An Efficient Derivation of the Versatile Chiron Antipode 1-*tert*-Butyldimethylsilylpenta-1,4-diyn-3-ol: Application to the Synthesis of (15*E*,*R*,*R*)-Duryne

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The title chiron, 1-*tert*-butyldimethylsilylpenta-1,4-diyn-3-ol (**5**), an essential segment of various bioactive polyacetylenic alcohols, has been efficiently resolved via a lipase-catalyzed acylation strategy. Lipases from different *Pseudomonas* species and *Candida rugosa* (CRL) furnished its (*S*)-antipode (as esters) with 86−96% ee. However, the (*R*)-alcohol **5** could be prepared with acceptable enantiomeric purity (93% ee) only using CRL−vinyl acetate−diisopropyl ether as the reagent protocol and under double filtration conditions. The chiron alcohol was then extended to the target compound (15*E*,*R*,*R*)-duryne (**I**) by its pyranylation, alkylation with the required achiral C_{20}-α,ω-dibromide **15**, and suitable functionalization.

Chirons with a small C-framework and possessing a diverse array of functionalities are essential in designing efficient enantiomeric syntheses of bioactive compounds. Thus, preparation of these intermediates not only assumes contemporary significance but also provides a great challenge especially when these are not easily amenable from the natural pool materials. The title compound 1-*tert*-butyldimethylsilylpenta-1,4-diyn-3-ol (**5**) is one such versatile chiron which can be derivatized to different types of compounds.

Furthermore, this also constitutes the precursor chiral segment of the bioactive polyacetylenic alcohols which are of recent interest. These 1,4-enynic-3-ols, obtained from marine sponges in the genera of *Cribrochaline*,[1] *Siphonochaline*,[2] *Petrosia*,[3a,b] etc. are attractive synthetic targets due to their structural novelty and unprecedented pharmacological activity. These compounds are known to exhibit[4] a very wide spectrum of bioactivity which includes antibacterial, antifungal, cytotoxic, and antitumor properties. Moreover, some of these even show unusual differential cytotoxicity profiles for different human tumor cell lines. Earlier, we have synthesized[5,6] several such compounds in racemic form. However, in view of the presence of stereogenic centers in these, lack of their efficient enantioselective syntheses, and low natural abundance, development of their enantioselective syntheses might provide better bioassay results. Hence, we developed an efficient synthesis of **5** and exploited it for the synthesis of the polyacetylenic alcohol, duryne (**I**), isolated[7] from the Caribbean sponge, *Cribrochalina dura*. Compound **I** is a symmetric long chain molecule (C_{30}) with the fragile 1,4-enyn-3-ol unit at its two terminals and is known to exhibit in vitro inhibitory activity against the growth of P388 murine leukemia and several human tumor cell lines. The absolute configurations of its two stereogenic centers as well as the olefinic geometry at C-15 are yet unresolved. Attempted correlation between the optical rotation and absolute configuration even for the homologues of these polyacetylenic alcohols has so far been misleading.[8] In this paper, we report the synthesis of its (15*E*,*R*,*R*)-isomer. However, since our strategy ensures availability of the key chiron in its antipodal forms and involves fixation of the C-15 olefin geometry via an acetylenic intermediate, the protocol can be extended to all possible stereoisomers of the target compound. So far only one synthesis of (±)-**I** has been reported,[9] and to the best of our knowledge, this is the first enantioselective synthesis of **I**.

From the retrosynthetic perspective, compound **I** can be prepared by alkylation of two molecules of the chiron by a symmetrical C_{20}-unit with terminal electrophilic centers and subsequent functionalization. On the basis of this analysis, we proceeded for the synthesis as follows.

