295. *Deoxy-sugars. Part XII. Experiments with the* O- *and* N-*Glycosides of Some Deoxy-sugars.*

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The preparation is described of some *O*- and *N*-glycosidic derivatives of 2-deoxy-pentoses and -hexoses and of the *O*-glycosides of 2 : 3-dideoxy-D-glucose. Comparative measurements are reported on the rates of acid hydrolysis of these glycosides, showing that the methylene groups in these sugars exert a profound effect on substituents attached at $C_{(1)}$ and increase their lability.

In earlier communications in this series (*J.*, 1949, 2841, 2846) it has been shown that a deoxy-group at $C_{(2)}$ in pentoses and hexoses exerts a profound effect on the glycosidic centre in these sugars. Methylglycosides of 2-deoxy-sugars are hydrolysed by acid much more rapidly than are the corresponding derivatives of the normal analogous sugar. In nucleic acids the basic constituents are linked to the sugar residues by *N*-glycosidic attachments, so we considered it worth while to study the effect of a deoxy-group at $C_{(2)}$ on *N*-glycosides of pentoses and hexoses. Sugar anilides were chosen as convenient derivatives for this purpose. For most sugars, the aniline derivatives are highly crystalline and consequently have been found useful for the characterisation of sugars. Until recently there was very little clear evidence concerning the structure of sugar anilides in general. It had not been demonstrated conclusively for example whether they were all *N*-glycosides or whether some were Schiff's bases. Even on the assumption that they were of the former structure, the nature of the lactol ring was unknown. It should be noted that Irvine and McNicoll (*J.*, 1910, 1449), from methylation studies, had obtained some indications that galactose anilide was a *N*-glycoside having a 1 : 5-lactol ring.

Recent work by Butler, Smith, and Stacey (*J.*, 1949, 3371) with galactose anilide and its acetylation products led to the isolation of two forms of the acetylated anilide which were considered to be α- and β-anomers of pyranose type, thereby providing further evidence in support of the ring structure for anilides. Furthermore, some of us, with other colleagues (Butler, Overend, Smith, and Stacey, *Chem. and Ind.*, 1949, 551) have proved conclusively that anilides in their normal crystalline form are *N*-glycosides and not Schiff's bases. We have now extended this work into the deoxy-sugar series.

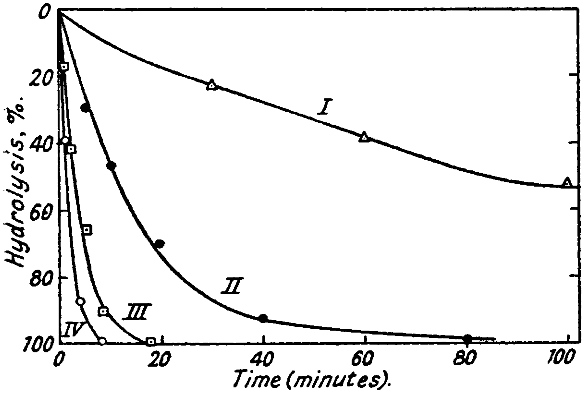
Crystalline *anilides* of 2-deoxy-D-galactose, 2-deoxy-D-glucose, 2-deoxy-L-ribose, and 2-deoxy-D-xylose have been obtained by the usual method for the synthesis of anilides, namely by heating a solution or suspension of the sugar with freshly distilled aniline in absolute or aqueous ethanol (cf. Kent, Stacey, and Wiggins, *J.*, 1949, 1232; Overend, Staněk, and Stacey, *ibid.*, p. 2841). These derivatives are excellent for the characterisation of the sugars named (see also Overend and Stacey, *ibid.*, p. 1358). The products exhibited mutarotation in solution in pyridine or dry methanol, indicating that in all probability they were *N*-glycosides. Attempts to get further evidence to support these optical rotational data by chemical methods were unsuccessful. Triacetyl D-galactal which is known to have a pyranose structure (Levene and Tipson, *J. Biol. Chem.*, 1931, **93**, 631) was treated with bromine and yielded 3 : 4 : 6-triacetyl 1 : 2-dibromo-1 : 2-dideoxy-D-hexose (cf. Fischer, *Ber.*, 1920, **53**, *B*, 509), which, however, on reaction with aniline in the presence of excess of silver carbonate underwent extensive decomposition. Similarly application of Butler, Smith, and Stacey's methods (*loc. cit.*), which proved successful with galactose anilide, were found to be too vigorous for the more unstable 2-deoxy-sugars. Either acetylation or methanesulphonation of the anilides of 2-deoxy-D-galactose, 2-deoxy-D-glucose, and 2-deoxy-L-ribose resulted in the isolation of syrupy mixtures from which suitable acetylated or methanesulphonated α- and β-anomers of the anilides could not be isolated. With 2-deoxy-D-glucose anilide it did seem that some of the required products were present in the syrupy acetylation mixture, since deacetylation by sodium methoxide resulted in the formation of some of the starting material. Lee *et al.* (*J. Org. Chem.*, 1946, **11**, 75) showed that, when an acidified aqueous solution of ribose (pH 3—5) is treated with aniline in the cold, an anilide is formed which differs from that obtained by the customary procedure. They proposed that their new anilide possessed a pyranose structure, and that the product obtained by the normal route was of the furanose form. From their results it would appear that the furanose form of ribose anilide is more stable than the pyranose form. Application of their method to 2-deoxy-sugars yielded the same anilides as those already described. The effect observed by Lee *et al.* (*loc. cit.*) does not appear to be general since Butler, Smith, and Stacey (*loc. cit.*) found that galactose would yield only one anilide. Since anilides in the 2-deoxy-sugar series are so labile we considered that some physical measurements might be a useful approach. In collaboration with Dr. H. P. Koch of the British Rubber Producers Research Association, Welwyn Garden City, it was demonstrated conclusively by infra-red absorption spectra measurements that the C=N linkage was absent in 2-deoxy-sugar anilides. Consequently they could not be of the Schiff's base type, but were *N*-glycosides. Furthermore, by analogy with other glycosides and anilides of known structure, it was clear that they possessed the 1 : 5-lactol (pyranose) ring.

