

Review of "A comprehensive evaluation of enhanced temperature influence on gas and aerosol chemistry in the lamp-enclosed oxidation flow reactor (OFR) system"

Tianle Pan et al. present a study on the influence of the heating effect of oxidation flow reactor (OFR) UV lamps on oxidant chemistry, flow conditions and secondary organic aerosol (SOA) formation. The authors find that while the increase in temperature does not greatly affect the oxidant chemistry, the effect of temperature gradient on residence time distribution shortens the mean residence time. Thus, the OH exposure at higher light intensities is affected by the heating effect. The temperature increase in the OFR influences the SOA yields and composition, so that the SOA yield is lower at higher temperatures and the O to C ratio of SOA is higher at higher temperatures.

The heat caused by the OFR lamps is an important aspect of OFR studies that has not been well characterized earlier. The measurements and analysis in this study are comprehensive and thoroughly done. However, the quality of reporting and language is not fully adequate. Another concern is the relevance of the SOM model for the SOA formation in the OFR. Thus, I recommend publishing this study in Atmospheric Measurement Techniques, but only after the following remarks have been addressed. Especially the language needs to be improved.

General comments

1. The reporting should be concise, and all statements should be well-defined and unambiguous. Currently, the text contains unnecessary extra words (like 'around', 'might'), which are sometimes necessary but could be mostly removed. The authors often use word 'support', which in many places could be replaced by a more exact wording. Furthermore, for many sentences in Section 3 it is unclear what the authors actually mean. Some of these are included in the following specific comments, but I recommend the authors read through the paper and for each sentence ponder whether the sentence is necessary, and whether the statement is unambiguous.
2. It is unclear why the authors used the ring flow manifold in RTD measurements when it was not used in the simulations. In my opinion, this is justified since the ring flow is typically used in actual measurements. However, the authors could discuss this justification when they describe the RTD measurement and simulation. This difference between measurement and simulation should also be mentioned in Fig. 8 caption. In addition, I think the description of RTD measurement (p. 13, l. 412-415) should be moved to Section 2. What were the flow rates in aerosol line and exhaust line during RTD or temperature measurements? The authors provide the flow rates in different occasions, but it is not clear whether this is the total flow rate (aerosol line + exhaust line) and what is the ratio between the aerosol line and exhaust line.
3. The authors use term 'Enhanced temp.' in figures to describe the difference between OFR and ambient temperature. In my opinion, e.g. 'Temp. enhancement' or just ΔT would be better.
4. When discussing the approaches to reduce the heating effect in Sect. 3.5, the authors actually only discuss approaches to reduce the effect of increased temperature. For example, when the fans are used to cool down the OFR external surface, the heat transfer inside the OFR is improved and this affects the RTD since the heat transfer occurs via convection. However, the authors did not characterize the effect of different cooling methods on the RTD, which at least should be mentioned in this section or the section headline should be changed.

5. The authors sometimes mix past and present tense. See e.g. Fig. 3 caption: four lamps were turned on, flow rate is 5 lpm.
6. Based on the current description of the SOM model, it seems that the authors first model the SOA formation in “normal” temperature and then study its evaporation in elevated temperature (e.g. p. 17, l. 494: “for the newly formed SOA in the OFR, the temperature impact was simulated based on SOM model”). In that case, what is the temperature where the SOA formation is modeled? If this is the case, the model results regarding e.g. the SOA yield are not very relevant, because in the OFR the SOA formation would take place in the elevated temperature.

The authors should change the heading of Section 3.4 to “Temperature influence on OA evaporation”, and describe more clearly that they are modeling the evaporation of SOA that was formed in temperature X and then injected into the OFR at elevated temperature. This needs rewriting of Sect. 3.4 so that the authors discuss OA evaporation instead of SOA formation.

Specific comments

p. 1 l. 44: box model using radical chemistry → radical chemistry box model

p. 2 l. 58: or → for

p. 2 l. 82: The high temperature inside the OFR does not cause the recirculating flows, it is the temperature gradient caused by lamp heating.

p. 3 l. 88: SOA simulation and study → SOA simulations and studies

p.3 l. 102: The acronym ARI has not been declared earlier.

p. 4, Fig. 1: What is the exhaust gas line? It seems that sensor (3) is measuring the ring flow outlet, but in the text it is unclear whether the exhaust gas means the ring flow or the N₂ purge flow. Please clarify.

