
2019 NAFA Annual Convention
Montreal | September 11-13
NAFA®
National Air
Filtration
Association

Air Filtration and IAQ for Indoor Grow Facilities

Moderator: *Kevin Delahunt, Senior Technical Advisor, BGE Indoor Air Quality Solutions*

Panelists*: Benoit Despatis, Chief Technology Officer, Sanuvox*
Michael Klump, VP Marketing and Innovation, Purafil Filtration Group
John Molnar, CEO and CTO, CoEng Advisors
Victor Rengel, Product Manager Molecular Contamination Control, Camfil Americas

Countries that have legalized Marijuana for Medical and Recreational Purposes

- Georgia
- Mexico
- South Africa
- Uruguay
- Canada
- Several other countries have maximum possession quantities ranging from 8-22 grams

Countries that have legalized Marijuana for Medical Purposes

- 39 countries

Countries that have Decriminalized Marijuana

- 28 countries

In the U.S.

- Recreational and medical use is legalized in 11 states and 2 territories
- Medical use only is legalized in an additional 23 states, 4 territories, and the District of Columbia
- Recreational and medical use is illegal at the Federal level.

Economic Benefits

- In Canada TD Bank estimates that the Cannabis industry will add $8 Billion to the economy……at least on paper.
- Colorado added $135 million in tax revenue in 2015
- In 2017 Washington state added ~$100 Million in tax revenues
- According to Forbes Magazine the legal Cannabis industry in the U.S. generated more than $10 Billion in sales and ~ 250,000 jobs.
- Moderate estimate (per CNBC) that legalized marijuana would generate $16-20 Billion in tax revenue and $40 Billion in sales

Canadian Regs & Filtration

John Molnar, P.Eng., LEED AP, CoEng Advisors

Canadian Regs

- MMAR – July 2001 – Start of medicinal cannabis in Canada
- MMPR – July 2013 – HEPA on exhaust and must control odour
- ACMPR – August 2016 - Similar to MMPR, more cultivation options
- Cannabis Act – October 2019 – Derivative Products, cultivation options

Exhaust

- “If you’re going to grow indoors, you’re obligated to filter your exhaust.”
- HEPA filtration is no longer specified by the Cannabis Act.
- Indoor VS Outdoor definition? Concrete Floor? Greenhouses?
- Health Canada is “Vague on purpose”
- No filtration is specified on intake, value add for the filter industry.
- No air changes are specified, vague “adequate ventilation”


IRINOX
IRINOX
IRINOX
EXIT

Odour Control

- Per regulation, Licensed Producers are required to control Odour for indoor grow
- There is no specification, inspectors are from Health Canada
- Carbon filtration seems to be most effective so far
- Injection, ionizer and spray nozzle type technologies being experimented with


Can-Filters

Contamination Control

- Contamination across rooms / cells is an issue
- Small rooms requires affordable, high CFM, small footprint filters

Gas-Phase Air Filtration for Cannabis Grow Houses

Michael Klump - Purafil
VP Marketing & Innovation

NAFA 2019 Annual Convention | Montreal, Canada | September 11-13

01 About Purafil

02 Odor Control & Regulations

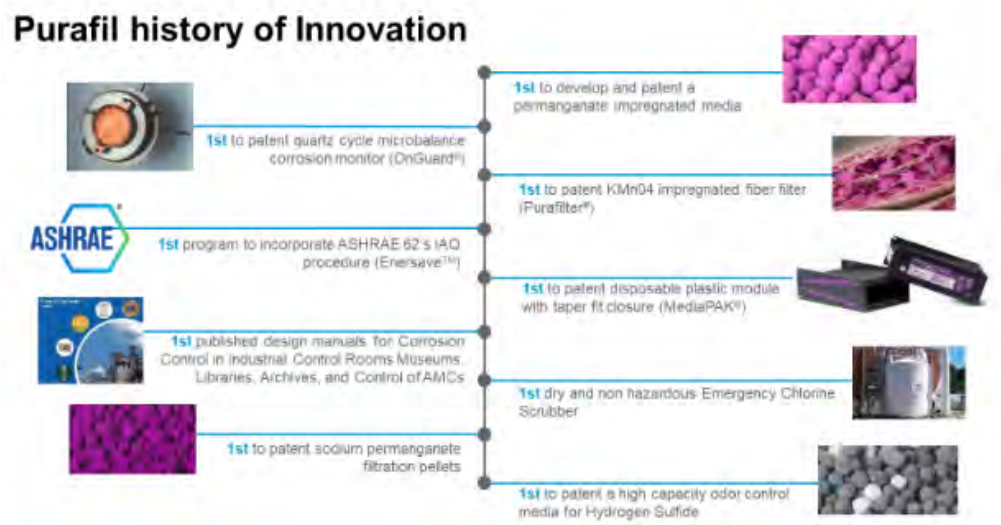
03 Odor Control Technologies & Facility Design

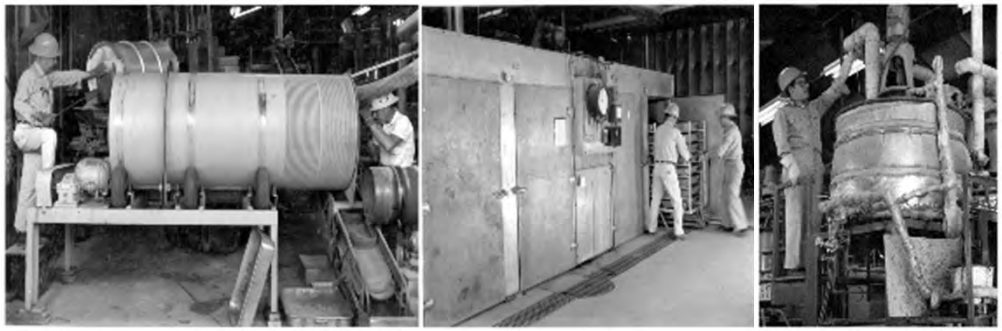
04 Limitations of Carbon

Purafil Leading Gas Phase Filtration for 50 Years

Purafil has been the leader in innovation for gas phase filtration

- ✓ 1st to engineer, manufacture and patent potassium and sodium permanganate-impregnated media for the oxidation of pollutants
- ✓ 1st to manufacture an engineered carbon media alternative to activated carbon to neutralize corrosive airborne pollutants
- ✓ 1st to develop Odor IoT sensor for waste water industry
- ✓ **1st to develop patented media for odor gases in the grow market**





Core Competencies

Toxic Gas Mitigation:
Substances that cause damage to living tissue, impairment of the CNS, or in extreme cases, death
Air cleaning systems must be 100% efficient, 100% of the time to eliminate risk

Corrosion Control:
Substances which are likely to cause deterioration or damage to the interior of a building or its contents
Air cleaning systems must be able to clean air to industry & OEM specified levels

Irritant Control:
Substances which can cause discomfort, and potentially permanent damage, to an exposed person
Air cleaning systems need to be able to remove a wide range of biological & chemical contaminants

Odor Gas Removal:
Substances which primarily affect the olfactory senses resulting in mild to extreme discomfort
Chemical filters placed in the HVAC system to “shave the peaks” of contaminant episodes

Odor Control and Regulations

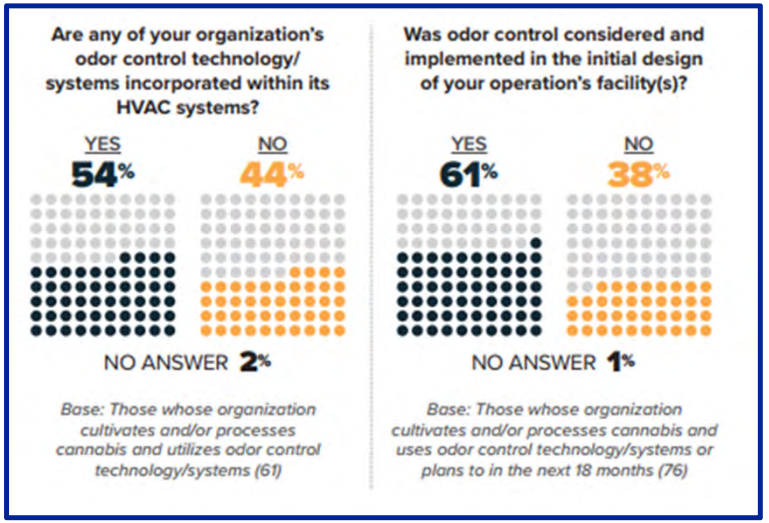
SPHINX™
GROW HOUSE AIR FILTRATION

Odor Control in Cannabis Grow Houses

Licensed producers (LPs) have sent numerous requests for odor control solutions in cannabis grow houses, extraction facilities, dispensaries, etc. since the legalization of its use in several states and nationally in Canada.

When growing indoors, it is necessary to maintain as close to an ideal atmosphere inside the grow room as possible.

- The air temperature should be maintained within a specific range, typically with deviations no larger than 10°C (18°F) with a cooler nights and warmer days.
- Adequate levels of carbon dioxide (CO_2) must be maintained for the plants to grow efficiently.
- It is also important to promote vigorous air circulation within the grow room, which is usually accomplished by mounting an extraction fan and one or more oscillating fans.
- Proper air flow management combined with properly designed filtration systems minimize powdery mildew potential



Cannabis Odor Control Report, Cannabis Business Times, May 2019

Cannabis Odor Regulations

Odor control is a serious problem for many licensed producers

Almost all cities / counties / states / etc. mandate that cannabis odors not leave the building. Many require an odor mitigation plan, but they are not being implemented.

