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Growth of amorphous calcium aluminosilicate gel facilitated by nanoparticles in a confined, drying environment

K. Yang, V.O. Ozcelik, N. Garg, K. Garg, and C.E. White (IRG-2)
Princeton University

Conventional drying of colloidal materials and gels (including cements) can lead to detrimental effects due to the buildup of internal stresses as water evaporates from the nano/microscopic pores. However, the underlying nanoscopic alterations in these confined gel materials that are, in part, responsible for macroscopically-measured strain values, remain a topic of open debate in the literature.

By employing in situ synchrotron X-ray total scattering measurements and pair distribution function (PDF) analysis, the Princeton MRSEC group showed that the significant contributing factor to the strain development in this material at extremely low relative humidity (0%) is disintegration of the gel (Figure 1). From a mitigation standpoint, it was found that small amounts (0.17 wt. %) of ZrO_2 nanoparticles are able to actively reinforce the nanoscale structure of the cement via growth of a silica-rich gel during drying (Figure 1).

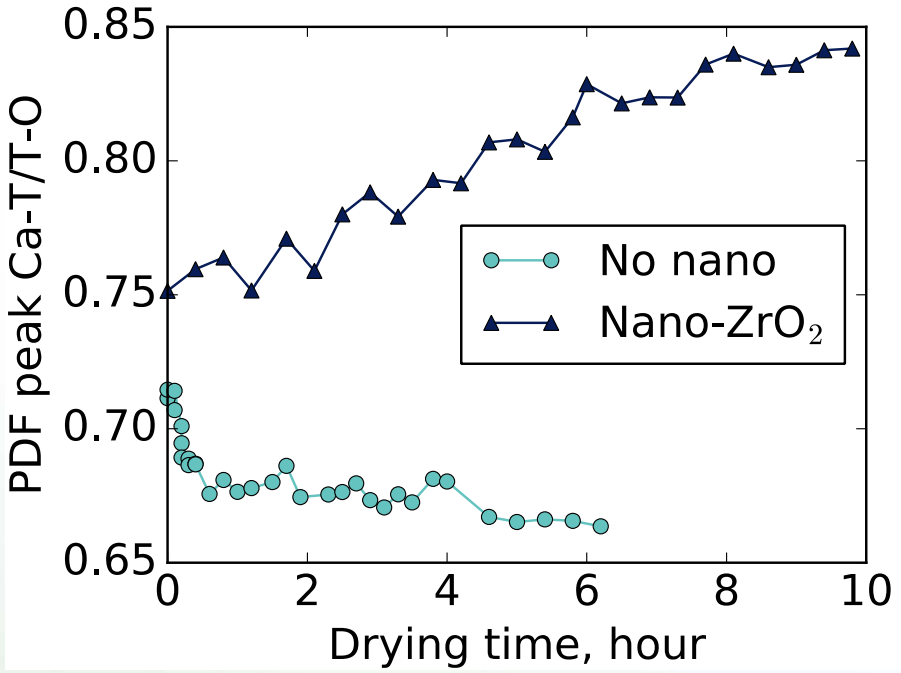

Figure 1: Time evolution of the peak intensity of Ca-O-T (T is Si or Al) atom-atom correlation in the pair distribution function, which is an indicator of the amount of sodium-based calcium aluminosilicate hydrate gel as drying proceeds.

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