with ether and the extract was washed with water and dried. Removal of ether gave 5.7 g of a yellow oil. Preparative glc on 15% QF-1 (0.375 in. × 50 ft column) gave the desired product, which was further purified by chromatography on neutral alumina with benzene. Removal of solvent gave a solid, mp 96.5–97° (lit.[8] mp 95–96°).

6- and 7-Nitro-4,4-dimethylbenzo[*a*]cyclopropa[*c*]cycloheptene (6′ and 7).—To a solution of 24 ml of acetic anhydride and 8 ml of fuming nitric acid at −40° was added dropwise 5.75 g (0.025 mol) of **6** at a rate such that the temperature did not rise above −20°. The reaction mixture was then allowed to come to room temperature and poured into hot water, the product was extracted with ether, washed with 5% sodium bicarbonate, and dried over magnesium sulfate, and the ether was removed under vacuum. The residue was chromatographed on a silica gel column (60–200 mesh, JTB) (4 × 50 cm) and eluted with a mixture of petroleum ether and ether (80:20) to afford 4 g of pale yellow oil. It was dissolved in petroleum ether and cooled to afford 2 g of pale yellow crystals, mp 66–68°. Recrystallization from petroleum ether gave a product: mp 69.5–71° (**6′**); ir 1345 and 1520 cm^{-1} (NO_2); nmr δ 1.47 (s, 3 H, CH_3), 1.62 (s, 3 H, CH_3), 0.2–2.4 (m, 8 H, aliphatic), 7.6 (d, 1 H, aromatic) and 8.0–8.2 (m, 2 H, aromatic).

Anal. Calcd for $C_{14}H_{17}NO_2$ (**6′**) C, 72.70; H, 7.41; N, 6.06. Found: C, 72.68; H, 7.25; N, 6.32.

The mother liquor was stripped of solvent and rechromatographed on a silica gel column (4 × 50 cm) using hexane to give a pale yellow liquid: $n^{25}D$ 1.5526 (**7**); ir 1515 and 1340 cm^{-1} (NO_2); nmr δ 0.2–2.5 (m, 8 H, aliphatic), 1.41 and 1.60 (s, 3 H, CH_3), 7.9–8.2 (m, 2 H, aromatic), 7.5 (d, 1 H, aromatic).

Anal. Calcd for $C_{14}H_{17}NO_2$ (**7**): C, 72.70; H, 7.41; N, 6.06. Found: C, 72.71; H, 7.37; N, 6.02.

4-Nitro-α-α-dimethylhomophthalic Anhydride (8). A. Authentic.—Potassium nitrate (3.4 g) in 10 ml of concentrated sulfuric acid was added slowly to a solution of 4 g of 3,3-dimethylindanone in 20 ml of concentrated sulfuric acid previously cooled to 0°. The reaction mixture was maintained at 0° for 1 hr and then poured over ice and allowed to stand for 15 min and filtered to give a product, mp 132–133° (lit.[19] mp 131–133°). The nitro ketone (1 g) and 4 g of potassium dichromate were suspended in 20 ml of water and 7 ml of concentrated sulfuric acid was added. After the mixture had cooled to room temperature had been refluxed for 30 min, it was poured over ice and an off-white solid was collected. Crystallization from petroleum ether gave a product, mp 161–163°, ir 1790 and 1750 cm^{-1} (anhydride).

Anal. Calcd for $C_{11}H_9NO_5$: C, 56.18; H, 3.86; N, 5.96. Found: C, 56.37; H, 4.10; N, 5.91.

B. Oxidation of 7.—A solution of 100 mg of **7** and 0.6 g of chromic acid was refluxed for 1 hr, poured into 50 ml of water, and extracted with ether. Removal of solvent afforded a crystalline product, mp 161–162°. Crystallization from acetone gave an off-white crystalline product, mp 162–163°, identical with that described above.

5-Nitro-α,α-dimethylhomophthalic Anhydride (9).—A solution of 200 mg of **6′** and 1 g of chromic acid in 10 ml of acetic acid was refluxed for 1 hr, diluted with 100 ml of water, and extracted with ether. Solvent removal followed by crystallization from petroleum ether afforded off-white crystals, mp 199–200°, ir 1735 and 1750 cm^{-1} (anhydride).

Anal. Calcd: C, 56.18; H, 3.86; N, 5.96. Found: C, 56.40; H, 3.70; N, 5.83.

Registry No.—**1**, 310-53-2; **1′**, 25178-99-8; **2**, 15677-15-3; **2′**, 25178-97-6; **3**, 25033-22-1; **3′**, 25178-98-7; **4**, 25033-23-2; **4′**, 25033-28-7; **6**, 34603-14-0; **6′**, 32113-65-8; **7**, 34603-16-2; **8**, 34603-17-3; **9**, 34603-18-4; PhC_3H_5, 873-49-4; 5,5-dimethyl-6,7-dihydro-5*H*-benzocycloheptene, 34603-19-5; 1,1-dibromo-4,4-dimethylbenzo[*a*]cyclopropa[*c*]cycloheptene, 34603-20-8.

