neath the Solar action incomparably more accentuated than those exhibited by the Earth.

As no rotatory motion has ever been observed in comets or their atmospheres, we feel authorized in saying that if it does exist it is exceedingly slow, without taking into account the fact that comets always present the same side to the Sun. The second method of heating should therefore be produced. In every plain passing through the centre of the Sun and the nucleus, there will be a double atmospheric circulation. On the interior, the comets advance towards the Sun as though the gravitation there was intensified. On the exterior, they deviate as if the gravitation was diminished, or rather as though there existed some repulsive force emanating from the Sun, affecting the exterior surface of the cometary atmosphere, and acting solely upon it. In reality, this repulsive force does not exist. It seems as though it did, however, and under conditions analagous to those inferred by M. Faye. All the consequences therefore, which he deduced in order to explain the formation of the tails, are developed naturally. There is nothing here to be altered.

I do not think, however, that this theory is sufficient to account for cometary appearances. On the contrary, it is my opinion that electricity has a great deal to do with them. But before entering upon this let us first return to terrestial phenomena.

It has been satisfactorily proved that considerable electricity exists in atmospheric altitudes, and that it increases according to the height. It is admitted generally that atmospheric motion results; that it is developed by evaporation at the ring of aspiration; that it moves from the time it leaves this ring until it reaches the poles under the form of two currents in the rarified air which it illumines. Towards the sun it is the zodiacal light, invisible when close to this planet, but extending a sufficient distance to be perceived, especially near the equator. Close to the poles it is the aurora borealis, which we see obliquely and which appears more luminous than at the zenith, because it has greater density and is more concentrated.

Upon a comet the warmth occurs at the point where the trade winds come together opposite to the sun. But analogous electric actions should be manifested, illuminate the head and produce the appearance of effluviums succeeding each other like the stratifications in a Geissler tube, accompany the counter trade winds to the opposite side to illumine the tail, and be prolonged to a great distance like the luminous rays in Mr. Crookes's apparatuses. No doubt, matter would be contained in the tail, but rarified to an extreme degree and made visible by both the solar light and the electric current.

M. Flammarion would be quite right then to attribute this shining to electricity. On the other hand, M. Berthelot's observation would be justified, and the development of this electricity would be due to the phenomena of evaporation and movement situated in the atmosphere. We must insist upon this point.

The recent study of cometary spectra has shown us beyond the possibility of a doubt that the interior aureole and the tail contain carburetted gases which emit a light of their own. Now, they can only become luminous in two ways; either by combustion or by an electric effluvium. If by combustion, we have yet to explain how they take fire and how they continue to burn indefinitely, which seems very difficult. For in this case, all the materials of which the comet is composed would be red, and the spectrum would contain the bright spectral rays of the metals as we see them in the electric arc burning n mid air. Nothing of this kind occurs. The light is absolutely like that of the arc when the vaporous carbon is transported to the torpid gases without burning. It shows no brilliant metallic bands, any more than this arc. The light, therefore, cannot be the result of fire, but is due to illumination made by the currents.

I think that the Sun determines gaseous currents in

cometary atmospheres analogous to terrestrial trade winds and counter trade winds; that this circulation produces near the Sun effluviums arising from the head of the nucleus and transports to the opposite side the substances which are on the exterior, producing upon these substances the effect of a repulsive force emanating from the Sun, a force which has absolutely no *raison d'être*. Besides this, I think this circulation is accompanied by an electric movement which illumines the gases either towards the head or tail, as the case may be, making them visible to us notwithstanding the feebleness of their density, and precisely on account of this feebleness.

AMYLOSE: ITS CONSTITUENTS AND METHODS FOR THEIR ESTIMATION.

By H. W. WILEY, Lafayette, Indiana.

I propose the name AMYLOSE for all the varieties of sugar and sugar-like substances derived from starch.

These substances are now known by many different appellations, and often the indiscriminate use of these terms gives rise to a great deal of misunderstanding and confusion. Among them I may mention grape sugar, starch sugar, dextrose, dextrine, glucose, maltose, fruit sugar, etc. These names do not always have the same signification in different localities. For instance, glucose and dextrose, in Europe, signify the same product, while in this country they embrace many other substances besides.

If we designate the starch sugar in general by amylose then the terms glucose, dextrose and maltose can be used to designate certain definite constituents of amylose.

Amylose is composed of three principal ingredients.

1st. Dextrine. Pure dextrine is very difficult to obtain. It is obtained almost pure by the dry roasting of starch. The temperature during torrefaction must not be carried too high, $210°-275°$. Starch itself has a specific rotatory power of $214°$ [1]. Bondonneau (*loc. cit.*), asserts that there are three dextrines, (a), in which aj [2] $=186°$; (β), in which aj $= 176°$; (γ), in which aj $= 164°$. According to Musculus and Grubber [3], there are five dextrines; viz.: (a), soluble starch colored wine red by iodine aj $= 218$; (b), Erythro dextrine, red color with iodine; rotating power not given.

