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## ECO-FRIENDLY PLASTICS: UTILIZING CITRUS SINENSIS PEEL FOR BIODEGRADABLE SOLUTIONS

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### ABSTRACT

In modern society, plastic plays an important role as a packaging material in almost all sectors of everyday life. This plastic does not deteriorate easily as it is impervious to microbes Decomposes and thus persists for a long time in the environment. Alternative approaches to the production of bio-based plastics are widely supported as a solution to this source of bio-based polymers. These bioplastics could be made of a variety of substances, such as cellulose and starch. Utilizing fruit waste comes first, followed by the creation of bioplastic. In this way, we have made a bioplastic from the Citrus sinensis (Orange) peel with the use of some additives like glycerine, starch, waste newspaper pulp, citric acid, etc. These biodegradable plastic properties were studied by FTIR, XRD and different types of biodegradation studies and this biodegradable plastic also showed good antibacterial activity.

**Keywords:** Biodegradable, Citrus sinensis peel, starch, glycerine

### INTRODUCTION:

The majority of ordinary plastics, including polyethylene, polypropylene, polystyrene, poly (vinyl chloride) and poly (ethylene terephthalate) are not biodegradable and the world is becoming more and more threatened by their growing environmental accumulation [1]. Starch is used to make

around half of the bioplastics that are now on the market. Bioplastics based on starch are simple to produce and are frequently used in packaging-related applications. Protein, chitosan, cellulose, and starch Biodegradable polymers are made from biomass that is sourced sustainably [2]. The

drawbacks of plastic are its durability and lack of biodegradability [3]. Biodegradable polymers containing environmental contaminants are converted to organic trash, and carbon dioxide and water are released [4]. The government and the corporate sector are currently contributing tremendous financial assistance for the development of sustainable and ecologically friendly product manufacture [5]. The technologies of the twenty-first century concentrated on producing bioplastic from non-edible materials and trash to meet high demand. Bioplastic can be materials, including grape seeds, orange peel waste, bananas, etc. [6]. Global awareness of the need to replace traditionally non-biodegradable materials has grown in the last few years due to the biodegradability of materials as non-hazardous to the environment [7]. Compared to manufactured polymeric materials (such as polylactic acid), Natural biopolymers are believed to be more abundant and less costly [8].

Versatile uses for bioplastics are product packaging, food packaging, eatable utensils, and insulation [9]. Bioplastic is largely incorporated in such as cutlery, diapers, packaging materials in many countries [10]. Looking towards global awareness of need to replace traditionally non-biodegradable materials and as compared to manufactured polymeric building blocks such as polylactic acid, natural biopolymers are to be more

abundant and less costly, designed and sculptured biodegradable plastics utilizing orange peel. An innovation which is a benchmark as best out of waste.

**Material and method: Preparation of Orange peel powder (01):**

After successive water washing to orange peels (200 gms), chopped to tiny pieces. Dry it for eight to ten hours in an air oven at 50° C. The peels ought to get brittle and dry. Blend the dried peels into powder employing a blender on high speed to get fine and smooth uniform particles. Keep your powdered orange peel in an airtight container stored in a dry location. Weight of Orange peel powder = 60 gms.

Bioplastic from orange peel powder film (IB-02) [without filtration]: Add 100 ml of distilled water to a mixture of 2 gm of powdered orange peel, 5 gm of corn starch, 3 ml of glycerine, 3 gm of gelatine and 1 gm of citric acid taken in a 250 mL beaker. Stir for 15 minutes to make homogeneous slurry and raise the temperature to 100°C. Maintain heating for 1 Hr. Pour the finished product onto a glass plate coated with Teflon and let it air-dry at room temperature for 72 Hrs. BP Film (02) weight = 15.16 gm.

