Immersion freezing by plant nano crystalline cellulose and plant phytolith particles

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Homogenous Ice nucleation in clouds occurs below -38 °C or heterogeneously at warmer temperatures due to the presence of a foreign particle (ice nuclei (IN)) that facilitates the nucleation process. Only a small subset of the atmospheric particles induce ice formation, among them are mineral dust, volcanic ash and biological particles. Recently, biological particles such as bacteria, pollen and fungal spores, received a lot of the attention as their high ice nucleation abilities were found in parallel to their presence in ice crystals residuals. Moreover, natural cellulose (β(1→4) linked D-glucose units), a fundamental component of biological cell wall, was found to be prevalent in the atmosphere and in a recent study it was shown that microcellulose particles have the ability to facilitate ice nucleation.

Plant opal phytoliths (POP) form in tissues of living plants during their growth, and can be found in soils following plants decay. Several measurements have identified these micro-sized particles in the atmosphere. They are mostly hydrated silica ($SiO_2 \cdot nH_2O$), but they can also contain other trace elements. POP can be released to the atmosphere during biomass burning or to be elevated by winds from the ground. These particles are very resistant towards atmospheric processing. Cellulose has been detected in atmospheric samples. Nano crystalline cellulose (NCC) particles are also assumed to be found in the atmosphere. If so, they may have longer lifetime compared to large cellulose particles and may be transported to greater distances and to higher altitudes. Hence they are more likely to be found in clouds droplets than the microcellulose particles.

In this study, we examined Nano crystalline cellulose and plant phytolith particles potential to nucleate ice heterogeneously by the immersion freezing mechanism. This mechanism is very important in mixed phase clouds. In this mechanism ice nucleation initiates on a surface of a particle immersed inside droplets. The study was performed in the newly introduced microfluidics WISDOM setup (**W**e**I**zmann **S**upercooled **D**roplets **O**bservation **on** **M**icroarray**)**. The particles were immersed in 100 micron droplets that were suspended in an oil phase using a new microfluidic device. An array containing the droplets is placed on a cooling stage and droplets are continuously monitored via CCD camera. The droplets are cooled in a rate of 1°CPM and freezing events are identified automatically by LabVIEW program. Nucleation parameters as INAS densities and heterogeneous freezing rates were then derived.

Our results indicate that both, NCC and POP particles can initiate ice formation in the immersion freezing mode. Freezing of NCC occurred below 255K and finished by 247K, and J_{het} rising steeply from 10^3 to 10^6 $m^{-2}s^{-1}$. Freezing of POP occurred between 251 and 246 and J_{het} ranged from 10^4 to 10^6 $m^{-2}s^{-1}$. In the talk, we will describe the experiments, new results and their atmospheric significance.

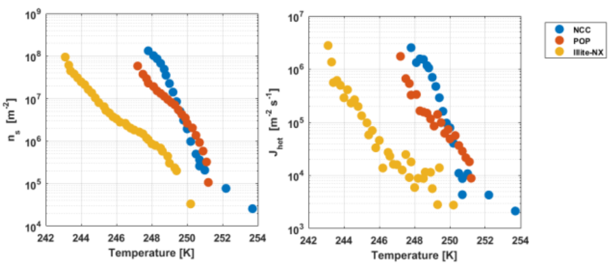

Figure 1. Immersion freezing ns(T) spectra and Jhet(T) (right) of NCC, POP and Illite-NX particles