

# On Balance

## New approach improves ability of environmental chemists to characterize atmospheric aerosols

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### PROBLEM

A detailed understanding of the sources, transformations and fates of aerosols — suspended atmospheric particles smaller than 1 micron — is crucial because they are a primary source of uncertainty in climate change projections and a principal health hazard to urban populations. About 50 percent of atmospheric aerosol mass consists of organic compounds emitted from both natural and anthropogenic sources. In the atmosphere, particulate organics can evolve through oxidation into secondary aerosols of large compounds, creating an atmospheric soup of such immense chemical complexity that the particles cannot be fully characterized using standard analytical methods. As a result, aerosols are generally described in terms of average properties, affording little insight into their chemical composition or atmospheric transformations.

### APPROACH

Oxidation occurs as airborne organic carbon undergoes chemical transformations over the several days to weeks it remains in the atmosphere. In order to estimate the atmospheric history of these particles, environmental chemists often use metrics such as the elemental ratio of oxygen to carbon. But such metrics tend to be approximate only, leaving a large gap in our ability to monitor atmospheric transformations. Professor [Jesse Kroll \(http://cee.mit.edu/kroll\)](http://cee.mit.edu/kroll), graduate student Sean Kessler and colleagues describe a new method for characterizing organic aerosol in terms of a single, unambiguous metric for atmospheric oxidation. They propose using a compound's average carbon oxidation state (which is related to the electron density associated with the carbon atoms), a quantity that necessarily increases the longer an aerosol stays in the atmosphere and that can be determined from elemental ratios. When coupled with the number of carbon atoms in the compound, this measurement makes it possible for scientists to identify different classes of organic aerosol and oxidative transformations to gain insight into key features of atmospheric organic chemistry.

### FINDINGS

Using commercially available analytical technologies, the team calculated carbon oxidation state and carbon number of organic aerosols from existing measurements taken in a range of environments representative of oxidative evolution: primary aerosol in urban areas, secondary aerosol found in rural areas, and aged aerosols in remote areas. They also carried out laboratory studies on the oxidative evolution of organic aerosol. The field and laboratory measurements confirmed that the formation and evolution of organic aerosol involves simultaneous increases in carbon oxidation state and decreases in carbon number. These measurements provide a new methodology for describing and characterizing atmospheric aerosols in a way that simplifies the immense complexity of organic particles while still accurately capturing their fundamental chemical properties.

### IMPACT

The general concept of carbon oxidation state has been used primarily as a teaching tool and in a few environmental chemistry contexts, such as soil chemistry. But this is the first study that shows it can be used to describe the evolving composition of a complex mixture of atmospheric organics undergoing dynamic oxidation processes. This novel methodology creates a new paradigm for environmental chemists, making it possible for them to characterize particles in the atmosphere and use readily available measurements to simplify descriptive and predictive models of the oxidative process of organic carbon. This, in turn, could begin to transform our collective understanding of atmospheric organics, which directly influence human health and global climate through the degradation of pollutants, the production of ozone and other toxic species, and cloud formation.

**MORE**

A paper describing this work appeared in [Nature Chemistry online](http://www.nature.com/nchem/journal/vaop/ncurrent/full/nchem.948.html) (<http://www.nature.com/nchem/journal/vaop/ncurrent/full/nchem.948.html>) Jan. 9.

*Points are colored by the logarithm of the number of possible compounds at a given oxidation state and carbon number, assuming a fairly simple chemical complexity. Figure / Jesse Kroll*

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