Monitoring Ambient Air 2015

Air Quality Monitoring
Evolving Issues and New Technologies

Conference with
Posters and Exhibition

Organised by the
Automation and Analytical Management Group -
Royal Society of Chemistry

Wednesday 9th & Thursday 10th December 2015

At The Royal Society of Chemistry,
Burlington House, Piccadilly,
London W1J 0BA

Email: conference@aamg-rsc.org
Website: http://www.aamg-rsc.org

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Wednesday 9th and Thursday 10th December 2015
at the Royal Society of Chemistry, Burlington House, Piccadilly, London

Day 1 - Wednesday, 9th December 2015

09:30 Registration

10:25 Welcome and Introductory Remarks

Session 1: Vehicle Emissions in the Real World

Chair: **Paul Monks** - University of Leicester, UK

10:30 Real World Emission Results by Remote Monitoring
David Carslaw
Ricardo Energy & Environment / University of York, UK

11:00 Real-World Performance of Euro 6 Vehicles - The London Perspective
Adam Moody
Transport for London, UK

11:30 Real World NOx Emissions from Passenger Cars in Europe
Nick Molden
Emission Analytics, UK

12:00 Real-World Black Carbon, Particle Number Concentration and Nitrogen Oxide Vehicle Emission Factors: On-Road Chasing Campaign Results
Griša Močnik
Aerosol d.o.o., Ljubljana, Slovenia

12:30 Short Presentations by Exhibitors

13:00 Lunch - Exhibition & Posters

Session 2: Vehicle and Shipping Emissions

Chair: **David Carslaw** - Ricardo Energy & Environment / University of York, UK

14:00 Trends of Air Pollutants in Roads in London: using a large population of monitoring sites to investigate the effects of policies abating atmospheric emissions from traffic
Anna Font
King's College London, UK

14:30 Real-time Measurement of the Optical Absorption Spectra of Vehicle Emissions
Ivan Iskra
Aerosol d.o.o., Ljubljana, Slovenia

15:00 Cleaner Sea Ships – Cleaner Air?
Saskia Willers
DCMR, Netherlands

15:30 Diesel-Related Hydrocarbons can Dominate Gas Phase Reactive Carbon in Megacities
Jacqui Hamilton
University of York, UK

16:00 Tea / Coffee - Exhibition & Posters

Day 2 - Thursday, 10th December 2015

Session 3: Urban Vegetation as a Means of Reducing Exposure

Chair: **Gary Fuller** - King's College London, UK

10:00 Air Quality and Urban Form
Rob Mackenzie
University of Birmingham, UK

10:30 The Utility of Data on Urban Vegetation in Air Pollution Exposure Models
John Gulliver
Imperial College London, UK

11:00 i-Tree Eco: Quantifying and Valuing Ecosystem Services Provided by Urban trees. A UK Perspective
Kieron Doick
Forest Research, UK

11:30 Tea / Coffee - Exhibition & Posters

Session 4: Ultrafine Particles

Chair: **Gary Fuller** - King's College London, UK

12:00 Sources and Atmospheric Processes Affecting Ultrafine Particles
Roy Harrison
University of Birmingham, UK

12:30 The UK Ultrafine Monitoring Network and Developments in Harmonisation
Paul Quincey
National Physical Laboratory, UK

13:00 Lunch - Exhibition & Posters

Session 5: Monitoring Technologies - Recent Developments

Chair: **Paul Quincey** - National Physical Laboratory, UK

14:00 Regulatory PAH Monitoring: ‘a tour of the bay'
Richard Brown
National Physical Laboratory, UK

14:30 Field Evaluation of a High Time Resolution Elemental Monitor (XACT 625) at Marylebone Road, London, UK
Anja Tremper
King’s College London, UK

14:50 The Development of a Portable $PM_{2.5}$ Personal Aerosol Measurement System (PAMS) and Automated Process Laboratory Measurements
David Dikken
Measurement Technology Laboratories, USA

15:10 Next Generation (Smaller, Lower Cost, Lower Energy Consumption) Portable Emissions Measurement Systems (PEMS)
Karl Ropkins
University of Leeds, UK

15:30 Challenges in Using Metal Oxide Sensors for Air Quality Monitoring
Philip Peterson
University of Leicester, UK

15:50 Nitrogen Dioxide Concentrations Variation and Road Infrastructure Interventions
Teresa Raventos
University of Leicester, UK

16:10 Closing Remarks

16:20 Tea / Coffee - Close of Conference

ABSTRACTS

Real World Emission Results by Remote Monitoring

David Carslaw
Ricardo Energy & Environment and the University of York

ABSTRACT

The accurate quantification of 'real world' emissions from road vehicles poses a significant challenge compared with most other source sectors. Not only are emissions from road vehicles of key importance to a wide range of air quality issues, they represent a highly complex source sector with literally millions of individual, mobile sources. Vehicle emission remote sensing is one of only a few techniques available that can quantify emissions under real world conditions. Arguably the principal benefit of the technique is that it is non-invasive and no modifications or disturbance of the vehicle being measured occurs. Additionally, it is practical to measure 1000s of vehicles a day, providing comprehensive and highly disaggregated emissions data.

This presentation will summarise some of the key findings of two vehicle emission campaigns carried out in London and elsewhere using an instrument from the University of Denver. The instrument is the only one in the world capable of measuring nitric (NO) and nitrogen dioxide (NO_2), giving a complete picture of total NO_x. Additionally, the Denver instrument measures ammonia (NH_3), which is important both for ageing three way catalyst systems from petrol vehicles and modern selective catalytic reduction (SCR) systems on heavy and light duty diesel vehicles. By carefully matching the vehicle license plate with comprehensive databases on vehicle information, it is possible to gain considerable insights into vehicle emissions that would be difficult or impossible by other means. The presentation will highlight some of the key findings from the measurement campaigns and consider some of the future challenges with a focus on ambient concentrations of NO_2.

Real-World Performance of Euro 6 Vehicles - The London Perspective

Adam Moody
Transport for London

ABSTRACT

In Europe, all new vehicles must go through a process of type-approval to ensure that they conform to common standards. Amongst these are standards for control of emissions from the vehicle. The Euro 1 standard for light duty vehicles, and heavy duty engines, became mandatory for new vehicles in 1993. Since then a series of progressively tighter standards have required vehicle manufacturers to incorporate new technology to control exhaust emissions from road vehicles. The latest is Euro 6/VI.

