Total Synthesis of (2*S*,3*S*,5*S*,10*S*)-6,9-Epoxynonadec-18-ene-7,10-diol and Formal Total Synthesis of (+)-*trans*-Kumausyne from D-Arabinose

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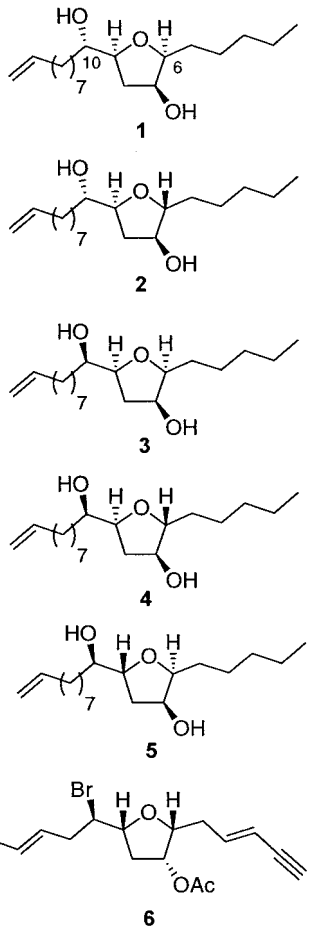
Introduction

Dihydroxytetrahydrofurans **1**[2] and **5**[3] (Chart 1) are marine natural products that have been isolated from *Notheia anomala*, a brown alga found along the southern Australian coast. Recently, Capon and co-workers have shown that these compounds and related analogues inhibit larval development in parasitic nematodes in vitro.[2] These natural products have attracted the attention of synthetic chemists, and a number of syntheses of **5** have been completed.[4] In contrast, only two total syntheses of **1** can be found in the literature. The first, reported by García, Soler, and Martín, involved conversion of *n*-heptanal to **1**, via a route that had as its key step a Sharpless asymmetric dihydroxylation.[5] More recently, Yoda and co-workers disclosed the synthesis of **1** from L-galactono-1,4-lactone.[6] We report here an efficient total synthesis of **1** and its C_6, C_{10}, and C_6/C_{10} epimers (**2**−**4**) from the readily accessible methyl 2,3-anhydro-5-*O*-benzyl-α-D-lyxofuranoside (**7**). As part of these investigations, we have also completed a formal total synthesis (+)-*trans*-kumausyne (**6**), a natural product isolated from the alga *Laurencia nipponica yamada*,[7] which has been the subject of a number of synthetic investigations.[8]

Chart 1



Results and Discussion

In designing a route to **1**−**4**, we chose **7** as an appropriate starting material. As outlined in Figure 1, the synthesis of the targets requires three major transformations: a regioselective hydride opening of the epoxide at C_3, the introduction of an alkyl group at C_1, and chain elongation at C_5.

The preparation of **7** was achieved in good overall yield from D-arabinose as previously described (Scheme 1).[9] Our initial attempts to reductively open epoxide **7** via reaction with DIBAL-H at −78 °C gave a mixture of **8** and **9** in a disappointing 1:2 ratio. A series of other hydride reagents were explored (Table 1), and LAH proved to be the most convenient, providing the product arising from C_3 attack with a high degree of regioselectivity. Thus, reaction of **7** with LAH at reflux in THF gave the 3-deoxy arabinofuranoside derivative **8** in 82% yield together with a 6% yield of the 2-deoxy isomer, **9**. The hydroxyl group in **8** was then benzoylated to afford **10** in excellent yield. Trimethylsilyltriflate-catalyzed *C*-allylation of **10** with allyltrimethylsilane at 0 °C produced a 1.4:1 mixture of tetrahydrofurans **11** and **12** in 89% yield. Although the two diastereomers could be readily separated by chromatography, improving the

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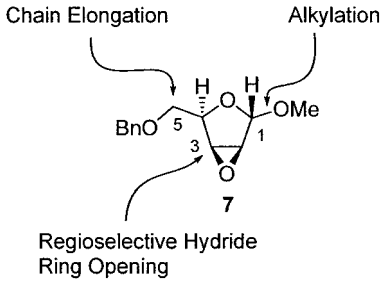


Figure 1.

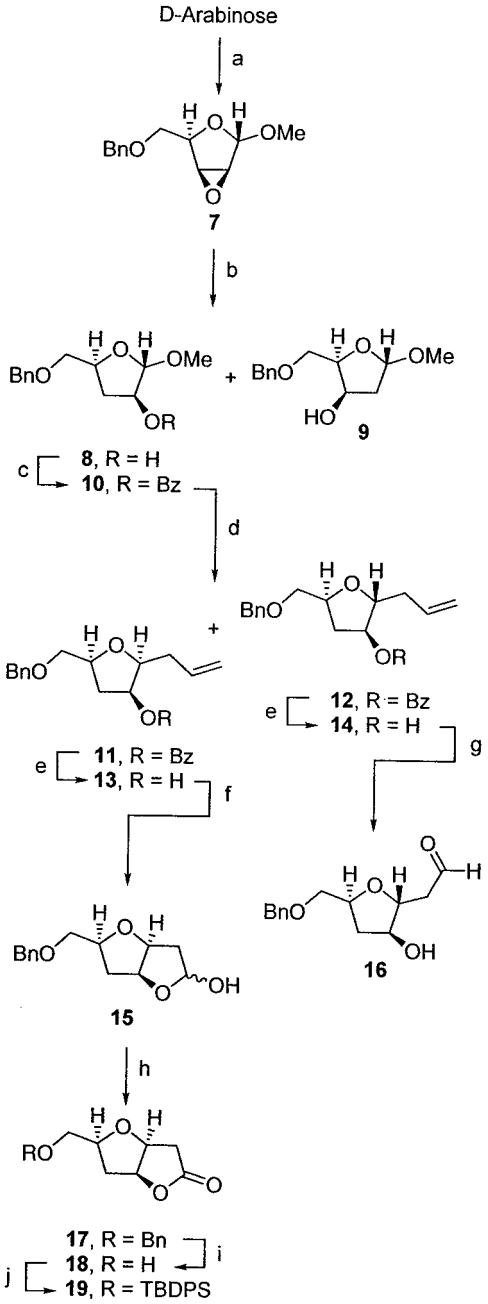
diastereoselectivity of this reaction was clearly desirable. We postulated that the **11**/**12** ratio could be improved in favor of **11** by substituting the benzoate ester in **10** with either a benzyl or MOM ether. Both compounds were prepared, but upon *C*-allylation, no improvement in diastereomeric ratio relative to **10** was observed.

The stereochemistry of the newly generated stereocenter in the allyl *C*-glycosides was confirmed as follows. First, Zemplén deacylation of **11** and **12** afforded alcohols **13** and **14**, respectively. Oxidation of **13** with OsO_4 and *N*-methylmorpholine oxide (NMO) followed by cleavage of the resulting vicinal diol with $NaIO_4$ gave lactol **15** in 92% yield as a 3:2 mixture of isomers. The structure of **15** could be readily determined by NMR spectroscopy. In the ^1H NMR spectrum, two acetal hydrogens at 5.38 and 5.62 ppm were apparent; in the ^{13}C NMR spectrum, resonances arising from the acetal carbons were present at 100.5 and 100.6 ppm. In contrast, dihydroxylation of **14**, followed by diol cleavage, gave the aldehyde **16**, not the isomeric lactol. The formation of lactol **15** from **13** and hydroxy aldehyde **16** from **14** clearly establishes the stereochemical relationship between the hydroxyl and allyl groups in these *C*-glycosides.

