Supporting Information
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A Stereocontrolled Synthesis of (±)-Ptilocaulin via a Rh(I) Catalyzed Intramolecular [4+2] Cycloaddition

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General information

Melting points were obtained using a Mel-Temp II apparatus equipped with a digital thermometer and are uncorrected. High Resolution Mass spectra were obtained on a Bruker MicroTOF spectrometer.

$^1$H NMR spectra were recorded on a Bruker AVANCE DPX-300 (300MHz), or AVANCE DPX-500 (500MHz) spectrometer. Chemical shifts are reported in ppm from tetramethylsilane with the residual protic solvent resonance as the internal standard (chloroform: d 7.24 ppm, or benzene: d 7.16 ppm). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplets, br s = broad singlet, br d = broad doublet, br m = broad multiplet), integration, coupling constants (in Hz), and assignments. $^{13}$C NMR spectra were recorded on a Bruker AVANCE DPX-300 (300MHz), or AVANCE DPX-500 (500MHz) spectrometer with complete decoupling. Chemical shifts are reported in ppm from tetramethylsilane with the solvent as the internal standard (CDCl$_3$: d 77.0 ppm).

Analytical thin layer chromatography was performed on Polygram® SIL G/UV$_{254}$ 1.25 mm silica gel plates with a fluorescent indicator. Flash chromatography was performed on Merck silica gel 60. Solvents for extraction and flash chromatography were reagent grade. All experiments were carried out under an argon atmosphere using standard anaerobic methods.
2-Eth-(E)-ylidenehexanal (2)

A 250-mL, round-bottomed flask equipped with a magnetic stirrer and a 10-mL pressure-equalizing funnel was charged with a ice-cooled solution of hexanal (18.5 mL, 0.15 mol, 1.0 equiv), acetaldehyde (16.8 mL, 0.30 mol, 2.0 equiv) in methanol (40 mL). A solution of 40% (w/w) benzyltrimethylammonium hydroxide in methanol solution (4.54 mL, 10.0 mmol, 0.067 equiv) was added dropwise over 10 min. The resulting mixture was stirred at 0 °C overnight. The solution was concentrated in vacuo and the residue was partitioned between ethyl ether (200 mL) and water (200 mL). The aqueous phase was separated and further extracted with two 100-mL portions of ethyl ether. The combined ether extracts were washed with brine (100 mL), dried over sodium sulfate and concentrated in vacuo. Purification of the residue by fractional distillation (water aspirator, 15 mmHg, b.p. 80 °C) gave 2-Eth-(E)-ylidenehexanal (2) (7.358 g, 58.3 mmol, 38%) as a colorless liquid. 

\[
\begin{align*}
\text{H NMR (500 MHz, CDCl}_3\text{)} & : 9.34 (s, 1H, -CHO), 6.54 (q, 1H, J=7.0 Hz, =CH), 2.17-2.25 (m, 2H, -CH}_2\text{), 1.96 (d, 3H, } J=7.0 \text{ Hz, =CH-CH}_3\text{), 1.23-1.34 (m, 4H, -CH}_2\text{CH}_2\text{), 0.88 (t, 3H, } J=6.0 \text{ Hz, -CH}_3\text{).}
\end{align*}
\]

\[
\begin{align*}
\text{C NMR (125 MHz, CDCl}_3\text{)} & : 195.10, 149.76, 144.96, 30.60, 23.75, 22.70, 14.76, 13.88. \text{IR (thin film), cm}^{-1}: 2957(s), 2931(s), 2871(s), 2862(s), 2814(m), 2712(m), 1687(s, C=O), 1642(s), 1465(m), 1456(m), 1401(m), 1380(m), 1238(m), 1191(m), 1107(m), 1067(m), 928(m), 838(m), 733(m). \text{HR-MS (ESI): Calcd for C}_8\text{H}_{14}\text{ONa (M+Na)}^+ : 149.0943; \text{Found : 149.0937.}
\end{align*}
\]
1,1-Dibromo-3-eth-\((E)\)-ylidenehept-1-ene \((3')\)

\[
\text{O} \rightarrow \text{CBr}_4, \text{PPH}_3 \xrightarrow{} \text{CH}_2\text{Cl}_2 \xrightarrow{87\%} \text{Br} \quad \text{Br}
\]

