Basic Structure and Properties of Proteins Relevant to Adsorption

Topics: Amino acid properties; overall structure; polyelectrolyte behavior; native/denatured structural transitions; multiple bonding

Some properties of proteins and their amino acids

1. Diversity originates in the linear sequence of amino acids

2. Properties of the amino acid side chains-see T's

3. Single, distinct three dimensional structure that it will assume under physiological conditions dictated by the formation of multiple non-covalent bonds-see T's

4. Hydrophobic residues end up "inside" the protein where they are shielded from water and the ionized and polar residues are on the outside of the protein and in contact with the aqueous phase. See T's

5. Density of about 1.4. In comparison to water's density of 1.0, or to the density of most synthetic polymers of about 1.1, this basic fact about proteins reflects their tightly folded structure.

6. Polyelectrolyte behavior of proteins: each protein molecule typically has many positive and many negative charges on it, although the overall charge may be net negative (anionic), net positive (cationic) or neutral (at the isoelectric pH). Overall charge and charge balance strongly depends on pH.

7. Denaturation: proteins can lose their inside/outside nature and also the singularity of their structure; and instead become much more like a random coil that is characteristic of synthetic polymers. Denatured proteins typically lose their solubility, become much less dense, and, in the case of biological functions such as enzyme activity, totally lose it.

Some overall features of protein adsorption and their relationship to protein structure

1. Protein adsorption to surfaces is often essentially irreversible. This is related to the large size of proteins and to denaturation.

Large size allows many bonds between one protein molecule and the surface. It is unlikely all bonds would break at once so the protein stays on the surface.

Denaturation also is related adsorption as follows: since the unfolded protein, with many more exposed amino acid residues, is clearly capable of forming many more bonds per molecule with a surface than the native protein, adsorption favors denaturation and.

2. Protein adsorption is often very pH dependent, due to polyelectrolyte behavior of proteins.

a. On neutral surfaces, adsorption is a maximum at the pH at which the net charge on the protein is minimal, i.e. near the isoelectric pH, because protein-protein charge repulsion is minimal there, allowing closer protein packing on the surface.

b. On charged surfaces, proteins adsorb strongly by "ion exchange" due to ionic bonding between opposite charges on proteins and surfaces. Thus, positively charged, cationic proteins often bind very strongly to negatively charged, anionic surfaces, and negatively charged proteins often bind very strongly to positively charged surfaces, but such adsorption is highly dependent on the ph and ionic strength of the solvent.