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Aakko-Saksa Päivi

Affiliation	VTT Technical Research Centre of Finland Ltd.
Email	paivi.aakko-saksa@vtt.fi
Coauthors	Päivi Koponen; Hannu Vesala; Pekka Piimäkorpi; Minna Aurela; Olli Sippula
Publication title	*Analysing Elemental Carbon from Ship Particulate Matter: Artefacts and Possible Solutions*
Publication type	Poster
Introduction & Background	International Maritime Organisation (IMO) is evaluating needs for control of Black Carbon (BC). Although EC is not a commensurable definition with BC, it is often discussed with the BC results. The EC determination using thermal-optical principle is challenging, particularly when samples contain minerals, organics or sulphates and bound water substantially. In this work, several pathways to alleviate artefacts in the EC analysis from ship PM were studied, including different temperature programs, extraction procedures and using constant split time as a quality control method. The Shipping Emissions in the Arctic – Black Carbon (SEA-EFFECTS BC) project in the Arctic Seas programme of Tekes aims at more reliable BC measurements from ships. The PM samples were collected from a marine diesel engine at VTT's engine laboratory.
Methodology	x
Results & Conclusions	Minerals or oxygen containing compounds in PM may lead to underestimated EC, while transformations in the sample (or leak in the instrument) may lead to the pre-oxygen split and overestimated EC. In this work, the EUSAAR2 (prEN 16909) and NIOSH 5040 with two peak temperatures (870 °C and 750 °C) were studied. The EUSAAR2 protocol suited best for the ship PM samples as its peak temperature in the inert mode is sufficiently low and temperature rise is sufficiently slow to avoid premature evolving EC and unintentional changes in the samples. Prolongation of EUSAAR2 was needed to avoid overlapping of the last sample peak and the methane calibration peak for samples from diesel engines using distillate-type fuels. EC may be biased when PM contains a large amount of organic carbon (OC) prone to pyrolysis, though the determination of the split point based on recording of the laser intensity over the analysis takes this into account. In this work, samples were extracted with water, alcohols and organic solvents prior to the analysis to remove OC and other soluble constituent that may interfere with the analysis. Extractions led to irregular changes in the EC results. Furthermore, OC cannot be determined after the washing procedure. Interpretation of thermograms for ship PM samples was challenging, if the samples contained liquid compounds. When samples were wet, the laser throughput drop in the first temperature step may be interpretated as the start of pyrolysis, though it is due to drying of filters. For the wet samples, manual split point determination was needed. The optical correction may lead to high differences in the EC results, though thermograms of the EC part were similar. The round-robin EC results were depended on a laboratory, personnel and generation of the instrument even when the EC part of thermograms was similar. When using the constant split time, the EC results were similar in different laboratories. The constant split method seemed feasible as the quality control method for the EC analysis.

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and from industrial partners, Wärtsilä, Pegasor, Spectral Engines, Gasmet, VG-Shipping, HaminaKotka Satama Oy, Oiltanking Finland Oy and Kine Robotics, and to the in-kind support from AVL and Neste. Authors would like to thank personnel at the research organisations of the project (VTT Technical Research Centre of Finland Ltd, Finnish Meteorological Institute, Tampere University of Technology and University of Turku) and at University of Eastern Finland and Metropolia. Grateful thanks are given for the engine operations to Sami Nyyssönen, Jarmo Kuusisto, Jarno Martikainen and Matti Niinistö at VTT.

Author CV:

Mrs. Aakko-Saksa graduated as M.Sc. in 1990 from University of Oulu, from the department of organic chemistry. She worked from 1990 to 1993 as a research scientist in the oil refinery in Finland. Since 1993 Mrs. Aakko-Saksa has worked at VTT Technical Research Centre of Finland. Her present position at VTT is a principal research scientist in the research area of fuels and exhaust emissions. Mrs. Aakko-Saksa has contributed in a number of national and international research programs.

Abramesco Viktoria

Affiliation	Technion - Israel Institute of Technology
Email	tartak@technion.ac.il
Coauthors	J. Czerwinski; A. Mayer; L. Tartakovsky

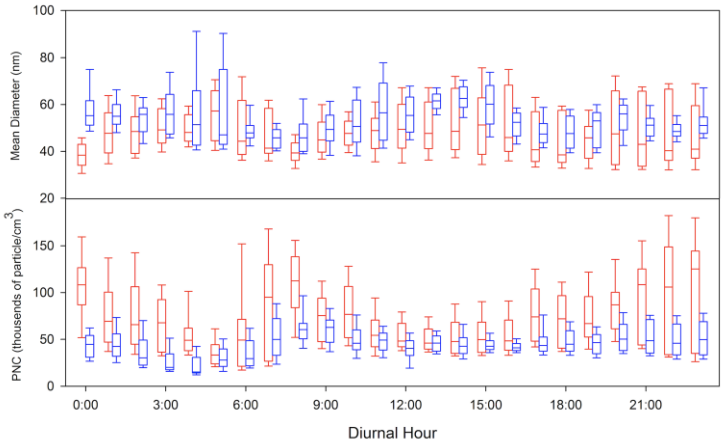
Publication title	*A comparative analysis of ultrafine particles air pollution inside diesel-propelled passenger trains and intercity buses*
Publication type	Poster
Introduction & Background	Locomotives with diesel engines are widely spread worldwide and are an important source of air pollution. Pollutant emissions by locomotive engines affect air quality inside passenger trains. This study is aimed at investigation of air pollution by ultrafine particles (UFP) inside passenger trains and a comparison with some other transportation modes like buses and cars. The gained data provide a basis for assessment of passengers' exposure to this dangerous pollutant.
Methodology	The ultrafine particle number concentrations inside passenger train carriages were measured by a diffusion size classifier (DiSC, Matter Engineering AG, Switzerland). This device is a small, easily portable, battery operated instrument and is therefore well suited for field measurements. Previously reported results of experiments with this instrument revealed that the measured particle number concentrations agree well with those gained with condensation particle counter. The time resolution of this instrument enables measurement of transient engine operation modes.
Results & Conclusions	Concentrations of UFP inside the carriages of push-pull trains are found to be dramatically higher when the train operates in pull mode. Minimal average UFP number concentrations (NC) measured in a train operating in pull mode are higher by a factor of 2.2 and by a factor of 2.4 than the average UFP NC value reported for car cabins (4.5·104 cm-3) and for buses (4.2·104 cm-3), respectively. The highest levels of air pollution by UFP are observed inside the carriages of pull trains close to the locomotive, whereas average UFP NC in these wagons are found to be higher by up to an order of magnitude than in car cabins. UFP concentrations are substantially lower in diesel multiple-unit trains as compared to those measured in trains operating in the pull mode. Significant influence of the train movement regime on UFP NC inside a carriage is found. Average UFP concentrations measured in the intercity buses using the same methods and instruments as in trains, were found to be relatively low – in average approximately 1.5·104 cm-3. This value is lower by a factor of 6.6 than minimal average UFP concentrations measured in a train operating in pull mode. The obtained results show that UFP's air pollution inside a bus is considerably higher at the back seats. Effective measures could be undertaken at affordable costs and in a short-term to substantially reduce passengers' exposure to air pollution inside trains (e.g. retrofitting locomotive engines with particle filters or even with more effective combined NOx-PN reduction systems; using HEPA filters in the carriage HVAC system, etc.). Further investigations in this field can contribute significantly to reduction of train passengers' exposure to harmful ultrafine particles.
Author CV:	Viktoria Abramesco holds ME in Mechanical Engineering degree from the Technion - Israel Institute of Technology.

Afroughi Mohammad Javad

Affiliation	University of Alberta
Email	afroughi@ualberta.ca
Coauthors	Vahid Hosseini; Jason S. Olfert

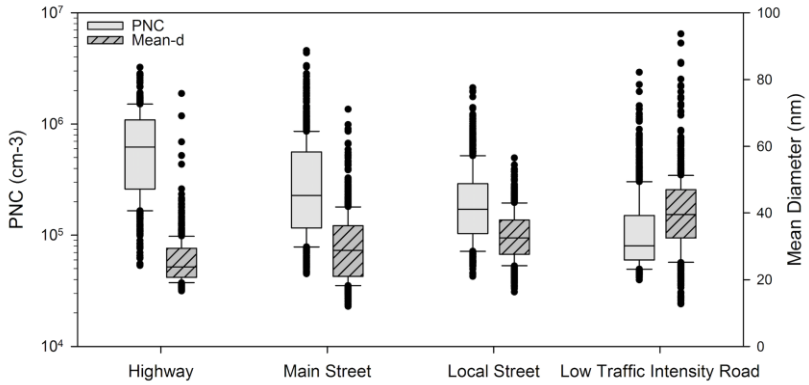
Publication title	*Tehran UFP Study: Spatial and Temporal Distribution*
Publication type	Poster
Introduction & Background	Exposure to ultrafine particles (UFP, < 100 nm) has become a serious threat for the urban population since their levels are associated with a variety of adverse health effects, particularly cardiovascular and pulmonary disease. Many combustion processes are a direct source of UFPs, with road traffic being a major contributor in urban areas. However, freshly emitted UFPs have a short atmospheric lifetime and their chemical and physical properties rapidly change in time and space. Knowing the underlying mechanism of these dynamic behaviors and exposure effects requires long-term studies, which still remains unclear in the most populous areas with highly polluting vehicles.
Methodology	This work presents fall-time spatiotemporal variation of UFPs across the city of Tehran, one of the largest cities in the Middle East and Asia, using a combination of stationary and mobile monitoring. Seven fixed-site air quality monitoring stations (3 roadside and 4 residential background) were selected to capture diurnal patterns of UFP, while mobile monitoring was conducted in a typical downtown area during evening rush hour (5-7 pm). To cover the whole spectrum of urban-specific, traffic-related UFP characteristics, stationary sites were distributed in different urban environments, and mobile monitoring routes consisted of four different road types including highways, main streets, local streets and low traffic intensity roads. The study focused on measuring the spatial and temporal variation of total particle number concentration (PNC) and count mean diameter of UFPs, with their potential relationship to traffic, meteorological and other pollutants records.
Results & Conclusions	The diurnal pattern of UFPs revealed higher concentrations of particles in both roadside and background stations, compared to clean large cities (e.g. Zurich). Daily average of PNC reached to 75,000 cm-3 with a mean diameter of 48 nm for roadside and 45,000 cm-3 with a mean diameter of 54 nm for background stations. For both types of stations, PNC had reasonable correlation with traffic intensity variations, and increased monotonically in morning and evening rush hour peaks. On the other hand, GIS techniques used to map UFP metrics showed that highway environments are influenced by extremely high particle concentrations with small diameters (622,000 cm-3 and 24 nm), whereas streets with low traffic intensities are characterized by larger particles (80,000 cm-3 and 40 nm). Furthermore, a correlation analysis was conducted between PNC and concentration of other urban-derived pollutants measured simultaneously in air quality monitoring stations. The non-parametric Spearman's rho indicated strong positive correlation with PM2.5 (rho = 0.72) and PM10 (rho = 0.62), and moderate positive correlation with CO (rho = 0.55), which suggests same source of emission and similar mechanisms of atmospheric dispersion. Correlation analysis also revealed weak positive relationship of PNC with NO2 (rho = 0.20) and negative moderate relationship with O3 (rho = -0.42) and SO2 (rho = -0.51), which is consistent with previous studies.

Caption Figure 1:



Diurnal variation of PNC and mean diameter for roadside (red box plot) and residential background (blue box plot) stations.

Caption Figure 2:



Box plot of PNC and mean diameter as a function of road type for mobile monitoring study area.

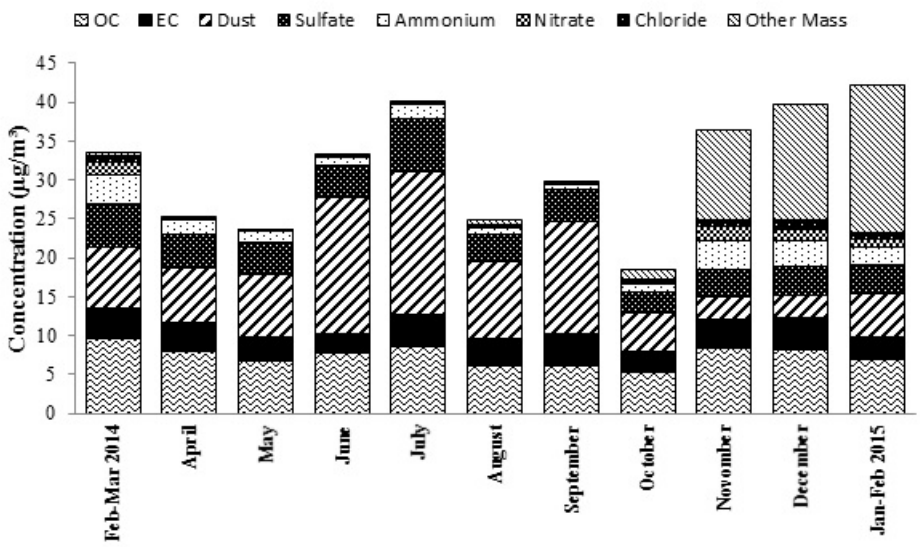
Author CV:

Mohammad Afroughi was born in Shiraz, Iran, 1992. He received B.Sc. in mechanical engineering from Sharif University of Technology, Iran, in 2015. In 2016, Mohammad started his M.Sc. program at University of Alberta under the supervision of Dr. Olfert and Dr. Kostiuk. His works mainly includes understanding soot particle formation during hydrocarbon pyrolysis.

	Arhami Mohammad
Affiliation	Sharif University of Technology
Email	arhami@sharif.edu
Coauthors	Vahid Hosseini; Maryam Zare Shahne; Alexandra Lai; James J. Schauer

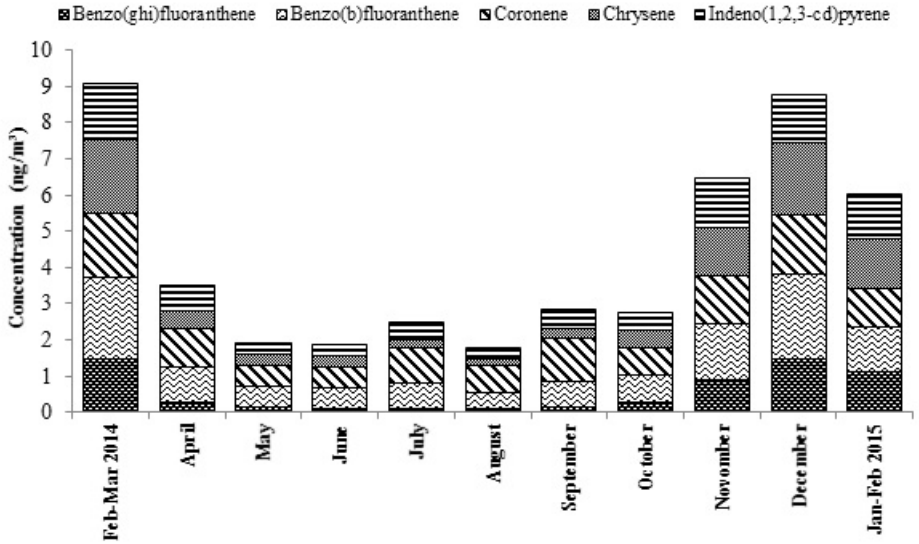
Publication title	*Carbonaceous, Organic and Toxic Metals Components of Particles and Their Seasonal Trends in Tehran, Iran*
Publication type	Poster
Introduction & Background	Tehran megacity, capital of Iran and the nation largest metropolitan area, is one of the world's most polluted cities. During recent years about one-third to half of the days each year were reported polluted, mainly due to PM2.5 exceeding national standard levels. These particles contain chemical contents such as organic trace elements, toxic metals and carbonaceous components particularly in the nanoparticles size fractions with major effects on population health. Hence, it is essential to determine the components of these particles. The present study aims to identify the major components including organic and elemental carbon and heavy metals of PM2.5 and their temporal variations in Tehran.
Methodology	PM2.5 samples were collected in a typical residential station at Sharif University of Technology, in Tehran. The quartz and Teflon filters were loaded by 24-hr samples every 6 days for a full year from February 2014 to February 2015, using two low-volume ambient air samplers. In order to determining the total mass concentration of PM2.5 and its components gravimetrical and chemical analyses were performed. These analyses includes thermal evolution/optical transmittance (TOT), ion chromatography (IC), sector field inductively coupled plasma-mass spectrometry (SF-ICP-MS), and gas chromatography mass spectrophotometry (GC-MS), which were performed at the Water Science and Engineering Laboratory and the Wisconsin State Laboratory of Hygiene at the University of Wisconsin-Madison. Hence, most components of particles including carbonaceous content, ions, toxic metals, and organic tracers were determined.
Results & Conclusions	The main constituent of airborne particles were determined to be carbonaceous components (organic matter and elemental carbon) with mean contribution and concentration of 47% and 11.32±2.52 μgm−3, respectively (Fig 1). This high contribution indicates the significance of anthropogenic urban sources in Tehran (mainly combustion by mobile sources), which are also known as important sources of nanoparticles. These components were dominant during the study period except hot and windy periods, which dust contribution was very high. The levels of more than 100 organic compounds such PAHs, n-alkanoic acids, as n-alkanes, n-alkenoic acids, aliphatic, aromatic dicarboxylic acids, and key tracer organic compounds and heavy metals, such as Cd, Cr, Ni, V, Pb, and Zn, which are mainly in nanoparticles fraction and have undesirable effects on health, were determined. The most abundant heavy metals were Zn and Pb, with maximum monthly averages of 0.23 and 0.19 μg/m3, respectively. As an example the monthly variation of several PAHs, which are mainly known as combustion product nanoparticles, are presented in Fig 2. These components generally had higher levels in cold seasons due to several reasons such stable atmospheric conditions, increased combustion rates, and cold starts. Most of these metals and organics are mainly originated from fuel oil combustion, break abrasion, and tire wear.

Caption Figure 1:



Chemical composition of ambient particulate matter in Tehran

Caption Figure 2:



Monthly concentrations of main PAHs in particulate phase in Tehran

Author CV:

EXPERIENCE

2016 – Present Associate Professor Civil Eng Dept, Sharif Univ of Tech
2012 – Present Head of Air Pol Div UNESCO Chair in Water & Env Manag for Sust Cities
2011 – Present Director of Environmental Eng Lab Civil Eng Dept, Sharif Univ of Tech
2009 –2016 Assistant Professor Civil Eng Dept, Sharif Univ of Tech
2011 – 2016 Head of Env Eng & Water Res Division Civil Eng Dept, Sharif Univ of Tech
2011 – 2014 Head of Air Pollution Group Sharif Environmental Eng Research Institute
2012 – 2013 Vice Excec Director UNESCO Chair in Water & Env Manag for Sust Cities
2010 – 2013 Director of Energy and Environment Group Sharif Energy Research Institute
2005 – 2009 Head Civil & Environmental Engineer Trencode, Los Angeles, CA
2005 – 2009 Ph.D. Candidate & Research Assistant University of Southern

California
2003 – 2004 Research Assistant Georgia Institute of Technology
2002 – 2003 Civil & Environmental Engineer PMBOK Co.
2000 – 2002 Graduate Research Assistant Environment & Water Resarch Center

EDUCATION

University of Southern California, PhD, Environmental Engineering, February 2009
Georgia Institute of Technology, MS, Civil and Environmental Engineering, August 2004
Sharif University of Technology, BS, Civil Engineering, September 2000

RESEARCH AREA

- Air Pollutant Measurement
- Aerosol Physicochemical Properties and Dynamics
- Air Pollution Modeling
- Applied Numerical Methods in Air Pollution
- Health Effects of Air Pollutants
- Emission Estimation

JOURNAL PUBLICATIONS
Citations: over 1500 and H-index: 19 based on GoogleScholar.
Atmospheric Environment, 153, 70–82.

Babu Praveen

Affiliation	Indian Institute of Technology Delhi
Email	civilengg.praveen@gmail.com
Coauthors	Mukesh Khare; Radha Goyal

Publication title	*Assessment of Respirable Suspended Particulate Matters in an Underground Metro Station Platform in Delhi City, India.*
Publication type	Poster
Introduction & Background	Indoor air quality (IAQ) has become a global health issue due to rapid urbanization resulting into construction of air tight high rise buildings affecting the indoor environments. People spend 80-90% of their time inside the indoor environments compared to ambient environment making IAQ assessment a sin qua non. This study evaluates the level of respirable suspended particulate matter (RSPM) (i.e. PM10, PM2.5 and PM1.0) along with thermal comfort parameter's (i.e. temperature and relative humidity) and it's characterization in one of the selected mechanically ventilated underground metro station (UMS) platform in Delhi city, India. This is the first comprehensive IAQ assessment which carried out in Delhi metro rail system so for.
Methodology	Hourly average PM10, PM2.5, PM1.0 and thermal comfort parameters (i.e. temperature and relative humidity) has been monitored in the middle of the platform using pre-calibrated environmental dust monitor (GRIMM Model 1.107) and IAQ monitors (GRIMM Aerosol Technik, 2003; YESAIR, 2012), respectively. The fixed ambient monitoring has been carried out simultaneously at roof top of the metro station Total RSPM mass was collected on 47 mm PTFE filters using GRIMM 1.107. A total of 7 Polymeric samples were collected, both indoor and outdoor environment and a blank filter for reference. After carbon coating, particles has been characterized using a ZEISS EVO50 SEM (ZEISS EVO 50 model) with a spatial resolution of 2.0 nm at 30 kV with 0.2 to 30 kV acceleration voltage and magnification of 5X to 1000000X. The ZEISS SEM was equipped with EDX, thus being able to obtain information on morphology and elemental composition of the particles. The analyses has been carried out at the Central Facility Unit of the Indian Institute of Technology (IIT) Delhi (India).
Results & Conclusions	Critical winter period diurnal monitoring has been done for a week in the month of January. Figure 1 whisker shows the ranges (i.e. 5 and 95% data distribution) of indoor and outdoor hourly average of PM10, PM2.5 and PM1.0 concentrations. PM10 concentration has found significantly highest in the UMS platform i.e. 2.6 times higher than the indoor acceptable limit. Past studies also report much higher RSPM concentrations in UMS platform compared with the other transport modes or surface platforms (Adams et al., 2001; Carteni et al., 2015; Martins et al., 2016; Seaton et al., 2005). Indoor/outdoor (I/O) ratio for PM10, PM2.5 and PM1.0 is 1.3, 0.9 and 0.7, respectively indicating that the PM10 concentration are generating internally within the UMS, but, PM2.5 and PM1.0 are infiltrating from outdoor environment. The morphology was characterized using SEM technique. The particles shows a wide range of morphologies under the SEM, from agglomerates (related to train movements within UMS and vehicle exhaust emissions at outdoor environments) and crustal forms (related to mineral components) (Figure 2). This physicochemical characterization suggested Fe as the main component in underground RSPM. This is in line with previous studies suggesting its origin from mechanical abrasion between rails, wheels and

brakes (Jung et al., 2012; Kam et al., 2013; Martins et al., 2016; Querol et al., 2012).

Caption Figure 1:

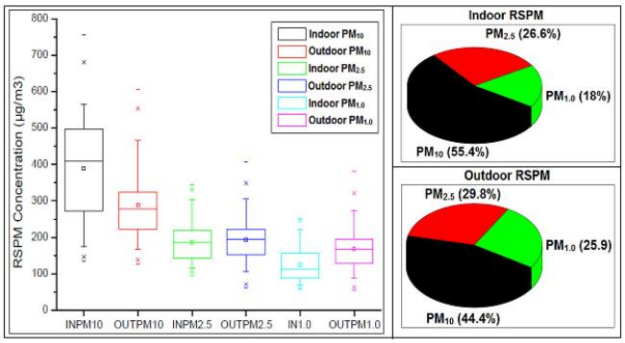


Figure 1 Boxplot and pie charts shows the percentage distribution of indoor and outdoor RSPM concentrations.

Boxplot and pie charts shows the percentage distribution of indoor and outdoor RSPM concentrations.

Caption Figure 2:

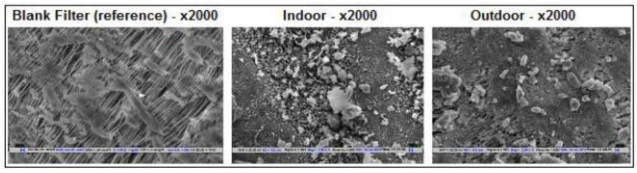


Figure 2 SEM images of the RSPM collected on the PTFE filters during winter season at selected UMS platform.

SEM images of the RSPM collected on the PTFE filters during winter season at selected UMS platform.

Author CV:

PRAVEEN BABU: Praveen Babu is a Senior Research Fellow from Indian Institute of Technology (IIT) Delhi, Ph.D. Full Time. My area of interest is indoor air quality (IAQ): monitoring, modelling and management in indoor environments. As a teaching assistant at IIT Delhi, I have expertise in various Bachelor level and Masters level courses in environmental engineering (including, Air pollution and control; Air Quality Modelling; Industrial waste management, pollution prevention and control; Environmental Science) and also I have delivered lectures in technical workshops. Apart from my research, I also served in Sustainable IIT Delhi as a Green Office Advisory Board member to maintain green campus. I have professional affiliations from both national and international level, such

as, life member from Indian Aerosol Science and Technology Association (IASTA), India; Student member from The Aerosol Society, United Kingdom; International Society for Indoor Air Quality and Climate (ISIAQ), USA; American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), USA. I have published 16 national/international peer reviewed journal papers, conferences and research articles. I also received student travel award (~€1000) from International Society for Indoor Air Quality and Climate (ISIAQ), USA, for attending 14th International Conference on Indoor Air Quality and Climate, Ghent, Belgium (2016) and best paper award from Indian Building Congress, New Delhi and best poster award from 3rd National Conference on Refrigeration and Air Conditioning (NCRAC-13), IIT Madras, Chennai

MUKESH KHARE: Mukesh Khare is a Professor, Environmental Engineering & Management, Department of Civil Engineering IIT Delhi, India and Former Atlantic LNG Chair (Professor) in Environmental Engineering, University of West Indies, Advisor (Air Pollution), Delhi Pollution Control Committee. Chairman, State Expert Appraisal Committee (SEAC), Non official independent director of Engineering India Limited, Delhi. Professor Khare received his PhD in Faculty of Engineering (Specialized in Air Quality) from the University of Newcastle, UK in 1989. He has published to date more than 80 refereed articles in professional journals, 70 articles in refereed conferences/seminars, 04 books: Modelling Vehicular Exhaust Emissions, WIT Press, UK; Artificial Neural Networks in Vehicular Pollution Modelling, Springer, USA; Aluminium Smelting: Environmental, Health and Engineering Perspectives, Ian Randle, Jamaica; 05 contributed chapters in books/handbooks, published by WIT Press, UK and Elsevier, USA. Additionally, he has published about 30 technical reports on research/consultancies conducted for government agencies and private industries. Prof. Khare continues to serve as peer reviewer for several government ministries grants programs and state programs and consultant/advisor to the Government of NCR Delhi.

Khare's research has focused on local scale urban air quality modelling targeting the predictions of episodes at urban roads/intersections, mainly arising out from undefined low-level/line sources sources. Current research areas include formulation of air quality models and their validation; indoor air quality modelling in air-conditioned and naturally ventilated buildings and exposure assessment of related pollutants on indoor occupants. He has been working on evaluation of photochemical models for predicting chemically reactive air pollutants such as tropospheric ozone.

RADHA GOYAL: Dr. Goyal is Deputy Director, Indian Pollution Control Association, New Delhi, India.

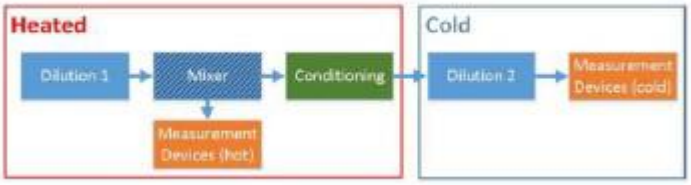
	Bagheri Mehdi
Affiliation	Technical University of Berlin - department of internal combustion engines (VKM)
Email	mehdi.bagheri@campus.tu-berlin.de
Coauthors	Prof. Dr. Roland Baar
Publication title	*Simultaneous Application of Exhaust Gas Recirculation and non-constant Injection Rates to reduce NOx and Soot Emissions in Diesel Engines*
Publication type	Poster
Introduction & Background	Fossil fuels are nowadays the main source of energy for combustion engines. This is mainly because of their high energy density, ease of storage and quick refueling process. As the emission regulations become more and more stringent, it gets harder for combustion engine manufacturers to adapt themselves to the new regulations. Especially with the advent of electric engines, it is now more vital to develop new emission control and reduction strategies for combustion engines. Although Diesel engine, as the main prime mover in today's industry, offers better fuel economy in comparison with other combustion engines, it generates normally higher levels of emissions. However, a handful of techniques could be used to overcome this issue. Today, EGR (exhaust gas recirculation) has become a must in Diesel engine design, by which the NOx emissions are reduced noticeably, as it decreases the peak combustion temperature in the engine. However, it normally leads to higher soot formation rates. One promising solution to tackle this problem is the application of non-constant fuel injection rates.
Methodology	In the present work, a combination of EGR and variation of injection rate has been used to keep both NOx and soot emissions at an acceptable level. To do so, a two-dimensional multi-zone phenomenological Diesel engine combustion model has been developed. The model consists of several sub-models for spray development, fuel atomization, evaporation, combustion, and emission formation. The fuel spray is divided into several small packets called zones, and consequently, the equations for conservation of mass and energy are solved for each individual zone at each time step, from which the cylinder temperature and pressure are calculated. Additionally, the formation of emissions is tracked as soon as the combustion starts. Moreover, Parallel processing programming techniques have been utilized, which reduce the computational time of the model considerably, making it a fast and reliable tool for combustion simulation.
Results & Conclusions	Using the model, different rates of EGR are applied, which as expected, shows a noticeable decrease in NOx emissions. Thanks to the modular design of the model, injection profile can be changed easily. Instead of using a constant rate injection, three different injection patterns are used. First, an upward step profile is used, in which fuel is initially injected with a lower and then with a higher rate. After that, a downward step profile was applied, which injects the fuel first with a lower and then a higher rate. Finally, a combination of the above profiles is used, i.e. the fuel is injected initially at a low rate, then the injection rate is increased, and finally decreased again. It is shown that use of EGR with a combined injection pattern at the same time can keep the NOx and soot emissions of the Diesel engine at an acceptable level.
Author CV:	Name: Mehdi Bagheri Address: Hohenzollerndamm 186,10713 Berlin Phone 017680525973 E-Mail mehdi.bagheri@campus.tu-berlin.de Birthdate and Place 02.08.1983 in Malayer - Iran

Marital Status Married

Education:
03/2014 – Today PhD – Mechanical Engineering
TU-Berlin, 10623 Berlin
Research Focus: Internal Combustion Engines – Diesel Engines
09/2006 – 09/2010 M.Sc. – Mechanical Engineering
K.N.Toosi University of Technology - Tehran
Focus: Internal Combustion Engines, Fluid Mechanics
09/2001 – 09/2006 B.Sc. – Mechanical Engineering
Amirkabir University of Technology - Tehran
Focus: Fluid Mechanics, Heat Transfer

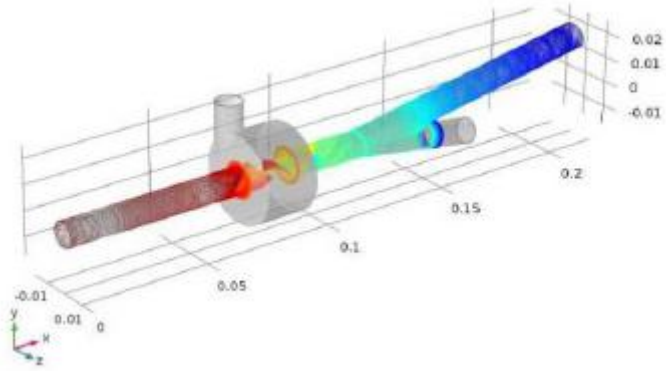
bh	Bainschab Markus
Affiliation	Graz University of Technology
Email	m.bainschab@tugraz.at
Coauthors	Bergmann, A.; Karjalainen, P.; Keskinen, J.; Andersson, J.; Giechaskiel, B.; Haisch, C.; Gerini, A.; Mamakos, A.; Klug, A.; Ntziachristos, L.; Samaras, Z.
Publication title	*Extending Particle Number Limits to below 23 nm: First Results of the H2020 DownToTen Project*
Publication type	Poster
Introduction & Background	We present the objectives, the impacts and first results of the Horizon 2020 Green Vehicle project “DownToTen”. This project is developing a robust methodology that will enhance the regulatory approach towards particle number (PN) emissions in the sub-23 nm region. The focus is on the newest generations of direct injection gasoline and diesel engines under real world conditions.
Methodology	Based on detailed investigations of the nature and characteristics of these particles, DownToTen is evaluating a variety of sub-23 nm PN measurement instruments and sampling approaches, using rigorous criteria under conditions of challenging aerosol from a variety of sources. The objective is a PN-Portable Emission Measurement System (PEMS) demonstrator with high efficiency in determining PN emissions of current and future engine technologies in the real world. DownToTen also aims to assess the fraction of particles left out of control and assist the better understanding of exhaust particle impacts on air pollution. Furthermore, the particle and sampling dynamics that lead to a bias between PEMS and CVS measurements are modelled.
Results & Conclusions	We present the first results on the iterative way to the PN-PEMS demonstrator. Important factors like robustness against artefacts (re-nucleation, growth of subcut particles), losses of (solid) particles, storage/release effects of gas phase compounds are assessed in detail by multiphysical simulations and experiments. Special attention is drawn to losses of secondary aerosol precursors within the primary dilution stage. A scheme of the preliminary sampling setup for testing in the synthetic aerosol laboratory is shown in Figure 1. This setup was designed to maximize the penetration of non-volatile particles below 23 nm while limiting the effects of gaseous artefacts. The selection of the setup’s components (primary and secondary dilution stage, conditioning system, mixing elements, measurement devices) in order to meet the aforementioned criteria are based on experimental and theoretical data. The success in meeting these criteria is evaluated by comparing the sampling setup to a PMP reference system. Critical components are discussed in detail. CFD simulations and particle penetration optimizations based on the simulation results are presented. The suppression of artefacts is emphasized. This is achieved by a systematic multi-step modification process which results in the presented setup.

Caption Figure 1:



Schematic illustration of the preliminary sampling setup

Caption Figure 2:



CFD simulation of porous tube dilutor including a static mixer and a flow splitter

Author CV:

Markus Bainschab finished his master's degree in technical physics at Graz University of Technology (TUG) in September 2016. The thesis' topic is femtosecond time-resolved molecular spectroscopy. Now he is a PhD student at the Institute of Electronic Sensor Systems (IES) at TUG working on nanoparticle sampling and measurement techniques.

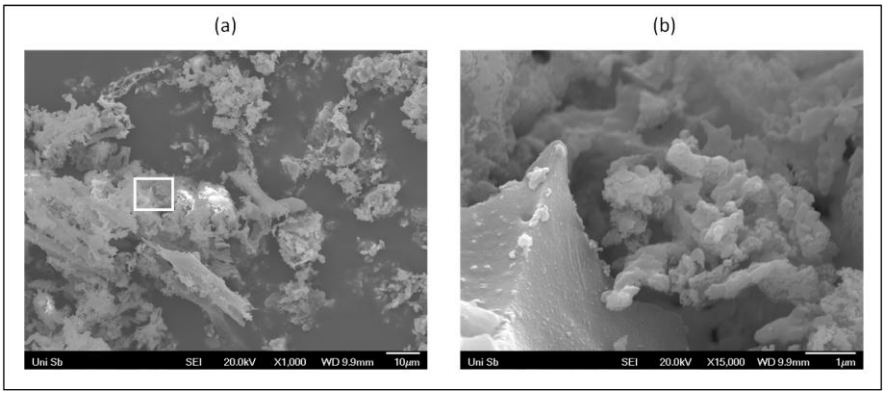
Berhardt Alexander

Affiliation	IZES gGmbH
Email	berhardt@izes.de
Coauthors	Dr. Bodo Groß, Dr. Ferenc Lezsovits

Publication title	*Field Tests of an Electrostatic Precipitator in Different Small Scaled Biomass Boilers: Chemical and Physical Properties of Different Ash Fractions*
Publication type	Poster
Introduction & Background	With the intention of developing an electrostatic precipitator (ESP) for small-scaled biomass combustion systems, several laboratory and field tests were carried out. During these field tests, samples of the three ash fractions of different biomass boiler systems were taken and then analyzed. The main aim of the ESP development is to be able to separate the fine dust out of the exhaust gas of biomass boilers with a maximum nominal heat output of 160 kW. By applying this secondary emission reduction measure, it should be possible to meet the new German legal limits for the fine dust emissions from biomass combustions. But by minimizing the flue gas ash content – as aimed by the politics – the amount of the collected ash, which has to be extracted by the operator increases. Especially the inside the precipitator collected ash is known from literature to be very harmful and toxic. Since several utilization and disposal methodologies for biomass ashes from large scale combustions exist, the ashes from small scaled and in private households used biomass heating systems are not analyzed or recognized in detail. By knowing the exact chemical and physical characteristics of the different ash fractions of the small scaled biomass combustion systems, suited disposal or if possible new utilization paths should be developed. Especially the properties of the precipitator ash should be investigated in detail, therefore several ash samples of different ESPs were taken, analyzed and compared.
Methodology	The ash samples were taken by using several different field test biomass boilers, which are originally operated for the development of the electrostatic precipitator (ESP). But in addition to the self-developed ESP, also other ESP types from different manufactures were used to obtain ash samples of the precipitator ash. The used field test systems differ concerning the used fuel, the nominal heat output and the applied emission reduction system. The sampling of the ashes was carried out by using an especially for the small scaled application developed sampling procedure. This sampling procedure was developed by following the already for the large scaled application existing procedures and regulations. Hereby the LAGA PN98 was the main source for the development of the downscaled ash sampling procedure. For each field test set-up, samples of the three different ash fractions were taken: Coarse or grate ash, heat exchanger or cyclone ash and precipitator ash. All three fractions were chemically and physically analyzed. By using SEM and particle sizer technology, the physical characteristics were determined. By the use of aqua regia digestion with inductively coupled plasma mass spectrometry ICP-MS (DIN EN ISO 17294-2) the heavy metal analysis was carried out. To analyze the nutrient content of the ashes, procedures such as inductively coupled plasma optical emission spectrometry ICP-OES (DIN EN ISO 11885) were used. Concerning the dioxine and general organic content, e.g. gas chromatography–mass spectrometry GC-MS (DIN EN ISO 14154) was used.
Results & Conclusions	Starting with a description of the tasks and issues which are addressed by the presented work, the especially for the small scale application developed sampling procedure is presented and discussed. Future optimizations of the

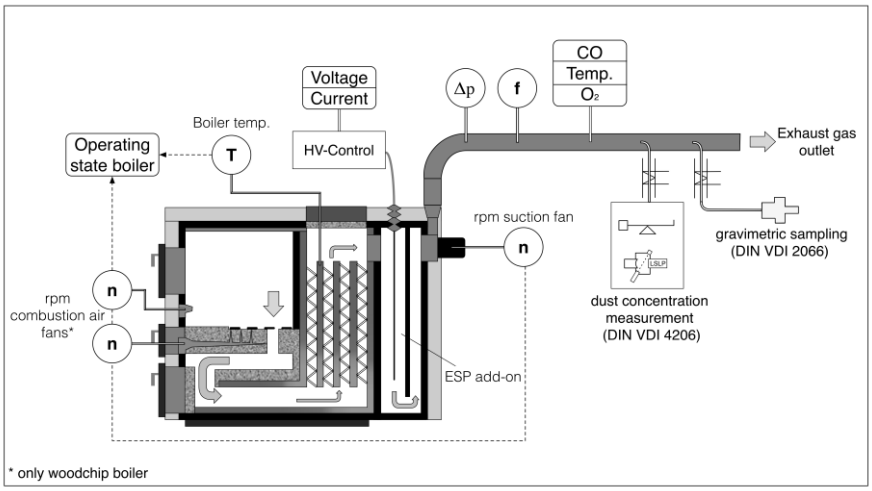
developed procedure and suggestions for an adjustment or an addition of the already existing sampling procedures are described. Examples of the results of the chemically and physically analysis from different field test set-ups are shown and discussed. The results from the field test set-ups differ concerning the used fuel (pellets or logwood), the nominal heat output (35 - 160 kWth) and the ESP type. As an outlook, a first overview of possible disposal or utilization paths by facing the results of the ash analysis, is shown.

Caption Figure 1:



Electron microscopy images of a sample of precipitated ash which was extracted out of the electrostatic precipitator. Picture (a) was taken with a magnification of 1.000 and (b) with a magnification of 15.000. The square in picture (a) marks the area which was enlarged and which is pictured in (b).

