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Book of Abstracts

Poster

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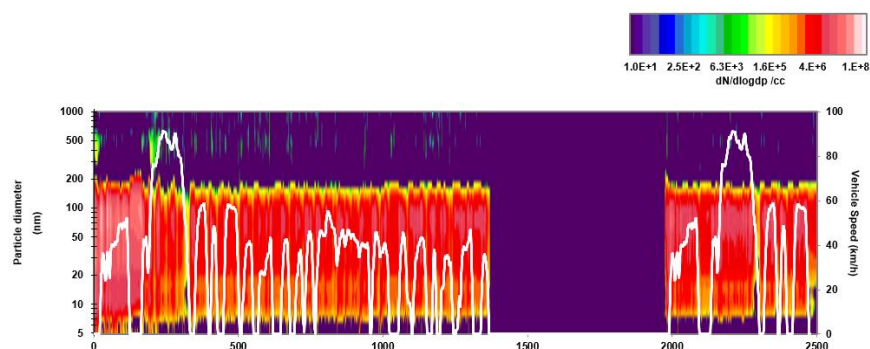
Al-Thuwaynee Ayad

Affiliation	BRIGHTON UNIVERSITY
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Coauthors	Khizer Saeed, Xing Ming Lu, Gelu Varghese
Publication title	Synthesis of Iron Oxide Nanoparticle in a Premixed Propane-air Premixed Flame.
Publication type	Poster
Introduction & Background	<p>In recent years, iron oxide nanoparticles have attracted a great deal of interesting due to their unique magnetic, electric, optic, and catalytic properties. Therefore, iron oxides nanoparticles have been widely used in many potential applications. In particular, nanoparticles of controlled morphology, size and composition called 'functional nanoparticles' have been attracting significant attention in the scientific literature due to their numerous practical applications. Scientific advancement on functional nanoparticles synthesis is essentially needed due to their significant impact on micro and nanoscale device and their potential applications. The chemical and physical properties of functional particles are strongly affected by the size, composition, shape of nanocrystal</p>
Methodology	<p>The main techniques for producing nanoparticles, gas phase combustion synthesis is one of the effective route with respect to uniform size and shape. Iron oxide nanoparticles are synthesised in a low-pressure flame reactor based on the gas phase. The proposed work is to stabilize the burner configuration by using a premixed flame with propane-air. A mixture of iron pentacarbonyl Fe (CO) 5 in the argon will be added to the gases as a precursor material using the premixed flames.</p>
Results & Conclusions	<p>Synthesize functional iron oxide nanoparticles phase and morphology using the premixed flame based technology from (1-10 nm) size diameter.</p> <p>To establish the effects of the flame parameters on the particle characteristics and properties. To establish the efficacy of the in achieving controlled particle synthesis with defined magnetic properties. Another aim of this research is explore the feasibility of the iron oxide nanoparticles in the functional particle range of 1- 50 nm on the premixed flames.</p>

Baek Sungha

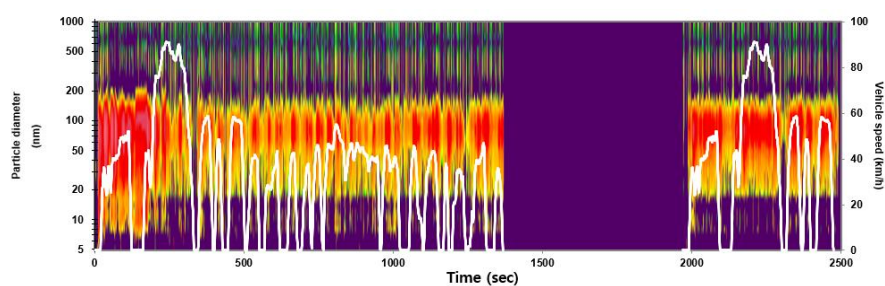
Affiliation	School of Mechanical Engineering, Korea University
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Coauthors	Dongyoung Jin; Jaeho Cho; Cha-Lee Myung; Simsoo Park
Publication title	Nano-particle Emissions Characteristics with Metal Foam Gasoline Particle Filter (GPF) for Turbo-charged Gasoline Direct Ignition Vehicle on FTP-75
Publication type	Poster
Introduction & Background	<p>Turbocharged spark ignition direct injection (SIDI) engines are widely adopted for improving fuel economy, comparable vehicle performance, and reducing greenhouse gas (GHG) emissions. However, some of SIDI engines showed higher particle number (PN) emissions characteristics of $E+11 \sim E+12$ N/km that exceed Euro 6 legislation ($6.0 E+11$ N/km), while PN from diesel particulate filter (DPF) equipped diesel vehicles emitted $E+10 \sim E+11$ N/km. PM from SIDI engines are primarily produced by poor fuel vaporization at the combustion stage, which caused heterogeneous mixture formation and incomplete combustion during the cold start phase. Furthermore, fuel-wetting at cylinder liner and piston bowl by high-pressure injection control has accelerated the PM formation. For those reasons, SIDI engines produced considerable amount of nucleation mode particles of semi-volatile and solid particles.</p> <p>After-treatment systems of gasoline particle filter (GPF) will be widely adopted for SIDI vehicles to reduce the PN emissions for meeting Euro 6 real driving emissions (RDE) legislation. Filtration efficiency of cordierite GPF can satisfy PN regulation, however high pressure drop impacted on vehicle performance. To improve pressure drop, this study used a metal-foam type filter on turbo-charged SIDI vehicle and investigated filtering efficiency and size-resolved PN emissions characteristics under Federal Test Procedure (FTP-75) cycle.</p>
Methodology	<ul style="list-style-type: none"> - Engine specifications and Vehicle test mode: A 2.0L T-GDI engine with TWC and 6-speed AT was used. The vehicle test mode is FTP-75 under cold start condition. - Test equipment and particulate emissions analysis: A 48-inch single roll chassis dynamometer (AVL, M4500) with a constant volume sampler (AVL, CVS i60) tunnel and an exhaust measurement system (AVL, AMA i60). The solid particle concentration was measured by a particle counter (AVL, APC), which complied with volatile particle remover (VPR) for particle number diluter (PND) for eliminating over 23 nm size particles. The size-resolved PN emissions was measured by a differential mobility spectrometer (Cambustion DMS500) that was installed downstream of the tailpipe. The DMS500 analyzed the size range of 5–1000 nm with a data-logging frequency of 10 Hz and a T10–90% response time of 200 milliseconds.
Results & Conclusions	<p>The PN emissions from T-GDI vehicle with TWC+GPF or not (TWC only) was investigated on FTP-75 mode in this study. In cold start phase (phase 1), PN emission of base vehicle was $2.77E+12$ N/km and then decreased to $1.46E+12$ N/km in hot start phase (P3). Total PN for FTP-75 mode from base vehicle was $1.64E+12$ N/km, however that of concentration with GPF reached $5.02E+11$ N/km. In case of GPF vehicle, filtration efficiency was measured 69% for FTP-75 mode, however 64% of particles was filtered due to the lower exhaust gas temperature during the engine cold start and fast idle operation. Size-resolved PN emissions characteristics below 23 nm particles formed at cold start phase were substantially reduced by adopting GPF. Almost all of the nucleation mode particles were effectively trapped in the GPF for whole driving cycle, and the accumulated particles also decreased with coolant and exhaust system warm-up. Exhaust system temperature of engine-out location (before TWC) was reached activation level 350 °C for TWC bed and 200 °C for GPF in 90 seconds.</p>

Caption Figure 1:



Size-resolved PN emissions characteristics from base GDI vehicle (TWC only) on FTP-75 mode

Caption Figure 2:



Size-resolved PN emissions characteristics from GDI vehicle with TWC+GPF on FTP-75 mode

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Publication title	Gaseous Pollutants and Particle Emissions of a 2.5 DCI Engine Fueled with Biodiesel from Waste Cooking Oil and Diacetyl Glycol
Publication type	Poster
Introduction & Background	<p>The transport sector is one of the main contributors to pollutant emissions into the atmosphere. Emissions from vehicles damage urban air quality and cause serious health problems. Both public administrations and research organizations are making big efforts to reduce pollutant emissions and a possible alternative to solve it is the use of unconventional fuels that reduce dependence on fossil fuels and also can reduce emissions. The vehicle emission group (GEV) of CIEMAT has spent years trying different types of fuels in different engines. Currently, among their projects, they are working on the LIFE Bioseville project, which aims to recover fried oils for the production of high quality biodiesel (García-Martín et al, 2018) and oxygenated additives from waste glycerin from biodiesel manufacturing.</p> <p>The aim of this work is to compare the gaseous emissions (CO₂, NO_x and HC) and nanoparticle emission in number and size distribution of a 2.5 dci diesel engine (Euro 5) with conventional diesel and different proportion of waste cooking oil and oxygenated additives from glycerin (diacetyl glycol) over the European Steady-State Cycle.</p>
Methodology	<p>The engine test bench used was composed of a diesel engine and dynamometer (SCHENK W150) controlled by a HORIBA's SPARC system. Particle size distribution data were measured using an Engine Exhaust Particle Sizer 3090 (EEPS, commercially available from TSI Inc.) and a Rotating Disc Raw Gas Diluter MD19-2E, a first hot dilution (150 C and dilution factor of 1:1695) and a second cold dilution (1:2 dilution factor). The fuels used were conventional diesel and 3 blends of diesel/biodiesel (75/15, 70/30 and 0/100), biodiesel with 3 proportions of oxygenated additives (5, 10 and 15%) and conventional diesel with 15% of oxygenated additive. Regulated emissions and particle emissions in number and size distribution were measured in the European Steady-State Cycle.</p>
Results & Conclusions	<p>In exploratory studies conducted in a 2.0 TDI engine (Euro 4) focused on studying the influence on the emission of particles from the addition of 15% acetyl glycol to conventional diesel, it was concluded that on average the total particle number remained constant (2E8 #/cc). On the other hand, the size distribution did show important changes. The use of acetyl glycol promoted the appearance of a greater number of particles in nucleation mode (dp</p> <p>Acknowledgements This work was supported by the European Union Funds under grant LIFE 13-Bioseville ENV/1113.</p> <p>References García-Martín J. F. et al (2018) Biodiesel production from waste cooking oil in an oscillatory flow reactor. Performance as a fuel on a TDI diesel engine. Renewable Energy 125, 546–556.</p>

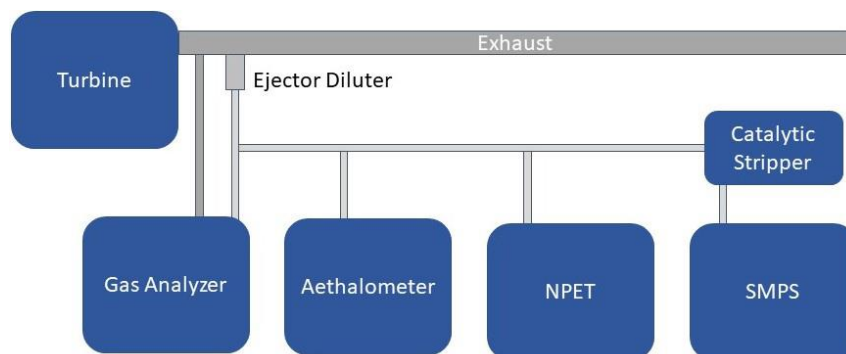
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Publication title	Pareto-Efficient Modeling of Nanoparticle Generating Turbulent Jet and Spray Flames
Publication type	Poster
Introduction & Background	<p>Soot is formed in almost every hydrocarbon-fueled combustion system as a pollutant emission. On the other hand, the application of soot and other forms of carbon particles in manufacturing is expanding. Besides carbonaceous nanoparticles, other forms of nanostructured particles are formed in practical flames as pollutant byproducts or as valuable mainstream products. The physicochemical processes of fine particle evolution in turbulent flames are highly sensitive to both flow physics and spatiotemporal distribution of thermochemical state. The main focus of this work is on development of a robust framework for efficient modeling of (nano-)particle generating turbulent flames, in order to accurately predict temperature, species concentrations, particle volume/mass fraction, and velocity field by proper selection of already developed software and hardware tools, especially for industrial applications.</p>
Methodology	<p>This work is the first step toward application of recently introduced Pareto-efficient combustion (PEC) framework of Wu et al. (Combustion and Flame, Vol.162, pp. 4208-4230, 2015) for simulation of nanoparticle generating turbulent jet and spray flames. Pareto-efficient combustion framework considers user-specific inputs about quantities of interest (QoI), desired simulation accuracy and computational cost, and a set of combustion models. This approach utilizes a Pareto efficiency of combustion models, and introduces a manifold drift term as a measure for determining the adequacy of using a certain combustion-manifold model to predict selected quantities of interest. In this work, after classification of suitable manifold models and quantities of interest, a penalty term is introduced to constrain computational cost and desired model accuracy. Also, a set of suitable models are considered to capture particle formation physics and chemistry, and also spray dynamics.</p>
Results & Conclusions	<p>A Pareto-efficient combustion framework is introduced for simulation of nanoparticle generating turbulent jet and spray flames that considers both gas phase combustion and particle/spray evolution processes. The proposed framework provides a general approach for accurate and computationally efficient simulation of nanoparticle evolution in this family of generic flames.</p>

Bird Matthew**Affiliation** Minnesota State University Mankato**Email** matthew.bird-1@mnsu.edu**Coauthors** Jacob Swanson, Rebecca Gardner, David Kittelson**Publication title** Emissions Testing of Microturbine Cogenerator Run on Diesel and Jet A Blended with Aromatic Compounds**Publication type** Poster

Introduction & Background Particle emissions pose environmental and health risks. It has been previously shown that aromatic compounds in the fuel, such as benzene and naphthalene, increase particle emissions from diesel and turbine engines. To test this hypothesis, a turbine generator was run on diesel and jet A fuel mixed with several different aromatic compounds. Particle and gas concentrations in the exhaust gas were analyzed to determine the relationships between aromatic concentrations in the fuel and emissions.

Methodology Testing was performed using a Capstone C30 microturbine cogenerator. The C30 uses a premixer type fuel injector. Figure 1 shows a system diagram that was used to test and analyze the emissions from the C30. The microturbine was run on diesel and jet A with mixtures which included either benzene, naphthalene, or xylene. We were able to dissolve up to 14% naphthalene in Jet A fuel. The loads varied from 16 to 67% of full load. Figure 2 shows a summary of the fuel mixtures and the loads at which they were run. Particle size and concentration was analyzed using a TSI SMPS 3080. To determine the differences in solid and semi-volatile particle concentration, for some tests, the exhaust gas passed through a catalytic stripper before the SMPS. This was found to have minimal effect because all particle emissions were solid, so the catalytic stripper was used in all later tests.

Results & Conclusions On average, the particle concentration corrected for dilution was extremely low. Results show no clear evidence that fuels blended with aromatic compounds caused greater emissions than pure fuels. Additionally, no there is clear pattern when comparing aromatic percent composition and emissions. NO_x and other gaseous emissions will be discussed.

Caption Figure 1:**Figure 1. Test System Diagram****Caption Figure 2:**

Base Fuel	Doping Agent	Load (kW)			
		5	10	15	20
Diesel	None	100	100	100	100
	Benzene	40	15,20,40	40	40
	Naphthalene	11, 14	11, 14	11, 14	11, 14
	Xylene		20		
Jet A	None	100	100	100	100
	Benzene	40	40		
Value in % composition.					

Figure 2. Summary of tests performed

Booker Douglas**Affiliation** NAQTS**Email** dbooker@naqts.com**Coauthors** Nick Molden**Publication title** Vehicle Interior Air Quality**Publication type** Poster**Introduction & Background**

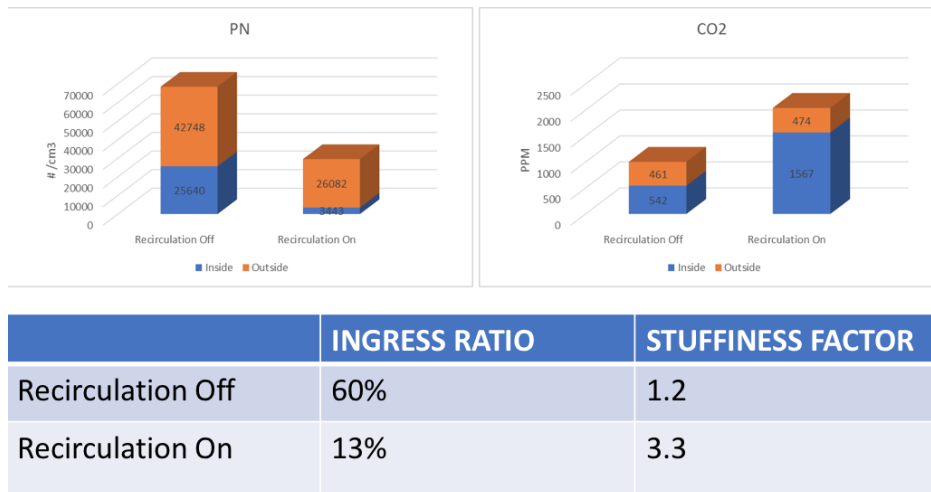
Many studies have addressed Ambient Air Pollution (AAP) that arises from traffic, and its associated negative impacts on public health. However, less has been done to understand Indoor Air Quality (IAQ) despite the average person now spending more than 90% of their time indoors (Klepeis et al. 2001). Around one hour of this indoor exposure is spent inside vehicles (Müller et al. 2011), and is referred to as Vehicle Interior Air Quality (VIAQ). This exposure is important to understand given the immediate proximity to significant pollutant sources (other vehicles), plus, in urban areas, high AAP concentrations compared to other micro-environments.

Methodology

To address this knowledge gap, two NAQTS V1000 Integrated Air Quality Monitors were used to simultaneously monitor inside-outside an array of vehicles for a holistic understanding of VIAQ, including measurements of PN (d50 15nm), Carbon Monoxide, Carbon Dioxide, Nitrogen Dioxide, and Volatile Organic Compounds. This information was supplemented with environmental and road comfort parameters; Noise, Temperature, Pressure, Relative Humidity, Speed, Location, and Vibration. The data was gathered on “real-world driving” routes encompassing urban, rural, and highway sections, under a wide range of HVAC operating modes. For the VIAQ measurements, the NAQTS V1000 was conveniently housed in a mannequin to reflect human exposure. For the AAP measurements, the NAQTS V1000 was mounted onto a suction cup, that could be fitted onto a wide range of vehicles easily. The objective of this project was to characterize the kinetics of air pollution inside-outside vehicles to understand Ingress Ratio (how much AAP is getting into the vehicle cabin) and Stuffiness (how well the vehicle is ventilating), as well as the effects of location, passenger habits, and vehicle technology (filtration etc.) on VIAQ.

Results & Conclusions

Consistent with other research (CARB, 2015; Müller et al. 2011), the data shows that the measured pollutants are often several times higher inside the vehicle than outside. The data shows the heterogeneity of Ingress Ratios and Stuffiness across different manufacturers and vehicle types. The results demonstrate an inherent trade-off between protecting passengers from ambient pollution ingress, and adequate ventilation to prevent Stuffiness. By driver education, and/or automation of HVAC controls, exposure can be reduced significantly.

Caption Figure 1:

American Hatchback Data

Caption Figure 2:



Example Experimental Set Up

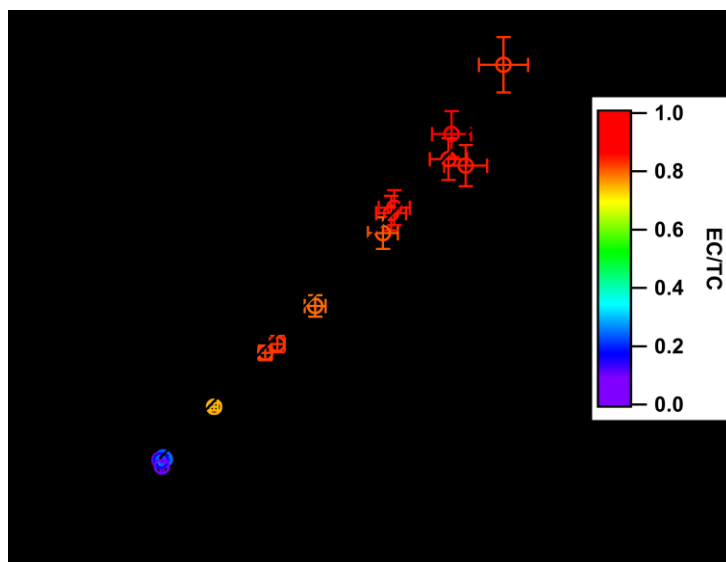
Booker Douglas

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Coauthors	Professor Gordon Walker; Dr Paul Young
Publication title	Indoor-Outdoor Air Pollution & Environmental Justice
Publication type	Poster
Introduction & Background	<p>Environmental Justice (EJ) research focused on demonstrating the extent to which air pollution is equally –or unequally- distributed across particular defined social groups has largely focused on Ambient Air Pollution (AAP). Most studies show that AAP is worse for poorer or more deprived communities (EA, 2002; Lucas et al. 2004; Mitchell, 2005; Namdeo and Stringer, 2008). However, the conclusions drawn —focusing on AAP and distributive justice— have a methodological myopia: the research assumes that AAP is an accurate indicator of personal exposure. On average, people spend more than 90% of their time indoors (Klepeis et al. 2001), where levels can be 2-5 more times more polluted than outdoors (Hulin, Simoni, Viegi, & Annesi-Maesano, 2012). Therefore, the current exposure-based assessments of likelihood of health consequences based on AAP are not reflecting “real-world” patterns of exposure. In understanding the “who gets what?” of EJ, Indoor Air Quality (IAQ) may be more important to research than AAP. However, simply studying IAQ is not enough. To understand IAQ, one must rely on the principle that the indoor atmosphere is an extension of the outdoor atmosphere (Yocom, 1982).</p> <p>This poster will outline the policy issues surrounding indoor air quality and environmental justice, and present some preliminary data from a small case study monitoring inside and outside a school in Lancaster, UK.</p>
Methodology	Three NAQTS V1000s were situated inside-outside of a primary school in Lancaster, UK, for one week. PN (d50 15nm), CO ₂ NO ₂ , VOCs (real-time and TD GC-MS) were measured. Prior to deployment, equipment was calibrated for PN (Ricardo - ISO 27891), CO ₂ , NO ₂ , VOCs (zero/span full linearity). One unit was located in the classroom, one in the dining hall, and one outside of the front of the school. Prior to deployment rooms were characterised for air changes using the CO ₂ concentration decay method.
Results & Conclusions	Results show indoor and outdoor related PN spikes. Indoor associated from activities (i.e. cooking) and outdoor (school pick-up / drop off). There was a significant correlation between indoor and outdoor PN levels during pick-up / drop off) as outdoor PN ingressed indoors.

Brem Benjamin

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Publication title	The Optics-chemistry Link of Dark Matter; Investigating Mass Absorption Cross Sections of Soot Particles from two Combustion Sources
Publication type	Poster
Introduction & Background	<p>“Soot” is a weakly defined term for particulate matter that mainly consists of elemental carbon (EC) and hydrocarbons (organic carbon, OC). The internal structure of combustion generated soot particles is highly variable. The grade of graphitization, i.e. sp² bonds, results in a mass specific optical absorption coefficient (MAC, m² g⁻¹). The MAC is a key property for predicting and understanding the climate forcing of these particles and is furthermore essential in the standardized calibration of most real time black carbon (BC) mass instrumentation.</p> <p>Various real-time methods such as photo-acoustic spectroscopy, photo-thermal interferometry or simply the difference of extinction and scattering are used to determine optical absorption coefficient of particles. The direct optical calibration of such measurements is rather challenging and closure experiments with mono-disperse, spherical, absorbing particles with a defined imaginary refractive index (e.g. nigrosine dye) are considered the benchmark. As a quasi-standard for determining the EC mass of carbonaceous particles, the thermal-optical transmittance (TOT) method, according to e.g. the NIOSH 5040 protocol is most commonly used as a reference.</p> <p>In this work we investigate the variability of MAC values referenced to EC mass for various soot types generated by a combustion aerosol standard (CAST) burner and an aircraft engine. The limitations and uncertainties of using an average combustion source unspecific MAC to measure equivalent BC mass concentrations will be also discussed.</p>
Methodology	<p>The experiments were conducted with a combustion aerosol standard (CAST) burner and an airworthy turbofan engine in the test cell of SR Technics at Zurich airport. The CAST setup consisted of ejector dilutors to adjust the particle concentrations and the aircraft sampling and measurements corresponded to the recommended practice (SAE International, 2013). The absorption coefficients were determined with a Photoacoustic Extinctionmeter (PAX) and by subtracting scattering from extinction coefficients using a cavity attenuated phase shift single scattering albedo monitor (CAPS PMSSA) at the wavelengths of 870nm and 532nm, respectively. EC mass was determined from filter measurements according to the modified NIOSH 5040 TOT protocol. In addition, optical closure experiments with nigrosine dye aerosol, measured size distribution and Mie- Lorenz theory were also performed.</p>
Results & Conclusions	<p>Figure 1 shows the correlation of the absorption coefficient determined by the PAX as a function of the EC mass for the aircraft measurements over the entire engine thrust range from ground idle to take-off. The color coding indicates the change in particle EC/TC content which decreases with engine thrust. Preliminary analysis indicates that using a single MAC value is able to provide robust and accurate measurements of equivalent BC for standardized aircraft measurements independent from engine operating condition. Current analysis focuses on relating the aircraft results to the results of the CAST burner.</p>

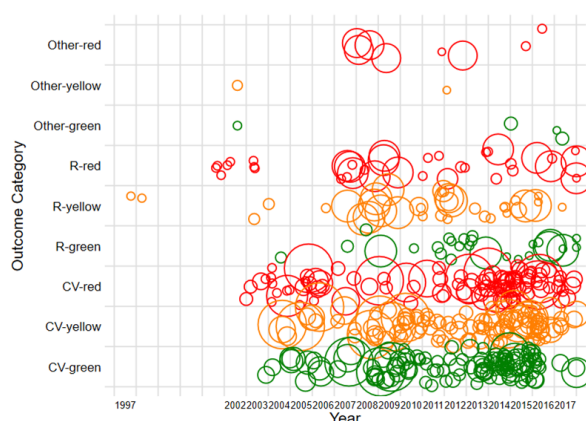
Caption Figure 1:



Regression of the absorption coefficient (b_{abs}) at 870nm with the elemental carbon (EC) to determine the mass absorption coefficient (MAC) of aircraft soot. The colors indicate EC to total carbon (TC) content of the particulate mass

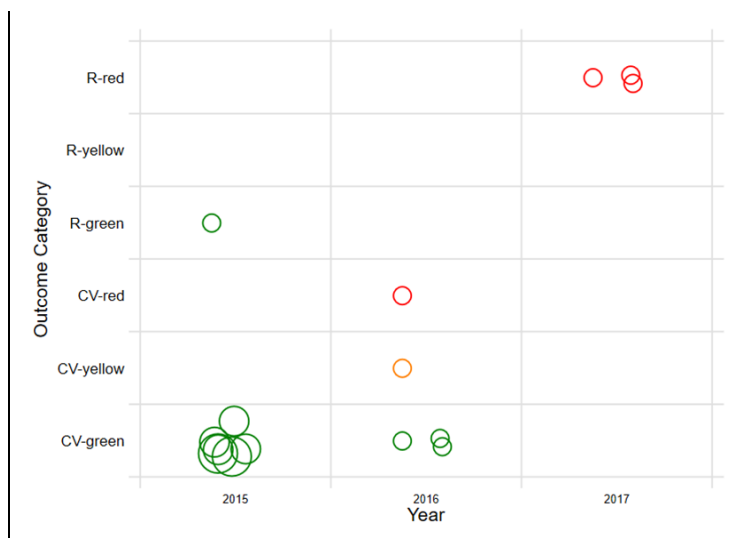
Brugge Doug

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Publication title	An evidence map based on a systematic review of ultrafine epidemiology
Publication type	Poster
Introduction & Background	There is growing interest in the health effects of ultrafine particles which are unregulated in the US.
Methodology	We conducted a systematic literature search in PubMed, Global Health, Scopus and TOXLINE from their inception through November 2017. Search terms were in three categories: exposure (e.g., particle number count, PNC), health outcomes (e.g., cardiovascular) and sources (e.g., traffic). We identified 8,630 records without duplicates. Abstract review by two independent screeners resulted in selection of 292 articles for full text review. Data was extracted from full text reviews using a standardized form.
Results & Conclusions	Of these, 101 are included in the evidence map. The largest reason for exclusion was not measuring PNC (66). We also excluded from the evidence map controlled exposure and occupational studies. And, we excluded studies that used a measure of ultrafine particles other than PNC. Most of the studies that were included (95) were short term

Caption Figure 1:

A bubble map of short term associations from the literature review. Each circle is an association. The size of circles represents the sample size of the study. Green is for null associations, orange for nonstatistically significant associations and red is for statistically significant associations. Associations are grouped by cardiovascular, respiratory and other..

Caption Figure 2:

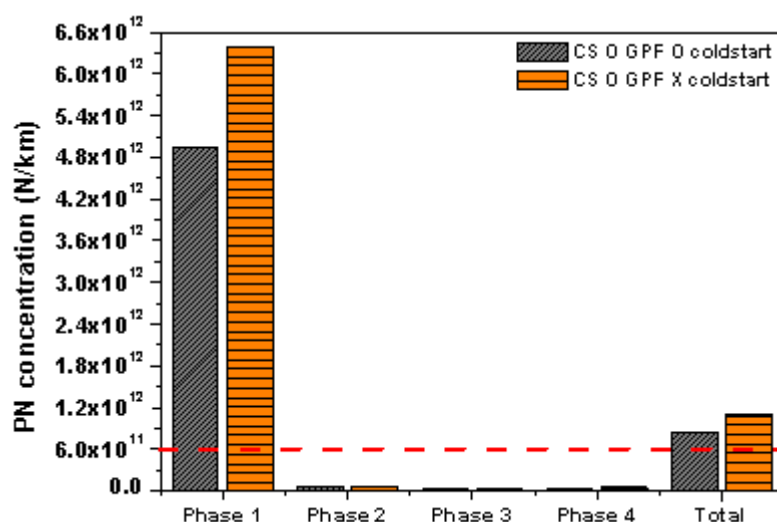


A bubble map of long term associations from the literature review. Each circle is an association. The size of circles represents the sample size of the study. Green is for null associations, orange for non-statistically significant associations and red is for statistically significant associations. Associations are grouped by cardiovascular, respiratory and other.

Chung Wonyong

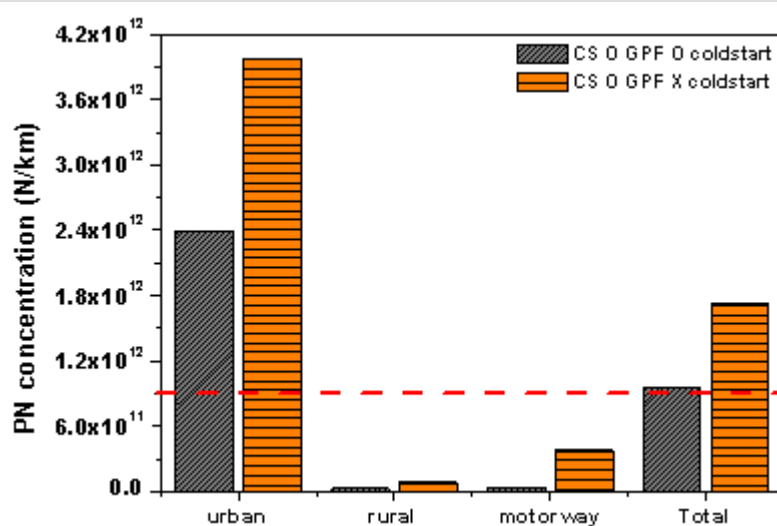
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Publication title	Comparison of PN Filtering Efficiency with GPF from a GDI Vehicle over Laboratory and Real World Driving Condition.
Publication type	Poster
Introduction & Background	<p>The propagating trend of a gasoline direct injection (GDI) engine has been magnified for satisfying emission regulations, which have been reinforced recently. It is well known that GDI engines are better achieving high efficiency compared to the conventional port fuel injection (PFI) engines. By spraying a fuel into each cylinder directly, precise fuel injecting control is feasible in Direct Injection (DI) engine. In addition, the flame quenching phenomenon occurs on the wall surface of the cylinder in GDI engine, which results in the incomplete combustion. Accordingly, GDI engine generally exhibits a higher Particle Number (PN) and Particulate Mass (PM) emissions than PFI engine. NEDC (New European Driving Cycle) was used as a certification test method for gasoline vehicles in Europe, but it did not reflect actual driving conditions properly. For this reason, the World-Harmonized Light-Duty Vehicle Test Cycle (WLTC) has been adopted as a certification mode since September 2017 and Real Driving Emissions (RDE) test procedure was introduced as a complement to WLTC alongside the introduction of WLTC. In this study, we analyzed the regulated gaseous emissions and PN emission characteristics over WLTC and RDE. We also examined real-time PN emission behavior with and without Gasoline Particulate Filter (GPF). The purpose of this study is to construct a database for the standard response by analyzing the characteristics of PN emissions over WLTC and RDE.</p>
Methodology	<p>In this study, a vehicle equipped with a 4-cylinder 2.4L GDI engine with a compression ratio of 11.3:1 was used. Under floor type of three-way catalytic converter (TWCs) was also mounted on the test vehicle as an after-treatment system. Regulated emissions from constant volume sampler (CVS) exhaust dilution tunnel system were measured using exhaust gas analyzer (AMA i60) during WLTC. The PN emissions were measured during WLTC and RDE tests by PPS-m (Pegasor) which operates by electrostatic charging particles passing through the sensor and then measuring the current caused by the charged particles leaving the sensor.</p>
Results & Conclusions	<p>The effect of GPF on regulated gas and PN emission characteristics from a GDI vehicle was investigated in this research. The total PN emissions reduced from 1.1×10^{12} N/km to 8.4×10^{11} N/km due to GPF over WLTC. About 23 % of PN reduced by GPF over WLTC. The total PN emissions reduced from 1.72×10^{12} N/km to 9.5×10^{11} N/km owing to GPF over RDE. About 45 % of PN reduced by mounting GPF during RDE. The results of this research will offer some insight into the characteristics of PN emissions for forthcoming emission regulation depending on installation of GPF.</p>

Caption Figure 1:



Comparison of PN emissions over WLTC at the cold start with or without GPF.

