400. *Deoxy-sugars. Part V. A Reinvestigation of the Glycal Method for the Synthesis of* 2-*Deoxy*-D- *and* -L-*ribose.*

By R. E. Deriaz, W. G. Overend, M. Stacey, Ethel G. Teece, and L. F. Wiggins.

The glycal method for the synthesis of 2-deoxy-D- and -L-ribose has been reinvestigated and improved. The mutarotations of the deoxy-sugars in various solvents have been studied. Some new derivatives, particularly in the L-series, have been prepared and serve further to characterise this sugar.

The chemistry of the naturally occurring 2-deoxy-D-ribose has been somewhat neglected owing to the difficulty of isolating the sugar from its natural sources and of synthesising it. Recently we have been engaged in developing methods for making the sugar available and in studying its chemical properties.

The usual preparation of 2-deoxyribose was by the well-known glycal method, whereby arabinal (prepared from arabinose by the usual standard reactions) was treated with ice-cold N-sulphuric acid. This was essentially the method of preparation employed by the early investigators of the sugar, namely Meisenheimer and Jung (*Ber.*, 1927, **60**, 1462), Gehrke and Aichner (*ibid.*, p. 918), and Felton and Freudenberg (*J. Amer. Chem. Soc.*, 1935, **57**, 1637). The best overall yield of 2-deoxy-D-ribose from D-arabinose obtained by these workers was about 5%. We considered that, in addition to developing alternative methods of synthesis of the deoxypentose, it was worth while to reinvestigate this glycal method with a view to improving the overall yield. Although we have succeeded in increasing the yield to about 10% and have developed a convenient method of purifying the sugar, there still remains the need for a general synthesis of 2-deoxy-sugars in reasonable yield.

A reliable method was first sought for the preparation of pure 1-bromo 2 : 3 : 4-triacetyl arabinose (acetobromoarabinose) in good yield. According to Felton and Freudenberg (*loc. cit.*), passing hydrogen bromide into a suspension of arabinose in acetic anhydride at 0° gives this 1-bromo-derivative rapidly and in 40% yield. Earlier, Meisenheimer and Jung (*loc. cit.*) claimed yields as high as 70%, using essentially this method. In our preliminary experiments a yield of only 30% of the 1-bromo-derivative was obtained, and consequently the acetylation and treatment of the acetylated product with hydrogen bromide were carried out in two stages. Gehrke and Aichner (*loc. cit.*) acetylated arabinose with acetic anhydride and sodium acetate, and treated the syrupy mixture of α- and β-tetra-acetyl arabinose with hydrogen bromide in glacial acetic acid; a 36% yield of 1-bromo 2 : 3 : 4-triacetyl arabinose was claimed to be afforded by this procedure. However, we have found that, when the α- and the β-form of tetra-acetyl arabinose were separated from the syrupy mixture by crystallisation of the α-isomer from aqueous alcohol, and the two forms were then separately treated with glacial acetic acid saturated with hydrogen bromide, the crystalline α-tetra-acetyl arabinose gave β-acetobromoarabinose in good yield (84%), whereas the syrupy β-form gave only 12%. By isolating the crystalline α-tetra-acetyl arabinose and then converting this into β-acetobromoarabinose, it was possible to convert arabinose into 1-bromo 2 : 3 : 4-triacetyl arabinose in 47% yield. The crystalline β-acetobromoarabinose isolated by this method was sufficiently pure to be used without further recrystallisation. It was apparent that use of imperfectly washed crystalline material decreased the yield obtained at the next stage of the synthesis of 2-deoxyribose, so that further advantages gained by the above procedure were, first, that the quantity of syrupy

material which needed to be removed from the crystalline β-acetobromoarabinose by washing was much reduced, and secondly that the valuable arabinose could be recovered from the syrupy β-tetra-acetyl arabinose by deacetylation.

Recently, Smith and Nicholas (*Nature*, 1948, **161**, 349) reported that treatment of glucose with acetic anhydride and glacial acetic acid in the presence of perchloric acid as catalyst gave α-penta-acetyl glucose in high yield. Accordingly, since we found that α-tetra-acetyl arabinose was the most suitable for our purpose, we treated D-arabinose according to this procedure; this, however, afforded a crystalline acetylated product which differed from both α- and β-tetra-acetyl D-arabinose, and which, as yet, we have not succeeded in identifying.

