Fabrication of nanocrystalline cellulose from banana peel obtained from unripe plantain bananas

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Abstract: Nanocellulose has been thought of as a more cost-effective various to carbon fiber and optical fiber for a few applications, associate degree is additionally thought of a helpful material for the paper and pulp industries that use nanocellulose as an economical suggests that to extend permeability in many product like napkins, ketches towels, etc. The nanocrystalline cellulose may be fully biobased or chemical based. NCC extracted from the cellulose of banana peel is considered to be a biodegradable and one of the bio-compatible materials. They are also considered to be attractive biomaterial. They are also strong and are highly crystalline with high thermal stability. NCC from banana peel also plays a significant role in packaging pharmaceuticals, biomedical, transparent material. Here we study the synthesis process of NCC from BP. The extracted NCC from BP is characterized using SEM, UV and FTIR.

1. Introduction:

There are almost 1000 banana varieties produced globally. They are largely produced in Asia, Africa and Latin American countries [1][2]. Among these India produces approximately 29 million tons per year and China about 11 million tons. These two countries serve the world’s domestic market. Bananas are the most extensively consumed fruit [1][2][3]. The peels of banana can cause environmental problem like bad smell and can also become a source of human disease. These problems can be reduced by converting these waste peels into a valuable product which is used in food industry. These banana peels are rich in cellulose and starch. These components serve as promising ingredients in the development of biodegradable products. The development of biodegradable products to replace the synthetic products from natural and renewable resources is a promising work nowadays.

Nanocellulose may be a lightweight solid substance obtained from plant matter that includes nanosized polyose fibrils [2][3]. This new material may be a pseudo-plastic and possesses the property of specific types of fluids or gels that area unit usually thick in traditional conditions [3]. The lateral dimensions of nanocellulose vary from five to twenty nm, and also the longitudinal dimension ranges from a number of 10's of nanometers to many microns. Nanocellulose is mostly created from pulp
though it may be ready from any plastic supply material [5]. Nanocellulose encompasses a big selection of applications, from cleansing of oil spills to usage in children’s toys. Nanocellulose is often employed in pharmaceutical, food and medical industries. This new material may replace some petrochemical-based product and is incredibly probably to be cheaper than most different kinds of superior nanoscale materials[12]. Nanocellulose has been thought of as a more cost-effective various to carbon fiber and optical fiber for a few applications, associate degree is additionally thought of a helpful material by the paper and pulp industries that use nanocellulose as an economical suggests that to extend permeability in many product like napkins, ketches towels, etc.

The nanocrystalline cellulose may be fully biobased or chemical based. NCC extracted from the cellulose of banana peel is considered to be a biodegradable and one of the bio-compatible materials. They are also considered to be attractive biomaterial. They are also strong and are highly crystalline with high thermal stability [17][18][19]. NCC from banana peel also plays a significant role in packaging pharmaceuticals, biomedical, transparent material.

Here in this paper we discuss about the fabrication of nanocrystalline cellulose from the peels of unripe plantain bananas and the various characterization techniques used to characterize the nanocrystalline cellulose. Here we also study the various applications of the obtained nanocrystalline cellulose and the future work that is to be continued.

2. Materials and methods:

2.1 Raw material:

Peels of unripe plantain bananas of variety Changalikodan – Musa Acuminata commonly called Nendran banana obtained from a chips shop in Kanyakumari district. Since Kanyakumari is the nearest district to Kerala which is the largest banana producer of bananas. The bananas should be at the mature edible stage i.e.) 45-55 days after inflorescence.

2.2 Chemicals required:

Chemicals such as sodium hydroxide (NaOH), ethanol (C₆H₄O), sulphuric acid (KOH), sodium chlorite (NaClO₂), sulphuric acid (H₂SO₄) and acetic acid (CH₃COOH). All the materials were used without any further purification.

![Figure 1: Unripe banana peels drying in sunlight](image1)

![Figure 2: Dried banana peels](image2)

2.3 Apparatus required:

Magnetic stirrer, magnetic bead, distilled water, hot air oven, shaker, conical flask, filter, mesh sieve are the apparatus required for the isolation of NCC from banana peel.

2.4 Bran preparation:
The peel of unripe plantain bananas are peeled manually and are dried at direct sunlight until the peels lose its moisture content [23][24]. The dried peels are weighed, ground and sieved using mesh sieve. After sieving the bran is stored at cooling temperature until the next process.

