Study on Virtual PM Sensor of Construction Machinery by utilizing Machine-Learning Algorithm

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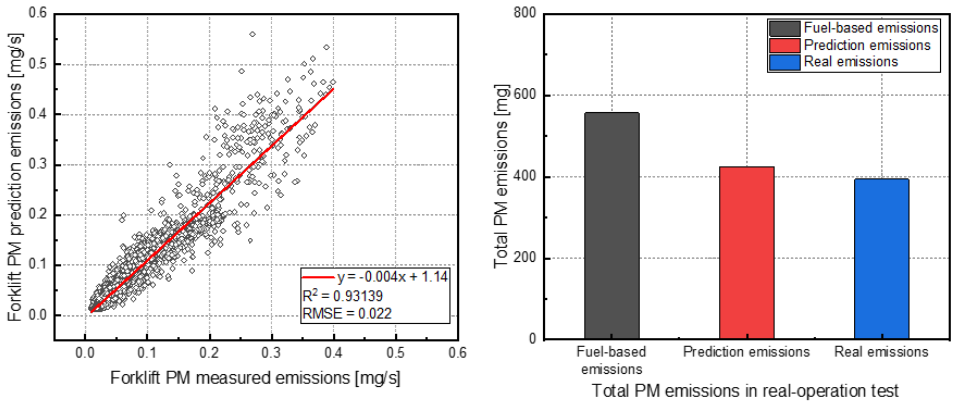
As environmental issues are continuously concerned all over the world, there is a growing focus on researching developing methods to manage and monitor the emissions from various forms of mobility. In the case of on-road vehicles such as light-duty vehicles (LDV), heavy-duty vehicles (HDV), quite accurate emissions management and monitoring are being implemented by utilizing a portable emissions measurement system (PEMS) and on-board diagnostics(OBD) system. As the emission management and monitoring methods for on-road vehicles demonstrate successful performance, the adoption of such techniques for non-road mobile machinery(NRMM) is expected.

The OBD system provides many information that effects to emissions such as engine speed, engine load, fuel rate, and Air/fuel ratio. The construction machineries equipped with a selective catalyst reduction(SCR) provide NOx emission information from the sensors at the upstream and downstream sections of the SCR. However, a particulate matter (PM), major emissions of diesel engines, is not provided by OBD system. So that, in this study, we aim to develop a virtual PM sensor utilizing machine-learning algorithm for construction machinery.



The input data for this study consists of engine characteristics which have relationship with PM emissions and PM emissions measurement data. Engine characteristics contains fuel rate, The Engine characteristic data were logged on the OBD and the emissions measurement data were logged using PEMS during the real-operation test of construction machinery. Among various types of construction machinery, we selected three types of construction machinery, such as forklift, excavator, loader, based on number of registered construction machineries in Korea. In the process of PM prediction for three types of construction machinery, each of type had different major variable in the prediction process and shown different accuracy. A PM prediction in a forklift shown the best accuracy, over 0.9 R^2 value, and remaining types shown strong correlation with actual measured emissions. Finally, to verify the feasibility and practicality of the method presented in this study, we compared PM prediction result with actual emissions and fuel consumption-based emissions that calculate emissions through emission factor

provided by EMEP/EEA. As a result, both error range and correlation value of construction machineries were more accurate than fuel consumption-based emission calculation method. Through the result of this study, we checked the validity of the PM predictive monitoring method and by conducting further research, we can expect precise and cost-effective virtual PM sensor development.

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27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: Aircraft, marine and other non-road sources;
Biomass-, biofuel- and synfuel combustion

Particulate emissions of a turboshaft engine running on HEFA-SPK and its Jet A-1 blends

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Global aviation substantially contributes to air pollution, emitting various pollutants, including CO_2, CO, NO_x, and particulate matter (PM), primarily in the form of soot. In this study, comprehensive measurements on an Allison 250 C20B turboshaft engine to explore the impact of sustainable aviation fuel (SAF) on emissions were conducted. 100% HEFA-SPK and two conventional Jet A-1 fuel blends with 30% and 50% HEFA-SPK content were tested. The emission results were then compared to pure Jet A-1.

The focus of the study was measuring particulate matter in terms of number and size. The engine power settings were selected based on thrust ratios specified in the International Civil Aviation Organization's (ICAO) Landing and Take-off-cycle (LTO-cycle). Multiple measurement techniques were utilized to characterize PM emissions, including the use of two distinct electrical mobility analyzers (an SMPS and a DMS 500). Furthermore, a concentration particle counter (CPC) was employed to validate the reliability of the results.

The measurement results indicate a reduced PM number and size with increasing HEFA-SPK content. The decrease in PM number exhibited a linear trend for the 30% and 50% HEFA-SPK blends for all power settings and was more pronounced when using 100% HEFA-SPK. Additionally, a more significant reduction in PM number emissions, up to 82%, was observed at lower power settings, such as Ground Idle (GI), compared to higher power settings, like Take-Off (TO), where the reduction was up to 40%. Furthermore, the emitted particles when burning HEFA-SPK are, on average, smaller than when burning conventional Jet A-1. This is reflected in the mode shift of the measured particle size distributions. The mode shift is again especially pronounced for 100% HEFA-SPK. The reason for this is considered to be the chemical composition of the fuel.

Real-world PM Emission Patterns according to Load Factor of off-road Construction Machinery

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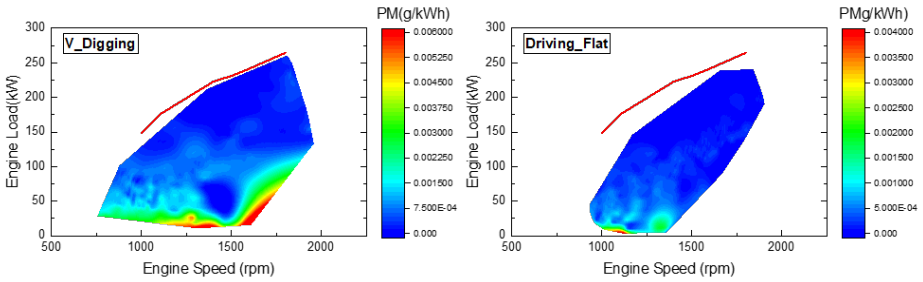
In recent decades, the construction industry has experienced rapid growth, driving urbanization and infrastructure development. Consequently, the usage of construction machinery has significantly increased, making it a major contributor to the emission of particulate matter (PM) on construction sites. PM is recognized as a key component of air pollution and has been associated with negative impacts on the human lungs. Understanding and analysing the relationship between the load factor of construction machinery and PM emissions is crucial research. The load factor refers to the ratio of the operating load applied to construction machinery and directly influences the operating conditions and fuel consumption of the machinery. Therefore, it is expected that variations in load factor would have an impact on PM emissions. Yoon et al., light-scattering sensor was used to measure PM2.5 on construction sites and compared it with the emission factor. However, this study installed sensors on the construction site to acquire PM and did not directly measure PM from construction equipment. So, to date, research on the actual relationship between load factor and PM emission patterns in construction machinery is limited, necessitating the need for empirical data and analysis.



The objective of this study is to analyse the actual PM emission patterns based on the load factor of construction machinery, aiming to identify the variability and characteristics of PM emissions associated with changes in load factor. To achieve this objective, real operation tests were conducted on construction machinery, where engine data and particulate matter (PM) were measured. Engine OBD data (power, torque, speed) were collected through an engine CAN communication device (neoVI FIRE2, Intrepid Control Systems), and PM was measured using PEMS (SEMTECH Ecostar, Sensors). Results suggest that emissions from construction machinery, specifically PM emissions, vary depending on the type and characteristics of work being performed and engine loads. Therefore, adjusting the emission factor (EF) used in the emission calculation formula to reflect the real-world load factor (LF) can prove to be a significant strategy for environmental improvement.

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27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: Emission control of combustion engines

In search of an optimal combustion strategy for mitigating secondary organic aerosol in combustion engines

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The heightened prevalence of respiratory ailments linked to the generation of secondary organic aerosols (SOA) underscores the need for combustion engines characterized by reduced emissions of volatile organic compound (VOC) precursors [1, 2]. The combustion process quality significantly influences the production of emitted VOCs from vehicles, thereby impacting the concentration of SOA in the atmosphere [3]. The study aims to control the aerosolization process of n-Heptane droplets in a premixed air-methane-contained RCCI engine by adjusting the injection pattern to identify the most efficient pattern from both thermodynamic (energy, exergy, and efficiency) and environmental (NOx, CO, CO2, and VOC emissions, as well as SOA concentration) perspectives. The intricate process of SOA formation resulting from engine combustion is modelled by integrating computational fluid dynamics (CFD) with combustion chemistry and atmospheric chemistry and physics. First, crucial in-engine aerosol phenomena, including spraying, break-up, atomization, turbulent dispersion, collision and coalescence, and vaporization of fuel droplets, combustion flame dynamics, and the generation of combustion products are modelled. Then, extending beyond the engine, another model considers the atmospheric chemistry of the emitted products and the subsequent nucleation, condensation, evaporation, deposition, and transport of species and particles across different atmospheric layers. Moreover, the simulation delves into aerosol particle chemistry, addressing phenomena such as dissolution, dissociation, and heterogeneous reactions of VOCs within the particles. The findings reveal that unlike expecting better combustion for the strategy of right triangle injection due to better atomization, smaller fuel droplet generation, faster gasification, and higher temperature, it yields the highest HC and outdoor particles and accounts for the lowest Gross Indicated and combustion efficiencies among its counterparts. On the other hand, the strategy of right double-boot fuel injection has the highest Gross Indicated and combustion efficiencies with 39.86% and 94.88%, implying a 0.3% and 0.5% improvement compared to the base (parabolic) injection strategy, respectively.

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Raman Spectroscopy and Principal Component Analysis on fine and ultrafine particles emitted from modern vehicles.

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The release of particulate matter from vehicles equipped with internal combustion engines constitutes a critical concern associated with air pollution, contributing to the emergence of respiratory diseases, including lung cancers. This research focuses on advancing the accuracy and efficiency of physico-chemical and morphological characterization of particulate samples collected from the exhaust of vehicles.
The present approach entails a comprehensive examination of the morphology and molecular composition of vehicle exhaust particles, employing a combination of optical microscopy and Raman spectroscopy. Particulate samples were collected following the guidelines outlined in the European Commission Regulation 1151 (2017) [1] during driving tests performed on vehicles in chassis dyno laboratories. These tests were conducted on various modern light-duty vehicles, encompassing diesel, port fuel injection gasoline (PFI), and direct injection gasoline (GDI) models, under standardized type-approval conditions. Additionally, various particulate samples were collected and sistematically investigated during tests performed with different driving styles (simulating high congested traffic conditions, rural or highway driving), ambient temperatures, and altitudes [2]. The study also encompasses the collection of particulate samples from heavy-duty diesel vehicles, contributing to an extensive database of Raman spectra. The impact of these diverse variables on the nature of emitted particulate matter at both micrometric and sub-micrometric scales was thoroughly investigated through Principal Component Analysis (PCA) applied to a database of more than 150 spectra (Figure 1). This analytical technique enables the rapid identification of clusters of spectra with similar characteristics, providing valuable insights into the complexities of samples of particulate emitted under different conditions. Moreover, the current analysis revealed distinctive spectra in certain diesel vehicle samples, indicating the presence of unique particles characterized by carbon nanotubes, sulphates, and metal oxides. This comprehensive investigation not only enhances our understanding of the complex factors influencing the nature of particulate emissions. It also underscores the emission of particular type of particles, which can be associated with potential health risks.

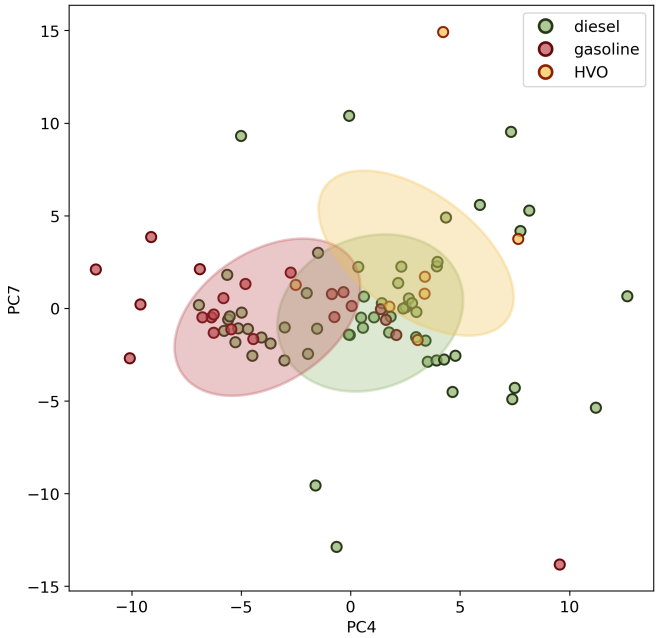

Figure 1: Example clusters identified in the Principal Component Analysis performed in this work on a broad database of Raman spectra measured on exhaust particulate emitted by Diesel, gasoline and hydrotreated vegetable oil (HVO) fuel.

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PN measurement at PTI in Japan

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PN measurements at periodic technical inspection (PTI) have been already installed in several European countries. Its aim is to detect failures with a diesel particulate filter (DPF). Some researchers reported that almost 10% of tested cars were found having DPF failures with PN measurement at PTI.

In Japan, differ from European countries, almost all of passenger cars have been powered by gasoline engine and diesel engine are used mainly for power sources of heavy-duty trucks. So, DPF failure ratios may differ from that in Europe. In this study, we have experimentally observed exhaust PN concentrations at PTI in Japan and estimated DPF failure ratio.

For the tests, we measured PN more than thirty vehicles at several PTI stations in Japan. PN measurements were conducted with the devices which have been adopted for PTI check in Europe.

Road to Lab Light-Duty vehicle campaign in terms of Particle Number emission over custom RDE test cycle

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INTRODUCTION

Both Real Driving Emission (RDE) and laboratory (WLTP, performed on a chassis dynamometer) procedures for quantifying particle emissions by number (particle number, PN) are mandated by current automotive exhaust emissions regulations. While the processes of PN emission measurement share similarities, notable differences exist between RDE and WLTP. The former has prescribed boundary conditions, but the characteristics and conditions during each RDE test can vary significantly – and thus it is inherently less repeatable than the latter. In contrast, the WLTP is a highly repeatable procedure in force in the EU since 2017, with narrow limitations in terms of temperature range, driving conditions, and other factors.

A comprehensive Light-Duty (LD) campaign, as part of the EU-funded PAREMPI project, was undertaken to investigate emissions of raw gaseous compounds, as well as particle emissions by mass (particle mass, PM), number (particle number,PN) and the simulation of atmospheric ageing of particles and aerosols from vehicles. This study outlines the 10-nm Particle Number (PN10) and 23-nm Particle Number (PN23) emission results obtained during custom RDE test cycle. Tests were executed both on road and in the laboratory conditions.

METHODS

Most regulated vehicle test procedures require adherence to specific standardized processes, such as a prescribed order of various driving modes or auxiliary usage during the tests. The methodology presented here was intentionally designed to deviate from these boundary requirements and includes additional components. Initial steps involved establishing the test cycle requirements, followed by selecting a reference vehicle (V3, consistent across all campaign cars) to execute the initial run. Subsequently, the test route underwent analysis, considering various output data, including ambient conditions, On-Board Diagnostics (OBD) parameters, driving style, traffic intensity, slope characterization, and, notably, speed characteristics, along with the frequency of stop events.

Upon approval, the test cycle, named ‘RDEsim’ (with ‘sim’ denoting simulation on the chassis dynamometer), was duplicated and integrated into the emission system at BOSMAL's chassis

dynamometer laboratory no. 2. Finally, six vehicles (see Table 1) underwent testing using the chassis dynamometer facility, traversing the identical 72-minute RDEsim cycle and subsequently replicating the same RDE cycle on the road.

Table 1: Cars used for this study with fuel and propulsion type, Euro emission class

Car number	Fuel type	Specificity	Euro emission class
V1	Gasoline	PHEV	6d
V2	Diesel	PHEV	6d
V3	Gasoline		6d
V4	Diesel		6d
V5	Gasoline	no GPF	5
V6	Diesel	no DPF	4

PHEV = Plug-in hybrid electric vehicle / GPF = gasoline particulate filter / DPF = diesel particulate filter

RESULTS

The investigation encompasses PN10 and PN23 emission data, OBD parameter readings, ambient conditions, and various other factors, for both RDE and chassis dyno tests. The analysis results will explain similarities or differences between the same route executed in real road conditions and a simulated dyno cycle. We will attempt to explain whether PN10 and PN23 results can be compared and if the methodology conducted in this manner deserves attention in future campaigns.

