REVIEWER COMMENT #1:

In "The impact of CO on secondary organic aerosols formed from the mixture of α-pinene and n-dodecane" Xie et al. present results from smog chamber experiments investigating the formation of secondary organic aerosol (SOA) from 3 different systems of precursors (two single-precursor systems and the mixed system) and each with and without CO added. Each added level complexity represents slightly more realism. NOx, ozone and UV illumination facilitate photochemical oxidation of the precursors. Concentration ratios of precursors to NOx and total precursor OH reactivities are chosen to be more or less constant in the initial mixtures. That approach plus an appropriate set of instrumentation (most importantly mass spectrometers to investigate SOA composition) allow the authors to hypothesize how differences in the mixtures modify radical chemistry as well as SOA yield.

Commendable features/highlights of the paper are the nice figures (including good use of distinctive colors for the 3 different aerosol precursor systems), and the candid discussion of the challenges in attempting to obtain similar conditions across experiments, in particular in terms of oxidant and radical concentrations when changing precursor mixtures, even if certain initial ratios can be controlled.

All in all, I judge the paper of high quality and good interest for the readership of Atmospheric Chemistry & Physics. I recommend its acceptance subject to minor revisions in consideration of my comments below. The comments generally call for a bit more clarity or slightly extended discussion (adding a few details, considering minor restructuring).

Line numbers refer to the preprint PDF.

Main comments:
1)

I wonder if the authors could briefly hypothesize, how changes in RO2 pathways (or other chemistry) between the different systems could relate to the observed changes in SOA yields?
2)

The DMPS is presented as part of the instrument line-up. But I do not recall any of its measurement results being presented or even discussed. How were its data used? Would it be worth discussing its results?
3)

Section 2.2: Precursor mixture ratios were chosen according to OH reactivity. Is it possible to assess, how relevant the resulting mixtures then are to atmospheric conditions?

4)

If Table 1 reports mean values over several experiments for each "experiment number", that should be somehow communicated within Table 1 (or its caption). And standard deviations shown.

Related to that, for Fig. 1:

- It should be clarified how many repeat experiments were done for each system.

- I believe Fig. 1 would work better if the (d) plots were incorporated into panel (c), either as a combined 3rd panel, or as purple lines into the existing (c)-panel plots.

- I would also more explicitly state that time 0 is the start of step iii (lights on, I guess)
5)

Section 4, L534: What instrumental limitations specifically? Figs. 2-4 suggest that accretion product concentrations do indeed decrease in the CO-added cases. Wouldn't the data shown there directly allow for making quantitative assessments?

6)

Sections 5 + 6: The last two sections confused me a bit. Section 6 ("Conclusions") is rather a summary (minus the last short paragraph), whereas Section 5 ("Implications") seems more like the conclusions I would have expected from Section 6.

To improve flow and readability, I suggest swapping those two sections (probably making that last paragraph in the current Section 6 superfluous) and rename them as appropriate.

Minor comments:
Abstract: A quick summary of employed methodology could be added. Presumably measurement methods, though when reading only the abstract, the paper kind-of could be a pure modeling study too.
L22: "better" than what else?
L52: "precursors" of what?
L60: The key findings of those more recent studies should be briefly summarized as well.
L66: Only older studies are cited here, though newer ones have contributed substantially to our understanding of the role of RO2 chemistry in SOA formation (e.g., autoxidation). I suggest somewhat expanding that discussion here accordingly.
L109: (major) wavelengths of those lamps?
L113: NOx cylinder specs?
L118: what kind of aerosol generator?
L122 (and 134): what is "cyclic flushing"?
L128: how was step iii initiated?
L167: DMPS specs?
2.3.1: There must be some mistake with the temperatures, as 310 °C would probably destroy a PTFE filter rather quickly.
L183: What is that weekly "instrument background procedure"? Please explain.
L185: Similarly, why was data only analyzed for a specific section of the mass spectrum?
L198: what is the "4 min chromatography cycle"? Judging from the timings, I guess that is mistake? (L188 even implied that chromatography was not required for the Vocus PTR-MS, but if some chromatography step was included nonetheless, that should of course be described.)
L203: does "set values" refer to calculated concentrations based on what was injected into the glass bulb?
L213-214: are these values to be expected based on previous studies?
Eq. 2: what does the superscript "SUS" refer to?
L216-221: unclear what the correction is trying to achieve (correct for; or "calibrate"?)
L225: "per unit of precursor" could be confusing. I assume DeltaHC is also in units of mass (like DeltaSOA)?
L277: "170-280 Da" ... From Section 2 I had assumed that data below 200 Da was not analyzed (L185)?

... Likewise, Figs. 2 etc...
L288: "the two systems" ... please clarify what the "systems" refer to.

Technical comments:
L224: typo (measured)
L297: missing "the"
L529: check grammar

ANSWER TO REVIEWER #1:

We would like to sincerely thank the referee for carefully reviewing our manuscript and for the constructive feedback provided. The reviewer's comments are presented in **bold blue**, the authors' responses in black, any revised manuscript text is shown in *italicised red font,* and unchanged original text is shown in *italicised black font*.

In addition to the revisions made in response to the reviewers' comments, several further changes were made to improve the overall readability of the manuscript and are summarised at the end of this response.

Main comments:

1) I wonder if the authors could briefly hypothesize, how changes in RO_2 pathways (or other chemistry) between the different systems could relate to the observed changes in SOA yields?

We thank the reviewer for this suggestion.

The changes in RO_2 pathways and SOA particle mass yields differed between the single- and mixed-precursor systems.

1. Single-precursor systems

AMS measurements showed that the presence of CO led to a pronounced reduction in SOA particle and organic nitrate concentrations. Based on CIMS results, the presence of CO led to a higher relative contribution of CHON compounds and fragment species, and a reduced fraction of C_{16}–C_{24} accretion products. In addition, the relative contributions of representative RO_2 + RO_2 termination products ($C_{10}H_{14}O_n$ and $C_{12}H_{24}O_n$) decreased.

These observations indicate that i) CO reduced the contributions of RO_2 + NO reactions, but to a less extent than the competing RO_2 termination pathways, and ii) CO decreased the contributions of RO_2 + RO_2 reactions, with a more pronounced effect on longer-chain accretion products than on shorter-chain ones. CHON and fragment products are typically more volatile than ROOH and accretion products. Accretion products, particularly for those with longer carbon chains, are expected to exhibit extremely low volatility and contribute efficiently to SOA formation. Consequently, the presence of CO leads to a decrease in SOA particle mass yield in the single-precursor systems.

2. Mixed-precursor system

AMS measurements showed that organic nitrate concentrations were largely unchanged in the presence of CO compared with CO-absent conditions, whereas SOA particle mass concentrations decreased slightly. Based on CIMS results, the presence of CO did not significantly alter the proportion of CHON compounds and fragment species, and the relative contributions of C_{13}–C_{24} accretion products (excluding C_{15}) slightly decreased. In addition, the fraction of $C_{10}H_{14}O_n$ decreased, whereas the fraction of $C_{12}H_{24}O_n$ increased.

These observations indicate that the influence of CO on RO_2 termination pathways was less pronounced than in the single-precursor systems. Consequently, SOA particle mass yields behaved differently in the mixed-precursor system.

