UPLC-MS Separation and Analysis of Carbonyl Compounds in e-Liquids Aerosol Samples

CARTER, K.M.; MAINES, J.H.; and GILLMAN I.G.
Enthalpy Analytical, Inc. Richmond, VA 23228, USA

ABSTRACT

The popularity and regulation of electronic nicotine delivery systems (ENDS) has drawn attention to the chemical composition of the e-liquids used in, and aerosols formed by these devices. The possible presence of carbonyl compounds like formaldehyde, acetaldehyde, diacetyl, acetylpropionyl, and acetoin are of concern due to their potential impact on human health when inhaled at sufficient concentrations. Flavoring added to the e-liquids may contain diacetyl, acetylpropionyl, and acetoin which can be easily transferred to the aerosol. Propylene glycol and glycerin, the main carriers used in e-liquids, are heated during the formation of the aerosol and may undergo thermal decomposition leading to the formation of formaldehyde and acetaldehyde. Analytical detection of carbonyls is commonly achieved by analysis of their corresponding 2,4-dinitrophenylhydrazine (DNPH) derivatives using liquid chromatography. This method can be problematic in this complex matrix due to the possibility of interfering peaks and can result in incorrect reporting of data.

OBJECTIVE

Develop a single rapid high-throughput method for the analysis and detection of carbonyls in complex mixtures of e-liquid and aerosol using ultra-performance liquid chromatography (UPLC) with tandem mass spectrometry detection (UPLC-MS/MS) after derivatization with DNPH. The LC-MS/MS method will be compared to an existing HPLC method with an emphasis on its application to the analysis of complex, highly flavored sample

ANALYTICAL METHOD

Waters AQUITY UPLC Conditions	
UPLC Column	Pursuit XRS Ultra C18, 2.0 x 100 mm, 2.8 µm
Column Temperature	40°C
Injection Volume	1 µL
Flow Rate	0.45 mL/min
Mobile Phase A	Water
Mobile Phase B	Acetonitrile
Analysis Time	7 min

Waters Xevo TQ MS /MS Conditions	
Ionization Mode	Electrospray negative
Source Temperature	150 °C
Desolvation Temperature	600 °C

Analyte	Precursor Ion (m/z)	Product Ion (m/z)	Cone Voltage (V)	Collision Energy (V)
acetaldehyde	223.1 223.1	151.0 163.1	20	10
acetone	237.2	151.0	20	10
acetoin	267.2	151.9 267.2	30	10
acetylpropionyl	279.2	279.2	30	10
acrolein	235.1	158.0 163.1	15	10
crotonaldehyde	249.4	163.1 172.2	20	10
diacetyl	265.2	176.9 265.2	30	10
formaldehyde	209.1	151.0 163.1	20	10

Sample Prep

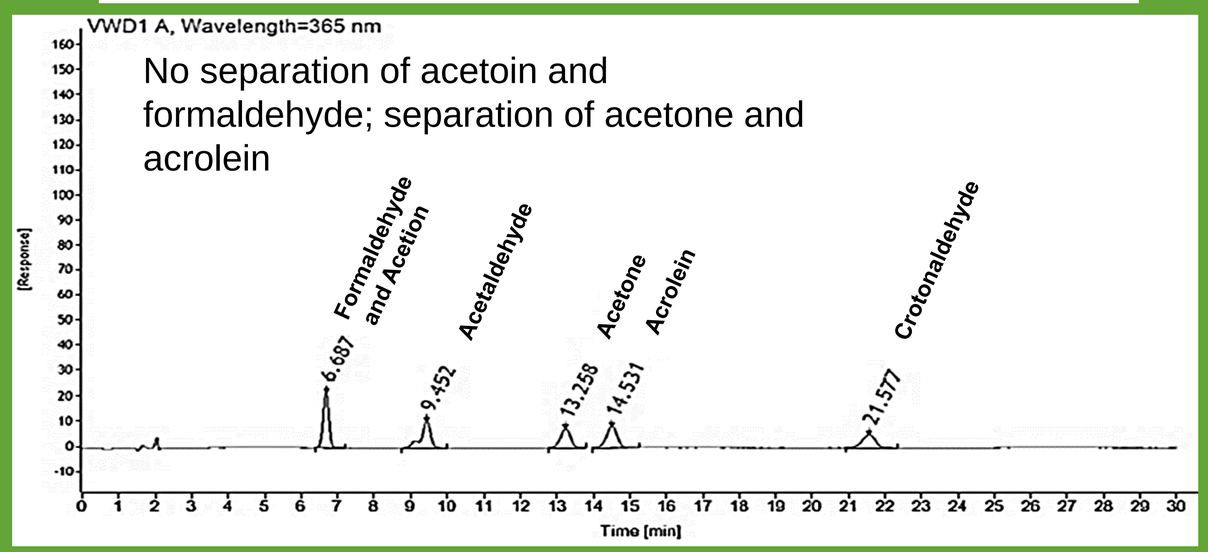
An aliquot of e-Liquid and/or e-Liquid flavor is derivatized with DNPH. After the derivatization reaction is complete, samples are neutralized with pyridine and analyzed.

