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Investigating Atmospheric Heterogeneous Reactions with X-ray Computed Tomography

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Abstract

Many fields including physics, chemistry, materials science, and engineering, use X-ray-based analytics on a regular basis. However, the full potential of such procedures in the biological sciences and medicine has yet to be realised. In the natural snowfall, chemical and physical processes like as heterogeneous chemical reactions, light scattering, and metamorphism occur. The specific surface area (SSA) is an important metric to consider when modelling these processes in the snowpack. In the atmosphere, heterogeneous reactions on the surface of aerosol particles play an essential role in air pollution, climate change, and global biogeochemical cycles. However, published absorption coefficients of heterogeneous reactions can vary widely and may not be representative of real-world air circumstances. One of the main reasons for this is that laboratory research employs bulk samples, whereas particles in the atmosphere are suspended individually. A number of technologies have recently been developed to examine heterogeneous reactions on individual particle surfaces. Calculating the uptake coefficient, quantifying reactants and products, and better understanding the reaction mechanism all require precise measurements on the reactive surface area, volume, and shape of individual particles.

Keywords: Computed Tomography, Heterogeneous Reactions, X-ray.

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Introduction

X-ray computed tomography, also known as X-ray tomography, is a technique for creating three-dimensional imaged volumes from two-dimensional X-ray image slices. X-ray imaging is a type of medical imaging that uses the differential absorption or scattering of an X-ray source to expose the interior characteristics of a structure or specimen. The capacity of X-ray radiation to permeate objects is used in X-ray tomography. A portion of the impinging radiation is absorbed when it passes through an item [1]. The longer the object's radiographic length, the less radiation is emitted from the opposing side. In the context of tropospheric ozone chemistry, the heterogeneous interactions of HO2 radicals and nitrogenous chemicals on aerosols have been investigated. The uptake of air molecules on solid and liquid surfaces, heterogeneous reactions on the surface, bulk reactions in the aqueous phase, and other factors are all involved in these processes. The reaction of solid metals with acids, iron corrosion, and the electrochemical reaction in batteries and electrolytic cells are all examples of heterogeneous reactions. While many biogenic and anthropogenic organic compounds in the atmosphere are surface-active and chiral, stereochemistry's function in heterogeneous oxidation chemistry has yet to be determined [2]. In the atmosphere, heterogeneous reactions on the surface of aerosol particles play an essential role in air pollution, climate change, and global biogeochemical cycles. However, published absorption coefficients of heterogeneous reactions can vary widely and may not be representative of real-world air circumstances. One of the main reasons for this is that laboratory research employs bulk samples, whereas particles in the atmosphere are suspended individually. A number of technologies have recently been developed to examine heterogeneous reactions on individual particle surfaces. Calculating the uptake coefficient, quantifying reactants and products, and better understanding the reaction mechanism all require precise measurements on the reactive surface area, volume, and shape of individual particles [3]. Future study will continue to focus on deconstructing complicated systems into their core components and investigating real-time alterations to organic surfaces under exposure to a regulated flux of gas-phase oxidants, in addition to very practical field measurements and air sampling [4]. As a result, scientists will be able to investigate how critical variables like gas-surface polarity, molecule structure, and density influence the outcome of interfacial collisions separately. Insight into the fundamental elements of atmospheric heterogeneous processes will continue to be gained using modern computer tools. In silico modelling is made possible by the same experimental tools that allow laboratory researchers to explore specific components of complex atmospheric interactions. Model organic surfaces, such as self-assembled monolayers, have a uniform structure that allows for easy computational modelling using quantum/molecular mechanical hybrid models and molecular dynamics techniques, providing valuable theoretical insight into oxidative processes on both the molecular and surface nano-scales.

Conclusion

Researchers studying the impact of surface structure and functionality in the reactions of air oxidants (O3, NO3, and OH) are learning more about heterogeneous reactions and reaction kinetics using x-ray tomography. More will be discovered about the effects of this chemistry on organic particles and the balance of oxidative gas concentrations in the troposphere as research in this field progresses. Researchers will be able to make well-informed predictions about the destiny of organics in the atmosphere as well as the influence of these oxidants on the environment once they have this information.

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