Efficient Water Harvesting from Atmospheric Air using Optimized Polyelectrolyte Hydrogel

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Objective

The reason why we are conducting this research is to determine what is the optimum combination of adsorption time and desorption time of hydrogel. This allows us to compare its viability against other materials such as silica gel, aluminum mesh, zeolite, etc. used in atmospheric water harvesting. We hypothesize that our current choice of hydrogel set to parameters of temperature, thickness, and time will outperform the other competitors. Our research could contribute to the field by potentially developing an atmospheric water harvester that could rapidly absorb and desorb water every 30 minutes throughout the day.

Introduction

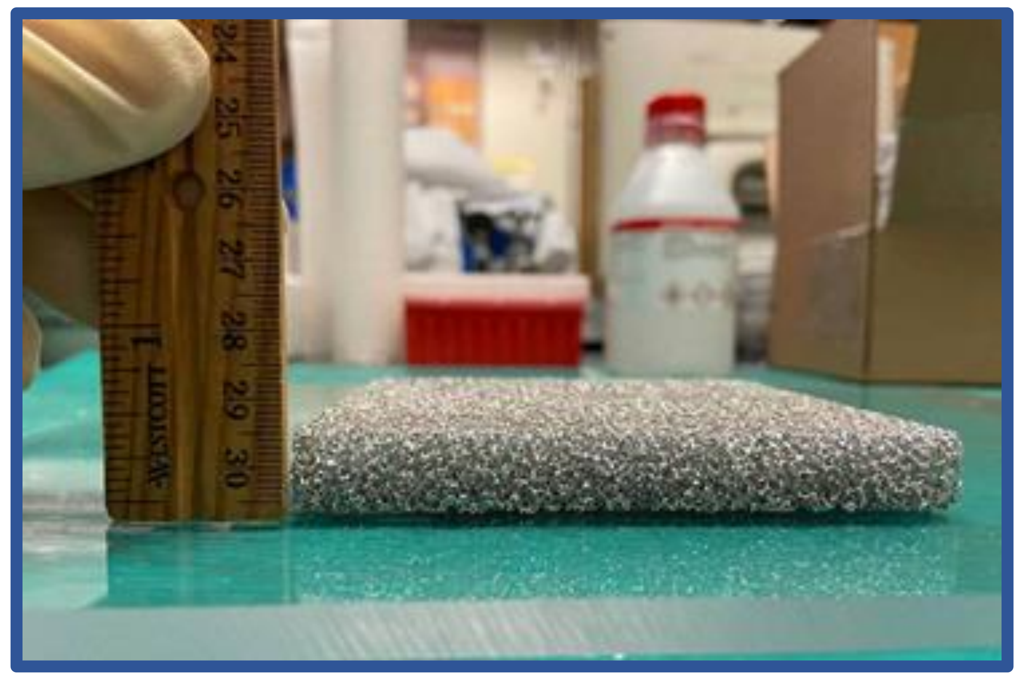

Figure 1: Aluminum foam coated with thin hydrogel layer on framework

Water stress is a phenomenon that is going to be increasingly prevalent in our daily lives in the near future. Earth has roughly 2.5 percent of its water as freshwater, and even less of it is accessible to humans because much of the supply is stored in glaciers or deep underground . Due to this, it has become necessary to find alternate ways to obtain clean drinking water for our everyday lives. The problem we are trying to solve is how to secure a good alternative water source while efficiently using the least amount of energy and resources (e.g., manufacturing materials, extensive research, cost of implementation). The areas of research opportunities are the different ways we can achieve this goal. Others have tried methods such as desalination from seawater, cooling ambient air, or different desiccants like silicon gels, zeolite, and activated alumina to try to absorb and desorb water. The problem with these is that they take up more energy for a low yield in comparison to hydrogels (a crosslinked network of hydrophilic polymer chains), which makes them unfeasible to use in mass production. Our research lab has been investigating hydrogel, which owing to its enormous surface area and high affinity for absorbing water can absorb up to 420% percent of its weight. This is very important because the hydrogel is laid out in thin layers, so the more water that can be absorbed in the least amount of initial weight is beneficial for the harvesters.

Theory and Methods

- Prepare foam thinly layered with hydrogel
- Place on hot plate to raise the temperature of the hydrogel-coated foam
- Model the absorption and desorption of hydrogel, changing parameters as necessary to obtain the greatest amount of yield from an average setting (around 60 percent in San Diego).
- After modeling, figure out the ideal cycle of absorption and desorption that was most efficient.

