PART III: THE TRIO OF TROPICANNA

Twinkle R. Paryani, Iain W. H. Oswald, PhD, Benjamin J. Disinger, T.J. Martin

FOREWORD:

The aroma of cannabis is evolving, becoming increasingly diverse and complex due to the work of breeders across the world, who have sought the newest, most unique aromatic notes possible. While they have done so with great success, the chemical understanding for why many of these varieties smell the way they do has historically not been well understood.

The terpene concentrations of two cultivars can be very similar and yet have widely different aromas. There are cracks in our current understanding of cannabis knowledge.

Our recent publication has transformed this understanding by introducing entirely new classes of compounds that distinctly influence the aromas of specific varieties.[1] We initiated research in collaboration with top breeders in the industry along with 710 Labs, a leading cultivation and extract company, and analytical instrument experts, SepSolve Analytical and Markes International. Our goal was to address the most pressing questions about cannabis's unique aromatic properties.

This work unveiled many compounds never reported before in cannabis literature.

To help explain the most important aspects of this research, we present a series of white papers focused on key aspects of the work conducted.

MARKES international 710LABS SepSolve Analytical

In this third paper, we challenge the long-standing belief that terpenes, such as d-Limonene, are solely responsible for the characteristic citrus flavor and aroma of cannabis, specifically the trendy tropical and "Tangie" notes. This distinctive aroma has surged in popularity over the past decade, particularly with the introduction of the Tangie cultivar from DNA Genetics, which echoes the classic Tangerine Dream strain from the 90s. Contemporary cultivars, including Sour Tangie, Tropicana Cookies, and Starburst are renowned for their unique tangerine and tropical profiles, but what is the chemical thread that weaves them together, bestowing such unique aromatics? **Hint: it's not terpenes.**

Our exploration here pivots towards a groundbreaking discovery: the identification and role of **tropicannasulfur compounds**. These non-terpene compounds, newly classified as "flavorants", are at the heart of driving these luscious and prized aromas. This third installment promises to unravel the mysterious chemistry of tropicannasulfurs and their profound correlation with the tropical Tangie notes that define a new era in cannabis connoisseurship.

TABLE OF CONTENTS

INTRODUCTION

Modern cannabis has brought us into a **new age of exotic flavor and aroma**. Never before has it been possible to even consider naming a variety "Papaya Peach" or "Starburst" without firmly stretching the imagination. Nonetheless, here we are, with many varieties possessing flavors and aromas containing nearly every combination of **sweet, tropical, citrus, or even ripe** (borderline *rotten*) fruits. These descriptors are commonplace yet, until now, we've had no clear chemical understanding as to how it's possible that cannabis can produce such a wide aromatic bouquet.

Figure 1. Schematic illustrating the divergent nature of the aroma of cannabis. This paper focuses on samples that contain a distinct tropical, citrus, or powerfully juicy aroma classification, as found on the left-hand side of the spectrum.

As we detailed in our previous two **The Science of Exotic** papers, the aroma of exotic cannabis falls on a spectrum ranging from sweet to savory as illustrated in **Figure 1**. Try to think of any other flower that can produce scents ranging from tangerines to toilets. In your face, *roses*.

This study aims to understand the rise of "Tangie" cultivars falling near the "sweet" end of the aroma spectrum. Typically characterized as "sativa-leaning" hybrids, they are renowned for their **complex tropical citrus aromas** that set them apart from other varieties, although these aromas have recently been reported in heavy indica cultivars as well. Certain Tangie varieties can possess heavy amounts of **dank cannasulfur gas**, providing clues about Tangie's chemical origins...

WHICH LEADS US TO WONDER:

What causes cannabis's tropical aromas like citrus, guava, passionfruit, and papaya?

Do terpenes like d-Limonene play a part in the distinctive aroma?

Why is the "Tangie" aroma so potent and tenacious?

These questions now have answers, thanks to new research published by Abstrax Tech in collaboration with 710 Labs and Markes International.[1] But before we get into this, we will first discuss what the current science says about the aroma of cannabis.

710LABS MARKES international

The cannabis plant is truly unique in the plant kingdom. It has a propensity to produce a wide array of compounds that are completely unique to itself, as shown in **Figure 2**. These range from cannabinoids – compounds such as tetrahydrocannabinol (THC) and cannabidiol (CBD) – to terpenes, cannflavins, and more. Why this plant produces many of these compounds is still up for debate, but one thing for certain is that **cannabis is a powerhouse** in producing unique chemical compounds that can have profound psychoactive effects on humans when consumed.

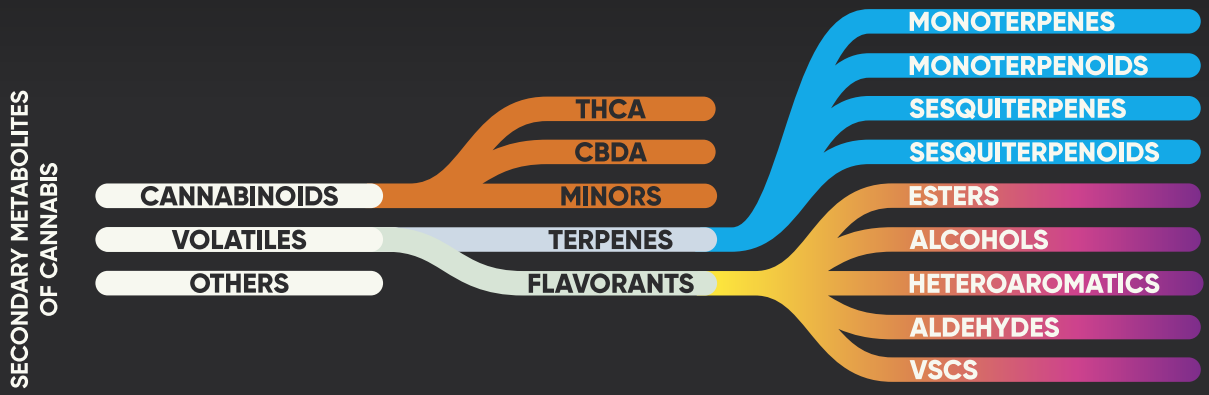


Figure 2. Sankey diagram showing the phytochemical makeup of cannabis.

While THC is the primary psychoactive constituent in cannabis, there is increasing evidence to suggest that the other hundreds of compounds present in a given variety may influence or modulate these effects. This phenomenon is referred to as the Entourage Effect and is being actively investigated to understand why certain compounds beyond THC may modify the effects brought on by consuming a specific strain. Further, these other compounds are responsible for the aroma of cannabis.

