Biochemistry of carbohydrates

Monosaccharides, Types and Properties

M.sc semester ii cc 07

Dr. Poonam kumari

Introduction

The term carbohydrate originally stood for compounds which are described as hydrates of carbon. According to the definition, only those compounds could qualify as carbohydrates which were composed of carbon, hydrogen and oxygen. Carbohydrates are aldehyde and ketone compounds with multiple hydroxyl groups. They are one of the most abundant classes of biomolecules in nature. They are widely distributed in all life forms and serves many roles, such as

- They serve as energy stores, fuels and metabolic intermediates.
- They are constituent of RNA and DNA backbones as ribose and deoxyribose sugars.
- Polysaccharides are constituents of cell walls of bacteria and plants.
- Carbohydrates are linked to surfaces of proteins and lipids where they play role as informational materials e.g. in cell-cell interaction and interaction between cells with other elements in the cellular environment. Carbohydrate can be classified into three groups: monosaccharide, oligosaccharides and polysaccharides.

Monosaccharide

Monosaccharide are the simplest sugars which contain free aldehyde (-CHO) and ketone (>C=O) groups that have two or more hydroxyl (-OH) groups. The general formula of monosaccharide is $C_n(H_2O)_n$.. Monosaccharides are sugars that can not be further hydrolysed into simple carbohydrates. They can be classified on the basis of number of carbon atoms for example triose, tetrose, pentose hexose, heptoses etc. and on the basis of functional group they possess for example, aldoses (those having aldehyde groups) or ketoses (those having ketone groups)

Properties of monosaccharide

Monosaccharides are those carbohydrates which are not easily hydrolysed into simpler carbohydrate units. Monosaccharide exists in both as straight chain structure and cyclic structure. Sugars with five membered rings and with six membered rings are most stable. Cyclic structures are the result of hemiacetal formation by intermolecular reaction between carbonyl group and a hydroxyl group.

1. Chiral centre

All monosaccharide except dihydroxy acetone contain one or more asymmetric (chiral) carbon atoms thus are optically active isomers (enantiomers). A molecule with n chiral centres can have 2^n sterioisomers. Glyceraldehydewith one chiral centrehas 2^1=2 and glucose with four chiral centres, have 2^4=16 stereoisomers.

2. D and L isomerism

One of the two enantiomers of glyceraldehyde is designated the D isomers and the other L isomers. The orientation of the –OH group that is most distant from the carbonyl carbon determines whether the sugar belongs the D or L sugars. When the –OH group on this carbon is on the right the sugar is D isomers, when is on the left the sugar is L isomers. Most of sugars present in biological system are D sugars.

3. Anomers

In aqueous solution all monosaccharide with five or more carbon atoms in the backbone occur as cyclic forms. Formation of cyclic structure is result of a reaction between alcohols and aldehydes or ketones to form derivatives called hemiacetal or hemiketals. The ring structure of monosaccharide are either similar to pyran (a six membered ring) or furan (a five membered ring). In linear form of monosaccharide, which is in equilibrium with the cyclic forms, the anomeric carbon is easily oxidised, making the sugar a reducing sugar. D-glucose exists in solution as an intramolecular hemiacetal in which the free –OH at C-5 has reacted with aldehyde C-1 producing two anomers called α and β. D-fructose also forms hemiketal in which –OH at C-5 has reacted with keto at C-2 producing two anomers called α and β

Isomeric forms of monosaccharide that differ only in their configuration about the hemiacetal or hemiketal carbon atom are called anomers, and the carbonyl carbon atom is called the anomeric carbon. The interconversion of α and β anomers in aqueous solution is called mutarotation, in which one ring form opens briefly into the linear form, then closes again to produce β anomers. Thus, a solution of β-Dglucose and solution of α-D-glucose eventually form identical equilibrium mixtures having identical properties. This mixture consists of about one third of α-isomers and two third β-D-glucose.

4. Epimers

Isomers having different configuration of –OH only at one carbon atoms are known as epimers. The most important epimers of glucose are mannose (epimers at C-2) and galactose (epimers at C-4).

Chemical Properties of Monosaccharides:

1. **Formation of Esters**
2. **Alkylation**
3. **Oxidation of Monosaccharides**
4. **Action of Concentrated Acids**
5. **Action of Phenylhydrazine**
6. **Action of Alcohols**