Euro 6/VI sets demanding limits for emissions of oxides of nitrogen from diesel engines in both light and heavy vehicles. In an effort to correct the shortcomings in previous Euro emissions legislation, a highlight of Euro 6/VI is the requirement for manufacturers to verify the emissions performance of their vehicles in on-highway driving, using portable emissions measurement equipment (PEMS). This process is known as Real Driving Emissions (RDE). It is not necessarily possible for a vehicle to meet the Euro 6 type approval emissions limits under any driving conditions, since the duty cycle that the vehicle is operated over may be more demanding and measurement techniques differ. Therefore a “conformity factor” must be agreed by all parties and applied to the on-highway measurements. This will take the form of a multiplication factor.

In order to better understand the in-service emissions performance of new Euro 6/VI vehicles, Transport for London has commissioned a programme of laboratory testing. The specific area of interest is NOx emissions and more particularly, as they apply to vehicles circulating on London streets. Transport for London has a suite of drive cycles developed to enable London urban driving conditions to be replicated in the test laboratory and these are being used to assess the emissions from a range of vehicles chosen to represent the broad range of vehicle types currently in-service. The data collected in this way will allow a direct comparison with tests carried out on similar vehicles of earlier Euro standards and inform future emissions modelling work.

The test programme has involved thirteen cars and four goods vehicles. Average emissions from the cars have been compared with emissions functions from COPERT 4, which is widely used for emissions modelling, to assess how closely modelled emissions may predict those of vehicles on the road in London. HGV emissions have been compared with those of Euro V vehicles tested earlier.

The results reveal an interesting mix of technological success for manufacturers of heavy-duty diesel engines and a still-to-be fully resolved challenge for light vehicle manufacturers.

Real-world NOx Emissions from Passenger Cars in Europe

Nick Molden
Chief Executive Officer, Emissions Analytics

ABSTRACT

Emissions Analytics conducts a large-scale real-world test programme on production passenger cars in the UK and USA using Portable Emissions Measurement System (PEMS) equipment. To date, it has tested over 400 European cars for NO_x. In the light of the Volkswagen emissions scandal, discrepancies between laboratory results and real-world have become highly relevant. At the same time, most major cities in Europe suffer poor quality, often above legal limits. Emissions Analytics' data helps explain these exceedances, linking the cause back to performance of particular vehicle models and technologies.

The presentation will cover the testing and analytical methodology, leading on to present real-world NO_x results and the trends over time as Euro standards have been tightened. Beyond NO_x, it will consider the component that is NO_2 and effects such as cold start. Finally, it will compare emissions factors derived from the real-world testing with those in a common traffic modelling software package, used for urban transport planning.

Real-World Black Carbon, Particle Number Concentration and Nitrogen Oxide Vehicle Emission Factors: – On-Road Chasing Campaign Results

Irena Ježek[1], Tomaž Katrašnik[2], Dane Westerdahl[3], ***Griša Močnik[1,4]***

[1]Aerosol d.o.o., Kamniška 41, Ljubljana, Slovenia
[2]University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia
[3]Cornell University, Sibley School of Mechanical and Aerospace Eng., Ithaca, USA
[4]Jožef Stefan Institute, Ljubljana, Slovenia
grisa.mocnik@aerosol.si

ABSTRACT

We report emission factors (EF) of black carbon (BC), particle number (PN) and nitrogen oxides (NOx) for three vehicle categories: goods vehicles (trucks, vans; GV), gasoline, and diesel cars, measured with the chasing method during an on-road campaign in December 2011. . We used the chasing method to determine EFs for all three pollutants for 139 individual vehicles of different types encountered on the roads. The composition of the sampled car fleet (139 vehicles of different types) determined from the national vehicle registry information is reflective the Slovenian and European vehicle fleets. These areis is the first on-road measurement study where BC EFs of numerous individual diesel cars were determined in real-world driving conditions. The median BC EF of diesel and gasoline cars that were in use for less than 5 years, decreased by 60% and 47% from respective those cars in use for 5 – 10 years, respectively. We found good agreement between EFs of goods vehicleGV EFs determined in this campaign and previous the results of previous studies (chasing, remote sensing). The median NOx and PN EFs of newer goods vehiclesGV that were (in use for less than five<5 years), decreased by 52% and 67%, respectively, compared to vehicles in use for 5 – 10 years. Surprisingly, we found an increase of BC EFs in goods vehicleGV that were in use for less than 5 years compared to 5 – 10 year old ones. The influence of engine maximum power on the measured EFs showed an increase in NOx EF from increased with the rated diesel engine maximum power.least to more powerful vehicles with diesel engines. A disproportionate contribution of The high emitters contributed disproportionally to the total emissions of the measured fleet was found: the top 25% of emitting diesel cars contributed 63%, 47% and 61% of BC, NOx and PN emissions, respectively. The approach cCombining relatively simple on-road measurements with sophisticated post- processing allows the determination of individual vehicles' EFs;, identification of super-emitters;, and monitoring how of the effectiveness in real-world conditions for different emission reduction approacheses are reflected in real-world conditions.

Trends of Air Pollutants in Roads in London: using a large population of monitoring sites to investigate the effects of policies abating atmospheric emissions from traffic

Anna Font and Gary W. Fuller
MRC PHE Centre for Environment and Health, King's College London

ABSTRACT

A large number of policy initiatives are being taken across London, the UK and the EU to improve air quality. To evaluate how effective these policies are, trends in air pollutants are usually analysed. Most of the approaches calculate trends in atmospheric concentrations over time measured in one single monitoring site; or by averaging the concentrations from a group of similar sites. Although useful, these can be misleading due to sampling bias and they can mask a wide heterogeneity in the impact of policies across an urban area.

In this study we calculate trends in roadside increments of air pollutants for 65 traffic locations in London for the period 2005-2014. Trends were calculated for NO_2, PM_{10} and $PM_{2.5}$ along with black, elemental and organic carbon, particle number and CO_2 using the Theil Sen estimator adjusted for seasonality. Results from individual roads were combined and overall means were calculated using the random-effects model.

Between 2005 and 2009 there was an overall increase in NO_2 reflecting the growing evidence on real world emissions from diesel vehicles (1). Conversely, NO_2 decreased by 5-10% from 2010 onwards along with $PM_{2.5}$ and black carbon consistent with diesel emissions abatement policies. PM_{10} concentrations showed no significant overall change suggesting an increase in coarse particles which offset the decrease in tailpipe emissions; this was especially the case in roads in outer London.

