CARBOHYDRATES

SECTION (1)

MONOSACCHARIDES

Carbohydrates

1. Definition:

Carbohydrates are organic substances containing **C, H, and O**.

They are **polyhydroxy-aldehydes** or **polyhydroxy-ketones**, or **any compound giving these substances on hydrolysis**.

2. Functions:

a. Providing **energy** for the body is its **primary function**.
b. Acting as a **storage form of energy** in the body.
c. Serving as **cell membrane components** that mediate some forms of **intercellular communication**.
d. Serving as a **structural component** of many organisms, including the **cell walls** of bacteria, the **exoskeleton** of many insects and the **fibrous cellulose** of plants.

3. Classification:

- **According to the number of sugar units:**

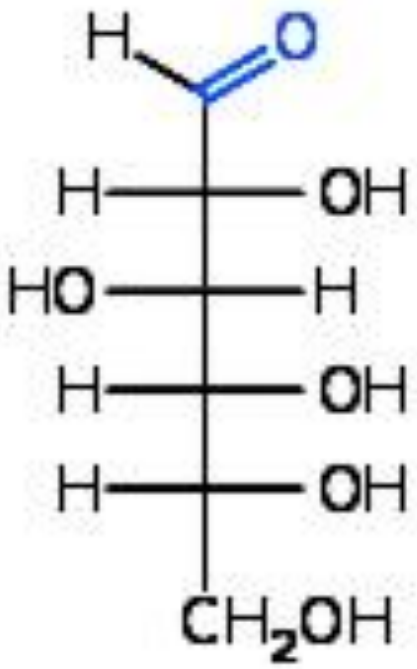
1. **Monosaccharides** (contain **one** sugar unit).
2. **Oligosaccharides** (contain **2-10** sugar units).
3. **Polysaccharides** (contain **more than 10** sugar units).

- **According to their most oxidized functional group:**

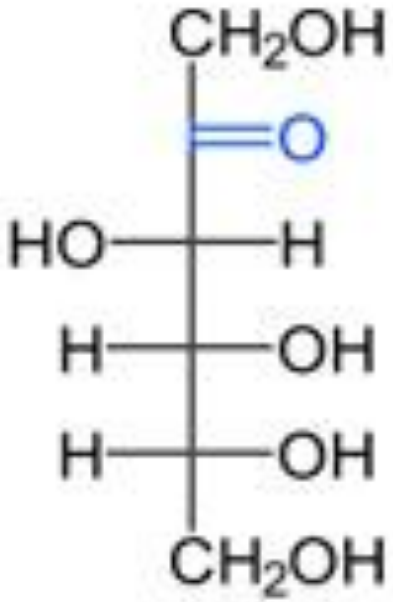
1. Aldoses: Carbohydrates with an **aldehyde** as their most oxidized functional group.

2. Ketoses: Carbohydrates with a **ketone** as their most oxidized functional group.

(1) Monosaccharides



Glucose



Fructose

General scheme for carbohydrates:

I. Physical properties:

Examine the **color**, **odor**, **aspect** and its **reaction to litmus paper.**

II. Chemical properties:

A. Molisch's reaction

B. Reactions for reducing sugars:

1. Fehling's test
2. Benedict's test
3. Barfoed's test
4. Moor's test
5. Osazone test

C. Ketose test

A. Molisch's reaction:

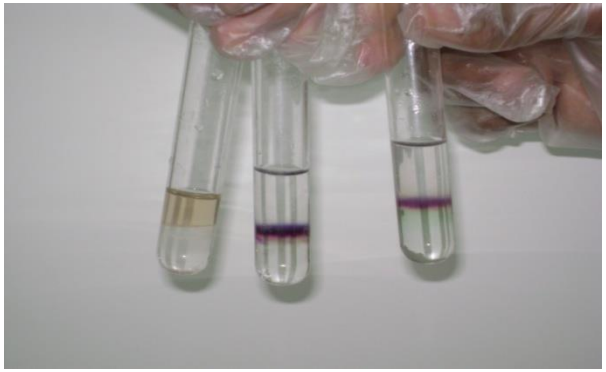
General reaction for **all** carbohydrates.

Procedure:

-Place about 1ml of sugar solution in a test tube.

-Add 2-3 drops of alcoholic α-naphthol, then shake.

-Add conc. sulfuric acid drop by drop carefully on the wall of the tube & don't shake.



Observation:

Violet ring at the junction of the 2 layers spreads by shaking.

Comment:

1- Dehydration of sugar to fufural in fructose or hydroxymethyl furfural (HMF) in glucose by conc. sulfuric acid.

2- Condensation of furfural or HMF with 2 molecules of alpha naphthol forming violet ring.

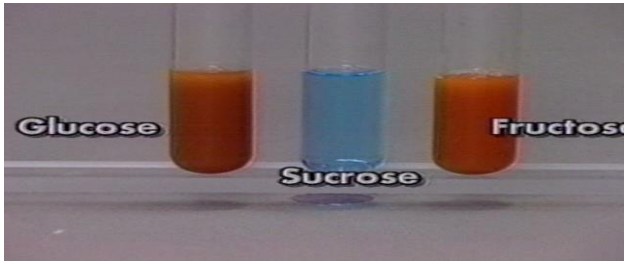
B. Reactions for reducing sugars

1. Fehling's test:

Procedure:

-Mix 1ml of Fehling A and 1ml of Fehling B in a clean test tube.

