VERTOSA

v 1.1

CASE STUDY

ENSURING THE QUALITY OF HEMP-DERIVED Δ9 THC

Introduction

Δ9-THC is the main psychoactive cannabinoid found in the cannabis plant. While most Δ9-THC in products (like vapes and edibles) is extracted from cannabis plants, hemp-derived Δ9-THC can be sourced two ways: 1) by *converting* hemp CBD in a lab or 2) *extracting* from hemp mother liquor.

Under the US 2018 Farm Bill, legal hemp is defined as a cannabis plant containing no more than 0.3% THC. Because it is possible to source Δ9-THC from legal hemp, many are taking advantage of this opportunity to manufacture Δ9-THC products in markets where it is not explicitly prohibited. Minnesota is the latest market to experience a mini "Green Wave" following the passage of a state law allowing for the sale of hemp-derived THC edibles in mainstream retail markets.

01 Hemp CBD converted Δ9-THC

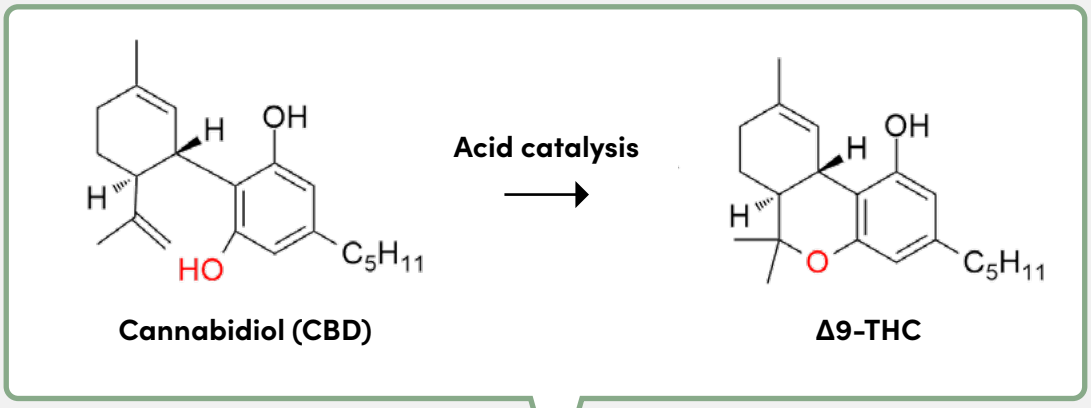
Background

How hemp CBD is converted to Δ9-THC

In a process called acid catalysis, CBD distillate or isolate extracted from hemp is dissolved in a solvent - usually ethanol or toluene. The solvent dissolves the extract and makes the cannabinoid structures accessible for reaction. Acid is then introduced to the solution.

Opposites attract, and the newly accessible negatively charged electrons in the cannabinoids attract the positively charged proton delivered by the acid. Under carefully controlled conditions, this can cause bond shifting within the cannabinoids, closing the structural ring and changing CBD to Δ9-THC *(see diagram on next page).*

CBD TO Δ9-THC CONVERSION PROCESS



Cannabidiol (CBD) **Δ9-THC**

CBD distillate or isolate extracted from hemp → **Dissolve CBD in solvent, then add acid catalyst to start reaction.** → **Stop reaction**

Aqueous wash (get rid of acid and other water soluable components) → Distillation (further purify the final product based on boiling point) → Finished product Δ9-THC

Converting CBD to THC: not so simple

Under acid catalysis, the reaction may convert CBD into many different compounds. A skilled chemist needs to control for a myriad of variables.

Reaction time, temperature, acid type and strength, solvent type, and moisture content all affect the end product. Poor practices and process controls will result in the creation of unintended cannabinoids or even non-naturally occurring by-products

