# GC-MS analysis of e-liquids taken from e-cigarettes and e-liquids (e-juice) before use in e-cigarettes

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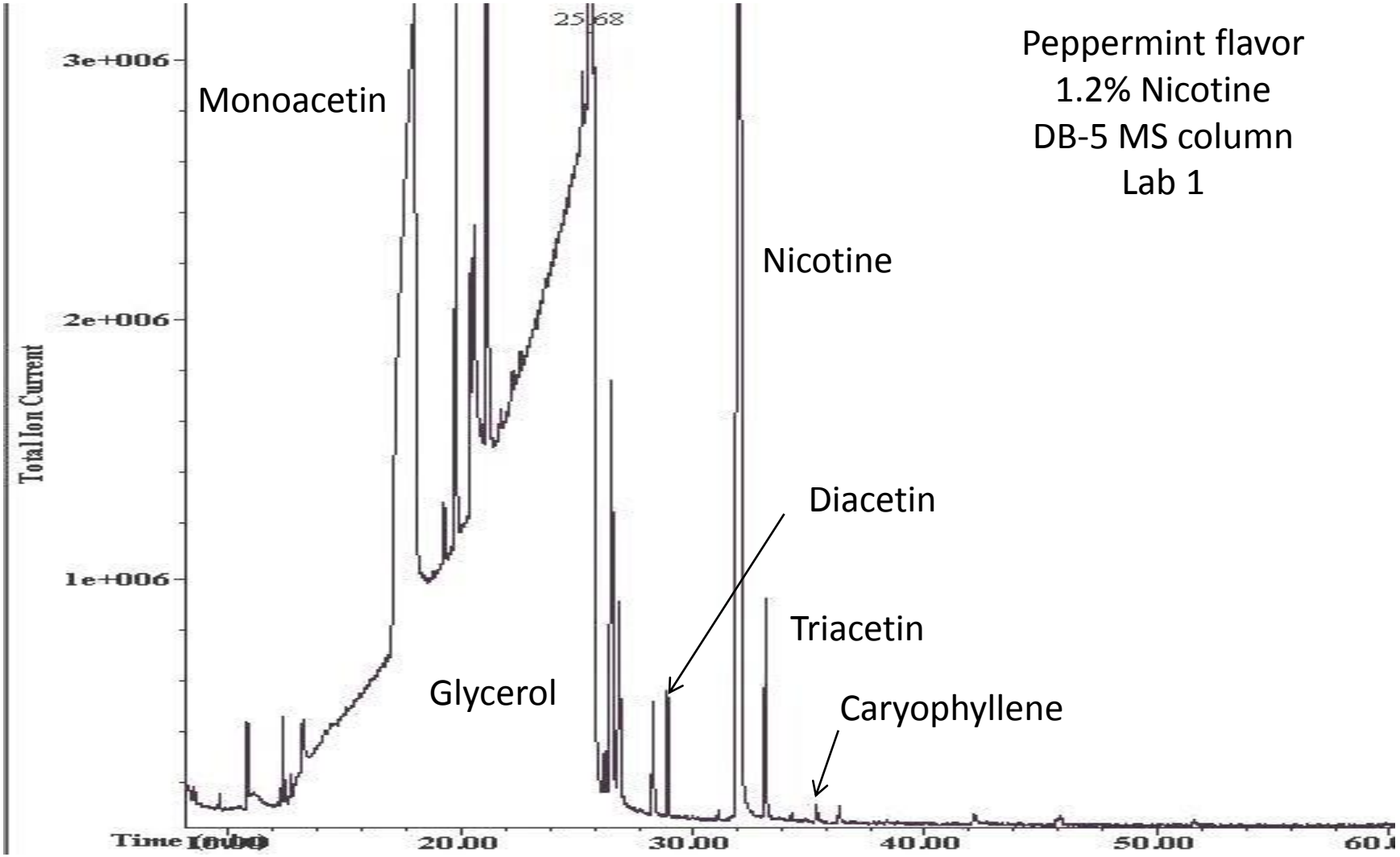
# Objectives for this presentation

- Identify major and minor species in e-liquids using traditional GC-MS analytical techniques
  - Main aerosol-forming species (PG, VG)
  - Flavorful components
  - Unexpected components
- Determine if published ingredient information was consistent with analytical findings
- Attempt to identify compounds present that might account for the cytotoxicity reported in some e-liquids (Bahl *et al*., Reproductive Toxicology 2012 34:529-37)