Bioplastic from orange peel powder film (IB-03) [with filtration]: 2 gm of orange peel powder, 5 gm of corn starch, 3 ml of glycerine, 3 gm of gelatine and 1 gm of citric acid poured in a 250 ml beaker containing 100 ml of distilled water. Stir for 15 minutes

to make a homogeneous slurry and raise the temperature to 90°C, filter through a cotton cloth filter, and heat the filtrate to 100 °C for 30 minutes. Spread the mixture over a glass plate coated with Teflon and let it air dry at room temperature for 72 Hrs. BP film (03) weight = 14.18 gm

**Bioplastic from orange peel powder and waste newspaper film (IB04) [without filtration]:** Measure up the term "paper sludge" is produced by pulverizing 5 gm of used newspapers into minute bits in a grinder and adding 10 ml of water. This mixture creates a lignocellulosic fibrous pulpy substance that is continually spun. This paper sludge was added to 100 ml of distilled water, glycerine, 3 ml, cornstarch 5 gm, orange peel powder 2 gm, gelatine 3 gm and citric acid 1 gm while continuously stirring. This mixture was heated at 130 to 140 °C for 60 minutes. Transfer the mixture onto a glass plate covered with Teflon and let it air dry at room temperature for 72 Hrs. BP film (04) weight = 13.75 gm

**Bioplastic from orange peel powder and waste newspaper film (IB 05) [with**

**filtration]:** Repeating the preparation of paper sludge same as in the above process was added to 100 ml of distilled water, 2 gm of orange peel powder, 5 gm of cornstarch, 3 ml of glycerine, 3 gm of gelatine, 1 gm of citric acid. Stir above mixture at RT for 15 minutes and raise the temperature between 80-90 °C. Then filter this mixture using a cotton cloth and heat the filtrate at 100 °C for 60 minutes with stirring. Spread evenly while pouring the liquid onto a glass plate covered with Teflon, then let it air dry for 72 Hrs. BP film (05) weight = 12.55 gm.

Table 1: Costing of the formulated biodegradable polymer (as per wt. obtained)

Raw material	Price/50 gm	Quantity for BP film IB 02/03	Price bp Film IB 02/03 (in Rs)	Quantity For BP film IB 04/05	Price for bp Film IB 04/05 (in Rs)
Orange peel powder	50	5 gm	5 Rs	10 gm	10 Rs
Citric acid	3.2 Rs	2 gm	0.12	-	-
Gelatine	30 Rs	6 gm	3.6 Rs	-	-
Glycerine	45 Rs	6 ml	5.4 Rs	9 ml	8.1 Rs
Corn starch	3 Rs	9 gm	0.54 Rs	12 gm	0.72 Rs
Vinegar	2.5 Rs	9 gm	0.54 Rs	12 gm	0.72 Rs
Waste	0.50 Rs	-	-	3 ml	0.15 Rs

Newspaper			15.200 Rs		19.690 Rs
Total cost (in INR Rs)					

Table 2: Comparison of final costs of synthesis of biodegradable films

FILM SAMPLE	Wt. obtained (gm)	Costing (in Rs)	Costing per kg (in Rs)
IB 02	15.16	15.200	1,002
IB 03	14.18	15.200	1,071
IB 04	13.75	19.690	1,432
IB 05	12.55	19.690	1,568

## RESULT AND DISCUSSION

**Water Absorption Test:** Two-centimeter square portions of a tiny piece of film were taken off. The cut-fill sample's starting weight was then calculated. The sample was then submerged for 24 hours in 50 ml of room-temperature water. After that, the sample was wiped off and removed from the

water. Finally, the weight was noted. The following formula was used to determine the quantity of water absorbed. According to **Table 3**, the BP film IB-01 had the maximum water uptake.

$$WA (\%) = \frac{\text{Final weight (gm)} - \text{initial weight (gm)}}{\text{initial weight (gm)}} \times 100$$

Table 3: Data for water absorption of Bioplastic films

Sample BP film	Initial weight BP Film (gm)	Final weight BP Film (gm)	Water absorption Water uptake (%)
IB -02	0.31	0.40	29.03%
IB-03	0.29	0.35	20.68%
IB -04	0.21	0.25	19.05%
IB -05	0.17	0.20	17.64%

**Biodegradability Test:** The water solubility test weighs a BP film in a beaker at room temperature to gauge how slowly it dissolves over the course of three days, reaching its maximal solubility 15–20 days later. A range of Analytical methods are employed in characterization processes to assess hydrolytic breakdown and modifications in polymer characteristics. These techniques include pre- and post-immersion weighing to ascertain mass loss indicative of degradation, as well as visual

inspection to track changes in surface morphology, color, texture and transparency. Materials strength and flexibility are assessed mechanically using tests like tensile strength and elongation at break, while chemical analysis using spectroscopic techniques detects changes in chemical composition like bond breakage or the formation of degradation products. Following is the result of biodegradability test in soil.

