Study on hydrous tin(IV) oxide adsorbent for a $^{82}Sr/^{82}Rb$ generator system

Yeong Su Ha*, Yeonji Lee, Kye-Ryung Kim
Korea Multi-purpose Accelerator Complex (KOMAC), Korea Atomic Energy Research Institute (KAERI), 181 Mirae-ro, Geonchon-eup, Gyeongju, Gyeongbuk, 38180, Korea
**Corresponding author: ysha19840704@kaeri.re.kr*

1. Introduction

Despite remarkable medical advances in recent decades, cardiovascular disease remains as one of the most common causes of high morbidity and mortality worldwide, making an early diagnosis is of paramount importance [1,2]. For these purpose, various imaging modalities have been developed and are increasingly used to improve the diagnosis and prognostic classification of patients at risk of cardiovascular diseases including positron emission tomography (PET) [3,4].

Rubidium (Rb), an alkali metal ion, acts biologically like potassium, and accumulates in cardiac muscle tissue. Rb has a rapid blood clearance profile which allows the use of ^{82}Rb (β^+ emitter) with an ultra-short physical half-life of 75 sec for non-invasive evaluation of regional cardiac blood flow. ^{82}Rb can be produced from a generator system by the decay of its 25.5-day half-life parent ^{82}Sr [5].

To the current date, since no history of the use of ^{82}Rb radioisotope for research or medical purpose in Korea, Korea multi-purpose accelerator complex (KOMAC) has plan to produce ^{82}Sr with certain purity and develop $^{82}Sr/^{82}Rb$ generator system utilizing our facility. The KOMAC has a 100-MeV proton linear accelerator which consists of a 50-keV proton injector, four vane-type radio-frequency quadruples (RFQs), and 100-MeV drift tube linacs (DTLs). One target room among 10 target rooms to support various application fields was already assigned to the target irradiation for the radioisotope (RI) productions [6].

Here, we report the results on characteristic studies of adsorbent in the generator system.

2. Methods and Results

2.1 Preparation of hydrous tin(IV) oxide

Hydrous tin oxide, approximately 3 g, was washed with 20 mL of 0.1 N NH_4Cl/NH_4OH buffer, pH 10. In order to activate its cationic exchange properties, 50 mL of the buffer solution was added. The tin oxide in the buffer was kept overnight at room temperature and repeatedly elutriated. After such treatment, the tin oxide was stored in the buffer solution until loaded in the generator column. The tin oxide adsorbent is then saturated with sodium cations by passing 120 mL of 2 M NaCl through the column at a flow rate of 0.5 mL/min. Excess sodium cations were washed by passing 300 mL of saline through the column at a flow rate of 5 mL/min.

The cationic exchange properties of the tin oxide were confirmed by passing through the column 10 mL of water that was acidified with 0.1 M HCl to pH 4.05. The pH of the eluate should not decrease below 6. After that, the ion-exchange capacity of the tin oxide adsorbent was recovered with sodium cations by passing through the column first 2 M NaCl and then saline.

2.2 Loading the purified Sr into the generator column

The pure Sr in 0.1 M HCl prepared by the optimized purification method was neutralized to pH7.4 with 20 mL of 0.5 M Trizma-HCl buffer. The mixture was loaded into the cation saturated column at a flow rate of 0.05 mL/min. Afterwards, the column was washed with 500 mL of saline at a flow rate of 0.5 mL/min.

2.3 Elution yields of Rb

Rb equal to the quantity of the purified Sr was also loaded into the generator column by the same procedure used for Sr loading. Saline was used to inject ^{82}Rb solution into animal models or patients. Effect of a flow rate on the Rb elution yield was tested at several different flow rates. The Sr and Rb loaded column was eluted with saline at the correct flow rate according to each experimental condition. The quality of the Rb eluate was inspected by visual appearance, pH measurement. The elution yield of Rb was calculated by dividing the quantity of Rb in the saline eluate by the quantity of Rb in the loading solution.

2.4 Chracteristics of the generator column

The adsorption of Sr into the generator column was 98.36±0.61% (n = 7). No significant Sr breakthrough was observed by ICP-MS analysis of elution solution of the generator column. The K_D value of Sr (II) was between 47,000 and 58,000. While the corresponding K_D value of Rb (I) was 2.5±1, 4 orders of magnitude lower than those of Sr (II) [7].

The eluted saline solution with Rb shows clear and neutral pH (Fig. 1). This enables direct injection of ^{82}Rb into animals or patients for medical purposes.

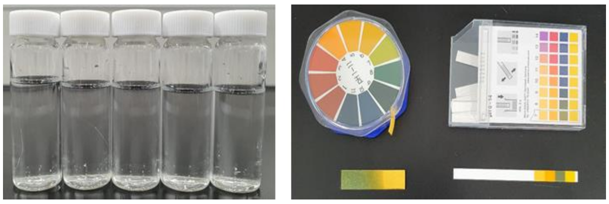

Fig. 1. Visual inspection (left) and pH measurement (right) of eluate.

For a flow rate of between 0.3 and 10 mL/min, the Rb elution yield varies between 4.79 and 55.74% (Fig. 2). A similar trend with previous reported data was observed up to 10 mL/min [8].

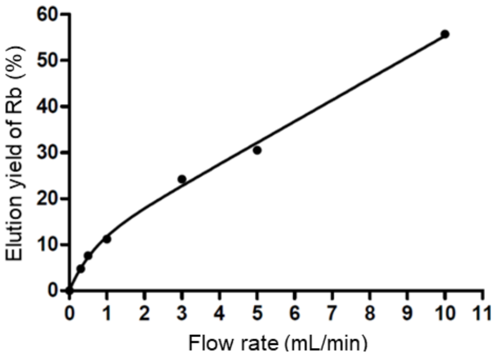

Fig. 2. Elution yield of Rb as a function of flow rate. Curve graph was generated using GraphPad Prism 5.0.

3. Conclusions

Hydrous tin(IV) oxide in sodium cation form shows a promising result as a cation exchange adsorbent of a ^{82}Sr/^{82}Rb generator. The elution yield of Rb is between 4.79 and 55.74% at the flow rates used (0.3–10 mL/min). For the same flow rate range, the Sr breakthrough is negligible values within specifications. These results support that the prepared hydrous tin oxide adsorbent could be used as a potential technique for development of a ^{82}Sr/^{82}Rb generator.

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