No-carrier-added Purification of 28Mg Using Co-precipitation and Cation Exchange Method

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V. 2. No-carrier-added Purification of ^{28}Mg Using Co-precipitation and Cation Exchange Method

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The isotope ^{28}Mg is useful in biological sciences as a radioactive tracer[1,2)]. Generally, ^{28}Mg is produced for each use in nuclear reactions because of its short half-life of 21.6 h[3)]. The reaction ^{27}Al(α,3p)^{28}Mg is often chosen for the production of ^{28}Mg owing to its potential to produce no-carrier-added ^{28}Mg tracer with a convenient and low-cost target. Several groups have reported separation methods of ^{28}Mg from Al targets based on adsorption[4,5)], co-precipitation[6)], solvent extraction[7)], and the cation exchange column method[8)]. Although the cation exchange column method should yield a high purity tracer, it requires a large column and an eluant volume of a few hundred milliliters. In this work, we applied a co-precipitation method before the cation exchange column method to downsize the column volume. Downsizing chemistry leads to the reduction of waste and labor in separation procedures and the quality improvement of the tracer.

Magnesium-28 was produced in the ^{27}Al(α,3p)^{28}Mg reaction. An α-particle beam was delivered from either the AVF Cyclotron at CYRIC, Tohoku University or the RIKEN K70 AVF Cyclotron. The target stack of 7 Al foils (99.9% pure) with a thickness of 100 μm was irradiated with an α-particle beam with a beam energy of 50 MeV and a mean current of approximately 3 μA.

First, the conditions for the separation of ^{28}Mg from Na, which get mixed at the time of co-precipitation process, were searched for. After the irradiation, the Al targets were dissolved in 12 M (mol/dm^3) HCl diluted with water to 15 mL. The ^{28}Mg isotopes were co-precipitated with iron hydroxide by adding 2 mg of Fe(III) and 25 mL of 6 M NaOH and separated from $[Al(OH)_4]^-$ ions. After centrifugal separation, the precipitation of iron hydroxide was dissolved in 9 M HCl. The solution was passed through an anion exchange resin column (Dowex 1×8, 100-200 mesh, 1 mL), which adsorbs Fe(III) ions, and the resin was washed with additional 9 M HCl. The eluate was heated to dryness and adjusted to 0.5 M oxalic acid. To investigate the behavior of the Na ions, approximately 300 Bq of ^{22}Na tracer was added to the solution. The solution was passed through a cation exchange resin column (Dowex 50W×8, 100-200 mesh, 1 mL) to adsorb ^{28}Mg isotopes. The resin was washed with 10 mL of 0.5 M oxalic acid to eliminate Al ions and then with 0.5 M HCl to eliminate Na ions. The elution curves of the cation exchange separation for Na and Mg are shown in Fig. 1. The Na ions are eluted completely within 10 mL of 0.5 M HCl whereas the Mg ions are retained onto the column. The ^{28}Mg isotopes were eluted from the column with 6 mL of 2 M HCl.

Next, the conditions for the separation of ^{28}Mg from ^{7}Be, which is produced in the side nuclear reactions, were searched for. The irradiated Al targets were dissolved in 12 M HCl. A portion of it, containing 0.1 mmol of Al and trace amounts of ^{7}Be, ^{24}Na, and ^{28}Mg, was heated to dryness and adjusted to 0.5 M oxalic acid. The solution was passed through a cation exchange column (Muromac 50W×8, 100-200 mesh, 1 mL), which adsorbs Al(III), ^{7}Be, ^{24}Na, and ^{28}Mg ions, following which the resin was washed with 7 mL of 0.5 M oxalic acid to eliminate Al(III) and 5 mL of 0.2 M HF. The elution curves of the cation-exchange separation is shown in Fig. 2. The ^{7}Be ions are eluted completely within 5 mL of 0.2 M HF, whereas the ^{24}Na and ^{28}Mg ions are retained onto the column.

