

## Stereoselective Synthesis of ( $\pm$ )-18,19-Dinor-13 $\beta$ H,14 $\alpha$ H-cheilanthane, the Most Abundant Tricyclic Compound from Petroleums and Sediments

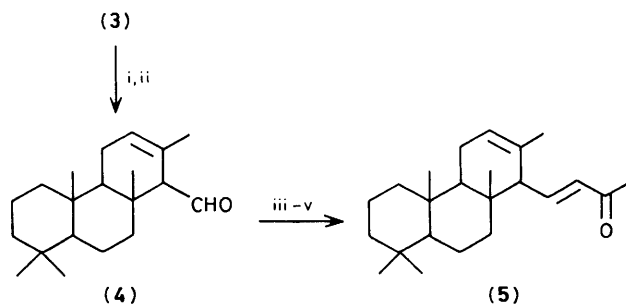
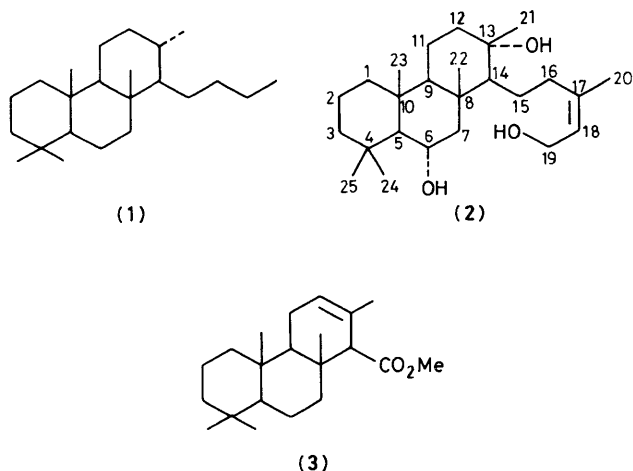
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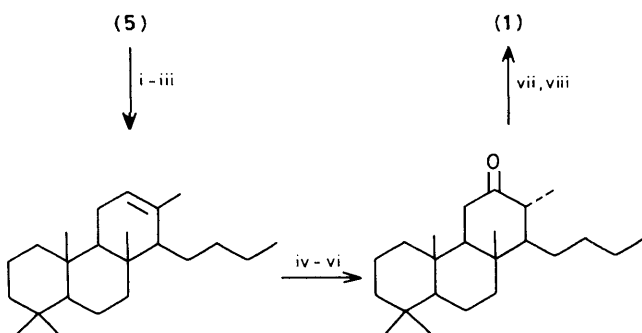
The syntheses of ( $\pm$ )-18,19-dinor-13 $\beta$ H,14 $\alpha$ H-cheilanthane (**1**) and its C-13 epimer (**6**), from ( $\pm$ )-methyl isocopalate (**3**) via the key intermediate (**5**) are described.

Tricyclic terpene hydrocarbons C<sub>20</sub> to C<sub>45</sub><sup>1</sup> have recently been recognized as widely occurring constituents of many petroleums and sediments and are being increasingly used, as biological markers, to provide information about the processes affecting organic matter in geological environ-

ments.<sup>2</sup> The most abundant member of this series (C<sub>23</sub>) was isolated from Athabasca oil sand bitumen and its structure was suggested as (**1**) on the basis of its mass spectrum and correlation of the <sup>1</sup>H n.m.r. methyl shifts with those of the sesterterpene cheilanthatriol (**2**).<sup>3</sup> In order to confirm the structure and relative stereochemistry of (**1**) we decided to synthesise it. ( $\pm$ )-Methyl isocopalate (**3**)<sup>4-6</sup> appeared to be an



**Scheme 1.** i, LiAlH<sub>4</sub>, tetrahydrofuran (THF), reflux; ii, pyridinium chlorochromate on Al<sub>2</sub>O<sub>3</sub>, benzene, 70%; iii, (EtO)<sub>2</sub>P(O)CH<sub>2</sub>CN, NaH, THF; iv, MeLi, Et<sub>2</sub>O, 0 °C, 76%; v, acetone-1 M H<sub>2</sub>SO<sub>4</sub> (9 : 1), 85%.



