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A Powerful Tool to Better Understand Cement Hydration

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Concrete is the most widely used material in the world, after water, and is essential in the current society in terms of infrastructure and housing. Cement is the main binding component of concrete and its production represents more than 4 billion tons per year. In presence of water, cement hardens, conferring to concrete its excellent mechanical properties. Furthermore, polymeric dispersants, so-called superplasticizers, are widely used in concrete to increase its fluidity or reduce its permeability, thus enhancing its durability. These dispersants also decrease the environmental impact of concrete as they allow the reduction of cement content per unit volume. Despite such wide use, cement hydration involves a complex dissolution/precipitation process that has not been fully elucidated yet.

The elemental characterization of the cement pore solution is important for gaining insight into the thermodynamics and kinetics of cement hydration, and predicting the durability of concrete. Eight elements are of crucial interest: calcium, potassium, sodium, sulfur, aluminum, iron, magnesium, and silicon. The first four are present at a concentration in the order of several g/L, while the others are at a level of microtraces (µg/L), thus constituting a major analytical challenge.

Researchers and operators working in the field of cement broadly use Inductively Coupled Plasma – Optical (or Atomic) Emission Spectrometry (ICP-OES), because of its versatility and relative ease of use. Yet, an easy and robust ICP-OES method for characterizing cement pore solutions has been missing and awaited for a long time.

By properly accounting the matrix effects and the careful analysis of the spectral lines, our study provides for the first time experimental guidelines and analytical performances for a highly accurate and versatile ICP-OES method for the elemental characterization of cement pore solutions with and without the presence of admixtures. The quantification of some elements is improved by a factor 34 when compared with what is generally reported.

In pore solutions from admixed cement pastes, our ICP-OES method allowed us to accurately observe an increase of the microtrace elements. This could be due to the formation of nanoparticles that may consist of intramolecular complexes between the polymeric admixtures and polyvalent cations, as aluminum, iron, and magnesium. The formation can be expected to have important consequences on the working mechanisms of chemical admixtures such as superplasticizers.

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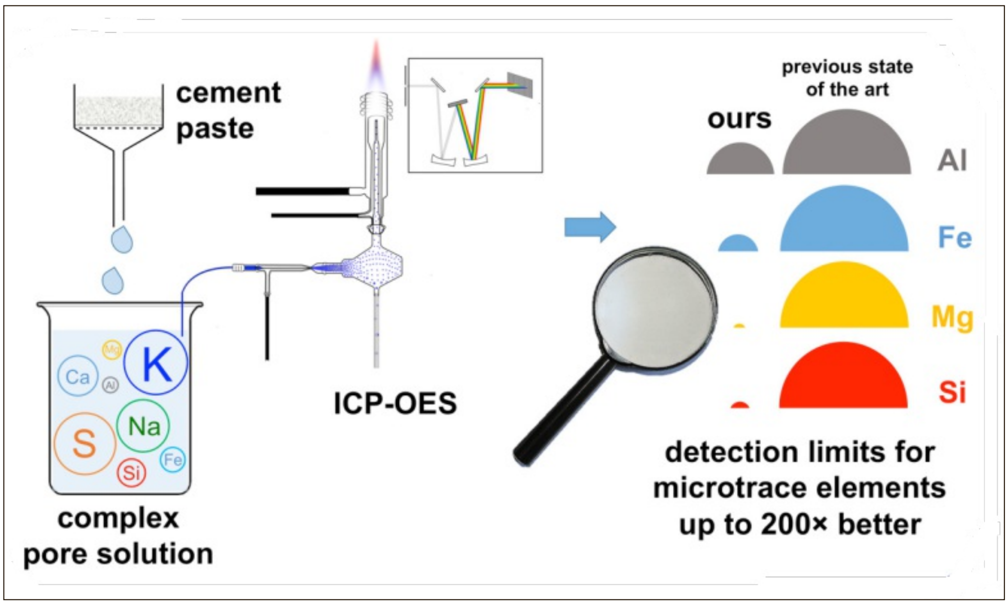

The proposed ICP-OES method allows the simultaneous, very accurate determination of high- (Ca, K, Na, S) and low-concentration (Al, Fe, Mg, Si) elements of the pore solutions from cement pastes, with and without superplasticizers.

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