Preparation of the Chiron. The propargyl alcohol derivative **1**[5] was C-silylated with TBSCl (*tert*-butyldimethylsilyl chloride) to furnish **2**. Its acid-catalyzed deprotection[10] gave the alcohol **3** which was oxidized with buffered pyridinium chlorochromate (PCC)[11] to furnish the aldehyde **4**. This on reaction with lithium acetylide afforded the key racemic synthon **5**. The next job was the resolution of **5** for which its enzyme catalyzed *trans*-esterification was attempted using different acylating agents and lipases (Table 1). Previously, several groups attempted[12a−c] lipase-catalyzed resolution of secondary

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Table 1. Lipase-Catalyzed Resolution of 1-*tert*-Butyldimethylsilylpenta-1,4-diyn-3-ol (5)

entry	lipase	acylating agent	solvent	% convrsn	% ee of alcohol	% ee of ester
1	PPL	vinyl acetate	diisopropyl ether	nd[a]		
2	PFL	vinyl acetate	CH_2Cl_2	26	25	87
3	PFL	TFEB	CH_2Cl_2	30	27	86
4	PSL	vinyl acetate	vinyl acetate	35	35	91
5	CRL	vinyl acetate	hexane	5	nd	nd
6	CRL	vinyl acetate	diisopropyl ether	35	71	96
7	CRL	vinyl acetate	diisopropyl ether	30[b]	93	nd

[a] No appreciable conversion was noticed. [b] Reaction done on the partially resolved alcohol obtained from the previous entry.

alkynols via hydrolysis. Among these, the pioneering contribution of Burgess and Jennings appears to be the best for practical application. We have also reported[12d] the first nonhydrolytic enzymatic protocol for the resolution of some alkyn-3-ols in organic medium. Among the enzymes tried for the present work, only the lipases from *Pseudomonas* and *Candida* were promising, (*S*)-**5** being the more reactive isomer in all the cases. With different *Pseudomonas* lipases, although good enantioselection was obtained for the (*S*)-esters the % ee's of the resolved alcohol (*R*)-**5** were modest. In contrast, better enantiocontrol was achieved using the *Candida rugosa* lipase (CRL) in conjunction with vinyl acetate as the acylating agent. Diisopropyl ether was the best solvent where at 35% conversion the (*S*)-acetate **6** and the resolved (*R*)-alcohol **5** were obtained in 96% and 71% ee's, respectively. For its optical enrichment, the partially resolved alcohol **5** was reacetylated until 30% conversion, to obtain the (*R*)-alcohol **5** with 93% ee. The efficacy of CRL for the resolution of **5** is in corroboration with our recently reported[12d] method for the resolution of alkyn-3-ols with the same lipase. The % ee's of the chirons were determined by the ^{1}H NMR analyses of their (*R*)-MTPA esters[13] in the presence of Eu(fod)$_3$. The signals for the OMe protons appeared at δ 4.28 and 4.37, respectively, for the compounds derived from (*R*)- and (*S*)-**5**. The (*R*)-alcohol **5** was then pyranylated to give the synthon **7**. The absolute configurations of **5** and **6** were empirically assigned on the basis of on our earlier result[12d] in CRL-catalyzed acylation of alkyn-3-ols. For confirmation, **7** was converted to the known compound 3-octanol[14] by alkylation with 1-bromopropane, depyranylation, desilylation, and hydrogenation. The optical data of the synthetic sample corroborated with that of (*S*)-3-octanol, and thus, the starting chiron was of opposite, i.e., (*R*)-configuration since the Cahn−Ingold−Prelog priority sequence is changed in the above transformations.

Preparation of the Achiral C_{20}-Unit. The easily available bromohydrin **8**[15] was pyranylated to afford compound **9**. On the other hand, the known alkynoic acid **10**[16] was reduced with LAH to furnish the alcohol **11** which on pyranylation gave the C_{11}-unit **12**.[5] Its was then alkylated at its alkyne terminus with the bromide **9** to afford **13**. Its depyranylation to the diol **14** and subsequent bromination with $Ph_3P{\cdot}Br_2$[17] gave the required C_{20}-synthon **15**.

Synthesis of (15*E*,*R*,*R*)-*I*. Alkylation of 2 mol of **7** with **15** in the presence of *n*-BuLi as the base gave compound **16** in modest yield. Its desilylation was carried out by treating with TBAF[18] in THF to afford **17**. This on subsequent acidic deprotection furnished the diol **18**. Stereo- and regioselective partial reduction of its internal alkyne functionalities with Li/NH_3[19ab] finally gave (15*E*,*R*,*R*)-**I** (Scheme 1) whose spectral data were similar to those reported.[7] However, due to the uncertainity of the absolute configuration as well as the olefinic geometry at the C-15 position of natural **I**, no correlation between the chiroptical data of natural and the synthetic **I** was possible.

