Preparation of a New Chiral Non-Racemic Sulfur-Containing Diselenide and Applications in Asymmetric Synthesis

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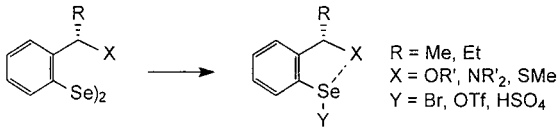
Abstract: The synthesis of the new chiral non-racemic sulfur-containing diselenide, di-2-methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl diselenide, is described. When treated with ammonium persulfate this diselenide is transformed into the corresponding selenenyl sulfate, which acts as a strong electrophilic reagent and adds to alkenes, in the presence of methanol or water, to afford the products of selenomethoxylation or selenohydroxylation, respectively, with excellent diastereoselectivities. Starting from alkenes containing internal nucleophiles, asymmetric cyclofunctionalization reactions also resulted in good chemical yields, complete regioselectivities, and high diastereoselectivities. This sulfur-containing diselenide can also be used in catalytic amounts to promote one-pot selenenylation – deselenenylation processes, from which several types of products can be obtained in high yield and with good enantiomeric excess.

Keywords: asymmetric synthesis · cyclization · selenium · selenohydroxylation · selenomethoxylation

Introduction

Organoselenium reagents are largely used in organic synthesis to introduce new functional groups into organic substrates under mild experimental conditions.[1] Several research groups have described the synthesis of a number of chiral non-racemic diselenides, which can be transformed in situ into electrophilic selenenylating reagents and can induce, in the presence of a suitable nucleophile, more or less efficient asymmetric addition reactions to alkenes.[1–6] Recently a new polymer-bound chiral electrophilic selenium reagent has also been developed, leading to improvements in stereoselective selenium-based solid-phase chemistry.[7]

A common characteristic of all the optically active diselenides described in the literature is the close proximity of an oxygen or a nitrogen atom to the selenium atom. This is exemplified in Scheme 1 by the diselenides **1** (X = OR′, NR′$_2$), which are some of the products investigated by Wirth.[1] On the basis of theoretical calculations, crystal structure determinations, and NMR data[8] it has been suggested that selenium can interact with nearby heteroatoms. This interaction, which is depicted by structure **2** in Scheme 1, and which is suggested to be the result of an orbital interaction between the heteroatom lone pair and the low-lying antibonding orbital of the SeY group (n-σ^*_{SeY}), would force the chiral center to approach the reaction center during the addition of the selenenylating agent to the alkene. This would result in asymmetric induction. Moreover, the same interaction should also dictate the structure of the active selenium reagent, thus playing a fundamental role in the formation of the preferred diastereomer of the addition products. We have recently prepared and investigated the sulfur-containing chiral diselenide **1** (X = SMe, R = Me).[9] The good results obtained in the asymmetric selenomethoxylations and selenohydroxylations of alkenes suggest that the interaction of selenium with sulfur is probably more important than those with oxygen or with nitrogen.



1 **2**

Scheme 1. Optically active diselenides **1** and the interaction with neighboring oxygen or nitrogen atoms in **2**.

It has recently been observed by Wirth and co-workers that in the case of the oxygen-containing diselenide **1** (X = OH, R = Me, Et), better diastereoselectivities could be obtained by introducing an appropriate substituent in the 6 position of

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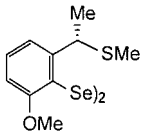
the aromatic ring.[10] The presence of a further substituent in the position *ortho* to the selenium atom can induce a greater conformational rigidity to the chiral electrophilic reagent and a more efficient transfer of chirality should be observed. On the basis of these considerations we have undertaken the synthesis of the methoxy-substituted sulfur-containing diselenide **3** in the hope that the corresponding electrophilic reagent should give rise to addition reactions to alkenes with a diastereoselectivity higher than those previously observed.



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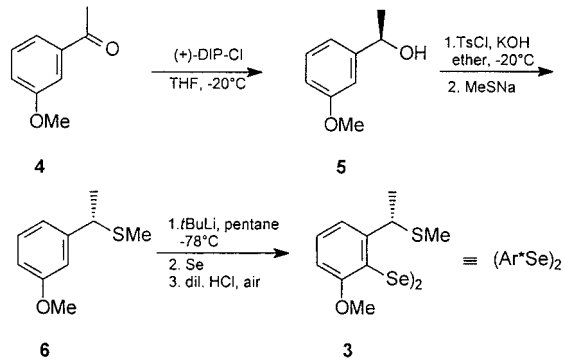
Results and Discussion

The synthesis of the diselenide **3** was very easy and was similar to that used by Wirth for the preparation of methoxy-substituted **1** (X = OH, R = Me). The commercially available ketone **4** was reduced to the corresponding optically active alcohol **5** with (+)-*β*-chlorodiisopinocampheylborane (DIP-Cl).[11] This alcohol (98% *ee*) was transformed into the tosylate and then treated with sodium methanethiolate to afford the sulfide **6**. The reaction of **6** with a 1.7 M solution of *t*BuLi in pentane gave the lithiated intermediate, which was dissolved in anhydrous THF and treated with selenium metal (Scheme 2). The diselenide **3** was obtained by oxidative

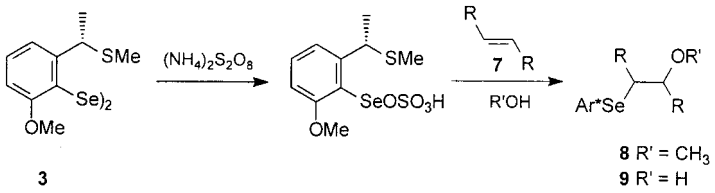


Scheme 2. Synthesis of diselenide **3**.

workup of the reaction mixture. The proton NMR spectrum, in the presence of (*S*)-(+)-2,2,2-trifluoro-1-(9-anthryl)ethanol, demonstrated that this compound was enantiomerically pure.

The efficiency of the diselenide **3** was first tested in the stereoselective selenomethoxylation and selenohydroxylation of several alkenes **7**. For this purpose the diselenide **3** was transformed in situ into the electrophilic selenenyl sulfate by treatment with ammonium persulfate according to the procedure described by us for the preparation of the phenylselenenyl sulfate from diphenyl diselenide.[12] Some preliminary experiments carried out with styrene indicated that at room temperature the diastereoselectivities were very poor. However, when the reactions were repeated at −30 °C the facial selectivities and the reaction yields were considerably increased.

In a typical experiment (Scheme 3) a solution of diselenide **3** (0.5 mmol) in CH_2Cl_2 (or CH_3CN in the cases of the selenohydroxylations) was treated with ammonium persulfate



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Scheme 3. Synthesis of **8** and **9**.

