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Note

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Synthesis of Vicinal Dichlorides via Activation of Aliphatic Terminal Epoxides with Triphosgene and Pyridine

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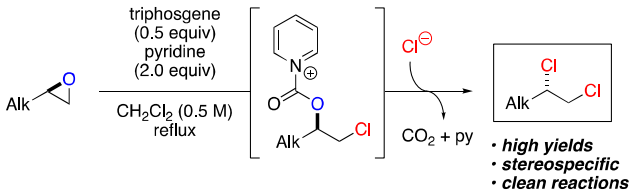
Abstract



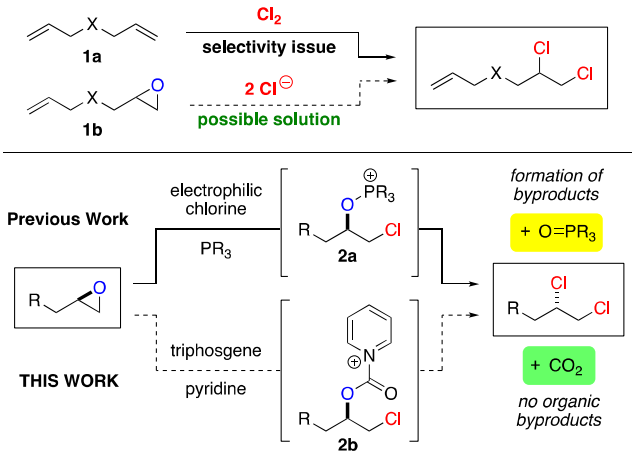
Herein we report a novel synthetic reaction to convert unactivated terminal aliphatic epoxide to alkyl vicinal dichloride based on triphosgene-pyridine activation. Our methodology is operationally simple and readily tolerated by a broad of scope of substrates as well as protecting groups. Furthermore, these mild conditions generally yield clean reaction mixtures that are free of byproducts upon aqueous workup.

The development of reactions to install carbon-chlorine bonds remains an important task in organic synthesis due to the ubiquity of chlorine atoms in various organic molecules, including natural products, pharmaceutical drugs, and agricultural agents.[1] A particular organochlorine structural motif that has been recently subjected to extensive synthetic studies is the alkyl 1,2-dichloride. The growing interests concerning this molecular structure are essentially driven by the strong prevalence of repetitive vicinal dichloride subunits found in a class of natural products, known as the chlorosulfolipids.[2] While both classical and contemporary methods to generate alkyl 1,2-dichlorides are commonly approached via addition of Cl_2 (or their equivalents) across double bonds,[3] synthetic applications of this strategy to complex substrates bearing multiple π systems, *viz.* **1a**, could be problematic due to the substantial challenge in controlling regioselectivity of the chlorination toward a specific double bond.

A viable solution to this problem could be envisioned through the use of an epoxide as an orthogonal precursor to alkyl 1,2-dichlorides, *viz.* **1b**. As a result of the two adjoining electrophilic carbons, epoxides could theoretically be subjected to double nucleophilic displacement by two chloride ions. There are a few reports demonstrating that treatment of epoxide with Appel-type activation conditions, *i.e.* triphenylphosphine and a source of electrophilic chlorine,[4] readily furnished the corresponding vicinal dichloride. Nonetheless, similar to any synthetic transformations that rely on nucleophilic activation of reactive intermediates using a stoichiometric amount of triphenylphosphine,[5] these established chlorination conditions suffered from disadvantages from both atom economical and operational perspectives, as it is necessary and often difficult to purify the corresponding alkyl chloride from

the leftover reagents and byproducts, especially given the potential instability of organochlorines under column chromatographic separation.

Scheme 1. Chlorination Reactions via Triphosgene-Pyridine Activation

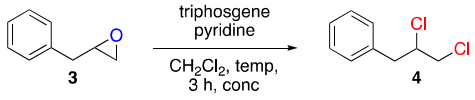


Recognizing both the significant potentials and challenges of this useful synthetic transformation, herein we report our investigation on the conversion of unactivated aliphatic epoxides to alkyl vicinal dichlorides using our triphosgene-pyridine activation technology. Recently, our group has developed new chlorination reactions of through the use of triphosgene as a source of chloride ions that can be effectively liberated upon treatment with pyridine.[6] We demonstrated that treatment of unactivated aliphatic secondary alcohols with triphosgene and pyridine in dichloromethane at reflux successfully produced the corresponding secondary alkyl chloride. This reaction was believed to have involved an intermediacy of pyridinium carbamate ions which proceeded to decarboxylative nucleophilic substitution by chloride ions at the carboxyl position in a stereospecific manner via an inversion of stereochemistry. Based on these mechanistic considerations, we proposed that activation of an epoxide with triphosgene and pyridine could potentially produce an analogous cationic intermediate in **2b** (Scheme 1). Such a reactive species should then undergo rapid decarboxylative fragmentation induced by chloride

ions to furnish the sought-after 1,2-dichloride structural motif, thus producing CO_2 gas as the only byproduct of the reaction.

The results of our pilot and optimization studies are summarized in Table 1, in which 2-benzyloxirane **3** was employed as a model substrate. Stemmed from our established protocols on the conversion of ketones to vinyl chlorides,[6b] we utilized 1.0 equiv of triphosgene and 4.0 equiv of pyridine in dichloromethane for the pilot experiments. While the reaction at room temperature only produced complex mixtures, the target 1,2-dichloride **4** was successfully produced in 62% yield simply by warming the reaction to reflux (entries 1-2). The ensuing screening of reaction concentrations and the molar amount of pyridine revealed that the use of 2.0 equiv of the base at 0.5 M concentration produced the highest yield (entries 3-5). As indicated in entry 6, pyridine was found to play a crucial role. Without it, the starting material was not largely affected as the reaction only produced a trace amount of chlorohydrin. Finally, an attempt to further optimize the amounts of triphosgene and pyridine led us to a conclusion that the use of 0.5 equiv of the chlorination reagent and 2.0 equiv of the base afforded the corresponding vicinal dichloride **4** in satisfactory 88% yield (entry 7).

Table 1. Reaction Optimization



3 **4**

entry	triphosgene (equiv)	pyridine (equiv)	temp	conc (M)	yield (%) [a,b]
1	1.0	4.0	rt	0.2	mixture [c]
2	1.0	4.0	reflux	0.2	62
3	1.0	4.0	reflux	0.5	81
4	1.0	2.0	reflux	0.5	89
5	1.0	2.0	reflux	1.0	80
6	1.0	0.0	reflux	0.5	NR
7	**0.5**	**2.0**	**reflux**	**0.5**	**88**
8	0.5	1.0	reflux	0.5	83
9	0.5	0.1	reflux	0.5	45 [d]

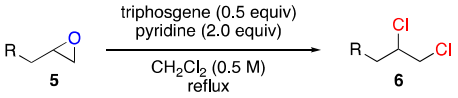
[a] Progress of reaction was monitored by GC. [b] Isolated yield after column chromatography. [c] The reaction mixture was stirred for 24 h. [d] The reaction never reached completion after 6 days.

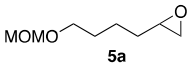
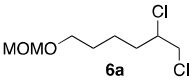
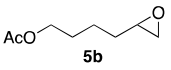
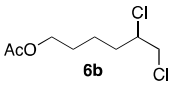
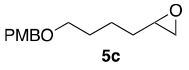
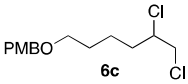
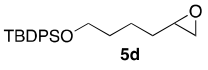
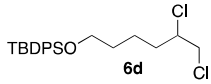
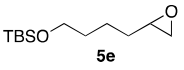
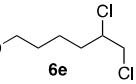
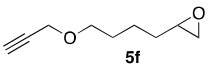
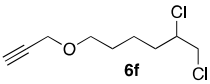
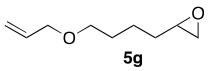
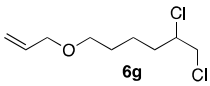
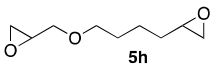
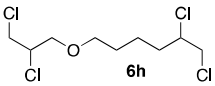
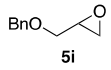
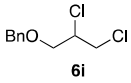
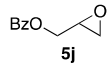
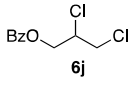
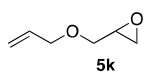
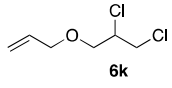
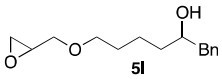
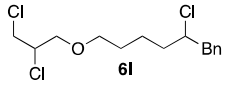
With the optimized reaction conditions in hand, we then examined the scope of epoxides (Table 2). Our method proved to be compatible with various common protecting groups, such as MOM **5a**, acetyl **5b**, PMB **5c**, TBDPS **5d**, and TBS **5e** which furnished the corresponding alkyl 1,2-dichlorides **6a-6e** in excellent yields (entries 1-5). Our ability to chlorinate epoxides using triphosgene and pyridine is highly advantageous, considering that this methodology enables the production of vicinal dichlorides orthogonally in the presence of π-systems, which are typically employed as precursors for the formation of 1,2-dichlorides. For instance, the use of substrates **5f** and **5g** afforded products **6f** and **6g** in high yields, and both the allyl and propargyl groups remained intact during the course of the reaction. When desired, access to *bis*-vicinal dichlorides **6h** could be realized simply by using the corresponding *bis*-epoxide **5h** and exposing it to a double amount of the optimized molar equivalents of triphosgene and pyridine.

As shown in entries 9-11, the utility of industrially important glycidol as starting materials in this chlorination reaction was examined. Indeed, treatment of benzyl, benzoyl, and allyl protected glycidol **5i-5k** with triphosgene and pyridine under the optimized conditions produced the corresponding dichlorinated glycerols **6i-6k** in moderate to high yields. Interestingly, as opposed to the aliphatic substrates **5a-5h**, these glycerol systems required a longer reaction time, suggesting that the adjacent oxygen atom perhaps readily deactivated the epoxide moiety. Finally, we also attempted to simultaneously chlorinate the epoxide functionality and secondary alcohol in **5l**. Gratifyingly, activation of this substrate with excess

triphosgene and pyridine successfully produced alkyl trichloride **6l** in 71% yield in just 1 hour of reaction time.

