272. N-*Substituted Glycosylamines. Part II.* The Influence of Water on the Preparation of* N-*Arylglycosylamines.*†

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The reaction of D-ribose with aniline has been investigated and the influence of water established in deciding which isomer is obtained. This result has been applied generally to the reaction of monosaccharides with primary aromatic amines, with the consequent preparation of new compounds. A general method for preparing a number of *N*-*p*-tolylaldosylamines is described : possible uses include the identification of aldoses. The ultraviolet absorption of some of the compounds in methanol has been measured : no change in absorption was observed during mutarotation.

The condensation of D-ribose with aniline was studied by Berger and Lee (*J. Org. Chem.*, 1946, **11**, 75), who obtained two isomers which they called aniline-*N*-D-ribofuranoside, formed when the reaction was carried out in boiling ethanol, and aniline-*N*-D-ribopyranoside, formed by condensation in aqueous ethanol at room temperature. The pyranoside was converted into the furanoside by heating it under reflux in ethanol for an hour or by leaving it in ethanol at room temperature. According to the nomenclature now being adopted these compounds are *N*-phenyl-D-ribofuranosylamine and *N*-phenyl-D-ribopyranosylamine respectively.

* Part I, *J.*, 1950, 967.

† Named arylamine-*N*-glycosides in Part I.

The evidence presented by Berger and Lee (*loc. cit.*) for assigning the furanose and pyranose structures to the isomers was critically reviewed by Honeyman and Tatchell (*J.*, 1950, 967), who pointed out that characterization of the isomers was incomplete. Because of the uncertainty of the structures the isomer previously considered to be *N*-phenylribofuranosylamine will now be called *A*, and that thought to be the pyranosylamine *B*.

Much of Berger and Lee's work on the substituted ribosylamines was repeated by Howard, Kenner, Lythgoe, and Todd (*J.*, 1946, 855), who confirmed most of the American workers' findings. They showed, however, that the conversion of *B* into *A* in refluxing ethanol did not always take place. In some cases no conversion at all took place, whereas in others, under apparently the same experimental conditions, some or all of *B* was converted into *A*.

The work described in this paper clarifies the conditions which govern the formation and interconversion of the two *N*-phenylribosylamines, and expands the previous communication on this subject (Ellis and Honeyman, *Nature*, 1951, **167**, 239). Experiments on the condensation of D-ribose with aniline at various temperatures and in various solvents showed that, contrary to the suggestions of previous workers, temperature was not an important influence on the nature of the isomer produced. Thus, *B* was produced in aqueous ethanol at room temperature or at the boiling point. Further, the presence of moisture invariably resulted in the production of *B*, whereas *A* was obtained only in anhydrous ethanol. Similarly, even a small amount of water prevented conversion of *B* into *A* in boiling ethanol; this probably explains why Howard *et al.* (*loc. cit.*) did not obtain consistent results. Conversely, a solution of *A* in aqueous ethanol, whether refluxed or not, deposits crystals of *B*. The importance of water in the formation of the *N*-phenylribosylamines was shown conclusively by two experiments. The sugar and amine were boiled in anhydrous ethanol with the exclusion of moisture and the hot reaction mixture divided into three parts. In the first vessel, which was immediately stoppered and cooled, crystals of *A* separated. A small amount of water was added to the other two parts. One was cooled immediately and the other boiled for 15 minutes more: both deposited crystals of *B*. In another experiment, the components were heated under reflux in aqueous ethanol and the reaction mixture was divided into two parts. One part was seeded with *B* and the other with *A*, but *B* separated from both. The specific rotations of the two isomers in methanol (which had not been reported at the time this work was done, but which have since been published by Butler, Laland, Overend, and Stacey, *J.*, 1950, 1433) showed a change in rotation in the same direction to approximately the same end-point: *A*, $[\alpha]_D^{20}$ +134·9° ⟶ +14·1° (*c*, 0·4 in methanol); *B*, $[\alpha]_D^{14}$ +23·8° ⟶ +8·3° (*c*, 0·4 in methanol). No mutarotation was observed in pyridine, even on addition of a drop of water. This is in contrast to observations by Berger and Lee, Howard *et al.*, and Butler *et al.*, who record mutarotation in pyridine or moist pyridine. It was largely on the basis of the mutarotation that Berger and Lee (*loc. cit.*) considered that the isomers had different rings. Certainly it is clear that mutarotation involves the production of at least a third compound, but no evidence has been obtained so far as to its nature. Evaporation of the solutions after equilibration resulted in the separation of *B*.

