Title
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STABILITY CONSTANTS OF ALPHA-HYDROXYISOBUTYRIC ACID COMPLEXES
WITH ACTINIDE ELEMENTS

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ABSTRACT

The stability constants of curium and americium alpha hydroxyisobutyrate complexes were determined by means of ion exchange equilibrium measurements on Dowex-50 four percent resin in the ammonium form.

The values obtained for curium alpha hydroxyisobutyrate are: $K_1 = 290, \quad pK_1 = 2.46; K_2 = 93, \quad pK_2 = 1.97; \quad$ and $K_3 = 9, \quad pK_3 = 0.95$. The value for $K_1$ is probably good to within 10 percent, for $K_2$ to within 40 percent and for $K_3$ to within a factor of 2. The total $pK = pK_1 + pK_2 + pK_3 = 5.38$.

For americium alpha hydroxyisobutyrate, only the first stability constant was determined. The value for this constant is $K_1 = 527, \quad pK_1 = 2.72$. 
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INTRODUCTION

Alpha hydroxyisobutyric acid has been used successfully as an eluting agent in the separation of the actinide elements in ion exchange columns.\(^1\) It was of interest to study the complexes which are formed between alpha hydroxyisobutyric acid and the actinide elements and to determine their stability constants as a means of understanding the elution behavior of the actinides with alpha hydroxyisobutyric acid. The method used was ion exchange equilibrium measurements with a cation exchanger.\(^2\) A similar method has been used by Schubert\(^3\),\(^4\),\(^5\) for the determination of the stability constants of strontium citrates and tartrates.

In a solution containing a cation exchange resin (in the form AR) and a positive ion (M\(^+\)), the following reaction occurs:

\[
AR + M^+ \rightleftharpoons MR + A^+(1)
\]

\[
Q = \frac{(MR)(A^+)}{(AR)(M^+)}
\]

where Q is a constant, (MR) and (AR) are the activities of the cations in the resin phase, (M\(^+\)) and (A\(^+\)) are the activities of the cations in solution.

In the presence of a chelating or other complexing agent, a quantity of the metal ion is retained in solution through complex formation:

\[
A^+ + C^- \rightleftharpoons AC(2)
\]

\[
K = \frac{(AC)}{(A^+)(C^-)}
\]

If a positively charged complex is formed, it may be absorbed on the resin along with the free metal ion. A distribution constant K\(_d\) may be defined for a metal ion in a solution containing a cation exchanger in the presence of a complexing agent as follows:

\[
K_d = \frac{\Sigma M^+_{\text{Resin}}}{\Sigma M^+_{\text{in solution}}}(3)
\]
where $\Sigma M^+_{\text{Resin}}$ = the total amount of cation in the resin phase and $\Sigma M^+_{\text{Solution}}$ = the total amount of cation in solution.

A distribution constant $K'_{d_{o}}$ may be defined for a metal ion in a solution containing a cation exchange resin in the absence of a complexing agent.

$$K'_{d_{o}} = \frac{(MR)}{(M^+)}$$  \hspace{1cm} (4)

where $(MR)$ = activity of cation in resin phase and $(M^+)$ = activity of cation in solution. Similar equations hold true for other than singly-charged ions.

The reactions taking place between alpha hydroxyisobutyrate ion ($\text{But}^-$) and the actinides are as follows:

$$M^{3+} + \text{But}^- \leftrightarrow M\text{But}^+$$  \hspace{1cm} (5)

$$K'_{1} = \frac{(M\text{But}^+)}{(M^{3+})(\text{But}^-)}$$

$$M\text{But}^+ + \text{But}^- \leftrightarrow M\text{But}_2^+$$  \hspace{1cm} (6)

$$K'_{2} = \frac{(M\text{But}_2^+)}{(M\text{But}^+)(\text{But}^-)}$$

$$M\text{But}_2^+ + \text{But}^- \leftrightarrow M\text{But}_3^+$$  \hspace{1cm} (7)

