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Diastereoselectivity in Epoxidation of Carbohydrate Fused [13]-Macro-dilactones

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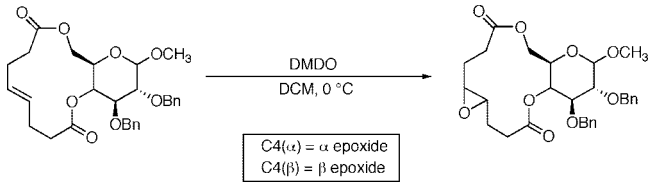
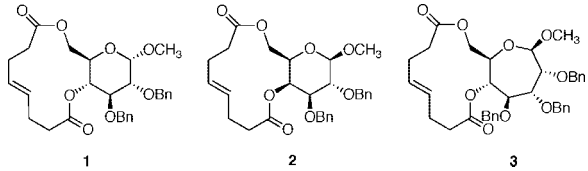


DMDO epoxidation of carbohydrate fused [13]-macro-dilactones was found to be highly diastereoselective. Facial selectivity of the epoxidation depended on the identity of the fused carbohydrate. *Gluco*-configured macro-dilactones gave the *R*,*R* epoxide, whereas the *galacto*- configuration gave the *S*,*S* epoxide. The epoxide stereochemisty was confirmed by independent syntheses of dimethyl 4*R*,5*R*-epoxyoctanedioate via Shi epoxidation of dimethyl *E*-oct-4-enedioate and by transesterification of the epoxide derived from the *gluco*-[13]-macro-dilactone. We demonstrate diastereoselectivity in alkene reactivity driven by remote rather than adjacent stereocenters.

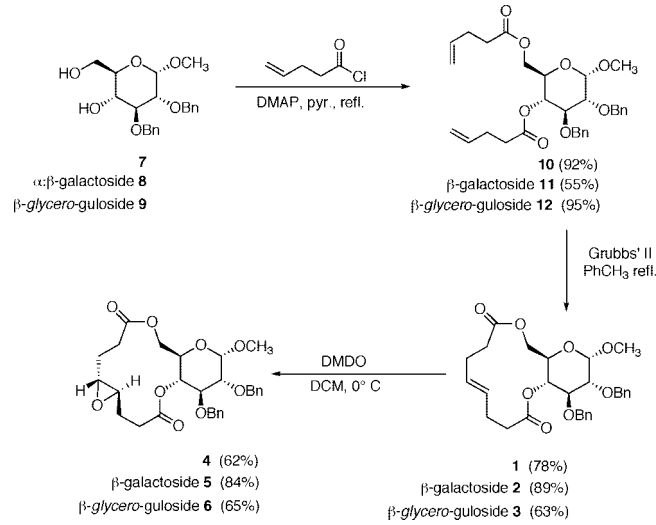
Here we report on the highly diastereoselective DMDO epoxidation of [13]-macro-dilactones **1**–**3**. Facial selectivity of the alkene in these molecules was governed by macrocyclic conformation. In contrast to earlier reports[1–4] where stereocenters adjacent to the alkene influenced conformational control, this work demonstrates the effect of remote stereocenters on macrocycle conformation and reactivity. Remote stereocenters in these molecules are supplied by fused carbohydrate moieties.



1 **2** **3**

Epoxidation of **1**–**3** was undertaken in an effort to prepare novel PKS[5,6]-carbohydrate hybrid [13]-macro-dilactones such as **4**–**6** (Scheme 1). These molecules can be categorized as unnatural products, which resemble natural products in their structure and functionality but are not synthesized by microorganisms. Unnatural products have become increasingly attractive

SCHEME 1



synthetic targets[7,8] as reagents for chemical biology investigations and as potential therapeutic leads.

