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Stereoselective Synthesis of Isomers of the Naturally Occurring 13-Hydroxy-2,4,9-tetradecatrienoic Acid. Part II [1]

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Summary. The stereoselective syntheses of four unsaturated hydroxy fatty acids (13*S*,2*E*,4*E*,9*E*)-13-hydroxy-2,4,9-tetradecatrienoic acid, (13*S*,9*Z*,11*E*)-13-hydroxy-9,11-tetradecadienoic acid, (13*S*,9*E*,11*E*)-13-hydroxy-9,11-tetradecadienoic acid, and (13*S*,2*E*,4*E*,9*E*)-13-hydroxy-2,4,9,11-tetradecatrienoic acid, are described. *Wittig* reactions, regioselective oxidation of dialcohol **3**, and diastereomerization were used.

Keywords. Fatty acid; Aldehydes; *Wittig* Reaction; (*Z*,*E*)-Isomerization.

Introduction

Hydroxy fatty acids, like hydroxylated arachidonic or linoleic acid, have attracted interest because they show very different biologic effects. Thus, *e.g.* (*S*,9*E*,11*Z*)-13-hydroxy-9,11-octadecadienoic acid (**1**, 13-*HODE*) alters cell proliferation [2, 3], cell adhesion [4], apoptosis [5], and inflammation [3].

Contrary to 13-*HODE* enamidonine, a lipopeptide with an (*E*,*E*,*E*)-13-hydroxy-2,4,9-tetradecatrienoic acid connected with a cyclic tetrapeptide *via* an enamide bridge, slows down the EGF induced proliferation of BALB fibroblasts [6, 7].

To provide material for biological tests four derivatives of these hydroxy fatty acids were synthesized. All of them possess a C_{14} skeleton with the OH-group in position 13, but differ in number and position of the double bonds.

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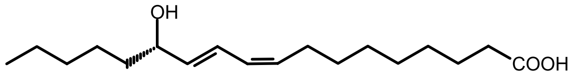

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Results and Discussions

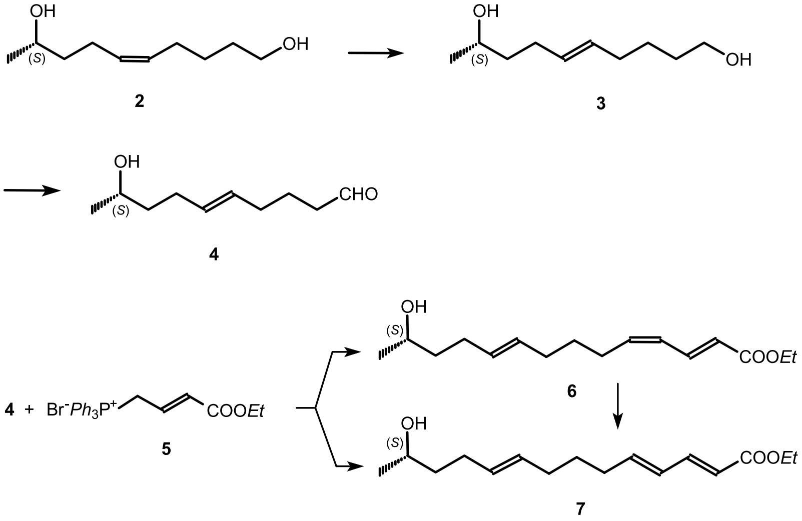
(13S,2E,4E,9E)-Ethyl 13-hydroxy-2,4,9-tetradecatrienoate (**7**)

In an earlier work [1] we described the synthesis of (9*S*,5*Z*)-5-decen-1,9-diol (**2**) and subsequently (13*S*,2*E*,4*E*,9*Z*)-ethyl 13-hydroxy-2,4,9-tetradecatrienoate. The final selective diastereomerization of the conjugated double bonds was performed by irradiation in presence of diphenyl disulfide. To prevent complete decomposition it was essential to filter the radiation with a 1% K_2CrO_4 solution. Like all later depicted diastereomerizations, this reaction was monitored directly by ^{1}H NMR in benzene-d_6 as solvent.

Irradiation of **2** with unfiltered UV light in the presence of diphenyl disulfide afforded the equilibrium mixture of **2** and *trans* diol **3**, and **3** was isolated by CC. After oxidation of **3** to **4** the large (15.3 Hz) *trans* coupling constant between H-5 and H-6 proved the (*E*)-configuration. *Wittig* reaction with 3-ethoxycarbonyl-2-propenyl-triphenylphosphonium bromide (**5**) and the final diasteromerization were performed as reported in Ref. [1]. That way (see Scheme 1) **7** was synthesized in an overall yield of 11% starting from **2**.

(S)-13-Hydroxy-9,11-tetradecadienoic acids ***14*** *and* ***17***

These syntheses started with *l*-ethyl lactate as chiral synthon. The OH-group was protected as its *TBDMS* ether [8] and the ester was reduced with *DIBALH* [9].



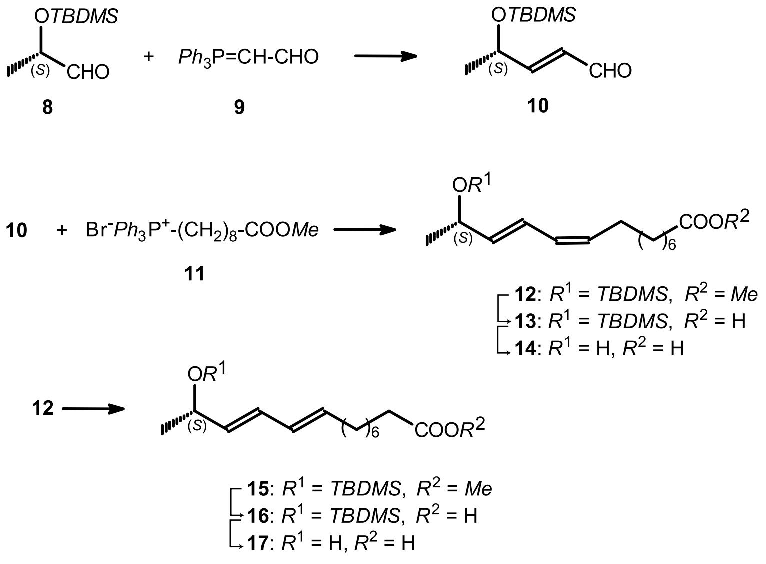
Scheme 1

Resulting **8** afforded **10** after a *Wittig* reaction with formylmethylentriphenylphosphorane (**9**). If the reaction temperature was increased from room temp. [10] to 40°C the reaction was finished after 20 h instead of 3 days with slightly decreased yield. Ylide **9** was prepared in a modification of the methods of Refs. [11, 12] to double the yield of Ref. [11] from 23 to 51%.

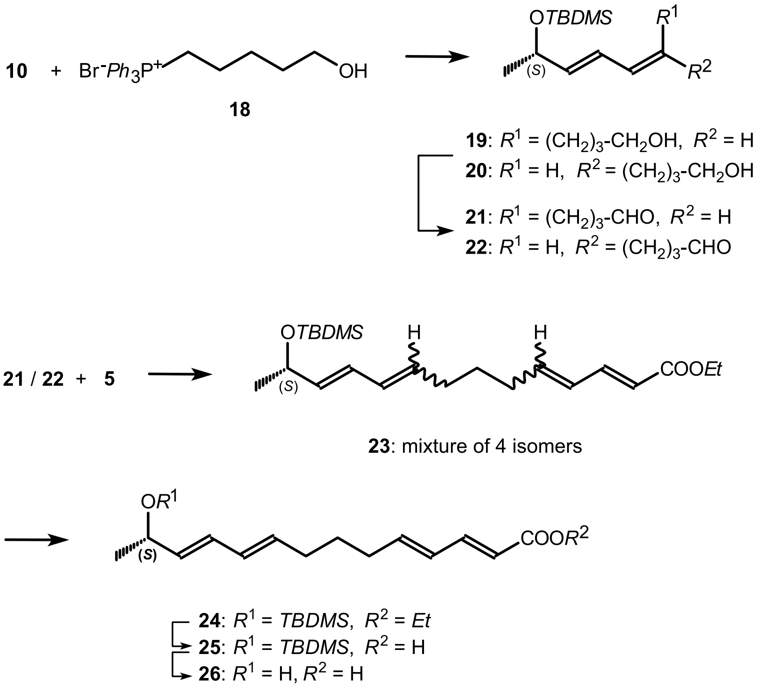
Phosphorous salt **12** was prepared in five steps from oleic acid with initial methylation of the carboxyl function with *Me*OH, HC(O*Me*)$_3$, and H_2SO_4. Ozonolysis of methyl oleate [13], reduction with $NaBH_4$ [14], and substitution of OH *versus* Br with CBr_4 and P*Ph*$_3$ [15] yielded methyl 9-bromononanoate. This was converted to the salt **11**. Using the method of *Gerard* and *Patin* [16] it was essential that P*Ph*$_3$ was recrystallized from light petrol ether (P*Ph*$_3$ recrystallized from ethanol did not work).