The stereochemistry of **13** was further proven by its conversion to the known lactone **19**. Oxidation of **15** with PCC gave lactone **17** in 97% yield. The benzyl group was removed in quantitative yield providing **18**, which was subsequently protected as a *tert*-butyldiphenylsilyl ether **19** (91%). Characterization of **19** by ^1H and ^{13}C NMR spectroscopy showed it to be identical to that previously reported.[8e] The elaboration of **19** to (+)-*trans*-kumausyne (**6**) has been reported earlier,[8e] and thus a formal synthesis of **6** has been achieved.

After confirming the structure of **11** and **12**, the synthesis of **1**−**4** could be completed (Schemes 2 and 3). To achieve the total synthesis of **1** (Scheme 2), compound **11** was first dihydroxylated with OsO_4/NMO. The resulting diol was treated with $NaIO_4$ to afford an aldehyde that was immediately treated with propylidene triphenylphosphorane. The olefin product, **20**, was obtained in an 87% overall yield from **11** as a 1:3 ratio of *E* and *Z* isomers. Hydrogenation of **20** over palladium on carbon resulted in both the reduction of the alkene and deprotection of the benzyl group to give alcohol **21** in 91% yield. On the basis of a previous report,[4f] we predicted that the C_{10} stereocenter could be stereoselectively introduced with the *S* stereochemistry, through oxidation of the hydroxyl group in **21** to the corresponding aldehyde and then reaction with the appropriate Grignard reagent. To that end, **21** was oxidized under Swern conditions and then immediately treated with 1-nonenylmagnesium bromide[10] in ether at −20 °C. Unexpectedly, this reaction sequence afforded in 75% yield an inseparable 4:1 mixture of alcohols **22**, with the desired 10*S* isomer being the minor component. However, the stereochemistry at

Scheme 1[a]



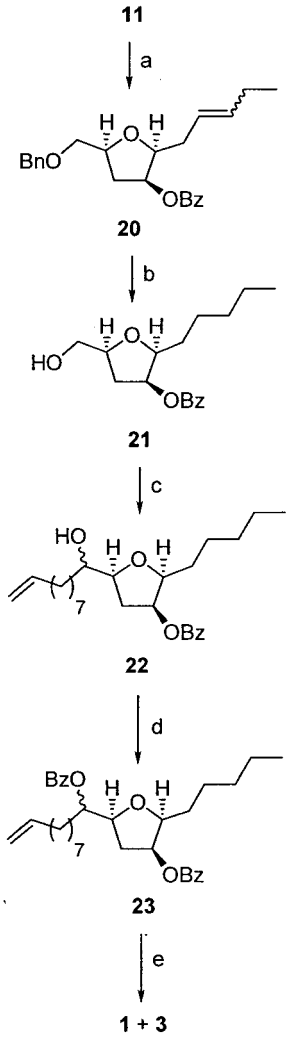
[a] Key: (a) ref 9; (b) $LiAlH_4$, THF, reflux, 88%, **8**/**9** 13.5:1; (c) BzCl, pyr, 0 °C → rt, 97%; (d) $CH_2{=}CHCH_2TMS$, TMSOTf, CH_3CN, −20 °C, 89% **11**/**12** 1.4:1; (e) $NaOCH_3$, CH_3OH, rt, quant; (f) OsO_4, NMO, acetone/water (5:1), rt, then $NaIO_4$, SiO_2, CH_2Cl_2, H_2O, rt, 92%; (g) OsO_4, NMO, acetone/water (5:1), rt, then $NaIO_4$, SiO_2, CH_2Cl_2, H_2O, rt, 85%; (h) PCC, NaOAc, 4 Å molecular sieves, CH_2Cl_2, 97%; (i) Pd/C, H_2, CH_3OH, rt, quant; (j) TBDPSCl, imidazole, DMF, rt, 91%.

Table 1. Regioselectivity of Epoxide Opening in 7 by Hydride Reagents

reagent	conditions	time (h)	yield (%)	ratio (**8**/**9**)[a]
DIBAL-H	−78 °C to rt	5	86	1:2
LAH	reflux (THF)	12	88	13.5:1
L-Selectride	−78 °C to rt	10	81	15:1
K-Selectride	−78 °C to rt	10		no reaction
$NaBH_4$	rt	10		no reaction

[a] Ratio based upon isolated yields of **8** and **9**.

Scheme 2[a]

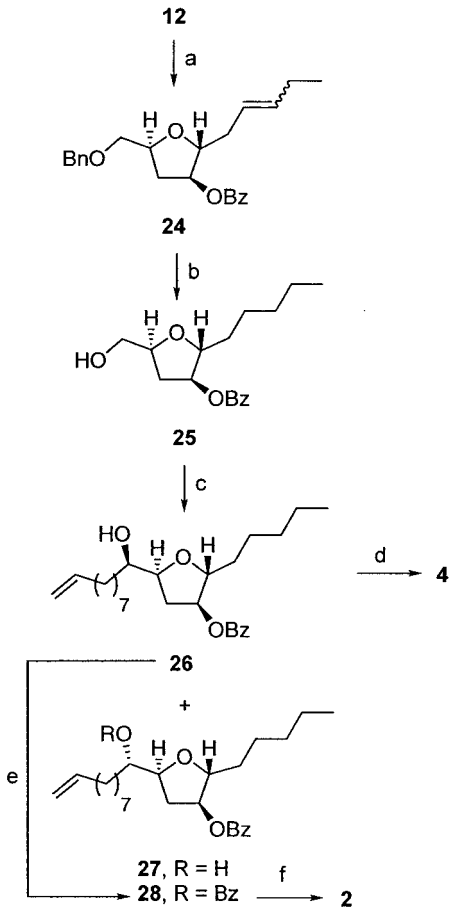


[a] Key: (a) (i) OsO_4, NMO, acetone/H_2O (5:1), (ii) $NaIO_4$, SiO_2, CH_2Cl_2, H_2O, rt, (iii) $Ph_3PCHCH_2CH_3$, THF, −20 °C, 87%, (three steps); (b) Pd/C, H_2, CH_3OH, 91%; (c) Swern oxidation, CH_2Cl_2, −78 °C, then $CH_2{=}CH(CH_2)_6CH_2MgBr$, THF, −40 °C, 75%; (d) (i) PPh_3, DIAD, BzOH, toluene, 0 °C, (ii) $NaOCH_3$, CH_3OH rt, 77%.

C_{10} could be readily inverted through a Mitsunobu reaction affording **23**. After deprotection of the benzoyl esters from **23**, it was possible to separate **1** from its isomer **3**. The spectral data of synthesized **1** were identical with those reported for the natural compound.[2]

With a route to **1** in place, we then synthesized **2** and **4** starting from *C*-glycoside **12** as outlined in Scheme 3. Thus, compound **12** was transformed into alkene **24** and then alcohol **25** using the same sequence of reactions used for the conversion of **11** into **21**. Oxidation of **25** followed by reaction of the corresponding aldehyde with 1-nonenylmagnesium bromide[10] afforded, in 76% yield, a 3:1 mixture of alcohols **26** and **27**, which could be separated by chromatography. A portion of the major isomer (**26**) was deprotected affording **4** in quantitative yield. The remainder was subjected to a Mitsunobu reaction, which provided dibenzoate **28** with the stereochemistry at C_{10} inverted. Treatment of **28** with sodium methoxide afforded **2** (79%, two steps).

