Investigating Ice Nucleation Activity of Arizona Test Dust

Samantha M. Gillette[1], Russell J. Perkins[2], Thomas C. Hill[2], Paul J. DeMott[2], Sonia M. Kreidenweis[2]

[1]Portland State University, Portland, OR. [2]Colorado State University, Fort Collins, CO.

Motivation

Ice formation is essential to:

- Precipitation processes
- Earth's freshwater distribution
- The absorption and reflectivity of clouds

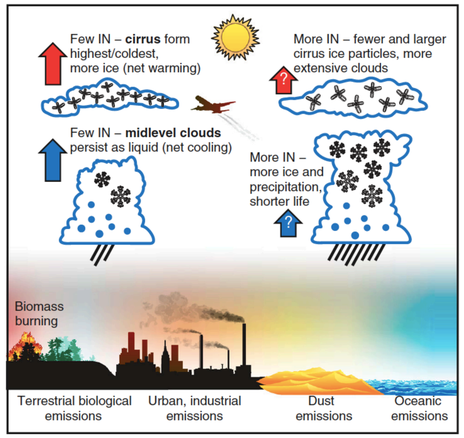


Fig 1: DeMott *et al.*, 2010.

- Homogenous freezing of water droplets does not occur until about -38ºC.
- Ice nucleating particles (INPs) allow water droplets to freeze at higher temperatures.
- Mineral dusts are one variety of INP, for which Arizona test dust (ATD), is a proxy.
- This study explored the effects of weathering processes on ATD.

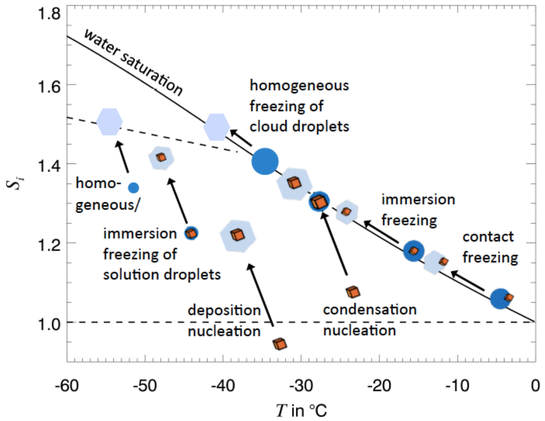
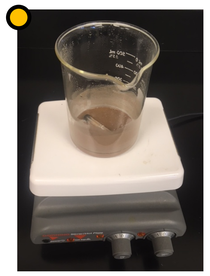


Fig 2: Hoose and Möhler, 2012.

Conclusions

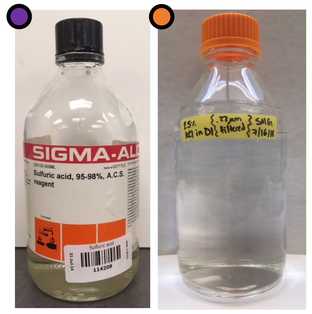
- The ice nucleation activity of ATD is reduced by even mildly acidic conditions, the presence of Na^+ ions, exposure to heat, and hydrogen peroxide digestion of organic matter.
- ATD is a real soil, which has been processed, and therefore, may have significant departures from a normal soil.
- Although the consistency of ATD makes it a desirable standard across laboratories, these studies indicate a complex ice nucleation activity partially controlled by organic components.

Methods



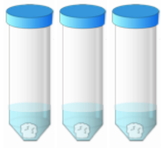
Treatments:

- H_2O_2 Digestion
- Heated at 600ºC for 4 hours in a furnace
- 2.5% Salt Solution
  - KCl
  - NaCl
- Acidic Conditions
  - 314 mM, 126 mM, and 63 mM HNO_3

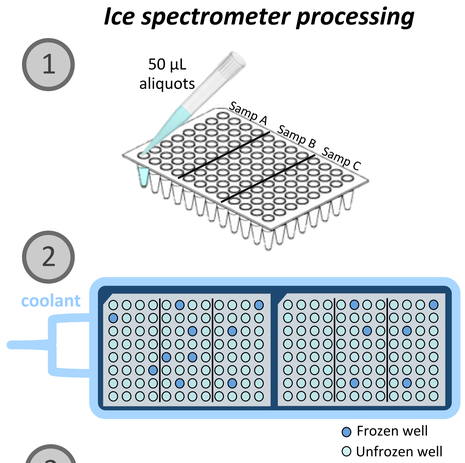


Mixtures were left to sit one to three days.

