Bioplastic Synthesis Using Banana Peels And Potato Starch And Characterization

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Abstract: Environmental pollution was due to industries, dumping of wastes etc. The plastics are the main threat to environment as they are non-bio-degradable. Based upon the above view, there is a need of sustainable material at the same time biodegradable. Such kind of materials are called "Bio plastics". Hence an investigation has been carried out to synthesize bioplastic using banana peels and potato starch and also to study its characterization using FTIR (Fourier Transform Infrared Spectroscopy) analysis, Solubility and Swelling tests. The result of synthesis of bioplastic film from banana peel showed that it was brown and that of potato starch was white in colour. Characterization was carried out by FTIR analysis, The FTIR spectrum was obtained at the wavelength in the range of 400-4000cm^{-1}. The results of Solubility test of synthesized bioplastic from banana peel and potato starch revealed that it was completely soluble in sulphuric acid, acetone, ethyl alcohol, acetic acid, partially soluble in ammonia and insoluble in water. The results of swelling test for both bioplastics synthesized showed that there was not much change when soaked in chloroform and methanol. Slight increase in weight was observed when treated with water medium. Hence the synthesized bioplastic material has the substantial properties like little or zero engorgement and insolubility in water makes it worth for commercial viability and use of renewable resource (banana and potato) will be the best raw material for bioplastics synthesis.

keywords : Bioplastic, Banana Peel, Potato starch, FTIR, Solubility Test, Swelling Test.

1. INTRODUCTION

Environmental pollution is one of the serious problems faced on humanity and other life forms on our planet today. Environmental pollution is a global problem and is common to both developed and developing countries. Plastic industry is considered as one of the most important industries which manufactures polymer materials-commonly called as plastic and used to a range of industries including packaging, building etc[(1)]. One of the important classification of plastics are thermoplast and thermosetting polymers. Bioplastics are plastics derived from renewable biomass sources, such as vegetable fats andoils, corn starch, straw, wood chips, food waste, agricultural by-products, also from used plastic bottles and other containers using microorganisms. Bioplastic is transparent, flexibile, durable, a great barrier and also a heat resistant. There are three types of bioplastics: 1.Starch based bioplastics, 2. Cellulose based bioplastics and 3. Protein based bioplastics[(2)]. Bioplastics are used for disposable items, such as packaging, crockery, cutlery, pots, bowls and straws. Beyond structural materials, electroactive bioplastics are being developed that are used to carry electric current. Biopolymers are available for coating paper rather than the more common petrochemical coatings. Low energy costs to manufacture bioplastics. Based upon the above views, an attempt has been made to synthesize biodegradable plastic material using banana peels and potato starch, to characterize the synthesized bioplastic material using FTIR analysis, solubility test and swelling test.

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2. MATERIALS AND METHODS

Banana peels and potato starch were used for synthesis of bioplastics because they are very rich in starch, which consist of two different types of polymer chains called amylose and amylopectin, made up of adjoined glucose molecules that are bonded together to form bioplastic. Banana fruits and potato were purchased from local market at Chennai, Tamil Nadu, India.

2.1 Preparation of banana peels from banana

Preparation of banana peels from banana (plate 1) for banana paste formation was carried out by following the procedure of[(3)]. Banana peels obtained from 5-6 bananas were boiled in water for about 30 minutes taken in a beaker. Water was decanted from the beaker and the peels were left to dry on filter paper for 30 minutes. The peels were completely dried and squashed using mortar and pestle until an uniform paste was obtained.

2.2 Preparation of starch from potato

Extraction of starch from potato involves crushing of 4-5 potatoes into a paste and then soaked in a bowl with water. The mixture was squeezed properly and the paste was crushed at an interval of 30 minutes for 3 to 4 times. Then the paste was sieved and cloudy water was collected in separate bowl. Water was vaporized to obtain the juice from potato paste.

