contain chemicals are prevalence in many drug candidates, biologically active compounds, functional organic materials as well as in food chemistry.[1] Considering the significance of organoselenium compounds, especially β -hydroxy phenylselenides, these compounds are valuable intermediates in the synthesis of allylic alcohols,[2] olefins[3] and vinyl selenides.[4] Therefore, the development of new synthetic route for the introduction of stable, economical selenium reagent into organic skeletons would be of significant synthetic value.

In recent years, the utilization of element selenium as linkage atom has received considerable attention due to their commercial available, stable and easily handled as compared to commonly

employed as aryl selenium reagents. Unlike the use of diaryl diselenides, a limited knowledge has been acquired when using transition-metal catalyzed transformation of selenium powder with aryl halides. This is probably due to the selenium has the high activation energy to destroy the structure of high polymer catenation, and the proclivity of elemental selenium for transition metal easily form the stability transition-metal selenium clusters,[5] which attenuate the activity of catalysts. In 2005, Taniguchi[6] realized the first selenation of aryl iodides using aluminum as reductant and $MgCl_2$ as additive in combination with CuI / bpy to provide the symmetrical diaryl selenides.[7] More recently, contributions have been extended to synthesis of ebselen,[8] selenium-containing heterocycles,[9] and trifluoromethylselenolation.[10] Despite the encouraging advancements, achieving direct cross-coupling of elemental selenium in a general way remains a daunting challenge. Lately, our group has established the copper-catalyzed 3-phenylselenation of indoles through double C−Se bonds formation of indoles with (hetero) aryl iodides and elemental selenium.[11] Inspired by this result, we envisioned that β -hydroxy phenylselenides, valuable synthetic intermediates of considerable interest in important natural compounds,[12] could be within achieved by transition-metal catalyzed selenation of aryl halides with elemental selenium and consequently further react with epoxides to afford the corresponding product under certain reaction conditions (Scheme 1).

Scheme 1. Strategies for Cross-Coupling Reactions of Epoxides

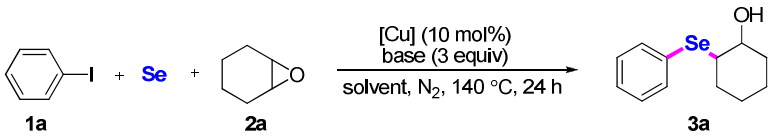


Such a methodology would constitute an alternative to the commonly ring opening reactions

of epoxides with selenolate anions.[13] The drawback of these reactions is the functional group tolerance and the loss of one equivalent of PhSe as waste. Clearly, such a single atom Se bridging different cross-coupling pratners strategy will be widely accepted and used for complex pharmaceutical compounds synthesis by synthetic chemists. Herein, we report the discovery of copper-catlayzed double C-Se bond formation that allow for regioselectivity ring opening of epoxides with (hetero) aryl iodides and elemental selenium.

Results and Discussion

Table 1. Reaction Optimization[a]



1a 2a 3a

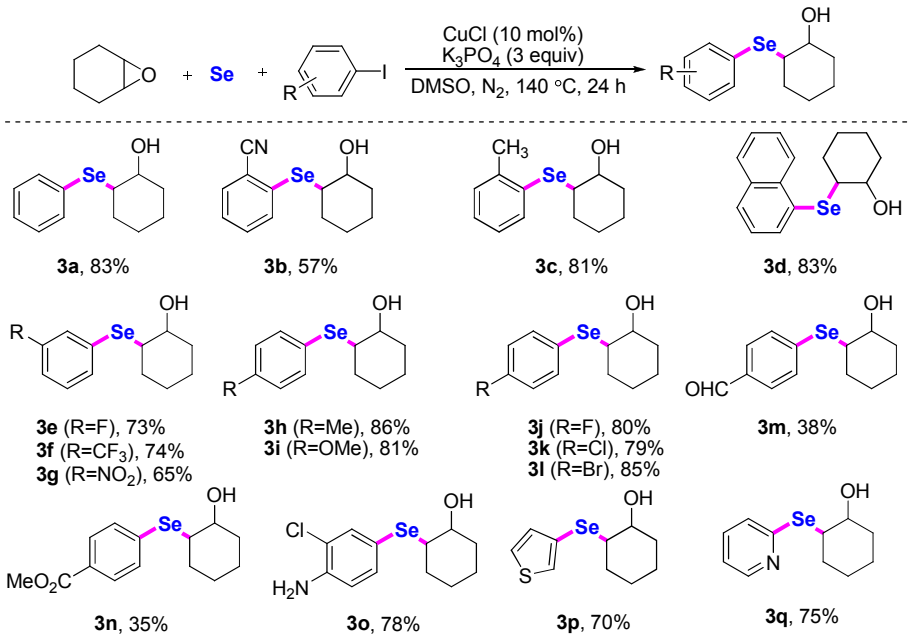
entry	[Cat]	base	solvent	yield %[b]
1	$Pd(OAc)_2$	K_3PO_4	DMSO	0
2	$Pd(PPh_3)_4$	K_3PO_4	DMSO	0
3	$Ni(acac)_2$	K_3PO_4	DMSO	0
4	$Ni(PPh_3)_2Cl_2$	K_3PO_4	DMSO	0
5	Cu	Cs_2CO_3	DMSO	32
6	Cu	Na_2CO_3	DMSO	0
7	Cu	K_2CO_3	DMSO	20
8	Cu	K_3PO_4	DMSO	45
9	Cu	KOH	DMSO	5
10	Cu	tBuOK	DMSO	4
11	CuO	K_3PO_4	DMSO	74
12	CuI	K_3PO_4	DMSO	64
13	CuBr	K_3PO_4	DMSO	76
14	CuCl	K_3PO_4	DMSO	83
15[c]	CuCl	K_3PO_4	DMSO	0
16[d]	CuCl	K_3PO_4	DMSO	33
17	$Cu(OAc)_2$	K_3PO_4	DMSO	70
18	$CuCl_2$	K_3PO_4	DMSO	79
19	CuCl	K_3PO_4	DMF	64
20	CuCl	K_3PO_4	HMPA	Trace
21	CuCl	K_3PO_4	DCE	Trace
22	CuCl	K_3PO_4	toluene	trace
23	CuCl	K_3PO_4	CH_3CN	trace

24[e]	CuCl	K_3PO_4	DMSO	45
25[f]	CuCl	K_3PO_4	DMSO	60

[a]Reaction conditions unless specified otherwise: 0.4 mmol of Iodobenzene, 0.8 mmol of Se, 1.2 mmol of Cyclohexene oxide, 0.04 mmol of [Cu], 1.2 mmol of base, 2 mL of solvent, under N_2, 140 ℃, 24 h. [b]Isolated yield. [c]Under O_2. [d]Under air. [e]At 90 ^oC. [f]At 110 ^oC.

