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OXYGEN HETEROCYCLES[1]

THE STRUCTURE OF THE ISOFLAVANONE SOPHOROL

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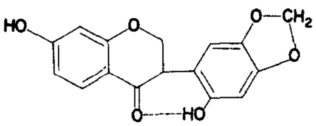
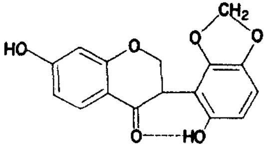
IN a previous paper[2] it was shown that the structure of sophorol, a new isoflavanone from the heartwood of <u>Maakia amurensis</u> Rupr. <u>et Maxim. var. Buergeri</u> (<u>Maxim.</u>) C. K. Schneid,* was either 2',7-dihydroxy-4',5'-methylenedioxyisoflavanone (I) or 2',7-dihydroxy-5',6'methylenedioxyisoflavanone (II). The former was favoured on the basis of biogenetical grounds.



I



II

The structure of sophorol has now been confirmed to be (I) by the syntheses of hydrolysed product (VI) R = CH_3 and palladium dehydrogenation product (VIII) of O-dimethylsophorol, as follows:

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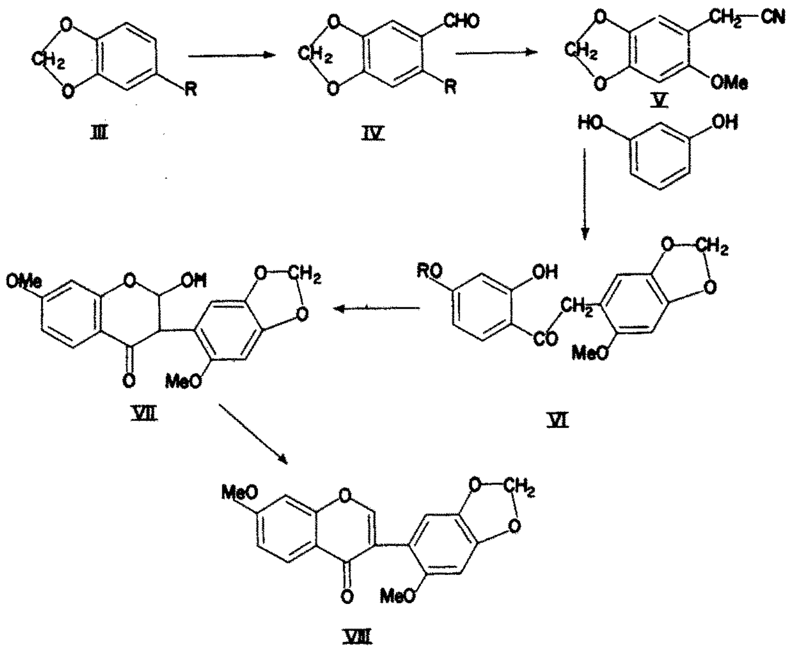
* Leaguminoceae. The plant material used in this work had been originally considered as <u>Sophora japonica</u>, L.

[1] Previous paper in this series: Hiroshi Suginome and Tsukasa Iwadare, <u>Bull.Chem.Soc. Japan</u> 33, 567 (1960).

[2] Hiroshi Suginome, <u>J.Org.Chem.</u> 24, 1655 (1959).



The earlier preparative method[3] of starting 2-hydroxy-4,5-methylenedioxybenzaldehyde (which is also an important building stone for the synthesis of some naturally occurring oxygen heterocycles, ayapin,[4] pachyrrhizon,[5] pachyrrhizin,[6] and jamaicin[7]) was rather laborious and therefore unsatisfactory.

By a revised preparation, sesamol[8] (III) R=OH, which was prepared by Baeyer-Villiger oxidation of piperonal (III) R = CHO, was formylated by

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[3] K.N. Campbell, P.F. Hopper and B.K. Campbell, J.Org.Chem. 16, 1736 (1951).

[4] E. Späth, P.K. Bose and J. Schläger, Ber. 70, 702 (1937).

[5] H. Bickel and H. Schmid, Helv.Chim.Acta 36, 664 (1953).

[6] E. Simonitsch, H. Forei and H. Schmid, Monatsh. 88, 541 (1957); P. Rajagopalan and A.I. Kosak, Tetrahedron Letters No. 21, 5 (1959).

[7] O.A. Stamm, H. Schmid and J. Büchi, Helv.Chim.Acta 41, 2006 (1958).

[8] J. Boeseken, W.D. Cohen and C.J. Kip, Rec.Trav.Chim. 55, 815 (1936). M. Beroza, J.Agr.Food.Chem. 4, 49 (1956).

Gattermann procedure, yielding (IV) R = H in high yield.

Methylated aldehyde (IV) R = CH$_3$ was converted into the corresponding substituted phenylacetonitrile (V) (m.p. 123-124°. Found: C, 63.10; H, 5.00; N, 7.18. $C_{10}H_9O_3N$ requires: C, 62.82; H, 4.75; N, 7.33%) I.R.-C≡N[9] 2241 cm^{-1} U.V. spectrum: λ_{max} (ethanol) 213, 239 and 301 mμ (ε; 4741, 5540 and 6946) through the corresponding azlactone (m.p. 260°. Found: C, 66.95; H, 4.27. $C_{18}H_{13}O_5N$ requires: C, 66.87: H, 4.05%). This was condensed with resorcinol into a desoxybenzoin derivative (VI) R = H (m.p. 164-165°. Found: C, 63.29; H, 4.50. $C_{16}H_{14}O_6$ requires: C, 63.57; H, 4.67%) under Hoesch condition using mixed solvent of chloroform-ether.

