DESIGN AND DEVELOPMENT OF PACKING MATERIAL FROM BIO CELLULOSE SYNTHESIZED FROM COIR WASTE -A Review

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ABSTRACT

Bacterial bio-cellulose derived from coir lignin is a promising and sustainable biomaterial with multifaceted applications. This abstract provides an overview of the production, properties, and potential uses of this eco-friendly biopolymer. Bacterial bio-cellulose, a highly pure and crystalline form of cellulose, is synthesized by acetic acid bacteria during the fermentation of coir lignin. Coir, a natural byproduct of the coconut industry, contains lignocellulosic materials, primarily lignin and cellulose. The unique production process involves the utilization of lignin, which is typically considered a waste product, and its conversion into a valuable bio-polymer. The resulting bacterial bio-cellulose exhibits exceptional characteristics, including high mechanical strength, high water retention capacity, and biocompatibility. Its porous structure and chemical composition make it suitable for various applications, such as wound dressings, tissue engineering scaffolds, and food packaging. Moreover, the biodegradability of bacterial bio-cellulose contributes to its environmental sustainability. This abstract underscore the potential of bacterial bio-cellulose derived from coir lignin as an innovative biomaterial that can address ecological and biomedical challenges while promoting circular economies and sustainable development.

KEYWORDS: *Bacterial bio cellulose, Coir lignin, packing material, Biodegradable, Sustainable development*

1.INTRODUCTION

In an era characterized by growing environmental concerns and the pursuit of sustainable materials, the exploration of alternative biopolymers has gained significant attention. One such innovative and promising biomaterial is bacterial bio-cellulose derived from coir lignin. This unique biopolymer holds the potential to revolutionize various industries by offering a sustainable and eco-friendly alternative to conventional materials. Its synthesis process, properties, and diverse applications underscore its significance in addressing both ecological and biomedical challenges. Coir lignin, an abundant waste product from the coconut industry, is traditionally underutilized and often considered a byproduct of minimal value. However, recent developments in biotechnology have unveiled a remarkable transformation of this lignocellulose material. Acetic acid bacteria, through a fermentation process, convert coir lignin into bacterial bio-cellulose, a highly pure and crystalline form of cellulose. This transformation not only harnesses the latent potential of lignin but also demonstrates the possibilities of circular economies and waste-to-resource strategies. The resulting bacterial bio-cellulose exhibits a set of extraordinary characteristics, making it an attractive biomaterial for various applications. It boasts exceptional mechanical strength, high water retention capacity, and biocompatibility, all of which are qualities highly sought after in industries ranging from healthcare to packaging. Its porous structure and chemical composition enable it to serve as an ideal candidate for wound dressings, tissue engineering scaffolds, and sustainable food packaging materials. Furthermore, its biodegradability aligns with the global shift towards reducing the ecological footprint of products. This introduction sets the stage for an in-depth exploration of bacterial bio-cellulose derived from coir lignin, highlighting its transformative potential in addressing contemporary environmental and biomedical challenges while simultaneously promoting the principles of sustainability and circular economies. The subsequent sections of this study will delve into the production process, properties, and diverse applications of this remarkable biomaterial, shedding light on the opportunities it presents for a more sustainable and eco-conscious future.

2.BIOCELLULOSE MATERIALS

Bacterial cellulose, often referred to as bio cellulose, is a unique and versatile biomaterial with remarkable properties and applications. It is distinct from plant-derived cellulose and is produced by acetic acid bacteria during a fermentation process

Microorganism	Carbon source	Supplementary materials	Culture time (days)	Yield (g/L)	Cultivation mode
G. xylinus, Trichodermareesei	Glucose	Fiber sludge	14	6.23	Static
G. xylinus	Glucose	Cellulosic fabrics	14	10.80	–
G. medellensis	Glucose	None	14	4.50	–
G. hansenii PJK (KCTC 10505 BP)	Glucose	Glucuronic acid oligomers	10	7.4	–
G. xylinus(PTCC, 1734)	Glucose	Date syrup	14	40.35	–
G. Persimmonis (GH-2)	Glucose	Fructose, beef extract	14	5.14	–
G. xylinus strain (ATCC 53524)	Sucrose	None	4	3.83	–
G. hansenii PJK (KCTC 10505 BP)	Waste from beer culture	None	14	8.6	–
G. xylinus strain (K3)	Mannitol	Green tea	7	3.34	–
G. xylinus(IFO 13773)	Sugar cane molasses	None	7	5.76	–
A. xylinum(ATCC 700178)	CSL-Fru	Carboxymethylcellulose	5	13.00	Agitated
A. xylinum	CSL-Fru	Sodium alginate, agar, carboxymethylcellu-lose	5	7.05	–
Gluconacetobacter sp. (RKY5)	Glycerol	None	6	5.63	–
A. xylinum(BPR2001)	Molasses	None	3	7.80	–
A. xylinum(BPR2001)	Fructose	Agar/Oxygen	3	14.10	–
G. hansenii PJK (KCTC 10505 BP)	Glucose	Ethanol	3	2.50	–