The study showed that polices to manage air pollution provided differential benefits across different roads in London. A technique to group roads which behaved similarly in terms of trends is proposed to help the evaluation of the effectiveness of policies to mitigate traffic emissions across London.

(1) Carslaw et al 2015 Atmos Env 105, 70-77

Real-time Measurement of the Optical Absorption Spectra of Vehicle Emissions

***Ivan Iskra*[1],** Griša Močnik[1], Anthony D. A. Hansen[2], Longwen Gong[3], Shaohua Hu[3] and Heejung Jung[4]

[1] Aerosol, Ljubljana, Slovenia
[2] Magee Scientific, Berkeley, CA 94704, USA
[3] California Air Resources Board, Sacramento, CA 95811, USA
[4] Dept. of Mechanical Engineering, University of California Riverside, CA 92521, USA
e-mail: **Ivan.Iskra@aerosol.eu**

ABSTRACT

We present results on the measurement of optical absorption by particulate emissions during dynamometer testing of new-technology vehicles and engines, including GDI. Data were acquired at 1 Hz simultaneously at 7 wavelengths from 370 nm to 950 nm using a Model AE33 Aethalometer. The multiple-wavelength analysis provides the Ångström Exponent of optical absorption, a parameter necessary for calculation of the climate-forcing effect of these emissions. A 1-Hz CO_2 detector was integrated with the Aethalometer: increases in CO_2 over ambient-atmosphere background reflect the fuel consumption rate. Combination of the BC and CO_2 data yield the instantaneous BC Emission Factor which can be correlated with engine load during the dynamometer drive cycle.

Data from the Model AE33 Aethalometer provide the time resolution, sensitivity, and spectral analysis which are necessary for studies of particulate emissions from advanced-technology engines. The instrument performance provides data both on peak transient emissions during rapid changes in engine load, as well as low levels of emissions during periods of constant load.

Cleaner Sea Ships – Cleaner Air?

Saskia Willers and Peter van Breugel

DCMR Regional EPA Rijnmond

ABSTRACT

From January 1 2015, the sulphur content of shipping fuel for international maritime transport in the Sulphur Emission Control Area (SECA) is only allowed to contain maximum 0.1% (1000 ppm). Bureau air quality of the DCMR Regional EPA Rijnmond has investigated whether the tightened SECA restriction has lead to measurably lower SO_2 concentrations in the Rijnmond area of the Netherlands, in the first half of 2015. This might be expected as the maritime sector still has a large contribution to ambient SO_2 concentrations.

The DCMR Regional EPA Rijnmond is monitoring SO_2 concentrations since many years on six locations within the Rijnmond area. With the aid of wind rose analysis, the average SO_2 concentrations are determined for each wind direction between 2014 and the first half of 2015. It has then been established how large the difference in SO_2 concentration was for the wind directions relevant for the maritime sector SO_2 contribution. With the use of this method, potential influence of other SO_2 sources than from the maritime sector were excluded as much as possible.

The study shows that SO2 concentrations in wind directions with contributions from the maritime sector are lower in the first half of 2015 than in 2014; the difference lies between the 2,5 and 3,0 $\mu g/m^3$. The shipping intensities did not decrease in 2015. Hence the observed decrease of SO2 concentration is very likely to be caused by the tightened SECA restriction. The difference in concentration gives an order of size for the absolute effect of this SECA measure.

Diesel-Related Hydrocarbons can Dominate Gas Phase Reactive Carbon in Megacities

Jacqueline F. Hamilton (1), Rachel E. Dunmore (1), James R. Hopkins (1,2), Richard T. Lidster (1), James D. Lee (1,2), Mathew J. Evans (1,2), Andrew R. Rickard (1,2), Alastair C. Lewis (1,2), Kelly Pereira (1), Riinu Ots (3), Mat Heal (3), Jamie Whitehead (4), Gordon McFiggans (4), Rami Alfarra (4) Stefan Reis (5), Massimo Vieno (5).

1: Wolfson Atmospheric Chemistry Laboratories, Department of Chemistry, University of York, Heslington, York, YO10 5DD, UK. 2: National Centre for Atmospheric Science, Heslington, York, YO10 5DD, UK. 3: School of Chemistry, University of Edinburgh, Edinburgh, UK. 4: Centre for Atmospheric Science, School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Manchester, M13 9PL, UK.5: Centre for Ecology and Hydrology, Penicuik, UK.

ABSTRACT

Hydrocarbons are key precursors to two priority air pollutants, ozone and particulate matter. Those with two to seven carbons have historically been straightforward to observe and have been successfully reduced in many developed cities through air quality policy interventions. Longer chain hydrocarbons released from diesel vehicles are not considered explicitly as part of air quality strategies and there are few direct measurements of their gaseous abundance in the atmosphere. We have used chemically comprehensive and continuous measurements of organic compounds in a developed megacity (London), which demonstrate that on a seasonal median basis, diesel-related hydrocarbons represent only 20-30% of the total hydrocarbon mixing ratio but comprise more than 50% of the atmospheric hydrocarbon mass and are a significant local source of secondary organic aerosols.

Our results show for the first time that, 60% of the winter primary hydrocarbon hydroxyl radical reactivity is from diesel-related hydrocarbons and using the maximum incremental reactivity scale, we predict that they contribute up to 50 % of the ozone production potential in London. Comparing real-world urban composition with regulatory emissions inventories in the UK and US highlights a previously unaccounted for, but very significant, under-reporting of diesel related hydrocarbons; an underestimation of a factor ~4 for C_9 species rising to a factor of > 70 for C_{12} during winter. These observations show that hydrocarbons from diesel vehicles can dominate gas phase reactive carbon in cities with high diesel fleet fractions.

Further modelling studies using improved estimates of diesel traffic related emissions will be presented, showing their larger scale impacts on secondary organic aerosol formation in London and across Europe. Preliminary results investigating hydrocarbon emissions from a test diesel engine at the Manchester Aerosol Chamber as part of the COM-PART project will highlight some of the issues that can arise if standard test cycles are used to estimate hydrocarbon emissions.

Future control of urban particulate matter and ozone in such locations requires a shift in policy focus onto gas phase hydrocarbons released from diesels as this vehicle type continues to displace gasoline across the globe.