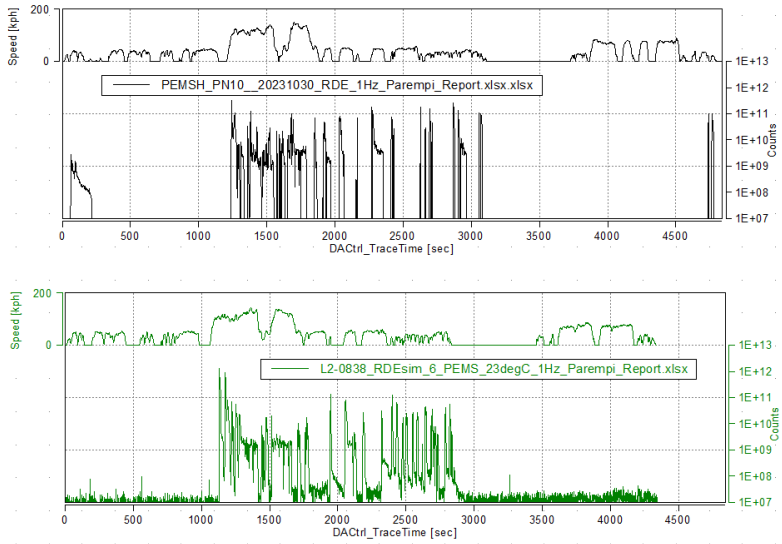

Figure 1: Speed and PN emission chart for the PHEV V1, the upper chart is PEMS RDE test with PN10 measurement while the lower chart is RDEsim test with regulated PN23 measurement.

CONCLUSIONS

This study focuses on the comparison of PN emission testing methodology and the obtained results in real driving conditions on the road and in the chassis dyno laboratory. Preliminary results reveal similarities between RDE tests conducted on the road and those simulated in the laboratory. However, certain distinctions have been identified, necessitating in-depth analysis and individual explanation.

ACKNOWLEDGEMENTS

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SECONDARY AEROSOL EMISSIONS FROM DIESEL AND NATURAL GAS VEHICLES

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INTRODUCTION

Exhaust from combustion engine vehicles is a mixture of gas phase and particle phase pollutants. It is known that these pollutants cause negative health effects to humans as well as deteriorate air quality. One way to cut down on the pollutants is to use alternative fuels, for example compressed natural gas (CNG) which produces lower carbon dioxide and volatile organic compound (VOC) emissions compared to gasoline vehicles (Zongyan et al., 2023). Yet, it is less known how the emissions evolve in the atmosphere when the exhaust is diluted and exposed to sunlight. For example, VOCs that exit the tailpipe in gas phase, can oxidize and then condense to form particles (see e.g. Karjalainen et al., 2016; Hartikainen et al., 2023). These particles are called secondary organic aerosol particles. Fuel affects the VOC composition of the exhaust, which leads to different potentials to form secondary aerosol particles.

In this study, we analyzed secondary aerosol formation comparing a diesel and a CNG vehicle. Diluted exhaust was aged in an aging chamber and the secondary particle mass was measured after the chamber. VOCs were measured from the fresh exhaust with a proton-transfer-reaction mass spectrometer to see which organic molecules contribute most to secondary aerosol formation.

METHODS

Two cars, 2006 Toyota Rav4 (diesel, Euro 4, no DPF) and 2020 Skoda Octavia (compressed natural gas with gasoline as backup, Euro 6), were measured on a chassis dynamometer, which was in a temperature-controlled test cell. The used simulated real driving emissions (RDE) cycle was 72 min and 47 km long, and the test temperatures were -9, 23, and 35 ˚C. The exhaust was sampled from the tailpipe, diluted with a combination of a porous tube diluter (PTD), a residence time tube (RTT) and an ejector diluter (ED) to simulate dilution in the atmosphere. Fresh exhaust was characterized with multiple particle and trace gas instruments, for example a VOC mass spectrometer (PTR-ToF-CIMS, Aerodyne Research, US).

The diluted exhaust entered a Potential Aerosol Mass (PAM, Aerodyne Research, US) chamber, which uses ozone, added water vapor and UV lights to simulate aging of the aerosol in the atmosphere. With the used settings, the equivalent age of the aerosol was 2-4 days, estimated with carbon monoxide as a trace gas. In addition to PAM, we also had a high time-resolution chamber called Dekati Oxidation Flow Reactor

(DOFR, Dekati Ltd., Finland). The aged aerosol was diluted with an additional ED and the particle size distribution was measured with an Electrical Low-Pressure Impactor (ELPI+, Dekati Ltd., Finland).

RESULTS

Based on preliminary analysis, an influence from the fuel was observed on the secondary particle mass produced. Fig. 1 shows average secondary particle mass distributions for the two vehicles over the driving cycle as a function of particle size.

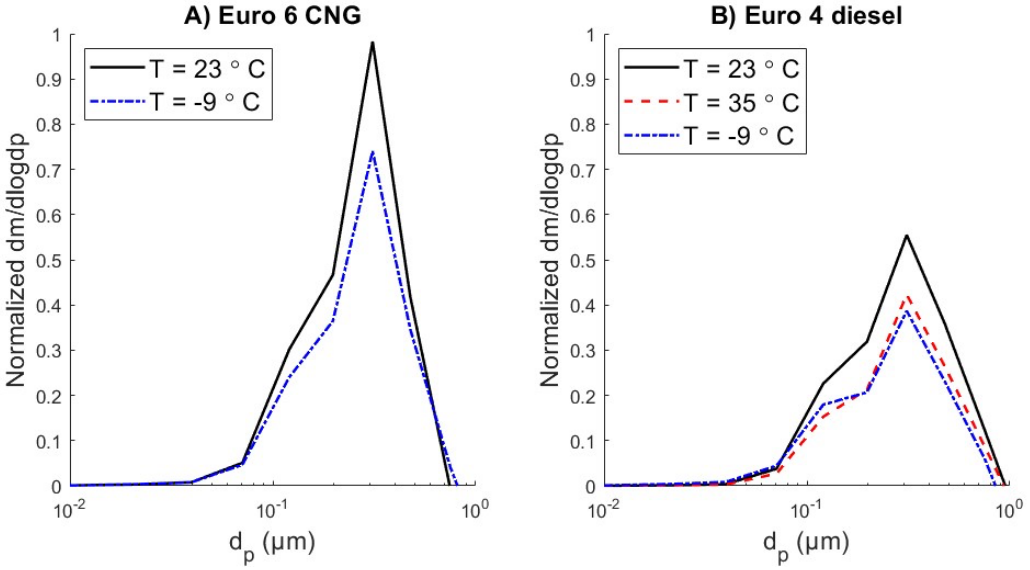

Figure 1. Particle mass size distributions of aged exhaust aerosol from a) Euro 6 CNG vehicle and b) Euro 4 diesel vehicle. Distributions are measured after PAM chamber and averaged over the driving cycle.

As seen from Fig. 1, the aged aerosol mass distributions are bimodal with modes at 100 and 300 nm. The Euro 6 CNG vehicle seems to produce more particle mass than the Euro 4 diesel.

CONCLUSIONS

Preliminary analysis showed that the Euro 6 CNG vehicle produced more aged particle mass than the Euro 4 diesel vehicle. The work continues with analysis of the VOC composition, which can explain the difference between the vehicles. However, the temperature of the test cell had only a small influence on the secondary particle mass emissions.

ACKNOWLEDGEMENTS

This work was supported by the European Union's Horizon Europe research and innovation programme under grant agreement No 101096133 (PAREMPI: Particle emission prevention and impact: from real-world emissions of traffic to secondary PM of urban air). The DOFR and the ELPI+ were borrowed from Dekati Ltd.

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Particulate number emissions during dynamic operating states of a hydrogen-fueled Turbulent Jet Ignition engine

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The dynamic operating states of an internal combustion engine significantly change the emission of toxic components of the exhaust gas, including the emission of the number of particulate matter [1, 2]. Controlling the operation of such an engine requires a number of systems that make it possible to change its dynamics while fully controlling the operating parameters [3–5].

The purpose of the work was to analyze the emission of exhaust components (including particulate number) during dynamic speed variation while keeping the initial operating parameters of the internal combustion engine mostly constant. The work was carried out with dynamic speed changes from n_1 = 1000 rpm to n_2 = 1800 rpm, and with the initial operating parameters of the engine:

- two values of the excess air coefficient λ = 2.0; 2.4
- the value of the center of combustion (AI50) determined at AI50 = 10 deg aTDC.

The study used a single-cylinder AVL5804 research engine with a two-stage combustion system equipped with a hydrogen injection system (P = 9 bar) into the intake channel (Fig. 1). The prechamber was equipped only with a spark plug (without gas supply).

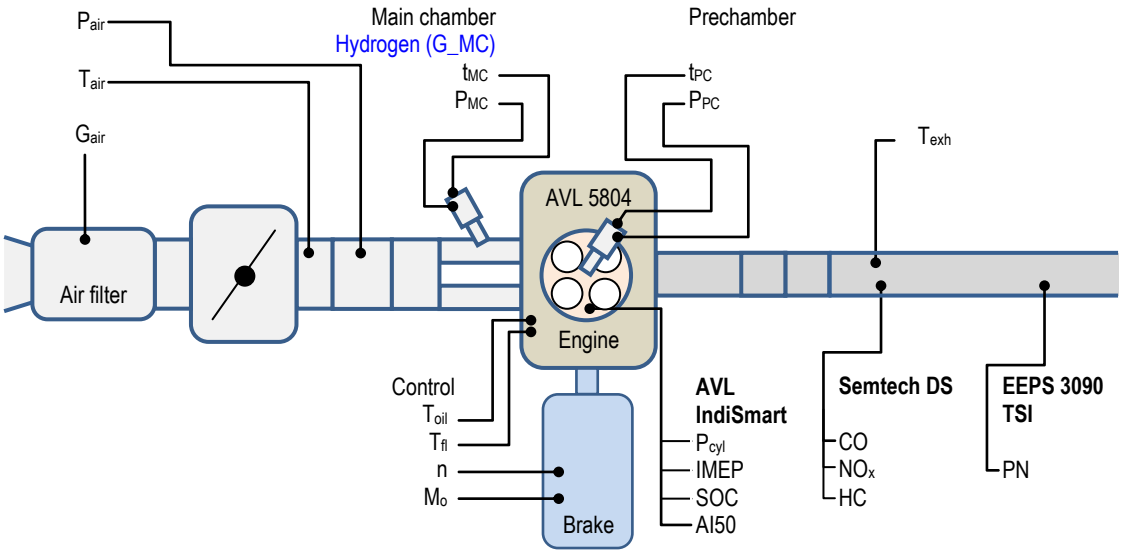

Fig. 1. Scheme of the test stand with measuring apparatus

The choice of initial conditions was dictated by the possibility of keeping many operating parameters (including ignition angle and maximum cylinder pressure angle) within the range of acceptable variations. The analysis was carried out with dynamic speed variation (Fig. 2a) at the initial IMEP setting. The resulting values of IMEP and AI50 increase slightly – with the larger values obtained at λ = 2.4 (Fig. 2b). At such a present rate of change, larger increases in NO_x concentration were noted during engine overdrive (the larger initial values are due to the higher engine load – Fig. 2c).

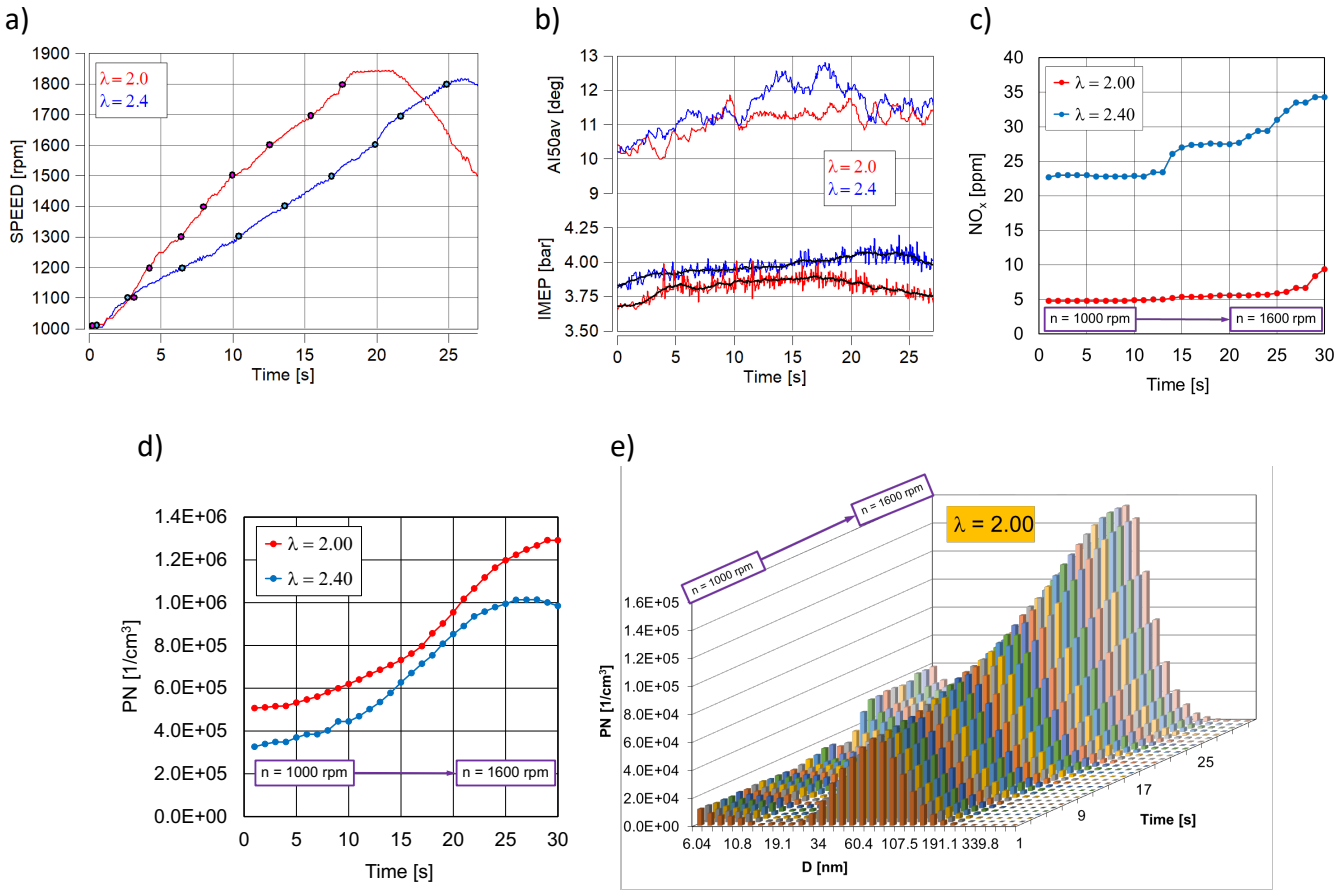

Fig. 2. Results of tests of exhaust gas components under different operating conditions of a hydrogen-powered engine: a) course of dynamic change of engine speed; b) conditions of change of engine operating indicators; c) concentration of nitrogen oxides; d) particle number at different values of excess air ratio λ; e) concentration histogram particle number under conditions of dynamic change of speed

Despite the lower load on the engine at λ = 2.0, the concentration of the particle number is about 100% higher with respect to its operating conditions at λ = 2.4 (Fig. 2d). Similar values can be observed during the final phase of increasing engine speed – regardless of the excess air coefficient, a twofold increase in particle number concentration is observed. The dynamic change of engine operating conditions indicates that the characteristic diameter value remains constant (in the range of 80–100 nm), but a proportional increase in the number of particles from the range of particle diameters over 100 nm is also observed (Fig. 2e).

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VERT GPF-Retrofit Program for Cleaner Urban Mobility within the HORIZON Europe AeroSolfd Project

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Emissions of ultrafine particles, from petrol engine combustion are a threat to human health and the environment. In particular sub-100 nm can deposit in the lung and reach other organs including the brain [1]. Above all in urban areas, the presence of high concentrations of toxic air contaminants needs to be drastically reduced. Clean urban mobility is the main goal of the HORIZON Europe AeroSolfd project launched by the European Commission that runs over a three years period until mid-2025. AeroSolfd will deliver affordable, adaptable, and sustainable retrofit solutions to reduce exhaust tailpipe emissions from petrol engines, brake emissions and pollution in semi-closed environments. The Swiss-based VERT association, with long expertise in nanoparticle emissions reduction via filtration, within AeroSolfd is in charge of reducing tailpipe emissions of gasoline vehicles by using best available retrofit filtration technology (BAT), and in particular the most efficient available GPF technology [2,3,4]. VERT with its member partners HJS, CPK and BFH will investigate the performance and deliver a TRL8 GPF retrofit system for future market applications. VERT is investigating the GPF-retrofit system performance in three different high mileage fleets, in Germany, Switzerland and Israel with totally 50 vehicles. The project not only provides a platform to continue research on PN and nanoparticle emissions but also on secondary emissions from GDI and PFI petrol engines. Moreover, a NPTI testing campaign of 1000 gasoline vehicles is conducted. Preliminary results of the VERT GPF-retrofit program within the AeroSolfd project are presented.

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INTEGRATING A PARTICULATE FILTER SYSTEM IN THE FRONTEND: A STEP TOWARDS ACHIEVING EMISSION-NEUTRAL VEHICLES

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ABSTRACT

The European Environmental Agency (EEA) has identified fine dust as a major environmental threat to human health (EEA, Healthy Environment, Healthy Lives: How the Environment Influences Health and Well-Being in Europe, 2020). While current regulations focus primarily on vehicle exhaust emissions, up to 85% of fine dust emissions come from unregulated sources such as brakes, tires, and road abrasion (Barlow et al., Non-exhaust particulate matter emissions from road traffic: summary report. Published project report PPR231, 2007).

