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The analytical determination of thorium with O-benzoyl bensoic acid.

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THE ANALYTICAL DETERMINATION OF THORIUM WITH O-BENZOYL BENZOIC ACID

by

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INDEX

INTRODUCTION

Ever since the chemists have realized that the earth on which we live was composed of many elements, they became aware that methods of separation and determination for these elements became of great importance in order to identify them. If one examines the literature, he is quickly convinced that qualitative and quantitative procedures for determination of these elements which now exist in nature are in great numbers.

Yet as the field of inorganic and analytical chemistry is being explored, some of the procedures and methods of yesterday become "have beens" of today because some research chemist has developed a method which surpasses older methods in speed and accuracy or has some practical advantage in our industrial age.

All research analytical chemists who work on methods of analysis always work with the same fundamental idea in mind. In investigating a new method of analysis, it should be simple and fast; it must be equally or more accurate than existing methods; the number of operations in the analysis must be at a minimum in order to reduce the possibilities of errors; the analysis must be cheap when it must be used in industry.

The purpose of this research is to investigate a method which came to the mind of the author for the analytical determination of thorium with the use of an organic acid other than those already existing in the literature. This method is primarily of a gravimmetric nature.

The problem was attacked by listing several possibilities and determining qualitatively whether or not a reaction took place which gave an insoluble residue. It was found that several of the cyclic organic acids gave positive results.

Keeping in mind the facts which make a method of analysis worth while, the author has chosen the cyclic organic acid, o-benzoyl benzoic acid, for investigating its quantitative reaction with a thorium solution. This acid was chosen because it has a high molecular weight; it is easily purified and its cost is comparatively low.

Whether or not the following procedure will compare or surpass existing methods of analysis for thorium must be confirmed by future investigators. However, the author has compared his method with the sebacic acid method of James and finds that it compares in accuracy within the limit of errors.

The author has made a thorough investigation of the solubility of the thorium organic salt at different hydrogen ion concentrations, in order to determine at what pH value the salt is most insoluble.

Since the organic acid used in this analysis does not give insoluble residues with all of the metallic elements tried, the author has attempted to determine the molecular weight and molecular structure of the salt in order to establish a theory as to why other metallic elements do not react in a similar way as thorium.

In order to confirm the results of this molecular weight investigation, the author has determined the molecular weights of thorium salts of other organic acids which have analogous structure to o-benzoyl benzoic acid.

The results of the investigation will show that the method of analysis will compare in accuracy with existing methods and will show that the molecular structure of the salt is not what would be predicted by the organic chemist.

OCCURRENCE AND USES OF THORIUM

Thorium, which is the heaviest metal of the rare earth series, was identified by Berzelius in 1829 as occurring in the form of silicate in the mineral, thorite, obtained from the island of Löv-ön near Brevig, Norway.

Thorium[1] occurs as a constituent in most rocks of volcanic origin. It is present as the main constituent in thorite, orangite and their alteration products: machentoslite, auerlite, calciothorite and thorianite. The only commercial source of thorium, however, is monazite sand, which contains from 2 to 10 p.c. ThO_2.

The largest use of thoria is in the manufacture of incandescent mantles. The salts of thorium are used in Rontgen ray research. Thoria has found use in the fabrication of fireproof articles and highly refractory materials.

Metallic thorium either alone or alloyed with other metals is utilized as a reducing agent in metallurgy. Alloys of tungsten and thorium are used for filaments of incandescent electric lamps. The additions of thorium prevents crystallization and imbrittlement of the filament. Thoria has found use in organic chemistry; namely as a catalyst in preparations of ketones; alcohols are easily converted into ethers and olefines with the

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1. Thorpe E. Dictionary of Applied Chemistry, Vol. 2 Pages (583-584), 35, (1921)

use of thoria. Alcohol and ammonia vapors produce primary amines when these vapors pass over heated thoria.

