134. Asymmetric Total Synthesis of (11*R*,12*S*,13*S*,9*Z*,15*Z*)-9,12,13-Trihydroxyoctadeca-9,15-dienoic Acid, a Self-defensive Agent Against Rice-Blast Disease

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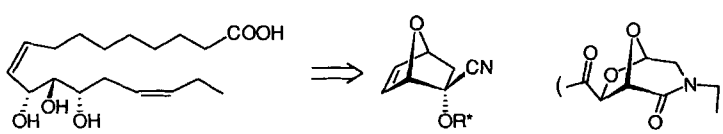
The *Diels-Alder* adduct of furan and 1-cyanovinyl (1′*R*)-camphanate was converted into methyl [(*tert*-butyl)-dimethylsilyl 5-deoxy-2,3-*O*-isopropylidene-β-L-*ribo*-hexofuranosid]uronate ((+)-**4**). Reduction with diisobutylaluminium hydride gave the corresponding aldehyde which was condensed with the ylide derived from triphenyl-(propyl)phosphonium bromide to give (1*R*,2*S*,3*S*,4*S*)-1-[(*tert*-butyl)dimethylsilyloxy]tetrahydro-2,3-(isopropylidenedioxy)-4-[(*Z*)-pent-2′-enyl]furan ((+)-**7**). Removal of the silyl protective group gave a mixture of the corresponding furanose that underwent *Wittig* reaction with the ylide derived from [8-(methoxycarbonyl)-octyl]triphenylphosphonium bromide to yield methyl (11*R*,12*S*,13*S*,9*Z*,15*Z*)-13-hydroxy-11,12-(isopropylidenedioxy)octadeca-9,15-dienoate ((−)-**9**). Acidic hydrolysis, then saponification afforded (11*R*,12*S*,13*S*,9*Z*,15*Z*)-11,12,13-trihydroxyoctadeca-9,15-dienoic acid (**1**).

Oxygenated metabolites of unsaturated fatty acids play important roles in animals and plants [1]. Several oxygenated C_{18} fatty acids were isolated from rice plants *Fukuyuki* suffering from rice-blast disease caused by the fungus *Pyricularia oryzae*, among them (11*R*,12*S*,13*S*,9*Z*,15*Z*)-trihydroxyoctadeca-9,15-dienoic acid (**1**) which is believed to be an endogenous fungicide in the rice variety resistant to the fungus [2]. In an effort to establish the structure of **1**, *Kato et al.* [2a] derived **1** from α-linoleic acid. More recently, *Yadav* and *Chander* [3] proposed a stereoselective synthesis of **1** starting from D-ribose [4], and *Wu* and *Wu* derived **1** from D-xylose [5]. We report here an alternative synthesis of **1** based on the 'naked sugar' technology [6] (*Scheme 1*).