To address this issue, a comprehensive approach has been developed that involves an integrated fine dust particle filter. This filter can be installed in unused spaces in the front end of vehicles and is an effective and sustainable way to improve the emission balance of vehicles and promote better air quality, regardless of the drive system used.

However, the implementation of this filter requires the development of specific, high-efficiency filter elements that have a low-pressure loss level to ensure proper thermal management. Additionally, the filter must have a high dust holding capacity to ensure customer-friendly service intervals and must be reinforced to withstand harsh operating conditions.

KEYWORDS

fine dust filtration, integrated fine dust particle filter, non-exhaust emissions

Distribution of particulate matter to extend heavy-duty diesel particulate filter service life

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The performance of diesel particulate filters (DPFs) is highly dependent on the distribution of accumulated ash inside the filter channels where plug-ash is more beneficial than wall-ash distribution. Many authors have linked the distribution pattern to the type of regeneration i.e., active oxygen-assisted regeneration and passive nitrogen dioxide-assisted regeneration [1]. Other work has decoupled the type of regeneration from the distribution of ash particles in DPFs, putting more emphasis on how individual parameters affect the particles [2]. Optimizing the distribution of particles would not only extend the life span of the DPF but also improve the overall energy efficiency of the vehicle as a result of lower back pressure and less frequent regenerations.

A lab-scale test rig has been used for carefully controlled experiments for performance assessment and enhancement of DPFs. The system has the capability of reproducing similar results realized in full-scale heavy-duty engine tests, maintaining a close connection to the actual application. The effects of temperature, flow, particle type, and concentration have been investigated on field-retrieved DPFs. Particulate filters previously used in operating heavy-duty vehicles were prepared for sub-scale testing. From each full-size DPF, multiple cores were tested to comprehend the role of vehicle history. Different cycles of soot loading and regeneration processes were repeated and after each cycle, the performance of the DPFs was assessed to understand the effect of individual parameters.

DPF performance can be improved without the need for external processes and the degree of improvement is dependent on the history of the DPF. Particulate filters with ash particles accumulated evenly over the axial distance of the DPF are more likely to see changes in performance. Altering the filling degree of the filter channels i.e., reducing the volume occupied by particles as shown in Figure 1 can be realized by normal operation. The increase in available filter volume results in an improved operation of the DPF and extended time of use.

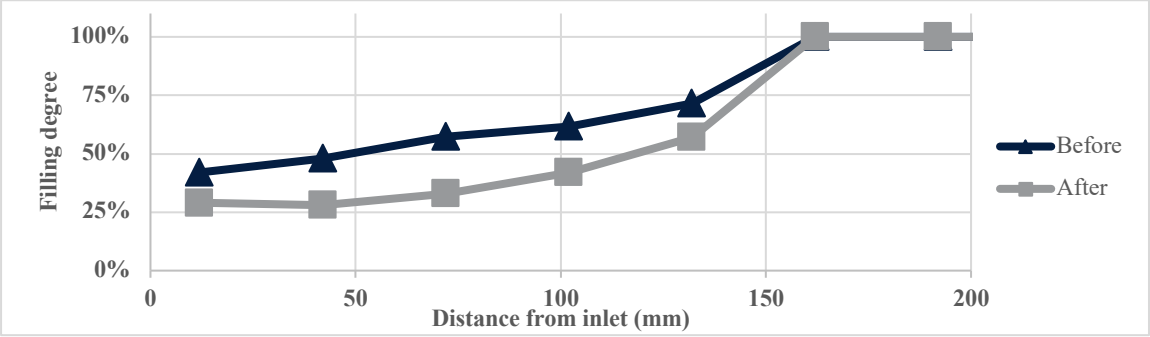

Figure 1 Volume occupied by ash in field-retrieved DPF before and after oxygen-assisted regeneration.

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Reference aerosols for PTI-PN counters

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Particle emissions in exhaust gases from motor vehicles are progressively being determined with number-based measuring instruments. Since July 2023 the measurement of the number concentration in the exhaust at the tailpipe is mandatory during periodical technical inspection in Germany [1]. For this purpose several measurement devices based on the technology of either condensation particle counters (CPC) or diffusion charge particle counters (DC) were developed. These measuring devices require periodic calibration against a reference system employing test aerosols.
Due to the fact that the signal from DC-detectors correlates to the aerosol length concentration but not to the number concentration, it depends on the particle size. Therefore, the test aerosols required for calibration have to be well-defined in terms of size distribution, particle shape and material. All required properties are specified in the "AU-Geräte Kalibrierrichtlinie" (German exhaust emission test equipment calibration guideline [2]). Typically, these test aerosols are produced by Collison-type atomizers employing saline solutions. Therefore, the humidity of the generated test aerosol has to be controlled to prevent the abrupt increase of particle size at the deliquescence point. This effect is illustrated in Fig. 1 and 2. The contribution discusses solutions for aerosol conditioning, which are technically and economically suitable for mobile calibration purposes.

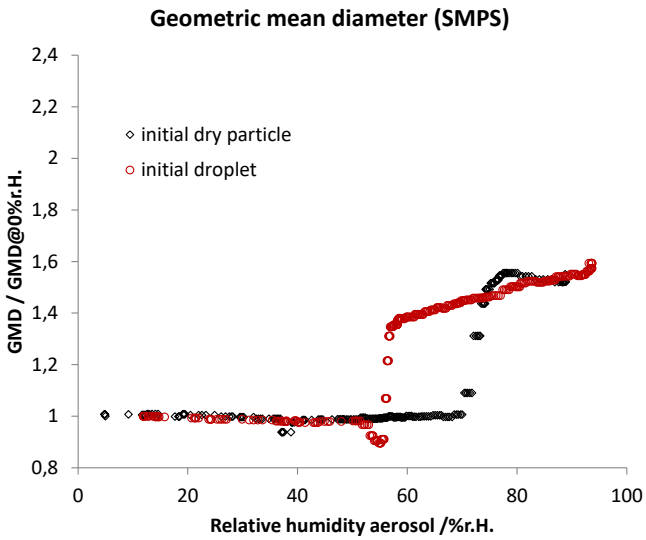

Fig. 1: Increase of geometric median diameter of test aerosol compared to the initial value at 0%r.H.

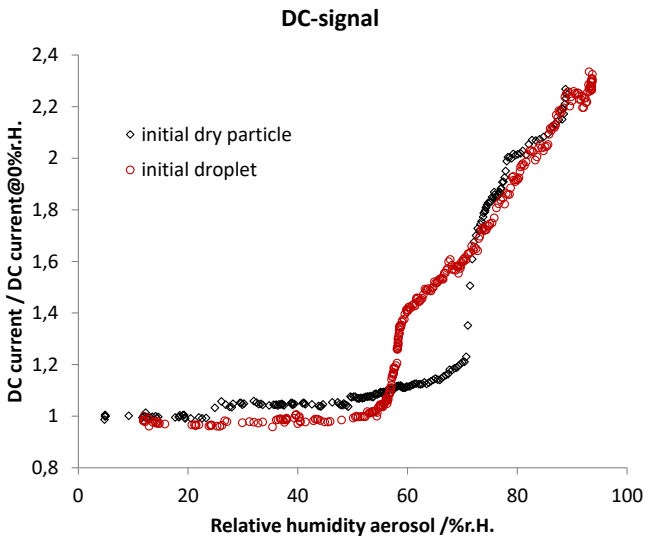

Fig. 2: Increase of the diffusion charge particle counter (DC) signal compared to 0%r.H.

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Cost-efficient sensor solution for reducing emissions from woodstoves through user guidance

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Woodstoves remain popular for heating and recreational uses, while at the same time being a major source of harmful gas and particle emissions in residential areas. There have been several technological improvements to woodstoves and related equipment (e.g., particle filters), and retrofitting older installations is often mandated by law. However, these technological improvements fail to account for the relatively large influence of the user [1]. Woodstoves with automatic air control are a possible solution, but these are expensive and therefore have a limited market share. In this project, an alternative approach is developed and investigated. A simple sensor system is installed on existing stoves, which gives the user direct feedback on e.g., air supply and refuelling intervals. Thereby, the user becomes part of the control loop, and improve firing techniques are reached, leading to lower emission of particles and harmful gasses.

Specifically, the system consists of a thermocouple and a low-cost oxygen probe from the automotive industry. The two sensors measure directly in the flue gas duct and are situated as close to the fire as possible. An algorithm was developed to connect the low-cost sensors with state-of-the-art equipment and determine the combustion quality, e.g., in terms of carbon monoxide (CO) , organic gaseous carbon (OGC) and particle emissions. Furthermore, knowledge of the air supply and 'optimal' user behaviour is implemented in the algorithm to assist the user.

Preliminary results indicate that the combination of temperature and oxygen concentration can be used to predict the progress and quality of combustion in a woodstove. The temperature measurement is strongly dependent on the placement of the measuring equipment and the woodstove model. We have analysed data to correlate combustion with type of wood (oak, birch, mixed), number and size of firewood, etc. All have influence on the quality of the combustion; however, none could be correlated directly with the measurements of CO, OGC, temperature, and oxygen because of the variance in data from charge to charge.

Currently, the prototype with sensors and algorithm is tested at end users and we will present preliminary results from this project. The new system is expected to reduce gaseous and particle emission by guiding the user towards correct firing techniques in real time, e.g., adjusting air flow and recharging at the proper time with the proper fuel.

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27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: Biomass-, biofuel- and synfuel combustion

Air Toxics Emissions from Cogeneration Boilers by Applying Multiple Fuels in Taiwan

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Reducing the consumption of coal as fuel is a key strategy for net-zero carbon emissions policy in Taiwan. The government plan to reduce the consumption of coal in cogeneration and industrial boilers at first. Cogeneration units consumed 21.5 million metric tons of coal annually, which accounted for approximate 36 % of total consumption. There are 53 cogeneration boilers using coal as fuel, and 14 facilities using multi-fuels for many years. The multi-fuels included waste rubber, pulp and paper sludge, waste plastic, and RDF/SRF. However, the air toxics issue causes public concern while increasing the use of industrial waste as fuel in these boilers. This study investigated the variation in air toxics emissions, including heavy metals (As, Cd, Pb) and Dioxins, from cogeneration units in Taiwan while introducing industrial waste derived fuels to replace part of coal usage.

Based on the data among 2019 ~ 2021, the coal-fired cogeneration units contributed most emissions of target air toxics in cogeneration sector due to their great amount use of coal. But the emission factors showed a different profile. The emission factors (emission based on the input heat value of multi-fuels) of these four target air toxics are 5.5 g/Tcal (As), 1.1 g/Tcal (Cd), 12.1 g/Tcal (Pb), and 20.7 μg I-TEQ /Tcal (Dioxins), respectively, from coal-fired cogeneration units. The emission factors of multi-fuels cogeneration facilities were 9.7 g/Tcal, 2.7 g/Tcal, 35.3 g/Tcal, and 99.7 μg I-TEQ /Tcal, respectively. The results indicated that these four target air toxics emission factors of multi-fuels facilities are higher than those of coal-fired facilities. The ratios of emission factors for multi-fuels to coal-fired units are 1.76 times for Arsenic, 2.45 times for Cadmium, 2.92 times for Lead, and 4.82 times for Dioxins. Research shows that higher emission factors of air toxics in multi-fuels units could be attributed to the complexity of industrial waste compositions and the emissions without effective control. The results also showed great variation of air toxics emission factors among multi-fuels units. It may be caused by the same reasons.

This study also investigated the emissions and air pollution control devices (APCDs) for two multi-fuels facilities. Process B uses solid derived fuel (SRF) as the major fuel (input heat value 79.2%) and uses waste rubber as minor fuel (input heat value 17.0%). The APCDs include bag filter and WFGD. The emission factors are 0.56 g/Tcal, 1.17 g/Tcal, 19.29 g/Tcal, and 58.3 μg I-TEQ /Tcal, respectively, which are 0.06, 3.08, 0.55, 0.58 times of the average emission factors of all multi-fuels systems. Process B has relatively high emission of cadmium. Process C has been designed to use various industrial waste as fuel. The input fuels are quite diverse, included RDF (73.8%), bituminous coal (14.1%), waste rubber (7.1 %), pulp and paper sludge (3.1%), and waste wood (0.7%). RDF made of waste from papermaking process, cartons, packaging paper, etc. The APCDs include LNB, bag filter, and WFGD. The emission factors are 6.73 g/Tcal, 6.12 g/Tcal, 8.18 g/Tcal, and 53.3 μg I-TEQ /Tcal, respectively, which are 0.69, 2.27, 0.23, and 0.53 times of the average emission factors

of all multi-fuels units. Process C also has relatively high emission of cadmium.

Research shows that cogeneration units use industrial waste as multiple fuels to reduce the consumption of coal will increase emissions of air toxics. The ratio of multiple fuels and the composition of alternative fuels influenced the emission profiles significantly. Potential impacts on environment and public health by air toxics in the neighborhood and effective emission control system should be further studied before adoption of the policy.

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27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: *Brake and tyre wear, non-combustion emissions*

Reducing particle exposure level at metro stations

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At underground metro stations, dust emissions from the train brakes are a main contributor to poor air quality. But what could be a good tracer for that? We will present and discuss physical and chemical analyses of particles emitted by a metro disc brake used in Lisbon Metro and of PM2.5 inhaled by passengers at the platform of one a demo stations of this metro system. This enables us to trace the air quality at the metro back to brake emissions. Finally, we will give an outlook on the next steps for demonstrating the application of stationary air purifiers to improve air quality at metro stations. This progress of the AeroSolfd project will be shown on one separate poster.

27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: Brake and tyre wear, non-combustion emissions

Particle characterization for the development of a brake wear particle collection system

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As exhaust pollutant reduction technology progresses with the reinforcement of automobile exhaust emission regulations, and the adoption of eco-friendly vehicles, such as electric and hydrogen cars, increases, the generation of particulate matter from exhaust systems is consistently decreasing. Nevertheless, there has been limited progress in the development of technology to reduce particulate matter generated from non-exhaust systems, such as tyre or brake wear. With the earnest implementation of Euro-7 regulations, aimed at regulating particulate matter from non-exhaust systems, significant efforts are required to mitigate non-exhaust emissions resulting from tyre and brake wear.

In this study, the characteristics of brake wear particles were analyzed to develop an effective method for collecting brake wear particles. In particular, the charge characteristics of particles were studied to develop a novel fine dust collection system that can replace filter-type dust collectors. Furthermore, we designed a dust collection system that can effectively capture brake wear particles using electrostatic force. When evaluating the performance of the developed dust collection system on the brake dynamometer, it was confirmed that approximately 78% of generated wear particles could be collected under WLTC cycle driving conditions.

Acknowledgement
This work was supported by the Technology Innovation Program(20007027, Mutually beneficial cooperative air purifying automobiles against atmospheric fine particles) funded by the Ministry of Trade, Industry & Energy(MOTIE, Korea).

27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: *Brake and tyre wear, non-combustion emissions*

EU PROJECT AEROSOLFD – PROGRESSING ON FAST TRACK TO CLEANER URBAN AIR

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AeroSolfd is an EU co-funded innovation action developing retrofit filtration solutions as a fast track to cleaner urban air. The focus is on reducing 1) tailpipe emissions of gasoline cars (EURO 6c and earlier) and 2) brake emissions of urban busses and improving 3) air quality at metro stations. The overarching theme driving the development and preparing a market for the retrofit solutions is a holistic view of sustainability by a social-environmental life cycle analysis.
The 3-year innovation action AeroSolfd started in May 2022. First results can now be reported. We will present the progress in three separate posters and a fourth one for the general project setup.

Poster 1: Reducing Tailpipe Emissions (Lars C Larsen, Lauretta Rubino)
Reducing tailpipe emissions by particle filters is standard for diesel engines. For gasoline engines, filters have recently been introduced, but cars with EURO 6c and earlier will still be on the road for a longer time and don't have a filter. Reducing these tailpipe emissions by a particle filter is a fast track to cleaner urban air. Typical vehicles and engines have been identified and particle filters designed for the available installation spaces and tested on four cars. Now we are seeking vehicles to install the retrofit solution for a field trial. We will present and discuss in one separate poster first results of this AeroSolfd work package.

Poster 2: Reducing Brake Dust Particle Emissions (Hartmut Niemann, Carlos Casado, Martin Lehmann)
Reducing brake emissions of urban busses by a brake dust particle filter addresses non-tailpipe emissions. Whereas methods and technologies for measuring tailpipe and passenger car brake dust emissions have been established over the past years, including a WLTP-like novel brake cycle, Developments towards reducing brake dust emissions from city busses are still at a rather infant state, in particular due to the lack of a defined cycle to assess the emissions in specific cities, including the local topography, traffic etc. This must be reflected in the driving cycle to measure brake emissions later on a dynamometer test rig. We will present and discuss in one separate poster how we derived a brake cycle specific for our partner cities and transferred the data into a cycle to run on a dynamometer as first results of this AeroSolfd work package.

Poster 3: Reducing particle exposure level at metro stations (Teresa Moreno, Christof Asbach, Katie Kedwell) At underground metro stations, dust emissions from the train brakes are a main contributor to poor air quality. But what could be a good tracer for that? We will present and discuss physical and

chemical analyses of particles emitted by a metro disc brake used in Lisbon Metro and of PM2.5 inhaled by passengers at the platform of one a demo stations of this metro system. This enables us to trace the air quality at the metro back to brake emissions. Finally, we will give an outlook on the next steps for demonstrating the application of stationary air purifiers to improve air quality at metro stations. This progress of the AeroSolfd project will be shown on one separate poster.