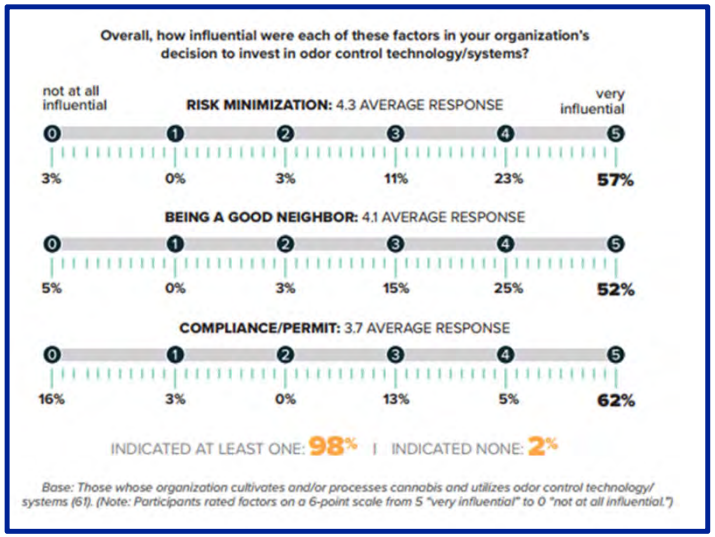
- In Denver, the regulation is 1 part cannabis odor per 7 parts filtered air. Health Canada also has stringent regulations

Odor control goes a long way to creating community goodwill

- The quickest way for someone who does not approve of cannabis to force growers out of the neighborhood is for them to complain about the smell.

Odor and particulates can be a health issue

- Some employees at these facilities have pollen and other seasonal allergies that become affected by the particulates in the air.



Cannabis Odor Control Report, Cannabis Business Times, May 2019

Stricter Odor Regulations within Provinces

"Despite requirements within Cannabis Regulations to mitigate the escape of odours, several licensed greenhouses in Delta are emitting odours which can be observed at significant distances from the facilities. The City of Delta and Metro Vancouver staff have been in contact with the operators"
https://www.thetcanada.com/2019/05/07/liberal-mlas-lobby-feds-to-address-stench-from-marijuana-greenhouses-reports/

"Pelham has banned any new cannabis cultivation facilities and existing ones are prohibited from expanding for one year, under an interim control bylaw put in place on Oct. 15 last year. Unfortunately, the ones that are here haven't been the best of corporate citizens," Junkin said."
https://www.thestar.com/business/2019/01/13/pot-producers-face-pushback-over-odour-smell-in-ontario-farming-town.html

"In its submission to the 13 members of the MVRD's Change Action Committee, which includes representatives from Vancouver, Surrey and Richmond, district staff noted that emissions from cannabis production include volatile organic compounds (VOC) that can contribute to the formation of ground-level ozone and fine particulate matter. In addition to environmental concerns, the interests of the public—who made more than 300 complaints about cannabis odour last year alone—and the needs of business to operate cost effectively will be weighed. "We want to make the most compatible use of land, [but] there is no silver bullet," he adds."
https://www.thegrowthop.com/cannabis-news/causing-a-stink-b-c-could-put-forward-cannabis-emissions-regulation-by-year-end

Odor Control and Prevention

Seal the grow & processing rooms

- If properly sealed, no air will be getting in or out of the room. If no air can escape, no odor will escape either. Caulk around everything – plug outlets, doorways, anything that could lead to a leak.
- This method requires close control of airflow, humidity, oxygen, carbon dioxide, and ethylene levels.

Use chillers instead of HVAC

- With traditional air conditioning, air is moved around the building and is often expelled to the outside.
- This allows any odors inside the building to be transferred to the outside.
- Conversely, chiller units move water around the building, leaving the air in place.
- As long as the rooms are sealed properly, odors will stay contained within the building.

Treat the air

- Some ventilation will always be necessary, so it is also important to treat any air that does leave the room.
- One way to do this is by using gas phase filtration connected to the exhaust fan.

Cannabis Odor Control Report, Cannabis Business Times, May 2019

Odor Control Technologies & Facility Design

Challenges "Inside" Grow Facilities

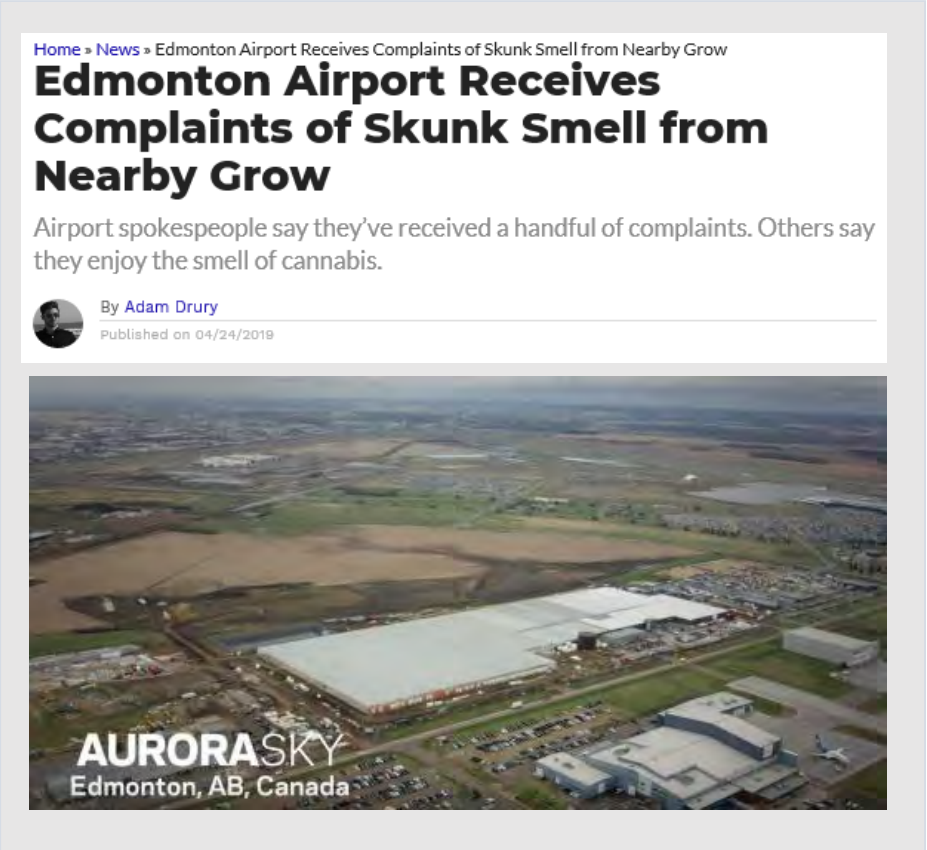
- Maximizing yield by optimizing growing conditions requires ventilation of large volumes of air.
- Contaminants that enter the facility in make-up air or on staff clothing, etc. can threaten the crop.

Common Threats:

- **Chemical:** Insecticides from adjacent agricultural activity.
- **Biological:** Plant Spores that exploit ideal growing conditions and colonize activated carbon media. (***i.e. Powdery Mildew)***

Challenges "Outside" Grow Facilities

- Indoor agricultural operations create a pungent odor that is characteristic of the strain of plant being grown.
- Pervasive odor is often objectionable to the neighboring community.
- Regulations and prescriptive penalties are still evolving but are certain to be enforced in the near future. $$$$
- Odor causing, gaseous emissions must be minimized or eliminated from the air being vented from the facility.



Indoor Grow House Stages & Room Types

Indoor Facility: 65% of market

- **Cultivation Rooms** *(low odor)*
  - Clone / Mother Room
  - Vegetative Growth Rooms
  - Flowering Rooms

- **Processing Rooms** *(high odor)*
  - Curing / Drying Rooms
  - Cutting / Deflowering Rooms
  - Extraction Rooms
  - Compounding Rooms
  - Packaging Rooms

Complexities of Retrofitting Greenhouses

- Managing proper airflow for temp & humidity
- Filtration – Particulate + Gas Phase
- Ducting Limitations
- Air management throughout the grow cycle
- Air intake and exhaust locations

Odor Control Technologies

For the control of odors from growing marijuana, growers are using everything up to and including:

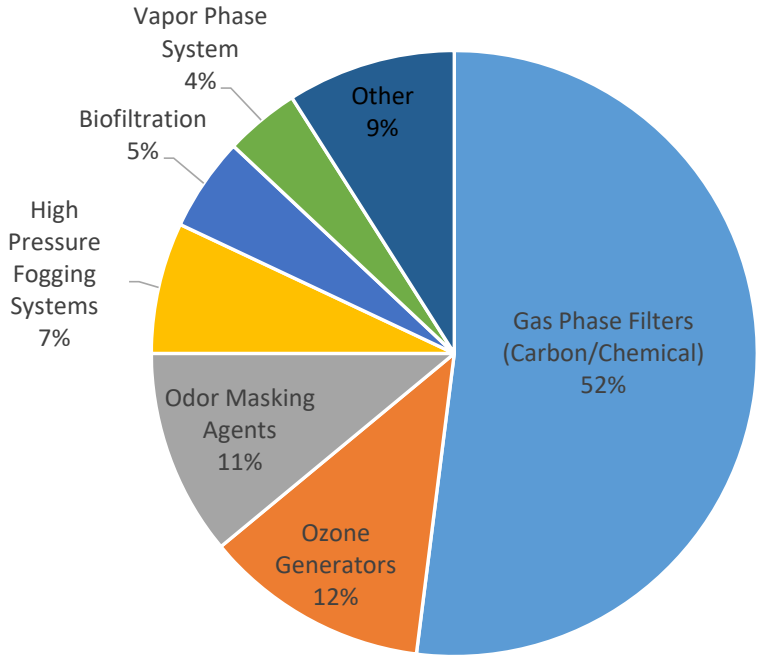
- Gas Phase Filtration (carbon / chemical)
- Biofiltration
- High Pressure Fogging Systems
- Ionizers (negative ion generators)
- Ozone Generators
- Odor neutralizers
- Odor Masking Agents
- Controls on air intake and exhaust to and from the room

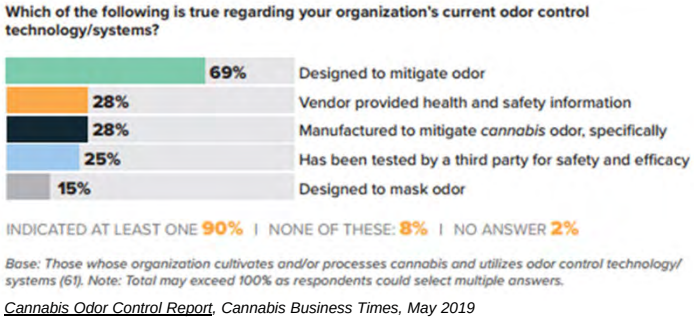
The main problems we have observed are the trend of:

- Using the cheapest odor control technology available
- Lack of standardized requirements
- Lack of enforcement to existing odor control ordinances

Particulates must also be controlled.