β-Acetobromoarabinose was reduced to **3**: 4-diacetyl arabinal by stirring it with zinc dust in 50% acetic acid at −10°, addition of a few drops of a solution of chloroplatinic acid at intervals serving to maintain a vigorous reaction. This improvement and use of pure crystalline β-acetobromoarabinose (see above) led to a 65% yield of **3**: 4-diacetyl arabinal. In addition to **3**: 4-diacetyl arabinal, α-tetra-acetyl arabinose was isolated from the reaction mixture. Deacetylation of diacetyl arabinal by the method of Meisenheimer and Jung (*loc. cit.*) gave arabinal in 80% yield. 2-Deoxyribose was obtained from the arabinal by treating it with N-sulphuric acid at 0°, the best yield obtained being about 40%, for which the difficulty in crystallising 2-deoxyribose in the presence of impurities is partly responsible. It is also possible that 1-deoxyribose and 1-deoxyarabinose may result from the addition of the elements of water to the ethylenic linkage in arabinal, but the extent of this reaction is not yet known. The 2-deoxyribose was purified by recrystallisation from ethyl acetate, and gummy impurities were removed as described in the Experimental section. By this improved method, β-2-deoxy-D-ribose was prepared from D-arabinose, and β-2-deoxy-L-ribose from L-arabinose, in overall yields of about 10%.

2-Deoxyribose is insoluble in chloroform, ether, benzene, or light petroleum. It is readily soluble in water, ethyl alcohol, methyl alcohol, and pyridine, in which solvents it displays mutarotation (see Experimental section).

The velocity constant (k) for the mutarotation of 2-deoxyribose in water was calculated for both the D- and the L-form from their specific rotations. These values of k for 2-deoxyribose were 2—3 times greater than that for L-arabinose, calculated from data given by Parcus and Tollens (*Annalen*, 1890, **257**, 160). In the presence of 0·01N-hydrochloric acid or 0·01N-sodium hydroxide, 2-deoxyribose reached the equilibrium value for the specific rotation immediately on dissolution. In concentrated hydrochloric acid at room temperature, the sugar gave the equilibrium value as soon as it was dissolved, and this value surprisingly was retained for more than one hour before decomposition commenced; thereafter the specific rotation decreased slowly for several days. When 2-deoxyribose was heated with 0·5N-hydrochloric acid at 100°, the optical rotatory power of the solution progressively decreased, and lævulic acid was detected in the reaction mixture.

Since 2-deoxyribose was found to be stable for some time in concentrated hydrochloric acid at room temperature, it was possible to prepare syrupy 2-*deoxy*-L-*ribose diethyl mercaptal* by shaking 2-deoxy-L-ribose with 2 moles of ethanethiol and concentrated hydrochloric acid. Similarly with toluene-ω-thiol, 2-*deoxy*-L-*ribose dibenzyl mercaptal* was obtained crystalline, being readily purified by chromatography.

According to Pacsu and Green (*J. Amer. Chem. Soc.*, 1937, **59**, 1205; 1938, **60**, 2056), glycofuranosides and thioglycofuranosides are formed by controlled removal of the thio-groups from sugar mercaptals by action of an alcohol in the presence of mercuric chloride and yellow mercuric oxide. Thus, they report the preparation of crystalline α-methyl- and α-ethyl-L-arabinofuranosides. However the exclusive formation of glycofuranosides under these conditions seems doubtful, since in our hands treatment of 2-deoxy-L-ribose diethyl mercaptal with ethyl alcohol, mercuric chloride, and mercuric oxide gave an ethyl-2-deoxyriboside which, in glacial acetic acid, reduced lead tetra-acetate in amount corresponding to the presence of 10% of ethyl-2-deoxy-L-ribopyranoside in the ethyl-2-deoxyriboside isolated.

When 2-deoxy-L-ribose was heated with aniline in ethyl alcohol it afforded crystalline 2-*deoxy*-L-*ribose anilide*. Similarly the D-isomer was prepared. These anilides have proved to be convenient derivatives for the characterisation of 2-deoxy-D- and -L-ribose.

