Preparation and Characterization of Porous Carbon Adsorbent Materials from Lignocellulosic Residuals

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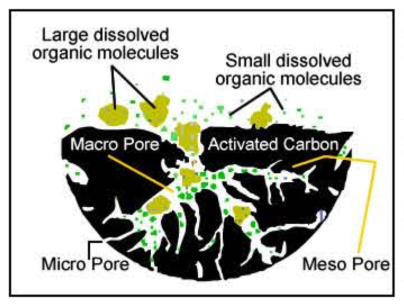
Introduction

- **What is activated carbon?** Activated carbon (AC) is porosity (empty space) enclosed by carbon atoms



- **What are some applications of activated carbon and how does it work?**

Hg Removal

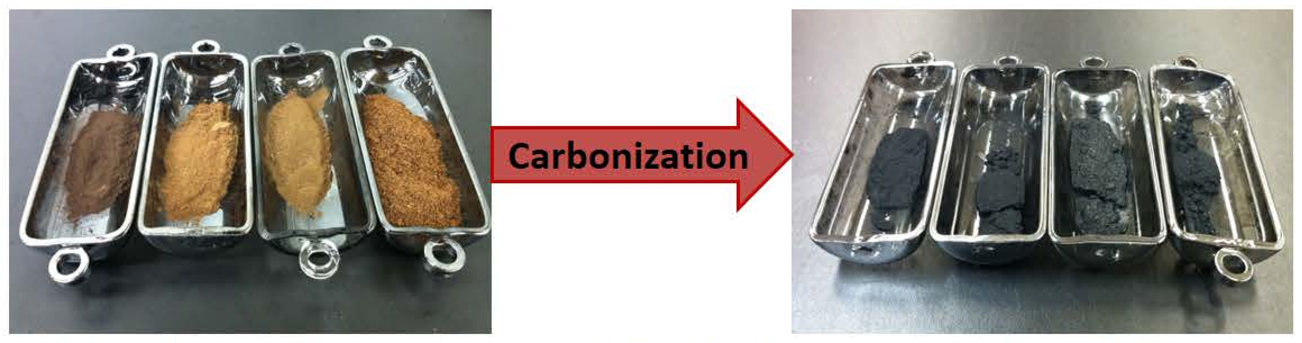
Water Purification

AC forms physical and chemical bonds with other molecules via ***ADSORPTION***.

Other applications: Wastewater treatment, adsorption of organic and inorganic solutes, separation of gases, odor control and many more

- **Who cares about activated carbon?** The US EPA, NARA project stakeholders, and everyone who breathes air and drinks water

Objective



To add value to biomass, specifically lignin, produced from forest residual biorefineries. By carbonizing lignin, it can be used for vapor phase mercury adsorption, one of the fastest growing applications for activated carbon.

Method of Preparation

- **Pretreated Lignin Varieties**
  - Wet Oxidation (WOX)
  - Sulfite Pretreatment to Overcome Recalcitrance of Lignocellulose (SPORL)
  - Dilute Acid (DA)
  - Catchlight Energy (CLE)

