The influence of $\{Ba^{2+}\}:\{SO_4^{2-}\}$ on particle charge, size and morphology during $BaSO_4$ Crystal Nucleation and Growth in Aqueous Solutions

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Barite ($BaSO_4$) is a major nuisance in terms of scale in oil and gas recovery and in the use of geothermal energy. Therefore, it is essential to study the physico-chemical paramaters influencing the particle charge, size, morphology and timing of formation, providing new insight into mitigating $BaSO_4$ scale formation. In this study, the impact of solution stoichiometry (r_{aq}) at a fixed supersaturation (Ω_{barite}), upon the formation (i.e. nucleation + growth) of $BaSO_4$ crystals in 0.02 M NaCl suspensions, on the development of particle size, charge and morphology was investigated using Dynamic Light Scattering (DLS), Mixed-Mode Measurement – Phase Analysis Light Scattering (M3-PALS) and Scanning Electron Microscopy (SEM). DLS batch experiments showed that the average particle size in all suspensions at $\Omega_{barite} = 1000$ with varying r_{aq} of the largest population present grew from ~ 200 to ~ 700 nm within 10 to 15 minutes and grew fastest near the ideal 1:1 stoichiometric ratio and more slowly at non-stoichiometric conditions. Additional flow DLS measurements at the same initial conditions confirmed that $BaSO_4$ nucleation kinetics were very fast and showed strong signs of aggregation of prenucleation clusters, which formed particles in the range of 200 – 300 nm. M3-PALS batch experiments showed that the charge stayed negative for $r_{aq} < 1$ during $BaSO_4$ crystal formation and positive for $r_{aq} > 1$. At $r_{aq} = 1$, positive and negative populations of particles prevailed for 2.5 hours before circumneutrally charged particles remained. Moreover, SEM results showed that morphology is drastically affected by Ω_{barite} and r_{aq}.