The next *Wittig* reaction was carried out similar to Ref. [16]. Using Na*HMDS* as base instead of Li*HMDS* resulted in a product containing (9*Z*)- and (9*E*)-isomers **12** and **15** in a ratio of about 9:1. The (9*Z*,11*E*)-configuration of the main product was confirmed by the small (10.6 Hz) *cis* coupling constant between H-9 and H-10 and the large *trans* (15.0 Hz) coupling constant between H-11 and H-12. Compound **12** was saponified with LiOH [17] and desilylated with *TBAF* [8, 18] obtaining unprotected acid **14** in an overall yield of 17% starting from **8**. Liberation of the alcohol function of **12** prior to the saponification resulted in complete decomposition of the intermediate methyl 13-hydroxy-9,11-tetradecadienoate.

Irradiation of **12** in the same procedure as used for the mixture of **5** and **6** yielded the (*E*,*E*)-isomer **15** containing about 10% of educt **12**. The large *trans* coupling constants between H-9 and H-10 and betweeen H-11 and H-12 (both 14.9 Hz) in the ^{1}H NMR spectrum of **15** verify the (*E*,*E*)-configuration. Deprotection as described for **12** gave **17** in an overall yield of 5% starting from **8**.



Scheme 2



Scheme 3

(13S,2E,4E,9E,11E)-13-Hydroxy-2,4,9,11 tetradecatetraenoic acid (**26**)

A *Wittig* reaction similar to the method of Ref. [19] with **10** and phosphonium salt **18** resulted in a 3:2 mixture of the (5*Z*)-dienol **19** and the (5*E*)-isomer **20**. In the ^{1}H NMR the coupling patterns of their olefinic protons compair to those of **12** and **15**. Though the isomers could be separated by CC we did later without because a diastereomerization was planned as for **12**. Aldehydes **21** and **22** were obtained by oxidation with *PCC* [20] of **19** and **20**. Coupling of **21** and **22** with **5** in a *Wittig* reaction resulted in the four isomers of **23**. This mixture was converted to the all-*trans* isomer **24** similar to the irradiation of **12** or **6**, yet the reaction time had to be extended to 90 h. Deprotection as performed for **12** gave **26** in an overall yield of 4% starting from **8**.

Experimental

Melting points: Melting point apparatus: *Tottoli*. Optical rotation: polarimeter 241 MC (Perkin Elmer). MS: Varian MAT 711 spectrometer 70 eV electron impact, GC/MS-Detector HP 6890 (MS: EI 70 eV electron impact), Shimadzu QP 5050a, EI-MS, 70 eV. IR spectra: infrared spectrometer System 2000 FT (Perkin Elmer). UV-Vis: UV-160A UV-visible recording spectrophotometer (Shimadzu). NMR spectra: Varian Unity Inova 400 (297 K) 5 mm tubes, solvent resonance as internal standard. ^{1}H- and ^{13}C-resonances were assigned using ^{1}H,^{1}H- and ^{1}H,^{13}C-correlation spectra. Irradiation: high pressure mercury lamp Hanau-Hochdrucklampe TQ 150 Hg. Materials: Column chromatography (CC) and filtration: silica: Kieselgel 60 (Merck) (70–230 mesh), pore-diameter 60 Å; alumina: Aluminiumoxid für die Säulenchromatographie standardized, basic $pH = 10 \pm 0.5$, *Brockmann* activity II, 0.05–0.15 mm (Fluka). Preparative thin-layer chromatography (PLC): PLC plates (Merck) Kieselgel 60 F_{254}, 1 mm, 200×200 mm. Analytical thin-layer chromatography (TLC): TLC plates (Merck) Kieselgel 60 F_{254}, 0.2 mm, 200×200 mm; the derivatives were detected in UV light at 254 nm and by spraying with molybdatophosphoric acid and subsequent heating.

(9S,5E)-Decen-1,9-diol (**3**, $C_{10}H_{20}O_2$)

First, 172 mg of **3** (1.00 mmol) and 437 mg of diphenyl disulfide (1.00 mmol) were dissolved in 8 cm^3 of abs. benzene. Then the solution was filled into four 5 mm NMR tubes and Ar was bubbled through for 5 min. The tubes were closed and placed in an irradiation apparatus and irradiated for 1.5 h at room temp. with a high pressure mercury lamp cooled with destilled H_2O. The reaction mixture was evaporated under reduced pressure. CC over 50 g silica with *Et*O*Ac* gave 90 mg (52%) of **3** as a colourless oil and 35 mg of **2** (20%). $R_f = 0.35$ (silica, *Et*O*Ac*); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 1.15$ (d, $J = 6.1$ Hz, H-10), 1.39 (m, H-3), 1.46 (m, H-8), 1.52 (m, H-2), 1.81 (s br, OH), 1.98 (m, H-4), 2.05 (m, H-7), 3.58 (t, $J = 6.6$ Hz, H-1), 3.77 (sext, $J = 6.2$ Hz, H-9), 5.41 (m, H-5, 6) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 23.3$ (C-10), 25.6 (C-3), 28.9 (C-7), 32.1 and 32.2 (C-2, 4), 38.9 (C-8), 62.7 (C-1), 67.7 (C-9), 130.1 and 130.5 (C-6, 5) ppm; IR (neat): $\bar{\nu} = 3334$ (s, br), 2964 (s), 2931 (s), 2859 (s), 1454 (m), 1374 (m), 1130 (m), 1067 (m), 969 (m), 733 (w) cm^{-1}; MS (70 eV): m/z (%) = 172 (M^+, 1.0), 154 ((M^+-H_2O), 1.0), 139 (1.3), 136 (1.9), 121 (6.0), 107 (11.8), 95 (22.8), 93 (29.5), 81 (20.8), 79 (100), 67 (72.6), 45 (83.4); $[\alpha]_D^{23} = -7.1° \, cm^2 \, g^{-1}$ ($c = 0.35$, CH_2Cl_2), $[\alpha]_{546}^{23} = -9.3° \, cm^2 \, g^{-1}$ ($c = 0.35$, CH_2Cl_2).

(9S,5E)-9-Hydroxy-5-decenal (**4**, $C_{10}H_{18}O_2$)

Under O_2, 49 mg of **3** (0.28 mmol), 9 mg of 2,2,6,6-tetramethylpiperidin-1-oxyl (*TEMPO*) (0.06 mmol), 83 mg of dry $CuCl_2$ (0.62 mmol), and 35 mg of CaH_2 (0.82 mmol) in 2.2 cm^3 of abs. CH_3CN were stirred vigorously in a 10 cm^3 round bottom flask overnight. The reaction mixture was evaporated under reduced pressure, diluted with 2 cm^3 of H_2O and extracted with 4×10 cm^3 of CH_2Cl_2. The combined organic phases were washed with 2 cm^3 of brine, dried over Na_2SO_4, and evaporated. CC over 20 g of silica with *Et*O*Ac* gave 20 mg (43%) of **4** as a colourless oil. $R_f = 0.51$ (silica, *Et*O*Ac*); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 1.15$ (d, $J = 6.3$ Hz, H-10), 1.46 (m, H-8), 1.63 (s br, OH), 1.65 (quint, $J = 7.4$ Hz, H-3), 1.99 (m, H-4), 2.04 (m, H-7), 2.38 (td, $J = 7.3$, 1.8 Hz, H-2), 3.75 (sext, $J = 6.3$ Hz, H-9), 5.34 (dt, $J = 15.3$, 6.1 Hz, H-5), 5.40 (dt, $J = 15.3$, 6.2 Hz, H-6), 9.71 (t, $J = 1.8$ Hz, H-1) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 21.8$ (C-3), 23.4 (C-10), 28.8 (C-7), 31.7 (C-4), 38.8 (C-8), 43.1 (C-2), 67.5 (C-9), 129.3 (C-5), 131.1 (C-6), 202.7 (C-1) ppm; IR (neat): $\bar{\nu} = 3419$ (s), 2965 (s), 2931 (s), 2850 (s), 2722 (m), 1724 (s), 1452 (m), 1409 (m), 1392 (m), 1374 (m), 1130 (m), 1011 (m), 971 (m) cm^{-1}; MS (70 eV): m/z (%) = 152 ((M^+-H_2O), 3.1), 137 (2.3), 123 (6.2), 108 (20.7), 93 (21.1), 79 ($C_6H_7^+$, 100), 67 (29.8), 55 (19.1), 31 (2.5); $[\alpha]_D^{23} = -10° \, cm^2 \, g^{-1}$ ($c = 0.49$, CH_2Cl_2), $[\alpha]_{546}^{23} = -13° \, cm^2 \, g^{-1}$ ($c = 0.49$, CH_2Cl_2).