- **Preparation of activated carbon**

Step 1. Carbonization in a tube furnace

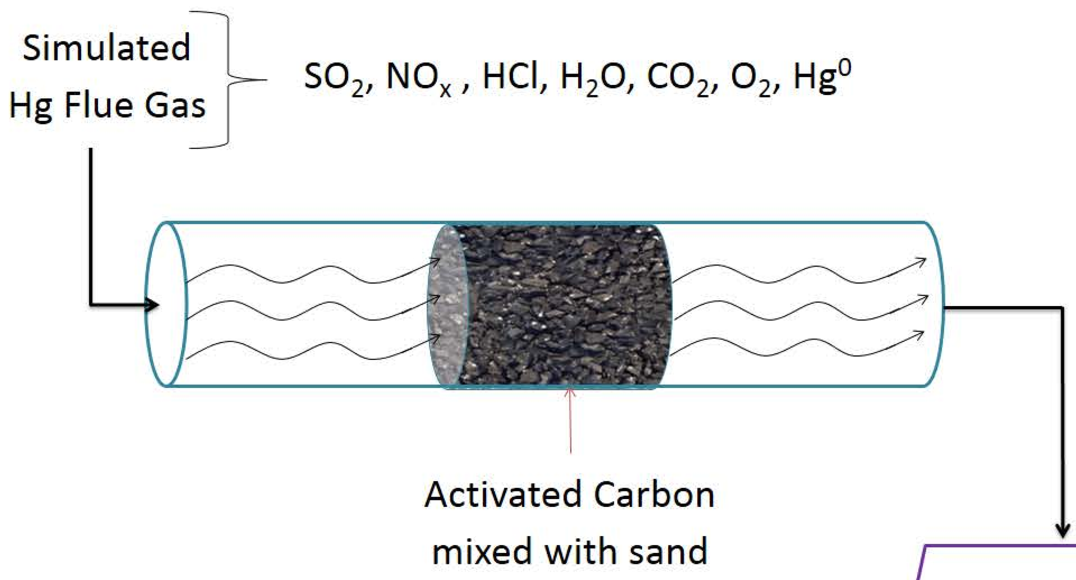
Step 2. Washing with dilute HCl and H_2O

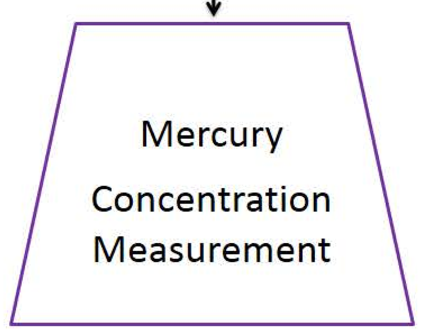
Step 3. Drying in an oven overnight at 105°C

Carbonization

Analysis Methods

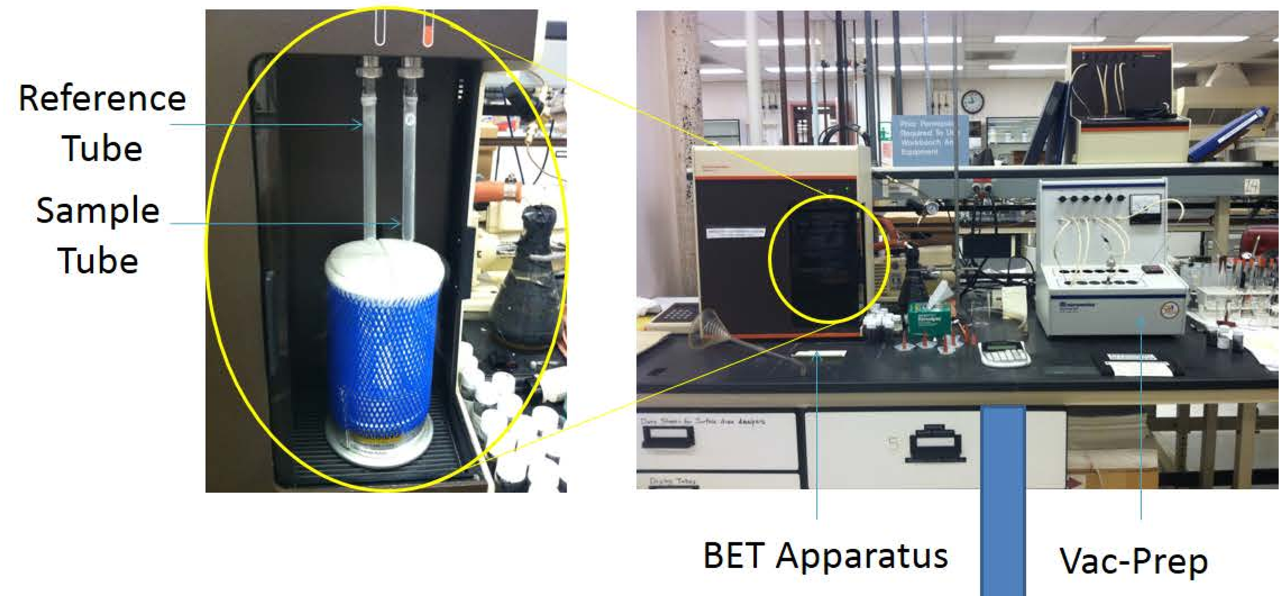
- **Mercury Adsorption**





Determines the equilibrium vapor phase elemental mercury adsorption capacity of the AC.

