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STPOST 06

# Correlation Between Heating Temperature of Nicotine Salt Pod System and Carbonyl Formation

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## Introduction / Purpose

Electronic Nicotine Delivery Systems (ENDS) function by heating and vaporizing an e-liquid at reduced temperatures compared to combustion. A potential concern with ENDS is the production and exposure to toxic carbonyl compounds (formaldehyde, acetaldehyde, acrolein, etc.) at elevated temperatures. This is a particular concern for devices with no heating coil temperature control. The JUUL system is a closed nicotine salt pod system (NSPS) with automated temperature regulation mechanisms designed to maintain temperature consistency and to minimize the generation of undesired degradation products. The purpose of this study was to investigate the production of carbonyl compounds present in the aerosol delivered by the NSPS device as a function of heating temperature (**Fig. 1**).

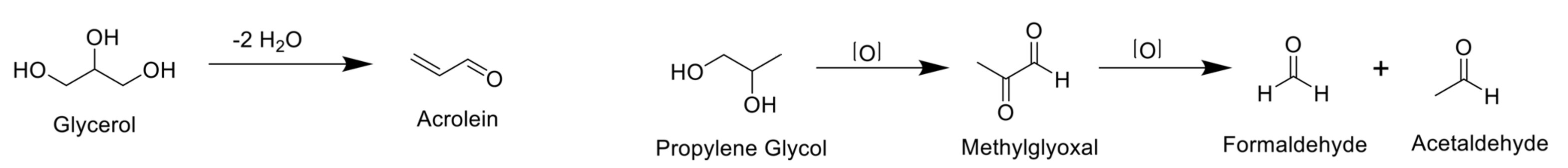


**Figure 1.**

## Materials and Methods

- 2 formulations of NSPS pods were tested: Mint and Mango, both at a nicotine concentration of 59 mg/mL, or 5% by weight. At present, these formulations are available in the US market.
- Prototype NSPS devices with modified firmware were used to allow adjustable heating temperatures.
- Atomizer temperatures were measured by infrared (IR) thermography and by resistance measurements of the coil.
- For IR thermography, a total of 10 puffs were collected across a 3 second duration with a 30 second puff interval.
- Total aerosol mass (TAM) measurements as a function of coil set temperature were determined under a fixed puffing profile (**Fig. 2**).
- Aerosol samples were collected in impingers with 2,4-Dinitrophenylhydrazine (DNPH) solution and analyzed for carbonyls via high performance liquid chromatography-mass spectrometry (HPLC-MS).
- 1 replicate was collected for IR thermography measurements and 3 replicates each were collected for TAM and carbonyl measurements.
- Total aerosol mass and carbonyl measurements were performed using validated methodologies by an accredited ISO 17025 3rd party laboratory.

