PhD Position – LIONS Laboratory, CEA, Université Paris-Saclay

Investigating the Evolving Porosity and Water Content of Sustainable Cements During Their Carbonation

Topic: The aim of the project is to use miniaturized carbonation devices and small- and wide-angle X-ray scattering (SAXS/WAXS) to better understand the accelerated carbonation of cements and alternative binder materials for carbon sequestration. The accelerated carbonation of cement and binder pastes can lead to rapid changes in their porosity and water content that are not accounted for by current analytical models of cement carbonation, which were originally developed for the natural carbonation of concrete based on ordinary Portland cement (OPC). SAXS/WAXS analysis combined with our recently developed "cement microreactor" [1], will be used to monitor the evolution of pastes during the early stages of CO_2 curing in order to update carbonation models and find conditions that maximize the carbon uptake of model alternative binders.

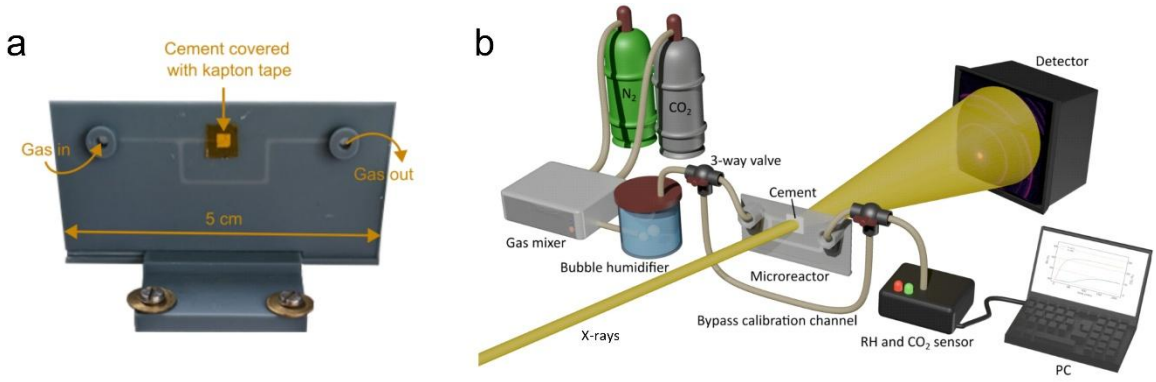

Figure 1: (a) The 3D-printed "cement microreactor". (b) Experimental setup for operando X-ray measurements of carbonation curing.

Context: The production of ordinary Portland cement (OPC) clinker accounts for up to 10% of global CO_2 emissions and 4% in Europe [2-3]. Approximately 40% of this CO_2 comes from the energy expended by heating the raw limestone and clays needed to produce the clinker, while the remaining 60% is released from the carbonates trapped within the limestone [2]. One potential method to reduce net emissions is the (re)carbonation of concrete structures, whereby the reaction of gaseous CO_2 with solid cementitious phases results in the long-term sequestration of carbon in stable mineral compounds. However, greater understanding of phenomena inhibiting carbonation is needed to improve CO_2 utilization efficiency [4].

Candidate profile: We are looking for a highly motivated student with a Chemistry, Materials Science, or Engineering background with previous laboratory experience. Ideally, the candidate would have previous experience with either SAXS/XRD or cement/concrete and would be confident in English. The ability to write experimental reports and publications is critical.

Duration and Start Date: 36 months, start date flexible but desired around October 2026

Supervisors: Dr. Mark Levenstein and Dr. Corinne Chevallard, CEA Paris-Saclay, DRF/IRAMIS//NIMBE/LIONS

Collaborations: David Carrière (LIONS), Stéphane Poyet (LECBA), Olivier Vincent (ILM, CNRS, Univ. Lyon 1)

Application: The candidate should send a CV and a letter of motivation including recommendations or a person to contact. The application should be sent to mark.levenstein@cea.fr and corinne.chevallard@cea.fr. Due to the security of the Saclay site, background checks and a clearance process of up to 3 months is required.

References: [1] V. Hérault *et al.*, *Lab Chip*, 2025, **25**, 6475-6489, https://doi.org/10.1039/D5LC00638D. **[2]** K. Scrivener *et al.*, *Cem. Concr. Res.*, 2018, **114**, 2-26. **[3]** A. Marmier, *Decarbonisation options for the cement industry*, Report JRC131246, Publications Office of the European Union, 2023. **[4]** X. You, *et al.*, *Cem. Concr. Compos.*, 2022, **125**, 104315.