VOLUME 69, NUMBER 14 JOC Articles JULY 9, 2004

Synthesis of Tricolorin F

Marco Brito-Arias,[1] Rogelio Pereda-Miranda,[2] and Clayton H. Heathcock*,[3]

Center for New Directions in Organic Synthesis,[†] Department of Chemistry, University of California, Berkeley, California 94720, Unidad Profesional Interdisciplinaria de Biotecnología, Instituto Politécnico Nacional, Av. Acueducto s/n Barrio La Laguna Ticomán, Mexico City 07340, Mexico, and Departamento de Farmacia, Facultad de Química, Universidad Nacional Autonoma de México, Ciudad Universitaria, Mexico City 04510, Mexico

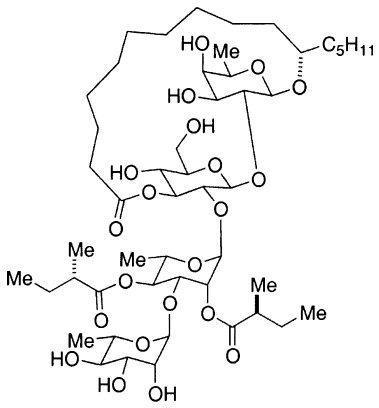
heathcock@cchem.berkeley.edu

Received July 29, 2003

A hetero-trisaccharide resin glycoside of jalapinolic acid known as tricolorin F has been synthesized. The approach involved the preparation of intermediate **5** and a subsequent coupling reaction with imidate **6** to produce disaccharide **7**, which after deacetylation generated intermediate **8**. A further coupling between this glycosyl acceptor and the quinovose glycosyl donor **9** resulted in the formation of the tricoloric acid C derivative **10**. Basic hydrolysis afforded the intermediate **11**, which was subsequently lactonized under Yamaguchi conditions to produce protected macrolactone **12**. Removal of acetonide and benzyl protecting groups afforded pure tricolorin F (**1**).

Resin glycosides, biodynamic constituents of the morning glory species [e.g., *Ipomoea* genus (Convolvulaceae family)], are amphipatic glycosyl derivatives of monohydroxy and dihydroxy C14 and C16 fatty acids. The hydrophilic moieties (sugar core) may simultaneously be composed of homo- and heteropolysaccharides linked to the hydrophobic aglycon. Sugar units found in these metabolites are epimers of hexoses (mainly D-glucose) and pentoses (L-rhamnose, D-fucose, and D-quinovose), with D-Glc-(12)-D-Fuc representing a highly conserved disaccharide subunit. Most of them contain jalapinolic acid, 11(*S*)-hydroxyhexadecanoic acid, as the aglycon which in turn is always tied back to form a macrolactone ring spanning two, three, or more units of their saccharide backbones.[4] Several biological activities have been described for the convolvulaceous resins, including antimicrobial, mammalian cytotoxicity, and plant toxicity, among others. Pharmacologically, the crude MeOH-soluble resin extracts from several Mexican *Ipomoea* species, commonly known as jalaps, constitute a group of traditionally valued purgative remedies. It has been demonstrated that all the activities are associated with the macrocyclic structure of these lipopolysaccharides, since the glycosidic acids derived from saponification have shown to be inactive.[4]

The ability of *Ipomea tricolor* to inhibit the growth of invasive weeds has been attributed to a mixture of these resin glycosides.[4,5] From the chloroform-soluble extract of this plant material a complex glycolipids mixture has been isolated and purified by recycling HPLC, from which tricolorins A−J have been fully characterized by means of high-resolution NMR spectrometry and FAB-mass spectrometry.[6,7] From the chloroform-soluble extract the most abundant and easy to purify resin was tricolorin A.[5]



tricolorin A

This was the first tricolorin to be fully characterized and was subsequently synthesized by Larson and Heath-

[†] The Center for New Directions in Organic Synthesis is supported by Bristol-Myers Squibb as Sponsoring Member and Novartis as Supporting Member.

(1) Permanent address: Instituto Politécnico Nacional.

(2) Universidad Nacional Autónoma de México.

