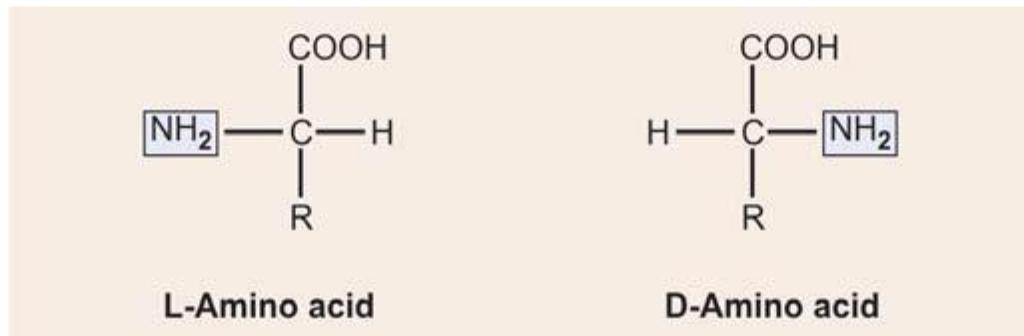


## PROPERTIES OF AMINO ACIDS

**A. Isomerism:** Two types of isomerism are shown by amino acids basically *due to the presence of asymmetric carbon atom. Glycine has no asymmetric carbon atom in its structure hence is optically inactive.*

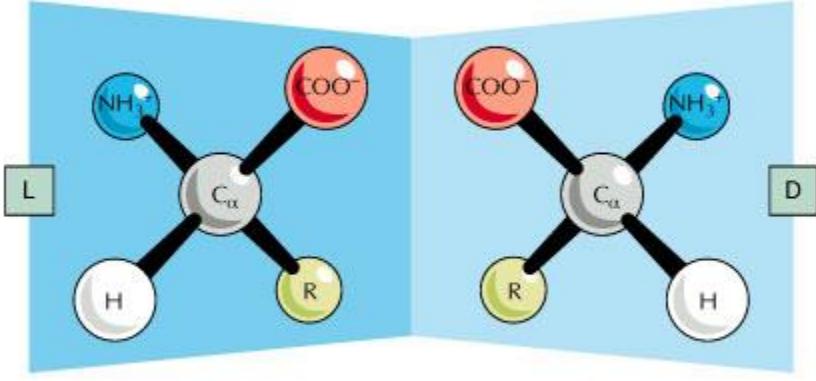
(a) Stereoisomerism: All amino acids except glycine exist in D and L isomers. In D-amino acids – NH<sub>2</sub> group is on the right hand while in L-amino acids it is oriented to the left. It is the same orientation of – OH group of the central carbon of glyceraldehyde. Natural proteins of animals and plants generally contain L-amino acids. D-amino acids occur in bacteria.



(b) Optical Isomerism: All amino acids except glycine have asymmetric carbon atom. Few amino acids like isoleucine and threonine have an additional asymmetric carbon in their structures. Consequently all but glycine exhibit ‘optical’ activities and rotate the plane of plane polarized light and exist as dextrorotatory (d) or laevorotatory (l) isomers. Optical activity depends on the pH and side chain.

**OPTICAL ISOMERS**

The  $\alpha$ -carbon atom is asymmetric, which allows for two mirror image (or stereo-) isomers, L and D.

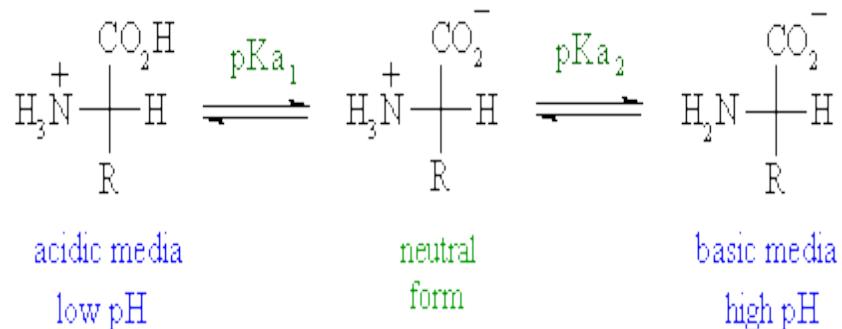


Proteins consist exclusively of L-amino acids.

