Evaluation of Algae-Derived Carbon Adsorbents for Direct CO_2 Capture from Ambient Air

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Synthesis Procedures

Figure 1: Furnace used for synthesis

1) Algae is dried in a furnace, shown above in Figure 1
2) Dry algae is mixed with melamine and $K_2C_2O_4$ in a 2:1:2 mass ratio
3) Mixture is ground via ball milling and then heated in a furnace
4) After cooling, solid powder is dispersed in HCl
5) Sample is collected from HCl then washed with DI water
6) Solution is dried under vacuum to remove remaining DI water
7) Solid powder is pelletized using a pelletizer and then sintered in a furnace

Breakthrough Experimentation Methodology

1) Roughly half of the fixed-bed column is filled with silica, then the adsorbent pellets is poured into the column and the remaining empty volume is filled with more silica
2) The filled column is placed into the breakthrough experimentation apparatus, shown below in Figure 2
3) Apparatus temperature is changed to the experimental temperature and gas flow meters are used to set the flow rate and concentration to their desired values
4) Data recorder is used to monitor the outlet CO_2 concentration until the outlet and inlet concentrations are the same, at which point data collection is stopped
5) Data is exported from the data recorder and then used to construct breakthrough curves, from which the amount of CO_2 adsorbed can be calculated and contrasted with other runs

Figure 2: Fixed-bed adsorption column apparatus

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. After algae-derived carbon adsorbents have been synthesized, they will be evaluated for their pore textual properties before being pelletized for use in column breakthrough experiments. Once pelletized, their CO_2 and N_2 adsorption performances in both batch and dynamic columns will be 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.

Findings Thus Far

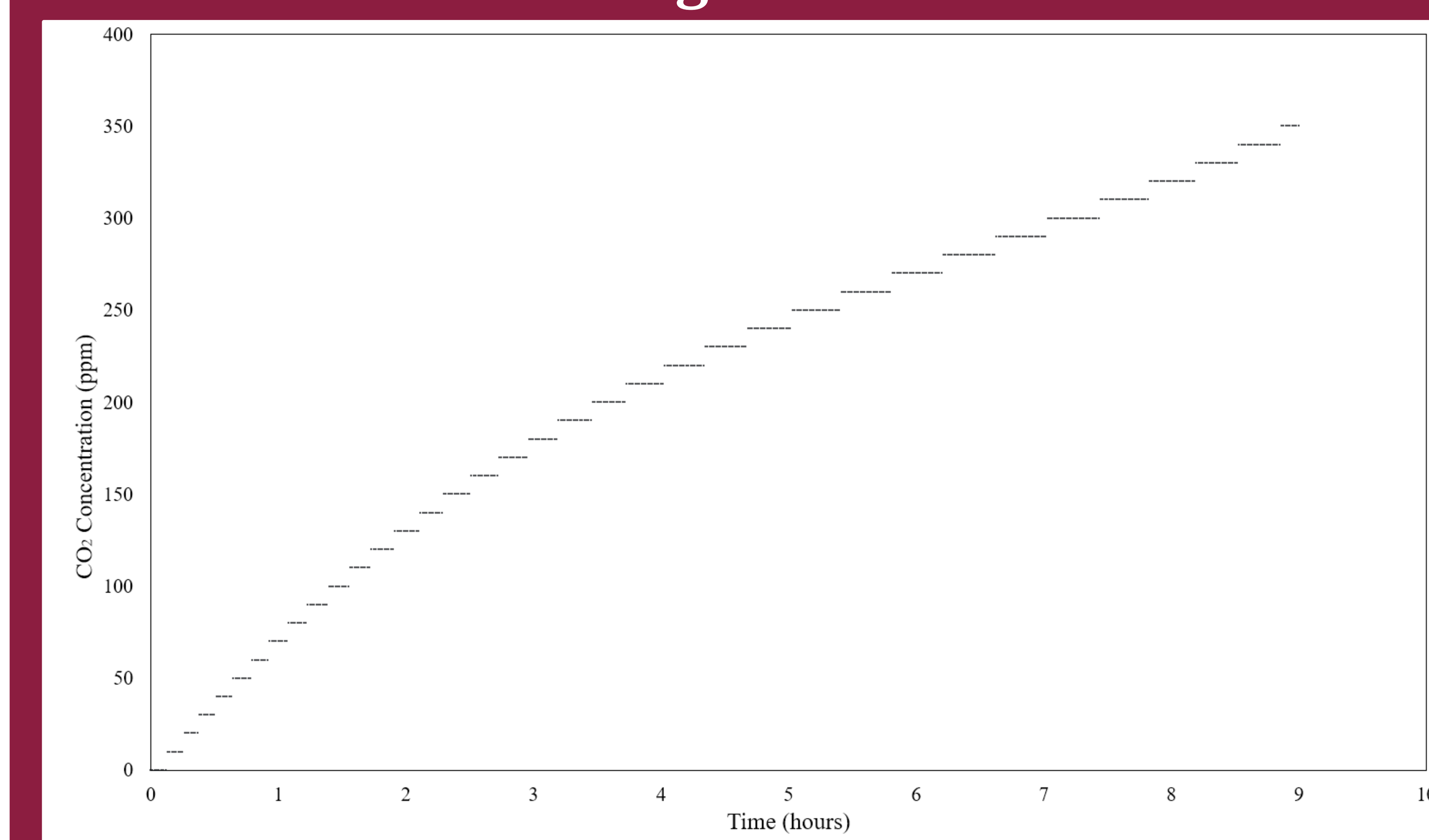

Figure 3: CO_2 concentration as a function of time for a run at near-atmospheric conditions

The run depicted above in Figure 3 was run at a CO_2 concentration of 390ppm and a temperature of 25°C to simulate atmospheric conditions. The total gas flow through the column was set at 200mL/min. The run ended up being incomplete due to a long breakthrough time exceeding 9 hours, but up to the point where experimentation was halted, the adsorbent was adsorbing upwards of 90% of the CO_2 being fed into the column.

Obstacles Faced/Overcome

There were several obstacles faced throughout the research process. The largest obstacle was the lengthy individual run times of the column breakthrough experiments. This resulted in multiple occurrences of having to go into lab late at night to stop a run and slowed the process in general. Another obstacle faced was busy schedules making it hard to find time to explain procedures, which again resulted in general slowdowns. Both of these obstacles were overcome with a lot of flexibility, such as being willing to go into lab late at night or going straight from a class in a different location to the lab for a quick conversation.

Next Steps and Future Work

The main next step in this research is to improve the packing of the adsorbent bed such that instantaneous CO_2 breakthrough is avoided. Once this is accomplished, the main focus will be on testing algae-derived adsorbents for their adsorptive behavior while varying parameters such as temperature and CO_2 concentration. After these breakthrough experiments have been conducted, the data collected will be used to model CO_2 adsorption isotherms for algae-derived adsorbents. Finally, the last priority for this research will be to process model the CO_2 adsorption equilibrium behavior and breakthrough performance. The obtained results for all of the listed next steps will also be compared to literature values of similar adsorbents for context.

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