(13S)-Ethyl 13-hydroxy-2,4,9-tetradecatrienoate (mixture of (4Z)- and *(4E)-isomer)* (**6** + **7**)

Under Ar, 242 mg of **5** (0.53 mmol) and 300 mg of K_2CO_3 in 10 cm^3 of abs. *DMF* were heated to 120°C. A solution of 90 mg of **4** (0.53 mmol) in 1 cm^3 of abs. *DMF* was added and stirring at 120°C was continued for 1.5 h. After cooling to room temp. the reaction mixture was poured into 20 cm^3 of H_2O and extracted with 4×25 cm^3 of Et_2O. The combined extracts were washed with 20 cm^3 of brine, dried over Na_2SO_4, and evaporated under reduced pressure. CC over 50 g of silica with *Et*O*Ac* gave 80 mg (57%) of the (*Z*/*E*)-mixture **6** + **7** as a colourless oil. $R_f = 0.63$ (silica, *Et*O*Ac*).

(13S,2E,4E,9E)-Ethyl 13-hydroxy-2,4,9-tetradecatrienoate (**7**, $C_{16}H_{26}O_3$)

The (Z/E) mixture **6** + **7** (80 mg, 0.30 mmol) and 131 mg of diphenyl disulfide (0.60 mmol) were dissolved in 6 cm^3 of abs. benzene. The solution was filled into three 5 mm NMR tubes and Ar was bubbled through for 5 min. The tubes were closed and placed in an irradiation apparatus and irradiated for 14 h at room temp. with a high pressure mercury lamp with a 1% potassium chromate filter in a thickness of 1 cm. The reaction mixture was evaporated under reduced pressure. CC over 10 g of silica with *Et*O*Ac* gave 55 mg (69%) of **7** as a colourless oil. $R_f = 0.63$ (silica, *Et*O*Ac*); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 1.13$ (d, $J = 6.3$ Hz, H-4), 1.24 (t, $J = 7.2$ Hz, OCH_2CH_3), 1.44 (m, H-7, 12), 1.82 (s br, OH), 1.95 (m, H-8), 2.03 (m, H-11), 2.11 (quint, $J = 6.9$ Hz, H-6), 3.84 (sext, $J = 6.2$ Hz, H-13), 4.15 (q, $J = 7.2$ Hz, OCH_2CH_3), 5.37 (m, H-9, 10), 5.73 (d, $J = 15.3$ Hz, H-2), 6.04 (m, H-5), 6.12 (m, H-4), 7.20 (dd, $J = 15.4$, 9.8 Hz, H-3) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 14.2$ (OCH_2CH_3), 23.5 (C-14), 28.9 (C-11), 31.9 (C-8), 28.4 (C-7), 32.3 (C-6), 38.8 (C-12), 60.1 (OCH_2CH_3), 67.5 (C-13), 119.1 (C-2), 128.5, 129.9, and 130.4 (C-4, 9, 10), 144.2 (C-5), 144.9 (C-3), 167.2 (C-1) ppm; IR (neat): $\bar{\nu} = 3430$ (m, br), 2966 (s), 2929 (s), 2856 (m), 1714 (s), 1642 (s), 1617 (m), 1447 (m), 1393 (m), 1369 (s), 1304 (s), 1264 (s), 1247 (s), 1137 (s), 1095 (m), 1039 (s), 1001 (s), 872 (w), 714 (w) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 0.90 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 260.5 (19200) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 266 (M^+, 1.6), 248 (4.0), 220 (9.8), 192 (7.0), 175 (10.3), 147 (14.0), 135 (22.2), 119 (28.1), 79 ($C_6H_7^+$, 100), 31 (7.8); $[\alpha]_D^{23} = -6.8°$ cm^2 g^{-1} ($c = 0.26$, CH_2Cl_2); $[\alpha]_{546}^{23} = -8.4°$ cm^2 g^{-1} ($c = 0.26$, CH_2Cl_2).

Formylmethylentriphenylphosphorane (**9**)

$CHCl_3$ (750 cm^3) was added to 67.5 g of a 50% aqueous solution of chloroethanal (0.39 mol). The $CHCl_3/H_2O$-azeotrope (bp 56°C) was destilled over a *Raschig* column. After destillation of about 400 cm^3 of the azeotrope, 102.3 g of P*Ph*$_3$ (0.39 mol) were added to the yellow solution and the mixture was refluxed for 5 h. The solvent was evaporated under reduced pressure, the residual phosphonium salt was dissolved in 400 cm^3 of H_2O, and the organic phases were separated and discarded. After addition of activated charcoal the mixture was stirred for 30 min at room temp. and filtered. Under vigrous stirring 250 cm^3 of 2 *N* NaOH solution were added dropwise to the filtrate and stirring was continued for another hour. The product was filtered with suction, washed with 20 cm^3 of cold H_2O, air dried, suspended in 200 cm^3 of acetone and stirred for 2 h at room temp. Filtration and drying over P_2O_5 gained 60.7 g (51%) of **9** as an ocher powder. Mp 180–181°C (Ref. [12] 186–187°C).

(4S,2E)-4-tert-Butyldimethylsilyloxy-2-pentenal (**10**)

Aldehyde **8** (824 mg, 4.38 mmol) and 1.60 g of ylide **9** (5.26 mmol) were stirred in 30 cm^3 of abs. benzene at 40°C under Ar for 20 h before benzene was evaporated under reduced pressure. CC over 100 g of silica with cyclohexane:*Et*O*Ac* = 9:1 afforded 675 mg (72%) of **10** as a colourless oil. ^{1}H NMR signals of H-1, 2, 3, and 4 were found to be identical with those described in Ref. [21].

^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 0.03$ and 0.05 (s, $Si(CH_3)_2$), 0.88 (s, $C(CH_3)_3$), 1.28 (d, $J = 6.6$ Hz, H-5), 4.55 (m, H-4), 6.25 (ddd, $J = 14.8$, 8.0, 1.5 Hz, H-2), 6.75 (dd, $J = 15.4$, 4.0 Hz, H-3), 9.55 (d, $J = 8.1$ Hz, H-1) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -5.2$ and -5.0 ($Si(CH_3)_2$), 18.1 ($C(CH_3)_3$), 23.3 (C-5), 25.7 ($C(CH_3)_3$), 67.7 (C-4), 129.8 (C-2), 160.9 (C-3), 193.7 (C-1) ppm.

Methyl oleate

Trimethyl orthoformiat (26.5 g, 0.25 mol) and 5 drops of conc. H_2SO_4 were added to a solution of 28.3 g of oleic acid (0.10 mol) in 50 cm^3 of *Me*OH. The mixture was stirred over night at room temp., evaporated, the residue was diluted with 300 cm^3 of Et_2O, washed with 2×100 cm^3 of 1 *N* $NaHCO_3$ solution and 2×100 cm^3 of H_2O and dried over Na_2SO_4. Evaporation under reduced pressure yielded 28.5 g (96%) of methyl oleate. The ^{1}H NMR spectrum was found to be identical with that of Ref. [22].

(13S,9Z,11E)-Methyl 13-tert-butyldimethylsilyloxy-9,11-tetradecadienoate (**12**, $C_{21}H_{40}O_3Si$)