(0.5 mmol) and trifluoromethanesulfonic acid (1.0 mmol) at room temperature for 15 min. The alkenes **7** (1.5 equiv), dissolved in the nucleophilic solvents (MeOH or MeCN/H_2O), were added at −30 °C and the solution was stirred for 24 h. The progress of the reaction was monitored by GC-MS and/or TLC. After the usual workup compounds **8** and **9** were obtained as mixtures of the two enantiomerically pure diastereomers by column chromatography on silica gel. In no case could the two diastereomers be separated. Reaction yields and diasteromeric ratios (d.r.) are reported in Table 1. The diastereomeric ratios were determined by ^{1}H NMR analysis of the crude reaction mixtures. In the cases of *trans*-5-decene (**7e**) and cyclohexene (**7f**), good results could only be obtained by using selenenyl triflate instead of the sulfate, and by working at −78 °C.

As indicated in Table 1 reaction yields are good and, most interestingly, the diastereomeric ratios are excellent in every case, with the exception of the selenohydroxylation products deriving from cyclohexene. In Table 1 also gives the diastereomeric ratios obtained with the di-2-[(1*S*)-1-(methylthio)-ethyl]phenyl diselenide **1** (X = SMe, R = Me). In every case the results obtained with the diselenide **3** are better than those obtained with **1**, indicating that the presence of the methoxy group in the proximity of the selenium atom is greatly beneficial for better chirality tranfer. As a matter of fact the diastereoselectivities obtained with **3** compare favorably with those observed with the most efficient chiral non-racemic diselenides described in the literature. Moreover, a further important property of the diselenide **3** is that the addition reactions can be carried out at relatively high temperatures, whereas with all of the other optically active selenenylating reagents efficient asymmetric inductions are obtained only by working at very low temperatures.

The absolute configurations of the major isomers were estabilished in some cases by deselenenylation and comparison of the resulting enantiomers with commercial products or with compounds described in the literature.[9] As indicated in Scheme 4, the reductive deselenenylation of **8a** and **9a** with triphenyltin hydride and 2,2′-azobisisobutyronitrile (AIBN) in refluxing benzene afforded (−)-(*S*)-**10** and (−)-(*S*)-**11**, whereas the oxidative elimination of **8b** and **9b** with hydrogen peroxide in methanol afforded (+)-(*S*)-**12** and (−)-(*S*)-**13**, respectively.

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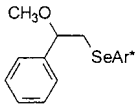
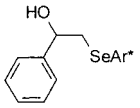
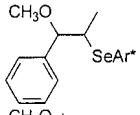
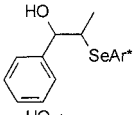
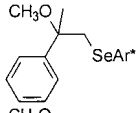
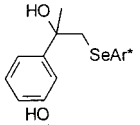
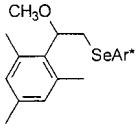
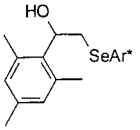
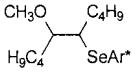
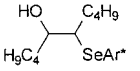
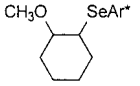
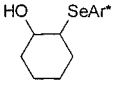
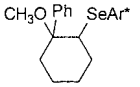
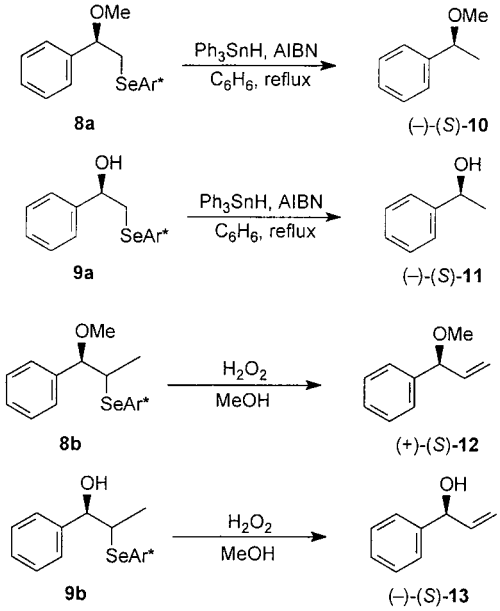
Table 1. Selenomethoxylation, in methanol, and selenohydroxylation, in acetonitrile and water (2:1), of alkene **7** with the diselenide **3** and ammonium persulfate at $-30\,^{\circ}C$.[a]

Starting alkenes **7**	Selenomethoxylation products **8**[b]		Yield [%][c]	d.r.[d]	Selenohydroxylation products **9**[b]		Yield [%][c]	d.r[d]
styrene **7a**		**8a**	72	98:2 *96:4*		**9a**	65	98:2 *95:5*
β-methylstyrene **7b**		**8b**	75	98:2 *96:4*		**9b**	70	98:2 *96:4*
α-methylstyrene **7c**		**8c**	58	95:5 *90:10*		**9c**	73	98:2 *90:10*
2,4,6-trimethylstyrene **7d**		**8d**	60	99:1		**9d**	75	99:1
trans-5-decene **7e**		**8e**	70	96:4 *90:10*		**9e**	79	96:4 *88:12*
cyclohexene **7f**		**8f**	77	91:9 *82:18*		**9f**	60	72:28
1-phenyl-1-cyclohexene **7g**		**8g**	60	98:2				

[a] In the cases of **7e** and **7f** the reactions were carried out at $-78\,^{\circ}C$ with the selenenyl triflate derived from **3**. [b] The two diastereoisomers could not be separated. In no case could the presence of regioisomers be detected. [c] Based on the amounts of the diselenide employed. [d] The diastereomeric ratios were determined from the proton NMR spectra of the crude reaction mixtures and confirmed after purification by column chromatography. The values reported in italics refer to the reactions carried out with the diselenide **1** (X = SMe, R = Me).[14]



Scheme 4. Reductive deselenenylation reactions of **8a** and **9a** and oxidative elimination reactions of **8b** and **9b**.

The enantiomeric excesses of **10**, **11**, **12**, and **13** were determined by recording their proton NMR spectra in the presence of (*S*)-(+)-2,2,2-trifluoro-1-(9-anthryl)ethanol. As expected, the values obtained corresponded to the diastereomeric ratios of **8a**, **9a**, **8b**, and **9b**. Under the reasonable assumption that the facial selectivity of selenomethoxylation and selenohydroxylation does not change on passing from styrene and β-methylstyrene to α-methylstyrene and 2,4,6-trimethylstyrene, it can be suggested that the chiral centers in **8c**, **9c** and **8d**, **9d** have the same absolute configurations as those of **8a**, **9a** and **8b**, **9b**.

The efficiency of the diselenide **3** in promoting selenocyclization reactions was then explored by using some selected examples. These reactions were carried out, as in the case of the intermolecular processes described above, at $-30\,^{\circ}C$ and with the selenenyl sulfate generated by the oxidation of **3**. The ring-closure reactions investigated were those of the alkenol **14**, the alkenoic acids **16** and **18**, and of the O-allyl oxime **20**, which afforded the cyclic ether **15**, the lactones **17** and **19**, and the isoxazolidine **21**,[13] respectively. The results are collected in Table 2. We also observed that in these cases the reactions promoted by the electrophilic reagent deriving from **3** proceed with diastereoselectivities higher than those observed with the diselenide **1** (X = SMe, R = Me).[14] The absolute configuration of compound **19** was established after conversion into the corresponding butenolide,[15] (–)-(*R*)-**29**, by oxidation with ammonium persulfate.