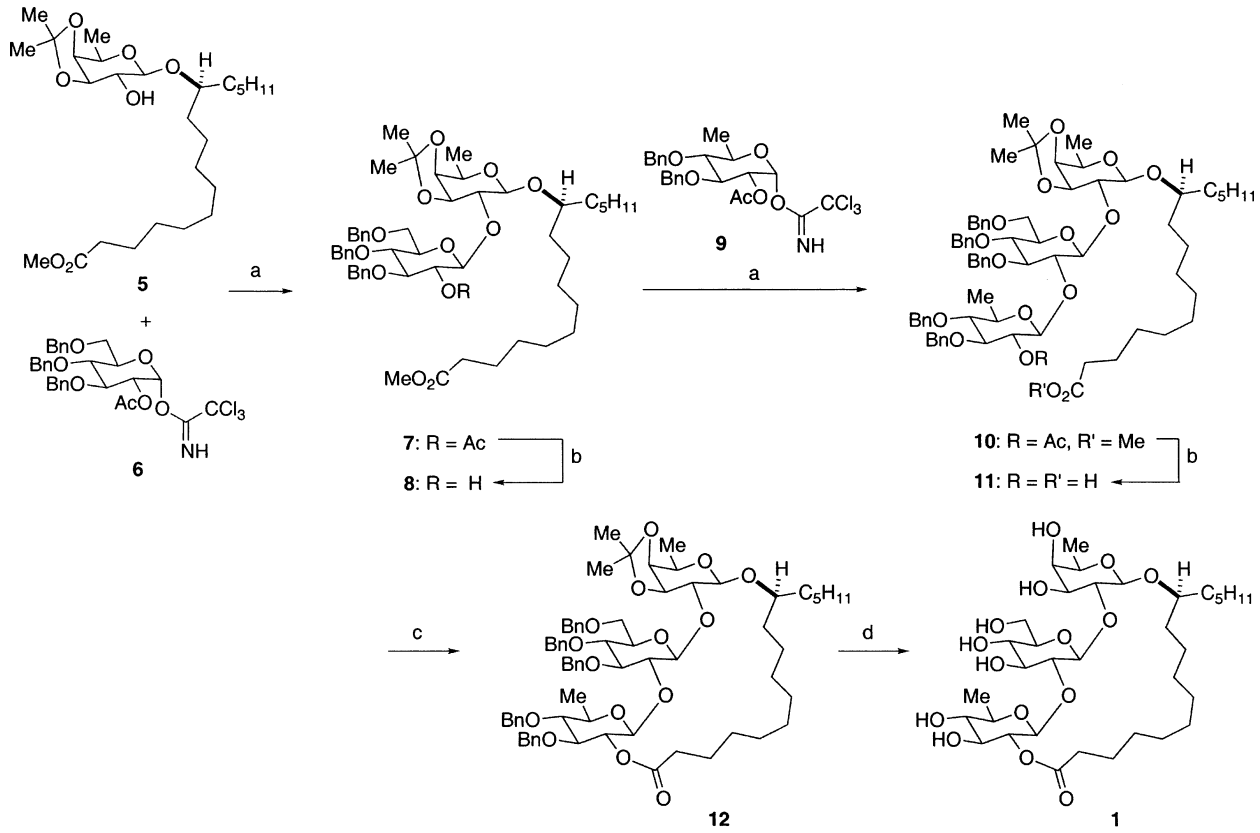
(3) University of California.

(4) Pereda-Miranda, R.; Bah, M. *Curr. Top. Med. Chem.* **2003**, *3*, 111−131.

(5) Pereda-Miranda, R.; Mata, R.; Anaya, A. L.; Wickramaratne, D. B. M.; Pezzuto, J. M.; Kinghorn, A. D. *J. Nat. Prod.* **1993**, *56*, 571−582.

10.1021/jo030244c CCC: $27.50 © 2004 American Chemical Society
Published on Web 01/06/2004

SCHEME 1[a]



[a] Key: (a) $BF_3{\cdot}Et_2O$, CH_2Cl_2, −20 °C, 1 h; (b) NaOMe, MeOH, 4 h, rt; (c) 2,4,6-trichlorobenzoyl chloride, Et_3N, DMAP, benzene; (d) H_2, 10% $Pd(OH)_2/C$, 10% HCl−MeOH, MeOH.

cock[8] and by Lu et al.,[9] using a macrolactonization approach, and by Fürstner and Müller,[10] employing a ring-closing-metathesis strategy.

