# New Neoflavanoids from *Machaerium kuhlmannii* and *Machaerium nictitans* and the Recognition of a New Neoflavanoid Type, the Neoflavenes

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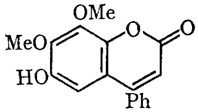
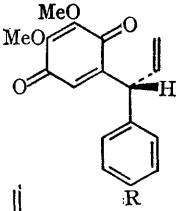
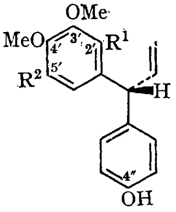
THE isolation of neoflavanoids[1,2] from the botanically related *Dalbergia* and *Machaerium* genera of the *Leguminosae* has been reported.[2–4] The neoflavanoid types which have been recognised include the dalbergins (4-arylcoumarins), the dalbergiquinols (3,3-diarylprop-1-enes), and the dalbergiones. We report the isolation of new examples of these known neoflavanoid types from the extracts of the wood of *Machaerium kuhlmannii* Hoehne and *Machaerium nictitans* (Vell.) Benth. In addition, a new neoflavanoid type, a neoflavene (4-arylchrom-3-ene), has been isolated from both plant sources. The structural relationship between these new natural products is of interest in view of the evidence[5] recently reported concerning the biosynthesis of neoflavanoids in *Calophyllum inophyllum*.



(I)



(II) R=OH
(III) R=H

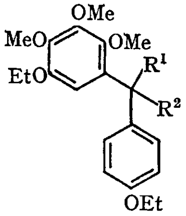


(IV) $R^1$=OMe, $R^2$=OH
(V) $R^1$=OH, $R^2$=OMe

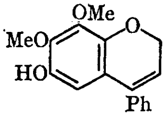
Kuhlmannin, $C_{17}H_{14}O_5$, m.p. 211°, isolated from both *Machaerium* species, had spectroscopic properties consistent with a hydroxy-dimethoxy-4-phenylcoumarin structure: the structure of this compound was established as 6-hydroxy-7,8-dimethoxy-4-phenylcoumarin (I)[6] by its synthesis from ethyl benzoylacetate and 4-hydroxy-2,3-dimethoxyphenol. A second compound, kuhlmanniquinol, also isolated from both *Machaerium* species as an oil, b.p. 130—140°/1 mm., had an n.m.r. spectrum which suggested a dalbergiquinol structure (3,3-diarylprop-1-ene) with three methoxy- and two hydroxy-substituents located in positions 2', 3', 4', 5', and 4'' [$\tau$ 2·97, $\tau$ 3·29 (4H), AA'BB' system, $J_{AB}$, $J_{A'B'}$ 8·5 c./sec.; $\tau$ 3·52 (s, 1H), aryl proton; $\tau$ 3·5—4·1 and 4·8—5·3 (6H), multiplets typical[7] of the ABCD system from a $\rangle$CH–CH=$CH_2$ unit and two exchangeable hydroxy-protons; $\tau$ 6·08 (s, 3H), $\tau$ 6·10 (s, 3H), $\tau$ 6·41 (s, 3H), three methoxy-groups]. Oxidation of kuhlmanniquinol with sodium periodate in acetic acid[8] gave a dalbergione with two unchelated quinonoid carbonyl groups (i.r. $\nu_{max}$ 1650 cm.$^{-1}$) and molecular formula and n.m.r. spectrum consistent with the constitution (II) [$\tau$ 2·98 and 3·23 (4H), AA'BB' system, $J_{AB}$ $J_{A'B'}$ 8·0 c./sec.;

τ 3·64 (d, 1H), *J* 1·0 c./sec., quinone proton coupled with an adjacent $-CH\langle$ substituent;[2] τ 3·7—4·3 and 4·6—5·3 (4H), multiplets from ABCD system of a $\rangle CH{-}CH{=}CH_2$ unit;[7] τ 6·00 (s, 3H), τ 6·07 (s, 3H), two methoxy-groups]. The quinone (II) was identical in structure and absolute configuration with 4′-hydroxy-3,4-dimethoxydalbergione isolated from *M. nictitans*. The natural dalbergione (II) and the dalbergione (II) prepared by oxidation of kuhlmanniquinol had identical optical rotatory dispersion (o.r.d.) curves ($[\phi]_{625}$ 0, $[\phi]_{476} + 2380$, $[\phi]_{443}$ 0, $[\phi]_{385} - 12{,}900$, in methanol, *c* 0·086) similar in form and shape to that[2] of (*R*)-3,4-dimethoxydalbergione (III) which also occurs in both *M. nictitans* and *M. kuhlmannii*. The dalbergione from *M. nictitans* therefore has the structure and absolute configuration (II) and kuhlmanniquinol therefore has the structure and absolute configuration (IV) or (V). The constitution (IV) was finally shown to be correct by the synthesis of the racemic dihydro-diethyl ether (VI) by the reaction of the benzophenone (VII) with ethylmagnesium bromide. The resulting 1,1-diarylprop-1-ene (VIII) was reduced catalytically to give the racemate (VI), which had spectroscopic properties (i.r., u.v., and n.m.r.) in solution identical with those of optically active (VI) derived from kuhlmanniquinol which could therefore be formulated as (IV).

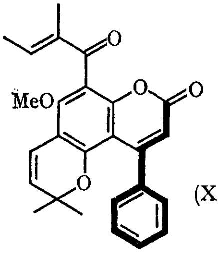
A third new natural product, kuhlmannene, m.p. 139°, obtained from both plant sources was optically inactive and had the molecular formula $C_{17}H_{16}O_4$. The n.m.r. spectrum of this compound [τ 2·71 (s, 5H); τ 3·65 (s, 1H); τ 4·26 (t, 1H), τ 5·23 (d, 2H), $AX_2$ system, $J_{AX}$ 4·0 c./sec.; τ 4·6 (broad s, 1H), exchangeable hydroxy-proton; τ 6·07 (s, 3H); τ 6·09 (s, 3H)] suggested a 4-phenylchrom-3-ene structure with two methoxy-substituents and one hydroxy-substituent. The constitution of kuhlmannene was shown to be (IX) by its formation when a chloroform solution of (*R*)-3,4-dimethoxydalbergione (III) was passed through a column of neutral alumina. This isomerisation (dalbergione → neoflavene) is mechanistically similar to the ubiquinone → ubichromenol transformation.[9] Careful studies have shown that kuhlmannene (IX) is a genuine natural product and that it is not an artefact produced by the isolation procedure.



(VI) $R^1$=Et, $R^2$=H
(VII) $R^1R^2$=O
(VIII) $R^1,R^2$=CHMe



(IX)



(X)

The isolation of the structurally and configurationally related neoflavanoids (I), (II), (III), (IV), and (IX) from *M. nictitans* and (I), (III), (IV), and (IX) from *M. kuhlmannii* strongly supports the suggestion[1,2] that the neoflavanoids form a group of compounds with a common biosynthetic origin. The biosynthesis of the neoflavanoids is clearly related to the established pathway[5] leading to calophyllolide (X) in which the $C_9$-unit (see thickened bonds) is provided by phenylalanine without aryl migration.

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