We thank the reviewers for their careful review of the manuscript. The comments greatly improved our manuscript. We revised our manuscript according to the reviewers' comments and suggestions. Overall, we have changed the mass concentration (μg m^{-3}) to the emission rate (μg min^{-1}) to avoid the influence of cooking time and sampling time according to the comments of the referees. We add more details to the volatility distributions of cooking emissions. We also added more comparisons with different studies. Following are our responses to the comments.

Response to referee #3:

This manuscript investigates the impact of cooking style and oil on the emissions from traditional Chinese cooking. A significant number of chemical species including aromatics, alkanes, oxygenated compounds, and PAHs have been detected. The authors observed that in addition to VOC species, S/IVOCs made up an important fraction of cooking emissions and SOA precursors. In general, dishes cooked by stir-frying and deep-frying styles emit more pollutants than relatively mild cooking styles. A volatility-polarity distribution framework of cooking emissions has been developed. Unlike the emissions that showed great variation, the volatility-polarity distribution of different cooking styles was similar. PLS-DA and MPCA analyses revealed that cooking oil was a critical influencing factor in the 2D distribution. Overall, this is a comprehensive study investigating the relationship among cooking emissions, cooking styles, and cooking materials. The manuscript is well written, and the results are valuable to the literature. I would like to recommend its publication in Atmospheric Chemistry and Physics, subject to minor revisions.

Thank you for your comments. The valuable suggestions addressed have greatly improved our manuscript. Following are our point-to-point responses to the comments.

1. Table S1: In regard to oil temperature, how was oil temperature measured and monitored? Was oil temperature controlled and maintained the same during the cooking? There seems to be a positive relationship between oil temperature (Table S1) and emissions (Figure S3). Have the authors tried to cook the dishes at the same oil temperature and compare the emission results?

Thank you for your comment. The oil temperature was measured by a thermometer placed in the oil.

The thermometer was removed from the oil before placing the cooking materials. As a result, the *initial* temperature of the oil was maintained the same for each dish. Dishes cooked at the same oil temperature were not conducted in this work. Further investigation will be carried on to illustrate the relationship between oil temperature and cooking emissions.

We revised Table S1 as follows.

Table S1. Details of cooking procedures.

Domestic cooking	**Material**	**Oil temperature** [#]
Fried chicken	170 g chicken, 500 mL oil (corn, peanut, soybean, or sunflower oil), a few condiments	145 ~ 150 °C
Kung Pao chicken	150 g chicken, 50 g peanut, 40 mL corn oil, a few condiments	Not stable
Pan-fried tofu	500 g tofu, 200 mL corn oil, a few condiments	100 ~ 110 °C
Stir-fried cabbage	300 g chicken, 40 mL corn oil, a few condiments	95 ~ 105 °C

[#] The oil temperature was measured by a thermometer placed in the oil. The thermometer was removed from the oil before placing the cooking materials. The temperatures listed in Table S1 were initial cooking temperatures and were maintained the same for each dish.

2. Line 117: What’s the dimension of the Tenax TA tube? A flow rate of 0.5 L min-1 was used in this study. Do you have any idea what were the collection efficiencies of chemical species with different volatility under this flow rate condition? How long was the sampling? What about the breakthrough of Tenax TA tubes?

Thank you for your comment. The Tenax TA tube is Gerstel 6 mm 97 OD, 4.5 mm ID glass tube filled with ~290 mg Tenax TA. A Tenax TA breakthrough experiment was conducted by introducing pure nitrogen gas (N_2) with a flow of 0.5 L min^{-1} to the desorption tube with pre-added standard chemicals (Figure S2). No significant breakthrough was observed within 24 h (<3% of TIC).

The sampling time in this work is 15 ~ 30 min (0.5 L min^{-1}) which is much less than 24h. The chemical species quantified in this work was stable on Tenax TA tubes even after 24h of N_2 flowing. We have revised the manuscript accordingly.