The approach followed by Bah and Pereda-Miranda[7] for establishing the structure of tricolorin F was to carry out acid-catalyzed hydrolysis, which indicated that the aglycon fragment corresponds to (11*S*)-hydroxyhexadecanoic acid (jalapinolic acid) and the trisaccharide fragment was composed of D-fucose (6-deoxy-D-galactose), D-glucose, and D-quinovose (6-deoxy-D-glucose). Because of signal overlapping in the region δ 3.5−4.5, it was necessary to peracetylate tricolorin F to fully resolve its ^{1}H NMR spectrum. The interglycosidic connectivities and site of lactonization were established on the basis of the observed ^{13}C−^{1}H long-range cross-peaks ($^{2,3}J_{CH}$) in the HMBC experiments. Through this analysis, it was deduced that the structure of tricolorin F is (11*S*)-hydroxyhexadecanoic acid 11-*O*-β-D-quinovopyranosyl-(1→2)-*O*-β-D-glucopyranosyl-(1→2)-β-D-fucopyranoside 1,2‴-lactone (**1**).

Our synthetic approach started with naturally occurring jalapinolic acid,[11] which was converted to the methyl ester and coupled with the known tri-*O*-acetyl-α-D-fucopyranosyl imidate in the presence of $BF_3{\cdot}Et_2O$ (Scheme 1). The resulting glycoside was deacetylated and trasformed to the glycosyl acceptor **5**.[8,9] The next reaction sequence involved the preparation of known glycosyl donor 2-*O*-acetyl-3,4,6-tri-*O*-benzyl-D-glucopyranosyl imidate **6**,[12] which was chosen as a glycosyl donor because it can be selectively deprotected under basic conditions at position 2, the point of attachment for the quinovose glycosyl acceptor. The coupling reaction between **5** and **6** in the presence of $BF_3{\cdot}Et_2O$ produced disaccharide **7** in 70% yield. That **7** had the desired β-configuration at the new glycosidic linkage was shown by the observed $^3J_{H-H}$[4,7] values between glucose H-1 (δ 4.73, d, $J_{1,2}$ = 8.0 Hz) and H-2 (δ 4.95, dd, $J_{2,3}$ = 8.0 Hz). Methanolysis of the acetyl group produced glycosyl acceptor **8** in quantitative yield.

The third sugar residue was the synthetically challenging quinovose, which was subsequently transformed to the glycosyl donor 2-*O*-acetyl-3,4-di-*O*-benzyl-α-D-quinovosyl trichoroacetimidate **9** following a procedure similar to the one described for the synthesis of a rhamnosyl analogue. The coupling reaction between **8** and **9** under the influence of $BF_3{\cdot}Et_2O$ afforded trisaccharide **10**. Again, the β-anomeric configuration for the new glycosidic bond was confirmed by the vicinal coupling

(6) Bah, M.; Pereda-Miranda, R. *Tetrahedron* **1996**, *52*, 13063−13080.
(7) Bah, M.; Pereda-Miranda, R. *Tetrahedron* **1997**, *53*, 9007−9022.
(8) (a) Larson, D. P.; Heathcock, C. H. *J. Org. Chem*. **1996**, *61*, 5208−5209. (b) Larson, D. P.; Heathcock, C. H. *J. Org. Chem*. **1997**, *62*, 8406−8418.
(9) Lu, S.-F.; O'Yang, Q. Q.; Guo Z−W.; Yu, B.; Hui, Y.-Z. *J. Org. Chem*. **1997**, *62*, 8400−8405.
(10) Fürstner A.; Müller, T. *J. Org. Chem*. **1998**, *63*, 424−425.
(11) (*S*)-Hydroxyhexadecanoic acid (jalapinolic acid) is available by hydrolysis of the crude convolvulaceous resins (ref 4) and also by total synthesis (ref 8).
(12) Schmidt, R. R.; Effenberger, G. *Carbohydr. Res*. **1987**, *171*, 59−79.

between quinovose H-1 (δ 5.29, d, $J_{1,2} = 8.0$ Hz) and H-2 (δ 5.48, dd, $J_{2,3} = 9.6$ Hz). Basic hydrolysis of the acetate and methyl ester gave tricoloric acid C (**11**).