$$K'_{3} = \frac{(M\text{But}_3^+)}{(M\text{But}_2^+)(\text{But}^-)}$$

The resin equilibrium for the $\text{NH}_4^+$ form resin may be represented as follows:

$$M^{3+} + 3 \text{NH}_4^+ \leftrightarrow \text{MR}_3^+ + 3 \text{NH}_4^+$$

$$K'_{R_{1}} = K'_{d_{o}} = \frac{(MR)^3}{(M^{3+})(\text{NH}_4^+)^3}$$  \hspace{1cm} (8)

$$M\text{But}^+ + 2 \text{NH}_4^+ \leftrightarrow M\text{But}_{R_{2}}^+ + 2 \text{NH}_4^+$$

$$K'_{R_{2}} = \frac{(M\text{But}_{R_{2}}^+)(\text{NH}_4^+)^2}{(M\text{But}^+)(\text{NH}_4^+)^2}$$  \hspace{1cm} (9)

$$M\text{But}_2^+ + \text{NH}_4^+ \leftrightarrow M\text{But}_{R_{3}}^+ + \text{NH}_4^+$$

$$K'_{R_{3}} = \frac{(M\text{But}_{R_{3}}^+)(\text{NH}_4^+)}{(M\text{But}_2^+)(\text{NH}_4^+)}$$  \hspace{1cm} (10)
K'\text{d} may then be defined as follows:

\[ K'\text{d} = \frac{(\text{MR}_3) + (\text{MButR}_2) + (\text{MBut}_2\text{R})}{(M^{+3}) + (\text{MBut}^{+2}) + (\text{MBut}_2^{+}) + (\text{MBut}_3)} \tag{11} \]

Substituting in equation 11 the values from the above equations we obtain:

\[ K'\text{d} = K'_0\frac{R_1}{R_2} (\text{M}^{+3}) + K'_0\frac{R_1}{R_2} (\text{M}^{+3})(\text{But}^-) + K'_0\frac{R_1}{R_2} (\text{M}^{+3})(\text{But}^-)^2 + K'_0\frac{R_1}{R_2} (\text{M}^{+3})(\text{But}^-)^3 \tag{12} \]

simplifying:

\[ K'\text{d} = \frac{K'_0\frac{R_1}{R_2} (\text{But}^-) + K'_0\frac{R_1}{R_2} (\text{But}^-)^2 + K'_0\frac{R_1}{R_2} (\text{But}^-)^3}{1 + K'_0\frac{R_1}{R_2} (\text{But}^-) + K'_0\frac{R_1}{R_2} (\text{But}^-)^2 + K'_0\frac{R_1}{R_2} (\text{But}^-)^3} \tag{13} \]

Although the above equations are given for the activities of the various ions, we shall use concentrations as the activities in the resin phase are not known. However, the ionic strength of the solutions is maintained constant, and therefore the activity coefficients may be considered constant at least at the low But concentrations. Thus the stability constants obtained are "concentration" constants rather than thermodynamic constants. All these constants are defined as before and designated without the prime.

To determine the stability constants \(K_1', K_2'\), and \(K_3'\), it is necessary to measure \(K_d\) at various concentrations of alpha hydroxyisobutyrate. \(K_{d0}\) must also be determined. The pH, ionic strength, temperature and \(\text{NH}_4^+\) concentration are all maintained constant as all of these factors affect the equilibria.

**EXPERIMENTAL METHOD**

**Resin and Solutions:**

Resin: Dowex-50, 4% cross linked, with a settling rate of 1 to 1.5 cm/min was used in the \(\text{NH}_4^+\) form. The resin had been previously cleaned by washing alternately with hydrochloric acid, water, ammonium hydroxide, water, perchloric acid, water, and hydrochloric acid. It was then analyzed and found to be spectroscopically pure. The \(\text{NH}_4^+\) form resin was then prepared by passing 4 M \(\text{NH}_4\text{Cl}\) through the hydrogen form resin in a column until the pH was that of \(\text{NH}_4\text{Cl}\). It was then washed with conductivity water until the test for chloride was negative. The resin was removed from the column and dried at 40°C overnight.

