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Role of alkanolamines in ordinary and alternative cement systems

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Ordinary cement resulting from the reaction of a calcium aluminosilicate-rich powder plus water works as binding matrix in modern concrete. The design of alternative binders is currently a global challenge in order to reduce the environmental footprint associated to the ordinary cement production. Alkali-activated calcined clay materials (AAccMs) represent a class of sustainable binders made of the blending of a concentrated alkaline solution and a solid fraction with thermally treated phyllosilicates. Metakaolin produced by the heat treatment at temperatures between 550-900°C of kaolinite, has long fascinated the scientific community for its high reactivity at high-pH stage. However, the higher costs of commercial metakaolin push towards the use of locally available low-purity kaolinitic soils, such as laterite covers, as potential raw materials to produce low-CO_2 cements with the benefit of reducing the cost of feedstock transportation.

The work is focused on the role of triethanolamine (TEA) and triisopropanolamine (TIPA) on the reaction kinetics of ordinary cement pastes and AAccMs, the latter with different aluminosilicate reactive fraction and degree of purity. TEA and TIPA are tertiary alkanolamines with a developed molecular structure. It has been assessed that low equal dosages of alkanolamines introduced in advance to the mixing water for cement hydration can act on the setting time and the degree of cement reaction. These chemical compounds, and above all TIPA, are recognized as iron-chelating agents that can increase the dissolution rate of ferric ions from the ferroaluminate phase of cement and promote their complexation. Moreover, alkanolamines can also form water-soluble calcium-complexes that may influence the hydration kinetics of calcium-silicate phases and the precipitation of hydrates in the binder microstructure.

The raw and the reacted materials are characterized by X-ray diffraction (XRD) and the kinetic pathways are followed with the aid of a semi-adiabatic calorimetry. The dissolution-precipitation steps of hydration in aqueous and alkaline solutions are subsequently simulated. Ordinary cement is used to clarify the role of alkanolamines as hardening accelerators. Afterwards, the kinetics of alkali-based pastes of high-purity metakaolin and a Fe-rich laterite, both blended with waste marble powder, are compared with the aim of assessing the formation of calcium-complexes in solution and any change in the kinetics due to the presence of iron in the raw material. Mechanical strength tests are performed to make clear the beneficial or detrimental effect of TEA and TIPA on the materials.