Table 2. Scope of Substrates

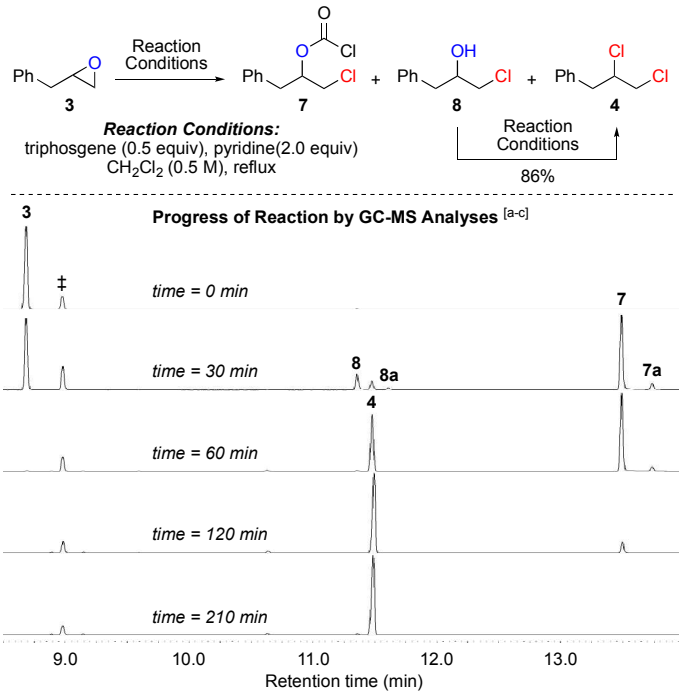


entry	substrate	product [a]	yield [b] (%)	time (h)
1	 **5a**	 **6a**	70	1
2	 **5b**	 **6b**	86	1
3	 **5c**	 **6c**	80	1
4	 **5d**	 **6d**	88	1
5	 **5e**	 **6e**	80	1
6	 **5f**	 **6f**	86	1
7	 **5g**	 **6g**	90	1
8	 **5h**	 **6h**	81 [c,d]	2
9	 **5i**	 **6i**	87	6
10	 **5j**	 **6j**	71	3
11	 **5k**	 **6k**	67	6
12	 **5l**	 **6l**	71 [c,d]	1

[a] Progress of reaction was monitored by GC. [b] Isolated yield after column chromatography. [c] A mixture of inseparable diastereomers. [d] 1.0 equiv of triphosgene and 4.0 equiv of pyridine was employed.

It is important to note that every epoxide listed in Table 2 led to a clean and quantitative conversion of the epoxide moiety to its corresponding vicinal dichloride as monitored by GC-analyses of the crude reaction mixtures. The reduced isolation yields are most likely originated from the loss of products due to their volatility or decomposition during silica gel column chromatographic purification. In fact, chromatographic purification became essentially optional, considering the high purity of the crude products upon reaction workup.

Scheme 2. Identification of Reaction Intermediates



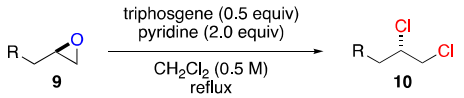
[a] All compounds are assumed to elicit identical GC responses. [b] Based on MS analyses, compounds **7a** and **8a** are presumably regioisomers of compounds **7** and **8**, respectively. [c] Naphthalene (‡) was added into the reaction mixture as a reference.

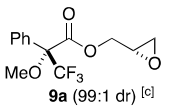
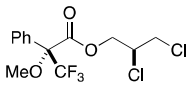
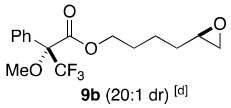
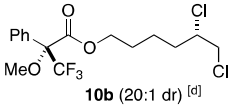
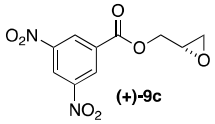
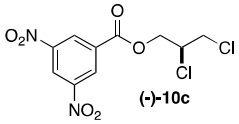
To probe the plausible reaction mechanism for this methodology, we designed and executed several experiments as depicted in Schemes 2 and Table 3. First, we monitored the progress of our chlorination reaction by periodically subjecting aliquots of the crude reaction mixture to GC-MS analyses (see Supporting Information). Using 2-benzyloxirane **3** as the starting material, this study revealed the presence of two transient reaction intermediates, β-chloro chloroformate **7** and chlorohydrin **8**. Attempts to isolate these compounds by prematurely quenching the reaction only led to the isolation of chlorohydrin **8** by column chromatography. In fact, β-chloro chloroformate **7** was not detected upon aqueous workup, suggesting that chlorohydrin **8** might be generated conceivably as a byproduct from the hydrolysis of chloroformate **7**. Nonetheless, the role of chlorohydrin **8** as an actual reaction intermediate could not be ruled out, considering that treatment of this compound with triphosgene and pyridine under the optimized conditions also furnished vicinal dichloride **4** in 86% yield. Monitoring the progress of this reaction by GC-MS analyses of the reaction mixture again revealed the presence of β-chloro chloroformate intermediate **7**.

The fate of the stereochemical information in this chlorination reaction was then examined (Table 3). We found that the use of diastereomerically pure Mosher ester-derived (*R*)-glycidol **9a** and (2*R*)-oxiranebutanol **9b** produced chiral vicinal dichlorides **10a** and **10b**, respectively, as a single diastereomer. These findings, therefore, suggested that our triphosgene-

pyridine activation did not compromise the enantiomeric purity of the starting epoxides. Furthermore, our studies confirmed that this chlorination methodology resulted in an inversion of stereochemistry based on the X-ray structures of 3,5-dinitrobenzoate ester-derived (*R*)-glycidol **(+)-9c** and the corresponding vicinal dichloride product **(-)-10c**.[7]

Table 3. Stereochemical Analyses



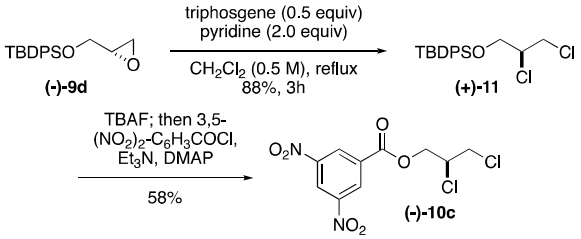
entry	substrate	product [a]	yield [b] (%)	time (h)
1	 **9a** (99:1 dr) [c]	 **10a** (99:1 dr) [c]	63	3
2	 **9b** (20:1 dr) [d]	 **10b** (20:1 dr) [d]	78	1
3	 **(+)-9c**	 **(-)-10c**	81	3

[a] Progress of reaction was monitored by GC. [b] Isolated yield after column chromatography. [c] Diastereomeric purity of **9a** and **10a** was determined by GC and NMR (^{1}H, ^{13}C, and ^{19}F). [d] Diastereomeric purity of **9b** and **10b** was determined by ^{13}C NMR. See Supporting Information for [c]-[e].

We also repeated this experiment with TBDPS-protected glycidol **(-)-9d** to rule out possible anchimeric assistance inherent to substrates **9a-9c** in regulating stereospecificity (Scheme 3). Chlorination of this substrate with triphosgene-pyridine, followed by removal of the silyl ether and acylation of the unmasked hydroxy group with 3,5-dinitrobenzoyl chloride produced vicinal dichloride **(-)-10c**. An optical rotation measurement of this compound ($[\alpha]^{23}_{D}$ =

-20.0) revealed a value that was within an agreement with **(-)-10c** ($[\alpha]^{23}_D$ = -21.0) obtained from **(+)-9c**, implying that chlorination of substrate **(-)-9d** also proceeded via an inversion of stereochemistry.

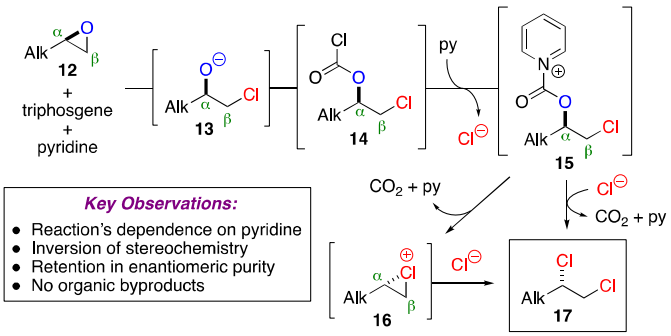
Scheme 3. Exclusion of Anchimeric Assistance



Our experimental data collectively led us to propose a reaction mechanism as depicted in Scheme 4. Reaction of epoxides **12** with triphosgene and pyridine is believed to produce transient β-chloro chloroformate **14** via a sequence of nucleophilic ring opening at the less congested β-carbon by excess chlorides ions, liberated upon decomposition of triphosgene by pyridine, followed by chloroformylation of the emerging chlorohydrin anion **13** by the *in situ* generated phosgene.[8] Analogous to our previous studies,[6c] β-chloro chloroformate **14** was further activated by pyridine to putative pyridinium carbamate ion **15**, allowing for the penultimate decarboxylative nucleophilic substitution by chloride ions at the α-carbon to produce the observed vicinal dichloride **17**, while regenerating pyridine and releasing CO_2 as the byproduct. This step would naturally invert the stereochemistry of the starting epoxide **12**. Nonetheless, given the close proximity of the electrophilic α-carbon from an adjacent chlorine

substituent, we could not exclude the possibility for pyridinium carbamate ion **15** to undergo decarboxylative self-decomposition to generate chloronium ion **16** through the release of pyridine and CO_2. The ensuing nucleophilic ring opening to this intermediate by chloride ions, again at the sterically more accessible β-carbon, would result in the production of vicinal dichloride **17** also with an inversion of stereochemistry. Either pathways would readily retain enantiomeric purity.

Scheme 4. Proposed Reaction Mechanism.



Conclusion

In summary, we have developed a new method to chlorinate terminal epoxides to the corresponding vicinal dichlorides in a stereospecific manner using triphosgene-pyridine activation. There are several advantageous associated with our technology. First, triphosgene exists as crystalline materials, and it can be conveniently handled under normal laboratory safety practices.[9] Second, our conditions were found to be very mild and readily tolerated by a broad range of substrates and protecting groups.[10] Lastly, this triphosgene-pyridine activation often leads to very clean crude mixtures as carbon dioxide and base are the byproducts. Furthermore, the absence of chromatographically nuisance byproducts rendered this novel methodology a

substantial improvement from the classical Appel chlorination reactions that are always hampered by the challenging removal of the excess reagents and their resulting byproducts.