A similar cycle of reactions was carried out with *p*-toluidine and D-ribose. Berger and Lee (*J. Org. Chem.*, 1946, **11**, 84) describe the only known *N*-*p*-tolylribosylamine, m. p. 102—103° (decomp.), $[\alpha]_D^{27·5}$ +53·2° (in pyridine), prepared at room temperature in ethanol containing a trace of water, as a white powder containing two molecules of ethanol. In the present work, *N*-*p*-tolylribosylamine, m. p. 123° (decomp.), $[\alpha]_D^{18}$ +58·6° (in pyridine), separated from aqueous ethanol at room temperature as a crystalline hemihydrate. This corresponds with the *N*-phenylribosylamine *B* obtained by a similar method and is called isomer *B*. When D-ribose was heated with *p*-toluidine in anhydrous ethanol an isomer (*A*), m. p. 130° (decomp.), $[\alpha]_D^{17}$ +178·2° ⟶ +76·0° (in pyridine), was obtained. The conditions of formation and interconversion of these two isomers followed those of the *N*-phenylribosylamines exactly. The change of rotation of their methanol solutions is also analogous, *viz.*: *A*, $[\alpha]_D^{20}$ +136·2° ⟶ +12·5°; *B*, $[\alpha]_D^{18}$ +22·1° ⟶ +11·7°. *A* showed mutarotation in dry pyridine but *B* did not.

Berger and Lee (*loc. cit.*, p. 84) prepared *N*-*o*-nitrophenyl-D-ribosylamine, m. p. 183—185° (decomp.), $[\alpha]_D^{28}$ −109° (in pyridine), by reaction at room temperature in aqueous ethanol. We have obtained the same compound *B* under these conditions and a new isomer *A*, m. p. 167—168° (slight decomp.), $[\alpha]_D^{20}$ −122·5° (in pyridine), by reaction in boiling anhydrous ethanol. The specific rotations of these isomers are more similar than in the previous cases, but *A*, $[\alpha]_D$ −122°, was consistently obtained from refluxing anhydrous ethanol and was converted into *B*, $[\alpha]_D$ −109°, by recrystallization from aqueous ethanol. The compounds were also more stable than other substituted ribosylamines and have remained as yellow needles with no signs of decomposition on normal storage for several months. The evidence points strongly to the existence of two isomers, as for the others reported above. Howard *et al.* (*loc. cit.*) mention, without experimental details, that only one *N*-*o*-nitrophenylribosylamine was obtained from condensation by the two methods described by Berger and Lee.

In view of the important role of moisture in the preparation of *N*-substituted ribosylamines, the investigation was extended to other sugars. The reaction of glucose and galactose with *p*-toluidine under anhydrous conditions was found to give new isomers. Similarly, with glucose and aniline, a dextrorotatory isomer was obtained, but the product of several reactions did not have such a consistent specific rotation as did the *N*-*p*-tolylglucosylamine. The amorphous nature of *N*-phenylglucosylamine, no matter how obtained, is a complicating factor in this instance. In the same way a different *N*-phenyl-D-galactosylamine was obtained. Attempts to recrystallize the new galactose and glucose derivatives under anhydrous conditions were not very successful, as some isomerization usually occurred. However, the same *N*-phenyl- or *N*-*p*-tolyl-D-xylosylamine was obtained by both methods of condensation.

In the majority of cases where two different isomers were prepared, the final value of the specific rotation was the same for both isomers. However, the facile conclusion that the two isomers are anomers is unjustified if the case of *N*-phenylribosylamines is borne in mind.

