**Furanophane Transannular Diels-Alder (TADA)
Approach to (+)-Chatancin:
An Asymmetric Total Synthesis of (+)-Anhydrochatancin**

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SUPPORTING INFORMATION:
EXPERIMENTAL PART:

All air sensitive reactions were carried out under argon. Solvents were distilled under nitrogen, tetrahydrofuran (THF) and ethyl ether (Et₂O) from sodium benzophenoneketyl and dichloromethane, diisopropylamine, triethylamine, dimethyl sulfoxide (DMSO), hexamethylphosphoramide (HMPA) and acetonitrile from calcium hydride. Flash chromatography (FC) was carried out using 230-400 mesh silica gel. Thin layer chromatography (TLC) was performed on precoated glass plates silica. Spots were visualized by UV light (254 nm) and/or with dipping in a cerium sulfate-ammonium molybdate developing solution and charring them on a hot plate. All concentrations are given in g/100 mL for the optical rotations measurements (1 dm, 1 mL cell),. Proton magnetic resonance (¹H NMR) and carbon magnetic resonance (¹³C NMR) spectra were recorded at a respective 300 MHz and 62.5 MHz in chloroform-d (7.26 and 77.0 ppm, respectively) as solvent. Chemical shifts are reported in ppm on δ scale. Coupling constants are reported to the nearest 0.1 Hz. Infrared (IR) spectra were recorded neat on KBr pastille. Only diagnostic bands are reported on cm⁻¹ scale.

(S)-N-methoxy-N-methyl-citronellic amide (13):

Isobutylchloroformate (21.1 mL, 160 mmol) was added to a CH₂Cl₂ (300 mL) solution of (S)-citronellic acid (**12**) ([α]_D²⁰: -8.61°, neat) 27.21 g, 160 mmol) and triethylamine (70 mL, 480 mmol) at -20°C. The mixture was allowed to warm to 0°C in 30 min then cooled back to -20°C. N,O-dimethylhydroxylamine hydrochloride (20.67 g, 208 mmol) was added and the resulting mixture was stirred at 23°C for 21 h. After an aqueous work-up, which included a basic and acidic wash, the oily crude product (37.31 g, 107%, ~92% pure) was used in the next step without further purification. **¹H NMR:** 5.10 (tt, J=7.1 and 1.4Hz, 1H), 3.67 and 3.18 (2s, 2x3H), 2.40 (dd, J=14.9, and 5.9Hz, 1H), 2.24 (dd, J=14.9 and 8.2Hz, 1H), 2.1-1.9 (m, 3H), 1.67 (d, J=1.1Hz, 3H), 1.60 (d, J=0.3Hz, 3H), 1.5-1.1 (m, 2H), 0.94 (d, J=6.7Hz, 3H). **¹³C NMR:** 173.6, 130.6, 124.1, 60.6, 38.6, 36.7, 31.5, 29.0, 25.2, 25.1, 19.4, 17.1.

(S)-N,3-dimethyl-N-methoxy-6-heptene amide (15):

Citronellic amide **13** (10.27 g, 45 mmol) was ozonized in CH₂Cl₂ (300 mL) at -78°C. After the reaction was complete, the bluish solution was purged with dry nitrogen then methylsulfide (10 mL) was added. The mixture was allowed to warm to 23°C then it was evaporated twice from pentane to afford aldehyde **14**: **¹H NMR:** (9.78 (t, J=1.7Hz, 1H), 3.68 and 3.18 (2s, 2x3H), 2.55-2.25 (m, 4H), 2.15-2.00, 1.85-1.70 and 1.60-1.45 (3m, 3x1H), 0.96 (d, J=6.7Hz, 3H). This crude aldehyde in THF (50 mL) was added at 0°C to a preprepared solution of Wittig reagent made as follows: butyllithium (30 mL, 48 mmol, 1.6 M in hexane) was added to a THF (450 mL) solution of methyltriphenylphosphonium bromide (17.86 g, 50 mmol) at 0°C and stirring of the resulted mixture at 23°C for 2h. The reaction mixture was stirred at 23°C for 2h then the reaction was quenched by addition of methanol (2 mL). The solution was evaporated to ~100 mL, triturated with a solution of hexane-ether (500 mL, 4:1) and filtered. The goo was dissolved in CH₂Cl₂ (20 mL), triturated with hexane-

ether (100 mL, 4:1) and filtered again. This process was repeated two more times. The unified organic solutions were washed with brine, dried, filtered through a silica plug and evaporated. The crude product was purified by FC (20% to 40% ether in hexane) to afford 4.59 g (57% over 3 steps) title product **15** as a colorless oil. **¹H NMR:** 5.81 (dddd, J=17.1, 10.3, 6.6 and 6.6Hz, 1H), 5.02 (ddd, J=17.1, 3.5 and 1.5Hz, 1H), 4.94 (ddd, J=10.3, 3.5 and 1.5Hz, 1H), 3.67 and 3.18 (2s, 2x3H), 2.41 (dd, J=15.0 and 6.0Hz, 1H), 2.25 (dd, J=15.0 and 8.0Hz, 1H), 2.2-2.0 (m, 3H), 1.55-1.40 and 1.35-1.20 (2m, 2x1H), 0.95 (d, J=6.6Hz, 3H). **¹³C NMR:** 173.9, 138.7, 114.2, 61.0, 38.9, 36.0, 31.9, 31.2, 29.2, 19.6. **IR:** 2933, 1668, 1384. **HR-MS:** 154.1236±0.0005 (154.1232 for (M-OMe)⁺: C₉H₁₆NO).