- HEPA filters may be required to remove mold and mildew spores to prevent powdery mildew and botrytis, world-wide scourges for cannabis cultivators.





Cannabis Odor Control Carbon

Most strains of cannabis emit distinctive odors at much higher levels during their reproductive phase and our data shows highest levels of terpenes during the cutting phase

- This presents difficulties for growers and a mixed approach to odor mitigation in the grow houses

The most common odor control method is exhausting the air inside a grow house through inexpensive "carbon" filters.

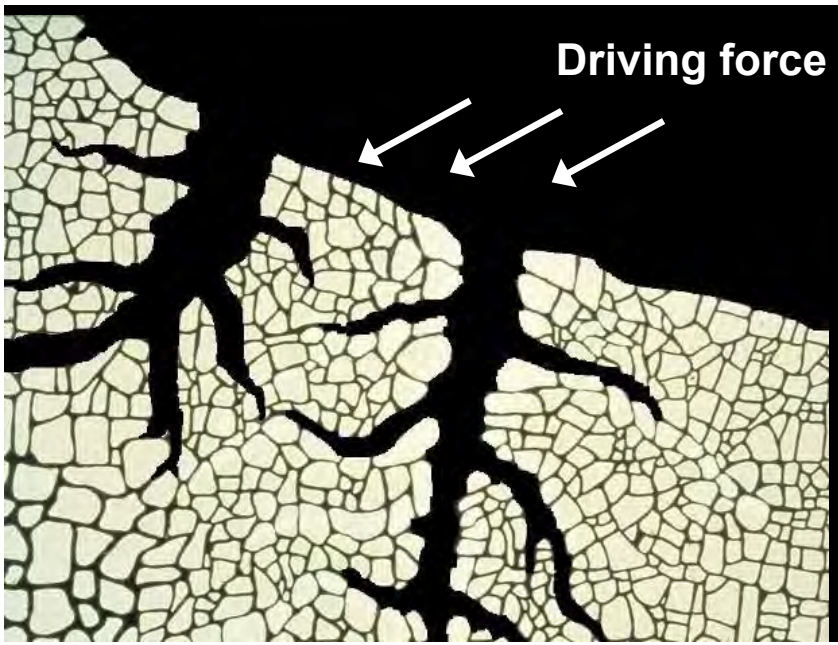
- Many cultivators simply attach a carbon filter to their air extraction system, thereby (hopefully) removing odors before the air is exhausted from the grow room into the surrounding neighborhoods.

The quality of the carbon being used and the effectiveness of the filter design are coming under closer scrutiny as odor complaints continue to be filed with local governments.

Cannabis Odor Control Report, Cannabis Business Times, May 2019

Limitations of Carbon

Physical Adsorption Process



Phyical adsorption relates to size of pores vs size and polarity of molecules

Micro pores < 2 nm
Meso pores 2-50 nm
Macro pores > 50 nm

	Pore Volume (ml/g) at Size Distribution		
AC Type	**Micro <2nm**	**Meso 2-50nm**	**Macro >50nm**
Lignite	0.22	0.35	0.45
Bituminous	0.39	0.13	0.27
Coconut	0.45	0.1	0.15

Typical Specs for AC by Raw Material Type Coal

Properties	Coconut	Bituminous	Sub-Bituminous	Lignite
Iodine Number (mg/g)	1,050-1,300	950-1,000	1,000-1,100	500-600
Apparent density (lb/cf)	30-34	30-34	22-23	23-24
Total ash (%)	<3	8-15	10-15	16-30
Molasses Number	<200	200-300	>300	>300
Hardness Number	98-99	85-90	85-90	65-75

Typical Specs for Asia Sourced Coal based AC

Properties	Pelletized AC	GAC	PAC
Iodine Number (mg/g)	950-1,100	900-1,050	800-1,000
CTC (%)	60-110	50-80	…
Hardness (%)	85-95	80-85	…
Methylene Blue Number (mg/g)	150-250	150-230	120-200
Bulk density (g/ml)	350-500	350-450	320-420
Ash (%)	5-15	5-15	8-15

Why your existing odor solution isn't working?

Current odor solutions only use activated carbon

- Carbon begins to preferentially adsorb water from the air above 40% RH. This takes up adsorptive sites and reduces the efficiency and capacity of the carbon.
- The water adsorption isotherm for activated carbon shows that as long as the relative humidity (RH) of the airstream remains below 40-50%, the carbon performance should not be affected.
- The carbon will equilibrate with the moisture content of the air; however, this can produce periods of much lower performance for a great number of gas (odor) contaminants.

Purafil engineered media can operate in specified RH range of 5-95%

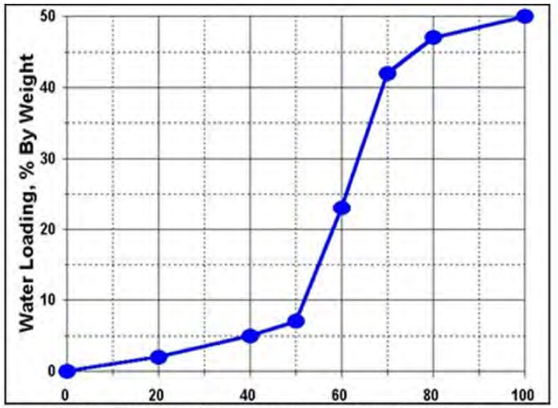


Figure 3. Water adsorption isotherm for activated carbon

*Knaebel, Kent S. Adsorbent Selection. Adsorption Research, Inc. Dublin, Ohio, http://www.adsorption.com/publications/AdsorbentSel1B.pdf.

Why your existing odor solution isn't working?

Carbon alone isn't effective on all odorous gases generated in grow facilities.

Trust the technical experts:

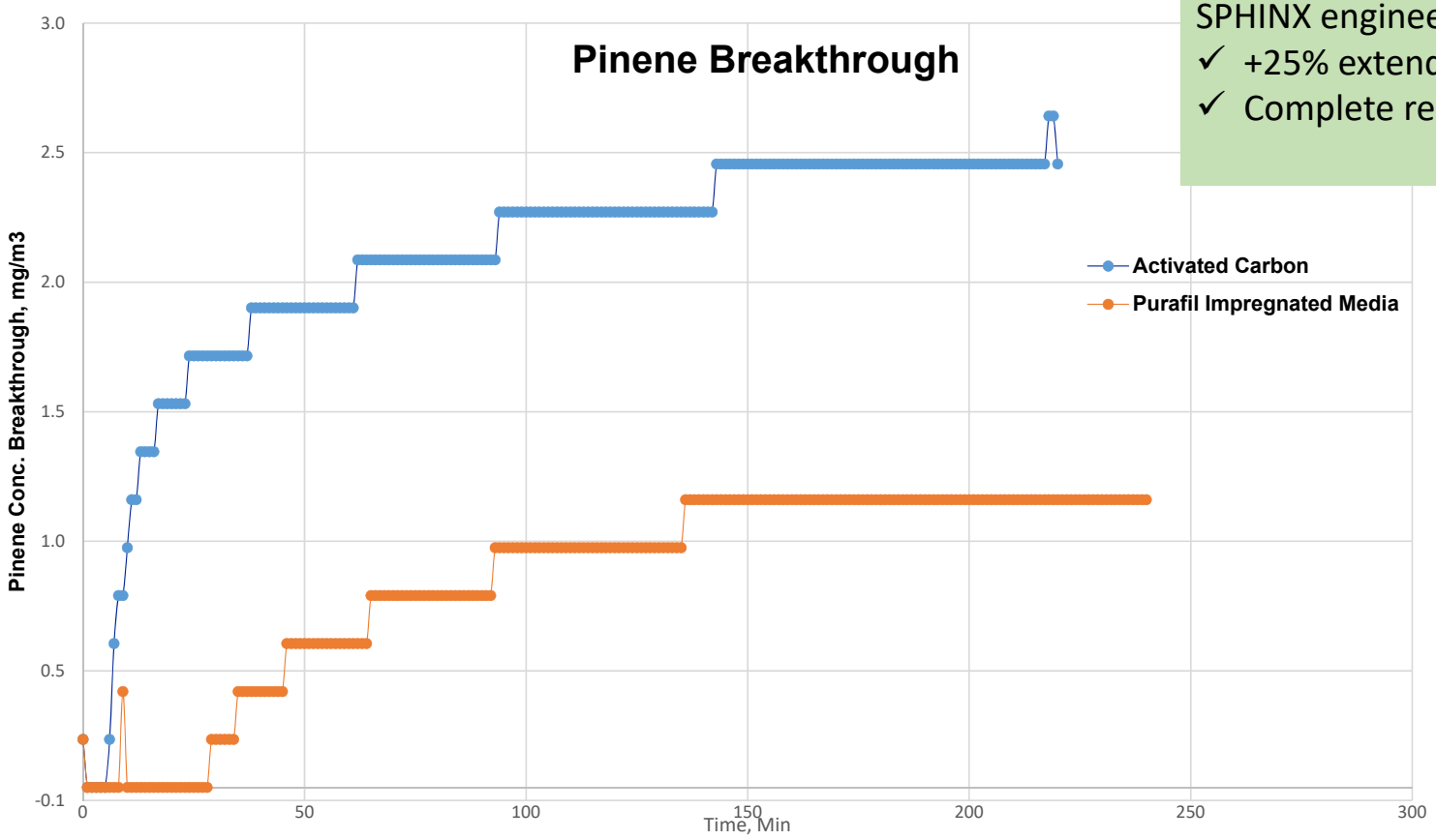
ABILITY TO COMPLETELY REMOVE TARGET ODOROUS GAS COMPOUNDS			
Odorous Gases by Detection Threshold	Activated Carbon	SPHINX Media REMOVES 99.9% OF GROW HOUSE ODORS*	Low Odor Threshold (ppb)
Mercaptans		✓	0.0001
Sulfides		✓	0.04
Aldehydes		✓	0.3
Fatty Acids	✓	✓	0.4
Terpenes	✓	✓	1.8
Aromatic Compounds	✓	✓	2
Ketones		✓	2.1
Alcohols		✓	100
Halogen Compounds	✓	✓	500