To a solution of 1.50 g of salt **11** (2.92 mmol) in 25 cm^3 of abs. *THF* at −78°C under Ar 3.4 cm^3 of a 1 *N* solution of Na*HMDS* in *THF* (3.4 mmol) were added and the mixture was stirred for 45 min. After addition of 7.7 cm^3 of *HMPA* and stirring for 2 min a solution of 419 mg of **10** (1.95 mmol) in 5 cm^3 of abs. *THF* were added and stirring was continued for further 45 min. The reaction was quenched by the addition of 38 cm^3 of warm (45°C) H_2O, the cooling bath was removed, and the mixture was warmed up to room temp., stirred for further 30 min, and extracted with 3×100 cm^3 of light petrol ether. The combined organic phases were washed with 80 cm^3 of brine, dried over Na_2SO_4, and evaporated under reduced pressure. CC over 50 g of silica with cyclohexane:*EtOAc* = 9:1 afforded 370 mg (34%) of **12** as a colourless oil. $R_f = 0.45$ (silica, cyclohexane:*EtOAc* = 9:1); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.03$ (s, $Si(CH_3)_2$), 0.88 (s, $C(CH_3)_3$), 1.20 (d, $J = 6.2$ Hz, H-14), 1.28 (m, H-4, 5, 6), 1.34 (quint, $J = 6.3$ Hz, H-7), 1.59 (quint, $J = 7.1$ Hz, H-3), 2.13 (q, $J = 7.2$ Hz, H-8), 2.28 (t, $J = 7.5$ Hz, H-2), 3.66 (s, OCH_3), 4.17 (quint, $J = 6.2$ Hz, H-13), 5.37 (dt, $J = 10.6$, 7.7 Hz, H-9), 5.63 (dd, $J = 15.0$, 5.1 Hz, H-12), 5.94 (t, $J = 11.0$ Hz, H-10), 6.42 (dd, $J = 15.0$, 11.4 Hz, H-11) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.7 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 24.5 (C-14), 24.9 (C-3), 25.9 ($C(\mathit{C}H_3)_3$), 27.7 (C-8), 29.0 and 2×29.1 (C-4, 5, 6), 29.6 (C-7), 34.1 (C-2), 51.4 (OCH_3), 68.9 (C-13), 123.4 (C-11), 128.0 (C-10), 131.7 (C-9), 137.7 (C-12), 174.3 (C-1) ppm; IR (neat): $\bar{\nu} = 2952$ (s), 2929 (s), 2857 (m), 1773 (s), 1617 (m), 1472 (m), 1463 (m), 1436 (m), 1362 (m), 1255 (s), 1196 (m), 1168 (m), 1142 (m), 1092 (m), 988 (m), 836 (s), 776 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 1.1\cdot10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 272.5 (2090), 236.5 (18400) nm; MS (70 eV): m/z (%) = 368 (M^+, 3.0), 353 ((M^+-*Me*), 0.1), 321 (1.0), 311 ((M^+-C_4H_9), 8.1), 279 ((311-CH_4O), 9.2), 237 ((M^+-O*TBDMS*), 0.9), 211 (3.9), 187 (2.9), 159 (4.1), 144 (4.1), 131 (4.2), 117 (9.2), 115 (7.8), 104 (9.2), 93 (15.1), 75 ((*Me*$_2$Si=OH)$^+$, 100), 73 (37.0), 57 (26.5); $[\alpha]_D^{25} = +18° cm^2 g^{-1}$ ($c = 0.092$, CH_2Cl_2); $[\alpha]_{546}^{25} = +16° cm^2 g^{-1}$ ($c = 0.092$, CH_2Cl_2).

(13S,9Z,11E)-13-tert-Butyldimethylsilyloxy-9,11-tetradecadienoic acid (**13**, $C_{20}H_{38}O_3Si$)

A solution of 252 mg of LiOH × H_2O (6.00 mmol) in 3 cm^3 of H_2O was added to 220 mg of **12** (0.597 mmol) in 6 cm^3 of *THF*. The mixture was stirred under reflux and Ar for 14 h, cooled to room temp., poured into 20 cm^3 of 2 *N* H_2SO_4, and extracted with 3×30 cm^3 of Et_2O. The combined organic phases were washed with 10 cm^3 of 2 *N* H_2SO_4 and 10 cm^3 of brine, dried over Na_2SO_4, and evaporated under reduced pressure. CC over 40 g of silica with cyclohexane:*EtOAc*:*Ac*OH = 69:31:4 afforded 182 mg (86%) of **13** as a colourless oil. $R_f = 0.44$ (silica, cyclohexane:*EtOAc*: *Ac*OH = 69:31:4); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.04$ (s, $Si(CH_3)_2$, 0.88 (s, $C(CH_3)_3$), 1.21 (d, $J = 6.2$ Hz, H-14), 1.29 (m, H-4, 5, 6), 1.33 (m, H-7), 1.59 (quint, $J = 6.8$ Hz, H-3), 2.13 (q, $J = 7.4$ Hz, H-8), 2.32 (t, $J = 7.5$ Hz, H-2), 4.35 (quint, $J = 6.0$ Hz, H-13), 5.37 (dt, $J = 10.3$, 7.8 Hz, H-9), 5.63 (dd, $J = 15.0$, 5.1 Hz, H-12), 5.94 (t, $J = 11.0$ Hz, H-10), 6.42 (dd, $J = 15.0$, 11.4 Hz, H-11), 10.2 (s, br, OH) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.6 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 24.5 (C-14), 24.6 (C-3), 25.9 ($C(\mathit{C}H_3)_3$), 27.6 (C-8), 2×29.0 and 29.1 (C-4, 5, 6), 29.6 (C-7), 34.1 (C-2), 69.0 (C-13), 123.4 (C-11), 128.1 (C-10), 131.7 (C-9), 137.7 (C-12), 180.1 (C-1) ppm; IR (neat): $\bar{\nu} = 3008$ (m), 2929 (s), 2857 (m), 2677 (m, br), 1712 (s), 1608 (w), 1471 (m), 1463 (m), 1442 (m), 1412 (m), 1362 (m), 1289 (m), 1255 (s), 1142 (m), 1092 (m), 1049 (m), 986 (m), 836 (s), 776 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 1.34\cdot10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 237.5 (17000) nm ($mol^{-1} dm^3 cm^{-1}$); MS (70 eV): m/z (%) = 354 (M^+, 21.4), 339 ((M^+-*Me*), 1.4), 321 ((339-H_2O), 7.6), 297 ((M^+-C_4H_9), 13.8), 279 ((297-H_2O), 68.0), 253 (3.2), 239 (7.8), 222 (14.0), 211 (13.1), 187 (21.8), 131 (18.8), 117 (38.5), 95 (47.4), 81 (64.0), 79 (45.5), 75 ((*Me*$_2$Si=OH)$^+$, 100), 73 (76.3), 55 (32.7); $[\alpha]_D^{22} = +14° cm^2 g^{-1}$ ($c = 0.20$, CH_2Cl_2); $[\alpha]_{546}^{22} = +11° cm^2 g^{-1}$ ($c = 0.20$, CH_2Cl_2).

(13S,9Z,11E)-13-Hydroxy-9,11-tetradecadienoic acid (**14**, $C_{14}H_{24}O_3$)

A 1 *N* solution of *TBAF* in *THF* (1.3 cm^3, 1.3 mmol) was added to a solution of 150 mg of **13** (0.423 mmol) in 5 cm^3 of abs. *THF* under Ar and it was stirred for 70 min. After evaporation under reduced pressure the residue was dissolved in 40 cm^3 of CH_2Cl_2, washed with 2×10 cm^3 of 2 *N* H_2SO_4 and 3×20 cm^3 of H_2O, dried over Na_2SO_4, and evaporated under reduced pressure. PLC with cyclohexane:*Et*O*Ac*:*Ac*OH = 25:25:2 yielded 80 mg (79%) of **14** as a colourless wax. $R_f = 0.41$ (cyclohexane:*Et*O*Ac*:*Ac*OH = 25:25:2); ^{1}H NMR (400 MHz, *DMSO*-d$_6$): $\delta = 1.10$ (d, $J = 6.6$ Hz, H-14), 1.25 (m, H-4, 5, 6), 1.31 (quint, $J = 6.3$ Hz, H-7), 1.44 (quint, $J = 6.6$ Hz, H-3), 1.79 (s, br, CH-O*H*), 2.07 (t, $J = 7.0$ Hz, H-2), 2.11 (q, $J = 7.3$ Hz, H-8), 4.17 (quint, $J = 6.2$ Hz, H-13), 5.34 (dt, $J = 10.8$, 7.7 Hz, H-9), 5.65 (dd, $J = 15.0$, 5.9 Hz, H-12), 5.92 (t, $J = 11.0$ Hz, H-10), 6.38 (dd, $J = 15.0$, 11.0 Hz, H-11) ppm; ^{13}C NMR (100 MHz, *DMSO*-d$_6$): $\delta = 24.0$ (C-14), 25.3 (C-3), 27.3 (C-8), 28.8, 28.9, and 29.0 (C-4, 5, 6), 29.3 (C-7), 35.3 (C-2), 66.5 (C-13), 123.2 (C-11), 128.5 (C-10), 131.3 (C-9), 139.3 (C-12), 175.6 (C-1) ppm; IR (neat): $\bar{\nu} = 3398$ (m, br), 2924 (s), 2854 (s), 1711 (s), 1562 (vs), 1462 (m), 1446 (m), 1423 (m), 1369 (m), 1280 (m), 1134 (m), 985 (m), 945 (m) cm^{-1}; UV-Vis (*Me*OH, $c = 1.27 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 229.5 (15800), 271.5 (1220) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 240 (M$^+$, 2.1), 222 ((M$^+$-H_2O), 21.9), 207 ((222-*Me*), 1.2), 194 ((222-C_2H_4), 3.7), 179 (8.3), 164 (11.2), 161 (12.0), 136 (20.8), 121 (19.2), 107 (23.6), 95 (97.2), 81 (83.7), 79 (99.5), 67 (100.0), 55 (94.6); $[\alpha]_D^{27} = +8.8°$ cm^2 g^{-1} ($c = 0.13$, *Me*OH); $[\alpha]_{546}^{27} = +6.4°$ cm^2 g^{-1} ($c = 0.13$, *Me*OH).