We commenced our study by examining the reaction between iodobenzene **1a** and 1, 2-epoxycyclohexane **2a** in the presence of elemental selenium (Table 1). It's observed that three critical reaction parameters have a remarkable effect on the reaction outcomes. First, the examination of different transition metals, copper was found to be the only efficient catalyst species for this transformation (entries 1-5). We were pleased to find that the desired product was isolated in 45% yield under Cu as the catalyst, and K_3PO_4 as the base in DMSO stirred at 140 ^oC for 24 h (entry 8). Different copper catalysts were screened, which showed that CuCl was the best choice (entry 14). Second, a strong base was necessary for the model reaction to occur probably because bases were required to activate the selenium powder and therefore trigger the reaction. The effect of bases on the reaction was also observed to depend on the amounts of bases and their anions (entries 7-10). The best result was obtained when 3 equiv K_3PO_4 was used (entry 8). Finally, the choice of suitable solvent is critical successful for this transformation. When the reaction was conducted in polar solvent DMF, the starting material was not completely converted. No product was detected when apolar solvent toluene, DCE or weak coordination CH_3CN were used instead of DMSO (entry 21-23). An N_2 atmosphere is essential for this reaction. No product was detected when the reaction was conducted under O_2 and air afforded the much lower 33 % yield (entry 15, 16). This is due to the fact that O_2 can intercept intermediates in the catalytic process. A control experiment showed that the copper catalyst is essential for this transformation and no coupling product was detected in the absence of copper.

Scheme 2. Aryl Iodide Scope[a]

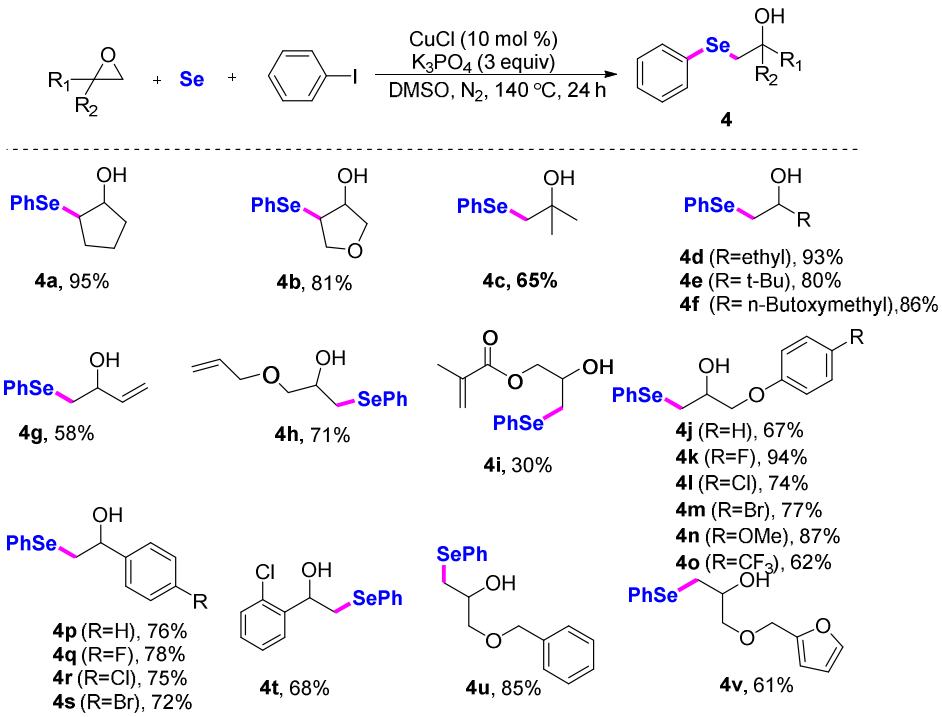


[a]Reaction conditions unless specified otherwise: aryl iodides (0.4 mmol), Se_8 (0.8 mmol), Cyclohexene oxide (1.2 mmol), CuCl (0.04 mmol), K_3PO_4 (1.2 mmol), DMSO (2 mL), 140 °C, 24 h, N_2. Isolated yields are given.

With the optimal conditions in hand, the scope of the reaction was explored. A wide range of aryl iodides were employed and the reaction generally proceeds smoothly, affording the corresponding products in good to excellent yields (Scheme 2). When the iodobenzenes bearing a variety of electron-donating groups were used, such as methyl (**3c, 3h**) and methoxy (**3i**) were highly reactive coupling partner gave the high yield. The reaction of iodobenzenes bearing the electron-withdrawing groups such as fluoro (**3e, 3j**), chloro (**3k**), bromo (**3l**), cyan (**3b**), trifluoromethyl (**3f**) and nitro (**3g**) all gave the corresponding products in the excellent yield. However, the efficiency of this transformation was comparatively low when aldehyde and ester group at the C4 position of iodobenzene, afforded the corresponding product in 38 % and 35 % isolated respective yield. Probably the low electron density on the phenyl ring would reduce the tendency of C-I oxidative addition. The compatibility of these transformation groups in this

reaction provided a platform for the further elaboration of the complex products. To our delight, substrates contain active hydrogen group amino (**3o**) also could be tolerated, which is a great challenge in many coupling reactions. This is in sharp contrast to the previous results,[13] in which the phenylselenium nuclephilic reagents are very sensitive to these functional groups. Thus, the current reaction features the advantage of the versatile and operational simplicity. It's remarkable that heterocyclic iodides such as pyridine and thiophene are competent coupling partners and could also provide the corresponding products (**3p**, **q**) in good yield.