A 250-mL, round-bottomed flask equipped with a magnetic stirrer was charged with a ice-cooled solution of 2-eth-(\(E\))-ylidenehexanal \(2\) (5.01g, 39.7 mmol, 1.0 equiv) and triphenylphosphine (41.65 g, 160 mol, 4.0 equiv) in dry dichloromethane (300 mL). Carbon tetrabromide (26.33 g, 79.4 mmol, 2.0 equiv) was added in portions. The resulting brown suspension was allowed to warm to room temperature and stirred overnight. The solution was concentrated in vacuo and to the resulting solid was added 600-mL of a 1:1 mixture of hexane and ethyl ether. After filtration, the filter cake was washed with two 200-mL portions of a 1:1 mixture of hexane and ethyl ether. The combined organic filtrate was concentrated in vacuo, Purification of the residue by flash chromatography (hexane for elution) gave 1,1-dibromo-3-eth-(\(E\))-ylidenehept-1-ene \((3')\) (9.77 g, 34.64 mmol, 87%) as a light yellow liquid \((3'\) is unsuited for fractional distillation due to decomposition). \(^1\)H NMR (500 MHz, CDCl\(_3\)): 6.82 (s, 1H, =CH-), 5.72 (q, 1H, J=7.0 Hz, CH\(_3\)CH=), 2.17 (t, 2H, J=7.0 Hz, -CH\(_2\)-), 1.82 (d, 3H, J=7.0 Hz, =CH-CH\(_3\)), 1.25-1.37 (m, 4H, -CH\(_2\)CH\(_2\)-), 0.91 (t, 3H, J=6.0 Hz, -CH\(_3\)). \(^{13}\)C NMR (125 MHz, CDCl\(_3\)): 140.00, 136.97, 128.59, 86.53, 30.35, 28.45, 22.48, 13.99, 13.58. IR (thin film), cm\(^{-1}\): 2957(s), 2929(s), 2871(s), 2858(s), 1720(m), 1590(m), 1465(m), 1457(m), 1378(m), 1188(m), 1145(m), 1104(m), 876(m), 839(m), 765(m). HR-MS (ESI): Calcd for C\(_9\)H\(_{15}\)Br\(_2\) (M+H)\(^+\): 280.9541; Found: 280.9535.
(Z)-1-Bromo-3-eth-(E)-ylidenehept-1-ene (3)

(Z)-1-bromo-3-eth-(E)-ylidenehept-1-ene (3) was prepared by using a modification of the procedure of J. Uenishi (J. Org. Chem. 1998, 63, 8965). A 500-mL, round-bottomed flask equipped with a magnetic stirrer and a 100-mL pressure-equalizing dropping funnel was charged with a mixture of triphenylphosphine (1.50 g, 5.72 mmol, 0.16 equiv) and palladium acetate (0.32 g, 1.43 mmol, 0.04 equiv) in anhydrous toluene (50 mL) at room temperature under an argon atmosphere. The resulting mixture was stirred at room temperature for 15 min to generate a light yellow solution. A solution of 1,1-dibromo-3-eth-(E)-ylidenehept-1-ene (3’) (10.08 g, 35.7 mmol, 1.0 equiv) in dry toluene (50 mL) was added to the mixture followed by tributyltin hydride (11.5 mL, 42.9 mmol, 1.2 equiv). The yellow solution was stirred room temperature overnight. After the completion of the reaction, the reaction solution was partitioned between hexane (500 mL) and water (500 mL). The aqueous layer was separated and further extracted with two 200-mL portions of hexane. The combined hexane extracts were washed with brine (200 mL) and dried over sodium sulfate. After the removal of solvents in vacuo, kugelrohr distillation of the residue (5 mmHg, b.p. 80 °C) provided (Z)-1-bromo-3-eth-(E)-ylidenehept-1-ene (3) (6.08 g, 29.9 mmol, 84%) as a colorless liquid. $^1$H NMR (500 MHz, CDCl$_3$): 6.44 (d, 1H, $J=8.0$ Hz, -CH=CH-), 6.02 (d, 1H, $J=8.0$ Hz, -CH=CH-), 5.81 (q, 1H, $J=7.0$ Hz, CH$_3$CH=), 2.29 (t, 2H, $J=7.0$ Hz, -CH$_2$-), 1.69 (d, 3H, $J=7.0$ Hz, =CH-CH$_3$), 1.25-1.37 (m, 4H, -CH$_2$CH$_2$-), 0.91 (t, 3H, $J=6.0$ Hz, -CH$_3$). $^{13}$C NMR (125 MHz, CDCl$_3$): 136.37, 135.28, 128.60, 102.84, 30.91, 28.49, 22.54, 14.02, 13.48. IR (thin film), cm$^{-1}$: 2957(s),
2929(s), 2871(m), 2859(m), 1680(m), 1458(m), 1378(m), 1327(m), 832(m), 720(m), 594(m). HR-MS ( ESI ): Calcd for C₉H₁₈Br (M+H)⁺: 203.0435; Found: 203.0430.