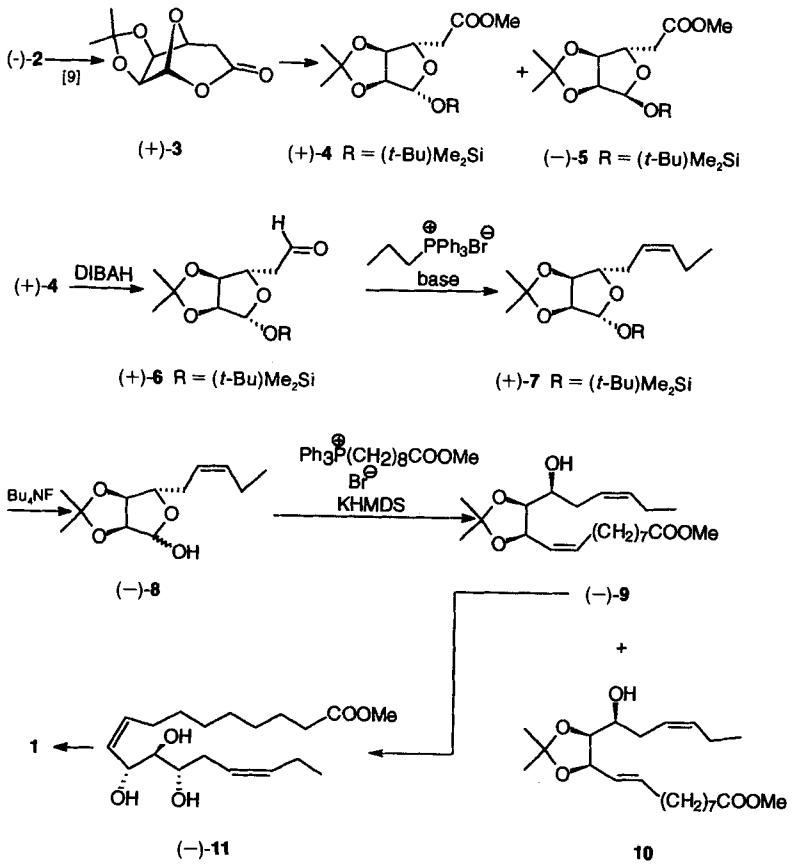
Scheme 1



1 (−)-**2** R* = (1*R*)-camphanoyl or SADO(Et) SADO(Et)

The optically pure *Diels-Alder* adduct (−)-**2** of furan and 1-cyanovinyl (1*R*)-camphanate [7] or 1-cyanovinyl (1*S*,5*R*,7*S*)-3-ethyl-2-oxo-3-aza-6,8-dioxabicyclo[3.2.1]octane-7-carboxylate (SADO(Et)) [8] was converted into uronolactone (+)-**3** (58% overall yield, 3 steps; *Scheme 2*) [9]. Methanolysis of (+)-**3** in the presence of K_2CO_3 afforded a mixture of the corresponding anomeric furanoses that was silylated with (*t*-Bu)Me_2SiCl (pyridine, 4-(dimethylamino)pyridine) to give 61% of β-L-furanoside (+)-**4** and 32% of

Scheme 2



α-L-furanoside (−)-**5** after separation und purification by flash column chromatography (FC) on silica gel. Reduction of (+)-**4** with 1.12 equiv. of diisobutylaluminium hydride (DIBAH; 1M in toluene) in CH_2Cl_2 (−78°) gave the corresponding aldehyde (+)-**6** (76%) whose reaction with the ylide prepared from triphenyl(propyl)phosphonium bromide and BuLi led to a 6:1 mixture of (+)-**7** and the corresponding (*E*)-alkene (yield 80%). A better stereoselectivity was obtained with the ylide generated with $(Me_3Si)_2NK$ in THF giving pure (+)-**7** in 61% yield. Treatment of (+)-**7** with Bu_4NF in THF gave furanose (−)-**8** (7:3 mixture of β-L/α-L anomers, an intermediate also obtained by *Wu* and *Wu* [5]), the condensation of which with the ylide generated by reaction of $(Me_3Si)_2NK$ in THF and [8-(methoxycarbonyl)octyl]triphenylphosphonium bromide [10] afforded a mixture from which the desired octadecadienoate (−)-**9** was isolated in 30% yield, together with unreacted starting material and a fraction containing a 1:10 mixture of (−)-**9** and **10** (3%). Acidic methanolysis of the acetonide (−)-**9** furnished ester (−)-**11** (83%), the spectral and physical data of which were identical with those reported for this compound [2a] [3]. Saponification of (−)-**11** is known to afford **1** [2a] [3].

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Experimental Part

General. See [9] [11]. None of the procedures was optimized. TLC Detection: *Pancaldi* (5% aq. H_2SO_4 with 4% $(NH_4)_6Mo_4O_7 \cdot 4H_2O$ and 0.2% $Ce(SO_4)_2$).