Cooking fumes were sampled directly without dilution. After collecting particles on quartz filters, gas-phase organics were sampled by pre-conditioned Tenax TA tubes (Gerstel 6 mm 97 OD, 4.5 mm ID glass tube filled with ~290 mg Tenax TA) with a flow of 0.5 L min^{-1}. The removal of particles on the quartz filter in front of the Tenax TA tubes affects the S/IVOC measurements, causing positive and negative artifacts. Some of the gaseous SVOCs could be lost to sorption onto filters, and some particle-phase SVOCs could evaporate off the filter. The emission pattern of the particulate organics diverged from gas-phase organics, and a small overlap of species is identified. Aromatics, aldehydes, and short-chain acids mainly occurred in the gas-phase. For instance, the detection of short-chain olefinic aldehydes in the gas-phase was 40 times that of the particle-phase aldehydes. The artifacts of particulates on gas-phase aromatics and oxygenated compounds could be less than 5%. A typical system blank chromatogram is displayed in Figure S1. A daily blank sampling of the air in the kitchen ventilator was conducted before cooking and was subtracted in the quantification procedure. All samples were frozen at -20°C before analyzing. A Tenax TA breakthrough experiment was conducted by introducing pure nitrogen gas (N_2) with a flow of 0.5 L min^{-1} to the desorption tube with pre-added standard chemicals (Figure S2). No significant breakthrough was observed within 24 h (<3% of TIC). The sampling time in this work is 15 ~ 30 min (0.5 L min^{-1}) which is much less than 24h.

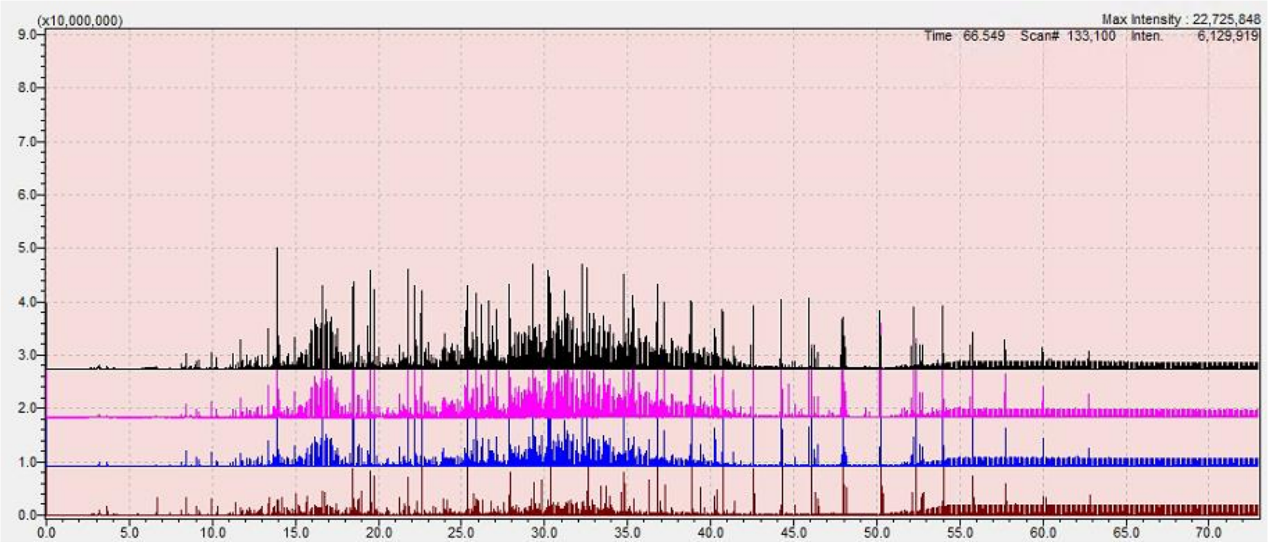

Figure S2. The chromatograms of standard chemicals after 6h（brown）, 24h（blue）, 48h (red), and 72h (blue) of flowing by pure nitrogen gas. The flow of nitrogen gas is set to be the same as the sampling flow (0.5 L min^{-1}). No significant breakthrough was observed within 24 h (<3%).

3. Lines 120-131: Chemical analysis using TD may have the following concerns (taking SVOCs as examples):

a) Some of the SVOCs are of relatively low volatility. A TD temperature of 280 °C may not be sufficient to thermally released all the SVOCs in a short period of time.

b) SVOCs such as acids may get decomposed during the TD processes.

c) The decomposition of SVOCs may produce small molecules that can be mistakenly identified as VOCs.

Both items a and b lead to underestimations of SVOCs. Item c may result in an overestimation of VOCs. In regard to these concerns, how long was the TD process in this study? Have the authors quantified the desorption efficiency of SVOC standards?

