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# Newsletter for August *2005*

For better communication with our friends, we plan to send this newsletter to you every month to let you know what is happening at the Thermal Analysis and Combustion Laboratories at Western Kentucky University. This newsletter was suggested to us by one of our advisory board members.

We always appreciate your suggestions and comments. Please let us know if you do not wish to receive this newsletter, and we will remove your name from our mailing list.

## Thermal Analysis Laboratory

ICSET was mentioned in the Journal of Materials Research Society of Japan, Vol.17, No. 3 August 2005, p4-5. A copy of article is presented below:

■研究所紹介■

Institute of Combustion Science and Environmental Technology (ICSET), Western Kentucky University

編集委員注：ウエスタンケンタッキー大学燃焼科学環境技術研究所は、ケンタッキー州ルイビルの南約180 km、テネシー州ナッシュビルの北約65 kmに位置する人口5万人の町ケンタッキー州ボーリングリーンにある（かつてトヨタや住友化学など日本企業の工場もあった）。南部ではかなりレベルの高い大学として認められており、150以上の専攻がある。全米ならびに46カ国から1万5千人の学生が在籍している。ICSETは3つの研究所―すなわち、熱分析研究所、燃焼研究所、水銀排出研究所、の統合体である。現在21人が在職しており、教授2人、助教授1人、10人の博士号取得者が研究に従事している。同研究所の運営は、DOE（米国エネルギー省）、NASA（米国航空宇宙局）、EPRI（米国電力研究所）、USDA（米国農務省）などの国家プロジェクトや企業の研究受託費によってまかなわれている。2002-2004年の間の受託プロジェクトの24件（総額$5,356,001）を含め、2004年までの累積受託件数は73件である。

***The Thermal Analysis Laboratory*** **(Fig. 1, Fig. 2)** is one of the best, if not the best, equipped thermal analysis laboratories in the United States. Since 1987 there have been many research projects conducted in this laboratory, including several federal and industrially related projects. For example, in collaboration with the Air Force Research Laboratory at WPAFB, Southern Clay Products, Inc., and Triton Systems, Inc., Dr. Pan's research team is studying the thermal stability, degradation mechanisms, and the properties of a specific polymer made from originally modified layered silicate nanocomposites. The goal of this project is to produce materials with properties suitable for cryogenic tanks for the aerospace industry.

Instrumentation:

Thermogravimetric Analyzer (TGA), Differential Scanning Calorimeter (DSC), Thermomechanical Analyzer (TMA), Dynamic Mechanical Analyzer (DMA), Simultaneous Thermogravimetric/Differential Thermal Analyzer (SDT), Dielectric Analyzer (DETA), Micro-Thermal Analyzer (μTA), Rheology, TG/FTIR, TG/MS, GC/TOF-MS/ThermEx, LC/MS, SEM/EDX and Optical Microscope/Image Analysis System, X-Ray Differaction Spectrometer, Thermo-IR

***The Combustion Laboratory***, which was established in 1992, focuses on the behavior of chlorine, sulfur, and mercury during combustion. Since the construction of the 0.1 MWth Laboratory scale Fluidized-Bed Combustion (FBC system) in 1995, over half a million dollars in research funding has been received from the U. S. Department of Energy, the Electric Power Research Institute, the Illinois Clean Coal Institute, and TVA. This FBC system has been involved in over 7000 hours of testing. This amount of testing time is the longest time that has been conducted by any University FBC system in the United States.

The Combustion Laboratory at Western Kentucky University is one of the five laboratories (Philips, EERC, Consol and TestAmerica) in North America capable of conducting Continuous Emission Monitoring (CEM) and the Ontario-Hydro Method (OH method) for mercury emissions in power plants. A mobile (53-foot) laboratory has been constructed at WKU and used at power plants. There are no interruptions in the power plant operation when we conduct the experiments.

The laboratory has been awarded a two million dollar grant from the U. S. Department of Energy for their project "Establishment of an Environmental Control Technology Laboratory with a Circulating Fluidized Bed Combustion System." The primary objective of this project is to establish an Environmental Control Technology Laboratory (ECTL) using a multifunctional circulating fluidized bed combustion (CFBC) system **(Fig. 3)**. The system can be easily configured to make combustion runs with various fuels under varying conditions to analyze and monitor air pollutant emissions, as requested by the lab's industrial partners.

The ECTL will help develop technologies that can be used to control emissions under multi-pollutant control legislation that is under consideration by Congress. The successful development of these technologies will provide scientific data on atmospheric pollutants resulting from combustion systems, and the methodologies required to reduce the emission of these pollutants across the United States. This grant award comes as a result of cooperative efforts between the Department of Chemistry and the Department of Architecture & Manufacturing Science through the Applied Research and Technology Program.

