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Synthesis and Determination of Absolute Configuration of α-Pyrones Isolated from *Penicillium corylophilum*

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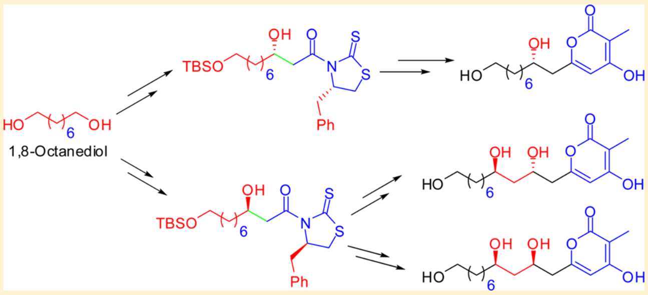
Ⓢ *Supporting Information*

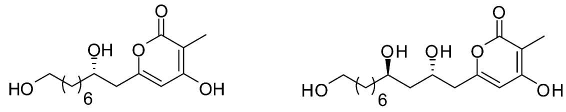
ABSTRACT: The first total synthesis of (*S*)-6-(2,9-dihydroxynonyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one, 4-hydroxy-3-methyl-6-((2*S*,4*R*)-2,4,11-trihydroxyundecyl)-2*H*-pyran-2-one, and its unnatural 2*R*,4*R*-isomer starting from commercially available 1,8-octanediol is described. The synthesis led to the revision of the proposed structural assignment of the natural product as (*R*)-6-(2,9-dihydroxynonyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one. The key steps include chiral auxiliary mediated asymmetric acetate aldol reaction, dianion addition, and base mediated cyclization to form an α-pyrone ring.



INTRODUCTION

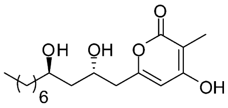
In recent years, numerous α-pyrone containing polypropionate natural products with a six-membered cyclic unsaturated ester have been isolated from bacteria, fungi, plants, insects, and animal systems. These compounds form key biosynthetic intermediates and metabolites and also exhibit biological processes such as defense and intercellular communication.[1] The 4-hydroxy α-pyrone motif is an important building block and forms the key precursor for several biologically active compounds, such as pheromones,[2a] solanopyrones,[2b] coumarins,[2c] and analogues.[2d]

Recently, Miller and co-workers[3] reported the isolation of three new α-pyrones **1**−**3** (Figure 1) from *Penicillium corylophilum* DAOM 242293 collected from damp building materials found in Halifax and Canada. Though the compounds with a 4-hydroxy-2*H*-pyrane-2-one core displayed antimicrobial activity against Gram-positive bacteria, but not Gram-negative bacteria, in the low micromolar range, the compounds (**1**−**3**) were inactive at <50 μg/mL for antibacterial activity. The structures of these α-pyrones have been determined by HRESIMS and 1D and 2D spectroscopic analysis, and the relative *anti* stereochemistry at C-8 and C-10 in compounds **2** and **3** was confirmed by Kishi's universal NMR database.[4] In continuation of our effort toward the total synthesis of biologically active pyrone containing natural products,[5,6f−j] we became interested in targeting these newly isolated compounds for their total synthesis. Herein, we report the first total synthesis of (*S*)-6-(2,9-dihydroxynonyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one **1**, and 4-hydroxy-3-methyl-6-((2*S*,4*R*)-2,4,11-trihydroxyundecyl)-2*H*-pyran-2-one **2**. Our synthesis has led to the structural revision of natural product **1**.



(*S*)-6-(2,9-dihydroxynonyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one (**1**)

4-hydroxy-3-methyl-6-((2*S*,4*R*)-2,4,11-trihydroxyundecyl)-2*H*-pyran-2-one (**2**)



6-((2*S*,4*R*)-2,4-dihydroxyundecyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one (**3**)

Figure 1. Structures of 4-hydroxy α-pyrones.

RETROSYNTHETIC ANALYSIS

Our approach relied on the utility of auxiliary based asymmetric acetate aldol addition reaction to install the chiral centers involving C−C bond formation reaction. The retrosynthesis for the target compounds **1** and **2** is depicted in Scheme 1. Accordingly, the target compound **1** was planned to be synthesized from β,δ-diketoester **4** through the base mediated cyclization, followed by TBS deprotection. The β,δ-diketoester **4** can be obtained from compound **5** by TBS protection, followed by addition of the dianion of ethyl-2-methylacetoacetate **6**. Compound **5**, in turn, can be synthesized from 1,8-octanediol **7** via asymmetric acetate aldol reaction. Similarly, compound **2** was planned to be synthesized from β,δ-diketoester **8** through the base mediated cyclization, followed by TBS deprotection. Compound **8**, in turn, can be accessed from 1,8-octanediol **7**

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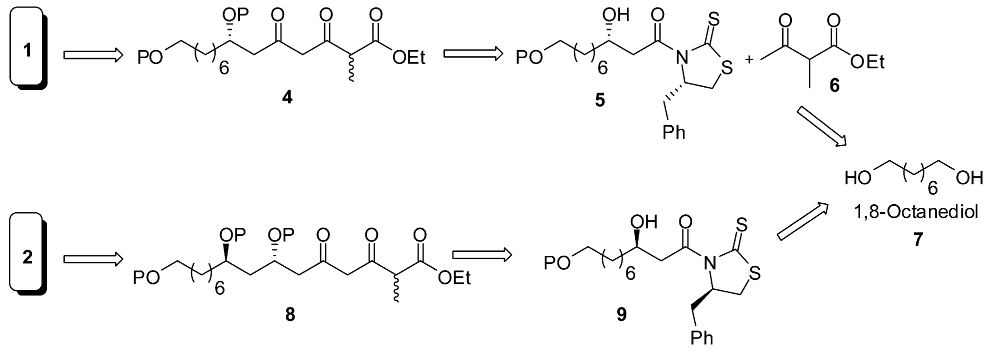
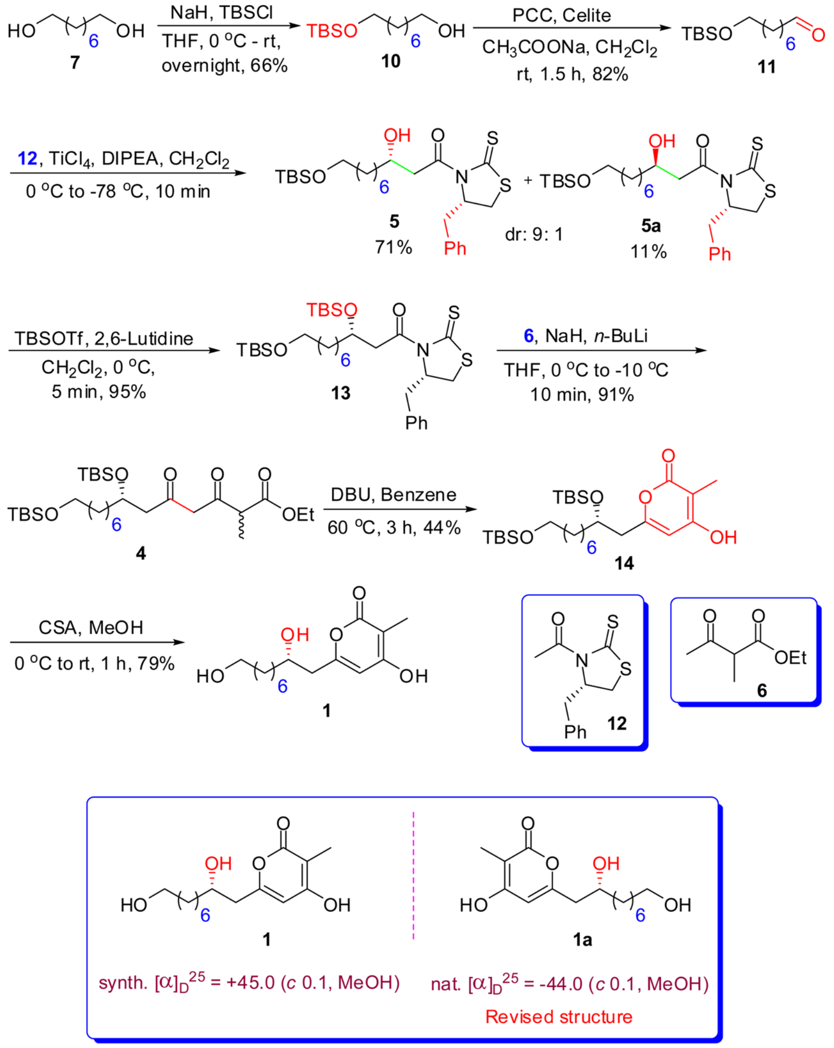
Scheme 1. Retrosynthetic Analysis of Compounds 1 and 2



Scheme 2. Synthesis of (S)-6-(2,9-Dihydroxynonyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one (1)



involving an iterative acetate aldol reaction as the key steps through an intermediate **9**.

