AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 5,September ,2025

ISOLATION OF CELLULOSE FROM COTTON STALK AND ITS COMPARATIVE IR SPECTRAL ANALYSIS

Madinabonu Yoqubjonova
Namangan State University
Faculty of Natural Sciences, Department of Chemistry, 2nd-year Master's Student
Email: madinabonuodiljonovna23@gmail.com

Abstract: In this scientific study, the infrared (IR) spectral analysis of cellulose extracted from cotton stalk using different concentrations of alkaline and hydrogen peroxide (H_2O_2) solutions was investigated. The main objective of the research is to determine the physicochemical properties of cellulose obtained from plant-based raw materials and evaluate the structural changes occurring during the processing stages. Cotton stalks, being a cost-effective and locally available raw material, offer great potential in the production of paper, biopolymers, medical materials, and other eco-friendly products.

Keywords: Cellulose, physicochemical properties, IR spectroscopy, functional groups

Introduction

Today, the rational use of renewable natural resources and the production of eco-friendly and biotechnological products is gaining increased attention. In this context, one-year plant residues, especially cotton stalks, play an important role as a valuable industrial raw material for the extraction of cellulose and other compounds.

Cellulose is the most abundant natural polymer, biodegradable, and environmentally safe. It is widely used in the production of paper, textiles, biomaterials, bioplastics, and pharmaceuticals. Utilizing fast-renewable plant sources instead of traditional sources (e.g., wood) helps conserve resources and reduce waste.

This study aims to extract cellulose from the one-year cotton stalk and assess its physicochemical characteristics to evaluate its potential applications. Currently, in the industrial sector and modern high-tech industries—including pharmaceuticals, information technology, biotechnology, alternative energy, and tourism—there is a growing opportunity to develop small businesses and private entrepreneurship.

As students, we must contribute our knowledge and experience to the development of our country's economy. In particular, we should mobilize our skills to support the pharmaceutical sector—a vital part of the national economy. Therefore, it is essential to identify, study, and apply ecologically clean and natural medicinal substances for the advancement of the pharmaceutical field in our country.

Cellulose and Its Importance in Industry and Science

Cellulose is a major component of plant cell walls and belongs to the polysaccharide group of complex carbohydrates. Its molecule consists of long chains of β-D-glucopyranose units linked by β-1,4-glycosidic bonds, giving cellulose a strong and insoluble structure.

Chemical formula: $(C_6H_{10}O_5)n$
It is a white, fibrous substance that is insoluble in water and common organic solvents. It is highly durable, flexible, and thermally unstable at high temperatures. It is flammable and found abundantly in plant stems, leaves, seed husks, and wood (95–98% in cotton, 40–50% in wood). Certain bacteria (e.g., *Acetobacter xylinum*) can also synthesize cellulose. [10]

Major Applications of Cellulose:

a) Paper and cardboard production: The largest consumer of cellulose; used to make writing, printing, and packaging materials from wood pulp or cotton fibers. [3]

b) Textile industry: Cotton fibers are mainly composed of pure cellulose; chemically processed into artificial fibers like viscose and acetate. [3]

c) Chemical industry: For making nitrocellulose (explosives, paints), cellulose acetate (films, plastics), and carboxymethyl cellulose (as thickening agent in food and pharmaceuticals). [4]

d) Food industry: Used as a thickener and stabilizer (E460); acts as a calorie-free filler in dietary products.

f) Packaging and biopolymers: Cellulose-based biodegradable films are environmentally friendly.