Detectable by human nose

All Grow House Gases							
Gas	Concentration (ppb)						
	Grow Room 1	Grow Room 2	Pre Pack	Grow Room 2	Deflower Room	Curing Room	Storage Room
Aromatic Compounds							
Benzene	12	1.9	1.8	2	1.5	2.3	0.99
Toluene	25	4.4	9.4	17	14	22	5.3
Xylene	7.4	2.1	1.9	5	6.1	2.6	1
Halogen Compounds							
1,1-dichloroethane	0.1	21	264	43	173	25	652
Hydrocarbons							
Butane	314	111	57	137	16	122	5.1
Acetone	191	50	38	201	257	41	42
HFC-152a	481	51	38	43	172	25	652
Methyl-Pentane	197	84	16	6.2	1.5	0.062	0.95
Isopropyl Alcohol	3.6	0.1	0.1	1044	8214	329	1850
Oxygen & Nitrogen Compounds							
Ethanol	477	110	169	108	759	94	104
Acetone	185	125	344	201	257	41	42
Isopropyl Alcohol	551	771	1054	1044	8214	329	1850
3-Methyl-Butanone	8.9	2.4	36	3.3	444	2.3	4.5
Methyl Ethyl Ketone	2.4	3.0	1.2	0.1	0.33	0.53	0.13
Ethyl Acetate	6.2	2.5	0.2	2.4	2	3.9	0.1
2-Methyl-1-Hexonal	14	7.7	7.8	1.1	94.1	0.99	11
Aldehydes							
Acetaldehyde	2.2	0.6	0.2	2.3	40	54	26
3-Methyl Butanal	0.2	3	6.8	0.1	0.1	0.9	
Hexanal	2.9	14	19	1.8	2.2	0.9	2.3
Fatty Acids							
Acetic Acid	353	73	342	41	161	64	32
Propionic Acid	39	11	48	5.2	7.5	10	5.4
Butanoic Acid	24	1.2	0.2	1.56	2.66	1.85	0.99
3-Methyl-Butanoic Acid	103	3.2	9.4	0.11	1.6	0.1	0.29
M-Hexanoic Acid	0.1	1.5	7.4	0.1	1.5	0.12	0.07
Hexanoic Acid	2.3	0.3	0.2	0.1	1.5	0.12	0.07
Decanoic Acid	0.5	0.1	0.7	0.12	1.3	0.78	
Dodecanoic Acid	0.3	0.2	4.8	0.1	0.98	1.9	1.2
Tetradecanoic Acid	0.1	0.2	3.7	0.46	0.1	2.9	0.17
Terpenes & Fragrance Compounds							
Alpha-Pinene	0.8	8.3	7.5	7	2.8	2.8	22
Beta-Myrcene	0.7	87	85	147	3270	17	25
Limonene	1.6	38	49	2.23	176	3	2.2
Gamma-Ocimene	96	13	7	1	5.4	0.16	0.62


SPHINX™
GROW HOUSE AIR FILTRATION

Custom Impregnation for Cannabis Odors



SPHINX engineered media:

- ✓ +25% extended life over carbon
- ✓ Complete removal of all odorous gases

QUESTIONS

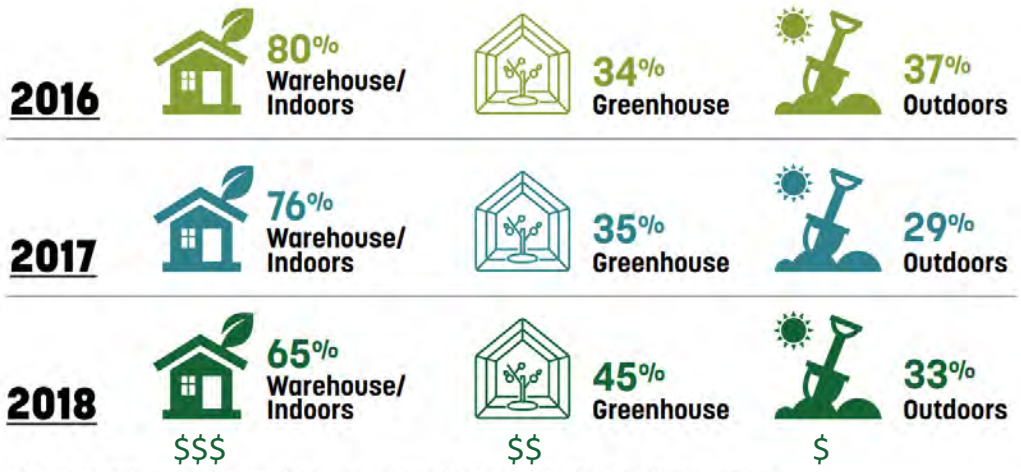
Focus on odor control for new facility construction vs. retrofitting green houses
Shifting governance of odor control and types of technologies
Importance of air flow management for control of powdery mildew
Limitations of basic activated carbon for odor control in grow facilities
Complexities of odor gases emitted from cannabis
Designing odor control systems to eliminate odor complaints from local communities

Air Filtration and IAQ for Indoor Grow Facilities Ultraviolet Germidical Technology

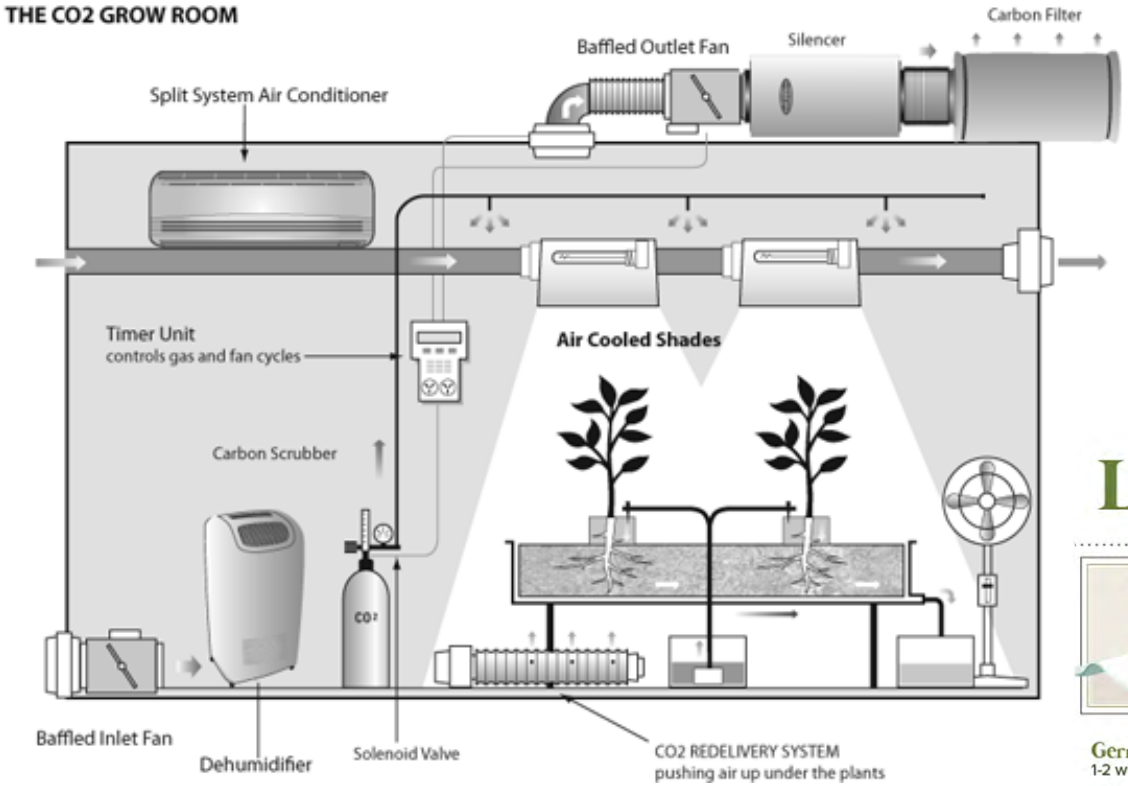
Benoit Despatis, P.Eng M.A.Sc.
Chief Technology Officer – Sanuvox Technologies

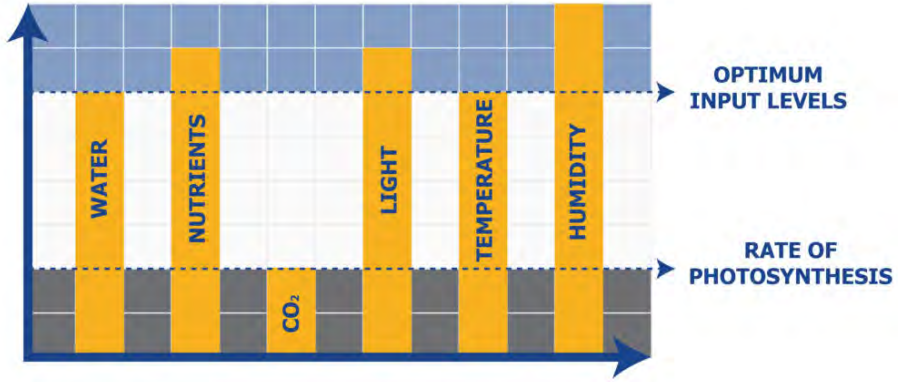
1. Cannabis, Marijuana Basic Knowledge
2. Challenges with Outside Air
3. Terpenes and Oxidation
4. UVC Germicidal Technology

