At the junction of humid and sticky: Relative humidity determines viscosity of carbon-based atmospheric particles

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If there were real highways in the atmosphere, scientists' discoveries are a "road guide" for tiny particles found when emissions from pine trees mix with emissions from pollution. They found the viscosity of these particles can vary from honey-like to thicker than tar, depending on the relative humidity in the atmosphere.

(Phys.org) —What climate component can be as thick and sticky as honey, peanut butter or even asphalt? It is tiny particles forming in the atmosphere. An international team of scientists used two new techniques to find the viscosity of organic particles produced when α-pinene, one gas given off by pine trees, meets ozone, a gas produced from pollution. The researchers, from the University of British Columbia, Harvard University, University of Canterbury in New Zealand, University of Leeds in England, and the Pacific Northwest National Laboratory found that the resulting carbon-containing particles behave like liquids, semi-solids or solids across a range of atmospheric relative humidity conditions. Their research was published in the *Proceedings of the National Academy of Sciences*.

People say it's not the heat, it's the humidity. Turns out, certain atmospheric particles are sensitive to relative humidity as well, and they reveal their sensitivity by varying their viscosity. To understand how pollution interacts with chemical compounds and particles naturally present in our atmosphere, scientists are looking at the fundamental properties of these materials. When the two mix in the atmosphere, new compounds called "secondary organic material" are born. Their complex interactions and impact on the climate are some of the toughest to model and predict. Determining their basic properties is necessary to accurately model them. In this study, scientists looked at the viscosity of these particles which may limit or encourage the particles to grow in the atmosphere.

"Using PNNL's continuous-flow environmental chamber, we were able to generate representative particles in the laboratory and study them under controlled environmental conditions," said Dr. John Shilling, PNNL atmospheric scientist and co-author of the study. "This data increased our understanding about the basic physical properties of organic particles and will help us understand how they form and grow in the atmosphere. This new knowledge will lead to improvement in model predictions of air quality, visibility, and climate."

The research team produced secondary organic material (SOM) in two laboratory environmental chambers, one of which is located at PNNL. They produced the SOM using dark ozonolysis of a-pinene, an organic volatile compound that is naturally released by pine trees. They collected the SOM on filters and extracted the water-soluble component. This component was nebulized to form supermicron particles which they placed on a hydrophobic glass slide and put into a temperature and humidity controlled cell. The researchers used two new techniques called Bead-mobility and Poke-flow to measure the viscosity of the particles. Bead-mobility involved observing the movement of glass beads sprayed onto the particles. Poke-flow involved poking the particles with a needle and monitoring their shape following the withdrawal of the needle.

Their data, combined with recent modeling studies or simple calculations, showed the following: 1) the growth of SOM by the exchange of organic molecules between gas and particle may be confined to the surface region of the particles for relative humidity ≤ 30 percent; 2) at ≤ 30 percent relative humidity, the particle-mass concentrations of semi-volatile and low-volatility organic compounds may be over-predicted in models by an order of magnitude if instantaneous equilibrium partitioning is assumed by the model in the bulk of SOM particles; and 3) the net uptake rates of semi-reactive atmospheric oxidants such as ozone decrease by two to five orders of magnitude for a drop in relative humidity from 90 to 30 percent.

Scientists plan to study particles produced from a wider variety of parent hydrocarbons. They will also study the viscosity of the entire organic particle mass, rather than just the water-soluble fraction employed in the present study.

More information: Renbaum-Wolff, L. et al. 2013. "Viscosity of α-pinene secondary organic material and implications for particle growth and reactivity." *Proceedings of the National Academy of Sciences*, April 25, 2013. DOI:10.1073/pnas.1219548110

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