N-*Substituted Glycosylamines. Part V.* Acetates and Benzoates.*

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The crystalline acetates and benzoates prepared from several *N*-aryl-aldosylamines are shown to be pyranose derivatives.

Unsuccessful attempts were made to characterize fully 1-deoxy-1-*p*-tolyl-amino-D-fructose.

N-Arylaldosylamines are readily prepared by condensing the appropriate sugar and amine and the methods used in this work are summarized in the Experimental section. Weygand, Perkow, and Kuhner's methods (*Chem. Ber.*, 1951, **84**, 594) have been convenient for making the stable *N*-*p*-nitrophenylaldosylamines; that from D-ribose is described for the first time. The nature and physical constants of these compounds confirm the German workers' results, except for D-xylose, from which they obtained two isomeric *N*-*p*-nitrophenyl-D-xylosylamines, considered to be a pyranose and furanose pair. During the present work only one form was obtained [that believed by Weygand *et al.* (*loc. cit.*) to be furanoid], and it was found to react on acetylation and benzoylation in the pyranose form

By a simple, general method of acetylation *N*-phenyl-D-mannosylamine, *N*-*p*-tolyl-D-galactosylamine, and *N*-*p*-nitrophenyl-D-glucosylamine, -D-mannosylamine, and -D-xylosylamine have been converted into sharp-melting, crystalline acetates. These are all pyranose because they were hydrolysed by dilute aqueous formic acid to the known, crystalline aldohexose 2 : 3 : 4 : 6-tetra-acetates or D-xylose 2 : 3 : 4-triacetates in yields of about 50%. The tetra-acetate obtained from *N*-*p*-tolyl-D-mannosylamine had a wide melting range and

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is a mixture; nevertheless, on hydrolysis it gave D-mannose 2 : 3 : 4 : 6-tetra-acetate only, and is, therefore, a mixture of pyranose anomers. This was substantiated by the preparation of the same mixture by condensing D-mannose 2 : 3 : 4 : 6-tetra-acetate with *p*-toluidine. Since the completion of this work Bognár and Nánási (*J.*, 1955, 185) have separated the mixture into two isomeric tetra-acetates. *N*-*p*-Nitrophenyl-D-galactosylamine also gives a tetra-acetate with a wide melting range: the same compound has been prepared by Frèrejacque (*Compt. rend.*, 1938, **207**, 638) who did not record a melting point. Again, the product is considered to be a mixture of pyranose anomers.

Nitration of *N*-*p*-tolyl-β-D-glucosylamine tetra-acetate with fuming nitric acid in acetic anhydride gave *N*-(2-nitro-*p*-tolyl)-D-glucosylamine tetra-acetate,* previously prepared by a different method. This structure was verified by hydrolysis of the compound to 2-nitro-*p*-toluidine. Further nitration of the mononitro-compound yielded a dinitro-derivative, hydrolysed to 2 : 6-dinitro-*p*-toluidine. This suggests that the structure is *N*-(2 : 6-dinitro-*p*-tolyl)-D-glucosylamine tetra-acetate but because migration of a nitro-group from the amino-nitrogen atom to the benzene ring can occur under the acid conditions used for hydrolysis the compound is as likely to be D-glucosyl-2-nitro-*p*-tolylnitramine tetra-acetate. The position of the second nitro-group has, therefore, not been firmly established. Nitration of *N*-*p*-tolyl-β-D-glucosylamine tetra-acetate with fuming nitric acid in chloroform yielded a trinitro-derivative, which with diphenylbenzidine in concentrated sulphuric acid gave the blue colour characteristic of nitric acid, suggesting the presence of either an aromatic nitramine with the *o*- and *p*-positions substituted (see Hughes and Ingold, *Quart. Rev.*, 1952, **6**, 50) or an ester nitrate. The latter is unlikely from the analysis and from the stability of acetates under the nitrating conditions. The most probable structure, *N*-D-glucopyranosyl-2 : 6-dinitro-*p*-tolylnitramine tetra-acetate, was confirmed by preparing it from 2 : 6-dinitro-*p*-tolylnitramine and D-glucopyranosyl bromide tetra-acetate.

Crystalline benzoates have been prepared by subjecting *N*-*p*-nitrophenyl-D-mannosylamine, -D-glucosylamine, -D-xylosylamine, and -L-arabinosylamine, and *N*-*p*-tolyl-D-galactosylamine to brief, mild treatment with benzoyl chloride in pyridine. Each gave one ester only, except *N*-*p*-nitrophenyl-D-glucosylamine from which a small amount of a second tetrabenzoate was also obtained. Because the latter was rapidly but partly converted into its isomer in methanolic hydrogen chloride solution these are considered to be anomeric. Each of the crystalline benzoates, except that from D-galactose, prepared from the above arylaldosylamines was hydrolysed to the corresponding aldohexopyranose tetrabenzoate or aldopentopyranose tribenzoate, all adequately characterized previously by preparation from the aldopyranosyl bromide benzoates.