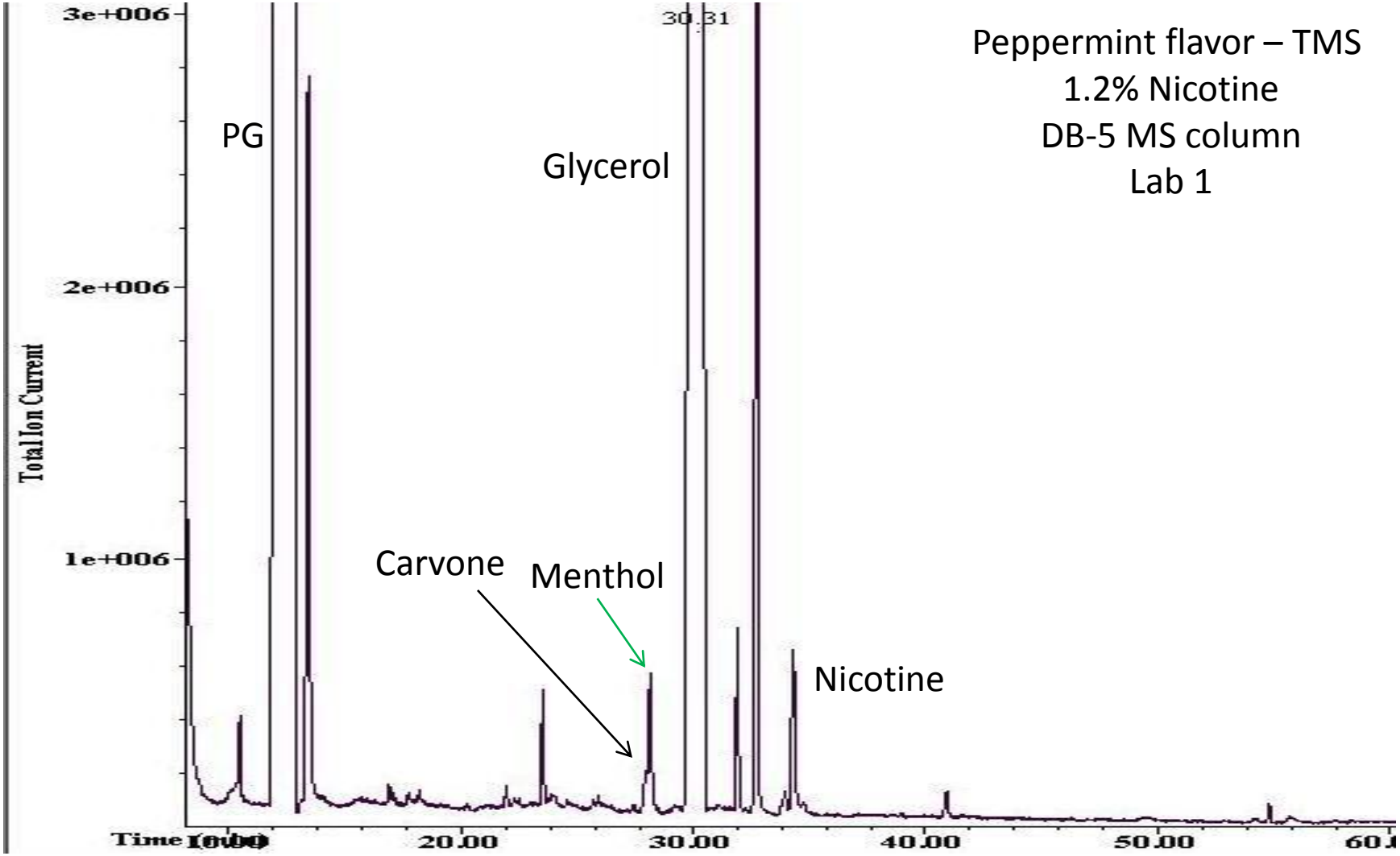
# Analytical approach

- Capillary column gas chromatography – mass spectrometry (GC-MS) has been main tool for analyses of flavors for more than three decades
  - Ability to separate and identify volatiles and semi-volatile components of complex mixtures
  - Long history of use in tobacco industry for analyses of flavor concentrates, finished flavors, and flavors applied to tobacco products
  - Tobacco flavors and flavor concentrates often formulated in propylene glycol (PG)
- These factors make GC-MS the ideal tool for the analyses of e-liquids and their components

