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Synthesis And Characterization of *Allium cepa* Bulb Bioplastic

Rohit Vinod Panchal
Sunita Manik Chauhan
Taufiq Shaikh
Nitin Labhane
Asmita Mestry

PG Department of Botany, M.M. College of Arts, N.M. Institute of Science & H.R.J. College of Commerce, Bhavan's College (Autonomous) Andheri (West), Mumbai 400 058 (MS) INDIA
E-mail: nitin.labhane@gmail.com

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Abstract

Plastic pollution is one of the most serious issues facing the environment as a result of the rapid manufacture of plastic. Synthetic plastic takes a very long time to decompose, reported at 500-1000 years, and becomes hazardous after decomposition. The only alternative available for synthetic plastic is bioplastics which are more economic, ecofriendly, and bio-degradable. The objective of this study is to synthesize biodegradable plastic from the dried peel of *Allium cepa* (ACP). One of the most consumed vegetables *A.cepa* (onion), contains the highest levels of cellulose (41–50%) and hemicelluloses (16–26%) which is important for the production of bioplastic. The main procedure in the preparation of *A.cepa* peel (ACP) bioplastic was delignified, bleached, acid hydrolyzed and neutralized which culminated in successfully extracting cellulose. By mixing the key components i.e., 15 g extracted cellulose, 10gms starch, and 5ml glycerol and 15ml acetic acid ACP bioplastic was obtained. This ACP bioplastic sample was subjected to various tests followed by soil degradability, water solubility, water absorption, and ash weight test respectively, to determine the properties of bioplastic. In this research paper, Bioplastic was made by using ACP, showing effective degradation with environmental factors. As a result, *A.cepa* peels bioplastic can be considered an excellent eco-friendly remedy for alleviating the adverse effects on the environment of synthetic plastic.

Keywords: Bioplastic, Environment, Cellulose-based, allium cepa peel, Bio- degradable.

Abbreviations: *ACP- Allium cepa peels, EDAX- Energy- dispersive X-ray spectroscopy, SEM- Scanning Electron Microscopy*

Introduction

Today, synthetic plastic has been employed substantially in industries and household appliances. Synthetic plastics are utilized extensively in the manufacturing process of a broad spectrum of products, notably beverage bottles, toys, alimentary packaging, furniture, and clothing. (Bezirhan and Bilgen, 2019). Bioplastics are created from renewable resources such as starch, cellulose, chitosan, and protein. Bioplastics are sustainable, degradable and eco-friendly. Bioplastic shrinks carbon dioxide emissions, is recyclable, environmentally conscious, and minimizes the need for fossil fuels. Natural resources like lignin's, proteins, lipids and polysaccharides (such as starch, chitin and cellulose) can be directly used to make bioplastics (Krishnamurthy and Amritkumar, 2019). In the present work, A. cepa peels were used to make cellulose-based bioplastic that has the potential to reverse the scenario impacting increasing plastic production. A. cepa peels contain cellulose (41–50%) and hemicellulose (16–26%) (Anjaneyulu et al., 2020), much of which is degraded over time. Dried A. cepa peels is readily available in excess amounts. The advantage of using A. cepa peels is that it is cost-effective and found to be non-toxic after degradation. Bioplastics after investigations were further found to be soluble in water and degradable in soil, making them ecologically beneficial. Because of the positive eco-friendly characteristics they possess, bioplastics can be utilized efficiently in packaging and various other industries.

Allium is a genus of monocotyledonous flowering plants in the family Liliaceae. *Allium cepa* grows commonly all over the world (Marrelli et al., 2018). It is a bulbous biennial herb and consists of 500 species. *A.cepa* has fibrous and adventitious roots, and the bulb is made up of concentric leaf bases which are fleshy .This plant is a bulbous geophyte that primarily grows in temperate biomes. It has environmental and social uses (POWO, 2023). The outermost covering of the bulb dries and forms a thin protective coat whereas the inner layer thickens and develops into a bulb. These bulbs are elongated and ovoid and their size varies depending on the species.

Materials And Methodology

Materials

Dried *A. cepa* peel, Magnesium hydroxide (Mg (OH)2, Sodium chlorate (NaClO3), Sulphuric acid (H2SO4), Corn starch, Acetic acid, Glycerol analytical grade chemicals were used.

