Chemist Discovers the Elusive Chemical Middleman That Removes Acid Rain

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(PhysOrg.com) -- Researchers have discovered the middleman in the complex chemical reaction that is essential to the atmosphere's ability to break down pollutants, especially the compounds that cause acid rain. The study improves the basic understanding of the chemical removal of acid rain and will allow scientists to better model how pollutants are removed from the atmosphere and to predict potential environmental conditions.

The first identification of $OH\text{-}HONO_2$ within this chemical reaction was performed by Marsha Lester, chair of the Department of Chemistry in the School of Arts and Sciences at the University of Pennsylvania and Joseph Francisco, professor of chemistry at Purdue University.

The molecule, speculated as the possible middleman, has eluded detection by scientists for more than 40 years. The breakthrough was provided by an improved experimental methodology that used direct spectroscopic characterization of the chemical, like an infrared fingerprint; this was the first time researchers employed a technique sensitive enough to observe the presence of the chemical. Complementary theoretical calculations performed with supercomputers validated the spectral signature of this novel molecule.

The paper, published in a special edition of the *Proceedings of the National Academy of Science*, showed for the first time all the steps the Earth’s atmosphere takes in oxidizing pollutants, akin to the human body’s ability to metabolize food.

"We've speculated about this unusual atmospheric species for many years, and then to actually see it and learn about its properties was very exciting," said Lester.

"The chemical details of how the atmosphere removes nitric acid have not been clear," Francisco says. "This gives us important insights into this process. Without that knowledge we really can't understand the conditions under which nitric acid is removed from the atmosphere."

An unusual aspect of the molecule helped it escape detection by scientists. The reaction involving this molecule proceeds faster as you go to lower temperatures, which is the opposite of most chemical reactions," said Lester. "The rate of reaction also changes depending on the atmospheric pressure, and most reactions don't depend on external pressure. The molecule also exhibits unusual quantum properties."

What makes the molecule of interest to basic chemistry as well as an understanding of the environment is its two hydrogen bonds. The two bonds enable the molecule to form a six-sided ring structure. Normally weaker than covalent bonds, the two hydrogen bonds are strong enough to affect atmospheric chemistry. These bonds may tell science more about biological systems that depend on hydrogen bonds.

Provided by University of Pennsylvania

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