GOVT. GENERAL DEGREE COLLEGE, CHAPRA

The Study Material for 6st Semester General (CBCS)

AMINO ACIDS

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1. Amino acids (A.A):

Amino acids are molecules that combine to form proteins. Amino acids and proteins are the building blocks of life. When proteins are digested or broken down, amino acids.

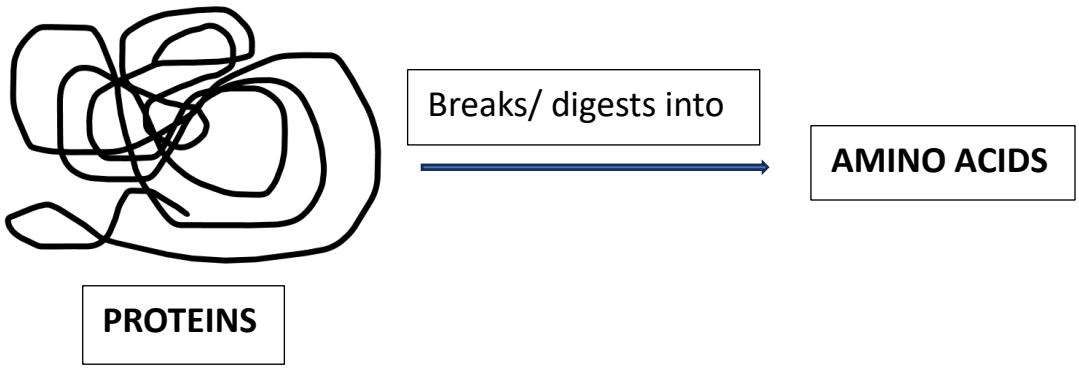

Figure-1.1. How amino acids produce

That means amino acids are the building blocks of proteins. They are the molecules that all living things need to make protein, and you need 20 of them to help your body function properly. Your body produces 11 of the necessary amino acids.

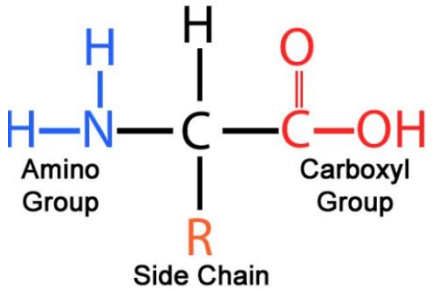

Figure-1.2. Structure of amino acid.

Glycine and alanine can combine with the elimination of a molecule of water to produce a dipeptide (Fig-1.3).

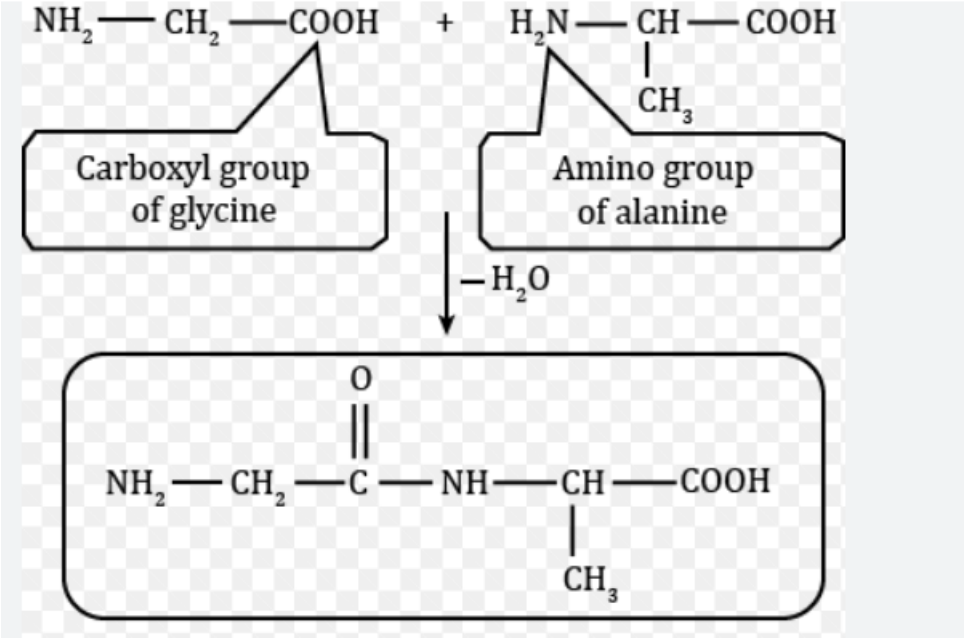

Figure-1.3. A dipeptide is formed by the combination of Ala and Gly.

