OXIDATION OF CELLULOSE WITH IODIC ACID

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Abstract. *This abstract is devoted to the oxidation reaction of cellulose with periodic acid. This chemical process involves using periodic acid as an oxidizing agent to modify cellulose molecules, resulting in the formation of carbonyl groups in its structure. The abstract highlights the main aspects of this reaction, including its chemical mechanism and potential applications of modified cellulose. Considering the complexity of the reaction and the influence of the conditions on the result, it seems important to in-depth study of this method of cellulose functionalization to unlock its potential in various fields of industry and science.*

Keywords: *cellulose, iodic acid, oxidation, carbonyl groups, cellulose modification, biomaterials, chemical industry, nanotechnology, chemical mechanism, functionalization of polymers, reaction conditions, potential applications, bioengineering, chemical process, reaction conditions.*

Cellulose, as the main component of the plant cell wall, is an exquisite polymer with unique properties. Its potential in various fields such as biomaterials, chemicals and nanotechnology is becoming the subject of widespread scientific research. In this context, the oxidation reaction of cellulose with periodic acid stands out as a promising method for the functionalization of this biopolymer.

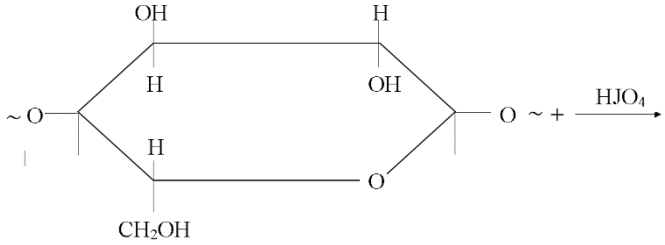
Due to the presence of aldehyde groups in this product, it is possible to graft carbon-chain polymers onto cellulose. In addition, on the basis of this product, due to the presence of a tertiary nitrogen atom, the synthesis of quaternary ammonium bases with high ion-exchange properties is possible.

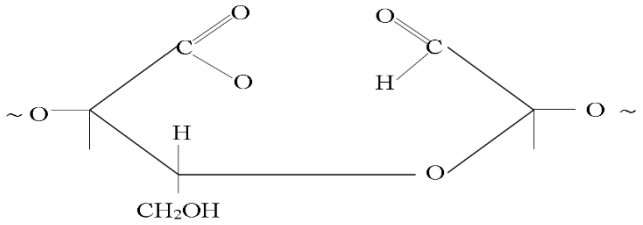
The purpose of this introduction is to review the chemical process of cellulose oxidation with periodic acid and highlight its potential applications. The oxidation process using periodic acid is an innovative approach to modify the structure of cellulose, enriching its chemical properties.

In further discussions, the main aspects of this chemical reaction will be considered, including its mechanism, the influence of conditions, as well as the prospects for the use of modified cellulose in modern technologies. The results of this study can provide valuable scientific and practical contributions in the field of functionalization of cellulosic materials and their applications in a variety of industrial and scientific fields.

When cellulose is exposed to periodic acid and its salts or lead acetate, simultaneous oxidation of both secondary hydroxyl groups to aldehyde groups occurs, accompanied by rupture of the pyran ring of the elementary unit of the cellulose macromolecule. When oxidation products are treated with sodium bromide or chlorite, aldehyde groups are oxidized to carboxyl groups.

The method of simultaneous oxidation of both secondary hydroxyl groups of cellulose, as well as other polysaccharides (starch) and monosaccharides, to aldehydes was developed in 1935-1938. Goodson and Jackson.





When periodic acid acts on polyhydric alcohols, in particular mono- and polysaccharides, simultaneous oxidation of two adjacent hydroxyl groups (glycol group) into aldehyde groups occurs with simultaneous rupture of the carbon-carbon bond between them.

The above methods for the oxidation of cellulose hydroxyl groups exhaust the hitherto known possibilities for the selective oxidation of cellulose. All other oxidizing agents used for the oxidation of cellulose cause the oxidation of both primary and secondary hydroxyl groups, and depending on the oxidation conditions and the nature of the oxidizing agent, hydroxyl groups are oxidized to carbonyl (aldehyde and keto groups) or to carboxyl groups.

All cellulose oxidation products obtained under the action of most oxidizing agents can be schematically divided into two types:

- products of a restorative nature;
- acidic products.

Preparations of oxidized cellulose of the reducing type are formed, as a rule, by the action of oxidizing agents in an acidic or neutral environment. During the oxidation of cellulose in an alkaline medium, a gradual transformation of aldehyde groups into carboxyl groups occurs, and the resulting oxidation products contain predominantly carboxyl groups. If the same oxidizing agents are used for the oxidation of cellulose, then, depending on the pH of the medium, the resulting preparations contain different amounts of carbonyl and carboxyl groups. The compounds formed in this case are of great interest as reactive derivatives of cellulose in the synthesis of new compounds with valuable performance properties.

Oxidation of cellulose with periodic acid leads predominantly to the formation of aldehyde groups at all acid concentrations studied.

However, the results of such a study may vary depending on many factors, including the specific reaction conditions, proportions of reagents, reaction time, etc. Typically, oxidation of cellulose with periodic acid can lead to the introduction of carbonyl groups into the cellulose structure.

Determination of the degree of oxidation of cellulose after its treatment with periodic acid can be carried out using various analytical methods. Here are some common techniques:

1. Fourier transform infrared (FTIR):

The technique involves recording the infrared spectrum of the modified cellulose and analyzing changes in the characteristic bands. The appearance of new peaks in the region of carbonyl groups may indicate the degree of oxidation.

2. Nuclear Magnetic Resonance (NMR):

NMR spectroscopy can be used to analyze structural changes in the cellulose molecule. The appearance of signals corresponding to carbonyl groups confirms oxidation.

3. Elemental analysis:

The use of elemental analysis methods, such as C, H, N, S analysis, makes it possible to determine changes in the elemental composition of cellulose after oxidation.

4. Titrimetric methods:

Depending on the nature of the oxidation reaction, titrimetric methods can be used to quantify the degree of oxidation. For example, the consumption of a reagent (iodine) during a titration may be proportional to the number of oxidized groups.

5. Gas chromatography (GC) or high performance liquid chromatography (HPLC):

These methods can be used to analyze reaction products and determine oxidation states. The choice of method depends on the objectives of the study, available laboratory facilities and the nature of the cellulose oxidation products formed. The combination of several methods can also provide a more complete understanding of the chemical changes that occur as a result of oxidation.

Conclusion: The study of cellulose oxidation with periodic acid represents a significant contribution to the field of functionalization of this biopolymer. The results obtained confirm the possibility of introducing carbonyl groups into the cellulose molecule, which opens up new prospects for the use of the modified material in various applications.

Analysis of the spectra using FTIR and NMR methods allows us to confirm changes in the chemical structure of cellulose after oxidation. Elemental analysis indicates redistribution of elements as a result of chemical modification. Titrimetric methods and chromatography provide quantitative data on the degree of oxidation and reaction products.

A certain degree of oxidation of cellulose with periodic acid creates the possibility of additional functionalization of the biopolymer for its use in biomaterials, biotechnology and other innovative fields. However, additional research is needed to better understand the influence of reaction conditions on the final properties of modified cellulose, as well as to optimize the process for environmental sustainability and efficiency. These studies have the potential to further develop sustainable and innovative cellulose-based materials.

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