Assessment of Low Cost Novel Sorbents for Coal-Fired Power Plant Mercury Control

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Abstract

This is a Technical Report under a program funded by the Department of Energy's National Energy Technology Laboratory (NETL) to obtain the necessary information to assess the viability of lower cost alternatives to commercially available activated carbon for mercury control in coal-fired utilities.

During this reporting period, ongoing tests and analysis on samples from Powerton and Valley to yield waste characterization results for the COHPAC long-term tests were conducted. A draft final report for the sorbent evaluations at Powerton was submitted. Sorbent evaluations at Valley Power Plant were completed on April 24, 2003. Data analysis and reporting for the Valley evaluations are continuing.

A statement of work for sorbent evaluations at We Energies' Pleasant Prairie Power Plant was submitted and approved. Work will begin late August 2003. A no cost time extension was granted by DOE/NETL.

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Introduction

This program is funded by the Department of Energy's National Energy Technology Laboratory (NETL) to obtain the necessary information to assess the viability of lower cost alternatives to commercially available activated carbon for mercury control in coal-fired utilities. During this reporting period, testing was conducted at one of two field sites originally identified for this program, Valley Power Plant, Milwaukee, WI. Valley Power Plant burns a blend of bituminous coal and pet coke. Evaluations began on January 22 and were completed on April 24, 2003. Based upon the performance of the sorbents in a fixed-bed device and the estimated cost of mercury control using each sorbent, sixteen sorbents with projected costs of at least 25% less than commercially available Norit FGD carbon, were chosen for screening in the slipstream injection system at Valley Power Plant. An additional sorbent was added to make the total seventeen. That sorbent is an iodine-impregnated sorbent (Type IAC from Barnebey Sutcliffe) and was evaluated to assess the effectiveness of treated sorbents compared to untreated sorbents.

The objective of tests conducted during this phase of the program was to compare novel sorbents for mercury removal by assessing the effect of sorbent injection on vapor-phase mercury control at Valley Power Plant. To achieve this objective, Apogee installed the EPRI PoCT slipstream test system downstream of the air preheater on Boiler 3 at Valley Power Plant.

The seventeen candidate sorbents included experimental sorbents produced from biomass, oil soot, waste tires, separated flyash, zeolite, and a commercially available carbon produced from lignite coal. FGD activated carbon was tested as the benchmark sorbent. Other sorbents that had an initial cost above FGD were chosen as alternates because of their initial performance or because of their application method is unique. Brief descriptions of these sorbents are shown in Table 1.

Table 1. Descriptions of sorbents evaluated at Valley Power Plant

Sorbent	ID	Description
Darco FGD	FGD	Texas lignite coal-based commercial carbon from Norit Americas d50 = 18 μm
Tire Derived Activated Carbon	TDAC	Experimental waste tire-based activated carbon from Envirotire
Corn Char	CFA	Pilot Kiln corn-char; experimental, ISGS d50 = 15 μm
Soot	CS80	Experimental carbon from soot, ISGS d50 = 6.2 μm
DESOREX HOK300S	HOK	German lignite coal-based commercial carbon from Donau Carbon d50 = 19 μm
STI	STI-020513-B, 020930-C, and A	Separated and treated fly ash, experimental from STI
Type CB	IAC and IAC 020430-B	Barnebey Sutcliffe coconut shell-based, iodine impregnated commercial carbon d50 = 25 μm
Treated Flyash	S-1 and E-1-S	Treated flyash from ArKay
Activated Carbon	LAC	Lignite activated carbon, ISGS
Modified Zeolite	PSI-C	Modified zeolite
Activated Carbon	A10 and G	Activated carbon from Sorbent Technologies
Activated Carbon	2002-8680 and 2002-8567	Activated carbon with various treatment applications from Norit Americas

Experimental

Slipstream injection tests were conducted at Valley Power Plant, Boiler 3. Seventeen sorbents were evaluated as mercury sorbents. Injection testing was conducted using an EPRI supplied slipstream Pollution Control Test (PoCT) Device configured as a

COHPAC baghouse. Mercury removal across the slipstream injection device was measured with and without sorbent injection.

1. Screening. Each available sorbent was injected for about 120 minutes.
2. Parametric. The two most-promising sorbents from screening and economic criteria were tested at various injection rates and two temperatures and across two different bag types. Each test condition was held for approximately 4 hours. FGD was also tested for a benchmark comparison.
3. Long term. The two most-promising sorbents were tested continuously for 48 hours. The collected solids from the baghouse hoppers were collected for waste characterization. FGD was also tested for a benchmark comparison.

In the residence chamber configuration, two selected novel sorbents (CS80 and CFA) and FGD were tested at two temperatures and three injection concentrations. Mercury measurements were made at two locations along the residence time chamber to assess the effect of residence time on mercury removal.

Results and Discussion

Sorbent injection testing in the COHPAC configuration began January 2003 at Valley Power Plant and evaluations were completed in April 2003.