The critical lactonization step was achieved following the Yamaguchi protocol, providing protected tricolorin F (**12**). Removal of the acetonide and benzyl groups was accomplished by hydrogenolysis under acidic conditions to obtain synthetic tricolorin F (**1**) identical by ^{1}H and ^{13}C NMR with an authentic sample of the natural product.[4]

Experimental Section

General Methods. Unless otherwise stated, ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ and C_5D_5N solution at 400 and 125 MHz, respectively. Coupling constants (J) are reported in Hz. Specific rotations were measured in CH_2Cl_2 at rt. Reagents and solvent were used as received from commercial suppliers. All intermediates were purified by flash chromatography on silica gel and eluted with EtOAc in hexanes. Reaction progress was monitored on glass silica gel 60 (E. Merck), heating after dipping in CAM solution ($(NH_4)_6Mo_7O_{24}\cdot 6H_2O$ (5 g) and $Ce(SO_4)_2$ (100 mg) in 5% aq H_2SO_4 (100 mL)).

Methyl (11S)-11-[[(2-*O*-Acetyl-3,4,6-tri-*O*-benzyl-*β*-D-glucopyranosyl)-(1→2)-3,4-*O*-isopropylidene-*β*-D-fucopyranosyl]oxy]hexadecanoate (7). Alcohol **5** (50 mg, 0.108 mmol) and imidate **6** (68 mg, 0.108 mmol) were coevaporated in freshly distilled benzene, and the oily residue was dissolved in 1 mL of CH_2Cl_2, and cooled to −20 °C. After careful addition of $BF_3\cdot Et_2O$ (0.25 M in Et_2O, 0.1 mL), the reaction was allowed to proceed for 1 h. The reaction mixture was treated with a saturated solution of $NaHCO_3$ and the resulting mixture extracted with CH_2Cl_2. The organic phase was dried over Na_2SO_4, filtered, and evaporated in vacuo. Purification by chromatography on silica gel, eluting with 20% EtOAc in hexanes, gave 60 mg (70%) of compound **7** as an oil: $[\alpha]_D$ −15 (*c* 1.8, CH_2Cl_2); IR (thin film) 1742 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.89 (t, $J = 7.0$, 3H) [Jal-16], 1.22−1.43 (m, 20H), 1.28 (s, 3H), 1.33 (d, $J = 6.5$, 3H) [Fuc-6], 1.39−1.49 (m, 5H), 1.44 (s, 3H), 1.50−1.59 (m, 2H), 1.97 (s, 3H), 2.26 (t, $J = 7.5$, 2H) [Jal-2], 3.42 (brd, $J = 10.0$, 1H) [Glu-5], 3.53 (quintet, $J = 6.0$, 1H) [Jalp-11], 3.63 (s, 3H), 3.78−3.65 (m, 6H), 3.92 (dd, $J = 1.9$, 5.7, 1H) [Fuc-4], 4.03 (dd, $J = 6.0$, 7.0, 1H), 4.26 (d, $J = 7.0$ Hz, 1H) [Fuc-1], 4.52 (d, $J = 12.0$, 1H), 4.58 (d, $J = 11.0$, 1H), 4.64 (d, $J = 12.0$, 1H), 4.66 (d, $J = 11.0$, 1H), 4.73 (d, $J = 8.0$, 1H) [Gluc-1], 4.74 (d, $J = 11.0$, 1H), 4.77 (d, $J = 11.0$, 1H), 4.95 (dd, $J = 8.0$, 8.0, 1H) [Glu-2], 7.10−7.51 (m, 15H); ^{13}C NMR ($CDCl_3$): δ 14.1, 16.7, 21.0, 22.6, 24.7, 25.0, 25.2, 26.3, 27.8, 29.1, 29.3, 29.6, 29.8, 29.9, 32.1, 33.8, 34.2, 34.7, 51.4, 68.2, 68.5, 73.4, 73.6, 74.6, 74.8, 75.3, 76.3, 78.0, 78.9, 79.4, 79.8, 83.0, 100.0, 100.4, 109.5, 127.4, 127.6, 127.7, 127.8, 128.2, 128.4, 138.1, 138.2, 138.3, 169.4, 174.2; negative-ion HRFAB-MS *m*/*z* 945.5368 [M − H] (calcd for $C_{55}H_{77}O_{13}$ *m*/*z* 945.5364).