*Methyl [(*tert*-Butyl)dimethylsilyl 5-Deoxy-2,3-*O*-isopropylidene-β-*L*-ribo-hexofuranosid]uronate* ((+)-**4**) *and Methyl [(*tert*-Butyl)dimethylsilyl 5-Deoxy-2,3-*O*-isopropylidene-α-*L*-ribo-hexofuranosid]uronate* ((−)-**5**). A mixture of (+)-**3** (492 mg, 2.46 mmol; prepared according to [9], starting with (−)-**2**), anh. MeOH (25 ml), and K_2CO_3 (36 mg, 0.26 mmol) was stirred at 20° for 40 min. The mixture was poured into H_2O (50 ml) and extracted with CH_2Cl_2 (100 ml, 4 times). The combined extracts were dried ($MgSO_4$) and evaporated. The residue was taken with anh. CH_2Cl_2 (7 ml) under Ar, and anh. pyridine (0.63 ml, 4.52 mmol), (*t*-Bu)Me_2SiCl (605 mg, 4.03 mmol), and 4-(dimethylamino)pyridine (24 mg, 0.2 mmol) were added. After staying at 20° for 5 days, the mixture was poured into H_2O (30 ml), the aq. layer extracted with CH_2Cl_2 (40 ml, 5 times), the combined org. extract dried ($MgSO_4$) and evaporated, and the residue purified by FC (silica gel (30 g), AcOEt/petroleum ether 1:10, *Pancaldi*): 520 mg (61%) of (+)-**4** and 271 mg (32%) of (−)-**5**.

(+)-**4**: Colorless oil. $[\alpha]_D^{25} = +42.6$, $[\alpha]_{577}^{25} = +42.5$, $[\alpha]_{546}^{25} = +56.5$, $[\alpha]_{435}^{25} = +112.8$, $[\alpha]_{405}^{25} = +130.0$ ($c = 1.0$, $CHCl_3$). IR (CH_2Cl_2): 2910, 2850, 1730, 1370, 1200, 1160, 1100, 1080, 1030, 1000, 850, 830. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.37 (*s*, H–C(1)); 4.67 (*d*, $^3J = 5.8$, H–C(3)); 4.58 (*dd*, $^3J = 8.0, 7.3$, H–C(4)); 4.57 (*d*, $^3J = 5.8$, H–C(2)); 3.70 (*s*, MeO); 2.75 (*dd*, $^2J = 15.9$, $^3J = 7.3$, H–C(5)); 2.63 (*dd*, $^2J = 15.9$, $^3J = 8.0$, H′–C(5)); 1.48, 1.31 (2*s*, Me_2C): 0.90 (*s*, *t*-Bu); 0.10, 0.09 (2*s*, Me_2Si). ^{13}C-NMR (100.61 MHz, $CDCl_3$): 170.9 (*s*, C(6)); 112.4 (*s*, Me_2C); 103.5 (*d*, ^1J(C,H) = 165, C(1)); 87.4 (*d*, ^1J(C,H) = 159, C(4)); 84.1, 83.2 (2*d*, ^1J(C,H) = 156, C(2), C(3)); 51.7 (*q*, ^1J(C,H) = 147, MeO); 40.1 (*t*, ^1J(C,H) = 130, C(5)); 26.4, 25.0 (2*q*, ^1J(C,H) = 128, Me_2C); 25.6 (*q*, ^1J(C,H) = 125, Me_3C); 17.8 (*s*, Me_3C); −4.4, −5.6 (2*q*, ^1J(C,H) = 120, Me_2Si). CI-MS (NH_3): 331 (7), 289 (21), 231 (40), 215 (32), 199 (15), 173 (13), 171 (15), 161 (12), 157 (11), 129 (29), 103 (29), 100 (42), 89 (31), 73 (100). Anal. calc. for $C_{16}H_{30}O_6Si$ (346.5): C 55.46, H 8.73, Si 8.11; found: C 55.58, H 8.79, Si 8.17.