2. Strecker synthesis of Amino acids:

The Strecker amino acid synthesis, also known simply as the Strecker synthesis, is a method for the synthesis of amino acids by the reaction of an aldehyde with cyanide in the presence of ammonia. The condensation reaction yields an α-aminonitrile, which is subsequently hydrolyzed to give the desired amino acid.

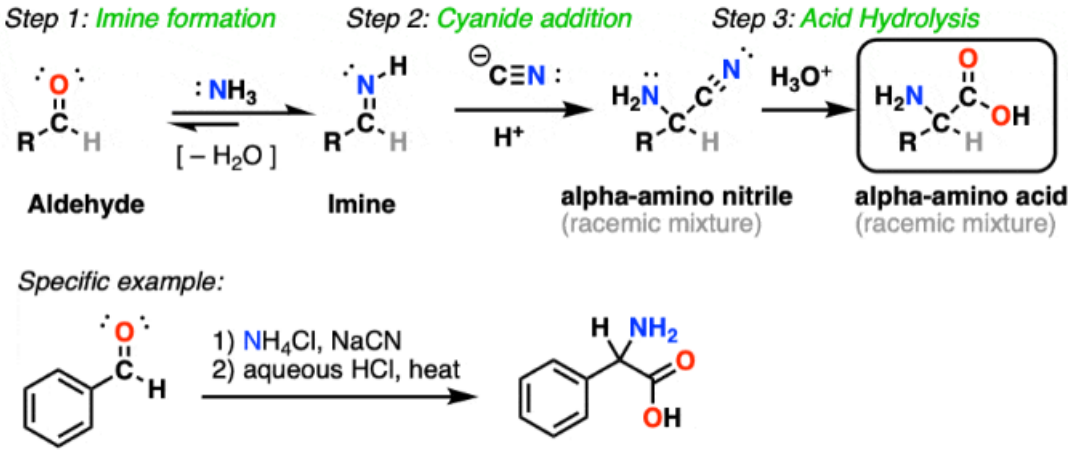

Figure-2.1. The Strecker amino acid synthesis from aldehyde by cyanide.

In this way, Ala and Gly can well be prepared including others crucial amino acids. However, Glycine has only two C'sa nd in Strecker synthesis one of which is supplied by CN^- so the second must be supplied by an aldehyde having one C only i.e. HCHO or its precursor CH3OH($CH_3OH \rightarrow HCHO$).

3. Gabriel's phthalimide synthesis:

Gabriel's phthalimide synthesis is a chemical method used to produce amino acids by first creating a nucleophilic nitrogen species from potassium phthalimide, which then reacts with an appropriate alkyl halide (typically an α-haloester) to attach the desired R-group, followed by hydrolysis to liberate the primary amine (amino acid) product; essentially, it allows for the controlled introduction of an amino group onto a carbon chain, making it a valuable tool in amino acid synthesis (**Fig-3.1**).

Key steps in Gabriel's phthalimide synthesis for amino acids:

I. Formation of potassium phthalimide:

Phthalimide is deprotonated using a strong base like potassium hydroxide, creating a highly nucleophilic potassium phthalimide salt.

II. Alkylation with an α-halo ester:

The potassium phthalimide reacts with an α-haloester (an alkyl halide with a halogen atom on the carbon adjacent to the carbonyl group) via a nucleophilic substitution reaction, attaching the desired R-group to the nitrogen atom.

III. Hydrolysis:

The N-alkyl phthalimide is then hydrolyzed under acidic or basic conditions to cleave the phthalimide group, releasing the amino acid.

