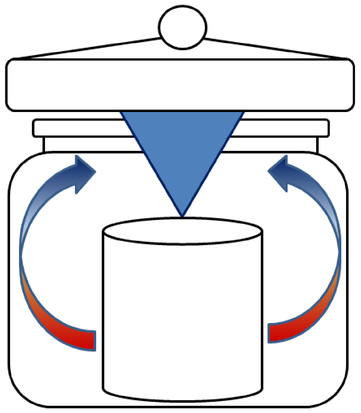
ESSENTIAL OIL EXTRACTION PROJECT

Microwave Oil Extraction in 6 Minutes or Less.



Introduction

All plants have some essential oils. These oils are produced to perform some biologically important process. An example is the essential oils that are in cells of the Peppermint Plant leaves. Primarily, Menthol and derivatives (see structures) are used to combat insect invasions! Similarly, fragrances to attract pollinators, herbicides and fungicides are components of essential oils. An example of the oil reservoirs on a peppermint leaf are in the SEM images. We are exploring the extraction of these essential oils by a steam distillation process in a common microwave oven.

We are seeking to learn which botanical materials yield essential oils using this simple device.

Dry Ice Condensing Unit

Due to the properties of water we can only condense a fixed amount of vapor from the plants. Students in the lab began looking into new condensing materials and discovered the non-polar proprieties and low temperatures of dry ice would allow for much more vapor condensing. Through trial and error in innovative design we created a new condensing unit which allowed for longer runs.

It was also believed to have beneficial impact on extracting smaller molecules due to increased exposure to microwave energy. Trials and GC testing is still underway to determine the results of this hypothesis.

HP 5890 GC with FID Detector

Background:

The OilExTech EssEx100 reactor uses microwave energy to complete steam distillation and extract essential oil compounds from botanicals. The students working in David Hackleman's lab use these reactors to conduct experiments and learn to apply the principals of mass and heat transfer in a innovative setting.

The Basics:

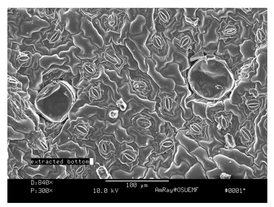
- Reactor assembled (ice core pre-frozen)
- Specified botanical material added to inside portion of reactor.
- Place into microwave for 4-6 minutes
- Allow cooling (Usually 2 minutes)
- Separate Oil and hydrosol and place into UV protected Vial.

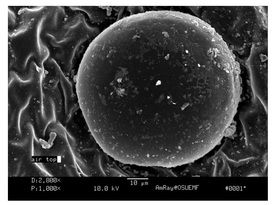
Engineering Principles at Play:

During the design and execution of experiments students must analyze the mass and heat transfer properties of the system. Specifically, the mass of steam that will be condensed and how much ice will be needed to acquire optimal results.

Specific Details:

- Energy transfer into plant material
- Mass flow rate of hot vapor to condensing liquid (arrows in diagram)
- Overall heat transfer coefficient at the vapor solid barrier.
- **ENERGY AND MASS BALANCES**
- Discrepancies between initial mass of reactor and final. Unknown mass transfer out of system.





pictures above: PEPPERMINT LEAF SEM – OIL CONTAINING CELLS ON TOP OF LEAF

Funds for this project were provided by a "Senior Scientist/Mentor" grant to Dr. David Hackleman from:

The Camille & Henry Dreyfus Foundation, Inc.

The Projects and results:

- Lavender:

Lavender oil has a light clear yellow color; the portion of the plant that is used to extract oil is from the flower buds. For best results remove stem from flow (only use small flower portions). Lab results show 100 grams of fresh lavender can yield around 1-3 mL of essential oil. We recommend running the reactor for roughly 5.5 minutes. Research into specific lavender scents are needed for desired smells and yields.

- Oregano:

Oregano oil has a light yellow color; the part used to extract the oil is dried plant or the flowering tops. The lab result shows that every 100 grams of dry plant material can yield around 1mm oil, which means the yield percentage is around 1%. The duration time in the Microwave reactor is around five minutes and for every 100 grams of dry Oregano, need to put around 30ml water to help the extraction.

- Orange

Orange is one of the plant materials that has a big yield percentage: Every 60 grams of plant material can be used to extract around 3~5 ml essential oil.

The duration time of Orange material is around 5.5 minutes , the part use to extract essential oil is Orange peels.

Different kind of Orange will have different of yield percentage.

- Mint

Mint family, especially peppermint, contains a lot of chemical compound that people have great interested in like Menthol and Menthone. The whole plant can be used to extract the essential oil except the root before flowering. The yield percentage of mint is around 1% for every 100 grams of plant material.

- GC machine (Gas chromatography):

Several members of the extraction team have been analyzing oil samples with GC Units. Unfortunately, only a small fraction have been analyzed thus far due to repair. Dr. Hackleman and several members have been working to repair the HP 5890 GC. This process has taught students how the devices operate through every portion of the machine.

Vernier® Mini-GC+

Why Essential Oils?

Essential oils have a wide use on pharmacy, cooking, massage and so on.

- **Oregano oil**:

The major components in the Oregano are Carvacrol, Thymol, Terpiene, Cymene and Menthene. Oregano oil can be used on respiration infection, bronchitis, rheumatism, arthritis, general debility, muscular pain, infections, cold and flu.

- **Lavender oil:**

Lavender oil contains Linaly Acetate, Linalool, Geraniol, Borneol, Isoborneol.