(−)-**5**: Colorless oil. $[\alpha]_D^{25} = -29.9$, $[\alpha]_{577}^{25} = -31.8$, $[\alpha]_{546}^{25} = -29.5$, $[\alpha]_{435}^{25} = -32.4$, $[\alpha]_{405}^{25} = -40.1$ ($c = 1.3$, $CHCl_3$). IR (CH_2Cl_2): 2920, 2850, 1730, 1370, 1200, 1150, 1090, 1080, 1030, 1020, 860, 835. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.26 (*d*, $^3J = 4.1$, H–C(1)); 4.62 (*dd*, $^3J = 7.4, 4.1$, H–C(2)); 4.54 (*dd*, $^3J = 7.4, 3.7$, H–C(3)); 4.46 (*ddd*, $^3J = 6.9, 5.6, 3.7$, H–C(4)); 3.71 (*s*, MeO); 2.68 (*dd*, $^2J = 15.6$, $^3J = 5.6$, H–C(5)); 2.60 (*dd*, $^2J = 15.6$, $^3J = 6.9$, H′–C(5)); 1.56, 1.35 (2*s*, Me_2C); 0.93 (*s*, *t*-Bu); 0.12, 0.115 (2*s*, Me_2Si). ^{13}C-NMR (100.61 MHz, $CDCl_3$): 170.7 (*s*, C(6)); 116.0 (*s*, Me_2C); 96.3 (*d*, ^1J(C,H) = 170, C(1)); 83.2 (*d*, ^1J(C,H) = 153, C(2)); 81.7 (*d*, ^1J(C,H) = 155, C(3)); 77.4 (*d*, ^1J(C,H) = 146, C(4)); 51.7 (*q*, ^1J(C,H) = 147, MeO); 37.8 (*t*, ^1J(C,H) = 130, C(5)); 26.3, 26.1 (2*q*, ^1J(C,H) = 128, Me_2C); 25.7 (*q*, ^1J(C,H) = 125, Me_3C); 18.1 (*s*, Me_3C); −4.7, −5.0 (2*q*, ^1J(C,H) = 119, Me_2Si). CI-MS (NH_3): 331 (11), 315 (6), 289 (8), 231 (100), 215 (35), 199 (13), 171 (15), 161 (11), 157 (26), 129 (37), 103 (35), 100 (43), 73 (94). Anal. calc. for $C_{16}H_{30}O_6Si$ (346.5): C 55.46, H 8.73, Si 8.11; found: C 56.04, H 8.65, Si 7.43.

*(*tert*-Butyl)dimethylsilyl 5-Deoxy-2,3-*O*-isopropylidene-β-*L*-ribo-hexodialdo-1,4-furanoside* ((+)-**6**). Dropwise 1M DIBAL in toluene (1.64 ml, 1.64 mmol) was added to a stirred soln. of (+)-**4** (506 mg, 1.46 mmol) in anh. CH_2Cl_2 (10 ml) cooled to −78° under Ar. After stirring at −78° for 1 h, MeOH (2 ml) was added dropwise (destruction of the excess of DIBAH) and the mixture poured into 0.5M HCl in H_2O (50 ml). The aq. layer was extracted with CH_2Cl_2 (40 ml, 4 times), the combined org. extract dried ($MgSO_4$) and evaporated, and the residue purified by FC (silica gel (30 g), AcOEt/petroleum ether 1:4, *Pancaldi*): 353 mg (76%). Colorless oil. $[\alpha]_D^{25} = +35.4$, $[\alpha]_{577}^{25} = +36.9$, $[\alpha]_{546}^{25} = +41.6$, $[\alpha]_{435}^{25} = +64.4$, $[\alpha]_{405}^{25} = +72.6$ ($c = 1.50$, $CHCl_3$). IR (CH_2Cl_2): 2920, 2840, 1720, 1370, 1200, 1150, 1090, 1070, 1020, 1000, 930, 850, 830. ^{1}H-NMR (400 MHz, $CDCl_3$): 9.75 (*dd*, $^3J = 2.4, 1.5$, H–C(6)); 5.27 (*d*, $^3J = 4.0$, H–C(1)); 4.63 (*dd*, $^3J = 7.5, 4.2$, H–C(3)); 4.54 (*ddd*, $^3J = 7.7, 5.0, 4.2$, H–C(4)); 4.46 (*dd*, $^3J = 7.5, 4.0$, H–C(2)); 2.77 (*ddd*, $^2J = 16.6$, $^3J = 5.0, 1.5$, H–C(5)); 2.67 (*ddd*, $^2J = 16.6$, $^3J = 7.7, 2.4$, H′–C(5)); 1.56, 1.35 (2*s*, Me_2C); 0.93 (*s*, *t*-Bu); 0.12, 0.115 (2*s*, Me_2Si). ^{13}C-NMR (100.61 MHz, $CDCl_3$): 199.6 (*d*, ^1J(C,H) = 175, C(6)); 116.4 (*s*, Me_2C); 96.2 (*d*, ^1J(C,H) = 170, C(1)); 83.3, 81.6 (2*d*, ^1J(C,H) = 157, C(2), C(3)); 76.1 (*d*, ^1J(C,H) = 152, C(4)); 46.6 (*t*, ^1J(C,H) = 128, C(5)); 26.3, 26.0 (2*q*, ^1J(C,H) = 127, Me_2C); 25.7 (*q*, ^1J(C,H) = 125, Me_3C); 18.1 (*s*, Me_3C); −4.7, −5.0 (2*q*, ^1J(C,H) = 119, Me_2Si). CI-MS (NH_3): 331 (2), 301 (8), 201 (41), 185 (15), 161 (12), 159 (11), 157 (21), 143 (10), 133 (11), 129 (33), 109 (11), 103 (28), 85 (12), 81 (13), 75 (100), 73 (84). Anal. calc. for $C_{15}H_{28}O_5Si$ (316.5): C 56.93, H 8.92, Si 8.87; found: C 56.79, H 8.82, Si 8.77.

