

General Remarks:

The manuscript fits the scope of the journal and is of scientific relevance to the community. As the manuscript title suggests, the study provides insight into organic aerosols as emitted primarily from gasoline vehicles (1x Euro 4 and 1x Euro 1) and reports on the secondarily formed organic aerosol (SOA) mass upon photo oxidation in a smog chamber. The tested gasoline vehicles are operated in China with Euro III compliant gasoline fuel. Modern state-of-the art instrumentation is used in the investigations. The article is well structured, and provides additional data for the community, adding to the statistics on gasoline vehicle SOA formation. This is of significance, as previous publications (Nordin et al., 2013, Platt et al., 2013, Platt et al., 2014, Gordon et al., 2014, May et al. 2013ab, and others) have shown large error bars on gasoline vehicle SOA formation estimations, and additional data help to constrain gasoline vehicle SOA formation further. However, I disagree with the repeated statements in the abstract, introduction and conclusions, that these experiments are representative of Chinese vehicles compared to previous experiments, due to (1) limited experimental conditions, and (2) the limited number of tests conducted (5 tests with 2 vehicles). However, in general, the results lie within previous findings (note that I do feel that an extended comparison with existing literature is recommended, see references mentioned above) and support the overall statistical quality of the data, despite the fact, that no significantly new conclusions are found. I believe before publication the authors should clearly state that the numbers reported are only valid for the tested cars and more data would be required to constrain the Chinese vehicular emissions.

Reply: As shown in the revised manuscript, aromatic hydrocarbons contributed 22.5%-38% of the total VOCs for idling conditions in this study, within the ranges of tunnel measurements and those measured under ECE and FTP urban driving conditions (Schauer et al., 2002; Gentner et al., 2013; Wang et al., 2013). Thus the composition of exhausts for our idling case is of relevance for gasoline vehicle

emissions. Yes, our manuscript just provided valuable additional data to the statistics on gasoline vehicle SOA formation. As replying to another reviewer, we admit that number of tests is quite limited. We have mentioned this in the revised manuscript.

Specific Remarks: Experimental Methods and Data Analysis:

While the data support the current literature, the experimental methods and sample size lead to limited results that are not globally representative and should not be used to draw global conclusions, e.g. on the vehicle fleet in China. The reason for stating the limited scope of the study is, that it relies on replicates (2 - 3x) of only two measurements of idling gasoline vehicles (1x Euro 4, 1x Euro 1), excluding the influence of different driving behavior and technologies. In addition, problems with the experimental set-up and the data processing have to be pointed out. The following major points regarding the experimental set up and data analysis must be addressed before I could recommend publication:

Q1- Sampling lines were unheated Teflon, and samples were taken through a pump: this will lead to losses of (1) primary particles through electrostatic losses, and (2) VOCs, IVOCs and SVOCs via adsorption on the Teflon surface; In addition, there might be significant losses in the pump. Could the authors add estimations for particle and gas-phase losses in the sampling system, or give more information on the operation of the pump and how this will affect the sample taken into the smog chamber? (Losses are potentially indicated by the small starting particle number concentration in the smog chamber). Please provide starting concentrations in SI.

Reply: We agree that losses in unheated transfer lines are important considerations. Therefore, a flow rate of as high as 20 L min^{-1} and a transfer line of as short as 5 m were used to provide residence time within seconds, and thus reduce the losses of particles and VOCs in the transfer lines. Furthermore, before being introduced into the reactor, gasoline vehicle exhausts were generally pumped through the transfer lines for half an hour to saturate the transfer lines with particles and VOCs while warming the catalytic converter. Losses of particles and VOCs in the introduction lines were determined by comparing the concentrations of total particle number and VOCs in the

directly emitted exhausts and the ones after passing through the transfer lines. As shown in Figure 1, the distributions of particle number in the directly emitted exhausts and the ones after passing through the transfer lines were similar. The loss of total particle number was estimated to be less than 3%. The penetration efficiency of particles in the transfer line was also estimated by a laminar diffusional deposition model (Gormley and Kennedy, 1949). For particles with diameters larger than 10 nm, the penetration efficiency was higher than 95%, indicating minor losses of particles in the transfer line. The losses of VOCs in the transfer line were estimated to be less than 5%, which might lead to a small underestimation of SOA production. The initial particle number concentrations were provided in SI. Primary particle numbers in the reactor in this study ranged from 82 to 18948 cm⁻³, 1-2 orders of magnitude higher than that of a Euro 2 car operated at idling with a similar dilution ratio (Nordin et al., 2013), indicating that the small starting particle number concentration might mainly due to the idling condition of tested cars rather than the losses in the introduction lines. In addition, upon entering into the chamber, emitted particles would partition due to dilution similar as in the atmosphere, regardless of the temperature and concentration in the sampling system, which might lead to the decrease of starting number concentrations. A certain extent of primary particles under the detection limit of 14 nm of SMPS also contributed to the measured small starting number concentration of particles.