The recommended chemical scheme for ^{28}Mg purification is shown in Fig. 3. The irradiated Al targets were dissolved in 9 M HCl and then diluted with water to 15 mL. The ^{28}Mg isotopes were co-precipitated with iron hydroxide by adding 2 mg of Fe(III) and 15 mL of 6 M NaOH and separated from Al, Na, and Be ions. The precipitation of iron hydroxide was dissolved in 9 M HCl. The solution was passed through an anion exchange resin column (Muromac 1×8, 100-200 mesh, 1 mL), which adsorbs Fe(III) ions, and the resin was washed with additional 9 M HCl. The eluate was heated to dryness and adjusted to 0.5 M oxalic acid. The solution was passed through a cation exchange resin column (Muromac 50W×8, 100-200 mesh, 1 mL) to adsorb ^{28}Mg isotopes. The resin was washed with 0.2 M HF for Be elimination, 0.5 M oxalic acid for Al elimination, and 0.5 M HCl for Na elimination. The ^{28}Mg isotopes were eluted from the column with 2 M HCl. The chemical yield of the separation procedure, determined by γ-spectrometry of ^{28}Mg, was approximately 85% and radioactivity other than ^{28}Mg was not detected in the Mg fraction.

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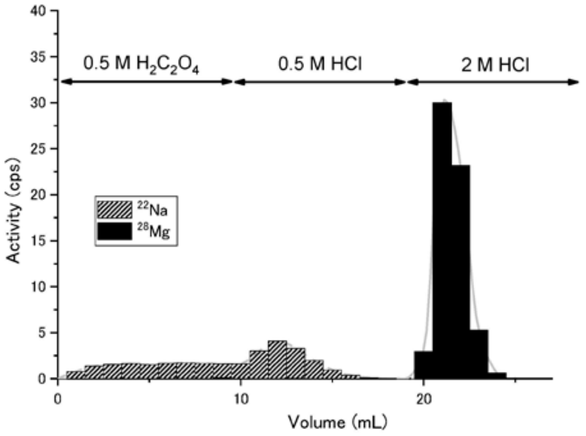

Figure 1. Elution curves for the cation exchange separation for Na and Mg.

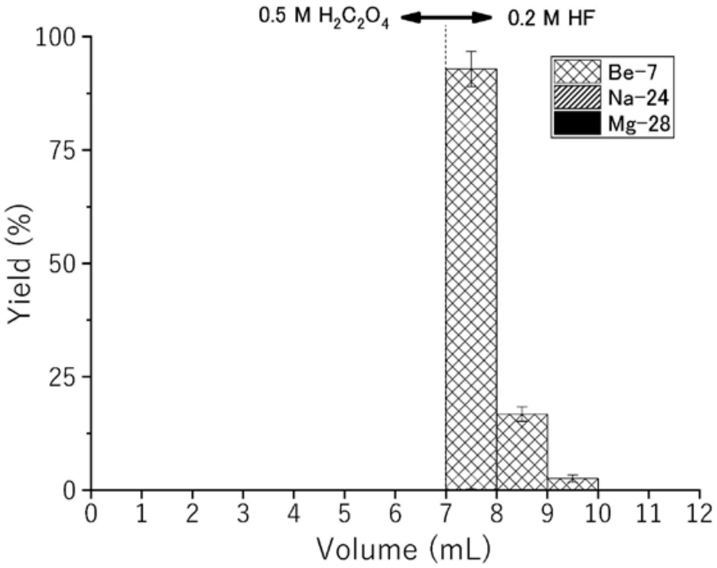

Figure 2. Elution curves for the cation exchange separation of Be, Na, and Mg.

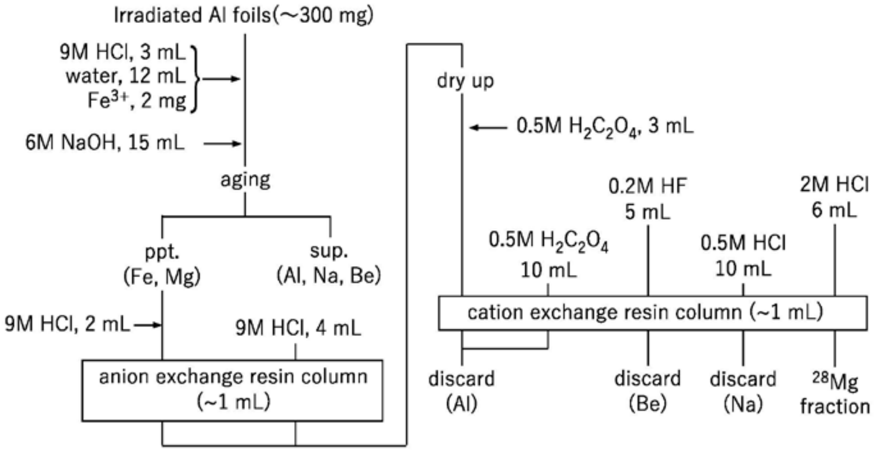

Figure 2. Chemical procedure for the preparation of no-carrier-added ^{28}Mg tracer.