Investigating the uptake of trace gases into grain boundaries of ice

PAUL SCHERRER INSTITUT

UNIVERSITÄT BERN

T. Ulrich[1,2]

M. Ammann[1]

S. Leutwyler[2]

T. Bartels-Rausch[1]

([1]) Laboratory of Radiochemistry and Environmental Chemistry, Paul Scherrer Institut, CH-5232 Villigen, Switzerland

([2]) Department of Chemistry and Biochemistry, University of Berne, CH-3012 Berne, Switzerland.

Contact:
thomas.ulrich@psi.ch

EGU General Assembly 2012

Poster: XY 158

Introduction:

Trace gases have an important impact on our lifes. While many of them are hazardous for health, others influence atmospheric reaction chains like production of ozone. Snow and ice have been proposed as a long term sink for such trace gases. Especially the boundary between ice crystals, so called **grain boundaries**, have been suspected to be a reservoir for certain species (1,2).

Few laboratory studies have addressed this uptake into grain boundaries experimentally. Here we present a new experimental setup, to measure this uptake directly. We use the zone refining process to control the number of ice grains in an ice surface. Then we perform uptake experiments of low concentrations of trace gases to the ice, comparing cases with a lot and few grain boundaries. The density of grain boundary is measured after each experiment by light microscopy. By the use of two pol-filters the ice grains become visible and the length of the grain boundaries can be measured on the ice surface.

What is new?

For the first time the length of the grain boundaries can be measured by light microscopy after each experiment directly.

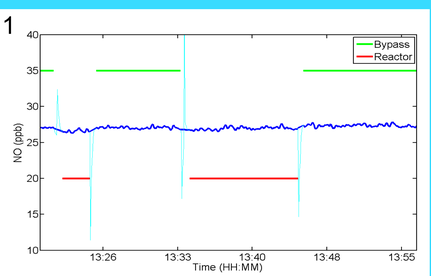
The number of grains can be controlled by the zone refining process.

Different trace gas species can by analyzed with this setup to identify chemical properties that promote uptake into grain boundaries.

The gas inlet:

The gas inlet and the parts of the ground plate, which are in contact with the analyzed gas phase species are entirely composed of PTFE Teflon. Above and below the Teflon, aluminum blocks with circulating ethanol cool the reactor.

1



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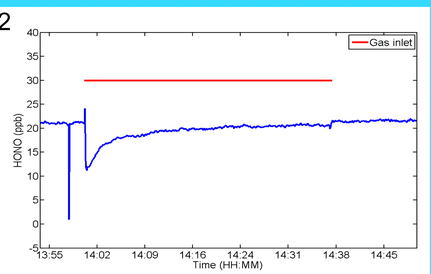
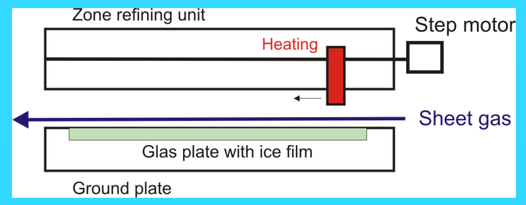
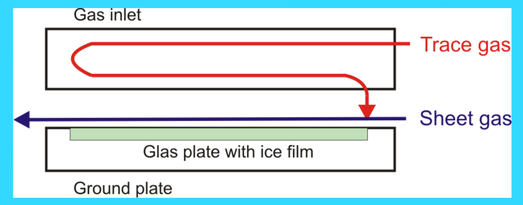


Results:

The gas inlet and the reactor space have been tested for NO and HONO. Figure 1 shows the mixing ratio of NO when the reactor is by-passed, and when the air flow is led through the gas inlet and the reactor with an ice surface at -24 °C. No change in concentration is observable, showing that the reactor is gas tight. In Figure 2 HONO is led through the gas inlet only at -30 °C. An uptake of HONO to the Teflon is visible, but the signal stabilizes after 30 min.

The planar flow reactor



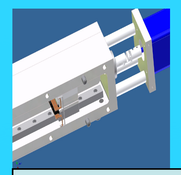


Zone refining setup:

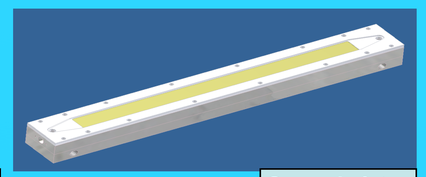
A heating unit consisting of a copper plate is slowly moved over the ice surface to induce zone refining. The atmosphere over the ice surface is kept in water vapor equilibrium by a sheet gas flow. The whole system is cooled by two aluminum blocks and circulating ethanol as cooling liquid.

Trace gas setup:

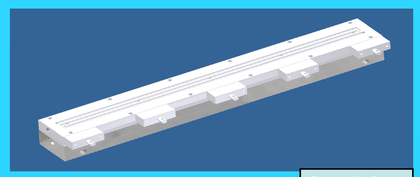
For the actual uptake experiment the gas inlet module is attached. The ice surface can be exposed to the trace gas flow at different lengths. A humidified sheet gas flow transports the trace gas to the analyzer and ensures water vapor equilibrium over the ice surface. The whole system is cooled by two aluminum block and circulating ethanol as cooling liquid.



Zone refining unit



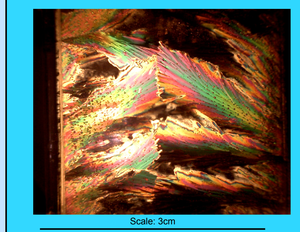
Ground plate



Gas inlet

Zone refining:

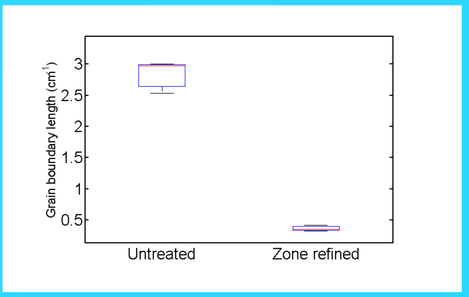
In the zone refining process a small heating unit is pulled slowly over the ice. By this process poly-crystalline ice crystals are molten and then refrozen, resulting in much less crystalline ice.



Poly-crystalline ice

Produced with: v = 50 mm/h, T = 160 °C

Zone refined ice



Results:

The zone refining results in ice with up to eight times lower grain boundary to surface area ratio.

References:

[1] R. Mulvaney et al., Nature, 331, 6153 (1988).

[2] T. Huthwelker et al., J. Colloid Interf. Sci., 238, 1 (2001).

Acknowledgement:

We appreciated funding by the Swiss National Science Foundation (grant number 200021_121857).