Experimental Section

1-(Tetrahydropyranyloxy)-2-propyne (1). A mixture of propargyl alcohol (10.0 g, 0.18 mol), DHP (3,4-dihydropyran) (18.0 g, 0.21 mol), and PPTS (0.2 g) in CH_2Cl_2 (100 mL) was stirred for 3 h. The reaction was quenched with 10% aqueous $NaHCO_3$, the organic layer was separated, and the aqueous layer was extracted with $CHCl_3$. The combined organic extract was washed with water and brine and finally dried. Removal of solvent in vacuo followed by column chromatography (silica gel, 0−10% EtOAc/hexane) of the residue gave pure **1**[5] (20.0 g, 80%): IR 3260, 2100, 880, 810 cm^{-1}; ^{1}H NMR δ 1.3−1.6 (m, 6H), 2.2 (t, J = 1.2 Hz, 1H), 3.4−3.7 (m, 2H), 4.15 (d, J = 2.1 Hz, 2H), 4.75 (br s, 1H). Anal. Calcd for $C_8H_{12}O_2$: C, 68.54; H, 8.63. Found: C, 68.68; H, 8.79.

1-(Tetrahydropyranyloxy)-3-*tert*-butyldimethylsilyl-2-propyne (2). To a cooled (−30 °C) and stirred solution of **1** (10.0 g, 0.07 mol) in THF (50 mL) was added *n*-BuLi (49.1 mL, 0.078 mol, 1.6 M in hexane). After 1 h, the reaction mixture was cooled to −78 °C and TBSCl (12.9 g, 0.086 mol) in THF (30 mL) added. Stirring was continued for 3 h at the same temperature and at room temperature for an additional 3 h. The reaction was quenched with an aqueous saturated NH_4-Cl solution, the organic layer was separated, and the aqueous portion was extracted with ether. The combined organic extract was washed with water and brine and finally dried. Removal of solvent followed by column chromatography (silica gel, 0−5% EtOAc/hexane) of the residue gave pure **2** (12.9 g, 71%): IR 2820, 2200, 880, 810 cm^{-1}; ^{1}H NMR δ 0.1 (s, 6H), 0.9 (s, 9H), 1.4−1.6 (m, 6H), 3.5−3.7 (m, 2H), 4.1 (s, 2H), 4.75 (br s, 1H). Anal. Calcd for $C_{14}H_{26}O_2Si$: C, 66.08; H, 10.30. Found: C, 65.87; H, 10.42.

3-*tert*-Butyldimethylsilylprop-2-yn-1-ol (3). A solution of **2** (12.5 g, 0.049 mol) and PTS (0.1 g) in MeOH (30 mL) was refluxed until depyranylation was complete (∼4 h). Most of the solvent was removed in vacuo, the residue was dissolved in EtOAc, and the organic extract was washed with water and brine. After drying and removal of solvent, the crude product was purified by column chromatography (silica gel, 0−15% EtOAc/hexane) to furnish **3** (7.7 g, 92%): IR 3380, 2180, 1280 cm^{-1}; ^{1}H NMR δ 0.1 (s, 6H), 0.93 (s, 9H), 1.9 (br s, D_2O exchangeable, 1H), 4.27 (s, 2H). Anal. Calcd for $C_9H_{18}OSi$: C, 63.46; H, 10.65. Found: C, 63.68; H, 10.40.

