

# Water-based Condensation Particle Counters (WCPCs)

## Applications

### 2006

Arhami, Mohhammad; Polidori, Andrea; Delfino, Ralph J.; Siousta, Constantinos, 2006, "Indoor/Outdoor Relationships, Trends and Carbonaceous Content of Fine Particulate Matter during the CHAPS study," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

The air quality standards established by the US EPA in 1997 were primarily based upon epidemiological studies conducted at stationary outdoor monitoring sites. However, it is well known that a significant portion of human exposures to fine particulate matter (PM<sub>2.5</sub>) occurs indoors where people spend approximately 85–90% of their time. Typically, indoor PM<sub>2.5</sub> consists of ambient (outdoor) particles that infiltrate indoors, particles emitted indoors (primary), and particles formed indoors (secondary) from precursors emitted both indoors and outdoors (Weschler 2004). When indoor sources are present (cooking and smoking, for example) indoor PM<sub>2.5</sub> concentrations can be substantially higher than outdoor PM concentrations. Organic compounds are a large, complex, and poorly understood contributor to indoor and outdoor PM<sub>2.5</sub>, and are believed to be an important factor in their adverse health effects. Particulate organic and elemental carbon (OC and EC, respectively) have been mostly measured off-line subsequent to particle collection on filters. Continuous and semi-continuous measurements (e.g. 1-2 hours) are generally preferred over integrated analyses as they can capture important short-term variations in particle properties and atmospheric dynamics. While several studies have been conducted to characterize exposure to indoor particles, not many semi-continuous indoor PM<sub>2.5</sub> data have been obtained. Thus, accurate real-time measurements by means of state-of-the-art instruments are necessary to better assess the relationships between indoor and outdoor PM<sub>2.5</sub> concentrations, their seasonal trends and their effects on human exposure. During the present work, conducted for the cardiovascular health and air pollution study (CHAPS), hourly indoor and outdoor PM<sub>2.5</sub> concentrations, their seasonal variations, and the effect of different particle sources on levels of indoor exposure have been analyzed at two different locations. The hourly OC and EC content of indoor particles was analyzed and compared to the corresponding ambient level at these two sites. For further insights, both indoor and outdoor hourly gaseous ozone (O<sub>3</sub>), carbon monoxide (CO) and nitrogen oxides (NO<sub>x</sub>) data were also analyzed.

Berndt, Torsten; Böge; Stratmann, Frank, 2006, "Formation of atmospheric H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O particles in the absence of organics," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Atmospheric particles have a strong impact on the Earth's radiation budget due to their radiative properties and the fact that they can act as condensation nuclei for clouds. Field measurements at ground level show atmospheric nucleation events for H<sub>2</sub>SO<sub>4</sub> concentrations of  $\sim 10^7$  molecule cm<sup>-3</sup> (Weber et al., 1999). Despite intensive research activities in the last decade, the mechanism leading to new particles has not been unambiguously revealed yet. In a previous investigation from this laboratory, experimental evidence for the formation of new particles in the system H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O under near-atmospheric conditions with H<sub>2</sub>SO<sub>4</sub> concentrations of  $\sim 10^7$  molecule cm<sup>-3</sup> was found (Berndt et al., 2005). Here, H<sub>2</sub>SO<sub>4</sub> was produced in situ via the reaction of OH radicals with SO<sub>2</sub> in the presence of water vapor. Similar observations are reported from investigations in the 590 m<sup>3</sup> Calspan chamber (Verheggen, 2004). In both studies organics were present in the reaction gas. In contrast, taking H<sub>2</sub>SO<sub>4</sub> from a liquid sample  $\sim 10^{10}$  molecules cm<sup>-3</sup> of H<sub>2</sub>SO<sub>4</sub> are needed for producing new particles (Ball et al., 1999). Subject of this study is to investigate whether the low threshold H<sub>2</sub>SO<sub>4</sub> concentration for nucleation of  $\sim 10^7$  molecule cm<sup>-3</sup> for in situ produced H<sub>2</sub>SO<sub>4</sub> arises from any contributions of organic substances.