(c), a Achroodextrine, not colored by iodine, j $= 210$.

(d), β Achroodextrine, aj $= 190$.

(e), γ Achroodextrine, aj $= 150$.

Of these varieties the first and second do not reduce the alkaline copper solutions while the others do. If the reducing power of dextrose be taken at 100, that of the third of the above dextrines will be 12; the fourth 12 and the fifth 28.

O'Sullivan admits the existence of but one dextrine with a $= 214$.

Thomsen [4] tries to show by history of multiples in the rotating power of the carbo-hydrates that there are at least three dextrines in which the value of aj is 186, 176 and 164 respectively.

I will not multiply authorities concerning the rotating power of dextrine. I have quoted enough to show the highly chaotic state of our knowledge on the subject.

The chemical properties of dextrine are equally as undeterminable.

Gentele [5] is quite confident that dextrine will reduce the alkaline copper solutions and on this he bases his method of separating dextrine from other reducing substances by ferricyanide of potassium.

Stommer [6], Bondonneau [7] and Rumpff [8], are equally

[1] Bondonneau, Ber. d. Deu. Chem. Gesel., IX, 69.
[2] a = specific rotatory power.
[3] Comptes Rendus, LXXXVI, 1459.
[4] Ber. d. Deutsch. Chem. Gesel., 14—2—158.
[5] Ding. Journal, CLII, p. 139.
[6]   "   "   CLVIII, p. 40.
[7] Bull. de la Soc. Chim., 1874, XXI, p. 50.
[8] Zeit. fur Anal. Chem., 1870, p. 358.

positive that dextrin does not reduce the copper solution except on prolonged boiling.

My own experience is that dextrine does not reduce Fehling's solution except on prolonged boiling and then by the dextrine being slowly converted into dextrose.

To secure the reduction of the dextrose and the reducible portion of maltose it is not necessary to boil the solution more than two minutes, and during this time the amount of dextrine reduced is wholly inappreciable.

Color with Iodine. Bondonneau ([9]) says, dextrine colors a solution of iodine a dark red, but that it is without effect on caustic soda. Musculus & Gruber ([9]), found that some varieties of dextrine colored iodine solution red, while others were without action on it.

In general it will be found that most substances purporting to be dextrine give a reddish color with iodine. For my part I do not know of any method by which absolutely pure dextrine can be prepared.

Fermentability. Respecting this property the most contradictory statements are found. The weight of authority leans to the non-fermentible doctrine. It is probable that before dextrine ferments it is first converted into dextrose.

Formation. In addition to the method by roasting, dextrine is always formed when diastase or dilute acids act on starch.

Some authorities maintain that dextrine in such cases is always the first transformation product and that the others are derived from it.

According to Musculus ([10]), dextrose and dextrin are formed synchronously by the action of sulphuric acid on starch and in the proportions of one part of the former to two of the latter. This proportion is maintained until all the starch disappears. The further action of the acid then tends to convert the dextrin into dextrose. O'Sullivan ([11]) states that by the action of diastase, both dextrine and maltose, and nothing else, are first produced from starch under certain conditions of temperature (below 63°), and in the proportions of one part of the former to two of the latter. The proportion, however, only obtains when the specific rotatory power of the mixed bodies is equal to 171°.

From a careful study of all the data I could obtain I concluded that very little is yet known of the real proportions of dextrine which amyloses formed by heating starch with dilute acids contain.

MALTOSE. Dubranfaut ([12]) first pointed out the probable existence of at third transformation product of starch in addition to the two which had long been known. But we must accord to O'Sullivan ([13]) the merit of having first isolated and studied the properties of this body. He has given in the *Journal of the Chemical Society,* within the last decade several papers on the properties of this important saccharide. He gives its specific rotatory power (a)= 150°. The same value is also given by Musculus and Gruber, ([14]),

Joshida[15] found a slightly higher number. For (a)j this would give 135.°36.

Maltose is formed chiefly by the action of diastase on starch at a temperature not exceeding 75°. But it is also formed, but in smaller quantities by the action of dilute acids.

It is well established that maltose has the power of reducing the alkaline copper solution and in the proportion of 65 to 100 compared with dextrose. We here find an easy explanation of the fact that so many chemists have affirmed that dextrine acted on copper solutions. In all these cases the dextrine doubtless contained maltose. Without citing further from the literature of maltose, which is

all recent, I wish to call your attention again to the numbers representing its rotating and reducing power, viz. 150 and 65.