A BRIEF HISTORY OF TANGIE

Throughout the history of cannabis, certain defining cultivars have emerged that have "**changed the game.**"

Iconic varieties like **Skunk #1**, **OG Kush**, **Jack Herer**, **Tangie**, and more recently, **Gelato**. Each of these varieties possess a distinct aromatic profile, setting them apart from their peers and cementing their status in breeding circles over time. The individual uniqueness of these cultivars has greatly influenced the landscape of all modern cannabis flavor and aroma.

Tangie, in particular, distinguishes itself with its remarkably petroleum-fueled citrus scent, a characteristic so pronounced that it inspired its namesake (*Tangie, tangerines, get it?*). While many cannabis varieties are often characterized by their 'lemon' or 'citrus' notes — a description commonly applied to certain OGs and Hazes — the citrus notes in Tangie stand in a league of their own, marked by a distinct potency and uniqueness. The individual characteristics of this fragrance **sets Tangie far apart** from other varieties, underscoring its special place in cannabis.

While we don't know exactly when the pungent citrus and tropical notes started to express in cannabis, we suspect that **Cali Orange**, or **Cali-O**, first bred in the 1980s and a parent of Tangie, may have been one of the first to possess these attributes.[2] Parallel to this, the 1990s marked the debut of '**Tangerine Dream**,' another cultivar celebrated for its citrusy flavor and aroma. Intriguingly, despite their similar scent profiles, 'Tangie' and 'Tangerine Dream' do not share a direct genetic lineage.[3,4] This divergence hints at the complex and varied paths through which these distinctive aroma traits have been developed and propagated in the cannabis gene pool.

Putting aside the lore surrounding the origins of these aromas, one thing is for certain: **people absolutely love them**. This love has even sparked the creation of brands who focus entirely on cultivars bearing these iconic Tangie flavors and scents.

It's easy to see why Tangie-like varieties are so popular. From **Mimosa**, **Tropicana Cookies**, and **Garlic Cocktail**, these cultivars often produce deep, rich citrusy aromas that are some of the most pleasant scents the plant has produced yet. And it's not just about the smell - these scents turn into really great flavors too. This is unlike some of the more complex aromas that get lost when inhaled or ingested in other varieties. **Tangie has proven itself to be a modern day cannabis juggernaut** with its aromatic fingerprint easily found in many highly popular cultivars.

So why does a specific subset of cannabis contain this attribute?

How can cannabis, a plant *best* known for its dank and skunky aroma, also produce such intensely sharp tropical/citrus scents?

And why has it taken almost four decades to understand them?

WE'RE SO GLAD YOU ASKED.

IF IT WAS EASY, EVERYONE WOULD DO IT

Why has it
taken almost four decades
to identify the source of the Tangie aroma?
Well, it just wasn't feasible, and **so nobody looked.**

Understanding the aroma of cannabis is not a simple task. **Analytical labs typically test for only 30 to 40 compounds commonly found in cannabis**.

Although terpenes are frequently discussed in cannabis aroma literature, such discussions don't capture the full essence of its scent, primarily because **cannabis emits an unparalleled array of compounds**.

To date, Abstrax has identified over 500 distinct compounds contributing to its aroma, many of which have never been seen before in nature.

For more information, check out The Science of Exotic I: The Dawn of Flavorants.

There are hundreds of different low-concentration molecules present in cannabis that produce potent and unique aromas, much more so than typical terpenes.

Recently, Abstrax unveiled that a novel class of prenylated volatile sulfur compounds, termed "cannasulfur compounds," are responsible for the gassy, skunky scent of cannabis.[5] Even though these compounds are found in the ***parts per billion***, they create an extremely potent aroma that greatly influences the overall bouquet. Terpenes aren't responsible for the quintessential dank aroma of cannabis. They also aren't responsible for the uniquely exotic aroma of cannabis. And, yet, cannabinoids and terpenes are the two major things tested for at every analytical cannabis lab around the world.

Could the potent citrus and tropical notes in exotic cannabis *also* originate from unidentified low-concentration compounds?

I THINK YOU ALREADY KNOW THE ANSWER.

TRUST THE PROCESS

To conduct this study effectively, we first sourced fresh, standout cultivars that exhibited the diverse aromas we aimed to analyze. We at Abstrax, being located in Southern California, had access to some of the most premiere and popular varieties on the marketplace. Additionally, **710 Labs** provided samples and procurement suggestions. Thirty-one different varieties in total were collected for evaluation.

One aspect of the study involved deciding what sample matrix would be ideal. There are many form factors of cannabis products, ranging from cured flower to live resin. **We found that ice-hash rosin was an ideal matrix for measuring the low concentration analytes using our instrumentation.**

ICE-HASH ROSIN WAS CHOSEN FOR THREE PRIMARY REASONS:

1

Ice-hash rosin is a concentrated form of cannabis, thus raising the overall levels of compounds in the sample and making it easier to detect them.

2

It is manufactured without exogenous solvents such as butane, thus reducing any sort of contamination or change in aroma profile due to the removal of solvents.

3

Many high-quality, cutting edge varieties with unique aromas are produced by ice hash rosin experts who selectively prioritize the extraction of flavor & aroma.

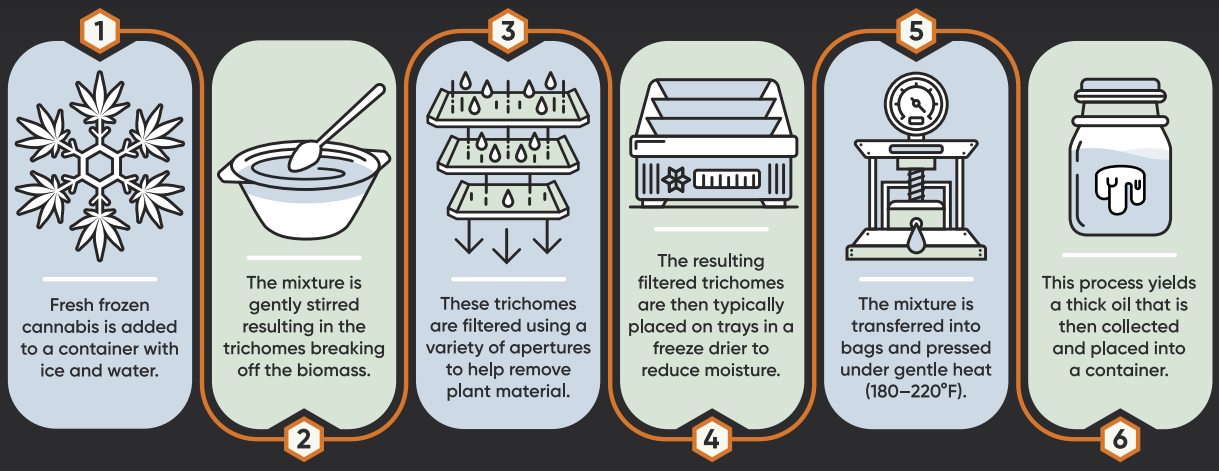


Figure 3. A general explanation of the ice-hash rosin making process.

