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Production of Biodegradable Plastic from Potato Starch

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Abstract: ***Plastic is everywhere. Today's life without plastics is unimaginable. The benefits are huge, but not many people know about the negative effects of plastic waste on the environment. If people use biodegradable plastics instead of petroleum - based plastics, the world would be much cleaner. This year's statistics show that world plastics production reached nearly 280 million tones. Recycling only does not solve the problem as still a huge amount of plastic waste ends up in landfills and oceans. If this kind of plastic was used instead of conventional plastics, besides the plastic waste reduction, land and water contamination would be reduced as well since our plastic contains no toxic substances. As plastic produce from potato starch is degrades easily, can be used for agricultural purposes and also for Food packaging. The aim of the project was to produce the starch - based bio - plastics using potato starch. The methodology of the project started with the preparation of the potato which included weighing, washing, peeling, dicing. It was followed by blending, slurring and filtration so as to extract maximum starch. The second step was the production of the bio - plastic where Glycerol was added to the starch with the presence of heat. Analysis of sample shows that bio - plastic samples could withstand an elongation of 72.16 mm at break and finally a young's modulus of 1.48 MPa. The Sample was analyze by different tests such as Tensile strength analysis, Water absorption test, Plastic Identification Test, Elongation &Young's modulus and also test for Bio - degradability. An analysis shows that the resulting plastic is biodegradable and that it can be used for certain purposes***

Keywords: Biodegradable, Starch, Glycerol, Tensile Strength, Young's Modulus, Elongation.

1. Introduction

Throughout the 20th century, plastics have been an essential part of the market industry. Most plastics are a combination of other organic and inorganic compounds; 20% of the content of a plastic is composed of additives. Polymers are large molecules consisting of many repeating units, called monomers.

This study focuses mainly on making biodegradable plastics, which is certainly safer than non - biodegradable plastics, from potato starch. Biodegradable plastics made from raw materials are completely reusable and can be composted easily.

Potato starch contains minimal protein and fat. Potato starch is a polymer made up of long chains of glucose units joined together. Potato starch contains two polymers: Amylopectin, highly - branched molecules, making up the majority of the starch found in plants, and Amylose which contains long, chain - like molecules. Potato starch is a versatile material because it has the ability to bind and thicken; it can also be used as an ingredient in making papers, construction materials, adhesives, and other non - food products. There are many product developments that are based on the starch of the potato, products like biodegradable eco - plastics, foam packaging chips, carrier bags, and trays that can be used for food. In terms of biochemistry, starch is a polysaccharide sugar. Its sugar has a component called glucose. The two components, Amylose and Amylopectin, determine the characteristic of the starch of the potato. Normally, the ratio of amylose to Amylopectin is around 1: 4 to 1: 5.

The most valued characteristics of starch such as good adhesive properties are due to the amylopectin, which is therefore the more coveted component. The separation of two components (amylose & amylopectin) is very expensive for the processing industry. It can also result in a very large amount of wastewater. For this reason, potatoes that have high contents of amylose and amylopectin are the primary sources of making raw materials.

Plastics made from potato starch are not much known in the global industry of plastic making. The starch of the potato is a biopolymer with the same properties such as those that are present in conventional plastics. Most plastics known are made from organic polymers that are based on chains of carbon atoms. There are over billion tons of plastics that have been wasted and may degrade for hundreds or thousands of years because of its durability. For this reason, all plastics that have been wasted can occupy a huge area of land that becomes a carbon sink and can cause climate change.

1.1 Background of the study

Due to the overwhelming demand of plastic bag production and its effects on our environment, our landfills are crammed with these non - biodegradable materials. Substances used in the manufacturing brought forth various harmful chemicals which worsen over time. As the destructive compounds such as Chlorofluorocarbon were introduced, the complete deprivation of the Ozone Layer starts. However, scientists and nature preservers alike managed to overthrow this hazard, but not entirely. To compensate for the damages, eco products were released. These are the most commonly made of recycled and/or natural organic materials. They utilize nature's abundant supplies to create a replica or substitute for our plastics. One example would be the "Biodegradable plastic bags" made from the starch of the Cassava plant (Manihot esculent). The new plastic has been able to capture the interests of buyers, enabling it to advocate the benefits and obvious effects one can receive from using an eco - friendly product. To further elaborate the example, scientist and researches aim to discover another substitute for this product and perhaps develop a completely new one along the way.