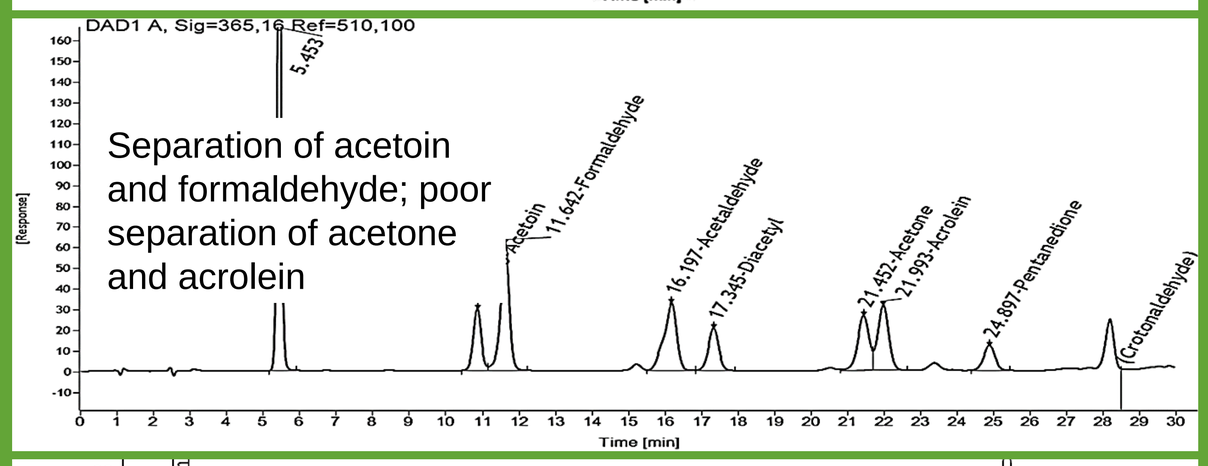
REFERENCES

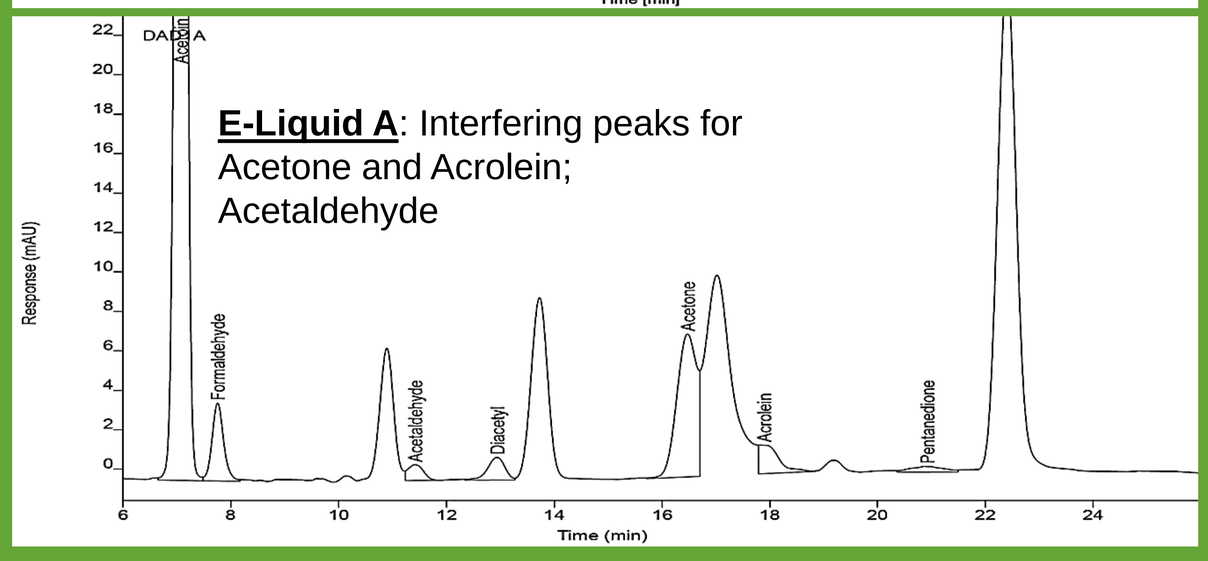
- Farsalinos KE, Kistler KA, Gillman G, Voudris V. Evaluation of Electronic Cigarette Liquids and Aerosol for the Presence of Selected Inhalation Toxins. Nicotine & Tobacco Research. 2015;17(2):168-174.
- Flora, J.; Wilkinson, C.; Wilkinson, J.; Miller, J. Sensitive and selective method for carbonyl determination in e-cigarette aerosols. CORESTA SSPT 2015, Jeju Island, South Korea, October 4-8, 2015.

