

Pine Rosin as a Toxic Cannabis Extract Adulterant

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Pine rosin (colophony) has been identified as a new adulterant in cannabis oil for vaping. Its inhalation toxicity is a significant health concern. For example, pine rosin fumes are released during soldering, and have been cited as a causative agent of occupational asthma. Symptoms also include desquamation of bronchial epithelium, which has been observed in EVALI patients. The sample analyzed herein also contains medium chain triglycerides and oleamide, the latter of which is found in the synthetic marijuana product Spice, or K2. A combination of NMR and HPLC-ESIMS was used to unambiguously identify major pine rosin ingredients such as abietic and other resin acids. Comparison to commercial samples of pure pine rosin confirmed the assignment.

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Pine Rosin as a Toxic Cannabis Extract Adulterant

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Abstract

Pine rosin (colophony) has been identified as a new adulterant in cannabis oil. Its inhalation toxicity poses a significant health concern to users. For example, pine rosin fumes are released during soldering, and have been cited as a causative agent of occupational asthma. Symptoms also include desquamation of bronchial epithelium, which has also been observed in EVALI patients. The sample analyzed herein was acquired from a cannabis industry source, also contains medium chain triglycerides and oleamide, the latter of which is a hypnotic that is commonly found in the synthetic marijuana product Spice, or K2. A combination of NMR and HPLC-ESIMS was used to unambiguously identify major pine rosin ingredients such as abietic and other resin acids. Comparison to commercial samples of pure pine rosin confirmed the assignment.

Keywords

Cannabis extract, BHO, marijuana, EVALI, rosin, pine rosin, adulterant, cutting agent

Introduction

Since the legalization of medical marijuana in California in 1996, and the legalization of recreational marijuana in Colorado in 2012, 33 states and the District of Columbia have medical cannabis programs, and 10 states and the District of Columbia have fully legalized recreational use as of 2020.¹ Canada first enacted medical marijuana laws in 2001, and now has recreational cannabis as of 2018.² With the passage of more lax laws, cannabis extracts (CEs) have surged in popularity as alternative products to cannabis flower, with expenditures on CEs in the legal Washington state cannabis market increasing 145 % between 2014 and 2016.³ CEs are consumed by inhalation using modified e-cigarettes or via dabbing,⁴ and increased usage of these among teens and young adults⁵ has led to concerns of safety, as up to 11 % of high schooler students⁶ report lifetime use of a cannabis vaporizer.

CEs may be consumed via inhalation by three main methods/devices: cartridge vaporizers (CVs), top-loading vaporizers (TLVs), and dabbing.⁴ In dabbing, a small amount of CE is placed on a hot surface (i.e. a “nail,” which may be heated with a blow torch or electrically) that is connected to a water pipe.^{4,7} A TLV is an electronic vaporizer device that consists of a battery-powered resistive heating coil in an atomizer, upon which a user manually places small amounts of CE.⁴

Disposable CV devices closely mimic nicotine e-cigarettes, and have surged in popularity given their ease of use and discretion, with sales of these increasing more than 10-fold to \$224 million in Colorado as of 2018.⁸

The cannabis concentrate hashish, commonly consumed in Europe from illicit manufacturers in North Africa, has an extensive history of containing adulterants.⁹ A recent analysis of hashish in Madrid found that 18 % suffers from contamination with glucose, sucrose, and abietic acid (a principal component of pine rosin).¹⁰ Pine rosin has also been identified as a hashish adulterant in Italy,¹¹ Israel, and the Czech Republic.¹²

CEs available in North America are generally manufactured via solvent extraction (most commonly with butane, though propane or supercritical CO₂ have widespread usage) followed by several refinement steps. Butane hash oil (BHO), propane hash oil (PHO) and CO₂ oil may all adopt one of several names depending on consistency: *shatter*, *wax*, *crumble*, *budder*, or *pull-n-snap*.⁷ Recently, applied heat and pressure has been used to press cannabis oils from flower to make a product known as *rosin*.¹³ Despite the similarity in naming, cannabis rosin and pine rosin share few chemical similarities.¹³

Cases of adulteration in North American cannabis products have only recently come into view. The synthetic cannabinoid 5-MDMB-PINACA and the antitussive dextromethorphan have been identified in certain commercially available cannabidiol e-liquids for CV devices.¹⁴ Online reports on Reddit.com and cannabis websites have become grounds where users have aired complaints of BHO adulterated with pine rosin, and have cited specific brands and products as bad actors.¹⁵⁻¹⁷ The timing of these forum posts about pine rosin being used as an adulterant for CEs, or as counterfeit BHO, coincide with the EVALI outbreak. Additionally, several recent patents mention methyl ester of rosin, a pine rosin derivative, as a potential additive to cannabis vaporizers.¹⁸⁻²⁰

