Reprinted from

International Journal of Applied Radiation and Isotopes, 1968, Vol. 19, pp. 147–149. Pergamon Press. Printed in Northern Ireland

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PERGAMON PRESS
OXFORD NEW YORK LONDON PARIS

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The Rapid Radiochemical Separation of Radioactive Praseodymium from Radioactive Cerium

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(*Received* 9 *August* 1967)

INTRODUCTION

IN ORDER to determine the half life, the decay scheme and other characteristics of a radioactive nuclide, it is important to obtain a sample of very high radiochemical purity. The time interval from the end of irradiation to the beginning of counting is very important, especially in the measurement of the decay constants of short lived radionuclides. In order to obtain pure-short-lived radioactive cerium and pure short-lived radioactive praseodymium from a praseodymium metal target (99·9 per cent pure) irradiated at the NBS Linac, the following two requirements must be met: (1) the rapid transfer of the target material; (2) the rapid dissolution and separation of cerium from praseodymium.

A procedure was developed to rapidly transfer and separate praseodymium and cerium. The praseodymium metal is dissolved in nitric acid and this solution is then divided into at least two aliquots. Fraction one is used to precipitate cerium (IV) iodate, giving an aqueous phase free of cerium radioactivity. A second fraction is extracted with a 0·7 M solution of hydrogen di-(2 ethylhexyl) orthophosphoric acid (HDEHP). The cerium (IV) in the organic phase is free of praseodymium radioactivity. The total time of transfer is 5 min and the time required for the separations is 5 min. Figure 1 shows the scheme for separating cerium and praseodymium.

EXPERIMENTAL

1. *General procedure*

Half or 1 gram of praseodymium metal was dissolved in 10 ml of concentrated nitric acid in less than a minute. After dissolution, 30 ml of 9 M nitric acid containing 1 M $KBrO_3$ was added to the dissolved sample. One aliquot was treated so as to precipitate ceric iodate within 5 min. The remaining aliquot was extracted by shaking with 0·7 M HDEHP within 5 min.

2. *The hydrogen di-(2-ethylhexyl orthophosphoric acid solvent extraction of cerium* (IV)

The hydrogen di-(2-ethylhexyl) orthophosphoric acid (HDEHP) was used as supplied from Victor Chemical Division of the Stauffer Chemical Company.* The HDEHP reagent was 84 per cent pure and a 0·7 M solution was prepared by diluting 12 ml of HDEHP to 50 ml with heptane. To the 10-ml aliquot taken for

* In order to specify adequately the procedures, it has been necessary occasionally to identify commercial materials and equipment in this paper. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.

analysis, add 0·5 ml of cerium carrier (10 mg) and 5 ml of freshly prepared 1·0 M $KBrO_3$ in 10 M HNO_3, then the solution is extracted by shaking with 10 ml of 0·7 M HDEHP for one minute.

3. *The precipitation of cerium* (IV) *iodate*

To 5 ml of the praseodymium solution is added one ml of 1·5 M $KBrO_3$, 0·5 ml of cerium-carrier and two ml of saturated KIO_3. The sample is centrifuged for one minute and the aqueous phase removed with a transfer pipette.

Using 4 M sulfuric acid, finely divided praseodymium metal dissolves within 2 minutes but lumpy praseodymium requires several hours to dissolve. The nitric acid dissolution of the praseodymium metal is satisfactory.

Several methods of separating praseodymium and cerium were investigated, including solvent extraction, precipitation and isotopic exchange. The acetylacetone extraction of cerium (IV) as reported by Suzuki and Ohi,[1,2] and the solvent extraction of ceric (IV) nitrate with methyl isobutyl ketone[3,4] were examined and found to be unsatisfactory in both cases. The use of hydrogen di-(2-ethylhexyl) orthophosphoric acid[5,6] gave a rapid separation of cerium with a decontamination factor $>10^5$ for the cerium in the organic phase, but the praseodymium isolated in the aqueous phase was not radiochemically pure under the conditions used. This method of separation can produce pure praseodymium, but the time required makes it unsatisfactory for rapid separation.

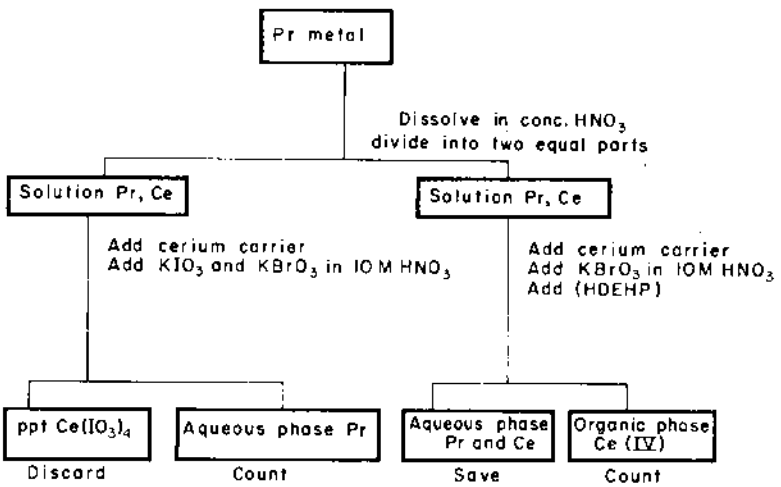

Fig. 1. Separation of cerium from praseodymium.

DISCUSSION

The time between the end of irradiation and the beginning of separation must be as short as possible, this requirement has been only partly satisfied. A pneumatic tube system can be used to deliver the sample from the Linac, but the sample must be hand-carried to another laboratory where it is separated from the rabbit.

Dissolution of two or three gram lumps of praseodymium metal occurs within less than a minute using concentrated or 9 M nitric acid. In order to obtain pure praseodymium, the isotopic exchange of cerium–144 with inactive

cerium (IV) iodate was investigated. This reaction proved to be too slow. The precipitation of cerium (IV) iodate gave a praseodymium solution which was free of cerium radioactivity (decontamination factor $>10^4$).

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