Production of high purity ^{52g}Mn from ^{nat}V targets with α beams at cyclotrons

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Research article

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Abstract

Background

Radioisotope $^{52}\text{g Mn}$ is of special interest for multimodal imaging (PET/MRI) applications and the main production route is based on proton/deuteron beams on Chromium (natural/enriched) targets. Using state-of-art nuclear reaction codes (Talys, Empire and Fluka), we perform a comparative study with the alternative $^{52}\text{g Mn}$ production with the reaction $\text{nat V}(\alpha, x) ^{52}\text{g Mn}$.

Results

This production channel, novel in the context of medical applications, provides a good source of $^{52}\text{g Mn}$, where very high radionuclidic purity can be maintained up to 3 weeks. Since nat V consists already of 99.75% ^{51}V , there is no need of enriched target material and the corresponding high-cost implications. The production of the main long-lived contaminants, i.e: ^{53}Mn and ^{54}Mn , is considered with care and the integral yields of the reactions are compared with the alternative production routes. Specifically, the production of the ^{54}Mn contaminant, which could be the most dangerous for clinical applications, turns out to be lower when compared with the natural Chromium target.

Conclusions

This channel turns out competitive with respect to the other considered production routes. The study also reveals poor accuracy of the relevant cross-section data set and indicates that better data and theoretical descriptions are needed for a precise evaluation of $\text{nat V}(\alpha, x) ^{52}\text{g Mn}$.

Full Text

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Figures

$^{nat}\text{V}(\alpha, x)^{52}\text{gMn}$ Isotopic Purity

Figure 1

Cross section for $^{nat}\text{V}(\alpha, x)^{52}\text{gMn}$ as predicted by three different codes and compared with the experimental data currently available in the EXFOR database [6]. To take into account the theoretical uncertainty of the all the models available in Talys, a grey band for the quartiles Q1-C23 and two dashed line for the minimum and maximum are plotted.

$\text{natV}(\alpha, x)^{52}\text{gMn}$ Integral yield

Figure 2

Total ratios of the calculated cross sections for $\text{natV}(\alpha, x)^{52}\text{gMn}$ and other Mn isotopes.

$\text{NatV}(\alpha, x)^{52}\text{gMn}$

Figure 3

Cross section for $\text{natV}(\alpha, x)^{54}\text{Mn}$.

$^{52}\text{Cr}(p,n)^{52g}\text{Mn}$ Radio Nuclidic Purity

Figure 4

Partial ratio of the calculated cross sections for $\text{natV}(\alpha,x)^{52g}\text{Mn}$ and the ^{54}Mn isotope. The energy window with the possibility of high purity production of ^{52g}Mn due to the favorable interplay of the different reactions thresholds is clearly visible.

$^{50}\text{V}(\alpha, x)^{52g}\text{Mn}$ vs $^{50}\text{V}(\alpha, x)^{54}\text{Mn}$

Figure 5

Time evolution of the $^{54}\text{Mn}/^{52}\text{Mn}$ Isotopic Purity for a long time window with an hypothetical one hour irradiation of a ^{50}V target with a beam energy of 48 MeV, thickness 200 μm (corresponding to an exit energy of 33.9 MeV), current of 1 μA . The inset shows the evolution for the first 24h, including the irradiation time.

^{52}Cr vs $^{\text{nat}}\text{Cr}(\text{p},\text{x})^{52\text{g}}\text{Mn}$ integral yield

Figure 6

Time evolution of the Radionuclidic Purity for a long and a short (inset) time window.

$^{51}\text{V}(\alpha, x)^{52g}\text{Mn}$ vs $^{51}\text{V}(\alpha, x)^{54}\text{Mn}$

Figure 7

Comparison of Mn production cross sections from ^{51}V (proton beams) and ^{51}V (neutron beams) targets. Data are shown only for ^{51}V targets (refer to Fig. 1 for data on ^{51}V targets).

$^{52}\text{Cr}(d,2n)^{52g}\text{Mn}$ Integral yield

Figure 8

Comparison of RNP for natV vs natCr.

$\text{NatV}(\alpha, x)^{54}\text{Mn}$

Figure 9

52gMn integral yield for a beam with 1 μ A current and one hour irradiation time. The green shaded area indicates the optimized energy interval used for the 200-gm thick target.

Cross sections for ^{52g}Mn production routes

Figure 10

^{52g}Mn integral yield from natCr and enriched ^{52}Cr targets for a proton-beam with 1 μA current and one hour irradiation time. The green shaded area indicates the optimized energy interval used for the 200- μm thick target.

Figure 11

^{52}gMn integral yield for a deuteron-beam irradiation on enriched ^{52}Cr . The irradiation conditions are the same of Figs. 9 and 10.

$^{52}\text{Cr}(\text{d},\text{x})^{52\text{g}}\text{Mn}$ Radio Nuclidic Purity

Figure 12

Time evolution of the radionuclidic purity for the reaction $^{52}\text{Cr}(\text{p},\text{n})^{52\text{g}}\text{Mn}$ assuming an 100% target enrichment. The irradiation conditions are those discussed for Tab.2.

Figure 13

The same as Fig. 12 for the reaction $^{52}\text{Cr}(d,2n)^{52g}\text{Mn}$.

$\text{NatV}(\alpha, x)^{52g}\text{Mn}$ vs $\text{NatCr}(p, x)^{52g}\text{Mn}$ Radio Nuclidic Purity

Figure 14

Cross sections for the production of ^{52g}Mn and ^{54}Mn with alpha beams on 50V.

$^{nat}\text{V}(\alpha, x)^{52g}\text{Mn}$ Radio Nuclidic Purity

Figure 15

Cross sections for the production of ^{52g}Mn and ^{54}Mn with alpha beams on ^{51}V .

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- [abbreviations.pdf](#)