Table 4: Data for Biodegradable test in soil of BP films

Sample Bp Film	Initial weight gm	Weight after 4 days	Weight after 8 days	Weight after 1 day
IB - 02	0.45	0.41	0.39	0.36

IB-03	0.36	0.35	0.34	0.33
IB -04	0.30	0.25	0.24	0.23
IB-05	0.27	0.24	0.23	0.22

**Photodegradability test:** A piece of each synthetic bioplastic is placed in sunlight to be to verify the photodegradability analysis. We measured the weight of biodegradable plastic every few days. Make sure that each

sample is labeled with an identification number. There are no significant changes in the weight of bioplastics hence they are photo-stable.

Table 5: Photo degradability study of synthesized biopolymers

Sample BP Film	Initial weight In gm	Weight after 5 days	Weight after 8 days	Weight after 15 days
IB -02	0.531	0.527	0.525	0.521
IB -03	0.471	0.470	0.468	0.460
IB -04	0.59	0.538	0.538	0.537
IB -05	0.462	0.462	0.461	0.461

#### OVERLAPPED FTIR Characterization:

The spectra were obtained in 256 scans between 4000 and 400  $\text{cm}^{-1}$  using the Spectrum 100 Bruker FTIR. FTIR analysis was performed on the spectra of the BP film and the powdered orange peel. A peak of 3278.63  $\text{cm}^{-1}$  was noted by the IR and the C-H peak of the  $\text{CH}_2$  group of the powder and bp film is the sharp peak that can be seen in the region of 2850–2950  $\text{cm}^{-1}$ . The O-H group is present. A large peak has been noted in the bp film. The film's moisture content is to blame for this. The overlapping spectra showed peaks at wavenumbers 1580 to 1700  $\text{cm}^{-1}$ , which were ascribed to the hydroxyl group deflection of the water, namely induced by hydroxyl groups that cause water molecules' modes to be bent. The other peak seen in both spectra fell between 1400 and 1450  $\text{cm}^{-1}$ , which

corresponds to the O-H bend and between 1350 and 1480  $\text{cm}^{-1}$ , which is associated with the  $\text{CH}_2$  bending vibration in the BP film. displayed in every IR data graphic. The overlapping infrared data of bioplastic orange peel (Red line (IB-02) & Pink Line (IB-03)) and orange peel powder (Blue line (IB-01)) are shown below. The overlapping infrared data of orange peel powder (Blue line IB-01) and bioplastic made of newspaper pulp mixed with orange peel powder (Red line IB-04 and Pink Line IB-05)) show the same peaks. The peaks in **Figure 1** correspond to O-H bending at 1400–1500  $\text{cm}^{-1}$ ,  $\text{CH}_2$  bending vibration of the bioplastic film at 1350–1480  $\text{cm}^{-1}$ , the water hydroxy group at 1580–1750  $\text{cm}^{-1}$ , the hydrogen-linked hydroxyl group (OH) stretching at 3100–3300  $\text{cm}^{-1}$ , and the C-O stretch of an anhydrous glucose ring at

1000–1050  $\text{cm}^{-1}$ . Particular interactions between hydrogen.