TABLE 1

	pH(1.2-2.8) cold sol.	pH(1.2-2.8) hot sol.	pH(3.-4.6) cold sol.	pH(3.-4.6) hot sol.	pH(4.-5.5) cold sol.	pH(4.-5.5) hot sol.	pH(6.-7.6) cold sol.	pH(6.-7.6) hot sol.
$Pb(Ac)_2$	-	-	-	-	-	-	-	-
$FeCl_3$	-	+	-	+	-	+	-	+
$NaCl$	-	-	-	-	-	-	-	-
$CuSO_4$	-	+	-	+	-	+	-	+
$Ag(NO_3)$	-	-	-	-	-	-	-	-
$MgSO_4$	-	-	-	-	-	-	-	-
$Ca(NO_3)_2$	-	-	-	-	-	-	-	-
$ZnCl_2$	-	-	-	-	-	-	-	-
$Sr(NO_3)_2$	-	-	-	-	-	-	-	-
$BaCl_2$	-	-	-	-	-	-	-	-
$HgCl_2$	-	-	-	-	-	-	-	-
$Al(NO_3)_3$	-	+	-	+	-	+	-	+
$SnCl$								
$CeSO_4$		-	-	-	-	-	-	-
$Bi(NO_3)_2$		+	+	+	+	+	+	+
$U(NO_3)_3$		-	-	-	-	-	-	-
$Th(NO_3)_4$		+	+	+	+	+	+	+

PURIFICATION OF THORIUM NITRATE FOR THE PREPARATION OF THE STANDARD SOLUTION

In order to determine the accuracy of the method of analysis, the investigator took great precautions and pains in the purification of thorium nitrate.

One hundred grams of thorium nitrate was dissolved in 500 mls. of distilled water, and enough freshly distilled HNO_3 was added to make the solution 0.5N. The solution was saturated under pressure with H_2S and maintained at this condition for one hour. The solution was then boiled to remove the excess H_2S and the precipitated PbS formed was filtered off.

The filtrate was again treated as above to insure complete removal of lead. The solution was then evaporated to dryness on a steam bath to remove the excess nitric acid. The crystals of thorium nitrate were then dissolved in distilled water and heated to boiling. To this hot solution, a saturated hot solution of purified sebacic acid was added until complete precipitation of thorium as a sebacate was effected. The thorium sebacate was filtered while in hot solution and washed thoroughly with hot water. This precipitate was then dissolved in freshly distilled HNO_3 and hot water added to effect the solution of the sebacic acid formed from the reaction.

The solution was allowed to cool in an ice bath and the crystallized sebacic acid was filtered off. The filtrate containing the thorium nitrate was evaporated to dryness on a steam bath several times with concentrated HNO_3 to oxidize any sebacic acid which remained from the purification process.

The crystallized thorium nitrate obtained from this process was subjected to fractional crystallization [1] in order to insure as complete as possible, the removal of the rare earth elements. The crystals of the fifth fraction of this process were used to prepare a standard solution of thorium nitrate.

PREPARATION AND STANDARDIZATION OF THORIUM NITRATE SOLUTION

A definite weight of purified thorium nitrate was dissolved in two liters of distilled water to give approximately 0.1500 grs. of thorium oxide per 25 mls. of solution.

The solution was carefully standardized by both the sebacic acid method and the hydroxide method.

In the standardization of the thorium solution, 25 mls. were taken from the stock bottle and neutralized with freshly prepared NH_4OH to methyl red. To the hot solution of the sample, a boiling solution of sebacic acid was added to excess. The precipitate formed was filtered, washed with hot water and ignited to ThO_2 in weighed crucibles.

In the standardization of the thorium nitrate solution with NH_4OH, 25 mls. were taken and diluted to 150 mls. with distilled

1. Little H. F. Text Book of Inorganic Chemistry Volume 4, Pages 325-324 (1921)

water. To each sample an excess of freshly prepared NH_4OH was added. The precipitate formed was filtered off and washed thoroughly with a water solution containing several drops of NH_4OH. The $Th(OH)_4$ was ignited in weighed crucibles to ThO_2. Table 2 shows the results of this standardization.

TABLE 2

Vol. of St. solution	Grs. of ThO_2 from $Th(OH)_4$	Grs. of ThO_2 from thorium sebacate
25 mls.	0.14014	0.14048
25 mls.	0.14014	0.14042
24 mls.		0.14062
Mean	0.14014	0.14050

SOLUBILITY OF O-BENZOYL THORIUM BENZOATE

Since the pH of the solution is a determining factor in the quantitative analysis of thorium with the use of o-benzoyl benzoic acid, the investigator prepared a purified sample of the thorium salt and determined its solubility at different hydrogen ion concentrations.