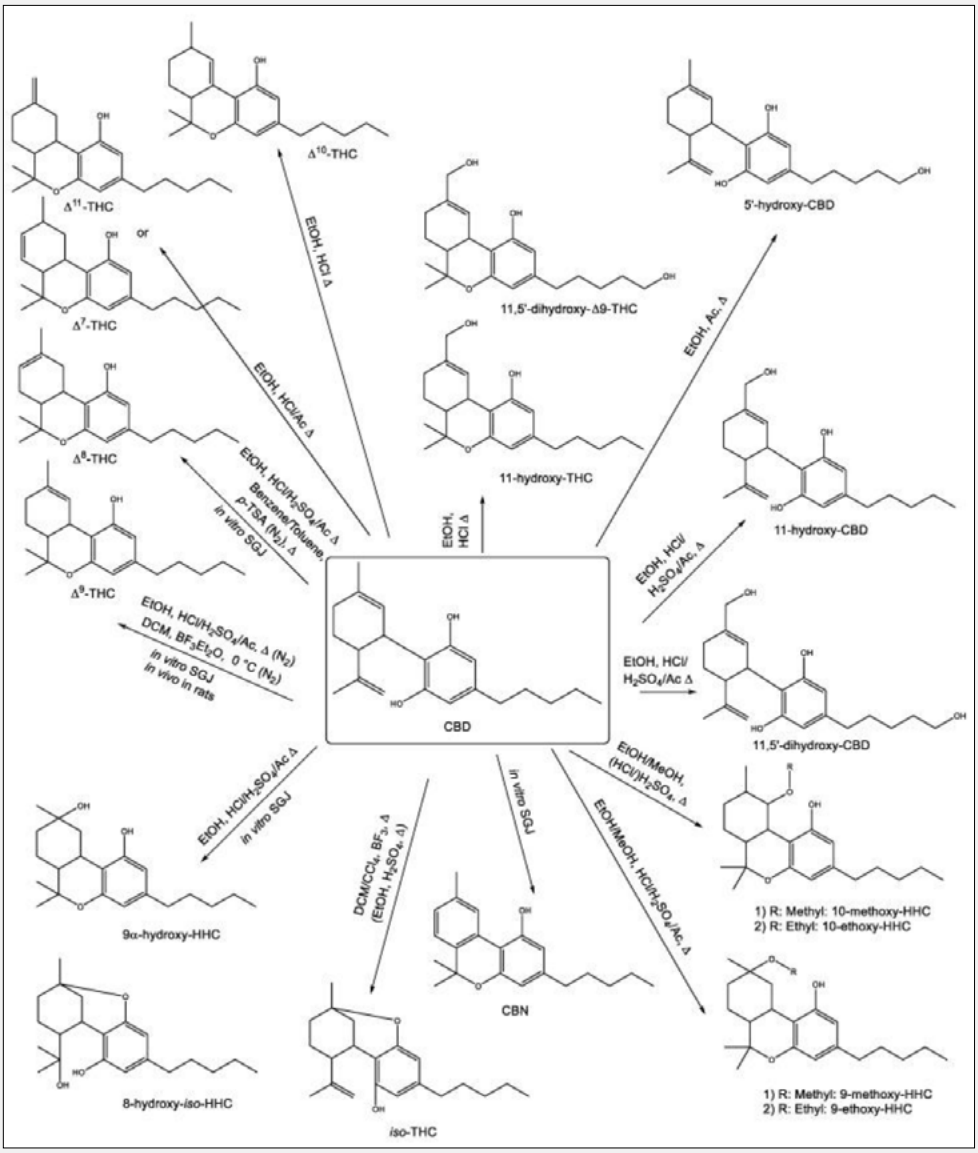


Chart of possible products when converting CBD using acid catalysis

Conversion of Cannabidiol (CBD) into Psychotropic Cannabinoids Including Tetrahydrocannabinol (THC): A Controversy in the Scientific Literature Toxics, 2020 Jun 3;8(2):41

Trouble in paradise

As you can probably guess, a lot of businesses are looking to capitalize on this as fast as possible. And while this is an incredible opportunity towards normalizing the plant, the lack of regulation in this market allows for improperly converted (therefore, mislabeled) products to land on shelves.