Cannabis is both an art and a science. We at Abstrax have (by far) the most thorough analytical capabilities of any terpene company in the world, but the human nose has evolved to be incredibly adept at recognizing and evaluating aromas. Toucan Sam was absolutely right to follow your nose, wherever it goes.

In order to analyze these samples thoroughly, we needed to perform both a qualitative and quantitative assessment in the form of a human sensory analysis *and* a chemical analysis.

THE ELECTRIC KOOL-AID ~~ACID~~ TANGIE TEST

To first gauge the aroma characteristics of the 31 rosin samples, we conducted a sensory trial on each, where a human panel was allowed to smell each sample independently and describe which aromas they detected. The panel was asked to rate from 0 to 100 their overall perception of how sweet/fruity (100) or how savory (0) the samples were.

Numerous participants used flavor/aroma descriptors such as “tropical, citrus, tangerine, or grapefruit” and other similar vocabulary to describe specific cultivars. This was the first clue that, as expected, the human panelists could easily identify aromas that possess these characteristics that are so common in Tangie or Tangie-like derivatives. **On the next page, Figure 4 displays a "correlation matrix" of the 31 cultivars compared against each other.**

The varieties that were described as "tropical" or "citrus" are highlighted in yellow.

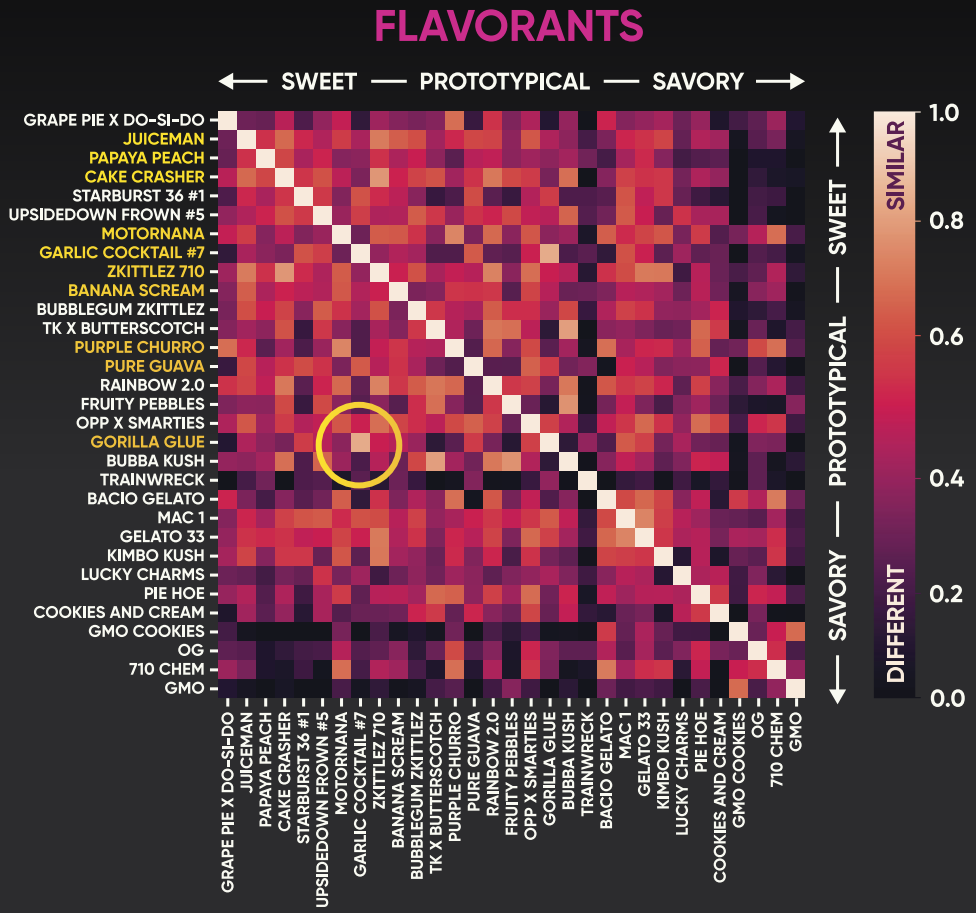


Figure 4. Correlation table of flavorants between the 31 different cultivars analyzed. Lighter colors indicate more of a similarity while darker colors indicate a divergence. Varieties with multiple tropical/citrus descriptors are annotated with yellow text, showing how these aromas tend to correlate strongly with sweet exotics.

THIS DATA SHOWS A FEW INTERESTING FEATURES:

1. **First**, you will notice that the cultivars in yellow are placed within the top half of the matrix. This indicates that they were each assigned a high exotic score by the human sensory panel. This is to be expected due to the fact that many of these aromas correspond to fruity or deep citrus scents.

2. **Second**, each of these are described by their name to indicate some form of sweet or fruity scent. You'd expect "Papaya Peach" to have some aromatic similarities to its namesake. Each cultivar aligned as expected... except for Gorilla Glue, which is characteristically known to possess an intensely gassy, earthy, piney aroma. So why then, was Gorilla Glue described to have similar aroma characteristics to the likes of Juice Man, Papaya Peach, Starburst, and more?

It turns out that this was a serendipitous event. **We initially procured this Gorilla Glue sample to act as a non-sweet/fruity prototypical control**. Gorilla Glue is a multiple award-winning cultivar and its characteristics are extremely well known. However, upon analysis of the sensory data (and subsequent chemical analysis as explained later), this sample did not possess the attributes of Gorilla Glue in the slightest. We had unwittingly fallen victim to a rampant problem facing the cannabis industry today.

EXOTIC CANNABIS AROMA SPECTRUM

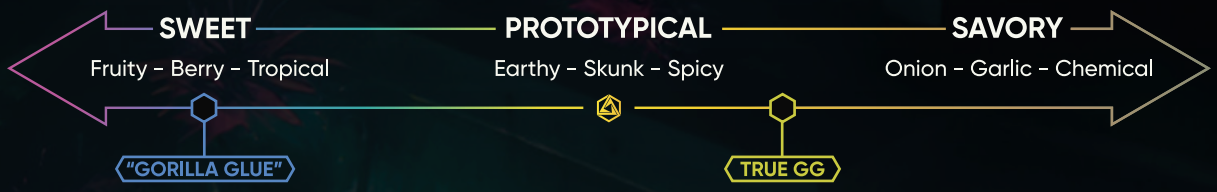


Figure 5. Gorilla Glue is known for its prototypical gassy, earthy, piney aroma. This figure shows where Gorilla Glue should have fallen on the spectrum, and where our "Gorilla Glue" actually ended up.

