

The Chemistry of the Natural Order Cupressales

XVII.* Heartwood Constituents of *Pilgerodendron uviferum* (D. Don) Florin (= *Libocedrus tetragona* Ends.)

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The heartwood constituents of *Pilgerodendron uviferum* (D. Don) Florin have been investigated. From the alkali soluble fraction a very small quantity of a highly dextrorotatory crystalline phenol, probably of the flavanone type has been isolated. The large neutral fraction has been shown to contain a mixture of cadinenes and also a new crystalline cadinol for which the name *pilgerol* is proposed.

As already mentioned in a previous communication¹ the genus *Libocedrus* *sensu lato* does not constitute a natural group and has been subdivided into several small or monotypic genera. It appears that the still very incomplete chemical investigation of the genus is in harmony with the views of modern botanical taxonomists as regards its heterogeneity. The monotypic genus *Pilgerodendron* differs botanically very distinctly from the other species of *Libocedrus* *s.l.* and as Florin has remarked it seems strange that this genus was ever included in *Libocedrus*. *Pilgerodendron uviferum* grows along the extremely humid western slopes of the Andes in southern Chile (down to Tierra del Fuego) at altitudes of 600—1 000 metres. The wood is renowned as the most durable wood in the country.

Through the good offices of Jägmästare J. Lagerborg, Talca, Chile, to whom our gratitude is expressed, we have been able to subject a sample of this wood to a preliminary chemical investigation. The wood came from a mature tree about one foot in diameter.

From the alkali soluble fraction of the ether soluble part of the acetone extract of the wood, a minute amount of a highly dextrorotatory crystalline compound was isolated which, judging from its ultra-violet absorption and composition, is probably a flavanone derivative but it is doubtful whether the substance was obtained in a completely pure state.

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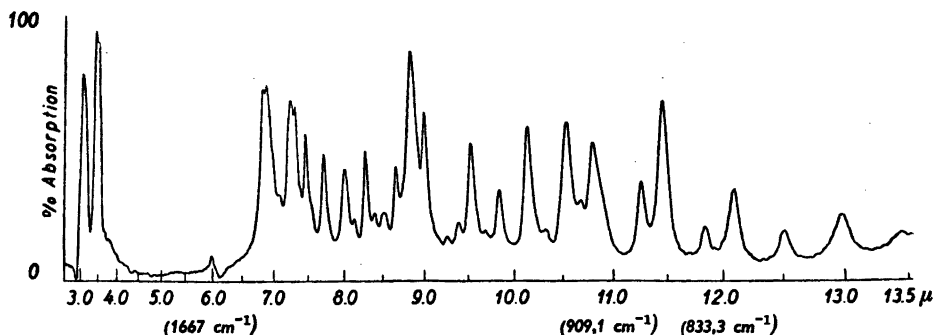
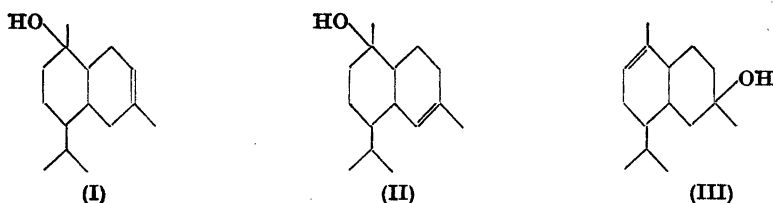


Fig. 1. Infra-red spectrum of pilgerol (KBr disc).

The bulk of the extract was neutral and the steam distillable portion of this was fractionally distilled *in vacuo*. The main hydrocarbon fractions yielded cadalene on dehydrogenation and cadinene dihydrochloride with hydrogen chloride and thus can be considered to be mixtures of cadinenes. From the high boiling fractions a crystalline sesquiterpene alcohol, $C_{15}H_{26}O$, was isolated for which the name *pilgerol* is suggested. It yielded cadalene on dehydrogenation and cadinene dihydrochloride on treatment with hydrogen chloride and is thus a cadinol. Attempts to prepare a crystalline phenylurethane were unsuccessful. Catalytic reduction of pilgerol in ethanol using Adams' catalyst afforded a mixture of diastereoisomeric dihydropilgerols which could be partially separated by fractional sublimation. The infra-red spectrum (Fig. 1) of pilgerol indicated the presence of a trisubstituted double bond (medium-strong band at 873 cm^{-1} and weak band at 1668 cm^{-1} , both absent in the spectrum of the dihydrocompound). Pilgerol must therefore possess one of the structures (I), (II) or (III). It is hoped to proceed with chemical studies which will distinguish between these three alternatives when more material becomes available.



The remainder of the high boiling fraction from which pilgerol had been separated was chromatographed on alumina and yielded, as the only solid product, a further small quantity of pilgerol. The chromatographic separation was not sharp but of the liquid fractions obtained one, $[\alpha]_D -90^\circ$ ($CHCl_3$), $n_D 1.5104$ and analysing for $C_{15}H_{26}O$ which corresponded to a peak on the weight per ml of eluate/volume of eluate graph of the chromatogram, was further investigated. On selenium dehydrogenation a good yield of cadalene was obtained but no crystalline hydrochloride was formed by reaction with hydro-

gen chloride. This fraction, therefore, does not appear to consist, in the main, of alcohols of the cadinol type.