It was found that drying the resin at a higher temperature caused it to decompose into the hydrogen form by evolution of \(\text{NH}_3\). A moisture
absorption curve was made for the resin, and it was found that the absorption of water was a steady process over the time range studied (see Fig. 1). It was also found that the resin slowly lost water while standing in a dessicator, thereby changing its equivalent weight. An analysis of the resin for nitrogen was made, and 6.02% nitrogen was reported. A subsequent analysis of the same sample which was left in a dessicator for about three months showed an increase in nitrogen to 6.50%. Therefore the resin for each series of experiments was weighed as rapidly as possible at the same time to avoid changes in the equivalent weight either through gain or loss of water.

**Alpha hydroxyisobutyric Acid:** A 1 M stock solution was prepared by dissolving 104.1 grams of acid (Eastern Chemical Corp.) in a liter of solution. The solution was filtered and further purified by passing through a column of H⁺ form resin. From this stock solution, solutions of the desired concentrations were prepared by dilution with conductivity water. All solutions were standardized with NaOH. The range of concentration of alpha hydroxyisobutyrate ion covered was 4.7 x 10⁻⁴ M to 0.124 M.

**Ammonium Perchlorate:** A 1 M solution was prepared by weighing Baker's Analyzed C. P. ammonium perchlorate. The Cm²⁴⁴ tracer in 0.1 M HCl solution, about 20 λ in volume, was introduced in 500 ml of 1 M NH₄ClO₄ solution. The chloride concentration was therefore negligible. A similar solution was prepared for the Am²⁴¹ tracer.

**Determination of Kₖₒ:** A weighed amount of resin, approximately 0.1 g, was introduced into a tube with a ground glass stopper. Five ml. of H₂O and 5 ml. of 1 M NH₄ClO₄ solution containing Cm²⁴⁴ or Am²⁴¹ in tracer concentration were then pipetted into the tube, giving a total volume of 10 ml. The tube was sealed with wax, placed on a revolving wheel in a constant temperature water bath at 25°C ± 0.05°C, and equilibrated overnight. A portion of the solution was removed with a pipette containing glass wool in the tip to act as a filter for the resin. From this filtered solution two 1000 λ samples were withdrawn and the ammonium ion destroyed with aqua regia by evaporation to dryness. 2000 λ of 6 M HCl were then added to each dried sample in the tube to dissolve the tracer, and from this solution, two 500 λ samples were removed, plated, and dried under an infrared lamp, flamed, and the activity measured in a 2 π geometry alpha particle counter.

An assay of the ammonium perchlorate solution containing the activity was made following the same procedure.
\[ K_{d0} = \frac{\text{number of counts added}}{\text{number of counts in solution}} \times \text{vol. (ml)} \times \frac{\text{number of counts in solution}}{\text{weight of resin (grams)}} \]

All pipettes used (both macro and micro) were coated with "Desicote" on the tip to prevent adherence of solution. Ionic strength was maintained at 0.5. The pH of each solution was measured after equilibration had been established.

Determination of \( K_d \): The same procedure was followed except that 5 ml of alpha hydroxyisobutyric acid of known concentration were introduced into the tube along with 5 ml of ammonium perchlorate solution containing the tracer. At low concentrations of isobutyric acid (.001 - .01) no correction was made for change in ionic strength or for change in pH. At higher concentration of isobutyric acid (.01 - 0.1), the procedure was slightly different. The pH at which the alpha hydroxyisobutyric acid was half neutralized was determined by titrating a blank with ammonium hydroxide for each concentration of acid in the presence of ammonium perchlorate at \( M = 0.5 \). The amount of ammonium hydroxide required was then added to each tube and the amount of ammonium perchlorate was changed accordingly to maintain constant ionic strength of 0.5 M. In this way the pH, ammonium ion concentration and the ionic strength were maintained fairly constant. Subsequent procedure was the same as in the \( K_{d0} \) determination.

