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In-situ hydration studies of C4AF at early ages in the presence of other phases

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The ferrite phase, C4AF in cement nomenclature, is the major iron-containing phase in Ordinary Portland Cement (OPC) and in iron rich belite calcium sulfoaluminate cements. The term "ferrite"usually refers to a solid solution with a wide range of composition with the general formula Ca2(AlyFe2−y)O5, where y can vary from 0 to about 1.33[1]. In cement chemistry the ideal composition C4AF, is used to describe the ferrite phase in OPC.
The hydration of pure C4AF with water initially forms metastable C-(A,F)-H hydrates which eventually convert to hydrogarnet phase C3(A,F)H6 (katoite) over time. The addition of sulfates to C4AF inhibits the direct hydration of C4AF to katoite. Ettringite is the most commonly hydration product observed under these conditions. In addition, ettringite could decompose to an AFm monosulfoaluminate hydrate[2].
The aim of this work is to better understand the early age hydration of ferrite in the presence of other phases at early ages. Chiefly, we want to determine the hydration kinetic and mechanisms of this phase using different reaction media.
Firstly, C4AF in the presence of water hydrates to form mainly katoite phase. The hydration of ferrite with w/s ratio of 1.0 yielded C3A0.84F0.16H6 as single crystalline phase. Its crystal structure has been determined by the Rietveld method. Figure 1 shows the Rietveld synchrotron X-ray powder diffraction plot for this sample.
Secondly, the presence of sulfates strongly modifies ferrite hydration behavior. The hydration of C4AF in the presence of gypsum gives AFt first and, crystalline AFm precipitates afterwards. Figure 2 shows a selected range of the SXRPD raw patterns for a sample with C4AF, gypsum and ye'elimite recorded at different time of hydration, with the main peaks due to a given phase labelled.
Finally, the effect of w/s ratio has also been studied for this sample. Results indicate that higher amounts of water favour the formation of AFm. A summary of the results for the hydration of C4AF will be discussed.
Cement nomenclature: C=CaO, A=Al2O3, F= Fe2O3, H=H2O.

References

[1] B. Touzo, K.L. Scrivener, F.P. Glasser, Phase compositions and equilibria in the CaO-Al2O3-Fe2O3-SO3 system, for assemblages containing ye'elimite and ferrite Ca2(Al,Fe)O5, Cem. Concr. Res. 54 (2013) 77-86.
[2] N. Meller, C. Hall, A.C. Jupe, S.L. Colston, S.D.M. Jacques, P. Barnes, J. Phipps, The paste hydration of brownmillertire with and without gypsum: a time resolved synchrotron diffraction study at 30, 70, 100 and 150 ºC, J. Mat. Chem. 14 (2004) 428-435.

Caption (s) - Add figures as attached files (2 fig. max)

Figure 1. Rietveld Synchrotron X-Ray Powder Diffraction plot for C3A0.84F0.16H6. The tic marks are the Bragg reflections: C3A0.84F0.16H6 (lower row); Quartz, internal standard (upper row). Figure 2. Selected range of the SXRPD raw patterns for C4AF with ye'elimite and gypsum (w/s=1.0) recorded at different time of hydration, with the main peaks due to a given phase labelled. AFt: circle; AFm: star; Qz: triangle; gypsum: rhombus; C4AF: inverted triangle and ye'elimite: square.

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