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Development and Characterization of Starch Based Bioplatics Using Banana Peels

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Abstract: A number of significant issues had expedite owing to the increased use of conventional plastic, including the shortage of raw materials for the production of plastic and the buildup of non-biodegradable plastic debris on the planet. Use of ecologically friendly, biodegradable plastic made from renewable resources is one of the problem's promising solutions. The objective of this research is to describe the characteristics of the bio-plastic made from banana peels. In order to create a bioplastic using banana peel powder, a sulphuric acid catalyzed acetylation process was used in the study. The bioplastic produced from this process was then characterized by Fourier Transform Infrared (FT-IR). The FTIR spectra of the product displayed the presence of OH, C-H, C=O and C-O absorption peaks. The results of Chemical resistance test demonstrated that, the produced bioplastic was much closer to or had the same chemical resistance test as traditional plastic, allowing the prepared bioplastic to replace the latter. The new bioplastic also showed some biodegradability and was only slightly affected by acid, salt, and alkali. As a result, it was revealed that, new bioplastics with appreciable material properties could be made from agricultural waste. Hence it may be concluded that bioplastics degrades easily and faster than petroleum based plastics and can be a solution to the long lasted environmental problems caused by petroleum based plastics.

Keywords: Starch, Bioplastic, Waste, Utilization, Banana Peels, FTIR

1. Introduction

Plastics are ubiquitous and used for a wide range of reasons because they are affordable, accessible, and durable [1]. Around 8.3 billion metric tons of plastics have been made worldwide to date, whereas 6.3 thousand metric tons of plastic wastes have been generated. Only 9% of that waste plastic was recycled, 12% was burned, and the remaining 79% was accumulated in a sanitary landfill or released into the atmosphere. By 2050, discarded plastics are expected to accumulate in sanitary landfills or in the open environment to the tune of 12,000 metric tons [2]. By 2050, the sea is expected to contain more plastic than fish due to current rising production and disposal trends, as well as the poor recycling rate [3].

Plastics have numerous drawbacks because they have a wide range of negative effects, including the fact that they do not degrade naturally and remain in the ecosystem for a very long time [4]. Energy is needed in large quantities for the manufacturing of plastic [5]. Plastics pose a threat to the ecosystem [6].

Additionally, as humans become more and more reliant on plastics, landfills become overflowing with plastic garbage, which has a variety of detrimental effects like endangering the health of living things and polluting groundwater [7]. In addition to endangering human health, marine creatures caught in waste plastic in the oceans also face health risks [8, 9]. Humans are subjected to plastic particles via fresh water, seafood, and the air [10–12], which can result in a variety of health issues like toxicity or pathogenic illnesses [13]. The significant carbon footprint of petroleum-based plastics is additionally another worldwide issue. Researchers are being compelled by the rising cost of nonrenewable crude oil to look for appropriate substitutes [14], and bioplastics are the best option because they are safe and friendly to the environment [15].

As the most prevalent macromolecules in both plants and animals, polysaccharides are one of the best sources of raw material for bioplastics because they are abundant, affordable, renewable, and take the shape of starch. Moreover, starch is biodegradable and has advantageous thermoplastic characteristics [16–19]. Although amylose and amylopectin, two types of glucose macromolecules, make up the majority of starch [20], there are functional and structural differences between the two types [21], and as a result, the effectiveness of starch as a raw material for bioplastics depends on its unique structure and composition [22]. Research is still lacking in the subject of bioplastics because it is a relatively new field. Agricultural waste has been promoted as a cheap and sustainable option to other raw materials [23]. Starch is increasingly being used as a biopolymer to produce biodegradable materials that can be used in a variety of uses [24, 25].

The goal of this research is to develop bioplastics using renewable agricultural refuse, such as banana peels. By using easily available, plentiful, biodegradable, and renewable natural waste as reinforcing fillers, this can be helpful in lowering the risks and issues associated with conventional plastics as well as the deterioration of their mechanical properties.

2. Materials and Methods

2.1. Chemicals and Sample Preparations

Acetic anhydride, acetone, glacial acetic acid, glycerol, NaOH, H_2SO_4, and distilled water are the chemicals used in this research. The banana peel sample was collected from Birnin Kebbi in the Kebbi State, frequently washed with distilled water, then washed with acetone, and finally dried in an oven at 60 °C for 24 hours.

Banana peels were cut into tiny pieces with a stainless steel knife after being removed. Afterward, it was submerged for 45 minutes in a sodium metabisulphite (0.2M) solution. For about 30 minutes, distilled water was boiled with banana skins. The skins were spread out on filter paper to dry for about 30 minutes after the water was decanted from the beaker. The peels were put in a beaker after drying, and a hand mixer was used to puree the peels until a smooth paste was created. [26].