2.3 Production of biofilm from banana paste and potato starch

Production of polymer from banana paste and potato starch was carried out by following the procedure of[(3)]. 25 grams of banana paste and potato starch were taken separately in a beaker and 3 ml of (0.1N) hydrochloric acid was added to these mixture, stirred using glass rod followed by the addition of 2 ml of glycerol and again stirred. 3ml of 0.1N sodium hydroxide was added in order to neutralize the pH upto 7. The mixture was poured on a glass petriplate which was placed in an oven at 130°C and was baked for drying. Later, petriplate was cooled and the plastic film formed was scraped off from the petriplate as the bioplastic film.

2.4 Characterization of synthesized biopastic

2.4.1 Fourier Transform Infrared Spectroscopy (FTIR)
FTIR spectroscopy was used to investigate the interaction between different species and changes in chemical composition of the mixtures. The FTIR spectra of biopastic film from banana peels and potato starch were recorded in SHIMADZU-8400 spectrometer using KBR pellet method.

2.4.2 Swelling test
Swelling test is generally conducted to check whether developed materials retains the original properties after formation by following the procedure of[3]. A pre-weighed piece of sample was used to check the protuberance and other morphological changes. The sample was immersed in various solvents such as water, chloroform and methanol medium in different test tubes for about 2 hours and the results were recorded accordingly.

2.4.3 Solubility test
The bioplastic material prepared was studied for their solubility. The solubility test was carried out to check persistence of these bioplastic materials by following the procedure of[3]. The sample was cut into small pieces and was inserted into different test tubes containing different solvents – ammonia, acetic acid, acetone, sulphuric acid and ethyl alcohol. The solvents were chosen in such a way that the activity of material with parameters like high acidic solvent, polar solvent, non-polar solvent and weak acid were determined.

2.5 Statistical analysis
The data obtained from various experiments were statistically analysed and expressed in terms of Mean and Standard Deviation.

3. RESULTS AND DISCUSSION
Environmental pollution has existed for centuries but became significant following the developing industries in the 19th century. Causes for pollution includes industries, radioactive substances, dumping of wastes in oceans and lands possess a serious threat to environment and surroundings as it can be eliminated or reused [3]. Plastic is being produced from organic compounds like crude oil, natural gas and so on. During the production of plastics, some toxic chemicals such as acetone, methylene, chloride, styrene, benzene, sulfuroxides, nitrogen oxides, methanol etc. and also some volatile organic compounds are frequently released. These toxic acids cause serious environmental pollution[4]. Plastic are main threat to environment as they are non biodegradable. They are the main concern of every environmentalist and nature conservationist. As we are dumping the plastics into ocean, it has turned out as a disaster for organism which live in. The major component of the plastic is a polymer (polypropylene/polystyrene) can leach into water and increase the toxicity in water. The plastic materials that floats on the surface of water is mistaken as food by aquatic organisms and feed on it which eventually leads to death[5]. Plastic is one of the major pollutants of earth. Hence to replace synthetic plastic, bioplastic is developed to decrease pollution. Bioplastic are plastics derived from renewable biomass sources such as vegetable fats and oils, corn starch, biodegradable bioplastic can break down in either anaerobic or aerobic environments. Microorganisms and algae are the agents that mostly degraded organic waste to form bioplastic[4]. Hence an investigation has been carried out to obtain bioplastic film from banana peels and potato starch and also to study the characterization of synthesized bioplastic using FTIR analysis, solubility and swelling tests.

3.1 Preparation of banana paste from banana peels
The result of preparation of banana peels was presented in plate 1a and 1b. The result of the study showed that the banana paste obtained from banana peels was brown in colour.

3.2 Preparation of potato starch from potato
The result of preparation of potato starch from potato was depicted in plate 2a and 2b. The result of the study showed that the extracted potato starch was white in colour.

3.3 Preparation of bioplastic (film) from banana paste
The result of formation of bioplastic film from banana peel was shown in plate 1c. The result of the study revealed that the bioplastic formed was brown in colour.

3.4 Preparation of bioplastic (film) from potato starch
The result of formation of bioplastic film from potato starch was depicted in plate 2c. The result of the study revealed that the bioplastic formed was whitish in colour.