6Z)-8-Eth-(E)-ylidene-1,6-dodecadien-5-ol (4a)

A 100-mL, round-bottomed flask equipped with a magnetic stirrer was charged with a solution of (Z)-1-bromo-3-ethyl-(E)-ylidenehept-1-ene (3) (1.10 g, 5.42 mmol, 1.0 equiv) in dry ethyl ether (35 mL). The solution was cooled to −78 °C with a dry ice-acetone bath and was added 1.7 M t-butyl lithium in pentane solution (6.7 mL, 11.4 mmol, 2.1 equiv) dropwise via syringe. After the resulting yellow mixture was stirred at -78 °C for 30 min, 4-pentenal (0.54 mL, 5.42 mmol, 1.0 equiv) was added and the resulting light yellow solution was allowed to warm to room temperature. The solution was quenched by the addition of water and the solution was partitioned between ethyl ether (100 mL) and water (100 mL). The aqueous layer was separated and further extracted with two 50-mL portions of ethyl ether. The combined ether extracts were washed with brine (100 mL) and dried over sodium sulfate. After the removal of solvents in vacuo, purification of the residue by flash chromatography (20: 1 hexane–ethyl acetate for elution) gave (6Z)-8-ethyl-(E)-ylidene-1,6-dodecadien-5-ol (4a) (0.914 g, 4.39 mmol, 81%) as a colorless oil. ¹H NMR (500 MHz, CDCl₃): 5.81-
5.90 ( m, 2H, alkene-H ), 5.34-5.41 ( m, 2H, alkene-H ), 5.03 ( d, 1H, J=17.0 Hz, trans-alkene-H ), 4.95 ( d, 1H, J=10.0 Hz, cis-alkene-H ), 4.47-4.53 ( m, 1H, -CH(OH)- ), 2.07-2.16 ( m, 4H ), 1.66 ( d, 3H, J=7.0 Hz, =CH-CH3 ), 1.24-1.59 (m, 6H ), 0.89 ( t, 3H, J=6.0 Hz, -CH3 ). 13C NMR ( 125 MHz, CDCl3 ): 138.38, 137.33, 134.28, 132.12, 124.28, 114.68, 67.70, 36.85, 30.51, 30.02, 29.90, 22.54, 13.99, 13.47. IR ( thin film ), cm⁻¹: 3400 ( br, -OH ), 3077(m), 2956(s), 2931(s), 2871(m), 2860(m), 1641(m), 1455(m), 1378(m), 1057(m), 994(m), 910(m). HR-MS ( ESI ): Calcd for C14H24OK (M+K): 247.1464; Found: 247.1643 Calcd for C14H23(M-H2O+H): 191.1800; Found: 191.1802.

(6Z)-8-Eth-(E)-ylidene-5-(triisopropylsiloxy)-1,6-dodecadiene (4b)

