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Revealing The Molecular Signature: Spectral Analysis Of Bioplastics Derived From Banana Peels.

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ABSTRACT

The spectrum characterizations of bioplastics originating from banana peels are crucial in clarifying their composition and characteristics, indicating its potential as a sustainable substitute for traditional plastics. To understand the intricate chemical and structural makeup of these biopolymers, this work makes use of sophisticated spectroscopic methods such as scanning electron microscopy (SEM), X-ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR). The bioplastics functional groups and chemical bonds can be found using FTIR spectroscopy, which also sheds light on the molecules that make up the materials. The crystallinity and ordering of polymer chains, on the other hand, are revealed by XRD examination, and these factors have a substantial influence on the mechanical and thermal properties of the material. SEM imaging helps evaluate the microstructure and surface morphology of the bioplastic by providing a thorough visual of its surface morphology. These spectral descriptions are important for various reasons. First of all, they make it possible to fully comprehend the structure-property correlations of bioplastics made from banana peels, which aids in the formulation of these materials for particular uses. Secondly, they aid in the evaluation of their biodegradability, thermal stability, and mechanical strength. Thirdly, they are essential to maintaining consistency and quality control in the production of bioplastics.

Keywords: *bioplastics, banana peels, structural characterization, sustainable materials*

1. INTRODUCTION

Understanding the structural and morphological characteristics of bioplastics[1] made from banana peels depends heavily on their spectral characterizations. Several analytical methods, such as scanning electron microscopy (SEM), X-ray diffraction (XRD), UV-Visible spectroscopy and Fourier-transform infrared spectroscopy (FTIR), are crucial for deciphering the intricate structure of these biopolymers and determining their biodegradability[2]. This thorough introduction examines the significance of these methods and how they fit within the field of bioplastics research[3]. An essential tool for examining the chemical make-up of bioplastics is FTIR spectroscopy. It offers details on the molecular bonds and functional groups that are present in the substance[4]. Determining the structure of the polymer and any chemical changes that take place during the synthesis process depend on this.

Fig: 1 Bioplastic obtained from banana peel waste

The crystallinity and phase structure of bioplastics must be investigated, and XRD is crucial for this[5]. Understanding a material's mechanical properties and thermal stability requires an understanding of the arrangement of its polymer chains[6]. The overall properties and degradation mechanisms of bioplastics are influenced by their crystalline structure[7].

The data on the material's optical characteristics, such as transparency and absorbance, provided by UV-visible spectroscopy enhance this analysis[8]. In order to evaluate the bioplastic's possible application in films, packaging, or other areas where optical clarity is crucial, this information is necessary. Surface morphology and microstructure of bioplastics can be effectively visualized with the use of SEM[9]. The physical properties, including porosity, surface roughness, and particle size, can be examined by researchers. The mechanical strength and permeability of bioplastics must be evaluated, and this requires an understanding of these characteristics[10]. Altogether, these methods offer a thorough grasp of bioplastics, which is necessary to maximize their characteristics and functionality. The analysis of biodegradation[11] potential is also aided by these data.

2. Objectives

Studying the viability of using banana peel as a raw material for bioplastic synthesis is one of the goals of the research work. Producing bioplastic from banana peel helps to lower the chemical content in plastics and produce sustainable products. This creation of an economical and ecologically sound process for turning fruit peel waste into bioplastic explains the bioplastic's strength, flexibility, and biodegradability, as well as its chemical and physical characteristics. This work also examines the environmental effects of banana peel bioplastic against conventional plastics using life cycle assessments, with an emphasis on minimizing environmental harm. Thus, promotes awareness and education on the benefits of using fruit peel bioplastic and the reduction of chemical constituents in plastics for the betterment of Mother Earth.