Birmili, Wolfran; Mordas, Genrik; Petäjä, Tuuka.; Aalto, Pasi P.; Riipinen, Ilona; Grönholm, Tiia; Hämeri, Kaarle; Kulmala, Markku, “Activation properties of atmospheric nano-particles in the size range of 3 to 10 nanometers: contrasts between urban and rural observations,” *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Knowledge on the sources, processes, and sinks of atmospheric aerosols is essential to understand their complex effects upon air quality (human health and atmospheric visibility), and climate change (direct and indirect radiative forcing). Many of these effects critically depend on particle size and number concentration rather than particle mass. The nucleation of supersaturated vapors and subsequent particle growth is one of the key processes that control atmospheric particle number (Kulmala et al., 2004). Any simulation or future projection of atmospheric particle number concentration relies on an accurate description of the particle formation process. The chemical composition of atmospheric nanoparticles and therefore, conclusions on the true molecular formation processes have generally been difficult to obtain due to the minuscule amounts of substance available for analysis. Thus, indirect methods of characterization, such as the measurement of particle activation may be useful in evaluating the atmospheric new particle formation process.

Hirschl, Rhonda S.; Lee, Shan-Hu, 2006, “Aerosol Nucleation Rates of Sulfuric Acid and Water Measured Under Atmospheric Conditions,” *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Nucleation is a gas to particle conversion process in which solid or liquid aerosol particles form directly from the gas phase species and thus is an important step in the chain of reactions that lead to cloud formation. However, the nucleation mechanisms are poorly understood. There are presently large discrepancies amongst the measured nucleation rates by different laboratory studies; nucleation rates taken under the atmospheric conditions are very rare. Laboratory experiments of aerosol nucleation are performed under atmospheric conditions with a novel chemical ionization mass spectrometer (CIMS), nano-particle differential mobility analyzer (Nano-DMA) and water condensation nuclei counter (WCPC). Our CIMS measures low concentrations of sulfuric acid (<0.1 pptv). Measurements of Nano-DMA and ECPC provide aerosol nucleation rates. An atmospheric pressure flow reactor is used to photochemically produce sulfuric acid particles from the reactions of OH and sulfur dioxide. Sulfur dioxide is also detected by CIMS. OH forms from the photo-dissociation of water vapor using a mercury lamp and the OH concentrations are calculated based on the known photochemical reaction rates and measured photon fluxes. We will compare our particle nucleation rates with those by Berndt et al. (2004) that show relatively high concentrations of sulfuric acid and water nucleation rates comparable to the atmospheric observations.

Iida, Kenjiro; Stolzenburg, Mark; McMurry, Peter H.; Dunn, Matthew; Smith, James; Eisele, Fred; Keady, Pat, “Identifying the Contribution of Ion Induced Nucleation from Measurements of Charge Distributions and Aerosol Size Distributions,” *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Ions are constantly generated in the atmosphere (Bricard 1966; Chalmers 1967). Laboratory studies have shown that the Fuchs' stationary state charge distribution reproduces measurements down to a few nanometers when charge distributions are determined solely by ion-aerosol attachment (Reischl et al., 1996). Charge distribution of atmospheric nanoparticles, however, are also influenced by their nucleation process, particle growth rate, and depletion. We previously showed that sub 10nm atmospheric nanoparticles should “remember” their nucleated charge state for the range of typically observed growth rates (Iida et al., 2006). We measured charge distributions of atmospheric nanoparticles from 2.5 – 25nm along with size distributions of nanoparticles, pre-existing particles, and small and intermediate ions. Nucleation rates, growth rates, and relative contributions of ion-induced nucleation were estimated by finding a solution of the population balance equation that reproduces the measured charge distribution and size distribution of atmospheric nanoparticles.

Jeong, Cheol-Heon; Evans, Greg J., 2006, “Intercomparison of the Performance of a Fast Mobility Particle Sizer and an Ultrafine Water-based Condensation Particle Counter for Measuring Particle Number and Size Distributions in the Atmosphere,” *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Continuous measurements of aerosol size and number concentrations are important in understanding the chemical and physical properties of nanometer ultrafine particles in the atmosphere. Fine and ultrafine particles have been known to cause adverse health effects and impact the radiation budget of the atmosphere. A Scanning Mobility Particle Sizer (SMPS) has been widely used to detect particle number and size distributions for aerosol research. In urban atmospheres motor vehicle emissions are the main source of ambient particles. Particle number and size measurements with high time and high size resolution are needed to evaluate rapidly changing concentrations of ultrafine particles on roads. The purpose of this study was to assess the performance of a newly developed Fast Mobility Particle Sizer (FMPS) and a nano-S<sub>2</sub>PS and compare their measurements under various conditions.

