POWERING SPACE EXPLORATION: Np-237 TARGET MANUFACTURING

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For exploration of the outer parts of our planetary system, solar panels combined with rechargeable batteries are no longer an option. Plutonium-238 (^{238}Pu) is the preferred isotope since it is a nearly pure alpha emitter with an almost total absence of penetrating gamma radiation and has a convenient half-life of 86.4 years combining high specific power density with steady power supply for decades. NASA's deep-space exploration probes and planetary rovers rely on radioisotope heating units (RHU) and thermoelectric generators (RTG) powered by ^{238}Pu. Production of ^{238}Pu was discontinued in Europe several decades ago, and no useful stock is left today. Europe's reference isotope is ^{241}Am which has a lower power density compared to ^{238}Pu and needs gamma ray shielding. Given the technological advantages of ^{238}Pu, there is a renewed interest to re-open a European ^{238}Pu production chain for its future deep space exploration missions.
^{238}Pu is produced through high-flux neutron irradiation of ^{237}Np. The fabrication of Np targets for reactor irradiation requires optimization to meet reactor physics and thermal-hydraulic constraints. Among several possible approaches, the zircaloy-clad full-ceramic NpO_2 target fabrication method was selected for further investigation due to its advantages in back-end processing.
The proposed $^{237}NpO_2$ target fabrication process consists of several key steps, including eventual $^{237}Np/^{233}Pa$ separation, Np liquid-to-solid conversion, Np oxide pellets manufacturing and encapsulation. In this work, liquid-to-solid conversion and NpO_2 powder characterization are presented in detail. As part of the Optimus Pro project, a liquid ^{237}Np source was characterized and precipitated in form of hydrated Np oxalate. Upon heating in the presence of oxygen, oxalates degrade to oxides. The thermal decomposition behaviour of produced Np oxalate was analysed, allowing for the determination of optimal calcination parameters. The morphology and specific surface area of the resulting NpO_2 were evaluated. Results of these analyses aim to support defining such pressing and sintering conditions, that ensure the production of dense, mechanically robust pellets which is one of the goals of Optimus Pro project. The demonstration of fabrication process yielding dense NpO_2 pellets in Europe within Optimus Pro project represents a significant advancement in the development of an independent ^{238}Pu production chain, supporting future deep-space missions.

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