*(1R,2S,3S,4S)-1-[(*tert*-Butyl)dimethylsilyloxy]tetrahydro-2,3-(isopropylidenedioxy)-4-[(Z)-pent-2′-enyl]-furan* ((+)-**7**). Dropwise, a 15% $(Me_3Si)_2NK$ soln. in toluene (2.0 ml, 1.32 mmol) was added to a stirred suspension

of triphenyl(propyl)phosphonium bromide (515 mg, 1.37 mmol) in anh. THF (20 ml) cooled to 0° under Ar. After stirring at 0° for 30 min, the orange soln. was cooled to −78° and (+)-**6** (353 mg, 1.11 mmol) in anh. THF (1 ml) added dropwise. After stirring at −78° for 1.5 h, the temp. was allowed to rise slowly to −10° and sat. aq. NH_4Cl soln. (1 ml) was added. After the addition of H_2O (20 ml), the aq. layer was extracted with Et_2O (20 ml, 4 times), the combined org. extract dried ($MgSO_4$) and evaporated, and the oily residue purified by FC (silica gel (30 g), AcOEt/petroleum ether 1:10, *Pancaldi*): 232 mg (61%). Colorless oil: $[\alpha]_D^{25} = +13.0$, $[\alpha]_{577}^{25} = +13.6$, $[\alpha]_{546}^{25} = +15.6$, $[\alpha]_{435}^{25} = +24.2$, $[\alpha]_{405}^{25} = +28.1$ ($c = 1.10$, $CHCl_3$). IR (CH_2Cl_2): 2840, 1720, 1210, 1150, 1100, 1075, 1040, 1000, 900, 850. ^{1}H-NMR (250 MHz, $CDCl_3$): 5.55 (*dtdd*, $^3J = 10.8$, 7.0, $^4J = 1.5$, 1.0, H–C(3′)); 5.39 (*dddt*, $^3J = 10.8$, 8.0, 6.0, $^4J = 1.2$, H–C(2′)); 5.38 (*s*, H–C(1)); 4.57 (br. *s*, H–C(2), H–C(3)); 4.12 (*dd*, $^3J = 9.0$, 6.5, H–C(4)); 2.42 (*ddddd*, $^2J = 14.0$, $^3J = 9.0$, 8.0, $^4J = 1.0$, $^5J = 0.5$, H–C(1′)); 2.34 (*ddddd*, $^2J = 14.0$, $^3J = 6.5$, 6.0, $^4J = 1.5$, $^5J = 0.5$, H′–C(1′)); 2.05 (*qdddd*, $^3J = 7.5$, 7.0, $^4J = 1.2$, $^5J = 0.5$, 0.5, CH_2(4′)); 1.48, 1.31 (2*s*, Me_2C); 0.98 (*t*, $^3J = 7.5$, Me(5′)); 0.90 (*s*, *t*-Bu); 0.13, 0.12 (2*s*, Me_2Si). ^{13}C-NMR (100.61 MHz, $CDCl_3$): 134.2 (*d*, ^1J(C,H) = 154, C(3′)); 124.1 (*d*, ^1J(C,H) = 156, C(2′)); 112.2 (*s*, Me_2C); 103.4 (*d*, ^1J(C,H) = 170, C(1)); 87.6 (*d*, ^1J(C,H) = 159, C(3)); 87.2 (*d*, ^1J(C,H) = 151, C(2)); 83.7 (*d*, ^1J(C,H) = 156, C(4)); 33.4 (*t*, ^1J(C,H) = 128, C(1′)); 26.6, 25.1 (2*q*, ^1J(C,H) = 125, Me_2C); 25.8 (*q*, ^1J(C,H) = 125, Me_3C); 20.8 (*t*, ^1J(C,H) = 126, C(4′)); 17.8 (*s*, Me_3C); 14.1 (*q*, ^1J(C,H) = 126, C(5′)); −4.2, −5.4 (2*q*, ^1J(C,H) = 119, Me_2Si). CI-MS (NH_3): 327 (4), 285 (3), 273 (38), 267 (2), 257 (2), 243 (6), 227 (26), 187 (66), 185 (14), 159 (12), 129 (22), 124 (33), 107 (11), 103 (15), 95 (55), 81 (24), 73 (100). Anal. calc. for $C_{18}H_{34}O_4Si$ (342.6): C 63.11, H 10.00, Si 8.20; found: C 63.13, H 9.93, Si 8.18.