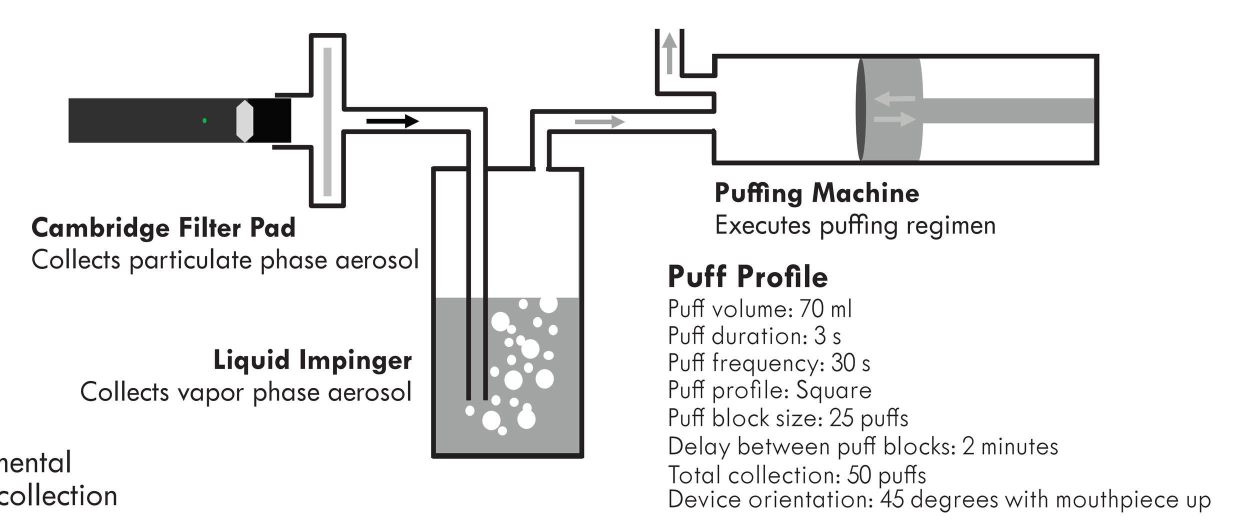


**Figure 2.** Experimental setup for aerosol collection

## IR Results

The NSPS devices were modified to heat to target temperatures from 237°C to 417°C (for reference, a non-modified NSPS device has a typical observed operating temperature below 300°C). IR thermography was performed with representative devices (high and low end) to verify that the set temperatures are accurate. Good correlation between set temperature and average maximum temperature in the analysis area was observed. Maximal achieved temperatures over the entire 10 puff test window were less than 30°C above set points in all cases. At the highest set temperature (417°C) the average maximal temperature began to dip, likely due to device power delivery limitations. IR thermography measurements corroborated the heating coil electrical resistance measurements.

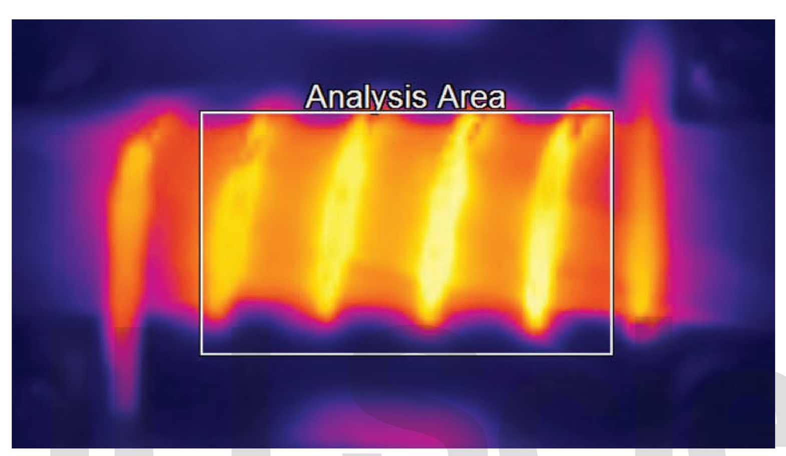


**Figure 3.** Typical IR thermography image showing average heating coil temperature analysis area

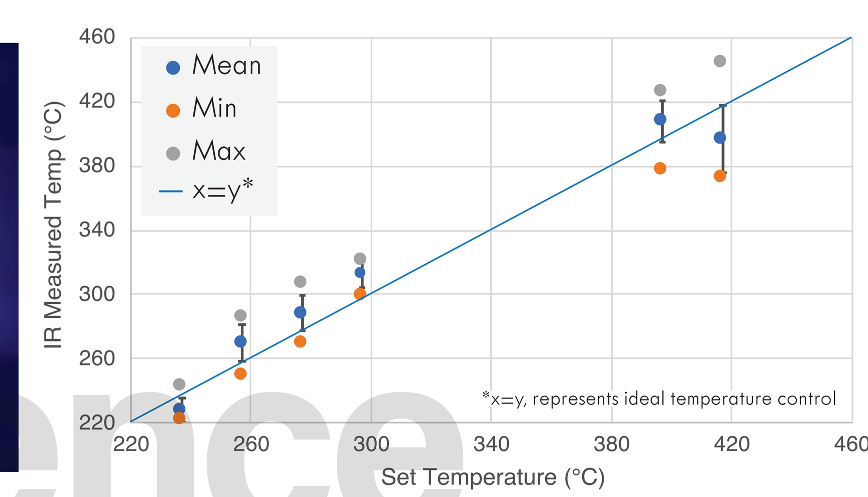


**Figure 4.** IR thermography measured maximum temperatures for 10 consecutive puffs for each set point

## Total Aerosol Mass (TAM) Results

TAM measurements were performed at all set temperatures and used to normalize harmful/potentially harmful constituents (HPHC) data to collected aerosol mass. As expected, TAM increases with increasing coil temperature.