This, on partial methylation by ethereal diazomethane, gave 2-hydroxy-, 4,2'-dimethoxy-4,5-methylenedioxydesoxybenzoin (VI) R = CH$_3$ (m.p. 131-132°. Found: C, 64.50; H, 5.07. $C_{17}H_{16}O_6$ requires: C, 64.55; H, 5.10%) identical with a specimen derived from the natural product as shown by the I.R. spectra and mixed melting point determination. This desoxybenzoin (VI) R = CH$_3$ was converted into 2',7-dimethoxy-4',5'-methylenedioxyisoflavone (VIII) m.p. 208-209°. (C, 65.98: H, 4.20. $C_{18}H_{14}O_6$ requires: C, 66.25; H, 4.32%) through the corresponding intermediary 2-hydroxyisoflavanone (VII) (m.p. 185°. Found: C, 62.60; H, 4.80. $C_{18}H_{16}O_7$ requires: C, 62.79; H, 4.68%) I.R. -CO. 1657 cm^{-1} OH. 3400 cm^{-1}. This isoflavone was identical with dehydro-O-dimethyl sophorol[2] (mixed melting point and I.R. spectra), thus confirming the structure (I) for sophorol.

The biogenesis of the flavonoids and the related compounds has already

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[9] R. E. Kitson and N. E. Griffith, *Analyt. Chem.* **24**, 334 (1952).

been discussed extensively.[10,11]

The occurrence of sophorol is of importance in view of the biogenesis of complex naturally occurring oxygen heterocycles namely, group A (rotenoids[12a,13]: rotenone, sumatrol, deguelin, toxicarol, tephrosin, elliptone,[12b] malaccol[12c] and pachyrrhizon[5]) and group B (chromanocoumarane or coumarinocoumarone ring systems: pterocarpin, homopterocarpin,[14] coumoestrol,[15] pachyrrhizin,[6] erosnin,[16] and wedelolactone[17]), derived from 3-phenylchroman system.

As pointed out previously[2] sophorol possesses essential core and oxygenation pattern of rotenoids.

Argument[7,11,13] seems to be justified that in rotenoids, the isoflavone or isoflavanone ring systems were initially constructed and formaldehyde unit could be introduced at a later stage.[*]

As Birch has noted,[18] the known occurrence of 2'-oxygenated flavonoids

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[*] See "Note added in proof" on p. 20.

[10] R. Robinson, *The Structural Relations of Natural Products* p. 43. Clarendon Press (1955); T.R. Seshadri, *Ann. Rev. Biochem.* **20**, 487 (1951); T.A. Geissman and Hinreiner, *Botan. Rev.* **18**, 77 (1952).

[11] T.R. Seshadri, *Tetrahedron* **6**, 169 (1959).

[12a] R.D. Haworth, *Ann. Rep. Chem. Soc.* 346 (1937); *Ibid.* 311 (1938);
[b] S. H. Harper, *J. Chem. Soc.* 1424 (1939); [c] S.H. Harper, *J. Chem. Soc.* 309 (1940).

[13] H.A. Offe, *Angew. Chem.* **60**, 9 (1948).

[14] A. McGookin, A. Robertson and W.B. Whalley, *J. Chem. Soc.* 787 (1940); E. Späth and J. Schläger, *Ber.* **73**, 1 (1940).

[15] O.H. Emerson and E.M. Bickoff, *J. Amer. Chem. Soc.* **80**, 438 (1958).

[16] J. Eisenbeiss and H. Schmid, *Helv. Chim. Acta* 61 (1959).

[17] T.R. Govindachari, K. Nagarajan, B.R. Pai and P.C. Parthasarathy, *J. Chem. Soc.* 545 (1957).

[18] A.J. Birch in L. Zechmeister's, *Progress in the Chemistry of Organic Natural Products* Vol. 14, p. 186. Springer, Vienna (1957).

had been comparatively rare. However, recent survey of plant material, particularly rotenone bearing leaguminous (fabaceous) plant, has showed a possibility of wide distribution of new 2'-oxygenated isoflavonoids.

These are mundulone,[19] tlatlancuayin,[20] ferreirin, homoferreirin,[21] jamaicin,[*7] toxicarol isoflavone[22] and munetone.[23] Among them, structural similarity of sophorol with jamaicin is of particular interest. Jamaicin is a corresponding isoflavone bearing one isoprene unit on 8-position of sophorol.

Furthermore, it may be mentioned in general that 2'-oxygenated isoflavanoids and above-mentioned group B compounds has also a possible biogenetic interrelationship, which King and Neill originally suggested[21] with respect to the pterocarpin-ferreirin link. Based on this consideration the synthesis of the pterocarpin ring system was recently accomplished[1] by the present authors.

A more detailed description of this work will be published shortly.

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Note added in proof: The structure determination and synthesis of munduserone, a "missing link" between rotenoids and simple 2'-hydroxy isoflavonoids, were very recently reported. [N. Finch and W.D. Ollis, Proc. Chem. Soc. 176 (1960); J.R. Herbert, W.D. Ollis and R.C. Russell, Ibid. 177 (1960)].

[*] The writer thanks Dr. W. D. Ollis of The University Bristol for drawing his attention to this example.

[19] B.F. Burrows, N. Finch, W.D. Ollis and I.O. Sutherland, Proc. Chem. Soc. 150 (1959).

[20] P. Crabbé, P.R. Leeming and C. Djerassi, J. Amer. Chem. Soc. **80**, 5258 (1958).

[21] F.E. King and K.G. Neill, J. Chem. Soc. 4752 (1952).

[22] S.H. Harper, J. Chem. Soc. 1178 (1940); Ibid. 595 (1942).

[23] N.L. Datta, J. Indian Chem. Soc. **36**, 165 (1959).