It was found that even at low concentrations of alpha hydroxyisobutyric acid, the pH did not remain constant and therefore a \( K_{d0} \) vs pH curve was determined to observe the effect of pH on \( K_{d0} \) (Fig. 2). At higher concentrations, where the pH was maintained constant, it was found that after equilibration with the resin, the pH rose by about 0.2 units from pH \( \sim 3.6 \) to pH \( \sim 3.8 \).

\( K_a \) of alpha hydroxyisobutyric acid: A series of titrations of alpha hydroxyisobutyric acid with NH\( _4 \)OH were carried out in the presence of NH\( _4 \)ClO\( _4 \) with ionic strengths from 0.1 to 0.8 (Fig. 3). A Beckman pH meter, Model 6 was used. A value of 3.54 was obtained for the \( K_a \) at \( M = 0.5 \). This value was used in calculating the concentrations of alpha hydroxyisobutyrate in solution.

RESULTS

Four series of experiments were carried out with alpha hydroxyisobutyric acid, three of which were with Cm\( ^{244} \) and one with Am\( ^{241} \).
In the first experiment with $\text{Cm}^{244}$, an attempt was made to determine the first stability constant of the complex formed by using very low concentrations of alpha hydroxyisobutyrate ion. This would enable us to determine $K_1$ as follows:

Using only the first portion of equation 13,

$$K_d = \frac{K_{d_0}}{1 + K_1 \left[\text{But}^-\right]}$$  \hspace{1cm} (14)

and neglecting the absorption of $\text{Cm But}^{+2}$ on the resin, we have:

$$\frac{1}{K_d} = \frac{1}{K_{d_0}} + \frac{K_1}{K_{d_0}} \left[\text{But}^-\right]$$  \hspace{1cm} (15)

Thus a plot of $1/K_d$ vs But$^-$ concentration should give a straight line whose slope is equal to $K_1/K_{d_0}$ and whose intercept is equal to $1/K_{d_0}$. Alternately, since $K_{d_0}$, $K_d$ and $\left[\text{But}^-\right]$ are all known, $K_1$ may be determined by a solution of equation 14.

The concentration of But$^-$ in this experiment was very low ($6.7 \times 10^{-5}$ to $2.6 \times 10^{-4}$) due to the fact that the pH of the equilibrium mixture was much lower than expected, i.e., 2.6 - 2.7. This indicated that the resin must have been at least partially in the hydrogen form. The resin used in this experiment had been dried at $110^\circ\text{C}$, and it was found that on heating the resin to this temperature, and even below it, i.e., at about $80^\circ\text{C}$, the ammonium from resin decomposed giving off ammonia. To avoid this, subsequently the resin was dried at $40^\circ\text{C}$.

The results of the second series of experiments with Cm$^{244}$ and alpha hydroxyisobutyric acid are summarized in Tables I and II. A plot of $1/K_d$ vs But$^-$ (see Fig. 4) gave a straight line indicating that the first stability constant $K_1$ was the most important at these low concentrations from about $5 \times 10^{-4}$ to $2 \times 10^{-3}$ and that the absorption of $\text{CmB}^{++}$ on the resin could be neglected. The stability constant $K_1$ was determined by solving equation 14. The values for $K_{d_0}$ were taken from Fig. 2 for the pH at which each $K_d$ was measured. The variation of $K_{d_0}$ with pH is of the magnitude expected for the reaction $\text{MR}_3 + 3\text{H}^+ \leftrightarrow 3 \text{HR} + \text{M}^{+3}$ at these $\text{H}^+$ ion concentrations.

In the third series of experiments with $\text{Cm}^{244}$ and alpha hydroxyisobutyric acid, a wide range of isobutyrate ion concentrations up to 0.1 M was studied in an attempt to obtain values for $K_2$ and $K_3$. The results of these
experiments are summarized in Tables III and IV. In Table III are the data for low concentrations of alpha hydroxyisobutyrate ions and in Table IV, the higher concentration range.

A plot of $1/K_d$ vs But$^-$ as given in Fig. 5 for low concentrations of But$^-$ $4.7 \times 10^{-4}$ to $1.3 \times 10^{-3}$ gave a straight line. The values obtained for $K_1$ using equation 14 agree fairly well with those obtained in the previous experiment.

