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Total syntheses of the sesquiterpenes β-corymbolol and corymbolone

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This paper is dedicated to Professor Nicola Petragnani, for his invaluable contribution to the development of the Brazilian Organic Synthesis

Abstract—The first total synthesis of racemic corymbolone, an eudesmane sesquiterpene isolated from *Cyperus* species used in traditional medicine to treat many diseases, is reported. In the developed sequence, the immediate precursor of corymbolone is the diol β-corymbolol, an epimer at C_1 of the natural α-corymbolol. Thus, starting from the readily available Wieland–Miescher Ketone, the title compounds were achieved in 11 and 12 steps, respectively, in ca. 3% overall yield.

1. Introduction

Corymbolone (**1**) is a sesquiterpenic keto-alcohol first isolated in 1985, in South America, from the rhizomes of *Cyperus corymbosus* Rottboll.[1] Some years later, corymbolone was isolated in Cameroon, from *Cyperus articulatus* L., along with another eudesmane sesquiterpene, the diol α-corymbolol (**2a**).[2] Since 1994, *C. articulatus* L. and *C. corymbosus* Rottb. are treated as synonymous.[3] This cyperaceae is a tropical sedge widely distributed in southern and western Africa, where it is known as 'mandassi',[2] as well as in the Amazonian region, where it is called 'piripiri'.[4] The crude drug prepared from the rhizomes of this plant has been used in traditional medicine as contraceptive[5,6] and for treating many other diseases.[7,8]

Both corymbolone and corymbolol (Fig. 1) bear an axial hydroxyl group at the C_5 position, which is not an usual feature of the eudesmane sesquiterpenes.

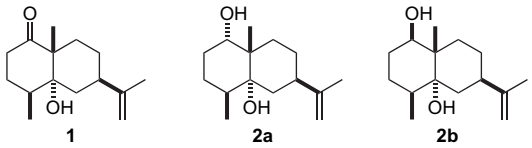
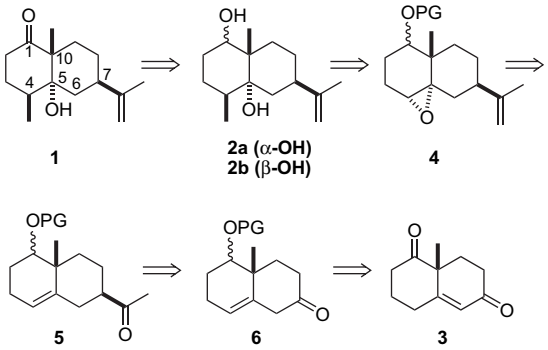


Figure 1. Corymbolone (**1**), α-corymbolol (**2a**) and β-corymbolol (**2b**).

The reported biological activity and the rare presence of an angular hydroxyl group, as well as the lack in the literature of any described synthesis of these compounds, stimulated us to investigate some approaches for their total synthesis. Thus, starting from the readily available Wieland–Miescher Ketone (**3**), we designed the retrosynthetic analysis depicted in Scheme 1.



Scheme 1. Retrosynthetic approach for **1** and **2**.

The functionalization of the A ring of **1** involves a nucleophilic opening of the α-epoxide **4**, by means of an adequate organometallic reagent, followed by oxidation of the secondary hydroxyl group of **2a** or **2b**. Since it is well known that the S_N2-type opening of cyclohexyl oxiranes is a trans-diaxial process, it can be foreseen that the organometallic reagent would attack the less substituted center (C_4) of **4** from the β-face. Therefore, the stereoselective α-epoxidation of **5** is a requirement to ensure the correct introduction of the axial methyl and hydroxyl groups at C_4

Keywords: Corymbolone; Corymbolol; Eudesmane sesquiterpenes; *Cyperaceae* species.
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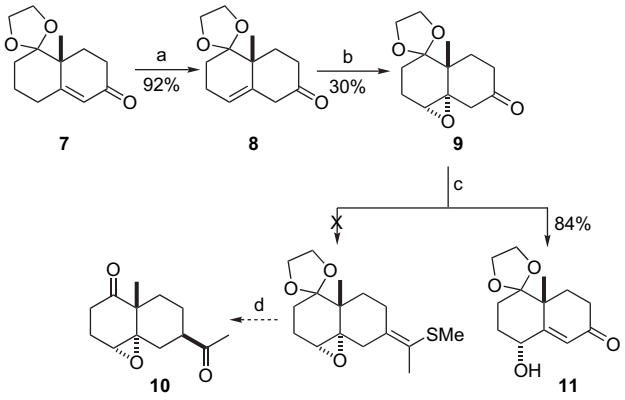
and C_5, respectively. A preferential epoxidation from the α-face could be expected, due to the steric hindrance offered by the C_{10} β-methyl group.