(S)-3-Bromo-2-(2-methyl-5-hexenyl)furan (16):

Butyllithium (63.5 mL, 101.6 mmol, 1.6 M in hexane) was added to a THF (100 mL) and HMPA (20 mL) solution of propargyl alcohol (2.778 g, 49.55 mmol) at -78°C. The mixture was allowed to warm to 0°C in 1 h then cooled back to -50°C. To this dilithium salt, a THF (20 mL) solution of Weinreb amide **15** (4.59 g, 24.78 mmol) was added at -50°C in 10 min. The mixture was allowed to warm to 15°C in 0.5 h and stirred at this temperature for 3 h. The reaction was quenched with a mixture of HBr (13 mL, 48%), water (10 mL) and ether (100 mL) at -78°C. Upon warming, hexane (200 mL) was added and the solution of crude enynolone was washed with water and brine, dried and evaporated. After adding benzene (100 mL) and HBr (30 mL, 4N), it was cyclized by heating for 5 h at 55°C. Following an aqueous work-up, crude **16** was purified by FC (hexane) to afford 3.82 g (63%) title product **16** as a colorless oil. $[\alpha]_D^{20}$: +0.82° (c:8, CH₂Cl₂). **¹H NMR:** 7.29 (d, J=0.8Hz, 1H), 6.50 (dd, J=1.4 and 0.8Hz, 1H), 5.79 (dddd, J=17.1, 10.2, 6.6 and 6.6Hz, 1H), 5.00 (ddd, J=17.1, 3.6 and 1.6Hz, 1H), 4.94 (ddd, J=10.2, 3.6 and 1.6Hz, 1H), 2.58 (ddd, J=14.9, 6.1 and 0.5Hz, 1H), 2.42 (ddd, J=14.9, 8.0 and 0.5Hz, 1H), 2.25-1.95 (m, 2H), 1.90-1.75, 1.50-1.35 and 1.30-1.15 (3m, 3x1H), 0.89 (d, J=6.7Hz, 3H). **¹³C NMR:** 156.4, 139.1, 138.6, 114.4, 109.6, 99.7, 35.5, 35.3, 31.9, 31.2, 19.3. **IR:** 2928, 1588, 924. **HR-MS:** 242.0293±0.0007 (242.0306 for M⁺: C₁₁H₁₅BrO).

(S)-2-(2-Methyl-5-hexenyl)furan-3-carboxylic acid (17):

Butyllithium (10.0 mL, 16 mmol, 1.6 M in hexane) was added in 10 min to a THF (50 mL) solution of bromofuran **16** (3.82 g, 15.71 mmol) at -78°C. After 15 min of stirring, a stream of dried CO₂ gas (from dry ice) was bubbled into the solution for 30 min. The reaction was quenched with HCl (20 mL, 1M). Following an aqueous work-up with CH₂Cl₂ (200 mL), the crude acid was purified by FC (20% to 100% ether in hexane) to afford 2.81 g (86%) title product **17** as an amorphous solid. **¹H NMR:** 7.98 and 6.37 (2s, 2x1H), 5.79 (dddd, J=17.1, 10.2, 6.7 and 6.7Hz, 1H), 5.00 (d, J=17.1Hz, 1H), 4.95 (d, J=11.8Hz, 1H), 2.63 (dd, J=15.0 and 4.0Hz, 1H), 2.46 (dd, J=15.0 and 7.7Hz, 1H), 2.25-1.95 (m, 2H), 1.90-1.75, 1.50-1.35 and 1.30-1.15 (3m, 3x1H), 0.91 (d, J=6.7Hz, 3H). **¹³C NMR:** 168.9, 157.2, 147.7, 138.7, 119.0, 114.5, 105.9, 35.5, 35.1, 31.8, 31.2, 19.3. **HR-MS:** 208.1104±0.0006 (208.1099 for M⁺: C₁₂H₁₆O₃)

(S)-2-Isopropyl-5-oxohexanoic acid^{18a} (18):

(*S*)-Piperitone^{18b} (7.22 g, 47.4 mmol) in methanol (70 mL) was ozonized (6 g/h) for 50 min at 0°C. Following an addition of water (50 mL) and H₂O₂ (10 mL, 30%), the mixture was refluxed for 15 h. Upon cooling to 0°C, NaHCO₃ (6.0 g) was added slowly. The solution was washed with hexane (2x50 mL), acidified with HCl (6 mL, 37%) and extracted with CH₂Cl₂ (2x100 mL+5x50 mL). The extract was dried and evaporated to afford 6.99 g (86%) title acid **18**, pure enough for the next step. ¹H NMR: 2.15 (s, 3H), 2.65-1.75 (m, 6H), 0.98 (d, J=6.7Hz, 6H). ¹³C NMR: 208.5, 181.1, 51.3, 41.3, 30.2, 29.8, 22.6, 20.3, 19.6. IR: 3200 (br), 2965, 1713. HR-MS: 155.164±0.0005 (155.1072 for (M-OH)⁺: C₉H₁₅O₂).

In the preparation of (*S*)-(+)-piperitone phenylselenenyl chloride was used instead of diphenyldiselenid for the selenylation.

