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NEW NATURAL ROTENOID AND PTEROCARPANOID ANALOGUES FROM *NEORAUTANENIA AMBOENSIS*

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Key Word Index—*Neorautanenia amboensis*; Leguminosae; rotenoids; pterocarpanoids.

Abstract—Four new natural rotenoid and pterocarpanoid analogues, neobanone, rotenonone, 12a-hydroxyisomillettone and neobanol were isolated from the benzene extract of the root of *Neorautanenia amboensis*. The structures were determined by investigation of IR, UV, MS, ^{1}H-NMR, CD and oxidative conversions.

INTRODUCTION

The isolation of rotenone, dolineone and their 12a-hydroxy- and 12a-*O*-methyl derivatives from the light petroleum extract of the root of *Neorautanenia amboensis* Schinz was described earlier [1]. Benzene extracts gave in addition three new rotenoids (**1**), (**2**) and (**3a**) as well as a new 6a-hydroxypterocarpan (**4**). Although only trace amounts (*ca* 1·0% of the crude extract) of these are present, spectrometry and simple oxidative conversions of biogenetic significance assist structure elucidations. Preliminary tests show (**3**) to be toxic to insects.

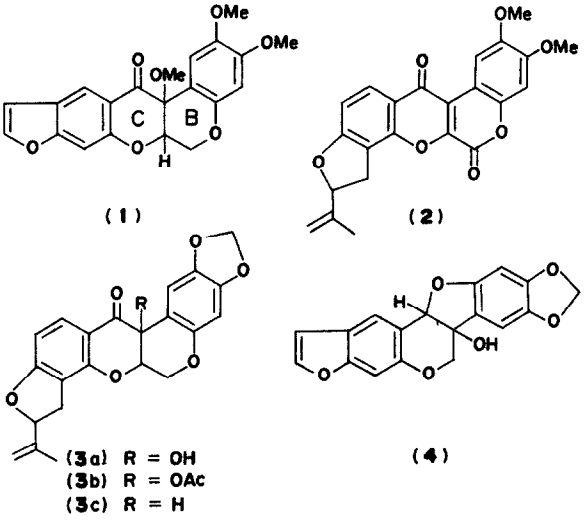
RESULTS AND DISCUSSION

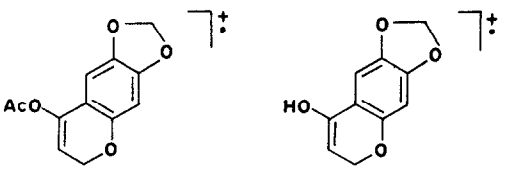
Neobanone (**1**) has the composition $C_{21}H_{18}O_7$, M^+ 382, $[\alpha]_D$ + 61°. The pale yellow oil gave a purple colour with the Durham test [2], which indicates a possible rotenoid structure. The nature of the structure of neobanone was indicated by its NMR spectrum which also confirmed the presence of an ABC system (arising from the $6_{ax,eq}$, 6a protons—τ 5·37, *m*, $H6_{ax,eq}$; 5·03, *m*, H6a) and provided evidence to the 12a-substituted nature of (**1**). The position of the 12a-*O*-methyl group (τ 6·44, *s*, 3H) is in agreement with that of similar compounds [1], while the MS was in full agreement with the proposed structure. The *cis* relationship at the B/C ring junction and absolute configuration (6aS, 12aS) was established from NMR [3] and CD data.

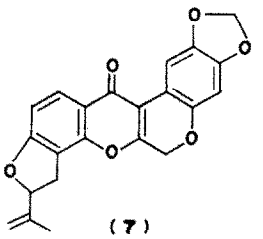
Rotenonone (**2**) crystallized as bright yellow needles from dichloroethane, mp 298–305° (decomp.), M^+ 406, ν_{max}^{KBr} 1750 (lactone C=O), 1630 (unsat. C=O) cm^{-1}. Oxidation of dehydrorotenone with *n*-amyl nitrite in acetic acid gave a product identical to the natural compound. The NMR spectrum was also in full agreement with that of the MnO_2 oxidation product, mp 298–300. 5° (decomp.) of dehydrorotenone obtained by Carlson *et al.* [4]

12a-Hydroxyisomillettone (**3a**), isolated as the acetate (**3b**) as light brown oil gave $[\alpha]_D$ − 192, $\nu_{max}^{CHCl_3}$ 1745 (acetyl (C=O), 1690 (C=O) cm^{-1}. The compound analyzed for the empirical formula $C_{22}H_{18}O_7$ in agreement with the MS. Fragments (**5**) and (**6**) suggest 12a-substitution [5] for (**3b**). This was confirmed by the NMR spectrum and the acid acatalyzed dehydration of (**3b**) to (**7**), yellow oil, $\nu_{max}^{CHCl_3}$ 1675 (unsat. C=O) cm^{-1}, τ 5·43 (H6, *s*, 2H). Isomillettone (**3c**) was previously isolated as a mixture from *Piscidia erythrina* L. [6]

