Final Technical Report

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Center Name: NYU-EPA PM Center: Health Risks of PM Components
Center Director: Morton Lippmann
Title: Urban $PM_{2.5}$ Surface Chemistry and Interactions with Bronchoalveolar Lavage Fluid (BALF)
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Project Period: June 1, 1999–May 31, 2005 (no-cost extension to May 31, 2006)
Period Covered by the Report: June 1, 1999–May 31, 2006
RFA: Airborne Particulate Matter (PM) Centers (1999)
Research Category: Particulate Matter

Objective(s) of the Research Project: The objective of this research project was to investigate the surface chemistry of urban fine particles ($PM_{2.5}$), and to quantify the adsorbed and desorbed species exposed to bronchoalveolar lavage fluid (BALF).

Summary of Findings:

Technical Aspects

Urban background and roadside $PM_{2.5}$ samples of different mass concentration and total weight were collected in triplicate in the South Bronx region of New York City. Simultaneously, the concentrations of other atmospheric pollutants (CO, NO_x, SO_2, O_3, EC) were measured, and weather conditions recorded. The collected $PM_{2.5}$ samples underwent one of three treatments; no treatment, treatment *in vitro* with BALF, or treatment in a saline solution (control). The surfaces of untreated, saline and BALF treated $PM_{2.5}$ samples were then analysed using X-ray photoelectron spectroscopy (XPS) and time-of-flight secondary ion mass spectrometry (ToF-SIMS). These results were then compared with ambient air pollutant concentrations, weather variables, selected BALF characteristics, and results from a previous London study conducted using identical methods.

Both surface techniques were useful in detecting surface species and observing changes in surface concentrations. The surface of untreated urban $PM_{2.5}$ consisted of 79 to 87% carbon and 10 to 16% oxygen with smaller contributions of N, S, Si and P in the samples from both locations. A wide variety of other inorganic (metals, Cl^-, NH_4^+) and organic species (aliphatic and aromatic hydrocarbons) were detected with ToF-SIMS. The surface characteristics of particles from the roadside and background sites were very similar, except for higher ($p<0.05$) nitrate concentrations at the roadside $PM_{2.5}$ that were attributable to higher roadside NO_x concentrations. Comparable species and quantities were identified in a previous study of London $PM_{2.5}$, but $PM_{2.5}$ surface chemistry differed considerably from other sources, particularly in surface concentrations of oxygen and trace species.

After treatment with BALF, the N-C signal detected by XPS analysis increased by an average of 372±203%, indicating significant surface adsorption of protein or other N-containing biomolecules. Lower N-C signals were observed for BALF from smokers. ToF-SIMS data confirmed N adsorption after BALF treatment, and also indicated an adsorption of phospholipid on the $PM_{2.5}$ surfaces in terms of increased fragment ions characteristic of phospholipid adsorption. The primary phospholipid in BALF is DPPC, although positive identification was not possible. Oxygen content of $PM_{2.5}$ surfaces was the most significant determinant of both N-C and phospholipid adsorption. The XPS signal of the soluble species NH_4^+, NO_3^{2-}, Si and S decreased in both saline and BALF treated samples, showing that these species may be bioavailable in the lung.

Thus, we have shown that $PM_{2.5}$ surface chemistry can be analyzed and differentiated using two sensitive surface analytical techniques, XPS and ToFSIMS. $PM_{2.5}$ surfaces in New York City are similar in overall composition to $PM_{2.5}$ surfaces analyzed in London. Distinct differences in surface chemistry were also found comparing urban $PM_{2.5}$ from different types of locations. In particular, surface oxygen concentrations increased with "aged" $PM_{2.5}$, so that clean air $PM_{2.5}$ was > NYC and London $PM_{2.5}$, which was > tobacco smoke $PM_{2.5}$. It is proposed that such a difference may be an important—and hitherto unconsidered—determinant in the health effects of $PM_{2.5}$ exposure. The wide variations in carbon:oxygen ratios detected could be used to distinguish smoke, urban and "clean air" $PM_{2.5}$. In this study, we also confirmed results from previous studies that $PM_{2.5}$ surfaces interact strongly with BALF over very short periods, and that $PM_{2.5}$ immersed in BALF are desorbed of particular components and coated with bio-molecules. We showed that consistently large increases of the N-C signal from $PM_{2.5}$ surfaces occur as a result of interactions with BALF, and we attribute these increases to protein adsorption.

Supplemental Keywords: NA

Relevant Web Sites: http://www.med.nyu.edu/environmental/
http://es.epa.gov/ncer/science/pm/centers.html