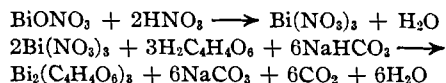


loids extracted is not affected; that, in the case of belladonna, at least, a slightly greater quantity of alkaloid can be extracted by means of the automatic devices than by means of a separatory funnel and that in view of the high efficiency already obtainable with the simple types (reported for nux vomica and belladonna), there would appear to be no practical advantage in using the more complicated apparatus for extracting nux vomica and belladonna alkaloids.

THE COMPOSITION OF THE BISMUTH SALT IN GLYCERITE OF BISMUTH.

BY C. C. GLOVER AND THEODORE F. THORSBERG. (1)

An attempt has here been made to determine the chemical composition of the bismuth salt in solution in the glycerite of bismuth of the "National Formulary IV." In the examination of the literature for previous work done on the subject of bismuth salts and chiefly that of bismuth tartrate, we found that a great deal of work had been done, but that few definite results had been recorded. Dr. Ruddiman in his "Whys in Pharmacy" gives the following chemical equation for the reaction taking place when the preparation is made up.



The first one to write about a bismuth tartrate was Schwarzenberg, (2) who obtained a white crystalline substance from Bi_2O_3 by digesting $\text{Bi}(\text{NO}_3)_3$ with $\text{NaC}_2\text{H}_3\text{O}_2$ and $\text{KHC}_4\text{H}_4\text{O}_6$. By this manipulation the bismuth went into solution. He concentrated the filtrate on the water-bath and obtained a white crystalline powder which he spoke of as bismuth potassium tartrate, giving it the formula $\text{C}_4\text{H}_4\text{O}_6\text{KBiO}$. R. Schneider (3) made a hot mixture of a moderately concentrated solution of five parts Bi_2O_3 in nitric acid with a concentrated solution of four parts $\text{KHC}_4\text{H}_4\text{O}_6$ in water. On cooling, small crystals formed which he gave the formula $\text{Bi}_2(\text{C}_4\text{H}_4\text{O}_6)_3 \cdot 6\text{H}_2\text{O}$, which he called a neutral bismuth tartrate. Later, Baudran (8) prepared salts of tartaric acid and a potassium salt with bismuth from freshly prepared $\text{Bi}(\text{OH})_3$, which was prepared by treating a bismuth solution with alkali at ordinary temperature. He added to this, tartaric acid and obtained a bismuth tartrate which he gave the formula $\text{BiOC}_4\text{H}_5\text{O}_6 \cdot \text{H}_2\text{O}$. This precipitate was soluble in two hundred twenty eight parts of water. It was in the form of small needles and was decomposed by alkalies. If the alkaline solution is treated with a large amount of potash lye, the bismuth potassium tartrate will crystallize out. He gave it the formula $\text{K}(\text{BiO})\text{C}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$.

Later, A. Rosenheim and W. Vogelsang (9) worked on the bismuth and alkali bismuth tartrate, since those previously engaged in the work had not come to any definite results. In order to make a nitric acid free bismuth tartrate, the Schneider salt was added in small portions to a boiling concentrated solution of tartaric acid. When the salt had all gone into solution, upon cooling, a nitric acid free bismuth tartrate was formed in beautiful, glazy, crystals. The crystals dissolved in alkali, giving a clear solution, and produced a basic salt when added to water. Its formula was given as $\text{Bi}(\text{C}_4\text{H}_4\text{O}_6)\text{C}_4\text{H}_5\text{O}_6 \cdot 2\text{H}_2\text{O}$. Rosenheim and Vogelsang could not

produce the substance that Schwarzenberg and Baudran had written about. They could not produce the sodium compound of bismuth tartrate in crystalline form.

H. Telle (7) prepared a bismuth tartrate by Baudran's method by treating twenty parts of freshly prepared bismuth hydroxide with a concentrated solution of twenty of tartaric acid. Small needle-like crystals formed, which were washed with alcohol. The substance was scarcely soluble in water. Since Baudran salt was soluble in two hundred twenty-eight parts of water, Telle made the statement that he had a different salt than Baudran had written about. The percentage of bismuth in this salt according to the results of analysis was 41.75.

