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ANION EXCHANGE SORPTION OF URANIUM FROM ACID SOLUTIONS: PHOSPHATE-SULFATE AND PHOSPHATE-NITRATE

By

E. Virginia Spivey
J. G. Moore
C. F. Coleman

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April 9, 1952

URANIUM CHEMISTRY OF RAW MATERIALS SECTION
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ABSTRACT

Batch equilibrium tests were made using Dowex-1 resin and uranium in a phosphate-sulfate and a phosphate-nitrate system with concentrations, resin ratio, and pH varied.

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INTRODUCTION

The Oak Ridge National Laboratory Raw Materials Chemistry Section is concerned with two types of study in regards to ion-exchange investigations; that which involves a specific raw materials recovery problem, and that which deals with fundamental investigations in uranium chemistry. A previous report, Y-816*, summarized the work done up to October, 1951. The present report shows the extension of the tests of uranium sorption in the presence of excess anion (Y-816, pp. 43-66) to systems containing two major anions. The phosphate-sulfate and phosphate-nitrate systems were chosen to be studied first because of the frequent occurrence of the former in raw-material development problems, and because nitric acid may be substituted for sulfuric acid in some future process developments.

Five variables were considered in these tests: pH, the quantity of resin, and the concentrations of uranium, phosphate, and sulfate or nitrate. Batch equilibrium tests were made in series with four of these held constant and the fifth varied.

EXPERIMENTAL

Phosphate resin was prepared by passing 3% phosphoric acid through a column of 20-40 mesh Dowex-1-chloride until no more chloride was found. The resin was then washed to constant pH, at about 3. Stock solutions were prepared as follows: approximately 10M sulfuric acid, 5M phosphoric acid, 5M nitric acid, 0.2M uranyl sulfate, and 0.2M uranyl nitrate. Test solutions were made up from these stock solutions, adjusted to the specified pH with sodium hydroxide, and diluted to 100 ml

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* Y-816, "Topical Report on Anion Exchange Studies," E. Virginia Spivey, Emily L. Leyshon, F. J. Hurst, D. J. Crouse, and C. F. Coleman, ORNL - Y-12, October, 1951.

[redacted]

with water. Seventy-five ml of each test solution was shaken overnight with resin in a plastic bottle in a Fisher-Kahn type shaker. Except where otherwise specified, 1.5 meq, 0.63g (dry basis), of resin was used in each test.

After 15 to 20 hours in the shaker, the solutions were separated from the resin and analyzed for uranium, the difference in uranium initially and after equilibrium being the amount sorbed by the resin. The analytical methods used for the determination of uranium are the same as those listed on page 111 of report Y-816.

DISCUSSION

In general, the results are similar to the results from studies of single anion systems reported in Y 816.

Figure 1 shows the influence of pH on uranium sorption. The upper limit was set by the fact that above pH 2 some precipitation of uranium occurred in both systems.

Figure 2 shows the increase of percent sorption and the corresponding decrease of loading as the ratio of resin to solution was increased.

The influence of uranium concentration on the sorption is shown in Figures 3, 4, 5, and 6. The percent pickup from phosphate-sulfate increased rapidly as the uranium concentration was decreased to about 0.002M. This is similar to the results found in phosphate solution (Y-816, p. 62), in which the lowest uranium concentration tested was about 0.005M. It was expected that the pickup would continue to rise toward 100% with further dilution of the uranium, but it was found to drop sharply below 0.002M, as shown in Figure 3. This may have been caused by formation of a different sulfate of phosphate complex as the ratios of sulfate and phosphate to uranium increased.

In the phosphate-nitrate system (Figure 5) the pickup remained low throughout the range, as to be expected from the greater interference by nitrate. The loading curves (Figures 4 and 6) are less sensitive at the low uranium concentrations, and appear similar to those found with phosphate solutions (Y-816, p. 63).

The variation of anion concentration and its effect on uranium sorption is shown in Figures 7, 8, and 9. These

results are very similar to the results for single anions given in Y-816. It should be noted, however, that the nitrate causes a more rapid decrease in the percent sorption and the loading than the sulfate.

The effect of initial phosphate and nitrate concentrations are shown in Figures 7 to 9. These concentrations could have been shifted by exchange to the maximum extent of about 0.02M, but probably much less.

If applied to a process for extracting uranium, these tests show that the phosphate-sulfate system is to be preferred. In either system for the best results the pH should be at least 1.5, if possible, and the concentration of the anions should be as low as possible. The quantity of resin used would depend upon the efficiency (loading) required and the costs involved.

SUMMARY

Batch equilibrations of uranyl with Dowex-1-PO_4 in phosphate-sulfate and phosphate-nitrate solutions showed improved sorption with rise of pH up to at least 1.5. The effect of resin quantity was normal, increased resin increasing the pickup and decreasing the loading. The effect of decreasing the uranium concentration was similar, except that the pickup from phosphate-sulfate solution dropped sharply when the initial uranium concentration was less than 0.002M. Excess anion depressed both the pickup and the loading, nitrate being much more effective than either sulfate or phosphate.

