

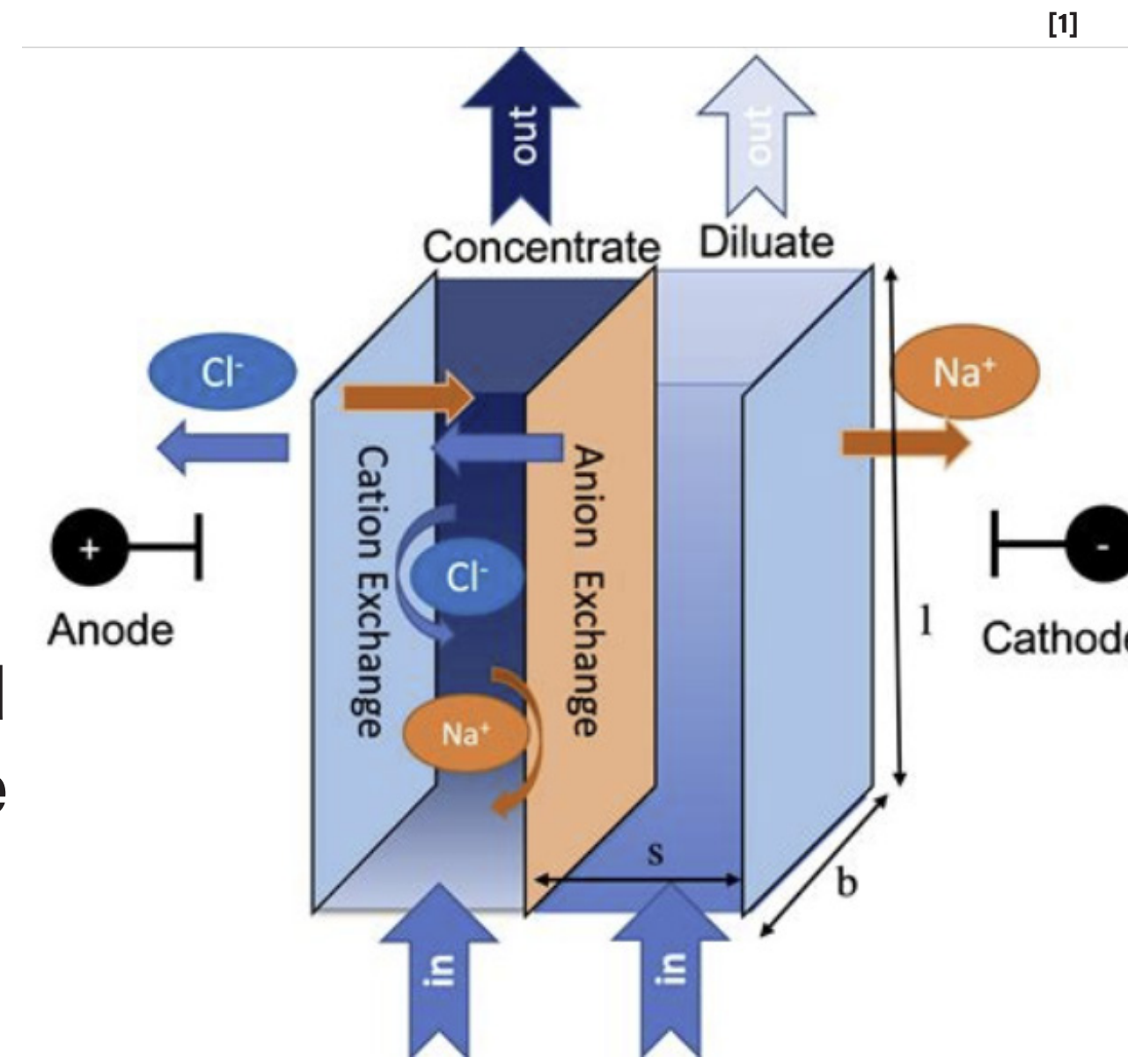
CHAMBERS FOR WATER DESALINATION VIA ELECTRODIALYSIS

OVERVIEW

Most of the planet is covered by sea water which is unusable by humans due to high salt concentrations. About 1/3 of the population lives near unusable water. The problem we aim to address is how to effectively desalinate water containing high amounts of salt into water usable for consumption, livestock or agricultural. We are aiming to find a solution that ensures desalination is able to be performed in an energy efficient manner to allow those with limited access to electricity or those impoverished to have access to this technology. There are billions of people around the globe who would benefit from a low power, low effort, reusable water desalination device. Our team was focused on building on the research by previous PRF groups working with the issue of water desalination. We took water with a saline concentration of 35 parts per thousand, then performed electro dialysis in order to convert it to clean drinking water. For the electro dialysis, we used ion-exchange membranes, which isolate sodium and chloride atoms in water, with a magnesium anode and stainless steel cathodes to create a charge. The reliably operating desalination device was then tested for use under multiple different conditions to monitor for increases in efficiency. As well as this, we developed a more streamlined design for the desalination chamber, which had the benefit of being able to be used modularly.