Caption Figure 2:



Comparison of PN emissions over real-world driving at the cold start with or without GPF.

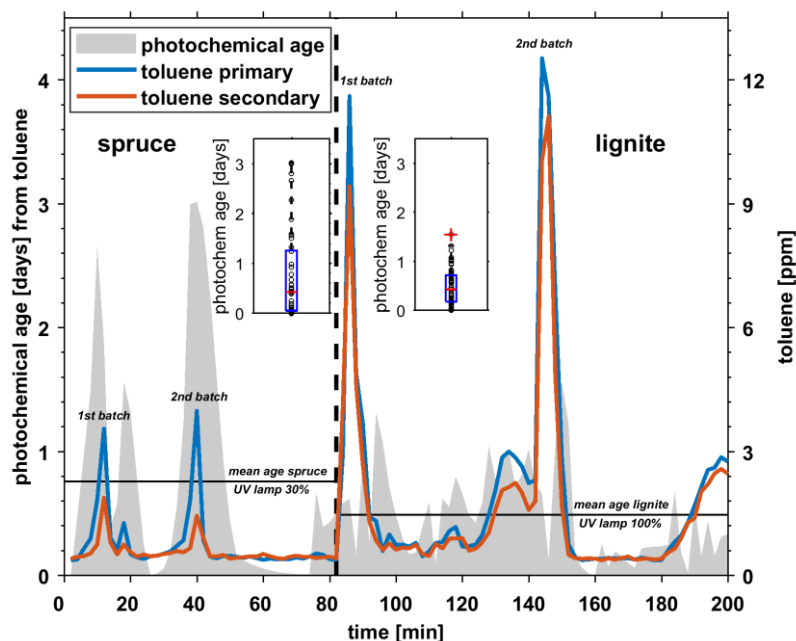
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Coauthors	Greg J. Smallwood; Tobias Schripp; Prem Lobo
Publication title	Laser-induced Incandescence of Aircraft Engine Black Carbon: Sensitivity to Laser Fluence
Publication type	Poster
Introduction & Background	Laser-induced incandescence (LII) is a powerful technique for measuring in situ black carbon (BC) particle concentrations at high time resolution (>1 Hz). The calculation of BC mass concentration requires knowledge of the absorption function $E(m)$, which is well known to vary between BC samples, reflecting the fact that the molecular structure (e.g. degree of graphitization) of BC varies between sources. Related to this variation, the optimal laser fluence for use in LII has been determined where particles are heated to incandescence (> 3000 K) while avoiding carbon sublimation at ~ 4500 K. However, this ideal fluence may differ for new sources, such as aircraft engine BC. To directly constrain this issue, we directly examined the dependence of LII-measured BC concentrations on laser fluence for aviation turbine BC produced by a variety of fuels and engine loads.
Methodology	Measurements took part within the ECLIF2/ND-MAX campaign at the Ramstein Air Base, Germany. The V2527 engines of the DLR A320-232 "D-ATRA" research aircraft were operated with two reference fuels (Jet A1) and three sustainable alternative jet fuels (SAJF) at a range of N1 thrust levels ranging from idle (25%) to maximum continuous thrust (82%). Two Artium LII 300 instruments measured the exhaust. One instrument was configured as the reference, operating at a laser fluence optimized for aircraft engine BC. The laser fluence of the second instrument was varied non-linearly from full laser fluence to very-low laser fluence by varying the Q-switch delay time. The full fluence data were used as a reference to determine periods of stable BC concentration.
Results & Conclusions	The sensitivity of LII-measured BC to laser fluence was quantified as the ratio of the modified signal to the reference signal, where the modified signal was the low-fluence condition (longer Q-switch delay) and the reference signal was the high-fluence condition (lowest Q-switch delay). We investigated this ratio as a function of Q-switch delay. The ratio fell below unity at Q-switch delays of about $163 \mu\text{s}$ for measurements at engine idle (25% N1 thrust), a substantially higher delay than the full-fluence value of $143 \mu\text{s}$. This fall-off point became systematically higher at higher thrusts, up to 82% N1 fan speed. Data for five fuels indicates that the variation between thrusts was greater than the variation between fuels. These measurements demonstrate that LII data obtained at full fluence are independent of the engine thrust and support the use of LII in quantifying BC in aircraft engine emissions.

Czech Hendryk

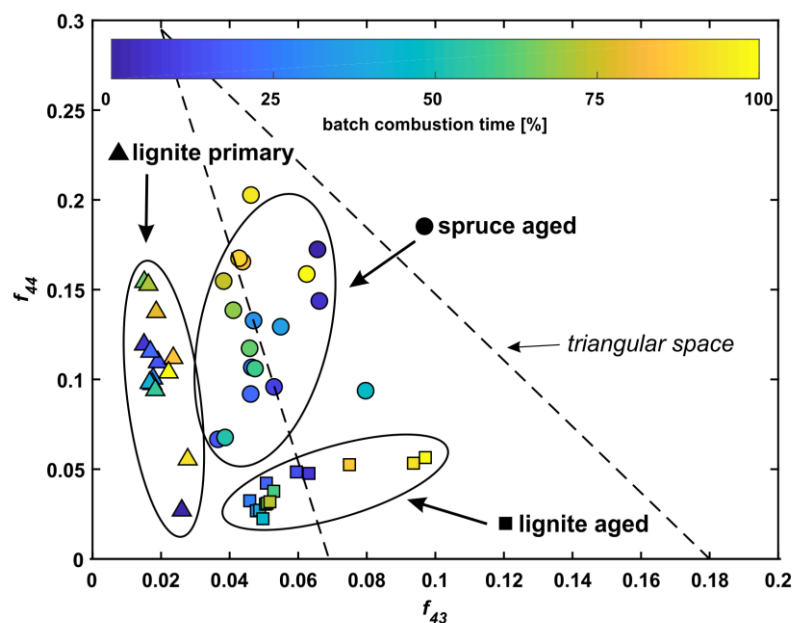
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Publication title	Primary and Secondary Aerosol Emissions from Residential Combustion of Lignite Briquettes
Publication type	Poster
Introduction & Background	<p>Despite increasing use of renewable energy sources, lignite is burned in power plants, but also for domestic heating. In contrast to coals of higher maturity, combustion in conventional wood stoves is possible due to their lower combustion temperature. Mainly emissions of PM were subject of emission studies in which polycyclic aromatic hydrocarbons (PAH) and heteroaromatic compounds were found to be associated with health effects. In this study, we focus on the composition of volatile organic emissions (VOC) of lignite briquette (Lausitz Energie Bergbau AG, Germany) combustion in a conventional wood stove as well as secondary organic aerosol (SOA) formation potential. Prior to lignite ignition, two batches of spruce logwood were burned and finally used for comparison.</p>
Methodology	<p>SOA formation was investigated with a new photochemical emission aging flow tube reactor (PEAR) with a volume of 100 L and a residence time of 1 min. The PEAR was equipped with 254 nm UV lamps and has an external feed of ozone. While emissions from spruce wood combustion were aged with 30% UV lamp power, lignite emissions were exposed to UV light from full lamp power. For untargeted VOC analysis, single-photon ionisation time-of-flight mass spectrometry (SPI-TOFMS) at 118 nm was deployed. An automatically-switching valve (VICI VALCO International) enabled sampling of the diluted flue gas in front and behind the PEAR with the same switching time as residence time of 1 min. Therefore, the same primary emission volume element could be analysed after ageing and used to calculate the photochemical age based on toluene degradation. An AMS (Aerodyne Inc., Billerica, USA) was used to investigate primary and aged particle compositions by manually-switching sampling lines in front and behind the PEAR after each batch.</p>
Results & Conclusions	<p>VOC emissions of lignite combustion appeared in the same range as spruce wood combustion for benzene and volatile PAHs, but distinctly lower for alkylated aromatics (e.g. methyl-naphthalene), small aliphatic unsaturated hydrocarbons (e.g. butadiene) and hydroxy-aromatics (e.g. phenol, cresol). Emission profiles of the two fuels were similar and followed typical solid fuel combustion phases "ignition" with peaking concentrations, "stable combustion" with emission minimum and slightly reincreasing concentrations in "ember". Lignite as well as spruce logwood revealed substantial SOA formation. However, OH exposition to VOCs expressed as photochemical age was higher for spruce despite lower UV lamp power. The used lignite briquettes contain 0.6 % fuel sulphur, which is first oxidised to SO₂ upon combustion and subsequently reacting with OH radicals to form sulphate. Therefore, the oxidation of VOCs is less favoured, leading to SOA with lower oxidation state than spruce logwood. Moreover, emissions during "ember" cover higher oxidation states due to lower emissions of SO₂, but release of aromatic hydrocarbons with considerable SOA formation potential.</p> <p>Because of economic reasons lignite is predominantly burned in areas with significant deposition. Therefore, primary and substantial secondary aerosol formation from this source should be considered in source apportionment and air quality studies.</p>

Caption Figure 1:



Temporal emission profile of toluene (m/z 92) over two batches of spruce logwood and lignite briquettes in front and after PEAR with calculated photochemical age.

Caption Figure 2:



f_{44} (CO_2^+) vs. f_{43} ($\text{C}_2\text{H}_3\text{O}^+$) of aged spruce as well as primary and aged lignite organic aerosol emissions with triangular space for ambient OA (Ng Atmospheric Chemistry and Physics, 2010, 10, 4625–4641). Colours indicate the point of time within one batch, with total duration of 35 min for spruce logwood and 60 min for lignite briquettes.

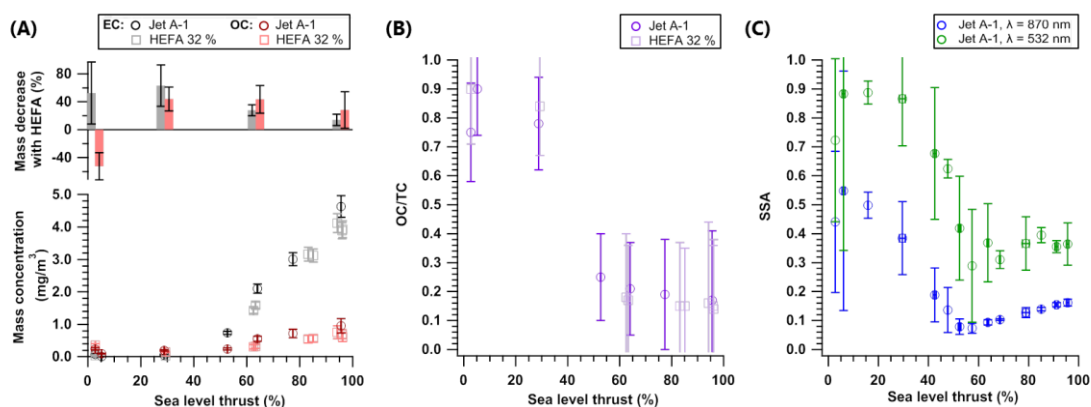
Czerwinski Jan

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Publication title	Nanoparticles Emissions of Gasoline Cars with Port Injection (MPI) and Potentials of Particle Filters (GPF)
Publication type	Poster
Introduction & Background	Further efforts to reduce the air pollution from traffic are undertaken worldwide and the filtration of exhaust gas will also be increasingly applied on gasoline cars (GPF*) ... gasoline particle filter).
Methodology	In the present paper, some results of investigations of nanoparticles from four MPI gasoline cars are represented. The measurements were performed at vehicle tailpipe and in CVS-tunnel. Moreover, two variants of GPF were investigated on a high-emitting modern vehicle, including attempts of soot loading in road application.
Results & Conclusions	The modern MPI vehicles can emit a considerable amount of PN, which in some cases attains the level of Diesel exhaust gas without DPF and can pass over the actual European limit value for GDI (6.0×10^{11} #/km). The GPF-technology offers in this respect further potentials to reduce the PN-emissions of traffic. With GPF, in the investigated steady state operation, there is no significant visible nuclei mode and the ultrafine particles concentrations below 10 nm size are insignificant. In the real road trial of uncoated GPF no increase of weight or backpressure could be observed up to 4100 km.

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Publication title	Carbonaceous Aerosols from Aircraft Engine Exhaust: Chemical Characterization, Optical Properties and Related Climate Effects
Publication type	Poster
Introduction & Background	<p>Aircraft engines are a unique source of gases and particles in the upper troposphere and lower stratosphere, where they can alter the atmospheric composition leading to climate change. Of special importance are the aerosol-light interactions by strongly absorbing black carbon (BC), which are known to cause positive radiative forcing (i.e. warming). BC is widely recognized as the primary component of aircraft particulate matter (PM) emissions. However, several recent works have measured substantial amounts of volatile organic PM close to the emissions. In this work we present the link between the chemical composition (i.e. fraction of elemental carbon (EC, more absorbing) and organic carbon (OC, more scattering)) and the major optical properties (absorption, scattering and single scattering albedo (SSA)) from aircraft PM for different engine loads and biofuel blends. The resulting optical properties are then integrated in a simple radiative model to estimate the climate effects related to aircraft PM emissions. Although the BC (or EC) emissions from aircraft engines are small relative to other anthropogenic sources, its radiative effect can be enhanced when emitted over high surface albedo backgrounds such as snow, ice or clouds.</p>
Methodology	<p>The emission measurements were carried out at the engine test cell of SR Technics at Zurich Airport with an in-use engine from the Boeing 737 Next Generation (representative of current fleet). The measurement points covered a wide range of engine thrust levels (from ground idle to take-off) using four different fuel blends of conventional Jet A-1 and HEFA (Hydro-processed Ester and Fatty Acids) biofuel. Quartz fiber filter samples were collected using a dual step stainless steel filter holder (back-up filter to quantify OC sampling artifacts) and then analyzed with a Sunset analyzer for the separation of the EC and OC fractions using the thermo-optical transmission method with a modified NIOSH 5040 protocol. The optical properties were measured online using a Cavity Attenuated Phase Shift-based single scattering albedo monitor (CAPS PMssa, $\lambda = 532$ nm) and a Photoacoustic Extinctionmeter (PAX, $\lambda = 870$ nm). This instrumental combination enabled the evaluation of the wavelength dependence of the optical properties, which is very valuable for the modeling of the radiative forcing.</p>
Results & Conclusions	<p>Figure 1 summarizes the main results from the EC/OC analyses and the optical properties at both measurement wavelengths. Both EC and OC mass concentrations increase with engine thrust and, at most thrust levels, a significant decrease is observed in both components with the use of the 32% HEFA blend. The OC fraction is dominant at low thrust levels (OC/TC: 75-90%), and decreases to 15-20% for thrusts above 50%. The elevated OC fraction at low thrust results into high SSA, which shows a maximum at ground idle ($SSA(532nm)=0.88$ and $SSA(870nm)=0.55$). For the estimate of the radiative forcing we consider the emissions during cruise (thrust 60%), where the EC fraction is dominant and the SSA is minimum ($SSA(532nm)=0.29$ and $SSA(870nm)=0.07$).</p>

Caption Figure 1:

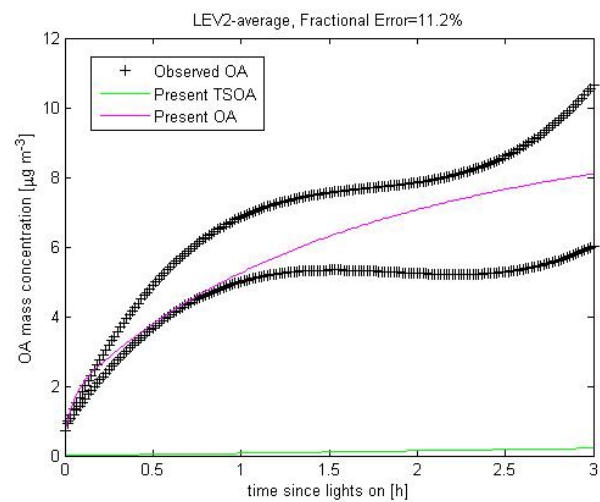


(A) EC and OC mass concentration as a function of engine thrust and fuel type (bottom) and decrease in EC and OC mass concentrations for the 32 % HEFA blend (top). (B) OC/TC as a function of engine thrust and fuel type. (C) Single scattering albedo measured at 870 nm (PAX) and 532 nm (CAPS) for base fuel (Jet A-1).

Esmaeilrad Sepideh

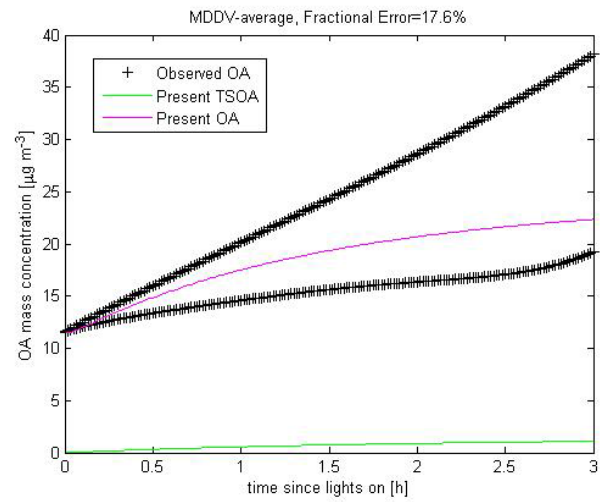
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Coauthors	Vahid Hosseini
Publication title	Modeling the Formation of Traditional and Non-Traditional Secondary Organic Aerosols from In-Use, On-Road Gasoline and Diesel Vehicles Exhaust
Publication type	Poster
Introduction & Background	<p>A great share of total OA mass (almost 72%) worldwide is attributed to SOA and SOA models usually underpredict this share, by ignoring lower volatility compounds (Semi-/Intermediate-VOCs). According to one-dimensional GC/MS analyses, S/IVOCs can only be classified as an unresolved complex mixture, and their exact molecular identity cannot be determined. However, Gas/particle partitioning measurements provide knowledge about volatility distribution of S/IVOC emissions. As a result, NT-SOA models use a volatility-based oxidation mechanism in order to model the SOA formation from these unspiciated precursors. Robinson et al. (2007) assumed that S/IVOC species and their products react with OH radical and produce new species whose volatility is one order of magnitude lower than precursors. Jathar et al. (2012) expanded this approach by distributing the products in a volatility set.</p>
Methodology	<p>In this study, we combine the Hybrid method proposed by Jathar et al. (2012) and the emission/SOA formation data from CAPS to simulate SOA formation from gasoline and diesel motor vehicle emissions. Mathematical formulation of this model accounts for the first and multigenerational oxidation of both T- and NT-SOA precursors and the gas/particle partitioning of their reaction products. In order to interpret smog chamber data, a box model is used that consists of two modules: A T-SOA and NT-SOA module. The T-SOA module uses the standard VBS formulation. In the NT-SOA module, first, the amount of NT-SOA formed is calculated by subtracting predicted T-SOA from the total measured SOA in smog chamber. Then, the NT-SOA mass yield is determined from fitting the NT-SOA data.</p>
Results & Conclusions	<p>The application of the model to two classes of Gasoline (LEV2) and Diesel (MDDV) vehicles is shown in Fig. 1. The model predictions are within the measurement uncertainty. The set of mass yields used in Fig. 1 are compatible with the VBS framework, and they can be used in any box modeling of SOA production from on-road vehicles, ignoring the removal and loss processes, provided that the required emission data are available. Along with particles, different types of organic vapors are also present in vehicle exhaust, which are distributed along a broad span of volatility. In all cases studied here, T-SOA alone was not able to explain the total amount of SOA formed. Effective NT-SOA yields were calculated for each experiment, and it was observed that for newer, supposedly lower emitting vehicles, NT-SOA yields were higher than one, denoting that the exhaust from these vehicles are more efficient in producing SOA. This result highlights the importance of NO concentration in the exhaust. A sensitivity assessment was performed on the initial precursors' concentrations, and it was found that aromatic VOCs and IVOCs have the highest impact on model predictions and need to be measured directly. However, SVOCs have lower influence, and their concentration can be approximated based on volatility distribution of POA. Results of the current study can be implemented in evaluating the effectiveness of emission reduction strategies in abatement of SOA formation from vehicles.</p>

Caption Figure 1:



Predicted average SOA formation for LEV2 (gasoline) vehicle class.

Caption Figure 2:

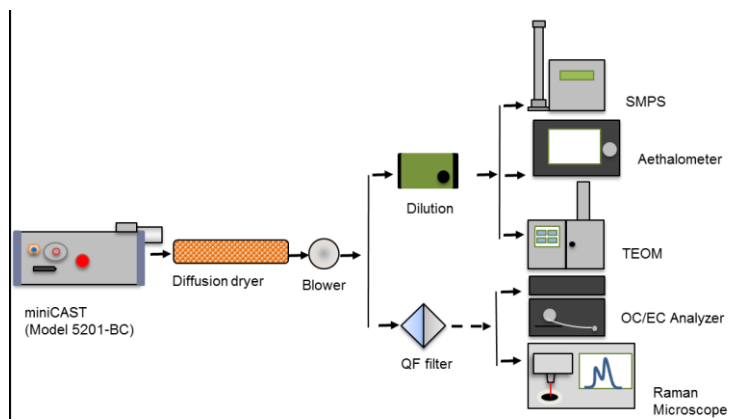


Predicted average SOA formation for MDDV (diesel) vehicle class.

Ess Michaela

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Publication title	Characterization of a New MiniCAST Generator (Model 5201 Type BC) Including Diffusion and Premixed Flame Options
Publication type	Poster
Introduction & Background	<p>As light-absorbing carbonaceous aerosols in the atmosphere, like Black carbon (BC), are known to have a huge impact on climate as well as on the human health these substances are strongly monitored. Normally, optical absorption methods (filter based or filter free) are used to monitor BC. For filter-based methods, which are affected by filter type and particle properties, a standardized calibration procedure based on well-characterized model aerosols that can be used to quantify aerosol absorption with traceability to primary standards, is needed. To this aim, different aerosol sources are tested within the EMPIR 16ENV02 Black Carbon project.</p>
Methodology	<p>A promising aerosol source for the generation of near-BC calibration aerosols is the new miniCAST soot generator Model 5201 Type BC (Jing Ltd.) that was designed with the aim to generate particles mainly composed of BC. While former CAST models rely entirely on diffusion flames of a fuel (often diluted with nitrogen) and air, the new model offers the possibility to add air (instead of nitrogen) to the propane fuel gas to achieve different levels of premixing. Although operation with a completely premixed flame is not possible because the (premixed) propane is still surrounded by the oxidation air cone causing also diffusion flame conditions, the new miniCAST model offers further possibilities to tune the properties of the generated BC particles e.g. by addition of oxygen to the oxidation air or the quench gas.</p> <p>The generated particles are analyzed with an SMPS (Scanning mobility particle sizer) with respect to their size and number concentration while the mass concentration is determined with a TEOM (Tempered element oscillating microbalance). An Aethalometer is used to determine the BC mass concentration and the Ångström absorption exponent α.</p> <p>Additionally, microstructure and chemical composition of the particles are analyzed with Raman Microspectroscopy and OC/EC-analysis, respectively.</p>
Results & Conclusions	<p>Using only the diffusion flame, particles with geometric mean diameter (GMD) up to 180 nm can be achieved with stable and reproducible operation. While at overall fuel rich conditions the EC (elemental carbon) content decreases fast with decreasing particle size, at fuel lean conditions also smaller particles (GMD \approx 65 nm) with high EC content (\approx 85 %) and low α (\approx 1.4) can be generated even without using volatile particle remover.</p> <p>With the premixing option, smaller particles were generated at the same overall fuel-to-air ratio compared to the pure diffusion flame. Thereby even particles with GMD as low as 40 nm with high EC content (\geq 70 %) and low α (\leq 1.4) could be generated. The new miniCAST soot generator Model 5201 Type BC is thus a promising candidate source for the generation of near-BC particles, which could serve as model aerosols for the calibration of filter-based absorption photometers.</p> <p>This work is part of the 16ENV02 Black Carbon project funded by the European Union through the European Metrology Programme for Innovation and Research (EMPIR).</p>

Caption Figure 1:



Schematic illustration of the experimental setup.

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Publication title	Recovery of Hidden Information from Retrofit Data-Logging
Publication type	Poster
Introduction & Background	<p>DPF-retrofitting requires data logging - usually for about 500 operating hours - to match the engine to a suitable DPF, which is quite a challenge for ic-engines of construction equipment. Usually the first two thirds are for monitoring the operation in view of selecting the right filter, while the final third is to verify the matching. Current custom is to record and transmit measurements of pressure and temperature every 10 seconds and any warning signals, should some threshold be exceeded - a rare event in case of fit, otherwise it is a case of reject. Given such a breadth of information, the legitimate question arises: Isn't there more that can be done with these data? From the several hundred thousands of measurements only a handful is used. This presentation deals with the recovery of hidden information through statistical means, such as stochastic processes. The Aim is to have predictive tools for fleet management and - hopefully - to bring more insight into regeneration processes for designing engineers.</p>
Methodology	<p>In terms of methodology we employ well established concepts such as moving average, regression and time-series analysis and supplement them with advanced techniques such as adaptive convex hulls and information-entropy. Adaptive convex hulls allow us to model complex multi-dimensional acceptance ranges in contrast to rigid upper and lower bounds for each component. Information-entropy, introduced by E. Shannon in analogy to entropy in statistical thermodynamics, allows us to estimate the reliability of received data. In combination with variance and other characteristics this provides the means to filter out anomalous data, which might otherwise contaminate further analyses. Since the reliability of data transmission constitutes a general problem in process engineering we aspire to provide some progress beyond the current application.</p>
Results & Conclusions	<p>Engines are not used continuously and they are subject to varying load conditions. Using a reference implementation in R and Java we succeeded so far to eliminate unreliable data as well as to identify operational cycles, idling times, soot levels and onsets of regeneration including poor regeneration.</p> <p>The final goal is to establish an application reducing operating costs of fleet operators in DPF-maintenance and – hopefully – also for engineers in DPF design. The application has yet to be designed, developed and thoroughly tested.</p>

Focsa Cristian**Affiliation** University of Lille, France**Email** cristian.focsa@univ-lille.fr**Coauthors** C. Irimiea; Y. Carpentier; O. B. Popovicheva; E. D. Kireeva; I. K. Ortega; J. Schwarz; M. Vojtišek-Lom**Publication title** Impact of Operating Regime and Fuel Type on the Chemical Composition of Soot Particles Emitted by In-use Gasoline and Diesel Engines**Publication type** Poster**Introduction & Background**

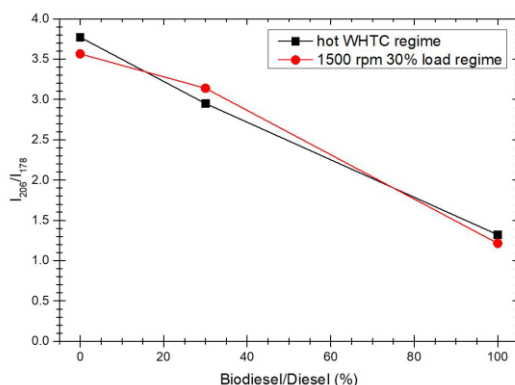
Particle emission, especially in urban environments subjected to heavy traffic, is a major public health concern. The use of biofuels, neat or blended with traditional fossil fuels, induces effects still poorly known on the chemical composition of the exhaust particles. As part of the BIOTOX project, campaigns including test runs of modern in-use combustion engines were carried out to investigate the chemical composition of particulate emission depending on engine technology, fuels, operating conditions, and driving cycles. The chemical composition of particles emitted by gasoline (Ecoboost 1.0 direct injection gasoline engine in a Ford Focus and 1.4 multi-point injection engine in a Škoda Fabia) or heavy-duty diesel (Iveco Tector) engines was analyzed according to the nature of these fuels (pure fossil fuels or mixed with biofuels).

Methodology

The soot particles, deposited on quartz fiber filters, were chemically characterized using complementary techniques: thermo-optical analysis, capillary electrophoresis, FTIR spectroscopy, two-step laser desorption/ionization mass spectrometry (L2MS) and secondary ionization mass spectrometry (SIMS). These measurements gave access to the ratio of organic carbon (OC) and elemental carbon (EC), concentration of water-soluble ions, functional groups and particle-bound chemical species. Associating individual molecules or their fragments detected by mass spectrometry with chemical functions determined by FTIR remains a delicate task. To facilitate this work, principal component analysis (PCA) and hierarchical clustering were applied to the mass spectrometry and FTIR data.

Results & Conclusions

Aliphatic, aromatic, hydroxyl carboxyl and carbonyl functionalities observed in FTIR spectra are found to depend on the engine working regime. Mass spectra are mainly characterized by alkyl fragments, associated with normal and branched alkanes, PAHs and their alkylated derivatives, as well as some oxygenated species. We show that the combined use of PCA and hierarchical clustering allows one first to distinguish among the various fuels used and the operating conditions and secondly to associate these differences to various classes of compounds. Especially, specific markers of the fuel used could be determined (see Figure). This kind of work could be considered as a first step towards the identification of the intricate combustion sources in dense traffic areas.

