

# Chemistry and Toxicology of Red, Green, Gold and Exotic E-Liquids

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# The regulatory nightmare

- Numerous e-liquid formulations in commerce
  - E-liquids in one-piece (disposable) devices
  - E-liquids in cartomizers and prefilled tanks
  - E-liquids in bottles for consumers to fill own devices
- Traditional regulatory approaches may not work
  - Accurate quantitative disclosures from ingredient formulators or manufacturers may not be available
  - Many e-liquid vendors may not have resources needed to fulfill likely regulatory requirements
  - Regulators unlikely to have resources to review numerous filings to make safety determinations

# Other issues

- Stability of e-liquids
  - Expected reactions of PG with aldehydes
  - Unexpected reactions that may occur during storage, distribution, and consumer use
  - Unexpected reactions when e-liquid flow to heaters decreases
- Suitability of e-liquids for all devices
  - Temperatures in some devices may be above decomposition temperatures for common e-liquid materials

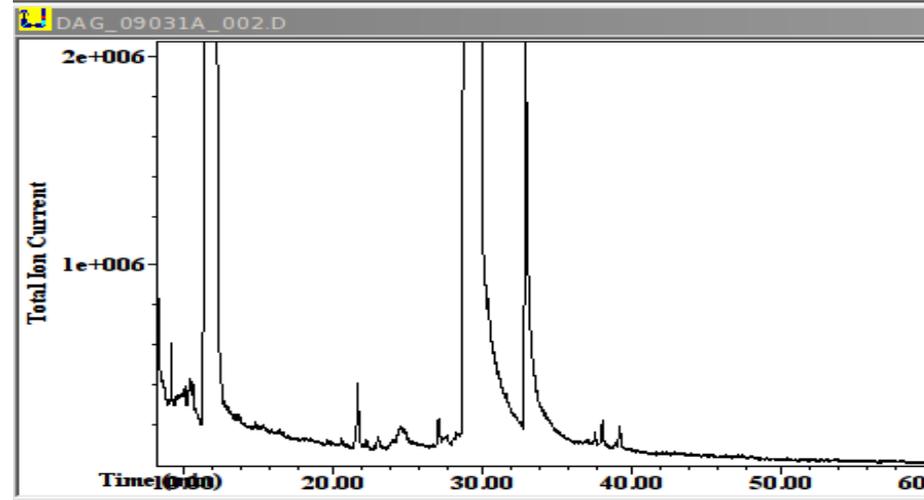
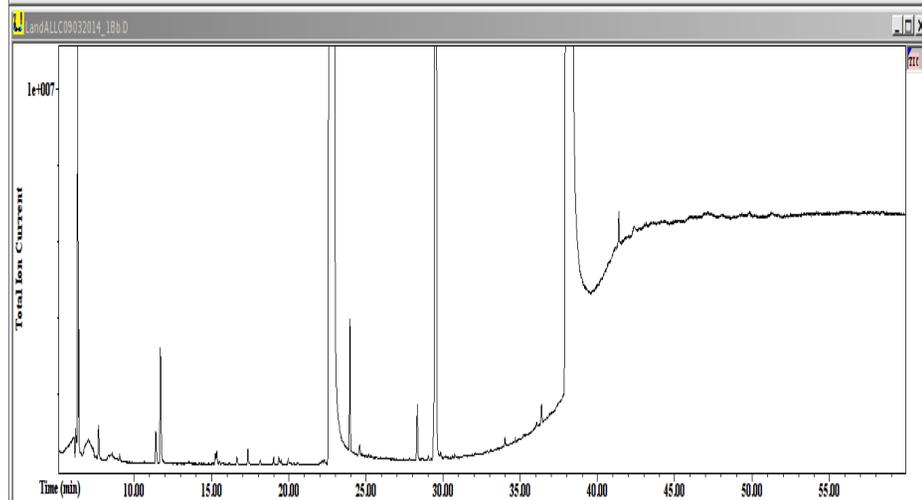
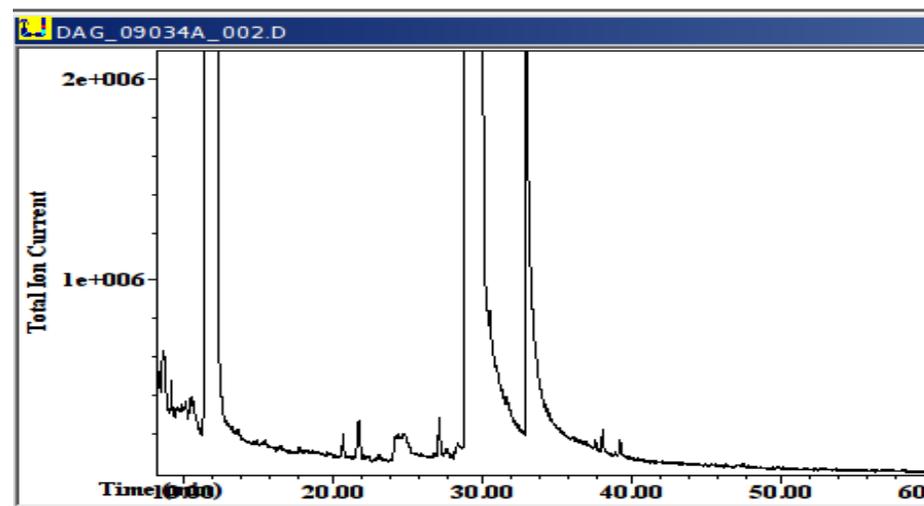
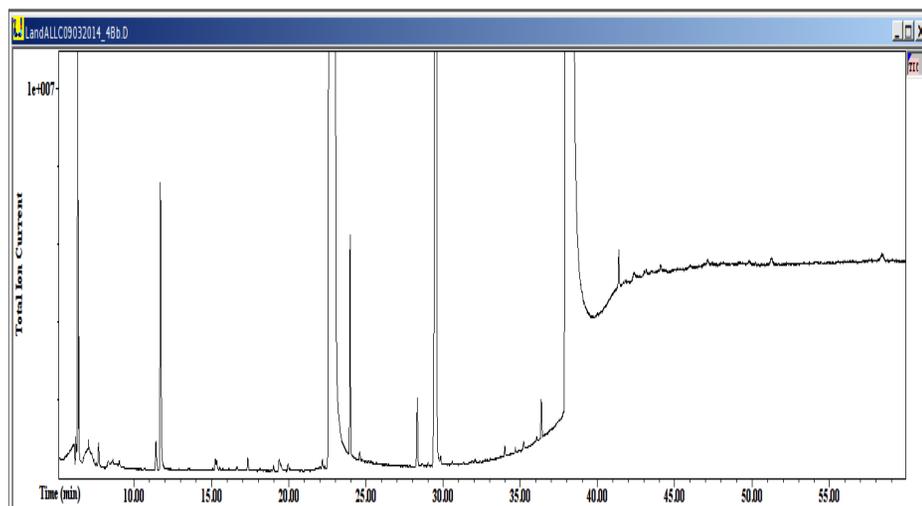
# Potential approaches