Only one crystalline cadinol (m.p. 72.5°, $[\alpha]_D$ —39.4) has previously been reported (from Java-citronella oil² and *Chamaecyparis lawsoniana*³). Cadinols have been reported to occur in several other species belonging to the natural order Cupressales, e.g. *Cryptomeria*, *Taiwania*⁴, *Fokenia*⁵, and *Chamaecyparis pisifera*⁶. No tropolones were found in *Pilgerodendron* in contrast to *Heyderia decurrens* (β - and γ -thujaplicin) and *Austrocedrus* (β -thujaplicin) and in no other respect does *Pilgerodendron* appear to exhibit chemical similarities to the other species of *Libocedrus s.l.*

EXPERIMENTAL

All melting points are corrected.

Extraction of the heartwood. The powdered heartwood (9 kg) was extracted continuously with acetone for 32 h and the acetone removed by distillation yielding 550 g of extract. This was vigorously shaken with ether (2.5 l) when it partly passed into solution leaving some of the material (ca. 200 g) undissolved. The latter was of the usual "membrane substance" type and was discarded. The ether solution (A) was shaken with a saturated solution of sodium bicarbonate (1.5 l). Ether phase = A', aqueous phase = B'. Acidification of B' with dilute sulphuric acid and extraction with ether *etc.* yielded only 3 g of an acidic material (B^{1a}). The ether solution A' was shaken with a 10 % solution of sodium carbonate (1.5 l). Ether phase = A², aqueous phase = B². Acidification of B² with dilute sulphuric acid and extraction with ether *etc.* yielded another acid fraction (B^{2a}, 14 g). The ether solution A² was shaken with a 5 % solution of potassium hydroxide (1.5 l). Ether phase = A³, aqueous phase = B³. Acidification of B³ and extraction with ether *etc.* yielded still another acidic material (B^{3a}, 25 g). A³ on evaporation of the ether yielded a neutral fraction (310 g).

Examination of the sodium carbonate extract. The material extractable with 10 % sodium bicarbonate solution (fraction B^{2a}) was dissolved in ether (35 ml) and the solution filtered through a column of aluminium oxide (1.5 × 3.5 cm) which was then washed with ether (100 ml). The solvent was evaporated, the residue treated with methanol and the crystals which separated were recrystallised from a little methanol. After several recrystallisations needles, m.p. 217–219°, were obtained (0.107 g), $[\alpha]_D$ 324° (c = 1.2, acetone). (Found: C 64.6; H 4.9. C₁₆H₁₁O₂ requires C 63.6; H 4.7), Ultra-violet absorption: min 248 m μ (ϵ 725), max 290 m μ (ϵ 9 000), shoulder 225 m μ (ϵ 1 800). The acetate was

Fraction	Boiling point	Volume in ml	Refractive index	Rotation (chloroform)
A ^{3a1}	95–99	4	1.4903	
A ^{3a2}	99.5–100	3	1.4909–1.4914 *	
A ^{3a3}	101–105.5	10	1.4918–1.4971	
A ^{3a4}	106–111.8	10	1.4981–1.5038	
A ^{3a5}	114–115	15	1.5060–1.5092	–19°
A ^{3a6}	115	10	1.5092–1.5105	–18°
A ^{3a7}	115–116	15	1.5117–1.5130	–16°
A ^{3a8}	116.5	25	1.5133–1.5136	–15°
A ^{3a9}	116.5	22	1.5140–1.5149	–13°
A ^{3a10}	116.5	12	1.5150–1.5158	–12°
A ^{3a11}	119–125.7	10	1.5158–1.5070	
A ^{3a12}	127–130	41	1.5040–1.5020	
			–1.5035 **	–59° to –69°
A ^{3a13}	130–132°	35	1.5050–1.5111	–73°

* refractive indices from first and last portions

** refractive indices from first, middle and last portions

prepared by dissolving the compound (0.030 g) in a mixture of acetic anhydride (2 ml) and pyridine (3 drops). After 24 h at room temperature water was added and the solid collected. This was recrystallised from ethanol, m.p. 187.5–189°. (Found: C 62.5; H 4.9; OCH₃ 8.8. C₁₅H₂₀O₂ (OCOCH₃)₂OCH₃ requires C 61.7; H 4.7; OCH₃ 7.25.). Ultra-violet absorption max 220 mμ (ϵ 7 400), min 250 mμ (ϵ 980), max 278 mμ (ϵ 4 500).

Examination of the neutral fraction. The neutral fraction A³ was steam distilled and the steam volatile part, (A^{3a}, 213 g) collected and subjected to fractional distillation at 6.5 mm with the results shown on p. 1565.

