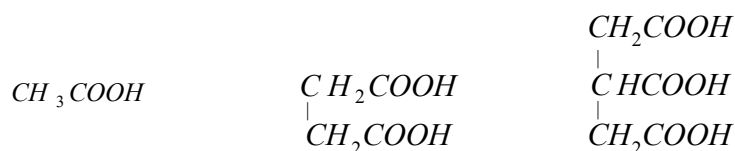# Classification, Structure, Nomenclature & Isomerism

(1) Classification

(i) Carboxylic acids are classified as monocarboxylic acids, dicarboxylic acids, tricarboxylic acids etc. depending on the number of – COOH groups present in the molecule.
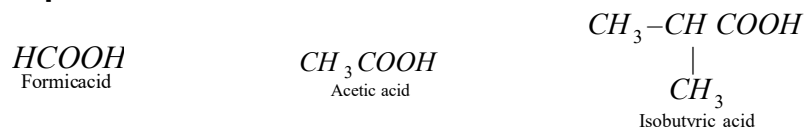
$$CH_3COOH$$

monocarboxylic acid

$$\begin{array}{c} CH_2COOH \\ | \\ CH_2COOH \end{array}$$

Dicarboxylic acid

$$\begin{array}{c} CH_2COOH \\ | \\ CHCOOH \\ | \\ CH_2COOH \end{array}$$

Tricarboxylic acid

(ii) Monocarboxylic acids of aliphatic series are commonly known as fatty acids such as palmitic acid $(C_{15}H_{31}COOH)$ and stearic acid $(C_{17}H_{35}COOH)$.
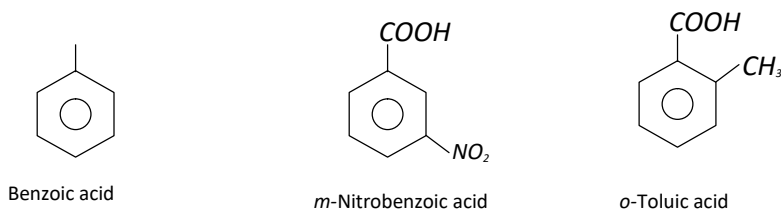
(iii) The general formula for monocarboxylic acids is $C_nH_{2n+1}COOH$ or $C_nH_{2n}O_2$. Where n = number of carbon atoms.

(iv) The carboxylic acids may be aliphatic or aromatic depending upon whether – COOH group is attached to aliphatic alkyl chain or aryl group respectively.
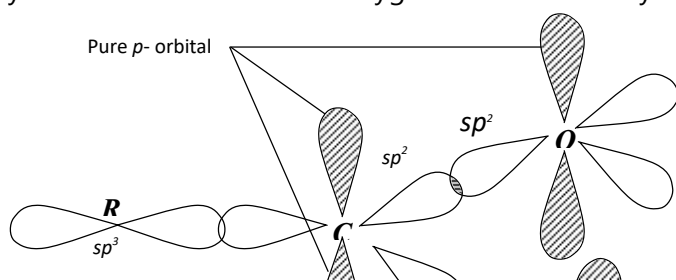
Aliphatic acids

$$HCOOH$$
Formicacid

$$CH_3COOH$$
Acetic acid

$$\begin{array}{c} CH_3-CH\,COOH \\ | \\ CH_3 \end{array}$$
Isobutyric acid

Aromatic acids
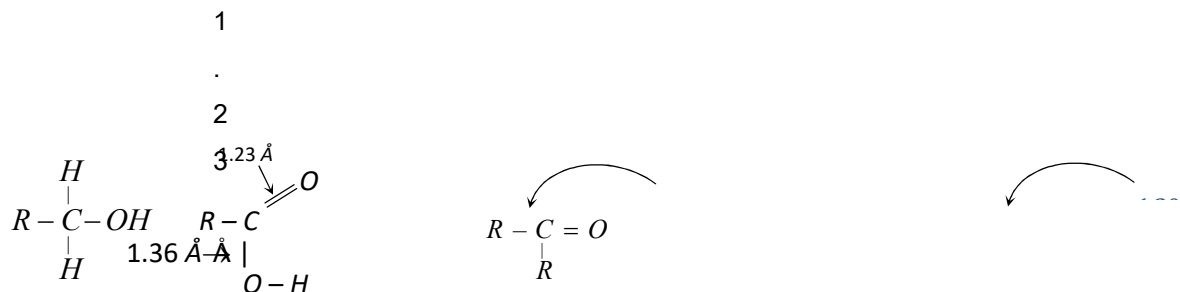
Benzoic acid

m-Nitrobenzoic acid

o-Toluic acid

(2) Structure:

(i) The name carboxyl is derived from carbonyl $C=O$ and hydroxyl (– OH) because both carbonyl and hydroxyl groups are directly linked to each other.