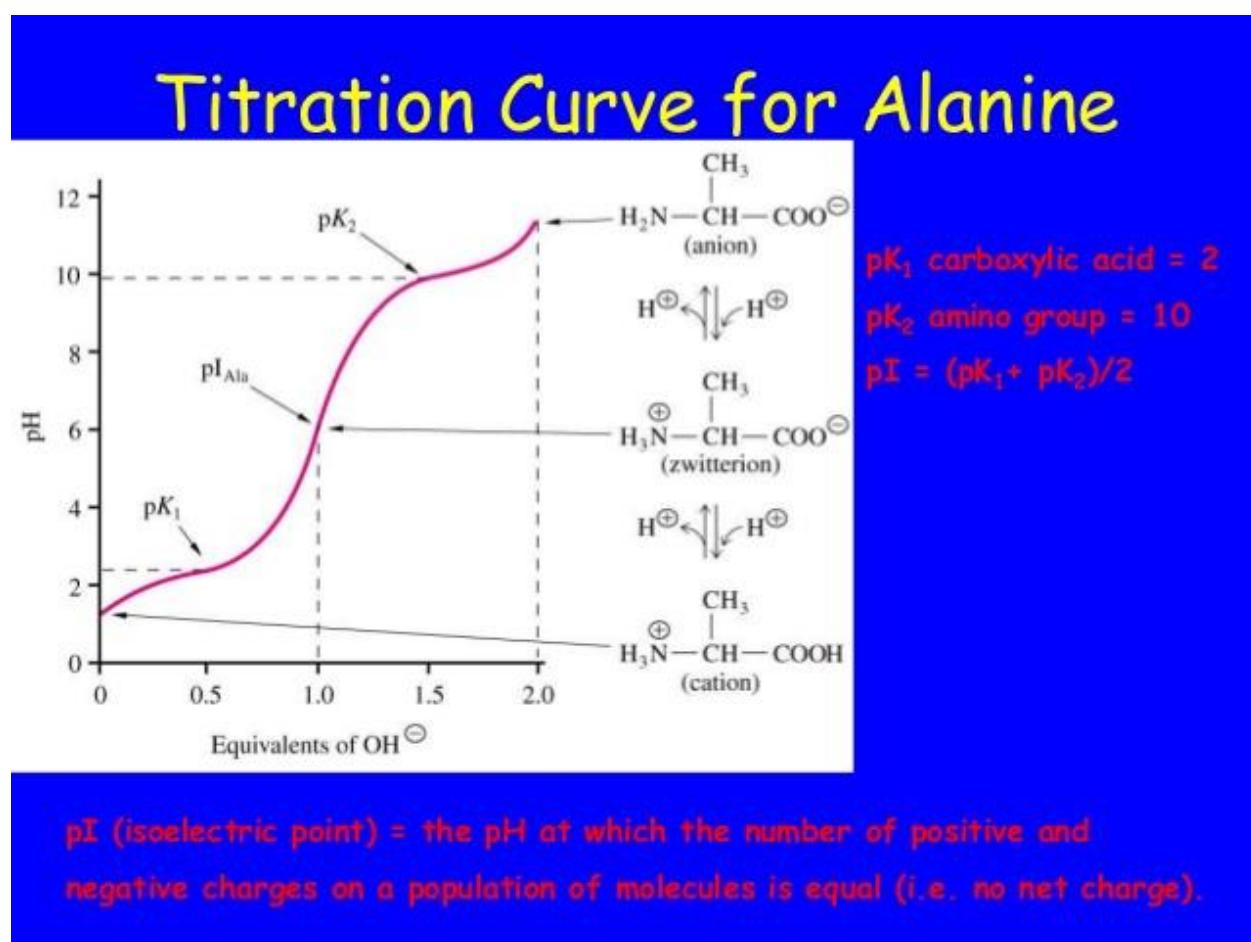
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**B. Amphoteric Nature and Isoelectric pH:** The  $-\text{NH}_2$  and  $-\text{COOH}$  groups of amino acids are ionizable groups. Further, charged polar side chains of few amino acids also ionize. Depending on the pH of the solution these groups act as proton donors (acids) or proton acceptors (bases). This property is called as amphoteric and therefore amino acids are called as ampholytes. At a specific pH the amino acid carries both the charges in equal number and exists as dipolar ion or “Zwitterion”. At this point the net charge on it is zero, i.e. positive charges and negative charges on the protein/amino acid molecule equalizes. The pH at which it occurs without any charge on it is called pI or isoelectric pH. Therefore at isoelectric point, there is **no mobility in an electrical field**. Solubility and buffering capacity will be minimum at iso-electric pH. To such a solution if we add hydrochloric acid drop by drop, at a particular pH, 50% of the molecules are in cation form and 50% in zwitterion form. This pH is  $\text{pK}_1$  (with regard to  $\text{COOH}$ ). If more  $\text{HCl}$  is added, more molecules become cationic in nature and solubility increases. On the other hand, if we titrate the solution from iso-electric point with  $\text{NaOH}$ , molecules acquire the anionic form. When 50% of molecules are anions, that pH is called  $\text{pK}_2$  (with respect to  $\text{NH}_2$ ).