2.2. Production of Bioplastics

The banana peels were carefully washed to remove dust and color before and then dried using oven. They were then bleached with 20ml of a common home bleaching agent (NaOCl and NaOH). Anhydrous acetic acid (100 ml). 100 ml of glacial acetic acid and 10 ml of sulfuric acid were combined and allowed to settle to about 7 ^{o}C. In order to initiate the acetylation process, 60 g of banana peel were gradually added to the prior mixture while being stirred. Centrifugation was used to separate the finished product from the ensuing viscous fluid. To make the product suitable for use, plasticizer (polyethylene glycol/glycerol) was added to the viscous liquid at a rate of 25% by volume with agitation. The final product was then dried in an oven at 60 ^{o}C until it reached a constant weight. In order to create a viscous fluid that could be poured into a mold or onto a flat surface for shaping, the product was first diluted with acetone [27].

2.3. Characterization Methods

2.3.1. FTIR Analysis

Using the Cary630 FTIR machine molecule model, the FTIR analysis was performed at the Usmanu Danfodio University Research Center both before and after the development of bioplastic. A few grams of sample were placed on the surface of a potassium bromide (KBr) plate that had been extensively polished, and a second plate was then layered on top of the first plate to spread the sample between the two plates and clamp them together. The plates were then cleaned to remove any spilled sample before being placed in the sample holder, where the reflectance accessory recorded data with a resolution of 2 cm^{-1} and 30 scans [28].

2.3.2. Biodegradability

The biodegradable nature of the film was tested by burying the prepared bioplastic in the soil with a relative humidity of 70 % for 7 days. Biodegradation test was done by weighing the prepared bioplastic polymer before and after burial in the soil to determine the loss in weight of the prepared bioplastic polymer [29].

2.3.3. Chemical Resistance Test

1) Effect of acids: A known weight of the prepared bioplasticswas weighed and put into 50% sulfuric acid. The dried sample was weighted periodically for four days in order to determine the percentage weight loss after each time period.
2) Effect of Alkalis: A known weight of the prepared bioplasticwasweighed and put into alkali solution of 50 % (sodium hydroxide). The percentage weight losses were calculated daily for a period of ten days.
3) Effect of Salt: The prepared bioplastic was mixed with solid salt (sodium chloride, trisodium orthophosphate and lead acetate) was left for five days, with periodic weighing every day, with the objective of determining its resistance to the action of salts [27].

2.3.4. Swelling Tests

Swelling studied was generally conducted to check whether developed materials retains the original property when it was formed during the preparations. A pre-weighed piece of sample was prepared and was taken in the test tube to check the protuberance and other morphological changes, it was carried out on the medium for about 2hours and the results was recorded accordingly [26].

2.3.5. Solubility Studies

Two types of bioplastics were prepared and solubility study was conducted and solubility of the extract was checked by simply by dissolving the sample in water. All the samples were cut into small pieces and were inserted into a test tube containing different solvents [26].

3. Result and Discussion

3.1. Banana Peels Powder Extraction

At the end of the first experiment results showed that the yield of powder obtain from 500 g banana peel was 241.0 g. In this study the colour of the starch is black soft, tasteless powder.

Figure 1. *Banana Peels Bioplastic.*

3.2. Prepared Bioplastic

The color of the viscous fluid obtain from bioplastic is black. Therefore, the acetylation process used in this work produced a black residue with bad smell, which indicate the formation of bioplastic.

Figure 2. *Banana Peels Bioplastic.*

3.3. Result of FTIR Spectra

The functional groups identified from the FT-IR spectra of the banana peels powder and banana peels bioplastic are presented in 3.3 figure below. Regions between 600 cm^{-1} and 1500 cm^{-1} are referred to as the finger print region [30]. The FT-IR spectra of the banana peels powder shows an absorption at 3303 cm^{-1} which is a broad rounded peak indicates the presence of O-H (alcohol), 2926 cm^{-1} which has a weak absorbing feature of C-H stretch (alkane). The peak 1602 cm^{-1} was observed as a result of C=O (carbonyl).

The FT-IR spectrum of the Banana peels bioplastic shows an absorption at 2938 cm-^{1}, this indicates the presence of O-H (alcohol) but the intensity has reduced compared to that of the banana peels powder, which provides an evidence of bioplastic formation. It also shows an absorption at 1616 cm^{-1} which indicates the presence of C=O (carbonyl) but with an increased intensity compared to that of the banana peels powder. The spectra are similar with that of a banana peels bioplastic that also displayed the presence of O-H, C-H and C=O [14]. This feature also indicates the formation of a bioplastic. In general, there were three major functional groups present in both the banana peels powder and the bioplastic which are; alcohol, carbonyl and alkane [14].