We first prepared a glycerite of bismuth, following closely the directions given in the N. F. IV, and a number of analyses were made on it, determining both the bismuth, tartrate and sodium. The procedure followed for the analysis was as follows: (6) A sample of the glycerite was made up and a couple of drops of HCl were added, and the whole diluted with water. Then a rapid stream of H_2S was passed in until all the bismuth was precipitated as Bi_2S_3 . This was filtered and the precipitate washed and dissolved in fifty per cent nitric acid. The excess nitric acid was neutralized with dilute ammonia, and then the bismuth precipitated with ammonium carbonate T. S. An excess should be avoided, as the precipitate is soluble in the reagent. The whole was heated on the steam-bath for an hour, then filtered, and the precipitate dried. The filter paper was charred, and ignited apart from the rest, and when ignited, a few drops of nitric acid were added, and the whole cautiously evaporated. Then the rest of the precipitate was added, and the whole ignited at a dull red heat to a constant weight. This was weighed as Bi_2O_3 . The filtrate from the H_2S precipitate was evaporated to dryness on the steam-bath, then taken up with ten cc. water, and an excess of potassium carbonate added. The excess potassium carbonate was neutralized with glacial acetic acid, and five cc. more added in order to form potassium bitartrate. This was precipitated by adding fifty cc. of ninety-five per cent alcohol, stirring vigorously during the addition. After standing for ten to twelve hours, it was then filtered and the precipitate washed free from acetic acid, with ninety-five per cent alcohol. The precipitate was dissolved in boiling water and titrated while hot with $N/10$ KOH, using phenolphthalein as indicator.

The method for determining sodium in the solution is as follows: Precipitate the bismuth from a sample as Bi_2S_3 , and filter off the precipitate and wash. Evaporate the filtrate to a small bulk, transfer to a tared crucible, and evaporate to dryness; then add one-half cc. concentrated H_2SO_4 and cautiously evaporate. Ignite and weigh the residue as Na_2SO_4 . From this weight calculate the percentage of sodium. The results of the analysis on the glycerite were as follows: Percentage of bismuth found was 8.11, percentage of tartrate was 14.66, ratio of bismuth to tartrate is 1 to 1.75. The free acid in the glycerite was determined and calculated as tartaric acid. This gave 3.84 per cent. The results of this analysis indicate the salt in solution is not a normal bismuth tartrate, as in that case, the ratio of bismuth to tartrate would be as 2 is to 3. In the preparation of glycerite of bismuth, a bismuth salt is formed as a magma, and at this point the magma is dried and the percentage of bismuth and tartrate determined. The analysis gave 56.27 per cent bismuth, and 41.57 per cent tartrate. Again not a simple ratio. When the glycerite was evaporated to dryness on the steam-bath, the residue

appeared as a varnish-like mass. Upon powdering, a sandy-like powder was obtained, and the bismuth and tartrate determined. The method for determining bismuth in this case differed from the previous method. The residue was weighed out, then charred at a low heat, and then ignited at the full heat of the Bunsen burner. The residue was weighed as Bi_2O_3 . The percentage of bismuth found was 52.28 and the percentage tartrate was 40.79. When a sample of 20 cc. of the glycerite was taken and an equal volume of ninety per cent alcohol added, a white precipitate was thrown out. Upon stirring the contents, a heavy plastic mass was formed and also a fine crystalline precipitate in suspension. The two were separated and dried. Each showed a crystalline structure when put under the microscope. The analysis of the plastic mass formed by the alcoholic precipitation showed it to contain 27.05 per cent tartrate and 53.62 per cent bismuth. Analysis of the crystalline suspension showed it to contain 83.29 per cent of tartrate and 17.47 per cent of bismuth. The precipitates formed were readily soluble in cold and hot water. A solution of these precipitates in distilled water was neutral to methyl orange.

When the glycerite was diluted with a volume of water and this added to alcohol so that the percentage of alcohol at the end was 50 per cent, a precipitate formed which was different in appearance from the precipitate obtained with the concentrated alcohol. The precipitate was not so crystalline and did not settle nor filter readily. When it was dried at 65 degrees it first formed a syrupy liquid and upon further drying, became a transparent mass. When powdered, it became a white, granular powder. It was slightly soluble in cold water, readily soluble in hot water and was neutral to methyl orange. It contained 24.66 per cent tartrate and 49.59 per cent bismuth. When some of the precipitate formed by the precipitation in fifty per cent alcohol was spread on a glass plate and dried in a desiccator, it first formed a transparent layer and on further drying, formed thin, white scales which could easily be powdered. It was slowly soluble in cold water, readily soluble in warm water and neutral to methyl orange. It contained 50.31 per cent bismuth, and 25.12 per cent tartrate.

From these analyses we have drawn the conclusion that when a sample of glycerite is precipitated with alcohol in various concentrations above fifty per cent, the percentage of bismuth remains fairly constant, but the percentage of tartrate varies, depending on the concentration of the precipitating agent. The tartrate percentage decreases with the decrease in the percentage of alcohol as the precipitating reagent. It would seem then, that if we used still more dilute solutions we would reach a certain concentration where the precipitate thrown down would be only that of the normal bismuth salt. Analyses seem to indicate that in higher concentrations of alcohol, the precipitates formed consist of a definite bismuth tartrate with tartrate carried down in loose combination with the bismuth salt or carried down as some other tartrate. On this supposition, we then precipitated out salt from the glycerite of bismuth using concentrations of alcohol varying from absolute to twenty per cent. The method of precipitation in each case was the same.