(19) M. K. Goo-On, L. H. Schwatzman, and G. Forrest Woods, *J. Org. Chem.*, **19**, 305 (1954).

Light-Sensitive Glycosides. I. 6-Nitroveratryl β-D-Glucopyranoside and 2-Nitrobenzyl β-D-Glucopyranoside

URI ZEHAVI,* BOAZ AMIT, AND ABRAHAM PATCHORNIK

Department of Biophysics, The Weizmann Institute of Science, Rehovot, Israel

Received October 26, 1971

Two light-sensitive glucosides, namely, 6-nitroveratryl and 2-nitrobenzyl β-D-glucopyranoside, were prepared and characterized. The two glucosides were more stable to acid hydrolysis, than benzyl β-D-glucopyranoside. They could be photolyzed, however, to give a high yield of D-glucose under conditions that leave the benzyl glucoside intact.

The utilization of light-sensitive blocking groups has great promise in synthetic carbohydrate chemistry and in synthetic chemistry in general. Ideally, such groups should be stable to a wide variety of chemical treatments, on one hand, and at the same time be sensitive to irradiation under conditions that leave other functional groups in the molecule unaffected.

Early studies utilizing photochemical cleavage of blocking groups include the work of Tănăsescu[1] and Heidt.[2] In a series of papers the former investigator used sunlight and long periods of irradiation to remove 2-nitrobenzylidene groupings. The reactions were limited by the fact that (a) not all the 2-nitrobenzylidene groups were affected and (b) di-2-nitrobenzylidene derivatives of different saccharides, namely glucose, mannose, and galactose, were claimed to yield the same galacto derivative following irradiation. The photolysis of different phenyl, benzyl, and phenylethyl glycosides upon irradiation at 254 nm was studied by Heidt.[2] The reported yields, however, were low.

We believe that many of the limitations inherent to the findings of Tănăsescu and Heidt can be overcome by the application of modern irradiation, analytical, and spectroscopic techniques. With the advent of such methods as nmr and ORD the reinvestigation of the stereochemistry of such reactions is especially worthwhile. The results of such a study should place these early contributions in their proper perspective.

Recently, the use of 2-nitrobenzyl derivatives as photosensitive blocking reagents for amino and carboxyl functions in amino acids and peptides has been described.[3–5] In these examples the blocking groups

(1) I. Tănăsescu, *Bull. Soc. Stiiute Cluj*, **2**, 111 (1924); *Chem. Zentr.*, **2**, 2827 (1924); and many later papers including in particular I. Tănăsescu and C. Costache, *Rev. Chim., Acad. Repub. Pop. Roum.*, **1**, 61 (1956).

(2) J. Heidt, *J. Franklin Inst.*, **234**, 473 (1942).

(3) J. A. Barltrop, P. J. Plant, and P. Schofield, *Chem. Commun.*, 882 (1966).

(4) A. Patchornik in "Pharmacology of Hormonal Polypeptides and Proteins," Plenum Press, New York, N. Y., 1968, p 11.

(5) A. Patchornik, B. Amit, and R. B. Woodward, *J. Amer. Chem. Soc.*, **92**, 6333 (1970).