Air Quality and Urban Form

Rob Mackenzie
University of Birmingham UK

ABSTRACT

The design of a city can have a significant impact on air quality; we identify 7 ways in which the urban surface impacts on urban air pollution concentrations. Five of these mechanisms are shared by the 'grey' (i.e. buildings, street furniture etc) and 'green' (street trees, parks, gardens, etc) elements of the urban landscape, two further mechanisms are specific to the green elements only. No modelling or measurement studies to date have quantified all of these mechanisms simultaneously. Focus on individual mechanisms has resulted in differing conclusions in the literature for the influence of green elements on urban air quality. Although comprehensive modelling and validating measurements remain to be done, it is possible to derive some robust rules-of-thumb to aid urban planning.

Allometry uncovers structures and patterns by relating the characteristics of complex systems to a measure of scale. We present an allometric analysis of air quality for UK urban settlements. We show that the scaling of traffic-related emissions is not simply a reflection of road length, and demonstrate that, although air quality is worse in large urban centres compared to small urban centres, the overall effect is an *economy of scale* (i.e., large cities reduce the overall burden of pollution). The model also explains which properties of nature-based solutions (urban greening) can make a significant contribution at city scale, and elucidates an opportunity to make large cities absolutely cleaner than smaller cities in terms of their airshed-average pollutant concentration. We describe this last point as an 'urbanisation dividend' and contrast it with the 'regulatory penalty' that smaller urban settlements pay when regulatory policy-making is not scale-aware.

The Utility of Data on Urban Vegetation in Air Pollution Exposure Models

***John Gulliver*[1]**, Weiyi Wang[1], Rob MacKenzie[2], Robert Tang[3]

1. MRC-PHE Centre for Environment & Health, Imperial College London.
2. School of Geography, Earth and Environmental Sciences
University of Birmingham.
3. Division of Epidemiology and Biostatistics, Hong Kong University

ABSTRACT

Airborne particles and gases can be deposited on and absorbed by vegetation yielding reductions in concentrations of some pollutant species and net benefits for air quality. The urban canopy in London, for example, is currently estimated to remove up to 2121 tonnes (1.4% from the urban boundary layer) of PM_{10} annually. Conversely, tall trees and tree canopies, especially in street canyons, can trap pollutants, reducing dispersion, and worsening air quality (i.e. fumigation). Recently developed high-resolution vegetation data sets with separate layers for ground cover and trees could potentially be used in air pollution models to assess spatial variations in the influence of vegetation on air quality. Two approaches were used to assess the utility of vegetation in air pollution exposure models for London: 1) combining the predictor variables on vegetation data with other variables (e.g. distance to nearest main road, household density) in land use regression (LUR) models, and 2) using the output from a dispersion model (ADMS-Urban) with the predictor variables on vegetation in "hybrid" dispersion-LUR models. Data on growing-season- (March-October) and annual- average concentrations of NO_2 (n=53) and PM_{10} (n=37) from the network of air pollution monitoring sites in London were used to develop and evaluate the performance of models. A variable on the area of ground cover vegetation within a 100m circle around monitoring sites explained 10% and 3% of the spatial variation in concentration of NO_2 in dispersion-LUR and LUR models, respectively. A variable on ground cover vegetation within 25m and 50m circles around monitoring sites in dispersion-LUR and LUR models, respectively, explained 3% of the variability in concentrations of PM_{10}. The significance of ground cover vegetation did not differ between models developed on growing-season and annual average concentrations. No variables on trees passed statistical significance tests ($p<0.05$) to be included in the models, which may be due to the low number of these monitoring site locations with the presence of trees.

i-Tree Eco - Quantifying and Valuing Ecosystem Services Provided by Urban Trees: a UK Perspective

***Kieron J. Doick*[1]**, Kenton Rogers[2]
[1]Centre for Forestry and Climate Change
Forest Research, Surrey
[2]Treeconomics Ltd,
Priesthawes Farm, Polegate, East Sussex

ABSTRACT

i-Tree is a suite of open source, peer-reviewed and continuously improved software tools developed by the USDA Forest Service and collaborators to help assess and manage urban tree populations and the benefits they can provide.

i-Tree Eco - one of the i-Tree suite of tools, is designed to use a complete or sample plot inventory from a study area along with local environmental data to characterise the structure of the tree population, quantify environmental functions performed and assess the value of the annual benefits derived from these functions. i-Tree Eco is adaptable to multiple scales from a single tree to area-wide assessments. In the UK, it's most common application has been to the full urban extent of a city, such as Edinburgh, or a town, such as Torbay. It has also been applied to parks, arboreta and the urban component of the Tawe catchment, Wales.

The environmental functions modelled include air quality improvement, carbon dioxide reduction, and storm water control. Air quality improvement is calculated using Nowak's UFORE D (Urban Forest Effects D: Dry Deposition of Air Pollution) model and local weather, climate and geographic information to quantify air pollutant removal across the study area. Across Greater London, annual uptake was quantified as 2,241 tonnes, a service valued at £126 million (2015 UKSDC values).

In November 2015, the Forest Service launched i-Tree Eco v6. This version includes new functions to simulate future tree population and canopy cover, and is preloaded with supplementary UK data to facilitate wider use and uptake.

Sources and Atmospheric Processes Affecting Ultrafine Particles

Roy M. Harrison
School of Geography, Earth and Environmental Sciences,
University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom

ABSTRACT

Ultrafine particles are defined as particles with one dimension of less than 100 nanometres. When present in the atmosphere, these can be measured by mass, usually referring to particles with an aerodynamic diameter below 100 nm, expressed as $PM_{0.1}$. Alternatively, since ultrafine particles typically comprise around 90% of the total particle load in ambient urban air, they are often expressed as a number concentration from measurements with a Condensation Particle Counter or Scanning Mobility Particle Sizer. The TNO Inventory for Europe is based upon particle number and shows a dominant influence of the transport sector, especially international shipping The UK Inventory of $PM_{0.1}$ includes only land-based sources and coastal shipping and shows major contributions from road transport and industrial/commercial/residential combustion. Major elevations in ultrafine particle number are seen at roadside sites, with background locations showing a generally coarser aerosol with a lower proportion of ultrafine particles. In roadside air there is typically a mode in the number size distribution at around 30 nanometres which reflects predominantly semi-volatile particles deriving from the condensation of lubricating oil vapour emitted from the exhaust. On advection into cleaner air locations, evaporative shrinkage of such particles is clearly seen. The diurnal cycles of particle number concentration at northern European sites are typically reflective of road traffic emissions, whereas in southern Europe there is an additional major peak in the middle of the day corresponding to regional nucleation processes. Measurements in the UK atmosphere show also an abundance of iron-rich particles which appear to be derived from engine emissions. Receptor modelling of ultrafine particles in the atmosphere of London reveals some similar sources and some different source categories when compared to source apportionment of PM_{10} mass. The factors contributing to particle number at a background site in London are attributed to local traffic, secondary particles, regional nucleation and an urban background attributable largely to road traffic and wood smoke. There was a marked reduction in the ultrafine particle count at UK sites in late 2007 which is attributed to a substantial reduction in the sulphur content of motor fuels. This was also accompanied by a change in the particle size distribution at roadside. Projections of future trends show a substantial reduction in total emissions by number count as other liquid fuels are reduced in sulphur content. It is projected that this will cause a substantial reduction in primary nanoparticle concentrations, the reductions in emissions of primary particles and reduced atmospheric formation of secondary particles is likely to lead to an increase in particle formation from regional nucleation processes due to a reduction in the condensation sink for vapour of low volatility.

The UK Ultrafine Monitoring Network and Developments in Harmonisation

Paul Quincey
National Physical Laboratory, Teddington, UK

ABSTRACT

The regulatory monitoring of airborne particles in ambient air - PM_{10} and $PM_{2.5}$, with additional requirements on particulate composition - is focussed on the coarse and fine fractions, dominated by the larger particles within the relevant size ranges, up to 10 or 2.5 µm.

However, the UK government set up a non-regulatory monitoring network which included measurements of ultrafine particles (typically defined as below 100 nm in diameter) in 2001, and this has been generating data continually since then, providing valuable long-term data sets.

The key measurement parameters, particle number concentration and particle size distribution, made with Condensation Particle Counters and Scanning Mobility Particle Sizers respectively, bring new challenges for calibration and harmonisation of methods, which are essential if measurements from different networks are to be comparable with known uncertainties.

The talk will summarise the measurement methods and results from the monitoring network relating to ambient ultrafine particles, together with progress towards international harmonisation of data, which provides a case study in cooperation between scientific organisations, standardisation bodies, and national metrology institutes.

Regulatory PAH Monitoring – A 'tour of the bay'

Richard J. C. Brown
Environment Division, National Physical Laboratory,
Teddington, Middlesex, TW11 0LW, UK
E-mail address: richard.brown@npl.co.uk

ABSTRACT

The measurement of the concentration of polycyclic aromatic hydrocarbons (PAHs) in the PM_{10} particulate phase of ambient air is a requirement imposed upon Member States of the European Union by the Fourth Air Quality Daughter Directive (Directive 2004/107/EC).

The National Physical Laboratory has operated the UK's PAH air quality network on behalf of the UK Department for Environment, Food & Rural Affairs for the last five years. In combination with National Measurement System work funded by the UK Department for Business, Innovation & Skills, NPL has produced a number of interesting and important outcomes from PAH measurement activities, which demonstrate the significant added value that regulatory monitoring can provide with a little extra effort. This presentation reviews these outputs and the new science they have generated.

The 'tour of the bay' sets sail by giving a brief introduction to the sources and measurement of PAHs, then describes the current status of these measurements in the UK and Europe. Avoiding shipwreck on the rocky outcrop of measurement comparability, it's onwards to a discussion of data loss and kriging before returning to harbour with suggestions for policy improvements and some proposals for surrogate measurements of PAHs.

Field Evaluation of a High Time Resolution Elemental Monitor (XACT 625) at Marylebone Road, London, UK

Anja H Tremper[1], David C Green[1], Max Priestman[1], Samera H Hamad[2]

[1]MRC HPE Centre for Environment and Health, King's College London
[2]University of Wisconsin-Madison

ABSTRACT

The Cooper Environmental Services XACT^{TM} 625 monitoring system is designed to monitor a suite of elements in near real time using X-Ray Fluorescence. During a first deployment in the UK the measurements from this instrument were evaluated and compared to a range of other techniques at a kerbside measurement station in London. Separately, a 6-week campaign in the $PM_{2.5}$ fraction chosen to coincide with high elemental emissions from fireworks was used to compare the XRF measurements to filter-based ICP-MS measurements.

The elements sampled by the XACT were chosen to either represent source categories or those required for regulatory purposes. Comparison data was provided by a URG AIM in PM_{10}, an Aerosol Chemical Speciation Monitor (ACSM) in PM_1 and ICP-MS analysis of filter samples collected using a $PM_{2.5}$ Thermo Scientific Partisol 2025.

It was found that the XACT measurements were strongly correlated with filter based measurements (R^2: 0.68 - 1; slopes: 0.94- 2.3). The predicted non-seasalt SO_4 concentrations in $PM_{2.5}$ compared well with SO_4 measured with an ACSM (R^2 =0.88, slope=2.33) and regional species compared well with background IC measurements (predicted SO_4/water-soluble SO_4: R^2 =0.98, slope=1.58; Cl/water-soluble Cl: R^2 =0.96, slope=1.28). It was possible to illustrate the influence of different sources on $PM_{2.5}$, including local bonfires and fireworks (Diwali and Guy Fawkes celebrations).

These first results from the UK using the XACT, in a location with a wide variety of sources, demonstrate the power of a multi- element measurement data to understand concentrations and sources of PM_{10} and $PM_{2.5}$.

The Development of a Portable $PM_{2.5}$ Personal Aerosol Measurement System (PAMS) and Automated Process Laboratory Measurements

David Dikken

Measurement Technology Laboratories, LLC
Minneapolis, Minnesota USA

ABSTRACT

Filter based ambient $PM_{2.5}$ measurements have occurred extensively and broadly over the past two decades providing for sound indicators of the adverse health effects of exposure to ambient aerosols. However, these measurements have been almost exclusively open air sampling site based, and make assumptions on an individual person's exposure. Furthermore, very few collected samples are analyzed beyond the gravimetric results. This situation has led to an effort to make a portable filter based $PM_{2.5}$ Aerosol Measurement System (PAMS) that: 1) is easily wearable 2) is battery operated and rechargeable 3) automatically logs data to in situ RFID positioned chip with the filter, 4) is easily operated without special training , and 5) sufficiently correlates to accepted reference methods. In parallel with the PAMS field unit, an automated robotic measurement system has been developed which can process large volumes (500 – 1000/day) of collected samples. The battery of tests includes gravimetric $PM_{2.5}$, black carbon via transmissometer, and elemental analysis via X-Ray Fluorescence. Probable applications for the measurement systems include broad based health studies, work place safety, military theater exposures, and traffic studies.