Our strategy for the synthesis of **1**–**3** is straightforward and related to one recently reported.[9] The synthesis of [13]-macro-dilactone **1** from methyl α-D-glucoside **7** is depicted in Scheme 1 along with yields for the same sequence that began with methyl α/*β*-D-galactoside **8**[10] or methyl *β*-D-*glycero*-D-guloseptanoside **9**.[11] Preparation of these structures began with the efficient acylation of carbohydrate diols **7**−**9** with 4-pentenoyl chloride giving diesters **10**–**12** (55–95%). Closure of the macrocycle by ring-closing metathesis (RCM) followed to give macro-dilactones **1**–**3** (63–89%). The syntheses reported here join a small but growing list of examples of carbohydrate-fused macrocycles.[9,12]

Isolation of RCM products with an exclusively *trans* olefin geometry in the preparation of macrolactones **1**−**3** is notewor-

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(10) Overall yield of **11** (α + *β*) was 79% from a 1:2 α/*β* mixture of **8**. The *β*-product (**11**) was isolated by chromatography.

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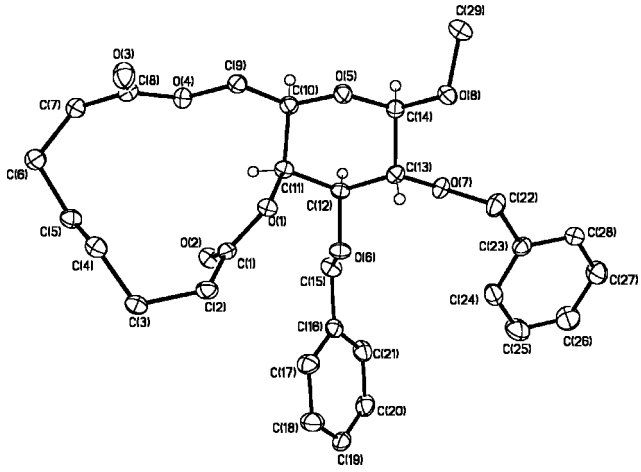


FIGURE 1. ORTEP diagram of methyl β-galactoside fused [13]-macro-dilactone **2**.

thy. The *trans* disposition[9] of the double bonds was determined by $^3J_{H,H}$ coupling constants for the olefinic vicinal protons of **1**, **2**, and **3** (14.8, 14.8, and 14.9 Hz).[13] The preference for the *trans* geometry in the case of the [13]-macro-dilactones is likely due to the fact that this carbohydrate-fused ring can not readily adopt low energy conformations that accommodate a *cis* double bond.

After recrystallization from hexanes/ethyl acetate, [13]-macro-dilactone **2** gave crystals suitable for X-ray analysis (Figure 1). Inspection of the macrolactone of **2** confirms the *trans* disposition of the alkene with its sp^2 plane perpendicular to the plane of the macrocycle. The carbonyl C−O bonds attached to C4 and C6 are oriented in opposite directions. Additionally, the methylene units that flank the alkene are in a staggered orientation relative to each other. A consequence of these features, which also define the overall conformation of the macro-dilactone, is that the *trans* alkene in **2** presents its pro-*S,S* face (Figure 2, configuration **A**) to the exterior environment. Attack on electrophiles (such as DMDO in the epoxidation) by the alkene would therefore give rise to the *S,S* configuration of the newly created stereocenters (**A′**).

DMDO-mediated epoxidation of **1**, **2**, and **3** gave one product in each case, indicating a high level of diastereoselectivity in the reaction. Attempts at determining the absolute stereochemistry of the epoxide in **4**, **5**, and **6** by spectroscopy were not successful. We developed an alternate plan for determining the stereochemistry at these centers. The plan was to isolate the epoxy-octanedioate from the [13]-macro-dilactones via transesterification with methanol and compare it to material prepared by an independent synthesis. We reasoned that epoxidation of dimethyl *E*-oct-4-ene-dioate (**13**, Scheme 2) under Shi conditions would give the *R,R* dimethyl 4,5-epoxyoctanedioate (**B′** in Figure 2) according to the proposed model for the reaction stereochemistry.[14]

Molecule **13** was prepared from the known di-*tert*-butyl ester[15] via transesterification in acidic methanol (88%).[16] Using the Shi protocol, **13** was converted to epoxide diester **14** (86%).

