Prof. Jia and Kirk's Green Lab Technology Group Summer Findings

"To what extent can N-doping and WBM thickness be optimized to maximize the photothermal conversion efficiency in solar water purification?"

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Over the summer, our group investigated how macroscopic and microscopic properties like thickness and Nitrogen-doping (N-doping) can affect the evaporation rate of WBM sugar maple biochar, which can be applied to designing more efficient filters for photothermal water purification. We hypothesized that after a certain thickness, evaporation rates would plateau, and that N-doped biochar would have, on average, higher evaporation rates compared to non-doped biochar, because of induced mid-gap states. We found that N-doped biochar performed on average 83% better than non-doped, and up to 341% more efficient than water alone. Contrary to our hypothesis, efficiency increased exponentially with thickness rather than plateauing.

We learned a lot of different things during our time at the lab:

1. A technical learning moment was learning to produce biochar with a muffle furnace, with a yield of around 27%. For future studies, we hypothesize that pyrolyzing biochar in a muffle furnace in sand may have more intact pores than in a tube furnace, as our muffle furnace samples performed better than the tube furnace in evaporation, and their SEM images looked more polished.
2. In terms of experimental design, we learned that there are many interdependent variables (thickness, doping level, room humidity, furnace type, ambient conditions) that must be carefully controlled and recorded. We spent approximately 2 weeks refining our experiment after our initial SRP proposal, looking at past research articles to see how we could best account for these variables and ensuring the validity of our results.
3. A successful experiment requires a strong foundation built up on background reading and literature review, to spot gaps in existing literature and call out the strengths and weaknesses of the methods other researchers used. We found ourselves taking inspiration from similar studies on biochar in photothermal water evaporation, from a variety of articles, ensuring we made our experiment as strong as possible.
4. Flexibility is key. As our results didn't fully align with our original hypothesis (no plateau trend), we had to adapt to our results and present something that countered what we had initially thought.

Additionally, we learned many soft-skills such as resilience – when our lab experiment did not go as planned, we were forced to redesign our apparatus and communicate our findings to our fellow labmates and professors to receive constructive feedback while also considering diverse perspectives. During this summer, we consulted various sources and literature reviews, and learned to efficiently find and make sense of information relevant to our research.

In the future, we will take these skills with us and apply them to not only research and academia, but also to any other projects that require critical thinking and experimental design. This 4 month project gave us so much more than just the results related to photothermal water purification, it also gave us crucial insight and experience in research. We were pleased when we were awarded the Best Podium in Chemical Engineering at UnERD 2025, and we hope to perform just as well in our endeavors in the future. We'd also like to thank Prof. Charles Jia and Donald Kirk for their guidance and insight this summer, and we wish them all the best in the future.