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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: New methodology for measuring viscosities in small volumes characteristic of environmental chamber particle samples" *by* L. Renbaum-Wolff et al.

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Comment #1a)

Given that the Reynolds number depends on gas speed and particle diameter, to what extent must variations in flow speed and particle diameter be accounted for? More specifically when considering the flowing gas field, how reproducible is the field around the particle from experiment to experiment, both in direction and in speed?

Response:

The results are very reproducible from experiment to experiment, suggesting that the

field around the particles are reproducible from experiment to experiment. For example, no significant difference (at 95% confidence) between average bead speeds (from the movement of multiple beads) measured on different days but with the same flow speed, relative humidity, temperature, and particle type was observed. This information has been added to the manuscript (see section 3.1).

Comment #1b)

Rather than measuring at only one gas speed, would more accurate measurements be possible if the gradient of the probe bead velocity with gas speed were measured?

Response:

The referee suggests an alternative to the presented technique- rather than measuring at only one gas speed, measuring the gradient of the probe bead velocity with gas speed. This is a very good alternative, and we thank the referee for the suggestion. However, this approach would be much more time consuming than the current method. In addition, since the dependence of the bead speed on gas flow rate becomes weaker with increasing viscosity (see Figure 5), it is not clear how much the accuracy of the technique would benefit from such a method.

Comment #1c)

When considering the variation with particle size, what variation in probe bead speed is there from measurements on particles of different size? Were deposited particles of a similar size chosen for measurements?

Response:

The particle sizes used in these experiments are between 30-50 microns in diameter. We have found that the variation in individual bead speeds within a single droplet is larger than the variation in the mean bead speed across the droplet sizes used herein and statistical analysis suggests there is no significant difference (at 95% confidence) in the mean bead speeds for 30 and 50 micron diameter droplets. Conversely, variation

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by a factor of 2-4 in individual bead speeds due to bead-to-bead variation exists, making this a more important source of variation in the measurements. This information has been added to the manuscript (see Section 3.1).

Comment #1d)

Do beads within the same particle move with the same speed independent of where they sit within the flow pattern? Or is the wide uncertainty in bead speed systematically dependent on where the bead circulates within the particle?

Response: Variations in the speed of individual beads with location in the droplet are apparent by observation of a single bead. In addition, there is bead-to-bead variation due to the variation in location of the beads within the particle flow field. The main variation in the bead speeds is due to the latter. This information has been included in the Section 3.1 to address the referee's comments.

Comment #2)

Are errors for viscosity measurements (eg. for olive oil) calculated from the spread in probe bead speeds in a single particle or are multiple measurements made over many particles?

Response: The average bead speed of many beads in multiple droplets is determined for both the calibration solution droplets as well as the measured (eg. Olive oil) droplets and the reported error is calculated from the 95% prediction intervals from the calibration curve. This detail is clarified in the text, Section 3.5, paragraph 1, sentence 3: "Like in the measurement of bead speeds for the standard particles, the average bead speed of many (5) beads in multiple (3) particles was determined." Section 3.5, paragraph 2, sentence 1: "The resulting viscosity of the olive oil particles at room temperature was 0.11 (+0.09/-0.05) Pa s where the reported error is calculated from the 95% prediction intervals from the calibration curve in Fig. 6a. "

Comment #3)

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The axes x and y should be defined and the direction of the gas flow indicated.

Response:

This has been addressed in the updated manuscript.

Comment #4)

Can the shape of the curve in Fig. 5 be rationalized?

Response:

To address this comment, a sentence has been added to the manuscript in Section 3.3, paragraph 2, sentence 3: “The shape of the curves in Figure 5 are roughly consistent with the shape expected for a spherical droplet in an axisymmetric gas flow (McDonald, 1954;Song et al., 2003).”

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 27021, 2012.