CHAPTER

13

CARBOXYLIC ACIDS

Animaton 13.1: Addition of HCl to a carbonyl group
Source & Credit : Ch.imperial

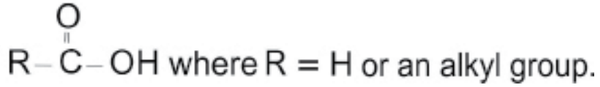
IN THIS CHAPTER YOU WILL LEARN:

1. How to name carboxylic acids and their derivatives.
2. The commercial method for the preparation of acetic acid.
3. The relationship between the structure of carboxyl group and its reactivity.
4. The effect of hydrogen bonding on the physical properties of carboxylic acids.
5. The ways of preparing four derivaties of carboxylic acids and the conversion of these derivatives back to carboxylic acids.
6. About amino acids and their significance.

13.1 INTRODUCTION

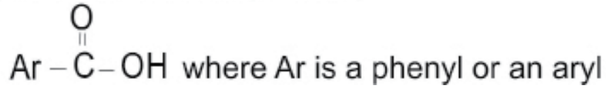
Organic compounds containing (-C(=O)-OH) as a functional group are called carboxylic acids. The (-C(=O)-OH) group which itself is made up of a carbonyl group (> C = 0) and a hydroxyl group (-0H) is called a carboxyl group (Carb from carbonyl and oxyl from hydroxyl). Carboxylic acid may be an aliphatic or an aromatic depending upon whether (-C(=O)-OH) is attached to an alkyl group (or a hydrogen atom) or an aryl group. Their general formulas are:

Aliphatic carboxylicacid



$R-C(=O)-OH$ where R = H or an alkyl group.

Aromatic carboxylicacid



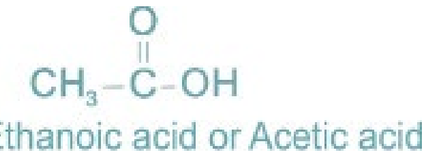
$Ar-C(=O)-OH$ where Ar is a phenyl or an aryl group

Carboxylic acids are further classified as mono, di, tri or poly carboxylic acids as they contain one, two, three or many carboxyl groups respectively in their molecules.

Animaton 13.2: Carboxyl
Source & Credit : Phschool

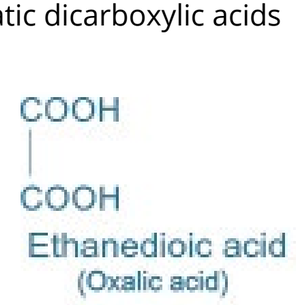
Aliphatic monocarboxylic acids

Methanoic acid or Formicacid

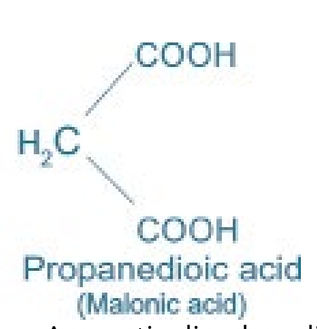


Ethanoic acid or Acetic acid

Aliphatic dicarboxylic acids

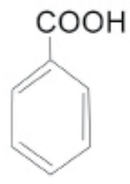


Ethanedioic acid
(Oxalic acid)



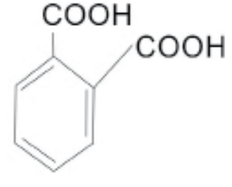
Propanedioic acid
(Malonic acid)

Aromatic monocarboxylic acid



Benzoic acid

Aromatic dicarboxylic acid:



1,2-Benzenedicarboyllic acid
or phthalic acid

In this chapter we will discuss, in some detail, the chemistry of monocarboxylic acids only.

13.2 NOMENCLATURE OF CARBOXYLIC ACIDS

The aliphatic monocarboxylic acids are commonly called fatty acids because higher members of this series such as palmitic acid ($C_{15}H_{31}COOH$), stearic acid ($C_{17}H_{35}COOH$), etc. are obtained by the hydrolysis of fats and oils. The aliphatic monocarboxylic acids may be given common names or IUPAC names.

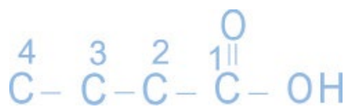
13.2.1 Common or Trivial names

The common names of carboxylic acids were derived from the source from which they are isolated. The irritation caused by an ant bite is due to formic acid (Latin word formica, ant). It was first isolated by the distillation of red ants. Similarly acetic acid was first isolated from vinegar and butyric acid was named after butyrum means butter.

13.2.2 The IUPAC Nomenclature

The IUPAC names of saturated monocarboxylic acids are alkanoic acids. These are derived from the names of the alkanes containing the same number of carbon atoms as the acid. The ending "e" of the alkane name is dropped and suffix-oic acid is added. Thus acetic acid gets the name ethanoicaeid.

The position of substituents are indicated by Arabic numerals with the carboxyl group given number 1 as shown below:



The common and IUPAC names of the some common monocarboxylic acids are given in the table below.

Table(13.1) Common and IUPAC names of some common carboxylic acids.