3.5 Characterization of synthesized bioplastic
The synthesized bioplastic material was further characterized by using FTIR analysis.

3.5.1 FTIR analysis of synthesized bioplastic from banana peel
FTIR spectroscopy was used to investigate the interactions between different components and changes in chemical compositions of the mixtures. FTIR measurements for synthesized bioplastic film were carried out to identify the possible biomolecules present in the bioplastic. The result of FTIR analysis of synthesized bioplastic was shown in figure 1. The result of FTIR analysis of the sample showed that FTIR spectrum of the sample was obtained at the wavelength in the range of 400-4000 cm^{-1}. The result of the study also showed that the peak 1402cm^{-1} was due to primary amine that produce 2 N-H stretching absorptions, peak at 1631cm^{-1} was attributed to the alkane C-H bonds. Stretching at 3386cm^{-1} was due to carboxylic O-H stretching. Peak at 3145cm^{-1} was attributed to C=O stretch.

3.5.2 FTIR analysis of synthesized bioplastic from potato starch
The result of FTIR analysis of synthesized bioplastic from potato starch was depicted in figure 2. The result of FTIR analysis of the sample showed that FTIR spectrum of the sample was obtained at the wavelength in the range of (400-4000nm). The results of the study also showed that

the peak at 716cm^{-1} was due to primary amine that produce 2 N-H stretch absorptions, peak at 857cm^{-1} was attributed to the alkane C-H bonds, stretching at 2096 cm^{-1} was due to carboxylic O-H stretch[3].

3.5.3 Solubility test of synthesized bioplastic from banana peel and potato starch

The results of solubility test of bioplastics (banana) were shown in (plate 3 and table 1). The results of the study revealed that the material was insoluble in water which makes it more eligible to be a bioplastic material. It was also insoluble in acetone (polar solvent), ethyl alcohol (non-polar solvent), acetic acid (polar solvent) and partially soluble in ammonia (polar solvent) and completely soluble in sulphuric acid (strongly acidic solvent). Similar results were recorded for biofilm of potato starch (plate 4 and table 2). Solubility plays a major role in selecting a sustainable biomaterial for bioplastic because if the material is soluble in water and other solvents then it cannot be accounted as bioplastic. Results from the solubility test showed that the material is insoluble in water and other organic solvents which makes it more efficient to produce bioplastic at low cost[6].

3.5.4 Swelling test of synthesized bioplastic from banana peels and potato starch

The results of the swelling test of bioplastic (banana) were shown in (plate 5 and table 3 and 4). The results of the study showed that there was not much change in sample when it was soaked in chloroform and methanol, but slight increase in weight was observed when it was kept in water medium. Similar results were recorded for swelling test of biofilm of potato starch (plate 6 and table 5 and 6). The results from swelling test show that low amount of engorgement in water which is more desirable to be a bioplastic material[8] [9].

3.6 Statistical analysis

The values obtained from the above experiment were expressed in the form of mean and standard deviation. Swelling test were found to be statistically significant at 5% level.

