

E-Liquid Quality by Design to Manufacture Safer Products

Case Study: VML's Mojito Lemonade – Liquid Ingredients



Mojito Flavor/Liquid Composition

Flavor Composition	CAS Number	Relative Percentage in Flavoring	Is the ingredient found in emissions?
Propylene Glycol	57-55-6	60-85	No
Polyethylene Glycol sorbitan monooleate	9005-65-6	1	No
Oils, lemon, psoralen-free	68916-89-2	1	No
Vanillin	121-33-5	1	No
Benzaldehyde, 3-ethoxy-4-hydroxy	121-32-4	1	No
(+)- Menthol	89-78-1	1	No
L-Menthan-3-one	14073-97-3	1	No
Oil, peppermint	8006-90-4	1	No
Alpha Pinene	80-56-8	1	No
Possible propylene glycol reaction products		5.9	No
Ethyl Citrate	77-93-0	2.4	No
Sabinene	3387-41-5	1	No
Unresolved 1,4-Cineole	470-67-7/99-86-5	1	No
Beta Phellandrene	555-10-2	1	No
2,2,4-trimethyl-1,3-dioxolane	1193-11-9	0.5	No
Ethanol	64-17-5	10.0-15.0	Yes
Acetylaldehyde ^b	75-07-0	1	Yes/No
Beta Pinene	127-91-3	1	Yes
Gamma terpinene	99-85-4	1.6	Yes
Geranial	5392-40-5	4.7	Yes
Limonene	138-86-6	10.0-15.0	Yes
Myrcene	123-35-3	1	Yes/No
Neral	106-26-3	3.5	Yes
Para cymene	99-87-6	0.6	Yes
Terpinolene	586-62-9	0.5	Yes

^bAcetylaldehyde is a known toxic ingredient that is banned in the UK & Germany

Bulk Flavor Ingredients (both natural and artificial)	Percent
Glycerin	74%
Lemonade	10%
Key lime	4%
Lemon Lime	4%
Mint Candy	1%
Sweetener - Old Formulation - Primarily Acetylaldehyde	1%
Nicotine (6 mg/mL)	6%

Sweetener (New Formulation)

- This study demonstrates how hazardous ingredients found in E-Liquids can be removed to produce a safer product
- Following flavor and vapor analysis Mojito Lemonade was found to contain 13 potentially harmful ingredients
- It was identified that these ingredients originated from the Sweetener ingredient used in the E-Liquid formulation
- Old sweetener was replaced with new Sweetener and the harmful ingredients were removed

E-Liquid Quality by Design to Manufacture Safer Products Compared to Combustion Cigarettes – Vapor Components



Mojito Vapor Composition

Emission Composition	CAS Number	Concentration (ug/puff)	
		Old Formulation	New Formulation
Nicotine		10	20
Formaldehyde	50-00-0	2.38	<0.1*
Acetaldehyde	75-07-0	16.32	<0.1
Acrolein	107-02-8	5.2	<0.1
Crotonaldehyde	123-73-9	<0.007	<0.1
Diacetyl	431-03-8	<0.014	<0.1
Acetyl Prionyl	600-14-6	<0.18	<0.1
Ethylene Glycol	107-21-1	0.7	<0.2
Di-ethylene Glycol	112-34-5	<0.20	<0.2

Emission Composition	CAS Number	Concentration (ng/puff)	
		Old Formulation	New Formulation
Acetone	67-64-1	560	Nd ^a
Benzene	71-43-2	26	<10*
1,3-Butadiene	71-43-2	6477	<10
Isoprene	106-99-0	92	<10
Toluene	78-79-5	22	<10
Propanal	108-88-3	557	nd
Methyl glyoxal	78-98-8	420	nd
1-Hydroxy-2-propanone	116-09-6	344	nd
2-Propen-1-ol	107-18-6	708	nd
Acetic acid	64-19-7	122	nd
Ethanol	64-17-5	959	1946
Beta Pinene	127-91-3	275	154
Gamma terpinene	99-85-4	162	129
Geranial	5392-40-5	nd	140
Limonene	138-86-3	2512	1967
Myrcene	123-35-3	167	nd
Neral	106-26-3	nd	135
Para cymene	99-87-6	165	120
Terpinolene & octanal	586-62-9	nd	134

*Below LOQ

5V, 9.3W

4.2V, 9.2W

^a Not Detected

Cigarette Smoke Composition ^c
1,3-Butadiene
Acetaldehyde
Acetone
Acrolein
Benzene
Crotonaldehyde
Formaldehyde
Isoprene
Nicotine
Toluene
1-aminonaphthalene
2-aminonaphthalene
Acrylonitrile
Ammonia
Benzo[a]pyrene
Butyraldehyde
Cadmium
Carbon Monoxide
Catechol
Chromium
Cresol
Hydrogen Cyanide
Hydroquinone
Lead
Methyl Ethyl Ketone (MEK)
Nickel
Nitric Oxide
NNN, NNK, and NAT
Phenol
Propionaldehyde
Pyridine
Quinoline
Resorcinol
Styrene
Tar

- Composition of E-Liquids can be modified to ensure safer components whereas combustion cigarettes cannot
- Nicotine levels can be controlled in E-Cigarettes whereas combustion cigarettes cannot

E-Liquid Quality by Design to Manufacture Safer Products Compared to Combustion Cigarettes

Heavy Metal Content



Old Mojito Formulation

Analyte	Concentration (µg/puff)
Aluminium	<0.0018
Arsenic	<0.0004
Cadmium	<0.0001
Chromium	0.0152
Copper	0.0089
Iron	0.0570
Lead	<0.0054
Mercury	<0.0004
Nickel	0.0077
Tin	<0.0015

New Mojito Formulation

Analyte	Concentration (µg/puff)
Aluminium	<0.0018
Arsenic	<0.0004
Cadmium	<0.0001
Chromium	<0.0024
Copper	<0.0015
Iron	<0.0023
Lead	<0.0054
Mercury	<0.0004
Nickel	<0.0018
Tin	<0.0015

Cigarette Smoke Composition

Chromium
Lead
Nickel

Heavy metals in Mojito Lemonade was removed in the new formulation making a safer product

Overall Conclusion:

- 1) Mojito Lemonade was successfully reformulated to remove all hazardous ingredients found in the original formulation
- 2) The only common ingredient of the new formulation with combustion cigarettes is Nicotine and Nicotine levels in Mojito Lemonade can be adjusted down to ZERO