The following compounds were used: (i) *n*-propylaniline, (ii) benzylideneaniline, (iii) D-arabinose, (iv) α-methyl-D-arabopyranoside, (v) 1 : 2-*iso*propylidene D-glucofuranose, (vi) 2-deoxy-D-ribose anilide, (vii) 2-deoxy-D-glucose anilide. The band positions observed were: (*a*) unconjugated phenyl in (i), (vi), and (vii) at 1600 cm.$^{-1}$; (*b*) conjugated phenyl in (ii) at 1572 cm.$^{-1}$; (*c*) C=N in (ii) at 1625 cm.$^{-1}$ (conjugated); (*d*) CH·OH in (iii), (iv), (v), (vi), and (vii) at 1050—1080 cm.$^{-1}$; (*e*) CH_2·OH (?) in (v) and (vii) only at 1030 cm.$^{-1}$; (*f*) pyranose ring in (iii), (iv), (vi), and (vii) at 985—995(??) cm.$^{-1}$; (*g*) >NH was not identified in (vi), (vii), or (i).

The rates of hydrolysis of these anilides were then measured quantitatively and compared with those already reported for some *O*-glycosides of the same sugars. Preliminary studies with 0·5% formic acid confirmed our observations that 2-deoxy-sugar anilides were highly labile.

FIG. 1.

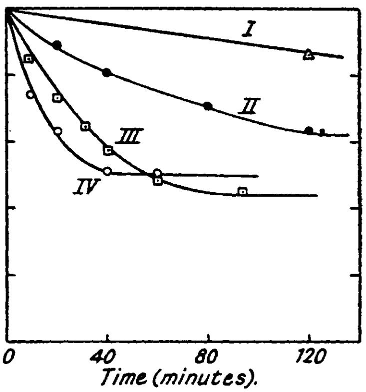
Hydrolysis with N-*sulphuric acid.*



I. D-*Glucose anilide.*
II. D-*Galactose anilide.*
III. 2-*Deoxy*-D-*glucose anilide.*
IV. 2-*Deoxy*-D-*galactose anilide.*

FIG. 2.

Hydrolysis with 0·1N-*sulphuric acid.*



I. D-*Glucose anilide.*
II. D-*Galactose anilide.*
III. 2-*Deoxy*-D-*glucose anilide.*
IV. 2-*Deoxy*-D-*galactose anilide.*

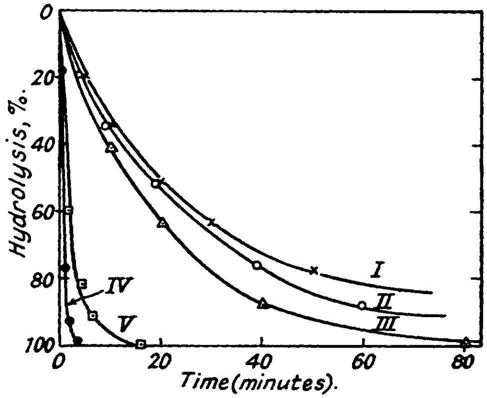
The rates of hydrolysis of anilides in the normal and corresponding 2-deoxy-sugars were compared by a method similar to that described by Hanaoka (*J. Biochem. Japan*, 1940, **95**, 31). The results are shown in Figs. 1—4. Figs. 1 and 2 refer to the hydrolysis of anilides of hexoses and 2-deoxy-hexoses, with N- and 0·1N-sulphuric acid (concentrations quoted refer to the acid before addition to the solution of sugar anilide). Figs. 3 and 4 refer to the corresponding pentose derivatives. The hydrolyses were followed polarimetrically at room temperature, after addition of mineral acid to a solution of the sugar anilide which had mutarotated to equilibrium in dry methanol. Equimolecular solutions of the sugar derivatives were used. Although hydrolysis of the normal sugar anilides by 5N-sulphuric acid could be followed polarimetrically, the rate was much too rapid in the deoxy-sugar series with acid of this concentration. However, the end values were identical with those obtained by using more dilute acid (N-H_2SO_4). With 0·1N-sulphuric acid, the normal sugar anilides were not always completely hydrolysed, since the liberated aniline reduced the acid concentration sufficiently to terminate eventually the hydrolysis reaction. In such cases, aniline sulphate could be isolated. The isolation of this salt, coupled with the fact that the end values obtained for the optical rotations after further additions of acid corresponded to those for solutions of the free sugars at equilibrium, was taken as indicating that the acid treatment resulted mainly in hydrolysis of the anilides. Separate experiments indicated that mutarotational changes resulting from the free sugars formed by the hydrolyses did not interfere with the results, except perhaps in the case of galactose, for which the rate of mutarotation of the free sugar in acid solution was comparable with the rate of hydrolysis of its anilide with N-sulphuric acid. However, since some discoloration was noted during the experiments, it was inferred that some secondary change (re-arrangement) accompanied the main reaction, *e.g.*, possibly some re-arrangement of the type indicated by Gottschalk and Partridge (*Proc. Biochem. Soc.*, in the press).