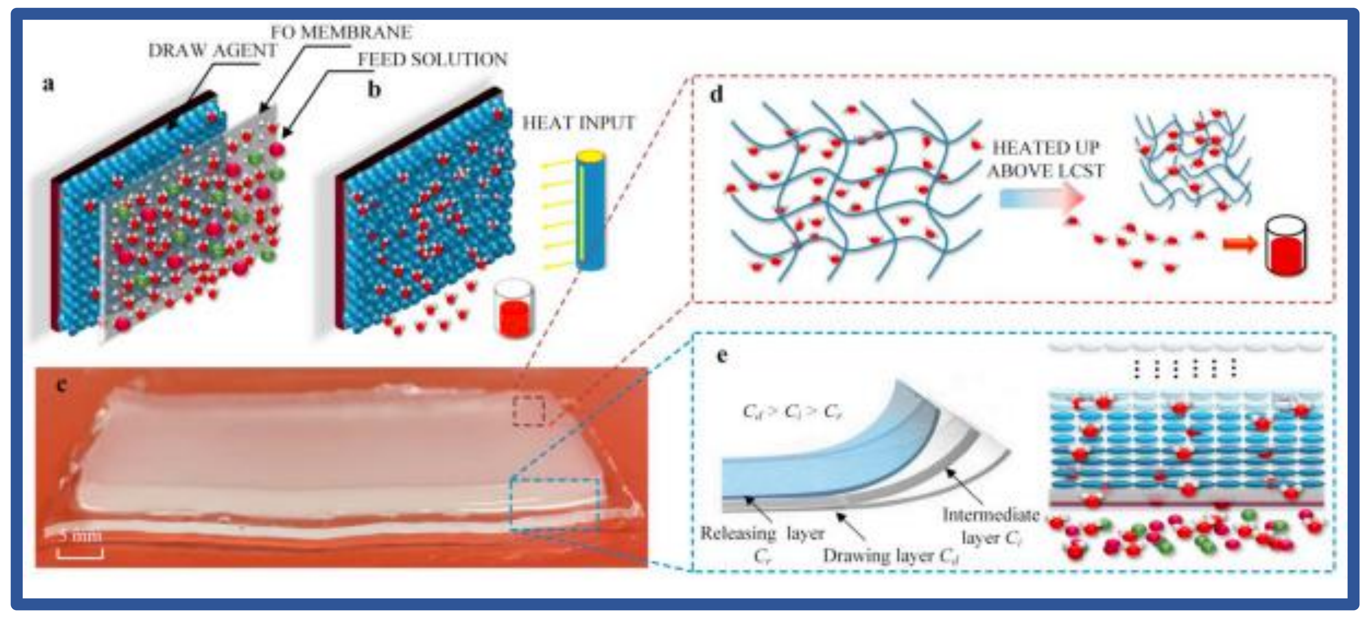

Figure 2: The absorption /desorption process on a molecular scale

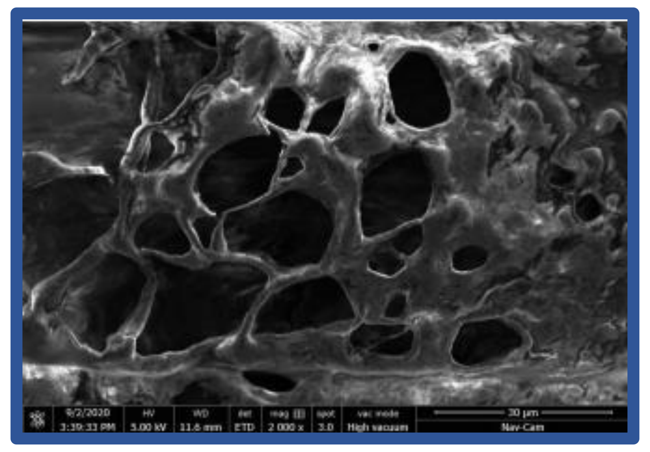

Figure 3: Microscopic view of the hydrogel framework

Discussion

From the graph, we saw that it was only important to look at relevant times in the graph as after a certain point the changes in capacity were negligible, which narrowed our focus to two regions. Looking at the two regions and using linear approximations, we tested different combinations of absorption and desorption times to estimate the ideal combination that would yield the most water absorbed in 24 hours. We found that the optimum cycle included 15 minutes of absorption and 5 minutes of desorption. With this, it yielded 17.48 g/g of water in 24 hours

While this optimization of harvesting the most amount of water is a good start, we must use this model of the best combination of absorption and desorption cycles and determine whether a 15-minute absorption cycle and 5-minute desorption cycle is the optimum cycle that yields with the most water captured and harvested. Our model does not take into account the existing water that isn't fully desorbed in each cycle, which could change the results over 24 hours.

Results

Our project sought to determine the optimum absorption and desorption cycles of hydrogel-coated graphite foam. Below is the raw data of the absorption and desorption process with 22 and 35 degrees Celsius.