The oxidation of 2-deoxyribose to 2-deoxyribonolactone has recently been described by Gakhokidze (*J. Gen. Chem. Russia*, 1945, **15**, 539), who however provided no polarimetric data concerning the rate of hydrolysis of the lactone, so that an investigation of this aspect seemed desirable. For converting aldoses into aldonic acids, bromine water is recognised as suitable, and the oxidation is more rapid if the hydrobromic acid produced in the reaction is removed, as

it is formed, by barium carbonate (Isbell, *J. Res. Nat. Bur. Stand.*, 1932, **8**, 615) or barium benzoate (Hudson and Isbell, *J. Amer. Chem. Soc.*, 1929, **51**, 2225). In view of the sensitivity of 2-deoxy-sugars to prolonged contact with mineral acids, comparative oxidations of 2-deoxy-L-ribose with bromine water were carried out, first using no neutralizing agent and then in the presence of calcium carbonate. The oxidation of 2-deoxy-L-ribose by bromine water alone required 4—5 days for completion, and pure 2-deoxy-L-ribonolactone was isolated in good yield (85·6%). The oxidation of 2-deoxy-L-ribose with bromine water in the presence of calcium carbonate was more vigorous and was complete in a shorter time, but the yield was lower (74·2%). A crystalline 2-*deoxy*-L-*ribonic acid phenylhydrazide*, m. p. 145—146°, was prepared by treating the lactone with phenylhydrazine in ether (cf. Gakhokidze who reports m. p. 176—178°).

The rate of hydrolysis of 2-deoxy-L-ribonolactone and the rate of lactonization of 2-deoxy-L-ribonic acid were studied polarimetrically. Surprisingly, no change in the specific rotation of a freshly prepared solution of the lactone was observed in 8 days, and the extent of hydrolysis of the lactone is less than can be detected polarimetrically. It is noteworthy that Wolfrom *et al.* (*J. Amer. Chem. Soc.*, 1942, **64**, 1701) report similar observations on 2-deoxy-D-glucoheptonolactone and suggest that this anomalous behaviour may be due to the influence of the deoxy-group at C_2. The lactonization of 2-deoxy-L-ribonic acid required 7—8 days. The specific-rotation figures for the rate of lactonization of 2-deoxy-L-ribonic acid provided no evidence for the transient formation of a second labile lactone; if such a labile lactone is formed during the initial stages of lactonization, the polarimetric method used was not sufficiently sensitive to detect it.

Sufficient evidence has not yet been provided to decide whether the lactone is a pyrano- or a furano-lactone.

Experimental.

α-Tetra-acetyl L-*Arabinose*.—L-Arabinose (40 g.) was acetylated with freshly distilled acetic anhydride (200 c.c.) and powdered fused sodium acetate (20 g.) on a water-bath at 70—80° with vigorous stirring. After the initial reaction had subsided, the mixture was kept at 100° for 0·5 hour. The product was worked up in the usual way, giving a syrupy residue of α- and β-tetra-acetyl L-arabinose (80 g.) which partly crystallised after 3 days. The crystals (50 g.) were separated from the syrupy material by washing with aqueous alcohol and were identified as α-tetra-acetyl L-arabinose, m. p. 88—92°, $[\alpha]_D^{20}$ + 42·4° (*c*, 3·16 in chloroform) (cf. Gehrke and Aichner, *Ber.*, 1927, **60**, 918, who give m. p. 96—97° and $[\alpha]_D^{20}$ + 42·7° in chloroform).

Acetylation of D-*Arabinose by the Perchloric Acid Method*.—D-Arabinose (30·5 g.) was treated with acetic anhydride (60 c.c.), glacial acetic acid (60 c.c.), and 60% perchloric acid (0·24 c.c.) according to Smith and Nicholas (*Nature*, 1948, **161**, 349). The mixture was shaken at room temperature for 10—15 minutes, but no reaction occurred. The mixture was heated at 100° for 2 hours, the sugar then slowly dissolving. The solution, worked up as usual, gave a pale yellow syrup (40·9 g.), which gradually crystallised to a semi-solid mass. By use of benzene, the syrup was separated from the crystals, which, recrystallised from benzene, had m. p. 166—168°, $[\alpha]_D^{20}$ − 75·7° (*c*, 1·8 in chloroform) (Found: C, 47·7; H, 6·05%).

