ANNUAL PROJECT REPORT
AS OF DECEMBER 1999

1. PROJECT SPONSOR:

Aerosol & Air Quality Research Laboratory
Dept of Civil & Environmental Engineering
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2. PROJECT MANAGER

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3. OCDO GRANT NO. OCRC/2-96-1, B4.7

4. PROJECT: UPDATE

5. PROJECT TITLE: Control of Toxic Metallic Emissions Formed During the Combustion of Ohio Coals

6. PROJECT TERM: from September, 1999 to August, 2000

7. PROJECT	**NAME**	**COST SHARE**
CO-SPONSORS:	OCDO	$75,000
	Univ. of Cincinnati	$25,023
TOTAL PROJECT COST:		$100,023

I. ABSTRACT

8. OBJECTIVES

The overall goals of the proposed study are to examine metallic species behavior in coal combustion environments, and develop control strategies. The vapor phase sorbent technique developed (Owens and Biswas, 1996a, Ind. Eng. Chem. Research, vol. 35, 792-798; Owens and Biswas, 1996b, J. Of the Air and Waste Mgmt. Associn., vol. 46, 530-538; Biswas and Zachariah, 1997, Env. Sci. Technol., 31, 2455) has been shown to be effective in capture of metallic species. The technique will be further developed for capture species such as mercury and several trace metal species present in coal. The emphasis will be on the use of trace quantities of sorbent materials for cost effective removal of metallic species.

The proposed project would lay the ground work for metals emissions to be controlled. It is anticipated that existing flue gas desulfurization systems with some modification can be used for metallic species control. The development of such control technologies will increase the usage of Ohio coal. Results of this

study will clearly indicate the degree of metallic species emissions and help develop control strategies. Previous work supported by OCDO has resulted in the filing of an US Patent and has attracted the attention of several companies, which will have a positive impact on the usage of Ohio coal.

9. WORK DONE AND CONCLUSIONS

The project is a continuation on development and evaluation of novel mercury control methodologies and study of mercury kinetics in combustion system. There has been extensive work carried out on the development of novel gas phase sorbent precursor injection methodology for capture of mercury. The primary advantage of the developed method is that trace quantities of sorbent material can be effectively used to capture the mercury species released on combusting coal. Extensive study on the various sorbent material for their mercury capture capabilities show that titania is very effective in the presence of UV irradiation under the various simulated conditions of real combustor/incinerator systems. Further testing of the titania precursor methodology was performed under a wide range of temperatures in the presence of UV irradiation. Results have indicated that titania is effective for mercury capture over a wide range of temperatures. It is also clear that several competing effects establish the capture characteristics. Experiments under the simulated combustion flue gas with SO_2 have indicated that it tends to inhibit the capture of mercury; however the high capture efficiency is realized on increasing the feed rate of the sorbent precursor. Also, titania in the presence of UV has been shown to be effective in mercury capture even in the presence of large amount of chlorine species (HCl, CH_2Cl_2). Extensive work has been done on the kinetic study of the heterogeneous chemical transformation of mercury species on the surface of titania particles. The study on the kinetic rate of mercury oxidation by titania under UV light has been initiated at various residence time and reactant concentration. Oxidation of mercury was studied at various reaction temperature. Preliminary studies on the heterogeneous mercury reaction with in situ generated fly ash (total & submicrometer size) has been carried out. The results will be used to identify the fate of mercury (not only qualitatively but also quantitatively) in real coal combustion system and ultimately provide the optimal mercury control condition using the proposed technology (TiO_2+UV) show that the reaction kinetics at various reaction temperature

10. PLANS FOR COMING YEAR

The work to be performed in 2000 will focus on the chemistry of mercury in real coal combustion environments. Heterogeneous mercury reaction with in situ generated fly ash particles (total & submicrometer) will be investigated for their kinetic parameters. Also, homogeneous gas phase mercury reaction in the presence of chlorine species will be studied along with the effectiveness of the

titania sorbents in the capture of mercury in the presence of UV irradiation. Establishing the pathways of mercury transformation are critical to the development of effective sorbent methodologies for its ultimate control. Kinetic data for the transformation and capture of mercury species will be obtained, and used in the modeling studies. The results of the metals capture studies will demonstrate the use of potential technologies for reducing metallic emissions.