(1S and 1R,2S,3S,4S)-Tetrahydro-2,3-(isopropylidenedioxy)-4-[(Z)-pent-2′-enyl]furan-1-ol ((−)-**8**). A mixture of (+)-**7** (143 mg, 0.417 mmol), THF (3.5 ml), and 1M BuNF in THF (0.5 ml) was stirred at 0° for 20 min. The mixture was poured into H_2O (15 ml), the aq. layer extracted with CH_2Cl_2 (30 ml, 4 times), the combined org. phase dried ($MgSO_4$) and evaporated, and the oily residue purified by FC (silica gel (30 g), AcOEt/petroleum ether 1:4, *Pancaldi*): 80 mg (84%). Colorless oil ((1*S*)/(1*R*) 7:3) that solidified in the freezer. M.p. 36–38. $[\alpha]_D^{25} = -0.6$ ([5]: $[\alpha]_D^{25} = +5.1$ ($c = 0.45$, $CHCl_3$)), $[\alpha]_{577}^{25} = -1.1$, $[\alpha]_{546}^{25} = -1.2$, $[\alpha]_{435}^{25} = -3.8$, $[\alpha]_{405}^{25} = -4.4$ ($c = 1.25$, $CHCl_3$). IR (CH_2Cl_2): 3580, 2920, 1370, 1200, 1150, 1070, 970, 830. ^{1}H-NMR (250 MHz, $CDCl_3$): 5.59–5.50 (*m*, H–C(3′)); 5.45 (*d*, $^3J = 2.4$, 0.7 H, H–C(1) of major (1*S*)-isomer); 5.40–5.27 (*m*, 1.3 H, H–C(2′), H–C(1) of (1*R*)-isomer); 4.66 (*d*, $^3J = 6.0$, 0.7 H, H–C(2)(1*S*)); 4.63 (*dd*, $^3J = 6.7$, 4.0, 0.3 H, H–C(2)(1R)); 4.58 (*dd*, $^3J = 6.0$, 0.7, 0.7 H, H–C(3)(1*S*)); 4.47 (*dd*, $^3J = 6.7$, 2.7, 0.3 H, H–C(3)(1*R*)); 4.18 (*td*, $^3J = 7.7$, 0.7, 0.7 H, H–C(4)(1*S*)); 4.11 (*td*, $^3J = 6.7$, 2.7, 0.3 H, H–C(4)(1*R*)); 3.89 (*d*, $^3J = 2.7$, 0.3 H, OH(1*R*)); 2.85 (*d*, $^3J = 2.4$, 0.7 H, OH(1*S*)); 2.41 (*t*, $^3J = 7.0$, 1.4 H, CH_2(1′)(1*S*)); 2.29 (*dd*, $^2J = 13.6$, $^3J = 6.7$, 0.6 H, CH_2(1′)(1*R*)); 2.06 (*m*, 2 H, CH_2(4′)); 1.57, 1.39 (2*s*, 1.8 H, Me_2C(1*R*)); 1.49, 1.33 (2*s*, 4.2 H, Me_2C(1*S*)); 0.98 (*t*, $^3J = 7.4$, 0.9 H, Me(5′)(1*R*)); 0.97 (*t*, $^3J = 7.4$, 2.1 H, Me(5′)(1*S*)). ^{13}C-NMR (100.61 MHz, $CDCl_3$): 134.6 (*d*, ^1J(C,H) = 156, C(3′)); 123.7 (*d*, ^1J(C,H) = 159, C(2′)); 112.3 (*s*, Me_2C); 103.2 (*d*, ^1J(C,H) = 174, C(1)); 87.1 (*d*, ^1J(C,H) = 151), 86.1 (*d*, ^1J(C,H) = 158), 83.8 (*d*, ^1J(C,H) = 156, C(2), C(3), C(4)); 33.4 (*t*, ^1J(C,H) = 128, C(1′)); 26.5, 25.0 (2*q*, ^1J(C,H) = 127, Me_2C); 20.8 (*t*, ^1J(C,H) = 130, C(4′)); 14.1 (*q*, ^1J(C,H) = 126, C(5′)). CI-MS (NH_3): 246 (3), 244 (1), 243 (1), 234 (2), 229 (8), 228 (32), 213 (42), 211 (47), 210 (100), 195 (16), 194 (17), 124 (23), 101 (43), 95 (82), 81 (62). Anal. calc. for $C_{12}H_{20}O_4$ (228.3): C 63.14, H 8.83; found: C 62.95, H 8.78.

