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Purification of lanthanides for double beta decay experiments

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There are many potentially double beta active isotopes among the lanthanide elements (136Ce, 138Ce, 142Ce, 146Nd, 148Nd, 150Nd, 144Sm, 154Sm, 152Gd, 160Gd, 156Dy, 158Dy, 162Er, 164Er, 170Er, 168Yb, 176Yb). However, even the high purity grade (99.99% - 99.995%) lanthanide compounds contain typically uranium and thorium on the level of ~ (0.1 - 1) Bq/kg. We present results of chemical purification of cerium, neodymium, and gadolinium oxides by using a combination of physical and chemical methods. The liquid-liquid extraction technique was used to remove traces of Th and U from neodymium, gadolinium and for the purification of cerium from Th, U, Ra and K. Co-precipitation and recrystallization methods were utilized for further reduction of the impurities. The radioactive contamination of the samples before and after the purification procedure was tested by using ultra-low-background HPGe gamma spectrometry at the underground Gran Sasso National Laboratories of the INFN (Italy). As a result of the purification procedure the radioactive contamination of gadolinium oxide (a similar purification efficiency was reached also with cerium and neodymium oxides) was decreased from 0.12 Bq/kg to 0.007 Bq.kg in 228Th, from 0.04 Bq/kg to <0.006 Bq/kg in 226Ra, and from 0.9 Bq/kg to 0.04 Bq/kg in 40K. However, the purification method is much less efficient for chemically very similar radioactive elements like lanthanum, lutetium and actinium. R&D of the methods to separate the lanthanides with improved efficiency are in progress.

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