(*S*)-2-Isopropyl-1,5-hexanediol (**19**):

BH₃ · THF (87 mL, 87 mmol, 1M in THF) was slowly added to a THF (50 mL) solution of acid **18** (6.99 g, 40.6 mmol) at -78°C. The mixture was slowly allowed to warm to 23°C and stirred at this temperature for 20h. The excess of the reagent was destroyed with a careful addition of HCl (5 mL, 1M) at 0°C. After evaporation of the solvent, CH₂Cl₂ (200 mL) and NaHCO₃ (100 mL, sat.) were added, the phases were separated and the aqueous phase was extracted with CH₂Cl₂ (8x50 mL). The unified organics were dried and evaporated to afford a 2:1 diastereomeric mixture of diol **19**, pure enough for the next step. ¹H NMR: 3.9-3.5 (m, 3H), 1.9-1.3 (m, 6H), 1.20 (d, J=6.1Hz, 3H), 0.91 and 0.90 (d, J=6.9Hz, 6H in 1:2 ratio). ¹³C NMR: **major**: 68.4, 63.2, 46.6, 37.2, 28.3, 24.0, 23.5, 19.8, 19.5. **minor**: 67.7, 63.4, 45.9, 36.5, 28.2, 23.6, 23.3, 19.7, 19.6. IR: 3340 (br), 2961, 1044. HR-MS: 145.1235±0.0004 (145.1228 for (M-CH₃)⁺: C₈H₁₇O₂) and 143.1433±0.0004 (143.1436 for (M-OH)⁺: C₉H₁₉O).

(*S*)-1-*tert*-Butyldimethylsilyloxy-2-isopropyl-5-hexanol (**20**):

tert-Butyldimethylsilyl chloride (6.18 g, 41 mmol) in CH₂Cl₂ (20 mL) was added to a CH₂Cl₂ (100 mL) solution of diol **19** (from the previous procedure) and imidazole (6.81 g, 100 mmol) at 0°C. After 2 h stirring at 23°C, a methanol quench and an aqueous work-up, the product was purified by FC (5% to 50% ether in hexane) to afford 6.06 g (54%, over two steps) diastereomeric mixture of alcohol **20** as a colorless oil. ¹H NMR: 3.85-3.70, 3.65-3.45, 1.9-1.7 and 1.55-1.25 (4m, 1H+2H+1H+5H, respectively), 1.19 (d, J=6.2Hz, 3H), 0.89 (s, 9H), 0.89-0.85 (m, 6H), 0.04 (2s, 2x3H). ¹³C NMR: **major**: 68.5, 63.8, 46.3, 37.4, 28.0, 25.9 (3C), 23.7, 19.9, 19.2, 18.1, -5.5. **minor**: 68.2, 63.8, 46.1, 37.5, 28.3, 25.9 (3C), 23.9, 19.9, 19.4, 18.1, -5.5. IR: 3356 (br), 2960, 1092. HR-MS: 217.1617±0.0006 (217.1624 for (M-C₄H₉)⁺: C₁₁H₂₅O₂Si).

(*S*)-1-*tert*-Butyldimethylsilyloxy-2-isopropyl-5-hexanone (**21**):

A CH₂Cl₂ (8 mL) solution of DMSO (3.9 mL, 54.6 mmol) was added to a CH₂Cl₂ (8 mL) solution of oxalyl chloride (3.1 mL, 35 mmol) in 10 min at -78°C. After 15 min of stirring, a CH₂Cl₂ (20 mL) solution of alcohol **20** (6.00 g, 21.85 mmol) was added at -78°C. Following a 90 min stirring, Et₃N (9.2 mL, 65.5 mmol) was

added and the mixture was allowed to warm to 23°C. An aqueous work-up and a filtration of the crude product through a silica pad afforded 5.00 g (84%) ketone **21** as a colorless oil. $[\alpha]_D^{20}$: -8.75° (c:10, hexane). **¹H NMR**: 3.53 (ddd, J=17.7, 10.2 and 6.1Hz, 2H), 2.6-2.35 (m, 2H), 2.13 (s, 3H), 1.85-1.45 (m, 3H), 1.35-1.15 (m, 1H), 0.88 (s, 9H), 0.88 (d, J=6.9Hz, 3H), 0.87 (d, J=7.2Hz, 3H), 0.03 (s, 6H). **¹³C NMR**: 209.2, 63.6, 45.7, 42.2, 29.7, 28.2, 25.8, 22.4, 19.8, 19.3, 18.1, -5.6. **IR**: 2930, 1720, 1088, 836. **HR-MS**: 215.1464±0.0006 (215.1467 for (M-C₄H₉)⁺: C₁₁H₂₃O₂Si).

(S)-6-tert-Butyldimethylsilyloxy-5-isopropyl-2-methyl-1-hexene (22):

Similar procedure to that applied in the preparation of **15** was used with methyltriphenylphosphonium bromide (11.50 g, 32.2 mmol) in THF (250 mL) and butyllithium (19 mL, 30 mmol, 1.6 M in hexane) to prepare the Wittig reagent to olefinate ketone **21** (5.00 g, 18.3 mmol) in THF (20 mL). Absorption of the crude product on a silica pad and elution with hot hexane (3x150 mL) afforded 4.81 g (97%) title product **22** as a colorless oil. $[\alpha]_D^{20}$: -10.4° (c:10, hexane). **¹H NMR**: 4.68 (s, br, 2H), 3.54 (d, J=5.6Hz, 2H), 2.2-1.9, 1.85-1.75 and 1.55-1.25 (3m, 2H+1H+3H, respectively), 1.72 (s, 3H), 0.89 (s, 9H), 0.88 (d, J=6.2Hz, 3H), 0.87 (d, J=6.8Hz, 3H), 0.04 (s, 6H). **¹³C NMR**: 146.4, 109.7, 63.4, 45.9, 36.1, 28.1, 25.9, 25.8, 22.4, 19.9, 19.4, 18.3, -5.4. **IR**: 2956, 836. **HR-MS**: 213.1679±0.0006 (213.1675 for (M-C₄H₉)⁺: C₁₂H₂₅OSi).

