Huang and Coggon et al. present theoretical and experimental evaluation of a newly-designed Caltech Photooxidation Flow Tube Reactor (CPOT). The CPOT incorporates components of, and is evaluated against, other recently developed oxidation flow reactor techniques. The authors use COMSOL to conduct CFD simulations of various inlet configurations (e.g. conical diffusers, static mixers) and lamp-induced temperature gradients, and their effects on flow fields. The penetration efficiency (η) and residence time distributions (RTDs) for vapors (O_3, SO_2, H_2O_2) and particles (polydisperse ammonium sulfate) are measured experimentally. For the vapors that were studied, η = 100%; for particles, $\eta \leq 80\%$ at D_p = 100 nm. The authors use a Taylor dispersion model to simulate the observed RTDs, and specifically to reproduce behavior of temperature-gradient-induced secondary flows.

Overall, in my opinion this manuscript is well written. The CPOT technique has potential applications for laboratory SOA studies that will presumably (based on title) be examined in related publications to follow. Another, perhaps even more important contribution is the theoretical and modeling framework that is presented which is applicable to other oxidation flow reactor techniques. I would support publication in Atmospheric Measurement Techniques after consideration of my comments below.

Comments

1. Aside from mentioning that the CPOT is equipped with UV-A, UV-B, and mercury lamps, there is no discussion of the photochemical oxidation capabilities of the CPOT despite the statement in Section 2.2 that "quantifying light fluxes for each type of lamp is the prerequisite for performing photochemical experiments in the CPOT." In my opinion, it is critical to provide basic information in this regard in this paper. I recommend supplementing Section 2.2 and Figure 1D by adding a section (or table) summarizing the basic photochemical oxidation capabilities of the CPOT. For example:

Lamp Type	Primary / Mean Emission λ	Minimum actinic flux	Maximum actinic flux	OH precursor(s)	Minimum [OH]	Maximum [OH]
UVC (Hg)	254	XX	XX	AA	xx	xx
UVB	305	YY	YY	BB	yy	yy
UVA	350	ZZ	ZZ	CC	zz	zz

2. I think it would also be useful to briefly mention how the lights are used. For example, are only UVA, UVB, or UVC lamps used depending on the experimental goals? Or are combinations of different lamp types used at the same time? How is the UV intensity adjusted and measured?
3. I want to point out that the "straight tube inlet" design portrayed in Figure 3A doesn't incorporate specific characteristics of the PAM reactor, which uses a drilled-out inlet nut on the inside of the front plate combined with a fine mesh screen or a Teflon disc (depending on version; see Figure 1 below) to promote radial mixing. If the goal of this analysis is to represent the specific characteristics of the PAM reactor -- which, for self-serving reasons, I'd be curious to see -- I suggest incorporating additional inlet components shown in the photo to evaluate the effect it has (if any). I can provide necessary specifications. Otherwise, if it is only meant to illustrate a

simplified reactor geometry, it shouldn't be specifically associated with the PAM reactor as is currently done in the Figure 3 caption.

Figure 1. PAM reactor "inlet mixer". A mesh screen or Teflon disc is press fit into a nut with drilled-out holes to promote axial mixing.

4. There are several sections in the paper where extensive sets of equations / derivations are used:
    - Section 4.2, Equations 3-7
    - Section 4.3.1, Equations 10-15
    - Section 4.3.2, Equations 16-22

    While informative and useful for advanced readers, in my opinion, this level of detail is potentially overwhelming for basic readers. Would it be possible to move some of this material to a new Appendix C?

5. **P14, L9-L11**: The authors state: "The extent of wall deposition of organic vapors in the flow tube reactor requires comprehensive study and will be addressed in a future publication." Isn't this also applicable to the conical diffuser / static mixer described earlier in the paper (P6, L27), which has higher surface-to-volume ratio than "Reactor 1" and "Reactor 2"? I suggest briefly stating somewhere in the manuscript that a limitation to using conical diffusers/ static mixers is losses of sticky organic vapors that may be important SOA precursors.

6. **P14, L28**: "Note that since we measured the particle size distribution after the static mixer, this loss does not arise from the static mixer." Related to #4, doesn't this imply that there is significant loss of particles through the static mixer? I suggest briefly stating somewhere in the manuscript that a limitation to using static mixers is particle losses. This may unimportant for CPOT-related applications, but is critical in applications of other oxidation flow reactors, particularly when a goal is to measure SOA-to-POA-enhancement ratios (e.g. Ortega et al., 2013; Tkacik et al., 2014; Ortega et al., 2016; Palm et al., 2016, Karjalainen et al., 2016; Simonen et al., 2016).

