Tetrahedron Letters No.34, pp. 2347-2353, 1964. Pergamon Press Ltd.
Printed in Great Britain.

TRITERPENES OF PINE BARKS:
IDENTITY OF PINUSENEDIOL AND SERRATENEDIOL*

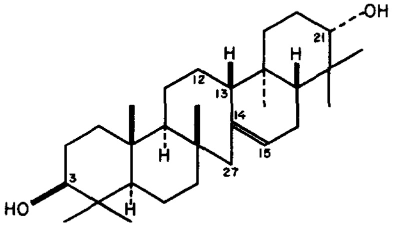
John W. Rowe

Forest Products Laboratory,** Forest Service

U.S. Department of Agriculture

(Received 25 June 1964)

During a survey on the benzene extractives of pine bark, new triterpenes were isolated in small amounts from the barks of jack pine (*Pinus banksiana* Lamb.), sugar pine (*P. lambertiana* Dougl.), loblolly pine (*P. taeda* L.), and longleaf pine (*P. palustris* Mill.). The major triterpene, pinusenediol, $C_{30}H_{50}O_2$, was shown to contain a new type of triterpene skeleton (2). Recently, pinusenediol and serratenediol (3), as well as the corresponding diacetates and hydrocarbons, have been compared and found to have identical and undepressed mixed melting points and superimposable infrared spectra. They are thus both represented by the structure:



Since this unique structure of serratenediol has been recently elucidated by Inubushi (4) and confirmed by synthesis (5), the name pinusenediol will

---

* Previous paper in this series: "The Sterols of Pine Bark" (1).

** Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

no longer be used. We originally found serratenediol in the terpene fraction from the unsaponifiables of the benzene extract of jack pine outer bark. Subsequently, we also found it in the sterol fraction of jack, loblolly, and longleaf pine barks (1) and in the terpene fraction of sugar pine bark. Lodgepole pine (P. contorta Dougl.) bark is the only pine bark of those we have extensively investigated from which no triterpenes were obtained, perhaps due to the presence of extraordinarily large amounts of labdane diterpenes (6).

Serratenediol, m.p. 302.5-304.5°*, $[\alpha]_D^{22°}$ -19° (c = 0.9), positive Salkowski and Liebermann-Burchard test, was characterized as its diacetate, m.p. 350.5-352.5°, $[\alpha]_D^{21°}$ +22° (c = 0.9), and di-3,5-dinitrobenzoate, m.p. 284.5-285°, $[\alpha]_D^{21°}$ +53° (c = 0.4). The diol was readily oxidized with chromic acid (7) to the diketone, m.p. 211.5-212°, $[\alpha]_D^{21°}$ -6-1/2° (c = 0.9), positive Zimmermann test, negative ferric chloride test, from which the original diol could be regenerated by reduction with sodium in boiling isoamyl alcohol. Wolff-Kishner (Huang-Minlon) reduction of the diketone yielded the parent hydrocarbon, m.p. 239.5-240°, $[\alpha]_D^{22°}$ -13° (c = 1.4), which was definitely different from taraxerene (8). It could be readily isomerized with hydrochloric acid in boiling acetic acid, or readily hydrogenated with Adam's catalyst in acetic acid to a saturated hydrocarbon.

The diol, dione, diacetate, and hydrocarbon all possessed a trisubstituted double bond as shown by a yellow color with tetranitromethane, bands in the infrared at about 2995, 1633, and 796 cm^{-1}, a strong end absorption in the ultraviolet, and a broad multiplet at τ 4.68 in the n.m.r. The n.m.r. showed seven angular (uncoupled) methyl groups. The diol could be shown to possess two equatorial secondary hydroxyl groups remote from each other and

---

* Melting points are given only for analyzed samples and are corrected. They run generally higher than those reported (3,4,5) due to decomposition at the melting point. Ours are determined in evacuated capillaries inserted in a preheated copper block. Optical rotations are in chloroform solution, and n.m.r. spectra in deuterochloroform at 60 Mc. with tetramethylsilane as an internal standard.

from the double bond. Thus, the diketone showed $\lambda_{max}^{i\text{-}PrOH}$ 288 $m\mu$ (ϵ 66), ν_{max} 1706 cm^{-1}. The n.m.r. of the diacetate showed a broad band at τ 5.55 for two axial hydrogens geminal to acetoxy groups (9). The o.r.d. curve for the dione showed a single negative carbonyl $n \longrightarrow \pi^*$ Cotton effect centered at 307 $m\mu$ with a molecular amplitude (10) of -8.2. The sign is as expected for 3-ketotriterpenes, with the low amplitude probably due to the subtractive effect of the 21-keto group. The mass spectrum of the saturated hydrocarbon confirmed the molecular weight and showed the absence of side chains other than methyl. The mass spectra of the diol, dione, and unsaturated hydrocarbon were consistent with one another. The most important ring cleavage products resulted from cleavage through ring C (m/e 191, 204, and 218 in serratene). The expected retro Diels-Alder products were also observed (m/e 286 and 271 in serratene). This indicated a Δ^{14} double bond, and indeed, the spectrum was somewhat reminiscent of that of myricadiol diacetate (11).