Thank you for your comment. The programming of the TD process was ramped 30°C to 280°C (60°C/min) and then retained at 280°C for 10 min (Table S2). The total thermal desorption time was 14 min. 280°C was chosen for thermal desorption temperature due to the less bleeding of Tenax TA compared with 300°C. The linearities of undecanoic acid (C11-acid), C31, and C32 were 0.97, 0.99, and 0.99 (Table S5). The good linearity of SVOC compounds under different concentration levels showed a good desorption efficiency of SVOCs. Furthermore, the deportation of SVOC occurred in both *standards* and *samples*, making the quantification face less uncertainty. Though the direct desorption efficiency of SVOC is not quantified, we add more uncertainty discussions to the implication part of the manuscript as follows.

We still need to stress that although GC×GC is utilized, UCMs still occur sharing a proportion of 5% of the total response in this work. Acids and aldehydes tail in the second column and cause uncertainties in the quantification procedure. Meanwhile, TD-GC×GC-MS does not comprehensively measure all compounds. Acids can decompose during thermal desorption if no derivatization was performed. Meanwhile, the decomposition of SVOC compounds could produce small molecules in the VOC or IVOC range. The TD process could introduce underestimation for SVOC compounds while causing overestimations of VOC and IVOC species. Highly polar compounds do not elute from the GC column. This may lead to biases in estimating volatility and polarity distributions. Comparisons between GC×GC and chemical ionization mass spectrometers (CIMS) should be further implemented to give a full glimpse of cooking organic compounds.

4. Line 126: The authors mentioned that the chromatogram was cut into different volatility bins (B9 to B31 with a decrease in volatility). However, Figure 2 and Table S3 start from “B8_before”. Please clarify.

Please add a sentence in the text defining the volatility of each bin (e.g., B8). Please also add a sentence in the text defining the polarity of each bin (e.g., P1). In this way, other studies can compare their results to this study when the volatility-polarity distribution framework is used.

Thank you for your comment. We have changed the statement of B9 to B8 as the 1D bins started with B8_before. We add instances of C12 and benzophenone to the main text to further illustrate the 2D binning method.

The total chromatogram was cut into volatility bins (B8 to B31 with a decrease in volatility) following the pipeline of previous studies (Tang et al., 2021; Zhao et al., 2014, 2017, 2018), while it was cut into slices by an increase of 0.5 s in the second retention time (called 2D bins, from P1 to P12 with an increase of polarity). For instance, C12 lies in B12 (saturated vapor concentration ~ 10^6

µg m^{-3}, IVOC range) and P2 bins (low polarity). Benzophenone lies in B16 (saturated vapor concentration ~ 10^5 µg m^{-3}, IVOC range) and P6 bins (medium to high polarity). A two-dimensional panel was developed in this way to investigate the emission of contaminants from aspects of their volatility and polarity properties (Song et al., 2022).

5. Equation 2: SOA yield of VOC can increase with increasing particle loading (Odum et al., ES&T, 1996). Were the values of SOA yields used herein the maximum SOA yields? Please clarify.

Thank you for your comment. The SOA yields utilized in this work are under high NO_x conditions which are underestimation of SOA due to the lower yields compared to low NO_x conditions. We have revised the manuscript as follows.

SOA (µg min^{-1}) was estimated by the following equation, where $[HC_i]$ is the emission rate of precursor *i* (µg min^{-1}) with OH reaction rate of $k_{OH,i}$, (cm^3 molecules^{-1} s^{-1}) and SOA yield of Y_i (Table S3). The SOA yields of precursors were from literature (Algrim and Ziemann, 2016, 2019; Chan et al., 2009, 2010; Harvey and Petrucci, 2015; Li et al., 2016; Liu et al., 2018; Loza et al., 2014; Matsunaga et al., 2009; McDonald et al., 2018; Shah et al., 2020; Tkacik et al., 2012; Wu et al., 2017) or surrogates from *n*-alkanes in the same volatility bins (Zhao et al., 2014, 2017). The SOA yields utilized in this work are under high NO_x conditions which are underestimation of SOA due to the lower yields compared to low NO_x conditions. $[OH] \times \Delta t$ is the OH exposure and was set to be 14.4×10^{10} molecules cm^{-3} s (~ 1.1 days in OH concentration of 1.5×10^6 molecules cm^{-3}) in order to keep pace with our previous work (Zhang et al., 2021b; Zhu et al., 2021).

$$SOA = \sum [HC_i] \times (1 - e^{-k_{OH,i} \times [OH] \times \Delta t}) \times Y_i \quad (3)$$

6. Lines 220-222: The authors mentioned that “an enhancement of ozone formation contribution and a decrease of SOA formation contribution were observed”. The sentence is confusing. In regard to “enhancement” and “decrease”, what were you comparing? Different types of VOCs, or VOCs vs. S/IVOCs, or VOC emissions from different cooking styles?