In the preparation of pure o-benzoyl thorium benzoate, a saturated 50 p.c. alcoholic solution of o-benzoyl benzoic acid was added in excess to a solution of purified thorium nitrate neutralized to methyl red with CH_3COONH_4. The precipitate was washed thoroughly by decantation with 50 p.c. alcoholic solution. To insure complete removal of the excess organic acid, the precipitate was washed by refluxing in a Soxhlet extractor for 24 hours with absolute alcohol.

The precipitate from this process was left to dry in a desiccator for several days.

Several volumes of different solutions at different pH and composition were saturated with this salt for different lengths of time. The solution was then filtered and a measured volume of the filtrate was evaporated to small volumes and placed in weighed crucibles. The evaporation to dryness was conducted in these crucibles and the precipitate which remained was ignited to ThO_2 and weighed as such.

Since the reaction of thorium and the organic acid was found not to be quantitative in solutions of a pH value greater than 7 and less than 1, the solubilities of the salt were determined between these limits. As indicated in Table 3 the solubilities of the salt were determined in distilled water and 50 p.c. alcoholic solution at different pH values. The pH values of the solutions were regulated with HNO_3 and CH_3 $COONH_4$. The indicators used to determine the pH were thymol blue, bromo thymol blue, bromo cresol green and bromo phenol blue.

The investigator has found that o-benzoyl thorium benzoate is very collodial in water and will pass through #42 fine quantitative filter paper. However, on the addition of alcohol to a water solution, the precipitate will coagulate immediately and is easily filtrable.

The high value of sample #5 of Table 3 are attributed to the collodial nature of o-benzoyl thorium benzoate as contrasted to the negligible value of sample 1 in solution of alcohol at the same pH value.

Table 3 shows that the solubility of o-benzoyl thorium benzoate decreases as the precipitation is carried out near the neutral point.

SOLUBILITY DETERMINATION

TABLE 3

Series	pH of solution	Vol. of Sat. Sol.	Grs. of ThO_2	Indicator used	Grs. of ThO_2/liter
1	(6.-7.)	50 mls.	(1)0.00002	Bromo	0.00040
	(6.-7.)		(2)0.00005	Thymol	0.00100
	(6.-7.)		(3)0.00006	Blue	0.00120
2	(4.-5.5)	50 mls.	(1)0.00030	Bromo	0.00600
	(4.-5.5)		(2)0.00035	Cresol	0.00700
	(4.-5.5)		(3)0.00026	Green	0.00520
3	(3.-4.5)	100 mls.	(1)0.00078	Bromo	0.00780
	(3.-4.5)		(2)0.00163	Phenol	0.01630
	(3.-4.5)		(3)0.00080	Blue	0.00800
4	(1.-2.8)	500 mls.	(1)0.08995	Thymol	0.17990
	(1.-2.8)		(2)0.09105	Blue	0.18210
5	Neutral	50 mls.	(1)0.03456		
	Neutral		(2)0.03435		

In the above table, series 1 is the filtrate of a saturated water solution containing 50 p.c. alcohol. Series 2, 3, 4, are the results of the filtrates in which the pH has been regulated by carefully adding HNO_3 and CH_3COONH_4. Series 2, 3, 4, were precipitated in 50 p.c. alcoholic medium.

DETERMINATION OF QUANTITATIVE REACTION OF THORIUM NITRATE WITH O-BENZOYL BENZOIC ACID

Im the investigation of the quantitative precipitation of thorium as the salts of the organic acid, o-benzoyl benzoic acid, the author performed the analysis on the standard thorium nitrate solution under varying pH conditions at which the reaction was considered a quantitative one. Since the solubility of o-benzoyl thorium benzoate was found to decrease as the pH approaches 7, the investigation was conducted between the pH of (3.-7).

In the process of analysis of standard solution of thorium nitrate, 25 mls. portions were used for each determination. These samples of standard solution were diluted to 150 mls. with distilled water. To each sample, 50 mls. of alcohol were added. A drop or two of the proper indicator was added which had a color-change at the pH at which the analysis was desired to be conducted. Since the pH of the standard thorium nitrate solution was below 2, the increase pH was effected by adding drop by drop a 10 p.c. solution of CH_3COONH_4 until a slight color change was observed in the solution. Then to each sample a saturated solution of o-benzoyl benzoic acid which contained 50 p.c. of alcohol was added in slight excess in the cold. The solutions were vigorously stirred and set aside for one hour. The precipitate formed was filtered and washed with 50 p.c. alcoholic solution with the same pH as that in which the precipitation was carried out.