Oxidation of the double bond proceeded quite differently after acid isomerization. Thus, oxidation of the isomerized hydrocarbon, isoserratene, with selenium dioxide in acetic acid yielded the transannular $\Delta^{12,14}$ diene, λ_{max} 236 $m\mu$ (ϵ 19000) with shoulders at 232 and 238 $m\mu$, ν_{max} 809 cm^{-1}, tetranitromethane test brown. Alternatively, oxidation with sodium dichromate in hot acetic acid yielded an α,β-unsaturated ketone, presumably 12-keto-Δ^{13}-serratene, λ_{max}^{isooct} 241 $m\mu$ (ϵ 4500) shifting to 250 $m\mu$ in ethanol, ν_{max} 1661 (s) and 1616 (w) cm^{-1}, tetranitromethane test negative. In contrast, the diacetate of serratenediol gave no products absorbing in the ultraviolet when treated with selenium dioxide under the same conditions. Analogous oxidation with sodium dichromate yielded 3β,21α-diacetoxy-15-keto-Δ^{13}-serratene; m.p. 325.5-336.5 dec.; $[\alpha]_D^{21°}$ +45° ($\underline{c}$ = 0.7); ν_{max} 1729 (OAc), and 1653 (s) and 1613 (w) cm^{-1} for the α,β-unsaturated carbonyl; λ_{max}^{isooct} 245 $m\mu$; λ_{max}^{EtOH} 255 $m\mu$ (ϵ 10500). These reactions are as expected for isomerization of the double bond from the Δ^{14} to the Δ^{13} position.

A slightly different and new triterpenediol, episerratenediol, was isolated from the terpene fractions of loblolly, jack, and sugar* pine barks. Evidence indicates that it is identical to serratenediol except that one of the hydroxyl groups is axial. Its properties are very similar to those of serratenediol with m.p. 303-308°, $[\alpha]_D^{23°}$ -19° (c = 1.29). The infrared spectra are very similar, except for minor differences as expected if one of the hydroxyl groups were axial (13). The behavior on thin-layer and column chromatography was identical, although they were clearly different on gas chromatography on SE-30; serratenediol passed through the column as a symmetrical peak while episerratenediol decomposed, probably via dehydration. Mixed melting points are undepressed. The di-3,5-dinitrobenzoate derivative, m.p. 278.5-279°, $[\alpha]_D^{22°}$ +25° (c = 0.85), was also difficult to distinguish from that of serratenediol, but the diacetate, m.p. 236-237° (dimorphous), $[\alpha]_D^{22°}$ -17° (c = 1.5), was clearly different from that of serratenediol. Their infrared spectra were different and in agreement with one of the acetoxy groups being axial (13). Of greatest interest was the n.m.r. spectrum which was identical for both diacetates except that the epi compound integrated for only one proton in the broad band at τ 5.55 for the axial proton geminal to an equatorial acetoxy group, and a new sharp band corresponding to one equatorial proton geminal to an axial acetoxy group was present at τ 5.33. The acetate methyls were also split into a doublet at τ 7.97 and 7.93 in the epi derivative. Serratenediol and episerratenediol are best separated from each other by chromatography and crystallization of their diacetates. Which hydroxyl group is epimerized is unknown, and insufficient amounts are available for this to be determined. Oxidation with chromic acid (7) yielded serratenedione.

---

* Probably identical to the high-melting uncharacterized compound previously reported in sugar pine bark (12).

Still another new triterpenediol, diepiserratenediol, was isolated from the terpene fraction of jack pine bark due to the fact that it is slightly more soluble in the usual solvents and elutes first on chromatography. It appears to be identical to serratenediol except that both hydroxyls are in the axial orientation. Its properties also are similar to those of serratenediol with m.p. 300-301°, $[\alpha]_D^{22°}$ -32° (c = 0.9). The di-3,5-dinitrobenzoate had m.p. 171-174°, $[\alpha]_D^{21°}$ +15° (c = 1.2). The diacetate gave an n.m.r. spectrum identical to that of the diacetate of serratenediol except that instead of the broad band at τ 5.55 for two axial hydrogens geminal to equatorial acetoxy groups, there were two sharp overlapping triplets at τ 5.38, J = 2-3 c.p.s., for two equatorial protons geminal to two axial acetoxy groups. Spin-spin decoupling at 100 Mc. showed that these protons were coupled to a methylene group at about τ 8.32.