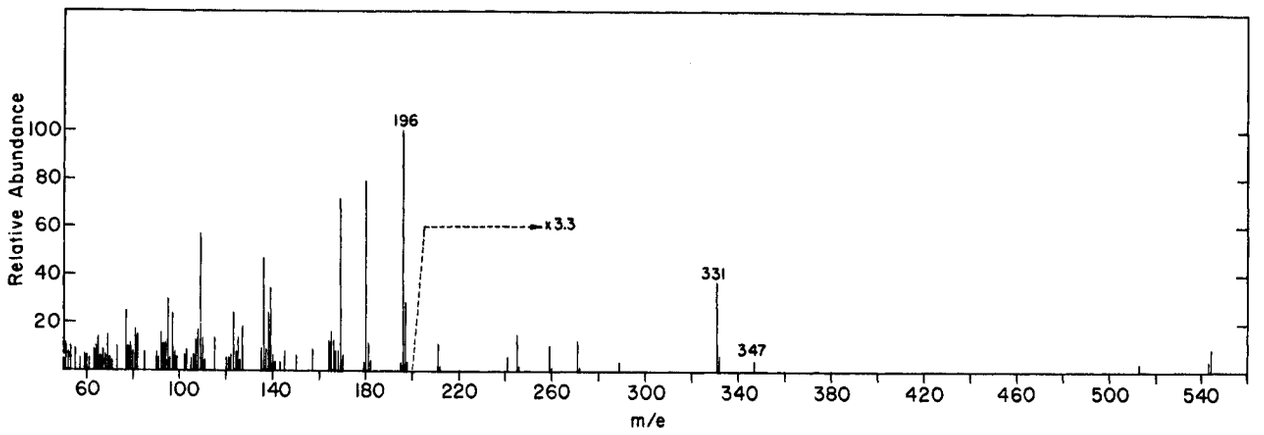


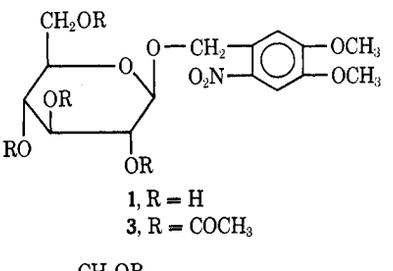
Figure 1.—Mass spectrum of 6-nitroveratryl 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside (**3**).

could be removed in high yields, and it became tempting therefore to try and use them in carbohydrate chemistry where they could be utilized in saccharide modifications and synthesis, in oligosaccharide synthesis, and for a variety of other purposes. One possible example is, for instance, the release of free saccharides in biological systems following a short irradiation.

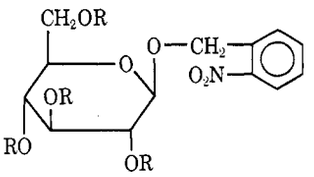
Results and Discussion

6-Nitroveratryl β-D-glucopyranoside (**1**) and 2-nitrobenzyl β-D-glucopyranoside (**2**) (Scheme I) were

SCHEME I



1, R = H
3, R = $COCH_3$

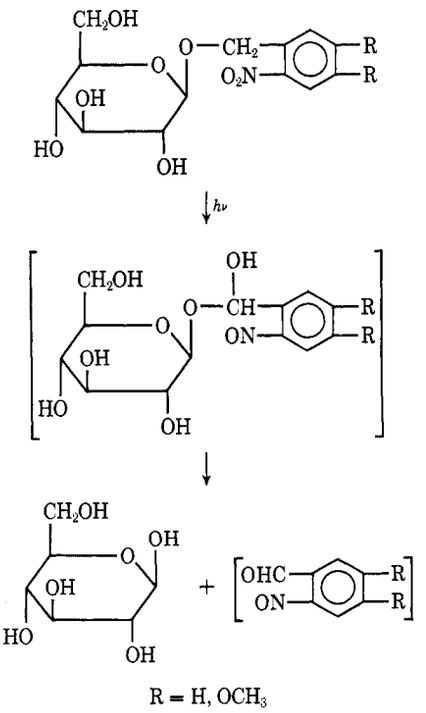


2, R = H
4, R = $COCH_3$

prepared through a modification of the Königs–Knorr reaction employing silver perchlorate in nitromethane. In the course of the reaction side products were formed that complicated the isolation of the desired glucosides. They were isolated conveniently, however, after de-O-acetylation and fractionation on a charcoal or a silica gel column. Both compounds were subjected to acid hydrolysis (0.1 *N* hydrochloric acid, 91°) and compared to benzyl-β-D-glucopyranoside[6] that has a half-life of 590 min under the said conditions (for the hydrolysis of this benzyl glucoside compare also ref 7 and 2). Compounds **1** and **2** hydrolyzed at rates of 0.78 and 0.70, respectively, of that for the benzyl glucoside (1.0). In contrast to their increased stability to acid, compounds **1** and **2**, were found to be labile to irradiation at wavelength longer than 320 nm, conditions where the benzyl glucoside remains unaffected. Irradiation of compound **1** yielded 80% hydrolysis after 10 min and quantitative hydrolysis after 30 min. Compound **2** gave under the same conditions quantitative hydrolysis after 10 min. In all cases the hydrolysis was followed by the release of D-glucose, as determined enzymatically with glucose oxidase[8] and was also demonstrated by paper chromatography in two solvent systems as the predominant carbohydrate product, occasionally accompanied by very minute amounts of a faster moving silver nitrate positive spot.

The mechanism of the photochemical reaction (Scheme II) is probably analogous to the one postu-

SCHEME II



R = H, OCH_3

lated[5] involving intramolecular oxidation–reduction, splitting of the newly formed hemiacetal followed by a further condensation of the aromatic moiety.

(6) E. Fischer and B. Helfrich, *Justus Liebigs Ann. Chem.*, **388**, 68 (1911); K. H. Slotta and H. Heller, *Ber.*, **63**, 1024 (1930).
(7) J. Heidt and C. B. Purves, *J. Amer. Chem. Soc.*, **60**, 1206 (1938).
(8) E. Raabo and T. C. Terkildsen, *Scand. J. Clin. Lab. Invest.*, **12**, 402 (1966).