■ RESULTS AND DISCUSSION

Synthesis of compound **1** is depicted in Scheme 2. Accordingly, the synthesis commences with known 1,8-octanediol **7**, which was protected as its corresponding mono TBS ether **10** by treating with NaH and TBSCl. The alcohol **10** was oxidized to aldehyde **11**, the precursor for the first acetate aldol reaction using PCC in 82% yield. The chiral auxiliary mediated acetate aldol reaction[6] of aldehyde **11** was achieved with (*S*)-1-(4-benzyl-2-thioxothiazolidin-3-yl)ethanone **12** to give **5** and **5a** (9:1) with good diastereoselectivity.[7] The product **5** was easily separated (silica gel column chromatography) and treated with TBSOTf and 2,6-lutidine to get the corresponding TBS ether **13** in 95% yield. The Li/Na dianion of ethyl-2-methylacetoacetate **6** (generated by treating **6** with NaH, followed by *n*-BuLi) was added to the TBS protected aldol product **13** to afford an inseparable mixture of desired *β*,*δ*-diketoester **4**.[8] Base mediated cyclization of **4** was achieved by

Table 1. Comparison of ^1H and ^{13}C NMR Data for Natural (**1a**) and Synthetic Compound (**1**)

	natural		synthesized 1	
position	H mult [J (Hz)] CD_3OD, 700 MHz	^{13}C NMR CD_3OD, 175 MHz	H mult [J (Hz)] CD_3OD, 700 MHz	^{13}C NMR CD_3OD, 125 MHz
2		169.4, C		169.2
3		98.7, C		99.0
4		170.6, C		168.4
5	6.00, s	104.1, CH	6.03, s	103.2
6		161.8, C		162.1
7	2.59, dd (4.5, 14.4) 2.47, dd (8.3, 14.4)	42.6, CH_2	2.61, dd (4.2, 14.5) 2.47, dd (8.5, 14.5)	42.6
8	3.90, m	70.0, CH	3.93−3.88, m	70.0
9	1.46, m	38.1, CH_2	1.54−1.43, m	38.2
10	1.34, m	26.6, CH_2	1.40−1.27, m	26.6
11	1.31, m	30.5, CH_2	1.40−1.27, m	30.5
12	1.34, m	30.6, CH_2	1.40−1.27, m	30.6
13	1.34, m	26.9, CH_2	1.40−1.27, m	26.9
14	1.51, m	33.7, CH_2	1.54−1.43, m	33.6
15	3.53, t (7.0)	63.0, CH_2	3.53, t (6.7)	63.0
16	1.83, s	8.3, CH_3	1.84, s	8.3

heating with 1,8-diazabicyclo[5.4.0]-undec-7-ene (DBU)[9] in benzene at 60 °C to afford 4-hydroxy pyrone **14**. Finally, TBS deprotection with CSA in methanol afforded target compound **1** in 79% yield. ^1H NMR data (Table 1) was found to be identical to those reported for the natural compound **1**.[3] An anomaly in ^{13}C NMR data was observed for the three carbons at C-2, C-4, and C-5 positions and has prompted us to relook at the spectral data for both the synthetic and isolated compounds along with other molecules with similar scaffolds (4-hydroxy-3-methyl-2-pyrones). When we have gone through the literature,[10a−f] it was observed that, at least for carbon at the C-3 position when methyl substitution is present, the peak was always found to be at less than δ 170 ppm, which is in concurrence with the data obtained from our compound (δ 169.2 ppm) in comparison with the isolated compound, wherein the peak was claimed to be present at δ 170.6 ppm.[10g] To further confirm the absolute structure, we have investigated 2D NMR studies, and the chemical shifts of ^1H and ^{13}C were analyzed by using HSQC, HMBC experiments (see the Supporting Information). The two bond ($^2J_{CH}$) HMBC correlations between H5−C4, H5−C6, H7−C6, H16−C3 along with the three bond HMBC ($^3J_{CH}$) correlations between H5−C3, H5−C7, H16−C2, H16−C4, H8−C6, H7−C5 confirmed the proposed structure of **1** as shown in Figure 2.

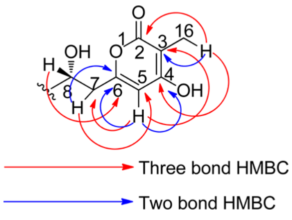
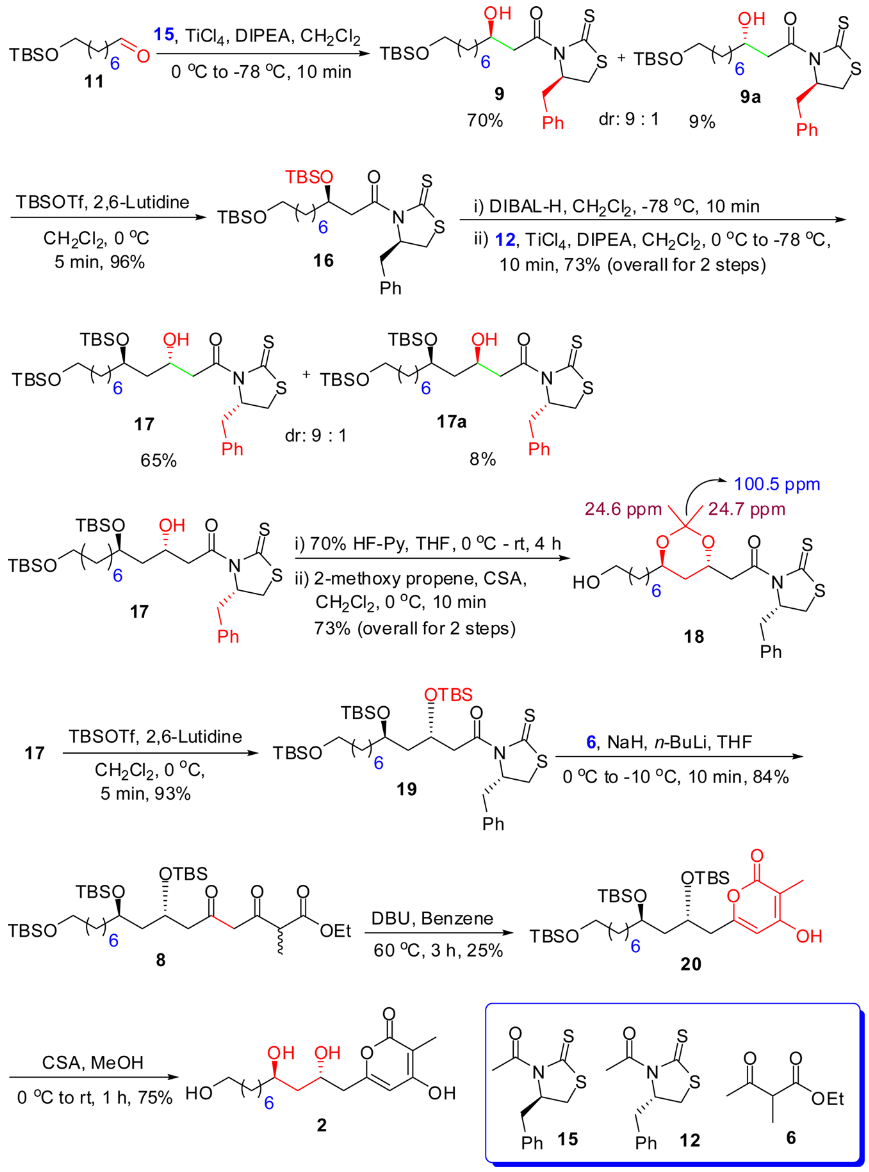


Figure 2. Key HMBC correlations for compound **1**.

Although, the optical rotation obtained for the synthetic product was of the same magnitude as the natural product, the rotation was found to be in opposite sign (synthetic product $[\alpha]_D^{25}$ = +45.0 (c 0.1, MeOH), natural product $[\alpha]_D^{25}$ = −44.0. (c 0.1, MeOH)).[3] We claim to accomplish the total synthesis of **1**, and the present synthesis unambiguously determines the absolute configuration of the synthetic product as the S-isomer. Since the natural product has the opposite rotation, the absolute structure of the natural product has to be revised to R-isomer (Scheme 2). Thus, we have accomplished the first total synthesis of unnatural α-pyrone and herein revise the structure of the natural product as **1a**.

The synthetic route for the natural product **2** is illustrated in Scheme 3. The synthesis commences with the addition of the titanium enolate of (R)-1-(4-benzyl-2-thioxothiazolidin-3-yl)-ethanone **15** to aldehyde **11** to give an easily separable diastereomeric mixture of **9** and **9a** (9:1 ratio).[6] Alcohol **9** was silylated by treating with TBSOTf in 96% yield to provide **16**. Since we needed one more chiral center at the third position to the newly generated chiral alcohol, we opted to proceed again with asymmetric acetate aldol reaction. Thus, the compound **16** was reduced with DIBAL-H to get the aldehyde and was then treated with (S)-1-(4-benzyl-2-thioxothiazolidin-3-yl)ethanone **12** in the presence of $TiCl_4$ and Hünig's base to provide the desired *syn* aldol product **17** in 65% yield along with **17a** in 8% yield (overall for 2 steps). The stereochemistry of the generated *anti*-1,3-diol motif was confirmed following Rychnovskys protocol,[11] wherein the compound **17** was subjected to desilylation and treated with 2-methoxy propene in the presence of CSA to give the corresponding acetonide derivative **18**. ^{13}C NMR of **18** revealed the presence of acetonide methyl groups resonating at δ 24.6 and 24.7 ppm and the ketal carbon resonating at δ 100.5 ppm, confirming the presence of the *anti*-1,3-diol system at C-8 and C-10 carbons. After obtaining the desired structural configuration, we proceeded further with the required major isomer **17** for silylation with TBSOTf to get the corresponding silyl ether **19**. Compound **19** was treated with the dianion of ethyl-2-methylacetoacetate **6** to produce an inseparable mixture of β,δ-dioxoethanoate **8**.[8] Compound **8**, upon exposure to DBU[9] in benzene at 60 °C, afforded the cyclized precursor **20**. 3-fold desilylation of **20** was easily achieved with CSA in MeOH to afford the natural product **2**. The ^1H NMR data of compound **2** were identical with those of the reported natural product data (Table 2).[3] There was a small difference in the ^{13}C NMR data as found in the case of compound **1** compared to the isolated natural product. The compound was also further analyzed by 2D NMR studies (HSQC and HMBC), and the structural confirmation was achieved (since similar correlations were observed for the

Scheme 3. Synthesis of 4-Hydroxy-3-methyl-6-((2*S*,4*R*)-2,4,11-trihydroxyundecyl)-2*H*-pyran-2-one (**2**)



2-pyrone moiety,[10a−g] see Figure 2 and the Supporting Information). The optical rotation of synthetic product **2** was found to be $[\alpha]_D^{25}$ = +10.00 (*c* 0.05, MeOH), and for the natural product, it was $[\alpha]_D^{25}$ = +20.0 (*c* 0.05, MeOH).[3]

Since we had enough material of compound **16** in hand, we proceeded further to synthesize an isomer **21** (diastereomer of **2**). Synthesis of compound **21** is depicted in Scheme 4. The stereochemistry at C-8 was installed by aldol reaction employing (*R*)-1-(4-benzyl-2-thioxothiazolidin-3-yl)ethanone **15** as a chiral auxiliary. Thus, the thioimide **16** was reduced to aldehyde with DIBAL-H and was subjected to acetate aldol reaction with chiral auxiliary **15** in the presence of TiCl$_4$ and DIPEA to afford **22** as the major diastereomer in 68% yield.[6]

The stereochemistry of aldol product **22** was verified by the studies similar to as summarized in Scheme 3 according to Rychnovsky's acetonide method.[11] The TBS groups were unmasked with 70% HF-pyridine, and the resulting triol was converted into the acetonide protected primary alcohol **23** in 80% yield (overall for 2 steps). In the ^{13}C NMR spectra of compound **23**, the acetonide methyl protons resonated as δ 30.1 and 19.7 ppm and acetal carbon resonated at δ 98.7 ppm, confirming the *syn* relationship between C-8 and C-10 hydroxyl moieties.

