A GRAPHITE TARGET FOR THE PRODUCTION OF ^{13}N NUCLEI

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INTRODUCTION

In the project of Radioactive Ion Beams at Louvain-la-Neuve,[1] the first step is the development of a ^{13}N beam. The ^{13}N production must take place in a suitable target bombarded by a proton beam of maximum E_p = 30 MeV and I = 500 μA. The ^{13}N atoms are injected in an E.C.R. source to be ionized and pre-accelerated to 8 keV before the final acceleration by CYCLONE to about 8.5 MeV.

CHOICE OF THE TARGET MATERIAL

In order to maximize the production and extraction of ^{13}N, the target must fulfill the following conditions:

- a high ^{13}N production cross-section
- a good thermal behaviour for heat extraction
- a good diffusion of the ^{13}N out of the target in a suitable molecule
- a low long term activation
- the availability of the chosen target

Taking these criteria into account, we have decided to use graphite made of ^{13}C:

- the $^{13}C(p,n)^{13}N$ cross-section is the largest one[2]
- graphite can stand temperatures up to 2600° K without macroscopic damages
- its thermal conductivity is good, even at high temperature
- the ^{13}N atoms come out of the target by the exchange reaction

$$^{13}N + {}^{14}N^{14}N \rightarrow {}^{14}N + {}^{13}N^{14}N$$

  by means of the N_2 molecules present in the graphite. This was proved by a chromatography. However, the outgassing of N_2 at high temperature can be compensated by the continuous injection of a small N_2 flow
- the high porosity of graphite and its small grain size favor the diffusion of the N_2 molecules. The extraction yield is about 80% at 2150° K [3]
- the only "long term" activities created in pure graphite are due to ^{13}N and ^{11}C with $t_{1/2}$ = 10 and 20 minutes
- however, ^{13}C graphite is not commercially available but has been developed at the C.E.N./S.C.K., Mol (Belgium)

DIFFERENT TARGET MODELS

In our preliminary studies of different target models and shapes, the ^{13}C graphite was replaced by a natural graphite, containing 1 % of ^{13}C.

<u>Stack of Thin Disks</u>

The target is made of 11 disks of graphite, 0.5 mm thick surrounded by a water-cooled copper cylinder. The contact between the disks and the cylinder is negligible and the disks cooling relies only on the radiation law. Due to that, the distance between two consecutive disks increases as we approach the

Bragg peak in the stopping power function.

This target can be suitable when a good extraction is needed with a very low beam power. In our case, even with a beam of about 1 Kw, all the disks around and behind the Bragg peak have been destroyed.

Disk Cooled by the Edge

A disk of 40 mm in diameter and 5 mm thick is by its edge in close contact with the copper cylinder. Cooling is highly dominated by conduction while radiation is almost negligible. A computer code shows that the radial distribution of the temperature is quite inhomogeneous and depends strongly on the beam profile.

The temperature can be too high in the centre (> 2600° K), inducing macroscopic damages in the disk while the temperature stays too low (< 2000° K) in outer regions inhibiting the ^{13}N extraction.

The advantage of this target model is its simple design and easy handling.

Disk Cooled by the Back Face

The same disk is plugged on a graphite finger 10 cm long moving in a cooling cylinder made of copper. The finger length is adjustable to the available beam power in order to keep the target in the optimum temperature range.

Because the cooling is insured by the back side, the whole disk is kept more or less at the same temperature (to some extent insensitive to the beam profile), avoiding the difficulties of the previous model and optimizing the extraction yield. With such a model we have been able to extract more than 80 % of the produced ^{13}N.

If a large disk of ^{13}C graphite is not feasible, it is possible to replace it by a series of small cylinders plugged in a honeycomb structure of natural graphite. We are presently testing this solution. This prototype should stand a beam power of 3 to 5 kW, the main uncertainties being due to the poor knowledge of the interfaces between the two graphites and of the thermal conductivity of the ^{13}C graphite.

CONCLUSIONS

Graphite seems to be the best target to produce ^{13}N ions under the bombardment of low energy protons. The best target geometry depends strongly on the beam power. A stack of isolated disks is suitable for a low intensity beam, with cooling insured only by radiation. A high beam power requires the use of a disk cooled mainly by conduction. With the natural graphite, an extraction yield of more than 80 % is obtained. A modified version of the present target should be able to stand a beam power of about 10 kW.

REFERENCES

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