We suspect that this sample, while named Gorilla Glue, was either intentionally mislabeled (possibly for marketing purposes), or erroneously done so. This is something we've seen more and more of as the industry continues to grow. If you're interested in learning more about this industry issue, visit our website to read our white paper *The Signature Series: The Cannabis Industry Has A Serious Problem.*

Either way, the sensory data firmly suggested the Gorilla Glue sample to have similar aroma characteristics to the sweet and fruity cultivars. As such, it, along with the other varieties, were ideal for investigating the chemical similarities to identify what makes these potent citrus and tropical scents.

COLLABORATIVE CANNABIS

As previously mentioned, we performed *both* a qualitative and quantitative analysis on these 31 ice-hash rosin samples.

After the human qualitative sensory analysis was performed, we took the data and used it in conjunction with our chemical data to identify trends between specific compounds and their aroma characteristics.

We explored the chromatographic space of each of the samples. Our aim was to spot any similarities between the cultivars known for their tropical & citrus aromas and those without these notes, helping us to understand what really sets these fragrant cultivars apart.

Our analytical suite is incredibly complex and extensive. We utilize an advanced two-dimensional gas chromatography system with a trio of specialized detectors including a **Mass Spectrometer**, a **Flame Ionization Detector**, and a **Sulphur Chemiluminescence Detector.** All three of these work in tandem to help identify and quantify the myriad of different compounds found in cannabis.

What eludes one detector will likely be picked up by another. We're unable to know for sure, but **it is likely that our machine is the only one in the cannabis world with these capabilities**, giving us the unique ability to not only see what's readily in front of us, but to also hunt for compounds that might be hiding.

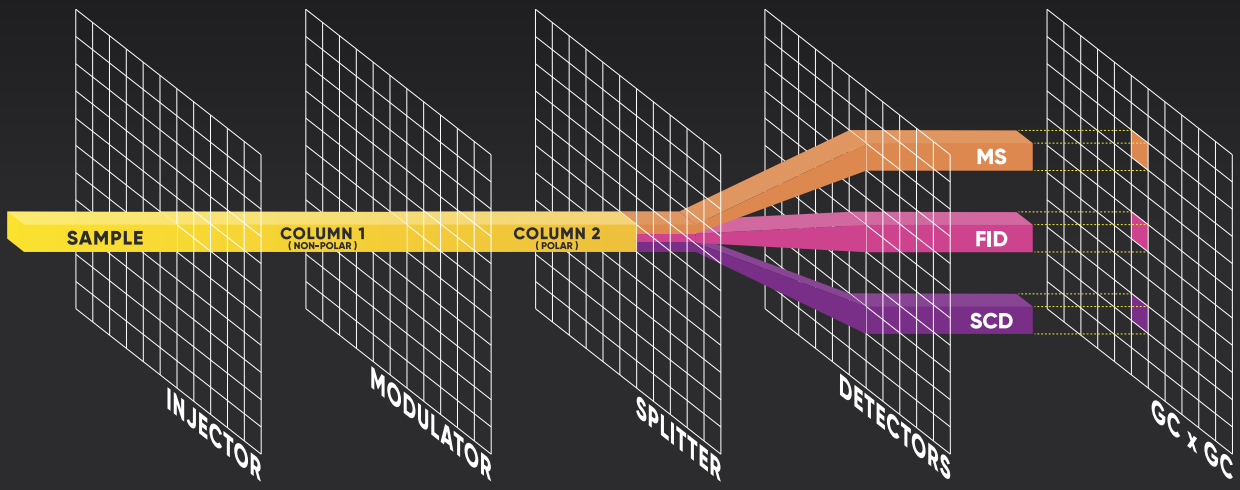
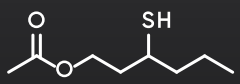


Figure 5. Gorilla Glue is known for its prototypical gassy, earthy, piney aroma. This figure shows where Gorilla Glue should have fallen on the spectrum, and where our "Gorilla Glue" actually ended up.

As previously mentioned in *The Science of Exotic I: The Dawn of Flavorants* we had to comb through this quantitative data with extreme care, as many of the major peaks (i.e. terpenes), were quite similar, suggesting that the origins of these exotic aromas arise from minor, low concentration compounds that are much harder to see than terpenes.



3-mercaptohexyl acetate

TROPICAL BLACKBERRY PASSIONFRUIT

We eventually happened upon a compound of extreme interest: ***3-mercaptohexyl acetate (3MHA)***. This compound is already well known in the food and beverage world to possess a powerful tropical flavor and aroma.

Upon our detection and identification of **3MHA**, we realized that perhaps this was the key missing compound in understanding the aromas associated with Tangie and other tropical varieties.

Could the mystery of Tangie really come from just one compound?

Is it possible that one single compound is responsible for all of the tropically exotic aromas of cannabis?

We were certain that we had only stumbled upon a single piece of the puzzle...

Fortunately, at Abstrax, our unique setup includes both a chemical analysis lab and a flavor formulation lab. This allows for us to collaborate and work on problems from different angles.

Our flavor chemist team explained that **3MHA is part of a wider family** of powerful tropical and citrus flavorants already widely in use by our flavor lab, as well as in the broader food and beverage industry, although it had never been identified in cannabis before.

Thanks to their insight, armed with this new understanding of similar compounds, we set a goal to discover whether other *3-mercapto* compounds might be present in these tropical or citrus cannabis cultivars.

This was the spark that lit the blaze.

THE TROPICAL TRIO

The knowledge that sulfur-containing compounds may be contributing to the potent citrus notes in cannabis was a revelation.

We immediately turned to focus on our **sulfur chemiluminescence data**. This specialized technique zeroes in on only the sulfur-containing compounds, effectively simplifying our data by filtering out everything else. Instead of sifting through hundreds of data points, we're left with just a few key peaks to analyze. You can see this clearly in **Figure 6**, where we compare the usual flame ionization detection (FID) data at the top with the more selective SCD data at the bottom, particularly looking at the mislabeled Gorilla Glue sample.

