

TOPIC 5: ORGANIC CHEMISTRY

APPENDICES

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Note:

Due to copyright considerations, Appendix 5.1: Underwater Fireworks is available only in the print document.

Appendix 5.2: Preparation of Esters

Purpose

To study a method for the preparation of esters and to study some of their properties.

Substances Used

Complete the structural formulas for the following alcohols and carboxylic acids before starting the lab.

Alcohols	Carboxylic Acids
1. isopentyl alcohol (3-methyl-1-butanol)	2. acetic acid ethanoic acid
3. isobutyl alcohol (2-methyl-1-butanol)	4. propanoic acid
5. ethyl alcohol ethanol	6. butanoic acid butyric acid
7. methyl alcohol methanol	8. salicylic acid

Safety Precaution

In this lab activity, you will be adding a very small amount of concentrated sulphuric acid to four of the test tubes. **This acid is very corrosive.** Your teacher will show you the safe location of this acid and how to add the correct amount safely.

Appendix 5.2: Preparation of Esters (*continued*)**Procedure**

1. Prepare a hot water bath, as indicated by your teacher.
2. Label five test tubes A to E.
3. Using the appropriate eye dropper, add 10 drops of each alcohol and 5 drops of each carboxylic acid to the test tubes according to the Observation Data Table that appears with this activity. Carefully mix the substances.
4. While adding each acid and alcohol to the test tubes, carefully smell each sample and record your observations in the Observation Data Table.
5. **Very carefully** add 4 drops of concentrate sulphuric acid to test tubes B, C, D, and E. Do not add any acid to test tube A.
6. Carefully mix the substances in each test tube.
7. Place the test tubes in the hot water bath for approximately five minutes.
8. Remove the test tubes from the hot water bath.
9. Pour the product from one of the test tubes onto cold water in an evaporating dish. Record the odour in the table provided.
10. Repeat the last procedure for each test tube and record as required.

Observation Data Table						
Test Tube	Alcohol	Odour	Carboxylic Acid	Odour	Ester	Odour
A						
B						
C						
D						
E						

Appendix 5.2: Preparation of Esters (*continued*)

General Observations**Questions**

1. What is the purpose of test tube A?
2. Was there a reaction in test tube A? How do you know?
3. What was the difference between the odour of the reactants and the odour of the products?
4. What conclusion could be drawn from this experiment?

Reactions

Write the reaction for each of the test tubes except test tube A in the space below.

Test Tube	Reaction
B	
C	
D	
E	

Appendix 5.3: Organic Model-Building Presentation (Teacher Notes)

The following activity may be used for assessment as well as for learning, either early in the topic of study or as a review toward the end.

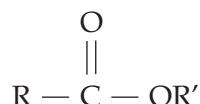
Preparation

1. Prior to the activity:
 - Give students the prefixes that specify the number of carbon atoms in an organic substituent:
methyl = 1, ethyl = 2, and so on.
 - Give students some of the basic functional groups using the R group format:
alcohol = R – O – H, ether = R – O – R', and so on.
 - Introduce the alkane, alkene, and alkyne series, along with the basics of numbering carbon atoms in a molecule.
2. On the day of the presentations, form teams of three to five students. One successful method of forming teams involves assigning those students having difficulty in chemistry as team captains. The captains choose team members and keep their team's score. Students may use whatever resources they have gathered during their study of organic chemistry.
3. Write the name of an organic molecule on the board or overhead projector and ask teams to build the molecule using ball-and-stick models. (**Note:** This game can be played in reverse, for variety. Make the models and ask the teams to write correct IUPAC names.)
4. Award points to all teams who successfully build the model. (For example, if there are five teams, the first team to complete their model scores 5 points, the second team scores 4 points, and so on.)
5. At the end of the class, collect and tally the score sheets.

Note: Make every effort to agree upon a scoring system that is friendly to all student groups, and downplay the competitive aspects. The primary goals are to have students participate and to see how well the models agree with theory.

