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Objective of the project

CO₂ emissions continue to rise globally, creating the need for sustainable utilization solutions rather than simple capture and storage. Transforming CO₂ into valuable chemicals represents a promising route for carbon circularity.

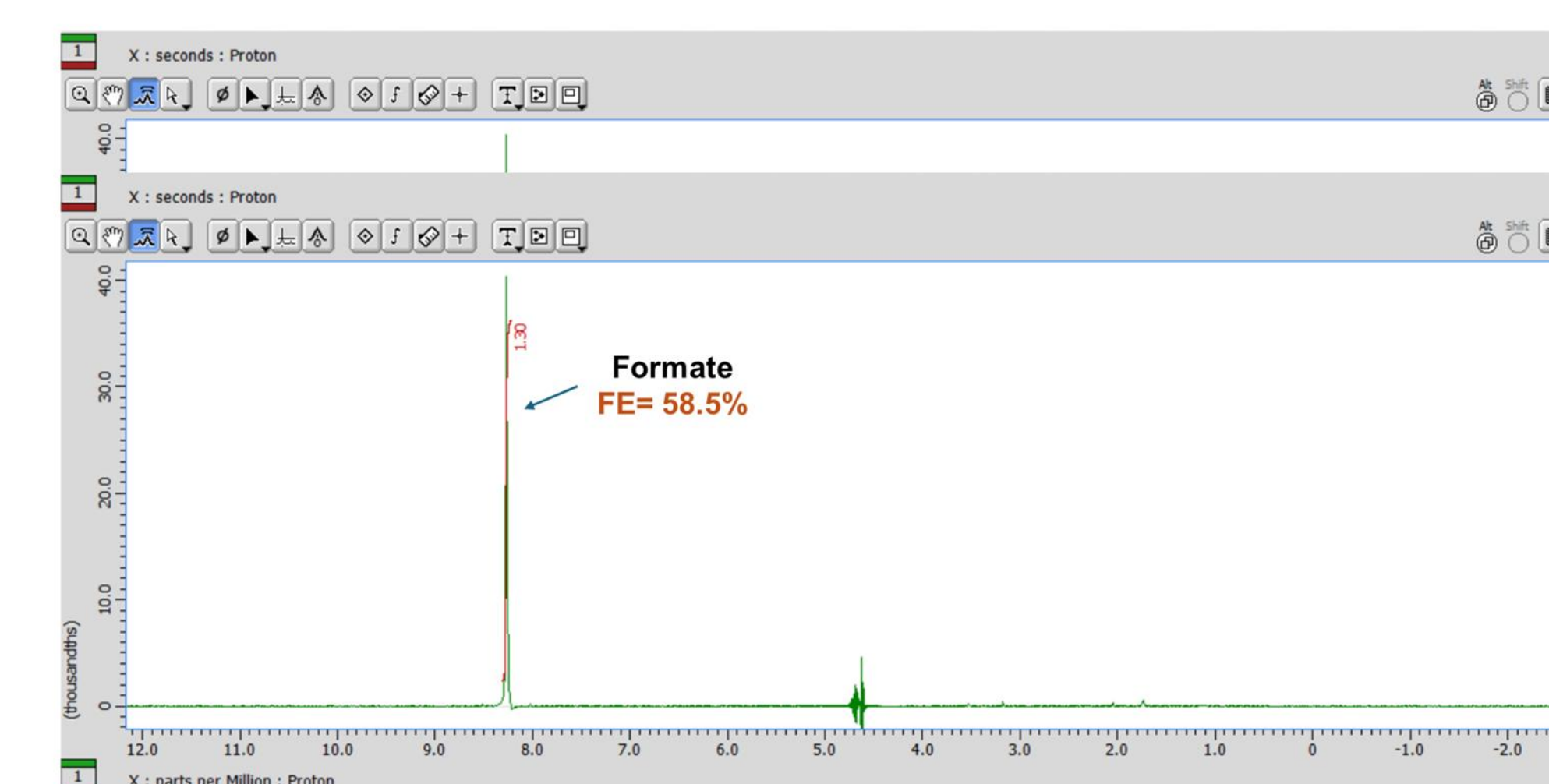
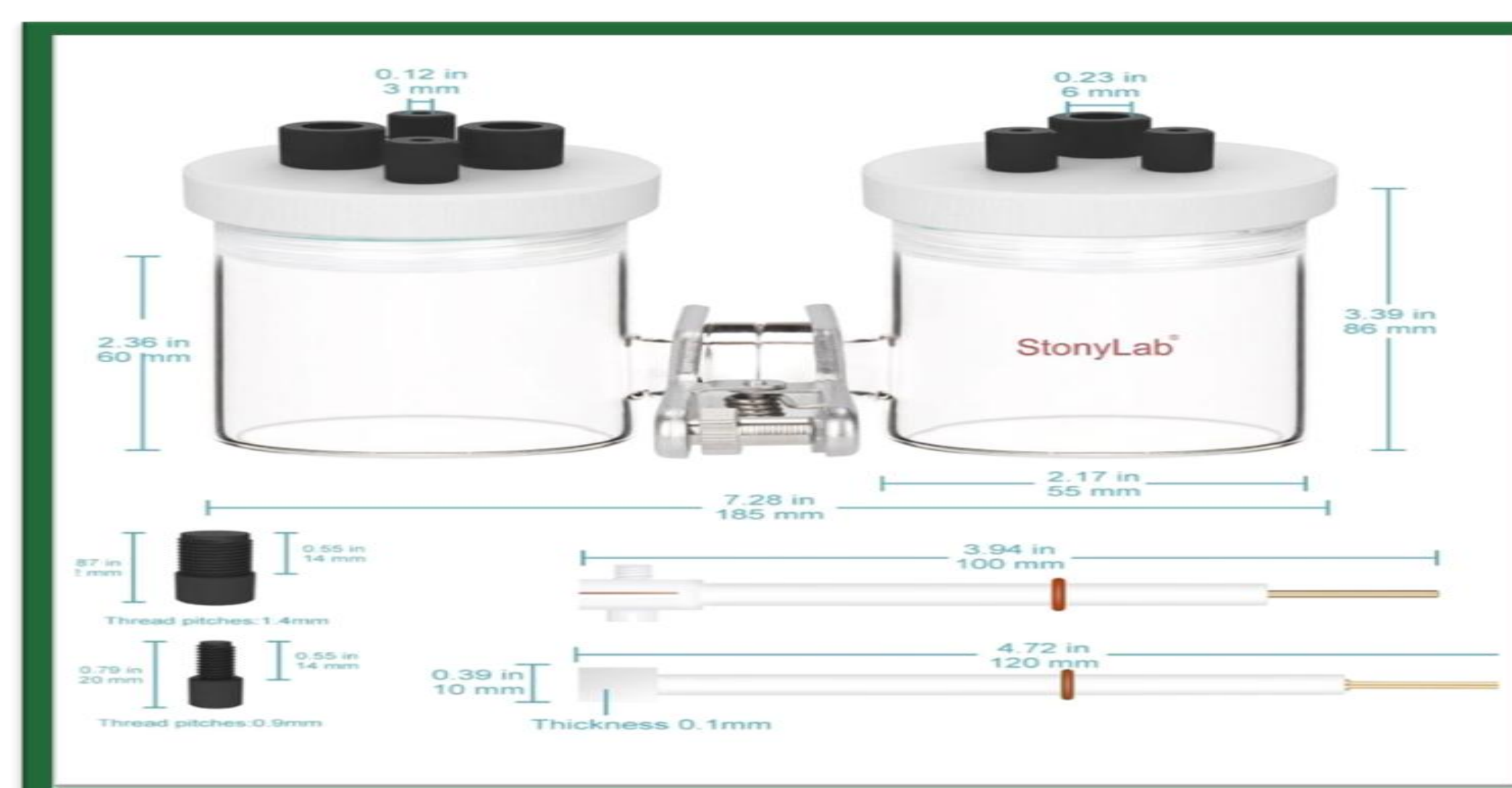
This project presents an electrochemical reduction system that converts CO₂ into formic acid using an H-cell electrolyzer. The design is low-cost, replicable, safe to operate, and suitable for research and educational demonstration at laboratory scale.

