Contribution ID: **26** Type: **Oral Presentation**

Alpha and Beta radiation effects on Re2MnCoO6 (Re = La, Sm, Nd)

Tuesday 8 July 2025 11:50 (20 minutes)

The rise in global demand for nuclear technology has resulted in an increase in radioactive waste and radioactive material. Some of these radioactive materials and nuclear waste undergo radioactive decay, emitting alpha and beta particles. Beta particles are energetic electrons with a single negative charge, while alpha particles are equivalent to a helium atom with a charge of +2. Both alpha and beta particles can cause significant damage along their path of travel. Therefore, there is a need for materials used for radiation shielding. This study was therefore aimed at simulating the effects of alpha and beta radiation on Re2MnCoO6 (Re = La, Sm, Nd) prepared by solid-state method.
The stoichiometric ratios of the starting materials were measured and ground into a fine powder then calcined at 900 oC for 12 hours before being annealed at 1200 oC for a further 48 hours. Finely ground samples were characterised by powder X-ray diffraction (XRD) to ascertain that the right structures were crystallized. A continuous scanning using Cu-Kα radiation (40 kV, 30 mA) was done, measuring between 10° and 90° with a step of 0.02° and speed of 0.145 s/step. The samples were indexed to the monoclinic phase of Re2MnCoO6 that belongs to a space group P21/n, number 14.
The continuous slowing-down approximation (CSDA) range of beta particles in the samples and the stopping power of the samples have been calculated using ESTAR. At 0.5 MeV, the beta particles have an CSDA range of 0.018 g/cm2 for Sm2MnCoO6, 0.2699 g/cm2 for Nd2MnCoO6 and 1.370 g/cm2 for La2MnCoO6. The mass stopping power of all the three samples decreases with energy up to about 1 MeV and then starts to increase again.
The ranges, energy deposition and displacement damages caused by alpha particles have been estimated using the ion transport Monte Carlo simulations using the Stopping and Range of Ions in Matter (SRIM) code with the Full Damage Cascades mode. A 4 MeV alpha particle has a range of about 23.53 µm in Sm2MnCoO6, 23.08 µm in Nd2MnCoO6 and 22.00 µm in La2MnCoO6. The mass stopping power for all the three samples ranged between 0.320 MeV.cm2/g and 0.414 MeV.cm2/g for a 0.1 MeV alpha particle.
The results show that double perovskites can be used as matrices for radioactive waste immobilization.

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Session Classification: Nuclear, Particle and Radiation Physics-1

Track Classification: Track B - Nuclear, Particle and Radiation Physics