The resulting secondary alcohol **22** (Scheme 4) was protected as its TBS ether **24** and then coupled with the dianion of ethyl-2-methylacetoacetate **6** to give an inseparable mixture of β,δ-diketoester[8] **25** in 82% yield. Compound **25** was converted to pyrone **26** by treating with DBU.[9] Finally, TBS deprotection with CSA in methanol afforded the target compound **21** in 80% yield. The optical rotation of compound **21** was found to be $[\alpha]_D^{25}$ = −20.87 (*c* 0.115, MeOH).

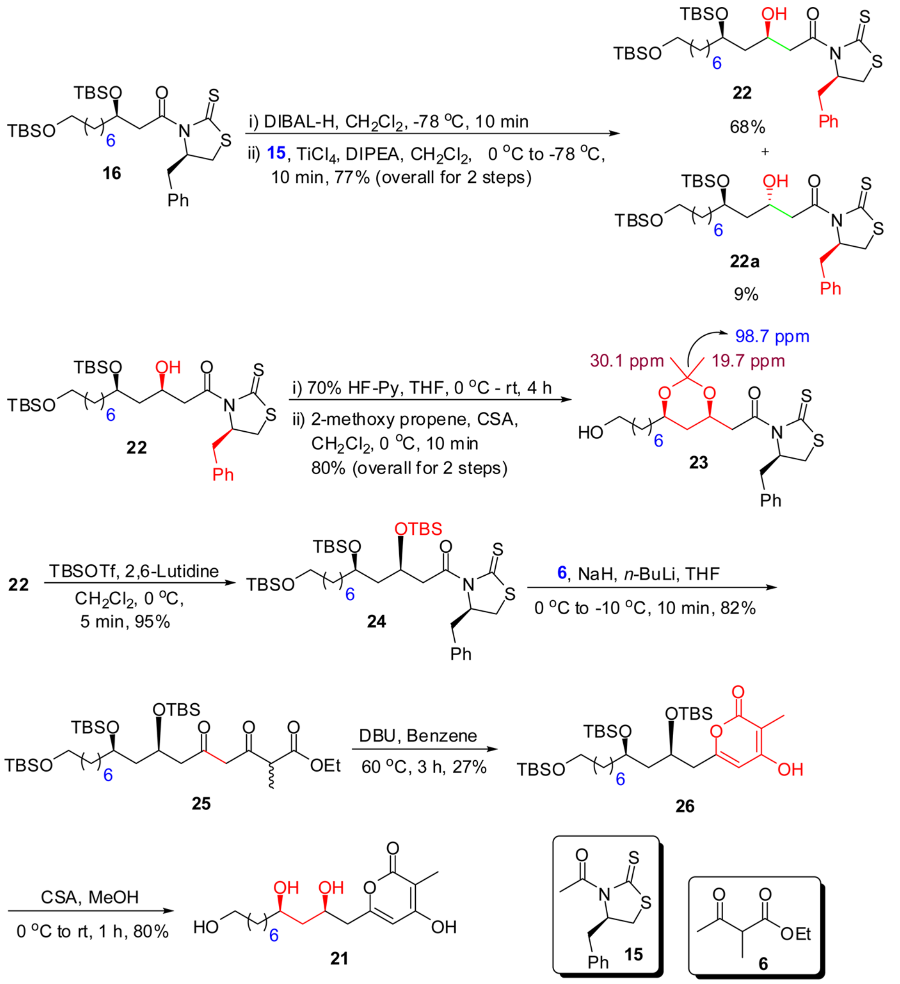
■ CONCLUSIONS

In conclusion, we have successfully synthesized the first total synthesis of (+)-(*S*)-6-(2,9-dihydroxynonyl)-4-hydroxy-3-methyl-2*H*-pyran-2-one **1**, 4-hydroxy-3-methyl-6-((2*S*,4*R*)-2,4,11-trihydroxyundecyl)-2*H*-pyran-2-one **2**, and its unnatural 2*R*,4*R*-isomer **21** from 1,8-octanediol in 7, 10, and 10, steps, respectively. The structural assignment for the natural product

Table 2. Comparison of ^{1}H and ^{13}C NMR Data for Natural and Synthetic Compound 2 and Its 2*R*,4*R*-Isomer 21

	natural		synthesized 2		synthesized 21	
position	H mult [*J* (Hz)] CD_3OD, 700 MHz	^{13}C NMR CD_3OD, 175 MHz	H mult [*J* (Hz)] CD_3OD, 700 MHz	^{13}C NMR CD_3OD, 125 MHz	H mult [*J* (Hz)] CD_3OD, 700 MHz	^{13}C NMR CD_3OD, 125 MHz
2		169.9, C		169.3		169.2
3		98.4, C		99.1		99.2
4		172.9, C		168.8		168.1
5	5.96, s	105.7, CH	6.03, s	103.5	6.05, s	103.3
6		161.2, C		161.9		161.8
7	2.58, dd (5.2, 14.4)	43.2, CH_2	2.60, dd (5.0, 14.5)	43.3	2.66, dd (4.2, 14.5)	42.5
	2.54, dd (7.8, 14.4)		2.52, dd (8.3, 14.5)		2.51, dd (8.3, 14.5)	
8	4.19, m	67.2, CH	4.21–4.15, m	67.2	4.14–4.08, m	68.8
9	1.55, m	45.3, CH_2	1.57–1.48, m	45.4	1.63–1.59, m	44.7
10	3.80, m	69.0, CH	3.81–3.76, m	69.0	3.78–3.73, m	70.9
11	1.45, m	39.1, CH_2	1.46–1.40, m	39.2	1.54–1.38, m	38.5
12	1.46, m	26.9, CH_2	1.38–1.26, m	26.9	1.37–1.27, m	26.9
13	1.36, m	30.8, CH_2	1.38–1.26, m	30.8	1.37–1.27, m	30.8
14	1.31, m	30.6, CH_2	1.38–1.26, m	30.6	1.37–1.27, m	30.6
15	1.37, m	26.8, CH_2	1.38–1.26, m	26.8	1.37–1.27, m	26.4
16	1.53, m	33.7, CH_2	1.57–1.48, m	33.7	1.54–1.38, m	33.6
17	3.54, t (6.7)	63.0, CH_2	3.53, t (6.7)	63.0	3.53, t (6.7)	63.0
18	1.83, s	8.3, CH_3	1.84, s	8.3	1.84, s	8.3

Scheme 4. Synthesis of 4-Hydroxy-3-methyl-6-((2*R*,4*R*)-2,4,11-trihydroxyundecyl)-2*H*-pyran-2-one (21)



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1 has been revised. Acetate aldol reaction has been utilized as the key step for the total synthesis. Biological screening of the synthesized compounds is our future interest, and efforts in this direction are currently underway.

■ EXPERIMENTAL SECTION

General Methods. ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ and CD_3OD as solvent on a 300 or 500 or 700 MHz spectrometer at ambient temperature. The coupling constant J is given in Hz. The chemical shifts are reported in ppm on a scale downfield from TMS as internal standard, and signal patterns are indicated as follows: s = singlet, d = doublet, t = triplet, q = quartet, sext = sextet, m = multiplet, br = broad. FTIR spectra were recorded using neat products or solutions in $CHCl_3$. Optical rotations were measured on a digital polarimeter using a 1 mL cell with a 1 dm path length. For low (MS) and high (HRMS) resolution, m/z ratios are reported as values in atomic mass units. HRMS analysis was done in an ORBITRAP analyzer. All reagents were reagent grade and used without further purification unless specified otherwise. Solvents for reactions were distilled prior to use: THF was distilled from Na and benzophenone ketyl, CH_2Cl_2 from CaH_2. All air- or moisture-sensitive reactions were conducted under a nitrogen or argon atmosphere in flame-dried or oven-dried glassware with magnetic stirring. Column chromatography was carried out using silica gel (60−120 mesh) packed in glass columns. Technical grade ethyl acetate and petroleum ether used for column chromatography were distilled prior to use.

*8-(tert-Butyldimethylsilyloxy)octan-1-ol (**10**).* A 60% dispersion of NaH in mineral oil (9.0 g, 0.226 mol) was suspended in distilled THF (400 mL), followed by the addition of octane-1,8-diol **7** (30 g, 0.205 mol) in THF (100 mL). The mixture was stirred at room temperature for 2 h, at which time a large amount of white precipitates were formed. After the addition of *tert*-butyldimethylsilyl chloride (31.0 g, 0.205 mol) in THF (50 mL), the mixture was stirred vigorously at room temperature overnight. The reaction was quenched with small ice pieces and extracted with ether. The organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated in vacuum. The residue was chromatographed on silica gel eluting with ethyl acetate/hexane (12%) to get the desired product 8-(*tert*-butyldimethylsilyloxy)octan-1-ol **10** (35.3 g, 66%) as a colorless liquid. R_f = 0.5 (30% EtOAc−hexane). IR (neat) υ_{max}: 3350, 2931, 2858, 1466, 1253, 1099, 837, 775 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.64 (t, J = 6.4 Hz, 2H), 3.60 (t, J = 6.6 Hz, 2H), 1.60−1.47 (m, 4H), 1.38−1.28 (m, 8H), 0.90 (s, 9H), 0.04 (m, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 63.2, 62.6, 32.7, 32.6, 29.3, 25.9, 25.6, 18.3, −5.4 ppm; Mass (ESI-MS) m/z: 261 $[M + H]^+$; HRMS (ESI): Calcd for $C_{14}H_{33}O_2Si$ $[M + H]^+$ 261.22443, found 261.22426.

