U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Oxidation of Mercury in Products of Coal Combustion

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Background

The 2005 Clean Air Mercury Rule will require significant reductions in mercury emissions from coal-fired power plants. A variety of mercury reduction technologies are under commercial development, but an improved understanding of the fundamental chemical mechanisms that control the transformations and capture of mercury in boilers and pollution control devices is required to achieve necessary performance and cost reduction levels.

Oxidized mercury is more easily captured by pollution control devices, such as Selective Catalytic Reduction (SCR) systems, than elemental mercury meaning, primarily because of its solubility in water. SCR catalysts able to promote and sustain the oxidation of mercury without affecting NO_x control, therefore, would be desirable in the development of effective mercury control strategies.

Primary Project Goal

The primary goals of this project are: (1) to develop new catalysts having high activity for both NO_x reduction and mercury oxidation and (2) to develop a fundamental chemical kinetic understanding of mercury reactions in flue gas, especially during selective catalytic reduction of NO_x.

Objectives

- Identify SCR catalyst formulations able to increase mercury oxidation without compromising NO_x reduction performance or catalyst life.
- Overcome the apparent inhibition of mercury oxidation in SCR catalysts by Powder River Basin coal ash.
- Evaluate the contributions to mercury oxidation from heterogeneous reactions with fly ash and unburned carbon under SCR conditions.
- Determine whether carbon monoxide is an inhibitor or promoter of mercury oxidation in SCR catalysts.
- Determine the effect of ammonia on the oxidation of mercury by SCR catalysts in the presence of ash.
- Devise a chemical kinetic mechanism and evaluate the rate coefficients needed to describe the homogeneous and heterogeneous reactions of mercury, chlorine, hydrogen, oxygen, sulfur, nitrogen, carbon, and ash species in an SCR catalyst with sufficient accuracy to be useful for design purposes.

PARTNERS

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PERIOD OF PERFORMANCE

09/14/2004 to 09/14/2007

COST

Total Project Value
$536,440

DOE/Non-DOE Share
$399,899 / $136,541

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Accomplishments

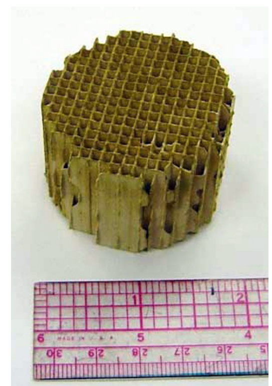
Three catalysts have been developed that contain iron, vanadium, and cerium, and tested for ability to oxidize mercury. The initial results indicate that the vanadium catalyst can oxidize 35 percent of the available elemental mercury at 371 °C and 14 percent of the available elemental mercury at 316 °C. In addition, homogeneous equilibrium and homogeneous kinetic models have been completed with results that agree with the published literature. A heterogeneous model is under development.

Benefits

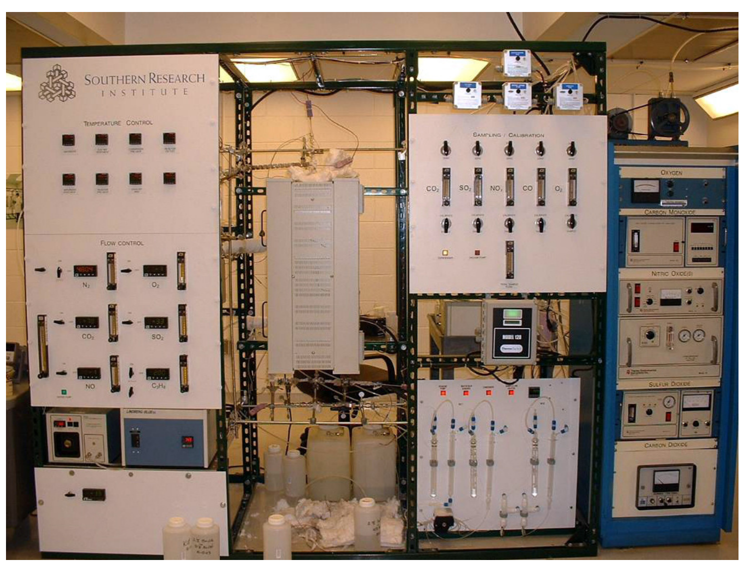
A fundamental understanding of the physical and chemical reactions of mercury in coal-fired flue gases will enable the development of more efficient and economical mercury control devices. In addition, Powder River Basin fly ash has been observed top inhibit the oxidation and capture of mercury in wet FGD systems so the identification of catalysts that can effectively oxidize mercury in the flue gases from Powder River Basin coal will permit more effective and economical mercury control devices in power plants that burn this type of western coal.

Planned Activities

The following activities are planned for the next year: (1) continue developing new catalysts for laboratory evaluation of NO_x reduction and mercury oxidation, (2) continue the experimental study at the University of Alabama's Catalyst Reactivity Test Facility to determine the effects of temperature, gas composition, fly ash composition, and other factors, and (3) continue the development of a chemical kinetic mechanism consistent with the results obtained in laboratory, data available in the literature, and data from field tests.



Catalyst Test Specimen



The Catalyst Reactivity Test Facility