

Advanced Gasification By-Product Utilization

Ari Geertsema, Rodney Andrews, Jack Groppo, Aurora Rubel
University of Kentucky, Center for Applied Energy Research

Harold Schobert and Mercedes Maroto-Valer
Pennsylvania State University

University Coal Research Contractors Review Meeting
Pittsburgh, PA, June 7-8, 2005
Contract DE-FG26-03NT41795



University of Kentucky
Center for Applied Energy Research

Outline

- Objectives and progress
- Experimental
 - Materials and characterization
 - Hg adsorption
 - Activation
- Results
 - Hg adsorption
 - Characteristics of good Hg sorbents
 - Activation
- Summary and Conclusions



Objective

To examine marketable applications of gasifier slag carbon by-products as adsorbents, fillers, and concrete additives



Progress

- ➡ All project gasifier slag carbons have been characterized by proximate, anions, BET, and pore size distribution
- ➡ All project gasifier slag carbons have been tested for Hg adsorption
- ➡ Some properties of good Hg adsorbing gasifier carbons have been identified
- ➡ Penn State activated a Hg adsorbing gasifier carbon and will investigate its uses as an activated carbon. The CAER will test for its Hg adsorption potential.
- ➡ Hg loaded gasifier carbons were produced and submitted for XAFS analysis to characterize Hg binding sites



Experimental



University of Kentucky
Center for Applied Energy Research

Gasifier slag carbons, A and B

➡ Carbon A

➡ A1: (-20+80)

➡ A2: (-20+80), (-60), and (-80)

➡ A3: (-20+80)

➡ Carbon B

➡ B: (-20+80), (soot), and (-80)



Experimental - CAER

- ▶ Characterization of materials
 - ▶ Analytical procedures
 - ▶ CHNS
 - ▶ Anions by IC
 - ▶ BET surface area
 - ▶ Pore size distribution
 - ▶ Hg and NO_x adsorption testing
 - ▶ Hg – fixed bed testing apparatus
 - ▶ NO_x – thermal analysis/mass spectrometry