Structural Formula	Common Name	IUPAC Name
$H-COOH$	Formic acid	Methanoic acid
CH_3COOH	Acetic acid	Ethanoic acid
CH_3-CH_2-COOH	Propionic acid	Propanoic acid
$CH_3-CH_2-CH_2-COOH$	Butyric acid	Butanoic acid
$CH_3-CH(CH_3)-COOH$	Iso-Butyric acid	2-Methylpropanoic acid

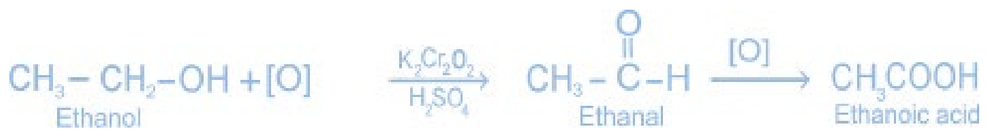
13.3 GENERAL METHODS OF PREPARATION

A number of methods for the preparation of carboxylic acids have already been discussed in the previous chapters. However, they are recalled again with different examples.

1. From Primary Alcohols and Aldehydes

Primary alcohols and aldehydes are readily oxidised to corresponding carboxylic acids by oxidising agents such as potassium dichromate in an acidic medium.

Animaton 13.5 : Undergo oxidation
ource & Credit : Biologie.uni-hamburg.de



Aldehydes are easily oxidised to corresponding carboxylic acids even by mild oxidizing agents such as Tollen's Reagent (Ammoniacal silver nitrate).

2. From Alkanenitriles

Compounds having a cyanide (- C ≡ N) group are called nitriles. Hydrolysis of an alkanenitrile on boiling with mineral acids or alkalis yields corresponding carboxylic acid.

Animaton 13.6 : Nucleophilic substitution
ource & Credit : Wikipedia.org

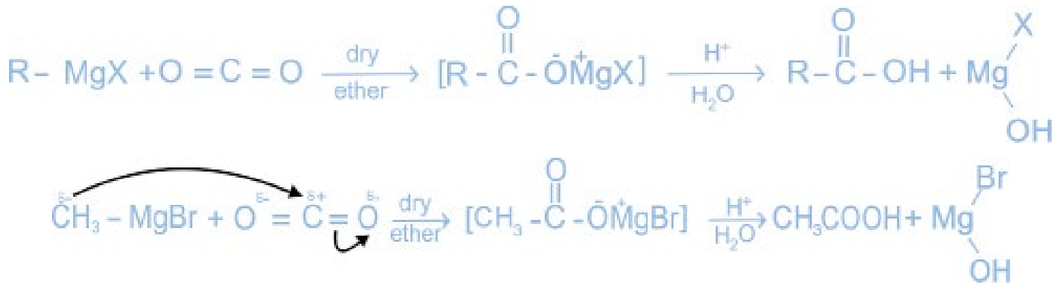
Alkanenitriles can be prepared by treating alkyl halide with alcoholic potassium cyanide.

It may be noted that acid produced has one carbon atom more than the original alkyl halide.

3. From Grignard Reagent

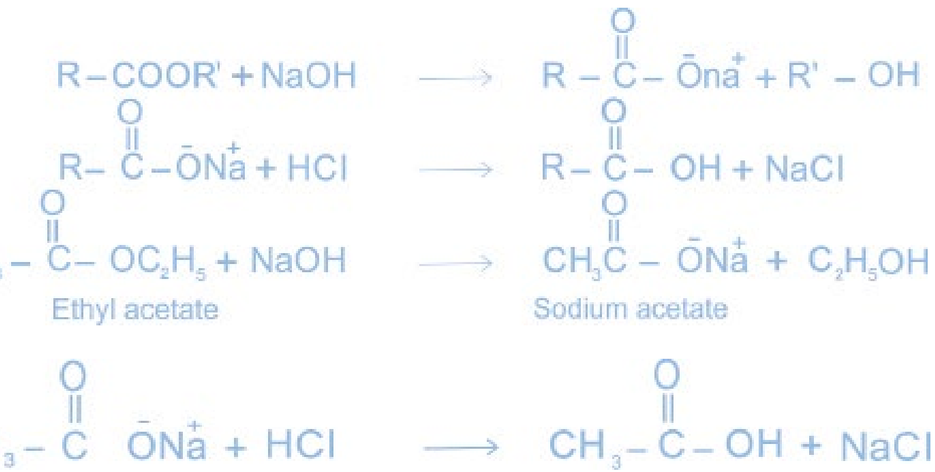
Carboxylic acids can be prepared by the action of Grignard reagent with carbon dioxide. This reaction is either carried out by passing carbon dioxide through the ethereal solution of corresponding Grignard reagent or by adding Grignard reagent to crushed dry ice suspended in ether. The addition product on reaction with a mineral acid produces carboxylic acid.

Animaton 13.7 : Grignard Reagent Attacking a Ketone
ource & Credit : Benettonplay



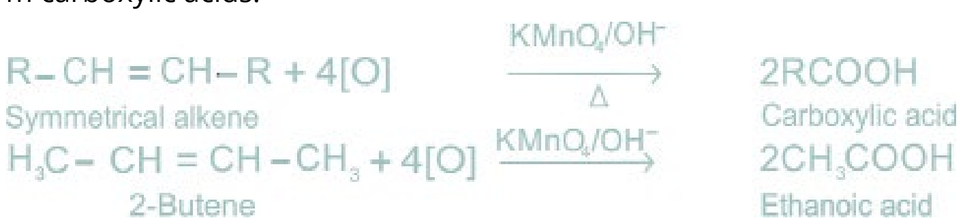
4. By the Hydrolysis of Esters

The appropriate ester on boiling with concentrated sodium hydroxide yields sodium salt of the acid.This resulting salt when treated with dilute HC1 gives the free carboxylic acid.