(13S,9E,11E)-Methyl 13-tert-butyldimethylsilyloxy-9,11-tetradecadienoate (**15**, $C_{21}H_{40}O_3Si$)

(11*Z*)-Isomer **12** (240 mg, 0.65 mmol) and 284 mg of diphenyl disulfide (1.30 mmol) were dissolved in 8 cm^3 of abs. benzene. The solution was filled into four 5 mm NMR tubes and Ar was bubbled through for 5 min. The tubes were closed and placed in an irradiation apparatus and irradiated for 16 h at room temp. with a high pressure mercury lamp with a 1% potassium chromate filter in a thickness of 1 cm. The reaction mixture was evaporated under reduced pressure. CC over 50 g of silica with cyclohexane:*Et*O*Ac* = 9:1 gave 184 mg (77%) of **15** as a colourless oil. $R_f = 0.42$ (cyclohexane: *Et*O*Ac* = 9:1); ^{1}H NMR (400 MHz, benzene-d$_6$): $\delta = 2\times0.21$ (s, Si(CH_3)$_2$), 1.12 (s, C(CH_3)$_3$), 1.25 (m, H-4, 5, 6), 1.35 (d, $J = 6.3$ Hz, H-14), 1.38 (m, H-7), 1.65 (quint, $J = 7.2$ Hz, H-3), 2.09 (q, $J = 7.1$ Hz, H-8), 2.22 (t, $J = 7.4$ Hz, H-2), 4.41 (quint, $J = 6.1$ Hz, H-13), 5.74 (dt, $J = 14.8$, 6.7 Hz, H-9), 5.75 (dd, $J = 14.8$, 5.9 Hz, H-12), 6.18 (dd, $J = 14.9$, 10.3 Hz, H-10), 6.38 (dd, $J = 15.2$, 10.6 Hz, H-11) ppm; ^{13}C NMR (100 MHz, benzene-d$_6$): $\delta = -4.6$ and -4.3 (Si(CH_3)$_2$), 18.4 (*C*(CH_3)$_3$), 24.9 (C-14), 25.2 (C-3), 26.1 (C(*C*H_3)$_3$), 29.3 and 2×29.4 (C-4, 5, 6), 29.6 (C-7), 33.0 (C-8), 34.1 (C-2), 50.9 (OCH_3), 69.5 (C-13), 129.1 (C-11), 130.4 (C-10), 134.3 (C-9), 137.4 (C-12), 173.3 (C-1) ppm; IR (neat): $\bar{\nu} = 2951$ (s), 2929 (s), 2857 (s), 1743 (s), 1660 (w), 1472 (m), 1436 (m), 1362 (m), 1287 (m), 1253 (m), 1196 (m), 1170 (m), 1143 (m), 1090 (m), 989 (m), 836 (s), 777 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 0.95 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 235.5 (16430) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 368 (M$^+$, 7.0), 353 ((M$^+$-*Me*), 1.0), 321 (0.5), 311 ((M$^+$-C_4H_9), 12.0), 279 ((311-CH_4O), 14.8), 237 ((M$^+$-O*TBDMS*), 1.8), 211 (6.7), 187 (4.8), 159 (2.8), 145 (4.8), 131 (4.7), 117 (16.9), 115 (7.9), 107 (20.0), 93 (23.0), 75 ((*Me*$_2$Si=OH)$^+$, 100), 73 (54.2), 59 (20.0); $[\alpha]_D^{25} = 0°$ cm^2 g^{-1} ($c = 0.09$, CH_2Cl_2); $[\alpha]_{546}^{25} = 0°$ cm^2 g^{-1} ($c = 0.09$, CH_2Cl_2).

(13S,9E,11E)-13-tert-Butyldimethylsilyloxy-9,11-tetradecadienoic acid (**16**, $C_{20}H_{38}O_3Si$)

As described for **12** hydrolysis of 110 mg of **15** (0.30 mmol) with 127 mg of LiOH×H_2O gave 47 mg (46%) of **16** as a colourless oil. $R_f = 0.37$ (cyclohexane:*Et*O*Ac*:*Ac*OH = 50:10:2.4); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.03$ (s, Si(CH_3)$_2$), 0.88 (s, C(CH_3)$_3$), 1.19 (d, $J = 6.2$ Hz, H-14), 1.28 (m, H-4, 5, 6), 1.32 (m, H-7), 1.60 (quint, $J = 7.2$ Hz, H-3), 2.03 (q, $J = 7.0$ Hz, H-8), 2.32 (t, $J = 7.5$ Hz, H-2), 4.29 (quint,

$J = 6.1$ Hz, H-13), 5.54 (dd, $J = 15.0$, 5.9 Hz, H-12), 5.60 (dt, $J = 14.8$, 6.5 Hz, H-9), 5.97 (dd, $J = 14.8$, 10.6 Hz, H-10), 6.06 (dd, $J = 14.8$, 10.3 Hz, H-11) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.6 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 24.5 (C-14), 24.6 (C-3), 25.9 ($C(\mathit{C}H_3)_3$), 2×29.0 and 29.1 (C-4, 5, 6), 29.2 (C-7), 32.6 (C-8), 34.1 (C-2), 69.1 (C-13), 128.5 (C-11), 129.8 (C-10), 134.2 (C-9), 135.5 (C-12), 180.2 (C-1) ppm; IR (neat): $\bar{\nu} = 3020$ (m), 2929 (s), 2857 (s), 2677 (m, br), 1711 (s), 1661 (w), 1471 (m), 1463 (m), 1441 (m), 1412 (m), 1362 (m), 1287 (m), 1255 (s), 1142 (m), 1089 (m), 1049 (m), 989 (m), 835 (s), 776 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 1.96 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 238.5 (12200) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): no significant spectrum gageable; $[\alpha]_D^{24} = +7.5°$ cm^2 g^{-1} ($c = 0.11$, CH_2Cl_2); $[\alpha]_{546}^{24} = 0°$ cm^2 g^{-1} ($c = 0.11$, CH_2Cl_2).

(13S,9E,11E)-13-Hydroxy-9,11-tetradecadienoic acid (**17**, $C_{14}H_{24}O_3$)

As described for **13** desilylation of 35 mg of **16** (0.10 mmol) with 0.30 cm^3 of a 1 *N* solution of *TBAF* in *THF* (0.30 mmol) afforded 14 mg (59%) of **17** as a colourless oil. $R_f = 0.39$ (silica, cyclohexane:*Et*OAc:*Ac*OH = 25:25:2); ^{1}H NMR (400 MHz, *Me*OH-d_4): $\delta = 1.22$ (d, $J = 5.9$ Hz, H-14), 1.33 (m, H-4, 5, 6), 1.39 (quint, $J = 6.4$ Hz, H-7), 1.59 (quint, $J = 6.4$ Hz, H-3), 2.07 (q, $J = 7.0$ Hz, H-8), 2.26 (t, $J = 7.3$ Hz, H-2), 4.23 (quint, $J = 6.2$ Hz, H-13), 5.57 (dd, $J = 15.2$, 6.8 Hz, H-12), 5.66 (dt, $J = 14.7$, 6.5 Hz, H-9), 6.01 (dd, $J = 15.0$, 10.6 Hz, H-10), 6.14 (dd, $J = 15.2$, 10.5 Hz, H-11) ppm; ^{13}C NMR (100 MHz, *Me*OH-d_4): $\delta = 23.9$ (C-14), 26.4 (C-3), 30.4 and 2×30.5 (C-4, 5, 6), 30.7 (C-7), 33.9 (C-8), 35.4 (C-2), 69.4 (C-13), 131.1 (C-11), 131.5 (C-10), 135.9 (C-9), 136.3 (C-12), 178.2 (C-1) ppm; IR (neat): $\bar{\nu} = 3368$ (m, br), 2971 (m), 2928 (s), 2856 (s), 1710 (s), 1456 (m), 1411 (m), 1370 (s), 1280 (m), 1136 (m), 1058 (m), 990 (s), 943 (m) cm^{-1}; UV-Vis (*Me*OH, $c = 1.41 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 230.5 (17000) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 240 (M^+, 3.0), 239 ((M^+-H), 1.6), 222 ((M^+-H_2O), 26.5), 207 ((222-*Me*), 2.0), 194 ((222-C_2H_4), 3.1), 179 (8.1), 164 (14.1), 161 (10.4), 136 (15.2), 121 (15.4), 104 (25.6), 95 (71.9), 81 (61.1), 79 (55.4), 67 (70.0), 55 (100); $[\alpha]_D^{20} = +20°$ cm^2 g^{-1} ($c = 0.071$, *Me*OH); $[\alpha]_{546}^{20} = +7.0°$ cm^2 g^{-1} ($c = 0.071$, *Me*OH).