Kulmala, Markku; Mordas, Genrik; Petäjä, Tuuka.; Grönholm, Tiia; Aalto, Pasi P. Vehkamäki, Hanna; Gaman, Anca; Herrmann, Erik; Sipilä, Mikko; Riipinen, Ilona; Hämeri, Kaarle; Birmili, Wolfran; Wagner, Paul E., 2006, "Estimation of composition of growing aerosol particles using a condensation particle counter battery" *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

A general characteristic of the Condensation Particle Counters (CPCs) is its detection efficiency as a function of the particle size. A cut-off size of a CPC is defined as a size, at which 50% of the sampled aerosol particles are successfully accounted for. Stolzenburg and McMurry (1991) showed that this cut-off diameter mostly depends on activation efficiency inside the CPC. In a laminar flow butanol and water CPC based on conductive cooling, the cut-off diameter tends to smaller sizes when a temperature difference between saturator and condenser increases. Theoretically, the detection efficiency depends on both the saturation ratio inside the CPC and on the chemical composition of sampled aerosol particles. In order to find out the activation probabilities for different type of aerosols it is possible to calculate heterogeneous nucleation and activation probabilities for soluble and insoluble particles (e.g. Kulmala et al., 2001; Wagner et al., 2003). These surface interactions depend on both the properties of the vapor and on the composition of particles, onto which the heterogeneous nucleation is initiated. In this study we used a CPC battery (CPCB) consisting of two butanol and two water CPCs. We studied the dependence of the cut-off size of the CPCs on aerosol material, on temperature difference between condenser and saturator and on working fluid in a laboratory. Based on laboratory experiments, we show that water soluble and insoluble as well as butanol soluble and insoluble aerosol particles have different activation diameters inside the CPCs. This enabled us to use the CPCB to estimate composition of growing aerosol particle in April-May 2005 at SMEAR II station, Hyytiälä, Finland at a stage, when the particle diameter is less than 20nm.

Polidori, Andrea; Arhamik, Mohammad; Sioutas, Constantino; Singh, Manisha, "Indoor and Outdoor Measurements of the Surface Area of Particles Deposited in the Human Lungs Using the TSI Model 3550 Nanoparticle Surface Area Monitor," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Numerous epidemiological studies have shown consistent association of cardiovascular hospital admissions and mortality with outdoor air pollution, particularly mass concentrations of fine particulate matter (PM<sub>2.5</sub>). The causal components relating the associations between increased exposure to PM<sub>2.5</sub> and adverse health effects remain unclear but an increasing number of studies have provided indirect evidence that products of fossil fuel combustion are important. In particular, particles with an aerodynamic diameter smaller than 0.1 μm (ultra-fine particles) (UFPs) dominate particle number concentration and surface area of the particulate component of motor-vehicle emissions and, thus, are capable of carrying large concentrations of adsorbed or condensed toxic air pollutants (Delfino et al., 2005). It is believed that the redox-active components in UFPs from fossil fuel combustion reach cardiovascular target sites and are the main responsible for the observed adverse health effects. A significant portion of human exposures to PM<sub>2.5</sub> and UFPs occurs indoors where people spend approximately 85-90% of their time. A substantial fraction of indoor particles originate outdoors and enters the building envelope through infiltration and ventilation. The contribution of outdoor air through infiltration depends on the building characteristics, particle concentration outside and particle sizes. While larger particles are removed by impaction when air enters the building, smaller particles are not removed as efficiently. In addition, when indoor sources are present (cooking and smoking, for example) PM<sub>2.5</sub> and UFP concentrations can be substantially higher indoors than outdoors. During the present work, conducted within the cardiovascular health and air pollution study (CHAPS), continuous (1-minute) particle number concentration and "lung-deposited" surface area measurements have been analyzed both indoors and outdoors. Accurate real-time measurements are necessary to better assess the relationships between indoor and outdoor PM<sub>2.5</sub> and UFG concentrations, their seasonal trends and their effects on human exposure. This is one of the first studies to employ the newly commercialized Nanoparticle Surface Area Monitor (Model 35500 manufactured by TSI (TSI Inc. Shoreview, MN)

Rogers, David C.; Herring, Susanne; Stolzenburg, Mark R.; Oberreit, Derek; Quant, Fred, 2006, "Airborne Tests of a New Low-Pressure Water-Based CN Instrument," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Measurements of aerosol particle number concentrations are used routinely for airborne atmospheric research. They are important, for example to characterize the air as clean background or pollution, to identify aerosol plumes, to serve as an air mass tracer, to indicate regions of new particle formation, and to estimate particle scavenging rates. For optimal utility, airborne particle counting instruments must have fast time response and be relatively insensitive to the large range of pressures that aircraft traverse. This paper describes the performance of a water-based condensation particle counter (WCPC) that is modified for airborne use.

