Surface extracts of birch tree samples contain ice-nucleating macromolecules

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Keywords: biological ice nucleation, aqueous surface extracts, ice-nucleating macromolecules, birch tree
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Introduction

The biosphere is a major contributor to global aerosol concentrations. Recent studies showed that rain can trigger the release of biological particles in the atmosphere, highlighting the importance of meteorological conditions in this process. The possible particles released in the atmosphere cover a wide range of possible substances (e.g. fragments of skin and plants, spores, pollen, proteins) and sizes (from several nanometre up to the millimetre size range), with protein carrying cellular material being an important part of it. However, our knowledge on biological particles in the atmosphere is still rather limited. While biological substances that act as ice nucleating particles (INP) are often found to trigger high freezing temperatures, their atmospheric impact remains understudied. Ice nucleation activity has been found in nearly all kingdoms of life such as e.g. different bacteria, fungi and fungal spores, moss spores, and lichen. Plants are often not considered as source of atmospheric INP, however, many species of plants have shown to contain INP. Some of which are winter rye, blueberry, pollen of several trees, citrus, and sea buckthorn berries. Further decayed leaf litter was found to be a potent source for INP. Many plants use INP in their extracellular spaces for freeze tolerance mechanisms. This indicates that many frost-hardy plants contain INP. If those INP are easily available for their direct surroundings, they add an important new source for INP, which has not been paid enough attention to in the past (Pummer et al., 2012).

Methods

All presented results stem from samples collected from nine different birches in Tyrol, Austria. The birches are named TB (Tyrolian Birch) are and numbered A to I. All samples were collected in summer of 2016 (Felgitsch *et al.,* 2018). The sampled birches grow in along a valley (Ötztal, Tyrol) along an altitudinal gradient (from 799 to 1925 m) under differing conditions. TBA and TBB both grow directly next to a road. TBC and TBD, as well as TBH and TBI grew next to a river. TBE and TBF grew next to a road and a river. TBG was the highest sampled tree growing at the timberline. Aqueous extracts of the birch tree samples were analysed. To determine the ice nucleation behaviour of the samples a cryo-microscopy method known as VODCA (Vienna Optical Droplet Crystallization Analyzer) was used.

Conclusions

We were able to extract ice nucleating macromolecules from nearly all samples, with ice nuclei concentrations ranging in the magnitude of 10^7 to 10^9 ice nuclei active at -34 °C or above extractable per cm^2 surface. Freezing temperatures are given for the bark samples and their onset temperatures range around the value for birch pollen washing water indicating similarities. Further we analysed drill cores of the stems of three selected trees and found a rapid decrease of the ice nucleating macromolecule concentration towards the inside of the tree.

Figure 1. Aqueous surface extraction of leaves from birches. Samples were dwelled 6h, centrifuged at 3500 rpm for 10 min and filtered through syringe filter (0.2 µm).

Norway, Sweden and Finland have more than 10 Mio ha birch forests. During a heavy rain event of 6 hours up to 10^{26} INP would be washed down only from leaves and barks, which is approximately 170 kg pure INP material of birch tree origin.

This work was supported by FWF (P26040).

Pummer B.G., et al. (2012). *Suspendable macromolecules are responsible for ice nucleation activity of birch and conifer pollen*. Atmospheric Chemistry and Physics. 12(5), 2541-2550.

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