

**ANNUAL PROJECT REPORT
AS OF DECEMBER 2004**

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| 1. <u>Project Sponsor</u>
Department of Mechanical Engineering
Ohio University
Athens OH 45701-2979 | 2. <u>Project Manager</u>
Dr. David J. Bayless
<i>bayless@ohio.edu</i>
Telephone: (740) 593 0264 |
| 3. <u>OCDO Grant No.</u> OCRC3-04-B.4.1. | 4. Project Update or Final Report X |
| 5. <u>Project Title:</u> <u>Capture of Air Toxics by Membrane Electrostatic Precipitator with Reagent</u> | |
| 6. <u>Project Term:</u> From: September 1, 2003 To: August 31, 2004 | |
| 7. Budget | |
| <u>Name</u> | <u>Cost Share</u> |
| OCDO | \$50,000 |
| Ohio University | \$48,651 |
| Total Project Cost | \$98,651 |

I. ABSTRACT

8. Overview of Project and Objectives

The goal for the proposed program is to develop cost-effective control technology for mercury and other air toxics using novel membrane-based wet electrostatic precipitation to enhance the use of Ohio coals. The first year of this work focused on three areas – first, the collection of oxidized mercury (Hg^{2+}) species, second, the use of photocatalytic “sorbents” to oxidize and capture elemental Hg (Hg^0) and the use of non-thermal plasmas to oxidize elemental mercury. The data collected in the first year indicated that capture of oxidized species of mercury was dependent on the chemistry of the species. For example, HgO was less effectively captured than HgCl_2 . Further, the results indicated that injection of aerosol TiO_2 , with augmented levels of *uv* radiation, was very effective at capturing elemental Hg. However, TiO_2 is not a cost-effective Hg sorbent, so other options had to be considered. Recent experimentation has found that by injecting Cl_2 through the discharge electrodes, a non-thermal plasma of dissociated Cl atoms could be created. This plasma was shown to very effectively (>90%) oxidized dilute mixtures ($5 \mu\text{g}/\text{m}^3$ of bulk gas flow) of elemental mercury in simulated flue gas.

For Year 4 of the Consortium, work was redirected to examine different potential oxidizing reagents in the presence of a typical Ohio coal flue gas containing SO_2 , NO, particulate matter, oxygen, water vapor, and HCl. Finally, the ultimate in the closing year of this work is to provide data so that the partners involved in this project, and co-funded by the Department of Energy under grant DE-FC26-02NT41592, can scale it to pilot-scale testing.

9. Work Done and Conclusions

The work done this year has been to examine the effectiveness of various chlorinating agents in the oxidation and subsequent capture of Hg^0 in a wet-membrane electrostatic precipitator via a non-thermal plasma technology known as Plasma Enhanced Electrostatic Precipitation (PEEsP). The testing results can be found in project reports, but the basic conclusions are as follows

- a) Cl_2 is a superior chlorinating agent (via PEEsP) compared to all other agents tested
- b) Chlorinating agents (such as HCl and Cl_2) are superior to other oxidizing agents, including steam (producing various oxidized mercury species), as HgCl_2 is easily captured in a wet membrane precipitator
- c) Cl_2 concentrations as low as 100 ppm have been shown to oxidize and promote capture to levels exceeding 90%
- d) Because we are measuring such high levels of capture, it follows that the oxidized mercury species are forming aerosols, because pure gases are not easily captured in electrostatic precipitators
- e) In order to observe 90% oxidation of mercury (which is injected at levels $\approx 5 \mu\text{g}/\text{m}^3$) by 100 ppm of chlorine, in such a short residence time, two effects must be present.
 1. Excellent mixing, which is likely possible because of the transport from the discharge electrodes (as shown in Figure 1) and

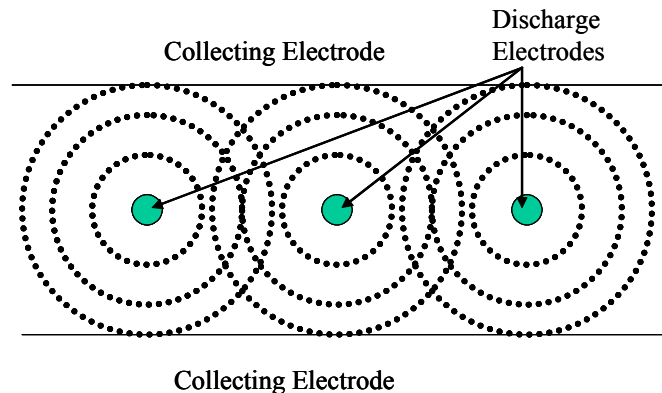


Figure 1. Path of the chlorinating ions moving from the discharge electrodes towards collecting electrodes

2. Excellent oxidizing potential by the oxidizing agent.

- f) HCl and FeCl_3 were also found to oxidize Hg^0 to Hg^{2+} , but not as effectively as Cl_2 .
- g) Because both these factors (in e.) are apparently present, the potential for scaling this process to a large precipitator, such as the pilot unit at the Bruce Mansfield Plant, is outstanding

10. Plans for Coming Year

None.

II. HIGHLIGHTS/ACCOMPLISHMENTS

11. In addition to the testing described in (9), the highlight of the year was completion of the testing of a pilot-scale wet membrane precipitation unit at FirstEnergy's Mansfield Station. This Department of Energy sponsored this project (at approximately \$600,000) , which teamed Croll Reynolds Clean Air Technologies with Southern Environmental Inc., FirstEnergy, and Ohio University to test pilot wet precipitation units using both metal plates and fabric membranes. Part of the testing quantified the removal mercury across the precipitator for both plates and membrane collectors, as well as to quantify the removal of acid aerosols and soot particles.

III. ARTICLES/PRESENTATIONS

12. Bayless, D., Shi, L., Kremer, G., Stuart, B. Reynolds, J., and Caine, J., "Demonstration of Membrane-Based Wet Electrostatic Precipitation," accepted for publication (paper # AW-04-00182) in the *Journal of the Air and Waste Management Association*, 2004.
13. Bayless, D., Shi, L., Kremer, G., Stuart, B. Reynolds, J., and Caine, J., "Membrane-Based Wet Electrostatic Precipitation," paper #610, presented at the Annual Meeting of the *Air and Waste Management Association*, June 2004