Scheme 3[a]



[a] Key: (a) (i) OsO_4, NMO, acetone/H_2O (5:1), (ii) $NaIO_4$, SiO_2, CH_2Cl_2, H_2O, rt, (iii) $Ph_3PCHCH_2CH_3$, THF, −20 °C, 83% (three steps); (b) Pd/C, H_2, CH_3OH, 94%; (c) Swern oxidation, CH_2Cl_2, −78 °C, then $CH_2{=}CH(CH_2)_6CH_2MgBr$, THF, −40 °C, 76%; (d) $NaOCH_3$, CH_3OH rt, quant; (e) PPh_3, DIAD, BzOH, toluene, 0 °C; (f) $NaOCH_3$, CH_3OH rt, 79% (two steps from **26**).

In conclusion, we have developed a concise route for the total synthesis of the marine natural product **1** and its C_6, C_{10}, and C_6/C_{10} epimers (**2**−**4**). A formal synthesis of (+)-*trans*-kumausyne (**6**) has also been completed. The general strategy described in this paper, the formation of a 2,3,5-trisubstituted tetrahydrofuran residue via a regioselective hydride ring opening of the epoxide moiety in **7**, should also enable the synthesis of other natural products containing this substructure, for example, kumausallene,[11] laurefucin,[12] and Hagen's gland lactones.[13]

Experimental Section

General Methods. Solvents were distilled from the appropriate drying agents before use. Unless stated otherwise, all reactions were carried out under a positive pressure of argon and were monitored by TLC on silica gel 60 F_{254} (0.25 mm, E. Merck). Spots were detected under UV light or by charring with 10% H_2SO_4 in ethanol. Solvents were evaporated under reduced pressure and below 40 °C (bath). Organic solutions of crude products were dried over anhydrous Na_2SO_4. Column chromatography was performed on silica gel 60 (40−60 μM). The ratio

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between silica gel and crude product ranged from 100 to 50:1 (w/w). Optical rotations were measured at 21 ± 2 °C. Melting points are uncorrected. ^{1}H NMR spectra were recorded at 500.12 MHz, and chemical shifts are referenced to either TMS (0.0, $CDCl_3$) or external dioxane (3.75, D_2O). ^{13}C NMR spectra were recorded at 125.75 MHz, and ^{13}C chemical shifts are referenced to $CDCl_3$ (77.00, $CDCl_3$) or external dioxane (68.11, D_2O). Electrospray mass spectra were recorded on samples suspended in THF or CH_3OH.

Methyl 5-*O*-Benzyl-3-deoxy-α-D-*threo*-pentofuranoside (8) and Methyl 5-*O*-Benzyl-2-deoxy-α-D-*threo*-pentofuranoside (9). To a solution of **7** (5.0 g, 19.6 mmol) in THF (100 mL) at 0 °C was added $LiAlH_4$ (1.87 g, 49.0 mmol). The solution was heated at reflux for 12 h. EtOAc (10 mL) was added, and the reaction mixture was stirred for 10 min followed by the addition of water (5 mL). The solution was diluted with EtOAc (200 mL), filtered through Celite, and concentrated. The compound was purified by chromatography (hexanes/EtOAc, 4:1) to yield **8** (4.15 g, 82%) and **9** (0.31 g, 6%) as a colorless oils.

8: R_f 0.34 (hexanes/EtOAc, 2:1); $[\alpha]_D$ +15.0 (*c* 0.9, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.41−7.34 (m, 5 H), 4.87 (s, 1 H), 4.73 (d, 1 H, J = 11.9 Hz), 4.58 (d, 1 H, J = 11.9 Hz), 4.38 (ddd, 1 H, J = 2.0, 4.2, 9.8 Hz), 4.07−4.00 (m, 2 H), 3.77 (dd, 1 H, J = 1.9, 10.3 Hz), 3.48 (dd, 1 H, J = 1.9, 10.3 Hz), 3.38 (s, 3 H), 2.45 (dddd, 1 H, J = 4.8, 4.9, 9.8, 9.9 Hz), 1.82 (dd, 1 H, J = 2.5, 13.7 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 137.4, 129.0, 128.5, 128.4, 110.4, 77.4, 74.5, 74.2, 71.5, 54.9, 34.2; HRMS (ESI) calcd for (2M + Na^+) $C_{26}H_{36}O_8$ 499.230238, found 499.23550.

9: yield 0.31 g, 6%; R_f 0.30 (hexanes/EtOAc, 5:1); $[\alpha]_D$ +71.1 (*c* 1.3, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.40−7.36 (m, 5 H), 5.20 (dd, 1 H, J = 5.0, 5.4 Hz), 4.67−4.60 (m, 2 H), 4.57−4.55 (m, 1 H), 4.17 (dd, 1 H, J = 4.7, 5.9 Hz), 3.85 (d, 2 H, J = 4.8 Hz), 3.40 (s, 3 H), 2.82 (bs, 1 H), 2.23−2.14 (m, 2 H); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 137.9, 128.9, 128.3, 128.2, 104.7, 78.7, 74.2, 72.8, 69.1, 55.6, 43.1; HRMS (ESI) calcd for (2M + Na^+) $C_{26}H_{36}O_8$ 499.230238, found 499.23540.

Methyl 2-*O*-Benzoyl-5-*O*-benzyl-3-deoxy-α-D-*threo*-pentofuranoside (10). To a solution of **8** (2.60 g, 10.9 mmol) in pyridine (10 mL) at 0 °C was added benzoyl chloride (1.7 mL, 14.1 mmol) dropwise. The reaction mixture was warmed to room temperature and stirred for 30 min before being diluted with CH_2Cl_2 (100 mL). The organic layer was washed successively with 5% HCl, a saturated aqueous $NaHCO_3$ solution, and water. The organic layer was then dried, filtered, and concentrated, and the compound was purified by chromatography (hexanes/EtOAc, 6:1) to yield **10** (3.61 g, 97%) as a colorless oil: R_f 0.41 (hexanes/EtOAc, 5:1); $[\alpha]_D$ +14.0 (*c* 2.2, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.02 (dd, 2 H, J = 1.0, 8.1 Hz), 7.59 (dd, 1 H, J = 7.3, 7.5 Hz), 7.46−7.30 (m, 7 H), 5.35 (dd, 1 H, J = 1.5, 6.4 Hz), 5.17 (s, 1 H), 4.69 (d, 1 H, J = 12.3 Hz), 4.63 (d, 1 H, 12.3 Hz), 4.54−4.49 (m, 1 H), 3.71 (dd, 1 H, J = 6.5, 10.1 Hz), 3.63 (dd, 1 H, J = 6.5, 10.1 Hz), 3.46 (s, 3 H), 2.62 (dddd, 1 H, J = 6.4, 6.5, 8.4, 12.3 Hz), 1.93 (dddd, 1 H, J = 1.5, 5.0, 5.1, 14.2 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.1, 138.5, 133.6, 130.2, 130.0, 128.9, 129.8, 128.1, 128.0, 107.6, 78.3, 77.6, 73.8, 72.9, 55.1, 32.9; HRMS (ESI) calcd for (M + Na^+) $C_{20}H_{22}O_5$ 365.1359, found 365.1381.