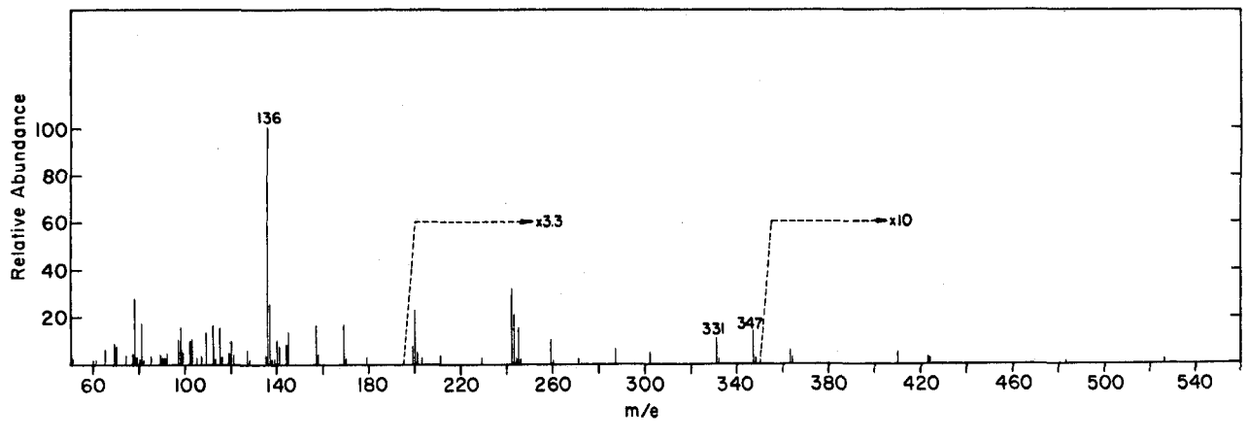


Figure 2.—Mass spectrum of 2-nitrobenzyl 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside (4).

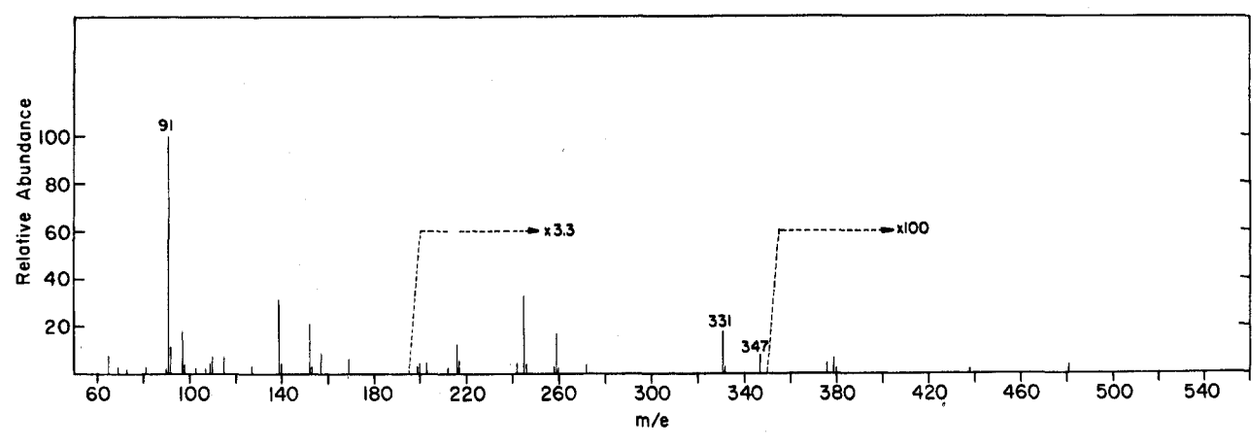
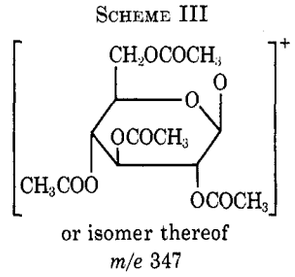


Figure 3.—Mass spectrum of benzyl 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside.

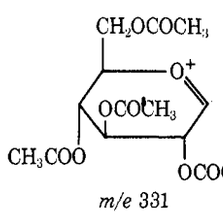
Acetylation in pyridine of compound **1** and of compound **2** afforded compounds **3** and **4** that served for spectroscopic studies. The infrared spectra were in accord with the proposed structures.