Methyl (11*S*)-11-[[(3,4,6-Tri-*O*-benzyl-*β*-D-glucopyranosyl)-(1→2)-3,4-*O*-isopropylidene-*β*-D-fucopyranosyl]oxy]-hexadecanoate (8). Compound **7** (50 mg, 0.053 mmol) was dissolved in anhydrous MeOH (1 mL), and a methanolic sodium methoxide solution (8 mg of Na in 1 mL MeOH) was added dropwise. The solution was stirred at rt under N_2 atmosphere for 4 h. The reaction solution was diluted with CH_2Cl_2, washed with cold 1 M HCl (10 mL), saturated solution of $NaHCO_3$ (2 × 10 mL), and water (1 × 10 mL), dried over Na_2SO_4, and evaporated with a rotary evaporator. Purification by chromatography on silica gel, eluting with 20% EtOAc in hexanes, gave 45 mg (95%) of an oily product: IR (thin film) 3500, 1738 cm^{-1}; $[\alpha]_D$ −6.8 (*c* 3.5, CH_2Cl_2); ^{1}H NMR ($CDCl_3$) δ 0.88 (t, $J = 6.5$, 3H) [Jal-16], 1.22−1.40 (m, 20H), 1.34 (s, 3H), 1.37 (d, $J = 6.5$, 3H) [Fuc-6], 1.46−1.53 (m, 2H), 1.53 (s, 3H), 1.60 (m, 2H), 2.28 (t, $J = 7.5$, 2H) [Jal-2], 3.65 (s, 3H), 3.59−3.71 (m, 5H), 3.75−3.79 (m, 2H), 4.00 (brd, $J = 5.5$, 1H) [Fuc-4], 4.16 (dd, $J = 7.5$, 7.5, 1H) [Fuc-2], 4.31 (d, $J = 7.5$, 1H) [Fuc-1], 4.47 (d, $J = 12.0$, 1H), 4.53 (brd, 2H), 4.62 (d, $J = 12.0$, 1H), 4.78 (d, $J = 12.0$, 1H), 4.83 (d, $J = 11.0$, 1H), 5.01 (d, $J = 11.0$, 1H), 7.10−7.51 (m, 15H); ^{13}C NMR ($CDCl_3$) δ 14.5, 16.8, 23.0, 25.0, 25.3, 25.5, 26.5, 28.3, 29.3, 29.6 (x2), 29.8, 29.9, 32.1, 33.8, 34.5 (x2), 51.5 68.8, 69.0, 71.5, 72.3, 73.5, 75.0 (x2), 75.8, 76.0, 78.5, 79.0, 79.8, 84.0, 100.0, 103.8, 109.5, 127.4, 127.6, 127.7, 127.8, 128.2, 128.4, 138.1, 138.2, 138.3, 174.2; negative-ion HRFAB-MS *m*/*z* 903.5260 [M − H] (calcd for $C_{53}H_{75}O_{12}$ 903.5258).