Benzoylation of *N*-phenyl-D-mannosylamine and -D-xylosylamine, and *N*-*p*-nitrophenyl-D-ribosylamine, gave from each a non-crystalline product whose exact nature was uncertain. But the isolation from their hydrolysis product of only the crystalline D-mannopyranose tetrabenzoate, and D-xylopyranose and D-ribopyranose tribenzoates, respectively, showed that the parent aldosylamines had reacted, at least predominantly, in the pyranose form. The case of the two crystalline *N*-*p*-tolyl-D-ribosylamines designated *A* and *B* (Ellis and Honeyman, *J.*, 1952, 1490) is of particular interest. By benzoylating *B* with the temperature initially low (−70°), and purifying the crude product chromatographically, a good yield was obtained of *N*-*p*-tolyl-D-ribosylamine 2 : 3 : 4-tribenzoate, whose structure was proved by its hydrolysis to D-ribose 2 : 3 : 4-tribenzoate. Isomer *A* gave the same tribenzoate. Solutions of both *A* and *B* in pyridine containing hydrogen chloride mutarotated rapidly to a common equilibrium value. These conditions exist during benzoylation and consequently the above tribenzoate is derived from a constituent of the equilibrium solution and not necessarily from either *A* or *B*. These findings are strong support for the belief that the poorly characterized compounds, one of $[\alpha]_D^{28}$ −22·1° (*c*, 8 in pyridine) and the other of $[\alpha]_D^{28}$ −20·3° (±1°) (*c*, 1·67 in pyridine), which Berger and Lee (*J. Org. Chem.*, 1946, **11**, 75) obtained by benzoylating the isomeric *N*-phenyl-D-ribosylamines and then hydrogenating the crude benzoates, are identical and not isomeric as

* In this and other toluidine derivatives recorded in this paper, the number 1 is assigned to the position in the aromatic ring carrying the amino-group (cf. *J.*, 1952, 5090, footnote 20).

originally stated. Since the same conditions exist during reaction with triphenylmethyl chloride serious doubt is cast on any conclusions regarding structure drawn from the preparation of trityl derivatives of *N*-arylpentosylamines (Berger and Lee, *loc. cit.*, and references therein).

Only few crystalline derivatives of the *N*-substituted 1-amino-1-deoxy-D-fructoses are known. Hodge and Rist (*J. Amer. Chem. Soc.*, 1953, **75**, 316) have prepared a mono-*O-iso*propylidene derivative of 1-deoxy-1-piperidino-D-fructose, and Helferich and Porck (*Annalen*, 1953, **582**, 233) have obtained 1-benzylamino-4 : 6-*O*-benzylidene-1-deoxy-D-fructose indirectly. Now, by shaking 1-deoxy-1-*p*-tolylamino-D-fructose with acetone containing concentrated sulphuric acid, the sulphate of a mono-*O-iso*propylidene derivative has been obtained. Treatment of this with ammonia gave the crystalline mono-*O-iso*-propylidene compound. (The authors are grateful to Dr. S. Bayne for communicating this process to them.) This derivative reduced Fehling's solution and 2 : 6-dichlorophenolindophenol, gave an oxime, and with phenylhydrazine gave an *O-iso*propylidene-D-glucosazone, so $C_{(2)}$ is unsubstituted. However, all attempts to methylate or esterify it by the methods successfully used for the *N*-arylglycosylamines have given syrups. An attempt was made to obtain further information about the compound by oxidizing it with sodium periodate in aqueous acetone. During the reduction of periodate the solution became dark; similar treatment of *p*-toluidine was found to involve the consumption of nearly the same amount of periodate with the same coloration. This surprising result, which shows that periodate oxidation is of doubtful value for structural studies on *N*-arylglycosylamines and the rearranged products, is now being studied in detail.

Unsuccessful attempts have been made to prepare crystalline ethers and esters of 1-deoxy-1-*p*-tolylamino-D-fructose.

Experimental

Chloroform solutions were washed with 0·5N-hydrochloric acid, sodium hydrogen carbonate solution, and water as required, and dried over sodium sulphate before being evaporated under reduced pressure. The light petroleum used had boiling range 60—80°. The alumina used for chromatography was "Activated Alumina, Type H," 100/200 S mesh, supplied by Messrs. Peter Spence and Sons Ltd.

General Methods for the Preparation of N-*Phenyl- and* N-p-*Tolyl-aldosylamines.*—(1) A solution of the sugar (5 g.) and the amine (5 g.) in ethanol (50 ml.) was boiled under reflux for 2 hr. and then cooled. The glycosylamine which crystallized was collected, washed with ethanol and with ether, and dried in a vacuum-desiccator.

(2) The amine (5 g.) in ethanol (12 ml.) was added to a solution of the sugar (5 g.) in 0·001N-sulphuric acid (10 ml.). This was left for 24 hr. and the crystalline product was collected and purified as in (1).

