Experimental Studies on Particles-induced Activation

III. 6. Experimental Studies on Particles-induced Activation

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We have been conducting the experimental study on the production of radio isotopes useful for medical application, development of nuclear facility, wear study by thin layer activation (TLA) analysis, and also radionuclide production which results in the production of radioactive wastes. The measurements of *p*- and *d*-induced activation cross-sections on silver and yttrium were carried out in the frame of systematic investigation[1-7] of particles induced nuclear reactions on metals.

With review of the reported data, few problems have been picked up, which should be solved or upgraded the previous method to obtain higher precision experimental data. Experimental technique was reviewed and refined to improve the data accuracy. Then the method was applied to obtain systematic experimental data.

The independent and "cumulative cross-sections" of the *p*- and *d*-induced activation reactions on silver and yttrium were measured by using a conventional stacked foil activation technique. The silver and yttrium containing stacks were irradiated with 50, 70, 80 MeV protons and 40 MeV deuterons using a k=110 AVF cyclotron, Cyclotron and Radioisotope Center, Tohoku University, Sendai, Japan. The activities of the residual nuclides were measured nondestructively using HPGe gamma-ray spectroscopy.

Few results of cross-sections and thick target integral yields deduced from the present cross-section data are shown in Figs.1-4. The present data as shown in Fig.1 are for the production of medically used ^{103}Pd by direct reaction and *via* the decay of ^{103}Ag and ^{103}Cd of γ-ray measurement. The production cross-sections for ^{101}Pd and ^{100}Pd from ^{nat}Ag(p,x) at 70 MeV are larger than that of proton-induced activation on ^{103}Rh target[8] <20 MeV. The separation of these nuclides from ^{103}Pd is very difficult by chemical treatment. ^{101}Pd ($T_{1/2}$ = 8.47 h) decays out within few days of cooling time. The ^{100}Pd and ^{101}Pd production cross-sections are not so large. Thus, the ^{103}Pd production process *via* silver

involves a slightly higher impurity level of γ-ray emitting radionuclides than ^{103}Rh. The present data are useful for the optimization of the ^{103}Pd production with minimum radionuclidic impurity. The ^{nat}Ag(p,x) route seems to be profitable for the ^{103}Pd production.

The maximum ^{103}Ag production cross-section is about 2.5 times as low as the cumulative production of ^{103}Pd. The use of the short-lived ^{103}Ag as a precursor of the widely used ^{103}Pd in brachytherapy of prostate cancer is not a real alternative in comparison with the cumulative ^{103}Pd production from proton-induced activation on natural silver. In some special cases this route should be an option.

The half-life of ^{109}Cd ($T_{1/2}$=1.267 y) is significantly longer compared with other neutron deficient radioisotopes of this element, therefore the effects of the simultaneously produced radionuclides are not critical. The ^{109}Cd nuclide can be obtained in pure form only by maintaining few days cooling time. As shown in Fig.2 the cross-sections for the productions of ^{109}Cd is large and the ^{nat}Ag+d process can be a significant route for a large-scale production using accelerator.

As shown in Figs.3&4, the direct production of the ^{88}Y is low compared to ^{88}Zr for both *p*- and *d*-induced activation on yttrium target. Significant amount of ^{88}Zr can be produced at low energy accelerators by using yttrium target. The measured nuclear data can be effectively used for selection of optimal production routes. The expected thick target yields for the production of ^{88}Zr and ^{88}Y by proton and deuteron bombardment on yttrium target are very much higher than the Mo, Nb and Zr targets. Therefore, Y+p and Y+d are the efficient route to give large scale production of ^{88}Zr and ^{88}Y at low energy accelerator.

References

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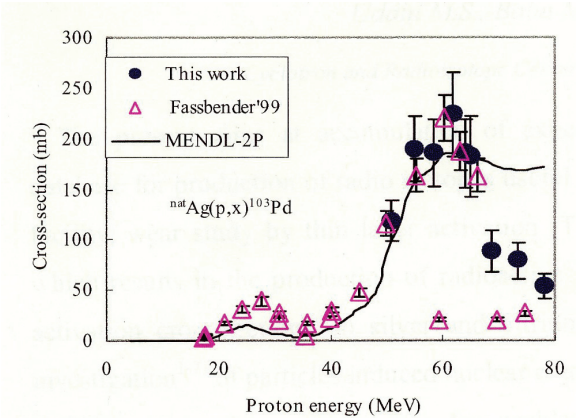

Figure 1. Excitation function of the $^{nat}Ag(p,x)^{103}Pd$ reaction.