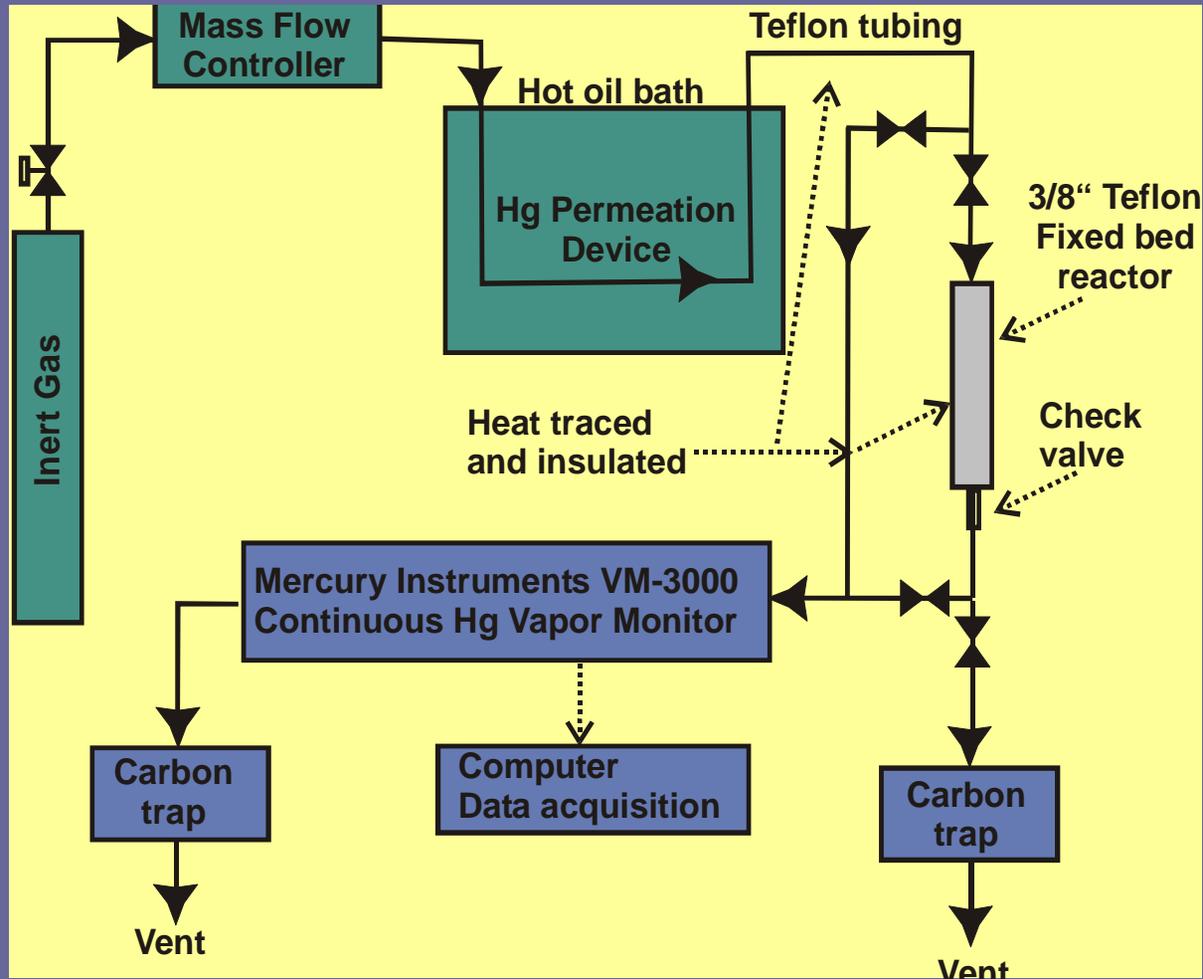


Experimental - CAER

- ▶ Hg adsorption testing
 - ▶ Hg vapor concentration, 0.20 mg/m³
 - ▶ Carrier gas air at flow rate 75 ml/min, rm T,P
 - ▶ Hg permeation cell, reactor by-pass and reactor temperature = 50°C
 - ▶ Carbon sample = approx 100 mg



Hg adsorption testing apparatus



Experimental – Penn State

- Characterization of gasifier slag carbon A1
 - Analytical procedures
 - Proximate, ultimate, and LOI
 - Petrography
 - BET surface area
 - Pore size distribution
 - Steam activation procedures
 - Horizontal stainless steel reactor
 - 2-3 g slag carbon
 - N₂ used as carrier gas for steam
 - Activation time 60-120 minutes
 - Activation temperature 850°C

