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THE OCCURRENCE, CONFORMATION AND CRYSTAL STRUCTURE OF 1,5-ANHYDRO-D-GLUCITOL IN *PROTEA* SPP.

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Key Word Index—*Protea* spp.; Proteaceae; 1,5-anhydro-D-glucitol.

Abstract—1,5-Anhydro-D-glucitol is a major leaf metabolite of *Protea arborea*, *P. barbigera* and *P. roupelliae*. The conformation of its pyran ring is close to a chair form.

INTRODUCTION

Carbohydrates occur [1–3] in the form of aryl glycoside esters as typical leaf metabolites of *Protea* spp. In the case of two winter-rainfall spp. (*P. eximia* [2] and *P. lacticolor* [1]) the sugar moiety is D-glucose. However, in one summer-rainfall sp. (*P. rubropilosa*) the sugar moiety of a similar glycoside ester is D-allose [3], suggesting that epimerization may in this case occur after glycoside formation. In this context it is interesting that two winter-rainfall spp. (*Protea arborea* and *P. barbigera*) and a summer-rainfall sp. (*P. roupelliae*) have now been found to contain 1,5-anhydro-D-glucitol as a major leaf constituent.

The isolation of 1,5-anhydro-D-glucitol ('polygalatol') from eight other winter-rainfall spp. (*Protea compacta*, *P. cynaroides*, *P. eximia*, *P. lepidocarpodendron*, *P. neriifolia*, *P. obtusifolia*, *P. pityphylla*, and *P. repens*) has been mentioned in ref. [4]. The compounds now isolated were, therefore, fully characterized and, in the absence of an authentic reference compound, confirmed by X-ray diffraction analysis.

This study also afforded the exact description of the conformation of 1,5-anhydro-D-glucitol in the crystal lattice.

RESULTS AND DISCUSSION

Milled dried leaves were exhaustively extracted with methanol, and the recovered extracts chromatographed to afford in each case 1,5-anhydro-D-glucitol (yields of 3–4%), characterized and derivatized as below. Well-formed platelets of the metabolite were obtained from ethanolic solution overlayered with *n*-hexane and these were directly suitable for detailed X-ray diffraction analysis. The stereoscopic view (Fig. 1) of the computed structure (Fig. 2) demonstrates the equatorial disposition of all ring substituents and, hence, the glucitol series, while the positive rotation of the compound defines [5] the D-configuration. The packing of the crystal lattice is shown by the stereoscopic view of the unit cell (Fig. 3).

It is noteworthy that the conformation of the pyran ring is close to that of a regular chair, in spite of the lack of substituents at C-1. The calculated parameter of pucker, $\phi = 177°$ for the six-membered ring (O-1–C-5–C-4–C-3–C-2–C-1), is close to the theoretical value [6] of 180° for a regular chair. This is, furthermore, confirmed by the calculated torsion angles ($\sigma = 0.2°$) of 59.1, −53.8, 51.4, −53.1, 57.2 and −61.1° for the ring bonds in the same sequence; for a regular chair these values would sequentially alternate between +60 and −60°.

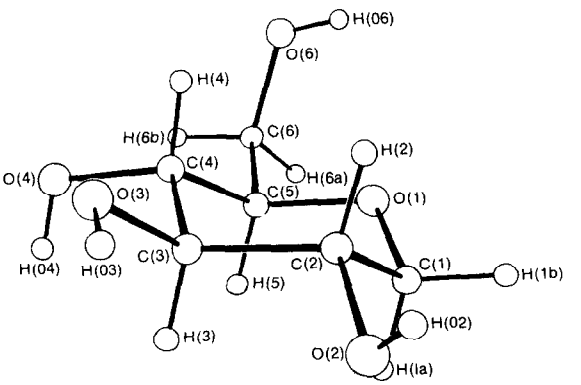

Fig. 2. The computed structure.

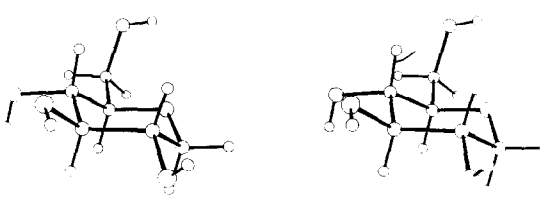

Fig. 1. 1,5-Anhydro-D-glucitol stereoscopic view.

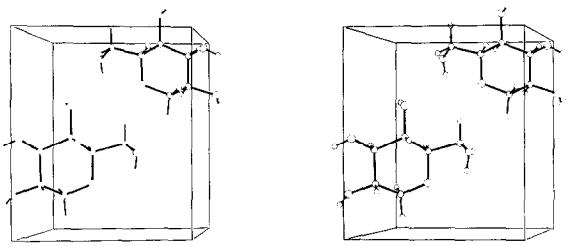

Fig. 3. Stereoscopic view of the unit cell.

All intra-molecular OH . . . O approaches are > 2.5 Å and cannot be interpreted as hydrogen bonds. The separations d[H(O-3) . . . O-6] = 1.94(5) Å and d[H(O-6) . . . O-4] = 2.06(5) Å indicate inter-molecular hydrogen bonds at those positions.