Methodology

Collection and preparation

The dried peels of *A. cepa* were collected, ground to a fine powder and weighed (15 g). The powdered A. cepa peels was boiled at 110°C for 1 h in a water bath. 18% Magnesium hydroxide was prepared in distilled water. This slurry of 18% magnesium hydroxide and powdered ACP was then kept in a water bath at 80°C for 1 h. The treated powder was washed with distilled water twice to ensure there should be minimum traces of 18% magnesium hydroxide. The lignin was removed from the material sodium chlorate, 0.7% sodium chlorate solution was prepared in distilled water, this washed powder was added to the solution. The slurry of 0.7% sodium chlorate and powdered ACP was then kept at 110°C for 1 hour in a water bath until the odour and colour were lost. The slurry was then washed twice using distilled water, this slurry treated with 0.7% of sodium chlorate was added to 17.5% magnesium hydroxide and kept at room temperature for 30 min. Finally, the A. cepa pulp was subjected to acid hydrolysis using 40% sulfuric acid, for 1hour at 40°C, which was washed to neutralize the slurry completely. The resulting product was cellulose obtained from the dried peels of A. cepa. (Fig.I) (Reddy et al.2018).

Fabrication of Bioplastic

10 grams of starch, 15ml of Acetic acid, 5 ml of glycerol, 60 ml of D.W., and 20-gram cellulose extracted from ACP was added, this mixture was kept in a hot plate stirrer for 15 mins stirred on continuous interval. Until a thick viscous slurry of the mixture is obtained. It is spread into an acrylic mold for 24 hours to air dry, resulting in a sheet of ACP bioplastic (Bezirhan and Bilgen 2019).

Fig.A. Extracted cellulose

Fig. B. Allium cepa bioplastic

Analysis

Physical Characterization of cellulose bioplastic (Marichelvam et al., 2019)

Thickness test

The sample of bioplastic was measured (2 cm × 2 cm), and the thickness was calculated using a Vernier caliper. For the measurements, readings were taken from 10 different spots and the means average of the same has been calculated for the thickness.

Water solubility test

The test of water solubility was carried out by taking 4cm x 4cm square of sample of bioplastic and weighed (1.0g). This sample was kept at 22oC for 10 days, stirred with a glass rod twice after the interval of 24 hours. The sample bioplastic was removed after 10 days, dried and weighed. Where, (Wi) is the Initial weight, and (Wf) is the final weight.

Moisture content (%) = [(Wi-Wf)/Wf] ×100

Ash weight

To determine the ash weight of the sample of bioplastic, the sample is weighed into an empty crucible and then kept into muffle furnace at 300 0 C temperature for 5 min to obtain ash. Let us assume the weight of the sample (WA), weight of crucible added to the ash content will be taken as (WB), the initial weight (Wi), take the weight of the empty crucible which is (Wo).

Ash weight (g) = [(WB - Wo)/WA] x 100

Absorption weight

The test of water absorption was carried out by a 5cm x 5cm square of sample of bioplastic. later, this sample was placed into D.W. and kept at 22oC. The measured bioplastic was placed into the D.W. for 10 days. The sample bioplastic was removed removed after 10 days, let us assume, Initial weight (Wi) and Final weight (Wf) (Bezirhan and Bilgen 2019).

Moisture Content (%) = [(Wi-Wf)/Wf] ×100

Soil degradability test

The test of soil degradability was carried out by burying the sample of bioplastic in the soil, a layer of 13 cm of soil was use to completely bury the bioplastic. This was sprinkled with water twice each day for 10 days and then the degradability of bioplastic was determined. Let us assume, Initial weight (Di) and final weight (Df) is the weight obtained from bioplastic after buried time.

Rate of Soil Degradation (%) = [(Di-Df)/Df] ×100

SEM Analysis

The surface characterization of bioplastic was determined through Scanning Electron Microscope (SEM) using (Model: Quanta 200) analysis (Amin et al., 2019).

EDAX (Energy Dispersive X-ray Spectroscopy)

The physio-chemical characterization of A. cepa bioplastics were analyzed using the EDAX-analysis, to determine the chemical component of A. cepa bioplastic (Amin et al., 2019).

