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Heterogeneous freezing of water and dilute salt solutions on unaltered and ion exchanged mica surfaces.

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Water freezes homogeneously at about -34ºC. If the water contains foreign particles, it typically freezes heterogeneously at higher temperatures. These foreign surfaces, called ice nucleating particles, are thought to act as a template for the nascent ice. In the case of mineral surfaces, surface ions play a crucial role in templating the water molecules.

To understand the effect of surface ions on freezing of water and other aqueous solutions, we have chosen muscovite micas a model substrate. Muscovite mica is a layered aluminosilicate, containing K^+ ions to balance the negative charge between the adjacent layers. One advantage mica offers, that it is nearly atomically smooth when cleaved' another advantage is that the K^+ ions can be readily exchanged for other ions. We have investigated freezing of pure water and selected solutions on freshly cleaved mica, which we call K^+-mica, as well as H^+, $Mg^{2+,}$ and Ca^{2+}-mica. (X^+ indicates the ion that has been exchanged with potassium through a suitable surface treatment). We observed repeated freezing events ($\sim$10) of a single drop of water or solution (NaCl and $(NH_4)_2SO_4$), then repeat the experiment with a different sheet of the mica.

From these experiments, we calculate the heterogeneous freezing rate coefficient. We find that Mg^{2+}-mica has significantly higher freezing rate than K^+-mica. When the mica is treated to substitute another bivalent ion, Ca^{2+}, the freezing rate coefficientis also higher than the K^+-mica but lower than Mg^{2+}-mica. Freezing rates on K^+-mica and H^+-mica are comparable. We also observed that the dilute solutions (0.015M NaCl, 0.015M $(NH_4)_2SO_4$) do not affect the freezing rate significantly on K^+-mica, but on Mg^{2+}-mica, a 0.015M $(NH_4)_2SO_4$ solution deactivates the ice nucleating ability. Combining the experimental results with simulations on similarly treated mica surfaces allows us to understand the influence of local electric fields and stearic hindrance on the structure of water near surfaces in more detail.