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SHORT COMMUNICATION

DITERPENES OF SPIKENARD ROOT (ARALIA RACEMOSA)

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Abstract—The occurrence of (-)-pimara-8(14), 15-diene, (-)-kaurene, (-)-pimara-8(14)-15-dien-19-oic acid and sucrose in Aralia racemosa is described.

(-)-PIMARANE diterpenes were required for our biosynthetic studies.¹ Extraction of Spikenard root (Aralia racemosa—Araliaceae) with light petroleum and chromatography of the acidic fraction yielded (-)-pimara-8(14),15-dien-19-oic acid* (I). This had previously been isolated² from a Japanese species, A. cordata, whilst chromatographic evidence suggested its presence in A. racemosa. This acid was readily characterized by conversion to its methyl ester and reduction with LiAlH₄. The resultant mono-ol, $C_{20}H_{32}O$ (II), contained two double bonds whilst its spectral properties characterized it as a pimaradiene. This was substantiated by oxidation of the alcohol with CrO_3 to form (-)-pimara-8(14),15-dien-19-al (III). Conversion of the aldehyde to its semicarbazone followed by Wolff-Kishner reduction gave (-)-pimaradiene (IV) identical in all respects except rotation with a sample prepared from pimaric acid. The position of the oxygen function at the axial C-19 followed from the position of the CH₂OH resonances in the NMR at τ 6.47 and 6.12 as opposed to τ 6.6-6.7 for equatorial hydroxymethyl protons.³

With a view to introducing a label [14C or 3H] at position 16, the 19-alcohol was treated with osmium tetroxide to afford the 15,16-glycol (V). This glycol was cleaved with periodate to form the 16-nor-15-aldehyde (VI). The vinyl function was readily regenerated from this using a Wittig reaction.

Chromatography of the neutral fraction from the light petroleum extract afforded a hydrocarbon mixture from which (-)-pimara-8,(14),15-diene (IV) and (-)-kaurene (VII). could be separated by preparative TLC using 10 per cent AgNO₃ on silica gel. Extraction of the plant material with not ethanol afforded sucrose in 1 per cent yield.

EXPERIMENTAL

M.ps. were determined on a Kofler block and are corrected. NMR spectra were in CDCl₃. I.r. spectra were determined as nujol mulls. Light petroleum refers to the fraction, b.p. 60-80°.

Isolation of the Constituents from Aralia racemosa

Dried ground root of Aralia racemosa (2 kg) (S. B. Penick & Co.) were extracted with light petroleum

- * Professor Shibata was unable to supply us with a comparison sample.
- ¹ J. R. HANSON and A. F. WHITE, J. Chem. Soc. (C), 891 (1969).
- ² S. SHIBATA, S. MIHASHI and O. TANAKA, Tetrahedron Letters 5241 (1967).
- ³ A. GAUDEMER, J. POLONSKY and E. WENKERT, Bull. Soc. Chim. (France) 407 (1964). 86 1359



(51.) for 32 hr. Evaporation of the solvent *in vacuo* yielded a dark-yellow gum (120 g) which was dissolved in ether and separated into acidic and neutral fractions using 2% aqu. NaOH. A portion (44 g) of the acidic fraction was chromatographed on silica:celite (1:2) (9 × 90 cm). Elution with 5% EtOAc:light petroleum gave crude (-)-pimara-8(14),15-dien-19-oic acid (28 g) $[\alpha]_D^{22} - 111^\circ$ (c. 0.5) [lit.,² $[\alpha]_D^{16} - 120^\circ$]. This was purified and characterized through its alcohol.

A portion (500 mg) of the neutral fraction was chromatographed on neutral alumina grade I (1 × 16 cm). Elution with light petroleum gave a hydrocarbon mixture (77 mg) which was purified by preparative TLC using silica: 10% AgNO₃ with benzene-light petroleum (7:3) as the mobile phase. This gave (–)-pimara-8(14),15-diene (15 mg) (" R_f " 0.25) as an oil [α] p-90°. (Found: C, 88.7; H, 11.4. Calc. for C₂₀H₃₂: C, 88.2; H, 11.8%,) ν_{max} 3090, 1007, 917, 831 cm⁻¹, τ 9.18, 9.15, 9.07, 8.98 (C--CH₃) 5.23; 5.00, 4.68, 4.13 (multiplets) (H / H

C=C and C=C
$$(-)$$
-Kaurene (6 mg) was isolated from a band (" R_f " 0.35). It had m.p. 50°

 $[\alpha]_{D} - 78^{\circ}$ (lit., 4 m.p. 51, $[\alpha]_{L}^{11} - 72^{\circ}$). (Found: C, 88.1; H, 11.65. Calc. for C₂H₃₂, C, 88.2; H, 11.8%.) ν_{max} 1660, 885 cm⁻¹, τ 9.22, 9.18, 9.01 (C—CH₃) 5.31 (C—CH₂).

The plant material remaining after light petroleum extraction was extracted with hot ethanol for 32 hr. A solid (20 g) crystallized from the extract on concentration. Recrystallization of the solid from methanol gave sucrose, as prisms, m.p. 186–188°, $[\alpha]_{\alpha}^{24} + 74^{\circ}$ (c. 1.5 in water). (Found: C, 42·25; H, 6·6. Calc. for C₁₂H₂₂O₁₁; C, 42·1; H, 6·5%.) This showed an identical i.r. spectrum to authentic sucrose. The mixed m.p. was undepressed.

