THE PHOTOMETRIC DETERMINATION OF BISMUTH IN URINE

NORBERT BENOTTI,* B.S., M.S., AND FRANCIS M. THURMON,* B.S., M.D.

(Received for publication April 30, 1940)

The clinical determination of bismuth in urine has enjoyed many and various procedures. The ordinary Duboscq colorimeter has served as a means to estimate the yellow color produced when potassium iodide is added to a salt of bismuth. Since advances in the use of the photoelectric colorimeter have been made, it has become possible to measure the intensity of a yellow solution with greater accuracy and ease. Bismuth therapy in syphilis led to a study of urinary excretion curves, which are said to reflect the relative amount of elemental bismuth in the circulation. In order to have accurate excretion curves it is necessary to have a method for the determination of bismuth which is accurate and simple for routine clinical tests.

The yellow color produced by the double salt of bismuth in combination with potassium iodide was described by Leonard (1), and used by Mehrtens, Hanzlik, and Marshall (2). Sollmann (3) and his associates have determined bismuth with a Duboscq colorimeter as a comparator, in amounts varying from 0.5 down to 0.005 mg. We were unable to reproduce these figures and found it very difficult to compare such light yellow solutions in our Duboscq colorimeter. Lehman, Richardson and Hanzlik (4) have used permanent standards, made from various dilutions of potassium chromate, and measured the unknown against the appropriate standard. They report an accuracy down to 0.001

* From the Chemistry Laboratory of the Joseph H. Pratt Diagnostic Hospital, and the Clinic of Dermatology and Syphilology of The Boston Dispensary, units of the New England Medical Center, and the Department of Medicine, Tufts College Medical School, Boston.
mg. of bismuth. Oral administration of bismuth compounds led to a rapid clinical method described by Hanzlik, Lehman, Richardson and Van Winkle (5). This method is not satisfactory for studying the excretion curves because intermediate quantities of bismuth have to be estimated by interpolation.

Our present paper came about from the difficulty we had in comparing such solutions. This led to the simple determination by photoelectric means of the intensity of the yellow color. Our method of obtaining the yellow color is a slight modification of the method of Lehman, Richardson and Hanzlik (4). We have made use of the Cenco Photelometer (6) for the estimation of the yellow color. A calibration curve eliminates the standards and simplifies the procedure.

The calibration curve was made by using various dilutions of a standard solution of bismuth with the necessary reagents and the respective transmissions were determined against distilled water as a blank. Concentrations from 0.025 to 0.175 mg. were used in making up the calibration curve. The curve in figure 1 represents the average of three determinations. The standard solution of bismuth was made by dissolving 0.2321 gm. of bismuth nitrate containing 5 molecules of water, in 10 cc. of dilute nitric acid 6N and made up to 1 liter with distilled water.
Through the courtesy of Professor Hardy's Color Measurement Laboratory at the Massachusetts Institute of Technology we were able to obtain the spectral distribution curves of the colored bismuth solution, and the Cenco filter #1. These curves appear in figure 2. It seems quite evident, to be consistent with theoretical colorimetry, we should have used a filter which had maximum transmission at 460 m\(\mu\). However, we chose to use the Cenco filter #1 because the spectral curve of the bismuth shows a dip at 460 m\(\mu\) and a possible dip in the ultra-violet. A spectral curve of the Cenco filter #1 shows that it extends into the ultra-violet in a similar manner to its extension into the visible spectrum. On this basis we chose the Cenco #1 filter, and thus the procedure was calibrated for this filter.

Reagents: Conc. sulfuric acid, conc. nitric acid, superoxol 30% caprylic alcohol, 0.4 N potassium iodide (freshly prepared).