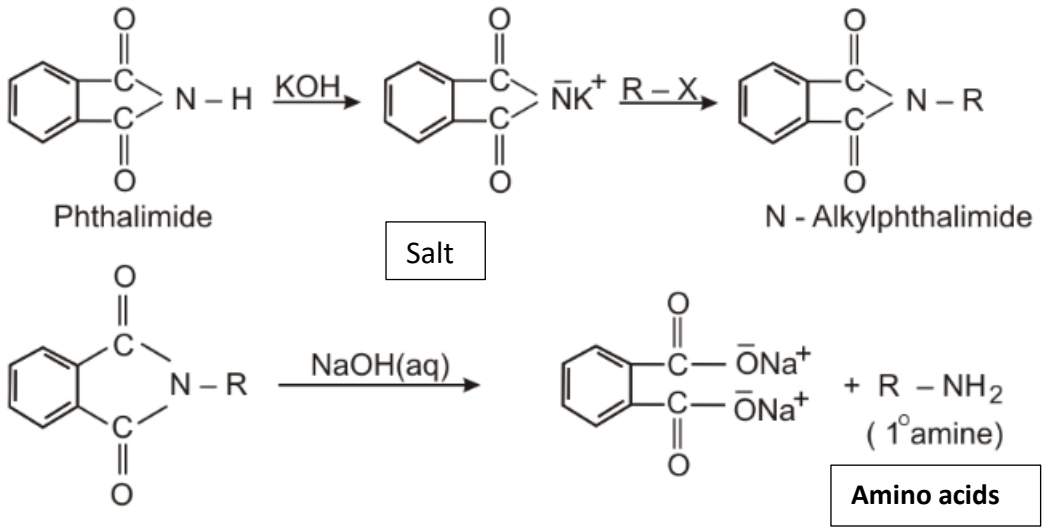

Figure-3.1. Gabriel's phthalimide synthesis of α-amino acids.

4. General Properties of Amino Acids:

- Structure: Amino acids are made up of an amino group, a carboxyl group, and a side chain.
- Solubility: Amino acids are soluble in water, but only slightly soluble in alcohol.
- Melting and boiling points: Amino acids have high melting and boiling points.
- Zwitterions: Amino acids are zwitterions, meaning they have both positive and negative charges that cancel each other out.
- Amphoteric: Amino acids can act as both acids and bases, depending on the pH.

- ❖ Optically active: All amino acids (except glycine) are optically active.
- ❖ Decomposition: Amino acids decompose when heated to high temperatures.
- ❖ Peptide bond formation: Amino acids can form peptide bonds with other amino acids.

5. zwitterion, isoelectric point (pI):

The Isoelectric Point, pI, Is The pH At Which Negative and Positive Charges Are Balanced. In practice, the zwitterionic amino acid will only have a net charge of zero at a very narrow range of pH values. The pH at which the negative and positive charges are in balance and do not move towards any electrode, is known as the isoelectric point (pI). This point is the pH value at which the charge in molecules is neutral. Usually, the net charge on a molecule is greatly affected by the pH of its surrounding environment (**Fig-5.1**).

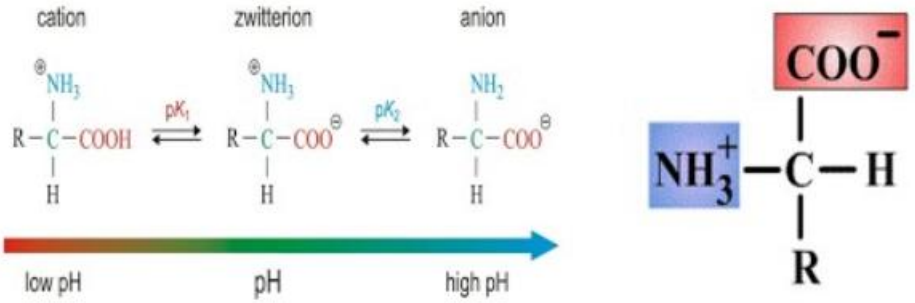

Figure-5.1. 5.zwitterion, isoelectric point (pI) of α-amino acids.

The isoelectric points of a few important amino acids are:

The PI of Glycine: 5.97

The PI of Alanine: 6.00

The PI of Aspartic Acid: 2.77

The PI of Glutamic Acid: 3.2

The PI of Cysteine: 5.0

The PI of Histidine: ~7.6

The PI of Lysine: 10.8

The PI of Arginine: 10.76

Isoelectric Points of Some Important Proteins:

The PI of lysozyme (Egg white) – 11.0

The PI of Insulin (Bovine) – 5.4

The PI of Myoglobin (Horse) – 7.0

The PI of Serum Albumin (Human) – 4.9

The PI of Ribonuclease (Bovine) 7.8 / 9.5

Key applications of isoelectric point (pI):

- ❖ Protein separation and purification:

By utilizing isoelectric focusing, where a pH gradient is established, proteins can be separated based on their pI, allowing for the isolation of specific proteins from a mixture.

- ❖ Protein characterization:

Knowing a protein's pI provides insight into its amino acid composition, as the abundance of acidic or basic amino acids directly affects the pI value.

- ❖ Solubility prediction:

At their pI, proteins tend to have minimal solubility due to the lack of net charge, which is important for protein precipitation and crystallization studies.

- ❖ Understanding protein interactions:

The pI of interacting proteins can influence their binding affinity, as charge interactions play a role in protein-protein complexes.

- ❖ Drug development:

When designing therapeutic proteins, considering the pI is important for optimizing their stability, delivery, and interaction with target molecules for therapeutic applications.