The ultra-violet light absorption of *N*-phenyl-D-mannosylamine and of both isomers *A* and *B* of *N*-*p*-tolylribosylamine was measured. Kuhn and Dansi (*Ber.*, 1936, **69**, 1745) recorded the ultra-violet light absorption of *N*-*p*-tolylglucosylamine in ethanol. In the present work, the absorption was measured in methanol for a number of days at the same time as the mutarotation was being observed polarimetrically. There was no appreciable change in the absorption corresponding to the change in specific rotation which took place simultaneously. In this connexion, it is interesting that the absorption curve for the *N*-substituted glycosylamines closely resemble those of the simple aromatic amines, the main difference being that the maxima are moved laterally to a slight extent. For *N*-phenyl-D-mannosylamine the maxima are at 2400 (log ε 4·48) and 2850 Å (log ε 3·52): *N*-*p*-tolylribosylamine *A* has $\lambda_{max.}$ 2450 (log ε 4·47) and 2900 Å (log ε 3·72); *N*-*p*-tolylribosylamine *B* showed $\lambda_{max.}$ 2500 (log ε 5·62) and 2940 Å (log ε 4·25). Aniline is reported (for references see *Ann. Reports*, 1945, **42**, 124) to have $\lambda_{max.}$ 2300 (log ε 3·90) and 2800 Å (log ε 2·30).

Physical constants of N-*aryglycosylamines obtained by present authors.*

	Isomer A		Isomer B	
	M. p.	$[\alpha]_D$ *	M. p.	$[\alpha]_D$ *
N-Phenylribosylamine	133—134°	+134·9° ⟶ +14·1°	112—114°	+24·3° ⟶ +9·4°
N-*p*-Tolylribosylamine	130	+136·2 ⟶ +12·5	123	+22·1 ⟶ +11·7
N-*o*-Nitrophenylribosylamine	167—168	− 122·5 †	193—194	−109·1 †
N-Phenylglucosylamine	134—135	+53 ⟶ −20·6	—	+10 ⟶ −52
N-*p*-Tolylglucosylamine	135—136	+209 ⟶ −45	117—118	−101 ⟶ −46
N-Phenylgalactosylamine ...	141—143	−22·1 ⟶ −40·3	157—158	−92 ⟶ −43·5
N-*p*-Tolylgalactosylamine ...	—	−33·0 ⟶ −14·1	161—162	−80 ⟶ +8·8

* In methanol, unless specified. † In pyridine.

The ease of reaction of amines with sugars in aqueous ethanol at room temperature, and the purity and frequent excellent crystalline form of the product, suggested the possible

development of a method for the characterization of sugars (see Table). The products obtained in this way are thought to be the same as those prepared by a different method by Weygand (*Ber.*, 1939, **72**, 1663), although this worker does not always record specific rotations of his products and melting points are not very reliable. The method described is preferred to Weygand's because, generally, the yield and purity were better and recrystallization was unnecessary. The chief disadvantage of these derivatives for characterization purposes is the impossibility of storing them for long without decomposition, but acetylation as described by Honeyman and Tatchell, Butler *et al.*, and others, gives very easily a more desirable product with sharp melting point, characteristic specific rotation without mutarotation, and excellent stability. An attempt was made to evolve a general procedure using one amine, which would condense with a number of sugars under these conditions. The most suitable tried was *p*-toluidine, which reacted readily (with standardized quantities) in aqueous ethanol at room temperature, to give a crystalline *N*-*p*-tolylglycosylamine with the following sugars: D-ribose, D-mannose, D-galactose, D-glucose, and, less successfully, D-xylose. The crystals which separated were filtered off, washed with ethanol and with ether until free from amine, and dried in a vacuum. With L-arabinose crystalline material was extremely difficult to obtain, even on removal of some of the solvent, owing to the solubility of the product. The ketoses tried, D-fructose and D-sorbose, did not react with *p*-toluidine under these conditions. The method has possibilities for separating certain aldoses from ketoses. With mannose and ribose, the separation of crystalline material was rapid and the final yield was high.

Experimental

Solvents used in the determination of specific rotations were purified and freed from water. The initial $[\alpha]_D$ stated was obtained, where necessary, by extrapolation to zero time: the final value is the equilibrium one. M. p.s, which are uncorrected, were somewhat variable; melting was accompanied by decomposition.