Fig. 1 An overview of Thermal Analysis Laboratory

Fig. 2 Operating TG/MS (left) and Q-series TG (right)

## Mercury Emission and Control Laboratory

**Trace Elements Determination in "Cuenca Cesar Rancheria – Colombia—second year":** The main purpose of this study is to determine the amount of trace elements (Hg, As, Pb, Se and Cd) in coal at four different locations of "Cuenca Cesar Rancheria – Colombia" Those areas are called "La Loma, El Descanso, La Jagua and Carrejon". Ninety-percent of Colombian coal exportation comes from these four areas. The spatial distribution of trace elements can be used for future extraction in order to satisfy the International markets and environmental laws. Four Colombian coals have been chosen to study mercury and other trace elements behavior during combustion at the WKU combustor. Gas phase Hg speciations and trace element analysis for the coal ash will be investigated. The coal contains between 0.18ppm and 0.33ppm mercury.

**In order to comply with the EPA mercury emission standards,** it is critical for the power industry to determine the amount of mercury emitted within the existing control devices. It is also critical to identify the mercury species--elemental form ($Hg^0$), oxidized form ($Hg^{2+}$) and particle-bound forms ($Hg^P$)--at various locations throughout the APCD train. However, such analysis is not an easy job. There are three mercury speciation measurement methods available, namely ASTM Method D6784-02, commonly known as the Ontario Hydro Method (OHM), ICSET Semi-Continuous Hg Emission Monitor (SCEM), and EPA appendix K (Spiking System, see **Figure1**).

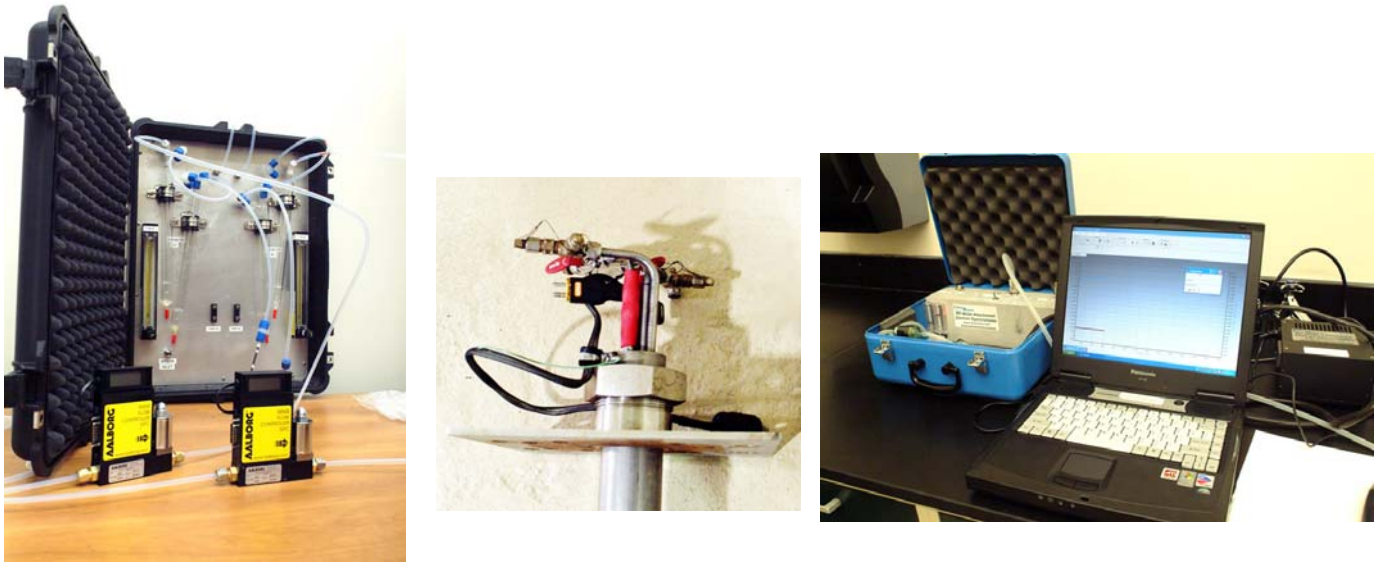

**Figure 1:** EPA Appendix K spiking, sampling and analytical instrumentation

ICSET field research team preformed a comparison test for mercury emission measurements across an electro-static precipitator (ESP) in September to cross check the method reliability and data integrity amongst the OHM, the SCEM, and the EPA appendix K.