# Example chromatogram 1a

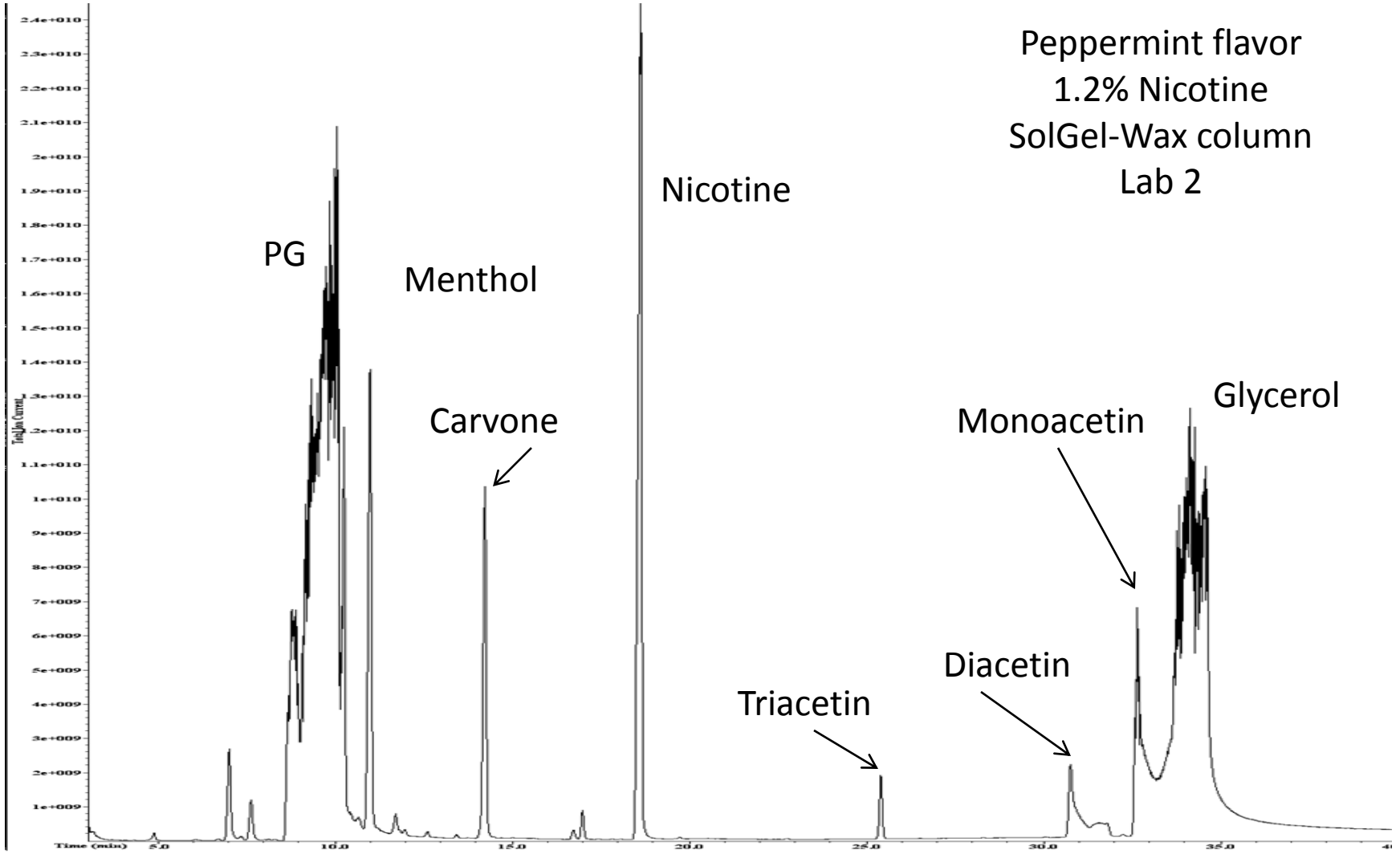


# Example chromatogram 1b




Peppermint flavor – TMS
1.2% Nicotine
DB-5 MS column
Lab 1

# Example chromatogram 1c



# Peppermint e-liquid

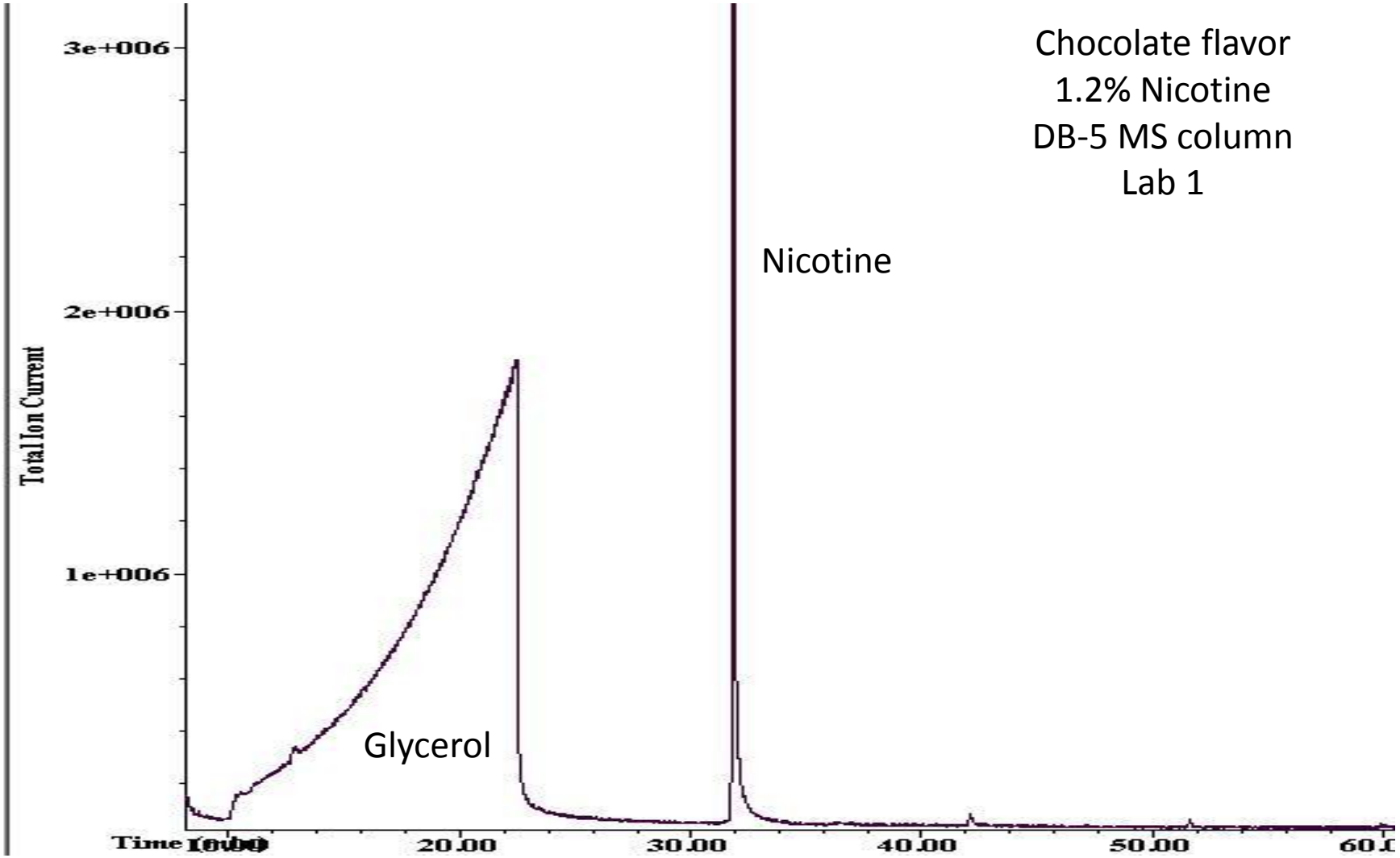
## Vendor's web page

| Compound | Amount |
|---|---|
| Propylene glycol | Very Large |
| Malic acid | Medium |
| Vanillin | Medium |
| Acetyl pyrazine | Small |
| Menthol | Small |
| Ethyl acetate | Small |
| Aliphatic acid | Very small |
| Common flavors | Very small |