3-*tert*-Butyldimethylsilylprop-2-ynal (4). To a cooled (0 °C) and stirred mixture of **3** (7.5 g, 0.044 mol) and anhydrous NaOAc (0.5 g, 6.0 mmol) in CH_2Cl_2 (30 mL) was added PCC (14.3 g, 0.067 mol). After stirring for 3 h, the mixture was diluted with an equal volume of ether and the organic extract passed through a 2 in. pad of silica gel. The eluent on

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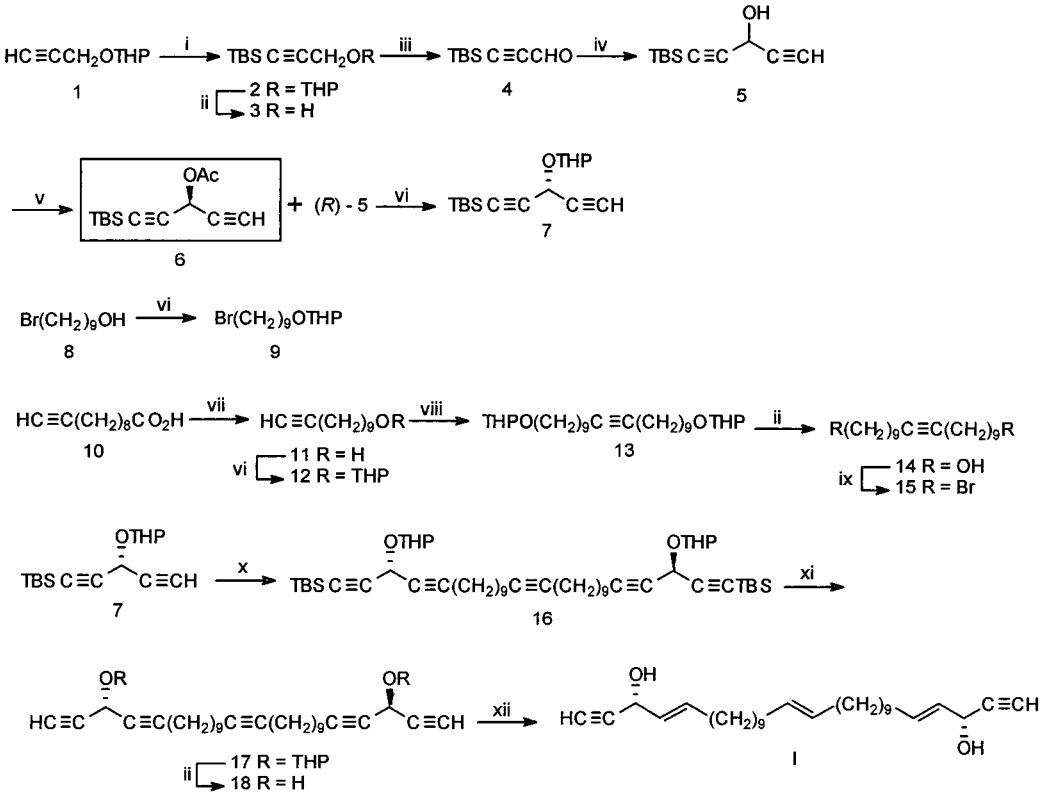
Scheme 1



i) *n*-BuLi/THF/TBSCl/-78 °C, ii) MeOH/PTS, iii) PCC/NaOAc/CH_2Cl_2, iv) HC≡CH/*n*-BuLi/THF/-40 °C, v) CRL/Vinyl acetate/diisopropyl ether, vi) DHP/PPTS/CH_2Cl_2, vii) LAH/ether, viii) *n*-BuLi/**9**/THF-HMPA, ix) Ph_3P/Br_2/Pyridine/CH_2Cl_2, x) *n*-BuLi/**15**/THF-HMPA, xi) TBAF/THF, xii) Li/NH_3.

concentration in vacuo gave **4** (5.6 g, 76%): IR 2720, 2180, 1720, 880, 810 cm^{-1}.

1-*tert*-Butyldimethylsilylpenta-1,4-diyn-3-ol (5). To a stirred and cooled (−40 °C) saturated solution of acetylene in THF (50 mL) was added *n*-BuLi (30.6 mL, 0.049 mol, 1.6 M in hexane) at the same temperature. After 0.5 h, **4** (5.5 g, 0.033 mol) in THF (20 mL) was introduced in the mixture which was stirred for 3 h at −40 °C and for 12 h at room temperature. It was poured in ice−water, the organic layer was separated, and the aqueous portion was extracted with ether. The combined extract was washed with water, brine, dried, and concentrated. The product obtained was purified by column chromatography over silica gel (0−15% EtOAc/hexane) to furnish **5** (3.9 g, 61%): IR 3440, 3300, 2180 cm^{-1}; ^1H NMR δ 0.11 (s, 6H), 0.95 (s, 9H), 1.5 (br s, D_2O exchangeable, 1H), 2.5 (d, J = 2.1 Hz, 1H), 5.1 (d, J = 2.4 Hz, 1H). Anal. Calcd for $C_{11}H_{18}OSi$: C, 67.98, H, 9.33. Found: C, 68.17; H, 9.57.