A 100-mL, round-bottomed flask equipped with a magnetic stirrer was charged with a solution of (6Z)-8-eth-(E)-ylidene-1,6-dodecadien-5-ol (4a) (0.914 g, 4.39 mmol, 1.0 equiv), 2,6-lutidine (0.77 mL, 6.58 mmol, 1.5 equiv) in dry dichloromethane (50 mL) at -30 °C. Triisopropylsilylethyl trifluoromethanesulfate (TIPSOTf) (1.41 mL, 5.26 mmol, 1.2 equiv) was added dropwise via syringe. The resulting mixture was stirred at -30 °C for additional 30 min and was then quenched by the addition of water. The solution was diluted with dichloromethane (100 mL), washed with two 100-mL
portions saturated cupric sulfate solution. The combined aqueous layers were extracted with dichloromethane (100 mL). The combined dichloromethane extracts were washed with brine (100 mL), dried over sodium sulfate and concentrated. Purification of the residue by flash column chromatography (hexane for elution) gave (6Z)-8-ethyl-(E)-ylidene-5-(triisopropylsiloxy)-1,6-dodecadiene (4b) (1.43 g, 3.91 mmol, 89%) as a colorless oil. $^1$H NMR (500 MHz, CDCl$_3$): 5.79-5.88 (m, 1H, -CH=CH$_2$), 5.72 (d, 1H, J=12.0 Hz, cis-CH=CH), 5.41 (dd, 1H, J=12.0, 8.5 Hz, cis-CH=CH), 5.27 (q, 1H, J=7.0 Hz, =CH-CH$_3$), 5.01 (dd, 1H, J=17.0, 2.0 Hz, terminal trans-alkene-H), 4.93 (d, 1H, J=10.5 Hz, terminal cis-alkene-H), 4.68-4.75 (m, 1H, -CH(OTIPS)-), 2.16-2.22 (m, 2H), 2.08-2.10 (m, 2H), 1.65 (d, 3H, J=7.0 Hz, =CH-CH$_3$), 1.56-1.70 (m, 2H), 1.22-1.35 (m, 5H), 1.00 (m, 18H, -CHMe$_2$ x 3), 0.78-.091 (m, 5H). $^{13}$C NMR (125 MHz, CDCl$_3$): 139.15, 137.41, 134.36, 130.13, 123.90, 114.12, 68.25, 38.45, 30.79, 30.58, 29.22, 22.85, 18.14, 14.02, 13.49, 12.49. IR (thin film), cm$^{-1}$: 2957(s), 2942(s), 2866(s), 1641(m), 1464(m), 1381(m), 1247(m), 1088(s), 1065(s), 996(m), 910(m), 883(s), 681(s). HR-MS (ESI): Calcd for C$_{23}$H$_{44}$OSiNa (M+Na)$^+$: 387.3059; Found: 387.3054.
A 250-mL, three-necked, round-bottomed flask equipped with a magnetic stirrer and a reflux condenser was charge with a solution of chlorobis(cyclooctene)rhodium (I) dimer (0.374 g, 0.52 mmol, 0.02 equiv) in dry THF (100 mL) under an argon atmosphere. Tris(hexafluoroisopropyl)phosphite (0.66 mL, 2.09 mmol, 0.08 equiv) was transferred via cannula to the catalyst flask. The transfer was quantitated with additional THF (2 X 2 mL). The resulting pale reddish-orange solution was stirred at room temperature for 15 min and then (6Z)-8-eth-(E)-ylidene-5-(triisopropylsiloxy)-1,6-dodecadiene (4b) (9.50 g, 26.06 mmol, 1.0 equiv) was added. The mixture was heated at 60 °C for 2 days. After cooling to room temperature, the mixture was concentrated. Purification of the residue by flash chromatography (hexane for elution) gave 1-(triisopropylsiloxy)-5-methyl-6-butyl-2,3,3αβ,4,5α,7aβ-hexahydro-1αH-indene (5a) (8.79 g, 24.1 mmol, 93%) as a pale yellow liquid. 

1H NMR (500 MHz, CDCl3): 5.32 (s, 1H, alkene-H), 3.92 (q, 1H, J=5.0 Hz, -CH(OTIPS)-), 2.34-2.42 (m, 1H), 2.25-2.30 (m, 1H), 2.06-2.13 (m, 1H), 1.98-2.06 (m, 1H), 1.86-1.98 (m, 2H), 1.76-1.84 (m, 1H), 1.18-1.55 (m, 11H), 1.03 (s, 18H, -CHMe2 x 3), 0.97 (d, 3H, J=7.0 Hz, -CH3), 0.87 (t, 3H, J=7.5 Hz, -CH3).