Scheme 3. Epoxides Scope

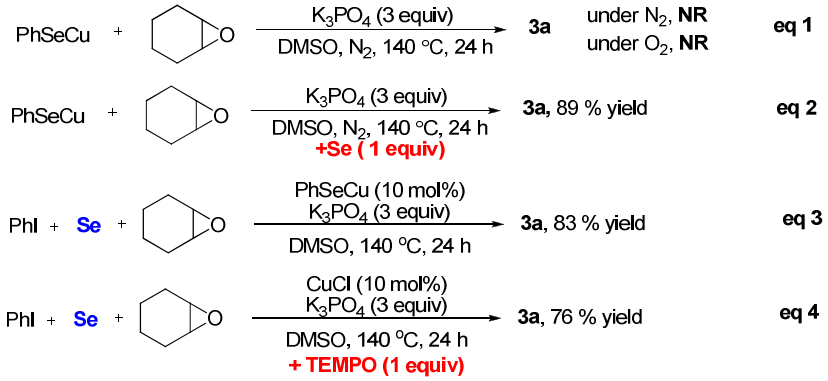


[a]Reaction conditions unless specified otherwise: Iodobenzene (0.4 mmol), Se_8 (0.8 mmol), epoxides (1.2 mmol), CuCl (0.04 mmol), K_3PO_4 (1.2 mmol), DMSO (2 mL), 140 °C, 24 h, N_2. Isolated yields are given.

Next, the scope of epoxides was further investigated under the optimized reaction conditions. As demonstrated in Scheme 3, the reaction worked well in region-selectivity and the great

functional group tolerance. Cyclic epoxides (**4a**, **b**) are efficiently opened to give corresponding product in excellent yield. The reaction can be applied to the linear and branched aliphatic oxirane all provided the products (**4c-f**) in good to excellent yields. Notably, double bond (**4g**, **h**) and ester (**4i**) substituents could afford the desired products. We found that different electronic property of substituents on the aromatic ring of 2-(phenoxymenthyl)oxirane were compatible, such as methoxy (**4n**), fluoride(**4k**), chloride (**4l**), bromide (**4m**), and trifluoromethyl (**4o**), to a certain extent, these functional groups have affected the substrates reactivity. Investigation of functionalized styrene oxides were high indispensable, as the resulting α-hydroxy-2-phenylethyl phenyl selenides is complement of the contrary products obtained by the previously reported methods that employed PhSeZnCl reagent as coupling partner.[13e]

Scheme 4. Preliminary Mechanism Investigation



To understand the reaction mechanism, control experiments were conducted (Scheme 4). First, a stoichiometric reaction of PhSeCu[6] with 1,2-epoxycyclohexane no matter whether under an N_2 or under an O_2 atmosphere did not promote the reaction (Scheme 4, **eq 1**). An interesting phenomenon was observed, the desired product **3a** was obtained in 89% isolated yield, when 1 equiv of selenium powder was added under standard reaction condition (**eq 2**); These experiments indicates that elemental selenium play a critical role in the process of oxirane opening reaction.

Secondly, As shown in **eq 3**, PhSeCu may be a chemically competent intermediate produced in situ during the catalytic cycle. It could also rationalize why a small amount of diphenyl diselenides were detected in the reaction. Finally, when the radical inhibitor TEMPO was added to the reaction conditions, product **3a** was still obtained in 76 % yield (**eq 4**), which return suggested that a radical-involved mechanism could be ruled out. Although, the details of the reaction mechanism remains unclear at the present time, we assume that the epoxides ring opening reaction is likely to involve a S_N2-type by the phenylselenium-copper complex intermediate generated in situ from the aryl iodide and elemental selenium.

In summary, we have demonstrated the synthesis of a broad range of β-hydroxy phenylselenides through a convergent three-component copper-catalyzed coupling approach. Commercially available, stable, easily handled elemental selenium was used as selenating reagent. The important feature of this method was operationally simple to perform and applied to broad substrate scope. Further studies to develop related transformations and deeply understand the mechanism are underway.

Experimental Section

General Remarks. ^{1}H NMR (500 MHz), ^{13}C NMR (125 MHz) and ^{19}F NMR (470 MHz) spectra were recorded in $CDCl_3$ solutions using a 500 MHz spectrometer. High-resolution mass spectra were recorded on an ESI-Q-TOF mass spectrometer. All reactions were conducted using standard Schlenk techniques. Column chromatography was performed using EM silica gel 60 (300−400 mesh). ^{1}H NMR and ^{13}C NMR spectra are provided as Supporting Information. 4-bromo styrene oxide,[14] 2-chloro styrene oxide,[14] 2-[(4-chlorophenoxy)methyl]oxirane,[14] 2-[(4-bromophenoxy)methyl]oxirane,[14] 2-[(4-fluorophenoxy)methyl]oxirane,[14]

2-[(4-methoxyphenoxy)methyl]oxirane[14] and 2-[(4-trifluromethylphenoxy)methyl]oxirane[14] were prepared according to the reported procedures. ^{1}H and ^{13}C spectra of known compounds were in accordance with those described in the literature.

Procedure for Intermolecular Phenylselenation of epoxides-opening Reactions. In a 25 mL Schlenk tube equipped with a stir bar were placed aryl iodides **1** (0.4 mmol), epoxides **2** (1.2 mmol), Se (0.8 mmol), CuCl (10 mol %), and K_3PO_4 (1.2 mmol) in DMSO (2 mL). The tube was evacuated and refilled with N_2 three times. The reaction mixture was stirred at 140 ^{o}C for 24 h. After it was colled, the reaction mixture was diluted with 10 mL of ethyl ether, and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3×15 mL). The organic phase was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

Preliminary Mechanism Investigation. In Two 10 mL of Schlenk tubes equipped with a stir bar were placed with PhSeCu (0.4 mmol), Cyclohexene oxide (1.2 mmol), and K_3PO_4 (1.2 mmol) in DMSO (2 mL). The first tube, was evacuated and refilled N_2 three times. The other tube, was fitted with a rubber septum, and then it was evacuated and refilled with O_2 three times. These reaction mixtures were stirred at 140 ^{o}C for 24 h (see Scheme 4, eq 1). To a 10 mL Schlenk tube equipped with a stir bar were placed PhSeCu (0.4 mmol), Se (0.4 mmol), Cyclohexene oxide (1.2 mmol), and K_3PO_4 (1.2 mmol) in DMSO (2 mL). The tube was evacuated and refilled with N_2 three times. The reaction mixture was stirred at 140 ^{o}C for 24 h (see Scheme 4, eq 2). In a 10 mL Schlenk tube equipped with a stir bar were placed iodobenzene (0.4 mmol), Cyclohexene oxide (1.2 mmol), Se (0.8 mmol), PhSeCu (10 mol %), and K_3PO_4 (1.2 mmol) in DMSO (2 mL). The

tube was evacuated and refilled with N_2 three times. The reaction mixture was stirred at 140 ^oC for 24 h (see Scheme 4, eq 3). After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether, and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3×15 mL). The organic phase was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