Combining the data in Tables III and IV, a plot of the entire range of isobutyrate concentrations covered versus $1/K_d$ gave a curve whose slope changed radically (see Fig. 6) indicating that at higher concentrations of isobutyrate the higher order complexes were being formed. Using the value of $K_1$ determined previously, and neglecting $K_{R_2}$ and $K_{R_3}$ (the adsorption of CmBut$^{+2}$ and CmBut$^+$), a solution of two simultaneous equations gave values for $K_2$ and $K_3$ which seemed fairly reasonable; $K_1 = 290$, $K_2 = 82$, $K_3 = 6$.

Substituting the average value for $K_1$ of 290 in equation 13 and using the data for the medium concentration range ($6.34 \times 10^{-3}$ to $6.34 \times 10^{-2}$) gave the value for $K_2 = 104$, and substituting this value for $K_2$ in the equation and using the data at $0.124 \text{ M}$ alpha hydroxyisobutyrate gave a value for $K_3 = 11$.

The results of the experiment with Am$^{241}$ and alpha hydroxyisobutyric acid are summarized in Table V. A plot of $1/K_d$ vs B$^-$ (see Fig. 7) gave a straight line. From the slope of the curve and using a value for $K_{d_0}$ obtained from the intercept a value for $K_1 = 527$ is obtained. This value is judged to be good to $\pm 30\%$ only. It is of interest that the value of $K_1$ for americium is greater than that for curium. This is the opposite of what was expected and seems quite odd.

The values for $K_1$, $K_2$, and $K_3$ for Cm alpha hydroxyisobutyrate calculated on the basis of the above results are approximate and further work will have to be done to determine the constants more exactly. The value for $K_1$ of 290 is probably good to within $10\%$ while $K_2$ to within $40\%$ and $K_3$ to within a factor of 2. The precision obtained in the measurements is good, i.e., within $2\% - 5\%$. However, the main source of error is due to the resin instability.

The $pK_1$, $pK_2$, $pK_3$ and $pK_T$ for Cm alpha hydroxyisobutyrate based on the average values for $K_1 = 290$, $K_2 = 93$, and $K_3 = 9$ are:

$pK_1 = 2.46$, $pK_2 = 1.97$ and $pK_3 = 0.95$

$pK_T = pK_1 + pK_2 + pK_3 = 5.38$

For comparison, the values for cerium oxalate given by Crouthamel and Martin$^7,8$ are:
The values for $pK_1$ of cerium, praseodymium and yttrium citrates as given by Tompkins and Mayer are respectively, 3.2, 3.4, and 3.6. Thus the mono-citrate complexes are stronger than the mono-butyrate ones. It is of great interest, then, to determine what factors are responsible for the greater separation values with butyrate even though the complex is weaker.
Table I
Influence of pH on $K_{d_0}$ for $^{244}\text{Cm}$

The solution volume was 10 ml. The initial concentration in counts/minute of tracer per 250\mu is $C_o$ and the final concentration, $C_s$:

<table>
<thead>
<tr>
<th>pH</th>
<th>Resin weight (s)</th>
<th>$C_o$</th>
<th>$C_s$</th>
<th>$K_{d_0}$</th>
<th>$K_{d_0} \text{ Av}$</th>
</tr>
</thead>
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<tr>
<td>4.43</td>
<td>0.06475</td>
<td>9710</td>
<td>668</td>
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<td>2117</td>
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<td>4.10</td>
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<td>0.06623</td>
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<td>0.08725</td>
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<td>3.57</td>
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<td>504</td>
<td>1952</td>
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<tr>
<td></td>
<td>0.09969</td>
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<td>481</td>
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<td>3.36</td>
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<td>407</td>
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<td>0.11476</td>
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<tr>
<td>3.20</td>
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<td>413</td>
<td>1914</td>
<td>1918</td>
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<td></td>
<td>0.11569</td>
<td>&quot;</td>
<td>419</td>
<td>1922</td>
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</table>
Measurements of $K_d$ for Cm$^{244}$ in the presence of alpha-hydroxyisobutyric acid (low concentration)

The solution volume was 10 ml. The $pK_a$ for alpha hydroxyisobutyric acid used was 3.54. $C_o$ represents counts per minute per 250 $\lambda$ of solution initially present, and $C_s$, the final counts.