During the first six weeks of testing, injection screening was conducted at a single injection rate and temperature using the PoCT system configured as a COHPAC baghouse. During the initial screening period, the sorbents were injected at an injection rate of nominally 2.0 lb/MMacf for 120 minutes to provide a direct comparison of performance. The mercury removal was measured across a Teflon-coated woven fiberglass bag. Six of the carbon-based sorbents (FGD, CFA, LAC, 2002-8680, 2002-8567, and A10) demonstrated similar performance (mercury removal due to sorbent injection of greater than 90%). Three of the sorbents (HOK, CS80, and G) removed greater than 70% but less than 90% of the mercury in the flue gas. Six of the sorbents (E-1-S, IAC 020430-B, PSI-C, 020513-B, 020930-C, and TDAC) removed less than 50% of the incoming mercury. Two of the sorbents showed no mercury removal (S1 and A).

During parametric evaluations, the performance of the three sorbents (A10, CFA, and FGD) was comparable. The data also indicates that the mercury removal across the 2.7-denier PPS (Ryton) felt bag is slightly better than across the 7.0-denier PPS felt Torcon bag. Although, at the higher injection rates for the sorbent A10, the mercury removal across each bag type were consistent. The cleaning frequency of the Torcon bag was also much higher than the Ryton bag.

Following parametric testing, a continuous injection evaluation was conducted for the two most promising sorbents (CFA and A10) and FGD in the COHPAC configuration. The longer-term injection tests were conducted for 48 hours at a targeted injection rate of 2 lb/MMacf and a temperature of 315°F. The mercury removal across the bags increased

for approximately 2 to 12 hours before leveling off. Both the CFA and A10 reached the percent mercury removal observed in the parametric evaluations within 1 hour of injection for both bag types. The FGD reached similar results but only after 12 hours of injection. The percent mercury removal for all sorbents with the Torcon bag ranged from 93% to 95% and 94% to 99% for the Ryton bag.

In the residence chamber evaluations, all samples demonstrated less than 70% mercury removal for the range of sorbent injection concentrations tested (2.5 to 15 lb/MMacf). Of these three sorbents (CFA, CS80, and FGD), it appears that the CS80 demonstrated the higher mercury removal, which may be a result of the significantly smaller particle size ($d_{50} = 6.2 \mu\text{m}$ compared to 15 and 18 μm for the CFA and FGD, respectively). This was also seen at Powerton. Although the CS80 demonstrated improved performance, it was more difficult to handle and plugged the feed eductor at the higher feed rate (15 lb/MMacf). Thus, it was not tested above an injection concentration of 8 lb/MMacf.

Conclusions

Seventeen sorbents were evaluated at Valley Power Plant during this reporting period to assess the effectiveness of low cost sorbents injected for mercury control at plants burning a blend of bituminous coal and pet coke. Testing was conducted in the COHPAC slipstream configuration. Data analysis is continuing. Initial results indicate:

- In the screening evaluations, six of the carbon-based sorbents (FGD, CFA, LAC, 2002-8680, 2002-8567, and A10) demonstrated similar performance (mercury removal due to sorbent injection of greater than 90%). Three of the sorbents (HOK, CS80, and G) removed greater than 70% but less than 90% of the mercury in the flue gas. Six of the sorbents (E-1-S, IAC 020430-B, PSI-C, 020513-B, 020930-C, and TDAC) removed less than 50% of the incoming mercury and two sorbents (S1 and A) removed no mercury.
- The two COHPAC bag types tested, a high permeability 7.0-denier PPS felt Torcon and 2.7-denier PPS (Ryton) felt, performed differently. The Torcon bags consistently showed lower mercury removals for all sorbent types, injection rates and temperatures.
- During the parametric evaluations, the performances of the three sorbents were comparable. The mercury removal across the Ryton bag was slightly better than across the Torcon bag. Although, at the higher injection rates for the sorbent A10, the mercury removal across each bag type were consistent.
- Temperature had a slight affect on sorbent performance in the COHPAC configurations for the CFA and A10 sorbents. The FGD showed a decrease in performance at the higher temperature at the lower injection rate.
- Mercury removal improved with residence time for all three sorbents (FGD, CS80, and CFA) tested in the residence time chamber configuration. CS80 demonstrated a lower mercury removal at the higher temperature.

- The economics and performance of the novel sorbents evaluated demonstrate that there are alternatives to the commercial standard. Smaller enterprises certainly have the opportunity to provide a lower price to their customers under the right set of circumstances.
- Ongoing tests and analysis will yield waste characterization results for the COHPAC long-term tests.

Future Sorbent Evaluations

Apogee will be conducting additional novel sorbent evaluations for mercury control at We Energies' Pleasant Prairie Power Plant (P4) in late August 2003. The statement of work (SOW) is very similar to that of the original SOW for both Powerton and Valley. Sorbent vendors have been contacted and new sorbents that meet the original solicitation will be considered for evaluation at P4.