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THE WOOD RESIN OF AGATHIS AUSTRALIS SALIS. - STRUCTURE AND STEREOCHEMISTRY OF THE MAIN CONSTITUENTS

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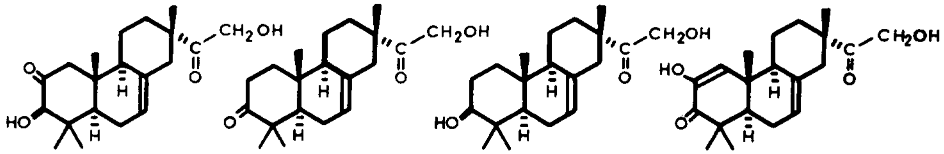
Kauri resin from the New Zealand tree Agathis australis has in the past been of considerable economic importance. However the constituents of the resins derived from this tree have remained comparatively little known though small amounts of agathic acid have been isolated from the fossil resin and α-pinene has been obtained from the essential oil of the resin[1].

An investigation of this species, to be described elsewhere, has now shown that the wood resin (acetone extract) contains two main components which represent about 60-70 per cent of the neutral fraction and about 3.5 per cent of the wood. The remainder of the resin is a fairly complex mixture of minor neutral, acid and phenolic constituents. The present



1 2 3 4

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paper describes evidence for assigning structures 1 and 2 to the main constituents and structures 3 and 4 to the two most important of the minor components. The names araucarolone (1) (isopimar-7-ene-2,15-dione-3,16-diol)*, araucarone(2), araucarol(3) and araucarenolone(4) are used here for these compounds.

The compound present in largest amount is araucarolone (1), m.p. 157-159°, $C_{20}H_{30}O_4$, $[\alpha]_D$-42° ($CHCl_3$, c 5.4). Infrared, ultraviolet and nmr spectra show that it contains one primary and one secondary hydroxyl group, no protons on the carbon atoms adjacent to the two carbinol groups, at least one carbonyl group, a trisubstituted double bond, a methylene group adjacent to a carbonyl group and four quaternary methyl groups. The second major compound was araucarone(2), m.p. 116°, $C_{20}H_{30}O_3$, $[\alpha]_D$-51° ($CHCl_3$, c 2.2). Spectroscopic evidence shows that this is similar to araucarolone but lacks the secondary hydroxyl group.

Selenium dehydrogenation of the tetrol, $C_{20}H_{34}O_4$, m.p. 229-231° (decomp), obtained from araucarolone by reduction with lithium hydrido-aluminate, gave a complex mixture from which was isolated a small amount of 1,7-dimethylphenanthrene indicating that the compound had a tricarbocyclic diterpene skeleton.

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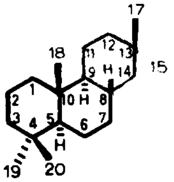
*The name isopimarane has been adopted here as a basis for the systematic naming of derivatives of the fully saturated hydrocarbon A.



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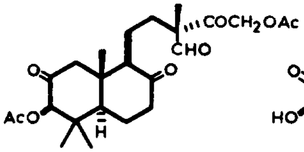
Ozonolysis of araucarolone diacetate gave a compound (5), m.p. 174-175° (decomp), with a single tertiary aldehyde group (nmr). Given a conventional diterpenoid structure, this indicated that cleavage could only have occurred between C(8) and C(14) in a pimarane type skeleton. A C(13) pimarane ethyl group in these compounds would have to carry the primary carbinol group and an oxo group since there was no sign in the nmr spectrum of an ethyl group, and there was no splitting of the methylene protons of the carbinol group other than by the hydroxyl proton.

The presence of a ketol grouping in the side chain of araucarolone was confirmed by oxidation with periodate followed by esterification with diazomethane to give a methyl ester (6), m.p. 123-125°, $C_{20}H_{30}O_4$, λ_{max}^{EtOH} 273 mμ (ε 49). The isolation of a diester aldehyde (7), m.p. 62-63° from the periodate reaction product showed that there was a second ketol grouping in araucarolone. The presence of two protons adjacent to a carbonyl group in araucarolone showed that this



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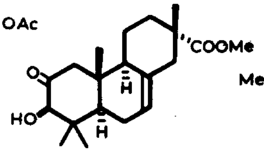

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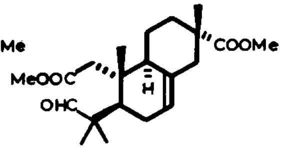

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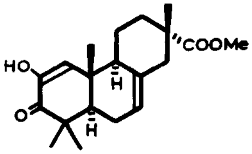

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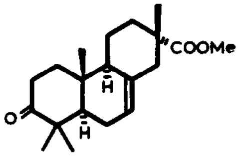

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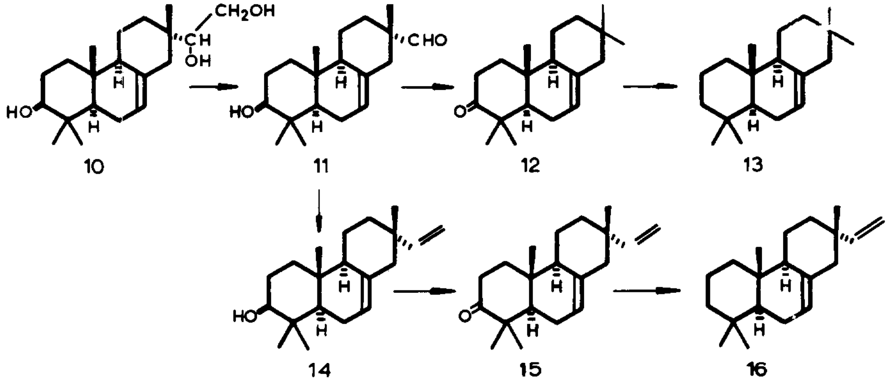
second ketol group had to be in ring A with the carbonyl group at C(2) and the hydroxyl group at C(1) or C(3). This was confirmed by oxidation of the methyl ester 6 with bismuth oxide to a diosphenol (8), m.p. 102-103°, $C_{20}H_{28}O_4$, λ_{max}^{EtOH} 267 $m\mu$ (ε 9400) which showed a second vinyl proton.