13C NMR (125 MHz, CDCl3): 142.89, 122.05, 79.82, 48.69, 35.44, 35.03, 34.58, 31.35, 30.20, 29.70, 27.89, 22.48, 19.01, 18.07, 14.04, 12.26. IR (thin film), cm⁻¹: 2957(s), 2942(s), 2928(s), 2896(s), 2867(s), 1463(s),
1380(m), 1366(m), 1246(m), 1123(m), 1063(m), 996(m), 883(m), 820(m), 680(m), 657(m). HR-MS (ESI): Calcd for C_{23}H_{44}OSiNa (M+Na)^{+}: 387.3059; Found: 387.3054.

1-(Hydroxy)-5-methyl-6-butyl-2,3,3αβ,4,5α,7αβ-hexahydro-1αH-indene (5b)

This reaction was conducted to confirm the relative stereochemistry of 5a. A 25-mL, round-bottomed flask equipped with a magnetic stirrer was charged with a solution of 1-(triisopropylsiloxyl)-5-methyl-6-butyl-2,3,3αβ,4,5α,7αβ-hexahydro-1αH-indene (5a) (32 mg, 0.088 mmol, 1.0 equiv) in dry THF (5 mL). Tetra-n-butylammonium fluoride trihydrate (TBAF•3H_2O) (46 mg, 0.18 mmol, 2.0 equiv) was added. The resulting pale yellow mixture was stirred at room temperature overnight. The solution was partitioned with ethyl acetate (50 mL) and water (50 mL). The aqueous layer was extracted with two 20-mL portions of ethyl acetate. The combined ethyl acetate extracts were washed with brine (50 mL) and dried over sodium sulfate. After the removal of solvents in vacuo, purification of the residue by flash chromatography (10:1 hexane–ethyl acetate for elution) gave 1-(hydroxy)-5-methyl-6-butyl-2,3,3αβ,4,5α,7αβ-hexahydro-1αH-indene (5b) (16 mg, 0.077 mmol, 88%) as a colorless oil for NOE experiments to confirm the cis-fused ring stereochemistry. ^1H NMR (500 MHz, CDCl_3): 5.34 (s, 1H, -CH=C<), 3.89
A 200-mL, round-bottomed flask equipped with a magnetic stirrer was charged with an ice-cooled solution of 1-(triisopropylsiloxyl)-5-methyl-6-butyl-2,3,3a\beta,4,5α,6β,7α,7αβ-hexahydro-1αH-indene (5a) (1.23 g, 3.36 mmol, 1.0 equiv) in dry THF (50 mL). Borane-dimethyl sulfide complex (10M, 1.01 mL, 10.1 mmol, 3.0 equiv) was added dropwise via syringe. The resulting mixture was allowed to warm to room temperature and stirred overnight. The stirred reaction mixture was cooled in an ice bath and carefully quenched by the addition of water, followed by 2M sodium hydroxide solution (20 mL) and subsequently 30% (w/w) hydrogen peroxide (20 mL). The resulting solution was stirred at room temperature for 1h. After concentration in vacuo, the residue was partitioned between ethyl acetate (200 mL) and water (200 mL). The aqueous layer was separated and further extracted with two 50-mL portions of ethyl acetate. The combined
extracts were washed with brine (200 mL) and dried over sodium sulfate. After the removal of solvents in vacuo, purification of the residue by flash chromatography on silica gel (100:1 hexane–ethyl acetate for elution) gave 1-(triisopropylsiloxy)-5-methyl-6-butyl-7-hydroxy-2,3,3αβ,4,5α,6β,7α,7αβ,octahydro-1αH-indene (6) (1.024 g, 2.68 mmol, 80%) as a colorless oil. 1H NMR (500 MHz, CDCl3): 4.45 (d, 1H, J=5.0 Hz, -CH(OTIPS) ), 4.41 (br s, 0.5H, >CH-OH ), 3.93 (br s, 0.5H, >CH-OH ), 2.92-3.00 (m, 1H ), 2.45-2.55 (m, 1H ), 2.02-2.10 (m, 1H ), 1.04 (s, 18H, -CHMe2 x 3), 0.80-1.80 (m, 23H ). 13C NMR (125 MHz, CDCl3): 71.07, 58.12, 49.89, 35.94, 35.57, 34.10, 28.47, 27.27, 27.04, 26.50, 23.55, 19.88, 18.09, 18.07, 14.13, 12.16. IR (thin film), cm⁻¹: 3500 (br, -OH), 2955 (s), 2941 (s), 2866 (s), 1464 (s), 1379 (m), 1255 (m), 1194 (m), 1155 (m), 1101 (m), 1065 (s), 1041 (s), 1013 (m), 883 (s), 680 (m). HR-MS (ESI): Calcd for C23H46O2SiNa (M+Na)⁺: 405.3165; Found: 405.3159.