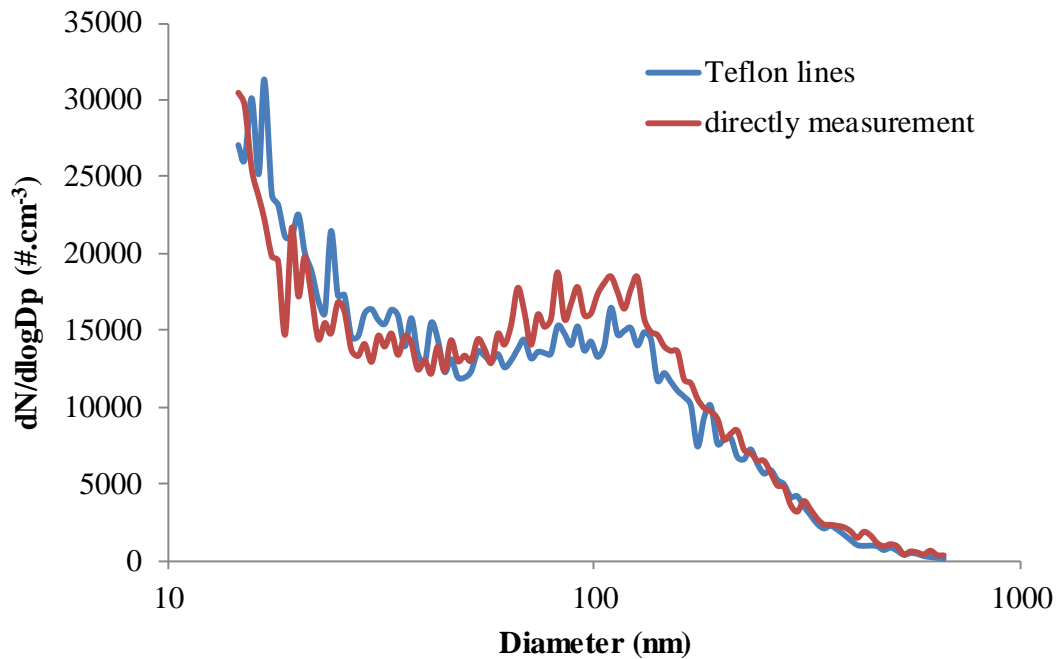


Figure 1. Particle number distributions of the directly emitted exhausts and the ones after passing through the transfer lines.

The following text has been added to the revised manuscript.

“During the introduction of exhausts, particles and VOCs might deposit to the surface of the transfer lines. Therefore, a flow rate of as high as 20 L min^{-1} and a transfer line of as short as 5 m were used to provide residence time within seconds, and thus reduce the losses of particles and VOCs in the transfer lines. Furthermore, before being introduced into the reactor, exhausts were generally pumped through the transfer lines for half an hour to saturate the transfer lines with particles and VOCs while warming the catalytic converter. Losses of particles and VOCs in the introduction lines were determined by comparing the concentrations of total particle number and VOCs in the directly emitted exhausts with the ones after passing through the transfer lines. The loss of total particle number was estimated to be less than 3%. The penetration efficiency of particles due to diffusion in a cylindrical tube, $\eta(dp)$, can be also estimated by a laminar diffusional deposition model (Gormley and Kennedy, 1949). For particles with diameters larger than 10 nm, the penetration efficiency was higher than 95%, indicating minor losses of particles in the transfer line. The losses of VOCs in the transfer line were estimated to be less than 5%, which

might lead to a small underestimation of SOA production.”

Q2- Nucleation is observed upon photooxidation, which points to the fact that there was not enough seed aerosol surface available in the smog chamber; potential losses of vapors to chamber walls should be taken into account. Can the authors estimate the starting seed aerosol surface? (Section 3.2, Page 10565, Line 11 – 17, “As shown in Fig. 5c, the total particle number concentration increased fast from 82 to 116143 cm⁻³ in approximately 10 min, indicating dramatic new particle formation. After nucleation occurred, the mean diameter increased from 20 to 60 nm).”

Reply: As shown in the Table below, which is now the Table S1 in SI, the starting surface concentrations of particles were all below a critical value (100–2000 μm² cm⁻³) (Wehner et al., 2004), which benefited the formation of new particles. The wall loss rate coefficient of vapors is related with the numbers of carbon and oxygen in the molecule (X. Zhang et al., 2015). Here, we take C₇H₈O₄, a product of the photo-oxidation of toluene as an example. The loss of C₇H₈O₄ to walls would be 7% in an hour before SOA formation when a wall deposition rate of 2 × 10⁻⁵ s⁻¹ was used (X. Zhang et al., 2015). After SOA formation, the surface concentrations of particles increased fast to as high as 2000 μm² cm⁻³ in an hour, which would reduce the vapor wall losses. The sentence “As shown in Fig. 5c, the total particle number concentration increased fast from 82 to 116143 cm⁻³ in approximately 10 min, indicating dramatic new particle formation. After nucleation occurred, the mean diameter increased from 20 to 60 nm). (Section 3.2, Page 10565, Line 11 – 17)” has been revised and now reads:

“As shown in Fig. 3c, the total particle number concentration increased fast from 82 to 116143 cm⁻³, indicating dramatic new particle formation, which might be due to that the starting surface concentrations of particles were all below a critical value (100–2000 μm² cm⁻³, Table S1) (Wehner et al., 2004). As shown in Table S1, primary particle numbers in the reactor in this study ranged from 82 to 18948 cm⁻³, 1-2 orders of magnitude higher than that of a Euro 2 car operated at idling with a similar dilution ratio (Nordin et al., 2013), indicating that the small starting particle number concentrations might mainly due to the idling condition of tested cars rather than the

losses in the introduction lines. In addition, upon entering into the chamber, emitted particles would partition due to dilution similar as in the atmosphere, regardless of the temperature and concentration in the sampling system, which might lead to the decrease of starting number concentrations. A certain extent of primary particles under the detection limit of 14 nm of SMPS also contributed to the measured small starting number concentration of particles.

Deposition of SOA-forming vapors to the walls might lead to the underestimation of SOA production. The wall loss rate coefficient of vapors is related with the numbers of carbon and oxygen in the molecule (X. Zhang et al., 2015). Here, we take $C_7H_8O_4$, a product of the photo-oxidation of toluene as an example. The loss of $C_7H_8O_4$ to walls would be 7% in an hour before SOA formation when a wall deposition rate of $2 \times 10^{-5} \text{ s}^{-1}$ was used (X. Zhang et al., 2015). After SOA formation, the surface concentrations of particles increased fast to as high as $2000 \mu\text{m}^2 \text{ cm}^{-3}$ in an hour, which would reduce the vapor wall losses.”

Table S1. The initial number and surface concentrations of particles at $t = 0$ h (since lights on) in each experiment.

Experiment #	Number (cm^{-3})	Surface ($\mu\text{m}^2 \text{ cm}^{-3}$)
1	114	2.23
2	82	2.9
3	332	4.7
4	337	4.2
5	18948	25.8

Q3- Problems with the AMS/SMPS analysis are indicated: Figure 2 presents SMPS size distribution from a HR-ToF-AMS. Likely a big fraction of the mass as measured with the HR-ToF-AMS is actually outside the optimum transmission efficiency of the lens. No direct correction for lens transmission was applied, but the authors scaled AMS data with SMPS data. However, lens transmission issues are not discussed in section 2.2. and 2.4.2. I recommend adding this to the manuscript. Additionally, I would like to ask the authors to clarify how refractory particulate matter (elemental carbon) has been taken into account in the analysis, or discuss, why it was assumed

that the vehicle exhaust studied in the smog chamber consist only of non-refractory material.

Reply: Figure 2 (to be included in SI as Fig. S2) shows the particle volume distribution measured by SMPS for a typical smog chamber experiment (experiment 2). As shown, most particles were in the range 40-120 nm after SOA formation. Since the transmission window of the standard lens of HR-TOF-AMS is 60-600 nm (aerodynamic diameter) (Liu et al., 2007), particles with diameter lower than 40 nm (mobility diameter) were cut from the lower edge of the volume distribution. After 1 h since nucleation occurred, only <5% of the mass was outside the transmission window of HR-TOF-MS, indicating that HR-TOF-AMS might underestimate the PM in the early stage of SOA formation.

The following text has been added to the revised manuscript.

“Fig. S2 shows the particle volume distribution measured by SMPS for a typical smog chamber experiment (experiment 2). Most particles were in the range 40-120 nm after SOA formation. Since the transmission window of the standard lens of HR-TOF-AMS is 60-600 nm (aerodynamic diameter) (Liu et al., 2007), particles with diameter lower than 40 nm (mobility diameter) were cut from the lower edge of the volume distribution. After 1 h since nucleation occurred, only <5% of the mass was outside the transmission window of HR-TOF-MS, indicating that HR-TOF-AMS might underestimate the PM in the early stage of SOA formation.”

Theoretically, the difference of PM mass measured by AMS and SMPS should be attributed to black carbon. As shown in Fig. S3 in the SI, the initial mass of PM measured by SMPS was comparable with that measured by HR-TOF-AMS, thus we assumed that the mass of black carbon (BC) in the reactor was negligible.

The following text has been added to the revised manuscript.

“As shown in Fig. S3, the mass of primary particles measured by SMPS was comparable with that measured by HR-TOF-AMS, thus we assumed that the mass of black carbon (BC) in the reactor was negligible.”

