Pollution Hitches Ride to Arctic

Research Highlight

Toxic pollutants, known as polycyclic aromatic hydrocarbons, or PAHs, regulated by environmental agencies and produced by fossil fuel and biomass burning, reach all the way to the Arctic, even though they should decay long before they travel that far. Now, ASR scientists explain how pollution makes its lofty journey. The team found that atmospherically abundant, carbon-based secondary organic aerosols, or SOAs, allow toxic pollution to tuck inside, providing a vehicle for the pollution's journey to the Arctic. In a one-two punch, the research shows that the PAHs and the SOAs last longer when the pollutants hitch a ride. The study was published in Environmental Science & Technology.

Numerous predictions are based on the assumption that the particles are like liquid spheres, whose fluidity allows PAHs to escape. But they don't escape, and one recent advance has helped to pin down why PAHs are remaining stuck in their particle lairs. Zelenyuk and her colleagues at EMSL developed an ultra-sensitive instrument that can determine the size, composition, phase, shape, and evaporation kinetics of individual particles.

Called SPLAT II, the instrument can analyze millions of tiny particles one by one. The ability of this novel instrument to simultaneously characterize multiple properties of individual particles provides unique insight into their properties and evolution.

Using SPLAT II to evaluate laboratory-generated SOA particles from alpha-pinene, the molecule that gives pine trees their piney smell, Zelenyuk has already discovered that SOA particles aren't liquid at all. Her team's recent work revealed they are more like tar, viscous nano-blobs that are too solid to be liquid and too liquid to be solid.

Armed with these data, Zelenyuk and researchers from Imre Consulting in Richland and the University of Washington in Seattle set out to determine the relation between the SOA particles and the PAHs. They used alpha-pinene for the SOA and several different PAHs, including pyrene, a toxic pollutant produced by fossil fuels or biomass burning.

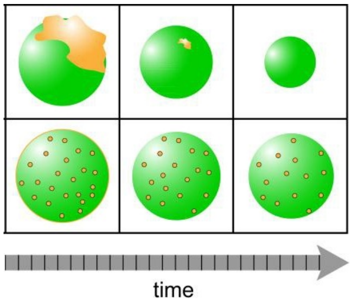
They created two kinds of particles. First, they produced the "classical SOA" particles with alpha-pinene and then coated them with pyrene. The second kind resembled what likely happens in nature: they mixed alpha-pinene and pyrene vapors and let the particles form with both molecules present. Then they sent the particles through SPLAT II and watched what happened to them over time.

With the pyrene-coated particles, the team found the pyrene evaporating off the surface of the particle quickly, all of it gone after four hours. By the next day, the particle itself had shrunk by about 70 percent, showing that the alpha-pinene SOA also evaporates, although more slowly than pyrene.

When they created the SOA particles in the presence of PAH, the PAH was incorporated into the particles, from where it evaporated much more slowly. Fifty percent of the original PAH still remained in the particle after 24 hours. In addition, the SOA particle itself lost less than 20 percent of its volume.

These results showed the team that PAHs become trapped within the highly viscous SOA particles, where they remain protected from the environment. The team discovered the surprising symbiotic relationship between the atmospheric particles and pollutants: SOAs help PAHs travel the world, and the PAHs help SOAs survive longer.

Zelenyuk and her colleagues performed comparable experiments with other PAHs and SOAs and found similar results.



When airborne particles (green) form before pollutants known as PAHs (yellow) glob on, the pollutants dissipate quickly, as shown in the top row. But when the particles form in the presence of pollutants, which is what likely happens in nature, the long-lasting particles can take the pollutants for a long-distance ride (bottom).

In the real world, Zelenyuk said, the evaporation will be even slower. These results will help modelers better simulate atmospheric SOA particles and transport of pollutants over long distances.

For decades, scientists have been trying to explain how atmospheric particles manage to carry harmful pollutants to pristine environments thousands of miles away from their starting point. The particles collected in areas such as the Arctic show significantly higher concentrations of pollutants than scientists' computer models predict. The results of this study will help scientists understand how pollution is transported over long distances and will help improve air-quality and particle transport models.

Reference(s)

Zelenyuk A, D Imre, J Beranek, J Wilson, and M Shrivastava. 2012. "Synergy between secondary organic aerosols and long-range transport of polycyclic aromatic hydrocarbons." Environmental Science & Technology, 46(22), doi:10.1021/es302743z.

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Aerosol Life Cycle