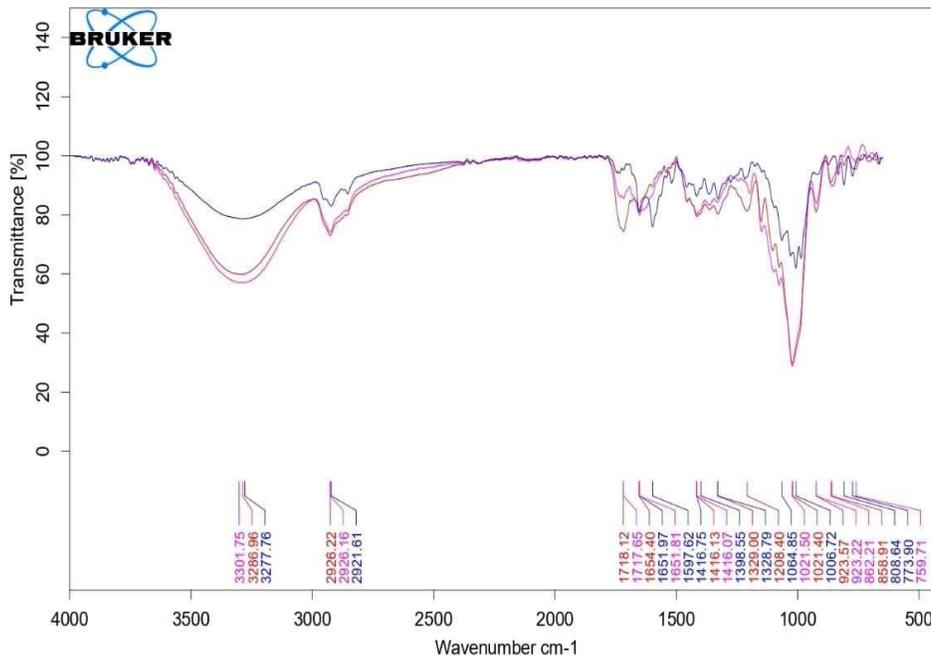
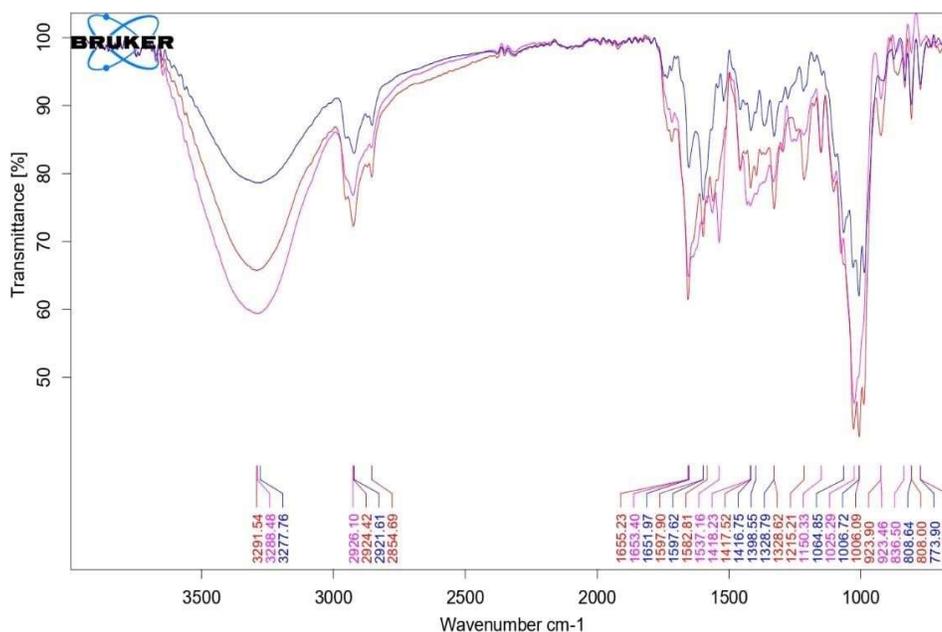


Figure 1: Overlapping FTIR data of orange Peels (Blue line) and Bioplastic from orange peel blue line (01) (Redline (02), Pink Line (03))



**Figure 2:** Overlapping FTIR data of orange peels (Blue line (01) and bioplastic from newspaper pulp with orange peel powder (Red line (04) & Pink Line (05))