After the transfer of all the precipitate on the filter paper, the salts were ignited to the thorium oxide in weighed quartz crucibles. In the ignition of o-benzoyl thorium benzoate brown and white fumes were given off. It was found that fast and slow ignition did not affect the accuracy of the process. The results of this analysis are tabulated in Table 4. In this table one can see that the salt is less soluble in solution with a pH near the neutral point. This coincides with the results obtained from the solubility of o-benzoyl thorium benzoate.

TABLE 4

Sample	pH of Precipitation	Grs. of ThO_2 Found	Grs. of ThO_2 in Solution	Error Grs. of ThO_2
1	3.-4.5	0.14028	0.14050	- 0.00012
2	less 3.	0.13952	0.14050	- 0.00098
3	less 3.	0.13970	0.14050	- 0.00080
4	greater than 7	0.13811	0.14050	- 0.00139
5	4.-6	0.14045	0.14050	- 0.00005
6	4.-6	0.14055	0.14050	+ 0.00005

In the above table samples 1, 5, 6, agree in accuracy with the sebacic acid method of James if the pH of precipitation is kept between 3.-6. but samples 2, 3, 4, definitely show that the salt o-benzoyl thorium benzoate is slightly soluble in solution with pH greater than 7 and less than 3. The pH of sample 4 was made greater than 7 by adding a large excess of 10 p.c. CH_3COONH_4. The pH of samples 2 and 3 were made less than 3 by adding several drops of concentrated HNO_3. The volume of standard solution taken for analysis in every case was 25 mls.

QUANTITATIVE SEPARATION OF THORIUM FROM LEAD AND URANIUM

In the investigation of the quantitative separation of thorium from a solution containing a lead and uranium salt, the author took 25 mls. of stock thorium nitrate solution and added a definite weight of these salts to each solution. The same procedure was followed as that in which pure thorium nitrate was determined. This process included the regulation of pH with CH_3COONH_4 buffer solution, precipitation of thorium as o-benzoyl thorium benzoate, washing with alcoholic solutions of proper composition and pH and the ignition of the residue to thorium oxide. As will be seen in Table 5 thorium can be separated from uranium quantitatively and possibly from lead if the conditions in which lead can be found not to coprecipitate with the thorium salt.

However, in order to obtain a quantitative separation of thorium with uranium present the author has found that a second precipitation of the o-benzoyl thorium benzoate decreased the coprecipitation of uranium.

In this investigation, the second precipitation was accomplished by dissolving the o-benzoyl thorium benzoate, formed in the first precipitation, in dilute HCl (1-4) containing alcohol. To this solution a few drops of indicator of proper pH range was added. Then from a burrette, freshly prepared NH_4OH was added carefully until the indicator showed a color change. At this point the o-benzoyl thorium benzoate precipitated. To insure complete precipitation more organic acid was added. The precipitate was washed thoroughly on the filter and ignited in weighed quartz crucibles to thorium oxide.

In Table 5 it can be seen that reprecipitation diminishes the error due to contamination of the uranium salt. However, in the separation of lead from thorium, the error was found to be positive even when the organic salt of thorium was re-dissolved and reprecipitated in the same manner as that used for the separation of thorium and uranium.

TABLE 5

Series	Grs. of ThO_2 found	Grs. of ThO_2 present	Grs. of $Pb(NO_3)_2$ in solution	Grs. of $U(NO_3)_3$ in solution	Error Grs. of ThO_2
1	0.27908	0.27892		0.32080	+ 0.00016
	0.27894	0.27892		0.37720	+ 0.00002
2	0.13318	0.14050		0.5 +	- 0.00732
	0.14099	0.14050		0.5 +	+ 0.00049
	0.14052	0.14050		0.5 +	+ 0.00002
3	0.14043	0.14050		0.5 +	- 0.00007
	0.14036	0.14050		0.5 +	- 0.00014
	0.14010	0.14050		0.5 +	- 0.00040
4	0.14232	0.14050		0.5 +	+ 0.00182
	0.14301	0.14050		0.5 +	+ 0.00252
	0.14403	0.14050		0.5 +	+ 0.00353
5	0.14424	0.14050	0.39159		+ 0.00374
	0.14185	0.14050	0.18893		+ 0.00135
	0.14354	0.14050	0.22472		+ 0.00304
6	0.14672	0.14050	0.5 +		+ 0.00622
	0.14634	0.14050	0.5 +		+ 0.00584
	0.14654	0.14050	0.5 +		+ 0.00604