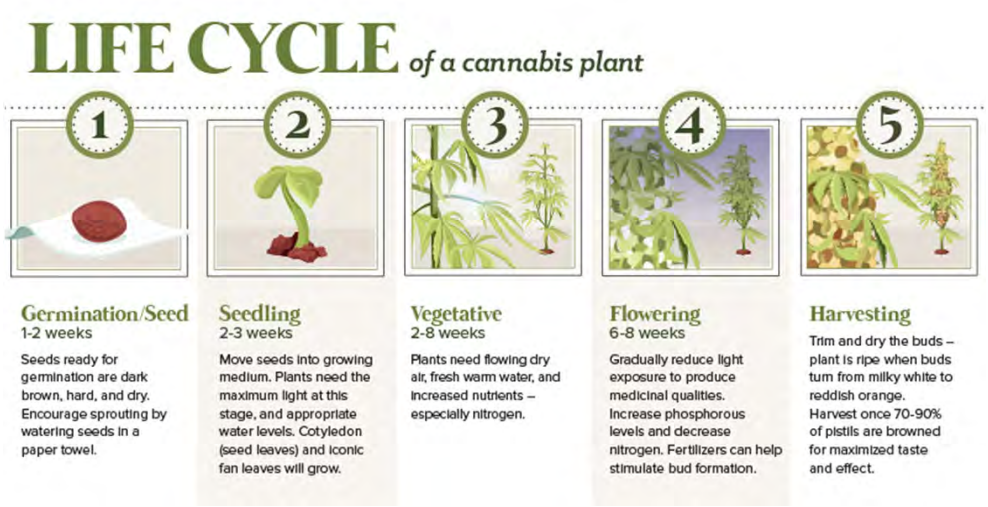

THC
CBD

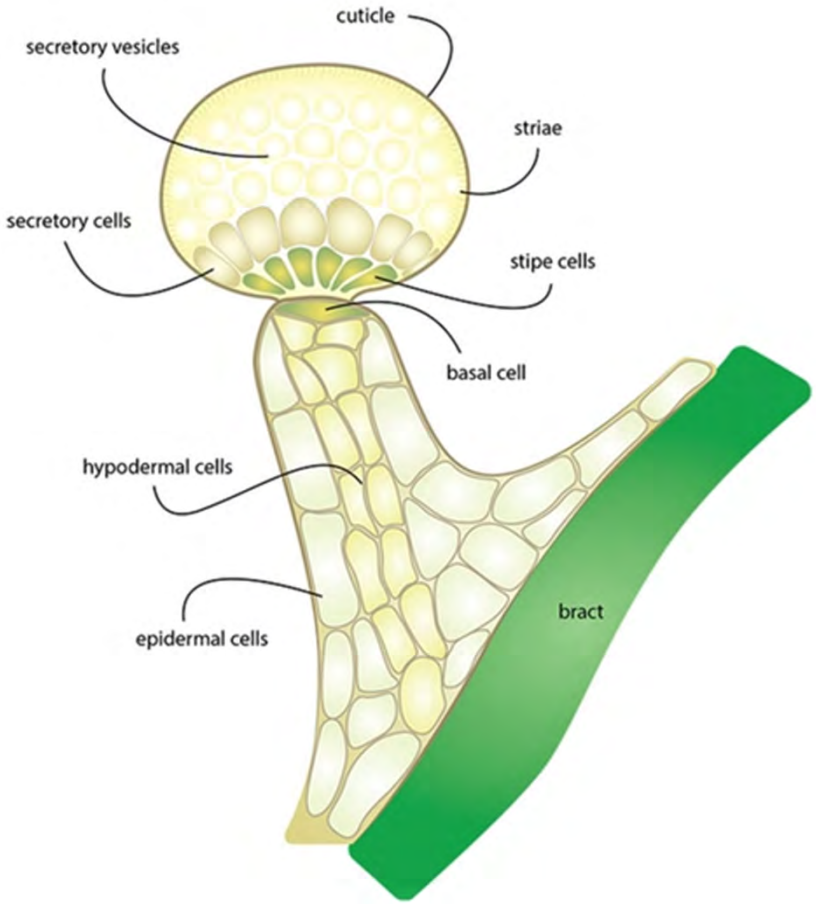


*Note: Totals exceed 100% because respondents could select multiple answers.


THE CO2 GROW ROOM
Carbon Filter
Baffled Outlet Fan
Silencer
Split System Air Conditioner
Timer Unit
controls gas and fan cycles
Air Cooled Shades
Carbon Scrubber
CO2
Baffled Inlet Fan
Dehumidifier
Solenoid Valve
CO2 REDELIVERY SYSTEM
pushing air up under the plants


WATER
NUTRIENTS
CO2
LIGHT
TEMPERATURE
HUMIDITY
OPTIMUM
INPUT LEVELS
RATE OF
PHOTOSYNTHESIS

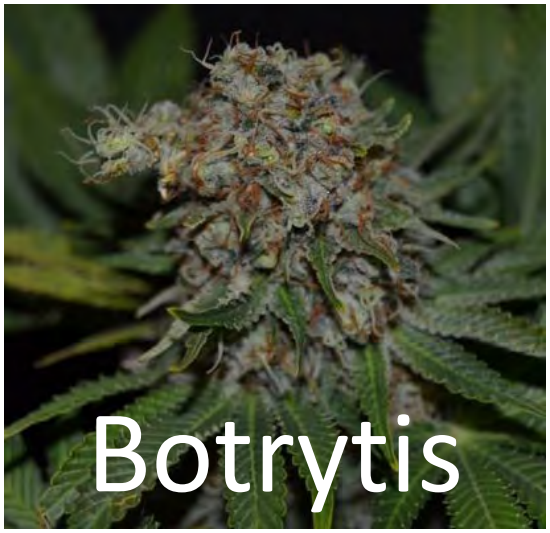

LIFE CYCLE of a cannabis plant
1
Germination/Seed
1-2 weeks
Seeds ready for germination are dark brown, hard, and dry. Encourage sprouting by watering seeds in a paper towel.
2
Seedling
2-3 weeks
Move seeds into growing medium. Plants need the maximum light at this stage, and appropriate water levels. Cotyledon (seed leaves) and iconic fan leaves will grow.
3
Vegetative
2-8 weeks
Plants need flowing dry air, fresh warm water, and increased nutrients – especially nitrogen.
4
Flowering
6-8 weeks
Gradually reduce light exposure to produce medicinal qualities. Increase phosphorous levels and decrease nitrogen. Fertilizers can help stimulate bud formation.
5
Harvesting
Trim and dry the buds – plant is ripe when buds turn from milky white to reddish orange. Harvest once 70-90% of pistils are browned for maximized taste and effect.

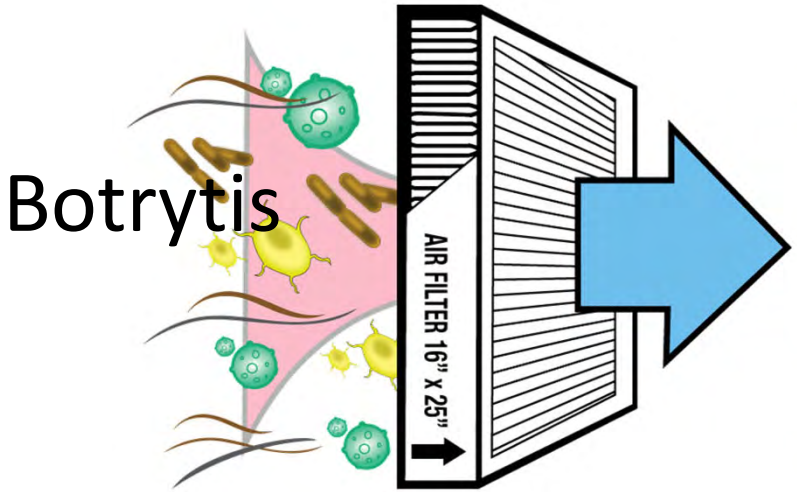

cuticle
secretory vesicles
striae
secretory cells
stipe cells
basal cell
hypodermal cells
bract
epidermal cells

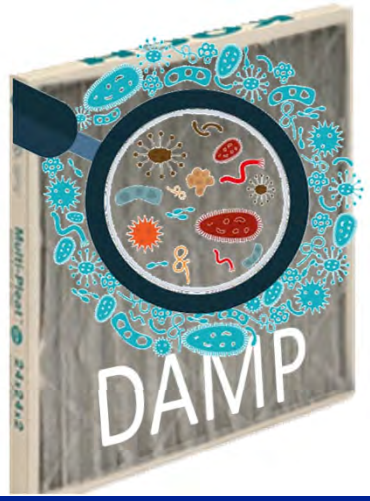

Trichomes
frost-like resin glands on the flowers and leaves that contain the active chemical compounds in cannabis
Cola
primary location at the top of the plant where the flower bud will start to form. Some refer to this as the "bud site."
Calyx
protective base holding up the flowering bud
Pistil
tiny colored hairs that grow from the calyx and are meant to collect pollen from male plants for reproductive purposes.
Nodes
connecting points on a stem of a plant where leaves grow
Fan leaves
The major function of fan leaves are to transfer light energy into chemical energy for the plant through the process of photosynthesis.
Stem
Provide the skeleton and support structure for all plant growth. They are also vital to transporting and storing fluids and nutrients from the roots to the rest of the plant.
FEMALE CANNABIS PLANT

