

Evaluation of Algae-Derived Carbon Adsorbents for Direct CO₂ Capture from Ambient Air

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Synthesis Procedures

- 1) Algae is dried in a furnace at 110 °C for 12 hours
- 2) Dry algae is mixed with melamine and K₂C₂O₄ in a 2:1:2 mass ratio
- 3) Mixture is ground via ball milling and then heated in a tube furnace, as shown in Figure 1
- 4) After cooling, solid powder is dispersed in 10 vol% HCl at 70 °C for 2 hours
- 5) Sample is collected from HCl then washed with DI water
- 6) Solution is dried under vacuum at 80 °C for 8 hours to remove remaining DI water



Figure 1: Tube furnace used for sintering

Abstract

One potential solution to the looming threat of radical global warming is carbon capture with algae-derived carbon adsorbents because of their low production cost. Once synthesized, algae-derived carbon adsorbents will be evaluated for their pore textural properties before their CO₂ and N₂ adsorption performances in both batch and dynamic columns are analyzed. The analysis done following experimentation will determine if algae-derived carbon adsorbents can be a broad solution to reducing carbon emissions or if they will remain viable only under certain conditions.

Obstacles Faced/Overcome

As mentioned previously, the biggest issue was me not using the proper carbonization temperature while synthesizing my adsorbent. This was eventually overcome and is expected to yield more proper results, albeit not in time for the FURI symposium. Another obstacle faced was the time duration involved in adsorption analysis. The long run times needed for degassing, sintering, and running experiments made communication with other members in lab crucial. Everyone trying to use the same equipment was eventually remedied by planning out who was going to use what apparatus on a weekly basis.

Findings Thus Far

Several runs have been conducted to determine the isotherm type and profile for the carbon adsorbent. Figure 3 to the right shows the expected behavior of the isotherm. Figure 4 below to the right shows an example of the isotherms that were collected. Several runs were conducted to determine if experiment parameters were the cause of the abnormal data. Gas identity, pressure, and temperature were all ruled out as the cause. After consulting with my mentor, it was determined that a subpar carbonization temperature during synthesis was the culprit, as too low of a carbonization temperature had caused a lack of micropores to form, which are the main pores needed for gas adsorption.