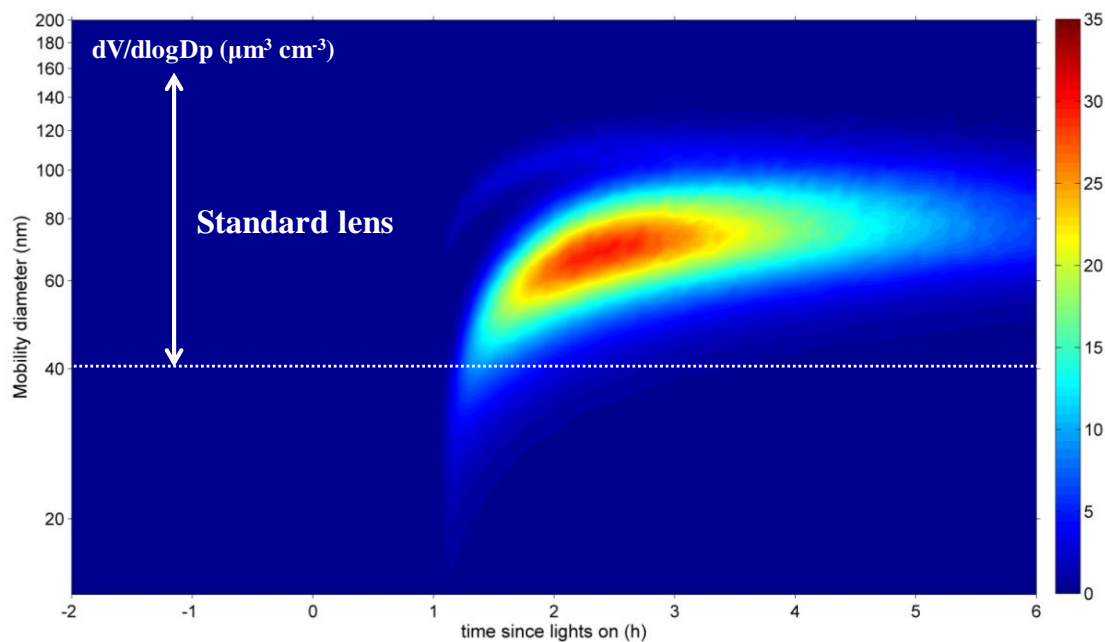


Figure 2. Particle volume distribution measured by SMPS for a typical smog chamber experiment (experiment 2).

Q4- Offline samples were taken with different systems (e.g. aluminum foil bags, stainless steel containers). Please clarify which systems were applied when, and which analysis was performed. I expect significant losses for SOA precursors on stainless steel surfaces (see e.g. section 2.4.3, page 10563, line 13). Did results from offline samples compare well with online PTR-ToF-MS results (please add this to section 3.1).

Reply: Raw exhausts were collected into aluminum foil bags with VOCs and CO₂ analyzed to characterize the primary emissions from exhaust pipe. At the beginning and end of each experiment, air samples in the reactor were collected into evacuated 2 L stainless steel canisters and analyzed by GC-MSD to determine the mass of reacted organic precursors. The sampling and analysis methods have been clarified in the revised manuscript. The inner surfaces of the canisters has been electropolished and passivated to eliminate absorption of VOCs. This method has been widely used to collect VOCs samples (Barletta et al., 2005). In addition, samples in canisters were analyzed immediately after collection. We believe that our sampling and analysis methods accurately measure VOCs in the chamber. The text “evacuated 2 L stainless

steel canisters” has been revised to “2 L electropolished and evacuated stainless steel canisters” in the revised manuscript.

In this study, GC-MS was the standard method to determine the mass concentrations of single-ring aromatics. PTR-TOF-MS was used for deriving the time-resolved concentrations of single-ring aromatics. In addition, the VOC concentrations measured offline were also used as an independent check of that measured online by the PTR-TOF-MS. The following text has been added to the revised manuscript to clarify:

“In this study, the offline measurement was the standard method to determine the mass concentrations of VOCs. PTR-TOF-MS was used for deriving the time-resolved concentrations of VOCs.”

Q5- Estimation of yields: Relatively low yields are found (3–17%), compared to previous publications on gasoline vehicles tested on driving cycles. Please provide extended discussion on potential reasons, and clarify how significant losses of IVOCs and SVOCs compared to VOCs in the unheated Teflon lines used for sample introduction and in the stainless steel containers used for sample collection would skew these results.

Reply: The effective SOA yields in the study of Nordin et al. (2013) were 60%-360% higher than those in this study at same concentrations of M_0 . In their calculation of the reacted SOA precursors, C4-benzene and naphthalene were excluded. The effective SOA yields would increase 7%-34% when C4-benzene and naphthalene were excluded in this study, which could explain a small portion of the discrepancy. According to the estimation above, the loss of VOCs in the transfer lines was less than 5%. A little higher than VOCs, if assumed to be 20%, losses of IVOCs and SVOCs in the transfer lines would increase the SOA effective yields by a factor of 2%-10% when the unexplained SOA discussed later was all attributed to the contribution from IVOCs and SVOCs. The existence of seed particles in the study of Nordin et al. (2013) might reduce the wall loss of semi-volatile organic vapors and thus increase the effective SOA yield (Kroll et al., 2007; Zhang et al., 2014; X. Zhang et al., 2015). However, Cocker et al. (2001) found that SOA formation from m-xylene and

1,3,5-trimethylbenzene photo-oxidation was unaffected by the presence of ammonium sulfate seed aerosols. The influence of seed particles on SOA yields still needs further investigations. The discussion in the manuscript has been rewritten and now reads:

“The effective SOA yields in the study of Nordin et al. (2013) were 60%-360% higher than those in this study at same concentrations of M_0 . In their calculation of the reacted SOA precursors, C4-benzene and naphthalene were excluded. The effective SOA yields would increase 7%-34% when C4-benzene and naphthalene were excluded in this study, which could explain a small portion of the discrepancy. According to the estimation above, the loss of VOCs in the transfer lines was less than 5%. A little higher than VOCs, if assumed to be 20%, losses of IVOCs and SVOCs in the transfer lines would increase the SOA effective yields by a factor of 2%-10% when the unexplained SOA discussed later was all attributed to the contribution from IVOCs and SVOCs. The existence of seed particles in the study of Nordin et al. (2013) might reduce the wall loss of semi-volatile organic vapors and thus increase the effective SOA yield (Kroll et al., 2007; Zhang et al., 2014; X. Zhang et al., 2015). However, Cocker et al. (2001) found that SOA formation from m-xylene and 1,3,5-trimethylbenzene photo-oxidation was unaffected by the presence of ammonium sulfate seed aerosols. The influence of seed particles on SOA yields still needs further investigations. Faster oxidation rates caused by higher OH concentrations in the study of Nordin et al. (2013) would also result in higher SOA yields (Ng et al., 2007).”

Specific Remarks: Language / Formulations:

Q6-Abstract: - Please remove the sentence “However, there are still no chamber simulation studies in China on SOA formation from vehicle exhausts” (Line 4-5) as it is not of significance in which country laboratory experiments are performed.

Reply: revised as suggested.

Q7- Please add “operated” to “in China” in Line 7, so that the sentence reads “. . . operated in China . . .”

Reply: revised as suggested.

Q8-Please reformulate “at the quite similar OH exposure” to “at comparable OH

exposure”.

Reply: revised as suggested.

Q9-Section 1, Introduction: - Section 1, Page 10557, Line 13: please reformulate or remove; see comments on Abstract.

Reply: The sentence has been removed and now the paragraph reads: “In China, the number of LDGVs reached 98.8 million in 2012 and increased.....”

Q10- Section 1, Page 10557, Line 26, please reformulate; see comments on Abstract.

Reply: Revised as “*operated in China*”.

Q11- Section 2, Materials and methods: - Please add a section on derivation of OH exposure to Materials and methods.

Reply: A section on the derivation of OH exposure has been added to the revised manuscript as below:

“Decay of toluene measured by PTR-TOF-MS is used to derive the average OH concentration during each experiment. Changes in the toluene concentration over time can be expressed as:

$$\frac{d[\text{toluene}]}{dt} = -k \cdot [\text{OH}] \cdot [\text{toluene}] \quad (3)$$

where k is the rate constant for the reaction between toluene and OH radical.

Assuming a constant OH concentration during an experiment, we can integrate Eq. (3)

to get Eq. (4):

$$\ln\left(\frac{[\text{toluene}]_0}{[\text{toluene}]_t}\right) = k \cdot [\text{OH}] \cdot t \quad (4)$$

So by plotting $\ln([\text{toluene}]_0/[\text{toluene}]_t)$ versus time t , we can obtain a slope that equals $k \times [\text{OH}]$. The average OH concentration is therefore calculated as:

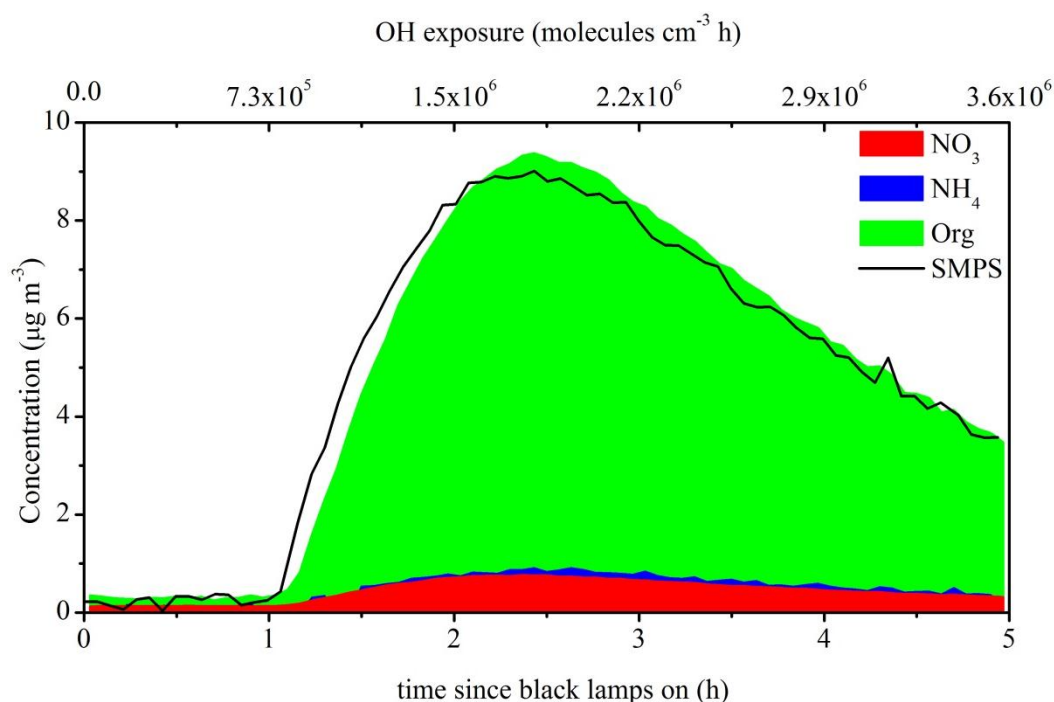
$$[\text{OH}] = \frac{\text{slope}}{k} \quad (5)$$

The OH exposure is then determined through multiplying the average OH

concentration by time.”