3. Spectral analysis of Bioplastic

3.1 Procedure for the Analysis of Fourier-transform infrared spectroscopy (FTIR)

The bioplastic sample synthesized from banana peels is analysed using FTIR (Fourier-transform infrared) spectroscopy[12]. It involves several steps to understand its chemical composition and molecular structure. Here's a detailed description of the process:

The bioplastic derived from banana peels should be finely ground into a powder to ensure uniformity. To perform FTIR analysis, the powdered bioplastic sample is typically mixed with a small amount of potassium bromide (KBr) powder. This mixture is then compressed into a pellet using a hydraulic press. The KBr serves as a matrix to hold the sample for analysis. The FTIR spectrometer is a specialized instrument that measures the interaction of infrared light with the sample. It consists of a light source, interferometer, and a detector. Before analysing the sample, a baseline measurement is taken using a blank KBr pellet to account for any interference or noise in the measurement. The KBr pellet containing the bioplastic sample is placed into the FTIR spectrometer. The instrument emits infrared light across a wide range of frequencies (wavenumbers). The interferometer in the spectrometer splits the incoming light into two beams. One beam passes through the sample, while the other does not (reference beam). Infrared light interacts with the bioplastic sample, and some frequencies are absorbed due to molecular vibrations. The remaining light is transmitted through the sample. The two beams recombine, creating an interference pattern called an interferogram. This pattern contains information about the absorption of specific frequencies by the sample. The interferogram is subjected to

Fourier transformation, which converts it from the time domain to the frequency domain. This process generates an FTIR spectrum. The FTIR spectrum displays absorbance (intensity) as a function of wavenumbers (inverse of wavelength). Each peak or trough in the spectrum corresponds to a specific molecular vibration. The positions and shapes of the peaks are used to identify functional groups and chemical bonds present in the bioplastic. For example, peaks at specific wavenumbers may indicate the presence of C-H, O-H, C=O, or C-O bonds. FTIR spectroscopy provides qualitative information about the sample's chemical composition. FTIR spectroscopy is a powerful technique for analysing the chemical composition and molecular structure of bioplastics synthesized from banana peels. It provides valuable insights into the types of bonds and functional groups present in the material, aiding in quality control and research on sustainable materials.

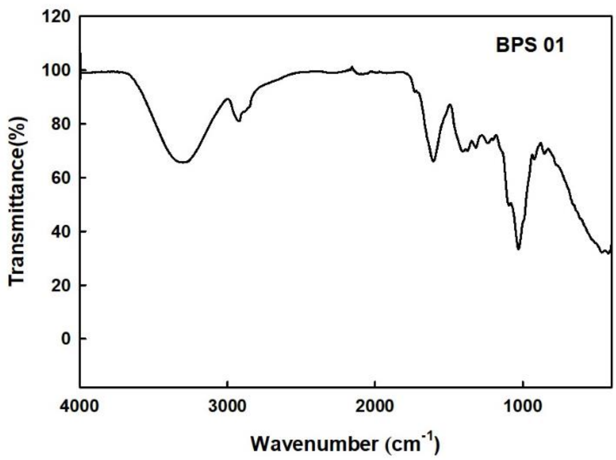


Fig: 2 FTIR spectra of bioplastic derived from banana peels.

Figure 2 displays the findings of the FTIR analysis of the bioplastic that was created. The sample's FTIR spectrum was obtained at a wavelength in the 400–4000 cm^{-1} range, according to the results of the FTIR analysis. The study's findings also demonstrated that the alkane C-H bonds were responsible for the peak at 1632 cm^{-1}, while the primary amine that produced the two N-H stretching absorptions was responsible for the peak at 1403 cm^{-1}. Carboxylic O-H stretching was the cause of the stretching at 3384 cm^{-1}. Peak was ascribed to the C=O stretch at 3146 cm^{-1}.

3.2 Procedure for X-ray diffraction (XRD)

The bioplastic sample synthesised from banana peel waste is transferred onto a glass slide or sample holder. The sample is aligned and assembled the diffractometer for X-rays. The components of this apparatus are an X-ray source, a sample stage, and a detector[13]. To guarantee precise measurements, the X-ray diffractometer with a standard reference material is calibrated. X-ray diffraction patterns after positioning the sample in the path of the X-ray beam are noted. The diffraction angles and intensities information is obtained, by rotating the sample holder at various angles, the data is collected(usually 2θ). The crystallographic characteristics of the bioplastic are determined by analyzing the diffraction data that has been gathered.