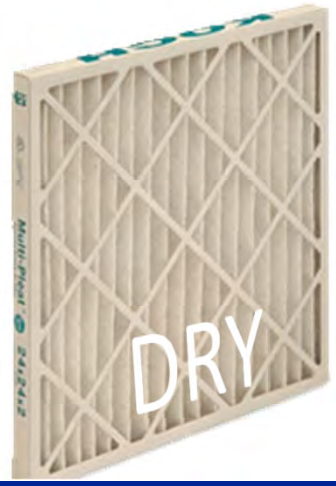
Others bacterias

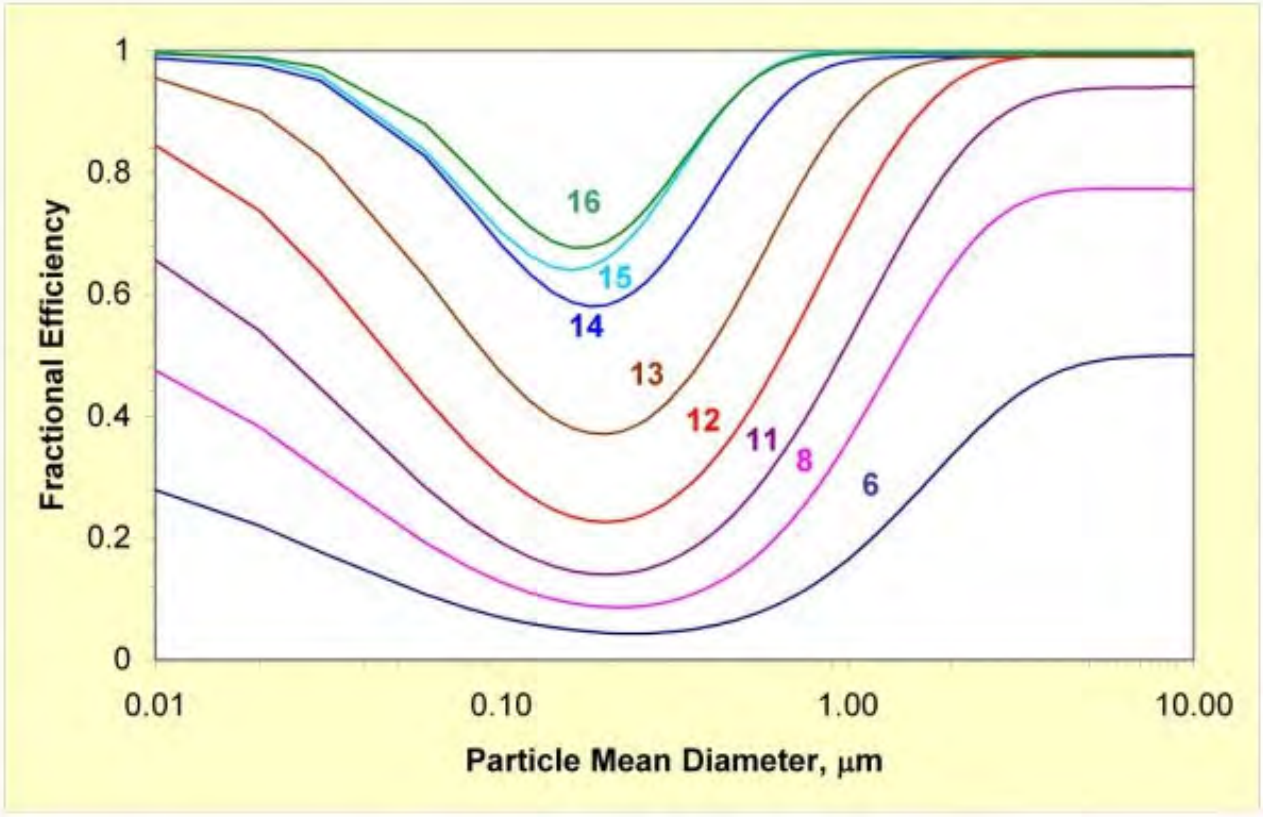
- E.Coli
- Salmonella
- Listeria



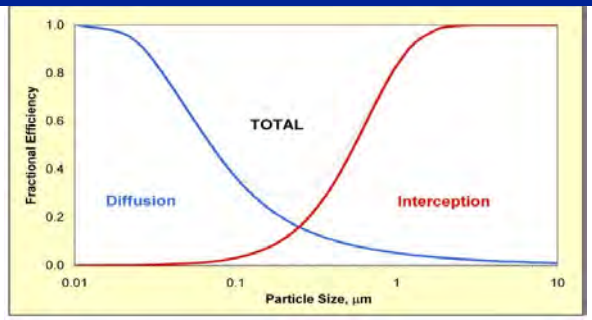


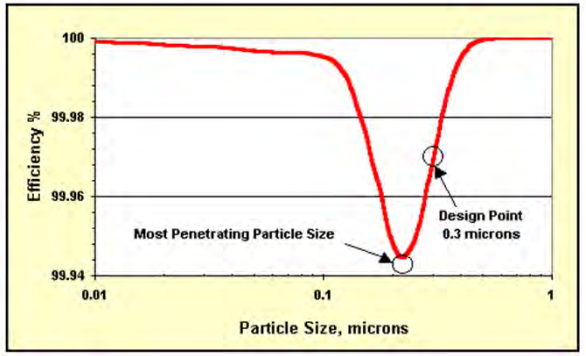


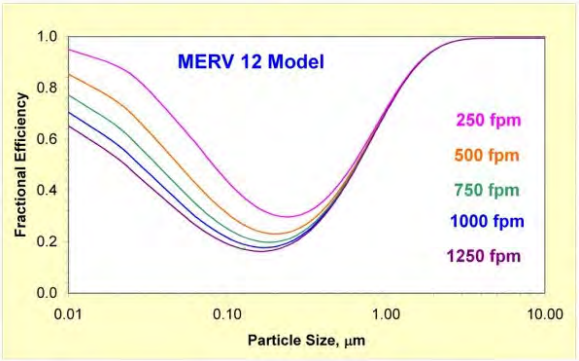




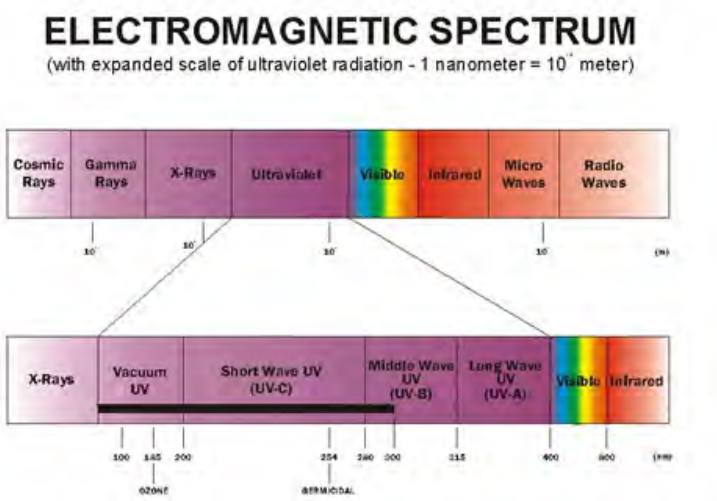
NAFA | National Air Filtration Association





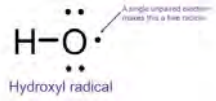


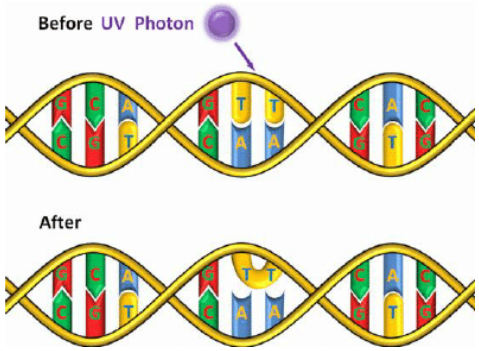
Corona Discharge



Oxidant

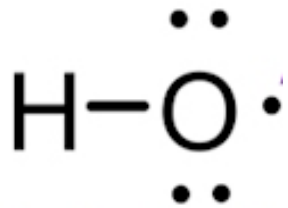
Free Radical, (-OH)
Ozone atom (O)
Ozone, (O3)
Hydrogen Peroxide, (H2O2)
Potassium Permanganate, (KMnO4)
Chlorine Dioxide, (ClO2)





MOST COMMON TERPENES IN CANNABIS

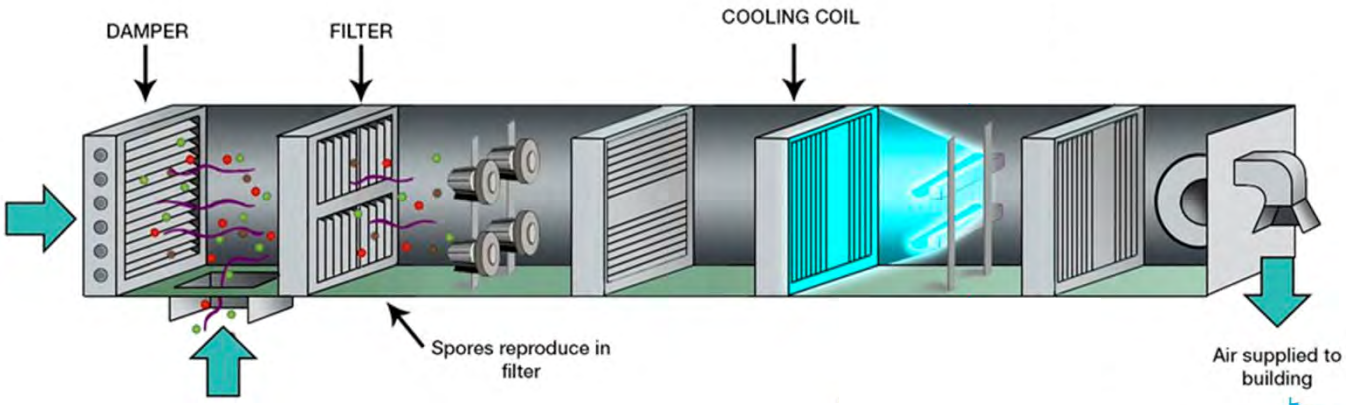
	MYRCENE	*LIMONENE*	*CARYOPHYLLENE*	*LINALOOL*	*A-PINENE*
AROMA	earthy cloves herbal	citrus lemon orange	pepper wood spicy	floral sweet citrus	pine wood mountain air
EFFECTS	analgesic anti-inflammatory antipsychotic antispasmodic hypnotic muscle relaxant sedative	antidepressant antifungal antimicrobial antispasmodic anxiolytic gastroprotective immunostimulant	anti-inflammatory analgesic protects digestive tract cell lining anti-depressant anti-septic	analgesic anticonvulsant antiepileptic antineoplastic antipsychotic anxiolitic sedative	anti-inflammatory gastroprotective energy booster bronchodilator aids memory anti-bacterial
ALSO FOUND IN					
	hops fresh mango lemongrass	citrus fruit rinds juniper peppermint	black pepper Thai basil cloves	lavender laurel mints	pine needles orange peel parsley



