

AN UPDATE ON CARBON-BASED CONCRETE-FRIENDLY MERCURY SORBENT

Yinzhi Zhang, Sid Nelson, Jr., Quihui Zhou
and Ronald Landreth

Albemarle Corporation,
1664 E. Highland Road, Twinsburg, OH

Introduction

Activated-carbon-based mercury sorbent injection has become the dominant method that U.S. coal-fired power plants are employing to reduce mercury emissions[1]. However, when standard carbon-based mercury sorbents used for mercury emission control they become mixed with the fly ash from coal-fired power plants, and the ash can no longer be sold for its highest-value use as a replacement for cement in concretes. Approximately 20% of U.S. power plant fly ash is profitably sold for use as a substitute for cement in concrete[2].

As reported at Carbon 2007[3], Sorbent Technologies (now part of Albemarle Corporation) developed a carbon-based concrete-friendly™ mercury sorbent, C-PAC™. C-PAC™ allows power plants to continue to sell their fly ash while still injecting a carbon sorbent. An update on the commercial application of this novel sorbent in various plants is provided in this paper.

Experimental

Material: C-PAC™ is brominated activated carbon, which is gas-phase brominated using the method described in details elsewhere[4].

Acid Blue 80 Index: The acid blue 80 adsorption of an activated carbon is determined by contacting a standard AB-80 solution (100mg/l) with different dosages of test activated carbon. The adsorption capacity, Acid Blue 80 Index, is calculated from the Freundlich isotherm plot[5].

Bromine Content: Schonige combustion/AgNO₃ titration.

Iodine number: The adsorption of iodine from a standard iodine solution is tested following the ASTM D4607 method[6].

Particle Size: The particle size is tested by an air jet sieve (Hosokawa Micron) following the ASTM D5158 method[7].

Mercury Reduction Test: C-PAC was injected into the ductwork of the power plants, and then collected, together with fly ash, by the existing particulate control device, such as an electrostatic precipitator (ESP). The mercury content in the flue gas was tested by Hg continuous emission monitors (Hg-CEM) from PS Analytical and Ohio Lumex. Additionally, an Appendix K Mercury Sorbent Trap Sampler was also used in this program to measure the total mercury content of the flue gas. More details of these full scale trials can be found in the next section.

Results and Discussion

The typical properties of C-PAC™ are listed below in Table 1. C-PAC™ has an Acid Blue Index less than 15mg/g and contains 7wt% bromine.

Table 1. Typical properties of C-PAC™

	Properties
Acid Blue 80 Index, mg/g	<15
Bromine, wt%	7
Moisture, %	8
Iodine Number, mg/g	>500
Tapped Bulk Density, lbs/ft ³	35
Particle Size, less than 325mesh %	>95
Ash Content, wt%	<12
Ignition Temperature, °C	>400

C-PAC™ has been tested in 14 full-scale power plants, as shown in the below map (Figure 1), and is currently being shipped to customers daily.

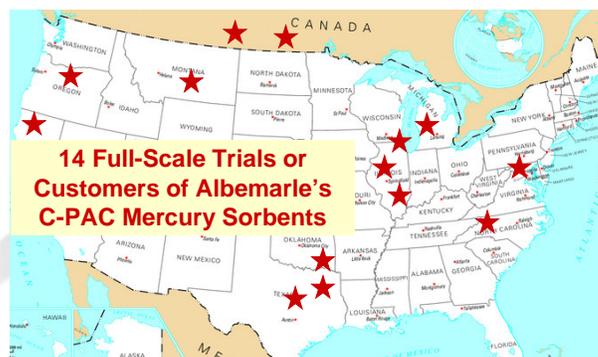


Figure 1. The Map of 14 power plants which have tested or are commercially using C-PAC™

Three of these full-scale C-PAC™ trials and results are presented below with more details.

a. Crawford Trial

The first full-scale demonstration trial of C-PAC™ was conducted at Midwest Generation's Crawford Station Unit 7 in Chicago in the summer of 2006 by Albemarle Sorbent Technologies with support from the Department of Energy. The Midwest Generation Crawford Station Unit 7 fires PRB coal and has an ESP with an SCA of only 120 ft²/Kacfm. The flue gas flow rate to ESP is approximately 460,000acfm at full load.

During the month-long continuous injection test, C-PAC™ was injected at an injection rate of about 4.6 lb/MMacfm. An average total mercury removal rate of 81% was achieved, as presented in Figure 2.

The fly ash from the long-term trial was extensively tested by two major fly ash marketing companies, Lafarge and Headwaters Resources, as well as by Albemarle Sorbent Technologies. The long-term fly ash passed all of the criteria necessary to be deemed acceptable for concrete use. With the addition of somewhat higher concentration of air entraining

admixture, it produced concrete with the same properties as concrete containing only baseline fly ash or no fly ash at all.