Plate 1a - *Banana peel from banana fruit for synthesis of bioplastic film*

Plate 1b *- Banana paste from banana peels*

Plate 1c - *Banana Biofilm*

Plate 2a - *Crushing of potato into paste*

Plate 2b *- Potato*

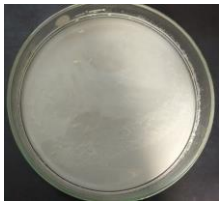


Plate 2c - *Potato starchBiofilm*

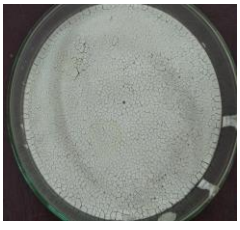


Fig 1 - *FTIR analysis of Synthesized Bioplastic (Banana Peel)*

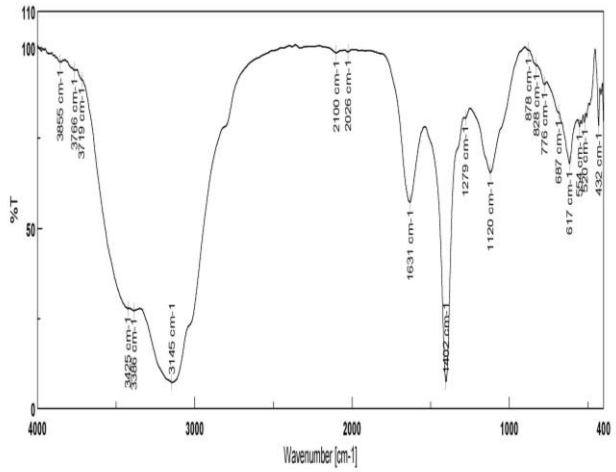


Fig 2 - *FTIR analysis of Synthesized Bioplastic (Potato Starch)*

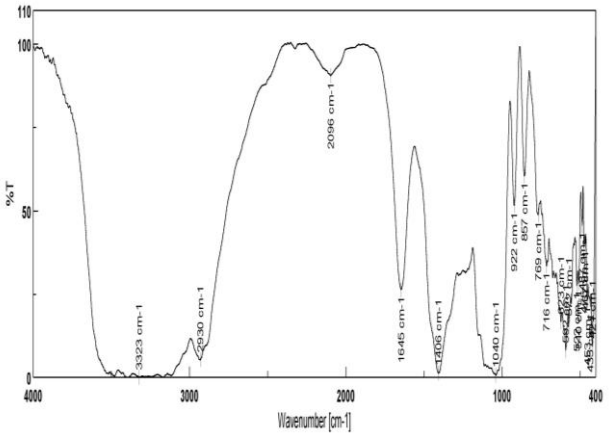
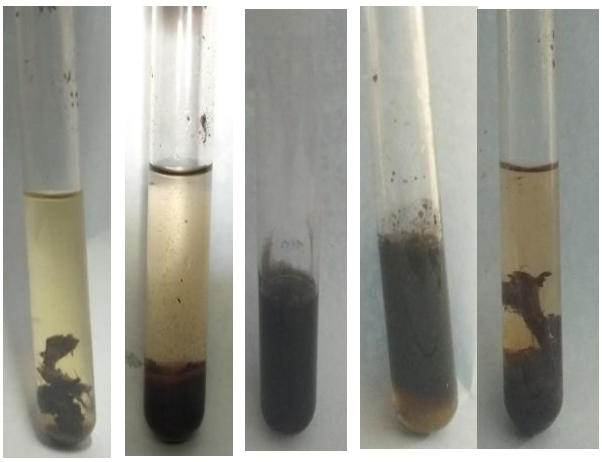


Plate 3 - *Solubility test of synthesized banana bioplastic in different solvents*



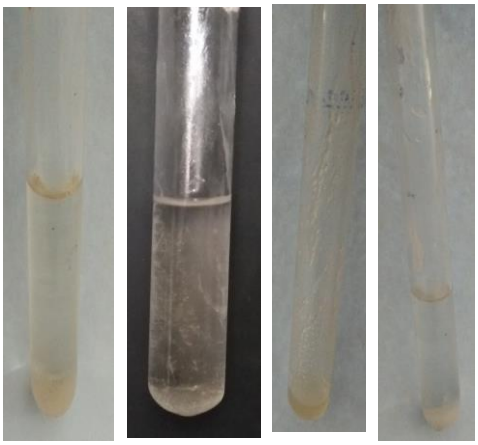
Ammonia Acetic acid Acetone Sulphuric acid Ethanol

Table 1 - *Solubility test of synthesized banana bioplastic in different solvents*

S.No.	Solvents used	Solubility Test		
		Insoluble	Partially soluble	Completely soluble
1.	Ammonia	-	+	-
2.	Acetic acid	+	-	-
3.	Acetone	+	-	-
4.	Sulphuric acid	-	-	+
5.	Ethyl alcohol	+	-	-

+ Positive ; - Negative

Plate 4 - *Solubility test of synthesized potato starch bioplastic in different solvents*