(*S*)-3-Acetoxy-1-*tert*-butyldimethylsilylpenta-1,4-diyne (6). A mixture of **5** (2.0 g, 0.01 mol), vinyl acetate (1.72 g, 0.02 mol), and CRL (0.5 g) in diisopropyl ether (20 mL) was stirred until 35% completion (~32 h). The mixture was filtered, the precipitated enzyme was washed with EtOAc, and the extract was concentrated in vacuo. The residue was chromatographed over silica gel column (0−15% EtOAc/hexane) to give (*R*)-**5** (1.14 g, 57%) and (*S*)-**6** (0.754 g, 31%).

(*R*)-5: $[\alpha]^{22}_D$ +3.6 (*c* 1.6, $CHCl_3$).

(*S*)-6: $[\alpha]^{22}_D$ −60.1 (*c* 1.2, $CHCl_3$); IR 1730, 1210 cm^{-1}; ^1H NMR δ 0.1 (s, 6H), 0.9 (s, 9H), 2.4 (s, 3H), 2.8−3.0 (m, 1H), 4.8−4.9 (m, 1H). Anal. Calcd for $C_{13}H_{20}O_2Si$: C, 66.05; H, 8.53. Found: C, 66.19; H, 8.34.

Using the same protocol, (*R*)-**5** (1.14 g, 5.9 mmol) obtained above was acetylated with vinyl acetate (1.0 g, 11.8 mmol) until 30% completion (~40 h). From the reaction mixture, optically enriched **5** (0.684 g, 60%) was isolated as above.

(*R*)-5: $[\alpha]^{22}_D$ +5.9 (*c* 0.8, $CHCl_3$).

(*R*)-3-(Tetrahydropyranyloxy)-1-*tert*-butyldimethylsilylpenta-1,4-diyne (7). A solution of (*R*)-**5** (0.65 g, 3.4 mmol), DHP (0.42 g, 5.0 mmol), and PPTS (0.05 g) in CH_2Cl_2 (15 mL) was stirred at room temperature for 8 h. Usual isolation as described earlier and column chromatography (silica gel, 5% EtOAc/hexane) of the crude product furnished pure **7** (0.615 g, 66%): $[\alpha]^{22}_D$ +12.6 (*c* 1.4, $CHCl_3$); IR 880, 810 cm^{-1}; ^1H NMR δ 0.12 (s, 6H), 0.93 (s, 9H), 1.4−1.6 (m, 6H), 2.8−3.0 (m, 1H), 3.5−3.7 (m, 2H), 4.55 (br s, 1H), 4.95 (d, J = 2.2 Hz, 1H). Anal. Calcd for $C_{16}H_{26}O_2Si$: C, 69.01; H, 9.41. Found: C, 68.88; H, 9.22.

1-(Tetrahydropyranyloxy)-9-bromononane (9). As described for **1**, the alcohol **8**[15] (6.5 g, 0.029 mol) was pyranylated with DHP (2.94 g, 0.035 mol) and PPTS (0.1 g) in CH_2Cl_2 (50 mL) to give compound **9** (7.52 g, 84%): IR 880, 810 cm^{-1}; ^1H NMR δ 1.34 (br s, 14H), 1.5−1.7 (m, 6H), 3.42 (t, J = 6 Hz, 2H), 3.5−3.9 (m, 4H), 4.62 (br s, 1H).