Concerning the B ring, the retrosynthetic analysis suggests that the isopropenyl unit could be introduced by homologation of the carbonyl group of **6**, followed by an olefination reaction of the resulting acetyl group present in **5** (or in some synthetic equivalent).

Finally, the migration of the double bond from the C_5–C_6 to the C_4–C_5 position, in an appropriate stage of the synthesis, would complete the retrosynthetic approach. The experimental results further described confirm the feasibility of the proposed sequence.

2. Results and discussion

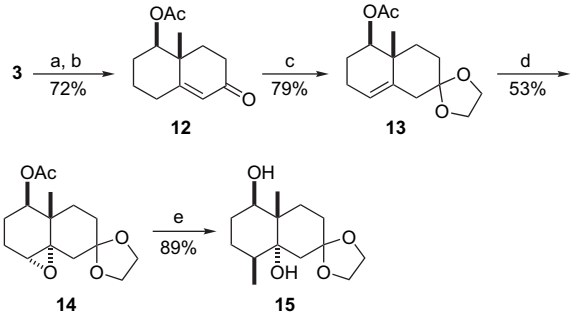
In a previous paper,[9] we presented the results of our attempts to promote the stereoselective α-epoxidation of the β,γ-unsaturated ketone **8**, obtained by deconjugation of **7**. By this first proposed protocol, the resulting product **9** would be submitted to a Horner–Emmons olefination, followed by hydrolysis, to furnish the advanced intermediate **10**. However, this sequence could not be achieved, since the desired epoxide **9** was obtained in very low yield (30%), accompanied by the reconjugated ketone **7** as the major product. Moreover, the epoxide **9** showed to be very unstable, even at 0 °C, and when submitted to the olefination reaction gave exclusively the allylic alcohol **11**, in 84% yield (Scheme 2). The formation of this alcohol can be rationalized on the basis of a deprotonation at C_6, with subsequent opening of the epoxide ring.



Scheme 2. Reagents and conditions: (a) i: *t*-BuOK/*t*-BuOH, 1 h, rt; ii: NaH_2PO_4 0.3 M; (b) *m*-CPBA, CH_2Cl_2, 2 h, rt; (c) $(EtO)_2P(O)CHCH_3(SMe)$, THF, 4 h, −78 °C and (d) H_3O^+.[9]

In view of these disappointing results, we formulated a second synthetic approach,[10] where none of the intermediates has acidic protons at C_6, for circumventing the undesirable reactions mentioned above. The envisaged key-intermediate of the new sequence was the α-epoxide **14**, which could be obtained from the ketone **3** (Scheme 3).

Thus, the acetate **12** was easily obtained by reduction[11] and acetylation[12] of **3**. The deconjugative ketalization of **12** was undertaken by treatment with ethylene glycol in the presence of *p*-TSA, leading to **13**[12] as a white crystalline solid.



Scheme 3. Reagents and conditions: (a) $NaBH_4$, EtOH, 0 °C, 92%; (b) Ac_2O, py, DMAP, rt, 78%; (c) ethylene glycol, *p*-TSA, PhH, 12 h, reflux; (d) *m*-CPBA, CH_2Cl_2, 3 h, rt and (e) MeMgI, CuI, Et_2O, 8 h, rt.[10]

