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Deposition Nucleation or Pore Condensation and Freezing?

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Ice nucleation plays an important role in moderating Earth's climate and precipitation formation. Over the last century of research, several mechanisms for the nucleation of ice have been identified. Of the known mechanisms for ice nucleation, only deposition nucleation occurs below water saturation. Deposition nucleation is defined as the formation of ice from supersaturated water vapor on an insoluble particle without the prior formation of liquid. However, recent work has found that the efficiency of so-called deposition nucleation shows a dependence on the homogeneous freezing temperature of water even though no liquid phase is presumed to be present. Additionally, the ability of certain particles to nucleate ice more efficiently after being pre-cooled (pre-activation) raises questions on the true mechanism when ice nucleation occurs below water saturation. In an attempt to explain the dependence of the efficiency of so-called deposition nucleation on the onset of homogeneous freezing of liquid water, pore condensation and freezing has been proposed. Pore condensation and freezing suggests that the liquid phase can exist under sub-saturated conditions with respect to liquid in narrow confinements or pores due to the inverse Kelvin effect. Once the liquid-phase condenses, it is capable of nucleating ice either homogeneously or heterogeneously. The role of pore condensation and freezing is assessed in the Zurich Ice Nucleation Chamber, a continuous flow diffusion chamber, using spherical nonporous and mesoporous silica particles. The mesoporous silica particles have a well-defined particle size range of 400 to 600nm with discreet pore sizes of 2.5, 2.8, 3.5 and 3.8nm. Experiments conducted between 218K and 238K show that so-called deposition nucleation only occurs below the homogenous freezing temperature of water and is highly dependent on the presence of pores and their size. The results strongly support pore condensation and freezing, questioning the role of deposition nucleation as an ice nucleation pathway.