REDUCTION OF THE RADIOACTIVITY IN SODIUM IODIDE (NaI) POWDER BY RECRYSTALLIZATION METHOD

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The COSINE collaboration has investigated low-background NaI crystal for detecting dark matter existed in the universe. The low-background NaI crystal as a radioactivity sensors is grown from highly purified NaI powder. Recrystallization method was used for purification of NaI from the natural radioactive isotope impurities, such as ^{39}K, ^{88}Sr, ^{137}Ba, ^{232}Th, ^{238}U, ^{226}Ra, and ^{208}Pb etc. Commercially available low level purity NaI powder was used as initial material. In order to reduce initial radioactive contamination, we try thrice recrystallization of dirty NaI. Content of impurities in initial and purified NaI powder was measured by Inductively Coupled Plasma Mass Spectrometer (ICP-MS) analysis, and radioactivity was measured with HPGe detectors at Yangyang underground laboratory in Korea. Preliminary results had shown effective reduction of impurities ^{39}K, ^{88}Sr, ^{137}Ba, and ^{208}Pb etc.

Key words: *dark matter, NaI crystal, purification, recrystallization*

I. INTRODUCTION

The scintillation crystal is well established technology for detection of dark matter [1]. Weakly interacting massive particles (WIMPs) are one of the most attractive dark matter particle candidates. The DAMA experiment observed an annual modulation signal interpreted as WIMP interactions [2]. Nowadays, the NaI is a dedicated experiment to prove DAMA observation. To prove this observation, the NaI crystal detector should achieve a lower background level and energy threshold than DAMA. The sensitivity of detector is limited to internal radioactive background impurities. Therefore, purification of raw powder is essential before growing the low-background of NaI crystal. Various methods are used to purify of NaI, such as ion exchange column chromatography, sublimation and recrystallization, etc. Recrystallization is one of the wet chemistry technique which based on different solubility of solid at different temperature.

II. EXPERIMENTAL AND MATERIALS

NaI powder 99.5 % purity grade (from X'ian, China) was used as initial material. High purity de-ionized water (18 $M\Omega cm^{-1}$, Milli-Q water purification system) was used as main solvent. PTFE membrane filters with 0.1 μm poresize (Merck Millipore) were used. First, for the recrystallization, the NaI powder was dissolved in Di-water at room temperature until saturation. Obtained solution was filtrated under vacuum with PTFE membrane filter for separation of insoluble impurities. Then the solution was evaporated until ~ 40 % of initial water content in order to achieve oversaturation. To make pure crystals, the solution was cool down until 25 °C with stirring for 24 hours. To separate obtained crystals from mother solution, vacuum filtration was conducted by PTFE membrane filter. Since the crystal may contain minor amount of mother solution with impurities, as-taken crystal is washed with pure ethanol. The wet NaI crystals were dried under the vacuum condition to make the desiccated powder. The NaI crystal was dried at 65 °C to make the monohydrate form of NaI and it is conducted at 110 °C in order to make anhydrous NaI crystal. The effect of the purification can be confirmed by decontamination factor (DF). DF describes effectiveness of recrystallization and expresses as ratio of concentration of impurities in initial and final product. The decontamination factor is calculated as Equ (1) Contents of impurities, such as ^{39}K, ^{88}Sr, ^{137}Ba, ^{232}Th, ^{238}U, and ^{208}Pb in initial and final NaI powder were measured by ICP-MS analysis and radioactivity were measured with HPGe detectors.

$$DF = \frac{Concentration\ of\ impurity\ in\ initial\ product}{Concentration\ of\ impurity\ in\ final\ product} \quad (1)$$

III. RESULTS

To estimate the purification technique, DF was calculated by Equ (1). The contents of K, Sr, Ba, Th, U, and Pb in initial powder and purified powder were observe by ICP-MS measurement. The concentrations of impurities in initial powder are Ba 2 ppt, K 180 ppt, Pb 5 ppb, Sr 35 ppb, Th <0.1 ppb, U <0.1 ppb, respectively. After 1 time recrystallization the impurities were reduced more than 20 times, the DF were Ba 27, K 31, Pb 21, and Sr 26, respectively. In case of Th and U contents were less than detection limit of ICP-MS analysis. After 3 times recrystallization, the DF of final product was Ba 642, K 1143, Pb 44, and Sr 350, respectively. Through thrice recrystallization, we produced the purified NaI powder that almost similar with 99.99% purity level NaI powder. In this study, main goal is reducing content of K. However, Na and K have same chemical properties as can be seen the position in the periodic table of the elements, the separation of K from NaI is very difficult. In case of the recrystallization method, it was shown effective in removal of K with other elements simultaneously.

III. CONCLUSION

The recrystallization method had shown effective removing of the impurities, such as Ba, K, Pb, and Sr in the initial NaI powder. In case of 99.5 % purity grade NaI have more reasonable price than ultrapure regent. Through this study, 99.5 % purity grade NaI could use as substitute ultrapure regent for crystal growing. As a result, this study was effective in reduction of K component along with other element. In this time, this study is ongoing to improve the DF and recovery efficiency.

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