Ammonia Acetic acid Acetone Sulphuric acid

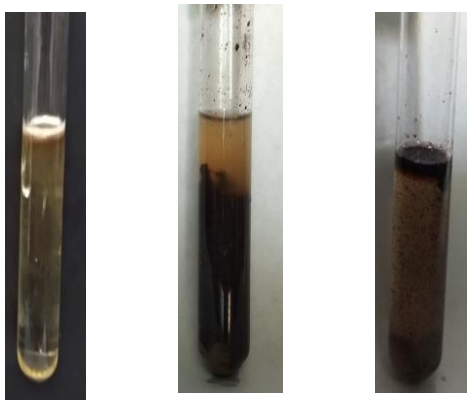
Ethyl alcohol

Table 2 - *Solubility test of synthesized potato starch bioplastic in different solvents*

S.No.	Solvents used	Solubility Test		
		Insoluble	Partially soluble	Completely soluble
1.	Ammonia	-	+	-
2.	Acetic acid	+	-	-
3.	Acetone	+	-	-
4.	Sulphuric acid	-	-	+
5.	Ethyl alcohol	+	-	-

+ - Positive ; - Negative

Plate 5 *– Swelling test of synthesized banana bioplastic in different solvents*



Distilled water Chloroform Methanol

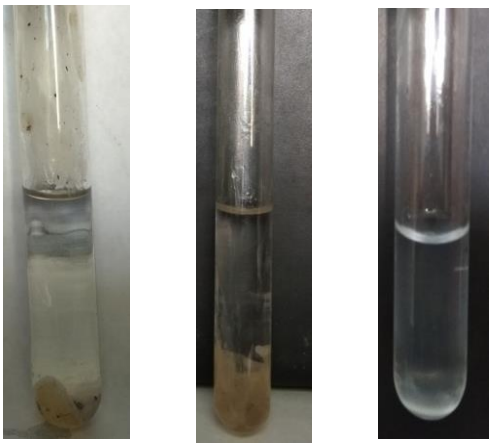
Table 3 - *Swelling test of synthesized banana peel bioplastic in different solvents*

S.No.	Sample	Solvent Medium	Quantity (ml)	Initial Weight (gm)	Final Weight (gm)	Difference in weight (gm)
1	Synthesized Bioplastic film	Distilled Water	5	1.0000	1.4000	0.4
2		Chloroform	5	1.0000	1.1800	0.18
3		Methanol	5	1.0000	1.0600	0.06

Table 4 *- Statistical analysis of swelling test of synthesized banana peel bioplastic in different solvents*

Solvent Medium	Difference (g)	Mean±S.D
Chloroform	0.18	0.18±0.09
Distilled water	0.4	0.4±0.2
Methanol	0.06	0.06±0.03

Plate 6 *Swelling test of synthesized Potato starch bioplastic in different solvents*



Distilled water Chloroform Methanol

Table -5 *Swelling test of synthesized Potato starch bioplastic in different solvents*

S.No.	Sample	Solvent Medium	Quantity (ml)	Initial Weight (gm)	Final Weight (gm)	Difference in weight (gm)
1	Synthesized Bioplastic film	Distilled Water	5	1.0000	1.2000	0.2
2		Chloroform	5	1.0000	1.4000	0.4
3		Methanol	5	1.0000	1.3000	0.3

Table 6 *- Statistical analysis of swelling test of synthesized Potato starch bioplastic in different solvents*

Solvent Medium	Difference (g)	Mean± S.D
Chloroform	0.18	0.18±0.2
Distilled water	0.4	0.2±0.1

Methanol	*0.06*	*0.06±0.15*

4. CONCLUSION

Thus the bioplastic synthesized using banana peels and potato starch is one of the main challenges in synthesizing bioplastic material. The current report has made an effort towards the synthesis and characterization of these types of natural polymeric material. Certainly, the research is a long way to go for both economic and environmental friendly products using bioplastic or bio polymer. But synthesis of bioplastic using fruit waste is more reliable method as it is economically convenient and using waste in effective manner. But this study will be a centralized project that can be applied on large scale to produce large quantity of plastic that suffices the needs of any company.

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