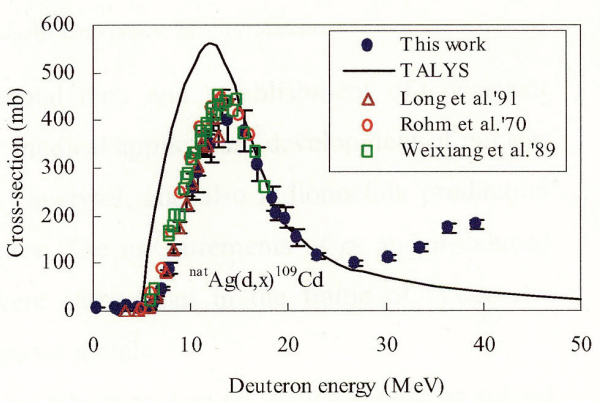

Figure 2. Excitation function of the $^{nat}Ag(d,x)^{109}Cd$ reaction.

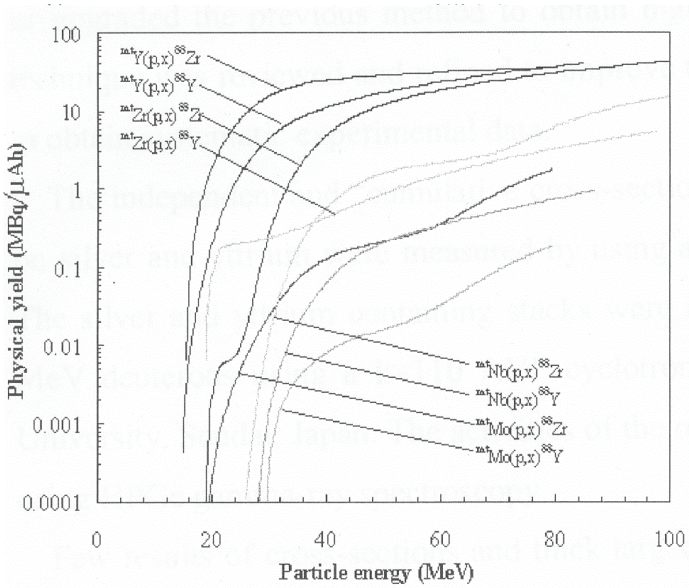

Figure 3. Physical yield of ^{88}Zr and ^{88}Y by *p*-induced activation on Y, Zr, Mo and Nb.

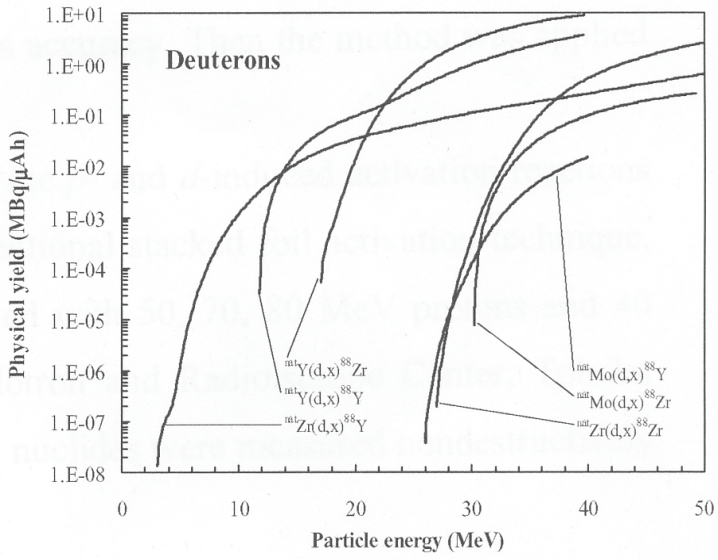

Figure 4. Physical yield of ^{88}Zr and ^{88}Y by *d*-induced activation on Y, Zr, Mo and Nb.