ACKNOWLEDGMENT

Most of the analyses were performed by the Y-12 Section of the Oak Ridge National Laboratory Analytical Chemistry Division under the direction of Mr. C. D. Susano

Original data are in Notebooks Y-NB-1361 and Y-NB-1611.

Figure 1

EFFECT OF pH ON URANIUM SORPTION

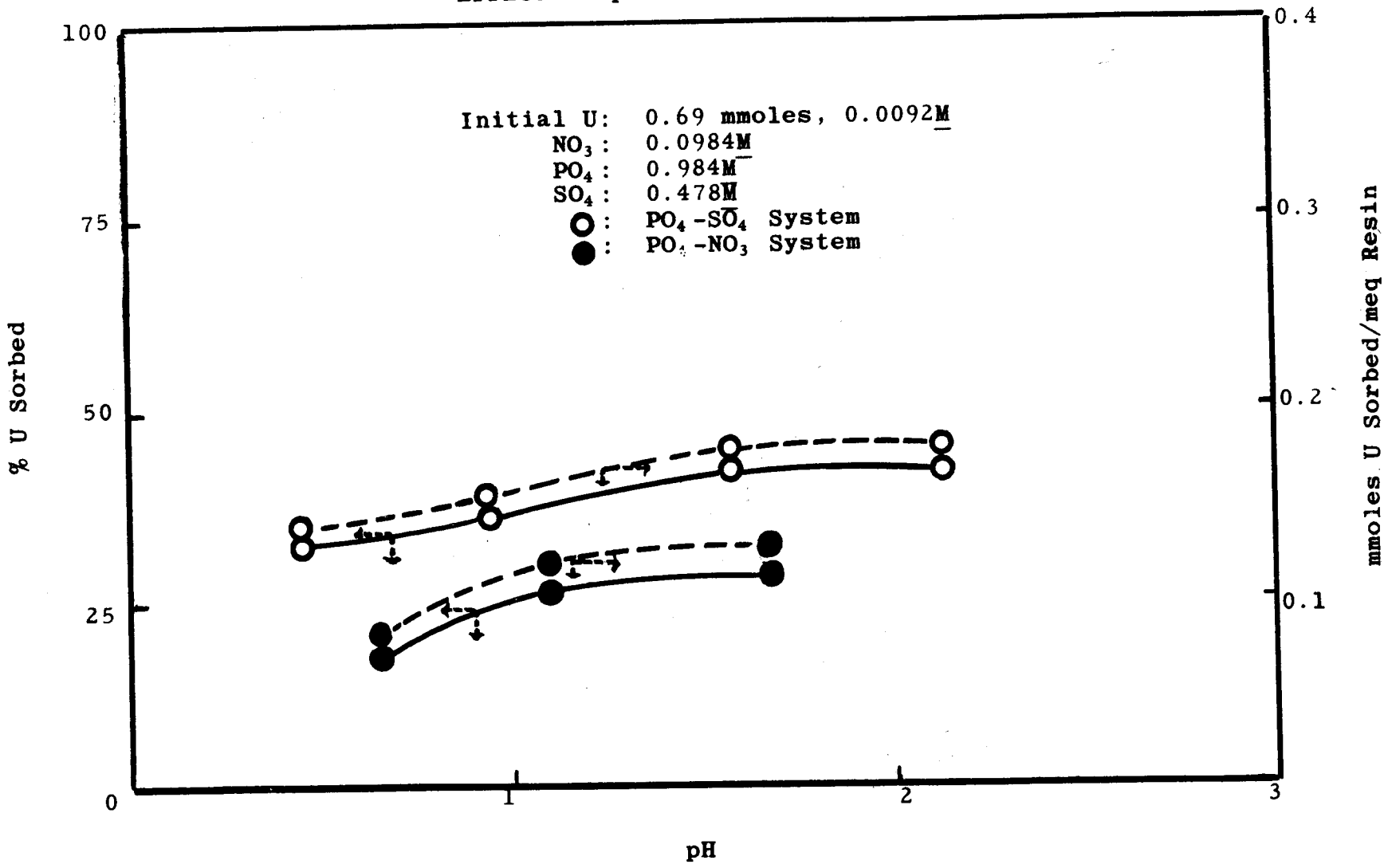