2.1 Production:

Bio cellulose production involves the cultivation of acetic acid bacteria in a culture medium containing glucose or other carbon sources. These bacteria synthesize cellulose in the form of long, interconnected nanofibers. Unlike plant cellulose, bio cellulose is produced as a highly pure and crystalline material, which contributes to its exceptional qualities.

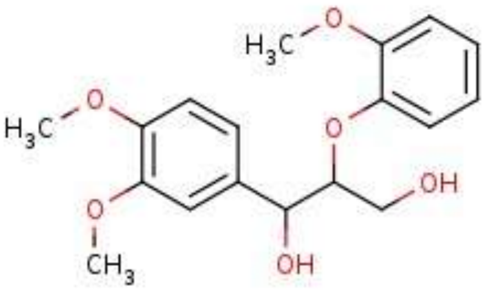

Fig 2.1 Lignin peroxidase

Fig 2.2 Acetobacter xylinum

2.2 Properties:

Bio cellulose possesses several noteworthy properties:

Purity and Crystallinity: Bio cellulose is remarkably pure and crystalline, which results in high mechanical strength and durability.

High Water Retention: It has a remarkable ability to retain water, making it suitable for various applications that require moisture control.

Biocompatibility: Bio cellulose is biocompatible, meaning it is well-tolerated by the human body and does not cause adverse reactions, making it suitable for medical and biomedical applications.

Nanostructure: Its Nano fibrous structure and high surface area make it ideal for diverse applications.

Porous Structure: The porous nature of bio cellulose allows for the incorporation of bioactive compounds or drugs, making it suitable for drug delivery systems.

2.3 Applications:

Biocellulose finds applications in various fields, including:

Medical and Healthcare: Biocellulose is used in wound dressings due to its biocompatibility and high moisture retention. It promotes wound healing and minimizes the risk of infection. It can also be used in tissue engineering as scaffolds for cell growth.

Food and Beverage: Biocellulose is employed in the food industry for sustainable packaging. It can replace single-use plastics in food packaging due to its biodegradability and moisture-retaining properties.

Cosmetics: It is used in skincare products like facial masks and cosmetic patches due to its ability to deliver active ingredients to the skin.

Environmental Sustainability: Biocellulose aligns with sustainability goals as it is biodegradable and can replace non-biodegradable materials in various applications.

Electronics: Biocellulose has potential uses in the electronics industry, such as flexible and biodegradable electronic components.

In summary, biocellulose is a remarkable biomaterial with unique properties that make it a valuable asset in various industries. Its applications in wound care, tissue engineering, sustainable packaging, and cosmetics demonstrate its potential to address contemporary challenges while contributing to a more sustainable and eco-conscious future.

3.METHODOLOGY

The production of bacterial bio-cellulose from coir lignin involves a series of carefully orchestrated steps to ensure the efficient synthesis of this unique biomaterial. This methodology section outlines the key processes involved in the production of bacterial bio-cellulose and highlights the experimental techniques and parameters utilized.

Fig 3.1 coir

1. Raw Material Preparation:

Coir lignin is obtained from coconut husks, and it is essential to prepare the raw material by extracting and purifying the lignin component. This may involve mechanical processing, chemical extraction, and purification techniques.

2. Isolation of Acetic Acid Bacteria:

Acetic acid bacteria strains capable of producing bacterial bio-cellulose are isolated and cultured. These strains are selected for their cellulose-producing capabilities and ability to thrive in the chosen fermentation conditions.

3. Fermentation Process:

The isolation of acetic acid bacteria is followed by the fermentation process. Key steps in this process include:

Inoculation: The isolated bacteria are inoculated into a suitable growth medium, which contains the coir lignin as a carbon source.

Culture Conditions: Maintaining optimal culture conditions, including temperature, pH, and oxygen supply, is critical for the growth of the bacteria and cellulose production.

Fermentation Duration: The fermentation process may last for several days, allowing the bacteria to produce bacterial bio-cellulose through their metabolic activities.