(S)-2-isopropyl-5-methyl-5-hexen-1-ol (23):

Tetrabutylammonium fluoride (18 mL, 18 mmol, 1M in THF) was added to a THF (20 mL) solution of silyl ether **22** (4.805 g, 17.76 mmol) at 0°C. After a 16 h stirring, an aqueous work-up with CH₂Cl₂, and FC (10% to 30% ether in hexane) afforded 3.022 g (94%) alcohol **23** as a colorless oil. **¹H NMR**: 4.70 (m, 2H), 3.61 (AA'X, J_{AA'}=5.6Hz, 2H), 2.15-1.75 (m, 3H), 1.73 (s, 3H), 1.6-1.25 (m, 3H), 0.91 (d, J=6.9Hz, 3H), 0.90 (d, J=6.8Hz, 3H). **¹³C NMR**: 146.1, 109.7, 63.1, 45.9, 35.8, 27.6, 25.4, 22.3, 19.6, 19.0. **IR**: 3332, 2959, 1650. **HR-MS**: 156.1511±0.0005 (156.1514 for M⁺: C₁₀H₂₀O).

(S)-2-isopropyl-5-methyl-5-hexenal (10):

Tetrapropylammonium perruthenate (28 mg, 80 μmol) was added to a stirred suspension of alcohol **23** (246 mg, 1.57 mmol), CH₂Cl₂ (4 mL), N-methylmorpholine N-oxide (221 mg, 1.89 mmol) and molecular sieve (50 mg, 4Å) at 0°C. After 30 min stirring at 23°C, the mixture was evaporated to ~1 mL and chromatographed directly (5% ether in hexane) to afford 200 mg (83%) aldehyde **10** as a colorless oil. $[\alpha]_D^{20}$: +35.1° (c:10, CDCl₃). **¹H NMR**: 9.64 (d, 3.2Hz, 1H), 4.73 and 4.68 (2s, br, 2H), 2.15-1.55 (m, 6H), 1.71 (s, 3H), 0.98 (d, J=6.8Hz, 3H), 0.97 (d, J=6.7Hz, 3H). **¹³C NMR**: 205.5, 144.9, 110.5, 57.4, 35.5, 28.2, 23.6, 22.2, 20.1, 19.6. **IR**: 2962, 1708. **HR-MS**: 170.1310±0.0005 (170.1307 for M⁺: C₁₀H₁₈O₂).

(1R,2S,2'S) Methyl 2-(1-hydroxy-2-isopropyl-5-methylhex-5-enyl)-5-(2'-methylhex-5'-enyl)-furan-3-carboxylate (24a):

Butyllithium (1.5 mL, 2.4 mmol, 1.6 M in hexane) was added to a THF (3 mL) solution of diisopropylamine (333 μ L, 2.4 mmol) at -78°C. After 30 min of stirring at 0°C, the solution was cooled again to -78°C and a THF (1 mL) solution of acid **17** (225 mg, 1.08 mmol) was added. Following a 30 min stirring at -78°C, a THF (1 mL) solution of aldehyde **10** (200 mg, 2.38 mmol) was added. The mixture was allowed to warm to -10°C in 30 min then the reaction was quenched with the addition of NH₄Cl solution (2 mL, sat.). Upon warming, an acidic aqueous work-up with CH₂Cl₂ gave a crude acid mixture, which was esterified with CH₂N₂ (10 mL, 0.4 M in ether) for 15 h at 0°C. Evaporation of the solvents afforded 412 mg (100%) crude ester **24** mixture. ¹H NMR of a sample shows 96% conversion and a 1*R*/1*S* ratio of 2:1. FC (5% to 10% ether in hexane) afforded 249 mg (61%) title 1*R*-ester **24a** as a colorless oil. [α]_D²⁰: +4.0° (c:6, hexane). ¹H NMR: 6.26 (s, 1H), 5.78 (dddd, J=17.0, 10.5, 6.6 and 6.6Hz, 1H), 5.00 (ddd, J=17.0, 3.6 and 1.6Hz, 1H), 4.94 (ddd, J=10.2, 3.2 and 1.2Hz, 1H), 4.91 (d, J=6.3Hz, 1H), 4.67 (AA'X, J_{AA'}=5.0Hz, 2H), 4.45 (s, br, 1H), 3.84 (s, 3H), 2.56 (ddd, J=15.0, 6.3 and 0.5Hz, 1H), 2.42 (ddd, J=15.0, 7.4 and 0.5Hz, 1H), 1.69 (s, 3H), 2.2-1.2 (m, 11H), 0.93 (d, J=6.8Hz, 3H), 0.90 (d, J=6.7Hz, 3H), 0.84 (d, J=6.8Hz, 3H). ¹³C NMR: 165.6, 163.0, 153.4, 146.2, 138.5, 114.4, 113.9, 109.6, 107.0, 70.5, 51.7, 49.2, 37.8, 35.4, 34.8, 31.8, 31.2, 28.7, 25.0, 22.3, 20.6, 19.2, 18.5. IR: 3420 (br), 2956, 1721, 1693, 1221, 1085. HR-MS: 376.2618±0.0011 (376.2613 for M⁺: C₂₃H₃₆O₄). It was followed by 1*S*-ester **24b** (111 mg, 27%) evaporated to a colorless oil. ¹H NMR: 6.27 (s, 1H), 5.78 (dddd, J=17.0, 10.2, 6.6 and 6.6Hz, 1H), 5.00 (ddd, J=17.0, 3.6 and 1.9Hz, 1H), 4.94 (ddd, J=11.2, 3.6 and 1.2Hz, 1H), 4.74 (d, J=9.0Hz, 1H), 4.60 (d, J=0.9Hz, 1H), 4.49 (dd, J=2.0 and 0.9 Hz, 1H), 4.30 (s, br, 1H), 3.84 (s, 3H), 2.57 (dd, J=14.9 and 6.1Hz, 1H), 2.41 (dd, J=14.9 and 7.5Hz, 1H), 1.57 (d, J=0.8Hz, 3H), 2.3-1.1 (m, 11H), 0.95 (d, J=7.0Hz, 3H), 0.94 (d, J=6.9Hz, 3H), 0.90 (d, J=6.7Hz, 3H).