<table>
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<tr>
<th>$\alpha$-hydroxyisobutyric acid conc. $M$</th>
<th>pH</th>
<th>$\alpha$-hydroxyisobutyrate conc. $M$</th>
<th>Resin Weight (s)</th>
<th>$C_o$</th>
<th>$C_s$</th>
<th>$K_d$</th>
<th>$K_{d\text{ Av}}$ (x 10$^{-4}$)</th>
<th>$l/K_d$ (from curve)</th>
<th>$K_{d_0}$ (extrapolated value)</th>
<th>$K_1$ (extrapolated value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 x 10$^{-3}$</td>
<td>3.51</td>
<td>4.82 x 10$^{-4}$</td>
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<td>574</td>
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<td>1764</td>
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<td>1993</td>
<td>305</td>
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<tr>
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<td>1336</td>
<td>7.49</td>
<td>1884</td>
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<tr>
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<td>8.61</td>
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</table>

Measurement of $K_d$ for $^{244}\text{Cm}$ in the presence of alpha-hydroxyisobutyric acid (low concentration)

The solution volume was 10 ml. The $p_K$ for alpha hydroxyisobutyric acid used was 3.54. $C_o$ represents counts per minute per 250 $\lambda$ of solution initially present, and $C_s$, the final count.

<table>
<thead>
<tr>
<th>$\alpha$-hydroxyisobutyric acid conc. (M)</th>
<th>pH</th>
<th>$\alpha$-hydroxyisobutyrate conc.</th>
<th>Resin Weight (s)</th>
<th>$C_o$ Av.</th>
<th>$C_s$ Av.</th>
<th>$K_d$</th>
<th>$K_d$ Av.</th>
<th>$1/K_d$ Av. (x 10$^{-4}$)</th>
<th>$K_d$ *</th>
<th>$K_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>3.49</td>
<td>$4.70 \times 10^{-1}^4$</td>
<td>0.06560</td>
<td>9750</td>
<td>756</td>
<td>1814</td>
<td>1793</td>
<td>5.51</td>
<td>2066</td>
<td>324</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.06903</td>
<td>&quot;</td>
<td>737</td>
<td>1772</td>
<td>1793</td>
<td>5.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0025</td>
<td>3.25</td>
<td>$3.54 \times 10^{-1}^4$</td>
<td>0.07472</td>
<td>&quot;</td>
<td>680</td>
<td>1785</td>
<td>1714</td>
<td>5.60</td>
<td>2024</td>
<td>272</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>0.07540</td>
<td>&quot;</td>
<td>728</td>
<td>1643</td>
<td>1714</td>
<td>6.09</td>
<td></td>
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</tr>
<tr>
<td>0.005</td>
<td>3.10</td>
<td>$13.3 \times 10^{-1}^4$</td>
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<td>1471</td>
<td>6.54</td>
<td>1990</td>
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<td>&quot;</td>
<td>806</td>
<td>1413</td>
<td>1471</td>
<td>7.08</td>
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</tbody>
</table>

* $K_{d,0}$ was obtained by normalizing to the $K_{d,0}$ vs. pH curve as given in Fig. 1.
Table IV

Measurement of $K_d$ for $^{244}$Cm in the presence of alpha-hydroxyisobutyric acid (higher concentration)

The solution volume was 10 ml. The $K_a$ for alpha hydroxyisobutyric acid used was 3.54. $C_o$ represents counts per minute per 250 $\lambda$ of solution initially present, and $C_s$, the final count.

