Atmos. Chem. Phys. Discuss., 10, C2288–C2291, 2010
www.atmos-chem-phys-discuss.net/10/C2288/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "On condensational growth of clusters and nanoparticles in sub-10 nm size range" *by* T. Nieminen et al.

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Received and published: 30 April 2010

We thank the referee for the constructive comments to help us to improve the manuscript. Our answers to the comments are given below. In this response all references to equation numbers etc. are based on the manuscript version published in ACPD (not the revised manuscript).

General Comments: This manuscript presents a useful expression for condensational growth rates for sub 10 nanometer particles, improving upon previous formulations by explicitly including physical properties of the condensing vapor (i.e., density, mass, diameter). The manuscript, however, is somewhat lengthy (especially in regards to the derivation of the growth rate expression from equations 1 - 13) and should be shortened before publication.

We have moved the material in section 2.1 related to Equations 3–8 into Appendix in the revised version of the manuscript. This shortens the main text, while still leaving the necessary details easily available for the reader.

Specific Comments: 1. Title: The term "cluster" is somewhat misleading as no justification is given to differentiate between cluster and nanoparticle within the text. The measured data that was presented and analyzed gives no indication that the growing "entities" were clusters.

We revised the title to "Sub-10 nm particle growth by vapor condensation - effects of vapor molecule size and particle diffusional motion" in order to avoid potential confusions by the different interpretations of the term effects.

2. Pg. 1694, lines 20 – 22: Growth of atmospheric particles is due to condensation, not "condensational growth", of low volatile vapors. Also, particle coagulation can contribute significantly to observed particle growth [Stolzenburg et al., 2005]

This sentence was revised to "... due to condensation of low volatile vapors (Kulmala et al., 1998), and it seems to be size dependent (Hirsikko et al., 2005). In situations of very high nucleation mode particle concentrations also intramodal coagulation of the nucleated particles can contribute to the observed particle growth rates (Stolzenburg et al., 2005; Kulmala and Kerminen, 2008)."

3. Pg. 1694, line 23: Please include a citation to the work of [Smith et al., 2008] when discussing direct measurement of nanoparticle composition.

We added the suggested reference and revised the sentence to "To date there are only a few reports of direct measurements of the chemical composition of atmospheric nucleation mode particle composition (see e.g. Smith et al., 2005; 2008). Because of the experimental challenges, various indirect methods to ..."

4. Page 1695, lines 21 – 24: It is not the initial growth that determines the fraction of nucleated particles reaching CCN size (which is rather far removed from the size of the

newly formed particle), but the likely size and time-dependent growth rate integrated from the detectionlimit to CCN size which gives the particle "lifetime" over which scavenging losses can be calculated, determining the fraction of newly formed particles that survive to CCN size [Kuang et al., 2009].

By initial growth we refer here to growth of sub-10 nm particles. When nucleated particles grow from 1 nm to 10 nm, their coagulation coefficient with larger particles is decreased by approximately an order of magnitude. This way the most critical step in determining their ability to grow to CCN sizes ($\sim$50 nm) is the initial growth. We revise this sentence to "... since the initial growth of the particles in sub-10 nm size range is the most important step determining the fraction of nucleated particles reaching ..."

5. Page 1696, lines 3 – 4: It should be mentioned that the derivation and subsequent growth rate expression are based on a single component model for the condensing vapor.

We added explaination of the assumptions used in this manuscript to the beginning of Section 2.1.

6. Page 1702, lines 26 – 30: Please include a citation to the work of [Iida et al., 2008] when discussing observations of sulfuric acid condensation contributing only a fraction to the measured growth rate.

We added the suggested reference into the revised manuscript.

References added to the revised manuscript:

Iida, K., Stolzenburg, M. R., McMurry, P. H., and Smith, J. N.: Estimating nanoparticle growth rates from size-dependent charged fractions: Analysis of new particle formation events in Mexico City, J. Geophys. Res., 113, D05207, 2008, doi:10.1029/2007JD009260.

Smith, J. N., Moore, K. F., Eisele, F. L., Voisin, D., Ghimire, A. K., Sakurai, H., and McMurry, P. H.: Chemical composition of atmospheric nanoparticles during nucleation

events in Atlanta, J. Geophys. Res., 110, D22S03, 2005, doi:10.1029/2005JD005912.

Smith, J. N., Dunn, M. J., VanReken, T. M., Iida, K., Stolzenburg, M. R., McMurry, P. H., and Huey, M. R.: Chemical composition of atmospheric nanoparticles formed from nucleation in Tecamac, Mexico: Evidence for an important role for organic species in nanoparticle growth, Geophys. Res. Lett., 35, L04808, 2008, doi:10.1029/2007GL032523.

Stolzenburg, M. R., McMurry, P. H., Sakurai, H., Smith, J. N., Mauldin III, R. L., Eisele, F. L., and Clement, C. F.: Growth rates of freshly nucleated atmospheric particles in Atlanta, J. Geophys. Res., 110, D22S05, 2005, doi:10.1029/2005JD005935.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 1693, 2010.