Shi, Qian; Han, Hee-Siew; Kerrigan, Steve W.; Fink, Melissa; Caldow, Rob; Liu, Wei, 2006, "Particle Number Concentration and Size Distribution Measurements of Ambient Aerosol in Minnesota with New TSI Condensation Particle Counters," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Condensation Particle Counters (CPCs) have been used in many applications for environmental monitoring and atmospheric aerosol size distribution measurements in last a few years. Three new TSI butanol-based CPCs and a water-based CPC were used to measure size distributions and number concentrations for ambient aerosol in an extended time period during the summer time in Minnesota compared to the data from the corresponding TSI legacy CPCs.

Thomas, Rick; Nemitx, Eiko; House, Emily; Hallquist, Mattias; Coe, Hugh, 2006 "Speciated Aerosol Fluxes above an Urban Canopy: Measurements during the GÖTE-2005 Campaign," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Online micrometeorological speciated aerosol flux measurements collected from the Lipstick tower during the GÖTE-2005 campaign are presented. Speciated aerosol flux and concentration measurements were collected using an Aerodyne Aerosol Mass spectrometer (AMS) (Jayne et al., 2000) together with an ultrasonic anemometer (Gill Solent R1012A). In addition, total particle number flux data were collected using a TSI 3785 water based condensation particle counter (CPC),  $\sim 5\text{nm} < D_p < 3\mu\text{m}$  and a Li-Cor LI-7000 infrared gas analyzer was used for CO<sub>2</sub> and water vapor fluxes. Monitored AMS masses (m/z's) were chosen to distinguish hydrocarbon-like organic aerosol (HOA) and oxygenated organic aerosol (OOA) (e.g. Zhang et al., 2005) as well as measuring inorganic species such as sulphate, nitrate and ammonium.

Tsang, Hamilton C.; Ma, Roger; Miguel, Antonio H., 2006, "Number Concentration Measurements Using a Water-Based CPC in Hong Kong Under Heavy Traffic Conditions," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Vehicle generated particle emissions are a major source of fine (PM<sub>2.5</sub>) and ultrafine (UF,  $dp < 100\text{nm}$ ) particulate matter in urban areas. Particulate matter in this range has been a matter of concern for its ability to penetrate the body and cause adverse health effects (Donaldson and Stone, 2003); Nemmar et al., 2002; Li et al, 2003; Li et al, 2004). To date, there are only a few studies focusing on the particle counts experienced by pedestrians in Hong Kong, one of the largest cities in the world. Our study focuses on measurements of particle number concentrations at several sites along a busy intersection in the center of Mong Kod, Kowloon in Hong Kong, and its correlation to the pedestrian environment.

Tuomenoja, Henna; Lamminen, Erkki; Nieminen, Elina; Ukkonen, Ari, 2006, "Real-time Number Size Distribution Measurement, and Density Estimation of Indoor Air Particles Using an ELPI and a CPC," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Workplace exposure to aerosols and resulting health effects have been a topic of discussion during recent years. Workplace aerosol exposure is important due to its repetitive long-term nature, and potential for high concentration aerosols with "unnatural" composition containing e.g. metal-oxides and/or heavy metals. Particle concentration, size and composition are important factors when determining health impact caused by aerosols in different environments.

Westerdahl, Dane; Fruin, Scott; Marshall, Julian; Fine, Phillip M.; Singh, Manisha, 2006, "Coarse, Fine and Ultrafine Particles in Jakarta, Indonesia," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Jakarta is one of the most polluted cities in the world. Air quality in this city of 12 million people appears to be impacted by vehicular traffic that is growing by 15% per year. Diesel-powered vehicles do not include catalytic converters because lead is added to fuels in some parts of Indonesia, thus they emit large quantities of carbon monoxide, oxides of nitrogen, hydrocarbons, and lead. Limited air monitoring is performed, but does not provide an adequate characterization of air pollution, especially particle phase pollutants. We performed community monitoring in Jakarta both to make observation of OM and its components and characteristics and to support the needs of a monitoring effort carried out to assess human exposure during commute and occupational activities.