A series of three 20-fold dilutions were made of each treated ATD mixture and pipetted into trays.

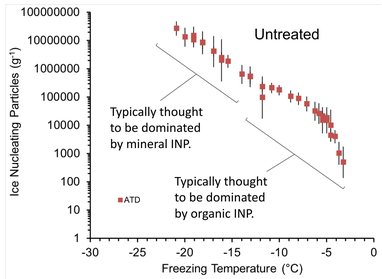


Ice spectrometer processing



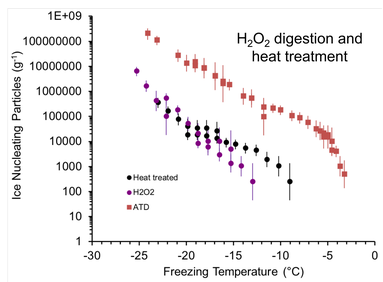
1. 50 µL aliquots of sample suspensions were dispensed into wells of two PCR trays
2. PCR trays are placed into two aluminum blocks in the ice spectrometer
3. The IS temperature is lowered from 0 to -27 °C and the number of frozen wells are recorded

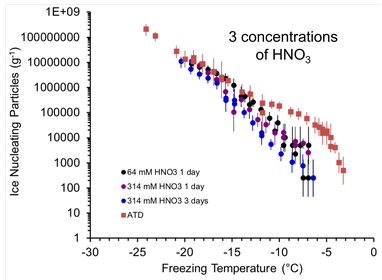
Results



"Burning"

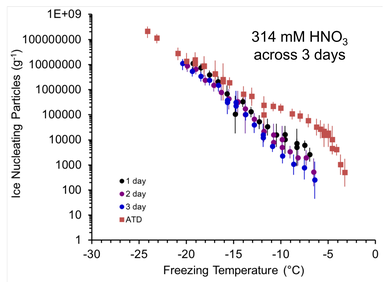
H_2O_2 digestion of organic matter mimics atmospheric oxidation. This, and heat treatment, suggest that ATD INPs are largely organic and susceptible to being oxidized.

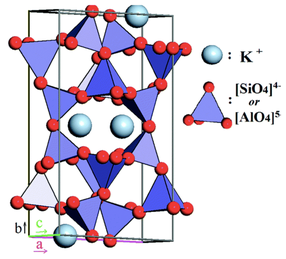




Acidic Conditions

Acidic conditions mimic processes in polluted regions. ATD's INP activity degrades in proportion to concentration and duration of exposure.





Ionic Solutions

ATD contains K-feldspar, which has a high ice nucleation activity dependent upon its K^+ ions. Displacement of the K^+ ions with Na^+ significantly reduces activity, analogous to processes in ionic cloud droplets.

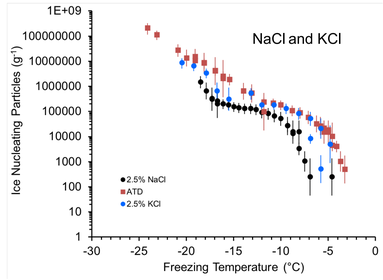


Fig 3: adapted from Richardson.

References

[1]DeMott, P., *et al*. 2010. *PNAS*, 107, 11217-22. [2]Hoose, C. and Möhler, O. 2012. *Atmospheric Chem. And Phys, 12, 9817-54*. [3]Richardson, J. *Introduction to Geology*, Retrieved from: https://opentextbc.ca/introductiontogeology.

Acknowledgements

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