

Reactions in organic chemistry

I. Reactions of oxidation – based on the example of various organic compounds

1. Oxidation of primary alcohol (ethanol and methanol)

Mark two tubes as 1 and 2. Add to them 1 cm³ of 5% K₂Cr₂O₇ solution and 0.5 cm³ of 20% H₂SO₄ solution. Next, add 1 cm³ of ethanol to tube 1, and 1 cm³ methanol to tube 2. Mix the solutions, wait two minutes and then, warm them over the burner. Observe the change of colour.

In these reactions, alcohol is oxidised and aldehydes are formed (acetaldehyde, formaldehyde), and chrome is reduced – therefore, the tint of solution change from yellow to green or brown. The reaction follows the scheme:



The solutions from tube 1 and 2 will be used in next experiment!

2. Oxidation of aldehyde using Tollens reagent

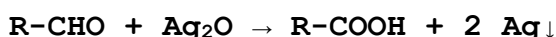
a) preparation of Tollens reagent

Pipette 1 cm³ of 0.1M AgNO₃ into a tube and add by drops the solution of 2M NH₃ * H₂O stirring the tube until the primary formed white precipitate of Ag₂O dissolves.

b) methanol and/or ethanol oxidation using Tollens reagent

Pipette 0.5 cm³ of fresh Tollens reagent and 0.1 cm³ of 20% NaOH solution. To one tube, add 0.1 cm³ of content of tube 1 from previous experiment, as the source of acetaldehyde, and 0.1 cm³ of tube 2 to other tube, as the source of formaldehyde.

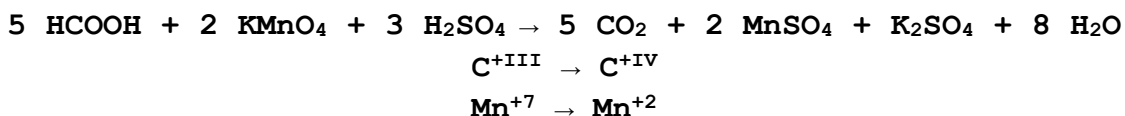
In both tubes, aldehydes are oxidised to adequate acid, and silver ions are reduced to metallic silver which precipitates on the internal walls of tube producing a mirror. The reaction follows the scheme:



3. Oxidation of formic acid to carbon dioxide

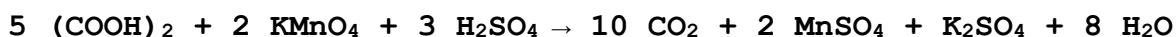
Add 1 cm³ of acetic acid solution and 1 cm³ of concentrated H₂SO₄ to glass tube and next, add drop by drop KMnO₄ solution. Observe the discolouration of the solution.

During this reaction, manganese is reduced, and acetic acid is oxidised to CO₂:



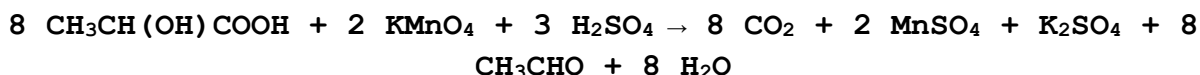
4. Oxidation of oxalic acid to carbon dioxide

Add 1 cm³ of oxalic acid solution and a few drops of concentrated H₂SO₄ into a tube, heat over the burner and add drop by drop KMnO₄ solution. Observe that the solution is discoloured and bubbles of CO₂ are formed. In this reaction, manganese is reduced, and oxalic acid is oxidised to CO₂:



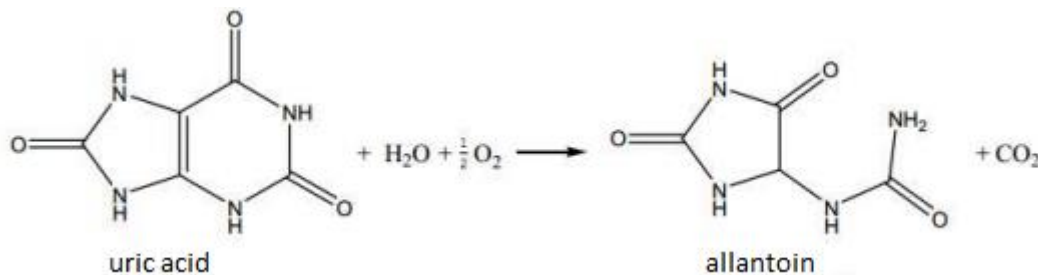
5. Oxidation of hydroxy acids on the example of lactic acid

Add a few drops of lactic acid solution { CH₃CH(OH)COOH } and 1 cm³ of 1 mol/dm³ H₂SO₄ solution to a tube, and then by drops the KMnO₄ solution. Manganese is reduced, and lactic acid is oxidised to CO₂ and acetaldehyde { CH₃CHO }:



6. Oxidation of ring compounds on the example of uric acid

Disolve some crystals of uric acid in 1 cm³ of 0.1 mol/dm³ NaOH solution in a tube, and then add drop by drop KMnO₄ solution. The solution is discoloured, manganese is reduced, and lactic acid is oxidised to CO₂ and allantoin.