1-(Triisopropylsiloxy)-5-Methyl-6-butyl-2,3,3αβ,4,5α,6β,7α,7αβ,octahydro-1αH-inden-7-one (7a)

A 100-mL, round-bottomed flask equipped with a magnetic stirrer was charged with a solution of 1-(triisopropylsiloxy)-5-methyl-6-butyl-7-hydroxy-2,3,3αβ,4,5α,6β,7α,7αβ,octahydro-1αH-indene (6) (1.024 g, 2.68 mmol, 1.0 equiv) in dry dichloromethane (50 mL). Pyridinium chlorochromate (PCC) (1.154 g, 5.35 mmol) was added in
portions. The resulting brown reaction mixture was stirred at room temperature overnight. The filtration of the mixture through a short pad of silica gel (20:1 hexane–ethyl acetate for elution) gave 1-(triisopropylsiloxy)-5-Methyl-6-butyl-2,3,3αβ,4,5α,6,7α,7αβ,octahydro-1αH-inden-7-one (7a) (0.967 g, 2.54 mmol, 95%) as a colorless oil. \(^1\)H NMR (500 MHz, CDCl\(_3\)) 4.82 (s, 1H, -CH(OTIPS)-), 2.80-2.88 (m, 1H), 2.56 (d, 1H, \(J=7.5\) Hz, -(O)CC\(\text{Bu}\)n), 1.90-2.00 (m, 2H), 1.64-1.75 (m, 4H), 1.46-1.59 (m, 3H), 1.33-1.42 (m, 1H), 1.20-1.30 (m, 7H), 1.01 (m, 18H, -CHMe\(_3\) x 3), 0.82-0.90 (m, 6H, -CH\(_3\) x 2). \(^{13}\)C NMR (125 MHz, CDCl\(_3\)) 212.78, 73.46, 62.41, 56.59, 40.13, 35.43, 34.88, 34.61, 29.53, 28.04, 25.45, 23.16, 20.74, 18.00, 14.00, 12.04. IR (thin film), cm\(^{-1}\): 2955(s), 2943(s), 2866(s), 1706 (s, C=O), 1463(m), 1380(m), 1244(m), 1107(m), 1049(m), 1035(m), 883(m), 681(m), 658(m), 464(m). HR-MS (ESI): Calcd for C\(_{23}\)H\(_{44}\)O\(_2\)SiNa (M+Na\(^+\)): 403.3009; Found: 403.3003.

1-(Hydroxy)-5-methyl-6-butyl-7-hydroxy-2,3,3αβ,4,5α,6β,7α,7αβ,octahydro-1αH-indene (7b)

A 100-mL, round-bottomed flask equipped with a magnetic stirrer was charged with a solution of 1-(triisopropylsiloxy)-5-methyl-6-butyl-7-hydroxy-2,3,3αβ,4,5α,6β,7α,7αβ,octahydro-1αH-indene (7a) (1.162 g, 3.05 mmol, 1.0 equiv) in dry THF (50 mL). Tetra-n-butylammonium fluoride trihydrate (TBAF•3H\(_2\)O) (1.596 g, 6.11 mmol, 2.0
equiv) was added in portions. The resulting solution was stirred at room temperature overnight. After concentration in vacuo, the residue was partitioned between ethyl acetate (200 mL) and water (200 mL). The aqueous layer was separated and further extracted with two 50-mL portions of ethyl acetate. The combined ethyl acetate extracts were washed with brine (200 mL) and dried over sodium sulfate. After the removal of solvents in vacuo, purification of the residue by flash chromatography (3:1 hexane-ethyl acetate for elution) gave 1-(hydroxy)-5-methyl-6-butyl-7-hydroxy-2,3,3αβ,4,5α,6β,7α,7αβ,octahydro-1αH-indene (7b) (600 mg, 2.67 mmol, 88%) as a colorless oil. $^1$H NMR (500 MHz, CDCl$_3$): 4.50-4.63 (m, 1H, -CH(OH)-), 2.65-2.85 (m, 1H, -(O)CCBu$n$), 2.50-2.56 (m, 1H), 2.10-2.35 (m, 1H), 2.02-2.08 (m, 1H), 1.88-1.96 (m, 1H), 1.10-1.85 (m, 12H), 1.04 (d, 3H, J=6.5 Hz, -CH$_3$), 0.82-0.90 (m, 3H, -CH$_3$).