To better clarify the role of RO_2 reaction pathways and their implications for SOA particle mass yields, we have made several structural and content revisions to the manuscript:
(1) We exchanged the positions of the original Sections 4.2 ("Effect of CO on SOA particle mass yields") and 4.3 ("Effect of CO on SOA particle chemical composition"), so that the discussion of SOA particle mass yield changes is now more explicitly linked to the shifts in RO_2 reaction pathways (Line 599-616).
(2) We added a concise overview of RO_2 reaction pathways in the Introduction **(Line 51-59)**.
(3) We added a new Section 2.1, "Generic peroxy radical chemistry", to provide a clearer mechanistic framework **(Line 118-175)**.

(4) In the revised Section 4.2 (formerly 4.3), we place greater emphasis on how CO influences RO_2 reaction pathways **(Line 517-555 and 557-583)**.

Line 599-616:

In the single-precursor systems, CO substantially reduced SOA formation, with a stronger effect for n-dodecane than for α-pinene. In the presence of CO, SOA particle mass concentrations and the overall yields decreased by 83 % and 79 % for n-dodecane, and by 57 % and 43 % for α-pinene, respectively. In contrast, the mixed-precursor system exhibited only an 8 % decrease in SOA mass concentration, and the overall yield slightly increased, indicating a markedly weaker sensitivity to CO.

Chemical composition analysis indicates that, in the single-precursor systems, the contributions of accretion products derived from $RO_2 + RO_2$ termination, particularly those with longer carbon chains, decreased in the presence of CO. Because such accretion species are expected to exhibit extremely low volatility and contribute efficiently to SOA formation, their reduction constitutes an important factor in the decrease in SOA particle mass yields (Peräkylä et al., 2023). The relative contributions of CHON and fragment products increased in the presence of CO, suggesting the contribution of the RO_2 + NO reactions were decreased, but to a lesser extent than the competing RO_2 termination pathways. Compared with ROOH and accretion products formed from $RO_2 + HO_2$ and $RO_2 + RO_2$ termination, respectively, CHON and fragment products are generally more volatile. The comparatively weaker reduction in their formation is therefore expected to shift the product distribution towards higher-volatility species and may further limit SOA formation.

Compared with the single-precursor systems, changes in RO_2 reaction pathways in the mixture appear to exert a weaker influence on the formation of lower-volatility products. Consequently, SOA particle mass concentrations and yields behaved differently in the mixed-precursor system.

Competition between CO and SOA precursors for available OH also represents a factor influencing the yields. However, the impact of differences in OH concentrations on SOA particle mass yields and chemical composition cannot be fully assessed in this study. Future work may need to re-adjust OH concentrations so that the systems can be maintained at comparable oxidation stages, thereby enabling more direct comparisons (Baker et al., 2024; McFiggans et al., 2019).

Line 51-59:

Organic peroxy (RO_2) radicals play a central role in SOA formation (Kroll and Seinfeld, 2008; Ziemann and Atkinson, 2012). They can undergo bimolecular termination reactions with hydroperoxyl (HO_2) radicals, other RO_2 radicals, or nitrogen oxides ($NO_x = NO + NO_2$), as well as unimolecular termination (Atkinson, 2000; Goldman et al., 2021; Molteni et al., 2019; Ziemann and Atkinson, 2012). Recent studies have focused on the autoxidation pathways of RO_2 radicals that produce highly oxygenated molecules (HOMs), which are considered potentially important contributors to SOA formation owing to their extremely low volatility (Bianchi et al., 2019; Ehn et al., 2014; Pospisilova et al., 2020). In real atmospheric environments, the coexistence of multiple SOA precursors and various inorganic trace gases introduces additional chemical complexity into the system (McFiggans et al., 2019; Xu et al., 2015). This complexity can substantially modify RO2 reaction pathways, thereby influencing product distributions and yields.

Line 118-175:

The analysis has been informed by the prevailing generic peroxy radical chemistry. RO_2 radicals can undergo bimolecular termination reactions with HO_2 radicals, other RO_2 radicals, or NO_x, leading to the formation of closed-shell products (Atkinson, 2000; Ziemann and Atkinson, 2012).

Hydroperoxides:

$$RO_2 + HO_2 \rightarrow ROOH + O_2 \qquad R1$$

Carbonyls and alcohols:

$$RO_2 + RO_2 \rightarrow R{=}O + ROH + O_2 \qquad R2$$

Organic nitrates:

$$RO_2 + NO \rightarrow RONO_2 \qquad R3$$

Peroxynitrates:

$$RO_2 + NO_2 \rightarrow RO_2NO_2 \qquad R4$$

Accretion products:

$$RO_2 + RO_2 \rightarrow ROOR \qquad R5$$

RO_2 radicals can also undergo unimolecular reactions that lead to the formation of carbonyls (Goldman et al., 2021; Molteni et al., 2019).

$$RO_2 \rightarrow QOOH;\ QOOH + O_2 \rightarrow O_2QOOH;\ O_2QOOH \rightarrow HO_2Q{=}O + OH \qquad R6$$

QOOH is a key oxidation intermediate formed via intramolecular hydrogen abstraction by RO_2 radicals.

Besides closed-shell products, RO_2 radicals can also form RO radicals (Orlando et al., 2003).

$$RO_2 + NO \rightarrow RO + NO_2 \qquad R7$$

$$RO_2 + HO_2 \rightarrow RO + OH + O_2 \qquad R8$$

$$RO_2 + RO_2 \rightarrow RO + RO + O_2 \qquad R9$$

HOMs are formed via autoxidation pathways of RO_2 radicals (Bianchi et al., 2019; Goldman et al., 2021).

$$RO_2 \rightarrow QOOH;\ QOOH + O_2 \rightarrow O_2QOOH \qquad R10$$

These reaction pathways compete with one another, thereby influencing the distribution of products.

α-Pinene photooxidation is expected to produce $C_{10}H_{15}O_x$ and $C_{10}H_{17}O_x$ as major RO_2 families. The $C_{10}H_{17}O_x$ family is initiated via OH addition to α-pinene (Berndt et al., 2016; Jenkin et al., 1997; Kang et al., 2025; Vereecken and Peeters, 2004). $RO_2 + HO_2$ termination (R1) of $C_{10}H_{17}O_x$ forms $C_{10}H_{18}O_n$ hydroperoxides, and $RO_2 + RO_2$ termination (R2) yields $C_{10}H_{16}O_n$ carbonyls and $C_{10}H_{18}O_n$ alcohols. Unimolecular termination (R6) of $C_{10}H_{17}O_x$ generates $C_{10}H_{16}O_n$ carbonyls. The $C_{10}H_{15}O_x$ family is formed via hydrogen abstraction from α-pinene or from first-generation oxidation products (e.g. pinonaldehyde), as well as directly from ozonolysis through the vinyl hydroperoxide pathway (Jenkin et al., 1997; Johnson and Marston, 2008; Kang et al., 2025). $RO_2 + HO_2$ termination (R1) of $C_{10}H_{15}O_x$ forms $C_{10}H_{16}O_n$ hydroperoxides, whereas $RO_2 + RO_2$ termination (R2) produces $C_{10}H_{14}O_n$ carbonyls and $C_{10}H_{16}O_n$ alcohols. Unimolecular termination (R6) of $C_{10}H_{15}O_x$ generates $C_{10}H_{14}O_n$ carbonyls. $RO_2 + RO_2$ reactions (R2) between $C_{10}H_{15}O_x$ and $C_{10}H_{17}O_x$ radicals lead to the formation of $C_{10}H_{14}O_n$ carbonyls and $C_{10}H_{18}O_n$ alcohols, and/or $C_{10}H_{16}O_n$ carbonyls and alcohols.

