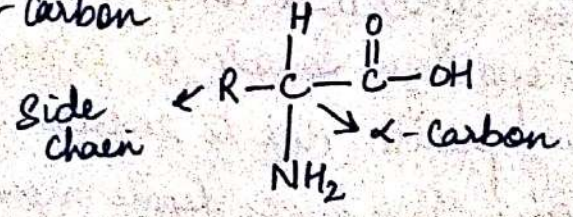
Amino Acids Peptides and Protein

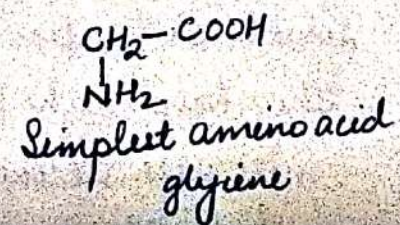
Proteins are the most abundant organic molecules in animals and human beings. We consume proteins primarily for growth and maintenance. Any balance diet must Contain adequate amount of proteins. They perform a variety of functions in living organisms. They are the principal material of muscles, skin, tendons, nerves and blood. As enzymes and hormones, proteins catalyse and regulate the reactions that occur in the body; as haemoglobins they transfer oxygen to its most remote corners.

Proteins are biopolymers of α-amino acids. They consist of long chains of α-amino acids bonded to each other by amide bonds also known as peptide linkages between the Carboxylic group of one amino acid with amino group of another. Thus, proteins are high molecular weight polypeptides. Their molecular weight may range from 5000 - 1,00,000 units.

Hydrolysis of proteins with acid or base yield a mixture of different amino acids. Naturally occuring proteins on hydrolysis may yield twenty-two different amino acids.

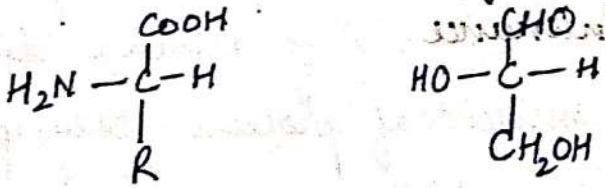
The naturally occuring prevalent amino acid are α-amino acids These are Carboxylic acids where amino functional group is present at α-Carbon





Simplest amino acid glycine

With exception to glycine (acheral) all naturally occuring amino acids have the L-configuration at α-Carbon. That means they have the same relative configuration as L-glyceraldehyde



An-L amino Acid

L-Glyceraldehyde

Amino acids differ from one another in the nature of side chain groups R. Therefore, the properties of the side chains of amino acids determine the properties of the proteins they constitute.

Classification of Amino acids

1) Neutral Amino acids
2) Acidic Amino acids
3) Basic Amino acids

Largest number of amino acid belongs to neutral amino acids. These neutral amino acids are further classified as Aliphatic neutral amino acids, Aromatic neutral amino acids, Sulfur containing neutral amino acids, Heterocyclic neutral amino acids

Based on their nutritional importance they are classified as Essential Amino acids, Semi essential and non essential amino acids.

Physical Properties

Amino acids are colourless, crystalline compounds which are generally soluble in water but sparingly soluble in organic solvent. They have high melting points (due to zwitter ion structure) most melt with decomposition. They have dipole moments and high dielectric constant.

All these properties show that amino acids exist as dipolar ions.

As evident from their general formula amino acids contain both an acidic carboxyl group and a basic amino group. These two groups interact and thus affect the properties of each other. Acutally they neutralize each other involving transfer of a proton from carboxyl group to the amino group with in the molecule.

As a result, amino acids largely exist as dipolar ions.

$$R-\underset{NH_2}{\underset{|}{CH}}-COOH \rightleftharpoons R-\underset{{}^{+}NH_3}{\underset{|}{CH}}-COO^-$$

Zwitter ion

The dipolar structure is commonly known as Internal salt or Zwitter ion.