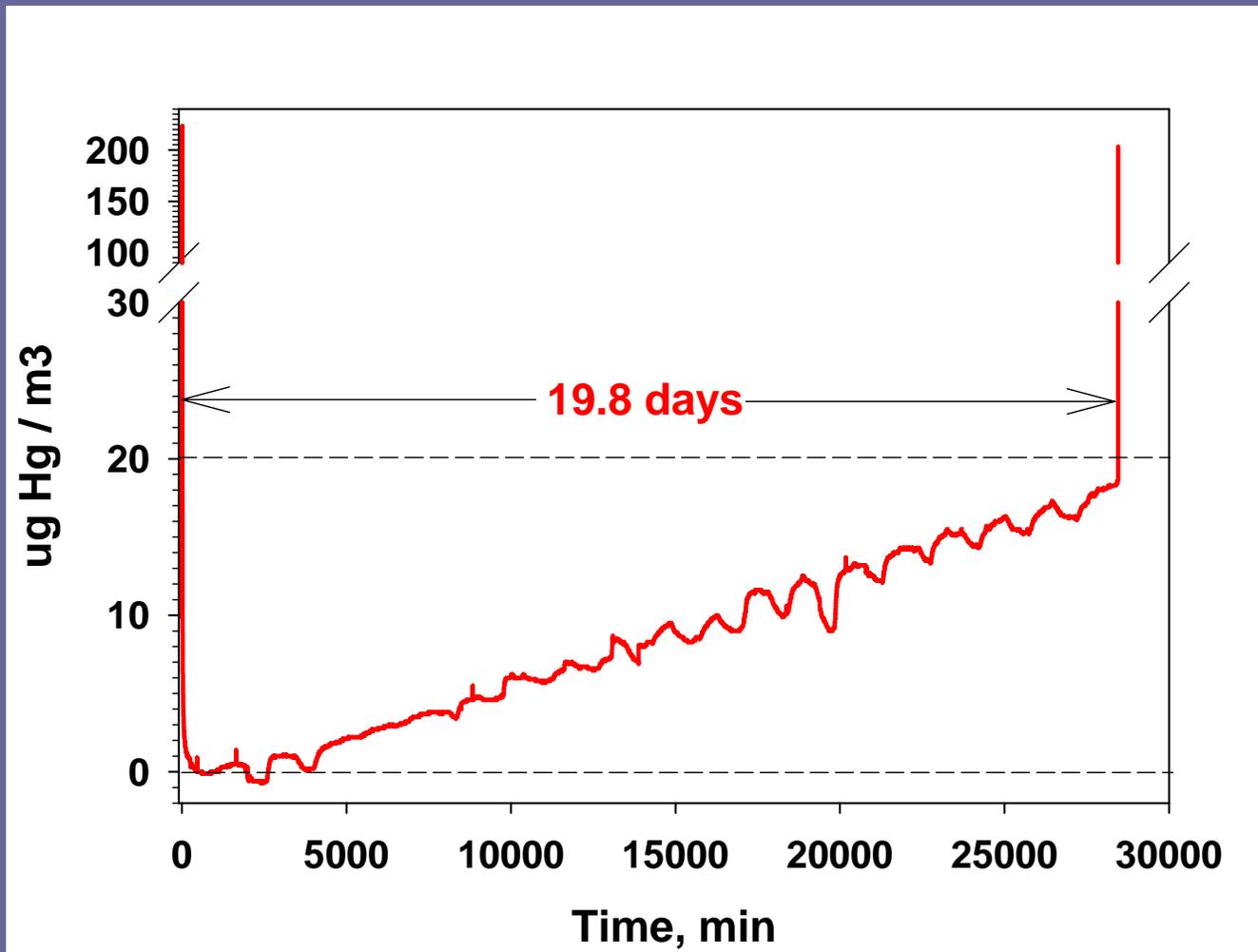


Results - CAER

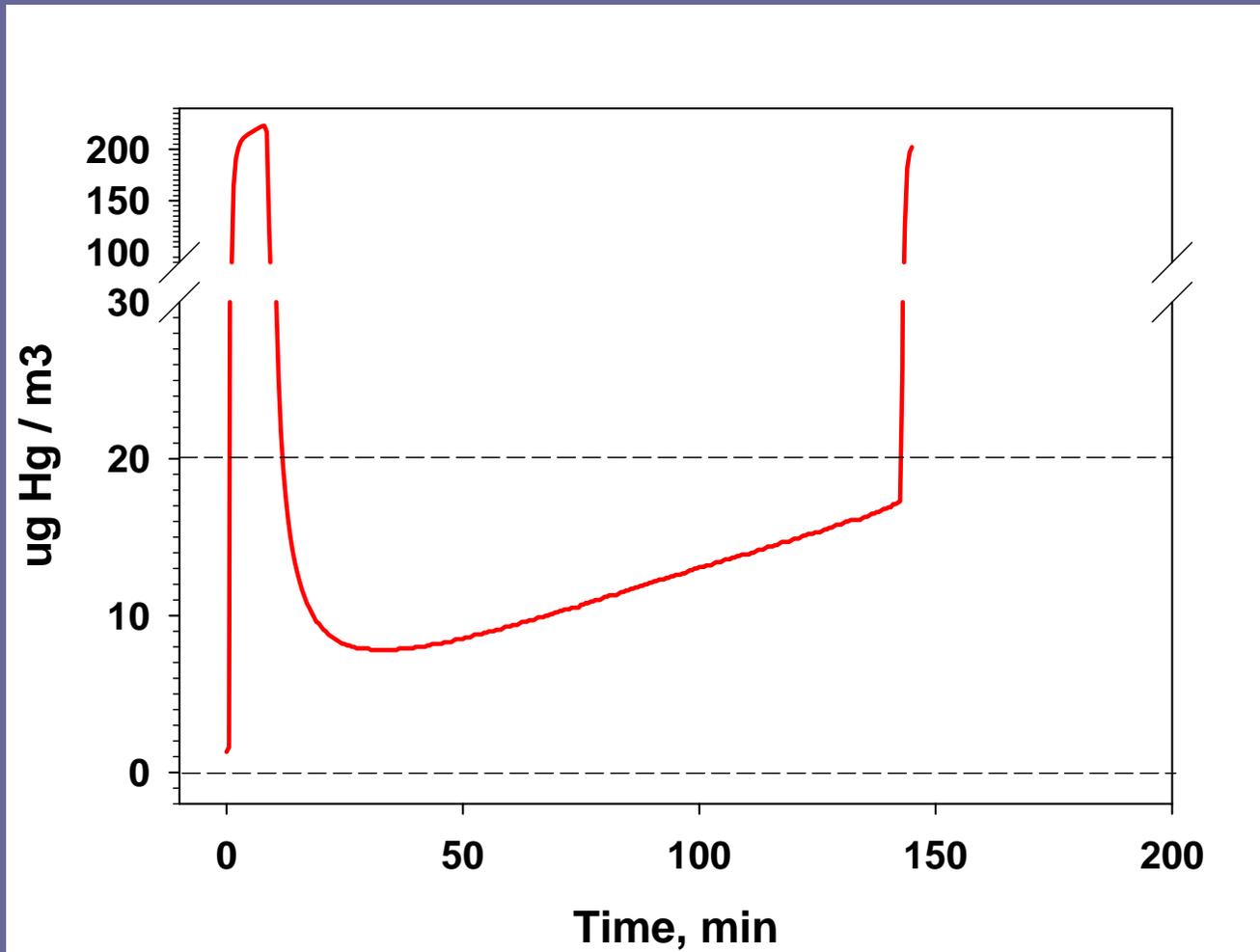


University of Kentucky
Center for Applied Energy Research