- Toxicological
  - Most e-liquids give no or minimal responses with common *in vitro* assays
  - Such assays would likely not provide understanding of toxic effects caused by thermal abuse
  - May not respond to trace-level impurities
- Chemical
  - Numerous chemical determinations could be employed, but would need more information on composition than may be available to select best combination of analyses

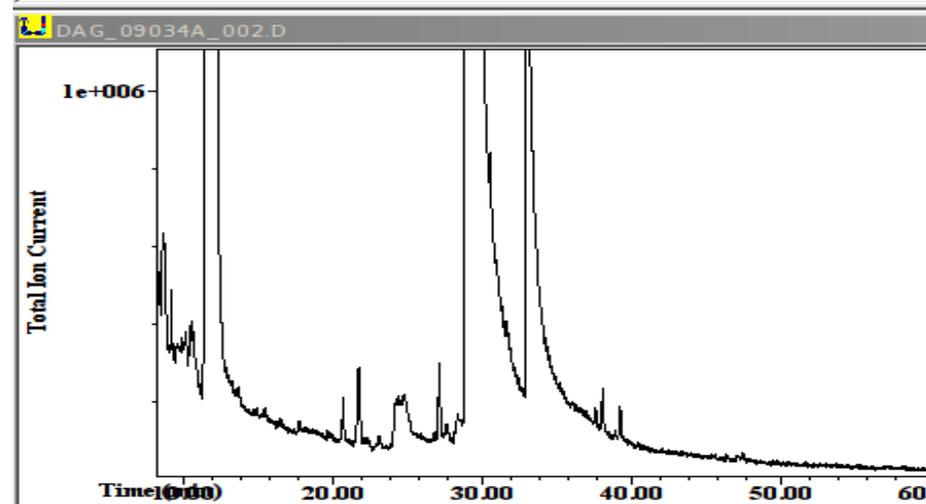
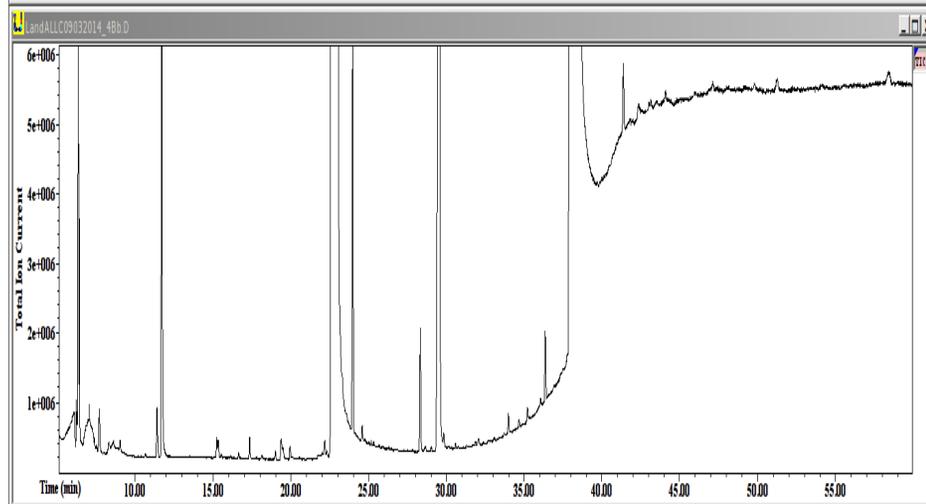
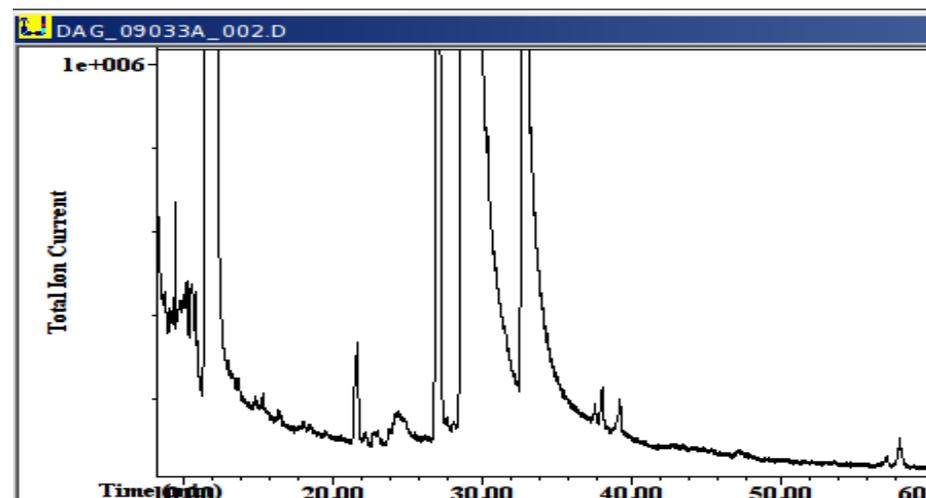
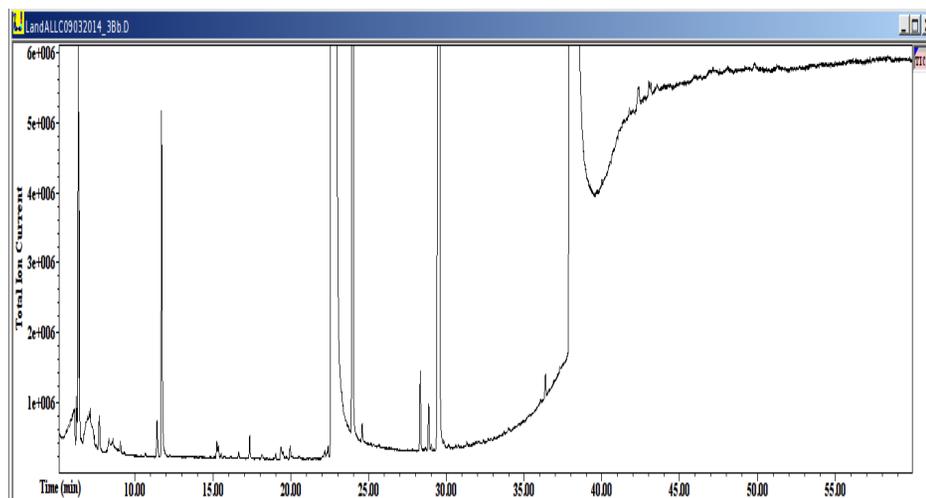
# Combination approach