2-Allyl-5-benzyloxymethyl-3-phenylcarbonyloxy-(2*S*,3*S*,5*S*)-tetrahydro-3-furanol (11) and 2-Allyl-5-benzyloxymethyl-3-phenylcarbonyloxy-(2*R*,3*S*,5*S*)-tetrahydro-3-furanol (12). To a solution of **10** (3.42 g, 10.0 mmol) and allyltrimethylsilane (3.3 mL, 20.0 mmol) in acetonitrile (100 mL) at −20 ° C was added TMSOTf (3.6 mL, 20.0 mmol). The reaction mixture was stirred for 4 h at that temperature and then diluted with CH_2Cl_2. The solution was washed with an aqueous saturated $NaHCO_3$ solution and water before it was dried and concentrated. The compound was purified by chromatography (hexanes/EtOAc, 8:1) to yield a 1.4:1 mixture of **11** and **12** (3.15 g, 89% combined yield) as a colorless oils.

11: R_f 0.62 (hexanes/EtOAc, 4:1); $[\alpha]_D$ +10.0 (*c* 0.6, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.05 (dd, 2 H, J = 1.0, 8.1 Hz), 7.61 (dd, 1 H, J = 7.3, 7.5 Hz), 7.47−7.29 (m, 7 H), 5.89−5.87 (m, 1 H), 5.55−5.53 (m, 1 H), 5.15−5.07 (m, 2 H), 4.65 (d, 1 H, J = 12.2 Hz), 4.62 (d, 1 H, J = 12.2 Hz), 4.00 (dd, 1 H, J = 2.3, 6.8 Hz), 3.98−3.87 (m, 1 H), 3.70 (dd, 1 H, J = 6.3, 9.9 Hz), 3.59 (dd, 1 H, J = 4.8, 9.9 Hz), 2.62−2.55 (m, 3 H), 1.98 (dddd, 1 H, J = 1.7, 5.8, 5.8, 7.5 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.2, 138.6, 134.5, 133.5, 130.5, 130.0, 128.9, 128.8, 128.7, 128.1, 128.0, 117.8, 82.1, 77.1, 75.1, 73.7, 73.0, 36.5, 34.3; HRMS (ESI) calcd for (M + Na^+) $C_{22}H_{24}O_4$ 375.1566, found 375.1583.

12: R_f 0.51 (hexanes/EtOAc, 4:1); $[\alpha]_D$ +13.8 (*c* 1.3, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.02 (dd, 2 H, J = 1.0, 8.1 Hz), 7.60 (dd, 1 H, J = 7.3, 7.5 Hz), 7.47−7.31 (m, 7 H), 5.96−5.90 (m, 1 H), 5.31 (ddd, 1 H, J = 3.1, 6.2, 6.7 Hz), 5.22 (dd, 1 H, J = 1.5, 15.4 Hz), 5.17 (dd, 1 H, J = 1.0, 10.3 Hz), 4.67 (d, 1 H, J = 12.2 Hz), 4.63 (d, 1 H, J = 12.2 Hz), 4.47−4.44 (m, 1 H), 4.33 (ddd, 1 H, J = 2.8, 6.5, 9.3 Hz), 3.70 (dd, 1 H, J = 6.4, 9.8 Hz), 3.58 (dd, 1 H, J = 5.0, 9.8 Hz), 2.57 (ddd, 1 H, J = 7.2, 7.8, 12.2 Hz), 2.45−2.42 (m, 2 H), 2.05 (dddd, 1 H, J = 3.3, 4.9, 5.0, 14.1 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.5, 138.6, 134.1, 133.5, 130.4, 130.0, 128.8, 128.7, 128.1, 128.0, 118.2, 83.4, 78.4, 77.2, 73.8, 72.9, 38.0, 34.6; HRMS (ESI) calcd for (M + Na^+) $C_{22}H_{24}O_4$ 375.1566, found 375.1583.

2-Allyl-5-benzyloxymethyl-(2*S*,3*S*,5*S*)-tetrahydro-3-furanol (13). To a solution of **11** (800 mg, 2.27 mmol) in CH_3OH (10 mL) was added 1 M $NaOCH_3$ in CH_3OH (0.5 mL). After being stirred for 1 h at room temperature, the reaction mixture was neutralized with Amberlite IR-120 (H^+) resin, filtered, and concentrated. The compound was purified by chromatography (hexanes/EtOAc, 6:1) to yield **13** (560 mg, 100%) as a colorless oil: R_f 0.31 (hexanes/EtOAc, 3:1); $[\alpha]_D$ +61.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.40−7.33 (m, 5 H), 5.96−5.88 (m, 1 H), 5.22 (dd, 1 H, J = 3.5, 17.1 Hz), 5.10 (dd, 1 H, J = 2.0, 11.2 Hz), 4.71 (d, 1 H, J = 12.2 Hz), 4.58 (d, 1 H, J = 12.2 Hz), 4.27−4.23 (m, 1 H), 4.04 (br. s, 1 H), 3.82−3.70 (m, 3 H), 3.45 (dd, 1 H, J = 2.1, 10.3 Hz), 2.51−2.48 (m, 2 H), 2.36 (ddd, 1 H, J = 5.3, 10.2, 12.9 Hz), 1.97 (dd, 1 H, J = 2.8, 13.8 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 137.6, 135.5, 128.9, 128.4, 128.2, 117.1, 84.3, 76.7, 74.0, 72.2, 71.9, 37.5, 34.1; HRMS (ESI) calcd for (M + Na^+) $C_{15}H_{20}O_3$ 271.1304, found 271.1323.

2-Allyl-5-benzyloxymethyl-(2*R*,3*S*,5*S*)-tetrahydro-3-furanol (14). Compound **14** was prepared from **12** (600 mg, 1.7 mmol) as described for the synthesis of **13** from **11**. Purification by chromatography (hexanes/EtOAc, 6:1) yielded **14** (420 mg, 100%) as a colorless oil: R_f 0.28 (hexanes/EtOAc, 3:1); $[\alpha]_D$ +43.6 (*c* 1.1, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.39−7.30 (m, 5 H), 5.89−5.81 (m, 1 H), 5.15−5.10 (m, 2 H), 4.96 (d, 1 H, J = 12.2 Hz), 4.58 (d, 1 H, J = 12.2 Hz), 4.33 (dd, 1 H, J = 2.5, 12.0 Hz), 4.10−4.04 (m, 3 H), 3.71 (dd, 1 H, J = 2.3, 10.2 Hz), 3.49 (dd, 1 H, J = 2.7, 10.2 Hz), 2.40−2.35 (m, 1 H), 2.25−2.15 (m, 2 H), 1.88 (dd, 1 H, J = 3.0, 13.8 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 137.6, 134.8, 128.9, 128.4, 128.3, 117.7, 87.6, 77.2, 75.1, 74.1, 73.0, 38.5, 36.4; HRMS (ESI) calcd for (M + Na^+) $C_{15}H_{20}O_3$ 271.1304, found 271.1323.

