Bacteria Encapsulation for Wastewater Treatment

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ABSTRACT

Human activities related to nitrogen have caused an overarching problem - an imbalance in the global nitrogen cycle. Through conventional wastewater treatment processes, a combination of aerobic nitrification and anoxic denitrification processes, ammonia and other forms of nitrogen can be converted into nitrogen gas and return back to the nitrogen cycle. However, this approach not only requires significant input of energy and oxygen but also produces greenhouse gas like nitrous oxides during denitrification. A novel way to reduce energy and oxygen inputs while minimizing greenhouse production for nitrogen removal is necessary.

Originally our research wanted to encapsulate Anaerobic AMmionium-oxidizing bacteria (anammox) and ammonia-oxidizing bacteria – AOB with PEG into a single reactor. The challenge of such an approach is that these bacteria grow extremely slow and require a much longer residence time than a traditional treatment process permits. To accelerate the research Nitrite-oxidizing bacteria -NOB was used to test the effectiveness of the encapsulation process. The specific objectives of this study are to 1) enrich AOB and NOB, 2) Keep AOB and NOB alive after they have been encapsulated with PEG, and 3) incorporate a novel reactor that will deplete ammonia efficiently and compare qualitatively to the suspended growth process commonly performed in wastewater treatment processes.

This phase of the project has been extensive, yet the results are promising. We have enriched AOB and NOB effectively (Fig 1). To provide a long solid retention time for the AOB and NOB, we have also successfully encapsulated them in polyethylene glycol (PEG) gel carriers. This phase has proven that after encapsulation cells are alive. Using an ammonia probe, nitrite reagents and optical density calculation test provided reason to conclude that encapsulation does not exterminate AOB and NOB. Eventually when the process of enriching anammox had been mastered, this study aims to develop Single-reactor Nitrification and Ammonia Removal using Encapsulated ANAMMOX, or SNARE ANAMMOX, completing the nitrogen cycle.

The expected results for the next phase include the providing a quantitative value for cell growth using PCR analysis, understanding how to enrich ammonium-oxidizing bacteria, and the efficient removal of nitrogen from synthetic wastewater using the proposed SNARE-ANAMMOX process. The anticipated benefits of this approach are lower energy input, less oxygen demand, reduced creation of sludge, reduced production of greenhouse gas, and high removal rate of nitrogen.

BACKGROUND

- Conventional wastewater treatment processes rely on aerobic nitrification and anaerobic denitrification to remove nitrogen in wastewater.
- Nitrification and Denitrification: How do they work?

PROPOSED APPROACH

- Enrich ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB) separately in a sequential batch reactors
- Double encapsulate the AOB and NOB in gel carriers that will...
- The bacteria in the gel carriers were placed in a reactor with AOB growth medium and monitored
- Simultaneously, bacteria that were not encapsulated were placed in a suspended growth reactor for comparison
- Measurement of ammonia levels in the reactors using an ammonia probe.

RESULTS

Ammonia Measurement
Enriching AOB and NOB

Our Solution: Improve the Efficiency of Wastewater Treatment Processes with Encapsulated Bacteria

What do we mean by Encapsulation?
Within each gel carrier, the NOB are encapsulated in a smaller carrier, surrounded by AOB and then both bacteria are encapsulated in a larger carrier

Possible Benefits of using Encapsulated Bacteria?
Longer Retention time

OBJECTIVES

- To enrich and encapsulate AOB and NOB
- To incorporate the encapsulated cells into a reactor
- To compare this reactor to a suspended growth reactor

ACKNOWLEDGEMENTS

• The team thank Lazar Kish and Dr. Jun Kameoka for their assistance in the encapsulation of the AOB and NOB.