Thank you for your comment. We compared the contribution to the mass proportion of VOCs in ERs. We have revised the manuscript as follows.

Although chemicals in the VOC range dominated ozone and SOA formation, an increase in ozone formation contribution and a decrease in SOA formation contribution compared with the mass proportion of VOCs in ERs were observed. VOCs contributed 90.3% - 99.8% of the ozone estimation, and 68.0% - 89.8% of the total SOA estimation, compared with 81.4% - 95.6% in ERs. S/IVOCs explained 10.2% - 32.0% of the SOA estimation.

7. Lines 236-237: The authors mentioned that “the emission patterns diverged from heated oil fumes as heated sunflower oil and peanut oil emitted more organics”. It seems that this statement conflicts with the results shown in Figure S7 (dishes cooked by sunflower oil had the lowest emission).

Thank you for your comment. We have revised the manuscript as follows.

Chicken fried with corn oil emitted the most abundant gaseous contaminants. The emission patterns in this work diverged from heated oil fumes (Liu et al., 2018) as in their work heated sunflower oil and peanut oil emitted more organics.

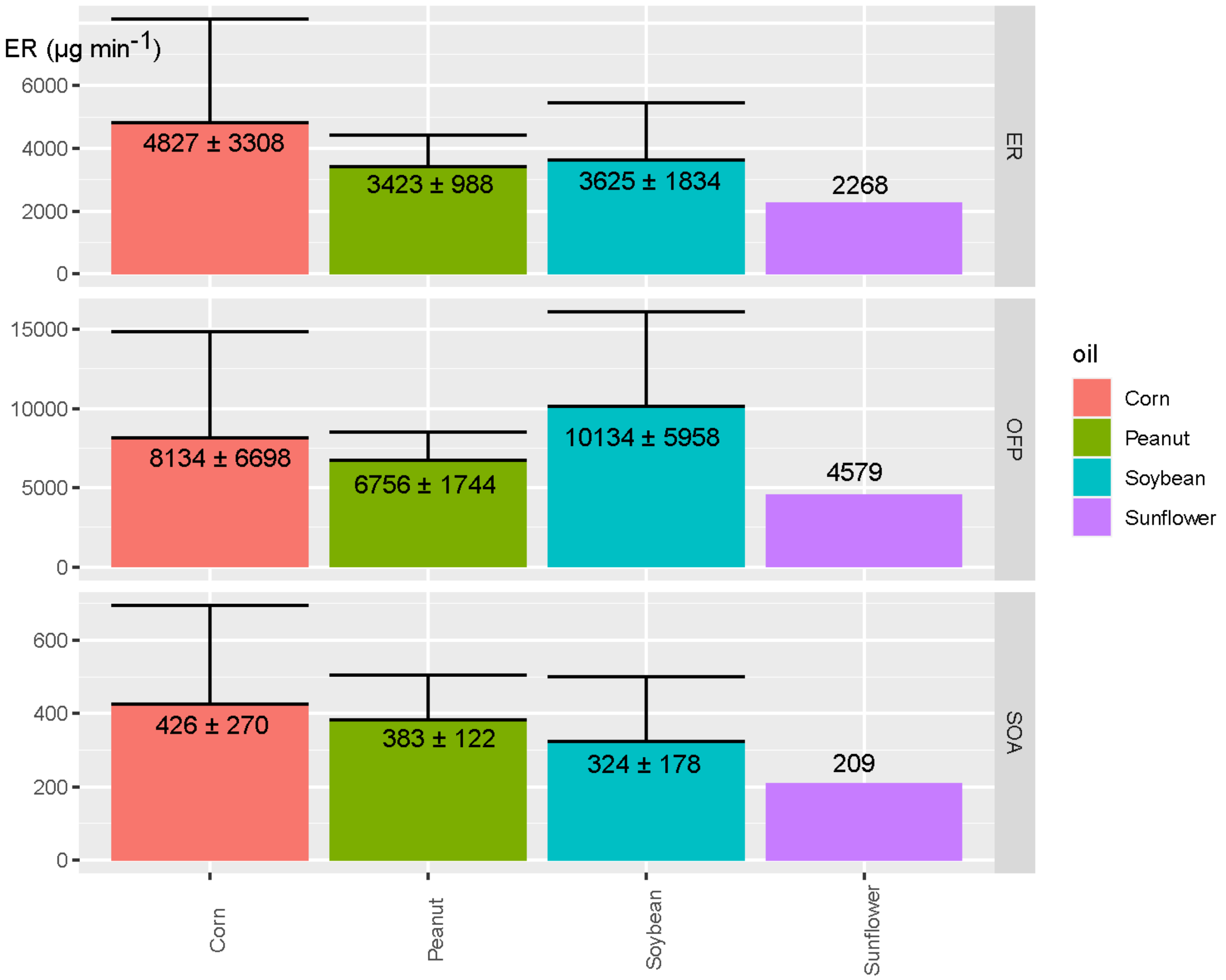

Figure 4. Emission rate (ER), ozone formation potential (OFP), and secondary organic aerosol (SOA) estimation from emissions of fried chicken cooked with corn, peanut, soybean, and sunflower oils. The unit of the *y*-axis is μg min^{-1}.

8. Lines 265-266: "In contrast, the volatility-polarity distributions of dishes did not vary much when corn oil was used for cooking". Please add a reference to Figure 2.

Thank you for your comment. We have deleted this statement. The revised manuscript is shown as follows.