Hydroxyl Radical

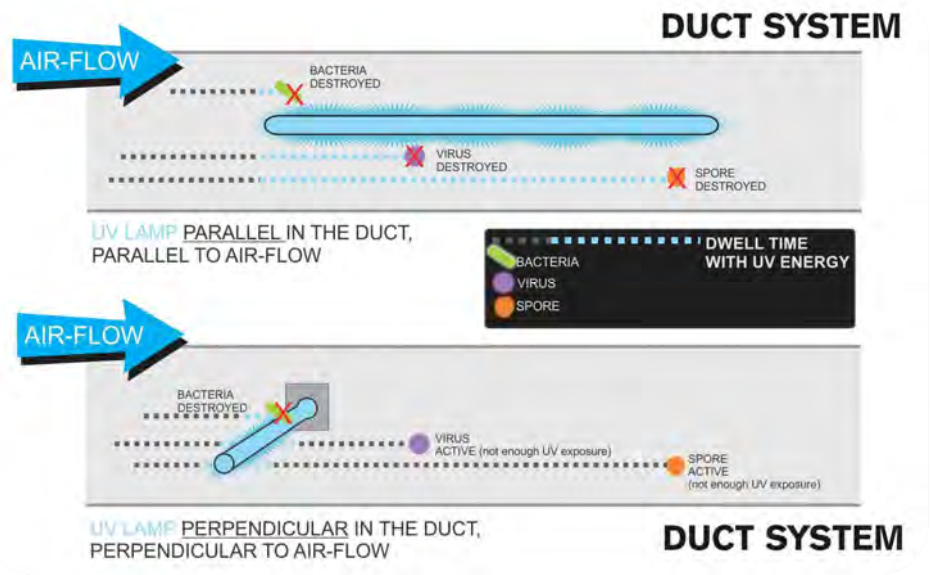
Terpenes

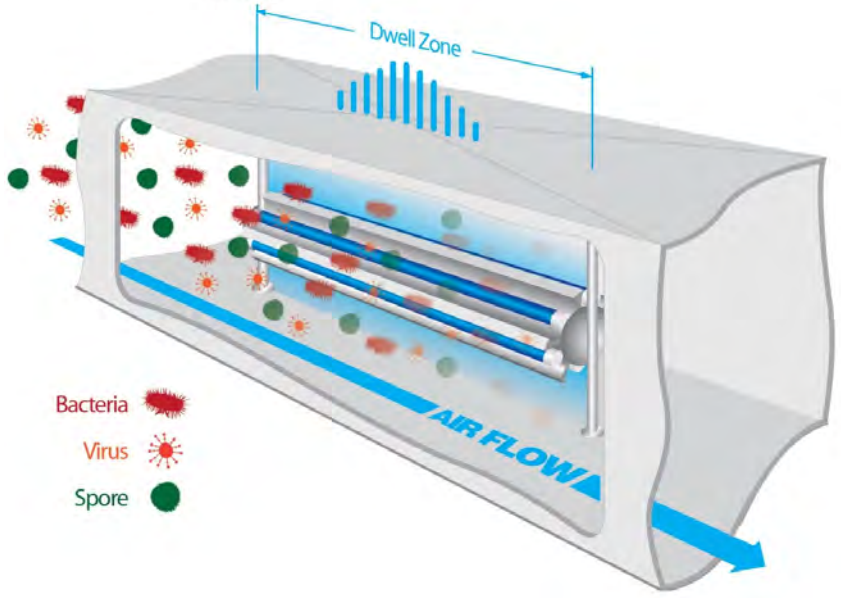
- Odors Reduction
- Terpenes Alteration



UV Dosage = Intensity x Time
(mWs/cm²) (mW/cm²) (sec)
(mJ/cm²)

(Btu/ft2) (Btu/h·ft2) [Imperial System]





Conclusion

- Indoor Marijuana will provide a higher purity and conform product
- Challenges Indoor for Plan Diseases can be address with UVC Germicidal Technology
- Oxidation inside Grow Room will alter Terpenes
- Unproper sizing can be detrimental to your harvest (too late if you get infected)

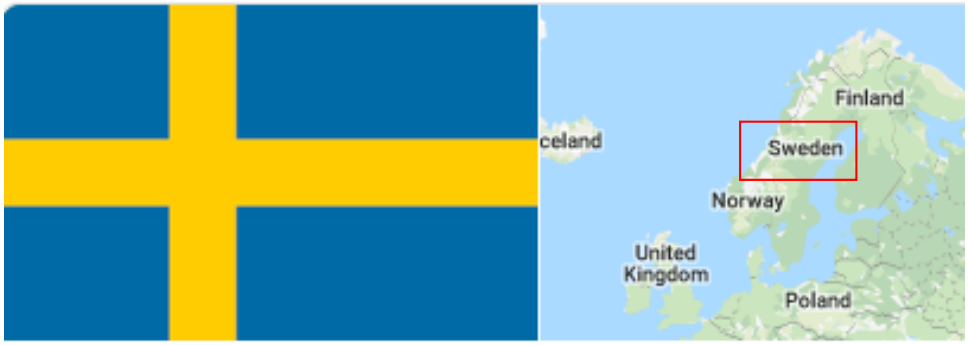
References

- Esteves, S., Varghese, A., Worrilow, K., & Brais, N. (2017). *Clean Room Technology in ART Clinics.*
- Latorre, B., Rojas, S., Díaz, G., & Chuaqui, H. (2012). *Germicidal effect of UV light on epiphytic fungi isolated from blueberry.* Ciencia E Investigación Agraria, 39(3), 473-480.
- Kowalski, W. (2014). *Ultraviolet Germicidal Irradiation Handbook.* Berlin: Springer Berlin.
- Nigro, Franco & Ippolito, Antonio & Lattanzio, Vincenzo & Di Venere, D & Salerno, M. (2000). *Effect of ultraviolet-C light on postharvest decay of strawberry.* Journal of Plant Pathology. 82. 29-37.
- Rosenthal, E. (2010). *Ed Rosenthal's marijuana grower's handbook.* Oakland, Calif.: Quick American Pub.

Best Practices for Odour Control

Victor Rengel, Product Manager, Molecular Filtration, Camfil

ABOUT CAMFIL



- Clean Air SolutionS
- Started in 1963 in Sweden
- 26+ manufacturing and R&D facilities
- **www.camfil.com**

camfil

VISION: CLEAN AIR, A HUMAN RIGHT

5.1.4.2 Air filtration

As per s. 85 of the Cannabis Regulations, the building or part of the building where cannabis is produced, packaged, labelled and stored must be equipped with a system that filters air to prevent the escape of odours. All conditions under which activities with cannabis are being conducted should maintain the quality of the cannabis.

Source: Health Canada / Production practices / Guidance document

Maintenance program

- *Ventilation and air filtration is maintained in accordance with a schedule*
- *Maintenance operations are carried out in a manner that does not present any risk to the quality of the cannabis.*
- *The presence of odours surrounding the facility is monitored in accordance to a schedule and responded to if necessary*
- *Inspection and repair activities occur when required*

Source: Health Canada / Production practices / Guidance document

INDOOR GROW FACILITIES: AIR FILTRATION PRIMARY GOALS

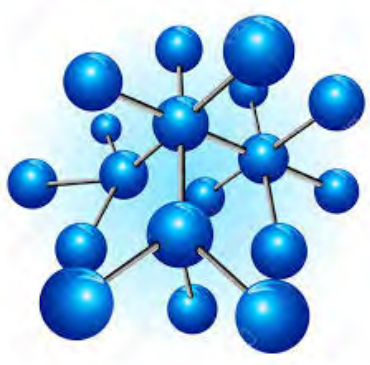
1- Achieve effective odour control. Key areas:

- ✓ Production
- ✓ Packaging
- ✓ Labelling
- ✓ Storage

2- Maintain the quality of the product

3- Create and follow a maintenance program (air filtration is maintained in accordance with a schedule)

INDOOR GROWING: UNDERSTANDING THE APPLICATION



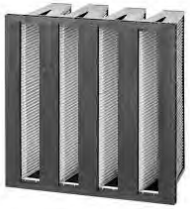
Why do we need **molecular** filtration?

- Source of odours: Terpenes as alpha-pinene, beta-pinene, beta myrcene, beta-caryophyllene and limonene
- In this application odours are produced by gas-phase contaminants (molecules)
- Molecules are 1,000 to 10,000 times smaller than particles than can be removed by HEPA filtration

1- EFFECTIVE ODOUR CONTROL

- ✓ Location of air filtration system
- ✓ Type of filter
- ✓ Quantity



<u>Most</u> important: use the right adsorbent




inimum

ffic ie nc y

eporting

alue

MERV

52.2-2012

"Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size,"

Air Filter Testing Standards Comparison									
ASHRAE Standard 52.2-2007B					EN 779 2012			ASHRAE 52.1-1992 (obsolete)	EN 779 2002 (obsolete)
Minimum Efficiency Reporting Value	Composite Average Particle Size Efficiency, % in Size Range, microns			Average Arrestance	Average Efficiency at 0.4 micron[1]	Group	Class	Average Dust Spot Efficiency	Class
	Range 1	Range 2	Range 3						
MERV	0.30 - 1.0	1.0 - 3.0	3.0 - 10.0	%	%			%	
1	n/a	n/a	E_3 < 20	A_{avg} ≥ 65	A<65	Coarse	G1	< 20	G1
2	n/a	n/a	E_3 < 20	A_{avg} ≥ 65	65< A ≤80		G2	< 20	G2
3	n/a	n/a	E_3 < 20	A_{avg} ≥ 70				< 20	
4	n/a	n/a	E_3 < 20	A_{avg} ≥ 75				< 20	
5	n/a	n/a	E_3 ≥ 20	80	80< A ≤90		G3	20	G3
6	n/a	n/a	E_3 ≥ 35	85				20-25	
7	n/a	n/a	E_3 ≥ 50	90	90< A		G4	25-30	G4
8	n/a	n/a	E_3 ≥ 70	92				30-35	
9	n/a	n/a	E_3 ≥ 85	95	40< E ≤60	Medium	M5	40-45	F5
10	n/a	E_2 ≥ 50	E_3 ≥ 85	96				50-55	
11	n/a	E_2 ≥ 65	E_3 ≥ 85	97	0< E ≤80		M6	60-65	F6
12	n/a	E_2 ≥ 80	E_3 ≥ 90	98				70-75	
13	n/a	E_2 ≥ 90	E_3 ≥ 90	98	F7 80< E ≤90	Fine	F7	80-85	F7
14	E_1 ≥ 75	E_2 ≥ 90	E_3 ≥ 90	99	F8 90< E ≤95		F8	90-95	F8
15	E_1 ≥ 85	E_2 ≥ 90	E_3 ≥ 90	99	F9 95< E		F9	95	F9
16	E_1 ≥ 95	E_2 ≥ 95	E_3 ≥ 95	100	H10	n/a	n/a	99	n/a

Notes:
The final MERV value is the highest MERV where the filter data meets all requirements of that MERV.
The characteristics of atmospheric dust vary widely in comparison with those of synthetic dust used in the tests. Because of this the test results do not provide a basis for predicting either operational performance or life. Loss of media charge or shedding of particles or fibers can also adversely affect efficiency.
[1] Minimum efficiency is the lowest efficiency among the initial efficiencies, discharged efficiency and the lowest efficiency throughout the test procedure.