Lavender oil has great effect on curing headache, DIMS and it can be used on children safely.

- **Orange oil:**

Orange oil contains D-limonene, N-Decylic Aldehyde, Linalool, Terpineol, B-Carotin.

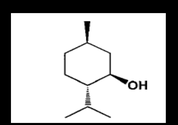
The Most common uses on Orange are for Diuretic, overindulgence, shin care, antiseptic, nervous anxiety, Disinfectant and general body tonic.

Most importantly, In the oil extension lab, Orange always used as the "basic" plant material to show the new members how the reactor works and Orange oil can be used as an "green" cleaner to clean some of the devices in the lab.

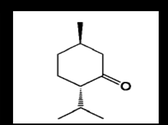
- **Mint oil:**

Mint contains Menthol, Menthone, Iso Menthone, Menthofuran and Menthol Ester.

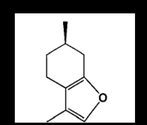
Mint oil can be used in headache, cough, mouth or gum infection, travel sickness, faintness, muscular pain, and digestive problems.



Menthol



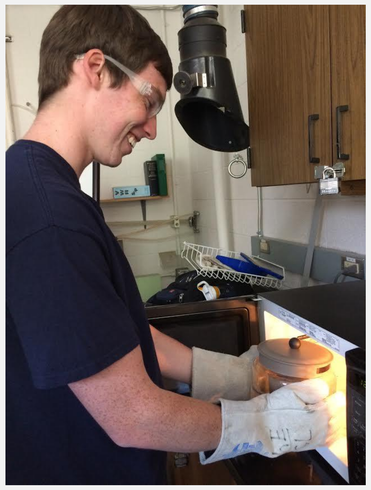
Menthone



Menthofuran

Oregon State University

Student Researchers



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Meet our team:

(Dr.) David Hackleman (The Research Advisor): PhD Chemistry, BS EECS.

After retiring from HP (2002) and from the Linus Pauling Chair in ChE (2007), I have remained on campus to enable self-motivated students the opportunity to work on projects related to sustainability in ChE, Chemistry, EECS and Physics. I am also a co-sponsor of the student group "The Sustainable Energy Initiative". I also serve as a UHC and Graduate school project and thesis advisor.

Xinhui Yu:

I am a sophomore in Biological engineering. I have great interest in Botany and chemistry because I have been learning traditional herb study in my country, so I came to Dr.Hackleman's research lab. I did a lot research on Oregano, rosemary and Orange in the lab.

From the day I joined the oil extraction group I wan to know how the reactions worked in a intermolecular way, and what can I did to make it easier and more affective to those plant materials.

So in future I decide to work more on how to increase the yield percentage of the essential oil from the Microwave reactor.

Michael Silvey:

I am a Senior in Bioengineering and have been working with the team for nearly a year and a half now. I began working for Dr. Hackleman looking for experience in areas applying the engineering principles, learned in class, to innovation. Throughout my time on the team I have worked on dozens of plants and developed a new condensing technique that is still undergoing testing. Overall, I have enjoyed the freedom our professor gives us to use innovation. He constantly pushes us to think outside of the box to solve complex problems and provides guidance without giving solutions.

MaLi Dong

I am a Junior in Bioengineering and just began my work with essential oils this term, Spring 2015. The first few weeks, I assisted with the experience of coastal redwood and learned how to run gas chromatography with several oil samples.
I first became involved when my advisor suggested Dr. Hackleman's lab as a possible resource for experience in lab work. As essential oils are a big part of everyday life, I became very interested in the process of extracting the oils through steam distillation.

Zhichun Zheng:

My name is Zhichun Zheng. I am Majoring in chemical engineering and biological engineering. I joined the essential oil extraction team at 2014. This opportunity allows me to learn about different extraction techniques and the chemistries within essential oils. Also from doing research, I learnt to analyze data and optimize microwave extraction process based on acquired data.

Brenden Fraser-Hevlin:

My name is Brenden Fraser-Hevlin. I am a junior majoring in bioengineering. I chose to join the essential oil extraction team because I wanted more lab and research experience and I was interested in learning about the extraction and properties of essential oils. In the time I have spent in the lab, I have experimented with the extraction of a number of different botanicals and investigated the effect of changing operating conditions on the extractions. I hope to learn in the future about how to optimize the extraction of oils with antimicrobial properties, and I would also like to examine and compare the properties of these oils using chromatography. I enjoy my time in the lab because it gives me an opportunity to apply my engineering knowledge in a hands-on, collaborative setting.

Eunbyeol Ko:

Hello, I'm Eunbyeol Ko. I'm a sophomore in Chemical Engineering. The reason I choose to be in this team is that I'm interested in the oil from plants. From the lab, I learn that to exact oil, we need lots of botanical. Also, I was working on the hibiscus oil, but it is soluble in water, so I had to find another way to extract oil from hibiscus. In addition, I learned that the orange oil from orange zest has much higher yield than just orange peel.

Eric Manning:

I am a junior studying biological engineering at Oregon State University. I find botany fascinating, and this project allows me to apply my engineering knowledge to botany. For most of the time I've spent working with this device, I've been studying and working with coastal redwood leaves and incense cedar leaves. Neither of these botanical materials have yielded much oil when run under standard conditions. Many of their components are semi-soluble in water, so this could be a factor in the low oil yields and is currently an area of my research.

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