p. 7 Fig. 2 caption: “assuming ambient OH concentrations are around 1.5e6...” I suppose you have used an exact value of 1.5e6 in the calculations, so please remove the word ‘around’ (also earlier regarding the water mixing ratio).

p. 10 l. 296: “In our case, the...” → “In our case, when the...”

p. 10 l. 298: What is “vertical axial direction”? I think axial would mean the direction of the central axis of rotation. It would be helpful to define the different directional terms (vertical, horizontal, probing depth) graphically e.g. by adding another panel in Fig. 1.

p. 11 l. 319: “OFR chambers (OFR metal tubes)” → “OFR surface”

p. 11 l. 331: surfaces → surface

p. 11 l. 333-339: The authors discuss in length why the temperature of the external surface is lower than that of the gas inside the reactor, while it is basic physics that since the OFR is not isolated and the ambient temperature is lower than the OFR internal temperature, there will be heat transfer from inside the OFR to the ambient, and the medium between these (the surface) will be at lower temperature than the OFR internals. This is correctly described in lines 338-339. The thermal mass of the OFR is not relevant, as it affects only the rate of temperature increase but not the final equilibrium temperature that is discussed here.

p. 12 l. 352: Here and elsewhere the authors use term 'OFR tubes' for the OFR casing. I would suggest finding a better term, since to my understanding this structure consists of a single large tube and the end plates, not 'tubes'.

p. 13 l. 395: was → is

p. 13 l. 396: What is 'more even and better-mixed air'? I think the purpose of the ring flow manifold is to reduce dead space at the end of the OFR and thus reduce the mixing.

p. 13 l. 397: Please check the tense of this sentence. Also, the flow distribution certainly will be different, so the word 'might' is not necessary here.

p. 13 l. 409-411: The definition of "sum of integrals of signal over time versus the sum of signals" is not correct. Please define the mean residence time correctly or just cite the relevant source.

p. 13 l. 412: Here and elsewhere: the authors have measured RTDs and thus also the mean residence times. "Average RTD values" is not correct term.

p. 14 l. 427: calculation → simulation ?

p. 14 Fig. 7:

- In panels a, c and e, there are 4 different cases in each panel. I assume these represent the situation at probing depths of 100, 200, 300 and 400 mm. Please indicate this somehow in the figure or in the caption.
- In panels g-j: What does the horizontal or vertical velocity mean? If these are the velocities towards the horizontal or vertical direction, then the labels 'backward' and 'forward' do not make sense. Or should it be axial velocity?
- Figure caption: "Enhanced temperature influences in panels (c) and (d) were considered" – should this be panels (e) and (f)? The last reference to panel (h) should be (j).

p. 15 Fig. 8: The y axis label should be "Probability density function" (or Residence time distribution) with unit of s^{-1} , not "probability distribution function". In figure caption, "The average RTD values were also estimated here" → "The mean (average) residence times are also shown here". The calculation of the mean residence time is not an estimate, but a well-defined property of the RTD.

p. 15 l. 456: RTD distributions → RTDs

p. 15 l. 460: reaction rates, concentrations of

p. 16 l. 467: "very minor to negligible impact on the gas-phase reactions". This is too strong a statement since only a limited set of gases and their reaction pathways was studied.

p. 16 l. 485: per ($^{\circ}C$ second) → $s^{-1}C^{-1}$

p. 16 l. 487: mass loss of ~32% for ambient OA

p. 17 l. 492: "might" is unnecessary here

p. 17 l. 519-520: unclear sentence

p. 17 l. 521: "Using a constant yield for HOMs..." → "The constant yield for HOMs used in this model might..."

p. 18 l. 534: "As the detailed..." → "The detailed..."

p. 19 l. 557-558: Unclear sentence. Consider e.g. "Increasing H_{vap} increases the sensitivity of SOA formation to temperature".

p. 19 l. 561: what does "based on different species and temperature" mean?

p. 19 Fig. 11: Is the $30 \mu\text{g}/\text{m}^3$ the inlet concentration? And is the x-axis in panels b and d the inlet concentration of OA?

p. 19 Fig. 12: "the ambient OH concentration"

p. 20 l. 572-573: "which shows varied extents for different precursors and reaction conditions" – what does this mean?

p. 20 l. 573: decreased → decreased

p. 20 l. 583: reducing → reduce

p. 20 l. 590: deduction → reduction

p. 20 Fig. 13: bellowing → blowing

p. 22 l. 621: trends → hystereses ?

p. 22 l. 639-640: is the shorter residence time really due to accelerated diffusion?