

Spring 5-11-2016

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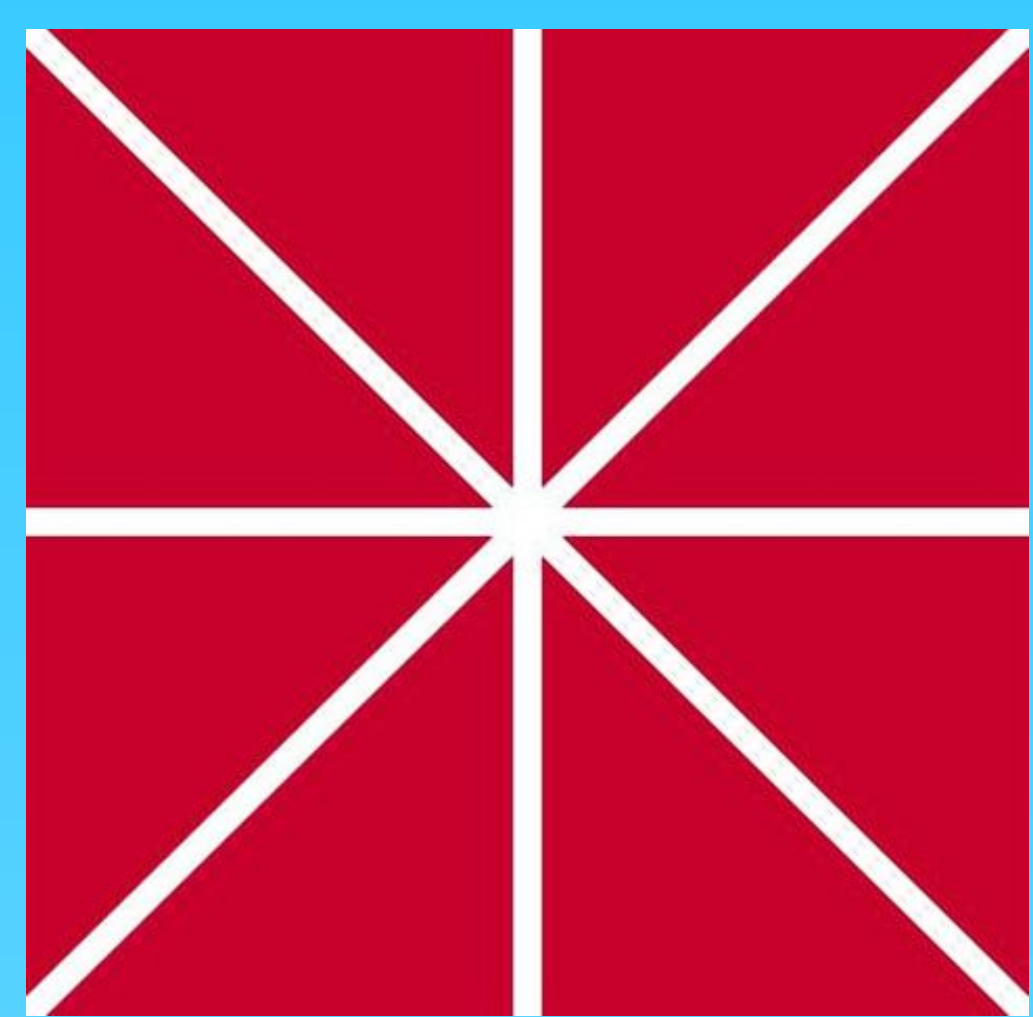
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Recommended Citation

Matranga, Austin; Sellers, Olivia; and Gartner, Matthew, "A Pilot Study Analyzing Solvents in Electronic Cigarette “E-liquid” Using High Performance Liquid Chromatography" (2016). *Student Scholar Symposium Abstracts and Posters*. 189.

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A Pilot Study Analyzing Solvents in Electronic Cigarette “E-liquid” Using High Performance Liquid Chromatography

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Introduction

Electronic cigarettes are battery-powered devices which use a heating element to vaporize an “e-liquid,” a vegetable glycerin (VG) and/or propylene glycol (PG) based solution of nicotine, although the e-liquid does not always contain nicotine, and flavorings. Places which retail electronic cigarettes tout them as being a safe alternative to tobacco cigarettes. Their reasoning behind this is that since electronic cigarettes do not burn tobacco, they are not as detrimental to our health as cigarettes. Since “e-liquids” and the electronic cigarettes are not regulated by the Food and Drug Administration, it is not known under what conditions, if any, carcinogenic compounds are produced. Heating elements in the electronic cigarettes can reach a temperature of up to 350°C and some of the e-liquid components may thus decompose into formaldehyde and acetaldehyde when heated. Formaldehyde is the simplest aldehyde. Studies have linked long term exposure to cancer and teratogenicity. Studies have shown that acetaldehyde may cause damage to DNA and increase cancer risk.