6. ninhydrin reaction:

The ninhydrin reaction is a multi-step process that detects amino acids and latent fingerprints. It uses ninhydrin, a reagent that reacts with amino groups to form a purple dye called Ruhemann's purple. Only proline and hydroxyproline- amino acid molecules which contain a secondary amino group produce yellow condensation product. The colour intensity is proportional to the concentration of amino acid i.e. ammonia from the amino groups. Proteins also contain free amino groups on the alpha carbon and can react with ninhydrin to produce a blue-purple product. That is why the reaction with ninhydrin is used for the quantitative analysis of amino acids and free amino groups in proteins. It can be used qualitatively (e.g. for chromatographic visualization) or quantitatively (e.g. for peptide sequencing). Ninhydrin is most commonly used as a forensic chemical to detect “fingerprints”, as amines left over from proteins sloughed off in fingerprints react with ninhydrin giving a characteristic purple colour.

Preparation of ninhydrin solution:

Weigh 0.2 g. of ninhydrin and dissolve in 10ml of acetone or ethanol.

How it works?

- ❖ Ninhydrin reacts with the amino group of an amino acid.
- ❖ The reaction oxidizes the compound, releasing ammonia and carbon dioxide.
- ❖ The released ammonia reacts with ninhydrin to form di-ketohydrin, which forms a purple-coloured complex.

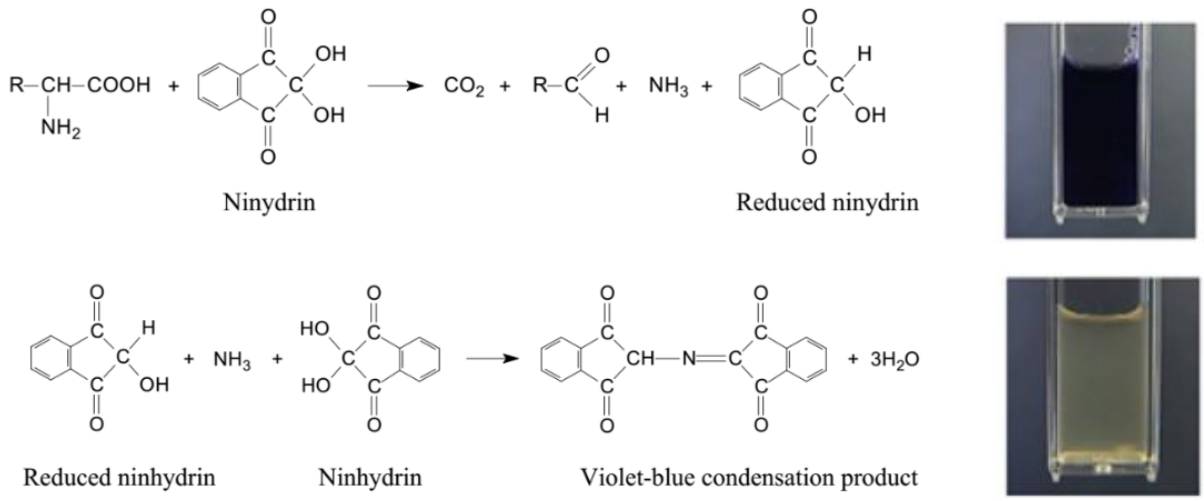

Figure-6.1. Ninhydrin reaction mechanism of α-amino acids (Detection of all amino acids, peptides, and proteins)

Utilization of Ninhydrin reaction:

- ❖ Fingerprint detection: Detects latent fingermarks on porous surfaces like paper and cardboard
- ❖ Agar plate method: Measures bile acid production
- ❖ Quantitative estimation of amino acids: The color produced is proportional to the amino acid concentration.

-:Problems:-

1. If $pK_1 = 2.34$ and $pK_2 = 9.60$, then the isoelectric point pI is?

2. Which among the following is a non-essential amino acid?

a) Serine

b) Threonine

c) Lysine

d) Histidine

3. Which of the following is an essential amino acid?

a) Cysteine

b) Asparagine

c) Glutamine

d) Phenylalanine

4. What is glucogenic and ketogenic?

5. Number of chiral centers in isoleucine is?

6. Give an example an achiral α-amino acids. How can you synthesize the amino acid by Gabriel's phthalimide method?

7. Why at isoelectric point amino acids do not move toward any electrode?

8. Write the ninhydrin reaction for Glycine with all reaction steps involved in it.

9. What is zwitterion? Write the zwitterionic structure of Alanine.

10. Write the structure of the peptide formed by condensation of Gly and Ala.

SUGGESTED READINGS/ REFERENCE BOOKS:

1. Finar, I. L. Organic Chemistry (Volume 1)
2. Madan, R. L. Organic Chemistry, S. Chand & Sons.
3. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
4. Banerjee, S. P. A Text Book of Analytical Chemistry,The New Book Stall.