Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
https://doi.org/10.5194/acp-2021-738-RC2, 2021
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Comment on acp-2021-738

Anonymous Referee #1

Referee comment on "Aerodynamic size-resolved composition and cloud condensation nuclei properties of aerosols in a Beijing suburban region" by Chenjie Yu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-738-RC2, 2021

This paper presents online, size-resolved measurements of black-carbon-containing particles and associated properties collected in a suburb of Beijing. The strength of this work is that it simultaneously probes size-resolved composition and other properties, which makes this work potentially useful for modeling studies in terms of providing ground truth of "what is out there". The work fits well within the scope of ACP. I have two major comments and a number of minor comments that should be addressed before the paper can be accepted for publication.

Major comment:

- Section 2.2: An important assumption for the calculation of density and D_v,all is that mineral dust is not present in the samples, since dust cannot be detected by the instrumentation used for this study. This should be mentioned here, and a discussion is needed to what extent this assumption can be justified and what error is introduced by this assumption.
- The large, heavily coated particles reported here are interesting. I would assume that it takes a long time to grow such thick coatings on such large cores by condensation of low-volatile vapors. The authors mention coagulation as another possibility of how such these particles could be formed. However, coagulation is usually also a slow process in the atmosphere (depending on number concentrations). Could such thick coatings be formed by in-cloud aqueous phase chemistry and resuspension of the coated aerosol after the cloud evaporates? Are the coatings of these particles really secondary in nature or are they possible at least partially primary? It would strengthen the paper if the authors provide could some back-of-the-envelope estimates of how these particles could be formed.

Minor comments:

- L. 36: "By applying the mixing state of refractory black carbon containing particles …". The word "applying" sounds strange here. Do you mean "considering"?
- L. 73-81: A relevant reference to motivate the work presented in this paper may be Ching J, Kajino M. Aerosol mixing state matters for particles deposition in human respiratory system. Scientific reports. 2018 Jun 11;8(1):1-1.
- L. 150: Since different kinds of diameters are used in this paper depending on measurement technique, please specify what kind of diameters are Dp and Dc.
- It would be good if the results found for Beijing could be contrasted to other environments, for example see Motos G, Schmale J, Corbin JC, Zanatta M, Baltensperger U, Gysel-Beer M. Droplet activation behaviour of atmospheric black carbon particles in fog as a function of their size and mixing state. Atmospheric Chemistry and Physics. 2019 Feb 20;19(4):2183-207 and Motos G, Schmale J, Corbin JC, Modini R, Karlen N, Bertò M, Baltensperger U, Gysel-Beer M. Cloud droplet activation properties and scavenged fraction of black carbon in liquid-phase clouds at the high-alpine research station Jungfraujoch (3580 m asl). Atmospheric Chemistry and Physics. 2019 Mar 25;19(6):3833-55.
- Section 2.2: The notation in this section is unclear. Equation (1) refers to a per-particle quantity, but this is not how the authors use it here, since Line 179 mentions "for all particles", which I assume means "averaged over all particles". However, Figure 6 presents size-resolved graphs of shape parameter, which implies that equation (1) is calculated as an average for each size bin. Please clarify and improve the notation so that this becomes clear.
- Line 276: "To test whether the mixing state varies according to ambient pollution concentrations…" Do you mean mixing state as in "internally/externally mixed" (i.e., within a given size range)? This sounds like an interesting idea, but I don't think it is answered in the results section since this is looking at the dependence of various quantities on particle size – I would not call this mixing state.
- Line 292: "no significant difference": suggest rephrasing this since it is not meant in the sense of "statistically significant"
- Section 3.2: It would help the reader if you could add to this section references to the individual figures that you are referring to.
- Definition of rBC-containing particles: What is the minimum core size that can be detected?
- Line 374: Is the more spherical-like morphology for larger particles because the coating material forms a spherical coating around the non-spherical core, or does the core itself become more spherical because it collapses? This may seem a minor point, but it is important when justifying the use of Mie calculations for BC-containing particles, which assumes a spherical core.
- Line 470: Why were optical properties evaluated for a wavelength of 880 nm? Unless this was done to compare to measurements (which is not the case here), it is more common to do this for ~500 nm (closer to the peak of the spectrum from sunlight).
- The use of English language is appropriate for the most part although some paragraphs/sentences would benefit from being proof-read by a native English speaker.