In the mass spectra of the acetylated glucosides (Figures 1–3) one observes in addition to low abundance of molecular ions (*m/e* 543, 483, and 438, respectively) in two cases (Figures 2 and 3) ions corresponding to M + 43.[9] Three major primary fragmentation processes are present leading to the formation of M-substituted benzyl radical (*m/e* 347), M-substituted benzyloxy radical (*m/e* 331), and the substituted benzyl (or tropylium) ion (Scheme III). The ratio of the intensities of the peaks at *m/e* 347 and 331 is different for the different glucosides. The extent of their further fragmentation through the loss of acetic acid and ketene (60 and 42 mass units, respectively) is also different for the three glucosides. The effect of substitution in the aglycone is manifested not only in the first stage of fragmentation but also in the decomposition of resulting ions of identical composition and which do not contain the substituted aglycone any more. This effect might be explained by the assumption that the ions *m/e* 347 and 331 are produced in the different cases with different internal energy distributions dependent on the substituents. The last phenomenon has been described for a few simpler cases.[10]

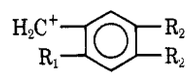
SCHEME III



or isomer thereof
m/e 347



m/e 331



m/e 196; $R_1 = NO_2$, $R_2 = OCH_3$ (Fig. 1)
m/e 136; $R_1 = NO_2$, $R_2 = H$ (Fig. 2)
m/e 91; $R_1 = R_2 = H$ (Fig. 3)

It is pertinent to note that the photochemical removal of *O*-nitrobenzyl blocking groups under the conditions described here occurs at high yield, which is a prerequisite for their utilization in synthetic organic chemistry where the blocking groups can be removed following a sequence of synthetic steps. One should

(9) J. H. Beynon, "Mass Spectrometry and Its Application to Organic Chemistry," Elsevier, Amsterdam, 1960, p 276; H. Budzikiewicz, C. Djerassi, and D. H. Williams, "Structure Elucidation of Natural Products by Mass Spectrometry," Vol. 2, Holden-Day, San Francisco, Calif., 1964, p 217.

(10) F. W. McLafferty and M. L. Gross, *Chem. Commun.*, 254 (1968); R. H. Shapiro, J. Turk, and J. W. Serum, *Org. Mass Spectrom.*, **3**, 171 (1970); S. Kozuda, H. Takahashi, S. Tamagaki, and S. Oae, *Bull. Chem. Soc. Jap.*, **43**, 1408 (1970).

also note that, in distinction from previous reports, no degradation[2] or change of configuration[1] in the carbohydrate moiety occurs in our case as the result of the photochemical reaction.

Experimental Section

All melting points are corrected. Optical rotations were determined with a Bendix polarimeter. The ir spectra were measured with a Perkin-Elmer Model 237 spectrophotometer in chloroform or in KBr disks. Nmr spectra were recorded on a Varian A-60 or a Brockmann HFX-10 instrument with tetramethylsilane as an internal standard; unless otherwise mentioned, exchangeable protons are not listed. The uv spectra were taken on a Cary Model 14 spectrophotometer and colorimetric determinations were done on a Klett-Summerson colorimeter equipped with filter no. 50. Mass spectra were measured on an Atlas CH4 mass spectrometer with 70 eV ionizing current. The samples were introduced through a direct inlet system and heating was applied until the vapor pressure was sufficient to obtain useable mass spectra. Acetyl (*m/e* 43) was always the most abundant peak. Column chromatography was carried out on Silica Gel "Grace," Davison Chemical Corp., grade 950, 60–200 mesh. Thin layer chromatography was carried out and the spots were observed under a uv lamp on fluorescent silica gel plates DF-B, Camag, Muttenz, Switzerland. R_{SR} refers to mobility relative to sudan red, a component of the test mixture supplied by C. Desaga, Heidelberg, Germany.

Paper chromatography was performed on Whatman No. 1 paper. The paper was developed with descending *n*-butyl alcohol–acetic acid–water (25:6:25, v/v/v, upper phase) I or with descending ethyl acetate–pyridine–water (2:1:2, v/v/v, upper phase) II. The chromatograms were revealed by silver nitrate[11] and by glucose oxidase spray.[12] Thick layer chromatography was done on "Chromar 1000" sheets supplied by Mallinckrodt. Sheets (20 × 20 cm) were developed with chloroform and viewed under a uv lamp. The band of the desired material was extracted with chloroform, filtered, and evaporated. 2-Nitrobenzyl alcohol was purchased from Fluka, Switzerland.

6-Nitroveratryl Alcohol.—6-Nitroveratraldehyde[13] (1.05 g, 5 mmol) was dissolved in a mixture of dioxane (10 ml) and methanol (15 ml). Sodium borohydride (0.57 g) was added and the mixture was stirred for 15 min at room temperature. The solvents were then evaporated *in vacuo* from the reaction mixture, water (50 ml) was added, and the suspension was stirred for an additional 5 min. The solid was collected after filtration, dried over phosphorus pentoxide, and crystallized from ethanol, yield 0.85 g (80%), mp 142°.