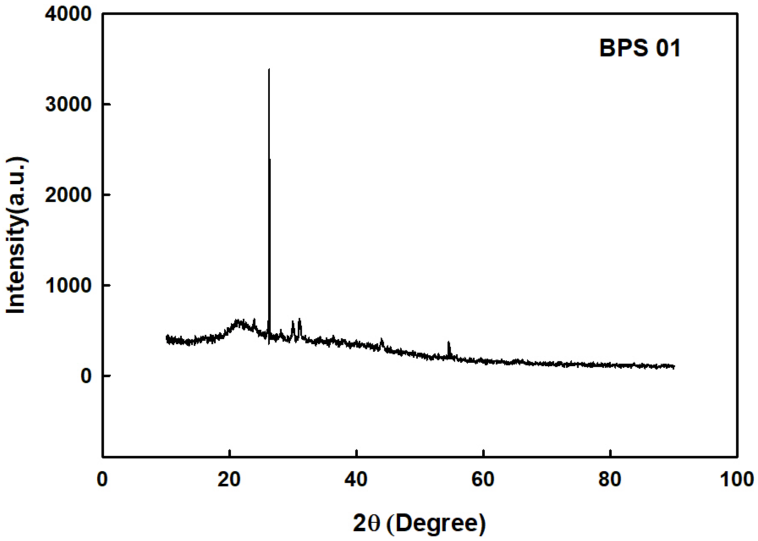


Fig: 3 XRD analysis of bioplastic sample

The diffraction pattern provides information about the unit cell's size, shape, and translational symmetry based on peak positions and peak intensities. It also provides information about the electron density inside the unit cell, or the locations of the atoms. It provides details on particle deviations from perfection as well. Glass was used for the drop-location XRD measurement of the synthesized bioplastic using a Bruker axs-D8 advance instrument operating at 40 Kv and 20 m A of current with Cu Ka radiation. Figure 3 shows the results of the XRD analysis of the bioplastics that were synthesized. The study's findings showed that the sample's structure was semi-crystalline.

3.3 Procedure for UV-Visible Spectroscopy

This procedure has been followed to conduct UV-Visible spectroscopy investigations on a bioplastic sample. Initially a bioplastic film obtained from banana peel waste is taken and the sample is placed in the right form, usually a thin film for UV-Vis analysis. After turning it on, the UV-Visible spectrophotometer is allowed to warm up. Usually between 200 and 800 nm, the wavelength range is adjusted to encompass both the UV and visible regions[14]. As a blank reference, a neutral solvent (often the same solvent used to prepare the sample) is taken. To get accurate readings, the blank solvent is inserted into the sample compartment and carry out a baseline correction. This stage aids in taking into consideration any absorption by the instrument and solvent. The blank solvent is taken out and bioplastic sample is placed. This data is mainly used to check the transmission of light through the sample for its application in food packaging