Tensile Strength Analysis

The Texture analyzer with TA-DGF probe was utilized to examine the bioplastic's tensile strength in order to ascertain the sample's tensile strength.

Results & Discussion

Bioplastic Sample	Initial weight	Final weight	Difference
Water solubility	1.00 gm	0.42gm	0.58 gm
Water absorption	1.00gm	1.73gm	0.73 gm
Soil degradability	5.00gm	4.79gm	0.21 gm
Ash weight	1.00gm	0.86gm	0.74 gm

Tab.I Physical property of bioplastic samples

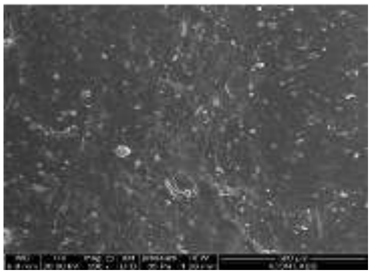
Physical characterization

The thickness of the bioplastic was measured where, the result showed thickness to be 0.30mm (300 micron). According to the regulation, the mandatory thickness for plastic is 500 microns, the research is successful in synthesizing a bioplastic of 300 micron. As the major constituent in the self-life of any biological derived or material made from waste or plant origin is the moister content in it, A. cepa peels bioplastic showed 16% of moisture content, this minimum percentage of moisture content can be considered as a decent amount enhance the shelf life of the bioplastic. Water solubility of the films is an indicator of the presence of hydrophilic compounds in the film (Sharma et al., 2016). The plastic made form the mixture of A. cepa peels and glycerol made has shown substantial water resisting property as it represents greater intermolecular interaction between the molecules, hence the A. cepa peels film has low water solubility percentage (Tab.I). The easiest method to determine the degradability of any material is the weight loss of the sample, in the case of A. cepa peels bioplastic the sample of 5 g were used calculate the degradation rate, in the initial 10 days the sample was of the same weight and strength after 20 days the sample started to change the structure as well as lost it weight in the amount of 0.023g for the 24th day. The sample started to break down into pieces on the 30th day of the test (Tab.I). These results showed that the A. cepa peels bioplastic is completely degradable and lasts for longer duration of time than any other organic component (Bilo et al., 2018).

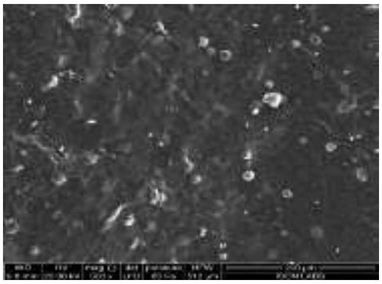
SEM (Scanning Electron Microscopy)

The machine used for micro structure or magnified observation of bioplastic was (Model: Quanta 200). The surface microscopic images of cellulose-based bioplastic, when it was observed at 200000X magnification it showed some starch molecules did not show any structural conformations to show binding to cellulose molecules (Amin et al., 2019). SEM imaging of cellulose bioplastic depicted some insoluble molecules, but these molecules are 1% of the area of investigation (white structure (Fig.III.3), the surface structure studied at the magnification of 200X, emphasized that the components of cellulose-based bioplastic are completely gelatinized and dissolvable (Fig.III.3). This analysis also discovered that cellulose bioplastic has a slightly irregular structure with furrows and grooves (Fig.III.1). Although outwardly it shows plain and uniform surface. However, showed uneven structure in higher magnification. This bioplastic has more compatibility in binding of molecules; however, presence of some non- gelatinized molecules has cause hinderance in strength and durability of the bioplastic in accordance to morphological structure. SEM analysis and (Fig.III.4) shows starch, glycerol, acetic acid the plasticizer and cellulose *has given bioplastic a considerable amount of homogenous structure similar results was shown by (Amin et al., 2019), whereas presence of grooves might be due to the non-gelatinized molecules. The smooth and uniformity in surfaces has increased due starch-cellulose binding in a significant amount. This cellulose bioplastic shows more compactable structure than another starch-based bioplastic.*

