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# AN ATTEMPT TO PRODUCE THE IMPLANTED $^{22}$Na SOURCE FOR POSITRON SPECTROMETRY

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Preliminary results of $^{22}$Na implantation into the metal foils in order to produce the positron source for annihilation experiments are presented.

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A convenient positron source could be produced by implantation of sodium $^{22}$Na ions of the energy $3\text{–}30\times10^4$ eV into the thin metal foil. Such a source could be used for liquids as well as for solids; low absorption of positrons, mechanical strength, small dimensions would be additional advantages.

Our early attempt to produce such a source by placing the active $^{22}$NaCl in the conventional ion source of a mass separator failed. The efficiency of collecting the activity on the foil did not exceed 10%. This is unacceptable, $^{22}$Na is a long-lived isotope ($T_{1/2} \approx 2.6$ y) and this efficiency means that 90% of activity remains in the separator as a long-term contamination.

A successful implantation of sodium with the efficiency of 56% was done by Ravn et al. [1] using $^{22}$Na produced in the spallation reaction. Similar idea was applied by us in the attempt to produce the implanted positron source. This is a preliminary report, first real source for testing its exploitation properties will be ready soon.

Activity of $^{22}$Na was produced by bombarding the target in the form of a set of Al wires with 660 MeV protons from the synchrocyclotron in JINR — Dubna (Russia). At this energy of protons the aluminium nuclei evaporate many nucleons and a rich spectrum of nuclides lighter than Al appears, among them radioactive $^{22}$Na and $^{24}$Na.

After 25 min irradiation by the proton current $i = 2.5$ $\mu$A total activity of $\approx$ 250 $\mu$Ci was produced. The dominant nuclides were $^{7}$Be and $^{22}$Na, as can be seen in Fig. 1. The spectrum in that figure was registered $\approx$ 1 month after the irradiation, thus $^{24}$Na (15 h) activity practically disappeared, but the long-lived $^{7}$Be (53 d) had to be eliminated by mass separation. The $^{22}$Na extraction, ionization and implantation were performed by the mass separator at the YaSNAPP-2 facility in the Laboratory of Nuclear Problems JINR.

In order to choose the optimal conditions of ionization in the source the measurements of $^{22}$Na diffusion velocity in aluminium were performed. The proton

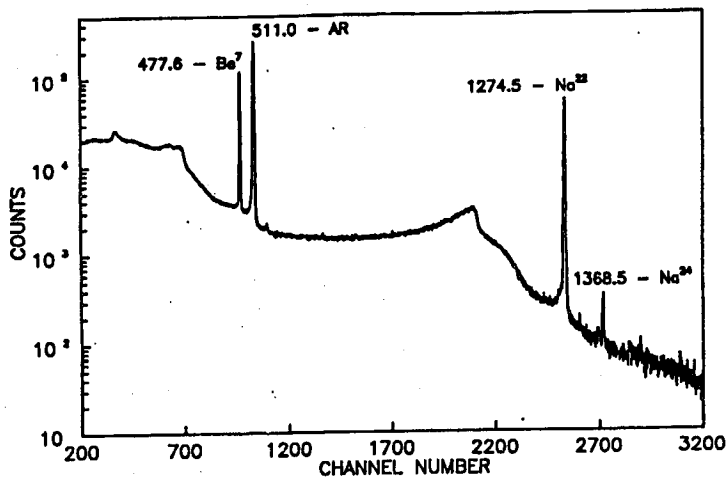


Fig. 1. The gamma spectrum of Al irradiated by 660 MeV protons ($\approx$ 1 month after irradiation).

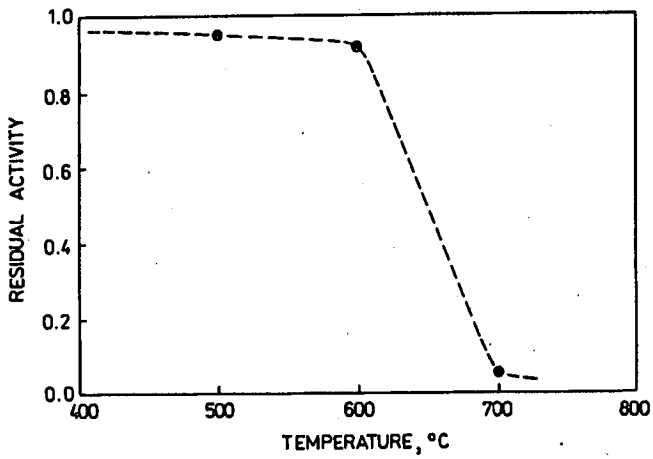


Fig. 2. Effectiveness of $^{22}$Na diffusion from Al target as a function of temperature.