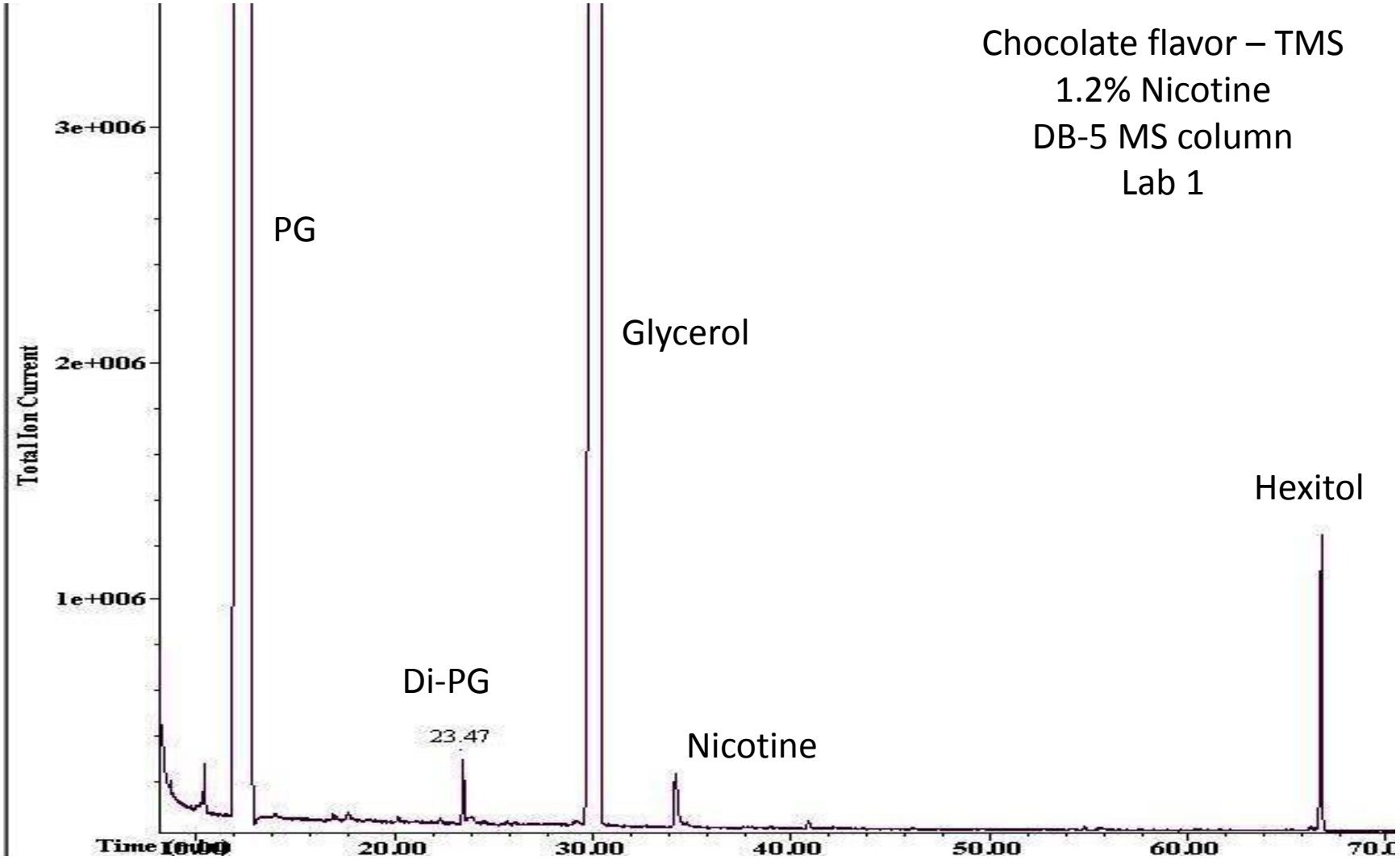
## Found by analysis

| Compound | Relative amount |
|---|---|
| Propylene glycol | Very large |
| Glycerol | Large |
| Monoacetins | Large |
| Diacetins | Medium |
| Triacetin | Medium |
| Menthol | Small |
| Menthone | Small |
| Carvone | Small |
| Pulegone | Very small |
| Anethol | Very small |
| Caryophyllene | Very small |