The main RO_2 radicals expected from n-dodecane photooxidation is $C_{12}H_{25}O_x$ family (Zhang et al., 2014). $RO_2 + HO_2$ termination (R1) yields $C_{12}H_{26}O_n$ hydroperoxides, while $RO_2 + RO_2$ termination (R2) produces $C_{12}H_{24}O_n$ carbonyls and $C_{12}H_{26}O_n$ alcohols. Unimolecular termination (R6) of $C_{12}H_{25}O_x$ generates $C_{12}H_{24}O_n$ carbonyls.

In the mixture, RO_2 radicals originating from different precursors can undergo cross-reactions. Reactions (R2) between $C_{10}H_{15}O_x$ and $C_{12}H_{25}O_x$ yield $C_{10}H_{14}O_n$ carbonyls and $C_{12}H_{26}O_n$ alcohols or $C_{12}H_{24}O_n$ carbonyls and $C_{10}H_{16}O_n$ alcohols. Similarly, reactions (R2) between $C_{10}H_{17}O_x$ and $C_{12}H_{25}O_x$ lead to the formation of $C_{10}H_{16}O_n$ carbonyls and $C_{12}H_{26}O_n$ alcohols, or $C_{12}H_{24}O_n$ carbonyls and $C_{10}H_{18}O_n$ alcohols.

RO radicals formed via reactions R7–R9 can subsequently undergo unimolecular decomposition, isomerisation, or react with O_2 (Orlando et al., 2003). Reaction of RO radicals with O_2 leads to the formation of carbonyl compounds and HO_2 radicals:

$$RO + O_2 \rightarrow R'CHO + HO_2 \qquad R11$$

RO radicals derived from $C_{10}H_{15}O_x$ can form $C_{10}H_{14}O_n$ carbonyls via this pathway, whereas RO radicals derived from $C_{12}H_{25}O_x$ yield $C_{12}H_{24}O_n$ carbonyls.

Theoretically, $C_{10}H_{14}O_n$ and $C_{12}H_{25}O_n$ carbonyls can be formed via multiple pathways, including $RO_2 + RO_2$ reactions (R2), unimolecular termination of RO_2 radicals (R6), and reaction of RO radicals with O_2 (R11). However, previous studies have demonstrated that, under ambient-temperature conditions and in the presence of NO_x, unimolecular termination pathways are not expected to be dominant in RO_2 chemistry (Goldman et al., 2021;

Goss et al., 2025). In addition, RO radicals derived from α-pinene generally favour fragmentation owing to the low energy barrier for C-C bond scission (Dibble, 2001). For linear RO radicals formed from long-chain alkanes, isomerisation dominates over reactions with O_2 (Atkinson, 2007; Ziemann and Atkinson, 2012). On this basis, both unimolecular termination and RO + O_2 reactions are expected to make only minor contributions and are therefore not explicitly considered in this study.

Therefore, $C_{10}H_{14}O_n$ and $C_{12}H_{24}O_n$ species are formed predominantly via RO_2 + RO_2 reactions (R2). In contrast, $C_{10}H_{16}O_n$, $C_{10}H_{18}O_n$, and $C_{12}H_{26}O_n$ species can be produced not only through RO_2 + RO_2 reactions (R2) but also via RO_2 + HO_2 pathways (R1). Accordingly, changes in the relative abundances of $C_{10}H_{14}O_n$ and $C_{12}H_{24}O_n$ compounds are used as diagnostic indicators to assess the influence of CO on RO_2 chemistry. In general, the presence of CO is expected to reduce the relative contribution of RO_2 + RO_2 termination, which would be reflected in decreased relative abundances of $C_{10}H_{14}O_n$ and $C_{12}H_{24}O_n$ species.

Line 517-555:

The presence of CO led to several consistent changes in the chemical composition of SOA particles in both the α-pinene and n-dodecane systems, including an increased relative contribution of CHON compounds and fragment species, and a reduced fraction of C_{16}–C_{24} accretion products (Fig.2 and 4). In addition, the relative contributions of representative RO_2 + RO_2 termination products ($C_{10}H_{14}O_n$ and $C_{12}H_{24}O_n$) within CHO products decreased (Fig. 3). These observations provide evidence for a similar alteration in RO_2 fate in the presence of CO for both systems. However, owing to the limitations of I^--CIMS measurements, the absolute changes in individual reaction pathways cannot be fully constrained. The following discussion is therefore based partly on relative changes.

Organic nitrate concentrations were estimated from AMS measurements using the method described by Kiendler-Scharr et al. (2016). The results show that, in the single-precursor systems, the presence of CO led to a pronounced reduction in organic nitrate concentrations (Fig. S13). This reduction can be attributed to two main factors. First, CO competes with SOA precursors for available OH (Fig 1b and S6). Second, CO enhances HO_2 formation, introducing an additional competing sink for RO_2 and thereby altering RO_2 reaction branching. In addition, lower NO concentrations were observed in the presence of CO (Fig. S5), consistent with enhanced conversion of NO to NO_2 by HO_2. The increase in HO_2 and decrease in NO reduces the likelihood of RO_2 reacting with NO. Despite this absolute reduction, FIGAERO-CIMS results showed that the relative contribution of CHON and fragment products increased in the presence of CO (Fig. 2 and 4). CHON products are formed through the $RO_2 + NO \rightarrow RONO_2$ channel, while fragment species originate from the fragmentation of RO radicals (Atkinson, 2000; Ziemann and Atkinson, 2012). Owing to the rapid reaction of RO_2 with NO and the high branching toward RO formation, reactions of RO_2 with NO represent an important source of RO radicals under NO_x conditions (Orlando et al., 2003; Ziemann and Atkinson, 2012). These observations therefore indicates that, in the presence of CO, the contribution of the RO_2 + NO reactions were decreased, but to a lesser extent than the competing RO_2 termination pathways.

AMS measurements showed a decrease in SOA particle mass concentrations in the presence of CO (Fig. 1c). Besides OH scavenging, another important factor is that CO introduces competition between RO_2 + RO_2 and RO_2 + HO_2 reactions, thereby reducing the formation of accretion products (Baker et al., 2024; McFiggans et al., 2019; Peräkylä et al., 2023). Despite this reduction, CO did not significantly alter the overall fraction of accretion products. However, the relative contribution of C_{16}–C_{24} species decreased (Fig. 2c and 4c), accompanied by an increase in C_{11}–C_{15} species in the α-pinene system and C_{13}–C_{14} species in the n-dodecane system. Accretion products with lower carbon numbers are expected to form via pathways that involve fragmentation of RO radicals (Kang et al., 2025), and their increased relative contribution is consistent with the elevated fraction of fragment products discussed above. In contrast, longer-chain accretion products are more likely to arise from RO_2 + RO_2 reactions involving non-fragmented C_{10}/C_{12} RO_2 radicals, including reactions between non-fragmented RO_2 radicals and fragmented RO_2 radicals ($<C_{10}$), or between two non-fragmented RO_2 radicals, yielding C_{20} and C_{24} accretion products in the α-pinene and n-dodecane systems, respectively. Combined with the reduced fractions of $C_{10}H_{14}O_n$ and $C_{12}H_{24}O_n$ families (Fig. 3), these observations indicate that CO preferentially suppressed RO_2 + RO_2 chemistry, particularly pathways forming longer-chain accretion products.

Overall, in the single-precursor systems, CO reduced the contributions of both RO_2 + RO_2 and RO_2 + NO reactions. However, reactions of RO_2 with NO decreased to a lesser extent than competing RO_2 termination pathways, and the reduction in RO_2 + RO_2 termination was more pronounced for longer-chain accretion products than for shorter-chain ones.