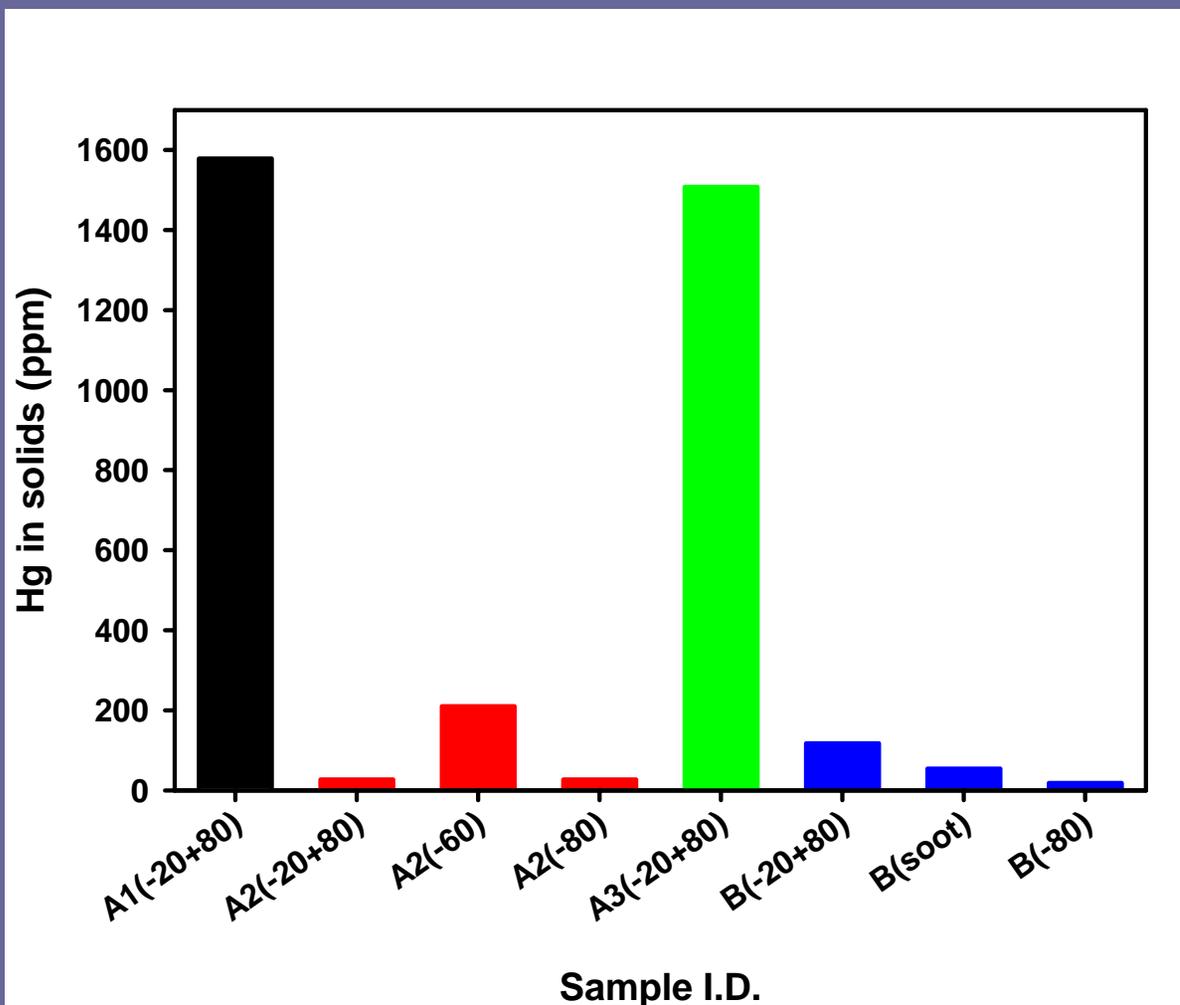
Hg adsorption on gasifier slag carbon A3 (-20+80)



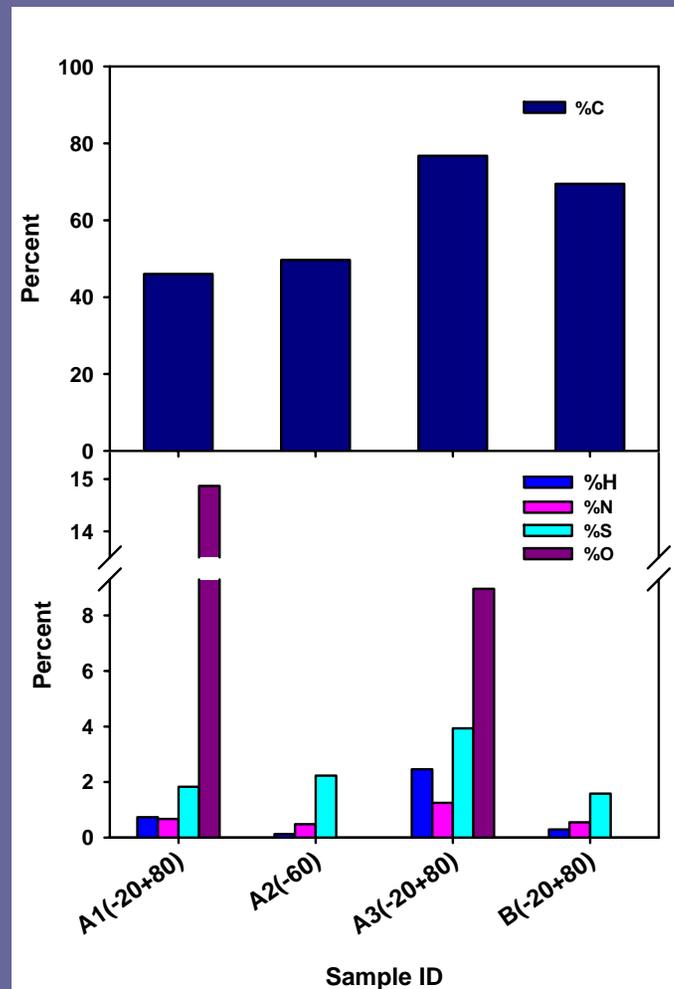
Hg adsorption on gasifier slag carbon A2 (-60)