Time (mins)	Capacity (g/g)
0	0
1	0.06569
3	0.12509
5	0.16115
10	0.21756
15	0.27038
30	0.35542
60	0.43657
90	0.47054
120	0.51076
122	0.42437
125	0.29679
135	0.1879
175	0.1248
190	0.12199
Adsorption Process	RH=90 T=22C
Desorption Process	RH=90 T=35C

Figure 4: Changes in capacity over time

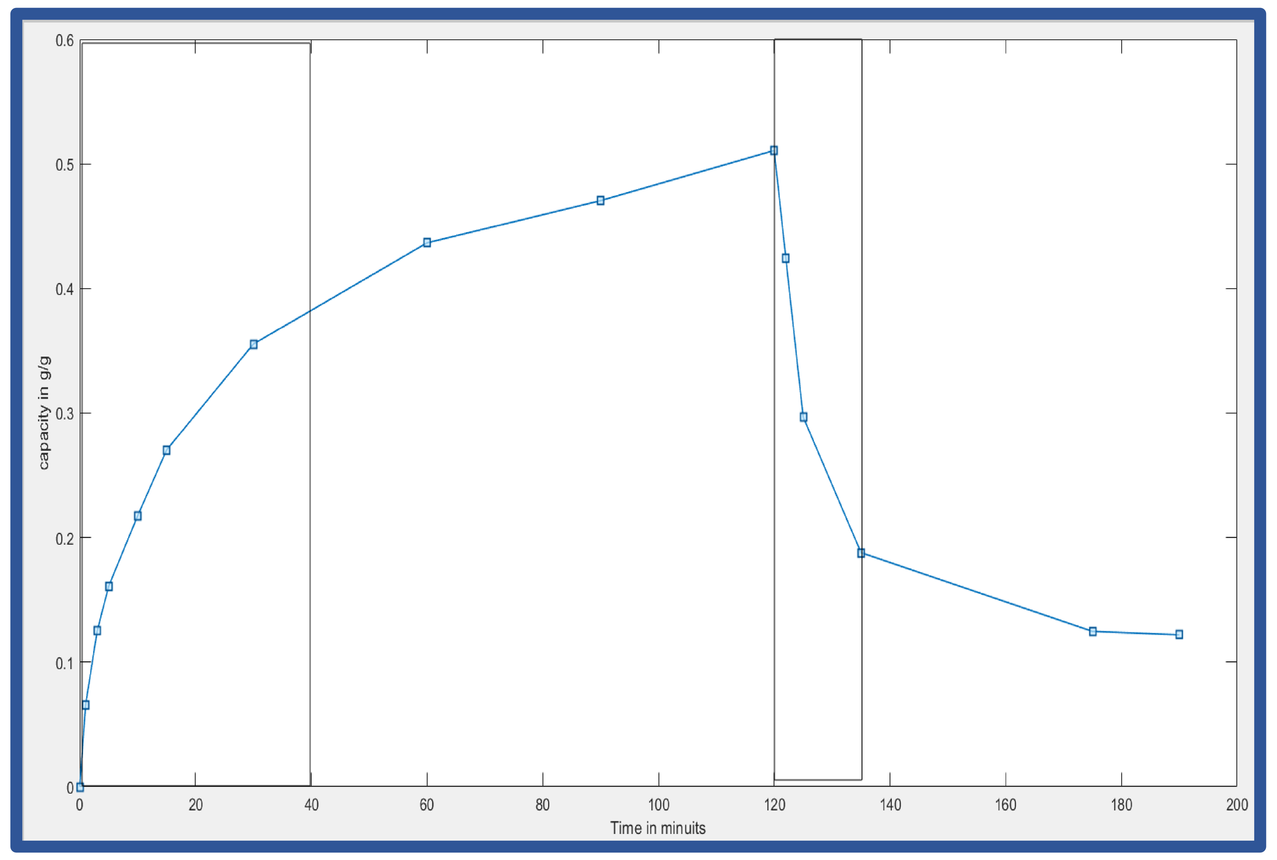

Figure 5: The absorption process follows a radical curve, while the desorption process follows a negative quadratic curve in a sudden decrease

Conclusion & Future Works

- The importance of our work is that we find the optimal material and absorption/desorption cycles for an atmospheric water harvester
- We used extensive data from research and modeled for different relative humidity and temperatures to find the absorption and desorption curve
- Our main findings are that 15 minutes of absorption and 5 minutes of desorption yield the most water using the shortest amount of time.
- The next steps for research would be different augmentations for the thin layer of hydrogel and what other materials we can combine hydrogel with.
- Optimize our method of finding optimal absorption time(used linear approximation which didn't allow us to find the exact time of absorption and desorption
- Find the optimal cycles for different relative humidity levels
- Try to make these cycles more energy efficient (change from absorption to desorption with energy from the sun)

References

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Acknowledgements

We would like to thank our Professor, Renkun Chen, and our Graduate Student Mentor, Jian Zheng for providing us with the opportunity to work in their lab and for teaching us so much. We would also like to thank Ved Vakharia for providing some much needed guidance, as well as the entire Gear Program staff for also providing us to be a part of this program.