5. By the Oxidative Cleavage of Alkenes

Alkenes when heated with alkaline $KMnO_4$ are cleaved at the double bond to form carboxylic acids.



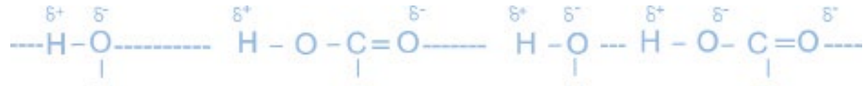
13.4 PHYSICAL CHARACTERISTICS

(i) Smell

The first three aliphatic acids i.e. formic acid, acetic acid and propionic acid are colourless liquids and have pungent smell. The next three acids C_4 to C_6 are colourless liquids with somewhat unpleasant smell.

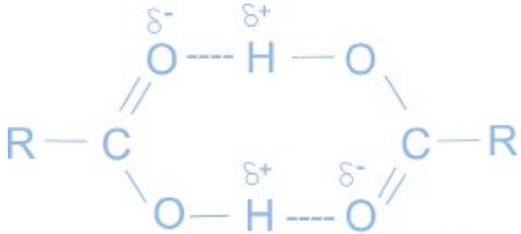
(ii) Solubility

Among the aliphatic acids, the first four members are very soluble in water due to hydrogen bonding.



(iii) Boiling Point

The boiling points of carboxylic acids are relatively high due to intermolecular hydrogen bonding. The molecular mass determination in non-polar solvent like benzene shows that Carboxylic acids exist as cyclic dimers.



Boiling Points

HCOOH	CH_3COOH	C_2H_5COOH
373K(100°C)	391K(118°C)	424K(141°C)

Melting Points

The melting points of carboxylic acids increase irregularly with the increase in molecular mass. It has been observed that the melting points of carboxylic acids containing even number of carbon atoms are higher than the next lower and higher members containing odd number of carbon atoms e.g.,

CH_3CH_2COOH, $CH_3CH_2CH_2COOH$, $CH_3CH_2CH_2CH_2COOH$
(3 carbon) (4 carbon) (5 carbon)

Melting points	251K(-22°C)	267 K (-6°C)	237 K (-36°C)

13.5 REACTIVITY OF CARBOXYL GROUP (– C(=O) – OH)

The carboxyl group displays the chemistry of both the carbonyl and the hydroxyl groups. In most reactions of carboxylic acids the carboxyl group is retained however, the reactivity of these molecules is a consequence of the presence of the carbonyl group.

13.6 Reactions of Carboxylic Acids

Carboxylic acids undergo the following type of reactions.

a) The reactions in which hydrogen atom of the carboxyl group is involved (salt formation).
b) The reactions in which OH group is replaced by another group.
c) The reactions involving carboxyl group as a whole.

(a) Reactions Involving H Atom of the Carboxyl Group

Carboxylic acids are weaker acids than mineral acids. They furnish H^+ when dissolved in water.

In the presence of water (H_2O), the proton breaks away as H_3O^+ ion.

1. Reactions with Bases
Carboxylic acids react with bases (NaOH, KOH) to form salts

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

2. Reactions with Carbonates and Bicarbonates
Carboxylic acids decompose carbonates and bicarbonates evolving carbon dioxide gas with effervescence.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COO^-Na^+ + CO_2 + H_2O$$

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COO^-Na^+ + CO_2 + H_2O$$

3. Reactions with Metals
Carboxylic acids react with active metals (Na, K, Ca, Mg etc) to form their salts with the evolution of hydrogen gas.

$$2CH_3COOH + 2Na \rightarrow 2CH_3COO^-Na^+ + CO_2 + H_2$$

(b) Reactions Involving the – OH Group of Carboxylic Acids

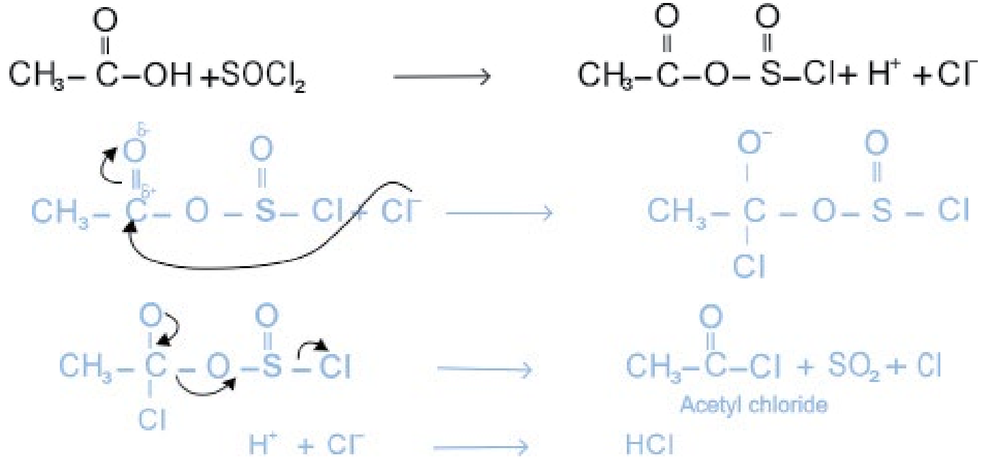
The carboxylic acid contains – C(=O) – OH functional group, and like the carbonyl group of aldehydes and ketones, is susceptible to attack by a nucleophile. The addition of a nucleophile to the carboxyl group is always followed by the displacement of the –OH group by some other group, producing a carboxylic acid derivative. The –OH group can thus be replaced by X, OR and NH_2 to form halides, esters and amides,respectively.