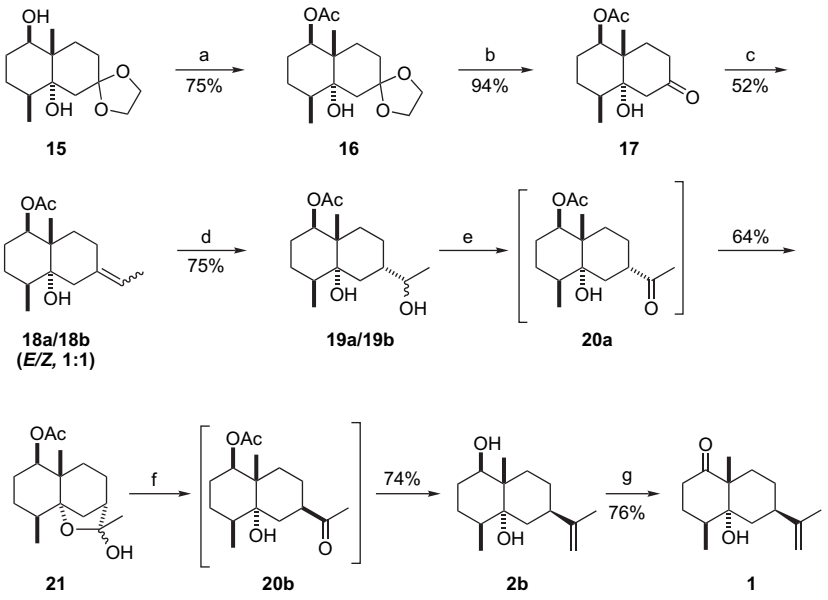
It must be noted that some years after the publication of the above mentioned results,[10] the same sequence of reactions (from **3** to **13**) was employed by Danishefsky et al. in the total syntheses of baccatin III and taxol.[13]

The epoxidation of **13** was performed by classical conditions (*m*-CPBA in dichloromethane), giving a diastereomeric mixture (ca. 7:3, by ^1H NMR analysis) of the epoxides, which were separated by silica column chromatography into the pure α-isomer **14** (53%) and the corresponding β-isomer (19%). The correct structure of **14** was determined by NMR spectroscopy, and confirmed by X-ray analysis.[14]

Although a greater ratio of the desired α-epoxide had been expected a priori, the lower assessed α/β ratio can be probably attributed to a competitive hindrance between the C_{10} β-methyl group and the α-oxygen of the ketal group at C_7. Other epoxidizing reagents (DMD and TBHPMo) were then tried, not only on the intermediate **13**, but also on other related substrates.[15] The results thus obtained were more unfavourable, since the major isomers were always the β-epoxides. We have then decided to pursuit the synthetic route using the earlier protocol (*m*-CPBA-promoted epoxidation of **13**), in spite of the moderate yield of **14**.

The trans-diaxial opening of the epoxide **14** was best performed employing methylmagnesium iodide in the presence of 10% of cuprous iodide, although with loss of the protecting group at C_1. Eventually, the presence of the copper salt should preserve the chemoselectivity towards the epoxide ring, therefore avoiding the attack to the acetyl group. Nevertheless, a great excess of the Grignard reagent was required to achieve good results in the epoxide opening, since 2 equiv were consumed by the acetate group, giving the diol **15** as final product. At this point, the synthetic problems concerning the construction of the ring A of the target molecule were solved.

The introduction of the isopropenyl unit at C_7, as stated in the retrosynthetic analysis, would be possible following a sequence of reactions already employed by Heathcock et al.,[12] and by de Groot et al.,[16] in their syntheses of other eudesmane sesquiterpenes. The approach consists in a Wittig reaction at the C_7 carbonyl group, followed by hydroboration of the C_7–C_{11} double bond, oxidation of the hydroxyl group at C_{11} and, finally, another olefination of the resulting methyl ketone.



Scheme 4. Reagents and conditions: (a) Ac_2O, Et_3N, DMAP, 72 h, rt; (b) AcOH, 20 min, 65°C; (c) $Ph_3P{=}CHCH_3$, DMSO, 15 min, rt; (d) i: $BH_3{\cdot}THF$, 21 h, rt; ii: NaOH 3 N, H_2O_2, 15 min, rt; (e) PCC, AcONa, CH_2Cl_2, 3 h, rt; (f) $Ph_3P{=}CH_2$, DMSO, 7 h, 50°C and (g) PCC, CH_2Cl_2, 3 h, rt.

The complete sequence from **15** to **1**, and hence to **2b**, was accomplished with success, as summarized in Scheme 4.

