Research Article

Role of EPS and Bio Surfactant in the Biodegradable Plastic Making based on Vegetable Waste

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ABSTRACT

Environment friendly biodegradable plastics are gaining popularity in the recent years because of the burning needs that facing the society. Natural polymers that use polysaccharides such as starch and microbial Exopolysaccharaides blends with accelerated degradation properties. Biodegradable plastic offers promise to solve the problem of the disposal of regular plastic. One possibility for achieving this aim would be through the use of an additive to the plastic. Additives to plastics are currently used to obtain desirable properties in the plastic and impart such properties as strength, hardness, flexibility, color, etc. Fruit processing industry produces wastes such as skin and seed, which are discarded in abundance. If not handled and managed properly, the vegetable and fruit wastes can cause disposal problems that lead to adverse environmental effects. Hence, the productive use of such wastes would certainly solve the disposal problems. The objectives are to increase the biodegradability of conventional biodegradable plastic by increasing the biodegradability rate and to utilize the waste produced from fruit and vegetable processing at an industrial production level. The present research relates to biodegradable plastics having enhanced rate of biodegradability due to the presence of powdered vegetable waste.

Keywords: Bioplastic, vegetable waste, Exopolysaccharaides, Biodegradability, Tensile strength.

INTRODUCTION

Bioplastics are made from biological materials which meets the need of keeping the huge advantages of conventional plastics by keeping away the harmful and serious environmental effects of it. Conventional plastics provide functionality that cannot be easily or economically replaced by other materials. Most of the plastics and plastic containing materials last for thousands of years. Most of the manufacturing goods including computers, car parts and refrigerators made of plastic products, now the bioplastic and are cheaper, lighter, safer, stronger and easier to recycle[1]. Plastics merge in the oceans and the coastlines. Ingestion of plastic affects the marine organisms. House hold purpose using plastic bags and bags found on streets in the world would definitely cause the environmental adverse effect. Plastics use valuable resources of oil, large amounts of energy usually from fossil fuel sources which therefore adds to the world's production of green house gases[2]. The world needs to find a solution that gives us continued access to plastics but avoids these serious problems. Plastic can do everything at a lower cost. It could be moulded, shaped, or cut. Today, many manufacturers use plastic in their products because it is light weight and durable and can be made into almost any shape. It also can be used in place of natural materials, like wood or ivory, which can help conserve those resources. But plastics also require natural resources since they are usually made from petroleum or oil byproducts[3]. Plastic also takes a long time to biodegrade so it can be harmful to the environment. Many industries recycle plastic, statistics reveal that about 20% of the trash in landfills was plastic.

Several research studies are going today to come up with more environmentally friendly plastic called bioplastic. Bioplastics can be made from materials like vegetable oil and corn starch. These plastics are biodegradable and are being used for things like disposable dishes, food packaging, and trash bags. Furthermore, biodegradable plastics can be recycled to useful metabolites[4]. Polysaccharides are the biopolymers and represent the largest group of polymers produced in the world in comparison with about 140 M tons of synthetic polymers[5]. Polysaccharides are widely found in plants, animals and microorganisms, performing different fundamental biological functions by maintaining mechanical shape and rigidity of the living cells and water-binding elements. About 99% of total natural polysaccharides are located in plants, fruits and vegetables consequently represent a major renewable source of these biopolymers exploitable for different purposes. Indeed, polysaccharides have several application such as food nutrients, food additives and feed production; material science concerning the formulation of polymeric materials for different biotechnological applications[6]. Exopolysaccharaides are also known to interact strongly with cations and could concentrate the metal elements. Addition of exopolysaccharaides will give the more tensile strength to the materials. Fruit and vegetable processing industry produces wastes, such as skin and seed, which are discarded in abundance. These fruit wastes can cause disposal problems that lead to adverse environmental effects. Hence, the productive use of such wastes would certainly solve the disposal problems. Biodegradable plastic offers promise to solve the problem of the disposal of regular plastic. One possibility for achieving this aim would be through the use of an additive to the plastic. Additives to plastics are currently used to obtain desirable properties in the plastic and impart such properties as strength, hardness, flexibility and color[7]. Plasticizer may be added in order to soften the biodegradable plastic by increasing its flexibility. Polymerization modifiers such as cross-linkers may be added to enhance the properties of the bio plastic, especially tensile properties and a surfactant may be added to lower the surface tension of the liquid, allowing easier spreading and lowering interfacial tension between liquid and dried skin powder. The plasticizer may be glycerol, sorbitol or an Exopolysaccharaide.