1 . Reactions with PCl_5 and $SOCl_2$

(a) $CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$

(b) $CH_3COOH + SOCl_2 \rightarrow CH_3COCl + SO_2 + HCl$

Mechanism



2. Formation of an Ester

When carboxylic acids are heated with alcohols in the presence of concentrated H_2SO_4, esters are formed.

$$CH_3COOH + C_2H_5OH \xrightarrow{H_2SO_4} CH_3COOC_2H_5 + H_2O$$

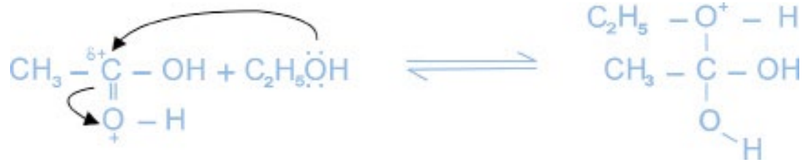
Animaton 13.8 : Ester formation
ource & Credit : Dynamicscience

Mechanism

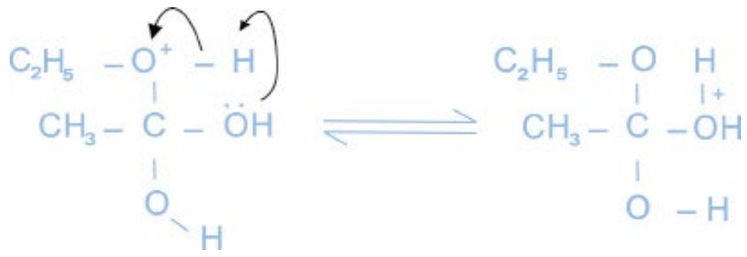
The various steps of the above reactions are as follows:

(i) Protonation of Carboxylic Acid

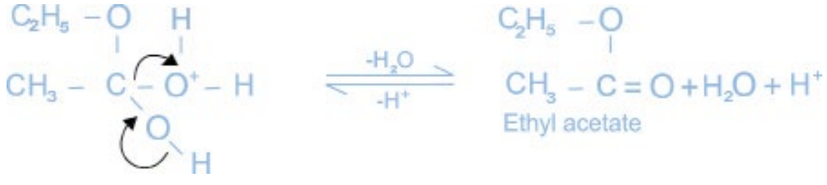
(ii) Attack of $CH_3 – CH_2OH$



(iii) Hydrogen Ion Transfer



(iv) Elimination of Water and H^+



Esters have fruity smell and are used as artificial flavours. Flavours of some estersare listed in the table.

3.Formation of Amide (Reaction with ammonia)

Carboxylic acids react with ammonia to form ammonium salts which on heating produce acid amides.

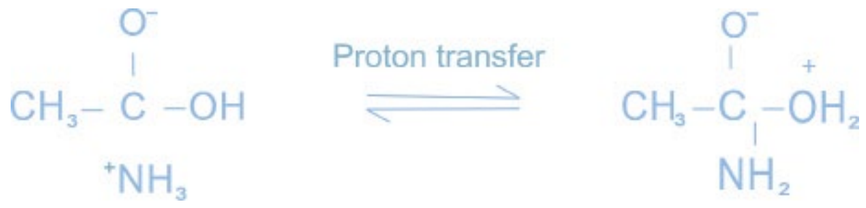
Ester	Flavour
Amylacetate	Banana
Isobutyl formate	Raspberry
Benzylacetate	Jasmine
Ethyl butyrate	Pineapple
Amyl butyrate	Apricot
Octyl acetate	Orange

(i) $CH_3COOH + NH_3 \rightarrow CH_3COONH_4$

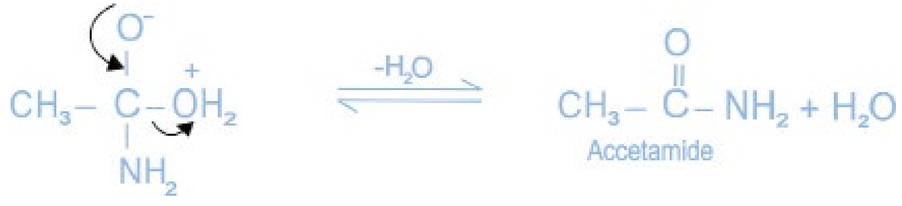
$$CH_3COO^-N^+H_4 \xrightarrow{Heat} CH_3CONH_2 + H_2O$$

Mechanism

(ii)

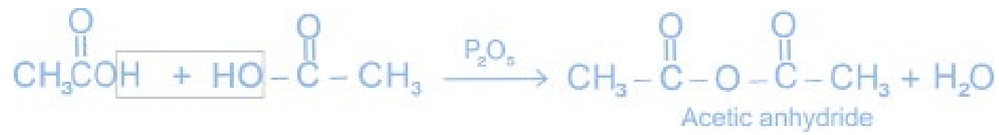


(iii)



4. Formation of Acid Anhydride

Carboxylic acids are dehydrated on heating strongly in the presence of phosphorus pentoxide.