Poster 4: Environmental-Social Life-Cycle-Assessment (Martin J. Lehmann, Keld A. Jensen, Bias Liguori, Dalia Antunes)
The overall project setup will be displayed in one separate poster. Besides the pilar of product development and demonstration the project AeroSolfd is built up on the second pilar of creating public awareness. A key part is the environmental and social Life-Cycle-Assessment and the teamwork of the partners. Both will be briefly shown.

www.aerosolfd-project.eu

Development of Dust Collector to Mitigate the BWPs (Brake Wear Particles) Using the Dispersion Characteristics of Particles

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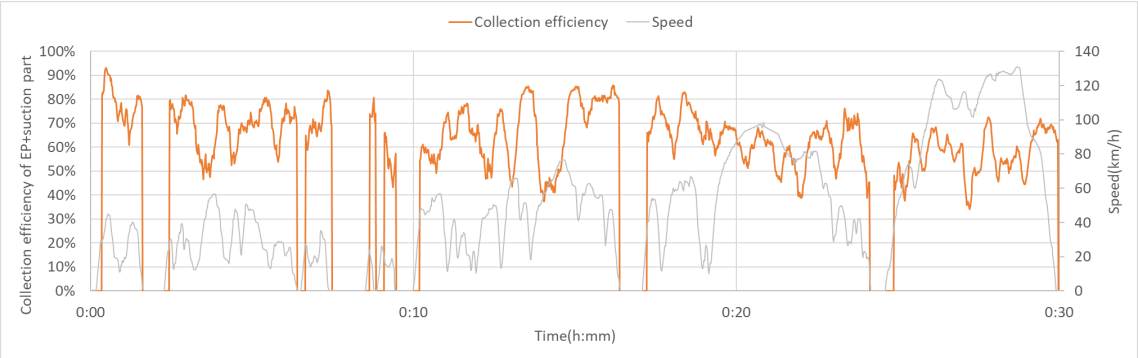
Brake wear particles (BWPs) are one of dominant sources of vehicular non-exhaust PM emissions. The properties of BWP emissions and the BWP emission factor have been extensively researched. This study examined the electrical and dispersion characteristics of BWPs and developed and tested a dust collector to mitigate the BWPs using a brake dynamometer and a chassis dynamometer. Steel fiber, the friction material used in low metallic (LM) brake pads, generated BWPs with a high iron (Fe) content. Conversely, in BWPs emitted from non-asbestos organic (NAO) brake pads, other components, such as zirconium (Zr), potassium hexatitanate ($K_2Ti_6O_{13}$), and others, were identified in addition to Fe. Because the primary component of the braking disk (gray cast iron) was Fe compound, which was similar material of LM pads, relatively little frictional charging occurred in BWPs from LM pads. However, because the brake pad and disk contain different compounds, the BWPs from the NAO pads were strongly charged. Thus, BWPs could be eliminated with an electrostatic precipitator (EP) that doesn't require an additional charging component. EP efficiency of NAO pads was higher than that of LM pads because of the comparatively high charging intensity of BWPs emitted from NAO pads.



Additionally, a suction part was developed to collect BWPs dispersed by the braking system. When the disk rotated at higher speeds, a large amount of the newly created BWPs was re-dispersed and released from the brake system. CFD was used to simulate the route taken by the released BWPs, and an inlet with high suction efficiency was constructed for the suction section. The ability of the BWP dust collector, combined with EP and suction part, to successfully lower the BWP emissions was demonstrated by testing on a chassis dynamometer using an actual vehicle.

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Characterization and application of a new oxidation flow reactor (DOFR) to study passenger car emissions

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Secondary particle emissions of vehicles are becoming increasingly important aspect for the human health and environment as the primary particle emissions have been efficiently cut down during last two decades by introducing particle filters to vehicles after treatments. Legislation has de facto enforced diesel vehicles to use highly efficient diesel particle filter (DPF) as the particle number emission limits cannot be met otherwise. In addition, gasoline vehicle primary emission limits are becoming stricter in Europe and GDI engines are also increasingly using gasoline filters. Nevertheless, despite more stringent particle emissions norms for tailpipe emissions, the continuous reduction of primary particle emissions has marginally reduced the nucleation mode particle concentrations (e.g., [1]). As a result, the focus is now shifting on the study of secondary emissions, which may have a great impact on health and environment and can be substantially higher compared to primary particle emissions (e.g., [2]).
The oxidation flow reactors (OFR, [3]) are a key tool for investigating secondary aerosol formation processes of different sources. Especially, OFR's are useful tools in studying the photochemical aging of transient emissions sources due their high time resolution compared to environmental chambers and compact size (see e.g., [2], [4]). The high time resolution stems from the short aerosol physical residence time (~1 min) compared to environmental chambers (~hours). Despite of the short physical residence time of the OFRs, the equivalent photochemical aging time can be in the order of several days accomplished by the high concentration of oxidants compared to atmospheric conditions. Despite the fact, that accelerated photochemistry of OFRs have some limitations on how accurately they simulate atmospheric aging [5], OFRs provide properly used a joint metrics that can be used to compare the potential of different emission sources to produce secondary aerosols.

In this study, we present characterization results of a new commercially available OFR called Dekati Oxidation Flow Reactor (DOFR) and its sampling unit. The DOFR design is similar with the previously introduced Tampere University Secondary Aerosol Reactor (TSAR) by Simonen et al. [6]. The main oxidizer in the DOFR is OH-radical that is formed by UV-C (254 nm) photolysis of externally injected O_3 and H_2O. The characterizations performed for the DOFR include the determination of the photochemical ageing range, the residence time distributions (RTD), particle penetration, and the SOA yield of toluene precursor. In addition, the combination of DOFR reactor and the sampling unit were also used for measurement of fresh and aged emissions of several passenger cars (gasoline and diesel) running in idle and the hot and the cold start emissions were compared. Moreover, the setup was used for measuring real-time primary and secondary emissions of passenger cars driven over WLTP driving cycle under different temperature conditions.

Particle size distribution measurements were conducted using the ELPI+ and the SMPS instruments. The particle RTD were measured using two CPCs with polydisperse solid particles. Particle penetration was determined as function of particle size using a CPC and the NanoDMA. The photochemical age was determined with the CO-trace gas method (see, e.g. [6]). Fresh emissions were measured extracting sample from the car tailpipe using cold dilution performed with eDiluter mimicking exhaust dilution to ambient. The fresh emission was then aged with the DOFR setup and secondary aerosol mass measured with ELPI+. Exhaust and toluene precursor ageing inside the DOFR were also modelled with a simple time dependent model based on the model presented by Li et al. [7].

The photochemical age was determined for several relative humidities (RH) and UV-light intensities as a function of O_3 concentration. The ageing range was found to be in 1 – 17 days with the CO tracer and was varied by switching the no. of UV lamps on (the ozone was 50 ppm and RH 50%). The toluene precursor oxidation experiments showed comparable results to previous studies showing 0.1 – 0.3 yields for tested toluene concentrations. The emission measurements showed that tested gasoline vehicles could produce 1 to 4 orders of magnitude more SA mass compared to primary mass with a cold engine. Figure 1. shows the aged PM1 after a cold start and a warm start.

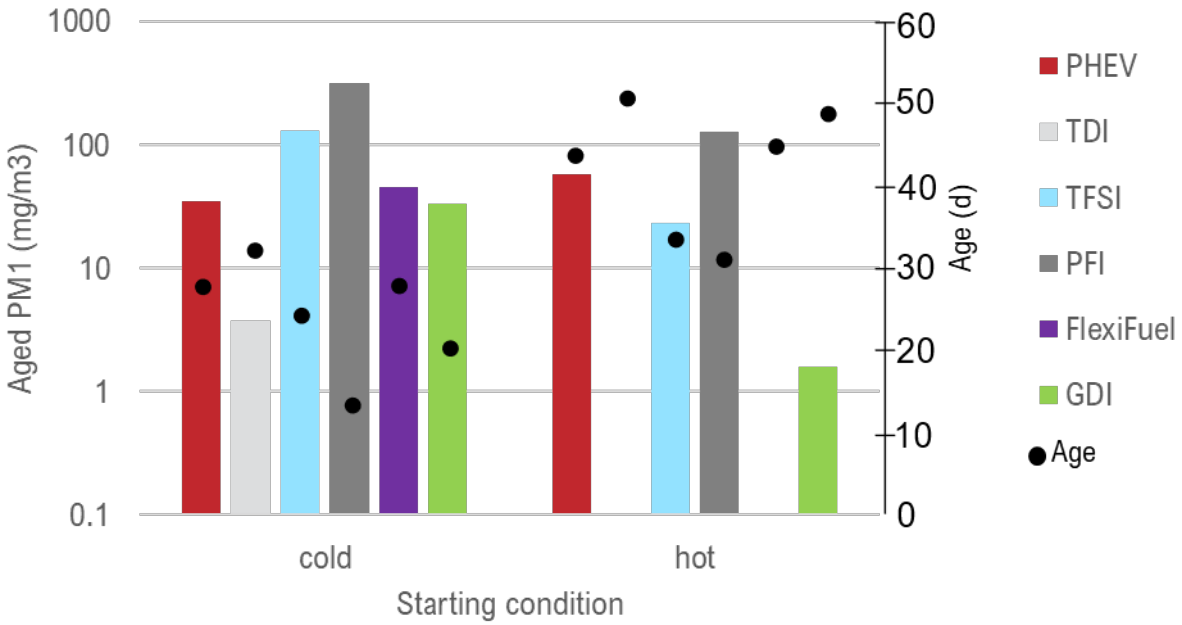

Figure 1. The aged PM1 of idling passenger car exhasut after a cold start and a warm start.

AKNOWLEDGEMENTS

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Atmospheric black carbon radiative forcing driven by coating morphology

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Upon release in the atmosphere, the morphology and surface properties of soot promote the adsorption of local vapour phase molecules which initiates condensation. Coated soot particles contribute significantly to radiative forcing, due to the so-called lensing effect and to their extensive atmospheric lifetime [1]. However, the knowledge of the coating morphology is still limited, and non-uniform coating – which has been observed repeatedly via microscopy [2] – is generally omitted in models. Similarly, there is a need to understand the mechanisms of coating morphology evolution from local particle sources up to the high troposphere. Multiple sources of uncertainty related to the coating are commonly identified in the literature when modelling atmospheric soot ageing, especially coating morphology, kinetics, and associated chemical composition.

In this work, the compact aerosol aggregate model (CA^2M) [3] model is extended to represent a liquid coating on the surface of soot agglomerates and study the optical properties during encapsulation by a non-uniform coating (NUC). Typical atmospheric agglomerates morphologies are studied, i.e., open or compact structures including non-idealities, with coatings composed of organic carbon and sulfates. To simulate the impact of atmospheric soot ageing, both the physical and optical particle properties are calculated by coupling CA^2M to a discrete dipole approximation model [4]. In addition, several properties inherent to the estimation of atmospheric lifetime such as volume, mass, effective density, and equivalent diameters are obtained simultaneously. Finally, a new parametrisation in terms of mass absorption cross-section is proposed and used in a global circulation model (ECHAM6.3) and the aerosol microphysics module (HAM6).

Our results in terms of absorption enhancement by NUC-BC (E_{abs} = 1.35 at m_{rt}) agree with experimental observations from traffic and urban emissions [5], whereas using a core-shell model leads to significant overestimations (E_{abs} = 1.75 at m_{rt}). The transition (m_{rt}~14) is defined as the mass ratio ([coating+particle]/particle) required for the combined droplet to become spherical. Beyond this transition the droplet grows radially up to mass ratios of 50, as typically observed in the upper troposphere. The direct radiative forcing (DRF) induced by NUC-BC is about 0.18 W/m² for initial DLCA soot agglomerates which is 25 % less than the DRF induced by core-shell particles. The maximum DRF corresponds to regions in the China and Indo-Gangetic plains and to a lesser extent in the Arabic peninsula, Central Africa, and South America. Finally, we will shed light into how the BC dry deposition is affected by the present non-uniform coating and how it compares with simplified morphologies.

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Particle Numbers at the traffic site in Istanbul in the autumn

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Nano particles between 10 to 400 nm were measured at the traffic site in Istanbul using a NanoScan SMPS the autumn and winter seasons. The average number counts and contributions of each PN fraction (Nucleation: <30 nm, Aitken: 30-100 nm, Accumulation: 100-400 nm) are given in Figure 1. Generally, the wintertime PN levels were slightly higher than in the autumn. The contribution of ultrafine particles (UFPs) to the total numbers are almost same (90 % in the autumn, 89 % in the winter). These contributions are higher than Asian cities ˜49 % [1] and approximately same in European cities [2]. Wu and Boor [3] analysed the particle number size distribution (PNSD) around the globe and reported that the PNSD in Europe, North America, Australia, and New Zealand are dominated by UFP, while in Asia they are dominated by the substantial contribution from the accumulation mode.

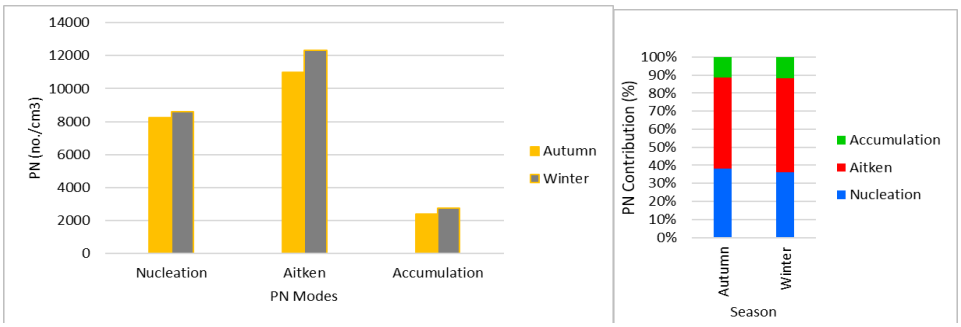

Figure 1: Particle numbers in the nucleation, Aitken and accumulation modes at the traffic site in Istanbul.

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Developing and Evaluating an Integrated Machine Learning Approach to Estimating Near Real-Time Local Level Concentrations of Outdoor Ultrafine Particles using Street-Level Images and City Sounds

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Existing epidemiological evidence suggests that outdoor ultrafine particles (UFPs, < 100 nm) have adverse impact on human health. However, most existing exposure modelling studies for outdoor UFPs have focused on predicting long-term exposures (e.g., annual average) and methods of predicting near real-time local level exposures are not readily available. To address this need, we developed a new platform including a solar-powered field monitoring device and machine learning algorithms that together provide near real-time predictions of outdoor UFPs and noise based on street-level images, audio data, and regional weather/air quality data. Machine learning models (convolutional neural networks and XGboost) were developed and evaluated using a large database of image/audio samples labelled with UFP/noise measurements (10-second samples) collected with research-grade instruments from 11 locations across Montreal, Canada, between 2021-2022.

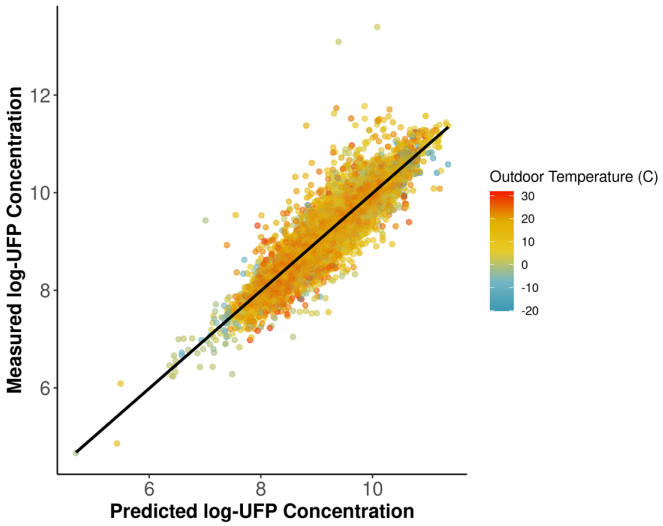

Figure 1. Measured vs. Predicted UFPs

In total, our new UFP model was based on approximately 120,000 samples and our noise model was based on approximately 99,000 samples. Outdoor UFP (median: 10,181 particles/cm^3; 1st: 1898, 99th: 51,390) and noise levels (median: 63.4 dB(A); 1st: 46.1, 99th: 80.3) varied substantially across our study period and reflect a wide range of weather conditions including very winter days (< -10 ^{o}C) warm summer days (>25^{o}C) periods. When evaluated in random test sets (15,000 samples for UFPs and 12,000 samples for noise), our algorithms explained the majority of local-level variations in outdoor UFPs (R^2=0.85) and noise (R^2=0.86) with slopes close to one between measured and predicted values (see Figure 1 for UFP results).

Collectively, this new platform offers an efficient means of predicting local-level UFP and noise levels in near real-time and can be used to track outdoor concentrations over-time in locations of concern across cities. Ongoing work is focussed on the transportability of these models (i.e., developing models in one set of locations and testing them in completely different locations) as well as extending this method for use in occupational exposure environments.