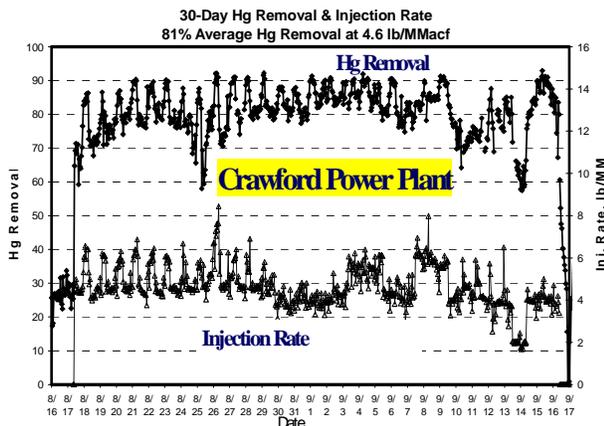


Figure 2. Mercury Removal and Injection Rate of C-PAC™ during the Crawford Trial

Fly ash samples from the baseline and long-term test periods at Crawford 7 were also tested for mercury leaching properties with de-ionized water (DI), an acetic acid solution as per the Toxic Characteristic Leaching Procedure (TCLP), and with an alkaline Na_2CO_3 solution per the Synthetic Groundwater leaching Procedure (SGLP).

The results of the leaching tests indicated that the mercury in the fly ash samples containing the mercury sorbent was not significantly leached out. The fly ash with mercury sorbent generally exhibited a lower rate of mercury release even though it contained as much as two orders of magnitude more mercury. In all cases except for distilled water, the mercury leachate concentration for the long-term fly ash samples was below that of the extraction water. These findings are understandable since the C-PAC™ bonds the mercury so it cannot be released and since the sorbent has more capacity with which to capture more mercury in the solutions.

b. Weston trial

C-PAC™ was recently tested in another power plant, Wisconsin Public Service's Weston unit 3. The generation capacity of Weston 3 is 360MW. Weston 3 also burns PRB coals and has a fabric filter for particulate control. More details of the power plant configuration is shown in Figure 3. C-PAC™ was injected before the air preheater (APH) at this site.

The plant is able to meet 80% to 85% mercury reduction target at the C-PAC™ injection rate of only 0.25 lb/MMacf, even C-PAC™ was injected on hot-side of APH at 430°C to 450°C.

The fly ash collected during C-PAC™ injection has been tested and the conclusion made by Weston is that it is acceptable for use in concrete.

Weston Power Plant Unit 3

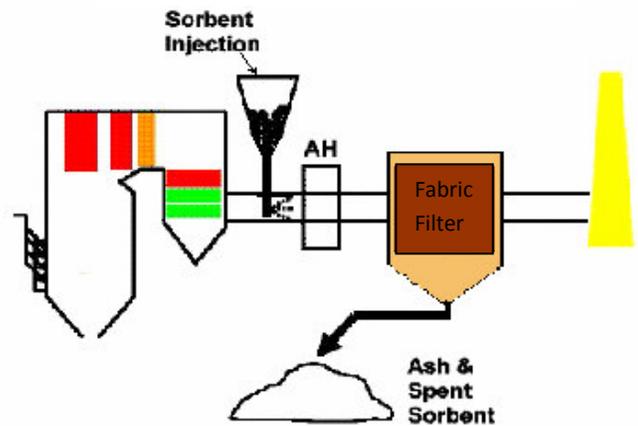


Figure 3. C-PAC™ trials at Weston 3

c. Another recent trial

Recently, C-PAC™ was also tested in another power plant. The plant duct has a positive pressure and a difficult geometry. C-PAC™ was injected before the air preheater at about 427°C.

The plant is able to meet the state mercury emission control requirement of 0.9 lb/TBtu by injecting 2.0 to 2.5 lb/MMacf C-PAC™. The fly ash collected containing C-PAC™ has been tested and accepted by the power plant for sale to the concrete market.

Conclusions

C-PAC™ was successfully developed to achieve a high level of Hg reduction while retaining fly ash sales for concrete. Truck loads of C-PAC™ are now being shipped to customers daily.

References

- [1] Thomas J. Feeley, III and Lynn A. Brickett, DOE/NETL's Mercury Control Technology R&D Program – Taking Technology from Concept to Commercial Reality,
- [2] American Coal Ash Association, 2008 Coal Combustion Product (CCP) Production & Use Survey Report
- [3] Zhang Y, Nelson S Jr., Zhou Q, Development of carbon-based concrete-friendly mercury sorbent, Proceedings of Carbon 2007, Seattle, 2007.
- [4] Nelson S Jr., Sorbents and methods for the removal of mercury from combustion gases, US Patent 6,953,494, 2005
- [5] Zhang Y and Nelson S Jr., Development of a new method to replace the foam Index Test, Proceedings of World of Coal Ash, Lexington, 2007
- [6] ASTM D4607: Standard test method for determination of iodine number of activated carbon.
- [7] ASTM D5158: Standard test method for determination of particle size of powdered activated carbon by air jet sieving.