FY19 IRTD Final Report Summary

Single Pass Ammonia Removal via MP-MAP Cycle

Demonstration Plan

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Project Description:

Removing ammonia from International Space Station wastewater.

Executive Summary:

Since 2010, NASA-KSC has been looking for alternative ways to remove ammonia (NH_3) from aqueous waste streams as this is critical for water reuse on the International Space Station (ISS). Work was performed on various Magnesium Phosphate (MP) salts in the attempts to convert them to Magnesium Ammonium Phosphate (MAP) hexahydrate, otherwise known as struvite which can be found in piping in wastewater treatment plants (WWTPs). Originally thought of as a one-time use (consumable) process, it was later discovered that partial to near complete regeneration of a specific MP salt could be performed at benign conditions instead of the 400 °C decomposition temperature commonly known for the solid. This allowed the envisioned process to act as a continuous ammonia removal cycle system for various waste streams.

Previous work performed at KSC developed an ammonia removal process using a MP absorption/precipitation column to precipitate out influent ammonia into MAP (aka, struvite). This struvite can decompose back to MP releasing ammonia gas by applying slight heat and vacuum. Tests in 2010 indicated that this plug-flow reactor concept was viable (compared to fluidize bed reactor tested) and it was demonstrated that the solid could be regenerated. Tests in 2016 confirmed the plug-flow reactor design and performance over multiple (three) regenerations and showed predicted capacity and selectivity, but much lower and better contact times required to reach removal targets. This allowed an efficient physical-chemical ammonia removal process for liquid and gas streams for use in spacecraft and terrestrial applications using less mass, volume, and energy than competing technologies.

With ammonia removal consuming around 1% of worldwide power generation having a process that does not require aeration of bulk wastewater and requiring two to three orders of magnitude less volume (and similar reduction in capital costs) is potentially game-changing if demonstrated to be effective for many cycles on the order of modern ion exchange resins, 1000s of cycles. Producing ammonia for modern agriculture additionally consumes 1-2% of all electricity and having a method to recover a portion of this ammonia in the wastewater and

recycle it can lead to additional savings which is not possible with current technologies used in wastewater treatment.

At the time we were finishing the planning, ordering, and beginning to move into the lab, the COVID-19 pandemic struck causing a systematic shutdown of normal base operations. We proposed an alternative work plan to develop a test plan that would be carried out at a later date once lab access was restored. This was later developed into the plan where the resulting deliverable would be added to the existing Struvite patent technology package available for licensing. We have previous experience with licensing this technology for commercial and academic licensing. If this work can be licensed and the licensee can acquire funding it will likely result in one to three peer-reviewed publications and perhaps additions to the core intellectual property of this process. Regardless, there is a backlog of work that we are working to get published by January 2021. This current deliverable will satisfy FY19 IRTD requirements and will result in an NTR for our proposed process for single pass testing and media production.