(1*R*,2*S*,2'*S*) Methyl 2-(1-*tert*-butyldimethylsilyloxy-2-isopropyl-5-methylhex-5-enyl)-5-(2'-methylhex-5'-enyl)-furan-3-carboxylate (9**):**

tert-Butyldimethylsilyl triflate (1.52 mL, 6.6 mmol) was added to a stirred CH₂Cl₂ (10 mL) solution of alcohol **24a** (827 mg, 2.20 mmol) and 2,6-lutidine (1.02 mL, 8.8 mmol) at 0°C. After stirring the mixture for 15 h at 23°C, the reaction was quenched by the addition of methanol (3 mL) and diluted with hexane (50 mL). Following an aqueous work-up which included a CuSO₄ washing, FC (3% ether in hexane) afforded 1.039 g (96%) title silylether **9** as a colorless oil. [α]_D²⁰: +27.2° (c:5.2, hexane). ¹H NMR: 6.25 (s, 1H), 5.81 (dddd, J=17.0, 10.2, 6.6 and 6.6Hz, 1H), 5.36 (d, J=6.8Hz, 1H), 5.00 (ddd, J=17.0, 3.4 and 1.5Hz, 1H), 4.94 (ddd, J=10.2, 3.2 and 1.2Hz, 1H), 4.66 (AA'X, J_{AA'}=3.5Hz, 2H), 3.81 (s, 3H), 2.58 (ddd, J=14.8, 7.1 and 0.5Hz, 1H), 2.42 (dd, J=14.8 and 7.4Hz, 1H), 1.71 (s, 3H), 2.2-1.2 (m, 11H), 0.89 (d, J=6.8Hz, 2x3H), 0.84 (s, 9H), 0.77 (d, J=6.8Hz, 3H), 0.02 and -0.25 (2s, 2x3H). ¹³C NMR: 164.1, 160.9, 154.0, 146.8, 138.7, 114.4, 114.1, 109.2, 106.7, 68.8, 51.2, 49.7, 37.8, 35.5, 35.1, 31.9, 31.3, 28.2, 25.7, 25.2, 22.6, 20.9, 19.3, 18.5, 18.0, -5.2. IR: 2930, 1720, 1062. HR-MS: 433.2777±0.0013 (433.2774 for (M-C₄H₉)⁺: C₂₅H₄₁O₄Si).

(3*S*,10*S*,11*R*,6*Z*) Methyl 11-*tert*-butyldimethylsilyloxy-10-isopropyl-3,7-dimethyl-15-oxabicyclo [10.2.1]-pentadeca-1(14),6,12-triene-13-carboxylate (27**):**

A CH₂Cl₂ (5 mL) solution of diene **9** (49.1 mg, 100 μmol) was added with a syringe pump over 1 h to a refluxing stirred CH₂Cl₂ (20 mL) solution of catalyst tricyclohexylphosphine[1,3-bis(2,4,6-trimethylphenyl)-4,5-dihydroimidazol-2-ylidene]benzylideneruthenium(IV) dichloride **25b** (8.5 mg, 10 μmol). Following 20 h reflux, the mixture was evaporated. FC (5% ether in hexane) afforded 43.2 mg (93%) title macrocycle **27** as a colorless oil. $[\alpha]_D^{20}$: +40.2° (c:5.0, hexane). **¹H NMR**: 6.29 (s, 1H), 5.65 (d, J=2.9Hz, 1H), 5.14 (t, J=7.4Hz, 1H), 3.81 (s, 3H), 2.67 (dd, J=14.6 and 4.6Hz, 1H), 2.45 (dd, J=14.6 and 11.7Hz, 1H), 2.75-2.60, 2.40-2.35, 2.10-1.95, 1.95-1.80, 1.80-1.60 and 1.40-1.25 (6m, 1H+1H+1H+1H+2H+4H, respectively), 1.67 (s, 3H), 1.14 (tt, J=13.3 and 4.2Hz, 1H), 1.07 (d, J=6.5Hz, 3H), 1.02 (d, J=6.9Hz, 3H), 0.98 (d, J=6.8Hz, 3H), 0.90 (s, 9H), 0.00 and -0.25 (2s, 2x3H). **¹³C NMR**: 164.1, 161.8, 154.7, 137.6, 124.5, 112.7, 106.0, 68.8, 51.3, 50.7, 35.2, 34.9, 33.2, 29.5, 28.1, 26.7, 25.7, 23.7, 22.0, 21.0, 20.9, 20.6, 18.1, -5.2, -5.4. **IR**: 2956, 1721, 1610, 1567, 1074. **HR-MS**: 405.2466±0.0012 (405.2461 for (M-C₄H₉)⁺: C₂₃H₃₇O₄Si).