$^{13}$C NMR (125 MHz, CDCl$_3$): 214.07, 73.57, 60.59, 56.16, 38.19, 35.61, 34.55, 33.38, 29.73, 28.32, 23.06 IR (thin film), cm$^{-1}$: 3386 (br, -OH), 2954(s), 2931(s), 2870(s), 1703 (s, C=O), 1462(m), 1379(m), 1358(m), 1241(m), 1157(m), 1082(m), 1024(m), 1004(m), 924(m) HR-MS (ESI): Calcd for C$_{14}$H$_{25}$O$_2$ (M+Na)$^+$: 247.1674; Found: 247.1649. Calcd for C$_{14}$H$_{24}$O$_2$Na (M+Na)$^+$: 247.1649.
5-Methyl-6-butyl-3,3αβ,4,5α,6,7-hexahydro-2H-inden-7-one (8)

A 100-mL, round-bottomed flask equipped with a magnetic stirrer and a reflux condenser was charged with a solution of 1-(hydroxy)-5-methyl-6-butyl-7-hydroxy-2,3,3αβ,4,5α,6β,7α,7αβ, octahydro-1αH-indene (7b) (2.45 g, 10.9 mmol, 1.0 equiv) in dry benzene (50 mL) at room temperature. p-Toluenesulfonic acid (2.08 g, 10.9 mmol, 1.0 equiv) was added to the solution. The resulting mixture was heated at 50 °C for 1 h. After cooling to room temperature, the mixture was partitioned between dichloromethane (200 mL) and saturated potassium carbonate solution (200 mL). The aqueous layer was separated and further extracted with two 100-mL portions dichloromethane. The combined dichloromethane extracts were washed with brine (200 mL) and dried over sodium sulfate. After the removal of solvents in vacuo, purification by flash chromatography (10:1 dichloromethane–ethyl acetate for elution) gave 5-methyl-6-butyl-3,3αβ,4,5α,6,7-hexahydro-2H-inden-7-one (8) (1.826 g, 8.85 mmol, 81%) as a colorless oil. 8 cis-Bu

\[ ^1H \text{NMR (500 MHz, CDCl}_3\text{):} \]

6.41 (d, 1H, J=2.0 Hz, -CH=C< ), 3.07 (br s, 1H ), 2.20-2.40 (m, 4H ), 1.95-2.04 (m, 1H ), 1.85-1.93 (m, 1H ), 1.50-1.58 (m, 2H ), 1.15-1.30 (m, 4H ), 0.88 (d, 3H, J=7.5 Hz, -CH₃ ), 0.88 (3H, t, J=7.5 Hz, -CH₃ ). 13C NMR (125 MHz, CDCl₃): 202.51, 145.56, 135.78, 54.66, 41.58, 39.36, 33.83, 33.53, 32.09, 29.68, 25.66, 22.83, 14.20, 14.07. IR (thin film), cm⁻¹: 2955(s), 2929(s), 2870(s), 2858(s), 1685 (s, C=O ), 1620(s), 1456(m), 1381(m), 1285(m), 1260(m), 1232(m), 1182(m), 1161(m), 972(m), 936(m), 920(m), 800(m). HR-MS (ESI): Calcd for
C_{14}H_{23}O (M+H)^+: 207.1749; Found: 207.1743. Calcd for C_{14}H_{22}ONa (M+Na)^+: 229.1569; Found: 229.1550. 8 trans-Bu\textsuperscript{n}

