Amino acids

BIOS 1006

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Objectives

- Describe the properties of amino acids, in general

- Learn the names, abbreviations, adjectives, functional groups (structures) and properties of all 20 common α-amino acids

- Identify the polar, hydrophobic, polar, acidic or basic features in amino acid structures, and predict how two amino acid R-groups can interact

- Rationalize the position of each amino acid R-group on the hydropathy scale

- Describe the spectroscopic properties of amino acids

- Know the pKa values of the R-groups (do not need to memorize), the average amino group and the average carboxylic acid group

- Determine the net charge of an amino acid or peptide at a specific pH

- Calculate the pI values of amino acids and small peptides

- Draw the chemical structures of amino acid functional groups at different pHs

- Extract pKa values from titration data

- Describe the importance of a protein's pI in biological function

- Describe the roles of amino acids in biological systems

- Identify the amino acid from which amino acid derivatives are derived

Definitions

Amino acids and peptides

Roles of amino acids

- Determine the structure of proteins

- Provide basis for protein function

- Signaling molecules

- Precursors for other biomolecules

- Intermediates in metabolic processes

Amino acid properties

- Zwitterionic (both positive and negative charges) and amphoteric (both an acid and a base) at pH 7

- Contains amino, hydrogen, carboxyl, and R-group (variant)

- Average molecular weight: 110 kDa

- α amino acids have 2 different stereoisomers (different arrangements) that are enantiomers (mirror images)

- Classified as D or L (in biological systems, L isomer is most common)

- Amino on the left = L, amino on the right = D

- Stereochemistry makes a big difference!

The amino acids

Functional groups found in amino acids

- Alcohols

- Thiols

- Thioethers

- Carboxylic acids

- Amides

- Basic groups

Classifications

Aromatic compounds are **flat rings**

Aliphatic are hydrocarbons that are not aromatic or planar, sp^3 hybridized (**straight, branched, cyclic**).

Polar tyrosine, serine, threonine, cysteine, asparagine, glutamine, histidine.

Acidic and negative aspartate, glutamate

Basic and positive arginine, lysine, histidine

Glycine, G, Gly

Neither hydrophilic nor hydrophobic, R group is H (doesn't have α carbon), not chiral

Alanine, A, Ala

Hydrophobic, aliphatic. Methyl R group.

Valine, V, Val

Hydrophobic, aliphatic. Isopropyl R group.

Leucine, L, Leu

Hydrophobic, aliphatic. Isobutyl R group.

Isoleucine, I, Ile

Hydrophobic, aliphatic. 2-methylbutyl R group.

Proline, P, Pro

Hydrophobic, aliphatic. Cyclic structure, R group is attached to the amino group and the α carbon.

Methionine, M, Met

Hydrophobic, aliphatic. Contains sulfur, thioether R group (sulfur instead of oxygen).

Phenylalanine, F, Phe

Aromatic. Phenyl R group. (alanine with a phenyl group)

Tyrosine, Y, Tyr

Aromatic. Phenolic R group (hydroxyl group on the phenyl ring).

Tryptophan, W, Trp

Aromatic, two rings. Indole R group (nitrogen in the ring).

Histidine, H, His

Basic at neutrality. Imidazole R group (two nitrogens in the ring).

Lysine, K, Lys

Basic at neutrality. Amino R group.

Arginine, R, Arg

Basic at neutrality. Guanidinium R group (three nitrogens).

Aspartate, D, Asp

Acidic at neutrality. Carboxylate R group (carboxylic acid group $\rightarrow$ aspartic acid).

Glutamate, E, Glu

Acidic at neutrality. Carboxylate R group (carboxylic acid group $\rightarrow$ glutamic acid).

Asparagine, N, Asn

Polar, uncharged. Amide R group.

Glutamine, Q, Gln

Polar, uncharged. Amide R group.

Serine, S, Ser

Polar, uncharged. Hydroxyl R group.

Threonine, T, Thr

Polar, uncharged. Hydroxyl R group (similar to serine, but with an additional methyl group).

Cysteine, C, Cys

Polar, uncharged. Thiol R group.

AMINO ACID

Nonpolar, aliphatic R groups: Glycine, Alanine, Valine, Leucine, Methionine, Isoleucine, Proline

Polar, uncharged R groups: Cysteine, Serine, Threonine, Asparagine, Glutamine

AMINO ACID

Positively charged R groups: Lysine, Arginine, Histidine

Negatively charged R groups: Aspartate, Glutamate

Nonpolar, aromatic R groups: Phenylalanine, Tyrosine, Tryptophan

Spectroscopic properties

- No amino acids absorb the visible wavelengths
- Some residues absorb UV light (W,Y) and are uesd for protein structure determination
- All amino acids absorb at infrared wavelengths
- W also exhibits fluorescence

Acid base properties

pH = 1, protonated: both, net charge = +1

pH = 7, protonated : amino group, net charge = 0

pH = 13, protonated: neither, net charge = -1