(c) Reactions Involving Carboxyl Group ($-\overset{O}{\overset{\|}{C}}-OH$)

i. Partial Reduction to Alcohols

Carboxylic acids on reaction with lithium aluminium hydride ($LiAlH_4$) are reduced to alcohols.

ii) Complete Reduction to Alkanes

Carboxylic acids on reduction with HI and red phosphorus give alkanes.

$$CH_3COOH + 6HI \xrightarrow{P} CH_3{-}CH_3 + 2H_2O + 3I_2$$

13.7 ACETIC ACID

It is the most important carboxylic acid. Its dilute solution is known as vinegar. Acetic acid can be prepared by any of the general methods described earlier.

13.7.1 Laboratory Methods

1. By the Oxidation of Ethyl Alcohol or Acetaldehyde

When ethyl alcohol is oxidised with $K_2Cr_2O_7$ and dilute H_2SO_4, acetic acid is produced.

$$CH_3—CH_2OH + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3CHO \xrightarrow{[O]} CH_3COOH$$

2. By the Hydrolysis of Methyl Cyanide

Ethanenitrile on hydrolysis with dilute HCI, gives acetic acid through acetamide.

$$CH_3CN \xrightarrow{H_2O/H^+} \underset{\text{Acetamide}}{CH_3-CO-NH_2} \xrightarrow{H_2O/H^+} CH_3COOH + NH_4^+$$

13.7.2 Manufacture of Acetic Acid

1 . From Acetylene

Acetylene is treated with 20% H_2SO_4 and 1.0% $HgSO_4$ at 80°C to give ethanal (acetaldehyde) which is then oxidised using V_2O_5 to give acetic acid.

$$HC \equiv CH + H_2O \xrightarrow[HgSO_4]{H_2SO_4} CH_2=CH-OH \rightleftharpoons CH_3-\overset{O}{\overset{\|}{C}}-H \xrightarrow[\text{Oxidation}]{V_2O_5} CH_3COOH$$

2. Acetic acid is also prepared commercially by the oxidation of ethyl alcohol.Ethyl alcohol can be commercially prepared from molasses by a process called fermentation.It is oxidized by potassium dichromate in the presence of conc. sulphuric acid to give acetaldehyde which is further oxidized under the same conditions to give acetic acid.

$$CH_3-CH_2-OH + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3-\overset{O}{\overset{\|}{C}}-H + H_2O$$

$$CH_3-\overset{O}{\overset{\|}{C}}-H + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3COOH$$

13.7.3 Physical Characteristics

Acetic acid is a colourless liquid with a boiling point 118°C. It has a strong vinegar odour and sour taste. The pure acid freezes to an ice like solid at 17 °C, therefore, it is called glacial acetic acid. It is miscible with water, alcoholand ether in all proportions.

13.7.4 Reactions of Acetic Acid

Chemical reactions of acetic acid have already been discussed in the general properties of the carboxylic acids.

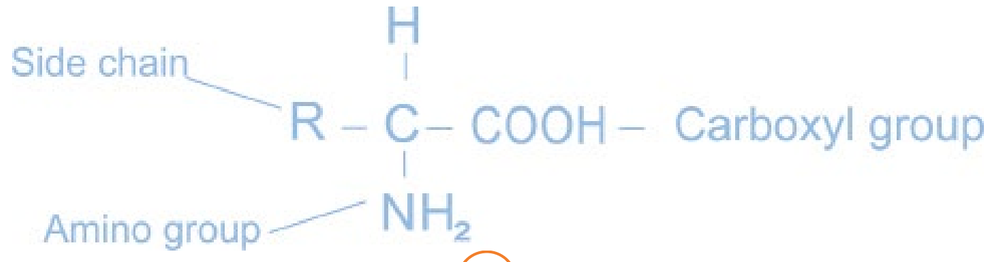
13.7.5 Uses of Acetic Acid

Acetic acid is used:

i) as a coagulant for latex in rubber industry.
ii) in the manufacture of plastics (polyvinyl acetate) rayon (cellulose acetate) and silk.
iii) in medicine as a local irritant.
iv) as a solvent in the laboratory for carrying out reactions.
v) in the manufacture of pickles.
vi) in the manufacture of many organic compounds like acetone, acetates and esters.

13.8 AMINO ACIDS

Amino acids are organic compounds containing both amino and carboxyl groups. They are represented by the general formula:



R is different for different amino acids. The amino group may be present at any carbon atom other than that of the carboxyl group (COOH). They are referred to as α, β, γ depending upon whether the amino group is present on the α, β, or γ carbon atom relative to the carboxyl group. Almost all the naturally occurring amino acids are α – amino acids. These amino acids are very important because they are the building blocks of proteins. Proteins are very important for us.

The amino acids which contain two carboxyl groups are called acidic amino acids while those containing two amino groups are called basic amino acids. For example, glutamic acid and aspartic acid are acidic amino acids while lysine is a basic amino acid.

About twenty amino acids have been identified as the constituents of most of the animal and plant proteins.

13.8.1 Essential and Non-essential Amino Acids

Out of twenty amino acids which are required for protein synthesis, the human body can synthesize only ten. The amino acids which body can synthesize are called non-essential amino acids. The remaining ten amino acids which the body is not able to synthesize are called essential amino acids.