The overlapping infrared data of orange peels (Blue line, IB-01) and the bioplastic made from newspaper pulp and powdered orange peel (Red line, IB-04 and pink line, IB-05) show the same peaks. Peaks in **Figure 2** range in size from 1400 to 1500  $\text{cm}^{-1}$ , representing O-H bending, 1350–1480  $\text{cm}^{-1}$  for the bioplastic film's  $\text{CH}_2$  bending vibration, 1580–1700  $\text{cm}^{-1}$  for the water hydroxy group, 3100–3700  $\text{cm}^{-1}$  for the stretching of the hydrogen-linked hydroxyl group (OH) and 1000–1150  $\text{cm}^{-1}$  for the C–O stretch of an anhydrous glucose ring. The particular interactions between hydrogen bonds cause the FTIR spectra to broaden and shift.

**X-ray diffraction (XRD):** X-ray diffraction (XRD) is a method frequently used to assess

bioplastic crystallinity. Never are the polymers perfectly crystalline. **Figure 3** displays the XRD spectra and yellow represents IB-01 (Orange peel powder). IB-04(bp) is shown in black. Produced without filtered orange peel powder and newspaper and the green represents IB-05 (bp created from filtered orange peel powder and newspaper). Since there are no distinct peaks in the spectrum we can conclude that IB-01 and orange peel powder are an amorphous substance. On the other hand, IB-04 and IB-05 are semi-crystalline. Their peaks may be seen in IB-04 and IB-05 at  $21.68^\circ$ ,  $17.92^\circ$ ,  $23.74^\circ$  and  $12.5^\circ$ . That is due to the Corn starch and Newspaper.

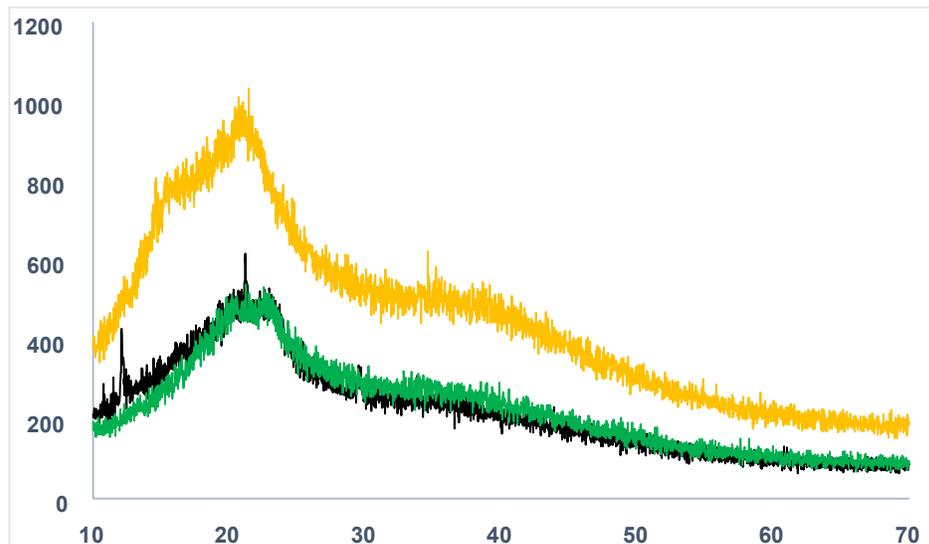


Figure 3: X-ray diffraction pattern of orange peel powder and bp films

**SEM analysis:** The surface of biodegradable polymers can be examined using a type of electron microscopy called scanning electron microscopy (SEM). SEM can be used to evaluate particle size and diameter as well as to assess a biopolymer's

surface topography, homogeneity and phase separation. SEM can also display the alterations in a biodegradable polymer's surface over time as a result of exposure to various environments.