Q12- Section 2.4.2., please move Fig 2 and 3. to SI and provide the integrated OH exposure as additional time axis.

Reply: As suggested we have moved Fig 2 and 3 to SI, and provided the integrated OH exposure in Fig 3 (now Fig. S3) as follows:



Q13- Section 2.4.2, please clarify how refractory particulate matter (elemental carbon) has been taken into account in the analysis, or discuss, why you assume that the vehicle exhaust studied in the smog chamber consist only of non-refractory material.

Reply: This question has been addressed in Q3.

Q14- Section 2.4.2, please clarify that the discrepancy between SMPS and AMS derived mass in the presented experiments also results from different size-dependent measurement cut-offs (you mention very small particle size of at least the primary particles, which are well below the optimum lens transmission of the AMS), and not only from AMS collection efficiency.

Reply: This question has been addressed in Q3.

Q15- Section 2.4.2, page 10562, line 12: please remove “the two”, the sentence should read: “However, both methods have limitations”.

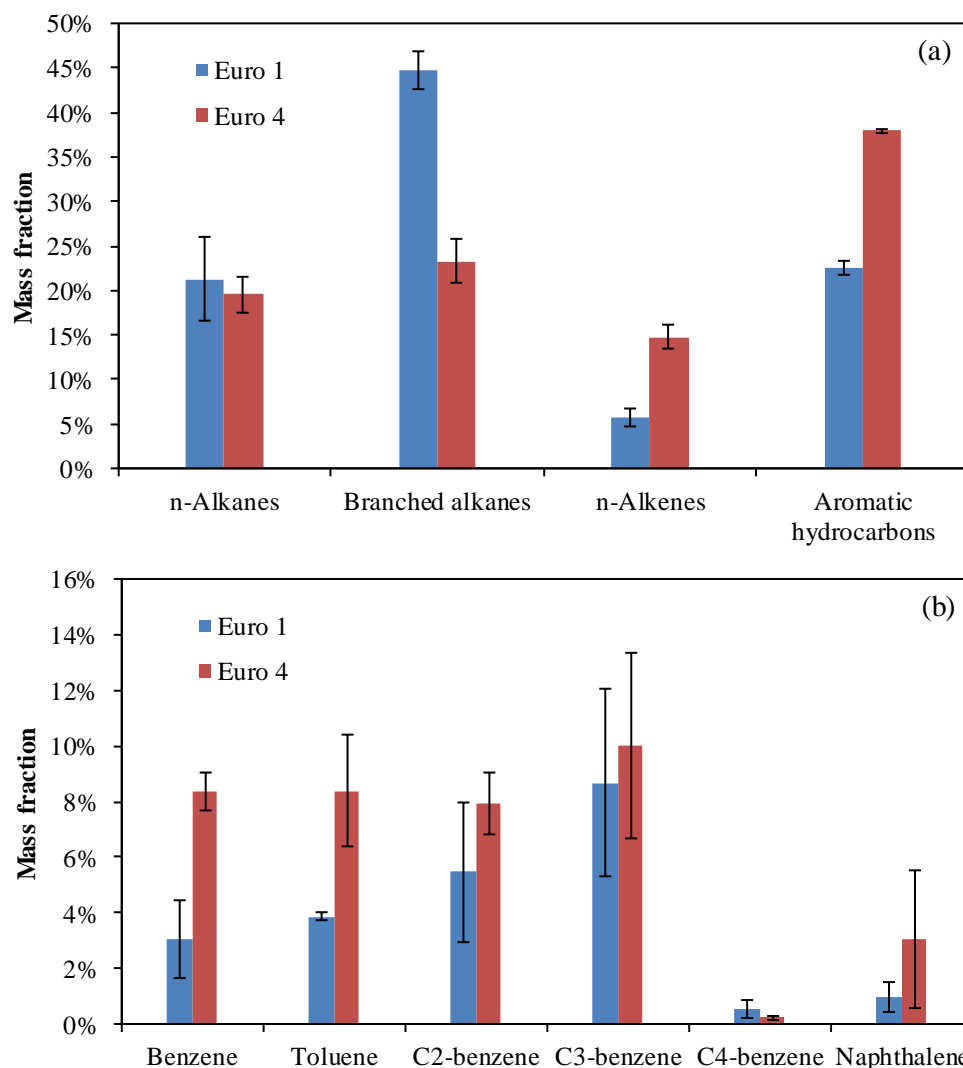
Reply: revised as suggested.