Line 557-583:

Compared with the single-precursor systems, the influence of CO on the chemical composition of SOA in the mixed-precursor system was different. Specifically, (i) the addition of CO did not significantly alter the relative contribution of CHON compounds and fragment species (Fig. 5a-b); (ii) the relative contributions of C_{13}–C_{24} accretion products (excluding C_{15}) slightly decreased (Fig 5c); and (iii) the relative contribution of $C_{10}H_{14}O_n$ within CHO products decreased, whereas that of $C_{12}H_{24}O_n$ increased (Fig. 3).

In the mixed-precursor system, organic nitrate concentrations exhibited little variation in the presence of CO (Fig. S13), consistent with the largely unchanged relative contribution of CHON compounds and fragment species. This suggests no clear reduction in the contribution of reactions of RO_2 with NO under CO conditions.

SOA particle mass concentrations and the fraction of accretion products both decreased slightly in the presence of CO (Fig. 1c and 5), indicating a slight reduction in the contribution of RO_2 + RO_2 termination.

Moreover, CO led to a lower fraction of $C_{10}H_{14}O_n$ within CHO products in the mixture, consistent with the trend observed in the α-pinene single-precursor system. In contrast to the n-dodecane single-precursor system, however, the relative contribution of $C_{12}H_{24}O_n$ increased in the presence of CO in the mixture. Together with the increase in the fraction of C_{12} species and decrease in that of C_{10} species (Fig. S11), these observations may indicate that CO affected RO_2 + RO_2 termination involving n-dodecane-derived RO_2 less strongly than that involving α-pinene-derived RO_2.

Overall, in the mixed-precursor system, the influence of CO on RO_2 termination pathways was less pronounced than in the single-precursor systems and may have affected n-dodecane- and α-pinene-derived RO_2 to different extents.

Although the underlying mechanism cannot be fully resolved in this study, the observed changes in product distributions provide important evidence for variations in RO_2 reaction pathways in the mixed-precursor system under different conditions. As α-pinene and n-dodecane were used as representative precursors, these findings may be specific to the present system. Future chamber studies covering a broader range of precursor combinations are therefore needed to assess the generality of the observed behaviour.

2) The DMPS is presented as part of the instrument line-up. But I do not recall any of its measurement results being presented or even discussed. How were its data used? Would it be worth discussing its results?

DMPS was employed to measure seed aerosol concentrations.

Line 230-232:

*The mass concentration of seed aerosols in the 20–500 nm size range was measured using a Differential Mobility Particle Sizer (DMPS), **consisting of a Vienna-design differential mobility analyser (DMA)** coupled to a Condensation Particle Counter (CPC, model 3775, TSI Inc.) (Alfarra et al., 2012).*

3) Section 2.2: Precursor mixture ratios were chosen according to OH reactivity. Is it possible to assess, how relevant the resulting mixtures then are to atmospheric conditions?

Owing to the detection limits of the instruments, the precursor concentrations used in this study were higher than typical atmospheric levels. Nevertheless, the α-pinene to n-dodecane concentration ratio falls within the range observed in urban and roadside environments.

Line 218-219:
The α-pinene to n-dodecane concentration ratio falls within the range observed in ***urban and roadside environments*** *(Okada et al., 2012).*

4) If Table 1 reports mean values over several experiments for each "experiment number", that should be somehow communicated within Table 1 (or its caption). And standard deviations shown.

The experiments listed in Table 1 are individual experiments.

No action

Related to that, for Fig. 1:

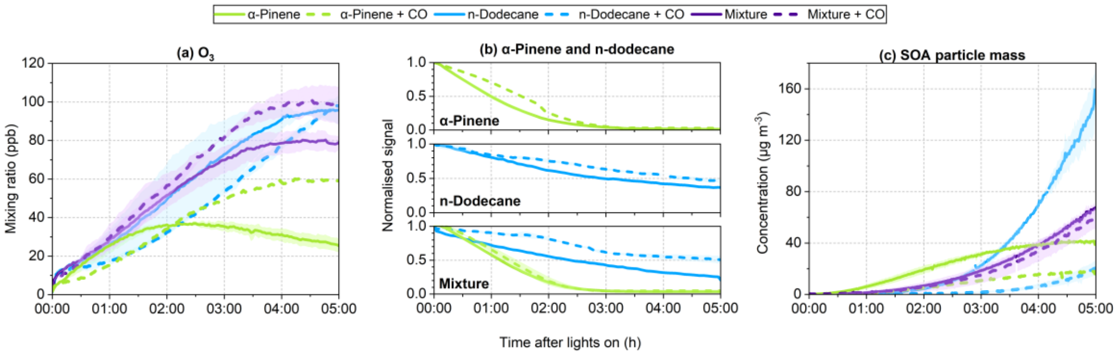
- It should be clarified how many repeat experiments were done for each system.

We thank the reviewer for this suggestion. As the number of repeat experiments differed between systems, we have clarified in the revised manuscript that the shaded area represents the envelope of the measurements from the repeat experiments listed in Table 1.

Line 311-312:
The shaded area represents the envelope of the measurements from repeat experiments ***listed in Table 1****.*

- I believe Fig. 1 would work better if the (d) plots were incorporated into panel (c), either as a combined 3rd panel, or as purple lines into the existing (c)-panel plots.

We thank the reviewer for this suggestion. In the revised figure, the former panels (c) and (d) have been combined into panel (b).



- I would also more explicitly state that time 0 is the start of step iii (lights on, I guess)

We thank the reviewer for this suggestion. We have now clarified that time 0 corresponds to the start of step iii, when the chamber lights were turned on.

Line 309-310:
Time 0 corresponds to the start of step iii (as described in Sect. 2.2), when the chamber lights were turned on.

5) Section 4, L534: What instrumental limitations specifically? Figs. 2-4 suggest that accretion product concentrations do indeed decrease in the CO-added cases. Wouldn't the data shown there directly allow for making quantitative assessments?

Owing to the lack of available calibration standards and the variability in instrument sensitivity across different oxygenated organic compounds, quantitative analysis using I^--CIMS remains challenging. Consequently, the data presented in Figs. 2-4 (now 2, 4, and 5), as well as the relevant discussion, are based on relative changes rather than absolute concentrations. For example, a decrease in accretion products refers to a reduction in their fraction within the total detected products rather than a decrease in their absolute concentration.

However, when considered alongside AMS measurements, results can be discussed in terms of absolute changes.

Line 260-262:

Owing to the lack of available calibration standards and the variability in instrument sensitivity across different oxygenated organic compounds, quantitative analysis using I^--CIMS remains challenging (Lee et al., 2014). As a result, a uniform instrument sensitivity was assumed for all detected products.

Line 361-363:

The overall ***relative*** *contribution of accretion products remained consistent at 9 % under both conditions. However, the fraction of accretion products containing 16–24 carbon atoms was lower in the presence of CO than in the absence of CO (Fig. 2c).*

Line 408-410:

While the overall ***relative*** *contribution of accretion products was comparable under both conditions, the presence of CO led to a lower fraction of accretion products containing 16–24 carbon atoms compared to the experiments without CO (Fig. 4c).*

6) Sections 5 + 6: The last two sections confused me a bit. Section 6 ("Conclusions") is rather a summary (minus the last short paragraph), whereas Section 5 ("Implications") seems more like the conclusions I would have expected from Section 6.

To improve flow and readability, I suggest swapping those two sections (probably making that last paragraph in the current Section 6 superfluous) and rename them as appropriate.