Characterization Data of Compounds 3 and 4:

2-phenylselenocyclohexan-1-ol (**3a**). Following the general procedure, using 8/1 petroleum ether /ethyl acetate as the eluant to afford yellow oil liquid (85.0 mg, 83 % yield). The ^1H and ^{13}C NMR spectra were in accordance with those described in the literature.[14]

2-(2-cyano)phenylselenocyclohexan-1-ol (**3b**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (64.1 mg, 57 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.79 - 7.77 (m, 1H), 7.70 - 7.68 (m, 1H), 7.51 - 7.48 (m, 1H), 7.44 - 7.41 (m, 1H), 3.48 - 3.42 (m, 1H), 3.13 - 3.08 (m, 1H), 2.77 (d, J = 2.5 Hz, 1H), 2.27 - 2.13 (m, 2H), 1.77 - 1.65 (m, 2H), 1.44 - 1.25 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 137.2, 133.7, 132.7, 131.9, 128.5, 119.5, 118.5, 73.0, 54.8, 34.3, 33.3, 26.8, 24.4. HRMS (ESI): calcd for $C_{13}H_{15}NOSeNa$ $[M+Na]^+$ 304.0212, found 304.0218.

2-(o-tolylseleno)cyclohexan-1-ol (**3c**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (87.5 mg, 81 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.59 (d, J = 7.5 Hz, 1H), 7.24 - 7.18 (m, 2H), 7.09 (t, J = 7.5 Hz, 1H), 3.46 - 3.41 (m, 1H), 3.00 - 2.95 (m, 1H), 2.82 (s, 1H), 2.48 (s, 3H), 2.19 - 2.12 (m, 2H), 1.75 - 1.19 (m, 1H), 1.50 - 1.43 (m, 1H), 1.36 - 1.22 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 141.5, 135.9, 130.1,

128.9, 128.1, 126.5, 73.1, 53.4, 34.1, 33.4, 26.8, 24.4, 23.3. HRMS (ESI): calcd for $C_{13}H_{18}OSeNa$ $[M+Na]^+$ 293.0416, found 293.0413.

2-(naphthalen-1-ylseleno)cyclohexan-1-ol (**3d**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (101.6 mg, 83 % yield). The ^1H and ^{13}C NMR spectra were in accordance with those described in the literature.[14]

2-(3-fluoro)phenylselenocyclohexan-1-ol (**3e**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (80.0 mg, 73 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.36 - 7.30 (m, 2H), 7.25 - 7.22 (m, 1H), 7.01 (t, J = 8.5 Hz, 1H), 3.38 - 3.34 (m, 1H), 2.98 - 2.93 (m, 1H), 2.80 (s, 1H), 2.20 - 2.13 (m, 2H), 1.76 - 1.64 (m, 2H), 1.48 - 1.20 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 162.4 (d, J_F = 248.8 Hz), 131.2 (d, J_F = 2.5 Hz), 130.2 (d, J_F = 7.5 Hz), 128.8 (d, J_F = 6.3 Hz), 122.3 (d, J_F = 21.3 Hz), 115.1 (d, J_F = 21.3 Hz), 72.6, 53.9, 34.1, 33.5, 26.8, 24.4. ^{19}F NMR (470 MHZ, $CDCl_3$): δ -111.92 (s, 1F). HRMS (ESI): calcd for $C_{12}H_{15}FOSeNa$ $[M+Na]^+$ 297.0165, found 297.0166.

2-(3-(trifluoromethyl)phenylseleno)cyclohexan-1-ol (**3f**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (95.9 mg, 74 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.52 (d, J = 8.0 Hz, 1H), 7.46 (s, 1H), 7.30 (t, J = 8.5 Hz, 1H), 7.17 (d, J = 8.0 Hz, 1H), 3.40 - 3.34 (m, 1H), 3.00 - 2.94 (m, 1H), 2.77 (s, 1H), 2.20 - 2.13 (m, 2H), 1.79 - 1.74 (m, 1H), 1.68 - 1.64 (m, 1H), 1.48 - 1.20 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 149.1, 133.8, 130.8, 129.1, 127.8, 120.5 (q, J_F = 256.3 Hz), 120.4, 72.7, 53.9, 34.2, 33.47, 26.8, 24.4. ^{19}F NMR (470 MHz, $CDCl_3$): δ -57.81 (s, 3F). HRMS (ESI): calcd for $C_{13}H_{15}F_3OSeNa$ $[M+Na]^+$ 347.0133, found 347.0134.

2-(3-nitro)phenylselenocyclohexan-1-ol (**3g**). Following the general procedure, using 8/1

petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid(78.3 mg, 65 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.44 (s, 1H), 8.15 (d, *J* = 8.0 Hz, 1H), 7.91 (d, *J* = 7.5 Hz, 1H), 7.46 (t, *J* = 8.0 Hz, 1H), 3.5 - 3.40 (m, 1H), 3.09 - 3.04 (m, 1H), 2.67 (s, 1H), 2.22 - 2.14 (m, 2H), 1.79 - 1.67 (m, 2H), 1.50 - 1.27 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 148.2, 140.9, 129.9, 129.6, 129.5, 122.7, 72.9, 54.1, 34.4, 33.5, 26.7, 24.3. HRMS (ESI): calcd for $C_{12}H_{16}NO_3Se$ $[M+H]^+$ 302.0290, found 302.0297.