Although pollutants were dominated by aromatics, alkanes, and oxygenated compounds with volatility bins of B9 to B12 (VOC-IVOC range, saturated vapor concentration > 10^6 μg m^{-3}) and polarity bins of P1 to P5 (low to medium polarity), significant diversities of volatility-polarity distributions were observed (Figure S9). The chemical compositions in each volatility bin were also distinct (Figure S11). IVOCs accounted for as much as 22.8% and 23.7% of the total ERs when peanut and sunflower oils were utilized for frying (Kostik et al., 2013; Ryan et al., 2008). The peanut oil was much more abundant in oleic acid (41.5%), while the proportion of linoleic acid in sunflower is 36.6% (Figure S10). The proportion of unsaturated acids in peanut and sunflower oils is higher than that of other oils.

9. Line 278: SOA production or reduction?

Thank you for your comment. We revised the manuscript as follows.

Despite the importance of aldehydes revealed in previous studies (Klein et al., 2016; Liu et al., 2018), our results demonstrated that alkanes, pinenes, and short-chain acids are also key precursors in cooking SOA **production** (Huang et al., 2020).

10. Lines 294-295: What do you mean by “physical reactions (evaporation)”? Evaporation of what?

Thank you for your comment. We revised the manuscript as follows.

The PLS-DA result showed that cooking emissions diverged from oils (Figure 5 (c)), indicating that the physical reactions (**evaporation of edible oils**) were not the main reactions during the cooking procedure.

11. Lines 295-296: “MPCA results showed the chromatogram similarities (positive loading) of oils and emissions.” Please add a reference to Figure 3d. What is the color bar of Figure 3d?

Thank you for your comment. We add a reference to Figure 5d. The color bar in Figure 5(d) is the positive loading of pixels. We revised the manuscript as follows.

MPCA results showed the chromatogram similarities (positive loading) of oils and emissions (**Figure 5(d)**).