The objective of the study is to determine what other plants can be used to substitute the Cassava in the production of Biodegradable Plastic Bags in terms of starch content and durability. Specifically, the study aims to achieve the following objectives: 1. to search for the plants with the same or similar starch content as the Cassava.2. To determine if the plant starch is durable enough to be compared against mass produced “Oxo - biodegradable” plastics.

1.2 Significance of the study

Discovering a new and different ingredient required for the Bio - plastic will provide an alternative source if ever needed. Doing so may also inspire at the same time, an entirely different product with the same components therefore contributing to the eco - friendly products.

2. Methodology

Extraction of starch from Potato tubers:

2.1 Extraction process

Water medium was chosen for the extraction because it was observed that the extraction rate was enhanced as compared to alkali extraction. With alkali medium, the extraction of starch from potato is decreased as compared to other tubers such as the family of Colossi which includes the cocoyam (Moorthy, 1990).

2.1.1 Selection of the potato

The potato selected for the extraction was bought from the local vegetable market of Nashik.

2.1.2 Preparation of the potato starch

There were a few procedures followed before the extraction of the starch from the sweet potato. These included the:

2.1.3 Production of starch based bio - plastic

The methodology of producing the bio - plastics is as follows

1) Weighing of 7.5gm starch approximately on weighing balance.
2) 7.5g of dried potato starch was diluted with 100ml distilled water in a 500ml beaker.
3) The beaker was brought on a heater plate including a magnetic stirrer.
4) A magnet stick was added in the beaker and let stirring at 200r. p. m.
5) 1.5ml of glycerol was added.
6) 1mg citric acid was added to the mixture.
7) Kept on hot - plate and was switched to 40^0C.
8) The mixture was allowed to heat for about 10 min
9) Kept on the stirrer and was brought to 300r. p. m as the mixture was hardening.
10) The mixture took about 1 hour to form an opaque gel.
11) The gel was spread on a mould of 2 mm thickness (Non - sticky Pan).
12) The sample was allowed to dry at room temperature for 48hrs.
13) Daily observations were done without disturbing the sample.

2.1.4 Biodegradability Test

Biodegradable behavior of bio - plastics was determined using soil burial degradation test, i. e. bio - plastics were buried in the soil, so that it would be degraded completely

1) The damage can be seen from the mass reduction of respective specimens buried in the ground.
2) Bio - plastics were cut into 10 mm x 10 mm.
3) Then, they were buried into the ground at 8 - cm depth; the burial duration varied (3, 6, 9, and 12 days).
4) Prior to burial, the initial mass (mass before degradation) was determined.
5) The final mass (mass after degradation) of the bio - plastics was measured afterwards.
6) Any changes in mechanical properties due to degradation process were observed and when the bio - plastics were completely degraded, the biodegradability was measured.

3. Results & Discussion

3.1 Extraction of Starch and Production of Bio - plastic

The starch was extracted from the starch by using water as extraction medium which undergoes washing, peeling, crushing, slurring and filtration. Dried starch was therefore use for the production of Bio - plastic. A 7.5g potato starch was added to distilled water (98.5ml), then the solutions were stirred using a magnetic stirrer for 5 minutes at 200 rpm. Next, glycerol 1.5 - 2 ml was added to solution, and then the solutions were stirred again for 5 minutes at 300 rpm. The solutions were heated in a water bath at a temperature of ±70°C, while being stirred with a Glass rod for ±15 minutes. It took nearly 1 hour to form an opaque gel. Then the gel was pour into a mould with non - sticky surface then dried at room temperature (27°C to 30°C) for 48 hours. The bio - plastics produced were hard, smooth and transparent. Potato starch consists of semi crystalline structures because its granules are disrupted as a result adding specific heat and solvent.