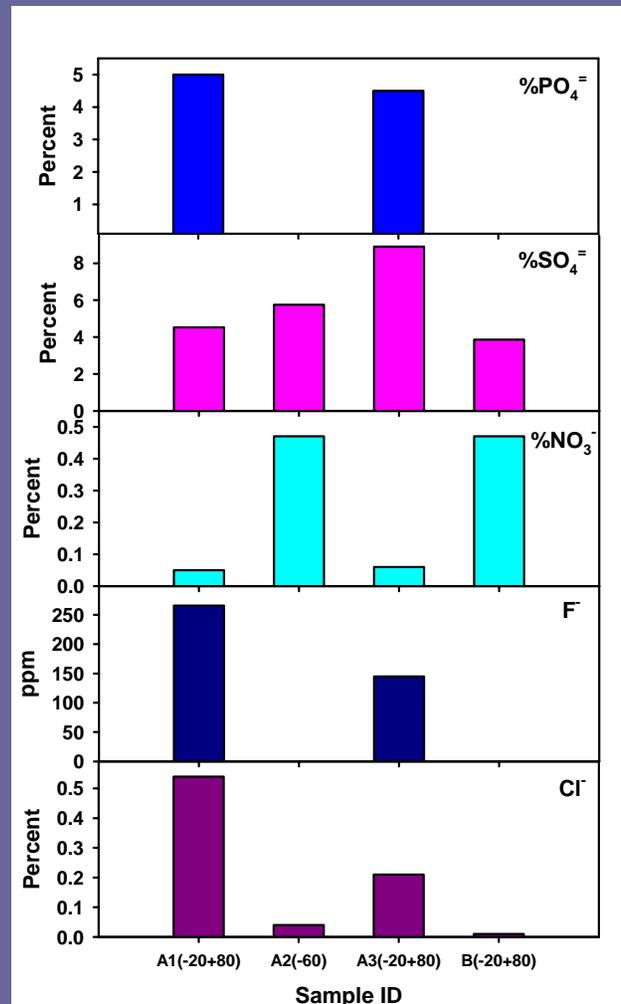
Hg adsorption on gasifier slag carbons



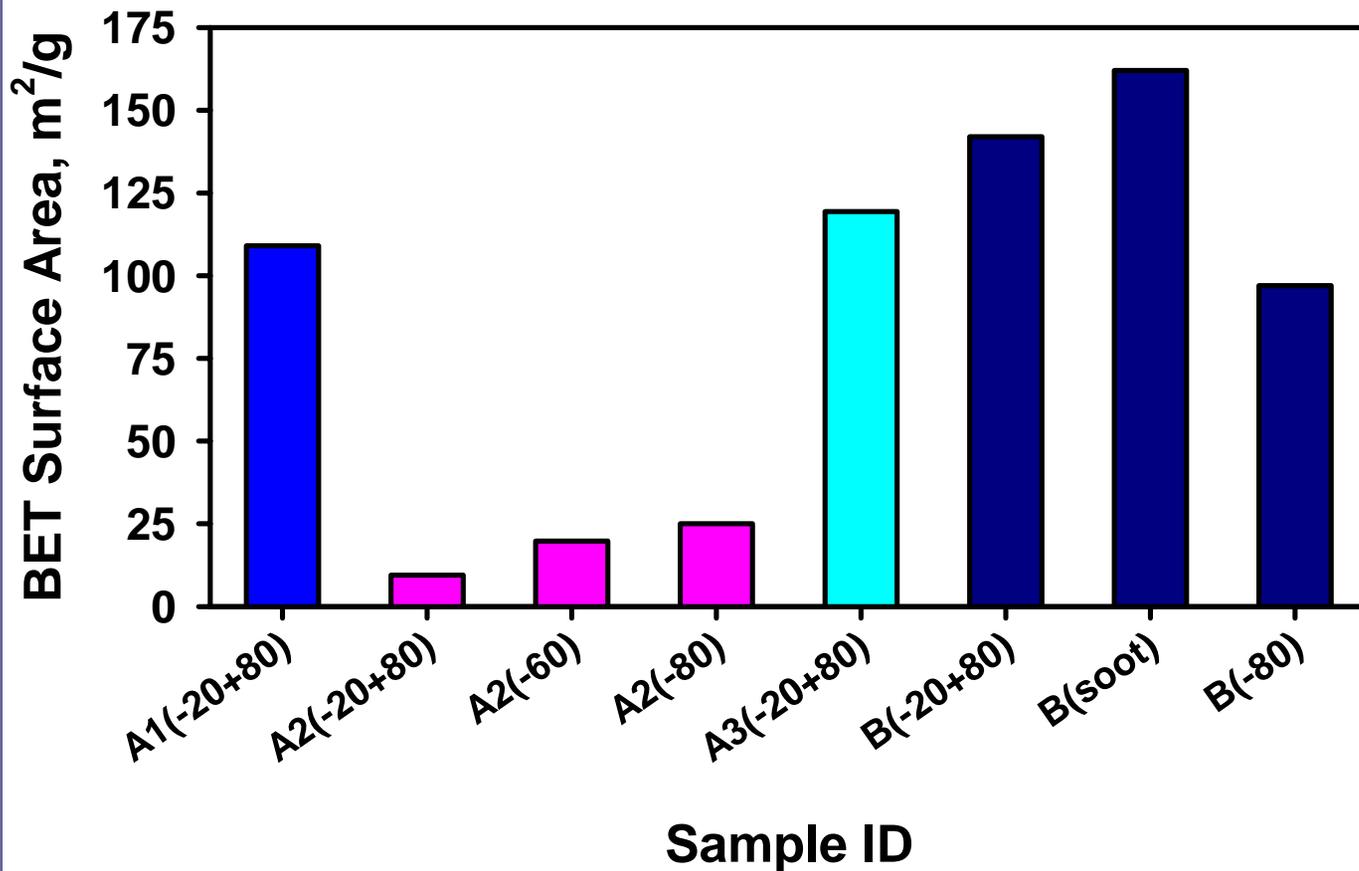
Elemental analysis of gasifier slag carbons