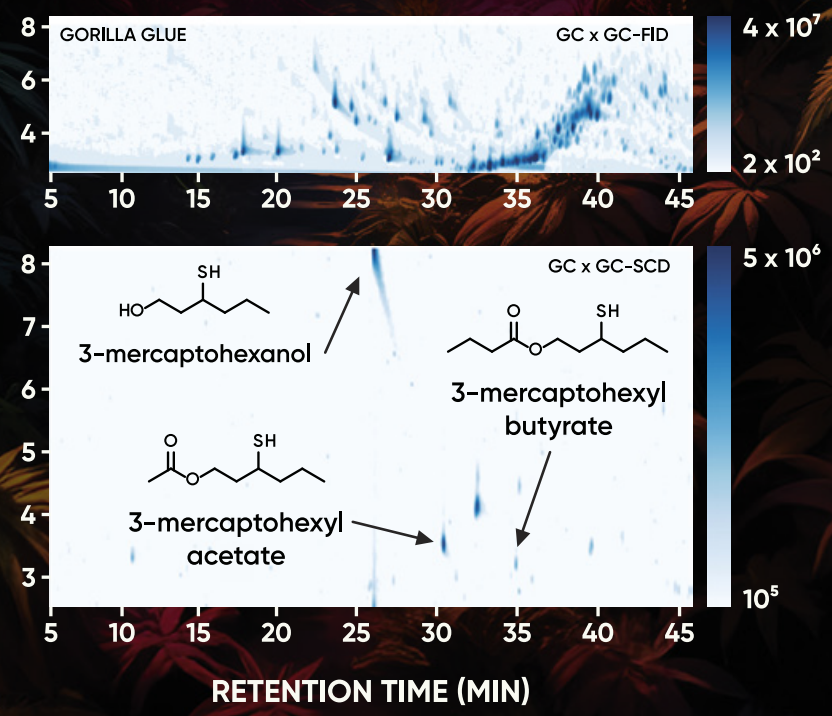


Figure 6. Two-dimensional chromatograms of Gorilla Glue which unusually contained these TCSCs.

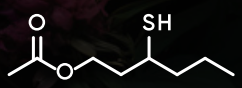
Top: Flame Ionization Detection (FID) data for Gorilla Glue reveals the extensive array of compounds present in the sample.

Bottom: Sulfur Chemiluminescence Detection (SCD) data for Gorilla Glue specifically highlights only the sulfur-containing compounds within the sample. This effectively narrows down the analysis, emphasizing the distinctive 'Tangie' compounds that are out of place in a true Gorilla Glue sample.

Right off the bat, we spotted the **3MHA** peak, just as we anticipated from our earlier mass spectral data. But there was more... two *other* significant peaks caught our eye.

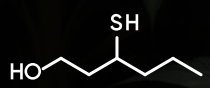
Upon deeper investigation and confirmation through their mass spectra, our findings echoed what our flavor chemists had predicted.

We identified not just **3MHA**, but also **3-mercaptohexanol (3MH)** and **3-mercaptohexyl butyrate (3MHB)**. Each of these compounds carries its own intense mix of sulfuric, citrus, and tropical scents, aligning perfectly with the sweet, fruity, exotic aromas we've noticed in many samples.



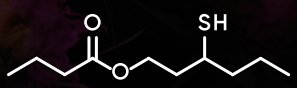
3-mercaptohexyl acetate

PASSIONFRUIT
BLACKBERRY
TROPICAL



3-mercaptohexanol

GUAVA
TROPICAL
PASSIONFRUIT



3-mercaptohexyl butyrate

GRAPEFRUIT
TROPICAL
CITRUS

Figure 7. Chemical structure and aroma descriptors for newly discovered tropicannasulfur compounds.

These compounds exhibit *extreme* chemical uniqueness relative to other compounds found in cannabis - including terpenes.

None of these compounds have been seen or described in cannabis literature before.

This discovery meant that not only were the gassy, skunky aromas of cannabis produced by cannasulfur compounds, but *also* the intensely deep tropical/citrus aromas found in exotic cultivars. This shows just how powerfully aromatic these sulfur-containing compounds are to the human nose.

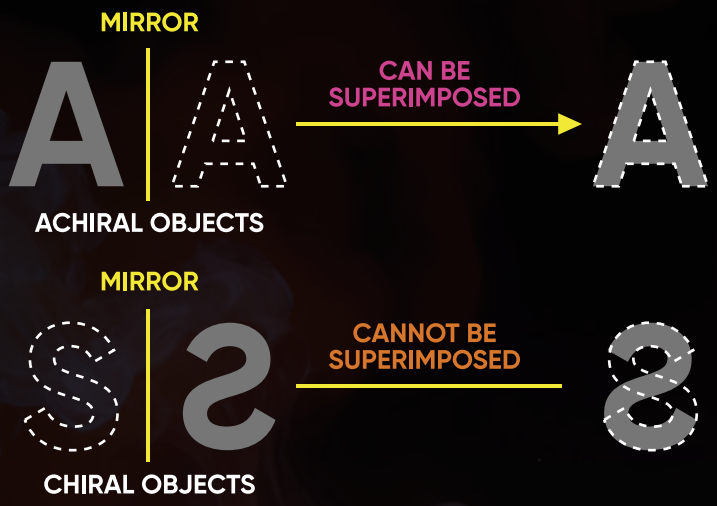


Figure 8. Chirality can have a significant impact on the properties and effects of biologically active compounds.

Interestingly, these compounds are chiral – meaning that their mirror images are non-superimposable, much like how your left and right hand are mirror images of each other but aren't identical. **This phenomenon is a critical aspect of organic chemistry in determining chemical functionality.**[5] Studies investigating the chiral distribution of these are ongoing.

INTRODUCING TROPICANNASULFURS

While these new compounds are *extremely* unique to other compounds found in cannabis, they do share a common family tie with other recently discovered molecules: **cannasulfur compounds**.

First reported in our breakthrough 2021 study[6], cannasulfur compounds (CSCs) are responsible for the gassy, skunky, and dank aromas of cannabis. If you remove the stigma and hype from cannabis, it's a plant that grows in the ground. Yet, remarkably, if someone sparks up within 50 yards of you, you're going to smell it. *Why?* You usually need to bury your nose in a bouquet of flowers just to get a good whiff of their aroma, but that's not the case with cannabis flower. **The reason is cannasulfur compounds.**

To read more about the discovery of cannasulfurs, check out our white paper The Science of Dank.

It turns out that these newly discovered compounds **3MH**, **3MHA**, and **3MHB** are a subset of the previously discovered cannasulfur compounds but they have vastly different aroma properties. Given their unique chemical properties, and the fact that they have never been reported before in cannabis literature, we have coined the term **tropicannasulfur compounds**, or TCSCs for short. And since the cannasulfur family is expanding, we are retroactively referring to the previously-discovered CSCs as **prenylated cannasulfur compounds**, or PCSCs for short.

