New, rapid mechanism for atmospheric particle formation

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Carnegie Mellon University researchers working with an international team of scientists have discovered a previously unknown mechanism that allows atmospheric particles to very rapidly form under certain conditions. The research, which was published in the journal *Nature*, could aid efforts to model climate change and reduce particle pollution in cities.

"The only real uncertainties in our understanding of climate in the atmosphere have to do with fine particles and clouds, how these have changed over time and how they will respond to climate change," said Neil Donahue, Thomas Lord University Professor of Chemistry and a professor in the departments of Chemical Engineering, and Engineering and Public Policy.

The number of particles in the atmosphere at any given time can have major effects locally and globally, including contributing to unhealthy smog in cities and influencing the Earth's climate. However, particles need to reach a certain size—around 100 nanometers in diameter—to contribute to those effects, Donahue noted.

If particles don't reach that size, they quickly get subsumed into other, larger particles. This means that one would expect few new particles to be created in polluted urban environments where the air is already full of larger particles that could gobble up small, new particles. Yet new particle formation is relatively common in those environments, as plainly seen when haze reforms rapidly after rainfall in cities around the world.

Donahue thinks the answer to that mystery may lie in this new research. "We found a new way for tiny nucleated particles in the atmosphere to grow up quickly to become large enough to affect climate and health," he said.

Donahue's lab group has long been part of the CLOUD experiment, an international collaboration of scientists that use a special chamber at CERN in Switzerland to study how cosmic rays affect the formation of particles and clouds in the atmosphere. The chamber allows researchers to precisely mix vaporous compounds and observe how particles form and grow from them.

In this study, designed by Carnegie Mellon chemistry doctoral candidate

Mingyi Wang, the CLOUD team condensed nitric acid and ammonia vapors across a wide range of temperatures and found that the resulting new particles can grow 10 to 100 times faster than previously observed, allowing them to reach sizes large enough to avoid being consumed by other particles. The compound formed from those two vapors, ammonium nitrate (a common fertilizer), was previously known to be a contributor to atmospheric pollution within larger particles, but its role in helping tiny particles grow was not known.

"This may help explain how nucleated particles grow up in polluted urban conditions in mega-cities, which has been a big puzzle, as well as how they form in the upper parts of the atmosphere, where they can have a strong climate effect," Donahue explained. The team is now working to study how this mechanism plays out in Earth's upper atmosphere.

For Wang, who served as co-leader of the study, this research has roots in his keen desire to understand air pollution. After an undergraduate research project where he got to sample and analyze PM2.5, Wang decided to continue in this field of research to better explore how these small particles can have such a big impact on the planet and how that impact could be remedied.

"I realized that those atmospheric particulate matters have never been a simple air quality problem that only Asia needs to deal with," Wang said. "Rather, they are a global challenge due to their health and climate effects."

More information: Rapid growth of new atmospheric particles by nitric acid and ammonia condensation, *Nature* (2020). DOI: 10.1038/s41586-020-2270-4 ,
www.nature.com/articles/s41586-020-2270-4