<table>
<thead>
<tr>
<th>$\alpha$-hydroxyisobutyric acid conc.</th>
<th>pH</th>
<th>$\alpha$-hydroxyisobutyrate conc.</th>
<th>Resin Weight (s)</th>
<th>$C_o$</th>
<th>$C_s$</th>
<th>$K_d$</th>
<th>$1/K_d$ ($x 10^{24}$)</th>
<th>$K_d*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 M</td>
<td>3.78</td>
<td>$6.34 \times 10^{-3}$</td>
<td>0.11973</td>
<td>9750</td>
<td>1285</td>
<td>550</td>
<td>18.2</td>
<td>2108</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.11804</td>
<td>9750</td>
<td>1475</td>
<td>475</td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>0.02 M</td>
<td>3.70</td>
<td>$1.18 \times 10^{-2}$</td>
<td>0.12342</td>
<td>9750</td>
<td>2203</td>
<td>278</td>
<td>36.0</td>
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<tr>
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<td>0.12563</td>
<td>9750</td>
<td>3083</td>
<td>172</td>
<td>58.1</td>
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</tr>
<tr>
<td>0.05 M</td>
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<td>$3.14 \times 10^{-2}$</td>
<td>0.16469</td>
<td>9263</td>
<td>5183</td>
<td>47.8</td>
<td>209</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>0.16196</td>
<td>9263</td>
<td>4754</td>
<td>58.5</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td>0.1 M</td>
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<td>$6.34 \times 10^{-2}$</td>
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<td>7538</td>
<td>12.5</td>
<td>860</td>
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<td>0.13043</td>
<td>15608</td>
<td>13043</td>
<td>15</td>
<td>667</td>
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</tr>
<tr>
<td>0.2 M</td>
<td>3.78</td>
<td>$1.24 \times 10^{-1}$</td>
<td>0.17986</td>
<td>7800</td>
<td>7437</td>
<td>2.71</td>
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<td>7507</td>
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<td>3278</td>
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</tr>
</tbody>
</table>

* $K_d*$ was obtained by normalizing to the $K_d$ vs. pH curve given in Fig. 1.
Table V

Measurement of $K_d$ for Am$^{241}$ in the presence of alpha-hydroxyisobutyric acid (low concentration)

The solution volume was 10 ml. The $p_f$ for alpha hydroxyisobutyric acid used was 3.54. $C_o$ represents counts per minute per 250 $\lambda$ of solution initially present, and $C_s$, the final count.

<table>
<thead>
<tr>
<th>$\alpha$-hydroxyisobutyric acid conc.</th>
<th>pH</th>
<th>$\alpha$-hydroxyisobutyrate conc.</th>
<th>Resin Weight (s)</th>
<th>$C_o$</th>
<th>$C_s$</th>
<th>$K_d$</th>
<th>$1/K_d$</th>
<th>$K_{d_0}$</th>
<th>$K_{d_0}^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 M</td>
<td>3.52</td>
<td>$4.88 \times 10^{-4}$</td>
<td>0.07872</td>
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<td>221</td>
<td>2021</td>
<td>4.95</td>
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<tr>
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<td>0.07449</td>
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<td>20.4</td>
<td>2324</td>
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<td>0.0025 M</td>
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<td>$9.14 \times 10^{-4}$</td>
<td>0.08864</td>
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<td>0.08701</td>
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<td>223</td>
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<td>0.005 M</td>
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<td>1527</td>
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<td>0.01 M</td>
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<td>$1.98 \times 10^{-3}$</td>
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<td>0.11876</td>
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<td>213</td>
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<tr>
<td>0.02 M</td>
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<td>$3.31 \times 10^{-3}$</td>
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<td>243</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

* $K_{d_0}$ obtained by normalizing to $C_m$
REFERENCES

Fig. 1. Moisture absorption curve at 23°C for Dowex-50 4% resin (0.1090g).
Fig. 2. Variation of $K_a$ of alpha-hydroxyisobutyric acid with ionic strength in NH$_4$ClO$_4$. X represents a separate measurement made 2 months previous to the others.
Fig. 3. Variation of $K_{d_0}$ with pH of the solution.