(3) A mixture of sugar (5 g.), amine (4 g.), and water (1·5 ml.) was heated on a steam-bath until homogeneous and then for 5 min. more. Ethanol (10 ml.) was added and, after cooling, the crystalline product was collected, washed with ethanol and with ether, and recrystallized from ethanol.

N-p-*Nitrophenylaldosylamines.*—Weygand, Perkow, and Kuhner's methods (*loc. cit.*) were used. The constants of the derivatives obtained from D-glucose, D-mannose, D-galactose, and L-arabinose were in good agreement with those recorded.

Preparation of N-p-*Nitrophenyl-*D-*xylosylamine.*—(1) A mixture of D-xylose (5 g.), *p*-nitroaniline (5 g.), water (1 ml.), methanol (10 ml.), and glacial acetic acid (0·1 ml.) was heated under reflux for 10 min. The solids gradually dissolved; the product which separated on cooling was *N-p*-nitrophenyl-D-xylosylamine, m. p. 191°, $[\alpha]_D^{20}$ +289° (*c*, 0·5 in pyridine). By this method, Weygand, Perkow, and Kuhner (*loc. cit.*) obtained *N-p*-nitrophenyl-D-xylosylamine, m. p. 109°, $[\alpha]_D^{20}$ −95·6° (*c*, 0·5 in pyridine).

(2) A mixture of D-xylose (5 g.), *p*-nitroaniline (5 g.), water (1 ml.), ethanol (5 ml.), and acetic acid (0·1 ml.) was warmed on a steam-bath for 15 min. The ethanol was evaporated and the solid residue, recrystallized from ethanol, washed with ethanol and with ether, and dried in a vacuum-desiccator, was *N-p*-nitrophenyl-D-xylosylamine, m. p. 193°, $[\alpha]_D^{20}$ +294° (*c*, 0·5 in pyridine), for which Weygand *et al.* (*loc. cit.*) record m. p. 192°, $[\alpha]_D^{20}$ +292·5° (*c*, 0·72 in pyridine).

Preparation of N-p-*Nitrophenyl-*D-*ribosylamine.*—By treating D-ribose with *p*-nitroaniline

according to method (1) described for D-xylose there resulted N-p-*nitrophenyl*-D-*ribosylamine* (70%), m. p. 178°, $[\alpha]_D^{20}$ +349° (*c*, 0·4 in pyridine) (Found: C, 48·6; H, 5·2; N, 10·2. $C_{11}H_{14}O_6N_2$ requires C, 48·9; H, 5·2; N, 10·4%).

Mutarotation of N-*Phenyl- and* N-p-*Tolyl*-D-*ribosylamines*.—The specific rotations of each pair, *A* and *B*, were observed in pyridine saturated with hydrogen chloride. With the *N*-*p*-tolyl-D-ribosylamines extensive darkening of the solutions occurred and no further readings were possible after 10 min. but with the *N*-phenyl analogues readings were possible up to an hour after dissolution.

	N-Phenyl-D-ribosylamine			*N*-*p*-Tolyl-D-ribosylamine		
	(1)	(2)		(1)		(2)
A	+ 178°	→ + 25·7°	→ + 11·3°	+ 163°	→ + 79·5°	→ + 25·9°
B	+ 60	→ + 22·4	→ + 10·9	+ 60·1		→ + 26

(1) = $[\alpha]_D^{20}$ in pyridine. (2) = $[\alpha]_D^{20}$ in pyridine–hydrogen chloride.

General Method for the Preparation of N-*Arylaldosylamine Acetates*.—A solution or suspension of the aldosylamine (5 g.) in acetic anhydride (25 ml.) and pyridine (25 ml.) was left overnight at 0° and then poured into ice and water. The precipitate was stirred until solid, collected, washed with water, and recrystallized from ethanol.

N-*Phenyl*-D-*mannosylamine* 2 : 3 : 4 : 6-*tetra-acetate* had m. p. 127°, $[\alpha]_D^{16}$ −103·1° (*c*, 0·5 in $CHCl_3$) (Found: C, 57·3; H, 5·9; N, 3·4. $C_{20}H_{25}O_9N$ requires C, 56·8; H, 5·9; N, 3·3%).

N-*p*-Tolyl-D-mannosylamine tetra-acetate formed stout prisms, $[\alpha]_D^{20}$ −12·4° (*c*, 1 in $CHCl_3$), m. p. 118—140°, not altered by several recrystallizations from ethanol. An alternative method of preparation gave a similar product.