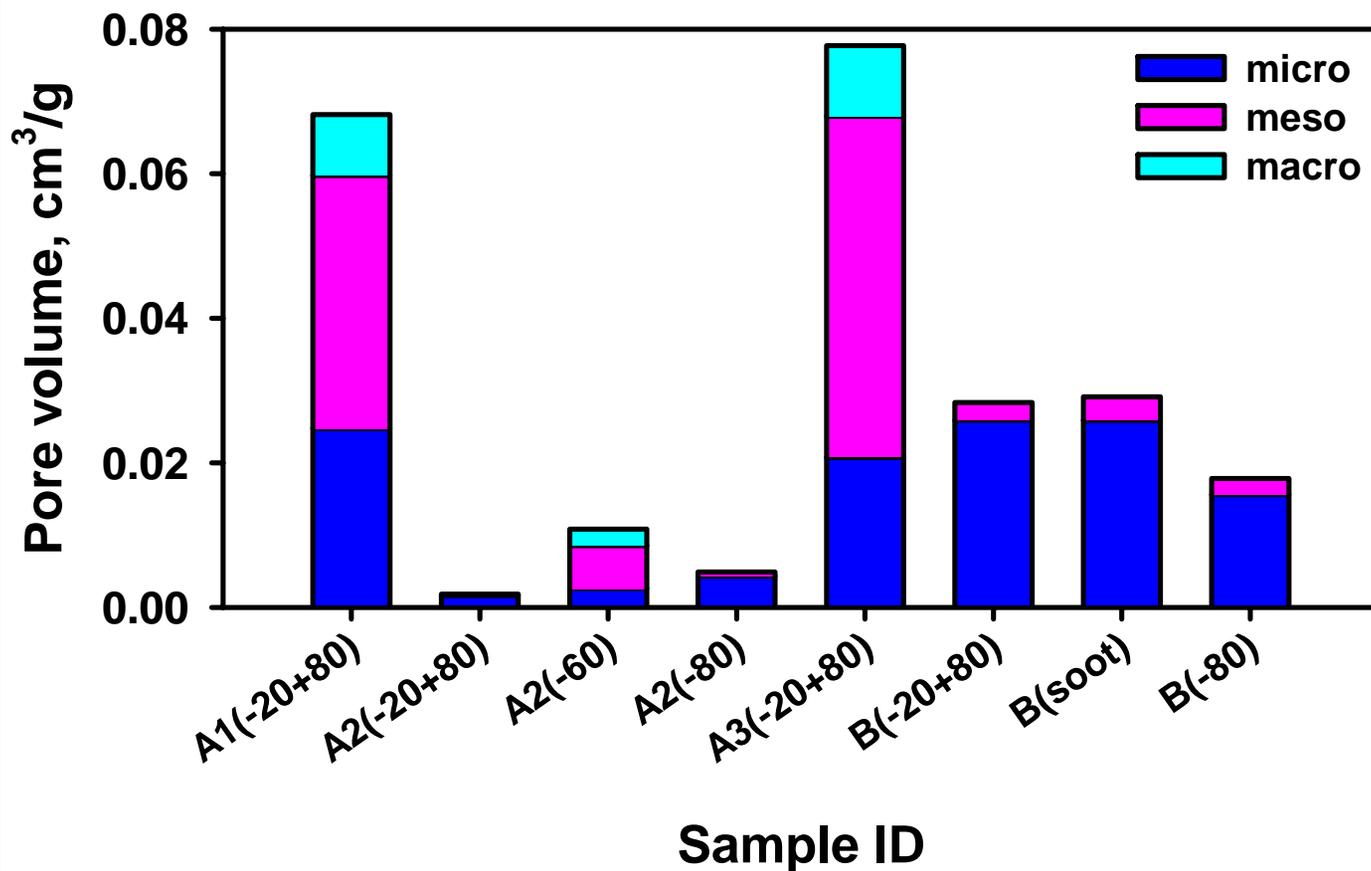
Anions analysis of gasifier slag carbons



