Assessing the Importance of Contact Ice Nucleation

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The indirect effect of aerosols on global radiative forcing via its impact on cloud formation is one of the key unknown in climate change science today. Though our understanding of warm cloud formation is fair, our inability to fully understand and describe cold cloud formation is what limits us in determining and predicting future climate change. It is believed that deposition freezing and immersion freezing are important ice nucleation mechanisms. Less known is the mode called "contact freezing", which involves particles coming into contact with a water droplet to form an ice nuclei (IN). Some experimental studies have shown that the IN formation due to contact freezing was initiated at higher temperatures compared with immersion freezing. However, few experiments were performed using atmospherically relevant conditions and parameters.

We are in the process of constructing a laboratory-based experiment to assess the importance of ice nucleation via contact freezing. The system diagram is shown in Figure 1. The system consists of an injector which is designed to bring a water droplet (diameter~ 15-25 microns) into contact with aerosol particles (diameter ~ 100 nm – 1000 nm) at cold temperatures. The collision between the water droplet and the aerosol particle(s) may induce IN formation, and the potential IN will grow as it travels down a glass flow tube supersaturated with respect to ice. A Bruker Fourier Transform Infrared (FTIR) spectrometer will be used to monitor ice presence and water vapor partitioning in the flow tube at multiple positions and help determine the onset temperature of contact freezing. At the end of the flow tube, a counterflow virtual impactor (CVI) is affixed to reject aerosol particles and let through only the large particles, i.e. the IN. The flow containing the IN will be directed to the Particle Analysis by Laser Mass Spectrometry (PALMS) instrument which performs *in situ* chemical analysis of a single particle. In PALMS, two 532 nm YAG laser beams set at a distance apart are used to detect particles and provide sizing information via scattering. A 193 nm excimer laser beam is then triggered to ablate and ionize the particle. The ions are accelerated into a reflectron mass spectrometer and detected. The water droplets and aerosol particles sent into the system will have different chemical signatures, as identified by PALMS, can confirm that contact freezing is the cause of the IN formation.

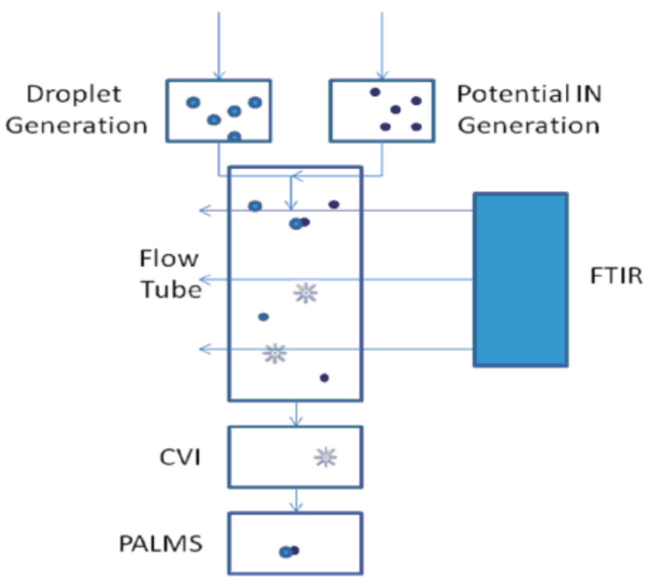

Figure 1. System diagram. Droplets and potential IN will be generated and equilibrated with the flow tube temperature before interacting. A Bruker FTIR spectrometer will be used to determine ice nucleation in multiple locations. A CVI will be used to separate ice crystals from unactivated aerosol particles and evaporated drop residue. The PALMS instrument will be used for ice residue analysis.