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Technical pitfalls in the production of ^{64}Cu with high specific activity

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Introduction

In 2008, we initiated production of ^{64}Cu aiming at high specific activities and high quantities. Routine production of ^{64}Cu as well as the reproducible and economical preparation of the ^{64}Ni target material with ultra-low metal contamination was established. Some technical pitfalls had then to be overcome. We faced a) aggressive corrosion by concentrated acid solutions, b) flaking of the target material during the irradiation, c) contamination of the target material with cooling water, d) formation of insoluble [^{64}Ni]NiO during the irradiation and e) incomplete dissolution of the irradiated target material.

Methods

Using the ^{64}Ni(p,n)^{64}Cu reaction with an optimized beam profile and proton energy (13.0±0.2 MeV), we routinely produce high quantities of ^{64}Cu (10-38 GBq) on our CC 18/9 cyclotron (Efremov Scientific Research Institute of Electrophysical Apparatus, St. Petersburg, Russia) as previously described (Avila-Rodriguez et al., 2008). A semiautomatic processing of the irradiated ^{64}Ni target material and a remote controlled separation of ^{64}Ni and ^{64}Cu has been developed, which yields ^{64}Cu with a high specific activity of 3 TBq/μmol. Using four miniature Geiger-Müller tubes, which are placed within the processing module, we monitor the distribution of activity and control the separation process of ^{64}Cu (Rajander et al., 2009). The recovery of the ^{64}Ni target material and the preparation of the ^{64}Ni electrolyte solution are done in a dedicated rotary evaporator. The computer controlled electrochemical deposition of the ^{64}Ni target material starts with a stepwise increase of the deposition voltage from 2.0 V to 2.5 V within 5 h, followed by a constant voltage of 2.5 V for 40 h.

Results

a) The use of concentrated acid solutions for preparing the ^{64}Ni electrolyte solution as well as for separating ^{64}Ni/^{64}Cu caused serious corrosion problems in the fume hood and in the hot cell. This problem was partly solved by using a closed and remote-controlled module for the processing of the irradiated ^{64}Ni target material, which includes dissolution, separation of ^{64}Ni/^{64}Cu and concentration of the acidic ^{64}Cu fraction. For recovery of the ^{64}Ni target material from the concentrated hydrochloric acid solution, a dedicated rotary evaporator is used inside a fume hood. Acidic vapour from the evaporation process is neutralized by passing the vapours through an alkaline aqueous solution in a flask.

b) Flaking of the ^{64}Ni material from the Au-backing was twice observed during the irradiation. Thus, we included an additional cleaning step for the gold disk in the target preparation procedure. After

cleaning with Deconex®, the gold disk is briefly soaked in 6 M HNO_3 and then rinsed subsequently with DI water to efficiently remove traces of metallic and organic contamination from the gold surface. After this step was included in target processing, no flaking of ^{64}Ni target material from the gold surface during the irradiation has occurred. Also the electroplating process is controlled with a computer program in order to obtain more reproducible results in the target preparation.

c) Due to scratches on the back of the gold disk and thus, insufficient sealing of the O-ring against the cooling water, contamination of the target material with cooling water was twice observed after the irradiation. Due to this, lower specific activities were obtained for ^{64}Cu. In order to solve this problem, the gold disks were henceforth visually inspected and serious scratches were removed by sanding.

d) A first series of targets was irradiated under ambient atmosphere. We then observed twice the formation of insoluble, greenish [^{64}Ni]NiO particles on the target material surface, resulting from an oxidation of ^{64}Ni during the irradiation. In order to avoid oxidation of nickel in the presence of atmospheric oxygen, we henceforth applied a stream of helium on the target material during irradiation. Subsequently, we have not observed formation of [^{64}Ni]NiO.

e) In some cases, a thermal treatment of the irradiated target material with 10 M HCl at 100 °C for 20 min was insufficient to dissolve the target material. This might be a result of a passivation of the ^{64}Ni surface during the irradiation. This problem was solved by applying a stream of helium on the target material during irradiation, and also by extending the period of thermal treatment with concentrated HCl from 20 to 40 min.

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