

Synthesis of Oil of Wintergreen

Author: Frank La Gatta
 Date Created: August 1, 2007
 Subject: Chemistry
 Level: Honors Regents – tenth grade
 Standards: Isomers of organic compounds have the same molecular formula, but different structures and properties
 Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are types of organic compounds that differ in their structures
 Functional groups impart distinctive physical and chemical properties to organic compounds
 Real World Connections: types, varieties, uses of organic compounds, organic isomers, odors, cosmetics, dyes
 Skills: classify an organic compound based on its structural or condensed formula
 Draw a structural formula with a functional group(s) on a straight chain hydrocarbon backbone when given the correct IUPAC name for the compound
 Schedule: Lab Activity: 45 minutes
 Cooperative learning activity- two 45 minute periods

Objectives:

To synthesize methyl salicylate by esterification of acetylsalicylic with methanol
 To separate the synthesized methyl salicylate by the extraction technique
 To construct and name organic molecules: mainly isomer structures
 To determine the differences in isomers

Students will:

- Construct various isomer structures by manipulating molecular model kits
- Use the IUPAC system to name isomers
- Classify isomers based on their physical and chemical properties
- Connect real world chemistry to isomers
- Synthesize oil of wintergreen
- Use an extraction technique to remove the product made
- Use quantitative skills to determine the number of moles of salicylic acid and methanol from the number of grams measured in the beginning of the lab
- Determine the limited reagent in the esterification reaction
- Determine the percent yield of product obtained
- Identify the functional groups in the

Vocabulary:

Isomers	Extraction technique
Functional groups	Limited reagent
Esterification	Percent yield

Materials:

For Each Pair:

- molecular model kits (Organic molecule cooperative learning activity)
- two aspirins
- 5 ml of methanol
- 4 drops of concentrated sulfuric acid
- sodium bicarbonate is used until fizzing with salicylic acid stops
- ether use in small quantity
- mortar and pestle
- two scintillation vials
- one pipette
- graduated cylinder
- hot plate

Safety:

Goggles, gloves, apron
 Work under fume hood
 Do not breathe vapors of methanol and ether

<p>reaction</p> <ul style="list-style-type: none"> • Determine the two additional byproducts produced in the synthesis of methyl salicylate • Determine the purpose of the extraction technique in the lab activity 	<p>Handle concentrated sulfuric acid with care - If spilled on your skin wash immediately with plenty of water If safety issues are a concern this lab could easily be used as a teacher demonstration</p>
---	--

Science Content for the Teacher:

Isomers are compounds that have the same molecular formula but different structural formulas; therefore different physical and chemical properties.

IUPAC rules for nomenclature of organic compounds

Esterification reaction- carboxylic acid reacts with an alcohol in the presence of sulfuric acid to produce an ester.

Functional groups and their importance in organic chemistry (OH alcohol, COOH carboxylic acid, COO ester) for the esterification reaction

To be able to find mass and understand the conversion of grams to moles

Limited reagent is the reactant that is used up in the reaction and the other reactant is in excess

Percent yield = actual/ theoretical x 100 %

Extraction is the technique used to obtain your product from the sample

Preparation:

Print student copies for the lab on the synthesis of wintergreen

Set up for the lab (look at materials needed)

Lab set up takes about 30 minutes

Print copies for activity for organic molecules (molecular model kits needed)

Classroom Procedure:**Engage (Time: 45 min.)**

Students will use molecular model kits to construct organic molecules. They will use these models to help them in the nomenclature of organic molecules. Students will use the provided worksheet on organic molecules. This will begin students to observe that various isomers constructed from one given structure have different physical and chemical properties.

Explore (Time: 45 min.)

Lab activity on the production of wintergreen. Students will understand the purpose of functional groups in chemical reactions. Students will once again reinforce nomenclature of organic molecules. Students will determine the purpose of sulfuric acid in the esterification lab. Students will write the esterification reaction for the synthesis of wintergreen.

Explain (Time: 45 min.)

Teacher will explain change of structure ... change of smell (use power point presentation). The discussion will focus on isomers, nomenclature and properties of isomers, interconversion of functional groups, the meaning of oxidation and reduction from the previous unit in Redox and its relationship in chemical reactions in changing structure... changing smell.

