

Nonlinearity and isotope effect in temporal evolution of mesoscopic structure during hydration of cement

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Abstract

Though cement is a ubiquitous material with global production exceeding that of any other material of technological importance, the mechanism of its hydration and evolution of cement-water mixtures into gels of high compressive strength is poorly understood, despite extensive research over the past century. Recent investigations, based on neutron scattering measurements, aims at unraveling this enigma and outlines, for the first time, the evolution of the mesoscopic structure of the cement paste which exhibits temporal oscillations, strongly dependent on the scale of observation and on the medium of hydration (light or heavy water). While the formation of hydration products is synchronous for hydration with H₂O, the process is non-synchronous for hydration with D₂O. The reason why morphological patterns of domains at different times look dissimilar, as seen before (Phys. Rev. Lett. 93, 255704 (2004); Phys. Rev. B. 72, 224208 (2005)), for different hydration media emerges as a natural consequence of this finding. Mesoscopic structure of cement paste exhibits isotope effect. The structures arise from well-characterised chemical reactions as water diffuses through the porous material to bring about the water-surface interactions within the complex local geometry. The noteworthy observations point to the effect of hydrogen bonding on mesoscopic structure resulting from hydration although hydrogen bond with deuterium is only slightly stabler yielding a longer lifetime vis-a-vis bond involving hydrogen. Aforementioned investigations also provide an explanation for disagreement with the hypothesis of dynamical scaling for hydration of cement with heavy water and is a step forward towards general understanding of hydration process.

References

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