



## **Do coal fly ash particles nucleate ice by pore condensation and freezing mechanism?**

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Coal fly ash particles, which are by-products of coal combustion, can be injected into the atmosphere via different processes. These particles can influence cloud formation processes by acting as ice-nucleating particles (INPs). The underlying mechanism with which CFA nucleate ice is still unclear. One of the mechanisms observed for some aerosol particles that show high ice nucleation activity near the pure water homogeneous freezing threshold is pore condensation and freezing (PCF). To investigate if CFA particles nucleate ice via PCF mechanism, we employed a temperature-cycling and freezing protocol which involves cooling down the particles to lower temperature (228 K), then warming up before performing freezing experiments. We conducted these experiments in the Aerosol Interaction and Dynamics in the Atmosphere (AIDA) aerosol and cloud simulation chamber in Karlsruhe, Germany. Our results show that when these particles are exposed to lower temperatures below the homogeneous freezing of pure water, they showed an increased ice-activated fraction in warmer temperatures up to 264 K. This enhancement in their ice nucleation abilities may have been induced by ice germs preserved in the pores of these particles which formed during the temperature-cycling process. Potentially, PCF could be an important freezing mechanism in mixed-phase clouds for CFA particles that have been pre-processed by atmospheric processes. Future study should focus on investigating the threshold temperatures and relative humidity range that ice germs could be preserved in the pores.