EXPERIMENTAL

Miled dried leaves (1 kg) of *Protea arborea*, collected at Stellenbosch, were extracted (Soxhlet, 50 hr) with MeOH. The extract was concd to 1 l., H_2O (3 l.) added, the filtered solns treated with basic lead acetate (200 g), filtered and de-leaded (H_2S) and evaporated. The residual syrup (112 g) in MeOH soln was dried on Si gel (150 g) and chromatographed over Si gel (850 g). Elution with C_6H_6–MeOH mixtures was monitored by TLC.

The appropriate fractions (R_f 0.6 in *n*-PrOH–EtOAc–H_2O, 7:2:1, or R_f 0.5 in C_6H_6–butanone, 3:1) afforded 1,5-anhydro-D-glucitol (35.5 g) mp 141–142° (from MeOH) (lit. [5] 142°). (Found: C, 44.1; H, 7.4. $C_6H_{12}O_5$ requires: C, 43.9; H, 7.4%.) $[\alpha]_D$ = +42° (H_2O; *c* 4.4) (lit. [5] +41°); IR ν_{max}^{KBr} cm^{-1}: 3410, 3330, 3240, (OH), 1105, 1075 (C–O); osmometric MW (in MeOH) 166 ($C_6H_{12}O_5$, 164); MS *m/z*; 146 $[M-H_2O]^+$. Its acetate (Ac_2O and pyridine, or Ac_2O and H_2SO_4) showed the dimorphism reported (mp 62° or 72–73°) [7].

Leaves (1.15 kg) of *P. barbigera* from Stellenbosch were extracted as above and chromatography yielded 1,5-anhydro-D-glucitol (47 g), mp 141–142° (from EtOH). (Found: C, 44.0; H, 7.5%.) $[\alpha]_D$ +42° (H_2O; *c* 4.9); IR absorption identical to the foregoing, osmometric MW (in MeOH) 162 ($C_6H_{12}O_5$, 164). Its acetate (Ac_2O and pyridine) was dimorphic (mp either 61 or 73° from HOAc [7]). (Found: C, 50.5; H, 6.0. $C_{14}H_{20}O_9$ requires: C, 50.6; H, 6.1%.) $[\alpha]_D$ +31° [EtOH–H_2O (1:1); *c* 0.88] (lit. [8] +39° in $CHCl_3$).

Leaves (1 kg) of *P. roupelliae* from Johannesburg yielded (as above) 1,5-anhydro-D-glucitol (30 g), mp 141–142°. (Found: C, 44.2; H, 7.3%.) IR absorption as above; $[\alpha]_D$ +43° (H_2O; *c* 5.0). Its acetate had mp 66–68° from Et_2O–hexane (lower-melting form, lit. [8] 65–67°).

Crystallography. After preliminary X-ray photographic analysis accurate cell constants and intensity data were measured on a PW 1100 Philips four-circle diffractometer, using graphite-crystal monochromated Mo K_α radiation at room temp. The cell constants are a = 7.85(1) Å, b = 9.39(1) Å, c = 5.34(1) Å, β = 109.91(5)° and the space group is $P2_1$, Z = 2. A total of 675 unique reflections were measured in the range $2° \leqslant \theta \leqslant 24°$. The structure was solved by direct methods and refined by full-matrix least squares, using the program SHELX [9]. The refined atomic coordinates (at R = 0.035) are in Table 1. The observed and calculated structure factors have also been archived.*

*Available from Professor J. B. Harborne, Editor of *Phytochemistry*, Department of Botany, University of Reading, Whiteknights, Reading, RG6 2AS, U.K.

Table 1. Fractional atomic co-ordinates (× 10^4) with estimated standard deviations in parentheses

Atom	*x/a*	*y/b*	*z/c*
O-1	3809(4)	2617	6714(6)
O-2	−683(3)	2081(4)	7211(6)
O-3	362(4)	4753(5)	9801(6)
O-4	2865(3)	6346(4)	8006(6)
O-6	6903(4)	4112(4)	9634(6)
C-1	2032(6)	2044(6)	6098(9)
C-2	1132(5)	2596(5)	7965(7)
C-3	1068(5)	4214(5)	7867(7)
C-4	2935(5)	4832(5)	8339(7)
C-5	3797(5)	4138(5)	6489(8)
C-6	5756(6)	4549(6)	7041(9)
H-1a	1217(43)	2333(41)	4100(63)
H-1b	2174(58)	945(49)	6199(82)
H-2	1772(49)	2284(47)	9814(70)
H-3	250(43)	4461(42)	6075(62)
H-4	3697(48)	4656(42)	10240(71)
H-5	3100(45)	4452(45)	4479(72)
H-6a	6153(57)	4113(56)	5470(89)
H-6b	3158(54)	8267(47)	9959(76)
H(O-2)	−808(54)	1620(52)	8255(83)
H(O-3)	−617(58)	4385(54)	9713(84)
H(O-4)	2201(78)	6539(61)	6500(112)
H(O-6)	5769(71)	5641(62)	7008(107)

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