PAREMPI

Particle emission prevention and impact: from real-world emissions of traffic to secondary PM of urban air

Transportation is crucial in the worldwide distribution of food, materials, energy and more. However, all transport sectors are substantial emitters of air pollutants.

The PAREMPI project will reveal the contribution of the **secondary aerosols (SecA)** from transport sources to the levels of ambient particulate matter smaller than 2.5 µm **(PM2.5)** via an increased understanding of precursor exhaust emissions (volatile, semivolatile, particles), their atmospheric reactions and by a novel digital software called **ePMI module** in the PAREMPI project.

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But what exactly are PM2.5 particles?

Particles in the **PM2.5** size range have diameters smaller than 2.5 µm and they can travel deeply into the respiratory tract and lungs. Exposure to fine particles can cause **short-term health effects** such as eye, nose, throat and lung irritation, and **contribute to medical conditions** such as asthma, heart and pulmonary diseases. Nanosized particles are linked even to brain diseases. Particles may carry carcinogenic and mutagenic compounds and reactive compounds causing inflammation and tissue damage. Particles typically contain black carbon, which is evaluated as the second important anthropogenic contributor to global warming after carbon dioxide emission.

Air pollution is estimated to cause around **4.2 million premature deaths*** worldwide, and around **300 000 premature deaths** due to fine particulate matter annually in Europe although atmospheric concentrations of many air pollutants have been reduced along with earlier policies.

The adverse health effects are projected to be prevented especially by reducing harmful fine particulate matter (PM2.5) emissions that adversely affects air quality and is strongly linked to the premature deaths caused by air pollution. Hence, the guidelines of the World Health Organization (WHO, 2021) were updated for PM2.5 and recommendations were given for monitoring ambient black carbon (BC) and particle number (PN) concentrations.

**WHO. Ambient (Outdoor) Air Pollution. Available online (accessed on 15 August 2022)*

Measurement test sites

RDE, on-road

Heavy-duty

RDE, on-chassis

Cars

Engine, on dyno

Marine

CAST, in laboratory

Aviation

Instrumentation

Gaseous and SVOCs:

NOx NO_2 NH_3 N_2O CO THC

VOC — C1-C8 hydrocarbons: e.g. benzene, toluene, xylenes
Aldehydes: e.g. formaldehyde, acetaldehyde

SVOC — >C8 alkanes, alkenes, napthenes, aromatics, e.g. decane, naphthalene, pyrene

Instruments: FTIR, GC-MS (off-line samples), VOCUS-PTR-MS, APi-ToF

Particles:

PM BC PN — Particle mass, black carbon, particle number
PN>3nm, >10nm, >23nm (non-volatile, total),
Particle size distribution

Instruments: SMPS, ELPI+, CPCs, PSM, AE33, MAAP, MSS, Filters

Secondary aerosols:

SecA — Secondary aerosol formed in oxidation flow reactors (OFR).

Instruments: SP-AMS, Oxidation flow reactors (PAM, TSAR)
Others: dilution set-up, thermodenuder, catalytic stripper

Toxicity

TOX — Toxicity: exposure to exhaust with toxicity incubator.

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Research

The ambitious goal of the PAREMPI project is to **produce scientific evidence of the contribution of transport sectors' precursor exhaust emissions to ambient PM2.5 levels** through reactions in the atmosphere to secondary aerosols (SecA), and to develop tools, methods, and recommendations to enable wider impacts to prevent these emissions leading to reduced smog formation, less premature deaths, and savings in the related external costs, and hence substantial benefits in healthy living, growth in economy and welfare in Europe and globally.

The PAREMPI project will **develop a unique digital software (ePMI module)** to estimate SecA mass formed from the precursor emissions. Hence, by measuring specific precursor emissions, SecA formation can be estimated, and the precursor emissions can be included in the emission standards. To fill in gaps in existing knowledge, comprehensive measurements will be conducted including precursor exhaust and SecA emissions, and toxicity testing, and also in-depth molecular level research, as input to modelling work.

Combined with health impact assessment, solid science-based policy recommendations will be elaborated in the Workshops within Consortium, Advisory Board and other stakeholders. The PAREMPI project will **build evidence to recommend policies to reduce and prevent transport-derived harmful ambient PM2.5 levels**, including SecA formed through atmospheric reactions.

PAREMPI will follow 5 pathways to achieve these objectives:

1. Understand the transport sectors' emissions of particles, gases and semi-volatile intermediates, the formation of secondary aerosols and their effects on air quality, in particular during the winter season.
2. Investigate the toxicity of transport-derived ambient PM2.5.
3. Improve quantification of the contribution of transport-derived SecA to ambient PM2.5 levels.
4. Improve assessment of transport-derived ambient PM2.5-related health effects and externalities.
5. Provide policy recommendations to reduce transport-derived ambient PM2.5.

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PAREMPI will work towards the key challenges of the project, having as its final goal to generate scientific evidence of the subject, that that will underpin the development of tools and policies:

SCIENTIFIC EVIDENCE

- Contribution of transport sectors' precursor exhaust emissions (volatile, semivolatile, particles) on Secondary Aerosols (SecA) through reactions in the atmosphere. Quantities and composition of formed secondary aerosol, particularly in winter conditions, and it s impact on transport-derived ambient PM2.5 levels.
- Harmfulness of transport sectors' total PM2.5 emissions.

TOOLS FOR POLICIES

- The novel digital software (ePMI module) developed for quantification of the SecA from precursor emissions.
- Robust emission measurement systems evaluated to enable measurements in real-driving conditions and monitoring SecA emissions.
- Estimate of external costs based on the health impact of PM2.5 originating from transport sources. Different PM2.5 compositions are considered to evaluate possibilities to reduce external costs by avoiding premature deaths, lowering healthcare costs, and increasing working years.

RECOMMEND POLICIES

- Identify policies targeting transport sources significantly contributing to the most harmful ambient PM2.5 from transport sectors (road, non-road, marine, aviation) to enable efficient and cost-effective actions to improve air quality.
- Evaluate economical justification based on an improved estimate of external costs.
- Policy recommendations to enable limit values, legal enforcement, and e-reporting.
- Identify retrofitting possibilities to achieve near-term impacts and cost savings.
- Evaluate "polluter pays" options to find ways to fund clean investments.

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