One of the most interesting and recent developments in organoselenium chemistry is represented by the one-pot selenenylation–deselenenylation sequences, which can be performed with only catalytic amounts of the organoselenium reagents.[16]

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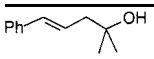
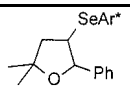
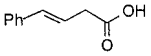
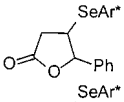
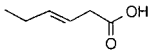
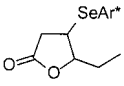
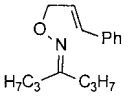
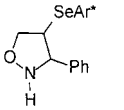
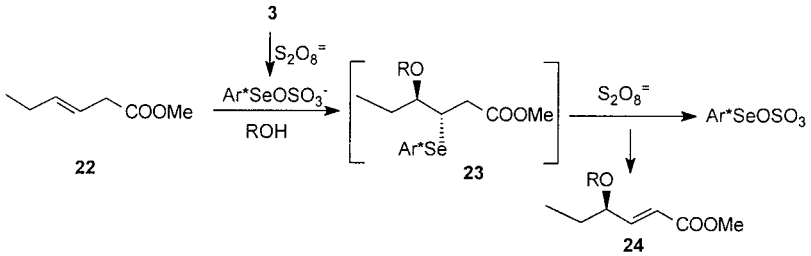
Table 2. Selenocyclization reactions of alkenes containing internal nucleophiles with the diselenide **3** and ammonium persulfate at −30 °C.

Starting alkenes		Cyclization products[a]		Yield [%][b]	d.r.[c]
	**14**		**15**	69	96:4 *93:7*
	**16**		**17**	72	98:2
	**18**		**19**	60	92:8 *89:11*
	**20**		**21**	70	96:4

[a] The two diastereoisomers could not be separated. In no case the presence of regioisomers could be detected. [b] Based on the amounts of the diselenide employed. [c] The diastereomeric ratios were determined from the proton NMR spectra of the crude reaction mixtures and confirmed after purification by column chromatography. The values reported in italics refer to the reactions carried out with the diselenide **1** (X = SMe, R = Me).[14]

As exemplified in Scheme 5 this sequence is carried out with the selenenyl sulfate, generated from diselenide and persulfate, as the electrophilic reagent for the initial addition to an alkene, as for instance **22**. The resulting selenide **23** is then oxidized by the excess of persulfate, affording the



Scheme 5. Selenenylation–deselenenylation sequence used to generate **24**.

deselenenylated compound **24** and, at the same time, regenerating the selenenyl sulfate. Several optically active diselenides have been employed in this reaction. Enantioselectivities of up to 70–80% were achieved, but turnover numbers were still small.[4c, 5a, 17, 18]

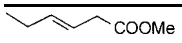
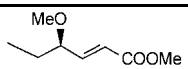
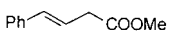
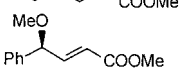
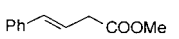
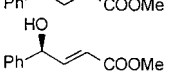
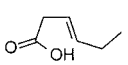
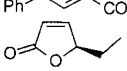
We have tested the efficiency of the diselenide **3** as a catalyst for the promotion of the one-pot conversion of β,γ-unsaturated esters **22** and **26** into the allyl ethers **25** and **27**, the ester **26** into the allylic alcohol **28**, and the γ-alkenoic acid **18** into the butenolide **29**. The reactions were carried out at room temperature using 5% of the diselenide **3** and an excess of ammonium persulfate. Reaction times, yields, and enantiomeric excesses, determined by recording the proton NMR spectra in the presence of (*S*)-(+)-2,2,2-trifluoro-1-(9-anthryl)-ethanol, are reported in Table 3. The use of a larger amount of the diselenide did not produce substantial increases in the enantioselectivity. In the case of **18** the cyclization reaction was performed at −30 °C to obtain a better enantiomeric excess. Absolute configurations of the reaction products were established by comparison with compounds already described in the literature.[15, 18]

The results collected in Table 3 indicate that reaction yields are very good in every case. The enantioselectivities of these ring-closure reactions are not as good as those obtained in the stoichiometric experiments described above. However, apart from the case of the butenolide **29**, the enantiomeric excesses obtained in the other conversions can be considered satisfactory and are better than those obtained in the most efficient catalytic processes promoted by other diselenides reported in the literature. In our opinion the enantiomeric excesses observed in these reactions are high enough to justify the further use of the diselenide **3** for the synthesis of enantiomerically enriched compounds using the selenenylation–deselenenylation sequence.

In conclusion, the experimental data described above demonstrate that the easily available diselenide **3** represents one of the most convenient reagents for very efficient selenium-promoted asymmetric syntheses under very simple experimental conditions. The diastereoselectivities obtained with **3** compare favorably with those observed with the most efficient chiral non-racemic diselenides described in the literature which, moreover, afford good results only at very low temperatures. The efficient catalytic one-pot selenenylation–deselenenylation sequences, which produce several types of products in high yield and with good enantiomeric excesses, represent a further advantage of this new diselenide.

The efficiency of the diselenide **3** confirms that the conformational restriction imposed by the interaction of the selenium atom with the close sulfur atom is very likely the most important factor responsible for the high facial selectivities observed in the addition of the electrophilic selenium

Table 3. Selenenylation–deselenenylation sequences promoted by catalytic amounts of the diselenide **3**.

Starting alkenes		Solvent	*T* [°C]	Time [h]	Reaction product		Yield [%]	*ee*[a] [%]
	**22**	MeOH	20	68		(+)-(*R*)-**25**	98	68
	**26**	MeOH	20	48		(−)-(*S*)-**27**	98	78
	**26**	MeCN/$H_2$0	20	96		(−)-(*S*)-**28**	98	82
	**18**	CH_2Cl_2	−30	48		(−)-(*R*)-**29**	85	55

[a] The enantiomeric excesses were determined by recording the proton NMR spectra in the presence of (*S*)-(+)-2,2,2-trifluoro-1-(9-anthryl)ethanol.

reagent to alkenes.[9] In this respect, as already observed by Wirth and co-workers with the diselenide **1** (X = OH, R = Me, Et),[10] the results now described confirm that the presence of the methoxy group in the proximity of the selenium atom is greatly beneficial for better chirality tranfer.

Experimental Section

General: All new compounds were fully characterized by ^{1}H NMR, ^{13}C NMR, mass spectra, and elemental analyses. ^{1}H, ^{13}C, and ^{77}Se NMR spectra were recorded at 400, 100.62, and 76.27 MHz, respectively, on a Bruker Avance-DRX 400 instrument. GC-MS analyses were carried out with an HP-6890 gas chromatograph (dimethyl silicone column, 12.5 m) equipped with an HP-5973 mass-selective detector. Optical rotations were measured with a JASCO DIP-1000 digital polarimeter. FT-IR spectra were recorded on a JASCO FT-IR-410 spectrophotometer. Elemental analyses were carried out on a Carlo Erba 1106 elemental analyzer. All the alkenes employed for the present investigation were commercially available.