3d. DEXTROSE. This substance is the final product of a complete saccharification of starch. It has a slightly bitter taste, which is probably due to the development of a bitter principle on long boiling with acids. This bitter taste is not noticed in the products less perfectly converted.

Dextrose possesses in the highest degree the power of reducing the copper solutions. One gramme reduces 2.205 g. weighed as cupric oxide. Its specific rotatory power has been the subject of much controversy.

O'Sullivan gives 57°.6 = (a)
Tollens " 56 = "
" " 53.17 = (a) j. ([16]).

The differences in results which the above numbers show do not indicate so much errors of observation as they do the impurities which the purest dextrose is likely to contain. As a mean of these numbers, we may take (a) = 56 and (a) j. = 50.5 (by calculation).

Pure dextrose is almost insoluble in absolute alcohol, while it is very soluble in water. According to Anthon ([17]) 100 parts water dissolve 81.68 parts dextrose. To dissolve one part, 50 parts of alcohol, .83 sp. gr. are required. When subjected to fermentation, dextrose affords 48 per cent alcohol ([18]), while cane sugar and maltose each gives 51 per cent and dextrine none at all.

I have thought it useful to give the above brief *resume* of the literature of amylose, because the conclusions to be drawn from it will go far to explain the anomalies of the numbers which the following analyses and methods of analysis will show. The whole subject is a matter of considerable scientific interest on account of the immense production of amylose in this country and the laws which some of the States have passed to regulate its sale. In the present state of our knowledge I am at a loss to see how the real constitution of an amylose, or mixed sugar, can be established before a court of justice. To show this I will give synopses of a few of the

METHODS OF ANALYSIS

which have been proposed.

I shall not attempt to give an out-line of all the methods which have been proposed for determining the amount of dextrine and dextrose in amylose. Until within a few years they were all based upon the assumption that these were the only transformation products of starch—an assumption which we know to be false. Reduced to first principles, all the methods may be comprised under three heads.

1st. The reduction of certain metallic salts by the dextrose, and estimation of dextrine by difference.

2d. Fermentation of dextrose and estimation of dextrine by difference.

3rd. Precipitation of the dextrine by strong alcohol and estimation of the dextrose by difference.

Remembering the facts established in the first part of this paper, it will not be hard to show the fallacies of these several methods.

1st. Metallic salts, especially the compounds of copper, mercury and ferro-cyonigen, are all reduced by maltose as well as by dextrose, and on prolonged boiling in a slight degree by dextrine also. Thus the total reducing effect does not measure the amount of dextrose present only in case maltose is completely absent. In commercial amyloses this is never the case unless it be in rare instances of high pressure conversion.

2d. Fermentation not only converts dextrose into alcohol and carbonic dioxide, but acts in the same manner on maltose. For a given weight maltose gives even

([9]). Loc. cit.
([10]). Annal. de Chem. et Phys., p. 203.
([11]). *Chemical News,* 1876, 861–218.
([12]). Anall. de Chem. et Phys. (3) XXI, p. 168.
([13]). Jour. Chem. Soc. Vol. X, 2d series.
([14]). Loc. cit.
([15]). Chem. News, 1881.

([16]). Ber. d. Deutsh Chem. Gesel., 1876, p. 420.
([17]). (*Ding. Journal,* CLV, p. 41).
([18]). O'Sullivan loc. cit.

a higher percentage of alcohol than dextrose, and in the proportion of 51 to 48. Whether dextrine is fermentible or not has long been a subject of bitter discussion. The weight of authority seems to be in favor of its fermentability by a slow conversion into dextrose. Thus by fermentation we are not sure of getting the amount of dextrose present even when maltose is absent. From this it appears that the process of fermentation is likely to give less reliable results than reduction affords.

3d. Precipitation with alcohol is even less reliable than the method just given. Alcohol of 90 per cent ceases to give a precipitate long before the dextrine is all converted into dextrose, as every grape sugar maker well knows. If absolute alcohol is used, dextrose is also precipitated. Anthon has shown[19] that fifty parts of alcohol of .83 sp. gr. will only dissolve 1 part of dextrose. Anything like an accurate separation, therefore, by this method is impossible.

As an illustration of the variations in the composition of different specimens of amylose I will cite the following analyses by Steiner[20]:

	I.	II.	III.	IV.
Water	15.50	6.00	13.30	7.60
Ash	.30	2.50	.40	1.10
Dextrose	45.40	26.50	76.00	....
Dextrine	9.30	15.90	....	39.80
Maltose	28.00	40.30	5.00	42.60
Carbo-hydrates	1.50	7.00	5.30	8.90

My own analyses have given results quite as puzzling as the above, although I have never been able to satisfy myself with such exact expressions of percents.

