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Carbohydrates

Biochemistry

It is the branch of biology in which we study the biology at molecular level and equally it is the branch of organic chemistry in which we study the chemistry of living system.

Carbohydrates

These are compounds of carbon, hydrogen and oxygen. Previously, it was assumed that carbohydrates are hydrates of carbon but now defined, as carbohydrates are polyhydroxy aldehydes, polyhydroxy ketones or compound that can be hydrolyzed to them.

Classification

As per chemical structure

i. ***Monosaccharide:*** Carbohydrates that cannot be hydrolyzed to simpler compounds. These are normally sweets and soluble in water.
   - The monosaccharide containing aldehyde group is called **aldose,** e.g. glucose.
   - The monosaccharide containing a keto group is called **ketose,** e.g. fructose.

ii. ***Disaccharide:*** Carbohydrates that can be hydrolyzed to two monosaccharide molecules. These are normally sweets, crystalline and soluble in water, e.g. sucrose, maltose, lactose, etc.

iii. ***Oligosaccharide:*** Carbohydrates that can be hydrolyzed to three to seven monosaccharides, e.g. raffinose, rhamminose, etc.

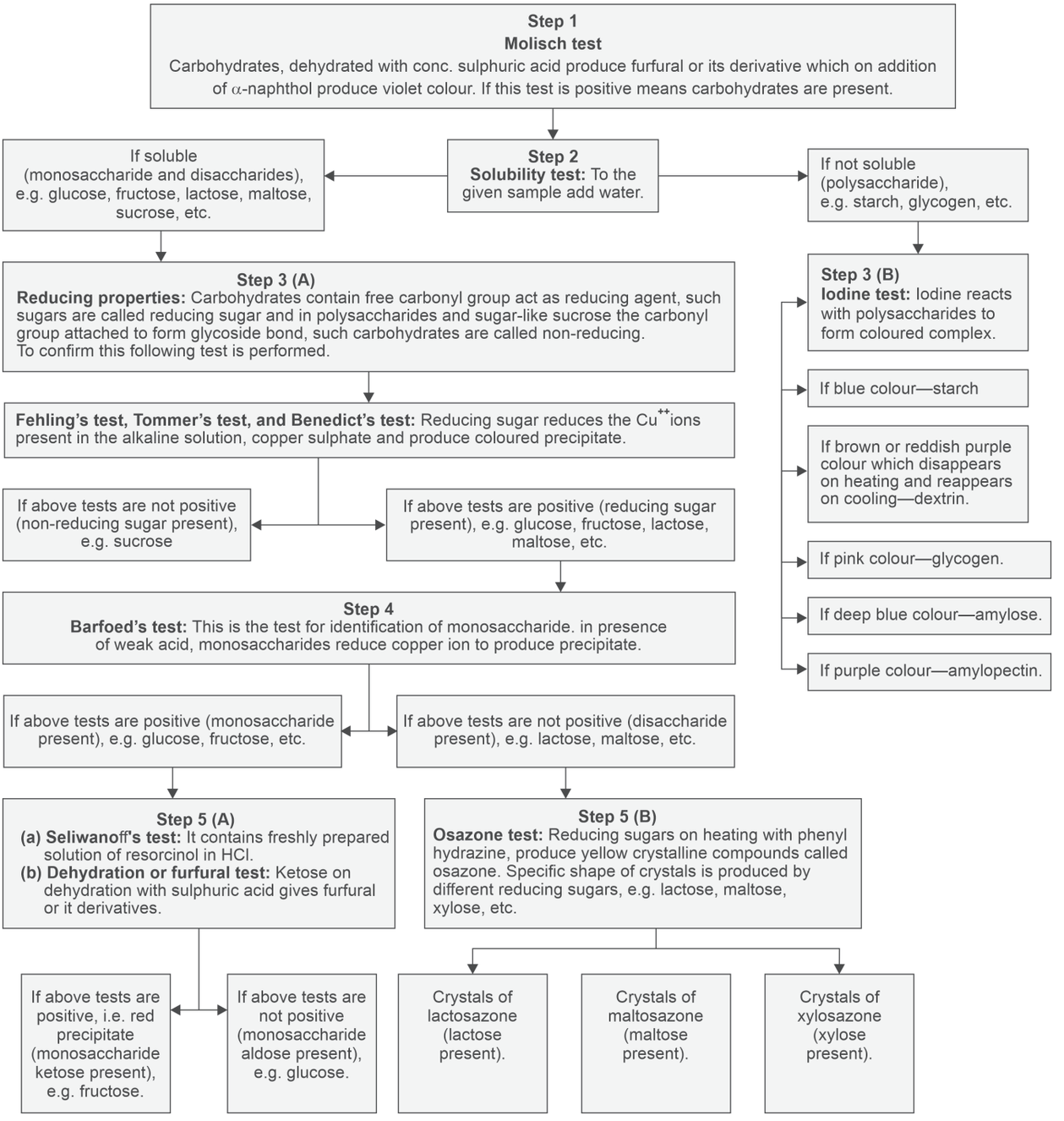
iv. ***Polysaccharide:*** Carbohydrates that can be hydrolyzed to many monosaccharide molecules. These are normally tasteless and insoluble in water.
   - *Homopolysaccharide:* Polysaccharide that gives only one type of monosaccharide on hydrolysis, e.g. starch, glycogen, cellulose, etc.
   - *Heteropolysaccharide:* Polysaccharide that gives two or three types of monomers on hydrolysis, e.g. heparin.

