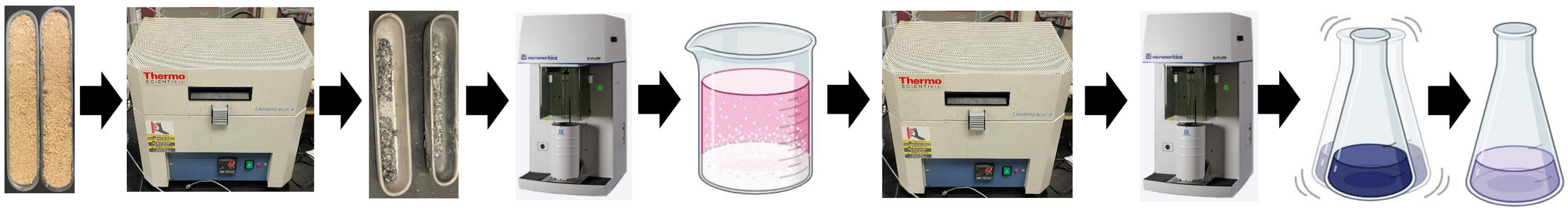
Synthesis of Algae-Derived MgO/Zn-Modified Activated Carbon for Nitrate and Phosphate Removal

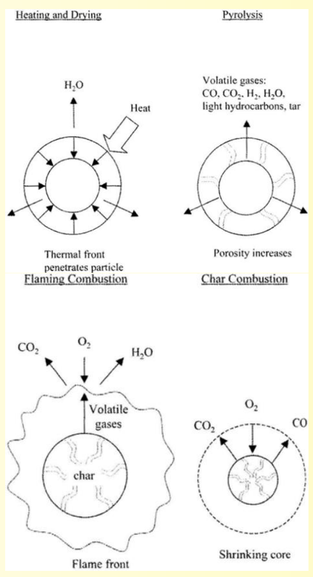
Eric Petronella, Chemical Engineering
Mentor: Dr. Shuguang Deng
School of Engineering of Matter, Transport, and Energy



Problem Statement

- Human activity causes **nitrates** and **phosphates** to be released into bodies of water
- Water run off from fertilizers and manure as well as sewage disposal → to the production of toxins in fresh water which pose a threat to aquatic species and humans
- Existing methodologies that can remove nitrate and phosphate from water include bioelectrical systems, membrane-based separation, and ion-exchange adsorption

Background Research/Objective



Steps of Solid Fuel Combustion

Background

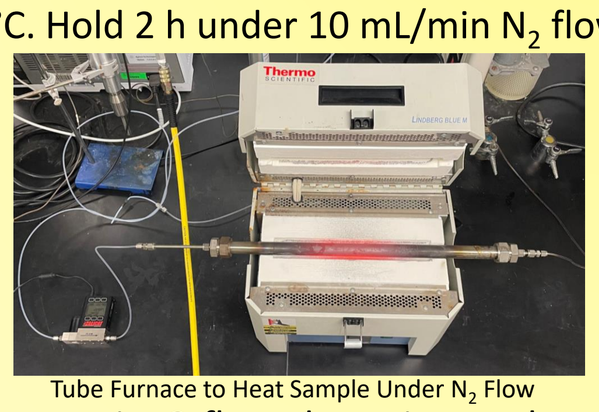
- To produce activated carbon, perform first two steps of solid fuel combustion
- **Pyrolysis**: Thermal decomposition under anerobic conditions
  - <u>Slow (2-7°C)</u> - favors char production over bio-oil
  - <u>High Temp</u> - activated carbon with well-organized C layers

Objective

- Develop a procedure using algae and pinewood to produce activated carbon sorbents
- Evaluate the effectiveness in removing aqueous nitrate and phosphate

Activated Carbon Synthesis

1. Fill ceramic boats with carbon source (algae/pinewood) and autoclave at 100°C to remove any remaining moisture
2. Heat carbon 7°C/min to 900°C. Hold 2 h under 10 mL/min N_2 flow
3. Remove samples and store in desiccator
4. Prepare adsorption test tubes with ~250 mg of derived samples
5. Degas samples for 24 h at 200 °C
6. Characterize samples on micrometrics 3-flex adsorption analyzer