The essential amino acids must be supplied to our bodies through our diet because they are required for proper health and growth. The deficiency of essential amino acids may cause diseases.

13.8.2 Nomenclature of Amino Acids

Although amino acids can be named according to IUPAC system, they are generally known by their trivial names. These trivial names usually reflect the origin or an obvious property of the compound.

Glycine, for example is so named, because it has a sweet taste (Greek glykys - sweet) and the tryosine was first isolated from cheese (from Greek tryos-cheese). For the sake of simplicity, each amino acid has been given an abbreviation w'hich generally consists of the first three letters of the common name.

For example, the simplest amino acid is glycine H_2NCH_2 COOH. It may be abbreviated as Gly. Similarly, alanine $CH_3-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$ may be represented as Ala.

Names, structural formulae and other features of some amino acids are given in Table 13.2.

Table 13.2 Names, structural formulae and other features of amino acids

	Name	Nature	Abbreviation	Structural formula
1	Glycine	Neutral	Gly	$\underset{\displaystyle NH_2}{\underset{|}{CH_2}}-COOH$
2	Alanine	Neutral	Ala	$CH_3-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$
3	Valine	Neutral	Val	$CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$
4	Proline	Neutral	Pro	$H_2C-\underset{\displaystyle H_2C}{\underset{|}{CH_2}}\!\!\diagdown\!\!\underset{\displaystyle NH}{\underset{|}{CHCOOH}}$
5	Aspartic acid	Acidic	Asp	$HOOC-CH_2-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$
6	Glutamic acid	Acidic	Gla	$HOOC-CH_2-CH_2-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$
7	Lysine	Basic	Lys	$\underset{\displaystyle NH_2}{\underset{|}{CH_2}}-(CH_2)_3-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$
8	Histidine	Basic	His	$\underset{\displaystyle N}{\underset{|}{CH}}=\underset{\displaystyle NH}{\underset{|}{C}}-CH_2-\underset{\displaystyle NH_2}{\underset{|}{CH}}-COOH$ $\diagdown\!\!\underset{\displaystyle CH}{/}$

13.8.3 Structure of Amino Acids

The amino acids exist as dipolar ion called Zwitter ion. It has positive as well as negative ends within the same molecule. In the formation of Zwitter ion, the proton goes from the carboxyl group to amino group. The Zwitter ionic structure of an amino acid may be written as:

Animaton 13.9 : Formation of the peptide bond
ource & Credit : Researchpeptides

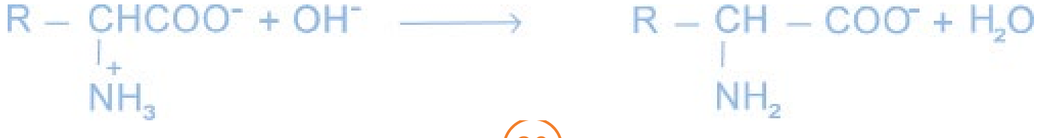
The dipolar structure is also called internal salt. All α - amino acids exist largely in dipolar ionic forms.

13.8.4 Acidic and Basic Characters of Amino Acids

On the basis of dipolar ion structure, the acidic and basic reactions of amino acids may be represented as :

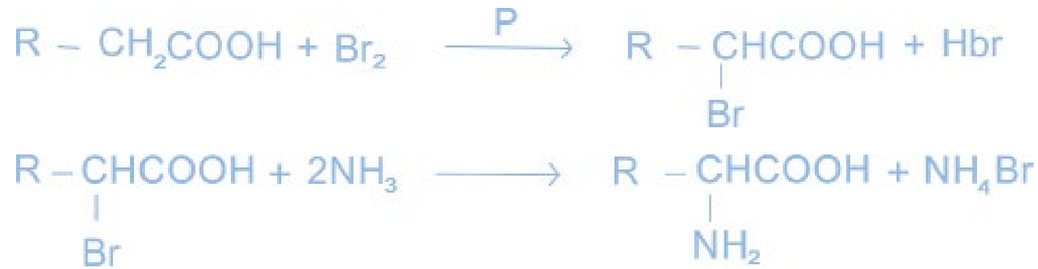
1. When an acid is added to an amino acid the carboxylate ion accepts the proton and, therefore, the basic character is due to this group.

2. When an alkali is added to an amino acid, – NH_3 group releases the proton and therefore the acidic character is due to this group.



13.8.5 Synthesis of Amino Acids

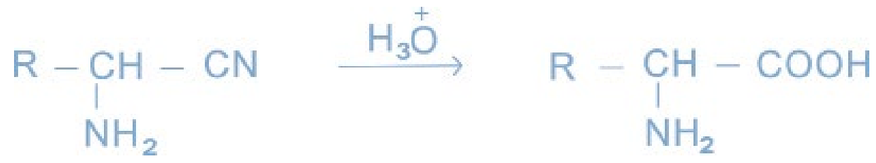
Amino acids can be synthesized by the following reactions.
1. By the reaction of α - bromoacid with ammonia.



2. The Strecker Synthesis

When hydrogen cyanide is added to an aldehyde in the presence of ammonia, α - amino acid is obtained.