Figure 2

EFFECT OF RESIN CONCENTRATION ON URANIUM SORPTION

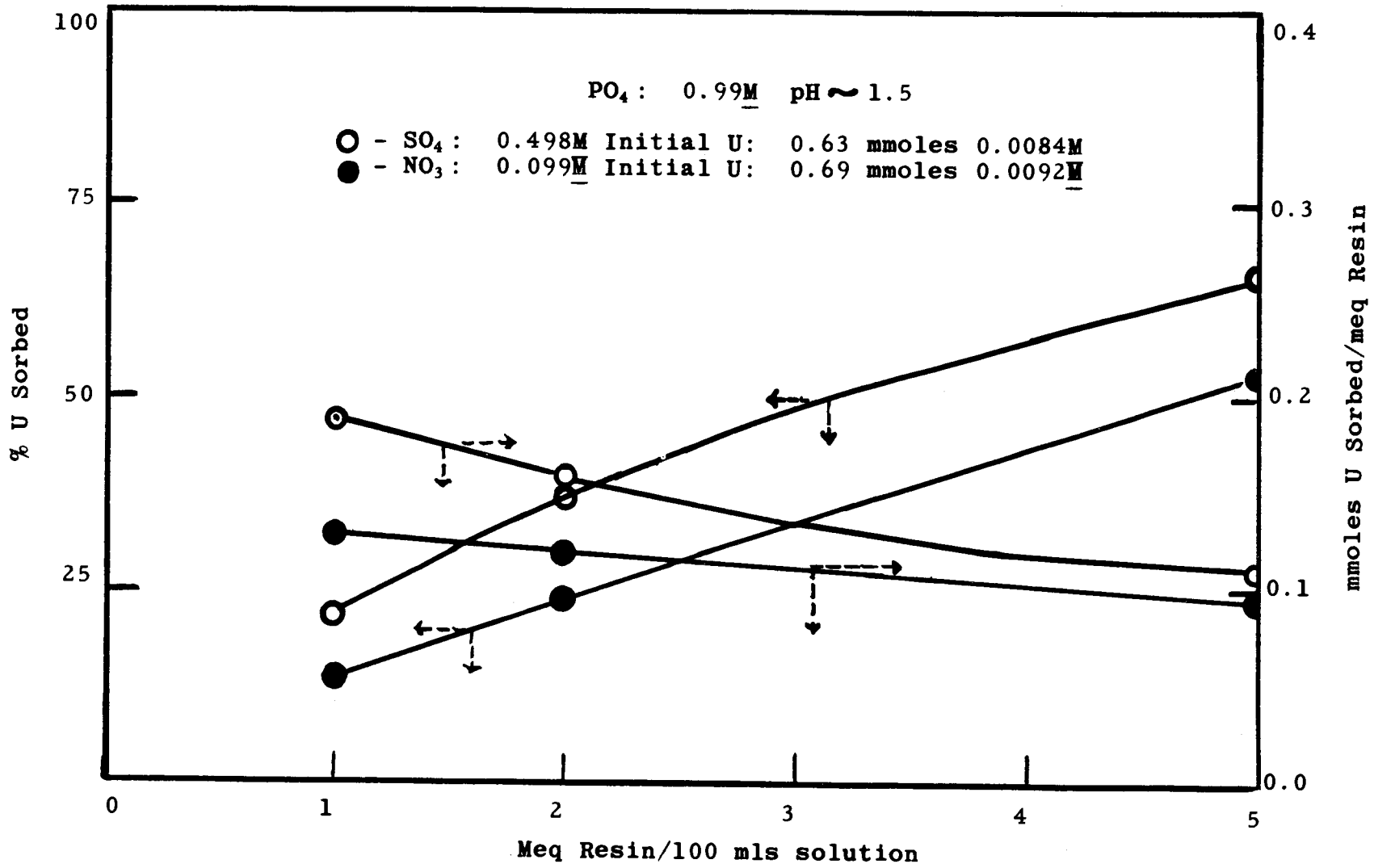


Figure 3

SORPTION OF URANIUM IN A PHOSPHATE-SULFATE SYSTEM