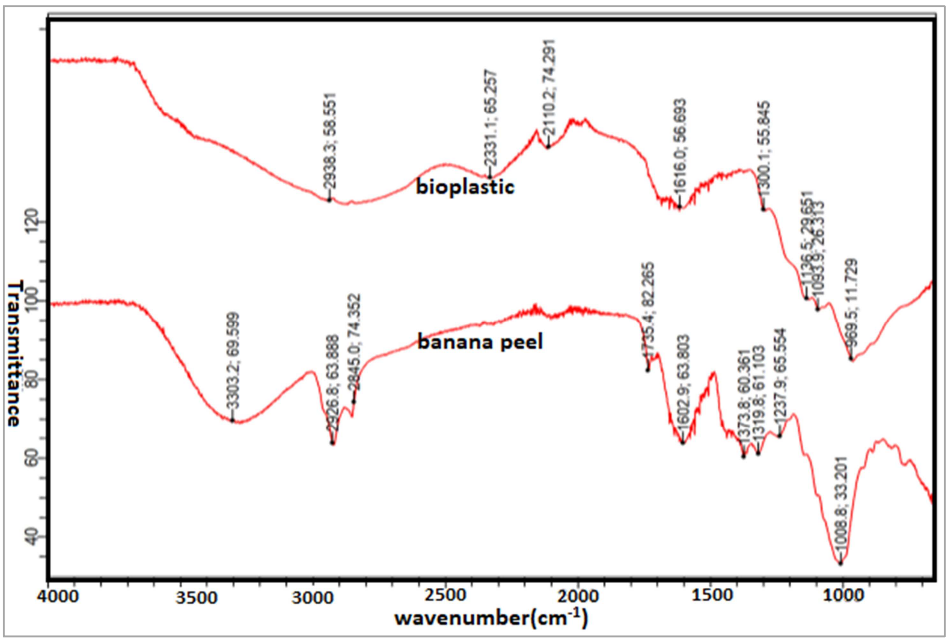

Figure 3. *FT-IR Spectra Banana Peels and Bioplastic.*

3.4. Results of Degradability Tests

From the study, after 8 days of careful observation, the banana peels made plastic has completely decomposed in the acidic medium, basic medium and salt solution. The rate of degradation is lower, compared to the literature values of bioplastic made from sorghum husks, which just showed 13.9% weight loss after 15 days, 76% weight loss within 10 days in the compost and alkaline medium respectively [31]. Also, comparing the rate of degradation with that of a cassava starch bioplastic that was buried in a compost soil took 10 days for the degradation [14, 32], the rate of degradation in the banana peels bioplastic is higher.

In the salt solution, the bioplastics were removed carefully from the medium and washed gently with distilled water to remove the remaining solution from them. The samples were dried in the oven until a constant weight was obtained. The made bioplastic has also decreased in its size, but not as that of the bioplastic in the acidic, basic and compost medium.

In general, this is a clear indication that it easily degrades ecofriendly and will reduce the accumulation of petroleum-based plastics in the environment.

Table 1. *Results for water uptake.*

Days	Weight loss (%)
7 days	35.71%
14 days	28.57%
21 days	25.58%

After 21 days of observation, the banana peels bioplastic has decreased in size. It showed a 35.71% decrease in the first 7 days. Which is a clear indication that it is slightly soluble in water. The solubility of the banana peels bioplastic is lower compared to that of a cassava starch based bioplastic in a mixed culture, which took just 10 days to degrade [30-32].

The decrease in size because of its solubility in water means the bioplastic is hydrophilic.

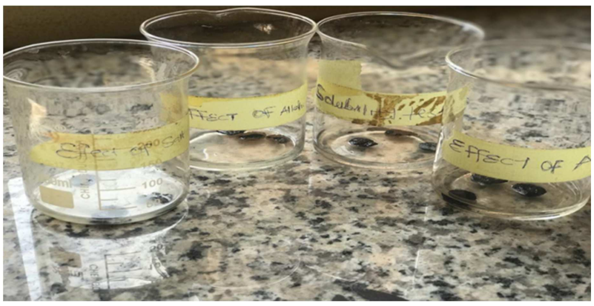

Figure 4. *Samples of Banana Peels Bioplastic in Chemical test medium.*

4. Conclusion and Recommendation

4.1. Conclusion

The research has revealed that the bioplastic prepared from banana peels is degradable in all the mediums; acidic, basic and salt. There is also a decrease in size of the bioplastics in the water.

It may be concluded that bioplastics degrades easily and faster than petroleum based plastics and can be a solution to the long lasted environmental problems caused by petroleum based plastics such as blocking of sewages, clogging of water bodies and also the emission of greenhouse gasses when burnt.

4.2. Recommendation

Further research on bioplastic is recommended in order to make them a substitute to petroleum-based plastics in different aspects such as packaging, medical field etc. This can be done by making them more versatile and low in cost than petroleum based plastics.

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