Continuous Struvite Seed Crystallization using Poiseuille Flow

Introduction:
Struvite particle size can be affected by continuous seeding. Seed size is expected to reduce with increased saturation due to increased nucleation. A Poiseuille flow reactor with both vortex and impinging jet mixing was used to examine a saturation index range of 0.8 to 1.4.

Approach:

Results:

Reactor Operation:
The reactor was designed to achieve a mixing time of 0.2s, a mixer residence time of 4s and an induction time >20s. Despite this, mixer scaling was still observed after extended operation (>6s), indicating that induction time may be a distributed variable. Scaling of the in line flow cell limited the timespan for accurate in line PSD measurements but was identified as a future method of crystal growth rate assessment. Response time of pH measurements was significantly increased by probe scaling. Filtration was successfully used to recover particles when filter cake did not exceed 46g/m².

Struvite crystallization was modelled using nucleation and crystal growth kinetic parameters determined by Galbraith (2014). Modelled steady state D[50] was consistently lower than filtered sonicated crystal samples but the relatively close result gives confidence in further use of these kinetic parameters.

Distribution width and median diameter magnitude and variance increased with saturation. They were also larger when impinging jets were used, as incomplete mixing creates concentration gradients. IJ mixing produced lower recovery for all SI. Formation of weak aggregates, which can be disrupted by filtration and sonication (FS), was significant at higher saturation.

Conclusions:
Poiseuille flow combined with rapid mixing provides a low pressure drop method of continuous seed production. Magnitude and variance of distribution width and volume median diameter (D[50]) measured in line (IL) increase with initial saturation index (SI), whereas filtered and re-suspended samples show little change. These effects are greater for the impinging jet (IJ) mixer than the Roughton (R) mixer. This illustrates that incomplete mixing before nucleation promotes formation of unstable aggregates, creating a variable product. The IJ mixer also produced a lower phosphorus recovery, which may be attributed to SI gradients caused by incomplete mixing. Differences in mass recovery measurements indicate that scaling is an issue and needs to be further investigated.