Experimental Section

All materials, unless otherwise stated, were purchased from commercial sources and utilized without further purification. Anhydrous reactions were conducted in oven-dried glassware, which was then cooled under vacuum and purged with nitrogen gas. Anhydrous solvents (dichloromethane, toluene, acetonitrile, diethyl ether, and tetrahydrofuran) were filtered through activated 3Å molecular sieves under nitrogen in a solvent purification system. Reactions were either monitored by analytical thin layer chromatography (TLC Silica Gel 60 F_{254}, Glass Plates) and analyzed using 254 nm UV light and anisaldehyde – sulfuric acid or potassium permanganate stains, or via Gas Chromatography – Mass Spectrometry (GC-MS). The column for the GC-MS system was TG-SQC (15m x 0.25mm x 0.25µm). Low and high mass readings were set to 60 to 400 amu, respectively. Oven, inlet, and detector temperatures were set to 250ºC, and helium was used as the inert carrier gas. Column chromatography was completed using silica gel or neutral alumina. Unless otherwise noted, all ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ using spectrometers operating at either 400 MHz for ^{1}H and 100 MHz for ^{13}C or 500 MHz for ^{1}H and 125 MHz for ^{13}C. Chemical shifts (δ) are reported in ppm relative to residual $CHCl_3$ as an internal reference (^{1}H: 7.26 ppm, ^{13}C: 77.00 ppm). Coupling constants (*J*) are reported in Hertz (Hz). Peak multiplicity is indicate as follows: s (singlet), d (doublet), t (triplet), q (quartet), p (pentet), x (septet), h (heptet), b (broad), and m (multiplet). FT-IR spectra were recorded using thin film, and absorption frequencies were reported in reciprocal centimeters (cm^{-1}). High Resolution Mass Spectrometry (HRMS) analyses were performed

using Electron Spray Ionization – Time of Flight (ESI-TOF) method. See Supporting Information for the chemical structures of compounds **S1** - **S10**.

2-Benzyloxirane (3). Allylbenzene **S1** (1.17 mL, 8.46 mmol) was added to a 100-mL round-bottom flask and dissolved in CH_2Cl_2 (17 mL). The solution was then cooled to 0 °C and *m*CPBA (2.80 g, 12.7 mmol, 77 wt %) was added in one portion. The solution was allowed to warm to room temperature overnight. After completion of reaction as determined by TLC, the reaction was cooled to 0 °C and quenched with 1 M NaOH (10 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were then dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using a 10% - 20% EtOAc in hexanes gradient to afford epoxide **3** as a clear oil in 91% yield (340 mg, 1.45 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.32 (m, 2H), 7.31 – 7.24 (m, 3H), 4.31 – 4.24 (m, 1H), 3.74 (dd, J = 11.3, 4.5 Hz, 1H), 3.67 (dd, J = 14.1, 5.6 Hz, 1H), 3.32 (dd, J = 14.6, 7.3 Hz, 1H), 3.08 (dd, J = 14.2, 7.3 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 136.3, 129.5, 128.6, 127.2, 61.0, 47.5, 41.0. Compound **3** is known.[5d]

(2,3-Dichloropropyl)benzene (4). Epoxide **3** (111 mg, 0.827 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.6 mL), followed by the addition of triphosgene (123 mg, 0.414 mmol). After complete dissolution of triphosgene, pyridine (134 µL, 1.65 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 3 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced

pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **4** as a clear oil in 88% yield (137 mg, 0.724 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.32 (m, 2H), 7.31 – 7.26 (m, 3H), 4.30 – 4.24 (m, 1H), 3.74 (dd, *J* = 11.2, 4.4 Hz, 1H), 3.67 (dd, *J* = 11.3, 6.8 Hz, 1H), 3.32 (dd, *J* = 14.2, 5.2 Hz, 1H), 3.08 (dd, *J* = 14.2, 7.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 136.3, 129.5, 128.6, 127.2, 61.0, 47.4, 41.0. Compound **4** is known.[5d]

(2,3-Dichloropropyl)benzene (4). Chlorohydrin **8** (53 mg, 0.311 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (0.6 mL), followed by the addition of triphosgene (46 mg, 0.155 mmol). After complete dissolution of triphosgene, pyridine (50 μL, 0.621 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **4** as a clear oil in 86% yield (50 mg, 0.265 mmol). NMR spectra are identical to those of dichloride **4** prepared from epoxide **3**.

2-(4-(Methoxymethoxy)butyl)oxirane (5a). 5-hexen-1-ol **S2** (1.5 mL, 12.5 mmol) was added to a 50-mL round-bottom flask and dissolved in CH_2Cl_2 (12 mL). The solution was subsequently cooled to 0 °C, *m*-CPBA (4.20 g, 18.7 mmol, 77 wt %) was added in one portion. The reaction mixture was allowed to warm to room temperature. Upon complete consumption of starting material as determined by TLC, the solution was cooled to 0 °C and quenched with 1 M NaOH (5 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2

(3 x 15 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using a 10% - 35% EtOAc in hexanes gradient to afford 4-(oxiran-2-yl)butan-1-ol **S3** as a clear oil in 86% yield, (1.25 g, 10.8 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.66 – 3.60 (m, 2H), 2.93 – 2.88 (m, 1H), 2.76 – 2.71 (m, 1H), 2.48 – 2.44 (m, 1H), 1.65 – 1.49 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 62.5, 52.2, 47.0, 32.3, 32.1, 22.2. Compound **S3** is known.[11a]

4-(Oxiran-2-yl)butan-1-ol **S3** (207 mg, 1.78 mmol) was added to a 50-mL round bottom flask. The epoxide was subsequently dissolved in CH_2Cl_2 (7 mL) and DIPEA (477 µL, 2.67 mmol) was added. MOMCl (203 µL, 2.67 mmol) was then added dropwise and off gassing was observed. After 4 hours, the reaction was determined to be complete by TLC analysis and 2 M HCl (2 mL) was added to quench. Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were dried over Na_2SO_4 and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford **5a** as a clear oil in 73% yield (209 mg, 1.30 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.61 (s, 2H), 3.53 (t, J = 6.5 Hz, 2H), 3.35 (s, 3H), 2.93 – 2.88 (m, 1H), 2.74 (dd, J = 5.0, 3.9 Hz, 1H), 2.46 (dd, J = 5.1, 2.9 Hz, 1H), 1.70 – 1.61 (m, 2H), 1.59 – 1.50 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 96.4, 67.5, 55.1, 52.2, 47.0, 32.2, 29.5, 22.7. Compound **5a** is known.[11b]

4-(Oxiran-2-yl)butyl acetate (5b). 4-(Oxiran-2-yl)butan-1-ol **S3** (200 mg, 1.72 mmol) was added to a 50-mL round bottom flask followed by DMAP (212 mg, 1.89 mmol). CH_2Cl_2 (4.7 mL) was added and the solution was cooled to – 78 ºC. Acetic anhydride (179 µL, 1.89 mmol) was added dropwise and the temperature was maintained at – 78 ºC. After 1 hour, the reaction was determined to be complete by TLC analysis. The crude solution was allowed to

warm to room temperature and quenched with 15% NaOH (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 15% EtOAc in hexanes to afford **5b** as a clear oil in 80% yield (200 mg, 1.26 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.05 (t, J = 5.7 Hz, 2H), 2.92 – 2.86 (m, 1H), 2.75 – 2.71 (m, 1H), 2.48 – 2.43 (m, 1H), 2.03 (s, 3H), 1.72 – 1.63 (m, 2H), 1.63 – 1.46 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.2, 64.2, 52.0, 46.9, 32.0, 28.4, 22.5, 20.9. Compound **5b** is known.[11c]

2-(4-((4-Methoxybenzyl)oxy)butyl)oxirane (5c). 4-(Oxiran-2-yl)butan-1-ol **S3** (193 mg, 1.66 mmol) was added to a vacuum purged 50-mL round bottom flask followed by PMB-TCA (690 μL, 3.32 mmol). CH_2Cl_2 (8.3 mL) was subsequently added to dissolve the reaction components and the solution was cooled to 0 ºC. CSA (38 mg, 0.166) was added in one portion and the reaction was allowed to gradually warm to room temperature. After 43 hours, the reaction was determined to be complete by TLC analysis and $NaHCO_3$ (2 mL) was added to quench the reaction. Upon the separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4 and concentrated under reduced pressure. The crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford **5c** as a clear oil in 71% (277 mg, 1.17 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 (d, J = 7.9 Hz, 2H), 6.89 (d, J = 10.0 2H), 4.44 (s, 2H), 3.81 (s, 3H), 3.46 (t, J = 8.6 Hz, 2H), 2.93 – 2.88 (m, 1H), 2.74 (t, J = 4.2, Hz, 1H), 2.46 (dd, J = 5.1, 2.5 Hz, 1H), 1.71 – 1.62 (m, 2H), 1.58 – 1.50 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.1, 130.7, 129.2, 113.7, 72.5, 69.8, 55.24, 52.2, 47.0, 32.3, 29.51, 22.7. Compound **5c** is known.[11d]

***Tert*-butyl(4-(oxiran-2-yl)butoxy)diphenylsilane (5d)**. 4-(Oxiran-2-yl)butan-1-ol **S3** (177 mg, 1.52 mmol) was combined with imidazole (114 mg, 1.67 mmol) in a 50-mL round-bottom flask. CH_2Cl_2 (3.0 mL) added and the solution was cooled to 0 ºC. TBDPSCl (430 µL, 1.67 mmol) was added dropwise. After stirring overnight, the reaction was quenched with 2 M HCl (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using 1% EtOAc in hexanes to afford **5d** as a clear oil in 71% (380 mg, 1.07 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 – 7.64 (m, 4H), 7.45 – 7.35 (m, 5H), 3.68 (t, *J* = 5.6 Hz, 2H), 2.93 – 2.86 (m, 1H), 2.74 (t, *J* = 4.7 Hz, 1H), 2.45 (dd, *J* = 5.1, 2.8 Hz, 1H), 1.66 – 1.49 (m, 2H), 1.05 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 135.5, 134.8, 134.0, 129.5, 127.7 127.6, 63.6, 52.3, 47.1, 32.3, 32.2, 26.9, 22.3, 19.2. Compound **5d** is known.[11e]