On the acidic side of its pI amino acids exist as a cation by accepting a proton and on alkaline as anion by donating a proton.



The iso-electric pH (pI) for mono amino mono carboxylic amino acids can be calculated :  $(\text{pK}_1 + \text{pK}_2)/2$   
e.g. pI of glycine =  $(2.4 + 9.8)/2 = 6.1$ .



In the case of amino acids having more than two ionizable groups, correspondingly there will be more pK values, e.g. Aspartic acid. It can be seen that **at physiological pH of 7.4, both carboxyl and amino groups of amino acids are completely ionized**. Thus to be very correct, zwitterion forms are to be shown as the structures of amino acids.

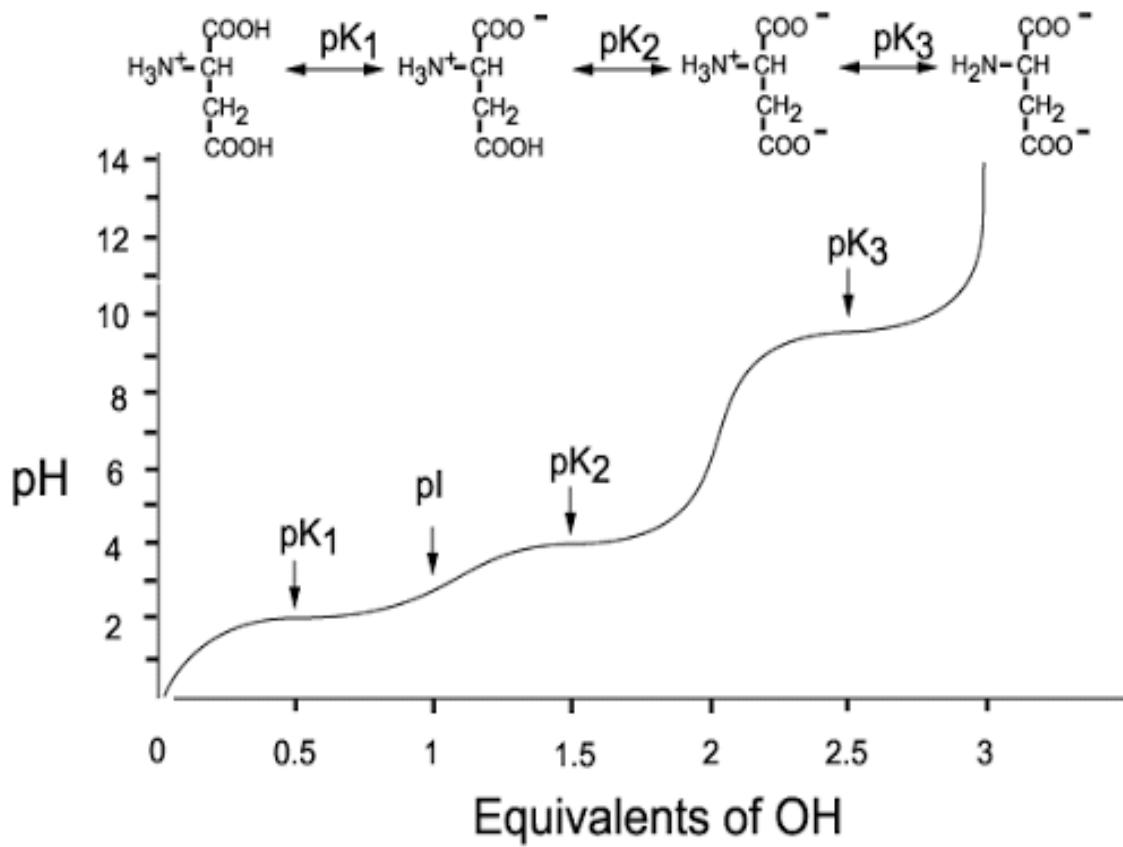


Figure: titration curve of aspartic acid with hydroxide

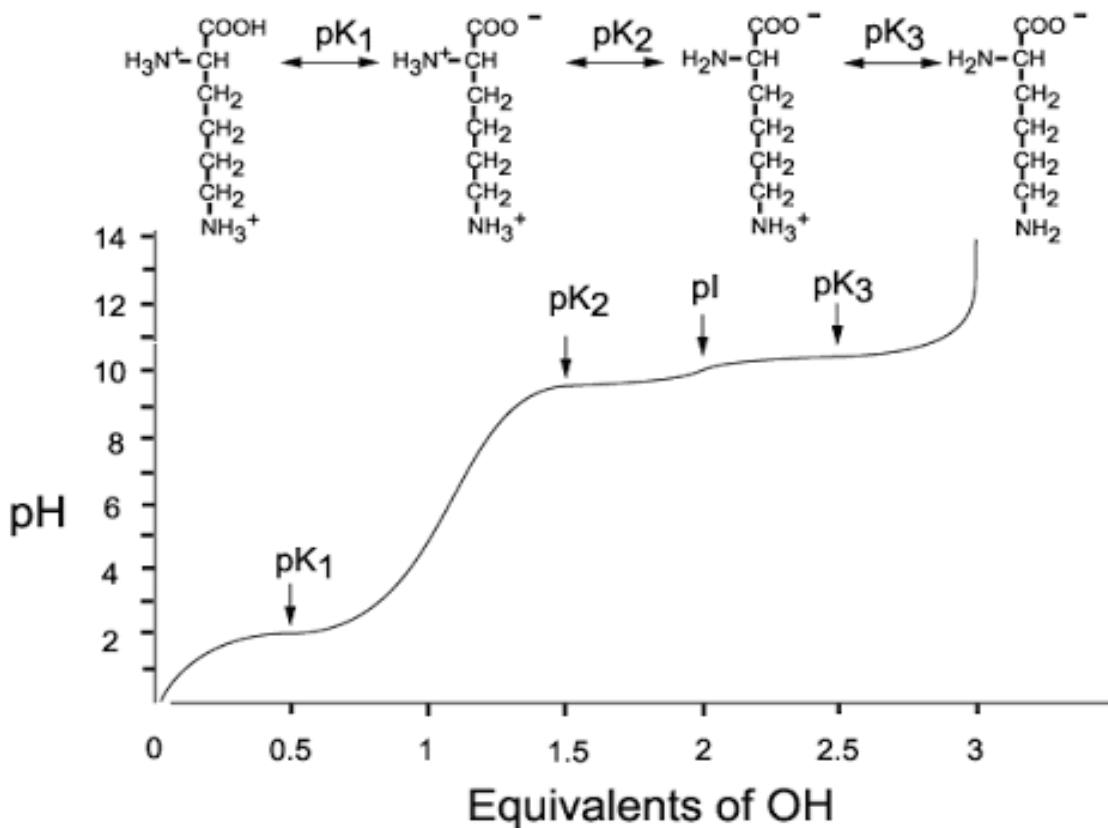


Figure: titration curve of Lysine with hydroxide

**C. Physical Properties:** They are colorless, crystalline substances, more soluble in water than in polar solvents. Tyrosine is soluble in hot water. They have high melting point usually more than 200°C. They have a high dielectric constant. They possess a large dipole moment.

