



LXIII. Water-analysis. Determination of cellulose and modified cellulose in drinking-water

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LXIII. *Water-Analysis. Determination of Cellulose and modified Cellulose in Drinking-Water.* By J. A. WANKLYN and W. J. COOPER*.

THE ammonia process of water-analysis provides an index to the nitrogenous organic matter in drinking-water; but it does not deal with the non-nitrogenous organic matter, and some method whereby the non-nitrogenous organic matter might be reached is still a desideratum. This desideratum the Frankland-and-Armstrong combustion process aims at supplying, but (as is now pretty well understood among chemists) fails to supply. The old permanganate process, which we owe to Forchhammer, which notoriously failed in practice, would accomplish the object in view if the practical difficulties which beset it could be overcome.

If the quantity of oxygen required to oxidize cellulose or sugar be calculated, it will be seen that rather more than its own weight of oxygen is consumed by a given weight of cellulose or sugar. The estimation, therefore, of cellulose or sugar by means of the oxygen consumed in burning down to carbonic acid and water would rank along with the more advantageous operations of analytical chemistry.

Forchhammer's process, as hitherto practised, does not effect any thing approximating to complete oxidation down to carbonic acid and water, as was illustrated by some experiments published by Frankland and Armstrong in 1868 (*vide Chem. Soc. Journ.* vol. vi. p. 82), which I quote:—

Name of substance (30 parts dissolved in 1,000,000 parts of water).	Oxygen absorbed during six hours.	Oxygen required for complete oxidation.
Gum arabic . . .	0·35	35·5
Cane-sugar . . .	0·15	33·7
Starch	0·30	33·5

showing that, as usually carried out, the oxidizing process does not avail to accomplish more than about one hundredth part of the task set before it. The manner in which the permanganate of potash is applied to drinking-water in Forchhammer's process is by simply mixing measured volumes of the permanganate-solution with a known volume of the water to be operated upon, and observing how many volumes are decolorized by the action of the organic matter. A quantity of

* Communicated by the Authors.

acid is usually added to the water, and some length of time allowed to elapse before making the final readings.

The modifications whereby we have completely altered the character of the Forchhammer process are as follows :—

Instead of simply mixing the standard solution of permanganate with the water to be examined, we *distil* a given volume of the water (say, 1 litre) with a considerable excess of standard solution of permanganate, and thereby get more oxidizing action than in the ordinary operation. We find advantage in having the liquid strongly alkaline during the distillation ; but we render acid before titrating the residue.

The following are the working details :—

A standard solution of permanganate of potash (strength 0·4 milligramme of active oxygen per 1 cubic centim.) is prepared.

A standard *reducing-solution*, containing protosulphate of iron, and of such a strength that each cubic centim. exactly corresponds to the permanganate solution, is also prepared.

Solution of caustic potash, 5 per cent., is prepared.

Diluted sulphuric acid (1 volume of oil of vitriol with 9 volumes of water) is prepared.

These solutions having been got into order, the operator may begin.

A litre of the water to be examined is placed in a retort which is conveniently mounted, just as in the ordinary course of water-analysis by the ammonia process. Into the retort the operator drops with a graduated pipette 5 cubic centims. of the solution of potash (to render the water alkaline), and then 5 cubic centims. of very carefully measured standard solution of permanganate ; and then the contents of the retort are boiled by means of a large Bunsen burner, and the water is rapidly distilled off. After the distillation has advanced, it will very often happen that the permanganate will show signs of having been used up : if that happens, a second, and, if necessary, a third 5 cubic centims. of standard permanganate must be dropped into the retort, and the distillation continued until 800 or 900 cubic centims. have distilled over, and only some 200 or 100 cubic centims. of liquid remain behind in the retort. When the distillation is stopped, the observation that the contents of the retort still contain unacted-upon permanganate must hold good ; otherwise too little permanganate would have been employed in the operation.

The manner of finishing the operation is of a very obvious description. The operator acidifies the residue in the retort (*i. e.* he adds 10 cubic centims. of the diluted sulphuric acid) ; then he adds a measured quantity of iron-solution, taking care

to use a considerable excess; and finally he titrates back with the standard permanganate, and thus becomes provided with numerical data expressing how much oxygen has been used up by the litre of water.

We have just directed that 1 litre of water should be taken for an operation; and that quantity will be found convenient; but, as will strike the chemical reader who reflects on the conditions which limit the accuracy of analytical processes, there is nothing to forbid resort to a much larger scale if the highest degree of delicacy and accuracy were desired. In such a case *ten litres successively* introduced into the same retort would be advantageous.

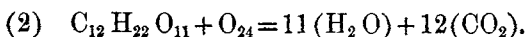
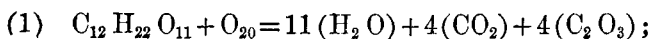
We have worked on 4 litres *successively* introduced.

On applying the process, we have obtained the following results :—

	Oxygen consumed per litre of water.
Excellent distilled water	0·13 milligram.
Thames water by a Water Company	2·30 „

which show a striking difference between common drinking-water and water of the purest description.

Experiments on dilute solutions of cane-sugar have given results approximating very well to theory. Cane-sugar, indeed, we have subjected to a course of oxidations ranging over a very varied scale—from 5 milligrms. to upwards of 10 grms., at a single operation. The reaction is precise, viz. :—



Equation (1) is valid if the action be restricted to the alkaline solution; and equation (2) is valid when the oxidation has been carried forward so as to be finished in the acid liquid. We postpone the publication of the experiments, and content ourselves with the general statement that we can by means of solution of permanganate effect perfect combustions of a number of organic compounds, the combustions taking place whilst the organic matter remains in aqueous solution.

Westminster, May 1878.