**Scheme 2.** i, Na, liquid  $\text{NH}_3$ ,  $\text{NH}_4\text{Cl}$ ; ii,  $\text{MeC}_6\text{H}_4\text{-}p\text{-SO}_2\text{Cl}$ , pyridine,  $\text{CH}_2\text{Cl}_2$ ; iii,  $\text{LiAlH}_4$ , THF, reflux; iv,  $\text{Me}_2\text{S}\cdot\text{BH}_3$ , THF,  $\text{H}_2\text{O}_2$ , 3 M NaOH; v, Jones, acetone,  $0^\circ\text{C}$ ; vi,  $\text{NaOMe}\text{-MeOH}$ , 40% overall; vii,  $\text{HSCH}_2\text{CH}_2\text{SH}$ ,  $\text{Et}_2\text{O}\cdot\text{BF}_3$ ,  $\text{CH}_2\text{Cl}_2$ ; viii, Raney Ni, EtOH, reflux, 90%.

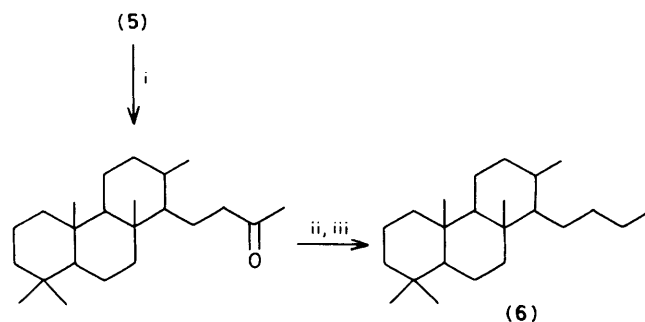
ideal precursor, since it possesses the required tricyclic skeleton with the necessary functional groups for obtaining required stereochemistry at C-13 and C-14, and building up the four-carbon side chain.

Methods for extending the side chain of (3) were subject to severe steric hindrance at C-15. However, a Wittig-Horner reaction, using diethyl cyanomethylphosphonate, on the aldehyde (4), followed by methyl lithium treatment of the resulting nitrile and further hydrolysis, afforded the  $\alpha,\beta$ -unsaturated ketone (5)<sup>†</sup> (m.p.  $105\text{--}106^\circ\text{C}$ ) in reasonable yield, (Scheme 1). Starting with (5) and following the sequence indicated in Scheme 2 the hydrocarbon (1) (m.p.  $39\text{--}41^\circ\text{C}$ ) was obtained; it had identical methyl  $^1\text{H}$  n.m.r. chemical shifts and mass spectral data to the naturally occurring compound.<sup>3,7</sup>

In order to establish fully the stereochemistry of (1), its C-13 epimer (6)<sup>‡</sup> (m.p.  $73\text{--}74^\circ\text{C}$ ) was synthesised by the method shown in Scheme 3. An exhaustive  $^{13}\text{C}$  n.m.r. spectral analysis of (1), (6), and the key intermediate (5) clearly showed that no epimerisation occurred at C-14 during the Wittig-Horner reaction. Therefore, the four-carbon side chain is equatorial ( $\beta$ ) and the methyl group at C-13 is equatorial ( $\alpha$ ) in (1) but

<sup>†</sup> Satisfactory spectroscopy data were obtained for all compounds.

<sup>‡</sup> Since the structure of this type of product is usually determined by mass spectrometry it is noteworthy that the low resolution spectra of (1) and (6) are practically identical.



**Scheme 3.** i,  $\text{PtO}_2$ ,  $\text{H}_2$ , 3 atm., EtOAc; ii,  $\text{HSCH}_2\text{CH}_2\text{SH}$ ,  $\text{Et}_2\text{O}\cdot\text{BF}_3$ ,  $\text{CH}_2\text{Cl}_2$ ; iii, Raney Ni, EtOH, reflux, 90%.

axial ( $\beta$ ) in (6). Finally, compound (1) was shown to be identical to the natural product by direct comparison. The route described represents a simple synthetic entry *via* (5) into other members of the homologous series of these geochemically important tricyclic terpene hydrocarbons.

We thank Dr. O. P. Strausz for carrying out the direct comparison of the synthetic and natural products, Dr. L. F. Sala for the 200 MHz  $^1\text{H}$  n.m.r. spectra, Dr. J. C. Oberti for the mass spectra, Dr. A. J. Marsaioli for the supply of 'oleo de copaiba,' and CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and UNR (Universidad Nacional de Rosario) for financial support and fellowships (R. M. C. and M. A. L.).

Received, 29th December 1983; Com. 1687

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