From the graphs of the rotational changes the degree of hydrolysis was calculated by a process of integration, and these are the results shown in Figs. 1—4. Reference to Figs. 1 and 2 shows that 2-deoxy-sugar anilides in the hexose series are hydrolysed much more rapidly than the corresponding normal sugar anilides. Similar results are obtained in the pentose series (see Figs. 3 and 4).

Comparison with the studies of Overend, Stacey, and Staněk (*J.*, 1949, 2841) revealed that *N*-glycosides (anilides) of 2-deoxy-sugars are more labile than the *O*-glycosides. This property is closely similar to that of corresponding derivatives of normal sugars. Since for both *O*- and *N*-glycosides it is clear that a deoxy-group at $C_{(2)}$ of a sugar exerts an influence on the glycosidic centre, it was decided to investigate further the effect of additional methylenic groups by preparing some dideoxy-sugar derivatives, *e.g.*, particularly the 2 : 3-dideoxy-derivatives. Because of the greater ease of manipulation the *O*-glycosides were used, and for comparative purposes the ethyl glycosides were prepared. α- and β-Ethyl-D-glucopyranosides were made according to the usual methods (see Fischer, *Ber.*, 1895, **28**, 1154; Ferguson, *J. Amer. Chem. Soc.*, 1932, **54**, 4086) and further characterised as their tetra-*p*-nitrobenzoates. α-Ethyl-D-glucofuranoside 5 : 6-carbonate was made by the method of Haworth and Porter (*J.*, 1929, 2796). Treatment of 2-deoxy-D-glucose with 0·2% ethanolic hydrogen chloride resulted in the formation of an *ethyl-2-deoxy-D-glucoside.* The same glycoside was obtained, in very poor yield, from the action of 1·6% ethanolic hydrogen chloride on D-glucal (an unidentified oil was also obtained and this will be the subject of a subsequent communication). Hydrolysis of this glycoside with N-hydrochloric acid resulted in the re-formation of 2-deoxy-D-glucose which was isolated as its dibenzyl mercaptal (cf. Overend, Stacey, and Staněk, *loc. cit.*). Oxidation by lead tetra-acetate resulted in the uptake of 1 mole of oxidant.

FIG. 3.

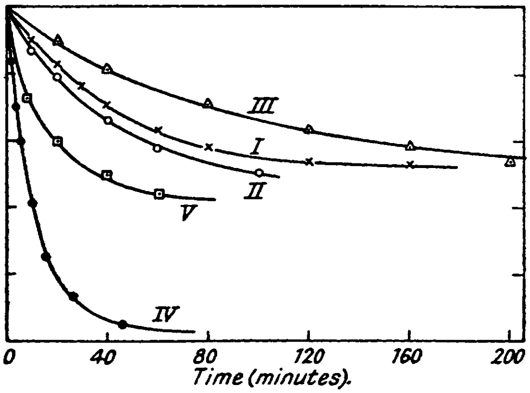
Hydrolysis with N-*sulphuric acid.*



I. D-*Ribopyranose anilide.*
II. D-*Ribofuranose anilide.*
III. D-*Xylose anilide.*
IV. 2-*Deoxy*-L-*ribose anilide.*
V. 2-*Deoxy*-D-*xylose anilide.*

FIG. 4.