## D. Chemical Properties

### I. Due to Carboxylic (—COOH) Group

#### 1. Decarboxylation

The amino acids will undergo alpha decarboxylation to form the corresponding amine. Thus, some important amines are produced from amino acids. For example, Histidine → Histamine + CO<sub>2</sub>

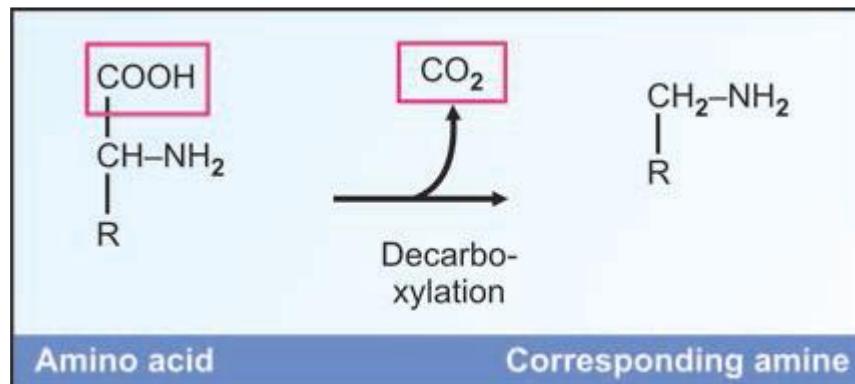


Figure: Decarboxylation of amino acid

### Amide Formation

The-COOH group of dicarboxylic amino acids (other than alpha carboxyl) can combine with ammonia to form the corresponding amide. For example,



These amides are also components of protein structure. The amide group of glutamine serves as the source of nitrogen for nucleic acid synthesis.

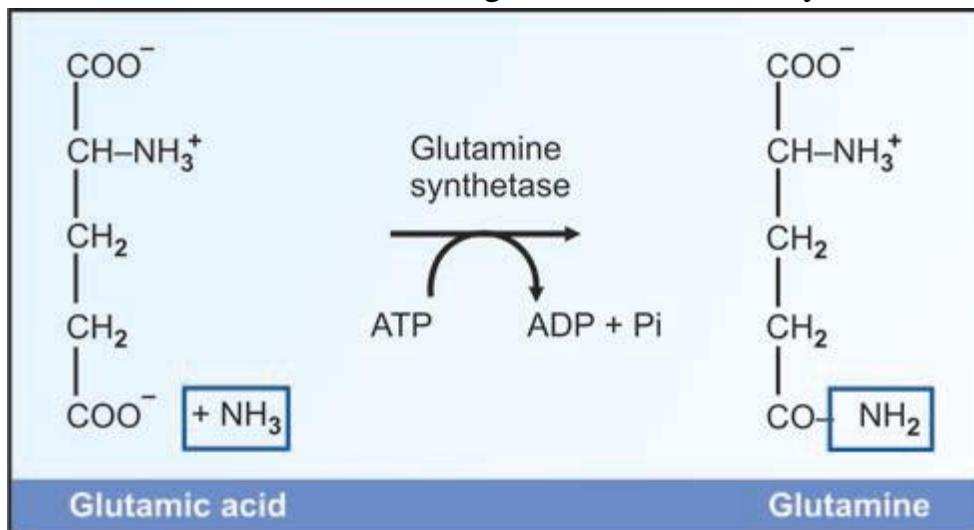


Figure: Formation of glutamine

## Due to Amino Group

### Transamination

The alpha amino group of amino acid can be transferred to alpha keto acid to form the corresponding new amino acid and alpha keto acid. This is an important reaction in the body for the interconversion of amino acids and for **synthesis of non-essential amino acids**.

### Oxidative Deamination

The alpha amino group is removed from the amino acid to form the corresponding keto acid and ammonia. In the body, **Glutamic acid** is the most common amino acid to undergo oxidative deamination.

### Formation of Carbamino Compound

Carbon dioxide adds to the alpha amino group of amino acids to form carbamino compounds. The reaction occurs at alkaline pH and serves as a mechanism for the transport of carbon dioxide from tissues to the lungs by hemoglobin



## Due to Side Chains

### Transmethylation

The methyl group of Methionine, after activation, may be transferred to an acceptor, which becomes methylated.