The relationship between araucarolone and araucarone was established by Wolff-Kishner reduction of 6 followed by methylation and chromic acid oxidation giving the ketone ester 9, m.p. 74-75°, $C_{20}H_{30}O_3$. This compound was identical (nmr and mixed m.p.) with the ketone prepared from araucarone by periodate oxidation and methylation.

The carbon skeleton of araucarolone and araucarone and the configuration of these compounds at C(5), C(9) and C(10) follow from the reactions shown in the scheme below.



Reduction of araucarone with lithium hydrido-aluminate gave a triol (10), m.p. 190°, $C_{20}H_{34}O_3$, which on periodate oxidation followed by Wolff-Kishner reduction, chromic acid oxidation and a second Wolff-Kishner reduction gave 16-nor-isopimar-

7-ene[3](13), m.p. 43-44°, $[\alpha]_D$-27° ($CHCl_3$, c 1.4). This establishes the C(7)-C(8) position of the double bond and shows that the ozonolysis follows an anomalous course as in the case of isopimaric acid[2].

The reactions establishing the orientation of the side chain are also shown in the scheme above. The hydroxy-aldehyde 11 was converted by a Wittig reaction to the diene alcohol 14, m.p. 146-147° and then by oxidation and Wolff-Kishner reduction to isopimara-7,15-diene[4] (16), $[\alpha]_D$-33° $CHCl_3$, c 4.4). This was identical with authentic material (infrared, nmr, rotation) and with a sample of the hydrocarbon isolated from the resin of Dacrydium biforme (infrared, nmr)[5]. Comparison of the 16-nor-isopimara-7-ene and the isopimara-7,15-diene with authentic material was kindly done for us by Dr. R.E. Ireland.

It follows that araucarolone and araucarone have the "normal" 5α-H, 9α-H, 10β-Me configuration. This is the opposite configuration to that of the hydrocarbon kaurene isolated from kauri leaves[6].

The secondary hydroxyl group of araucarolone and the ring A keto group of araucarone were shown to be at C(3) by rearrangement of the saturated alcohol, m.p. 132-133° obtained from the hydroxy-aldehyde 11 by Wolff-Kishner reduction and catalytic hydrogenation. The configuration of this compound at the new asymmetric centre (8α-H) follows from the method of preparation and from the positive RD curve (a +20) for the corresponding ketone. Treatment of the saturated alcohol with phosphorus pentachloride followed by ozonolysis gave acetone, isolated as 2,4-dinitrophenylhydrazone, and a non-crystalline material which contained a five-membered ring ketone ($\nu_{max}^{CCl_4}$ 1742 cm^{-1}), thus demonstrating the formation of a hydrocarbon with an isopropylidene group and ring A contracted.

The equatorial configuration of the 3-hydroxyl group of araucarolone followed from a comparison of the ultraviolet spectra of the ketol ester 6 with that of the 2-keto ester, m.p.89-90°, obtained by reduction of the acetate of 6 with calcium and liquid ammonia. The absorption maximum of the ketol ester occurred at lower wavelength (λ_{max}^{EtOH}273 mμ, ε 49) than that of the ketone ester (λ_{max}^{EtOH} 285 mμ, ε 38).

The evidence described above completely fixes the structure and stereochemistry of araucarolone (1) and araucarone (2).

The minor constituent araucarol (3) had m.p. 135-136°, $[\alpha]_D$-24° ($CHCl_3$, c 1.7). The nmr spectrum indicated that it had the side chain ketol grouping and a β-hydroxyl group at C(3). Its structure was established by reduction with lithium hydrido-aluminate to the triol 10 and by oxidation with periodate followed by esterification with diazomethane to give the corresponding alcohol ester, m.p. 103-105°.

The structure of the diosphenol (4), m.p. 143-144°, $[\alpha]_D$-58° ($CHCl_3$, c 2.0), was apparent from the nmr, infrared and ultraviolet spectra (λ_{max}^{EtOH} 267 mμ, ε 8000). It was prepared from araucarolone 16-acetate by bismuth oxide oxidation followed by saponification.

A diterpenoid ketone-ketol-diosphenol set similar to that now obtained from kauri has recently been found in the South African Spirostachys africana which contains stachenol, stachenone and the corresponding diosphenol[7]. Also closely related to the kauri compounds is darutigenol (isopimar-8(14)-ene-3,15,16-triol) isolated by Lederer et al from Siegesbeckia orientalis[8]. Both stachenol and darutigenol have absolute configurations opposite to that of araucarolone(1) and araucarone (2).

All new compounds gave satisfactory analyses or mass spectrometric molecular weights. A full account of this work will be published elsewhere.

We wish to thank Mr. J.S. Reid, New Zealand Forest Service, for the kauri wood used in this investigation, Dr. R.E. Ireland for comparison of the norisopimarene and the isopimaradiene with authentic material and Dr. W. Klyne for RD measurements and helpful discussion.

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