

Preparation for Simultaneous Determination of Stable Isotope Dy/Ho Separation by High-Performance Liquid Chromatography

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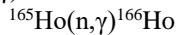
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1. Introduction

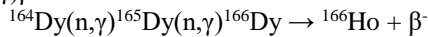
Holmium-166 (^{166}Ho) have been utilized in field of medical radiotherapeutic applications such as radioimmunospecific pharmaceuticals, bone marrow ablation and radiation synovectomy due to its high- β radiation energy [$T_{1/2}=26.6$ h, $E_{\text{max}}^{\beta}=1855$ keV(51%), $E_{\text{av}}^{\beta}=666$ keV] [1].

^{166}Ho can be produced by two approach using (n, γ) reaction and (n, γ) β reaction.

(n, γ) reaction:



(n, γ) β reaction:



^{166}Dy as parent nuclide can be produced by double neutron capture reaction of stable ^{164}Dy . ^{166}Ho produced by (n, γ) β reaction from ^{166}Dy [$T_{1/2}=81.5$ h, $E_{\text{max}}^{\beta}=486.8$ keV, $E_{\text{av}}^{\beta}=130$ keV] is a carrier free state [2].

Successful separation of adjacent lanthanides is complicated process to obtain pure target nuclide. Several papers have reported that the ionic character change of lanthanides with appropriate chelating agents can isolate the target lanthanides [1-3]. These specific agents to the metal ion are called as 'complexing agents' including α -HIBA, tartaric acid, mandelic acid, lactic acid etc.

Radioisotope research division of KAERI has developed separating technique for target lanthanides, total 20mg scale, by using complexing agents and ion-pairing agents in cold state. Furthermore, our division has developed an automated system for separating pure target radioisotopes, which is aimed to protect operators from harmful radiation as well as to reduce the separation time. The separation of the RI can be confirmed by the RI detection part to control the RI separation. However, the stable isotopes are difficult to confirm directly without the addition of any reagents.

Robards et al. [4] have published a review of the simultaneous determination of lanthanides in chromatographic fields. The post-column reaction system has been used to enhance the sensitivity and specificity effects for the simultaneous determination of metal analysis. The post-column reactions are based on spectrophotometric determination after formation of metal complexes with the appropriate chromogenic complexing reagents [5].

In this research, we will present the preparation for the post-column reaction system of lanthanide separation by HPLC in cold state. Preliminary test was carried out with four different post-column derivatization reagents, 4-(2-pyridylazo)resorcinol (PAR), arsenazo III, xylenol orange and cupferron to evaluate suitable material in this system.

2. Experiments

2.1. Materials

Dysprosium oxide (Dy_2O_3) and holmium oxide (Ho_2O_3) were obtained from Sigma-Aldrich. α -Hydroxyisobutyric acid (HIBA), PAR, arsenazo III (2,7-bis(*o*-arsenophenyl) azo-1,8-dihydroxynaphthalene-3,6-disulfo-nicacid), xylenol orange (3,3'-bis[N,N-bis(carboxymethyl)aminomethyl]-*o*-cresolsulfonphthalein disodium salt) and cupferron (ammonium N-nitrosophenylhydroxylamine) were purchased from TCI. Ammonium hydroxide and glacial acetic acid were purchased from Daejung Chemicals and Merck, respectively.

Stock lanthanide solutions (1,000 ppm) were prepared by dissolving the corresponding amount of the oxides in concentrated hydrochloric acid, and working solutions were obtained by dilution with water. A 0.1 M HIBA was adjusted to pH 4.2 with ammonium hydroxide. The stock solutions of the post-column derivatization reagent were prepared by the following procedures [6]: 0.2 mM PAR solution (detection at $\lambda = 510$ nm) in 1.5 M ammonium hydroxide and 1 M acetic acid (pH 9.8); 0.1 mM arsenazo III solution (detection at $\lambda = 654$ nm) in 1 M acetic acid (pH 2.4); 0.1 mM xylenol orange solution (detection at $\lambda = 570$ nm) in 1 M acetic acid and 6 M NaOH (pH 5.8); 0.1 mM cupferron solution (detection at $\lambda = 276$ nm).

2.2. Manufacture of automated system

After neutron bombardment, dissolving and separation step of target nuclide should be done under shielding condition. In case of separation of (n, γ) β lanthanides, it takes 3~4 hours to get the aimed isotopes. To obtain target RIs, the mixed isotopes go through series of the following steps: injecting RIs to the column, adjusting flow rate, fractionalizing sample and then washing each isotope. These complicated steps are illustrated by a flow diagram is shown as below (Fig. 1).

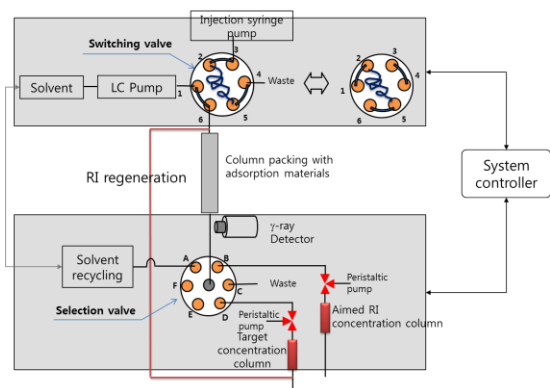


Fig. 1. Flow diagram of (n,γ)β separation and target recovery.

2.3. Preliminary study of the post-column reaction

Calibration curves of the post-column reagent against the concentration of lanthanide was employed. The absorbance was measured with UV-vis spectrophotometer (Agilent 8453). Metal identification was performed by using atomic adsorption spectroscopy (AA-7000, Shimadzu).

2.4. Instrumentation with the post-column reaction system

The HPLC instrument consisted of a high pressure pump and a six-port Rheodyne valve equipped with sample loop of 500 μl. The lanthanide sample was injected into the mobile phase HIBA delivered at a flow rate of 1.0 ml/min. The eluted metal ions were mixed in a mixing-tee with the post-column reagent added using a syringe pump with a flow rate of 0.7 ml/min. Then, the mixed solution was monitored using a UV-vis spectrophotometer. (Fig. 2)

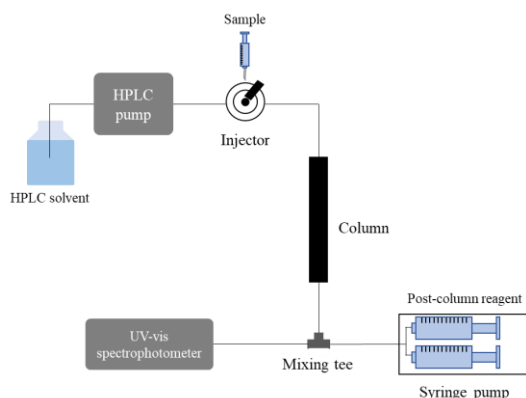


Fig. 2. Schematic diagram for system of lanthanide separation in cold state.

3. Results and Discussion

As a result of considering the sensitivity and specificity for lanthanide, PAR and arsenazo III is considered as a suitable reagent among the post-column

reagents. The color of PAR and arsenazo III varied in solution from yellow to red and red to bluish grey upon reaction with lanthanide, respectively. The calibration curves obtained with PAR and arsenazo III show that PAR is more sensitive to lanthanide. In addition, AAS measurement confirmed that there was no absorption interference of PAR.

The ultimate aim of this study is to find optimal system conditions to separate lanthanide. We try to establish proper separation conditions by adjusting the column length, flow rate, etc.

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