Caption Figure 1:

Evolution of the m/z 206 to 178 ratio according to the biodiesel to diesel ratio for the two tested engine regimes

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Publication title	Particle Number Emissions from Technological Lubricants Used in the Manufacturing of the Automotive Exhaust System
Publication type	Poster
Introduction & Background	<p>This work reports on experimental investigation of particular matter emissions resulting from the use of technological lubricants during the manufacture of the exhaust system. These technological lubricants are used primarily for tube bending and are retained in the exhaust system. Once exposed to high temperature at some point during the initial operation of the vehicle, they are likely to form particles, which are either emitted via the tailpipe, and may also be retained at or interact with active surfaces of exhaust aftertreatment. This work aims to investigate the effect of different amounts of technological lubricants used on resulting particle emissions from a typical automobile spark ignition engine.</p>
Methodology	<p>The tests were carried on a Škoda 1.0 TSI spark ignition engine coupled with a manual transmission mounted on a powertrain dynamometer (used for testing of the vehicle powertrain, with dynamometers in place of vehicle wheels), fitted with a typical exhaust system. A coupling system was fabricated to allow for a quick change of the center tube connecting the three-way catalyst and the muffler, containing five bends. A total of 22 center tubes were manufactured using 1 to 17 grams of lubricants per tube, with about 10 g representing the „technological optimum“. Particle emissions were measured at the tailpipe by an electric mobility particle sizer (EEPS, TSI, all particles including volatiles, 5-560 nm) coupled with a rotating disc diluter, and by a portable analyzer measuring total number of non-volatile particles (NanoMet3, Testo). Gaseous emissions were measured by a portable analyzer developed in-house. The engine was operated at steady-state points corresponding to idle, cruise at 50, 90 and 130 km/h, and cruise at 130 km/h with additional load, selected to stay clear of fuel enrichment region.</p>
Results & Conclusions	<p>The „background“ levels, corresponding to engine-out emissions, ranged from 105 particles per cm³ (#/cm³) to 107 #/cm³ at 130 km/h. The effect of lubricant was observed at all points, and was most pronounced at 130 km/h, where concentrations have increased to 108-109 #/cm³ for up to several minutes, after which particle emissions were comparable to background levels at all operating points. The magnitude and duration of elevated particle concentrations were both increasing with increasing amount of lubricant. A net contribution of 1-5 x 10¹⁵ non-volatile particles was observed depending on the amount of lubricant, corresponding to approximately 0.3-1 x 10¹⁵ particles per gram of lubricant used. Size distribution measurements on all particles, including volatiles, at 130 km/h suggest that at load corresponding to level road the highest contribution was around 50 nm, while at higher engine load, most of the contribution was at around 10 nm. Considering that only one part of the exhaust system was evaluated, the contribution of technological lubricants to the lifetime emissions of automobiles may be non-negligible. Optimization and control of the lubricant dosing is recommended as the first step to minimize this contribution.</p>

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Publication title	Temperature vs Ozone Concentration: New Insights to the CCN-activity and LDSA of Soot Particles after Long Term Exposure to Ambient Ozone Concentrations.
Publication type	Poster
Introduction & Background	<p>Freshly emitted soot particles are known to be poor cloud condensation nuclei (CCN), but from atmospheric measurements it can be deduced that a significant fraction of soot particles act as CCNs. One process which might contribute to this discrepancy is the heterogeneous oxidation of soot particles. Soot particles have an average atmospheric lifetime of one week during which they are exposed to different aging processes (e.g. ozone oxidation).</p> <p>The investigation of such processes is an experimentally challenging task due to the long time span which should be covered. Generally, studies are conducted in which soot is treated with high oxidant concentrations (up to 1000 x atmospheric average). This approach reduces the observation time needed but does not consider potential non-linear reaction kinetics (e.g. ozone with soot).</p>
Methodology	<p>In Winter 2017/18 we investigated the reaction of ozone with soot particles under atmospheric conditions during a lab campaign at ETH Zurich. With the CSTR-approach we could observe 100 nm size selected soot particle up to 16 h. The particles were exposed to Ozone concentrations between 0 and 220 ppb at a temperature range of 5 to 35°C. We measured the CCN-activity at different super saturations between 0.3 % and 1.4 %.</p>
Results & Conclusions	<p>We found that an increase of the ozone concentration by a factor of 10 (from 22 to 220ppb) almost halves the activation time at 1.0 % super saturation and 25 °C. In contrast, a temperature increase from 5°C to 35°C at a constant Ozone concentration (200 ppb) lead to a reduction of the activation time by a factor 5. Our results indicate, that the ambient temperature should be considered as much as the ozone concentration for a reasonable assessment of the cloud formation potential of soot particles.</p> <p>According to literature, the initial reaction step is the adsorption of ozone (Langmuir-Hinshelwood-mechanism) which we confirm by analysis of auxiliary measurements of the physical properties of the particles. Our observations show the reaction speed being approximately proportional to concentration of ozone adsorbed on the soot surface but not to the concentration of ozone in the gas phase[1]. After exposure of soot particles to different Ozone concentrations the particle diameter increased by 3% and the particle mass by 20% within minutes but remained almost constant during further exposure. While the particle mass and diameter changed significantly the lung-deposited surface area (LDSA) does not change throughout the aging process, which indicates that no restructuring of the soot particle takes place.</p> <p>Based on our temperature experiments we calculated an activation energy of 40 kJ/mol for the time limiting step causing CCN-activation. This value is in accordance with previous findings[2] indicating that the conversion of physisorbed Ozone into reactive organic intermediates might be the limiting reaction step for CCN-activation of soot particles.</p> <p>[1] S. Lelièvre et.al, PCCP, (2004),6, 1181-1191 [2] T. Berkemeier et.al., PCCP, (2016),18, 12662-12674</p>

Fuchsig Heinz

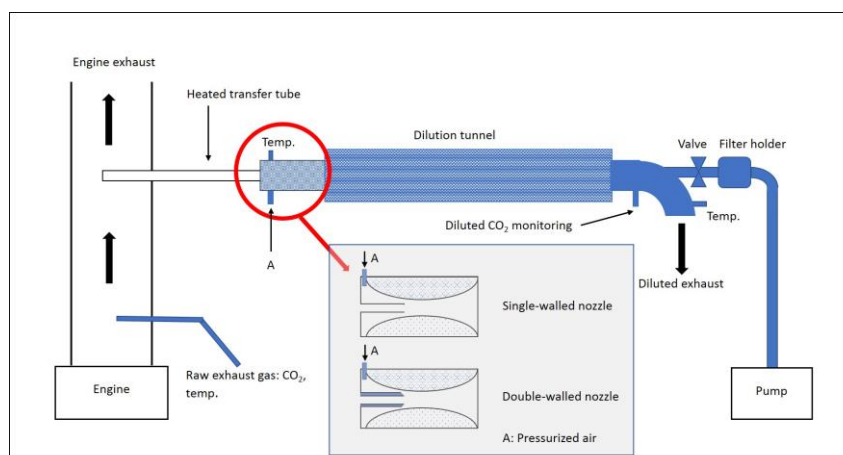
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Publication title	The Diesel Scandals - an Attempt to Highlight the Priorities
Publication type	Poster
Introduction & Background	<p>this is not a scientific work, it is an attempt to sequence the needs to protect health today and for future Generations from vehicles exhaust,</p> <ol style="list-style-type: none"> 1. the need for a not to hot climate with predictable weather 2. the Need for a sustainable economy in times of high dependence from single producers (esp. natural gas) 3. the Need to be protected from chronic health -damages, esp. through particles 4. the Need to be protected from acute health effects from particles and Nitrogen dioxide <p>this ist the main part of the presentation and will Show the priority for retrofitting particle filters</p>
Methodology	<p>overview with Facts from OECD, WHO and IEA</p> <p>Synopsis of presentations held at the yearly conference of the Society for occupational and environmental medicine, DGAUM about the question is ultrafine particle the main reason for harm caused epidemiological by Nitrogen dioxid</p>
Results & Conclusions	<p>the diesel scandal is mislead. Instead of adding SCR - Catalysts to 12 Million Diesel - Cars only in Germany with costs of 25-36 Billion Euros it would be much more effective for health to retrofit lorries, busses and offroads with particle filters, which would cost about 5 Billion Euros</p>

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Publication title	Measurement of PM Emissions from Ship Engines: Effect of Particle Deposition in Sampling Equipment Designed According to the ISO8178 Method.
Publication type	Poster
Introduction & Background	<p>ISO8178 is a commonly used reference method for measurement of PM emission from marine diesel engines. As described in ISO8178-1 (2006), PM measurement involves the sampling of a partial or full flow of the exhaust gas from the engine, followed by a dilution step in which the exhaust gas is cooled and subsequently sampled on a filter to a temperature of 42°C - 52°C. The dilution step involves the introduction of unheated (20-30 °C) pressurized air into a venturi nozzle in which the hot exhaust gas is introduced through a transfer tube. As shown in Figure 1, the pressurized air will cool the transfer tube nozzle, and this will lead to an increased deposition of particles in the unheated part of the transfer tube that is located inside the dilution tunnel. The deposition of particles through thermophoretic deposition in the heated transfer tube system is described in annex C of ISO8178:2006 (i.e. the deposition in the heated part of the transfer tube connecting the probe at the sampling point with the dilution tunnel). Maeda, K. et al. 2010 has suggested that the soot deposition inside the dilution tunnel may be significant and should be reduced by introducing a double-walled, coaxial transfer tube nozzle. In this study, we have tested a single-walled transfer tube nozzle design (according to ISO8178) in parallel with a double walled transfer tube design. The objective of this study was to assess the effect of the thermophoretic deposition inside the ISO8178 dilution tunnel. The measurement campaign performed in this study was supported by the Danish Maritime Fund through the INNO+ Blue INNO ship program.</p>
Methodology	<p>Two sampling equipment designed according to ISO8178-1 (2006) was installed in parallel at MAN Diesel & Turbo's test facilities in Copenhagen. A series of tests were performed in February 2018 during an EGR test at MAN's test engine 4T50ME-X using MGO (26 ppm % S) and HFO (1.7 % S), respectively. The two equipment were designed for partial flow sampling, and they were identical except for their transfer tube nozzle (see Figure 1). Sampling were performed over periods of 10-15 minutes. The dilution ratio was determined through a measurement of the CO₂ concentration in the exhaust gas and in the diluted exhaust from the dilution tunnel. Filters were conditioned and weighed according to ISO8178-1 (2006).</p>
Results & Conclusions	<p>For the measurements performed on HFO fuel, the PM results obtained with the single-walled transfer tube nozzle were 20% lower compared to the PM results obtained the double-walled transfer tube nozzle design. This is expected to be caused by an increased thermophoretic deposition of particles in the single-walled tube nozzle inside the dilution tunnel. The single-walled nozzle is cooled significantly by the pressurized dilution air introduced into the dilution tunnel, whereas the double-walled nozzle is insulated and will therefore minimize thermophoretic deposition. With MGO, the difference between the single-walled and double-walled transfer tube nozzle design were within the uncertainty of the measurement, indicating that the thermophoretic deposition increases with increasing PM concentration. It should be mentioned that the measurement of PM as described in ISO8178-1 is only proven to be effective for combustion of fuels with a sulfur content less than 0.8% (ref.: ISO8178-1 (2006), section 3.1). However, the ISO8178 standard has been widely used for sulfur contents up to 3.5%. The results of this study clearly show that the ISO8178 method for measurement of PM from large diesel engines should be equipped with a double walled transfer tube nozzle when low grade, residual fuel with a high sulfur content is used.</p>

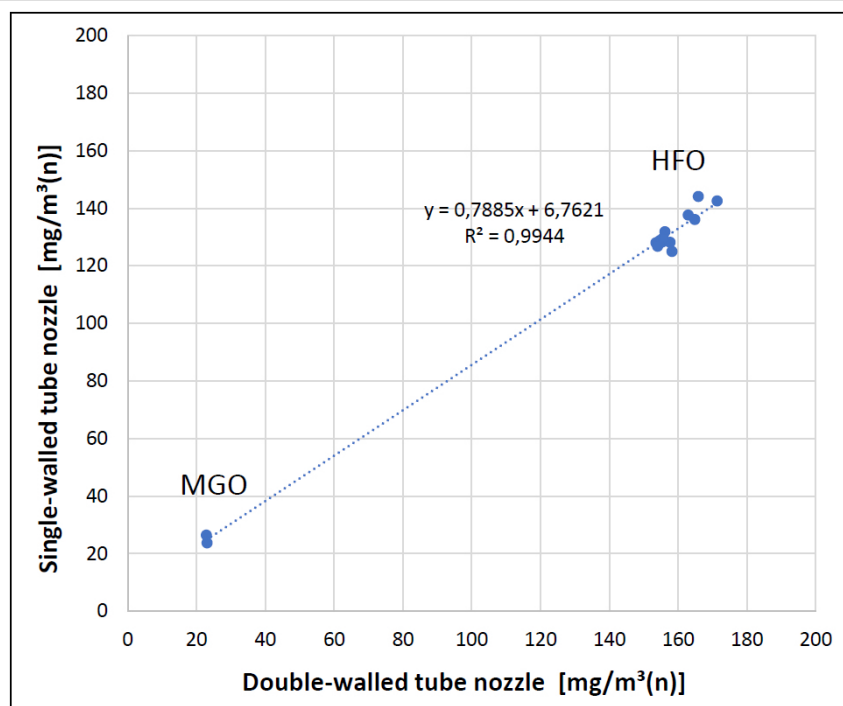
Images

Caption Figure 1:



Instrument setup according to ISO8178-1 (2016), modified with a double-walled tube nozzle inside the dilution tunnel.

Caption Figure 2:



Results from parallel PM measurements with single- and double-walled tube nozzle in ISO8178 dilution tunnel.

Gerken Stefan**Affiliation** Testo SE&Co. KGaA**Email** sgerkens@testo.de**Coauthors****Publication title** Convenient Method for the Systematic Evaluation of Instrument Calibration Regarding its Particle Size Dependency**Publication type** Poster**Introduction & Background**

The last decade has seen an increasing variety of measured (nano-)particle size number distributions (PSND) emitted from combustion engines. This poses a challenge for the calibration of nanoparticle measuring instruments, as most of the equipment used exhibits particle size-dependant transfer functions or detection efficiency curves. Therefore, conventional calibration methods using only one PSND may be insufficient to model real world measurements. Several particle generators have been developed which allow a variation of particle sizes, thus an extension of instrument calibration to multiple PSNDs is technically doable. But due to the experimental effort involved, it is not the most preferred option.

Methodology

To address this, we have developed a hybrid method simulating the response of any given DC-sensor to several PSNDs, based on its individual physical properties. This allows for an improved adjustment of the sensor to real world measurement situations, as well as an optimization of calibration procedures.

Results & Conclusions

In this work, we will show the application of this method to systematically study particle size-dependant agreement of a DiSC-sensor using different adjustment strategies.

Ghaziaskar Hassan S.

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Publication title	In Field Application of HHI96 as a Fuel Additive for Reduction of Air Pollution in Iranian Cities
Publication type	Poster
Introduction & Background	Most fuels such as gasoline, kerosene (jet fuel), gas oil (diesel fuel) and fuel oil have drawbacks which do not allow their long term storage, make difficult transportation and even use. About 20 properties of fuels can be improved, maintained or imparted new beneficial characteristics by the adding of small amounts of certain chemicals named fuel additives. Fuel additives are added in very small concentrations: from several ppm to several thousand ppm. It is important that additives which improve some properties should not deteriorate other properties of fuels and its quality in general. Fuel additives are organic substances soluble in fuels: antifoams, anti-icing additives, anti-knock additives, antioxidants, antistatic additives, anti-valve seat recession additives, biocides, cetane improvers, combustion chamber deposit modifiers, corrosion inhibitors, demulsifiers, deposit control additives, detergents, diesel fuel stabilizers, drag reducing agents, dyes and markers, leak detector additives, lubricity improvers, metal deactivators, and wax anti-settling additives.
Methodology	To reduce NO _x , CO and unburnt hydrocarbon (HC) emissions, improve acceleration, reducing engine octane requirement, eliminate hesitation, stopping knocks and pings, and improve fuel mileage, the HHI96 was developed in the pilot scale after several years of research work. The initial emission testing was performed and the results are presented in the Table 1. In the test HHI96 was added 5% by weight to Euro 4 gasoline and 3% by weight to diesel fuel. The exhaust outlet was analyzed in the presence and absence of HHI96, in the car examination center. Also increased vehicle acceleration, by the driver was quite tangible after taking HHI96.
Results & Conclusions	HHI96 can be used to reduce the emissions for gasoline and diesel fuel engines and fuel consumption as much as 13.5%.

Images**Caption Figure 1:**

Table 1: The changes in exhaust emissions using HHI96 fuel additive

Fuel Type	Opacity m ⁻¹	O ₂ Vol. %	λ	NO _x Vol. ppm	HC Vol. ppm	CO ₂ Vol. %	CO Vol. %
Gasoline Euro 4	–	0.34	0.85	81	278	11.30	5.45
Gasoline Euro 4 + 5% HHI96	–	0.67	0.91	15	220	12.9	3.68
Diesel Fuel	1.9	–	–	–	–	–	–
Diesel Fuel + 3% HHI96	0.7	–	–	–	–	–	–
Changes (%)	-62.4	97	7	-81.5	-20.9	14.2	-32.5

Table 1: The changes in exhaust emissions using HHI96 fuel additive

Goel Vikas

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Publication title	Effect of Vehicular Emission Control Measures on PM Characteristics over Delhi
Publication type	Poster
Introduction & Background	Air pollution has become the fourth highest risk factor for premature death globally. In India itself, air pollution causes nearly 1.59 million deaths per year. Unfortunately, Delhi has been listed among the most polluted cities of the world where the living beings are suffering from several cardiovascular and respiratory diseases. In view of this, Delhi government has implemented vehicular emission control policy to ensure good air quality in the winter of 2016 by implementing the road rationing policy from 1-15 January, 2016. According to the scheme, the odd numbered private cars were allowed on the road on odd dates only and even numbered on even dates only.
Methodology	Measurements were carried out at CSIR-NPL using Envirotech© APM550 (for collecting PM _{2.5}), aethalometer (for real time black carbon, BC measurement), temperature and humidity sensors. PM _{2.5} particles were analysed using wavelength dispersive X-ray fluorescence spectroscopy to investigate their elemental composition. The sampling period was divided into three categories; Phase 1 (P1, 1-31 Dec 2015), Phase 2 (P2, 1-15 Jan 2016) and phase 3 (P3, 16-31 Jan 2016) period.
Results & Conclusions	<p>During the study period, the BC and PM_{2.5} mass concentration were observed to be ranging from 6.7 to 40.33 µg/m³ and 21.94 to 283 µg/m³, respectively. The average BC and PM_{2.5} mass concentration during P1, P2 and P3 were measured to be 14.01 µg/m³, 19.87 µg/m³, 17.79 µg/m³ and 163.51 µg/m³, 186.98 µg/m³ 197.45 µg/m³, respectively. The lowest (6.7 µg/m³) and highest (40.33 µg/m³) BC concentration were observed on 28 December, 2015 (P1) and 7 January, 2016 (P2). Figure 1&2 shows the daily variation of BC and PM_{2.5}. During the entire study period, the mean PM_{2.5} mass concentration was measured to be 186.98 µg/m³ which was substantially higher than the standards set by Indian National Air Quality Standard [i.e. 60 µg/m³ (www.cpcb.nic.in)] and the US National Ambient Air Quality Standards [i.e. 35 µg/m³].</p> <p>According to the XRF analysis of PM_{2.5} particles, concentration of Cu, As and Pb were observed to be minimum during P2 that may be attributed to the reduced traffic density. The concentration of dust related elements (road dust) was also observed to be low during P2 as compared to that of P1 which is also may be due to the decrease in number of vehicles on the road due to policy enforcement. However, the concentration further decreases in P3 that may be attributed to the high humid conditions that limits the road side dust emission.</p> <p>Conclusion: The fate of air pollution depends on the cumulative effect of various parameters like meteorological conditions (temperature, humidity and wind speed) and emissions from various sources. In the present study, the reduced traffic density was not found to be sufficient to make visible decrease in BC and PM_{2.5} mass concentration. However, the concentration of vehicle related elements like Cu, As and Pb were observed to be minimum during P2. The daily variation of meteorological parameters was found to superimpose the effect of reduced traffic density.</p>

Caption Figure 1:

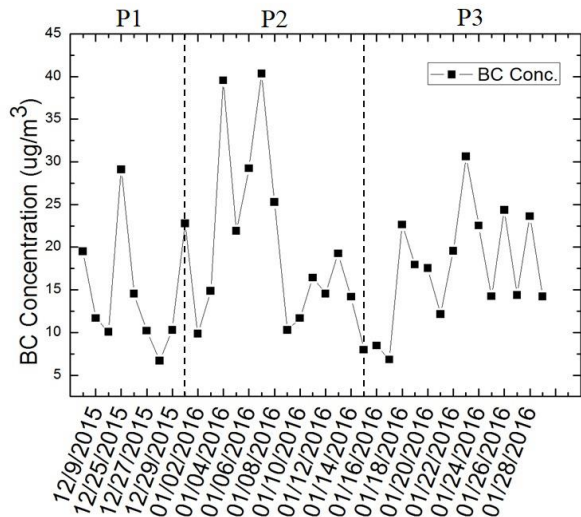


Figure 1. Daily variation of BC mass concentration.

Caption Figure 2:

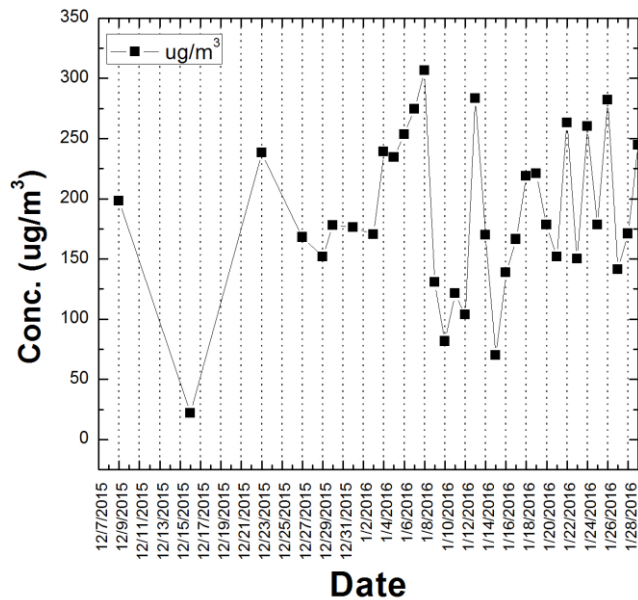


Figure 2. Daily variation of PM2.5 mass concentration.

Hagino Hiroyuki

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Publication title	Real-time Measurement of Lubricant Oil additive Elements in Automotive Exhaust Particles by Inductivity Coupled Plasma Time-of-flight Mass Spectrometry
Publication type	Poster
Introduction & Background	<p>Inductively coupled plasma mass spectrometry (ICP-MS) is widely used when rapid and sensitive detection of a wide range of elements in airborne particles is required, such as the monitoring of ambient particulate matter (PM) and emission sources. In ICP-MS analysis, airborne particles are usually collected on filters, and elemental analysis is carried out after preprocessing the resultant sample, a method known as off-line analysis. However, off-line analysis using ICP-MS takes up to a few days and prevents the collection of real-time information about the behavior of particle concentration. Furthermore, all preparation steps and analysis must be performed in a clean room to minimize contamination during handling, in order to reduce filter blank levels. A clean laboratory for trace metals staffed by personnel with extensive experience in trace level techniques is also required. Consequently, an on-line analysis technique such as direct aerosol sample introduction into the instrument, without difficult handling methods, is preferred for providing not only the data to elucidate the dynamic properties of airborne particles but also for high sensitivity to distinguish between samples and blanks.</p> <p>For on-line and real-time analysis of aerosol samples using ICP-MS, gas exchange devices (GED) for replacing air with argon and transporting it to the ICP-MS are needed in order to sustain the plasma. When ICP-MS uses a quadrupole mass spectrometer (ICP-QMS), a detailed study on the fine signal structure with scanning-based mass spectrometers is possible, but no simultaneous multi-element measurements could be obtained. To further improve the time resolution of ICP-QMS and to extend its capabilities to determine single particle information, ICP-MS equipped with a time-of-flight mass spectrometer (ICP-TOFMS) was recently developed. This study presents the application of real-time measurements for elements in particles using ICP-TOFMS. This technique is capable of detecting engine oil additive elements in gasoline vehicle exhaust particles.</p>
Methodology	<p>ICP-TOFMS systems consist of two major sections: the aerosol inlet interface and the ICP-TOFMS. The aerosol inlet interface, equipped with a GED, is used to introduce the aerosol particles into the ICP ion source on ICP-TOFMS by exchanging the air with argon gas. To determine engine oil additive elements in gasoline vehicle exhaust particles, a micro-flow glass concentric nebulizer was used for instrument calibration aerosol generation from serial dilutions of multiple elemental-salt standards. To investigate the fast, transient, multi-element aerosols from vehicle emissions, one light-duty passenger gasoline vehicle was tested at the chassis dynamometer facility for fuel economy; exhaust emissions testing was performed at Japan Automobile Research Institute (JARI).</p>
Results & Conclusions	<p>From several emissions cycles, including testing at high loads and cold start driving conditions, engine oil additive elements (P, S, Ca, Zn, and Mo) in gasoline vehicle exhaust particles were observed for sub-0.1 s measurements. Engine ignition at cold start and under high loads increased the particle emissions, in some cases by a substantial amount; however, the engine oil additive elements were not uniform, unlike the composition ratio in engine oil. The data show that the ICP-TOFMS effectively detects engine oil additive elements. This ICP-TOFMS technique appears to support the observations reported for the dynamics of engine oil additive elements in particles and the contribution to engine exhaust limits over both sulfur tracer and solid particle number measurements.</p>

Hansel Armin**Affiliation** University of Innsbruck, Austria**Email** armin.hansel@uibk.ac.at**Coauthors** Johannes Moser**Publication title** Spatial distribution of LDSA in Innsbruck confirm combustion related nanoparticles as source**Publication type** Poster**Introduction & Background**

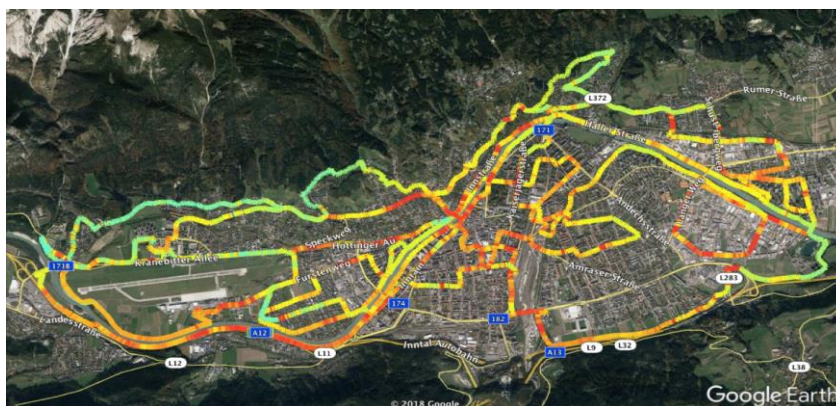
Air pollution is traditionally measured at a few localized stations equipped with a suit of expensive sensors. This approach gives a very accurate but only locally valid air pollution level depending on the pollutant. While single point measurements of PM₁₀ (particulate mass smaller 10 micrometer) give a good pollution estimate that is valid for a larger area such as an entire city, particle number or particle surface area are dominated by local sources that are mostly traffic related. Modern combustion engines that are not equipped with special particle filters emit ultrafine particles coated with toxic compounds with high numbers. At present, there is a broad discussion about the health impacts caused by ultrafine particles in cities. Ultrafine particles penetrate alveoli and are deposited in humans. Human Exposure to ultrafine particles in an urban area can be assessed by monitoring the lung deposition surface area (LDSA). Here we present how LDSA values are distributed over the city of Innsbruck. We monitored LDSA with a diffusion charger mounted on to a bicycle. We present results obtained at different meteorological conditions.

Methodology

We mounted a Partector (Naneos), a GPS and a GoPro camera on to a bicycle and monitored the personal exposure of the cyclized. Due to the small size, low weight and long battery lifetime, the Partector is well suited for mobile measurements. The Partector with its high time resolution of seconds is an ideal tool to map out the spatial distribution of Lung deposition surface area (LDSA) in the urban environment of Innsbruck with a bike at different seasons.

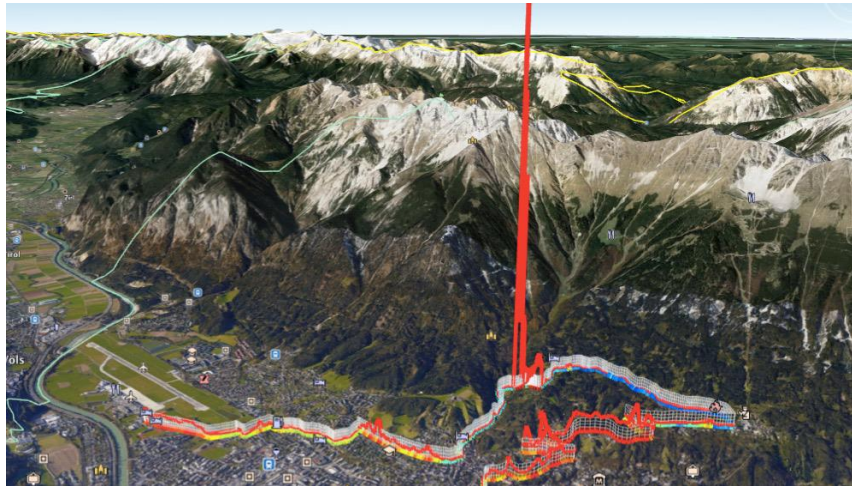
Results & Conclusions

We found highest LDSA values close to busy streets and street crossings. Combustion engines under high load during speeding up from street crossings or steep uphill climbs cause largest emissions. In addition, two stroke engines show very high emissions. Meteorological conditions impact the base level and the distribution of LDSA. During Föhn conditions LDSA “hot spots” are strongly localized at emission sources.

Caption Figure 1:

The image is from several bike rides at similar meteorological conditions in Innsbruck. “Hot spots” in red show LDSA values $> 200 \text{ micro-m}^2/\text{cm}^3$ located at busy streets and street crossings

Caption Figure 2:



Overtaking maneuver of a "Pickup" driving uphill. LDSA: 8200 200 micro-m²/cm³

Heutz Niels

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Publication title	Investigation of Particle Emissions with a Light Duty Diesel Vehicle – Challenges by 3rd RDE Regulatory Package
Publication type	Poster
Introduction & Background	<p>Tightening emission targets within Euro 6d legislation and implementation of RDE requirements since September 2017 are creating challenges for future Diesel powertrains. Especially the validation of vehicle emissions under real driving conditions enforces exhaust after treatment (EAT) systems to operate efficiently under various conditions. This increases the effort for the evaluation of future EAT technologies significantly. RDE boundary conditions are defined by the RDE packages 1-4 which are applied in a step-by-step manner using a phase-in with the introduction phase of the monitoring phase of RDE started in September 2017. The first step of RDE consists of Conformity Factors (CF) for NO_x (CF1NO_x) as 2,1 and for Particle Number (PN, CF1PN) as 1,0 plus margin of 0,5 taking measurement accuracy of PEMS into account. 2nd step of RDE will start from January 2020 unifying the Conformity Factors of NO_x and PN CFs (CF2NO_x, CF2PN) as 1,0 plus margin of 0,5. The last adopted package is the 3rd version including extensions for the legislative package. It comprises Adoptions include the CFPN to apply to both the urban part and the complete RDE trip. Furthermore, cold start emissions have to be included in the post-processing analysis</p>
Methodology	<p>. In response to the challenges of RDE package 3 it is investigated how current regulations can be realized under RDE conditions and used for implementation on an engine test bench to allow depiction of RDE cycles for future studies. Therefore RDE tests were performed and investigated using a Diesel vehicle equipped with a state of the art diesel particulate filter. In a second step vehicle and emission data were used to create an artificial RDE cycle to depict emissions (especially particle number) under real driving scenarios by testing on an engine test bench.</p>
Results & Conclusions	<p>The results obtained under real driving conditions show that current high porosity diesel particulate filters developed by NGK are capable to fulfill current requirements of the RDE package 3. Furthermore, PN emission trends for real driving could be successfully depicted on the engine bench based on the artificial RDE cycle. In addition also exceptional scenarios like filter regeneration were successfully depicted on the engine test bench to investigate particulate filtration on a more detailed level.</p>

Hoa Le Phuoc

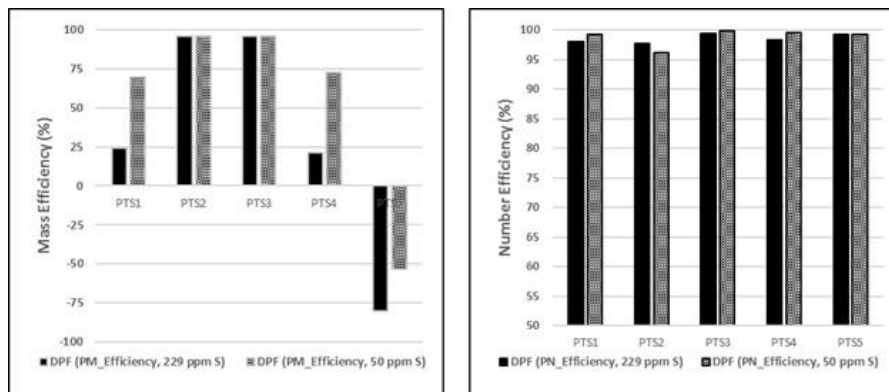
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Publication title	Fuel Supply System by Porous Ceramic Tube to Diesel Oxidation Catalyst
Publication type	Poster
Introduction & Background	<p>Biomass burning has significant impacts on air quality, ecosystem, climate change and human health. Biomass burning emissions are the major sources of chemically gases (carbon monoxide, carbon dioxide, nitric oxide, volatile organic compounds) and aerosols. The biomass burning organic compounds are reacted with the atmospheric radicals (OH, NO₃) and ozone. The reactions are formed the secondary organic aerosols (SOA). However, there was been the little research conducted on primary and secondary biomass burning aerosols. Hence, biomass burning emissions are not well understood today. Therefore, the aim of this study has investigated the aging of chemical and physical properties of primary and secondary gases and aerosols from the Vietnam rice straw and German wheat straw burning in the aerosol chamber LEAK (Leipziger Aerosol Kammer).</p>
Methodology	<p>The aging of straw burning emissions is performed with Leipzig biomass burning facility (LBBF) connected to the LEAK chamber. The LBBF includes in the traditional stove, DEKATI dilution system and control temperature. The straw burning smokes were burnt in LBBF. During the burning experiments, straw burning smokes are sampled and injected in aerosol chamber LEAK.</p> <p>Biomass burning reactions were studies under night experiments (dark) and day experiment (UV, H₂O₂, NO). The Methods include the various online and offline chemical characterization of biomass burning gases and aerosols in LEAK chamber. The 19m³ volume of LEAK chamber is cylindrical, a surface to volume of 2m⁻¹ and made of the Teflon film.</p> <p>The online measurements consist of CO, CO₂, NO_x and ozone monitors, a proton transfer reaction mass spectrometer (PTR-TOFMS), a scanning mobility particle sizer (SMPS) and aerosol mass spectrometer (AMS).</p> <p>Offline measurements (GC/MS, CE/TOFMS, HPLC/TOFMS) were used for analyzing the chemical characterization of primary and secondary organic aerosols.</p>
Results & Conclusions	<p>In this study, the results are shown that the emission of primary gases and organic aerosols from Vietnam rice straw burning are higher than the German wheat straw burning.</p> <p>For aging of chemical gases, the NO and NO₂ concentration are constant under dark conditions. However, NO concentration is decreased and NO₂ is increased during UV light aging. Furthermore, The formation of ozone is faster and enhanced by a factor 10 in UV rice straw aging than in UV wheat straw aging.</p> <p>Finally, the results indicate that secondary biomass burning organic aerosols increase during UV aging.</p>

Hosseini Vahid

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Publication title	Evaluation of CRT-DPF Filters with Low and Medium Sulfur Diesel Fuels in Iranian Market
Publication type	Poster
Introduction & Background	<p>DPF was first introduced into Iranian market is 2014 which then followed by several legislations for retrofit and newfit. The current Iranian national emission standard level for all diesel vehicles is Euro IV + DPF or Euro V EEEV and above. approximately 50% of distributed Iranian diesel fuel contains high level of sulfur content. up to 7000 ppm, which makes it hard to maintain and use of CRT filters. In this study CRT DPF filters were evaluated using two levels of sulfur contents in the fuel of 50 ppm and 229 ppm. The objective was to understand the performance and endurance of the technology under Iranian operating conditions. The results show that in the steady-state test, the selected filter technology removed up to 99.8% of the solid particles. The average PN efficiency for LSD and MSD was 98.8% and 98.5%, respectively, and no considerable difference was observed in the effect of fuel sulfur on the CRT's PN-efficiency. Despite a high PN efficiency, the PM efficiency was low for both the tested fuels, with an average of 83.5% and 59.5% for LSD and MSD, respectively. Further studies are underway to understand the durability of such systems in real world driving conditions using PEMS instruments.</p>
Methodology	<p>The study is based on experimental tests (VFT1) and a commercial CRT system operation was evaluated using a heavy-duty Euro II engine (Daimler OM457-LA) on an engine dynamometer.</p> <p>Steady-state tests (PTS 1 to PTS 5) were performed in order to calculate the filtration efficiency. The test cycle included test stages 5, 7, 3, and 1 of the type C1 test cycle in accordance with ISO 8178/4.</p> <p>The regeneration test was carried out in stationary operation at engine rated speed. The filter was loaded with soot, and the regeneration was triggered by gradually increasing the engine torque in ten steps, from 10% to 100% load, according to the VERT test procedure.</p>
Results & Conclusions	<p>In the steady-state test, the selected filter technology removed up to 99.8% of the solid particles. The average PN efficiency for LSD and MSD was 98.8% and 98.5%, respectively, and no considerable difference was observed in the effect of fuel sulfur on the CRT's PN-efficiency. Despite a high PN efficiency, the PM efficiency was low for both the tested fuels, with an average of 83.5% and 59.5% for LSD and MSD, respectively. Comparing the results for MSD and LSD shows that the effect of the fuel sulfur level on PM efficiency was significant. So low PM efficacy, despite very high PN efficiency, was attributed to sulfate species production.</p> <p>For gaseous emissions, $[\text{NO}]_x$ values did not change remarkably during any of the operation points by the implementation of CRT, with both LSD and MSD fuels. On the other hand, the $[\text{NO}]_2/[\text{NO}]_x$ ratio changed significantly by the use of CRT. In PTS 1 and 5, CRT's downstream $[\text{NO}]_2/[\text{NO}]_x$ ratio was lower than the engine baseline due to the high temperature of the exhaust gas and high rate of combustion of $[\text{NO}]_2$ for soot oxidation. But for PTS 2, PTS 3, and PTS 4, the $[\text{NO}]_2/[\text{NO}]_x$ ratio increased because of the implementation of CRT. The favourable temperature for NO to $[\text{NO}]_2$ conversion, besides low $[\text{NO}]_2$ combustion rate, result in some $[\text{NO}]_2$ slip from the filter media. CO and HC emissions significantly reduced and were about zero in all the operation points for both the tested fuels.</p> <p>As was expected, the favourable area for CRT systems regeneration is limited, due to the kinetic and thermodynamic control of NO oxidation at low and high temperatures, respectively. Comparing the results for MSD and LSD shows that favourable regeneration area decreased for MSD to two-thirds in comparison with that for LSD, and the balance point temperature increased to about 50 °C.</p> <p>This study shows the potential of CRT-DPF technology for the removal of solid particles</p>

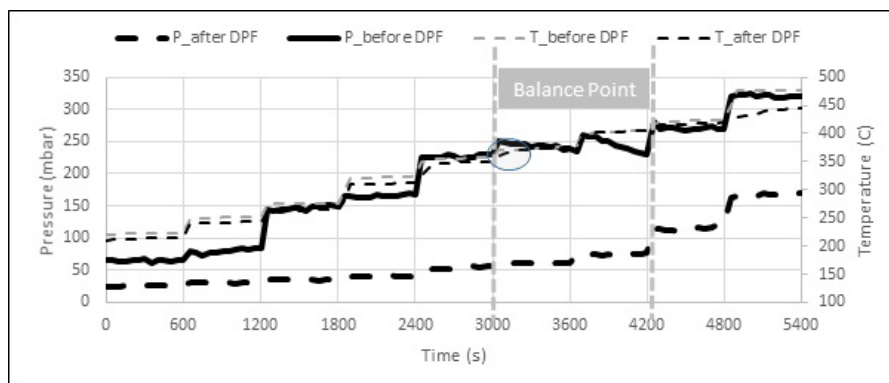
from diesel exhausts in situations where MSD and LSD are available. However, considering the situation in Tehran where LSD is commonly used with occasional fueling with MSD, field-testing of CRT is necessary to evaluate the possibility of using CRTs in Tehran's public bus fleet.