Unveiling potent toxic chemicals associated to primary or aged (secondary) wood combustion particles: a bio-analytical approach

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Residential wood combustion (RWC) is a significant source of fine particulate matter ($PM_{2.5}$) in ambient air especially in winter. Due to large amounts of volatile and semi-volatile organic compounds (VOCs and SVOCs) emitted, this source also induces the formation, through atmospheric photo-(oxidation) processes, of secondary organic aerosols (SOA) which account for a significant fraction of $PM_{2.5}$. As PM are complex mixtures, chemical analyses alone cannot fully characterize them nor identify unknown bio-active species. Implementing complementary integrated strategies, combining effect-based assessment and analytical methods (bio-analytical approach) can allow to evaluate the overall PM biological activity and reveal the presence of potent toxicological compounds. In this context, the main objectives of this work were first, to assess and compare, using in vitro bioassays, the biological responses of the primary and aged RWC PM emissions, as well as of SOA formed from the oxidation of key precursors largely emitted by biomass burning processes namely PAHs and furans; and second, to identify, using effect-directed analysis (EDA), the key species involved in the observed biological responses. The daytime (OH radicals) or nighttime (NO_3 radicals) atmospheric aging of 4 pure PAHs and 3 furans, or RWC emissions, was simulated using a Potential Aerosol Mass - Oxidation Flow Reactor (PAM-OFR). RWC experiments have been carried out using two modern residential heating appliances (logwood and pellets stove) under different output conditions (nominal and reduced). The biological responses of the generated PAHs and furans SOA, as well as primary and aged RWC PM, were assessed using in vitro bioassays targeting different modes of action (aryl hydrocarbon receptor (AhR), (anti)estrogenicity, and (anti)androgenicity). Selected active samples were fractionated by liquid chromatography and fractions obtained were individually tested for their AhR activity. Non-targeted screening (NTS) chemical analyses were then performed by GC-MS and GC(×GC)-ToF-MS on the most potent fractions to identify the bioactive compounds. Results obtained showed that only the SOA formed from the oxidation of PAHs induced significant AhR-mediated activity, which was even higher when SOA were formed through NO_3 radical oxidation processes. The biological responses observed for RWC emissions, mainly AhR (and partial anti-androgenic), were dependent on the heating appliances and output conditions. They typically decreased, or remained comparable, after aging due to the degradation or inactivation of active primary ligands and/or the formation of new active compounds. Targeted chemical analyses of 45 PAHs, oxy- and nitro-PAHs explained only 1 to 23% of the observed AhR biological activity. Finally, EDA identified 18 AhR ligands that were confirmed for their individual activity, including 6 in PAH SOA samples and 2 in RWC emissions never reported before. Overall, this work has shown the relevance of combining effect-based methods with NTS chemical characterization to discover new key PM bioactive constituents that might be later monitored in ambient air as well as in combustion emissions.

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Effect of UFP produced by anthropogenic combustion on human lung macrophages and motor neurons: role in pulmonary inflammation and neurodegeneration

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Anthropogenic particulate matter (PM) is one of the primary pollutants found in the atmosphere of industrialized cities. It can be inhaled by humans and accumulate in the lungs. According to recent research, PM is harmful to respiratory conditions. The primary cause of these effects is the ultrafine particles (UFP, PM < 100 nm), which are effectively deposited in the alveolar, tracheobronchial, and nasal regions due to their PM size. However, after air pollution inhalation, UFP has a strong ability to penetrate human brain deeply, with a poor possibility to be cleared. In this work, we examined how UFP affected the activation of human lung macrophages (HLMs) mainly involved in the inflammatory response to injury and neuronal function by measuring the release of proinflammatory cytokines and chemokines, the generation of reactive oxygen species (ROS), and the intracellular Ca^{2+} concentration ($[Ca^{2+}]_i$) in macrophages, and organellar dysfunction and neurotoxicity in motor neurons and primary cortical neurons. Additionally, a well-designed analytical procedure, set-up in a previous paper [1], allowed UFP to be fractionated in nanoparticles larger (NP100) and smaller (NP20) than 20 nm after the organic fraction was removed, allowing for the isolation of each particle's unique contribution. More in detail, dichloromethane (DCM) was used to extract UPFin order to separate the particles from the organic carbon soluble in DCM. Additionally, dry particles were dissolved in N-methyl-pyrrolidinone (NMP). The soot particles with a diameter more than 20 nm were separated from the NMP dispersions using membrane filters (Anodisc).

It's interesting to note that NP100 had no effect on the release of HLM cytokines, whereas PM0.1 and NP20 did. Specifically, PM0.1 caused HLMs to release IL-6, IL-1β, and TNF-α but not CXCL8. Furthermore, HLMs' preformed mediator β-glucuronidase release was not induced by UFP, NP20, or NP100. Given the lengthy (18 h) period required for the release of cytokines, it is possible that UFP and NP20 will cause the tested mediators to be produced ex novo.Consequently, mRNA expression of IL-6, TNF-α, and IL-1β was induced by UFP and NP20 after 6 hours of incubation. Furthermore, without causing cytotoxicity, NP20 induced the production of ROS and an increase in $[Ca^{2+}]_i$ in a time-dependent manner.

Furthermore, PM0.1 and NP20 exposure induced detrimental effects in motor neurons through the dysfunction of mitochondrial and endoplasmic reticulum (ER), the main calcium storing organelles deputed to relevant cellular functions such as energetic metabolism and protein folding. In this respect, after 48 hrs of incubation, PM0.1 and NP20induced ER stress, a type of apoptotic cell death measured as

organellar calcium dysfunction, and BIP and CHOP protein expression. Of note ER stress induced by PM0.1 and NP20 in motor neurons was associated to pathological changes in ER morphology and dramatic reduction of organellar Ca^{2+} level through the dysregulation of the Ca^{2+}-pumps SERCA2 and SERCA3, the Ca^{2+}-sensor STIM1, and the Ca^{2+}-release channels RyR3 and IP3R3.

An exemplificative scheme of the role of UFP role in pulmonary inflammation and neurodegeneration is reported in Figure 1.

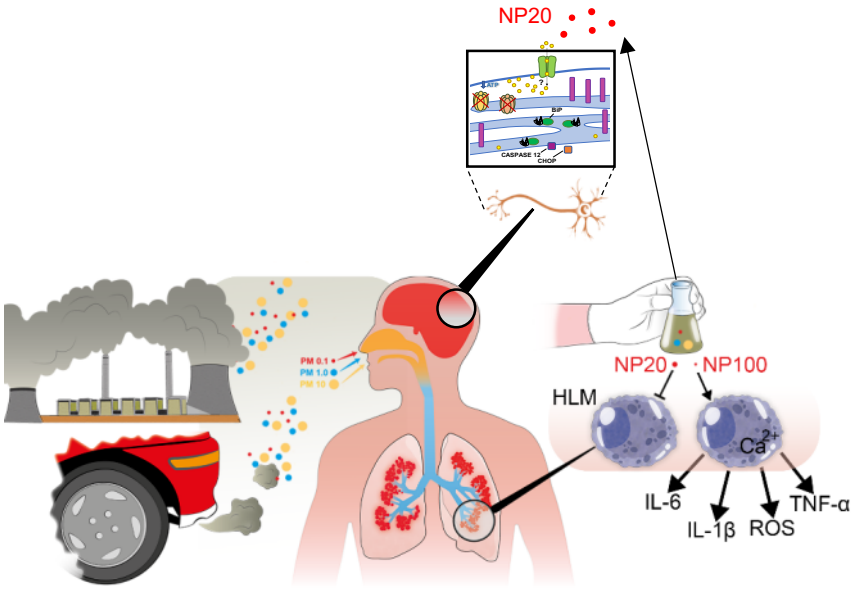

Figure 1- Scheme of the role of UFP role in pulmonary inflammation and neurodegeneration.

All of the current data point to NP20's primary detrimental effect among PM fractions [2]. This is especially concerning because the existing analytical techniques do not readily measure this fraction at the exhausts, making it impossible to set legal limits. This means that new monitoring methods and strategies to limit NP20 formation must be found.

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Assessing the direct and indirect effects of diesel exhaust particles on human intestine tissue

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Traffic-borne pollutants represent a notable proportion of ambient air pollution that can contribute to adverse effects in humans. During inhalation, fractions of traffic-borne aerosols can translocate from the alveoli to the bloodstream and accumulate within secondary organs beyond the lungs, such as the brain, liver, kidney, and intestine. However, understanding the specific impact of traffic-borne aerosols on those secondary organs remains an ongoing challenge. In this study, we aim to evaluate the direct and indirect effects of standard diesel exhaust particles (DEPs) on human intestine tissue *in-vitro*. The direct exposure of combustion-derived aerosols simulates aerosols that are swallowed after being cleared by the airway mucociliary activity. In contrast, indirect exposure simulates the translocation of the particles and/or release of lung-derived mediators through the blood circulation to the secondary tissues. The human intestinal Caco-2 / HT-29 and THP-1 monocyte-derived macrophage cell lines were co-cultured for 21 days in cell culture media and then exposed directly to 20 and 80 $\mu g.mL^{-1}$ DEPs for 24 hours. To mimic indirect exposure, the same DEP concentrations were given to lung cells, and the collected supernatants were added to the intestine tissues. Subsequently, tissue integrity and cell viability of the intestinal tissue, as well as the release of mediators such as pro-inflammatory IL-8 chemokine and IL-6, IL-1β cytokines in the media were assessed to understand the adverse effects of DEPs on the intestinal tissue. Our data suggested that the adverse effects of DEPs on the intestine tissue were induced upon indirect exposure to lung cell supernatants with an increase of IL-8 release from the intestinal cells, suggesting that translocated DEPs or lung-derived mediators could be the main contributors to adverse effects on the secondary tissues. We will expand the time of intestine exposure to DEPs and include additional key events to highlight the importance of lung-derived mediators and fractions of combustion-derived particles in traffic-borne pollutants toxicity on the secondary tissues.

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Reactive Oxygen Species Build-up in Photochemically Aged Iron- and Copper-doped Secondary Organic Aerosol Proxy

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The toxicity of particulate matter (PM) is highly linked to the concentration of particle-bound reactive oxygen species (ROS).[1] Chemical properties including metal dissolution and the sources of PM influence ROS production and its oxidative potential.[2,3] Here, the photochemical aging of a secondary organic aerosol proxy (citric acid, CA) with metal complexes (iron citrate) is assessed towards the build-up of particle-bound ROS. The photolysis of the carboxylate complexes initiates free radical chemistry that leads to ROS via the formation of peroxy radicals.[4] Although the photochemistry in viscous iron citrate particles and its effect on degradation and radical persistence has been studied,[5,6] the formation of ROS has not been directly measured so far for this or related systems. Furthermore, we additionally studied the impact of copper on the ROS concentration in the existing iron citrate particle system.

The photolysis of iron/copper citrate particles was experimentally mimicked with an aerosol flow tube in which UV-light irradiation periods and dark periods could be probed. Downstream of the flow tube an online particle-bound ROS instrument (OPROSI), using the acellular assay 2',7'-dichlorofluorescein with horseradish peroxidase continuously quantified ROS.[7] To test different atmospheric conditions influencing the particle's physicochemical properties, the experiments were conducted by combining relative humidity (RH) of 25% or 75%, iron citrate or iron-copper citrate samples, and a nitrogen or air sheath flow used a carrier gases. We found that irradiated CA aerosol containing 10 mole % iron citrate generated ROS concentrations on the order of 0.1 nmol H_2O_2 equivalent μg^{-1}, indicating the photochemically driven formation of peroxides. Increased RH leads to only slight, but overall lower ROS concentration, possibly due to a loss of volatile HO_2 and H_2O_2 into the gas phase in the less viscous particles.[6] The RH effect is enhanced in a nitrogen sheath flow, but in air and compared to the iron citrate particles, the iron-copper citrate samples show a uniformly decreased ROS level. Interestingly, in the high humid, nitrogen experiment with copper, we found a much more pronounced decline of the ROS concentration down to 0.02 nmol H_2O_2 equivalent μg^{-1} compared to all other irradiation experiments. We suggest that copper may suppress radical redox reactions and therefore consume ROS in an anoxic regime.

For the first time, we quantify continuously sampled particle-bound ROS concentrations from an aerosol experiment at different atmospherically relevant conditions. The results prove ROS production from organic aerosol aging processes that adds a natural pathway of enhancing PM toxicity. Assessing the availability of transition metals and their chemical interplay with themselves and with ROS is found to be crucial to exactly determining the oxidative potential of ambient aerosol.

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Nanoparticle profiling: a comprehensive assessment of physical, chemical, and toxicological characteristics at Thessaloniki airport

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Despite the growing attention towards ground-level aircraft emissions and air pollution near airports, numerous research gaps persist [1]. This study focuses on air quality measurements conducted in proximity to runways during take-offs and landings at Thessaloniki Airport, emphasizing particle characteristics in both summer and winter seasons. Employing various instruments, we evaluated particle mass, number, size distribution, and nanoparticle concentration in the air. Chemical analysis, including examination of volatile organic compounds and metal components, was carried out to provide a more thorough understanding of the particulate matter composition. Background measurements served as a reference for comprehensive results. In parallel, Air-Liquid Interface (ALI) tests with human lung cells were performed, shedding light on the toxicological effects of the measured particles on the respiratory system. The results indicate a decrease in cell viability and an increase in cytokine release, contributing valuable information to the assessment of air quality near active runways. This study enhances our comprehension of particle pollution in airport environments, with potential implications for environmental management and regulatory considerations.

Acknowledgments
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Direct observation of the internal and external morphology of size-segregated single particles and their interactions with alveolar epithelial cells

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Aerosol morphology depends on aerosol formation processes and atmospheric transformation and is a crucial factor relevant to aerosols' ensuing interactions with surrounding gases, vapors, and other environments [1]. Although single-particle techniques have improved significantly [2], considerably less is known concerning the three-dimensional (3D) external and internal morphology at the single-particle level. Particle-particle variability is a source of uncertainty in human and environmental impact assessments. Building on our earlier work [3], this study explores the 3D internal chemical mixing states and external shapes of single urban aerosols and expands the synchrotron-based techniques to single aerosol particles containing low-density (e.g., carbonaceous or biological) elements.

Urban aerosols were size-fractionated and collected on transmission electron microscopy (TEM) grids using a cascade impactor. On the other hand, standard reference particles (e.g., carbon back [CB] and diesel engine particles) were directly added to alveolar epithelial cell samples. The transmission (hard) X-ray microscopy (TXM) at the 01B1 beamline of Taiwan Light Source and the soft X-ray tomography (SXT) at the 24A beamline of Taiwan Photon Source were used to acquire 2D radiographic and 3D tomographic images of aerosol samples at a spatial resolution of 30–60 nm. Subsequently, the 3D morphology of single aerosol particles was reconstructed using sequential projections with the azimuth angle rotating from –90° to +90°. The synchrotron-based data were supplemented with TEM and energy-dispersive X-ray spectrometer (EDS) analysis for 2D images and elemental composition.

The TXM 3D tomographic images show that single urban aerosol particles exhibit complex, as well as transient, internal mixing states and structures, e.g., homogeneously-, heterogeneously-mixed, multiple inclusions, fibrous, porous, and core-shell configurations. After exposing the alveolar epithelial cells to standard reference CB particles, the SXT results show that the cell membrane and organelles (e.g., lipid bodies, mitochondria, etc.) and the CB particles can be clearly imaged and visualized in 3D. Interestingly, some CB particles were observed inside the cells. The potential biological or pathological responses in terms of cell morphology, the size and number of lipid bodies, and mitochondria are still under study. Updated results will be presented at the time of presentation at the conference.

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27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Conference Topic: *Instrumentation (Nanoparticle metrology and chemical characterization)*

Soot Nanostructure Investigation

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Soot formation and transformation, occurring through pyrolysis and oxidation reactions of carbon-based fuels, are the basic processes affecting the properties and level of soot emission from both stationary (heating, power and energy production systems) and non-stationary (engines) combustion devices. To this regard it is noteworthy that, beside diesel engines, also new-concept gasoline direct injection (GDI) engines are now a significant source of soot emissions because of the peculiarity of inherent combustion process [1].

Soot properties like particle size, surface area, H/C atomic ratio, and reactivity are responsible for their dangerous effects on the environment, climate change and human health. Among them, soot reactivity is particularly important as determining soot consumption in the course of combustion process and the following transformation in the atmosphere. Moreover, soot reactivity is the property relevant for regenerating, by oxidation, particulate filters used for soot reduction at the exhaust of internal combustion engines (ICE). In spite of many research works, no clear relationships of soot reactivity with the operating conditions and with bulk properties like surface area ad size have been found [2] especially in practical complex combustion devices like ICE, where diverse factors as the air/fuel ratio, the fuel quality and so on, affect soot, often in a contrasting way.

What, instead, seems more clearly related to soot reactivity, and in some respect also to soot source, is the nanostructure [1-3] here investigated through the tools mainly based on optical properties as UV-Visible, FT-IR and Raman spectroscopy used for getting nanostructural parameters which could be traced back to the oxidation reactivity.