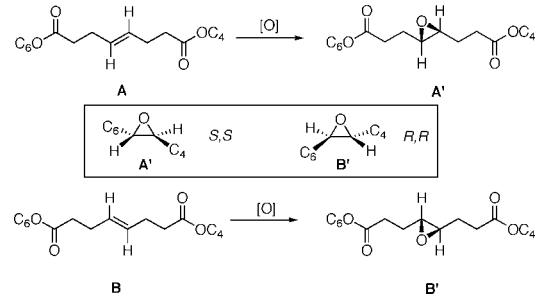
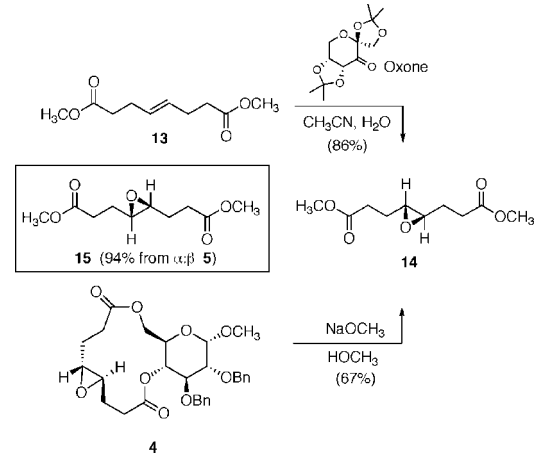


FIGURE 2. Orientation of [13]-macro-dilactone alkene unit relative to C4 and C6 of fused carbohydrates (pyranose numbering).

SCHEME 2



Despite the use of up to 5.5 equiv of Oxone, this reaction did not go to completion, indicating the electron-deficient character of the alkene in **13**. The *R,R* configuration was assigned to epoxide diester **14** based on analogy to similar examples that invoke the model proposed for Shi epoxidation. The same epoxide (**14**) was obtained from the transesterification of **4** under Zemplén conditions (67%). Material obtained by each of these methods was identical by polarimetry, ^{1}H and ^{13}C NMR, NMR chiral shift experiments, and chiral HPLC (see the Supporting Information), strongly suggesting an *R,R* absolute configuration for the epoxide stereocenters of target structure **4**. We concluded that the epoxide in **6** was also in the *R,R* configuration because the stereocenters that fuse the carbohydrate to the macro-dilactone in **3** are the same as in **1**. Transesterification of a ~1:1 (α/β) anomeric mixture of **5** under the established conditions gave the dimethyl 4*S*,5*S*-epoxyoctanedioate **15** (94%) which confirmed the facial selectivity predicted by inspection of the crystal structure.

Conformational control of the reaction stereoselectivity in unsaturated macrocyles[17] has been exploited in the synthesis of numerous macrolactone-containing natural products[1,3] and in the preparation of chiral, open-chain molecules using the macrocycle as a stereobiased intermediate.[18] Allylic branch-points may further enrich the conformational bias of a macrocycle.[19] Indeed, in the literature, examples of macrocyclic

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stereocontrol are primarily governed by substituents in close proximity to the reactive site.[20] For [13]-macro-dilactones **1–3**, the only stereocenters present are those from the fused carbohydrate ring which are remote relative to the reactive alkene. Our results clearly suggest that the observed stereoselectivity in the epoxidation of these [13]-macro-dilactones is not influenced by sterics near the reactive site but rather is entirely attributed to the macro-dilactone ring conformation as governed by the fused carbohydrate moiety. The switch in facial selectivity observed for the DMDO epoxidation of **1** versus **2** depended solely on the epimerization of the C4 stereochemistry. That is, the *anti*-relationship of the stereocenters in **1** dictated presentation of one *E*-alkene diasteroface (*pro-R,R*), while the *syn*-oriented stereocenters in **2** dictated presentation of the *pro-S,S* face. The results reported here are among the rare examples of highly diastereoselective macrocycle epoxidations at a site delimited only by the adjacent methylene chains of the macro-dilactone.[21]

Through the analysis of the spectroscopic data for **1–3**, inspection of the crystal structure of **2**, and the assignment of absolute configuration of the epoxides **14** and **15**, a consistent picture of the structure and reactivity of the novel carbohydrate-fused [13]-macrolactones has emerged. Conformational control of a modestly functionalized macrolactone was therefore achieved by the incorporation of a fused sugar moiety. This unique facial selectivity is directed by remote stereocenters that influence the shape of the macrolactone rather than by stereocenters adjacent to the alkene. Further, we used a Shi epoxidation as a key step in the determination of the absolute stereochemistry of the macrolactones.