### Ester Formation by the OH Group

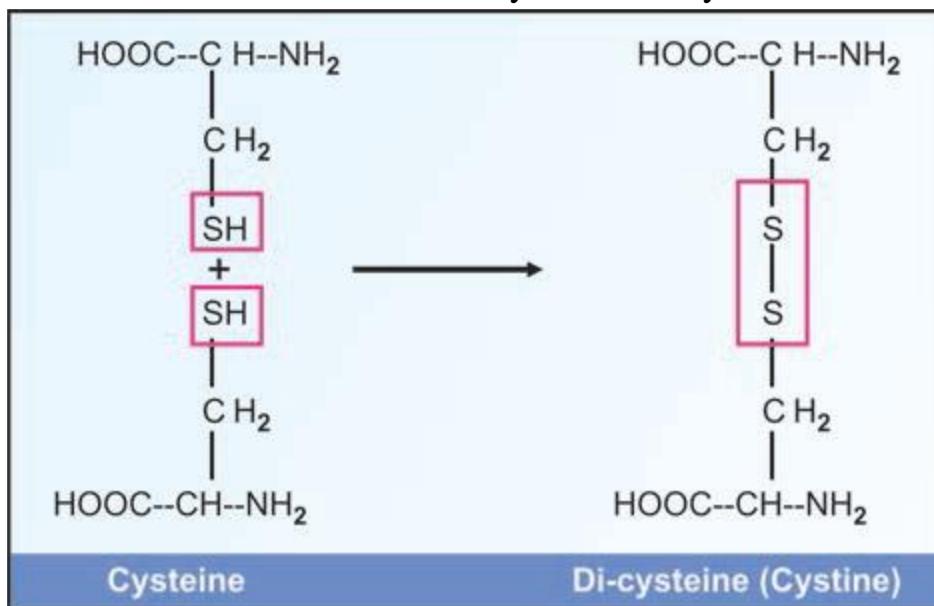
The hydroxy amino acids can form esters with phosphoric acid. In this manner, the Serine and Threonine residues of proteins are involved in the formation of phosphoproteins. Similarly, these hydroxyl groups can form O-glycosidic bonds with carbohydrate residues to form glycoproteins.

### Reaction of the Amide Group

The amide groups of Glutamine and Asparagine can form N-glycosidic bonds with carbohydrate residues to form glycoproteins.

## Reactions of SH Group

Cysteine has a sulphydryl (SH) group and it can form a disulfide (S-S) bond with another cysteine residue. The two cysteine residues can connect two polypeptide chains by the formation of interchain disulfide bonds or links. The dimer formed by two cysteine residues is sometimes called Cystine or Dicysteine.



**Figure:** Formation of disulphide bridges

## III. Properties of Amino acids Due to Both NH<sub>2</sub> and COOH Groups

In addition to the property of reacting with both cation and anion, the amino acids form chelated, co-ordination complexes with certain heavy metals and other ions. These include Cu<sup>++</sup>, Co<sup>++</sup>, Mn<sup>++</sup> and Ca<sup>++</sup>.

### Importance of side chains of amino acids:

$\alpha$  carboxy groups and  $\alpha$  amino groups in proteins are unavailable as they form peptide bonds; nature of side chains determine physical properties, including protein folding.

| Non-polar side chain | Uncharged polar side chains | Acidic side chains | Basic side chains |
|----------------------|-----------------------------|--------------------|-------------------|
| Alanine              | Asparagine                  | Aspartic acid      | Arginine          |
| Glycine              | Cysteine                    | Glutamic acid      | Histidine         |
| Isoleucine           | Glutamine                   |                    | Lysine            |
| Leucine              | Serine                      |                    |                   |
| Methionine           | Threonine                   |                    |                   |
| Phenylalanine        | Tyrosine                    |                    |                   |
| Proline              |                             |                    |                   |
| Tryptophan           |                             |                    |                   |
| Valine               |                             |                    |                   |

Found on the outside of proteins that function in an aqueous environment and in the interior of membrane-associated proteins

Found in the interior of proteins that function in an aqueous environment and on the surface of proteins (such as membrane proteins) that interact with lipids

## Summary

All amino acids except glycine exist in D and L isomers. The -NH<sub>2</sub> and -COOH groups of amino acids are ionizable groups. Further, charged polar side chains of few amino acids also ionize. At a specific pH the amino acid carries both the charges in equal number and exists as dipolar ion or zwitterion. Amino acid are colorless, crystalline substances, more soluble in water than in polar solvents. They have chemical properties due to carboxyl and amino groups, also they form chelated, co-ordination complexes with certain heavy metals and other ions.