Synthesis of 1-methoxy-3-[(1*S*)-1-(methylthio)ethyl]benzene (6): TsCl (1 mmol) and KOH (2 mmol) were added to a solution of the optically pure (1*R*)-1-(3-methoxyphenyl)ethanol (**5**)[19] (1 mmol) in diethyl ether at $-20\,^\circ$C. After 24 h MeSNa (4 mmol) was added and the reaction mixture was warmed to room temperature and stirred for 12 h. After the usual workup the reaction mixture was purified by flash chromatography on a silica gel column with a mixture of diethyl ether and light petroleum (1:9) as eluant. Pure **6** was obtained as an oil in 75% yield. $[\alpha]_D^{23.9} = -128$ ($c = 9.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.26$ (dt, ^3J(H,H) = 8.1 Hz, ^5J(H,H) = 1.0 Hz, 1H; CH), 6.9 (m, 2H; CH), 6.81 (ddd, ^3J(H,H) = 8.1 Hz, ^4J(H,H) = 2.6 Hz, ^4J(H,H) = 1.0 Hz, 1H; CH); 3.84 (q, ^3J(H,H) = 7.0 Hz, 1H; CH), 3.83 (s, 3H; OCH_3), 1.95 (s, 3H; SCH_3), 1.6 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.1$, 145.8, 129.8, 120.1, 113.3, 112.7, 55.6, 46.1, 22.5, 15.0; GC-MS: *m*/*z* (%): 182 (44) [M^+], 135 (100), 120 (9), 105 (23), 103 (13), 91 (14), 79 (8), 77 (8), 65 (5), 51 (2); elemental analysis calcd (%) for $C_{10}H_{14}OS$ (182.3): C 65.89, H 7.74; found: C 66.05, H 7.64.

Synthesis of the di-2-methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl diselenide (3): The sulfide **6** (1 mmol) was treated with a 1.7 M solution of *t*BuLi (1.5 mmol) in pentane at $-78\,^\circ$C. After 15 min the temperature was raised to 25 °C and the mixture was stirred for 30 min. The resulting red precipitate was dissolved in freshly distilled THF at $-78\,^\circ$C, and elemental selenium (2 mmol) was added at the same temperature. The solution was stirred for 12 h at room temperature and then poured into a 7% solution of hydrochloric acid. The mixture was worked up in the usual way and the crude product was purified by flash chromatography on a silica gel column with a mixture of diethyl ether and light petroleum (2:8) as eluant. The diselenide **3** was obtained as a yellow oil in 70% yield. $[\alpha]_D^{19} = -336.1$ ($c = 0.5$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.3$ (dd, ^3J(H,H) = 8.2, 7.8 Hz, 2H; CH), 7.09 (dd, ^3J(H,H) = 7.8 Hz, ^4J(H,H) = 1.2 Hz, 2H; CH), 6.8 (dd, ^3J(H,H) = 8.2 Hz, ^4J(H,H) = 1.2 Hz, 2H; CH); 4.5 (q, ^3J(H,H) = 7.0 Hz, 2H; CH), 3.78 (s, 6H; OCH_3), 1.89 (s, 6H; SCH_3), 1.35 (d, ^3J(H,H) = 7.0 Hz, 6H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.1$, 148.4, 130.1, 122.0, 118.8, 109.3, 56.1, 44.5, 21.1, 14.0; ^{77}Se NMR (76.27 MHz, $CDCl_3$, 25 °C): $\delta = 365.7$; GC-MS: *m*/*z* (%): 392 (7) [M^+], 377 (100), 261 (29), 213 (47), 198 (17), 149 (94), 134 (14), 91 (7), 77 (5); elemental analysis calcd (%) for $C_{20}H_{26}O_2S_2Se_2$ (520.5): C 46.17, H 5.04; found: C 45.84, H 5.32.

Selenomethoxylation of alkenes, general procedure: Ammonium persulfate (0.5 mmol) and trifluoromethanesulfonic acid (1 mmol) were added to a solution of the diselenide **3** (0.5 mmol) in CH_2Cl_2 and the resulting red solution was stirred at room temperature for 15 min. The solution was cooled to $-30\,^\circ$C and a solution of the alkene **7** (1.5 mmol) in methanol was added. The mixture was stirred for 24 h at the same temperature. The progress of the reaction was monitored by GC-MS and/or TLC. The reaction mixture was then poured into a 10% solution of $NaHCO_3$ and extracted with diethyl ether. The combined organic layers were washed with brine, dried over sodium sulfate, filtered, and evaporated. The reaction products were separated by column chromatography on silica gel with a mixture of diethyl ether and light petroleum (1.5:8.5) as eluant. The reaction yields and the diastereomeric ratios of the selenomethoxylation products thus obtained are reported in Table 1. Physical and spectral data are reported below.

1-Methoxy-2-{[(2*R*)-2-methoxy-2-phenylethyl]seleno}-3-[(1*S*)-1-(methylthio)ethyl]benzene (8a): Oil; $[\alpha]_D^{22} = -103.2$ ($c = 0.31$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.4-7.3$ (m, 6H; CH), 7.18 (dd, ^3J(H,H) = 7.7 Hz, ^4J(H,H) = 0.9 Hz, 1H; CH), 6.8 (dd, ^3J(H,H) = 8.2 Hz, ^4J(H,H) = 0.9 Hz, 1H; CH), 4.92 (q, ^3J(H,H) = 7.0 Hz, 1H; CH), 4.29 (dd, ^3J(H,H) = 8.7, 4.9 Hz,1H; CH), 3.8 (s, 3H; OCH_3), 3.27 (s, 3H; OCH_3), 3.19 (dd, ^2J(H,H) = 12.1 Hz, ^3J(H,H) = 8.7 Hz, 1H; CH_2), 3.09 (dd, ^2J(H,H) = 12.1 Hz, ^3J(H,H) = 4.9 Hz, 1H; CH_2), 1.96 (s, 3H; SCH_3), 1.57 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 159.4$, 148.1, 141.1, 129.1, 128.3, 127.8, 126.4, 125,7, 119.1, 108.9, 83.3, 56.8, 55.9, 44.2, 34.7, 21.6, 13.9; ^{77}Se NMR (76.27 MHz, $CDCl_3$, 25 °C): $\delta = 146.8$; GC-MS: *m*/*z* (%): 396 (41) [M^+], 381 (5), 361 (100), 345 (17), 213 (94), 198 (43), 135 (40), 121 (38), 103 (27), 91 (29), 77 (20), 61 (7); elemental analysis calcd (%) for $C_{19}H_{24}O_2SSe$ (395.4): C 57.72, H 6.12; found: C 58.10, H 6.15.

