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Interactive comment on “A single parameter representation of hygroscopic growth and cloud condensation nucleus activity – Part 3: Including surfactant partitioning” by M. D. Petters and S. M. Kreidenweis

Anonymous Referee #1

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General comments

This paper extends the well-known kappa-Köhler framework for surfactant solutions while accounting for bulk-surface partitioning. The paper also gives an explanation for the differences between theoretical predictions and observations. Although the discussion about the differences and the explanation are based on previous studies and do not provide new evidence about the topic, the kappa framework can be very useful for modeling community. In general, the topic is scientifically relevant and within the scope of ACP. The language is also fluent and the text is well organized and written. There-

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fore, this paper should be published in the ACP after few corrections and clarifications.

Specific comments

Page 22692, lines 9-11: Can this new approach show something that the previous approaches could not show? In general, this work offers a convenient measure (κ) for surfactant hygroscopicity, but does not provide new information about the role of surfactants or validity of the partitioning model. New experiments would have been needed for that.

Page 22701, lines 13-17: For this purpose Γ_{max} (or $f\Gamma_{max}$) can be interpreted as a fitting parameter, so it does not matter if it accurately describes saturation surface excess. The only requirement for the parameters Γ_{max} and β is that the fitted equation describes concentration dependent surface tension accurately.

Page 22701, lines 17-27: Using different values for f should not change the resulting apparent hygroscopicity (see the previous comment), so check the calculations. It should be noted that the analytical solutions for the partitioning equilibrium change when f is not equal to one (Γ_{max} changes to $f\Gamma_{max}$) and f is not the dissociation factor (ν). This part of the text should be reformulated or deleted.

Page 22702, lines 1-3: What about water? Depending on the definition of the surface and the model simplifications, water molecules can have non-zero surface excess.

Page 22702, lines 11-27: This discussion ignores two relevant topics: dynamic surface tensions and implications for microscopic droplets. Dynamic surface tension gives an indication of time scales in bulk solutions. Typically surface tension changes gradually which indicates gradually developing surface phase rather than instant formation after a nucleation step. Even if some bulk solutions (not SDS) need a long time to reach the equilibrium, this can be much faster process for microscopic droplets and especially for the thin surface layer. Especially the dynamic surface tension behavior needs to be discussed here (e.g. connection with the nucleation, observed time scales for reaching

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equilibrium surface tension and implications for current conclusions).

Page 22703, lines 11-13: Why would Γ_{max} and κ_{chem} not be easily constrained by *reliable* experimental data? For this purpose, Γ_{max} should be considered as a fitting parameter.

Technical corrections

Page 22689, Equation 1: Units are not matching. Maybe T should be T^3 and the unit of A is $\text{K m}^3 \text{J}^{-1}$. See also the unit of A in Table 1.

Page 22690, line 11: Add reference and explain (briefly) AIM

Page 22693, Equation 4: Check the equation and possibly remove either volume fraction or subscript i from $V_{s,i}^b$

Page 22693, Equation 5 (upper): Check the equation and possibly remove surfactant volume fraction from the denominator

Page 22694, line 4: Molarity is moles per volume of solution

Page 22695, line 5: Add space to "1generally"

Page 22696, lines 11-12: Add at least one comma or reformulate this sentence

Page 22697, line 1: Add right parenthesis after "Eq. (5)"

Page 22697, line 5: Equation 7 instead of 5

Page 22697, Equation 8: Parameter a_0 depends on k_2 and not ν

Page 22697, line 17: Change " $(n)=0$ " to " $(n^-=0)$ "

Page 22700, line 22: "must be obtained"

Page 22701, line 2: "surfactants. In"

Page 22703, line 25: Change CCC to CCN

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