(2S,2'S) Methyl 2-(1-oxo-2-isopropyl-5-methylhex-5-enyl)-5-(2'-methylhex-5'-enyl)-furan-3-carboxylate (28):

Dess-martin periodinane (551 mg, 1.3 mmol) was added to a CH₂Cl₂ (10 mL) solution of epimeric alcohol **24** (376 mg, 1 mmol) at 0°C. After stirring the mixture for 1 h at 0°C, it was diluted with hexane (30 mL) and stirred with a solution of Na₂SO₃ (5 mL, sat.) for 10 min at 23°C to destroy the excess reagent. Following an aqueous work-up, FC (10% to 20% ether in hexane) afforded 342 mg (91%) title ketone **28** as a colorless oil. **¹H NMR**: 6.42 (s, 1H), 5.78 (dddd, J=17.0, 10.2, 6.6 and 6.6Hz, 1H), 5.01 (ddd, J=17.2, 3.3 and 1.6Hz, 1H), 4.96 (dd, J=10.2 and 1.4Hz, 1H), 4.64 and 4.59 (2s, 2x1H), 3.87 (s, 3H), 3.25-3.15 (m, 1H), 2.68 (dd, J=15.0, and 6.0Hz, 1H), 2.55 (dd, J=15.0 and 7.6Hz, 1H), 1.67 (s, 3H), 2.2-1.2 (m, 10H), 0.93 (d, J=6.7Hz, 6H), 0.91 (d, J=7.0Hz, 3H). **¹³C NMR**: 193.1, 163.6, 157.7, 150.6, 145.3, 138.2, 122.8, 114.6, 110.2, 110.1, 53.1, 52.2, 35.6, 35.4, 35.1, 31.8, 31.1, 30.6, 26.0, 22.1, 20.7, 19.4, 19.2. **IR**: 2960, 1732, 1680, 1646, 1530, 1230. **HR-MS**: 374.2450±0.0011 (374.2457 for M⁺: C₂₃H₃₄O₄).

(3S,10S) (6Z and 6E) Methyl 11-oxo-10-isopropyl-3,7-dimethyl-15-oxabicyclo[10.2.1]pentadeca-1(14),6,12-triene-13-carboxylate (29Z and 29E):

A CH₂Cl₂ (5 mL) solution of diene **28** (290 mg, 774 μmol) was added with a syringe pump over 1 h to a refluxing stirred CH₂Cl₂ (190 mL) solution of catalyst tricyclohexylphosphine[1,3-bis(2,4,6-trimethylphenyl)-4,5-dihydroimidazol-2-ylidene]benzylideneruthenium(IV) dichloride **25b** (65 mg, 77 μmol). Following 2 h reflux, the mixture was evaporated to ~20 mL, filtered through silica and eluted with CH₂Cl₂ (200 mL) and a mix of 20% ether and hexane (100 mL). Crude ¹H NMR showed a **29Z/29E** ratio of 63:37. FC (60% to 100% CH₂Cl₂ in hexane, then 10% ether in hexane) of this mixture afforded 118 mg (44%) **6Z**-macrocycle **29Z** as a colorless oil. **¹H NMR**: 6.42 (s, 1H), 5.11 (t, J=6.8Hz, 1H), 3.89 (s, 3H), 2.94 (dd, J=14.7 and 4.1Hz, 1H), 2.84 (ddd, J=8.8, 7.4 and 4.2Hz, 1H), 2.43 (dd, J=14.7 and 8.0Hz, 1H), 2.2-1.2 (m, 10H), 1.68 (d, J=1.0Hz, 3H), 1.04 (d, J=6.8Hz, 3H), 1.00 (d, J=6.9Hz, 3H), 0.93 (d, J=6.6Hz, 3H). It was followed by **6E**-macrocycle **29E** (71 mg, 26%) evaporated to a colorless oil. $[\alpha]_D^{20}$: +19.8° (c:4.0, hexane). **¹H NMR**: 6.47 (d, J=1.1Hz, 1H), 4.33 (ddd, J=10.3, 2.6 and 1.4Hz, 1H), 3.89 (s, 3H), 3.22 (t, J=9.0Hz, 1H), 2.67 (ddd, J=14.8, 3.1 and 1.1Hz, 1H), 2.32

(dd, $J=14.8$ and 12.5Hz , 1H), 2.1-1.2 (m, 10H), 1.54 (s, 3H), 1.12 (d, $J=6.8\text{Hz}$, 3H), 1.01 (d, $J=6.7\text{Hz}$, 3H), 0.90 (d, $J=6.6\text{Hz}$, 3H). **^{13}C NMR:** 195.0, 163.6, 157.6, 150.5, 133.4, 128.1, 122.1, 111.3, 52.3, 50.6, 37.6, 36.4, 34.9, 31.9, 31.4, 27.3, 26.6, 22.0, 21.1, 20.6, 14.2. **IR:** 2955, 1742, 1680, 1529, 1216. **HR-MS:** 346.2146 ± 0.0010 (346.2144 for M^+ : $\text{C}_{21}\text{H}_{30}\text{O}_4$).