Figure 1: Starch before Drying

Figure 2: Starch after Drying

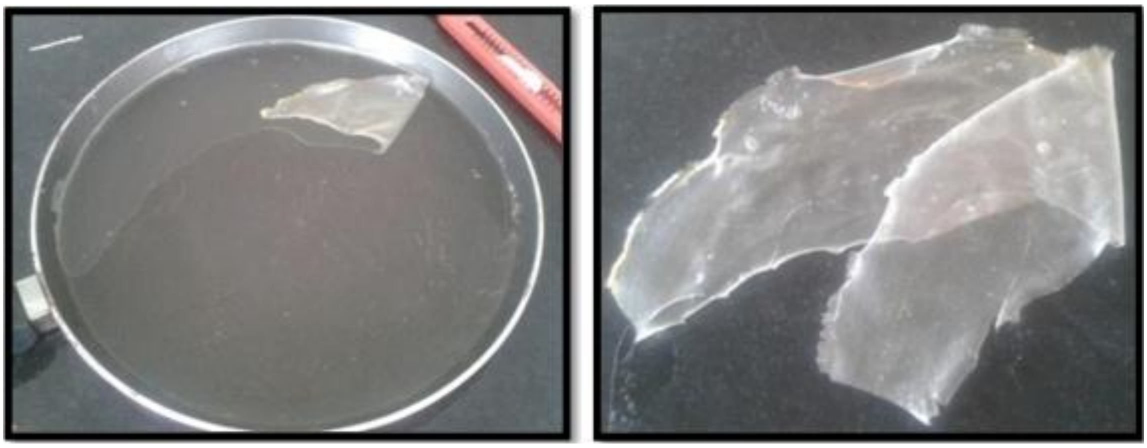


Figure 3: Bio - plastic Film

3.2 Biodegradability Test

Biodegradable behavior of bio - plastics was determined using soil burial degradation test, i. e. bio - plastics were buried in the soil, so that it would be degraded completely. Degradation testing serves to determine the extent of damage of bio - plastics. The damage can be seen from the mass reduction of respective specimens buried in the ground.

Initial weigh of the sample was 1.22g, after 3 days it was found to be 1.10g and the final mass taken before degradation was 1.09g.

A sample was put into the soil and was measured weight until it is degraded completely. Weight of sample was reduced after each three days. After 15 days' sample was degraded completely. This proves the biodegradability and compost ability of our plastic.

Biodegradation of bio - plastics can be done by several bacteria found in the soil such as *Pseudomonas sp., Streptococcus sp., Staphylococcus sp., Bacillus sp., and Moraxella sp.* Moreover, it can be done due to the breaking of polymer chain of potato starch. The addition of more glycerol can increase the degradation of bio - plastics, since glycerol has the ability to absorb hydroxyl water or absorb water easily. Water is the medium of most bacteria and microbes, particularly those in the soil. As a result, water content results in plastics becoming degraded more easily.