Caption Figure 2:



Schematic view of a field test set-up, which was used to obtain the ash samples.

Author CV:

-Born in 1987 in Trier
-Dual Bachelor-Studies in electrical engineering with the focus of automation and power at the University of Applied Sciences Trier in cooperation with a training as industrial automation electrician, graduated in February 2010
-Followed by the master studies in “Environmentally oriented Energy Technology” in Birkenfeld. Completion of the master thesis in November 2011 with the “Development of a methodology to implement a controllable load in a virtual power plant by using historical data”.
-Since August 2011: Co-founder and deputy leader of the department “Technical Innovations” at the IZES gGmbH in Saarbrücken. The applied research and development group works in the fields of electrostatic precipitation, development of embedded systems and electronics, energetically optimization of buildings due to intelligent measurement techniques and storage supplied electric mobility.

Bhardawaj Avdesh

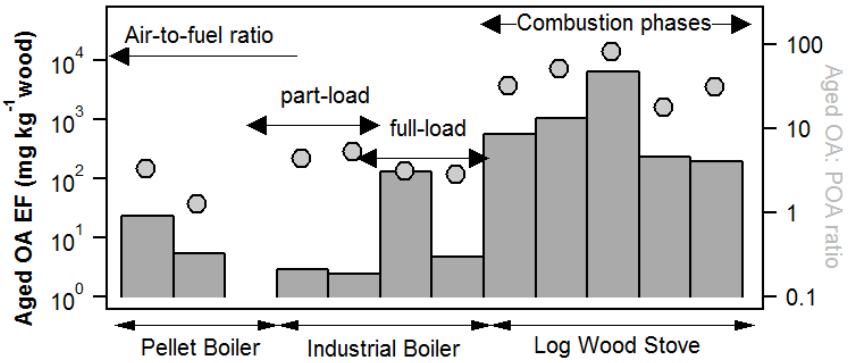
Affiliation	Indian Institute of Technology Delhi
Email	avdeshiitd@gmail.com
Coauthors	NISAR ALI BAIG; GAZALA HABIB; SANDEEP SINGH
Publication title	*A Study of Fine and Ultrafine Particle Exposure, Dietary Habits and Link to Cardiovascular Diseases among Volunteer Subjects in Delhi*
Publication type	Poster
Introduction & Background	The health effects of aerosols have been a topic of much interest and research in recent times [Foster and Kumar, 2011; Patankar and Trivedi, 2011; Langrish and Mills, 2014; Greenstone, 2015; Newby et al., 2015; Brunekreef & Hoffmann, 2016]. 5.5 million people die prematurely worldwide each year due to fine (PM2.5 i.e. particles with aerodynamic diameter less than 2.5 micrometers) and ultrafine particles (UFP i.e. particles with aerodynamic diameter less than 1 micrometers) [AAAS, 2016]. Outdoor air pollution is a major causes of morbidity and mortality in India [Lozano et al., 2013; Vos et al., 2015]. The deposition of inhaled particles inside the human respiratory tract is dependent upon the particle diameter [Buzea et al., 2007] and fine and ultrafine particles easily penetrate deep into the human system and translocate to other parts of the body enabling them to enter deeper into lungs, causing both acute and chronic adverse health effects such as asthma, cardiovascular and ischemic heart diseases due to systemic inflammation [Smith et al., 1993; Smith et al., 2003; Oberdorster et al., 2005; Pope 2015]. The present paper investigates the effect of such fine and ultrafine particles in causing cardiovascular diseases (CVD) and also correlates the lifestyle and dietary habits with such CVD to better understand and relate closely the contribution of aerosol on CVD.
Methodology	A case cross over study was designed and carried out at a semi urban location, the Indian Institute of Technology (IIT) Delhi campus from July 2016 to December 2016. Firstly recruitment of volunteer subjects (security guards) was done through a detailed health, dietary and pollution exposure questionnaire with strict inclusion and exclusion criteria like being non-smokers, non-alcohol drinkers and not on any kind of medication etc. The sampling was carried out at the five gates of the IIT Delhi campus at which the subjects did their duties for 8 hours each. The subjects were exposed continuously to traffic generated smoke and other aerosol at the location. The mass and number concentration of PM2.5 and UFP were measured using Portable Wide Range Aerosol Spectrometer (Mini WRAS-1371). On each day of sampling, the blood pressure (BP), saturation of peripheral oxygen (sPO2) and pulse rate of participants were measured using BP meter, and pulse oximeter. In case of any abnormal reading, the sampling for that participant was not carried out. The participants were tagged with ECG holters for 8 hours duration and an activity chart was provided to the participants to record for any abnormal activity that can affect the ECG like running or emotional distress during the sampling period. The Mini WRAS was run at exact same time as ECG holter and for the exact same duration as the ECG recording period at 1 minute interval frequency. Thereafter the number and mass concentrations of aerosol were compared with ECG patterns to identify for cardiovascular diseases in consultation with a cardiologist. The lifestyle and dietary details of subjects obtained from the detailed health questionnaire were also analysed and correlated with CVD.
Results & Conclusions	The incidences of CVD increases with the increase in the concentration of fine and ultrafine particles. Even in relatively cleaner Monsoon season period, the ambient aerosol concentration was mostly above the permissible standards in

	Delhi and cases of CVD were reported. Due to an increases in compressed natural gas (CNG) usage in vehicles and public buses, the nano size particles have increased in Delhi's air and the recent increase in CVD cases may be attributed to it especially to people exposed to traffic smoke like the subjects in our study. People with a history of smoking or drinking, excess non-vegetarian or oily food intake habits, having little or no physical exercise, more sugar and less water intake have more chances of developing CVD and the exposure to aerosol may increase the chances of CVD in such cases. More long duration case crossover studies are required to better understand these results.
Author CV:	Mr. Avdesh Bhardawaj is an academician, author and environmental consultant. He has done his B.Sc, M.Sc. and M.Phil with distinction from premiere universities in India. At present he is pursuing his PhD from Indian Institute of Technology Delhi, India in which he is developing a risk assessment model for cardiovascular illness due to urban aerosol burden over Delhi region in India. He has extensive teaching experience in reputed colleges and universities. He has published more than 30 research papers in international journals and presented more than 50 technical research papers in reputed international and national conferences apart from co-authoring a book on environmental sciences. He is life member of many leading professional organizations. He is also associated as a consultant in various projects with leading organizations. His research interests include health effects of aerosol, environmental risk assessment, innovations in teaching methodology, etc.

	Bhattu Deepika
Affiliation	1Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Villigen, Switzerland; 2Lucerne School of Engineering & Architecture, CC Thermal Energy Systems & Process Engineering, Bioenergy Research Group, Technikumsstrasse 21, CH-6048, Horw, Switzerland; 3Aix Marseille Univ, CNRS, LCE Marseille, France
Email	deepika.bhattu@psi.ch
Coauthors	G. Stefenelli1, P. Zotter2, J. Zhou1, T. Nussbaumer2, A. Bertrand3, N. Marchand3, B. Temime-Roussel3, U. Baltensperger1, J. G. Slowik1, A.S.H. Prevot1, I. El Haddad1 and J. Dommen1
Publication title	*Gas and Particle Phase Emissions from Residential Wood Combustion*
Publication type	Poster
Introduction & Background	Residential wood combustion has been assessed to be one of the major source of particulate emission, polycyclic aromatic hydrocarbons (PAHs), and other gaseous pollutants, such as CO, CH4 and volatile organic compounds (VOCs). The intense wood burning emissions in combination with boundary layer dynamics in winter time makes this source an important contributor to adverse health and environmental effects (Schauer et al., 2001). Recent literature studies have also shown that a large portion (~80%) of secondary organic aerosol (SOA) mass originates from the aging process of non-traditional precursors not accounted for in models (Bruns et al., 2016). Current legislation limits the emission of particulate matter, but does not regulate the precursors potentially forming SOA. Till date, the investigation of gas phase emissions from wood combustion and their SOA formation potential have largely focused on single combustion devices with limited variations of the operating conditions.
Methodology	As both, primary emissions and SOA formation are a strong function of device type, fuel load and type, and operating conditions, we have performed a detailed study in a secondary aerosol formation chamber investigating the factors responsible for the variability in gas-phase and particle phase emissions from beech wood logs, beech wood chips and pellets using seven types of combustion devices, namely: 1. Pellet boiler (15 kW) with advanced combustion technology at different combustion conditions: optimum, lack and high excess of oxygen, 2. Two-stage combustion logwood boiler (30 kW), 3. An industrial wood chip grate boiler (150 kW) at full and part load operation (100% and 30% load) with electrostatic precipitator, 4. Pellet stove with standard combustion technology (varying heat output: 2-6 kW), 5. Single-stage combustion log wood stove (6 kW), 6. Two-stage combustion log wood stove (4.6 kW), 7. Two-stage combustion log wood stove (8 kW).
Results & Conclusions	Using a potential aerosol mass reactor (PAM), the physical and chemical effects of different aging conditions were monitored with an SMPS, an Aethalometer, an HR-ToF-AMS, as well as a PTR-ToF-MS and additional gas monitors. The short residence time in the reactor allowed a time resolved picture of SOA production potential and reduced wall losses. In general, significant SOA mass enhancement is observed in high excess oxygen conditions compared to optimum and oxygen deprived combustion conditions (Figure 1). For single-stage combustion log wood stove, the highest concentrations of non-methane organic gases (NMOGs) are emitted during start of each burn cycle and the lowest at the end of each burn cycle. Despite of the comparable NMOGs emissions in the log wood stove during

flaming and burn out phase and during excess air conditions in the pellet boiler, the percentage contribution are largely occupied by SOA precursors (C>6) in the stove compared to the pellet boiler. Higher combustion temperatures and optimized combustion conditions (air-to-fuel ratio of 1.5-2) in the industrial boiler (942-1027 °C) and in the pellet boiler (589-852 °C) resulted in lower NMOGs and aged OA production. In addition, OA:POA ratios of aged aerosol in the log wood stove have also been observed to be 6-27 times higher than in the pellet boiler depending on operating conditions. Overall, an increase in the emissions has been observed with decrease in temperature and increase in excess air conditions above an optimum operation range.
We investigated the relationship between operational parameters (such as air-to-fuel ratio and combustion temperature) of the combustion devices, and emissions composition and relative emission factors. Further, we also present the relationships between gas phase emissions and composition with their SOA formation potential to ascertain the contribution of residential wood burning to the total carbonaceous OA budget.

Caption Figure 1:



Aged OA emission factors (left axis) and Aged OA: POA ratios (right axis) for pellet boiler (air-to-fuel ratio: reduced, optimum and elevated), industrial boiler (part and full load) and single stage combustion log wood stove (Combustion phases: cold start, flaming, burn out and reload) under different operational conditions.

Author CV:

Since 2016 Scientist at Laboratory of Atmospheric Chemistry at Paul Scherrer Institute, Villigen, Switzerland
2010 – 2016 Ph.D. in Environmental Engineering at Indian Institute of Technology, Kanpur, India
2008 – 2010 Master's Degree in Energy and Environmental Engineering at Vellore Institute of Technology, Tamil Nadu, India
2004 – 2008 Bachelor's Degree in Biotechnology at University Institute of Engineering and Technology, Haryana, India

	Bisht Thapa Gunjan
Affiliation	Kathmandu University, Dhulikhel, Nepal
Email	gunjan.thapa@ku.edu.np
Coauthors	Sanjila Neupane
Publication title	*Fast and Efficient Removal of Arsenic through Supercritical Carbon Dioxide Assisted Modified Magnetic Nanoparticles*
Publication type	Poster
Introduction & Background	Arsenic contamination in groundwater is an alarming issue in Terai region (the low-lying land at the foot of the Himalayas) of Nepal as ground water serves as major drinking water source; therefore it is required to decrease arsenic below maximum permissible limit (50ppb). Among the various nanoparticles used for heavy metal removal iron oxide nanoparticles (FeNPs) are magnetically responsive adsorbents that offer high adsorption capacity, rapid adsorption rate, regeneration, simple separation and ease in recovery. Therefore, this study focuses on surface modification of FeNPs and their application in removal of arsenic from water.
Methodology	In this study, we report coprecipitation method of synthesis of FeNPs and a supercritical carbon dioxide (ScCO2) assisted green chemical technology was used to synthesize 2-mercaptobenzothiozol modified iron oxide nanoparticles (MBT-FeNPs). MBT-FeNPs were used to remove arsenic from water. Various techniques were used to characterize magnetic nanoparticles (FeNPs) and starch modification on FeNPs surface viz., transmission electron microscopy, scanning electron microscopy, Fourier transform-Infra red spectroscopy and vibrating sample magnetometer. To optimize the arsenic removal experiment parameters adsorption of As (III) from aqueous solution was measured in batch experiments. The effect of pH (2-12), kinetics time (0–480 min), adsorption isotherms (initial concentration 5–30 mg/ L) of As (III) and effect of temperature (30–50°C) were studied.
Results & Conclusions	Results showed highest arsenite (AsIII) removal in a synthetic laboratory solution of 10 ppm was 99.7% at pH of 6 with MBT-FeNPs and while complete removal of arsenic from groundwater sample was attained within five minutes using MBT-FeNPs. Arsenite adsorption agreed well with pseudo-second order kinetic model and Langmuir isotherm model. Adsorption of arsenite on MBT-FeNPs reached 140.8 mg/g at pH of 6. MBT-FeNPs could be regenerated in NaOH solutions and could retain more than 50% arsenite removal capacity even in fifth regeneration/reuse cycle. On the basis of these findings it can be concluded that FeNPs and MBT-FeNPs can be utilized as an effective, convenient, and cost effective adsorbent for the treatment of arsenic contaminated water.
Author CV:	Personal Information: Name: Gunjan Bisht Thapa, (Ph.D.) Your affiliation: Kathmandu University, Dhulikhel, Nepal Your contact details:Tel. No. 977-9818874898 E-mail: gunjan.thapa@ku.edu.np Education: Doctor of Philosophy: Major in Agricultural Chemicals (research specialization in Nanotechnology) & Minor in Biochemistry. Dissertation topic: Supercritical Synthesis of Magnetic Nanocomposites for Biomedical Applications

G.B. Pant University of Agriculture & Technology, Pantnagar, India

Master of Science: Chemistry
Dissertation topic: Effect of Gold Nanoparticles on Physiological and Biochemical Parameters of Brassica juncea.
G.B. Pant University of Agriculture & Technology, Pantnagar, India

Bachelor of Science : (Zoology Botany and Chemistry)
Kumaun University, D.S.B. Campus Nainital, India

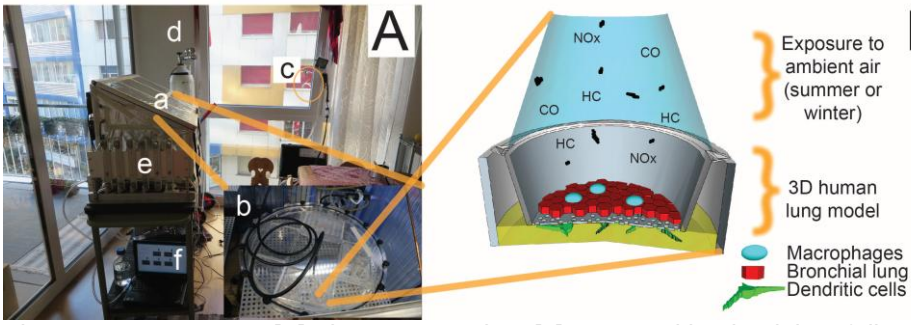
Summary of your research contribution/innovation:
My research work has been focused on the synthesis and characterization of nanoparticles and polymer based nanocomposites. I have worked on synthesis of different types of nanomaterials by various technique viz. chemical reduction, co-precipitation and by the use of supercritical CO2 and N2 as solvent. The prepared nanoparticles/ nanocomposites were characterized by various analytical techniques such as UV/VIS, GPC-HPLC, TG-DTA-DTG, DSC, FT-IR, NMR, XRD and TEM, SEM and AFM etc.
At Kathmandu University I have a laboratory named “Nanomaterials and supercritical fluid processing lab” (NSP Lab), where we exclusively work on nanomaterials-based drug delivery system and therapeutic agents, magnetic nanocomposites for environmental remediation and supercritical fluid assisted chemical processing of polymers.

	Bisig Christoph
Affiliation	Adolphe Merkle Insitute, University of Fribourg, Switzerland
Email	christoph.bisig@unifr.ch
Coauthors	Pierre Comte; Jan Czerwinski; Andreas Mayer; Alke Petri-Fink; Barbara Rothen-Rutishauser

Publication title	*An in vitro Exposure Method to Assess Adverse Effects of Ambient Air Using Human Lung Cells*
Publication type	Poster
Introduction & Background	Ambient air consists mainly of nitrogen and oxygen, additionally it is polluted by particulate matter (PM), nitrogen oxides (NOx), and ozone (O3). Epidemiological studies have associated these air pollutants with cardiovascular and pulmonary diseases (e.g. asthma), potentially leading to premature deaths [1-3]. Complementing these studies with in vitro or in vivo models is important, to gain a better understanding of the potential hazard at the cellular level and to eliminate confounders (e.g. smoking). Our aim was to evaluate the usability of a portable in vitro exposure system to detect adverse effects. Proof of concept was performed using ambient air (in summer and winter), where a multi-cellular human lung model was directly exposed at the air-liquid interface.
Methodology	A portable system containing two exposure chambers was placed on a balcony in Fribourg, Switzerland (Figure 1). Ambient air was pumped through one chamber with a constant flow of 2 L/min. In parallel, filtered medicinal air was applied to the other chamber. The multi-cellular lung model (epithelial 16HBE14o- cells combined with macrophages, and dendritic cells [4]) was placed in the chambers and exposed on up to three subsequent days each for 12 h (7am to 7pm) to ambient air. Biological endpoints included cell morphology assessment, gene expression analysis, and cytotoxicity. Particle number (PN) concentrations were measured with a DiSCmini. Additionally, the official air pollution observation station of the canton of Fribourg is within 300m of the exposure site providing PM10, NOx, and O3 levels.
Results & Conclusions	Averages of PN and PM10 concentrations were 10’000 and 15’000 particles/cm3 and 14 and 27 µg/m3 for summer and winter ambient air, respectively. Morphology, cytotoxicity, and oxidative stress markers were unchanged upon ambient air exposures. The summer ambient air did not lead to increased pro-inflammatory responses compared to the filtered medicinal air at the gene expression level. On the other hand, winter ambient air showed an increase in the expression of pro-inflammatory genes already after one day. The exposure system which was previously validated with gasoline and diesel exhaust has been shown to be additionally suited for repeated exposures to ambient air. Already after one day of exposure the pro-inflammatory markers measured were elevated after winter ambient air but not summer ambient air. This system could further be implemented in other locations as well where epidemiological studies are difficult to perform. References: [1] WHO. http://www.who.int/mediacentre/factsheets/fs313/en/. 2014. [2] Dockery, D.W., et al., N Engl J Med, 1993. [3] Pope, C.A., et al., Circulation, 2004.

[4] Blank et al., Am J Respir Cell Mol Biol. 2007.
[5] Bisig, C.J. et al., CHIMIA Intern J for Chem, 2015.

Caption Figure 1:



The exposure system. [A] The exposure box [a], wrapped in aluminium foil to protect the cells from light, is placed on a balcony (in summer) or inside the apartment (winter). The exposure box contains two chambers ([b], one for ambient air [c] and another for filtered medicinal air as a control [d]). Conditions inside the exposure box were controlled by flowmeters [e] and monitored in real time [f]. [B] Scheme of the human lung model composed of three different human cell types. The cells are cultured at the air-liquid interface, ambient air (or filtered medicinal air) on the top, and cell culture medium (yellow) at the bottom. Cells were exposed for 12 hours [Figure adapted from 5].

Author CV:

Christoph Bisig
Technikumstrasse 47, 3400 Burgdorf, Switzerland
Date & Place of birth: 09.02.1989; Zweisimmen, Switzerland
Nationality: Swiss
TEL: +41263009522 e-mail: christoph.bisig@unifr.ch

Education and experience
05/2014 – Present University of Fribourg, Switzerland
Doctoral research student at the Adolphe Merkle Institute (Prof. B. Rothen-Rutishauser)
Project: Effects of gasoline and diesel engine exhaust on a multi-cellular human lung model
08/2011 – 04/2013 University of Basel, Switzerland
Master of Science in Pharmaceutical Sciences
08/2012 – 04/2013 University of Copenhagen, Denmark
Master thesis at the Dept. Drug Design and Pharmacology (Prof. H. Bräuner-Osborne)
Project title: Screening for ligands on GPR139, an orphan G-protein coupled receptor
05/2012 - 07/2012 University of Basel, Switzerland
Internship at the Dept. of Chemistry (Prof. N. Bruns)
Project title: Implementation of Gold nanoparticles in PAMAM
09/2008 – 07/2011 University of Basel, Switzerland
Bachelor of Science in Pharmaceutical Sciences

Personal Scientific Achievements

Conferences and award
¬ 12th Concawe symposium, Antwerp, Belgium, March 2017, awarded first poster price in the category “Health”
¬ EUROTOX2016, Seville, Spain, August 2016, poster presentation
¬ 20th ETH conference on combustion generated nanoparticles, Zürich Switzerland, July 2016, awarded first poster price
¬ 7th VERT Forum, EMPA Dübendorf, Switzerland, March 2016, oral presentation

¬ 6th VERT Forum, EMPA Dübendorf, Switzerland, March 2015, oral presentation
¬ 19th ETH conference on combustion generated nanoparticles, Zürich Switzerland, July 2015, oral presentation

Publications
¬ Bisig C, Roth M, Müller L, et al., 2016. Hazard Identification of Exhausts from Gasoline-ethanol Fuel Blends using a Multi-cellular Human Lung Model. Environmental Research.
¬ Steiner S, Bisig C, Petri-Fink A and Rothen-Rutishauser B, 2016. Diesel Exhaust: Current Knowledge of Adverse Effects and Underlying Cellular Mechanisms. Archives of Toxicology, 90(7), pp.1541-1553.
¬ Nussbaumer M, Bisig C, Bruns N, 2016. Using the dendritic polymer PAMAM to form gold nanoparticles in the protein cage thermosome. Chemical Communications
¬ Bisig C, Steiner S, Comte P, et al., 2015. Biological Effects in Lung Cells in vitro of Exhaust Aerosols from a Gasoline Passenger Car With and Without Particle Filter. Emission Control Science and Technology, 1(3), pp.237-246.
¬ Bisig C, Steiner S, Czerwinski J et al., 2015. A Fast and Reliable in vitro Method for Screening of Exhaust Emission Toxicity in Lung Cells. Chimia, 69(1-2), p.68.
Teaching
¬ Supervision of high school and bachelor students
Further Qualifications

Technical competences
¬ Routinely working in cell culture, exposure to nanomaterials (diesel exhaust particles)
¬ Various bio-analytical methods such as realtime RT PCR, ELISA, confocal microscope, FACS
¬ IT skills: Microsoft office, LaTeX, Prism, Adobe Illustrator, Sketchup.
Languages
¬ German: Mother tongue
¬ English: Fluent both written and oral
¬ French: Basic oral skills (B2)

	Bleicker Dirk
Affiliation	CARIT Automotive GmbH & Co. KG
Email	bleicke@carit-automotive.de
Coauthors	
Publication title	*Increased Exhaust Aftertreatment Availability and Efficiency by User Friendly Data Logging and Communication*
Publication type	Poster
Introduction & Background	Today availability and cost efficiency are the most important arguments using exhaust aftertreatment devices in on-road and non-road applications. As far as measurement and modelling is concerned, reliable values are indispensable for system suppliers. CPK Automotive, which belongs to the Heinzmann Group since October 1st 2013, has specialized experiences for many years with regard to the development of environmental solutions, chiefly in the field of automotive technology. Taking on the task of developing out paths into a livable future for the coming generations is one of the most important scopes according to the inner drive to improvement. The worldwide requirement that on-road and non-road applications have to be retrofitted, repowered or replaced to reduce particulate matter emissions becomes increasingly important for suppliers and governmental organisations. Additionally the effective monitoring of the condition and particularly the effectiveness of the devices in the field becomes more and more necessary.
Methodology	Filters, which are essential for a reliable removement of particulate matter from the exhaust gas of diesel engines, always require maintenance. Therefore it is important to harmonize the interests of the stakeholders (especially authorities and operators). This approach is discussed in the concerned contribution using the example of diesel particulate filter applications that show how appropriate diagnosis data are generated, recorded and handled with modern communication technologies. Data analysis and remote maintenance from any place in the world embody the according features, which are needed to guarantee fast and efficient processes using aftertreatment devices. Fast, inexpensive retrieval of data and round-the-clock readouts are additional requirements to fit the customer's needs. Besides, the offered potential using bidirectional communication between the devices gets intensified: a solution will be presented, that gives operators and service contractors the opportunity to ensure the availability of the machines and simultaneously fulfill their service- and monitoring-contracts efficiently. With regard to the modular platform used in this case, the presented solution is also transferable to any further technologies and applications in the field of exhaust aftertreatment, which expands the possibilities of fulfilling growth targets of authorities and operators.
Results & Conclusions	Due to the dependence on changes in the law for suppliers, a flexible, individual and quick reacted approach is guaranteed using modular solutions. In order to improve emission control technologies to achieve a healthy urban and suburban air quality worldwide, the selectively targeted topics of our company's contribution will lead the focus on the 21st ETH Conference.
Author CV:	Vocational Training o 1984: Vocational training as an electronics engineer at Mannesmann DEMAG, Wetter

o 1996: Dipl.-Ing (FH) electrical engineering (Automation technology), University of applied sciences, Hagen

Professional experience:
o 1996-2001: R & D engineer at HSB Umwelttechnik, Hemer (Development, production and sales of tecnik for underground tanks and tank trucks)
o 2002-2008: Development engineer => Senior Manager Testing at PUREM Abgassysteme GmbH & Co. KG, Unna
o 2008-2012: Head of R & D at Albonair GmbH, Dortmund
o 2013-2014: Teamcoach Systemhaus Christian Bürkert GmbH & Co. KG, Menden
o 2014-2015: Head of Testing at Twintec Technologie GmbH, Witten
o Seit 2016: Head of R & D at CARIT Automotive GmbH & Co. KG, Münster

Booker Douglas

Affiliation	NAQTS
Email	dbooker@naqts.com
Coauthors	Nick Molden; Dr. David Booker; Dr. Ian Marshall
Publication title	*Quantifying Solid and Total Particle Number Concentrations from An Array of Vehicles Using the "Plume Chaser Method"*
Publication type	Poster
Introduction & Background	The population of countries from the EU spend approximately one hour per day in vehicles. Despite this relatively short period of time, exposure levels are of concern given the immediate proximity to other vehicles, plus in urban areas, high ambient concentrations. For vehicle-related pollutants such as particulates, this contribution is particularly important. The adverse health effects of particulate matter have been clearly established in the scientific community, and it has frequently been proposed that ultrafine particles (UFPs) have a more significant effect on human health per unit mass of similar chemical composition than larger particles (see Delfino et al. 2005; Harrison et al. 2012; Seaton et al. 1995). The development of a Solid Particle Number (SPN) measurement programme - under the Particle Measurement Programme (PMP)- has standarised the measurement protocol for vehicular UFPs. The PMP protocol has been extensively scrutinized, with its repeatability and reproducibility being widely lauded. However, several studies have shown that a significant number of sub-23 nm particles can remain present downstream from the PMP system (Giechaskiel et al. 2009; Herner et al. 2007; Johnson et al. 2009). Consequently, research was conducted to investigate the composition of these sub-23nm particles, demonstrating that most of them were formed through the renucleation of semi-volatiles, and therefore not of a solid state (Zheng et al. 2011; Zheng et al. 2012). In developing informed public policy to protect public health, it is vital that the concentrations of SPN as well as Total Particle Number (TPN) -which includes particles of a non-solid state- within vehicles are better quantified, as the health concerns associated with particulate matter are a function of particle size, rather than particle state of matter.
Methodology	This study used the NAQTS V1000 -with its core component being a "regulatory compliant" CPC for measuring PN- in a "chaser" vehicle to "sniff" SPN and TPN concentrations from an array of vehicles (for example, old and new, petrol and diesel etc.) in London (an area with high ambient air pollution). A series of "real-world driving" cycles, in city, urban and rural environment were carried out to examine the in-cabin differences. This allowed the researcher to characterise vehicles on both their SPN performance, as well as on TPN. Moreover, the decay of the high-peak events was examined to look at vehicle HVAC and the absorption/desorption of different vehicle interior fabrics. Two NAQTS V1000 units were co-located and their respective particle measurements normalized with both SPN and TPN. For the solid measurements, the PMP approach was used; namely a hot pre-diluter (PND1, a catalyst / evaporator tube, and a second diluter (PND2) for cooling and further dilution to maintain the CPC in single count mode.
Results & Conclusions	Although the source was regarded consistent (the air surrounding and entering the vehicle) the results showed different levels. Albeit, with a limited

data set, the results highlight that vehicles behave differently and moreover the vehicle interior materials may be shown to have a significant effect. More work is needed.

Caption Figure 1:

"Justin" the in cabin-air quality monitor. Can also be used for micro-environmental/mobile air quality monitoring.

Caption Figure 2:

Calibration Chamber for V1000 Integrated Air Quality Monitor.

Author CV:

Douglas Booker
Co-Founder / Managing Director NAQTS Ltd: National Air Quality Testing Services Ltd (NAQTS) is a social business that seeks to improve awareness of indoor air quality through widespread public and commercial monitoring.

Supervising PhD project with Lancaster University “Understanding indoor air pollution using state-of-the-art integrated multi-pollutant air quality monitoring equipment.”

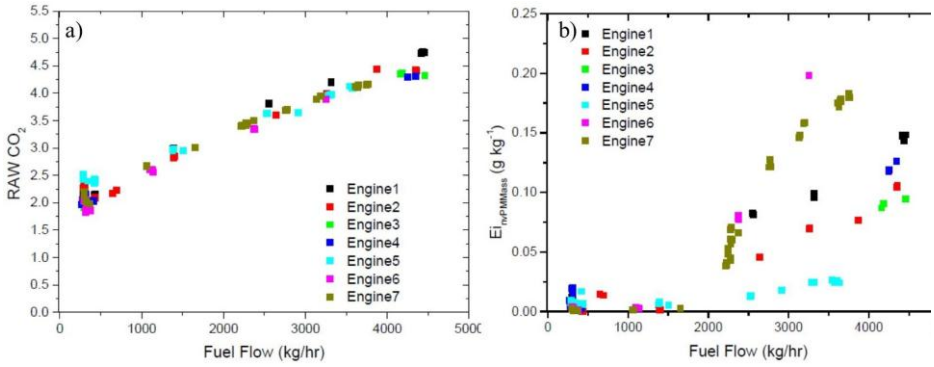
PhD Lancaster University (2016-2020)
- Indoor Air Quality and Socioeconomic Status: an environmental justice analysis
MSc Public Policy University College London
- Booker, D 2016, What should the EU's vehicle emissions strategy be for COP22? in International Public Policy Review. 1 edn, vol. 10, UCL Department of Political Science, London, pp. 57-63.

Dr. David Booker
Consultant to NAQTS
Adjunct Professor at West Virginia University Center for Alternative Fuel Engines and Emissions
Relevant publications:
Booker, D. R. Urban pollution monitoring: Oxford City Centre. Research Report, AEA Technology, Aerosol Science Centre, Oxfordshire, UK, 1997.
Earnshaw, K., and D. R. Booker. "City centre and industrial pollution measurement using mass-and number-weighted instrumentation." Journal of Aerosol Science 29 (1998).
Booker, D. R., Gautam, M., Carder, D. K., & Gautam, S. (2001). ETH Nanoparticle Conference, August 6-8, 2001.
Booker, D. R., R. A. Giannelli, and J. Hu. Road test of an on-board particulate matter mass measurement system. No. 2007-01-1116. SAE Technical Paper, 2007.
Hu, Jingnan, Booker, David R., et al. "Real-world fuel efficiency and exhaust emissions of light-duty diesel vehicles and their correlation with road conditions." Journal of Environmental Sciences 24.5 (2012): 865-874.

	Brem Benjamin
Affiliation	EMPA
Email	benjamin.brem@empa.ch
Coauthors	Lukas Durdina, Miriam Elser, David Schönenberger, Frithjof Siegerist, Ari Setyan, Jing Wang

Publication title	*Variability in Non-volatile Particulate Matter Emissions of Aero Gas Turbines; Engine Deterioration*
Publication type	Poster
Introduction & Background	Non-volatile particulate matter (nvPM) emissions from aircraft gas turbines are a concern for human health, environmental pollution and climate change. Regulatory agencies as well as emission inventories require accurate emission factors under variable engine load and environmental conditions. While ambient conditions have been previously identified as a source of variability in nvPM mass and number emissions, this work identifies another important source of emission variability: engine deterioration.
Methodology	All data were obtained with “piggy back” measurements at the engine test cell at SR Technics, Zürich Kloten. In total, emissions of over 40 engines were measured. The engines included Pratt and Whitney 4000 series engines (94” and 100” variants) and CFM-56 engines (-7B, -5B and -5C variants). The sampling system and system operation corresponded to the SAE AIR6241 standard and are only briefly outlined here. PM-laden exhaust was continuously sampled by a single point retractable Inconel sampling probe at the engine exit plane. The aerosol sampled was then diluted with dry synthetic air by a factor of eight to ten and transported via temperature-controlled lines to minimize condensation, particle agglomeration, and gas-to-particle conversion. nvPM mass was determined with a micro soot sensor (MSS, Model 483, AVL Inc.) based on the photoacoustic detection principle. In parallel to the MSS, an AVL particle counter (APC) and a CO2 analyzer (Model 410i, Thermo Inc.) provided PM number and CO2 concentrations emitted. Raw CO2, oxides of nitrogen (NOx), carbon monoxide (CO), and hydrocarbons (HC) were also measured in parallel.
Results & Conclusions	Preliminary data for typical nvPM mass emission deterioration cases are shown in Figure 1. While CO2 emissions as a function of fuel flow are nearly identical for all engines (Panel a) as expected, the nvPM mass emissions show a strong variability (Panel b). Ambient temperature ranging from 12 to 25°C in the datasets of Figure 1 is estimated to influence the variability by less than 10% and alone cannot explain this large variation in nvPM mass emissions. The repeatability of the nvPM mass concentration measurement is also expected to be better than ± 12%. Therefore, we attribute this high variability in nvPM mass data to engine deterioration. Operational history indicates further that most engines were repaired and had a deteriorated operation performance while engines 3 and 5 were overhauled with a near new performance. Current analysis also includes nvPM number and gaseous measurement data which will also be presented at the conference.

Caption Figure 1:



CO2 data as data quality check (a) and nvPM mass emission indices (b) as a function of fuel flow measured for seven specimens of the same engine variant

Author CV:

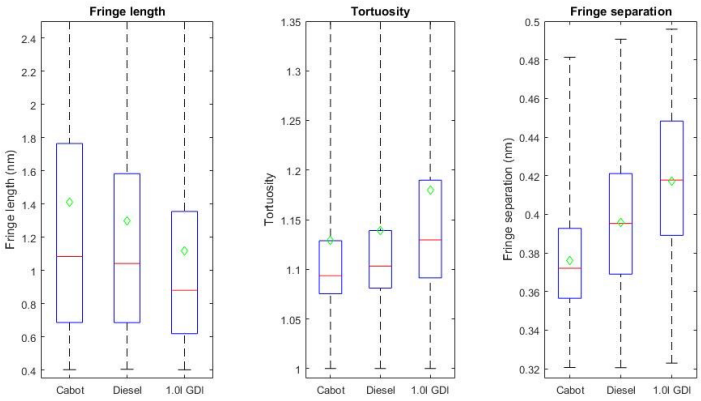
1996 – 2000 Apprentice as a precision mechanic “Feinmechaniker”
2001 – 2005 FH Diploma “Prozessinformatik”
2006 – 2012 Ph.D. in Environmental Engineering University of Illinois, Ph.D. in Environmental Engineering
2013 – present Postdoc and Scientist, Empa Dübendorf

Brough Robert

Affiliation	University of Nottingham
Email	antonino.larocca@nottingham.ac.uk
Coauthors	S Malizia; E Haffner-Staton; A La Rocca; M Fay

Publication title	*Structure Analysis of Primary Carbon Nanoparticles from a Modern Turbocharged Direct-injection Gasoline Engine*
Publication type	Poster
Introduction & Background	Modern gasoline direct injection engines need to comply with stringent emissions legislation limiting particulate matter under real driving emissions (RDE) testing; with the Euro 6c emissions legislation being shortly introduced, gasoline particulate filters are considered to be the most immediate solution. Filter design and an appropriate strategy for regeneration by the oxidation of the collected particulate matter are linked to the soot nanostructural properties. The work carried out in this investigation is driven by the needs to investigate soot produced by GDI engines and understand its reactivity and oxidation characteristics. Diesel engines have been the main source of PM and therefore widely investigated. Conversely, there is a lack of available data related to gasoline direct injection (GDI) soot morphology and nanostructure. The disorder of the primary particle nanostructure and the increase of accessible carbons on the edge sites is linked to soot oxidative reactivity.
Methodology	Three model systems of soot were compared in this investigation: commercial carbon black, diesel, and gasoline engine soot. Gasoline soot samples were collected from a passenger car equipped with a modern three-cylinder 1lt turbocharged direct-injection gasoline engine during real driving conditions in a city/urban environment. The diesel soot was collected from a single cylinder variant of a multi-cylinder design. Carbon black, diesel and GDI soot particles were characterised in terms of the primary particle size distribution, while their nanostructural properties were assessed in terms of fringe length, tortuosity and interlayer spacing using High Resolution Transmission Electron Microscopy (HRTEM) images. Soot characterisation was carried out at the Nanoscale and Microscale Research Centre (NMRC) at the University of Nottingham using a JEOL 2100F TEM equipped with a Gatan Orius CCD camera operating at 200 kV. A MATLAB in-house code was developed to process the HRTEM images of primary particles.
Results & Conclusions	The structure of diesel soot agglomerates was fairly typical, as they were fractal aggregates of primary particles, with modal skeleton length around 100nm. The gasoline soot shows presence of typical soot, similar to the Diesel soot, but also amorphous (sludge-like) structures. The gasoline soot has shorter fringe lengths, higher fringe tortuosity and larger fringe separations than carbon black and diesel soot. Gasoline soot consequently will have increased oxidation rates relative to diesel soot and carbon black, and so will be more reactive. Fringe separation shows the most significant change when comparing carbon black with GDI soot.

Caption Figure 1:



Comparison of nanostructure parameters between the three types of soot. Green marks indicate the mean value, red the median and blue the interquartile range

Author CV:

Robert Brough is a MEng student at the University of Nottingham. A Masters project under the supervision of Dr Antonino La Rocca focussed on the characterisation of particulate matter (soot) from a turbocharged direct-injection gasoline driven in a city/urban environment. The results generated by this project have formed the basis of a research project carried out by the Engine Research Group at the University of Nottingham

Cha Junepyo

Affiliation	Department of Automotive Engineering, Korea National University of Transportation
Email	chaj@ut.ac.kr
Coauthors	Junhong Park; Mun Soo Chon

Publication title	*Evaluation of Real Driving Emissions Characteristics with Light Duty Vehicles on Domestic Sales*
Publication type	Poster
Introduction & Background	Recently, the certification procedure for the exhaust emissions regulation from light-duty vehicles has been conducted with the standard test cycle (e.g., NEDC) in the laboratory under standardized operating conditions. But the exhaust emissions in the on-road conditions generally exceed the standard emission limits. Therefore, it is important to evaluate and research the real-driving emissions (RDE) using a portable emission measurement system (PEMS). Important factors in evaluating real-driving emissions are after-treatment system applied to test vehicles and RDE test routes. Especially, the test routes in present study are made in reflecting traffic and road conditions in Korea.
Methodology	In present study the real-driving emissions are measured with a PEMS and analyzed by two methods, which are moving averaging window (MAW) and power binning. The MAW method is divided in sub-sections (or windows) and the subsequent the statistical method aims at identifying which windows are suitable to evaluate the real-driving emissions. Especially, the windows are based on the reference CO2 mass emitted by the vehicle over the reference laboratory cycle (WLTC). In the power binning method, the exhaust emission values are classified in accordance with the corresponding the wheel power. And then, the classified average emissions per power class are weighted to obtain the emission values for a test with a normal power distribution.
Results & Conclusions	Generally, the RDE level on most of test vehicles exceeded the standard emission limits. In test route including rural driving applying to excessive gradient of elevation, the RDE level through MAW and power binning method is higher than that in other test route including relatively plane rural driving. In addition, there was difference in accordance with after-treatment system applied to vehicles as well as test routes.
Author CV:	(1st Author) Junepyo Cha. He received his B.S., M.S. and Ph. D degrees from Hanyang University in Korea. He is currently a assistant professor in department of automotive engineering at Korea National University. (2nd Author) Junhong Park. He is Ph. D and currently working on Transportation Pollution Research Center at National Institute of Environmental Research (NIER). (3rd Author) Mun Soo Chon. He received his B.S., M.S. and Ph. D degrees from Hanyang University in Korea. He is currently a professor in department of automotive engineering at Korea National University.