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Modelling laser-induced incandescence of soot and tarballs in the SP2

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Depending on the sample, the majority of light absorption in smoke emitted to the atmosphere is due to either soot black carbon or tarballs (TBs). Soot is the primary absorber in smoke from relatively efficient, flaming combustion, while TB is the primary absorber in inefficient combustion such as some wildfires and marine-engine smoke. It is well known that soot particles entering a high-intensity laser beam (e.g. about 1 MW/cm2 of continuous-wave 1064 nm radiation) both scatter light and absorb sufficient light to reach incandescent temperatures, then sublimate. The resultant laser-induced incandescence (LII) signal is proportional to the mass of refractory black carbon (rBC) in the soot particle, while the scattered light is proportional to the overall volume (rBC plus other material) of the particle. It is also well known that detailed modelling of scattering and incandescence requires knowledge of several key physical parameters affecting heat transfer, mass transfer, spectroscopy, and annealing [1]. Here, we extend the substantial body of literature on models of rBC incandescence from pulsed LII experiments to the continuous-wave LII context employed in the commercial Single Particle Soot Photometer (SP2). We apply our model to both soot, also known as black carbon, and tarballs, which are non-volatile, amorphous carbon spheres emitted by wildfire smoke and marine engines [2] and which may anneal in the high-intensity laser [2,3]. We validate this model against real SP2 data. We discuss the assumptions required to reproduce signals from soot, and the constraints on tarball properties that can be obtained from the model. This work provides the basis for the future application of LII for distinguishing tarballs from rBC in real time.

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Measurement of nanoparticles true volume and density in the aerosol phase

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Harnessing the high surface-to-volume ratio of aerosol nanoparticles is essential for improved photo-and-thermal catalysis, nanotube synthesis, and medicine. However, adverse effects on health and environment due to fossil fuel combustion, brake, and tyre wear are still to be assessed and mitigated. All these phenomena are linked to fundamental nanoparticle properties, but in the aerosol phase current knowledge is limited to the measurement of equivalent metrics. The mass is commonly measured using particle mass analysers, relying on knowledge of the particle charging state, from which particle volume can be inferred using a predefined bulk density. Online measurements of volume have been attempted based on charging [1]. Semi-online and offline techniques for volume measurement also exist such as tapered element oscillating microbalance and microscopy retrieval. However, most of these approaches rely on a prescribed density, which is commonly retrieved from aerosol-microscopy techniques [2] or pycnometry. These methods have high uncertainty and very low throughput, but the error propagation inherent to using inadequate densities has dramatic consequences, especially in material synthesis, metrology, and models, e.g., optical and global climate models.
Therefore, it is crucial to develop techniques that can measure the true particle volume and infer the material density of nanoparticles with unknown properties, e.g., alloys, oxidised metals, matured soot, or coated particles. In this work, we propose two prototype techniques aiming at measuring the mass-to-charge change between bare particles and fully-encapsulated particles (Δm) using a centrifugal particle mass analyser (CPMA), along with a final size measurement, i.e., electrical mobility or aerodynamic, of the combined droplets (d_{mf},d_{aef}). Knowing a pair (Δm,d_{*f}) allows the true volume of the particles inside the droplets to be calculated. The density is then recovered from the mass and true volume.

The first technique uses a growth apparatus to condense oil on the surface of the particles. To achieve full encapsulation in a spherical droplet, a moderately high temperature is needed within the saturator to evaporate the oil and large temperature difference is required to reach the radial growth mode of the droplets. The minimum T_{sat} and ΔT_{min} are then set with the previous constraints, whereas ΔT_{max} is both constrained by the minimum energy required for unwanted homogeneous nucleation and the higher limit of detection of the instruments. Validated with PSL nanoparticles of multiple sizes, the technique is applied to silver agglomerates and is able to recover the true volume and density, as well as several important properties such as the agglomerates porosity and packing factor.
The second technique employs electrostatically-enhanced coagulation of oppositely charged sample nanoparticles and oil droplets. The collision-coagulation takes place inside a dedicated large volume mixing chamber. The resulting combined droplets are measured with a CPMA and an aerodynamic aerosol classifier (AAC), the latter allowing for charge-independent size measurements. Through this combination the volume of silver agglomerates has been recovered and we show that the volume error using an equivalent sphere approximation reaches up to 60 %.
Our results will analyse an extended set of samples and compare the suitability of each technique.

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Assessing the benefits of novel nanoporous silicon nitride membranes to capture and analyse particulate emitted from spark ignited hydrogen internal combustion engine.

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The objective of this study was to determine whether, in comparison to the most advanced graphene oxide (GO) grids, there would be any further advantages to analysing the exhaust particle captured on a novel nanoporous silicon nitride (SiN) grid. A spark ignited internal combustion engine powered by hydrogen was used in this investigation and it was operated using a baseline lubricant oil. One speed-load condition was chosen to generate a nanometric particulate output. As part of the capturing setup, an in-house probe was designed and manufactured to hold the TEM grid in the centre of the exhaust stream. The exhaust stream was sampled using a modified AVL smokemeter, which was set to sample "n" times 20,000 mL based on the length of time the grid was left exposed to the gas. While the engine was run at steady-state conditions, a DMS500 with the catalytic stripper was used to measure the particles concentration in the exhaust. As solid particles were detected, two TEM grids, one in graphene oxide (GO) and one in silicon nitride (SiN) were used in turn to capture the particles in the exhaust. Following capture, the particles were examined by HR-TEM at the University of Nottingham's Nanoscale and Microscale Research Centre (nmRC) using a JEOL 2100F TEM. A 250kV incident electron beam was used, and it could be magnified up to 250,000 times. The microscope was equipped with a Gatan Orius CCS camera. Additionally, EDX could be carried out using the X-MaxN 80 T that is available.
The results shows that the custom-made particle sampling setup successfully capture particles including sub-10 and sub 23nm particles on both grids. TEM analysis shows a wide range of particle types i.e. clusters, agglomerates, small particles and crystalline features. As expected, the main elemental composition of these particle can be correlated to oil composition. Particulates can be observed using EDX on the GO grid, but the amount of background carbon from the substrate overwhelms the amount from the particles. The small number of particulates from the H_2 engine required our proposed new method to fully understand composition. However, because silicon and nitrogen make up the majority of the C-free substrate, the SiN grid quantifies the carbon from the particle with greater accuracy. Additionally, elemental analysis can be studied anywhere on the SiN grid, but the GO grids need to be used away from the lacey carbon film and the copper mesh.

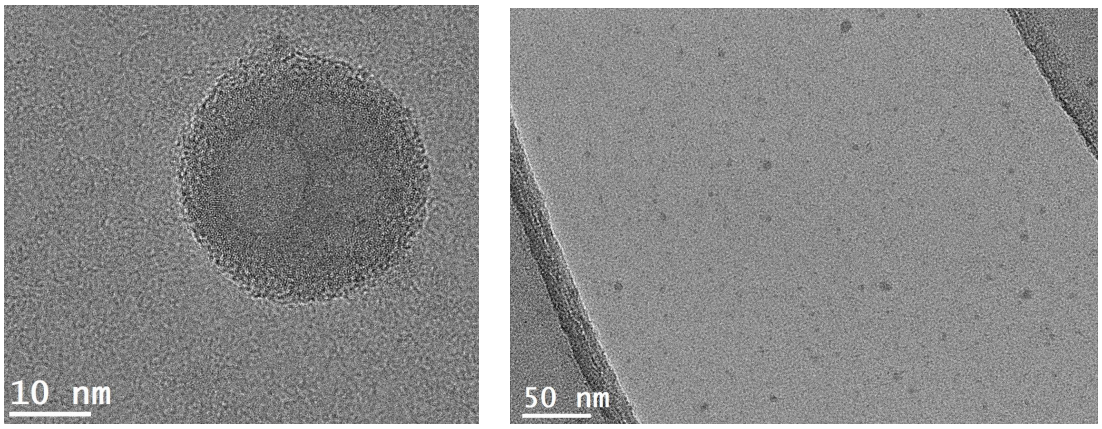

Figure 1. TEM images of particles captured on the grids: sigle particle (left), multiple 10nm particles on the right.

Development of a primary standard for particle number concentration

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Background:
Currently, the primary standard used at PTB for a metrological calibration of particle counters is a commercially available device. In this abstract, we are presenting the development of a manufacturer-independent method for the measurements of particle number concentration. The independency is a necessary step to better understand the measured raw values for establishing a robust pathway of traceability to the SI unit Ampere. For this purpose, a Faraday Cup Aerosol Electrometer (FCAE) [1] is used together with an Ultrastable Low-Noise Current Amplifier (ULCA) [2] for the measuring current to convert it into a measurable voltage scale.

Methods:
To identify the signal to noise ratio (SNR) of the system, all individual components were measured without input signal (baseline check) and the Allan variance [3] was calculated for several lab studies. The influence of vibration was investigated and reduced by a provisional vibration decoupling. Furthermore, the previous standard coaxial cable connecting the FCAE and the ULCA was replaced by a low-noise type. Finally, an intercomparison study was conducted with two commercially available FCAEs, which are typically used for international key comparisons of National Metrology Institutes [4]. Therefore, the SNR and the consistency of the results (EN score) were determined, and a moving average was used to visualize the correlation between the measured values.

Results:
The first version of our primary standard shows good agreement with the results of commercially available FCAEs. The SNR for a particle concentration of 5500/cm³ is about 20 dB, while the SNR of commercially available FCAEs is about 30 dB. The calculated correlation coefficient is about 0.84 and higher. Regarding SNR, there is room for further improvement because the system still reacts sensitively against vibrations, which are mostly caused by other devices running in the laboratory. The dominant noise source during the measurement is the FCAE itself in its current state.

Conclusion and further goals:
The aim of this work was to optimize the system for improved counting efficiency of airborne nanoparticles below 20 nm over a wide range of particle number concentration. In this range, the measured current lies between 8 fA for 1000 charged particles/cm³ and 400 fA for 50,000 charged particles/cm³ at a volume flow of 3 l/min. Future strategies are aiming to detect even smaller particle sizes and lower particle number concentrations.
For precise measurement with the new primary standard at PTB, especially in the current range below 8 fA, further investigation and modification are necessary. First, a better vibration decoupling of the system is essential, therefore the housing of the system must be optimized. Second, shorter low-noise cables can also minimize interfering effects caused by vibration. Additionally, a new housing offers the possibility of using technologies such as Peltier elements to reduce temperature effects.
However, to measure small quantities of charges with a Faraday cup pushes this technology to its limits. [5] We assume that the movement of the electrons within the system can cause interactions that degrade the SNR. A more compact design and new materials may reduce this interference.

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Exploring the morphological and structural attributes of Carbon nanoparticles used as soot replica in combustion studies: A Comprehensive 2D/3D Analysis

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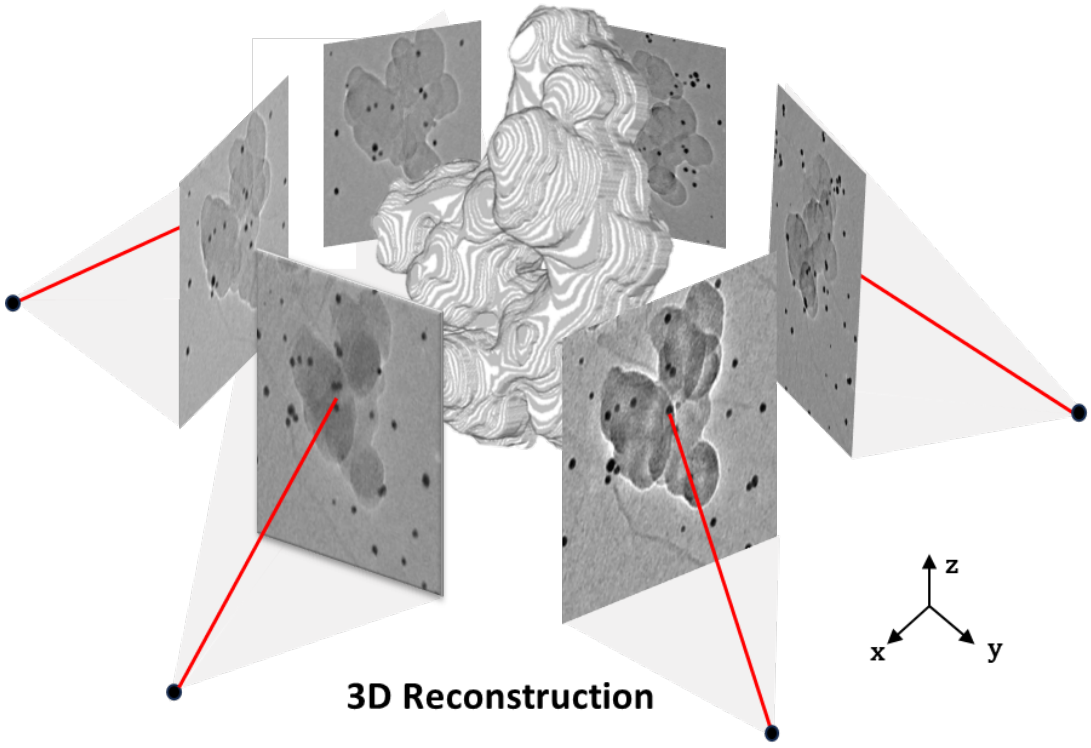
The proposed work focuses on a comprehensive characterization of 3 commercially available carbon black samples typically used in combustion studies. Particle sizes were determined using transmission electron microscopy. A novel high-throughput Electron tomography was used to create 3D volume reconstructions of carbon particles, while the microstructure was investigated by fringes analysis.

A JEOL 2100F TEM microscope with a Gatan Orius CCD camera, based in the Nanoscale and Microscale Research Center (nmRC) at the University of Nottingham was used to perform the imaging. The 3D reconstruction is enabled by a series of 2D images of the particle from different angles [1]

All carbon blacks were found in their agglomeration form on TEM grid, however, monodisperse carbon aggregates of 200 nm in size also occur as distinct entities. At the primary particles size level, Vulcan showed a more diverse nanostructure and more graphitic character, with particles ranging from 10 to 60 nm in diameter. Monarch and Mogul showed instead a comparable morphology in the 10 - 40 nm range, with a mean primary particles size 48% smaller than Vulcan.

Three-dimensional volume reconstructions of carbon aggregates revealed small 3D structures in the Monarch and Mogul samples, while the Vulcan particles were noticeably 2D, with just a single primary particle thick in the z-direction. A lower surface-to-volume ratio suggests a limited tendency to oxidation for this sample.



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A portable optoacoustic Black Carbon Sensor for Exhaust Emissions Measurement

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Introduction

Black Carbon (BC) is a significant pollutant that has strong absorption in the visible spectrum hence heavily contributing to climate change [1] while it also has significant negative effects on human health [2]. Despite these, there are currently no legislations to reduce BC emissions mainly due to lack of a consensus on definition and standardised measurement methods. Only recently IMO has started considering monitoring of BC emissions from ships (5th meeting of the Sub-Committee on Pollution Prevention and Response (PPR 5)). Optoacoustics is a promising technology for BC measurement because it is a non-destructive absorption based technique that allows for low-maintenance operation and offers miniaturization potential. Here we present a portable optoacoustic sensor for real-time emissions measurement that has been deployed in various campaigns including ships, cars and motorbikes.

Sensor Technology

The sensor is based on an innovative geometry that comprises an ellipsoid chamber [3]. The sample flow meets with the light path at the first focal point of the ellipse where sound waves are produced due to the optoacoustic phenomenon. A very sensitive yet inexpensive sound transducer (QTF) is placed at the second focal point where the signal is captured. This way the QTF is protected from particle contamination without inducing significant loss of sensitivity of the measurement. Currently the sensor has a lower detection limit of ~1 μg/m3.

Test cases

The first application of the sensor was on-board two ships, measuring directly from the funnel. The first was a RoRo ferry transporting passengers and cargo in the Baltic. Exhaust from one of the main engines of the ship was sampled with an eDiluter Pro (Dekati, eDiluter Pro). An aethalometer (ObservAir) is used as a reference. The second implementation was on a large container ship with a scrubber where measurements were performed both before (Upstream-US) and after (Downstream - DS) the scrubber. An eDiluter Pro was used for sampling and an optoacoustic instrument (AVL MSS) was used as a reference.

The sensor was also tested in real-world driving conditions on a vehicle using PEMS as a reference device. Even though the PEMS device measures particle number correlation is found between the measurements. Finally, exhaust measurements were also performed in real-world driving conditions for motorbikes. Since PEMS is too large to be attached to a motorbike, there was no reference instrument for the road measurements. Some comparisons were made in the lab while performing various testing cycles.

Conclusions

We demonstrate a portable optoacoustic BC sensor that is able to measure real-time (1 s resolution) exhaust emissions of various internal combustion engine sources that are comparable to reference instruments. Its dynamic response makes it suitable for on-board real-world measurement of different vehicles. Also the high sensitivity of the sensor makes it suitable for in-field source apportionment measurements, which is a next goal moving forward.