CEs added to CV devices often require fluidizing agents to ensure better wicking efficiency in the atomizer of a vape pen, given the high viscosity of cannabis extracts.⁴ Substances such as terpenes, medium chain triglyceride (MCT) oil, and phytol, among others are commonly used.²¹ One CE additive to CV devices, vitamin E acetate (VEA), has been linked with the recent outbreak of e-cigarette, or vaping, product use associated lung injury (EVALI).²² It's use as a thickening agent has been suggested, however, the markedly lower viscosity of VEA relative to Δ^9 -tetrahydrocannabinol (THC), indicates that the former is used to dilute CEs, and that a different additive is the thickening agent, which is introduced to give the appearance of unadulterated CE. Herein is the first report of an adulterant containing pine rosin (a.k.a. rosin colophony or pine resin) for cannabis CV devices. The adulterant was acquired from a formulations consultant that works in the cannabis vaporizer formulations space, which itself acquired the adulterant from cannabis CV device manufacturer.

Materials and Methods

Two adulterants were donated by Vialpando LLC. Initial analysis by nuclear magnetic resonance spectroscopy (NMR) identified one of them to be pure VEA, while the other (Figure 1, dubbed cannabis extra adulterant [CEA]) required further analysis for identification. The CEA was

initially assayed by GC-MS, which first suggested the presence of substituted abietanes and pimaranes. Analysis of the NMR spectrum showed peaks in the alkenyl region that are known to be characteristic of the resin acids in question,²³ and the characteristic glycolic methylene peaks from a triglyceride (Figure S1). 2D NMR techniques COSY and NOESY aided the confirmation of the identity of different isomeric resin acids, as well as the identification of communic acid, which was aided by semi-preparative HPLC. An HPLC-ESIMS chromatogram of CEA provided confirmation of the abietane and pimarane molecules and oleamide (Figure S2). Oleamide is not directly visible in the NMR spectrum of CEA, but the amide N-H protons are visible in the semi-preparative HPLC fraction that contains it when this is dissolved in DMSO-*d*₆ (Cambridge Isotope Laboratories), which was spiked with a pure standard of oleamide (TCI America) to confirm its presence (Figure S3). Commercially available medium chain triglyceride (MCT) oil (Nature’s Way) was spiked in a CEA NMR sample (Figure S4). Identified components were quantified by quantitative NMR (Q-NMR). See SI for further experimental details.

Results and Discussion

Common Name	CAS Number	RT in LC/MS (min.)	NMR Shift (ppm)	Mass Accuracy (ppm)	% in Sample
Dehydroabietic acid	1740-19-8	16.5	6.88	0.03	3
Communic acid	2761-77-5	21.8	6.32	0.03	4
Pimarol	1686-59-5	23.9	NA	0.52	NA
Pimaric acid	127-27-5	23.9	5.71	1.25	3.2
Sandaracopimaric acid	471-74-9	23.9	5.22	1.25	1.5
Palustric acid	1945-53-5	23.9	5.39	1.25	14
Abietic acid	514-10-3	25.1	5.77	1.25	17
Oleamide	301-02-0	25.1	6.65-7.19	0.64	NA
Neoabietic acid	471-77-2	25.1	6.2	1.25	12
Isopimaric acid	5835-26-7	25.1	5.81	1.25	13
Sandaracopimarinal	3855-14-9	30.3	5.22	0	NA
MCT oil	438544-49-1	NA	4.3	NA	15

Table 1: Components identified in CET by nuclear magnetic resonance (NMR) spectroscopy and HPLC-ESIMS, and quantified by Q-NMR.

The analytical methods used discovered that the unknown CEA contains resin acids consistent with pine rosin (68 %), MCT oil (15 %), and small amounts of oleamide (Table 1). An overlay of a commercially available sample of gum rosin (Sigma Aldrich) and CEA demonstrates the similarity of these two substances (Figure 2), with the major visible difference being the presence of the triglyceride peaks from MCT oil in the CEA. Rosin, a solid at room temperature, appears to have been amended with MCT oil to thin its consistency to allow extrusion from a syringe, making its final appearance very similar to pure THC or clarified cannabis extract.



Figure 1: Cannabis extract thickener provided in a glass syringe.