Experimental Section

General RCM Procedure. To a solution of diester in dry toluene (0.1 mmol scale, final diene concentration = 4 mM) was added Grubbs II catalyst (5 mol %). The reaction mixture was heated to reflux for 12–16 h and then concentrated under reduced pressure. The mixture was purified by column chromatography (hexanes/EtOAc 7:3).

Methyl 2,3-di-*O*-benzyl-4,6-*O*-(*E*-oct-4-enedioyl)-α-D-glucopyranoside (1): R_f 0.57 (7:3, hexanes−EtOAc); $[\alpha]_D$ –1.53 (*c* 2.74, $CHCl_3$); IR (KBr) cm^{-1} 3088, 3063, 3031, 2925, 2856, 1735, 1454, 1355, 1260, 1237, 1170, 1138, 1101, 1043, 780, 739, 698; ^1H NMR ($CDCl_3$) 400 MHz δ 7.36–7.28 (m, 10H), 5.60–5.52 (m, 1H), 5.36 (ddd, J = 14.9, 9.0, 5.4 Hz, 1H), 5.11 (dd, J = 9.9, 9.9 Hz, 1H), 4.89 (d, J = 11.6 Hz, 1H), 4.83 (d, J = 12.1 Hz, 1H), 4.68 (d, J = 2.2 Hz, 1H), 4.65 (d, J = 2.8 Hz, 1H), 4.56 (d, J = 3.6 Hz, 1H), 4.24 (dd, J = 12.3, 2.5 Hz, 1H), 4.03 (dd, J = 12.5, 3.0 Hz, 1H), 3.96 (ddd, J = 10.0, 2.7, 2.7 Hz, 1H), 3.89 (dd, J = 9.6, 9.6 Hz, 1H), 3.65 (dd, J = 9.5, 3.7 Hz, 1H), 3.40 (s, 3H), 2.48–2.10 (m, 8H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 173.9, 171.2, 138.7, 138.0, 131.9, 129.4, 128.7, 128.5, 128.4, 128.2, 128.0, 127.7, 98.9, 80.0, 79.6, 75.3, 73.9, 70.8, 67.0, 64.3, 55.7, 34.9, 29.0, 26.9; EMS [M + Na]$^+$ *m/z* calcd for $C_{29}H_{34}O_8Na^+$ 533.2146, found 533.2149.

Methyl 2,3-di-*O*-benzyl-4,6-*O*-(*E*-oct-4-enedioyl)-β-D-galactopyranoside (2): mp 148–151 °C; R_f 0.41 (7:3, hexanes−EtOAc); $[\alpha]_D$ + 35.57 (*c* 1.28, $CHCl_3$); IR (KBr) cm^{-1} 3064, 3030, 2926, 2857, 1739, 1454, 1363, 1345, 1244, 1169, 1128, 1085, 1049, 985, 950, 905, 740, 700; ^1H NMR ($CDCl_3$) 300 MHz δ 7.41–7.28 (m, 10H), 5.61 (dd, J = 3.6, 1.4 Hz, 1H), 5.58–5.53 (m, 1H), 5.36 (ddd, J = 14.8, 9.3, 5.0 Hz, 1H), 4.94 (d, J = 11.4 Hz, 1H), 4.87 (d, J = 10.9 Hz, 1H), 4.73 (d, J = 10.9 Hz, 1H), 4.58 (d, J = 11.4 Hz, 1H), 4.34 (d, J = 7.6 Hz, 1H), 4.18–4.06 (m, 2H), 3.91 (ddd, J = 9.4, 6.7, 1.5 Hz, 1H), 3.65 (dd, J = 10.0, 3.7 Hz, 1H), 3.58 (s, 3H), 3.54 (dd, J = 10.0, 7.6 Hz, 1H), 2.59–2.16 (m, 8H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 173.5, 172.0, 138.8, 138.2, 132.0, 129.5, 128.5, 128.4 (2), 128.2, 127.8 (2), 104.7, 79.2, 78.8, 75.5, 72.7, 69.8, 66.2, 61.3, 57.3, 34.8, 33.7, 29.4, 27.6; EMS [M + Na]$^+$ *m/z* calcd for $C_{29}H_{34}O_8Na^+$ 533.2146, found 533.2144.