1-Methoxy-2-[(1*S*,2*R*)-2-methoxy-1-methyl-2-phenylethyl]seleno-3-[(1*S*)-1-(methylthio)ethyl]benzene (8b): Oil; $[\alpha]_D^{23.5} = -103.2$ ($c = 0.34$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.3-7.2$ (m, 7H; CH), 6.8 (dd, ^3J(H,H) = 8.1 Hz, ^4J(H,H) = 1.0 Hz, 1H; CH), 4.79 (q, ^3J(H,H) = 7.0 Hz, 1H; CH), 4.17 (d, ^3J(H,H) = 4.6 Hz, 1H; CH), 3.84 (s, 3H; OCH_3), 3.63 (dq, ^3J(H,H) = 4.6, 7.0 Hz, 1H; CH), 3.15 (s, 3H; OCH_3), 1.86 (s, 3H; SCH_3), 1.43 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3), 1.2 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.2$, 149.0, 140.4, 129.7, 128.5, 127.9, 127.3, 126.2, 119.7, 109.3, 86.6, 57.9, 56.7, 44.7, 44.5, 30.1, 16.1, 14.5; GC-MS: *m*/*z* (%): 410 (9) [M^+], 261 (100), 213 (71), 198 (19), 181 (4), 149 (19), 17 (24), 115 (17), 105 (7), 91 (21), 75 (18); elemental analysis calcd (%) for $C_{20}H_{26}O_2SSe$ (409.4): C 58.68, H 6.40; found: C 58.47, H 6.52.

1-Methoxy-2-[(2*R*)-2-methoxy-2-phenylpropyl]seleno-3-[(1*S*)-1-(methylthio)ethyl]benzene (8c): Oil; $[\alpha]_D^{29.6} = -3.5$ ($c = 1.5$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.4-7.5$ (m, 6H; CH), 7.2 (dd, ^3J(H,H) = 7.7 Hz, ^4J(H,H) = 0.9 Hz, 1H; CH), 6.6 (dd, ^3J(H,H) = 8.2 Hz, ^4J(H,H) = 0.9 Hz, 1H; CH), 4.85 (q, ^3J(H,H) = 7.0 Hz, 1H; CH), 3.8 (s, 3H; OCH_3), 3.28 (d, ^3J(H,H) = 11.5 Hz, 1H; CH), 3.17 (d, ^3J(H,H) = 11.5 Hz, 1H; CH_2), 3.08 (s, 3H; OCH_3), 1.85 (s, 3H; SCH_3), 1.5 (s, 3H, CH_3), 1.3 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.0$, 148.4, 130.3, 129.2, 128.1, 128.0, 127.1, 126.2, 119.1, 109.3, 96.1, 55.9, 50.9, 44.4, 41.4, 23.5, 21.1, 14.0; GC-MS: *m*/*z* (%): 410 (13) [M^+], 261 (39), 245 (11), 213 (31), 198 (14), 149 (20), 135 (100), 117 (13), 105 (8), 91 (12), 77 (6); elemental analysis calcd (%) for $C_{20}H_{26}O_2SSe$ (409.4): C 58.68, H 6.40; found: C 58.02, H 6.54.

2-[(1*R*)-1-Methoxy-2-({2-methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)ethyl]-1,3,5-trimethylbenzene (8d): Oil; $[\alpha]_D^{20.9} = -47.9$ ($c = 1$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.23$ (dd, ^3J(H,H) = 7.8, 7.2 Hz, 1H; CH), 7.07 (dd, ^3J(H,H) = 7.8 Hz, ^4J(H,H) = 1.2 Hz, 1H; CH), 6.69 (s, 2H; CH), 6.68 (dd, ^3J(H,H) = 7.2 Hz, ^4J(H,H) = 1.2 Hz, 1H; CH), 4.91 (q, ^3J(H,H) = 7.0 Hz, 1H; CH), 4.58 (dd, ^3J(H,H) = 10.5, 3.9 Hz, 1H; CH), 4.8 (s, 3H; OCH_3), 3.23 (dd, ^2J(H,H) = 12.4 Hz, ^3J(H,H) = 10.5 Hz, 1H; CH_2), 3.09 (s, 3H; OCH_3), 2.99 (dd, ^2J(H,H) = 12.4 Hz, ^3J(H,H) = 3.9 Hz, 1H; CH_2), 2.16 (s, 9H; CH_3), 1.87 (s, 3H; SCH_3), 1.51 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.0$, 149.2, 137.2, 137.1, 133.4, 129.8, 128.9, 119.7, 119.5, 109.4, 80.2, 56.8, 56.4, 45.1, 31.7, 21.9, 21.2, 20.6, 14.4; elemental analysis calcd (%) for $C_{22}H_{30}O_2SSe$ (437.5): C 60.41, H 6.91; found: C 61.01, H 5.97.

2-[1-Butyl-2-methoxyhexyl]seleno-1-methoxy-3-[(1*S*)-1-(methylthio)ethyl]-benzene (8e): Oil; $[\alpha]_D^{29.2} = -25.4$ ($c = 0.5$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.3$ (dd, ^3J(H,H) = 8.0, 7.8 Hz, 1H; CH), 7.2 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 1.2 Hz, 1H; CH), 6.76 (dd, ^3J(H,H) = 7.8 Hz, ^4J(H,H) = 1.2 Hz, 1H; CH), 5.03 (q, ^3J(H,H) = 7.0 Hz, 1H; CH), 3.9 (s, 3H; OCH_3), 3.65 (dt, ^3J(H,H) = 7.04, 4.3 Hz, 1H; CH), 3.51 (s, 3H; OCH_3), 3.5 (q, ^3J(H,H) = 7.04 Hz, 1H; CH), 1.95 (s, 3H; SCH_3), 1.56 (d, ^3J(H,H) = 7.0 Hz, 3H; CH_3), 1.4–1.2 (m, 12H; CH_2), 1–0.8 (m, 6H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.0$, 149.0, 130.7, 129.5, 120.1, 109.2, 84.5, 58.0, 56.3, 48.9, 44.8, 31.5, 31.0, 30.9, 28.4, 23.1, 23.0, 22.4, 14.6, 14.5, 14.4; elemental analysis calcd (%) for $C_{21}H_{36}O_2SSe$ (431.5): C 58.46, H 8.40; found: C 58.55, H 8.90.