Experimental Methods

Preparation and analysis of standards

Standards of nicotine, vegetable glycerin, propylene glycol, acetaldehyde, and formaldehyde were made and analyzed using HPLC in order to compare to e-liquid and electronic cigarette vapor samples.

HPLC Analysis of E-liquids

Each of the 5 e-liquids purchased were analyzed using HPLC to determine if formaldehyde or acetaldehyde was present before being heated in the electronic cigarette.

Generation and capture of vapors from electronic cigarette

Vapor from the electronic cigarette was generated using a vacuum to provide the suction. The electronic cigarette was activated by hand and the vacuum was used to pull the vapor through a “U” shaped tube which contained 5 mL of a 1 mg/mL solution of DNPH in ACN.

Experimental Methods (cont.)

The smoking apparatus was used to take 10 4-second “puffs” of the electronic cigarette to simulate the real use of the electronic cigarette. After the 10 4-second puffs, the DNPH solution was added to a glass vial and stirred for 5 minutes using a Teflon stir bar to give time for the DNPH derivatives to form. The sample was then analyzed using HPLC.

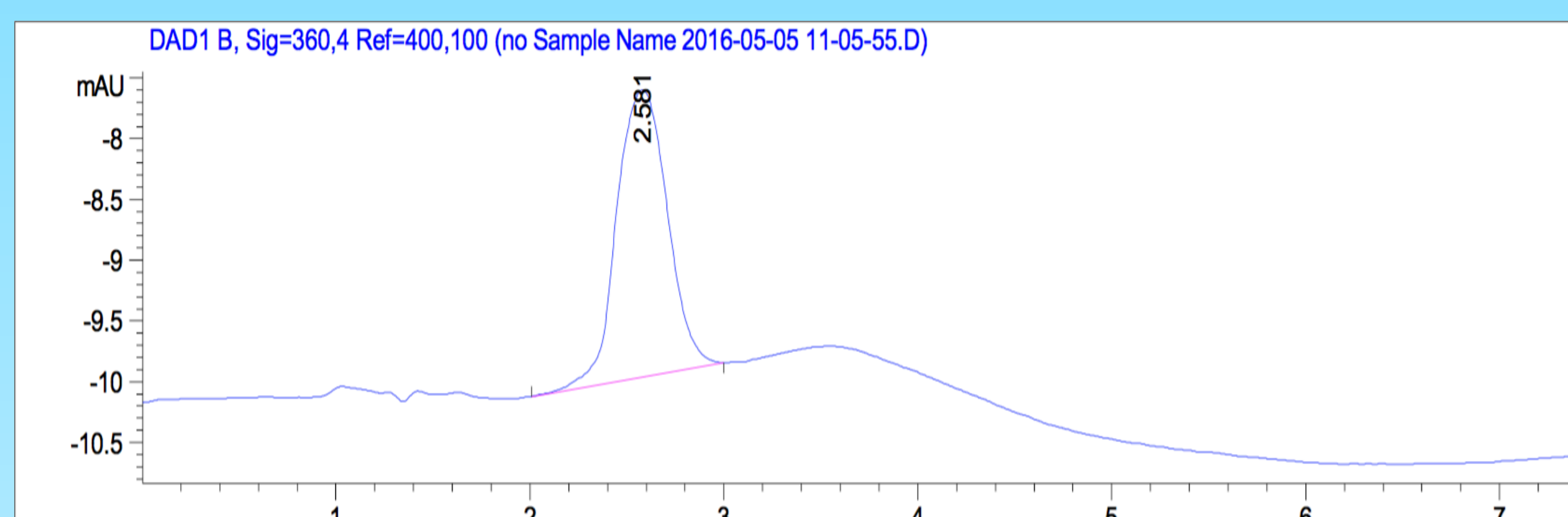


Figure 2. “Cola gummy” e-liquid pre heat

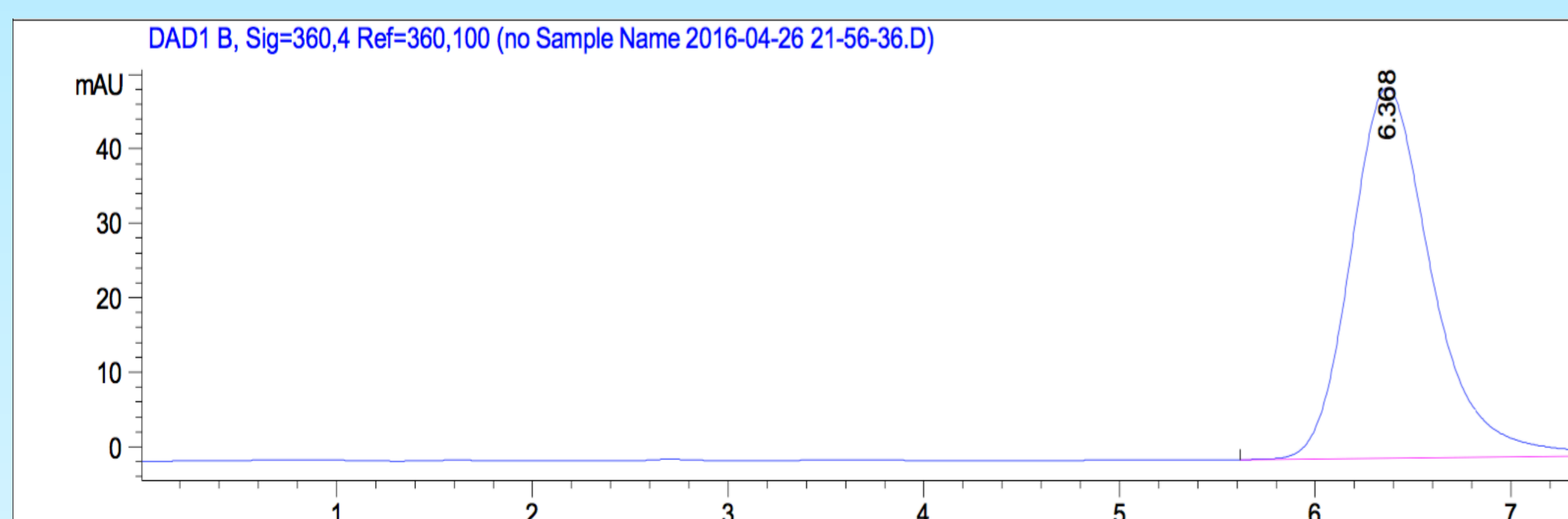


Figure 3. Formaldehyde standard at absorbance of 360 nm

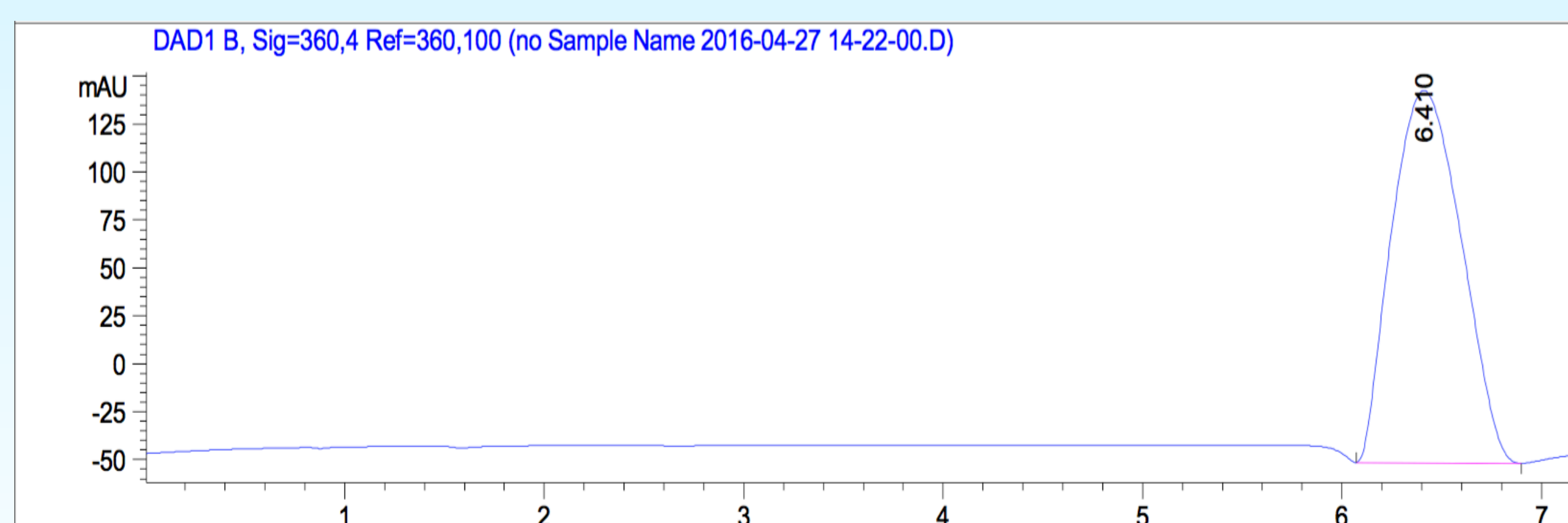


Figure 4. “Cola gummy” vapor at absorbance of 360 nm

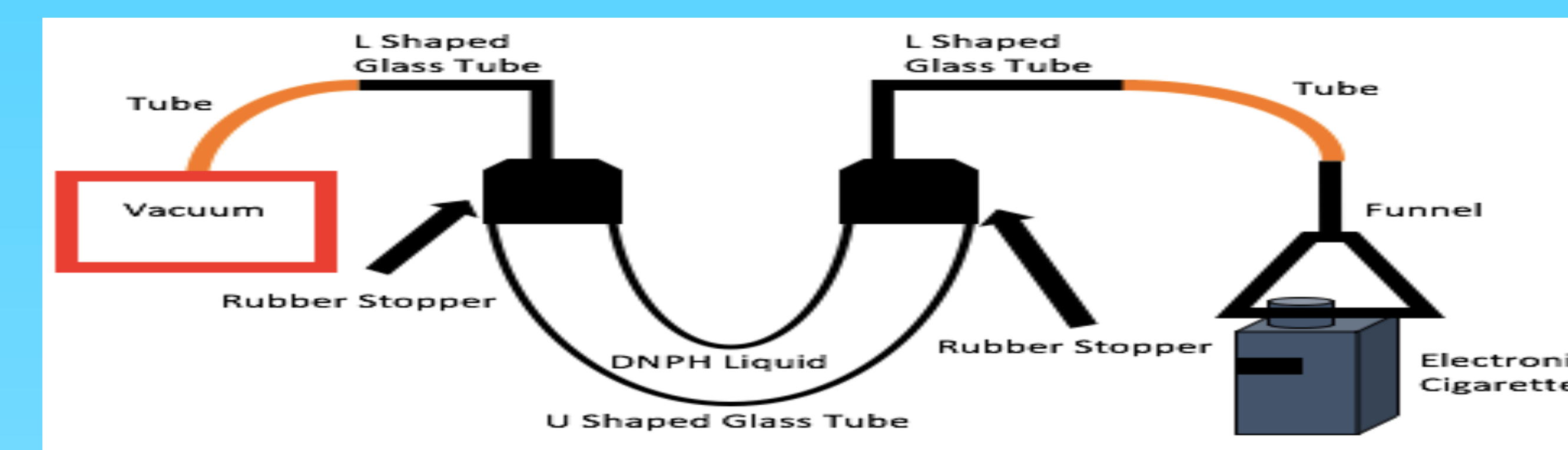


Figure 1. Diagram of apparatus used to generate and collect vapors from electronic cigarette.

Results

Before being heated in the electronic cigarette, formaldehyde was not found in any of the e-liquid samples. After being heated, formaldehyde was detected in the electronic cigarette vapors of each of the 5 e-liquid samples. However, acetaldehyde was not confirmed as being present in the e-liquid or electronic cigarette vapors of any of the 5 samples. The content of formaldehyde ranged from 8.28 µg/ml to 36.1 µg/ml.

Conclusion

- Decomposition of the e-liquid solvents yields a significant amount of formaldehyde.
- These levels of formaldehyde are well above what the Center for Disease Control considers a high exposure level.
- Formaldehyde has been found in numerous studies to be carcinogenic to humans.

Future Work

Future work is required to determine the exact mechanism of the decomposition of solvents to formaldehyde and to determine under what conditions other carcinogenic compounds may form.

Acknowledgements

This project was supported and funded by the Chapman University Schmid College of Science and Technology Senior Capstone Fund. Special thanks to Dr. Gartner and Dr. Schwartz.