10-Undecyn-1-ol (11). To a stirred suspension of LAH (2.5 g, 0.066 mol) in ether (50 mL) was added the acid **10**[16] (10.0 g, 0.055 mol) in ether (50 mL). The mixture was refluxed for 4 h and brought to room temperature, and the excess hydride was decomposed with aqueous saturated Na_2SO_4. The mixture was filtered and the solid residue washed with ether. The combined organic layer was concentrated in vacuo to yield **11**[5] (7.8 g, 84%): IR 3380, 3300, 2210 cm^{-1}; ^1H NMR δ 1.29 (br s, 14H), 2.1−2.4 (m, 3H), 2.84 (br s, D_2O exchangeable, 1H), 3.68 (t, J = 7 Hz, 2H).

1-(Tetrahydropyranyloxy)-10-undecyne (12). As described for **1**, compound **11** (7.5 g, 0.045 mol) was pyranylated with DHP (4.5 g, 0.054 mol) in CH_2Cl_2 (100 mL) in the presence of PPTS (0.2 g) to give the known compound **12**[5] (10.12 g, 90%): IR 3300, 2110, 880 and 810 cm^{-1}; ^1H NMR δ 1.32 (br s, 14H), 1.4−1.6 (m, 6H), 2.2−2.4 (m, 3H), 3.2−3.7 (m, 4H), 4.5 (br s, 1H).

Docos-10-yne-1,20-diol (14). To a cooled (−25 °C) and stirred solution of **12** (2.52 g, 0.01 mol) in THF (30 mL) was added *n*-BuLi (6.88 mL, 0.011 mol, 1.6 M in hexane). After stirring for 0.5 h at the same temperature, the mixture was cooled to −25 °C and HMPA (5 mL) was added followed by

the bromide **9** (3.4 g, 0.011 mol) in THF (40 mL). Stirring was continued for 6 h at the same temperature and at room temperature for 16 h. The reaction was quenched with aqueous saturated NH_4Cl, the organic layer was separated, and the aqueous portion was extracted with ether. The combined organic extract was washed with water and brine and dried. Removal of solvent followed by column chromatography of the residue over silica gel (0−15% EtOAc/hexane) gave pure **13** (3.25 g, 68%): IR 880 and 810 cm^{-1}; ^1H NMR δ 1.32 (br s, 28H), 1.4−1.6 (m, 12H), 1.9−2.2 (m, 4H), 3.2−3.8 (m, 8H), 4.53 (br s, 2H). Anal. Calcd for $C_{30}H_{54}O_4$: C, 75.26; H, 11.37. Found: C, 75.44; H, 11.61.

The above compound was then dissolved in MeOH (30 mL) and refluxed for 4 h in the presence of PTS (0.1 g) to furnish **14** (1.86 g, 88%): mp 75 °C; IR 3380, 1060 cm^{-1}; ^1H NMR δ 1.32 (s, 28H), 1.8−2.0 (m, 4H), 2.4 (br s, D_2O exchangeable, 2H), 3.68 (t, J = 7 Hz, 4H). Anal. Calcd for $C_{20}H_{38}O_2$: C, 77.36; H, 12.33. Found: C, 77.48; H, 12.48.

1,20-Dibromodocos-10-yne (15). To a cooled (0 °C) and stirred solution of Ph_3P (3.66 g, 13.94 mmol) in CH_2Cl_2 (40 mL) was added dropwise Br_2 (2.32 mL, 12.8 mmol, 5.5 M in CCl_4). After 0.5 h, a solution of **14** (1.8 g, 5.8 mmol) and pyridine (1.12 mL, 13.94 mmol) in CH_2Cl_2 (20 mL) was slowly added to the reaction mixture and stirring was continued for 3 h. Most of the solvent was removed in vacuo, the residue was thoroughly extracted with hexane, and the extract was concentrated. The residue was again dissolved in hexane and passed through a 6 in. pad of silica gel to furnish **15** (1.54 g, 61%): IR 2980, 1460, 1240 cm^{-1}; ^1H NMR δ 1.32 (s, 28H), 1.9−2.2 (m, 4H), 3.42 (t, J = 7 Hz, 4H).