*β-Acetobromo-*L-*arabinose*.—α-Tetra-acetyl L-arabinose (96 g.) was treated with glacial acetic acid, saturated with hydrogen bromide at 0° (200 c.c.), in an ice-bath for 2 hours, according to the method of Gehrke and Aichner (*loc. cit.*). The product was poured into ice-water and extracted with chloroform. The extract was washed with sodium hydrogen carbonate solution, dried (Na_2SO_4), and freed from solvent by evaporation at 40°. The syrupy residue crystallised spontaneously, and the crystals were carefully washed free of syrupy material with ether and were stored in a vacuum over sodium hydroxide; they had m. p. 138°, $[\alpha]_D^{20}$ + 282·0° (*c*, 3·67 in chloroform) (Gehrke and Aichner, *loc. cit.*, give m. p. 139° and $[\alpha]_D^{20}$ + 283·6° in chloroform for β-acetobromo-L-arabinose).

3 : 4-*Diacetyl* L-*Arabinal*.—β-Acetobromo-L-arabinose (54 g.) was dissolved in glacial acetic acid (350 c.c.) at 30—35° and added during 10 minutes to a mechanically stirred mixture of zinc dust (108 g.) and 50% acetic acid (540 c.c.) containing a few drops of a solution of chloroplatinic acid, kept at − 10° by a freezing mixture. At intervals of 30 minutes a few drops of a solution of chloroplatinic acid were added to maintain a vigorous reaction. Sitrring was continued for 3 hours, and the mixture kept overnight at 0°. After filtration from the excess zinc dust, the filtrate was extracted with chloroform. The chloroform extracts were washed with sodium hydrogen carbonate solution and then with water and finally dried (Na_2SO_4). Removal of the solvent by evaporation at 40° afforded a syrup. Fractional distillation of this gave 3 : 4-diacetyl L-arabinal (22·0 g.) as a clear, colourless mobile liquid, b. p. 110—140°/0·01 mm., $[\alpha]_D^{19}$ − 231° (*c*, 1·6 in chloroform), and four other fractions, namely, (i) (2·7 g.) b. p. 126—150°/0·01 mm., $[\alpha]_D^{19}$ + 52·6° (*c*, 1·45 in chloroform), (ii) (4·6 g.) b. p. 150—170°/0·005 mm., $[\alpha]_D^{19}$ + 65·6° (*c*, 1·99 in chloroform), (iii) (5·8 g.) b. p. 170—190°/0·01 mm., $[\alpha]_D^{19}$ + 70·0° (*c*, 1·63 in chloroform), and (iv) (6·0 g.), b. p. 190—195°/0·01 mm., $[\alpha]_D^{19}$ + 79·8° (*c*, 2·1 in chloroform). Fractions (iii) and (iv) crystallised and were recrystallised from ethanol; both had m. p. alone or in admixture with α-tetra-acetyl L-arabinose 95—97°, $[\alpha]_D^{20}$ + 35·2° (*c*, 0·90 in chloroform) (Found: C, 48·7; H, 5·6. Calc. for $C_{13}H_{18}O_9$: C, 49·0; H, 5·6%).

L-*Arabinal*.—3 : 4-Diacetyl L-arabinal (41·7 g.), deacetylated by the method of Meisenheimer and Jung (*Ber.*, 1927, **60**, 1462), readily gave L-arabinal as colourless hygrosocpic needles. Recrystallisation

from benzene afforded a product (19·0 g., 79%), m. p. 79—81°, $[\alpha]_D^{20}$ − 196·0° (*c*, 3·54 in water) (Meisenheimer and Jung, *loc. cit.*, give m. p. 81—83° and $[\alpha]_D^{19}$ − 202·8° in water).

β-2-Deoxy-L-ribose.—L-Arabinal (19·0 g.) was treated with N-sulphuric acid at 0° according to Meisenheimer and Jung (*loc. cit.*). 2-Deoxy-L-ribose (8·54 g.) was obtained and was recrystallised from ethyl acetate as follows. 7·3 G. were dissolved in dry ethyl acetate (3 l.) under reflux. The solution was decanted from the insoluble material and evaporated under reduced pressure at 50° to 2·2 l. This solution was set aside at room temperature for 1—2 hours and then filtered from the brown material which had separated. After concentration of the filtrate at 50° to 840 c.c., 2-deoxy-L-ribose separated, during 3—5 days at 0°, as hard compact nodules on the sides of the vessel, and had m. p. 87—93°. Repeated recrystallisation gave β-2-deoxy-L-ribose, m. p. 92—95° (Levene and Mori, *J. Biol. Chem.*, 1929, **83**, 803, give m. p. *ca.* 80°, and Meisenheimer and Jung, *loc. cit.*, m. p. *ca.* 90°).

