Session 10: Nanoparticle toxicity and health effects, Talk

**Characteristics of Brake-Wear Particles and Chemical Speciation Profiles and Potential Health Effects of the Particles in California**

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Brake-wear emissions have become the dominant source of directly emitted particles from motor vehicles, as tailpipe emissions have been substantially reduced in response to stringent tailpipe emissions standards in California. Understanding the characteristics of brake-wear particles, including particle number, size distributions, and mass, as well as their chemical speciation profiles, is a crucial step in understanding their potential adverse health effects. The presence of heavy metals in the particles is a concern for public health, particularly in communities near major urban arterials and highways.

The California Air Resources Board (CARB) has undertaken investigations to measure airborne brake-wear particles under brake-dynamometer testing conditions, characterize their chemical speciation profiles, and assess their potential health effects locally and regionally. Airborne brake-wear particles are generated during vehicle braking when shear forces increase between the friction material and the disk. CARB analysis revealed that the major inorganic contents of brake-wear particles from California light-duty and heavy-duty vehicles include iron (Fe), barium (Ba), copper (Cu), zinc (Zn), and titanium (Ti), while approximately half of the particles consisted of non-metallic components. The oxidative potentials of the particles collected near roadways were significantly greater than those collected in urban background areas, indicating that brake-wear particles may have a greater adverse health effect in near-road communities and populated urban areas.

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**Systematic review and meta-analysis on the health effects of long-term exposure to ultrafine particles**

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**BACKGROUND**: Ultrafine particles (UFP; ≤100 nm diameter) may have a higher toxicity than larger particles but are still not regulated nor part of routine air pollution monitoring. So far, health effects of long-term exposure to ambient UFP are not well understood, due to a lack of exposure data and epidemiological studies.

**METHOD**: We conducted a systematic review and meta-analysis on the health effects of long-term exposure to UFP, including studies published until December 2024. Meta-analysis was conducted for outcomes with at least four available effect estimates. Confidence in the body of evidence was evaluated using the Office of Health Assessment and Translation (OHAT) method.

We identified 85 studies investigating various mortality, morbidity, and subclinical outcomes. In meta-analyses of single-pollutant models, we found positive associations with natural mortality (hazard ratio: 1.06 [95% confidence interval [CI]: 1.04; 1.08]) and C-reactive protein (10.14% increase [95% CI: -0.51; 21.99]), per 10,000 pt/cm$^3$ increase in long-term exposure to UFP, with low and inadequate levels of evidence, respectively. The remaining studies revealed overall limited evidence for adverse effects on a wide range of outcomes. Less than half of the studies adjusted for co-pollutants.

**CONCLUSION**: The evidence base on long-term health effects of UFP has increased substantially in the last decade, while the overall evidence for independent effects of long-term UFP exposure remains inadequate to low. More studies are needed to draw firm conclusions about the independent adverse effects of long-term UFP on various health endpoints, with a special focus on the influence of co-pollutant adjustment.

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**Real-time monitoring of particle-bound reacti**

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Understanding biomass burning emissions is critical as they represent a major source of atmospheric particulate matter, impacting air quality, climate, and public health. The chemical complexity and dynamic evolution of these particles during atmospheric aging pose challenges for predicting their environmental and health effects. A critical knowledge gap concerns the evolution of particle-bound reactive oxygen species (ROS) during aging, particularly short-lived ROS that are difficult to quantify using conventional offline methods. In this study, we examine the formation and transformation of particle-bound ROS in smoke generated from eucalyptus leaves under controlled photochemical aging. Atmospheric oxidation was simulated using a Rapid Aerosol Aging Device (RAAD), enabling real-time monitoring of aerosol compositional changes and oxidative potential. A suite of instruments, including two Particle Into Nitroxide Quencher (PINQ) systems, a Scanning Mobility Particle Sizer (SMPS), gas monitors, Selected Ion Flow Tube mass spectrometry (SIFT), and a High-Resolution Aerosol Mass Spectrometer (HR-AMS) was employed to characterize both physical and chemical transformations during aging. Relative humidity was maintained using an integrated humidification system, as it can significantly influence oxidation reactions and ROS formation. Fresh smoke was initially analysed under dark, low-oxidant conditions to establish baseline properties, after which the aerosol was subjected to RAAD-driven photochemical aging equivalent to 1–6 days of atmospheric OH exposure. The first PINQ measured initial particle-bound ROS levels, while the second PINQ quantified ROS after aging. SIFT provided measurements of key gas-phase species associated with oxidation chemistry, and the HR-AMS supplied real-time information on chemical composition and mass-based size distribution. This integrated approach enabled continuous evaluation of ROS formation and transformation during simulated atmospheric aging, offering new insight into how biomass burning emissions develop enhanced oxidative potential over timescales of several days. Dual-PINQ measurements showed clear differences in particle-bound ROS before and after photochemical aging, demonstrating that aging processes substantially modify particle-bound ROS levels compared to those measured immediately after burning. This highlights the importance of real-time techniques for detecting short-lived species that cannot be preserved through offline sampling. Overall, the results indicate that photochemical aging significantly alters the oxidative potential of biomass burning aerosols over short atmospheric timescales, with implications for air-quality assessment and human exposure during fire events.

Keywords: biomass burning aerosol, reactive oxygen species, atmospheric aging, oxidative potential, PINQ.