Retarding Effects of Cellulose Ethers on Early Portland Cement Hydration

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Cellulose ethers (CEs) have phase-specific retarding effects on cement hydration. The retardation is correlated with the CE-adsorption on the mineral surfaces and depends on the CE´s degree of substitution (DS). The lower the DS the higher the amount of adsorbed CE and the stronger the retardation. The following phase reactions have been monitored in situ using synchrotron X-ray powder diffraction with a fast multi-strip detector:

1. $C_3A + C\overline{S} / C\overline{S}_{0.5} + H \rightarrow$Aft ($1^{st}$ ettringite formation)
2. $C\overline{S} / C\overline{S}_{0.5} + H \rightarrow C\overline{S}_2$ (gypsum crystallization)
3. $C_3A + C\overline{S}_2 + H \rightarrow$ AFt (2^{nd} ettringite formation)
4. $C_3S/C_2S + H \rightarrow$ CSH + CH (portlandite precipitation)

The C_3S-hydration is strongly and DS-specifically retarded. The retardation of gypsum crystallization is much weaker but distinguished, depending on DS. The first ettringite formation is not affected by CE. This is correlated with the adsorption rates, e.g. for a CE with a DS of 1.7: 540 µg/m² on portlandite, 240 µg/m² on gypsum and no adsorption on ettringite. The second ettringite formation does not fit into the scheme. It is strongly DS-dependently retarded although no CE adsorbs on ettringite. In the presence of silicates the second ettringite formation always takes place simultaneously with portlandite precipitation. The kinetics of the second ettringite formation in cement might therefore be influenced by the Ca-concentration in the pore water. The hydration of pure phase mixtures of C_3A and sulfates without silicates was studied in experiments using water and $Ca(OH)_2$-saturated solution. The ettringite crystallization is strongly inhibited in $Ca(OH)_2$-saturated solution.

Keywords: in-situ cement hydration, synchrotron powder diffraction, microstrip detector