The crystalline products were purified by washing them with ethanol and with ether and were dried in a vacuum desiccator.

N-*Phenyl*-D-*ribosylamine* A.—D-Ribose (0·4 g., 1 mol.) was dried for 2 hours at 75° and placed in a dry flask containing magnesium-dried ethanol (4 ml.). Freshly redistilled aniline (0·3 g., 1·2 mols.) was added and the mixture boiled for 2 hours under a dried condenser carrying a calcium chloride tube. The flask was then stoppered and cooled. The solution deposited crystals (0·4 g., 67%) of *N*-phenyl-D-ribosylamine *A*, m. p. 133—134°, $[\alpha]_D^{20}$ +176·4° (*c*, 0·8 in pyridine), +134·9° ⟶ +14·1° (after 12 days) (*c*, 0·4 in methanol), $[\alpha]_D^{16}$ +172·1° ⟶ +37·2° (*c*, 0·2 in ethanol).

N-*Phenylribosylamine* B.—Prepared by Berger and Lee's method (*loc. cit.*), *N*-phenylribosylamine *B* was obtained as white needle-shaped crystals (93%), m. p. 112—114°, $[\alpha]_D^{20}$ +60·2° (*c*, 1·0 in pyridine), $[\alpha]_D^{14}$ +23·8° ⟶ +8·3° (*c*, 0·4 in methanol).

Recovery of N-*Phenylribosylamine* B *from Methanolic Solutions.*—(i) The methanolic solution used for determination of the specific rotation of *A* was allowed to evaporate at room temperature in the laboratory atmosphere. It gave crystals of *B*, m. p. 112—115°, $[\alpha]_D^{15}$ +62·2° (*c*, 1·0 in pyridine), +24·0° ⟶ +9·9° (*c*, 0·7 in methanol).

(ii) A methanolic solution of *B* was left in a stoppered flask until its specific rotation had reached a constant value. It was then allowed to evaporate slowly at room temperature and gave crystals of *B*, m. p. 114—116°, $[\alpha]_D^{16}$ +60·4° (*c*, 0·7 in pyridine), +24·3° ⟶ +9·4° (*c*, 0·6 in methanol).

Conversion of N-*Phenylribosylamine* A *into* B.—A sample of *A* (1 g.) was added to absolute ethanol (5 ml.) and water (10 ml.). After being refluxed for 10 minutes it was left at room temperature overnight. The solution deposited crystals of *B*, $[\alpha]_D^{17}$ +62·2° (*c*, 1·0 in pyridine).

Conversion of N-*Phenylribosylamine* B *into* A.—(i) A solution of *B* (1 g.) in magnesium-dried ethanol (8 ml.) was refluxed in dried apparatus in the absence of moisture for 1 hour. The flask was then stoppered and cooled. The solution deposited crystals of *A*, $[\alpha]_D^{15}$ +186·2° (*c*, 0·8 in pyridine), $[\alpha]_D^{16}$ +153·8° ⟶ +14·2° (*c*, 0·4 in methanol).

(ii) A solution of *N*-phenylribosylamine *B* (3 g.) in anhydrous ethanol (24 ml.) was refluxed under anhydrous conditions for 1 hour and then divided into three portions. The first was immediately stoppered and left to cool, whereupon it deposited crystals of *A*, m. p. 132—

134°, $[\alpha]_D^{17}$ +176·4° (*c*, 1·0 in pyridine). The second was left to cool after one drop of water had been added to it. This gave crystals of *B*, $[\alpha]_D^{17}$ +59·8° (*c*, 0·8 in pyridine). The third was refluxed for 15 minutes with two drops of water. On cooling, it deposited crystals of *B*, $[\alpha]_D^{17}$ +60·1° (*c*, 0·9 in pyridine).