Since the first step in the construction of the ring B would be a Wittig olefination of the regenerated carbonyl group at C_7, the protection of both the hydroxyl groups in **15** seemed to be a requirement. We attempted at first the diacetylation of **15**, by treatment with Ac_2O/Et_3N under DMAP catalysis. Unfortunately, several experiments employing these conditions, as well as changing Et_3N for pyridine, and running the reaction at different times and temperatures, furnished exclusively the monoacetylated derivative **16**. Attempts to protect the C_5 hydroxyl group of **16** with different alkoxy groups were also fruitless.

In view of this somewhat surprising stability of **15** and **16** towards both acidic and basic media, we decided to disregard the protection of the tertiary alcohol and to submit the ketone **17** directly to the Wittig reaction. It must be pointed out that a successful Wittig reaction in a hydroxylated substrate has already been reported.[16] In a first set of experiments, **17** was treated with excess (ranging from 2 to 5 equiv) of ethylidene triphenylphosphorane in ethyl ether, at room temperature, furnishing the desired olefin **18** as a mixture of *E* and *Z* isomers, in poor yields. The main product of these reactions was the α,β-unsaturated ketone formed by dehydration of **17**. Under these conditions, the best yield of **18** was 29%.

Assuming that the low yield of **18** could be due not only to the concurrence of the elimination reaction, but also to the low solubility of **17** in ethyl ether, a set of experiments was performed using DMSO as the solvent (where the substrate is more soluble) and the corresponding lithium dimsyl as the base. Under these conditions, and using 2 equiv of the phosphonium salt, the desired olefin **18** was obtained in a considerably increased yield. A rigorous control of the reaction time showed to be necessary, the best result (52% yield) being achieved after 15 min at room temperature. Although quite modest, this yield can be considered acceptable, since it was recompensed by accomplishing the conversion of **17** into **18** in a single step, avoiding the protection (and subsequent deprotection) of the hydroxyl group at C_5.

The regioselective hydroboration of **18** gave mainly, as expected, the anti-Markovnikov product **19** (75% yield, after silica column chromatography), together with minor amounts of its regioisomer. The stereoselectivity of the reaction was remarkably high, with the hydroxyalkyl substituent at C_7 assuming exclusively the undesired α-axial position. Probably, this high stereoselectivity is due to the steric hindrance offered by the axial hydroxyl group at C_5.

Considering the relative configurations of corymbolone and α-corymbolol, an essential requirement for pursuing the synthesis would be the axial to equatorial inversion of the hydroxyalkyl substituent at C_7. An obvious attempt involves the oxidation of **19**, expecting that the produced methyl ketone (**20a**) would assume the thermodynamically more stable equatorial position (**20b**). Nevertheless, the oxidation of **19**, using PCC in the presence of AcONa, led directly to the lactol **21**, instead of the expected methyl ketone.

Fortunately, the desired epimerization of C_7 was successfully achieved by submitting the lactol **21** to a Wittig reaction with methylene triphenylphosphorane. The highly basic medium of the reaction promoted the opening of the hemiketal **21**, followed by equilibration to **20b**, which was then converted irreversibly into the olefinic product. The conditions employed—warming at 50 °C—also promoted the deprotection of the hydroxyl group at C_1, in contrast to that observed in the olefination of **17**, performed at room temperature.

Therefore, to our delight, β-corymbolol (**2b**) was obtained in a single step from the lactol **21**, in 74% yield. Finally, the oxidation of **2b** to corymbolone (**1**) was performed in 76% yield, by treatment with PCC.

In summary, the first total syntheses of racemic β-corymbolol and corymbolone was accomplished in 11 and 12 steps, respectively, from the commercially available Wieland–Miescher Ketone (**3**). As the enantiomerically pure ketone **3** can be easily prepared,[17,18] the approach herein reported could be adapted for the chiral synthesis of the title compounds. Since α-corymbolol (**2a**) was already obtained by reduction of corymbolone,[2] our sequence also represents a racemic formal synthesis of this natural product.

