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QUANTITATIVE DETERMINATION OF UREA BY ALKALINE HYPOCHLORITES AND HYPOBROMITES.

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The determination of the amount of urea present in the urine by the volume of nitrogen evolved under its decomposition by sodium hypochlorite, was first proposed by Davy (*Philosoph. Mag.*, 1854, p. 385). According to his observations, the quantity of nitrogen evolved corresponded very closely to the calculated amount present in the urea. But according to the observations of M. Leconte (*Chem. Gaz.*, 1858, 433), with a different form of apparatus, under the action of this reagent only about 92 per cent. of the nitrogen is evolved.

Messrs. Russell and West proposed to substitute for the hypochlorite an alkaline solution of sodium hypobromite, and advised a special form of apparatus for the application of the test (*Jour. Chem. Soc.*, Aug. 1874, and *Am. Jour. Med. Sci.*, April 1875, p. 531). These observers however obtained only about 94 per cent. of the total nitrogen.

Under the action of either of these reagents, as is well known, the urea is resolved into carbon dinoxide, water, and free nitrogen, thus:—

$$CN_2H_4O + 3NaBrO = CO_2 + 2H_2O + N_2 + 3NaBr.$$

Theoretically, therefore, the whole of the nitrogen should be evolved, but it is generally admitted that in practice this is not the case. According to at least one observer, this loss is due to a portion of the nitrogen being retained as a cyanate; whilst according to another it is retained as a nitrate.

To remedy this defect, M. Mehu advised to mix either glucose or cane-sugar with the urine before adding the hypobromite, when the whole of the nitrogen would be set free (*Compt. rend.*, 1879, 175). But, according to M. Esbach (*Ibid.*, 417), and also to M. Jay (*Bull. Soc. Chim.*, 1880, 105), a solution of glucose *alone* evolves some gas under the action of the reagent. Again, M. Fauconnier obtained in the presence of glucose, from a given quantity of urea, the theoretical amount of nitrogen; whilst in the presence of cane-sugar he obtained only 94 per cent. of the total nitrogen (*Ibid.*, 102).

According to my own experiments, when a solution either of cane-sugar or of glucose is mixed, at least in certain proportions, with the hypobromite reagent, without the presence of urea, the temperature of the mixture increases and its yellow colour is gradually discharged, but *no gas is evolved.* When 1 gramme of cane-sugar in 5 c. c. water was added to 10 c. c. of the reagent (prepared as stated hereafter) at 21.1° C. (70° F.), the mixture at the end of twenty-five minutes acquired a temperature of 30° C. (86° F.), after which the temperature slowly fell.

In a similar experiment with glucose, the temperature increased from 21° C. (69.8° F.) to 35.5° C. (96°. F.) in ten minutes, which was the maximum reached. It was also observed that the presence of large excess of glucose entirely prevented the decomposition of urea by the hypobromite reagent.

For the purpose of examining the accuracy of this test for urea, without the presence of cane-sugar or glucose, the form of apparatus, at least in principal, advised by R. Apjohn (*Chem. News*, Jan. 1875, 37), was employed. This consists of a wide-mouthed bottle in which is placed the reagent, and also a small test-tube, for containing the urea solution, of about 10 c. c. capacity and of such length as to stand inclined in the bottle. The mouth of the bottle is closed with a rubber stopper carrying a glass tube, by which it is connected by rubber tubing to a graduated burette divided into $\frac{1}{10}$ c. c. and suspended in a long cylinder of water from an adjustable arm.

The urea solution is placed in the small tube within the charged bottle, the apparatus closed, and when there is no longer any change in the height of the column of liquid within the graduated tube, this is so adjusted that the surface of the contained liquid exactly coincides with that in the cylinder. This point, the temperature, and in exact experiments the barometric pressure being noted, the urea solution is mixed with the reagent by inclining the bottle and gently shaking the mixture. As the evolved nitrogen collects in the graduated tube, the latter is gradually raised to relieve the contained gas from the increased pressure. When the evolution of gas has entirely ceased and there is no longer any change in the volume of gas, the tube is finally adjusted and the exact volume noted. The reagent employed was prepared, as first advised by Messrs. Russell and West, by dissolving 100 grains caustic soda in 250 c. c. water, and adding to the cooled mixture 25 c. c. bromine. In applying the reagent it was diluted with a volume and a half of pure water.

With this arrangement a series of experiments was performed employing 1 c. c. of a standard solution of pure urea varying in strength from one to six per cent., variously diluted, and added to varying quantities of the reagent. These experiments gave different results, in some only about 90 per cent., and even less, of the nitrogen being evolved, while in others a larger proportion was obtained, and in still others the *whole* of the nitrogen was set free. It was finally observed that under certain conditions the whole of the nitrogen is uniformly eliminated. These conditions are:—

1. The reagent should be freshly prepared.
2. The urea solution should be wholly added to the reagent, none of the latter being allowed to mix with the urea solution in the containing tube.
3. The amount of urea operated upon should not exceed one part to about twelve hundred parts of the diluted reagent.

Moreover, the diluted urea solution should be added in small portions at a time to the reagent, thoroughly mixed, and the effervescence allowed to cease before any further addition of urea. So, also, it would appear, at least when comparatively large quantities of urea are present, that the surrounding temperature should not be less than about 20° C. (68° F.).

In the practical application of the test, if a two per cent. solution of urea is under examination, 1 c.c. of the solution, diluted with from 5 to 10 c. c. water, is placed in the containing tube, and the mixing bottle charged with 10 c. c. of the reagent diluted with 15 c. c. water; whereas, for 1 c. c. of a four per cent. solution of urea, similarly diluted, not less than about 50 c.c. of the diluted reagent should be employed.

In a final series of experiments, in which the above conditions were observed, the temperature being noted to $\frac{1}{10}$ degree, and the results reduced to the standard temperature (0° C.) and barometric pressure (760 mm.), the following average results were obtained:—

Urea employed.	Nitrogen evolved =
10 milligrammes,	9.98 mgrm. urea.
20 "	20.07 "
30 "	29.95 "
40 "	39.88 "

In these experiments it was assumed that 1 gramme of urea contains 372 c.c. nitrogen, measured at 0° C. and 760 mm. barometric pressure; or, that each c. c. of nitrogen evolved, measured under the conditions stated, represented .002688 gramme urea.

During these investigations it was observed, in cases in which the whole of the nitrogen was not evolved, that so long as the conditions remained the same, the relative proportion of the nitrogen eliminated was pretty uniform. Hence, if the volume of nitrogen evolved from a known quantity of urea under certain conditions, or by a given form of apparatus, be determined, the result may be taken as the basis for the determination of the urea in the urine with sufficient accuracy for clinical purposes.

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