Expand (Time)

Discuss real world connections/ odors, flavorings, cosmetics, dyes in Organic Chemistry. Loop information from other concepts taught in previous units: mole conversion that is needed for question 1 in the lab activity. Students will connect the concept of limited reagent with the lab on production of wintergreen (Stoichiometry Unit). Students will connect a neutralization reaction from the unit on Acid and Bases. Catalysts concept from Kinetics unit can be integrated in the use of sulfuric acid. Covalent bonding, the number of bonds carbon can form in a structure to help students logically draw structures. Carbon forms four bonds.

Assessment:

Students are assessed by the written lab reports they hand in and their class participation. Completing the lab activity sheet and related activities accurately also serves as an assessment.

Extension Activities:

Students can choose a particular isomer and draw as many structures possible and discuss their physical and chemical properties.

Supplemental Information:

Advanced students can be exposed to chiral centers and chirality of molecules. Handedness also plays a role in organic chemistry due to the tetrahedral formation of hybridized carbon. Most drugs and most molecules in our bodies are handed. Discuss enantiomers and their properties. One important concept is that different enantiomers of chiral compounds often taste and smell different. This correlates nicely with the power point presentation.

References:

Textbook: *Modern Chemistry*, Holt, 1999 version is a great book for Chemistry Honors. Wikipedia has some valuable information on chirality, and enantiomers, and handedness. *Organic Chemistry*, McMurry, Cornell University

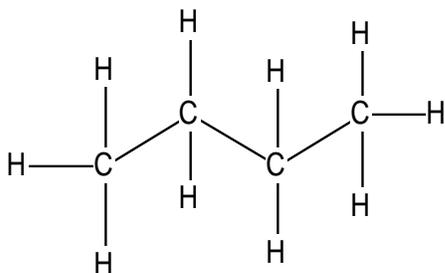


ORGANIC MOLECULES ACTIVITY

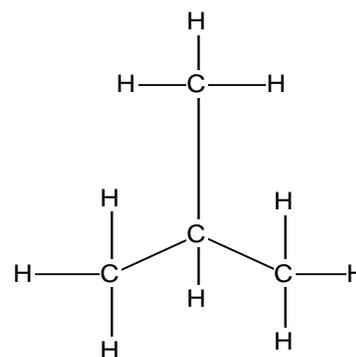
Organic chemistry is the study of carbon and its carbon compounds. The number of organic compounds is vast in nature. Organic molecules are predominantly found in all organisms.

Carbon has the ability to form covalent bonds not only with other kinds of atoms, but also with other carbon atoms. The ability of carbon to form chains, rings, and networks constitutes is responsible for the numerous number of organic compounds. Not only are carbon atoms linked by single covalent bonds, but they are sometimes linked by double or triple covalent bonds.

Carbon atoms represented by a specific molecular formula may be arranged in several different ways, which creates compounds with different properties and structures. Compounds that have the same molecular formula but different structures are called isomers. A structural formula indicates the exact number and types of atoms present in a molecule and also shows how atoms are bonded to each other. The various isomers with a specific molecular formula are referred to as structural isomers.



n- butane



isobutane

Materials: Molecular Model kits

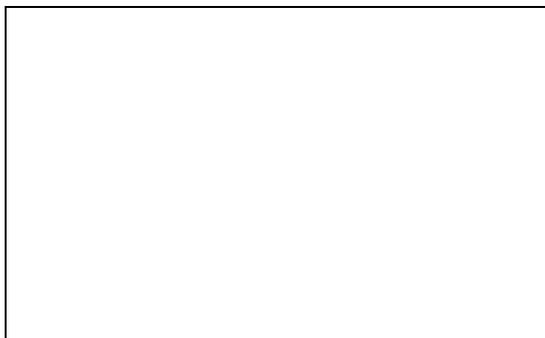
Procedure: Construct the models of the compounds listed below using the following key:

black - carbon green- chlorine

yellow- hydrogen orange (or purple)- bromine

2. Draw the molecular structure and properly name each of the compounds.

a) CH₄



b) CH₃Cl



c) C_2H_6



d) C_2H_5Br



e) C_3H_8



- (f) Replace one of the hydrogens from compound (e) with a bromine atom and draw and name the two possible structures.