3. Experimental

3.1. General

Melting points (Kofler hot-stage) are uncorrected. ^{1}H NMR spectra were recorded at 200 MHz on a Bruker AC-200 spectrometer, in $CDCl_3$, using TMS as an internal standard. ^{13}C NMR spectra were recorded at 50.3 MHz on a Bruker AC-200 spectrometer. IR spectra were measured on a Perkin–Elmer 1750 or Nicolet 510 FT-IR Spectrometer. Mass spectra were measured with a Finnigan MAT (ITD) 800. The intermediates **12–15** were prepared as previously described.[10]

3.2. 1β-Acetoxy-5α-hydroxy-4β,10β-dimethyl-7,7-ethylenodioxy-decalin (16)

To a solution of the alcohol **15** (0.15 g, 0.59 mmol) in Et_3N (5 mL) was added Ac_2O (1 mL), followed by DMAP (some crystals) at room temperature. After stirring for 72 h the reaction mixture was diluted with MeOH (10 mL). The mixture was concentrated under reduced pressure and the residue was quenched with diluted HCl and extracted with AcOEt. The organic layer was washed with satd aq $NaHCO_3$ and brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by silica gel chromatography ($CHCl_3$/AcOEt, 7:3 as eluent), to give **16** as an oil, which decomposes partially to the corresponding ketone **17**, and therefore was used without further purification (75%; 0.13 g, 0.44 mmol). ^{1}H NMR δ 5.06 (dd, J 7.8, 6.1 Hz, 1H), 4.27 (s, 1H), 3.93–3.79 (m, 4H), 2.05 (d, J 14.0 Hz, 1H), 1.90 (s, 3H), 2.22–1.15 (m, 10H), 0.99 (s, 3H), 0.89 (s, 3H); ^{13}C NMR δ 170.4, 109.6, 76.9, 76.8, 64.1, 63.7, 41.1, 39.2, 38.8, 31.2, 30.4, 25.8, 22.6, 21.0, 16.2, 16.0; IR (film) ν_{max}: 3431, 2931, 1730, 1247, 986 cm^{-1}.

3.3. 1β-Acetoxy-4β,10β-dimethyl-5α-hydroxy-octal-7-one (17)

A solution of **16** (0.53 g, 1.8 mmol) in AcOH (5 mL) was stirred at 65 °C for 20 min, and then cooled to 10 °C, when a satd solution of $NaHCO_3$ was added. After extraction with AcOEt, the organic layer was washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by silica gel chromatography (hexanes/AcOEt, 7:3 as eluent), affording **17** (94%; 0.42 g, 1.7 mmol) as white crystals. Mp 184–185 °C; ^{1}H NMR δ 5.12 (dd, J 8.0, 6.3 Hz, 1H), 2.90 (d, J 14.7 Hz, 1H), 2.85–1.32 (m, 11H), 2.00 (s, 3H), 1.27 (s, 3H), 1.06 (d, J 7.6 Hz, 3H); ^{13}C NMR δ 211.9, 170.6, 80.5, 76.8, 50.0, 40.9, 40.6, 37.5, 33.9, 25.8, 22.6, 21.1, 17.2, 16.0; IR (film) ν_{max}: 3405, 2935, 1726, 1699, 1256 cm^{-1}; MS (EI) m/z (%) 254 ($M^{\bullet+}$, 2), 109 (100); Anal. Calcd for $C_{14}H_{22}O_4$: C=66.12%, H=8.72%; Found: C=66.51%, H=9.05%.

3.4. *E*- and *Z*-1β-Acetoxy-4β,10β-dimethyl-5α-hydroxy-7-ethylidene decalin (18a/18b)

