may, however, be conveniently used for the very accurate determination of nearly pure titanic oxide, and especially for the detection of this oxide in the acid earths. As a test for titanium in the absence of molybdenum and iron, the delicacy of the reaction considerably exceeds any reaction for this metal with which the writer is acquainted. As little as 0.00005 gram of titanic oxide in 100 cc. shows a pale yellow, while 0.0001 gram in the same volume produces a very marked and permanent sulfur-yellow color. In the presence of large quantities of columbium or zirconium the brownish yellow color produced might be mistaken for the yellow of titanium, but this yellow color of titanium solutions is immediately discharged by ammonia, while the brownish yellow color due to columbium or zirconium is permanent in alkaline solution, and only appreciable when a large quantity of the last-mentioned metals are present.

Ten grams of sodium tungstate dissolved in 200 cc. of water gave no precipitate with salicylic acid. Ten grams of sodium molybdate, containing 66.66 per cent. MoO_3, were treated in the same manner as the tungstate. The behavior was almost the same as that of the tungstate. The solution, however, was deep yellow, while a lighter colored very similar amorphous substance separated when the solution was concentrated to a small volume (25–30 cc.).

The tungsten and molybdenum solutions failed to give a precipitate with ammonium hydroxide while the alkaline solutions remained colorless. The above reactions seemed to indicate a possible separation of these two metals from titanium by precipitation of the salicylic acid solution with ammonium hydroxide. Likewise the solubility of the molybdate and tungstate in salicylic acid suggested the removal of columbic and tantalic oxides from molybdenum and tungsten.

Molybdic oxide in large quantity completely prevented the precipitation of columbium by salicylic acid. The attempt to separate titanium from both tungsten and molybdenum, by this method, gave incomplete precipitation and turbid filtrates, which could not be cleared by a second or third filtration.

The separation of tungsten and columbium was more satisfactory, giving values not far from quantitative, requiring for success, however, a relatively small amount of tungsten.

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AN EMPIRICAL RELATION BETWEEN THE CONFIGURATION AND ROTATION OF SUGARS.

BY ERNEST ANDERSON.

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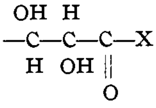
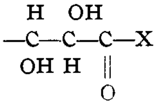
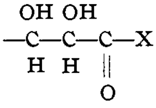
It has long been known that some sugars rotate polarized light very strongly while other closely related sugars rotate this light but slightly. No satisfactory explanation of this fact has ever been given.

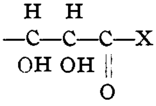
Recently, while comparing the configurations and rotations of the various sugars, I noticed that the configuration of the α and β carbon atoms seems to determin the direction and degree of optical rotation of the sugars. It is possible, in fact, to decide from a glance at the configuration of these carbon atoms, approximately what the rotation of a sugar will be.

There are four possible configurations for the α and β carbon atoms in sugars. These configurations with their corresponding rotations are:

1.  $-\underset{H}{\overset{OH}{C}}-\underset{OH}{\overset{H}{C}}-\underset{\overset{\|}{O}}{C}-X$;[1] dextro, strongly.[2]

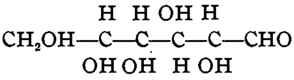
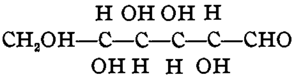
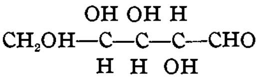
2.  $-\underset{OH}{\overset{H}{C}}-\underset{H}{\overset{OH}{C}}-\underset{\overset{\|}{O}}{C}-X$; levo, strongly.[2]

3.  $-\underset{H}{\overset{OH}{C}}-\underset{H}{\overset{OH}{C}}-\underset{\overset{\|}{O}}{C}-X$; dextro or levo, slightly.[3]

4.  $-\underset{OH}{\overset{H}{C}}-\underset{OH}{\overset{H}{C}}-\underset{\overset{\|}{O}}{C}-X$; dextro or levo, slightly.[3]

Sugars having any one of the above groups rotate as indicated. The following table shows that this statement is true for all sugars for which both configuration and rotation are known.[4]

TABLE I.

