

Innovative Methods of Monitoring of Diesel Engine Exhaust Toxicity in Real Urban Traffic

MEDETOX

LIFE10 ENV/CZ/651

AFTER LIFE COMMUNICATION PLAN



Contacts

Institute of Experimental Medicine CAS

Jan Topinka

jtopinka@biomed.cas.cz

Technical University of Liberec

Michal Vojtisek-Lom

michal.vojtisek@tul.cz

www.medetox.cz

1. Introduction

Ultrafine particles emitted by internal combustion engines are considered one of the main environmental problems in urban areas. The particles are emitted in the direct proximity of many people, have a high probability of deposition in human lung alveoli and of penetration through cell membranes into the bloodstream, and are considered a proven carcinogen by the World Health Organization (WHO), the California Air Resources Board (CARB) and International Agency on the Research of Cancer (IARC). Epidemiological studies have found association between residence location near the busy road and pulmonary impairments as well as increase in the risk of cardiovascular disease and other ailments. Particulate matter in urban air is believed to be responsible, both in the Czech Republic and in the EU, for approximately one order of magnitude more premature deaths compared to traffic accidents.

Real driving emissions measurements show that engine UFP emissions are not evenly distributed among vehicles or along the path of travel, but rather, a small number of vehicles is responsible for a large fraction of the total emissions from the vehicle fleet, and a large fraction of UFP emissions from a given vehicle is attributable to short episodes with high emissions. Various studies also show that emissions can be substantially higher during real driving than during prescribed laboratory type-approval tests. For this reason, assessment of the effect of new engine and exhaust aftertreatment technologies and new fuels should include tests done in real driving.

Particulate matter has been traditionally assessed, and emissions and ambient air quality limits expressed, based on the total mass of the particles. Large portion of the health effects of the particles is, however, associated with compounds representing only a very small fraction of the total mass, such as polyaromatic hydrocarbons (PAH). It is also known that the combined toxicological effect due to the interaction of various compounds cannot be expressed as a mere sum of the effects of the individual compounds. Rating of health risks should therefore be based primarily on interaction of exhaust components with model biological systems; not based only on chemical analysis of its composition. For this reason, assessment of the effect of new engine and exhaust aftertreatment technologies and new fuels should include toxicity tests which would serve as a more direct metric of the resulting health effect.

The MEDETOX project aimed to demonstrate innovative methods of monitoring toxicity of diesel engine exhaust emissions during real urban driving with detailed focus on situation on the ring road of Prague.

The project was focused to following topics:

- Construction and validation of several innovative emissions monitoring and/or sampling systems for assessment of emissions on the road.
- Preparation and validation of simplified toxicity assays which could be carried on the collected samples.
- Investigation of real-world emissions and of the toxicity of particle-bound organic compounds collected during real-world operation and during its simulation in the laboratory, with particular focus on urban driving and on the effects of congestion.
- Investigation of real-world emissions and of the toxicity of particle-bound organic compounds collected during operation of engines on various candidate replacement fuels.

2. Main results

The following key technologies and methods were demonstrated within the project:

- Miniature and low-cost portable on-board systems for vehicle emissions monitoring.
- Miniature ultra-low-cost detector of particle length, used for vehicle emissions monitoring, and also tested within the European Metrology Program as a novel tool for periodic emissions inspections of motor vehicles.
- Portable FTIR (Fourier Transform Infra Red) spectrometer for measurement of unregulated pollutants of interest, such as nitrogen dioxide, ammonia, formaldehyde, acetaldehyde, and greenhouse gases methane and nitrous oxide.
- Particle size distributions and particle counts have been measured in vehicle exhaust and in ambient air near roadways using instruments mounted on hand carts.
- Acellular tests of DNA adducts and oxidative DNA damage have been demonstrated as, relative to the toxicological tests in general, a relatively easy, fast, inexpensive screening test, requiring a relatively small amount of material.
- The standardized protocols for sampling and toxicity testing of diesel emissions under various real traffic conditions as tools for hazard identification and risk assessment based on toxic events of vehicle emissions.
- These tests are described in details on www.medetox.cz/methods and include:
 - Sampling
 - Analysis of cytotoxicity
 - Analysis of DNA adducts
 - Micronucleus test
 - Oxidative stress
 - Comet assay



The results of this project should be used for improvement of legislation relevant to the regulation vehicle emissions in the European Union.

3. After LIFE communication strategy, methods and actions

By the end of the MEDETOX project, a wide range of communication tools had been exploited in order to disseminate the outcomes to the stakeholders and other target audience. The most important dissemination methods are direct contacts with experts, seminars and conferences, newspaper articles, radio, television, Internet. Publications produced by the project are available for all in a PDF-format at the project's Internet site. These publications have been delivered to experts, different stakeholders etc. A monograph on the project MEDETOX was delivered at the end of the project.

Maintenance of the project website

The project Internet site www.medetox.cz demonstrates the project results, reports and publications including Layman`s Report and project monograph. Most of the materials are in pdf-format available for all. The project's Internet site will be available for at least 5 years of duration after the end of the project. After this majority of the information at the Internet site will be transferred into the websites of the project partners.

All data and publications are available for authorities of municipalities and the government.

Presentations in international meetings/conferences

A group of experts working in the project will be presenting the project`s results in various national and international meetings. At least ten presentations is expected within next five years. Participation on such meetings should be covered from follow-up projects.

