Fabrication of enriched ^{176}Yb self-supporting targets for the study of fission dynamics in mass region A~ 200

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Introduction

Study on heavy ion nuclear reactions involve many complex dynamical processes, which have been under study for many decades, but yet not fully understood, because of the complexities involved. During the dynamical path of fusion-fission reaction, neutron emission is one of the dominant decay channel. Neutron multiplicity measurement has been used as an effective probe to study such kind of dynamical evolution of nuclear system [1]. For the present study of fusion-fission dynamics through neutron multiplicity measurements we plan to populate ^{208}Rn through ^{32}S + ^{176}Yb entrance channel. The neutron multiplicity measurement requires, isotopically enriched, self-supporting ^{176}Yb target of thickness of about 1.0 to 2.0 mg/cm^2.

Since lanthanide targets are chemically very active, therefore, preparation and storage of such targets is a challenging task. Only one reference on Yb has been found in literature, which describes a method for making Yb targets by simultaneous metallothermic reduction technique, reported by D. J. Yaraskavitch and Y. K. Peng [2], but the thickness reported was only ~ 300 µg/cm^2. One such attempt to make thinner target of ^{176}Yb was carried at IUAC, New Delhi for mass distribution measurements and was reported earlier [3]. Thicker target of ^{172,173,174}Yb were made using rolling technique [2], however, the details of target preparation were not reported. Here we present the method used to make self-supporting ^{176}Yb targets of thickness about 1.0 to 2.0 mg/cm^2. The target was fabricated using rolling technique at IUAC. Target fabrication by rolling technique has been used as a very effective way to prepare self-supporting foils with a variety of thickness. Such technique is preferred for conserving material, especially for expensive and chemically very active isotopic materials.

Fabrication Equipment

The rolling machine, as shown in Fig. 1, was used to prepare thin target foils of isotopically enriched ^{176}Yb by cold rolling method. The material to be rolled was placed inside a pack of mirror polished stainless steel (SS) plate and rolled through especially hardened rollers. The gap between the rollers is reduced gradually to produce good quality foils.

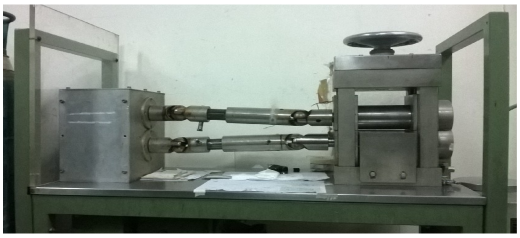

Fig. 1 Rolling machine at target lab of IUAC

Preparation of Target

In order to roll the target to required thickness we need to prepare the good quality SS pack. Therefore, a piece of SS plate of dimension 6 cm × 15 cm was folded to form a pack as shown in Fig. 2a. To avoid slackness in SS pack which can cause unwanted strain to the target foil, it was heated up to ~ 500°C. The pack was rolled out for about 4 hours to make the inner surface smooth and non-sticky for target material. As the enriched material of ^{176}Yb is quite expensive, an initial attempt was made using natural Yb. The metallic bead (weight ~ 40mg) of natural Yb was placed inside the SS pack. On rolling, the bead acquires the shape of circular foil and small cracks appeared at its edges. To avoid the propagation of cracks in the remaining foil, the edges of foil were removed immediately, resulting in rectangular foil as shown in Fig. 2b. This process was repeated several times whenever cracks appeared.

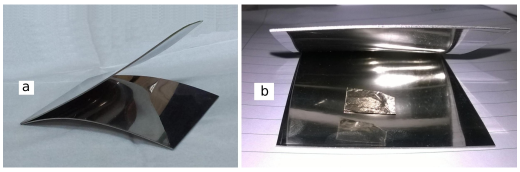

Fig. 2 a) SS pack, b) Thin foil inside the SS pack

On rolling the foil up to the thickness of 2.5 mg/cm^2, foil becomes very sticky to SS pack. As the use of forceps to remove the foil can cause damage to it, a sharp and clean piece of paper was used to remove it. On further rolling the size of foil goes to ~ 4 cm × 4 cm and the thickness to ~ 2.3 mg/cm^2. As it is difficult to roll such a big size foil with equally distributed thickness, therefore, the foil was divided into small parts. Further rolling was carried very slowly for long duration and at uniform pressure. After the thickness of about ~ 1.5 mg/cm^2, the foil starts sticking to SS pack very frequently. In order to avoid the sticking, various releasing agents were attempted. As an initial attempt Silicone oil was applied between SS plate and one of the foil, but it was not very helpful in reducing the sticking. Use of acetone was also not helpful because Ytterbium is chemically very active. Teflon pack was also attempted but its slackness damages the target foil. However, on applying a very thin alcohol layer in between the SS pack and the target foil, sticking reduced remarkably. Therefore, for further rolling we used thin alcohol layer between the SS plate and the target foil. However, again at such low thickness the use of piece of paper for edge-trimming started damage the foil, therefore, smooth wax-paper was used. Through this way, we were able to achieve a thickness of ~ 1.2 mg/cm^2. The thickness of target foil was estimated by measuring the area in graph-paper with precision of 1 mm^2 and by measuring weight in electric micro-balance. The above procedure as for natural Yb material was then applied to the enriched isotope of Ytterbium i.e., ^{176}Yb, which was in the form of metallic bead (weight ~ 30 mg). During rolling of the foil, presence of dust particles on it causes tiny holes in the foil. Therefore, to prevent the foil from the dust particles, the target foil was washed very gently with alcohol.

Fig. 3 Thin ^{176}Yb foils of various thickness

On further rolling, thickness ranging from ~ 1.0 to 2.2 mg/cm^2 and surface area ranging from ~ 2 cm × 2 cm to 1.5cm × 1.5cm were achieved successfully (Fig.3). Fabricated thin foils will be mounted on the target holders. These targets will be used for proposed experiment in National Array of Neutron Detectors (NAND) at IUAC, New Delhi.

Result and Conclusion

Self-supporting enriched ^{176}Yb targets of good quality and thickness ranging from ~ 1.0 to 2.2 mg/cm^2 were fabricated successfully by rolling technique. The amount of oxidation of targets was measured by Rutherford Back-Scattering (RBS) technique at IUAC and it was found within the acceptable level. The targets were stored in Argon environment to make it survive for a long duration.

Acknowledgments

One of the authors (Neeraj Kumar) acknowledges the financial assistance provided by IUAC in the form of research fellowship (UFR No. 52305) to carry out this work. We also acknowledge the RBS group, IUAC for their support. One of the authors (S. V.) acknowledges the support in the form of R&D Grant, D. U.

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