Shedding Light on the Physical and Chemical Characteristics of Ice-Nucleating Macromolecules from Birch Trees

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Introduction

Birch pollen are able to trigger heterogeneous ice nucleation at -18°C (Diehl *et al.*, 2001). For a long time it was assumed that macroscopic features of the pollen surface are responsible for triggering the freezing process. A-long with this, it was thought that birch pollen do not contribute to ice nucleation events in the atmosphere since they do not reach high altitudes due to their size (diameter: ~ 20 µm) and high settling velocity. However, our working group has shown that not the whole pollen grain, but rather macromolecules, which can be leached off the grains with water, are ice nucleation active (Pummer *et al.*, 2012). Furthermore, Felgitsch *et al.* (2018) found that ice-nucleating macromolecules (INM) are not only present in birch pollen but are spread throughout the whole birch tree.

Methods

In this study, we focus on the physical and chemical characterization of INM from different parts of the birch tree, including pollen, leaves, branches, bark and fruits. Aqueous extracts of birch tree samples were analysed with various techniques including solid phase extraction, centrifugal filtration, infrared spectroscopy, fluorescence spectroscopy, as well as fluorescence microscopy. The determination of the samples' ice nucleation activity was carried out with a cryo-microscopy setup known as VODCA (Vienna Optical Droplet Crystallisation Analyser) (Figure 1).

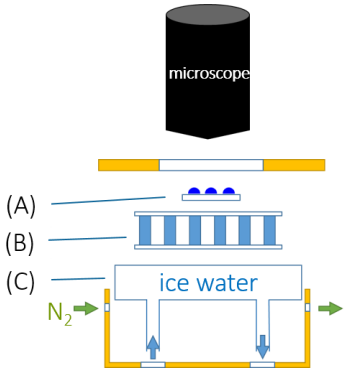

Figure 1. Schematic picture of the cryo-cell, the core part of VODCA, where freezing takes places. A: sample carrier, B: peltier-element, C: copper cooling block.

Conclusions

Results showed a link between the concentration of INM in leaves and fluorescence intensity. Moreover, infrared spectra of the extracts imply the presence of similar chemical substances. Centrifugal filtration experiments indicate that the size of INM is between 30 and 100 kDa (Figure 2). Due to the small size of INM from birch tree samples, they could have the potential to reach high altitudes and play a role in atmospheric freezing processes.

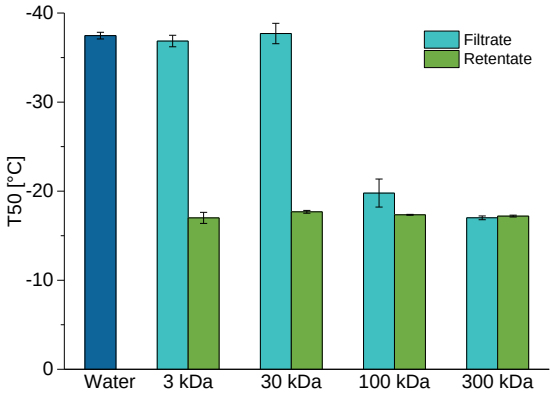

Figure 2. Ice nucleation activity of filtrated birch pollen extracts using nominal filters with 3-, 30-, 100- and 300 kDa cut-offs.

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Diehl, K., C. Quick, S. Matthias-Maser, S. K. Mitra, and R. Jaenicke. (2001). *The ice nucleating ability of pollen Part I: Laboratory studies in deposition and condensation freezing modes*. Atmospheric Research, 58, 75-87.

Pummer B.G., Bauer H, Bernardi J, Bleicher S, Grothe H. (2012). *Suspendable macromolecules are responsible for ice nucleation activity of birch and conifer pollen*. Atmospheric Chemistry and Physics. 12(5), 2541-2550.

Felgitsch, L., Baloh, P., Burkart, J., Mayr, M., Momken, M.E., Seifried, T.M., Winkler, P., Schmale III, D.G., and Grothe, H. (2018). *Birch leaves and branches as a source of ice-nucleating macromolecules.* Atmospheric Chemistry and Physics. 18(21), 16063-16079.