(3*R*,28*R*)-1,30-Di-(*tert*-butyldimethylsilyl)-3,28-di-(tetrahydropyranyloxy)-triaconta-1,4,15,26,29-pentyne (16). As described for **13**, compound **7** (0.6 g, 2.16 mmol) was alkylated with **15** (0.518 g, 1.19 mmol) in THF (25 mL) and HMPA (2 mL) in the presence of *n*-BuLi (1.5 mL, 2.37 mmol, 1.6 M in hexane). The product was purified by column chromatography (silica gel, 0−10% ether/hexane) to afford the alkylated product **16** along with some unreacted starting materials. It was not possible to purify the required product by column chromatography and hence a small part of it was purified by preparative TLC to give pure **16** (0.43 g, 48%): $[\alpha]^{22}_D$ +6.4 (*c* 0.78, $CHCl_3$); IR 2980, 1460, 1240 cm^{-1}; ^1H NMR δ 0.12 (s, 12H), 0.93 (s, 18H), 1.32 (br s, 28H), 1.4−1.6 (br s, 12H), 1.8−2.0 (m, 4H), 2.05−2.2 (m, 4H), 3.4−3.55 (m, 2H), 3.6−3.8 (m, 2H), 4.6−4.7 (m, 2H), 4.9−5.05 (m, 2H). Anal. Calcd for $C_{52}H_{86}O_4Si_2$: C, 75.12; H, 10.43. Found: C, 75.39; H, 10.24.

(3*S*,28*S*)-Triconta-1,4,15,26,29-pentyne-3,28-diol (18). The entire mixture was then taken in THF (10 mL), cooled to −78 °C, and treated with a solution of TBAF (1.0 mL, 1.0 mmol, 1 M in THF). After stirring for 3 h, it was diluted with ice-cooled water and extracted with EtOAc. The organic extract was washed with water and brine and dried. Removal of solvent followed by column chromatography (silica gel, 0−5% ether/hexane) gave **17** (0.310 g, ∼quanitative).

A solution of **17** (0.310 g) and PTS (0.05 g) in MeOH (10 mL) was stirred for 16 h. The usual workup followed by chromatography (silica gel, 0−15% ether/hexane) gave pure **18** (0.152 g, 68%): $[\alpha]^{22}_D$ +21.2 (*c* 1.12, $CHCl_3$); IR 3400, 3310, 2150, 1060 cm^{-1}; ^1H NMR δ 1.32 (s, 28H), 1.7 (br s, D_2O exchangeable, 2H), 1.8−2.5 (m containing a d at δ 2.1, J = 2.5 Hz, 10H), 4.95 (d, J = 6 Hz, 2H). Anal. Calcd for $C_{30}H_{42}O_2$: C, 82.90; H, 9.74. Found: C, 82.75; H, 9.84.

(3*R*,28*R*,4*E*,15*E*,26*E*)-Triaconta-1,29-diyne-4,15,26-triene-3,28-diol (I). To a stirred solution of **18** (0.15 g, 0.35 mmol) in liquid NH_3 (20 mL) at −78 °C was added Li metal (63.5 mg, 9.1 mmol) in pieces. The mixture was stirred for 3 h until the blue color persisted. Solid NH_4Cl was carefully added into the mixture followed by ice-cold water, and the mixture was extracted with ether. The ether layer was washed with water and brine and dried. After removing the solvent, the residue was purified by column chromatography (silica gel, 0−15% ether/hexane) to give pure **I** (0.103 g, 68%): $[\alpha]^{22}_D$ +24.8 (*c* 0.84, $CHCl_3$) (lit.[7] $[\alpha]_D$ +29 (*c* 2, $CHCl_3$)); IR 3440, 3340, 2200, 1060, 970 cm^{-1}; ^1H NMR δ 1.2−1.4 (m containing a s at δ 1.29, 28H), 1.7−1.9 (m, 4H), 1.95−2.1 (m, 4H), 2.57 (d, J = 2.1, 2H), 4.0 (br s, D_2O exchangeable, 2H), 4.84 (dist d, J = 2.1, 2H), 5.3−5.4 (m, 2H), 5.5−5.65 (m, 2H), 5.8−5.95 (m, 2H). Anal. Calcd for $C_{30}H_{48}O_2$: C, 81.76; H, 10.98. Found: C, 81.86; H, 10.71.

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