II. HIGHLIGHTS AND ACCOMPLISHMENTS

Extensive kinetic study of the mercury uptake by in-situ generated titania particles using the novel gas phase sorbent injection technique in the presence of UV irradiation has been carried out for simulated flue gas, whose technology has been shown to be effective for mercury capture for a wide range of flue gas temperature under UV irradiation. The effectiveness has been proven in the presence of high concentrations of SO_2, HCl and CH_2Cl_2. The cost calculations indicate that the gas phase sorbent precursor injection technique is significantly cost effective than activated carbon methodologies (Wu et al., 1997, 1998). Due to the potential of this methodology for Hg control, a US Patent Application has been filed. (see 1997 OCDO Final Report). Also, preliminary study of mercury reaction with fly ash (total & submicrometer size) particles in coal combustion system has been performed. More experiment will be followed extensively to evaluate the kinetic parameters of mercury-fly ash reaction.

III. ARTICLES/PRESENTATIONS

List of Publications and Conference Presentations Resulting from Previous Work Supported by OCDO (September 1997 to September 1998)

Biswas P. and Zachariah M.I.(1997) “In situ immobilization of lead species in combustion environments by injection of gas phase silica sorbent precursors”, Env. Sci. Technol., 31, 2455.

Wu, C. Y., Lee, T. G., Arar, E., and Biswas, P. (1997) “Novel *In Situ* Generated Sorbent Methodology and UV Irradiation for Capture of Mercury in Combustion Environments,” Proc. EPRI-DOE-EPA Combined Utility Air Pollutant Control Symp., Electric Power Research Institute, Washington, DC, Aug.25-29.

Biswas, P., and Wu, C. Y.(1998) “Control of Toxic Metal Emissions from Combustors Using Sorbents: A Review”, J. of Air & Waste Mgmnt. Assocn., 48, 113.

Biswas, P. (1998) “Mechanisms of Volatile Metallic Species Aerosol Formation in Combustion Environments and Control of Emissions”, 17th Annual AAAR Conference, June 22-26, Cincinnati, Ohio.

Lee, T. G. “Study of Mercury Kinetics and Control Methodologies in Simulated Combustion Flue Gases,” Ph.D. Thesis, Advisor: Prof. Pratim Biswas, Department of Environmental Engineering, University of Cincinnati, 1999.

Lee, T. G., Yang, G., and Biswas, P.(1999) “Comparison of the Electrical Mobility Equivalent Radius and Light Scattering Inferred Radius of Gyration for Silica”, to be submitted to, Aerosol Sci. Tech.

Lee, T. G., and Biswas, P.(1999) “Comparison of the Mercury Capture Efficiencies Using Different Sorbents in Simulated Combustion Flue Gases”, to be submitted to, AIChE J.

Lee, T. G., and Biswas, P. (1998) “Study of Various Sorbent Materials for their Mercury Capture Efficiencies in the Combustor/Incinerator with Controlled Chemical Environment”, 17th Annual AAAR Conference, June 22-26, Cincinnati, Ohio.

Lee T. G., and Biswas, P.(1998) "Kinetics of Mercury Capture Using Titania Sorbents", J. Aerosol Sci., vol. 29, S577-578.

Lee, T. G., and Biswas, P. (1998) “Kinetics of Mercury Capture using Titania Sorbents”, 5th International Aerosol Conference, Sep. 14-18, Edinburgh, Scotland.

Lee, T. G., and P. Biswas, “Kinetics of Heterogeneous Mercury Reactions with Sorbent Particles: In Situ Capture Methodology,” *1999 Annual Meeting of Air & Waste Management Association*, G1-410, June 20-24, St. Louis, MO (1999).

Lee, T. G., and P. Biswas, “Kinetics of Heterogeneous Mercury Reaction with TiO_2 Particles: In Situ Capture Methodology,” *18th Annual AAAR Conference*, October 11-15, Tacoma, WA (1999).

P. Biswas, Y. Zhuang, T. G. Lee, E. Arar, “Kinetics of Mercury –Coal Fly Ash Reactions,” The Combustion Institute, 28th International Symposium on Combustion, July 30-August 4, paper submitted.

Wu, C.Y., and Biswas, P.(1998) "Study of Numerical Diffusion in a Discrete-Sectional Model and Its Application to Aerosol Dynamics Simulation", to appear, Aerosol Science and Technology, vol. 29, 359-378.

Wu, C. Y., Lee, T. G., Arar, E., and Biswas, P.(1998) “Capture of Mercury in Combustion Systems by In Situ Generated Titania Particles with UV Irradiation,” Environ. Eng. Sci.,15, 137.

Zhuang, Y., and Biswas, P.(1999) “Formation Mechanism of Submicrometer Particle from Pulverized Coal Combustion”, to be submitted to, Energy & Fuels.

Zhuang, Y., Kim, Y. J., Lee, T. G., and Biswas, P.(1999) “Experimental and Theoretical Studies of Ultra Fine Particle Capture in ESPs,” to be submitted, Aerosol Sci. Tech.