*8-(tert-Butyldimethylsilyloxy)octanal (**11**).* A mixture of PCC (3.10 g, 14.42 mmol) and Celite (3.10 g) was added to a solution of 8-(*tert*-butyldimethylsilyloxy)octan-1-ol **10** (2.5 g, 9.61 mmol) in CH_2Cl_2 (50 mL), followed by NaOAc (1.18 g, 14.42 mmol). The reaction mixture was stirred for 90 min at rt and diluted with diethyl ether (30 mL), the ethereal mixture was suction filtered, and the filter cake was washed with diethyl ether and EtOAc. After evaporation under vacuum, the residue was purified by flash column chromatography with ethyl acetate/hexane (10%) as eluent to afford 8-(*tert*-butyldimethylsilyloxy)octanal **11** (2.05 g, 82%) as a colorless liquid. R_f = 0.5 (10% EtOAc−hexane). IR (neat) υ_{max}: 2932, 2858, 1726, 1253, 1099, 772 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.76 (t, J = 1.8 Hz, 1H), 3.60 (t, J = 6.6 Hz, 2H), 2.42 (td, J = 7.4, 1.8 Hz, 2H), 1.67−1.60 (m, 2H), 1.54−1.47 (m, 2H), 1.37−1.29 (m, 6H), 0.89 (s, 9H), 0.04 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 202.7, 63.1, 43.8, 32.7, 29.1, 25.9, 25.5, 22.0, 18.3, −5.3 ppm; Mass (ESI-MS) m/z: 281 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{14}H_{31}O_2Si$ $[M + H]^+$ 259.20878, found 259.20874.

*(S)-1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-10-(tert-butyldimethylsilyloxy)-3-hydroxydecan-1-one (**5**).* A dry two-neck, round-bottom flask was charged under argon with a solution of (*S*)-1-(4-benzyl-2-thioxothiazolidin-3-yl)ethanone **12** (2.5 g, 9.96 mmol) in CH_2Cl_2 (30 mL). The solution was cooled to 0 °C, and $TiCl_4$ (1.3 mL, 11.95 mmol) was added dropwise. The thick yellow suspension was stirred for 10 min before *i*-Pr_2NEt (2 mL, 11.95 mmol) was added dropwise at 0 °C. The solution was stirred for 10 min at 0 °C and cooled to −78 °C, and a solution of freshly prepared aldehyde **11** (2.0 g, 7.96 mmol) in CH_2Cl_2 (10 mL) was added. The mixture was stirred for 10 min, and then the reaction was quenched with sat. aq. NH_4Cl. The mixture was warmed to rt., and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (2 × 30 mL), and the combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography with ethyl acetate/hexane (5%) as eluent to afford the major diastereomer **5** (2.82 g, 71%) as a yellow liquid; minor diastereomer. **5a** (0.45 g, 11%). R_f = 0.4 (20% EtOAc−hexane). **Major (5)**: $[\alpha]_D^{24}$ = +78.35 (c 1.46, $CHCl_3$); IR (neat) υ_{max}: 3456, 2930, 2856, 1688, 1341, 1257, 1163, 1089, 837, 775 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.38−7.33 (m, 2H), 7.31−7.267 (m, 3H), 5.43−5.38 (m, 1H), 4.19−4.10 (m, 1H), 3.65 (dd, J = 17.8, 2.2 Hz, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.41 (dd, J = 11.5, 7.2 Hz, 1H), 3.23 (dd, J = 13.2, 3.7 Hz, 1H), 3.12 (dd, J = 17.8, 9.5 Hz, 1H), 3.05 (dd, J = 13.1, 10.6 Hz, 1H), 2.90 (d, J = 11.6 Hz, 1H), 2.72 (d, J = 3.0 Hz, 1H), 1.62−1.55 (m, 3H), 1.55−1.44 (m, 3H), 1.39−1.29 (m, 6H), 0.90 (s, 9H), 0.05 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.3, 173.2, 136.3, 129.4, 128.9, 127.2, 68.3, 67.8, 63.2, 45.8, 36.8, 36.3, 32.8, 32.0, 29.5, 29.3, 25.9, 25.6, 25.5, 18.3, −3.6, −5.3 ppm; Mass (ESI-MS) m/z: 532 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{26}H_{43}O_3NNaS_2Si$ $[M + Na]^+$ 532.23458, found 532.23365. **Minor (5a)**: $[\alpha]_D^{24}$ = +48.04 (c 1.07, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37−7.33 (m, 2H), 7.31−7.27 (m, 3H), 5.44−5.38 (m, 1H), 4.08−4.02 (m, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.46 (dd, J = 17.6, 9.4 Hz, 1H), 3.41(dd, J = 10.9, 7.5 Hz, 1H), 3.33 (dd, J = 17.5, 2.5 Hz, 1H), 3.23 (dd, J = 13.2, 3.9 Hz, 1H), 3.05 (dd, J = 13.2, 10.4 Hz, 1H), 2.91 (d, J = 11.6 Hz, 1H), 1.65−1.42 (m, 4H), 1.40−1.27 (m, 8H), 0.90 (S, 9H), 0.05 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 201.3, 173.7, 136.3, 129.3, 128.8, 127.2, 68.3, 68.1, 63.2, 45.4, 36.7, 36.5, 32.7, 31.9, 29.4, 29.2, 25.9, 25.6, 25.4, 18.3, −5.3; Mass (ESI-MS) m/z: 532 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{26}H_{43}O_3NNaS_2Si$ $[M + Na]^+$ 532.23458, found 532.23355.

*(S)-1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-3,10-bis(tert-butyldimethylsilyloxy)decan-1-one (**13**).* 2,6-Lutidine (0.68 mL, 5.89 mmol) was added to a solution of secondary alcohol **5** (2 g, 3.92 mmol) in anhydrous CH_2Cl_2 (30 mL), and the mixture was stirred at 0 °C under N_2. After 15 min, TBSOTf (1.17 mL, 5.10 mmol) was added dropwise and the mixture was stirred at 0 °C for 5 min. The reaction was quenched with H_2O (8 mL), and the mixture was extracted with CH_2Cl_2 (2 × 30 mL). The organic extract was washed with brine (20 mL), dried (Na_2SO_4), filtered, and concentrated under reduced pressure. The residue was purified by column chromatography using ethyl acetate/hexane (3%) as eluent to give a yellow liquid **13** (2.3 g, 95.8%). R_f = 0.5 (5% EtOAc−hexane). $[\alpha]_D^{24}$ = +57.8 (c 1.38, $CHCl_3$); IR (neat) υ_{max}: 2930, 2856, 1699, 1255, 1097, 836, 772 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.38−7.32 (m, 2H), 7.32−7.27 (m, 3H), 5.29−5.23 (m, 1H), 4.36−4.29 (m, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.56 (dd, J = 16.7, 8.2 Hz, 1H), 3.34 (dd, J = 11.4, 7.1 Hz, 1H), 3.26 (dd, J = 13.1, 3.3 Hz, 1H), 3.14 (dd, J = 16.8, 3.6 Hz, 1H), 3.04 (dd, J = 13.0, 10.8 Hz, 1H), 2.88 (d, J = 11.5 Hz, 1H), 1.55−1.47 (m, 4H), 1.27−1.38 (m, 8H), 0.89 (s, 9H), 0.86 (s, 9H), 0.08 (s, 3H), 0.04 (s, 9H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.0, 172.4, 136.6, 129.4, 128.9, 127.2, 69.3, 68.6, 63.2, 45.8, 37.7, 36.5, 32.8, 32.2, 29.7, 29.4, 26.0, 25.8, 25.7, 24.9, 18.3, 18.0, −4.5, −5.3 ppm; Mass (ESI-MS) m/z: 646 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{32}H_{57}O_3NNaS_2Si_2$ $[M + Na]^+$ 646.32106, found 646.32150.

*(S)-Ethyl 7,14-Bis(tert-butyldimethylsilyloxy)-2-methyl-3,5-dioxotetradecanoate (**4**).* To a stirred suspension of NaH (57.7 mg, 1.44 mmol, 60% dispersion in mineral oil) in THF (4 mL) at 0 °C was added ethyl-2-methylacetoacetate **6** (0.2 mL, 1.44 mmol), and the resulting mixture was stirred for 10 min before *n*-BuLi (0.9 mL; 1.6 M in hexanes, 1.44 mmol) was added dropwise at 0 °C. The solution was stirred for 10 min at 0 °C and cooled to −10 °C, and a solution of compound **13** (300 mg, 0.48 mmol) in THF (3 mL) was added dropwise via cannula. Then, the reaction mixture was stirred at −10 °C for 10 min. The reaction was quenched by addition of sat. aq. NH_4Cl (5 mL) and allowed to warm to rt. The mixture was extracted with Et_2O (2 × 10 mL), and the combined organic extracts were washed with brine (10 mL), dried over Na_2SO_4, and concentrated in *vacuum*. Residual ethyl-2-methylacetoacetate was removed under high vacuum,

and the residue was purified by column chromatography using ethyl acetate/hexane (3%) as eluent to give a colorless liquid **4** (245 mg, 91%). R_f = 0.6 (5% EtOAc−hexane). IR (neat) υ_{max}: 2932, 2858, 1742, 1606, 1465, 1263, 1096, 836, 775 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$): δ 15.16 (bs, 1H, OH), 5.60 (s, 1H), 4.18 (q, *J* = 7.1 Hz, 2H), 4.12−4.02 (m, 1H), 3.59 (t, *J* = 6.6 Hz, 2H), 3.41−3.32 (m, 1H), 2.44−2.30 (m, 2H), 1.55−1.42 (m, 5H), 1.37 (d, *J* = 7.1 Hz, 3H), 1.35−1.22 (m, 12H), 0.89 (s, 9H), 0.85 (s, 9H), 0.04 (s, 9H), 0.03 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 193.3, 193.3, 189.4, 189.4, 170.7, 100.2, 100.0, 69.9, 69.8, 63.3, 61.3, 49.7, 49.6, 45.5, 37.8, 32.8, 29.7, 29.4, 26.0, 25.8, 25.7, 24.9, 18.4, 18.0, 14.1, 14.0, 13.8, −4.6, −4.6, −4.9, −5.3 ppm; Mass (ESI-MS) *m/z*: 581 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{29}H_{58}O_6NaSi_2$ $[M + Na]^+$ 581.36641, found 581.36623.