Methyl 2,3,4-tri-*O*-benzyl-5,7-*O*-(*E*-oct-4-ene-dioyl)-β-D-*glycero*-D-guloseptanoside (3): R_f 0.72 (7:3, hexanes−EtOAc); $[\alpha]_D$ +19.42 (*c* 0.94, $CHCl_3$); IR (KBr) cm^{-1} 3088, 3062, 3030, 1734, 1497, 1454, 1385, 1354, 1238, 1207, 1171, 1134, 1076, 1038; ^1H NMR ($CDCl_3$) 400 MHz δ 7.38–7.17 (m, 15H), 5.58–5.51 (m, 1H), 5.37 (ddd, J = 14.8, 9.0, 5.4 Hz, 1H), 5.25 (dd, J = 10.0, 3.6 Hz, 1H), 4.79 (d, J = 12.0 Hz, 1H), 4.70–4.56 (m, 6H), 4.40 (ddd, J = 9.9, 3.1, 3.1 Hz, 1H), 4.31 (dd, J = 12.1, 3.0 Hz, 1H), 4.06 (dd, J = 12.2, 3.0 Hz, 1H), 3.84 (d, J = 6.2 Hz, 2H), 3.70 (dd, J = 6.6, 3.4 Hz, 1H), 3.52 (s, 3H), 2.48–2.14 (m, 8H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 174.2, 171.6, 138.8, 138.5, 138.4, 131.6, 129.3, 128.6, 128.5, 128.2, 128.1, 128.0, 127.8, 127.7, 105.9, 79.9, 79.8, 79.4, 74.0, 73.8, 73.3, 71.1, 65.7, 56.6, 35.0, 34.2, 29.2, 27.5; EMS [M + Na]$^+$ *m/z* calcd for $C_{37}H_{42}O_9Na^+$ 653.2721, found 653.2722.

General Epoxidation Procedure. The macro-dilactone (0.1 mmol) was dried via azeotropic distillation from toluene (3 × 5 mL) and dissolved in dry CH_2Cl_2 (5 mL). The solution was cooled to 0 °C and a DMDO (2.4 eq.) solution was added dropwise. The mixture was stirred at 0 °C for 1 h and the solvent was removed under reduced pressure. The residue was purified by column chromatography (hexanes/EtOAc 7:3).

Methyl 2,3-di-*O*-benzyl-4,6-*O*-(4*R*,5*R*-epoxyoctanedioyl)-α-D-glucopyranoside (4): mp 128–130 °C; R_f 0.37 (7:3, hexanes−EtOAc); $[\alpha]_D$ –22.78 (*c* 1.07, $CHCl_3$); IR (KBr) cm^{-1} 3088, 3065, 3033, 2947, 2932, 2905, 2860, 1740, 1461, 1365, 1234, 1212, 1179, 1102, 882, 731, 697; ^1H NMR ($CDCl_3$) 400 MHz δ 7.39–7.21 (m, 10H), 5.21 (dd, J = 10.1, 10.1 Hz, 1H), 5.00 (dd, J = 13.0, 3.6 Hz, 1H), 4.91 (d, J = 11.8 Hz, 1H), 4.84 (d, J = 11.9 Hz, 1H), 4.67 (d, J = 12.1 Hz, 1H), 4.63 (d, J = 11.8 Hz, 1H), 4.57 (d, J = 3.8 Hz, 1H), 4.00 (dd, J = 10.2, 2.8 Hz, 1H), 3.90 (d, J = 9.5, 9.5 Hz, 1H), 3.73 (d, J = 12.8 Hz, 1H), 3.67 (d, J = 9.4, 3.8 Hz, 1H), 3.41 (s, 3H), 2.90 (ddd, J = 10.0, 2.3, 2.3 Hz, 1H), 2.66 (ddd, J = 10.0, 2.1, 2.1 Hz, 1H), 2.56–2.39 (m, 2H), 2.31–2.07 (m, 4H), 1.55–1.44 (m, 2H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 172.9, 171.5, 138.7, 138.0, 128.8, 128.5 (2), 128.3, 128.1, 127.8, 99.2, 80.2, 79.6, 75.4, 74.0, 69.2, 67.6, 62.4, 59.4, 58.4, 55.8, 29.5, 29.2, 26.9, 26.4; EMS [M + Na]$^+$ *m/z* calcd for $C_{29}H_{34}O_9Na^+$ 549.2095, found 549.2112.