MATERIALS AND METHODS

Collection and preparation of raw material

The left over solid material of vegetable waste was collected from the local market at Guntur (Andhra Pradesh) and kept away from direct sunlight and are rinsed under running tap water to remove dirt and then are soaked in a disinfectant agent for 30 minutes for sanitization purpose and then washed with distilled water. The cleaned vegetable waste is then sliced by using a slicer and then dried in a vacuum at 60-80°C for 12 hours to remove moisture and then grinded using a grinder to produce a fine powder.

Estimation of Total Polysaccharide Content

10 mg of powder is dissolved in 100ml of distilled water. From this use 1ml for sugar analysis to estimate the polysaccharide content, add 1ml of 5% phenol to the 1ml of sample solution, and then add 5ml of concentrated H_2SO_4 and measure the absorbance after 10 minutes at 480 nm against blank. Then compare it with standard solution of glucose[8].

Extraction of crude precipitate

Weigh about 100 g of fine powder and add about 100 mL distilled water. After some time pour the liquid off through the tea strainer into the beaker, leaving the precipitate and again add 100 mL water to the precipitate. Leave the mixture to settle in the beaker for 5 minutes. Decant the water from the beaker, leaving behind the white precipitate which should have settled in the bottom. Add about 100 mL distilled water to the starch and stir gently. Leave to settle again and then decant the water, leaving the precipitate containing starch behind.

Preparation of bioplastic

To 50 mL of distilled water add 2.5 g crude precipitate, 3 mL hydrochloric acid and 2 mL propanol. Heat the mixture using the Bunsen burner and boil it gently for 15 minutes. Dip the glass rod into the mixture and dot it onto the indicator paper to measure the pH. Add enough sodium hydroxide solution to neutralise the mixture and then add a drop of food colouring and mix thoroughly. Pour the mixture onto a petri dish and then leave it to dry out at 50°C for an hour

EPS extraction from a biofilm producing marine bacterium

The biofilm producing marine bacterium was collected from vignan university, Guntur (Andhra Pradesh) was tested by staining the heat fixed cells with crystal violet and was further assessed by using the crystal violet (CV) assay done in microtitre plate[9]. The Exopolysaccharaide (EPS) was extracted according to Smitinont et al[10]. The overnight culture was and centrifuged at 10,000 rpm for 20 min at 4°C to remove bacterial cells. The obtained supernatant was collected into a fresh vial and precipitated with two volumes of absolute chilled ethanol by incubating the mixture at 4°C for overnight. The precipitated EPS was collected by centrifugation at 10,000 rpm for 20 min at 4°C and the supernatant was decanted. The pellet containing EPS was dried at room temperature[11].

Biosurfactant production

The biosurfactant producing marine bacterium was collected from vignan university, Guntur (Andhra Pradesh) was tested for the surfactant activity using blood-agar medium. Marine bacterium was inoculated on the mineral salt broth which contain 2% of diesel and it was incubated in an optimized condition for 48 hours in a shaker operating at 120 rpm/min. biosurfactant was isolated using acid precipitation method at pH 2 using 6N HCl[12].

Addition of EPS as a plasticizer and Biosurfactant as a surface tension reduction agent

10 µg of crude EPS was dissolved in 10 mL of distilled water and 1gm of biosurfactant was dissolved in 10 mL distilled water and add about 5.0 to 10 weight percent of EPS as a plasticizer and about 2.5 to 5.0 weight percent of surfactant to the mixture of bioplastic and let the sample dry in hot air oven

Tensile Strength using spring testing machine

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength. Carefully peel the plastic film from petri dish Cut 1cm x 3cm rectangular testing template Use the C-clamps fix the sample at both ends of the rectangle. Attach the hook of the spring scale to one clamp. Hold one C-clamp stationary by pulling the other clamp slowly until the sample breaks. Measure the cross-sectional area.