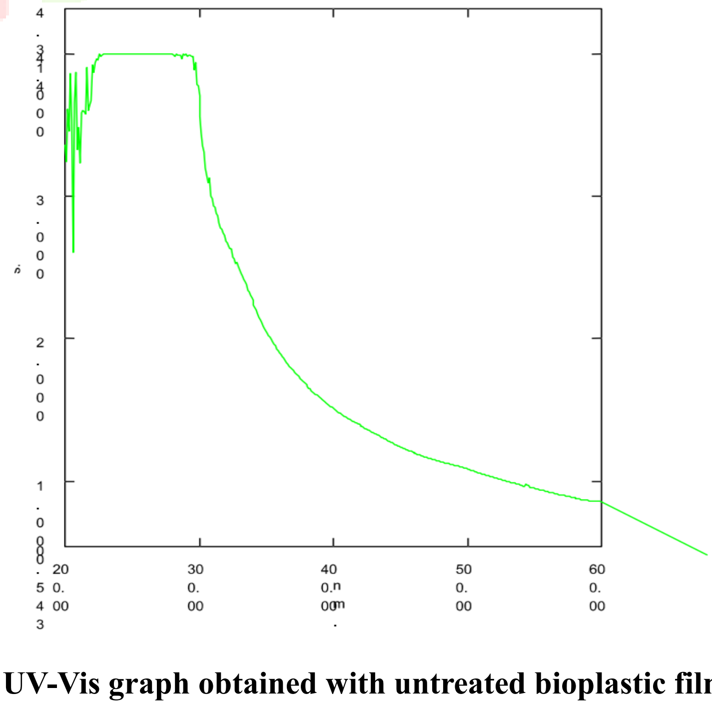


Fig: 4 UV-Vis graph obtained with untreated bioplastic film

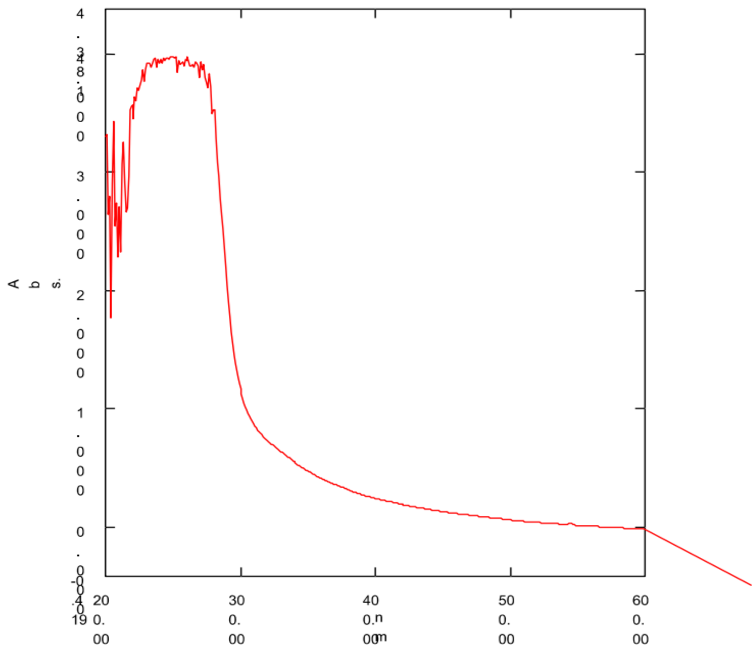
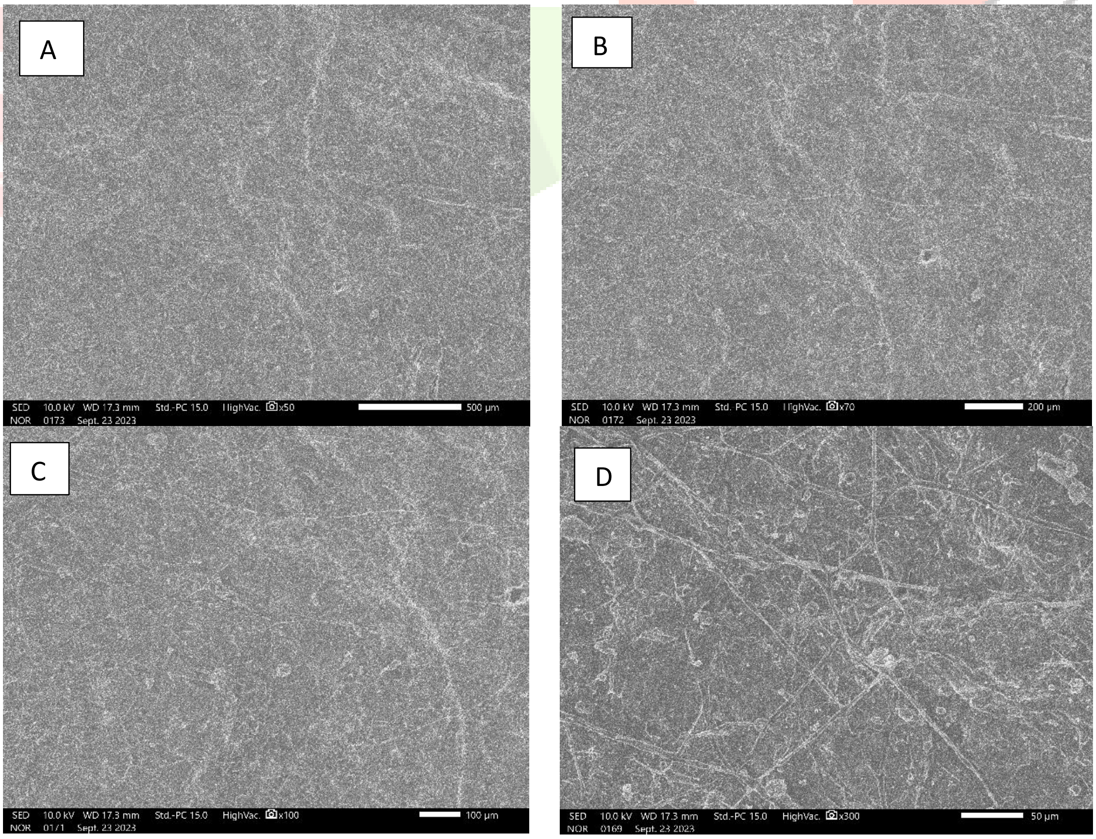


