ON ^{123}I PRODUCTION BY IRRADIATION OF ^{124}Xe WITH THE PROTONS OF MEAN ENERGY

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ABSTRACT

Experimental data of ^{123}I yield at 21.5 MeV proton bombardment of enriched ^{124}Xe are presented. The dependence of ^{123}I yield on proton energy up to 30 MeV for targets of different thickness calculated on the base of published data is also presented.

INTRODUCTION

Nuclear medicine shows great interest to ^{123}I because of its advantages in comparison with other iodine radionuclides. ^{123}I is an ideal radionuclide for receiving images of internal organs of a man.

In connection with this some methods of ^{123}I production were developed /1-8/. Three methods of these secure high productivity necessary for practice: irradiation of thin ^{124}Te target with about 25 MeV protons (p,2n reaction), irradiation of thin iodine target with about 65 MeV protons (p,5n) reaction, irradiation of high enriched ^{124}Xe with about 30 MeV protons (p,2n and p,pn reactions). The last method /4,5,7,8/ in contrast with the previous ones secure ^{123}I production without other radionuclides of iodine. This is an important advantage from the three points of view: lowering patient dose, quality of receiving image and increase of period of validity.

The purpose of the present work was to obtain ^{123}I yield by irradiation of high enriched ^{124}Xe with 21.5 MeV protons to compare these data with the published ones and to determine the optimal condition for ^{123}I production by the described method.

EXPERIMENT

To obtain ^{123}I yield dependence on proton energy six thin gas targets containing enriched (99.9%) ^{124}Xe in quantity of 16.6 mg/cm^2 were simulteniously irradiated. These targets were nickel cylinders of 30 mm in internal diameter butt-ends of which were aluminium foils of 50 microns thick. Between the targets and in the beam trap monitor foils made of copper were placed to determine dose of irradiation by measuring ^{65}Zn activity which is formed in these foils. The intensity of proton beam which passed through collimator of 8 mm in diamater was 0.5 A. The cooling of the targets was performed by air stream.

Target irradiation was performed on the external beam on the cyclotron of the Institute of Physics and Power Engineering in Obninsk /9/. Energy of protons was 22 MeV.

The activity of ^{123}I was measured after 16, 42 and 64 hours later the end of irradiation. We measured the activity of ^{123}I using Ge(Li) detector and multichannel analyzer /10/. The activity of ^{123}I was calculated from the area of photopeak of 153.97 keV(83.4%). The cross-section of ^{65}Cu(p,n)^{65}Zn reaction which is necessary for calculation of irradiation dose of monitor foils were taken from the published papers /11,12,13/.

DISCUSSION

To characterize the production rate of ^{123}I for the studied method we propose to use the conventional thick target yield in the end of irradiation, becuase the common thick target yield /14/ in this case can not be used because ^{123}I is formed as a result of ^{123}Xe decay. After the end of irradiation of ^{124}Xe by protons ^{123}I activity in the target at first increases then after achieving maximum decreases. This dependence of ^{123}I activity on time after the end of irradiation has the form of the curve one shown in the fig.1. The waiting period after the end of irradiation in which