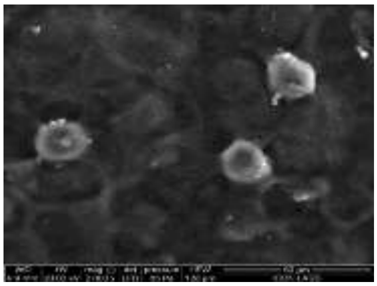
Fig. SEM photograph of cellulose bioplastic



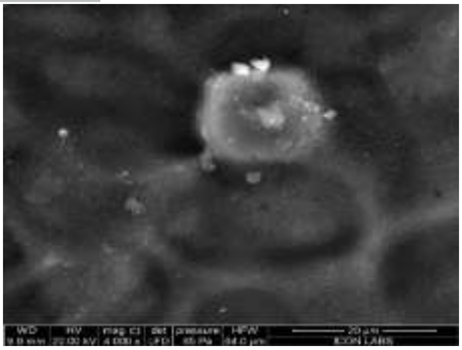
(1) Surface of bioplastic, Presence of grooves & furrows (200 X)



(2) Non-gelatinized Starch molecule in bioplastic (4000 X)



(3) Presence of granules (2000 X)



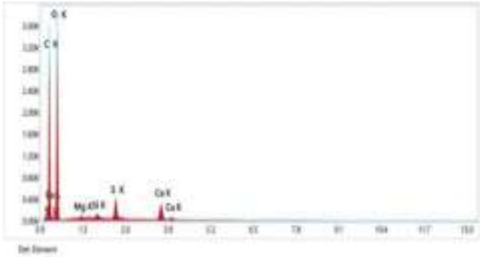


Fig. EDAX (Energy Dispersive X-ray Spectroscopy)

Element	Weight	MDL	Atomic (%)	Net Int.	R	A	F
C K	54.8	0.31	62.4	636.7	0.9344	0.1427	1.0000
O K	42.8	0.21	36.6	748.4	0.9425	0.0868	1.0000
Mg K	0.1	0.05	0.1	15.6	0.9542	0.4160	1.0025
Si K	0.2	0.04	0.1	26.6	0.9591	0.6853	1.0062
S K	0.9	0.04	0.4	119.4	0.9635	0.8457	1.0114
Ca K	1.3	0.09	0.4	106.1	0.9712	0.9585	1.0288

Tab. II eZAF Quant Result

EDAX (Energy Dispersive X-ray Spectroscopy)

Energy-dispersive X-ray spectroscopy (EDX) is a powerful technique for elemental analysis of materials. In this study, EDX analysis was conducted sample showed the presence of carbon, oxygen, magnesium, silicon, sulfur, and calcium. The weight percentages of these elements in the sample were found to be 54.8%, 42.8%, 0.1%, 0.2%, 0.9%, and 1.3%, (Tab. II) respectively. carbon and oxygen were the predominant elements in the sample, which is consistent with the composition of organic materials. The presence of magnesium and calcium suggests that the sample may contain minerals or biominerals. The small amount of silicon and sulfur may indicate the presence of impurities or trace elements. The results of this EDX are a simple and versatile technique, quickly used for quantification of macro elements (i.e. C, O, S, Cl, Na, Mg, Al, Si, P, K, Ca, Ti, Fe, Mn and Ni) in soil which organic materials and minerals. In the same study, they investigated the elemental composition of soil samples and it was found that carbon and oxygen were the major elements present (Sharma et al., 2016). Similarly, in a EDX analysis was used to determine the elemental composition of ACP bioplastic and it represented that calcium and carbon were the predominant elements. The results of this analysis showed that bioplastic made from peels of allium cepa has the component which are degradable and non-hazardous which are not harmful even when dissolved in to the water or soil, over it this all elements can be used by the biological process i.e., by plants and animals.

Tensile Strength Analysis

Tensile strength Analysis is basic done to determine the amount of stress material can withstand when being stretched. In the current finding tensile strength analysis of sample measuring 8 x 2.8 cm was done in triplicate. The sample was named as Trial sample, Final sample-1 & Final Sample-2. The results obtained that the bioplastic can bear maximum peak load of 16563.00 g & the deformation at the peak load was 9.26 mm, However the results show discrepancy in the Peak load which can be accounted to the uneven surface area of the bioplastic.