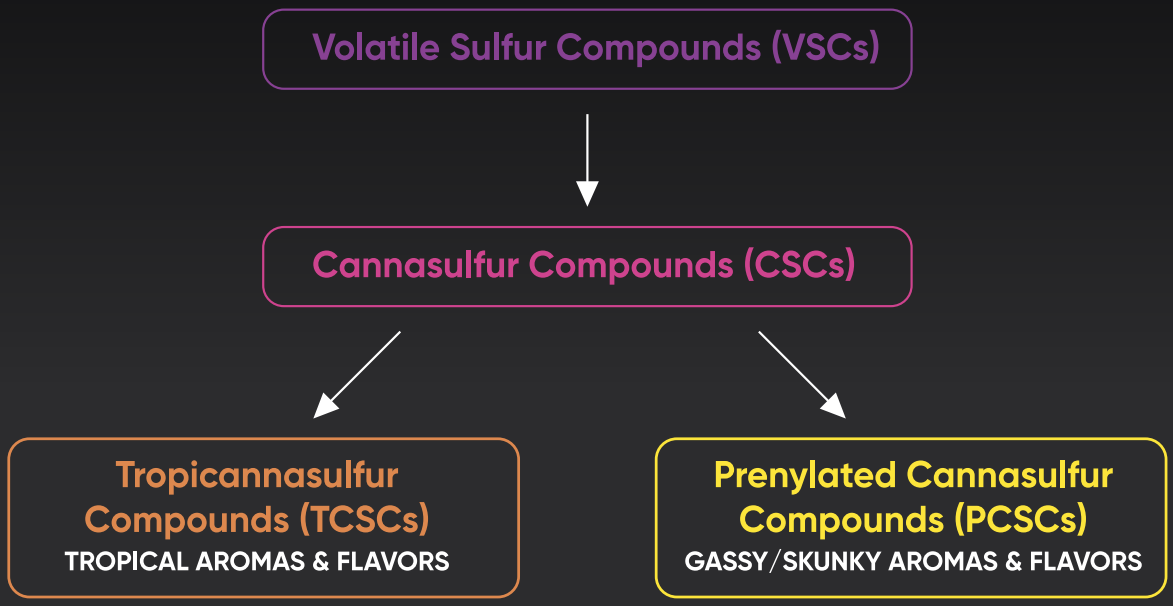


Figure 9. A schematic showing how tropicannasulfur compounds fit into the greater hierarchy of sulfur chemistry in cannabis.

These new tropicannasulfur compounds (**3MH**, **3MHA**, and **3MHB**) have an intense and tenacious odor that is starkly different from the other cannasulfurs discovered in 2021. These TCSCs, when combined with other compounds found in cannabis such as PCSCs and terpenes, impart a citrus-like aroma with the underlying funk of petroleum and/or sulfur.

Tropicannasulfur compounds are the mystery compounds responsible for the tropical aromas like citrus, orange, guava, passionfruit, and papaya found in cannabis. And since they are members of the dank cannasulfur family, even their minimal presence will leave a loud and lasting impact. Whereas PCSCs impart savory flavors alongside a rich complement of dank gas, tropicannasulfurs instead deliver a tropically fruity essence tinged with sulphuric skunk.

If PCSCs are savory, and TCSCs are fruity, could there be other undiscovered CSCs responsible for imparting a variety of unique, gassy flavors and aromas to cannabis? Just how big is this family?

Only future research will tell.

TRUST YOUR NOSE

Interestingly, **tropicannasulfurs are easily discernible by even untrained noses**. You, the reader, have likely experienced them without knowing it. Our sensory panel, *even without any special training*, could easily pick up on these tropical/citrus scents and relate them to the quantified levels of TCSCs in the samples. In other words, regular people are easily able to tell when cannabis has high levels of TCSCs.

As shown in **Figure 10**, the more tropical the description from our sensory panel, the higher the concentration of TCSCs as verified in our chemical analysis, suggesting that even though these compounds are present in small amounts, they make a big impact on the aroma and are quite noticeable to the average person.

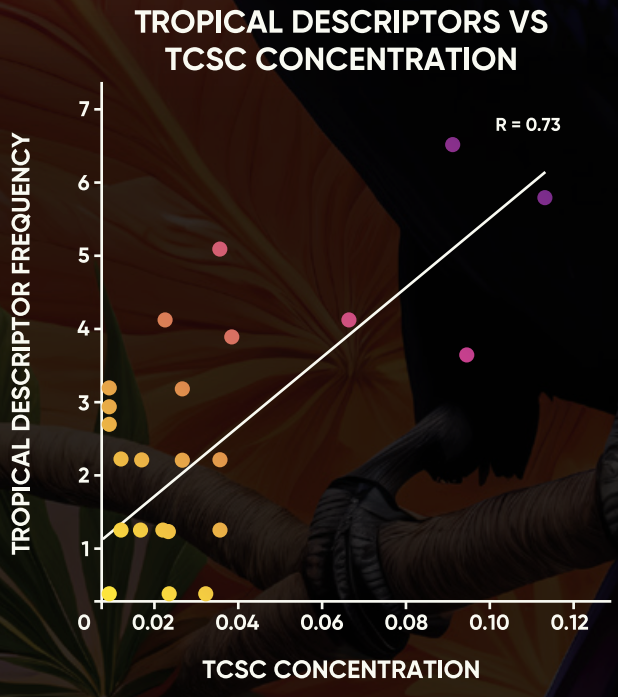


Figure 10. There's a clear positive correlation between tropical descriptors and TCSCs, confirming these compounds' critical role in giving tropical exotic cannabis its distinctive flavors and aromas.

When taken altogether, tropicannasulfur compounds make up a **small but significant** portion of the newly discovered flavorants in cannabis, as shown in **Figure 11**.