Anal. Calcd: C, 50.70; H, 5.20; N, 6.52. Found: C, 50.52; H, 5.03; N, 6.70.

6-Nitroveratryl β-D-Glucopyranoside (1).—A mixture of bromo-2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranoside ("acetobromoglucose")[14] (2.05 g, 5.0 mmol), 6-nitroveratryl alcohol (1.1 g, 5.2 mmol), calcium sulfate (200 mg), and calcium carbonate (500 mg) in anhydrous nitromethane (10 ml) was stirred under a calcium chloride seal at −16° for 30 min. Anhydrous silver perchlorate (1.0 g) was added and the stirring was continued for 1 hr at −16° and overnight at room temperature. The mixture was filtered through a Celite filter with the aid of some ethyl acetate and evaporated. The oily residue was dissolved in a methanolic solution of barium methoxide (0.1 *M*, 25 ml) and was left overnight at room temperature. The solution was then neutralized with carbon dioxide, evaporated *in vacuo*, and extracted with 25% ethanol (5 ml), and the resulting solution was applied to a charcoal column (Darco G 60, Celite 535, 1:1; 80 cm long, 1.0 cm diameter). The column was first washed with a gradient of water (500 ml) and 50% ethanol (500 ml). Compound **1** (amorphous yellow solid, 300 mg, 16%) was eluted subsequently as a broad, homogeneous peak (uniform by tlc, phenol–sulfuric acid test[15] on 1-ml samples and optical rotation throughout the peak) with another gradient of 50% ethanol (500 ml) and 70% ethanol (500 ml). The product was recrystallized from methanol–ethyl acetate: mp 172–175°; $[\alpha]^{23}D$ −1.7 ± 0.5° (*c* 0.7, pyridine); R_{SR} 0.70 (acetone–methanol, 3:1), R_{SR} 0.0 (chloroform).

Anal. Calcd for $C_{17}H_{29}O_{12}N$ ($C_{15}H_{21}O_{10}N \cdot 2CH_4O$): C, 46.45; H, 6.66; N, 3.18. Found: C, 46.26; H, 5.99; N, 3.39.

Compound **1** could also be crystallized from water: mp 186°; $[\alpha]^{25}D$ −5.0 ± 0.5° (*c* 1.6, pyridine); uv max (water) 348 nm (ε 6.1 × 10²), 304 (5.0 × 10²), 242 (1.0 × 10³); nmr (90 MHz, dimethyl sulfoxide-d_6, hexamethylsiloxane as an external standard) τ 2.08 and 2.10 (apparent d, 2, aromatic), 4.75 (s, 2, benzylic CH_2), 5.48 (d, 1, H-1, $J_{1,2}$ = 7.0 Hz), 5.92 (s, 3, OCH_3), 5.98 (s, 3, OCH_3), 6–7 (ring protons and C-5 CH_2).

Anal. Calcd for $C_{15}H_{21}O_{10}N$: C, 48.00; H, 5.64; N, 3.73. Found: C, 47.77; H, 5.53; N, 3.75.

2-Nitrobenzyl β-D-Glucopyranoside (2).—The preparation described for compound **1** was repeated with 2-nitrobenzyl alcohol (0.79 g, 5.2 mmol) instead of with 6-nitroveratryl alcohol. Following the neutralization with carbon dioxide the solution was evaporated *in vacuo* and extracted with methanol and the resulting solution was evaporated on silica gel (10 g). The absorbed material was placed on top of a silica gel column (100 g, 2 cm diameter) packed in ethyl acetate. The column was first washed with ethyl acetate (400 ml) and 5% acetone in ethyl acetate (400 ml). Compound **2** was then eluted as a broad, homogeneous peak (by tlc) with 10, 20, 30, and 50% acetone in ethyl acetate (400 ml each), yield 1.1 g (69%). The product was crystallized from water as yellow prisms that sintered at 90–95°: mp 131°; $[\alpha]^{25}D$ −4.39 ± 0.5° (*c* 0.55, pyridine); R_{SR} 0.68 (acetone–methanol, 3:1); uv max (water) 265 nm (ε 5.4 × 10³).

Anal. Calcd for $C_{13}H_{19}O_9N$ ($C_{13}H_{17}O_8N \cdot H_2O$): C, 46.84; H, 5.74; N, 4.20. Found: C, 46.77; H, 5.54; N, 4.20.

A sample of compound **2** was dried at 80° under high vacuum for 5 hr, yielding opaque crystals, mp 126°.

Anal. Calcd for $C_{13}H_{17}O_8N$: C, 49.52; H, 5.44; N, 4.44. Found: C, 49.36; H, 5.43; N, 4.28.