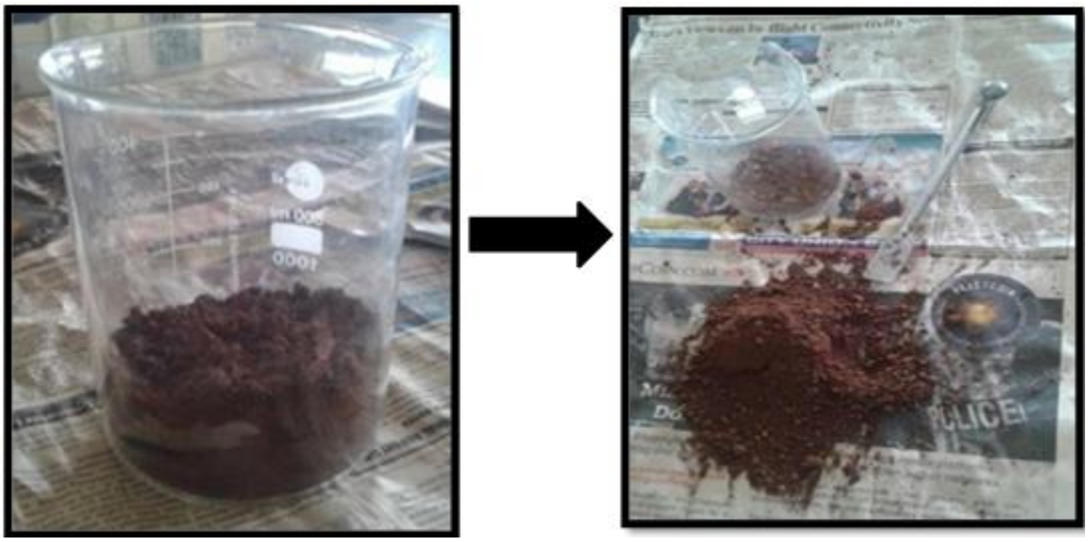
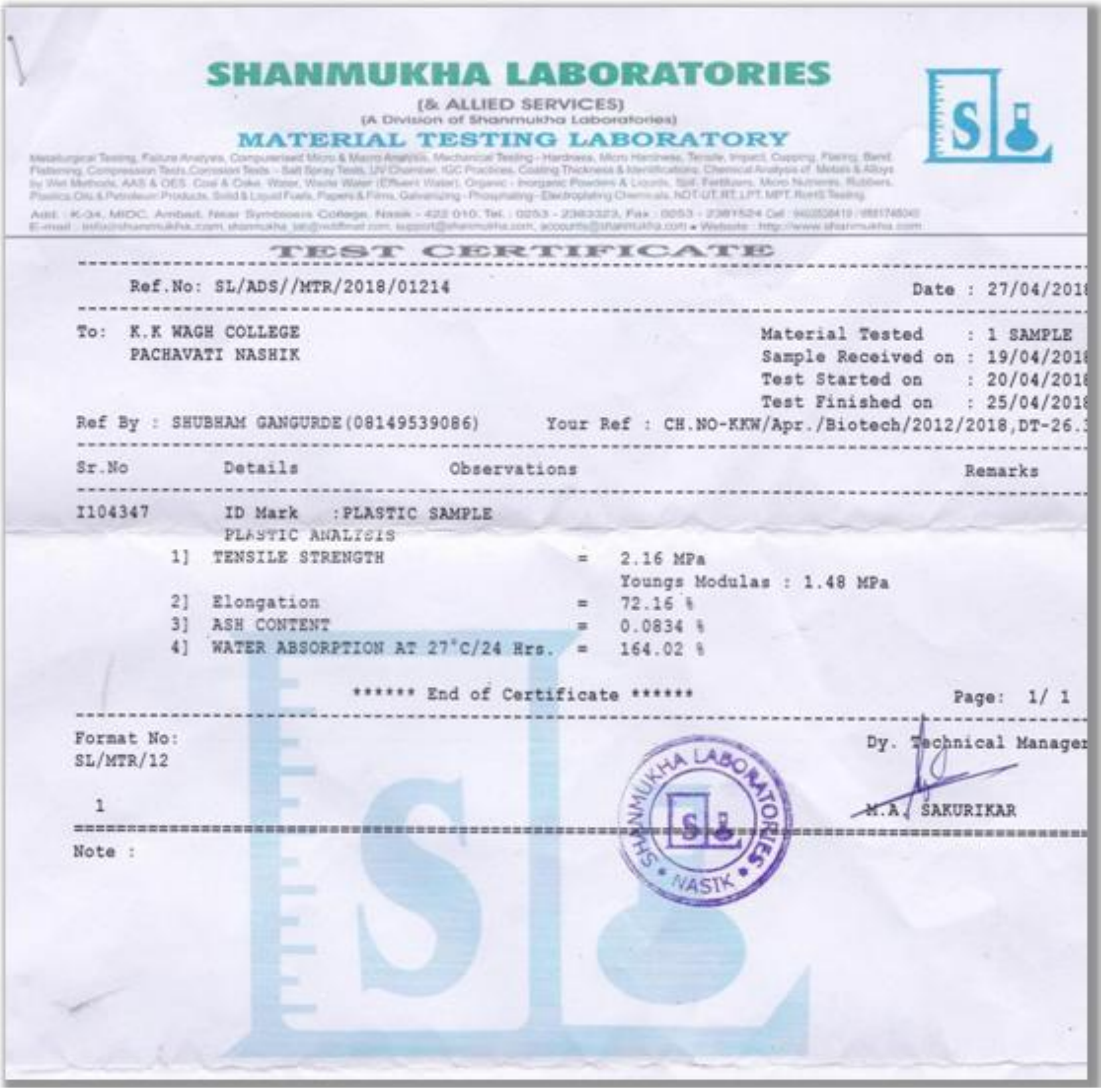


Figure 4: Biodegradation of the Bio - Plastic Sample

3.3 Mechanical Testing of the Bio - plastic Samples

The mechanical testing was carried out at the Shanmukha laboratory located at the Ambad, (Nashik) under the guidance of prof. M. A. Sakurikar sir. The Universal testing machine, Tensile strength analyzer& Burner was used to perform several physical tests and hence obtaining values for the elongation, young's modulus, Ash content & Water absorption of the Bio - plastic.