Methyl 11(*S*)-11-[[2-*O*-Acetyl-3,4-di-*O*-benzyl-*β*-D-quinovosyl)-(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-glucopyranosyl)-(1→2)-3,4-*O*-isopropylidene-*β*-D-fucopyranosyl]oxy]hexadecanoate (10). Compound **8** (32 mg, 0.035 mmol) and imidate **9** (19 mg, 0.035 mmol) were coevaporated with freshly distilled benzene. The oily residue was dissolved in 1.5 mL of CH_2Cl_2, and the resulting solution was cooled to −20 °C and then treated with ethereal $BF_3\cdot Et_2O$ (0.25 M, 0.05 mL). The resulting mixture was stirred for 1 h under N_2, the reaction was then quenched by the addition of saturated aqueous $NaHCO_3$, and the resulting mixture was extracted with CH_2Cl_2. The organic phase was dried over Na_2SO_4 and evaporated with a rotary evaporator. Purification by chromatography, eluting with 20% EtOAc in hexanes, gave 27 mg (60%) of **10** as a syrup: $[\alpha]_D$ −14 (*c* 7.3, CH_2Cl_2); IR (thin film) 1747 cm^{-1}; ^{1}H NMR (C_5D_5N) δ 0.84 (t, $J = 7.0$, 3H) [Jal-16], 1.22−1.40 (m, 20H), 1.48−1.51 (m, 4H), 1.40 (s, 3H), 1.50 (d, $J = 6.1$, 3H) [Qui-6], 1.52 (d, $J = 6.5$, 3H) [Fuc-6], 1.56 (s, 3H), 2.02 (s, 3H), 1.60−1.66 (m, 3H), 2.31 (t, $J = 7.5$, 2H) [Jal-2], 3.45 (dd, $J = 9.2$, 9.2, 1H) [Qui-4], 3.61 (s, 3H), 3.66 (dq, $J = 6.2$, 9.3, 1H) [Qui-5], 3.73 (m, 1H) [Glu-5], 3.83−4.03 (m, 6H), 4.07 (dd, $J = 7.5$, 8.0, 1H) [Glu-2], 4.22 (dd, $J = 2.0$, 6.0, 1H) [Fuc-4], 4.35 (dd, $J = 6.2$, 7.1, 1H) [Fuc-3], 4.66 (d, $J = 11.3$, 1H), 4.70−4.74 (m, 5H), 4.83 (d, $J = 11.3$, 1H), 4.85 (d, $J = 11.3$, 1H), 4.96 (d, $J = 11.3$, 1H), 4.98 (d, $J = 11.3$, 1H), 5.04 (d, $J = 11.3$, 1H), 5.14 (d, $J = 11.3$, 1H), 5.29 (d, $J = 8.0$, 1H) [Qui-1], 5.40 (d, $J = 7.5$, 1H) [Glu-1], 5.48 (dd, $J = 8.0$, 9.6, 1H) [Qui-2], 7.14−751 (m, 25H); ^{13}C NMR (C_5D_5N) δ 12.8, 15.7, 16.9, 19.5, 21.4, 23.8 (x2), 24.1, 24.9, 26.5, 27.9, 28.3, 28.5, 28.7, 29.0, 30.7, 32.6, 33.3, 33.8, 50.0, 67.2, 67.6, 70.4, 71.9, 72.9, 73.3, 73.7, 73.9, 74.0, 74.1, 75.2, 75.4, 77.4, 77.8, 78.2, 79.5, 82.2, 82.5, 83.7, 98.1, 99.4, 99.8, 108.2, 127.3, 127.5, 128.5, 138.9, 168.4, 172.4; negative-ion HRFAB-MS *m*/*z* 1271.6885 [M − H] (calcd for $C_{75}H_{99}O_{17}$ *m*/*z* 1271.6882).

