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Lab Activity 2

Identifying Macromolecules

Introduction

Many biological molecules are very large macromolecules made up of many similar smaller molecules. The smaller subunits or monomers are linked together, sometimes simply in a long chain, to form a large polymer (not all macromolecules are polymers, however). The central element in all biological molecules is carbon, with other elements like oxygen, nitrogen, sulfur, and especially hydrogen, bonded to the carbon atoms. It is carbon that makes it possible to form very large chains or rings that are stable in a fairly broad range of conditions.

The most common macromolecules (organic compounds) found in living organisms are lipids, carbohydrates, proteins, and nucleic acids. Common foods, which often consist of plant materials or substances derived from animals, are also combinations of these macromolecules. Some of these compounds can be detected by taste, while others cannot. Therefore, scientists use certain tests to identify the presence of macromolecules. A chemical test that is sensitive to a unique functional group in a large molecule can be used to identify the molecule.

Benedict's Test for Monosaccharides

The Benedict's test can be used to identify aldehyde functional groups that are found on some monosaccharides and some disaccharides. The Benedict's solution contains CuSO_4 , which has a bright blue color when it is hydrated. If an organic compound that contains an aldehyde functional group, such as a monosaccharide, is added to this solution and the solution is heated to boiling, an oxidation-reduction reaction will take place, in which the aldehyde group becomes oxidized into a carboxyl functional group while the copper(II) ions (Cu^{2+}) become reduced to copper(I) ions (Cu^+). This reduction causes the color of the solution to change from a bright blue to a color that can range anywhere from brown to orange to brick red, depending on the concentration of the aldehyde functional group.

Some monosaccharides have an aldehyde functional group in their linear form. Other monosaccharides have a ketone functional group in their linear form. However, the aldehyde and ketone functional groups are interconvertible, and thus all monosaccharides give a positive reaction with the Benedict's test. Some disaccharides (such as maltose and lactose) will also give a positive reaction with the Benedict's test, because the second monosaccharide in the disaccharide can become momentarily linear. Other disaccharides (such as sucrose) and all oligosaccharides and polysaccharides give a negative reaction with the Benedict's test. The medical significance of the Benedict's test is that this test can be used to detect blood sugar (glucose) in urine, the presence of which can indicate diabetes.

Iodine Test for Starch

Starch is a polysaccharide, a polymer of glucose, in which the chains are coiled up in a distinctive arrangement. Iodine can be used to distinguish starch from other polysaccharides, disaccharides, or monosaccharides, because only the precise coiled structure of starch will interact with iodine to produce a blue-black color.

3 Biuret Test for Proteins

Proteins are polymers made of amino acids linked together by peptide bonds, which are formed, when the carboxyl group of one amino acid and the amino group of the next amino acid undergo a dehydration reaction. The biuret reagent is a blue solution that contains copper(II) ions (but not biuret!). The copper ions form a violet or purple complex with peptide bonds in alkaline conditions. Therefore, the appearance of a violet or purple color is indicative of the presence of peptide bonds in the test solution. Thus, polypeptides and proteins, which contain multiple peptide bonds, will give a positive reaction with the biuret test. However, the color change in this test is much more subtle than it was in the earlier tests, so make very careful observations.

4 Sudan Test for Lipids

There are many different types of lipid molecules. Triglycerides, for example, are lipids used by organisms for energy storage. Triglycerides are composed of three fatty acid molecules and one glycerol molecule bonded in an ester linkage. The base elements of these molecules are C, H, and O. Like lipids, the chemical Sudan III is not soluble in water; it is, however, soluble in lipids. If lipids are present in a solution, then Sudan III will dissolve and stain the lipids red.