SHANMUKHA LABORATORIES
(& ALLIED SERVICES)
(A Division of Shanmukha Laboratories)
MATERIAL TESTING LABORATORY

TEST CERTIFICATE

Ref.No: SL/ADS//MTR/2018/01214 — Date : 27/04/2018

To: K.K WAGH COLLEGE
PACHAVATI NASHIK

Material Tested : 1 SAMPLE
Sample Received on : 19/04/2018
Test Started on : 20/04/2018
Test Finished on : 25/04/2018

Ref By : SHUBHAM GANGURDE(08149539086) — Your Ref : CH.NO-KKW/Apr./Biotech/2012/2018,DT-26.

Sr.No	Details	Observations	Remarks
I104347	ID Mark :PLASTIC SAMPLE		
	PLASTIC ANALYSIS		
	1] TENSILE STRENGTH	= 2.16 MPa Youngs Modulas : 1.48 MPa	
	2] Elongation	= 72.16 %	
	3] ASH CONTENT	= 0.0834 %	
	4] WATER ABSORPTION AT 27°C/24 Hrs.	= 164.02 %	

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Dy. Technical Manager
M.A. SAKURIKAR

SHANMUKHA LABORATORIES NASIK

Note :

Figure 5: Photocopy of Results obtained from Laboratory

3.4 Moisture Absorption Test

The moisture absorption test identified the ability of bio - plastics to absorb water (H_2O) as determined by standard ASTM D 570. Bio - plastics, which had been previously dried for 24 hours in an oven at 50°C, cooled in a desiccator, and weighed, were cut into 10mm x 10mm. The moisture absorption data of bio - plastics was obtained by soaking them in water for 24 hours at 27^0C. After that, the bio - plastics were dried with a cloth and immediately weighed. The water absorption capacity of bio - plastics can be calculated as follows:

$$Moisture\ Content\ (\%) = \frac{(Post - Brake\ Weight) - (Initial\ weight)}{Initial\ weight} X100$$

= 164.02%

It shows that, Change in water - absorption of bio - plastics varied depending on the variations in the concentration of glycerol. The more the glycerol is, the higher the water swelling ratio will be. It is associated with hydrophilic properties of glycerol and starch. These properties increase the affinity between glycerol and water, hence the increase of water absorption.

Table 3.1: Tensile Test Analysis

Information	Unit	Values
Sample Number	No.	1
Glycerol amount	Ml	1.5
Starch amount	G	7.5
Elongation (ΔL)	%	0.215
Strain (ε)	%	49
Stress	MPa	1
Tensile Strength	MPa	2.16
Young's Modulus	MPa	1.48

4. Summary & Conclusion

This study was carried out with the aim to investigate the potential of producing starch based plastic films and consequently plastic carry bags from potato starch in India. After the completion of the work we had ended with a cheaper alternative in comparison to other polymeric films by blending potato starch, glycerol and citric acid. The Tensile test of the film helped us to find the efficiency and durability of the film which were more efficient than from films made by cassava, corn or any other starch containing product. The decrease in puncture and tensile strength with increase amount of glycerol control showed us that increased use of plasticizer would reduce the efficiency of the film. From water absorption test it was clear that pore size varies with the amount of potato starch. This data can be used to design specific food packaging film system. The water absorption test result, tensile strength test result, Elongation at break result are given and result are comparable those with already existing result. Resistance to degradation of bio - plastics made of potato starch was strongly influenced by the amount of glycerol used as the plasticizer. The greater the amount of glycerol was used, the faster the degradation process (the complete degradation occurred on the 14th day). Our plastic feels and looks like real plastic and it is biodegradable. With a good ratio between the ingredients, we were able to make real bio - plastic utensils. We will do further research in order to improve our project. We intend to find some other natural additives which will make our plastic have better properties.

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