Physical Constants of N-*Phenylribosylamines.*—The physical constants of the *N*-phenylribosylamines, together with those given by other workers, are tabulated below :

Reference (*locc. cit.*)	*A*, m. p.	*A*, $[\alpha]_D$ in methanol	*A*, $[\alpha]_D$ in pyridine	*B*, m. p.	*B*, $[\alpha]_D$ in methanol	*B*, $[\alpha]_D$ in pyridine
Present authors	133—134°	+134·9° ⟶ +14·1°	+176·4°	112—114°	+23·8° ⟶ +8·3°	+60·2°
Berger and Lee	138—140	—	+176·5 ⟶ +156·6	125—127	—	+63·4 ⟶ +48·6
Butler *et al.* ...	123—124	+135 ⟶ +12	+182 ⟶ +52·3	114—116	+23 ⟶ +13	+62 ⟶ +50
Howard *et al.* ...	126—127	—	+180 (dry solvent) +180 ⟶ +161 (moist solvent)	119	—	+60 (dry slovent) +60 ⟶ +48·4 (moist solvent)

N-p-*Tolyl*-D-*ribosylamine* A.—(i) D-Ribose (0·5 g., 1 mol.) was dried at 75° for 2 hours and dissolved in freshly dried ethanol (4 ml.). After addition of *p*-toluidine (0·35 g., 1 mol.) the solution was refluxed for 2 hours with exclusion of moisture. The flask was immediately stoppered and on cooling deposited N-p-*tolyl*-D-*ribosylamine* A, m. p. 130°, $[\alpha]_D^{20}$ +136·2° ⟶ +12·5° (*c*, 0·3 in methanol), $[\alpha]_D^{17}$ +178·2° ⟶ +76·0° (*c*, 0·3 in dry pyridine) (Found : C, 60·3; H, 6·9; N, 6·0. $C_{12}H_{17}O_4N$ requires C, 60·3; H, 7·1; N, 5·9%).

N-p-*Tolylribosylamine* B.—(i) (cf. Berger and Lee, *loc. cit.*, p. 84). To D-ribose (2 g., 1 mol.) in 0·001N-sulphuric acid (5·5 ml.), *p*-toluidine (2 g., 1·5 mols.) in ethanol (10 ml.) was added. The white needles (3·0 g., 94%) which separated after 20 hours at room temperature and 5 hours at 0° were found to be N-p-*tolyl*-D-*ribosylamine* B, m. p. 123°, $[\alpha]_D^{18}$ +58·6° (*c*, 1·0 in pyridine), $[\alpha]_D^{18}$ +22·1° ⟶ +11·7° (*c*, 0·4 in methanol) (Found : C, 58·1; H, 7·3; N, 5·8%. $C_{12}H_{17}O_4N,\frac{1}{2}H_2O$ requires C, 58·1; H, 7·3; N, 5·6%). Berger and Lee (*loc. cit.*) describe *N*-*p*-tolyl-D-ribosylamine, m. p. 102—103°, $[\alpha]_D^{27·5}$ +53·2° (*c*, 2·0 in pyridine) as a white powder, analysis indicating the presence of two molecules of ethanol.

(ii) The product present in a solution obtained by heating D-ribose (0·5 g., 1 mol.) with *p*-toluidine (0·38 g., 1·2 mols.) in anhydrous ethanol for 2 hours was refluxed for 5 minutes more after addition of two drops of water. On purification it gave crystals of *B*, $[\alpha]_D^{18}$ +65° (*c*, 0·3 in pyridine), $[\alpha]_D^{18}$ +22·6° ⟶ +12·7° (*c*, 0·4 in methanol).

(iii) A mixture of D-ribose (0·5 g., 1 mol.), *p*-toluidine (0·4 g., 1·3 mols.), and water (0·3 ml.) was heated together on a steam-bath for 5 minutes after the solution became homogeneous. On cooling, ethanol (2 ml.) was added, whereupon it gave *N*-*p*-tolylribosylamine *B* (0·6 g., 75%), m. p. 123—124°, $[\alpha]_D^{18}$ +60·2° (*c*, 0·7 in pyridine).

Conversion of N-p-*Tolylribosylamine* B *into* A.—A solution of *N*-*p*-tolylribosylamine *B* (0·3 g.) in anhydrous ethanol (3 ml.) was refluxed in previously dried apparatus with exclusion of moisture for 1 hour. The flask was stoppered and cooled, whereupon the solution gave *A*, m. p. 129—130°, $[\alpha]_D^{19}$ +127·6° ⟶ +11·7° (after 24 hours) (*c*, 0·2 in methanol).

