Contract No. W-7401-eng-37

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CORROSION OF METALS IN URANYL NITRATE SOLUTION

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Report received: July 19, 1945 Figures received: August 1, 1945
Issued: AUG 7 1945

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SUMMARY

4 Data on the corrosion of ^{Al,} ~~Aluminum~~ ^{Be,} ~~Beryllium~~ and ^{Nb} ~~Niobium~~ at 90°C by aqueous solutions containing up to 4 gm H/liter and up to 3 N HNO₃ are presented. ~~Aluminum~~ was seriously attacked, whereas ~~Niobium~~ was very resistant during 15 days exposure, even in the presence of 10⁻³ N H₂O₂. ~~Beryllium~~ was attacked to an important extent (1.5 mg/cm² in 5 days) in 0.1 N HNO₃ and more rapidly in higher concentrations of ~~nitric acid~~. ^{acid} /end

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INTRODUCTION

The choice of a corrosion resistant metal capable of withstanding the action of $\text{UO}_2(\text{NO}_3)_2$ solutions in the case of a "swimming pool" type pile is limited by two different considerations: Neutron absorption coefficient and resistance to nitric acid.

Neutron absorption data permits the use of the following metals: Bi, Pb, Al, Be and Cb. Among these metals lead and bismuth cannot be used since both are soluble in nitric acid. The three remaining metals have a much lower degree of solubility in HNO_3 and, therefore, they were studied.

The study is separated into three different parts:

1. Effect of acid and heavy metal concentration on the corrosion resistance of the three metals.
2. Determination of the corrosion rate of the metals in a uranyl solution having 3 gr. of heavy metal per liter of 1 N HNO_3 .
3. Effect of H_2O_2 on the corrosion resistance of metals in the solution defined in 2.

I. Effect of Acid and Heavy Metal Concentration on Corrosion Resistance of Aluminum, Beryllium, and Columbium.

Experimental Technique:

The samples used for each experiment were cut from the same piece of metal; for aluminum the samples were 0.25" diameter bars, 1.5" long. For Be the samples were .12" thick disks of 0.9" diameter. For columbium the samples were 0.9 mm. 951-3

sheets 16 mm. long and 16 mm. wide. The samples were degreased and weighted. They were then suspended in gas washing bottles containing various solutions of different concentration of heavy metal and acid. The bottles were kept in a thermostat at 90°C. for 6 days. After that the samples were washed in water, the product of corrosion was eliminated by brushing the samples with a clean brush. They were then dried and weighted.

Results:

Aluminum: The results are represented in the graph (fig. 1). One may see that the solution rate of aluminum in uranyl nitrate solutions increases linearly with the normality of nitric acid and with the concentration of heavy metal in the solution. The solution rate of the metal varies from 80 mg/cm² (0.1 N HNO₃ - 1g/liter U) to 300 mg/cm² (1 N HNO₃ - 4g U) for a period of 6 days and is much too high to permit the use of aluminum as structural material.

Beryllium: The results are represented on the graph of the fig. 2. The corrosion rate increases with the concentration of the nitric acid but seems to be practically independent from the concentration of heavy metal. For a five-day period of time the loss of weight varies from 1.5 mg/cm² for 0.1 N HNO₃ solution to about 30 mg/cm² for 1 N HNO₃ solutions. These results show that beryllium is much more resistant to uranyl nitrate solutions than aluminum.

Columbium: No alteration of surface and no loss of weight could be detected. The results described lead us to conclude that aluminum cannot be used in contact with uranyl nitrate solution at 90°C. Columbium on the contrary appears to have an excellent resistance. Beryllium seems to resist the action of nitrate (weak) solutions. The study of corrosion resistance as a function of time was undertaken in the case of beryllium and columbium.

II. Determination of Corrosion Rate of Be and Co.

The experiments were run in the conditions described before. The composition of the solution was 3 gr. per liter in 1 N HNO₃.

Beryllium: The loss of weight as a function of time is represented by the

graph of the fig. 3. One may see that the corrosion rate increases with time. The rate which is very low after one day exposure (about 2 mg/cm²) reaches an important figure of 60 mg/cm² after 15 days of exposure.

This result seems to indicate that beryllium cannot be used as structural material. However, a further study was undertaken in order to determine the effect of H₂O₂ which should play the role of inhibitor.

Columbium: No change in weight could be determined after 15 days of exposure.

III. Effect of H₂O₂ on the Corrosion Resistance of Beryllium and Columbium.

Experimental Technique:

The same apparatus as for the previous experiment was used. In order to maintain the concentration of H₂O₂ constant the rate of decomposition of H₂O₂ was first studied and then a concentrated H₂O₂ solution was fed into the uranyl solution so as to maintain H₂O₂ concentration at 10 N⁻³. Frequent titration insured the consistency of the composition of the electrolyte. The samples remained in the solution for a given period of time. They were then rinsed, the product of corrosion removed, and the change of weight determined.

Results:

The results are represented by the graphs on fig. 3.

Beryllium: There is essentially no difference between the loss of weight registered in the case of H₂O₂ free solution and in that of the solution to which H₂O₂ was added. This result indicates that H₂O₂ at the concentration of 10⁻³ N does not have any effect on the corrosion resistance of beryllium.

Columbium: No change of weight could be determined on the samples remaining in the solution for a period of 15 days.

Conclusion:

The results described here show that neither beryllium nor aluminum can be used in contact with a 70°C. uranyl nitrate solution (3 gr. of U in 1 N HNO₃), the

rate of corrosion of these metals being too high.

Columbium on the contrary resists perfectly well the action of uranyl nitrate solution as well in presence as in absence of H_2O_2 . The surface of the metal remains unaltered during the entire length of the experiment (15 days).

CORROSION RATE OF ALUMINUM
IN $UO_2(NO_3)_2$

—○— = 1 gr. U/liter
—□— = 2 gr. U/liter
x = 4 gr. U/liter

LOGS OF WEIGHT IN mg/cm²

360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0

.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0

NORMALITY OF HNO_3

CT-3152

CORROSION RATE OF BERYLLIUM
IN $\text{UO}_2(\text{NO}_3)_2$

- = 1 gr. U/liter
—X— = 2 gr. U/liter
—□— = 4 gr. U/liter

CP-3152

CORROSION RATE OF BERYLLIUM IN $\text{UO}_2(\text{NO}_3)_2$
SOLUTION CONTAINING 3 GR. OF U IN 1N HNO_3

CT-3152