Scientific Applications:

a) Materials science: Nanocellulose (nanocrystalline cellulose, NCC) is used in making composite materials due to its high strength and light weight.

b) Biomedical field: Used in wound healing materials and as a drug delivery carrier through modified cellulose. [5]

Hydrolysis Reaction:
Cellulose consists of glucose residues and undergoes acid hydrolysis as follows:
$(C_6H_{10}O_5)n + nH_2O \rightarrow nC_6H_{12}O_6$

Cellulose fibers contain 300–2500 glucose units and form a structure with no lateral branching. Hydrogen bonds between the chains give it strong mechanical properties. [2]

When hydrolyzed with sulfuric acid, cellulose turns blue in color. It also reacts with iodine, turning brown. In addition to cellulose, plant cell walls contain other carbohydrates collectively called hemicelluloses, which can be extracted using 1% hydrochloric or sulfuric acid. [2]

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5,September ,2025

Research Object and Methodology

Object of Study: Cotton stalks grown in Namangan region
Subject of Study: Cellulose

Preparation of Plant Samples:
Cotton stalks collected from Kosonsoy district, Namangan region, were ground into powder form.

Steps for Cellulose Extraction:

-

An alkaline extraction method was applied.

-
-

200 g of ground cotton stalk was boiled in water for 6 hours.

-
-

After boiling, the mass difference was calculated:
200 g – 167.72 g = 32.28 g (mass loss)

-
-

From the remaining 167.72 g, 150 g was divided into three 50 g portions.

-
-

Each portion was treated with 5%, 7%, and 8% NaOH solution at 90°C for 3 hours.

-
-

Afterwards, bleaching was performed using 5%, 10%, and 15% hydrogen peroxide solutions.

-

Findings:
Alkaline treatment effectively removed most of the lignin and other impurities. However,

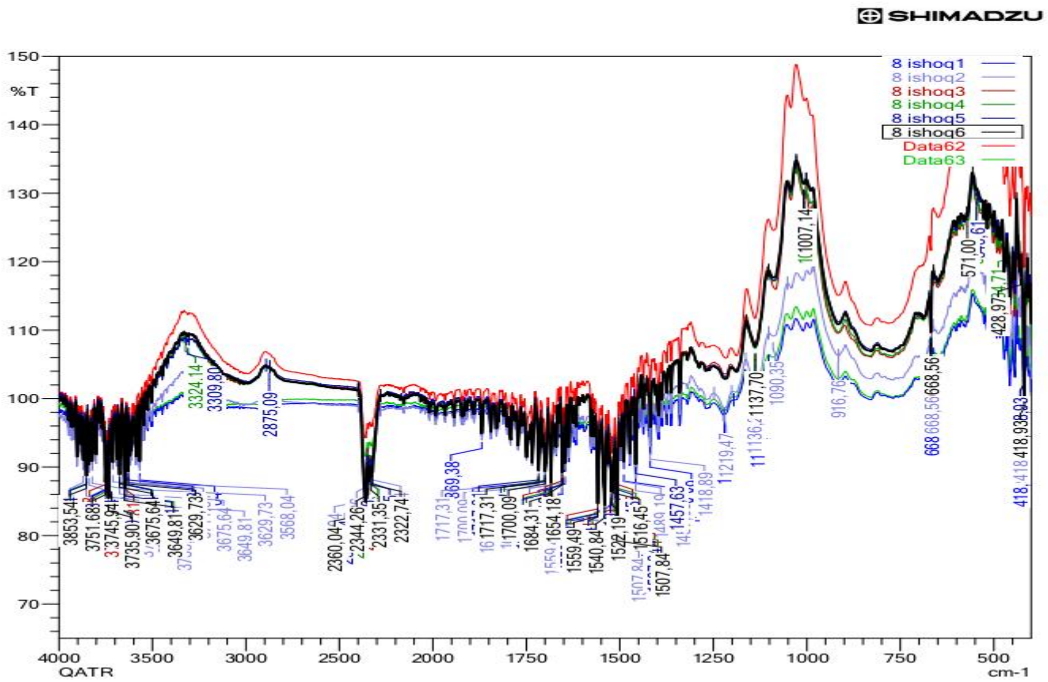
AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 5,September ,2025

bleaching was not sufficiently effective, likely due to residual lignin or low hydrogen peroxide concentration. The resulting powder turned a light yellow color.

Infrared (IR) spectral analysis of the bleached samples showed the presence of additional compounds containing functional groups such as alkynes, aldehydes, amides, and others.