Sugar.	Configuration.	Specific rotation.
d-Glucose	 $CH_2OH-\underset{OH}{\overset{H}{C}}-\underset{OH}{\overset{H}{C}}-\underset{H}{\overset{OH}{C}}-\underset{OH}{\overset{H}{C}}-CHO$	+52°.5
d-Galactose	 $CH_2OH-\underset{OH}{\overset{H}{C}}-\underset{H}{\overset{OH}{C}}-\underset{H}{\overset{OH}{C}}-\underset{OH}{\overset{H}{C}}-CHO$	+83°
l-Arabinose	 $CH_2OH-\underset{H}{\overset{OH}{C}}-\underset{H}{\overset{OH}{C}}-\underset{OH}{\overset{H}{C}}-CHO$	+105°

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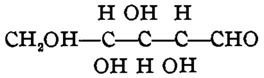
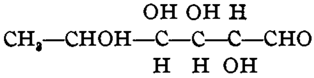
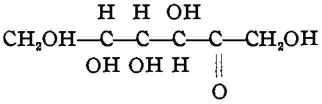
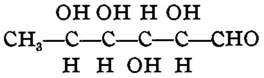
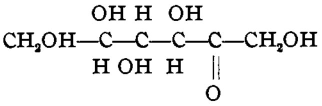
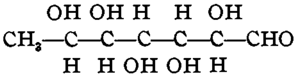
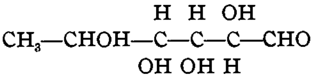
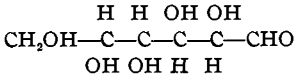
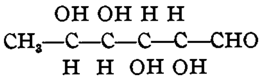
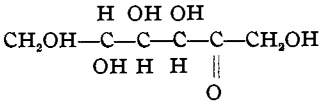
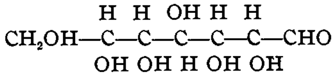
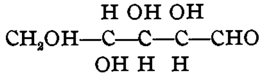
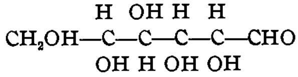
[1] X may be H or CH_2OH.

[2] More than 20°.

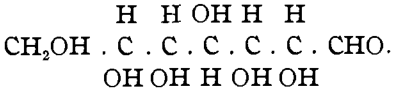
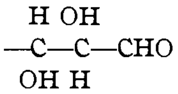
[3] Less than 20°.

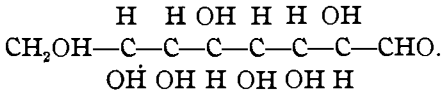
[4] The data in all the tables of this paper have been taken from: Maquenne, *Les Sucres et Principaux Derives*; Lippmann, *Chemie der Zuckerarten*; Fischer, *Untersuchungen über Kohlenhydrate und Fermente*; and from the articles by Hudson, THIS JOURNAL, 32, 338; 33, 405.

TABLE I (*Continued*).

Sugar.	Configuration.	Specific rotation.
l-Xylose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-CHO$	+20°
Rhodeose	 $CH_3-CHOH-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-CHO$	+86°
d-Fructose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\underset{\overset{\Vert}{O}}{C}-CH_2OH$	—92°
Isorhamnose	 $CH_3-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO$	—30°
d-Sorbose	 $CH_2OH-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\underset{\overset{\Vert}{O}}{C}-CH_2OH$	—43°
α-Rhamnohexose	 $CH_3-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO$	—61°.4
Fucose	 $CH_3-CHOH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO$	—77°
d-Mannose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO$	+14°
l-Rhamnose	 $CH_3-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO$	+9°
d-Tagatose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\underset{\overset{\Vert}{O}}{C}-CH_2OH$	+1°
α-Glucoheptose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO$	—19°.7
d-Lyxose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO$	—14°
l-Gulose	 $CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO$	—(slightly)

The above-described relation between configuration and rotation makes possible the determination of the unknown configuration of some sugars. For this purpose it is necessary to know the specific rotation of the sugar whose configuration is unknown and the configuration of the sugar from which the sugar of unknown configuration was synthesized.