In aqueous solution an equilibrium exist between the dipolar ion, anionic form and cationic form of amino acid.

$$H_3\overset{+}{N}-\underset{R}{\underset{|}{CH}}-COOH \underset{H_3O^+}{\overset{OH^-}{\rightleftharpoons}} H_3\overset{+}{N}-\underset{R}{\underset{|}{CH}}-COO^- \underset{H_3O^+}{\overset{OH^-}{\rightleftharpoons}} H_2N-\underset{R}{\underset{|}{CH}}-COO^-$$

(I) (II) (III)

The predominant form of the amino acid in the solution depends on the pH of the solution and on the nature of amino acid. For each amino acid there is a particular pH value at which conc. of dipolar ion is maximum.

At some intermediate pH the conc. of cationic form (I) & anionic form (II) will become equal and consequently amino acids exist as neutral dipolar ion. At this pH there will be no net migration of amino acid in an electric field. This pH at which there is no net migration of amino acid under the influence of

an applied electric field called isoelectric point. Each amino acid has a characteristic isoelectric point. For a neutral amino acid isoelectric point is slightly less than 7 (glycine = 6·1), for acidic amino acid isoelectric point lies between: 3·2 - 3·5 (Aspartic acid 3) and for basic amino acid it lies between pH 7·6 to 10·8

At isoelectric point, an amino acid has the property has been used in Separation of different amino acid obtained from hydrolysis of proteins

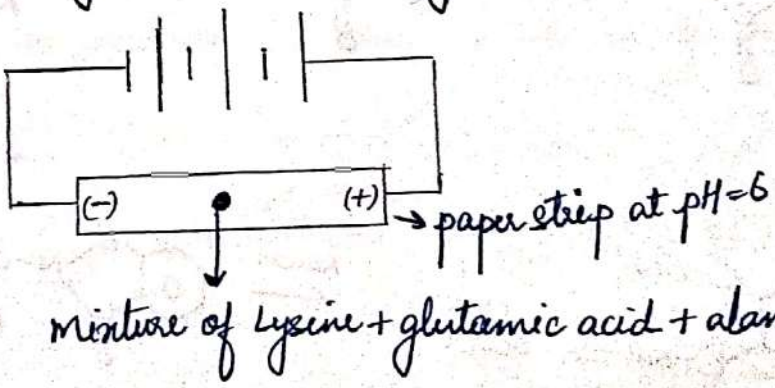
* Amino acids exist as cations (I) in acidic medium and migrate towards Cathode under the influence of electric field.
* Amino acids exist as anions (III) in basic medium and migrate towards anode under the influence of electric field.

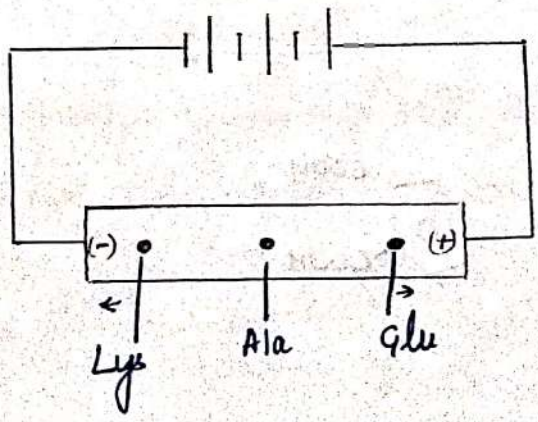
Electrophoresis:-

It is a method used for separation an analysis of Amino acids. This method is based upon pH control and electric charge. The amino acid differ in their isoelectric point. A mixture of amino acid is placed on the centre of a paper strip at a certain pH. The pH is maintained by saturating the paper strip with the buffer Solution. Paper strip is attached to electrodes. On passing electric current through the strip amino acid migrate towards electrodes depending upon the net charge present on them.

Ex- A mixture of lysine, alanine, glutamic acid at pH=6 when subjected to above conditions results in movement of glutamic acid towards anode and lysine towards cathode. Alanine has no net charge and therefore dosnot move. Ameno acid with isoelectric point greater than buffer pH gains a proton becomes positively charged (move towards cathode). On the other hand ameno acid with isoelectric point less than buffer pH loses a proton becomes negatively charged (move towards anode) The ameno acid with buffer and isoelectric point comparable dosnot migrate towards any electrode.