Comparison of Bleaching in Alkaline and Hydrogen Peroxide Solutions

In the figure above, a comparison of samples bleached in 7%, 8%, and 15% alkaline solutions using 10%, 15%, and 30% hydrogen peroxide (H_2O_2) solutions is presented. Among these, the sample treated with **15% alkaline solution and 30% hydrogen peroxide** showed better IR peaks compared to the others.

Conclusion

During the experiment, cellulose samples were treated with sodium hydroxide (NaOH) and hydrogen peroxide (H_2O_2) solutions of varying concentrations. As a result, IR spectroscopy revealed changes in functional group vibration frequencies, shifts in hydroxyl groups, and the intensification or weakening of C–H, C–O, and C=O bonds.

The analysis indicated that increasing the concentration of the alkaline solution significantly reduces the content of inorganic impurities and lignin in the cellulose structure. Treatment with hydrogen peroxide enhanced the bleaching of the cellulose, thereby improving its quality characteristics.

This study contributes to the development of biotechnological processes based on cellulose and expands the potential for efficient processing of local raw materials.

Physicochemical analyses of the isolated cellulose were carried out. It was found that **annual local plants serve as a source of cellulose**, although **the cellulose content in cotton stalks is relatively lower compared to other one-year plants**.

References

1. Mutalibov, E. Murodov, S. Masharipov, H. Islomova. *Organic Chemistry*, Textbook for 10th-grade secondary and vocational education students, Tashkent, 2017, p. 127
2. Zokirov Jasur. *Extraction of Cellulose from Potato Stems*, Master's Thesis, Tashkent, 2017
3. Harika K. et al. "*Basic Concepts of Cellulose Polymers – A Comprehensive Review*," Archives of Pharmacy Practice, 2012
4. Jean-Luc Wertz, Olivier Bédué, Jean P. Mercier. *Cellulose Science and Technology*
5. UNESCO – EOLSS Sample Chapter: "*Cellulose and Pulp*," Author: Hsiu Hwa (Cathy) Wang
6. Jo'raqulov B., Mirzayev Sh. *Irrigation Technologies and Productivity of Fine-Fiber Cotton Varieties*, Uzbekistan Agriculture Journal, 2001, No. 3, pp. 36–38
7. Rajabov T.Ya., Omonov N.S. *Cultivation Technology of the Prospective Cotton Variety "Qarshi-9"*, Tashkent, 2003, pp. 108–111
8. Nazarov R.S., Yaqubov M., Ziyoev Z. *Application of Phosphorus to New Cotton Varieties*, Uzbekistan Agriculture Journal, Tashkent, 2002, No. 3, p. 49
9. Tojiyev M., Qurbonova G., Hujmanov O. *Effect of Seedling Density, Water and Fertilizer Systems on Cotton Yield in Southern Uzbekistan*, Agrarian Science Bulletin, 2003, No. 1(II), pp. 20–22
10. Abdusamatov, R. Mirzayev, R. Ziyayev. *Organic Chemistry*, Textbook for Academic Lyceums and Vocational Colleges, "O'qituvchi" Publishing, Revised Edition, 2015, pp. 155–157
11. G. Kuregian, S.V. Pechinsky. *IR Spectrometry and Practical Methods*, Digital Learning Guide, Russia, Buk, 2023, pp. 21–24
12. Tarasevich B.N. *IR Spectra of Major Classes of Organic Compounds*, Reference Materials, Moscow, 2012, pp. 3–48
13. Tarasevich B.N. *Fundamentals of FTIR Spectroscopy*, Sample Preparation in IR Spectroscopy, Guide for Senior Students, Department of Organic Chemistry, Moscow, 2012, pp. 3–8
14. H.M. Shohidoyatov, H.O. Khojaniyozov, H.S. Tojimuhammedov. *Organic Chemistry*, Textbook for Higher Education, Chemistry Major, Tashkent, 2012, pp. 687–688
15. B. Umarov, Q.G'. Avezov, M.A. Tursunov. *Methods of Physical Research*, Textbook, Tashkent, 2020, pp. 195–200