Methyl 2,3-di-*O*-benzyl-4,6-*O*-(4*S*,5*S*-epoxy-octanedioyl)-β-D-galactopyranoside (5): mp 135–149 °C; R_f 0.24 (7:3, hexanes−EtOAc); $[\alpha]_D$ +55.72 (*c*. 0.90, $CHCl_3$); IR (KBr) cm^{-1} 3064, 3031, 2963, 2924, 2866, 1745, 1454, 1369, 1261, 1222, 1178, 1076, 1028, 878, 799, 736, 699; ^1H NMR ($CDCl_3$) 400 MHz δ 7.36–7.28 (m, 10H), 5.68 (d, J = 2.2 Hz, 1H), 4.88 (d, J = 10.9 Hz, 1H), 4.82 (d, J = 11.6 Hz, 1H), 4.76–4.71 (m, 2H), 4.56 (d, J = 11.3 Hz, 1H), 4.35 (d, J = 7.4 Hz, 1H), 3.88 (dd, J = 10.6, 6.3 Hz, 1H), 4.03–3.98 (m, 1H), 3.65 (dd, J = 9.8, 3.6 Hz, 1H), 3.59–3.53 (m, 4H), 2.89 (d, J = 9.9 Hz, 1H), 2.70 (d, J = 9.8 Hz, 1H), 2.65–2.46 (m, 4H), 2.29–2.13 (m, 2H), 1.62–1.49 (m, 2H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 172.4, 172.2 (2), 172.0, 138.7, 138.6, 138.3, 138.0, 128.5 (2), 128.4, 128.2 (2), 128.1, 127.9 (2), 127.8, 104.8, 99.4, 78.9, 78.8, 75.7, 75.6, 75.5, 73.9, 72.6 (2), 70.1, 67.2, 66.1, 65.8, 60.7, 60.4, 59.4, 59.3, 58.5, 57.4, 56.0, 29.6, 29.5, 29.1, 27.1 (2), 26.5 (2); EMS [M + Na]$^+$ *m/z* calcd for $C_{29}H_{34}O_9Na^+$ 549.2095, found 549.2093.

Methyl 2,3,4-tri-*O*-benzyl-5,7-*O*-(4*R*,5*R*-epoxyoctanedioyl)-β-D-*glycero*-D-guloseptanoside (6): R_f 0.33 (7:3, hexanes−EtOAc); $[\alpha]_D$ +14.65 (*c* 0.69, $CHCl_3$); IR (KBr) cm^{-1} 3088, 3062, 3030, 2926, 2856, 1736, 1454, 1385, 1362, 1275, 1223, 1180, 1097, 1072, 1043, 933; ^1H NMR ($CDCl_3$) 400 MHz δ 7.38–7.16 (m, 15H), 5.40 (dd, J = 9.9, 6.6 Hz, 1H), 4.82 (dd, J = 12.2, 2.8 Hz, 1H), 4.78 (s,

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2H), 4.73–4.70 (m, 2H), 4.67 (s, 2H), 4.53 (d, J = 11.9 Hz, 1H), 4.36 (d, J = 10.5 Hz, 1H), 3.93–3.90 (m, 2H), 3.84–3.78 (m, 2H), 3.51 (s, 3H), 2.90 (ddd, J = 9.9, 2.2, 2.2 Hz, 1H), 2.63 (ddd, J = 10.0, 2.0, 2.0 Hz, 1H), 2.56–2.42 (m, 2H), 2.28–2.03 (m, 4H), 1.54–1.44 (m, 2 H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 173.2, 171.0, 138.5, 138.4, 128.6, 128.5 (2), 128.2, 128.0 (2), 127.9, 127.7, 104.3, 81.1, 80.7, 80.0, 74.4, 74.0 (2), 72.2, 70.5, 64.5, 59.4, 58.5, 56.6, 29.7, 29.4, 27.1, 26.4; EMS $[M + Na]^+$ m/z calcd for $C_{37}H_{42}O_{10}Na^+$ 669.2670, found 669.2661.