Hydrolysis with 0·1N-*sulphuric acid.*

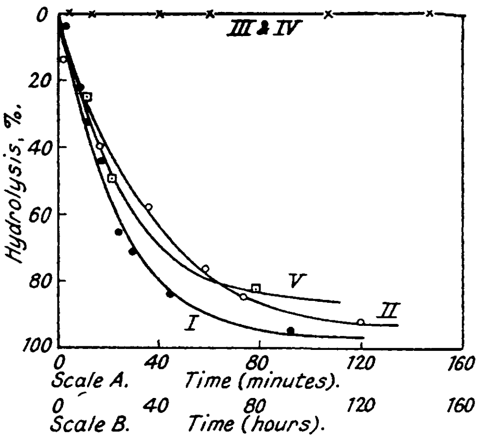


I. D-*Ribopyranose anilide.*
II. D-*Ribofuranose aniline.*
III. D-*Xylose anilide.*
IV. 2-*Deoxy*-L-*ribose anilide.*
V. 2-*Deoxy*-D-*xylose anilide.*

In like manner ethyl-2-deoxy-D-glucoside reduced one mole of sodium metaperiodate, but no formaldehyde was formed, indicating that the glycoside has a pyranose structure. Treatment of it with *p*-nitrobenzoyl chloride in pyridine yielded 3 : 4 : 6-*tri*-p-*nitrobenzoyl ethyl-2-deoxy*-D-*glucoside.* A crystalline 3 : 4 : 6-*tritoluene*-p-*sulphonyl* derivative was also obtained, both derivatives being useful for the characterisation of the glycoside. α-Ethyl-2 : 3-dideoxy-D-glucoside was prepared according to Laland, Overend, and Stacey (*J.*, 1950, 738). It was non-reducing to lead tetra-acetate, showing that it had a pyranose structure, and yielded a crystalline 4 : 6-*di*-p-*nitrobenzoate.*

The various glycosides described were treated with acid and their rates of hydrolysis were followed polarimetrically. Fig. 5 illustrates the results obtained. Equimolecular solutions were used for the experiments and, since the glycoside concentration in solution was low, the hydrolytic reaction was assumed to be of the first order, and the results are represented as percentages of hydrolysis based on the initial and final rotations obtained. From the data recorded, and from comparisons with the work of Overend, Stacey, and Staněk (*loc. cit.*) it seems that the glycosides of 2-deoxy-hexoses are more stable than those of the corresponding deoxy-pentoses (cf. Hirst, *J.*, 1949, 522) and that, as in the normal sugar series, glycofuranosides are much more labile than glycopyranosides. Moreover, an increase in the number of deoxy-groups in the sugar chain definitely increases the lability of glycosidic residues to acid. For example, α-ethyl-2 : 3-dideoxy-D-glucopyranoside is more labile to acid than is α-ethyl-2-deoxy-D-glucopyranoside. So far we have been unsuccessful in our attempts to prepare α- or β-ethyl-2 : 3-dideoxy-D-glucofuranoside, no doubt because of its extreme lability. Finally it appears that the ethylglycosides of 2-deoxy-sugars are somewhat more stable than the corresponding methylglycosides.

FIG. 5.



I. *α-Ethyl-D-glucofuranoside* 5 : 6-*carbonate* (*scale A*).
II. *α-Ethyl-2* : 3-*dideoxy-D-glucoside* (*scale A*).
III. *and* IV. *α- and β-Ethyl-D-glucopyranoside* (*scale B*).
V. *Ethyl* 2-*deoxy-D-glucoside* (*scale B*).

EXPERIMENTAL.

2-*Deoxy-D-glucose Anilide.*—(*a*) An alcoholic solution of aniline (0·1 c.c. in 1 c.c.) was added to an aqueous solution of 2-deoxy-D-glucose (0·1 g. in 5 c.c.) which had been treated with 0·01N-sulphuric acid until it was just acid to Congo-red. The mixture was shaken at room temperature for 10 minutes and then left at 0° for 24 hours. Needle-shaped crystals separated and were collected. After recrystallisation from ethanol, the anilide was obtained as colourless needles (0·06 g., 43%), m. p. 188—189°. If the addition of sulphuric acid to the solution of the deoxy-sugar was omitted an increased yield (70%) was obtained (Overend, Stacey, and Staněk, *J.*, 1949, 2841, quote m. p. 193—194° for this compound).

(*b*) 2-Deoxy-D-glucose (0·1 g.) in ethanol (12 c.c.) containing water (1 c.c.) was heated under reflux with aniline (0·1 g.) for 2 hours. A slight brown residue was removed, and on storage crystals separated and were collected. Concentration of the mother-liquors yielded a further crop of crystals. These were recrystallised from ethanol, and the anilide (0·09 g., 64%) was obtained as colourless needles, m. p. 193—194°. The m. p. on admixture with the product of (*a*) was 188—189° (Found : C, 60·3; H, 7·1; N, 5·6. Calc. for $C_{12}H_{17}O_4N$: C, 60·2; H, 7·1; N, 5·9%). The product was soluble in hot water and slightly soluble in hot acetone. It showed mutarotational changes as follows : $[\alpha]_D$ −153° (5 minutes) $\longrightarrow$ −102° (19 hours) (*c*, 1·0 in pyridine); $[\alpha]_D$ −64° (20 minutes) $\longrightarrow$ −60° (approx.) (4 hours) (in methanol). Attempts to acetylate 2-deoxy-D-glucose anilide with acetic anhydride in dry pyridine at 0° for 4 days yielded only syrupy mixtures. When the anilide (0·08 g.) prepared by method (*a*) in solution in absolute ethanol (20 c.c.) was heated under reflux for 4 hours it underwent no change.

