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DEVELOPMENT OF $^{90}Sr/^{90}Y$ GENERATOR USING ELECTROCHEMICAL SEPARATION

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Abstract

Using of radiopharmaceuticals based on ^{90}Y in the treatment of solid cancer is increasing in recent years. Therefore, generators have been developed for obtaining the ^{90}Y using a feature of ^{90}Sr for spontaneous breakthrough and its equilibrium with ^{90}Y. Electrochemical separation of ^{90}Y from ^{90}Sr has become the basic method for obtaining ^{90}Y in high radiochemical yield. For the preliminary study, we used the electrochemical system with two electrochemical cells. Quality control was performed using extraction paper chromatography (EPC). Preliminary results showed that the separation completed successfully in both ways, quantity and quality.

Introduction

Because of its properties yttrium-90 (^{90}Y) is widely used for labelling of targeted molecules which could be useful in the treatment of cancer. These characteristics are reflected in the radiation of high β-energy ($E_{max\beta^-}$ = 2.27 MeV) and half-life time ($t_{1/2}$ = 64.4h) [1-3]. ^{90}Y is almost pure beta emitter; the gamma photon emission from yttrium breakthrough was so weak that it could be ignored. Significant advantage in the treatment of solid tumors represents a penetration of β^- particles in tissue with range of 5.9 mm [4].

Y-90 can be obtained as the product of neutron activation of the ^{89}Y in nuclear reactors (^{89}Y (n,γ)), but thus obtained yttrium has small specific activity. The second method is the generator system that is based on equilibrium $^{90}Sr/^{90}Y$. Generators systems consist of long life parent that spontaneous breakthrough and gives short-life daughter. ^{90}Sr with the half-life of 28.74 years decays by emission of β^- particles (energy of 0.546MeV) to ^{90}Y. A scheme of breakthrough is presented as:

$$^{90}_{38}\mathrm{Sr} \xrightarrow[28.74\,y]{\beta^-\,(0.54\mathrm{MeV})} {}^{90}_{39}\mathrm{Y} \xrightarrow[64.4\,h]{\beta^-\,(2.28\mathrm{MeV})} {}^{90}_{40}\mathrm{Zr}\ \text{(stable)}$$

^{90}Sr is extremely toxic due to similar chemical behaviour to calcium, it deposits in bones. Therefore it is very important that strontium could not be found in the final product. The current generators are based on chromatographic separation, extraction, separation by liquid membrane and electrochemical separation [5-8].

In preliminary research we used electrochemical method to provide the most efficient $^{90}Sr/^{90}Y$ separation [9]. Also, using this method radioactive waste is minimized.

Experimental

Electrolysis was performed potentiostatically on Potenciostat/Galvanostat/ZRA, Serie G 750, Gamry Instruments. Electrochemical cells consisted of three electrodes. Working and counter electrode were platinum electrodes and the reference electrode was saturated calomel electrode. Electrochemical cells of 100 cm^3 capacity was filled up to 75 cm^3 with 0.001M HNO_3. pH value was adjusted with 3 % ammonia and 0.003 M HNO_3 to 2.5-3.0. Before electrolysis the argon was bubbled through solution for a period of 15 min. Electrolysis was performed at -2.5 V with respect to SCE; the current of 100 mA was used. The first electrolysis lasted 90 min and then the working electrode was washed in acetone and transferred to second electrochemical cell, where it was used as counter electrode. The second electrolysis was performed at the same potential (-2.5 V) with respect to SCE, and pH of solution 2.5-3. After the second electrolysis, the working electrode with deposited ^{90}Y was washed out in acetate buffer. Quality control is performed using EPC with chromatography paper impregnated with 2-ethyl hexyl, 2-ethyl hexyl phosphonic acid (KSM-17). Paper strip (Whatman N^o1) was developed in saline. ^{90}Y remains at the beginning of the strip (Rf=0) while strontium was moved with mobile phase (Rf=1). As in the first experiments the mixture of ^{90}Sr and ^{90}Y with low activity, at the megabecquerel level, was used, the activity at the solvent front was estimated by use of dose calibrator (Capintec CRC 15R, USA) which contains calibration factor and compared with the total spotted activity. In addition, activity of solution was tested during the month and activity was measured.

Results and Discussion

Comparative results of radiochemical purity of ^{90}Y before and after electrolysis, obtained by paper chromatography, are given in Figure 1.

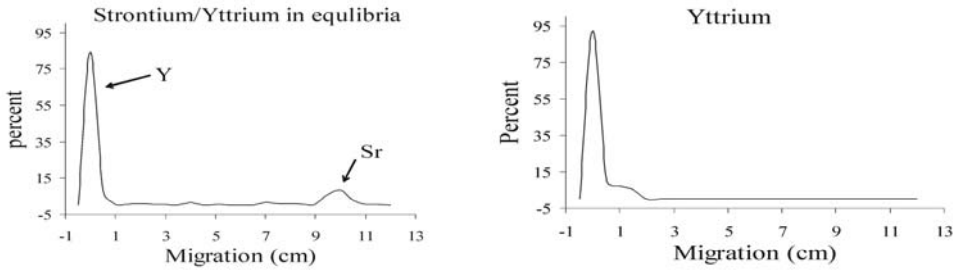

Fig.1. Extraction paper chromatohraphy a) strontium/yttrium in equilibrium; b) yttrium after electrolyses

Solution of strontium and yttrium is in balance, and its layout is shown in Fig. 1a, where two peaks are visible. The absence of peak at 10cm (Fig. 1b) which

represents strontium, indicate that separation of yttrium from strontium by electrochemical separation was successful.

The quality of separation was investigated by measuring radioactivity of obtained 90Y – solution during 35 days. Results are presented in figure 2 in CPM (counts per minute) versus time. The absence of deviation at the lower end of the stright line confirms the absence of 90Sr.

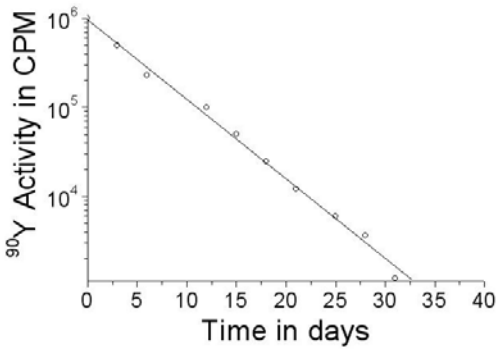

Fig.2. Radioactive decay of ^{90}Y prepared by the separation method studied for 35 days

Conclusion

Electrochemical separation method has a practical application for obtaining yttrium from ^{90}Sr/^{90}Y generator in routine nuclear medicine practice.The eficiency of the ^{90}Sr/^{90}Y generator was above 96% of the theoretical value and represent good basis for further development of this generator. Also, a satisfactory quality of the ^{90}Se/^{90}Y separation makes this product suitable for further use. Operating costs of such generators can be very low ensuring a stable supply of ^{90}Y for therapeutic use. Advanced technology has the potential for widespread use that would bring significant benefits to patients. Unlike other generators, the amount of radioactive waste produced by electrochemical generator is reduced to a minimum, which present significant advantage.

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