Ministry of Health of the Russian Federation

Volgograd State Medical University

Department of Pharmaceutical and Toxicological Chemistry

GENERAL PHARMACEUTICAL CHEMISTRY

Redox Titration.

Bromatometry.

Lesson 15

V term

Volgograd, 2022

QUESTIONS FOR THE LESSON

1. Essence of the method
2. Preparation of a titrated potassium bromate solution
3. Fixing the titration end point
4. Direct bromatometric titration
5. Bromometric determination
   a) Applications in pharmaceutical analysis
   b) The advantages of bromatometry
   c) Disadvantages of bromatometry

ESSENCE OF THE METHOD

Bromatometry is a redox titration method, based on the reduction reaction of a bromate ion. The basic reaction bromatometry is:

$$BrO_3^- + 6H^+ + 6e^- \longrightarrow Br^- + 3H_2O$$

If bromate ions are added to a solution of bromide ions in the presence of acid, molecular bromine is formed:

$$BrO_3^- + 5Br^- + 6H^+ \longrightarrow 3Br_2 + 3H_2O$$

In neutral solutions this reaction does not occur. The released elemental bromine can react stoichiometrically with organic organic substances without the formation of by-products.

An aqueous ***solution of potassium bromate*** is used as a ***titrant***.

Bromatometric determinations can be divided into two types:

1. ***Determinations based on the oxidation of the substance with bromate in an acidic environment***. The bromate ion is reduced to bromide:

$$BrO_3^- + 6H^+ + 6\bar{e} = Br^- + 3H_2O$$

2.
3. ***Determinations based on the interaction of the substance of determination with bromine produced by the reaction of $KBrO_3$ with KBr in an acidic medium***:

$$BrO_3^- + 5Br^- + 6H^+ = 3Br_2 + 3H_2O.$$

Definitions of the second kind are also called bromometric.

PREPARATION OF A TITRATED POTASSIUM BROMATE SOLUTION

A solution of potassium bromate can be prepared from an *exact sample*.

Mass of recrystallised and dried at 150°C potassium bromate is weighed on an analytical scale (exact weight) and a solution is prepared in an analytical flask.

The standardisation of the $KBrO_3$ solution is carried out iodometrically. Firstly the reaction of $KBrO_3$ with KI is conducted:

$$KBrO_3 + 6KI + 6HCl = 3I_2 + 6KCl + KBr + 3H_2O$$

and then titrate the released iodine with a standard solution of $Na_2S_20_3$.

$$I_2 + 2Na_2S_2O_3 = 2NaI + Na_2S_4O_6$$

The standard solution of $KBrO_3$ is stable during storage.

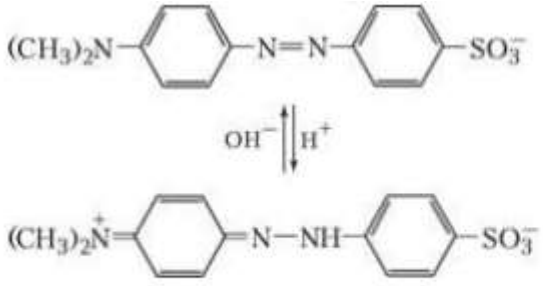
FIXING THE TITRATION END POINT

The indication-free method

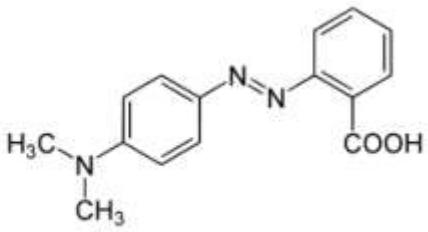
The endpoint in titration with $KBrO_3$ (or in cases of direct bromometric titration) is indicated by the appearance of free bromine in the solution. The release of bromine is indicated by a yellow colouring of the solution.

Indicators

As indicators in bromatometry methyl orange, methyl red are used. These indicators are irreversibly oxidized by bromine and the colour disappears.



methyl orange



methyl red

Quinoline yellow, a-naphthoflavone etc. are also used, whose colouring changes reversibly.

Instrumental methods

The titration endpoint can also be detected potentiometrically or photometrically.

DIRECT BROMATOMETRIC TITRATION

Direct bromatometric titration can be used for the determination of antimony Sb(III), arsenic As(III), hydrazine, ascorbic acid, oxalic acid, etc.

