

discussed above, we assumed the $\omega = 0$ method to be suitable for wall loss corrections in experiments involving externally mixed particles.

The emission rates (ERs, $\mu\text{g min}^{-1}$) of NMOG and POA and the production rate (PR, $\mu\text{g min}^{-1}$) of SOA were calculated using the following equation:^{16,20,46}

$$\text{ER or PR} = [\text{P}] \times \text{DR} \times F \quad (2)$$

where $[\text{P}]$ is the NMOG, POA, or SOA concentration in $\mu\text{g m}^{-3}$, DR is the dilution ratio, and F is the flow rate of cooking emission carrier gas in $\text{m}^3 \text{min}^{-1}$.

3. RESULTS AND DISCUSSION

3.1. SOA Production. Figure 1a shows the NMOG ERs from different heated cooking oils. These NMOGs were

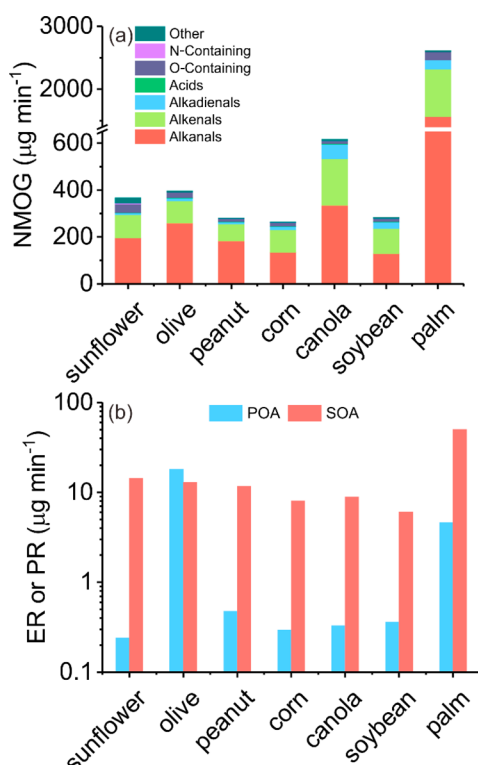


Figure 1. (a) Emission rates of NMOGs from different heated cooking oils. (b) POA emission rates and SOA production rates for different heated cooking oils. SOA production rates were determined after the emissions were exposed to OH of 1.0×10^{10} molecules cm^{-3} s.

classified into seven families on the basis of their molecular characteristics. Alkanals, alkenals, and alkadienals dominated the NMOG emissions, which is consistent with previous studies.^{14–16} In general, the PTR-TOF-MS detects the majority of VOCs from heated cooking oils; undetected alkanes, which are known not to form SOA, have been reported to contribute <5% of the total NMOG mass from cooking with seed oils.¹⁷ Typically, the contributions of other isomers, such as ketones, are negligible, and only one aldehyde isomer is present for a specific molecular formula.^{14–16} Therefore, we assume that the contributions of other isomers were negligible in our experiments considering the current experimental limitation in identifying isomers. Heated palm oil had the highest NMOG emissions, followed by canola, olive, and sunflower oils, while peanut, corn, and soybean oils had the lowest NMOG

emissions. The different emission patterns for different cooking oils (Figure S2) may be explained by varying oil triglyceride compositions.⁴⁷

The amounts of SOA formed from the photochemical aging of emissions from heated cooking oils were substantial, generally exceeding the amounts of POA emitted (Table 1). Figure 1b shows the POA ERs and SOA PRs for different cooking oils. POA ERs were determined after the introduction of emissions from heated cooking oils. SOA PRs were determined at an OH exposure of 1.0×10^{10} molecules cm^{-3} s, which corresponds to 1.9 h of photochemical age, assuming 24 h average ambient OH concentrations of 1.5×10^6 molecules cm^{-3} .⁴⁸ Figure S3 shows that the POA ERs were not correlated with the cooking oil smoke points. The SOA PRs were 6–50 $\mu\text{g min}^{-1}$ and ranged from 0.7 times the POA ER for olive oil to 60 times the POA ER for sunflower oil. Heated palm oil had the highest SOA PR, followed by sunflower and olive oils. When POA was included, palm oil still had the highest OA ER, but the OA ER for olive oil exceeded that for sunflower oil.

These PRs were 1–2 orders of magnitude higher than the SOA PRs from gas-phase emissions from the same cooking oils after approximately 5 h of photochemical aging in our earlier study.²⁰ Liu et al.²⁰ stated that filtration of the POA prior to introduction to the flow reactor removed a large fraction of the SVOCs and IVOCs. In addition, the aging experiments of Liu et al.²⁰ were conducted in the absence of NO_x , which has been found to enhance the formation of SOA from aldehydes.⁴⁹ Both factors may have contributed to the SOA PR discrepancy between the two studies.

3.2. Contributions of Individual NMOGs to Observed SOA. The concentrations of SOA formed from individual NMOGs were estimated from the reacted NMOG mass at a certain OH exposure and the corresponding SOA yield obtained from the literature.^{49,50} The OH-reaction rate constants and the applied SOA yields of precursors used in the calculation are listed in Tables S2 and S3 and discussed in detail in the Supporting Information. Although alkanals contributed a large fraction of the NMOG emissions (Figure 1a and Figure S2), C_{11} alkanals were not included in the calculation because of their negligible SOA mass yields.⁵¹ The concentrations of all traditional SOA precursors included in typical SOA models, i.e., isoprene, aromatics, and monoterpenes, were below the PTR-TOF-MS detection limit; therefore, these species were also excluded from the estimates. Figure 2 shows the estimated contributions of 10 individual alkenals to the observed SOA. The circles and triangles denote the lowest and highest estimates, respectively, based on the lowest and highest SOA yields. Over all experiments, these alkenals accounted for 5–34% of the observed SOA; they would account for 8–55% of SOA if the highest yield estimates were used. These alkenals resulted in effective yields ranging from 0.07 to 0.50.

Figure 2 also shows that the contributions of individual alkenals to observed SOA were highly variable for different cooking oils. Acrolein, hexenal, and heptadienal altogether contributed to 26 and 17% of the observed SOA for canola and soybean oils, respectively; however, they contributed only to 4, 4, and 8% of the observed SOA for olive, peanut, and corn oils, respectively. The unexplained SOA may be attributed to the oxidation of unspiciated SVOCs and IVOCs, which have been recognized as important precursors for biomass burning^{52,53} and vehicle exhaust^{43,54,55} SOA. *n*-Alkanes, *n*-alkanals, and fatty