Analysis of Reducing Sugars

Background

Sugars are members of the carbohydrate family. Examples include glucose, fructose and sucrose. Some sugars can act as reducing agents and these sugars will contain an aldehyde functional group. This property can be used as a basis for the analysis of reducing sugars. For example Fehling's solution contains copper (II) ions that can be reduced by some sugars to copper (I) ions. This reaction can be used for the quantitative analysis of reducing sugars.

Practical Techniques

You will need to find out about volumetric analysis (titrations) and how to make up accurate solutions.

Where to start

Fehling's solution can be added to a solution of the sugar whose concentration is known. As the Fehling's solution is added the blue copper (II) ions will be reduced to copper (I) ions. These will precipitate out of solution as red copper (I) oxide. The resulting solution will be colourless. A titration can be carried out to determine an equivalent amount of the sugar to the Fehling's solution. The end point would be when the blue colour has just disappeared.

Possible Investigations

- Investigate the accuracy of this technique – you could assess how critical it is to boil the sugar solution and how critical it is to have "fresh" Fehling's solution. What is the lowest concentration of glucose that can be detected? How reproducible are the results?

- Methylene blue can be used to indicate the end point more clearly. A few drops can be added just before the endpoint is reached. The end point is indicated by the disappearance of the methylene blue colour. Does this make the titration more accurate?

- Sources indicate that this method is affected by the presence of proteins – is this the case?

- Can this method be used to determine the amount of reducing sugars present in foods?

- When starch is hydrolysed with hydrochloric acid it is broken down into sugars. Can you adapt the method to determine the extent of the hydrolysis under different conditions?

- A variation of this method is to add excess of the Fehling's solution to the sugar and to determine the amount of copper (II) left in solution. This can be done by acidifying with dilute sulphuric acid and then adding excess potassium iodide. The iodine that is liberated can be titrated with sodium thiosulphate solution. A blank titration can be carried out without the sugar. The difference can be used to determine the amount of Fehling's that has reacted with the sugar.

- The addition of 3,5-dinitrosalicylic acid to glucose will produce a compound that absorbs light strongly at 540nm. Could you find a method of analysing for glucose using a colorimeter? Can you use this method to find the concentration of glucose in soft drinks?

- Glucose is optically active and the concentration of a solution can be determined using a polarimeter. How does the accuracy of this method compare the to method with Fehling's solution?

Sources of Information

- The Chemistry Video Consortium and The Royal Society of Chemistry (2000) *Practical Chemistry for Schools and Colleges* CD ROM

- Thorpe A., Making a standard solution, *Chemistry Review,* November 2002

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- Mendham J., Denney R.C., Barnes J.D., Thomas M., (2000), *Vogel's Textbook of Quantitative Chemical Analysis*, Pearson Education Ltd, England

- Battye P., Titrations, *Chemistry Review*, February 2003

- Thorpe A., Colorimetry, *Chemistry Review*, February 2003

- Thorpe A., Assessing the risks in practical work, *Chemistry Review, September 2000*

- Thorpe A., Experimental error and error analysis: just how good are those results, *Chemistry Review*, November 2001

Teachers Notes

General

Sources indicate that 1cm^3 of Fehling's solution is equivalent to 0.005g of glucose.
The endpoint of the titration is difficult to see but with practice accurate results should be obtained.
Methylene blue can be added near the end of the titration to help determine the endpoint more clearly. The dye is reduced to a colourless compound immediately an excess of the sugar is present. Students should add the sugar solution to within 1cm^3 of the endpoint, heat the solution to maintain gentle boiling and then add 3-5 drops of a 1% aqueous solution of methylene blue. More concentrated solutions of sugar (more than 0.5%) give less consistent results with this method.

Chemical Principles

Carbohydrates, reduction/oxidation, volumetric analysis

Essential Equipment

Burettes, pipettes,

Essential Chemicals

copper (II) sulphate, sodium potassium tartrate, sodium hydroxide, glucose, methylene blue

Safety

No risk assessment has been given. It is essential that students prepare a detailed risk assessment before they start. Teachers should check all plans and must be satisfied that this is suitable for the proposed investigation.

Starter Experiment Sheet - Analysis of Reducing Sugars

You need to prepare the following solution

- Fehling's solution
  - Solution A – Dissolve 17.32g of copper (II) sulphate ($CuSO_4.5H_2O$) made up to 250cm^3 in a standard flask.
  - Solution B – Dissolve 86.5g of sodium potassium tartrate in warm water. Dissolve 30g of sodium hydroxide in water. Mix the two solutions and make up to 250cm^3 in a standard flask.

When the Fehling's solution is required transfer equal quantities of solution A and B to a dry flask and mix thoroughly. This solution will deteriorate slowly so only make up sufficient to meet your immediate requirements.

Weigh out accurately about 1.25g of pure anhydrous glucose, dissolve in water and make up to 250cm^3 in a standard flask. Place some of this solution into a burette. Take 25cm^3 of the Fehling's solution and place into a conical flask. Dilute with 25cm^3 of distilled water. Boil very gently and slowly add the glucose solution 1cm^3 at a time into the boiling solution until the blue colour has disappeared.

You can allow the solution to cool at intervals which will allow the red copper (I) oxide precipitate to settle. Then tip the flask to one side and look through the solution onto a white background. Bring the glucose solution to the boil each time you add the Fehling's solution.

From the results of your titration you should be able to calculate an equivalent amount of glucose that reacts with 1cm^3 of Fehling's solution.