

Radiochemical studies relevant to the production of ^{86}Y and ^{88}Y at a small-sized cyclotron

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Summary. Excitation functions were measured by the stacked-foil technique for $^{88}\text{Sr}(p, xn)^{86,87,88}\text{Y}$ reactions from threshold up to 25 MeV. From the measured cross sections integral yields of ^{86}Y , ^{87}Y and ^{88}Y were calculated. The optimum energy range for the production of ^{86}Y is $E_p = 14 \rightarrow 9$ MeV; the ^{86}Y yield amounts to 1.75 MBq (47.3 $\mu\text{Ci}/\mu\text{A}\cdot\text{h}$) and the ^{87}Y and ^{88}Y impurities to 2.0 and 4.4%, respectively. The isomeric cross section ratio for the pair $^{88\text{m},88}\text{Y}$ was determined as a function of incident proton energy and the results are discussed in terms of the spins of the two isomeric states involved. Medium scale production of both ^{86}Y and ^{88}Y has been carried out more than 15 times each using the (p, n) reaction. In the former case 96.3% enriched $^{88}\text{SrCO}_3$ was used as target material, and in the latter $^{88}\text{SrCO}_3$. The method of separation of radioyttrium has been improved. After coprecipitation with $\text{La}(\text{OH})_3$, cation-exchange HPLC was applied to isolate radioyttrium from the carrier lanthanum. The radionuclidic and chemical purities of the products were good. Batch yields of ^{86}Y and ^{88}Y amounted to about 3.5 GBq and 35 MBq, respectively.

1. Introduction

The radionuclide ^{86}Y ($T_{1/2} = 64.1$ h, $I_{\beta^-} = 100\%$, $E_{\beta^-} = 2.3$ MeV) is one of the widely used therapeutic nuclides. However, it is not suitable for imaging. A general solution to this problem has been to substitute ^{86}Y by a γ - or β^+ -emitting yttrium radioisotope. In a few studies ^{87}Y ($T_{1/2} = 79.8$ h, EC = 99.8%, $E_{\gamma} = 388.5$ keV (82.1%) and $E_{\gamma} = 484.8$ keV (89.7%)) in combination with Single Photon Emission Computed Tomography (SPECT) was used. It is produced either via the $^{88}\text{Sr}(p, 2n)$ reaction [cf. 1] or the $^{88}\text{Rb}(\alpha, 2n)$ process [cf. 2]. The positron emitting ^{86}Y ($T_{1/2} = 14.7$ h, $I_{\beta^+} = 33\%$, $E_{\beta^+} = 1.2$ MeV), however, has proved to be more useful because of the possibility of imaging via Positron Emission Tomography (PET). For its production several nuclear processes were considered and the reaction $^{88}\text{Sr}(p, n)^{88}\text{Y}$ was found to be most suitable [3], partly because it could be used at a small-sized cyclotron.

The method was developed to produce about 1 GBq quantities of ^{86}Y [4]. In the meantime, the longer-lived ^{88}Y ($T_{1/2} = 106.6$ d, $I_{\beta^-} = 0.2\%$, EC = 99.8%, $E_{\gamma} = 898$ keV (92.7%) and $E_{\gamma} = 1836$ keV (99.4%)) has also gained some attention with respect to the development of novel chemical syntheses and investigation of slow metabolic processes, especially in animal experiments. The aim of this work was therefore to improve the known production method of ^{86}Y and to develop a method for the production of ^{88}Y in no-carrier-added form. The radionuclide ^{88}Y has hitherto been produced in no-carrier-added form only via the spallation process, mainly at the Los Alamos National Laboratory, USA. We describe its production at a small-sized cyclotron.

2. Study of $^{88}\text{Sr}(p, xn)^{86,87,88}\text{Y}$ processes

2.1 Experimental techniques pertaining to cross section measurements

Cross sections for the formation of ^{86}Y and $^{87,88}\text{Y}$ were determined via the activation technique. In order to obtain a large body of data from a few irradiations, the conventional stacked-foil technique [cf. 5,6] was used.

The thin samples of SrCO_3 required for these measurements were prepared via a special sedimentation method described earlier [3]. A suspension of very fine strontium carbonate powder in water-free acetone (about 50 mg carbonate per mL acetone) was obtained by mixing and stirring. Additionally, cellulose nitrate was added in concentration of 3%–5% with respect to the metal carbonate. About 200 μL of the suspension was then transferred to the sedimentation device placed in a desiccator. The suspension evaporated slowly at room temperature. After 2–3 hours the device was opened carefully and the homogeneous and mechanically stable deposit on a 25 μm thick Cu-backing ($\varnothing = 13$ mm) was removed. The surface of the deposit was covered with a 25 μm thick Al foil. The prepared sample was then used for irradiation.

Several stacks, each consisting of about 5 samples and a few monitor foils, were irradiated at the Jülich compact cyclotron CV 28 at a beam current of about 100 nA. The irradiation time in each case was 60 min. One stack was irradiated at the PSI in Villigen (Switzerland) for 7.7 h at a beam current of 40 nA. The beam currents were determined via the monitor reactions $^{64}\text{Cu}(p, xn)^{62,63}\text{Zn}$ and

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