***Tert*-butyldimethyl(4-(oxiran-2-yl)butoxy)silane (5e).** 4-(Oxiran-2-yl)butan-1-ol **S3** (284 mg, 2.44 mmol) was added to a 50-mL round-bottom flask and dissolved in CH_2Cl_2 (12 mL). TBSCl (387 mg, 2.57 mmol) was subsequently added and the solution was cooled to 0 °C. Imidazole (250 mg, 3.67 mmol) followed by DMAP (10 mg) were then added and the reaction as allowed to warm to room temperature. After stirring for 3 hours, the reaction was cooled and quenched with 2 M HCl (3 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using 5% EtOAc in hexanes to afford **5e** as a clear oil in 89% yield (501 mg, 2.17 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.64 – 3.59 (m, 2H), 2.94 – 2.88 (m, 1H), 2.74 (dd, *J* = 5.0, 3.9 Hz, 1H), 2.46 (dd, *J* = 5.0, 2.7 Hz, 1H), 1.62 – 1.48 (m, 6H), 0.89 (s, 9H), 0.04 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 62.9, 52.3, 47.1, 32.6, 32.3, 26.0, 22.3, 18.3, -5.30. Compound **5e** is known.[11f]

2-(4-(Prop-2-yn-1-yloxy)butyl)oxirane (5f). 4-(Oxiran-2-yl)butan-1-ol **S3** (324 mg, 2.79 mmol) was added to a 50-mL round-bottom flask and dissolved in THF (2.8 mL). The resulting solution was cooled to 0 °C. Neat NaH (134 mg, 5.58 mmol) was quickly added in one portion and after the cessation gas evolution, propargyl bromide (311 μL, 2.79 mmol) was added slowly, dropwise. After 6 hours, the reaction was determined to be complete by TLC analysis and cooled to 0 °C. The reaction was then quenched with saturated NH_4Cl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using a 5% - 15% EtOAc in hexanes gradient to afford **5f** as a yellow oil in 55% yield (237 mg, 1.54 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.12 (t, J = 2.1 Hz, 2H), 3.52 (dd, J = 7.7, 5.6 Hz, 2H), 2.92 – 2.87 (m, 1H), 2.76 – 2.71 (m, 1H), 2.48 – 2.43 (m, 1H), 2.41 (t, J = 2.6 Hz, 1H), 1.68 – 1.60 (m, 2H), 1.58 – 1.49 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 79.9, 77.3, 77.0, 76.7, 74.1, 69.8, 58.0, 52.1, 47.0, 32.2, 29.2, 22.6. IR (cm^{-1}): f = 3262, 3047, 2861, 1480, 1442, 1094, 944, 916, 783, 753. HRMS-ESI: $(M + H)^+$ = 155.1067 calcd for $C_9H_{15}O_2$, found = 155.1070.

2-(4-(Allyloxy)butyl)oxirane (5g). 4-(Oxiran-2-yl)butan-1-ol **S3** (183 mg, 1.57 mmol) was added to a 50-mL round-bottom flask and dissolved in THF (2.0 mL). The resulting solution was cooled to 0 °C. Neat NaH (77 mg, 3.15 mmol) was added in one portion and after the cessation of gas evolution, allyl bromide (136 μL, 1.57 mmol) was added slowly, dropwise. After stirring overnight, the reaction was determined to be complete by TLC analysis and cooled to 0 °C. The reaction was then quenched with saturated NH_4Cl (1.0 mL). Upon separation of

the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using a 5% - 10% EtOAc in hexanes gradient to afford **5g** as a clear oil in 87% yield (214 mg, 1.37 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.89 (ddt, *J* = 16.0, 10.7, 5.7 Hz 1H), 5.21 (dd, *J* = 13.8, 6.6 Hz, 2H), 3.94 (dd, *J* = 5.6, 1.7 Hz, 2H), 3.42 (t, *J* = 6.2 Hz, 2H), 3.03 – 2.82 (m, 1H), 2.72 (dd, *J* = 10.9, 1.8 Hz, 1H), 2.45 (dd, *J* = 9.4, 1.9 Hz, 1H), 1.63 (t, *J* = 7.7 Hz, 2H), 1.56 – 1.45 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 134.9, 116.7, 71.7, 70.0, 52.2, 47.0, 32.2, 29.5, 22.7. Compound **5g** is known.[11g]

2-((4-(Oxiran-2-yl)butoxy)methyl)oxirane (5h). 5-Hexen-1-ol **S2** (480 μL, 3.99 mmol) was added to a 50-mL round-bottom flask and dissolved in THF (8.0 mL). The resulting solution was cooled to 0 °C. Neat NaH (240 mg, 9.98 mmol) was added in one portion and after the cessation of gas evolution, allyl bromide (520 μL, 5.99 mmol) was added slowly, dropwise. After stirring overnight, the reaction was determined to be complete by TLC analysis and cooled to 0 ºC. The reaction was then quenched with saturated NH_4Cl (5 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using a 5% - 10% EtOAc in hexanes gradient to afford 6-(allyloxy)hex-1-ene **S4** as a clear oil in 85% yield (475 mg, 3.38 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.91-5.86 (m, 1H), 5.80 (ddt, *J* = 17.0, 10.3, 6.7 Hz, 1H), 5.23 (d, *J* = 16.3 Hz, 1H), 5.16 (d, *J* = 10.5, 1H), 5.00 (d, *J* = 17.1 Hz, 1H), 4.96 (d, *J* = 9.9 Hz, 1H), 3.96 (d, *J* = 5.6 Hz, 2H), 3.43 (t, *J* = 6.7 Hz, 2H), 2.07 (q, *J* = 7.2 Hz, 2H), 1.66 – 1.55 (m, 2H), 1.52 – 1.39 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.7, 135.1, 116.6, 114.5, 71.7, 70.2, 33.5, 29.2, 25.5. Compound **S4** is known.[11h]

6-(Allyloxy)hex-1-ene **S4** (458 mg, 3.27 mmol) was added to a 50-mL round-bottom flask, followed by CH_2Cl_2 (7.0 mL). The solution was subsequently cooled to 0 °C. *m*CPBA (2.20 g, 9.80 mmol, 77 wt %) was added in one portion and the solution was allowed to warm to room temperature overnight. Upon complete consumption of starting material as determined by TLC, the solution was cooled to 0 °C and quenched with 1 M NaOH (3 mL). Upon separation of the two layers the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered. and concentrated under reduced pressure. The crude oil was then purified by column chromatography using a 10% - 20% EtOAc in hexanes gradient to afford **5h** as an inseparable mixture of diastereomers as a clear oil in 65% yield, (364 mg, 2.11 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.70 (dd, *J* = 11.8, 2.8 Hz, 1H), 3.49 (qt, *J* = 8.9, 6.1 Hz, 2H), 3.35 (dd, *J* = 11.2, 6.2 Hz, 1H), 3.15 – 3.10 (m, 1H), 2.92 – 2.87 (m, 1H), 2.75 (dt, *J* = 19.8, 4.3 Hz, 2H), 2.59 (dd, *J* = 5.0, 2.5 Hz, 1H), 2.45 (dd, *J* = 5.1, 3.1 Hz, 1H), 1.63 (p, *J* = 7.2, 6.4 Hz, 2H), 1.58 – 1.48 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 71.4, 71.2, 52.1, 50.8, 47.0, 44.2, 32.2 29.4, 22.6. IR (cm^{-1}): *f* = 3050, 2992, 2932, 2862, 1481, 1434, 1337, 1256, 1159, 1104, 835, 758. HRMS-ESI: $(M + H)^+$ = 173.1172 calcd for $C_9H_{16}O_3$, found = 173.1175.

2-((Benzyloxy)methyl)oxirane (5i). Glycidol **S5** (447 μL, 6.75 mmol) was added to a 100-mL round-bottom flask and dissolved in THF (23 mL). The resulting solution was then cooled to 0 °C. Neat NaH (200 mg, 8.20 mmol) was then added in one portion. After the cessation of the evolution of gas, benzyl bromide (1.20 mL, 10.1 mmol) was added slowly, dropwise. After 7 hours, the reaction was determined to be complete by TLC analysis and the reaction mixture was cooled to 0 °C. The cooled solution was then quenched with saturated NH_4Cl (5 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated

under reduced pressure. The crude oil was then purified by column chromatography 5% - 10% EtOAc in hexanes gradient to afford **5i** as a clear oil in quantitative yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.27 (m, 5H), 4.62 (d, *J* = 11.9 Hz, 1H), 4.56 (d, *J* = 11.9 Hz, 1H), 3.77 (dd, *J* = 11.6, 3.1 Hz, 1H), 3.45 (dd, *J* = 11.3, 5.9 Hz, 1H), 3.22 – 3.16 (m, 1H), 2.83 – 2.78 (m, 1H), 2.62 (dd, *J* = 5.4, 2.5 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.9, 128.4, 127.7, 73.3, 70.8, 50.8, 44.3. Compound **5i** is known.[11i]

Oxiran-2-ylmethyl benzoate (5j). DMAP (82 mg, 0.675 mmol) was added to a 100-mL round-bottom flask. Glycidol **S5** (895 μL, 13.5 mmol) and pyridine (1.15 mL, 14.2 mmol) were added stepwise and the contents were subsequently dissolved in CH_2Cl_2 (13 mL). The solution was then cooled to 0 °C before the dropwise addition of benzoyl chloride (1.65 mL, 14.2 mmol). After stirring for 6 hours, the reaction was determined to be complete by TLC analysis and subsequently cooled to 0 °C. The cooled reaction mixture was then quenched with 2 M HCl (3 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using a 5% - 10% EtOAc in hexanes gradient to afford **5j** as clear oil in 21% yield (498 mg, 2.79 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.2 Hz, 2H), 7.56 (t, *J* = 8.0 1H), 7.45 (t, *J* = 7.9 Hz, 2H), 4.65 (dd, *J* = 12.2, 3.1 Hz, 1H), 4.17 (dd, *J* = 12.9, 6.1 Hz, 1H), 3.34 (m, 1H), 2.89 (t, *J* = 4.4 Hz, 1H), 2.73 (dd, *J* = 4.9, 2.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.2, 133.2, 129.7, 129.6, 128.4, 49.5, 44.7. Compound **5j** is known.[11f]

