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THE STRUCTURE OF WODESHIOL - THE FIRST OF A NEW SERIES OF LIGNANS

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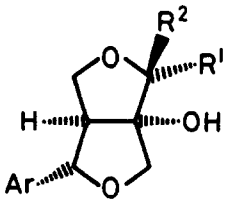
Wodeshiol, a new lignan from Cleistanthus collinus, is shown to be 1, 5-dihydroxy-2e, 6e-dipiperonyl-3, 7-dioxabicyclo[3, 3, 0]octane, the first member of a new series of dihydroxy lignans.

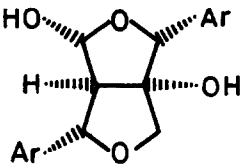
We have recently reported the isolation of a number of new lignans including arboreol (1), isoarboreol (2), and gummadiol (3) from Gmelina arborea Linn.[1,2] We now report the isolation of an isomeric compound, wodeshiol (4) from Cleistanthus collinus Roxb.

Wodeshiol occurs along with (-)-dihydrocubebin (5), and the 4-O-(β-2, 3-di-O-methyl-D-xylopyranosyl-(1→4)-β-D-glucopyranoside) of diphyllin (6).[3] (-)-Dihydrocubebin, $C_{20}H_{22}O_6$, m.p. 112°, $[\alpha]_D$ -42°, has not been previously isolated from natural sources, but was identical (m.m.p. and n.m.r.) with the product obtained by reduction of (-)-cubebin.[4]

Wodeshiol, $C_{20}H_{18}O_8$, m.p. 153-4°, $[\alpha]_D$ -12°, contains two hydroxyl groups (ν_{O-H} 3480 and 3360 cm^{-1}) and gave a diacetate (7), $C_{24}H_{22}O_{10}$, m.p. 169-70°. The ^1H and ^{13}C n.m.r. spectra (Tables 1 and 2) contained signals at similar positions to those of other 2, 6-diaryl-3, 7-dioxabicyclo[3, 3, 0]octanes,[1,2] but showed clearly that wodeshiol has a very symmetrical structure. In addition to signals due to aromatic protons there were just four singlets in the ^1H n.m.r. spectrum due to the OCH_2O groups (4.07 τ), the H-2/H-6 protons (5.04 τ), the H-4/H-8 protons (5.94 τ), and the OH groups (6.51 τ). There were no high field signals corresponding to H-5 of paulownin (8) or arboreol, or H-1 of sesamin, asarinin, etc. In the spectrum of the diacetate (7) the H-4/H-8 protons appeared as a pair of doublets at 5.60 and 5.72 τ (J = 10 Hz). The spectrum of the diacetate also confirmed that there were no CHOH or CH_2OH groups in wodeshiol since none of the signals were moved downfield by more than 0.3 p.p.m. relative to wodeshiol itself.



(1) R^1=OH, R^2 = Ar
(2) R^1=Ar, R^2 =OH
(8) R^1=Ar, R^2 =H
(10) Acetate of (8)



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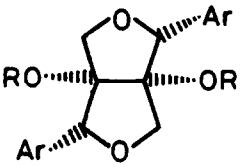
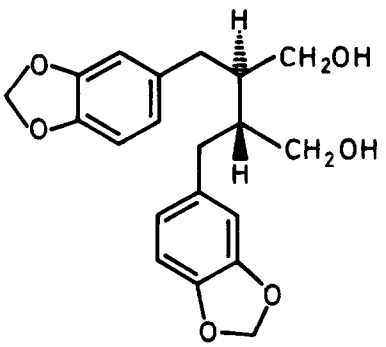


(4) R =H
(7) R =Ac

Ar = 3,4 -methylenedioxyphenyl.



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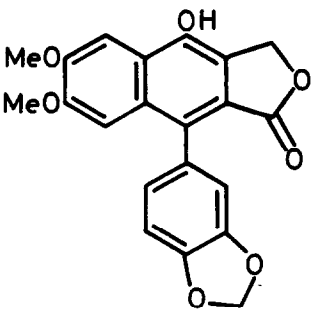


(6)

The ^{13}C n.m.r. spectrum contained only nine peaks. In addition to those due to aromatic carbon atoms and OCH_2O groups there were just three signals which correspond in terms of chemical shift to C-1, C-2 and C-8 of paulownin (see Table 2). There was no high field signal corresponding to C-5 in paulownin, and furthermore off-resonance experiments confirmed that the signal at δ 87.51, assigned to C-1/C-5, was that of a tertiary carbon atom. The off-resonance spectrum also completely confirmed the number of hydrogens assigned to C-2 (6) and C-4 (8).