Surface areas for gasifier slag carbons



Pore size distribution gasifier slag carbons



Results – Penn State



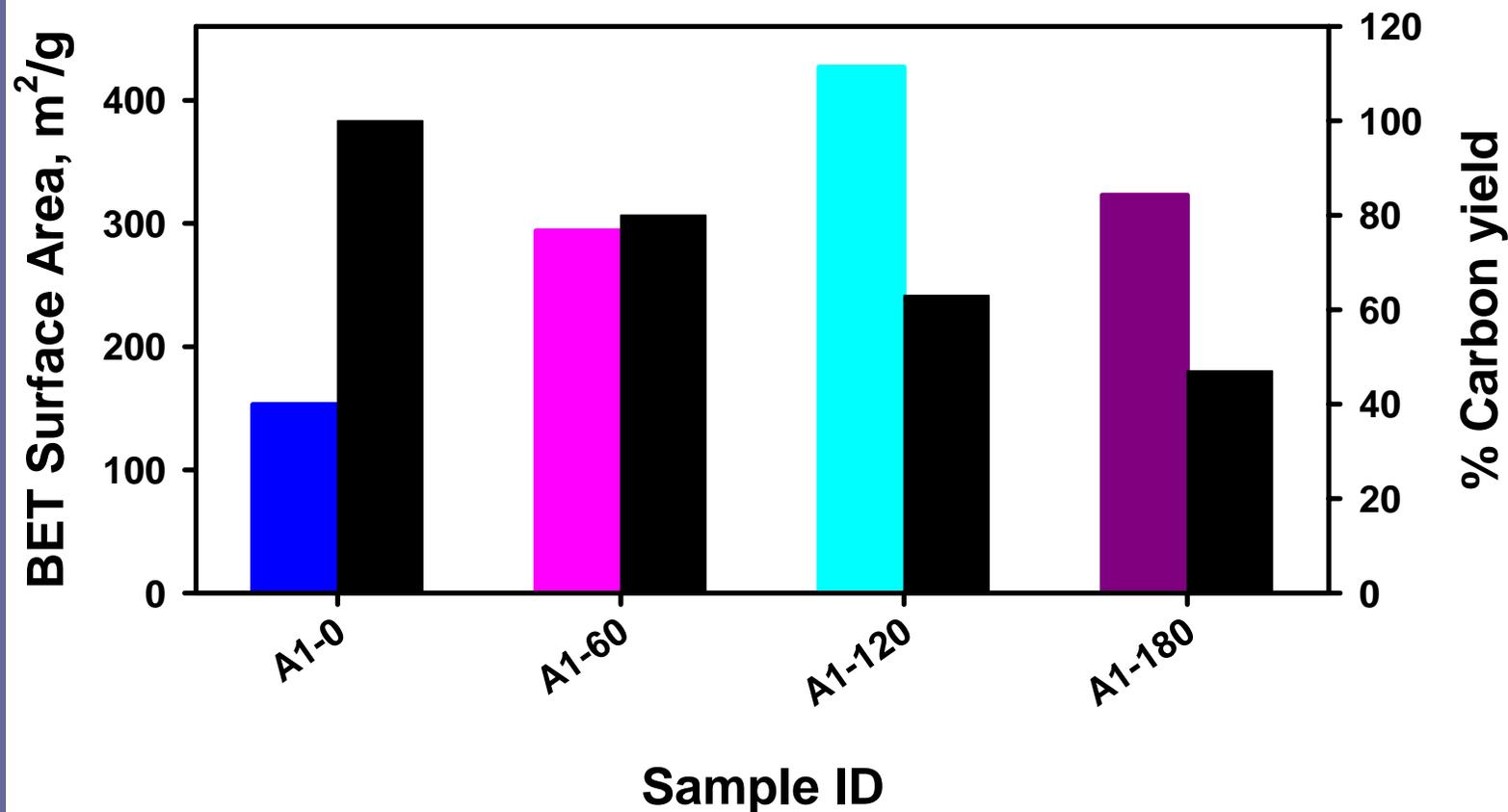
University of Kentucky
Center for Applied Energy Research