2-(p-tolylseleno)cyclohexan-1-ol (**3h**). Following the general procedure, using 8/1 petroleum ether/ ethyl acetate as the eluant to afford yellow oil liquid (92.9 mg, 86 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.47 (d, *J* = 8.0 Hz, 2H), 7.09 (d, *J* = 8.0 Hz, 2H), 3.32 - 3.27 (m, 1H), 2.97 (s, 1H), 2.85 - 2.80 (m, 1H), 2.34 (s, 3H), 2.17 - 2.11 (m, 2H), 1.73 - 1.70 (m, 1H), 1.63 - 1.59 (m, 1H), 1.40 - 1.18 (m, 4H); ^{13}C NMR (125 MHZ, $CDCl_3$): δ 138.3, 136.5, 129.8, 122.6, 72.2, 58.5, 33.9, 33.3, 26.9, 24.5, 21.2. HRMS (ESI): calcd for $C_{13}H_{18}OSeNa$ $[M+Na]^+$ 293.0416, found 293.0418.

2-(p-methoxy)phenylselenocyclohexan-1-ol (**3i**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (92.7 mg, 81 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.50 (d, *J* = 9.0 Hz, 2H), 6.82 (d, *J* = 8.5 Hz, 2H), 3.81 (s, 3H), 3.27 - 3.23 (m, 1H), 2.98 (s, 1H), 2.79 - 2.73 (m, 1H), 2.13 - 2.10 (m, 2H), 1.72 - 1.59 (m, 2H), 1.33 - 1.19 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 159.9, 138.4, 115.9, 114.7, 71.9, 55.3, 53.4, 33.8, 33.2, 26.9, 24.5. HRMS (ESI): calcd for $C_{13}H_{18}O_2SeNa$ $[M+Na]^+$ 309.0365, found 309.0362.

2-(p-fluoro)phenylselenocyclohexan-1-ol (**3j**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (87.7 mg, 80 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.57 (t, *J* = 6.5 Hz, 2H), 6.99 (t, *J* = 8.5 Hz, 2H), 3.29 (s, 1H), 2.87 -

2.81 (m, 2H), 2.17 - 2.12 (m, 2H), 1.75 - 1.72 (m,1H), 1.63 - 1.62 (m, 1H), 1.38 - 1.19 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.1 (d, J_F = 247.5 Hz), 138.5 (d, J_F = 8.8 Hz), 120.9, 116.3 (d, J_F = 21.3 Hz), 72.1, 53.7, 33.9, 33.3, 26.8, 24.5. ^{19}F NMR (470 MHz, $CDCl_3$): δ -113.07 (s, 1F). HRMS (ESI): calcd for $C_{12}H_{16}FOSe$ $[M+H]^+$ 275.0345, found 275.0347.

2-((4-chlorophenyl)seleno)cyclohexan-1-ol (**3k**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (91.6 mg, 79 % yield). ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.51 (d, J = 8.0 Hz, 2H), 7.25 (d, J = 8.5 Hz, 2H), 3.34 - 3.29 (m, 1H), 2.91 - 2.87 (m, 1H), 2.84 (s, 1H), 2.17 - 2.12 (m, 2H), 1.74 - 1.62 (m, 2H), 1.43 - 1.22 (m, 4H); ^{13}C NMR ($CDCl_3$, 125 MHz): δ 137.4, 134.6, 129.2, 124.9, 72.3, 53.8, 34.0, 33.7, 26.8, 24.4. HRMS (ESI): calcd for $C_{12}H_{15}ClOSeNa$ $[M+Na]^+$ 312.9870, found 312.9873.

2-((4-bromophenyl)seleno)cyclohexan-1-ol (**3l**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (113.6 mg, 85 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.46 - 7.39 (m, 4H), 3.32 (s, 1H), 2.92 - 2.83 (m, 2H), 2.17 - 2.12 (m, 2H), 1.75 - 1.62 (m, 2H), 1.40 - 1.23 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 137.6, 132.2, 125.6, 122.8, 72.3, 53.8, 34.0, 33.4, 26.8, 24.4. HRMS (ESI): calcd for $C_{12}H_{15}BrOSeNa$ $[M+Na]^+$ 356.9364, found 356.9368.

2-((4-formylphenyl)seleno)cyclohexan-1-ol (**3m**). Following the general procedure, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (43.2 mg, 38 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.97 (s, 1H), 7.77 - 7.70 (m, 4H), 3.47 - 3.44 (m, 1H), 3.17 - 3.11 (m, 1H), 2.68 (s, 1H), 2.25 - 2.15 (m, 2H), 1.79 - 1.67 (m, 2H), 1.57 - 1.27 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 191.6, 137.9, 135.2, 133.9, 129.9, 73.1, 53.7, 34.3, 33.6, 26.8, 24.4. HRMS (ESI): calcd for $C_{13}H_{16}O_2SeNa$ $[M+Na]^+$ 307.0209, found 307.0211.

2-(p-methoxycarbonyl)phenylselenocyclohexan-1-ol (**3n**). Following the general procedure, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (44.0 mg, 35 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.92 (d, J = 8.5 Hz, 2H), 7.63 (d, J = 8.5 Hz, 2H), 3.91 (s, 3H), 3.43 - 3.38 (m, 1H), 3.08 - 3.03 (m, 1H), 2.75 (s, 1H), 2.22 - 2.13 (m, 2H), 1.77 - 1.66 (m, 2H), 1.49 - 1.26 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.7, 134.7, 134.3, 129.9, 129.3, 72.8, 53.7, 52.22, 34.2, 33.5, 26.8, 24.4. HRMS (ESI): calcd for $C_{14}H_{18}O_3SeNa$ $[M+Na]^+$ 337.0314, found 337.0316.

2-((3-chloro-4-amino)phenylseleno)cyclohexan-1-ol (**3o**). Following the general procedure, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid(95.2 mg, 78 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.24 - 7.21 (m, 1H), 7.16 (d, J = 8.5 Hz, 1H), 6.69 (t, J = 8.5 Hz, 1H), 3.85 (s, 2H), 3.27 - 3.22 (m, 1H), 2.95 (s, 1H), 2.77 - 2.71 (m, 1H), 2.13 - 2.11 (m, 2H), 1.73 - 1.70 (m, 1H), 1.62 - 1.60 (m, 1H), 1.36 - 1.17 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 151.7, 149.8, 135.3, 133.7, 123.9, 116.9, 71.8, 53.5, 33.8, 33.1, 26.8, 24.5. HRMS (ESI): calcd for $C_{12}H_{16}ClNOSeNa$ $[M+Na]^+$ 327.9979, found 327.9980.