Next Generation (Smaller, Lower Cost, Lower Energy Consumption) Portable Emissions Measurement Systems (Pems)

Karl Ropkins
University of Leeds, Institute for Transport Studies, Leeds

ABSTRACT

The in-use emissions testing industry, academic research and the emission abatement technology development sector have all been pushing for smaller, lighter, lower cost and, ever more importantly, lower energy consumption portable emissions measurement systems (PEMS). While there is an obvious and understandable natural tension here for the more established PEMS technology manufacturers, it is worth both acknowledging this and considering the routes and barriers for such a next generation system.

Therefore, the intension here is to focus on the issues that are perhaps most pressing for the larger emissions measurement community: (1) Do we really need a smaller PEMS? (2) What emissions do we need to be measuring? (3) What are the design bottlenecks for reducing the footprints of the different PEMS component? (4) What are the hidden challenges for anyone delivering truly small/light/low cost PEMS? And, (5) With the recent VW emissions scandal in mind, what does this mean for the dynamometer facilities, the PEMS testers and the cheats?

Recent work to develop, optimize and evaluate the parSYNC® PLUS, a next generation integrated PEMS (or iPEMS), will be used to illustrate this talk.

Challenges in Using Metal Oxide Sensors for Air Quality Monitoring

P Peterson, M Thompson, K Grant, J Vande Hey, R Leigh
University of Leicester

ABSTRACT

The University of Leicester is developing a new multi-sensor platform for characterizing urban air quality. SOGS (small, open, general-purpose sensor) combines a high quality 32-channel datalogger and solar battery charger with a flexible interface for supporting both analog and digital instruments. Recent work with the system has been focused on the use of Metal Oxide Semiconductor (MOS) gas sensors in urban air quality monitoring, due to their potentially high sensitivity and low cost. This kind of sensor is widely used in industrial warning systems thanks to its responsiveness to a broad range of gasses, but that same feature has limited their utility for serious pollution monitoring. Field testing and modelling work have led to a prototype low cost instrument design with promising accuracy and precision. This poster will address the use and current limitations of MOS gas sensors, including their calibration, best practices for reliable atmospheric monitoring instrument design using MOS in-situ sensors, the design of the SOGS instrument platform and show preliminary calibration results.

Nitrogen Dioxide Concentrations Variation and Road Infrastructure Interventions

***Teresa Raventos*[1]**, Zoe Fleming[2], Paul Monks[1]

1) Department of Chemistry, University of Leicester
2) National Centre for Atmospheric Science (NCAS), Department of Chemistry, University of Leicester

ABSTRACT

Traffic-related air pollution measurements are valuable as a basis for urban air-quality policy decisions and traffic management. However, local authorities usually lack resources and equipment to monitor air pollution before and after changes are made and instead often rely on data models for decision-making. The focus of this paper is to understand the impact of road infrastructure interventions to local air pollution. A set of four low cost sensors (AQMeshes - NOx, CO and O_3) were installed in three roundabouts of Leicester (UK) to measure concentrations before, during and after the highway improvement works as part of the Leicester North West Scheme. The infrastructure changes include new traffic lights, additional traffic lanes at the roundabouts as well as new and improved cycle lanes and pedestrian crossings. Recent studies have indicated that the two major parameters influencing the concentration of pollutant from traffic emissions are the number of vehicles and the wind speed. Furthermore, the relationship between the number of vehicles and the concentration of pollutant is approximately linear. Traffic information (vehicle numbers, types of vehicle and fluidity) from each direction of the roundabouts where considered as possible indicators to measure and compare the evolution of air pollution. This study shows the first comparisons between NOx levels and traffic flows.

POSTER ABSTRACTS

Using Diffusion Tubes for Dynamic Generation of Trace Vapour Standards of Vvocs, Vocs & Svocs for Calibration, Method Validation and Statistical Quality Control of Air Quality Measurement Technologies

***John M. Thompson*[1&2]**, David C.Howse[1&2] and Daniel J. Blenkhorn[2]

(1) Tracer Measurement Systems Ltd., Institute of Research and Development, Birmingham Research Park, Edgbaston, Birmingham B15 2SQ

(2) Molecular Physics Group, School of Physics and Astronomy, University of Birmingham, Edgbaston, Birmingham B15 2TT

POSTER ABSTRACT

The design of diffusion tubes shown in ISO 6145-8-2005 "Gas Analysis – Preparation of calibration gas mixture using dynamic volumetric methods – Part 8: Diffusion Methods" is clearly not at all easy to use for volatile liquids but is impossible to use with viscous or solid SVOCs. On the other hand, we has developed a new range of uniquely identifiable, laser-engraved, refillable and re-useable Tracer Cert® diffusion tubes which are easy to fill even with such SVOCs, as well as VVOCs and VOCs (Thompson & Perry, Journal of Environmental Monitoring, 2009, 11, 1543-4).

Results are reported of calibration experiments in which examples of both solid and liquid SVOCs are used in Tracer Cert® diffusion tubes at various temperatures in a newly designed Tracer Cert® Super-ambient Thermostat™ system using either air or oxygen-free carrier gas. Results are also reported, for illustration, of similar calibration experiments with some VOCs.

A novel use of these diffusion tubes at 252K (-21°C) in our new Tracer Cert® Sub-ambient Thermostat™ for the dynamic generation of trace standard mixtures of the oxygen-sensitive VVOCs, isoprene and acetaldehyde, in an oxygen-free nitrogen carrier gas flow at ppb(v/v) concentrations is described and results shown. This method can be widely applied to the dynamic generation of trace standard mixtures of oxygen-sensitive VVOCs in the ppm(v/v) to sub-ppb(v/v) range.

Using Exploratory Statistical Methods for Evaluation and Assessment of Patterns of Exposure to Air Pollutants

***John M. Thompson*[1&2]**

(1) Tracer Measurement Systems Ltd., Institute of Research and Development, Birmingham Research Park, Edgbaston, Birmingham B15 2SQ

(2) Molecular Physics Group, School of Physics and Astronomy, University of Birmingham, Edgbaston, Birmingham B15 2TT

POSTER ABSTRACT

Previously, I developed statistical approaches for handling and analysing of large occupational data sets (HSE Research Report 373, 2005). The large data set was of measurements of occupational exposure to dusts and gases over a 30 year period for UK Iron and Steel Foundry Industry (about 55000 sets of measurements) which are equally applicable to assessment of exposures to ambient air pollutants.