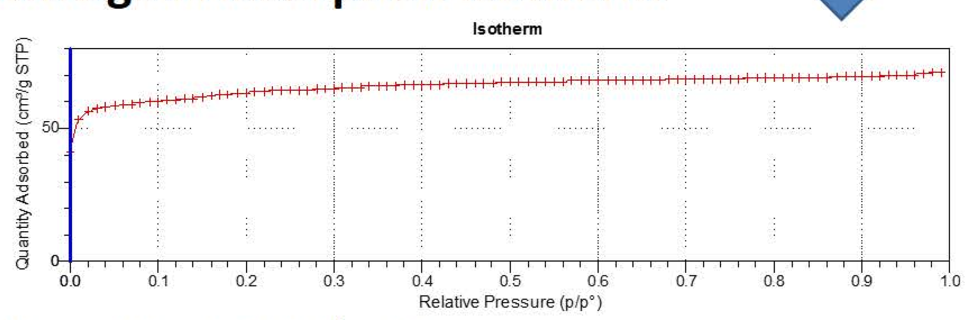
- **BET Nitrogen Adsorption**



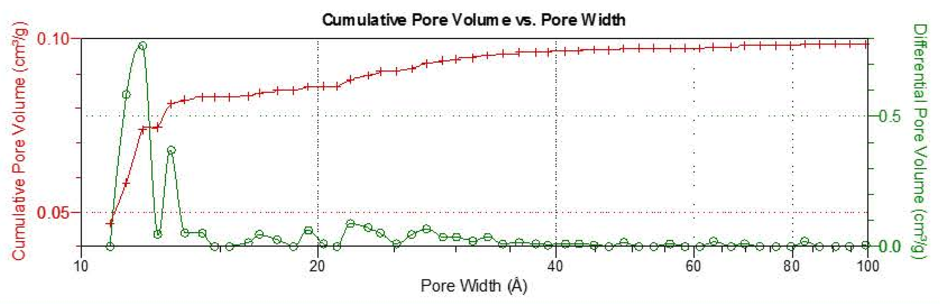
The vac-prep vacuum dries the AC before it is placed in the BET apparatus to have its porosity measured (graphs shown below).

