Strategies to Influence the Crystallization Process of Calcium Silicate Hydrates

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Calcium silicate hydrate, the reaction product of cement with water, is the main binding phase in hardened cement pastes and the principal reason for the strength of concrete. Therefore it is of major importance in various fields of research [1]. Cement clinker as the corresponding “starting-material” and essential component for concrete-formation, is produced by high-temperature treatment of carbonate minerals. This leads to release of carbon dioxide, mainly resulting from process- and fuel-combustion-emissions. Due to rising global production volumes (4.3 billion t in 2014) caused by economic growth, cement manufacturing contributes up to 7 % to the worldwide man-made CO2-emissions. One conceivable approach to produce sustainable cements is clinker substitution by natural puzzolanes. [2] However, they are not suitable for all kinds of cements, for instance because of low early strength. In order to solve this issue, application of organic additives or so-called templates which directly influence the physicochemical properties are imaginable. The presence of templates affects the product formation during a chemical reaction or crystallization process, leading to different morphologies, phase compositions or geometries of the final compounds in comparison with the template-free reaction. The most interesting structures with regard to shape, phase composition and mechanical characteristics are created by nature itself. Therefore, the research area of biomimlication is closely related to approaches that use organic templates in order to create new functional “biomimetic” materials with practical applications. While many scientific publications deal with biomimilation of calcium carbonate, silica or hydroxyapatite, research on biomimetic approaches of influencing calcium silicate hydrates or cements in general is very scarce so far [3]. Hence, the current work demonstrate and evaluate the impact of different approaches to influence the crystallization process of calcium silicate hydrates (Fig. 1). Various organic additives, herein, the selection of additives aims at organic compounds showing similarities to natural templates regarding partial structural elements or functional groups, e.g. imidazole-rings or carboxy and amino functionalities. Calcium silicate hydrates are grown via the puzzolanes method by using pure SiO2 and CaO as starting materials and under variation of reaction parameters like time and temperature. The final products are analyzed via x-ray powder diffraction and gas-adsorption measurements. In order to obtain detailed information regarding structural parameters like crystallite-size, lattice-parameters and interplanar spacing, the Pawley method is applied.

Fig.1: Influencing strategies for crystallization (nano fibers, layer-by-layer, templating, imprinting, sol-gel method

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