1-Methoxy-2-[2-methoxycyclohexyl]seleno-3-[(1*S*)-1-(methylthio)ethyl]-benzene (8f): Oil; $[\alpha]_D^{27.3} = +1.1$ ($c = 1$ in $CHCl_3$); ^{1}H NMR (400 MHz,

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$CDCl_3$, 25 °C, TMS): $\delta = 7.32$ (dd, $^3J(H,H) = 7.8$, 7.9 Hz, 1H; CH), 7.25 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.3$ Hz, 1H; CH), 6.77 (dd, $^3J(H,H) = 7.9$ Hz, $^4J(H,H) = 1.3$ Hz, 1H; CH), 5.03 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 3.9 (s, 3H; OCH_3), 3.5 (m, 1H; CH), 3.37 (s, 3H; OCH_3), 3.3 (m, 1H; CH), 1.96 (s, 3H; SCH_3), 1.8–1.6 (m, 8H; CH_2), 1.5 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.3$, 149.5, 129.8, 129.0, 119.9, 109.2, 83.4, 56.4, 46.6, 45.0, 31.6, 30.4, 30.1, 26.0, 23.7, 23.0, 14.9; GC-MS: *m/z* (%): 374 (27) [M^+], 261 (100), 213 (86), 198 (21), 181 (6), 134 (8), 113 (7), 81 (24), 77 (3), 71 (5), 55 (3); elemental analysis calcd (%) for $C_{17}H_{26}O_2SSe$ (373.4): C 54.69, H 7.02; found: C 55.01, H 7.20.

1-Methoxy-2-[(2-methoxy-2-phenylcyclohexyl)seleno]-3-[(1*S*)-1-(methylthio)ethyl]benzene (8g): Oil; $[\alpha]_D^{24.4} = -88.8$ ($c = 0.47$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): δ 7.3–7.1 (m, 6H; CH), 6.81 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.5 (dd, $^3J(H,H) = 8.2$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 3.92 (q, $^3J(H,H) = 6.9$ Hz, 1H; CH), 3.75 (s, 3H; OCH_3), 3.74 (m, 1H; CH), 2.78 (s, 3H; OCH_3), 2.4–2.2 (m, 6H; CH_2), 1.73 (s, 3H; SCH_3), 1.8–1.7 (m, 2H; CH_2), 1.2 (d, $^3J(H,H) = 6.9$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.6$, 148.0, 144.2, 128.9, 128.0, 127.7, 127.1, 121.2, 119.0, 109.3, 80.0, 56.2, 53.5, 50.5, 44.1, 28.6, 26.0, 22.1, 21.9, 21.4, 13.8; elemental analysis calcd (%) for $C_{23}H_{30}O_2SSe$ (449.5): C 61.46, H 6.73; found: C 61.15, H 6.54.

Selenohydroxylation of alkenes, general procedure: Ammonium persulfate (0.5 mmol) and trifluoromethanesulfonic acid (1 mmol) were added to a solution of the diselenide **3** (0.5 mmol) in CH_3CN and the resulting red solution was stirred at room temperature for 15 min. The solution was then cooled to −30 °C and a solution of the alkene **7** (1 mmol) in CH_3CN/H_2O (2:1) was added. The mixture was stirred for 24 h at the same temperature. The progress of the reaction was monitored by GC-MS and/or TLC. The reaction mixture was then poured into a 10% solution of $NaHCO_3$ and extracted with diethyl ether. The combined organic layers were washed with brine, dried over sodium sulfate, filtered, and evaporated. The reaction products were separated by column chromatography on silica gel with a mixture of diethyl ether and light petroleum (3:7) as eluant. The reaction yields and the diastereomeric ratios of the selenohydroxylation products thus obtained are reported in Table 1. Physical and spectral data are reported below.

(1*R*)-2-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)-1-phenylethanol (9a): Oil; $[\alpha]_D^{23.4} = -38.8$ ($c = 1.03$ in $CHCl_3$); FT-IR (neat): 3381 cm^{-1} (broad band); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta =$ 7.4–7.1 (m, 7H; CH), 6.8 (dd, $^3J(H,H) = 8.1$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 4.86 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 4.55 (dd, $^3J(H,H) = 9.9$ Hz, 3.0 Hz, 1H; CH), 3.89 (s, 3H; OCH_3), 3.75 (s, 1H; OH); 3.28 (dd, $^2J(H,H) = 12.5$ Hz, $^3J(H,H) = 3.0$ Hz, 1H; CH_2), 2.88 (dd, $^2J(H,H) =$ 12.5 Hz, $^3J(H,H) = 9.9$ Hz, 1H; CH_2), 1.95 (s, 3H; SCH_3), 1.55 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.1$, 149.3, 148.8, 143.1, 130.5, 128.8, 128.0, 126.1, 120.3, 109.8, 72.7, 56.6, 45.2, 39.6, 22.1, 14.7; GC-MS: *m/z* (%): 382 (14) [M^+], 261 (88), 259 (45), 245 (7), 213 (100), 211 (52), 198 (36), 181 (8), 134 (14), 103 (14), 91 (19), 77 (16), 61 (8); elemental analysis calcd (%) for $C_{18}H_{22}O_2SSe$ (381.4): C 56.70, H 5.81; found: C 56.43, H 5.95.

(1*R*,2*S*)-2-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)-1-phenylpropan-1-ol (9b): Oil; $[\alpha]_D^{22.8} = -10.4$ ($c = 0.53$ in $CHCl_3$); FT-IR (neat): 3437 cm^{-1} (broad band); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.3-7.2$ (m, 7H; CH), 6.8 (dd, $^3J(H,H) = 8.1$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 4.9 (q, $^3J(H,H) = 6.9$ Hz, 1H; CH), 4.47 (d, $^3J(H,H) = 2.6$ Hz, 1H; CH), 3.91 (s, 3H; OCH_3), 3.8 (dq, $^3J(H,H) = 2.6$, 7.1 Hz, 1H, CH), 3.35 (s, 1H; OH), 2.0 (s, 3H; SCH_3), 1.5 (d, $^3J(H,H) = 6.9$ Hz, 3H, CH_3), 1.1 (d, $^3J(H,H) = 7.1$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.0$, 149.5, 139.3, 135.9, 130.3, 128.0, 127.0, 125.9, 120.0, 109.3, 96.1, 73.6, 56.3, 47.2, 30.3, 22.0, 13.0; GC-MS: *m/z* (%): 396 (1) [M^+], 281 (16), 261 (100), 213 (85), 207 (48), 198 (24), 134 (21), 122 (11), 117 (16), 105 (31), 91 (29), 77 (32), 57 (19); elemental analysis calcd (%) for $C_{19}H_{24}O_2SSe$ (395.4): C 57.72, H 6.12; found: C 57.44, H 6.34.

(2*R*)-2-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)-2-phenylpropan-2-ol (9c): Oil; $[\alpha]_D^{23.9} = -6.7$ ($c = 4.3$ in $CHCl_3$); FT-IR (neat): 3461 cm^{-1} (broad band); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta =$ 7.5–7.45 (m, 2H; CH), 7.4–7.3 (m, 3H; CH), 7.26 (m, 1H; CH), 7.18 (dd, $^3J(H,H) = 7.84$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.79 (dd, $^3J(H,H) = 8.2$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 4.89 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 3.96 (s, 1H, OH), 3.95 (s, 3H; OCH_3), 3.5 (d, $^2J(H,H) = 12.3$ Hz, 1H; CH_2), 3.15 (d, $^2J(H,H) = 12.3$ Hz, 1H; CH_2), 1.99 (s, 3H; SCH_3), 1.5 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3), 1.6 (s, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta =$ 159.5, 148.9, 147.3, 137.0, 130.3, 128.6, 127.2, 125.2, 120.1, 109.8, 73.8, 56.6, 45.1, 30.7, 30.3, 22.2, 14.6; GC-MS: *m/z* (%): 396 (25) [M^+], 261 (100), 245 (11), 213 (91), 198 (32), 134 (15), 121 (9), 105 (12), 91 (16), 77 (9), 61 (7); elemental analysis calcd (%) for $C_{19}H_{24}O_2SSe$ (395.4): C 57.72, H 6.12; found: C 57.14, H 6.23.