De-anilination of 2-*Deoxy-D-glucose Anilide.*—2-Deoxy-D-glucose anilide (0·08 g.) was treated with 0·5% formic acid (20 c.c.) at 80° for 1 hour. The mixture was steam-distilled and then neutralised with lead carbonate. After filtration the neutral solution was concentrated to dryness under diminished pressure. The residue was extracted with 95% ethanol and filtered, and then hydrogen sulphide was passed through the solution. After filtration through a charcoal pad the solution was evaporated to dryness. Nucleation with 2-deoxy-D-glucose and trituration with ethanol induced the syrupy residue to crystallise. The crystals were washed with ethanol and dried (13 mg.), m. p. 142° alone or on admixture with authentic 2-deoxy-D-glucose.

2-*Deoxy-D-galactose Anilide.*—A suspension of 2-deoxy-D-galactose (0·4 g.) in aniline (0·5 c.c.) and ethanol (10 c.c.) was heated under reflux for 1 hour. The sugar gradually dissolved. Concentration of the solution yielded a syrup which crystallised. The crystals (0·4 g., 60%) were collected, washed with absolute ethanol, and dried. *2-Deoxy-D-galactose anilide* had m. p. 134—135° (decomp.), $[\alpha]_D^{18}$ −116° (initial) $\longrightarrow$ −53° when catalysed with 1 drop of 0·1N-H_2SO_4 (*c*, 1·3 in methanol) (Found : C, 59·9; H, 7·4; N, 5·4. $C_{12}H_{17}O_4N$ requires C, 60·2; H, 7·1; N, 5·9%). Acetylation of the anilide with acetic anhydride in pyridine afforded only syrupy materials.

2-Deoxy-L-ribose Anilide.—(*a*) A solution of 2-deoxy-L-ribose (0·1 g.) in water (2 c.c.) was added to aniline (0·1 c.c.) in ethanol (5 c.c.). The mixture was kept at 0° for 18 hours. Crystals separated and were collected. After being washed with ice-cold absolute ethanol and dried, the anilide (0·1 g., 65%) had m. p. 172—173° (Deriaz *et al.*, *J.*, 1949, 1879, give m. p. 169·5—170·5°).

(*b*) A suspension of 2-deoxy-L-ribose (0·14 g.) in absolute ethanol (5 c.c.) was boiled under reflux with aniline (0·11 g.) in ethanol (5 c.c.) until complete dissolution was effected (3 hours). Concentration of the solution yielded the anilide (0·19 g., 90%), m. p. 174—175° [on admixture with the product from method (*a*), 172—173°], $[\alpha]_D$ −142° (10 minutes) $\longrightarrow$ −58° (240 minutes) (*c*, 1·0 in dry pyridine), $[\alpha]_D$ −73° (16 minutes) $\longrightarrow$ −6·6° (20 hours) (*c*, 0·4 in methanol).

2-Deoxy-D-xylose Anilide.—This was prepared according to Overend, Shafizadeh, and Stacey (*J.*, 1950, 1027).

D-Glucose Anilide.—This anilide was prepared from D-glucose and aniline by the usual procedure (Cameron, *J. Amer. Chem. Soc.*, 1926, **48**, 2233), and had m. p. 142—143° (decomp.), $[\alpha]_D^{18}$ +1·7° $\longrightarrow$ −48·1° when catalysed with 2 drops of 0·1N-sulphuric acid (*c*, 1·2 in methanol) {Cameron, *loc. cit.*, gives m. p. 140—147° (decomp.) and $[\alpha]_D$ −52° in methanol}.

D-Galactose Anilide.—This sample, prepared according to Butler, Smith, and Stacey (*J.*, 1949, 3371), had m. p. 146—148° (decomp.), $[\alpha]_D$ −112° (15 minutes) $\longrightarrow$ −56° (24 hours) (*c*, 1·1 in pyridine), −92° (1·5 hours) $\longrightarrow$ −37° (92 hours) (*c*, 1·2 in methanol).

D-Ribopyranose Anilide.—This was prepared according to Lee and Berger (*J. Org. Chem.*, 1946, **11**, 75) in 83% yield and had m. p. 114—116° (sintering 112—114°), $[\alpha]_D$ +62° (3 minutes) $\longrightarrow$ +50° (24 hours) (*c*, 1·0 in pyridine), +23° $\longrightarrow$ +13° (17 hours) (*c*, 1·0 in methanol). Lee and Berger (*loc. cit.*) give m. p. 125—127° and $[\alpha]_D^{24}$ +63·4° $\longrightarrow$ +48·6° in 48 hours (*c*, 1·0 in pyridine). Howard, Kenner, Lythgoe, and Todd (*J.*, 1946, 855) give m. p. 119°, $[\alpha]_D^{17}$ +60° constant during 30 hours (*c*, 0·95 in dry pyridine), +60° (initial value) $\longrightarrow$ +48·4° (final value after 2 days) (*c*, 0·95 in moist pyridine), $[\alpha]_D^{18}$ +71° (initial value) $\longrightarrow$ +43° (final value after 4½ hours) (*c*, 0·75 in pyridine containing 10% of acetic acid).

