Technology Offer

Enhanced ice-nucleating compositions with extremly low INPs concentrations

File no.: MI0903-6307

We offer an innovative aqueous composition that promotes ice nucleation at high efficiencies, even at extremely low concentrations of ice-nucleating particles. This breakthrough is particularly relevant in the fields of agriculture, atmospheric science, and the biosphere, where the control over ice formation can significantly impact environmental dynamics and technological applications.

Background

Ice nucleation is a critical physical process where ice forms from supercooled water. Although water freezes at 0 °C under ideal conditions, the absence of nucleating agents can allow it to remain in a liquid state down to -38 °C. Biological entities, especially certain bacteria like Pseudomonas syringae, have been identified as highly efficient ice nucleators due to specific proteins anchored to their outer membrane. These ice-nucleating proteins (INPs) facilitate ice formation at temperatures much higher than would be possible in their absence, with implications for natural processes and industrial applications, such as artificial snowmaking and food preservation.

Technology

The disclosed aqueous composition comprises three key components:

1. Ice-nucleating particles (INPs) at a concentration of 0.005 mg/ml or less, derived from bacteria, bacterial ghosts, or fragments thereof.
   These particles are capable of initiating ice formation.

2. A buffer system to maintain the solution's pH between 5 to 8,
   ensuring the stability and functionality of the INPs.

3. A polyfunctional compound like polyvinyl alcohol (PVA) featuring two or more functional groups (e.g., hydroxy, ether, carboxylic acid or carboxylate, carboxylic acid ester, amine, and amide groups).
   This compound plays a critical role in enhancing the ice-nucleation efficiency of the composition.

The novel compositions achieve remarkable ice-nucleation activity even at minimal concentrations (as low as 10-6 mg/mL) of ice-nucleating particles. We assume that polyfunctional compounds like PVA form a protective polymer layer on the membrane surface that reduces structural fluctuations and stabilizes intramolecular INP interactions leading to a higher amount of highly efficient class A ice nucleators originating from larger INP aggregates.

With the enhanced composition we are addressing a common challenge in the field: maintaining high ice-nucleation efficiency without the need for high concentrations of nucleating agents like Snomax®, which can be impractical or cause unwanted side effects in certain applications.

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de

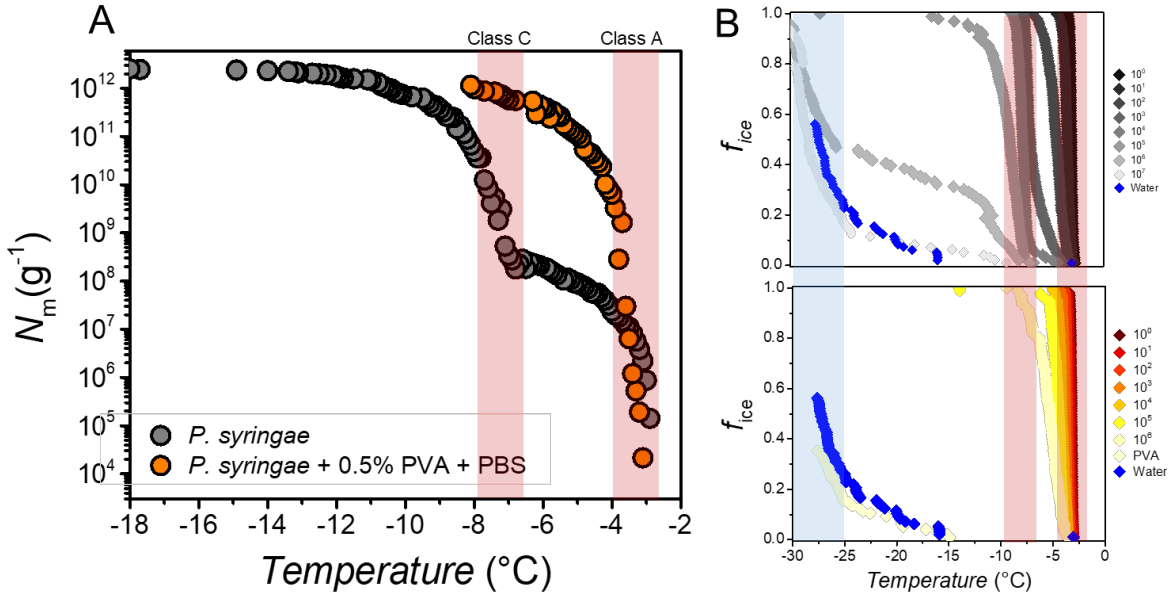

Figure 1: Freezing experiments with solutions of Snomax® in water and in the presence of 0.5 wt% polyvinyl alcohol in PBS buffer. (A) Cumulative number of ice nucleators per unit mass of sample (N_m) plotted against temperature. (B) Fraction of frozen droplets (f_{ice}) for different Snomax® dilutions. Symbol colors indicate data from droplets with different concentrations and are identical to the plots shown in A. The temperature range for class A and C INs are shaded in red. The blue-shaded region presents the temperature range in which pure water freezes in our system.

The innovative composition finds utility in various applications, including but not limited to:

- Artificial snow production for recreational and environmental management purposes.
- Food processing, where controlled ice formation can impact the texture and preservation of food products.
- Cryopreservation techniques for biological samples, where ice formation can be both a tool and a challenge.
- Cloud seeding, with potential implications for weather modification and the study of atmospheric processes.

The composition's ability to function effectively at low concentrations of INPs reduces the material and ecological footprint of ice-nucleation technologies. Furthermore, the flexibility in the choice of polyfunctional compounds allows for the tailoring of the composition to specific applications, enhancing its utility and effectiveness.

Literature

M. Lukas, R. Schwidetzky, R. J. Eufemio, M. Bonn, K. Meister: "Toward Understanding Bacterial Ice Nucleation", J. Phys. Chem. B 2022, 126, 1861−1867

Patent Information

EP4278895A1 filed May 16th 2022

Contact

Dr. Lars Cuypers
Senior Patent- & License Manager
Chemist
Phone: +49 (0)89 / 29 09 19 - 21
eMail: cuypers@max-planck-innovation.de

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de