Neobanol (**4**), $C_{18}H_{12}O_6$, M^+ 324, $[\alpha]_D$ − 246° was obtained as colourless needles, mp 244–246°C from ace-







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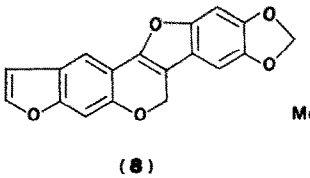
tone. The IR spectrum showed no bands in the carbonyl region. The NMR spectrum indicated the presence of a furan ring (pair of doublets, τ 2·27 and 3·24, J2·2 Hz), methylenedioxy group at τ 4·09, *s*, and a hydroxy group (τ 5·00, *br. s*, exchangeable with D_2O). The tertiary nature of the hydroxy group was indicated by the conversion of (**4**) to neoduleen (**8**) [7]. The downfield shift of the $6_{ax,eq}$ protons from τ 5·46 (*s*, 2H) in (**4**) to 4·46 (*s*, 2H) in (**8**) is in agreement with the conversion of 6a-hydroxypterocarpans to pterocarpenes [8]. The *cis* relationship and absolute configuration (6aR, 11aR) were determined by NMR and optical rotation measurements in comparison with known structures.

The isolation of stemonone (**9**) [9] and rotenonone (**2**) as natural products is of biogenetic interest because the association of (**2**) with known rotenoids in the same plant [1] may be indicative of the biogenetic sequence (rotenone → 12a-hydroxyrotenone → dehydrorotenone → rotenonone) in their formation.



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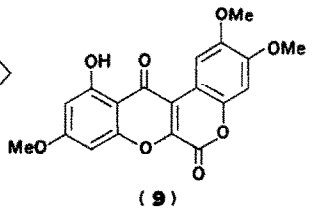

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EXPERIMENTAL

Mp's are uncorrected. IR spectra were recorded in KBr discs or $CHCl_3$ soln. NMR were determined using a Varian T-60 spectrometer and MS were recorded on a Varian CH-5 instrument CD spectra were measured in MeOH on a Jasco J-20 spectropolarimeter. Chemical shifts are expressed in ppm downfield from TMS. Preparative TLC was carried out on Si gel 60 PF_{254} plates (1 mm thick).