Apparatus produces data below

- **Nitrogen Adsorption Isotherm**



- **Pore Size Distribution**



Results

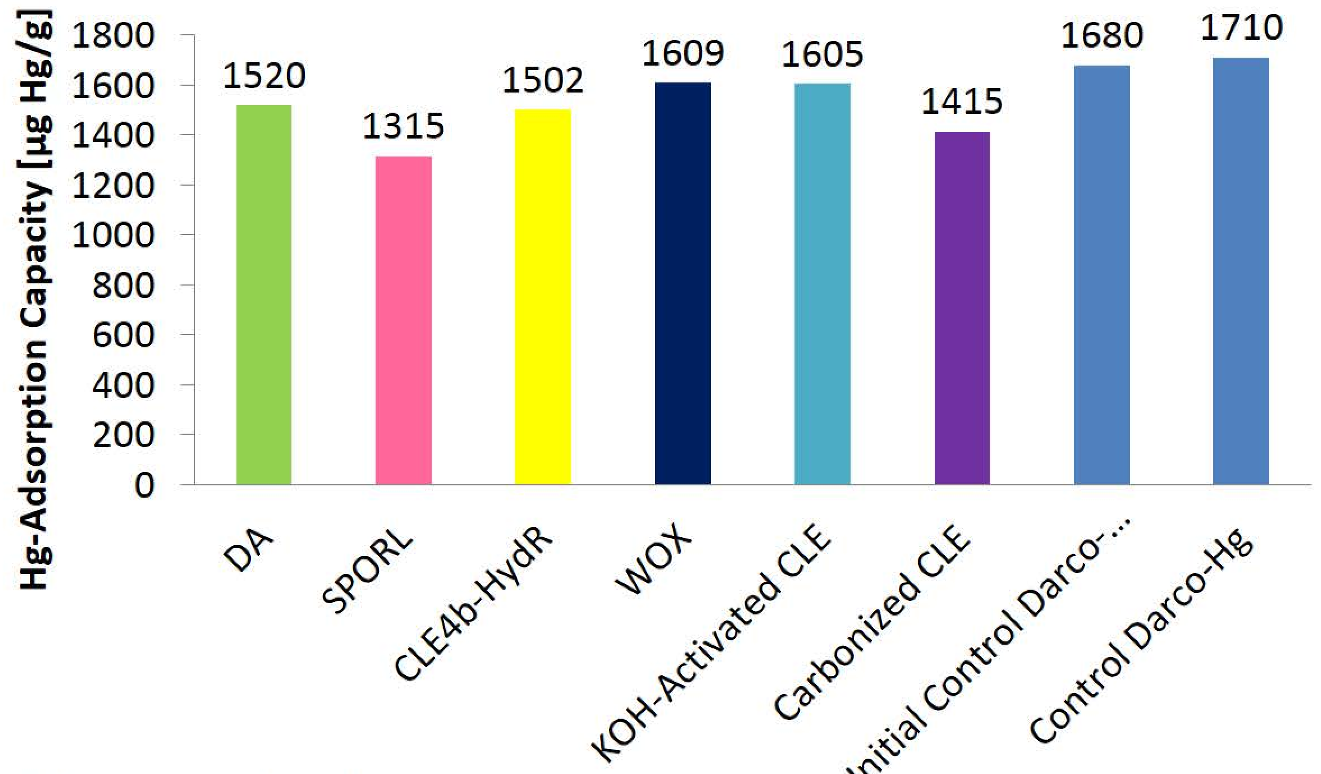
- **Elemental Analysis**

AC Type	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulfur (%)	Ash Content (%)	Oxygen* (%)
WOX	89.0	1.3	0.4	0.05	4.8	4.5
SPORL	81.8	1.1	0.5	0.4	12.1	4.1
DA	88.5	1.1	0.7	0.03	4.7	4.9
CLE	81.7	1.0	0.6	1.7	12.7	2.4