STANDARDS RELATED TO MOLECULAR FILTRATION PERFORMANCE

ISO 10121: 2014

Test method for assessing the performance of gas-phase air cleaning media and devices for general ventilation, Parts 1 and 2.

- *Media and full size filter testing, application realistic concentrations, many different challenge gases.*

ASHRAE 145: 2015

Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Loose Granular Media, Parts 1 and 2.

- *Media and full size filter testing, application realistic concentrations, many different challenge gases.*

ASTM D6646 (2014)

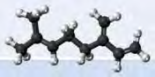
Standard Test Method for Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon

- Media only testing, artificial test conditions (highly accelerated)
- Not representative of real-world conditions.

TEST PARAMETERS

Temperature	70 °F (23 °C)
Relative humidity	50 %
Residence time	0.1 s

CONTAMINANT

Parameter	Chemical preperties
Substance	Beta-myrcene
Molecule	
Mol.Formula	$C_{10}H_{16}$
Cas No	123-35-3
Mol weight [g/mol]	136.24
Boiling point [^{o}C]	166-168
Vapor pressure @ 23^{o}C [kPa]	0.251
Refractive index	1.471
Density [g/cm^{3}]	0.794
Saturated air @ 23^{o}C [ppm]	2477
Odor threshhold [ppb]	13

Sources:
Prevent – Chemical substances database
NIST – Chemistry webbook

Gas	Odor thresholds
β-Myrcene	13 ppb
α-Pinene	18 ppb
Limonene	38 ppb
B-Pinene	33 ppb

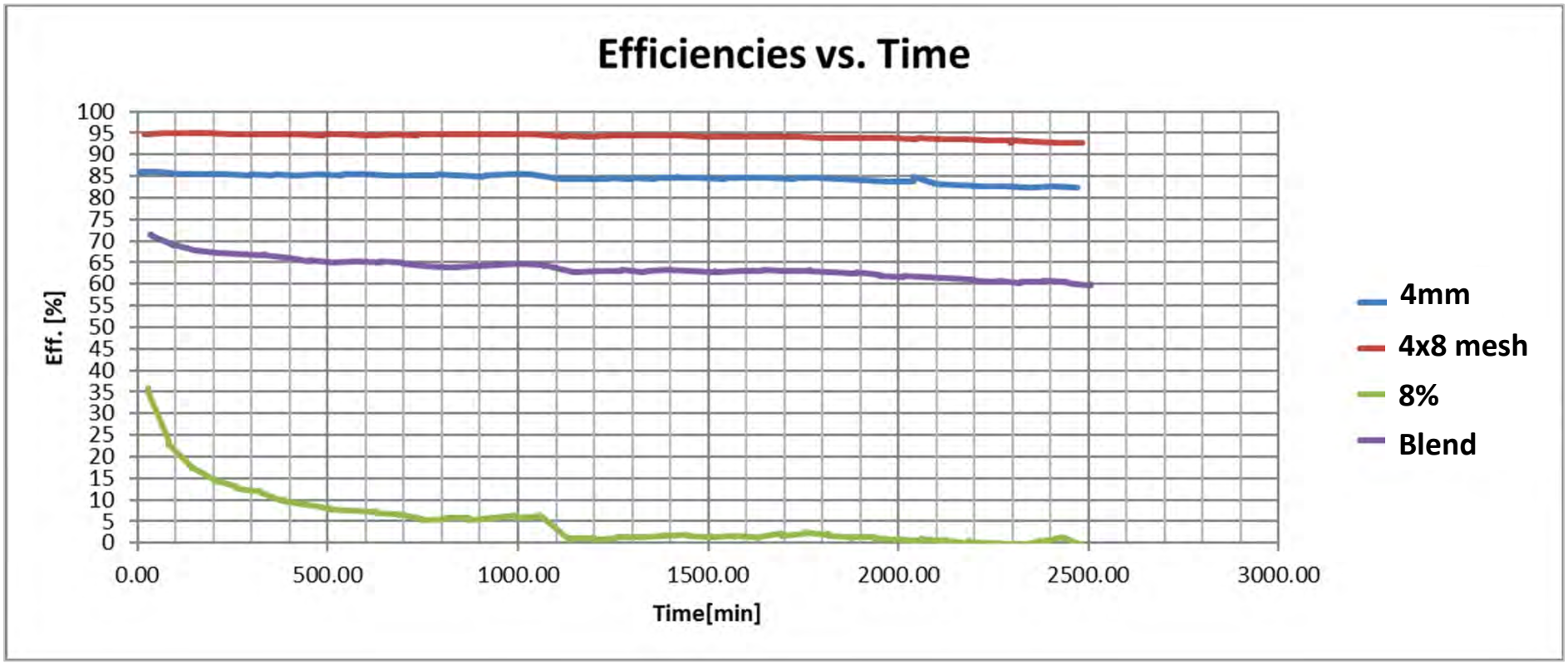
	4x8 Mesh Activated Carbon	4mm Activated Carbon	8% Potassium Permanganate	Blend: Carbon + 8% Potassium Permanganate
Base material	Coconut shell	Coal	Alumina oxide + $KMnO_4$	
CTC [%]***	62	68	2	
Micro pore volume [cm3/g]*	0.39	0.42	0.014	
Micro pore volume [cm3/g]**	0.38	-	-	
Particle size [us.mesh]	4x8	-	-	
Particle size [mm]	-	4	3-5	




- Calculated from adsorption at Toluene saturated air

** Calculated from adsorption Beta-Myrcene saturated air

** Mesured with Toluene and recalculted into CTC


Efficiencies vs. Time
Eff. [%]
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0.00
500.00
1000.00
1500.00
2000.00
2500.00
3000.00
Time[min]
4mm
4x8 mesh
8%
Blend

KEY FINDINGS

1- There is no need to use several types of media in order to achieve effective odour control in indoor growing facilities. Activated carbon is the best adsorbent for odour control caused by terpenes

2- **Coconut shell activated carbon** offers the highest molecular filtration efficiency for a longer period of time. Coconut shell activated carbon is also called granular activated carbon

AIR FILTRATION PRIMARY GOALS

1- Effective odour control

2- Maintain the quality of the product

3- Create and follow a maintenance program (air filtration is maintained in accordance with a schedule)

MAINTENANCE OF MOLECULAR FILTERS IN ACCORDANCE TO A SCHEDULE (cont.)

- Use molecular filtration lab services

Granular activated carbon (coconut shell)

1) End User: Collects a sample of media (carbon) or provides a filter that has been used

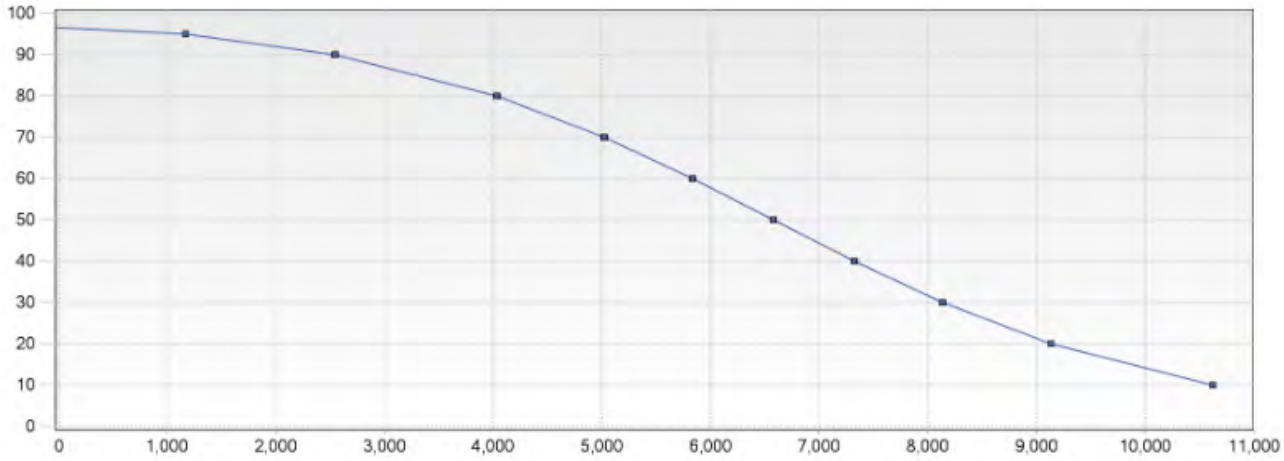
2) Laboratory: Receives the sample and performs the test. The existing condition of the media will be compared to the initial condition in order to estimate the remaining lifetime

GOAL: Make educated decisions and create a maintenance program

MAINTENANCE OF MOLECULAR FILTERS IN ACCORDANCE TO A SCHEDULE (cont.)

- Use other tools (molecular filter lifetime determination software)

Efficiency,[%]	Life Time Hours,[hours]
95	1165
90	2539
80	4030
70	5021
60	5833
50	6579
40	7324
30	8137
20	9128
10	10619



CURRENTLY RESEARCHING

- Powdery mildew

- Trim space allergens

- Phytotoxic gases

Stay Current on Molecular Filtration

Victor.Rengel@camfil.com

Questions?