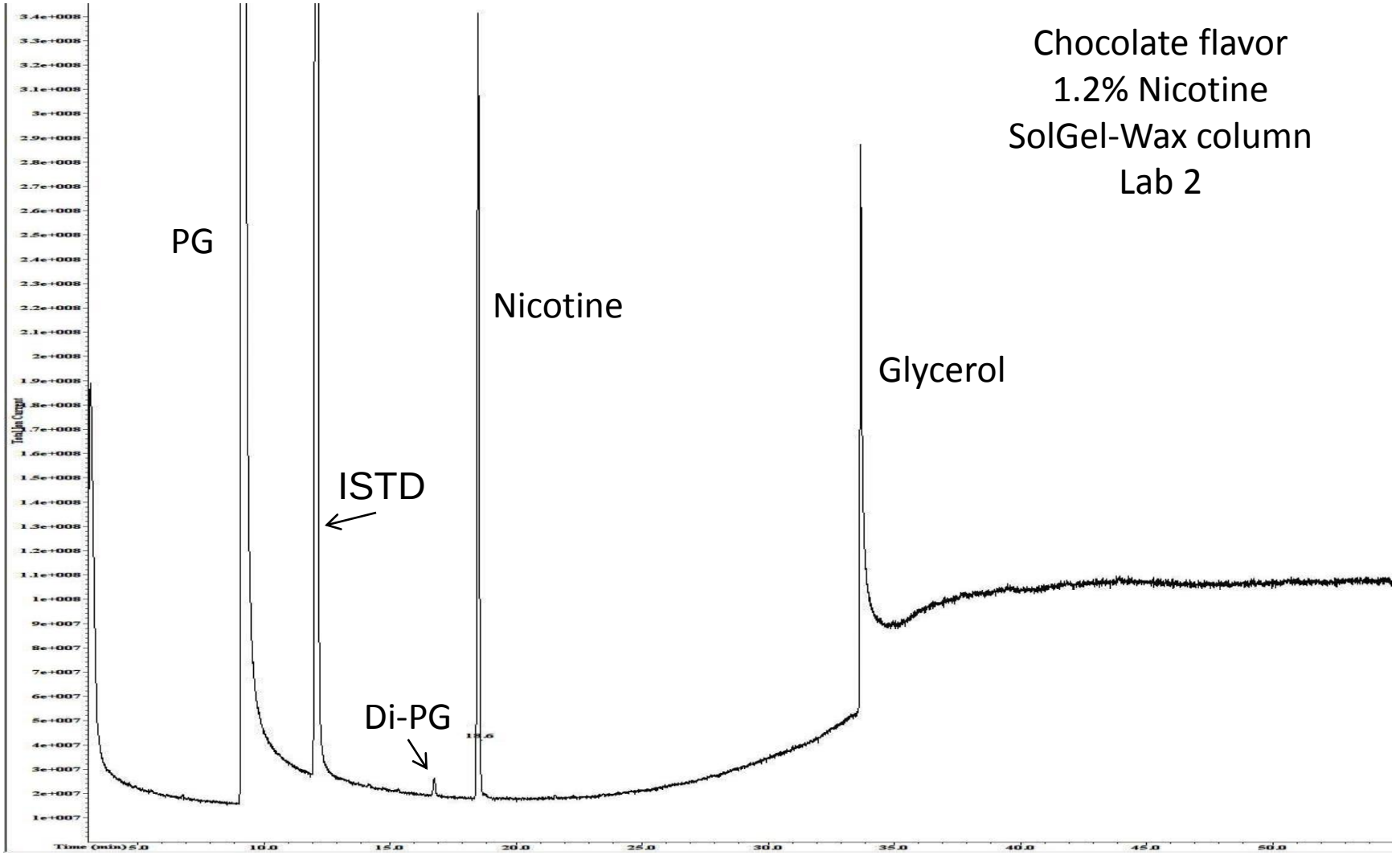
# Example chromatogram 2a



# Example chromatogram 2b



# Example chromatogram 2c



# Chocolate e-liquid

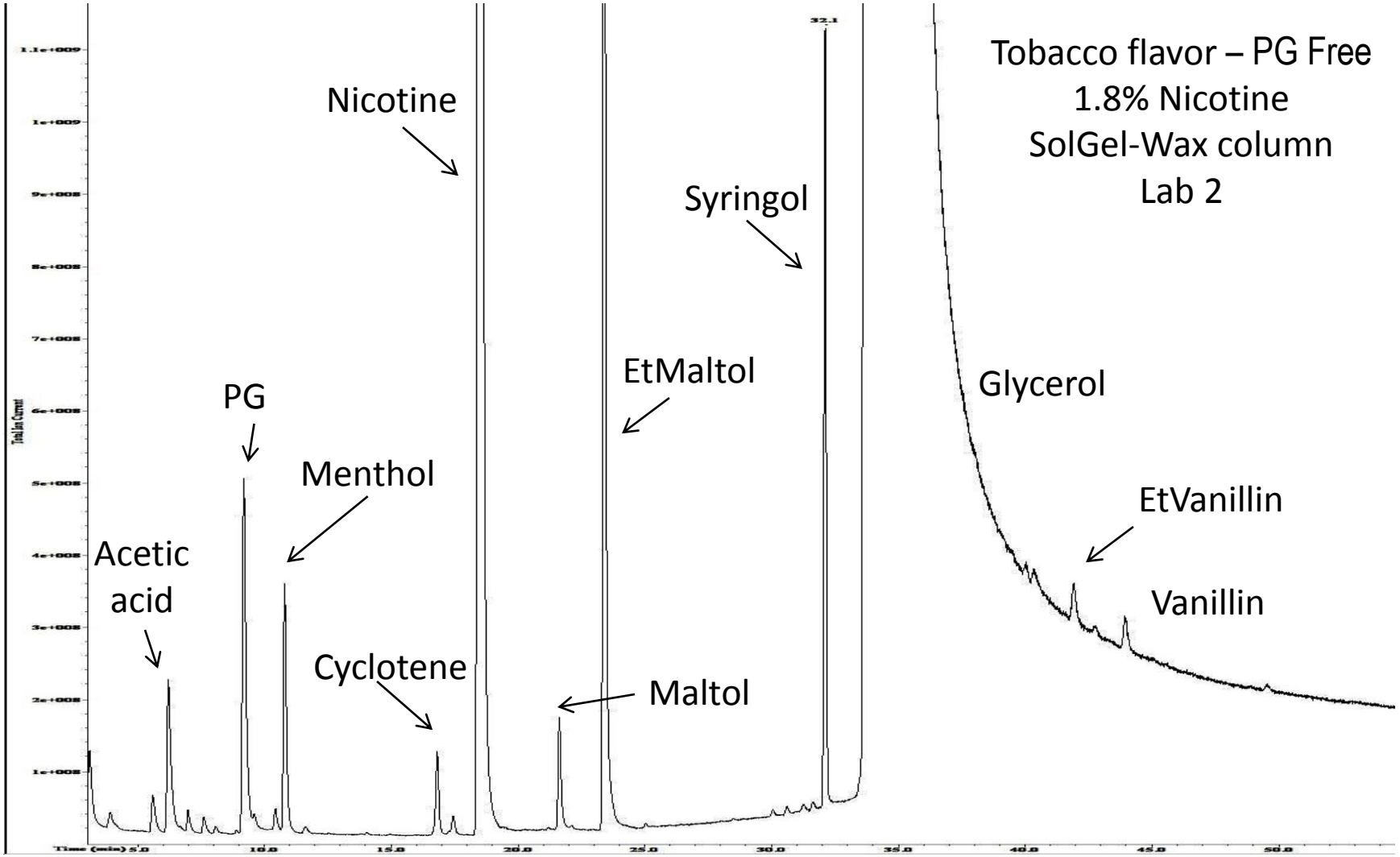
## Vendor's web page

| Compound | Amount |
|---|---|
| Propylene glycol | Very Large |
| Vanilla extract | Large |
| Terpene alcohol | Medium |
| Acetyl pyrazine | Small |
| Alkyl pyrazine | Small |
| C-5 aliphatic acid | Small |
| Common flavors | Small |