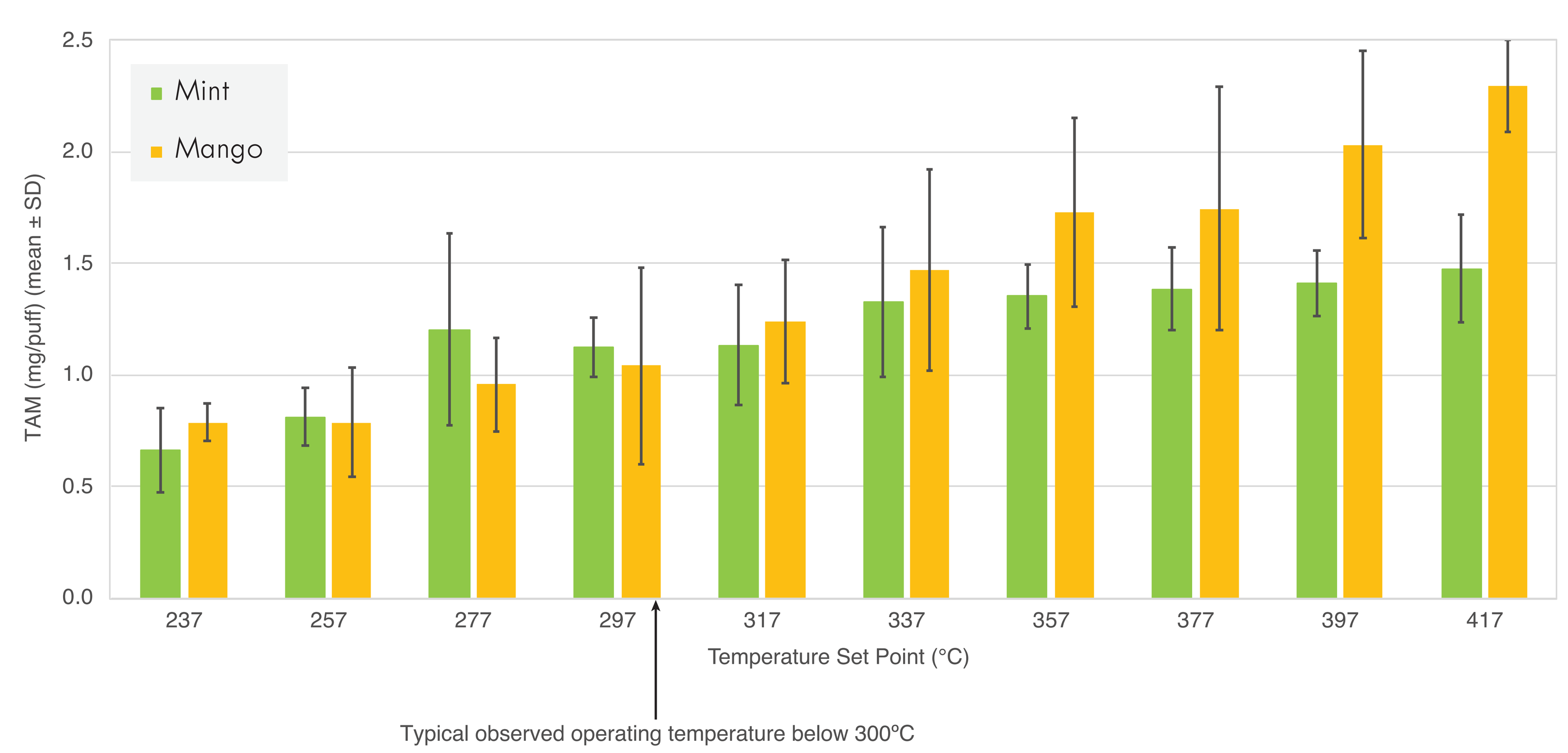


**Figure 5.** Measured TAM at various temperature set points

## HPHC Results

TAM, carbonyl analysis, and IR thermography were executed using heating coil temperature set points of 237°C to 417°C. TAM and carbonyls increased with an increase in coil temperature.

