

Advanced Gasification By-Product Utilization

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OBJECTIVES

The objectives of the work at the CAER were to investigate the potential use of gasifier slag carbons as a source of low cost sorbent for Hg and NO_x capture from combustion flue gas and as a source of activated carbons. Primary objectives are to determine the relationship of surface area, pore size, pore size distribution, and mineral content on Hg storage of gasifier carbons and to define the site of Hg storage. The ability of gasifier slag carbon to capture NO_x and the effect of NO_x on Hg adsorption are secondary goals.

Since gasifier chars have already gone through a devolatilization process in a reducing atmosphere in the gasifier, they only require to be activated to be used as activated carbons. Therefore, the principal objective of the work at PSU is to characterize and utilize gasification slag carbons for the production of activated carbons. Increasing the surface area of gasifier carbons should improve their NO_x adsorption potential. Testing the Hg and NO_x adsorption potential of these activated gasifier carbons is a secondary objective of this work.

ACCOMPLISHMENTS TO DATE

Previously, the Hg adsorption capacities of four slag carbons obtained from two different gasification plants (A and B) were compared with respect to their Hg capture potential at the CAER. Two of the gasifier slag carbon samples had exceptional Hg capture potential which was confirmed this year by work at PSU. Factors found to influence good Hg adsorption on these carbons were the carbon and sulfur content, high oxygen content, and the presence of either Cl⁻ or SO₄⁻² or both.

This year's work at the CAER focused on a better understanding of the Hg capture mechanism/site. Mercury, sulfur and chlorine XAFS spectra were collected for two samples of differing Hg contents and a control sample. Analysis of the Hg XAFS data would suggest that the Hg is bound predominantly to S; however, it should be noted that Cl is not eliminated by these data because of its proximity to sulfur in the periodic table and its similar X-ray scattering properties. In addition, the data indicate that the Hg coordination and bond length to sulfur are significantly reduced compared to that in cubic HgS. However, this may be a result of the mercury being bound at the surface of the sorbent rather than in a well-defined crystal structure. Sulfur and chlorine XANES spectra indicate that the sulfur and chlorine speciation between the two sorbent samples is very different. In the slag sample which had a low Hg capture capacity, sulfur is present mostly as metal sulfides, whereas the high Hg sorbent sample contained elemental sulfur, thiophene and sulfate forms as major forms and very little, if any, sulfur as metal sulfide. Analysis of the chlorine XANES data indicated the possible presence of organochlorine compounds; however, this awaits confirmation depending on the calibration of the Cl XANES spectra.

A reactor system was also developed at the CAER for testing Hg capture under simulated flue gas conditions. The final configuration of the reactor system has addressed issues with interferences due to NO_x and SO₂ in the simulated flue gas with Hg detection by the available Hg vapor monitors. The system is capable of measuring the Hg uptake over extended periods.

FUTURE WORK

Work is progressing as per the task schedule previously established. In the coming year, UK will concentrate on finishing Hg-sorption testing of activated char samples under simulated flue gas conditions. Work will also be concluded on the suitability of the highest carbon content fractions as conductive fillers in plastics. In particular, the activated carbon generated from the gasifier char carbon at PSU via steam activation will be tested for Hg and NO_x adsorption potential. Samples will be tested at both UK and at PSU. All parent gasifier slag carbons will be tested for NO_x adsorption potential and the best Hg adsorbing carbons will be tested for both Hg and NO_x in a simulated flue gas at UK.

Mercury loaded char samples will be subjected to leaching analysis to determine any detrimental release of Hg from these samples under storage conditions. Finally, PSU will undertake determination of the suitability of the high carbon content samples as replacements for bulk carbon fines in filling carbon bodies (as a coke replacement).

PUBLICATION, PATENTS, AND PRESENTATIONS, STUDENTS

Presentation: R. Andrews; A. Rubel; J. Groppo; D. Graham; A. Geertsema; M. Maroto-Valer; Z. Lu; H. Schobert. "Advance Gasification By-Product Utilization," 2005 UCR Contractors Meeting, June 2005.

Paper: A. Rubel; R. Andrews; R. Gonzalez; J. Groppo; T. Robl. "Adsorption of Hg and NO_x on coal by-products," Fuel, 84(7-8) 911-916, 2005.

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