GluPI = 3.2
LysPI = 9.7
AlaPI = 6

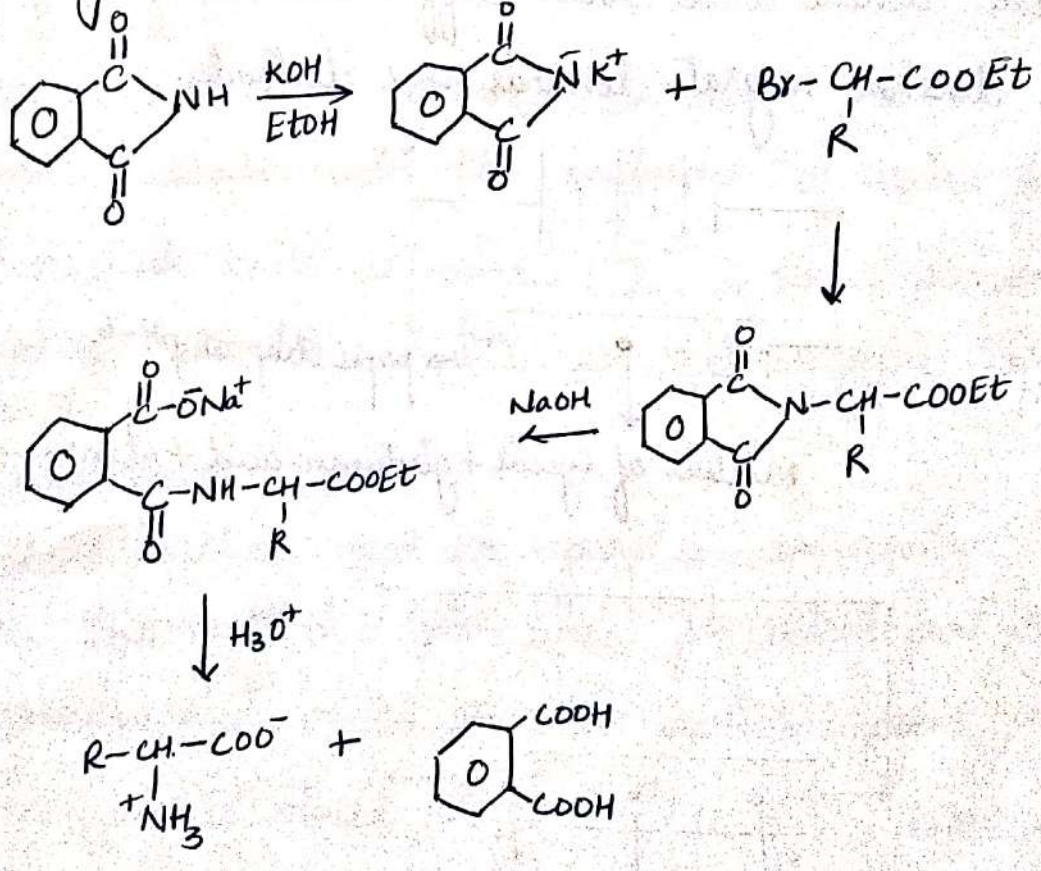




Synthesis

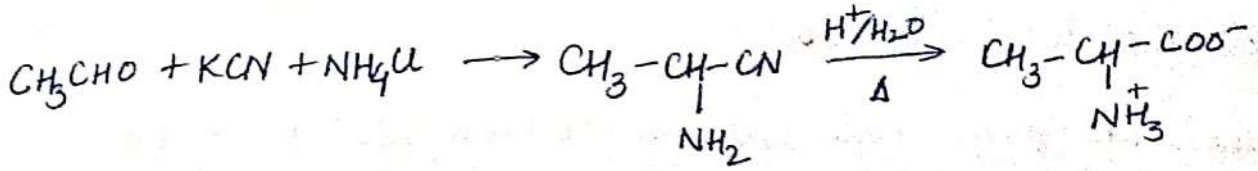
1) Gabriel phthalimide Synthesis :-

Better yields of amino acids are obtained by Gabriel Phthalimide Synthesis. The halogen in the α-haloesters is replaced by a phthalimido group either by fusion or by gentle heating with potassium phthalimide in DMF. The intermediate ester yield the desired amino acid by drastic hydrolysis or better in steps by treatment first with alkali followed by acid hydrolysis.