5-Benzyloxymethyl-(2*S*,3a*S*,6a*S*)-perhydrofuro[3,2-*b*]-furan-2-ylmethanol (15). To a solution of compound **13** (400 mg, 1.61 mmol) and *N*-methylmorpholine oxide (227 mg, 1.94 mmol) in acetone/water (5:1, 10 mL) at 0 °C was added OsO_4 (4 mg, 0.10 mmol). The reaction mixture was stirred for 12 h at room temperature and then concentrated. The resulting residue was dissolved in CH_2Cl_2 (10 mL), and solid sodium sulfite was added. The mixture was filtered through Celite, silica gel (100−200 mesh, 10 g) was added to the filtrate, and the mixture was cooled to 0 °C. Sodium metaperiodate (690 mg, 3.22 mmol) was added in a solution of water (2 mL). The reaction mixture was stirred at room temperature for 1 h followed by filtration through Celite. The filtrate was dried and concentrated, and the compound was purified by chromatography (hexanes/EtOAc, 2:1) to yield **15** (371 mg, 92%, 3:2 mixture of isomers) as a colorless oil: R_f 0.19 (hexanes/EtOAc, 4:1); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.34−7.26 (m, 5 H), 5.62−5.59 (m, 0.6 H), 5.38 (dd, 0.4 H, J = 6.3 11.7 Hz), 4.79−4.76 (m, 0.6 H), 4.69−4.68 (m, 0.4 H), 4.63−4.42 (m, 3 H), 4.19−4.11 (m, 1 H), 3.80 (d, 0.6 H, J = 4.3 Hz), 3.67 (dd, 0.4 H, J = 2.7, 10.3 Hz), 3.54−3.42 (m, 2 H), 2.35−2.99 (m, 3 H), 1.79 (dddd, 1 H, J = 2.2, 6.7, 8.4, 13.8 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 138.5, 137.8, 129.0, 128.8, 128.7, 128.3, 128.2, 128.1, 128.0, 100.6, 100.5, 85.5, 84.3, 84.2, 83.1, 80.2, 79.9, 73.7, 73.6, 73.1, 70.0, 41.7, 41.0, 37.2, 35.9; HRMS (ESI) calcd for (M + Na^+) $C_{14}H_{18}O_4$ 273.1097, found 273.1104.

2-[5-Benzyloxymethyl-3-hydroxy-(2*R*,3*S*,5*S*)-tetrahydro-2-furanyl]acetaldehyde (16). Compound **16** was prepared from **14** (400 mg, 1.61 mmol) as described for the preparation of **15** from **13**. The compound was purified by chromatography (hex-

anes/EtOAc, 2:1) to yield **16** (343 mg, 85%) as a colorless oil: R_f 0.39 (hexanes/EtOAc, 1:1); $[\alpha]_D$ +5.4 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, δ) 9.76 (dd, 1 H, J = 1.8, 2.4 Hz), 7.36−7.28 (m, 5 H), 4.65 (d, 1 H, J = 12.2 Hz), 4.58−4.48 (m, 2 H), 4.35−4.28 (m, 1 H), 4.14−4.00 (m, 2 H), 3.67 (dd, 1 H, J = 2.5, 5.0 Hz), 3.48 (dd, 1 H, J = 2.5, 5.0 Hz), 2.54−2.48 (m, 2 H), 2.40−2.34 (m 1 H), 1.92−1.86 (m, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$, δ) 201.0, 137.5, 129.0, 128.7, 128.5, 128.1, 128.0, 82.7, 77.5, 75.8, 74.1, 72.6, 48.0, 36.2; HRMS (ESI) calcd for (M + Na^+) $C_{14}H_{18}O_4$ 273.1097, found 273.1083.

(3a*S*,5*S*,6a*S*)-5-Benzyloxymethylperhydrofuro[3,2-*b*]-furan-2-one (17). To a stirred solution containing pyridinium chlorochromate (452 mg, 2.09 mmol), powdered 4 Å molecular sieves (100 mg), and sodium acetate (114 mg, 1.40 mmol) in CH_2Cl_2 (10 mL) was added a solution of **15** (350 mg, 1.40 mmol) in CH_2Cl_2 (10 mL). The reaction mixture was stirred at room temperature for 2 h, and then hexanes (5 mL) and diethyl ether (5 mL) were added. The mixture was filtered through silica gel and washed with excess diethyl ether. The resulting organic solution was concentrated, and the compound was purified by chromatography (hexanes/EtOAc, 2:1) to yield **17** (341 mg, 97%) as a colorless oil: R_f 0.27 (hexanes/EtOAc, 4:1); $[\alpha]_D$ +4.3 (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, δ) 7.36−7.26 (m, 5 H), 5.01 (dddd, 1 H, J = 1.7, 4.3, 4.4, 6.4 Hz), 4.61−4.58 (m, 2 H), 4.53 (d, 1 H, J = 12.2 Hz), 4.26−4.20 (m, 1 H), 3.54−3.47 (m, 2 H), 2.78−2.67 (m, 2 H), 2.39 (dddd, 1 H, J = 6.8, 7.8, 7.9, 14.2 Hz), 2.03 (dddd, 1 H, J = 1.7, 6.9, 7.0, 14.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$, δ) 175.8, 138.3, 128.8, 128.6, 128.4, 128.2, 128.1, 84.5, 79.6, 79.5, 73.8, 72.7, 36.9, 35.0; HRMS (ESI) calcd for (M + Na^+) $C_{14}H_{16}O_4$ 271.0941, found 271.0945.

(3a*S*,5*S*,6a*S*)-5-Hydroxymethylperhydrofuro[3,2-*b*]furan-2-one (18). To a solution of **17** (320 mg, 1.29 mmol) in CH_3OH was added 10% Pd/C (10 mg). The reaction mixture was stirred under an atmosphere of H_2 for 5 h and then filtered through Celite. Concentration of the filtrate afforded **18** (203 mg, 100%) as a colorless oil: R_f 0.20 (hexanes/EtOAc, 2:1); $[\alpha]_D$ +15.3 (*c* 0.7, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, δ) 5.05 (ddd, 1 H, J = 1.7, 4.2, 6.3 Hz), 4.63 (dd, 1 H, J = 3.2, 7.3 Hz), 4.18 (ddd, 1 H, J = 3.2, 7.2, 10.4 Hz), 3.74 (dd, 1 H, J = 3.2, 11.9 Hz), 3.60 (dd, 1 H, J = 6.3, 11.8 Hz), 2.75 (d, 2 H, J = 3.2 Hz), 2.39 (ddd, 1 H, J = 6.9, 7.8, 14.6 Hz), 2.12 (ddd, 1 H, J = 3.2, 7.1, 14.6 Hz), 2.04 (br s, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$, δ) 175.2, 84.4, 80.7, 79.0, 64.6, 36.4, 34.0; HRMS (ESI) calcd for (2M + Na^+) $C_7H_{10}O_4$ 339.1050, found 339.1048

(3a*S*,5*S*,6a*S*)-5-*tert*-Butyldiphenylsiloxymethylperhydrofuro[3,2-*b*]furan-2-one (19). To a solution of **18** (180 mg, 1.13 mmol) in dry DMF (5 mL) was added imidazole (200 mg, 2.90 mmol) followed by *tert*-butylchlorodiphenylsilane (406 mg, 1.47 mmol). The mixture was stirred for 6 h at room temperature, and then brine (10 mL) was added. The resulting mixture was extracted with CH_2Cl_2, and the organic layer was washed with water, dried, and evaporated. The compound was purified by chromatography (hexanes/EtOAc, 3:1) to yield **19** (414 mg, 91%) as a white solid: R_f 0.38 (hexanes/EtOAc, 2:1); $[\alpha]_D$ −26.0 (*c* 1.5, $CHCl_3$); mp = 38−39 °C; ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.72−7.69 (m, 4 H), 7.45−7.41 (m, 4 H), 5.06 (m, 1 H), 4.62 (ddd, 1 H, J = 1.9, 4.4, 6.3 Hz), 4.21−4.16 (m, 1 H), 3.80−3.73 (m, 2 H), 2.76 (d, 2 H, J = 1.6 Hz), 2.42 (ddd, 1 H, J = 1.6, 7.4, 14.5 Hz), 2.26 (dddd, 1 H, J = 3.4, 7.2, 7.3, 14.5 Hz) 1.12 (s, 9 H); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 175.7, 136.1, 136.0, 133.8, 133.7, 130.2, 128.1, 84.8, 81.1, 79.3, 66.0, 36.9, 35.1, 27.2, 19.7(3); HRMS (ESI) calcd for (M + Na^+) $C_{23}H_{28}O_4Si$ 419.1649, found 419.1686.