(1*R*)-1-Mesityl-2-(2-methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenylseleno)-ethanol (9d): Oil; $[\alpha]_D^{23.2} = -22.5$ ($c = 1.7$ in $CHCl_3$); FT-IR (neat): 3478 cm^{-1} (broad band); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta =$ 7.4 (dd, $^3J(H,H) = 7.8$, 8.2 Hz, 1H; CH), 7.2 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.83 (dd, $^3J(H,H) = 8.2$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.76 (s, 2H; CH), 4.94 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 4.89 (dd, $^3J(H,H) = 8.75$, 5.8 Hz, 1H; CH), 3.9 (s, 3H; OCH_3), 3.4 (s, 1H; OH), 3.35 (m, 2H; CH_2), 1.9 (s, 3H; SCH_3), 1.6 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.3$, 150.0, 137.1, 136.5, 134.8, 130.5, 130.4, 120.2, 118.0, 109.6, 70.0, 56.6, 45.2, 35.5, 22.1, 21.1, 20.8, 14.6; elemental analysis calcd (%) for $C_{21}H_{28}O_2SSe$ (423.5): C 59.57, H 6.67; found: C 60.20, H 6.68.

6-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)decan-5-ol (9e): Oil; $[\alpha]_D^{29.7} = -13.8$ ($c = 0.5$ in $CHCl_3$); FT-IR (neat): 3484 cm^{-1} (broad band); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.4$ (dd $^3J(H,H) = 8.1$, 7.8 Hz, 1H; CH), 7.24 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) =$ 1.1 Hz, 1H; CH), 6.8 (dd, $^3J(H,H) = 8.1$ Hz, $^4J(H,H) = 1.1$, 1H; CH), 4.95 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 3.9 (s, 3H; OCH_3), 3.48 (ddd, $^3J(H,H) = 9.4$, 4.3, 2.8 Hz, 1H; CH), 3.43 (s, 1H; OH), 3.38 (ddd, $^3J(H,H) = 8.7$, 3.8, 2.8 Hz, 1H; CH), 2.0 (s, 3H; SCH_3), 1.8–1.5 (m, 6H; CH_2), 1.57 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3), 1.4–1.2 (m, 6H; CH_2), 0.94 (t, $^3J(H,H) =$ 7.2 Hz, 3H; CH_3), 0.86 (t, $^3J(H,H) = 7.2$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 160.3$, 149.8, 130.5, 130.2, 120.2, 109.7, 72.7, 56.6, 54.7, 45.5, 33.2, 31.2, 30.1, 29.4, 29.0, 23.1, 23.0, 22.6, 15.0, 14.3; GC-MS: *m/z* (%): 418 (4) [M^+], 261 (100), 213 (65), 198 (16), 181 (4), 134 (10), 91 (5), 77 (2), 69 (8), 55 (8); elemental analysis calcd (%) for $C_{20}H_{34}O_2SSe$ (417.5): C 57.54, H 8.21; found: C 57.69, H 7.88.

Product **9f** was isolated as mixture of diasteroisomers (2.5:1), which were characterized on the basis of proton spectra. Major isomer: ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.38$ (dd, $^3J(H,H) = 8.0$, 7.8 Hz, 1H; CH), 7.25 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.84 (dd, $^3J(H,H) = 8.0$ Hz, $^4J(H,H) = 1.2$, 1H; CH), 5.0 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 3.94 (s, 3H; OCH_3), 3.38 (td, $^3J(H,H) = 10.0$, 4.3 Hz, 1H; CH), 2.85 (m, 1H; CH); 2.1 (s, 1H; OH), 2.0 (s, 3H; SCH_3), 1.8–1.5 (m, 6H; CH_2), 1.58 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3), 1.4–1.2 (m, 2H; CH_2); minor isomer: ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.36$ (dd, $^3J(H,H) = 8.0$, 7.8 Hz, 1H; CH), 7.24 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.83 (dd, $^3J(H,H) = 8.0$ Hz, $^4J(H,H) = 1.2$, 1H; CH), 4.9 (q, $^3J(H,H) =$ 7.0 Hz, 1H; CH), 3.95 (s, 3H; OCH_3), 3.45 (td, $^3J(H,H) = 10.1$, 4.5 Hz, 1H; CH), 2.84 (m, 1H; CH); 2.3 (s, 1H; OH), 2.1 (s, 3H; SCH_3), 1.8–1.5 (m, 6H; CH_2), 1.57 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3), 1.4–1.2 (m, 2H; CH_2).

Cyclofunctionalization reactions, general procedure: A mixture of diselenide (0.5 mmol), ammonium persulfate (0.5 mmol), and trifluoromethanesulfonic acid (1 mmol) in CH_2Cl_2 was stirred at room temperature for 15 min. The reaction mixture was cooled to −30 °C and the alkenes **14**, **16**, **18**, and **20** (1 mmol) were added. The progress of the reaction was monitored by GC-MS and/or TLC. After 24 h the reaction mixture was worked up in the usual way. The cyclization products were isolated in pure form by column chromatography on silica gel with a mixture of diethyl ether and light petroleum (2.5:7.5) as eluant. The reaction yields and the diasteroisomeric ratios are reported in Table 2. Physical and spectral data are reported below.

4-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)-2,2-dimethyl-5-phenyltetrahydrofuran (15): Oil; $[\alpha]_D^{26.6} = -3.2$ ($c = 1.5$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.3-7.2$ (m, 6H; CH), 7.06 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.2$ Hz, 1H; CH), 6.5 (dd, $^3J(H,H) =$ 8.2 Hz, $^4J(H,H) = 1.1$, 1H; CH), 4.8 (d, $^3J(H,H) = 9.3$ Hz, 1H; CH), 4.79 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 3.8 (dt, $^3J(H,H) = 8.4$, 9.3 Hz, 1H; CH), 3.7 (s, 3H; OCH_3), 2.37 (dd, $^2J(H,H) = 12.8$ Hz, $^3J(H,H) = 8.4$, 1H; CH_2), 2.06 (dd, $^2J(H,H) = 12.8$ Hz, $^3J(H,H) = 9.3$, 1H; CH_2), 1.9 (s, 3H; SCH_3), 1.5 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3), 1.44 (s, 3H; CH_3), 1.41 (s, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 159.7$, 148.4, 140.9, 130.1, 128.5, 128.3, 128.0, 127.1, 119.5, 109.3, 87.6, 80.9, 56.0, 47.6, 46.4, 44.7, 29.8, 29.1, 21.8, 14.3;

elemental analysis calcd (%) for $C_{22}H_{28}O_2SSe$ (435.5): C 60.69, H 6.48; found: C 61.20, H 6.32.