11(*S*)-11-[[2-*O*-Acetyl-3,4-di-*O*-benzyl-*β*-D-quinovosyl)-(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-glucopyranosyl)-(1→2)-3,4-*O*-isopropylidene-*β*-D-fucopyranosyl]oxy]hexadecanoic Acid (11). A solution of compound **10** (20 mg, 0.015 mmol) and KOH (10 mg) in CH_3OH-H_2O (4 mL, 9:1 v/v) was refluxed for 4 h. The resulting solution was dissolved in 5 mL of CH_2Cl_2 and washed with 1 M HCl (1 × 5 mL), dried over Na_2SO_4 and evaporated. Purification by chromatography, eluting with 20% EtOAc in hexanes, gave 15 mg (80%) of acid **11** as a syrup: $[\alpha]_D$ −8 (*c* = 0.90, CH_2Cl_2); IR (CH_2Cl_2 solution) 3430, 1710 cm^{-1}; ^{1}H NMR (C_5D_5N) δ 0.79 (t, $J = 7.0$, 3H) [Jal-16], 1.18−1.25 (m, 20H), 1.34 (s, 3H), 1.47 (d, $J = 6.5$, 3H) [Fuc-6], 1.48 (d, $J = 6.1$, 3H) [Qui-6], 1.53 (s, 3H), 1.57 (m, 3H), 1.65 (m, 2H), 2.45 (t, $J = 7.5$, 2H) [Jal-2], 3.37 (dd, $J = 9.0$, 9.0, 1H) [Qui-4], 3.62 (dq, $J = 6.1$, 9.0, 1H), [Qui-5], 3.70 (m, 1H) [Glu-5], 3.79 (quintet, $J = 6.0$, 1H) [Jal-11], 3.95−3.80 (m, 6H), 3.99 (dd, $J = 7.7$, 8.5, 1H) [Qui-2], 4.12 (dd, $J = 2.0$, 6.5, 1H) [Fuc-4], 4.14 (dd, $J = 7.2$, 8.5, 1H) [Glu-2], 4.31 (dd, $J = 6.5$, 7.5, 1H) [Fuc-3], 4.67 (d, $J = 7.5$, 1H) [Fuc-1], 4.63 (d, $J = 12.0$, 1H), 4.66 (d, $J = 12.0$, 1H), 4.68 (d, $J = 12.0$, 1H), 4.69 (dd, $J = 6.5$, 7.5, 1H) [Fuc-2], 4.71 (d, $J = 11.2$, 1H), 4.79 (d, $J = 11.2$, 1H), 4.99 (d, $J = 10.5$, 1H), 5.01 (d, $J = 10.3$, 1H), 5.03 (d, $J = 11.5$, 1H), 5.15 (d, $J = 7.7$, 1H) [Qui-1], 5.31 (d, $J = 11.5$, 1H), 5.33 (d, $J = 10.3$, 1H), 5.40 (d, $J = 7.2$, 1H) [Glu-1], 6.97−7.66 (m, 25H); ^{13}C NMR (C_5D_5N) δ 14.1, 17.6, 18.4, 22.5, 22.6, 24.9, 25.3, 25.6, 26.5, 27.7, 29.3, 29.6, 29.9, 29.5, 30.1, 31.9, 34.5, 34.9, 37.4, 68.3, 69.2, 71.4, 73.2, 74.4, 74.7, 74.8, 75.3, 75.8, 76.5, 76.8, 78.5, 79.5, 80.4, 83.4, 85.2,

85.4, 99.5, 100.9, 103.6, 109.6, 127.2, 127.5, 128.2, 128.5, 138.9, 178.1; negative-ion HRFAB-MS *m*/*z* 1215.6646 $[M - H]^-$ (calcd for $C_{72}H_{95}O_{16}$ *m*/*z* 1215.6620).

11(*S*)-11-[[3,4-Di-*O*-benzyl-*β*-D-quinovosyl)-(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-glucopyranosyl)-(1→2)-3,4-*O*-isopropylidene-*β*-D-fucopyranosyl]oxy]hexadecanoic Acid 1,2‴-Lactone (12). 2,4,6-Trichlorobenzoyl chloride (0.012 mmol) was added to a mixture of hydroxy acid **11** (15 mg, 0.012 mmol) and Et_3N in benzene (5 mL), and the solution was stirred under N_2 for 2 h at rt. The resulting mixture was filtered through a short pad of Celite, diluted with toluene (5 mL), and added to a refluxing solution of DMAP (0.3 mmol) in toluene (10 mL) over a period of 6 h. The reaction was washed with cold 1 M HCl (1 × 5 mL), a saturated solution of $NaHCO_3$ (2 × 5 mL), and brine (1 × 5 mL) and dried over Na_2SO_4. The organic phase was concentrated and purified by chromatography on silica gel with 2% EtOAc in hexanes to give 9 mg (60%) of compound **12** as a syrup: $[\alpha]_D$ −28 (*c* = 0.80, CH_2Cl_2); IR (CH_2Cl_2 solution) 1738 cm^{-1}; ^1H NMR ($CHCl_3$) *δ* 0.86 (t, 3 H, *J* = 7.1), 1.13−1.90 (m, 33H), 2.30−2.58 (m, 2H), 3.50−4.40 (m, 15H), 4.42 (d, *J* = 10.8 Hz, 1H), 4.59 (d, *J* = 10.8 Hz, 1H); 4.62 (d, *J* = 10.5 Hz, 1H); 4.80−5.00 (m, 8H), 5.47 (m, 1H), 5.50 (dd, *J* = 7.5, 8.5, 1H) [Qui-2], 7.10−8.40 (m, 25H); ^{13}C NMR (C_5D_5N) *δ* 14.2, 17.7, 18.3, 22.4, 22.5, 24.8, 25.3, 25.7, 26.5, 27.8, 29.3, 29.7, 29.9, 29.5, 30.1, 31.9, 34.5, 34.9, 37.4, 67.6, 69.5, 71.9, 73.2, 74.4, 74.8, 74.9, 75.2, 75.3, 76.2, 76.9, 77.4, 77.9, 80.3, 80.4, 83.1, 85.0, 85.2, 100.0, 101.7, 101.9, 109.6, 127.2, 127.5, 128.2, 128.5, 138.9, 178.1; negative-ion HRFAB-MS *m*/*z* 1197.6517 $[M - H]^-$ (calcd for $C_{72}H_{93}O_{15}$ *m*/*z* 1197.6514).