-Add 1 ml of the fehling mixture to 1ml sugar and heat for 1-2 min on direct flame.



Observation:

Red precipitate of cuprous oxide.

-Fehling A is a **copper sulfate solution**.

-Fehling B contains **sodium hydroxide** and **Rochelle salt** (**sodium potassium tartrate**).

-**Role of Rochelle salt:** It act as chelating agent for Cu+2 to prevent its reaction with NaOH and formation of black cupric oxide.

$$Cu^{+2} + 2\,OH^- \longrightarrow \underset{\text{(blue ppt)}}{Cu(OH)_2} \longrightarrow \underset{\text{(black ppt)}}{CuO}$$

Comment:

-Reduction of Cu^{2+} to Cu_2O (Due to the presence of free carbonyl group). It is a reducing sugar.

2. Benedict's test:

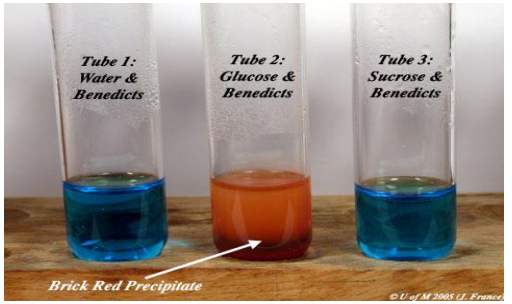
Procedure :

-Heat 1ml of Benedict's reagent with 1ml of the sugar solution for 1-2 min. on direct flame.

Observation:

Red precipitate of cuprous oxide.

-Benedict's reagent is composed of **copper sulfate, sodium carbonate and sodium citrate.**



-Role of citrate: as Rochelle salt in fehling's test.

- Benedict's reagent is a single solution.

-Advantages:

1- The alkali is weaker and easier to handle.

2- More sensitive than Fehling's as it is not readily reduced by urates (as in urine) as Fehling's reagent.

Comment:

-Reduction of Cu^{2+} to Cu_2O (Due to the presence of free carbonyl group). It is a reducing sugar.

3. Barfoed’s test:

Procedure:

-Mix 1ml of the sugar solution with 1ml of Barfoed's reagent.

-Heat in a boiling water bath for 3 minutes.

Observation:

Red precipitate of cuprous oxide.

-Barfoed's reagent contains **cupric acetate** in **dilute acetic acid**.

Comment:

-Reduction of Cu^{2+} to Cu_2O (Due to the presence of free carbonyl group). It is a reducing sugar.

4. Moore's test (Action of Alkali):

Procedure:

-Add 1ml of sugar solution to 1ml of **30% sodium hydroxide** solution then heat on direct flame for 1-2 minutes.

Observation:

Yellowish brown color and **caramel odor.**

- The odor is intensified by carefully acidifying it with diluted sulfuric acid.

Comment:

-It is a reducing sugar containing free carbonyl groups which undergo aldol condensation (caramelization) reaction in alkaline medium.

5. Osazone test (Phenylhydrazine test):

Procedure:

- To 5ml sugar in a test tube, add 10 drops of **glacial acetic acid**.
-Add about 1g of a freshly-prepared **mixture of phyenylhydrazine hydrochloride and sodium acetate**.
-Mix well and heat in a boiling water bath for about 5-10 minutes.
- Cool.
-With a clean pipette, remove a few osazone crystals and examine them under the microscope.

Observation:

Yellow crystals of glucosazone & fructosazone (Brush-shaped or Raphides).

Comment:

-Due to the reaction of free aldehydic or ketonic group of one sugar molecule with 3 molecules of phenyl hydrazine HCl in three successive steps: **condensation**, **oxidation** then **condensation**.

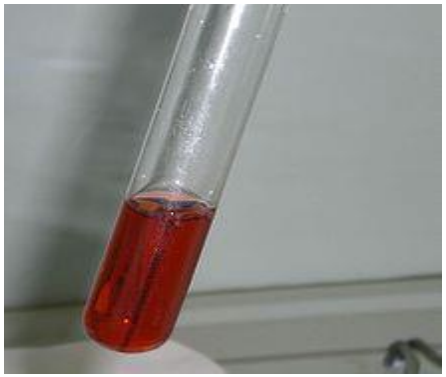
C. Reaction for differentiation between glucose and fructose

Ketose test:

Procedure:

-Add 1ml of sugar solution to 3ml of conc. HCl solution.

-Heat for 1-2 min. on direct flame.



Observation:

-Fructose: Reddish brown color.

-Glucose: Colorless.

Comment:

- In case of Fructose: Dehydration of fructose and formation of furfural which is reddish brown in acidic medium.

- In case of Glucose: Dehydration of glucose and formation of hydroxymethyl furfural (HMF) which is colorless in acidic medium.


THank
YOU!