TEAM 034

Water-Based Electrochemical Ethanol Synthesis from Direct Air Capture of Carbon Dioxide

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EE CHE 3 ME

Introduction

Problem Statement

Fermentation-based ethanol requires water-intensive crop feedstocks. With scarce water and limited arable land, Saudi Arabia produces very little ethanol and relies mostly on imports.

Project Objective

To design a compact, portable ethanol production system that efficiently converts CO_2 into ethanol with minimal water usage.

Constraints

- Electronics should operate at 24/12/-5VDC using a single DC source.
- The CO_2 capture material should be commercially available.
- Pump suction pressure must be > 0.6 bar.
- The battery should operate the system up to 8 hours with a single charge
- All components must fit within a base area of 0.84 m^2.
- System must withstand up to 100°C without material degradation.

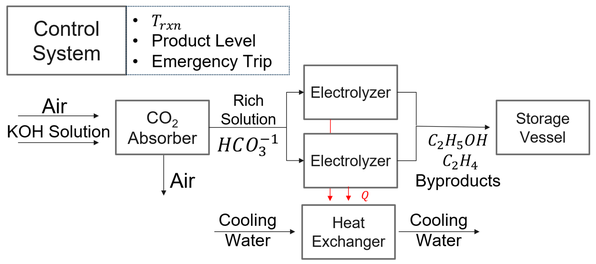
Specifications

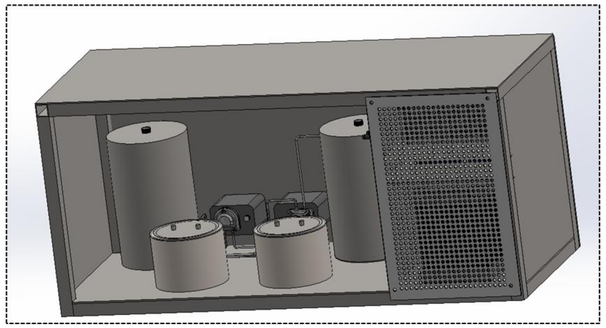
- Maintaining process temperature & pressure within ± 10% of setpoint.
- The operating temperatures should be within the range 0-100°C.
- Process tripped when (P<1 or P>5 bar) or (T<10 or T>60°C).
- Operating temperature within 15°C of optimal ethanol conversion point.
- Heat Exchange Efficiency > 0.70

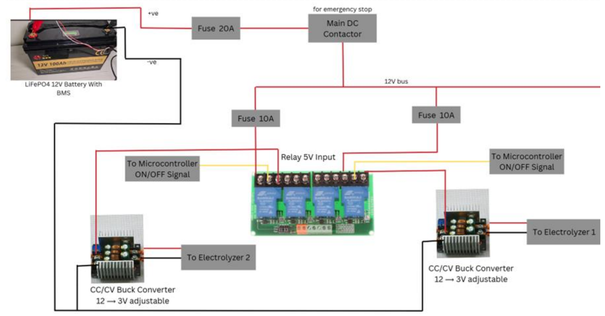
- The ability to operate within ± 50% of base ethanol production capacity.
- The overall CO2 conversion should be 60% or more of the theoretical limit.
- Mole fraction of impurities <10% in product.
- Total system weight must be < 70 kg
- Ethanol production rate should be >= 1 mL/hour

Prototype Design

$Key\ Reaction: 2CO_2 + 3H_2O \rightarrow C_2H_5OH + 3O_2$





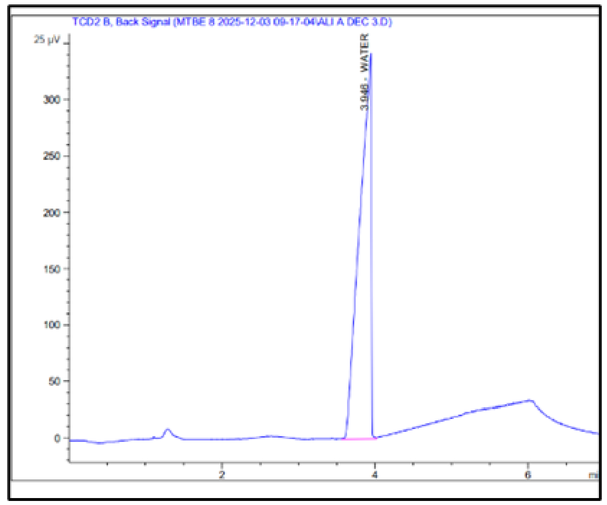


Testing & Validation

Weight: 50.55 Kg

After testing the heat exchange effectiveness, the result shows 85.3% effectiveness.

After running the reaction, the sample was tested using Gas chromatography which did not detect any ethanol.



Conclusion

The full prototype was successfully built and tested. While system integration was successful across other components, the system did not produce ethanol above the detection limit. This failure was due to a necessary shift to a less efficient, alternative catalyst to adhere to the project timeline, as the originally specified catalyst required specialized equipment and external collaboration.