GENERAL PRINCIPALS

The design of the desalination chamber consists of the main tank, which is subdivided by alternating positively and negatively ionized membranes. There are two steel cathodes and one magnesium anode which are also alternating. The difference in charge isolates salt ions in one chamber, while leaving potable water in the other.



Desalination Chamber			
Electric Minor		Body	Electric Major
Ionized Membranes	Cathode/Anode	Caseing	Power Supply
Blue anode membrane	Stainless steel bolt 6"	PVC toilet flanges	DC Power- 1V, 0.1A
Yellow cathode membrane	Magnesium Rod	Fasteners (stainless steel screws and nuts)	DC Power - 3.3V, 0.5A
		Rubber Gasket	Wires

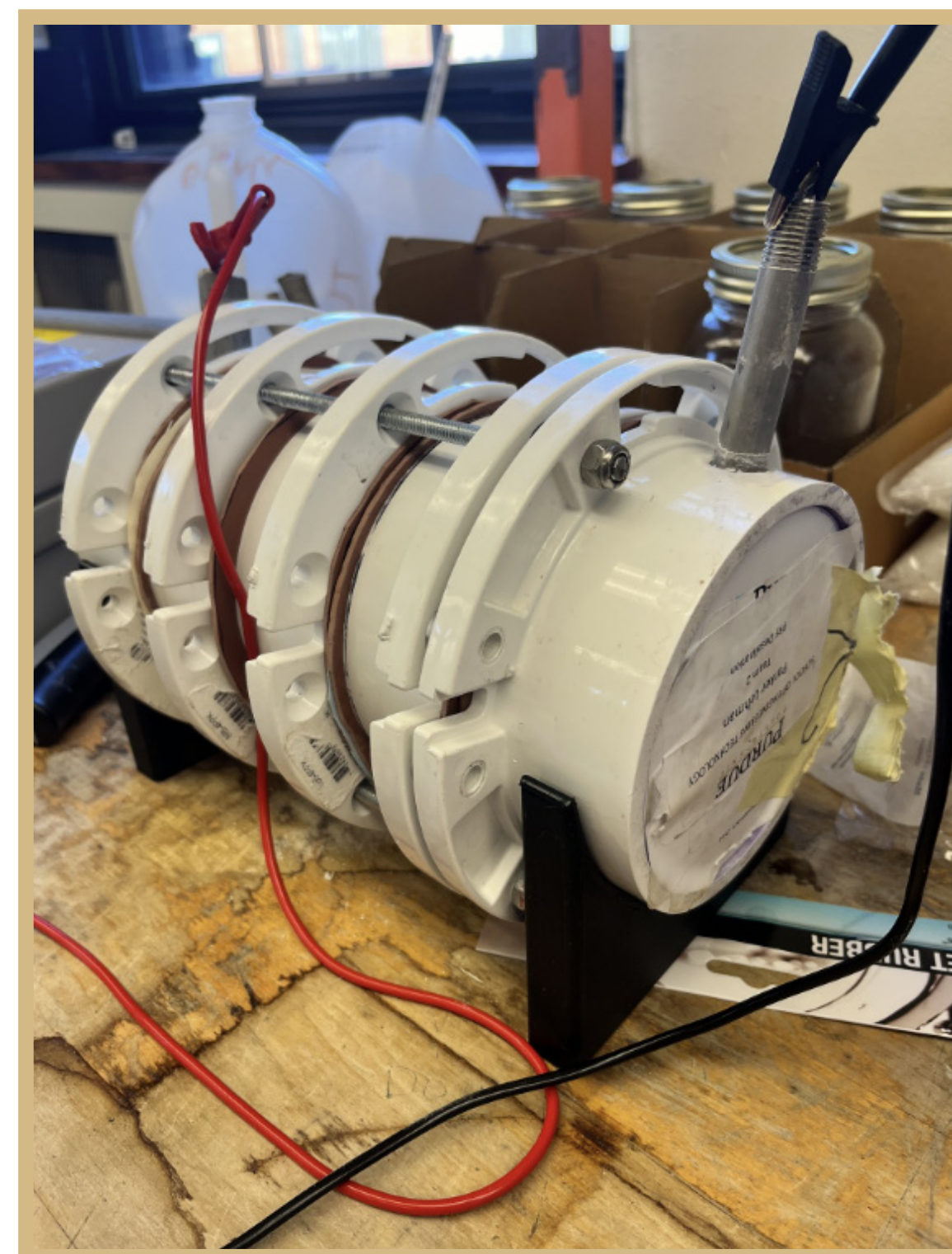
System decomposition of desalination chamber