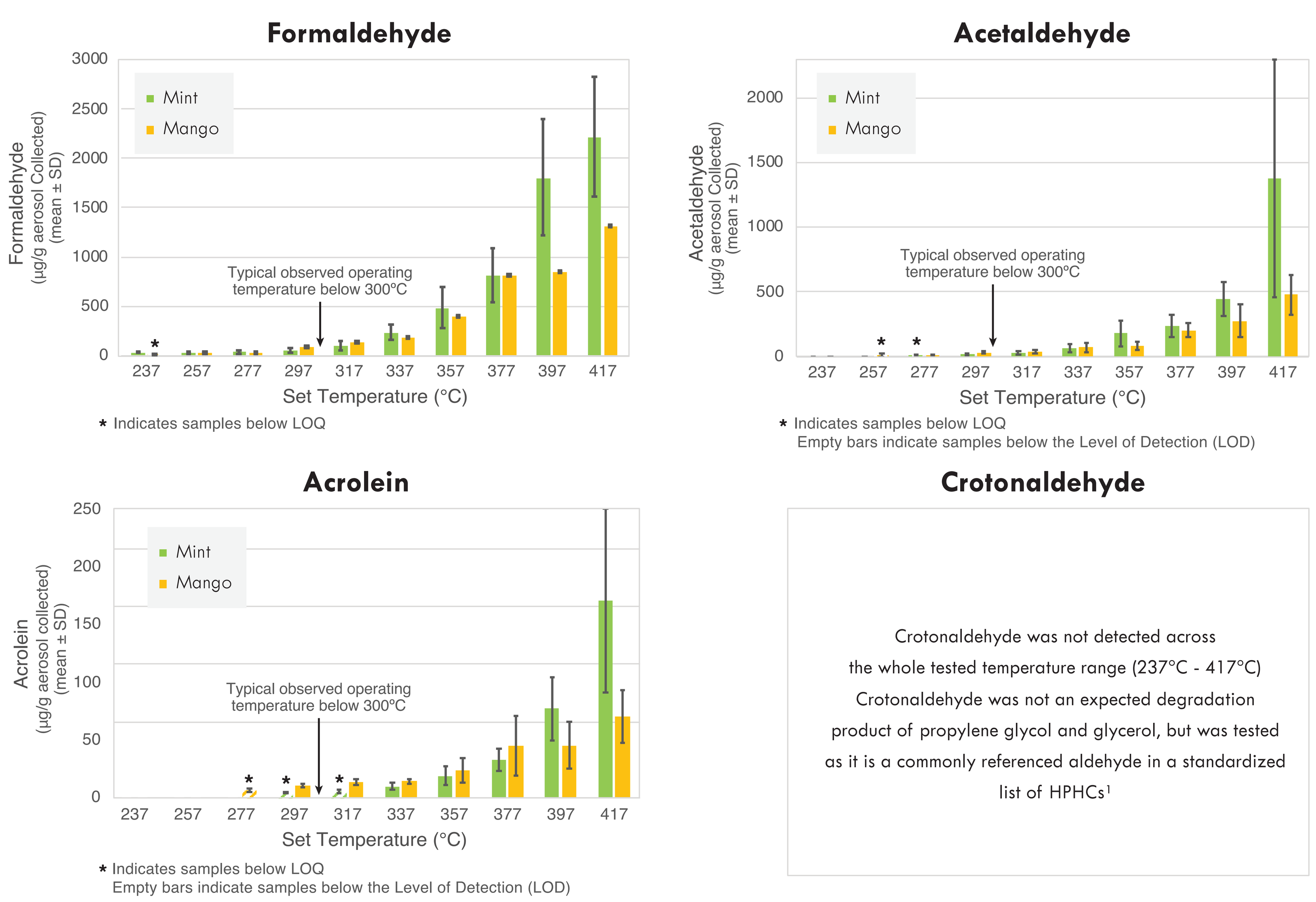


**Figure 6.** Production of Formaldehyde, Acetaldehyde, Acrolein and Crotonaldehyde from 5% Mint and 5% Mango formulations produced by modified NSPS devices to operate at set temperatures ranging from 237°C to 417°C

Limit of quantification (LOQ) represented as LOQ of assay/(collected aerosol mass) for each temperature set point

## Conclusions

Consistent with previous results, carbonyl generation is related to an increase in atomizer temperature, demonstrating the importance of temperature control within the NSPS hardware. Under normal operating conditions, the unmodified NSPS devices produce lower levels of carbonyl products.

## Limitations

This was a preliminary assessment of three replicates for each formulation of carbonyl emission as the function of temperature, using one puffing regime on a puffing machine under laboratory conditions.

## References

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