irradiated Al targets in the form of wires $\phi \approx 1$ mm were isochronally annealed in vacuum at the temperatures 500, 600 and 700°C during 600 s. Then, the residual $^{22}$Na activity after annealing was measured and compared to that initial one. The results are shown in Fig. 2. From these data one can make a rough estimate of sodium diffusion coefficient at 600°C, its value is $D \approx 4 \times 10^{-9}$ cm$^2$/s. It means that the process of diffusing out the active Na atoms up to 600°C is relatively slow. Fast diffusion appears close to the melting temperature of Al ($T_m = 660$°C).

These data determine the construction of ion source and the conditions of

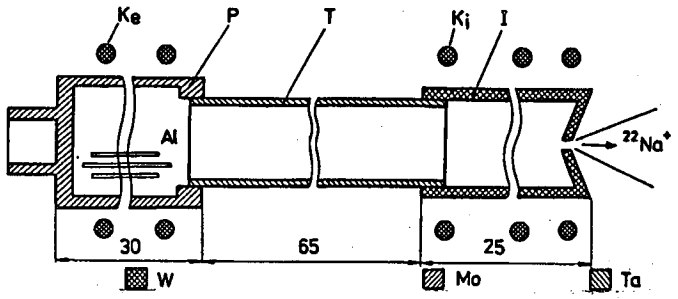


Fig. 3. The construction of ion source for high efficiency Na ionization.

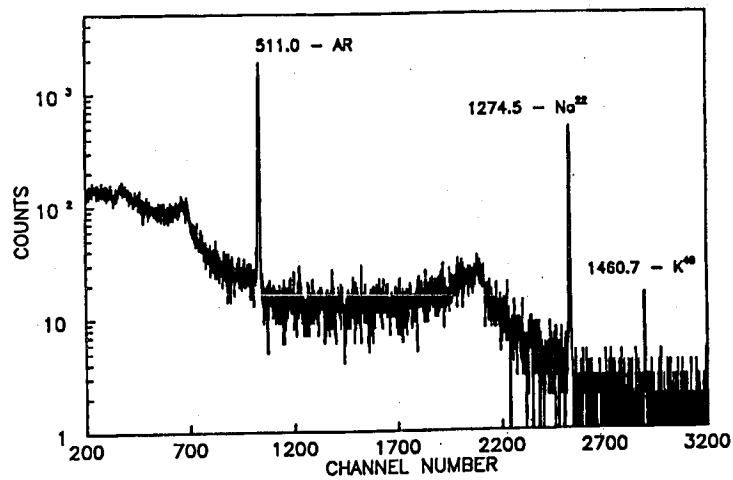


Fig. 4. The gamma spectrum of mass separated activity implanted into an Al foil.

electromagnetic separation and implantation of Na. The scheme of thermoemission ion source [2, 3] modified especially for our purposes is shown in Fig. 3. The irradiated Al target in the form of wire was placed in a molybdenum evaporator $P$ heated by own cathode $K_e$; the tantalum tube $T$ was made sufficienty long to be sure that the temperature of evaporator does not exceed 600°C when the ionizer $I$ reaches its working temperature $T_i \approx 2700$°C. After selecting the working conditions of the ionizer (heated by the electrons from $K_i$ cathode) and of whole separator, the evaporator was heated slowly up to temperature 800°C. The ions extracted from the source were accelerated to 40 keV, deflected by the magnetic field and implanted into a metal foil. The gamma spectrum of the activity implanted in the foil is seen in Fig. 4: beside $^{22}Na$ only the negligible natural peaks are present. Total separation process lasted 10–15 min and after that time the activity left in the evaporator was less than 4% of its initial value. The efficiency

of whole implantation process was over 50% (max. 55%) and we expect it can be still increased after respective modifications of ion source construction.

## References

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