We thank the reviewer for this suggestion. We have reorganised the original Sections 5 and 6, merged them into a single section, and revised the content accordingly to improve readability and logical flow. The final paragraph of the original Section 6 has been removed as suggested.

Line 621-648:

We established a photochemical system in the MAC that incorporated both biogenic and anthropogenic SOA precursors in the presence of CO and NO_x. Compared to the chamber studies using single precursors or simplified conditions, this setup provides a more representative characterisation of real-world SOA formation processes. Our results show that, under altered reaction conditions, changes in SOA particle mass yields and chemical composition differed markedly between single- and mixed-precursor systems.

In the single-precursor systems, the presence of CO led to a notable reduction in SOA particle mass yields, with a stronger effect for n-dodecane than for α-pinene. By contrast, no such suppression was observed in the mixture. Chemical composition analysis indicates that, in the single-precursor systems, CO reduced the contributions of both the RO_2 + RO_2 and RO_2 + NO reactions. In the mixed-precursor system, however, no evident reduction in the RO_2 + NO reactions were observed, while the decrease in RO_2 + RO_2 termination was comparatively small. In addition, CO affected the two precursors to different extents in the mixture.

Although biogenic precursors contribute more substantially to SOA formation on a global scale, anthropogenic precursors can play a significant role in urban and suburban environments (Srivastava et al., 2022; Stone et al., 2010; Volkamer et al., 2006). Such regions are often characterised by elevated levels of other pollutants with strong anthropogenic sources, such as CO and NO_x*, which can alter oxidant budgets and shift radical reaction pathways. Consequently, model parameterisations derived under single-precursor or idealised conditions may misrepresent SOA formation in non-pristine environments. Future laboratory studies should better represent the chemical complexity of the real atmosphere, thereby providing a more reliable basis for the development of accurate SOA model parameterisations.*

Establishing comparable experimental conditions representative of real atmosphere remains challenging. The coexistence of multiple precursors, inorganic trace gases, and oxidants, together with their nonlinear interactions, substantially increases the complexity of the system. In this study, even when the initial OH reactivity and precursor/NO_x *ratios were controlled, fully comparable experimental conditions across such systems cannot be achieved. This highlights the need for future work to systematically investigate SOA formation under controlled variations in oxidant levels and precursor/*NO_x *ratios to improve the reliability and comparability of results.*

Minor comments:

Abstract: A quick summary of employed methodology could be added. Presumably measurement methods, though when reading only the abstract, the paper kind-of could be a pure modeling study too.

We thank the reviewer for this suggestion. We have now clarified in the Abstract that the study was conducted in the Manchester Aerosol Chamber and that a combination of online and offline measurements was used to characterise gas- and particle-phase compounds.

Line 20-24:

Within this framework, we investigated the impact of CO on the mass yields and chemical composition of SOA particles formed from a biogenic volatile organic compound (VOC, α-pinene), an anthropogenic intermediate-volatility organic compound (IVOC, n-dodecane), and their mixture in the presence of nitrogen oxides ($NO_x = NO_2 + NO$*) in the Manchester Aerosol Chamber (MAC), using a combination of online and offline measurements to characterise gas- and particle-phase compounds.*

L22: "better" than what else?

We thank the reviewer for this comment. We have removed the use of the comparative term "better" and revised the sentence to more explicitly state that the present study extends previous investigations conducted under single-precursor and simplified experimental conditions.

Line 16-20:

However, many chamber studies are conducted under simplified conditions or with a single SOA precursor to address specific research questions, which may limit their applicability to real-world scenarios. Here, we employed a photochemical system relevant to polluted atmospheric conditions by considering mixtures of biogenic and anthropogenic precursors together with multiple inorganic trace gases commonly associated with anthropogenic emissions.

L52: "precursors" of what?

We thank the reviewer for this comment. The sentence has been rephrased to specify that these compounds are SOA precursors.

Line 46-49:

However, many laboratory experiments are conducted under simplified conditions or with a single ***SOA precursor*** *to address specific research questions, which may introduce uncertainties when extrapolating these results to atmospheric models (Kenagy et al., 2024; Shrivastava et al., 2017; Tsigaridis et al., 2014).*

L60: The key findings of those more recent studies should be briefly summarized as well.

We thank the reviewer for this suggestion. We have added an explanation noting that the overall SOA particle mass yields in the mixture deviate from those predicted by additive calculations.

Line 69-73:

More recent studies have extended such investigations to ternary mixtures comprising biogenic (α-pinene and isoprene) and anthropogenic (o-cresol) precursors, and ***have also shown that the overall SOA particle mass yields in the mixture deviate from those predicted by additive calculations*** *(Voliotis et al., 2022a). These findings suggest that simple linear addition of SOA particle mass yields from individual components may lead to inaccurate estimates of total SOA formation in mixed-precursor systems.*

L66: Only older studies are cited here, though newer ones have contributed substantially to our understanding of the role of RO2 chemistry in SOA formation (e.g., autoxidation). I suggest somewhat expanding that discussion here accordingly.

We thank the reviewer for this suggestion. In the revised manuscript, we have added a description of the mechanisms of HOM formation and discussed the effects of precursor mixing and inorganic trace gases on HOM formation.

Line 54-56:

Recent studies have focused on the ***autoxidation pathways*** *of RO_2 radicals that produce highly oxygenated molecules (HOMs), which are considered potentially important contributors to SOA formation owing to their extremely low volatility (Bianchi et al., 2019; Ehn et al., 2014; Pospisilova et al., 2020).*

Line 133:

HOMs are formed via autoxidation pathways of RO_2 radicals (Bianchi et al., 2019; Goldman et al., 2021).

$$RO_2 \rightarrow QOOH;\ QOOH + O_2 \rightarrow O_2QOOH \qquad R10$$

Line 61-66:

McFiggans et al. (2019) demonstrated that mixing α-pinene with isoprene substantially suppresses SOA formation from α-pinene, reducing SOA mass formation by about 60% and SOA mass yield by 40%. This suppression was attributed to two main mechanisms. First, isoprene, which exhibits a relatively low yield, efficiently competes with α-pinene for available OH, thereby suppressing the formation of α-pinene-derived RO_2 radicals. Second, isoprene-derived ***RO_2 radicals can scavenge HOM-RO_2 derived from α-pinene****, leading to the formation of products with higher volatility.*

Line 75-77:

Atmospheric inorganic trace gases, such as CO and NO_x, can alter oxidant levels and RO_2 reaction pathways (Atkinson, 2000; Baker et al., 2024; Chen et al., 2022; Kang et al., 2025; Kroll and Seinfeld, 2008; Lane et al., 2008; Pullinen et al., 2020; Pye et al., 2019; Sarrafzadeh et al., 2016).

Line 84-88:

McFiggans et al. (2019) showed that CO suppressed α-pinene dimer *(containing 17 to 20 carbon atoms) formation by a factor of two, while the amounts of HOMs were suppressed by factors of 4 to 5. Baker et al. (2024) further demonstrated that, under constant OH conditions, the addition of CO increased the HO_2/RO_2 ratio from approximately 1/100 to about 1/1, leading to a ~ 60 % reduction in the abundance of* ***HOM-accretion products*** *and a ~ 30 % decrease in the* ***SOA formation potential of HOMs****.*

Line 98-100:

Pullinen et al. (2020) revealed that higher NO_x concentrations reduced the formation of ***gas-phase α-pinene HOM-accretion products****, leading to a lower SOA particle mass yield.*

L109: (major) wavelengths of those lamps?

