PhD thesis Proposal 2026

Study of PVC behavior under the combined action of alpha particles and temperature: gas emission in the context of radioactive waste transportation

Polymers are present in numerous technological radioactive wastes. Among those, Polyvinylchloride (PVC) is the most common. In the course of its usage, it is contaminated with α-emitting particles, leading to radiolysis, resulting in the formation of macromolecular defects and gas emission. The main gases emitted from PVC under irradiation are H_2 and HCl, each of which presents a specific risk in presence of molecular oxygen: flammability and explosion for H_2 and corrosion (in the presence of H_2O) for HCl. As corrosion also initiates H_2 emission, the mitigation of the risk resulting from H_2 is a major challenge for safe storage and transportation of radioactive wastes.

In the framework of nuclear waste transportation, polymers can be subjected to the combined effect of radiolysis and temperature in presence of molecular oxygen. Numerous studies exist on the behavior of PVC exposed to electron beams or γ rays at room temperature but very few exist on the influence of the irradiation temperature in these conditions of low LET. In presence of α particles the studies are sparser; even at room temperature.
The aim of the present thesis is thus to study the behavior of PVC under α particle irradiations at temperatures varying from room temperature to 180°C with the goal of understanding the impact of temperature on defects creation and gas emission mechanisms. The objectives are to characterize and quantify outgassing and macromolecular defects first at room temperature under various oxygen pressures and then at different temperatures under the same oxygen conditions. Besides, the evolution of the same defects will be studied under the sole thermolysis conditions with the aim of decoupling the radiolysis from the thermolysis and extracting a potential synergetic effect.

The effect of α particles will be simulated using finely selected swift heavy ion beams at GANIL. Some low LET irradiations (X-rays and γ-rays) will also be performed to assess the specific effect of the high LET induced by ions on the mechanisms under study. These irradiations will be performed using a specific device to be developed during the thesis. Defects will be analyzed on-line using FTIR, mass spectroscopy and μ-GC and off-line using DSC, HPLC (for extracted solutions), and GC-MS.

Upon completion of this thesis, the PhD candidate will have acquired valuable expertise in the study of materials under ionizing radiation, in oxidative ageing and radiolysis, in analytical chemistry and in ion/mater interaction physics. These skills are applicable

beyond the field of radiolysis. More broadly, the candidate will also have gained solid experience in managing a multidisciplinary research project.

Administrative information

The PhD student will be hired by the university of Caen and will be located at the CIMAP laboratory, on the GANIL site at Caen. Various travels are expected at CEA-Saclay and Cadarache for experimental purposes or scientific discussions.

Application requirements

The applicants should hold - or be in the process of completing - a Master's degree (M2) in chemistry, physical chemistry or material science and should have a strong interest in experimental research.
For the application procedure, a resumé and a motivation letter are mandatory as a first step.

Key words: Polymers, ageing, aging, ionizing radiation, ionising radiation, radiation/matter interactions, defects

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