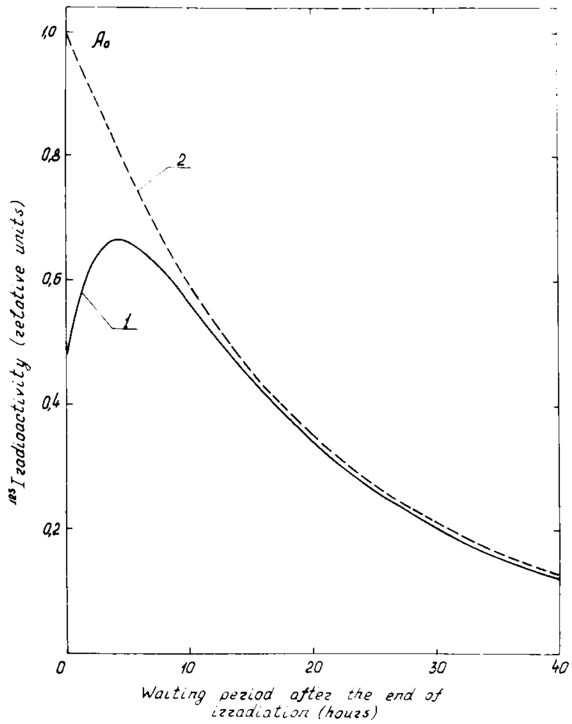

Fig.1. The dependence of ^{123}I activity on the waiting period after the end of irradiation: 1 - real change of activity; 2 - conventional change of activity; A_o - ^{123}I conventional activity in the end of irradiation.

maximum activity of ^{123}I is achieved was calculated in paper /15/. In 15-16 hours after the end of irradiation practically all ^{123}Xe decayed in ^{123}I and so the curve 1 has the form of ^{123}I decay exponent. Extrapolation of this exponent in the end of the irradiation (curve 2) gives the value of conventional activity of ^{123}I in the end of the irradiation A_o. Using the value of A_o the value of conventional thick target yield of ^{123}I can be calculated by means of the known formulae /14/:

$$A_o = Y_o I t_o \frac{1 - e^{t_o}}{\lambda t_o} \quad ....(1)$$

Here Y_o - conventional thick target yield of ^{123}I; I - beam current of protons; t_o - time of target irradiation; λ - ^{123}decay constant.

The value of conventional thick target yield in formulae (1) is a constant and does not depend on time irradiation and on waiting period and so is a convenient characteristic of ^{123}I production rate.

Our experimentally obtained values of ^{123}I conventional thick target yield are presented in fig.2. The value of ^{123}I conventional thick target yield at the energy of protons 21.5 MeV is (12.5±1.25) mCi/μAh. The value of ^{123}conventional thick target yield calculated by us by using experimental data of paper /8/ and

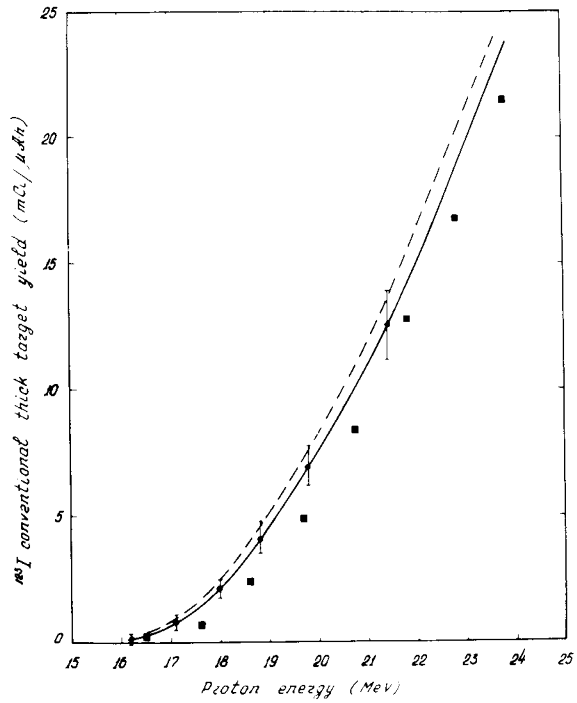

Fig.2. Dependence of ^{123}I conventional target yield on proton energy: (•) experimental data obtained in this work; (▪) the value of ^{123}I conventional yield calculated from experimental data taken from the work /8/; dotted line - ^{123}I conventional yield calculated from theoretical data taken from the work /5/.

theoretical data of paper /5/ is presented in the same figure. It is seen that all these values of ^{123}I conventional thick target yield agree with each other.

Contamination of other radionuclides of iodine was not found in our case. ^{121}Te activity resulting from ^{121}I decay which resulted from $^{124}Xe(p,\alpha)^{121}I$ reaction was found. ^{121}Te conventional thick target yield in the end of irradiation at Ep=21.5 MeV was equal to 8.9μCi/μAh. It means that ^{121}Te conventional activity in the end of irradiation is about 0.07% of ^{123}I conventional activity.