The volumes of standard solution used to obtain the data of Table 5 were 50 and 25 mls. portions. In Table 5, the weights of thorium oxide found represent those obtained from solutions in which the pH conditions of precipitation were kept between 4.-6. Series 1, 2, 3, 5, 6 are the results of double precipitation according to the method mentioned previously. However, in the precipitation of sample 1 of series 2, an excess of CH_3COONH_4 was added to determine its effect. Since an excess of CH_3COONH_4 increases the pH to a value greater than 7 the low results of this sample is no doubt due to the solubility of the salt in the original solution.

Series 4 of the table represents the weight of ThO_2 obtained on the ignition of the precipitate obtained from the first precipitation. The high results of this series is probably due to the fact that uranium must have been included in the o-benzoyl thorium benzoate salt. This error can be seen to have been reduced by reprecipitation of the salt as shown from the results of ThO_2 found in series 1, 2, 3.

In sample 1 of series 6, the salt of the first precipitation was ignited directly to ThO_2. It is seen that the error is of the same magnitude as the other samples of series 5 and 6 which have been subjected to double precipitation in the same manner as that used in the separation of thorium from uranium. The author believes that the occlusion of lead cannot be reduced by reprecipitation.

DETERMINATION OF FORMULAR WEIGHT OF O-BENZOYL THORIUM BENZOATE

Several methods were used in determining the formular weight of o-benzoyl thorium benzoate. The methods used were the ignition of definite weights of pure salt to thorium oxide and calculate the formular weight by using the proper proportionalities. The second method used was that in calculating molecular weight directly from the dried precipitate obtained from the reaction of a definite weight of thorium nitrate and the organic acid. The other method used was the absorption of CO_2 and H_2O quantitatively from definite weights of the salt assuming that on ignition only CO_2 and H_2O were evolved.

The procedure followed in determination of the formular weight of o-benzoyl thorium benzoate was to weigh out accurately dry purified samples of the salt in weighed crucibles. The samples were ignited in these crucibles to thorium oxide and the formular weight calculated from the known weight of thorium oxide, o-benzoyl thorium benzoate and the formular weight of thorium oxide. Table 6 will show the results of this investigation. It includes also the results obtained by analogous investigation with other organic acids of similar structure.

The second method of determining the formular weight of o-benzoyl thorium benzoate was to pipette out accurately 25 mls. of standard thorium nitrate solution and precipitate the thorium quantitatively as o-benzoyl thorium benzoate. The precipitate was washed thoroughly with 50 p.c. alcohol solution and filtered through weighed sintered glass crucibles. The crucibles were dried in an oven at 100°C. to constant weight. The weight of the precipitate was the weight of o-benzoyl thorium benzoate obtained from the reaction of a definite weight of thorium nitrate in 25 mls. of solution and o-benzoyl benzoic acid. The molecular weight was calculated from the known weights of the salt, thorium nitrate in solution and the formular weight of thorium nitrate. Table 7 shows the result of the investigation using o-benzoyl benzoic acid and benzoic acid. The weight of thorium nitrate in 25 mls. of standard solution was calculated from the weight of thorium oxide obtained from the standardization of the standard solution.

Assuming that on the ignition of o-benzoyl thorium benzoate CO_2 and H_2O are given off, the third method consisted in absorbing the CO_2 and H_2O quantitatively from a definite weight of the pure salt in a combustion apparatus[1]. In this procedure, CO_2 was absorbed in a weighed ascarite absorption tube and H_2O was absorbed in a weighed magnesium perchlorate absorption tube.

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1. Kolthoff I. M. and Sandell E. B. Textbook of Quant. Analysis Page 668 (1937)

TABLE 6

Thorium Salt		Grs. of Salt ignited	Grs. of ThO_2 obtained	Cal. formular weight	
Thorium benzoate	(1)	0.23763	0.12656	495.93	
	(2)	0.23565	0.12911	482.58	
	(3)	0.22245	0.12289	478.10	
				Mean	483.53
m.Nitro Thorium Benzoate	(1)	0.18215	0.08550	562.6	
	(2)	0.47250	0.22684	550.58	
				Mean	556.59
o-Benzoyl Thorium Benzoate	(1)	0.07791	0.03050	674.67	
	(2)	0.06871	0.02668	680.20	
	(3)	0.10948	0.04222	684.90	
				Mean	679.92

