REDUCTION OF RADIOACTIVITY IN MOLYBEDNUM TRIOXIDE (MoO_3) POWDER WITH SUBLIMATON METHOD

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Abstract

Molybednum-100 is one of the most promising candidates for neutrinoless double beta decay ($0\nu_{\beta\beta}$) owing to its high transition energy ($Q_{\beta\beta}$=3034 keV), high natural abundance and relatively easy enrichment. The AMoRE (Advanced Mo Based Rare Process Experiment) collaboration is using scintillating crystal containing molybdenum to search for neutrinoless double beta decay of ^{100}Mo. As part of the R&D in support for this effort, MoO_3 powder is purified by high vacuum sublimation method in order to remove radioactive elements such as Ra, Th, U and etc. The purification is done at different temperatures in order to determine the optimum conditions for high decontamination purification factors and high recovery efficiencies. The purified MoO_3 powder is subsequently used to grow crystals containing Mo. The effectiveness of the purification techniques are checked with ICP-MS (Inductively Coupled Plasma Mass spectrometry) measurements and radioactivity from Ra, Th and U is checked with HPGe detectors at Yangyang underground laboratory in Korea.

Key words: Neutrinoless double beta decay, radioactive elements$_3$, sublimation, ICP-MS, HPGe

1. Introduction

The neutrino oscillation experiment reveals the existence of non-zero neutrino mass [1]. After this results, the next things to find is the mass value of neutrinos and its nature, if it is Dirac or Majorana particle. The $0\upsilon\beta\beta$ is one of the promising factor for knowing the nature of neutrions. Thus, the detection of $0\upsilon\beta\beta$ would help to find the effective mass of υ and would reveals that the neutrino is Majorana particle, i.e. neutrino is equivalent to anti-neutrino [2]. Different groups are searching for the $0\upsilon\beta\beta$ using the different candidate isotopes ^{76}Ge, ^{130}Te, ^{136}Xe, ^{82}Se, ^{150}Nd, ^{100}Mo, ^{48}Ca, and ^{116}Cd [3] . Among those groups, AMoRE collaboration is searching for $0\upsilon\beta\beta$ of ^{100}Mo. Since, ^{100Mo} is one of the most promising detector, owing to its high transition energy ($Q\beta\beta$ = 3034 keV), comparative ease of enrichment [4] and higher natural abundance (δ = 9.82%) [5].

The sensitivity of the detector used by AMoRE is determined by the background in the region of expected peak [6]. The major sources for such background is due to decay of natural radioisotopes which exists as impurities in detector material: the isotopes of ^{208}Tl (^{232}Th series) and ^{214}Bi (^{226} Ra decay product in ^{238}U series) [7]. These isotopes has higher decay energy than 3034 keV. The reduction of these isotopes assures the removal of Uranium, Thorium and Radium. The effectiveness of the purification techniques are checked with ICP-MS measurements and radioactivity from Ra, Th and U is checked with HPGe detectors at Yangyang underground laboratory in Korea.

The main goal of this work is to develop the methods for deep purification of isotopically enriched materials for growing the Mo content scintillators.

2. Experiment

The radioactive contaminants contained in the sample MoO_3 powder were reduced using sublimation. The sublimation machine was specially designed for the experiment. Outer quartz tube of the machine consisted of three inner quartz tubes: left tube is for support, middle tube was to keep samples for sublimation, and the right one was for condensation. The sublimation was conducted at different temperature (670˚C, 680˚C, 690˚C, 700˚C, 710˚C, 720˚C, 730˚C, 740˚C, 750˚C, 800˚C). Each experiment was conducted in low vacuum condition ($<$ 10 mm torr). Low vacuum condition helps to sublimate MoO_3 powder. After finishing, powder has been collected quantatively into plastic bottle in order to check efficiency process.

3. Results and Discussion

MoO_3 starts to sublimate already at 600˚C at vacuum condition. On increasing of temperature, the elapsed time for processing is short and yield efficiency also increases as well as purification factor.. But temperature beyond 740˚C yield efficiency and purification factor is also low. At higher temperature critical decreasing of yield is observed. It can be explained by melting of MoO_3, that's why decreasing of Surface Square of sublimation. By the way, increasing of Sr decontamination could be explained by melting and interaction together Pb, U impurities. The decontamination factor for the different radioactive isotopes after sublimation was shown in the Fig.1 and the yield efficiency at different

temperature is shown in Fig.2. Hence, that best temperature for getting good decontamination factor is 720˚C since, at this temperature yield efficiency and decontamination factor for Ba is high..

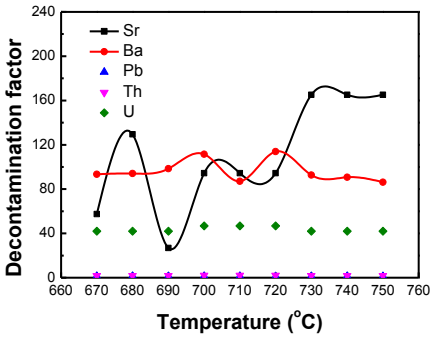

Fig. 1: Decontamination factor versus temperature

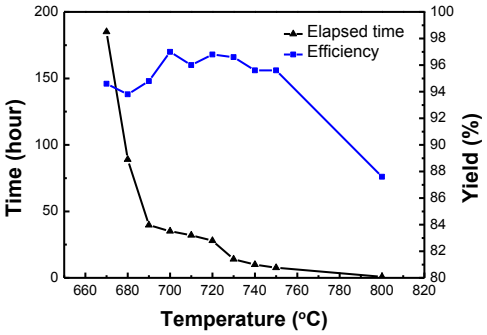

Fig 2. Recovery efficiency and elapsed time at different temperatures

4. Conclusion

The optimum condition for the high vacuum sublimation of MoO_3 powder was 720˚C.At this temperature both the decontamination factor of radioactive isotopes and yield efficiency was high.

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