THE ABSTRAX PERIODIC TABLE OF FLAVORANTS

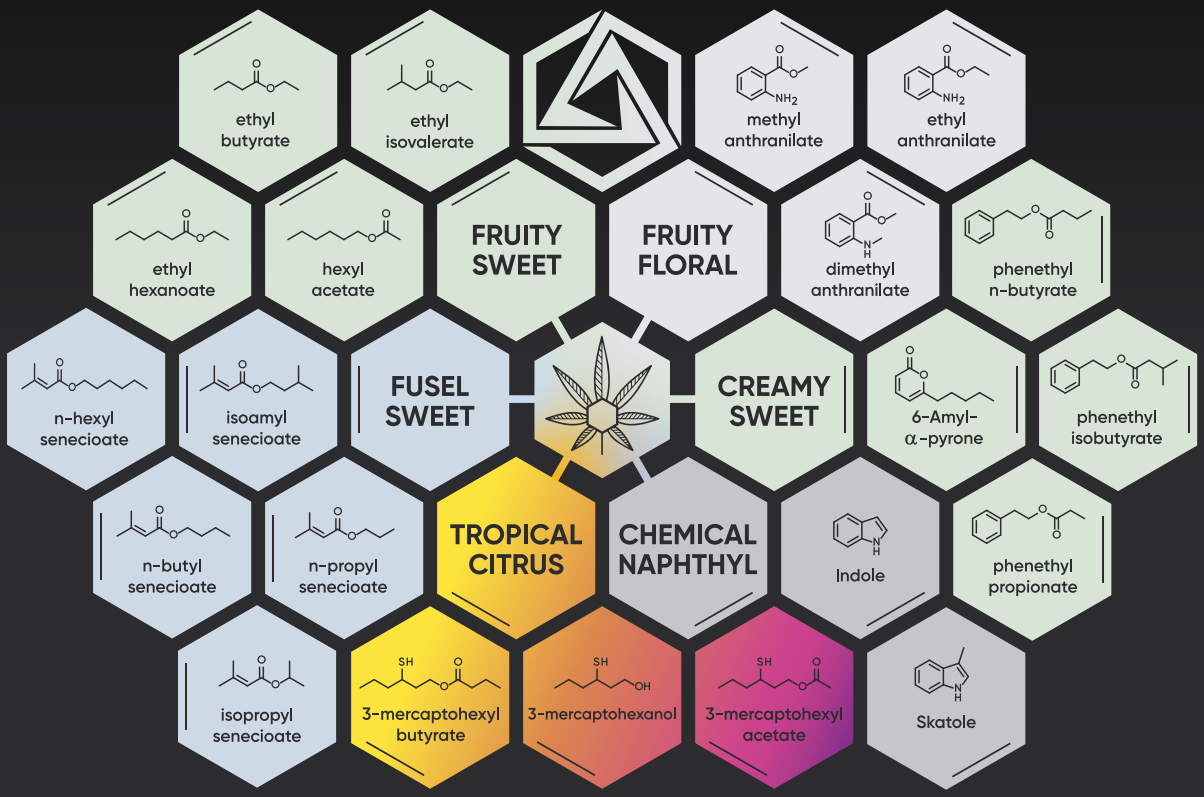


Figure 11. Schematic illustrating many of the newly discovered flavorants that are responsible for the exotic aroma of cannabis. The trio of tropicannasulfur compounds sit in the lower middle.

So the next time you pick up some bud (doesn't matter if it's flower or a concentrate), see if you can identify any tropical or citrus notes, and know that what you're smelling are tropicannasulfurs in action.

D-LIMONENE: THE MISUNDERSTOOD TERPENE

What about Limonene? **For decades, Limonene has been credited as the source of cannabis's citrusy flavor and aroma**. Ask any terp-aficionado about Limonene and they'll likely tell you about limes, lemons, and citrus in general.

Limonene is a prevalent monoterpene found in varying, but often high, concentrations in many cannabis cultivars. It's prevalent in the peels and oils of citrus fruits like lemons, limes, oranges, and grapefruits, as well as in juniper berries, rosemary, fennel, dill, and black pepper.

So how does Limonene impact the citrus notes of cannabis?

BARELY AT ALL.

It turns out that Limonene's impact on the intense and desirable citrus notes in cannabis is close to negligible. We know this because out of all 31 ice-hash rosin samples that we analyzed for this study, nineteen of them have Limonene as the dominant terpene in the cultivar, including varieties that displayed absolutely no hint of tropical or citrus flavors and aromas.

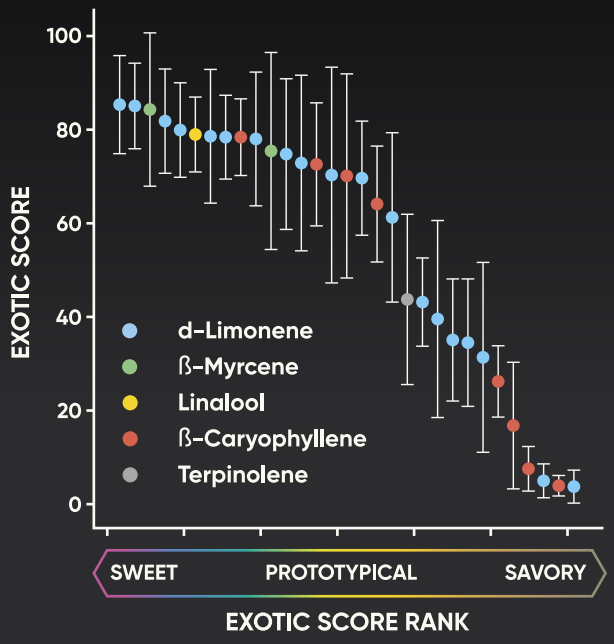


Figure 12. This figure presents the predominant terpene across all 31 samples analyzed in our study, juxtaposed against the Exotic Score of each sample. Observe that cultivars, irrespective of high or low Exotic Scores, frequently have d-Limonene as their primary terpene. This consistently points to the minimal role d-Limonene plays in influencing the overall aroma profile.

Take, for instance, our **OG** sample, which is typically known for its deep, rich, earthy, and gassy scent. Despite d-Limonene being its dominant terpene, it wasn't characterized by any citrus or tropical notes at all.

Even more indicative of Limonene's limited role is its dominance in the most savory cultivar we analyzed in this study - **GMO** - a strain *completely* devoid of any citrus, tropical, or sweet undertones. This strongly suggests that while Limonene may bring some infinitesimal nuance of lemon or lime, it is fundamentally different from the actual citrus perceived by consumers when referring to fruity exotic varieties.

And, to put the nail in the coffin, some of the cultivars in our study that indeed possessed a citrus and tropical aroma **weren't dominated by Limonene at all**. Some were even primarily characterized by beta-Caryophyllene, a compound known for its rich, spicy, and clove-like aroma. If Limonene were truly the main contributor to the citrus fragrance of cannabis, it would likely dominate in cultivars with those specific aromas and, yet, that's not what we found.

This underscores the idea that dominant terpenes alone cannot fully explain a cultivar's aroma.

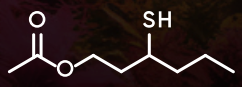
FLAVORANTS, NOT TERPENES, DRIVE THE UNIQUE AROMAS IN CANNABIS.

Our findings suggest that **the most minuscule presence of any tropicannasulfur compound can significantly enhance the citrus aroma**, due to their abnormally strong odor profile.

This revelation is crucial for the industry, as it can lead to **more accurate descriptions of cannabis products**, helping consumers identify strains based on their preferred aromatic qualities. It also allows for us to **quantify the exotic aroma of cannabis**, equipping breeders with the insights needed to develop new and more exotic cultivars.

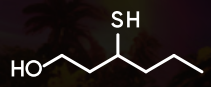
GOING BEYOND CANNABIS:
TROPICANNASULFURS IN BEER, WINE, AND NATURE

While Abstrax is the first to discover tropicannasulfur compounds in cannabis, TCSCs are also found in other natural sources such as hops, grapes, and a wide array of tropical fruits, as illustrated in **Figure 13**. Their prevalence, especially in tropical fruits, underscores their critical role in creating the unique and delightful citrus and tropical flavors that make these fruits so appealing.[7]



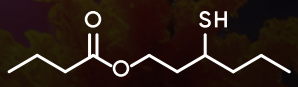
3-mercaptohexyl acetate

HOPS, PASSIONFRUIT, GRAPEFRUIT, VARIETIES OF WINE GRAPES



3-mercaptohexanol

PINEAPPLE, PAPAYA, HOPS, SAUVIGNON BLANC GRAPES



3-mercaptohexyl butyrate

PINEAPPLE, PAPAYA, HOPS, PASSIONFRUIT, GRAPEFRUIT

Figure 13. The trio of tropicannasulfur compounds - 3MHA, 3MH, and 3MHB. Each are found natively in different fruits, berries, and even hops.