- Gas chromatography – mass spectrometry (GC-MS)
  - Well known for characterizing flavor concentrates and final flavors used in tobacco industry
- Thermal analysis
  - Provides information on changes in e-liquids with heating such as decomposition and percent volatile at a given temperature
  - Thermogravimetric analysis (TGA) and differential thermal analysis (DTA)
- Cost of combined approach ~ \$2000/sample

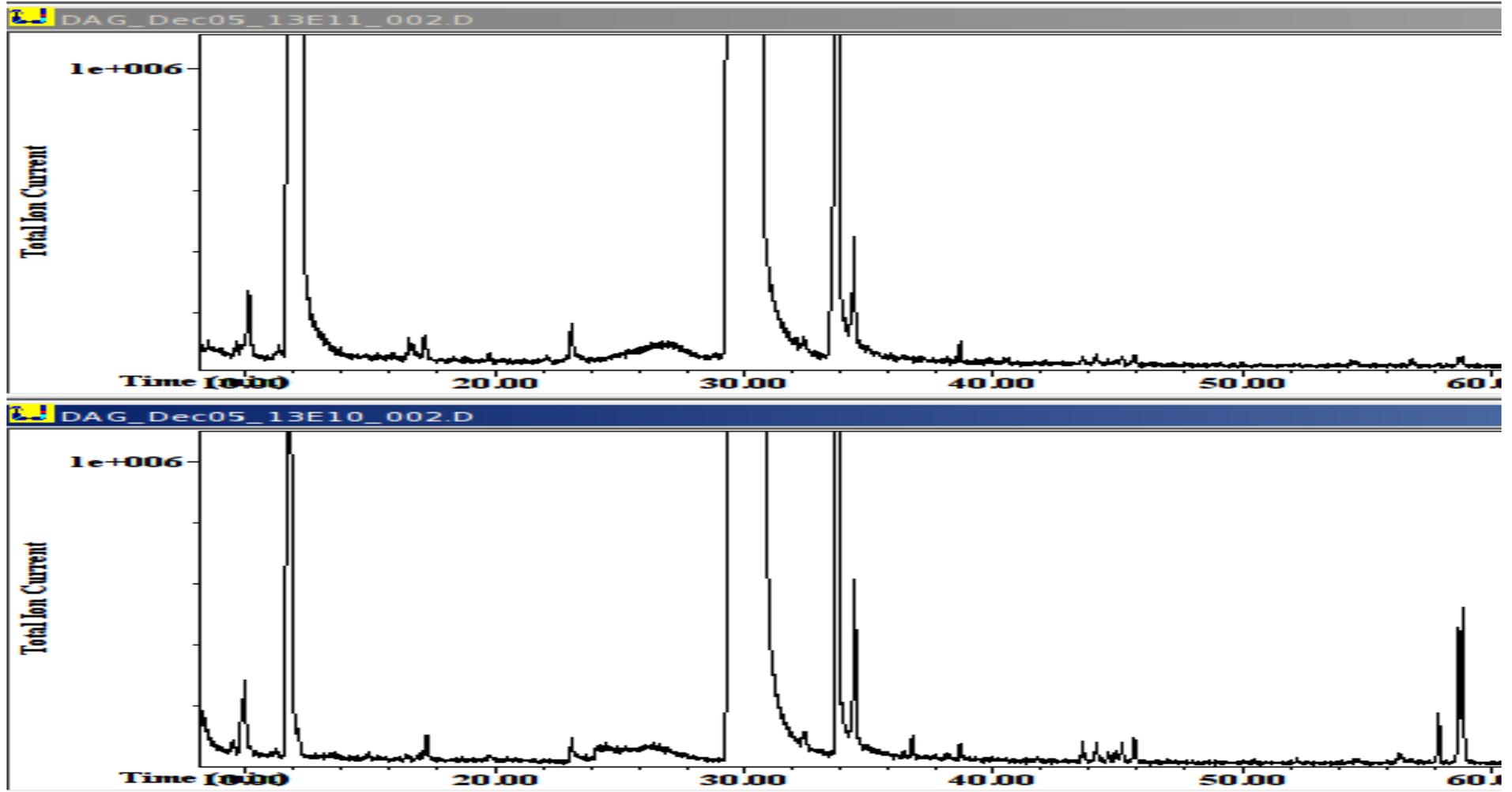
# Example GC-MS (Red vs. Gold)