The feature of the present method of ^{123}I production is the use of high enriched and very expensive ^{124}Xe. To save ^{124}Xe thin targets are usually used /7/. With the thin targets ^{123}I yield will be less than with the thick targets. In connection with this we performed a calculation of ^{123}I conventional yield for targets of different thickness. This calculation was performed on the base of experimental data presented in paper /8/. The obtained results are presented in fig.3. It is seen that with the use of thin targets the dependence of ^{123}I yield on proton energy has a maximum. The optimal energy corresponding to maximum yield depends on the thickness of targets. With the change of target thickness from 1.0 g/cm^2 optimal energy changes from 31 MeV to 28 MeV.

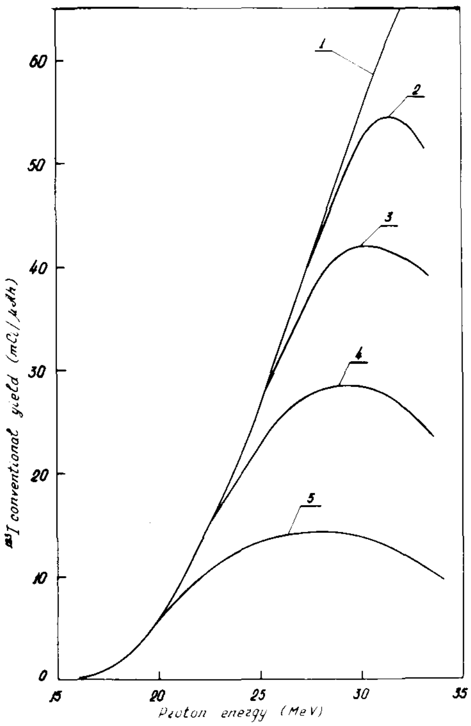

Fig.3. The dependence of ^{123}I conventional yield in the end of irradiation on proton energy for targets of different thickness: 1 - thick target, 2 - 1.0 g/cm^2, 3 - 0.75 g/cm^2, 4 - 0.5 g/cm^2, 5 - 0.25 g/cm^2

REFERENCES

1. Stöklin G. Int. Radiat. Isotope 1977, 28, 131.
2. Proc. Conf. on Radioiodines: Production, Chemistry, Applications, Banff, Canada, Sept. 1980.
3. J. Radioanal Chem. 1981, 65, N°1-2.
3. Qain S.M., Stocklin G.Radiochim.Acta 1983, 34, 25-40.
4. Grabmayr P., Nowotny R. Int. J. Appl. Radiat. Isotop., 1978, 29, 261-267.
5. Zuravlev B.V., Ivanova S.P., Krasnov N.N., Shubin Yu.N., Atomnaya Energia, 1986, 60, N°5.
6. Graham D., Trevena J., Webster B., Williams D. J. Nucl. Med. 1985, 26, 105.
7. Qain S.M. Recent Developments in the Production of ^{18}F, ^{75,76,77}Br and ^{123}I. J. Appl. Radiat. Isotope, 1986, 37, 803.
8. Firouzbakht M.L., Teng R.R. Schlyer D.J. and Wolf A.P. Production of High purity Iodine-123 for Xenon-124 at Energy Between 15 and 34 MeV, Radiochim Acta, 1987, 41, 1-4.
9. Krasnov N.N. et al. "The Use of the Cyclotron for radionuclide production and some other applied purposes". Proceedings of Institute of Physics and Power Engineering. P.399-413, Moscow: Atomizdat, 1974.
10. Dmitriev P.P. et al. Atomnaya Energia, 1980, 48, 402.
11. Kopecky P. Int. J. Appl. Radiat. Isotopes, 1985, 36, 657.
12. Grutter A. Nucl. Phys., 1982, A383, 98.
13. Colle R. et al. Phys. Rev. C., 1974, 6, 1819.
14. Krasnov N.N. Thick target yield, Int. Appl. Radiat. Isotop., 1974, 25, 223.
15. Malinin A.B., Kurenkov N.V. Radiochem radioanal. letters, 1982, 57, N°5-6, 311.