(9S,5Z,7E)-9-tert-Butyldimethylsilyloxy-5,7-decadienol (**19**, $C_{16}H_{32}O_2Si$) and *(9S,5E,7E)-9-tert-Butyldimethylsilyloxy-5,7-decadienol* (**20**, $C_{16}H_{32}O_2Si$)

To a suspension of 1.34 g of **18** (3.13 mmol) in 42 cm^3 of abs. *THF* at room temp. under Ar 3.9 cm^3 of a 1.6 *N* solution of *BuLi* in *n*-hexane (6.2 mmol) were added and the mixture was stirred for 45 min. A solution of 675 mg of **10** (3.13 mmol) in 5 cm^3 of abs. *THF* was added and stirring was continued for 60 min. The mixture was evaporated under reduced pressure, diluted with 40 cm^3 of H_2O, and was extracted with 3×70 cm^3 of CH_2Cl_2. The combined organic phases were washed with 2×20 cm^3 of brine, dried over Na_2SO_4, and evaporated under reduced pressure. CC over 400 g of silica with cyclohexane:*Et*O*Ac* = 1:1 gave 518 mg (58%) of a 2:3 mixture of **19** and **20**. **19**: $R_f = 0.51$ (silica, cyclohexane:*Et*O*Ac* = 1:1); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 2 \times 0.01$ (s, $Si(CH_3)_2$), 0.85 (s, $C(CH_3)_3$), 1.18 (d, $J = 6.6$ Hz, H-10), 1.41 (quint, $J = 7.1$ Hz, H-3), 1.54 (quint, $J = 7.1$ Hz, H-2), 2.18 (q, $J = 7.3$ Hz, H-4), 3.62 (t, $J = 6.4$ Hz, H-1), 4.33 (quint, $J = 6.0$ Hz, H-9), 5.36 (dt, $J = 10.6$, 7.7 Hz, H-5), 5.64 (dd, $J = 15.0$, 5.1 Hz, H-8), 5.95 (t, $J = 11.0$ Hz, H-6), 6.41 (dd, $J = 15.0$, 11.0 Hz, H-7) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.7 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 24.4 (C-10), 25.8 (C-3), 25.9 ($C(\mathit{C}H_3)_3$), 27.4 (C-4), 32.3 (C-2), 62.7 (C-1), 68.9 (C-9), 123.3 (C-7), 128.4 (C-6), 131.2 (C-5), 137.9 (C-8) ppm; IR (neat): $\bar{\nu} = 3347$ (m), 2956 (s), 2930 (s), 2858 (s), 1472 (m), 1463 (m), 1255 (s), 1148 (m), 1074 (s), 984 (m), 835 (s), 776 (s) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 0.67 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 236.5 (20400) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 284 (M^+, 2.0), 269 ((M^+-*Me*), 0.1), 253 ((M^+-O*Me*), 0.1), 227 ((M^+-C_4H_9), 2.9), 211 (3.9), 183 (11.3), 171 (3.9), 155 (8.8), 145 (4.9), 135 (8.8), 119 (9.8), 117 (9.1), 115 (9.1) 107 (17.2), 105 (11.3), 93 (31.9), 91 (22.1), 79 (43.1), 77 (22.1), 75 ((*Me*$_2$Si=OH)$^+$, 100), 73 (39.2), 67 (12.1), 57 (23.0), 55 (13.2); $[\alpha]_D^{19} = +16°$ cm^2 g^{-1} ($c = 0.28$, CH_2Cl_2), $[\alpha]_{546}^{19} = +18°$ cm^2 g^{-1} ($c = 0.28$, CH_2Cl_2).

20: $R_f = 0.48$ (silica, cyclohexane:*Et*O*Ac* = 1:1); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 0.02$ and 0.03 (s, $Si(CH_3)_2$), 0.88 (s, $C(CH_3)_3$), 1.18 (d, $J = 6.6$ Hz, H-10), 1.43 (m, H-3), 1.55 (m, H-2), 2.08 (q, $J = 7.1$ Hz, H-4), 3.61 (t, $J = 6.6$ Hz, H-1), 4.29 (quint, $J = 6.2$ Hz, H-9), 5.55 (dd, $J = 14.7$, 5.5 Hz, H-8), 5.60 (dt, $J = 14.7$, 7.0 Hz, H-5), 5.98 (dd, $J = 14.7$, 10.6 Hz, H-6), 6.07 (ddd, $J = 14.7$, 11.6, 1.1 Hz, H-7) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.6 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 25.8 and 25.9 (C-3, 10), 25.9 ($C(\mathit{C}H_3)_3$), 32.2 and 32.3 (C-2, 4), 62.8 (C-1), 69.0 (C-9), 128.3 (C-7), 130.1 (C-6), 133.7 (C-5), 135.9 (C-8) ppm; IR (neat): $\bar{\nu} = 3347$ (m), 2956 (s), 2930 (s), 2858 (s), 1472 (w), 1463 (w), 1255 (m), 1143 (w), 1073 (m), 988 (s), 835 (s), 776 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 0.81 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 235.0 (16300) nm ($mol^{-1}\,dm^3\,cm^{-1}$); MS (70 eV): *m/z* (%) = 284 (M^+, 3.9), 269 ((M^+-*Me*) 0.1), 253 ((M^+-O*Me*), 0.1), 227 ((M^+-C_4H_9), 2.0), 211 (4.9), 183 (8.8), 171 (3.9), 155 (7.8), 145 (6.7), 135 (13.2), 119 (6.7), 117 (12.7), 115 (11.8), 107 (19.1), 105 (10.8), 93 (41.2), 91 (20.1), 79 (42.8), 77 (19.2), 75 ((*Me*$_2$Si=OH)$^+$, 100), 73 (44.1), 67 (12.9), 57 (15.0), 55 (17.6); $[\alpha]_D^{19} = 0^\circ\,cm^2\,g^{-1}$ ($c = 0.31$, CH_2Cl_2); $[\alpha]_{546}^{19} = 0^\circ\,cm^2\,g^{-1}$ ($c = 0.31$, CH_2Cl_2).

(9S,5Z,7E)-9-tert-Butyldimethylsilyloxy-5,7-decadienal (**21**, $C_{16}H_{30}O_2Si$) and (9S,5E,7E)-9-tert-Butyldimethylsilyloxy-5,7-decadienal (**22**, $C_{16}H_{30}O_2Si$)

To a solution of 729 mg of *PCC* (3.38 mmol) in 17 cm^3 of abs. CH_2Cl_2 four drops of pyridine were added . After stirring for a few min at room temp. 469 mg of the (*Z*/*E*) mixture **19** + **20** (1.65 mmol) in 4.5 cm^3 of abs. CH_2Cl_2 were added and stirred for further 60 min at room temp. The reaction mixture was filtered over a column (3 cm diameter, 3 cm alumina, 3 cm silica, 3 cm alumina) and eluted with CH_2Cl_2. Eluate and washings were dried over Na_2SO_4. Evaporation under reduced pressure yielded 401 mg (86%) of a 2:3 mixture of **21** and **22** as a colourless oil. **21**: $R_f = 0.61$ (silica, cyclohexane:*Et*O*Ac* = 2:1); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.03$ (s, $Si(CH_3)_2$), 0.86 (s, $C(CH_3)_3$), 1.20 (d, $J = 6.2$ Hz, H-10), 1.70 (quint, $J = 7.4$ Hz, H-3), 2.19 (q, $J = 7.6$ Hz, H-4), 2.41 (td, $J = 7.7$, 1.5 Hz, H-2), 4.33 (quint, $J = 5.9$ Hz, H-9), 5.32 (dt, $J = 10.6$, 7.7 Hz, H-5), 5.65 (dd, $J = 15.0$, 5.8 Hz, H-8), 5.98 (t, $J = 11.5$ Hz, H-6), 6.38 (dd, $J = 15.0$, 11.4 Hz, H-7), 9.73 (t, $J = 1.5$ Hz, H-1) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.7 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 21.9 (C-3), 24.4 (C-10), 25.8 ($C(\mathit{C}H_3)_3$), 26.9 (C-4), 43.2 (C-2), 68.1 (C-9), 123.0 (C-7), 129.3 (C-6), 129.9 (C-5), 138.6 (C-8), 202.3 (C-1) ppm; IR (neat): $\bar{\nu} = 2956$ (s), 2929 (s), 2887 (m), 2857 (s), 1728 (s), 1472 (w), 1463 (w), 1256 (s), 996 (s), 952 (w), 835 (s), 776 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 1.4 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 238.5 (15900) nm ($mol^{-1}\,dm^3\,cm^{-1}$); MS (70 eV): *m/z* (%) = 282 (M^+, 0.1), 225 ((M^+-C_4H_9), 15.2), 207 (1.0), 197 (1.0), 181 (7.8), 169 (6.7), 157 (3.9), 143 (6.4), 133 (13.7), 119 (13.7), 107 (11.8), 105 (19.0), 95 (16.8), 91 (23.0), 79 (31.9), 77 (13.7), 75 ($(CH_3)_2Si{=}OH)^+$, 100), 73 (38.7), 67 (9.1), 57 (11.0), 55 (8.2); $[\alpha]_D^{22} = 21^\circ\,cm^2\,g^{-1}$ ($c = 0.16$, CH_2Cl_2); $[\alpha]_{546}^{22} = 21^\circ\,cm^2\,g^{-1}$ ($c = 0.16$, CH_2Cl_2).