A solution of D-mannopyranose tetra-acetate (1 g.), m. p. 90—94°, $[\alpha]_D$ +25·8° (*c*, 1 in $CHCl_3$) [prepared by hydrolysis of *N*-*p*-tolyl-D-mannosylamine tetra-acetate], and *p*-toluidine (0·3 g.) in ethanol (10 ml.) was boiled under reflux for 2 hr. and then evaporated at room temperature in the laboratory atmosphere. Large crystals were obtained of *N*-*p*-tolyl-D-mannosylamine 2 : 3 : 4 : 6-tetra-acetate (79%), $[\alpha]_D^{20}$ −16·0° (*c*, 1 in $CHCl_3$), m. p. 120—150°, unaltered when mixed with the above sample (Found: C, 57·7; H, 6·1; N, 3·2. Calc. for $C_{21}H_{27}O_9N$: C, 57·7; H, 6·2; N, 3·2%).

Condensation of p-*Toluidine with* D-*Galactose* 2 : 3 : 4 : 6-*Tetra-acetate*.—Ethanol (10 ml.) containing *p*-toluidine (0·3 g.) and D-galactopyranose tetra-acetate (1 g.) was boiled under reflux for 2 hr. and then evaporated at room temperature in the laboratory atmosphere. The residue, crystallized and recrystallized from ethanol–light petroleum, gave *N*-*p*-tolyl-D-galactosylamine 2 : 3 : 4 : 6-tetra-acetate, m. p. 120—121° (undepressed on admixture with that prepared by the general method), $[\alpha]_D^{19}$ −23·7° (*c*, 1 in $CHCl_3$) (Found: C, 57·9; H, 6·2; N, 3·4. Calc. for $C_{21}H_{27}O_9N$: C, 57·7; H, 6·2; N, 3·2%).

Preparation *of* N-p-*Nitrophenyl*-D-*glucosylamine* 2 : 3 : 4 : 6-*Tetra-acetate*.—Acetylation of *N*-*p*-nitrophenyl-D-glucosylamine gave the 2 : 3 : 4 : 6-tetra-acetate (88%), m. p. 155°, $[\alpha]_D^{20}$ −95° (*c*, 1 in pyridine). Frèrejacque (*loc. cit.*) records m. p. 155°, $[\alpha]_D^{20}$ −101° (in $CHCl_3$). However, after one recrystallization from ethyl acetate and two from ethanol, the compound had m. p. 179°, $[\alpha]_D^{20}$ −97·8° (*c*, 1 in $CHCl_3$), −120° (*c*, 1 in pyridine), in good agreement with the values recorded by Weygand, Perkow, and Kuhner (*loc. cit.*).

N-p-*Nitrophenyl*-D-*mannosylamine* 2 : 3 : 4 : 6-*Tetra-acetate*.—Prepared by the standard method in 96% yield this compound had m. p. 186°, $[\alpha]_D^{20}$ −153° (*c*, 1 in $CHCl_3$), −229° (*c*, 1 in pyridine). Frèrejacque (*loc. cit.*) records m. p. 184°, $[\alpha]_D^{20}$ −150° (in $CHCl_3$).

N-p-*Nitrophenyl*-D-*galactosylamine Tetra-acetate*.—This compound, from different preparations, had different melting ranges, starting between 90° and 130°, and continuing to an indefinite upper limit; $[\alpha]_D^{20}$ were −68·3°, −57·8°, and −70·5° for three different preparations (*c*, 1 in chloroform). Frèrejacque (*loc. cit.*) reports $[\alpha]_D^{20}$ −73° (in $CHCl_3$), but does not record the m. p.

N-p-*Nitrophenyl*-D-*xylosylamine* 2 : 3 : 4-*Triacetate*.—Acetylation of *N*-*p*-nitrophenyl-D-xylosylamine gave N-p-*nitrophenyl*-D-*xylosylamine* 2 : 3 : 4-*triacetate* (86%), m. p. 209—211°, $[\alpha]_D^{17}$ −11·5° (*c*, 1 in $CHCl_3$) (Found: C, 51·6; H, 5·2; N, 7·0. $C_{17}H_{20}O_9N_2$ requires C, 51·5; N, 5·1; N, 7·1%).

Hydrolysis of N-*Arylaldosylamine Acetates*.—Aqueous formic acid (80 ml.; 0·5%) was added to a solution of the acetate (2 g.) in acetone (20 ml.), and the mixture was boiled under reflux until homogeneous. *N*-*p*-Tolylaldosylamine acetates were hydrolysed in an atmosphere of

nitrogen to reduce coloration, but this was unnecessary with the *N*-*p*-nitrophenyl analogues. After evaporation of acetone, the sugar acetates were isolated by extraction with chloroform, etc. The products were recrystallized from ether or alcohol. The results are shown in Table 1.

TABLE 1.