D-Ribofuranose Anilide.—In like manner this compound was obtained in 70% yield after Lee and Berger's (*loc. cit.*) instructions, and had m. p. 123—124°, $[\alpha]_D$ +182° (4 minutes) $\longrightarrow$ +52·3° (22 hours) (*c*, 2·0 in pyridine), +135° (13 minutes) $\longrightarrow$ +12° (47 hours) (*c*, 1·0 in methanol). Lee and Berger give m. p. 138—140° and $[\alpha]_D^{27}$ +176·5° $\longrightarrow$ +156·6° (24 hours) (*c*, 3·0 in pyridine). Howard, Kenner, Lythgoe, and Todd (*loc. cit.*) give m. p. 126—127°, $[\alpha]_D^{17}$ +180° constant during 30 hours (*c*, 0·85 in dry pyridine), $[\alpha]_D^{18}$ +176° (initial value) $\longrightarrow$ +161° (final value after 3 days) (*c*, 0·85 in moist pyridine), $[\alpha]_D^{18}$ +176° (initial value) $\longrightarrow$ +44° (final value after 2·5 hours) (*c*, 1·11 in pyridine containing 10% of acetic acid). It is the view of Lee and Berger (*loc. cit.*) that the m. p.s of ribose anilides are not critical but vary with the conditions of isolation of the derivatives.

D-Xylose Anilide.—A suspension of D-xylose (2 g.) in methanol (15 c.c.) was heated under reflux with aniline (2·4 c.c.) for 3 hours. The clear yellow solution was concentrated to small bulk, whereupon crystals separated. Recrystallisation from methanol gave D-xylose anilide (0·317 g.), m. p. 142—144° (decomp.), $[\alpha]_D^{19}$ −90° (5 minutes) $\longrightarrow$ −48° (46 hours) (*c*, 1·0 in methanol) (Found : C, 58·9; H, 6·5. Calc. for $C_{11}H_{15}O_4N$: C, 58·7; H, 6·6%). Howard, Kenner, Lythgoe, and Todd (*loc. cit.*) give m. p. 142°, $[\alpha]_D^{19}$ −87° (*c*, 2·37 in pyridine).

Optical Rotations of Galactose, Glucose, and Ribose in Methanol or Aqueous Methanol in the Presence of Sulphuric Acid.—(*a*) *Anhydrous α-D-galactose.* 0·983N-Sulphuric acid (1·1 c.c.) was added to a solution of anhydrous α-galactose in aqueous methanol (4 : 1) (10 c.c.) (*c*, 1·0; 0·0052 mols./100 c.c. of solvent), and the change in optical rotation was observed.

Time (mins.)	1	2	4	5	8	13	18	107
$[\alpha]_D^{18}$	+110°	+103°	+95·5°	+89·8°	+84·2°	+78·6°	+77·4°	+74·1°

(*b*) *Anhydrous α-D-glucose.* 0·983N-Sulphuric acid was added to a solution of anhydrous α-glucose in aqueous methanol (13 c.c. of methanol; 1 c.c. of water) (10 c.c.) (*c*, 1·3; 0·0042 mol./100 c.c. of solvent). Changes in optical rotation were :

Time (mins.)	1	3	5	10	16	35	100
$[\alpha]_D^{18}$	+104°	+96·5°	+88°	+78·9°	+73·1°	+64·3°	+62·8°

(*c*) D-Ribose. When 0·983N-sulphuric acid (1 c.c.) was added to a solution of ribose in absolute methanol (10 c.c.) (*c*, 0·7; 0·0047 mol./100 c.c. of methanol) there was an immediate change in the specific rotation from −17° to −25°. This value then remained constant for 1 hour.

