



# Why the STX-90 Outperforms Every Other Terpene Extraction Method

*A Method-by-Method Analysis of Purity, Yield, Oxidation Risk & Biomass Integrity*

## THE CHALLENGE OF TERPENE PRESERVATION

Terpenes are among the most chemically fragile compounds in the cannabis plant. As volatile short-chain hydrocarbons, they begin evaporating the moment the plant is harvested, degrade under heat, oxidize in the presence of oxygen, react with solvents, and are lost irreversibly during conventional drying and curing. Research shows cannabis loses up to 31% of its terpenes after just one week of drying, and 55% after a three-month cure. Every extraction method in common use today compromises the terpene profile in some way — except one.

## METHOD-BY-METHOD ANALYSIS

### STEAM DISTILLATION

**Process:** Boiling water generates steam that passes through cannabis biomass, volatilizing terpenes into a vapor stream that is then condensed and collected. The terpene fraction separates and floats above a water hydrolyat layer.

**The moisture problem:** Steam distillation introduces significant water into the biomass. Before the cannabis can proceed to cannabinoid extraction, it must be dried — an additional, time-consuming step that itself causes further terpene loss and creates a window for microbial contamination. This negates the efficiency advantage the method might otherwise offer.

**Thermal degradation:** Operating temperatures of 100°C or above destroy the most volatile and therapeutically valuable monoterpenes. Limonene, myrcene, linalool and other heat-sensitive compounds are degraded into foul-smelling breakdown products or lost entirely to the vapor stream before collection.

**Oxidation:** The process occurs in an open, water-saturated, oxygen-rich environment. Terpenes are highly susceptible to oxidation — exposure to oxygen at elevated temperatures causes rapid chemical alteration of the aromatic profile, producing peroxides and degradants that compromise both aroma and therapeutic integrity.

**Incomplete spectrum:** Steam distillation preferentially captures heavier hydrocarbon terpenes (myrcene,  $\beta$ -caryophyllene) while failing to recover the lighter, more volatile monoterpenes. The result is a skewed, incomplete terpene profile that does not reflect the living plant.

■ **VERDICT:** High heat, oxygen exposure, water contamination, and a mandatory post-extraction drying step make steam distillation the most damaging method for terpene integrity. Profile is incomplete, oxidized, and biased toward heavier compounds.

### MICROWAVE-ASSISTED (MAE)

**Process:** Microwave energy heats internal plant water, rupturing cell walls and releasing terpenes into a solvent or directly into a collection vessel. Operates at atmospheric pressure, typically requiring 1 hour per run.

**Oxidation risk:** Standard MAE operates in an oxygen-containing environment. Research explicitly identifies oxidation as a key risk that must be controlled via extraction time management. Terpenes exposed to microwave-generated heat in the presence of air undergo oxidative degradation — the same pathway that produces rancid aromas and altered therapeutic profiles.

**Thermal degradation:** Although faster than steam distillation, microwave energy still generates localized heat within the biomass. PMC research confirms terpenes “undergo thermal degradation with prolonged extraction time and increased temperature.” The most volatile monoterpenes are disproportionately affected.

**Post-extraction drying required:** Industry data confirms that excess moisture introduced during MAE processing reduces yield from subsequent cannabinoid extraction. A forced-air drying step is required before solvent extraction can proceed — the same post-process biomass damage problem as steam distillation.

**Scale limitations:** MAE throughput maxes at 40 kg per 8-hour shift at the largest commercial scale (Milestone ETHOS XL), and requires specialized industrial microwave infrastructure with rigorous temperature and pressure controls.

■ **VERDICT:** Faster than steam distillation but shares its core weaknesses: oxidation exposure, thermal degradation of monoterpenes, moisture contamination of biomass, and a mandatory drying step before downstream cannabinoid processing.

## HYDROCARBON EXTRACTION (BHO/PHO)

**Process:** Butane, propane, or a blend of both is used as a solvent to dissolve terpenes and cannabinoids from cannabis biomass at low temperatures. The solvent is then purged under heat and vacuum, leaving behind a concentrated extract.

**Loss of low vapor-pressure terpenes:** This is the critical and often overlooked flaw of hydrocarbon extraction. During the solvent recovery and purging stage, heat and vacuum are applied to remove the hydrocarbon solvent. The most volatile terpenes — those with the lowest vapor pressures, including the lightest and most fragrant monoterpenes — evaporate and are lost along with the solvent. The resulting extract is systematically depleted of the lightest aromatic fractions.

**Oxidation:** While hydrocarbon extraction occurs at low temperatures, the solvent recovery and purging process reintroduces heat and involves extended exposure to the atmosphere. Terpenes are oxidized during this stage, altering their molecular structure and producing degradants.

**Solvent contamination risk:** Residual butane and propane must be rigorously purged; incomplete purging leaves solvent residues in the final product. Third-party lab testing is mandatory. Regulatory requirements for CID1 explosion-proof facilities add significant capital cost and compliance burden.

**Biomass consumption:** Unlike pre-extraction terpene capture, hydrocarbon extraction co-extracts terpenes and cannabinoids simultaneously, making it impossible to preserve the terpene profile independently from the cannabinoid fraction.

■ **VERDICT: Systematically destroys low vapor-pressure monoterpenes during purging. Oxidation during solvent recovery alters terpene chemistry. Residual solvent risk, explosion hazard infrastructure, and inability to independently preserve terpenes make hydrocarbon extraction fundamentally unsuited for premium CDT production.**

## SUPERCRITICAL / SUBCRITICAL CO<sub>2</sub>

**Process:** Carbon dioxide is pressurized and temperature-controlled to achieve either subcritical (liquid-phase) or supercritical (gas+liquid-phase) states, then passed through cannabis to selectively dissolve terpenes and cannabinoids.

