Combination of pine scent and ozone as super source of particulate emissions

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Scientists have managed to figure out why conifer forests produce so many fine particles into the atmosphere. Aerosol particles are particularly abundant when α-pinene, the molecule responsible for the characteristic pattern of pine trees reacts with atmospheric ozone.

Atmospheric aerosol particles affect the Earth's climate by forming clouds, but at the same time they also pollute the air, thereby increasing

mortality.

Aerosol particles in the atmosphere have their origins in many sources. The significant amount of aerosol particles in the atmosphere is caused by the oxidation of hydrocarbon molecules produced by trees and other plants. One of the most important hydrocarbons forming particles is α-pinene, that is, the molecule that causes the characteristic smell of pine trees.

"Especially efficiently aerosols are produced when α-pinene reacts with ozone, which in turn smells 'like electricity,'" explains Theo Kurtén, university lecturer in Department of Chemistry at the University of Helsinki.

The chemical details of this particle formation have been studied for decades, but only recently research groups at Tampere University, the University of Helsinki, and the University of Washington (in Seattle, USA) have established the blueprints for the conversion of α-pinene into products that lead to aerosol. They managed to solve the problem by using a combination of modeling based on quantum mechanics and targeted mass spectrometric experiments.

"The key issue, unaccounted for in previous studies, is the vast excess energy released in the initial reaction of ozone with the α-pinene molecule. Our research reveals how this energy can break certain chemical bonds inside the α-pinene molecule, which would otherwise slow down the formation of aerosol-forming products to the point of irrelevance. In contrast, the reaction mechanism discovered by us allows these products to form within less than one second," says Siddharth Iyer, postdoctoral researcher in Aerosol Physics Laboratory at Tampere University.

"This is an extremely important finding for aerosol scientists as we are

finally able to bridge the gap between theory and observation concerning the formation of aerosols from hydrocarbons emitted by trees," adds Matti Rissanen, assistant professor in Experimental Aerosol Science at Tampere University.

The study helps demystify some of the complexity of atmospheric reactions in the aerosol context. It also provides a methodological framework for studying other similar reactions where excess energy can lead to hitherto unexplored reaction channels.

The research has been published in *Nature Communications*.

More information: Siddharth Iyer et al, Molecular mechanism for rapid autoxidation in α-pinene ozonolysis, *Nature Communications* (2021). DOI: 10.1038/s41467-021-21172-w

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