Dimethyl 4*R,5R*-Epoxyoctanedioate (14) (Shi Epoxidation). Alkene **13** (0.053 g, 0.267 mmol) was stirred in CH_3CN (15 mL) at 0 °C in a three-neck round-bottom flask for about 20 min. To this solution were added aqueous $Na_2B_4O_7$ (10 mL, 0.05 M), Bu_4NHSO_4 (0.030 g), and catalyst 1,2:4,5-di-*O*-isopropylidene-β-D-erythro-2,3-hexodiulo-2,6-pyranose (0.034 g, 0.133 mmol). Simultaneous addition of K_2CO_3 (1.64 g, 12 mL H_2O) and Oxone (0.900 g, 12 mL 0.4 mM Na_2EDTA) via addition funnel was performed at 0 °C over 4.5 h. The reaction mixture was quenched with 60 mL of EtOAc/H_2O mixture (1:1). The organic layer was separated, and the reaction mixture was extracted with EtOAc (2 × 30 mL). The organic layer was dried (Na_2SO_4), and the solvent was removed under reduced pressure. Purification of the residue by column chromatography using 3:1 hexanes/EtOAc as eluent gave the epoxide **14** (0.050 g, 86%) as a clear colorless liquid with 0.007 g (13%) of recovered **13**: R_f 0.30 (4:1, hexanes:EtOAc); $[\alpha]_D$ +38.32 (c 2.50, $CHCl_3$); IR (KBr) cm^{-1} 2959, 2929, 2850, 1739, 1439, 1363, 1261, 1198, 1173, 1095, 1021, 882, 801, 699; ^{1}H NMR ($CDCl_3$) 300 MHz δ 3.66 (s, 6H), 2.79–2.74 (m, 2H), 2.42 (dd, J = 7.3, 7.3 Hz, 4H), 1.97–1.85 (m, 2H), 1.79–1.68 (m, 2H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 173.4, 57.7, 51.8, 30.3, 27.3; EMS $[M + Na]^+$ m/z calcd for $C_{10}H_{16}O_5Na^+$ 239.0890, found 239.0886.

Dimethyl 4*R,5R*-Epoxyoctanedioate (14) (Transesterification). Macro-dilactone **4** (0.072 g, 0.138 mmol) was dissolved in 5 mL of NaOMe in MeOH (0.5 mg/mL) and the mixture stirred at rt for 72 h. An additional 0.5 mg of NaOMe was added to the reaction and stirring continued for 24 h. The reaction mixture was concentrated under reduced pressure, and the residue was purified via column chromatography using 7:3 hexanes/EtOAc as eluent to give **14** (0.020 g, 66%) as a clear colorless liquid: R_f 0.30 (4:1, hexanes/EtOAc); $[\alpha]_D$ +33.69 (c 2.49, $CHCl_3$); IR (KBr) cm^{-1} 2962, 2930, 2850, 1739, 1439, 1363, 1261, 1198, 1173, 1095, 1020, 881, 800, 703; ^{1}H NMR ($CDCl_3$) 300 MHz δ 3.68 (s, 6H), 2.80–2.75 (m, 2H), 2.43 (dd, J = 7.4, 7.4 Hz, 4H), 1.99–1.88 (m, 2H), 1.82–1.70 (m, 2H); ^{13}C NMR ($CDCl_3$) 100 MHz δ 173.4, 57.8, 51.9, 30.4, 27.3; EMS $[M + Na]^+$ m/z calcd for $C_{10}H_{16}O_5Na^+$ 239.0890, found 239.0886.

Crystallographic data for **2** and **5** have been submitted to the Cambridge Crystallographic Data Centre (CCDC), nos. 670783 and 678794. Copies of this information may be obtained free of charge from CCDC, 12 Union Road, Cambridge CB2 1EZ, UK (Fax: +44-1223-336033; Web: www.ccdc.cam.ac.uk/conts/retrieving/html; E-mail: deposit@ccdc.cam.ac.uk).

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Supporting Information Available: Complete characterization of epoxide **14** derived from **13** and **4**. Data for epoxide **15** from **5** (polarimetry, ^{1}H NMR chiral shift reagent, and chiral HPLC). ^{1}H and ^{13}C NMR spectra for all new compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

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