As per Physical Nature

i. ***Sugars:*** These are the compounds, which are sweet, crystalline and soluble in water, e.g. glucose, sucrose, maltose, lactose, etc.
   - *Reducing sugars:* These are the compounds, which reduce Fehling's (or Benedict's) or Tollens' reagent, e.g. all monosaccharides.
   - *Non-reducing sugars:* These are the compounds, which do not reduce Fehling's (or Benedict's) or Tollens' reagent, e.g. sucrose.

ii. ***Non-sugars:*** These are the compounds, which are non-crystalline, tasteless and insoluble in water, e.g. starch, cellulose, etc.

Stepwise Details for Identification of given Sample of Carbohydrate



For glucose

1. Sample sol. + Sod. hydroxide	Brown resinous
2. Sample sol. + Methylene blue + 1 ml sod. hydroxide sol.—boil	Depolarization of solution
3. Sample sol. + 1 ml picric sol. + 1 ml sod. hydroxide sol.—boil	Red colour produced

For lactose

1. Sample sol. + Ammoniacal silver nitrate sol.—warm	Silver mirror

For sucrose

Inversion tests: Sample sol. + 5 drops conc. HCl. Boil for 3 minutes –cool–neutralize with sod. hydroxide and perform following test:	Positive

1. Fehling's test
2. Benedict's
3. Tommer's test
4. Barfoed's test

For galactose

Sample sol. 2.0 ml + 2.0 ml conc. HCl, mix, add a few drops of phloroglucinol, boil on water bath, red colour will appear.

Reagents

1. Fehling's reagents

(a) Fehling's solution A

Dissolve 34.6 gm of copper sulphate in 500 ml distilled water.

(b) Fehling's solution B

Dissolve 17.3 gm of sodium potassium tartrate and 50 gm of NaOH in 500 ml of distilled water. Both the solutions are mix in equal volumes when needed for use otherwise it will deteriorate if they are mix together and kept for longer time.

2. Benedict's reagent

Dissolve 173 gm of sodium citrate and 100 gm of anhydrous sodium carbonate in 800 ml hot distilled water. Dissolve 17.3 gm of copper sulphate ($CuSO_4$ 5 H_2O) in 100 ml distilled water. Add copper sulphate solution slowly to carbonate citrate solution with constant stirring. Make up the volume to 1 L with distilled water.

3. Molisch reagent

5% W/V of α-naphthol in 95% alcohol.

4. Tommer's reagent

1% W/V of copper sulphate solution in distilled water. Make alkaline with equal volume dilute NaOH solution.

5. Barfoed's reagent

Dissolve 6.6 gm of crystalline copper acetate in 100 ml of distilled water. Add 0.9 ml of glacial acetic acid.

6. Seliwanoff's reagent

Dissolve 50 mg of resorcinol in 33 ml of 33% HCl.

7. Iodine solution

Dissolve 20 gm KI and 12.7 gm iodine in one litre distilled water.

Experiment 1

OBJECT

To identify the given sample of carbohydrate (glucose).

S. no.	*Test*	*Observation*	*Inference*
A.	**Physical test**		
1.	Colour		
2.	Smell		
3.	Solubility		
B.	**Chemical test**		
1.	***Molisch's test:*** Aq. or alcoholic solution of substance + 10% alcoholic sol. of naphthol, shake, add conc. sulphuric acid through side of test tube.		
2.	***Fehling's test:*** 2 ml Aq. solution of substance + 2 ml Fehling's sol. A + 2 ml Fehling's sol. B, boil.		
3.	***Benedict's test:*** 3 ml Aq. solution of substance + 5 ml Benedict's reagent, boiling for 2 minutes.		
4.	***Tommer's test:*** 3 ml Aq. solution of substance + 2 ml Tommer's reagent, boiling for 2 minutes.		
5.	***Seliwanoff's test:*** 1 ml Aq. solution of substance + 3 ml Seliwanoff's reagent, boiling for 2 minutes.		
6.	***Dehydration or furfural test:*** 2 ml Aq. solution of substance + 2 ml α-naphthol sol. (1% in alcohol) + 5 ml conc. HCl, boiling for 2 minutes.		

