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Multilength Scale Imaging of Cement Hydration

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Portland cements are environmentally contentious, accounting for ≈7% of anthropogenic CO2 emissions. If cement production is considered a country, it would be the third emitter just after China and USA. Hence, developing concretes with lower embodied carbon contents is central to maintaining our well-being. The main drawback of the most ambitious proposals for sustainable low-carbon cements is their slow hydration kinetics in the first three days. This is the focus of many hundreds of researchers and mine.
My original contribution is to develop 4D (3D+time) cement hydration nanoimaging within a multiscale framework with the final aim to decrease the CO2 emissions. Full-field laboratory X-ray micro Computer Tomography (μCT) is widely used to study cement hydration but the best spatial resolution is about 2 μm for a Field of View (FoV) of ≈ 1×2 mm (H×V) with measurements taking hours. Moreover, the contrast between the different components is poor. Full-field propagation-based phase-contrast synchrotron X-ray μCT can study similar FoVs ≈ 1×2 mm with better spatial resolution, close to 0.50 μm. The measurements are fast, i.e. 5-10 minutes. Unfortunately, the contrast is only slightly better and its availability is scarce. Cement hydration can be studied with much better contrast and spatial resolution by scanning near-field ptychographic nano-computed tomography (nCT). In this case the FoV could be of the order of ≈ 200×30 μm with spatial resolution, close to 250 nm, and excellent component contrast. Even air and water can be differentiated. Unfortunately, these nCTs takes about 3-4 hours in optimized beamlines (BL) at third generation synchrotrons. Example of different imaging modalities for 4D nCT and μCT cement hydration will be discussed. Finally, some expected performances at CoDI (ALBA-II optimized BL to be built) will be commented.

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