(S)-6-(2,9-Bis(tert-butyldimethylsilyloxy)nonyl)-4-hydroxy-3-methyl-2H-pyran-2-one (14). To a stirred solution of tricarbonyl **4** (100 mg, 0.178 mmol) in benzene (4 mL) was added DBU (0.161 mmol, 0.02 mL) dropwise, and the resulting solution was heated to 60 °C for 3 h. The reaction mixture was then cooled to 0 °C and neutralized by addition of 1 M HCl (1 mL). The mixture was extracted with EtOAc (3 × 10 mL), and the combined organic extracts were washed with brine (2 × 10 mL), dried (Na_2SO_4), and concentrated in *vacuo*. The resulting residue was purified by column chromatography using ethyl acetate/hexane (5%) as eluent to give α-pyrone **14** (40 mg, 44%) as a colorless liquid. R_f = 0.7 (40% EtOAc−hexane). $[\alpha]_D^{24}$ = +20.86 (*c* 0.35, $CHCl_3$); IR (neat) υ_{max}: 2930, 2857, 1675, 1585, 1412, 1254, 1056, 836, 773 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.95 (s, 1H), 4.11−4.04 (m, 1H), 3.69−3.59 (m, 2H), 2.58−2.47 (m, 2H), 1.95 (s, 3H), 1.54−1.39 (m, 4H), 1.38−1.22 (m, 8H), 0.90 (s, 9H), 0.83 (s, 9H), 0.07 (m, 6H), 0.01 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 167.7, 165.8, 160.6, 102.5, 98.8, 69.7, 63.5, 41.6, 37.2, 32.7, 29.5, 29.1, 26.0, 25.7, 25.6, 24.4, 18.4, 17.9, 8.2, −4.7, −5.0, −5.2, −5.25 ppm; Mass (ESI-MS) *m/z*: 535 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{27}H_{53}O_5Si_2$ $[M + H]^+$ 513.34260, found 513.34259.

(S)-6-(2,9-Dihydroxynonyl)-4-hydroxy-3-methyl-2H-pyran-2-one (1). To a solution of **14** (57 mg, 0.111 mmol) in dry MeOH (3 mL) under an argon atmosphere was added CSA (13 mg, 0.05 mmol). The mixture was stirred under argon for 1.5 h. The suspension was then quenched with solid $NaHCO_3$, filtered, and concentrated. The final mixture was chromatographed on a silica gel column with MeOH/$CHCl_3$ (7%) as eluent, and compound **1** (25 mg, 79%) was obtained as a white solid. mp 112−115 °C; R_f = 0.7 (15% MeOH−$CHCl_3$). $[\alpha]_D^{25}$ = +45.0 (*c* 0.1, MeOH); Lit. $[\alpha]_D^{25}$ = −44.0 (*c* 0.1, MeOH);[3] IR (KBr) υ_{max}: 3423, 2926, 2854, 1660, 1616, 1381, 1257, 1061, 827, 752 cm^{-1}; ^{1}H NMR (700 MHz, CD_3OD): δ 6.03 (s, 1H), 3.93−3.88 (m, 1H), 3.53 (t, *J* = 6.7 Hz, 2H), 2.61 (dd, *J* = 14.5, 4.2 Hz, 1H), 2.47 (dd, *J* = 14.5, 8.5 Hz, 1H), 1.84 (s, 3H), 1.54−1.43 (m, 4H), 1.40−1.27 (m, 8H) ppm; ^{13}C NMR (125 MHz, CD_3OD): δ 169.2, 168.4, 162.1, 103.2, 99.0, 70.0, 63.0, 42.6, 38.2, 33.6, 30.6, 30.5, 26.9, 26.6, 8.3 ppm; Mass (ESI-MS) *m/z*: 307 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{15}H_{24}O_5Na$ $[M + Na]^+$ 307.15160, found 307.15146.

(R)-1-((R)-4-Benzyl-2-thioxothiazolidin-3-yl)-10-(tert-butyldimethylsilyloxy)-3-hydroxydecan-1-one (9). A dry two-neck, round-bottom flask was charged under argon with a solution of (*R*)-1-(4-benzyl-2-thioxothiazolidin-3-yl)ethanone **15** (1.5 g, 5.97 mmol) in CH_2Cl_2 (30 mL). The solution was cooled to 0 °C, and $TiCl_4$ (0.78 mL, 7.17 mmol) was added dropwise. The thick yellow suspension was stirred for 10 min before *i*-Pr_2NEt (1.12 mL, 7.17 mmol) was added dropwise at 0 °C. The solution was stirred for 10 min at 0 °C and cooled to −78 °C, and a solution of freshly prepared aldehyde **11** (2.23 g, 4.78 mmol) in CH_2Cl_2 (10 mL) was added. The mixture was stirred for 10 min, and then the reaction was quenched with sat. aq. NH_4Cl. The mixture was warmed to rt, and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (2 × 30 mL), and the combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography with ethyl acetate/hexane (5%) as eluent to afford the major diastereomer **9** (1.71 g, 70%) as a yellow liquid, minor diastereomer **9a** (0.232 g, 9%). R_f = 0.4 (20% EtOAc−hexane). **Major (9)**: $[\alpha]_D^{24}$ = −80.72 (*c* 0.75, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.39−7.27 (m, 5H), 5.45−5.35 (m, 1H), 4.20−4.09 (m, 1H), 3.70−3.62 (m, 1H), 3.60 (t, *J* = 6.6 Hz, 2H), 3.41 (dd, *J* = 11.5, 7.1 Hz, 1H), 3.23 (dd, *J* = 13.1, 3.9 Hz, 1H), 3.12 (dd, *J* = 17.5, 9.4 Hz, 1H), 3.05 (dd, *J* = 10.7, 8.1 Hz, 1H), 2.90 (d, *J* = 11.6 Hz, 1H), 1.64−1.43 (m, 6H), 1.39−1.27 (m, 6H), 0.90 (s, 9H), 0.05 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.3, 173.2, 136.3, 129.4, 128.9, 127.2, 68.2, 67.7, 63.2, 45.8, 36.7, 36.3, 32.8, 32.0, 29.5, 29.3, 25.9, 25.7, 25.4, 18.3, −5.3 ppm; Mass (ESI-MS) *m/z*: 532 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{26}H_{43}O_3NNaS_2Si$ $[M + Na]^+$ 532.23458, found 532.23438. **Minor (9a)**: $[\alpha]_D^{24}$ = −57.01 (*c* 0.62, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37−7.33 (m, 2H), 7.31−7.27 (m, 3H), 5.44−5.38 (m, 1H), 4.08−4.02 (m, 1H), 3.60 (t, *J* = 6.7 Hz, 2H), 3.46 (dd, *J* = 17.5, 9.4 Hz, 1H), 3.43−3.38 (m, 1H), 3.33 (dd, *J* = 17.5, 2.5 Hz, 1H), 3.23 (dd, *J* = 13.2, 3.9 Hz, 1H), 3.12 (d, *J* = 4.0 Hz, 1H), 3.05 (dd, *J* = 13.2, 10.4 Hz, 1H), 2.91 (d, *J* = 11.6 Hz, 1H), 1.55−1.41 (m, 4H), 1.39−1.27 (m, 8H), 0.89 (s, 9H), 0.04 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.4, 173.8, 136.3, 129.4, 128.9, 127.2, 68.4, 68.2, 63.3, 45.5, 36.8, 36.6, 32.8, 32.0, 29.5, 29.3, 26.0, 25.7, 25.4, 18.3, −5.3 ppm; Mass (ESI-MS) *m/z*: 532 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{26}H_{43}O_3NNaS_2Si$ $[M + Na]^+$ 532.23458, found 532.23436.

(R)-1-((R)-4-Benzyl-2-thioxothiazolidin-3-yl)-3,10-bis(tert-butyldimethylsilyloxy)decan-1-one (16). 2,6-Lutidine (0.26 mL, 2.29 mmol) was added to a solution of alcohol **9** (900 mg, 1.76 mmol) in anhydrous CH_2Cl_2 (15 mL), and the mixture was stirred at 0 °C under N_2. After 15 min, TBSOTf (0.52 mL, 2.65 mmol) was added dropwise and the mixture was stirred at 0 °C for 5 min. The reaction was quenched with H_2O (8 mL), and the mixture was extracted with CH_2Cl_2 (2 × 20 mL). The organic extract was washed with brine (20 mL), dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by column chromatography using ethyl acetate/hexane (3%) as eluent to give a yellow liquid **16** (1.06 g, 96%); R_f = 0.5 (5% EtOAc−hexane). $[\alpha]_D^{24}$ = −105.60 (*c* 0.83, $CHCl_3$; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.38−7.27 (m, 5H), 5.31−5.21 (m, 1H), 4.38−4.28 (m, 1H), 3.60 (t, *J* = 6.6 Hz, 2H), 3.53 (d, *J* = 8.2 Hz, 1H), 3.34 (dd, *J* = 11.4, 7.1 Hz, 1H), 3.26 (dd, *J* = 13.2, 3.5 Hz, 1H), 3.14 (dd, *J* = 16.8, 3.7 Hz, 1H), 3.04 (dd, *J* = 13.0, 10.8 Hz, 1H), 2.88 (d, *J* = 11.5 Hz, 1H), 1.58−1.45 (m, 4H), 1.37−1.28 (m, 8H), 0.90 (s, 9H), 0.85 (s, 9H), 0.09 (s, 3H), 0.05 (s, 6H), 0.02 (s, 3H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.0, 172.4, 136.6, 129.4, 128.9, 127.2, 69.3, 68.7, 63.3, 45.8, 37.7, 36.5, 32.8, 32.2, 29.7, 29.4, 26.0, 25.8, 25.7, 25.7, 24.9, 18.3, 18.0, −3.0, −4.4, −4.7, −5.3 ppm; Mass (ESI-MS) *m/z*: 646 $[M + Na]^+$; HRMS (ESI): Calcd for $C_{32}H_{57}O_3NNaS_2Si_2$ $[M + Na]^+$ 646.32106, found 646.32146.