(3*S*,10*S*,11*R*) Methyl 11-hydroxy-10-isopropyl-3,7-dimethyl-15-oxabicyclo[10.2.1]pentadeca-1(14),6,12-triene-13-carboxylate (5):

Sodium borohydride (80 mg) was added to a methanol (2 mL) solution of ketone **29E** (40.1 mg, 114 μmol) at 0°C . After stirring the mixture for 5 h at 10°C , hexane (10 mL) and HCl (1 mL) were added. Following an aqueous work-up, FC (5% to 10% ether in hexane) afforded 33.2 mg (91%) title alcohol **5** as a colorless oil. $[\alpha]_{\text{D}}^{20}$: -82.7° (c:3.3, hexane). **^1H NMR:** 6.21 (d, $J=7.7\text{Hz}$, 1H), 6.16 (d, $J=1.3\text{Hz}$, 1H), 5.05 (d, $J=7.7\text{Hz}$, 1H), 4.75 (dd, $J=6.9$ and 6.1Hz , 1H), 3.85 (s, 3H), 2.58 (ddd, $J=14.4$, 1.7 and 1.7Hz , 1H), 2.15 (dd, $J=14.4$ and 11.8Hz , 1H), 2.1-1.1 (m, 11H), 1.30 (s, 3H), 1.08 (d, $J=6.7\text{Hz}$, 3H), 1.07 (d, $J=6.9\text{Hz}$, 3H), 1.04 (d, $J=6.7\text{Hz}$, 3H). **^{13}C NMR:** 167.0, 163.7, 153.4, 135.8, 124.4, 114.7, 106.8, 71.5, 52.3, 49.0, 38.1, 35.9, 35.3, 30.8, 29.9, 25.0, 23.5, 22.1, 21.6, 20.4, 16.4. **IR:** 3373 (br), 2953, 1693, 1571, 1088. **HR-MS:** 348.2289 ± 0.0010 (348.2300 for M^+ : $\text{C}_{21}\text{H}_{32}\text{O}_4$).

(1*R*,2*S*,4*aR*,4*bR*,7*S*,8*aS*,10*aR*) 4a,7-dimethyl-8a,10a-epoxy-1-hydroxy-2-isopropyl-10-methoxycarbonyl-1,2,3,4,4a,4b,5,6,7,8,8a,10a-dodecahydrophenanthrene (4):

Furanophane **5** (122 mg, 350 μmol) was heated in a mixture of DMSO (15 mL) and water (10 mL) for 3 days at 115°C . Upon cooling, water (100 mL) and CH_2Cl_2 (20 mL) were added then the mixture was extracted with hexane (3x100 mL). After drying and evaporation, ^1H NMR spectra of the crude product indicated a clean TADA reaction with a ratio of **4:5** ~ 4/1. FC (10% to 20% ether in hexane) afforded 32 mg (26%) recovered furanophane **5** and 82 mg (67%, 91% corrected) title tetracycle: $[\alpha]_{\text{D}}^{20}$: $+14.0^\circ$ (c:8.2, hexane). **^1H NMR:** 7.12 (s, 1H), 4.79 (d, $J=4.0\text{Hz}$, 1H), 3.75 (s, 3H), 2.21 (ddd, $J=14.3$, 3.4 and 1.1Hz , 1H), 2.1-0.7 (m, 13H), 1.09 (d, $J=6.5\text{Hz}$, 3H), 1.04 (d, $J=6.4\text{Hz}$, 3H), 0.90 (d, $J=6.7\text{Hz}$, 3H) 0.77 (s, 3H). **^{13}C NMR:** 164.2, 147.7, 143.8, 94.3, 87.8, 68.7, 57.3, 51.7, 43.7, 43.2, 39.2, 35.3, 34.6, 31.0, 27.4, 26.4, 23.5, 23.1, 22.4, 22.0, 18.6. **IR:** 3570 (br), 2927, 1719, 1608, 1454. **HR-MS:** 348.2289 ± 0.0010 (348.2300 for M^+ : $\text{C}_{21}\text{H}_{32}\text{O}_4$).

(2*S*,4*aR*,4*bR*,7*S*,10*aR*) 4a,7-dimethyl-1-oxo-2-isopropyl-10-methoxycarbonyl-1,2,3,4,4a,4b,5,6,7,10a-decahydrophenanthrene (30): (anhydrochatancin)

SnCl_4 (770 μL , 770 μmol , 1 M in CH_2Cl_2) was added to a CH_2Cl_2 (3 mL) solution of tetracycle **4** (27 mg, 77 μmol) at -78°C . The mixture was stirred at 23°C for 19 hours, diluted with hexane and quenched with a saturated NaHCO_3 solution. Aqueous work-up and FC (5% to 20% ether in hexane) afforded 23 mg (90%) anhydrochatancin. $[\alpha]_{\text{D}}^{20}$: $+110^\circ$ (c:2.3, CH_2Cl_2) **^1H NMR:** 7.18 (s, 1H), 5.87 (s, 1H), 3.73 (s, 3H), 3.34 (s, 1H), 2.3-1.1 (m, 12H), 1.00 (d, $J=7.1\text{Hz}$, 3H), 0.91 (d, $J=6.8\text{Hz}$, 3H), 0.84 (d, $J=6.7\text{Hz}$, 3H), 0.83 (s, 3H). **^{13}C NMR:** 209.9, 167.8, 142.7, 139.6, 134.2, 124.1, 59.2, 56.2, 51.7, 41.8, 36.6, 34.6, 31.9, 31.2, 25.9, 23.9, 22.8,