Q16- Section 2.4.3, line 13 (page 10563), please specify “simulating air”.

Reply: “simulating air” was changed to “*air samples*” in the revised manuscript.

Q17- For all data presented in Tables and Figures: where data are available, please add error bars to the data and indicate which kind of averaging method has been applied to the data of different experiments.

Reply: Uncertainties for temperature and relative humidity were presented in Table 2 in the revised manuscript. Error bars of NMHCs measurements were added to Fig. 4 (now Fig. 2 in the revised manuscript) as follows:



Q18- Please use either NMHC or VOC in the manuscript for purpose of consistency, and specify the measurement principle (GC-FID or GC-MSD or PTR-TOF-MS where needed, e.g. in Table 2, 3, 5, and Figure 4 and 5.

Reply: NMHCs were changed to “VOCs” throughout the revised manuscript. The

sentence “C2-C3 and C4-C12 hydrocarbons were measured by GC-FID and GC-MSD, respectively.” was added to the revised manuscript. The measurement principle has been specified.

Q19- Section 3.1, line 11-13 and line 18-19, please compare the results with Huang et al., 2015, ACPD (doi:10.5194/acpd-15-7977-2015), and other literature to narrow down whether fuel, vehicle type or emission standards are causing the difference in the two vehicles, or whether the difference lies within the statistical range. Previous publications have shown a wide spread in vehicle emissions for different vehicles and test conditions, and a comparison of 1 vehicle to another to conclude for a whole class of vehicles from one emission standard is not justified.

Reply: The discussion has been extended in the revised manuscript and also presented here.

Change “Aromatic hydrocarbons accounted for about...vehicle type and emission standard” to “Aromatic hydrocarbons accounted for about 38.0% and 22.5% of the total VOCs for Euro 4 and 1 vehicle, respectively, relatively higher than 10-15% observed by Nordin et al. (2013) for idling Euro 2, 3 and 4 vehicles. The mass fraction of aromatic hydrocarbons for Euro 4 vehicle was comparable with 32.2% for idling private cars in Hong Kong (Guo et al., 2011) and 38.3% for Euro 3 light-duty gasoline vehicles operated through ECE cycles with an average speed around 18.7 km h⁻¹ (Wang et al., 2013). Both Schauer et al. (2002) and Gentner et al. (2013) observed that aromatic hydrocarbons contributed around 27% of the total VOCs for gasoline-powered automobiles driven through the cold-start Federal Test Procedure urban driving cycle and on-road gasoline vehicles in the Caldecott tunnel, similar with that of Euro 1 vehicle in this study. Recently, Huang et al. (2015) reported that mass fractions of aromatic hydrocarbons were as high as 46.4% for Euro 1, 2, and 3 light-duty gasoline vehicles operated through ECE cycles. Therefore, the variations of the composition of LDGV exhausts in this study were within the range of previous studies.”

Add “Using 7.87 L/100 km as the average fuel efficiency (Wagner et al., 2009), we obtained the VOCs emission factors based on g km⁻¹ for Euro 4 and 1 vehicle to be

0.12 and 0.46 g km⁻¹, respectively, comparable with the previous reported values for Euro 1 and 4 gasoline vehicles in China (Huo et al., 2012; Huang et al., 2015). According to previous studies, there is a clear reduction of VOCs emissions from gasoline vehicles with stricter emission standards (Huo et al., 2012; Huang et al., 2015).” before “It is worth noting that...”

Q20- Section 3.1, the authors have used a PTR-TOF-MS in the course of the study. I suggest adding a comparison of GD-FID/MSD data with PTR-TOF-MS data to this section.