(3S,5R)-1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-5,12-bis(tert-butyldimethylsilyloxy)-3-hydroxydodecan-1-one (17). A 25 wt % solution of DIBAL-H in toluene (1.87 mL) was added slowly over 5 min to a stirred solution of compound **16** (700 mg, 1.12 mmol) in anhydrous CH_2Cl_2 (10 mL) at −78 °C, and the mixture was stirred at −78 °C for 10 min. When the reaction was completed, sat. aq. sodium potassium tartrate solution (10 mL) was added and the mixture was stirred vigorously at rt for an additional 1 h and then extracted with CH_2Cl_2 (3 × 30 mL). The combined organic layer was washed with brine (30 mL), dried over Na_2SO_4, and concentrated under reduced pressure to give a crude aldehyde, which was used in the next reaction without further purification; R_f = 0.7 (10% EtOAc−hexane).

A dry two-neck, round-bottom flask was charged under argon with a solution of (*S*)-1-(4-benzyl-2-thioxothiazolidin-3-yl)ethanone **12** (300 mg, 1.19 mmol) in CH_2Cl_2 (10 mL). The solution was cooled to 0 °C, and $TiCl_4$ (0.15 mL, 1.43 mmol) was added dropwise. The thick yellow suspension was stirred for 10 min before *i*-Pr_2NEt (0.24 mL, 1.43 mmol) was added dropwise at 0 °C. The solution was stirred for 10 min at 0 °C and cooled to −78 °C, and a solution of freshly prepared aldehyde (0.95 mmol) in CH_2Cl_2 (5 mL) was added. The mixture was stirred for 10 min, and then the reaction was quenched with sat. aq. NH_4Cl. The mixture was warmed to rt, and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (2 × 20 mL), and the combined organic layer was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography with ethyl acetate/hexane (5%) as eluent to afford the major diastereomer **17** (415 mg, 65%) as a yellow liquid, minor diastereomer **17a** (50 mg, 8%).

R_f = 0.4 (10% EtOAc−hexane). **Major (17)**: $[\alpha]_D^{24}$ = +70.82 (*c* 0.83, $CHCl_3$); IR (neat) υ_{max}: 3508, 2930, 2856, 1687, 1465, 1255, 1162, 1097, 835, 774 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ 7.38−7.27 (m, 5H), 5.44−5.33 (m, 1H), 4.60−4.49 (m, 1H), 4.05−3.94 (m, 1H), 3.71 (s, 1H), 3.60 (t, *J* = 6.6 Hz, 2H), 3.47−3.20 (m, 4H), 3.04 (dd, *J* = 13.0, 10.7 Hz, 1H), 2.89 (d, *J* = 11.5 Hz, 1H), 1.79−1.43 (m, 6H), 1.36−1.23 (m, 8H), 0.90 (s, 18H), 0.11 (s, 3H), 0.08 (s, 3H), 0.05 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.2, 172.3, 136.5, 129.4, 128.8, 127.2, 71.0, 68.5, 64.6, 63.2, 46.7, 41.1, 36.6, 36.5, 32.8, 32.0, 29.7, 29.4, 25.9, 25.8, 25.7, 25.5, 18.3, 17.9, −4.6, −4.7, −5.3 ppm; Mass (ESI-MS) *m/z*: 690 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{34}H_{61}O_4NNaS_2Si_2$ [M + Na]$^+$ 690.34727, found 690.34766. **Minor (17a)**: $[\alpha]_D^{24}$ = +32.03 (*c* 0.6, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$): δ 7.38−7.27 (m, 5H), 5.44−5.33 (m, 1H), 4.30−4.16 (m, 1H), 4.01−3.88 (m, 1H), 3.60 (t, *J* = 6.6 Hz, 2H), 3.53 (d, *J* = 2.5 Hz, 1H), 3.48−3.33 (m, 3H), 3.24 (dd, *J* = 13.2, 3.6 Hz, 1H), 3.04 (dd, *J* = 13.0, 10.7 Hz, 1H), 2.89 (d, *J* = 11.6 Hz, 1H), 1.79−1.42 (m, 6H), 1.38−1.22 (m, 8H), 0.89 (s, 18H), 0.09 (s, 3H), 0.08 (s, 3H), 0.05 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 201.1, 172.9, 136.3, 129.3, 128.8, 127.1, 71.3, 68.3, 66.8, 63.1, 45.7, 42.8, 37.3, 36.6, 32.7, 31.9, 29.7, 29.3, 25.9, 25.8, 25.6, 24.6, 18.3, 17.9, −4.3, −4.7, −5.3 ppm; Mass (ESI-MS) *m/z*: 690 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{34}H_{61}O_4NNaS_2Si_2$ [M + Na]$^+$ 690.34727, found 690.34791.

*1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-2-((4S,6R)-6-(7-hydroxyheptyl)-2,2-dimethyl-1,3-dioxan-4-yl)ethanone (**18**).* To a solution of compound **17** (40 mg, 0.06 mmol) in 2 mL of THF was added 0.10 mL of 70% HF/pyridine solution. The solution was allowed to stand at rt for 4 h, then the reaction was quenched by addition of saturated $NaHCO_3$ solution. After the layers were separated, the aqueous layer was extracted with CH_2Cl_2 (2 × 5 mL). The combined organic layers were dried over Na_2SO_4 and evaporated. Which was used in the next reaction without further purification; R_f = 0.6 (EtOAc).

To a solution of triol (0.06 mmol) in 1 mL of CH_2Cl_2 was added 3 drops of 2-methoxypropene and a catalytic amount of CSA at 0 °C. The solution was stirred for 10 min at 0 °C, and quenched by addition of saturated $NaHCO_3$ solution. The mixture was extracted with CH_2Cl_2, and the combined organic layers were dried over Na_2SO_4 and evaporated. The residue was subjected to column chromatography using ethyl acetate/hexane (30%) as eluent to provide **18** as a yellow liquid (21 mg, 73%). R_f = 0.5 (50% EtOAc−hexane). $[\alpha]_D^{25}$ = +54.0 (*c* 0.25, $CHCl_3$), IR (neat) υ_{max}: 3418, 2929, 1694, 1261, 1217, 1163, 1042, 770 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.38−7.32 (m, 2H), 7.31−7.27 (m, 3H), 5.38−5.32 (m, 1H), 4.47−4.40 (m, 1H), 3.81−3.74 (m, 1H), 3.64 (t, *J* = 6.6 Hz, 2H), 3.45 (dd, *J* = 17.5, 8.6 Hz, 1H), 3.41−3.34 (m, 2H), 3.23 (dd, *J* = 13.2, 3.8 Hz, 1H), 3.03 (dd, *J* = 13.2, 10.7 Hz, 1H), 2.87 (d, *J* = 11.5 Hz, 1H), 1.70 (t, *J* = 7.8 Hz, 2H), 1.40 (s, 3H), 1.37−1.24 (m, 15H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 201.3, 170.9, 136.5, 129.5, 128.9, 127.2, 100.6, 68.5, 66.6, 63.0, 44.7, 38.1, 36.6, 35.8, 32.8, 32.0, 29.5, 29.3, 25.7, 25.3, 24.7, 24.6; Mass (ESI-MS) *m/z*: 502 [M + Na]$^+$.

*(3S,5R)-1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-3,5,12-tris(tert-butyldimethylsilyloxy)dodecan-1-one (**19**).* 2,6-Lutidine (0.06 mL, 0.48 mmol) was added to a solution of alcohol **17** (216 mg, 0.32 mmol) in anhydrous CH_2Cl_2 (5 mL), and the mixture was stirred at 0 °C under N_2. After 15 min, TBSOTf (0.1 mL, 0.42 mmol) was added dropwise and the mixture was stirred at 0 °C for 5 min. The reaction was quenched with H_2O (5 mL), and the mixture was extracted with CH_2Cl_2 (2 × 10 mL). The organic extract was washed with brine (10 mL), dried (Na_2SO_4), filtered, and concentrated under reduced pressure. The residue was purified by column chromatography using ethyl acetate/hexane (3%) as eluent to give a yellow liquid **19** (235 mg, 93%); R_f = 0.5 (5% EtOAc−hexane). $[\alpha]_D^{24}$ = +68.79 (*c* 0.55, $CHCl_3$); IR (neat) υ_{max}: 2830, 2856, 1700, 1466, 1255, 1099, 835, 775 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 7.37−7.32 (m, 2H), 7.31−7.27 (m, 3H), 5.29−5.21 (m, 1H), 4.40−4.32 (m, 1H), 3.78−3.69 (m, 1H), 3.60 (t, *J* = 6.7 Hz, 2H), 3.33 (dd, *J* = 11.4, 7.0 Hz, 1H), 3.29−3.17 (m, 2H), 3.04 (dd, *J* = 13.1, 10.8 Hz, 1H), 2.87 (d, *J* = 11.5 Hz, 1H), 1.76−1.58 (m, 2H), 1.54−1.38 (m, 4H), 1.37−1.24 (m, 8H), 0.90 (s, 9H), 0.89 (s, 9H), 0.85 (s, 9H), 0.10 (s, 3H), 0.08 (s, 3H), 0.07 (s, 3H), 0.06 (s, 3H), 0.05 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.0, 171.9, 136.6, 129.4, 128.9, 127.2, 70.0, 68.7, 67.4, 63.3, 46.9, 45.8, 37.8, 36.5, 32.8, 32.1, 29.8, 29.4, 25.9, 25.8, 25.8, 25.0, 18.3, 18.1, 18.0, −4.1, −4.2, −4.2, −4.3, −5.3 ppm; Mass (ESI-MS) *m/z*: 804 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{40}H_{75}O_4NNaS_2Si_3$ [M + Na]$^+$ 804.43375, found 804.43339.