2-((Allyloxy)methyl)oxirane (5k). Glycidol **S5** (448 μL, 6.75 mmol) was added to a 50-mL round-bottom flask and dissolved in THF (13 mL). The resulting solution was then cooled to 0 °C. Neat NaH (324 mg, 8.20 mmol) was added in one portion and after the cessation of the

evolution of gas, allyl bromide (1.20 mL, 10.1 mmol) was added slowly, dropwise. After 7 hours, the reaction was determined to be complete by TLC analysis and the reaction was cooled to 0 °C. The cooled solution was then quenched with saturated NH_4C (5 mL). Upon separation of the two layers, the aqueous layer was extracted with EtOAc (3 x 15 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using a 10% - 20% EtOAc in hexanes gradient to afford **5k** as a clear oil in 43% yield (334 mg, 2.93 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.89 (ddt, *J* = 16.2, 11.0, 5.9 1H), 5.28 (d, *J* = 17.8 Hz 1H), 5.19 (d, *J* = 10.4 Hz 1H), 4.03 (dq, *J* = 13.0, 5.9 Hz 2H), 3.71 (dd, *J* = 11.6, 3.1 Hz, 1H), 3.39 (dd, *J* = 11.2, 5.2 Hz, 1H), 3.18 – 3.12 (m, 1H), 2.79 (t, *J* = 4.4 Hz, 1H), 2.60 (dd, *J* = 5.2, 2.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 134.4, 117.3, 72.2, 70.7, 50.7, 44.3. Compound **5k** is known.[11j]

6-(Oxiran-2-ylmethoxy)-1-phenylhexan-2-ol (5l). CuI (30 mg, 0.160 mmol) was added 50-mL round-bottom flask while the flask was still hot. The flask was then vacuum purged with N_2 and gradually cooled to room temperature. Phenylmagnesium bromide (1.1 mL, 3.20 mmol, 3 M in THF) was added to the flask and the solution was cooled to -78 °C. After cooling for 5 minutes, epoxide **5g** (250 mg, 1.60 mmol) was added via cannula in a solution of THF (5.3 mL), dropwise. After 5 minutes, the reaction was then warmed to 0 °C. After 1 hour, the reaction was determined to be complete by TLC analysis and quenched with saturated NH_4Cl (1 mL), while still at 0 °C. Upon separation of the two layers, the aqueous layer was back extracted with Et_2O (3 x 10 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using a 10% - 20% EtOAc in hexanes gradient to afford 6-(allyloxy)-1-phenylhexan-2-ol **S6** as a clear oil in 91% yield (340 mg, 1.45 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (t, *J* = 7.2 Hz,

2H), 7.26 – 7.20 (m, 3H), 5.91 (ddt, *J* = 17.2, 10.8, 5.6 Hz, 1H), 5.27 (dd, *J* = 17.2, 1.3 Hz, 1H), 5.17 (dd, *J* = 10.3, 1.5 Hz, 1H), 3.96 (d, *J* = 5.7, 1.5 Hz, 2H), 3.88 – 3.79 (m, 1H), 3.44 (t, *J* = 6.3, 1.3 Hz, 2H), 2.83 (dd, *J* = 13.9, 4.4 Hz, 1H), 2.66 (dd, *J* = 13.6, 8.1 Hz, 1H), 1.68 – 1.42 (m, 6H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.5, 135.0, 129.4, 128.5, 126.4, 116.7, 72.5, 71.8, 70.2, 44.0, 36.5, 29.6, 22.4. IR (cm^{-1}): *f* = 3415, 3062, 2935, 1602, 1495, 1347, 1269, 1100, 997, 853, 746. HRMS-ESI: $(M + H)^+$ = 235.1693 calcd for $C_{15}H_{23}O_2$, found = 235.1695.

6-(Allyloxy)-1-phenylhexan-2-ol **S6** (340 mg, 1.45 mmol) was added to 50-mL round-bottom flask, and dissolved in CH_2Cl_2 (3 mL). The solution was then cooled to 0 °C and *m*CPBA (535 mg, 2.17 mmol, 70 wt %) was added in one portion. The solution was allowed to warm to room temperature gradually. After 28 hours, the reaction was determined to be complete by TLC analysis. The reaction was then cooled to 0 °C and quenched with 1 M NaOH (3 mL). After separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude oil was then purified by column chromatography using a 10% - 50% EtOAc in hexanes gradient to afford **5m** as a 1:1 mixture of inseparable diastereomers as a clear oil in 83% yield, (303 mg, 1.21 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 – 7.28 (m, 4H), 7.26 – 7.19 (m, 6H), 3.87 – 3.79 (m, 2H), 3.71 (dd, *J* = 11.7, 3.3 Hz, 2H), 3.59 – 3.45 (m, 4H), 3.37 (dd, *J* = 11.7, 5.8 Hz, 2H), 3.17 – 3.11 (m, 2H), 2.87 – 2.77 (m, 4H), 2.66 (dd, *J* = 13.5, 8.4 Hz, 2H), 2.60 (dd, *J* = 5.2, 2.9 Hz, 2H), 1.67 – 1.42 (m, 12H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.6, 129.4, 128.6, 126.5, 72.5, 71.5, 71.5, 50.9, 44.3, 44.1, 36.5, 29.6, 22.3. IR (cm^{-1}): *f* = 3446, 3059, 3000, 2935, 2862, 1601, 1495, 1394, 1030, 852, 701. HRMS-ESI: $(M + H)^+$ = 251.1642 calcd for $C_{15}H_{23}O_3$, found = 251.1649.

1,2-Dichloro-6-(methoxymethoxy)hexane (6a). Epoxide **5a** (113 mg, 0.705 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.4 mL), followed by the addition of triphosgene (105 mg, 0.353 mmol). After complete dissolution of triphosgene, pyridine (114 μL, 1.41 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6a** as a clear oil in 70% yield (107 mg, 0.497 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.61 (s, 2H), 4.04 (dddd, J = 8.7, 7.5, 5.0, 3.6 Hz, 1H), 3.77 (dd, J = 11.3, 5.1 Hz, 1H), 3.65 (dd, J = 11.3, 7.6 Hz, 1H), 3.57 – 3.51 (m, 2H), 3.36 (s, 3H), 2.04 (m, 1H), 1.84 – 1.47 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 96.5, 67.4, 61.0, 55.2, 48.1, 34.8, 29.1, 22.7. IR (cm^{-1}): f = 2941, 2871, 2772, 1457, 1440, 1146, 1041, 918, 729. HRMS-ESI: $(M + Na)^+$ = 237.0420 calcd for $C_8H_{16}Cl_2NaO_2$, found = 237.0416.

5,6-Dichlorohexyl acetate (6b). Epoxide **5b** (131 mg, 0.828 mmol) was added to a vacuum cooled, nitrogen purged 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.6 mL), followed by the addition of triphosgene (123 mg, 0.414 mmol). After complete dissolution of triphosgene, pyridine (134 μL, 1.66 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4,

filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6b** as a clear oil in 86% yield (151 mg, 0.708 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.08 (t, *J* = 6.3 Hz, 2H), 4.05 – 3.98 (m, 1H), 3.77 (dd, *J* = 10.8, 5.0 Hz, 1H), 3.64 (dd, *J* = 10.7, 6.9 Hz, 1H), 2.08 – 1.98 (m, 4H), 1.79 – 1.59 (m, 4H), 1.56 – 1.45 (m, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.1, 64.0, 60.8, 48.0, 34.6, 28.0, 22.4, 20.9. IR (cm^{-1}): *f* = 2953, 1733, 1434, 1365, 1039, 807, 729. HRMS-ESI: $(M + H)^+$ = 213.0444 calcd for $C_8H_{15}Cl_2O_2$, found = 213.0452.

1-(((5,6-Dichlorohexyl)oxy)methyl)-4-methoxybenzene (6c). Epoxide **5c** (122 mg, 0.516 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.0 mL), followed by the addition of triphosgene (76 mg, 0.258 mmol). After complete dissolution of triphosgene, pyridine (83 μL, 1.03 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6c** as a clear oil in 80% yield (135 mg, 0.463 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, *J* = 8.4 Hz 2H), 6.89 (d, *J* = 8.6 Hz 2H), 4.44 (s, 2H), 4.07 – 3.98 (m, 1H), 3.81 (s, 3H), 3.75 (dd, *J* = 11.2, 5.3 Hz, 1H), 3.64 (dd, *J* = 11.2, 7.2 Hz, 1H), 3.46 (t, *J* = 6.2 Hz, 2H), 2.04 – 1.95 (m, 1H), 1.78 – 1.45 (m, 5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.2, 130.6, 129.2, 113.8, 72.6, 69.6, 61.1, 55.3, 48.2, 34.9, 29.1, 22.7. IR (cm^{-1}): *f* = 3001, 2936, 1612, 1458, 1361, 1244, 1209, 1172, 1097, 730. HRMS-ESI: $(M + Na)^+$ = 313.0733 calcd for $C_{14}H_{20}Cl_2NaO_2$, found = 313.0722.

***Tert*-butyl((5,6-dichlorohexyl)oxy)diphenylsilane (6d).** Epoxide **5d** (122 mg, 0.516 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.0 mL), followed by the addition of triphosgene (76 mg, 0.258 mmol). After complete dissolution of triphosgene, pyridine (83 μL, 1.03 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6d** as a clear oil in 88% yield (135 mg, 0.463 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26 (d, *J* = 8.4 Hz 2H), 6.89 (d, *J* = 8.6 Hz 2H), 4.44 (s, 2H), 4.07 – 3.98 (m, 1H), 3.81 (s, 3H), 3.75 (dd, *J* = 11.2, 5.3 Hz, 1H), 3.64 (dd, *J* = 11.2, 7.2 Hz, 1H), 3.46 (t, *J* = 6.2 Hz, 2H), 2.04 – 1.95 (m, 1H), 1.78 – 1.45 (m, 5H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.2, 130.6, 129.2, 113.8, 72.6, 69.6, 61.1, 55.3, 48.2, 34.8, 29.1, 22.7. IR (cm^{-1}): *f* = 3001, 2936, 1612, 1585, 1361, 1244, 1209, 1097, 820, 730. HRMS-ESI: $(M + Na)^+$ = 313.0733 calcd for $C_{14}H_{20}Cl_2NaO_2$, found = 313.0722.

***Tert*-butyl((5,6-dichlorohexyl)oxy)dimethylsilane (6e).** Epoxide **5e** (154 mg, 0.668 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.3 mL), followed by the addition of triphosgene (99 mg, 0.334 mmol). After complete dissolution of triphosgene, pyridine (108 μL, 1.34 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2

(3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6e** as a clear oil in 80% yield (135 mg, 0.463 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.09 – 3.99 (m, 1H), 3.76 (dd, *J* = 11.3, 5.2 Hz, 1H), 3.68 – 3.61 (m, 3H), 2.07 – 1.96 (m, 1H), 1.79 – 1.67 (m, 1H), 1.67 – 1.44 (m, 4H), 0.90 (s, 9H), 0.05 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 62.7, 61.2, 48.2, 34.9, 32.1, 26.0, 22.3, 18.3, -5.3. IR (cm^{-1}): *f* = 2929, 1472, 1387, 1253, 1095, 833, 774. HRMS-ESI: $(M + H)^+$ = 285.1203 calcd for $C_{12}H_{27}Cl_2OSi$, found = 285.1204.

