



PROJECT FACTS

UNIVERSITY OF KENTUCKY
CENTER FOR APPLIED ENERGY RESEARCH

ADVANCED GASIFICATION BY-PRODUCT UTILIZATION

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UK CAER

COST SHARING

DOE-UCR...\$200,000
UK CAER.....\$50,000

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The purpose of this project was to investigate the potential of waste streams from integrated gasification combined cycle (IGCC) power generation units to serve as precursors for value-added products. These by-products can be considered a new material resource from coal. The objectives were to find applications and market options for by-products produced from IGCC chars. Four samples of gasifier char carbons were acquired from two commercial gasifiers and were extensively chemically and physically characterized (proximate, ultimate, anions by ion chromatograph, forms of sulfur, BET surface area determinations, pore volumes and pore size distributions by density functional theory).

The carbon-rich fractions of the gasifier chars were assessed as adsorbents for flue gas mercury (Hg) capture using an Hg adsorption test apparatus. Two of the four gasifier slag carbons had excellent Hg capture potential compared to an activated carbon that was developed for Hg adsorption from flue gases. Common characteristics of these two coal by-product sorbents were a surface area of 100-130 m²/g and high Cl, F, SO₄, and PO₄ anions. Good gasifier Hg adsorbing carbons also had higher pore volumes and higher mesopore volumes than poor gasifier Hg adsorbing carbons. Mercury-laden samples of the gasifier carbon were subject to X-ray Absorption Fine Structure Spectrometry (XAFS) to define the Hg adsorption sites. The results from mercury-loaded gasifier carbon indicate that even though the adsorption gas in our experiments contained only Hg⁰, Hg⁺² was the captured species and it was bound to sulfur. The results indicated that good versus poor mercury adsorbing gasifier carbons had different Cl and S speciation. The good sorbent contain elemental sulfur, thiophene and sulfate, whereas the poor mercury-adsorbing gasifier carbon contained sulfur primarily as metal sulfides. This work indicated that the mercury was chemically bonded on the sorbents since it was only released above 300°C during heating. The ionic binding of mercury to the surface of pores changes in the characteristics of the pores. This has been confirmed by increased micropore volume at the expense of mesopore volume in Hg loaded gasifier carbons.

The carbon-rich by-product was evaluated as a precursor of activated carbons at The Pennsylvania State University Energy Institute (EI). The gasifier-char carbons were subjected to thermal and chemical activation. The properties of the activated carbons were characterized using state-of-the-art techniques available at the CAER and EI. Thermal activation significantly increased the surface area (SA) of the carbons but chemical activation decreased SA and resulted in the breakdown of the carbon matrix. While the results indicated that the chars can be enhanced by classical activation approaches, none were competitive with commercially prepared activated carbons.

All thermally-activated slag carbons were tested for Hg adsorption potential at the CAER. The char carbons with high Hg adsorption capacity lost 94% of their Hg adsorption capacity on activation. No correlation was found between BET SA or pore volumes and Hg adsorption capacities. This suggested that factors other than higher SA and pore volume were important in Hg adsorption. Mineral content of the slags may play an important role.

The results from this work indicated that certain gasifier slag carbons have the potential to capture Hg from combustion flue gas. Two slag carbons performed as well as a commercial activation carbon prepared specifically for Hg adsorption. It did so without further treatment, making it an inexpensive alternative to commercial activated carbon.