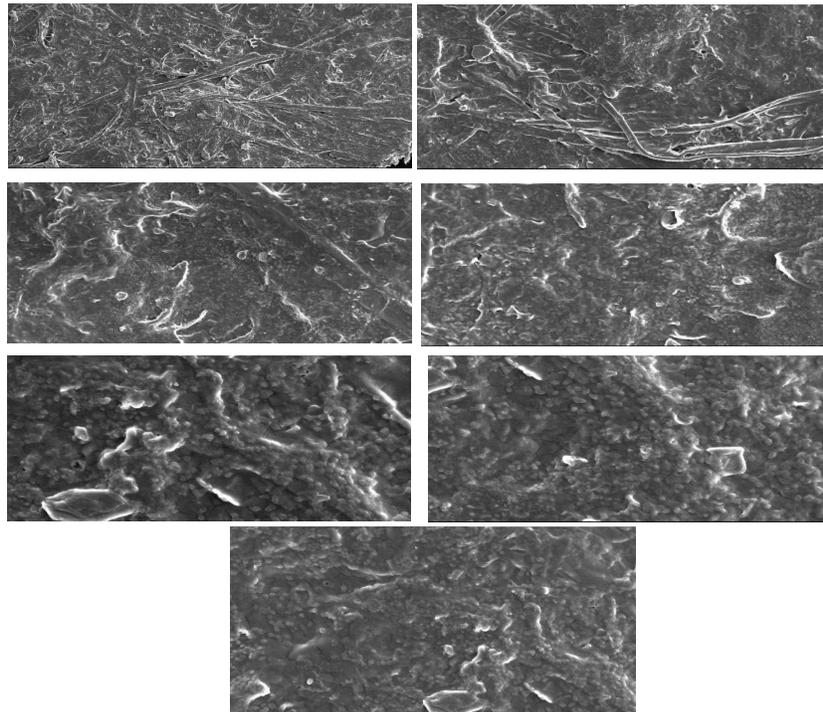


Figure 4: SEM Images of designed bioplastics

**Anti-bacterial activity:** The antibacterial activity of the produced film was evaluated against *Pseudomonas aeruginosa* (gram-negative), *Escherichia coli* (gram-negative), *Bacillus subtilis* (gram-positive) and *Staphylococcus aureus* (gram-positive) using the disc diffusion method at 100 ppm (10 mg/ml), concentration in a solvent called

dimethyl sulfoxide (DMSO). employing a disc diffusion method as outlined in the Kirby-Bauer approach. Penicillin G was the usual medication. Every experiment was carried out twice. Each bioplastic film underwent an antimicrobial test, result tabulated as follows.

**Table 6: Result of Antibacterial activity test**

Name of sample	Microorganisms and zone of inhibition (in mm)			
	Gram-positive bacteria		Gram-negative bacteria	
	<i>Staphylococcus aureus</i>	<i>Bacillus subtilis</i>	<i>Escherichia coli</i>	<i>Pseudomonas aeruginosa</i>
IB-02	15	14	15	14
IB-03	13	15	09	12
IB-04	12	12	11	16
IB-05	10	10	09	12
Control (Penicillin G)	8	10	10	12

## CONCLUSION:

This research is an innovation of biodegradable plastic designed from discarded orange peel and newspaper looking towards solutions that complement nature and add value without causing harm and continue to be profitable. All of the bioplastic films are hydrophilic, according to the water absorption test. The FTIR analysis of the bioplastic film reveals various functional groups in the powdered orange peel and the bioplastic film that was generated from it by figuring out the majority of the IR spectrum's peaks. According to XRD examination, some of the peaks exhibit a crystalline nature, while others reveal an amorphous nature. IR and XRD results strongly support the

incorporation of orange peel powder in synthesized biodegradable peels. SEM analyses shows same nature of created bioplastic films. Created bioplastic films showed potency against gram positive (*Staphylococcus aureus*, *Bacillus subtilis*) and gram negative (*Escherichia coli*, *pseudomona aeruginosa*) bacterial strains. With an eye toward a sustainable future, the call to action is to increase the market for bioplastics and bring in a new era of advanced manufacturing. Notably, Composition IB-02 & 03 has a remarkable rate of commercial biodegradability in addition to cost-effectiveness. Encouraged by these opportunities, our efforts have produced versatile biodegradable polymers derived from the abundance of nature,

offering an array of intriguing economic possibilities and industrial scope.

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