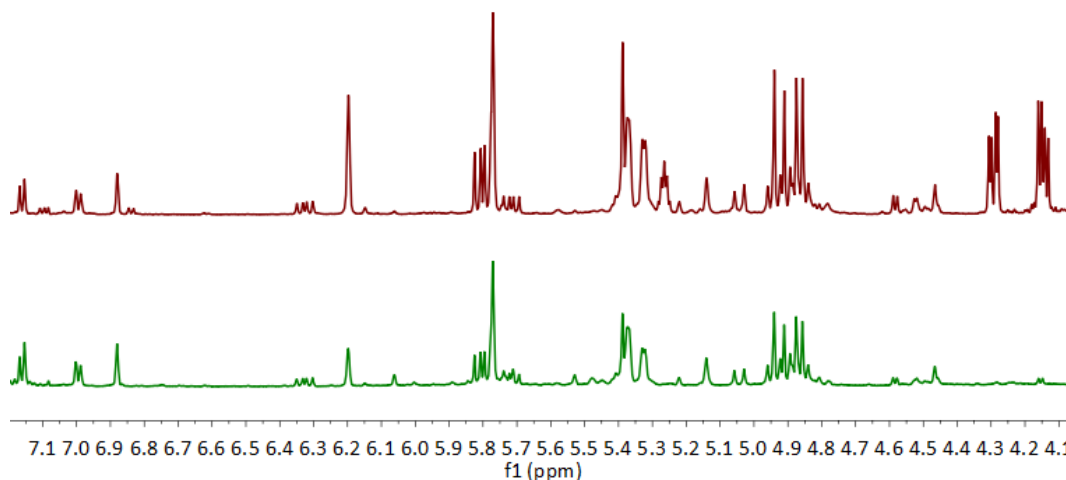


Figure 2: Overlaid ^1H NMR spectra of CEA (top, maroon) and commercially-available gum rosin (bottom, green) from Sigma Aldrich (CAS no. 8050-09-7).

Rosin is a known respiratory tract irritant and a significant contributor to occupational asthma due to its use in soldering.²⁴ Occupational exposure to pine rosin vapor from solder flux at levels of $50 \mu\text{g}/\text{m}^3$, the 8-h Time Weighted Average (TWA) exposure limit, has not been known to produce severe acute lung injuries.²⁴ However, CEA added to CE at a level of just 1 % will produce nearly $0.6 \text{ g}/\text{m}^3$ of pine rosin in the aerosol from a cannabis vaporizer pen with each puff, or $\sim 3,500$ times the 15-min TWA exposure limit.²⁴ In vivo exposure of abietic acid to rat lungs produced desquamation of bronchial epithelium,²⁵ which has also been reported in EVALI cases.²⁶ We are unaware of efforts to date to test for pine rosin compounds in samples from patients with vaping-induced lung injuries. Oleamide appears to have been added to increase the psychoactivity of resulting adulterated CE, as this compound is a cannabinoid receptor agonist and sleep-inducing agent.²⁷ Interestingly, oleamide is a common additive to synthetic cannabinoid “Spice” mixtures.²⁸ It is unknown what, if any, are the health effects of inhaling oleamide. Oleamide is also mentioned as a potential additive to vaping formulations in a patent registered to a cannabis vaporizer formulations company.²⁹

Conclusion

The use of pine rosin as an adulterant in cannabis oil has not been previously reported in the scientific literature. It is available through online vendors, typically used as an ingredient in industrial products such as varnishes, adhesives, soldering fluxes and sealing wax. It has

significant inhalation toxicity. To date, there are no reports of testing for this substance in cannabis oil samples from patients with lung injury. Due to the significant toxicity and prevalence based on social media posts, regulators and laboratory personnel should be aware of its use in adulterated cannabis oil.

Acknowledgments

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Supplementary Appendix

Pine Rosin as a Toxic Cannabis Extract Adulterant

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Table of Contents

Materials and Methods.....	S1
Figure S1.....	S2
Figure S2.....	S2
Figure S3.....	S3
Figure S4.....	S3
References.....	S3

Materials and Methods

The quantitative NMR sample for CET was dissolved in CDCl₃ (Cambridge Isotope Laboratories) and acquired at 512 scans, a 6.7 second repetition rate, with a 30° flip angle, and with 64 k data points on a Bruker Avance III 600 MHz NMR spectrometer. Spectra were processed with 0.3 Hz of line broadening with a final data size of 64 k real data points. Quantification was performed using Global Spectral Deconvolution from MestreLab software.

