研究論文

90. (α, n) Cross Sections for ^{48}Ti and ^{51}V

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The excitation functions for the reactions $^{48}\text{Ti}(\alpha, n)^{51}\text{Cr}$ and $^{51}\text{V}(\alpha, n)^{54}\text{Mn}$ up to $E_\alpha = 31$ MeV have been measured by the activation method using a stacked-foil technique. The cross sections at maximum yield in the (α, n) reactions for ^{48}Ti and ^{51}V are $(6.8^{+1.4}_{-2.0}) \times 10^{-25} \text{cm}^2$ and $(5.6 \pm 1.1) \times 10^{-25} \text{cm}^2$, respectively. The (α, n) reaction for ^{51}V is economically attractive for the production of carrier-free ^{54}Mn .

INTRODUCTION

This experiment is a part of the systematic study in which the present authors and their collaborators investigate the cross section for the alpha-induced reactions on medium-weight nuclei at intermediate energies⁽¹⁾⁻⁽³⁾. In this experiment, the excitation functions for the reactions $^{48}\text{Ti}(\alpha, n)^{51}\text{Cr}$ and $^{51}\text{V}(\alpha, n)^{54}\text{Mn}$ up to $E_\alpha = 31$ MeV have been measured by the activation method using a stacked-foil technique.

The (α, n) reaction for ^{48}Ti and ^{51}V may be thought as profitable methods for the production of the useful radioisotopes, ^{51}Cr and ^{54}Mn . And the cross sections as a function of bombarding energy should be considered for the economic production of them.

I. EXPERIMENTAL

The target foils were activated with the external alpha-particle beam from the 160 cm INSJ cyclotron⁽⁴⁾. The stack of the target foils was placed at the bottom of a long cylindrical cup which was served as a Faraday cup. The beam was measured by a 100% feed-back type current integrator. The energy dependence of cross sections was measured by using the stacked-foil technique in which target foils were interspaced with aluminum absorbers. The value of energy loss of alpha-particles in aluminum absorber was taken from the works of Bichsel, Mosley and Aron⁽⁵⁾, Burkig and MacKenzie⁽⁶⁾, and Sternheimer⁽⁷⁾. The values of energy loss of

alpha-particles in titanium and vanadium targets were calculated from the stopping power formula of Bethe *et al.*⁽⁸⁾, using the estimated mean excitation potential ($I = 13 \text{ Z}$).

The titanium target foils were natural-titanium metal foils of about 1.8 mg/cm^2 . The vanadium target foils of about 9 mg/cm^2 were prepared by spattering slurries of vanadium pentoxide in clear lacquer onto thin aluminium backingfoils of known thickness.

After the bombardment, the shorter-lived interfering activities were allowed to decay. And then the 325 keV gamma-ray from ^{51}Cr and the 840 keV gamma-ray from ^{54}Mn were measured with an 1-3/4 in. dia. $\times$ 2 in. high well-type NaI scintillation counter. The decay of titanium target was followed to distinguish ^{51}Cr from other interfering activities including ^{48}V . The disintegration rates were obtained by applying the intrinsic photopeak efficiencies to the counting rates. The photopeak efficiencies of 325 and 840 keV gamma-rays were assumed as 0.4 and 0.085, respectively, in this experiment. The emission probabilities of 352 keV gamma-ray from ^{51}Cr and of 840 keV gamma-ray from ^{54}Mn were taken as 0.09 and 1.00, respectively.

Rather thin titanium target foil was used, so that the amount of "recoil loss" of the

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product nucleus, ^{51}Cr , from the titanium target was measured to be amount to about 20% at 20 MeV. And this was involved in the calculation of cross sections for the $^{48}\text{Ti}(\alpha, n)^{51}\text{V}$ reaction.

II. RESULTS

The excitation functions for the (α, n) reactions on ^{48}Ti and ^{51}V are shown in Figs. 1 and 2, together with the estimated error of the magnitude of cross section and with the energy spread in target. The energy values below 10 MeV may be in error by over 1 MeV.

Fig. 1 The excitation function for the reaction $^{48}\text{Ti}(\alpha, n)^{51}\text{Cr}$

Fig. 2 The excitation function for the reaction $^{51}\text{V}(\alpha, n)^{54}\text{Mn}$

The production rates for ^{51}Cr and ^{54}Mn with the 30 MeV alpha-particles can be calculated from the present results and they are listed in Table 1.