(-)-Pimara-8(14),15-dien-19-ol (II). (-)-Pimaric acid (2 g) was methylated to give the methyl ester (2·1 g) as a gum, ν_{max} (film) 1720, 1658, 1640, 1004, 920, 884, 830 cm.⁻¹. Without further purification the ester in dry ether was refluxed with LiAlH₄ for 2 hr. EtOAc and dil. HCl were added and the product recovered in EtOAc as a semi-crystalline solid (2·0 g). This residue was chromatographed on alumina (1·5 × 25 cm). Elution with 5% EtOAc in light petroleum afforded (-)-pimara-8(14),15-dien-19-ol (II) (1·9 g), as needles from aqueous methanol, m.p. 105-108° (lit.,² 109-110°). (Found: C, 83·45; H, 11·0. Calc. for C₂₀H₃₂O: C, 83·3; H, 11·2%.) ν_{max} 3360, 1637, 1035, 1007, 917, 880, and 821 cm⁻¹, τ 9·01 (two 3H singlets; methyl). 8·94 (3H singlet; C-CH₃), 6·47, 6·12 (two 1H doublets; J 11Hz; CH₂.OH), 5.22, 4·98, 4·66, 4·12 (multiplets)

$$\begin{pmatrix} H \\ C = C \\ H \\ H \end{pmatrix}$$
 and $C = C \\ H \end{pmatrix}$

Oxidation of (-)-pimara-8(14),15-dien-19-ol. The alcohol (940 mg) in acetone (20 ml) was treated with 8 N chromium trioxide reagent (1.5 ml) for 1 hr at room temperature. Methanol was added and the organic

- 4 L. H. BRIGGS and J. CAWLEY, J. Chem. Soc. 1888 (1948).
- ⁴ R. E. IRELAND and P. W. SCHIESS, J. Org. Chem. 28, 6 (1963).

solvents removed *in vacuo*. Water was added and the product (930 mg) recovered in EtOAc and chromatographed on silica gel (1.5 × 25 cm). Elution with 2.5% ether in light petroleum yielded (-)-pimara-8(14),15diene-19-al (III) (304 mg) as a gum, v_{max} 2730, 1730 (C=O), 1640 and 920 cm⁻¹.

The semicarbazone, prepared by reaction with semicarbazide hydrochloride, had m.p. 187-188° from ethanol. (Found: C, 73.6; H, 9.95. C₂₁H₃₃N₃O required: C, 73.4; H, 9.7%). ν_{max} 3500 (NH₂), 1693 (C=O), 1585 (C=N), and 920 cm⁻¹.

Wolff-Kishner reduction of the semicarbazone of (-)-pimara-8(14),15-dien-19-ol. The semicarbazone (60 mg) in ethylene glycol (3 ml) was slowly heated with NaOH pellets (100 mg) to 210° over 3 hr, and then refluxed for a further 3 hr at 210-220°. Recovery in ether gave a gum (19 mg) which was purified by preparative TLC giving (-)-pimara-8(14),15-diene $([\alpha]_D - 89^\circ)$ (" R_f ", 0.8) with light petroleum as solvent. The hydro-carbon showed identical i.r. and NMR spectra to a specimen $([\alpha]_D + 95^\circ)$ prepared⁵ from pimaric acid.

Hydroxylation of (-)-*pimara*-8(14),15-*dien*-19-*ol*. The alcohol (1·13 g) in ether (20 ml) was treated for 24 hr with O₃O₄ (1 g) in pyridine (10 ml). Water (20 ml),NaHSO₃ (4 g) were added and the solution left for 1 hr. Dil. HCl was added and the solution extracted with ether. The extracts were washed with dil. HCl and water. Recovery gave a gum (1·1 g) which was chromatographed on silica gel (1·5 × 27 cm). Elution with 50% EtOAc in light petroleum gave (-)-*pimara*-8(14)*ene*-15,16,19-*triol* (V) as plates from EtOAc, m.p. 180-183°. (Found: C, 74·1; H, 10·3. C₂₀OH₃₄O₃ required: C, 74·5; H, 10·6%). ν_{max} 3360 br and 820 cm⁻¹.

Periodate oxidation of the glycol (V). The glycol (360 mg) in methanol (50 ml) was treated with NaIO₄ (1.8 g) in water (10 ml) at room temp. for 20 hr. The solution was concentrated *in vacuo*, dil. HCl added and the product recovered in EtOAc. The residue (363 mg) was chromatographed on silica gel (1.5 × 24 cm). Elution with 15% EtOAc gave 19-hydroxy (-)-16-norpimara-8(14)ene-15-al (VI) as a gum (139 mg), ν_{max} (film) 3440 br, 2710, 1743, and 820 cm⁻¹, τ 9.0 (3H singlet; methyl), 8.91 (6H singlet, methyl), 6.3 (2H quartet; CH₂.OH), 4.59 (1H multiplet; 14-H), 0.53 (1H singlet; CHO).

The aldehyde (VI) was converted to (-)-pimara-8(14), 15-dien-19-ol by a Wittig reaction as described previously.¹

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