*(7S,9R)-Ethyl 7,9,16-Tris(tert-butyldimethylsilyloxy)-2-methyl-3,5-dioxohexadecanoate (**8**).* To a stirred suspension of NaH (28 mg, 0.70 mmol, 60% w/w) in THF (3 mL) at 0 °C was added ethyl-2-methylacetoacetate **6** (0.1 mL, 0.70 mmol); the resulting mixture was stirred at 0 °C for 10 min before *n*-BuLi (0.43 mL, 1.6 M in hexanes, 0.70 mmol) was added dropwise at 0 °C. The solution was stirred for 10 min at 0 °C and cooled to −10 °C, and a solution of **19** (183 mg, 0.23 mmol) in THF (3 mL) was added dropwise via cannula. Then, the reaction mixture was stirred at −10 °C for 10 min. The reaction was quenched by addition of sat. aq. NH_4Cl (5 mL) and allowed to warm to rt. The mixture was extracted with Et_2O (2 × 10 mL), and the combined organic extracts were washed with brine (10 mL), dried (Na_2SO_4), and concentrated in *vacuo*. Residual ethyl-2-methylacetoacetate was removed under high vacuum, and the residue was purified by column chromatography using ethyl acetate/hexane (3%) as eluent to give a colorless liquid **8** (142 mg, 84%); R_f = 0.6 (5% EtOAc−hexane). IR (neat) υ_{max}: 3441, 2932, 2857, 1741, 1607, 1253, 1096, 835, 771 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 15.14 (bs, 1H, OH), 5.60 (d, *J* = 1.2 Hz, 1H), 4.22−4.10 (m, 2H), 3.74−3.68 (m, 1H), 3.59 (t, *J* = 6.6 Hz, 2H), 3.36 (qd, *J* = 7.2, 1.2 Hz, 1H), 2.53−2.44 (m, 1H), 2.39−2.27 (m, 1H), 1.68−1.56 (m, 2H), 1.54−1.47 (m, 2H), 1.46−1.40 (m, 1H), 1.38 (dd, *J* = 7.1, 1.2 Hz, 3H), 1.33−1.24 (m, 14H), 0.89 (s, 9H), 0.87 (s, 9H), 0.84 (s, 9H), 0.05 (s, 6H), 0.04 (s, 12H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 193.7, 193.6, 188.8, 188.7, 170.7, 100.1, 99.9, 70.0, 69.3, 68.1, 68.0, 63.3, 61.3, 49.7, 49.6, 46.3, 45.8, 45.5, 37.7, 37.7, 32.8, 29.7, 29.5, 26.0, 25.9, 25.8, 25.0, 18.4, 18.0, 17.9, 14.1, 14.0, 13.9, −4.0, −4.3, −4.4, −4.4, −4.6, −5.3; Mass (ESI-MS) *m/z*: 739 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{37}H_{76}O_7NaSi_3$ [M + Na]$^+$ 739.47911, found 739.47994.

*4-Hydroxy-3-methyl-6-((2S,4R)-2,4,11-tris(tert-butyldimethylsilyloxy)undecyl)-2H-pyran-2-one (**20**).* To a stirred solution of tricarbonyl **8** (50 mg, 0.07 mmol) in benzene (3 mL) was added DBU (0.01 mL, 0.06 mmol) dropwise, and the resulting solution was heated to 60 °C for 3 h. The reaction mixture was then cooled to 0 °C and quenched by addition of 1 M HCl (2 mL). The mixture was extracted with EtOAc (3 × 10 mL), and the combined organic extracts were washed with brine (2 × 20 mL), dried (Na_2SO_4), and concentrated in *vacuo*. The resulting residue was purified by column chromatography using ethyl acetate/hexane (5%) as eluent to give α-pyrone **20** (13 mg, 25%) as a colorless liquid. R_f = 0.7 (40% EtOAc−hexane). $[\alpha]_D^{24}$ = +5.55 (*c* 1.0, $CHCl_3$); IR (neat) υ_{max}: 2931, 2857, 1675, 1586, 1412, 1255, 1056, 835, 774 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): δ 6.03 (s, 1H), 4.11−4.04 (m, 1H), 3.75−3.69 (m, 1H), 3.60 (t, *J* = 6.4 Hz, 2H), 2.65 (dd, *J* = 14.1, 5.0 Hz, 1H), 2.50 (dd, *J* = 14.2, 7.4 Hz, 1H), 1.95 (s, 3H), 1.72−1.56 (m, 2H), 1.55−1.39 (m, 4H), 1.36−1.22 (m, 8H), 0.89 (s, 9H), 0.85 (s, 9H), 0.82 (s, 9H), 0.05 (s, 6H), 0.03 (s, 6H), 0.02 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.9, 164.8, 160.4, 102.1, 98.8, 70.0, 68.2, 63.5, 45.7, 42.6, 37.7, 32.8, 29.7, 29.4, 26.0, 25.9, 25.7, 25.7, 25.0, 18.4, 18.0, 17.9, 8.1, −4.0, −4.2, −4.5, −4.6, −5.2 ppm; Mass (ESI-MS) *m/z*: 671 [M + H]$^+$; HRMS (ESI): Calcd for $C_{35}H_{71}O_6Si_3$ [M + H]$^+$ 671.45530, found 671.45591.

*4-Hydroxy-3-methyl-6-((2S,4R)-2,4,11-trihydroxyundecyl)-2H-pyran-2-one (**2**).* To a solution of **20** (10 mg, 0.015 mmol) in dry MeOH (2 mL) under an argon atmosphere was added 10-camphorsulfonic acid (CSA) (1.7 mg, 0.007 mmol). The mixture was stirred under argon for 1.5 h. The suspension was then quenched with solid $NaHCO_3$, filtered, and concentrated. The final mixture was chromatographed on a silica gel column with MeOH/$CHCl_3$ (10%) as eluent, and final product **2** (3.7 mg, 75%) was obtained as a white solid. mp 120−122 °C; R_f = 0.5 (20% MeOH−$CHCl_3$). $[\alpha]_D^{25}$ = +10.00 (*c* 0.05, MeOH), Lit.[3] $[\alpha]_D^{25}$ = +20.0 (*c* 0.05, MeOH); IR (KBr) υ_{max}: 3430, 2926, 2854, 1659, 1615, 1555, 1407, 1258, 1059, 824, 754 cm^{-1}; ^1H NMR (700 MHz, CD_3OD): δ 6.03 (s, 1H), 4.65 (bs, 1H, OH), 4.21−4.15 (m, 1H), 3.81−3.76 (m, 1H), 3.53 (t, J = 6.7 Hz, 2H), 2.60 (dd, J = 14.5, 5.0 Hz, 1H), 2.52 (dd, J = 14.5, 8.3 Hz, 1H), 1.84 (s, 3H), 1.57−1.48 (m, 4H), 1.46−1.40 (m, 2H), 1.38−1.26 (m, 8H) ppm; ^{13}C NMR (125 MHz, CD_3OD): δ 169.3, 168.8, 161.9, 103.5, 99.1, 69.0, 67.2, 63.0, 45.4, 43.3, 39.2, 33.7, 30.8, 30.6, 26.9, 26.8, 8.3 ppm; Mass (ESI-MS) m/z: 329 [M + H]$^+$; HRMS (ESI): Calcd for $C_{17}H_{29}O_6$ [M + H]$^+$ 329.19587, found 329.19655.

(3R,5R)-1-((R)-4-Benzyl-2-thioxothiazolidin-3-yl)-5,12-bis(tert-butyldimethylsilyloxy)-3-hydroxydodecan-1-one (**22**). Compound **22** was synthesized according to the procedure followed for compound **17** and was obtained in 77% yield. Major diastereomer **22** (365 mg, 68%) as a yellow liquid, minor diastereomer **22a** (51 mg, 9%). R_f = 0.4 (10% EtOAc−hexane). **Major (22)**: $[\alpha]_D^{24}$ = −98.56 (c 0.66, $CHCl_3$): ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37−7.32 (m, 2H), 7.31−7.27 (m, 3H), 5.43−5.37 (m, 1H), 4.38−4.31 (m, 1H), 3.98−3.92 (m, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.52 (dd, J = 17.6, 3.1 Hz, 1H), 3.42−3.36 (m, 2H), 3.31−3.20 (m, 2H), 3.07−3.01 (m, 1H), 2.89 (d, J = 11.5 Hz, 1H), 1.75−1.63 (m, 2H), 1.56−1.46 (m, 4H), 1.36−1.24 (m, 8H), 0.90 (s, 18H), 0.11 (s, 3H), 0.09 (s, 3H), 0.05 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.2, 172.4, 136.4, 129.4, 128.9, 127.2, 71.9, 68.3, 66.7, 63.2, 46.2, 42.5, 37.5, 36.7, 32.8, 32.0, 29.8, 29.4, 26.0, 25.8, 25.7, 24.7, 18.3, 18.0, −4.1, −4.6, −5.3 ppm; Mass (ESI-MS) m/z: 690 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{34}H_{62}O_4NS_2Si_2$ [M + H]$^+$ 668.36533, found 668.36579. **Minor (22a)**: $[\alpha]_D^{24}$ = −78.30 (c 0.45, $CHCl_3$): ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37−7.32 (m, 2H), 7.31−7.27 (m, 3H), 5.44−5.38 (m, 1H), 4.10−4.34 (m, 1H), 4.02−3.96 (m, 1H), 3.65 (d, J = 2.3 Hz, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.47 (dd, J = 17.2, 8.6 Hz, 1H), 3.42−3.34 (m, 2H), 3.24 (dd, J = 13.2, 3.7 Hz, 1H), 3.04 (dd, J = 13.2, 10.6 Hz, 1H), 2.89 (d, J = 11.6 Hz, 1H), 1.72−1.65 (m, 1H), 1.58−1.47 (m, 5H), 1.35−1.24 (m, 8H), 0.90 (s, 9H), 0.89 (s, 9H), 0.11 (s, 3H), 0.08 (s, 3H), 0.05 (s, 6H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.2, 172.9, 136.4, 129.4, 128.9, 127.2, 70.2, 68.3, 65.0, 63.3, 46.4, 41.9, 37.0, 36.7, 32.8, 31.8, 29.8, 29.4, 26.0, 25.9, 25.7, 25.2, 18.3, 18.0, −4.5, −4.7, −5.3 ppm; Mass (ESI-MS) m/z: 690 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{34}H_{61}O_4NNaS_2Si_2$ [M + Na]$^+$ 690.34727, found 690.34625.