Illumination was primarily provided by a combination of xenon arc lamps and halogen lamps, producing irradiation over the wavelength range 290–800 nm to mimic the atmospheric radiation spectrum. In addition, to promote OH radical production, a UVC lamp (TUV 130W XPT SE UNP/20, Philips) operating at 254 nm was installed, with more than 90 % of its length masked to prevent excessive irradiation.

Line 179-184:

The irradiation source, consisting of two xenon arc lamps (XBO 6000W/HSLA OFR, Osram) and a series of halogen lamps (50W/4700K MR16, Solux), is mounted inside the chamber and generates irradiation over the wavelength range of ***290–800 nm*** *to mimic the atmospheric radiation spectrum. The corresponding actinic flux spectrum is presented in Shao et al. (2022). The photolysis rate of NO_2 (J_{NO_2}) was 1.38×10^{-3} s^{-1}. To promote OH radical production, an additional UVC lamp (TUV 130W XPT SE UNP/20, Philips) was installed, with more than 90 % of its length masked to prevent excessive irradiation.*

L113: NOx cylinder specs?

It is a custom-made cylinder, primarily containing NO_2 with a minor NO impurity.

Line 186-188:

NO_x was introduced from a ***custom-made*** *cylinder using ECD N_2 as the carrier gas. NO_2 served as the source of O_3, and the subsequent O_3 photolysis generated OH radicals, thereby initiating photochemical oxidation.*

L118: what kind of aerosol generator?

The aerosol generator used in this study was an ATM 230 (Topas). Detailed information is available on the website (https://www.topas-gmbh.de/en/products/generation/product/atm-230).

> "The ATM 230 is designed as a serial instrument with an external compressed air supply. The liquid reservoir is arranged within the housing."

Line 189-191:

*Seed particles with a mass concentration of 40.2 ± 8.0 μg m^{-3} were generated by nebulising aqueous ammonium sulfate solutions ($((NH_4)_2SO4$, ACS reagent, ⩾ 99.0 %, Sigma-Aldrich) using an aerosol generator (****ATM 230, Topas****).*

L122 (and 134): what is "cyclic flushing"?

"Cyclic flushing and filling" refers to automated repeated flush-fill cycles with clean air at a high flow rate for approximately 1.5 h to remove the contamination in the chamber. Each cycle consists of ~7 min of flushing followed by ~7 min of refilling.

Line 196-199:

(i) *Pre-experiment: Repeated flush-fill cycles were conducted to achieve a low-background condition. During these cycles, the chamber was flushed for approximately 7 min and then refilled with clean air at the same flow rate, with this procedure repeated for about 1.5 h. Subsequently, SOA precursors, NO_x, CO, and seed aerosols were introduced into the chamber. The* temperature and relative humidity were adjusted to approximately 25 °C and 50 ± 5 %, respectively.

L128: how was step iii initiated?

Upon illumination, photo-oxidation and subsequent SOA formation were initiated.

Line 201-202:

(ii) Experiment: When the lights were turned on, photo-oxidation and subsequent SOA formation were initiated. Each "experiment" phase lasted for approximately 5 h.

L167: DMPS specs?

DMPS composes of a Vienna-design DMA coupled to a CPC (model 3775, TSI Inc.).

Line 230-232:

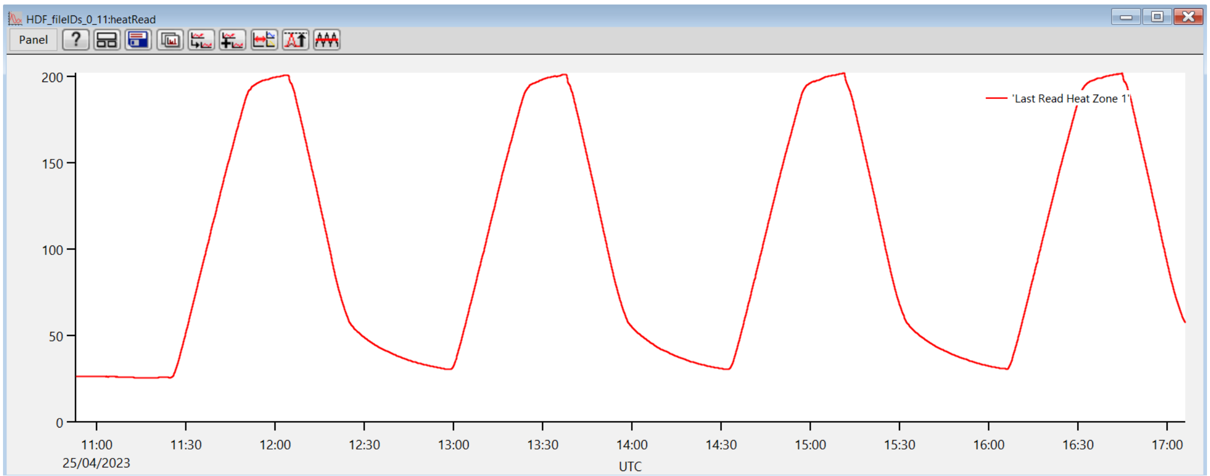
The mass concentration of seed aerosols in the 20–500 nm size range was measured using a Differential Mobility Particle Sizer (DMPS), consisting of a Vienna-design differential mobility analyser (DMA) coupled to a Condensation Particle Counter (CPC, model 3775, TSI Inc.) (Alfarra et al., 2012).

2.3.1: There must be some mistake with the temperatures, as 310 °C would probably destroy a PTFE filter rather quickly.

We thank the reviewer for pointing this out.

The temperature of 310 °C refers to the set value of the heating unit. As shown in the figure below, the actual temperature experienced by the PTFE filter did not exceed 200 °C throughout the desorption process.

We have corrected the temperature reported in the manuscript and added a clarification that the filters were pre-heated to 200 °C to remove potential contaminants.



Line 240-247:

- *(i) 30 min of gas-phase sampling and simultaneous particle collection onto a PTFE filter (2.0 µm pore size, Zefluor; filters were pre-heated to 200 °C to remove potential contaminants) both at 1 L min^{-1}. During this step, the instrument was flushed with N_2 for 0.5 min every 4.5 min to obtain the gas-phase instrument background signal.*
- *(ii) 25 min of temperature-programmed thermal desorption of the collected particles, with the temperature ramped from ambient to 200 °C.*
- *(iii) 15 min of isothermal soaking at 200 °C.*
- *(iv) 20 min of cooling from 200 °C to ambient temperature.*

(v) *2 min of N_2 flushing to clean the instrument.*

L183: What is that weekly "instrument background procedure"? Please explain.

We apologise for the error in the original manuscript. The term "instrument background procedure" should be "Chamber background measurement".

Two types of blank measurements were performed in this study.
(1) Chamber background measurement:
All components (SOA precursors, seed particles, CO, and NO_x) were injected into the chamber under the same experimental conditions as the regular experiments, while the chamber was kept in the dark. CIMS data obtained during these background measurements were subtracted from both the gas- and particle-phase data acquired during the "experiment" phase.
(2) Instrument background measurement:
As described in Section 2.4.1, during the 30 min gas-phase sampling, the instrument was flushed with N_2 for 0.5 min every 4.5 min to obtain the gas-phase instrument background signal.

Line 241-242:
During this step, the instrument was flushed with N_2 for 0.5 min every 4.5 min to obtain the gas-phase instrument background signal.