Popularisation and technical papers

Although the project MEDETOX produced already dozens of popularisation and technical papers (as demonstrated on project`s website), at least twenty of manuscripts, articles, and similar materials will be further published within 5 years after the project deadline.

Continuing projects

Although the project has ended, several methods developed by the project, are used and will be used further in other projects. A wide group of experts will be participating in these projects. The experts have a close contacts with other professionals both in Czech Republic and abroad.

Already completed, ongoing or confirmed projects include



- A basic research project aimed at better understanding of mechanisms of toxicity of particles arising from the combustion of contemporary and advanced biofuels
- A work package within a larger Czech Ministry of Education funded project at the Czech Technical University aiming at the assessment of realistic effects of new fuels and technologies on emissions during real-world operating conditions and on the human health
- An industry-sponsored study on real driving emissions of ultrafine particles from modern automobiles, including vehicles powered by advanced fuels
- Fabrication and delivery of a miniature portable on-board emissions monitoring system

The table below summarizes and quantifies after LIFE communication activities of the MEDETOX project:

Actions to be developed	Target group(s)	Comments	Estimated budget
Maintenance of the project`s website	General public, scientific community, stakeholders and policymakers	MEDETOX website maintenance is prepaid for next 5 years	2,000 €
Presentations in international meetings/ conferences	Scientific community, industry, policymakers	The final scientific results will be presented in at least 5 conferences	4,000 € (will be covered from follow up grants which are already going-on)
Popularisation and technical papers	General public, Scientific community, industry, policymakers	At least 5 popularisation and technical papers will be published	2,000 € (will be covered from follow up grants which are already going-on)
Educational programmes	General public, students	At least 5 educational programmes is planned	No cost
Media (TV, radio, newspapers)	General public, scientific community, stakeholders and policymakers	At least 5 media outputs is planned	No cost
Distribution of Layman`s Report	General public, scientific community, stakeholders and policymakers	We have printed 1,000 of bilingual Layman`s Report on the project. The rest will be distributed within next 5 years	No cost
Distribution of MEDETOX Monograph	Scientific community, industry, policymakers, other stakeholders	We have printed 500 of MEDETOX monographs which will be distributed within next 5 years.	No cost
Communication of the results to other projects	Scientific community, industry, policymakers	By participating on their conferences	4,000 €

Current and envisioned impacts of the project on public policy

- Project results and project staff have contributed to the formation of the current plans to introduce monitoring of real driving emissions of nitrogen oxides and particulate matter in the EU.
- Portable on-board emissions monitoring systems (PEMS) for vehicle emissions measurements were used to uncover excess emissions during real-world operation, including the first "DieselGate" involving heavy vehicles and excess NO_x emissions in the United States two decades ago, and including the "current" DieselGate affair with diesel automobiles.
- Demonstration of a miniature PEMS serves as an enabling tool to extend real driving emissions measurements, established in the EU legislation for heavy-duty vehicles and planned for automobiles, to motorcycles and other smaller vehicles within the EU legislation.
- Demonstration of online, on-road measurement of ammonia, nitrous oxide, and other pollutants of interest with a portable FTIR serves as an enabling tool for real driving emissions limits of such compounds within the EU legislation.
- Demonstration of low-cost miniature particle sensor serves as an enabling tool for replacement or supplementation of the current opacity measurements during periodic vehicle inspections with another method capable of assessing the functionality of a diesel particle filter.
- Project findings and background information gathered during the project have been used in citizen actions against unwise land-use choices that would have likely resulted in deterioration of air quality, including a construction of a large shopping center which would have brought large amounts of traffic into a historical city center.
- Project findings on the reality of motor vehicle emissions have been implemented in many public lectures, including lectures at many conferences, but also at the Committee for Sustainable Transportation of the Czech Government, at political meetings, and at meetings and seminars for automobile repair technicians.
- Toxicity assays demonstrated within the project have, along with different types of laboratory toxicity assays carried by several other groups, contributed to the increase in cooperation between engineering and toxicology groups in the field of a more direct assessment of effects of new fuels and technologies on health risks.
- Ambient air measurements have sparked an interest from local authorities and citizen groups to assess air quality on a local (microscale) basis.
- Technologies and methods demonstrated within the project are directly applicable to small home heating appliances, another distributed source of air pollution responsible for a large fraction of total particulate matter in the air.



New approaches developed within the project are now prepared to be applied for realistic assessment of engine emissions and their adverse health effects:

- Miniature and low-cost portable on-board monitoring systems is an enabling technology for extension of the monitoring of real driving emissions to small engines and to small or specialized non-road mobile machinery, where “classic” portable on-board monitoring systems are too bulky.
- Mini particle length detector offers an inexpensive way to detect malfunctions of diesel particle filters.
- Portable FTIR is an enabling technology for extension of the monitoring of real driving emissions to specific non-regulated pollutants of interest, arising out of new fuels and technologies.
- Mobile, time-resolved measurements of particle size distributions and particle number concentrations in ambient air allow for a more realistic assessment of particle-related health hazard than particle mass measurements used to date.
- Acellular tests of DNA adducts and oxidative damage may be used in future for high throughput analyses of toxic effects induced by engine emissions.
- Application and extension of the methods used for heavy diesel vehicles to gasoline engines, to small and non-road engines, and to home heating appliances has been planned in detailed and is subject of several currently proposed projects.