**Water interaction problem:** CO<sub>2</sub> reacts with water present in the biomass to form carbonic acid ( $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ ), introducing an acidic pH shift that affects the flavor profile and final product quality. This means CO<sub>2</sub> extraction is poorly suited to fresh or fresh-frozen material — the very starting material that best preserves terpene content.

**Incomplete monoterpene capture:** Even subcritical CO<sub>2</sub> at its gentlest parameters struggles to efficiently capture the lightest, most volatile monoterpenes. Research shows CO<sub>2</sub> extracts a greater diversity of oxygenated terpenes, but misses a significant fraction of the volatile headspace terpenes that define a strain's fresh aroma.

**Throughput and cost:** CO<sub>2</sub> extraction is slow, capital-intensive, and requires experienced operators. A 20 lb batch can take up to six hours. The equipment investment is among the highest in the industry, and the two-phase extraction process (subcritical for terpenes, then supercritical for cannabinoids) significantly reduces overall throughput.

**Oxidation:** While CO<sub>2</sub> itself is inert, the post-extraction handling and fractionation steps expose sensitive terpenes to atmospheric oxygen, introducing oxidation risk during collection and transfer.

■ ■ **VERDICT: More selective than hydrocarbon but undermined by carbonic acid formation, poor compatibility with fresh material, incomplete volatile monoterpene capture, high capital cost, and slow throughput. Better than steam or hydrocarbon, but still fundamentally solvent-dependent.**

## THE STX-90: NITROGEN-CAPTURE SOLVENTLESS EXTRACTION

The Tandem Technology STX-90 was engineered from first principles to eliminate every failure mode of the methods above. Drawing on patent-pending cryogenic cold trap technology developed in semiconductor-grade precision manufacturing, the STX-90 uses nitrogen as an inert carrier gas under deep vacuum to gently transport terpenes from the biomass to a liquid nitrogen cold trap — where they are instantly preserved at cryogenic temperatures. No heat. No solvents. No oxygen. No post-extraction drying. No solvent purging. No residual contaminants. The biomass exits the process lower in moisture content and gently conditioned — ready for immediate cannabinoid extraction without any additional processing step.

### ZERO OXIDATION

Nitrogen is a completely inert gas. Operating under deep vacuum with an oxygen-free nitrogen atmosphere means terpenes never contact oxygen at any stage of capture. The aromatic profile is chemically identical to the living plant.

### FULL VOLATILE SPECTRUM

The STX-90 captures terpenes under deep vacuum at cryogenic trap temperatures, preserving even the lowest vapor-pressure monoterpenes — the fragrant, therapeutically active compounds that every other method loses. >90% monoterpene content in the isolate is validated by GC/MS.

### NO THERMAL DAMAGE

The process applies only gentle, precisely controlled warmth to the rotating biomass drum — far below the degradation threshold of any cannabis terpene. The cryogenic trap instantly locks captured terpenes at temperatures that halt all degradation chemistry.

<p><b>NO POST-PROCESSING OF BIOMASS</b></p> <p>Unlike steam and microwave methods, the STX-90 leaves the biomass drier than it entered — with reduced moisture content and gently conditioned cell structure. No drying step. No waiting. Cannabinoid extraction begins immediately.</p>	<p><b>COMPATIBLE WITH ALL BIOMASS</b></p> <p>Works on dry biomass, fresh-frozen material, leaves, trim, and small nuggets. No need to sacrifice premium flower — material that would otherwise be discarded or sold at low value yields high-purity, strain-specific CDT isolate.</p>	<p><b>&gt;99.9% PURITY — NO RESIDUAL SOLVENTS</b></p> <p>Because no solvents are used at any stage, the resulting isolate contains no residual hydrocarbons, CO<sub>2</sub>, ethanol, or water beyond what separates cleanly in the collection step. Purity is verified by cool on-column GC/MS at &gt;99.9% terpene fraction.</p>
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HEAD-TO-HEAD COMPARISON SUMMARY

Criterion	Steam Distillation	Microwave (MAE)	Hydrocarbon (BHO/PHO)	Subcritical CO <sub>2</sub>	STX-90 (Nitrogen)
Full terpene spectrum (CDTs)	✗ No	✗ No	✗ No	~ Partial	✓ Yes
Zero oxygen / oxidation	✗ No	✗ No	✗ No	~ Partial	✓ Yes
Full monoterpene spectrum	✗ No	✗ No	✗ No	~ Partial	✓ Yes
No heat damage to terpenes	✗ No	~ Partial	~ Partial	~ Partial	✓ Yes
No solvents / residuals	✓ Yes	✓ Yes	✗ No	✗ No	✓ Yes
No post-extraction biomass drying	✗ No	✗ No	✓ Yes	✓ Yes	✓ Yes
Works on fresh-frozen material	✓ Yes	✓ Yes	✓ Yes	✗ No	✓ Yes
Works on trim / leaves / small nugs	✓ Yes	✓ Yes	✓ Yes	✓ Yes	✓ Yes
Biomass available post-extraction	✗ No	✗ No	✗ No	✗ No	✓ Yes
No flammable / explosive materials	✓ Yes	✓ Yes	✗ No	✓ Yes	✓ Yes
Purity >99%	✗ No	~ Partial	~ Partial	~ Partial	✓ Yes
Plug-and-play with existing workflow	✗ No	~ Partial	✗ No	✗ No	✓ Yes

**★ The STX-90 is the only terpene extraction system that simultaneously delivers zero oxidation, zero solvent contact, full volatile monoterpene capture, no thermal damage, no post-extraction biomass drying, and a biomass ready for immediate downstream cannabinoid extraction. It is not merely better than the alternatives — it operates on an entirely different set of principles, eliminating the root causes of terpene compromise rather than managing them.**

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