The direct bromatomeric determination is based on the equation for reducing bromates to bromides:

$$BrO_3^- + 6H^+ + 6e^- \longrightarrow Br^- + 3H_2O$$

Potassium bromide is not added to the titrated solution, because the bromide ions are produced by the reduction of the titrant. After all of the substance to be determined has reacted, the excess amount of titrant reacts with the bromide ions.

$$BrO_3^- + 5Br^- + 6H^+ = 3Br_2 + 3H_2O$$

This produces Br_2, which leads to the disappearance of the methyl orange colour.

This indicator should preferably be added to the titrated solution shortly before the end of the titration, and the titration should be carried out slowly near the end point.

It should be noted that this method is not widely used in pharmaceutical analysis.

BROMOMETRIC DETERMINATION

Bromometric determinations are carried out in the presence of excess KBr which is added to a solution of the substance to be determined or to a titrant (Potassium bromide).

A neutral solution containing $KBrO_3$ and KBr (bromide-bromate mixture), is stable, because these substances react with each other only in an acidic medium.

Titration is based on reaction:

$$BrO_3^- + 5Br^- + 6H^+ = 3Br_2 + 3H_2O$$

This type of is used to the determination of organic substances that undergo electrophilic substitution reactions (phenols, aromatic amines) or electrophilic addition (organic substances with multiple bonds in the molecule) with bromine.

Bromatometry methods use:

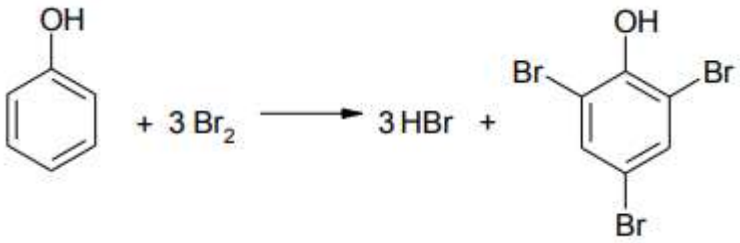
- direct;
- indirect (substitution titration);
- reverse titration.

Applications in pharmaceutical analysis

Direct bromometric titration

Phenol determination

Potassium bromide and hydrochloric acid are added to the test solution and titrated with potassium bromate. All of the bromine released will react with the phenol.



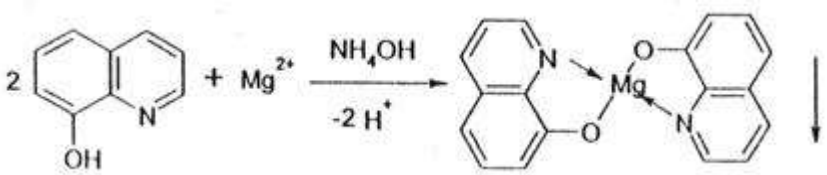
At the point of equivalence, methyl orange is discoloured.

Indirect (substitution) bromometric titration

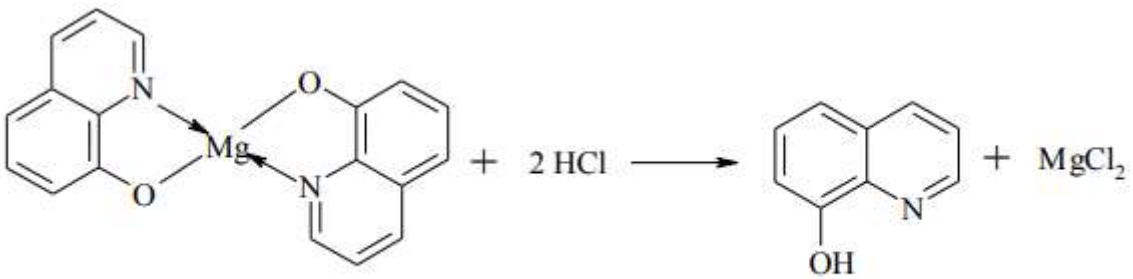
The bromination method can be used in the indirect analysis of many metals: magnesium, aluminium, copper, cadmium, zinc using 8- oxyquinoline.