The results of these determinations using different concentrations of alcohol are tabulated as follows:

% Alcohol.	Nature of precipitate.	Bismuth.	Tartrate.	Ratio.
99	white crystalline mass	45.67	48.99	1-1.12
95	white crystalline mass	46.07	54.56	1-1.19
75	semi-crystalline mass	51.21	47.46	1- .925
50	gray magma	54.45	43.51	1- .8
40	gray magma	55.82	39.98	1- .715
30	light magma	56.49	39.66	1- .705
25	light magma	56.26	38.56	1- .71
20	no precipitate, only cloudy			

It will be seen from the results of the foregoing analyses that the ratio of bismuth to tartrate is in no case a simple ratio, so that under the conditions of our investigations, no simple bismuth tartrate was formed. If we examine a number of possible bismuth tartrates and oxytartrates, and from their composition, calculate the ratio of bismuth to tartrate, we are led to conclude that what we have is not a simple salt, but a mixture of tartrates, and oxytartrates. The ratio of bismuth to tartrate in the normal bismuth tartrate is as 2 is to 3, as is seen from the formula, $\text{Bi}_2(\text{C}_4\text{H}_4\text{O}_6)_3$. There are two possible oxytartrates of bismuth. One $\text{Bi}_2\text{O}(\text{C}_4\text{H}_4\text{O}_6)_2$, where the ratio of bismuth to tartrate is 1 to 1. The other, possible tartrate would have a formula $\text{Bi}_2\text{O}_2(\text{C}_4\text{H}_4\text{O}_6)$, where the ratio of bismuth to tartrate is 1 to 0.500. If we examined the ratios of bismuth to tartrate as found in our analyses, we would see that they vary from 1 to 1.12, and 1 to 0.70, and that these ratios lie within the limits of the ratios of 1 to 1.5 and 1 to 0.5, so that our precipitates would consist of not a simple compound, but a mixture of one or more of the tartrates and oxytartrates. It will be noticed that the total percentage of bismuth and tartrate decreases from one hundred per cent to ninety-five per cent as we decrease the alcoholic strength from one hundred to twenty-five per cent. We must conclude then, that as we increase the dilution, we increase the amount of the two oxytartrates which would lower the total percentage of bismuth and tartrate present. We made a number of sodium determinations on these samples and in each case, the percentage was too low to justify our considering a sodium salt as present.

We tried a number of methods for the estimation of tartrate and the one that gave the best results was that of A. C. Chapman and Percy Whitteridge. (4) The method which they have developed and which we found to give accurate results as well as a great time saver over the bi-tartrate method is as follows: They have found that tartaric acid and tartrates may be completely precipitated from solution by a bismuth salt. The bismuth salt is insoluble in dilute acetic acid, and may be readily oxidized by KMnO_4 . According to Peau de St. Giles, (5) the oxidation of tartaric acid by KMnO_4 in the presence of a mineral acid is as follows:



and the changes during oxidation of the bismuth salt are apparently similar. For the estimation of tartaric acid and tartrates by this method, four reagents of definite strength are required. The bismuth reagent is made by dissolving thirty grams of $\text{Bi}(\text{NO}_3)_3$ in twenty cc. glacial acetic acid, and diluting to three hundred cc. with water. If a precipitate forms after dilution, it should be removed by filtration before use. The other solutions necessary are as follows: H_2SO_4 —10 per cent by volume; KMnO_4 —1 per cent solution of the pure salt; $\text{H}_2\text{C}_2\text{O}_4$, (oxalic

acid), 19.9 grams of pure salt per litre. The procedure of the method is as follows: Weigh out a sample which contains about one-tenth of a gram of tartaric acid and precipitate with the bismuth reagent, adding excess. Filter and wash the precipitate and dissolve in 50 cc. of the hot H_2SO_4 , then run in the KMnO_4 solution until an excess of not over five-tenths of a cc. is added. Then titrate back with the oxalic acid solution. It has been found by trial on various tartrates that fourteen cc. of the KMnO_4 solution is equivalent to one-tenth of a gram of tartaric acid. The bismuth precipitate is very soluble in nitric acid, so it is very essential to see that there is no nitric acid present. For our work, the substance under consideration was in the form of a bismuth salt of tartaric acid, so that it was unnecessary to prepare the bismuth reagent or use it in the procedure. We weighed out a sample of the bismuth salt and then dissolved it directly in the hot H_2SO_4 and then titrated as previously stated. Upon working with known solutions, we found that 14 cc. of our KMnO_4 was equivalent to one-tenth of a gram of tartaric acid. The authors of the article have stated that since the percentage of bismuth in the precipitates vary, it would probably not be possible to make the process directly volumetric.

SUMMARY.

The interpretation of a large number of analyses leads to the conclusion that the salt present in the glycerite of bismuth N. F. IV is not a simple tartrate but a mixture of tartrate and oxytrates.

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