Strecker Synthesis :-

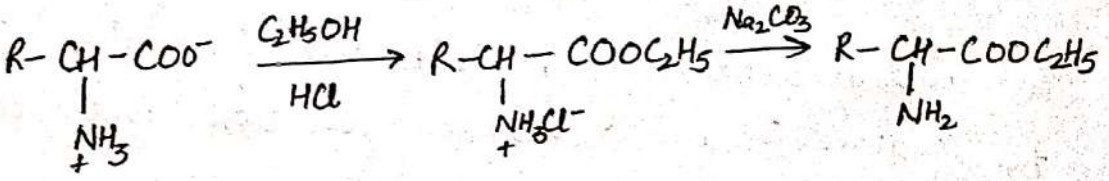
An aldehyde on reaction with KCN in presence of NH_3 or NH_4Cl result in the formation of α-amino nitrile. Hydrolysis of α-amino nitrile in acidic medium yields an α-amino Carboxylic acids. Reaction Basically involves conversion of aldehydes to α-amino Carboxylic acid one more Carbon than the parent aldehyde.



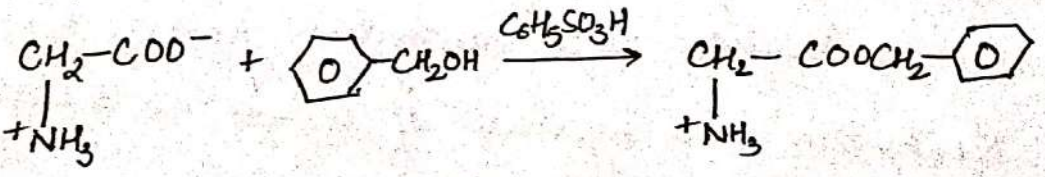
Reactions of Amino acids:-

① Esterification :-

The amino acid reacts with alcohol to produce ester hydrochloride The free ester may be obtained by the action of aqueous Na_2CO_3 on the ester salt.

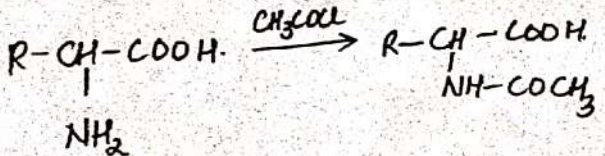


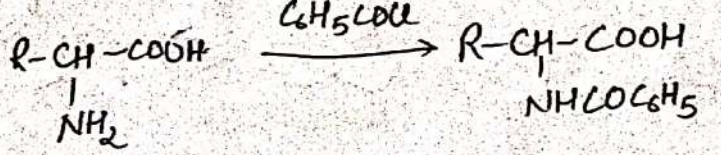
Benzyl esters are often prepared by using benzene sulphonic acid as the Catalyst. The water produced in the reaction is removed by azeotropic distillation



② Acetylation:

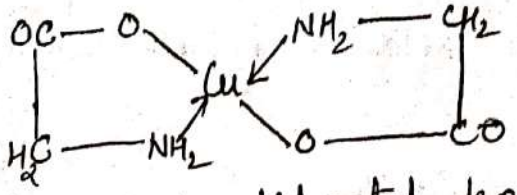
The amino group of amino acid reacts readily with acid Chloride, acetic anhydride to form N-acetyl derivative





Complexation with Cu^{2+} ions :-

Amino acids form salts with metal ions; the salt of the heavy metals are chilate compounds. The copper salt of glycine which has deep blue colour (needle) is formed by heating copper oxide with an aqueous of glycine.



The amino acid may be liberated from their alkali salts by treatment in ethanolic solution with ethyloxoamino cyanoacetate.

Ninhydrin Reaction :-

This reaction is used for identification of amino acids as amino acid on reaction with ninhydrin gives a blue voilet colour. Ninhydrin is a hydrate of indane-1,2,3 trione.