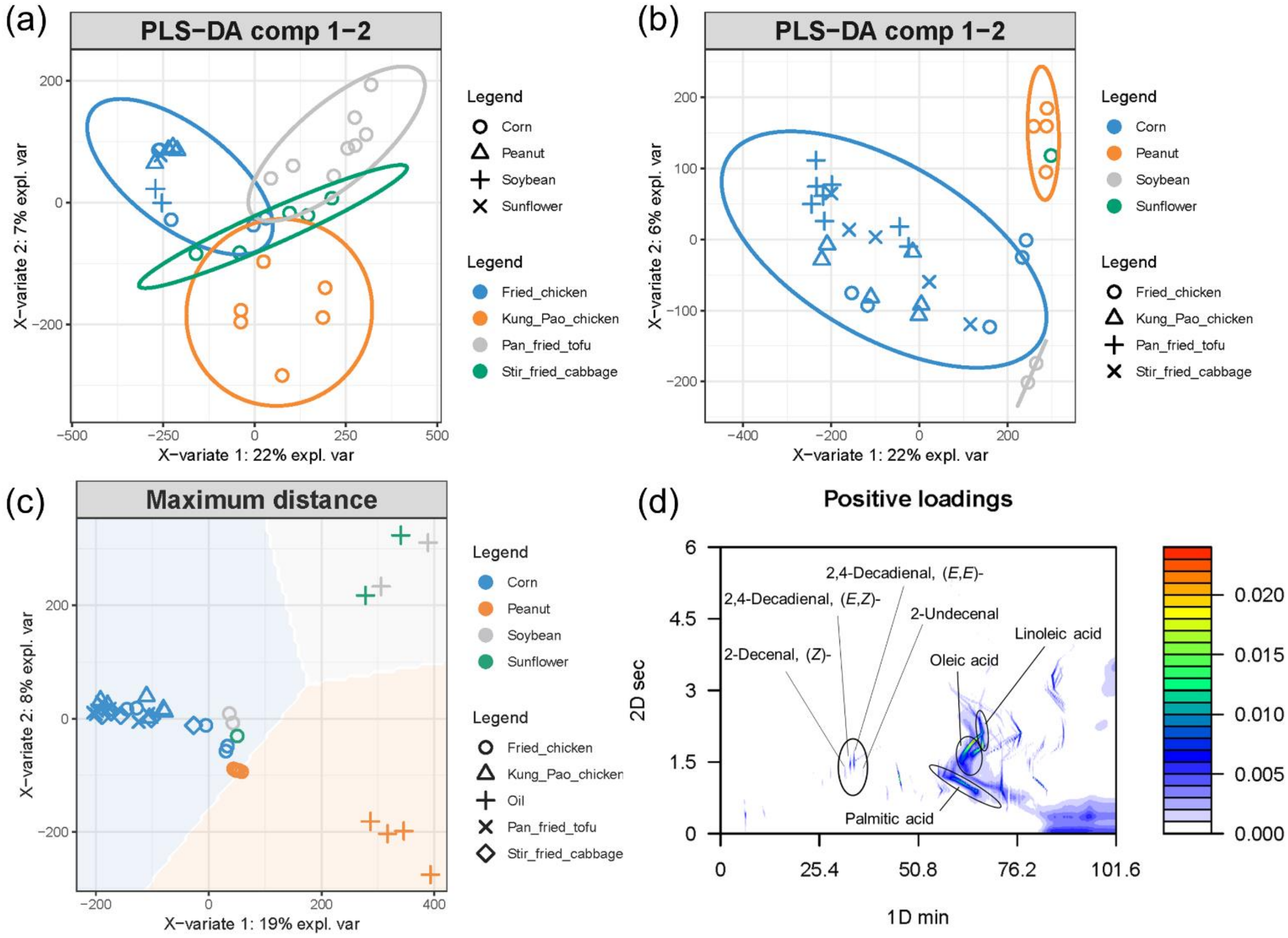

Figure 5. PLS-DA classification results in setting the cooking style (a) or oil (b) as grouping variables. When oil was set as the grouping variable, the separation of groups was much better than setting the dish as the grouping variable. The PLS-DA comparison result of cooking emissions and oils is displayed in (c), indicating that the cooking fume is not just the evaporation of oil itself. Positive loadings of oil and cooking fume chromatograms (d) demonstrated the key components contributing to the similarities of samples. **The color bar in (d) is the positive loading of pixels.**

Technical comments:

1. Line 167: duplicate word “form”

Thank you for your comment. We revised the manuscript as follows.

Chromatograms were imported from the network common data form (netCDF).

2. Line 174: Change “results” to “result”

Thank you for your comment. We revised the manuscript as follows.

PLS-DA is a supervised method for the classification of grouped data. The main influencing factor could be apportioned if one separation **result** of PLS-DA is much better than the other.

3. Line 313: Change “gas-phase” to “gas phase”

Thank you for your comment. We revised the manuscript as follows.

These highly volatile contaminants escape from oil immediately and lead to an accumulation of oxygenated compounds in the **gas phase**.

Reference:

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