Proximate and LOI Analysis – A1

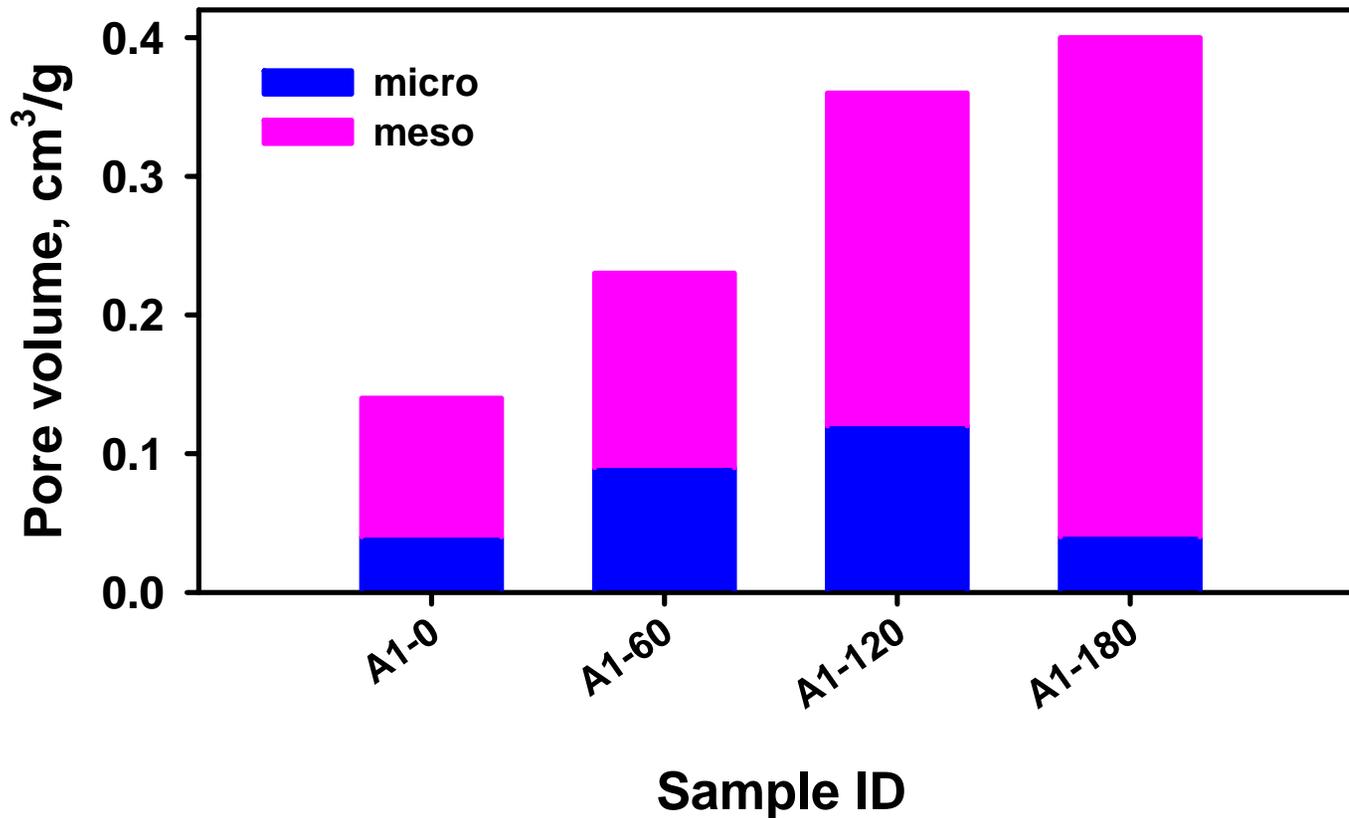
Mois, %	Ash, %	VM, %	FC, %	LOI, %
1.9	36.1	13.1	50.8	58.7



SA, carbon yield before and after activation



Pore size volumes before & after activation



Summary and Conclusions



University of Kentucky
Center for Applied Energy Research

Findings

- ▶ Gasifier carbons, A1 and A3 had exceptional Hg adsorbing capacity
- ▶ A1 and A3 had high oxygen and sulfur, similar anion contents (Cl^- , F^- , SO_4^{-2} , PO_4^{-2}), SA, and pore volumes
- ▶ High carbon content and SA may not be the determining factor in good Hg adsorption
- ▶ Gasifier slag carbon can be steam activated



Next

- ➡ Relationship between SA, pore size, pore size distribution, anions, oxygen and sulfur on Hg adsorption will be explored
- ➡ Obtain information on nature of Hg adsorption sites on slag carbons from XAFS results
- ➡ Hg adsorption testing of activated slag carbons from Penn State
- ➡ Penn State to activate other gasifier carbons and test for uses
- ➡ Begin work on NO_x adsorption on project carbons
- ➡ Begin work on other by-product applications such as fillers and concrete additives



Rubel, A.M.,; Andrews, R.; Gonzalez, R.; Groppo, J.G.; Robl, T.L. "Mercury Adsorption on Combustion and Gasifier By-Products," 56th Southeastern Meeting of the American Chemical Society, Nov 11-12, Research Triangle Park, NC, 2004.

Thanks to students, David Graham, UK, and Zhe Lu, Penn State Un for their work on this project.



University of Kentucky
Center for Applied Energy Research