- (g) Draw and name two isomers of C_4H_{10} :





(h) Draw and name three isomers of C_5H_{12} :

--	--

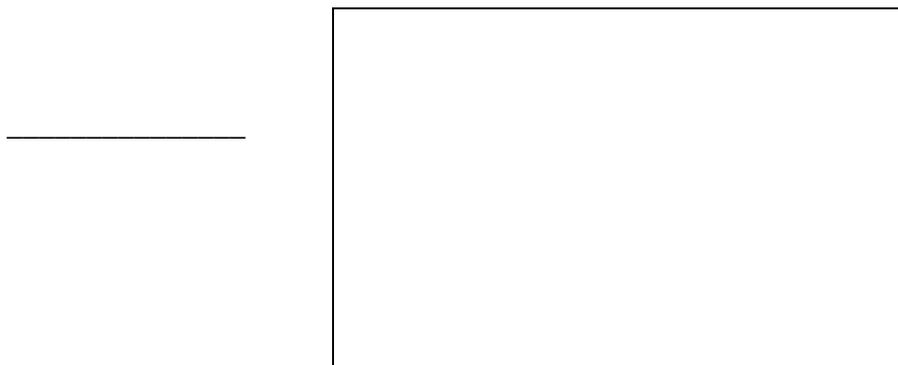
--

Alkenes:

(i) C_2H_6

--

(j) C_3H_6



(k) Draw and name three isomers of C_4H_8 :

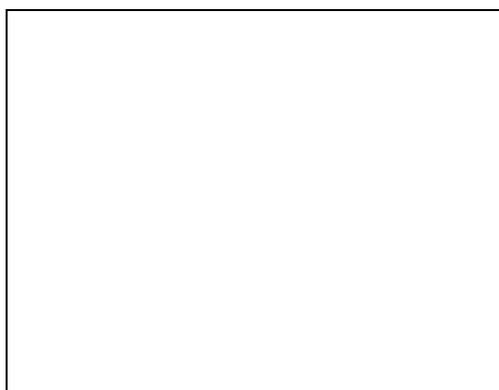




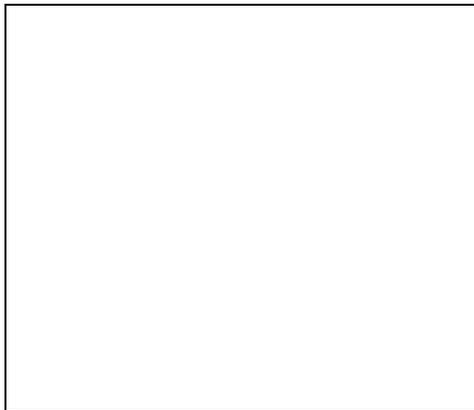


Alkynes:

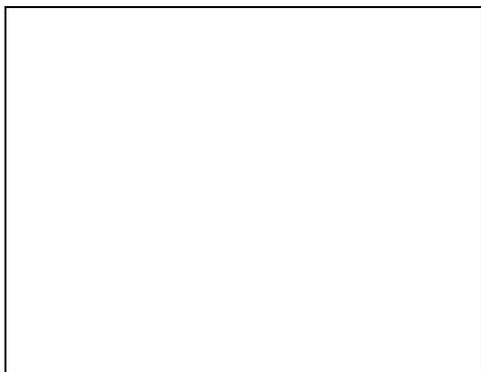
(1) C_2H_2

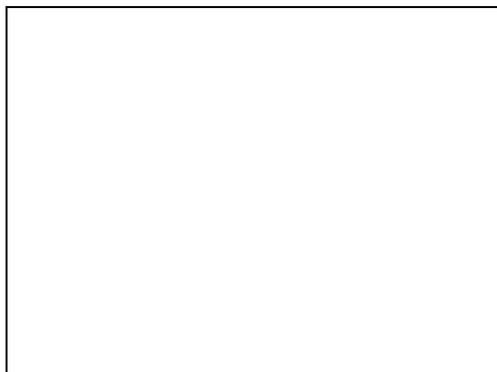


(m) C_3H_4

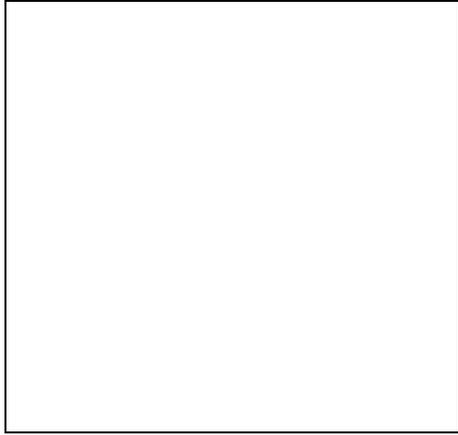


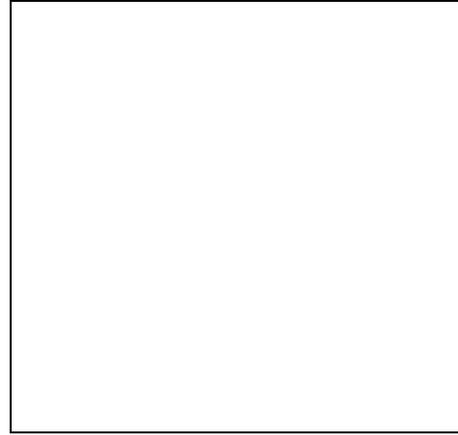
(n) Draw and name two isomers of C_4H_{10}

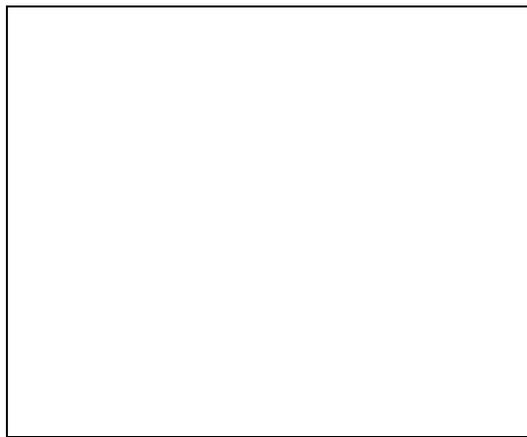




(O) Draw and name three isomers of C_5H_{12}







Conclusion:

1. What type of carbon bonds are found in the following?

Alkanes _____

Alkenes _____

Alkynes _____

2. Make a table listing the homologous series (alkane, alkene, alkyne) that have up to six carbon atoms. Include the general formula for each hydrocarbon family and list the characteristics of each distinct family.
3. List four major characteristics of organic molecules:
 - 1.
 - 2.
 - 3.
 - 4.
4. Identify and discuss in detail the physical and chemical properties for the three isomers of C_5H_{12} .
5. What connections do the isomers of C_5H_{12} have in the real world of science?
6. Which of the following objects are chiral?
 - a) A basketball
 - b) A fork
 - c) A wine glass
 - d) A golf ball
 - e) A monkey wrench
 - f) A snowflake

:

7. Draw the following compounds:

- a) 2, 4- Dimethylheptane
- b) 5- Ethyl- 3, 3- Dimethylheptane
- c) cis- 1,4- Dichlorocyclohexane
- d) 4, 5- Dimethyl – 2, 6- octadyne

b) Which of the above compounds are chiral?

c) Label the chirality centers for the compounds that are chiral.