Caption Figure 1:



Tested DPF's Mass (left) and Number (right) efficiency

Caption Figure 2:



Pressure and temperature of exhaust gases during regeneration test (MSD)

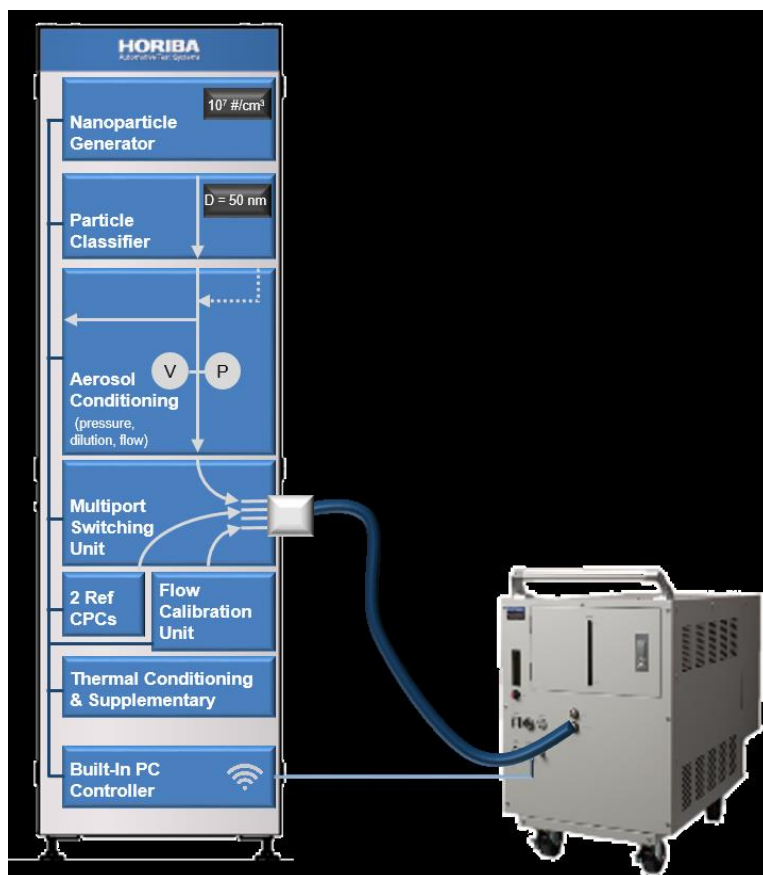
Huewe Florian

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Publication title	Automated Validation and Calibration of Solid Particle Counters: Tackling the Accuracy Challenge
Publication type	Poster
Introduction & Background	<p>Since its regulation in Euro 5b automotive emission legislation introduced in 2011, determining particle number emissions from internal combustions engines has always been far more prone to measurement variation than any other regulated exhaust gas component. On the one hand, this is due to intrinsic nature of nanoparticles. Compared to molecular gas emissions, they consist of different materials, sizes and shapes, all affecting their physical and chemical properties. On the other hand, measurement systems defined by Global Technical Regulation (GTR) No. 15 are also affected by calibration uncertainties allowing for certain mismatch between different units. The latter problem may be tackled by optimized calibration procedures for which new tools will be necessary.</p>
Methodology	<p>We present a novel calibration setup installed within a temperature-controlled rack in order to automatically validate the calibration of solid particle counting systems (SPCS). It considers two major approaches: First of all, every flow sensing element inside the SPCS can be checked against a built-in reference flow meter held at defined conditions. This ensures highly reproducible flow control inside the SPCS in order to accurately dilute any sampled particle aerosol. Secondly, a variable particle generation unit is included being able to supply the SPCS with a calibration aerosol of adjustable concentration and particle size at defined pressure and flow. By this, the particle detection efficiencies and linearities of all functional units inside the SPCS can be checked. The reference concentration is always measured against a built-in, temperature-stabilized condensation particle counter (CPC). Examples of tests that can be performed are size-dependent detection efficiencies, linearity verifications and investigation of external factors affecting particle measurement.</p>
Results & Conclusions	<p>An aerosol and flow calibration laboratory of outstanding reproducibility has been created. First tests allow to investigate the origin of spreads between particle counters. Different environmental factors, such as temperature, wick depletion and miscalibration have been experimentally simulated in order to tests their impact on the particle number measurement. The most important results will be presented in this contribution in order to minimize the error potential of solid particle counting in automotive emission regulation.</p>

Caption Figure 1:

Automated Calibration & Validation Rack for Solid Particle Counters

Caption Figure 2:



Schematic of the Calibration Rack

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Publication title

Tandem Configurations of Different Aerosol Classifiers with the AAC

Publication type

Poster

Introduction & Background

The Aerodynamic Aerosol Classifier (AAC) is a novel aerosol instrument that classifies particles based on their relaxation time. It selects particles independent of their charge-state and has a transmission efficiency 2.6 to 5.1 times higher than current electrostatic classifiers, while producing a monodispersed aerosol with no multiple-charging artifacts (Johnson et al. 2018). These characteristics allow the AAC to be utilized for a wide range of applications, including different configurations with other aerosol classifiers, such as the Differential Mobility Analyzer (DMA) and Centrifugal Particle Mass Analyzer (CPMA). While tandem DMAs and DMA-CPMA configurations have been previously studied, limited research has investigated AAC-DMA or AAC-CPMA systems.

Methodology

This study used an AAC to select particles based on their aerodynamic diameter from a polydispersed DOS (Bis-2-ethylhexyl sebacate) aerosol generated using a BGI Collison nebulizer. The particle mobility and mass of the AAC classified aerosol was determined by diluting, charging and dividing the sample between a stepping DMA and stepping CPMA in parallel as shown in Figure 1. The particle number concentration of each twice classified aerosol was measured using a Condensation Particle Counter (CPC) and recorded as a function of the downstream classifier (i.e. DMA or CPMA) setpoint. The charge-states of the monodispersed aerosol appeared as distinct peaks in the DMA or CPMA scans. The area under the peaks relative to the AAC classified particle number concentration was used to determine the particle charging fractions, while the position of the peaks in the mobility or mass domain relative to the AAC aerodynamic diameter setpoint was used to determine the effective particle density. These measurements were calculated by fitting the theoretical tandem transfer function to the data from each tandem configuration using chi-squared minimization.

Results & Conclusions

The agreement between the charge fractions measured by the AAC-DMA system versus theory (Wiedensohler 1988; Gunn and Woessner 1956) shown in Figure 2 validates this new methodology.

The effective density results provide further validation by allowing comparison between the AAC-DMA and AAC-CPMA system measurements as well as to the expected effective particle density of 914 kg/m³.

Caption Figure 1:

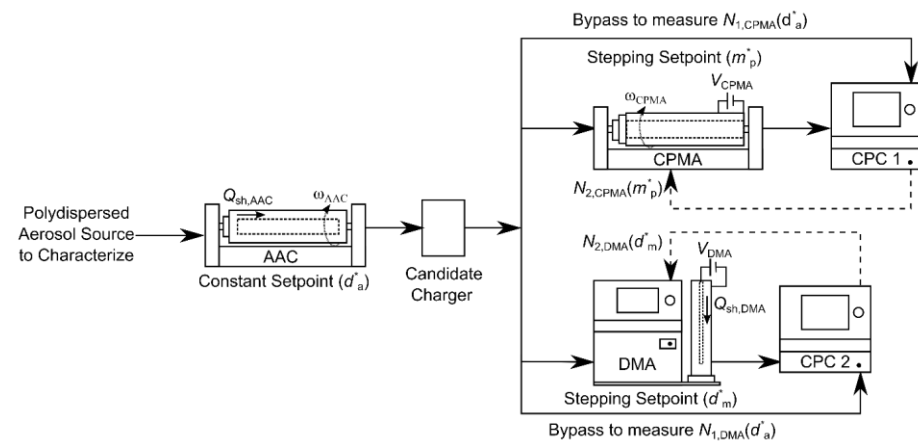


Figure 1: Experimental setup
Results and Conclusions:

The agreement between the charge fractions measured by the AAC-DMA system versus theory (Gunn & Woessner, 1956; Wiedensohler, 1988) shown in Figure 2 validates this

Caption Figure 2:

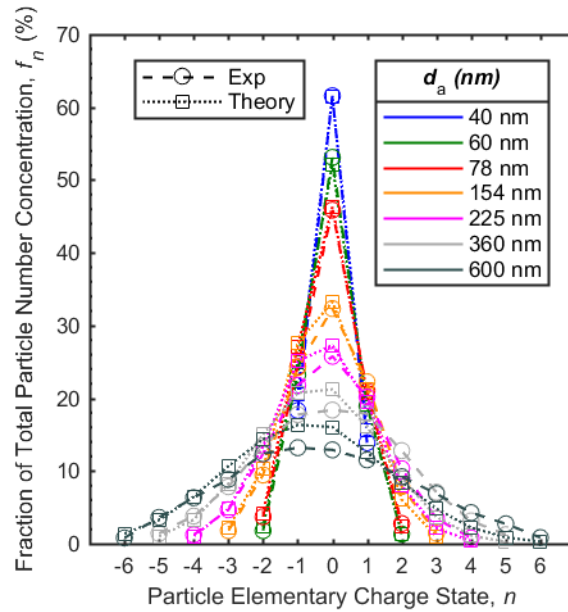


Figure 2: Particle charging fractions produced by a Kr85 neutralizer and measured with the AAC-DMA system

The effective density results provide further validation by allowing comparison between the AAC-DMA and AAC-CPMA system measurements as well as to the expected effective particle density of 914 kg/m³.

Jensen Thomas N.

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Coauthors	Peter B. Pedersen
Publication title	Development and Characterization of Candles with Reduced Particle Emissions
Publication type	Poster
Introduction & Background	<p>The awareness of particle emissions from candles is increasing and in Denmark candles are responsible for approximately 60% of the particle pollution in the candle-using homes. New types of candles are constantly being developed such as candles made of beeswax, mixes of traditional candles waxes and paraffin, vegetable waxes, animal fat based waxes etc. In order to develop new and better candles with reduced particle emissions, additional knowledge about candle emissions is needed.</p> <p>The purpose of the present project is to develop new candles with reduced particle and VOC emissions by utilizing new types of waxes and wicks. The development has been carried out as a part of an international joint venture co-financed by the Danish EPA.</p>
Methodology	<p>Measurements were carried out in a custom-built climate room with air change control. The room concentration of particle and VOC emissions have been characterized while maintaining an air change rate of 0,5 per hour. Particle measurements were performed using a TSI scanning mobility particle sizer spectrometer using a size range from 4.3 nm to 167 nm.</p> <p>Additionally, sampling on filters and analytical thermal desorption (ATD) tubes was performed for subsequent chemical analysis of content of selected metals and salts as well as volatile organic compounds (VOC). Candles have been burned in a wire mesh test cylinders according to the well-established standard EN15426.</p>
Results & Conclusions	<p>Emissions from two reference candle types have been thoroughly characterized, which have led to the development of three new candles by utilizing new wax and wick types.</p> <p>It is unfortunately not possible to publish the results in the present abstract, however, the results will be presented at the ETH conference in June 2018.</p>

Kazemimanesh Mohsen**Affiliation** University of Alberta**Email** kazemima@ualberta.ca**Coauthors** Alireza Moallemi, Larry W. Kostiuik, Jason S. Olfert, Sotiris E. Pratsinis**Publication title** The Effect of Sodium Chloride on the Nanoparticles Observed in a Laminar Methane Diffusion Flame**Publication type** Poster**Introduction & Background**

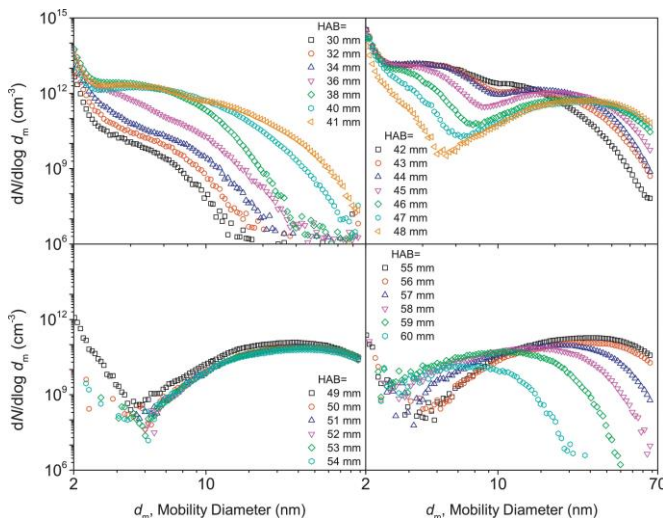
Soot formation and evolution have been extensively investigated in different experimental and theoretical studies. One less-investigated area of research is regarding the effect of alkali metals on soot formation. Extractive sampling is a method which has been employed in studies related to soot formation and emission from combustion sources. In this method, a probe is being used to extract a sample which is subsequently sent to particle measurement instruments. The occurrence of nanoparticles along the centreline of a laminar co-flow diffusion flame with a fuel jet diameter of 10 mm was investigated under two conditions: a methane diffusion flame with and without the addition of NaCl particles of the order of 100 nanometers in diameter in the fuel flow.

Methodology

Samples of nanoparticles from different heights above the burner (HAB) were extracted through a small pinhole in a tubular probe and were immediately diluted several thousand times. Subsequent to sampling, particles were directed to a scanning mobility particle sizer (SMPS) to measure the particle size distribution. A rapid thermocouple insertion method was used to measure the temperature of the flow at different axial and radial positions. Extracted nanoparticles from different HABs were collected on grids and their structure was studied using transmission electron microscopy (TEM).

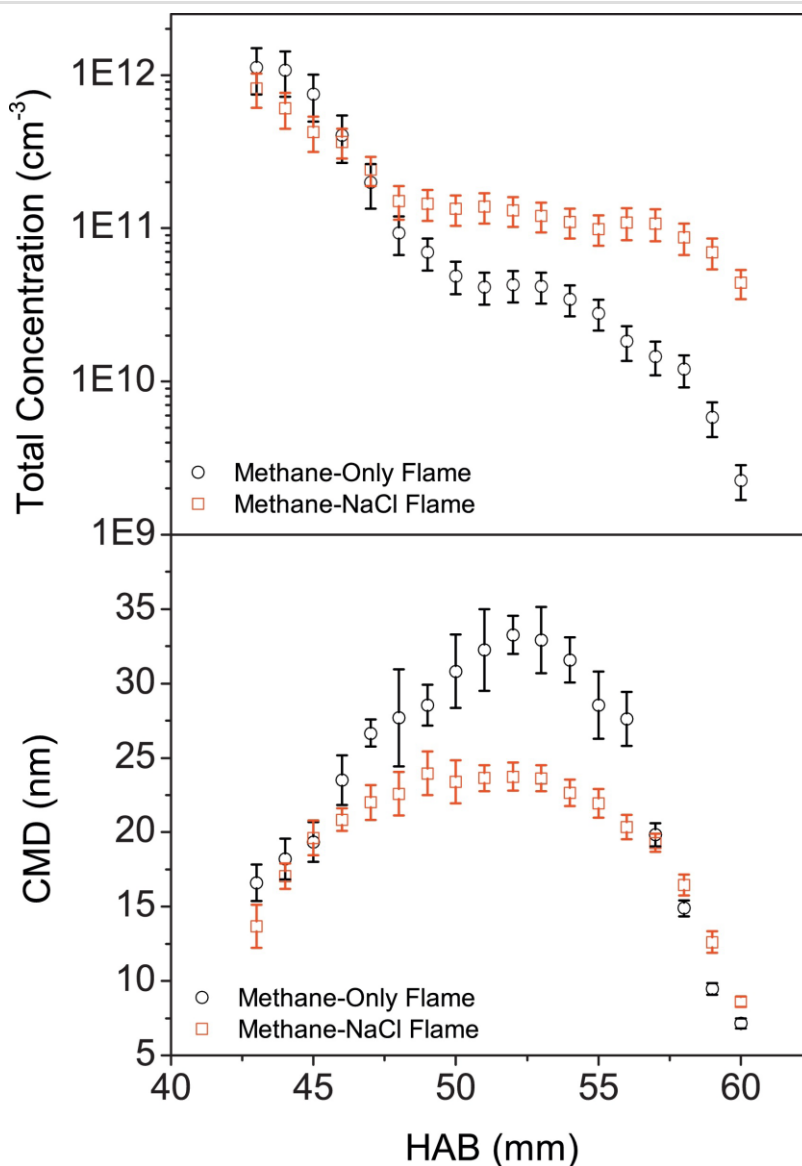
Results & Conclusions

Particle size distributions for the methane-only flame showed different stages of nanoparticle evolution, from inception and surface growth to coagulation and oxidation. TEM images showed that primary soot particles had core-shell structures. Particle size distributions for the methane-NaCl flame showed that considerable concentrations of sub-10 nanometer particles appeared at heights above the burner where soot inception is typically not expected in a methane flame. The TEM images showed that the structure of these nanoparticles was similar to cubical NaCl particles. For higher HABs the particle size distribution followed a similar trend as the methane-only flame, except for regions of the flame where coagulation is the dominant process. The addition of NaCl reduced the mobility diameter of soot particles and increased their number concentration. These results indicate that the addition of NaCl to the flame reduces the coagulation between soot primary particles.

Caption Figure 1:

Size distribution of particles from HAB = 30 to 60 mm for methane-only flame

Caption Figure 2:



Variation of count median diameter (CMD) and total number concentration of particles for HAB = 43–60 mm for methane-only and methane–NaCl flames.

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Publication title	Soot morphology, Light Scattering and Direct Radiative Forcing
Publication type	Poster
Introduction & Background	Soot nanoparticles generated by combustion sources involving transportation, power generation and fires form fractal-like, porous clusters (agglomerates). Yet, their optical properties are calculated using the Mie theory for spheres neglecting the ramified agglomerate morphology and impeding the accurate estimation of soot environmental impact [1], characterization by optical diagnostics and selective detection with fire sensors [2].
Methodology	Here, the soot morphology and radiative properties are investigated experimentally and simulated during surface growth and agglomeration by Discrete Element Modeling (DEM) coupled with Discrete Dipole Approximation (DDA). The DDA is validated against Mie theory and scattering measurements of polystyrene spheres [2].
Results & Conclusions	The DEM-derived number of constituent primary particles (PPs), effective density and differential scattering cross-sections for vertically-, C_v , and horizontally-polarized incident light, Ch , are in excellent agreement with those measured here in different premixed ethylene flame conditions. In contrast, the RDG theory coupled with a scaling law for agglomerates with monodisperse, single, non-aggregated PPs [3] underestimates the DEM-derived C_v and Ch by 60 %. The integral mass scattering (MSC) and absorption cross-sections (MAC) estimated by DEM-DDA account for the detailed soot fractal-like morphology finding good agreement with absorption and scattering measurements in premixed [4] and diffusion flames [5] and yielding average direct radiative forcing, $\Delta F = 0.70 \pm 0.07 \text{ W/m}^2$. This is 45 % smaller than the maximum global climate model predictions using the Mie theory for spheres [1]. The C_v , Ch , MSC and MAC derived by RDG theory coupled with a DEM-derived scaling law accounting for PP aggregation and polydispersity [6] are in good agreement with those estimated by DDA. Thus, both DEM-DDA and the revised RDG theory can be used for the optimization of climate forcing estimations and soot optical diagnostics and selective detection by fire sensors.

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Publication title	Development of a Semi-continuous Measurement System for the Carbonaceous Fraction in Ambient Aerosol
Publication type	Poster
Introduction & Background	<p>Total aerosol carbon mass (TC) is a major constituent of the atmospheric fine aerosol particles. However, this fraction is not yet continuously monitored at atmospheric measurement stations. Adding a TC measurement is thus crucial to complete the existing measurement program for a comprehensive interpretation impact of aerosols on our climate. Currently, carbonaceous aerosols are permanently monitored with, e.g., Aethalometer or MAAP via the light absorption coefficient, which is a measure of the eBC content. However, no information on organic carbon is available. Within Switzerland, measurements of OC and EC via Sunset devices are rare, routinely performed only for a few stations of the Swiss air pollution monitoring network (NABEL) using very low time resolution (i.e. every 12th day). For the Junfrauoch (JFJ) Global Atmosphere Watch (GAW) site, this data is only available for a handful of individual supervised measurement campaigns. The situation extends beyond the Swiss borders. Within the GAW global network, only one-week resolution data is being reported at two regional stations in Norway. This does not fulfill recommendations by the GAW Scientific Advisory Group (SAG), which dictates that the aerosol long-term measurements in the global network include the measurement of carbonaceous aerosol and in particular TC.</p>
Methodology	<p>Within the framework of the MeteoSwiss GAW-Plus 2018-2021 program, we are developing a carbonaceous aerosol measurement system for long-term monitoring of TC. The instrument will be a redesign of the FAsT Thermal CARbon Totalizator (FATCAT), a successfully tested technology for emission monitoring developed by our research group. The standardization and the development of a simplified continuous TC measurement method aim to fill a major gap in the GAW aerosol monitoring program, i.e., to provide an affordable method of carbonaceous aerosol measurement at monitoring sites and to assure comparability of data measured by different research groups. Within this paper, we will present this project and discuss the redesign steps and challenges of adapting our emission measurement-system to a stand-alone instrument for measuring ambient aerosol. Planned activities include several unsupervised long-term measurement campaigns at monitoring stations, within the NABEL network as well as on the GAW JFJ site, which are influenced by different types of carbonaceous aerosol throughout the year. The resulting dataset and post-analysis data products represent an upgrade to the available measurement inventory and serve as quality control for other measurement techniques. Prominently, measurements of eBC via MAAP or Aethalometer and organic mass using AMS or ToF-ACSM require calibration and are susceptible to systematic errors. Our unattended semi-online TC measurement can be used in parallel to these devices to warranty mass closure.</p>
Results & Conclusions	<p>Our improved FATCAT instrument deployed may be the first of many such instruments that could be deployed at various GAW stations. The experience gained during the unsupervised long-term measurement campaigns, including the development of quality control measures, will provide a protocol and standard for the assurance of high-quality measurements consistent with the recommendations of the GAW SAG for other GAW sites. In other words, FATCAT will finally provide a suitable measurement technology for this purpose. This is an urgent matter as current commercial TC measurement technology has not yet being successfully deployed for long-term high-resolution unattended monitoring.</p> <p>This work is supported by MeteoSwiss.</p>

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Publication title	Effect of an Oxidizing Catalyst on PAH Emissions at Log Wood Combustion
Publication type	Poster
Introduction & Background	<p>Catalysts have been shown to be an effective measure against emissions from biomass combustion. Especially for gaseous emissions but also for particulate emissions a significant reductive effect was shown. Nonetheless, the impact on the composition of bulk parameters like OGC and PM is not clarified yet. Polycyclic aromatic hydrocarbons (PAHs) have received increasing attention, because of their genotoxic and carcinogenic properties. So far the impact of oxidative catalysis on the composition of PAHs in the flue gas of biomass combustion is not clarified.</p>
Methodology	<p>In this work a highly effective metallic oxidation catalyst (EnviCat® LongLife) was tested for its effect on PAH emissions from log wood stoves. The tests were conducted with a special test device, which enables parallel measurements of catalytically treated and untreated flue gas. In the parallel flue gas lines the flue gas passes either the Pt/Pd-honeycomb EnviCat® catalyst or a uniform dummy without catalytic layer. Therefore the flow conditions are equal in both lines. PAH sampling was conducted by filtration of diluted flue gas with quartz fiber filters. The filters were extracted with cyclohexane and dichlormethane (1:1) and analyzed with GC-MS (Quadrupole – mass spectrometer) for 19 different PAHs.</p>
Results & Conclusions	<p>In this work the high reduction of CO (-90%) and OGC (-45%) according to a previous work was confirmed. The sum of the 19 determined PAHs decreased by more than 60%, whereas higher (4- to 6-ring PAHs) decreased mostly by more than 75% and lower (2- and 3-ring PAHs) actually clearly increased. It seems that a share of higher PAHs is transformed to lower PAHs, which are typically less toxic. However, the PM which was sampled in this work from the diluted and thus cooled flue gas indicated an increase of 15% after catalytic treatment which is different compared to measurements of PM from hot flue gas in previous measurements.</p> <p>In a previous study it was shown that after catalytic treatment of Diesel soot the concentration of PAHs decreased but the concentrations of some higher toxic nitro-PAHs increased. Therefore the present samples are also analyzed for nitro-PAHs, as the high reduction rates of up to >90% for example for Benzo(a)pyrene could be also a consequence of nitrification processes. Processes occurring at heterogeneous catalysis like nitrification might be also an explanation for the increases of PM at the respective sampling conditions, as vapor pressures of various compounds are lowered for example by the addition of nitro-groups. Analyses on nitro-PAHs are currently conducted and the results will be presented at the conference.</p> <p>The results of this work show the impact of oxidative catalysis on the toxicity of flue gas from biomass combustion, which depends not only on concentrations changes but also on possible transformations into lower toxic PAHs with lower molecular masses or higher toxic nitro-PAHs.</p>

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Publication title	Development of DPF, SCR System with Low Balance Point Temperature for Retrofit Market of Diesel Engine
Publication type	Poster
Introduction & Background	<p>The emissions of newly manufactured diesel vehicles have been greatly reduced by adoption of the Euro6 regulations, the latest European regulation, in Korea. The Ministry of Environment in Korea is trying to reduce the exhaust gas from aging diesel vehicles because the emissions of new cars are greatly reduced but older diesel cars are still emitting relatively high emissions. The purpose of this study is to develop a DPF(Diesel Particulate Filter) and SCR(Selective Catalytic Reduction) system for reducing both PM and NOx emissions for retrofit market of diesel vehicles. The main research contents are focused on the lower BPT(Balance Point Temperature) of DPF which does not require separate regenerator such as burner or post-injection, and lower amount of catalyst for cheaper system. Additionally, development of SCR control strategy suitable for DPF with low BPT is included in the study.</p>
Methodology	<p>The price of the DPF and SCR system for retrofit market is the most important factor for the success of the Ministry of Environment's emission reduction public works project. To satisfy this requirement, the amount of catalyst used in the DPF should be reduced by 70 – 80% compared with the conventional DPF, and at the same time, the BPT should be attained at a enough low level that could activate the regeneration of DPF under normal driving condition. Various catalyst components were experimented to find suitable promoter and various catalyst coating methods were tried to reduce the quantity of catalyst. And each after-treatment systems was verified on the engine bench test and vehicle test.</p>
Results & Conclusions	<p>It was verified by SEM(Scanning Electron Microscope) analysis that Catalyst coating properties, especially catalyst particle diameter and uniformity, were greatly improved by selecting appropriate binder and improving the slurry production method. As a result, BPT was lowered to 260°C by selecting suitable promoter and improving of catalyst coating properties while reducing the amount of catalyst, Pt and Pd, used in the DPF by 50%. The DPF was mounted on a diesel vehicle and the actual road test was carried out more than 5000km. It was confirmed that the differential pressure of the DPF was kept constant without increasing. In addition, NO and NO2 emission characteristics, especially conversion characteristics, through the DPF were analyzed and development of control strategy for SCR was performed to maximize NOx reduction efficiency without NH3 slip. The NO and NO2 reduction characteristics of SCR and the correlation between the exhaust gas temperature and NH3 adsorption-desorption mechanism have been analyzed.</p> <p>Acknowledgment : This research was supported by the CEFV(Center for Environmentally Friendly Vehicle) as Global-Top Project of KMOE(Ministry of Environment, Korea).</p>

Lawrence Alfred Joseph

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Publication title	Indoor Air Quality Exploration - In Relation to Ambient Pollution and House Characteristics in Urban Lucknow houses
Publication type	Poster
Introduction & Background	<p>According to a recent declaration by World Health Organization, 13 out of the 20 most polluted cities in the world belong to India. Lucknow, the capital city of Uttar Pradesh also featured in the list. Pollution in cities has been associated with serious to moderate health risks. The city was placed as the sixth most polluted city in India with recorded Air Quality Index (AQI) 468. Indoor air pollution (IAP) is a direct consequence of outdoor contamination. IAP is one of the major causes of health risks to exposed population. Indoor air pollution (IAP) mediates the release of gases or particles into the air which are the primary cause of indoor air quality problems in homes. Statistics reveal that in developing countries, health impacts of indoor air pollution far outweigh those of outdoor air pollution. The 2016 Environmental Performance Index ranked India 141 out of 180 countries surveyed thereby highlighting the poor environmental quality. In cities it is largely associated with rapid urbanization and industrialization that has led to release of many hazardous pollutants in air leading to deterioration of environmental quality.</p>
Methodology	<p>This study is an attempt to highlight the indoor air quality of Lucknow region in urban houses which were selected after a questionnaire survey with respiratory patients in two medical colleges. The assessment was done from November 2016- October 2017. SO₂, NO₂, CO, CO₂, PM_{2.5} and PM₁₀ were monitored through 24 hrs monitoring in selected households. The urban sites were categorized under three microenvironments 1. Residential (Site I) 2. Commercial (Site II) 3. Roadside (Site III). Average temperature, wind speed and wind direction were collected from Lucknow weather station during the study period. Indoor samples were collected once a week during all monitoring months from each house. Instruments were set up in main living area of the selected houses. The gaseous pollutants (NO₂ & SO₂) were measured using a portable YES-205 multigas monitor and also measured and compared by the Impinger method (spectrophotometer method) using handy samplers. CO and CO₂ were measured through YES-205 multigas monitor, YES Environment Technologies Inc. Canada and YES-206 Falcon IAQ monitor, Geo Scientific Ltd., Canada. PM₁₀ and PM_{2.5} were measured using APM-550 Fine particulate Sampler (Envirotech). Instruments were calibrated before and at the end of every monitoring period or 07 days. Coefficient of correlation (R²) between indoor and outdoor concentrations was used as an indicator of the degree to which indoor pollutants' level was attributed to infiltration from outdoors. Environmental index can predict overall environmental status. The predictions are done using specific standards. AQI prediction can help general public to understand the quality of air. In the present study AQI was calculated for indoor particulate (PM₁₀ and PM_{2.5}) concentrations in both the environments using three different methods.</p>
Results & Conclusions	<p>In urban houses during winter season the PM₁₀ concentration varied from 394-121 µg m⁻³ with an average of 196 µg m⁻³. The PM_{2.5} concentrations varied from 269-57 µg m⁻³ and an average of 117 µg m⁻³. Among the gaseous concentrations CO and CO₂ were highest during winter season. The higher value of an index refers to a greater level of air pollution and consequently greater health risks. By all three methods, poorest AQI was obtained for the commercial sites. Long term exposure to PM is associated with reduced average life expectancy from 8.5 to 20 months and increase in the long term risk of cardiopulmonary mortality by 6-13% per µg m⁻³. In addition to common household emission sources and indoor activity, vehicular exhaust from heavy automobiles was a prominent source in houses situated in commercial microenvironment. The pollutant concentration was lowest in Site I. This can be attributed to the negligible commercial activity and low vehicular exhaust in the area.</p>

Outdoor concentration of pollutants greatly affects the indoor levels in most of the cases. A regression analysis was done between the indoor and outdoor concentrations. In general a positive correlation was observed between the two. For commercial and roadside houses high $R^2 = 0.702273$ and 0.882122 (for SO_2) were obtained respectively showing high dependence of indoor air pollutant level on infiltration. Since the roadside houses experience heavy traffic rush in the nearby surroundings, so high regression coefficient can be attributed to vehicular exhaust. For most of the pollutants high dependence was obtained especially in summer season when the ventilation is mainly natural. Other than outdoor infiltration several indoor factors like cooking, cleaning, dusting, burning of incense sticks and re-suspension of particles were responsible for high particulate concentration. Health status of the subjects was linked to poor indoor air quality. Skin irritation, dry throat, cough, sneezing, occurrence of cataract were some of the common symptoms. The study provided enough evidence of indoor air pollution in considered households, still there is scope to further strengthen the correlation between the exposure of indoor pollutants with pulmonary and cardiovascular health symptoms.