Optical Rotation of β-2-Deoxy-L-ribose.—The following values were recorded, values for zero time being obtained by extrapolation.

(*a*) In water (*c*, 1·14) : time (mins.) ...	0	4·25	6	8·5	21	41		
$[\alpha]_D^{16.5}$	+80°	+72·5°	+71°	+66°	+59°	+59°		
(*b*) In methanol (*c*, 0·90) : time (mins.)	0	3·5	6·5	9·5	12·5	27·5	81·5	136·5
$[\alpha]_D^{20}$	+105°	+87°	+76°	+71°	+67°	+58°	+49°	+49°
(*c*) In ethanol (*c*, 1·07) : time (mins.)...	0	9	25	75	135	20 (hr.)		
$[\alpha]_D^{18}$	+89°	+78°	+71°	+47°	+37°	+37°		
(*d*) In pyridine (*c*, 0·75) : time (mins.)	0	22	72	137	217	3 (days)		
$[\alpha]_D^{16.5}$	+95°	+85°	+69°	+58°	+53°	+45°		

Levene and Mori (*loc. cit.*) quote $[\alpha]_D^{25}$ +92° (initial) ⟶ +40·5° (equilibrium) in pyridine.

β-2-Deoxy-D-ribose.—β-2-Deoxy-D-ribose was prepared from β-D-arabinose by the method used for β-2-deoxy-L-ribose. After one recrystallisation from ethyl acetate, β-2-deoxy-D-ribose had m. p. 96—98° (Gakhokidze, *J. Gen. Chem. Russia*, 1945, **15**, 539, gives m. p. 91°) (Found : C, 44·7; H, 7·4. Calc. for $C_5H_{10}O_4$: C, 44·8; H, 7·5%).

Optical Rotational of β-2-Deoxy-D-ribose.—The following values were recorded, values for zero time being obtained by extrapolation.

(*a*) In water (*c*, 1·65) : time (mins.).....	0	2·5	3·5	5	7	10·5	14·5	23·5	61·5
$[\alpha]_D^{17}$.....	−91°	−82°	−81°	−75°	−71°	−63°	−59°	−58°	−58°
(*b*) In methanol (*c*, 5·8) : time (mins.).....	0	4	11·5	19·5	33	100	180	285	24 hr.
$[\alpha]_D^{20.5}$	−96·9°	−93°	−87°	−83°	−76°	−57°	−50°	−46°	−46°
(*c*) In ethanol (*c*, 2·1) : time (mins.).....	0	15	30	73	115	215	265	295	
$[\alpha]_D^{20}$.....	−99°	−81°	−71°	−57°	−50°	−40°	−36°	−36°	
(*d*) In pyridine (*c*, 3·0) : time (mins.).....	0	4	13	71	141	242	19·5 hr.	23 hr.	25 hr.	43·5 hr.
$[\alpha]_D^{20}$.....	−106°	−104°	−102°	−93°	−83°	−76°	−47°	−45°	−42°	−41°

Treatment of 2-Deoxyribose with Acid.—(*a*) When 2-deoxy-L-ribose (0·048 g.) was dissolved in concentrated hydrochloric acid (5 c.c.), polarimetric observations were as follows : $[\alpha]_D$ + 35° (5 mins.), + 35° (82 mins.), + 17° (15 hrs.), and + 12° (26 hrs.). No coloration of the solution was observed.

(*b*) When 2-deoxy-L-ribose (0·034 g.) was heated with 0·5N-hydrochloric acid (6 c.c.) at 100°, polarimetric observations were as follows : $[\alpha]_D$ + 50° (initially), + 39° (10 mins.), + 21° (25 mins.), and + 14° (70 mins.). The solution became progressively more coloured, and after 70 minutes no further readings could be taken ; it gave a positive iodoform test for lævulic acid.