N-o-*Nitrophenyl*-D-*ribosylamine* B (cf. Berger and Lee, *loc. cit.*, p. 84).—D-Ribose (0·5 g., 1 mol.) in 0·001N-sulphuric acid (1 ml.) was added to *o*-nitroaniline (0·7 g., 1·5 mols.) in ethanol (2 ml.). The amine dissolved as the reaction proceeded at room temperature. After 30 days, the solution deposited yellow anhydrous crystals (0·8 g., 89%) of *N*-*o*-nitrophenylribosylamine, m. p. 193—194°, $[\alpha]_D^{20}$ −109·1° (*c*, 0·3 in pyridine). This is provisionally called *B*, and was prepared by Berger and Lee (*loc. cit.*), who give m. p. 183—185°, $[\alpha]_D^{28}$ −109° (*c*, 1·0 in pyridine).

N-*o*-*Nitrophenyl*-D-*ribosylamine* A.—(i) A suspension of D-ribose (1 g., 1 mol.), ammonium chloride (0·05 g.), and *o*-nitroaniline (0·96 g., 1·1 mols.) was heated under reflux in anhydrous ethanol (5 ml.) for 2 hours with exclusion of moisture. The flask was then stoppered and placed in the refrigerator. This produced orange-yellow crystals (1·7 g., 94%) of N-o-*nitrophenyl*-D-*ribosylamine* A, m. p. 167—168°, $[\alpha]_D^{20}$ −122·5° (*c*, 0·2 in pyridine) (Found : C, 49·3; H, 5·0. $C_{11}H_{14}O_6N_2$ requires C, 48·9; H, 5·2%).

(ii) A solution of *B* (0·5 g.) was refluxed for 2 hours in anhydrous ethanol (12 ml.) with

careful exclusion of moisture. The crystals which separated were *A*, m. p. 192—193°, $[\alpha]_D^{17}$ −123·9° (*c*, 0·2 in pyridine).

Conversion of N-o-*Nitrophenylribosylamine* A *into* B.—Isomer *A* (0·5 g.) was heated for 2 hours in 90% aqueous ethanol (12 ml.). On cooling, the solution deposited yellow crystals of *B*, m. p. 192—193°, $[\alpha]_D^{19}$ −108·2° (*c*, 0·3 in pyridine).

The solubility of both *N-o*-nitrophenylribosylamines in methanol and in ethanol was too low for optical observations to be made.

N-*Phenyl*-D-*xylosylamine*.—Dry D-xylose (2 g., 1 mol.) and redistilled aniline (2 ml., 1·6 mols.) were refluxed in anhydrous ethanol (12 ml.) for 1½ hours. The pale yellow solution was divided into two portions. One was stoppered and allowed to cool. White needles of *N*-phenylxylosylamine, m. p. 144—145°, $[\alpha]_D^{21}$ −82·1° ⟶ −21·6° (*c*, 0·6 in methanol), separated. Two drops of water were added to the other and the solution was refluxed for 5 minutes more. On cooling, it deposited crystals of the same xylosylamine, m. p. 143—144°, $[\alpha]_D^{20}$ −84·1° ⟶ −21·9° (*c*, 0·8 in methanol). Weygand (*loc. cit.*) gives m. p. 140—141°. Butler *et al.* (*loc. cit.*) give m. p. 142—144°, $[\alpha]_D^{19}$ −90° ⟶ −48° (*c*, 1·0 in methanol).

N-p-*Tolyl*-D-*xylosylamine*.—(i) Dry D-xylose (2 g., 1 mol.) and *p*-toluidine (2 g., 1·6 mols.) were heated under reflux in anhydrous ethanol (12 ml.) for 2 hours with the exclusion of moisture. The light brown solution on cooling deposited *N-p*-tolylxylosylamine (2·4 g., 74%), m. p. 124—125°, $[\alpha]_D^{20}$ −76·6° ⟶ −21·2° (*c*, 0·4 in methanol).