I have heretofore been glad when, by hard work and liberal guessing, I could come any way near the truth. The author of the above table leaves us in charming ignorance of the methods by which such accurate percents were obtained; at least, of methods which would stand the test of criticisms, while the bunching of all the unknowables as *carbo hydrates* .s quite worthy of the reasoning of the Concord School of Philosophy. I have given enough, I think, to show the untrustworthiness of methods now in use, and of the results obtained by them. I am sorry that I have nothing very much, if any better, to propose as a substitute. What I have been able to accomplish I will now briefly describe.

THE ANALYSIS OF AMYLOSE.

Water. I have estimated water in a flat platinum dish. Only two or three grammes should be taken, though in many of my analyses I have used more. This dish is placed in a second one, and this in a paraffine bath heated to 150°–170°. The object of the second dish is to keep the wax from touching the dish which is to be weighed. After two hours the weight is sensibly constant, and the whole mass is quite brown. I believe the method will give the water to within one-half of one per cent.

Ash. There is only one method of determining the ash, *i. e.*, by incineration in a shallow platinum dish in a muffle. The per cent of ash in a strait amylose is extremely small. In most cases its quantity may be neglected as far as practical purposes are concerned. The determination of the ash is chiefly useful to furnish a clue to the purity of the sample.

Reducing Matter. I determine by Fehling's solution. It will be found most convenient to take 10 g. in 1000 $c. c.$ In all cases the volumes of the solutions employed should be as nearly the same as possible.

Rotating Power is determined by using 10 g. of the amylose in 100 $c. c.$ If 26,048 g. are taken the weight of cane sugar, which gives 100 divisions on most polariscopes, the rotation is so great that the neutral point is thrown entirely beyond the graduation. In many cases of high conversion, however, this would not be the case. If the solution is turbid it must be classi-

fied by blood charcoal, or plumbic acetate. These substances, as I have shown ([21]), tend to diminish the rotating power. The clearer definition, however, of the neutral point in part compensates for this loss in gyratory power.

In the light of the foregoing *resumé* it is possible to explain the results of my own work, although I am far from thinking that anything better than approximate per cents can yet be obtained.

We have seen that an ordinary amylose, whether liquid or solid, contains about 86 per cent of material not water. One per cent, nearly, of this is ash and optically non-active matter. Ten grammes of amylose, therefore, will contain an average of 8.5 grammes optically active matter. If this were all dextrose it would give in 100 $c.c.$ an angular rotation of 8°.67. This is obtained by the formula $a = \dfrac{\theta \times v}{\lambda \times w}.$

Here a_j. = sp. rot. power for yellow ray.

θ = angular rotation.

V = volume of solution in $c. c.$

λ = length of observation tube.

W = weight of substance in grammes.

In a large number of cases where I heated the amylose with dilute sulphuric acid from 4 to 6 hours, I obtained an average value of θ= 8°.85. This shows that prolonged boiling does not convert all the amylose into homogeneous dextrose.

If the substance under examination were all maltose the value of a_j would be 135.36 and θ would become 23° nearly. The highest number I ever obtained for an amylose was 22°.24. This shows that even this specimen, with such a high rotating power contained some matter in a weaker degree of optical activity.

Finally, if all the snbstances present were dextrine, I would not be able to tell theoretically what its rotating power would be, since we have just seen that dextrine is assigned different degrees of activity by different authors. As a mean of these I think we may place dextrine a_j =176°, although I do not wish to be understood as stating its real value.

This would give a total angular deflection of 29° nearly. The problem of analysis is therefore at the present time in the following *status :*

1. In every amylose there are present at least three kinds of optically active matter, viz., dextrose, maltose and dextrine.

2. There are present in every amylose two kinds of reducing matter, viz., dextrose and maltose.

3. A high reducing power shows a high percentage of dextrose present.

4. A high rotating power, which is always shown when the reducing power is low, indicates a large percentage of maltose and dextrine.

5. From a very extended series of analyses, I will say that there is no method known which will give reliable, or rather exact, numbers for the percentage of the different constituents.

6. I propose to attempt the accomplishment of this very desirable result by first polarizing and then reducing the sample, and then repolarizing the residue. The difficulties of preserving a standard volume and of getting a solution sufficiently clear for polarization have prevented me hitherto from obtaining any results. I hope to overcome these troubles and to establish thereby a reliable optical method of determining the percentages of dextrose, maltose and dextrine in amylose.

Prof. Cantoni has been appointed director of the meteorological observatory, to be erected at Pavia. Observations are to be made on the influences of light, heat, and electricity upon vegatable growth, in addition to the ordinary meteorological and magnetical work.

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[20] Zeitsch. f. d. Gesch. Brauwesen, 1879, No. 11, p. 339.
(21). (These proceedings Vol. 28, p. 317.)

[19] Ding. Jour., CLV., p. 41.