	Ciajolo Anna
Affiliation	istituto ricerche sulla combustione, CNR
Email	ciajolo@irc.cnr.it
Coauthors	barbara apicella, carmela russo, antonio tregrossi

Publication title	*Integrated Approach for the Structural Analysis and Sizing of Flame-formed Organic Carbon and Ultrafine Carbon Particles*
Publication type	Poster
Introduction & Background	The complexity of the routes through which carbon particles suddenly arise from the gas (homogeneous) phase to become a heterogeneous carbonaceous aerosol reflects in the structural complexity and variability of fine/ultrafine carbon particles and related organic carbon generated from combustion systems. The structural analysis has to cover the very wide size distribution range, featuring ultrafine carbon particles from small aggregates (
Methodology	Size and structural order/disorder degree of carbon particles were evaluated by electron microscopy (TEM and HR-TEM) in collaboration with CNRS and Penn State University, by Raman spectroscopy, dynamic light scattering (DLS), and Laser Desorption Ionization Mass Spectrometry, (LDI-MS). Chemical properties associated with the structure were measured by bulk analysis as elemental analysis of hydrogen and carbon. Infrared (IR) and UV-visible spectroscopy were used to measure aromatic/aliphatic carbon and hydrogen bonding. The size/Molecular Weight (MW) distribution of organic carbon and carbon particles was obtained by means of Size Exclusion Chromatography (SEC) coupled with UV-Visible spectroscopy. SEC of organic carbon extracted by dicloromethane (DCM) and of residual carbon particles sampled in premixed flames furnished MW distributions of carbon particulates. The bimodal MW distribution of organic carbon in the 200-1000 u range has been found by SEC and verified by LDI-MS analysis of the separated SEC fractions (Apicella, 2006).
Results & Conclusions	SEC of organic carbon extracted by dicloromethane (DCM) and of residual carbon particles sampled in premixed flames furnished MW distributions of carbon particulates. The bimodal MW distribution of organic carbon in the 200-1000 u range has been found by SEC and verified by LDI-MS analysis of the separated SEC fractions (Apicella, 2006). A typical multimodal MW distribution of the carbon particles (soot) with three main peaks can be observed in the 100-1010 u MW range corresponding to about 0.5-100 nm size range as evaluated for a spherical shape with 1.8 g/cm3 density. Information coming from the other techniques, and in particular from UV-Vis analysis coupled to SEC(Tregross, 2013), was used in combination with size/MW analysis to infer the structure of the different components from the light PAH to soot aggregates and the possible relationship between them. References Apicella, B.; Millan, M.; Herod, A. A.; Carpentieri, A.; Pucci, P.; Ciajolo, A. (2006): “Separation and measurement of flame-formed high molecular weight polycyclic aromatic hydrocarbons by size-exclusion chromatography and laser desorption/ionization time-of-flight mass spectrometry”. Rapid Communications in Mass Spectrometry , 20(7), 1104-1108. C. Russo, F. Stanzione, A. Ciajolo, A. Tregrossi: (2013) Study on the contribution of different molecular weight species to the absorption UV-Visible spectra of flame-formed carbon species” Proceedings of the Combustion Institute 34,3661-3668.

Caption Figure 1:

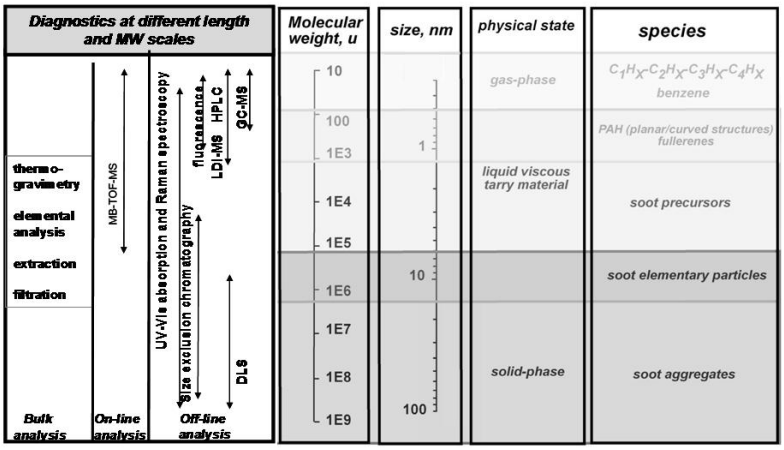


Figure 1 Scheme of diagnostics of flame-formed organic carbon and carbon particles in reference to the relevant length and molecular weight scales

Author CV:

Institution: Istituto di Ricerche sulla Combustione IRC-CNR
Piazzale Tecchio, 80, 80125 Napoli, Italia
Telephone Home institution:+39 081 7682252
E-mail ciajolo@irc.cnr.it
Nationality Italian
Date of birth 20 february 1955

EDUCATION
1978-Università degli Studi di Napoli Federico II
Degree in Chemistry Mark: 110/110 cum laude
1973-High school diploma at ITIS-L.da Vinci Grade: 60/60

PRESENT POSITION
Research Director at IRC-CNR

SCIENTIFIC AREA
Fossil Fuel Characterization and Combustion
Environmental Impact of combustion and industrial plants.
Characterization of Fine and Ultrafine Particulate formation from combustion and gasification systems.
Soot formation and oxidation.
Management of laboratory combustion plants and evaluation of efficiency and environmental impact, through sampling and chemical and spectroscopic analysis of combustion products.
Fuel Characterization: measurements of chemical and physical properties
Analytical techniques: UV-visible spectroscopy, fluorescence spectroscopy, gascromatografy fid/tcd, FT-IR spectroscopy, gaschromatography/mass spectrometry (gc-ms), size exclusion chromatography, elemental analysis, thermogravimetry, mass spectrometry.

Authors of 100 publications on peer-reviewed journals.

Contreras Barbosa Yadert

Affiliation	Air quality researcher at Universidad de los Andes. Bogotá - Colombia.
Email	yd.contreras@uniandes.edu.co
Coauthors	Juan Camilo Vigoya Rodríguez; Ana Paola Corredor Barrera; Ricardo Morales Betancourt

Publication title	*Variation of Number of Particles Distribution by Temperature Effects in an Exhaust of a two-stroke Engine in a High Altitude City*
Publication type	Poster
Introduction & Background	The increasingly frequent use of two stroke mopeds in developing countries demands a detailed analysis of their particles emissions. In this poster we present the particles emitted directly from a – 50 c.c – two stroke engine was studied in a emissions laboratory at the local conditions of a high altitude city such as Bogotá (Colombia), with the focus on the dilution temperature dependence of particle number emissions. An oil-petrol mix was used as fuel. Exhaust gases while running at high engine load and at idle were sampled and analyzed with an Electrical Low Pressure Impactor Dekati DMM-230. Various setting carburetor -scenarios were considered and normalized by fuel consumption rate-. Both during acceleration and steady conditions, the number size distribution of exhaust particles varied as the temperature changes. It was observed that low size particles prevail at high sampling temperatures and, as the temperature decreases, the "dpg" of the distribution shifts toward larger values. Results indicate the characteristic fine mode of the 2-stroke engine exhaust emission to be the responsible of the described behavior: Mainly composed by non-volatile hydrocarbons, the particles of this mode start to condense and agglomerate when temperature falls; in consequence, the sample becomes less dense in particle number and more predominant in large size particles. Those differences in particle size distribution should be taken into account in the emission monitoring protocols as well as in the development of environment and human health quality standards.
Methodology	A methodology was developed to analyze emission of two-stroke engine getting until 70 samples. Due to the first achievement was develop an appropriate methodology, it was changing and improving throughout the first stages of this research. We carried out around 40 samples at the. We carried out around 40 samples at the emissions laboratory, each experimental assembly was executed in order to see the variability in particles concentrations and the engine operation. The biggest differences were the relation fuel-air and the different mixing ratios in the operation of the engine (oil-petrol). The samples were measured with an Electrical Low Pressure Impactor Dekati Mass Monitor (DMM-230) previously diluted with a Dekati Double Diluter. In some of these samples we used a heater in order to understand and predict the control of this parameter and how would change the number of particles concentrations in each impactor stage. Every single measurement was designed following five basic steps: firstly we tried to measure the local particles concentration at the emissions laboratory (of course we had to adjust the main characteristics of "background" particles to calculate the concentration logarithm as better as possible) after that we always calculated the dilution ratio under the double dilution system and then we measured the different operation modes of the engine and its variability in particles concentrations by temperature effects.Each sample has a length of approximately 30 minutes and a distribution data per second.
Results & Conclusions	Although the similarity in the measurements procedure, our main goal was to identify the variability in each particles concentration of the different

	measurements. The biggest mass concentration that we found was in a five similar samples average, it was over eleven thousand (11.000) micro-grams per cubic meter under a stable engine operation. We also identified that temperature can modify some of the different samples among the measurement protocol for each test. Particles number concentration can be found updating the log-normal algorithm of the distribution.Likewise number concentration in each impactor stage even if we calculated previously the mobility cut diameter.
Author CV:	Yadert Contreras Barbosa, Environmental and Sanitary Engineer from Universidad de la Salle (Bogotá, Colombia) currently Master in Science student, School of Engineering at Universidad de los Andes (Bogotá, Colombia) and Air Quality Researcher Assistant in the same institute. Yadert also has some researches about urban air quality and emissions of particulate matter in high altitude cities such as Bogotá.

	Coplin Nick
Affiliation	Orbital Australia
Email	ncoplin@orbitalcorp.com.au
Coauthors	

Publication title	*Wall-flow Type DPF System to Replace Existing Wet Element Filter Systems Used in Typical LHDs in Underground Coal Operations*
Publication type	Presentation
Introduction & Background	The need to protect workers from diesel particulate matter (DPM) has lead the Australian underground coal mining industry to install disposable filter systems on their vehicles. While the disposable filters are efficient at removing significant DPM, the following major issues have arisen: • High cost of operations. Disposable filters need to be changed at least once per shift, and additionally incur environmental costs for disposal and management. • Improper installation, damaged seals and lack of installing a new filter when the old filter is removed means that workers are still being exposed to excessive amounts of DPM. ACARP, the Australian Coal Association Research Program, funded the studies into the suitability of conventional on-road heavy duty diesel wall-flow filter systems to be adapted for use in underground coal operations. In addition to regulatory constraints including maximum limits on system surface and tailpipe temperatures, the relatively light duty of the machines in operations looked set to make it challenging for wall-flow filter systems to satisfactorily regenerate.
Methodology	The bulk of the ACARP system development program uses Orbital's state-of-the-art heavy duty engine testing facility to replicate LHD onsite operations using its transient dynamometer capability so as to not interrupt site operations. This also minimises safety risk as early prototypes could present an explosion risk if tested at site given the gaseous nature of underground coal operations. Another important consideration is test repeatability. Use of a test facility ensures that factors such as changes in the mine operation do not impact the test results. The development of both customised steady-state and transient engine test cycles for LHD type vehicles was based on measured and analysed data gathered from onsite testing and data collection. This type of data acquisition and analysis is understood to have been an Australian coal industry first. The developed engine test cycles are expected to have applicability beyond this current project, assisting the industry to quantify not just emissions but in optimising other operational aspects, such as fuel use and operator training. The process adopted whereby the core activities were undertaken off-line from the operational mining environment, but still retaining engagement with industry through frequent onsite testing and re-testing, has allowed for a complex program to be executed in a safe and very fast timeframe;
Results & Conclusions	The ACARP project successfully demonstrated both comparable significant DPM emissions reduction and satisfactory system robustness on a proof-of-concept (PoC) wall-flow DPF system for implementation on a Load Haul Dump (LHD) vehicle typical of that used by the Australian underground coal industry. It was noted in testing that the technology increased modal NO2 formation, but was compliant over typical operational duty cycles. One of the

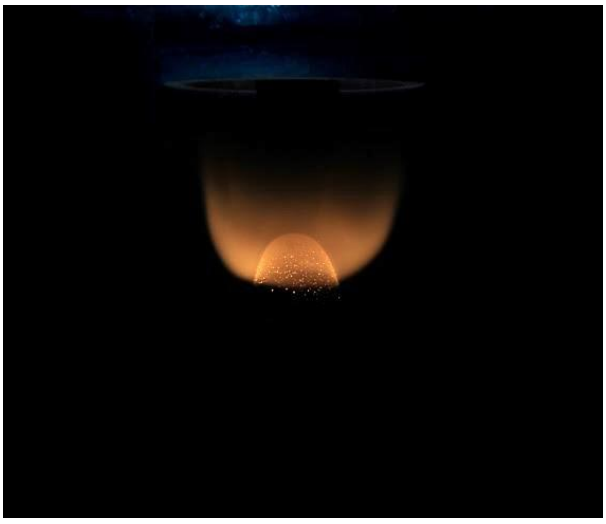
	key benefits with the use of a wall-flow DPF system is its tamper-proof design mitigating the risk of operating unfiltered diesel plant in poorly ventilated areas. Elimination of the need for continual replacement of disposable filters provides significant operational savings estimated to be up to 80% of the incumbent technology. ACARP project C25073 was scoped to fund only the proof-of-concept phase of the wall-flow DPF development program. Industrialisation of the project system was beyond the scope of the project budget and is deferred to the next stage. The system looks to have potential as both an OEM and retrofitable solution.
Author CV:	Nick has over twenty years of powertrain engineering experience. He has managed research and development programs in high technology, low emissions fuel systems as well as advanced application-engineering programs for customers around the globe. Nick's project exposure has been diverse. He's guided the Australian government on fuels policy, helped OEMs meet the latest emissions norms on both petrol and diesel products, worked with catalyst technology leaders to develop state-of-the-art aftertreatment systems and partnered with CSIRO on health effects of engine emissions. He has also published several technical papers and holds patents in fuel injection and vapour handling systems.

	Czerwinski Jan
Affiliation	Abgasprüfstelle und Motorenlabor (AFHB) / Berner Fachhochschule, Biel
Email	jan.czerwinski@bfh.ch
Coauthors	Comte Pierre (AFHB), Güdel Martin (AFHB), Mayer Andreas (TTM), Hensel Volker (VERT/Aurigna)

Publication title	*Nanoparticle Emissions from Gasoline Cars DI & MPI*
Publication type	Poster
Introduction & Background	The nanoparticles (NP) count concentrations are limited in EU for Diesel passenger cars since 2013 and for gasoline cars with direct injection (GDI) since 2014. The limit for GDI was temporary extended to 6 x 1012 #/km (regulation No. 459/2012/EU). For the particle number (PN) of MPI gasoline cars there are still no legal limitations.Nuclei of metals as well as organics are suspected to significantly contribute especially to the ultrafine particle size fractions, and thus to the particle number concentration.
Methodology	In the present paper some results of investigations of nanoparticles from five DI and four MPI gasoline cars are represented. The measurements were performed at vehicle tailpipe and in CVS-tunnel. Moreover, five variants of "vehicle – GPF" were investigated.
Results & Conclusions	The PN-emission level of the investigated GDI cars in WLTC without GPF is in the same range of magnitude very near to the actual limit value of 6.0 x 1012 #/km. With the GPF's with better filtration quality, it is possible to lower the emissions below the future limit value of 6.0 x 1011 #/km. The modern MPI vehicles also emit a considerable amount of PN, which in some cases can attain the level of Diesel exhaust gas without DPF and can pass over the actual limit value for GDI (6.0 x 1012 #/km). The GPF-technology offers in this respect further potentials to reduce the PN-emissions of traffic. There is no visible nuclei mode and the ultrafine particle concentrations below 10mm are for both engine technologies GDI & MPI insignificant. Some of the vehicles show at constant speed operation a periodical fluctuation of the NP-emissions, as an effect of the electronic control.
Author CV:	- Study of Mechanical Engineering in Austria - Assistant on the Technical University, Vienna / Ph.D. about combustion in SI-engines - R & D diesel injection systems, diesel combustion, Voest Alpine Friedmann, Austria - R & D turbocharging systems / Asea Brown Boveri, Switzerland - Since 1989, professor for thermodynamics and IC-engines, head of the laboratory for emission gas control, University of Applied Sciences, Biel-Bienne, Switzerland - Member of Societies of Automotive Engineering / SAE: USA, Switzerland, Austria, Poland - Swiss Delegate to the IEA Implementing Agreement / Advanced Motor Fuels. - Honorary Member PTNSS Polish Scientific Society of Combustion Engines, 2007 - Professional Fellow of European Science Society of Powertrain and Transport KONES, 2008 - Nominated for SAE Fellow 2009 - Author & Coauthor of more than 220 technical / publications: engine technology, emissions & environment

Davis Justin

Affiliation	University of Washington
Email	justid3@uw.edu
Coauthors	Kartik Tiwari; Igor Novosselov

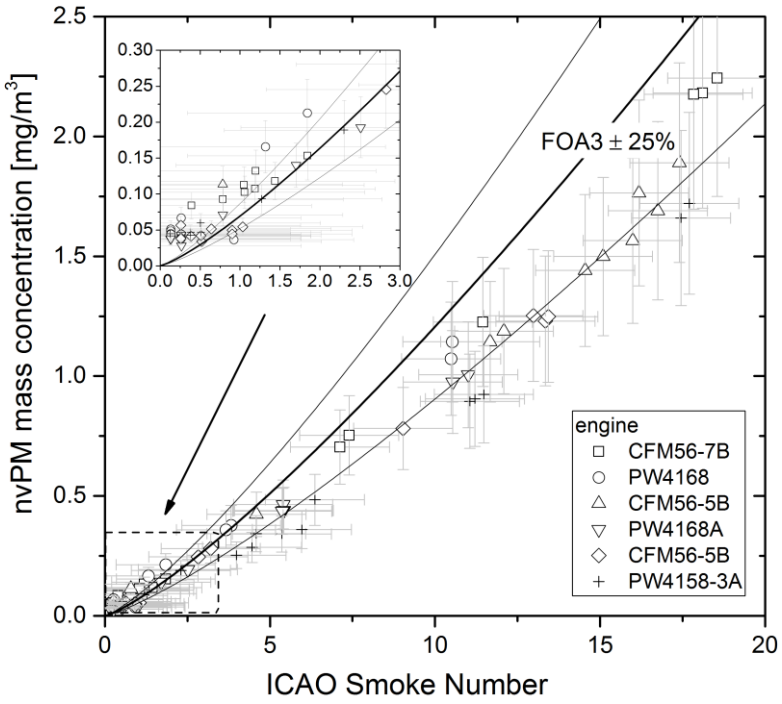
Publication title	*Growth Mechanism for Soot Primary Particles in Recirculating Hydrocarbon Flame*
Publication type	Poster
Introduction & Background	The effect of residence time and combustion conditions on primary soot particles size is investigated. Though the size of ultrafine particulate matter from combustion is known to vary, the effect fuel composition and combustion environments has on the gaseous to solid state transition is not well understood. The knowledge of primary particle size is an important parameter for aerosol agglomeration studies, health exposure studies, material synthesis, and other applications. The primary particle size dependence on fuel composition, residence time and other combustion characteristics is studied in an inverted gravity flame reactor (IGFR). The inverted laminar diffusion flame provides unique conditions to study soot growth, controlled recirculating flow patterns, and a long residence time that promotes growth of carbon soot particles.
Methodology	Four gaseous fuel are used: methane, propane, ethylene and acetylene. Volumetric flow rates of the fuel and air are varied to achieve desired flow patterns by balancing the convective and buoyancy components in the IGFR. The soot formed in the experiments is measured using electron microscopy. The results from the negative gravity reactor are compared with the traditional laminar axisymmetric co-flow flame.
Results & Conclusions	Primary particle diameters for the traditional co-flow setup are in the range of 25-40 nm, while average primary particle diameter from the inverted gravity flame is in the range of 60-80nm. The primary particle size distribution width from the IGFR is greater than in the upright flame, possibly due to a wide range of particle residence times in the soot forming recirculation zone. A chemical reaction network (CRN), consisting of a hydrocarbon pyrolysis (fuel rich) region, followed by a diffusion flame front (stoichiometric) region, and a recirculation pathway, was constructed based on CFD simulations. The CRN is used to gain insight into the formation of ployaromatic hydrocarbons with IFGR conditions.
Caption Figure 1:	

	For the methane diffusion flame in the IFGR, certain flow rates result in the formation of a recirculation region. Soot formed with these conditions result in large primary particle diameters.
Author CV:	Justin Davis EDUCATION: PhD Candidate, Molecular Engineering, 2015-Current University of Washington, Seattle, WA, United States B.S. Math and Physics, Linfield College, 2015 McMinnville, OR, United States Graduated Magna Cum Laude PRESENTATIONS American Association for Aerosol Research 2016, Portland, OR American Physical Society 2015, March Meeting, San Antonio, TX American Physical Society 2014, March Meeting, Denver, CO PUBLICATIONS Determination of damage characteristics of saw damage on Si wafers by Minority Carrier Lifetime Measurement. Conference paper: 25th Workshop on Crystalline Silicon Solar Cells & Modules: Materials and Processes, 2015. Keystone, CO

	Durdina Lukas
Affiliation	Advanced Analytical Technologies, Empa, Dübendorf; Institute of Environmental Engineering, ETH Zurich
Email	lukas.durdina@empa.ch
Coauthors	Miriam Elser, Benjamin Brem, David Schönenberger, Jing Wang

Publication title	*Correlations of Nonvolatile Particulate Matter Mass and Number Emissions and Particle Size with Smoke Number Determined for Commercial Aircraft Jet Engines*
Publication type	Poster
Introduction & Background	For over 30 years, aircraft jet engines have been certified for visible exhaust smoke using the smoke number (SN). SN is obtained as a relative reduction of reflectance of a filter paper after drawing 16.2 kg/m2 of exhaust through it. Since SN has been the only indirect measure of nonvolatile particulate matter (nvPM) emissions available for all certified commercial jet engines, it has served for estimating nvPM mass concentration for the airport air quality assessment. The recommended method for estimating nvPM emissions from airport operations has been the first order approximation version 3 (FOA3, Wayson et al., J. Air Waste Manage., 2009). In the near future, the assessments might become more accurate owing to the new regulation for nvPM emissions from commercial gas turbine engines. However, this standard will only concern in-production engines. Since the service life of jet engines spans up to 30 years, nvPM emissions of many in-service engines will never be reported. Therefore, the nvPM emissions will need to be estimated from the certification SN data. Here, we present correlations of nvPM mass and number concentrations and emission indices as well as GMD with SN determined for 5 types of commercial aircraft engines used on single-aisle and wide body airliners.
Methodology	The engine tests were done in the test cell of SR Technics, Zurich airport, Switzerland. Data were collected on engines during post-maintenance test runs burning standard Jet A-1 fuel. The exhaust was sampled within 2 m downstream of the engine exit plane using a single orifice traversing probe. The nvPM emissions and SN were measured according to the regulatory standards and using state-of-the-art instrumentation.
Results & Conclusions	Preliminary results show good agreement of the measurement data with FOA3 for various engines in the SN range from 0.5 to 20 (Figure 1). Note that the nvPM mass concentration data shown are not corrected for particle loss in the sampling system. The loss correction factor due to thermophoresis and diffusion is expected to correct the nvPM mass concentrations upwards by a factor of 1.5 (high thrust, largest GMD) to 2 (low thrust, smallest GMD). We will address the particle loss in the standardized sampling system to provide the best estimates of engine-out emissions relevant for the environmental impact assessment. The correlations of nvPM concentrations, emission indices (amount of pollutant / kg fuel), and particle size with SN developed in this study can be implemented in air quality models as well as in methods to estimate aircraft cruise emissions.

Caption Figure 1:



Nonvolatile PM mass concentration as a function of SN. The error bars for SN are ± 1.5 SN (half of the maximum estimated error of the method) and 22% for the nvPM mass (estimated total uncertainty of the nvPM mass measurement).

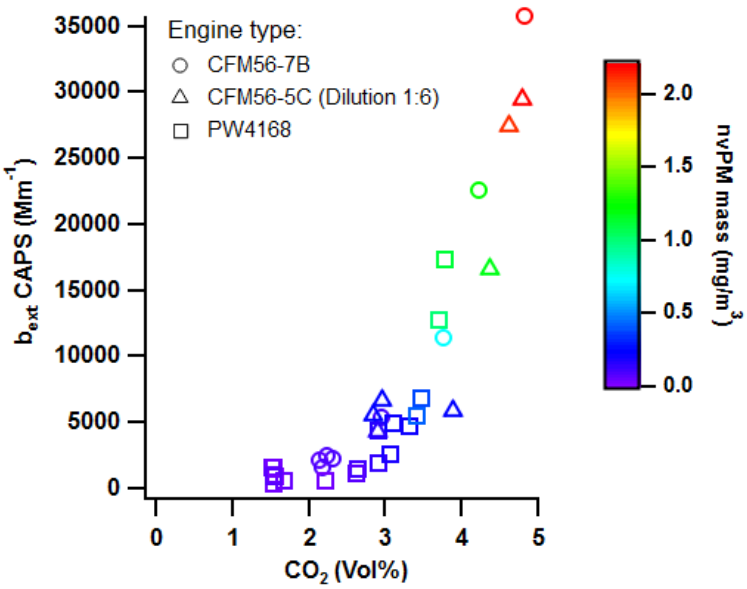
Author CV:

2017 – now Postdoctoral Researcher at Empa
2012 – 2016 PhD in Environmental Engineering, ETH Zurich
2007 – 2012 Master's degree in Mechanical Engineering, Brno University of Technology, Czech Republic

	Elser Miriam
Affiliation	EMPA
Email	miriam.elser@empa.ch
Coauthors	Benjamin Brem; Lukas Durdina; David Schönenberger; Jing Wang

Publication title	*Optical Properties of Black Carbon Particles in Aircraft Engine Exhaust*
Publication type	Poster
Introduction & Background	The steady growth of aviation transport in the last decades and the predicted 4.5% global annual air traffic growth for the next 20 years, have raised interest on the gaseous and particulate emissions from aircraft engines. Although the contribution of aviation to global black carbon (BC) is low in comparison to other anthropogenic sources, this is a unique contributor to the particulate mass in the upper troposphere and therefore has significant impacts on radiative forcing and climate. A detailed characterization of the optical properties of BC emissions from aircraft engines is essential to estimate its related climate effects.
Methodology	Measurements were performed at the engine testing facility of SR Technics at Zurich Airport (Switzerland). Different engine types were tested at various thrust levels using standard Jet A-1 fuel. The engine exhaust was sampled at the engine exit by a single-orifice probe and the major physico-chemical characteristics of the non-volatile particulate matter (nvPM) and major gaseous pollutants were measured according to the regulatory standards. >A Cavity Attenuated Phase Shift-based single scattering albedo monitor (CAPS PMssa, λ = 532 nm) and a Photoacoustic Extinctiometer (PAX, λ = 870 nm) were deployed to study the wavelength-dependence of the optical properties of the BC emissions. Filter measurements were performed during two engine runs to characterize the interference of nitrogen dioxide in the extinction and scattering signals at the measurement wavelengths
Results & Conclusions	Figure 1 shows the extinction coefficient (bext) measured with the CAPS for three different engine types as a function of CO2 concentration in the engine exhaust. The CO2 concentration is directly proportional to aircraft fuel burn and an indication of engine thrust level. The color scale indicates the range of nvPM mass (up to 2.2 mg/m3) measured with a Micro Soot Sensor. Similar trends are observed in bext for increasing CO2 concentration and nvPM mass for all three engine types. Specifically, bext below 2000 Mm-1 were measured at ground idle conditions and increased up to around 15000 Mm-1 (PW engines) to 35000 Mm-1 (CFM engines) at take-off conditions This work will allow a detailed characterization of the major optical properties (including single scattering albedo, absorption and extinction Angstrom exponents, and mass absorption cross sections) of aircraft BC emissions and their dependence on engine type and operating conditions

Caption Figure 1:



CAPS extinction coefficient (bext) as a function of CO2 concentration and nvPM mass for three different engine types. A constant dilution factor of 1:6 was used to take into account the mixing of the bypass and core flows in the mixed-exhaust nozzle of the CFM56-5C engines..

Author CV:

11/2016 - present Postdoctoral Researcher, EMPA
04/2013 - 09/2016 PhD in Atmospheric Chemistry, ETH Zurich / Paul Scherrer Institute
01/2011 - 11/2012 Master studies in Physics, University of Milan, Italy

	Fierz Martin
Affiliation	naneos particle solutions
Email	martin.fierz@naneos.ch
Coauthors	Romea Bucher, Patrick Küry
Publication title	*Simple periodic DPF inspection with a handheld device*
Publication type	Poster
Introduction & Background	Diesel particle filters belong to the success stories of pollution control; reducing the number of emitted particles of Diesel vehicles by large amounts, typically on the order of a factor 1000. However, these filters may be damaged during use and lose a large amount of their effectiveness, e.g. through cracks where the exhaust gas can pass unfiltered. Due to the high effectiveness of the filters, a single car with a damaged filter may emit as many carcinogenic soot particles as 1000 cars with properly functioning filters, and it is therefore highly desirable to detect damaged filters – for example during periodic inspections in the garage. DPF test equipment that could be used in a garage should be easy to operate, robust and cheap. Currently available devices marketed for DPF testing fulfil none of these properties.
Methodology	A different approach is thus required, and TNO has shown the way in a recent report [1]. Emissions of Diesel cars were measured at low idle, where the air-to-fuel ratio of Diesel engines is so high that no dilution of the exhaust is necessary, and the measurement could be performed with a standard device readily available on the market (TSI CPC 3007). Unfortunately, the handheld CPC has an upper limit of detection (105 pt/cm3) that is at or even below envisaged limit values (105 - 5·105 pt/cm3). We therefore decided to attempt a similar campaign with the naneos partector. This device measures charge transfer to the particles, a quantity which is proportional to particle number and mean particle diameter (Q ~N·), so it cannot directly measure particle number as required by legislation. However, by assuming an average particle diameter of 70nm (which is usually a good approximation for Diesel engines), the signal can be converted to particle number by multiplying the displayed LDSA value with 280. The number-equivalent measurement range of the partector is about 500 - 5·106 pt/cm3, covering the necessary concentration range perfectly for this application. The integrated humidity sensor allows for a validation of the assumption that the dilution by the engine alone is sufficient, and finally, the measurement principle based on induced currents is insensitive to electrometer zero offset drifts that may occur due to gas temperature and humidity changes during the measurement. It would therefore appear that the partector is ideally suited to implement the measurement strategy outlined by TNO. To verify this, we used a very slightly modified partector to measure the emissions of multiple Diesel vehicles at low idle.
Results & Conclusions	Measurements could be performed quickly and easily, and the relative humidity measured inside the device remained far from problematic values, Clear differences between vehicles with working DPF and vehicles without DPF could be observed. Detailed results will be presented at the conference. We conclude that the methods (measurement at low idle) and the technology (diffusion charging) to verify proper functioning of DPFs in the field are readily available today (also from other manufacturers), and could

	easily be implemented to improve air quality and public health, if the political will for such measures was present.
Author CV:	*1971 in Geneva, Switzerland 1991-1996: Physics study at ETH Zürich 1997-2000: PhD in Physics with Professor H.C. Siegmann at ETH Zürich 2001: PostDoc with Professor K. Sattler at University of Hawaii 2002-present: Research Fellow with Professor H. Burtscher at Fachhochschule Nordwestschweiz, Windisch, Switzerland 2012-present: Founder and CEO of naneos particle solutions Martin's interest mainly lies in the development of new nanoparticle sensors. He is the inventor/designer of several miniature electrical nanoparticle detectors (DiSCmini, Partector, automotive Partector).

	Friebel Franz
Affiliation	Institute for Atmospheric and Climate Science
Email	franz.friebel@env.ethz.ch
Coauthors	Prem Lobo; Saskia Drossaart van Dusseldorp; Evelyn Mühlhofer; Amewu. A. Mensah

Publication title	*CCN-Activation of Soot Particles after Long Term Exposure to Atmospherically Relevant Ozone Concentrations*
Publication type	Poster
Introduction & Background	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 contributes to this discrepancy is the heterogeneous oxidation of soot particles. Soot particles have an average atmospheric lifetime of one week. During this time, they are exposed to different oxidants which might change how the soot particles interact with water. The investigation of those processes is an experimentally challenging task, due to the long time span which should be covered. Many studies were conducted in which soot was treated with oxidants at concentrations exceeding the atmospheric average by a factor of 1000. This approach reduces the needed observation time, but also bares the risk of not representing chemical processes well.
Methodology	The soot aerosol was produced with a propane flame burner and had a high organic carbon content. 100 nm particle were size selected and diluted with particle free and VOC-filtered wall air. To investigate the impact of oxidation and deposition of VOCs in the surrounding gas phase onto the soot particles, a charcoal denuder was used. The aerosol flow was filled continuously into a 3 m3 stainless steel tank at a rate of 25 liter per minute (CSTR-like aerosol tank). Inside the tank the soot particles were exposed to different levels of humidity (0-80 %) and ozone concentrations (0-200 ppb). The fresh and the modified aerosol was characterized by following properties: CCN-activity, ice nucleation activity, size distribution, single particle mass, and hygroscopicity.
Results & Conclusions	In summer 2016 we conducted a lab campaign at ETH Zurich where we exposed soot particles to atmospherically relevant ozone concentrations for 12 h in an CSTR-like aerosol tank. We observed that 100 nm size selected soot particles showed significant CCN-activity at a supersaturation of 0.4 % after they were exposed for 8 h to 200 ppb Ozone at 80 % humidity. Additionally, a linear correlation between exposure time and critical supersaturation was observed
Author CV:	experiences since 06/2016 PhD-student „The chemistry of aging soot particles under atmospheric conditions“, ETH Zürich, Institute for Atmospheric and Climate Science, Group of Ulrike Lohmann 08/2015 – 05/2015 research assistant, TU Graz, Institute of Process and Particle Engineering, Group of Michael Narodoslawsky education and foreign experiences 10/2012 – 07/2015 master studies „Technical Chemistry“, Graz University of Technology - degree: 07/2015: Diplom-Ingenieur - thesis: Optimisation of the use of renewable resources in a German project region - specialisation: renewable resources, surface and interface technologies

04/2013 – 04/2016 master studies „Chemical and Process Engineering“, Graz University of Technology
- process and particle engineering, recycling
- no graduation planned

01/2014 – 06/2014 exchange semester at the Tomsk Polytechnic University, Russia

10/2011 – 12/2012 research internship „Quantum dot sensitized solar cells“, Indian Institute of Technology Hyderabad
10/2008 – 09/2012 bachelor studies „Chemistry“, Chemnitz University of Technology
- degree: Bachelor of Science (1,7)
- Thesis: Examination of the pyrolysis of plant and waste fats and oils

internships, summer schools

06/2014 summer school "Resource-efficient technologies: Experience of Russia and Germany", Tomsk Polytechnic University, Russia

07/2013 summer school "International Economic Relations" and Russian language course, St. Petersburg State Polytechnical University, Russia

03/2012 – 08/2012 internship at BASF SE, Ludwigshafen "Automated text analysis based on semantic networks"

09/2010 summer school "Electrochemical processes in electro-organic synthesis", Chemnitz University of Technology

miscellaneous
12/2013 joint study travel scholarship
09/2011 travel scholarship from DAAD

05/2011 scholarship from INDUSTRY-CLUB of SAXONY 1828 regd. assoc.

language German: native speaker
English: fluent
Russian: intermediate

	Gerkens Stefan
Affiliation	Testo
Email	sgerkens@testo.de
Coauthors	Luis Cachon

Publication title	*Systematic Study on the Robustness of a Diffusion Size Classifier Sensor for Nanparticle Characterisation*
Publication type	Poster
Introduction & Background	The diffusion charging (DC) measuring principle to characterize nanoparticles is earning a great acceptance in several applications due to its versatility, high performance and robustness as well as user friendly maintenance. Applications like personal exposure (Rivas, 2014), occupational health and safety (Kaminski, 2015) or ambient air monitoring (Hudda, 2016) are typical fields where the diffusion charging has demonstrated its effectiveness. Moreover, the trend to measure particle emissions in different vehicle categories for type approval and technical inspection with portable instrumentation (Gallus, 2014) has motivated the introduction of diffusion charging in this field as well. All these very diverse applications benefit from the comparatively insensitivity of diffusion charging to varying particle morphology or surface chemistry On the other hand, especially these new applications bring along new challenges on the nanoparticle sensor, especially if the sensor is used in rough environments, like RDE driving cycles (e.g. on heavy duty vehicles) with external mounting of the measuring equipment
Methodology	In order to access this variety of potential disturbance variables, we used a cascading sequence of experiments together with a hybrid approach of experiment and simulation developed only recently by us to enhance sensitivity of the method.
Results & Conclusions	The effects of various potential disturbance variables (like temperature gradients or strong vibrations) on the stability of sensor calibration, as well as their impact on sensor output are shown in this work.
Author CV:	Dr. Stefan Gerkens: Diploma in Physics at Bielefeld University. Scientific Assistant at Particle Technology Group of University of Paderborn, conferral of a doctorate 2013. Since 2012 senior researcher R&D particle instrumentation at Testo SE & Co. KGaA.

Haffner-Staton Ephraim

Affiliation	The University of Nottingham
Email	antonino.larocca@nottingham.ac.uk
Coauthors	Antonino La Rocca; Mike Fay

Publication title	*Optimisation of 3D-TEM Methods for High-throughput Flame-generated Soot Nanoparticles Analysis*
Publication type	Poster
Introduction & Background	Soot forms in automotive engines due to incomplete combustion conditions, and takes the form of clustered or chain-like fractal agglomerates, usually 50-500 nm in size, composed of tens to hundreds of monodisperse spherical particles with diameters in the range of 20-50 nm. Highly detailed characterisation of soot nanoparticles can help to more fully understand soot formation and its health and environmental implications. Due to their size, transmission electron microscopy (TEM) has been the most widely used method to achieve this. TEM produces 2D projections of soot agglomerates, and the lack of depth perception leads to underestimation of commonly measured morphological parameters [1-3], such as volume, number of primary particles, and fractal dimension. High quality 3D reconstruction of soot agglomerates would eliminate this error, or the need for empirical correction factors and approximations to estimate the values of 3D parameters from 2D projections. However, 3D study of soot aggregates is in its infancy, and a major barrier to the success of the technique is its speed. A useful 3D technique must be able to produce models of a statistically significant number of soot particles in order to fully characterise samples and facilitate greater understanding of soot formation and its effects in engines and the environment. Currently, such work would take too long to offer a viable alternative to the traditional 2D TEM methods.
Methodology	Flame-generated soot imaged on a graphene oxide coated TEM grid at 100 kV using a JEOL 2100F TEM equipped with a Gatan Orius CCD camera. Tilt series were captured over a ±60° range using SerialEM [4]. To aid alignment of tilt series images, 10 nm diameter gold nanoparticles were deposited onto the TEM grid. All reconstructions were carried out using IMOD with eTomo [5], while segmentation and morphological analysis was performed using ImageJ (with the BoneJ plugin) and Matlab [6].
Results & Conclusions	This work involves the study of several steps in the 3D reconstruction procedure in order to assess what improvements may be made. For a flame-generated (FG) soot agglomerate, the relative speed and quality of 3 different reconstruction algorithms, 6 different tilt series formulations, and 5 different levels tomogram segmentation are tested. The FG particle considered represents a case study that is towards the upper limits of reconstruction difficulty, as morphological complexity is high and contrast in the TEM images is low; we estimate that npo = 222, via 3D volume divided by the assumed spherical, 25nm diameter primary particle volume. Typically only 4.5% of the agglomerates sampled from diesel exhaust are composed of more than 200 primary particles [3]. In comparison to a typical procedure, our optimised methodology reduced the time required by over 70% and cut beam exposure by two thirds with no appreciable decrease in the quality of the produced 3D model. References: [1] K. Adachi, S.H. Chung, H. Friedrich, P.R. Buseck, Fractal parameters of individual soot particles determined using electron tomography: Implications for optical properties, J Geophys Res-Atmos 112(D14) (2007).

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[5] J.R. Kremer, D.N. Mastronarde, J.R. McIntosh, Computer visualization of three-dimensional image data using IMOD, J Struct Biol 116(1) (1996) 71-76.
[6] M. Doube, M.M. Klosowski, I. Arganda-Carreras, F.P. Cordelieres, R.P. Dougherty, J.S. Jackson, B. Schmid, J.R. Hutchinson, S.J. Shefelbine, BoneJ Free and extensible bone image analysis in ImageJ, Bone 47(6) (2010) 1076-1079.

