STEVENS INSTITUTE OF TECHNOLOGY 1870

Ph.D. DISSERTATION DEFENSE

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Date:	Friday, December 2nd, 2022
Time/Location:	11:00 a.m./https://stevens.zoom.us/j/95959059253
Title:	2-Stage Anaerobic Digestion (AD) of Whole Algae and Post Extracted Algae Residue (PEAR) using Immobilized Bacteria Reactor System
Chairperson:	Dr. Adeniyi Lawal, Department of Chemical Engineering and Materials Science, Schaefer School of Engineering & Science.
Committee Members:	Dr. Christos Christodoulatos, Civil, Environmental and Ocean Engineering Dr. George Korfiatis, Civil, Environmental and Ocean Engineering Dr. Junfeng Liang, Chemistry and Chemical Biology

ABSTRACT

Bioenergy synthesis from algae can be achieved via diverse pathways. We have chosen algal oil extraction followed by fermentative biogas production from the post-extracted algae residue (PEAR) as one of the most promising paths. Conventionally, anaerobic digestion (AD) is performed by introducing strict anaerobes or mixed cultures of bacteria and substrate into fermenters and allowing efficient mass transfer through mixing under anaerobic conditions to generate biogas. Adopting this approach results in the inseparability of the digestate from the spent biocatalyst (microbes) at the end of the AD. In addition, organic acids generated directly impact the biokinetics of the microbes leading to reduced bioactivity or death. Thus, a state-of-art method of encapsulation of microbes in calcium alginate is developed to improve biogas yield, allow the re-use of microbes, and allow recovery of digestate for further processing.

PEAR of alga is carbohydrate- and protein-rich after stripping alga of lipids. Thus, in the present study, dark fermentation (DF) of PEAR is performed first to generate bioH_2, while bioCH_4 is synthesized from recovered digestate after DF. To our knowledge, this is the first time encapsulated microbes (mixed microbes in digested sludge (DS)) are used to process PEAR to yield biohythane (bioH_2 + bioCH_4) via a 2-stage AD process. Although pure hydrogen formers and methanogens permit better control when deployed in fermenters, for this study, heat-shocked digested sludge (DS) enriched with *Clostridium spp.* and untreated DS that do not require a sterile environment to thrive were encapsulated in calcium alginate to digest whole alga and PEAR of *S.obliquus* for bioH_2 and bioCH_4, respectively. Remarkably, more than 100% bioH_2 yield was actualized in lab-scale encapsulated bacteria fermenters compared to the conventional suspended system from the DF of PEAR and whole alga. The digestates from the DF of both substrates were recovered and processed to generate bioCH_4 using encapsulated untreated DS yielding about 75% of bioCH_4 produced when fresh whole alga or PEAR is digested. The AD process is the rate-limiting step compared to the mass transfer of solute into the calcium gels. A stable encapsulated system of bacteria without bead breakage was achieved after 10 days of AD and gentle stirring at 100rpm, indicating lower energy input for effective mass transfer.

This promising discovery would be directed towards improving the economics of alga-to-biofuel technology by utilizing the bioH_2 produced as a sustainable H_2 source for green diesel production, while bioCH_4 would be used in combined heat and power (CHP) systems. Spent PEAR after the 2nd stage of AD can be used as animal feed.