Wu, Yun; Hu, Weiwei; Chalmers, Jeffrey; Wyslouzil, Barbara, 2006, "Electrohydrodynamic Spraying of Lipid Nanoparticles for Drug Delivery," *2006 International Aerosol Conference*, St. Paul, MN, September 10–15, 2006

Lipid nanoparticles have been proposed as an alternative drug delivery system, especially for lipophilic drugs, to traditional colloidal carriers such as emulsions, liposomes, and polymeric nanoparticles (Muller et al., 2000; 20004). As drug delivery vehicles, emulsions and liposomes are often limited by physical instability and low drug loading capacity (Muller et al., 2000;

2004). Polymeric nanoparticles can exhibit cytotoxicity, and there are no industrialized production methods (Muller et al., 2000). Many lipids, such as oleic acid and cholesterol, are biocompatible and classified as GRAS (Generally Regarded As Safe). They readily solubilize lipophilic drugs, and this can lead to high drug stability and loading capacity. For solid lipids, the slow change from an amorphous phase to a crystal phase can control the drug release process (Muller et al., 2000). Currently, the most popular preparation technique for lipid nanoparticles is High Pressure Homogenization (HPH). Although this method is good for large-scale production, the energy input is very high, and, thus, it is often unsuitable for use with temperature sensitive biomolecules. Furthermore, as the mixtures cook, some drugs do not incorporate into the lipids but only stick to the surface, resulting in burst drug release kinetics and low drug loading (Muller et al., 2004; Jores et al, 2004). Electrohydrodynamic spraying (EHDS) is an alternate way to produce lipid nanoparticles. Because the particles can be produced at or near room temperature, EHDS can be used to disperse sensitive biomolecules, such as DNA (Chen et al, 2000). The goal of our work is to explore EHDS as a production method for lipid nanoparticles. To date we have demonstrated the feasibility of spraying lipid nanoparticles and capturing them in liquid media. We have followed their stability in the liquid phase and have tested their cytotoxicity against Chinese Hamster Ovary (CHO) cells.

## 2005

Allen, J; Cubison, M.; Hering, S.; Ogren, J.; Jimenez, J-L; Carlo, P.; Goldstein, A.; Millet, D., 2005, "Observation of Biogenic Nucleation Events at Low Tide in Nova Scotia, Canada." Presentation, *24th Annual AAAR Conference*, Austin TX, October 17–21, 2005

Evidence of new particle formation was found for the approximately one-half of the days of a six-week study period in the summer 2004, at Chegogue Point, a rural site located on the coast near Yarmouth, Nova Scotia, Canada. Concentrations, as measured by a water-based and butanol-based condensation particle counters, reached as high as  $100,000\text{ cm}^{-3}$ . Mobility size distributions show that most of the periods of high concentration were dominated by particle in the sub-10nm size range. These high number concentration events coincided with low tide, and are believed to be associated with the biogenic release of iodine, as has been observed at Mace Head by O'Dowd and coworkers. Occasional spikes in of particles in the 20-40 nm size range were observed coincident with ferry crossings. The overall profile of particle number concentrations was characterized by sharp spikes of one to three hours duration overlaying a slowly varying background. The background aerosol varied from  $500$  to  $5000\text{ cm}^{-3}$ , and correlated with carbon monoxide concentrations, indicative of transport from an urban source region. Although some of the tidal nucleation events were of several hours duration, there was no evidence of particle growth.

Bischof, O.F; Zerrath, A.F., 2005, "Measurements of Urban Aerosol in a Light Industrial Area – Physical Properties, Including Particle Size, Number, and Diameter Concentrations." Poster, *24th Annual American Association for Aerosol Research Conference*, Austin, Texas, October 17–21, 2005

The physical properties of urban aerosol particles in a light industrial area in the city of Aachen (Germany) have been investigated. Urban aerosol is typically dominated by ultrafine particles with diameters below 100nm, which often originate from local sources such as traffic and industry. The sapling site was located within a commercial area, about 250m away from a freeway and just opposite of the depot of the local public transport company that is used by a fleet of diesel-powered busses. In this study several aerosol measurement techniques were employed. Scanning mobility particle sizers (SMPS) have been used for many years to characterize aerosol in the atmosphere. The single-box SMPS used in this study is of a novel design that was specifically improved for continuous monitoring. Both differential mobility analyzer (DMA) and CPC are integrated in the same cabinet and operated using a scanning algorithm. The SMPS scanned from 10 to 500 nm in 3 min to achieve size distributions with 54 channel resolution. Further, two continuous flow CPCs measured the number concentration. The instruments were similar in their continuous operation, but used different working fluids to enlarge the particles for optical detection. The 3022A CPC used n-butanol as its condensing fluid, while the 3785 belonged to a novel series of water-based CPCs (WCPC). Both CPCs were selected based on comparable specifications, particularly their suitability to measure high concentrations.

