California Energy Commission
Public Interest Energy Research (PIER) Program
TRANSPORTATION ENERGY RESEARCH

Assessment of Particulate Matter from Heavy- and Light-Duty Vehicles for Various Fuel Types

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Fact Sheet

The Issue

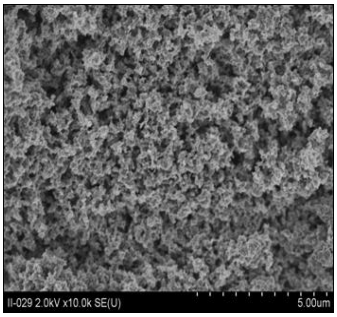
Epidemiological and toxicological studies have demonstrated links between ambient particulate matter and illnesses, which range from cancer to cardiopulmonary disease. Health effects are particularly associated with ultrafine (less than 0.1 micrometer in diameter) particulate matter that penetrates deep into the lungs. In urban environments, such as Los Angeles, the dominant source of ultrafine particulate matter is motor vehicle emissions.

In addition to ultrafine particulate matter, semi-volatile particulate matter in vehicle emissions is extremely important in terms of its contributions to human exposure. Depending on vehicle type, age, and ambient conditions, between 70-90 percent of particulate matter emitted from vehicles by *number*, and 10-30 percent by *mass*, are semi-volatile. When heated, semivolatile particulate matter will partially or completely evaporate. These facts represent a need to investigate the ultrafine and semivolatile particulate matter vehicle emissions.

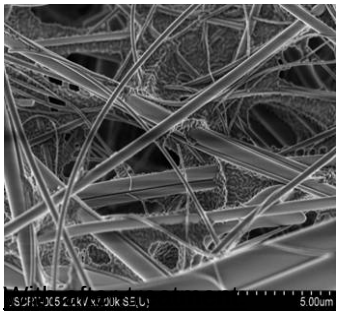
Project Description

This research will determine the relative toxicity of all particulate matter fractions in heavy- and light-duty vehicle emissions that operate with, and without, control technologies. Heavy-duty diesel engines will be tested with and without controls for advanced particulate matter and oxides of nitrogen. Identical particulate matter emission testing methods will be adopted for the light-duty vehicle portion of the study, which will include a compressed natural gas car. The physical, chemical, and toxicological properties of emissions from the compressed natural gas car will be compared with emissions from other fuel types (diesel, biodiesel, gasoline, E85 ethanol), as well as heavy-duty vehicle emissions.

Emissions collected from a Teflon filter sampling from the exhaust of a diesel vehicle



Without after-treatment: Visible agglomerates of soot.



No visible agglomerates of soot. Only the fibers that make up the filter media are visible.

Image Credit: Dr. Su., Fritz-Haber Institute

The systems are evaluated by placing a vehicle on a dynamometer (a large treadmill for vehicles) and exercising it over various driving cycles. While running the vehicle, emissions will be captured and characterized. Testing is conducted in the California Air Resources Board's vehicle emission laboratories. The testing will use the unique University of Southern California particle concentrator technology for collection of sufficient emission samples for subsequent toxicological analysis. The particle concentrator is a particulate matter collector that can capture particulate matter that is coarse (between 2.5 and 10 micrometers), fine (between 0.1 and 2.5

micrometers) and ultrafine. This project will attempt to determine which fractions of the emissions are responsible for illnesses, the extent of those effects, the physical and chemical nature of the emissions, and the effectiveness of control technology at reducing the toxicity of exhaust particulate matter.

To comply with the Air Resources Board's most stringent emission standards, which took effect in 2010, most engine makers have chosen an after-treatment approach. The diesel particle filter (commonly known as a trap) will be widely used to control particulate matter and select catalytic reduction to control oxides of nitrogen. A conventional oxidation catalyst will control hydrocarbon and carbon monoxide emissions.

Preliminary Results

The results of the heavy-duty diesel truck testing show that after-treatment systems can meet their design goals. A well-functioning diesel trap can reduce particulate matter emissions by more than 95 percent. Similarly, when a trap is integrated with selective catalytic reduction, it achieves a decrease of more than 70 percent in oxides of nitrogen. The same after-treatment technology, when applied as original equipment, can be improved to yield greater emission reductions and better durability. Diesel after-treatment systems can provide the reductions in particulate matter and oxides of nitrogen required by the diesel control program, resulting in corresponding health benefits. Based on a reduction of diesel particulate matter, the relative cancer risk is reduced by more than 90 percent.

PIER Program Objectives and Anticipated Benefits for California

The objective of this research is to characterize particulate matter emissions from light- and heavy-duty vehicles. These measurements, when combined with the recorded health effects and the effectiveness of current emission control technologies, will enable the development of improved emission control technologies. These technologies will, in turn, reduce barriers to alternative fuel vehicle deployment and fulfill the Public Interest Energy Research Transportation Program's research goal to expand the availability and use of alternative fuels.

Project Specifics

Agreement Number: 500-06-043 (Task 4)
Recipient: California Air Resources Board
City/County: Sacramento, Sacramento County
Application: Statewide
Agreement Amount: $225,000
Agreement Term: June 2007 to December 2011
Match Funding:
$338,975 South Coast Air Quality Management District
$113,975 Air Resources Board

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