2-Deoxy-L-ribose Diethyl Mercaptal.—2-Deoxy-L-ribose (1·2 g.) was dissolved in concentrated hydrochloric acid (2 c.c.) at 0° and ethanethiol (1·5 c.c., 36% excess) was added. After 5 minutes' shaking at 0°, the mixture was diluted with water (20 c.c.) and extracted several times with chloroform. The combined chloroform extracts (100 c.c.) were washed with, successively, water, sodium hydrogen carbonate solution, and water. The chloroform extract was dried (Na_2SO_4), and the solvent removed by evaporation *in vacuo* at 40°. The residual *2-deoxy-L-ribose diethyl mercaptal* (1·39 g.) was distilled, to give a colourless viscous syrup (0·835 g.), b. p. 170—175°/0·06 mm., n_D^{20} 1·5385, $[\alpha]_D^{25}$ + 8·8° (*c*, 0·96 in ethyl alcohol) (Found : C, 45·6 ; H, 8·5. $C_9H_{20}O_3S_2$ requires C, 44·9 ; H, 8·3%).

2-Deoxy-L-ribose Dibenzyl Mercaptal.—2-Deoxy-L-ribose (3·75 g.) was mixed with toluene-ω-thiol (7·0 c.c., 7% excess), and the mixture cooled to 0°. Concentrated hydrochloric acid (7·0 c.c.) was added and the mixture shaken for 5—10 minutes. After chloroform (25 c.c.) had been added, the mixture was poured into water, and the chloroform layer removed. The aqueous solution was further extracted with chloroform (50 c.c.). The combined chloroform extracts were washed with, successively, water, sodium hydrogen carbonate solution, and water, and dried (Na_2SO_4), and the solvent removed by evaporation *in vacuo* at 40°. Crystallisation of the residual syrup (9·1 g.) gave some crude solid material (5·0 g.). Recrystallisation from ether–light petroleum (2 : 1 by volume) gave *2-deoxy-L-ribose dibenzyl mercaptal* (2·5 g.), m. p. 66—70°, unchanged by further recrystallisation, $[\alpha]_D^{20}$ − 12·0° (*c*, 1·6 in chloroform) (Found : C, 61·3 ; H, 6·7. $C_{19}H_{24}O_3S_2$ requires C, 62·6 ; H, 6·7%).

Further quantities of 2-deoxy-L-ribose dibenzyl mercaptal were obtained by chromatography of the combined syrupy residues which were placed on an alumina column (30 × 1 cm.) wetted with benzene–light petroleum (1 : 1 by volume). Elution of the column with this solvent mixture first removed

toluene-ω-thiol with some 2-deoxy-L-ribose dibenzyl mercaptal. The remaining mercaptal (3 g.) was removed completely after successive elution with benzene, chloroform, and ethyl alcohol; crystallisation of this material after removal of the solvents gave 2-deoxy-L-ribose dibenzyl mercaptal (2·35 g.), m. p. 62—68°, free from toluene-ω-thiol.

Ethyl-2-deoxy-L-riboside.—2-Deoxy-L-ribose diethyl mercaptal (0·835 g.) was dissolved in ethanol (12 c.c.), and to the solution mercuric oxide (1·87 g.) and mercuric chloride (1·9 g.) were added. The mixture was shaken at room temperature for 2 hours and then filtered. Subsequent operations were carried out according to Pacsu (*loc. cit.*). The material finally obtained was a syrup (0·5 g.) which was distilled, giving a colourless viscous syrup (0·246 g.), b. p. 110—120°/0·1 mm. (approx.), $[\alpha]_D^{21}$ − 26·5° (*c*, 4·5 in ethanol), which did not crystallise (Found: OEt 26·1. $C_7H_{14}O_4$ requires OEt, 27·8%). The *compound* gave a negative test for sulphur and a negative Fehling's test. Treatment with lead tetra-acetate in glacial acetic acid resulted in the uptake of 0·1 mol. corresponding to the presence of 10% of ethyl-2-deoxyribopyranoside in the syrup.

2-Deoxy-L-ribose Anilide.—2-Deoxy-L-ribose (0·146 g.) was heated under reflux for 4 hours with the theoretical quantity of freshly distilled aniline (0·112 g.) in ethyl alcohol (3·4 c.c.). The solution was allowed to cool, and *2-deoxy-L-ribose anilide* (0·137 g.) crystallised. Recrystallisation from ethyl alcohol gave colourless needles, m. p. 169·5—170·5° (Found: C, 63·3; H, 7·3; N, 6·3. $C_{11}H_{15}O_3N$ requires C, 63·1; H, 7·2; N, 6·7%).