1,2-Dichloro-6-(prop-2-yn-1-yloxy)hexane (6f). Epoxide **5f** (123 mg, 0.797 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.6 mL), followed by the addition of triphosgene (118 mg, 0.399 mmol). After complete dissolution of triphosgene, pyridine (130 µL, 1.60 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6f** as a clear oil in 86% yield (144 mg, 0.689 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.13 (d, *J* = 2.6 Hz, 2H), 4.08 – 3.99 (m, 1H), 3.76 (dd, *J* = 11.2, 5.1 Hz, 1H), 3.65 (dd, *J* = 11.6, 7.3 Hz, 1H), 3.54 (t, *J* = 6.0 Hz, 2H), 2.42 (t, *J* = 2.3 Hz, 1H), 2.08 – 1.97 (m, 1H), 1.80 – 1.71 (m, 1H), 1.71 – 1.57 (m, 3H), 1.55 – 1.46 (m, 1H). 13C NMR (101 MHz, CDCl3) δ 79.9, 74.2, 69.7, 61.0, 58.1, 48.2, 34.8, 28.9, 22.6. IR (cm^{-1}): *f* =3296, 2944, 1438,

1355, 1270, 1181, 1097, 919, 814. HRMS-ESI: $(M + H)^+$ = 209.0494 calcd for $C_9H_{15}Cl_2O$, found = 209.0494.

6-(Allyloxy)-1,2-dichlorohexane (6g). Epoxide **5g** (119 mg, 0.762 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.5 mL), followed by the addition of triphosgene (113 mg, 0.381 mmol). After complete dissolution of triphosgene, pyridine (123 μL, 1.52 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6g** as a clear oil in 90% yield (145 mg, 0.687 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.91 (ddt, *J* = 15.9, 10.3, 5.6 Hz, 1H), 5.42 – 4.93 (m, 2H), 4.04 (dddd, *J* = 8.9, 7.4, 5.1, 3.7 Hz, 1H), 3.97 (dt, *J* = 5.6, 1.5 Hz, 2H), 3.84 – 3.58 (m, 2H), 3.45 (t, *J* = 6.0 Hz, 2H), 2.38 – 1.90 (m, 1H), 1.83 – 1.37 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 134.9, 116.8, 71.9, 69.9, 61.1, 48.2, 34.9, 29.1, 22.7. IR (cm^{-1}): *f* = 3014, 2940, 2861, 1646, 1478, 1456, 1102, 923. HRMS-ESI: $(M + H)^+$ = 211.0651 calcd for $C_9H_{17}Cl_2O$, found = 211.0648.

1,2-Dichloro-6-(2,3-dichloropropoxy)hexane (6h). Epoxide **5h** (152 mg, 0.883 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.8 mL), followed by the addition of triphosgene (262 mg, 0.883 mmol). After complete dissolution of triphosgene, pyridine (285 μL, 3.53 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 2 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2

M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6h** as a clear oil in 81% yield (201 mg, 0.713 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.16 (p, *J* = 11.2, 5.2 Hz, 1H), 4.08 – 4.00 (m, 1H), 3.85 (dd, *J* = 11.2, 6.2 Hz, 1H), 3.75 (dq, *J* = 11.2, 5.4 Hz, 4H), 3.65 (dd, *J* = 11.2, 7.6 Hz, 1H), 3.53 (t, *J* = 6.3 Hz, 2H), 2.08 – 1.99 (m, 1H), 1.80 – 1.44 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 71.3, 71.0, 60.9, 58.2, 48.1, 45.3, 34.7, 28.8, 22.5. IR (cm^{-1}): *f* = 2944, 2866, 1667, 1457,1432, 1256, 1117, 818, 731. HRMS-ESI: $(M + H)^+$ = 281.0028 calcd for $C_9H_{17}Cl_4O$, found = 281.0028.

((2,3-Dichloropropoxy)methyl)benzene (6i). Epoxide **5i** (188 mg, 1.16 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (2.3 mL), followed by the addition of triphosgene (172 mg, 0.579 mmol). After complete dissolution of triphosgene, pyridine (187 μL, 2.32 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 6 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6i** as a clear oil in 87% yield (222 mg, 1.01 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.31 (m, 5H), 4.65 – 4.57 (m, 2H), 4.19 (p, J = 5.3 Hz, 1H), 3.89 (dd, J = 11.6, 6.6 Hz, 1H), 3.83 – 3.75 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.5, 128.5, 127.9, 127.7, 73.5, 70.4, 58.3, 45.3. Compound **6i** is known.[12a]

2,3-Dichloropropyl benzoate (6j). Epoxide **5j** (218 mg, 1.22 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (2.5 mL), followed by the addition of triphosgene (181 mg, 0.612 mmol). After complete dissolution of triphosgene, pyridine (198 μL, 2.45 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 3 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **5j** as a clear oil in 71% yield (202 mg, 0.867 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (d, J = 8.2 Hz, 2H), 7.60 (t, *J* = 7.6 Hz 1H), 7.47 (t, J = 7.6 Hz, 2H), 4.71 – 4.61 (m, 2H), 4.42 – 4.36 (m, 1H), 3.87 (d, J = 6.4 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.8, 133.4, 129.7, 129.3, 128.5, 64.7, 56.9, 44.7. Compound **6j** is known.[12b]

3-(2,3-Dichloropropoxy)prop-1-ene (6k).[13] Epoxide **5k** (165 mg, 1.45 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (2.9 mL), followed by the addition of triphosgene (215 mg, 0.723 mmol). After complete dissolution of triphosgene, pyridine (234 μL, 2.89 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 6 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6k** as a clear oil in 67% yield (165 mg, 0.976 mmol). ^{1}H NMR (400

MHz, $CDCl_3$) δ 5.90 (ddt, *J* = 16.0, 10.7, 5.3 Hz, 1H), 5.30 (d, *J* = 17.2 Hz, 1H), 5.22 (dt, *J* = 10.7 Hz, 1H), 4.17 (p, *J* = 10.8, 5.1 Hz, 1H), 4.06 (d, *J* = 5.2 Hz, 2H), 3.86 (dd, *J* = 11.3, 6.6 Hz, 1H), 3.79 (dd, *J* = 11.4, 5.2 Hz, 1H) 3.74 (dd, *J* = 4.6, 1.5 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 134.0, 117.7, 72.4, 70.2, 58.3, 45.2. Compound **6k** is known.[12c]

(2-Chloro-6-(2,3-dichloropropoxy)hexyl)benzene (6l). Epoxide **5l** (122 mg, 0.487 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.0 mL), followed by the addition of triphosgene (144 mg, 0.487 mmol). After complete dissolution of triphosgene, pyridine (158 μL, 1.95 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **6l** as a clear oil in 71% yield (111 mg, 0.343 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (t, *J* = 7.9 Hz, 4H), 7.28 – 7.24 (m, 2H), 7.21 (d, *J* = 7.5 Hz, 4H), 4.18 – 4.06 (m, 4H), 3.84 (dd, *J* = 11.3, 6.3 Hz, 2H), 3.77 (dd, *J* = 11.4, 5.3 Hz, 2H), 3.74 – 3.66 (m, 4H), 3.49 (t, *J* = 6.0 Hz, 4H), 3.11 – 2.99 (m, 4H), 1.86 – 1.76 (m, 2H), 1.75 – 1.47 (m, 10H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.0, 129.3, 128.4, 126.8, 76.7, 71.4, 71.1, 63.7, 58.3, 45.3, 45.1, 37.3, 28.9, 23.1. IR (cm^{-1}): *f* = 3028, 2942, 1495, 1454, 1366, 1254, 1119, 1030, 748, 700. HRMS-ESI: $(M + Na)^+$ = 345.0550 calcd for $C_{15}H_{21}Cl_3NaO$, found = 345.0562.

1-Chloro-3-phenylpropan-2-ol (8). Epoxide **3** (288 mg, 2.15 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (4.3 mL), followed by the addition of triphosgene (317 mg, 1.07 mmol). After complete dissolution of triphosgene, pyridine (347

μL, 4.29 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour the reaction was quenched prematurely with 2 M HCl (3 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using a 5% - 15% EtOAc in hexanes gradient to afford halohydrin **8** (210 mg, 1.23 mmol) and dichloride **4** (66 mg, 0.349 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.31 (m, 2H), 7.30 – 7.21 (m, 3H), 4.11 – 4.02 (m, 1H), 3.62 (dd, *J* = 11.3, 3.9 Hz, 1H), 3.51 (dd, *J* = 11.2, 6.2 Hz, 1H), 2.90 (d, *J* = 6.6 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 137.0, 129.3, 128.6, 126.8, 77.3, 77.0, 76.7, 72.2, 49.1, 40.6. IR (cm^{-1}): *f* = 3389, 3028, 2952, 2922, 1602, 1495, 1298, 1196, 1083, 1044, 960, 914, 885. HRMS-ESI: $(M + H - H_2O)^+$ = 153.0466 calcd for $C_9H_{10}Cl$, found = 153.0464.

((*S*)-Oxiran-2-yl)methyl (*R*)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate ((+)-9a). (*R*)-(+)-α-Methoxy-α-trifluoromethylphenylacetic acid (72 mg, 0.306 mmol) was added to a 50-mL round-bottom flask followed by (*R*)-glycidol **(+)-S5** (19 μL, 0.291 mmol). The two components were then dissolved in CH_2Cl_2 (2.9 mL) and stirred vigorously. EDCI (84 mg, 0.436 mmol) and DMAP (39 mg, 0.320 mmol) were subsequently added and dissolved. After 6 hours, the reaction was determined to be complete by TLC analysis and quenched with H_2O (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 20% EtOAc in hexanes to afford **(+)-9a** as a clear oil in 45% yield (38 mg, 0.131 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.50 (m, 2H), 7.44 – 7.36 (m, 3H), 4.66 (dd, *J* = 12.4, 3.2 Hz, 1H), 4.21 (dd, *J* = 12.3, 5.6 Hz, 1H), 3.57 (s, 3H), 3.29 – 3.23 (m, 1H), 2.86 – 2.80 (m, 1H), 2.66

(dd, J = 4.8, 2.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 132.0, 129.7, 128.5, 127.3, 127.3, 124.6, 121.7, 65.9, 55.5, 48.7, 44.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -71.77. IR (cm^{-1}): f = 3004, 2953, 2925, 2850, 1749, 1451, 1346, 1165, 1081, 999, 817, 764, 717. HRMS-ESI: $(M + H)^+$ = 291.0839 calcd for $C_{13}H_{14}F_3O_4$, found = 291.0841. $[\alpha]^{25}_D$ = +80.4° (c = 1 $CDCl_3$).