Line 252-255:
To further correct for background species in the chamber, background measurements were conducted weekly. During these measurements, all components (SOA precursors, seed particles, CO, and NO_x) were injected into the chamber under the same conditions as the regular experiments, while the chamber was kept in the dark. Data obtained during these background measurements were subtracted from both the gas- and particle-phase data acquired during the "experiment" phase.

L185: Similarly, why was data only analyzed for a specific section of the mass spectrum?

We thank the reviewer for pointing this out. The majority of the total signal was contained within the molecular mass range of 200–550 Da (as iodide adducts).

Line 257-359:
The FIGAERO-CIMS data were analysed using the Tofware package (v4.0.0) in Igor Pro 7.0.8 (WaveMetrics©). *I^-, H_2OI^-, $CH_2O_2I^-$, and I_3^- were used for mass-to-charge calibration (error less than 3 ppm). High-resolution peak identification and fitting were performed in the m/z range of 200–550 (iodide adducts), which contained the vast majority of the total signal.*

L198: what is the "4 min chromatography cycle"? Judging from the timings, I guess that is mistake? (L188 even implied that chromatography was not required for the Vocus PTR-MS, but if some chromatography step was included nonetheless, that should of course be described.)

We thank the referee for noting this point. The VOCUS was not operated with a GC column in this study. The reference to a "chromatography cycle" was a wording error and has been corrected to "sampling" in the revised manuscript.

Line 277-278:
Measurements were made on a 5 min cycle, consisting of 4 min of sampling followed by 1 min of instrumental background.

L203: does "set values" refer to calculated concentrations based on what was injected into the glass bulb?

We thank the reviewer for this question. The “set values” refer to the target concentrations used in the chamber, rather than concentrations calculated from the injected amounts. For α-pinene, the target concentration was 40 ppb in the single-precursor system and 20 ppb in the mixed-precursor system. For n-dodecane, the corresponding target concentrations were 160 ppb in the single-precursor system and 80 ppb in the mixed-precursor system.

we have replaced the term “set value” with “target value” in the revised manuscript and added a corresponding clarification in Sect. 2.3.

Line 281-283:
*Therefore, alternative approaches were adopted for its quantification: (i) the initial concentrations were taken as the **target** values (160 ppb in the single-precursor system and 80 ppb in the mixed-precursor system), and (ii) the relative consumption of n-dodecane was inferred from the temporal evolution of the $C_{10}H_{21}^+$ fragment ion (Fig. S4).*

Line 217-218:
*The **target concentration** of α-pinene was 40 ppb in the single-precursor system and 20 ppb in the mixed-precursor system, while the corresponding concentrations of n-dodecane were 160 ppb and 80 ppb, respectively.*

L213-214: are these values to be expected based on previous studies?

Yes, these values are comparable to those reported in the literature.

> “The RIE values usually used in AMS ambient concentration calculations are 1.4 for organic molecules and 1.1, 1.15, and 3.5-6 for NO_3, SO_4, and NH_4 moieties, respectively.” (Canagaratna et al., 2007)
>
> “The ionization efficiency (IE) with respect to nitrate anions was calculated at the beginning and at the end of the campaign using nebulised 350 nm mobility diameter ammonium nitrate particles (BFSP software was used and values varied between 2.2×10^{-7} - 2.5×10^{-7}).” (Lannuque et al., 2023)

Line 288-291:
The average IE of NH_4NO_3 was determined to be 2.75×10^{-7} ions molecule^{-1}, while the RIE for NH_4^+ and SO_4^{2-} were 4.71 ± 0.24 and 1.13 ± 0.01, respectively. These values are comparable to those reported in the literature (Canagaratna et al., 2007; Lannuque et al., 2023).

Eq. 2: what does the superscript "SUS" refer to?

We thank the reviewer for this question. SUS refers to the suspended particles. To avoid potential confusion, we have removed this abbreviation.

Line 297-298:

$$C_{OA}(t) = \frac{C_{OA}(t)}{C_{seed}(t)} C_{seed}(0) \tag{2}$$

where $C_{OA}(t)/C_{seed}(t)$ represents the SOA-to-sulfate ratio derived from AMS measurements, and $C_{seed}(0)$ denotes the sulfate concentration at the beginning of the experiment.

L216-221: unclear what the correction is trying to achieve (correct for; or "calibrate"?)

We apologise for the ambiguity in the original manuscript. The correction refers to a chamber wall-loss correction applied to the SOA particle mass concentrations derived from AMS measurements. The text has been revised to clarify this point.

Line 293-294:

In this study, the OA/sulfate correction method was used to correct for chamber wall losses in the SOA particle mass concentration measured by AMS (Wang et al., 2018).

L225: "per unit of precursor" could be confusing. I assume DeltaHC is also in units of mass (like DeltaSOA)?

We apologise for the ambiguity in the original manuscript. We have removed the term “HC (hydrocarbon)” and replaced it with “precursor” to improve clarity. Both SOA and precursor concentrations are expressed in units of μg m^{-3}.

Line 303-304:

$$Y_{SOA} = \frac{\Delta SOA}{\Delta precursor} \quad (3)$$

For the single-precursor systems, Δprecursor (μg m^{-3}) denotes the consumption of α-pinene or n-dodecane, whereas for the mixed-precursor system, it refers to the total consumption of α-pinene and n-dodecane.

L277: "170-280 Da" ... From Section 2 I had assumed that data below 200 Da was not analyzed (L185)? ... Likewise, Figs. 2 etc...

We apologise for the ambiguity in the original manuscript. The m/z range 200–550 refers to iodide adducts (including the mass of I^-), whereas the range 170–280 Da corresponds to the molecular masses of the products without I^-. This has now been clarified in the Sect. 2.4.1 by explicitly stating that the masses correspond to iodide adducts.

Line 258-259:

High-resolution peak identification and fitting were performed in ***the m/z range of 200–550 (iodide adducts)****, which contained the vast majority of the total signal.*

L288: "the two systems" ... please clarify what the "systems" refer to.

We apologise for the ambiguity in the original manuscript. The “systems” referred to the α-pinene system with and without CO. Following revision, the original sentence has been removed, and similar expressions throughout the manuscript have been replaced with “under both conditions”.

Line 361:

The overall relative contribution of accretion products remained consistent at 9 % ***under*** *both* ***conditions****.*

Line 408-410:

While the overall relative contribution of accretion products was comparable ***under both conditions****, the presence of CO led to a lower fraction of accretion products containing 16–24 carbon atoms compared to the experiments without CO (Fig. 4c).*

Technical comments:

L224: typo (measured)

We thank the reviewer for pointing out this typo. We have made the corresponding revision.

Line 300-301:

SOA particle mass yields (Y_{SOA}) for each system were derived from SOA particle mass concentrations measured by AMS and precursor concentrations measured by PTR.

L297: missing "the"

We thank the reviewer for pointing out this mistake. However, following revisions to the manuscript, the original sentence has been removed in the revised version.

L529: check grammar

We thank the reviewer for pointing out this grammatical error. However, following revisions to the manuscript, the original sentence has been removed in the revised version.

Additional revisions:

1. **The opening of the Introduction was shortened**

Line 33-38:
Secondary organic aerosol (SOA) constitutes a substantial fraction of ambient aerosol and has significant impacts on air quality, climate and human health. It is formed through the oxidation of gas-phase organic compounds followed by gas-particle partitioning (Atkinson and Arey, 2003; Hallquist et al., 2009; Jimenez et al., 2009; Ramanathan et al., 2001; Robinson et al., 2007). These processes are complex and strongly influenced by atmospheric conditions (Hallquist et al., 2009; Kroll and Seinfeld, 2008; Xu et al., 2015). Despite extensive research, achieving a comprehensive understanding and accurate prediction of SOA formation remain challenging (Kenagy et al., 2024; Shrivastava et al., 2017).