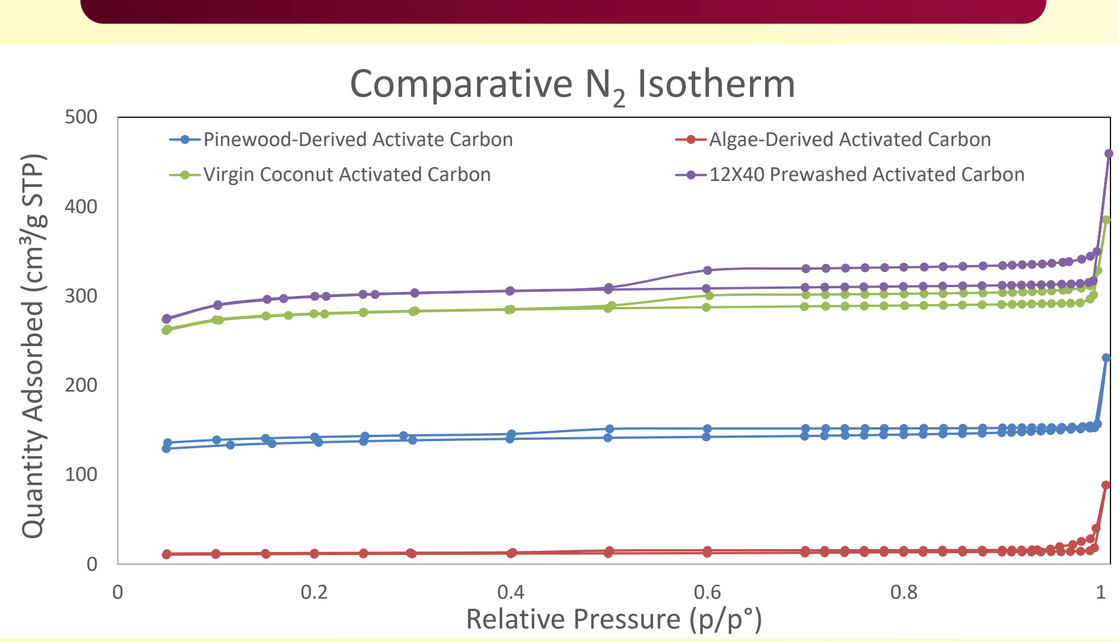
Tube Furnace to Heat Sample Under N_2 Flow


Sample Tube

Vacuum and 3-flex Adsorption Analyzer


Sample Tubes Over Liquid N_2 Dewar

Characterization Results



BET SA and V_{PORE} of Activated Carbon Samples

Sample Type	S_{BET}(m^2/g)	V_{PORE}(cm^3/g)
Algae-Derived	36.82	0.029
Pinewood-Derived	439.34	0.237
Virgin Coconut	902.22	0.467
12X40 Prewashed	1010.21	0.492

Conclusion & Future Work

Conclusion

- Synthesis of Activated Carbon was a success for both carbon materials chosen for this study
- Algae-Derived: (moderately successful)
  - **S_{BET}**: 36.82 m^2/g
  - **V_{PORE}**: 0.029 cm^3/g
- Pinewood-Derived: (Success)
  - **S_{BET}**: 439.34 m^2/g
  - **V_{PORE}**: 0.237 cm^3/g

Future Work

- Better Activated Carbon
  - Pyrolyze longer, Use CO_2 rather than N_2
- Metal Impregnation
  - Soak activated carbon in solutions of $MgCl_2$ and $ZnCl_2$
  - Carbonize in tube furnace
  - Rinse with HCl and dry
- Adsorption Trials
  - Prepare dilutions of KNO_3 and K_2HPO_4E
  - Run 24-hour trials while shaken with sorbent
  - Assess effectiveness of derived nanocomposites in removal of nitrate and phosphate

MORE
Masters Opportunity for Research in Engineering

1. *Nutrient Pollution: The issue*. EPA, Environmental Protection Agency. (2019, February 4). https://www.epa.gov/nutrientpollution/issue
2. Sengupta, S., Nawaz, T. & Beaudry, J. Nitrogen and Phosphorus Recovery from Wastewater. *Curr Pollution Rep* **1,** 155–166 (2015). https://doi.org/10.1007/s40726-015-0013-1GS
3. Sergio C. Capareda, Introduction to Biomass Energy Conversions, CRC Press, ISBN: 978-1-4665-1333-4
4. Suwimon Thowphan et al 2022 J. Phys.: Conf. Ser. 2175 012009
5. Zhang, M., Gao, B. Yao, Y., Xue, Y., & Inyang, M. (2012). Synthesis of porous MgO-biochar nanocomposites for removal of phosphate and nitrate from aqueous solutions. *Science Direct: Chemical Engineering Journal*, 210, 26-32. https://doi.org/10.1016/j.cej.2012.08.052

Ira A. Fulton Schools of Engineering
Arizona State University