2-(thiophen-3-ylseleno)cyclohexan-1-ol (**3p**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (73.4 mg, 70 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.44 - 7.42 (m, 1H), 7.32 - 7.30 (m, 1H), 7.12 (d, J = 5.0 Hz, 1H), 3.29 - 3.25 (m, 1H), 2.92 (s, 1H), 2.79 - 2.74 (m, 1H), 2.18 - 2.10 (m, 2H), 1.74 - 1.63 (m, 2H), 1.40 - 1.18 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 134.3, 131.1, 126.3, 118.9, 72.2, 53.4, 33.9, 33.3, 26.9, 24.5. HRMS (ESI): calcd for $C_{10}H_{15}OSSe$ $[M+H]^+$ 263.0004, found 263.0008.

2-(o-pyridylseleno)cyclohexan-1-ol (**3q**). Following the general procedure, using 2/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (77.1 mg, 75 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.39 - 8.37 (m, 1H), 7.50 - 7.44 (m, 2H), 7.09 - 7.06 (m, 1H), 6.24 (s, 1H), 3.66 -

3.61 (m, 1H), 3.49 - 3.43 (m, 1H), 2.28 - 2.21 (m, 2H), 1.80 - 1.73 (m, 1H), 1.71 - 1.70 (m, 1H), 1.61 - 1.53 (m, 1H), 1.42 - 1.27 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 156.0, 149.4, 136.5, 126.6, 120.8, 76.1, 50.9, 36.7, 32.6, 26.9, 24.3. HRMS (ESI): calcd for $C_{11}H_{15}NOSeNa$ $[M+Na]^+$ 280.0212, found 280.0211.

2-(phenylseleno)cyclopentan-1-ol (**4a**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (92.0 mg, 95 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.58 - 7.55 (m, 2H), 7.28 - 7.26 (m, 3H), 4.18 - 4.15 (m, 1H), 3.42 - 3.38 (m, 1H), 2.30 - 2.23 (m, 1H), 2.09 - 2.03 (m, 1H), 1.82 - 1.60 (m, 5H); ^{13}C NMR (125 MHz, $CDCl_3$) : δ 134.20, 129.36, 129.11, 127.48, 79.06, 49.29, 32.90, 31.12, 22.05. HRMS (ESI): calcd for $C_{11}H_{14}OSeNa$ $[M+Na]^+$ 265.0103, found 265.0101.

4-((2-hydroxycyclohexyl)seleno)tetrahydrofuran-3-ol (**4b**). Following the general procedure, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (79.1 mg, 81 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.57 - 7.54 (m, 2H), 7.30 - 7.27 (m, 3H), 4.37 - 4.31 (m, 2H), 4.02 (dd, J_1 = 4.5 Hz, J_2 = 9.5 Hz, 1H), 3.77 - 3.72 (m, 2H), 3.63 - 3.60 (m, 1H), 2.63 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 134.1, 129.4, 128.7, 127.9, 77.8, 74.0, 72.2, 47.4. HRMS (ESI): calcd for $C_{10}H_{12}O_2SeNa$ $[M+Na]^+$ 266.9896, found 266.9898.

2-methyl-1-(phenylseleno)propan-2-ol (**4c**). Following the general procedure, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (59.8 mg, 65 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.56 - 7.54 (m, 2H), 7.26 - 7.23 (m, 3H), 3.15 (s, 2H), 2.26 (s, 1H), 1.31 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 132.5, 130.9, 129.2, 127.0, 70.4, 44.4, 29.0. HRMS (ESI) : calcd for $C_{10}H_{14}OSeNa$ $[M+Na]^+$ 253.0103, found 253.0106.

1-(phenylseleno)butan-2-ol (**4d**). Following the general procedure, using 8/1 petroleum ether/ethyl

acetate as the eluant to afford yellow oil liquid (85.6 mg, 93 % yield). The ^{1}H and ^{13}C NMR spectra were in accordance with those described in the literature[16].

3,3-dimethyl-1-(phenylseleno)butan-2-ol (**4e**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (82.6 mg, 80 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.52 - 7.50 (m, 2H), 7.27 - 7.25 (m, 3H), 3.27 (dd, J_1 = 11.0 Hz, J_2 = 26.0 Hz, 2H), 2.80 (t, J = 12.0 Hz, 1H), 2.49 (s, 1H), 0.92 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 132.9, 129.4, 129.2, 127.2, 77.1, 34.9, 33.3, 25.8. HRMS (ESI): calcd for $C_{12}H_{18}OSeNa$ $[M+Na]^+$ 281.0416, found 281.0417.

1-butoxyl-3-(phenylseleno)-propan-2-ol (**4f**). Following the general procedure, after 12h, butyl glycidyl ether (156 mg, 3 equiv, 1.2 mmol) was added using syringe, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (99.1 mg, 86 % yield). The ^{1}H and ^{13}C NMR spectra were in accordance with those described in the literature[17].

4-(phenylseleno)buten-3-ol (**4g**). Following the general procedure, using 8/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (52.9 mg, 58 % yield). The ^{1}H and ^{13}C NMR spectra were in accordance with those described in the literature[18].

1-(phenylseleno)-3-(2-propen-1-yloxy)-propan-2-ol (**4h**). Following the general procedure, after 12h, allyl glycidyl ether (136.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (77.2 mg, 71 % yield). The ^{1}H and ^{13}C NMR spectra were in accordance with those described in the literature[17].

2`-propenoic acid-2-hydroxy-3-(phenylseleno)propyl ester (**4i**). Following the general procedure, after 12h, glycidyl methacrylate (170.4 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (36 mg, 30 % yield). The ^{1}H

and ^{13}C NMR spectra were in accordance with those described in the literature[17].

1-phenoxy-3-(phenylseleno)propan-2-ol (**4j**). Following the general procedure, after 12h, glycidyl phenyl ether (180.0 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether/ethyl acetate as the eluant to afford yellow oil liquid (82.6 mg, 67 % yield). The ^{1}H and ^{13}C NMR spectra were in accordance with those described in the literature[17].

