Evaporation of polonium from LBE-cooled reactors

I. Zivadinovic[1,2], P. J. Steinegger[1,2]*, J. Neuhausen[2]*

[1]Laboratory of Inorganic Chemistry, Department of Chemistry and Applied Biosciences, ETH Zürich, Switzerland, [2]Laboratory of Radiochemistry, Nuclear Energy and Safety Division, Paul Scherrer Institut, Switzerland

Liquid metal-cooled reactors are among the proposed designs for Generation IV nuclear reactors. These designs are distinguished from the current generation by their enhanced safety, increased energy efficiency, and reduced costs. The use of liquid metals, like lead-bismuth eutectic (LBE), as a substitute for the traditional coolant water, significantly bolsters the safety of these reactors, particularly in accident scenarios. Moreover, this coolant enables reactors to be employed for transmutation purposes, presenting a viable promising solution to reduce nuclear waste and thus facilitate its storage in deep-geological repositories.

LBE showcases an array of favorable properties, such as superior thermal capabilities, low vapor pressure, a high boiling point, a notable capacity for γ-radiation shielding and transparency to fast neutrons. To employ it as a coolant, it is crucial to understand the distribution and behavior of radionuclides within LBE, as this is paramount for assessing the safety aspects of such systems. For precise predictions, a comprehensive understanding of radionuclide release from the coolant is vital.

The HORIZON2020 project PATRICIA extends previous research on radionuclide volatilization from LBE, a topic of significant relevance to the licensing and safety of future accelerator-driven systems. A particular focus is given to the volatility of polonium in the presence of other impurities, generated in or transferred to the liquid metal during operation. This research is of utmost importance, as polonium is one of the most radiotoxic and volatile radionuclides produced during reactor operation.

Here, we present the most recent findings from our volatilization studies of polonium from LBE. Representative samples were retrieved from the prototype high-power spallation target, MEGAPIE, irradiated in 2006 at the Swiss Spallation Neutron Source SINQ at the Paul Scherrer Institute. The chemical environment in the MEGAPIE target closely represents that encountered within a reactor coolant. Hence, samples from MEGAPIE provide, for the first time, valuable insights into potential interactions of polonium and other impurities during reactor operation. These investigations were conducted using the transpiration method, which measures the amount of a volatile substance evaporated from a condensed phase.