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Characterization of Emissions of Wax-Based Products During Combustion

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E3 Fuels

- E3 Fuels is a Boise based company that has developed an additive that reduces emissions during combustion of fossil fuels.
- These emissions have immediate and long-term negative effects on environmental and human health.
- Their proprietary formula is claimed to:
  - Be biodegradable, renewable, and sustainable
  - Reduce particulate emissions by 98%
  - Increase fuel efficiency 10-24%
- Preliminary testing of additive performance in wax-based products looks promising.

Particulate Emissions Testing

- Emissions collection hood, left, utilizes a vacuum system to draw emission through a Whatman GF/C 1.7 μm glass microfibre filter.
- The mass of the filter was obtained before and after the experiment to 10 μg.
- 5 g of paraffin was combusted during each test.

Microstructure

- Two unique microstructures were observed in the paraffin: amorphous and crystalline.
- Pure paraffin and the 118:1 ratio exhibited amorphous structure.
- Large ratios of E3 became a catalyst for crystallization. The driving force of this reaction is unknown.
- All higher ratios showed crystalline structures which severely deteriorated the mechanical properties of the paraffin.

Conclusions

- Additive shows a visual reduction in particulate emissions.
- Preliminary results show a reduction in particulates greater than PM 1.7.
- Small concentrations of E3 exhibit reductions in particulate concentrations.
- Successful proof of reduced emissions will result in a decrease in the negative effects candles have on indoor air quality.

Future Work

- Obtain additional data on particulate mass during combustion. This will be completed using both previous method and additional instrumentation that give particulate counts and gas emission data.
- Statistical analysis of particulate mass gain in vacuum hood.
- Capture and analysis of gaseous emissions.

Kinetics of Candles

- Paraffin is the widest used product in candle making in the US.
- Paraffin is a hydrocarbon chain with the formula of:
  \[ C_nH_{2n+2}, n = 19-35 \]
- Paraffin typically exhibits incomplete combustion.

Hydrocarbon Combustion

- Complete: \[ \text{H}_2\text{C}=\text{C}=\text{C}+\text{O}=\rightarrow \text{CO}_2+\text{H}_2\text{O} \]
- Incomplete:
  - Longer hydrocarbon chains cause other by-products
  - These emissions cause a rise of indoor pollutants
  - Symptoms associated with indoor air quality are the number one environmental health issue doctors face.

Candle Manufacturing

- Pillar candles, dimension 38 x 50 mm
- HTP-31 cotton wicks protruding 13 mm
- Paraffin wax (CAS 8002-74-2)
- Wax was heated to a pouring temperature of 80 °C
- Additive was mixed and immediately poured into molds.

Propane Flame \((C_3H_8)\)

Paraffin Flame \((C_nH_{2n+2})\)

\(n = 19-35\)

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Particulate Emissions

- Additive could decrease the size of particulates to smaller than 1.7 μm. This could be the reason for no measurable mass change in filters B and C.

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