2-Deoxy-D-ribose Anilide.—2-Deoxy-D-ribose (0·045 g.) was heated under reflux for 4 hours with the theoretical quantity of freshly distilled aniline (0·0347 g.) in ethyl alcohol (2·78 c.c.). On cooling, crystals of 2-deoxy-D-ribose anilide were deposited, having m. p. 168°, $[\alpha]_D^{20}$ + 19·5° (*c*, 0·21 in ethyl alcohol). The material was soluble in methyl alcohol, sparingly soluble in ethyl alcohol, and insoluble in water or chloroform. Treatment of the anilide with lead tetra-acetate in glacial acetic acid resulted in its complete decomposition.

2-Deoxy-L-ribonolactone.—2-Deoxy-L-ribose (0·5 g.) was dissolved in water (3 c.c.). Calcium carbonate (0·75 g.) and bromine (1·0 c.c.) were added to the solution. The reaction mixture was shaken and set aside for 2 days. The solution, which then did not reduce Fehling's solution, was aërated to remove excess of bromine and filtered from the excess of calcium carbonate. Oxalic acid (1·0 g.) was dissolved in the filtrate, and an excess of silver carbonate was immediately added. The syrupy mixture was isolated in the usual way. The residual syrup was lactonized by being heated at 70°/12 mm., and 2-deoxy-L-ribonolactone (0·365 g.) was obtained, having n_D^{20} 1·4834 (Found: equiv., 131. Calc. for $C_5H_8O_4$: equiv., 132).

(ii) 2-Deoxy-L-ribose (0·5 g.) was dissolved in water (3 c.c.), and bromine (1 c.c.) added. The mixture was shaken and set aside for 5 days. The product, which did not reduce Fehling's solution, was isolated as usual as a syrup (Found: C, 39·6; H, 5·8. Calc. for $C_5H_{10}O_5$: C, 40·0; H, 6·7%). This was lactonized by heating it for 2 hours at 70°/12 mm., to yield 2-deoxy-L-ribonolactone (Found: equiv., 125; C, 45·6; H, 6·4. Calc. for $C_5H_8O_4$: C, 45·6; H, 6·1%), n_D^{20} 1·4821, $[\alpha]_D^{20}$ − 13·8° (initial) ⟶ − 14·5° (in 8·29 days) (in water) (Gakhokidze, *J. Gen. Chem. Russia*, 1940, **10**, 497, gives m. p. 153—155° and $[\alpha]_D^{19}$ 2·1°). The lactone (0·00967 g.) was dissolved in 0·6N-sodium hydroxide (0·150 c.c.), and the solution kept at 40° for 6 hours. After a further hour at room temperature, the solution was exactly neutralised with hydrochloric acid (0·152 c.c.) and then had $[\alpha]_D^{20}$ + 8·16° (initial), becoming − 11·2° in 8·1 days. For 2-deoxy-L-ribonic acid Gehrke and Aichner (*Ber.*, 1927, **60**, 918) give $[\alpha]_D$ + 8·5° ⟶ −10·7°, and Levene, Mikeska, and Mori (*J. Biol. Chem.*, 1930, **85**, 785) reported $[\alpha]_D$ + 8·5° ⟶ −12·2°.

2-Deoxy-L-ribonic Acid Phenylhydrazide.—2-Deoxy-L-ribonolactone (0·046 g.) was mixed with the exact equivalent of phenylhydrazine in ether (0·721 c.c. of a solution containing 0·0209 g. in 4·0 c.c. of solution). The ether was removed by evaporation under reduced pressure at 30°, and the resultant product recrystallised from acetone, giving *2-deoxy-L-ribonic acid phenylhydrazide* (7 mg.) as pale yellow crystals, m. p. 145—146° (after four recrystallisations) (Found: C, 54·9; H, 6·9. $C_{11}H_{16}O_4N_2$ requires C, 55·0; H, 6·7%). Gakhokidze (*J. Gen. Chem. Russia*, 1945, **15**, 539) reports m. p. 176—178° for the compound isolated from this reaction.

The analyses were carried out by Dr. W. T. Chambers to whom our thanks are due. One of us (W. G. O.) thanks the Board of the British Rubber Producers' Research Association for financial assistance and another (E. G. T.) acknowledges with gratitude the award of a Beit Fellowship for Medical Research. We thank also the British Empire Cancer Campaign (Birmingham branch) for financial assistance.

THE UNIVERSITY, EDGBASTON, BIRMINGHAM, 15. [*Received, February 28th*, 1949.]