Methyl (11R,12S,13S,9Z,15Z)-13-Hydroxy-11,12-(isopropylidenedioxy)octadeca-9,15-dienoate ((−)-**9**). At 0° 1M $(Me_3Si)_2NK$ in THF (0.43 ml, 0.43 mmol) was added to a stirred mixture of 0.5M [8-(methoxycarbonyl)-octyl]triphenylphosphonium bromide [10] (0.87 ml, 0.43 mmol) and anh. THF (6 ml). After stirring at 20° for 0.5 h, the orange soln. was cooled to −10° and a soln. of (−)-**8** (33 mg, 0.144 mmol) in anh. THF (1 ml) pretreated with activated 4-Å molecular sieves (20 mg) was added dropwise. After stirring at −10° for 0.5 h, the temp. was allowed to rise to 25° and the mixture stirred for 2.5 h. Sat. aq. NH_4Cl soln. (3 ml) was added, the mixture poured into ice-water (15 ml), the aq. layer extracted with AcOEt (15 ml, 4 times), the combined org. extract dried ($MgSO_4$) and evaporated, and the oily residue purified by FC (silica gel (8 g), Et_2O/CH_2Cl_2/petroleum ether 1:1:8, *Pancaldi*): unreacted (−)-**8**, then 15 mg (30%) of (−)-**9**, and then 2 mg (4%) of (−)-**9**/**10** 1:10.