22: $R_f = 0.61$ (silica, cyclohexane:*Et*O*Ac* = 2:1); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.03$ (s, $Si(CH_3)_2$), 0.88 (s, $C(CH_3)_3$), 1.18 (d, $J = 6.2$ Hz, H-10), 1.71 (quint, $J = 7.3$ Hz, H-3), 2.10 (q, $J = 7.2$ Hz, H-4), 2.42 (t, $J = 7.1$ Hz, H-2), 4.30 (quint, $J = 6.0$ Hz, H-9), 5.55 (dt, $J =$ *ca.* 15, *ca.* 7 Hz, H-5), 5.57 (dd, $J =$ *ca.* 15, *ca.* 6 Hz, H-8), 5.98 (dd, $J = 14.7$, 10.3 Hz, H-6), 6.07 (dd, $J = 14.7$, 10.6 Hz, H-7), 9.74 (s, H-1) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.6 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 21.6 (C-3), 24.5 (C-10), 25.9 ($C(\mathit{C}H_3)_3$), 31.8 (C-4), 43.2 (C-2), 68.9 (C-9), 128.0 (C-7), 130.9 (C-6), 132.4 (C-5), 136.5 (C-8), 202.4 (C-1) ppm; IR (neat): $\bar{\nu} = 3430$ (w), 2956 (m), 2930 (s), 2858 (m), 1689 (m), 1472 (w), 1463 (w), 1255 (m), 1092 (w), 989 (w), 836 (s), 777 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 1.2 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 236.0 (15700) nm ($mol^{-1}\,dm^3\,cm^{-1}$); MS (70 eV): *m/z* (%) = 281 ((M^+-1), 0.1), 267 ((M^+-*Me*), 1.0), 225 ((M^+-C_4H_9), 7.8), 211 (2.0), 197 (2.0), 181 (8.8), 169 (6.8), 157 (5.9), 143 (6.8), 133 (16.1), 119 (14.2), 107 (18.1), 105 (27.8), 95 (20.0), 91 (31.3), 79 (47.9), 77 (20.0), 75 ((*Me*$_2$ Si=OH)$^+$, 100), 73 (43.9), 67 (10.9), 57 (20.0), 55 (9.8); $[\alpha]_D^{22} = 0^\circ\,cm^2\,g^{-1}$ ($c = 0.073$, CH_2Cl_2), $[\alpha]_{546}^{22} = 0^\circ\,cm^2\,g^{-1}$ ($c = 0.073$, CH_2Cl_2).

(13S,2E,11E)-Ethyl 13-tert-butyldimethylsilyloxy-2,4,9,11-tetradecatetraenoate
(**23**, mixture of four 4,9-isomers, $C_{22}H_{38}O_3Si$)

Under Ar 646 mg of **5** (1.42 mmol) and 851 mg of K_2CO_3 in 30 cm^3 of abs. *DMF* were heated to 120°C. A solution of 401 mg of aldehydes **21** + **22** (1.42 mmol) in 7 cm^3 of abs. *DMF* was added and stirring at 120°C was continued for 1.5 h. After cooling to room temp. the reaction mixture was poured into 75 cm^3 of H_2O and extracted with 3×120 cm^3 of Et_2O. The combined extracts were washed with 185 cm^3 of brine, dried over Na_2SO_4, and the solvent was evaporated under reduced pressure. CC over 100 g of silica with cyclohexane:*Et*O*Ac* = 20:1 gave 257 mg (48%) of the (Z/E) mixture **23** as a colourless oil. R_f: 0.28 (silica, cyclohexane:*Et*O*Ac* = 20:1).

(13S,2E,4E,9E,11E)-Ethyl 13-tert-butyldimethylsilyloxy-2,4,9,11-tetradecatetraenoate
(**24**, $C_{22}H_{38}O_3Si$)

The mixture **23** (254 mg, 0.67 mmol) and 586 mg of diphenyl disulfide (2.68 mmol) were dissolved in 10 cm^3 of abs. benzene. The solution was filled into three 5 mm NMR tubes and Ar was bubbled through for 5 min. The tubes were closed and placed in an irradiation apparatus and irradiated for 90 h at room temp. with a high pressure mercury lamp with a 1% potassium chromate filter in a thickness of 1 cm. The reaction mixture was evaporated under reduced pressure. CC over 50 g of silica with cyclohexane:*Et*O*Ac* = 20:1 gave 133 mg (45%) of **24** as a colourless oil. $R_f = 0.24$ (silica, cyclohexane:*Et*O*Ac* = 20:1); ^1H NMR (400 MHz, benzene-d_6): $\delta = 0.20$ (s, $Si(CH_3)_2$), 1.12 (s, $C(CH_3)_3$), 1.13 (t, $J = 7.0$ Hz, $O{-}CH_2CH_3$), 1.32 (quint, $J = 7.3$ Hz, H-7), 1.34 (d, $J = 6.6$ Hz, H-14), 1.89 (q, $J = 7.5$ Hz, H-8), 1.97 (q, $J = 7.5$ Hz, H-6), 4.18 (q, $J = 7.2$ Hz, $O{-}CH_2CH_3$), 4.39 (quint, $J = 6.2$ Hz, H-13), 5.64 (dt, $J = 15.1$, 7.2 Hz, H-9), 5.74 (dt, $J = 15.8$, 6.7 Hz, H-5), 5.76 (dd, $J = 14.2$, 6.0 Hz, H-12), 5.97 (dd, $J = 15.2$, 10.9 Hz, H-4), 6.00 (d, $J = 15.4$ Hz, H-2), 6.13 (dd, $J = 15.3$, 10.6 Hz, H-10), 6.38 (dd, $J = 14.8$, 10.2 Hz, H-11), 7.57 (dd, $J = 15.4$, 11.2 Hz, H-3) ppm; ^{13}C NMR (100 MHz, benzene-d_6): $\delta = -4.6$ and -4.3 ($Si(CH_3)_2$), 14.4 ($O{-}CH_2CH_3$), 18.4 ($C(CH_3)_3$), 24.9 (C-14), 26.1 ($C(CH_3)_3$), 28.4 (C-7), 32.3 (C-6), 32.4 (C-8), 60.1 ($O{-}CH_2CH_3$), 69.4 (C-13), 120.1 (C-2), 128.8 (C-11), 129.0 (C-4), 130.9 (C-10), 133.4 (C-9), 136.5 (C-12), 143.7 (C-5), 145.0 (C-3), 166.8 (C-1) ppm; ^1H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.02$ (s, $Si(CH_3)_2$), 0.86 (t, $J = 6.2$ Hz, $O{-}CH_2CH_3$), 0.87 (s, $C(CH_3)_3$), 1.18 (d, $J = 6.6$ Hz, H-14), 1.50 (quint, $J = 7.3$ Hz, H-7), 2.06 (q, $J = 7.0$ Hz, H-8), 2.14 (q, $J = 7.1$ Hz, H-6), 4.17 (q, $J = 7.1$ Hz, $O{-}CH_2CH_3$), 4.29 (quint, $J = 6.1$ Hz, H-13), 5.54 (m, H-12), 5.58 (m, H-9), 5.75 (d, $J = 15.4$ Hz, H-2), 5.98 (m, H-10), 6.05 (m, H-11), 6.13 (m, H-4), 6.13 (m, H-5), 7.23 (dd, $J = 15.4$, 9.9 Hz, H-3) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.6 ($Si(CH_3)_2$), 14.3 ($O{-}CH_2CH_3$), 18.2 ($C(CH_3)_3$), 24.5 (C-14), 25.9 ($C(CH_3)_3$), 28.2 (C-7), 32.0 (C-8), 32.3 (C-6), 60.1 ($O{-}CH_2CH_3$), 68.9 (C-13), 119.3 (C-2), 128.2 (C-11), 128.6 (C-4), 130.4 (C-10), 133.1 (C-9), 136.1 (C-12), 144.0 (C-5), 144.9 (C-3), 167.2 (C-1) ppm; IR (neat): $\bar{\nu} = 3436$ (w), 2956 (s), 2930 (s), 2858 (m), 1716 (s), 1645 (m), 1472 (w), 1463 (w), 1368 (m), 1256 (s), 1141 (m), 1093 (w), 1000 (m), 836 (s), 777 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 1.5\cdot10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 255.5 (14300) nm ($mol^{-1}\,dm^3\,cm^{-1}$); MS (70 eV): m/z (%) = 378 (M^+, 0.1), 363 ((M^+-*Me*), 1.0), 321 ((M^+-C_4H_9), 38.2), 305 ((M^+-$C_3H_5O_2$), 1.0), 295 (18.3), 275 (2.9), 249 (2.9), 223 (2.9), 207 (1.0), 185 (2.5), 173 (9.8), 147 (14.7), 131 (16.7), 119 (14.7), 117 (18.1), 105 (15.7), 103 (14.2), 91 (25.5), 79 (24.0), 75 ((*Me*$_2$Si=OH)$^+$, 100), 73 (33.3), 67 (11.8), 57 (19.6); $[\alpha]_D^{22} = +5.3°\,cm^2\,g^{-1}$ ($c = 0.13$, CH_2Cl_2); $[\alpha]_{546}^{22} = +3.1°\,cm^2\,g^{-1}$ ($c = 0.13$, CH_2Cl_2).