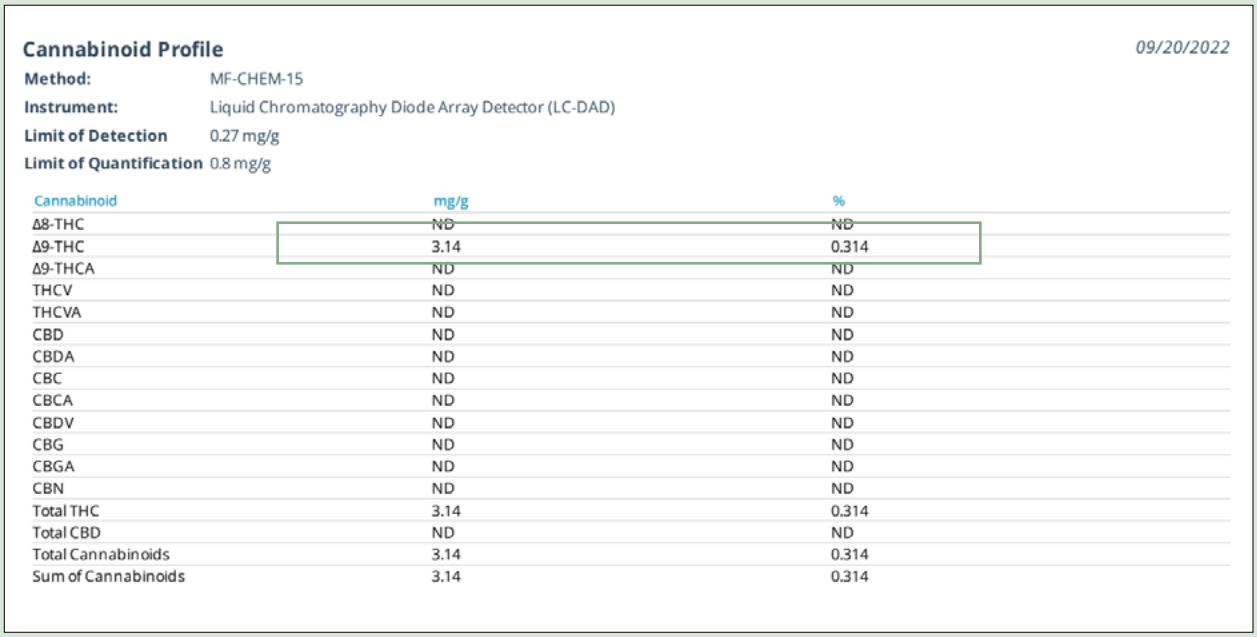
A standard CoA will include results from a high performance liquid chromatography (HPLC) analysis. Unfortunately, since labs are operating within a regulatory framework, they are not typically looking for the minor cannabinoids that could be major products from these reactions — not to mention the non-cannabinoid by-products.

So if analysis from a standard CoA isn't sufficient, what else is needed to ensure quality?

The Investigation

The acid catalysis of CBD can go through many routes depending on the reaction conditions. We have to ensure that the reaction results in the intended product – in this case, Δ9-THC.

For instance, in Vertosa's search for a quality supplier of hemp Δ9-THC, we encountered a sample with only 0.3% Δ9-THC.