Acknowledgements
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An online measurement approach to monitor diesel exhaust particles in lung cells during exposure

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Diesel exhaust particles (DEPs) can deposit onto the respiratory epithelial surface upon inhalation. The cellular burden of DEPs is important for dose-response relationships in the cells. However, non-destructive methods to continuously monitor DEPs on cells during exposure are still challenging and not well established. Our study investigated an alternative particle detection system, i.e., the miniaturized lock-in thermography Calorsito mini (NanoLockin GmbH, Switzerland), which uses a thermosensitive detection method that applies light illumination to induce heat of carbon-based particles. This Calorsito system was further integrated into the commercially available Cloud Alpha system (VITROCELL Systems GmbH, Germany) to combine cell exposure to particles under the air-liquid interface (ALI) conditions and online monitoring of particles on cells. To test system performance, the Cloud Alpha / Calorsito device was used to expose lung cells (i.e., A549 epithelial type II lung cells) to a standard DEP sample (SRM2975) at different concentrations. Particles deposited on cells were then measured with the Calorsito system under a light wavelength of 525 nm. A positive linear relationship (R2 = 0.98) was established between the thermal emission signals and DEP levels ranging from 0 to 500 ng/cm2, with a limit of detection (LOD) at around 40 ng/cm2. The interaction of DEP with cells was verified by transmission electron microscopy (TEM). Our results indicate that the Cloud Alpha/Calorsito device can combine cell exposure to DEPs and DEP monitoring on cells at a relatively low concentration. Further studies on continuous monitoring of DEPs are still ongoing to evaluate the interaction of DEPs with lung cells during exposure.

Health effect assessment of hybrid gasoline vehicle emissions by *in-vitro* cell exposure experiments in air-liquid interface

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Towards vehicles' electrification, the trade of hybrid cars in the EU registered a significant increase holding the 27% of the current EU market in 2022 [1]. Although hybrid vehicles are clean enough to mitigate air pollution and improve air quality, their emissions still contain ultrafine particles (UFPs) [2] that are harmful [3], maintaining the need to investigate the health effects of their emissions under different driving conditions.

In the current study, the health effects of emissions from a state-of-the-art gasoline plug-in hybrid electric passenger vehicle were assessed by performing Air-Liquid Interface (ALI) *in-vitro* cell exposure experiments. The tested vehicle was equipped with an emission control system consisted of a three-way catalyst (TWC) and a gasoline particulate filter (GPF) and assessed under transient driving at cycles that correspond real driving conditions of different dynamics i.e. mild dynamics for mainly urban driving (moderate-RDE driving cycle) and more dynamic driving at highway (Combined driving cycle), during cold and hot start. The cell exposure to vehicle emissions was sustained by the Multiculture *in-vitro* Cell exposure Chamber (MEC) [4] where particulates are deposited due to diffusion achieving doses equivalent to human inhalation during realistic daily exposure [5]. A549 human epithelial cells were exposed and subjected to Alamar Blue staining and lactate dehydrogenase (LDH) assays to assess cell viability, as well as to IL-1β and TNFa assays to assess production of cytokines and inflammatory response. Despite the advanced vehicle technology and emission control systems applied, a measurable biological effect of decreased viability and increased cytokine release was observed in all driving scenarios with more intense one the m-RDE driving cycle under cold start.

Acknowledgement: CERTH would like to thank EU Project nPETS (G.A. No 954377) for including the MEC device in the project's experimental campaigns.

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On the effects of combustion generated nanoparticles on human health: Overview of the current body of understanding

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During combustion, various materials undergo chemical reactions that lead to the formation of ultrafine particles or nanoparticles, that can be composed of different materials depending on the source, such as metal oxides, carbon, or other combustion byproducts. After the year 2000, there has been a continuous research effort to evaluate the toxicity of particles resulting from combustion [1], and epidemiological investigations have successfully pinpointed particles derived from combustion as a significant factor contributing to the adverse effects associated with particulate matter [2]. There is a wide palette of pathologies already associated, or under scrutiny to be associated, with combustion generated nanoparticles, which possess the capability to migrate from their initial deposition site in the lungs [3] to other organs, such as kidneys, liver or brain, with their ultimate accumulation site being contingent upon their specific physicochemical properties. Our comprehension of the molecular toxicology of combustion-generated nanoparticles has advanced, revealing a clearer understanding. The ultimate shared pathways involving oxidative stress-mediated inflammation are now recognized as the foundation for the effects induced by various combustion-generated nanoparticles [4]. However, there is still a long way ahead of fully comprehending the complete health hazards of combustions generated nanoparticles, not to mention, the progress still required for identifying ways to fully cancel such hazards. In this work we provide a literature overview summarizing the current level of knowledge existing on the adverse health effects combustions generated nanoparticles. We also discuss a series of perspectives on potential remedies, either on the prevention, or on the therapeutic side, enabled by emerging nanotechnologies [5].

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Portable air-liquid interface exposure chamber for field emissions toxicity assays

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Exposure of living cell cultures at air-liquid interface, mimicking, for example, the surface of human lungs, is believed to be one of the most realistic means to model toxicity of complex mixtures of pollutants on human health. Such assays, along with measurements under realistic conditions, such as portable emissions monitoring systems (PEMS) for measurement of real driving emissions, are important components of monitoring the anticipated effects of new technologies and emissions reduction efforts, typically based on surrogate measurements such as total particle number or mass. In this work, the concepts of air-liquid interface exposure and real-world emissions monitoring are combined into a portable exposure chamber, along with a mobile toxicological laboratory base, for field studies.

Living cell cultures are contained in standard 24-well holders, placed in airtight 17x13x9 cm exposure boxes, with a symmetrical head distributing the sample into 8 wells at 25 cm^3/min per well with standardized 6 mm inserts. Sample and control air are conditioned to 5% CO_2 by volume, heated to 37°C, and relative humidity is increased to above 85% by membrane humidifier with deionized water. Up to four exposure boxes, two for sample and two for control, are placed in a commercial small scale (40x35x45 cm inner dimensions) incubator, housing sample conditioning, pump and various accessories. The mobile base laboratory, deployable in a van or indoor, includes a small laminar flow box for manipulation with cell cultures, an additional incubator for housing exposure boxes that are not actively undergoing exposition, a freezer and pressure bottles with CO_2 (conditioning) and synthetic air (control sample).

The system has undergone an extensive field validation sampling diluted vehicle exhaust as well as ambient air, including 4 h of exposure and 2 h transport in a vehicle each day for 5 days, 5-day operation in vans and sheds at -10 to +30°C outside temperatures, and transport of up to 800 km per week. Sampling system losses characterised with 4-200 nm carbonaceous and metallic particles and particle deposition rates characterized with transmission electron microscope on silver nanoparticles will be reported on and discussed. Toxicological tests performed in four localities on ambient air included measurements of cytotoxicity, oxidative stress, DNA damage and gene expression changes. The analyses are ongoing, however, so far, the most pronounced effects were observed near major road in Prague.

This setup overcomes the distance between the source and the toxicological laboratory, which is, in the opinion of the authors, the main hurdle of toxicity studies. While the toxicological side of the experiment is neither simple nor low-cost, it is the opinion of the authors that the mobile setup allows for field evaluation of toxicity of emissions from combustion engines, friction brakes, local heating appliances, nanomaterial production and handling facilities, and other sources, and of highly polluted ambient air.

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Size-Classified Bioaerosol Detection from Recombination of Technically Proven Components

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From the perspective of re-creating detection strategies using existing principles and devices, the detection of airborne adenosine triphosphate (ATP) bioluminescence has often been proposed to represent a biological population in the air as an alternative because of fast response speed with a high resolution and correspondence to the culture-based bioaerosol monitoring. Nevertheless, there is a need to improve in instrumental and data processing techniques to offer more informative results for general applications, even by non-experts with hand-held devices.

This study attempted to recombine technically proven devices (ATP luminometer and airborne particulate matter (PM) monitor) and components (inertial impactor and ultrasonic humidifier) to generate size-classified (biological populations for different PM sizes) and specific (biological fraction per unit mass of PM) bioluminescence without a technical delay. Through this recombination, it was possible to provide which size of airborne PMs has physical dominance and intensity, thereby providing meaningful information for proper intervention measures within minutes.

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Fabrication of O_2-TiO_2/CuO heterojunction photocatalyst as a nanocorals for the photocatalytic inactivation of bioaerosols

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Indoor particles and workplace aerosols has significant impact on human health and its effect depends on characteristics and nature of pollutants orginating from vaied sources. In recent years, outbreaks of middle East respiratory syndrome-associated coronavirus (MERS-CoV), severe acute respiratory syndrome (SARS), COVID-19 and its recent variants (e.g., Delta and Omicron) has attracted the global attention for the airborne microbial prevention and control measures (Lu et al., 2021; Zacarías et al., 2020; Zacarías et al., 2021). Therefore, for protecting the public health effective air sterilization and purification are critical to mitigate the challenges of airborne pathogen transmission (Liu et al., 2023). In this regard, photocatalytic disinfection was performed for the purification of indoor air in a continuous flow reactor and its performance was evaluated. Herein, the O_2 doped TiO_2/CuO nanocrystalline materials was syntheiszed as a novel photocatalyst for the disinfection of *Serratia marcescens* as an airborne bacterial model. Various properties of the synthesized photocatalyst was characterized using different characterization techniques such as XRD, XPS, SEM-EDX, Raman spectroscopy, diffuse reflectance spectroscopy, and photoluminescence spectroscopy. The study showed that maximum disinfection of 95.21% and 58.82% was achieved under photocatalytic and photolytic processes at optimal conditions. Thus, the study revealed that O_2-TiO_2/CuO photocatalyst has tremendous potential for the disinfection of *Serratia marcescens*. The possible reason for the disinfection was the active participation of reactive oxygen specieses ($OH^{\bullet}$ and $O_2^{-}\bullet$) disrupting the genetic materials as well as the cell wall of bacteria. Consecutively, it also restricts the bacterial regrowth which usually happens in case of photolytic treatment (Negishi et al., 2023). Now, due to poor maintenance of heating, ventilation and air conditioning (HVAC) systems of different indoor settings, excessive dirt may be collected and serve as a breeding ground for the microorganisms. Therefore, economical and effective inactivation of bioaerosols and air cleaning systems are needed and this study could provide the possible solutions to these problems.

Keywords: Bioaerosols, Heterojunction photocatalyst, Photocatalysis, Reactive Oxygen Species (ROS).

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Indoor particle pollution from cooking in Denmark

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Background: In most developed countries, people spend most of their lives in their homes, where particle pollution from cooking food is a significant pollution source. The pollution increases the risk of cancer, cardiovascular diseases, blood clots and respiratory disorders. Powerful cooker hoods discharging the pollution outside are efficient solutions. However, our hypothesis is that many families still do not have powerful cooker hoods or use their cooker hood on a level that is too low. **Purpose:** The purpose was to investigate how efficient cooker hoods are in 20 Danish homes and if they are used correctly. **Methods**: Particle measurements (PN and $PM_{2.5}$ with calibrated P-Traks and DustTraks from TSI), ventilation calculations and in-depth interviews in 20 representative Danish homes with cooker hoods: 7 detached houses with a traditional separate kitchen, 3 newer detached houses with a combined kitchen and living room (new building style), and 10 apartments of which 7 apartments have recirculating cooker hoods with activated carbon filters (often used in apartments). In each measurement, we used a carefully developed reproducible bacon frying setup on our own cooking plate with our clean pan (homogeneous pollution source): Without the use of the cooker hood, with the cooker hood on medium level, with the cooker hood on the highest level, with the cooker hood on the highest level and a carefully cleaned grease filter. All measurements were carried out simultaneously in the kitchen and the connected room in two separate measurement rounds with open and closed door to the kitchen, respectively. In addition, an efficient air purifier was tested as supplement - and alternative – to cooker hoods in 7 apartments with recirculating cooker hoods. In total around 150 measuring situations were made (ventilation between each measurement). The type of cooker hood in each kitchen was noted, and the volume of each kitchen was measured and sketched - the distance between the cooker hood and the stove is indicated. The location of the hood above the stove was noted to evaluate it in relation to the requirements of the Danish building code. Finally, acoustic measurements of the noise levels were carried out during each cooker hood's various operating levels. Candles, tobacco smoking, wood stoves, vacuum cleaning or other activities that could generate air pollution inside the house were avoided during measurements. **Results:** This study confirms that many Danish homes do not have powerful cooker hoods and/or use their cooker hood on a level that is too low due to noise. The particle pollution from cooking food (PN and $PM_{2.5}$) quickly spread to the rest of the home when the door to the kitchen is left open thereby polluting the entire home to much higher particle levels than observed on the most polluted streets in Copenhagen during rush hour. Families are not aware of the health consequences of particle pollution from cooking food. Recirculating cooker hoods were not at all as efficient as cooker hoods discharging outside. In general, the placement of the cooker hoods fulfills the requirements of the Danish building code. Cooker hoods discharging the pollution outside used on a high level with cleaned grease filters can efficiently remove pollution from cooking thereby significantly reducing particle pollution in the home. In addition, efficient air purifiers or through draught can be a supplement/alternative to recirculating cooker hoods. **Acknowledgement:** This study is funded by the philanthropic organisation Realdania.

Design of an innovative personal air cleaner to prevent airborne disease transmission in transport microenvironments

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SUMMARY
This paper presents the fluid dynamics design of a personal air cleaner intended to reduce the airborne transmission of respiratory pathogens in transport microenvironments and improve indoor air quality in these confined spaces. The design is realized through 3D Computational Fluid Dynamics (CFD) simulations, performed with the finite volume based open-source OpenFOAM code. Positioned above the user's head, the device purifies the air at the inlet and generates a conical air shield that extends 40 cm along the vertical direction according to the preliminary CFD results. This shield is capable of protecting exposed individuals from virus-laden particles suspended in the environment.

1 INTRODUCTION

Transport microenvironments are confined spaces of concern in terms of the spread of respiratory viruses, owing to high levels of crowding and the potential for inadequate supply of clean (i.e., pathogen-free) air. The airborne droplet route has been identified as the primary pathway of indoor infection transmission, therefore proper ventilation control is necessary to minimize the risk of susceptible individuals becoming infected. Rather than increasing the air supply rates, which may lead to high energy consumption without effectively enhancing particle removal, control of local airflow patterns is desirable [1], especially in environments characterized by fixed seating arrangements, such as transportation. This can be achieved through the adoption of personalized ventilation and air cleaners. In previous research activities [2], we investigated the effectiveness of a newly designed personal air cleaner in reducing the indoor airborne transmission of respiratory pathogens. The device was conceived to be placed on desks, creating a protected volume in which the user can breathe clean air. This concept is herein extended to transportation, proposing a device to be installed above the user's head and creating a clean zone where they can breathe safely. Presented in the next sections are the concept of device and the preliminary results from CFD analyses.

2 METHODS

The design of the personal air cleaner is realized by means of 3D CFD analyses, assuming an incompressible, unsteady and turbulent flow. Turbulence was modelled using the unsteady Reynolds-averaged Navier-Stokes (URANS) approach, closing continuum equations with the Realizable k–ε model. The centre and right pictures in Figure 1 show the schematic of the device. It samples the particle-laden air from the environment, purified with an electrostatic filter, and reintroduces clean air through an annular section at its bottom. The internal geometrical configuration ensures the development of a diverging conical air shield, protecting the user (supposed to be sitting below the diffuser) from the surrounding environment. To numerically design the air cleaner, the blue-coloured computational domain in the left picture of Figure 1 was employed. The domain comprises both the inside of the device, to determine the internal air flow patterns, and an external cylinder with a diameter of 3m and 1m high, to assess its fluid dynamics behaviour in the immediate surroundings.
A velocity of 0.6 m/s was set as boundary condition at the inlet of the device.

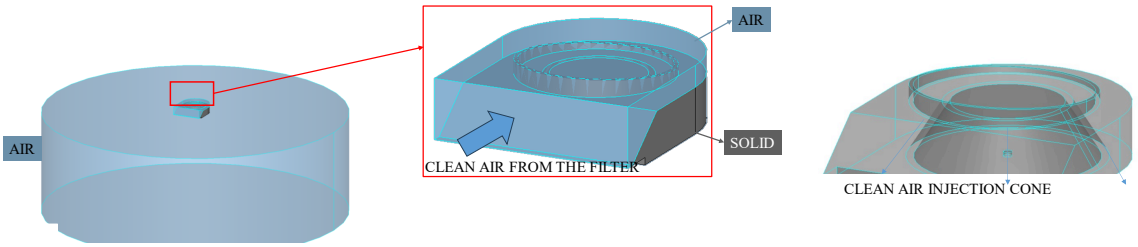
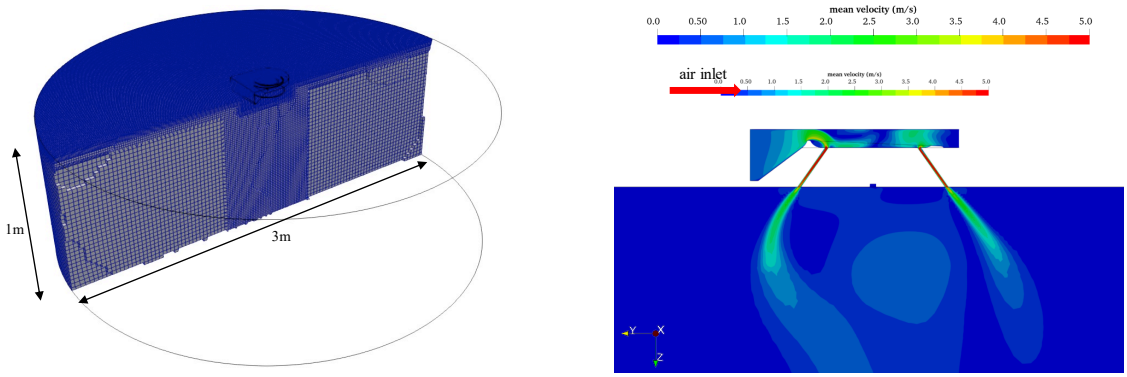


Figure 1. Schematic of the air cleaner (centre and right images) and computational domain employed in numerical simulations (left image).