MATHEMATICAL MODELING

Each chamber has a diameter of 10.16 cm and is 8.89 cm deep. The membrane surface area is 32 cm² and there are 4 membranes. Two out of the five chambers will see water desalination after running the device for three days (see "Comparison of Results"). The total water desalinated is approximately 960 mL. This means the ratio of membrane area to water desalinated is 0.133 cm²/mL. As for power consumption, it takes 10.872 watt hours for this amount to be desalinated down to 2-3 PPT(Parts Per Thousand) salinity.

PREVIOUS ITERATIONS

The chamber developed by a previous group consisted of three chambers, with a steel cathode on chambers one and five, and a magnesium anode in chamber three. The frame was constructed from PVC fastened with bolts which span its length. This model's strength was its robustness, while its drawbacks included difficulty in filling and emptying the chambers, as well as a lack of modularity.

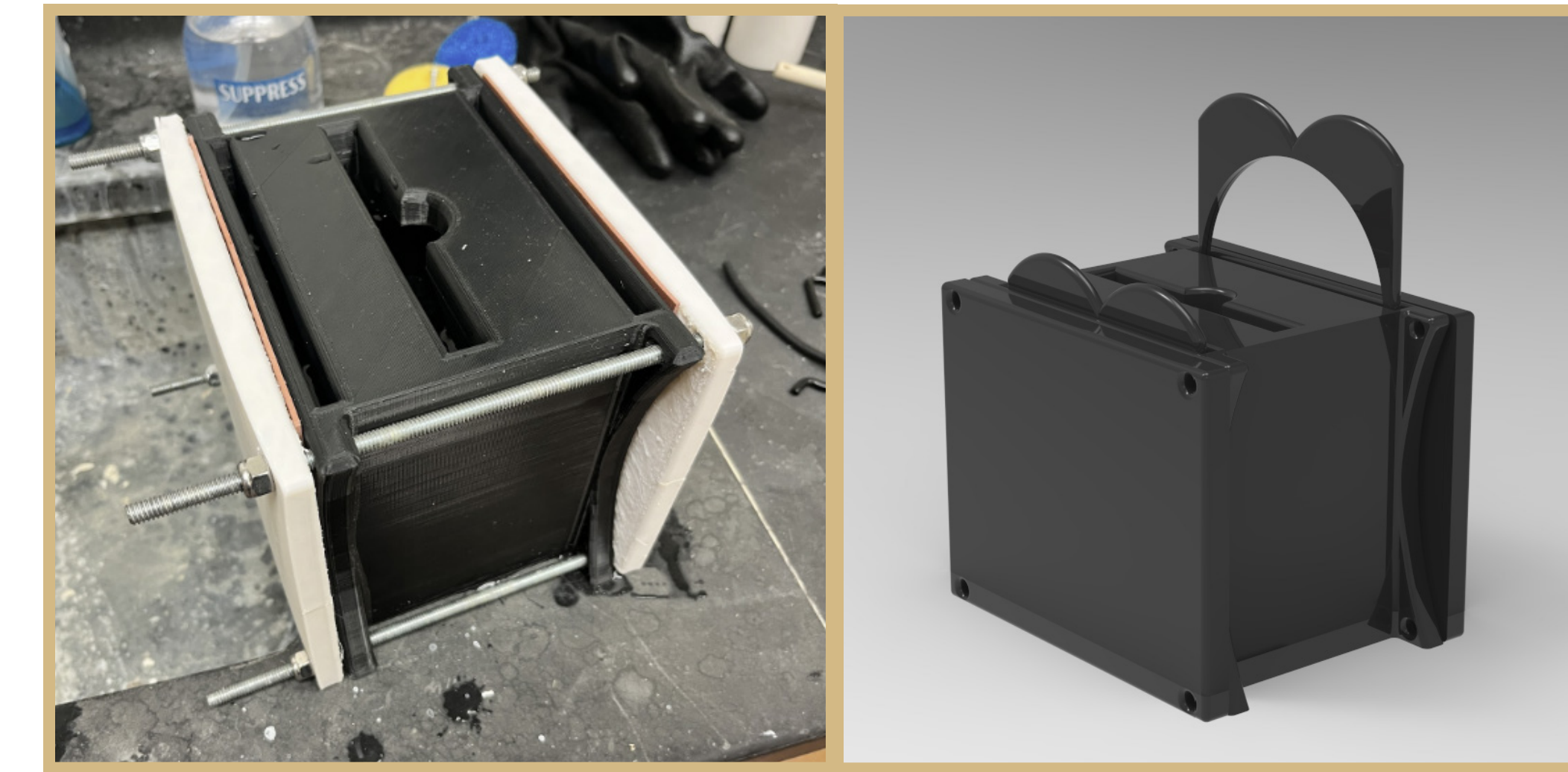


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FINAL DESIGN

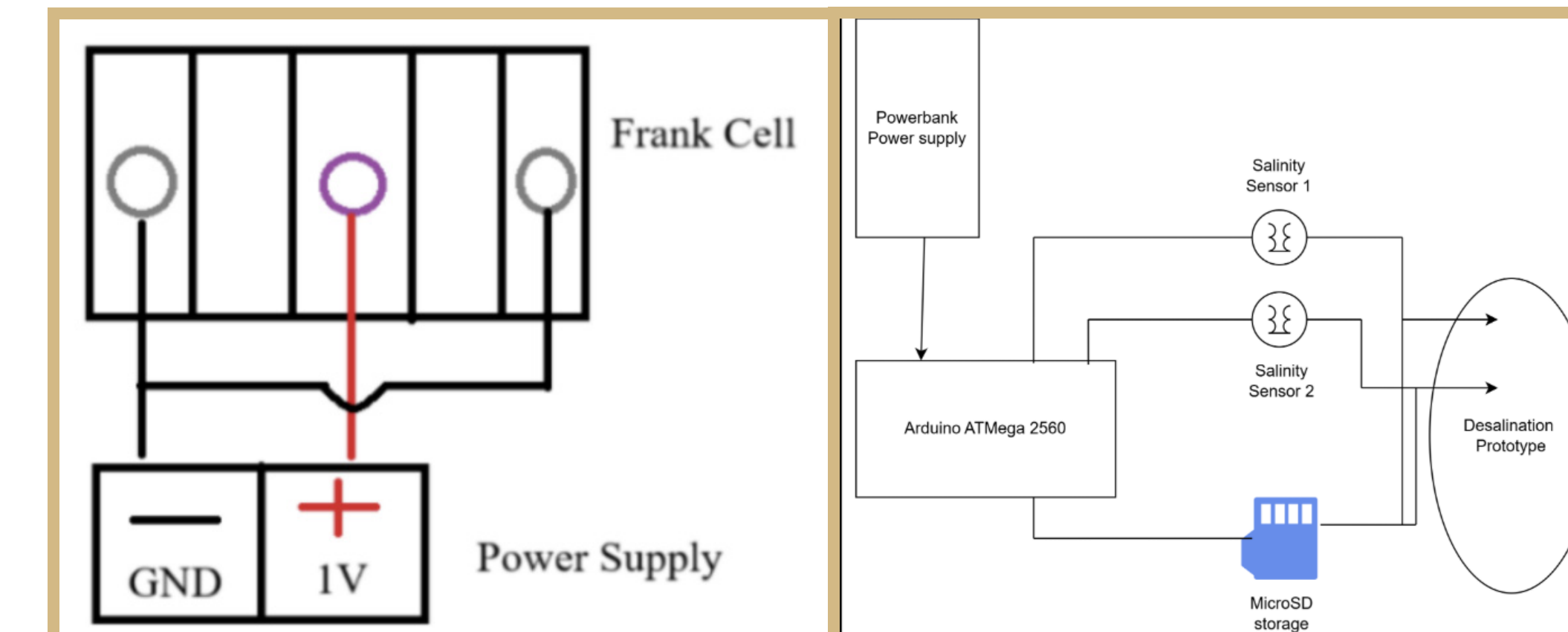
The final design revolves primarily on increasing the scalability of the design. Our improvements are: increased volume, repeatable manufacturing design, and ease of membrane installation and monitoring. The new internal volume is 169.65 in² per chamber and can be scaled to as many chambers as the power supply in use can support.

