Interagency Agreement DE-A126-06NT42821

Recipient: National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Health Effects Laboratory Division

Title: Novel collection and toxicological analysis techniques for IC engine exhaust particulate matter

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Executive Summary

The project staff partnered with Costas Sioutas from the University of Southern California to apply the VACES (Versatile Aerosol Concentration Enhancement System) to a diesel engine test facility at West Virginia University Department of Mechanical Engineering and later the NIOSH Lake Lynn Mine facility. The VACES system was able to allow diesel exhaust particulate matter (DPM) to grow to sufficient particle size to be efficiently collected with the SKC Biosampler impinger device, directly into a suspension of simulated pulmonary surfactant. At the WVU-MAE facility, the concentration of the aerosol was too high to allow efficient use of the VACES concentration enhancement, although aerosol collection was successful. Collection at the LLL was excellent with the diluted exhaust stream. In excess of 50 samples were collected at the LLL facility, along with matching filter samples, at multiple engine speed and load conditions. Replicate samples were combined and concentration increased using a centrifugal concentrator. Bioassays were negative for all tested samples, but this is believed to be due to insufficient concentration in the final assay suspensions.

Goals versus accomplishments

1. Modifications to surfactant impinger sampler

The SKC Biosampler was evaluated and chosen as the collection device, and operation was optimized by variations in the flow rate (to a sub-sonic flow that improved efficiency), liquid level, and concentration of simulated surfactant in the collection medium, in such a way as to minimize aerosol impaction on the impinger walls downstream of the impactor jets above the liquid level.

2. Surfactant impinger sampler testing

DISCLAIMER

The sampling system, complete with a pump, liquid trap, and Biosampler was evaluated over a 2 day period at the west Virginia University Mechanical Engineering Department facility for diesel engine emissions. The Cummins diesel engine/dynamometer system was exhausted into a dilution tunnel system and the sampling system drew from a port in the diluted stream. Six samples were collected and later analyzed. Dr. Geller from the University of Southern California was onsite to operate and optimize the VACES system during sampling. The collection was successful, but the aerosol stream was too concentrated to fully realize the concentration enhancement capabilities of the system. The system was adapted for use at the NIOSH Lake Lynn mine facility by Dr. Aleks Bugarski of NIOSH to sample diluted exhaust in a mine drift from an Isuzu engine with various exhaust aftertreatments. Over 50 Biosampler samples were successfully collected, along with corresponding filter samples.

3 – Bioassays of impinger tests and bioassays

Initial bioassays of the WVU samples were negative, and calculations revealed that the resultant mass concentrations were lower than usual test concentrations. Techniques were developed using a centrifugal concentrator system to successfully enhance concentrations by an order of magnitude. All *Salmonella* mutagenicity assays were negative, but a single sample was positive for micronucleus induction.

4 - Data analysis, evaluation, and reporting

Data analysis of studies during the course of the Interagency agreement were presented at the Diesel Engine Emissions Reduction (DEER) conferences, as well as 2 journal publications, all listed below.

Summary of Project activities

1. Developed optimal methods for assay/extraction of diesel particulate matter
2. Completed comparison study of extracted and solubilized DPM samples
3. Demonstrated collection of DPM using the combined VACES/Biosampler system
4. Demonstrated collection at enhanced concentration with the VACES/Biosampler at the LLL facility of DPM diluted in the mine; 50 samples collected.
5. Developed method to concentrate DPM in collection medium by a factor of at least 10.
6. Completed genotoxicity assays on pooled surfactant samples and extracted filtered samples.

Presentations and publications

Presentations at Diesel Engine Exhaust Reduction (DEER) Conferences:
http://www1.eere.energy.gov/vehiclesandfuels/resources/proceedings/2002_deer_presentations.html#session5

http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2003/session9/2003_deer_wallace.pdf

http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2005/session2/2005_deer_wallace.pdf

http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2006/session4/2006_deer_wallace.pdf

http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2007/poster3/deer07_wallace.pdf

Peer-reviewed journal publications:

Gu Z-W, Keane MJ, Ong T, Wallace WE. [2005] "Diesel exhaust particulate matter dispersed in a phospholipid surfactant induces chromosomal aberrations and micronuclei but not 6-thioguanine-resistant gene mutation in V79 cells in vitro". J Toxicology & Environmental Health, Part A, Vol. 68(6) 431-444.

Liu Y-Q, Keane M, Ensell M, Miller W, Kashon M, Ong T, Mauderly J, Lawson D, Gautam M, Zielinska B, Whitney K, Eberhardt J, Wallace WE. "In vitro genotoxicity of exhaust emissions of diesel and spark-ignition gasoline engine vehicles operated on a unified driving cycle". Journal of Environmental Monitoring 7: 60-66 (2005).