

## Analysis of Cellulose and Nanocellulose by Infrared spectroscopic Method

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*Manuscript received online 21 April 2024, accepted on 25 May 2024*

**Abstract** : Cellulose and Nanocellulose are extensively studied biopolymers due to their renewable nature, biodegradability and impressive mechanical properties. This research aims to conduct a comprehensive comparison of Cellulose and Nanocellulose using Fourier Transform Infrared Spectroscopy (FTIR) to highlight their structural differences and similarities at the molecular level. The O-H stretching and C-H bending regions displays significant variations indicating changes in hydroxyl group interaction and cellulose chains conformations. Microcrystalline cellulose was used in this analysis. Nanocellulose was prepared by Acid hydrolysis. This comparative study enhances the understanding of the structural modifications induced by the nanofibrillation process and providing insights into the potential applications and functionalization strategies for nancellulose.

**(Keywords** : Biodegradable, Fourier transform Infrared spectroscopy, Microcrystalline cellulose, Acid hydrolysis, Renewable nature.)

### Introduction

Cellulose was identified in 1838 by French chemist Anselme Payen, who extracted it from plant material and established its chemical formula<sup>1,2,3</sup>. In 1992 Kobaayashi and shoda chemically synthesized the compound for the first time without using any enzymes derived from biological sources<sup>4</sup>. Cellulose having general formula ( $C_6H_{10}O_5$ ) is a polysaccharide up of a linear sequences of D-glucose units, which are linked together by  $\beta$  (1-4) bonds, ranging from hundred to many thousands in number<sup>5-6</sup>. Nanocellulose refers to a group of cellulose

based materials where at least one dimensions in nanoscales. Nanocellulose can be derived from natural cellulose fibers using various production methods. Cellulose hydrolysis was found primarily take place at the specific “Disordered” intercrystalline areas of the fibers, resulting in leftover material that remained unhydrolyzed<sup>7</sup>. Subsequent investigations determined that this residual material was composed of colloiddally stable and highly crystalline nanorod particles<sup>8-10</sup>.

Nanocellulose can be produced from various natural cellulose sources such as wood, cotton, agriculture [11] or household wastes [12], algae [13], bacteria or tunicate. Wood pulp is currently the most widely used raw material for industrial nanocellulose production. The increasing interest in the sustainable materials has led to the exploration of cellulose and its derivatives particularly Nanocellulose, for a range of advanced application including biocomposites, pharmaceuticals, and electronics.

Infrared spectroscopy is a analytical technique widely used to investigate the molecular structure and composition of cellulose and nanocellulose. By measuring the absorption of infrared light at different wavelengths, IR spectroscopy provides insights into the functional groups present in the material enabling the identification of chemical bonds and the detection of structural changes. This analysis focus on the use of IR Spectroscopy to characterize cellulose and nanocellulose, detailing the spectral features that corresponds

to different functional groups and examining the differences between various forms of cellulose.

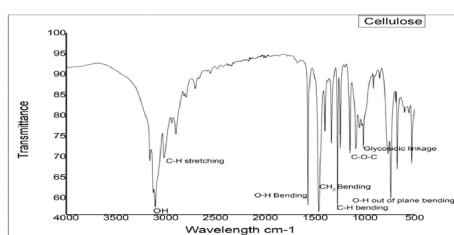
## Experimental

### Materials and Methods

Microcrystalline cellulose was used for this experiment. Microcrystalline cellulose was associated with Sigma Aldrich Company. For the preparation of Nanocellulose, Acid hydrolysis method was used. Hydrolysis of cellulose performed with 64%(w/w) sulphuric acid at 45°C for 45 min with constant stirring. To quench the reaction, the suspension was diluted 10 fold deionized water. The suspension was centrifuged at 15000 rpm for 10 min. The precipitate was washed until constant neutral pH was achieved<sup>14</sup>.

## Result and Discussion

### FTIR Graph of Cellulose

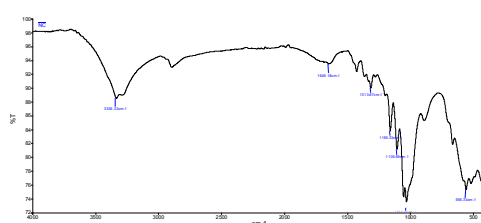


The Infrared spectra of cellulose

In FTIR graph of Cellulose, 3200  $\text{cm}^{-1}$  is attribute to -OH group, 3015  $\text{cm}^{-1}$  contribute to -CH stretching of alkane, 2898  $\text{cm}^{-1}$  indicates the presence of C-H stretching of aldehyde, 2703  $\text{cm}^{-1}$  attribute O-H stretching, 1571  $\text{cm}^{-1}$  contribute to C=C stretching of cyclic alkene, 1462  $\text{cm}^{-1}$  attribute to C-H bending of alkane, 1401  $\text{cm}^{-1}$  contribute to -OH bending of alcohol, 1335  $\text{cm}^{-1}$  contribute to O-H bending of alcohol, 1246  $\text{cm}^{-1}$  C-N stretching of amine and 1089  $\text{cm}^{-1}$  contribute to C-O-C stretching. The broad peak indicates the presence of hydrogen bond (around 3200  $\text{cm}^{-1}$ ) which is abundant due to polysaccharide structure. The intensity and broadness of this peak are influenced by hydrogen

bonding. C-H Stretching (around 2800-3000  $\text{cm}^{-1}$ ) are due to glucose unit of cellulose. The region around 1089  $\text{cm}^{-1}$  shows the ether bonds within the glucose rings of the cellulose. Peak around 1450  $\text{cm}^{-1}$  corresponds the bending vibrations of the C-H bonds within glucose rings.

### FTIR Graph of Nanocellulose



### FTIR Graph of Nanocellulose

In FTIR Graph of Nanocellulose around 3200  $\text{cm}^{-1}$  contributes to -OH stretching of the hydroxyl group present in the cellulose. This peak can shows the degree of hydrogen bonding 2800  $\text{cm}^{-1}$  attributes C-H stretching of alkyl group, 1600  $\text{cm}^{-1}$  around -OH bending, The peak around 1370  $\text{cm}^{-1}$  shows C-H bending vibration of C-H bonds, 1330  $\text{cm}^{-1}$  contribute to -OH group, Peaks around 1030  $\text{cm}^{-1}$  C-O-C stretching vibration which is a characteristics of glycosidic linkage and peaks around 895  $\text{cm}^{-1}$  contribute to<sup>2</sup> glycosidic -linkage. The nanocellulose shows retains its fundamental structure cellulose structure after processing and modifications.

## Conclusion

Both Cellulose and Nanocellulose exhibited key functional group associated with cellulose, confirming the retention of the core chemical structure. The notable differences were observed such as shifts in the -OH and -CH stretching due to nanostructuring process. These changes can provide insights into the degree of crystallinity, surface chemistry and the presence of functional group which are critical for understanding and optimizing nanocellulose for specific applications.

### Acknowledgement

I am thankful to Ranchi University for providing the necessary resources and a conducive environment for this research. I would like to thank my guide who helped me a lot in gathering different data and information

regarding research. Special thanks to Birla institute of technology whose contributions in completing this work.

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An International Peer Reviewed Research Journal of Chemistry

Abstracted / Indexed in : Chemical Abstract U.S.A.

JC- 1589/2K24 (ISSN:0973-239X), INDIA

Journal Chemtracks Vol. 26 (1&2), 149-152, January to December 2024