(11*S*)-Hydroxyhexadecanoic Acid 11-*O*-*β*-D-Quinovopyranosyl-(1→2)-*O*-*β*-D-glucopyranosyl-(1→2)-*β*-D-fucopyranoside 1,2‴-Lactone (Tricolorin F, 1). To a solution of **12** (15 mg, 0.012 mmol) in 0.5 mL of MeOH was added 0.5 mL of 10% HCl in MeOH and 8 mg of $Pd(OH)_2$−C 10% (Pearlman's catalyst). The reaction mixture was evacuated, back-filled with H_2, and stirred overnight under the pressure of a balloon filled with H_2. The reaction mixture was basified with 0.5 mL of Et_3N and filtered through a small plug of Celite. Purification by chromatography was performed with a short column, eluting with 10:10:1 acetone−chloroform−methanol, to give 7 mg (80%) of tricolorin F (**1**) as a white solid: mp 116−118 °C; $[\alpha]_D$ −30 (*c* = 0.1, MeOH); ^1H NMR (C_5D_5N) *δ* 0.85 (t, *J* = 7, 3H), 1.20−1.70 (m, 30H), 1.55 (d, *J* = 6.1, 1H), 1.72(d, *J* = 5.8, 1H), 2.42−2.60 (m, 2H), 3.77 (m, 2H), 3.81 (m, 2H), 3.94 (m, 1H), 4.05−4.09 (m, 2H), 4.17−4.20 (m, 4H), 4.36−4.38 (m, 2H), 4.74 (d, *J* = 7.5, 1H) [Fuc-1], 5.23 (d, *J* = 7.5, 1H) [Glu-1], 5.23 (d, *J* = 7.5, 1H) [Qui-1], 5.65 (dd, *J* = 7.5, 8.5, 1H) [Qui-2]; ^{13}C NMR (C_5D_5N) *δ* 13.8, 16.9, 17.8, 18.8, 22.5, 25.2, 28.5, 29.0, 32.0, 35.1, 63.6, 71.3, 73.6, 74.7, 75.5, 76.2, 81.1, 103.0, 173.2; positive-ion HRFAB-MS *m*/*z* 731.3833 $[M + Na]^+$ (calcd for $C_{34}H_{60}O_{15}Na$ *m*/*z* 731.3829). The spectra were identical with those of an authentic sample of natural tricolorin F.[7]

Acknowledgment. This work was supported by the National Institutes of Health (GM 46057). The National Council of Science and Technology of Mexico (CONACyT) is thanked for funding the sabbatical visit of M.B.A. to the University of California (010141). R.P.-M. acknowledges financial support from Direccion General de Asuntos del Personal Academico, UNAM (IN200902-2). We thank Mariela Colón and Chambers Hughes for NMR determination.

Supporting Information Available: NMR spectra of **7**, **8**, **10**, **11**, **12**, **1**, and authentic tricolorin F. This material is available free of charge via the Internet at http://pubs.acs.org.

JO030244C