4. Harvesting and Cleaning:

After the fermentation period, the bacterial bio-cellulose is harvested from the culture medium. It is essential to clean the harvested material to remove any residual bacterial cells, growth medium components, and impurities.

5. Drying and Processing:

The harvested bacterial bio-cellulose is dried to remove excess moisture. Depending on the intended application, the material can be processed into desired forms, such as sheets, membranes, or powders.

Fig 3.3 biocellulose packing material

4.TESTING

Moisture Content Analysis:

Moisture content affects the physical and mechanical properties of bacterial bio-cellulose. Packaging materials need to maintain moisture control to prevent mold growth and ensure product integrity.

Measuring moisture content helps ensure that the bio-cellulose packaging material is within the acceptable range for maintaining product freshness and preventing spoilage.

Barrier Properties Testing:

Packaging materials must act as effective barriers against external factors such as oxygen, moisture, and UV radiation to protect the packaged contents.

Evaluating the barrier properties ensures that the bacterial bio-cellulose effectively preserves the quality and shelf life of packaged products.

Biodegradability Assessment:

Sustainability is a critical concern in packaging. Biodegradability testing assesses how quickly and effectively the bio-cellulose packaging material breaks down in different environmental conditions.

Packaging materials that are biodegradable contribute to reducing environmental pollution and waste, aligning with eco-friendly packaging goals.

Tensile Strength Testing:

Packaging materials need to have sufficient tensile strength to withstand handling, transportation, and external stresses.

Tensile strength testing ensures that the bio-cellulose packaging material is durable and can resist tearing or puncturing during its lifecycle.

Microbial Safety Assessment:

Packaging materials should not promote microbial growth, which could lead to contamination of the packaged product.

Microbial safety testing ensures that the bio-cellulose packaging material is free from contaminants and does not support the growth of harmful microorganisms, maintaining the integrity of the packaged items.

Permeability Testing:

Packaging materials should have controlled permeability to gases (e.g., oxygen, carbon dioxide) to extend the shelf life of packaged products.

Permeability testing ensures that the bio-cellulose packaging material allows or restricts the passage of gases as required, contributing to the preservation of product freshness and quality.

Temperature and Humidity Stability Testing:

Packaging materials must maintain their structural integrity and barrier properties under various temperature and humidity conditions during storage and transportation.

Testing for temperature and humidity stability ensures that the bio-cellulose packaging material can withstand fluctuations in environmental conditions, safeguarding the packaged items from external factors that may compromise their quality.

These tests are essential because they verify the quality and performance of bacterial bio-cellulose packaging materials. Packaging serves as a critical protective barrier for various products, and conducting these tests ensures that the material meets industry standards and specific application requirements. Moreover, in an era of increased emphasis on sustainability, biodegradability testing addresses environmental concerns by verifying that the material breaks down responsibly after use. By conducting these tests, manufacturers and consumers can have confidence in the effectiveness and safety of bacterial bio-cellulose as a sustainable and reliable packaging material.

CONCLUSION

Bacterial bio-cellulose, derived from coir lignin, is a sustainable biomaterial that finds valuable applications in the realm of packaging. Its production process stands out as an innovative approach that effectively transforms coir lignin, often considered a waste byproduct, into a versatile and eco-friendly material. This not only highlights the importance of circular economies and responsible resource utilization but also emphasizes the growing trend towards sustainable material science. The properties of bacterial bio-cellulose further underline its significance. With high levels of purity, crystallinity, water retention capacity, and biocompatibility, it emerges as an exceptional biomaterial with a wide array of applications. Notably, its biodegradability aligns with the global shift towards reducing the ecological footprint of materials and products. The material's porous and Nano fibrous structure makes it a strong candidate for various uses, ranging from wound dressings to tissue engineering scaffolds and sustainable packaging. The journey of bacterial bio-cellulose in packaging applications necessitates rigorous testing to ensure its quality, safety, and reliability. Tests such as moisture content analysis, barrier properties assessment, biodegradability testing, and stability under different environmental conditions become pivotal in substantiating the material's suitability for packaging purposes. These tests guarantee that the bio-cellulose effectively maintains product freshness, preserves quality, and supports sustainability goals. Bacterial bio-cellulose, derived from coir lignin, is a sustainable, versatile, and innovative solution to the modern challenges of packaging. Its transformative production process, unique properties, and successful applications represent a beacon of change in materials science, one that champions environmental responsibility, product preservation, and sustainability as pivotal aspects of modern packaging practices.

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