CAPSTONE/SENIOR DESIGN EXPERIENCE 2018

Production of Biohydrogen Gas through Modification of E. *coli*

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Background Statement of Problem:

- Fossil fuels are in limited supply, which are the main sources for hydrogen production.[1]
- Hydrogen demand is expected to increase to replace the increasing petroleum demand as a renewable energy source[2]

Objective:

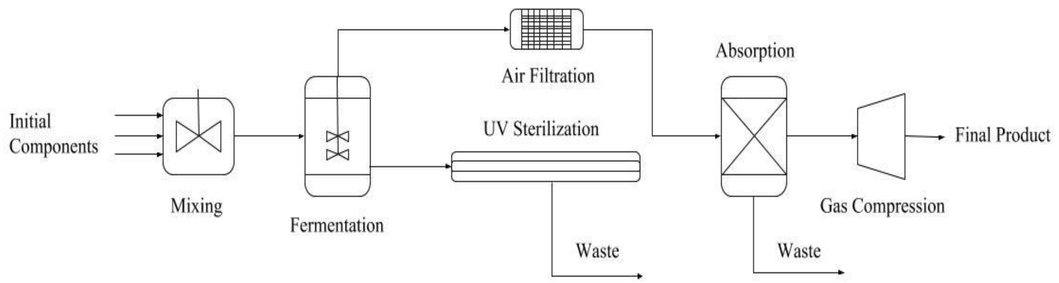
To develop a microbially-based manufacturing process for producing hydrogen gas on a commercial scale that is:

- robust
- economically feasible
- environmentally

Global and Societal Impact:

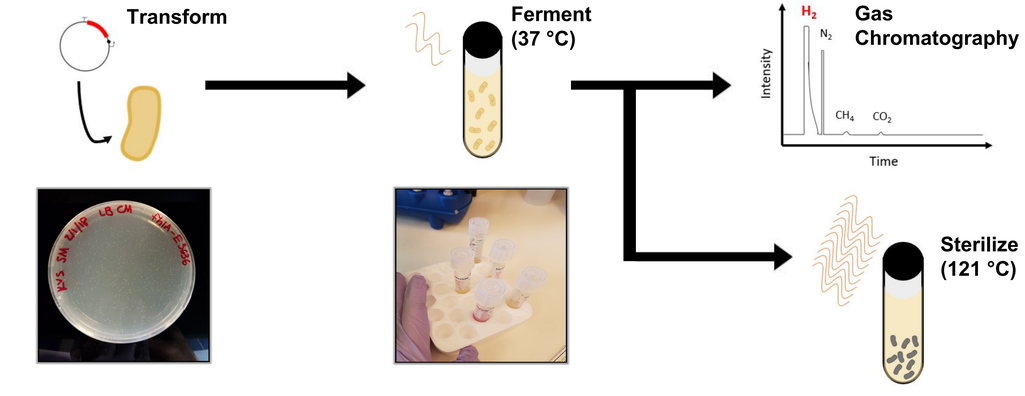
- Hydrogen gas as a renewable resource will be important for a society with increasing energy needs and decreasing fossil fuels
  - Produces zero greenhouse emissions
  - The most abundant element in the known universe
- CO_2 emissions from biomass consumption nearly equivalent to CO_2 consumed through source biomass growth[4]
  - biomass considered a carbon-neutral energy source
- Life Cycle Assessments show that CO_2 emissions from hydrogen producing processes are minimized[3]
- As long as bacterial culture is preserved and biomass input is available, process can be maintained indefinitely

Final Process Diagram:

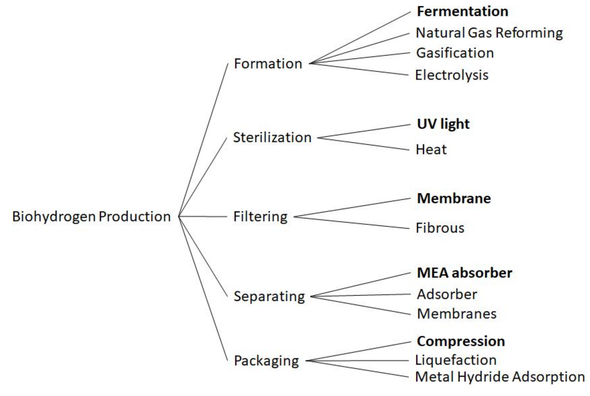


Unit Operation	Optimization Parameter	Minimized Parameter
Mixing	Volume	Operating Cost
Fermentation	Fermentation time, tank volume, glucose concentration, and initial cell concentration	Material Cost and Operating Cost
Sterilization	Chamber Area	Capital Cost
Separation	Separation Efficiency	Capital Cost
Packaging	Pressurization	Capital Cost and Operating Cost

Lab Scale Production:

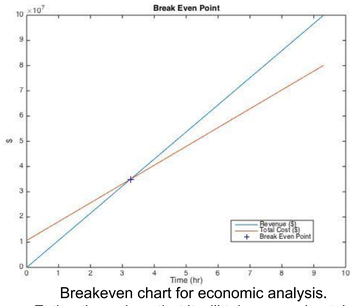


Alternative Solutions:



Economic Analysis:

Economic Parameter	Value
Yearly Production	537,180 kg hydrogen/year
Total Capital Investment (TCI)	$10,863,000
Fixed Costs	84.99% of TCI
Variable Cost per unit of sale	$13.89/kg of hydrogen
Yearly profit	$3,283,400



Breakeven chart for economic analysis. Estimations show that it will take approximately 3.4 years to break even.

Recommendations:

- Utilize produced hydrogen immediately to avoid having to compress, store, and transport the gas, either in the plant, hydrogen cells, or a neighboring facility
- Consider a continuous process with multiple fermenters
- Couple packaging operation with CO_2 to possibly remove waste stream

References:

1. Energy, U. S. D. o. (2017). Alternative Fuels Data Center: Hydrogen Production and Distribution. Retrieved from https://www.afdc.energy.gov/fuels/hydrogen_production.html
2. World Hydrogen: Freedonia Focus Reports June 2014 (pp. 1-30, Rep.). (2014). Freedonia.
3. Dincer, I., & Acar, C. (2015). Review and evaluation of hydrogen production methods for better sustainability. International Journal of Hydrogen Energy, 40(34), 11094-11111.
4. Biomass and the Environment. (2018, March 28). Retrieved from https://www.eia.gov/energyexplained/index.cfm?page=biomass_environment

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