3 RESULTS AND DISCUSSION

Figure 2a displays a clipped view of the hexahedral-based unstructured grid employed in the simulations, composed by 7,747,639 cells. Figure 2b, on the other hand, shows the predicted mean velocity field (on the same y-z slice of Figure 2a). CFD results show that the device creates quite symmetrical diverging jets, a bit deflecting owing to their mutual influence. They extend for 40 cm along the vertical direction and effectively create a protected inner control volume, where the user can breathe safely.



a) b)

Figure 2. Pictures showing a) the computational grid employed for CFD simulations, b) the predicted mean velocity field on a selected y-z slice.

5 CONCLUSIONS

This paper presents the preliminary results of the CFD design of a novel device aimed at reducing the airborne transmission of respiratory pathogens in transport microenvironments. Additional numerical analyses are being performed, to determine the optimal velocity at the inlet section of the device. Moreover, an experimental campaign is currently underway, in order to validate the numerically predicted velocity fields and to test the filtration efficiency of the proposed device.

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Indoor TVOCs, RSPM and Fine Particulate matter: Health impact on young women of a rapidly growing urban city of Northern India

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Total volatile organic compounds and particulate matter (PM_{10}, $PM_{2.5}$ and PM_1) have negative effects on the heart and lungs, and even cause cancer on prolong exposure. As young women in this part of world spends most of their time indoor doing their various studies and households' activities. This study was conducted to see effect know of toxic indoor air pollutants on them. The present study, was conducted from November 2022 to February 2023 in six urban households of Lucknow, which is a growing mega metropolitan city and capital of most polluted state of world. Envirotech (APM 550 and 577) sampler and portable sensors were used to measure PMs and TVOCs respectively. The mean average concentrations of PM_{10}, $PM_{2.5}$, PM_1 and TVOCs were found to be 236.6933 µg/m^3, 116.5596 µg/m^3, 17.596 µg/m^3 and 618.833 µg/m^3 respectively. The highest $PM_{2.5}/PM_{10}$, $PM_1/PM_{2.5}$ and PM_1/PM_{10} mass ratio was found to be 0.562, 0.22 and 0.11 respectively. The ratio was indicating the distribution of fine and ultrafine particulate dominance in different areas. The young women dwellers were classified in three categories pre-teenage, teenage, post-teenage and they were asked to till questionnaire related to their health. The health risk of exposure to PM_{10}, $PM_{2.5}$, PM_1, and TVOCs was determined using the US Environmental Protection Agency prescription of average daily dose calculation. The results showed that the carcinogenic values for $PM_{2.5}$ and TVOCs in 20-21 year were 0.165µg kg-1day-1 ,0.87µg kg-1day-1. The dose-concentration was used to assess health risks employing the ICRP and MPPD modelling approaches. The results suggested that both PM and TVOCs concentrations were primarily connected to the experiments respondents' activities within their homes. According to the data collected, the results are very alarming and exposure to PM_{10}, $PM_{2.5}$, PM_1 and TVOCs from indoor air may raise risk of developing lung cancers in young women in near future.

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Nanocluster aerosol generation from squalene-ozone reaction

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1 INTRODUCTION

Nanocluster aerosols (NCA, particles <3 nm) have strong impacts on climate feedbacks and potentially on human health. Our recent study [1] unveiled the NCA formation owing to gas-phase ozone reaction with human surfaces. However, the underlying mechanisms driving NCA emissions remain unexplored. Squalene is the most abundant compound in human skin lipids that react with ozone, followed by unsaturated fatty acids. This study aims to examine the contribution of squalene-ozone reaction to NCA formation and the influence of ozone and ammonia (NH_3) levels.

2 METHODS

We performed experiments in a 1.9 m^3 stainless-steel climate chamber, which was ventilated by filtered compressed air to ensure low background levels of particles (<100 #/cm^3 below 10 nm) and ozone (<1 ppb). The air temperature was controlled at 24 °C and the relative humidity was maintained at 40%. Ozone was generated by a Jelight 600 UV generator (Jelight Co. Inc., USA). In experiments with NH_3, we injected NH_3 from a gas cylinder (10 ppm, purity >99.9%, Cabagas Inc., CH). Reactants (squalene or C16:1n6) painted on a 0.24 m^2 glass plate were exposed to ozone to investigate NCA formation. A specific quantity of pure squalene (purity >99%, Acros Organics, Thermo Fisher Scientific, USA) or pure C16:1n6 (purity >99%, Cayman, USA) was dissolved in 10 mL methanol and then evenly painted on the glass plate using a glass stick. The painted glass plate was then placed on the stand inside the chamber. Ozone was subsequently injected into the chamber to initiate the reaction for 3 h at 1 h^{-1} air change rate. The reaction was investigated at 15 and 90 ppb ozone to investigate the influence of ozone, whereas NH_3 was injected at 0 and 375 ppb to explore the impact of NH_3. NCA in the size range 1.18-2.81 nm were sampled at 2.5 L/min flow rate and measured in real time at 2-min time interval with a Nano Condensation Nucleus Counter (Airmodus A11 nCNC System, Airmodus, Finland). The ozone concentration inside the chamber was measured with a time resolution of 1 min with an ozone monitor (Model 724, Tanabyte, USA) at 2.0 L/min sampling flowrate. The level of NH_3 was monitored at 30-sec time intervals with a 140 mL/min sampling flowrate using an NH_3 analyzer (LSE NH_3-1700, LSE Monitors, NL).

3 RESULTS AND DISCUSSION

Fig. 1 shows time-series of ozone mixing ratio and NCA size distribution in experiments comparing ozone reaction with squalene and fatty acid C16:1n6. After ozone injection into the chamber, NCA levels in both reaction experiments started to increase. This finding supports the inference from our previous study that ozonolysis of human skin lipid compounds contributes to NCA formation. Although the steady-state ozone levels were similar in both experiments (55 vs. 56 ppb), the steady-state NCA levels were 40 times higher during ozonolysis of squalene relative to C16:1n6, indicating that squalene plays a dominant role in NCA formation when ozone reacts with human skin lipids. The size distributions of NCA further demonstrated

the disparity between the two reactions. Squalene-ozone reaction generated an abundant concentration of NCAs in the smallest size (1.18-1.55 nm), which subsequently grew to larger sizes. In comparison, the ozonolysis of C16:1n6 emitted much lower level of the smallest NCA, with no obvious signals detected for NCAs larger than 1.71 nm. Regarding the influence of ozone and NH_3, results showed that NCA generated by squalene-ozone reaction were positively correlated with ozone level, whereas elevated NH_3 levels were associated with the stronger generation of larger NCA but fewer smallest ones.

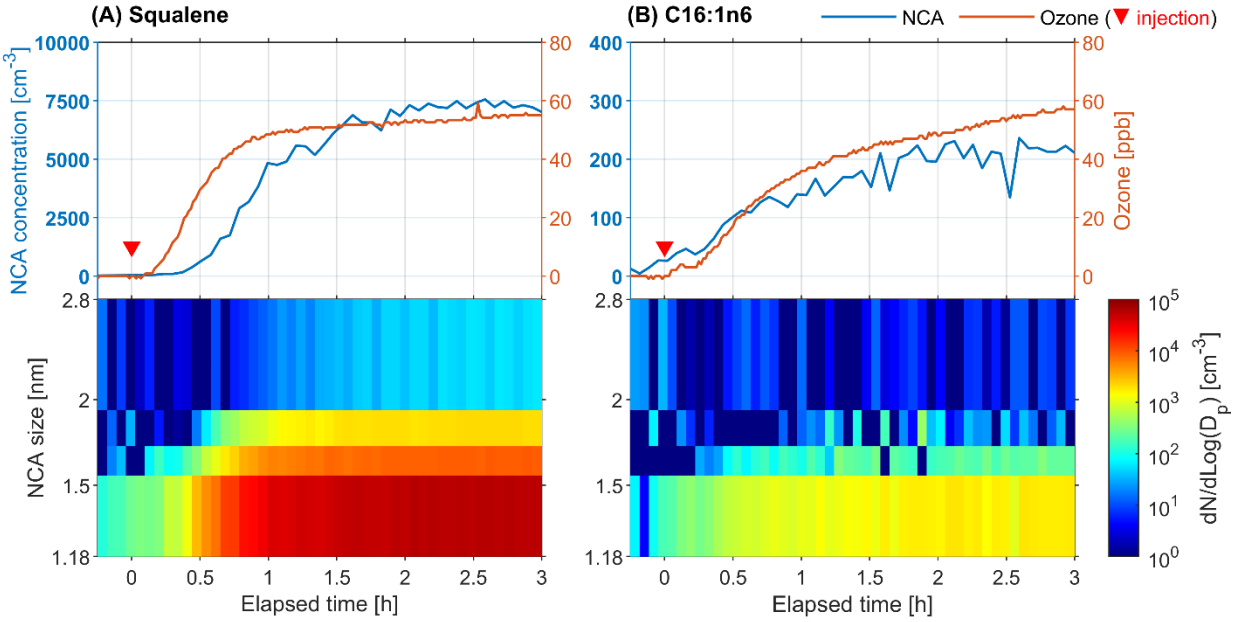

Fig 1. Time-series of total NCA number concentration (1.18-2.8 nm) and ozone (top), and size-resolved NCA concentration (bottom) in experiments comparing ozone reaction with (A) squalene and (B) fatty acid C16:1n6.

4 CONCLUSIONS

The ozonolysis of human skin lipid compounds contributes to NCA formation. With a typical ratio found in human skin lipids (4:1), squalene generated 40 times more NCA than C16:1n6, and thus dominated the NCA formation. NCA generated from squalene-ozone reaction is influenced by ozone and NH_3 levels. This study provides a deeper understanding of the mechanisms driving NCA generation from humans.

ACKNOWLEDGEMENT

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Indoor TVOCs, RSPM and Fine Particulate matter: Health impact on young women of a rapidly growing urban city of Northern India

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Total volatile organic compounds and particulate matter (PM_{10}, $PM_{2.5}$ and PM_1) have negative effects on the heart and lungs, and even cause cancer on prolong exposure. As young women in this part of world spends most of their time indoor doing their various studies and households' activities. This study was conducted to see effect know of toxic indoor air pollutants on them. The present study, was conducted from November 2022 to February 2023 in six urban households of Lucknow, which is a growing mega metropolitan city and capital of most polluted state of world. Envirotech (APM 550 and 577) sampler and portable sensors were used to measure PMs and TVOCs respectively. The mean average concentrations of PM_{10}, $PM_{2.5}$, PM_1 and TVOCs were found to be 236.6933 µg/m^3, 116.5596 µg/m^3, 17.596 µg/m^3 and 618.833 µg/m^3 respectively. The highest $PM_{2.5}/PM_{10}$, $PM_1/PM_{2.5}$ and PM_1/PM_{10} mass ratio was found to be 0.562, 0.22 and 0.11 respectively. The ratio was indicating the distribution of fine and ultrafine particulate dominance in different areas. The young women dwellers were classified in three categories pre-teenage, teenage, post-teenage and they were asked to till questionnaire related to their health. The health risk of exposure to PM_{10}, $PM_{2.5}$, PM_1, and TVOCs was determined using the US Environmental Protection Agency prescription of average daily dose calculation. The results showed that the carcinogenic values for $PM_{2.5}$ and TVOCs in 20-21 year were 0.165µg kg-1day-1 ,0.87µg kg-1day-1. The dose-concentration was used to assess health risks employing the ICRP and MPPD modelling approaches. The results suggested that both PM and TVOCs concentrations were primarily connected to the experiments respondents' activities within their homes. According to the data collected, the results are very alarming and exposure to PM_{10}, $PM_{2.5}$, PM_1 and TVOCs from indoor air may raise risk of developing lung cancers in young women in near future.

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Eco-friendly synthesis of Hydroxyapatite nanoparticles by Liquid Flame Spray

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Calcium phosphate-based (CaP-based) bioceramics have been widely applied in biomedical applications (such as dental roots, hard (bone) tissue engineering, bioimaging, drug/gene delivery, coating metallic implants, etc.) for the last two decades. This is because of their excellent biomedical properties, which include biocompatibility, bioactivity, osteoconductivity, and osteoinductivity, as well as favorable mechanical, surface, and physio-chemical properties. Among the phases of CaP bioceramics, Hydroxyapatite (HA, $Ca_5(OH)(PO_4)_3$) has gained the most attentions as it is the main inorganic constituent of bones, dentin, and enamel. Therefore, developing a simple, fast, and/or up-scalable synthesis method for HA nanoparticles has gained intensive attention.

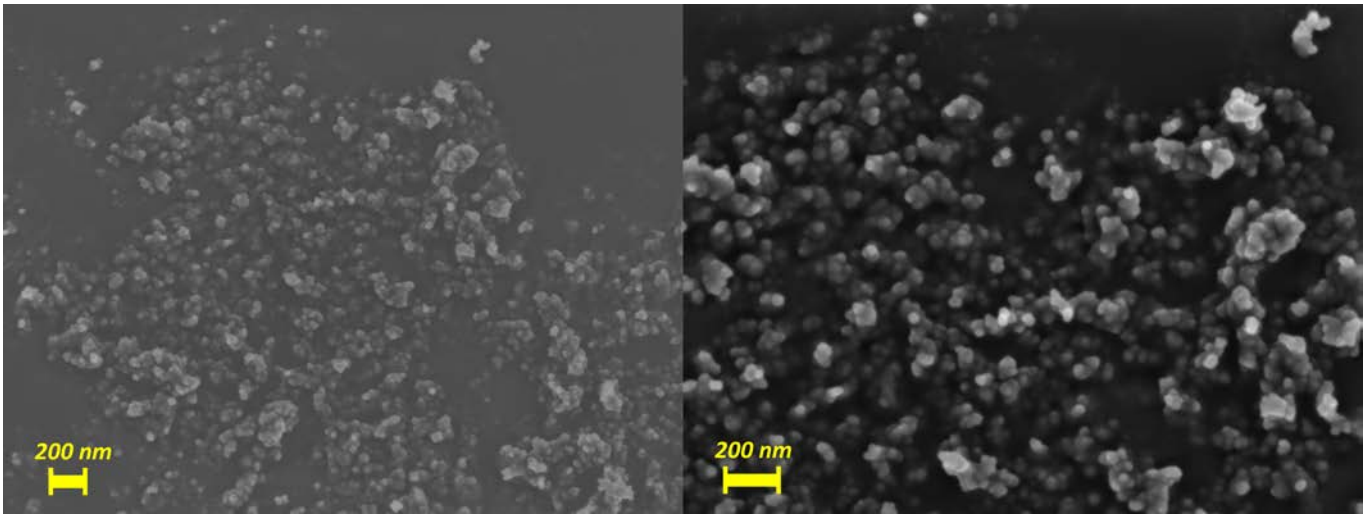

Figure 1. SEM images of Flame-made HA nanoparticles.

In this study, HA nanoparticles were successfully synthesized by an eco-friendly, continuous, simple, fast, and up-scalable aerosol synthesis method. Ca and P precursors have been dissolved in only deionized water then the precursor solution fed into a H_2/O_2-flame to develop an eco-friendly synthesis route of HA nanoparticles. After that, the flame-made nanoparticles were collected directly from the gas flow as a powder with an electrostatic precipitator. Thereafter, effect of synthesis parameters on the structural properties of the flame-made nanoparticles were investigated by applying different analyses methods such as XRD, SEM, BET, etc.

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Airborne particulate matter and diesel engine exhaust on infrastructure construction sites in the Copenhagen metropolitan area

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Diesel engine exhaust (DEE) is a known carcinogen but many industries continue to deploy diesel-powered machines, albeit with improved filtration systems and regulatory standards. The goal of this study is to evaluate workplace exposure to DEE on outdoor construction sites. To that end, we carried out a series of online and offline measurements at four sites in the Copenhagen metropolitan area. We used quartz-fiber filters to measure elemental carbon (EC), a standard proxy for DEE exposure; scanning mobility particle sizers and optical particle sizers to measure particle number concentrations, mass concentrations, and particle size distributions; and micro-aethalometers to collect time-course data on black carbon (BC) concentration. We sampled at near-field and far-field positions, as well as from the breathing zones of workers and machine operators. We report that the average EC concentration ranged from < 0.3 to 6.4 $\mu g/m^3$. EC exposure was highest for ground workers (3.4 ± 0.8 μg EC $/m^3$), followed by drilling-rig operators (2.8 ± 0.5 μg EC $/m^3$). Non-drilling-rig machine operators (1.4 ± 1.3 μg EC $/m^3$) did not differ significantly from background (1.0 ± 0.3 μg EC $/m^3$). Construction sites with active drilling rigs had higher average particle number concentrations (22,000, 70,000, and 20,000 $/cm^3$) than sites without (5,000 $/cm^3$). Overall, although DEE exposures were below current occupational exposure limits (10 $\mu g/m^3$ in Denmark; 50 $\mu g/m^3$ in the European Union), they generally exceeded the 1:1000 cancer risk (0.45 μg EC $/m^3$).