Author CV:

Author: Ephraim Haffner-Staton obtained an MSci in Chemistry from the University of Nottingham in 2015. A Masters project under the supervision of Dr Robert Mokaya focussed on the production of highly porous activated carbon from wood, and started an interest in carbon nanostructures. He has since joined the Engines Research Group at the University of Nottingham as a PhD student under the supervision of Dr Antonino La Rocca, where he is working on the tomographic reconstruction of soot-in-oil nanoparticles from automotive engines.

Presenter: Dr Antonino La Rocca, PhD is Assistant Professor of Thermofluids and Member of Engine Research Group at the University of Nottingham. His expertise are in areas of combustion, performance and emissions for light duty spark ignition and diesel engines. He has a strong track record in experimental research in collaboration with industry related to diesel emissions and performance and published more than 65 papers. Recently awarded EPSRC grants and the EPSRC Impact Acceleration Account to accelerate uptake of fundamental science related to soot characterisation.

Höfert Norbert

Affiliation	VDI Verein Deutscher Ingenieure e.V., Düsseldorf (Germany)
Email	hoefert@vdi.de
Coauthors	Christoph Helsper

Publication title	*An Approach to a Harmonized Method for Monitoring the Particle Number Size Distribution of Ultrafine Particles in Ambient Air*
Publication type	Poster
Introduction & Background	There is a growing awareness of the significance of aerosol particles with diameters of D < 1 µm for human health as well as for their climatic impact. To assess air quality, it appears necessary to supplement gravimetrically determined mass concentrations such as PM10 or PM2.5 with a measurement of the particle number concentration or even the particle surface concentration. Since ultrafine particles with diameters of D < 0.1 µm make an almost insignificant contribution to the mass of atmospheric aerosol particles, they can best be detected with counting measuring methods of sufficient sensitivity.
Methodology	In 2008 two European standardization projects (Technical Specifications) on the two most relevant measurement techniques were initiated: Condensation Particle Counter (CPC) for determining the particle number concentration and Mobility Particle Size Spectrometer (MPSS) for determining the particle number size distribution. These Technical Specifications define performance characteristics and the associated minimum requirements that enable these instruments, together with a suitable sampling system, to be used in air quality monitoring networks and provide data of adequate accuracy. The knowledge and experience of scientific networks like WHO, EUSAAR and ACTRIS, and also national air monitoring networks (e.g. Saxony/Germany), including the calibration infrastructure, are considered in these projects. The first of these Technical Specifications dealing with the CPC (CEN/TS 16976) was ratified in June 2016 and subsequently published in the CEN member states. Manufacturers responded quickly and flexibly and marketed CPC instruments which met the requirements. The second Technical Specification dealing with the MPSS is expected to be finished in 2018. The state of the discussion concerning performance characteristics and minimum requirements for this instrument type as well as the necessary quality assurance and quality control procedures is presented in this paper.
Results & Conclusions	The Technical Specifications on CPC and MPSS measurement for ambient aerosol provide harmonized methods to describe air quality with respect to ultrafine particles. The discussion is still in progress if it is necessary and useful to implement limit values for the particle number concentration in ambient air and to set up the necessary quality monitoring infrastructure. The main counter-argument is that the results of long-term epidemiologic studies are still missing which demonstrate the evidence of human health effects with sufficient significance. If such results will be available once and limit values will be implemented the concept of air quality monitoring can then be based on already existing European Standards.
Author CV:	University: Chemistry at the University of Karlsruhe (Germany) 1979 - 1985 Diploma Thesis: Forschungszentrum Karlsruhe (Germany) 1985 PhD Thesis: Forschunsgzentrum Karlsruhe (Germany) 1986 - 1990 1990 - now: VDI Verein Deutscher Ingenieure e.V., Düsseldorf (Germany) VDI/DIN Commission on Air Pollution Prevention - Standards Committee

(national, European and International Standardization in the field of Air Quality)

	Holubcik Michal
Affiliation	University of Zilina, Faculty of Mechanical Engineering, Department of Power Engineering, Univerzitna 1, 010 26 Zilina, Slovakia
Email	michal.holubcik@fstroj.uniza.sk
Coauthors	Jozef Jandacka; Radovan Nosek
Publication title	*Particulate Matter Production of Small Heat Source Depending on the Bark Content in Wood Pellets*
Publication type	Poster
Introduction & Background	Biofuel in the form of wood pellets is used also in small heat sources. Due to the fact that there are not only pellets made from pure wood but also pellets with bark content, it is necessary to pay attention to the impact of bark on fuel combustion characteristics (performance, net calorific value). Bark content in pellets influences also the fuel quality. It has impact on such parameters as moisture content, ash content, ash fusion temperature, produced emissions and particulate matter (PM). High content of bark, which is frequently a component of burned pellets, results in more frequent maintenance of heat sources as bark contains more ash than bark less wood. Increased ash content also generates higher amount of particulate matter which belongs to the most harmful emissions discharged into the atmosphere. PM discharged from local heat sources in combination with the weather has recently led several times to smog situations having adverse impact on health and living conditions of people in a particular region. The work deals with the impact of bark content in wood biomass on PM production of small heat source.
Methodology	In the framework of experimental activities there were spruce wood pellets samples with 1 %, 2 %, 5 %, 10 % and 20 % content of bark. Samples were produced on an experimental device for biofuel pelleting. The combustion took place in a small heat source with a rated heat output of 18 kW which was tested on an experimental device designed for the measuring of heat output and emission production. The device is built from an experimental boiler, a heat consumption device, a gaseous emission analyser, a particulate matter analyser, measuring apparatus to which all measuring instruments are connected and a computer for the processing of measured data. Various parameters are recorded every 20 seconds. During the measurements constant chimney draft 12 ± 2 Pa via a flue fan is ensured. Particulate matter measurement was conducted by gravimetric method in accordance with the standard ISO 9096. All pellet samples with various bark content were burned at the same operating settings of the boiler.
Results & Conclusions	Based on the achieved results we can conclude that bark content in pellets has a significant impact not only on performance but also on environmental characteristics of pellets. Higher bark content in pellets increases ash content, which can adversely influence combustion process, mainly due to higher ash production during combustion and consequent necessity of more frequent boiler cleaning. The results showed that the PM production increased with growing bark content.
Images	
Author CV:	Michal Holubcik received the doctoral degree PhD. in field of study Energy machines and equipment in year 2013 at Department of Power Engineering at University of Žilina. He defended the thesis: Possibilities of increasing of ash melting temperature from biomass. Currently, he works as a research worker and he solves issues with use of renewably energy sources, especially

improving energy and mechanic parameters of biofuels, improving combustion process of biofuels, reducing emission production during solid fuels burning, energetic use of waste and micro-cogeneration.

Iojoiu Eduard Emil

Affiliation	Volvo Group Trucks Technology
Email	eduard.emil.iojoiu@volvo.com
Coauthors	V. Lauga; J. Abboud; G. Legros; A. Matynia; J. Bonnety; P. Da Costa; J. Schobing; A. Brillard; G. Leyssens; V. Tschamber; P. Anguita; J.M. Garcia-Vargas; L. Retailleau; S. Gil; A. Giroir-Fendler; M.-L. Tarot; F. Can; D. Duprez; X. Courtois
Publication title	*Biofuel Impact on Diesel Engine After-treatment: Deactivation Mechanisms and Soot Reactivity*
Publication type	Poster
Introduction & Background	The new emission standards empower the need of complex after-treatment systems for diesel engines, the durability being a crucial aspect. When biofuel is used, the after-treatment catalytic system is exposed to large amounts of poisons, the particles composition being as well impacted. The comprehension of the involved deactivation mechanisms as well as soot reactivity is a complex and multidisciplinary challenge.
Methodology	One focus was the study of the deactivation of the DOC and SCR catalysts through poisoning. Limited information is available about the physics and chemistry of the particles formed when biodiesel is used. The second focus was therefore devoted to the impact on soot reactivity in mechanistic and kinetic terms using model and real soot.
Results & Conclusions	The DOC was exposed to different poisoning elements specific to biofuel, the impact on catalytic performance being studied on each component as well as on combinations. K, Ca and Na have a negative impact on CO oxidation, whereas an improvement can be observed in presence of P. However, K, Ca and P poisoned catalysts enhance C3H6 conversion, while Na impurities have the contrary effect. All elements have shown a negative effect on NO oxidation, the reaction rate being lowered differently (Ca > Na > P > K). The impact of Na and P on the SCR activity of a Cu/FER catalyst was studied depending on the mineral loading (until ≈2wt%) and the solvent for the impregnation step (H2O or ethanol). Acidity was poisoned after Na addition which directly affected the NOx conversion at low temperature (250°C). Na impregnation in water led to a stronger catalyst deactivation than in ethanol, because water favors the migration of the Cu exchanged species, leading to the formation of CuO extra framework species. It appears that the deNOx efficiency at high temperature (500°C) is clearly related to the amount of active exchanged copper. Cu-P interactions were evidenced after phosphorus addition, leading to a decrease in redox behaviors (NO oxidation and NH3 oxidation) and consequently in the SCR activity (especially at low temperature and in Standard SCR condition). Again, lower deactivations were observed when the wet impregnations were performed in ethanol. The real soot samples were collected from filters operated on a medium-duty truck in real driving conditions or from engine bench using standard or 100% biofuel as well as doped biofuel. The use of biodiesel significantly reduces the soot formation, the soot loading decreasing with increasing part of biofuel. The real soot is smaller due to the added oxygenated compounds, containing more volatile fraction and ash. There is no significant impact of biodiesel on the soot specific surface, the higher value being obtained for an accelerated soot loading. No relationship between volatile fraction and real soot reactivity under passive regeneration conditions was also found. Adding alkali metals to the real Diesel soot enhances soot oxidative reactivity in the whole temperature range (200-600°C), regardless the cycle of production applied. Those species act as

catalyst for soot oxidation process. The kinetic of soot oxidation at low temperature (≤400 ° C.) is significantly increased in the presence of phosphorus. Particle size distribution and oxidative reactivity of model soot from the burner are in the same range as real soot derived from Diesel engine.

The authors gratefully acknowledge the French National Agency for Research for its financial support (Appibio Project, Ref. ANR-14-CE22-0003).

Author CV:

Dr. Eduard Emil IOJOIU
Diesel engine after-treatment technology specialist

Volvo Group Trucks Technology, Powertrain Engineering
Saint-Priest, France
TER G50 1 75
99 route de Lyon, 69800 Saint-Priest Cedex, France
Tel : +33 665 89 56 22
Mail : eduard.emil.iojoiu@volvo.com

Educational background:

2015: Habilitation
2001: Ph.D in chemistry (automotive catalysis)
1995: MSc. Anticorossion protection
1994: Chemical engineering

Profesional background:

2007 - : Volvo Group Trucks Technology (R&D Lyon, France): Technology specialist/ System engineer medium duty (diesel engine after-treament for medium duty applications)

2002 – 2007 : Scientist at CNRS, IRCELYON, Villeurbanne, France (environmental catalysis : waste water, biomass valorisation, automotive catalysis)

2002 : Scientist Fraunhofer ICT, Berghausen, Germany (nanostructured energetic materials)

1996 – 2001: PhD thesis Gh.Asachi University, Iasi, Romania (zeolites for SCR deNOx) with stages at University Karlsruhe TH, Germany (1998-1999) and University Claude Bernard Lyon1 (2000)

Jensen Thomas Nørregaard

Affiliation	Danish Technological Institute, Aarhus, Denmark
Email	tnje@teknologisk.dk
Coauthors	Peter B. Pedersen, Morten Køcks
Publication title	*Characterization of particle emissions from candles*
Publication type	Poster
Introduction & Background	All sorts of candles are being used in widely different situations and locations all over the world. New types of candles see the light of day every year, such as candles made of beeswax, mixes of traditional candle waxes and paraffin, vegetable waxes, animal fat based waxes etc. The growing awareness regarding particle emissions from various sources is increasing, demanding additional information and knowledge. In a study, particle emissions in 56 Danish homes were measured, and it was found, that in the homes where candles were used, candles were responsible for approx. 60% of the residential integrated exposure. This has resulted in an increasing demand for measurements on particle emissions from various candle types, such as square candles, tealight candles, candlestick candles and oil lamps. In the present work, particle emission from 32 different candles were measured as true duplicates, which means that measurements were carried out on 64 candles.
Methodology	Measurements were carried out in a climate room with temperature, air change and humidity control. Particle emissions have been measured using an SMPS (Scanning Mobility Particle Sizer), model 3080 from TSI, and CPC (Condensation Particle Counter), model 3776. The particles have been counted and size distributed in the size interval from 4.3 nm to 167 nm. Older equipment for particle sizing in the nano-range is often been limited down to 10-20 nm, giving an enormous bias in the results, as the main part of the particles emitted from candles are in the 5 nm to 25 nm range in size. Additionally, sampling on filter was performed for subsequent chemical analysis of emitted particles for content of lead and nickel. Sooting behaviour has been measured according to the well-established standard EN15426.
Results & Conclusions	In average, the particle emission from paraffin and wax was approximately 9 million particles/cm3, whereas the emission from stearin was about 19 million particles/cm3. Lead and nickel was identified in a few of the waxes and lead was identified in 26 out of the 32 different candles. This work is continued in a new and larger project where new candle types will be developed with the purpose of reducing particle emissions. It is expected that preliminary results from this project can be presented. The project is co-financed by the Danish EPA.
Author CV:	2015 – present Consultant, Danish Technological Institute, Aarhus, Denmark. Areas of interest are: Characterization of airborne particles, emission reducing technologies, online measurement technologies, and advanced spectroscopy for chemical identification

2010 – 2015
PhD nanoscience, Aarhus University, Denmark

2006 – 2012
M.Sc. nanoscience, Aarhus University, Denmark

Publications:
8 peer reviewed papers

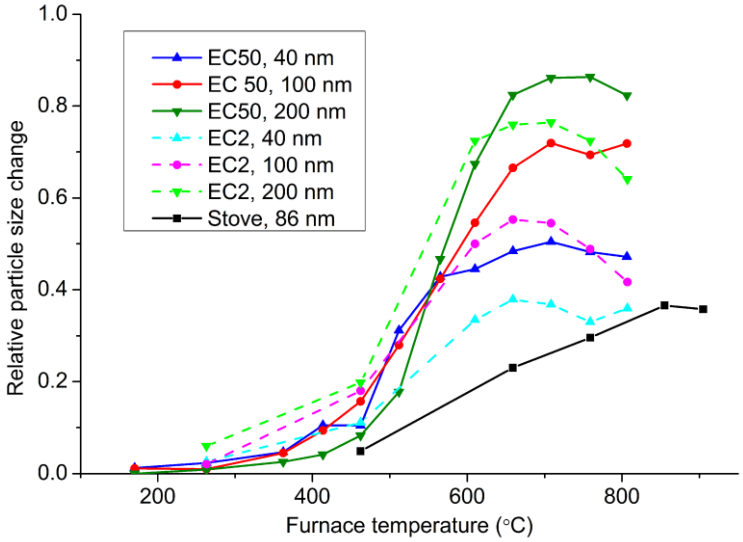
Presentations :
+10 conference posters and speaker at +5 scientific conferences/workshops.

Jokiniemi Jorma

Affiliation	Professor
Email	jorma.jokiniemi@uef.fi
Coauthors	Heikki Lamberg; Olli Sippula; Jorma Joutsensaari; Mika Ihalainen; Anna Lähde; Jarkko Tissari

Publication title	*Study of High-temperature Oxidation of Wood Combustion Particles Using Tandem Differential Mobility Analysis*
Publication type	Poster
Introduction & Background	Soot particles from combustion sources have significant environmental impact on human health and climate. One of the major sources of soot particles is small-scale wood combustion and there is an urgent need to develop methods to abate soot emissions from these appliances. In this work, we aimed to identify the temperature conditions required for the oxidation of wood combustion particles by using a tandem differential mobility analyzer with a high temperature reactor.
Methodology	The oxidation behavior of the particles was studied with a wood stove and a pellet boiler. The pellet boiler was operated both in normal and deteriorated combustion procedure. The change of particle size and concentration were measured after the high-temperature reactor of both size-classified and unclassified particles. Furthermore, electron microscopy and chemical analyses, combined with thermodynamic equilibrium calculations, were carried out for interpreting the effect of ash species in the observed particle shrinking at various temperatures. Finally, kinetic parameters for assessing wood combustion soot oxidation in conditions representing post-combustion zone of small appliances were derived.
Results & Conclusions	Wood combustion particles were shrinking already below 500 °C according to the measured particle mobility size, most likely related to evaporation of KCl. The main change in particle size was seen between 510 °C and 660 °C with classified pellet combustion particles, and the smallest particle size was repeatedly seen at 710 °C (Figure 1). The wood stove particles oxidized at slower rate compared to pellet combustion particles and they reached their minimum at 810 °C. Electron microscope images revealed that deteriorated combustion pellet particles (100 nm and 200 nm) contained alkali species and soot agglomerates in room temperature and 460 °C. At 710 °C, the 100 nm agglomerates, mostly soot, were removed by oxidation, while the 200 nm soot agglomerates were not fully oxidized. At 860 °C, only spherical zinc containing core particles were left in the samples of 100 nm and 200 nm particles. The 40 nm pellet combustion particles did not contain soot agglomerates and the changes in their sizes were due to evaporation of inorganic species. The relative size decrease was the greatest with 200 nm particles from deteriorated pellet combustion, followed by the 100 nm. Pellet combustion particles were rich of inorganic species, which affected the decrease of particle size in two separate ways; they evaporate easily in high temperature conditions and catalyze the soot particle oxidation. The wood combustion particle oxidation was found to take place at lower temperatures compared with previously studied diesel combustion particles. The results are important for the development of strategies and technologies to abate soot emissions from small-scale wood-fired combustion appliances.

Caption Figure 1:



Relative change of particle diameter in different temperatures.

Author CV:

Prof. Jorma Jokiniemi (M) is the director of the Fine Particle and Aerosol Technology Laboratory (FINE) at University of Eastern Finland, Department of Environmental and Biological Sciences. He has 172 peer reviewed journal publications (h-index 29), 8 national and 4 international patents. He has supervised 18 Ph.D. theses (6 on-going) and given over 20 international invited talks. The research topics of Jorma Jokiniemi cover fine and nanoparticle particle measurements, combustion emissions, nanoparticle/nanomaterial synthesis, and modelling aerosol dynamics.

Kelesidis Georgios A.

Affiliation	ETH Zürich
Email	gkelesidis@ptl.mavt.ethz.ch
Coauthors	Eirini Goudeli; Sotiris E. Pratsinis

Publication title	*Agglomerate Structure and Size Distribution in the Transition Regime: The Effect of Primary Particle Polydispersity*
Publication type	Poster
Introduction & Background	In combustion engines operating at high pressures (Musculus et al., 2013) or flames quenched at low temperatures, such as the Cast generator, soot agglomeration takes place in the transition regime. The agglomeration dynamics in these conditions are dependent on the width of the primary particle (PP) size distribution, induced by the different residence times and equivalence ratios experienced by soot aggregates (Dastanpour et al., 2014).
Methodology	Here, an event-driven method for agglomeration of polydisperse primary particles in the free molecular regime is extended to investigate the agglomerate morphology and size distribution in the transition regime. Spherical primary particles (PPs) having a lognormal size distribution with geometric standard deviation, $\sigma_{g,p}$, of 1-3 are randomly distributed in a cubic simulation box. Their ballistic or diffusive trajectories are calculated using the Stokes friction coefficient with the Cunningham correction factor describing the drag force from the free molecular to the transition regime (Goudeli et al., 2015). The particles stick in point contact upon collision forming a new agglomerate.
Results & Conclusions	Agglomerate morphology becomes more compact as the primary particle size distribution broadens and leads to larger fractal dimension, Df, and mass-mobility exponent, Dfm, similarly to agglomerates made in the free molecular regime (Goudeli et al., 2016). The fractal, kf, and mass-mobility prefactors, kfm, increase up to 30 and 6, respectively, for $\sigma_{g,p} = 3$, indicating that agglomerates become more symmetric for larger PP polydispersity (Heinson et al., 2010). The attainment of the asymptotic Df = 1.91 and Dfm = 2.15 is delayed with increasing PP polydispersity. The difference between the agglomerate mobility radius, rm, and radius of gyration, rg, is enhanced by PP polydispersity, as rm becomes 2.5 times larger than rg for $\sigma_{g,p} = 3$. Broader gyration- and mobility-based size distributions are attained for larger $\sigma_{g,p}$ in both the free molecular and the transition regime. For large residence times, a quasi-self-preserving size distribution is attained in the transition regime characterized by gyration-, $\sigma_{g,g}$, and mobility-based geometric standard deviations, $\sigma_{g,m}$, of 1.62 ± 0.02 and 1.48 ± 0.03, respectively, regardless of $\sigma_{g,p}$. The dimensionless mobility-based quasi-self-preserving size distribution is in excellent agreement with soot size distributions measured from propane diffusion flames quenched at low heights above the burner (Rissler et al., 2013).
Author CV:	Georgios A. Kelesidis is a PhD student at the Particle Technology Laboratory of Prof. S.E. Pratsinis at ETH Zürich. He has obtained his Diploma in Chemical Engineering from University of Patras, Greece in 2013. He then accomplished the Master of Science in Process Engineering from ETH Zürich, Switzerland in 2015.

Kelesidis Georgios A.

Affiliation	ETH Zürich
Email	gkelesidis@ptl.mavt.ethz.ch
Coauthors	Joel Zürcher; Sotiris E. Pratsinis

Publication title	*Optical Properties of Nascent and Mature Soot Aggregates Growing by Agglomeration & Surface Growth*
Publication type	Poster
Introduction & Background	Soot optical properties are typically approximated with the well-known and relatively easy-to-use Mie theory for spheres, neglecting the fractal-like nature of soot. The Rayleigh-Debye-Gans (RDG) theory for agglomerates consisting of primary particles in point contact has been applied alternatively, resulting in better agreement with optical measurements (Loepfe et al., 2014). However, it is unable to resolve the effect of overlapping soot primary particles typically observed in microscopic images of soot. The robust Discrete Dipole Approximation (DDA) has been validated against RDG for the case of agglomerates (Liu et al., 2008) and can also be used for aggregates of chemically-bonded primary particles.
Methodology	Here, the Discrete Element Model (DEM) for agglomeration and surface growth by acetylene pyrolysis in the absence of oxidation (Kelesidis et al., 2017) is used to derive the evolution from nascent to mature soot morphology, quantified by the fractal dimension, Df, and mass-mobility exponent, Dfm.
Results & Conclusions	The good agreement found between the DEM-derived Df and Dfm evolutions and microscopy (Schenk et al., 2013) and mass-mobility measurements (Rissler et al., 2013; Yon et al., 2015), respectively, indicates that the present DEM for agglomeration and surface growth accurately captures the transition from nascent to mature soot morphology by agglomeration and surface growth, before oxidation takes over. The DEM-derived soot aggregate optical properties are quantified by the absorption, Cabs, and extinction cross-sections, Cext, calculated by DDA and compared to those of agglomerates having monodisperse primary particles. The DDA calculations for agglomerates are validated against those of Liu et al. (2008). Nascent soot aggregates formed in the early stages of soot formation, when surface growth is dominant, have to 86 % larger Cext and Cabs for mass, m = 0.002 fg compared to agglomerates formed at the same residence time in the absence of surface growth. At longer residence times, however, when surface growth has stopped and mature soot grows primarily by agglomeration, the difference between aggregates and agglomerates decreases to about 1 % for both Cext and Cabs. The DEM-derived mature soot Cext obtained as function of the incident light wavelength is in fair agreement with Laser Induced Incadescence measurements from diesel engines (Yon et al., 2011). The ratio of Cabs estimated at 532 nm over that estimated at 1064 nm is 1.79, in excellent agreement with the asymptotic ratio of 1.8 measured from mature soot aggregates in diffusion flames (Xerxes et al., 2014).
Author CV:	Georgios A. Kelesidis is a PhD student at the Particle Technology Laboratory of Prof. S.E. Pratsinis at ETH Zürich. He has obtained his Diploma in Chemical Engineering from University of Patras, Greece in 2013. He then accomplished the Master of Science in Process Engineering from ETH Zürich, Switzerland in 2015.

	Keller Alejandro
Affiliation	University of Applied Sciences Northwestern Switzerland
Email	alejandro.keller@fhnw.ch
Coauthors	Heinz Burtscher; Pierre Comte; Jan Czerwinsk; Maria Muñoz; Adrian Wichser; Norbert Heeb; Simone Piebers; Nivedita Kumar; Andre Prévot

Publication title	*High Time-resolved SOA-formation Potential of Emissions from GDI engines*
Publication type	Poster
Introduction & Background	In the decades to come, we will be exposed to exhausts of gasoline direct injection (GDI) vehicles with yet unknown consequences. The GASOMEP (Current Status and New Concepts of Gasoline Vehicle Emission Control for Organic, Metallic and Particulate Non-Legislative Pollutants) project investigates the emission characteristics of various GDI vehicles. Among aspects covered by GASOMEP is the secondary organic aerosol (SOA) forming potential from GDIs. This is being investigated with smog chamber experiments, executed by PSI Switzerland, and two independent oxidation flow reactors (the Potential Aerosol Mass, PAM, chamber and the Micro Smog Chamber, MSC). The advantage of the flow reactor approach, and in particular of the MSC, is that the fast time resolution data can be paired with real-time vehicle data to establish a real cycle average emission factor. These experiments cannot be performed from a CVS sample since the dilution air of a CVS already has a high secondary aerosol forming potential.
Methodology	The MSC (Keller and Burtscher 2012) exposes emissions to high intensity UV light to achieve photochemical aging within 10 seconds. During GASOMEP, we chose to perform experiments with the MSC on the gas-phase of the emissions in order to measure exclusively the formation of SOA without interference from primary particulate matter. In absence of seed aerosol, SOA condenses as nucleation mode particles. Steady state data is used to establish an average size distribution of the these particles, which is then combined with fast number concentration information from a CPC to establish a seconds-resolved emission factor during transient cycles.
Results & Conclusions	For most of the driving cycle, the secondary aerosol production remained mostly under 10 mg/lt-fuel. However, intervals with emissions as high as 300 mg/lt-fuel were observed during cold start operation of some vehicles. Average emission factors of the order of 0.1 mg/km were observed for the world-wide light duty test cycle (WLTC). All the studied vehicles presented increased emission of gas phase hydrocarbons during cold start. However, our measurements show that it cannot be generalized that the cold start causes the highest SOA potential. This may be explained by variations of the chemical composition of the gas-phase hydrocarbons caused by the use of different fuels (gasoline vs gasoline-ethanol blends) and/or differences in engine and after-treatment technologies (our flote included EURO 3, EURO 4, and EURO 5 vehicles). Previous measurements performed on wood-burning appliances show that few hydrocarbon molecules may be responsible for most of the SOA (Burns et al. 2016; Keller and Burtscher 2017). This research was supported by the Competence Center Energy and Mobility (CCEM) from the ETH Zurich.

Author CV:	Alejandro Keller studied physics engineering at the Iberoamericana University in Mexico City. He joined the group of Prof. Hans-Christoph Siegmann at the ETH Zurich, where he worked in the field of aerosol science, and was awarded with a doctoral degree in 2001. Alejandro works as a research scientist at the Institute for Aerosol and Sensor Technology of the University of Applied Sciences and Arts Northwestern Switzerland.

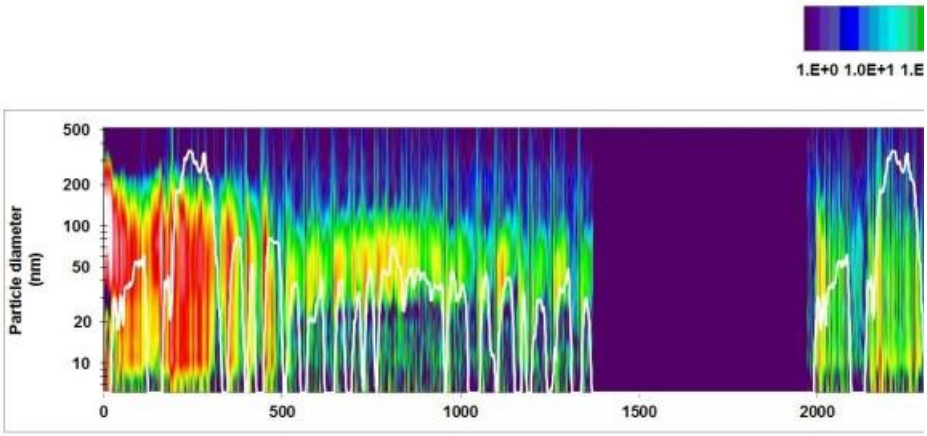
Kim Kangjin

Affiliation	University Korea
Email	attackkk@korea.ac.kr
Coauthors	Dongyoung Jin; Cha-Lee Myung; Youngjae Lee; Simsoo Park

Publication title	*Size-resolved Nanoparticle and Hazardous Air Pollutants (HAPs) Emissions Characteristics with Low-, Medium-, and High-proportion of Ethanol Contents Fuels from a Direct Injection Spark Ignition (DISI) Vehicle*
Publication type	Poster
Introduction & Background	The enforcement of more stringent worldwide vehicle emissions legislations and fuel economy standards has motivated the reduction of hazardous air pollutants (HAPs) emissions and developing energy-efficient engines. Particle number (PN) from gasoline direct injection (GDI) engines are produced under transient vehicle running conditions of low coolant temperature and aggressive acceleration phases mainly due to the wall wetting and fuel pool formation in combustion chamber. Several studies showed that PN formation from engines can be substantially reduced via a combination of engine hardware modifications, precise air-fuel mixture control, and sophisticated engine control strategies during transient phases. Ethanol as an automotive fuel presents several advantages on PN and HAPs emissions because of clean combustion characteristics of oxygenated fuels. Ethanol flexible fuel vehicles (FFVs), which are intended to be used with E0 to E85 fuel, were widely propagated in the Brazilian, European Union (EU) and United States (US) automotive markets. The goal of our study is to compare the regulated, PN, and unregulated toxic emissions from a GDI vehicle operating under fuels of various ethanol contents (E0, E10, E30, E50, E85).
Methodology	- Engine specifications and Vehicle test mode: A 2.4L wall-guided GDI engine with three-way catalytic converters (TWCs) combined with a double split injection (DSI) strategy were applied for cold phase of the FTP-75 cycle Fuel preparation: Different ethanol volume fractions have been manufactured, consisting of 10%, 30%, 50% and 85% in commercial gasoline Engine calibration: The target lambda (λ) values and fuel injection quantity of all ethanol-blended formulations were modified for cold-start, lambda closed-loop control region, and transient conditions using base gasoline mapping data (non-FFV ECU). Test Equipment: A 48-inch single roll chassis dynamometer (AVL, M4500) and gaseous emissions analyzer (Horiba, MEXA-7200H) were employed. The PN concentration was analyzed with a TSI condensation particle counter (CPC) 3790A. Engine particle sizer (EEPS) 3090 spectrometer was used to determine the size-resolved particle distribution. The carbonyl compounds were analyzed with the high-performance liquid chromatography (HPLC, Waters, ACQUITY UPLC) system. The volatile organic compounds (VOCs) were determined by a gas chromatography-mass spectroscopy (GC-MS) selective detector (Agilent, HP6890-HP5973N). Also, real-time individual HCs (IHCs) and alcohols were analyzed with a Fourier transform infrared (FTIR, SESAM FTIR).
Results & Conclusions	In this study, impact of various gasoline-ethanol blending ratio of E0-E85 fuels on regulated, particle, and unregulated gaseous emissions characteristics from a DISI vehicle was investigated. The PN values were reduced from 1.62×1012 N/km (E0) to 1.37×1012 N/km (E10), 5.89×1011 N/km (E30), 2.50×1011 N/km (E50), and 1.40×1011 N/km (E85). Adoption of ethanol-blended fuels above 30% in SIDI engines has the potential to meet stringent worldwide emissions regulations by an increase in

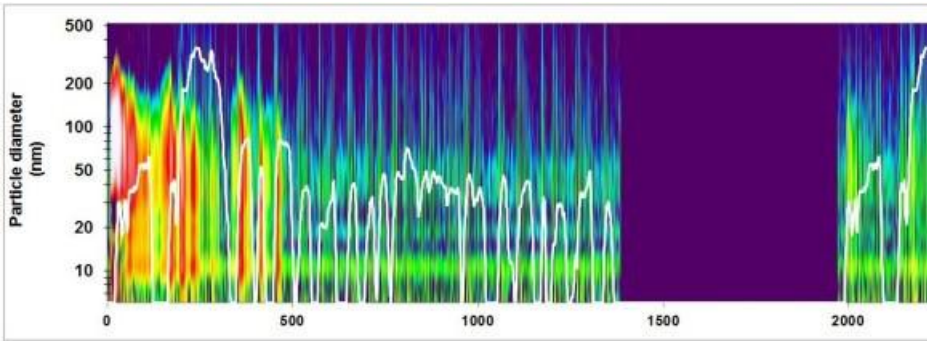
oxygen content and lighter HCs. The size-resolved PN concentrations decreased, and the fraction of sub-23 nm particles occupied more of the PN concentration with growing ethanol contents over each phase of the FTP-75 mode. From the FTIR and GC/MSD emissions analysis, hazardous chemicals such as acetaldehyde, formaldehyde, and ethylene produced by partial oxidation and incomplete combustion of ethanol, resulted in much higher emission than those from E0 fuel

Caption Figure 1:



Real-time particle concentration and size distributions with ethanol-gasoline blended fuels (E0)

Caption Figure 2:



Real-time particle concentration and size distributions with ethanol-gasoline blended fuels (E85)

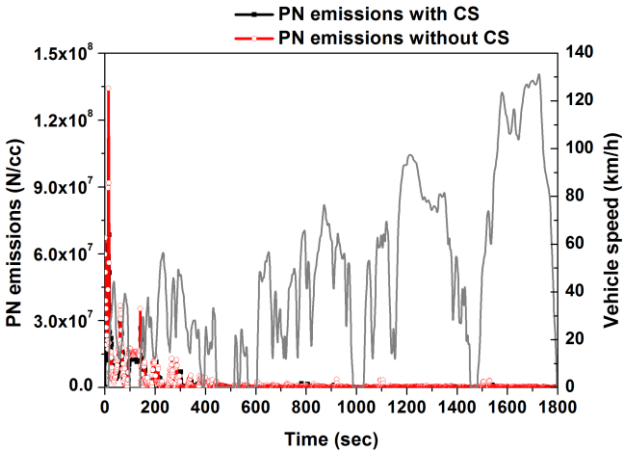
Author CV:

1) (1st Author) Kangjin Kim. He is currently doctorate course in school of mechanical engineering at Korea University.
2) (Academic Advisor) Simsoo Park. He received his B.S. and M.S. degrees from Seoul National University and a Ph.D. from the State University of New York at Stony Brook. He served as a Chief Research Engineer at Hyundai Motor Company and a Technical Advisor of Hyundai-Kia Motor Company. He was an Editor-in-Chief of IJAT at KSAE and President of KSAE. He is currently a professor in school of mechanical engineering at Korea University.

	Ko Jinyoung
Affiliation	University Korea
Email	gojin88@korea.ac.kr
Coauthors	Seonghoon Kim; Cha-Lee Myung; Simsoo Park

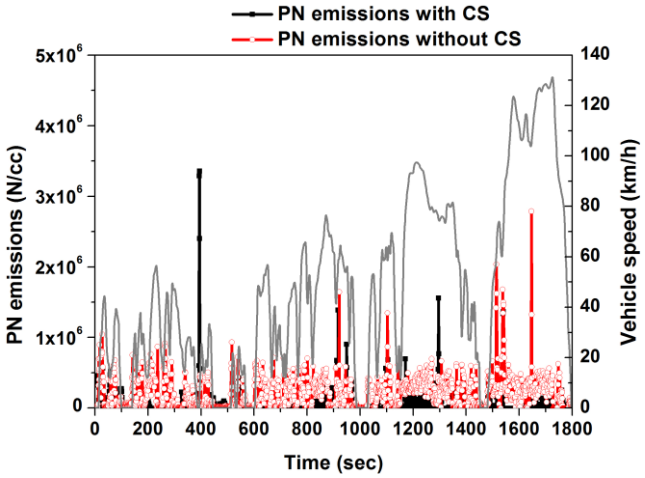
Publication title	*Impact of Catalytic Stripper (CS) on the Characteristics of Particle Number (PN) Emissions from a GDI Vehicle over the World-harmonized light-duty Vehicle Test Cycle (WLTC)*
Publication type	Poster
Introduction & Background	As global warming becomes a serious problem throughout the world, lower CO2 emissions have been required. In case of gasoline vehicles, gasoline direct injection (GDI) engines have come into wide use owing to lower fuel consumption. However, direct injection technology causes further partially fuel-rich zones, incomplete combustion, and wall wetting to piston compared with port fuel injection (PFI), which leads to increased particle number (PN) emissions. In the European Union, the regulation of vehicular emissions has continued to become more stringent. Subsequently, World-harmonized light-duty vehicle test cycle (WLTC), which includes higher loads and velocity distributions than the new European driving cycle (NEDC), will be introduced to emission regulations in 2017. From September 2017, PN emissions of gasoline vehicles should be lower than 6.0 x 1011 N/km over WLTC. Moreover, PN emissions of gasoline vehicles have to be lower than 9.0 x 1011 N/km (conformity factor = 1.5) during real driving emissions (RDE) test which includes cold start phase. As volatile particles were required to be separated from solid particles, there is much attention towards the use of catalytic stripper (CS) while measuring PN emissions. Consequently, the purpose of this research is to evaluate the characteristics of PN emissions for a GDI vehicle over WLTC with or without CS.
Methodology	A vehicle used in this study featured a 2.4L in-line 4 wall guided GDI engine with a compression ratio of 11.3: 1 and under floor type of three-way catalytic converter (TWCs) as an after-treatment system. Regulated emissions and particle emissions were measured over the WLTC at the cold start and hot start with or without CS. Regulated emissions from constant volume sampler (CVS) exhaust dilution tunnel system were measured using exhaust gas analyzer (AMA i60). The PN emissions were measured 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. The catalytic stripper (Pegasor catalytic stripper) used in this research operated at the 300 ℃ to remove the volatile particles.
Results & Conclusions	Observing the effect of catalytic stripper on the total PN emissions over WLTC at the cold start, the total PN emissions were 1.10 x 1012 N/km with CS and 1.50 x 1012 N/km without CS. The 27 % of PN emissions at the cold start were volatile particles which were removed by the CS. In the case of hot start, the total PN emissions were 3.35 x 1010 N/km with CS and 1.49 x 1011 N/km without CS. It is assumed that the 23 % of PN emissions at the hot start were solid particles. Examining the effect of cold start and hot start on the total emissions over WLTC, PN emissions at the hot start decreased up to 90 - 97 % compared to them at the cold start. The results of this research will offer some insight into the characteristics of PN emissions for forthcoming emission regulation depending on start condition and usage of CS.

Caption Figure 1:



Time-resolved particle emissions over WLTC at the cold start with or without CS.

Caption Figure 2:



Time-resolved particle emissions over WLTC at the hot start with or without CS.