Hydrolysis of Anilides.—The general procedure adopted was to add either N- or 0·1N-sulphuric acid (1 c.c.) to an equilibrated solution, in methanol (10 c.c.), of the sugar anilide (*c*, 0·044 mol/l.) (N.B. for 2-deoxy-D-glucose and 2-deoxy-D-ribose this concentration was found to exceed the maximum solubility in the solvent, and so for these derivatives saturated solutions were used). The ensuing reactions were followed polarimetrically. Results are indicated in Figs. 1—4. Times taken for the various solutions to reach a constant value for the optical rotation are as follows :

Sugar anilide.	Time, mins. (N-H_2SO_4).	Sugar anilide.	Time, mins. (N-H_2SO_4).	Sugar anilide.	Time, mins. (N-H_2SO_4).
2-Deoxy-D-xylose	15	2-Deoxy-D-glucose	18	D-Galactose	80
2-Deoxy-L-ribose	3	D-Ribofuranose	120	D-Glucose	600
2-Deoxy-D-galactose	8	D-Ribopyranose	140	D-Xylose	80

*β-Ethyl-*D*-glucopyranoside.*—This was prepared in the usual manner (Ferguson, *J. Amer. Chem. Soc.*, 1932, **54**, 4086) and recrystallised from ethyl acetate–acetone as hygroscopic needles, m. p. 98—100°, $[\alpha]_D^{21}$ −37·9° (*c*, 1·84 in water). Ferguson (*loc. cit.*) gives m. p. 90·4° and $[\alpha]_D$ −36·4° in water. It formed a crystalline tetra-acetate, m. p. 106°, and *tetra-*p*-nitrobenzoate*, m. p. 215—216°, $[\alpha]_D^{16}$ +28° (*c*, 0·71 in acetone) (Found: C, 53·9; H, 3·0; N, 7·0. $C_{36}H_{28}O_{18}N_4$ requires C, 53·7; H, 3·3; N, 7·0%).

*α-Ethyl-*D*-glucopyranoside.*—This was prepared according to Fischer (*Ber.*, 1895, **28**, 1154). When treated with *p*-nitrobenzoyl chloride in pyridine it afforded a crystalline *tetra-*p*-nitrobenzoate*, which, after recrystallisation from ethanol–acetone, had m. p. 110—115° (Found: C, 53·4; H, 3·4; N, 6·8%).

*α-Ethyl-*D*-glucofuranoside* 5 : 6-*Carbonate.*—The ethyl glucofuranoside 5 : 6-carbonate, prepared from 1 : 2-*iso*propylidene-D-glucose 5 : 6-carbonate by the method of Haworth and Porter (*J.*, 1929, 2796), had m. p. 131—132°.

*Ethyl-2-deoxy-*D*-glucopyranoside.*—(a) *From 2-deoxy-*D*-glucose.* Small-scale trial experiments showed that 0·2% ethanolic hydrogen chloride was most suitable for the glycosidation. 2-Deoxy-D-glucose (100 mg.) was dissolved in dry ethanol (8·5 c.c.) to which was added 3·49% ethanolic hydrogen chloride (0·53 c.c.). The solution was kept at room temperature and the reaction was followed polarimetrically. After 24 hours the solution was neutralized with silver carbonate and filtered through charcoal, and the filtrate evaporated to dryness under diminished pressure. The residue crystallised and was recrystallised from ethyl acetate. *Ethyl-2-deoxy-*D*-glucoside* (60 mg.) was obtained as colourless prisms; m. p. 122—123°, $[\alpha]_D^{18}$ +120° (*c*, 1·1 in water) (Found: C, 49·8; H, 8·3; OEt, 23·1. $C_8H_{16}O_5$ requires C, 49·97; H, 8·4; OEt, 23·4%).

(b) *From* D*-glucal.* D-Glucal (2·92 g.), dried *in vacuo* over phosphoric oxide, was dissolved in 1·6% ethanolic hydrogen chloride (31 g.). After 5 hours at room temperature the solution was neutralised with silver carbonate, and the crude product isolated in the usual manner. This oily product partly crystallised and the crystals were separated and washed with ether. After recrystallisation from ethyl acetate, ethyl-2-deoxy-D-glucoside, m. p. 121—122°, was obtained (0·16 g.) identical with the product described above. In addition oily material (0·43 g.) was obtained, b. p. 100—130° (bath temp.)/0·005 mm., which is not yet identified (Found: C, 57·6; H, 7·3%).

*Hydrolysis of Ethyl-2-deoxy-*D*-glucoside.*—Ethyl 2-deoxy-D-glucoside (60 mg.) was dissolved in N-hydrochloric acid (5 c.c.), and the solution was kept at room temperature for 48 hours. The solution was neutralised (silver carbonate) and then filtered, and the filtrate evaporated at room temperature in a vacuum-desiccator over phosphoric oxide or sulphuric acid. The syrupy residue partly crystallised and was treated with concentrated hydrochloric acid (2 vols.) and toluene-ω-thiol (2 vols.). The mixture was shaken for one hour and then diluted with water. The precipitate formed was filtered off, washed with water, and recrystallised from 70% ethanol. 2-Deoxy-D-glucose dibenzyl mercaptal (35 mg.) was obtained, m. p. 153—154° alone or on admixture with the product described by Overend, Stacey, and Staněk (*J.*, 1949, 2841).

*Oxidations of Ethyl-2-deoxy-*D*-glucoside.*—(a) *By lead tetra-acetate.* Ethyl-2-deoxy-D-glucoside (52·1 mg.) was added to a solution of lead tetra-acetate in acetic acid. The reaction was followed titrimetrically (Hockett and McClenahan, *J. Amer. Chem. Soc.*, 1939, **61**, 1667).

