
environmentalresearchweb

NEWS

Jan 20, 2010

Aerosol breakthrough reveals role of organics

Aerosols play an important role in climate change, both by absorbing or reflecting radiation themselves and by affecting the formation of clouds. The particles can be emitted directly or form from chemical reactions between gaseous pollutants. In this latter case, researchers have found it hard to simulate the formation of real-life aerosol particles in the laboratory. Now a team from Switzerland, The Netherlands, Finland and the UK has made a breakthrough by achieving realistic particle formation rates from sulphuric acid and an organic species inside a smog chamber.



(http://images.iop.org/objects/erw/news/5/1/28/Baltensperger_Dommen_smogchamber2.jpg)

Clearing the smog

(http://images.iop.org/objects/erw/news/5/1/28/Baltensperger_Dommen_smogchamber2.jpg)

"We expect our findings to trigger a change in paradigm in the analysis of nucleation [particle formation] events in the ambient atmosphere," Urs Baltensperger of the Paul Scherrer Institute told **environmentalresearchweb**. "We suggest that in most nucleation events in the boundary layer and lower free troposphere both sulphuric acid and organic molecules participate in the nucleation process. As a significant fraction of the particles that grow to cloud condensation nuclei are formed by such homogeneous nucleation rather than direct emission of the particles, these mechanisms may have an impact on cloud properties, and thus on climate."

Baltensperger says that the team started this investigation because of the puzzling discrepancy in the results of nucleation research in the lab and the field. "Much higher concentrations of sulphuric acids are needed in the lab than in the field until a nucleation of new particles is seen," he explained.

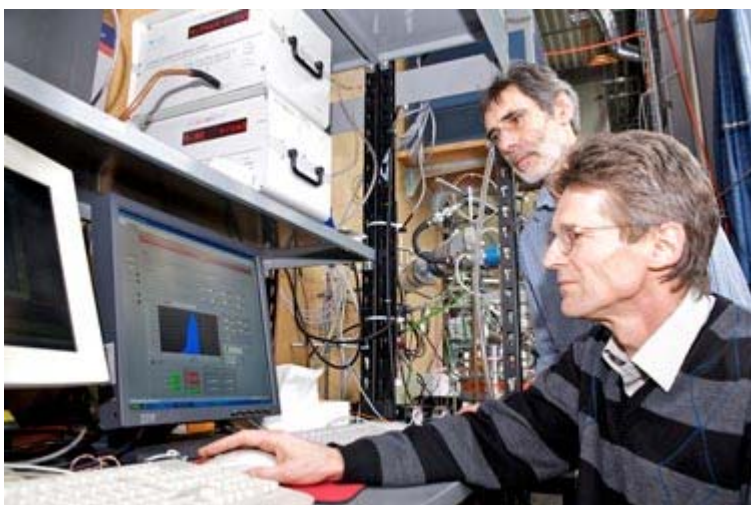
Laboratory and field conditions also gave different slopes for the nucleation rate versus the sulphuric acid concentration. "This resulted in the dilemma that in the lab at least about five sulphuric acid molecules are needed to form a critical cluster, while in the ambient atmosphere two sulphuric acid molecules are sufficient," said Baltensperger.

Baltensperger and colleagues' breakthrough was to trigger nucleation in the laboratory at concentrations of sulphuric acid that correspond to results from the real atmosphere. At first sight, according to the team, the results indicated that the critical cluster needed two sulphuric acid molecules, a finding that has been reported for many nucleation analyses in the ambient atmosphere.

"However, by varying the ratio of the concentration of sulphuric acid and of organics we could show that organics play an important role as well," he said. "At a higher concentration of organics, a lower sulphuric acid concentration is needed for the same nucleation rate. A detailed analysis then yields the surprising result that the critical cluster contains only one sulphuric acid molecule but also a co-nucleating organic molecule."

Baltensperger reckons it appeared that two sulphuric acid molecules were needed because sulphuric acid and this type of organic molecule have the same sources and sinks – the reaction of a precursor gas with the OH radical, and condensation to any surface, respectively.

The team conducted their photooxidation experiments in a 27 cubic metre environmental chamber at the Paul Scherrer Institute, using various mixing ratios of SO₂, NO_x, and 1,3,5-trimethylbenzene (TMB), an organic compound known to act as a precursor for the formation of secondary organic aerosol particles. Irradiation of the chamber produced OH radicals which in turn oxidized SO₂



(http://images.iop.org/objects/erw/news/5/1/28/Baltensperger_Dommen_PC.jpg)

Particle screening (http://images.iop.org/objects/erw/news/5/1/28/Baltensperger_Dommen_PC.jpg)

Out in the field, it's likely that volatile organic compounds such as monoterpenes or sesquiterpenes would be involved, rather than TMB. But these chemicals break down to similar functional groups to TMB.

Using the details of the researchers' findings in the three-dimensional chemical transport model GLOMAP gave a good match to field measurements. The new nucleation mechanism involving organics replicated the vertical distribution of particle numbers observed by aircraft, producing the typical Z-shaped profile often seen over continents. Employing other "traditional" mechanisms in models tends to overpredict the numbers of aerosol particles in the free troposphere, at 2–8 km.

Similarly, using the traditional mechanisms generally indicates substantial nucleation of particles over ocean regions where there are ship emissions of SO₂ or natural emissions of DMS (dimethyl sulphide). But this is not seen in the field. The Baltensperger team's new organic activation mechanism, in contrast, reproduces the general lack of nucleation in oceanic regions, due to a low concentration of organics.

Now the researchers plan to repeat the experiments with additional instrumentation, by inviting new groups to join in. Plans include measuring the sulphuric acid concentration, and particle concentrations at smaller diameters, as well as learning as much as possible about the chemistry of the clusters that are present. "In addition, we want to extend the experiments to other precursor gases than the one used so far (trimethylbenzene)," said Baltensperger. "In general, our further activities in this field have two major goals, i.e. to learn more about the process by added instrumentation, and to generalize our findings in order to test their global applicability."

The researchers, from the Paul Scherrer Institute, Switzerland, Energy Research Centre of the Netherlands, University of Helsinki, Finland, and University of Leeds, UK, reported their work in **PNAS**.

About the author

Liz Kalaugher is editor of environmentalresearchweb.