Sample	**Trial Sample**	**Final Sample-1**	**Final Sample-2**
Dimensions	8 x 2.8 cm	8 x 2.8 cm	8 x 2.8 cm
Load Cell Used (Kg)	50.00	50.00	50.00
Peak load (g)	9321.00	136976.00	16653.00
Deformation at Peak Load (mm)	2.21	8.52	9.26
Work (mJ)	482.60	1107.30	1361.90
Mean Load Between 1 to 10 (s)	171.00	2377.00	2942.00

Table III showing results of Tensile strength.

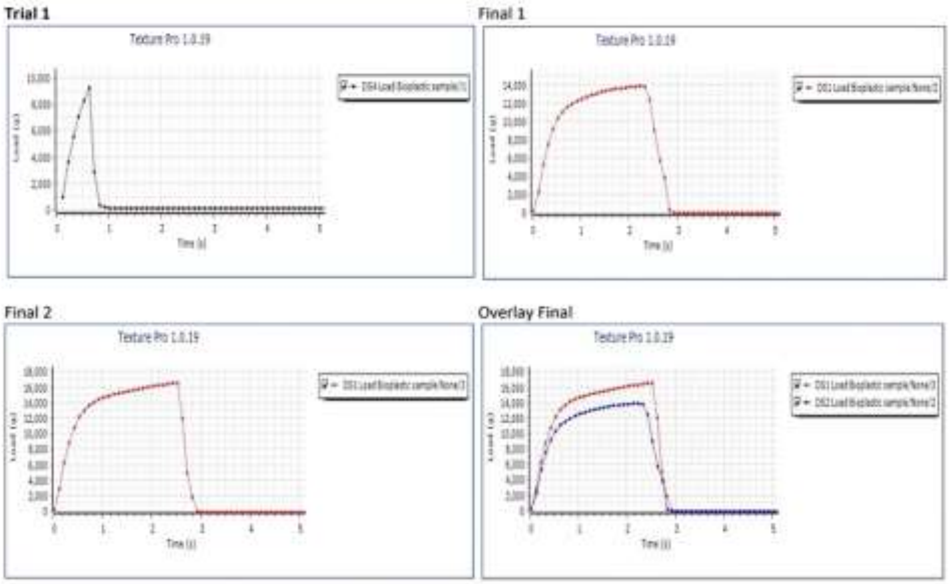


Fig. Tensile strength Analysis of Sample using Texture Analysis CTX model TA-DGF Probe.

Conclusion

The study presents that the formation of bioplastic which is eco - friendly and provides high durability and biodegradable properties. Various characterization techniques and physical tests were used to evaluate these characters. The surface analysis carried out through SEM represents the irregularity in structure with the presence of furrows and grooves. However, it represented the presence of non-gelatinous molecules (Fig.III.2). Accordingly, these molecules cause hindrances in the strength of the bio-plastic (Amin et al., 2019). The chemical characterization of bio-plastic was done by EDAX (Tab. II) (Sharma et al., 2016) analysis which determines that in the process of making the bioplastic there were no use of any hazardous elements. The physical properties of synthesized bio-plastic have an average thickness of 0.034 cm. The biodegradability test was performed by soil burial method in which the sample showed a degradation of 15% in the duration of 10 days from its initial weight. Whereas the same sample when was kept for 24 days it showed over 40% loss of its structure, reduction in size. The solubility test results showed that the bioplastic dissolved only 9.3% in the water after 20 days, whereas the water absorption capacity has determined that bioplastic after the duration of continuous 20 days submerged into water holds 16% of water (Tab.I) at temperature of 28oC (Marichelvam et al., 2019). The properties confirm that the bio-plastic produced using the peels of A. cepa is more efficient and can be used as an alternate source over synthetic plastic. Resulting from the interaction of cellulose with starch has proven the possibility that it is easily soluble, degradable, and recyclable in terms for CO2 emission extensive evaluation is need, improvement of A. cepa bioplastic can be utilized for packaging purposes (Singh et al., 2012). Furthermore, efficient research is required to improve the thickness and tensile strength of the bio-plastic and as well as to incorporate bio-plastic based products that are both cost effective and sustainable.

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