2.5 Extraction of cellulose:

The cellulose from the banana peel is extracted first using three different steps which extracts all the unwanted fat, protein, starch, and other particles present in the banana peel[24][25]. The various steps involved in the extraction of cellulose include:

I. Extraction of fat
II. Extraction of protein
III. Extraction of cellulose

2.6 Extraction of fat:

Fat is extracted from cellulose using ethanol. First the bran is soaked in ethanol solution and is placed in a water bath at 50˚C and placed in shaker at 150 rpm for 10 hrs at the shaking speed of 150 rpm. Then the solution is washed 3 times with distilled water and filtered and dried in hot air oven at 80˚C for 7hrs. Here the distilled water acts as a control.

2.7 Extraction of protein:

To extract protein from the defatted bran, it is soaked in sodium hydroxide for 24 hrs and soaked in distilled water which serves as a control. Then it is placed under water bath at 50˚C at 150rpm for 6 hrs. Now the deproteined bran is washed 3 times with distilled water, filtered and dried in hot air oven at 80˚C for 7 hrs.

![Image of defatted and deproteine bran in distilled water](image-url)

Figure 3: Defatted and Deproteine bran in distilled water

2.8 Bleaching of cellulose:

Once the bran is defatted and deproteinated it is soaked in hydrogen peroxide solution for 2 hrs. It is then washed 3 times with distilled water, filtered and dried at 60˚C for 10 hrs.
2.9 Conversion of cellulose into nanocrystalline cellulose:

The conversion of banana peel cellulose (BPC) into nano crystalline cellulose (NCC) includes chemical and acidic treatment [3][4][5][6]. The cellulose obtained from banana peel is treated with 1% of sulphuric acid using magnetic stirrer at 70˚C for 1 hour. The insoluble residues are hydrolyzed with 10% acetic acid and is simultaneously washed with deionised water and centrifuged at 5000 rpm for 15 mins at 5˚C until the pH is neutralized. The final residue is washed and filtered with deionised water.

3. Results and discussion:

The bran consists of carbohydrates, fibre, ash, crude fat, moisture content and protein and other contents. The obtained NCC is characterized using scanning electron microscope (SEM), UV spectroscopy, FTIR spectroscopy [31][32][33].

3.1 FTIR SPECTROSCOPY:

![FTIR spectra of NCC obtained from banana peel.](image-url)
The spectra show that the obtained NCC consists of hydrogen bond that gives unique property of mechanical strength and chemical stability. The analysis is done in the infrared region with 16 scans and resolution 4cm⁻¹ and the obtained spectra shows that at the wavelength 3000 to 3800 the sample is NCC. From the references the NCC should posses OH bond also. But there is less amount of OH bond in the obtained NCC [45][46].

3.2 Scanning Electron Microscopy (SEM):

![SEM image of NCC obtained from banana peel 1000X.](image1)

![SEM image of NCC obtained from banana peel at 2000X.](image2)

The SEM image shows that the obtained BPC is glacial and porous at various sizes. This may be due to the impurities in the NCC which may after the micro structural characteristics. The reference papers
shows that the NCC obtained from banana peel should possess less porous and if it is more there is a characteristical change [45-48].

3.3 UV Visible Spectroscopy:

![UV image of cellulose obtained from NCC](image)

Figure 8: UV image of cellulose obtained from NCC

UV images of cellulose obtained from NCC. From this spectrum it is confirmed that the obtained result is NCC at the wavelength 556. Since the wavelength of cellulose ranges between 500 to 600. From the UV wavelength chart the NCC should be between 500 to 600 but here the wavelength is 556. Though it is NCC there are some microbial and characteristical changes in the obtained NCC [48][42][47][45].

4. Future work:

As my future work I would like to fabricate this nanocrystalline cellulose obtained from banana peel into nanopaper which is used for water filtration, substitute for plastics, used in electronic devices, and much more applications.

5. Conclusion:

Thus the nanocrystalline cellulose from banana peel is extracted and is characterized using SEM, UV and FTIR. Though the results seem to be nanocrystalline cellulose due to some microbial change and characteristical change there are some impurities and imperfections in the obtained nanocrystalline cellulose.

6. Acknowledgment:

The authors would like to acknowledge the support given by the Nanotechnology Division, Department of Electronics and Communication Engineering, PMIST, Vallam for making this possible. The authors would also like to acknowledge NANOMAT-2020 for this opportunity.

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