(13S,2E,4E,9E,11E)-13-tert-Butyldimethylsilyloxy-2,4,9,11-tetradecatetraenoic acid
(**25**, $C_{20}H_{34}O_3Si$)

A solution of 81 mg of $LiOH\times H_2O$ (1.9 mmol) in 1.0 cm^3 of H_2O was added to 73 mg of **24** (0.19 mmol) in 1.9 cm^3 of abs. *THF* under Ar. After stirring under reflux for 18 h and cooling to room temp. the reaction mixture was poured into 6.4 cm^3 of 2 *N* H_2SO_4 and extracted with 3×10 cm^3 of Et_2O. The combined organic layers were washed with 2×3 cm^3 of 2 *N* H_2SO_4 and 2×3 cm^3 of brine, dried over Na_2SO_4, and the solvent was evaporated under reduced pressure. CC over *ca.* 2 g of silica with cyclohexane:*Et*O*Ac*:*Ac*OH = 35:15:2 gave 63 mg (94%) of **25** as a colourless oil. $R_f = 0.31$ (silica, cyclohexane:*Et*O*Ac*:*Ac*OH = 35:15:2); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 2\times0.04$ (s, $Si(CH_3)_2$), 0.89 (s, $C(CH_3)_3$), 1.19 (d, $J = 6.6$ Hz, H-14), 1.52 (quint, $J = 7.3$ Hz, H-7), 2.08 (q, $J = 7.1$ Hz, H-8), 2.18 (q, $J = 6.8$ Hz, H-6), 4.30 (quint, $J = 6.2$ Hz, H-13), 5.56 (dd, $J = 15.8$, 4.8 Hz, H-12), 5.58 (dt, $J = 15.0$, 7.0 Hz, H-9), 5.76 (d, $J = 15.4$ Hz, H-2), 5.99 (m, H-10), 6.04 (m, H-11), 6.17 (m, H-4), 6.17 (m, H-5), 7.32 (dd, $J = 15.4$, 9.9 Hz, H-3) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = -4.8$ and -4.6 ($Si(CH_3)_2$), 18.3 ($\mathit{C}(CH_3)_3$), 24.5 (C-14), 25.9 ($C(\mathit{C}H_3)_3$), 28.2 (C-7), 32.0 (C-8), 32.4 (C-6), 67.0 (C-13), 118.4 (C-2), 128.2 (C-11), 128.5 (C-4), 130.5 (C-10), 133.1 (C-9), 136.1 (C-12), 145.6 (C-5), 147.3 (C-3), 172.6 (C-1) ppm; IR (neat): $\bar{\nu} = 2956$ (s), 2929 (s), 2857 (m), 2667 (w, vbr), 1690 (s), 1640 (m), 1472 (w), 1463 (w), 1417 (m), 1305 (m), 1275 (m), 1257 (s), 1143 (m), 1089 (w), 1000 (m), 990 (m), 835 (s), 776 (m) cm^{-1}; UV-Vis (CH_2Cl_2, $c = 0.58 \cdot 10^{-4}$ mol dm^{-3}): λ_{max} (ε) = 236.0 (23100), 263.0 (26400) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 350 (M^+, 1.1), 293 ((M^+-C_4H_9), 4.1), 275 ((293-H_2O), 9.0), 249 (7.7), 235 (3.6), 218 (8.9), 211 (13.1), 185 (25.5), 173 (24.3), 159 (13.7), 147 (15.4), 133 (27.5), 117 (24.4), 107 (22.9), 91 (24.4), 81 (26.1), 79 (36.5), 75 (($\mathit{Me}_2Si{=}OH)^+$, 100), 73 (62.7), 55 (20.0); $[\alpha]_D^{21} = +5.0°$ cm^2 g^{-1} ($c = 0.30$, CH_2Cl_2); $[\alpha]_{546}^{21} = +4.3°$ cm^2 g^{-1} ($c = 0.30$, CH_2Cl_2).

(13S,2E,4E,9E,11E)-13-Hydroxy-2,4,9,11-tetradecatetraenoic acid (**26**, $C_{14}H_{20}O_3$)

In a procedure as described for **13** desilylation of 25 mg of **25** (0.071 mmol) with 0.21 cm^3 of a 1 *N* solution of *TBAF* in *THF* (1.3 mmol) afforded 9 mg (54%) of **26** as a colourless oil. $R_f = 0.36$ (silica, cyclohexane:*Et*O*Ac*:*Ac*OH = 25:25:2); ^1H NMR (400 MHz, *Me*OH-d_4): $\delta = 1.22$ (d, $J = 6.5$ Hz, H-14), 1.54 (quint, $J = 7.3$ Hz, H-7), 2.11 (q, $J = 7.0$ Hz, H-8), 2.19 (q, $J = 7.0$ Hz, H-6), 4.24 (quint, $J = 6.2$ Hz, H-13), 5.60 (dd, $J = 15.2$, 6.4 Hz, H-12), 5.67 (dt, $J = 14.7$, 7.0 Hz, H-9), 5.78 (d, $J = 15.8$, Hz, H-2), 6.04 (dd, $J = 15.2$, 10.5 Hz, H-10), 6.16 (m, H-5, 11), 6.23 (dd, $J = 15.2$, 10.5 Hz, H-4), 7.23 (dd, $J = 15.2$, 10.0 Hz, H-3) ppm; ^{13}C NMR (100 MHz, *Me*OH-d_4): $\delta = 23.9$ (C-14), 29.8 (C-7), 33.4 (C-8), 33.7 (C-6), 69.3 (C-13), 121.0 (C-2), 130.3 (C-4), 130.9 (C-11), 132.0 (C-10), 135.2 (C-9), 136.6 (C-12), 145.6 (C-5), 147.0 (C-3), 171.2 (C-1) ppm; IR (neat): $\bar{\nu} = 3420$ (m, br), 2934 (s), 2868 (s), 1715 (s), 1644 (m), 1455 (m), 1436 (m), 1374 (m), 1258 (s), 1182 (m), 1141 (m), 1061 (m), 1002 (m), 978 (m) cm^{-1}; UV-Vis (*Me*OH, $c = 0.54$ 10^{-4} mol dm^{-3}): λ_{max} (ε) = 232.0 (29900), 254.0 (28800) nm (mol^{-1} dm^3 cm^{-1}); MS (70 eV): m/z (%) = 218 ((M^+-H_2O), 3.3), 199 ((218-*Me*), 8.5), 183 (6.9), 173 (7.4), 147 (12.0), 131 (17.0), 107 (41.9), 95 (40.1), 81 (52.3), 79 (93.9), 67 (53.0), 55 (100); $[\alpha]_D^{21} = +15°$ cm^2 g^{-1} ($c = 0.065$, *Me*OH); $[\alpha]_{546}^{21} = 0°$ cm^2 g^{-1} ($c = 0.065$, *Me*OH).

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