4-((*R*)-Oxiran-2-yl)butyl (R)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate ((+)-9b). (*R*)-(+)-α-Methoxy-α-trifluoromethylphenylacetic acid (196 mg, 0.839 mmol) was added to a 50-mL round-bottom flask containing (*R*)-4-(oxiran-2-yl)butan-1-ol **(+)-S3** (80 mg, 0.799 mmol).[11k] The two components were then dissolved in CH_2Cl_2 (8 mL) and stirred vigorously. EDCI (230 mg, 1.20 mmol) and DMAP (195 mg, 1.60 mmol) were subsequently added and dissolved. After spinning overnight, the reaction was determined to be complete by TLC analysis and quenched with H_2O (5 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was purified by column chromatography using 20% EtOAc in hexanes to afford **(+)-9b** as a clear oil in 51% yield (135 mg, 0.406 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.55 – 7.47 (m, 2H), 7.43 – 7.37 (m, 3H), 4.33 (ddt, J = 24.1, 17.5, 6.6 Hz, 2H), 3.55 (s, 3H), 2.89 – 2.84 (m, 1H), 2.73 (t, J = 4.5 Hz, 1H), 2.43 (dd, J = 5.1, 2.6 Hz, 1H), 1.77 (p, J = 6.9 Hz, 2H), 1.63 – 1.46 (m, 4H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.6, 132.3, 129.6, 128.4, 128.3, 127.3, 124.4, 122.2, 84.9, 84.7, 84.5, 84.3, 66.1, 55.4, 51.9, 46.9, 31.8, 28.1, 22.3. ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.59. IR (cm^{-1}): f = 3045, 2948, 2850, 1745, 1587, 1452, 1387, 1164, 1080, 997, 916, 882, 821, 732. HRMS-ESI: $(M + H)^+$ = 333.1308 calcd for $C_{16}H_{20}F_3O_4$, found = 333.1302. $[\alpha]^{25}_D$ = +47.0° (c = 1 $CDCl_3$).

(*S*)-Oxiran-2-ylmethyl 3,5-dinitrobenzoate ((+)-9c). (*R*)-glycidol **(+)-S5** (448 μL, 6.75 mmol) was added to an oven-dried 100-mL round-bottom flask. Triethylamine (2.82 mL, 20.3

mmol) and DMAP (10 mg) were combined with the epoxide and subsequently dissolved in CH_2Cl_2 (27 mL). The resulting solution was cooled to 0 °C and 3,5-dinitrobenzoyl chloride was added via cannula as a 1 M solution in CH_2Cl_2 (1.80 g, 7.80 mmol, 7.8 mL). The dark orange solution was allowed to warm to room temperature gradually. After 3 hours, the reaction was determined to be complete by TLC analysis and 5 mL of 2 M HCl was added to quench. Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 20 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was purified by column chromatography using a 10% - 30% EtOAc in hexanes gradient eluting epoxide **(+)-9c** in 85% (1.78 g, 6.64 mmol) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.25 (t, *J* = 2.2 Hz, 1H), 9.19 (d, *J* = 2.2 Hz, 2H), 4.81 (dd, *J* = 13.2, 2.9 Hz, 1H), 4.27 (dd, *J* = 12.3, 6.6 Hz, 1H), 3.40 (tdd, *J* = 6.8, 4.1, 2.7 Hz, 1H), 2.97 (dd, *J* = 4.8, 4.1 Hz, 1H), 2.76 (dd, *J* = 4.8, 2.6 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.3, 148.7, 133.3, 129.6, 122.6, 67.5, 48.9, 44.7. IR (cm^{-1}): *f* = 3099, 1730, 1629, 1461, 1342, 1274, 1165, 982, 921, 864, 773. HRMS-ESI: $(M + H)^+$ = 269.0404 calcd for $C_{10}H_9N_2O_7$, found = 269.0411. $[\alpha]^{25}_D$ = +32.8° (c = 1 $CDCl_3$).

(*S*)-*Tert*-butyl(oxiran-2-ylmethoxy)diphenylsilane ((-)-9d). (*R*)-glycidol **(+)-S5** (250 μL, 3.77 mmol) was added to a 100-mL round-bottom flask and dissolved in THF (25 mL). After cooling the solution to 0 °C, imidazole (513 mg, 7.53 mmol) was added in one portion followed by the dropwise addition of TBDPSCl (1.25 mL, 4.90 mmol). After warming to room temperature overnight, the reaction was quenched with $NaHCO_3$ (5 mL). Upon separation of the two layers, the aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was purified by column chromatography using 2% EtOAc in hexanes to afford **(-)-9d**

as a clear oil in 72% yield (1.00 g, 3.20 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.71 – 7.67 (m, 4H), 7.46 – 7.37 (m, 6H), 3.85 (dd, *J* = 11.9, 3.4 Hz, 1H), 3.71 (dd, *J* = 11.7, 4.8 Hz, 1H), 3.16 – 3.09 (m, 1H), 2.75 (t, *J* = 4.6 Hz, 1H), 2.61 (dd, *J* = 5.2, 2.5 Hz, 1H), 1.06 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 135.6, 135.6, 133.3, 129.7, 127.707 64.3, 52.3, 44.5, 26.7, 19.24. $[\alpha]^{20}_{D}$ = -2.9° (c = 1, $CDCl_3$). Compound **(-)-9d** is known.[111]

(*S*)-2,3-Dichloropropyl (*R*)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate ((+)-10a). Epoxide **(+)-9a** (25 mg, 0.0861 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (170 μL), followed by the addition of triphosgene (13 mg, 0.0431 mmol). After complete dissolution of triphosgene, pyridine (14 μL, 0.172 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 3 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **(+)-10a** as a clear oil in 63% yield (19 mg, 0.0550 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.55 – 7.51 (m, 2H), 7.44 – 7.40 (m, 3H), 4.69 (dd, *J* = 12.1, 4.5 Hz, 1H), 4.61 (dd, *J* = 11.7, 5.6 Hz, 1H), 4.32 – 4.26 (m, 1H), 3.74 (dd, *J* = 11.5, 6.1 Hz, 1H), 3.70 (dd, *J* = 11.6, 7.6 Hz, 1H), 3.57 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.0, 131.8, 129.8, 128.5, 127.4, 124.3, 122.0, 65.7, 55.8, 55.5, 44.0. ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.66. IR (cm^{-1}): *f* = 2965, 2850, 1754 1380, 1238, 1120, 1107, 1017, 873, 764. HRMS-ESI: $(M + H)^+$ = 345.0267 calcd for $C_{13}H_{14}Cl_2F_3O_3$, found = 345.0262. $[\alpha]^{25}_{D}$ = +15.6° (c = 1 $CDCl_3$).

(*S*)-5,6-Dichlorohexyl (R)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate ((+)-10b). Epoxide **(+)-9b** (74 mg, 0.223 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (0.5 mL), followed by the addition of triphosgene (33 mg, 0.111 mmol). After complete dissolution of triphosgene, pyridine (36 μL, 0.445 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product (+)-**10b** as a clear oil in 78% yield (67 mg, 0.173 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 – 7.50 (m, 2H), 7.43 – 7.39 (m, 3H), 4.38 (dt, *J* = 11.0, 6.4 Hz, 1H), 4.31 (dt, *J* = 11.0, 6.4 Hz, 1H), 3.97 (tdd, *J* = 8.6, 5.0, 3.5 Hz, 1H), 3.74 (dd, *J* = 11.3, 5.0 Hz, 1H), 3.59 (dd, *J* = 11.4, 7.8 Hz, 1H), 3.56 (d, *J* = 1.5 Hz, 3H), 2.04 – 1.95 (m, 1H), 1.81 – 1.68 (m, 3H), 1.68 – 1.58 (m, 1H), 1.51 – 1.42 (m, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.6, 132.4, 129.6, 128.4, 128.3, 127.3, 124.5, 122.2, 84.8, 84.5, 65.9, 60.6, 55.4, 47.9, 34.4, 27.8, 22.24. ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.56. IR (cm^{-1}): *f* = 2952, 2849, 1745, 1495, 1265, 1121, 1021, 998, 818. HRMS-ESI: $(M + H)^+$ = 387.0736 calcd for $C_{16}H_{20}Cl_2F_3O_3$, found = 387.0733. $[\alpha]^{20}_D$ = +21.6° (c = 1, $CDCl_3$).

(*S*)-2,3-Dichloropropyl 3,5-dinitrobenzoate ((-)-10c). Epoxide **(+)-9c** (166 mg, 0.619 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (1.2 mL), followed by the addition of triphosgene (92 mg, 0.309 mmol). After complete dissolution of triphosgene, pyridine (100 μL, 1.24 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 3 hours, the starting material was fully consumed as

determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **(-)-10c** as a clear oil in 81% yield (161 mg, 0.498 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.26 (t, *J* = 2.0 Hz, 1H), 9.17 (d, *J* = 2.0 Hz, 2H), 4.85 (dd, *J* = 11.6, 4.1 Hz, 1H), 4.75 (dd, *J* = 12.0, 6.0 Hz, 1H), 4.49 – 4.41 (m, 1H), 3.93 (dd, *J* = 11.6, 4.7 Hz, 1H), 3.85 (dd, *J* = 11.7, 8.2 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 161.9, 148.8, 133.0, 129.5, 122.8, 66.475 56.2, 44.3. IR (cm^{-1}): *f* = 3124, 3107, 3097, 1729, 1543, 1294, 1256, 1168, 1075, 987, 910, 818, 716. HRMS-ESI: $(M + Cl)^-$ = 356.9453 calcd for $C_{10}H_8Cl_3N_2O_6$, found = 356.9456. $[\alpha]^{25}_D$ = -21.0° (c =1 $CDCl_3$).