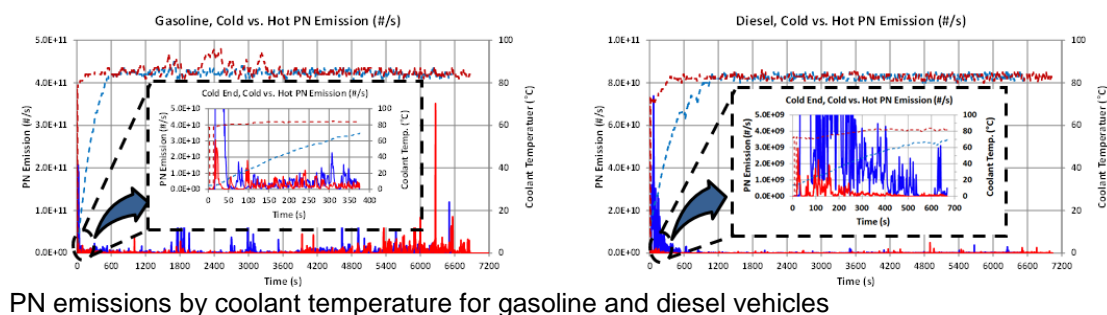
Le Cornec Clémence

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Publication title	Prediction of Soot Loading onto DPFs Using Artificial Neural Networks
Publication type	Poster
Introduction & Background	<p>Diesel exhaust particulate matter (PM) is composed of a solid carbon fraction (soot) and a soluble organic fraction (SOF). PM (mainly composed of soot) has a mutagenic action associated with adverse health and environment effects including lung cancers, asthma and increased mortality rate [1]. Increasing concerns about these effects lead to stringent new emissions standards (from 0.14 g/km for Euro 1 to 0.005 g/km for Euro 6) which motivated the development of PM control technologies such as a diesel oxidation catalyst (DOP) in combination with a diesel particulate filter (DPF).</p>
Methodology	<p>Real-time modelling of soot emissions is an interesting way to evaluate the effectiveness of PM control technologies. Soot formation is a highly complex process and consequently difficult to describe purely mathematically [2]. Empirical and semi-empirical models are easier to implement but are generally limited to specific operating conditions and are not able to generalize accurately [2]. One promising method is the use of Artificial Neural Networks (ANNs) which are able to model highly non-linear relationships. ANNs are trained on a representative dataset to adequately generalise for new data. Long-short term memory (LSTM) networks are a variant of ANNs where each node (called a memory cell) is a complex unit with gates controlling which information is passed through [3]. LSTM networks are able to capture time dependencies [3] and are known to perform well when dealing with time series data. Python 3.6 and TensorFlow are used for development.</p> <p>Soot measurements for two Euro 5 heavy-duty diesel vehicles equipped with Selective Catalytic Reduction (SCR) but without DPF [4] are used to develop soot predictions models. The 1Hz measurements of particle size distributions from a Cambustion DMS500 cover various operating conditions (including steady-state and transient tests). Data from the on-board diagnostic device (OBD), including engine RPM, throttle position, engine out temperature, engine pre-aftertreatment temperature and post-aftertreatment temperature are used as an input to the neural network.</p>
Results & Conclusions	<p>The developed algorithm is able to predict with PM mass, number and size distribution. A robustness analysis is conducted to identify the limits of the model and we investigate model capability with different input parameters. We discuss whether the algorithm could be used as a virtual soot sensor to model the deposition of soot onto a DPF.</p>

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Publication title	Characteristics of PN-Emission during Cold- and Hot-starts in Real World Driving Tests
Publication type	Poster
Introduction & Background	Currently NO _x Emissions from diesel and gasoline vehicle are significantly reduced due to the strengthening of real driving emissions – light duty vehicles (RDE-LDV) regulations and development of post-treatment. Also, the emission of PN is increasing globally each year. However, there is a lack of research on actual road exhaust gas for PN. In this study, one diesel vehicle and one gasoline vehicle were selected from Korean commercial vehicles. We analyzed the PN characteristics of cold- and hot-start conditions followed by 3rd RDE package in RDE-LDV regulations.
Methodology	The test vehicles are a 2000cc diesel (LNT+DPF) and a 2400cc gasoline (TWC). The test route was developed to satisfy test the cold- and hot-start condition in accordance with RDE-LDV regulations. The test equipment used PN-PEMS with applying diffusion charging (DC) method. The OBD and emission data were measured based on real-time acquisition. The test route has developed a route that meets the emissions certification regulations. Cold start conditions and hot start conditions were tested in the same route. The data analysis method was compared with real - time data and the total emission data was analyzed by moving average window (MAW).
Results & Conclusions	The difference between the cold start and the hot start showed a large difference from the start of the test, when the coolant temperature increased to 70 °C. As a result of real-time data analysis, the PN emissions of diesel vehicles were measured to be about 10 times higher than the cold start conditions. In the case of gasoline vehicles, the PN emissions were measured to be about 4 times higher than the hot start conditions for cold start conditions. As a result of analysis of moving average window (MAW) in Urban with cold start, the cold start condition of gasoline vehicle was about 3 times as much as that of hot start condition. In the case of diesel vehicles, PN emissions were estimated to be about 4 times higher in urban than hot start conditions in cold start conditions. RDE-PN of cold-start conditions in both of diesel and gasoline vehicle were higher than that of hot-start conditions. The PN emissions of DPF-equipped diesel vehicles were lower than those of gasoline vehicles.

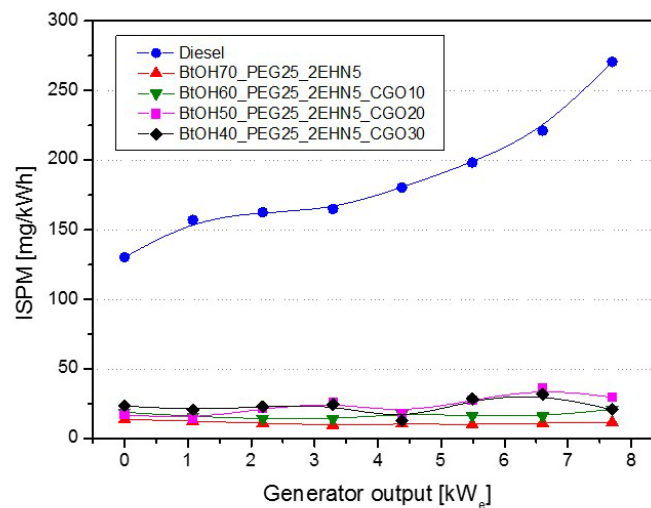
Caption Figure 1:



Lee Seokhwan

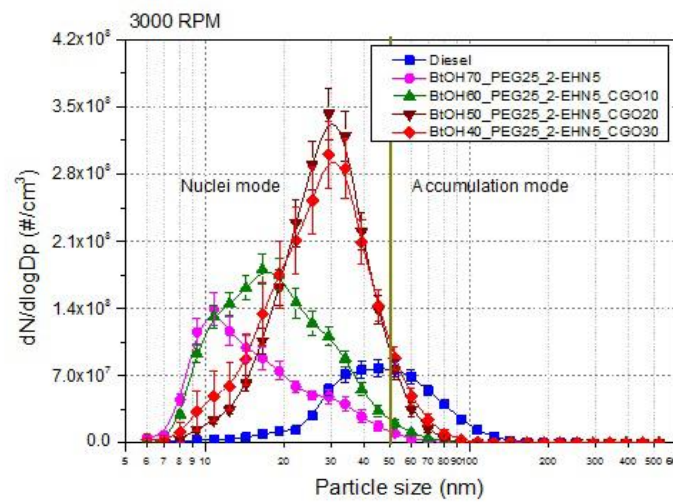
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Publication title	Particulate Emissions from Diesel Engine Operated with Coffee Ground Pyrolysis Oil
Publication type	Poster
Introduction & Background	<p>The replacement of petroleum-based fuels has been of interest as the problems of global warming, depletion of the fuels, and environmental pollution have become increasingly significant in recent years. One of the viable methods to overcome the worldwide problems is the application of alternative fuels especially derived from biomass. Pyrolysis oil derived from coffee ground has been of interest as an alternative fuel to be used in diesel engines. However, direct use of coffee ground pyrolysis oil (CGPO) in a diesel engine requires modifications of their fuel supply systems due to its poor fuel properties such as high acidity, high viscosity, high water content and low cetane number. In addition, the tar in CGPO can become a gum-like material through polymerization, which can accumulate in the injection system. In our previous study, it was found that polymerization of CGPO can be prevented by diluting CGPO in n-butanol fuel. Early mixing with alcohol fuels has an added benefit of significantly improving the storage and handling properties of CGPO. Additionally, the lower viscosity of n-butanol can effectively lower the viscosity of the blended fuel. As an organic solvent, n-butanol is capable of dissolving solid particles existing in CGPO and suppressing polymerization. However, CGPO-butanol blended fuel still does not produce the self-ignition; hence additional cetane enhancements should be added in the blended fuel. In this study, we would like to use WPO through the blending with n-butanol and cetane enhancements (PEG 400 and 2-EHN).</p>
Methodology	<p>Engine bench experiments were performed on a four-stroke, in-direct injection (IDI) diesel generator equipped with a mechanical fuel supply system. Because the char from CGPO can accumulate in the fuel injection system, a mechanical fuel supply system was adopted instead of a common-rail injection system, which is sensitive to sediments. The experiments were conducted at an engine speed of 3,600 rpm and under changing the generator output power.</p> <p>On-road tractor test was conducted on the actual road conditions using a diesel tractor equipped with the mechanical fuel supply system. The experiments were carried out at engine speeds of 2,300 and 3,000 rpm while travelling on the same route of about 5 km distance.</p> <p>PM mass and particle number (PN) concentration were measured to evaluate the effect of oxygen contents in CGPO on the PM formation. All the experimental results were compared to the results of pure diesel under the same experimental conditions.</p>
Results & Conclusions	<p>Experimental results showed that highly stable engine operation was obtained for CGPO-blended fuels with a maximum CGPO content of 30 wt%. The combustion of CGPO-butanol blended fuels produced slightly higher hydrocarbon (HC) and carbon monoxide (CO) emissions than diesel combustion due to the incomplete combustion of the blended fuels. And nitrogen oxides (NO_x) emissions for the blended fuel were higher than those of diesel due to the high oxygen content of the blended fuels. PM generation from the blended fuels was not significant due to the high oxygen content of the CGPO and n-butanol.</p>

Caption Figure 1:



Particulate matter (PM) mass with various test fuels according to generator outputs

Caption Figure 2:



Particle number size distributions with various test fuels at tractor engine speed of 3,000 rpm

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Publication title	Particle emissions from gas engine utilizing natural gas and propane as fuel
Publication type	Poster
Introduction & Background	<p>Natural gas is already an important fuel in energy production and its utilization is increasing. Also, new gas compositions are going to be utilized in some applications; while the natural gas (NG) is primarily composed of methane, the use of new gases like ethane and propane is expected to increase. Biogases are also more and more relevant to be utilized, solely or mixed with natural gas.</p> <p>Recent research results show that compounds like methane (strong greenhouse gas), formaldehyde (toxic), CO (toxic, indirect greenhouse gas), NO_x (health and environmental effects) and particles (health and environmental effects) are found from the exhaust of a natural gas engine (Alanen et al., 2015; Lehtoranta et al., 2017). Changing the gas composition is likely to alter the emissions from gas combustion and also its environmental and health impacts. In this study, we examine particulate emissions from the engine operated by NG and propane. Two lubricant oils with different sulphur and ash content were tested to investigate the influence of lubricant oil particle emissions. In addition, the influence of different catalyst systems (oxidation catalysts and selective catalytic reduction, SCR) on exhaust particles emitted from the gas engine utilizing propane as fuel was studied.</p>
Methodology	<p>Experiments were conducted utilizing a recently developed gas engine facility (Murtonen et al., 2016). Engine was a passenger car gasoline engine adjusted to run with NG and propane. Two different catalyst setups were tested of which the first one consisted of a combination of an oxidation catalyst and a SCR, while the other setup included only one oxidation reactor. Exhaust gas temperature was varied from 350 to 500 °C while the effect of catalyst space velocity was studied with exhaust gas flows of 80 kg/h and 40 kg/h. Particle mass emissions were studied with standard methods. Particle number concentration and particle size distribution were measured with a variety of instruments. The chemical composition of exhaust particles was investigated by using a Soot Particle Aerosol Mass Spectrometer (SP-AMS).</p>
Results & Conclusions	<p>The particle mass emissions were found to be small in all cases studied. The sizes of observed particles were very small with both fuels. Most of the particles were below 10nm in size and significant amount of the particles were even below 3nm in size. Changing the lubricating oil from higher sulphur content to lower sulphur content had a small decreasing effect on the particle mass emission while it caused significant reduction in total particle number concentration and the mean size of observed particles was also found to decrease. The particle composition was found to be dominated by organic matter that consisted mostly of hydrocarbon compounds.</p> <p>This work was conducted in NewGas project, funded by Tekes and several Finnish companies.</p>

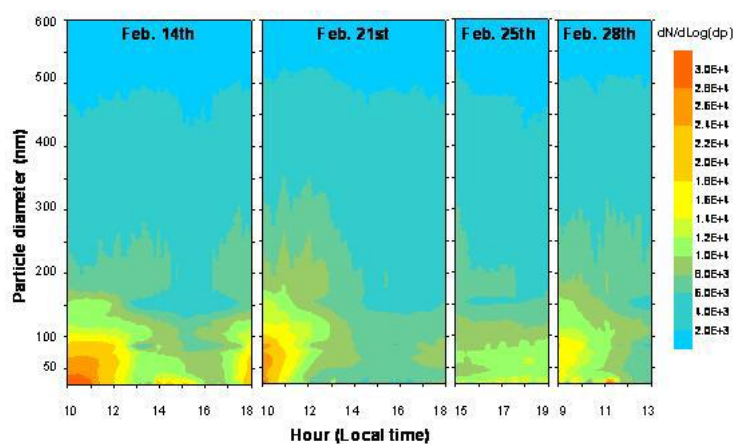
Liu Peng

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Publication title	The Formation Pathway of Soot Precursors (PAHs) and its Transformation to Soot in Flame
Publication type	Poster
Introduction & Background	<p>The haze pollution received increasing attentions during the last two decades due to their negative influence on our health and environment. In metropolis, soot produced from combustion source is the main contributor to the haze pollution. For example, the engine and coal combustion is the primary emission source in Beijing region in China. In order to meet the stringent vehicle emission regulation, clean combustion mode of engine is under constant development, where soot modeling plays important role. The soot model mainly consists of PAHs gas-phase chemistry and the soot particle dynamics. The accuracy of the latter greatly relies the accuracy of the former, as the PAHs is regarded as the precursor of soot. However, our understanding of PAHs formation and its transform to nascent soot particle is not clear enough. For example, the well-known hydrogen-abstraction—carbon-addition (HACA) pathway is hard to explain the experimental fact that the growth of PAHs and soot still happen in the combustion environment where the H atom is rare. This study aims to provide some new insights into PAHs growth and its transform to nascent soot particle.</p>
Methodology	<p>The optimization of molecule structures and vibrational frequency calculations were carried out using the DFT B3LYP 6-311+G(d,p) method. The rate coefficients of reactions were evaluated based on the TST and RRKM theory. The modelling of PAHs formation in sooting flames was carried out via Chemkin Pro software.</p>
Results & Conclusions	<p>Soot modeling plays important role in the development of clean combustion engines. The soot model mainly consists of PAHs gas-phase chemistry and the soot particle dynamics. In this study, we revisited the well-known HACA (PAHs + H → PAHs radical (+C₂H₂) → intermediate → product + H) pathway with considering the reaction possibility of isomer formation. The results of potential energy surface using the DFT B3LYP 6-311+G(d,p) method, and the reaction rate coefficients using the TST theory, indicate that the yield of phenanthrene and pyrene is less than 10 % in HACA frame, and corresponding isomer is the main products. In order to explore the potential reaction pathways leading to phenanthrene and pyrene formation, the reaction of PAHs radical and C₄H₄, as well as the reaction of close-shell PAHs and C₂H₂ are discussed. Results show that the reaction of naphthalene radical and C₄H₄ gives birth to phenanthrene with competitive rates. Meanwhile, it is found that the pyrene is the dominant product in the reaction of phenanthrene+C₂H₂→ pyrene+H₂. The kinetic modelling of pyrene formation under sooting flame condition shows that the proposed PAHs radical-C₄H₄ and PAHs-C₂H₂ pathways are the preferred pathway for the increase of benzene ring number in PAHs growth. Our study also suggests that the soot nucleation involving a chemical coalescence of moderate-sized PAHs into a crosslinked three-dimensional structure via the addition reactions of PAHs and PAH radicals in the main-flame region should be considered for inclusion in any soot modeling.</p>

Lonati Giovanni

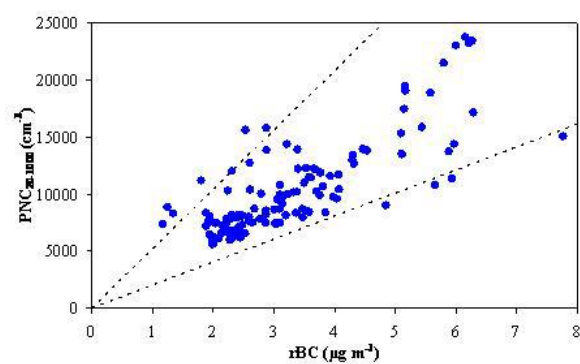
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Publication title	Ultrafine Particles and Black Carbon Measurements at an Urban Background Site in Milan (Italy)
Publication type	Poster
Introduction & Background	<p>Ultrafine particles (UFPs) and black carbon (BC), even though not considered by air quality standards, have been recently attracting growing attention for the related impacts on atmospheric processes and for their adverse effects on human health.</p> <p>In urban areas, size-resolved UFP data and BC data can profitably trace the activity of combustion sources, namely fresh traffic emissions and diesel engine exhaust. In particular, high time-resolved measurements can offer great advantages if compared to hourly-resolved data for criteria pollutants considered for air quality assessment.</p>
Methodology	<p>During the PoAir extensive air quality monitoring campaign over Northern Italy, collocated UFP and BC measurements were performed at an urban background site in Milan for a few days in February 2014.</p> <p>Size-resolved particle number concentration data in 6 size intervals in the 20-1000 nm range have been collected by means of a TSI 3031 UFP monitor. Carbonaceous nanoparticles have been measured through both Laser-Induced Incandescence (LII) technique and by light absorption through a one-wavelength Aethalometer AE51. Size segregated chemical composition data for nr-PM₁ (non-refractory particles with aerodynamic diameter below 1 µm) were obtained through a High Resolution – Time of Flight – Aerosol Mass Spectrometer (HR-TOF-AMS). All measurements were taken at 10-min high time resolution, enabling to track the diurnal pattern of the concentration levels.</p>
Results & Conclusions	<p>Total particle number concentration (PNC, 20-1000 nm range), BC, and nr-PM₁ averaged 10000 cm⁻³, 3.3 µg m⁻³, and 28 µg m⁻³, respectively, but measurements were able to capture the short-period fluctuations.</p> <p>On average, particles in the 20-100 nm range (PNC₂₀₋₁₀₀) accounted for 75% of the total PNC but up to 85% in the morning, hours when they reached concentrations in the orders of 18000-19000 cm⁻³ (Feb. 14th and Feb. 21st). In the afternoon PNC₂₀₋₁₀₀ levels were generally in the orders of 5000-7000 cm⁻³ with a relative contribution to the total PNC of about 70%.</p> <p>Using rBC as a tracer of the primary emission from combustion processes, the total PNC was split into two components: a first component directly associated with primary combustion emissions, and a second component associated with secondary aerosol formation and atmospheric ageing. The former component accounted for 65% of the total PNC, but with higher contributions (71-77%) for the size bins between 30 nm and 100 nm; conversely, the latter component, accounting for only 35% the total PNC, displayed the highest contribution (70%) to the particle number between 200 and 1000 nm.</p> <p>In spite of the limited extension of the dataset, the results suggest that the concurrent measurements at high time resolution of different features of the aerosol (optical properties, number size distribution, chemical composition) can be extremely useful for a better understanding of the nature and origin of ultrafine particles in urban environments.</p>

Caption Figure 1:



Time patterns of the particle size distribution during the monitoring days

Caption Figure 2:

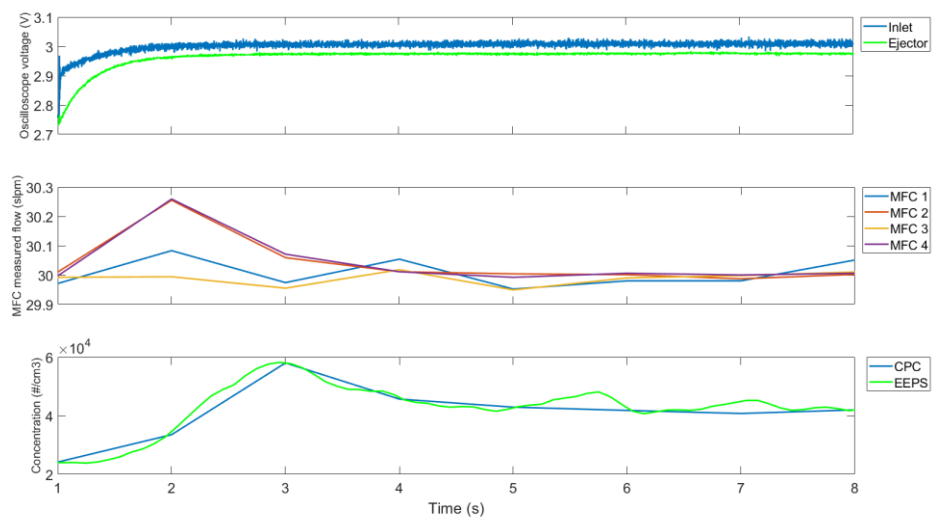


Scatter plot of PNC20-1000 vs. rBC.

Martikainen Sampsa

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Publication title	Dependence of Dilution Performance of a Prototype Setup for Sampling Non-volatile Engine Exhaust Particles down to ten Nanometer in Diameter on Pressure Variations in Sample Line
Publication type	Poster
Introduction & Background	<p>The European Union limits particle number emissions of vehicles by legislation, but particles smaller than 23 nanometers in diameter are left out of consideration. The number of sub-23 nanometer particles emitted by vehicles can be significant and studies suggest that they might be even more harmful to humans than larger particles.</p> <p>In the project "DownToTen", funded by the Horizon 2020 EU Research and Innovation programme, a prototype setup for sampling non-volatile engine exhaust particles down to ten nanometer in diameter has been built. It consists of two porous tube diluters (PTD), a catalytic stripper and an ejector diluter and five mass flow controllers that adjust the flows of the diluters. In order for the setup to be used in a reliable way, its dependence on the operating conditions needs to be well known.</p> <p>In this study, the setup was tested: the dilution performance was characterized by challenging it with rapid (5-20 millisecond) changes in inlet pressure. More precisely, the questions to be answered were: How does the total dilution ratio change? How does the fast change in the inlet pressure affect the operation of the mass flow controllers? How does the ejector diluter (that is located after the two PTD:s) react to changes in system inlet pressure? How are the changes then seen in the measurement instruments after the dilution?</p>
Methodology	A flow of pressurized air was injected in the main line with a mass flow controller. A tracer, NaCl particles formed by an atomizer, was injected to a line connecting the main line and the sampling setup, after which three instruments measuring the particle concentration were connected: a Condensation Particle Counter (CPC) and an Engine Exhaust Particle Sizer (EEPS) by TSI and a Pegasor Particle Sensor PPS-M. The pressure shocks were generated with an additional flow to the main line by turning a fast magnetic valve. By adjusting the magnitudes of the main flow and the additional flow the duration and magnitude of the pressure shock could be varied.
Results & Conclusions	<p>A rapid (5-20 milliseconds) change in the inlet pressure (30-140 mbar increase) was found to cause a significantly slower reaction in the mass flow controllers, as the readjustment of their valves takes about 3-5 seconds. Increasing the inlet pressure decreases the dilution ratio of the ejector diluter. The combined effect is seen by the measurement devices as presented in figure 1. From the obtained results a model for the response of the system to an ideal impulse can be derived, which again allows for correcting the dilution ratio of the system by observing the pressure level in the inlet.</p> <p>The results show that the adjustments made by the mass flow controllers damp the impact of varying pressure levels on the dilution ratio but leaving the MFCs unadjusted (operated as mass flow meters) make the system easier to model and therefore facilitate a robust correction of the dilution ratio for different pressure levels.</p>

Caption Figure 1:



Effect of rapidly increasing the pressure at the inlet of the sampling system. Pressure at the inlet of the sampling system and at the inlet of the ejector diluter (top figure), measured flow through the mass flow controllers (middle figure) and particle number concentration measured by CPC and EEPS downstream of the sampling system.

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Publication title	100 Million of Highly Efficient Particle Filters, now Operational in Diesel Vehicles - a Unique Success for Preventive Medicine
Publication type	Poster
Introduction & Background	<p>To abandon the criterion “particle mass” PM [g/kWh], because it is unspecified with respect to size and substance and to introduce a new emission criterion PN [#kWh] for internal combustion engines the “solid particle number in the lung penetration size range 20-400 nm” was the key element for progress in emission mitigation of engines. Switzerland implemented this step first at the working place in 1994 with the VERT-project for DPF in tunneling, followed by regulation for construction and public transport and demonstrated the feasibility in all applications, even ships and rail. Swiss NanoMet, new particle counting instruments became the “golden instrument” for the UN-ECE-PMP program and with this EU has introduced PN criteria for Euro 5/6 and Euro VI in 2011 and 2014. From the first VERT pilot fleet with 10 DPF on construction machine in 1996 we have now reached 100'000'000 DPF in all LDV and HDV. NRMM is following and petrol engines will also be equipped with filters from 2018. Efficiency of filtration is a revolution with > 99% and detoxification by catalysis is a very powerful side effect. Key was the understanding that small solid particles need to be identified, measured, filtered, eliminated. This metrological step, supported by physics, chemistry and biology is now state of the art to define best available technology BAT. These modern Diesels are cleaning the ambient air from nanoparticles produced by petrol cars and other sources.</p>
Methodology	<p>However</p> <ul style="list-style-type: none"> - ambient air quality is still defined by PM – the effects of these 100 Mio DPF is hardly visible in PM - epidemiology is still correlating health effects with PM10 – particles which not even enter the lungs - legislation has not introduced yet PN in the inspection routines so failures cannot be properly detected - the need for retrofit of the in-use fleet is not understood by the clean air administration - large emitters like aircraft, marine and hand-held are lagging behind in international regulation - USA is delaying this emission reduction process by not accepting PN
Results & Conclusions	<p>This anachronistic discrepancies are not only misleading the health effect research but also policy makers and the industry and engineers have no support from the medical society since epidemiologic studies still correlate a non-defined PM with health effects.</p>

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Publication title	Uniform Metrics for Toxic Air Contaminants are Required to Link Vehicle Emissions, Air Quality Criteria and the Working Place
Publication type	Poster
Introduction & Background	<p>Ambient air in urban environments is overloaded with all kind of particles and other toxic substance: natural and manmade, solid and volatile, soluble and insoluble, some are ultrafine and some – by far not all are highly toxic. We have to discriminate, detect the sources of the most dangerous ones and eliminate them by setting the correct metrics, monitor correctly and use best available technology for mitigation measures for each of them.</p>
Methodology	<p>Health research has concluded that particle size is very important for lung uptake and organ translocation and has pinpointed engine emitted particles since they are nanosize, rather insoluble, coated with PAH and metals and appear in high concentrations - WHO has classified Diesel engine exhaust “carcinogenic class 1”. Those engines emit solid “soot” particles and other toxic substances – which are carcinogens? Is it BC or PAH or Metals and do we define it correctly by mass PM?</p> <p>Even at very high concentration (PN > 108 P/cc or 1014 P/km) these engines emitted solid particles in the size range of 10-300 nm however contribute very little to particle mass PM. Therefore we needed a more sensitive metric for vehicle homologation and control of modern engines and this step is successfully completed with Euro VI and NRMM in Europe, not in the US. So we can no longer compare engine emission quality between Europe and the US</p>
Results & Conclusions	<p>But even worse: ambient air quality control is lagging behind with outdated definitions like PM10 and PM2.5, which are neither taking into account the importance of particle size nor the fact of different toxicity of contained substances nor are they able to correlate air pollution by carcinogenic solid nanoparticles to combustion engine emissions and are thus not supporting any specific mitigation measures – can not even predict climate effects, known from black soot to be by mass unit 600'000 times higher than CO₂.</p> <p>Concluding we also need to talk on NO_x, NO/NO₂ definition differences, SO₂/SO₃, HC-definitions, and missing limits for highly toxic trace elements like Dioxins, Furans, PAH and Nitro PAH besides measurement protocols which might characterize a certain emission source under well defined operation criteria but have no meaning for air pollution under real world conditions.</p> <p>This anachronistic discrepancy is not only misleading the health effect research but also policy makers and the industry.</p> <p>The problem however is, that hundreds of epidemiologic studies correlate PM with different health effects and these studies are regarded to be sacrosanct by existence.</p>

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Publication title	PN as Toxic Air Contaminant is by far Underestimated while NO ₂ is Overestimated
Publication type	Poster
Introduction & Background	<p>EC Particles are carcinogenic and the Miners Study 2011 found 180 lung cancer mortality cases within 16000 workers observed in 8 US metal mines. Based on this finding WHO in 2012 moved Diesel soot from class 3 to class 1 like Asbestos. Using the usual number of max. 4 death within a population of 100'000 as acceptable guideline for a carcinogen in ambient air leads to a limit value of < 0.1 µg/m³ for EC as the NL-official OCR study concluded on 26.Oct.2017. Actually, we have not even a limit value for EC in ambient air! And at the working place in Switzerland, where EC is used to characterize Diesel particle emissions, the actually valid limit value is 0.1 mg/m³ – obviously 1000 times too high! This is unacceptable and the fact that worldwide no single government has adapted their limit values for PM after the clear statement of WHO in 2012 is not acceptable either. Adapting limit values for emission and ambient air would permit to enforce particle elimination strategies for the whole vehicle fleet as well as other sources and to implement them within a short period, which will be outlined in the paper. A reduction of 200'000 mortality cases in Europe would probably be possible within 5 years.</p> <p>NO₂ is also toxic and an irritating gas when inhaled by disabled persons and asthmatics. However it is not a carcinogen and according to US-EPA and many occupational health studies it is not confirmed by any toxicity studies that it could be responsible for mortality at concentrations below 400 µg/m³. Most epidemiological studies are misleading since they principally cannot separate between the health effects of PN and NO₂. And wild speculations about indirect effects though secondary particle formation in the atmosphere are to be rejected since there is no evidence at all available. Today's legal limit values are on the safe side – which is a good finding from a point of view of ambient air hygiene - and the implemented emission reduction technologies as they are now required by European and US-Law will bring NO₂ concentration easily below the legally requested level. This could even be accelerated if the existing HD-fleet in cities would be retrofitted with SDPF technology, which is readily available, as the paper will also demonstrate.</p>
Results & Conclusions	This strategy to upgrade the existing HD fleet will permit another big step in emission reduction while at the same time CO ₂ and other short living global air warming substances will reduced remarkably.