Determination of magnesium salts

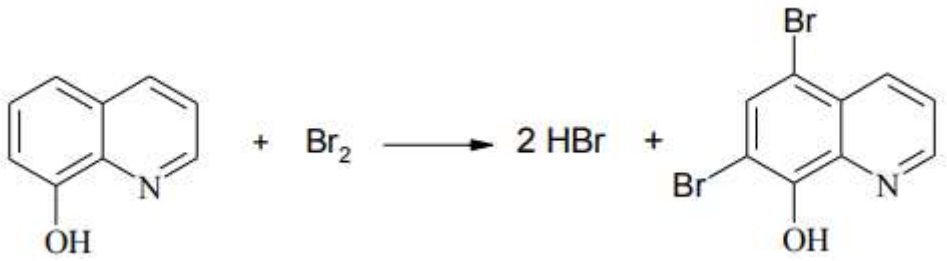
The magnesium cation is first precipitated with 8-oxyquinoline.



The filtered and washed precipitate is dissolved in hydrochloric acid and titrated with a bromate solution in the presence of potassium bromide with methyl red indicator.



$$KBrO_3 + 5KBr + 6HCl \longrightarrow 3Br_2 + 6KCl + 3H_2O$$



Reverse bromometric titration (bromide-bromate determination)

In pharmaceutical analysis, the bromimetric method is often used in combination with the iodometric method (bromatometric titration with iodometric termination).

This method is used in the quantitative determination of Salicylic acid and its salts, some sulphonamides, thymol, resorcinol and streptocide. sulphonamide preparations, thymol, resorcinol, streptocide.

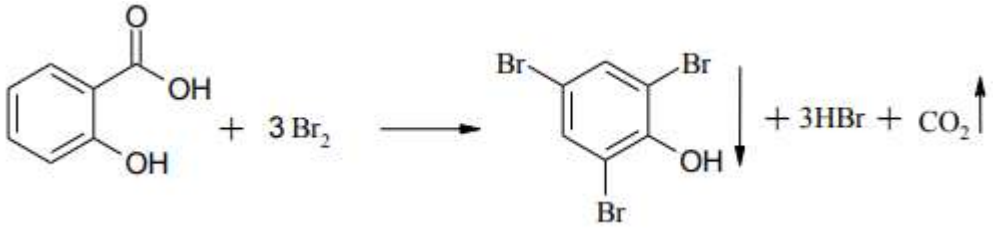
Determination of salicylic acid

The determination comes in four stages:

- *Reaction of potassium bromide with Potassium bromate in an acidic medium:*

$$KBrO_3 + 5KBr + 6HCl \longrightarrow 3Br_2 + 6KCl + 3H_2O$$

- *Bromination reaction of an organic compound*



Since the titrated solution of $KBrO_3$ is added in excess, only an equivalent amount (1:3) of salicylic acid reacts with bromine - some of the bromine remains in solution.

- *Reaction of the interaction of excess bromine with potassium iodide:*

When a concentrated solution of potassium iodide is added to the reaction medium, a redox reaction with the release of molecular iodine takes place.

$$2KI + Br_2 \rightarrow 2KBr + I_2$$

- *Iodometric ending*

The excess bromine is determined by iodometric determination. The released iodine is titrated with sodium thiosulphate solution.

Indicator is starch, at the point of equivalence the blue staining disappears.

The advantages of bromatometry

1. ***Widespread use.*** Bromate-bromide solutions can be used not only for the determination of reducing agents and oxidizing agents but also for the analysis of organic unsaturated, aromatic and heterocyclic compounds. Also for the indirect determination of a variety of ions precipitated as water insoluble compounds, for example as oxyquinolates.
2. ***Stability of the potassium bromate solution during storage and accuracy of analysis.*** In contrast to standard solutions of iodine or bromine used for the analysis of the same compounds, solutions of potassium bromate are stable and does not change its titre over a long period of time. Therefore the use of bromate leads to more reliable results.

Disadvantages of bromatometry

1. Water present in solution or produced during titration of non-aqueous solutions interferes with the determination of many organic compounds.
2. The oxidation of some organic compounds is accompanied by undesirable side reactions of hydrolysis, substitution and and addition caused by the action of water and bromine ions.
3. In some cases the reactions of potassium bromate with organic substances are not strictly stoichiometric. This leads to a distortion of the final analytical results.