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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Birch and conifer pollen are efficient atmospheric ice nuclei" *by* B. G. Pummer et al.

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We thank Dr. A. Sesartic for her comments. As some of the arguments are congruent with those of Cindy Morris, we also refer to our reply to her.

Sesartic: The structure of the manuscript in the present form is confusing. I suggest presenting the material and methods section before the results, i.e. try to merge chapters 2 and 5, or at least move chapter 5 right after the introduction. In order to facilitate the understanding, use present tense for accepted facts and the past tense for methods and results. There are typographical and grammatical errors present throughout the manuscript. Please correct them.

Answer: see reply to C. Morris

Sesartic: p. 27221 l.20ff: Please mention here where you procured the pollen from (e. g. collected in the field or from plants grown in greenhouse conditions). As suggested in the review by Cindy Morris, it would be also prudent to check the pollen for microbial activity. As plants are not sterile, the pollen might contain IN active bacteria or fungal spores on their surface.

Answer: We exclude the possibility of IN caused by bacterial contamination due to the different properties (see reply to C. Morris).

Sesartic: p. 27224 l.3: You speak about the surface topology. This would be an opportunity to mention active sites for ice nucleation.

Answer: We have mentioned them in p.27221, line 6 and p.27224, line 22. In the new version we will mention them two more times (see reply to C. Morris, point 1 and 2). But we see no sense in straining the term "active sites" too much, as our study shows, that it is not the surface topology, which is important of ice nucleation. In bacteria the situation is different, as the IN protein is embedded in the membrane, but with pollen and IN-positive fungi the situation is different (see studies by Kieft et al. and Pouleur et al. concerning fungal IN).

Sesartic: p. 27224 l.12: You write here about mixing the pollen with water. However, it would be good to know the details of the procedure. The pollen being "left for some hours" seems quite imprecise and might lead to further questions: could some chemical reactions have happened during that time? Are you really measuring the pollen surfactants or some newly created compounds? Where were the samples left? In the dark, or exposed to sunlight?

Answer: For the measurements with whole grains we mixed untreated pollen with oil emulsion and measured it immediately, so it can be excluded, that the chemical components are generated immediately. The lab where the experiments are carried out is lighted only by electric light (which is turned off when nobody is measuring in the lab) and not by sun. We will improve the wording, but in fact it is as trivial as we have

described it. Leaving the samples for some hours and shaking suspensions up several times shall just make sure that enough material is suspended. In the case of birch it would take far less time, but in order to apply the same conditions on all pollen and as we wanted to eliminate one more parameter to discuss, we did not publish this cognition.

Of course one might argue that our pollen were exposed to sunlight before being harvested and packed, but in this case it is part of a natural process (as pollen develop outside on the plants exposed to several natural impacts) and cannot be discarded as artefact of our measurement.

Sesartic: Chapter 3 in general: Please add here your definition of ice nucleation activity. It would also be interesting to see the activity per pollen grain or mass. I agree with Cindy Morris' comment that it is important to know the number of pollen tested, in order to make the results comparable in between the plant species and to mineral dust on a per-grain basis.

Answer: see reply to C. Morris.

Sesartic: p. 27230 l.20: I would like to point out here that while polymers might indeed be a candidate for IN, Wowk & Fahy (Cryobiology, 44, 2002, 14–23) found that polyglycerol polymers can actually inhibit bacterial ice nucleation. I wonder if they would have the same effect on pollen.

Answer: This would be interesting indeed and could be a part of future research. Nevertheless, we think that publishing the data we have now is important to make new information accessible and in return get some new inspirations, as we intend to continue our investigation on the nature of pollen IN.

Sesartic: p. 27232 l.1-10: Linking the IN activity of pollen to the adaptation of plant species to colder climate is a great idea. However, I think that this hypothesis needs to be fleshed out a bit. Looking up following books might help: Mauseth, J. D., Botany,

Jones Bartlett Publishers, 2008 – for general information. Körner, C. Alpine Plant Life, Springer, 2003 – for insight into the ecology of plants adapted to cold climate.

Answer: We have set this task on our agenda and will comment our results when we have completed it. But we want to point out that our main intention was to analyze pollen as atmospheric ice nuclei, as presented in the introduction.

Sesartic: Table 1: What were the criteria for choosing pollen species which were to be investigated in the smog chamber? Why were not all species investigated in the chamber?

Answer: Principally, we just wanted to show that pollen show similar behaviour in the chamber, no matter where the median freezing temperature in the oil matrix lies. This makes a qualitative comparison between emulsion experiments and chamber experiments (both are common methods) possible. If we had found totally different results, we would have had to question both methods. But we want to emphasize that this paper focuses on the laboratory study using emulsions, as all the efforts to analyze pollen IN have been realized only in the oil immersion setup. As the schedules of the common chambers are usually densely populated, we see the main advantage of an oil immersion setup in its simple installation without reducing the quality of results. We will emphasize it more intensely at the beginning of chapter 2.2. by rearrangement and reformulation of the first paragraph (although the information was already there before):

"To compare our results from the cryo-microscopic measurements with a different setup some of the pollen species were additionally investigated in a simulation chamber, which is closer to reality and eliminates the possible influence of the oil matrix. Samples of different IN activities were chosen to check, if the chamber measurements show the same pattern as the oil immersion methods. Droplets of an aqueous pollen suspension were nebulized into the chamber with an ultrasonic nebulizer. Then the chamber was cooled adiabatically by partial evacuation."

Why did we choose these species? We were most interested in the best and the

weakest ice nuclei (birch and ragweed). Apart from that we chose rather randomly another good, another weak and two mediocre ice nuclei. Furthermore, we oriented on the amount of sample we had and the local abundance of the species.

Further time-consuming investigations were not possible, as our measurement campaign in Bayreuth was a time-limited Eurochamp2 initiative (even though, the colleagues in Bayreuth have already made some additional measurements for us, for which we are grateful). Anyway, we achieved what we had in mind.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 27219, 2011.