Acidified sodium sulfite solution: 1 gm. of sodium sulfite is dissolved in 150 cc. of water and 0.8 cc. conc. sulfuric acid is added and made to 200 cc. with water.
Method. A suitable quantity of urine, which was usually 50 cc., containing between 0.05 to 0.175 mg., was used. The urine was placed in a 300 cc. Kjeldahl flask in the hood on a sand bath. 5 cc. of conc. sulfuric and 10 cc. of conc. nitric acid were added, followed by 5 cc. of 30% superoxol, and 1 cc. of caprylic alcohol. The urine was heated to boiling and when white fumes appeared, nitric acid was cautiously added until the oxidation was complete and the remaining solution was water-clear. Several additions of nitric acid were sometimes necessary. Superoxol was added drop by drop and allowed to run down the walls of the flask to insure complete removal of the oxides of nitrogen. If the oxides of nitrogen are not removed completely they will cause the liberation of the iodine from the potassium iodide and make the results erroneous. After the flask has cooled the contents are transferred quantitative to a 25 cc. glass-stoppered cylinder with distilled water, and the volume made to 21 cc. by successive washings. The cylinder will become hot due to the dilution of the sulfuric acid, and after cooling 4 cc. of the acidified sulfite mixture is added. This is followed by freshly prepared 0.4 N potassium iodide, which produces the yellow color. The transmission of the solution is determined in the photoelectric colorimeter and from the calibration curve the amount of bismuth in the sample is determined. If a cloudy solution results after the ash solution is diluted it is necessary to centrifuge the mixture before determining the transmission.

Discussion. We employed 0.4 N potassium iodide because by experimentation we were able to show that 0.4 N potassium iodide gave the optimum color for a definite amount of bismuth, which was 0.1 mg. The test solution contained a constant amount of bismuth, with the other necessary reagents and 5 cc. of varying normality of potassium iodide. The blank contained all the reagents, and
5 cc. of varying normality of potassium iodide with no bismuth. Figure 3 shows the decrease in transmission with increasing normality of potassium iodide up to 0.4 N potassium iodide where the transmission stays constant. Therefore we have elected to use 0.4 N potassium iodide as the proper concentration to give the maximal amount of color.

The color is stable and remains constant for at least one-half hour and the transmission can be determined within this period of time.

RECOVERY EXPERIMENTS

In table 1 is shown the recovery of bismuth after the addition of known amounts of bismuth to urine originally bismuth-free.

<table>
<thead>
<tr>
<th>BISMUTH ADDED</th>
<th>BISMUTH OBSERVED</th>
<th>RECOVERY</th>
<th>ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg.</td>
<td>mg.</td>
<td>per cent</td>
<td>per cent</td>
</tr>
<tr>
<td>0.175</td>
<td>0.185</td>
<td>105</td>
<td>+5.6</td>
</tr>
<tr>
<td>0.150</td>
<td>0.15125</td>
<td>100.8</td>
<td>+0.8</td>
</tr>
<tr>
<td>0.125</td>
<td>0.12625</td>
<td>101.0</td>
<td>+1.0</td>
</tr>
<tr>
<td>0.100</td>
<td>0.1025</td>
<td>102.5</td>
<td>+2.5</td>
</tr>
<tr>
<td>0.075</td>
<td>0.075</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>0.050</td>
<td>0.050</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Average error................................. +1.6%

CONCLUSION

1. A simple, rapid and accurate method for the photo-electric determination of bismuth in urine is outlined.

2. The average error of the method is +1.6% which is within the range of the colorimeter.

3. 0.4 N potassium iodide is essential for the development of the maximal color from a constant amount of bismuth.

4. The color is stable and the transmission may be made any time up to one-half hour after the addition of potassium iodide.

BIBLIOGRAPHY


NOTE

The editor wishes to call attention to the fact that the article on "Nails and Nail Changes. III. Brittleness of Nails (Fragilitas Unguium)" by Dr. Henry Silver and Mr. Bernard Chiego, appearing in the October issue of THE JOURNAL OF INVESTIGATIVE DERMATOLOGY, was reprinted without permission by the journal Drug and Cosmetic Industry. This journal did not receive the permission of the publishers, the authors or of the editors, and this reprinting was, therefore, a clear infringement of copyright. The attention of the editors of Drug and Cosmetic Industry was first called to this fact by the authors, and in view of the circumstances, they have apologized for the infringement and have agreed to publish a statement to this effect in a conspicuous manner, stating that the article was reproduced without the foreknowledge of anyone connected with the JOURNAL OF INVESTIGATIVE DERMATOLOGY or of the authors concerned. In view of this, it was decided not to proceed at this time against the Drug and Cosmetic Industry journal for the infringement of copyright. Articles appearing in the JOURNAL OF INVESTIGATIVE DERMATOLOGY may not be abstracted directly or indirectly, in whole or in part, without the express permission of the publishers, editors or authors, for any commercial or promotional purpose whatsoever. If in the future there should occur any infringement of copyright of articles appearing in the JOURNAL OF INVESTIGATIVE DERMATOLOGY, the publishers and the editor will be constrained to invoke the statutory laws covering copyright material.