\textsuperscript{1}H NMR ( 500 MHz, CDCl\textsubscript{3} ). 6.52 ( d, 1H, J=2.5 Hz, -CH=C< ), 3.03 ( br s, 1H), 2.20-2.45 ( m, 3H ), 2.05-2.13 ( m, 1H ), 1.70-1.77 ( m, 1H ), 1.35-1.60 ( m, 4H ), 1.20-1.30 ( m, 5H ), 1.04( d, 3H, J=7.5 Hz, -CH\textsubscript{3} ), 0.86 ( t, 3H, J=7.0 Hz, -CH\textsubscript{3} ). \textsuperscript{13}C NMR ( 125 MHz, CDCl\textsubscript{3} ) 203.88, 144.06, 137.81, 55.73, 40.75, 33.51, 33.35, 32.96, 31.96, 31.96, 29.17, 22.58, 20.17, 13.92. IR (neat), cm\textsuperscript{-1}: 2955(s), 2929(s), 2870(m), 2859(m), 1683 ( s, C=O ), 1617(m), 1459(m), 1380(m), 1262(m), 1231(m), 979(m), 914(m).

HR-MS ( ESI ): Calcd for C_{14}H_{23}O (M+H)^+: 207.1749; Found: 207.1743. Calcd for C_{14}H_{22}ONa (M+Na)^+: 229.1569; Found: 229.1553.

(±)-Ptilocaulin nitrate (1)

(±)-Ptilocaulin nitrate was prepared from (8) by the procedure of T. Uyehara et al. (J. Org. Chem. 1988, 53, 3669). A solution of guanidine (29 mg, 0.49 mmol, 2.0 equiv) in methanol was prepared from guanidine carbonate (44 mg, 0.24 mmol, 1.0 equiv) by sonication for 5 min with sodium methoxide (29 mg, 0.53 mmol, 2.2 equiv) in methanol (25 mL) under argon. The reaction mixture was carefully filtered and the filtrate was concentrated in vacuo. A 50-mL
Schlenk flask containing the residue was fitted with a Soxlet extractor in which were placed 4Å molecular sieves and charge with argon and a solution of 5-methyl-6-butyl-3,3αβ,4,5α,6,7-hexahydro-2H-inden-7-one (8) (50 mg, 0.24 mmol, 1.0 equiv) in dry benzene (25 mL). The resulting mixture was heated under reflux for 24 h and then allowed to cool to room temperature. The solution was neutralized with 1% nitric acid (4 mL) and the aqueous layer was extracted with three 50-mL portions of chloroform. The combined chloroform extracts were washed with saturated sodium nitrate solution (50 mL), dried over magnesium sulfate and concentrated in vacuo. Purification of the residue by careful chromatography on silica gel (6:1 chloroform-methanol for elution) afforded crude (±)-Ptiloaulin nitrate (22 mg, 0.090 mmol, 37%). Further purification of crude product by HPLC gave rise to an analytical sample of (±)-Ptiloaulin nitrate (1) (20 mg, 0.082 mmol, 33%) as white solid. m. p. 150-151 °C. Litt.2b 151-152 °C. ¹H NMR (500 MHz, CDCl₃): 8.86 ( br s, 1H, -NH- ), 8.33 ( br s, 1H, -NH- ), 7.13 ( br s, 2H, =NH₂ ), 3.68-3.76 ( m, 1H ), 2.32-2.48 ( m, 3H ), 2.18-2.28 ( m, 1H ), 1.97-2.10 ( m, 2H ), 1.62-1.70 ( m, 2H ), 1.33-1.48 ( m, 3H ), 1.20-1.30 ( m, 4H ), 1.03 ( d, 3H, J=7.0 Hz, -CH₃ ), 0.86 ( t, 3H, J=7.0 Hz, -CH₃ ). ¹³C NMR (125 MHz, CDCl₃): 151.78, 126.90, 120.92, 53.17, 36.48, 33.94, 33.05, 32.18, 29.64, 27.76, 27.00, 24.61, 22.42, 19.49, 14.00. IR (thin film), cm⁻¹: 3276 ( br, -NH- ), 2958(s), 2932(s), 2873(s), 1681 ( s, C=NH₂⁺ ), 1612(s), 1463(m), 1427(m), 1378(m), 1345(m), 1201(s), 1183(s), 1139(s), 837(m), 800(m), 756(m), 721(m). HR-MS (ESI): Calcd for C₁₅H₂₆N₃ (M+H)⁺: 248.2126; Found: 248.2121.
500 MHz
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