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On the kinetics of trapping air bubbles and salt precipitates during freezing of diluted salt solution droplets

Markus M. Miedaner (1), Th. Huthwelker (2), F. Enzmann (1), M. Kersten (1), M. Ammann (2), M. Stampanoni (3)

(1) University Mainz, Environmental Geochemistry, Becher Weg 21, D-55128 Mainz, Germany (miedaner@uni-mainz.de), (2) Paul Scherrer Institut, Radio- and Environmental Chemistry, Villigen, Switzerland, (3) Paul Scherrer Institut, Swiss Light Source, Villigen, Switzerland

The freezing of diluted salt solutions occurs manifold in nature. Especially in marine areas sea-salt-aerosols hydrate fast and transform into liquid droplets bearing a certain salt content [1-4]. Once these droplets freeze, the air and other impurities get expelled from the liquid phase and form inclusions of various shapes. So far, the dependence of the freezing rate of ice with respect to the chemical composition of the solution was investigated [5 - 7]. In this study however, we concentrate on the kinetics of bubble and inclusion formation inside a polycrystalline ice-matrix. These are of key importance to fully describe the reactivity of an ice particle with respect to its environment. Knowing the surface area and the volume of each inclusions as well as their spatial distribution allows a better estimate of possible chemical reactions occurring with the surrounding gas phase. Besides, inclusions influence the radiative properties of atmospheric ice particles which are strongly coupled to climatic changes.

To elucidate the kinetics of inclusion trapping droplets of 10E-4 molar NaBr were frozen at different exposure temperatures ranging from 203 K to 271 K under atmospheric conditions. The largest salt precipitates as well as air bubbles were found at the extreme points of the range of exposure temperatures. Synchrotron micro tomography was performed to obtain a fully three-dimensional representation of the internal structure of the samples in situ. Therefore the tomography end station of the material science beam line at the Swiss Light Source was modified in an appropriate manner

[8].

The individual surface area as well as the volume were extracted from the tomographic data. These were analyzed using the Crystal Size Distribution (CSD) approach [9] and the nucleation and growth rate of each pore could be derived Additionally the characteristic conditions of inclusion formation were reconstructed.

The growth and nucleation rate reach their maxima at an exposure temperature of 240 K. While the lowest (203 K) and highest (271 K) degree of under-cooling yield similar conditions. These effects can be explained taking into account melting point depression by increasing brine concentration and latent heat effects.

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