1-(p-fluoro)phenoxy-3-(phenylseleno)propan-2-ol (**4k**). Following the general procedure, after 12h, (4-fluoro)phenoxymethyl oxirane (201.6 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether /ethyl acetate as the eluant to afford yellow oil liquid (122.6 mg, 94 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.55 - 7.53 (m, 2H), 7.25 - 7.23 (m, 3H), 6.96 - 6.92 (m, 2H), 6.80 - 6.77 (m, 2H), 4.11 - 4.07 (m, 1H), 4.01 - 3.95 (m, 2H), 3.22 - 3.19 (m, 1H), 3.14 - 3.10 (m, 1H), 2.68 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δδ 157.5 (d, J_F = 237.5 Hz), 154.5 (d, J_F= 1.3 Hz), 132.9, 129.3, 129.2, 127.4, 115.9 (d, J_F = 23.8 Hz), 115.6 (d, J_F= 8.8 Hz), 71.2, 69.0, 31.9. ^{19}F NMR (470 MHz, $CDCl_3$): δ -123.35 (s, 1F). HRMS (ESI): calcd for $C_{15}H_{15}FO_2SeNa$ $[M+Na]^+$ 349.0114, found 349.0120.

1-(p-chloro)phenoxy-3-(phenylseleno)propan-2-ol (**4l**). Following the general procedure, after 12h, (4-chloro)phenoxymethyl oxirane (220.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether /ethyl acetate as the eluant to afford yellow oil liquid (101.2 mg, 74 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54 - 7.52 (m, 2H), 7.25 - 7.24 (m, 3H), 7.20 (d, J = 9.0 Hz, 2H), 6.77 (d, J = 9.0 Hz, 2H), 4.12 - 4.07 (m, 1H), 4.01 - 3.95 (m, 2H), 3.20 (dd, J_1 = 5.5 Hz, J_2 = 13.0 Hz, 1H), 3.12 (dd, J_1 = 7.0 Hz, J_2 = 13.0 Hz, 1H), 2.73 (d, J = 4.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.0, 133.0, 129.4, 129.3, 129.1, 127.5, 126.1, 115.8, 70.8, 69.0, 31.9. HRMS (ESI): calcd for $C_{15}H_{15}ClO_2SeNa$ $[M+Na]^+$ 364.9819, found 364.9814.

1-(p-bromo)phenoxy-3-(phenylseleno)propan-2-ol (**4m**). Following the general procedure, after 12h, (4-bromo)phenoxymethyl oxirane (273.6 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether / ethyl acetate as the eluant to afford yellow oil liquid (118.9 mg, 77 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54 - 7.52 (m, 2H), 7.36 - 7.33 (m, 2H), 7.25 - 7.24 (m, 3H), 6.74 - 6.71 (m, 2H), 4.11 - 4.07 (m, 1H), 4.00 - 3.95 (m, 2H), 3.20 (dd, J_1 = 6.0 Hz, J_2 = 13.0 Hz, 1H), 3.11 (dd, J_1 = 7.0 Hz, J_2 = 13.0 Hz, 1H), 2.67 (d, J = 4.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.5, 133.0, 132.3, 129.3, 129.1, 127.5, 116.4, 113.4, 70.8, 68.9, 31.9. HRMS (ESI): calcd for $C_{15}H_{15}BrO_2SeNa$ $[M+Na]^+$ 408.9314, found 408.9310.

1-(p-methoxyl)phenoxy-3-(phenylseleno)propan-2-ol (**4n**). Following the general procedure, after 12h, (4-methoxy)phenoxymethyl oxirane (216.0 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether / ethyl acetate as the eluant to afford yellow oil liquid (117.6 mg, 87 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54 - 7.52 (m, 2H), 7.24 - 7.23 (m, 3H), 6.81 - 6.75 (m, 4H), 4.10 - 4.07 (m, 1H), 4.00 - 3.93 (m, 2H), 3.75 (s, 3H), 3.20 (dd, J_1 = 6.0 Hz, J_2 = 13.0 Hz, 1H), 3.11 (dd, J_1 = 7.0 Hz, J_2 = 13.0 Hz, 1H), 2.81 (d, J = 4.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 154.2, 152.5, 132.9, 129.4, 129.3, 127.4, 115.6, 114.7, 71.3, 69.2, 55.8, 31.9. HRMS (ESI): calcd for $C_{16}H_{18}O_3SeNa$ $[M+Na]^+$ 361.0314, found 361.0318.

1-(p-trifluoromethyl)phenoxy-3-(phenylseleno)propan-2-ol (**4o**). Following the general procedure, after 12h, (4-trifluoromethyl)phenoxymethyl oxirane (261.6 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether/ ethyl acetate as the eluant to afford yellow oil liquid (93.3 mg, 62 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54 - 7.50 (m, 4H), 7.24 - 7.23 (m, 3H), 6.89 (d, J = 8.55 Hz, 2H), 4.14 - 4.11 (m, 1H), 4.07 - 4.01 (m, 2H), 3.22 (dd, J_1 = 5.5 Hz, J_2 = 13.0 Hz, 1H), 3.13 (dd, J_1 = 7.0 Hz, J_2 = 13.0 Hz, 1H), 2.78 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$):

δ160.8, 133.1, 129.3, 128.9, 127.6, 127.0, 126.9, 126.8, 125.4, 123.4 (q, J_F = 31.3 Hz), 114.5, 70.6, 68.9, 31.9. ^{19}F NMR (470MHz, $CDCl_3$): δ -61.55 (s, 3F). HRMS (ESI): calcd for $C_{16}H_{15}F_3O_2SeNa$ $[M+Na]^+$ 399.0082, found 399.0084.

1-phenyl-2-(phenylseleno)ethan-1-ol (**4p**). Following the general procedure, after 12h, phenyl oxirane (144mg, 3equiv, 1.2mmol) was added using syringe, using petroleum ether/ ethyl acetate as the eluant to afford yellow oil liquid (84.5 mg, 76 % yield). The ^{1}H and ^{13}C NMR spectra were in accordance with those described in the literature[18].

1-(4-fluoro)phenyl -2-phenylselenoethan-1-ol (**4q**). Following the general procedure, after 12h, (4- fluoro)phenyl oxirane (184.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether / ethyl acetate as the eluant to afford yellow oil liquid (92.4 mg, 78 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.55 - 7.52 (m, 2H), 7.31 - 7.27 (m, 5H), 7.01 (t, J = 8.5 Hz, 2H), 4.72 - 4.70 (m, 1H), 3.26 (dd, J_1 = 3.5 Hz, J_2 = 13.0 Hz, 1H), 3.09 (dd, J_1 = 9.5 Hz, J_2 = 13.0 Hz, 1H), 2.85 (s,1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 162.4 (d, J_F = 248.7 Hz), 138.2 (d, J_F = 3.7 Hz), 133.2, 129.3, 128.9, 127.5, 127.5, 115.4 (d, J_F = 21.2 Hz), 71.6, 38.6. ^{19}F NMR (470 MHz, $CDCl_3$): δ -114.40 (s, 1F). HRMS (ESI): calcd for $C_{14}H_{14}FOSe$ $[M+H]^+$ 297.0189, found 297.0183.