(ii) D-Xylose (2 g., 1 mol.) and *p*-toluidine (1·6 g., 1·3 mols.) were heated in water (0·6 ml.) according to Weygand's method (*loc. cit.*). The product had m. p. 124—125°, $[\alpha]_D^{14}$ −59·0° (*c*, 0·5 in pyridine), $[\alpha]_D^{24}$ −75·6° ⟶ −20·0° (*c*, 0·8 in methanol). Weygand (*loc. cit.*) gives m. p. 124—125°, $[\alpha]_D$ −41·5° (*c*, 0·8 in pyridine).

N-p-*Tolyl*-D-*glucosylamine*.—Owing to its low solubility in anhydrous ethanol D-glucose (10 g., 1 mol.) was suspended in anhydrous methanol (150 ml.). To this was added *p*-toluidine (6 g., 1 mol.) and the mixture was refluxed for 3 hours with the exclusion of moisture. The flask was stoppered and cooled, but as no crystals appeared the methanol was removed under reduced pressure at 35° (moisture excluded). This left a pale yellow syrup which during 5 days deposited N-p-*tolyl*-D-*glucosylamine*, m. p. 135—136°, $[\alpha]_D^{18}$ +208·9° ⟶ −44·6° (after 67 hours) (*c*, 0·7 in methanol) (Found: C, 56·8; H, 6·8; N, 4·9. $C_{13}H_{19}O_5N$ requires C, 58·0; H, 7·1; N, 5·2%). Recrystallisation was attempted, every care being taken that moisture was excluded, but normal *N-p*-tolylglucosylamine, m. p. 113°, $[\alpha]_D^{18}$ −97·5° ⟶ −42·7° (*c*, 1·0 in methanol), was obtained.

N-*Phenyl*-D-*glucosylamine*.—On repetition of the above reaction with aniline (1·8 ml., 1·6 mols.) and D-glucose (3 g., 1 mol.), the product obtained had m. p. 134—135°, $[\alpha]_D^{17}$ +53° ⟶ −20·6° (*c*, 0·7 in methanol). *N*-Phenyl-D-glucosylamine, as usually isolated, has m. p. 146° (variable), $[\alpha]_D^{18}$ +10° ⟶ −52° (in methanol).

N-*Phenyl*-D-*galactosylamine*.—(i) Butler, Smith, and Stacey's method of preparing this compound (*J.*, 1949, 3371) was slightly modified as follows. A solution of D-galactose (2 g., 1 mol.) in 0·001N-sulphuric acid (6 ml.) was added to aniline (2 ml., 2 mols.) in ethanol (2·5 ml.), and the mixture left for one day at room temperature. Crystals (1·6 g., 57%) were obtained of *N*-phenylgalactosylamine, m. p. 157—158°, $[\alpha]_D^{18}$ −92° ⟶ −43·5° (*c*, 0·5 in methanol). Butler *et al.* (*loc. cit.*) give m. p. 157—159°, $[\alpha]_D$ −92° ⟶ −37° (*c*, 1·2 in methanol).

(ii) The reaction of galactose and aniline under anhydrous conditions in methanol was attempted as in the case of glucose. The product, which isomerized on recrystallization, was *N*-phenylgalactosylamine, m. p. 141—143°, $[\alpha]_D^{19}$ −22·1° ⟶ −40·3° (*c*, 0·4 in methanol).

N-p-*Tolyl*-D-*galactosylamine*.—The compound, $[\alpha]_D^{18}$ −33·0° ⟶ −14·1° (*c*, 0·2 in methanol), prepared under anhydrous conditions, also differs from the compound prepared in aqueous solution (see below).

N-*Phenyl*-D-*mannosylamine*.—A solution of D-mannose (3 g., 1 mol.) in 0·001N-sulphuric acid (10 ml.) was added to a solution of aniline (3 ml., 2 mols.) in ethanol (4 ml.). After a few hours at room temperature crystals appeared. After 3 hours in the refrigerator *N*-phenyl-D-mannosylamine (4·0 g., 95%), m. p. 181°, $[\alpha]_D^{18}$ −179·3° (*c*, 0·3 in pyridine), $[\alpha]_D^{17}$ −101·4° ⟶ −45·0° (in 70 hours) (*c*, 0·2 in methanol), was collected. Weygand (*loc. cit.*) prepared this compound, m. p. 180—181°, by heating an aqueous suspension of the components.