Time (hours)	0	0·5	1·2	2	3	5	7	8	9	20
Mole of $Pb(OAc)_4$ consumed	0	0·055	0·074	0·11	0·148	0·260	0·52	0·63	0·63	0·90

(b) *By sodium metaperiodate* (cf. Reeves, *J. Amer. Chem. Soc.*, 1941, **63**, 1476). From the oxidation of ethyl-2-deoxy-D-glucoside (10 mg.) by sodium metaperiodate no formaldehyde–dimedon complex could be isolated.

3 : 4 : 6-*Tri-*p*-nitrobenzoyl Ethyl-2-deoxy-*D*-glucoside.*—Ethyl-2-deoxy-D-glucoside (50 mg.) was added to *p*-nitrobenzoyl chloride (250 mg.) in pyridine (0·2 c.c.). The mixture was kept at room temperature for 20 hours and the product was isolated in the usual manner. The 3 : 4 : 6-*tri-*p*-nitrobenzoate* (70 mg.) was recrystallised from 96% ethanol as colourless nodules, m. p. 140—142°, $[\alpha]_D^{19}$ +72·5° (*c*, 1·2 in benzene) (Found: C, 54·4; H, 3·5. $C_{29}H_{25}O_{14}N_3$ requires C, 54·5; H, 3·7%).

3 : 4 : 6-*Tritoluene-*p*-sulphonyl Ethyl-2-deoxy-*D*-glucoside.*—Ethyl-2-deoxy-D-glucoside (32 mg.) and toluene-*p*-sulphonyl chloride (110 mg.) were added to dry pyridine (1 c.c.). The resulting mixture was kept at room temperature for 24 hours and then poured into water. The insoluble material was collected and recrystallised from 96% ethanol. The 3 : 4 : 6-*tritoluene-*p*-sulphonate* was obtained as colourless needles, m. p. 100—101°, $[\alpha]_D^{17}$ +83° (*c*, 0·44 in benzene) (Found: C, 53·2; H, 5·3. $C_{29}H_{34}O_{11}S_3$ requires C, 53·2; H, 5·2%).

*α-Ethyl-*2 : 3-*dideoxy-*D*-glucopyranoside.*—This was prepared according to Laland, Overend, and Stacey (*J.*, 1950, 738) by the catalytic hydrogenation of α-ethyl-2 : 3-didehydro-2 : 3-dideoxy-D-glucoside. It had m. p. 67—69° and $[\alpha]_D^{20}$ +140·6° (*c*, 0·69 in water) (Found: C, 54·4; H, 9·0. Calc. for $C_8H_{16}O_4$: C, 54·5; H, 9·1%). It was non-reducing to lead tetra-acetate solution in acetic acid.

4 : 6-*Di-*p*-nitrobenzoyl α-Ethyl-*2 : 3-*dideoxy-*D*-glucoside.*—The glucoside (50 mg.) and a solution of *p*-nitrobenzoyl chloride (130 mg.) in dry pyridine (0·2 c.c.) were kept together for 20 hours at room temperature. The mixture was poured into water, and the product isolated in the usual manner. After recrystallisation from ethanol, the *di-*p*-nitrobenzoate* (75 mg.) was obtained as colourless needles, m. p. 131·5—132·5°, $[\alpha]_D^{19}$ +109° (*c*, 1·35 in benzene) (Found: C, 55·6; H, 4·6; N, 5·8. $C_{22}H_{22}O_{10}N_2$ requires C, 55·7; H, 4·7; N, 5·9%).

Rates of Hydrolysis.—The hydrolysis of α- and β-ethyl-D-glucopyranoside, α-ethyl-D-glucofuranoside 5 : 6-carbonate, α-ethyl-2 : 3-dideoxy-D-glucoside, and ethyl-2-deoxy-D-glucoside by N-hydrochloric acid (*c*, 1·2) at 18° was followed polarimetrically.

(*a*) α- and β-Ethyl-D-glucopyranoside showed no change in optical rotation.

(*b*) α-Ethyl-D-glucofuranoside 5 : 6-carbonate showed the following changes:

Time (mins.)	5	6	9	12	18	24	30	45	54	74	92	1480
$[\alpha]_D^{18}$	+100°	+96°	+80°	+70°	+60°	+40°	+34°	+24°	+20°	+14°	+10°	+10°

(*c*) With α-ethyl-2 : 3-dideoxy-D-glucoside the changes observed were :

Time (mins.)	3	17	37	58	73	121	161	199
$[\alpha]_D^{18}$	+124°	+96°	+76°	+55·5°	+47°	+36°	+30°	+30°

(*d*) A similar procedure with ethyl-2-deoxy-D-glucoside, gave :

Time (hours)	0	11·5	24·5	48·5	75·5	96·5	125·5
$[\alpha]_D^{18}$	+126°	+106°	+87°	+75°	+57°	+50°	+46·8°

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