(*S*)-2,3-Dichloropropyl 3,5-dinitrobenzoate ((-)-10c). Dichloride **(+)-11** (383 mg, 1.04 mmol) was added via cannula in THF (5.2 mL) to an oven-dried 50-mL round-bottom flask. The resulting solution was subsequently cooled to 0 °C and TBAF (1.56 mL, 1.56 mmol) was added slowly, dropwise. After 20 minutes, the reaction warmed to room temperature. After 1 hour, the dichloride had been completely consumed as determined by TLC analysis. The solution was then cooled back to 0 °C and Et_3N (435 μL, 3,12 mmol) was added. A solution of 3,5-dinitrobenzoyl chloride (252 mg, 1.09 mmol) and DMAP (13 mg, 0.104 mmol) was prepared in a conical flask dissolved THF (~3 mL). This pale yellow solution was subsequently added via cannula to the cooled flask containing the deprotected dichloride and Et_3N. After 3 hours, acylation of the dichloride was complete based as determined by TLC, and the reaction was quenched with $NaHCO_3$ (5 mL). Upon separation of the two layers, the aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic layers were, dried over Na_2SO_4,

filtered, and concentrated under reduced pressure. The resulting crude oil was purified by column chromatography using 1% EtOAc in hexanes to afford **(-)-10c** as a white solid in 58% yield (194 mg, 0.600 mmol). $[\alpha]^{20}_{D}$ = -20.0° (c = 0.8, $CDCl_3$). NMR spectra are identical to those of dichloride **(-)-10c** prepared from epoxide **(+)-9c**.

(*S*)-*Tert*-butyl(2,3-dichloropropoxy)diphenylsilane ((+)-11). Epoxide **(-)-9d** (454 mg, 0.1.45 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (2.9 mL), followed by the addition of triphosgene (215 mg, 0.726 mmol). After complete dissolution of triphosgene, pyridine (235 µL, 2.90 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After stirring overnight, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (3 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **(+)-11** as a clear oil in 88% yield (473 mg, 1.29 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 – 7.67 (m, 4H), 7.49 – 7.39 (m, 6H), 4.15 – 4.07 (m, 1H), 4.04 – 3.96 (m, 2H), 3.88 (m, 2H), 1.10 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 135.6, 135.5, 132.8, 132.7, 129.9, 127.8, 127.8, 64.1, 60.1, 44.8, 26.7, 19.3. IR (cm^{-1}): *f* = 3071, 3050, 2958, 2930, 2892, 2857, 1589, 1427, 1215, 1135, 1083, 1006, 936. HRMS-ESI: $(M + H)^+$ = 367.1046 calcd for $C_{19}H_{25}Cl_2OSi$, found = 367.1055. $[\alpha]^{20}_{D}$ = +21.6° (c = 1, $CDCl_3$).

Oxiran-2-ylmethyl (2*R*)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate (S7). (*R*)-(+)-α-Methoxy-α-trifluoromethylphenylacetic acid (72 mg, 0.307 mmol) was added to a 50-mL round-bottom flask followed by glycidol (19 µL, 0.293 mmol). The two components were then

dissolved in CH_2Cl_2 (2.9 mL) and stirred vigourously. EDCl (84 mg, 0.439 mmol) and DMAP (39 mg, 0.322 mmol) were subsequently added and dissolved. After 6 hours, the reaction was determined to be complete by TLC analysis and quenched with H_2O (2 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was purified by column chromatography using 20% EtOAc in hexanes to afford **S7** as an inseparable mixture of diastereomers, as a clear oil in 45% yield (38 mg, 0.131 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 – 7.50 (m, 7H), 7.47 – 7.37 (m, 10H), 4.69 – 4.58 (m, 2H), 4.23 – 4.17 (m, 2H), 3.57 (s, 6H), 3.28 – 3.21 (m, 2H), 2.86 – 2.80 (m, 2H), 2.68 – 2.61 (m, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.3, 132.0, 131.9, 129.7, 128.5, 127.3, 124.3, 122.0, 77.3, 66.3, 65.9, 55.5, 48.7, 48.7, 44.5, 44.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -71.77. IR (cm^{-1}): f = 2956, 2924, 2850, 1749, 1451, 1345, 1242, 1165, 1119, 1081, 1020, 999, 901, 848, 801, 764, 717, 697, 645, 551, 509, 424. HRMS-ESI: $(M + H)^+$ = 291.0839 calcd for $C_{13}H_{14}F_3O_4$, found = 291.0841.

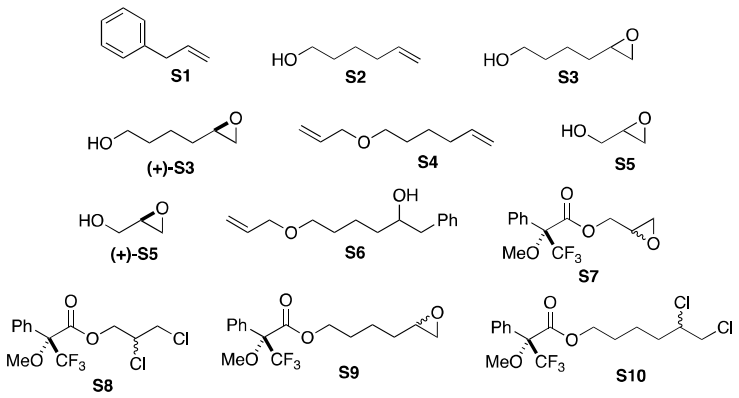
2,3-Dichloropropyl (2*R*)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate (S8). Epoxide **S7** (54 mg, 0.186 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (370 μL), followed by the addition of triphosgene (27 mg, 0.0930 mmol). After complete dissolution of triphosgene, pyridine (30 μL, 0.372 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 3 hours, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **S8** as a clear

oil in 62% yield (40 mg, 0.116 mmol). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 – 7.51 (m, 4H), 7.48 – 7.38 (m, 6H), 4.72 – 4.59 (m, 4H), 4.32 – 4.26 (m, 2H), 3.76 – 3.63 (m, 4H), 3.60 – 3.56 (m, 6H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.0, 131.8, 129.8, 128.5, 127.3, 127.3, 124.3, 122.0, 65.6, 65.5, 55.8, 55.7, 55.6, 55.6, 44.0, 43.9. ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.66, -71.73. IR (cm^{-1}): *f* = 2953, 2850, 1753, 1494, 1451, 1379, 1236, 1165, 1120, 1081, 1017, 914, 814, 764, 717, 696, 641, 568, 549, 507. HRMS-ESI: $(M + H)^+$ = 345.0267 calcd for $C_{13}H_{14}Cl_2F_3O_3$, found = 345.0271.

4-(Oxiran-2-yl)butyl (2*R*)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate (S9). (*R*)-(+)-α-Methoxy-α-trifluoromethylphenylacetic acid (372 mg, 0.1.59 mmol) was added to a 50-mL round-bottom flask containing epoxide **S3** (176 mg, 1.52 mmol). The two components were then dissolved in CH_2Cl_2 (15 mL) and stirred vigorously. EDCl (435 mg, 2.27 mmol) and DMAP (370 mg, 3.03 mmol) were subsequently added and dissolved. After spinning overnight, the reaction was determined to be complete by TLC analysis and quenched with H_2O (5 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 15 mL). The combined organic layers were, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was purified by column chromatography using 20% EtOAc in Hexanes to afford **S9** as a clear oil in 40% yield (196 mg, 0.606 mmol). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.54 – 7.48 (m, 2H), 7.42 – 7.37 (m, 3H), 4.40 – 4.26 (m, 2H), 3.56 (s, 3H), 2.89 – 2.81 (m, 1H), 2.73 (t, *J* = 4.6 Hz, 1H), 2.43 (dd, *J* = 4.7, 2.7 Hz, 1H), 1.81 – 1.70 (m, 2H), 1.63 – 1.43 (m, 5H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.55, 132.28, 129.59, 128.40, 127.26, 124.43, 122.14, 84.68, 84.46, 77.25, 77.00, 76.75, 66.13, 66.11, 55.41, 51.90, 51.88, 46.84, 31.80, 28.06, 22.31, 22.30. ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.59. IR (cm^{-1}): *f* = 2947, 2849,

1746, 1452, 1411, 1257, 1167, 1122, 1081, 1021, 998, 917, 839, 766, 717, 698, 509. HRMS-ESI: $(M + H)^+$ = 333.1304 calcd for $C_{16}H_{20}F_3O_4$, found = 333.1308.

5,6-Dichlorohexyl (2*R*)-3,3,3-trifluoro-2-methoxy-2-phenylpropanoate (S10). Epoxide **S9** (86 mg, 0.266 mmol) was added to a 15-mL pressure vessel. This compound was dissolved in CH_2Cl_2 (0.5 mL), followed by the addition of triphosgene (40 mg, 0.133 mmol). After complete dissolution of triphosgene, pyridine (43 μL, 0.532 mmol) was added. The vessel was sealed and heated to gentle reflux in a warm sand bath. After 1 hour, the starting material was fully consumed as determined by GC analysis. The reaction was cooled to room temperature and quenched with 2 M HCl (1 mL). Upon separation of the two layers, the aqueous layer was extracted with CH_2Cl_2 (3 x 10 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The resulting crude oil was then purified by column chromatography using 10% EtOAc in hexanes to afford product **S10** as a clear oil in 70% yield (72 mg, 0.186 mmol). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.55 – 7.50 (m, 2H), 7.43 – 7.38 (m, 3H), 4.41 – 4.27 (m, 2H), 4.02 – 3.94 (m, 1H), 3.74 (dd, *J* = 11.2, 5.2 Hz, 1H), 3.59 (dd, *J* = 11.3, 8.0, 1.3 Hz, 1H), 3.56 (s, 3H), 2.05 – 1.95 (m, 1H), 1.83 – 1.55 (m, 4H), 1.52 – 1.39 (m, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.55, 132.27, 129.62, 128.44, 127.25, 124.43, 122.14, 84.70, 84.47, 60.59, 60.57, 55.45, 47.90, 34.38, 27.76, 22.22. ^{19}F NMR (471 MHz, $CDCl_3$) δ -71.59. IR (cm^{-1}): *f* = 2953, 2847, 1745, 1494, 1451, 1258, 1164, 1120, 1081, 918, 804, 765. HRMS-ESI: $(M + H)^+$ = 387.0736 calcd for $C_{16}H_{20}Cl_2F_3O_3$, found = 387.0744.



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Supporting Information

^{1}H and ^{13}C NMR spectra for characterized compounds. GC Chromatograms of epoxides and their corresponding crude dichlorides for Tables 1-3. Synthesis of epoxides and their corresponding dichlorides as a mixture of diastereomers for Table 3. X-ray structures of compounds **(+)-9c** and **(-)-10c**. These materials are available free of charge via the Internet at http://pubs.acs.org.

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