Compound hydrolysed : 2 : 3 : 4 : 6-tetra-acetate of	Reaction time (hr.)	Product : 2 : 3 : 4 : 6-tetra-acetate of	Yield (%)	M. p.	$[\alpha]_D$ †	Previous data M. p.	Previous data $[\alpha]_D$ †	Previous data Ref.
N-Phenyl-D-mannosylamine	5	D- Mannose	48	90—94°	+23·5°	93°	+26·3°	1
N-*p*-Tolyl-D-mannosylamine	5	,,	51	90—94	+25·8			
N-*p*-Nitrophenyl-D-mannosylamine	4	,,	56	90—92	+24·7			
N-*p*-Tolyl-D-galactosylamine	5	D-Galactose	50	124—125	+27·5	125—126	+26	2
N-*p*-Nitrophenyl-D-galactosylamine	2	,,	47	124—125	+26·9			
N-*p*-Nitrophenyl-D-glucosylamine	2	D-Glucose	55	123—126 *	+30·8	124—126	+31·6	3
						136—138	+18·8 → +78	4
						120—122	+40	4
						114—117	+46	4
N-*p*-Nitrophenyl-D-xylosylamine 2 : 3 : 4-triacetate	8	D-Xylose 2 : 3 : 4-triacetate	40	132—135 *	−4·5 → +38	136—137	+22·4 → +40·7	5

* Undepressed on admixture with an authentic specimen. † In $CHCl_3$.

References : (1) Levene and Tipson, *J. Biol. Chem.*, 1931, **90**, 89. (2) Butler, Smith, and Stacey, *J.*, 1949, 3371. (3) Ellis and Honeyman, *J.*, 1952, 2053. (4) Hendricks, Wulf, and Liddel, *J. Amer. Chem. Soc.*, 1936, **58**, 1997. (5) Ballou, Roseman, and Link, *ibid.*, 1951, **73**, 1140.

Nitration of N-p-*Tolyl*-β-D-*glucosylamine* 2 : 3 : 4 : 6-*Tetra-acetate*.—(1) Acetic anhydride (4 ml.) containing fuming nitric acid (1 ml.; 95%) was added to a suspension of *N*-*p*-tolyl-β-D-glucosylamine tetra-acetate (10 g.) in acetic anhydride (15 ml.) at 0°. After an hour at 0° and another hour at room temperature the solution was poured into ice-water. Evaporation of the chloroform extract of this gave a gum which after crystallization and recrystallization from methanol was *N*-(2-nitro-*p*-tolyl)-D-glucosylamine 2 : 3 : 4 : 6-tetra-acetate (2·5 g.), $[\alpha]_D^{18}$ −65·6° (*c*, 1 in $CHCl_3$), m. p. 180—182°, undepressed by a specimen prepared by Mamalis, Petrow, and Sturgeon (*J. Pharm. Pharmacol.*, 1950, **2**, 491).

The yield was doubled by starting the reaction at −70°.

A suspension of this product (5 g.) in glacial acetic acid (5 ml.) was mixed with acetic anhydride (5 ml.) containing fuming nitric acid (1 ml.) at 0°. The yellow precipitate which formed after initial dissolution was dissolved by warming the mixture on a steam-bath for 5 min. After dilution with chloroform (50 ml.) the mixture was poured on ice. Evaporation of the chloroform followed by crystallization and repeated recrystallization of the residue from methanol gave *nitro*-N-(2-*nitro*-p-*tolyl*)-D-*glucosylamine* 2 : 3 : 4 : 6-*tetra-acetate* (5·1 g.), m. p. 157—159°, $[\alpha]_D^{17}$ −51·6° (*c*, 1 in $CHCl_3$) (Found : C, 47·2; H, 4·7; N, 8·1. $C_{21}H_{25}O_{13}N_3$ requires C, 47·8; H, 4·7; N, 8·0%).

(2) Chloroform-soluble nitric acid (50 ml.) was added to a cooled solution of *N*-*p*-tolyl-β-D-glucosylamine 2 : 3 : 4 : 6-tetra-acetate (5 g.) in chloroform (50 ml.) and the solution was stirred at room temperature for 3 hr. The solution gradually changed from deep red to pale yellow. The solution was shaken with water and then with aqueous sodium hydrogen carbonate. Evaporation of the chloroform gave a red syrup, which crystallized from methanol, giving pale yellow crystals of D-*glucosyl*-2 : 6-*dinitro*-N-p-*tolylnitramine* 2 : 3 : 4 : 6-*tetra-acetate* (90%), m. p. 170—171°, $[\alpha]_D^{20}$ −58·4° (*c*, 1 in $CHCl_3$) (Found : C, 44·1; H, 4·3; N, 9·8. $C_{21}H_{24}O_{15}N_4$ requires C, 44·1; H, 4·2; N, 9·8%).

Hydrolysis of N-(2-*Nitro*-p-*tolyl*)- *and of Nitro*-N-(2-*nitro*-p-*tolyl*)-D-*glucosylamine Tetra-acetate*.—Separate solutions of each of these two compounds (1 g.) in acetone (10 ml.) containing aqueous formic acid (40 ml., 0·5%) were boiled under reflux for 3 hr. Evaporation of the acetone yielded 2-nitro-*p*-toluidine (0·26 g.) and 2 : 6-dinitro-*p*-toluidine (0·3 g.), respectively.

