When the air turns brown: Scientists discover reactions that create climate-changing brown carbon aerosol

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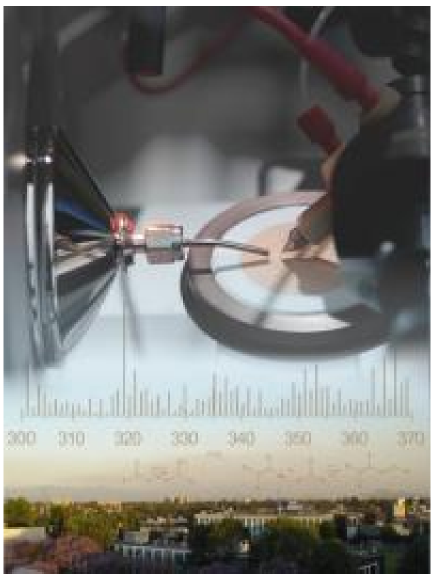

Scientists from Pacific Northwest National Laboratory and the University of California, Irvine revealed atmospheric chemistry processes that turn white organic carbon aerosol into brown carbon particles, which have a warming effect

(PhysOrg.com) -- A recent study led by Drs. Julia and Alexander Laskin from Pacific Northwest National Laboratory and Prof. Sergey Nizkorodov from the University of California, Irvine revealed atmospheric chemistry processes that turn white organic carbon aerosol into brown carbon particles. The white aerosol has no warming effect, but brown does. Also, this research presents the first application of a new analytical approach for studying transformations of organic aerosols developed at EMSL.

When studying the climate, scientists include the light-absorbing properties of carbon particles in their models. In creating the models, scientists assume that organic carbon particles scatter light and black carbon particles absorb light. Scientists want to improve their models by adding brown carbon particles, with light-absorbing properties that lie between organic and black carbon. Understanding the formation of brown carbon is a major challenge, and these particles present uncertainties in atmospheric studies. Discovering the fundamental processes that govern brown carbon formation and its evolution is vital to accurate model predictions.

This research began by "cooking" up a batch of fresh secondary organic aerosol (SOA). Using limonene and ozone, the researchers created "limonene/O_3 SOA" (LSOA) particles in a large Teflon bag. These tiny particles are initially white in color. The particles were then deposited on substrates. The chemical composition of the white particles is known from the previous work by the same team.

For aging experiments, the samples were exposed to atmospherically relevant concentrations of ammonia for 24 hours. Gradual browning of the LSOA was monitored. The scientists applied DESI-MS analysis to fresh and aged samples of LSOA. Detailed analysis of the experimental data allowed the team to identify key aging reactions responsible for browning of the LSOA material.

"With DESI, we can bring aerosols into lab and age them," said Dr. Julia Laskin, a chemist at Pacific Northwest National Laboratory. The team saw how the chemistry of aging alters the composition of the particles and what molecules are responsible for the absorption of visible light.

The high-resolution DESI-MS method used in this study created a lot of data. The Laskins turned to Gordon Anderson and Gordon Slysz to create the computational tools necessary to pull out the relevant data. They modified tools created to sift through complex biological data to help the team make sense of the spectra. "One of the advantages of working at a national lab is the ability to pull together scientists from different disciplines for these types of studies," said Dr. Julia Laskin.

Analyzing the data, the team found that the white organic aerosols exposed to ammonia formed a large number of nitrogen-containing molecules that could absorb visible light. "This research shows one of the possible processes in the atmosphere that transform white carbon into brown carbon," said Dr. Alexander Laskin of Pacific Northwest National Laboratory. "The reality is definitely more complicated—with many other possible routes responsible for the formation of brown carbon."

This study is moving forward on several fronts. Dr. Alexander Laskin is leading studies into the processes that form atmospheric aerosols to better understand brown carbon and its effects on the atmospheric chemistry and climate. Dr. Julia Laskin is leading the development of a more sensitive and robust DESI methodology. Prof. Nizkorodov's group is investigating the chemical mechanisms of various browning processes.

More information: Laskin J, A Laskin, PJ Roach, GW Slysz, GA Anderson, SA Nizkorodov, DL Bones, and LQ Nguyen. 2010. "High-Resolution Desorption Electrospray Ionization Mass Spectrometry for Chemical Characterization of Organic Aerosols." *Analytical Chemistry* 82, 2048-2058. DOI: \10.1021/ac902801f

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