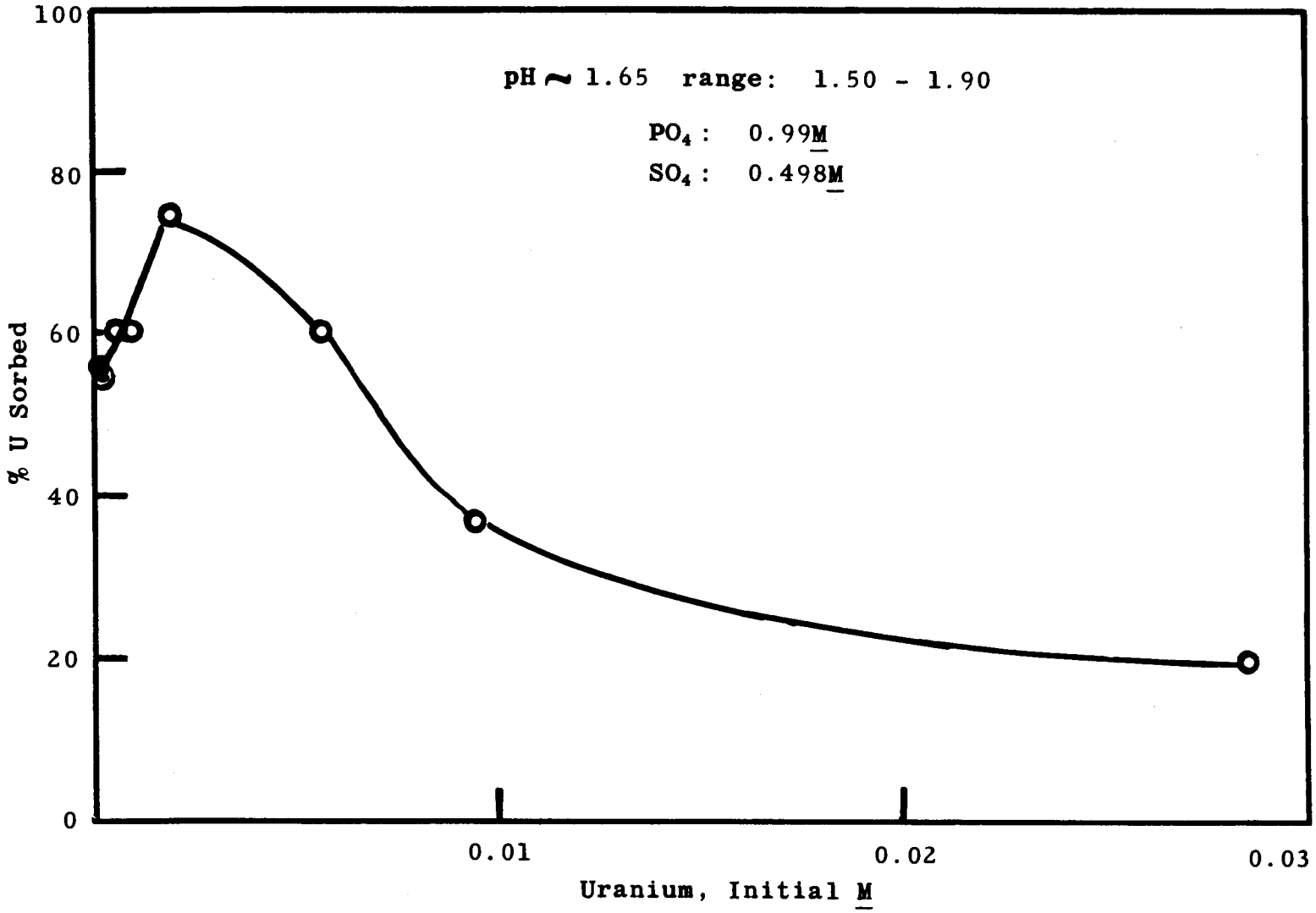


Figure 4

SORPTION OF URANIUM IN A PHOSPHATE-SULFATE SYSTEM

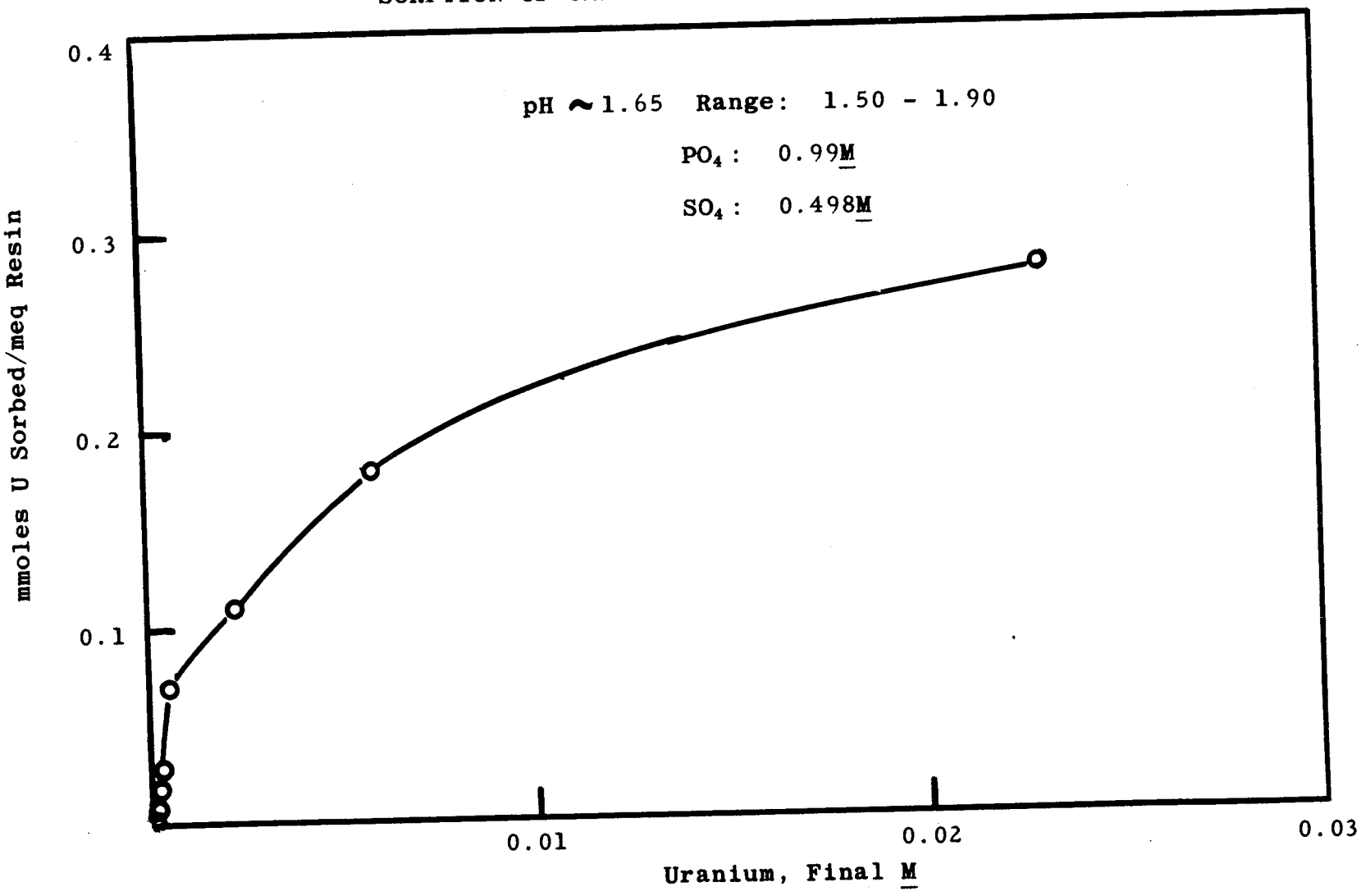


Figure 5

