HEI

STATEMENT

Synopsis of Research Report 197

HEALTH EFFECTS INSTITUTE

Cellular and Acellular Assays for Measuring Oxidative Stress Induced by Ambient and Laboratory-Generated Aerosols

BACKGROUND

In this study Dr. Nga (Sally) Ng, who was a recipient of HEI's Walter A. Rosenblith New Investigator Award, and her colleagues characterized and compared the oxidative properties of ambient PM and laboratory-generated secondary organic aerosol (SOA) using in vitro assays. SOA is formed in the atmosphere from the products of photochemical reactions of organic compounds. The chemistry involving the formation of SOA is complex and depends on many factors, such as precursor composition, temperature, humidity, concentration of oxides of nitrogen (NO_x), and existing aerosols.

APPROACH

Dr. Ng studied the relative oxidative activity of resuspended ambient PM and laboratory-generated SOA using a chemical assay (DTT) and a cellular assay (C-DCFH). The former assay assessed the ability of particle extracts to oxidize DTT in a test tube, while the latter assessed the ability of particle extracts to induce ROS production in macrophages grown in culture. Dr. Ng also studied induction of two markers of inflammation (tumor necrosis factor-α and interleukin-6) by SOA.

The ambient PM samples were collected as part of a previous study by the authors. The SOA samples were generated in an environmental chamber in the presence of simulated sunlight and ammonium sulfate (which serves as a seed particle onto which the semivolatile products condense) under different conditions (high and low humidity, high and low NO_x, and presence of redox-active metal). Separate experiments were performed using six organic compounds (SOA precursors) to generate different types of SOA: three precursors are commonly emitted by anthropogenic sources (*m*-xylene, naphthalene, and pentadecane) and three from biogenic sources (isoprene, α-pinene, and β-caryophyllene).

MAIN RESULTS AND INTERPRETATION

Ambient PM There was an association between oxidative potential (DTT assay) and ROS response

What This Study Adds

- The study provides a systematic analysis of the ability of ambient particulate matter (PM) and laboratory-generated secondary organic aerosol (SOA) to induce the production of reactive oxygen species (ROS) as measured by both chemical (DTT) and cellular (C-DCFH) assays.
- The results show that all of the types of aerosol tested have the ability to induce production of ROS to some extent. For ambient PM, positive correlations were observed for water-soluble organic compounds, black carbon, and some metals in summer samples. Among the different types of SOA tested, naphthalene-derived SOA had the highest activity in both assays. There was a correlation between cellular ROS production and aerosol carbon oxidation state.
- The results of the SOA activity are novel and point to the need to better understand their effects on human health.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr. Nga Lee (Sally) Ng at the Georgia Institute of Technology, Atlanta, Georgia, and colleagues. The complete report, *Cellular and Acellular Assays for Measuring Oxidative Stress Induced by Ambient and Laboratory-Generated Aerosols* (© 2019 Health Effects Institute), can be obtained from HEI or our website (see next page).

(C-DCFH assay) for ambient PM collected in summer, but not for PM collected in winter. Some constituents of summer PM (water-soluble organic compounds, brown carbon, iron, and titanium), but not of winter PM, were correlated with increased ROS production in the C-DCFH assay.

Laboratory-Generated SOA SOA formed from the photo-oxidation of naphthalene elicited the largest response in both the DTT and C-DCFH assays across all chamber conditions. SOA formed from isoprene oxidation had the lowest DTT activity. For the other precursors, the DTT activities were low. There was more variability in the ROS and inflammatory responses than in the DTT assay across the SOA, with naphthalene-derived SOA showing the largest range in inflammatory responses and isoprene-derived SOA, the lowest response. While there was no clear trend between chamber conditions (high and low NO_x and high and low humidity) and ROS production across the six types of SOA, the investigators reported a positive correlation between ROS production and carbon oxidation state.

CONCLUSIONS

In its independent review of this study by Ng and colleagues, the HEI Review Committee noted that the study provides an overview of whether components or characteristics of PM influence ROS formation. The Committee thought the results indicate that both ambient PM and SOA have some oxidative potential and ability to induce ROS production. While a correlation was observed between the two assays for summer PM samples, for SOA the correlation seemed to be driven by SOA produced by naphthalene, and thus not generalizable. The Committee noted that, because the chemical and cellular assays measure different aspects of oxidative activity, a correlation would not necessarily be expected. The experiments with laboratory-generated SOA also show that ROS production is accompanied by production of inflammatory mediators. However, there was no clear trend between ROS production and SOA precursor identity or formation condition. The Committee noted that biological relevance of these results is not known. However, SOA is a major component of fine particulate matter in many areas of the country, and the results of this study underscore the need to better understand the effects of SOA on human health.

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