

Nordivarcatic Acid, a New Depside from the Lichen *Heterodea beagleholei*

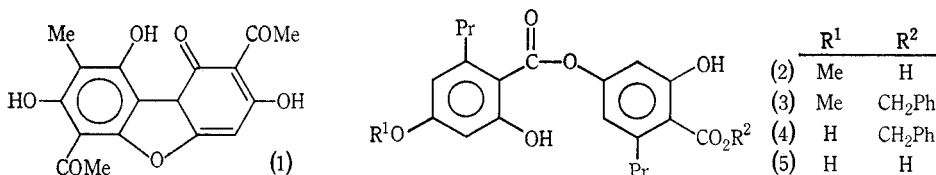
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Abstract

The depside nordivarcatic acid (5) has been isolated from the lichen *Heterodea beagleholei* R. Filson. The structure of this compound followed from the spectroscopic data and has been confirmed by total synthesis.

In the continuation of our chemotaxonomic survey of the lichens of eastern Australia^{1,2} we observed that *Heterodea beagleholei* R. Filson³ produced three phenolic metabolites, only two of which correspond to known lichen substances.



Usnic acid (1) and divarcatic acid (2) can readily be identified as components of the lichen, by comparison with the authentic materials. Subsequently we have undertaken the large-scale extraction of this lichen and followed this by benzylation of the mixture of lichen acids obtained. Similar benzylation procedures followed by chromatography of the benzyl esters and eventual debenylation have been used previously in the separation of complex mixtures of natural carboxylic acids. Preparative layer chromatography of this particular mixture of esters led to the isolation of benzyl divarcate (3) and benzyl nordivarcate (4).

The New Depside*

When benzyl nordivarcate (4) was subjected to hydrogenolysis in the presence of palladized carbon and hydrogen, nordivarcatic acid (5) was obtained. The thin-layer chromatographic behaviour of this compound in three independent solvent

* Recently this depside has been tentatively identified.⁴

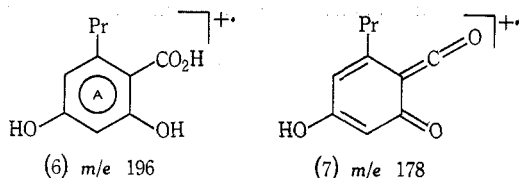
¹ Elix, J. A., *Aust. J. Chem.*, 1975, **28**, 849.

² Elix, J. A., and Engkaninan, U., *Aust. J. Chem.*, 1976, **29**, 2701, and references therein.

³ Filson, R., *Muelleria*, 1977, in press.

⁴ Culbertson, C. F., and Johnson, A., *J. Chromatogr.*, 1976, **128**, 253.

systems⁵ was identical to that of the natural material thus substantiating that no artefact formation had occurred during these transformations. The structure of the compounds (4) and (5) followed initially from the spectroscopic properties. The observed p.m.r. spectra were very similar to those of divaricatic acid (2) and benzyl divaricatate (3), but lacked the *O*-methyl resonance. Further evidence was provided by mass spectroscopy, for nordivaricatic acid (5) exhibited a molecular ion at m/e 374 and the expected ring A fragments (6) and (7) at m/e 196 and 178.^{6,7}



The structure of this depside was confirmed by total synthesis by the now well established procedures.⁷ The condensation of 4-benzyloxy-2-hydroxy-6-propylbenzoic acid (8)⁸ with benzyl 2,4-dihydroxy-6-propylbenzoate (9)⁷ in the presence of trifluoroacetic anhydride gave rise to benzyl 4-*O*-benzyl nordivaricatate (10), and hydrogenolysis of this compound in the presence of palladized carbon and hydrogen produced nordivaricatic acid (5) identical with the natural material.

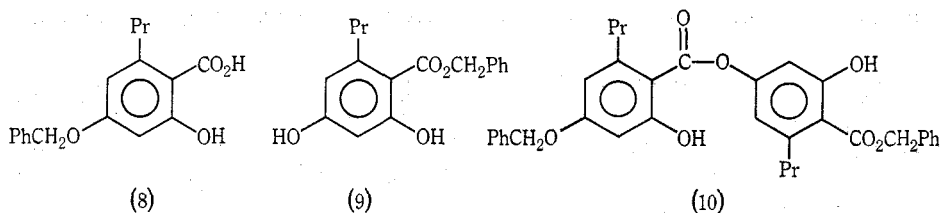


Table 1. T.l.c. data for nordivaricatic acid

On silica gel; A, benzene/dioxan/acetic acid 180/45/5; B, n-hexane/diethyl ether/formic acid 130/80/20; C, toluene/acetic acid 200/30

Compound	$R_F(A)$	$R_F(B)$	$R_F(C)$
Atranorin (standard)	0.75	0.76	0.78
Norstictic acid (standard)	0.41	0.32	0.27
Divaricatic acid	0.39	0.68	0.51
Nordivaricatic acid	0.33	0.55	0.26
Anziaic acid	0.40	0.59	0.33

As thin-layer chromatography is now undoubtedly the most widely used method for the identification of lichen constituents,⁵ the relevant data for nordivaricatic acid (5) are listed in Table 1.

⁵ Culberson, C. F., *J. Chromatogr.*, 1972, **72**, 113.

⁶ Huneck, S., Djerassi, C., Becher, D., Barber, M., Ardenne, M. von, Steinfeldt, K., and Tümmeler, R., *Tetrahedron*, 1968, **24**, 2707.