Dehydrogenation. Of the distillation fractions, numbers A^{3a5}–A^{3a10} were subjected to dehydrogenation with selenium (14 h, 300°) and all yielded cadalene, identified as the picrate m.p. 114.5–115°, not depressed on admixture with an authentic sample.

Hydrochloride. A sample (0.40 g) corresponding to a mixture of fractions A^{3a5}–A^{3a10} was dissolved in ether (40 ml), and the solution cooled to 0° and saturated with dry hydrogen chloride. After 15 min. the ether and excess of hydrogen chloride were removed and the remaining oil dissolved in ethanol (3 ml). After 24 h in the refrigerator 0.40 g of a crystalline hydrochloride had separated, m.p. 117–118°, $[\alpha]_D -36^\circ$ ($c = 1.4$ in CHCl₃). The melting point was not depressed on admixture with an authentic sample of cadinene dihydrochloride (kindly supplied by Professor F. Šorm, Prague).

Pilgerol. From the highest boiling fraction A^{3a13} crystalline material (2 g) slowly separated and was collected by filtration. After several recrystallisations from ethanol-water followed by sublimation *in vacuo*, pure pilgerol, m.p. 138.5–139°, $[\alpha]_D -107^\circ$ ($c = 1.1$ in CHCl₃) was obtained. (Found: C 80.63; H 11.60. C₁₅H₂₀O requires C 81.00, H 11.78.) Infra-red spectrum (Fig. 1): bands at 873 cm⁻¹ and 1 668 cm⁻¹, (trisubstituted double band).

Dehydrogenation. Pilgerol was dehydrogenated with selenium (24 h, 300°) giving cadalene (65 % yield), identified as the picrate.

Hydrochloride. Pilgerol (0.100 g) was dissolved in dry ether and dry hydrogen chloride passed into the solution at 0°. After removal of the ether and excess of hydrogen chloride the crystalline residue was recrystallised from ethanol (2 ml) affording cadinene dihydrochloride, m.p. 117–118°, $[\alpha]_D -35^\circ$ (CHCl₃), in 80 % yield. The melting point was un-depressed on admixture with an authentic sample of cadinene dihydrochloride.

Attempted preparation of the phenylurethane. Pilgerol, when heated with excess of phenylisocyanate at 90° for 1 h or treated with excess of phenylisocyanate at room temperature for several days or refluxed with phenylisocyanate (1.1 mole) in petroleum ether (60–80°) solution for 30 min. did not yield any crystalline phenylurethane.

Hydrogenation. Pilgerol (0.076 g) was hydrogenated in ethanol (15 ml) in the presence of Adams' catalyst (0.044 g), at room temperature and atmospheric pressure for 100 h. The catalyst was then removed by filtration, the alcohol evaporated and the residue sublimed *in vacuo* to give dihydropilgerol (ca. 0.06 g) as feathery needles, m.p. 79–80°, $[\alpha]_D +17^\circ$ ($c = 1.4$ in CHCl₃), (Found: C 80.39; H 12.60. C₁₅H₂₀O requires C 80.29; H 12.57). The product showed no unsaturation by the tetranitromethane test (in contrast to pilgerol itself) and the infrared spectrum exhibited no bands corresponding to a double bond. Fractional sublimation, however, gave a small fore-fraction m.p. 74–75° and a main fraction m.p. 80–81°. Resublimation of the latter fraction gave more of the previously obtained fore-fraction m.p. 74–75° and a less volatile fraction m.p. 90–94°. The hydrogenation product thus appears to consist of a mixture of diastereoisomers. Substantially the same result was obtained when the hydrogenation was carried out in glacial acetic acid as solvent.

Chromatography of the sesquiterpene alcohol fraction. The distillation fraction A^{3a13} (from which the separated pilgerol had been removed by filtration) (7.5 g) in petroleum ether (25 ml), was placed on a column of alumina (250 g) and eluted successively with petroleum ether, petroleum ether-benzene mixtures, benzene, benzene-ether mixtures, ether and finally methanol. In all 49 fractions were taken. The fractions (total weight 1.74 g) corresponding to a peak in the weight per unit volume of eluate/volume of eluate graph all completely or partially solidified. By addition of a little petroleum ether and filtration the solid material was isolated and recrystallised from petroleum ether (40–60°) (needles) giving pure pilgerol (0.150 g) m.p. 140–141°, un-depressed on admixture with pilgerol previously isolated. Other fractions (total weight 1.37 g) corresponded to another main peak in the weight per volume of eluate/volume of eluate graph. A middle fraction of these, $[\alpha]_D -90^\circ$ ($c = 2.14$ in CHCl₃), $n_D^{25} 1.5104$, was analysed, (Found: C

80.45; H 11.44. $C_{15}H_{20}O$ requires C 81.00; H 11.78.). Further samples were (a) dehydrogenated by heating with selenium powder to give a good yield of cadalene (identified as the picrate, m.p. and mixed m.p. 116–116.5°) and (b) treated with dry hydrogen chloride in dry ether at -10° to 0° when no crystalline hydrochloride could be obtained.

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