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Acrylic and liquid scintillator radiopurity screening by ICP-MS for the JUNO experiment

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The Jiangmen Underground Neutrino Observatory is building the world's largest liquid scintillator (LS) detector, and the radiopurity in LS should reach 0.01-1 ppq (10^{-17}-10^{-15} g/g) ^{238}U/^{232}Th. The 20 kt LS is filled in the acrylic sphere with 35.4 m diameter, and both the acrylic bulk (<1 ppt ^{238}U/^{232}Th) and the surface (<5 ppt ^{238}U/^{232}Th in the first 50 μm thickness) should be clean enough. The radiopurity screening of acrylic and LS to the level near the requirement is challenging. The Inductively Coupled Plasma Mass Spectrometer (ICP-MS) is a common equipment for high-precision material composition analysis. The ICP-MS lab is built in the clean room, and the counting rate for 1 ppt (10^{-12} g/g) ^{238}U/^{232}Th solution can reach ~1000 counts/s. We have developed a practical method for screening U/Th in acrylic to sub-ppt level with ICP-MS, and the pre-treatment is mainly acrylic ashing. In addition, careful surface treatments on JUNO acrylic panel in the company were studied, and the resulted surface contamination can reach ~20 ppt in the first 5-10 μm thickness. In addition, we have developed a method for detecting U/Th in LS to sub-ppq level, and the main pre-treatment is acid extraction for LS. With meticulous cleanliness control, U/Th in approximately 2 kg of LS is concentrated by acid extraction with 0.4 (0.3) pg ^{238}U (^{232}Th) contamination. The method detection limit at a 99% confidence level of this approach can reach approximately 0.2-0.3 ppq for ^{238}U/^{232}Th with nearly 100% recovery efficiency. In this report, I will introduce the setup and method for the pretreatment and the measurement results of ^{238}U/^{232}Th in acrylic and LS, as well as the strategy of JUNO acrylic surface treatment.

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