Eiguren-Fernandez, A; Zhu, Y.; Miguel, A.; Hinds, W.; Hering, S.; Nazaroff, W., 2005, "In-Cabin and Outdoor Nanoparticles, and Ultrafine Particles II: Collocated Number Concentration Measurements on Los Angeles Roadways." Presentation, *24th Annual AAAR Conference*, Austin TX, October 17–21, 2005

In Part I, we pointed out the importance of human exposure to nanoparticles (NPs,  $dp < 50\text{nm}$ ), and ultrafine particles (UF,  $dp < 100\text{nm}$ ) with respect to increasing concern related to human exposure and their toxicity, and presented our observations of in-cabin and outdoor particle size distribution measurements in the 7 – 300nm size range, carried out on Los Angeles roadways. We now describe our observations of simultaneous in-cabin and outdoor measurements of number concentration observed while driving in the same 2003 VW Jetta Wagon 1.8T equipped with a factory-installed HEPA-activated carbon particle filtration system.

Filimundi, E.; Bischof, O.F.; Bennett, I.P., "Measurement of nucleation mode particles using an ultrafine water-based condensation particle counter." Presentation, *Le 21ème Congrès Français sur les Aérosols (CFA 2005)*. ASFERA, Paris, France, December 14–15, 2005

Atmospheric nucleation is a process of environmental importance. It has both a direct and an indirect effect on the climate influencing the albedo and leading to optical extinction. The direct effect is due to the presence of newly formed particles and their interaction with sun light while the indirect effect is caused by the particles acting as cloud condensation nuclei. Additionally, newly generated nucleation particle in the nanometer range are said to have adverse effects on human health as they deeply penetrate into the lung where a fraction of them is deposited. The measurement of such nanoparticles generated by nucleation is a measurement challenge for conventional aerosol instruments. We describe a newly developed ultrafine water-based condensation particle counter (UWCPC), the TSI 3786, that is well suited for such measurements by extending the range of ultrafine particle detection techniques. We evaluated the performance of the instrument in the laboratory and describe its use in two experiments.

Hering, S., Keady, P.B.; Stolzenburg, M.R.; Fernandez, A.E.; Miguel, A. H.; Quant, F.R.; Oberreit, D.R., 2005, "Response of Water-Based Condensation Particle Counters to Ambient and Vehicular Particulate Matter," Presentation, *2005 European Aerosol Conference*, Ghent, Belgium, August 28–September 2, 2005

Concerns regarding the health effects of ultra-fine particles and particulate emission from vehicular traffic is motivating the measurement of these particles in ambient air. Water-based condensation particle counting is an attractive approach for monitoring particle number concentration because it eliminates the need for toxic and costly working fluids. Reported here is the response of a laminar-flow water-based condensation particle counter (WCPC) to ambient and vehicular traffic aerosols. The WCPC is a continuous, thermally diffusive instrument that enlarges particles by water condensation to enable them to be counted by optical means. The WCPC uses a "growth tube" technology that explicitly takes into account the high diffusivity of water vapor wherein the supersaturation necessary for particle activation and growth is produced in a wetted tube whose walls are warmer than the entering flow.

Miguel, Antonio H.; Eiguren-Fernandez, Arantzazu; Zhu, Yifang, 2005, "In-Cabin Commuter Exposure to Ultrafine and Nanoparticles in Los Angeles Roads and Freeways: Measurements with a New Water-Based Condensation Particle Counter," Presentation, *the Particulate Matter Supersite program and Related Studies, An International Specialty Conference sponsored by the American Association for Aerosol Research*, Atlanta, GA, February 2005