*determined by difference

Results

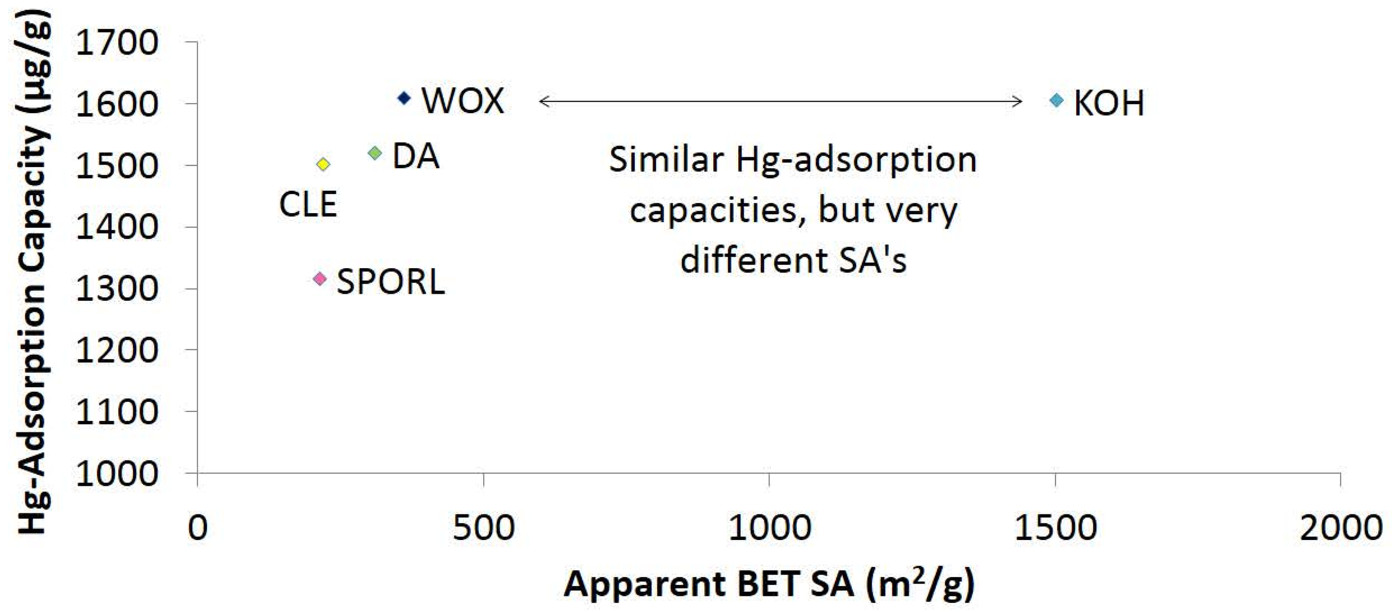
- **Vapor Phase Mercury Adsorption Results**



- **Characterization Data**

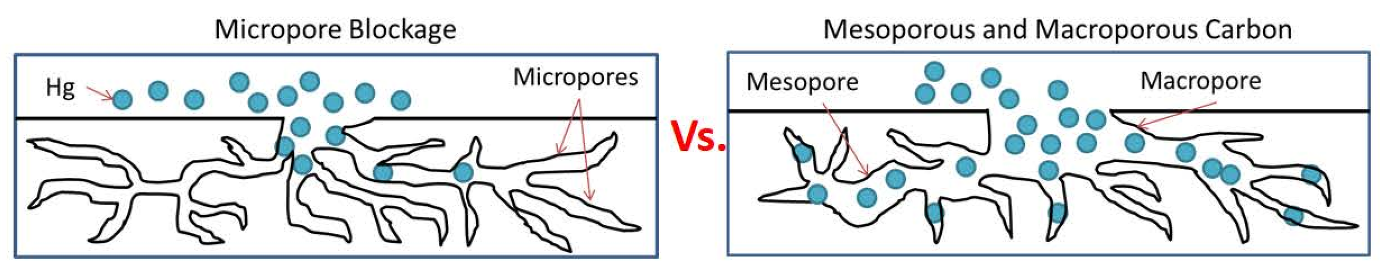
Lignin	% Yield	Porosity Data: Apparent BET SA (m^2/g)	Pore Volume (cm^3/g)	Pore Size (nm)	Ash Content (%)
WOX	35	360	0.2	1.1 - 1.4	5
SPORL	42	213	0.1	1.1 - 1.4	12
DA	30	309	0.1	1.1 - 1.4	5
CLE	41	220	0.1	1.1 - 1.4	13
KOH	-	1501	0.7	1.1 - 1.4	-

- **Surface Area Dependence**



Conclusion

- AC made from NARA lignin are **microporous** (pore size <2nm) and are **comparable** Hg-adsorbents to the commercially available coal-based activated carbon Norit Darco-Hg
- Hg-adsorption had a **LOW dependence on sulfur content**
- Hg-adsorption had a **LOW dependence on apparent BET Surface Area**



- <u>Future Research:</u> Engaging in thermal or a chemical activation to increase the number of mesopores and macropores may help create highways to the micropores, increasing the accessible adsorption area and improving the Hg-adsorption capacity.

Acknowledgements

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