Condensation of Acetobromoglucose with 2 : 6-*Dinitro*-p-*tolylnitramine*.—A solution of sodium

hydroxide (0·1 g.) in water (1 ml.) was added to a solution of acetobromoglucose (1 g.) and 2 : 6-dinitro-*p*-tolylnitramine (0·6 g.) in acetone (50 ml.). After 7 days at room temperature, the solution was evaporated at room temperature, to yield crystals of D-glucosyl-2 : 6-dinitro-*p*-tolylnitramine 2 : 3 : 4 : 6-tetra-acetate, m. p. 169° (undepressed on admixture with an authentic specimen prepared as described above), $[\alpha]_D^{20}$ −56·0° (*c*, 1 in $CHCl_3$).

Preparation of Benzoates of N-*Arylaldosylamines*.—Benzoyl chloride (10 ml.) and pyridine (10 ml.) were added slowly to a solution or suspension of the aldosylamine (5 g.) in pyridine (25 ml.), usually at 0°. After periods ranging from 20 min. to 1 hr., usually at 0°, excess of benzoyl chloride was decomposed by adding drops of ice-water, and the solution was stirred into crushed ice. The precipitate was stirred and, if solid, was collected, washed and recrystallized. In most instances, however, the syrup was extracted with chloroform, and the product isolated by washing and evaporating the chloroform solution. The resulting syrups usually crystallized when triturated with cold alcohol, but for *N*-*p*-nitrophenyl-D-mannosylamine tetrabenzoate and -L-arabinosylamine tribenzoate, and *N*-*p*-tolyl-D-ribosylamine tribenzoate, crystalline products were obtained only after chromatography on alumina with benzene–chloroform (3 : 1 by volume) as solvent and eluant. Recrystallizations were from ethanol–acetone.

Preparation of N-p-*Nitrophenyl*-D-*glucosylamine* 2 : 3 : 4 : 6-*Tetrabenzoate*.—(1) Benzoylation of *N*-*p*-nitrophenyl-D-glucosylamine gave, after purification of the chloroform solution, a gum which crystallized when triturated with methanol. Recrystallization gave pure N-p-*nitrophenyl*-β-D-*glucosylamine* 2 : 3 : 4 : 6-*tetrabenzoate* (76%), m. p. 205—207°, $[\alpha]_D^{20}$ −33·3° (*c*, 1 in $CHCl_3$), −4·3° (*c*, 0·7 in pyridine) (Found : C, 67·0; H, 4·4; N, 3·9. $C_{40}H_{32}O_{11}N_2$ requires C, 67·0; H, 4·5; N, 3·9%).

(2) A crude, syrupy tetrabenzoate, obtained by the usual benzoylation procedure, followed by purification of the chloroform solution, was dissolved in acetone–benzene, and the solution was evaporated on a steam-bath until crystallization just began. On cooling, the first crop of crystals (0·2 g.) was collected and recrystallized from ethanol–acetone, yielding N-p-*nitrophenyl*-α-D-*glucosylamine* 2 : 3 : 4 : 6-*tetrabenzoate*, m. p. 246—248°, $[\alpha]_D^{18}$ +166·4° (*c*, 0·7 in pyridine) (Found : C, 66·9; H, 4·5; N, 3·8%). The solubility of this compound in chloroform was unusually low. The main product of the reaction was the β-anomer.

Partial Conversion of N-p-*Nitrophenyl*-β-D-*glucosylamine Tetrabenzoate into its Anomer*.—The β-compound (1 g.) was dissolved at room temperature in a mixture of methanolic hydrogen chloride (25 ml.; 0·1N) and acetone (25 ml.), and left for 20 min. The tetrabenzoate was precipitated by water and recrystallized. The first crop was the α-anomer (0·1 g.), m. p. 246° (undepressed on admixture with a sample prepared as above), $[\alpha]_D^{20}$ +165·0° (*c*, 0·7 in pyridine).

Preparation of N-p-*Nitrophenyl*-D-*mannosylamine* 2 : 3 : 4 : 6-*Tetrabenzoate*.—An amorphous solid was obtained by benzoylation of *N*-*p*-nitrophenyl-D-mannosylamine (1 g.) and subsequent extraction with chloroform. This, purified chromatographically on alumina and crystallized from ethanol–acetone, gave N-p-*nitrophenyl*-D-*mannosylamine* 2 : 3 : 4 : 6-*tetrabenzoate* (92%), m. p. 120°, $[\alpha]_D^{16}$ −124° (*c*, 0·9 in $CHCl_3$) (Found : C, 66·7; H, 4·6; N, 3·9%).