As an illustration, the configuration of α-glucooctose: The configuration of α-glucoheptose is,  $\mathrm{CH_2OH\,.\,\overset{H}{\underset{OH}{C}}\,.\,\overset{H}{\underset{OH}{C}}\,.\,\overset{OH}{\underset{H}{C}}\,.\,\overset{H}{\underset{OH}{C}}\,.\,\overset{H}{\underset{OH}{C}}\,.\,CHO}$. The α-hydroxyl in this sugar becomes the β-hydroxyl in α-glucooctose. The specific rotation of α-glucooctose is $-50.5°$ and, hence, it must have the configuration  $\mathrm{-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$ about the α and β carbon atoms and must therefore be,



$$\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO.}$$

Table II contains four groups of sugars in each of which the configuration of the first member is known and the configurations of the succeeding members are obtained as indicated for α-glucooctose.

TABLE II.

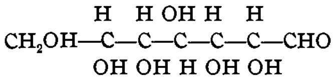
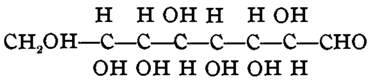
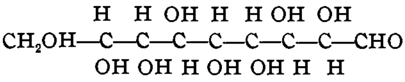
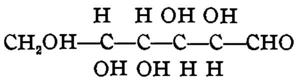
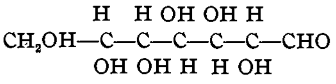
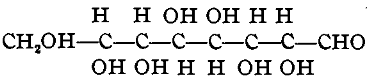
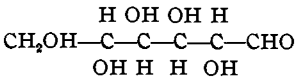
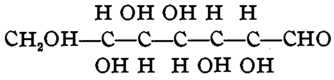
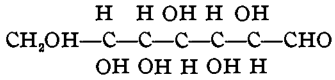
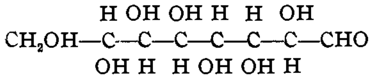
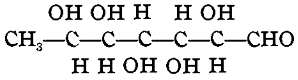
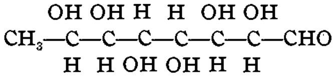
Sugar.	Specific rotation.	Configuration.
		Group 1.
ad-Glucoheptose	—19°.7	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$
ad-Glucooctose	—50°.5	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$
Gluconononse	+ (slightly)	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$
		Group 2.
d-Mannose	+ 14°	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$
d-Mannoheptose	+ 85°	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$
d-Mannooctose	—3°.3	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$
		Group 3.
d-Galactose	+ 83°	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$

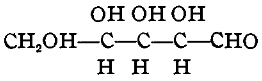
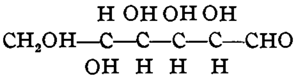
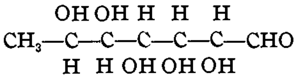
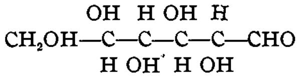
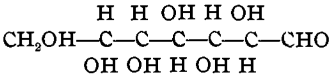
TABLE II (*Continued*).

Sugar.	Specific rotation.	Configuration.
α-Galaheptose	—(slightly)	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$
βd-Galaheptose	—54°.4	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$
Galaoctose (from α-Galaheptose)	—40°	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$
	Group 4.	
α-Rhamnohexose	—61°.4	 $\mathrm{CH_3-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$
α-Rhamnoheptose	+8°.4	 $\mathrm{CH_3-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$

. The above table establishes the configurations of eight sugars, which up to the present were only partially known.

The relation between configuration and rotation makes possible the prediction of unknown rotations of sugars whose configurations are known. Table III contains five such sugars.

TABLE III.

Sugar.	Configuration.	Predicted rotation.
l-Ribose	 $\mathrm{CH_2OH-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$	± (slightly)
d-Talose	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$	± (slightly)
β-Rhamnohexose	 $\mathrm{CH_3-\overset{OH}{\underset{H}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$	± (slightly)
d-Idose	 $\mathrm{CH_2OH-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-CHO}$	+ (strongly)
β-Glucoheptose	 $\mathrm{CH_2OH-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{OH}{\underset{H}{C}}-CHO}$	—(strongly)

There is a very simple theoretical explanation of the above described relation between configuration and rotation but this will not be presented until the evidence has been completed.

CHICAGO, ILL.