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Publication title	Using a Battery of Airmodus A20 Butanol Condensation Particle Counters for Fast Aerosol Particle Number Size Distribution Measurement
Publication type	Poster
Introduction & Background	<p>Ultrafine aerosol particle size distribution measurement often relies on size classification based on electrical mobility. This is done by first giving the particles a known charge state, then classifying the charged particles using a differential mobility analyser (DMA), and detecting the particles using a condensation particle counter (CPC) or an aerosol electrometer. This method suffers from both low sensitivity for the smallest particles due to losses and low charging probability and low temporal response. In this work we calibrated the Airmodus A20 butanol CPC for different lower cut-offs, to measure fast response size distribution starting from 2-3 nm in particle diameter.</p>
Methodology	<p>Temperature difference of the saturator and the condenser of a CPC can be used to tune the lowest cut-off size. Barmbounis et al. 2017 showed that lowering absolute temperatures of both elements can enhance the detection efficiency for the smallest particles even further. In this work we changed the temperature settings of the A20 to achieve lower cut-off sizes of roughly 3, 5 (factory settings), 10 and 23 nm. Table 1 presents the temperature and flow settings used in each case. Additionally, the optical detectors were tuned. In the “3nm” case the nozzle of the instrument was changed, and the flow rate was increased to reduce diffusion losses for the smallest particles and to increase counting statistics.</p> <p>The CPCs were calibrated using NiCr-oxide particles produced with hot wire generator and size selected using a HalfMini DMA (Kangasluoma et al. 2013) for 1–4 nm, and silver particles produced with a tube furnace and size selected with a Vienna type DMA for 2.5–60 nm. The instruments were calibrated for concentration using NaCl particles.</p>
Results & Conclusions	<p>Figure 1 presents the detection efficiency curves measured against an aerosol electrometer. The 50% cut-offs with different settings are at 2.6 nm, 5.6 nm, 10 nm and 23.1 nm. We also studied how particle charge affected the detection behaviour of the “3nm” CPC and found that the effect was not significant. Detection efficiency for positively charged NiCr-oxide particles was only slightly better than for the negatively charged ones.</p> <p>Using these four A20 bCPCs in parallel, particle number size distribution can be achieved in the size range 2.6–23 nm, with the total particle number concentration >23 nm in addition, with time response of 1 Hz. Such a system can be used to measure also very low concentrations due to extremely high signal to noise ratio of a CPC. Also, the CPCs are sensitive for both electrically charged and neutral particles. The system was tested with ambient aerosol in urban environment and with test aerosol in laboratory.</p>

Caption Figure 1:

Name	Flow rate (lpm)	Saturator temperature (°C)	Condenser temperature (°C)
“3nm”	2.25	37	2
“5nm”	1.03	39	15
“10nm”	1.03	35	20
“23nm”	1.03	39	32.5

Table 1. Temperature and flow settings for the CPCs

Caption Figure 2:

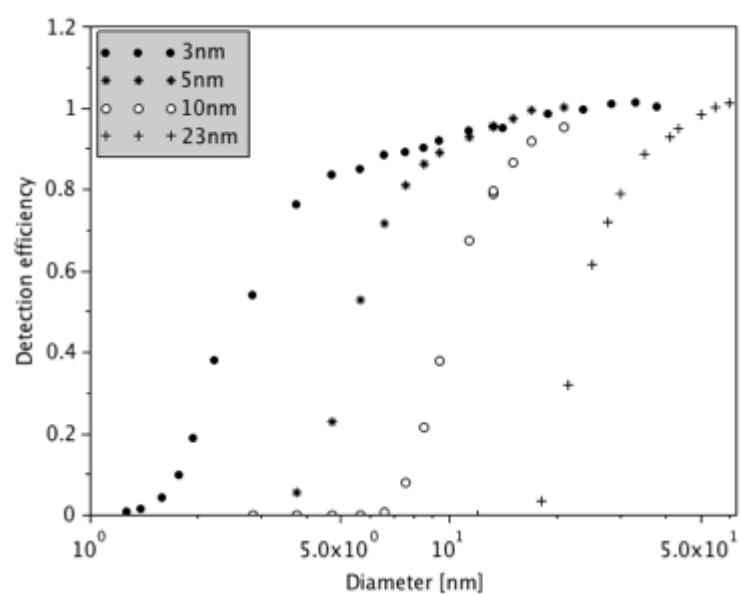
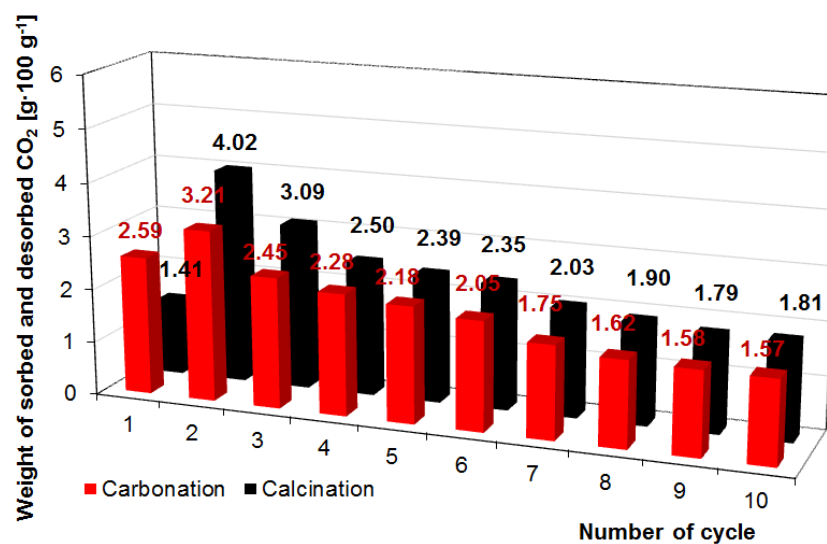


Figure 1. Examples of detection efficiencies of A20 bCPC with different temperature and flow settings.

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Publication title	Dangerous Fly Ash as a Solution for Global Warming
Publication type	Poster
Introduction & Background	<p>Non-combustible particles releasing during coal combustion are monitored by EU legislation for two groups of particles PM 10 and PM 2.5. During incineration process are, however, produced also the particles having diameter below these values. They cannot be captured sufficiently by electrostatic precipitators, which represent predominating system. EU regulations reflect this fact and project it into new requirements on decreasing concentration of these particles. In general terms it is known that these particles have negative effect on human health. Despite the negative properties of fly ash, this material can be used to mitigate global warming. The idea is to use the fly ash in adsorption process to capture CO₂ from flue gases. The use of this material is a new method how to reduce CO₂ emissions and thereby comply with the EU regulations that come in near future.</p>
Methodology	<p>The aim of the experiments was to determine the fly ash properties for possible application in the process of high temperature CO₂ capture from flue gases. The fundamental analyses were performed to characterize the selected samples. XRF method was carried out to evaluate elemental composition. Measurement of nitrogen adsorption at low temperatures and its evaluation via BET method was used to measure specific surface area and pore size distribution. TGA was applied to determine if the samples contain any thermolabile carbonates. The adsorption tests were based on the principle of carbonate loop. The essence of the method consists in reversible decomposition of CaCO₃ to CaO and CO₂. For laboratory simulation the real flue gas was substituted by a gas mixture with the composition of 12 % CO₂, 12 % O₂ in nitrogen. This type of model gas represents ideally desulphurised flue gas, where CO₂ content corresponds with lignite combustion in standard power plant burner. The experiment itself consisted of repeated calcination/carbonation tests at high temperatures up to 900 °C. The cyclical measurement of calcination/carbonation was always performed in 10 cycles. The CO₂ capture was realized at isothermal conditions (650 °C) and the regeneration of a sorbent was carried out by the change of temperature up to 900 °C.</p>
Results & Conclusions	<p>Based on the characterization, two different materials were chosen and then described adsorption tests were applied to them. The samples provided fairly stable CO₂ sorption capacities during the whole experiment. Fly ashes are waste materials, and therefore long-term stability is not required, this finding shows that some of them can be used repeatedly. In the process of CO₂ capture the regeneration can be done simply by the temperature change. During high temperature CO₂ capture, physical and chemical sorption is taking place, but the chemical sorption predominates significantly. Evaluation of obtained results showed that the characterization of fly ash in the view of BET analysis etc. is not a determining factor for chemisorption. However, very satisfying sorption capacities of fly ashes were reached and therefore the fly ash can be considered as a future sorbent able to eliminate CO₂ from flue gas.</p>

Caption Figure 1:



The course of CO₂ capture.

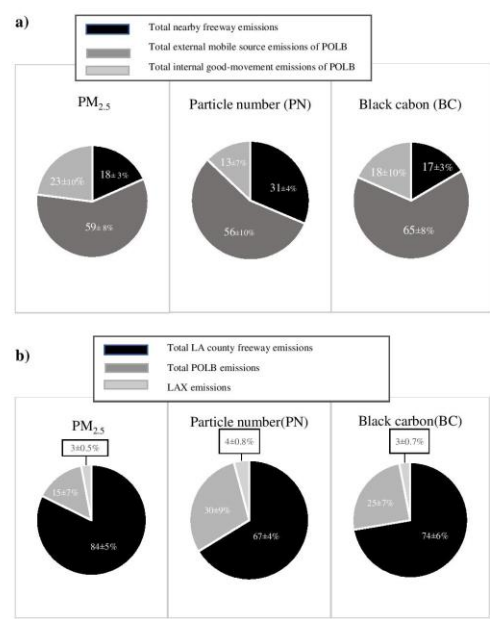
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Publication title	Biomass Burning Dominates Brown Carbon Absorption in Switzerland
Publication type	Poster
Introduction & Background	<p>The optical properties and sources of atmospheric aerosols are of prime importance in the context of a changing climate (Pöschl, 2005). Primary and secondary organic aerosol (OA) emissions introduce light-absorbing compounds (brown carbon, BrC) in the atmosphere that affect tropospheric chemistry and might exert, along with soot carbon, a significant direct radiative forcing on the climate system (Feng et al., 2013). This effect has been largely acknowledged (Alexander et al., 2008) but remains uncertain, since either most climate models have been ignoring the contribution of BrC to absorption or the associated mixed emission sources (Daellenbach et al., 2017) and atmospheric lifetime (Sumlin et al., 2017) are not accounted for.</p>
Methodology	<p>In this work, we propose positive matrix factorization (PMF) as a framework to apportion the contributions of various primary and secondary OA source components of BrC absorption, by combining long-term aerosol mass spectrometry (AMS) data with concurrent UV/Vis spectroscopy measurements. The former feature time-dependent factor contributions to OA mass and the latter consist of wavelength-dependent absorption coefficients, determined using real-world mixedsource filter samples.</p>
Results & Conclusions	<p>Using this approach for a full-year case study in Switzerland, we estimate for the first time the mass absorption efficiency (MAE) of major light-absorbing water-soluble OA components in the atmosphere. We show that secondary biogenic emissions, largely consisting of low molecular weight monoterpene oxidation products, contribute negligibly to absorption despite dominating the mass concentration in summer. In contrast, the MAE of strongly absorbing BrC from primary and aged wood burning emissions can be constrained within a confined range. For the primary emissions, this range is consistent with previous laboratory tests of open and residential burning of biomass or other fuels and near-source ambient samples, but lower than non-conventional BrC types. The MAE of the aged emissions follows that of common anthropogenic precursor (benzene, naphthalene, toluene) secondary OA formed under high NO_x conditions. We note the reduced MAE of aged vs primary wood burning emissions at most wavelengths, in agreement with recent laboratory experiments and a post-biomass-burning event observation.</p> <p>The MAE constrain here can be used to predict the impact of the identified BrC sources on climate, through Mie calculations and radiative transfer modeling. This novel platform may be applied to other datasets, including environments that are heavily polluted or largely represented by other sources (e.g. coal combustion in China). The approach may also be suited for online datasets, acquired using aerosol mass spectrometry and various online optical measurement techniques. The sensitivity of the PMF model results to the applied mass spectrometric analysis has to be assessed in similar future studies.</p>

Mousavi Amirhosein

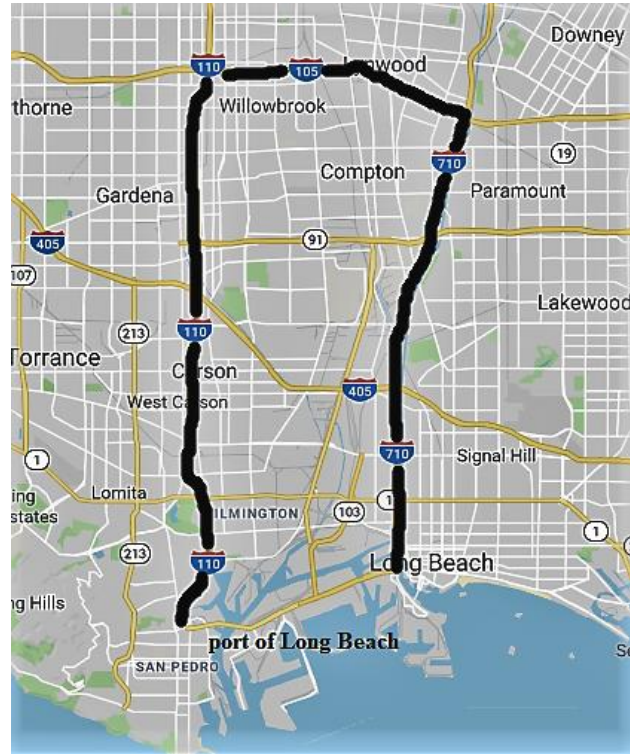
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Publication title	Relative importance of emissions from ships, locomotives, and freeways in the communities near Ports of Los Angeles and Long Beach and their impact on the air quality of Los Angeles Basin
Publication type	Poster
Introduction & Background	In this work, the impact of emissions from different sources (ships, major freeways, locomotive railway and LAX airport) in the vicinity of port of Long Beach (POLB)(north Long Beach community) and their contribution in the local and regional scale emissions in the Los Angeles air basin is evaluated.
Methodology	particle number (PN), PM _{2.5} mass and black carbon (BC) ship emission factors were obtained by plume analysis reported by a comprehensive study at POLB by Chalmers University in October-November 2015. In addition, freeway emission factors for the aforementioned species were calculated based on the on-road emission measurements on I-710 and I-110 freeways. Local scale emission rates were quantified with respect to the “impact zone” of POLB with the predominant southerly winds from coast to inland, considering emissions from cargo handling equipment, locomotive railway in POLB and truck activities in the port area.
Results & Conclusions	At the local scale, PM _{2.5} emission rates were driven by locomotive and ship emissions with emission rates of 43.5 ± 7.8 and 39.1 ± 12.1 kg/day, respectively. While locomotive emissions dominated the PN emissions at the local scale, freeway PN emission rates in the impact zone with $8.72 \times 10^{19} \pm 1.21 \times 10^{18}$ particles/day were comparable with the POLB good-movement emission rate. At the local scale, POLB vessel and cargo handling emission sources contributed to the PN, BC and PM _{2.5} emissions by $16 \pm 4\%$, $21 \pm 10\%$ and $28 \pm 11\%$, respectively. Moreover, In the regional scale, PN, PM _{2.5} and BC total freeway emissions rates of Los Angeles County are 2.92 ± 0.84 , 5.53 ± 1.22 and 2.34 ± 0.76 times greater than the total local POLB emissions, respectively. Presented statistics highlights the importance of locomotive and ship emissions from POLB within the impact zone as well as regional scale.

Caption Figure 1:



Local impact zone of Port of Long Beach

Caption Figure 2:



Relative contributions of major sources at Port of Long Beach to particle number (PN), black carbon (BC), and PM_{2.5} emissions: a) at the local scale; and b) at the regional scale.

Muñoz Maria

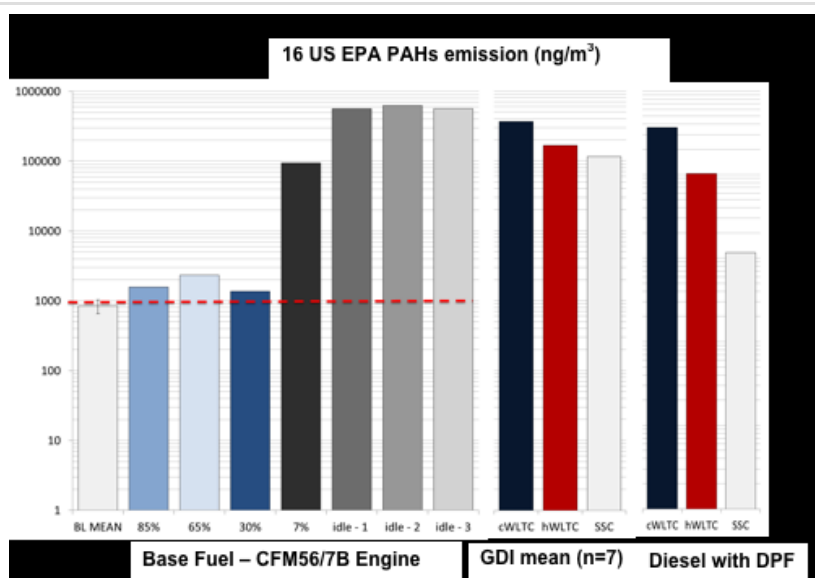
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Publication title	Thrust-dependent Emissions of PAHs of an In-service Turbofan Jet Engine
Publication type	Poster

Introduction & Background Incomplete combustion of carbon-based fuels like kerosene produces partially oxidized compounds such soot and HCs (like PAHs). As shown in literature HCs emissions increase with low thrust loads while particles do at high thrust, thus different as observed for diesel and gasoline vehicles. Efforts have been done to measure these compounds (PAHs) during the operation of jet engine. This has been done in the Empairex Project and preliminary results of the first campaign are shown here.

Methodology In this study, complete exhaust samples, including solid, condensed and gaseous fractions, have been collected in all-glass sampling devices from a in-service jet engine operated with base fuel and tested at different thrust loads in the test cell of SR Technics in Zurich airport. Samples were processed following several extraction and cleanup procedures. Final extracts were analyzed by HRGC-HRMS and concentrations of PAH and alkyl-PAHs were determined.

Results & Conclusions Figure 1 displays concentrations of the 16 US EPA PAHs in ng/m³ at different thrust levels of the tested jet engine (left). A blank sample is also included and the level of that is indicated with a dashed-red line. Highest PAH concentrations were obtained at idling and 7% thrust being up to 2 orders of magnitude higher than those obtained at highest loads. If these emissions at idle are compare to those under steady driving of a GDI (figure in the middle) and a Diesel with DPF vehicle (right figure), jet engine emissions turn out to be more than 5-fold higher and more than 480-fold higher than GDI and Diesel respectively. PAHs not only are deposited on soot particles but also formed in the combustor and can be considered as soot precursors so they must be well characterized. Effects of fuel and plume evolution are to be also studied in the project.

Caption Figure 1:



Emissions of the 16 US EPA PAHs in ng/m³ of a in-service jet engine (CFM56 type) with base fuel and different thrust levels and comparison with emissions produced from GDI and Diesel with DPF under the standardized cycle WLTC (cold in blue, hot in red) and SSC (grey).

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Publication title	Investigation of Polycyclic Aromatic Hydrocarbons and Soot Formation in Swirled Flames of n-Butanol and Conventional Diesel Fuel
Publication type	Poster
Introduction & Background	<p>Particulate emissions from on-road traffic have been linked to various negative health effects, and on top of that uncontrolled emission levels affect the whole ecosystem and the global climate. A huge effort is invested on reducing and tackling particulate matter emissions especially soot and its polycyclic aromatic precursors (PAH). This problem leads to the development of engine systems which deliver the maximum desired energy with the minimum emission levels and alternatively the petroleum based fuels are replaced with biofuels. As a highly potential candidate for alternative transportation fuel produced via fermentation processes, n-butanol is promising to be used as a fuel or a blend in spark ignition, diesel and homogeneous charge compression ignition (HCCI) engines. However, the impact of this biofuel on the emission levels, especially soot and PAHs, has been scarcely investigated.</p>
Methodology	<p>In this framework, a burner was designed to test conventional diesel fuel and n-butanol in combustion conditions similar to real engines. The burner is equipped with a direct injection high efficiency nebulizer which is used to atomize the liquid fuel. A swirl air shield (swirl number 1.2) was added to improve the stability of the flame and the efficiency of combustion. Soot particles and the gas phase are mapped in parallel along the flame using non-destructive in situ laser techniques as laser induced fluorescence and incandescence (LIF and LII). The flames are also sampled at different heights above the burner (HAB) with a dilutive microprobe. The sampled materials are further analyzed with two-step laser mass spectrometry (L2MS) and secondary ion mass spectrometry (SIMS) techniques.</p>
Results & Conclusions	<p>The flame of n-butanol produces significantly less particles compared to the flame of conventional Diesel. This observation probably links to the signature of the fuel. In this case – the absence of aromatic compounds from the n-butanol composition and its oxygen-bound structure might lead to a delay on the formation of soot precursors and nano-soot particle as shown in the figure 1. We observed that the diesel flame quickly creates soot precursors which lead to the formation of soot particles. However, in the sooting zone and oxidation zone, the amount of PAHs decreases fast, while the soot volume fraction quickly increases against HAB. In the flame of n-butanol, the formation of PAHs is delayed with respect to Diesel, but they persist even in the oxidation zone of the flame up to circumcoronene (C₅₄H₁₈). In this work, we discuss the different behaviors of PAHs profiles and soot formation processes on the selected flames based on the detected LII signal, LIF precursor families and mass spectrometry measurements.</p> <p>This work was financially supported by the IREPSE and GDR SUIE (Groupe de Recherche No. 3622) and CLIMIBIO.</p>

Caption Figure 1:

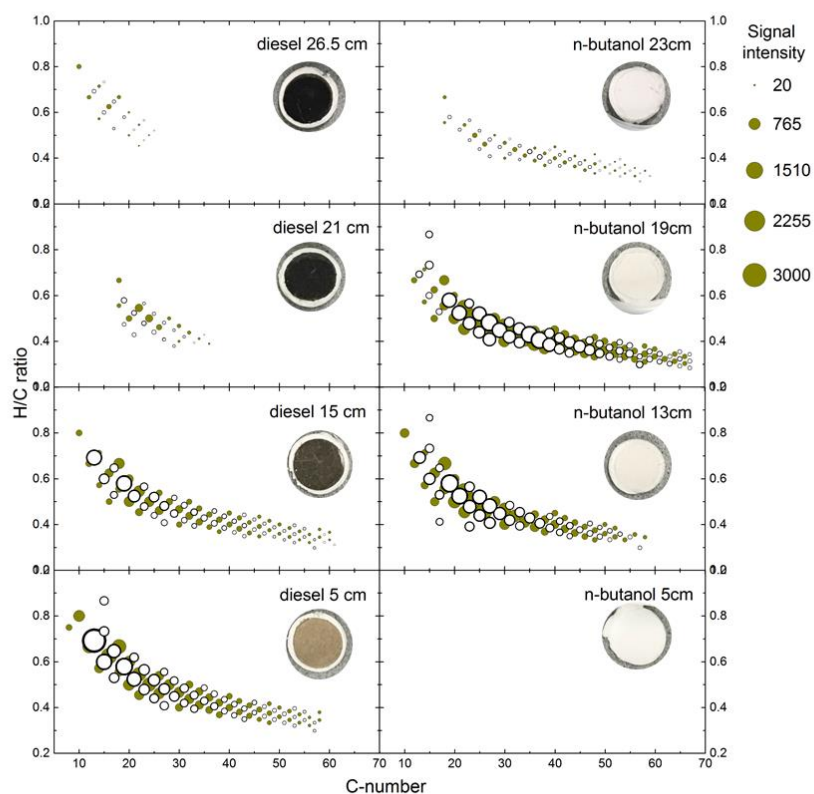


diagram presenting the H/C ratio versus the C-number of the combustion products collected at different HABs from the flames of conventional diesel fuel and n-butanol from time-of-flight secondary ion mass spectra. Full dots: even masses. Open dots: odd masses. Pictures of the filters are displayed for each sampling height.

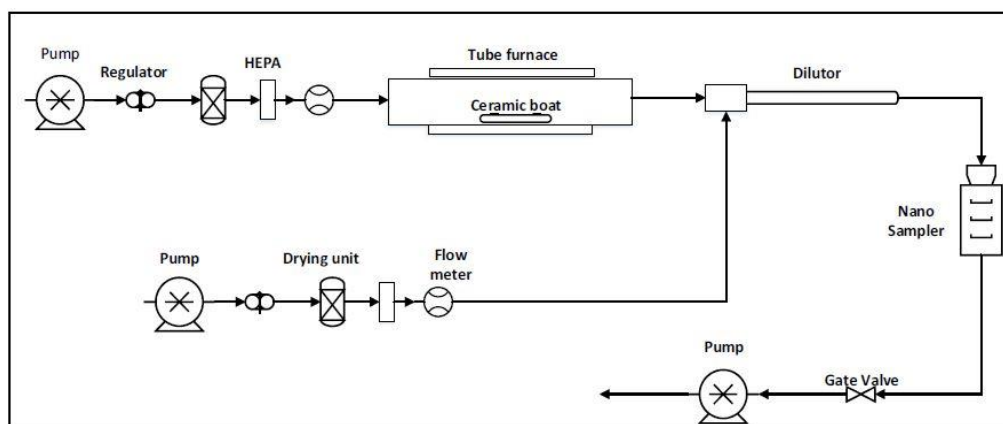
Phairuang Worradorn

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Publication title	Development of Emission Factors of Nanoparticles (PM _{0.1}) from Solid Biomass Combustion.
Publication type	Poster
Introduction & Background	<p>The direct combustion of biomass fuel dominates the utilization of biomass fuels and is most important. On the other hand, it produces many air pollutants such as ion in the form of carbon dioxide (CO₂), nitrogen oxides (NO_x), particulate carbons and other pollutants. Particularly, much of ultra to nanoparticle are generated as reported elsewhere. Therefore, knowledge about characteristics and the control of pollutant emission is essential for biomass utilization with the minimum environmental load. However, such point of view has not been taken into account for the biomass fuel utilization but focused only on so-called "carbon neutral" behavior so far. This is not only important in Thailand but also in other regions in the world where the direct biomass fuel burning is usually used on a small scale without a full set of pollution control devices. The current emission estimate of biomass burning in each fuel type is vital to air quality management and environmental protection. Emission Inventory of PMs in developing countries are rarely developed so far. To our best knowledge, the PM_{0.1}, or nanoparticle emission inventory from solid biomass burning have not been study so far in Thailand and Asian countries. The lack of data both of activity level and corresponding Emission Factor (EF) would lead to large uncertainty inventory. So, the result of EF evaluation of solid biomass fuel will be important to develop high quality emission inventory.</p>
Methodology	<p>Six types of biomass selected based on data of the solid biomass utilization in Thailand. Material solid biomass fuel 6 types including para-rubber wood, rice straw, oil palm kernel, bagasse, sugarcane leave, and corn stem was investigated, respectively. Each sample prepared into a small piece before chamber experiment. The solid biomass burned in a horizontal tube furnace with an inserted quartz column. The particulate matters and the flue gas were respectively sampling using a Nano-sampler with four impactor stages (>10, 2.5-10, 1-2.5, 0.5-1 μm), an inertial filter stage (0.1-0.5 μm) and a backup filter (</p>
Results & Conclusions	<p>The EFs values for six types of solid biomass burning in the laboratory range from 0.11 to 0.22 g/Kg. The highest EFs come from Bagasse (0.22 g/Kg), the minimum EFs derive from rice straw and sugarcane leave (0.11 g/Kg). The Emission Factors is important for the development of strategies for pollution control and decrease the biomass burning.</p>

Caption Figure 1:

Pararubber fuelwood in agroindustry, Thailand

Caption Figure 2:

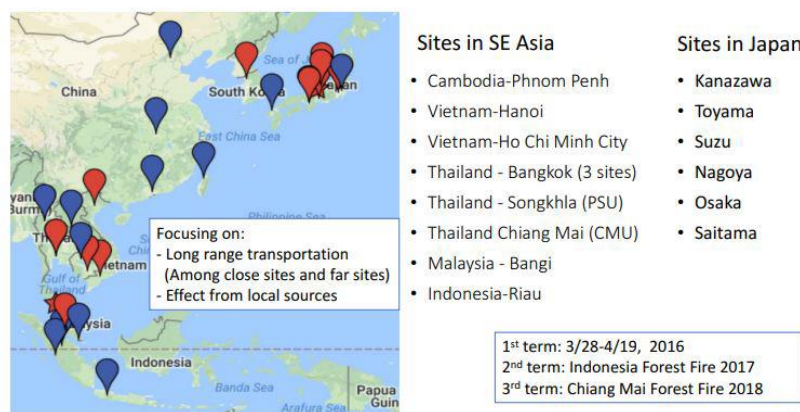


Schematic diagram of combustion system

Phairuang Worradorn

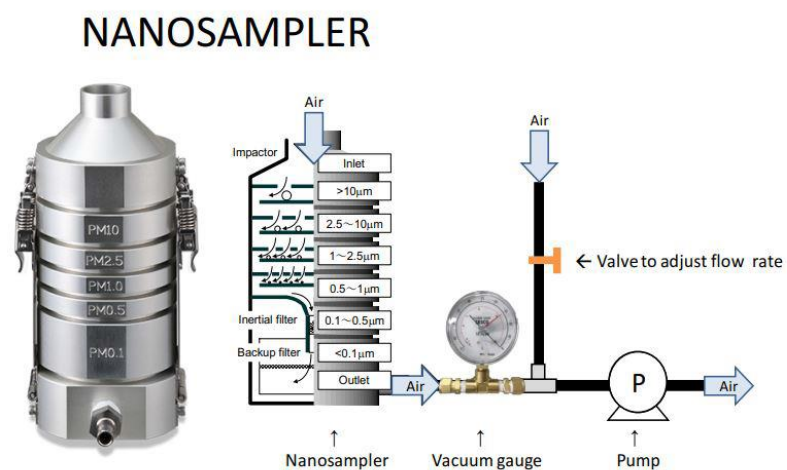
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Publication title	Ambient Nano-Aerosol in East Asian Cities based on East Asia Nanoparticle Monitoring Network (EA-Nanonet)
Publication type	Poster
Introduction & Background	East Asia-Nanoparticle Monitoring Network (EA-Nanonet) that was found based on the air quality status in East Asia that experiences smoke and haze problem. The campaigns have been conducted to discuss the status and characteristics of PM _{0.1} , or, nanoparticles in 10-countries in East and South-East Asia including Japan, China, South Korea, Taiwan, Vietnam, Malaysia, Cambodia, Singapore, Indonesia, and Thailand. Current ongoing activities are continuous monitoring of atmospheric pollutants such as Particulate Matter (PMs especially, nanoparticles), Black Carbon (BC), and others.
Methodology	The particulate matter (PM) was collected by Nano-samplers for size-classified ambient particles. The Nano-sampler can be used to sample a greater amount of nanoparticles at ambient pressure. The used sampler consisted of four impactors stages (>10, 2.5-10, 1-2.5, 0.5-1 μ m), an inertial filter stage (0.1-0.5 μ m) and a backup filter (
Results & Conclusions	Nanoparticles were collected from 11 sites in East Asian countries by East Asia-Nanoparticle Monitoring Network (EA-Nanonet) from March 28th to April 3rd, 2016 using Nano-samplers for nanoparticle ,or PM _{0.1} with flow rate 40 L/min. Organic carbons (OC) and elemental carbons(EC) concentrations were quantified. OC derives from primary sources and from the formation of secondary organic carbon (SOC) by photochemical process in the atmosphere. The concentrations of OC were higher than EC in every site. The OC/EC ratios in PM _{0.1} at the sampling sites ranged from 1.91 to 9.06. The highest of OC/EC ratios were observed at Hat Yai, Thailand (9.06). High OC/EC ratios might be attributed to OC-rich source emissions (such as biomass burning and coal combustion) as well as secondary organic aerosol (SOA) formation. Lowest OC fractions was Bangkok, Thailand (1.91). This reveals that sources are soot emissions from domestic fires, industrial and coal power plant emissions, in addition to aged traffic emissions transported.

