The precipitation of synthetic C-S-H in the presence of aluminates and sulfates: from nucleation and growth to kinetics and morphology

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As concrete-based infrastructure becomes more commonplace in the world, cement's contribution to CO_2 emissions will increase. Consequently, it is imperative that more sustainable cementitious materials with the same costs, same strengths, and lower emissions are put into use. To effectively supplement the materials on the market, strength mechanisms of cement must be understood and controlled.

Calcium-silicate-hydrate or C-S-H is the glue of Portland Cement. C-S-H is the main product of the hydration phase and the chief contributor to early-age strength. As a result, a sound understanding of C-S-H nucleation and growth will allow cement scientists to copy and control these mechanisms in supplemental materials, increasing cement sustainability.

Therefore, the objective of this thesis is to study the nucleation and growth of pure C-S-H, and C-S-H with sulfates and aluminates at Ca:Si molar ratios which range between 1 and 2 by way of thermodynamic modelling, kinetic modelling, and experimental synthesis. These three different types of C-S-H will be analyzed in the presence of substrates to better understand how the chemical makeup of a cementitious system affects nucleation, growth, morphology, and water distribution in C-S-H. Synthetic C-S-H will be characterized using x-ray diffraction, thermogravimetric analysis, inductively-coupled plasma spectrometry, x-ray fluorescence, proton nuclear magnetic resonance, scanning electron microscopy, and transmission electron microscopy.

This first year has focused on constructing a reproducible protocol for the production of pure, single-phase C-S-H, understanding what parameters need to be better controlled, and validating the obtained values. Additionally, C-S-H with aluminates has been successfully produced.

Synthetic C-S-H allows the opportunity to study the main product of hydration in isolation. A better understanding of how to control the nucleation and growth of C-S-H will be useful to implement the same mechanisms in cements with supplementary materials.