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Production Strategies for High-Purity Terbium Radionuclides for Theranostic Applications

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Terbium offers a unique set of four clinically relevant radionuclides, 149Tb, 152Tb, 155Tb, and 161Tb,covering a broad spectrum of nuclear medicine applications, from PET and SPECT imaging to targeted alpha and beta therapies. Their complementary decay properties make them ideal candidates for theranostic approaches, where diagnostic and therapeutic isotopes can be used in matched pairs [1]. Despite their clinical potential, scalable production of these isotopes with sufficient radionuclidic purity remains a key challenge, particularly for hospital-based facilities.

This study investigates the 155Gd(p,n)155Tb reaction using the TALYS nuclear reaction code [2] to evaluate excitation functions, yields, and impurity profiles, with a focus on minimizing co-production of long-lived contaminants such as 156Tb. Cross section predictions were benchmarked against experimental data [3] to refine yield estimates under realistic irradiation conditions. Thick-target yields and radionuclidic purity were derived across multiple 155Gd enrichment levels, and corresponding dosimetric impact was assessed using OLINDA software [4], quantifying patient dose increase (DI) from contaminant isotopes. The analysis identifies a 98% 155Gd enrichment as the optimal trade-off between production efficiency and clinical safety [5, 6].

In parallel, nuclear reaction modeling was utilized to investigate promising proton-induced production routes for 152Tb from Gadolinium and Dysprosium targets. The simulations provide key insights into reaction mechanisms and potential yields, supporting the optimization of irradiation parameters and guiding future experimental studies aimed at confirming production feasibility for clinical applications.

This study demonstrates how nuclear reaction modeling and parameter refinement can guide the development of scalable, high-purity production routes for terbium radionuclides, supporting their future adoption in clinical theranostic strategies.

References

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