Data distributions for trace gases and dusts in occupational exposures in the UK iron and steel foundry industry data set submitted by Castings Technology International (UK HSE Research Report 374 (2005)) were left truncated, right skewed (departing from symmetry, stretching out to the right) and right heavy elongated (a heavy (greatly extended) right tail). Left truncation is a common in trace analyte data distributions arising from the limit of quantitation (LoQ). Another feature of trace analyses is “less than” data (<LoQ values). Heavy right elongation is not uncommon in trace pollutant analyses in environmental regulation. None of these deviations can be characterised using classical statistical methods.

Exploratory statistical methods using quantiles (based on Letter Values) are shown to be valuable in describing and comparing these “real life” distributions and in assessing changes in pollutant exposure patterns. When assessing variations of pollutant exposures with time, the non-Gaussian features described above make classical time series analysis unsuitable. Robust nonparametric regression invoking a local linear fit using Cleveland’s “loess” methods overcomes these difficulties and examples are shown illustrating the effects on exposures of changes in regulatory occupational exposure limits.

Comparison of Commercial Low Cost Air Quality Monitoring Instruments Against DEFRA Instruments

***Zoë L. Fleming*[1],** Teresa Raventos[2], Paul S. Monks[2]

1) National Centre for Atmospheric Science (NCAS), Department of Chemistry, University of Leicester
2) Department of Chemistry, University of Leicester

POSTER ABSTRACT

Several low cost air quality instruments (AQMesh, Elm, cairclip, AirPi) have been set to measure alongside official DEFRA instrumentation at the Leicester Automatic Urban and Rural Network (AURN) station. Running alongside DEFRA calibrated instruments has allowed a clearer picture of their accuracy and reliability. Various uses of these small mobile sensors either for outreach activities or for gaining greater coverage in local authority monitoring have been carried out over the last 2 years. For some measurements, we will show that they are a useful alternative but for others, the need to check and calibrate them regularly mean that the user does need to be aware that the numbers they download cannot always be trusted.

Levels of Respirable Crystalline Silica in UK Ambient Air

Owen Butler, Paul Roberts, Peter Stacey and Andrew Thorpe
Health and Safety Laboratory,
Harpur Hill, Buxton SK17 9JN

POSTER ABSTRACT

Crystalline silica is an abundant mineral and is widely used in building and industrial materials. In the workplace, the health related particle size range of interest for airborne crystalline silica measurements is termed the 'respirable' (RCS) fraction i.e. 50% cut-off aerodynamic diameter of 4.25 µm, where exposure can result in a range of adverse health effects including silicosis and lung cancers. The UK workplace limit value is 100 µg m^{-3} and exposures should be reduced to as low as is reasonably practicable below this value.

Epidemiological data suggests that silicosis can occur in some proportion of the wider population at levels much lower than workplace limits. In the US long-term health benchmark values, around 3 µg m^{-3} and extrapolated from worker epidemiological studies, have been set at which there is thought to be little or no risk to the wider population.

A mobile battery powered high volume air sampler was successfully developed to collect RCS and in conjunction with an X-ray diffraction technique enabled a method detection of 0.2 µg m^{-3} to be achieved.

At the industrial fence-line locations surveyed, few air samples exceeded 10 µg m^{-3}, urban background values rarely exceed 0.3 µg m^{-3} and a median background value of 0.02 µg m^{-3} was determined at a long-term static location on the rural HSL campus.

Characterising Organic and Elemental Carbon Sources in the London Area

***E. Nicolosi*[12]**, G.W. Fuller[1] and P. Quincey[2]
[1]King's College London, 150 Stamford Street, London SE1 9NH, UK
[2]National Physical Laboratory, Hampton Road, Teddington, TW11 0LW, UK

POSTER ABSTRACT

To investigate London's OC and EC sources, filter samples were collected from rural, urban background and roadside locations, together with a small set of emission samples. The EC/OC measurements were explored in order to define different characteristics from each site, including the effects of seasonality, and if it is possible characterise pollution sources by EC/OC measurement.

A Sunset Laboratory Thermal-Optical Carbon Aerosol Analyzer was used for the OC analysis following the EUSAAR2 protocol (Cavalli et al, 2010). This determined total OC and EC (and their correspondent peaks) for each sample. To account for seasonality, PM10 samples were collected during winter and summer. Exhaust samples from the main air pollutant sources (Watson, 1994) were also analysed to characterize them by their relative OC and EC peak abundances.

The poster will present conclusions relating to characterising sources accordingly to the peak abundances generated during the OC/EC analysis, seasonality, and applicability of the analysis method to different types of sample.

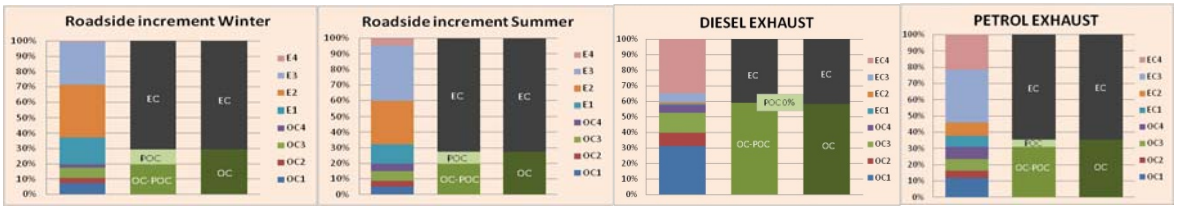

Figure 1: Carbonaceous partitioning urban and roadside increments and diesel and petrol exhaust.

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Watson, J. G., et al 1994. Differences in the carbon composition of source profiles for diesel-powered and gasoline-powered vehicles. AtmosEnv 28, 2493-2505.