The mass spectrum of wodeshiol contained, in addition to the molecular ion, a number of important fragment ions, notably m/e 236 ($M^{\cdot+}$-ArCHO), m/e 177 ($ArCH{=}C(OH){-}\overset{+\cdot}{C}H_2$), and m/e 162 ($ArCH{=}C{=}O^{+\cdot}$) which confirmed the proposed structure.

Table 1. ^{1}H n.m.r. spectra [x]

Proton	Paulownin (8) ($CDCl_3$)	Paulownin acetate (10) ($CDCl_3$)	Wodeshiol (4) ($CDCl_3$)	Wodeshiol acetate (7) ($CDCl_3$)	Periodate product (9) ($CDCl_3$-DMSO)
5	7.02 m	6.76 m	-	-	-
2	5.26 s	5.01 s	5.04 s	4.89 s	5.60 br. s
6	5.23 d (6)	5.32 d (5)			
4a	6.24 dd (6, 9)	6.28 dd (5, 9)	5.94 s	5.72 d (10)	6.69 dd (11, 1.5)
8a	6.17 d (10)	5.83 d (10)			
4e	5.56 dd (8, 9)	5.63 dd (7, 9)		5.60 d (10)	6.25 d (11)
8e	6.01 d (10)	5.61 d (10)			
OCH_2O	4.10 s, 4.12 s	4.10 s, 4.12 s	4.07 s	4.11 s	4.14 s
arom.	3.1 - 3.4 m	3.1 - 3.4 m	3.1 - 3.3 m	3.1 - 3.4 m	2.9 - 3.4 m
OH	8.15 s	-	7.55 s	-	3.58 br. s
$OCOCH_3$	-	8.29 s	-	8.17 s	-

[x] Values given in τ, coupling constants (Hz) in brackets.

All assignments supported by appropriate spin decoupling experiments and correct integration.

Table 2. ^{13}C n.m.r. spectra [ø]

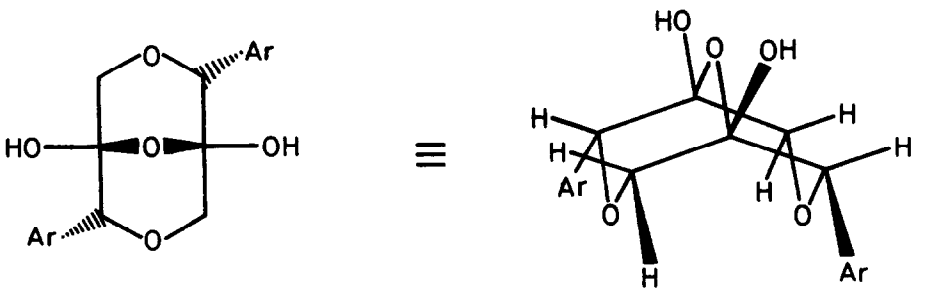
Carbon	Paulownin (8) ($CDCl_3$)	Paulownin acetate (10) ($CDCl_3$)	Wodeshiol (4) ($CDCl_3$)	Wodeshiol acetate (7) ($CDCl_3$)
1	91.74	97.08	87.51	92.31
5	60.58	58.95		
4	71.58	69.85	76.43	74.26
8	74.98	75.08		
2	87.48	86.75	86.86	86.83
6	85.88	85.67		

[ø] Signals due to aromatic, OCH_2O, and $COCH_3$ not included.

Measurements are given as p.p.m. downfield from TMS as internal standard at zero.

All assignments are supported by off-resonance decoupling experiments.

Periodate oxidation of wodeshiol was complete in 4 hr. and gave a compound, $C_{20}H_{18}O_9$, m.p. 210°, which had no carbonyl band in its infrared spectrum but gave a broad hydroxyl peak centred at 3300 cm^{-1}. The ^1H n.m.r. spectrum confirmed that this compound was the cyclic hemiketal (9) formed from the expected diketone, and the long range coupling between the axial proton at C-2 (6) and the axial proton at C-4 (8) is consistent with the conformation shown. The molecular ion in the mass spectrum corresponded to the diketone rather than the cyclic hemiketal.



(9)

The coincidence of the signals due to H-2 and H-6 and those due to H-4 and H-8 suggests very strongly that the stereochemistry at C-2 and C-6 in wodeshiol is identical. Furthermore since the H-4/H-8 protons all come below 6τ then the configuration of both aryl groups must clearly be equatorial.[5,6] Thus wodeshiol is 1, 5-dihydroxy-2e, 6e-dipiperonyl-3, 7-dioxa-bicyclo[3, 3, 0]octane, the first example of a lignan with hydroxyl groups at both of the tertiary (1, 5) positions.

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