

# OBTAINING THE RADIONUCLIDES FOR MEDICAL AND BIOLOGICAL INVESTIGATIONS AT THE TANDEM GENERATOR

I.N. Vishnevsky, Yu.I. Totsky, E.N. Mozhzhukhin, L.P. Katsubo and A.V. Rusavsky;  
F.G. Garashchenko\*, I.I. Kharchenko\*,  
Institute for Nuclear Research, Kiev, Ukraine, \*National University, Kiev, Ukraine

The tandem electrostatic accelerators are widely used in science, industry, education, medicine and other fields of activities for successful development of the scientific research and modern applications. This accelerator requires a small electrical power consumption which is very important at the present in view of energy saving tendency.

Physical experiments and applied works need the acceleration of a wide set of ions, including radioactive. Accelerated radioactive nuclei are often neutron excess nuclei and the nuclear reaction with beam allow us to get isotopes, which are rather to make by other methods. Restrictions and complications of the acceleration of radioactive nuclides are connected with problems of radioactive contamination of the facility and surroundings. Such kind of work was carried out in several laboratories as Dsresbury, Munich, Brookhaven, and Strasbourg. The acceleration of the triton with 7-10 MeV is of particular interest for science and applied purposes which can be realized at 5 MV tandem at Kiev Institute for Nuclear Research (KINR) [1,2] where also the tritium laboratory has been operating successfully.

The acceleration of tritons is very important for production of radioisotopes  $^{28}\text{Mg}$ ,  $^{42}\text{K}$ , and  $^{43}\text{K}$  which are of great interest for tracer experiments on biological systems. Both isotopes are produced by (t, p) reaction having a large cross section at the energy of e 7-10 MeV tritons. This is more effective than the double neutron capture in the nuclear reactor. The main characteristics of these isotopes are described below:

1.  $^{26}\text{Mg}(t, p)^{28}\text{Mg} - \frac{20,9\text{h}}{\rightarrow} ^{28}\text{Al} - \frac{2,2\text{min}}{\rightarrow} ^{28}\text{Si}(\text{stable})$

The target material is enriched with  $^{26}\text{Mg}$  metal and the yield of this reaction is about 100  $\mu\text{Ci}/\mu\text{A h}$  for a 10  $\text{mg}/\text{cm}^2$  target thickness. The beam current is usually 5-10  $\mu\text{A}$  for several hours. The  $^{28}\text{Mg}$  isotope is widely used in investigations of biochemical processes in human's organism.

2.  $^{41}\text{K}(t, p)^{43}\text{K} - \frac{22\text{h}}{\rightarrow} ^{43}\text{Ca}(\text{stable})$ .

The yield of this reaction  $\sim 70 \mu\text{Ci}/\mu\text{A h}$  from enriched  $^{41}\text{K}$  target of a  $\sim 5 \text{ mg}/\text{cm}^2$  thickness of KCl form.

3. The  $^{42}\text{K}$  isotope is not directly produced, but it can be extracted from a  $^{42}\text{Ar} \rightarrow ^{42}\text{K}$  generator.

$^{40}\text{Ar}(t, p)^{42}\text{Ar} - \frac{33\text{y}}{\rightarrow} ^{42}\text{K} - \frac{12\text{h}}{\rightarrow} ^{42}\text{Ca}(\text{stable})$

The  $^{42}\text{Ar}$  is produced under high pressure (2 bar) with the  $^{40}\text{Ar}$  - gas target sealed by a 5  $\mu\text{m}$  thick molybdenum foil. An electrostatic extraction can be used for obtaining of the  $\sim 10 \mu\text{Ci}$  pure  $^{42}\text{K}$  every 24 hours for several years independently at any places. The  $^{42}\text{Al} \rightarrow ^{42}\text{K}$  - minigenerator is extremely convenient and

useful in a wide range of biological research especially in medicine and agriculture. The  $^{42}\text{K}$  minigenerator is also very useful for the education experiments as a suitable isotope with short half-life and low activity.

Biological exchange in the nature, especially Kalium and its combinations during plant growth, are studied by the  $^{42}\text{Al} \rightarrow ^{42}\text{K}$  minigenerator. The significance of various of some agricultural plants in areas of world can be determined on the base of these experiments. It is important to rise the agricultural productivity in drought regions. Similar to these experiments a biological research was made in the study of human's organism, where the Na-K exchange has an important role (membrane exchange). By using the  $^{42}\text{K}$  isotope one can control the salt presence in organism and its assimilation, so it is very important, for example, to hypertonia illness.

4.  $^{70}\text{Zn}(t, p)^{72}\text{Zn} - \frac{46,5\text{h}}{\rightarrow} ^{72}\text{Ga} - \frac{14\text{h}}{\rightarrow} ^{72}\text{Ge}(\text{stable})$

The yield of this reaction is  $\sim 1 \mu\text{Ci}/\mu\text{A h}$  from the enriched to 45%  $^{70}\text{Zn}$  target of a  $\sim 1 \text{ mg}/\text{cm}^2$  thickness.

Above mentioned isotopes were produced at the tandem accelerator using the triton ion beam from the negative ion source.

The injector of negative tritium ions consists of a sputter type source (Fig.1), and a Wien velocity filter and a focusing transport system. The application of the sputter source permits to obtain the sufficient current of beam with low consumption of target material and is well suited to the production of radioactive beams. The sputter material in this type of sources stays in solid form, that is important for increasing the safety of the acceleration of radioactive ions.

