PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Environmental and Water Resources

12/2006

TOXICOLOGICAL EVALUATION OF REALISTIC EMISSIONS OF SOURCE AEROSOLS (TERESA): APPLICATION TO COAL-FIRED POWER PLANT-DERIVED $PM_{2.5}$

Objective

The primary objective of the Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA) program is to investigate and clarify the impact of the sources and components of fine particulate matter ($PM_{2.5}$) on human health via a set of realistic animal exposure experiments. Secondary objectives of the study include: (1) evaluation of the relative toxicity of coal combustion emissions and mobile source emissions, their secondary products, and ambient particles; (2) providing insight into the effects of atmospheric conditions on the formation and toxicity of secondary particles from coal combustion and mobile source emissions; (3) providing information on the impact of coal type and pollution control technologies on emissions toxicity; and (4) providing insight into toxicological mechanisms of PM-induced effects on normal and susceptible subpopulations.

Background

The TERESA program, managed by the Electric Power Research Institute (EPRI) and including the Harvard University School of Public Health as a key participant, was initiated in July 2002 with non-Department of Energy (DOE) sources of funding. The work is a significant improvement over previous studies to investigate the toxicity of coal combustion-derived PM by virtue of several highly innovative and unique design features. All toxicological studies of coal combustion emissions have used primary emissions, i.e., coal fly ash. The relevance of primary emissions to human population exposure is unclear, since primary emissions are now very low with the widespread introduction of particulate controls on power plants. It is the secondary PM formed from sulfur dioxide (SO_2) and nitrous oxide (NO_X) in stack emissions as well as any residual primary PM that is of interest. To date, no efforts to consider and account for secondary atmospheric chemistry have been made.

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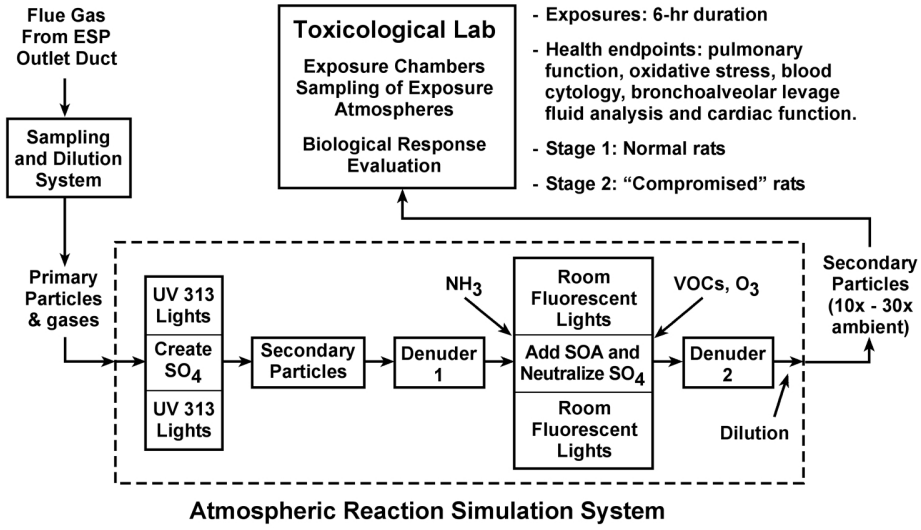
Summary

The DOE-EPRI Cooperative Agreement involves the analysis and interpretation of the field data collected at an Upper Midwest plant, followed by the performance and analysis of similar field experiments at two additional coal-fired power plants in the Southeast and Midwestern United States, utilizing different coal types and with different plant configurations. Emissions are introduced into a reaction chamber within a mobile laboratory to simulate oxidative atmospheric chemistry. Both primary and secondary materials are extensively characterized, including nitrogen dioxide, SO_2, ozone, ammonia, hydrocarbons, particle number and mass, sulfate, nitrate, elemental/organic carbon, ammonium, and metals. Test atmospheres containing realistic concentrations of primary emissions and oxidative products – including oxidized plant emissions and secondary organic aerosols (SOA) from other sources that are often present in real atmospheres – are utilized in two toxicological assessment steps within a separate mobile laboratory. The first step utilizes normal laboratory rats and the second uses rats that have been surgically compromised to model the responses of individuals with cardiovascular problems. This last step includes telemetric methods for the assessment of cardiac function.



Accomplishments

- Fieldwork was completed at the Upper Midwest power plant, which burns sub-bituminous coal. Primary particles extracted from the stack and diluted by the atmospheric simulation system within the mobile laboratory were found to be representative of particles actually being emitted from the stack.

- Three sets of animal exposures were performed at the Upper Midwest plant: (1) oxidized emissions + SOA, (2) oxidized and neutralized emissions + SOA, and (3) oxidized emissions. Toxicological assessments were carried out and no significant differences between the exposed and unexposed animals were observed.

- Fieldwork was completed at the Southeast power plant, which burns eastern bituminous coal. Five toxicological endpoints were evaluated at the Southeast power plant including (1) pulmonary function and breathing pattern, (2) bronchoalveolar lavage fluid cytological and biochemical analyses, (3) blood cytological analyses, (4) *in vivo* oxidative stress in heart and lung tissue, and (5) heart and lung histopathology. In some scenarios, pulmonary function data suggest subtle changes in some respirator parameters. The *in vivo* chemiluminescence data suggests that both lung and heart oxidative stress occur in response to several scenarios. No changes in histology, bronchoalveolar lavage fluid, or blood cytology were evident. Stage II assessment suggests no apparent effect of any of the scenarios on heart rate or on several measures of heart rate variability. However, one scenario did result in an increase in cardiac arrhythmias in exposed animals compared to control animals.

- Fieldwork was initiated at the Midwestern power plant, which burns an eastern bituminous coal. The exposure and toxicological data are currently being analyzed.

PERIOD OF PERFORMANCE

September 2003
to December 2008

COST

Total Project Value
$1,609,122

DOE/Non-DOE Share
$771,351 / $837,771

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Planned Activities

- Complete analysis of Midwestern power plant exposure and toxicological data.
- Prepare a topical report and peer-reviewed journal articles for the Midwestern power plant findings.

Issues

Pilot-scale combustors, which were used in many previous toxicological studies of coal plant emissions, may not accurately mimic actual stack emissions due to differences in surface to volume ratios and thus time-temperature histories. Some studies have also collected coal fly ash from power plant electrostatic precipitators and used this collected material in intra-tracheal instillation or *in vitro* studies. Neither of these modes of PM delivery is optimal due to the likelihood of extremely high tissue doses and the non-representative nature of the particles.