Some general characteristics of each method are list as follows:

- **Ontario Hydro Method**
  - Wet chemistry
  - Snapshot, average speciated Hg data over a 1.5 to 2-hour sampling period
  - Limited data on mercury emission and its speciation
  - Biased data under ash rich conditions, such as sampling at the ESP inlet
- **Continuous Mercury Emission Monitor**
  - On-line, real-time data collected under changing conditions, as well as normal ranges of operating conditions
  - A statistical approach is scientifically defensible in accounting for plant operational variability
  - Reliability issues
  - Biased data under high temperature conditions, such as sampling at SCR inlet/outlet, APH inlet
- **EPA Appendix K**
  - A known volume of flue gas is sampled
  - Flow rates between 0.2 to 0.6 liters per min.
  - Each trap acid is leached and the product is analyzed via CVAFS from EPA 1631 or AA by EPA Method 29/ASTM D6784-02
  - Uses “sorbent traps” to capture the mercury.
  - These traps have to be handled very carefully due to easy contamination
  - Moisture interference
  - Not real-time data
  - Not suitable for high temperature applications

The testing results are fairly consistent at the ESP outlet. The total mercury curves (Hg(T)) for the three methods show a difference within 10%. However, during the testing, the two Appendix K “carbon traps” were plugged up with some fine particles only two hours after the test was initiated

At the ESP inlet, the two Appendix K “carbon traps” were plugged up even earlier than those at the ESP outlet. Therefore, less than two hours of flue gas sample was collected while originally the Hg data collection was scheduled to run 24 hours. The results of SCEM and Appendix K also show great consistency. However, due to the ash interference, the OHM data is lower than the other two methods.

# Combustion Laboratory

CO2 sequestration: Big progresses are made recently for DOE funded project *Development of a Method for Measuring Carbon Balance in the Chemical Sequestration of $CO_2$*. The experiment system was set up completely. This included: 1) designing and building six triple-cell growth chambers; 2) designing and building twenty glass impingers for collecting escaped $^{14}CO_2$; 3) designing and building special syringe for water injection, exhaust gas control; 4) installation of instrument for sample preparation and analysis; 5) collection and pre-treatment of more than 4000lbs soil for experiment. **Figure 2** shows a corner of the greenhouse. In addition, a preliminary test was performed successfully on corn, wheat, and lettuce in a simulated natural mature cycle (over 40 days) with non-$^{14}C$ fertilizer applied. The preliminary experiment tested important experiment parameters and offered extremely invaluable information for later on $^{14}C$-applied experiment. License of $^{14}C$ application in this project was eventually approved by Kentucky government. A paper entitled "Development of an analytical method for distinguishing ammonium bicarbonate from the products of an aqueous ammonia $CO_2$ scrubber" was submitted to *Analytical Chemistry* and has been accepted for publication.

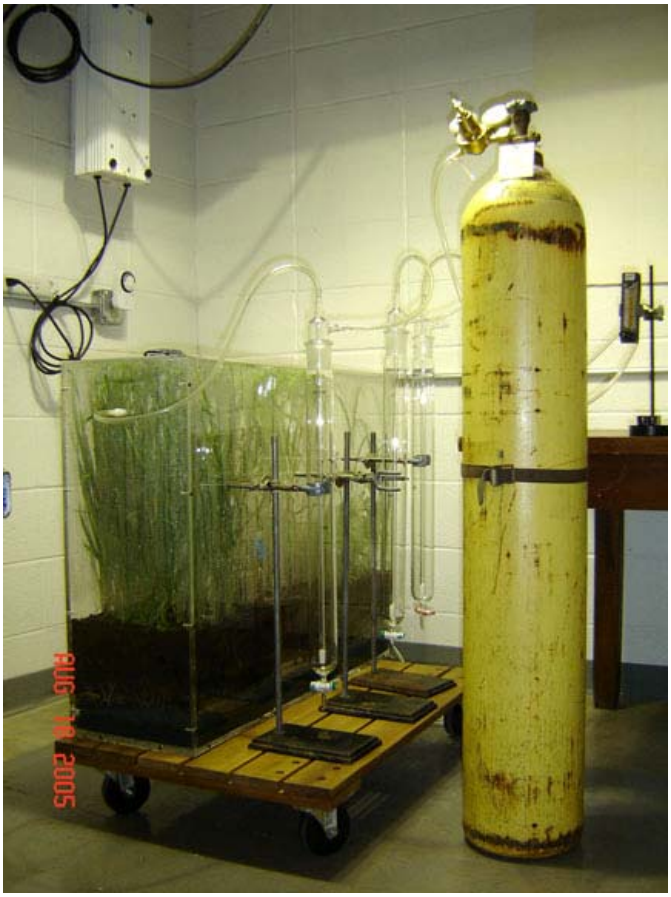


**Figure 2**