Preparation of N-p-*Tolyl*-D-*ribosylamine* 2 : 3 : 4-*Tribenzoate*.—(1) Benzoyl chloride (10 ml.) in pyridine (10 ml.) was added to a solution of *N*-*p*-tolyl-D-ribosylamine *B* (5 g.) in pyridine (25 ml.) at −70°. The mixture was allowed to attain room temperature during 1 hr., and the product, a red gum, was then isolated. After purification by chromatography the resultant yellow gum was crystallized from ethanol–acetone–light petroleum, followed by recrystallization from aqueous acetone, to give small white needles of N-p-*tolyl*-D-*ribosylamine* 2 : 3 : 4-*tribenzoate* (7·75 g., 64%), m. p. 183—184°, $[\alpha]_D^{17}$ +28·5° (*c*, 1 in $CHCl_3$) (Found : C, 72·1; H, 5·1; N, 2·6. $C_{35}H_{29}O_7N$ requires C, 71·9; H, 5·3; N, 2·5%).

(2) *N*-*p*-Tolyl-D-ribosylamine *A* (2 g.), benzoylated by the procedure used for *B*, gave, after purification in chloroform, a product which crystallized on addition of methanol. After recrystallization from aqueous acetone, the crystals (69%) had m. p. 183—184° (undepressed on admixture with the above tribenzoate), $[\alpha]_D^{19}$ +29·0° (*c*, 1 in chloroform).

Preparation of N-p-*Nitrophenyl*-L-*arabinosylamine* 2 : 3 : 4-*Tribenzoate*.—Benzoylation of *N*-*p*-nitrophenyl-L-arabinosylamine, followed by extraction with chloroform and chromatography, gave from ethanol–acetone, crystals of N-p-*nitrophenyl*-L-*arabinosylamine* 2 : 3 : 4-*tribenzoate* (43%), m. p. 113—116°, $[\alpha]_D^{20}$ +117° (*c*, 0·9 in $CHCl_3$) (Found : C, 66·0; H, 4·6; N, 4·7. $C_{32}H_{26}O_9N_2$ requires C, 66·0; H, 4·5; N, 4·8%).

Preparation of N-p-*Nitrophenyl*-D-*xylosylamine* 2 : 3 : 4-*Tribenzoate*.—Benzoylation of *N*-*p*-nitrophenyl-D-xylosylamine (2 g.) gave N-p-*nitrophenyl*-D-*xylosylamine* 2 : 3 : 4-*tribenzoate* (3·45 g., 80%), m. p. 152—156°, $[\alpha]_D^{19}$ +100° (*c*, 1 in $CHCl_3$) (Found : C, 65·8; H, 4·6; N, 5·0%).

N-p-*Tolyl*-D-*galactosylamine Tetrabenzoate.*—Prepared by the standard method N-p-*tolyl*-D-*galactosylamine tetrabenzoate* had m. p. 190°, $[\alpha]_D$ +101·2° (*c*, 1 in $CHCl_3$) (Found: C, 71·6; H, 5·4; N, 2·3. $C_{41}H_{35}O_9N$ requires C, 71·8; H, 5·2; N, 2·1%).

Benzoylation of N-*Phenyl*-D-*xylosylamine*, N-*Phenyl*-D-*mannosylamine, and* N-p-*nitrophenyl*-D-*ribosylamine.*—When benzoylated these compounds gave syrups.

General Method for Hydrolysis of N-*Arylaldosylamine Benzoates.*—A solution of the *N*-arylaldosylamine benzoate (2 g.) in acetone (100 ml.), water (50 ml.), and concentrated hydrochloric acid (4 ml.) was boiled under reflux during 5 hr. After evaporation of acetone, the sugar benzoate was isolated through extraction with chloroform. D-Glucose tetrabenzoate was recrystallized once from ether and three times from light petroleum (b. p. 100—120°); D-mannose tetrabenzoate and L-arabinose tribenzoate were crystallized from methanol, D-galactose tetrabenzoate from ethanol–light petroleum (attempted recrystallization), and D-ribose tribenzoate from ethanol–water (2 : 1 by vol.).

The results of these hydrolyses are shown in Table 2.

TABLE 2.

Compound hydrolysed	Product	Yield (%)	M. p.	$[\alpha]_D$	Previous data: M. p.	Previous data: $[\alpha]_D$	Previous data: Ref.
N-Phenyl-D-mannosylamine tetrabenzoate	D-Mannose 2 : 3 : 4 : 6-tetrabenzoate	—	181° *	−83·6°	182—184°	−82·6°	1
N-*p*-Nitrophenyl-D-mannosylamine 2 : 3 : 4 : 6-tetrabenzoate	,,	75	180—182 *	−85			
N-*p*-Tolyl-D-galactosylamine tetrabenzoate	Syrup	—	—	—			
N-*p*-Nitrophenyl-β-D-glucosylamine 2 : 3 : 4 : 6-tetrabenzoate	D-Glucose 2 : 3 : 4 : 6-tetrabenzoate	80	117—120 *	+72·4	119—120 114—116	+70·6 † +90·1	2 3
N-Phenyl-D-xylosylamine benzoate	D-Xylose 2 : 3 : 4-tribenzoate	—	180—181 *	+22·5	188—189	+39·5	4
N-*p*-Nitrophenyl-D-xylosylamine 2 : 3 : 4-tribenzoate	,,	67	180—182	+22·2	180—182	→ +23·4 ‡	5
N-*p*-Nitrophenyl-L-arabinosylamine 2 : 3 : 4-tribenzoate	L-Arabinose 2 : 3 : 4-tribenzoate	63	161—163	+241	162—163	+236	6
N-*p*-Tolyl-D-ribosylamine 2 : 3 : 4-tribenzoate	D-Ribose 2 : 3 : 4-tribenzoate	86	130—132 *	−41·1	135—137	−42·2	7
N-*p*-Nitrophenyl-D-ribosylamine 2 : 3 : 4-benzoate	,,	—	130—132	−40·0			