Ultra-violet Absorption Spectra.—The spectra of *N*-phenylmannosylamine and of *N-p*-tolylribosylamines *A* and *B* were measured in methanol over the range 2200—3100 Å. Measurements were made at intervals of *ca.* 24 hours during the time for which mutarotation was proceeding, but no appreciable change in the spectrum was observed. The changes in rotation taking place simultaneously (in methanol) with the absorption measurements were: *N*-phenyl-

mannosylamine, $[\alpha]_D^{17}$ −101·4° ⟶ −45·0° (in 70 hours) (*c*, 0·2 in methanol); *N*-*p*-tolylribosylamine, *A*, $[\alpha]_D^{21}$ +135·1° ⟶ +12·0° (in 60 hours) (*c*, 0·3 in methanol); *N*-*p*-tolylribosylamine *B*, $[\alpha]_D^{20}$ +21·8° ⟶ +11·7° (in 62 hours) (*c*, 0·3 in methanol). Spectral data are tabulated.

Compound	Interval after dissolution	$\lambda_{max.}$ (Å)	log $\epsilon_{max.}$	$\lambda_{min.}$ (Å)	log $\epsilon_{min.}$
N-*p*-Tolylribosylamine *A*	nil	2450	4·47	2680	3·44
		2900	3·72		
	1 day	2450	4·47	2680	3·40
		2900	3·65		
	2 days	2450	4·46	2680	3·37
		2900	3·78		
N-*p*-Tolylribosylamine *B*	Nil	2500	5·62	2740	3·97
		2950	4·25		
N-Phenylmannosylamine	Nil	2400	4·48	2620	2·68
		2850	3·52		
	1 day	2400	4·49	2620	2·76
		2850	3·53		
	2 days	2400	4·50	2620	2·74
		2850	3·50		

General Preparation of N-p-*Tolylglycosylamines.*—To a solution of the sugar (1 g., 1 mol.) in 0·001N-sulphuric acid (2 ml.) was added a solution of *p*-toluidine (1 g., 1·3 mols.) in absolute ethanol (2·4 ml.). The mixture was left at room temperature until crystallisation appeared to be complete and then placed in the refrigerator for 2 hours. The crystals were collected and purified. The product did not need to be recrystallised. Fructose and sorbose did not react under these conditions, whereas L-arabinose gave a very dark solution from which no crystalline product separated even after evaporation of some of the solvent. The physical constants of the products obtained are tabulated below, together with those recorded for the compounds prepared by other workers using different methods.

N-*p*-Tolylglycosylamine prepared from:	Approx. time of reaction (days)	Yield (%)	M. p.	Rotation	Previous data: M. p.	Previous data: Rotation	Previous data: Workers (*locc. cit.*)
Ribose	¼	90					
Galactose	2	67	161—162°	$[\alpha]_D^{19}$ −80° ⟶ +8·8° (*c*, 0·2 in methanol)	154—155°	$[\alpha]_D$ −49·5° ⟶ +10·5° (in 83% methanol)	Weygand
Glucose	3	50	107—109	$[\alpha]_D^{16}$ −95·5 ⟶ −42·5 (*c*, 0·4 in methanol)	117—118	$[\alpha]_D^{24}$ −101·2 ⟶ −45·8 (*c*, 0·2 in methanol)	Honeyman and Tatchell
Mannose.....	⅙	93	183	$[\alpha]_D^{17}$ −101·4 ⟶ −45·0 (*c*, 0·2 in methanol)	183—184	—	Weygand
Xylose	4	38	124—125	$[\alpha]_D^{19}$ −59·0 (*c*, 0·3 in pyridine) $[\alpha]_D^{24}$ −72·2 ⟶ −20·4 (*c*, 0·6 in methanol)	124—125	$[\alpha]_D^{20}$ −41·5 (in pyridine)	Weygand

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