6-Nitroveratryl 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranoside (3).—Compound **1** (90 mg) was dissolved in dry pyridine (3.0 ml), acetic anhydride (1.0 ml) was added, and the mixture was left overnight at room temperature. A crystal of ice was then added and after 1 hr the solution was evaporated *in vacuo* with the aid of some benzene. The yellow oily residue that solidified after prolonged storage, (103 mg, 86%) was almost pure by tlc, R_{SR} 0.60 (chloroform), and was further purified on two sheets of "Chromar 1000:" $[\alpha]^{23}D$ −3.81 ± 0.5° (*c* 0.7, chloroform); nmr (60 MHz, $CDCl_3$) τ 2.15 (s, 2, aromatic), 4.3–5.9 (m, 9), 4.63 (s, benzylic CH_2), 5.93 (s, 3, OCH_3), 5.97 (s, 3, OCH_3), 7.88 (s, 3, $OCOCH_3$), 7.94 (s, 9, three $OCOCH_3$).

Anal. Calcd for $C_{23}H_{29}O_{14}N$: C, 50.83; H, 5.38. Found: C, 50.14; H, 5.25.

2-Nitrobenzyl 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranoside (4) was prepared by acetylation of compound **2** as described for the preparation of compound **3**: yield, after chromatography, 75 mg (57%) of yellow, glassy residue that solidifies; R_{SR} 0.54 (chloroform); $[\alpha]^{25}D$ −7.5 ± 0.5° (*c* 2.0, chloroform); nmr (60 MHz, $CDCl_3$) τ 1.8–2.5 (m, 4, aromatic), 4.5–6.4 (m, 9), 4.86 (apparent d, benzylic CH_2, *J* = 5.0 Hz), 7.93 (s, 3, $OCOCH_3$), 7.95 (s, 3, $OCOCH_3$).

Anal. Calcd for $C_{21}H_{25}O_{12}N$: C, 52.17; H, 5.21. Found: C, 51.87; H, 5.07.

Acid Hydrolysis.—Samples (1.0 ml, 0.555 m*M* in 0.1 *N* hydrochloric acid) of benzyl β-D-glucopyranoside, compound **1**, and compound **2** in closed ampoules were kept at 91° for different periods of time (0–20 hr). The ampoules were subsequently stored at 4° until analyzed for their glucose content. Samples after 20 hr of hydrolysis were also lyophilized, dissolved in water (50 μl), and checked (20 μl) by paper chromatography in systems I and II. The chromatograms were stained with silver nitrate or with glucose oxidase spray reagent.

Photolysis.—Samples (1.0 ml, 0.555 m*M* in water or in $^1/_{15}$ *M* potassium dihydrogen phosphate, disodium hydrogen phosphate buffer, pH 7.0) of benzyl β-D-glucopyranoside, compound **1**, and compound **2** in Pyrex test tubes that had been evacuated and closed were irradiated in a RPR-100 apparatus (Rayonet, the Southern Co., Middletown, Conn.) with 320-nm lamps. The tubes were kept in the dark until analyzed for their glucose con-

(11) N. Sharon and R. W. Jeanloz, *J. Biol. Chem.*, **235**, 1 (1960).

(12) M. R. J. Salton, *Nature (London)*, **186**, 966 (1960); A. Martinsson, *J. Chromatogr.*, **24**, 487 (1966).

(13) C. A. Fetscher, "Organic Syntheses," Collect. Vol. IV, Wiley, New York, N. Y., 1963, p 735.

(14) C. E. Redemann and C. Niemann, *Org. Syn.*, **22**, 1 (1942).

(15) M. Dubois, K. A. Gilles, J. K. Hamilton, P. A. Rebers, and F. Smith, *Anal. Chem.*, **28**, 350 (1956).

tent. Samples after 4 hr irradiation were also lyophilized and checked by paper chromatography as described above.

Registry No.—**1**, 34546-52-6; **2**, 34546-53-7; **3**, 34546-54-8; **4**, 34546-55-9; 6-nitroveratryl alcohol, 1016-58-6.

Acknowledgments.—We wish to thank Dr. Asher Mandelbaum for his help in the interpretation of mass spectra. This work was supported by Grant No. AM05098 from the National Institutes of Health, Public Health Service.

Light-Sensitive Glycosides. II. 2-Nitrobenzyl 6-Deoxy-α-L-mannopyranoside and 2-Nitrobenzyl 6-Deoxy-β-L-galactopyranoside

URI ZEHAVI* AND ABRAHAM PATCHORNIK

Department of Biophysics, The Weizmann Institute of Science, Rehovot, Israel

Received October 26, 1971

The two title compounds possessing α and β anomeric structures were prepared, characterized, and photochemically split to 6-deoxymannose (rhamnose) and 6-deoxygalactose (fucose), respectively. 2-Nitrobenzyl 6-deoxy-2,3-isopropylidene-α-L-mannopyranoside was synthesized and the isopropylidene grouping subsequently removed by acid hydrolysis without affecting the nitrobenzyl glycoside.