7. **Section 4.3**: Please also cite the use of Taylor dispersion modeling to characterize vapor and particle residence time distributions in the PAM and TPOT reactors by Lambe et al. (2011). On a related note, an RTD comparison figure presented by Campuzano-Jost et al. (2016) is reproduced below (Figure 2). Can the authors provide any insight or hypotheses as to how the (seemingly) minor improvement in RTD obtained with the CPOT would influence the corresponding measured properties of secondary organic aerosols produced in both systems?
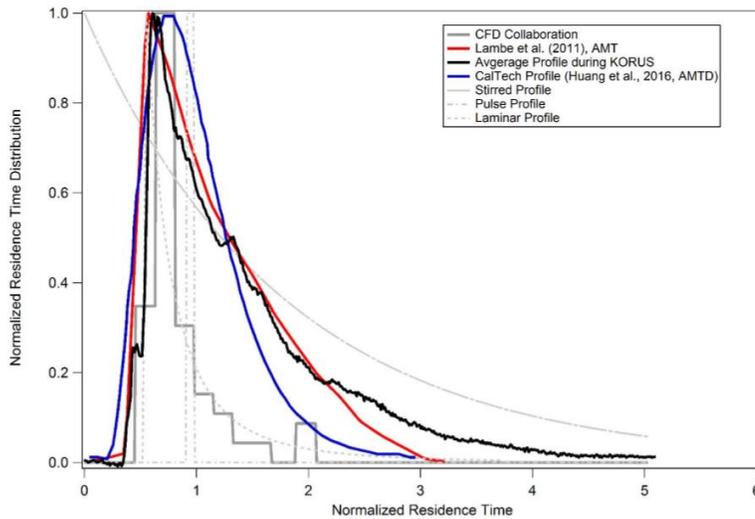
Figure 2. Comparison of theoretical and measured oxidation flow reactor residence time distributions (RTDs) in CPOT and PAM by Campunazo-Jost et al. (2016)

8. **Sect. 4.2.3**: Please define size limits for "diffusive" and "non-diffusive" particles.

9. **Figures 7-8**: I am not certain if these figures are necessary. If they are, I wonder if they could be moved to an appendix/supplement.

10. **Figure 9**: For "100 nm, 99%", "200 nm, 95%", "500 nm, 88%", and "1000 nm, 65%), I assume that the 99%, 95%, 88% and 65% values are penetration efficiencies. This could be made clearer, for example, "100 nm, η = 99%". In the open area (white spaces), the authors may also consider adding an "η = 0%" label, or modifying the caption to read: "The open space between the dashed curve and the tube wall indicates the region in which particles have deposited on the tube wall **(η = 0%)**".

11. **Figure 11**: Please indicate in the caption that the penetration efficiency as defined here does not include particle losses in the diffuser/static mixer, and thus represents a lower limit to the pentration efficiency of the entire CPOT.

12. **Figure 13**: The authors might consider mentioning in the legend or the caption that Eq. 14 represents a Taylor dispersion model.

References

A.M. Ortega, D.A. Day, M.J. Cubison, W.H. Brune, D. Bon, J. de Gouw, and J.L. Jimenez. Secondary organic aerosol formation and primary organic aerosol oxidation from biomass-burning smoke in a flow reactor during FLAME-3. *Atmos. Chem. Phys.*, 13, 11551-11571, doi:10.5194/acp-13-11551-2013, 2013.

D. S. Tkacik, A. T. Lambe, S. Jathar, X. Li, A. A. Presto, Y. Zhao, D. R. Blake, S. Meinardi, J. T. Jayne, P. L. Croteau, and A. L. Robinson, Secondary organic aerosol formation from in-use motor vehicle emissions using a Potential Aerosol Mass reactor. *Environ. Sci. Technol.*, 48, 11235-11242, 2014.

B.B. Palm, P. Campuzano-Jost, A.M. Ortega, D.A. Day, L. Kaser, W. Jud, T. Karl, A. Hansel, J.F. Hunter, E.S. Cross, J.H. Kroll, A. Turnipseed, Z. Peng, W.H. Brune, and J.L. Jimenez. In situ secondary organic aerosol formation from ambient pine forest air using an oxidation flow reactor. *Atmospheric Chemistry and Physics*, Atmos. Chem. Phys., 16, 2943-2970, doi:10.5194/acp-16-2943-2016, 2016

A.M. Ortega, P.L. Hayes, Z. Peng, B.B. Palm, W. Hu, D.A. Day, R. Li, M.J. Cubison, W.H. Brune, M. Graus, C. Warneke, J.B. Gilman, W.C. Kuster, J. de Gouw, and J.L. Jimenez. Real-time Measurements of Secondary Organic Aerosol Formation and Aging from Ambient Air in an Oxidation Flow Reactor in the Los Angeles Area. *Atmospheric Chemistry and Physics*, 16, 7411-7433, doi:10.5194/acpd-16-7411-2016, 2016.

P. Karjalainen, H. Timonen, E. Saukko, H. Kuuluvainen, S. Saarikoski, P. Aakko-Saksa, T. Murtonen, M. Dal Maso, E. Ahlberg, B. Svenningsson, W. H. Brune, R. Hillamo, J. Keskinen, and T. Rönkkö. Time-resolved characterization of primary and secondary particle emissions of a modern gasoline passenger car. Atmos. Chem. Phys. Discuss., 16, 8559–8570, doi: 10.5194/acp-16-8859-2016, 2016.

P. Simonen, E. Saukko, P. Karjalainen, H. Timonen, M. Bloss, P. Aakko-Saksa, T. Rönkkö, J. Keskinen, and M. Dal Maso: A New Oxidation Flow Reactor for Measuring Secondary Aerosol Formation of Rapidly Changing Emission Sources, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-300, in review, 2016.

P. Campunazo-Jost, Z. Peng, B. B. Palm, W. Hu, and J. L. Jimenez. Recent OFR work from the Jimenez Group at CU-Boulder, 4th PAM Users Meeting, Portland, OR, USA, 20-Oct-2016.