Project Summary

Applicant: The Research Foundation for the State University of New York, University at Albany
Principal Investigator: Yanna Liang, Ph.D.
Project Title: Novel and Viable Technologies for Converting Wet Organic Waste Streams to High Value Products
Major Participants:
Argonne National Laboratory (ANL): Drs. Meltem Urgun Demirtas, Uisung Lee, Troy Hawkins
University of Michigan: Dr. Anish Tuteja; *Princeton University*: Dr. Jason Ren
Objectives of the Project: Although anaerobic digestion (AD) has been broadly used for producing biogas from wet wastes, it has major known drawbacks. Producing volatile fatty acids (VFAs) from organic waste streams using AD, although technically feasible and having good potential, has been plagued by at least four bottlenecks: low carbon conversion efficiency, low product titers, inefficient product separation, and CO_2 emission. To overcome these roadblocks, we seek to develop a comprehensive controlled AD approach that enables the production of VFAs and higher carbon alcohols (HCAs) containing more than two carbon atoms, from waste streams in an environmentally sustainable, economically viable, and socially acceptable way. Specifically, we aim to develop a prototype where organic wastes can be pretreated efficiently, converted to target products with high rates in continuous operation, and where the desired compounds can be separated and recovered with high efficiency. The overarching goal of this project is, thus, to evaluate the whole process of conversion from wet wastes to high value VFAs and HCAs using a systematic approach. In particular, based upon our baseline data, we aim to improve the carbon conversion efficiency by $\geq$ 50%, and reduce disposal costs of the target feedstocks by $\geq$ 25%.

Description of the Project: To achieve our goal of producing VFAs/HCAs from sewage sludge, food waste, and mixtures of these two with high efficiency, we aim to accomplish seven tasks:
(1) Identification of the optimal pretreatment method for each target waste stream. For this purpose, thermal hydrolysis and ultrasonication will be thoroughly investigated in terms of releasing VFAs and HCAs and increasing the content of soluble organic matter during pretreatment;
(2) Determination of the best process parameters for arrested methanogenesis (AM). To enhance target products' yield, titer, and production rate, AM will be evaluated under different hydraulic retention times, organic loading rates, and with different microbial communities;
(3) Evaluation of product yield and titer of VFAs and HCAs from the waste streams separately through Microbial Electrosynthesis (MES) with CO_2 capture and conversion. By doing so, a potentially zero-CO_2 emission process can be developed for converting wastes to valuables;
(4) Developing an innovative membrane based liquid-liquid extraction process for extracting VFAs and HCAs out of the fermentation broth. This unique extraction technique is featured by its low energy cost, high efficiency, and exceptional scalability;
(5) Performing preliminary life-cycle analysis (LCA) and techno-economic analysis (TEA) for each process block and the overall process. These analyses will help identify the optimal process for each step and assist in developing an integrated process;
(6) Operating the integrated process continuously at a 5-Liter scale for at least 3 months;
(7) Operating the integrated process continuously at a 50-Liter scale for at least 100 hours. TEA and LCA will be performed for this operation.

Upon completion of the proposed project, new and fresh insight, innovative processes, and comprehensive process analyses will become available. All of these will bring revolutionary changes to how we perceive, handle, and valorize wet wastes.