SORPTION OF URANIUM IN A PHOSPHATE-NITRATE SYSTEM

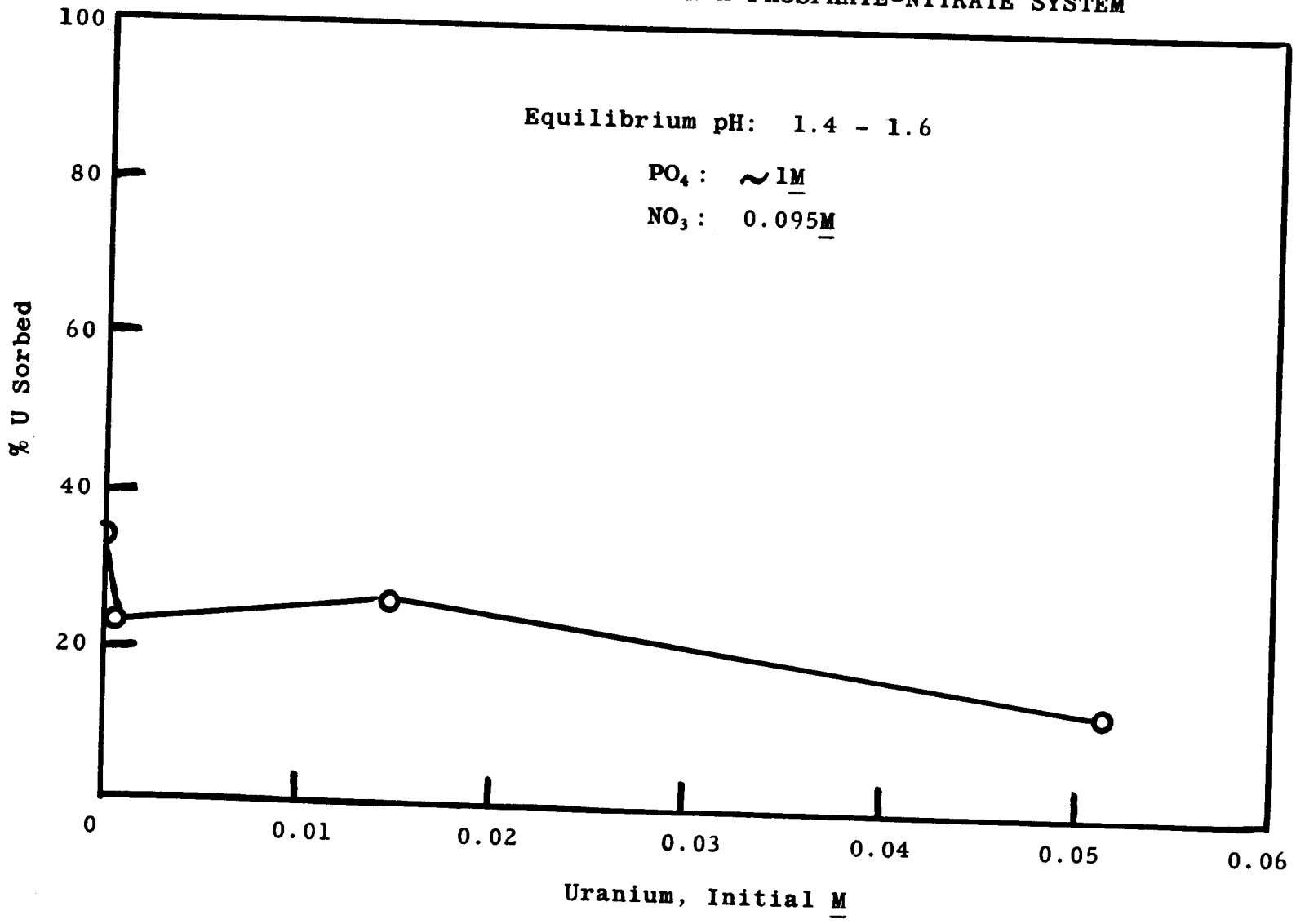


Figure 6

SORPTION OF URANIUM IN A PHOSPHATE-NITRATE SYSTEM