Particle and Gaseous Emissions from Traffic During Real-World Dilution

Å.M. Hallquist [1], H. Fallgren [1], C. Faxon [2], M. Hallquist [2], M. Jerksjö [1], S. Jutterström [1], J. Moldanova [1], R.K. Pathak [2], M. Psychoudaki [2], H. Salberg [1], Å. Sjödin [1], Å.K. Watne [2]

[1] IVL Swedish Environmental Research Institute Ltd, Box 53021, 400 15, Gothenburg, Sweden

[2] Atmospheric science, Department of Chemistry and Molecular Biology, University of Gothenburg, 412 96, Gothenburg, Sweden

Presenting author email: asa.hallquist@ivl.se

POSTER ABSTRACT

It is acknowledged that traffic-related emissions contribute significantly to total particulate air and gaseous pollutants in urban environments. Many epidemiological studies have shown that particles have adverse health effects (Pope and Dockery, 2006). Particles also affect climate either directly via scattering and absorption of radiation, or indirectly via its influence on the formation of clouds. More than 80 % of world trade is transported by ships and shipping is projected to increase further in the future (Buhaug *et al.,* 2009). Emissions from shipping are today poorly regulated in legislation. Shipping has therefore become a more and more important source for urban air quality in coastal and harbour cities. Shipping also contributes globally to climate effects.

E.g. the global contribution of particles from shipping is almost as large as from road traffic, 1.7 compared to 2.1 Tgy^{-1} (Eyring *et al.,* 2005).

In this work comprehensive studies on particles originating from combustion with specific focus on size distributions of nanoparticles and their chemical characterisation- including the potential to form secondary aerosol mass from the gaseous emission fraction, using road-and sea-traffic as important examples of combustion sources from the transport sector have been carried out. Preliminary data will be presented.

This work was financed by VINNOVA (Sweden's Innovation Agency) and Formas (2013-1430).

References: Buhaug, Ø., et al. (2009) *Second IMO GHG study 2009,* Int. Marit. Organ., London Eyring, V., Köhler, H. W., van Aardenne, J., Lauer, A. (2005) *J. Geophys. Res,* **110**, doi:10.1029/2004JD005619 Pope C.A and Dockery D.W., (2006), *J Air Waste Manag Assoc*, 56(6), 709-42

The Effects of the Built Environment, Traffic Patterns and Micrometeorology on Street Level Ultrafine Particle Concentrations at a Block Scale: Results From Multiple Urban Sites

Wonsik Choi[1], Dilhara Ranasinghe[1], Karen Bunavage[1], J.R. DeShazo[2], Lisa Wu[2], Rodrigo Seguel[1,3], Arthur M. Winer[4], and ***Suzanne E. Paulson[1*]***

[1]University of California, Los Angeles, Department of Atmospheric and Oceanic Sciences, 405 Hilgard Ave., Los Angeles, California 90095, USA.

[2]University of California, Los Angeles, Luskin Center for Innovation, Luskin School of Public Affairs, 3250 Public Affairs bldg., Los Angeles, California 90095, USA

[3]Center for Environmental Sciences, Faculty of Sciences, University of Chile Las Palmeras 3425 Ñuñoa, Santiago, Chile.

[4]University of California, Los Angeles, Fielding School of Public Health, Environmental Health Sciences Department, 650 Charles Young Dr., Los Angeles, California 90095, USA

*presenting author, corresponding author

POSTER ABSTRACT

This study attempts to explain explicitly the direct and quantitative effects of complicated urban built-environment on near-road dispersion and levels of vehicular emissions at the scale of several city blocks, based on ultrafine particle concentrations ([UFP]). On short timescales, ultrafine particles are an excellent proxy for other roadway emissions. Five measurement sites in the greater Los Angeles area that have different built environments but similar mesoscale meteorology were explored. After controlling for traffic, morning [UFP] were mostly higher than those in the afternoon due to limited dispersion capacity combined with a relatively stable surface layer. [UFP] at the intersection corners were also higher than those over the sampling sites, implying that accelerating vehicles around the intersections contributed to [UFP] elevation. In the calm morning, the areal aspect ratio (Ar_{area}), developed in this study for real urban configurations, showed a strong relationship with block-scale [UFP]. Ar_{area} includes the building area-weighted building height, the amount of open space, and the building footprint. In the afternoon, however, when wind speeds were generally higher and turbulence was stronger, vertical turbulence intensity $_w$ was the most effective factor controlling [UFP]. The surrounding built environment appears to play an indirect role in observed [UFP], by affecting surface level micrometeorology. The effects are substantial; controlling for traffic, differences in Ar_{area} and building heterogeneity were related to differences in [UFP] of factors of two to three among our five study sites. These results have significant implications for pedestrian exposure as well as transit-oriented urban planning.

Using GC×GC-Tof-MS to Anaylse SVOC Nanoparticle Emission from Light Duty Diesel Engine

Z.R. Liang [a,b], S.Zeraati Rezaei [a], M.S. Alam [c], C Stark [c], H.M. Xua [a],R.M. Harrison[c,d]

a.School of Mechanical Engineering, University of Birmingham, UK
b. School of Energy and Power Engineering, Beihang University, China
c.School of Geography, Earth and Environmental Sciences, University of Birmingham, UK
d.Division of Environmental Health and Risk Management. School of Geography, Earth and Environmental Sciences, University of Birmingham, UK

POSTER ABSTRACT

2D-Gas Chromatography Time-of-Flight Mass Spectrometry (GC×GC-ToF-MS), has been utilised to characterise the composition of particulate matter exhaust emissions, in particularly Semi-volatile Organic Compounds (SVOC), which are difficult to be quantified due to their unstably partitioning between the gas and aerosol phases. This technique has demonstrated the capability of resolving specific components of the Unresolved Complex Mixture (UCM), the large “hump” that makes up approximately 95% of the area of the chromatogram.

Tests were conducted on a light duty automotive Ford Puma diesel engine, using a state of the art testing facility involving AVL PUMA, Horiba MEXA-7100-EGR analyser and DMS500. A cascade impactor (nano-MOUDI) with 13 stages was used to collect particles with diameters 10-10,000nm. Experiments performed included a range of engine conditions, different sulphur containing fuels and lubricants.

The SVOC in the diesel engine exhaust emissions was observed to contain n-alkanes, branched alkanes, alkyl-cyclohexanes and alkyl-benzene, PAH and various aromatic compounds, all in the C13-C36 range. Results indicate that the lubricating oil fraction contributing to particulate emission is large, confirming previous studies which indicate that a significant engine oil fraction exists in the exhaust emissions. MOUDI sample analysis shows high molecular weight n-alkanes, favored to attach on the smaller cut size stages while low molecular weight n-alkanes were collected at the initial stages with large cut size point.