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Abstract. Struvite is a white crystalline chemical known as magnesium ammonium phosphorus hexahydrate ($MgNH_4PO_4.6H_2O$). Struvite is soluble in acidic conditions and slightly soluble in neutral and alkaline conditions. In industry, struvite is known as scale in pipes. Urinary stones can be called struvite because struvite crystals can form easily in the urine of animals and humans infected with ammonia organisms produced in the urine. Struvite can potentially be formed by alkaline urine and high magnesium excretion due to a high magnesium plant- based diet. The formation of struvite minerals is carried out in an insulated reactor by mixing a solution of $MgCl_2$, NH_4OH, and H_3PO_4 in a ratio of 1:1:1. The treatment of struvite mineral formation was carried out with a feed inlet rate of 35 ml/minute, the temperature at the reactor was carried out at 30oC while the intake air rate was carried out in the range of 0.25-1.25 liters/min. The pH of the solution was kept at a value of 9. The process was carried out until a steady state was reached. The formation of struvite minerals using an insulated column reactor was obtained at conditions of pH 9, operating temperature of 30°C and air rate of 1.25L/min.

Keyword: Air Rate; Bulkhead Reactor, *Struvite*, SEM

1. Introduction

Struvite is known as magnesium ammonium phosphate hexahydrate ($MgNH_4PO_4.6H_2O$). Struvite can be made by reacting the two ionic solutions that form it, namely from stock solutions of $MgCl_2$ and $NH_4H_2PO_4$ each with a certain concentration so that the molarity ratio of Mg2+, NH + the formation of struvite is:

$$Mg^{2+} + NH + HnPO^{3-n} + 6H_2O \rightarrow MgNH_4PO_4.6H_2O + nH^+$$

According to (3) Struvite has the following properties: The molecular formula of Struvite $MgNH_4PO_4.6H_2O$. It is a white crystalline powder but may also appear as very large crystals, small crystals, large curds or jelly. Has a specific gravity of 1,7. Easily soluble in acidic pH and difficult to dissolve in alkaline pH.

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Figure 1. Crust in the pipe

Struvite precipitation is usually found in areas with high turbulence, this turbulence releases carbon dioxide and raises the pH. Thermodynamic data from the literature indicate that some Mg2+ compounds will precipitate from solutions containing NH4+ ions, and PO43-: MAP, magnesium hydrogen phosphate trihydrate or newberyite (MgHPO4•3H2O), trimagnesium phosphate in the form Mg3(PO4)2•22H2O and Mg3(PO4)2•8H2O (bobierrite). Struvite precipitation occurs at neutral pH or more. Struvite crystals have a distinguishing orthorhombic structure and can be identified by SEM (4).

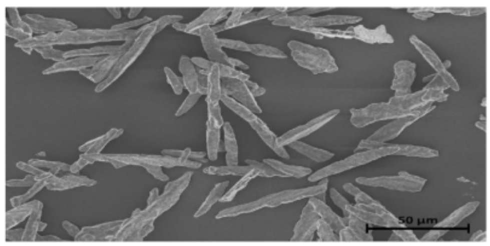


Figure 2. SEM Analysis of Struvite Crystals

Struvite precipitation is controlled by pH, degree of saturation, and the presence of ions in solution such as calcium. In the formation of struvite crystals from leachate, the same [Mg2+] : [NH4-] : [PO43-] molar ratio is required [5]. Sources of magnesium ions can come from MgCl2.6H2O, MgO and MgSO4.7H2O. Source of phosphate ion Na2HPO4.12H2O, H3PO4 and Ca(H2PO4)2.H2O. Factors that influence the formation of struvite include pH of solution, at pH 9, struvite crystals are formed with the highest number compared to pH 7 and 8. When struvite crystals are formed, positively charged ions (H+) will be released into the solution so that it will lower the pH of the solution. To increase the pH of the solution can be done by adding alkaline solutions such as NaOH and KOH. However, the addition of air (aeration) can also be of little help in increasing the pH of the solution (1).

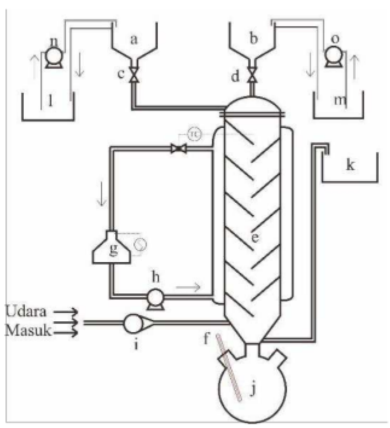
The other factor is Stirring speed / air flow rate. Stirring is one way to make a solution into a homogeneous solution. The stirring speed / air flow rate given will increase the surface area of each solution so that the reactions that occur between chemical compounds take place more quickly. Although pH adjustment can be done in the formation of struvite, the air flow rate will also assist in the process of increasing the pH (6). Temperature is also one of the affecting factor, in the study (7) an increase in temperature from 10 oC to 35 oC showed that the solubility product of struvite decreased from 0.436 x 10-4 to 5.920 x 10-14. These data indicate that if the temperature of the solution at 35o then decreases or increases, the struvite crystals will be more soluble in the solution.

