Rethinking the Future of Dairy Wastewater at the Water-Energy Nexus: Steam Hydrogasification Based Process for Synergistically Treating Agriculture-Derived Waste Streams

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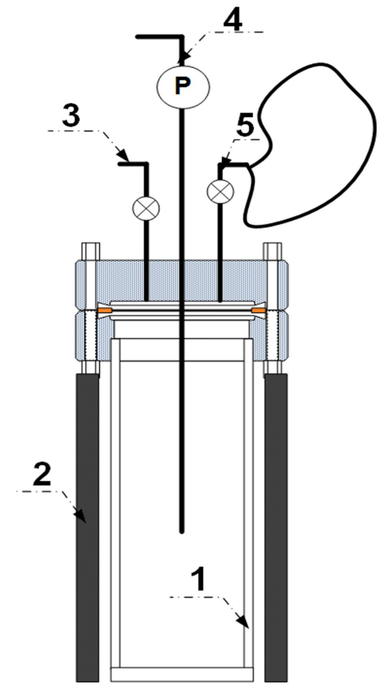
Research Background

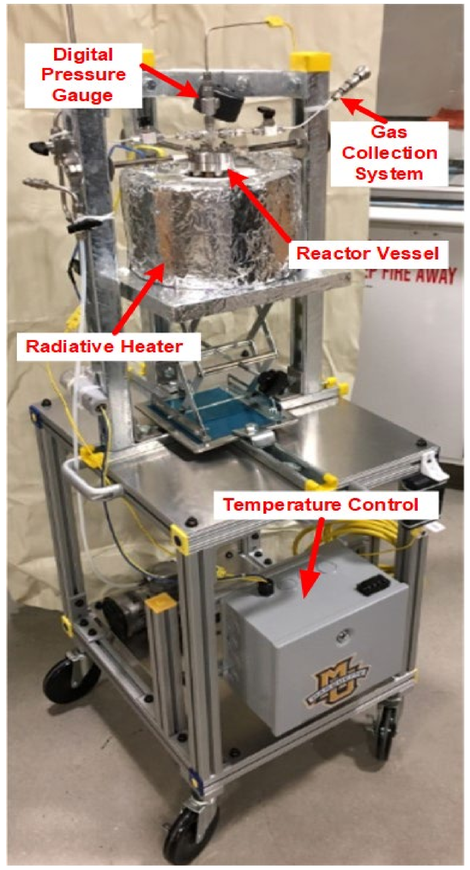
California is the largest producer of agricultural products in the United States and holds almost all of the nation's top ten agricultural counties according to the Census of Agriculture by the USDA. In particular, the Central Valley of California is one of the world's most productive agricultural regions and many Valley's counties (e.g., Tulare, Fresno, Kern) are at the top of the nation's agriculture producing counties. Accordingly, California generates more than 20 million dry tons of agricultural residues per year and the Valley has the highest concentration of agricultural wastes (e.g., orchard and vineyard pruning, crop residues, animal manure). However, traditional treatment methods such as land application, burning, and biological conversion still generate some concerns (e.g., parasite, air pollution, non-stabilized byproducts). In addition, the Valley is home to the largest concentration of dairies in California. Tulare County is the largest milk producer in the United States, accounting for about $1.6 billion in 2016. The City of Tulare established a large industrial wastewater treatment facility for treating regional dairy wastewater. Treating high-strength wastewater such as dairy wastewater is still challenging and has a higher cost compared to municipal wastewater. Hence, new solutions to sustainable and synergistic treatment of regional agricultural wastes and dairy wastewater are highly needed.

Steam hydrogasification reaction (SHR) is an advanced and self-sustainable technology that can convert agriculture-derived waste streams (typically high moisture content) into renewable energy and fuels without costly drying process. The Department of Energy National Energy Technology Laboratory has performed an in-depth techno-economic analysis of the SHR-based process and confirmed that the SHR-based process has the potential for 12% higher efficiency at 18% lower capital costs compared to other state-of-the-art gasification technologies. In this study, the SHR-based process was used to synergistically treat the commingled agricultural wastes (e.g., dairy wastewater, orchard prunings) for the first time. The preliminary experimental data showed that SHR-based process led to high carbon conversion and desired syngas composition for further downstream upgrading such as water gas shift (WGS) reaction. When WGS is integrated with SHR, the final product is renewable fuel, synthetic natural gas (SNG).

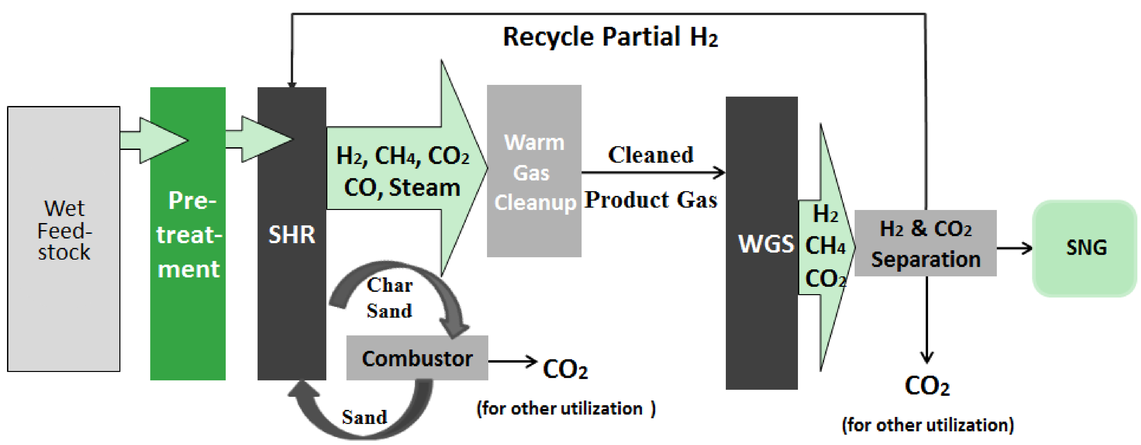
Experimental Setup



1. Reactor vessel
2. Radiative heater
3. Gas purge and release system
4. Thermocouple and pressure gauge
5. Gas collection system with Tedlar® bag

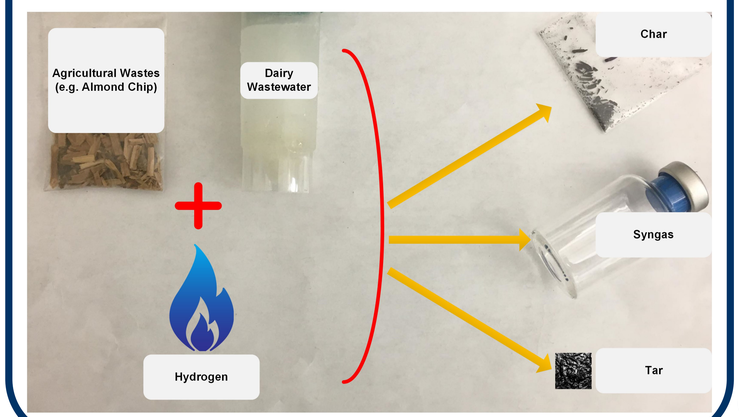


Steam Hydrogasification Based Process for Synthetic Natural Gas Production



Preliminary Results

Almond chip is converted to char and syngas



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