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Case Study

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MODELING STRUVITE CRYSTALLIZATION IN A BATCH REACTOR USING POPULATION BALANCE MODULE COUPLED WITH 3-D CFD MODEL

Mousavi, Seyyed Ebrahim [1, 3], Rahaman, Md. Saifur [2]
[1,2] Concordia University, Canada
[3] ebrahim.mousavi65@gmail.com

Discharge of significant amounts of phosphate from nutrient-rich wastewater is a problematic issue considering the potential contamination of groundwater and eutrophication of recipient water bodies. On the other hand, phosphorus is also a limited, non-renewable resource with reserves that may be depleted in the near future. As a result, phosphorus recovery is receiving due attention as an environmental concern. The recovery of phosphorus using a crystallization technique is one proven solution for this issue. In this work, crystallization of Magnesium Ammonium Phosphate (Struvite) as an alternative method for the recovery of phosphorous is modeled in a batch stirred tank reactor. Different aspects of agricultural benefits of struvite have been discussed by the researchers, e.g. having low water solubility makes struvite a candidate for slow nutrient releasing fertilizer. Since the crystal size distribution is a cornerstone to control the quality of produced struvite, this study focuses on developing a model to predict the crystal size.

The aim of this work is to link Computational Fluid Dynamics (CFD) with Population Balance Modeling (PBM) to develop a 3-D CFD model which could predict Crystal Size Distribution (CSD) of struvite. In the simulation, the CFD flow field was solved through a Eulerian multiphase approach and RNG k-ε turbulence model, using a commercial CFD package, ANSYS Fluent 17.1. The population balance equation was solved using the discrete method, implementing 25 different size classes. The size-independent growth rate as a function of the supersaturation index (SI) was employed in the model through User Defined Function (UDF). A series of batch experiments were conducted utilizing synthetic wastewater in a 1-L glass stirred tank reactor agitated with a Rushton impeller to confirm the simulation results. Some CSD results presented in fig. 1

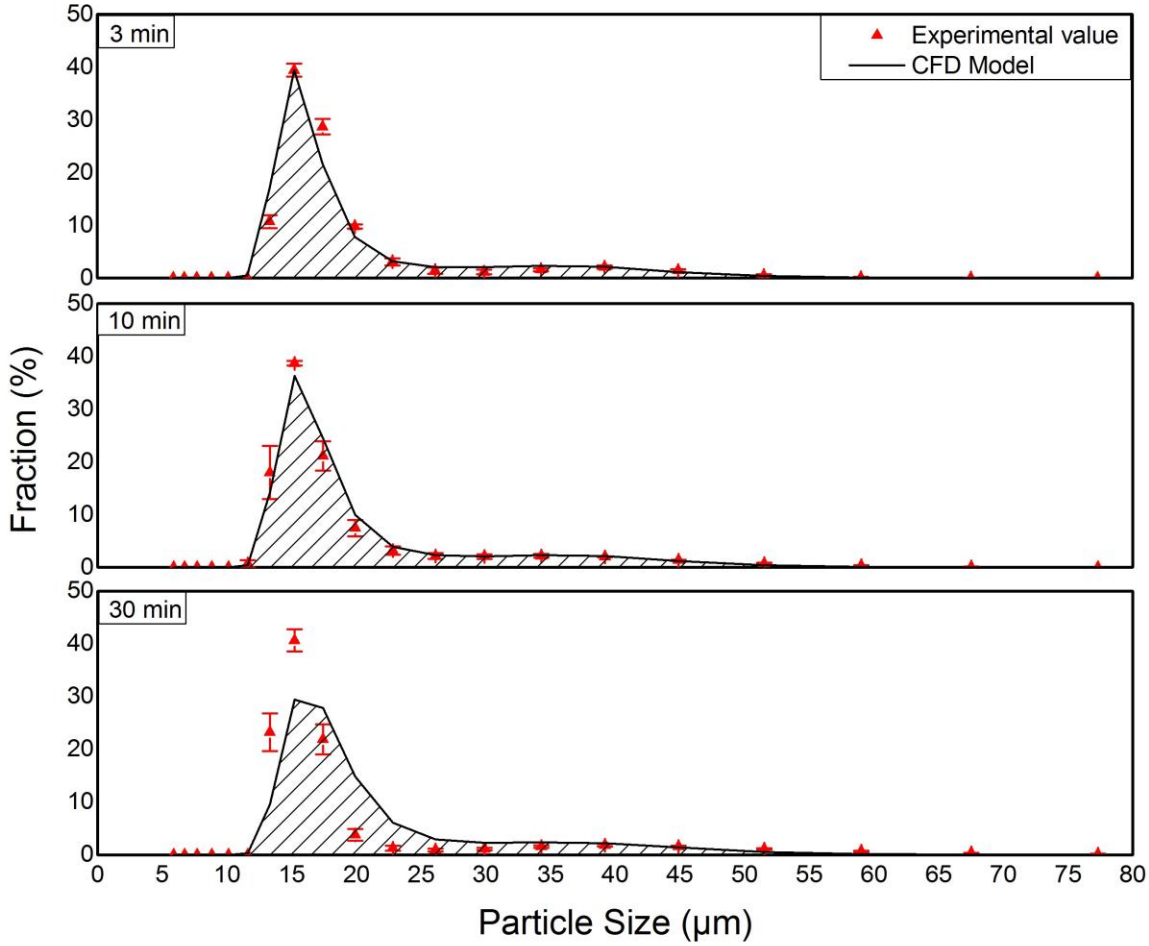

Figure 1 Experimental and CFD model predicted number based CSD at 3, 10 and 30 min

The model successfully predicted the variation of crystal size distribution as well as SI values with experiment time. Results showed that the general trend and the position of the peaks in CSD curves are in a good accordance with the experimental measurements.

KEYWORDS: Struvite, Crystallization, CFD Simulation, Population Balance Model, Stirred Reactor, Growth rate