TABLE 7

Vol. of Stand. solution $Th(NO_3)_4$	Grs. of $Th(NO_3)_4$ in solution	Grs. of Salt found	Precipitant used	Cal. Formular Weight
25 mls.	0.25476	0.36645	$C_6H_4{COC_6H_5 \atop COOH}$	679.29
25 mls.	0.25476	0.35454	Same	668.18
				Mean 673.74
25 mls.	0.25476	0.23112	C_6H_5COOH	435.56
25 mls.	0.25476	0.25925	Same	488.59
25 mls.	0.25476	0.23887	Same	456.28
				Mean 460.14

TABLE 8

Wt. of o-Benzoyl Th. Benzoate	Wt. of H_2O	Wt. of CO_2	p.c. C in sample
0.13694	0.02705	0.07032	13.97
0.14919	0.03070	0.08972	16.30
		Mean	15.14

Theoretical p.c. C in $\left[C_6H_4{COOC_6H_5 \atop COO}\right]_2 ThO$	p.c. H in sample	Theoretical p.c. H in $\left[C_6H_6{COOC_6H_5 \atop COO}\right]_2 ThO$
47.0%	2.11	3.20
47.0%	2.23	3.20
	2.17	

From the results of tables 6, 7, it appears that the molecular weight of o-benzoyl thorium benzoate is not what the organic chemist would predict it to be. Since thorium has a **valence** of four, one would predict that four atoms of o-benzoyl benzoic acid would react with one atom of thorium. However, if this were the case the results of tables 6, 7 would be entirely different. According to predictions the theoretical molecular weight of thorium benzoate should be about 716.15, the molecular weight of o-benzoyl thorium benzoate should be **1132.15** and that of m. nitro thorium benzoate should be 896.15. Although the results of the analysis of tables 6, 7, are not extremely accurate, the error of determination is far from favoring the predicted value given above. From the tabulated results it is very probable that only two atoms of these organic acids unite with one atom of thorium. The other valence of thorium is satisfied by either one oxygen atom or two hydroxyl atoms. From this investigation the author has arrived at the empirical formula of o-benzoyl thorium benzoate as being $\left[C_6H_4\begin{smallmatrix}COC_6H_5\\COO\end{smallmatrix}\right]_2$ ThO, that of thorium benzoate as being $[C_6H_5COO]_2$ ThO, and of m. nitro thorium benzoate as being $\left[C_6H_4\begin{smallmatrix}COO\\NO_2\end{smallmatrix}\right]_2$ ThO. The author has arrived at this conclusion because the weights of his empirical formulae agree much more closely than to the predicted formula.

CONCLUSION

According to the results of the foregoing investigations, the author has made the following conclusions:

(1) O-Benzoyl benzoic acid does not give insoluble salts with many cations, thus making this reagent nearly a specific one for thorium alone. From the results of the quantitative separation of thorium from uranium,which does not give an insoluble salt, it is reasonable to believe that thorium can be separated quantitatively from solutions containing the elements of Table 1 which give negative results with this reagent. Although in the separation of thorium from lead the error is positve, the author believes that further investigation on conditions of precipitation, the error can be made negligible.

(2) The solubility of o-benzoyl thorium benzoate is decreased as the pH conditions of the solution increases to the neutral point from the acid side. This fact is confirmed in Table 4 which shows that the results of quantitative analysis agree more closely to the known as the pH approaches 7.

(3) The reaction of o-benzoyl benzoic acid with thorium gives an insoluble precipitate which is quantitative. The best results obtained in this analysis is when the reaction is carried out in a solution which has a pH no less than 3.5 or greater than 6.5. This method as seen from Table 4 compares in accuracy with the sebacic acid method of James.

(4) In the separation of thorium from uranium, it was found that a second precipitation reduces the occlusion of the uranium ion. From this fact it is reasonable to believe that the high value of thorium oxide of Table 2, when it is precipitated in the presence of lead, is not due to the reaction of lead and o-benzoyl benzoic acid, but is due to the occlusion of the lead to the thorium precipitate.

(5) The formular weight of o-benzoyl thorium benzoate is not what is predicted. This fact is confirmed by obtaining experimental data which is far from agreeing with the theoretical values. The determination of formular weight of other thorium organic salts, in which analogous organic acids were used, does not confirm with theoretical values.

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