For obtaining tritium ions constructed was the sputter target consisting of a copper substructure with a zirconium (or titanium) layer on which 50 Ci (20  $\text{cm}^3$ ) absorbed tritium gas is used. The sputter target was shaped as a cone having 5 mm in diameter and 5 mm height. The positive cesium ions are extracted from the tungsten ionizer heater surface (3) and hit the cathode (5). The atomic cesium beam is obtained by heating the solid pellets in the cesium boiler (2). The source is connected with the accelerator by a tube of a small diameter (30 mm) which restricts the flow of tritium gas from the source in the accelerator and the main vacuum system.

The accelerator vacuum system with tritium handling system is shown in Fig. 2. The basic effort for utilization of tritium is carried out by a high vacuum sorption pump located directly near the source. This pump is assembled together with the source and is removed in vacuum state for cleaning and repairing.

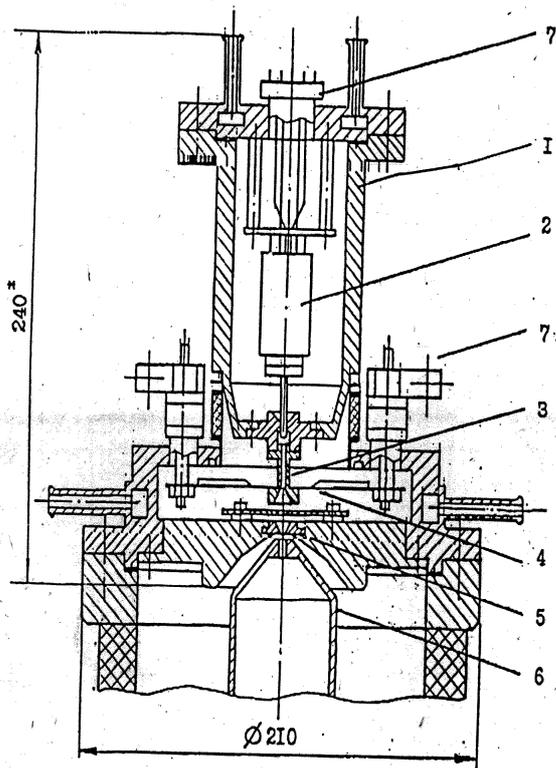


Fig. 1 Tritium negative ions source.

1. Source body, 2. Cesium boiler, 3. Tungsten surface ionizer,
4. Ionizer heater, 5. Sputter target, 6. Extraction electrode,
7. Ionizer heater feed-through.

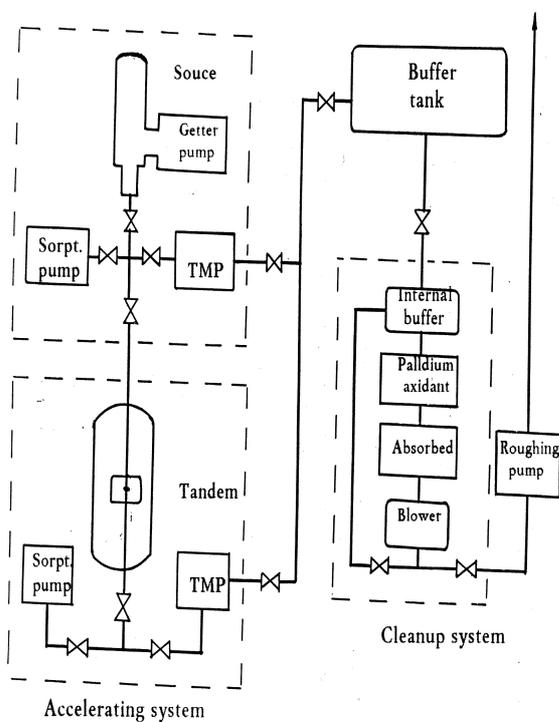


Fig. 2 The tritium handling system.

The main accelerator vacuum system is composed of two 1000 l/s ion pumps and two 1500 l/s

turbomolecular pumps located at both ends of the tank. The high vacuum is achieved by these pumps before the ion source and sorption pump start in operation. The pumping is realized through the buffer tank (4 m<sup>3</sup>), which is supplied by tritium clean-up system with the palladium oxidant and serpent. The gas from accelerator after purifying is exhausted outside of the building at a high level.

The vacuum condition and efficiency of the work of sputter source will be examined with the saturated deuterium cathodes of the same form.

It is very important to carry out the monitoring of radioactive surfaces in injector, accelerator, experimental halls and exhausting gas in order to check constantly their contamination [2]. The careful design of the tritium handling system and monitoring provide safety work with triton.

The new method of the beam dynamic modeling in electrostatic accelerator is carried out. It is based on the method of the practical stability and on numerical simulation of equations of moving. Discrete-continuous equation system is used for calculation of trajectories of charged particles. The elaboration of new software can be used in electrostatic accelerator design. The analysis of such problems of optimum designing the various accelerating and focusing systems lead to new mathematical statement in the area stability and optimization. On the basis of a stated and proved general theorem the optimum estimations for analysis of various dynamic systems of practical stability are developed. The criteria have practical orientation. They are easy algorithmic and simulated in a computer. To calculate the practical stability area being maximum by volume, the conception of stability in the direction was introduced.

The tritium beam can be also used for other useful radioisotopes.

Also, since the tritium beam is not yet much exploited, many new original works could be performed in KINR with this beam in future.

## REFERENCES

- [1] I.N. Vishnevsky, Yu.I. Totsky, E.N. Mozhzhukhin et al., // Nucl. Instr. and Meth. A328 (1993) p. 39-40.
- [2] H. Wegmann, E. Huenges, H. Muthig and H. Morinaga, // Nucl. Instr. and Meth. 179 (1981) p. 217-222.
- [3] Yu.I. Totsky, L.P. Katsubo, F.G. Garashchenco, I.I. Kharchenko, VANT, 2,3(29,30), v.1, 1997 p. 99-101.