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The impact of cation size on sulfate scaling

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The aim of this study is to further our understanding of mineral precipitation behaviour from solution by examining how it varies as a function of physicochemical conditions, both in the absence and presence of various classes of additives. We used a high-throughput diagnostic setup with a multicell UV-Vis spectrophotometer and automated data analysis to determine nucleation induction times under controlled conditions. In the experiments, a fixed volume of Na_2SO_4 was added to the same volume of $CaCl_2$, $BaCl_2$ or $SrCl_2$. The solutions were continuously stirred at 800 rpm and maintained at 20 ºC. The induction time, defined as the period between the creation of a supersaturated solution and the first detectable change in absorbance measured by UV-Vis spectrophotometry, was automatically determined using a custom Python script that fits absorbance curves with a smoothing spline and identifies the induction time when the first derivative of the curves exceeds a set threshold. The obtained data reveal an inverse relationship between cation size and nucleation kinetics: larger cations lead to longer induction times. This is counterintuitive, as the lower charge density and hydration enthalpy of larger cations should exhibit lower desolvation energies, which would theoretically accelerate nucleation by lowering the energy barrier for their integration into a cluster. In this presentation, we will explore potential explanations for this discrepancy and discuss the implications for using additives to control precipitation in different sulfate systems.