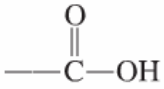
Chapter 16: Carboxylic Acids, Esters, and Other Acid Derivatives

In Chapter 15, we discussed the carbonyl group and two families of compounds -aldehydes and ketones—that contain C=O group. In this chapter, we discuss four more families of compounds in which the carbonyl group is present: a) carboxylic acid, b) esters, c) amides, d) acid chlorides, and e) acid anhydrides and f) carboxylic acid salts.

16.1 Structure of Carboxylic Acids and Their Derivatives

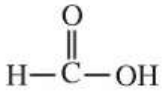
A carboxylic acid is an organic compound whose functional group is the carboxyl group. What is a carboxyl group? A carboxyl group is a carbonyl group (C=O) with a hydroxyl group (—OH) bonded to the carboxyl carbon atom. A general structural representation fit a carboxyl group is



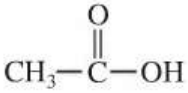
Abbreviated linear designations for the carboxyl group are

—COOH and —CO_2H

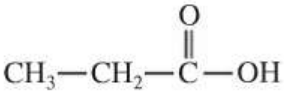
Although we see within a carboxyl group both a carbonyl group (C=O) and hydroxyl group (—OH).



Methanoic acid



Ethanoic acid



Propanoic acid

16.2 IUPAC Nomenclature for Carboxylic Acids

The naming of carboxylic acids is fairly simple. You simply find the longest carbon chain which includes the carboxylic group. Use that as the stem for the name, cross off the **-e** on the ending of the alkane name and replace it with **-oic acid**.

I think you can see how that works, if you look at this example (which is also shown in Example 1-a in your workbook). It gives you, in this case (with a three-carbon-atom chain), the name **propanoic acid**.

propanoic acid
(from **propan** + **oic acid**)

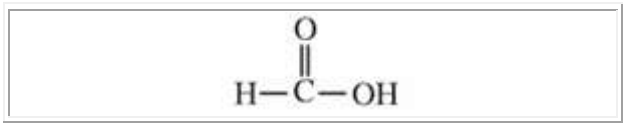
As with aldehydes, it is **not necessary to indicate where** the acid functional group is because it has to be at the end of the molecule, on the #1 carbon. There is no way that this functional group can be anywhere else. Therefore, if there is any numbering to be done, it will be to show where additional alkyl groups or other groups are attached to the carbon chain. The numbering starts from the carboxylic group.

Carboxylic acids	Formula
methanoic acid	$HCOOH$
ethanoic acid	CH_3COOH
propanoic acid	CH_3CH_2COOH
butanoic acid	$CH_3(CH_2)_2COOH$
pentanoic acid	$CH_3(CH_2)_3COOH$
hexanoic acid	$CH_3(CH_2)_4COOH$
octanoic acid	$CH_3(CH_2)_6COOH$
decanoic acid	$CH_3(CH_2)_8COOH$
hexadecanoic acid	$CH_3(CH_2)_{14}COOH$
octadecanoic acid	$CH_3(CH_2)_{16}COOH$

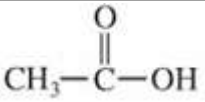
16.3 Common Names for Carboxylic Acids

Carboxylic acids are another example of a situation where the compounds were known and named long before anyone thought of the IUPAC method of naming compounds. Consequently, many carboxylic acids have their own common name which is distinct from the IUPAC name. The two most important of these (and the only two you will be held responsible for in this course) are shown below. They are **formic acid** and **acetic acid**. (These are also shown in Examples 1b and c in your workbook.)

Here is the structural formula for **formic acid**. Its IUPAC name is methanoic acid, using the **meth-** stem because it has **one** carbon atom.



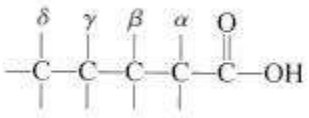
Acetic acid has two carbon atoms. Therefore it can also be called ethanoic acid.

formic acid methanoic acid

acetic acid ethanoic acid

Structural Formula	Latin or Greek Root	Common Name*
H—COOH	form-	formic acid
CH_3—COOH	acet-	acetic acid
CH_3—CH_2—COOH	propion-	propionic acid
CH_3—$(CH_2)_2$—COOH	butyr-	butyric acid
CH_3—$(CH_2)_3$—COOH	valer-	valeric acid
CH_3—$(CH_2)_4$—COOH	capro-	caproic acid

Naming using Greek letters ε δ γ β α

There are two ways to identify substituent carbons in carboxylic acid: numbers or Greek letters.
Using numbers, the carboxyl group carbon is given the number one.



6 5 4 3 2 1
C-C-C-C-C-COOH
ε δ γ β α

When Greek letters are used, Greek letters are used to designate the position of substituent relative to the carbon of the carboxyl group. The carbon of the carboxyl group is **NOT** given a Greek letter.
6) A special group of carboxylic acids are those that also have a keto group. They are called alpha-keto carboxylic acids