1-(4-chloro)phenyl -2-phenylselenoethan-1-ol (**4r**). Following the general procedure, after 12h, (4-chloro)phenyl oxirane (184.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether /ethyl acetate as the eluant to afford yellow oil liquid(93.6 mg, 75 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.52 - 7.50 (m, 2H), 7.28 - 7.23 (m, 7H), 4.68 (d, J = 9.0 Hz, 1H), 3.24 (dd, J_1 = 3.5 Hz, J_2 = 13.0 Hz, 1H), 3.05 (dd, J_1 = 9.0 Hz, J_2 = 13.0 Hz, 1H), 2.93 (s, 1H); ^{13}C

NMR (125 MHz, $CDCl_3$): δ 140.9, 133.6, 133.3, 129.4, 128.9, 128.7, 127.6, 127.3, 71.5, 38.4. HRMS (ESI): calcd for $C_{14}H_{14}ClOSe$ $[M+H]^+$ 312.9893, found 312.9891.

1-(4-bromo)phenyl-2-phenylselenoethan-1-ol (**4s**). Following the general procedure, after 12h, (4-bromo)phenyl oxirane (237.6 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether/ ethyl acetate as the eluant to afford yellow oil liquid (102.5 mg, 72 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.54 - 7.50 (m, 2H), 7.43 (d, J = 8.0 Hz, 2H), 7.29 - 7.27 (m, 3H), 7.19 (d, J = 8.5 Hz, 2H), 4.69 - 4.66 (m, 1H), 3.25 (dd, J_1 = 3.5 Hz, J_2 = 12.5 Hz, 1H), 3.06 (dd, J_1 = 9.0 Hz, J_2 = 12.5 Hz, 1H), 2.87 (d, J = 3.0 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 141.5, 133.3, 131.6, 129.4, 128.8, 127.6, 127.6, 121.7, 71.6, 38.4. HRMS (ESI): calcd for $C_{14}H_{14}BrOSe$ $[M+H]^+$ 356.9388, found 356.9390.

1-(2-chloro)phenyl-2-phenylselenoethan-1-ol (**4t**). Following the general procedure, after 12h, (2-chloro)phenyl oxirane (184.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether /ethyl acetate as the eluant to afford yellow oil liquid (84.9 mg, 68 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.64 - 7.56 (m, 3H), 7.29 - 7.17 (m, 6H), 5.12 - 5.09 (m, 1H), 3.47 (dd, J_1 = 2.5 Hz, J_2 = 13.0 Hz, 1H), 2.95 (dd, J_1 = 9.5 Hz, J_2 = 13.0 Hz, 1H), 2.92 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 139.8, 133.2, 131.7, 129.4, 129.2, 128.8, 128.7, 127.5, 127.2, 127.01, 68.7, 36.6. HRMS (ESI): calcd for $C_{14}H_{14}ClOSe$ $[M+H]^+$ 312.9893, found 312.9890.

1-(phenylmethoxy)-3-(phenylseleno)-propan-2-ol (**4u**). Following the general procedure, after 12h, benzyl glycidyl ether (196.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether / ethyl acetate as the eluant to afford yellow oil liquid (109. 5 mg, 85 % yield). ^1H NMR (500 MHz, $CDCl_3$): δ 7.52 - 7.50 (m, 2H), 7.35 - 7.30 (m, 2H), 7.30 - 7.28 (m, 3H), 7.24 - 7.23 (m, 3H), 4.49 (s, 2H), 3.94 - 3.90 (m, 1H), 3.56 (dd, J_1 = 4.0 Hz, J_2 = 9.5 Hz, 1H), 3.51 (dd, J_1 = 6.0

Hz, J_2 = 9.5 Hz, 1H), 3.08 (dd, J_1 = 5.5 Hz, J_2 = 12.5 Hz, 1H), 3.02 (dd, J_1 = 7.0 Hz, J_2 = 12.5 Hz, 1H), 2.72 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 137.8, 132.9, 129.6, 129.2, 128.5, 127.9, 127.8, 127.2, 73.4, 72.9, 69.5, 31.9. HRMS (ESI): calcd for $C_{16}H_{18}O_2SeNa$ $[M+Na]^+$ 345.0365, found 345.0369.

1-(furan-2-ylmethoxy)-3-(phenylselanyl)propan-2-ol (**4v**). Following the general procedure, after 12h, furfuryl glycidyl ether (184.8 mg, 3 equiv, 1.2 mmol) was added using syringe, using 4/1 petroleum ether / ethyl acetate as the eluant to afford yellow oil liquid (76.1 mg, 61 % yield). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.52 - 7.50 (m, 2H), 7.39 (s, 1H), 7.26 - 7.24 (m, 3H), 6.34 - 6.33 (m, 1H), 6.30 - 6.29 (m, 1H), 4.44 (s, 2H), 3.91 - 3.86 (m, 1H), 3.56 (dd, J_1 = 4.0 Hz, J_2 = 9.5 Hz, 1H), 3.48 (dd, J_1 = 6.0 Hz, J_2 = 9.5 Hz, 1H), 3.06 (dd, J_1 = 5.5 Hz, J_2 = 12.5 Hz, 1H), 2.99 (dd, J_1 = 7.0 Hz, J_2 = 12.5 Hz, 1H), 2.61 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 151.4, 142.9, 132.8, 129.6, 129.2, 127.2, 110.3, 109.5, 72.7, 69.4, 65.4, 31.9. HRMS: (ESI) calcd for $C_{14}H_{16}O_3SeNa$ $[M+Na]^+$ 335.0158, found 335.0155.

ASSOCIATED CONTENT

Supporting Information

^{1}H, ^{13}C and ^{19}F NMR spectral data of all compounds reported. Supporting Information is available free of charge the ACS Publications website at http://pubs.acs.org.

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Notes

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