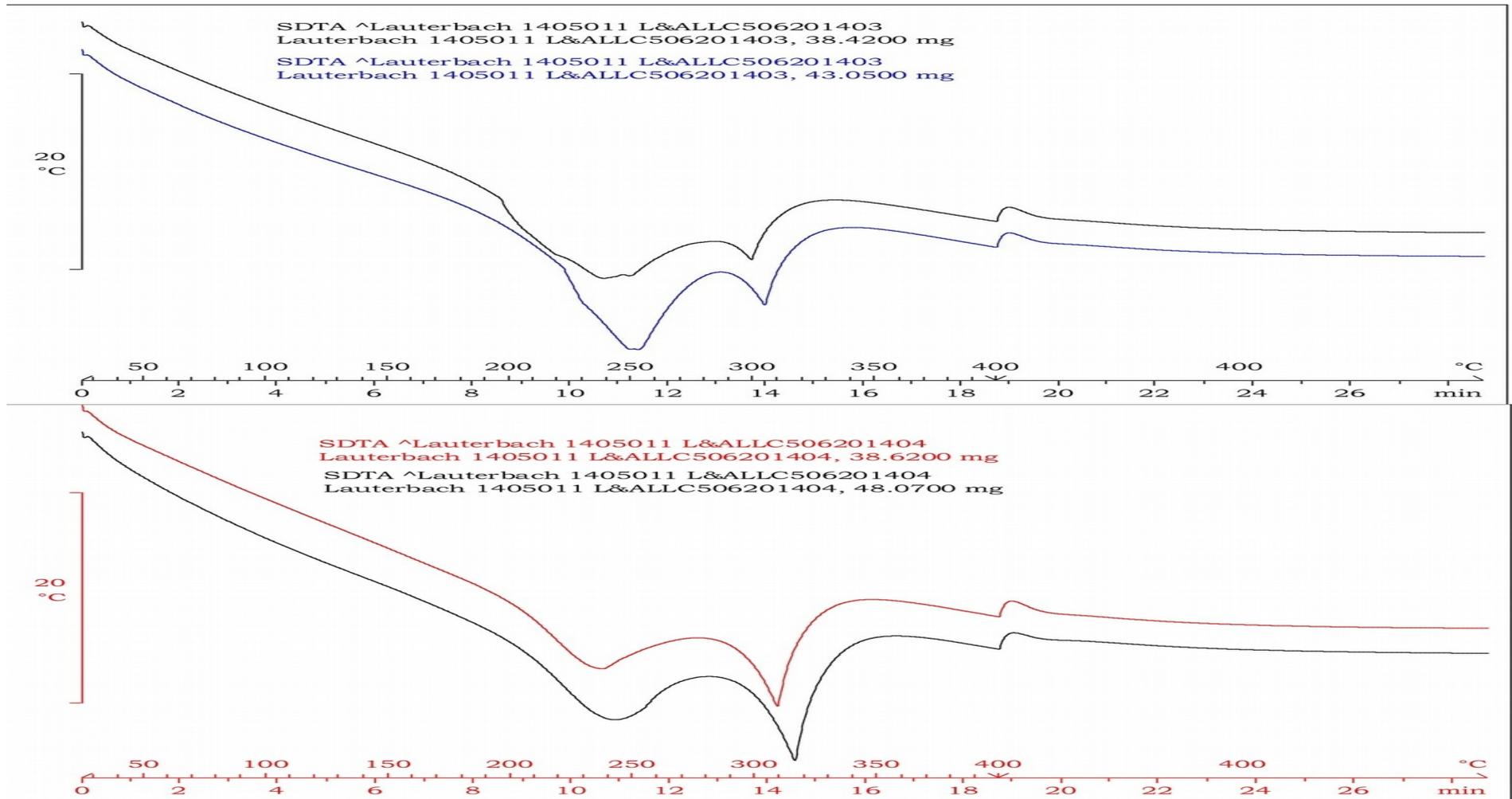
# Example GC-MS (Green vs. Red)



# Example GC-MS (normal vs exotic)



# Thermal analysis (E-liquid versus mix)



# Conclusions

- There is no substitute for a full quantitative disclosure of all ingredients in an e-liquid along with expert review of the information
- However, if full disclosure is not available, several GC-MS techniques along with thermal analysis applied to the e-liquid may provide sufficient information to rule out formulations which may contain constituents of toxicological concern or yield sugar pyrolysis products