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Development of radiopure cadmium tungstate crystal scintillators from enriched 106Cd and 116Cd to search for double beta decay

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Cadmium tungstate crystal scintillators enriched in 106Cd up to 66% (106CdWO4) and 116Cd up to 82% (116CdWO4) have been developed to investigate double beta processes in 106Cd and 116Cd. The metal samples of the enriched cadmium were purified by heating with filtration in combination with distillation through getter filters. The cadmium tungstate compounds were synthesized from solutions by using quartz or polypropylene lab-ware, materials with low level of radioactive contaminations, and reagents of high purity grade (concentration of any metal less than 0.01 ppm). The 106CdWO4 and 116CdWO4 crystal boules with masses of 231 g and 1868 g, respectively (87% of initial charges) were grown by the low-thermal-gradient Czochralski technique. The total irrecoverable losses of the isotopically enriched materials in the whole production processes do not exceed 2%. The produced scintillators exhibit excellent optical and scintillation properties thanks to the deep purification of the initial materials and utilization of the low-thermal-gradient Czochralski method to grow the crystals. Radioactive contamination of the scintillators was measured both by scintillation method and using ultra-low-background HPGe gamma detectors. The contamination of the crystals is on the level of <1.5 mBq/kg (40K), <0.005-0.012 mBq/kg (226Ra), 0.04-0.07 mBq/kg (228Th), 2-3 mBq/kg (total alpha activity). We have observed a considerable activity of 113mCd in both the crystals: 116 Bq/kg in the 106CdWO4 and 0.46 Bq/kg in the 116CdWO4. The measurements of the scraps of the melt after the 116CdWO4 crystal growth by using an ultra-low-background HPGe detector indicate a very low segregation of thorium, radium and potassium, which gives a strong motivation to re-crystallize the crystals with an aim to improve further their radiopurity in 228Th and 226Ra. Experiments to search for double beta processes in 106Cd and 116Cd by using the crystal scintillators are in progress at the underground Gran Sasso National Laboratories of the INFN (Italy).

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