n-BuLi (1.7 M in hexane; 2.1 mL, 3.5 mmol) was added to anhydrous DMSO (20 mL), under N_2 atmosphere. After stirring for 30 min, ethyl triphenylphosphonium bromide (1.6 g; 4.3 mmol) was added and the mixture was stirred for 1 h at room temperature. A solution of **17** (0.40 g; 1.6 mmol) in anhydrous DMSO (10 mL) was added, the mixture was stirred for 15 min at room temperature and then poured into H_2O (100 mL). After extraction with AcOEt, the organic layer was washed with satd NaCl solution, dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was chromatographed on silica gel (hexanes/AcOEt, 9:1 as eluent) to give a 1:1 mixture of **18a/18b** (52%; 0.22 g, 0.83 mmol). ^{1}H NMR δ 5.50 (q, J 6.6 Hz, 1/2H), 5.23 (q, J 6.7 Hz, 1/2H), 5.08 (dd, J 10.4, 5.7 Hz, 1H), 2.90–1.20 (m, 15H), 2.00 (s, 3H), 1.16 (s, 3H), 1.06 (d, J 8.1 Hz, 3/2H), 1.02 (d, J 8.2 Hz, 3/2H); ^{13}C NMR δ 170.8, 135.7/135.5, 121.9/121.7, 77.4, 76.8/76.4, 43.6, 42.2, 39.2/39.1, 35.7/35.3, 34.9/31.3, 26.4, 22.9/22.8, 21.2, 16.6/16.5, 16.1/15.8, 12.9/12.6; IR (film) ν_{max}: 3509, 2959, 2931, 1714, 1263 cm^{-1}; MS (EI) m/z (%) 266 ($M^{\bullet+}$, 2), 124 (100); Anal. Calcd for $C_{16}H_{26}O_3$: C=72.14%, H=9.84%; Found: C=71.71%, H=9.53%.

3.5. 1β-Acetoxy-4β,10β-dimethyl-5α-hydroxy-7α-(1′-hydroxy)-ethyl decalin (19a and 19b)

A solution of $BH_3\cdot THF$ (1.0 M; 2.9 mL, 2.9 mmol) was slowly added to a solution of **18** (0.19 g, 0.71 mmol) in anhydrous THF (15 mL) at 0 °C, under N_2. The mixture was stirred for 21 h at room temperature and then for 1 h at reflux. The reaction mixture was cooled to 0 °C, and a mixture of NaOH 3 M (2 mL) and H_2O_2 30% (1.8 mL) was added. After stirring for 15 h at room temperature, the mixture was stirred for 1 h under reflux and then was allowed to reach room temperature, when brine was added. The layers were separated and the aqueous phase was then extracted with CH_2Cl_2. The combined organic phases were concentrated under reduced pressure. The residue was purified by silica gel chromatography (hexanes/AcOEt, 7:3 as eluent), to give a 1:1 mixture of the diastereoisomeric diols **19a** and **19b** (75%; 0.15 g, 0.53 mmol). Analytical samples were obtained by further purification. **19a**: ^{1}H NMR δ 5.10 (dd, J 10.4, 5.8 Hz, 1H), 4.54 (br s, 2H), 3.90 (q, J 6.4 Hz, 1H), 2.40 (dd, J 14.7, 7.9 Hz, 1H), 2.31–1.58 (m, 11H), 1.99 (s, 3H), 1.19 (d, J 6.4 Hz, 3H), 1.08 (s, 3H), 1.04 (d, J 7.7 Hz, 3H); ^{13}C NMR δ 171.0, 77.3, 75.8, 73.6, 41.0, 39.6, 38.1, 37.1, 31.5, 26.2, 22.8, 22.7, 21.2, 17.7, 17.2, 16.4; IR (film) ν_{max}: 3367, 2931, 1714, 1248, 1083 cm^{-1}.

19b: ^{1}H NMR δ 5.10 (dd, J 10.9, 5.4 Hz, 1H), 3.98 (q, J 6.1 Hz, 1H), 3.41 (br s, 2H), 2.29–1.29 (m, 12H), 2.00 (s, 3H), 1.17 (d, J 6.2 Hz, 3H), 1.09 (s, 3H), 1.03 (d, J 7.6 Hz, 3H); ^{13}C NMR δ 171.0, 77.1, 75.6, 70.9, 41.3, 39.8, 38.3, 30.5, 30.2, 26.2, 23.6, 22.8, 22.5, 21.2, 17.1, 16.3; IR (film) ν_{max}: 3156, 2971, 2959, 1729, 1248 cm^{-1}.

Anal. Calcd for $C_{16}H_{28}O_4$: C=67.57%, H=9.92%; Found: 67.30%, H=10.13%.