Caption Figure 1:

Nano-aerosol monitoring campaign

Nano-aerosol monitoring campaign

Caption Figure 2:



Nanosampler for atmospheric nanoparticle collection

Poláčik Ján

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Publication title	Experimental observation of fine particle production decrease at ignition temperature level of wood samples
Publication type	Poster
Introduction & Background	Fine particles generated from laboratory scale biomass combustion are discussed in this study. It deals with the identification of the formation of fine particles during the temperature increase of the wood mass. The approach combines the thermogravimetric analysis during thermal decomposition of beech wood sample with detailed monitoring of the size distribution of produced fine particles.
Methodology	Thermogravimetric analysis (TGA) allows monitoring the exact temperature influence of a small fuel sample (wood) according to the desired schedule. TGA also influences the composition of the atmosphere flowing around the sample. The cool aerosol stream leaving TGA enters a Scanning Mobility Particle Sizer (SMPS) where the particle size fractions are separated. The monodisperse aerosol is counted by the condensation particle counter (CPC). The parametrical study was carried out to assess the influence of temperature and the composition of the atmosphere on the production and size distribution of ultrafine particles during a heating process.
Results & Conclusions	From carried out measurements follow that majority of emitted fine particles is in the range 40 nm to 500 nm. The peak number of particles is between 100 nm an 300 nm. Significant amount of particles was observed during entire temperature increase of the samples. However, fine particle production is significantly lower at the temperature layer close to the ignition temperate. This contribution focuses on quantification of the particle concentration decrease at this ignition temperature level.

Caption Figure 1:

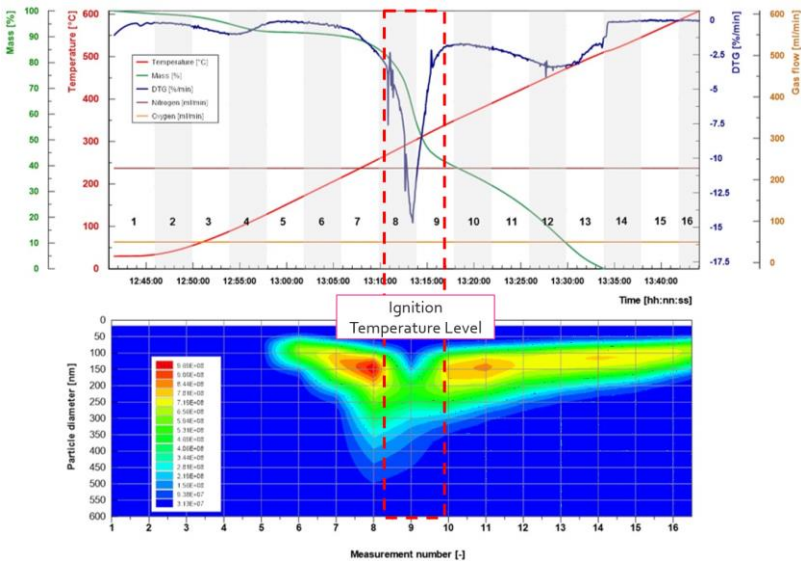


Figure 1: The field of the ultrafine particles distribution and TGA curves for the wood sample

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Publication title	Flue Gas Cleaning for Small Stoves and Boilers
Publication type	Poster
Introduction & Background	Residential heating with wood (and coal) in small stoves and boilers emits about 50 percent of the total fine particle and black carbon emissions in Europe. Furthermore, several studies have confirmed a significant emission of ultrafine particles from residential heating. In other sectors, particle emissions have been successfully reduced by the use of particulate filters. However, flue gas cleaning is still not standard equipment for small stoves and boilers.
Methodology	This study investigates the removal efficiency in two different Danish filter systems adapted for stoves and boilers: An enhanced electrostatic filter and a condensing flue gas system with a bag filter. Measurements were performed with dilution tunnels to include condensate particles. Removal efficiencies were calculated by measuring before and after both filters using P-Trak's and traditional particle mass collection (on quartz filters). The collected particle mass was then analysed for elementary carbon (black carbon, soot) and organic carbon.
Results & Conclusions	<p>Average removal efficiencies over a burning cycle (40 min.) are shown in table 1. Both filters showed high removal efficiencies for fine particles, elementary carbon and organic carbon, with the bag filter having the highest efficiency. The bag filter showed a high removal of ultrafine particles as well. However, no net removal of ultrafine particles over a burning cycle (40 min.) was observed in the electrostatic filter: in the ignition phase (0-10 min.) the filter almost doubled the ultrafine particle emission, whereas it reduced the particle emission around 85 percent in burning phase (10-40 min.).</p> <p>If all stoves and boilers were fitted with one of these filters it could reduce the total emission of fine particles and black carbon in Europe around 50 percent.</p> <p>The prototypes of both filter systems (incl. regeneration) have now been successfully tested for several years on chimneys for small stoves operated under controlled conditions at test facilities. Next steps are crash testing the filter systems and testing under real conditions in private households.</p> <p>Even if the filters are reliable in use and maintain the high efficiencies, next challenge will be to get filters installed on chimneys. This will either require legal filter requirements or high taxes on residential heating without filters since the filter price is believed to be around 3,000 euro.</p>

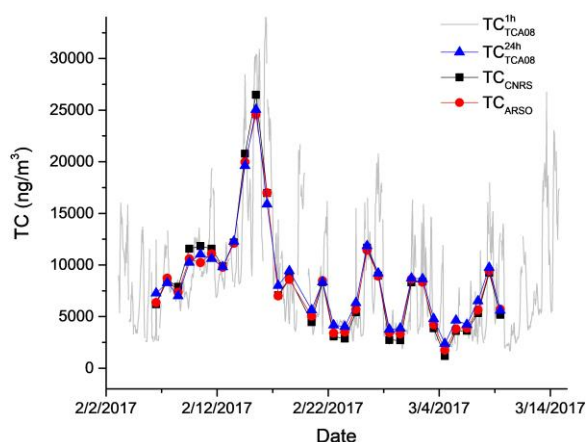
Caption Figure 1:

	PM _{0.1}	PM _{2.5}	EC	OC
Electrostatic filter	0 %	87 %	98,5 %	74 %
Bag filter	98,7 %	94 %	99,6 %	85 %

Table 1: Average removal efficiencies over a burning cycle (40 min.)

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Publication title	Optical and thermal measurements and source apportionment of TC, BC, OC, EC and CM with high time-resolution and comparison to aerosol mass spectrometry
Publication type	Poster
Introduction & Background	Recently developed TC-BC online method, which combines an optical method for measuring black carbon (BC) by the Aethalometer AE33, and a thermal method for total carbon (TC) determination by the Total Carbon Analyzer TCA08 was used for source apportionment of carbonaceous aerosols with high time resolution at several measuring sites around the world. TC-BC method determines organic carbon (OC) fraction of carbonaceous aerosols as $OC = TC - b \cdot BC$, where $b \cdot BC$ is equivalent to elemental carbon (EC). The determined proportionality parameter b is region/site specific and depends to a large extent on a thermal protocol used to determine the EC fraction with the conventional OC/EC method.
Methodology	TCA08 measures concentration of TC by a rapid combustion of carbonaceous matter (CM) collected on a quartz filter. Pulse of CO ₂ which is created during combustion phase of the analysis is detected as a large transient increase above the CO ₂ level in the ambient air used as the carrier gas. Simplicity of the analysis allow us to have high time resolution measurement and easier field deployment of the instrument as no high purity gases are needed.
Results & Conclusions	TC-BC method was validated by comparing averaged high time resolved data of AE33 and TCA08 to a conventional OC/EC analysis on 24h filters using different thermal protocols (IMPROVE, NIOSH, EUSAAR2 in the following winter campaigns in Europe, Asia and N. America: Ljubljana (SI), urban background site; Loški Potok (SI), rural; Milano (IT), urban background, Paris (FR), urban background; London (UK), urban background; Zurich (CH), urban background; Magadino (CH), rural; Beijing (CN), urban; New Delhi (IN), urban; Los Angeles (CA, US), urban; Additionally, parallel measurements with aerosol mass spectrometry (AMS) allowed us to obtain hourly comparison of OMAMS to OCTC-BC.

Caption Figure 1:

Timeseries comparison of offline results for TC=OC+EC derived from CNRS and ARSO measurements to 1h TC data and 24h averaged TC data from online TCA08 measurements.

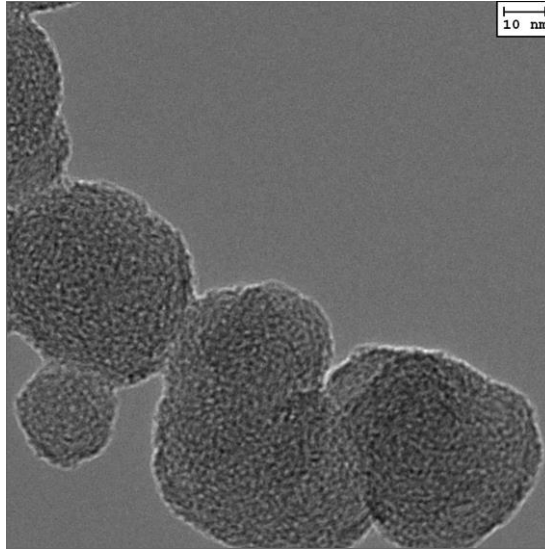
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Publication title	Uncertainties in the Determination of the Penetration Efficiency of the Volatile Particle Remover Used in Number Emission Measurement of Non-volatile Nanoparticles from Aircraft Turbine Engines
Publication type	Poster
Introduction & Background	We experimentally evaluated uncertainties in the determination of the particle size-dependent penetration efficiency (Pen) of a volatile particle remover (VPR) used in number emission measurement of non-volatile nanoparticles from aircraft turbine engines. Since the lower limit of the particle size range for the number emission measurement for aircraft turbine engines is 10 nm, the determination of Pen is required at 15 nm as well as 30, 50, and 100 nm in the SAE Aerospace Information Report (AIR) 6241. Therefore we paid special attention to potential errors that may occur in the determination of Pen at 15 nm.
Methodology	The method for the determination of Pen was based on AIR6241. We tested a unit of the AVL Particle Counter Aviation (APC Aviation). Size-classified, non-volatile test particles were introduced into the VPR of the APC Aviation while the particle number concentrations upstream and downstream of the VPR were measured simultaneously with two condensation particle counters (CPCs). The Pen value was calculated as the ratio of the downstream concentration (Nout) times the dilution factor (DF) recorded by the VPR to the upstream concentration (Nin), i.e., $N_{out} \times DF / N_{in}$, with temperature and pressure corrections. The size-classified particles were soot generated by a propane diffusion flame with a CAST with thermal pre-treatment at about 350 °C, bipolar charge conditioning, and electrical mobility classification by a differential mobility analyzer (DMA). The two CPCs were both TSI model 3775 with the lower size limit at 4 nm in high flow mode. Two DMAs were used to cover the wide particle size range: At 15 and 30 nm, a TSI model 3085 nano DMA was used at the sheath air flow rate of 30 L/min and the aerosol flow rate of 3 L/min. At 50 and 100 nm, a long-column DMA by Sibata Scientific Technology Ltd. (Soka, Japan) was used at the sheath air flow rate of 50 L/min and the aerosol flow rate of 5 L/min.
Results & Conclusions	In the determination of Pen at 15 nm, we found that a small bias in the size of the test particles could cause a significant error in the obtained Pen value, which occurs because the size dependency of Pen is steeper as particle size gets smaller. This means that the particle sizing by the DMA must be accurate especially at 15 nm and therefore needs to be calibrated with an appropriate procedure and particle size standard. Another source of error was found when the VPR's dilution factor was high (i.e. more diluting). The high dilution factors resulted in low particle number concentration downstream of the VPR, which caused large random dispersion in the obtained Pen due to low particle counts. The dispersion was larger at 15 nm because the particle count was lower due to low penetration efficiency (about 30 %). While it specifies the lower limit of the upstream concentration, AIR6241 does not specify how many particles should be counted downstream of the VPR in the Pen determination. A requirement for sufficient particle count statistics should be added to AIR6241.

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Publication title	Problems with Synthetic Soot Loadings for the Development of Gasoline Particulate Filter (GPF) Load Sensors
Publication type	Poster
Introduction & Background	<p>The recent and more stringent EU6d-TEMP regulation and the current social discussion about combustion engines require the usage of particulate filters in modern Direct Injection (DI)-gasoline engines. Nowadays, the Particle number (PN)-limit of $9 \cdot 10^{11}$ #/km for a Real Driving Emission (RDE)-cycle according to (EU) 2016/427 is a big challenge for the producers. Generally, due to hotter conditions in the exhaust pipe of gasoline engines and the oxygen in the towing phase no sensor technology would be required.</p> <p>Borderline cases, as permanent cold start-conditions or bad fuel quality, close to the limit of regulation number 2009/30 EG, are issues that make it necessary to monitor the GPF. Additionally, powertrain concepts of future hybrid-vehicles enable the partial decoupling of the engine. As a result, less oxygen for the particulate filter regeneration is available during the towing operation in the exhaust. Therefore, the state of health and the current loading status are the main points for diagnosing the GPF.</p> <p>Different sensor concepts are available. For example electrostatic or resistive particle matter-sensors, High Frequency-sensors and Differential Pressure-sensors. Soot loading under "normal" (low fuel consumption and emissions) and stoichiometric conditions is time-consuming and therefore causes high development costs. Hence, various tests are made with synthetic conditions to generate more soot and ash in less time. Through this, the morphology of the soot is very different to the one from the standard settings with low PN-Emissions and fuel consumption at stoichiometric conditions.</p>
Methodology	<p>For a 1.8 l DI-gasoline engine different modal points of a RDE-cycle are chosen to load the particulate filter under steady state and stoichiometric conditions up to 3 g/l. At a medium load point (3500 rpm / 150 Nm) the start of the injection, the fuel pressure and the air/fuel-ratio (λ) are varied by using design of experiments (DoE) (D-design AVL CAMEO). The steady state loading was repeated for extreme values of the DoE, namely pool fire, extreme low injection pressure and λ</p>
Results & Conclusions	<p>Under "normal" (low fuel consumption) stoichiometric conditions, the structure and the size of the primary particles and the agglomerates are comparable. The size of the primary particles is in a range of 6 nm up to 60 nm and matches with the results of other investigations collected in [1]. For the synthetic soot loading conditions, the structure of the primary particles and the agglomerates is completely different, in contrast to the standard settings. Furthermore, the aerosol is different to the standard settings, due to the effect that the Three Way Catalyst (TWC) does not work. This causes the compositions of the aerosol and especially soot to be different. Also the reactivity, which arises the regeneration-process, completely differs from the standard settings. This differences can be detected by the HF-antenna as well.</p> <p>[1] Giechaskiel Engine Exhaust Solid Sub-23nm Particles: Literature Survey</p>

Caption Figure 1:



TEM-images from a primary particle under "normal" stoichiometric conditions

Sermon Paul A.**Affiliation** Brunel University**Email** psermon@btinternet.com**Coauthors** Victoria E. Bull**Publication title** Efficiency of scavenging of atmospheric carbonaceous nanoparticles by human lungs: Real-time non-invasive analysis of retention of airborne UFPs by an individual**Publication type** Poster**Introduction & Background**

Our lungs provide the first line of defence against airborne irritants and infectious agents and remove various products of the body's metabolic reactions as a result of a rapid establishment by molecular diffusion to give dynamic equilibrium between air and pulmonary blood in the lung alveoli.

The inhaled atmosphere inevitably contains pollutants and particulates (carbonaceous and inorganic) of varying type and concentration. There may be a synergy between organic and particulate pollutants that aggravates their impact. Ultrafine particles (UFP; diameters

Methodology

Here the authors explore this with real-time analysis of (i) CO₂ ($m/z=44$) and HCN ($m/z=27$) in exhaled air using an RGA (VG Sensorlab and ESS Genysis; RGA analysis of CO₂ is well established [42]) and (ii) UFP concentrations using a TSI P-Trak 8525 condensation particle number counter of UFPs (whose performance has been reviewed) as a function of time with a resolution of 0.1s (RGA) or 1s (P-Trak 8525) during repeated inhalation-exhalation by one of the authors while they were sedentary and inactive during tidal breathing by the authors in urban air.

Results & Conclusions

RGA exhalation profiles do not show the presence biomarker HCN, but were reasonably consistent (see Figure 1) with CO₂ concentrations (red) falling during inhalation and rising to 3kPa during exhalation. The minima are above current atmospheric level (i.e. seasonal levels of CO₂ at the atmospheric boundary layer in 2013 were 450ppm (high; 0.045kPa) and 390ppm (low; 0.039kPa) at a suburban site]).

On the other hand Figure 1 shows that the background UFP concentrations (18UFPs/mm³ or 18000/cm³) were in line with data for an urban atmosphere (e.g. in cities some find roadside concentrations of UFPs of 30-131/mm³). Inhalation is when the UFPs are at this background level. Exhalation is when (if there is some UFP retention) a minimum UFP level is seen. CO₂ maxima and UFP minima correlated with exhalation. It is relevant that more than half of the prevailing UFPs were retained by the subject.

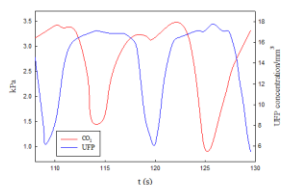
Caption Figure 1:

Figure 1. Inhalation-exhalation profiles for CO₂ (red) concentrations in exhaled air measured by RGA at 0.1s intervals and for UFPs measured by TSI P-Trak 8525 at 1s intervals (blue).

Caption Figure 2:

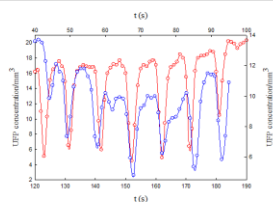


Figure 2. Inhalation-exhalation profiles for UFPs measured by a TSI P-Trak 8525 at 1s intervals for a 72-year old male (red; left and bottom scales)) and a 72-year old female (blue; top and right scales).

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Publication title	Analysis of Jet A-1 Deposits Containing Carbon Spheres and Nanostructures: Effect of Trace Metals and Heteroatomic Components
Publication type	Poster
Introduction & Background	<p>Thermal instabilities result in the deposition in jet fuel when used as coolant by routing through fuel oil heat exchanger in the aircraft gas turbine engine [1, 2]. Thermal stressing of Jet A-1 by flask tests produced deposits containing large molecular weight compounds, spherical nanostructures and carbon spheres [3]. In this study, the effect of trace metals and heteroatomic components on the Jet A-1 deposit formation is investigated. Jet A-1 deposit nanostructures and carbons spheres are also extensively analyzed by electron microscopic methods. Jet A-1 is a potential hydrocarbon source for carbon spheres synthesis [3]. The objective of current research is to investigate the jet fuel deposit growth process in the complex hydrocarbon fuels with fossil origin such as Jet A-1. Predicting fuel deposits growth process, their dependence on fuel source, deposits morphology, size and approximate quantity can contribute in adopting and developing the deposition mitigation measures.</p>
Methodology	<p>Thermal stressing of Jet A-1 was done by flask tests in the autoxidation regime (185 to 190 °C) for 6 hours (JF6) and 24 hours (JF24). Transmission electron microscope (TEM) energy dispersive x-ray spectroscopy (EDS) and elemental mapping recorded by high angle annular dark field (HAADF) micrographs confirmed the presence of trace metallic components in the Jet A-1 deposits. Inductively coupled plasma mass spectrometry (ICP-MS) also detected trace metals in the deposits. Analysis by electrospray ionization mass spectrometry (ESI-MS) and Fourier transform infrared (FTIR) confirmed the presence of heteroatomic and large molecular weight species. High resolution transmission electron microscope (HRTEM) and X-ray diffraction (XRD) analysis measured interplanar d spacing values for Jet A-1 deposits. Size distribution of deposit nanoparticles is measured by ImageJ and MATLAB.</p>
Results & Conclusions	<p>Spherical nanostructures and sub-micron carbon spheres produced by Jet A-1 thermal stressing are abundant and representative as illustrated in the SEM and TEM micrographs. Mean diameter measured is 26.6 nm in the particle size range 10-80 nm and 5.6 nm in the size range 2 to 20 nm. Nascent nanoparticles of Jet A-1 deposits are captured by the TEM and HRTEM micrographs. High temperature annealing and metal catalysis is known to produce graphitic structures [4]. Graphitic layer arrangement and underdeveloped layered regions show coexisting disordered amorphous carbon and graphitic layers in the JF24 samples. Metal catalytic effect possibly generates such structures in the Jet A-1 deposits produced in the low temperature autoxidation regime in this study. HRTEM analysis of Jet A-1 deposits shows nanostructures of metallic compounds with relatively high contrast and lattice fringes (Figure 1). Onion rings like ordered structure of carbonaceous particles are structural property of nanostructures produced at high temperatures such as soot. 0.34 to 0.36 nm is the range for d values of soot which is similar to the d spacing measured for carbon black [5]. Jet A-1 HRTEM and XRD analysis shows a range of interplanar d-values 0.12 to 0.20 and 0.29 to 0.36 nm (Figure 1).</p> <p>Jet A-1 deposits ICP MS analysis identified trace levels of Cu, Zn, Fe and Al in the parts per billion (ppb) range. Elemental mapping of deposits in the STEM mode and HAADF micrographs revealed the presence of multiple trace metals and heteroatomic components in the deposit samples (Figure 2). Heteroatomic polar fuel components are also recorded in the ESI-MS and FTIR spectra of unstressed and thermally stressed jet fuel. Noticeably, mass spectra of thermally stressed Jet A-1 show a mass difference pattern which</p>

corresponds with $R\cdot$ or $RO\cdot$ (R is alkyl) radical removal and suggests free radical mechanism. Carbon spheres formation however support condensed phase reactions. Catalytic effect of metals on fuel hydrocarbons contributes in the free radical generation and hydroperoxide decomposition [1]. Metal particles present in the trace levels thus catalyze the deposition in the thermally stressed Jet A-1. Thermal stressing duration of 6 hours or longer generates carbon spheres and long residence time contributes in their synthesis in this work. Jet A-1 deposits analysis in this study thus suggests metal catalyzed free radical and condensed phase reactions resulting in the large molecules and carbonaceous particles formation.

Caption Figure 1:

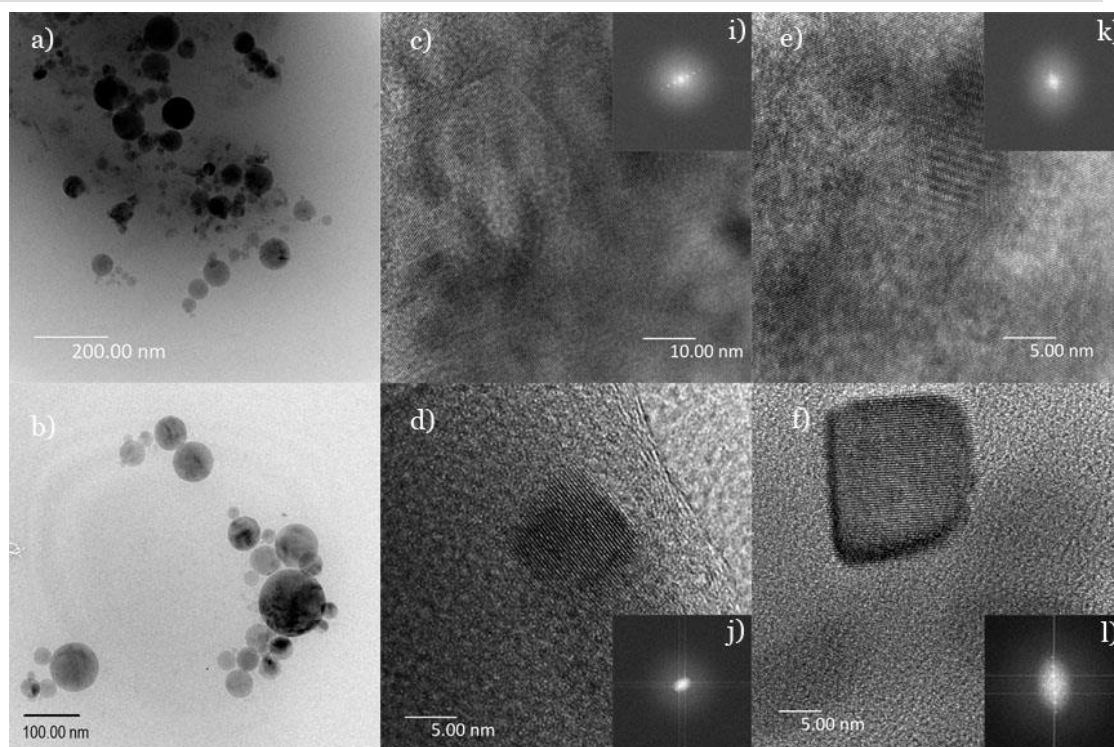


Figure 1: a),b) Jet A-1 deposit nanoparticles , c) to f) are HRTEM images of nanoparticles with lattice fringes, and i) to l) are FFTs of the HRTEM micrographs of c) to f) respectively.

Caption Figure 2:

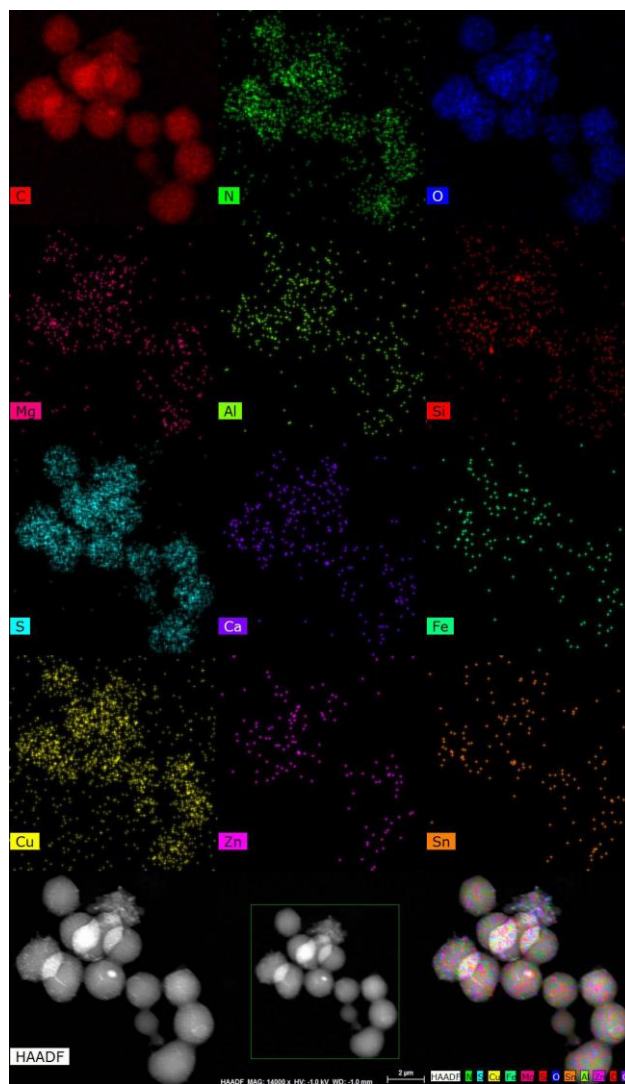


Figure 2: HAADF images and elemental mapping of Jet A-1 deposit carbon spheres

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Publication title	Systematic Evaluation of PM loading and Oxidation in Diesel Particulate Filters
Publication type	Poster

Introduction & Background

Future transportation will require zero local emissions, especially in urban areas. Internal Combustion engines using liquid renewable fuels will continue to be a major technology for transportation. Particulate filters with very high filtration efficiency need to be well understood in order to optimize and control the exhaust aftertreatment system. In order to control the filtration and oxidation process, detailed and accurate models are needed. However, the oxidation process for real applications is still not understood and the effect of previously trapped soot and upstream components need more accurate models. Another issue with realistic emissions experiment is the difference in size, and lab scale experimentation using synthetic soot is often far from representative for real applications. There is thus a need to bridge between lab scale and full scale experimentation to obtain the necessary accurate models. The objective of this study was to address the issues listed above by designed experiments and that can bridge between the full scale and the lab scale.

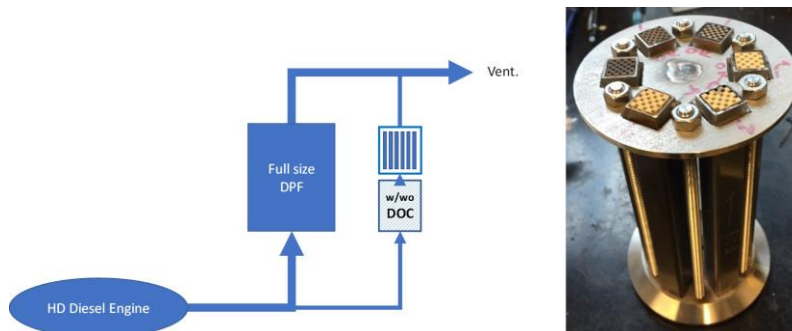
Methodology

A design of experiments (DoE) comprising different diesel particulate filters (DPFs) (cordierite, SiC only, SiC/CeO₂ and SiC/CeO₂/Pt), different soot loading and with/without upstream diesel oxidation catalyst (DOC) was conducted using cartridges of mini-DPFs. The pressure drop of a parallel full-size DPF was used to sample exhaust through the cartridges. A Heavy-Duty diesel engine was run for specific drive cycles using low sulfur diesel fuel. The mini DPFs were then analyzed using an oven and oxidants using lab-scale mass flow controllers. The experiment comprised different temperatures and two levels of oxygen (approx. 1000 ppm and 4000 ppm) and NO₂ (approx. 400 ppm and 800 ppm). The amount of stored soot was evaluated by integrating the CO and CO₂ signals. Apparent activation energies (E_a) and pre-exponential factors (assuming first order reaction of gas phase oxidant and shrinking core mechanism) and analysis of the CO/CO₂ ratio were evaluated and compared for the different DoE variables.

Results & Conclusions

The results confirmed previous findings that the upstream DOC removed volatile components resulting in different specific pressure drop which in turn resulted in different amount of stored soot. From the kinetic analysis, the E_as were different depending on upstream DOC and the amount stored. The E_as were lower without the upstream DOC indicating effects of adsorbed hydrocarbons. The E_as were also lower for the high level of stored soot indicating effects of the soot cake, potentially mass transfer limitations. While the E_as were changing with soot loading and DOC, the effect of CeO₂ was minor. DPFs with Pt had higher selectivity towards CO₂, but the promotion effect using NO₂ was minor.

