NOTE

The Separation of ^{199}Au from Neutron-irradiated Platinum with Lubricating Base Oil as Extractant[†]

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1. Introduction

The carrier-free ^{199}Au is a useful nuclide for medical uses and other applications due to its appropriate half-life and rather low energy of γ -rays emitted. The reaction $^{198}\text{Pt}(n, \gamma) \xrightarrow[30 \text{ min}]{\mu^-} ^{199}\text{Pt} \rightarrow ^{199}\text{Au}$ takes place when platinum is irradiated with neutrons. After separation procedure ^{199}Au thus produced is ready for medical uses. The method of separation for gold from platinum has been reported elsewhere¹⁾. However, some of the extractants used are very expensive. Lubricating base oil can be used as extractant to separate gold from a mixed solution containing other metallic ions²⁾. Since lubricating base oil is one of the by-products of petroleum, it is easy to obtain and yet inexpensive. Throughout this experiment lubrication base oil was used as extractant, and its application in the separation of ^{199}Au from ^{199}Pt - ^{199}Au solution was investigated.

2. Experimental

In this work, the medium grade lubricating base oil produced by China Petroleum Company was used. It was diluted with benzene. All reagents were of CP grade.

The radioactive tracer was produced in the 1 MW Tsing Hua Open-pool Reactor by irradiating platinum wire of high purity with neutron. The irradiation time was

12 h at the flux of $10^{12} \text{ n cm}^{-2} \cdot \text{s}^{-1}$. After cooling for 10 h, the target was dissolved in aqua regia, and evaporated to dryness. Then 0.5M HCl was added and it was diluted to 100 ml. Small quantity of ^{199}Pt - ^{199}Au was prepared with HClO_4 , HNO_3 , HCl , and H_2SO_4 , respectively in different acidities. Equal volumes (10 ml) of aqueous and organic phase were shaken in a 50 ml glass-stoppered Erlemmeyer flask at room temperature for 2~3 min. An aliquot of 5 ml each taken from organic and aqueous phases was transferred into a test tube, and was counted with a 38 cm³Ge(Li) detector coupled with a 4096-channel pulse height analyzer. Both the 159 keV γ peak for ^{199}Au and the 190 keV γ peak for ^{199}Pt were detected to determine the extraction capability. The extraction yield was determined to study the effect of acidities on extraction yield which is defined as

$$\text{Extraction yield} = \frac{\text{Total counts in organic phase}}{\text{Total counts in organic plus aqueous phase}} \times 100(\%)$$

In addition to the γ -ray spectrum measurement, the purity of ^{199}Au was also examined with half-life tracing.

3. Results and Discussion

1) The effect of acidities on extraction yield

The extraction capability for gold and platinum in various acidity conditions is shown in Fig. 1. The extraction yield for gold in HClO_4 , HNO_3 , HCl , or H_2SO_4 solution can reach beyond 99% in the acidity range of 0.5-8.0M. Platinum can be extract-

[†] 潤滑基油抽出による中性子照射白金からの ^{199}Au の分離. 曾家亮: 国立清華大学保健物理組 (中華民國台灣省新竹市)

ed with lubricating base oil only when it is in H_2SO_4 solution of the acidity beyond $4M$, and it cannot be extracted in HClO_4 , HNO_3 or HCl solution. To separate ^{199}Au from $^*\text{Pt}$ - ^{199}Au solution, we should perform the procedures in the acidity range of 0.5 - $8.0M$ HClO_4 , HNO_3 , or HCl .

Fig. 1 The extraction yield of ^{199}Au and $^*\text{Pt}$ in various acidity conditions of lubricating base oil.

The chemical composition of lubricating base oil is very complicated. How does the lubricating base oil react with gold is unknown. It needs further investigation. However, it is postulated that the extraction reaction is probably due to sulfides, nitrides, and oxides of high molecular compound contained in the lubricating base oil.

2) The relationship between concentration

Fig. 2 The extraction yield for various concentrations of lubricating base oil.

of lubricating base oil and extraction yield

The extraction capability of ^{199}Au for different concentrations of lubricating oil is presented in Fig. 2. It appears that extraction yield can reach beyond 99% for lubricating base oil beyond 5%. The extraction capability of lubricating base oil for gold is $2\text{ mg Au/mL}^{(2)}$. Since ^{199}Au is of carrier-free form, in practice it is possible that 5% extractant would be sufficient for the satisfactory results.

3) The back-extraction of ^{199}Au in organic phase

Several reagents such as KCN or NH_4OH can back-extract ^{199}Au into aqueous solution. Our experimental results show that satisfactory result can be obtained with $0.1M$

Fig. 3 The back-extraction yield of ^{199}Au from organic phase for various of $0.1M$ HCl containing 5% thiourea.

Fig. 4 The γ -ray spectrum of ^{199}Au in aqueous solution after back-extraction.

HCl containing 5% thiourea. Fig. 3 shows the back-extraction of ^{199}Au into aqueous solution from organic phase with different volumes of 0.1M HCl containing 5% thiourea. It appears in Fig. 3 that 5 ml reagent mentioned above would reach a back-extraction yield beyond 98%.

4) Identification of ^{199}Au purity

After the process of the back-extraction into aqueous solution, the γ -ray spectrum of ^{199}Au was measured with a 38 cm³ Ge(Li) detector coupled to a 4096-channel pulse height analyzer. The spectrum is shown in Fig. 4. The half-life of the sample was found to be 3.15 d which is in consistent with that of ^{199}Au .

4. Conclusion

The experimental results show that lubricating base oil can be used as a simple, economical, and efficient extractant in performing the separation of ^{199}Au from ^{199}Pt - ^{199}Au solution and can be used for routine production of ^{199}Au .

References

- 1) M. Iqbal and E. Ejaz: *J. of Radioanal. Chem.*, **27**, 15 (1975)
- 2) C.L. Tseng: "The Separation of Mercury, Gold, and Silver from a Mixed Solution by Lubricating base oil" *Radiochem. and Radioanal. lett.* (in press)