## Found by analysis

| Compound | Relative amount |
|---|---|
| Propylene glycol | Very large |
| Glycerol | Medium |
| C-6 sugar alcohol | Very small |
| Dipropylene glycol | Very small |

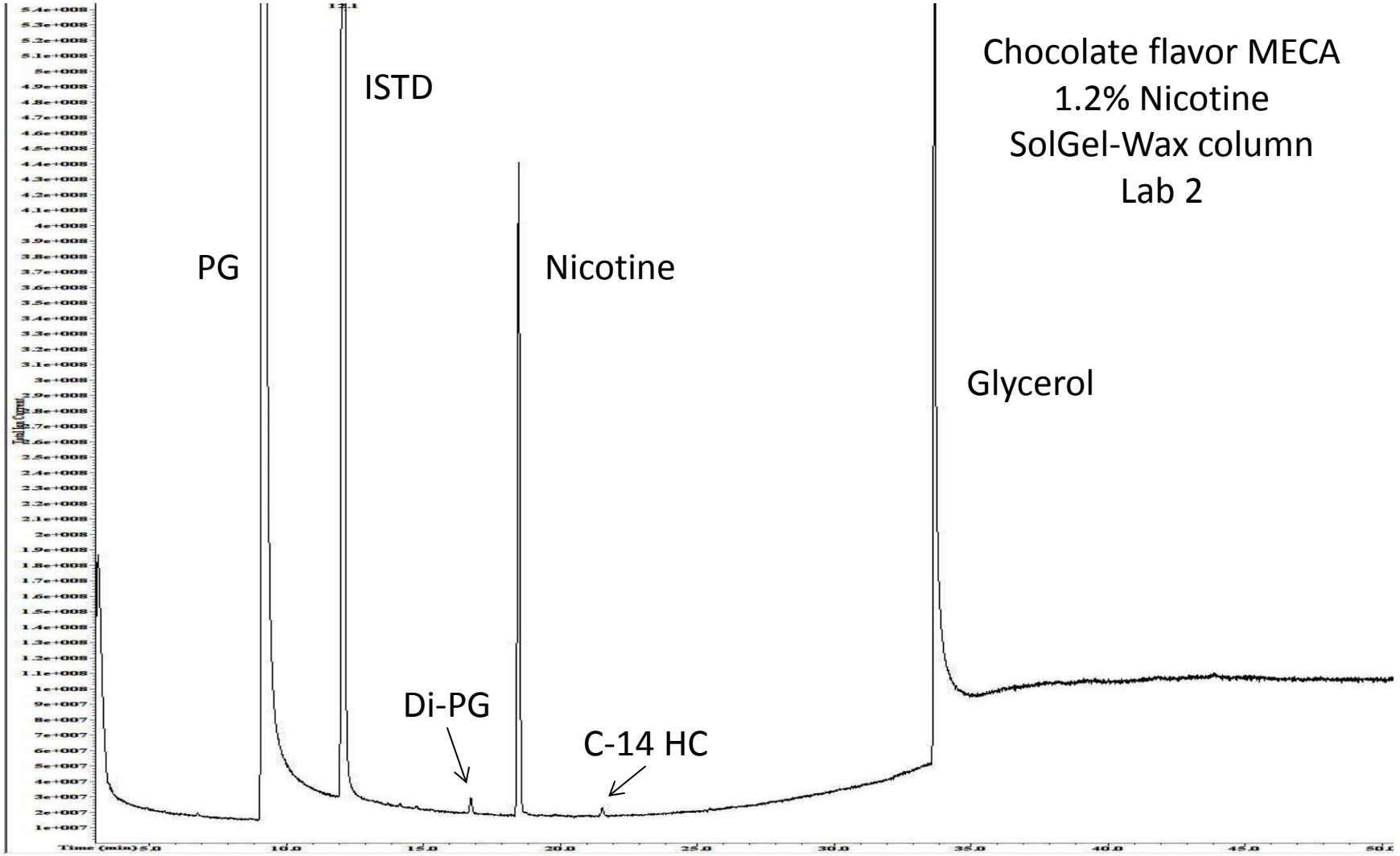
# Example chromatogram 3



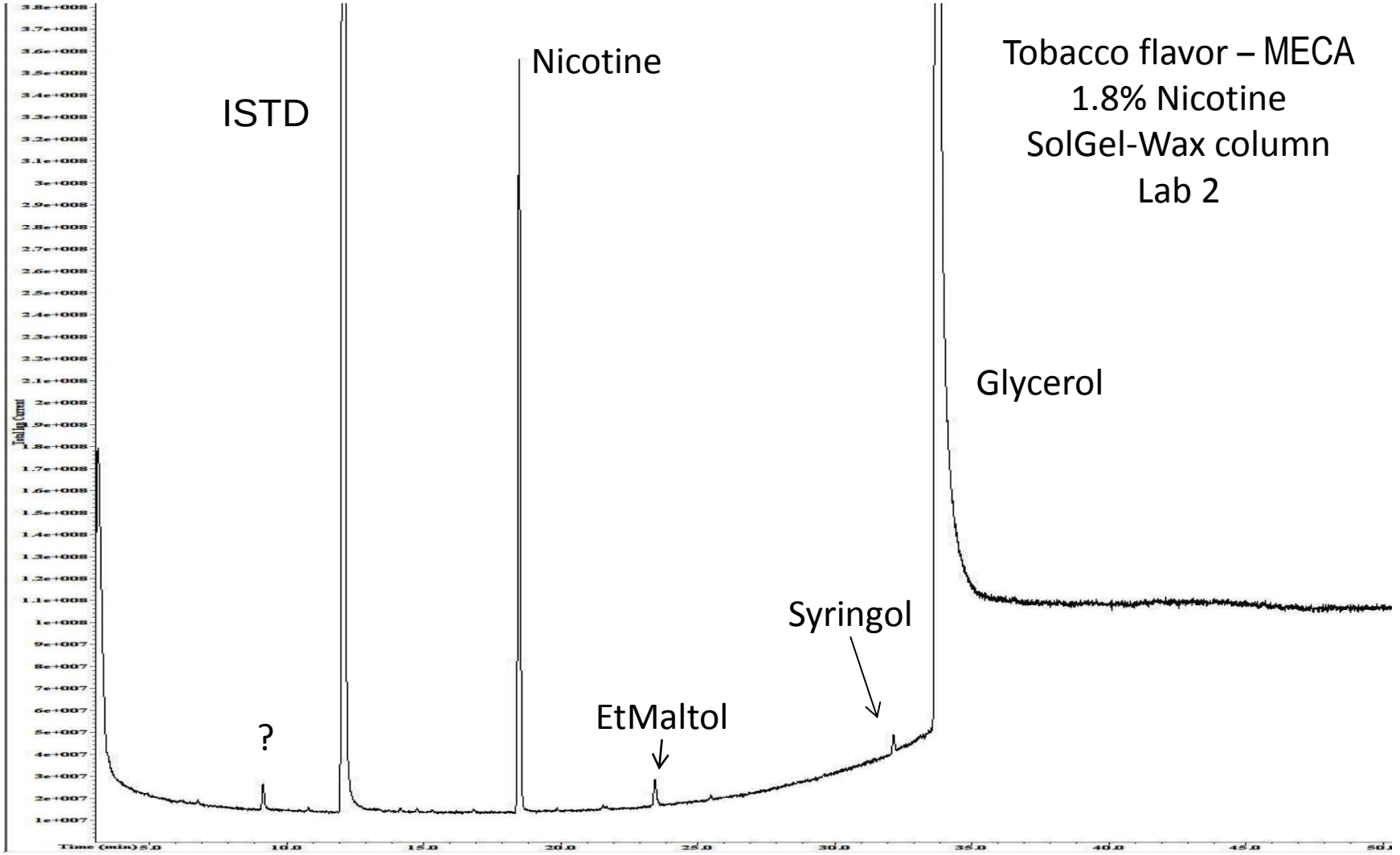
# Lagniappe

- Most information reported to date on the mainstream e-cigarette aerosol (MECA) has focused on nicotine content and/or known smoke toxicants
- However, the same techniques that are used for analyses of e-liquids should be useful for analyses of major components of MECA
  - Collect MECA on Cambridge pad
  - Health Canada Intensive smoking
  - 100 puffs (≈ 90 mg)
  - Extract pad with 2-propanol containing heptadecane as the internal standard (ISTD)

# Example chromatogram 4



# Example chromatogram 5



# Concluding remarks

- Traditional GC-MS techniques for analyses of flavors and smoke can be applied to e-liquids and mainstream e-cigarette aerosols (MECA)
- There were differences in e-liquid composition between what was expected and what was found
  - Are users getting the hedonic properties expected by the manufacturers of the e-liquids?
  - Do e-liquid vendors have accurate information on the composition of the products they are selling?
  - However, nothing to support report of cytotoxicity
- Is there sufficient flavor transfer for superior consumer satisfaction?

# Acknowledgement


- Some of the GC-MS analyses reported in this presentation were performed by Dr. Andrae Spencer of Global Laboratory Services of Wilson, NC. The author would like to thank Dr. Spencer very much for his excellent scientific work on the GC-MS analyses.
- The lead author of this presentation and Lauterbach & Associates, LLC, are totally responsible for the content of this presentation.