⁷ Elix, J. A., *Aust. J. Chem.*, 1974, **27**, 1767.

⁸ Elix, J. A., and Norfolk, S., *Aust. J. Chem.*, 1975, **28**, 399.

Experimental

The general experimental details have been published previously.²

Extraction of Heterodea beaugleholei R. Filson

The lichen material was collected on soil on the western slopes of Black Mountain, Canberra, A.C.T. (J. A. Elix—1258, CANB).

The dried thallus (208 g) was extracted with anhydrous benzene in a Soxhlet extractor for 36 h. The extract was then concentrated to yield 8.3 g of a brown solid.

A portion (1.0 g) of this crude material was dissolved in acetone (20 ml) and treated with an excess of ethereal phenyldiazomethane for 15 min at room temperature. The reaction mixture was then concentrated and the residue chromatographed with 20% ethyl acetate/light petroleum as eluent.

The major band yielded *benzyl divaricate* (3) (168 mg, 6.7%) which was recrystallized from n-hexane to form colourless prisms, m.p. 72.5–73.5° (Found: C, 70.5; H, 5.9. $C_{28}H_{30}O_7$ requires C, 70.3; H, 6.3%). P.m.r. ($CDCl_3$) δ 0.72, 0.94 (each 3H, t, J 7 Hz, CH_2CH_3), 1.30–1.90 (4H, m, CH_2CH_3), 2.68–3.08 (4H, m, $ArCH_2$), 3.78 (3H, s, OCH_3), 5.40 (2H, s, OCH_2), 6.40 (2H, s, H 3', H 5'), 6.60, 6.78 (each 1H, d, J 3 Hz, H 3, H 5), 7.44 (5H, bs, C_6H_5), 11.48 (2H, br, OH). A minor band yielded *benzyl nordivaricate* (4) (49 mg, 2.0%) as a pale yellow oil; p.m.r. ($CHCl_3$) δ 0.64–1.10 (6H, m, CH_2CH_3), 1.20–1.84 (4H, m, CH_2CH_3), 2.72–3.08 (4H, m, $ArCH_2$), 5.45 (2H, s, OCH_2), 6.36 (2H, s, H 3', H 5'), 6.60, 6.67 (each 1H, d, J 3 Hz, H 3, H 5), 7.48 (5H, s, C_6H_5), 11.42, 11.64 (each 1H, s, OH).

A mixture of *benzyl nordivaricate* (49 mg), ethyl acetate (6 ml) and 10% palladium on carbon (25 mg) was stirred in an atmosphere of hydrogen for 5 h. The catalyst was then removed by filtration and the solvent evaporated. The residue was recrystallized from chloroform/carbon tetrachloride/n-hexane to give *nordivaricate* (5) (36 mg, 90%) as colourless needles, m.p. 126–128° (Found: C, 63.8; H, 6.2. $C_{20}H_{22}O_7$ requires C, 64.2; H, 5.9%). P.m.r. ($CDCl_3$) δ 0.82–1.14 (6H, m, CH_2CH_3), 1.48–1.90 (4H, m, CH_2CH_3), 2.82–3.22 (4H, m, $ArCH_2$), 6.40 (2H, s, H 3', H 5'), 6.68, 6.80 (each 1H, d, J 3 Hz, H 3, H 5), 9.20, 11.50 (each 1H, bs, OH); mass spectrum m/e 374 (M, 0.6%), 197 (5), 196 (37), 179 (21), 178 (100), 163 (8), 152 (15), 150 (32), 137 (9), 124 (5), 123 (17), 122 (24), 121 (46), 94 (7), 91 (8), 79 (6), 77 (10).

Benzyl 4-O-Benzyl-nordivaricate (10)

A mixture of 4-benzyloxy-2-hydroxy-6-propylbenzoic acid (0.286 g), *benzyl 2,4-dihydroxy-6-propylbenzoate* (0.286 g), anhydrous toluene (6 ml) and trifluoroacetic anhydride (1 ml) was stirred at room temperature for 20 h. The solvent was then evaporated and the residue chromatographed, with 20% ethyl acetate/light petroleum as eluent. The faster-moving band yielded *benzyl 4-O-benzyl-nordivaricate* (10) (132 mg, 24%) which crystallized from cyclohexane as colourless plates, m.p. 94–95° (Found: C, 73.9; H, 6.0. $C_{34}H_{34}O_7$ requires C, 73.6; H, 6.2%). P.m.r. ($CDCl_3$) δ 0.60–1.08 (6H, m, CH_2CH_3), 1.16–1.82 (4H, m, CH_2CH_3), 2.66–3.08 (4H, m, $ArCH_2$), 5.02, 5.36 (each 2H, s, OCH_2), 6.46 (2H, s, H 3', H 5'), 6.58, 6.74 (each 1H, d, J 3 Hz, H 3, H 5), 7.40 (10H, s, C_6H_5), 11.44, 11.62 (each 1H, s, OH).

Synthesis of Nordivaricate Acid (5)

A mixture of *benzyl 4-O-benzyl-nordivaricate* (132 mg), ethyl acetate (10 ml) and 10% palladium on carbon (10 mg) was stirred in an atmosphere of hydrogen for 17 h. The catalyst was then removed by filtration and the solvent evaporated. Recrystallization of the residue from chloroform–carbon tetrachloride–n-hexane gave *nordivaricate* (5) (90 mg, 85%) which was identical in all respects (m.p. and m.m.p., p.m.r. and t.l.c. behaviour) with the sample of natural material obtained above.

Acknowledgment

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