According to Ariyanto et al., 2015, physical characteristics such as the pH of the solution, the amount of supersaturation, stirring, temperature, and the existence of interfering ions in the solution can influence the time it takes for struvite crystals to form. Stirring is an important element of the struvite formation process because it influences the pace of the struvite formation reaction, particle size development, and settling speed. However, utilizing a stirred reactor to generate struvite is not lucrative since the struvite produced is inferior because it gets torn up by the stirring blade during the swirling process. In 2017, Y. J. Shih et al. published a study on the production of struvite from a waste using Fluidized Bed Reactor.

The research that we carried out was using a bulkhead reactor. The principle of this bulkhead reactor was to use a counter-current flow, i.e. feed enters through the top hole, while the air as a stirrer passes through the bottom hole. Inside the reactor is equipped with a bulkhead where the function of the bulkhead is as a breaker for air bubbles that enter the reactor. With the insulation, the incoming air bubbles will split into smaller sizes so that the homogeneity of the mixture of the *struvite-forming* solution will be better (10).

2. Research Methodology

The struvite formation process is carried out in the bulkhead column reactor. *Magnesium Ammonium Phosphate* (MAP) solution was introduced into the reactor until it reached a height of ¾ from the reactor. The pH of the solution was controlled by adding KOH solution and the process temperature was maintained at 30 ^{O}C. The air flow rate is carried out at a rate of 0.25; 0.5; 0.75; 1; 1.25 L/min. The air flow rate serves as a stirrer, while the function of the bulkhead contained in the reactor is to break the air bubbles into smaller ones. Thus, the reaction process of the formation of struvite becomes more perfect.



Information:

a. MAP holding tank

b. KOH storage tank

c and d are the faucets of the holding tank

e. Bulkhead

f. Thermometer

Figure 3. The series of bulkhead reactors

3. Results and Discussion

From this research process, it is assumed that all the precipitates formed are struvite. In the graph it can be explained that the air flow rate affects the recovery of struvite which is obtained at an air flow rate of 0.75 l/min and then decreases at a flow rate of 1 – 1.25 l/min. This is because the faster the air flow rate, the greater the turbulence that occurs in the reactor which causes the reaction process to run imperfectly so that the struvite formed decreases. In the graph it can be explained that the air flow rate affects the recovery of struvite which is obtained at an air flow rate of 0.75 l/min and then decreases at a flow rate

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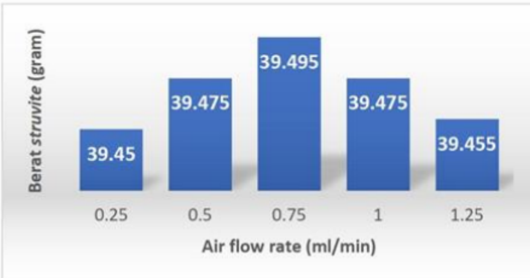

Figure 4. Effect of air flow rate on Struvite air recovery

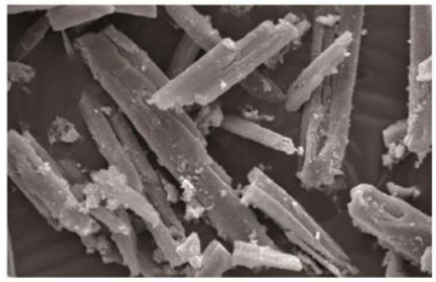

Figure 5. SEM analysis at a flow rate of 0.75 ml/min

According to (Fitriana, 2016), the faster the stirring, the greater the induction and nucleation. However, if the stirring speed is too high, the magnesium removal could be reduced because the struvite crystals' stability could be damaged, causing the crystals to shatter. The proportionate air rate in the creation of struvite crystals, according to (Rahman et al., 2013), is roughly 0.73 L/min.

4. Conclusion

The purpose of stirring with air is to let out a certain amount of dissolved or free ammonium from the solution. The air flow rate will agitate the solution, allowing the dissolved ammonia to escape and evaporate. Furthermore, the air flow can reduce the concentration of NH_4-N in the gas phase and increase the driving force for dissolving NH_4-N to separate the phases. As a result, the air rate influences the development of struvite minerals. The optimal air rate for the generation of struvite minerals in this investigation was 0.75 liters per minute.

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