HPLC-UV DATA

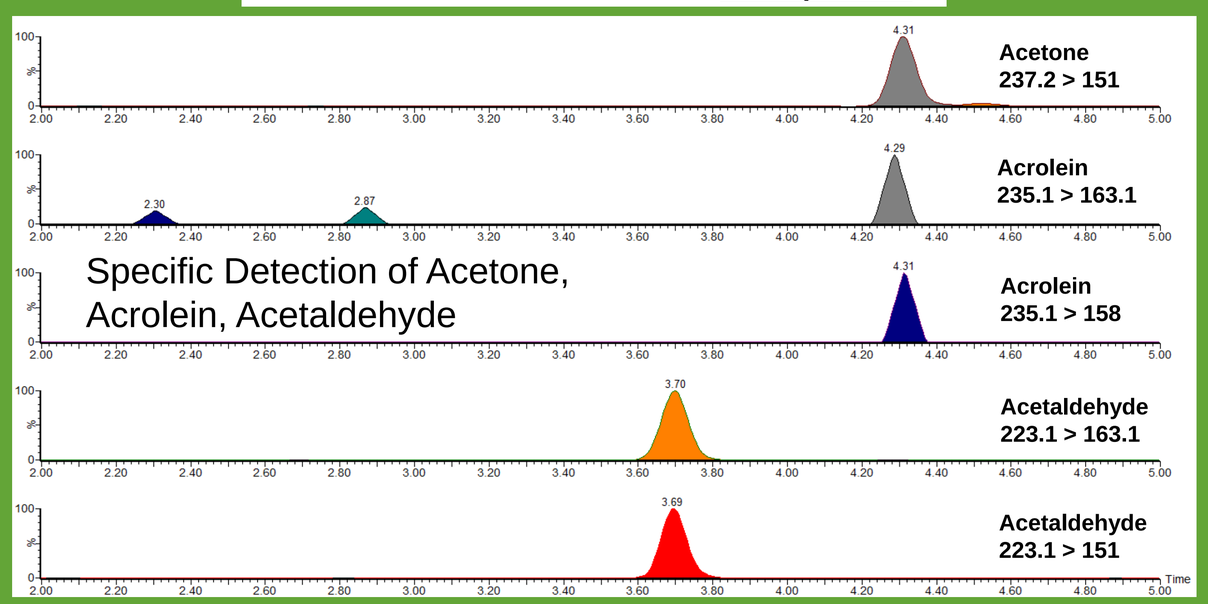
Inadequate separation and interfering peaks

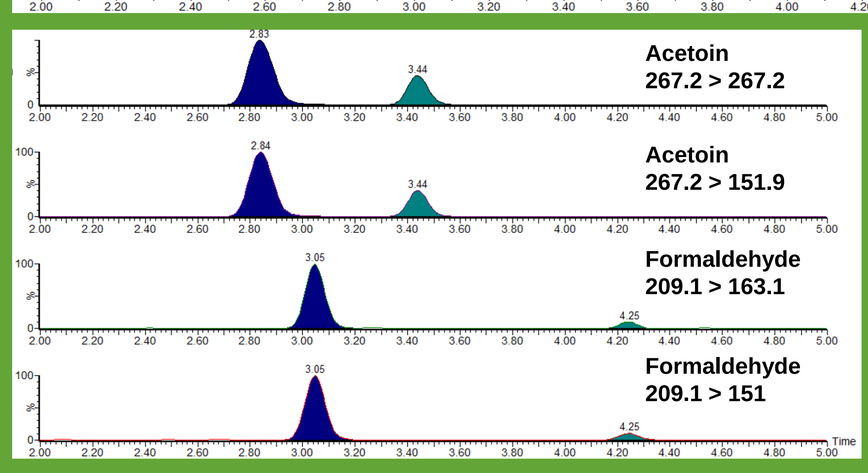






UPLC-MS/MS DATA E-liquid A





Specific Detection of acetoin and formaldehyde by LC separation and use of MS/MS

SUMMARY

- A rapid high-throughput method for determination of carbonyl compounds after derivatization with DNPH by UPLC-MS/MS was developed and successfully applied to the evaluation of complex e-liquid and aerosol samples.
- By utilizing the capabilities of MS/MS detection, analytes are identified by their unique masses even in the presence of interfering/overlapping peaks. Each analyte's individual MRM indicates only the target analyte.
- This method allows for detection and analysis of carbonyls including formaldehyde, acetaldehyde, acetone, diacetyl, acetylpropionyl, acrolein, acetoin, and crotonaldehyde in e-liquid and aerosol samples in less than ten minutes.
- This method can identify carbonyls in e-liquids containing complex mixtures due to flavor components.