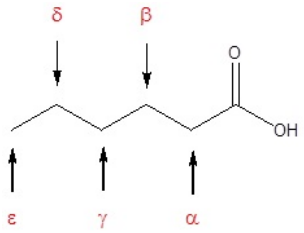
3.13: CARBOXYLIC ACIDS

learning objectives

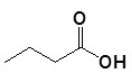
- name carboxylic acids using IUPAC (systematic) and selected common name nomenclature
- draw the structure of carboxylic acids from IUPAC (systematic) and selected common names

The IUPAC system of nomenclature assigns a characteristic suffix to these classes. The **–e** ending is removed from the name of the parent chain and is replaced **-anoic acid**. Since a carboxylic acid group must always lie at the end of a carbon chain, it is always is given the #1 location position in numbering and it is not necessary to include it in the name. Many carboxylic acids are called by the common names that were chosen by chemists to usually describe the origin of the compound. In common names of aldehydes, carbon atoms near the carboxyl group are often designated by Greek letters. The atom adjacent to the carbonyl function is alpha, the next removed is beta and so on.

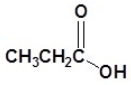


Formula	Common Name	Source	IUPAC Name	Melting Point	Boiling Point
HCO_2H	formic acid	ants (L. formica)	methanoic acid	8.4 ºC	101 ºC
CH_3CO_2H	acetic acid	vinegar (L. acetum)	ethanoic acid	16.6 ºC	118 ºC
$CH_3CH_2CO_2H$	propionic acid	milk (Gk. protus prion)	propanoic acid	-20.8 ºC	141 ºC
$CH_3(CH_2)_2CO_2H$	butyric acid	butter (L. butyrum)	butanoic acid	-5.5 ºC	164 ºC
$CH_3(CH_2)_3CO_2H$	valeric acid	valerian root	pentanoic acid	-34.5 ºC	186 ºC
$CH_3(CH_2)_4CO_2H$	caproic acid	goats (L. caper)	hexanoic acid	-4.0 ºC	205 ºC
$CH_3(CH_2)_5CO_2H$	enanthic acid	vines (Gk. oenanthe)	heptanoic acid	-7.5 ºC	223 ºC
$CH_3(CH_2)_6CO_2H$	caprylic acid	goats (L. caper)	octanoic acid	16.3 ºC	239 ºC
$CH_3(CH_2)_7CO_2H$	pelargonic acid	pelargonium (an herb)	nonanoic acid	12.0 ºC	253 ºC
$CH_3(CH_2)_8CO_2H$	capric acid	goats (L. caper)	decanoic acid	31.0 ºC	219 ºC

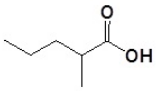
EXAMPLES (COMMON NAMES ARE IN RED)



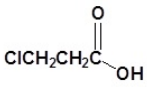
Butanoic acid
(Butyric Acid)



Propanoic acid
(Propionic Acid)



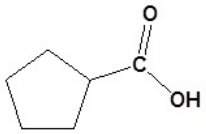
2-Methylpentanoic acid
(β-Methylvaleric acid)



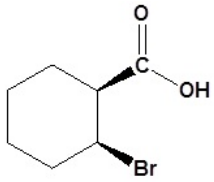
3-Chloropropanoic acid
(γ-Chloropropionic acid)

NAMING CARBOXYL GROUPS ADDED TO A RING

When a carboxyl group is added to a ring the suffix **-carboxylic acid** is added to the name of the cyclic compound. The ring carbon attached to the carboxyl group is given the #1 location number.



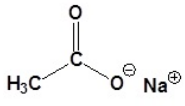
Cyclopentanecarboxylic acid



Cis-2-Bromocyclohexanecarboylic acid

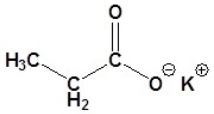
NAMING CARBOXYLATES

Salts of carboxylic acids are named by writing the name of the cation followed by the name of the acid with the **–ic acid** ending replaced by an **–ate** ending. This is true for both the IUPAC and Common nomenclature systems.



Sodium ethanoate

(Sodium Acetate)

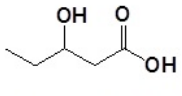


Potassium Propanoate

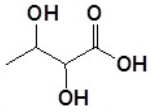
(Potassium propionate)

NAMING CARBOXYLIC ACIDS WHICH CONTAIN OTHER FUNCTIONAL GROUPS

Carboxylic acids are given the highest nomenclature priority by the IUPAC system. This means that the carboxyl group is given the lowest possible location number and the appropriate nomenclature suffix is included. In the case of molecules containing carboxylic acid and alcohol functional groups the OH is named as a hydroxyl substituent. However, the **l** in hydroxyl is generally removed.

