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Interactive comment on "Modelling the cloud condensation nucleus activity of organic acids" *by* Z. Varga et al.

Z. Varga et al.

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Answer to Barbara Ervens

Thank you for your comment that helped us to focus on some interesting issues. We fully agree with you that at subsaturated conditions (small droplets), the saturation (S) is dominated by the Raoult term (B/r3) and only as one approaches saturation (larger droplets) does the importance of the Kelvin term (A/r) increase. However, we disagree with the statement that "At the critical supersaturation, the growth factor (wet/dry size) is larger than shown in Figure 1Ĕ" since at the critical supersaturation, the growth factor (wet/dry size) depends on the dry size, increasing with increasing dry size (e.g. at the critical supersaturation GF=2.53 for a d=20 nm glutaric acid particle and GF=5.53 for a d=100 nm particle of the same compound). GF is ranged from 2 to 12 in Figure 1 of our paper. Nevertheless, we partially accept the statement that the surface tension depres-

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sion at the critical supersaturation is $<$ 10% compared to the surface tension of water (it is true for most of organic acids studied here except cis-pinonic acid). However, we would not call the effect of this surface tension depression negligible. For example, for a d=25 nm glutaric acid particle σ=0.065 Jm-2 at the critical supersaturation, so the surface tension reduction is about 10% as compared to that of pure water. The critical supersaturation is 1.86 % while calculating with σ=0.072 Jm-2 the critical supersaturation would be 2.16%. The surface tension effect on critical supersaturation is even more pronounced for cis-pinonic acid: for a d=100 nm cis-pinonic acid particle σ=0.051 Jm-2 at the critical supersaturation, so the surface tension reduction is about 30% as compared to that of pure water. The critical supersaturation is 0.25 % while calculating with σ=0.072 Jm-2 the critical supersaturation would be 0.41%. Considering the Raoult effect, we agree that for week acids molecular weight (and density) is an important parameter. However, the results in figure 5 of our paper reflects more than simply the difference in MW and it is just an “accident” that the order of activation in figure 5 follows the order of molecular weights. For example, the MW of citric acid (192.12) is bigger than that of cis-pinonic acid (184.24). Following your train of thoughts, the number of dissolved moles would be higher for cis-pinonic acid resulting in lower water activity for this compound. However, as shown in figure 4 higher water activity was measured for cis-pinonic at any GF (although we admit that it was difficult to see in figure 4). However, in figure 5 we can see that cis-pinonic acid activates at lower supersaturations than citric acid which cannot be explained by water activity (and MW) but is the consequence of its surface tension depression. Another example to show that the effect of chemical nature (functional groups, unsaturated bond) is also reflected in figure 5: The MW of maleic acid, succinic acid and malic acid is 116.1, 118.1 and 134.1, respectively. Thus, following your chain of thoughts again, very similar water activity should be obtained for maleic and succinic acid and somewhat higher for malic acid (assuming that MW is the determinant property). Instead, very similar water activity was obtained for malic and succinic acid and somewhat lower for maleic acid as shown in figure 4 (although we admit that it was difficult to see in figure 4

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again, thus the figure has been redrawn). This is the overall effect of dissociation (pK), MW and density (to a minor extent). Maleic acid is a fairly strong acid (pK1=1.97) as compared to malic (pK1=3.46) and succinic (pK1=4.16) acid. Thus, maleic acid dissociates into more ions leading to lower water activity at any GF than malic and succinic acid. As a final consequence, malic and succinic acid activate at very similar supersaturation while maleic acid activates at lower supersaturation. We understand that you handled CCN activation as a dynamic process and accept that the role of updraft velocity reduces the importance of chemical composition.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 5341, 2007.