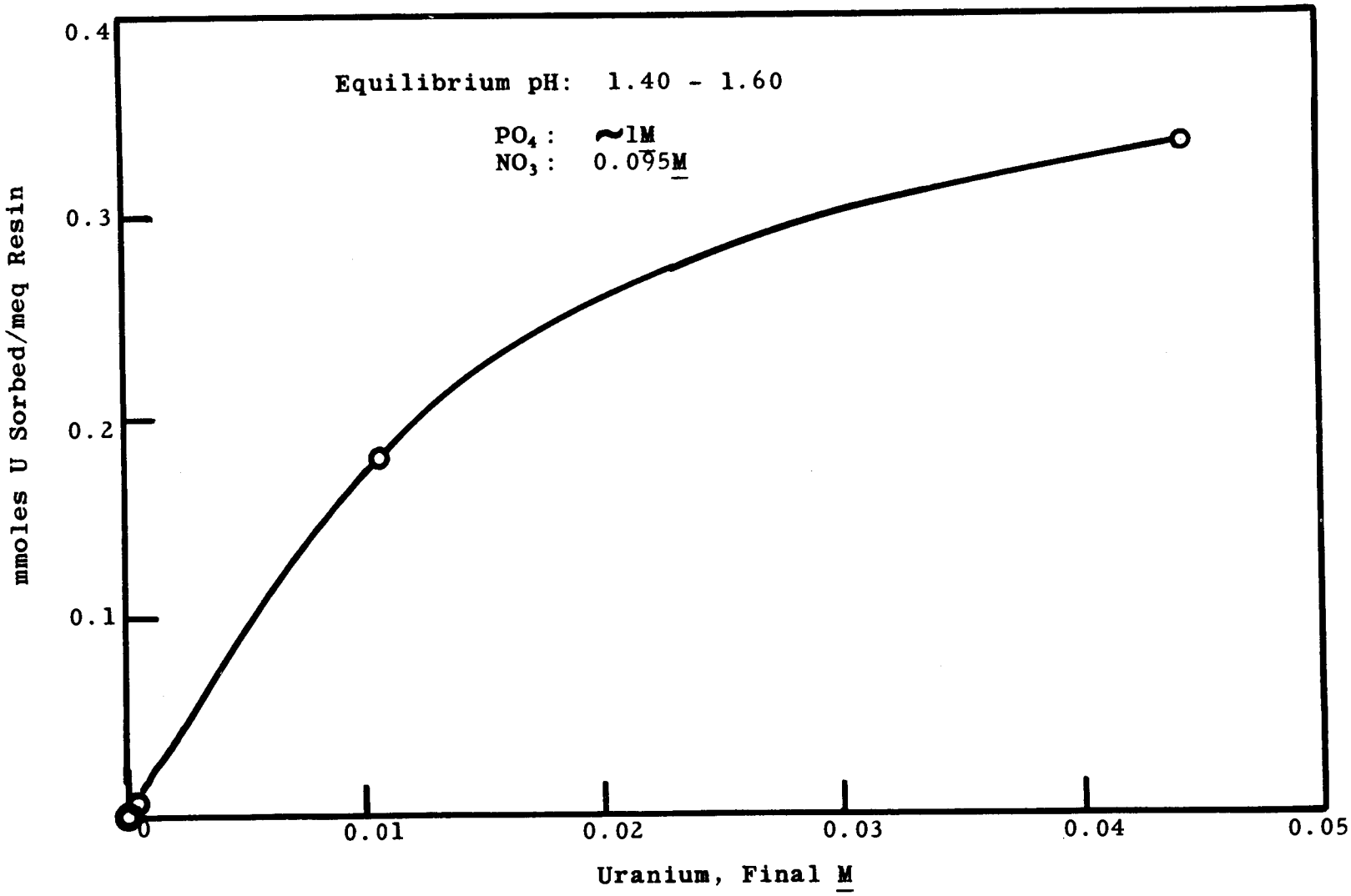


Figure 7

EFFECT OF EXCESS ANION ON URANIUM SORPTION

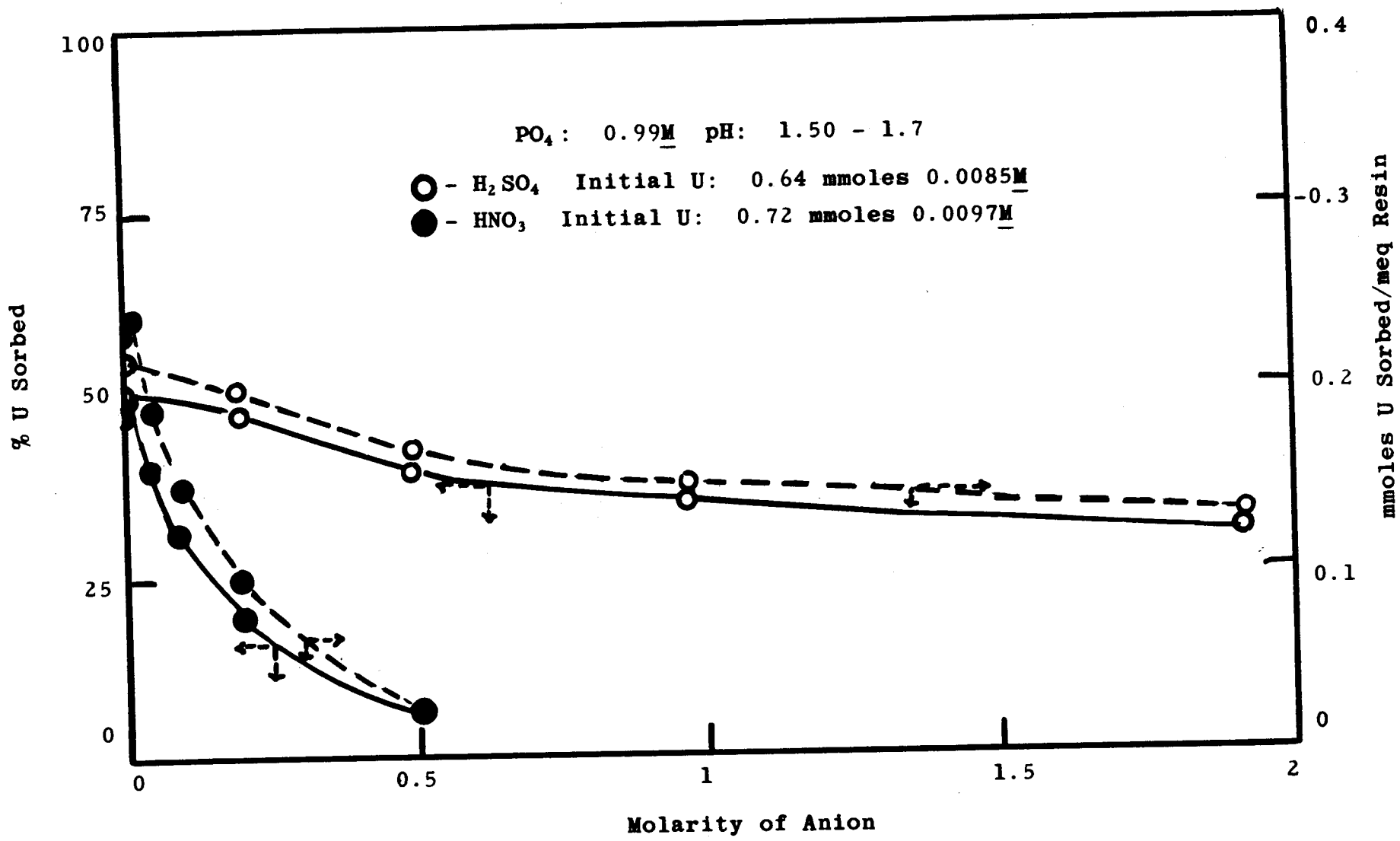
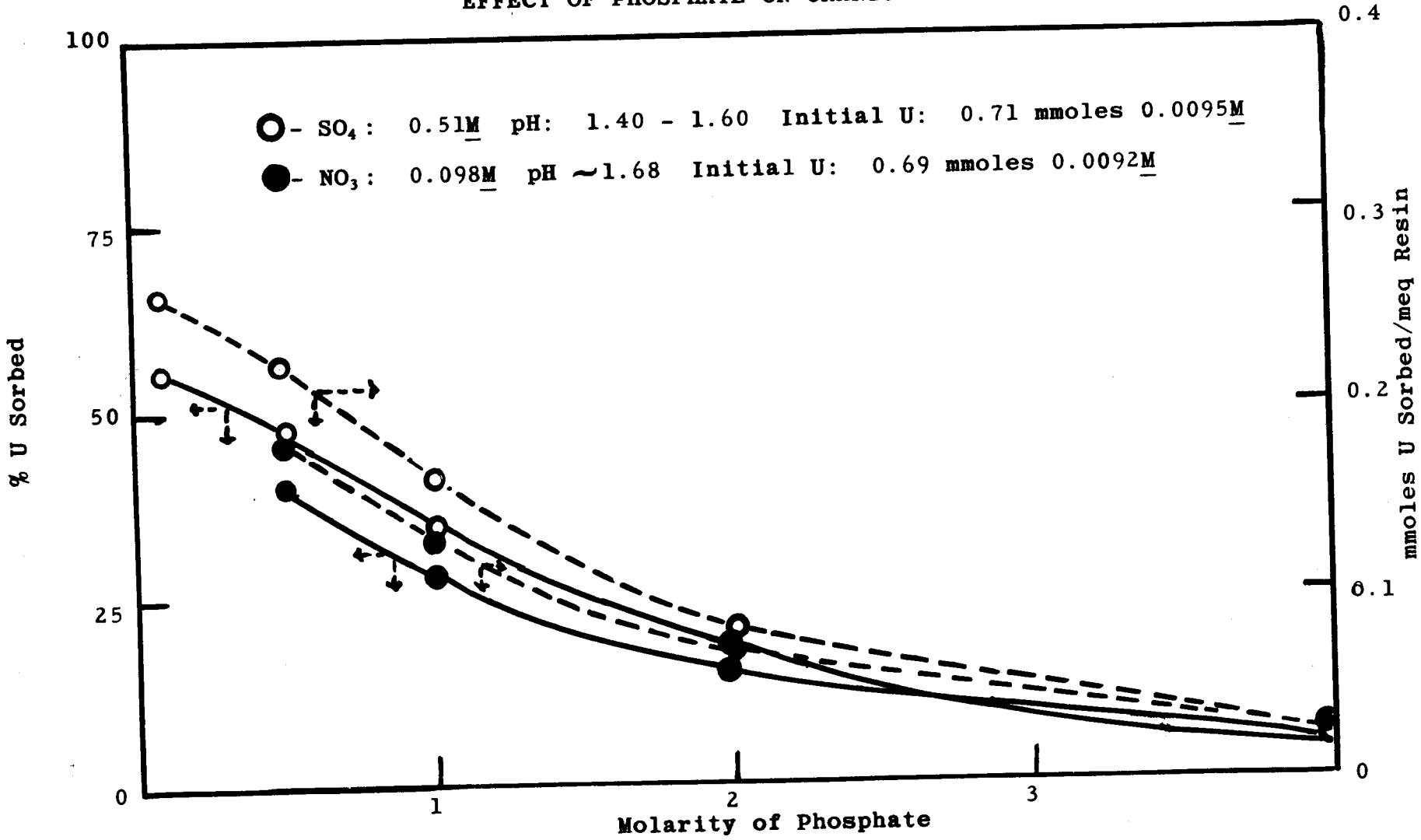