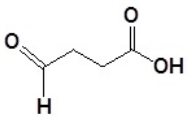


3-Hydroxypentanoic acid

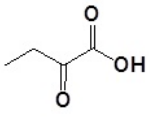


2,3-Dihydroxybutanoic acid

In the case of molecules containing a carboxylic acid and aldehydes and/or ketones functional groups the carbonyl is named as a "Oxo" substituent.

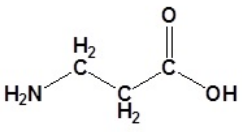


4-Oxobutanoic acid

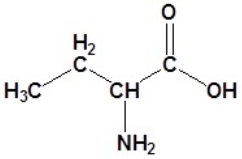


2-Oxobutanoic acid

In the case of molecules containing a carboxylic acid an amine functional group the amine is named as an "amino" substituent.



3-Aminopropanoic acid

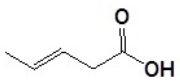


2-Aminobutanoic acid

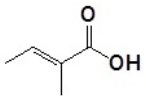
When carboxylic acids are included with an alkene the following order is followed:

(Location number of the alkene)-(Prefix name for the longest carbon chain minus the **-ane** ending)-(an **–enoic acid** ending to indicate the presence of an alkene and carboxylic acid)

Remember that the carboxylic acid has priority so it should get the lowest possible location number. Also, remember that cis/tran or E/Z nomenclature for the alkene needs to be included if necessary.



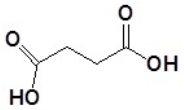
Trans-3-pentenoic acid



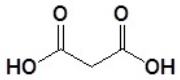
(E)-2-Methyl-2-butenoic acid

NAMING DICARBOXYLIC ACIDS

For dicarboxylic acids the location numbers for both carboxyl groups are omitted because both functional groups are expected to occupy the ends of the parent chain. The ending **–dioic acid** is added to the end of the parent chain.



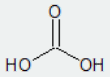
Butanedioic acid



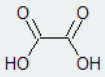
Propanedioic acid

Common Names for selected dicarboxylic acids

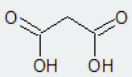
The following common names for these selected dicarboxylic acids are important to memorize; they are prevalent in biochemistry or industrial applications.



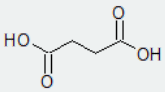
carbonic acid



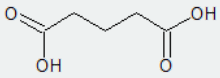
oxalic acid



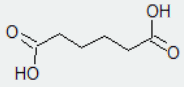
malonic acid



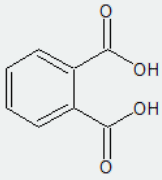
succinic acid



glutaric acid



adipic acid



phthalic acid

The saying, "Oh my, such good apple pie!", can help us remember these common names by correlating the first letters of each word with the common names:

oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, and phthalic.

Exercise

1. Draw the bond-line structure and write the condensed structural formula for each compound.

a) octanoic acid

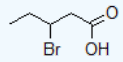
b) 4-hydroxypentanoic acid

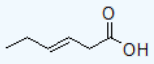
c) cis-4-hexenoioc acid or cis-hex-4-enoic acid

d) (E)-5-bromo-3-heptenoic acid or (E)-5-bromohept-3-enoic acid.

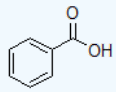
e) 2-aminopropanoic acid

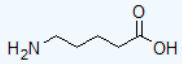
2. Give the IUPAC name and condensed structural formula for each compound.

a) 

b) 

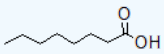
c) 

d) 

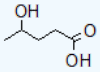
e) 

Answer

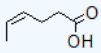
1.

a) 

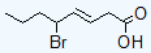
$CH_3(CH_2)_6CO_2H$

b) 

$CH_3CH(OH)CH_2CH_2CO_2H$

c) 

$CH_3CHCHCH_2CH_2CO_2H$

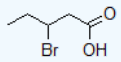
d) 

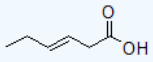
$CH_3CH_2CH_2CHBCHCHCH_2CO_2H$

e) 

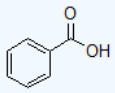
$CH_3CH(NH_2)CO_2H$

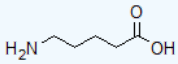
2.

a)  3-bromopentanoic acid $CH_3CHBrCH_2CO_2H$

b)  (3*E*)-hex-3-enoic acid $CH_3CH_2CHCHCH_2CO_2H$

c)  2-hydroxypropanoic acid $CH_2CH(OH)CO_2H$

d)  benzoic acid $C_6H_5CO_2$

e)  5-aminopentanoic acid $NH_2CH_2CH_2CH_2CH_2CO_2H$ or $NH_2(CH_2)_4CO_2H$

CONTRIBUTORS AND ATTRIBUTIONS

- Prof. Steven Farmer (Sonoma State University)
- William Reusch, Professor Emeritus (Michigan State U.), Virtual Textbook of Organic Chemistry