Finally, the new design uses slides to encase the membranes, enabling the membranes to be removed without disassembling the entire device, unlike the previous setup. This reduces the downtime of the device, as fouled membranes may be changed much quicker.



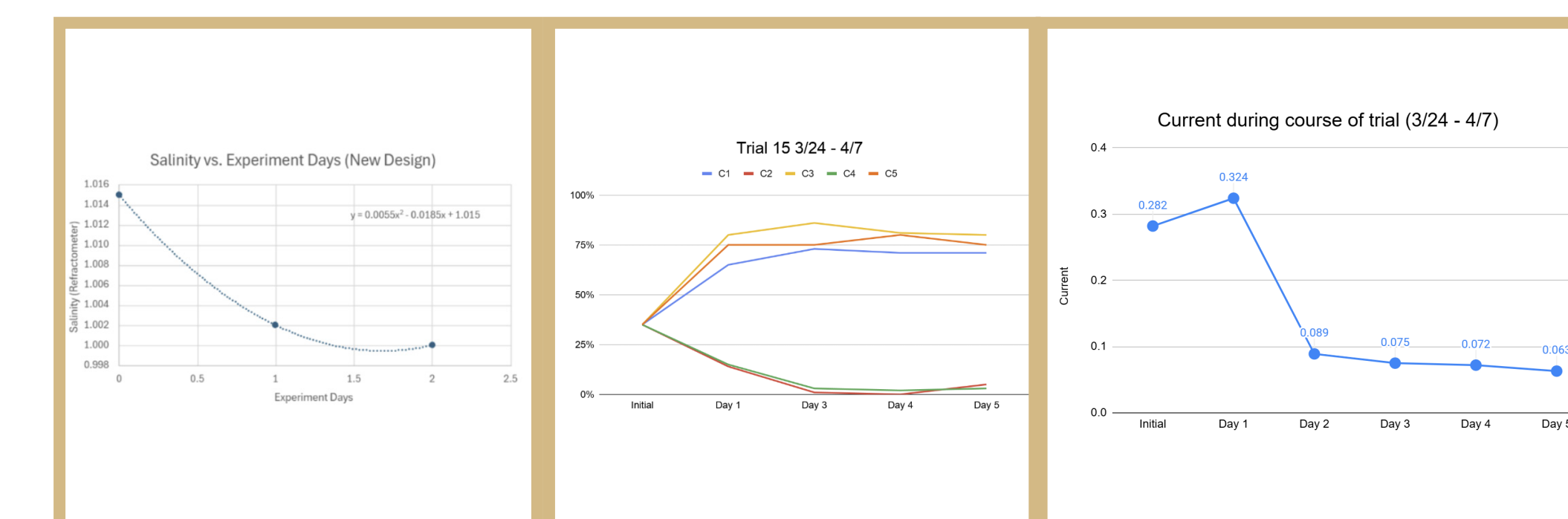
Printed and CAD rendered final chamber designs