Two other new triterpenes were also isolated in trace amounts. Infrared and n.m.r. spectral data again suggest a close relationship to serratenediol, but these two appear to be the monomethyl and dimethyl ethers. The monomethyl ether was first isolated from the sterol fraction of jack pine bark and has already been described (1). A small amount of a similar compound, m.p. 318-326°, was later isolated from the terpene fraction of sugar pine bark, but it could not be satisfactorily purified. A methoxyl analysis confirmed the one methoxyl indicated by infrared (2817 and 1096 cm^{-1}) and n.m.r. (τ 6.67) spectra. The same infrared bands were present for one hydroxyl and a Δ^{14} double bond as in serratenediol and the monomethyl ether from jack pine. Both monomethyl ethers had the same retention time on gas chromatography on SE-30. The n.m.r. again integrated to only seven angular methyl groups.

The dimethyl ether was similarly isolated in trace amounts from the terpene fraction of sugar pine bark. The spectral, physical, and gas, thin-layer, and column chromatographic properties were all as expected for a dimethyl ether of serratenediol. A 100 Mc. n.m.r. with spin-spin decoupling was the most informative. In addition to seven angular methyls, two methoxyls at τ 6.64 (ν_{max} 2819 and 1105 cm^{-1}), and a single vinylic proton at τ 4.63 (broad) (ν_{max} 795 cm^{-1}), there appeared to be two overlapping quartets for two axial protons geminal to two equatorial methoxyls at τ 2.62 and 2.66 (J_{ae} = 3 c.p.s., J_{aa} = 8 c.p.s.). These are coupled to protons at τ 8.96 and 9.11.

In conclusion, with the exception of a "triterpene oil" reported in the heartwood of P. wallichiana (griffithii) A. B. Jacks. (14), this is the first report of triterpenes other than squalene in the genus Pinus.* The small amounts present are consistent with the fact that terpene biogenesis in pines is predominately of the monoterpene-diterpene type.

---

* Dr. G. A. Nicholls, New Zealand Forest Products Limited, Auckland, N.Z., has kindly informed me that he has found triterpenes which may be related to serratenediol and its methyl ethers in P. radiata bark.

Acknowledgements

The author is deeply indebted to D.P. Hollis at Varian Associates and E. J. Corey at Harvard for the n.m.r. spectra and help in their interpretation; to C. Djerassi and H. Budzikiewicz at Stanford, V. W. Meloche at the University of Wisconsin, and the California Research Corp. for the mass spectra and help in their interpretation; to W. Herz at Florida State University for the o.r.d. curve; to V. Meloche for the high resolution i.r. spectra; to Y. Inubushi at Osaka University for authentic samples of serratenediol derivatives; to K. Schaffner at the E. T. H. for a sample of taraxerone; and to H. L. Hergert at Rayonier, Inc., for samples of triterpenes from sugar and longleaf pine barks.

REFERENCES

(1) J. W. Rowe, *Phytochem.*, in press.

(2) J. W. Rowe, Abstracts of Papers, p. 83Q, Division of Organic Chemistry, 140th Meeting, ACS, Chicago, Ill., September 1961.

(3) Y. Inubushi, Y. Tsuda, H. Ishii, M. Hosokawa and T. Sano, *Yakugaku Zasshi*, **82**, 1339 (1962).

(4) Y. Inubushi, T. Sano and Y. Tsuda, *Tetrahedron Letters* No. 21, 1303 (1964).

(5) Y. Tsuda, T. Sano, K. Kawaguchi and Y. Inubushi, *Tetrahedron Letters* No. 20, 1279 (1964).

(6) J. W. Rowe and J. H. Scroggins, *J. Org. Chem.*, **29**, 1554 (1964).

(7) R. G. Curtis, I. Heilbron, E. R. H. Jones and G. F. Woods, *J. Chem. Soc.*, 457 (1953).

(8) C. J. W. Brooks, *J. Chem. Soc.*, 1675 (1955).

(9) R. A. Abramovitch and R. G. Micetich, *Can. J. Chem.*, **41**, 2362 (1963).

(10) This term is discussed by N. L. Allinger and M. A. DaRooge, *J. Am. Chem. Soc.*, **84**, 4561 (1962), and D. Djerassi and W. Klyne, *J. Chem. Soc.*, 4929 (1962).

(11) C. Djerassi, H. Budzikiewicz and J. M. Wilson, *Tetrahedron Letters* No. 7, 263 (1962).

(12) E. F. Kurth, J. K. Hubbard and J. D. Humphrey, *Proc. Forest Prod. Research Soc.*, **3**, 281 (1949); *Paper Trade J.*, **130**(17), 37 (1950).

(13) I. L. Allsop, A. R. H. Cole, D. E. White and R. L. S. Willix, *J. Chem. Soc.*, **1956**, 4868.

(14) V. B. Mahesh and T. R. Seshadri, *J. Sci. Ind. Research* (India), **13B**, 835, (1954).