Prototype Development

- H-cell assembled with dual glass chambers
- Sn/Bi catalyst electrodes installed
- Nafion 211 membrane integrated
- Power + monitoring circuit functioning
- Temperature & pH sensors planned for integration

Constraints & Specifications

Item	Requirement / Target
Budget Limit	Total project cost ≤ 9,000 SAR
Runtime Limit	Maximum operation ≤ 2 hours per run
Current Restriction	Current must remain < 2 A to prevent overheating
Sensor Accuracy	Reading error margin must be < 0.1 V
Formic Acid Concentration Safety	Must remain < 50% (flammability risk above 85%)
CO₂ Feed Pressure	Must remain < 2 bar for cell safety
Microcontroller Constraint	Must use ESP32 , costing ≤ 100 SAR
Faradaic Efficiency Target	Produce formic acid with ≥ 50% FE
CO₂ Utilization Target	System must convert ≥ 50% of input CO₂
Product Selectivity	Reaction ≥ 50% selective toward formic acid
Budget Allocation Rule	≥ 80% of cost for major hardware components
Production Cost Goal	10–20 SAR/L of formic acid produced
Temperature Monitoring Range	0–100°C with ESP32 sensor feedback
pH Monitoring Range	System alerts if pH goes outside 7.0–10.0



Testing & Validation

- **Faradaic Efficiency Measurement: 58%**
- **Catalyst Evaluation:** Sn/Bi catalysts showed stable formic acid production
- **PH of product: 6.8**
- **Number of moles of formic acid produced: 0.054 moles**
- **the power efficiency of the hole system is 34.68%**

Conclusion

The H-cell electrolyzer demonstrated successful CO₂ conversion to formic acid using an affordable and safe laboratory setup. The system provides measurable performance, supports research and education, and shows promise for future enhancement through improved efficiency, monitoring integration, and catalyst optimization.