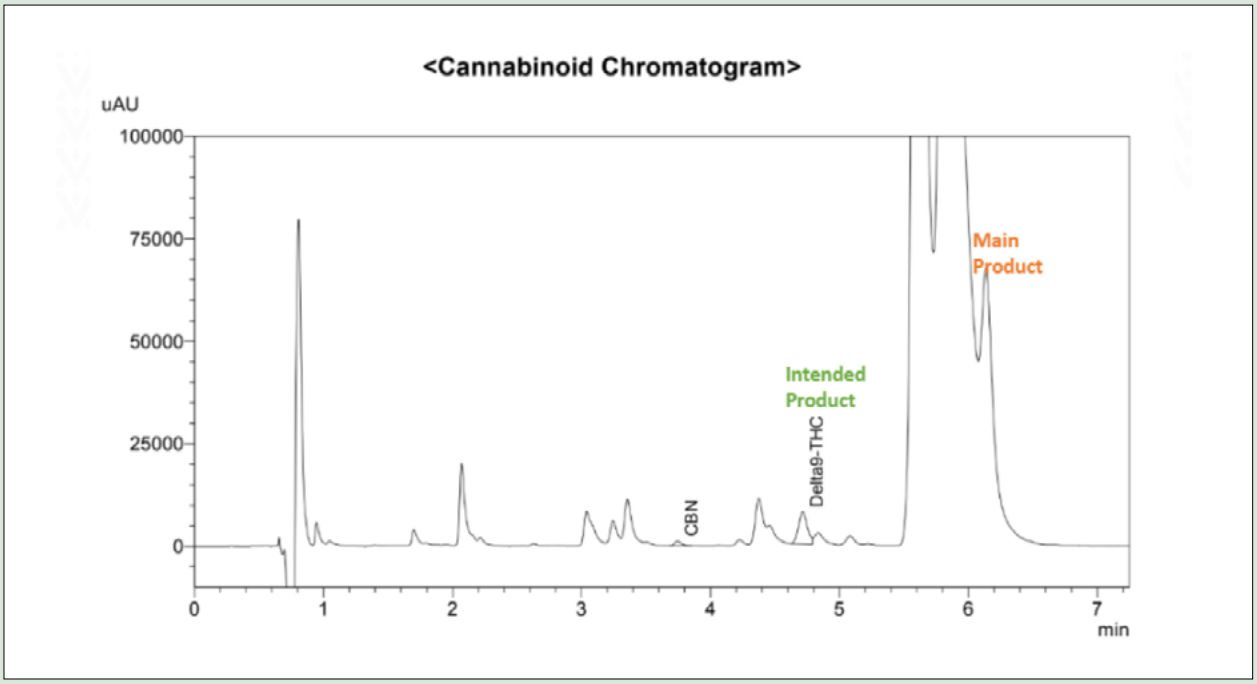


Cannabinoid Profile *09/20/2022*

Method: MF-CHEM-15
Instrument: Liquid Chromatography Diode Array Detector (LC-DAD)
Limit of Detection 0.27 mg/g
Limit of Quantification 0.8 mg/g

Cannabinoid	mg/g	%
Δ8-THC	ND	ND
Δ9-THC	3.14	0.314
Δ9-THCA	ND	ND
THCV	ND	ND
THCVA	ND	ND
CBD	ND	ND
CBDA	ND	ND
CBC	ND	ND
CBCA	ND	ND
CBDV	ND	ND
CBG	ND	ND
CBGA	ND	ND
CBN	ND	ND
Total THC	3.14	0.314
Total CBD	ND	ND
Total Cannabinoids	3.14	0.314
Sum of Cannabinoids	3.14	0.314

When we studied the chromatogram of the HPLC, we dscovered the main product was not Δ9-THC, but possibly other THC isomers.



ABOVE: In this chromatogram, the peak indicating the presence of Δ9 is significantly smaller than the peaks representing the presence of other THC isomers. A skilled chemical analyst can identify these by-products from this reading.

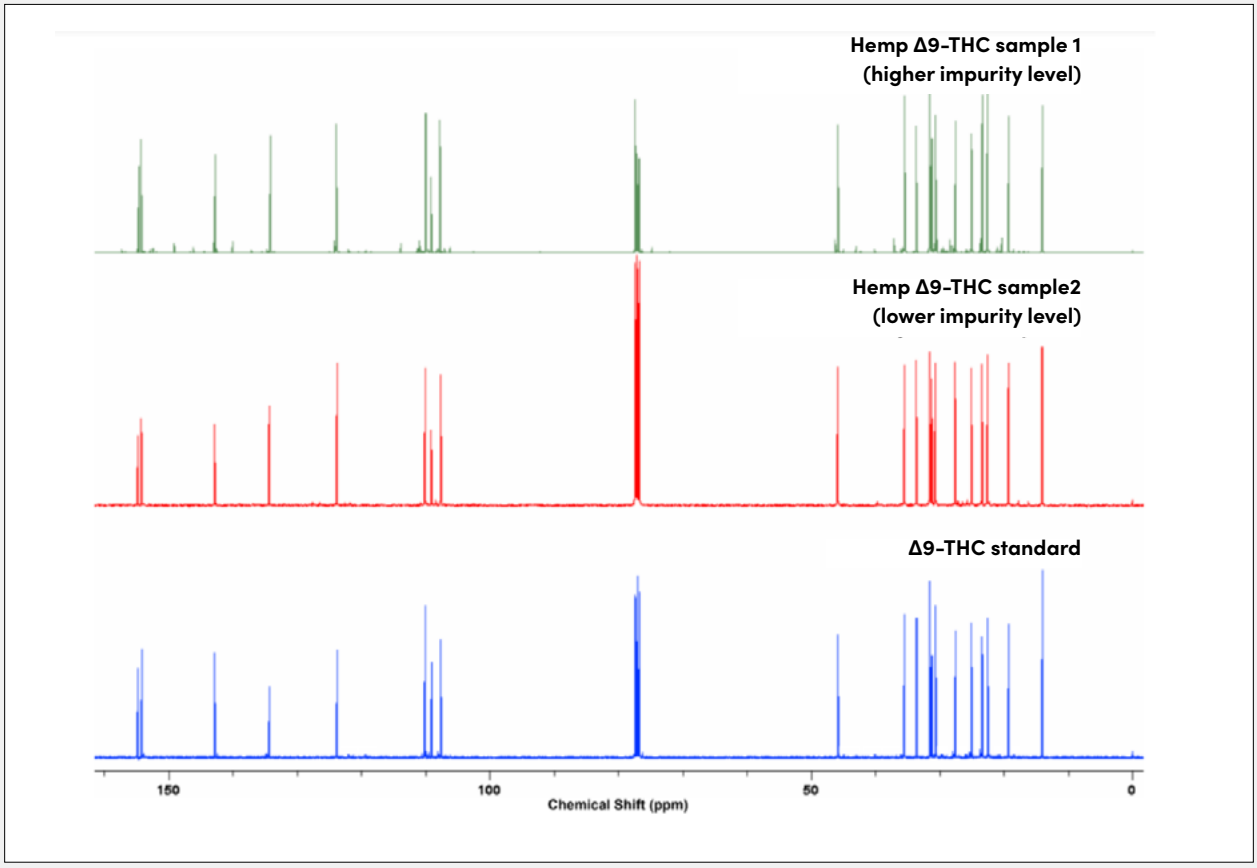
Another way to test: nuclear magnetic resonance (NMR) analysis