5-Benzyloxymethyl-2-[(*E*/*Z*)-2-pentenyl]-3-phenylcarbonyloxy-(2*S*,3*S*,5*S*)-tetrahydrofuran (20). To a stirred suspension of *n*-propyltriphenylphosphonium bromide (1.52 g, 3.95 mmol) in THF (40 mL) at 0 °C was added sodium amide (14 mg, 3.68 mmol). The mixture was stirred for 12 h at room temperature under an atmosphere of argon. Separately, alkene **11** (0.480 g, 1.36 mmol) was oxidized to the corresponding aldehyde as described for the preparation of **15**, except that the product was not purified following the final evaporation step. Instead, the aldehyde was immediately dissolved in THF (20 mL) and cooled to −20 °C, before the orange ylide solution was added. After the mixture was stirred for 1 h, an aqueous saturated solution of NH_4Cl was added followed by ether. The organic layer was dried and concentrated, and the compound was purified by chromatography (hexanes/EtOAc, 15:1) to yield **20** (441 mg, 87%, *E*/*Z* 1:3) as a colorless oil: R_f 0.16 (hexanes/EtOAc, 10:1); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.05−8.04 (m, 2 H), 7.62−7.28 (m, 8 H), 5.53−5.47 (m, 3 H), 4.67−4.60 (m, 2 H), 4.30−4.25 (m, 1 H), 3.97−3.93 (m,1 H), 3.68 (dd, 1 H, J = 6.5, 9.9 Hz), 3.58 (dd, 1 H, J = 4.8, 10.0 Hz), 2.63−2.54 (m 3 H), 2.24−1.93 (m, 3 H), 1.05 (t, 3 H, 7.5 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.2, 138.5, 136.2, 134.6, 133.5, 133.,4 130.8, 130.5, 128.9, 128.8, 128.4, 128.1, 127.1, 124.1, 82.6, 77.0, 75.0, 74.6, 73.8, 73.7, 73.0, 72.6, 67.2, 39.4, 36.6, 27.7, 21.5, 21.0, 14.9, 14.8; HRMS (ESI) calcd for (M + Na^+) $C_{24}H_{28}O_4$ 381.2060, found 381.2072.

5-Hydroxymethyl-2-pentyl-3-phenylcarbonyloxy-(2*S*,3*S*,5*S*)-tetrahydrofuran (21). To a solution of **20** (400 mg, 1.05 mmol) in CH_3OH (10 mL) was added 10% Pd/C (10 mg). The reaction mixture was stirred under an atmosphere of H_2 for 6 h and then filtered through Celite. The filtrate was concentrated to provide **21** (280 mg, 91%) as a colorless oil: R_f 0.29 (hexanes/EtOAc, 6:1); $[\alpha]_D$ +24.8 (*c* 1.0, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.08 (dd, 2 H, J = 1.1, 8.2 Hz), 7.61 (dd, 1 H, J = 7.4, 7.5 Hz), 7.48 (dd, 2 H, 7.88, 13.9 Hz), 5.55−5.52 (m, 1 H), 4.19−4.15 (m, 1 H), 3.95−3.92 (m, 1 H), 3.80 (dd, 1 H, J = 3.17, 11.5 Hz), 3.66 (dd, 1 H, J = 5.7, 11.5 Hz), 2.55 (dddd, 1 H, J = 6.5, 8.6, 8.7, 14.5 Hz), 1.98 (dddd, 1 H, J = 1.6, 5.7, 5.7, 7.4 Hz), 1.79−1.69 (m, 2 H), 1.52−1.28 (m, 6 H), 0.92 (t, 3 H, J = 7.0 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.3, 133.5, 130.4, 129.9, 128.8, 82.9, 78.3, 75.5, 65.4, 35.6, 32.2, 29.4, 26.3, 22.8, 14.3; HRMS (ESI) calcd for (M + Na^+) $C_{17}H_{24}O_4$ 293.1747, found 293.1768.

(6*S*,7*S*,9*S*,10*R*/*S*)-6,9-Epoxynonadec-18-ene-7-*O*-benzoyl-10-ol (22). Oxalyl chloride (120 μL) was dissolved in CH_2Cl_2 (10 mL), the mixture was cooled to −78 °C, and a solution of DMSO (100 μL, 1.37 mmol) in CH_2Cl_2 (2 mL) was added over the course of 10 min. Alcohol **21** (200 mg, 0.68 mmol) dissolved in CH_2Cl_2 (3 mL) was then added dropwise over the course of 5 min, and the resulting cloudy solution was stirred for 40 min at −78 °C. Triethylamine (0.3 mL, 2.04 mmol) was added slowly, and the reaction was allowed to stir for 15 min. The reaction mixture was then diluted with water and CH_2Cl_2. The organic layer was separated and washed with water, dried, filtered, and evaporated to yield the crude aldehyde, which was dried under vacuum for 1 h.

To a solution of the crude aldehyde in THF (15 mL) at −40 °C was added nonenylmagnesium bromide,[10] freshly prepared from nonenyl bromide (275 mg, 1.36 mmol) and magnesium (49 mg, 2.04 mmol) in dry diethyl ether (30 mL). The reaction mixture was allowed to stir for 4 h at room temperature before a saturated aqueous solution of NH_4Cl (10 mL) was added. To the mixture was added EtOAc, and the organic layer was dried and evaporated. The compound was purified by column chromatography (10:1 hexanes/EtOAc) to yield **22** (214 mg, 75%) as an inseparable mixture of isomers as an oil: R_f 0.55 (hexanes/EtOAc, 10:1); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.10−8.05 (m, 2 H), 7.62−7.30 (m, 3 H), 5.85−5.82 (m, 1 H), 5.53−5.05 (m, 1 H), 5.04 (m, 2 H), 3.96−3.86 (m, 4 H), 2.40−2.05 (m, 4 H), 1.75−1.32 (m, 22 H), 0.89 (dd, 3 H, J = 6.7, 6.7 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.4, 139.6, 133.6, 133.5, 130.5, 129.9, 128.9, 114.5, 82.5, 81.0, 80.9, 75.7, 74.4, 72.4, 36.4, 34.,2 34.0, 33.1, 32.9, 32.4, 32.3, 29.9, 29.8, 29.7, 29.4, 29.3, 29.2 (2), 26.4, 26.3, 26.2, 26.0, 22.9, 22.9 (2), 14.3; HRMS (ESI) calcd for (M + Na^+) $C_{26}H_{40}O_4$ 439/2819, found 439.2808.