8. Draw the chiral molecules that meet the following description:

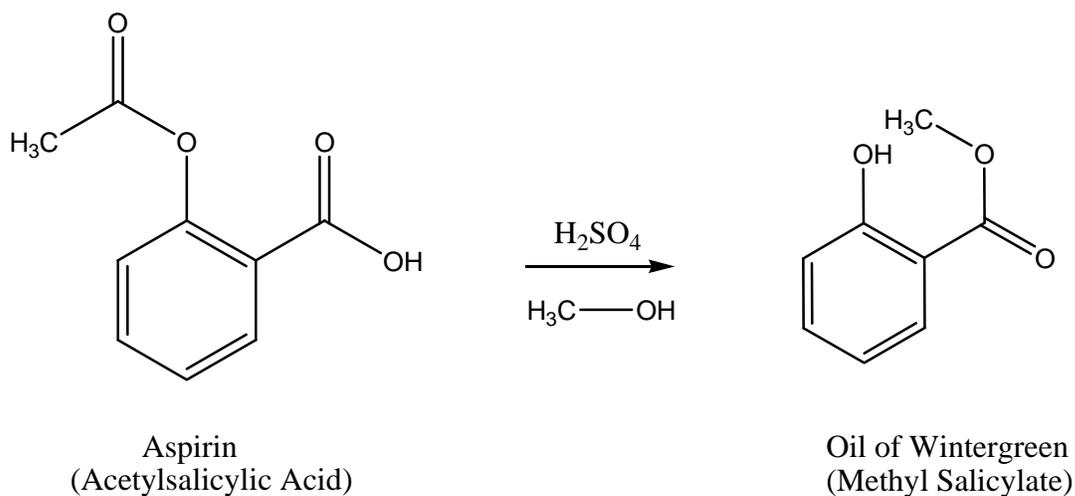
a) a chloroalkane, $C_5H_{11}Cl$ c) an alcohol, $C_6H_{14}O$

b) an alkene, C_6H_{12} d) an alkane, C_8H_{18}

Synthesis of Oil of Wintergreen

Pre- Lab Discussion: Methyl salicylate $C_6H_4(OH)COOCH_3$, also known as salicylic acid methyl ester, oil of wintergreen, is a natural product of many species of plants. Methyl salicylate may be used by plants as a pheromone to warn other plants of pathogens such as tobacco mosaic virus. Methyl salicylate is used in deep heating liniments and in small amounts as a flavoring agent. Oil of wintergreen is used in the field of medicine in aromatherapy.

Reaction:



Objectives: To synthesize methyl salicylate by esterification of acetylsalicylic acid with methanol.

To separate the synthesized methyl salicylate

Materials: Bottle of aspirin, methanol, concentrated sulfuric acid, sodium bicarbonate, Ether, mortar and pestle, scintillation vials, pipettes, graduate cylinder, hot plate.

Safety: Always wear goggles and gloves
Work under fume hood
Do not breathe vapors of methanol and ether
Handle concentrated sulfuric acid with care. If spilled on your skin wash immediately with plenty of water.

- Procedure:
1. Weigh two tablets of aspirin on the analytical balance scale to 0.01 gram.
 2. Place in mortar and decompose the aspirin to a powder form.
 3. Pour the powder aspirin into a scintillation vial. Add 5 ml of methanol.
 4. Add 4 drops of concentrated sulfuric acid to the bottle. Gently swirl so the contents are thoroughly mixed. Be careful the reaction is exothermic.
 5. Gently warm on hot plate for approximately 5 minutes.
 6. Cool down and then neutralize the salicylic acid with sodium bicarbonate. Add one drop at a time until the reaction stops fizzing.

Extraction: Use ether (or any other solvent available)

Do several extractions to remove by products

For each extraction two layers form. The top layer is ether and the bottom layer is water/ methanol

Remove top layer with pipette .

Continue to evaporate the ether by a water bath in the fume hood. After evaporation the smell of methyl salicylate is produced .

- Conclusion:
1. How many moles of salicylic acid and methanol are used in this experiment?
 2. Draw the two functional groups found in esters?
 3. What is the purpose of concentrated sulfuric acid in an esterification reaction?
 4. Write the neutralization reaction between sulfuric acid and sodium bicarbonate
 5. Which substance is the limited reagent in the esterification reaction? Explain!
 - 6a. What is the percent yield of methyl salicylate?
 - b. Why is the percent yield of the product either too high or low ?
 7. What are the two additional byproducts produced in the synthesis of methyl salicylate?
 8. What is the purpose of the extraction technique in this lab?