α - amino nitdle upon acidic hydrolysis yields an α - amino acid:



13.8.6 Reactions of Amino Acids

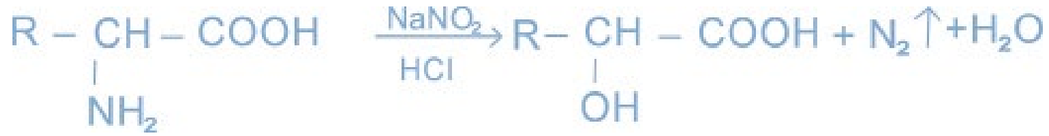
Amino acids undergo many chemical reactions characteristics of either amino group or carboxyl group.

1. Esterification

Amino acids form aminoester when treated with an alcohol in the presence of catalytic amount of a strong acid.

2. Reaction with Nitrous Acid

Amino acids react with nitrous acid to produce α - hydroxy carboxylic acid and nitrogen gas.



13.8.7 Test of Amino Acids

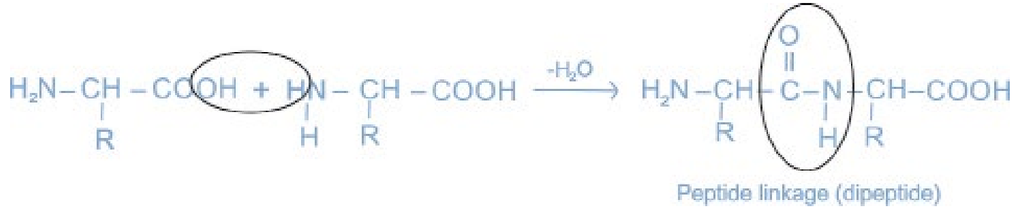
Ninhydrin Test

Ninhydrin reacts with amino acid to form an intensely coloured bluish violet product. The ninhydrin reaction is also widely used to "visualize" amino acids separated by paper chromatography.

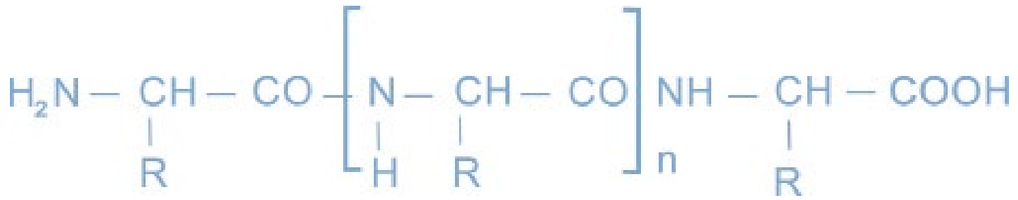
13.8.8 Peptidos and Proteins

Peptides are the compounds formed by the condensation of two or more same or different a-amino acids. The condensation occurs between amino acids with the elimination of water. In this case, the carboxyl group of one amino acid and amino group of another amino acid gets condensed with elimination of water. The resulting – CO – NH – linkage is called a peptide linkage.

The formation of peptide is shown below:



If a large number of amino acids (hundreds to thousands) are joined by peptide bonds, the resulting polymide is called a polypeptide.



Depending upon the number of amino acids per molecule, the peptides are dipeptides, tripeptides, polypeptides, etc. The formation of peptide bonds can continue until a molecule containing several hundred thousand amino acids is formed. Such a molecule is called polypeptide or protein. By convention a peptide having molecular mass upto 10,000 is called a polypeptide while a peptide having a molecular mass more than 10,000 is called a protein.

KEYPOINTS

1. Organic compounds containing carboxyl group (–C(=O)–OH) are called carboxylic acids. There are two classes of carboxylic acids i.e., aliphatic and aromatic carboxylic acids. Aliphatic carboxylic acids are also called fatty acids
2. Carboxylic acids can be produced by the oxidation of alcohols and aldehydes and by the hydrolysis of nitriles.
3. Lower members of the series are water soluble and have pungent smell. Solubility decreases with the increase in molecular mass.
4. Carboxylic acids have higher boiling points than the corresponding alcohols. Boiling point increases with the increase in the molar mass.
5. Acid chlorides, acid amides, esters and acid anhydrides are called derivatives of carboxylic acids.
6. Acetic acid is synthesized on commercial scale from acetylene.
7. Carboxylic acids containing amino group in their molecules are called amino acids. They are classified as neutral, basic and acidic amino acids.
8. Amino acids join together to produce peptides. A polypeptide has a molecular mass upto 10,000 whereas the molecular mass of protein is greater than 10,000.

EXERCISE

Q. 1 Fill in the blanks.

(i) Formula of malonic acid is_____.
(ii) Methyl nitrile upon acidic hydrolysis produces_____ .
(iii) Melting points of carboxylic acids containing even number of carbon atoms are_____ than the next lower and higher members containing odd number of carbon atoms.
(iv) Acetic acid on heating with_____produces acetic anhydride.
(v) Acid chloride and acid anhydride are called_____ of acid.
(vi) Pure acetic acid is called _____ .
(vii) Fox mula of alanine is_____.
(viii) Proline is a_____ amino acid.
(ix) A peptide having a molecular mass more than 10000 is called_____.