Author CV:

1) (1st Author) Jinyoung Ko. He is currently doctorate course in school of mechanical engineering at Korea University
2) (Academic Advisor) Simsoo Park. He received his B.S. and M.S. degrees from Seoul National University and a Ph.D. from the State University of New York at Stony Brook. He served as a Chief Research Engineer at Hyundai Motor Company and a Technical Advisor of Hyundai-Kia Motor Company. He was an Editor-in-Chief of IJAT at KSAE and President of KSAE. He is currently a professor in school of mechanical engineering at Korea University

	Koczak Justin
Affiliation	University of Michigan
Email	jskoczak@umich.edu
Coauthors	Andre Boehman; Matthew Brusstar; Frank Ruiz

Publication title	*Morphology and Nanostructure of Size-Selected Ultrafine Particles Emitted by a Gasoline Direct Injection Engine*
Publication type	Poster
Introduction & Background	A number of researchers have shown that modern GDI engines emit very large numbers of particles, particularly with sizes less than 100 nm, despite having low mass emissions. Particle number reduction (via filtration or specialized engine calibrations) is a highly sought after goal in light of upcoming regulations. However, in just considering the number or mass of the particles, a large wealth of information is ignored, including particle morphology, structure, and chemical composition. Additionally, all particles classified into a particular size or size range do not necessarily have the same (or even similar) properties. It will therefore be useful for health effects research, filtration studies, secondary aerosol formation research, and even regulation development to understand the size dependence of the aforementioned properties that are often overlooked. This work seeks to shed light on this area by considering specific sizes of ultra fine particles emitted by GDI engines, and examining their properties. The vehicle for exploring these properties is the variation of fuel injection parameters (e.g., number of injections, injection pressure, apportioning of fuel into different injections, and the timing of the various injections), which is one technique that offers promise in the near future for improving combustion, much in the same way as it has for diesel engines in the past.
Methodology	This study (part of a larger Ph.D. project) only considered physical characteristics. A matrix of twelve test points was created examining two injection pressures for three different triple fuel injection strategies, each at two different loads. A single-cylinder research engine consisting of an FEV Systemmotor crankcase coupled to a 1.6L SGDI Ford EcoBoost cylinder head was used. Combustion phasing, engine speed, and global equivalence ratio were held constant for the studies. The fuel was E0 Tier II EPA certification gasoline. Particles were obtained by using a custom-built two stage ejector pump dilution system. The first stage was heated, while the second stage was at ambient temperature. Air was used as the diluent, after having been prepared with a 3-stage filtration system. Size distributions were obtained with a TSI SMPS system (3080 classifier and 3776 CPC). To obtain specific size cuts, first a full size distribution was taken for a particular condition. Five cut points were selected from this distribution, being the mode and four steps of 30 nm above and below the mode (e.g., for a mode of 100 nm, this would mean cuts at 40 nm, 70 nm, 100 nm, 130 nm, and 160 nm). The cuts were taken using the 3080 classifier (with 3081 DMA), and sampled onto TEM grids using a Naneos Partector TEM sampler. This instrument also gave surface area information. The collected particles were imaged in a JEOL 3011 HRTEM, and the images were processed using propriety codes. Both low resolution and high resolution studies were conducted (i.e., the above process was repeated twice, once for each level of resolution), to understand the morphology and nanostructure, respectively, of the collected particles.
Results & Conclusions	The vast majority of particles collected were aggregates. For the smaller sizes, singlets, doublets, and triples were observed. Across all operating conditions, and in the sizes examined for each of the conditions, the

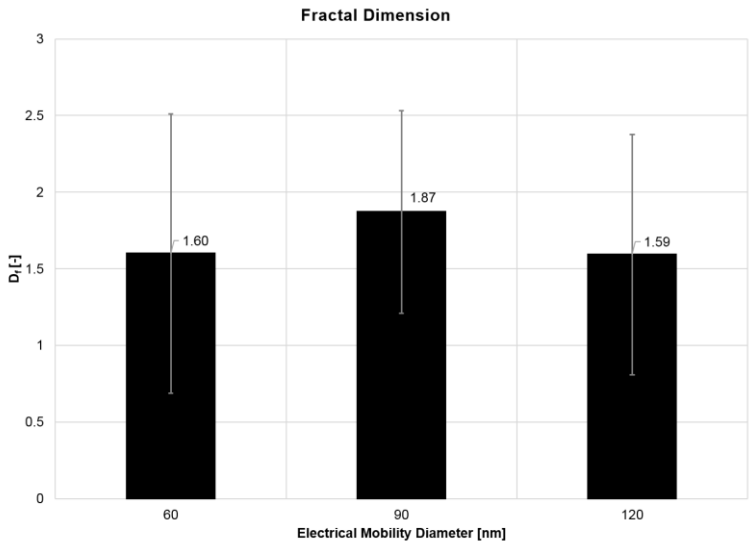
morphology of the particles varied widely. Many particles were long aggregates with fractal dimensions closer to one, while others were collapsed aggregates with fractal dimensions closer to three. Primary particle diameters and quantity per aggregate varied widely. Higher load conditions producer more particles, but high injection pressure reduced concentrations, which agrees well with the wide variety of papers published on this subject. A great deal of variability was observed to occur in the analyzed results, but this is partly a consequence of some images not being well-suited for image analysis, a limited sample size (although at least 25 images were taken for each sample), and the limitations of the image analysis code. As of this abstract writing, the author is still analyzing high resolution images, so for now, the comments on high resolution results will be left out (they will be addressed at the conference in June). It is expected that features such as fringe length, fringe spacing, tortuosity, and other results for non-amorphous primary particles will be available and will be discussed.

Caption Figure 1:

Image not found or type unknown

An example selection of particles, each with 90 nm electrical mobility diameter. The magnification is 40 kX for all images.

Caption Figure 2:



An example comparison of fractal dimension for different sizes at a particular operating condition.

Author CV:

1) (1st Author) Kangjin Kim. He is currently doctorate course in school of mechanical engineering at Korea University
2) (Academic Advisor) Simsoo Park. He received his B.S. and M.S. degrees from Seoul National University and a Ph.D. from the State University of New York at Stony Brook. He served as a Chief Research Engineer at Hyundai Motor Company and a Technical Advisor of Hyundai-Kia Motor Company. He was an Editor-in-Chief of IJAT at KSAE and President of KSAE. He is currently a professor in school of mechanical engineering at Korea University.

	Køcks Morten
Affiliation	Danish Technological Institute
Email	mly@dti.dk
Coauthors	Thomas N. Jensen, Jesper N. Holm, Jacob B. Jeppesen

Publication title	*Shipboard characterization of a combined particle filter and SCR system: Influence on particle number concentration, particle size distribution and gas emissions*
Publication type	Poster
Introduction & Background	Particle and gas emissions from diesel engines have profound impact on human health and as result; emissions from marine engines are under scrutiny. Although regulations on NOX emissions from ships have been implemented and sulphur content in marine fuel is limited to 0.1% in emission control areas (ECAs), and globally limited to 0.5% in 2020, emissions from ship traffic is still a much-debated subject. Particle emissions are today unregulated but expected regulated in the future. Thus, different mitigation strategies are being exploited including implementation of emission reducing technologies such as particle filters, SCR catalysts and scrubbers. In this study emission data from a Danish inland ferry with a retrofitted, integrated particle filter and SCR system (Dinex F-SCR) is presented. All measurements were carried out on-board the Danish inland ferry connecting the island of Ærø with Fyn. The ferry has two main engines (MaK M20C, 1020 kW 4-stroke diesel engine) both of them running on marine diesel, in which the sulphur content is limited to 0.1%.
Methodology	The emission was characterized at 4 points of engine load: Idle, 50%, 85% and 100% MCR, and measured according to the ISO 8178 steady state method. Nanoparticle size distribution and number concentration was measured using a scanning mobility particle sizer (SMPS) (TSI) in connection with a rotating disc dilutor (Testo) and further connected with a catalytic stripper (Catalytic Instruments) for measuring the solid particle fraction. Gas emissions (CO2, CO, HC and NOx) was measured using standard laboratory gas analyzer equipment as well as a Thermo Scientific Antaris IGS FTIR analyzer.
Results & Conclusions	Particle number concentration was in average reduced by more than 90 % by the filter – similar findings as compared to the previously installed filter without catalytic coating. The mean particle size was largest with the ferry operating in idle in the harbour during load and unload, and between 50 and 200 nm during all four engine loads tested. A NOx-reduction of at least 40% was measured when the system was put into operation. However, the efficiency of the filter dropped significantly during the day, probably due to soot contamination of the filter catalyst material. This shows that the efficiency might be even higher early in the morning during the first crossing. A solution for this problem might be more frequent regeneration. In conclusion, the installed particle filter in average reduced the particle emission with minimum 90% by number, measured in real-time during operation. The expected reduction was 99 % and the difference is very likely due to leaky bypass valves in the exhaust gas system. The NOx reduction was about 40% and the actual NOx level measured after the filter was below the IMO TIER II regulation for ships and comparable to the

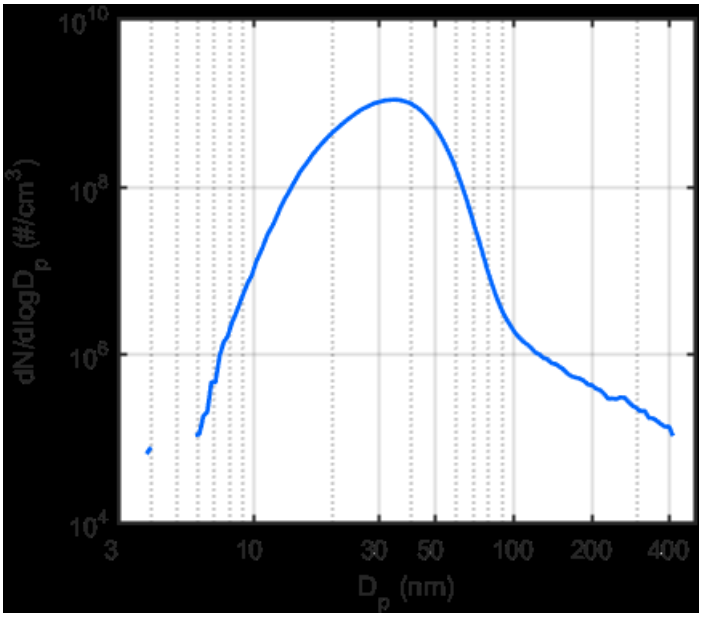
	EURO III norm for on-road heavy-duty diesel engines. The visible smoke from the vessel's funnel, which is typically seen while manoeuvring in the harbour, is also reduced to a minimum. Following this work, a larger Danish project, also co-financed by the Danish EPA, has just been initiated (2017-2020) where three different particle/NOx-reducing technologies will be tested on three different ship engines.
Author CV:	2009 – present Senior Specialist, Danish Technological Institute, Aarhus, Denmark. Areas of interest are: Characterization of airborne particles, emission reducing technologies, online measurement technologies, and advanced spectroscopy for chemical characterization 2003 – 2008 M.Sc. physics, Aarhus University, Denmark Publications: 10 peer reviewed papers Presentations : +10 conference posters and speaker at +5 scientific conferences/workshops.

Kuittinen Niina

Affiliation	Tampere University of Technology
Email	niina.kuittinen@tut.fi
Coauthors	Panu Karjalainen; Päivi Aakko-Saksa; Hilkka Timonen; Pauli Simonen; Fanni Mylläri; Hugo Wihersaari; Jorma Keskinen; Topi Rönkkö
Publication title	*Number and Characteristics of Particles Emitted from a Marine Engine Using Different Fuels*
Publication type	Poster
Introduction & Background	Annual primary particulate matter (PM) emissions of 1.7 Tg from international shipping have been evaluated to be in the order of PM emissions from road traffic (2.1 Tg) (Eyring et al., J. Geophys. Res., 110, D17305, 2010). The particulate emissions originated from shipping contribute to impaired air quality and have been estimated to cause 60 000 pulmonary and lung cancer deaths annually (Corbett et al., Envir. Sci. Tech., 41, 8512-8518, 2007). PM emissions from international shipping are not directly regulated but limits on SO2 emissions are expected to have a reducing effect. In sulphur emission control areas and EU ports, the maximum fuel sulphur content (FSC) has been limited to 0.1% and the FSC allowed globally will be narrowed to 0.5% in 2020. Diesel engines typically emit particles that can be seen in the particle size distribution as one, two or three separate modes. Soot mode particles consist of agglomerates that can have volatile condensates on them. Nucleation mode particles in ship emissions usually consist of volatile compounds such as water, sulphur compounds and hydrocarbons but can include fuel ash components and soot spherules (eg. Fridell et al., Atmos. Environ., 42, 1160-1168, 2008). In previous studies, marine engines have been observed to produce a pronounced nucleation mode under 50 nm in size (eg. Kasper et al., Aerosol Sci. Tech., 41, 24-32, 2007; Hallquist et al., Envir. Sci. Tech., 47,773-780, 2013).
Methodology	In this study (Kuittinen et al., manuscript in prep.), the number and characteristics of particles emitted from a marine engine were studied with four alternative fuels. Particle number and size distributions were measured from a 1.6 MW test-bed marine diesel engine. Two steady load conditions, 75% and 25%, were chosen, corresponding to typical operation conditions at open sea and near harbour, respectively. Measurements were conducted with four fuels that included marine diesel oil (0.1% S), intermediate fuel oil (0.5% S), heavy fuel oil (2.5% S) and a blend of biofuel and distillate oil in ratio of 30:70. The exhaust sample was diluted using a porous tube diluter followed by a residence time chamber. The primary dilution ratio was set to 12 and the sample was further diluted with an ejector diluter with a nominal dilution ratio of 8. In part of the measurements, thermodenuder or catalytic stripper (Amanatidis et al., J. Aerosol Sci., 57, 144-155, 2013) were applied to examine particle volatility. Particle number and size distributions were measured using CPC (Airmodus A20), SMPS (TSI Inc.) and NanoSMPS (TSI Inc.).
Results & Conclusions	The measured particle number size distributions showed distinct nucleation modes with particle diameters in the ultra-fine size range and concentrations two to three orders of magnitude higher than for the soot mode particles. The size distributions were generally bi-modal, but for the heavy fuel oil, tri-modal distribution was observed. Modal number emission factors were calculated by fitting lognormal distributions into the measured data. In general, the choice of fuel seems to have only a modest effect on the total number emission factors. The emitted particles included a high

share of volatile compounds but did not completely evaporate during thermal treatment.

Caption Figure 1:



Example of particle number size distribution at 75% load condition.

Author CV:

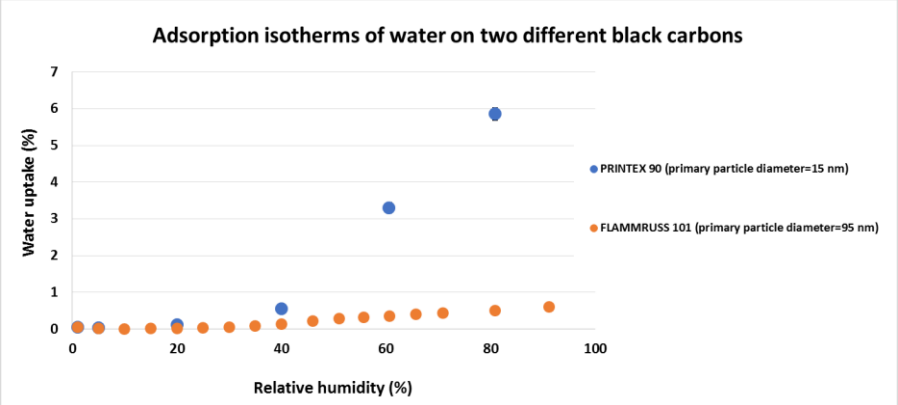
Niina Kuittinen is a doctoral student in the Emission Group of Aerosol Physics laboratory at Tampere University of Technology, Finland. She started in the group as research assistant in 2015 and completed her M.Sc. in Environmental and Energy Technology during 2016. Her diploma work concerned characterization of particle emissions from a marine engine and after graduation she proceeded to doctoral studies within the topic of climatic and air quality effects of particles emitted from marine engines. While working in the laboratory, she has participated in emission studies on gas and marine engines.

	Lintis Laura
Affiliation	Institut de Radioprotection et de Sûreté Nucléaire
Email	laura.lintis@irsn.fr
Coauthors	Vallières C. ; Coppalle A. ; Salm F. ; Ouf F.-X

Publication title	*Water Sorption Phenomenon on Solid Particles Emitted during a Fire: Identification of the Influencing Physico-chemical Parameters*
Publication type	Poster
Introduction & Background	Fire is the most likely hazard in a nuclear facility and can lead to production of radioactive particles and soot. Understanding and predicting the behavior of the HEPA (High Efficiency Particulate Air) filters, which are the last barriers between the facility and the atmosphere, is essential. The aeraulic resistance of clogged HEPA filters is modified by the water vapor adsorbed or condensed on soot cake The principal aim of this study is to develop a water adsorption model, based on the theory of multimolecular adsorption and capillary condensation (Ribeyre et al., 2014), for soot emitted in fire conditions. Determining the most influencing physico-chemical parameters of soot on the sorption process would improve the current HEPA clogging models (Mocho & Ouf, 2011 ; Thomas et al., 2014). This communication highlights the influence of fuel nature and soot morphology on the interaction between water and soot cake.
Methodology	Water sorption measurements are carried out with the DVS (Dynamic Vapor Sorption) Vacuum microbalance supplied by Surface Measurement Systems. Samples used in this study are commercial black carbons (PRINTEX 90 and FLAMMRUSS 101), provided by Orion (Engineered carbons) and have mean primary particle diameter of 15 and 95 nm respectively. Such materials exclusively composed of elemental carbon are morphologically similar to soot particles under fire conditions. Real “fire” soot particles have been produced by combustion of hydraulic oil, a gloves box and two types of electrical cables composed of PVC or halogen free fire retardant (HFFR) sheath. Those materials and elements represent potential fuels commonly handled in nuclear facilities. Morphological and physico-chemical characterizations of soot have been performed with a transmission electron microscope and an OC/TC thermo-optical analyzer respectively, for determining the primary particle diameter and the ratio of organic to total carbon.
Results & Conclusions	Figure 1 shows the adsorption isotherms of the two black carbons previously mentioned. The only varying parameter is the primary particle diameter. The black carbon PRINTEX 90 adsorbs much more water, especially for the relative humidities superior to 40%. Moreover, these type III isotherms according to the IUPCA classification are characteristic of low interactions between sorbate and adsorbent. This is in accordance with the known low affinity of elemental carbon with water. Figure 2 presents the adsorption isotherms of water on soot tested in this study. It is compared with other sorption results for aeronautic and burner soot (Popovicheva et al., 2008). Soot produced by a gloves box fire in an over-ventilated room adsorbs less water compared to the other “fire” soot produced within a poorly ventilated facility. Soot from electric cables fire are the most water adsorbing soot and those with PVC sheath lead to more hydrophilic soot, certainly due to the presence of chlorine atoms. Overall, water isotherms of “fire” soot have the characteristic sigmoidal shape of high sorbate-adsorbent interactions.

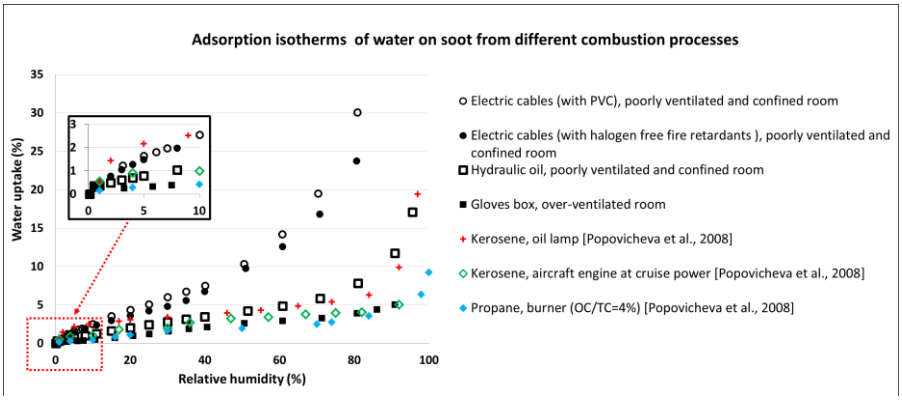
The combustion process and fuel nature strongly impact the water sorption properties of soot. A relative humidity of 40% has been identified as a critical limit above which the primary particle size is an influencing parameter on water sorption.

Caption Figure 1:



Adsorption isotherms of water on two different black carbons

Caption Figure 2:



Adsorption isotherms of water on soot from different combustion processes

Author CV:

Education:
Karlsruher Institut für Technologie (CIW, AME) : 09/2013 to 08/2014
Ecole Nationale Supérieure des Industries Chimiques (Nancy) : 09/2011 to 08/2013
Physics and Chemistry sector at the preparatory classes for the grandes écoles, Lycée Claude Fauriel (Saint-Etienne, France) and Lycée Jean Perrin (Lyon, France) : 09/2008 to 06/2011

Work experience:
Preparation for PhD degree, IRSN (Saclay, France) and LRGP (Nancy, France) : 10/2015 to present Saint-Etienne Automotive Components (assistant of finance management, fixed term contract) : 06/2015 to 09/2015
Galderma R&D (fixed-term contract) : 04/2015 to 06/2015
Solvay Novecare (Internship in the Bitumen Additives Laboratory, Lyon) : 09/2014 to 04/2015

	Lohe Saurabh
Affiliation	IIT Bombay, Mumbai, India
Email	saurabhlohe7@gmail.com
Coauthors	Arpan Patra; Harish C. Phuleria
Publication title	*Lung-Deposited Surface Area, Number, Black Carbon and Mass Concentration of PM2.5 from Different Kerbside Measurements*
Publication type	Poster
Introduction & Background	In urban areas emissions from road traffic is the most dominant source of combustion nanoparticles. High exposures to these nanoparticles pose serious risks to human health due to their high surface area and by the virtue of their deeper penetration in the respiratory system. Particle Number Concentration (PNC) and Lung-Deposited Surface Area (LDSA) seem to be reliable metrics for anticipating pulmonary inflammation of insoluble and poorly soluble nanoparticles.
Methodology	Currently, there are few studies which considered LDSA, PNC, black carbon (BC) and PM2.5 together to understand nanoparticles properties and distribution. The aim of this study is to examine the Kerbside exposures to nanoparticles and their variation under real-world driving conditions in the metropolitan city of Mumbai. Kerbside measurements of real-time LDSA, PNC, BC and PM2.5 were conducted on various major roads, an express highway and an urban background location during Jun 2016 to Feb 2017 in North Central Mumbai resulting in a total of 36 and 24 measurements for PM2.5, LDSA and PNC, BC respectively. All measurements were done on weekdays during rush (8-12pm) and non-rush (12-4pm) hours.
Results & Conclusions	Mean (± SD) of LDSA, PNC, BC and PM2.5 concentrations during rush hours are 292±118 (µm²/cm³), 25±9.1 (#/cm³*103), 19.6±7.3 (µg/m3) and 99.1±45.5 (µg/m3), respectively. Corresponding non-rush hours concentrations are slightly lower for all particulate metrics which are, 233 ± 105 (µm²/cm³), 20 ± 7.7 (#/cm³*103), 15.4 ± 7.5 (µg/m3) and 73.9 ± 20.4 (µg/m3), respectively. PNC, LDSA are found to have a 30%-50% lower concentration and PM2.5, BC are found to have 20%-40% higher concentration on major Link-roads as compare to Express highway. A comparison with the background levels shows an enrichment of 2.7 to 4.2, 3.4 to 4.6, 1.9 to 2.9 and 1.2 to 1.5 for LDSA, PNC, BC and PM2.5 respectively. This enrichment is found to be highly correlated with traffic volume on those particular roads for LDSA and PNC. The extensive data analysis for spatial and temporal variations is currently underway.
Author CV:	SAURABH LOHE Address: IIT Bombay,CESE, Powai, Mumbai, India - 400076 Email: Saurabhlohe7@gmail.com Pursuing Master in IIT Bombay,CESE Thesis: "Field performance of New portable nano-particle monitor" ARPAN PATRA Address: IIT Bombay,CESE, Powai, Mumbai, India - 400076 Email: arpanonline4@gmail.com Pursuing Doctor of Philosophy in IIT Bombay,CESE Thesis: "Chemical Characterization of fine aerosol from different driving condition" HARISH CHANDRA PHULERIA Address: IIT Bombay,CESE, Powai, Mumbai, India - 400076 Email: phuleria@iitb.ac.in

Currently Working as Assistant Professor
CESE, IIT Bombay, Mumbai, India
Research Interest
Aerosols & air quality characterization with a focus on nano/ultra-fine particles
Size-resolved outdoor PM chemical composition
Improved cook stoves efficacy, efficiency, longevity and adoption assessment
Environmental noise exposures
Exposure modelling using GIS, land use, questionnaire data
Improved cook stoves efficiency, efficiency, longevity and adoption assessment
Environmental health and risk assessment

Lonati Giovanni

Affiliation	Politecnico di Milano
Email	giovanni.lonati@polimi.it
Coauthors	Paola Fermo; Marina Marinovich; Roberta Vecchi

Publication title	*Toxicity of Biomass Combustion Generated Ultrafine Particles: Evidence from Stack-sampled and Airborne UFPs*
Publication type	Poster
Introduction & Background	Wood burning for domestic heating is a relevant source of fine and ultrafine particles in urban areas. Nevertheless, there is still a gap of knowledge on health impacts associated to UFPs (dp The TOBICUP (TOxicity of BIomass COmbustion generated Ultrafine Particles) project was designed to gain deeper insight on the possible health effects of ultrafine particles (UFP, dp
Methodology	UFP stack samples generated by wood (beech and fir) combustion in a 11 kW pellet stove (automatically stoked) and in a 8 kW wood stove (manually stoked) were collected during combustion tests intended to simulate real-world combustion cycles. Airborne UFP samples where collected during monitoring campaigns carried out at a small alpine town (Morbegno) in Northern Italy, where wood burning is largely diffused for domestic heating in winter. For comparison purpose, integrated UFP samples were collected both in wintertime (over three/four days) and summertime (seven days). Both stack an airborne UFP samples were collected by means of three parallel multistage impactors equipped with different collection substrates, depending on the subsequent analysis to be performed. Chemical analysis included elemental composition (ICP-AES), the main inorganic ions (IC), levoglucosan, mannosan and galactosan (HPAEC-PAD), total organic carbon by thermal-optical trasmittance (TOT), and PAH (GC-MS). Biological effects were assessed by investigating the induction of the pro-inflammatory cytokine interleukin-8 (IL-8) in two human cells lines (THP-1 and A549), used as surrogates of alveolar macrophages and lung epithelial cells, and in human peripheral blood leukocytes. UFP-induced oxidative stress and genotoxicity were investigated in A549 cells by alkaline comet assay and γ-H2AX. Observed pro-inflammatory and genotoxic effects were compared to those in cells treated with NIES certified diesel exhaust particles (DEP).
Results & Conclusions	Stack-sampled UFPs induced IL-8 production in both A549 and THP-1 cell lines, with logwoods UFPs more active compared to pellet UFPs. With the exception of the higher effect of beech logwood UFPs only in THP-1 cells, the induced release of IL-8 was not influenced by the kind of wood; in addition, on a weight base, IL-8 release was similar or even lower compared to DEP, arguing against a higher biological activity of UFP compared with larger particles. Genotoxic effects, with statistically significant increase of all DNA damage markers, were more evident for UFPs generated by logwood combustion than by pellet, but without differences between the two types of wood. Our tests confirmed that pellet stoves generate UFPs with reduced in vitro activity compared to wood stoves but showed that cells treated with DEP suffered more damage than those treated with UPFs from both logwood and pellet combustion. Airborne UFPs were able to stimulate an inflammatory response, with the release of IL-8 in several cellular models, including THP-1 cells and peripheral blood leukocytes. Summertime UFPs were more active in inducing IL-8

release compared to winter UFPs in both cells lines, but the release was overall similar to the one observed with DEP. Opposite to the inflammatory effects, genotoxic effects induced by wintertime UFPs were higher than those induced by summertime UFPs, indicating that seasonal differences in UFPs composition differently affected biological responses. Results also indicated that cell types and toxicological parameters were differently triggered depending on the seasonal composition of airborne UFPs, but did not show a higher reactivity of airborne UFPs compared to DEP.

Acknowledgments
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Participants to the TOBICUP project: S. Ozgen (Politecnico di Milano), L. Corbella (Dept. of Chemistry, Università degli Studi di Milano), D. Caruso, E. Corsini, C.L. Galli, L. Marabini, A. Papale (Dept. of Pharmacological and Biomolecular Sciences, Università degli Studi di Milano), V. Bernardoni, M. Dell'Acqua, G. Valli (Dept. of Physics, Università degli Studi di Milano), S. Becagli (Dept. of Chemistry, Università degli Studi di Firenze), S. Signorini (Energy and Environment Laboratory (LEAP) Piacenza.

Author CV:

Giovanni Lonati is associate professor of Environmental engineering at the Civil and Environmental Engineering Department of Politecnico di Milano. He has 20 years of research experience on atmospheric pollution in urban areas, airborne particulate matter characterization, air quality impact assessment of emissions form industrial processes. He has authored and co-authored more than 25 peer-reviewed articles.

Moore Richard

Affiliation	NASA Langley Research Center
Email	richard.h.moore@nasa.gov
Coauthors	Michael A. Shook; Luke D. Ziemba; Joshua P. DiGangi; Edward L. Winstead; Bastian Rauch; Tina Jurkat; Kenneth L. Thornhill; Ewan C. Crosbie; Claire Robinson; Taylor J. Shingler; Bruce E. Anderson

Publication title	*Engine Particle Emission Indices for Aircraft Taking Off at Los Angeles International Airport*
Publication type	Poster
Introduction & Background	Aircraft engine particle emissions are important contributors to local air quality near airports. These emissions occur during multiple stages of aircraft movement including idling at terminal gates, taxiing, runway take-offs, and runway landings, which are collectively referred to as the landing-takeoff (LTO) cycle. Engine LTO emissions are quantified by their manufacturers prior to certification and operation in terms of a smoke number; although, current and future efforts are underway to measure engine LTO emissions in a more rigorous fashion by measuring particle number and/or mass emissions indices. While these data will inform transportation modeling of the next generation of aircraft engines, there are currently no plans to recertify older engines that are currently in service. In addition, the LTO certification process is idealized as engine conditions are measured under discrete, steady thrust settings that may differ from thrusts actually applied by pilots. Consequently, there is a need to understand the emissions from these currently in-service engines under real-world conditions. Here, we investigate particle emissions emitted by aircraft during takeoff operations at Los Angeles International Airport (LAX).
Methodology	Aircraft engine particle emissions indices (EIs) are calculated from measured ambient particle concentrations normalized by carbon dioxide. The data were sampled approximately 400 m downwind of the northern runway at LAX (24L), which is an ideal sampling location as the aircraft takeoff plumes are advected down the runway by a persistent sea breeze. Particle number, mass, and size distribution EIs are reported.
Results & Conclusions	Emissions indices from over 300 distinct aircraft takeoff plumes are reported for a variety of engine types and aircraft configurations. The most prevalent single aircraft type sampled were 737 class -700, -800, and -900 series with CFM56-7B engines. Other engine types included contrasting Engine Alliance and Rolls-Royce Trent 970 engines on the Airbus A380-800 aircraft and GE Genx engines on Boeing 747-800s. Particle number EIs are in the range of 10^16-10^17 kg-fuel^(-1) on a number basis and 100-1000 mg kg-fuel^(-1) on a mass basis, which are consistent with previous advected plume measurements (e.g., Lobo et al., Atmos. Environ., 2012). This work substantially expands the database of takeoff emissions indices both in terms of plumes sampled and diversity of engine types.
Author CV:	Educational Background: Ph.D., Chemical & Biomolecular Engineering, Georgia Institute of Technology, USA, 2006-2011 Dissertation on Measurements of Atmospheric Aerosol as Cloud Condensation Nuclei Awards: NASA ESS Graduate Fellowship (2010-2011), DOE Global Change Graduate Research Fellowship (2007-2010), Georgia Tech Sam Nunn School of International Affairs Fellowship (2010-2011), Georgia Tech President's Fellowship (2006-2010), AGU Outstanding Student Paper Award (2011), First-Place Winner in AMS Oral and Poster Competitions

(2010), Poster Competition Winner at AAAR Annual Meeting (2009), Georgia Tech Chemical Engineering Department Award for Exemplary Academic Achievement (2006-2007).
M.S., Chemical Engineering, Bucknell University, USA, 2004-2006

Thesis on Measurements of the Hygroscopic Growth of Laboratory-Generated Aerosols B.S., Chemical Engineering, Bucknell University, USA, 2000-

Professional Background:
Research Physical Scientist, NASA Langley Research Center, 2014-present

NASA Postdoctoral Program Fellow, NASA Langley Research Center, 2011-2014

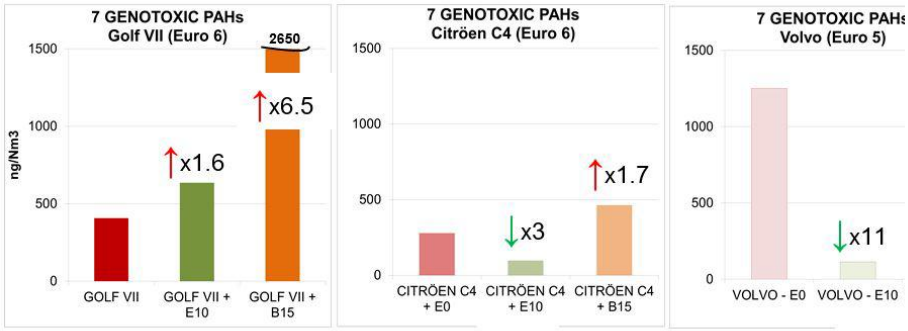
Graduate Research Assistant, Georgia Institute of Technology, 2006-2011
Graduate Research Assistant, Bucknell University, 2004-2006
Undergraduate Research Assistant, Bucknell University, 2003
Author or co-author of 28 peer-reviewed journal publications since 2008
Professional Society Memberships:
American Association for Aerosol Research (AAAR), American Geophysical Union (AGU)

Muñoz Maria

Affiliation	Empa
Email	maria.munozfernandez@empa.ch
Coauthors	Heeb, Norbert; Comte, Pierre; Czerwinski, Jan; Haag, Regula; Zeyer, Kerstin; Mohn, Joachim;

Publication title	*Effect of two Oxygenated Fuels on Genotoxic Emissions of GDI Vehicles*
Publication type	Poster
Introduction & Background	Gasoline Direct Injection has been introduced in the market due to their enhance efficiency, low fuel consumption and lower CO2 emission. However, a large number of particles are emitted from GDI vehicles exceeding the current Euro 6 limits (6x1011 particles/km). It is expected that 30% of the EU fleet will be GDI in 2020 and this will induce changes in the exhaust composition and with it may produce new health risks for humans. Some of the critical pollutants are polycyclic aromatic hydrocarbons (PAHs), alkyl-PAHs and nitro-PAHs with many of them being genotoxic. Alternative fuels could be a solution to lower emissions of toxic pollutants.
Methodology	In this study, complete exhaust samples, including solid, condensed and gaseous fractions, have been collected in all-glass sampling devices from 2 Euro 6b-GDI vehicles (Golf VII and Citröen C4)) at the chassis dynamometer of the UASB (Biel, Switzerland). Vehicles were driven following the WLTC under hot and cold start conditions. Three fuels were tested: gasoline (E0), an ethanol-gasoline blend with 10% ethanol (E10) and a butanol-gasoline blend at 15% butanol (B15). Diluted exhausts were sampled from a CVS tunnel. In the laboratory, samples were processed following several extraction and cleanup procedures. Final extracts were analyzed by HRGC-HRMS and concentrations of PAH, alkyl-PAHs and nitro-PAHs were determined. An SMPS and a nano-SMPS were used to determine particle number emissions from 9-400 nm.
Results & Conclusions	Emissions in ng/Nm3 are shown in figure 1 for the two vehicles and the fuels tested (Fig. 1, A and B). Moreover, fig. 1 C shows the results of a similar study previously done with a Euro 5 vehicle (reference vehicle in the research project) and two ethanol blends. Emissions of the two euro 6 vehicles are similar and lower than emissions of the Euro 5 vehicle. The use of E10 only lowers emissions with the Citröen as observed with the Volvo, however these emissions slightly increase in the Golf. The use of butanol produces an increase in the emissions of both vehicles. The hypothesis that ethanol lowers GDI vehicle emissions seems to be dependent on the engine type, however the increase is low compared to butanol (for the Golf VII) and emissions are reduced in the Citröen and the Volvo. According to these tests, the use of butanol does not reduce emissions. The oxygen content in butanol is similar to that of the ethanol, however, the octane nr. is similar to that of gasoline. Therefore, butanol behaves similar to gasoline and might be the reason why the emissions with it are similar or even higher than the GDI with E0. Emissions (ng/Nm3) obtained in the GDI fleet tested in the same project (n=7, Euro 3 to Euro 6b) ranged from 280 to 6700 ng/Nm3. With PN concentrations there is a tendency of higher concentrations with E10, the contrary is observed for the PAH emissions. In conclusion, it can be said that for the vehicles tested emissions were increased with the use of butanol, however the trend with ethanol is unclear.

Caption Figure 1:



-A- **-B-** **-C-**

Figure 1. Emissions of the sum of the 7 genotoxic PAHs in the WLTC-H (Benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and dibenzo(ah)anthracene) in ng/Nm3. Figure A with the Golf VII, figure B with th Citröen and C shows the results already published in a previous research with another GDI vehicle1. X-increase is indicated with a red arrow and is related to the vehicle with E0, likewise, green arrow indicates a decrease.

Author CV:

Maria Muñoz is a postdoctoral researcher at the Laboratory for Advanced Analytical Technologies at Empa, Dübendorf since September 2014. She is currently working in a project on GDI vehicle emissions and jet engine emissions. She gained her Ph.D. in 2013 at the University of Alicante, Spain. She developed her research based on the analysis of organohalogen compounds emitted in different waste treatment processes. During her more than 7 years of research experience she has published more than 12 papers in relevant journals and contributed with several oral and poster communication in several national and international conferences.

Okamura Kazumasa

Affiliation	Toyota Motor Corporation
Email	kazumasa_okamura@mail.toyota.co.jp
Coauthors	Tetsuya Yamashita; Toru Kidokoro; Motoki Ohtani

Publication title	*Investigation of the Simplified Measurement Technique of the Secondary Aerosols Formed from Gaseous Emissions of Vehicle Exhaust.*
Publication type	Poster
Introduction & Background	[motivation] In order to grasp the contribution of vehicle exhaust to PM2.5 concentrations, it is necessary to clarify the secondary aerosols formed from gaseous emissions. Recently, it was reported the simplified measurement technique of the secondary aerosols formed from gaseous emissions with the flow reactor (PAM: potential aerosol mass chamber or MSC: micro smog chamber). It is concerned that the non-realistic volume or character of secondary aerosols are formed from gaseous emissions by those techniques, because they use the shorter wavelength UV which are not included in the sunlight on the surface of the earth. Our objective is to clarify actual situation of the secondary aerosols formed from vehicle emissions by the development of the realistic measurement technique of secondary aerosols. In this work, we investigated the influence of shorter wavelength UV and humidity to the secondary aerosols formed from traditional precursors such as toluene, benzene and so on.
Methodology	[methods] The influence of UV wavelengths and humidity to the secondary aerosols were examined with GL-15 (254nm), SGL-1000 (185nm+254nm), BLB-15 (350nm as a UV of sunlight) lamps and a flow reactor (quarts glass chamber; 250mmφ* 500mm). The secondary aerosols and their precursors were analyzed with SMPS (particle number and size-distribution), GC-MS(Hydrocarbons in particle phase), PRT-MS(Hydrocarbons in gas phase).
Results & Conclusions	[results] Tens of thousands of secondary aerosols were formed from 1ppm toluene by UV lamps of 254nm whereas several hundred of aerosols by UV of 350nm in our flow reactor. Mass 30 (formaldehyde), 44 (acetaldehyde) and 58 (propionaldehyde) specifically increased as precursors derived from toluene by UV of 254nm. And we confirmed that aromatics were easy to decrease than paraffins by UV of 254nm. Reduction rate (254nm/350nm) of paraffins and aromatics were double and three times or over, respectively. Next, we investigated the influence of humidity to the formation of aerosols in UV of 254nm. The secondary aerosols formed from a toluene increased depending on humidity. Generally, it is said that formation of secondary aerosols is promoted by the increase of water on the surface of aerosol. However, we also found the increase of radicals depending on humidity. [conclusion] We understand that there are two concerns about evaluating the secondary aerosols formed from vehicle emissions in the flow reactor accelerated a photochemical reaction by the UV of shorter wavelength. 1) We may evaluate the non-realistic volume and character of secondary aerosols which are increased by aerosols formed from aromatics broke down by the UV of shorter wavelengths which are not included in the sunlight on the surface of the earth (such as the UV of 254nm). 2) It is necessary to make humidity constant in flow reactor not to be affected by the humidity of vehicle exhaust. Finally, we will show the results with some vehicle exhausts in the presentation.
Author CV:	I took a doctor's degree in Pharmacy at Kanazawa University, Japan. Since joining Toyota Motor Corporation in 2007, I have worked on chemical analysis

of materials emitted from automobile.
Assistant manager, Advanced Unit Management System Development Dvi. at Higashifuji Technical Center of Toyota.