(6*S*,7*S*,9*S*,10*S*)-6,9-Epoxynonadec-18-ene-7,10-diol (1) and (6*S*,7*S*,9*S*,10*S*)-6,9-Epoxynonadec-18-ene-7,10-diol (3). To a solution of **22** (200 mg, 0.48 mmol) in THF (10 mL) were added triphenylphosphine (188 mg, 0.72 mmol) and benzoic acid (86 mg, 0.72 mmol). The solution was cooled to 0 °C, and diisopropylazodicarboxylate (0.19 mL, 0.96 mmol) was added dropwise over a period of 5 min. The reaction mixture was warmed to room temperature and stirred for 2 h. The solution was then concentrated to dryness, and the residue was purified by column chromatography (10:1 hexane/EtOAc) to obtain **23**. Dibenzoate **23** was dissolved in methanol (10 mL), and 1 M NaOMe in MeOH (1 mL) was added. After being stirred for 3 h at room temperature, the reaction mixture was neutralized with Amberlite IR-120 (H^+) resin, filtered, and concentrated. Purification by chromatography (hexanes/EtOAc, 6:1) yielded a 4:1 ratio of **1** and **3** (116 mg, 77% combined yield from **22**).

1: white solid; R_f 0.26 (hexanes/EtOAc, 10:1); $[\alpha]_D$ +24.3 (*c* 0.3 $CHCl_3$); mp = 34−35 °C; ^{1}H NMR (500 MHz, $CDCl_3$, δ) 5.84 (dddd, 1 H, *J* = 6.7, 6.7, 12.3, 16.9 Hz), 4.98 (dd 1 H, *J* = 1.6, 16.9 Hz), 4.96 (d, 1 H, *J* = 9.8 Hz), 4.08 (dd, 1 H, *J* = 2.7, 5.4 Hz), 3.98 (dd, 1 H, *J* = 5.4, 9.8 Hz), 3.66 (ddd, 1 H, *J* = 2.7 6.9, 6.9 Hz), 3.52 (ddd, 1 H, *J* = 2.4, 5.2, 8.1 Hz), 2.42 (ddd, 1 H, *J* = 5.6, 9.9, 14.1 Hz), 2.05 (dd, 2 H, *J* = 6.9, 14.5 Hz), 1.88 (dd, 1 H, *J* = 3.5, 14.1, Hz), 1.71−1.30 (m, 22 H), 0.93 (dd, 3 H, *J* = 6.8, 6.8 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 139.6, 114.6, 84.8, 79.5, 74.4, 72.0, 39.2, 34.8, 34.2, 32.5, 29.9, 29.8, 29.3, 29.3, 26.4, 26.3, 23.0, 14.4; HRMS (ESI) calcd for (M + Na^+) $C_{19}H_{36}O_3$ 335.2556, found 335.2552.

3: white solid; R_f 0.21 (hexanes/EtOAc, 4:1); $[\alpha]_D$ +23.1 (*c* 1.2 $CHCl_3$); mp = 73−74 °C; ^{1}H NMR (500 MHz, $CDCl_3$, δ) 5.84 (dddd, 1 H, *J* = 6.7, 6.7, 12.3, 17.3 Hz), 5.02 (dd, 1 H, *J* = 2.0, 17.3 Hz), 4.97 (dd, 1 H, *J* = 1.0, 10.1 Hz), 4.06−4.02 (m, 2 H), 3.87−3.85 (m, 1 H), 3.63 (ddd, 1 H, *J* = 2.5, 6.8, 9.3 Hz), 3.40 (br.s, 1 H), 2.65 (br.s, 1 H), 2.22 (ddd, 1 H, *J* = 5.4, 9.9, 14.3 Hz), 2.07 (m, 2 H), 1.94 (dd, 1 H, *J* = 3.4, 14.1 Hz), 1.76−1.29 (m, 22 H), 0.92 (dd, 1 H, *J* = 6.4, 6.4 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.4, 139.6, 133.5, 133.4, 130.6, 129.9, 128.8, 114.6, 82.6, 82.5, 81.0, 80.9, 75.7, 75.5, 74.4, 71.6, 36.4, 34.2, 33.9, 33.1, 33.0, 32.3, 29.9, 29.8, 29.7, 29.4, 29.3, 26.4, 26.3, 26.2, 26.0, 22.9, 14.4; HRMS (ESI) calcd for (M + Na^+) $C_{19}H_{36}O_3$ 335.2556, found 335.2550.

5-Benzyloxymethyl-2-[(*E*/*Z*)-2-pentenyl]-3-phenylcarbonyloxy-(2*R*,3*S*,5*S*)-tetrahydrofuran (24). Alkenes **24** were prepared from **12** (1.40 g, 3.97 mmol) as described for the preparation of **20** from **11**. The compound was purified by chromatography (hexanes/EtOAc, 15:1) to yield **24** (1.25 g, 83%, *E*/*Z* 1:8) as a colorless oil: R_f 0.26 (hexanes/EtOAc, 10:1); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 7.96 (dd, 2 H, *J* = 1.1, 8.2 Hz), 7.55 (dd, 1 H, *J* = 7.3, 7.4 Hz), 7.43−7.24 (m, 7 H), 5.54−5.40 (m, 2 H), 5.25−5.22 (m, 1 H), 4.60 (d, 1 H, *J* = 12.2 Hz), 4.57 (d, 1 H, *J* = 12.2 Hz), 4.40−4.38 (m, 1 H), 4.25 (dddd, 1 H, *J* = 3.3, 8.3, 8.4, 11.5 Hz), 3.64 (dd, 1 H, *J* = 8.0, 12.4 Hz), 3.52 (dd, 1 H, *J* = 6.3, 12.4 Hz), 2.56−2.30 (m, 3 H), 2.10−1.96 (m, 3 H), 0.96 (t, 3 H, *J* = 7.0 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.5, 138.5, 135.0, 133.5, 130.3, 130.0, 129.9, 128.8, 128.7, 128.1, 123.7, 120.8, 115.7, 84.0, 78.6, 73.7, 72.9, 34.7, 32.3, 31.3, 30.4, 30.1, 23.1, 21.1, 14.5; HRMS (ESI) calcd for (M + Na^+) $C_{24}H_{28}O_4$ 381.2060, found 381.2052.

5-Hydroxymethyl-2-pentyl-3-phenylcarbonyloxy-(2*R*,3*S*,5*S*)-tetrahydrofuran (25). Alcohol **25** was prepared from **24** (400 mg, 1.05 mmol) as described for the preparation of **21** from **20**. The product **25** (289 mg, 94%) was obtained as a colorless oil: R_f 0.31 (hexanes/EtOAc, 6:1); $[\alpha]_D$ +38.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 8.05 (dd, 2 H, *J* = 1.1, 8.2 Hz), 7.61 (dd, 1 H, *J* = 7.3, 7.4 Hz), 7.48 (dd, 2 H, *J* = 7.8, 14.2 Hz), 5.29−5.26 (m, 1 H), 4.34−4.29 (m, 1 H), 4.21 (dd, 1 H, *J* = 2.5, 7.7 Hz), 3.77−3.71 (m, 2 H), 2.55 (ddd, 1 H, *J* = 7.1, 7.2, 14.0 Hz), 2.10 (br.s, 1 H), 2.00 (dddd, 1 H, *J* = 3.0, 5.4, 5.5, 14.0 Hz), 1.62−1.29 (m, 8 H), 0.93 (t, 3 H, *J* = 7.0 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.5, 133.6, 130.3, 130.0, 128.8, 84.2, 79.2, 78.3, 65.3, 33.7, 33.2, 32.1, 25.7, 22.9, 14.4; HRMS (ESI) calcd for (M + Na^+) $C_{17}H_{24}O_4$ 293.1747, found 293.1763.

