Minimum fluidization velocity prediction for struvite particles using an upflow fluidized bed system

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1. Introduction – Struvite crystallization in a fluidized bed reactor is an alternative method to remove and recover nutrients from wastewater streams. The minimum fluidization velocity is an essential parameter in designing a fluidized bed crystallizer. There are several correlations that allow to predict the minimum fluidization velocity (u_{mf}), known the hydrodynamic characteristics for different fluid-particle systems. The usual correlation to predict the minimum fluidization for struvite particles reported in the literature is the correlation of Wen and Yu [1]; but depending on the particle size in bed, the achieved accuracy by this correlation needs to be improved. This study was conducted to define the best minimum fluidization velocity correlation for different struvite particle size using a bench-scale upflow system.

2. Experimental – The bench-scale upflow system was made of acrylic plastic, with 6 cm inside diameter and 100 cm height dimensions. A pH 9.0 water (to avoid struvite solubilization) was fed into the bottom of the system, through a peristaltic bomb. The minimum fluidization velocities for two different size classes of struvite (Sieve test, particle diameter dp: 0.5–1.0 mm and 1.0–2.0 mm) were determined experimentally by increasing the upflow velocities and measuring the pressure drop with a manometer of inverted piezometric tubes. The two struvite Sieve groups were prepared by semicontinuous using NH_4Cl and KH_2PO_4 or $(NH_4)_2HPO_4$ respectively. The experimental u_{mf} values were compared with the predicted u_{mf} estimated using different reported correlations [1-5]. These different correlations are based on the Ergun's Equation [6], and Xu's correlation [5] also incorporates cohesive forces. The Delebarre's Equation [4], incorporates the sphericity factor (φ_s); this parameter was determined experimentally using the Ergun's Equation in a fixed bed, knowns the void fraction, height and weight of the bed.

3. Results - The experimental and predicted u_{mf} are presented in Table I.

Table I. Minimum fluidization velocity [$mm \cdot min^{-1}$]: experimental and predicted values (25°C)

	u_{mf} Predicted					**u_{mf} Experimental**
dp (mm)	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	
0.5–1.0 $\varphi_s = 0.14$	142	164	173	79.3	11.6	11.8
1.0–2.0 $\varphi_s = 0.40$	490	536	567	335	19.2	156

4. Conclusions – For small particles of struvite (0.5-1.0 mm) with high degree of cohesiveness, the minimum fluidization velocity can be predicted with very good accuracy using Xu's correlation, and this correlation should be utilized for design purposes for particles of struvite with analogous sizes. For struvite particles with higher diameters (1.0-2.0 mm) all the evaluated correlations overestimate u_{mf}, except Xu's Equation, which underestimate in ≈90% the experimental u_{mf}. The Delebarre's correlation presented a better prediction than the commonly used Wen and Yu's Equation for this Sieve group.

5. References

[1] C.Y. Wen and Y.H. Yu, A generalized method for predicting the minimum fluidization velocity. *AIChE Journal*, **12**(3), (1966) pp. 610-612.
[2] J.F. Richardson, Incipient fluidization and particulate systems, *Fluidization*, (1971) pp. 26-64.
[3] J.R. Grace, Fluidized bed hydrodynamics, *Handbook of multiphase systems*, (1982) p. 5.
[4] A. Delebarre, Revisiting the Wen and Yu equations for minimum fluidization velocity prediction, *Chemical engineering research and design*, **82**(5), (2004) pp. 587-590.
[5] C.C. Xu and J. Zhu, Prediction of the minimum fluidization velocity for fine particles of various degrees of cohesiveness. *Chemical Engineering Communications*, **196**(4), (2008) pp. 499-517.
[6] S. Ergun, Fluids flow through packed column, *Chem. Eng. Prog.*, **48**(2), (1952) p. 88–94.