RESULTS AND DISCUSSION

Total yield of the raw material and Total Polysaccharide Content

Several examples concerning the exploitation of vegetable and fruit wastes for the production of useful polysaccharides are available in literature. Vegetable wastes are rich in polysaccharides. All the selected wastes were treated by means of a newly developed extraction technique aiming at a more eco-friendly exploitation of residues. In recent years isolation of polysaccharides has been the focus of several research studies dealing with the implementation of technologies for their extraction from various natural sources. From the series of experiments performed we got satisfactory results, the total yield of the dried fine powder containing polysaccharides was found to be 25%. From the standard graph using 100µg/ml of glucose as a standard the calibration was done. The total polysaccharide content of our fine powder obtained after water extraction was found to be 11.69 (%W/W)

EPS and Biosurfactant extraction

The crude EPS was isolated from the marine bacterium as shown in (figure 1) using ethanol precipitation method and the EPS concentration was found to be 18.4 µg/mL. Biosurfactant was isolated using chloroform: methanol extraction technique as shown in (figure 2) and the crude biosurfactant concentration of 150 mg/L was obtained corresponding to a yield per gram cell dry weight of 0.20 g/g.

Figure 1: EPS extraction

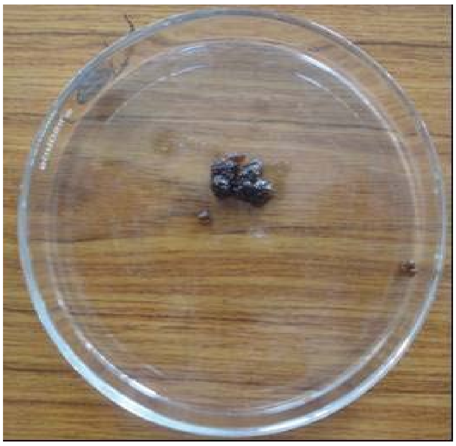

Figure 2: Biosurfactant production

Tensile strength

Taking into consideration of our obtained results we can conclude that type and amount of applied plasticizer as well as Biosurfactant affected the mechanical properties of the bioplastic. Changing the type and concentration of the plasticizer and amount of can definitely modify the strength and extensibility of the bioplastic. As shown in (figure 3) the addition of the plasticizer with Biosurfactant makes the bioplastic harder and more brittle and exhibiting good flexibility resulting in an increase in tensile strength, in comparison with the values obtained as shown in the (table 1).

Figure 3: Making of bioplastic with the addition of EPS and Biosurfactant

Table 1: Effect of additives on the tensile strength of the bioplastic

Sample	Additive	Cross-sectional Area (Thickness x width)	Tensile Strength (MPa)
Vegetable waste powder (extracted)	NO	1cm x 3cm	16
Vegetable waste powder (extracted)	EPS	1cm x 3cm	21
Vegetable waste powder (extracted)	Biosurfactant	1cm x 3cm	17
Vegetable waste powder (extracted)	EPS and Biosurfactant	1cm x 3cm	23

CONCLUSION

From the obtained results we conclude that vegetable waste comprised of starch units. The flexibility and other mechanical properties of the bioplastic was improved by the addition of the EPS as a plasticizer and the EPS acts as a hygroscopic molecule that traps the water in the crude precipitate containing starch units by making the product less crystalline. Biosurfactant acts as a surface tension reducing agent thereby increasing the flexibility of the bioplastic and by keeping a high tensile strength of it. Natural sources such as Plants are renewable resources. Most Bioplastics are decomposable. Although Bioplastics can be decomposed, they cannot be recycled to new plastic products at this time. Compost from bioplastic runs the risk of contamination if not closely monitored.

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