Fractions from the HPLC chromatogram were collected manually using the method in Nilsson *et al.*¹ using an 25 cm x 10 mm, 5 μm Discovery C18 semi-preparative column on a Waters 1525 Binary HPLC Pump and a Waters 2996 Photodiode Array Detector. Product peaks were eluted using an isocratic method consisting of 80 % 95:5 MeOH:H₂O and 20 % 5:95 MeOH:H₂O with 0.05 % formic acid in each with a total flow of 3.5 mL/min. Methanol was removed via rotary evaporation, and product was extracted in dichloromethane.

The HPLC-ESIMS chromatogram was collected on an Vanquish UHPLC system. 20 μL of CET in methanol at 930 ng/μL were injected over an Acclaim RSLC Polar Advantage II 3 μm, 120 Å 3.0 x 75 mm column using the following elution program: hold 30 % A for 5 min., ramp to 27 % A until 18 min., hold until 40 min. with a total flow of 0.5 mL/min. Solvent A: 0.05 % formic

acid in H₂O, solvent B: 0.05 % formic acid in methanol. MS data was acquired using a high-resolution (35,000) Thermo Scientific Q Exactive Mass Spectrometer with an electrospray ionization source operating in the positive mode. The Orbitrap was externally calibrated prior to data acquisition allowing accurate mass measurements for [M+H]⁺ to be obtained within 4 ppm. The ionization interface was operated using the following settings: source voltage, 4 kV; sheath and auxiliary gas at 75 and 20 units respectively; capillary temperature, 400 °C.

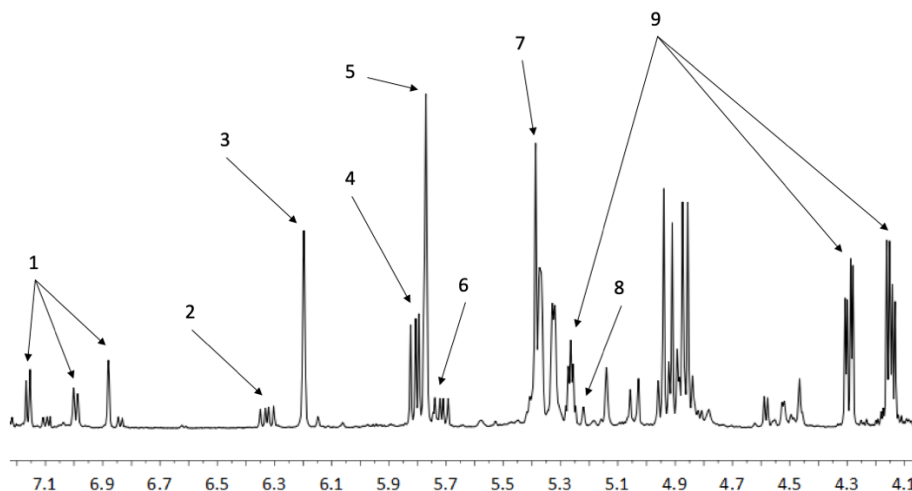


Figure S1: ¹H NMR spectrum of CET showing relevant peaks for (1) dehydroabiatic acid, (2) communic acid, (3) neoabiatic acid, (4) isopimaric acid, (5) abiatic acid, (6) pimaric acid, (7) palustric acid, (9) sandaracopimaric acid, (9) MCT oil.