Table 1 (α, n) production rates of carrier-free radioisotopes with a cyclotron

Radio-isotope	Half-life (day)	Target	Natural abundance (%)	Production rate $\mu\text{c}/\mu\text{A}\cdot\text{hr}$ 30 MeV
^{51}Cr	27.8	^{48}Ti	73.9	21.5
^{54}Mn	29.1	^{51}V	99.8	2.5

The production of carrier-free ^{54}Mn in a cyclotron by the (p, n) reaction for ^{54}Cr was reported by Martin, *et al.*⁽⁹⁾⁽¹⁰⁾. And the production rate for ^{54}Mn with the 22 MeV protons was measured as 0.5 mc/mA·hr. The production rate for ^{54}Mn by the (d, α) reaction ^{56}Fe was also reported by Irvine⁽¹¹⁾ and was $1\mu\text{c}/\mu\text{A}\cdot\text{hr}$ in the 14 MeV deuteron bombardment. The other methods of producing ^{54}Mn are the (d, n) reaction for ^{53}Cr ⁽¹²⁾, the $(d, 2n)$ reaction for ^{54}Cr ⁽¹²⁾ and the (n, p) reaction for ^{54}Fe ⁽¹³⁾. Among these methods of producing carrier-free ^{54}Mn , the (α, n) reaction for ^{51}V is economically attractive.

Carrier-free ^{51}Cr can be produced otherwise by the (p, n) reaction for ^{51}V , the $(d, 2n)$ reaction for ^{51}V , the $(d, p + d, n)$ reaction for ^{50}Cr ⁽¹²⁾ and the (n, γ) reaction for ^{50}Cr followed by the Szilard-Chalmers' process. The (p, n) reaction cross section for ^{51}V at maximum yield is about the same magnitude as the present (α, n) cross section for ^{48}Ti ⁽¹²⁾. Then the use of the former reaction is much more profitable than that of the latter for the production of ^{51}Cr .

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^{48}Ti および ^{51}V の (α, n) 反応の反応断面積

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^{48}Ti , ^{51}V の (α, n) 反応の断面積を $E_\alpha=31$ MeV まで Stacked foil 法を使った放射化法で測った。

これらの反応は ^{51}Cr および ^{54}Mn の無担体放射性同位元素の製造に対しても考慮するべき経路の1つであろう。照射には核研160cmサイクロトロンを使用し、ビームの強さはファラデー・カップを用いて測った。 Ti -ターゲットとしては約 1.8 mg/cm^2 の金属箔を、 V -ターゲットとしてはAl箔の上に V_2O_5 を少量のクリヤー・ラッカーと共に吹きつけたものを用いた。照射後短寿命放射能を崩壊させてのち、 ^{51}Cr の325 keV- γ 線、 ^{54}Mn の840 keV- γ 線を $1\frac{3}{4} \times 2$ in. の井戸型シンチレータで測定した。放射能の絶対値は γ 線の光電ピークの計算値に325, 840 keVの γ 線に対してのそれぞれの効率0.4, 0.085を用いて求めた。得られた反応断面積の結果は $^{48}\text{Ti}(\alpha, n)^{51}\text{Cr}$ 反応では $E_\alpha=14$ MeV で約700 mb の、 $^{51}\text{V}(\alpha, n)^{54}\text{Mn}$ 反応では $E_\alpha=14$ MeV で約559 mbの最大値を示した。

この結果を製造に便利のように thick-target yield (厚いターゲットによる反応収率) に換算すると

$^{48}\text{Ti}(\alpha, n)^{51}\text{Cr}$ に対しては $21.5 \mu\text{c}/\mu\text{A}\cdot\text{hr}$

$^{51}\text{V}(\alpha, n)^{54}\text{Mn}$ に対しては $2.54 \mu\text{c}/\mu\text{A}\cdot\text{hr}$

となった。

(1961年) 日本工学会手帳

残部 僅少

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(左段Table 1の末行)

^{141}Ce , ^{141}Ce - ^{144}Pr

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^{144}Ce , ^{144}Ce - ^{144}Pr