In an NMR analysis, the lab applies a magnetic field to the dissolved hemp THC. Due to the chemical environmental difference, each carbon has its own unique resonance which can be plotted to generate a unique "fingerprint". The resulting report is then compared to the same analysis performed on pure Δ9-THC. Any additional carbons indicated in the results represents potential contamination. A hemp Δ9-THC sample with fewer additional contaminants is of higher quality.

Ensure minimal by-products for quality hemp converted Δ9

Why do we even care about minimizing by-products? These by-products can be non-naturally occurring and there is no toxicology data on them. Without a targeted analysis, we can't even quantify these impurities. This means that the health risks and effects are unknown and create safety concerns. On top of that, emulsifying these by-products for infusion into edibles actually boosts bioavailability, magnifying any adverse effects.

Comparing NMR spectra of hemp converted Δ9



ABOVE: By comparing the cleanliness of the NMR baseline, we can access the impurity levels in the sample.

To honor our commitment to supplying the highest quality ingredients, Vertosa provides robust documentation of all our hemp converted Δ9-THC ingredients.

As a science-first infusion technology partner, Vertosa requires several pieces of documentation to ensure the quality of the hemp Δ9-THC we emulsify:

- proof of hemp origin
- BIG 6 CoAs (potency, microbial, heavy metals, pesticide residue solvents, mycotoxins) from a third party lab
- the HPLC chromatogram and
- a nuclear magnetic resonance (NMR) analysis.

Building trust in this industry is a responsibility all infused product makers should take seriously. Our survival depends on it. And to do that, we should demand proper documentation and analysis from our suppliers.

02
Mother liquor: Extracting Δ9-THC from hemp biomass

Background

How Δ9-THC is extracted from hemp biomass

We can also get Δ9-THC from hemp without chemical conversion. The process of creating CBD isolate involves adding ethanol to hemp biomass (the mixture of flower, stems, and other parts of the plant). After the CBD is extracted, the liquid waste left behind is high in THC, but still contains some CBD remnants. This liquid is called ***mother liquor.***

This process is repeated several more times until the optimal amount of CBD has been from the liquid.