* Denotes undepressed on admixture with an authentic specimen. $[\alpha]_D$ are in $CHCl_3$ unless otherwise stated. † In EtOH. ‡ In dioxan–water (18 : 7) containing a drop of aqueous ammonia.

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Preparation of 1-*Deoxy*-O-iso*propylidene*-1-p-*tolylamino*-D-*fructose.*—Concentrated sulphuric acid (4 ml.) was added to a suspension of 1-deoxy-1-*p*-tolylamino-D-fructose (10 g.) [prepared from D-glucose and *p*-toluidine by Weygand's method (*Ber.*, 1940, **73**, 1259)] in acetone (200 ml.), and the mixture was shaken vigorously. The solid dissolved, and after 1 min., the hydrogen sulphate of 1-deoxy-mono-*O*-*iso*propylidene-1-*p*-tolylamino-D-fructose separated, was collected, and, while suspended in acetone (200 ml.), was neutralized by concentrated aqueous ammonia. After the precipitated ammonium sulphate had been collected, the filtrate, evaporated under reduced pressure, yielded crystals (7·4 g., 80%), recrystallization of which from ethanol–light petroleum gave 1-*deoxy*-O-iso*propylidene*-1-p-*tolylamino*-D-*fructose*, m. p. 120—124°, $[\alpha]_D^{19}$ −89·3° (*c*, 1 in EtOH) (Found: C, 62·3; H, 7·6. $C_{16}H_{23}O_5N$ requires C, 62·1; H, 7·4%). This compound was soluble in pyridine, ethanol, and acetone, but sparingly soluble in water, chloroform, and light petroleum.

Hydroxylamine hydrochloride (8 g.) was warmed with a solution of sodium (2·3 g.) in ethanol (100 ml.) until the solution was no longer alkaline. Sodium chloride was filtered off and the resulting solution of hydroxylamine was boiled under reflux with 1-deoxy-*O*-*iso*propylidene-1-*p*-tolylamino-D-fructose (12·4 g.) for 1 hr. On cooling, crystals (10·7 g.), m. p. 122—128°,

separated. Three recrystallizations from ethanol–light petroleum gave 1-*deoxyisopropylidene*-1-p-*tolylamino*-D-*fructose oxime*, m. p. 132—134°, $[\alpha]_D^{21}$ −26·6° (*c*, 1 in EtOH) (Found: C, 59·4; H, 7·6; N, 8·6. $C_{16}H_{24}O_5N_2$ requires C, 59·3; H, 7·4; N, 8·6%).

Preparation of O-iso*Propylidene*-D-*glucosazone*.—Phenylhydrazine (2 ml.) and 1-deoxy-*O*-*iso*propylidene-1-*p*-tolylamino-D-fructose (1 g.) were boiled in methanol (40 ml.) and aqueous acetic acid (3 ml.; 50%) for 4 hr. Evaporation of the solvent left a gum which was crystallized, and recrystallized from benzene as yellow crystals of O-iso*propylidene*-D-*glucosazone*, m. p. 186·5—188·5°, $[\alpha]_D^{19}$ +6° (*c*, 0·4 in EtOH) (Found: C, 63·7; H. 6·7; N, 13·9. $C_{21}H_{26}O_4N_4$ requires C, 63·3; H, 6·5; N, 14·0%).

Periodate Oxidation of 1-*Deoxy*-O-*isopropylidene*-1-p-*tolylamino*-D-*fructose and of* p-*Toluidine*.—Aqueous sodium periodate (60 ml.; *ca.* 0·15M) was added to the fructose derivative (1·0100 g.) dissolved in acetone (20 ml.). The consumption of periodate (mole/mole of derivative) was: after 2·5 hr., 1·92; 5 hr., 2·15; 24 hr., 2·68; 48 hr., 2·80.

With *p*-toluidine (0·3466 g.) in a similar solution the consumption of periodate after 24 hr. was 2·55 mole/mole.

Periodate was estimated by adding excess of standard aqueous sodium arsenite, potassium iodide, and sodium hydrogen carbonate and determining the excess of arsenite after 15 min. with standard iodine solution. Figures given above are corrected for control experiments.

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