Fig: 5 UV-Vis graph obtained with treated bioplastic film (Sodium meta bisulphite)

3.4 Scanning Electron Microscopy (SEM)

SEM is an effective tool for displaying the microstructure and surface morphology of bioplastics. It enables to investigate the physical attributes, including porosity, surface roughness, and particle size. To evaluate the mechanical strength and permeability of bioplastics, it is essential to comprehend these characteristics[15]. The following are the SEM images obtained.



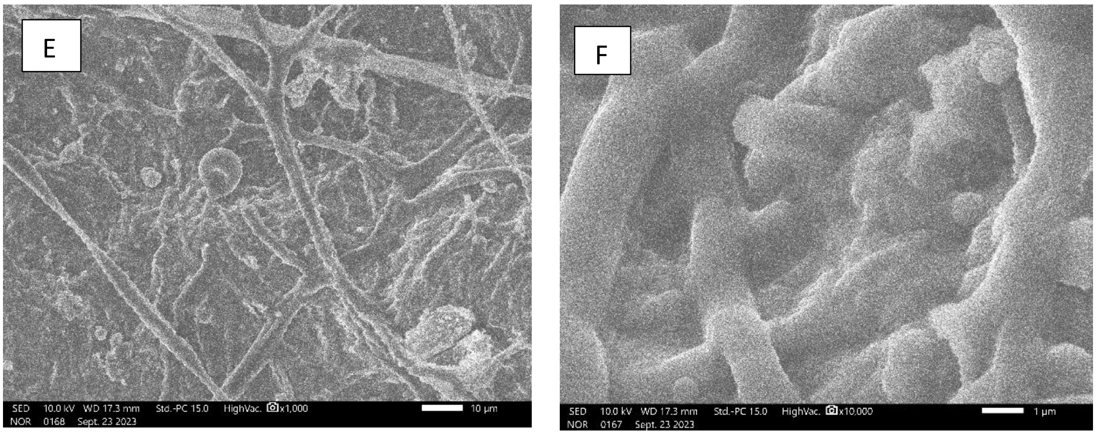


Fig: 6 SEM images of bioplastic made from banana peels.

4. Test for Biodegradation of synthesised bioplastics

The bioplastic synthesised from fruit waste i.e., banana peels is buried in soil in a depth of 100cms and then left for a week. The results showed that the biopolymer film has turned to brownish black as the time increases. Its texture has become brittle and delicate[16]. The weight of the bioplastic is also decreased with increase in days. This degradation in soil is depicted in the table below.

S. No	Days	Appearance	Weight of the samples		
			Sample A	Sample B	Sample C
1.	7	Fresh and shiny	1.3	1.5	1.7
2.	14	Brown shaded	0.9007	0.9005	0.9003
3.	21	Brownish black	0.8643	0.8646	0.8648

5. Conclusion

Banana peel-derived bioplastics exhibit promising characteristics for use as an alternative to conventional plastics in the packaging industry. Their environmentally friendly nature, surface morphology is crystalline, and optical properties make them suitable for various packaging applications. By reducing the reliance on petrochemical-based plastics and utilizing sustainable sources, these bioplastics contribute to the goals of reducing plastic waste and minimizing the environmental impact of packaging materials. Further research and development are needed to optimize their properties and production processes, but the potential is evident for a more sustainable and eco-friendly future in the packaging industry.

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7. References

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