1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-2-((4R,6R)-6-(7-hydroxyheptyl)-2,2-dimethyl-1,3-dioxan-4-yl)ethanone (**23**). Compound **23** was synthesized according to the procedure followed for compound **18** and was obtained as a yellow liquid (20 mg, 80%). R_f = 0.5 (50% EtOAc−hexane). $[\alpha]_D^{25}$ = −66.0 (c 0.65, $CHCl_3$), ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.36−7.32 (m, 2H), 7.30−7.27 (m, 3H), 5.38−5.33 (m, 1H), 4.52−4.45 (m, 1H), 3.89−3.82 (m, 1H), 3.63 (t, J = 6.6 Hz, 2H), 3.44−3.31 (m, 3H), 3.22 (dd, J = 13.2, 3.8 Hz, 1H), 3.03 (dd, J = 13.2, 10.7 Hz, 1H), 2.87 (d, J = 11.5 Hz, 1H), 1.62−1.49 (m, 3H), 1.48 (s, 3H), 1.41−1.20 (m, 14H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 201.2, 171.1, 136.5, 129.4, 128.9, 127.2, 98.7, 68.4, 65.5, 63.0, 45.4, 36.6, 36.3, 32.7, 32.1, 30.2, 29.5, 29.3, 25.6, 24.8, 19.7; Mass (ESI-MS) m/z: 502 [M + Na]$^+$.

(3R,5R)-1-((S)-4-Benzyl-2-thioxothiazolidin-3-yl)-3,5,12-tris(tert-butyldimethylsilyloxy)dodecan-1-one (**24**). Compound **24** was synthesized according to the procedure followed for compound **19** and was obtained as a yellow liquid (247 mg, 95%). $[\alpha]_D^{24}$ = −127.40 (c 0.28, $CHCl_3$): ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.40−7.27 (m, 5H), 5.31−5.20 (m, 1H), 4.48−4.37 (m, 1H), 3.78−3.67 (m, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.53 (dd, J = 16.6, 8.0 Hz, 1H), 3.40−3.19 (m, 3H), 3.04 (t, J = 11.8 Hz, 1H), 2.88 (d, J = 11.6 Hz, 1H), 1.80−1.40 (m, 6H), 1.39−1.22 (m, 8H), 0.90 (s, 18H), 0.86 (s, 9H), 0.09 (s, 3H), 0.05 (s, 15H) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ 201.0, 172.2, 136.6, 129.4, 128.9, 127.2, 69.4, 68.7, 66.9, 63.3, 46.2, 45.1, 37.2, 36.4, 32.9, 32.2, 29.9, 29.5, 26.0, 25.9, 25.8, 25.0, 18.4, 18.0, 17.9, −4.3, −4.6, −5.2 ppm; Mass (ESI-MS) m/z: 804 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{40}H_{75}O_4NNaS_2Si_3$ [M + Na]$^+$ 804.43375, found 804.43250.

(7R,9R)-Ethyl 7,9,16-Tris(tert-butyldimethylsilyloxy)-2-methyl-3,5-dioxohexadecanoate (**25**). Compound **25** was synthesized according to the procedure followed for compound **8** and was obtained as a colorless liquid (212 mg, 82%). IR (neat) υ_{max}: 2931, 2857, 1742, 1620, 1466, 1253, 1097, 835, 772 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 15.14 (bs, 1H, OH), 5.60 (d, J = 2.0 Hz, 1H), 4.24−4.14 (m, 2H), 3.76−3.66 (m, 1H), 3.60 (t, J = 6.6 Hz, 2H), 3.37 (qd, J = 7.2, 2.2 Hz, 1H), 2.54−2.46 (m, 1H), 2.34−2.28 (m, 1H), 1.73−1.64 (m, 1H), 1.62−1.47 (m, 6H), 1.38 (dd, J = 7.2, 1.3 Hz, 3H), 1.35−1.22 (m, 12H), 0.89 (s, 18H), 0.85 (s, 9H), 0.06 (s, 6H), 0.05 (s, 6H), 0.04 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 193.6, 193.5, 188.9, 170.7, 100.2, 100.1, 69.3, 67.4, 63.3, 61.3, 49.8, 49.7, 45.6, 45.2, 37.4, 32.9, 29.8, 29.4, 26.0, 25.9, 25.8, 25.0, 18.4, 18.0, 17.9, 14.1, 14.0, 13.9, −4.2, −4.4, −4.6, −4.9, −5.3 ppm; Mass (ESI-MS) m/z: 739 [M + Na]$^+$; HRMS (ESI): Calcd for $C_{37}H_{76}O_7NaSi_3$ [M + Na]$^+$ 739.47911, found 739.47869.

4-Hydroxy-3-methyl-6-((2R,4R)-2,4,11-tris(tert-butyldimethylsilyloxy)undecyl)-2H-pyran-2-one (**26**). Compound **26** was synthesized according to the procedure followed for compound **20** and was obtained as a colorless liquid (13 mg, 27%). $[\alpha]_D^{30}$ = −44.51 (c 0.7, $CHCl_3$); IR (neat) υ_{max}: 2932, 2850, 1657, 1413, 1254, 1075, 834, 770 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.94 (s, 1H), 4.17−4.10 (m, 1H), 3.80−3.73 (m, 1H), 3.61 (t, J = 6.6 Hz, 2H), 2.65 (dd, J = 14.1, 4.6 Hz, 1H), 2.50 (dd, J = 14.1, 7.6 Hz, 1H), 1.95 (s, 3H), 1.72−1.55 (m, 4H), 1.55−1.35 (m, 2H), 1.34−1.20 (m, 8H), 0.90 (s, 9H), 0.88 (s, 9H), 0.84 (s, 9H), 0.07 (s, 3H), 0.06 (s, 6H), 0.04 (s, 3H), 0.02 (s, 6H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 166.3, 164.0, 160.5, 101.8, 98.8, 69.1, 67.4, 63.5, 44.8, 42.1, 37.2, 32.8, 29.7, 29.4, 26.0, 25.9, 25.8, 25.7, 24.9, 18.4, 18.0, 17.9, 8.1, −4.3, −4.3, −4.6, −4.9, −5.2 ppm; Mass (ESI-MS) m/z: 671 [M + H]$^+$; HRMS (ESI): Calcd for $C_{35}H_{71}O_6Si_3$ [M + H]$^+$ 671.45530, found 671.45585.

4-Hydroxy-3-methyl-6-((2R,4R)-2,4,11-trihydroxyundecyl)-2H-pyran-2-one (**21**). Compound **21** was synthesized according to the procedure followed for compound **2** and was obtained as white solid (5.1 mg, 80%). mp 142−144 °C; R_f = 0.5 (20% MeOH−$CHCl_3$). $[\alpha]_D^{25}$ = −20.87 (c 0.115, MeOH), IR (KBr) υ_{max}: 3404, 2924, 1732, 1654, 1557, 1391, 1248, 1063, 832, 761 cm^{-1}; ^{1}H NMR (700 MHz, CD_3OD): δ 6.05 (s, 1H), 4.65 (bs, 1H, OH), 4.14−4.08 (m, 1H), 3.78−3.73 (m, 1H), 3.53 (t, J = 6.7 Hz, 2H), 2.66 (dd, J = 14.5, 4.2 Hz, 1H), 2.51 (dd, J = 14.5, 8.3 Hz, 1H), 1.84 (s, 3H), 1.63−1.59 (m, 2H), 1.54−1.38 (m, 4H), 1.37−1.27 (m, 8H) ppm; ^{13}C NMR (125 MHz, CD_3OD): δ 169.2, 168.1, 161.8, 103.3, 99.2, 70.9, 68.8, 63.0, 44.7, 42.5, 38.5, 33.6, 30.8, 30.6, 26.9, 26.4, 8.3 ppm; Mass (ESI-MS) m/z: 329 [M + H]$^+$; HRMS (ESI): Calcd for $C_{17}H_{28}O_6Na$ [M + Na]$^+$ 351.17781, found 351.17752.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Copies of ^{1}H and ^{13}C NMR spectra for all new compounds; HRESIMS, HSQC, and HMBC spectra; and spectra comparisons. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interests.

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(7) The ratio was determined based on the yield of the isolated products after column chromatography. The products **5** and **5a** were characterized based on ^{1}H NMR analytical data. The major *syn* product **5** showed chemical shift signals for the α-protons at δ 3.65 (dd, J = 17.8, 2.2 Hz) for the less shielded proton and at δ 3.12 (dd, J = 17.8, 9.5 Hz) for the more shielded proton. The minor *anti* product **5a** gave chemical shift signals for the α-protons at δ 3.46 (dd, J = 17.6, 9.4 Hz) for the less shielded proton and at δ 3.33 (dd, J = 17.5, 2.5 Hz) for the more shielded proton. These data were comparable with the known *syn* and *anti* products whose structures were earlier determined by X-ray crystallographic analysis. See ref 6e. The data were also comparable with refs 6c and 6d, wherein similar *syn* and *anti* products were synthesized.

(8) Keto and enol forms were observed by ^{1}H NMR spectroscopy. The enolic hydroxyl group shows a peak at δ 15.1 ppm as a broad singlet and the olefinic CH proton shows a peak at δ 5.60 ppm as a singlet.

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