2. **The discussion of the influence of NO_x on SOA formation has been revised (Introduction)**

Line 89-102:
In the ambient atmosphere, high concentrations of CO are often co-emitted with anthropogenic pollutants, such as NO_x*.* NO_x *can react with* RO_x *radicals (*$RO_x = OH + HO_2 + RO_2$*), thereby influencing* RO_x *cycling and, consequently, the formation of SOA and* O_3 *(Chen et al., 2022; Clapp and Jenkin, 2001; Pusede et al., 2015).* RO_2 *radicals react rapidly with NO to form alkoxy (RO) radicals or organic nitrates (Atkinson, 2000; Chen et al., 2022; Kang et al., 2025; Ziemann and Atkinson, 2012).* RO_2 *can also react with* NO_2 *to form peroxynitrates; however, these species are generally thermally unstable, except at very low temperatures or when derived from acylperoxy radicals (Atkinson, 2000; Goldman et al., 2021; Ziemann and Atkinson, 2012). The effects of* NO_x *on SOA particle mass yields have been extensively studied. Sarrafzadeh et al. (2016) reported that SOA particle mass yields increased with rising* NO_x *concentrations under low-*NO_x *conditions in β-pinene photooxidation experiments, which they attributed to enhanced OH concentrations. However, after removing the effect of OH, the yields decreased with increasing* NO_x*. Pullinen et al. (2020) revealed that higher* NO_x *concentrations reduced the formation of gas-phase α-pinene HOM-accretion products, leading to a lower SOA particle mass yield. When CO and* NO_x *coexist, oxidant levels and* RO_2 *reaction pathways are regulated by multiple interacting processes, which partially reflect the complexity of the ambient atmosphere. It is therefore essential to consider SOA formation in the presence of multiple coexisting trace gases.*

3. **The description of the FIGAERO cycle was moved from Sect. 2.2 (formerly 2.1) to Sect. 2.4.1 (formerly 2.3.1)**

Line 249-250:
Each cycle spanned approximately 1.5 h, and each experiment comprised four such cycles. In the final cycle, the photochemical reaction was terminated after procedure (i), corresponding to the completion of particle sampling (Fig. S1).

4. **The description of the advantages of the Vocus PTR-ToF-MS in Sect. 2.3.2 (formerly 2.2.2) was revised**

Line 268-273:

The Vocus PTR-ToF-MS provides high-sensitivity and fast-response measurements of organic compounds without the need for pre-concentration or chromatographic separation. Compared to traditional PTR-MS, the Vocus employs a focusing ion-molecule reactor (IMR) *consisting of a glass tube that is mounted inside a radio frequency (RF) quadrupole, with an axial electric field applied along the tube. This design enhances ion transmission efficiency and suppresses the clustering of ions with water molecules, thereby improving sensitivity and lowering the limit of detection (Jensen et al., 2023; Krechmer et al., 2018; Yuan et al., 2017).*

5. **Parts of the chemical composition description were revised**

Line 356-361:

Within the CHO products, fragments contributed more than 60 %, with a large fraction falling within the C_7 *to* C_9 *range (Fig. S11). In the absence and presence of CO, monomers accounted for 36 % and 31 %, respectively. Within the CHON compounds, monomers were dominant, contributing more than 50 %. The presence of CO led to a lower proportion of* C_{10} *CHO compounds (e.g.,* $C_{10}H_{16}O_{4-6}$*) and higher proportion of* C_{10} *CHON compounds (e.g.,* $C_{10}H_{15}NO_{7-8}$*) compared with the experiment conducted without CO (Fig. 2a).*

Line 396-398:

In the absence of CO, the most abundant compounds were $C_{12}H_{25}NO_5$*,* $C_{12}H_{24}O_5$*, and* $C_{12}H_{26}O_3$*, whereas in the presence of CO,* $C_{12}H_{25}NO_4$*,* $C_{12}H_{23}NO_7$*, and* $C_{12}H_{25}NO_3$ *dominated. CHON compounds accounted for 37 % and 43 % of the total signal in the absence and presence of CO, respectively.*

Line 402-408:

Within the CHON products, monomers contributed more than 70 %. The presence of CO led to a lower proportion of C_{12} *CHO compounds (e.g.,* $C_{12}H_{24}O_5$ *and* $C_{12}H_{26}O_3$*) and higher proportion of* C_{12} *CHON compounds (e.g.,* $C_{12}H_{25}NO_4$ *and* $C_{12}H_{23}NO_7$*) compared the experiment without CO (Fig. 4a). However, a few exceptions were observed. For example, an increased contribution from a series of highly oxygenated* C_{13} *CHO compounds, such as* $C_{13}H_{24}O_9$ *and* $C_{13}H_{22}O_{10}$*, was detected in the presence of CO. In contrast,* $C_{12}H_{25}NO_5$ *showed a higher abundance in the absence of CO. In the absence and presence of CO, monomers accounted for 30 % and 37 %, respectively.*

Line 439-441:

In the absence of CO, $C_8H_{10}O_5$*,* $C_8H_{12}O_6$*, and* $C_{12}H_{24}O_5$ *had the highest signal intensities, whereas in the presence of CO, the most abundant compounds were* $C_{12}H_{24}O_5$*,* $C_8H_{10}NO_5$*, and* $C_{12}H_{25}NO_6$*. CHON compounds accounted for 30 % and 29 % of the total signal in the absence and presence of CO, respectively.*

Line 445-448:

As shown in Fig. S11, the effect of CO on the carbon distribution in the mixture was generally less pronounced than in the single-precursor systems. Nevertheless, subtle compositional shifts were still observed in the CO-added case, and these shifts followed a pattern distinct from that in the single-precursor systems.

6. **The presentation of product hydrogen atom distributions in Sects. 3.1.2, 3.2.2, and 3.3.2 (formerly Line 294-299, 346-353, and 398-403), as well as the corresponding figure (formerly Fig. S11) in the Supplementary Information, were removed**

7. **The discussion of precursor/NO_x conditions in Sect. 4.1 was revised**

Line 556-570:

The precursor/NO_x *ratio is important for determining the chemical regime of* O_3 *and SOA formation (Chen et al., 2022). However, when multiple precursors are involved, maintaining similar initial precursor/*NO_x *ratios may not be sufficient to establish comparable chemical regimes across systems. In this study, the temporal profiles of* O_3 *and* NO_x *differed substantially between the single- and mixed-precursor systems (Fig. 1a and S5). In the α-pinene system,* O_3 *concentrations peaked after approximately two hours of reaction and subsequently declined, while*

NO_x levels stabilised. By this point, over 80 % of α-pinene had been consumed, and the SOA particle formation rate began to decline (Fig. 1b–c). These trends may indicate a diminished contribution of RO_2 + NO reactions, which slowed the depletion of NO, thereby enhancing the titration of O_3 and leading to a net O_3 loss. NO can also be consumed via reactions with HO_2; however, in the absence of CO, HO_2 concentrations are expected to be relatively low. Consequently, changes in the HO_2 + NO pathway are not considered further here. In contrast, in the n-dodecane and mixture systems, over 50 % of n-dodecane was still unreacted after two hours of reaction, and the SOA particle formation rate continued to increase (Fig. 1b–c), indicating that the RO_2 + NO pathway remained active. This sustained reactivity enabled continuous NO consumption, thereby limiting O_3 titration and leading to a net accumulation of O_3.