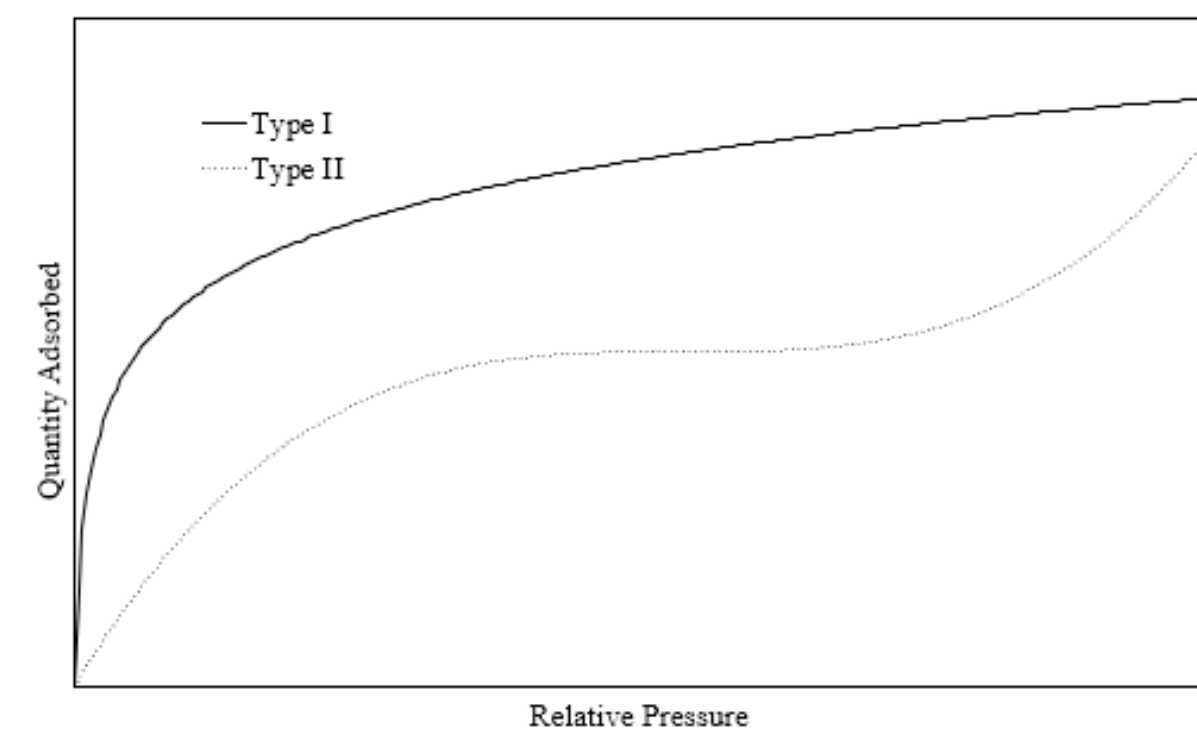


Figure 3: Example Type I and II isotherms

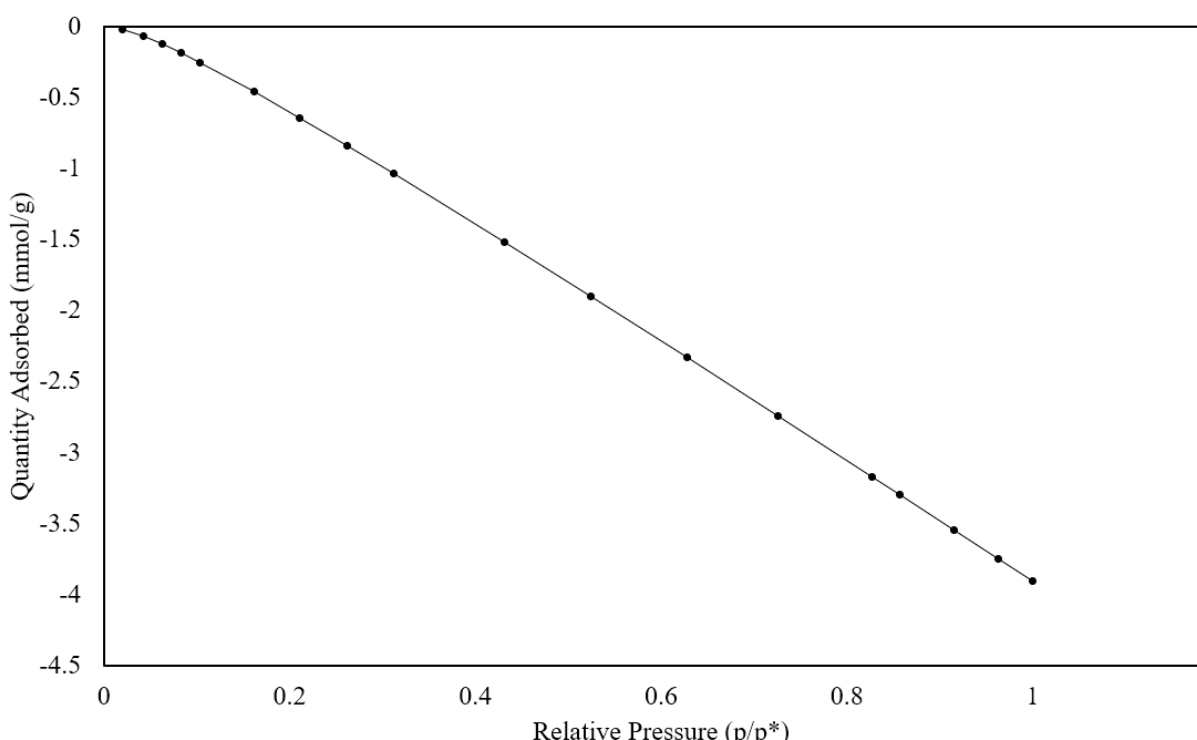


Figure 4: N₂ isotherm from AC with low carbonization temperature

Adsorption Isotherm Experimental Setup

- 1) Roughly 0.25g of adsorbent is loaded into each sample vial and stoppers are inserted to seal the vials
- 2) Each sealed vial is then connected to the VacPrep 061 via tubing and fittings before the dial is set to vacuum and the prep temperature of 200 °C is set
- 3) After 12 hours, the vials are disconnected from the VacPrep and connected to the 3Flex, shown to the right in Figure 2
- 4) Sample settings for gas identity, temperature, and pressure are entered into the 3Flex software
- 5) The 3Flex records the quantity adsorbed at various relative pressures over the course of several hours, and produces a graph showing the resultant isotherm
- 6) With the isothermal data from the 3Flex, the isotherm constants can be calculated for the desired isotherm equation



Figure 2: Micromeritics 3Flex

Next Steps and Future Work

The main next step in this research is to collect data on the adsorbent prepared using the correct carbonization temperature. This will include characterizing the pore textural properties using the 3Flex once liquid nitrogen has been procured, as well as more adsorption isotherms for both CO₂ and N₂, and kinetic breakthrough experiments. All this data will then be used to construct the adsorbent inside of gPROMS, for further simulations and evaluations as a more widely-adopted adsorbent. Additionally, I will be working to dope the surface of the activated carbon adsorbent with N-based functional groups to potentially improve adsorptive performance even more.

Acknowledgements

I would like to first acknowledge the incredible support I have received from my mentor, Dr. Shuguang Deng, as well as Dr. Mai Xu, Yixin Liu, and Allan Buyinza in experimental technique, general advice, and everything else they have assisted me with throughout this process. Without all of them I would not have been able to get to this point. In addition, I'd like to thank the FURI program for providing me with the opportunity and funding to carry out this research over the course of the year.