4-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)-5-phenyldihydrofuran-2(3*H*)-one (17): Oil; $[\alpha]_D^{20.2} = +1.5$ ($c = 0.53$ in $CHCl_3$); FT-IR (neat): 1782 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.5-7.3$ (m, 7H; CH), 6.8 (m, 1H; CH), 5.34 (d, $^3J(H,H) = 5.8$ Hz, 1H; CH), 4.7 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 4.05 (ddd, $^3J(H,H) = 5.8$, 7.1, 8.4 Hz, 1H; CH), 3.79 (s, 3H; OCH_3), 3.01 (dd, $^3J(H,H) = 8.4$ Hz, $^2J(H,H) = 18.2$ Hz, 1H; CH_2), 2.68 (dd, $^3J(H,H) = 7.1$ Hz, $^2J(H,H) = 18.2$ Hz, 1H; CH_2), 1.97 (s, 3H; SCH_3), 1.55 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 175.6$, 160.0, 149.1, 139.0, 130.8, 129.0, 128.7, 126.5, 125.9, 120.0, 109.8, 87.2, 56.3, 41.1, 36.1, 30.7, 21.4, 14.2; elemental analysis calcd (%) for $C_{20}H_{22}O_3SSe$ (421.4): C 57.01, H 5.26; found: C 55.98, H 5.30.

(4*S*,5*R*)-5-Ethyl-4-({2-methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)dihydrofuran-2(3*H*)-one (19): Oil; $[\alpha]_D^{21.6} = -3.2$ ($c = 0.75$ in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 7.3$ (dd, $^3J(H,H) = 7.9$, 8.0 Hz, 1H; CH), 7.1 (dd, $^3J(H,H) = 7.8$ Hz, $^4J(H,H) = 1.1$ Hz, 1H; CH), 6.74 (dd, $^3J(H,H) = 8.0$ Hz, $^4J(H,H) = 1.1$, 1H; CH), 4.67 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 4.25 (ddd, $^3J(H,H) = 4.8$, 6.2, 7.5 Hz, 1H; CH), 3.82 (s, 3H; OCH_3), 3.67 (ddd, $^3J(H,H) = 6.2$, 7.6, 8.6 Hz, 1H; CH), 2.85 (dd, $^3J(H,H) = 8.6$ Hz, $^2J(H,H) = 18.2$ Hz, 1H; CH_2), 2.52 (dd, $^3J(H,H) = 7.6$ Hz, $^2J(H,H) = 18.2$ Hz, 1H; CH_2), 1.98 (s, 3H; SCH_3), 1.65–1.55 (m, 2H; CH_2), 0.86 (t, $^3J(H,H) = 7.4$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C, TMS): $\delta = 194.0$, 175.0, 160.0, 149.3, 131.0, 120.1, 109.8, 88.2, 56.4, 44.7, 38.0, 36.7, 27.6, 21.8, 14.4, 9.9; GC-MS: *m*/*z* (%): 374 (1) [M^+], 261 (96), 230 (6), 213 (100), 197 (34), 181 (7), 134 (13), 91 (12), 77 (5), 57 (7); elemental analysis calcd (%) for $C_{16}H_{22}O_3SSe$ (373.4): C 51.48, H 5.94; found: C 52.20, H 5.55.

4-({2-Methoxy-6-[(1*S*)-1-(methylthio)ethyl]phenyl}seleno)-3-phenylisoxazolidine (21): Oil; $[\alpha]_D^{24.0} = -20.9$ ($c = 3.17$ in $CHCl_3$); ^1H NMR (400 MHz, C_6D_6, 67 °C, TMS): $\delta = 7.75-7.68$ (m, 1H; CH), 7.4 (d, $^3J(H,H) = 7.3$ Hz, 1H; CH), 7.3–7.1 (m, 5H; CH), 6.45 (d, $^3J(H,H) = 7.7$ Hz, 1H; CH), 5.02 (q, $^3J(H,H) = 7.0$ Hz, 1H; CH), 4.4 (d, $^3J(H,H) = 4.6$ Hz, 1H; CH), 4.25 (ddd, $^3J(H,H) = 11.8$, 8.0, 4.6 Hz, 1H; CH), 4.17 (dd, $^3J(H,H) = 11.8$, 5.2 Hz, 1H; CH_2), 3.95 (dd, $^3J(H,H) = 8.0$, 5.2 Hz, 1H; CH_2), 3.31 (s, 3H; OCH_3), 1.9 (s, 3H; SCH_3), 1.55 (d, $^3J(H,H) = 7.0$ Hz, 3H; CH_3); ^{13}C NMR (100 MHz, C_6D_6, 67 °C, TMS): $\delta = 159.6$, 148.8, 137.4, 136.2, 128.2, 127.7, 127.3, 126.7, 119.6, 109.3, 70.6, 67.7, 55.1, 44.7, 30.5, 21.4, 14.0; elemental analysis calcd (%) for $C_{19}H_{23}NO_2SSe$ (408.4): C 55.88, H 5.68; found: C 55.74, H 5.63.

Catalytic selenenylation–deselenenylation sequences, general procedure: Ammonium persulfate (3 mmol) was added to a solution of diselenide **3** (0.025 mmol) in MeOH (selenomethoxylation) or CH_3CN (selenohydroxylation and cyclofunctinalization), and the resulting mixture was stirred at 60 °C for 15 min. The temperature was cooled to 25 °C and the alkene (1 mmol) in MeOH (selenomethoxylation), or in CH_3CN/H_2O (selenohydroxylation), or in CH_3CN (cyclofunctionalization) was added. The progress of the reaction was monitored by GC-MS and/or TLC and the reaction mixture was worked up in the usual way. The selenenylation–deselenenylation products were isolated in pure form by column chromatography on silica gel with CH_2Cl_2 as eluant. The reaction yields, the reaction times, and the diastereomeric ratios are reported in Table 3. Physical and spectral data for **29**[15] and for the enantiomers of compounds **25**,[18a] **27**,[18a] and **28**[18a] have previously been described. Optical rotation data of compounds **25, 27**, and **28** are reported below.

Methyl (2*E*,4*R*)-4-methoxyhex-2-enoate (25): $[\alpha]_D^{24.0} = +4.1$ ($c = 2.1$ in $CHCl_3$).

Methyl (2*E*,4*S*)-4-methoxy-4-phenylbut-2-enoate (27): $[\alpha]_D^{32.0} = -56.9$ ($c = 3.0$ in $CHCl_3$).

Methyl (2*E*,4*S*)-4-hydroxy-4-phenylbut-2-enoate (28): $[\alpha]_D^{25.0} = -29.9$ ($c = 1.0$ in $CHCl_3$).

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