	Oles Jan Piotr
Affiliation	The University of Nottingham
Email	antonino.larocca@nottingham.ac.uk
Coauthors	Dr. Antonino La Rocca, The University of Nottingham; Dr. Lauretta Rubino, General Motor Europe, GPS, Rüsselsheim Germany

Publication title	*Evaluating Performance on Uncoated GPF in Real World Driving Using Experimental Results and CFD Modelling*
Publication type	Poster
Introduction & Background	Environmental authorities such as EPA, VCA have enforced stringent emissions legislation governing air pollutants released into the atmosphere. Of particular interest is the challenges introduced by the limit on particulate number (PN) counting (#/km) and real driving emissions (RDE) testing; with the Euro 6c emissions legislation being shortly introduced for the gasoline direct injection engines gasoline particulate filters are considered to be the most immediate solution. While engine calibration and testing over the NEDC allows for the limits to be met real driving emission can constitute a challenge.
Methodology	The present work focuses on an experimental durability study on road under real word driving conditions. Two set of experiments were carried out. The first study analised a Gasoline Particulate Filter (GPF) (2,4 liter, diameter 5,2" round) installed in underfloor (UF) position driven for up to 200.000 km. A 1.6liter direct injection Spark Ignition (DISI) engine was used for the investigation. Ash accumulation versus mileage and soot loading were of interest. A parallel investigation up to 160.000 km with same engine (2 vehicles on road on a "specific average" cycle) and GPF installed in closed coupled (CC) position was also carried out.The CC GPF was a 2 liter model with same diameter – spec GPF is a NGK 360 cpsi 5 mil wall thickness. An Ansys Fluent CFD model was also developed and calibrated using the experimental results to gather insight on flow information inside the channels of the particulate filters as well as the porous filter walls. Individual 3-D GPF channels, with front plugs were modeled to obtain detailed flow information such as velocity and static pressure distributions inside inlet and outlet channels, as well as across the porous filter wall. Only two quarters of an inlet and two quarters of an outlet channels were modelled in order to reduce computational time and complexity.
Results & Conclusions	The 3D-CFD modelling of the uncoated Gasoline Particulate filter allowed for pressure distribution along the channels centre lines to be determined. Pressure drop and the velocity magnitudes at wall were also investigated. The experimental durability studies using two identical vehicles with different GPF location in the exhaust (UF GPF vs. CC GPF) show very little soot amount accumulated, increasing filter PN filtration efficiency with mileage (over 90% after 160.000 km) and total ash amount of circa 17 g after 200.000 km with UF GPF. Further investigation and data analysis is ongoing.
Author CV:	Jan Piotr Oles is a MEng student at the University of Nottingham. He is in his final year and has carried out a project under the supervision of Dr Antonino La Rocca, The University of Nottingham, and Dr Lauretta Rubino, General Motor Europe , focusing on the evaluation of performance of GPF in real world driving using experimental results and CFD modelling.

Padmanaban Vishnu

Affiliation	University West Virginia
Email	vipadmanaban@mix.wvu.edu
Coauthors	Arvind Thiruvengadam; Marc C.Besch

Publication title	*Characterization of Particle Number (PN) Emissions from Modern Gasoline Vehicle during High Transient Vehicle Activity*
Publication type	Poster
Introduction & Background	Improving engine efficiency has been a priority for light-duty gasoline vehicle industry. Of various engine technologies that have been introduced to achieve higher engine efficiency, gasoline direct injection (GDI) technology has found wide acceptance in recent times. In cylinder injection of gasoline fuel can result in combustion characteristics that produce larger fraction of elemental carbon (EC) as opposed to port fuel injection (PFI) engines. Studies have shown greater solid particle number from GDI engines compared to PFI engines and in some cases, solid particle number greater than diesel particulate filter (DPF) equipped diesel engines. From a regulatory and health effects standpoint, there is interest in evaluating if future GDI engines would require filters to meet emissions standards. The formation of PM in GDI combustion is not clearly understood, however, it is known that GDI PM concentrations are elevated during engine transients. Therefore, it is important to study the engine operating characteristics that contribute to high PM emissions from GDI engines. Moreover, from a design of exhaust after treatment perspective, it is also important to study the physical characteristics of GDI PM during highly transient vehicle activity.
Methodology	There is a gap in knowledge, with regards to the solid PM emissions rate, morphology and chemical characteristics of PM from GDI engines during highly transient engine operation. Therefore, the objective of this study is to compare PM size distribution and number concentration between GDI and DPF equipped diesel. Furthermore, the study aims to study the morphology of GDI. The test procedure involved chassis dynamometer testing of the two candidate vehicles, assessed on the following evaluation schemes– i) FTP 75 ii) US06 and ii) real world drive cycle based on driving activity in and around Morgantown city (MGW). Particle size distribution and number count measurements were recorded by TSI EEPS particle spectrometer and the nanoparticle samples for microscopic analysis were acquired using SMPS 3080 electrostatic classifier unit. GDI PM samples were collected and analyzed using Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM) techniques.
Results & Conclusions	Characterizing the time averaged particle number (PN) emissions resulting from transient operating conditions, it was observed that diesel vehicle was associated with peaks, only at 1E+8/cm3 for the acceleration event above 60mph vehicle speeds while for rest of all operating conditions, the DPF system reduced the particles to significantly lower limits. This trend was observed consistently for both stabilized driving phase and aggressive transient phase, as well. Meanwhile, the regeneration event consisted of nanoparticles to the order of 1E+10/cm3. However, for GDI vehicle the medium load transients (30 mph-40 mph) contributed most substantially to the elevated PN levels, with concentration of PN emissions greater than one order magnitude as compared to DPF equipped diesel vehicle. Overall, the GDI vehicle emissions consisted of averaged particles with mean diameter at 52nm and diesel vehicle consisted of smaller particles around 10nm. Slightly higher difference in particle mode diameter was observed

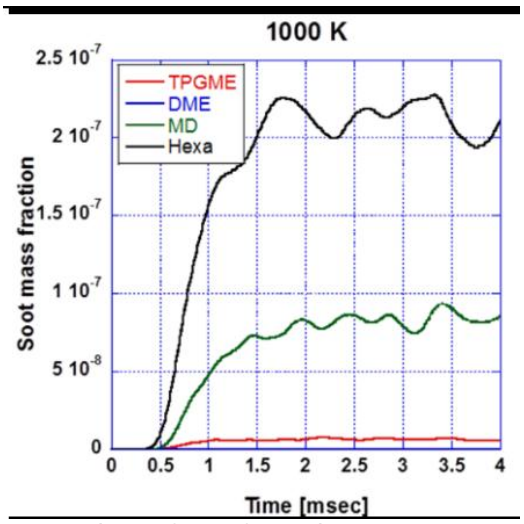
	during the real-world driving cycle which consisted of greater proportion in medium load transient events and a high-speed cruising phase. Furthermore, to this discussion the paper will also include comparative analysis of size and morphology of solid particles from AFM/SEM images, between different types of transient drive cycles that will lead to better understanding of PM formation in GDI engines during highly transient vehicle activity.
Author CV:	Vishnu Padmanaban is a PhD candidate at the Center for Alternative Fuels, Engines & Emissions in West Virginia University, USA. His research interests are in the field of GDI engine technology, in-cylinder combustion visualization and bio-fuels for heavy duty diesel engine. He completed his master's in Mechanical Engineering at WVU on investigation of combustion and emission characteristics of natural gas heavy duty engine with optical access. Mr.Padmanaban holds 10 scientific articles and one patent publication to his credit.

Park Wonah

Affiliation	Korea Institute of Machinery & Materials
Email	wpark@kimm.re.kr
Coauthors	

Publication title	*Effects of Oxygenated Fuels on Soot from Diesel Spray*
Publication type	Poster
Introduction & Background	Current engine research is focused on reducing exhaust emissions and improving fuel economy. This is motivated by increased environmental concerns, strict government regulations on exhaust emission standards. Direct injection diesel engines have advantages for reducing fuel consumption and greenhouse gas emissions due to the potential of high fuel conversion efficiency. However, it is necessary to reduce emissions, particularly NOx and soot to meet the emission regulations. Among the various methods to reduce soot emissions in diesel engines, many studies have shown that oxygenated fuel additives can effectively reduce soot emissions. The present research focuses on investigating the soot formation characteristics of oxygenated fuels using the CFD analysis. To address the effects of oxygenated fuels on combustion and emissions, three different oxygenated fuels, including tri-propylene glycol methyl ether (TPGME), methyl decanoate (MD), and dimethyl ether (DME), were considered and compared with n-hexadecane which is a neat n-alkane without oxygen.
Methodology	Four different fuels were used to help understand which fuel properties affect soot formation. Three oxygenated fuels, TPGME, DME, and MD, which have different fuel oxygen contents and molecular structures were considered. A fourth fuel was a neat n-alkane without oxygen: n-hexadecane; this fuel served as the baseline reference fuel. The reduced fuel mechanisms were implemented in the KIVA-ERC code to predict the combustion and emission characteristics. The SpeedCHEM code was coupled to the KIVA code to reduce the computational time of the multi-component reaction mechanisms. For the spray calculations, the KH-RT model was used, and the vaporization of the spray was modeled by using a discrete multi-component (DMC) model. All spray combustion simulations were carried out under the ECN ‘Spray A’ ambient conditions.
Results & Conclusions	The effects of the molecular structure of TPGME, DME, MD, and n-hexadecane were investigated for spray injections under engine relevant conditions. The formation of soot precursors was seen to decrease with increased oxygen content in the fuel and with decreased number of C–C bonds in the fuel molecule. The results show that fuel molecular structure strongly affects soot formation than fuel-air mixing.
Images	

Caption Figure 1:



Comparison of soot foramtion

Author CV:

1. Education
- Sep. 2007 ~ Aug. 2013, Ph.D. in Mechanical and Aerospace Engineering, College of Engineering, Seoul National University (Seoul, South Korea)
- Mar. 2000 ~ Feb. 2004, Bachelor of engineering in Mechanical and Aerospace Engineering, College of Engineering, Seoul National University (Seoul, South Korea)

2. Professional Experience
- May 2015 ~ current, Senior Researcher, Korea Institute of Machinery & Materials (Daejeon, South Korea)
- Sep. 2013 ~ Mar. 2015, Post-doctoral Associate, Engine Research Center, University of Wisconsin (Madison, WI, USA)
- May 2004 ~ Aug. 2007, Research Engineer, R & D Center, Hyundai Motor Group (Hwaseong, South Korea)

Paulson Suzanne

Affiliation	Department of Atmospheric and Oceanic Sciences, University of California at Los Angeles
Email	paulson@atmos.ucla.edu
Coauthors	David H. Gonzalez, Christopher K. Cala and Qioyun Peng and Suzanne E. Paulson

Publication title	*HULIS Enhancement of Hydroxyl Radical Formation from Fe(II): Kinetics of Fulvic Acid-Fe(II) Complexes in the Presence of Lung Anti-Oxidants*
Publication type	Poster
Introduction & Background	Oxidative stress mediated by production of reactive oxygen species (ROS) is a hypothesized mechanism for particulate matter-related health effects. Fe(II) is a key player in ROS formation in aqueous solutions, including surrogate lung fluid (SLF) solutions containing lung antioxidants, chelators and the ionic strength of lung-lining fluid. Humic-like substances (HULIS) from biomass burning aerosols interacts with transition metals, but its effect on ROS formation is not well known, and no studies have investigated its activity in the presence of lung antioxidants.
Methodology	We use Suwanee River Fulvic Acid (SRFA) as a surrogate for HULIS and investigate its effect on OH formation from Fe(II) in SLF. In the absence of SRFA, ascorbate and citrate enhance OH production from Fe(II). SRFA introduces competing ligands that strongly chelate Fe. A series of experiments were performed to probe the effect of SRFA on Fe-mediated ROS formation. For the first time, a chemical kinetics model was developed to explain the behavior of the Fe(II), SLF and SRFA system. The model combined with experimental results are used to find best-fit rate coefficients for key reactions: Fe-mediated reduction of O2 to O2-, and the Fenton reaction, (destruction of H2O2 to produce OH).
Results & Conclusions	The results indicate SRFA enhances Fe-mediated reduction of O2 to O2-, enhancing the rate coefficient from 8.8 x 10-3 M-1s-1 for Fe alone to (5.1 ± 1.5) M-1s-1 for pH = 7.4, I = 0.17 and T = 20 oC. SRFA also enhances the destruction of H2O2 to OH ((4.3 ± 1.4) x 103 M-1s-1). We also found best-fit rate coefficients for Cit-Fe(II) mediated O2 to O2- (3.0 ± 0.7 M-1s-1) and H2O2 to OH ((4.2 ± 1.7) x 103 M-1s-1) formation. The resulting kinetics model agrees well with both the experimental results and thermodynamic calculations of chemical speciation for 0 and 5 µg/mL SRFA. Both the kinetics and thermodynamic models are less successful at predicting further enhancements to OH formation at higher SRFA. Addition of Fe to ambient biomass burning aerosol (BBA) is also shown to enhance OH formation relative to the sum of BBA and Fe separately.

Caption Figure 1:

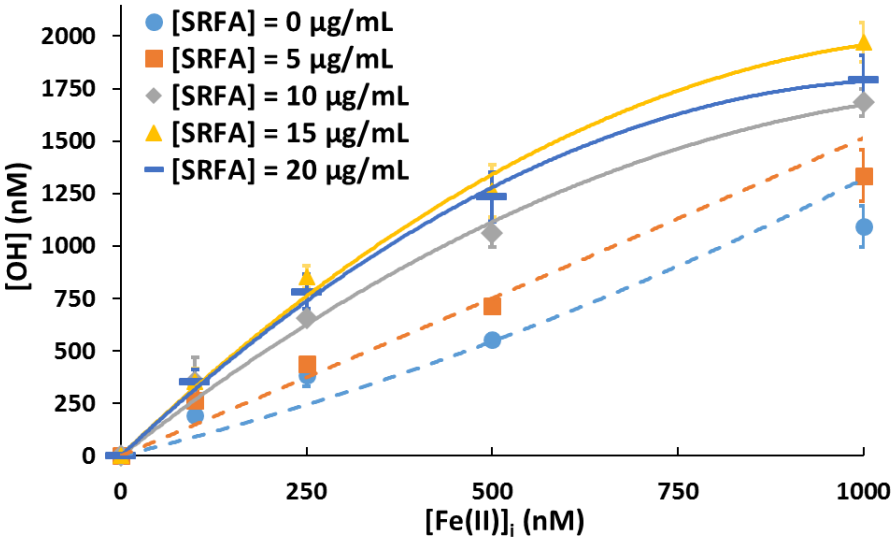


Figure 1. OH produced at 2 hours as a function of [Fe(II)]i. Each filled data point represents the average of three measurements and error bars denote range of data. Solid lines denote fit to experimental data. Dashed lines denote model results.

Author CV:

CURRICULUM VITAE

SUZANNE E. PAULSON March., 2017

email: paulson@atmos.ucla.edu

CURRENT POSITION

Professor, Department of Atmospheric and Oceanic Sciences
Professor and Director, Clean Air Center,
http://www.environment.ucla.edu/cleanair/
UCLA Institute of the Environment & Sustainability
Faculty Fellow, UCLA Institute of Transportation Studies
University of California at Los Angeles 90095-9565

PROFESSIONAL HISTORY

Vice Chair, Department of Atmospheric and Oceanic Sciences 2010 - 2013
Assistant & Associate Professor of Atmospheric Chemistry 1994-2005
Department of Atmospheric Sciences, University of California at Los Angeles

Advanced Study Program Post-Doctoral Fellow, National Center for Atmospheric Research, Boulder, CO 10/1991-2/1994

EDUCATION

Ph.D., Environmental Engineering Science, June 1991, California Institute of Technology. Course Concentration in Chemistry and Chemical Engineering. Thesis: "Contributions of Biogenic and Anthropogenic Hydrocarbons to Photochemical Smog Formation." Advisor: Professor John H. Seinfeld.
M.S., Environmental Engineering Science, June 1987, California Institute of Technology.
M.S., Plant Biology, August 1986, University of Illinois, Urbana-Champaign.
B.A., Chemistry, December 1983, University of Colorado at Boulder.

HONORS AND AWARDS

2014 Environmentalist of the Year Award (with others), Faith2green and Councilman Koretz, Los Angeles
2011, 2002, 1999 Gordon Conference Invited Lectures
2011 Invited article, Journal of Physical Chemistry
2001 Guest Professor, University of Innsbruck, Austria
1999 University of California Regents Faculty Fellowship
1999 Invited feature article, Journal of Physical Chemistry
1999 - Who's Who in American Women in Science & others
1996 NSF CAREER Award
1995 Award for Excellence in Teaching and Education, UCLA Dept. of Atmospheric Sciences.
1991-1993 National Center for Atmospheric Research Advanced Study Program Post-Doctoral Fellowship.
RECENT SCIENTIFIC SERVICE

Expert Panelist, Comision de Nacional de Investigacion Cientifica y Technologica –CONYCIT
(Chilean National Science Foundation) 2015
American Association of Aerosol Research Development Committee 2013-2016
Publications Committee 2009-2012
Chair 2010-2012
Research Screening Committee Appointee, California Air Resources Board 2008-
(lifetime appointment)
Expert, Whitney v. Hyatt Legionella Case, Silicon Valley Law 2014
Science Advisory Board member, EPA Clean Air Research Center, Georgia Tech 2011-2016
72. 27th Southern California Photochemistry and Kinetics Conference, Universtiy of California at San Diego, CA May 12, 2017.
71. Parks, Obesity, Air Pollution and Health, Panelist, California Endowment April, 2017.
70. "Effectiveness of Soundwall-Vegetation Combination Barriers as Near-Roadway Pollutant Mitigation Strategies." Coordinating Research Council Mobile Source Air Toxics Workshop, Sacramento, Feb. 15, 2017.
69. "The wind, the traffic and the buildings: the role of the built environment in determining air pollution exposures" 20th Combustion Nanoparticles Conference, ETH Zurich June 15, 2016.
68. "Particle Dynamics in the Road-toAmbient in the Stable Early Morning Atmosphere" Cambridge Particle Conference, Cambridge, UK June 12, 2016.
67. University of Cambridge, Cambridge UK 2-16 "The Tangled World of Reactive Oxygen Species: the Search for the Bad Actors in Ambient Particles" Feb. 2016.
66. University of Birmingham, Birmingham UK "Roadway Pollution in Complex Urban Environments: Spatial Distributions, Built Environment Characteristics and Dynamics of Ultrafine Particles" Feb. 2016.
65. University of Surrey Guildford, UK "The wind, the traffic and the buildings: the role of the built environment in determining air pollution exposures" Dec. 2015.
64. Breathe California Sacramento Symposium on near roadway mitigation strategies Sacramento Apr., 2015.

	Pratte Pascal
Affiliation	Philip Morris International R&D, Philip Morris Products S.A., Neuchâtel, Switzerland (part of Philip Morris International group of companies)
Email	pascal.pratte@pmi.com
Coauthors	Stéphane Cosandey; Catherine Goujon Ginglinger

Publication title	*Solid Particle Investigations in the Mainstream of 3R4F Reference Cigarettes, and the Tobacco Heating System THS2.2 and Commercial Cigarettes*
Publication type	Poster
Introduction & Background	An aerosol is a mixture containing liquid droplets and potentially solid particles suspended within a gas. The production of solid carbon particles in aerosols such as smoke appears to be largely due to the combustion process, and is unlikely to occur when the organic substrate is heated without any combustion (K.C. Oha et al.). Using this observation, comparing the presence, absence or levels of solid particles in aerosols from different sources may be useful to indicate the level to which combustion may have contributed to the formation of the aerosol. To this end, the potential release of particles in the mainstream aerosol generated by the heat-not-burn product THS2.2 and some e-cigarette products was assessed in comparison with the smoke produced from the 3R4F reference cigarette. For this purpose, a methodology using a Dekati commercial Thermo-denuder operating at 300°C associated with chemical characterization was developed.
Methodology	Prior to investigating the possible presence of solid particles in the mainstream of tobacco products, the thermo-denuder removal efficiency was quantified using model glycerine and propylene glycol-based droplets. From findings, the effective removal efficiently of droplets was determined to be larger than 96%. In separate experiments, a thermo-resistant aerosol constituted by NaCl dry crystals was used to determine the thermo-denuder average aerosol penetration for sizes ranging from 20 to 300 nm. The penetration yield was measured to be 0.80 +/- 0.08. As a result, the detection of solid particles or high boiling point droplets is possible only when their fraction exceed 3.86% in number otherwise they would be indistinguishable from remaining liquid droplets. Furthermore, when the penetration yield is above 11.58%, the quantification of solid particles or high boiling point droplets is achieved. For chemical characterization of any detected particles, the thermo-denuder was coupled in a separate experiment with a two stages impactor trap (T. Jalanti and P. Henchoz) used to perform Scanning Electron Microscope (SEM) and Energy Dispersive X-ray (EDX) analyses of the collection substrates.
Results & Conclusions	From experiments conducted using the 3R4F reference cigarette, the methodology allowed to determine that more than 60% in number of the total particulate matter was neither evaporated nor removed in the thermo-denuder. This was likely attributed to the presence of solid particles or low volatile liquid droplets. For the experiments with THS2.2, the removal of the particulate matter from the mainstream was at the same level than the limit of quantification determined based on the glycerine/propylene glycol droplet removal efficiency. To confirm the absence/presence of solid particles in the mainstream of 3R4F reference cigarettes and THS2.2, similar experiments were conducted and potential solid particles were trapped in the impactor. The collection substrates used to trap particles present in the mainstream of 3R4F reference combustible cigarette and THS2.2 were analysed separately using SEM and EDX analyses. Figure 1 presents blank experiments (left hand side pictures) against 3R4F (A) and THS2.2 (B). From the pictures related to 3R4F experiments (A), solid particles were identified and

composed mainly of carbon based material, oxygen and traces of potassium/chlorine whereas a related Count Median Diameter (CMD) of 75 nm was determined. When considering the picture for THS2.2 (B) in comparison to the blank (experiments prior aerosol generation started), no particle were identified using SEM imaging. This result is consistent with the fact that no combustion process takes place in THS2.2 and that the aerosol differs from cigarette smoke.

More recently, similar experiments were performed using commercial e-cigarettes in an Indoor Air Quality (IAQ) dedicated room. Mainstream aerosols of test items were generated using simultaneously two programmable dual syringe pumps (PDSP). One part of the aerosol was transported to a bypass line to a dedicated CPC while the second part passed through the thermo-denuder operated at 300°C prior to being measured in a second dedicated CPC. The number concentration measured in the bypass line represents the room concentration. This includes potential solid particles, high boiling point droplets and liquid droplets. Conversely, the number concentration measured after the aerosol passage in the thermo-denuder represents any remaining solid particles or/and high boiling point droplets. From the data, to verify whether solid particles or high boiling point droplets were present, the aerosol penetration was calculated; that is the ratio of the number concentration measured after the aerosol passage through the thermo-denuder (CPCTD) to one from the bypass line (CPCroom) and compared to the LLOQ. The resulting value can range from 0.8 to 0 as inevitable wall losses would lead to a penetration of 0.80 for pure solid test particles. The findings demonstrated that the measured penetration was below the LOD for two commercial e-cigarette brands while furthermore SEM pictures from laboratory testings did not reveal the presence of combustion solid particles. Consequently, this is a strong evidence that e-cigarettes aerosols are constituted by liquid droplets as this the case for THS2.2.

Caption Figure 1:

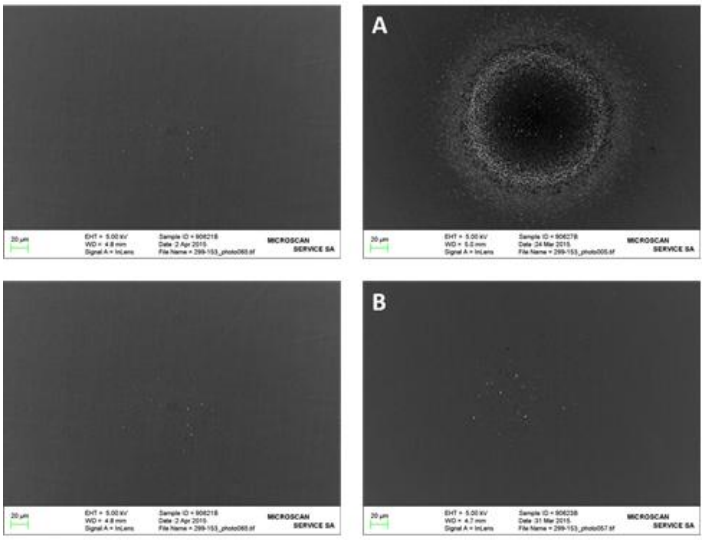


Figure 1: Pictures of trapped particles from mainstream smoke after its passage in the Thermo-denuder operating at 300°C. A) 3R4F B) THS2.2. Left side: blank

Author CV:

Professional experience (Philip Morris International)

Manager Aerosol Physics (2015 – current)
• Develop a strategic vision, anticipate future needs and develop analytical tools in the field of Aerosol Physics
• Team Management (implement Quality Systems, documentation review, resource optimization…)

• Work in cross-functional team and propose solutions to solve scientific challenges for Stakeholders (Toxicology, Product Development, IP, Product Innovation, Indoor Air Quality applications, Modeling)
• Study Director for Product Assessment under GLP

Associate Staff Scientist, Head of Aerosol Physics in Analytical Research & App. (2013- 2015)
• Team Management (Set-up a team, define roles and responsibilities)
• Develop new innovative scientific tools to answer Stakeholders' core questions and enhance scientific understanding
• Study Director for Product Assessment under GLP

Associate Staff Scientist, Supervisor Aerosol and Thermochemical Investigation (2012-2013)
• Supervision of laboratory technicians (Set schedules, deliverables, instrument maintenance)
• Provide aerosol and material physico-chemical properties data for Stakeholders
• Support the implementation of methods under GLP.

Associate Staff Scientist in Product Testing and Characterization (2011-2012)
• Provide experimental support and scientific expertise on aerosol characterization and thermal analysis of materials.
• Coordinate and plan analytical measurements with the Aerosol, Physical, GC and LC labs to support Product Development.
• Support the implementation of methods under GLP.

Aerosol scientist (2007-2011)
• Identify Business Needs related to aerosol physics
• Write Business Cases and purchase equipment
• Build up a laboratory
• Cross-functional work with different scientists (modeling, material assessment…)
• Supervision of laboratory technicians

Education
• Ecole Polytechnique Federal de Lausanne (EPFL): PhD. student on atmospheric science and aerosol heterogeneous chemistry (March 2002 – February 2006)
• Université de Montréal - École Polytechnique de Montréal: B. Ing title in Physics obtained in 2001 (1996-2001)

Languages
French: Mother language
English: Fluent

Skills
• Complex concepts translated in simple ideas
• Agility to perform presentations
• Cross-functional network development
• Creative mind

Press-Kristensen Kåre

Affiliation	Senior advisor on air quality, Danish Ecological Council
Email	karp@env.dtu.dk
Coauthors	Lotte Laurvig, Patrick Huth, Hannah von Blumröder & Axel Friedrich

Publication title	*Taxation of Residential Burning*
Publication type	Poster
Introduction & Background	Residential burning of wood, lignite, straw and waste is and will be the dominating emission source of particles (fine and ultrafine) and black carbon in many European countries and in the EU as a whole unless further actions are taken to reduce the pollution. Ban against residential burning is, of course, the ultimate solution and is used in a few European cities. However, another possibility, not often discussed, is taxation of pollution from residential burning motivating consumers to buy less polluting stoves/boilers, install filters and/or change to cleaner heat sources and better insulation. This paper describes a cost-efficient way to tax pollution from residential burning.
Methodology	Damage costs per kg emitted fine particulate matter (including condensates) from wood burning in Denmark have been calculated for different geographical regions based upon air quality models, demographic data, dose-response relationships and valuation of increased mortality and morbidity. In an ideal “polluter pays” world consumers should pay the damage costs caused by their pollution. This can be done by introducing tax on wood burning reflecting the damage costs from the emitted particulate matter. However, then the total annual particle emission for each heat unit (stove/boiler) needs to be measured as a basis of taxation. Since particle emissions from heat units (kg particles per GJ wood burned) is known (can be estimated) from the type approval (assuming quite correct operation); the challenge is to measure how many GJ of wood is burned annually in each unit. The power (kW or MW) and efficiency of each heat unit is known (can be estimated) from the type approval. Then GJ wood burned can be estimated from the time in seconds (s) the unit has been used since W = J/s (Watt is Joule per second). The time each heat unit has been used annually can be measured by a simple temperature sensor placed and sealed in the chimney (close to the heat unit) and connected to a temperature logger measuring how many hours the temperature in the chimney is above 60 °C which only occurs when the heat unit is in use. This methodology was used to calculate taxes on fine particulate matter from three categories of wood stoves in different geographical regions in Denmark.
Results & Conclusions	The calculated taxes (euro per hour of use) due to health damage caused by fine particle emission from old, newer and new eco-labelled (Nordic Swan) wood stoves are shown in Table 1 for larger cities and in desolated areas in Denmark. The taxes do not reflect health costs outside Denmark caused by the fine particle emission from Danish stoves. Table 1: Taxes reflecting health damage from fine particles emitted by wood stoves in Denmark (Uploaded as figure 1) On top of the taxes suggested in table 1 can be added mandatory energy taxes and damage costs due to other types of pollution from wood burning and health costs caused in other countries. Equivalent taxes can be calculated for wood boilers, straw-fired boiler, cold fired heat units etc. based on their emission.

The technology producer CB Svendsen has calculated that the technical system for logging the hours of operation will have the same costs as a standard electricity meter.

The national Danish Council of Economist and the Danish Centre for Environment and Energy have together calculated that the suggested taxation is the most cost-efficient way to regulate pollution from wood burning. They estimate that taxation will reduce pollution from wood burning and the related health effects with 85 % and provide a massive socio-economic benefit. The Danish Ministry of Taxation has confirmed the socio-economic benefit in a separate study.

Caption Figure 1:

Taxes (euro per hour operation)	Old wood stove (→ 1990)	Newer wood stove (1990-2004)	Eco-lab
Larger cities	5.5	3.3	
Rural areas	0.7	0.4	

Table 1: Taxes reflecting health damage from fine particles emitted by wood stoves in Denmark

Author CV:

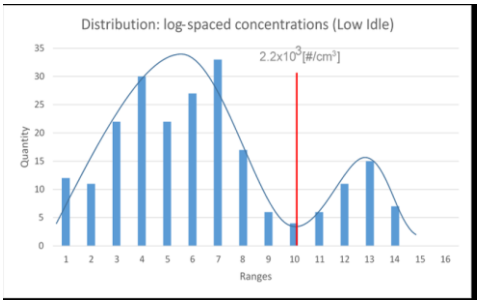
Kaare Press-Kristensen holds a master degree and a Ph.D. degree in environmental engineering from the Technical University of Denmark. He has been teaching air pollution (focus: combustion generated particles) at the Technical University for 13 years. Today he works in a non-governmental organization, Ecological Council, doing measurements of ultrafine particles from wood burning, traffic, ships, aircrafts, non-road mobile machinery etc. His work considers both emissions and ambient air concentrations and the connected risk assessment in relation to public health and work related exposure. He is focused on technical as well as regulatory solutions. His work is funded by international and national foundations and organizations, the EU, the Danish EPA, private companies, trade unions, municipalities etc.

Reinoso Aliosha

Affiliation	GEASUR
Email	aliosha.reinoso@geasur.cl
Coauthors	-

Publication title	*Santiago de Chile Experience with Respect to Inspection and Maintenance Using Particle Number Measurement*
Publication type	Poster
Introduction & Background	As a part of a comprehensive program aiming towards the implementation of DPF on public transport buses in Santiago, conducting by a partnership between Ministry of Transport of Chile and Swiss Agency for Cooperation and Developing (COSUDE), one randomly measurement campaign with solid particle number metric, was done over a fleet of 3,200 buses with DPF, aged between 150,000 to 750,000 km. These measurements were useful to do an on road evaluation of real conditions of aged filters and to evaluate portable instruments and this new metric for a future Inspection and Maintenance program aiming to retrofitted buses and future Euro VI.
Methodology	A randomly sample of 400 buses were measured in Solid Particle Number linked up to road side opacity control routine, applied by National Enforcement Program in Santiago of Chile. Opacity and Particle Number were simultaneously measured at end of pipe. Additionally, 22 buses were tested in-depot, upstream and downstream of DPF, to evaluate DPF efficiency. A NPET-TSI instrument, METAS certified, portable and highly sensitive PN counting instrument was used. Three different engine conditions were tested: free acceleration, high idle and low idle engine speed.
Results & Conclusions	Considering free acceleration mode, 30% of the opacity results were close to 0 [m-1] (below opacimeter sensibility limit of 0.025 [m-1]), but simultaneously between 102 to 109 [#/cm3], measured with PN instrument. Conventional opacimeter attending European Directive 70/302, used to enforcement in Santiago, is not sensitive enough to detect emissions coming from modern engines, neither failed DPF. In order to try a PN limit to detect high PN emitters as indicator of DPF quality, data were binned into log-spaced concentrations ranges looking for a bimodal structure (good and bad). This separation was clearest for low idle testing mode. Additionally, low idle was easier to implement in road side control because no driver or RPM electronic control interferences and it is sensitive enough to distinguish high emitters. Agreed to bimodal structure the proposed limit was 2.2x105 [#/cm3]. Comparing proposed end of pipe threshold with DPF efficiency tested on 22 buses, all buses with efficiency over than 95% approve limit (with average efficiency of 99.5%). All but one bus with efficiency below 90% failed limit (with average efficiency of 50%). Conforms to proposed threshold and randomly sampling, 17,5% of DPF could have a failure, mainly concentrated on early stage of implementation (without monitoring pressure or good maintenance practices). More recently implemented DPF show 9% of probably failures, with 300,000 km average. As a result, Ministry of Environment of Chile is planning to implement PN measurement for Inspection and maintenance program for new Euro VI buses.

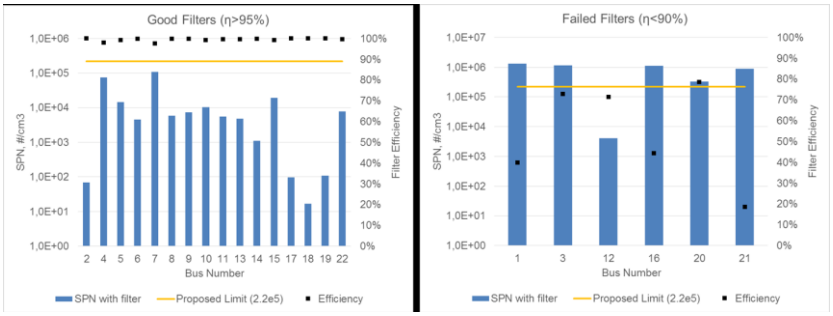
Caption Figure 1:



Range	≥	<	N	Condition
1	1,00E+02	2,20E+02	12	Normal
2	2,20E+02	4,70E+02	11	Normal
3	4,70E+02	1,00E+03	22	Normal
4	1,00E+03	2,20E+03	30	Normal
5	2,20E+03	4,70E+03	22	Normal
6	4,70E+03	1,00E+04	27	Normal
7	1,00E+04	2,20E+04	33	Normal
8	2,20E+04	4,70E+04	17	Normal
9	4,70E+04	1,00E+05	6	Normal
10	1,00E+05	2,20E+05	4	Indifferent
11	2,20E+05	4,70E+05	6	Abnormal
12	4,70E+05	1,00E+06	11	Abnormal
13	1,00E+06	2,20E+06	15	Abnormal
14	2,20E+06	4,70E+06	7	Abnormal
15	4,70E+06	1,00E+07	0	Abnormal
16	1,00E+07	2,20E+07	0	Abnormal
		TOTAL	223	

Bimodal structure in log-spaced binned concentrations ranges.

Caption Figure 2:



Comparison between threshold emissions and DPF efficiency using Solid Particle Number metric.

Author CV:

With twenty years of experience in vehicular emissions and transportation, he has developed several high impacting programs in Chile for transport emissions control and mitigation. First as a technical leader working for governmental institutions, and subsequently as a private consultant. He has developed too, international professional activities, in Latin American countries and Switzerland, linked to The Swiss Agency for Developing and Cooperation (COSUDE) and Bank of Latin America Development (CAF), as technical advisory.

All these experience has consolidated strong technical skills in internal combustion engines and its emissions, including measurement methods and result data analysis; in decontamination policies design, for transport sector with multi affected stakeholders; in leadership of multidisciplinary teams.

Rönkkö Topi

Affiliation	Aerosol Physics, Faculty of Natural Sciences, Tampere University of Technology
Email	topi.ronkko@tut.fi
Coauthors	Jenni Alanen; Erkka Saukko; Kati Lehtoranta; Sanna Saarikoski; Panu Karjalainen; Pauli Simonen; Timo Murtonen; Hilkka Timonen; Kimmo Teinilä; Heino Kuuluvainen; Risto Hillamo; Jorma Keskinen
Publication title	*Nanoparticles in natural gas engine exhaust*
Publication type	Poster
Introduction & Background	Particulate emissions from gas-fueled engines are typically low if compared to gasoline engines or diesel engines without a DPF. Some previous studies indicate, however, that gas-fueled engines can emit nanoparticles, frequently called as nucleation mode particles. In diesel and gasoline engine exhaust the initial exhaust nanoparticle formation takes place already in high temperature conditions or, alternatively, when the exhaust is cooled and diluted in the atmosphere. The amount as well as physical and chemical characteristics of these nanoparticles significantly depend on their formation processes and, on the other hand, on the technologies used in vehicles and engines. This study, conducted in CENGE and NewGas projects, investigates the characteristics and formation of nanoparticles in the exhaust of natural gas fueled engine.
Methodology	The test engine utilized was a passenger car engine modified to run with natural gas. Exhaust studies were conducted for the engine out emissions and for the test engine equipped with catalyst systems during two separate campaigns. Exhaust was sampled for nanoparticle measurements by partial flow sampling system where the exhaust undergoes cooling dilution. Particle number and size distributions were measured utilizing an Electrical Low Impactor (ELPI), a Particle Size Magnifier (PSM) combined with a Condensation Particle Counter (CPC), a High Temperature ELPI+ (HT-ELPI+), an Engine Exhaust Particle Sizer (EEPS) and a Scanning Mobility Particle Sizer (nano-SMPS). The chemical composition of particles was studied by using a Soot Particle Aerosol Mass Spectrometer (SP-AMS). The volatility of particles was studied by a thermodenuder, and in part of the experiments also the electrical charging state of the exhaust particles was studied. After the engine exhaust experiments, the particle formation in the exhaust sampling and dilution system was further studied with aerosol laboratory facilities.
Results & Conclusions	The particle number size distribution of natural gas engine exhaust was dominated by nanoparticles so that the mean particle size was typically approximately 10 nm or even smaller (Fuel, DOI: 10.1016/j.fuel.2015.09.003; Emiss. Control Sci. Technol., DOI 10.1007/s40825-016-0057-8). Exhaust nanoparticle concentration, size and volatility depended on the driving mode and on the catalyst temperature; e.g when the test engine was equipped with catalyst, the particle concentration and size increased when the catalyst temperature was increased. According to preliminary results from aerosol laboratory studies, this phenomenon can be qualitatively repeated by feeding the mixture of SO2 and air to heated oxidation catalyst and, further, by diluting and cooling the resulted gas mixture with the same sampling system as used in the engine exhaust studies. This result and particle composition measurements indicate that sulfur compounds have a role in natural gas engine exhaust nanoparticle formation. In the aerosol laboratory experiment, the presence of soot particles in the test gas was not observed to decrease the formation

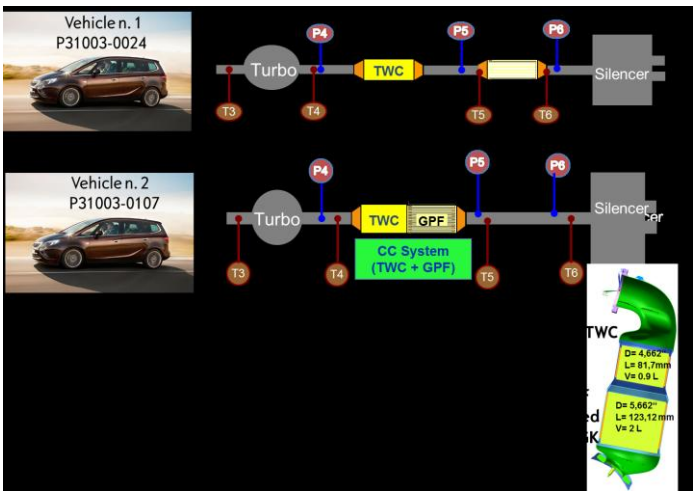
	potential of nanoparticles. The study was funded by Tekes (Finnish Funding Agency for Innovation) and several Finnish companies.
Author CV:	Dr., adjunct professor Topi Rönkkö is a research manager in Aerosol Physics unit of Tampere University of Technology. He has published more than 50 scientific articles, focusing on particle emissions of vehicles, engines and power plants.