Isolation of compounds. Dried, milled root (3 kg) was extracted in 100 g portions with C_6H_6 for 24 hr. Combined C_6H_6 soln was concentrated to give a dark brown syrup (43 g) which was chromatographed on Si gel (170–230 mesh) with C_6H_6–MeOH (99:1, v/v). Eight crude fractions were collected and rechromatographed as follows. Fraction 2: Column chromatography in C_6H_6–Me_2CO (95:5) and preparative TLC in hexane–C_6H_6–EtOAc (5:4:0·5), R_f 0·29, gave neobanol (**4**) as colourless needles, mp 244–246°; τ (Py-d_5) 2·17, *s*, 1-H; 2·27, *d*, J2·2 Hz, 2′-H; 3·24, *d*, J2·2 Hz, 3′-H; 2·79, *br. s*, 4-H + 7-H; 3·40, *s*, 10-H; 4·07, *s*, 11a-H; 4·10, *s*, $OC\underline{H}_2O$; 5·00, *br. s*, 6a-O<u>H</u>; 5·46, *s*, $6_{eq,ax}$-H. Fraction 7: Rotenonone (**2**) was crystallized from $C_2H_4Cl_2$ as bright yellow needles, mp 298–305° (decomp.), τ (100 MHz) 1·02, *s*, 1-H; 1·85, *br. d*, J8, 11-H; 3·01, *br. d*, J8, 10-H; 3·12, *s*, 4-H; 4·55, *br. q*, J_1 9, J_2 17, 5′-H; 4·83, *br. s*, =C<u>H</u>$_2$; 5·00, *s*, 4′-H; 5·98, 6·04, *s*, 2 × OMe; 8·17, *s*, Me; UV (MeOH) λ_{max} 217, 265, 295 nm (log ϵ 4·48, 4·29, 4·19) after chromatography in C_6H_6–hexane–EtOAc (5:5:2) and TLC in the same solvent system, R_f 0·49. *Neobanone* (**1**). TLC R_f 0·15 in C_6H_6–hexane–EtOAc (6:4:0·5), was obtained as a light yellow oil, M^+ 382, τ ($CDCl_3$) 1·76, *s*, 11-H; 2·44, *d*, J2.2 Hz, 2′-H; 3·00, *s*, 8-H; 3·33, *s*, 1-H; 3·34, *d*, J2·2 Hz, 3′-H; 3·46, *s*, 4-H; 5·03, *m*, 6a-H; 5·37, *m*, 6–H; 6·17, *s*, OMe; 6·24, *s*, OMe; 6·44, *s*, 12a-OMe; CD (MeOH) $[\theta]_{200}$ + 34500, $[\theta]_{205}$ 0, $[\theta]_{235}$-34500, $[\theta]_{250}$ 0, $[\theta]_{265}$ + 6320, $[\theta]_{300}$ + 8050, $[\theta]_{370}$ 0, $[\theta]_{380}$-2300. Acetylation of fraction 8 gave after chromatography in $CHCl_3$–Et_2O (97:3) and preparative TLC R_f 0·56 in hexane–C_6H_6–EtOAc (5:5:0·5), 12a-acetoxyisomillettone (**3b**) as light brown oil, M^+ 436, τ ($CDCl_3$) 2·09, *d*, J8, 11-H; 3·08, *s*, 1–H; 3·44, *d*, J8 10-H; 3·50, *s*, 4-H; 4·07, *br. s*, $OC\underline{H}_2O$; 4·51, *m*, 6a-H; 4·65, *m*, 5′-H; 5·53, *m*, 6-H; 6·92, *m*, 4′-H; 7·85, *s*, 12a-OAc; 8·23, *br. s*, 8′-Me; UV, (EtOH) λ_{max} 210, 240, 300 nm (4·42, 4·08, 4·01), CD (MeOH) $[\theta]_{220}$-38368, $[\theta]_{240}$ 0, $[\theta]_{245}$ + 49704, $[\theta]_{252}$ 0, $[\theta]_{280}$-43600, $[\theta]_{293}$ 0, $[\theta]_{300}$ + 26160, $[\theta]_{310}$ 0,$[\theta]_{325}$-68016, $[\theta]_{390}$ 0.

Rotenonone (**2**). Dehydrorotenone (50 mg) in glacial HOAc (10 ml) was cooled to −5°. The reaction mixture was stirred for 1 hr at 0° after *n*-amyl nitrite (1·5 ml) was added after which it was allowed to warm to room temp. The mixture was extracted with C_6H_6, dried (Na_2SO_4) and evaporated to dryness to give after crystallization from $C_2H_4Cl_2$ (**2**) identical with the natural product.

12-Acetoxyisomillettone (**3b**). Acetylation was done with Ac_2O and dry pyridine according to standard procedure.

Dehydroisomillettone (**7**). (**3b**) (20 mg) in EtOH–10% H_2SO_4 (20 ml) was heated under reflux for 2 hr. Extraction with Et_2O gave, after preparative TLC R_f 0·29 in hexane–C_6H_6–EtOAc (6:5:1), dehydroisomillettone (**7**) as a yellow oil, ν_{max} $CHCl_3$ 1675 cm^{-1} (unsat. C=O); $[\alpha]_D$-236°; UV EtOH λ_{max} 210, 237, 295 nm (4·50, 4·13, 4·18); τ ($CDCl_3$) 2·12, *d*, J8·5, 11-H; 3·40, *s*, 1-H; 3·42, *d*, J 8·5, 10-H; 3·50 *s*, 4-H; 4·12, *s*, $OC\underline{H}_2O$; 4·80, *m*, 5′-H; 5·02, *m*, 7′=C<u>H</u>$_2$ 8·22, *br. s*, 8′-Me; 5·43, *br. s*, 4′-CH_2 + 6-CH_2; 6·83, *m*, 4′-H.

Neoduleen (**8**). Neobanol (20 mg) was dehydrated in a similar way as (**3b**) to give (**8**) as white needles (14 mg) from MeOH, mp 222–223°; M^+ 306; UV λ_{max}^{EtOH} 224, 252, 294, 346, 364 nm (4·30, 4·16, 3·84, 4·28, 4·18); τ ($CDCl_3$) 2·33, *s*, 1-H; 2·90, *s*, 7-H; 3·23, *s*, 10-H; 2·94, *s*, 4-H; 2·47, *d*, J2.2, 2′-H; 3·30, *s*, J2·2 Hz, 3′-H; 3·98, *s*, $OC\underline{H}_2O$; 4·45, *s*, 6-C<u>H</u>$_2$.

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