Appendix 5.4: Esters: Flavours and Fragrances

Esters are a class of compounds widely distributed in nature. They have the following general formula:



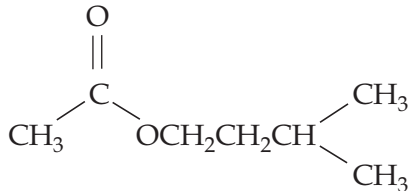
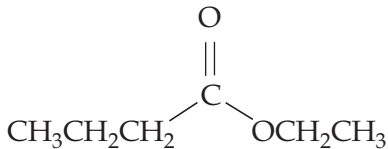
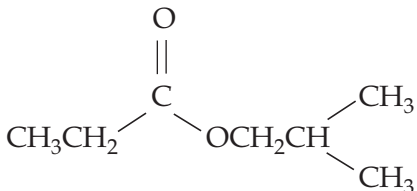
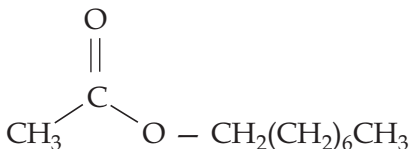
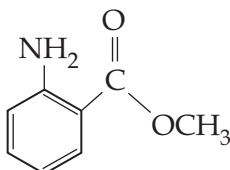
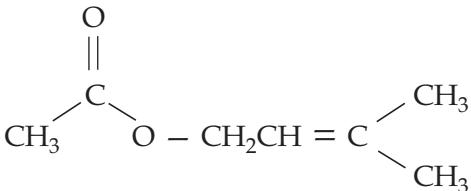
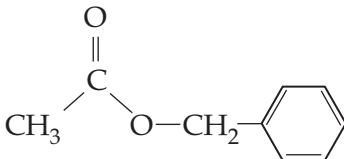
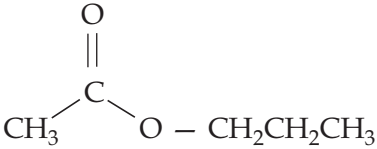
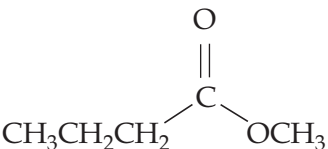
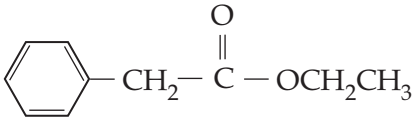
The simpler esters tend to have pleasant odours. In many cases, although not exclusively so, the characteristic flavours and fragrances of flowers and fruits are due to compounds with the ester functional group. An exception is the case of the essential oils. The organoleptic qualities (odours and flavours) of fruits and flowers may often be due to a single ester, but, more often, the flavour or the aroma is due to a complex mixture in which a single ester predominates. Some common flavour principles are listed in Table 1. Food and beverage manufacturers are thoroughly familiar with these esters and often use them as additives to spruce up the flavour or odour of a dessert or beverage. Many times such flavours or odours are not even naturally occurring, as is the case with the “juicy fruit” principle, isopentenyl acetate. An instant pudding that has “rum” flavour may never have seen its alcoholic namesake—this flavour can be duplicated by the proper admixture, along with other minor components, of ethyl formate and isobutyl propionate. The natural flavour and odour are not *exactly* duplicated, but most people can be fooled. Often only a trained person with a high degree of gustatory perception, a professional taster, can tell the difference.

A single compound is rarely used in good quality imitation flavouring agents. A formula for an imitation pineapple flavour, which might fool an expert, is listed in Table 2. The formula includes ten esters and carboxylic acids which may easily be synthesized in the laboratory. The remaining seven oils are isolated from natural sources.

Flavour is a combination of taste, sensation, and odour transmitted by receptors in the mouth (taste buds) and nose (olfactory receptors). The four basic tastes, sweet, sour, salty, and bitter, are perceived in specific areas of the tongue. The sides of the tongue perceive sour and salty tastes, the tip is most sensitive to sweet tastes, and the back of the tongue detects bitter tastes. The perception of flavour, however, is not that simple. If it were, it would only require the formulation of various combinations of four basic substances: a bitter substance (a base), a sour substance (an acid), a salty substance (sodium chloride), and a sweet substance (sugar), to duplicate *any* flavour! In fact, we cannot duplicate flavours in this way. The human tongue actually possesses 9000 taste buds. It is a combined response of these taste buds that allows us to perceive a particular flavour.