In the preceding paper[1] we have described a 6-nitroveratryl and a 2-nitrobenzyl β-D-glucopyranoside. Both compounds were found to be more stable to acid hydrolysis than benzyl β-D-glucopyranoside and were susceptible to photolysis under conditions that do not affect the benzyl glucoside.

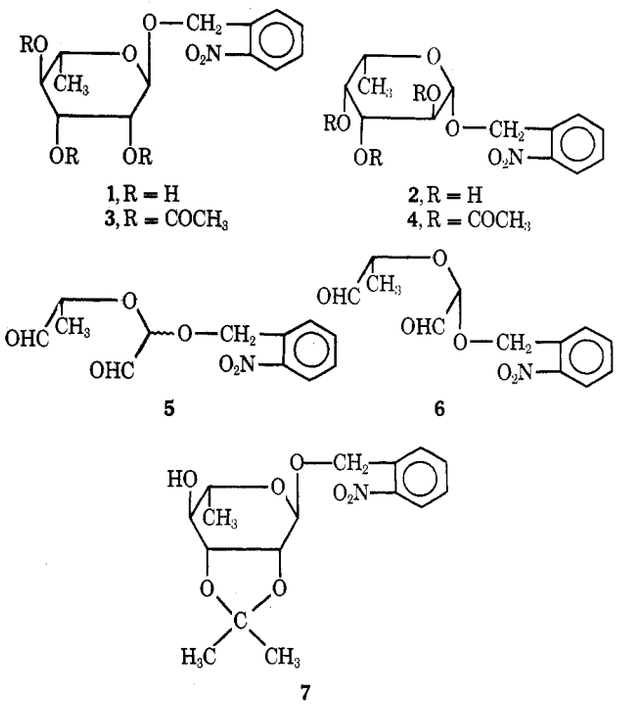
In the present work we tried to broaden the scope of our investigation to glycosides of different configurations and different anomeric structure. We also prepared and hydrolyzed an isopropylidene derivative without affecting the glycoside. Such an isopropylidene derivative might serve as a convenient intermediate in carbohydrate synthesis.

Results and Discussion

2-Nitrobenzyl 6-deoxy-α-L-mannopyranoside (**1**) and 2-nitrobenzyl 6-deoxy-β-L-galactopyranoside (**2**) were prepared by the Zémplen modification[2] of the Königs–Knorr reaction, followed by de-O-acetylation with barium methoxide and fractionation on silica gel. Compound **2** was accompanied by what is, most probably, the α anomer. The Zémplen modification was chosen as it was reported to yield clean 6-deoxy-α-mannopyranosides.[3] The optical rotations, uv, ir, and nmr spectra of the two compounds and their acetates (**3** and **4**) were in accord with the proposed structures (Scheme I). Only in the case of compound **4** (and hence compound **2**), however, had the anomeric configuration firm support from the nmr data, $J_{1,2}$ = 7.5 Hz, that should correspond to *axial–axial* interaction present in the β anomer. The anomeric configuration in compound **1** was established by its periodate oxidation to the dialdehyde **5** possessing a different rotation from the corresponding dialdehyde **6** obtained in a similar oxidation of compound **2**. As a result, compound **1** was assigned as the α anomer.

Irradiation of compounds **1** and **2** afforded quantitatively 6-deoxymannose (rhamnose) and 6-deoxygalactose (fucose), respectively, as determined by viewing the chromatograms. The reducing sugar tests gave too high yields (over 120%) due to the interference of the

SCHEME I



formed aldehyde. In the preceding work this difficulty was overcome by the enzymic determination of D-glucose that was formed during the cleavage.

The isopropylidene derivative (**7**) of compound **1** was prepared in high yield, using copper sulfate in acetone. The material absorbed at 3620 and 3480 cm^{-1} (OH) indicative of a free hydroxy grouping. Such a group on C-4, should be available for selective chemical modification. In view of the increased stability of the 2-nitrobenzyl glycosides to acid hydrolysis, the isopropylidene moiety could be neatly removed by sulfuric acid in aqueous acetone (Figure 1) without affecting the glycoside function.

The mass spectra of compounds **3** and **4** (Figures 2 and 3) are in principle similar to the spectra of the glucosides described before.[1] The molecular ions, however, are absent and one observed four major primary fragments: M − acetic acid, *m/e* 365; M − nitrobenzyl radical, *m/e* 289; M − nitrobenzyloxy

(1) Part I: U. Zehavi, B. Amit, and A. Patchornik, *J. Org. Chem.*, **37**, 2281 (1972).
(2) G. Zémplen, *Ber.*, **62**, 990 (1929).
(3) P. A. J. Gorin and A. S. Perlin, *Can. J. Chem.*, **37**, 1930 (1959).