Figure 8

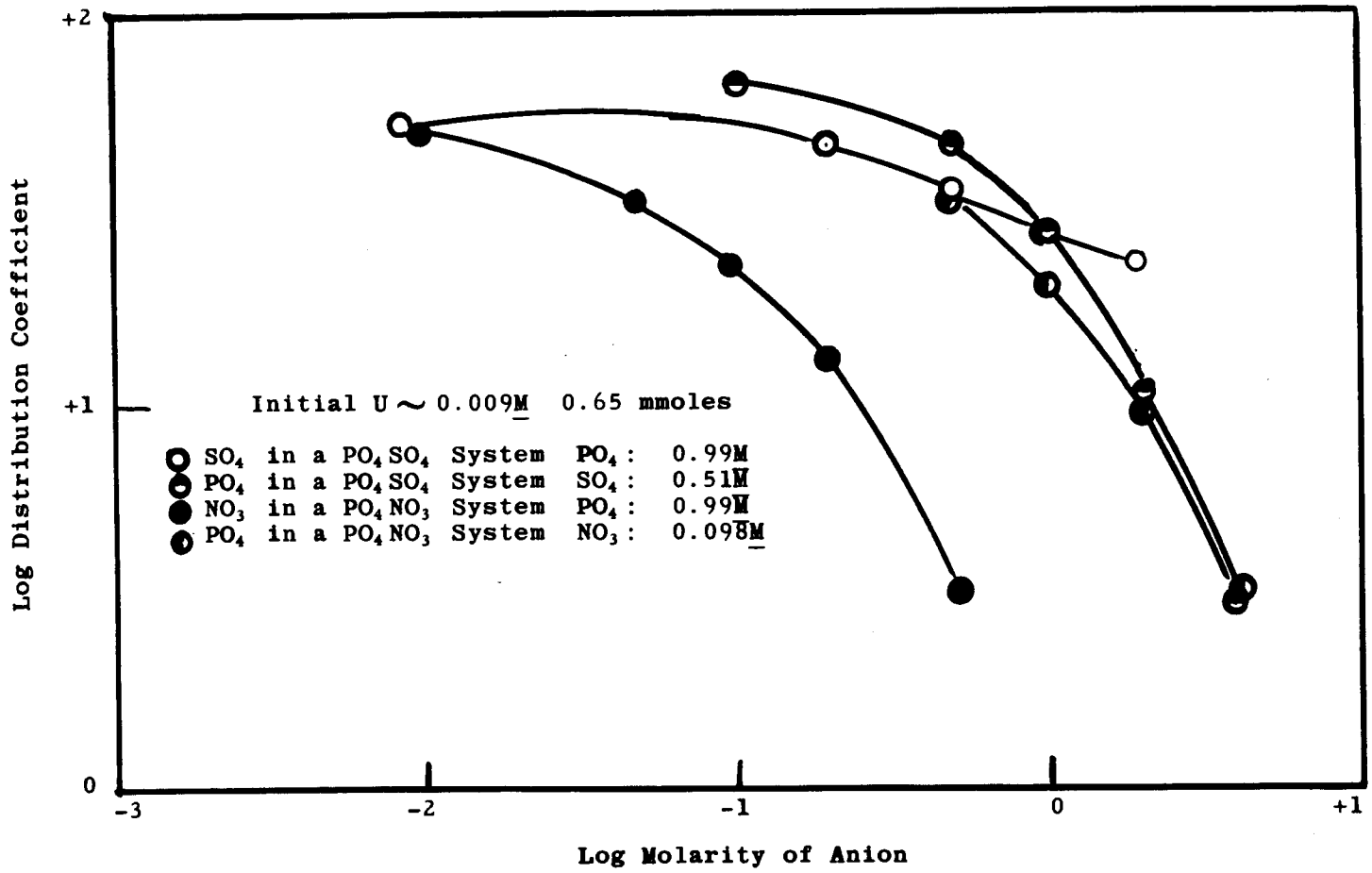
EFFECT OF PHOSPHATE ON URANIUM SORPTION



[redacted]

Figure 9

EFFECT OF EXCESS ANION ON URANIUM SORPTION



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