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学 位 論 文 内 容 の 要 旨

DISSERTATION ABSTRACT

博士の専攻分野の名称　博士（工学）　氏名　Wendkouni John Steve Kabore

学 位 論 文 題 名

Title of dissertation submitted for the degree

Design of the process for the production of nitrogen slow release fertilizer from human urine

(人尿からの緩効性窒素肥料製造プロセスの開発)

The present study was carried out to design the production of nitrogen slow release fertilizer from human urine. The world demand of nitrogen fertilizers keeps growing and most of them are made of fossil fuel which is limited resource. Common nitrogen fertilizers that are easily soluble in water like ammonia and urea may be subject to low utilization efficiency of nutrients by plants, evaporation, washing out by streaming, eutrophication of surface water by transportation and bad odor emission. Slow release fertilizers can solve these problems by increasing the efficiency to reduce the demand. On the other hand, human urine which supplies more than 90

In this thesis, the primary part of the study focused on the chemical reaction based on the reported evidence of by-products formation that reduces the nitrogen recovery, while the second part was the evaluation of the final product. Finally, the reactor design was discussed by developing a mathematical model for the production process through the explanation of the reaction mechanism.

In Chapter 1, the literature review on slow release fertilizers, the utilization of urine as fertilizer and the issues to be addressed is performed. This chapter summarizes the objectives of the thesis.

In Chapter 2, based on the observation that the formaldehyde to urea ratio (F/U) has an impact on the recovery percentage of nitrogen due to sub-reactions, the inventory of the involved chemical species was performed and a reaction model was proposed. It was found that the recovery was low for F/U lower than 1 because the formaldehyde was totally consumed while the urea was remaining in the liquid phase. For higher F/U, all urea reacted but the sub-reactions drove to by-products of low molecular weight that could not precipitate therefore reducing the recovery.

In Chapter 3, a simplified reaction model based on the findings of the previous chapter was proposed. The original mathematical model of the reaction in chapter 1 considered intermediate polymers (monomer and dimer), solid product (trimer) and intermediate by-products. The simplified reaction model was adopted because the concentration of the intermediate polymers and by-products could not be accurately measured. Therefore, only the initial reactants (urea and formaldehyde), the monomer, the trimer and some representative by-products were used. The model was divided in 3 parts that are the addition reaction, the polymerization and the sub-reactions. The related equations of the kinetics rate laws for each part were then written and solved. From a computer simulation, the reaction con-

stants that fitted the experimental data were determined. The formation mechanism of the by-products and the relationship of the nitrogen recovery to the F/U ratio were explained. The optimum F/U ratio for the highest recovery was found from the simulation.

In Chapter 4, physicochemical properties of the fertilizer were evaluated. The controllability of those properties was possible through the formaldehyde dosage. The lower F/U ratios produced fertilizer of (1) higher crystallinity with (2) higher requirement of enthalpy for the degradation, (3) easy release of nitrogen in acidic solution.

In Chapter 5, different chemical operations were tested to determine the appropriated process for the production with the objective to reduce the by-products. Case A: batch reaction process, case B: the formaldehyde was injected intermittently in the urine, case C: the urine was injected intermittently in the formaldehyde, Case D: the formaldehyde and the urine was injected simultaneously. In case B and C, the concentration of by-products was regenerated at every injection while the recovery was decreasing. At the opposite case A and D had better efficiency with higher recovery of nitrogen and appeared to be suitable for the production process.

In Chapter 6, a summary of the findings from the study is presented with recommendations.
The reaction model was developed and the mechanism explained.
The kinetics constants were determined and the optimum F/U for the highest recovery was found.
The controllability of the physicochemical properties of the fertilizer was possible through the dosage of formaldehyde. Lower F/U produces more crystalline particles with higher requirement of degradation parameters.

The batch reaction or the simultaneous intermittent injections of urine and formaldehyde are the best chemical processes for the production.