(ii) The carboxylic carbon atom and two oxygen atom in carboxylic acid are sp^2 hybridized.

Pure p- orbital

sp^2

sp^2

O

R

sp^3

C

$$1.$$
$$2$$

$$\underset{H}{\overset{H}{\underset{|}{R-C-OH}}} \quad \underset{\underset{1.36\,Å\,Å\,|}{}}{R-C}\overset{3.23\,Å}{\overset{\searrow}{\diagdown}}\overset{O}{\underset{O-H}{}}$$

$$R-C=O$$
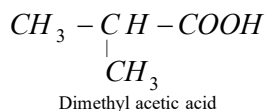$$\underset{R}{|}$$

Delocalized π-electron cloud

(iii) The shorter bond (c – o) and longer bond (c = o) of carboxylic acid than alcohol and ketone is due to delocalization of π electrons.

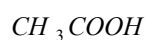(3)**Nomenclature:** The monocarboxylic acids are named according to following systems.

(i) **Common or trivial names:** The names of lower members are derived from the Latin or Greek word that indicates the source of the particular acid. The common names have ending –ic acid.

Formula	Source	Common name
$HCOOH$	Red ant (Latin, ant = Formica)	Formic acid
CH_3COOH	Vinegar (Latin; vinegar = Acetum)	Acetic acid
C_2H_5COOH	Proton-pion (Greek; Proton = first, Pion = Fat)	Propionic acid
C_3H_7COOH	Butter (Latin ; Butter = Butyrum)	Butyric acid
C_4H_9COOH	Root of valerian plant	Valeric acid

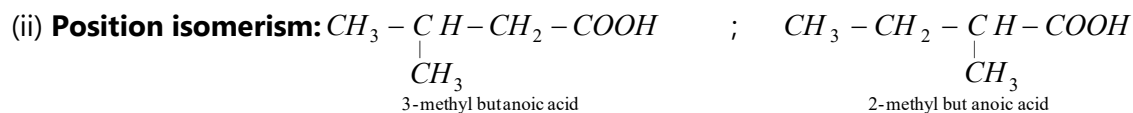(ii) **Derived system:** Monocarboxylic acids may be named as alkyl derivatives of acetic acid.

$$CH_3CH_2COOH$$
Methyl acetic acid

$$CH_3 - \overset{|}{C}H - COOH$$
$$\overset{|}{C}H_3$$
Dimethyl acetic acid

(iii) **IUPAC system :** Acids are named as alkanoic acids (Alkane – e + oic acid). The name is derived by replacing 'e' of the corresponding alkane by –oic acid.

HCOOH   Methanoic acid (Methane – e + oic acid)

CH_3COOH Ethanoic acid (Ethane – e + oic acid)

In case of substituted acids,

$$\overset{5}{C}H_3 - \overset{4}{C}H - \overset{3}{C}H - \overset{2}{C}H_2 - \overset{1}{C}OOH \; ; \qquad \overset{4}{C}H_3 - \overset{3}{C}H - \overset{2}{C}H - \overset{1}{C}OOH \; ;$$
$$\overset{|}{C}H_3 \quad \overset{|}{C}H_3 \qquad\qquad\qquad\qquad \overset{Br}{\overset{|}{}} \quad \overset{|}{C}H_3$$
3,4-Dimethylpentanoic acid   3-Bromo-2-methyl butanoic acid

(4) **Isomerism**

(i) **Chain isomerism:** $CH_3 - CH_2 - CH_2 - CH_2 - COOH \; ; \quad CH_3 - CH_2 - \overset{|}{C}H - COOH$
$$\qquad\qquad\qquad\qquad \text{Pentanoic acid} \qquad\qquad\qquad\qquad \overset{CH_3}{\overset{|}{}}$$
Pentanoic acid   2-methyl butanoic acid

(ii) **Position isomerism:** $CH_3 - \overset{|}{C}H - CH_2 - COOH \qquad ; \qquad CH_3 - CH_2 - \overset{|}{C}H - COOH$
$$\qquad\qquad\qquad\qquad \overset{|}{C}H_3 \qquad\qquad\qquad\qquad\qquad\qquad \overset{|}{C}H_3$$
3-methyl butanoic acid   2-methyl butanoic acid

(iii) **Functional isomerism:** $CH_3 - CH_2 - COOH \qquad ; \quad CH_3COOCH_3 \quad ; \quad HCOOC_2H_5$
Propanoic acid   Methyl acetate   Ethyl formate

(iv) **Optical isomerism**

$$\overset{C_2H_5}{\overset{|}{CH_3 - \underset{|}{C} - C_3H_7}} \qquad\qquad \overset{C_2H_5}{\overset{|}{C_3H_7 - \underset{|}{C} - CH_3}}$$
$$\qquad COOH \qquad\qquad\qquad\qquad COOH$$
2-Ethyl-2Methyl Pentanoic Acid