Caption Figure 1:



Experimental setup showing how the pressure drop of the full size DPF was providing sample flow to the min-DPF cartridge (left) and a photo of one cartridge of mini-DPF's (right)

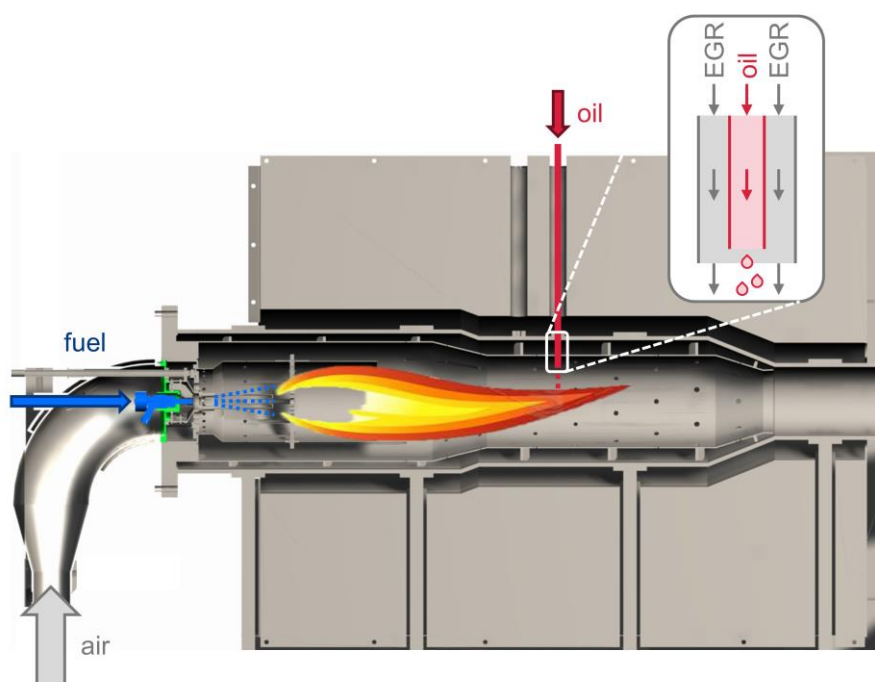
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Publication title	Black Sheep - Detecting Vehicles on the Road that are too Black to be there Using Roadside Particle Measurement
Publication type	Poster
Introduction & Background	<p>Automotive emissions have been environmental and health issue since mass expansion of internal combustion engine. In the past, the challenge has been to develop technology that would make engines clean. Today efficient and affordable aftertreatment technology is available for both gasoline and diesel engines.</p> <p>Challenge today is the in-use performance in the field. Low durability, poor maintenance or deliberate tampering with aftertreatment results in much higher real world emissions compared to nominal values.</p> <p>Due to insufficient regular in-use checks it is hard to detect such vehicles. Poor air quality leads some cities to extreme measures like limiting or banning vehicles entering them.</p> <p>The goal of this study is to detect high particulate matter emitting vehicles in urban traffic, specifically, to identify vehicles that should have DPF, but for some reason the DPF is not operational or even absent.</p>
Methodology	<p>This study uses vehicle roadside measurement to detect particulate mass and number emissions for passing vehicles.</p> <p>Gaseous emissions - CO₂, CO and NO_x are measured as well. CO₂ is used to determine specific particle emissions per liter of fuel.</p> <p>In order to assess vehicle nominal emissions, number plate is recorded and vehicle technical data obtained from the national vehicle registry.</p> <p>Nominal and as measured values are compared, and suspicious vehicles are identified. Vehicle speed is also recorded to assess the engine load.</p> <p>Measurement sites were selected as single lane uphill one directional roads so that engine would be loaded and single vehicle will pass the measurement apparatus.</p>
Results & Conclusions	<p>Over 25 thousand vehicles were identified during a two-week measurement campaign in Prague in October 2017. Measurements were performed during morning and afternoon rush hour at three locations.</p> <p>Particulate number and mass in roadside measurement were assessed generating</p> <ul style="list-style-type: none"> - Vehicle fleet Emission Distribution - High particulate mass emitters identification - Comparison with technical data from vehicle registry based on vehicle registration plate - Judgement if vehicle is or is not in satisfactory condition (OK / NOK). <p>Results show that relatively small percentage of vehicles constitutes majority of the particulate emissions. Therefore efficient air pollution improvement measure would affect small percentage of vehicles that would have to be fixed or kept of the road.</p> <p>Key challenge appears to be matching vehicle and emission trace due to high frequency of passing vehicles and variability in sampling delay.</p>

Sterlepper Stefan

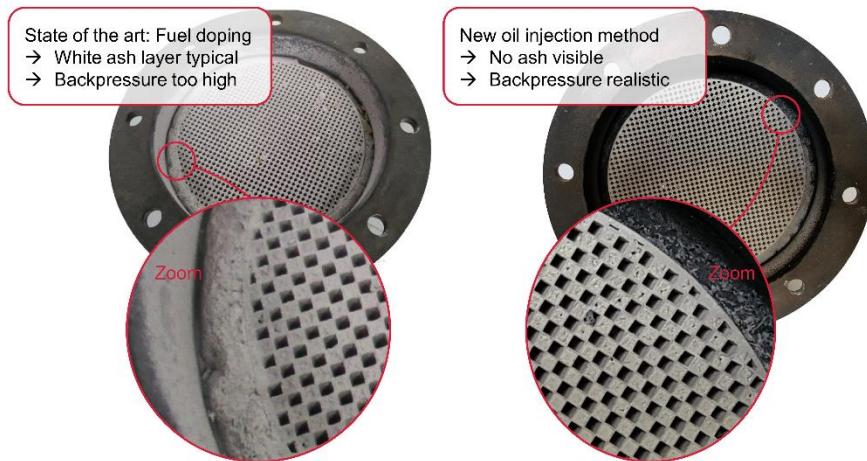
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Publication title	Design of a Novel Gasoline Particulate Filter Aging Method
Publication type	Poster
Introduction & Background	The introduction of limits for the real driving emissions (RDE) is fostering a rapid and comprehensive gasoline particulate filter (GPF) integration into gasoline engine powered vehicles. However, to date, there is only limited field experience regarding GPF aging. This refers especially to ash loading and the impacts of exhaust backpressure changes over lifetime. In order to gain a thorough understanding of the influencing factors on GPF aging, application of a fast and reproducible aging method is essential.
Methodology	Efficient burner test benches, designed for catalyst aging, are compatible with fuel doping methods commonly described in the literature. However, drawbacks such as unrealistically high backpressure, low ash permeability and low comparability with aging during real world vehicle operation, were the reasons for the development of a system for separate oil injection into the burner flame. This novel method allows a precise control of the oil combustion and thus enables the generation of ash characteristics, which come close to those of real world vehicle operation. An intelligent EGR cooling unit prevents the oil from coking without affecting the relative air/fuel ratio. Moreover, the separation of oil and fuel mass flows enables a free choice of the ratios between thermal aging and ash loading.
Results & Conclusions	The paper presents aging results that were achieved with the new oil injection system. Compared to ash generating by fuel doping, the results show a significantly reduced backpressure build-up, which provides a significantly improved reflection of the ash accumulation characteristics in the GPF of a real vehicle. The application of tailor-made transient cycles has the potential to investigate the ash formation for specific vehicles and operation conditions. Also, in order to evaluate the ash loading and backpressure impacts, a comparison to literature results and vehicle durability test runs will be shown. Moreover, the next steps of fundamental ash investigations will be outlined by a detailed test matrix.

Caption Figure 1:



Burner test bench incl. oil injection

Caption Figure 2:

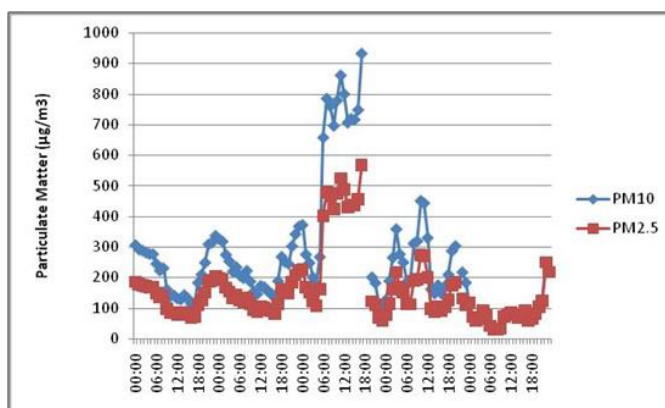


Front view of accelerated ash loaded GPF

Taneja Kanika

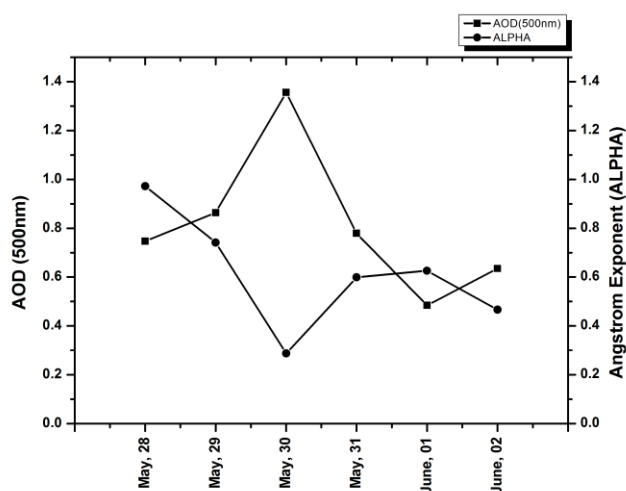
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Publication title	Impact of Dust Storm on Ambient Air Quality over North India
Publication type	Poster
Introduction & Background	<p>Dust storms are common in the north-western part of the Indian subcontinent adjacent to Thar Desert, which is a primary source of dust storms in south Asia. Dust storms have considerable impacts on climate variability, nutrient dynamics and biogeochemical cycles of oceans, soil characteristics, and ambient air quality. The main effect of dust storm on the weather are wind shift, reduced visibility and very low humidity and change in temperature. Often the air ahead of a dust storm becomes extremely hot. Then behind the leading edge of the front or dust storm the temperature drops several degrees. The mineral aerosols having very large surface area strongly absorb the shortwave solar radiation (Dickerson et al., 1997) and cause photolysis rate reduction inhibiting the ozone production (Bonasoni et al., 2004).</p> <p>An intense dust storm generated from a western disturbance as a cyclonic circulation over north Pakistan and adjoining Afghanistan affected the north-west region of India between May 28 and 31, 2014, causing significant reductions in air quality and visibility. Delhi was hit by a huge storm on 30th May 2014 at 17:00 hrs. The dust storm soon turned into a full-fledged rainstorm, with high winds raging through the entire city. In the present study, aerosol optical properties have been monitored using ground based multi-wavelength Sky radiometer for the dust period. The ambient air quality parameters were monitored from the System of Air Quality and Weather Forecasting And Research (SAFAR-India) installed in New Delhi to analyze PM₁₀ and PM_{2.5}.</p>
Methodology	<p>The System for Air Quality Forecasting and Research (SAFAR), which records air quality at ten stations in Delhi. In the present study, the particulate matter PM₁₀ and PM_{2.5} data is retrieved from IMD Lodhi Road station.</p> <p>The aerosol optical properties were derived from Prede Skyradiometer (POM-02) data. The sky radiometer observes simultaneously direct and solar aureole radiance at various scattering angles from the Sun which enables estimation of optical parameters of aerosols such as aerosol optical Depth (AOD), single scattering albedo (SSA), Ångström exponent (Alpha), phase function, asymmetry parameter (ASY) as well as columnar size distribution of aerosols. The measured sky radiometer data have been analysed using SKYRAD.PACK (version 4.2) software (Nakajima et al., 1996) for deriving aerosol optical properties</p>
Results & Conclusions	<p>The major conclusions drawn out of the study are listed below:</p> <ul style="list-style-type: none"> • The ground based measurement of the average daily AOD at 500 nm reached 1.456 at Delhi while AE dropped to 0.287 on May 30, 2014. • Low daily mean SSA at 500 nm was recorded as 0.85 on the dust day, indicating predominance of absorbing type of aerosols. • PM₁₀ concentration peaked at unusually high value of more than 933 µgm⁻³ during dust storm hours of May 30 at Delhi. • The concentration of coarse mode particles is found to be higher on May 30 than other days under study.

Caption Figure 1:



Hourly mean concentration of PM10 and PM2.5 at IMD Lodhi Road, Delhi from May 28 to June 02, 2014

Caption Figure 2:



Variation in AOD and Alpha (500nm)

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Publication title	A Methodology to Relate Black Carbon Particle Number and Mass Emissions from various Combustion Sources
Publication type	Poster
Introduction & Background	Black Carbon (BC) Particle Number (PN) emissions from various sources contribute to the deterioration of air quality, adverse health effects, and anthropogenic climate change. The transport sector is a major source of BC emissions and PN concentrations are typically elevated downwind of major highways and airport runways.
Methodology	This research topic critically reviews the different fractal aggregate theories to develop a methodology to relate BC PN and mass emissions. The new methodology, named as the FA model is validated with three distinct BC emission sources: an internal combustion engine, an inverted burner, and two aircraft gas turbine engines.
Results & Conclusions	Using these BC emission sources, validation results of the FA model show that the estimated BC PN emissions is in good agreement with the measured value. R ² values range from 0.68 to 0.99, while Normalised Mean Bias (NMB) values are in between -10.6% and +41.5%. This is a significant improvement when compared with results from previous methodologies used to estimate aviation BC PN emissions, which relied on simplified assumptions. However, uncertainty and sensitivity analysis showed that the uncertainty bounds of the FA model outputs remain large at $\pm 52\%$ (1.96σ), with inputs of the Geometric Standard Deviation (GSD) contributing to the largest sensitivity in the FA model outputs. An uncertainty bound on estimated BC PN emissions was not quantified in previous models. Given the improved performance in estimating BC PN emissions from various sources, we recommend the FA model for use in health and climate studies, where the impacts of PN are significant.

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Publication title	Optimizing Gasoline Particulate Filter Technologies in order to Improve Filtration Performance under Current RDE Conditions
Publication type	Poster
Introduction & Background	<p>: In order to meet the challenging CO₂ targets beyond 2020 without sacrificing performance, Gasoline Direct Injection (GDI) technology, in combination with charged aspiration, is expanding in the automotive industry. However, while this technology does provide a significant CO₂ reduction, one side effect is an increased particle number (PN) emission. As a result, since September 2017, GDI vehicles in Europe are required to meet the stringent PN emission limits of 6x10¹¹ #/km under the Worldwide harmonized Light vehicles Test Procedure (WLTP). In addition, it is required to maintain a PN emission of 9x10¹¹ #/km under Real Driving Emission (RDE) testing, which includes a Conformity Factor (CF) of 1.5 to account for current measurement inaccuracies on the road. Especially this introduction of RDE testing in Europe and China is providing a unique challenge for the design of exhaust after-treatment systems due to its wide boundary conditions.</p>
Methodology	<p>Previous investigations have shown that gasoline particulate filter (GPF) technology is an effective method to reduce PN emissions, with minimal impact on CO₂ emissions. However, further improvement of the PN filtration efficiency will be required in order to satisfy many current and future global applications. Specifically, the urban portion of the RDE test has been identified as a critical design aspect, since it includes the high PN raw emissions resulting from the cold start phase. High variations in global fuel quality and the difficulty of defining the “worst case” condition during RDE tests add to the increasing requirement, of a robust GPF solution.</p>
Results & Conclusions	<p>The poster investigates the next development steps and iterations in GPF technologies which will result in improved fresh filtration performance while maintaining acceptable pressure drop levels. Potential development materials will be compared by looking at their performance under laboratory and RDE conditions.</p>

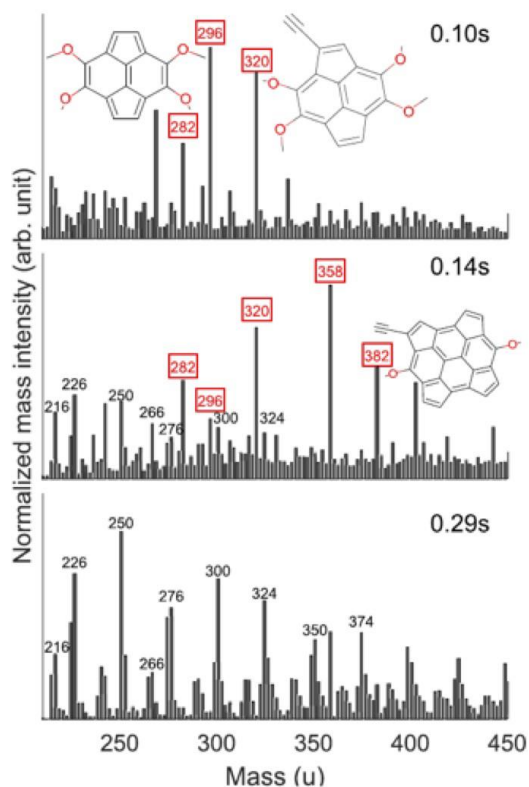
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Publication title	Metrology for Light Absorption by Atmospheric Aerosols: the EMPIR Black Carbon Project
Publication type	Poster
Introduction & Background	Black carbon (BC) is widely recognized as the foremost particulate absorber of solar radiation in the atmosphere and has been associated with the detrimental health effects of air pollution. To monitor BC concentrations, the atmospheric-science community has developed an array of technologies based on light absorption measurements. These absorption measurements are typically reported as mass concentrations of Equivalent Black Carbon (EBC) by using a standard mass absorption cross-section at a given wavelength. However, there is currently a lack of SI traceability for such absorption measurements. In addition, the most common field instruments measure EBC after depositing aerosol particles onto a filter, which introduces complex uncertainties and a need for standardized calibration methods.
Methodology	The EMPIR Black Carbon project, Metrology for light absorption by atmospheric aerosols (2017 – 2020), aims to establish SI traceability for atmospheric aerosol light absorption measurements, based on filter-free methods such as extinction-minus-scattering, photoacoustic spectroscopy, or photothermal interferometry, as well as standardised calibration routines for filter-based instruments. To this end, its specific objectives are to (1) develop a traceable and primary method for measuring aerosol absorption at specific wavelengths, with defined uncertainties and (2) recommend well-characterized reference aerosols suitable for challenging filter-based instruments. Further co-benefits of this work are (3) the establishment of a set of well-defined physical parameters for the traceable quantification of EBC concentrations and (4) the development of a validated method for the in-situ calibration of filter-based field instruments.
Results & Conclusions	This presentation aims to motivate and summarize the goals of the EMPIR project, which is currently in its early stages, in order to encourage and invite contributions from the community.

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Publication title	Formation of oxygenated polycyclic aromatic compounds in flame
Publication type	Poster
Introduction & Background	<p>The formation of oxygenated hydrocarbon species during combustion is of great importance to address the impact on environment as well as human health. Indeed, compounds like furan-type can be highly carcinogenic and have hygroscopic characteristics that influence regional and global climate. While many studies have been reported on mixtures of hydrocarbon and oxygenated as fuels, very little is known about the formation of large oxygenated polycyclic aromatic compounds in hydrocarbon flames. In this study, we report on our latest results that show the formation of oxygenated polycyclic aromatic compounds in a counterflow flame, using a combination of techniques that include atomistic computations, kinetic mechanisms and fluid dynamic simulations. Counterflow diffusion flames are ideal to study the effects of differences in local environment as the thermal and chemical properties vary substantially in space. Reactions responsible for soot precursor growth are highly dependent on the local conditions, for example, with oxygen chemistry overshadowing the hydrogen-abstraction-acetylene-addition (HACA) mechanism under specific conditions.</p>
ethodology	<p>We investigated the growth mechanisms of soot precursors in an atmospheric-pressure ethylene/oxygen/argon counterflow diffusion flame, using a combination of computational fluid dynamics (CFD) simulations and stochastic discrete modeling techniques. While threedimensional CFD computes the temperature profile and compositions of gas-phase species present in the flame, the formation of soot precursors is modeled using a recently developed code, SNapS2, by taking CFD results as inputs. They were employed together to identify key reaction pathways along various flow streamlines.</p>
Results & Conclusions	<p>Results show the presence of oxygenated polycyclic aromatic compounds in flame as result of oxygen-insertion reactions and the HACA mechanism. The relative importance of these pathways is determined by flame conditions along the streamlines in the counterflow flame. Figure 1 shows the mass spectra obtained at different time along a streamline in the counterflow flame. Masses highlighted in boxes show the presence of oxygenated species. Oxygenated species were detected in regions of high temperature, high atomic oxygen concentration, and relatively low acetylene abundance. Oxygen atoms also has a great propensity to add to the edge sites of polycyclic aromatic compounds. The study highlights the importance of including hydrocarbon oxidation mechanisms in current combustion kinetic models. This study also emphasizes the need to model the counterflow flame in three dimensions to capture the spatial dependence on growth mechanisms of soot precursors.</p>

Figure 1



SNapS2-generated mass spectra at different times along a streamline in the counterflow flame. Boxes enclose masses of oxygenated species. 2D structures show the most probable molecules at peaks of 296u, 320u, and 382u. Mass intensities have a maximum relative error of 0.6%, 2.8%, and 3.5%, from top to bottom panel, respectively.

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Publication title	Measurement Artefacts from Evaporation and Recondensation of Volatiles in In-situ Aerosol Light Absorption Techniques
Publication type	Poster
Introduction & Background	<p>In situ photothermal methods investigate aerosol absorption without the complicating effects of deposition of particles onto a filter. These methods rely on the direct link between absorbed energy by the aerosol particles and heat transfer to the surrounding gas, which is typically measured as an induced pressure wave or a change in the gas refractive index. Instruments employing these methods can be highly accurate and precise for the case of black carbon (BC) particles. The accuracy of these methods suffers, however, in the measurement of particles with (semi)volatile coatings. Upon light absorption, the internal energy of the particles rises and, in the case of a coated particle, a portion of the deposited energy will be lost due to the latent heat consumed by the evaporation of the volatile coating. This leads to a signal that is lower than expected and can result in a significant underestimation of the total aerosol mass. The measurement accuracy of photoacoustic spectrometry was reported to degrade for particles with a mass accommodation coefficient of more than about 0.01 (Murphy et al. (2009)) or above 30% humidity (Langridge et al. (2013)). The negative effects of volatile coatings are particularly important for resonant in situ methods, such as resonant photoacoustic spectrometry. In addition to the reduced heat transfer detailed above, resonant photoacoustic signals are damped due to the release of energy (heat) from the recondensation of the volatile substances onto the aerosol particles out of phase with the primary excitation.</p>
Methodology	<p>Photothermal interferometry (PTI) is an in situ absorption technique that does not rely on resonant excitation for signal detection (Moosmüller et al. (1996), Sedlacek (2006)). In this technique the local change of refractive index within the coincident volume of the excitation (pump) and detection (probe) beams, resulting from the absorption of light by aerosol particles and subsequent transfer of heat to the surrounding gas, is detected using interferometry. As PTI is a non-resonant method, it is immune to the damping effect detailed above for resonant photoacoustic instruments. It does, however, suffer from the same reduction in signal for particles coated with volatile substances as other in situ methods. An important distinction can be made here for PTI compared to other in situ techniques. As PTI excitation and detection are not tied to a particular resonant frequency, it is possible to examine the time evolution of the absorption signal. Given that the recondensation process is expected to be considerably longer than the excitation time, this allows the detection of the latent recondensation heat of the volatile coatings. Assuming that the evaporation and recondensation processes are fully reversible, then the measurement of the recondensation heat enables this effect to be taken into account and, therefore, the reconstruction of the same total signal as for an equivalent dry particle. Additionally, it may be possible to deduce information on the composition of the volatile aerosol coating.</p>
Results & Conclusions	<p>In this work we report on numerical modelling of the heat transfer process for coated BC particles for the case of PTI measurements. We investigate the time evolution of the local refractive index of a BC aerosol upon light absorption and quantify the cooling and heating processes of evaporation and recondensation, respectively. These results are compared to experimental parameters such as measurement period and duty cycle, laser power and efficiency to determine the lower bounds of mass concentration and humidity required for the observation of the recondensation signal.</p>

This work is supported by the Swiss National Science Foundation (Grant No 200021_172649) and the EMPIR Black Carbon project (Metrology for light absorption by atmospheric aerosols).

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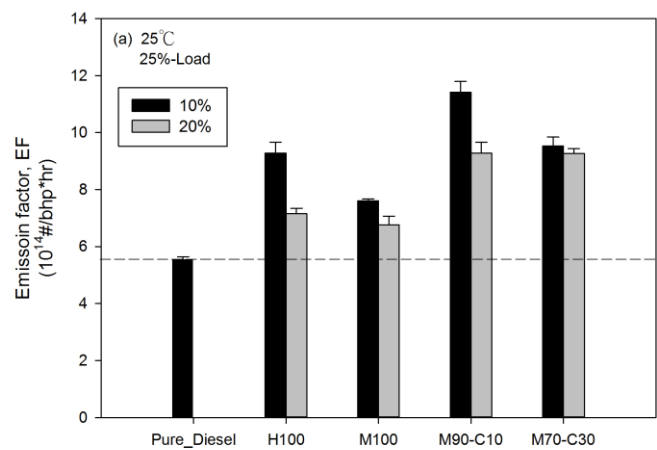
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Publication title	Fuel Supply System by Porous Ceramic Tube to Diesel Oxidation Catalyst
Publication type	Poster
Introduction & Background	<p>In the diesel exhaust after-treatment system, a diesel particulate filter (DPF) has been widely used. Normally, it is a porous ceramic filter of silicone carbide (SiC) or cordierite material. The filter has a honeycomb structure, with alternate closure of inlet and outlet channels. The mechanism for filtration is simple: when the exhaust gas passes through the filter wall, the soot is trapped inside the porous substrate. However, the filter would be plugged with the soot to cause an increase of filter backpressure. If the backpressure is large, the engine may stall or the fuel consumption increases. In order to prevent these disadvantages, the filter must be cleaned periodically by oxidizing the deposited soot, which is called the filter regeneration.</p>
Methodology	<p>To conduct the filter regeneration, it is necessary that the DPF inlet temperature is increased to 550 °C or higher for ensuring the soot oxidation. It should be noted that such high temperature can hardly be observed in normal driving condition. To make the exhaust gas temperature high enough temporary, there are two ways: one is an in-cylinder post fuel injection, and the other is a fuel injection to the downstream exhaust pipe. For both cases, the unburned fuel is supplied to the diesel oxidation catalyst (DOC) to increase the exhaust temperature at the DPF inlet. However, in the case of the in-cylinder post injection, the disadvantage is that the engine oil is inevitably diluted. On the other hand, as for the downstream fuel injection to the exhaust flow, the uniform fuel spray is difficult. In some cases, the efficient fuel supply to DOC could not be achieved because the ejected fuel may be adhered to the exhaust pipe.</p>
Results & Conclusions	<p>We have proposed a new fuel supply system, which is shown in Figure 1. The fuel is vaporized on the surface of the porous ceramic tube filled with the diesel fuel, which is transported to the DOC. It is expected that the uniform fuel vapor is formed by the porous ceramic tube. Figure 2 shows the mass of the vaporized fuel by setting the porous ceramic tube in the mimic exhaust flow. The temperature of the flow was controlled by the tubular furnace. We tested three kinds of ceramic tube, whose average pore size is 150, 500, 1300 nm. It is found that as the pore size is larger, more fuel is reasonably supplied. Moreover, it is confirmed that the amount of the fuel supply can be controlled by changing the pore size, the tube diameter, and the tube length.</p>

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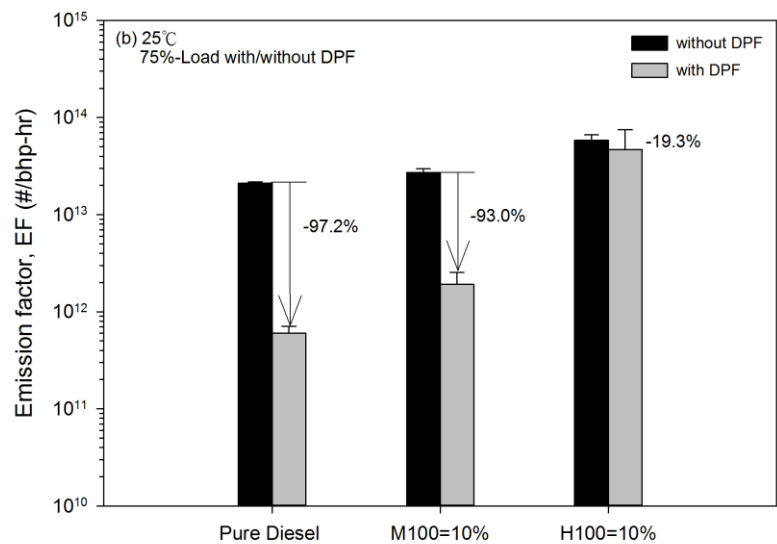
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Publication title	Emissions of Volatile and Nonvolatile Nanoparticles from HDDE Running on Different Gas-Diesel Mixture Fuels
Publication type	Poster
Introduction & Background	<p>Diesel engine exhaust contains hazardous gas pollutants and nanoparticles that have been linked to adverse health effects and environmental impact. Amongst, diesel engine particles (DEP) are a complex mixture of nonvolatile (or solid) and semivolatile components. The nonvolatile component are known as soot particles, whereas the volatile component is mainly composed of low- and semivolatile organic and sulfuric acid vapors. The emission characteristics of the DEP depend on engine type, speed, load, fuel type, aftertreatment and sampling conditions. With that in mind, this study aims to evaluate the effects of gas-diesel mixture fuels on the emissions of volatile and nonvolatile nanoparticles in heavy-duty diesel engine (HDDE) exhaust.</p>
Methodology	<p>The experiments were conducted on a 6-cylinder, 6 L, naturally aspirated, water-cooled, equipped with DPF, direct-injection HDDE of model year 1992 (Hino W06E). The HDDE was tested under two loads, 25% and 75%, under steady cycle on a dynamometer. The test fuels included neat diesel (reference fuel), hydrogen-, methane- and natural-gas mixed with diesel. Aerosol sampling, dilution and thermal conditioning were carried out using a rotating disc thermo-dilution system that consists of a rotating disc dilutor (Matter Engineering Model MD19-2E) followed by a thermal conditioner (ThC, Matter Engineering Model ThC-1). The diluted diesel exhaust samples were then measured under room temperature and 300 C, with which the former is referred to as "volatile" and the latter as "nonvolatile" particles. The number size distributions of diesel particles were then measured with a scanning mobility particle sizer and condensation particle counter (SMPS) system (GRIMM Model 5.500).</p>
Results & Conclusions	<p>The results show that that the use of gas-diesel mixture fuels results in an increase of both volatile and non-volatile particles number emissions, compared to that from pure diesel fuel, but have no negligible effects on the particle number-size distribution. An example of volatile nanoparticle emission under 25% load for different fuels is given in Figure 1. The diesel particulate filter (DPF) remained effective in removing nonvolatile nanoparticles, regardless of the fuel types, but became less effective for volatile nanoparticles emitted from HDDE running on gas-diesel mixture fuels, shown in Figure 2. The corresponding size-distribution revealed that the decreased DPF efficiency was due to new volatile particle formations occurring downstream of the DPF. The above results indicate that the use of gas-diesel mixture fuels could increase the number emission of nanoparticles, and that particle formation could occur post-DPF. This highlights that the benefits of gas-diesel mixture fuels for aerosol mass reductions are possibly accompanied by the increase of aerosol number emissions.</p>

Caption Figure 1:



Volatile nanoparticle emission under 25% load for different fuels

Caption Figure 2:



Volatile nanoparticle emission under 75% load for different fuels and with or without DPF

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Publication title	A Study on the Characteristics of Particle Emissions from Diesel and Gasoline Vehicles on Real Driving Emission for Ambient Temperature
Publication type	Poster
Introduction & Background	<p>To reduce the hazardous air pollutants(HAPs) emissions and meet the strict emission regulations, after-treatment and fuel economy standard development of vehicles became inevitable as of Euro 5. European-commission(EC) has conducted research on real driving emission light duty vehicles(RDE-LDV) using Portable Emission Measurement System(PEMS) equipment.</p> <p>Since the currently certification test mode does not reflect the driving characteristics of real road, it is confirmed that there is large gap between RDE and emission of chassis test. In EU and RDE 3rd package were introduced as regulations in September 2017. Research on RDE-PN included in package 3 of RDE has also been extended. The RDE-PN concentration can not exceed 9×10^{12} #/km since the limit of PN emission(Euro 6) is 6×10^{12} #/km.</p>
Methodology	<ul style="list-style-type: none"> - Test of vehicles : A 2.4L Gasoline Direct Injection(GDI) engine which is equally blending of fuel and air in cylinder is using three-way catalytic converters(TWCs) and A 2.0L Diesel engine with Lean NO_x Trap(LNT) and Diesel Particle Filter(DPF). - Specifications of equipment : The Portable Emissions Measurement System(PEMS) is consist of Exhaust Flow Meter(EFM), On-Board Diagnostics(OBD), Global Positioning System(GPS) and Gas analyzer. Gas analyzer measures the exhaust emissions (CO, CO₂, NO_x, PN) The Particle Number(PN) concentration was analyzed with a Diffusion Charging(DC) method. - Vehicle chassis test mode : Gasoline vehicle is currently chassis testing for cold phase of the FTP-75 mode. Currently chassis test of diesel vehicle is in use that the world-harmonized lightduty vehicle test cycle(WLTC) which has more higher speed and loads than New European Driving Cycle(NEDC). - Real Driving Emission(RDE) test conditions : The route is designed to be operated on cold-start conditions in RDE package 3 and it is consist of urban, rural and motorway. Also, the tests were carried out under only cold-start condition.
Results & Conclusions	In this study, real driving test was conducted using PEMS in order to analyze the impact of ambient temperature with gasoline and diesel vehicles. As a results, the PN emissions of diesel vehicle were lower than gasoline vehicle at various temperature conditions. The reason is that diesel equipped with DPF system. It drastically reduced particulate emissions. Despite the absence of particulate filters, gasoline vehicle met the PN emissions limit (6×10^{11} #/km) of Euro 6.

Caption Figure 1:

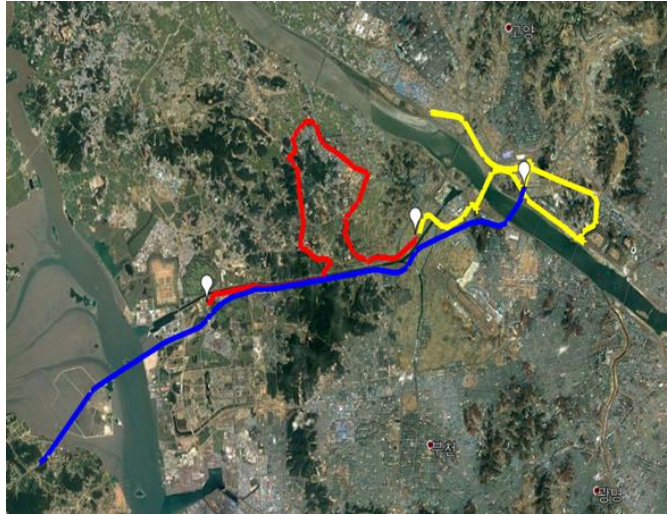


Figure 1: RDE route in korea