ELECTRICAL SYSTEM BREAKDOWN

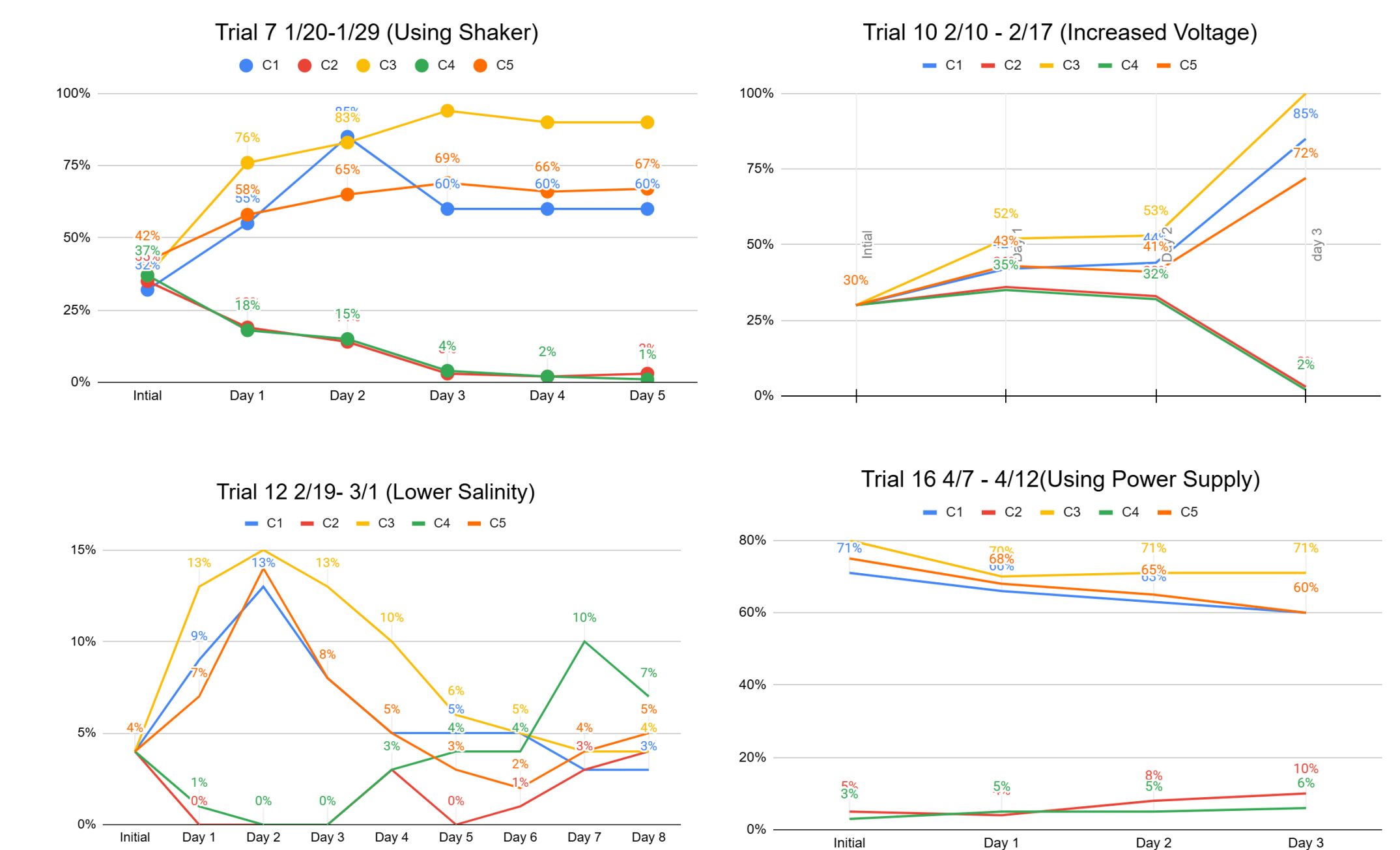


The device is electrically connected to a DC power supply. 1V is supplied to chamber 3 through a magnesium rod anode. The ground is connected to chambers 1 and 5 through a steel rod cathode. This setup results in both chambers 2 and 4 desalinating simultaneously.

COMPARISON OF RESULTS



We successfully replicated the results of the previous group and additionally provided graphical representations to illustrate the progression of the desalination process across the trials conducted. Overall, this strengthened the validity of the original findings while providing clearer insight into the desalination dynamics of the system.



LESSONS LEARNED

- Descaling:** Flipping polarity or applying an alternating waveform demonstrated minimal effectiveness for descaling.
- Agitation:** Agitation did not result in any noticeable effect on desalination efficiency.
- Varied Salinity:** When starting the test at less than 10 PPT initial salinity, the device desalinated the water to less than 1 PPT.
- Varied Voltage:** Tests were run at higher voltages showed small improvements in efficiency but ultimately lead to higher power consumption.

RECOMMENDATIONS

- Continue to iterate and print interlocking chambers and slides along with modifying the files as necessary.
- Refine descaling techniques to preserve the membranes and keep efficiency high.
- Finalize testing device to further accurate data collection.
- Implement a draining system to improve efficiency of filling and collection of water in chambers.
- Test using magnesium plates to determine impact of surface area impact of anodes on efficiency.

RESULTS

The result of the project was successful desalination that was proven to be repeatable. The group achieved taking water that had roughly the equivalent amount of salinity as seawater and after it had been ran in the device it read zero parts of salt per thousand parts water. This was according to the refractometer that was used to test the water. Throughout the process the group desalinated roughly 14 liters of water.

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Our group successfully desalinated water from average ocean salinity (3.5%) to at or near 0% every trial. These results show the efficacy of the chamber in being able to be used at scale for desalination of saline water for agricultural and drinking purposes.