22.1, 21.3, 21.3, 18.6. **IR:** 2931, 1712, 1631, 1256. **HR-MS:** 330.2198±0.0010 (330.2195 for M^+ : $C_{21}H_{30}O_3$). 1H NMR, ^{13}C NMR and IR spectra are identical to that of Goessinger's anhydrochatancin^{1,26} (which was identical to Sato's, according to personal communication).

(2*S*,4*aR*,4*bR*,7*S*,8*aS*,10*aR*) 4*a*,7-dimethyl-8*a*,10*a*-epoxy-1-oxo-2-isopropyl-10-methoxycarbonyl-1,2,3,4, 4*a*,4*b*,5,6,7,8,8*a*,10*a*-dodecahydrophenanthrene (31):

Dess-Martin periodinane (4.2 mg, 10 μ mol) was added to a $CDCl_3$ (0.8 mL) solution of alcohol **4** (3.5 mg, 1 mmol) at 0°C. After 30 min at 0°C, it was diluted with hexane (10 mL) and stirred with a solution of Na_2SO_3 (5 mL, sat.) for 10 min at 23°C to destroy the excess reagent. The product (3.3 mg, 94%) was pure enough for the further investigation. $[a]_D^{20}$: -53° (c:0.3, hexane). **1H NMR:** 7.10 (s, 1H), 3.73 (s, 3H), 2.72 (ddd, $J=9.4$, 7.3 and 7.3Hz, 1H), 2.3-1.5 (m, 8H), 1.49 (d, $J=13.7$ Hz, 1H), 1.48 (d, $J=12.9$ Hz, 1H), 1.40 (d, $J=12.0$ Hz, 1H), 1.15-1.10 (m, 1H), 1.04 (d, $J=6.5$ Hz, 3H), 0.98 (d, $J=6.6$ Hz, 3H), 0.98 (s, 3H), 0.92 (d, $J=6.7$ Hz, 3H), 0.74 (qd, $J=13.3$ and 3.5Hz, 1H). **^{13}C NMR:** 207.7, 163.4, 146.5, 143.7, 93.6, 88.9, 56.8, 51.8, 46.9, 39.0, 35.1, 34.8, 31.0, 29.7, 27.0, 26.4, 23.0, 22.3, 21.2, 19.0 18.2. **IR:** 2927, 1724, 1608, 1453, 1200. **HR-MS:** 346.2144±0.0010 (346.2144 for M^+ : $C_{21}H_{30}O_4$).

S-16

#	ADDRESS	18	FREQUENCY [Hz]	[PPM]	INTENSITY
1	12931.8		643.787	2.1450	12.42
2	14192.6		297.776	0.9922	14.24
3	14217.2		291.026	0.9697	13.31

ppm
209.182

#	ADDRESS	FREQUENCY [Hz]	[PPM]	INTENSITY
1	2214.4	15786.476	209.1817	0.30
2	9399.0	5842.872	77.4221	1.07
3	9422.1	5810.882	76.9982	1.11
4	9445.2	5778.944	76.5750	1.12
5	10150.0	4803.463	63.6492	4.11
6	11126.3	3452.269	45.7450	4.18
7	11317.5	3187.603	42.2379	3.05
8	12002.8	2239.178	29.6707	1.46
9	12081.0	2130.883	28.2357	5.46
10	12212.8	1948.550	25.8196	13.09
11	12399.7	1689.826	22.3914	4.67
12	12541.1	1494.059	19.7973	4.88
13	12569.0	1455.496	19.2863	5.31
14	12632.1	1368.245	18.1302	0.97
15	13923.8	-419.489	-5.5585	4.52

77.422
76.998
76.575

63.649

45.745
42.238

29.671
28.236
25.820
22.391
19.797
19.286
18.130

-5.559

S-30

#	ADDRESS	FREQUENCY [Hz]	[PPM]	INTENSITY
1	4731.5	2894.550	9.6443	3.16
2	4743.0	2891.380	9.6338	3.13
3	7339.1	2178.920	7.2599	12.36
4	10101.2	1420.880	4.7342	1.65
5	10104.1	1420.101	4.7316	2.03
6	10106.0	1419.574	4.7299	2.13
7	10108.7	1418.821	4.7274	1.84
8	10110.9	1418.242	4.7254	1.60
9	10161.0	1404.466	4.6795	1.88
10	10164.1	1403.637	4.6768	2.34
11	10168.0	1402.572	4.6732	2.14
12	10171.1	1401.708	4.6703	1.57
13	13064.8	607.565	2.0243	2.31
14	13088.1	601.176	2.0031	1.82
15	13410.0	512.842	1.7087	10.02
16	13571.2	468.579	1.5613	3.85
17	14197.3	296.774	0.9888	16.14
18	14209.2	293.500	0.9779	15.54
19	14221.9	290.024	0.9663	14.83
20	14233.7	286.769	0.9555	13.92

S-41

S-49

S-50

S-51