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Production of Sulfur-35 by the Cation Exchange Process

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1. Introduction

Sulfur-35 is the most commonly used radioactive isotope of sulfur, and it is a cosmogenic isotope that has a half life of 87 days. The short half life of ^{35}S allows it to be used to examine the influence of recent (~1yr) precipitation. The presence, or subsequent absence, of ^{35}S indicates the source of at least part of the water is recent precipitation, and there is a flowpath which delivers this water to the sampled location. ^{35}S is a conservative tracer, and acts as sulfate as it flows through the system.

Sulfur-35 is usually produced by neutron irradiation on potassium chloride, utilizing the $^{35}Cl(n,p)^{35}S$ reaction. Although the $^{34}S(n, \gamma)^{35}S$ reaction can also be utilized, it produces a product of low specific activity and is not practical.

In this study, technique to produce carrier-free sulfur-35 from neutron irradiated potassium chloride was developed. For the post-irradiation process, the cation exchange method based on the selective adsorption of phosphate on Fe^{+3}-cation exchange resin was adopted.

2. Methods and Results

2.1 Cation Exchange Process

The simplest way of separating the ^{35}S from potassium chloride is by cation exchange resin. An aqueous solution of the irradiated potassium chloride is passed through a hydrogen form cation exchange resin to remove potassium. The effluent is evaporated to dryness to remove chlorine and ^{36}Cl. The ^{35}S is leached by dilute hydrochloric acid. It is obtained directly in the form of sulfuric acid without any oxidation of the product.

The ^{35}S produced by this procedure is adequately pure except for minute quantities of ^{32}P, which must be separated when present in non-negligible amount. This is done by adsorption of the ^{32}P in iron form cation exchange resin.

2.2 Experimental Method

The 2g of KCl target was irradiated in a flux of 1.76 x 10^{12} n/cm^2·s in IP-15 of HANARO for about 170 hours, which produced about 7 mCi of ^{35}S. Sulfur-35 was separated from irradiated KCl by the cation exchange process shown in Figure 1. An exchange resin column of 1 cm in diameter by 20 cm long filled with Dowex-50 of 50/100 mesh size was used to treat 25 cm^3 of dissolved KCl.

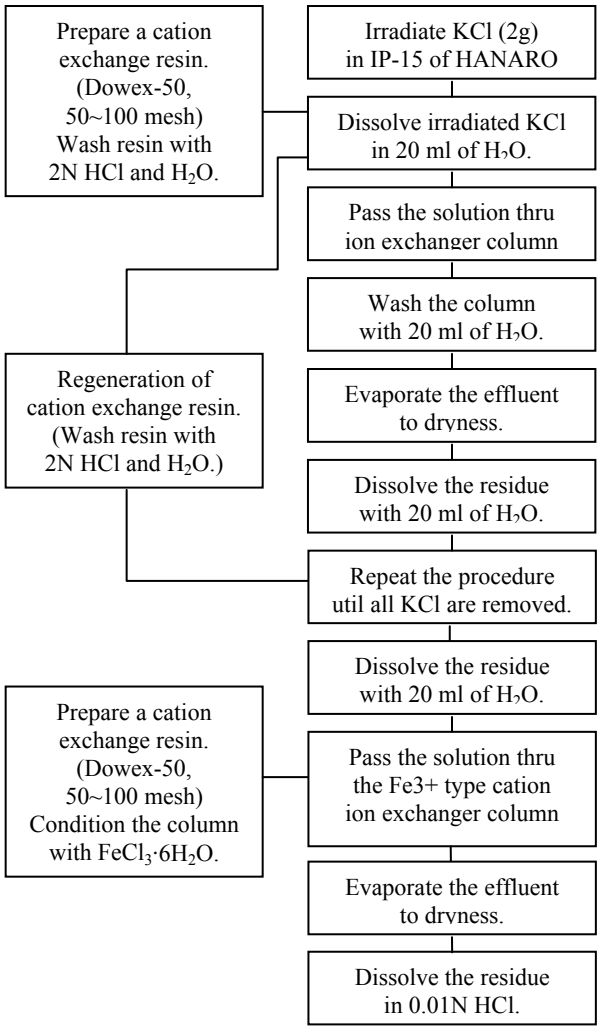

Figure 1. The flow-sheet for the production of ^{35}S by the cation exchange process.

2.3 Results

The radioactivity of ^{35}S produced was measured using a liquid scintillation method. The measurements were performed using the Hidex model Triathler liquid scintillation counter.

The liquid scintillation samples were prepared from a solution of ^{35}S in hydrochloric acid by gravimetrically adding ^{35}S solution into 20 ml low-potassium glass

vials containing 10 ml liquid scintillator. Liquid scintillator Aqualight from Hidex was used. The samples used for the measurement were prepared by deposition of known amounts, about 20 mg, into the scintillator. The masses were determined accurately by the pycnometer method. Pycnometer was weighed on a micro balance before and after the drops had been expelled. The samples were measured for 2 minutes. The spectrum for ^{35}S obtained experimentally using liquid scintillation counting is shown in Figure 2(a).

Radionuclide purity was determined by Cerenkov counting and by gamma-spectrometry. The impurity $^{32}P(E_{max}=1.71Mev)$ can be measured in the presence of $^{35}S(E_{max}=0.166MeV)$ by Cerenkov counting, which has been applied to beta-ray emitters with different maximum energies. As a result, it was confirmed that the impurity ^{32}P did not exist.

The γ-radionuclidic impurities were measured by HPGe detector(Ametec_ortec). The spectrum shown in Figure 2(b) was recorded by multi-channel analyzer DSPec(Ametec_ortec) and Maestro-32 software. The volume of 1 ml of the diluted solution in a 20 ml glass vial was measured, but γ-radionuclidic impurities were not detected except environmental radioactivity. The amount of γ-impurities in the solution of ^{35}S was not exceed 0.0001%.

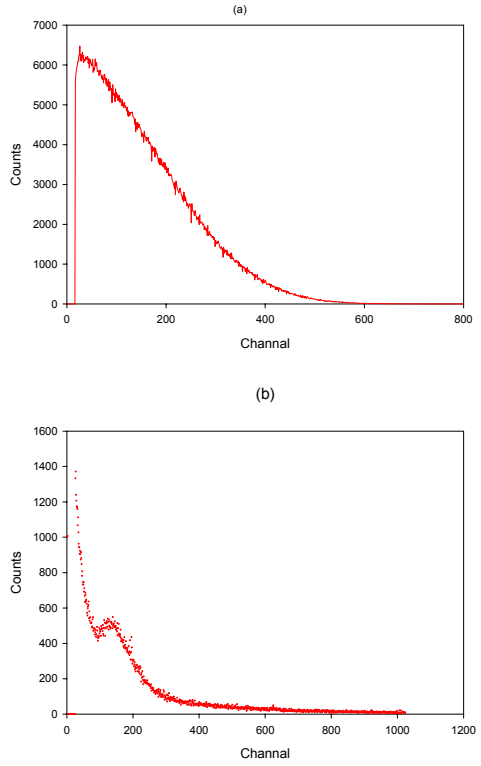

Figure 2. (a) The beta spectrum of ^{35}S recorded in the triathler, (b) gamma spectrum of ^{35}S on HPGe detector

3. Conclusion

Procedure to produce sulfur-35 from neutron irradiated potassium chloride was developed. The cation exchange process which is based on the selective adsoptrion of phosphorous-32 on Fe^{3+}-cation exchange resin was adopted. Sulfur-35 has been produced by this process, and product of high quality has been obtained..

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