S. no.	*Test*	*Observation*	*Inference*
7.	***Osazone test:*** 0.2 gm sample + 0.4 gm phenyl hydrazine hydrochloride + 0.6 gm sodium acetate + 4 ml water. Heat on water bath for 20 minutes. Cool and allow for crystallization and observe crystals under microscope.		
8.	***Iodine test:*** Suspension of polysaccharide + 2 drops of iodine solution.		
9.	***Confirmation test:***		

Conclusion

The given sample is _____.

Remarks

1. If Molisch's test positive means given sample contains carbohydrate.
2. If Fehling's test, Benedict's test and Tommer's test are positive, means given sample contains reducing sugar.
3. If Seliwanoff's test is negative means aldose (i.e. glucose) present and ketose (i.e. fructose) absent.
4. If iodine test is negative means polysaccharide absent.
5. If confirmatory test for glucose is positive, means glucose is confirmed.

Experiment 2

OBJECT

To identify the given sample of carbohydrate (sucrose).

S. no.	*Test*	*Observation*	*Inference*
A.	**Physical test**		
1.	Colour		
2.	Smell		
3.	Solubility		
B.	**Chemical test**		
1.	***Molisch's test:*** Aq. or alcoholic solution of substance + 10% alcoholic sol. of naphthol, shake, add conc. sulphuric acid through side of test tube.		
2.	***Fehling's test:*** 2 ml Aq. solution of substance + 2 ml Fehling's sol. A + 2 ml Fehling's sol. B, boil.		
3.	***Benedict's test:*** 3 ml Aq. solution of substance + 5 ml Benedict's reagent, boiling for 2 minutes.		
4.	***Tommer's test:*** 3 ml Aq. solution of substance + 2 ml Tommer's reagent, boiling for 2 minutes.		
5.	***Seliwanoff's test:*** 1 ml Aq. solution of substance + 3 ml Seliwanoff's reagent, boiling for 2 minutes.		
6.	***Dehydration or furfural test:*** 2 ml Aq. solution of substance + 2 ml α-naphthol sol. (1% in alcohol) + 5 ml conc. HCl, boiling for 2 minutes.		

S. no.	*Test*	*Observation*	*Inference*
7.	***Osazone test:*** 0.2 gm sample + 0.4 gm phenylhydrazine hydrochloride + 0.6 gm sodium acetate + 4 ml water. Heat on water bath for 20 minutes. Cool and allow for crystallization and observe crystals under microscope.		
8.	***Iodine test:*** Suspension of polysaccharide + 2 drops of iodine solution.		
9.	***Confirmation test:***		

Conclusion

The given sample is _____.

Remarks

1. If Molisch's test positive means given sample contains carbohydrate.
2. If Fehling's test, Benedict's test and Tommer's test are negative mean given sample contains non-reducing sugar.
3. If Barfoed's test is negative means monosaccharide absent (i.e. glucose and fructose absent).
4. If iodine test is negative means polysaccharide absent.
5. If confirmatory test for sucrose is positive means sucrose is confirmed in the given sample.

Experiment 3

OBJECT

To identify the given sample of carbohydrate (fructose).

S. no.	*Test*	*Observation*	*Inference*
A.	**Physical test**		
1.	Colour		
2.	Smell		
3.	Solubility		
B.	**Chemical test**		
1.	***Molisch's test:*** Aq. or alcoholic solution of substance + 10% alcoholic sol. of naphthol, shake, add conc. sulphuric acid through side of test tube.		
2.	***Fehling's test:*** 2 ml Aq. solution of substance + 2 ml Fehling's sol. A + 2 ml Fehling's sol. B, boil.		
3.	***Benedict's test:*** 3 ml Aq. solution of substance + 5 ml Benedict's reagent, boiling for 2 minutes.		
4.	***Tommer's test:*** 3 ml Aq. solution of substance + 2 ml Tommer's reagent, boiling for 2 minutes.		
5.	***Seliwanoff's test:*** 1 ml Aq. solution of substance + 3 ml Seliwanoff's reagent, boiling for 2 minutes.		
6.	***Dehydration or furfural test:*** 2 ml Aq. solution of substance + 2 ml α-naphthol sol. (1% in alcohol) + 5 ml conc. HCl, boiling for 2 minutes.		

S. no.	*Test*	*Observation*	*Inference*
7.	***Osazone test:*** 0.2 gm sample + 0.4 gm phenylhydrazine hydrochloride + 0.6 gm sodium acetate + 4 ml water. Heat on water bath for 20 minutes. Cool and allow for crystallization and observe crystals under microscope.		
8.	***Iodine test:*** Suspension of polysaccharide + 2 drops of iodine solution.		
9.	***Confirmation test:***		

Conclusion

The given sample is _____.

