Proteins as Ice Nucleating Particles: Effect of Molecule Size, Concentration, Aging and Aggregation

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Abstract

It is now understood that biological aerosols are important contributors to heterogenous nucleation and may even contribute most of the INP at temperatures above -20 C. However, "biological aerosol" is a grossly oversimplified description of the composition of this group of particles with a variety of types, sources, compositions and sizes with a similarly diverse range of nucleation temperatures. On a fundamental level, we lack an understanding of what physicochemical properties are root causes of ice nucleation ability. Beyond the chemical formula, our measurements suggest that the role of aggregation plays is a key role in the ice nucleation ability of certain proteins. Specifically, ice nucleation temperature of the protein RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase) occurs at temperatures as warm as -6.8 °C. The warmest nucleation events coincided with the formation of large aggregates with a hydrodynamic diameter of ~ 10^3 nm. Preliminary results show while many additional proteins, including cytochrome C, thyroglobulin, pyruvate kinase, alkaline phosphatase, lipase, and insulin also aggregate in solution, trends in aggregation and ice nucleation efficiency are not straightforward. Complications which can arise due to concentration effects or aging of the proteins in solution will be presented. This presentation will identify fundamental gaps in our knowledge of biological ice nucleation and present recent measurements designed to reduce those gaps.

Early Career Scientist

NO, I am not an early career scientist.

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