Rubino Lauretta

Affiliation	GM Europe /OPEL
Email	lauretta.rubino@gm.com
Coauthors	Dominic Their; Thorsten Schumann;

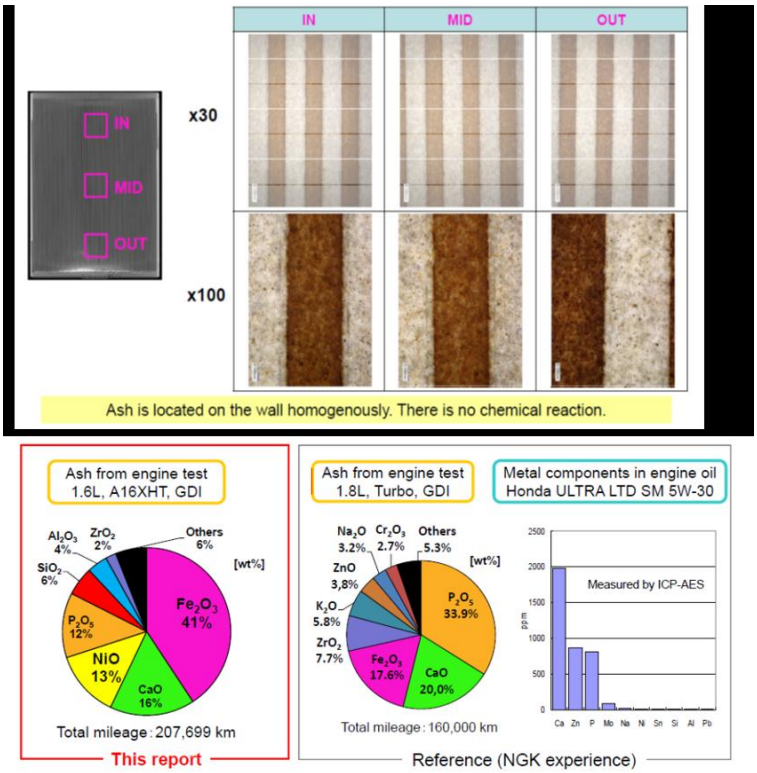
Publication title	*GPF Durability Study at two Different Exhaust Locations for two Identical Vehicles: Effect of Soot and Ash accumulation over Lifetime*
Publication type	Poster
Introduction & Background	Increasing tight PN emissions regulations consider Gasoline Direct Injection (GDI) engines in addition to Diesel. Gasoline Particle Filters are potential solutions to comply with the tight legislation requirement on PN. Even if some learnings from the development and application of particulate filters to diesel engines can be transferred to gasoline engines, the particulate consistence, the mass to number ratio and the temperature as well as the gas composition of gasoline engines are significant different to Diesel engines. Therefore, there is need to study the application of gasoline particulate filters (GPF) in depth.
Methodology	The current work summarizes the performance of an NGK GPF (C-680 5/360) placed in 2 different locations (Close Couple (CC) and under-floor (UF) in two identical vehicles (Zafira) with a 1,6 liter GDI engine displacement. Both vehicles are running on road over a pre-defined cycle that reflects the average customer behavior. PN emissions measurements over WLTP are performed every 20.000 km together with GPF CT scan to monitor GPF performance. GPF PN filtration performance over lifetime are reported as well as soot and ash accumulation vs. mileage and corresponding backpressure increase versus time.
Results & Conclusions	Results show a relatively low ash accumulation over the lifetime of the two vehicles, having same engine and PN engine out emissions and 2 GPF placed in different location (CC vs. UF). Results of PN filtration efficiency performance for the GPF and ash accumulation vs. mileage over life time show an overall ash accumulation on GPF circa 17g total at 200.000 km and circa 16 g total over 160.000 km for the CC GPF case. Post Mortem Analysis of the UF GPF at 200.000 km is reported for the full analysis of ash composition and ash location on the GPF. The investigation shows that ash related effects in this application are mainly influenced by the oil consumption pattern of the engine. Vehicle data analysis well match a more fundamental study of GPF ash accumulation over well-defined cycles still ongoing. Further work and data analysis is in progress.

Caption Figure 1:



Durability Vehicles and GPF lay-out

Caption Figure 2:



GPF Post Mortem Analysis: Ash composition and distribution at 200k km

Author CV:

Dr. Lauretta Rubino
June 2013– current Lead Technical Expert Gasoline Particle Filter (GPF) / Aftertreatment
Systems - GM OPEL, Germany
• Nanoparticle emissions reduction from GDI using GPF / PEMS / PN emissions measurements & RDE expert
• Project Management & Coordination. Engine and vehicle testing, data analysis
• International projects - Collaboration with Universities and Research Centre
• European founded projects expert
• Acea– PN PEMS / PN subgroup expert
• Emissions legislation

May 2011 – March 2013 System Engineer CORNING GmbH, Wiesbaden, Germany
• After-treatment development for both Light duty and Heavy duty vehicles

(LDV and HDV) – CO2 emissions reduction, NOX, PM / Engine and vehicle testing using Gasoline and Diesel Particulate Filters (GPF & DPF), SCR and integrated systems for gaseous and PN emissions reduction

December 2008 – October 2010 Corporate Scientist, Sensors Europe GmbH, Erkrath, Germany
• Portable Emission Measuring Systems (PEMS) R&D, PM & gaseous emission measurements
• Responsible R&D for EU PEMS activity / Project Leadership / International Clients interface & Support / International Projects Coordination & Management

December 2005 – November 2008 Scientific Officer (C.A.) – European Commission DG Joint Research Centre (JRC) Ispra, IT
• Effects of fuels & biofuels, additives & After-treatments (i.e. SCR, DPFs etc) – Ultrafine particle emissions measurements (PMP program) • Team Leader EU PM PEMS program
• Project Management / Support EU legislation activity on Heavy-duty, Light-duty and Off-road engines

January 2003 – November 2005 Development Engineer – Johnson Matthey Plc. Royston UK

• 2000 - 2003 Research Assistant – Imperial College London
Mechanical Engineering Dept – Thermofluid Section
1997 - 1999 Research Assistant – University of Toronto, Canada
Mechanical & Industrial Engineering Dept

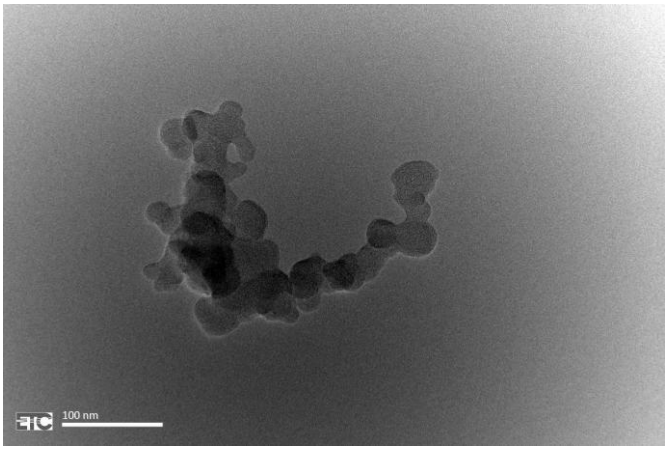
EDUCATIONAL BACKGROUND

2000 – 2003 Ph. D. in Mechanical Engineering, Imperial College London, UK
Thesis Title: ‘After-treatment of Particulate Emissions from Simulated and Engine Combustion’
1997 – 1999 Master of Applied Science (M.A.Sc.) in Mechanical & Environmental Engineering, University of Toronto, Canada
Thesis Title: ‘The Effects of Oxygenated Additives on Soot Precursors Formation’
1990 – 1996 “Laurea” in Mechanical Engineering- University of Rome TorVergata - Thesis Title: ‘Analysis and Interpretation of Air Quality Data in Central Rome’
Research area: Internal Combustion Engines, Emissions, Air quality modeling

	Schlickum Volker
Affiliation	Senate Department for the Environment, Traffic and Klimax
Email	volker.schlickum@SenUVK.berlin.de
Coauthors	

Publication title	*Defects by DPF*
Publication type	Poster
Introduction & Background	The DPF is a highly efficient technology to reduce the particle emission of all Diesel vehicles and ships. When a cleaning or changing of the filter is nessesary, manipulation is in the longtime a cheaper alternative, with this manipulations the DPFs goes out of function. Therefore it is interesting to know which use the manipulation.
Methodology	Testing the exhaust emissions of cars, busses, lorrys and ships in the streets and waterways of Berlin with an mobile PN-counter. Check the emission-datas with the vehicles-specifications and find the manipulated systems.
Results & Conclusions	Presentation of the differences and the potential of this manipulations for the Berlin air quality
Author CV:	Ministry of Urban Development of the city of Berlin Technical Engineer in the Department on General Aspects of the Air Quality Management - set up and evaluation of different inventories of air emissions; reporting to the European Commission; member of a Federal/State Working group on emission inventories; development of emission factors; preparation of environmental reports - Construction of the Berlin Environmental Zone - the reduction of emissions in trucks, buses, cars and ships - Pilot projects particulate filter on ships and construction machinery - SCR retrofitting city buses - Low-emission vehicle fleets - Assessment of electromobility

	Sermon Paul
Affiliation	Brunel University
Email	paul.sermon@brunel.ac.uk
Coauthors	Jean-Charles Eloi

Publication title	*Carbonaceous Combustion-Generated Nanoparticles (PM0.1)*
Publication type	Poster
Introduction & Background	There is concern about combustion-generated carbonaceous PM10, PM2.5 and PM0.1/ultrafine particles (UFPs) in the atmosphere [European Commision 'Industrial Emissions of Nanomaterials and Ultrafine Particles' (2011)] and their effect on human health and the environment.
Methodology	We have tracked and sampled the atmosphere from San Diego, San Francisco, New York, Boston, London, Zurich and Ebensee in Austria and from diesel and petrol engined vehicles. We have measured the concentration and nature of carbonaceous combustion-generated nanoparticles (PM0.1) using transmission electron microscopy (TEM), Raman and dynamic light scattering (DLS) and for passenger nitrate by X-ray photoelectron spectroscopy (XPS) and hydrocarbons by temperature-porgrammed desorption (TPD)-GCMS-RGA. We have measured their surface energy and tendency to aggregate from UFPs, PM0.1s to PM2.5 to PM10. We have directly followed their uptake by flora, spores and algae relevant to green cities with in-situ measurements. We have then measured and shown their bioactivity/toxicity, suggesting how they interact with humans and affect human health.
Results & Conclusions	Results show (i) the abundant distribution of carbonaceous combustion-generated nanoparticles (PM0.1) worldwide (ii) how their sp2:sp3 structure varies with time and conditions (iii) how their passenger nitrate and hydrocarbon levels vary (iv) why and how they aggregate from PM0.1 to PM2.5 to fractal PM10 (v) how they are taken up by flora, spores and algae (vi) how green cities might be more effective at controlling atmospheric pollution (vi) why their are so bioactive and (vii) how we might move forward with improved abatement technology.
Caption Figure 1:	 Figure 1. TEM of PM0.1 at moderate magnification

Caption Figure 2:

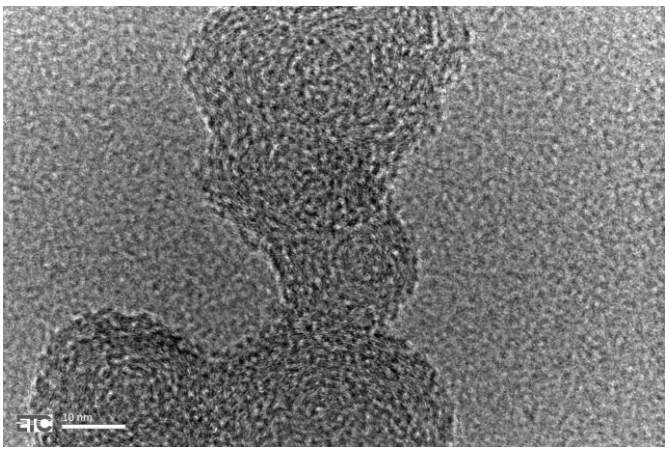


Figure 2. TEM of PM0.1 at higher magnification

Author CV:

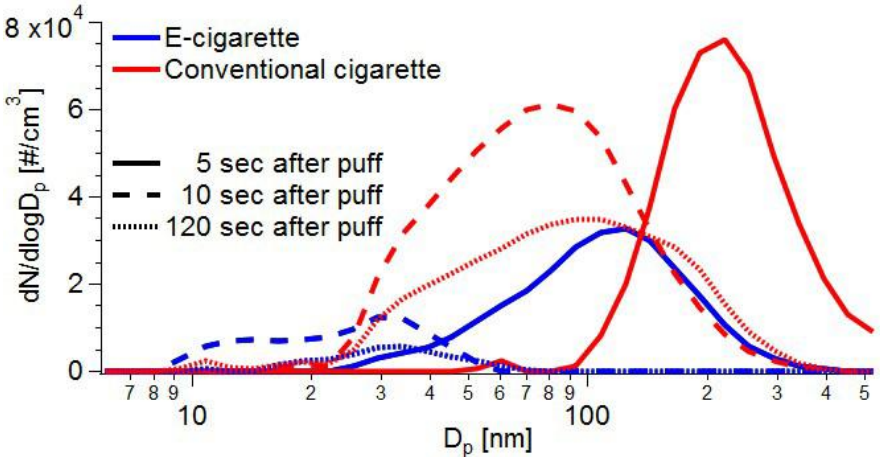
PAS is Professor of Nanomaterials at Brunel University. He was previously Professor of Physical Chemistry at the University of Surrey. He has published on unusual carbonaceous chains and nanofibers in diesel engine exhausts [A.Evelyn, S.Mannick and P.A.Sermon Nano Lett. 3,63-64,(2003)].

	Setyan Ari
Affiliation	Empa
Email	ari.setyan@empa.ch
Coauthors	Tadas Prasauskas; Dainius Martuzevicius; Grant O'Connell; Xavier Cahours; Stéphane Colard; Jing Wang

Publication title	*Dynamic Properties of Exhaled e-Cigarette Aerosol vs. Conventional Cigarette Smoke*
Publication type	Poster
Introduction & Background	Electronic cigarettes (e-cigarettes) are gaining acceptance with consumers as an alternative to conventional cigarettes. Both regulators and public health organizations are beginning to examine whether particles exhaled following the use of such products have potential implications for bystanders in workplaces and enclosed public spaces. E-cigarettes do not contain tobacco, do not require combustion and do not generate side-stream smoke. There is currently limited data available on the properties of exhaled e-cigarette particles and how they differ from those released during the smoking of a conventional cigarette. To that end, we aimed to investigate the spatial and temporal variations of exhaled particles following the use of an e-cigarette and the smoking of a conventional cigarette in a chamber under controlled environmental conditions.
Methodology	An exposure chamber was used with a bystander simulated using a "dummy". The surface of the "dummy" was heated up to 31-34°C, similar to the temperature of the surface of the human body. A volunteer vaped an e-cigarette or smoked a conventional cigarette according to a set puffing regime (1 puff every 30 seconds during 5 minutes), at three different distances from the bystander (0.5, 1, and 2 m), and under three different ventilation rates (0, 1, and 2 air change per hour [ACH]). Three volunteers participated in the study. The concentrations, size distributions, and decay rates of airborne particles were measured using a fast mobility particle sizer (FMPS), an electrical low pressure impactor (ELPI), and a scanning mobility particle sizer (SMPS) at the bystander's position.
Results & Conclusions	During the use of the e-cigarette, a very fast change in the particle concentration was observed both in time and space. In the worst case scenario (shortest distance between the vaper and the bystander, minimal room ventilation), the increase of the particle concentration was observed 5 seconds after each puff, reaching a concentration of 10^6 #/cm3. The particle concentration rapidly returned to background levels (~1000 #/cm3) after 5 seconds, irrespective of the number of puffs taken, while the peak particle size shrank from 100-150 nm to 20-30 nm. This is in stark contrast to the conventional cigarette. Indeed, the particle concentration at the bystander's position increased also up to 10^6 #/cm3, but did not return to background levels after the puffs. Instead, there was accumulation of particles after successive puffs, reaching 50000 #/cm3 after the last puff of the experimental session (~50 times higher than with the e-cigarette). Regarding size, particles released during one puff on the conventional cigarette were in the range 200-300 nm, and shrank to 80-100 nm within a few seconds. Interestingly, this particle size was unchanged until their removal after 30-45 minutes. The rapid removal and the decrease of the size of e-cigarette particles suggest that exhaled e-cigarette particles are mainly liquid droplets which evaporate very rapidly. This is in contrast to the tobacco combustion particles, which remain suspended with a stable size in the ambient air for some time. This study shows clear and substantial differences between

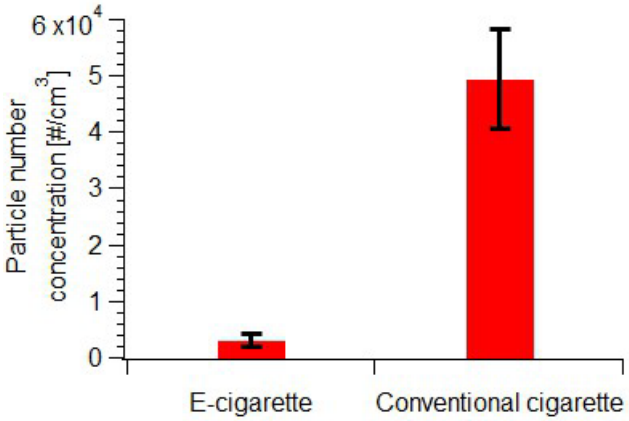
exhaled e-cigarette liquid droplets and conventional cigarette smoke particles.

Caption Figure 1:



Average size distribution of exhaled particles during the use of e-cigarette and conventional cigarette 5, 10, and 120 seconds after the puff.

Caption Figure 2:



Average particle number concentration in the exposure chamber 2-3 minutes after the end of the experiments.

Author CV:

2004/09 Ph.D. thesis in Life Sciences at the Institute for Work and Health (Lausanne, Switzerland), in collaboration with the Swiss Federal Institute of Technology (EPFL, Lausanne).
2010/12 Postdoctoral scholar at the University of California, Davis (United States).
2012/13 Postdoctoral scholar at Université du Littoral Côte d'Opale (Dunkirk, France).
2013/14 Postdoctoral scholar at Ecole des Mines de Douai (France).
Since 2014 Research scientist at Empa (Dübendorf, Switzerland). Current work: physico-chemical characterization of particles emitted by various sources (aircraft engines, e-cigarettes, municipal solid waste incineration plants).

	Shaygani Afshin
Affiliation	Sharif University of Technology
Email	shayganiafshin@gmail.com
Coauthors	Reza Saifi; Mahdi Sani; Mohammad Said Saidi;

Publication title	*Bayesian Inference Applied to a CFD-generated Database for Calibration of Electrical Mobility Spectrometer (EMS) and Size Distribution Measurements of Particles*
Publication type	Poster
Introduction & Background	One of the most crucial steps in combustion studies is particle classification and characterization. Electrical Mobility Spectrometers (EMSs) are instruments by which particles are classified according to their electrical mobility. Size distribution of particles can be interpreted by inversion of mobility spectra to size spectra. Accuracy of this inversion is subjected to blurring effect of Brownian motions of ions and ultrafine particles as well as multiple-charging phenomena and uncertainties in the instrument. In the present study, a procedure for inversion of mobility distribution to size distribution is proposed based on Bayesian interpretation. This method employs Computational Fluid Dynamics (CFD) to simulate particle charging phenomena in an aerosol charger and particle classification in the EMS. Mobility distribution of injected particles is given through particle tracking and estimation of charge (as signal) transfer to the signal detectors. A database containing size distributions of injected particles and corresponding mobility distributions reported by the classifier is constructed from tracking 1000 poly-disperse particles. In this construction, in each step, particles are injected with a randomly chosen size distribution (normal distribution) and this procedure continued for many iterations, to form a full database from a wide range of size distributions. Through Bayesian analysis, we predicted size distributions from transferred signals (by the injected clouds of particles) and compared our predictions to the exact size distributions. Subsequently, we discussed the sensitivity and accuracy of the predictions with respect to the number of detectors. It was found that the predictions of a classifier with less than three detectors, could be strongly sensitive to the noisy data and therefore cannot be reliable (for particles with unimodal normal distributions).
Methodology	CFD method is adopted to simulate particle charging phenomena in a charger and particle classification in an EMS. For the simulation of the charger, a single species model of corona discharge, decoupled to the flow field is used to estimate space charge density and electric field intensity. The birth-and-death charging theory is used to simulate charging phenomena. Some other assumptions: spherical particles; steady state flow field; the total signal transferred by a detector is equal to the sum of the charges on particles deposited on that detector; poly-disperse particles have normal size distributions; Uncertainties as noise is introduced in terms of normally distributed random variables (Gaussian white noise);
Results & Conclusions	For a noisy data, Bayesian analysis is a robust method for inversion of mobility to size spectra. Size distribution estimation from posterior densities is an appropriate alternative to other conventional methods like ordinary linear regressions and calculation of classical confidence intervals. According to the assumptions and simplifications, minimum number of detectors was found to be three for a reliable interpretation of unimodal size distribution.
Author CV:	Afshin Shaygani: He holds a master degree in Mechanical Engineering (Energy Conversion) and works as a freelance researcher and mechanical engineer. His research

interests include but not limited to turbulence, particle technology, CFD and computational physics, micro and nanotechnology, machine learning and statistical analysis.
(MScME. Sharif University of technology, Int'l. Campus, Iran)

	Shaygani Afshin
Affiliation	Sharif University of Technology
Email	shayganiafshin@gmail.com
Coauthors	Reza Saifi; Mahdi Sani; Mohammad Said Saidi;

Publication title	*Quasi-Smoluchowski Equation and Deposition of Macro-Nano Particles onto a Surface*
Publication type	Poster
Introduction & Background	An abundance of fields in science and engineering is concerned with the study of particulate dynamics and morphology. From the study of particle-laden flows in turbulence and combustion, and study of bubbles and sprays, to the study of polymerization or even microbial population and dynamics. Smoluchowski equation is a population balance equation, describing spatio-temporal evolution of particulates' concentrations, applicable to aforementioned areas. In the present work, we studied the deposition and sedimentation of particles onto a surface by means of theoretical, numerical methods and discussed the results. We found that the number density and size evolution of deposited particles/clusters can be described and modeled mathematically by a system of differential equations. This system would be approached as a form of Smoluchowski coagulation equation, called quasi-Smoluchowski equation (QSE) hereafter. Further attempts made to obtain deposition kernels through numerical analysis in order to derive QSE and therefore to model the particle deposition process onto a surface. The kernels known as operators, formulate particle-particle and particle-surface interactions in the probability language, obtained by numerical or analytical studies.
Methodology	As particles deposit on a surface, they either form aggregates to the existing particles or land on free spaces on the surface. Moreover, as aggregates grow on the surface, cluster-cluster interactions may take place and result in decrement of the total number of clusters and increment of the size. The governing equations (QSE) describe evolution of aggregate concentrations and size in time. Size of the clusters can be obtained based on the number of constituent mono-disperse particles or equivalent diameters of the clusters such as aerodynamic diameter or gyradius. The kernels are extracted based on some rules attained from numerical and/or experimental observations. For example, a simple rule based on pure geometry would dictate that, the probability of forming aggregates to an existing cluster (deposited on the surface) is proportional to the size of the cluster, since larger clusters have larger surface area and therefore higher chance for particle collisions. As the cluster grows, transformation to a larger cluster accelerates through higher chance of particle attraction. Therefore, there would be a few fast-growing large clusters whereas so many small clusters with slow rate of growth.
Results & Conclusions	We theorized and derived governing equations (QSE) of deposition phenomenon describing the growth and concentration of deposited clusters versus time, which can also be used to model deposition behavior of droplets. According to the results, at any instance, number density versus size can be well approximated by a Power-law distribution.
Author CV:	Afshin Shaygani: He holds a master degree in Mechanical Engineering (Energy Conversion) and works as a freelance researcher and mechanical engineer. His research interests include but not limited to turbulence, particle technology, CFD and computational physics, micro and nanotechnology, machine learning and statistical analysis.

(MScME. Sharif University of technology, Int'l. Campus, Iran)

Shingler Taylor

Affiliation	National Aeronautics and Space Administration - Langley
Email	taylor.j.shingler@nasa.gov
Coauthors	R. H. Moore; C. E. Robinson; E. L. Winstead; E. C. Crosbie; L. D. Ziemba; L. K. Thornhill; B. E. Anderson
Publication title	*Black Carbon Shootout: Instrument Intercomparison*
Publication type	Poster
Introduction & Background	The U.S. NASA Langley Aerosol Research Group (LARGE) has been providing BC based measurements and engine emission factors for over 15 years in a variety of airborne and ground based field campaigns, and laboratory studies. These data are made available to the general public and must be of the highest quality to enable assessments and prediction of environmental impacts related to changing technology and emission patterns. Studies are needed to more firmly establish the accuracy and precision of these measurements and to resolve observed differences between techniques in similar test venues. Work is also needed to develop calibration and correction schemes for new sensors and to link there measurements to heritage instruments on which our understanding of BC emissions and characteristics is built. A laboratory-based intercomparison of instruments measuring black carbon has been performed.
Methodology	Black carbon particles were produced from a mini-CAST (Jing) diffusion flame soot generator and passed to instruments measuring optical absorption, extinction, scattering, and black carbon mass. Generated particles were analyzed with and without treatment from a 350 C thermal denuder. Measurements of optical absorption were performed using a PSAP (Radiance Research), PASS-3 (DMT), TAP (BMI), MSS-plus (AVL), and a MAAP (Thermo-Scientific). Measurements of aerosol extinction and scattering were performed using a CAPS (Aerodyne Research) and an integrating nephelometer (Air Photon). Black carbon mass was also measured using laser incandescence from an SP2 (DMT) and an LII-300 (Artium Technologies). Mass measurements were inferred using an OC/EC (Sunset Labs) and gravimetric analysis from quartz filters collected concurrently during sampling.
Results & Conclusions	Black carbon quantification measurements are analyzed between instruments to assess agreement between platforms using manufacturer's calibration settings as well as after calibrations performed to a single standard soot source (mini-CAST). Impacts of organic carbon content of mini-CAST emissions on instrument agreement are investigated as well.
Author CV:	Taylor Shingler, Ph.D. EDUCATIONAL EXPERIENCE University of Arizona Chemical and Environmental Engineering Minor: Chemistry B.S. 2011 University of Arizona Chemical Engineering Minor: Atmospheric Science Ph.D. 2016 PROFESSIONAL EXPERIENCE Postdoctoral Fellow, NASA Langley Research Center, Science Directorate (2016 – Present) Research Associate II, Technology and Applied Research, Ventana Medical Systems, Inc. – Roche Tissue Diagnostics (2006 – 2016) Staff Assistant, Department of Chemistry, University of Arizona (2007) Teaching Assistant, Department of Chemical Engineering, University of

Arizona (2012, 2014-15)

	Singh Ankur
Affiliation	Indian Institute of Technology Delhi, India
Email	eraks12@gmail.com
Coauthors	IMAM HUSSAIN; D SARIKA; ANNADA PADHI; CHANDRA VENKATARAMAN; GAZALA HABIB

Publication title	*Understanding the Current Usage Pattern of Residential Biomass Fuel and its Implications in Northern Indian Region*
Publication type	Poster
Introduction & Background	Presently in most of the middle-income countries meals are cooked with traditional stoves or open fires using biomass fuel as a source of energy as well as for heating purposes. It is estimated that as many as 70% of households in developing countries use fuels such as wood, dung and crop residues for cooking [International Energy Agency, 2002; WHO, 2006]. Many researchers have reported with exhaustive data that solid biomass fuels emit substantial amounts of climate and health-damaging pollutants. Apparently the so far 'free' availability of biomass fuels from nature and at a very varied low cost are the obvious reasons behind their being used as a primary fuel source for household purposes. The objective of the study was to determine the pattern and determinants of household sources of energy for cooking and heating in rural north India.
Methodology	The present study is based on a structured questionnaire survey used for evaluating the cookstove and fuel usage pattern and identifies the knowledge gaps in previously conducted household level surveys. The primary data is collected from more than 500 households in many categories ranging from cooking energy, cookstove preferences, educational background and financial status and also the health related issues. These survey based data are then analysed comprehensively which would be primarily used in the refinement of activity data to be used for further emission estimate of aerosol and gaseous pollutants in the future. Also, the results can be helpful to draw various co-relations and dependant factors to understand the various challenges in the residential energy sector like shift from traditional to improved cookstoves or substituting the fuel to cleaner ones like LPG.
Results & Conclusions	The results of this paper concludes that with the ever increasing pollution and added biomass exposure to rural people, there are negative health effects and burden on the economy of the country by extra health costs. The lessons learned during refinement of the results from this study would further add up into governmental policies and monitoring programmes, studies on understanding the environmental risk assessment of indoor air pollution from biomass burning in rural areas. This report also intends to set the background for key data gaps that need to be addressed in order to facilitate a better understanding of household fuel choices which can better improve the situation of energy access and enhance further development to ensure a better solution.
Author CV:	Ankur Singh received his Bachelor's degree in Electronics & Communication Engineering from UPTU, India. He has substantial industrial experience and is a consultant in many projects. Currently he is engaged as Research Associate in National Carbonaceous Aerosol Programme (NCAP) at the Department of Civil engineering, Indian Institute of Technology Delhi, India. He has presented many technical papers in reputed conferences.

	Šperka Jiří
Affiliation	Czech Metrology Institute Brno
Email	jsperka@cmi.cz
Coauthors	Václav Hortvík; Radek Šlesinger; Jan Martinek, Petr Klapetek

Publication title	*3D Printed Module for Air Flow Control of PPD42 Particle Sensor*
Publication type	Poster
Introduction & Background	Affordable particle monitoring instruments based on low-cost sensors may offer a means to supplement and extend existing particle measurement infrastructure and increase measurements density & coverage (Holstius 2014). Recently, low-cost optical particle sensor, model Shinyei PPD42NS has been employed for several different air pollution monitoring devices, such as air quality monitoring device described by Chris Nafis (Nafis, 2012), prototype of fine particulate matter monitor with acronym PANDA (Holstius, 2014), Portable University of Washington Particle (PUWP) monitor (Seto, 2014) or DustDuino (Schroyer, 2013). Shinyei PPD42NS sensor has been also successfully employed e.g. for testing of spatiotemporal variations of PM2.5 in Xi'an, China (Gao 2015).
Methodology	Aerosol is drawn by means of a convection flow that is induced by heat of a small 0.25 W resistor through the sensing volume of PPD42NS detector. This makes the airflow sensitive to orientation with respect to gravity (Holstius, 2014). The main drawback is that the air flow rate is not known. Moreover, due to design of the sensor, gas flow in sensing volume can be influenced by external air flow conditions such as wind in outdoor environment.
Results & Conclusions	This contribution presents the design of 3D printed solution for PPD42NS sensor which includes 3D printed enclosure box for sensor with connection to standardised gas inlet together with venting exhaust fan system for forced air flow through PPD42NS sensor. STL files for 3D print of whole solution can be downloaded for free at http://www.nanometrologie.cz/en/. Connection of the enclosure box to venting fan enables forced gas flow that is higher than convection flow induced by resistor and the response of the detector can be therefore faster. The gas flow can be easily estimated using off the shelf flow meter and gas outlet can be connected to outlet particle filter using 3D printed filter holder. Performance of sensor combined with 3D printed parts is tested under various conditions for several days of operation. PPD42NS sensor is operated using Arduino microcontroller with modified freely available code (Nafis, 2012, Schroyer, 2013).
Author CV:	Born in 1987 in Brno, Czech Republic EDUCATION • 2011-2015: PhD degree in Plasma Physics, Faculty of Science, Masaryk University, Brno; PhD thesis: “Dynamic Phenomena in Atmospheric Pressure Discharges”. • 2009-2011: Master’s degree in Plasma Physics, Faculty of Science, Masaryk University, Brno; master thesis: “Plasmachemical

deposition diamond films in dual microwave/radio frequency discharge".
• 2006-2009: Bachelor's degree in Physics, Faculty of Science, Masaryk University, Brno; bachelor thesis: "Deposition of nanocrystalline diamond films in microwave discharge".

SCHOLARSHIPS AND AWARDS
• 2016: Dean's Prize for publishing of excellent results of research that were carried out during PhD studies at Masaryk University, Faculty of Science.
• 2015: Best student oral presentation in physical sciences, The European Low Gravity Research Association 22nd biennial Symposium and General Assembly, Corfu, Greece; presentation entitled "Hypergravity Experiments at Large Diameter Centrifuge with Gliding Arc Plasma".
• 2014: Best student poster, The XXII Europhysics Conference on Atomic and Molecular Physics of Ionized Gases, Greifswald, Germany; poster entitled "Non–thermal Atmospheric Pressure Plasma Jet Operated in Krypton and Argon: Visual Characterisation of Discharge using High-speed Cam- era".

EMPLOYMENT
• since April 2015: Czech Metrology Institute Brno, Department nanometrology and technical length.

GENERAL RESEARCH INTERESTS
• Nanometrology
• Light scattering on small particles
• Gravity related research
• Dusty plasmas

Stanciu Stefan G.

Affiliation	University Politehnica of Bucharest
Email	stefan.stanciu@cmmip-upb.org
Coauthors	Denis E. Tranca; Alina Holban; Radu Hristu; Marius Popescu; George A. Stanciu

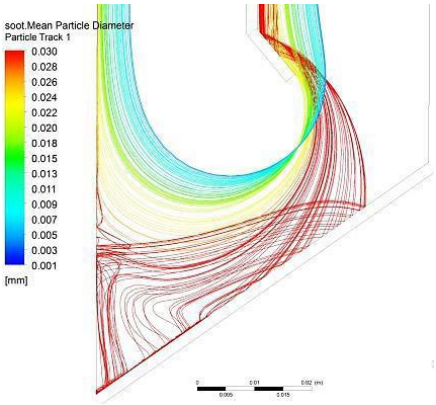
Publication title	*Characterization of Nanostructured Materials, Biological Specimens, and their Interaction by means of Correlative Optical Imaging in the Far-field and Near-field Regimes*
Publication type	Poster
Introduction & Background	During the past decades we have witnessed major advances in the fields of microscopy and nanoscopy. Efforts in this area have deep implications for the scientific field of nanoparticle research as investigating the chemical and physical properties of nanosized and nanostrucutred materials at high and ultra-high spatial resolutions is key for gaining an in-depth understanding of their impact over the environment and for developing novel sensing technologies. Furthermore, imaging technologies capable of resolutions lying in the nanoscale realm represent tools of utmost importance for understanding the interaction of such materials with biological specimens, which is important for comprehending potential health hazards and developing associated diagnostic and therapeutic approaches. Progress in these fields requires the combination of different imaging modalities, because the specifics of an investigation technique can be suitable to image certain structural, physical or chemical aspects, yet may exclude others. Therefore, most experiments focused at imaging nanosized and nanostructured materials usually require multiple imaging modalities, each of these capable of shedding light over complementary aspects. An existing problem in this regard consists in the fact that that identifying sample regions of interest after switching between imaging systems based on distinct contrast mechanisms, and working at different resolution scales is time demanding (and sometimes impossible). Correlative imaging using multi-modal systems alleviate part of these difficulties by eliminating the need of sample repositioning and registration and providing significant advantages in regard to investigating samples with time-dependent properties.
Methodology	Recently, a multimodal imaging system capable to collect optical data on overlapping field-of-views by several far-field and near-field techniques was developed at the Center for Microscopy-Microanalysis and Information Processing at University Politehnica of Bucharest (CMMIP-UPB). The contrast mechanisms of the incorporated imaging techniques provide complementary information, which plays an important role in facilitating nanoscale data understanding and interpretation. The combination of Apertureless Scanning Near-Field Optical Microscopy (ASNOM) and Laser Scanning Microscopy (LSM), two of the incorporated imaging modalities, proves to be very valuable with respect to investigating nanosized/nanostructured samples and their interaction with microorganisms, cells and tissues. In particular, scattering-type ASNOM (s-SNOM) can be used to probe the optical properties of non-labeled specimens and also to extract quantitative information over their dielectric properties at nanoscale resolutions [1]. On the other hand, LSM techniques can be used to non-invasively investigate biological specimens at resolution and detail levels suitable to assess their structure and functionality, and hence help place ASNOM data into a broader biomedical context.
Results & Conclusions	In this contribution we discuss a series of recent experiments in which the

	combination of the ASNOM and LSM techniques available in the multi-modal system developed at CMMIP-UPB was employed for the correlative characterization of nanosized/nanostructured materials, biological specimens and their interaction. Special emphasis is placed on highlighting the capabilities of s-SNOM to extract information over the real-part and imaginary-part of the dielectric function, and of connected optical constants such as the refractive index, at spatial resolutions beyond the diffraction barrier. In biomedicine these properties can be exploited for providing an estimate of the concentration of cell constituents, and indicate cell intoxication with certain exogenous agents. Characterization of carbonaceous materials formed in combustion, such as nanoparticles and primary soot, can also benefit of these possibilities offered by s-SNOM. A precise understanding of how their dielectric and optical properties correlate with size can lead to developing sensing technologies [2] with capabilities beyond the current state-of-the-art. The presented experiments highlight as well the complementarity between ASNOM and LSM techniques. In particular, we discuss how LSM variants such as Confocal Scanning Laser Microscopy or Multiphoton Excitation Microscopy can be used to place ASNOM data into a well understood biological context, probed on the basis of intrinsic and extrinsic contrast. Our results indicate that multimodal imaging with optical techniques operating in the far-field and near-field regimes holds significant potential for enabling new perspectives in many fields of science such as materials science, biology or medicine
Author CV:	Dr. Stefan G. Stanciu received a Ph.D. degree in Electronics and Telecommunications from the University Politehnica of Bucharest (UPB) in 2011. Currently he is conducting his research activities as Principal Investigator at the Center for Microscopy-Microanalysis and Information Processing of UPB. His main research interests revolve around scanning laser and scanning probe microscopies, and connected image processing and computer vision topics. Stefan’s current research agenda focuses on optical characterization of cells, tissues and biomaterials using combined biophotonics approaches, but also on the design and development of novel image classification frameworks for automated disease diagnostics.

	Sulovcova Katarina
Affiliation	University of Zilina, Faculty of Mechanical Engineering, Department of Power Engineering, Univerzitna 1, 010 26 Zilina, Slovakia
Email	radovan.nosek@fstroj.uniza.sk
Coauthors	Radovan Nosek; Jozef Jandacka; Michal Holubcik

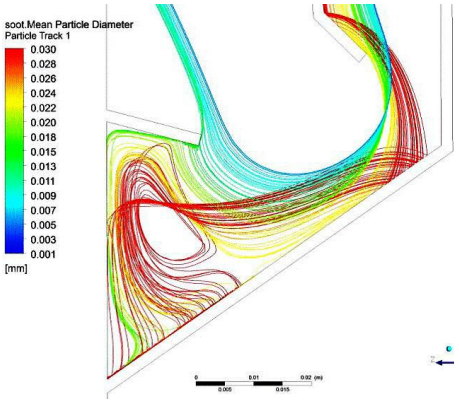
Publication title	*Geometrical Optimization of the Flue Gas Path with Regard to Particulate Matter Reduction*
Publication type	Poster
Introduction & Background	With regard to decrease particulate matter (PM) formation in small heat sources are used various kinds of methods and devices which are expensive. Therefore, one of the ways how to decrease concentration of PM is to make modification straightaway in the source. This can be done by change of geometrical parameters of combustion chamber or flue gas path. This work deals with the changes of flue gas path in laboratory scale. A special tunnel labyrinth was produce in order to investigate the behaviour of PM emitted into the ambient air from combustion process in the small heat sources. This device is made of few parts that together create tunnel. Construction of this tunnel also make second combustion zone and work as built-in mechanical separator too.
Methodology	The simplified model of small heat sources, based on real condition was created for simulation. With the intention to simplify the model of the flow as much as possible and also to reduce solving time was needed to take into account following assumptions: the combustion is not considered in the simulation and model includes just fluid (air) flow. The further assumptions are that processes are time independent and the fluid is incompressible. Very important is to consider gravity force, which has a major impact on the PM separation in this case.
Results & Conclusions	The flow of particles is result of simplified simulation. This flow is much idealized, also without particle turbulence and interaction among them. Particles were flowing in the tunnel labyrinth, in place, where is biggest change of flow direction. There is separation zone of tunnel labyrinth where is lover velocity. The most of bigger particles were separated at the bottom of tunnel in the original design of tunnel labyrinth. The smaller particles were not influenced by tunnel construction and flown away into the chimney (Figure 1). Various construction of labyrinth were created in order to simulate the flow of PM and to analyse the best option. In this case was important to evaluate the amount of trapped particles. According to the results was chosen the best modified construction (Figure 2). This construction is theoretically able to trap more particles compare to original design. The results indicate that modification of geometrical parameters has an influence on PM concentration in flue gas and on its separation. This can lead to reduction of emitted particulate matters. In the future more tests and experiments are necessary to do in order to improve construction of heat source and reduce PM concentration. This way of observation seems to be good possibility of finding optimal solution of various problems also decreasing of PM. Using of numerical simulation is also financially more convenient than experimental searching by itself.