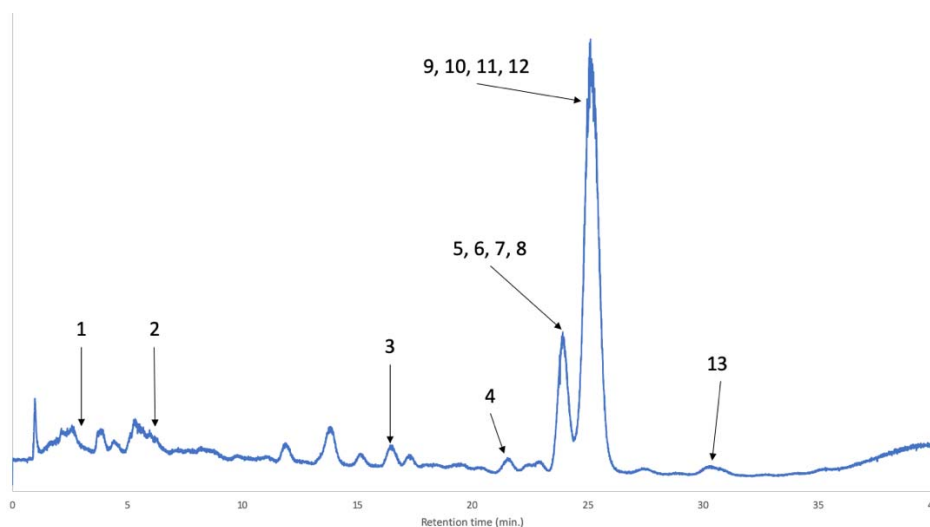


Figure S2: HPLC-ESIMS total ion chromatogram with several peaks of interest highlighted: (1) 15-hydroxyperoxyabiatic acid, (2) 12-oxopimaric acid, (3) dehydroabiatic acid, (4) communic acid, (5) pimarol, (6) pimaric acid, (7) sandaracopimaric acid, (8) palustric acid, (9) abiatic acid, (10) oleamide, (11) neoabiatic acid, (12) isopimaric acid, (13) sandaracopimarol.

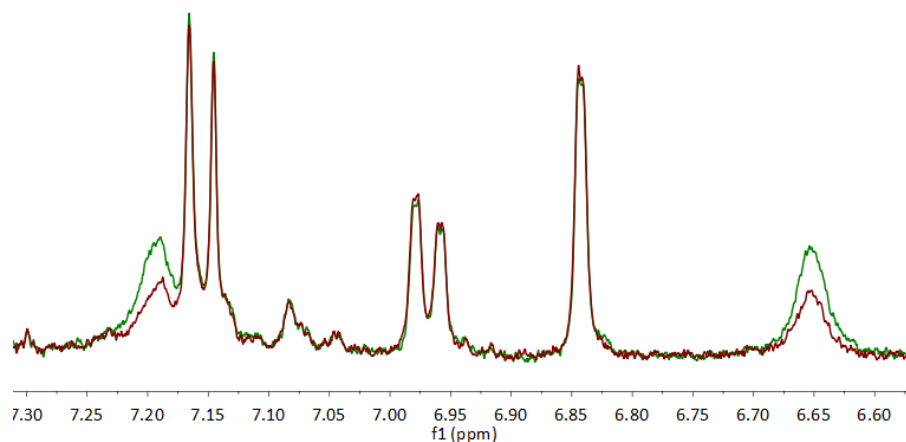


Figure S3: Overlaid ^1H NMR spectra of the semi-preparative HPLC band containing oleamide in $\text{DMSO-}d_6$ (maroon), and the same sample spiked with $\sim 100\ \mu\text{g}$ oleamide (green). An increase in the amide N-H proton peaks in the sample without the introduction of new peaks confirms the presence of this compound in CET.

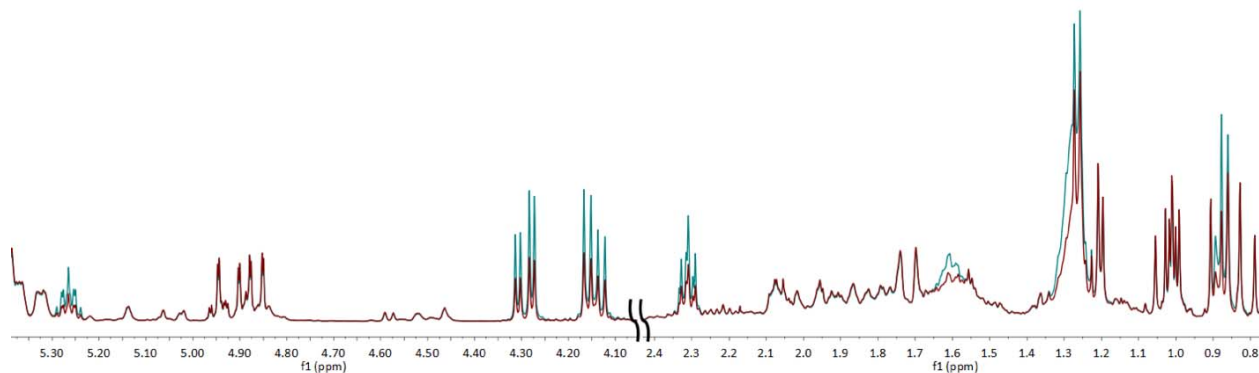


Figure S4: Overlaid ^1H NMR spectra of pure CET in CDCl_3 (maroon) and the same sample spiked with $\sim 1.3\ \text{mg}$ of MCT oil. An increase in the proton signals at 5.26, 4.31, 4.28, 4.16, 4.13, 2.31, 1.61, 1.26, 0.88 ppm in the sample without the introduction of new peaks confirms the presence of this substance in CET.

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