High concentrations of ultrafine (UF,  $dp < 100\text{nm}$ ) and nanoparticles (NPs,  $dp < 50\text{nm}$ ) have been observed on or near freeways in urban areas by a number of investigators. A component of fine particles ( $\text{PM}_{2.5}$ ), UF particles are toxic to lab animals and are able to enter the circulatory system when inhaled. Thus, it is reasonable to expect that, as a result of increasing traffic congestions and commute times occurring worldwide, in-cabin exposure may constitute the most important route of exposure to toxic PM. Despite these findings, limited in-cabin information is available for human exposure to PM while traveling on congested freeways, or walking on sidewalks of city streets with high volume of traffic. We report the first set of in-cabin observations of particle number concentration ( $\#/ \text{cm}^3$ ) acquired with an all new water-based condensation particle counter (WCPC) while driving in Los Angeles roads and freeways. A TSI Inc. model 3785 WCPC, sensitive to fast-changing aerosol concentrations ranging from ca 10 nm to over 3  $\mu\text{m}$  in diameter, was used to test two vehicles in this study: A model 2002 1.8T Jetta Wagon and a model 2004 Audi A4 1.8T passenger car, each equipped with a factory-installed high efficiency particulate matter filter (HEPA) followed by a bed of activated carbon. The driver and a passenger drove in typical high-traffic Los Angeles freeways and roadways, with varying fractions of heavy duty diesels vehicles, under a variety of in-cabin test vehicle parameters and operating conditions including open or closed windows, engagement of the vehicle air conditioning system and intake air, vehicle speed, and traffic conditions. In-cabin carbon monoxide (CO) concentrations were measured at one-minute intervals on a continuous basis by a TSI Model 8550 Q-TRAK monitor. Our results show that, in general, while driving on freeways and surface streets, carbon monoxide (CO) concentration and particle number concentration went up and down together. Relatively low CO concentrations with high particle number concentrations were observed on freeways with free flow traffic. Dramatic increase in particle number concentration occurred when the vehicle went from local streets onto freeways. The highest on-board cabin particle number concentration, about  $3.0 \times 10^5$  particle/ $\text{cm}^3$ , was observed while driving on the I-710 (a major truck route with up to 25% heavy-duty diesels) and I-105 freeway with all windows open when traffic was moving at 65 mph. The lowest particle number concentration, 2,000 particle/ $\text{cm}^3$ , was observed while the vehicle was at a shopping center's parking lot with the engine off and windows closed. The factory installed standard HEPA filter offers good protection against PM. Differences between observed highest and lowest particle number concentrations in this study were ca 130 times.

Miguel, A.; Zhu, Y; Eiguren-Fernandez A.; Hinds, W.; Hering, S.; Nazaroff, W., 2005 “In-Cabin and Outdoor Nanoparticles, and Ultrafine Particles I: Size Distribution Measurements on Los Angeles Roadways.” Presentation, *24th Annual AAAR Conference*, Austin TX, October 17–21, 2005

On-road exposure to nanoparticle (NPs,  $dp < 50\text{nm}$ ) and ultrafine particles (UF,  $dp < 100\text{nm}$ ) is of growing concern worldwide in megacities and other large urban centers as a result of increasing traffic congestion. Such particles represent an important component of  $\text{PM}_{2.5}$ , and show high toxicity in laboratory animals. Human exposure to high concentrations typically found near major freeways and roadways lead to concern about adverse human health impacts. NPs and UF particles are capable of entering the circulatory system when inhaled and exert adverse pulmonary effects by generating airway inflammation. Increasing evidence suggests that the toxicity of these particles may result from their small size, large number concentration, high organic carbon content (including polycyclic aromatic hydrocarbons and quinines), and their ability to localize in subcellular organelles such as mitochondria (Li et al, 2004, Miguel et al., 2005).

Zerrath, Axel F.; Bischof, Oliver F., 2005, “Urban Aerosol in a Light Industrial Area—Particle Size Distribution and Number Concentration Measurements In the Submicron Range.” *European Aerosol Conference 2005*, Ghent-Belgium, August 28–September 2, 2005

Urban air quality has been under increased scrutiny over the last few years. With the beginning of the year 2005 a new EU regulation limits the fine particle fraction of particulate matter in ambient air. Urban air consist of a significant fraction of submicrometer, and ultrafine particles in particular, which make a small contribution to the particulate mass, but are said to be associated with a number of health effects (see also figure 5). The most significant adverse health effects have been reported for areas with the highest levels of particle concentrations. Industrial areas within European cities with their increased traffic and industrial emissions are typical examples for those high levels.



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