Caption Figure 1:



Flow of particulate matter in the original design of tunnel labyrinth

Caption Figure 2:



Flow of particulate matter in the modified design of tunnel labyrinth

Author CV:

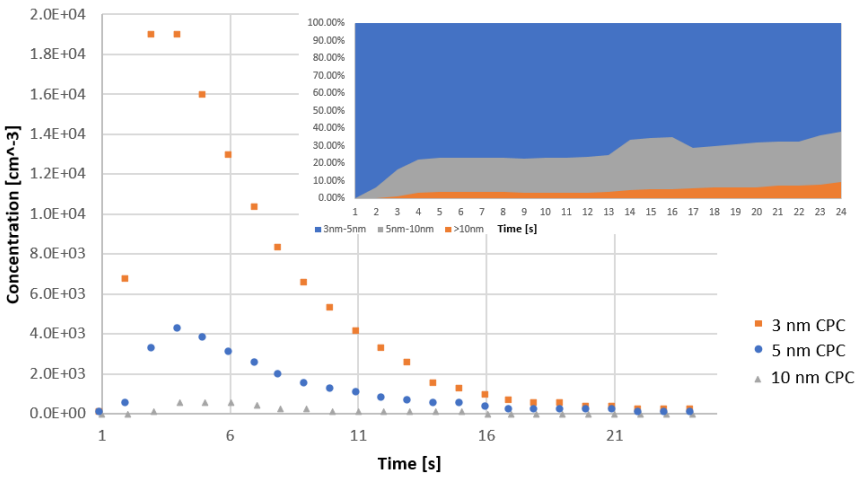
Radovan Nosek was awarded his PhD inCombustion Science by the University of Zilina and Silesian University of Technology, where he spent 20 months in the frame of Marie Curie Research Training Network. Much of his work has focussed on combustion, particulate matters, improving properties of wood pellets and heat recovery.

Svedberg Mika

Affiliation	Airmodus Ltd
Email	mika.svedberg@airmodus.com
Coauthors	Joonas Vanhanen

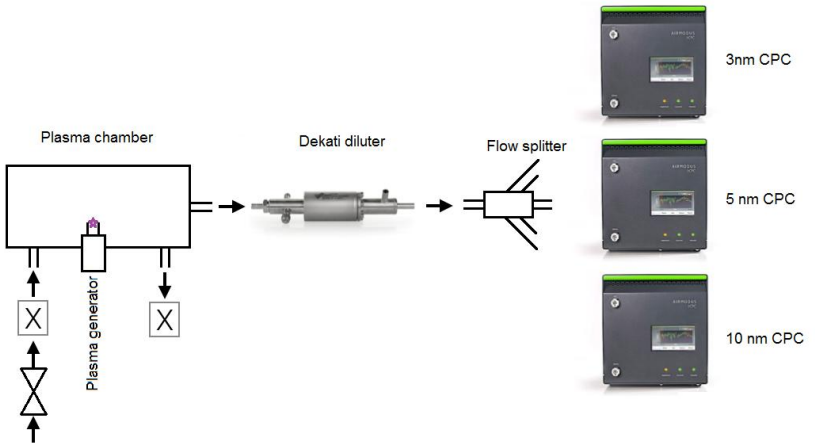
Publication title	*Fast Size Distribution Measurement for < 10 nm Plasma Generated Particles*
Publication type	Poster
Introduction & Background	Introduction Measuring ultrafine particle number size distribution in the sub - 10 nm size range from a combustion source is challenging due to high dynamics of the system. Both number concentrations and particle sizes change quickly. Most of the instruments capable of measuring the size distribution below 10nm have time resolution in the range of minutes, which is too long for measurement of combustion generated particle formation and growth. In this work we used condensation particle counter battery to achieve particle number concentration and size distribution with 1 second time resolution. Background Condensation particle counter battery consists of two or more CPCs that have different counting characteristics, for example lowest 50% cut point diameter or working fluid (Kulmala et al.. J. Aerosol Science 38 (2007) 289-304). In this study, we used three laminar flow CPCs using n-butanol as a working fluid (Airmodus A20 bCPC). One of the CPCs was modified to have lowest 50% cut point at 3 nm, one was left to factory settings with 5 nm cut point and one was tuned to 10 nm cut point diameter. The size information of the measured particle sample can be achieved by comparing number concentrations measured with the CPCs.
Methodology	The measurement setup consisted of 3 Airmodus A20 CPCs connected to a flow splitter, Dekati ejector diluter, a chamber, and a plasma lighter. Description of the setup is represented in figure 1. The active parts of the plasma lighter were inside the chamber which mixes and dilutes the sample before entering the additional 1/8 dilution factor diluter. The chamber's dilution and removal of background particles were achieved by introducing HEPA filtered air flow into the chamber. Excess air was allowed to flow out freely from the chamber via another vent and HEPA filter equalizing the chamber's pressure with ambient pressure.
Results & Conclusions	The lighter was activated for about 10th of a second and the sample was measured with the battery. Second-by-second concentrations measured by the CPCs is shown in figure 2 main plot. The same data is represented in subplot of the figure 2 showing relative concentrations of three particle ranges: 3-5nm, 5-10nm and >10nm. The figure shows clearly growth of 3-5nm particles into 5-10nm and finally into >10nm size range. During presentation of this work we will also present measurements of particle number concentration down to molecular sized (1.2 nm in diameter) using Airmodus nano Condensation Nucleus Counter system (Airmodus A11). Acknowledgements: Thanks for Dekati for co-operation.

Caption Figure 1:



Measurement setup for plasma generated nanoparticles.

Caption Figure 2:



Concentrations as function of time and relative concentrations of different particle size ranges (subplot).

Author CV:

Mika Svedberg
M.Sc. in Solid state physics

Background:
- R&D Engineer at Airmodus Ltd
- Sensing HW engineer at Microsoft Mobile
- Consultant at Magnet Technology Centre at Prizztech Ltd

	Teoh Roger
Affiliation	Imperial College London
Email	m.stettler@imperial.ac.uk
Coauthors	Marc Stettler

Publication title	*Aircraft Black Carbon Particle Number Emissions – New Predictive Method & Uncertainty Analysis*
Publication type	Poster
Introduction & Background	Black Carbon (BC) particle number emissions from aircraft jet engines contribute not only to anthropogenic climate change, but also on the deterioration of human health. The largest uncertainty in evaluations of civil aviation's impact on the climate is the contribution of BC particles to the formation of contrails, which have a significant and short-lived climate impact. Previous studies have shown that the number of contrail ice particles is strongly correlated with the number of BC particles emitted by aircraft engines.
Methodology	At present, existing methods to estimate the BC particle number emissions index (EIn), the number of BC particles per kg of fuel, are limited by several assumptions, including that BC aggregate morphologies remain constant irrespective of thrust settings. Using a bottom-up approach based on fractal aggregate theories, this paper proposes a new method to estimate EIn for global civil aviation. BC EIn estimates calculated using this new approach have been validated and agree well with direct measurements from both ground and cruise conditions. A review of its model input parameters such as different BC mass emissions (EIm) methodologies available, Geometric Mean Diameter (GMD), and Geometric Standard Deviation (GSD) have also been conducted prior to performing an uncertainty and sensitivity analysis.
Results & Conclusions	The new BC EIn predictive model is subsequently applied to an aircraft activity sample dataset from the Aviation Environmental Design Tool (AEDT). This subset consists of 3371 individual flights during cruise, which parameters are mainly captured by the US FAA radar coverage from the 9th to 11th of March 2006. Preliminary analysis suggests the average BC EIn to be around 1.2x1015 #/kg-fuel, around 85% higher than previous estimates. This higher number of estimated BC EIn in the baseline scenario implies a smaller contrail ice particle diameter, potentially increasing its optical depth and radiative forcing. Several topics are identified for further research.
Author CV:	Roger Teoh is a PhD student in the Centre for Transport Studies, Imperial College London. Dr Marc Stettler is Lecturer in Transport and Environment at the Centre for Transport Studies, Imperial College London.

	Topinka Jan
Affiliation	Institute of Experimental Medicine CAS, Czech Republic
Email	jtopinka@biomed.cas.cz
Coauthors	Jiří Horák; František Hopan; Alena Milcová; Antonín Ambrož; Pavel Rossner; Kamil Krpec; Petr Kubesa

Publication title	*Genotoxic Potential of Particulate Emissions from Residential Solid Fuel Boilers: The Effect of Technology, Fuel, and Operation Output*
Publication type	Poster
Introduction & Background	Combustion of various solid fuels in different types of small boilers is a widely used form of heating family houses. However, these types of combustion processes emit large quantities of harmful gaseous and PM emissions. Epidemiological studies show that PM created in small heating appliances contains carcinogens and mutagens and thus may have undesirable and harmful impacts on health. Previous studies have noted that the quality of combustion is affected by the combustion technology, user operation, and fuel used, all of which affect the formation of emissions.
Methodology	Various solid fuels (hard coal, lignite, dry wood, wet wood, lignite briquettes, wood pellets) were burnt in four different types of boilers representing both old structural designs (over-fire and under-fire boilers) and also up-to-date combustion devices (gasification and automatic boilers). Two different performance outputs (i.e., nominal and reduced) of boilers were tested to compare the concentration of organic PM components, their toxicity and biological response. For this purpose, the organic components of collected total particulate matter (formed by 93-100% by PM2.5) were extracted, 16 priority PAHs were quantified in extracts by GC-MS, and the analysis of the genotoxic potential of extracts using acellular assay of DNA adducts in calf thymus DNA (relatively simple method to identify genotoxic potential of complex mixtures) was employed.
Results & Conclusions	We found that depending on the boiler's technology, fuel quality and output (reduced or nominal) the mass of emitted PM2.5 varied from 0.2 to 84 kg/ton of fuel. The concentrations of the representative carcinogenic PAH – benzo[a]pyrene varied from 5 to 18,000 mg/ton of fuel. Such huge differences in PAH content are reflected by results of measurement of genotoxic potential in acellular assay: DNA adducts in calf thymus DNA after metabolic activation of PAHs (by S9 microsomal fraction) varied from 6 to 140 adducts/108 nucleotides. Differences in adduct levels are even higher after normalization of results per kg of fuel. The results of the study suggest that: (1) Mass of particulate emissions from boilers highly correlate with PM2.5 and PAH content; (2) For all fuels the highest genotoxicity was observed for over-fire and down-draft boilers compared to boilers gasification and automatic boilers; (3) Reduced output exhibited more emissions and higher toxicity than nominal output; (4) In over-fire boiler are emissions from coal substantially higher and more genotoxic worse than from biomass; (5) Modern boilers (gasification and automatic) produced lower emissions and exhibited lower genotoxicity. In summary, the results of the study suggest huge differences in mass, composition and genotoxic potential of complex mixtures of organic compounds forming PM emissions from various small boilers. These results reveal the need of further study in target human cells aiming to identify mechanisms of the action, targeted biological processes and human health risk. Supported by Czech Science Foundation (grant No. P-503-12-G147). This work was prepared within the project „Innovation for Efficiency and Environment – Growth", identification code LO1403 with the financial

support from the Ministry of Education, Youth and Sports in the framework of the National Sustainability Programme I.

Author CV:

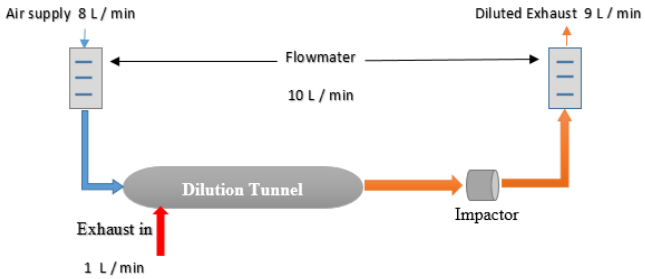
Short CV:Jan Topinka (Ph.D. in Physical and Nuclear Chemistry – 1986, D.Sc. in Biomedicine – 2005) is Head of the Department of Genetic Toxicology and Nanotoxicology, Institute of Experimental Medicine AS CR, Prague. His scientific activities are in the field of (1) toxicity testing of nanoparticles(2) genotoxicity testing of complex mixtures in vitro and in vivo, (3) chemical carcinogenesis, biomarkers of exposure to mutagens and carcinogens and (4) molecular epidemiology. He participated in several EU funded projects related to nanotoxicology (NANOREG, QNANO, MODENA). He coordinated EU project LIFE+ Evironment on new methods of detection of emissions toxicity (MEDETOX). He has published more than 100 papers in peer-reviewed scientific journals.

Varghese Gelu

Affiliation	Brighton University
Email	g.varghese@brighton.ac.uk
Coauthors	Dr.Khizer Saeed, Zaid, Al –Harbi, Xing, L

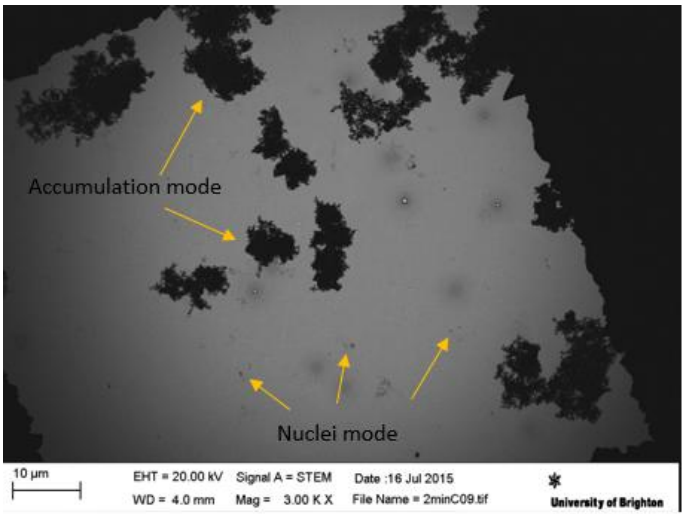
Publication title	*Investigation of the Characteristics of Nanoparticles Emissions from the Small Diesel Engine*
Publication type	Poster
Introduction & Background	Particle matter emissions from internal combustion engines (IC) of size distribution of less than 100 nm have been attracting considerable attention due to their adverse environmental and health effects The particle size and shape or morphology directly affects atmosphere's optical properties. Particle morphology also influences particle's interaction with epithelial cells. Moreover, it was observed that both large (aggregates) as well as single sphere particles possess the capability of affection the deposition efficiency present in the lungs. It was indicated by toxicological researches that nanoparticles toxicity depends on the size, surface area and shape of the nanoparticles, rather than only on the size. Particles that are 1 nm size particles are deposited in the lungs upper regions. In the pharynx and the nose, and the bronchial tubes and windpipe, 5nm particles were deposited. The alveoli were the region where the 20nm nanoparticles were deposited. Irrespective of the routes that are taken, these particles can also reach the brain. Recent diesel engines reduced mass of particles but can produce greater number of 'nuclei mode' nanosized particles which can be highly variable size and shape, as well as large aggregates of small agglomerates. The exact mechanism of the formation and growth of these nanosized particles in diesel engine is still subject of active research investigations. Identification and analysis of the nanoparticles morphology is considerably crucial for determining the impacts it has on human health. In this study, the aim was to experimentally investigates and identify the characteristics of nanoparticles emitted from the small diesel engines for their size, shapes and morphological features.
Methodology	Small diesel engine operated under variable loading conditions has been used as a source of generating particles. A new particle collection method was developed for the collection of the nanoparticles for direct analysis of their size and morphology. In this method, a copper grid was directly mounted on a cascade impactor plates for the collection of particles. Cascade impactor was then integrated with the dilution tunnel attached to small direct injection diesel engine exhaust. Particles collected on the copper grid were then directly analysed on the of the high-resolution transmission electron microscope (TEM) for their size and morphology. Measurements of the particles shape and morphology were under taken at transient and steady state operating conditions of engines at different load (0-4 kW) conditions.
Results & Conclusions	Results revealed that, during idle operation, the particles take the form of liquid droplets in combination with a limited number of aggregates. However, upon application of a load, chain aggregates take the place of the droplets, displaying a 55 nm average primary particle size at varying loads. The application of load on the engine caused the exhaust temperature to rise, resulting in the gradual disappearance of round and irregular primary particle droplets due to volatile substance loss and non-volatile substance oxidation.

Caption Figure 1:



New Particle Collection System integrated with Impactor placed with Particle Collection Copper Grid

Caption Figure 2:



The size and morphological feature of primary and agglomerate particles

Author CV:

Gelu Varghese
Research Student
Brighton University, UK

Working in Ford Motor Company, UK

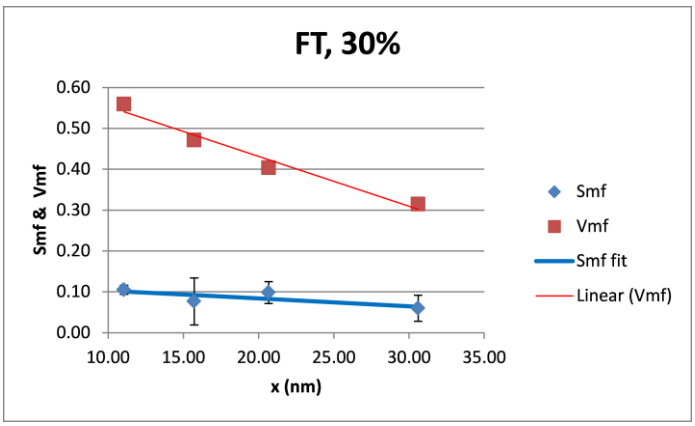
Vojtisek-Lom Michal

Affiliation	Czech Technical University in Prague & Technical University of Liberec
Email	michal.vojtisek@fs.cvut.cz
Coauthors	Martin Pechout; Vit Beranek; Jonas Jirku

Publication title	*On-track Measurements of Exhaust Emissions from Diesel Motorized Car and Locomotives During Line-haul passenger Service*
Publication type	Poster
Introduction & Background	Particulate matter from local heating appliances and internal combustion engines is one of the leading causes of premature deaths in many urban areas, as particles are small, carcinogenic, and are distributed at nearly the ground level. Particle emissions from on-road vehicles have been successfully reduced, at least in wealthier regions, by the widespread introduction of particle filters. Legislation targeting especially very small and very large non-road engines has been lagging. Targeting of large - over 560 kW – engines has been also difficult due to longevity of the engines and due to very limited and rather expensive options for laboratory testing. This study summarizes results and experiences with on-rail tests of two diesel electric locomotives and one diesel hydraulic motorized car, which were fitted with portable on-board monitoring instrumentation and their emissions were measured during regular scheduled operation on passenger train service to demonstrate the feasibility of such approach and to establish a baseline.
Methodology	In all cases, raw exhaust gas was sampled by instruments located in the engine compartment, and the exhaust flow was calculated from engine operating and technical data. On two vehicles, an in-house designed miniature on-board system was used, featuring an NDIR bench for CO and CO2, electrochemical cells for NO and NO2, light scattering unit for total particle mass and ionization chamber for total particle number, with all data measured online at 1 second resolution, and a proportional gravimetric sampling system. On one locomotive, a charge-based nanoparticle analyzer (NanoMet3) and an in-house designed system using an industrial Fourier Transform Infra Red spectrometer, both sharing a 6 m heated sample line, were also used. The instrumentation installation was adapted, among others, to the presence of overhead traction lines during portion of the run, vegetation outside of the minimum clearance outline, usage of both engineer's cabins at locomotive ends, and relatively narrow locomotive access doors. The measurement took place on a 140 km Prague to Tanvald run, which was run multiple times in different train configurations.
Results & Conclusions	Overall, particle mass emissions were on the order of tenths of grams per kg of fuel. NOx emissions, primarily emitted as NO, were typical for a diesel engine without aftertreatment. Little hydrocarbons or CO was produced. The particle emissions were not dissimilar from high-emitting diesel cars on a per km basis, suggesting that large engines can have relatively low emissions deterioration rates. NOx and PM emissions per passenger per km are in line with an average EU diesel car. The experiences suggest that on-rail (on-track) emissions ("real rolling emissions"?) can be readily measured with an on-board system not relying on direct measurement of exhaust flow. The on-board FTIR has proven to be a useful instrument covering the gases of interest, and may be used in the future for non-regulated pollutants such as ammonia, nitrous oxide, or methane. Transient and cold start emissions of particulate matter are not negligible, suggesting that online measurement offers advantages over steady-state conditions only. Similar approaches are likely to be applicable

	to other types of non-road engines.
Author CV:	Michal Vojtisek-Lom has designed and built one of the first portable emissions monitoring systems (PEMS) twenty years ago. It was used to assess real driving emissions from a fleet of natural gas buses at the University of Pittsburgh, where he obtained a M.S. degree in Energy Resources. He is currently a resident alchemist and Associate Professor at the Center of Sustainable Mobility at the Czech Technical University in Prague, and Associate Professor of Mechanical Engineering at the Technical University of Liberec, where he also obtained Ph.D. in Mechanical Engineering. Michal's primary interest are combustion of alternative fuels, real-world emissions, and evaluation of the effects of new fuels and technologies on emissions, environment, and human health.

	Whitefield Philip
Affiliation	missouri University of Science and Technology
Email	pwhite@mst.edu
Coauthors	Donald E. Hagen, Prem Lobo and Max Trueblood

Publication title	*Plume Processing of Soot Aerosol in a Jet Engine Exhaust*
Publication type	Poster
Introduction & Background	Limited information is available on the soluble mass fraction (SMF) and volatile mass fraction (VMF) of aircraft engine soot particles. These parameters play an important role in the water absorption, airborne lifetime, obscuring effect, and detrimental health effects of these particles. Plume processing occurs as the exhaust sample cools and mixes with ambient air when it leaves the engine exit plane. Soluble and volatile materials condense onto the exhaust soot.
Methodology	During Project AAFEX-II (Alternative Aviation Fuel Emissions eXperiment), PM emissions measurements were made on a CFM56-2C1 gas turbine engine mounted on a NASA DC-8 aircraft. The engine was operated at several power levels, and burned several fuels: JP-8, a coal-based Fischer-Tropsch (FT) fuel, and a Tallow-based Hydroprocessed Renewable Jet (HRJ) fuel. In addition, blends of JP8 and HRJ and FT with 1000 ppm sulfur added (THT) were also studied. The objectives of the AAFEX-II campaign were to evaluate alternate fuel effects on engine performance and fuel-handling equipment, determine fuel effects on engine PM and gas phase emissions, study the role of sulfur on exhaust PM, investigate the impact of sample line chemistry and line losses on emission measurements, and to support the development of standardized exhaust sampling methodology. Emission samples were extracted at the engine exit plane (1m), in the near field (30m), and in the advected plume (145m). Condensation particle counters and electrical mobility-based size spectrometers were used for number and size distribution measurements. Volatility and deliquescence and measurements were conducted on the downstream samples, using a thermal denuder operating at 300 C and a tandem differential mobility analyzer with saturator, to determine the aerosol's SMF and VMF.
Results & Conclusions	The SMF was observed to increase as did the fuel sulfur content; the highest SMF and VMF were found in particles around 10nm; and the SMF increased with increasing engine thrust levels. Figure 1 shows the 145m PM SMF and VMF as a function of particle diameter (x) for the conditions of 30% engine power when burning FT fuel.
Caption Figure 1:	 Fig. 1. Soluble Mass Fraction and Volatile Mass Fraction for exhaust aerosol as functions of particle diameter, using Fischer-Tropsch fuel at 30% engine

	power.
Author CV:	Dr. Philip Whitefield received his BSc and PhD degrees from the University of London, England. He is a Professor of Chemistry and Director of the Missouri S&T Center for Research in Energy and Environment. He is also Chairman of the Department of Chemistry at Missouri S&T. Dr. Whitefield is Lead Scientist for Emissions Characterization related projects in ASCENT, the FAA Center of Excellence for Alternative Jet Fuels and Environment. He is a member of Society of Automotive Engineers E-31 committee on aircraft engine exhaust emissions measurements. Dr. Whitefield has 28 years' experience in aerospace-related emissions research focusing on the development and application of novel techniques for future recommended standard measurement practices and the measurement and interpretation of aerospace emissions data with a particular emphasis in particulate matter (PM) characterization and quantification.

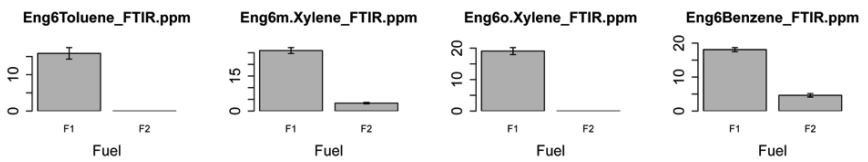
Yamada Hiroyuki

Affiliation	Tokyo Denki University
Email	h-yamada@mail.dendai.ac.jp
Coauthors	-

Publication title	*Sub-10 nm Particles Observation Using PMP Methodology -Down from Ten-*
Publication type	Poster
Introduction & Background	Sub-23 nm particle is one of the hottest topic among emission scientists. And there are some projects concerning an extension of PMP methodology down to 10 nm. In this study, we discuss possibility of PMP methodology detection limit from 10 nm.
Methodology	Particles from DPF diesel and gasoline DI passenger cars were observed using chassis dynamometer. For the emission measurement, addition to normal PMP system (AVL APC), two condensation particle counters (CPC; TSI 3772 and TSI 3776) which D50s are 10nm and 2.5 nm were set after a volatile particle remover (VPR). We also set EEPS (TSI, 3090) to CVS for monitoring high volatility particles which disappear at VPR.
Results & Conclusions	We observed sub 10 nm particles emissions. The emissions were affected by engine type, PCRF and evaporation tube temperature.
Author CV:	Kazuhiro Yamamoto is an Associate Professor of Nagoya University. He received his BE, ME, and DE in Chemical System Engineering at the University of Tokyo in Japan. His current research field is thermal engineering, especially combustion science. His recent achievement is the development of numerical code for fluid dynamics including Lattice Boltzmann method. One of its applications is the diesel particulate filter (DPF), where soot deposition and oxidation are simulated to understand the phenomena in small-scale multiphase flow. At 17th ETH-conference, a numerical simulation of exhaust gas after-treatment has been presented.

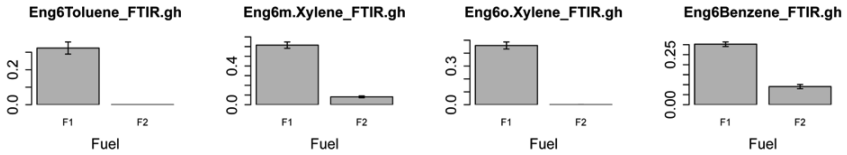
Zardini Alessandro

Affiliation	European Commission
Email	Alessandro.ZARDINI@ec.europa.eu
Coauthors	Suarez-Bertoa R.; Forni F.; Montigny F.; Garcia M.; Carriero M.; Astorga C.

Publication title	*Exhaust Emissions from Small Utility Engines: Effect of Different Fuels and Lube Oils*
Publication type	Poster
Introduction & Background	Intro Small utility, spark-ignited internal combustion engines are commonly used in gardening and forest management. They are known to be strong emitters of hydrocarbons (HC), carbon monoxide (CO), and particulate mass (PM). With hand-held machines the impact on human health of toxic substances in the exhaust may be locally amplified by their use close to the operator. The use of environmentally improved fuels, such as alkylate fuels with only trace amounts of aromatic compounds, seems promising in the reduction of primary carcinogenic species and secondary species like organic particles and Ozone. This study characterized the exhaust of 5 small utility spark-ignition engines (displacement between 20 and 50 cm3). For their type approval in the EU these engines need to fulfill environmental requirements on HC, CO and nitrous oxides (NOx), while at present particulate emissions (mass or number of particles) are not monitored. The engines were fueled with standard or alkylate petrol and standard or low ash-forming potential lube oils. We quantified the emissions of regulated compounds (HC, CO, NOx), gaseous unregulated compounds (e.g., some aromatics) and particle mass. The experiments were performed in the facility for small engines of the Vehicle Emission Laboratory (VELA-6) at the European Commission - Joint Research Centre (Italy).
Methodology	We performed raw exhaust sampling (gases) and diluted sampling (PM) on an engine test bed in a 75 m3 climatized test cell. We measured THC with Flame Ionization Detector (FID), CO and carbon dioxide with non-dispersive infrared (NDIR), nitrogen oxides (NOx) with chemiluminescence detector (CLD), oxygen (O2) with electrochemical cell, PM with a dedicated particle sampling system (Teflon filter, gravimetric method), and unregulated compounds with FTIR technique. Several engine and test cell parameters were monitored during the experiments: spark plug and engine-out temperatures (K-type thermocouples), engine speed, brake torque and power, air/fuel ratio lambda, room and intake air temperature, humidity, and pressure. Measurements were carried out on 5 engines, with 2 fuels and 2 lube oils.
Results & Conclusions	With the use of the standard fuel, we observed average emissions of about 285 g/h of carbon monoxide, 18 g/h of aromatics, 400 mg/h of formaldehyde. The use of alkylate fuel resulted beneficial in the reduction of several compounds, in particular all the monitored aromatics (from 70 to 90%). The use of low-ash forming potential oil was engine specific and had a lower impact compared to the change of fuel from standard to alkylate.
Caption Figure 1:	 Example of concentration reduction (ppm) with the use of standard fuel (F1)

and alkylate fuel (F2) over a G3 cycle composed of full mode and idle weighted 85% and 15%, respectively.

Caption Figure 2:



Example of emission reduction (g/h) with the use of standard fuel (F1) and alkylate fuel (F2) over a G3 cycle composed of full mode and idle weighted 85% and 15%, respectively.

Author CV:

Degree in Physics, University of Padua, Italy.
Specialization in environmental physics, meteorology dynamics.

PhD in Science, ETH-Zurich. Topic: organic/inorganic mixed aerosol particles.

Postdoc, University of Copenhagen. Particle/gas phase interactions.

Research assistant, Joint Research Centre of the European Commission (JRC-EC). Topic: exhaust emissions and secondary aerosol particles.

Scientific and technical support officer, Joint Research Centre of the European Commission (JRC-EC). Topics: Euro 5 for L-category vehicles, unregulated compounds. Small Engines emissions.

Zerrath Axel

Affiliation	TSI Incorporated
Email	axel.zerrath@tsi.com
Coauthors	Thomas Krinke; Oliver Bischof; Torsten Tritscher; Jacob Scheckman

Publication title	*Design Criteria and Early Stage Development of the Next Generation of Butanol CPC's*
Publication type	Poster
Introduction & Background	Over four decades Butanol-based Condensation Particle Counters (CPCs) have contributed significantly to the understanding of nanometer-sized particles and their physical properties. As times and research requirements changed, the instrumentation has evolved as well. A decade has past again and the needs of CPC users and their research activities are leading to new design criteria and early stage developments of Butanol-CPCs of the 4th generation.
Methodology	Butanol-CPCs serve specific research needs such as high sensitivity in low concentration emissions, vice versa counting in dense concentrations or reaching down to the smallest, typically freshly-formed particles at the 1 nm threshold or their use as detector within a particle sizer, resulting in a number concentration size spectrum. Specialized CPCs improve the suitability to those needs. Further specialization is needed to meet requirements where regulations exist, e.g. the CEN/TS 16976 guideline that harmonizes the measurement of ultrafine particles in the atmosphere for regulatory purposes. This range of requirements resulted in a group of five new Butanol-CPCs being developed at TSI. Consistency of results over years of research is very important to get most out of the data and to make sustainable conclusions. This requirement needs to be balanced with the need of improvements and a critical part in the review process leading to the next generation.
Results & Conclusions	The most-used and referenced Butanol-CPCs are the models 3010 and 3772 (TSI Inc., Shoreview, USA). Those models experienced significant changes but also have a proven track record of long-term comparable results. This basic version of a CPC has been adapted with regards to counting efficiency to meet a variety of special requirements such as those for engine exhaust measurements (with a lower size limit 50% efficiency at 23 nm) and regulated environmental monitoring (50% efficiency at 7 nm) compared to its standard specification. Researchers performing size distribution measurements using electrical mobility classification covering ultrafine and fine particulates in ambient and related airborne particle research often apply size classifiers (DMA, Differential Mobility Analyzers) operating up to 1,000 nm or above with a start size of somewhere between 5 and 10 nm. The sizing range of interest may lead to the conclusion to lower the nominal counting efficiency of the base model CPC from 10 nm into the midpoint of the most commonly used start size range. This change needs to maintain highly comparable concentration readings. Quality control also becomes increasingly important in the measurement of nanometer-sized particles. This is evident in for example data protocols requiring status codes to validate the results, but also in enhancements spreading in more and more products, such as continuous monitoring of the particle-to-droplet growth process using pulse height or related analysis.
Author CV:	2001 - 2003 PhD student in Chemistry at Technical University of Munich (Prof. Niessner).

2004 - now Application Engineer for Particle Insturments at TSI Inc.

Zöllner Christian

Affiliation	Department of Engineering Thermodynamics and Transport Processes (LTTT), Bayreuth Engine Research Center (BERC), University of Bayreuth, Germany
Email	christian.zoellner@uni-bayreuth.de
Coauthors	Dieter Brüggemann

Publication title	*Comparison of Loading and Regeneration Behavior of Uncoated, Coated and Aged Diesel Particulate Filters*
Publication type	Poster
Introduction & Background	The potential hazards of diesel exhaust emissions are a well-known fact and were officially confirmed by the International Agency for Research on Cancer (IARC) that belongs to the World Health Organization. To meet the strict emission standards for diesel engines, an additional exhaust aftertreatment system is essential. Diesel particulate filters (DPF) are particularly effective devices to remove particulate matter (PM) from the diesel exhaust. In case of wall-flow filters, the particulates are deposited in the porous wall and on the surface of the filter channels. This results in an increase of filter backpressure and thus has a negative impact on the engine performance and the fuel consumption. For this reason, the filter has to be regenerated periodically due to oxidation of the deposited PM. However, this DPF operating behavior is influenced by the characteristics of the deposited and accumulated soot, which is affected by different diesel engine operating parameters. This is especially relevant for the thermal control of the regeneration process that poses a challenge resulting from the lack of knowledge concerning the operation behavior of the DPF. In the future, this topic might become more important because of lower exhaust temperatures due to more efficient combustion and hybridization.
Methodology	In this study, the loading and regeneration behavior of diesel particulate filters is compared. For that purpose, filters were loaded under steady state conditions at the engine test bench. Several filters were loaded under different engine operating parameters that implicate different mass flows and particle properties in the exhaust. The subsequent regeneration was applied via post-injection under defined engine operating conditions to ensure comparability. The filters used in this study are standard wall-flow filters made out of silicon carbide. Uncoated as well as coated filters, with a platinum coating, were used. Furthermore, some of the filters were rapidly aged with an oil burner system that brings ash into the channels. Therefore, it was possible to investigate to influence of different ash levels on the DPF operating behavior.
Results & Conclusions	The results show significant differences concerning loading and regeneration behavior of uncoated and coated filters as well as filters with several ash levels. The most relevant differences are visible when the filters were loaded under engine operating conditions with smaller particles. Those differences particularly include the duration and the temperature levels and gradients inside the filter during loading and regeneration. Also the beginning of the PM oxidation is influenced by the filter-type respectively the ash level.
Author CV:	Born 1987, German - 07/2006 Abitur (equivalent to A level), Gymnasium Burgkunstadt, Germany - 03/2013 Diplom-Ingenieur (equivalent to M. Sc.) in Energy Science and Technology at University of Bayreuth - since 05/2013 Scientific Assistant at the Department of Engineering Thermodynamics and Transport Processes (LTTT), Bayreuth Engine Research Center (BERC) at University of Bayreuth, Germany

Zotter Peter

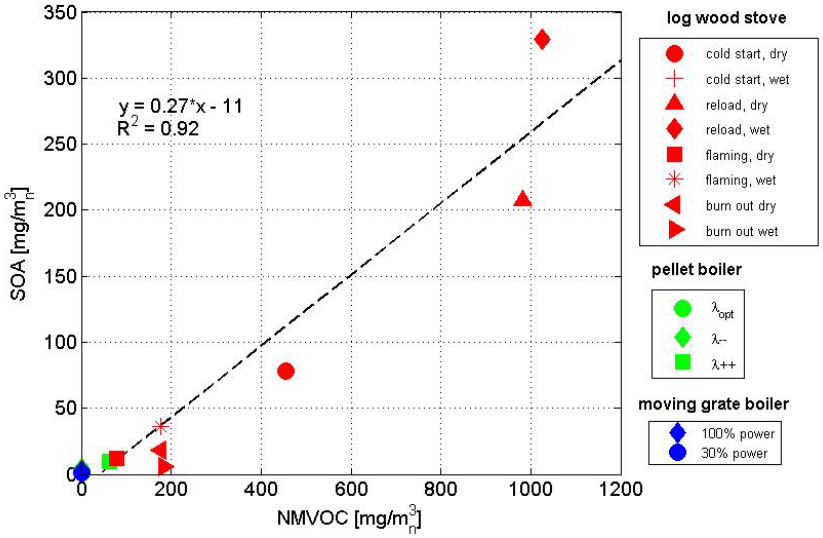
Affiliation	Bioenergy Research, CC Thermal Energy Systems & Technology, Lucerne School of Engineering and Architecture, Lucerne University of Applied Sciences and Arts, 6048 Horw, Switzerland
Email	peter.zotter@hslu.ch
Coauthors	D. Bhattu; J. Zhou; A. Lauber; G. Stefenelli; S. Brown; J. Slowik; A.S.H. Prévôt; I. El-Haddad; J. Dommen; T. Nussbaumer

Publication title	*Primary and Secondary Particle and Gas Phase Emissions from nine State-of-the-art Wood Combustion Devices*
Publication type	Poster
Introduction & Background	Since there is a potential to increase the energy supply from wood combustion by more than 50 % in Switzerland, energy wood utilisation is expected to increase in the next years. However, wood combustion contributes to ambient air pollution, especially with particulate matter (PM). Consequently, there is a target conflict between air pollution control and the propagation of wood as a renewable energy source. Furthermore, PM in ambient air not only results from primary particles emitted at the source and accounted for by emission limit values, but is also caused by secondary organic aerosol (SOA) formed from oxidation of co-emitted volatile organic compounds (VOC). Therefore, in this project primary emissions and SOA formation from nine different state-of-the-art combustion devices are compared in order to identify the most ecological technologies and operation conditions.
Methodology	To identify the influence of combustion technology, fuel type, operation type, combustion regime, and flue gas cleaning, flue gases were produced under well-determined conditions in the combustion laboratory. The experimental setup enabled an on-line characterization of the gas phase species O2, CO, CO2, NOx, CH4, VOC amount and composition, of the concentration of total particle mass, black carbon, total organic and inorganic (NO3, Cl, NH4 and SO4) matter, and of particle number concentration and size distribution. The SOA formation potential is investigated in a potential aerosol mass chamber, which simulates the photochemical ageing in the atmosphere. In addition, reactive oxygen species were determined as a measure for PM-induced oxidative stress within the lung. To identify the influence of the combustion type, the investigated combustion devices cover different log and pellet stoves, log and pellet boilers as well as an industrial wood chip boiler. In addition, influences of operation and fuel type, combustion phase, and particle precipitation in the flue gas are investigated.
Results & Conclusions	Experiments show clearly different gas phase and primary PM emissions as well as different SOA yields for different combustion technologies, operation types and fuels used. The highest emissions were found in the log wood stoves during re-fill and operation with humid wood whereas optimum combustion conditions in the investigated pellet and log wood boilers as well as in the industrial wood chip boiler reveal low emissions. However, at non-ideal conditions (lack and high excess of O2, load change to standby) also pellet and industrial grate boilers exhibit increased emissions. As shown in Figure 1 SOA yields are low, but not zero, for devices and conditions with low VOC emissions whereas a clear increase of SOA is observed with increasing non-methane VOC (NMVOC) concentrations. Therefore, SOA should be considered for future reduction measures. In addition, a linear correlation between NMVOC and SOA (R2=0.92 and R2=0.86 excluding very high concentrations) is evident. This relationship could be used in the future to estimate SOA when complex experimental setups as implemented in this study cannot be applied. Furthermore, the large dataset acquired in this project can serve as a basis for governmental authorities to develop target-oriented air pollution control strategies and enforce wood

combustion technologies with the least environmental and health impact.

Acknowledgements:
This work was supported by the Swiss National Science Foundation (NRP 70 “Energy Turnaround”).

Caption Figure 1:



Comparison of NMVOC and SOA for three different combustion devices with different operation modes.

Author CV:

Since 2015: Senior Scientist at Bioenergy Research Group, CC Thermal Energy Systems & Process Engineering, Lucerne School of Engineering and Architecture, Horw, Switzerland
2010 – 2014: PhD at the Laboratory of Atmospheric Chemistry at the Paul Scherrer Institute, Villigen, Switzerland
2003 – 2007: Master Program Environmental System Science at the Karl-Franzens-University Graz, Austria