Sustainable Recovery of Volatile Fatty Acids from Swine Wastewater

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Background

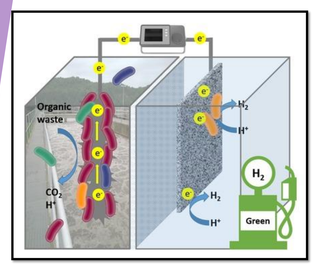
Volatile fatty acids (VFAs) are short-chain organic acids (C1-C4 carboxylic acids) naturally generated from complex organic compounds (including wastewater) through intermediate fermentation reactions during anaerobic digestion, and these VFAs serve as feedstock for various commodity products when recovered effectively from the waste streams. Currently, 90% of these organic acids are produced as byproducts of petrochemical reactions. Production of VFAs is high in demand since they are the building blocks of many valuable commercial and cosmetic chemical products. However, the over-dependence on fossil fuels for organic acids production and the simultaneous opportunity to valorize wastewater to a variety of end products forms the basis of this study.

Objective

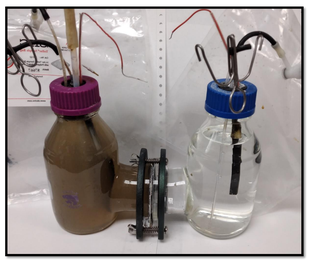
This study aims to develop a modified fermentation biotechnology platform from swine wastewater coupled with membrane filtration and further aided by microbial electrochemistry. The first step is to understand the anode reactions, as explained in this study.

Swine Wastewater

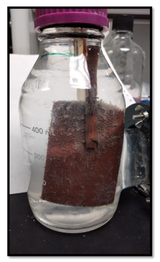
Microbial Electrolysis Cell (MEC)



Schematic Diagram



Experimental Setup

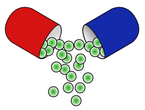


Biofilm Anode

Commodity applications of VFAs

Rubber
(butyrate)

Plastics
(lactate, acetate)



Probiotics
(lactate)

Animal Feed
(most VFAs)

Cosmetics
(acetyl esters)

Experimental Results

Effects of inoculum on VFA distribution

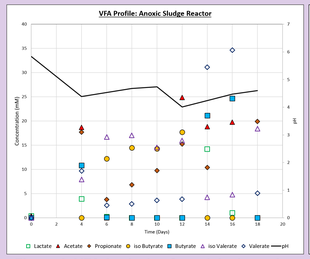


Figure 1. VFA Analysis of municipal anoxic wastewater sludge

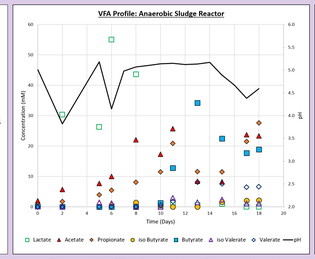


Figure 2. VFA Analysis of municipal anaerobic wastewater sludge

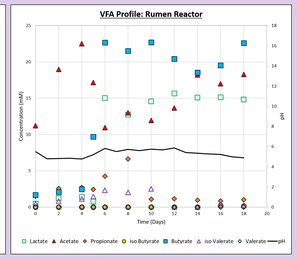


Figure 3. VFA Analysis of rumen fluid from cattle

With and without a MEC biofilm anode

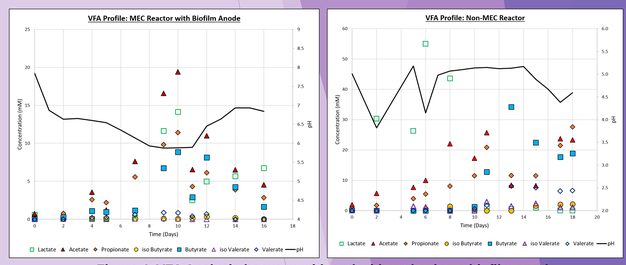


Figure 4. VFA Analysis between with and without having a biofilm anode

The inocula exhibited a decisive shift in the fermentation product profile from glucose and is anticipated to continue when the reactors treat swine wastewater. The microbial biofilm anode showed a different fermentation product profile with an accumulation of higher molecular weight VFAs compared to the non-electrode reactor. The anode area was observed to be a rate-limiting step that drives the kinetics and extent of swine wastewater fermentation.

Kansas Relevance

- Precursors for chemical products in biotechnology business.
- Recovery of nutrients from wastewater such as ammonia-N and phosphate-P for use as sustainable fertilizers.
- Water for indirect potable reuse
- Preventing deterioration of precious surface and groundwater by capturing the nutrients and organic carbon in wastewater.

Conclusion

The recovery of VFAs from wastewater based on microbial reactions is becoming a promising research and development portfolio in the future due to its favorable life cycle and techno-economic footprint through innovations in research.

Acknowledgments

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