Fabrication of ^{203,205}Tl targets on carbon backing

J. Gehlot[1,2],* S.R. Abhilash[1], S. Ojha[1], D. Mehta[3], D. Kabiraj[1], and A.M. Vinodkumar[2]

[1]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, India*
[2]*Department of Physics, University of Calicut, Kerala - 673635, India and*
[3]*Department of Physics, Punjab University, Chandigarah - 160014 , India*

A target of suitable thickness and purity is very important to carry out any nuclear reaction experiment with proper energy and angular resolution. Special properties of the target material, like hardness, high melting point, oxidation or toxicity etc. make the target fabrication, difficult. Targets of soft and malleable materials can be prepared by rolling. For hard materials and for low thickness, other techniques like vacuum evaporation, ion beam sputtering or electro-deposition etc. are used.

We plan to investigate heavy ion-induced reactions with ^{203}Tl and ^{205}Tl. For this purpose we attempted to prepare thin isotopic targets of thallium (Tl).

Several investigators had prepared Tl films or targets by various methods. Most of them were using natural Tl (29.5 % ^{203}Tl, 70.5 % ^{205}Tl) as target material and several approximations had to be made to determine whether the reaction occurred on ^{203}Tl or ^{205}Tl. Only a limited number of attempts were made with isotopic Tl material , mainly for making thick targets.

Tl is highly oxidising and toxic, which makes the target fabrication difficult. We had attempted to make self-supporting target, but could not succeed in floating the evaporated target film on a frame. So we decided to go for targets with thin carbon backing.

Targets were prepared using a diffusion pump based coating unit, at the Inter University Accelerator Centre (IUAC), New Delhi. This chamber can achieve a pressure $\sim 10^{-7}$ mbar and is equipped with a resistive heating system as well as a 2 kW electron gun. Resistive heating is used for evaporating materials with comparatively lower melting point, and electron gun is used for materials with high melting point.

The deposition can be controlled for desired thickness by covering the source with a manual shutter. Also the rate of deposition and deposited thickness can be monitored by a quartz crystal monitor fixed inside the chamber.

Thin carbon backings of thickness $\sim$ 25 to 40 μg/cm^2 were prepared using this coating unit. For this a 100 nm thick layer of releasing agent ($BaCl_2$) was deposited on glass substrate, by resistive heating. Then carbon layers of desired thickness were deposited over it by electron gun evaporation, using a smooth graphite rod as source. After annealing these glass slides at 325° C, in order to release any stress developed, the carbon films were floated in warm deionized water and taken on stainless steel target frames. Thickness of these foils were estimated by measuring α-particle energy loss through them.

These foils were again loaded in coating unit for Tl deposition. The substrate was held at a distance $\sim$ 10 cm above the source. Tl was deposited over these foils by resistive heating.

Before preparing isotopic target, a number of trials were done with natural Tl. A narrow tubular tantalum boat was used to minimize the solid angle of evaporation and thus material consumption. Due to this the quartz crystal monitor was not in the line of sight of the material boat, and hence could not be used for exact thickness monitoring during the deposition. Quantity of material loaded in boat was varied each time to get the desired thickness of Tl by evaporating the whole material, keeping

*Electronic address: jagdishgehlot@iuac.res.in

the distance of source to substrate constant.

Tl being an oxidising material, α-particle energy loss method could not be used for thickness measurement, as it was not possible to estimate the degree of oxidation. Hence thickness of natural Tl target was measured using X-ray fluorescence (XRF)technique. The quantity of isotopic Tl material used in the final evaporation was then determined by scaling this result.

We had procured ^{203}Tl (96.54 % enrichment) and ^{205}Tl (99.90 % enrichment) from ORNL, USA and ISOFLEX, USA, respectively. We did some charecterizations of the fabricated targets in order to check any impurity, either in supplied materials or added inadvertently during depositions.

XRF measurements of the prepared targets were carried out at the Department of Physics, Punjab University, Chandigarh, for detecting elements with Z > 13. Fig. 1 shows the XRF spectra of targets prepared. It is observed that only Tl peaks are visible except for a trace of Mo X-rays, which is probably due to X-ray tube anode. XRF being an atomic process, the same can not distinguish between different isotopes of Tl.

Thickness of the targets was estimated by comparing the XRF count rate from the prepared targets with the count rate from a standard $TlCl_3$ target. Thickness obtained for ^{203}Tl and ^{205}Tl targets were 175±9 and 156± 8 μg/cm^2.

Rutherford back-scatterig (RBS) charecterizations of the targets were done using 2 MeV α-particle beam from 1.7 MV accelerator at IUAC, in order to detect any lower Z contamination. Fig. 2 shows the RBS spectra for both the targets. Other than Tl, only oxygen and carbon peaks are present. Carbon peak comes from the backing and presence of oxygen is expected, as Tl is an oxidising element.

We shall perform our experiments with the fabricated targets using recoil separators having very high selectivity [1, 2]. Hence carbon and oxygen impurities, which are much lighter than thallium, will not cause any difficulty in identifying the desired reaction products.

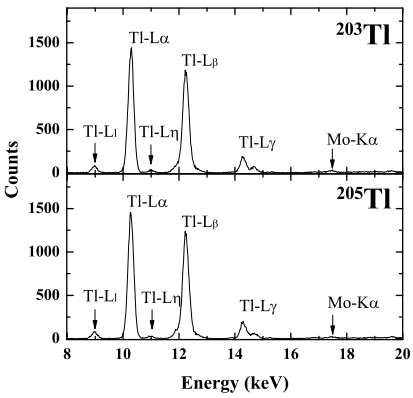

FIG. 1: X-ray fluorescence spectra of ^{203,205}Tl targets.

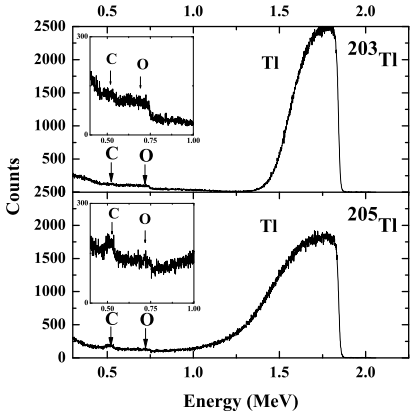

FIG. 2: Rutherford back-scattering spectra of ^{203,205}Tl targets, using 2 MeV He^+ ions detected at 170° with respect to beam.Carbon and oxygen peaks are shown in insets.

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References

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