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Immersion freezing potential of anhydrous $CaSO_4$ and the effect of hydration on immersion freezing measurements with coal fly ash

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Previous investigations of the immersion freezing behavior of coal fly ash (CFA) particles show a significant decrease in ice nucleation efficiency when switching from dry (dispersion of CFA powder) to wet particle generation (spraying of a suspension) [3, 2]. In the present study, we aim at explaining this discrepancy by examining the freezing behavior of anhydrous $CaSO_4$ (anhydrite), which is known to be contained in CFA particles [5, 1], and its dihydrate $CaSO_4 \bullet 2H_2O$ (gypsum), which is formed in contact with water.

Immersion freezing measurements were performed at the Leipzig Aerosol Cloud Interaction Simulator (LACIS) [4] with size selected particles (300 nm). Measurements with pure anhydrite show the same trend as the measurements with CFA, i.e., dry-generated anhydrite is much more efficient in the immersion mode than wet-generated anhydrite.

In order to verify the hypothesis that anhydrite is hydrated to gypsum at the CFA particle surface leading to the observed decrease in ice nucleation efficiency, the suspensions were evaporated and the remaining particles were heated to above 200 °C. In this temperature range, gypsum is dehydrated and will return to the original anhydrite state. Immersion freezing measurements with the heated samples show an increase in efficiency compared to the non-heated samples, however, the efficiency of the original dry dispersed CFA sample could not be restored.

These measurements indicate that the hydration of anhydrite contributes to the partial deactivation of CFA particles in suspension, but further research is needed to identify other ongoing processes.

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