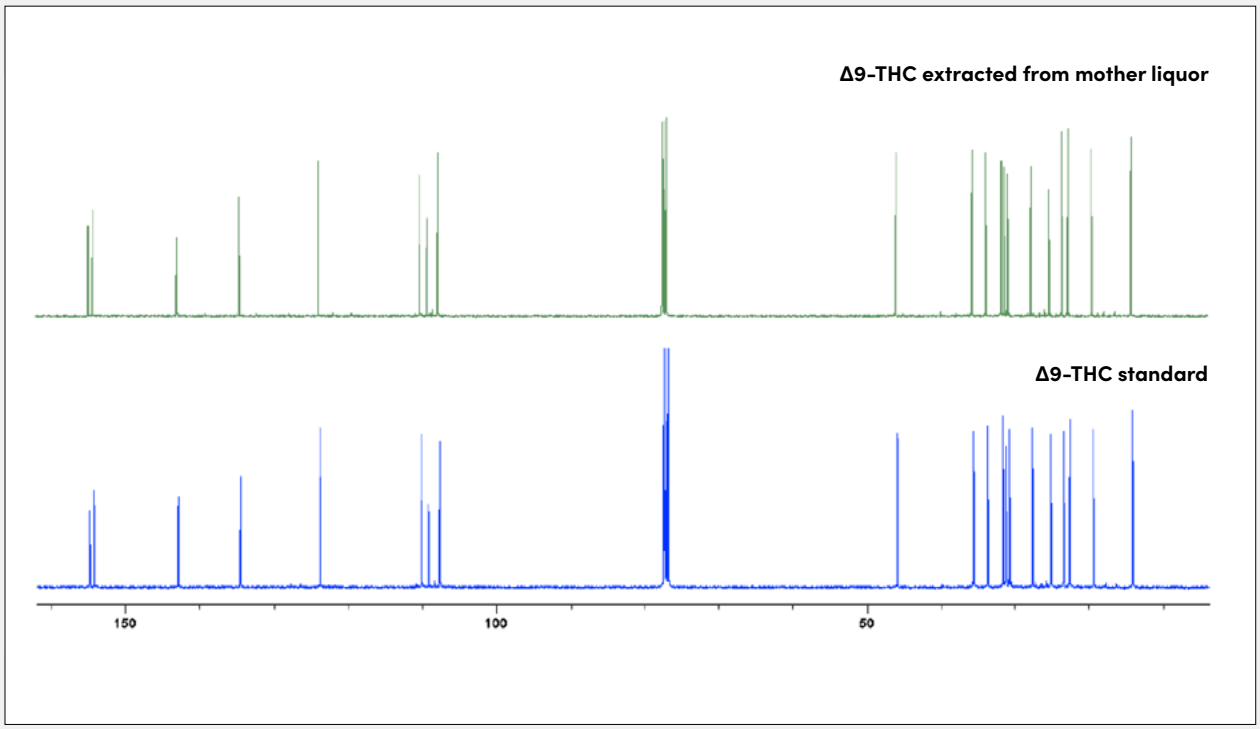
The mother liquor is then purified and distilled to obtain a high purity THC distilliate.

Is Δ9-THC extracted from mother liquor safe?

Yes! Because Δ9-THC extracted from mother liquor does not go through chemical conversion, there is no danger of synthetic by-products contaminating the final product. Furthermore, distillation as a technique has been around a lot longer than the conversion methods and we have a much better understanding of the safety risks.

Compare the NMR results below against the results from regular Δ9-THC. The peaks are nearly identical and the clean baseline indicates input from mother liquor does not have high levels of impurities.

Comparing NMR spectra of Δ9-THC extracted from mother liquor



Comparing hemp converted Δ9-THC to Δ9-THC extracted from mother liquor

	CBD CONVERTED Δ9-THC	Δ9-THC FROM HEMP MOTHER LIQUOR
Hemp Origin	✓	✓
Chemical Conversion	✓	✗
THC purity > 85%	✓	✓
Minimum Herbaceous Flavor	✓	✓
Full Panel Testing Approval	✓	✓
Vertosa Safety Evaluation Approval	✓	✓

Conversion and extraction: methods with their own strengths

While extraction from mother liquor has no risk for contamination from synthetic by-products, conversion can be just as safe when the appropriate quality checks are performed.

There's also the possibility to obtain other cannabinoids using conversion. Because each cannabinoid follows a different reaction path when converting, the risk level of synthetic by-products needs to be analyzed on a case by case basis. Vertosa is currently expanding testing into CBN, THCv and Δ8 to identify which suppliers have the best of each input.

Vertosa is dedicated to creating the highest quality inputs so that we can infuse the highest quality products. If you're ready to jump into the world of hemp derived THC, contact your account manager or reach out to us here.

Vertosa Inc. | info@vertosa.com