3.6. 5-7(1′)-Hemiacetal of 1β-acetoxy-4β,10β-dimethyl-5α-hydroxy-7α-(1′-oxo-1′-methyl)-decalin (21)

To a solution of **19a/19b** (0.080 g, 0.28 mmol) in CH_2Cl_2 (10 mL), was added PCC (0.16 g, 0.74 mmol), followed by anhydrous NaOAc (0.018 mg, 0.22 mmol). After stirring for 3 h at room temperature, the reaction mixture was quenched with water and diluted with CH_2Cl_2. The organic layer was washed with $NaHCO_3$ (5%) and brine, dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was chromatographed on silica gel (hexanes/AcOEt, 7:3 as eluent), to give **21** (64%; 0.051 g, 0.18 mmol). This product showed to be very unstable and was employed in the next step without any purification. ^{1}H NMR δ 4.92 (dd, *J* 9.2, 6.7 Hz, 1H), 2.18–1.19 (m, 13H), 2.01 (s, 3H), 1.50 (s, 3H), 1.11 (s, 3H), 1.03 (d, *J* 7.5 Hz, 3H); ^{13}C NMR δ 170.8, 104.7, 90.8, 79.8, 44.9, 42.4, 39.4, 36.0, 33.8, 27.0, 23.5, 22.4, 22.3, 21.2, 17.4, 16.7.

3.7. Octahydro-4β,8aβ-dimethyl-6β-(1-methylethenyl)-1β,4aα-(2*H*)-naphthalenediol; corymbolol (2b)[2]

To anhydrous DMSO (20 mL) under N_2, *n*-BuLi (2.5 M in hexane; 0.92 mL, 2.3 mmol) was added. After stirring for 30 min, methyl triphenylphosphonium bromide (0.82 g; 2.3 mmol) was added and the mixture was stirred for 1 h. A solution of **21** (0.13 g; 0.46 mmol) in anhydrous DMSO (5 mL) was added and the mixture was stirred for 7 h at 50 °C. After this period the reaction mixture was quenched with water (50 mL) and extracted with AcOEt, the organic layer was washed with satd NaCl solution, dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was chromatographed on silica gel (hexanes/AcOEt, 7:3 as eluent), to give **2b** as an oil (74%; 0.081 g, 0.34 mmol). ^{1}H NMR δ 4.73 (s, 2H), 3.89 (dd, *J* 10.5, 5.9 Hz, 1H), 2.48–1.19 (m, 14H), 1.75 (s, 3H), 1.04 (d, *J* 7.2 Hz, 3H), 1.02 (s, 3H); ^{13}C NMR δ 150.2, 108.5, 77.4, 74.1, 41.7, 41.1, 39.6, 38.3, 33.2, 26.7, 26.3, 25.9, 21.0, 16.7, 15.5; IR (film) ν_{max}: 3422, 2941, 2867, 1456, 1011 cm^{-1}; MS (EI) *m*/*z* (%) 220 ([M−H_2O]$^{\bullet+}$, 2), 109 (100).

3.8. Octahydro-4aα-hydroxy-4β,8aβ-dimethyl-6β-(1-methylethenyl)-1(2*H*)-naphthalenone; corymbolone (1)[1]

To a solution of **2b** (0.040 g, 0.17 mmol) in CH_2Cl_2 (10 mL), PCC (0.11 g, 0.51 mmol) was added. After stirring for 3 h at room temperature, the reaction mixture was quenched with water and diluted with CH_2Cl_2. The organic layer was washed with $NaHCO_3$ (5%) and brine, dried over $MgSO_4$ and concentrated under reduced pressure. The crude product was chromatographed on silica gel (hexanes/AcOEt, 7:3 as eluent), to give **1** as an oil (76%; 0.031 g, 0.13 mmol). ^{1}H NMR δ 4.74 (s, 2H), 2.72–2.60 (m, 1H), 2.48–2.33 (m, 3H), 1.96–1.32 (m, 9H), 1.75 (s, 3H), 1.24 (s, 3H), 1.19 (d, *J* 7.5 Hz, 3H); ^{13}C NMR δ 215.8, 149.5, 108.9, 78.6, 51.2, 40.5, 39.3, 37.2, 34.2, 30.1, 27.9, 25.4, 21.1, 20.4, 17.7; IR (film) ν_{max}: 3430, 2959, 2927, 2859, 1692 cm^{-1}; MS (EI) *m*/*z* (%) 236 (M$^{\bullet+}$, 10), 109 (100).

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