(−)-**9**: Colorless oil. $[\alpha]_D^{25} = -30.0$, $[\alpha]_{577}^{25} = -30.3$, $[\alpha]_{546}^{25} = -34.7$, $[\alpha]_{435}^{25} = -60.7$, $[\alpha]_{405}^{25} = -73.7$ ($c = 0.30$, $CHCl_3$). IR (CH_2Cl_2): 2920, 2840, 1740, 1360, 1205, 1155, 1050, 890. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.72 (*dddd*, $^3J = 10.5$, 7.5, 7.0, $^4J = 0.8$, H–C(9)); 5.59 (*dddd*, $^3J = 10.5$, 9.3, $^4J = 1.4$, 1.3, H–C(10)); 5.58 (*dtdd*, $^3J = 10.8$, 6.5, $^4J = 1.2$, 0.8, H–C(16)); 5.44 (*dddt*, $^3J = 10.8$, 8.0, 6.5, $^4J = 1.2$, H–C(15)); 5.00 (*ddd*, $^3J = 9.3$, 6.3, $^4J = 0.8$, H–C(11)); 3.98 (*dd*, $^3J = 8.4$, 6.3, H–C(12)); 3.70 (*dddd*, $^3J = 8.4$, 8.3, 3.8, 3.7, H–C(13)); 3.66 (*s*, MeO); 2.45 (*ddddt*, $^2J = 14.0$, $^3J = 6.5$, 3.8, $^4J = 1.2$, $^5J = 0.2$, H–C(14)); 2.30 (*ddddt*, $^2J = 14.0$, $^3J = 8.3$, 8.0, $^4J = 0.8$, $^5J = 0.2$, H′–C(14)); 2.30 (*t*, $^3J = 7.4$, CH_2(2)); 2.20 (*ddtd*, $^2J = 13.1$, $^3J = 7.5$, 1.2, $^4J = 1.3$, H–C(8)); 2.13 (*ddtd*, $^2J = 13.1$, $^3J = 7.0$, 1.2, $^4J = 1.4$, H′–C(8)); 2.11 (*qdddd*, $^3J = 7.5$, 6.5, $^4J = 1.2$, 0.2, 0.2, CH_2(17)); 1.88 (*d*, $^3J = 3.8$, OH); 1.61 (*m*, CH_2(3)); 1.47, 1.37 (2*s*, Me_2C); 1.30 (*m*, CH_2(4), CH_2(5), CH_2(6), CH_2(7)); 0.98 (*t*, $^3J = 7.5$, Me(18)). ^{13}C-NMR (100.61 MHz, $CDCl_3$): 174.3 (*s*, C(1)); 135.6, 135.1 (2*d*, ^1J(C,H) = 153, C(9), C(16)); 125.4,

124.0 (2*d*, ^1J(C,H) = 158, C(10), C(15)); 108.5 (*s*, Me_2C); 80.2, 73.1 (2*d*, ^1J(C,H) = 148, C(4), C(12)); 69.8 (*d*, ^1J(C,H) = 143, C(13)); 51.4 (*q*, ^1J(C,H) = 147, MeO); 34.0 (*t*, ^1J(C,H) = 128, C(14)); 31.4, 29.3, 29.2, 29.0 (2C); 25.3, 24.9 (7*t*, ^1J(C,H) ≈ 128, C(2) to C(8)); 27.9, 27.7 (2*q*, ^1J(C,H) = 128, Me_2C); 20.7 (*d*, ^1J(C,H) = 128, C(17)); 14.2 (*q*, ^1J(C,H) = 123, C(18)). CI-MS (NH_3): 393 (1), 382 (1), 364 (1), 275 (6), 267 (5), 260 (3), 255 (23), 226 (14), 213 (11), 194 (6), 123 (7), 113 (9), 111 (10), 107 (13), 101 (40), 97 (100), 95 (28), 93 (16), 85 (22), 83 (40), 81 (60), 71 (22). Anal. calc. for $C_{22}H_{38}O_5$ (382.5): C 69.08, H 10.01; found: C 68.94, H 9.98.

*Methyl (11*R*,12*S*,13*S*,9*Z*,15*Z*)-11,12,13-Trihydroxyoctadeca-9,15-dienoate* ((−)-**11**). A soln. of (−)-**9** (20 mg, 0.052 mmol) and TsOH (16 mg, 0.08 mmol) in MeOH (1.5 ml) was allowed to stand at 20° for 24 h. After evaporation, the residue was purified by FC (silica gel (8 g), AcOEt/petroleum ether 1:2, *Pancaldi*): 15 mg (83%). Colorless oil. $[\alpha]_D^{25} = -16.5$ ([3]: $[\alpha]_D^{25} = -16$ ($c = 0.7$, $CHCl_3$)), $[\alpha]_{577}^{25} = -17.4$, $[\alpha]_{546}^{25} = -20.5$, $[\alpha]_{435}^{25} = -35.0$, $[\alpha]_{405}^{25} = -41.9$ ($c = 0.58$, $CHCl_3$). IR (CH_2Cl_2): 3580, 2920, 2840, 2640, 1750, 1600, 1370, 1210, 1180, 1170, 1060, 1025, 860. Other spectral data: identical with those published [2a]. Anal. calc. for $C_{19}H_{34}O_5$ (342.5): C 66.64, H 10.01; found: C 65.53, H 9.81.

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