Beyond their role in tropical fruits, brewers are increasingly recognizing **the potential of TCSCs in enhancing beer flavors**, particularly in the popular hazy IPA category.

Similar to cannabis, **hops produce various sulfur-containing compounds**. While chemically distinct, resulting in somewhat similar yet uniquely different aromas compared to cannabis, these compounds become integral during the brewing process, contributing to the beer's pleasant flavors. In hops, these compounds can be found as 'bound thiols,' meaning they're attached to a protein residue, which limits their release into the beer.[8] Innovative brewing technologies are being developed to overcome this and enhance flavor release.

As for cannabis, the exact biosynthetic pathways of these compounds and their binding nature are not yet fully understood. However, the fact that we can readily smell these compounds in cannabis suggests they might be more freely available than in hops, contributing to the plant's rich fragrance. **Further research is needed to confirm this**. Nevertheless, the high demand for these compounds in both hops and other fruits underscores their allure in cannabis as well, pointing to a shared appreciation for their contribution to complex and desirable aromas.

WE'RE LEFT WITH THE FOLLOWING QUESTIONS:

ONE: How, when, and why does cannabis produce tropicannasulfur compounds?

TWO: Do tropicannasulfur compounds serve a different purpose to the plant than prenylated cannasulfur compounds?

THREE: Does the existence of tropicannasulfur compounds imply that there are other CSCs out there waiting to be discovered?

FOUR: Do heterocyclic compounds like Indole and Skatole increase the aromatic strength of tropicannasulfur compounds?

FIVE: Do tropicannasulfur compounds have any impact on the mood-enhancing or euphoria-inducing properties of cannabis?

SIX: Can tropicannasulfur compounds be used in strain-validation to prevent the misnaming of cultivars at the consumer level?

Further research will hopefully fully understand the importance of these compounds.

CONCLUSION

We've uncovered the elusive chemical roots of some of **the most captivating aromas in cannabis**: the robust and distinct citrus scents found in many tropical and exotic cultivars.

The driving force behind these distinct aromas has been pinpointed to a newly discovered class of volatile sulfur compounds, termed **tropicannasulfur compounds (TCSCs)**. These TCSCs represent a fresh addition to the recently discovered family of cannasulfur compounds.

Contrary to previous beliefs, d-Limonene, once credited as the primary contributor to the citrus flavor and aroma in cannabis, has minimal, if any, influence on the plant's actual potent citrus scent and taste.

Despite their low concentration, **TCSCs have a significant impact**, imparting potent and sought-after citrus/tropical notes to many prized varieties. These findings demonstrate cannabis's ability to produce a diverse range of sulfur-containing compounds, from the skunky smells of prenylated cannasulfur compounds to the entirely different, appealing flavors and aromas of TCSCs.

Overall, **tropicannasulfur compounds emerge as the key class of compounds** that define the aromatic profile of modern cannabis cultivars known for their exotic tropical and citrus aromas.

If you'd like to experience tropicannasulfur compounds in action, Abstrax Tech has created a formulation of Orange Apricot that utilizes the key defining characteristics identified in this study. See for yourself what tropical, exotic cannabis can be like.

NATIVE SERIES

ADVANCEDTERPENEPROFILES
Powered by Terplytics

AVAILABLE TODAY AT ABSTRAXTECH.COM

EPILOGUE

DO YOU WANT TO LEARN MORE ABOUT THE CHEMISTRY OF EXOTIC CANNABIS? BE SURE TO READ THE OTHER WHITE PAPERS IN OUR ANTHOLOGY OF EXOTIC CANNABIS.

- **The Science of Exotic I: The Dawn of Flavorants –** Learn why terpenes might not be the most effective method for discerning the aromas of cannabis.
- **The Science of Exotic II: The Curious Case of Chem –** Learn about what makes some of the most savory, or chemical-like varieties smell and taste the way they do.
- **The Science of Exotic IV: Sweet –** Learn about all of the new chemistry in many of your favorite sweet, fruity, or dessert-like varieties.

LEARN HOW ABSTRAX IS USING THIS DISCOVERY TO MAKE THE WORLD'S MOST ACCURATE TERPENE PROFILES.

REFERENCES

1. Oswald, I. W. H.; Paryani, T. R.; Sosa, M. E.; Ojeda, M. A.; Altenbernd, M. R.; Grandy, J. J.; Shafer, N. S.; Ngo, K.; Peat, J. R., III; Melshenker, B. G.; Skelly, I.; Koby, K. A.; Page, M. F. Z.; Martin, T. J., Minor, Nonterpenoid Volatile Compounds Drive the Aroma Differences of Exotic Cannabis. *ACS Omega* **2023**. [Editor's Choice Article]

2. https://www.weedmaps.com/strains/californian-orange

3. https://www.weedmaps.com/strains/tangie

4. https://www.weedmaps.com/strains/tangerine-dream

5. Tominaga, T.; Niclass, Y.; Frérot, E.; Dubourdieu, D., Stereoisomeric Distribution of 3-Mercaptohexan-1-ol and 3-Mercaptohexyl Acetate in Dry and Sweet White Wines Made from Vitis vinifera (Var. Sauvignon Blanc and Semillon). *J. Agric. Food Chem.* **2006**, *54* (19), 7251-7255.

6. Oswald, I. W. H.; Ojeda, M. A.; Pobanz, R. J.; Koby, K. A.; Buchanan, A. J.; Del Rosso, J.; Guzman, M. A.; Martin, T. J., Identification of a New Family of Prenylated Volatile Sulfur Compounds in Cannabis Revealed by Comprehensive Two-Dimensional Gas Chromatography. *ACS Omega* **2021**, *6* (47), 31667-31676.

7. El Hadi, M. A.; Zhang, F.-J.; Wu, F.-F.; Zhou, C.-H.; Tao, J. Advances in Fruit Aroma Volatile Research Molecules [Online], **2013**, p. 8200-8229.

8. Roland, A.; Viel, C.; Reillon, F.; Delpech, S.; Boivin, P.; Schneider, R.; Dagan, L., First identification and quantification of glutathionylated and cysteinylated precursors of 3-mercaptohexan-1-ol and 4-methyl-4-mercaptopentan-2-one in hops (Humulus lupulus). *Flavour Fragr. J.* **2016**, *31* (6), 455-463.