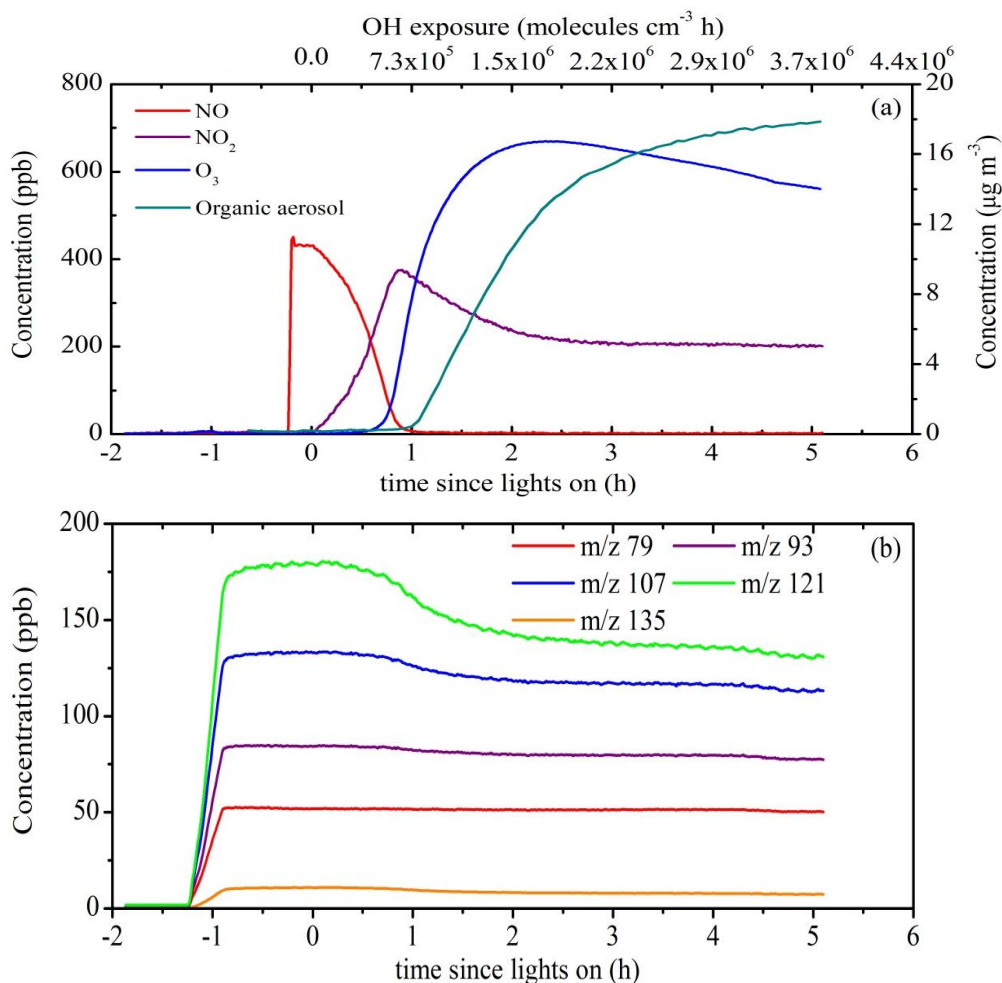
Reply: This question has been addressed in Q4.

Q21- Section 3.1, I suggest to include information in Table 5 into Figure 4, and remove Table 5 or provide in SI.

Reply: Additional information in Table 5 was added to Figure 4, now Fig. 2 in the revised manuscript, also shown in Q17.

Q22- Section 3.2, Fig 5ab: please provide also the integrated OH exposure as time axis in addition to the “time since lights on” in the Fig.

Reply: The integrated OH exposure was added as time axis to Fig 5ab (now Fig. 3ab).



Q23-I suggest to discuss Fig. 5c and the statement in section 3.2, page 10565, line 11 – 14, “As shown in Fig. 5c, the total particle number concentration increased fast from 82 to 116 143 cm⁻³ in approximately 10 min, indicating dramatic new particle formation. After nucleation occurred, the mean diameter increased from 20 to 60 nm in about 1.5 h” as a potential limitation of the study, rather than a result. Rather than this being a significant result of the investigations, the fact that nucleation occurs during these experiments points to experimental weakness of the study, which is, that no sufficient aerosol seed surface is provided. This can lead to significant losses of vapors to chamber walls, as demonstrated in recent publications (Zhang, et al., 2014). In addition, the small starting particle number concentration in the smog chamber (82 cm⁻³), points to significant losses during sampling into the smog chamber.

Reply: This question has been addressed in Q1 and Q2.

Q24- The statement in section 3.2, page 10565, line 14 – 17 “Because particles with diameters larger than 50 nm can act as cloud condensation nuclei (CCN) (Mc Figgans

et al., 2006) and influence the radiative forcing, SOA from vehicle exhausts may have climate effects to a certain extent as well as air quality effects.” should be removed, unless the authors can provide experimental evidence.

Reply: This sentence has been removed in the revised manuscript.

Q25- Section 3.2, page 10565, please reformulate Line 18 to “SOA production factors (PF) for the LDGVs tested in this study” instead of “for LDGVs in China”.

Reply: revised as suggested.

Q26-Section 3.2, page 10565, Line 25 onwards (“Decay of toluene . . .”): the section on estimation of OH exposure should be moved to “Materials and methods”.

Reply: revised as suggested.

Q27- Section 3.3: Table 3 and Figure 7 present essentially the same information. Please include additional information provided in Table 3 into Figure 7 and remove Table 3 or provide Table 3 in SI.

Reply: Table 3 has been moved to SI.

Q28- Section 3.3: Table 4: please provide some extended discussion on why the yields observed in the smog chamber are around 3% for vehicle II and 10 – 20% for vehicle I. Please link the difference in the yield with the chemical composition of the precursor gases to find an explanation.

Reply: The discussion has been extended in the revised manuscript and also presented here.

“As shown in Table 3, SOA yields for Euro 1 vehicle were around 3%, quite lower than 10%-17% for Euro 4 vehicle. The mass fraction of aromatic hydrocarbons for Euro 4 vehicle was about two times higher than that for Euro 1 vehicle (Fig. 2a), which would form more semi-volatile organic compounds (SVOCs) partitioning into particle phase under similar OH exposure and thus lead to the relatively higher SOA yields.”

Q29-Section 4, Conclusions: I recommend removing this section fully, as no real conclusions are drawn and a summary of the results and discussion section is superfluous.

Reply: This section has been removed as suggested.

References

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