(6*R*,7*S*,9*S*,10*R*)-6,9-Epoxynonadec-18-ene-7-*O*-benzoyl-10-ol (26) and (6*R*,7*S*,9*S*,10*S*)-6,9-Epoxynonadec-18-ene-7-*O*-benzoyl-10-ol (27). Alcohols **26** and **27** were prepared from **25** (230 mg, 0.78 mmol) as described for the preparation of **22** from **21**. The compounds were purified by chromatography (hexanes/EtOAc, 20:1) to yield a 3:1 ratio of **26** and **27** (249 mg, 76% combined) as colorless oils.

26: R_f 0.60 (hexanes/EtOAc, 10:1); $[\alpha]_D$ +6.6 (*c* 0.3 $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 5.83 (dddd, *J* = 6.7, 6.7, 10.2, 13.4 Hz), 5.29−5.26 (m, 1 H), 5.03 (dd, 1 H, *J* = 1.1, 17.1 Hz), 4.99 (d, 1 H, *J* = 10.1 Hz), 4.20 (ddd, 1 H, *J* = 2.5, 7.2, 7.2 Hz), 4.08 (ddd, 1 H, *J* = 3.3, 7.4, 7.5 Hz), 3.93−3.90 (m, 1 H), 2.42 (ddd, 1 H, *J* = 7.4, 7.6, 14.2 Hz), 2.20−2.16 (m, 2 H), 2.10−2.06 (m, 2 H), 1.64−1.30 (m, 22 H), 0.93 (dd, 3 H, *J* = 6.4, 6.4 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.7, 139.6, 133.5, 130.4, 130.0, 128.8, 114.6, 84.1, 80.5, 79.2, 72.0, 34.2, 33.2, 32.6, 32.1, 31.2, 30.3, 29.7, 29.5, 29.3, 26.3, 25.8, 22.9, 14.4; HRMS (ESI) calcd for (M + Na^+) $C_{26}H_{40}O_4$ 439.2819, found 439.2818.

27: R_f 0.55 (hexanes/EtOAc, 10:1); $[\alpha]_D$ +7.6 (*c* 0.3 $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 5.81 (dddd, *J* = 6.7, 6.7, 10.2, 13.4 Hz), 5.21 (ddd, 1 H, *J* = 4.2, 8.6, 8.7 Hz), 5.00−4.90 (m, 2 H), 4.13 (ddd, 1 H, *J* = 3.7, 8.7, 8.8 Hz), 3.97−3.92 (m, 1 H), 3.62−3.56 (m,1 H), 2.51 (ddd, 1 H, *J* = 6.7, 9.2, 17.1 Hz), 2.45 (d, 1 H, *J* = 5.0 Hz), 2.05−2.89 (m, 3 H), 1.56−1.28 (m, 22 H), 0.88 (dd, 3 H, *J* = 6.7, 6.7 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 166.2, 139.2, 133.2, 129.9, 129.6, 128.5, 114.1, 83.3, 80.7, 78.9, 73.6, 34.1, 33.8, 33.3, 32.8, 31.7, 29.6, 29.4, 29.1, 28.9, 25.7, 25.4, 22.6, 14.0; HRMS (ESI) calcd for (M + Na^+) $C_{26}H_{40}O_4$ 439.2818, found 439.2811.

(6*R*,7*S*,9*S*,10*S*)-6,9-Epoxynonadec-18-ene-7,10-diol (2). Compound **2** was prepared from **26** (100 mg, 0.24 mmol) as described for the preparation of **1** and **3** from **22**. Purification by chromatography (hexanes/EtOAc, 10:1) yielded **2** (59 mg, 79%) as an oil: R_f 0.12 (hexanes/EtOAc, 10:1); $[\alpha]_D$ +41.7 (*c* 0.6 $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 5.84 (dddd, 1 H, *J* = 6.7, 6.7, 9.3, 16.9 Hz), 5.05 (dd, 1 H, *J* = 1.6, 16.9 Hz), 4.98 (d, 1 H, *J* = 10.8 Hz), 4.12−3.86 (m, 5 H), 2.24 (ddd, 1 H, *J* = 5.9, 9.3, 14.2 Hz), 2.08 (dd, 2 H, *J* = 6.9, 14.4 Hz), 1.91 (dd, 1 H, *J* = 2.8, 13.9 Hz), 1.52−1.29 (m, 22 H), 0.93 (dd, 3 H, *J* = 6.7, 6.7 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 139.6, 114.6, 87.9, 80.5, 75.4, 72.9, 34.2, 33.7, 33.5, 33.2, 29.5, 29.7, 29.6, 29.3, 26.3, 26.0, 23.0, 14.4; HRMS (ESI) calcd for (M + Na^+) $C_{19}H_{36}O_3$ 335.2556, found 335.2570.

(6*R*,7*S*,9*S*,10*R*)-6,9-Epoxynonadec-18-ene-7,10-diol (4). Compound **4** was prepared from **26** (50 mg, 0.12 mmol) as described for the preparation of **13** from **11**. Purification by chromatography (hexanes/EtOAc, 6:1) yielded **4** (37 mg, 100%) as a colorless oil: R_f 0.13 (hexanes/EtOAc, 10:1); $[\alpha]_D$ +47.5 (*c* 0.2 $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$, δ) 5.85 (dddd, 1 H, *J* = 6.7, 6.7, 10.2, 13.2 Hz), 5.03 (dd, 1 H, *J* = 1.5, 17.1 Hz), 4.97 (dd, 1 H, *J* = 1.1, 10.1 Hz), 4.07−4.00 (m, 2 H), 3.93 (ddd, 1 H, *J* = 1.9, 7.8, 7.9 Hz), 3.54 (ddd, 1 H, *J* = 0.5, 7.9, 8.1 Hz), 2.42 (ddd, 1 H, *J* = 6.3, 8.9, 14.0 Hz), 1.20−2.06 (m, 2 H), 1.82 (ddd, 1 H, *J* = 3.6, 3.7, 13.7 Hz), 1.60−1.30 (m, 22 H), 0.92 (dd, 3 H, *J* = 6.5, 6.5 Hz); ^{13}C NMR (125.7 MHz, $CDCl_3$, δ) 139.6, 114.6, 87.7, 79.9, 75.9, 74.6, 37.7, 34.5, 34.2, 33.7, 32.2, 29.9, 29.8, 29.4, 29.3, 26.3, 26.0, 22.9, 14.4; HRMS (ESI) calcd for (M + Na^+) $C_{19}H_{36}O_3$ 335.2556, found 335.2527.

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Supporting Information Available: ^{1}H and ^{13}C NMR spectra for **1**−**4**, **7**−**22**, and **24**−**27**. This material is available free of charge via the Internet at http://pubs.acs.org.

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