Esters: Flavours and Fragrances: From *Introduction to Organic Laboratory Techniques, A Contemporary Approach* 1st edition by PAVIA. 1976. Reprinted with permission by Brooks/Cole, a division of Thomson Learning; www.thomsonrights.com. Fax 800 730-2215.

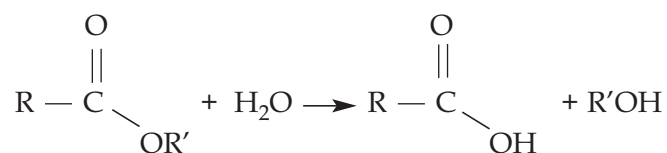
Appendix 5.4: Esters: Flavours and Fragrances (continued)

Table 1: Ester Flavours and Fragrances	
 <p>Isoamyl acetate banana (alarm pheromone of honeybee)</p>	 <p>Ethyl butyrate pineapple</p>
 <p>Isobutyl propionate rum</p>	 <p>Octyl acetate oranges</p>
 <p>Methyl anthranilate grape</p>	 <p>Isopentenyl acetate "juicy fruit"</p>
 <p>Benzyl acetate peach</p>	 <p>n-Propyl acetate pear</p>
 <p>Methyl butyrate apple</p>	 <p>Ethyl phenylacetate honey</p>

Appendix 5.4: Esters: Flavours and Fragrances (*continued*)

Pure Compounds	%	Essential Oils	%
Allyl caproate	5	Oil of sweet birch	1
Isoamyl acetate	3	Oil of spruce	2
Isoamyl isovalerate	3	Balsam Peru	4
Ethyl acetate	15	Volatile mustard oil	1
Ethyl butyrate	22	Oil cognac	5
Terpinyl propionate	3	Concentrated orange oil	4
Ethyl crotonate	5	Distilled oil of lime	2
Caproic acid	8		
Butyric acid	12		19
Acetic acid	5		
	81		

Although the “fruity” tastes and odours of esters are pleasant, they are seldom used in perfumes or scents that are applied to the body. The reason for this is a chemical one. The ester group is not as stable to perspiration as the ingredients of the more expensive essential oil perfumes. The latter are usually hydrocarbons (terpenes), ketones, and ethers extracted from natural sources. Esters, however, are only used for the cheapest toilet waters, since on contact with sweat, they undergo a hydrolysis reaction to give organic acids. These acids, unlike their



precursor esters, generally do not have a pleasant odour. Butyric acid, for instance, has a strong odour similar to that of rancid butter (of which it is an ingredient) and is, in fact, a component of what we normally call “body odour.” It is this substance that makes foul-smelling humans so easy for an animal to detect when it is downwind of them. It is also of great help to the bloodhound that is trained to follow small traces of this odour. The *esters* of butyric acid, ethyl butyrate and methyl butyrate, however, smell like pineapple and apple, respectively.

A sweet fruity odour also has the disadvantage that it may attract fruit flies and other insects in search of food. The case of isoamyl acetate, the familiar solvent called banana oil, is particularly interesting. It is identical to the alarm *pheromone* of the honeybee. Pheromone is the name applied to a chemical secreted by an organism that evokes a specific response in another member of the same species. This kind of communication is common between insects that otherwise lack means of intercourse. When a honeybee worker stings an intruder, an alarm pheromone,

Appendix 5.4: Esters: Flavours and Fragrances (continued)

composed in part of isoamyl acetate, is secreted along with the sting venom. This chemical causes aggressive attack on the intruder by other bees, which swarm after the intruder. Obviously it wouldn't be wise to wear a perfume compounded of isoamyl acetate near a beehive.

References

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