II. Reactions of reduction – based on the example of various organic compounds

1. Reducing properties of alcohols – see experiment I. 1.

2. Demonstration of reducing properties of aldehydes – on the example of formaldehyde reaction with KMnO_4

Add 1 cm^3 of formaldehyde solution, 2 cm^3 of KMnO_4 solution and 1 cm^3 of 1 M H_2SO_4 , and heat the solution in a tube. The solution discolours. Manganese is reduced, and formaldehyde is oxidised to formic acid.



3. Demonstration of reducing properties of aldehydes on the example of formaldehyde using Fehling reaction

Pipette 1 cm^3 of Fehling I and 1 cm^3 of Fehling II solutions* into a tube, and add a few drops of formaldehyde solution. Heat the tube over the burner. The orange or red precipitate of copper oxide is formed.



*Fehling I – it is CuSO_4 solution, Fehling II it is the base solution of sodium-potassium tartrate

III. Reactions of condensation

1. Biuret formation, and its detection with biuret reaction

Heat up about 1 g of urea in dry tube until the crystals of urea dissolve. Wait until it cools. Dissolve the clotted mass in 5 cm^3 of distilled water and add 1 cm^3 of 2 mol/dm^3 NaOH . Filter the obtained solution if it is turbid. Add drop by drop 1% CuSO_4 solution until red-purple colour occurs. This colour is characteristic for complex of peptide bond with copper which is present in biuret reagent.



IV. Reactions of substitution

1. Preparation of iodoform

Principles of determination

Yellow iodoform is produced and precipitated during the heating up the mixture of ethanol and iodine in basic solution. It is multi-step reaction, in which atoms of hydrogen are substituted by iodine. The summary equation of this reaction:



It is one of the most sensitive reactions for the detection of ethanol in small quantities.

Procedure

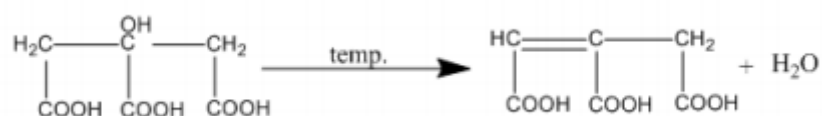
Mix in a tube 1 cm³ of ethanol with 2 cm³ of 5% solution of iodine in IK and add drop by drop the solution of 2 mol/dm³ NaOH until discolouration. Heat it over the burner until the solution has light yellow tint. At the outlet of the tube, the characteristic smell of iodoform is noticeable. After cooling the tube, the precipitate of iodoform crystals can be formed.

V. Reactions of elimination

1. Formation and detection of product of citric acid dehydration - aconic acid

Principles of determination

Citric acid in high temperature loses the water molecule and transforms into aconic acid. This reaction occurs in Krebs cycle.



Procedure

Heat a few crystals of citric acid in dry tube over the burner. At the outlet of the tube, the smoke of aconic acid occurs, and characteristic, unpleasant smell is noticeable.

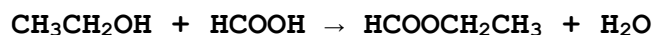
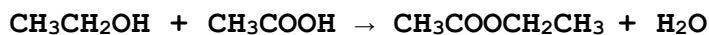


VI. Reactions of esterification

1. Formation of ethyl acetate and/or ethyl formate

Principles of determination

Ethanol can react with acetic acid and/or formic acid. The results of these reaction are esters: ethyl acetate and/or ethyl formate:



a) formation of ethyl acetate

Mix 1 cm³ of ethanol with 1 cm³ of concentrated acetic acid in a tube. Add 5 drops of concentrated sulphuric acid. Heat the tube over the burner until boiling. Alcohol and acid are esterified. Smell carefully the vapours of ethyl acetate which has a nice, fruity smell.

b) formation of ethyl formate

Mix 1 cm³ of ethanol with 1 cm³ of concentrated formic acid in a tube. Add 5 drops of concentrated sulphuric acid. Heat the tube over the burner until boiling. Smell carefully the vapours of ethyl formate which remains the smell of rum.