Q. 2 Indicate True and False.

(i) Acetic acid exists as a dimer in benzene.
(ii) First three aliphatic acids have fruity smells.
(iii) Carboxylic acids on reduction with $LiAlH_4$ produce alkenes.
(iv) Acetic acid on dehydration produces CO and H_2.
(v) Sodium formate on heating with soda lime produces $NaHCO_3$ and hydrogen.
(vi) Amino acids exist as Zwitter ion.
(vii) Histidine is an acidic amino acid.
(viii) A peptide having molecular mass upto 10000 is called protein.
(ix) Phthalic acid is a monocarboxylic acid.
(x) Formula of glycine is CH_2COOH.

Q. 3 Multiple choice questions. Encircle the correct answer.

(i) Acetic acid is manufactured by
(a) distillation (b) fermentation (c) ozonolysis (d) esterification

(ii) A carboxylic acid contains
(a) a hydroxyl group (b) a carboxyl group
(c) a hydroxyl and carboxyl group (d) a carboxyl and an aldehydic group

(iii) Which acid is used in the manufacture of synthetic fibre
(a) formic acid (b) oxalic acid (c) carbonic acid (d) acetic acid

(iv) Which following derivative can not be prepared directly from acetic acid.
(a) acetamide (b) acetyl chloride (c) acetic anyhdride (d) ethyl acetate

(v) Which reagent is used to reduce a carboxylic group to an alcohol.
(a) H_2/Ni (b) H_2/Pt (c) $NaBH_4$ (d) $LiAlH_4$

(vi) The solution of which acid is used for seasoning of food.
(a) formic acid (b) acetic acid (c) benzoic acid d) butanoic acid

(vii) Organic compounds X and Y react together to form organic compound Z. What type of compounds can X, Y and Z be?

	X	Y	Z
(a)	alcohol	ester	acid
(b)	acid	ester	alcohol
(c)	ester	alcohol	acid
(d)	alcohol	acid	ester

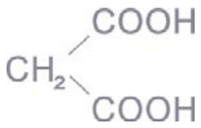
(viii) An aqueous solution of an organic compound reacts with sodium carbonate to produce carbon dioxide gas. Which one of the following could be the organic compound.
(a) $CH_2 = CH - CH_3$ (b) $CH_3 - CHO$
(c) $CH_3COOC_2H_5$ (d) $CH_3 - CH_2 - COOH$

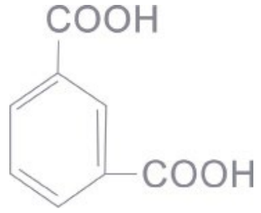
(ix) Which of the following is not a fatty acid?
(a) propanoic acid (b) acetic acid
(c) phthalic acid (d) butanoic acid

(x) Acetamide is prepared by
(a) heating ammonium acetate (b) heating methyl cyanide
(c) heating ethyl acetate (d) the hydrolysis of methyl cyanide

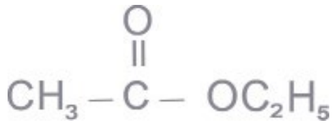
Q. 4 Write down the structural formulae of the followings
(i) Valeric acid (ii) Propionic acid (iii) Oxalic acid
(iv) Benzoic acid (v) Acetic anhydride (vi) Acetyl chloride

Q. 5 Write down the names of the following compounds by IUPAC system.

(i) 

(ii) 

(iii) 

(iv) 

(v) CH_2COOH
NH_2

(vi) $HCOOC_3H_7$

Q. 6 (a) How is acetic acid manufactured? What is glacial acetic acid?
(b) How would you convert acetic acid into the following compounds?
(i) Methane (ii) Acetyl chloride (iii) Acetamide
(iv) Acetic anhydride

Q. 7 (a) What are fatty acids ?
(b) What is vinegar? Describe how is vinegar prepared from ethanol?

Q. 8 How would you carry out the following conversions?
(i) Acetic acid into acetamide (ii) Acetic acid into acetone

Q. 9 Write down the mechanisms of the following reactions.
(i) between acetic acid and ethanol (ii) between acetic acid and ammonia
(iii) between acetic acid and thionyl chloride

Q. 10 What happens when the following compounds are heated.
(i) Calcium acetate (ii) Sodium formate and soda lime
(iii) Ammonium acetate

Q. 11 What are amino acids? Explain their different types with one example in each case.

Q. 12 Write a short note on acidic and basic characters of an amino acid.

Q. 13 What is a peptide bond? Write down the formula of a dipeptide.

Q. 14 What are zwitter ions?

Q. 15 What are a amino acids, proteins and peptides? How are they related?

Q. 16 Study the facts given in (a), (b) and (c) below and then answer questions which follow.
(a) A is an organic compound made up of C, H and O. It has a vapour density 15. [Hint: Molecular mass = 2 x vapour density].
(b) On reduction A gives a compound 'X' which has the following properties.
(i) X is a colourless liquid miscibie with water.
(ii) X is neutral to litmus.
(iii) When X is warmed with a few drops of conc. H_2SO_4 followed by a little salicylic acid a characteristic smell is produced.
(c) When X is subjected to strong oxidation, it gives compound B, which has the following properties.
(i) B is a pungent smelling mobile liquid.
(ii) It is miscible with water, alcohol or ether.
(iii) It is corrosive and produces blisters on contact with skin.
(iv) B can be obtained by passing the vapours of A with air over platinum black catalyst.
(v) B liberates H, with sodium.
(vi) It givesCO_2 with $NaHCO_3$.
1. What is the molecular mass of A?
2. Identify A, X and B.
3. Give five appropriate reactions to confirm the identities of A, X and B.
4. State one large-scale use of either A, X or B.