Remarks

1. If Molisch's test positive means given sample contains carbohydrate.
2. If Fehling's test, Benedict's test and Tommer's test are positive, means given sample contains, reducing sugar.
3. If Seliwanoff's test is positive means aldose (i.e. glucose) absent and ketose (i.e. fructose) present.
4. If iodine test is negative means polysaccharide absent.
5. If confirmatory test for fructose is positive, means fructose is confirmed in the given sample.

Experiment 4

OBJECT

To identify the given sample of carbohydrate (starch).

S. no.	*Test*	*Observation*	*Inference*
A.	**Physical test**		
1.	Colour		
2.	Smell		
3.	Solubility		
B.	**Chemical test**		
1.	***Molisch's test:*** Aq. or alcoholic solution of substance + 10% alcoholic sol. of naphthol, shake, add conc. sulphuric acid through side of test tube.		
2.	***Fehling's test:*** 2 ml Aq. solution of substance + 2 ml Fehling's sol A + 2 ml Fehling's sol. B, boil.		
3.	***Benedict's test:*** 3 ml Aq. solution of substance + 5 ml Benedict's reagent, boiling for 2 minutes.		
4.	***Tommer's test:*** 3 ml Aq. solution of substance + 2 ml Tommer's reagent, boiling for 2 minutes.		
5.	***Seliwanoff's test:*** 1 ml Aq. solution of substance + 3 ml Seliwanoff's reagent, boiling for 2 minutes.		
6.	***Dehydration or furfural test:*** 2 ml Aq. solution of substance + 2 ml α-naphthol sol. (1% in alcohol) + 5 ml conc. HCl, boiling for 2 minutes.		

S. no.	*Test*	*Observation*	*Inference*
7.	***Osazone test:*** 0.2 gm sample + 0.4 gm phenylhydrazine hydrochloride + 0.6 gm sodium acetate + 4 ml water. Heat on water bath for 20 minutes. Cool and allow for crystallization and observe crystals under microscope.		
8.	***Iodine test:*** Suspension of polysaccharide + 2 drops of iodine solution.		
9.	***Confirmation test:***		

Conclusion

The given sample is _____.

Remarks

1. If Molisch's test positive means given sample contains carbohydrate.
2. If sample is insoluble in water means polysaccharide is present.
3. If iodine test is positive, i.e. blue colour obtained means polysaccharide (starch) is present.
4. If confirmatory test for starch is positive, means fructose is confirmed in the given sample.

Viva Voce/Synopsis

Q1. Define and classify carbohydrates.
Q2. Write the composition of Fehling's solutions (A and B)
Q3. Write the composition of Benedict's reagent.
Q4. Why are two Fehling's solutions kept separate?
Q5. Write the composition of Barfoed's reagent.
Q6. Which test is given by all carbohydrates?
Q7. Which test differentiates between fructose and glucose?
Q8. What are reducing sugars?
Q9. Which chemical test differentiates lactose from maltose?
Q10. Which chemical test differentiates starch, dextrin and glycogen?

MCQs

Q1. Which of the following does not belong to disaccharide?
(1) Sucrose (2) Maltose (3) Lactose (4) Fructose

Q2. Which of the following does not belong to reducing sugar?
(1) Fructose (2) Glucose (3) Both (4) None

Q3. Which of the carbohydrate gives positive test with Fehling's or Benedict's reagents?
(1) Polysaccharides (2) Oligosaccharides (3) Monosaccharides (4) Disaccharides

Q4. Copper sulphate solution is called _____.
(1) Fehling A (2) Benedict's reagents (3) Fehling B (4) Molisch reagent

Q5. Sodium potassium tartrate solution is called _____.
(1) Fehling A (2) Benedict's reagents (3) Fehling B (4) Molisch reagent

Q6. 5% alcoholic naphthol solution is called _____.
(1) Fehling A (2) Benedict's reagents (3) Fehling B (4) Molisch reagent

Q7. Which of the following carbohydrate gives blue color with iodine solution?
(1) Starch (2) Maltose (3) Glycogen (4) Amylose

Q8. Which of the following carbohydrate gives pink color with iodine solution?
(1) Starch (2) Maltose (3) Glycogen (4) Amylose

Q9. Osazone formation, while heating with phenyl hydrazine is characteristic test for:
(1) Reducing sugar (2) Non-reducing sugar (3) Both (4) None

Q10. Silver mirror test is given with ammoniacal silver nitrate solution by:
(1) Sucrose (2) Maltose (3) Lactose (4) Fructose

Ans

Q1. (4) **Q2.** (3) **Q3.** (3) **Q4.** (1) **Q5.** (3) **Q6.** (4) **Q7.** (1)
Q8. (3) **Q9.** (1) **Q10.** (3)