Formation of Bio Degradable Plastic from Different Raw Material

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Abstract— Biomaterial based plastic is a promising material for solving various environmental issues, the development of biodegradable plastic for both industrial and commercial applications is essential today. The main objective of this research to developed various starch based bioplastic for different applications. The present work investigates the corn and rice starch based bioplastics for various application. Various sample of bioplastic are produced, with different composition of corn and rice starch, glycerol, citric acid, gelatin. The tensile properties were improved after adding rice starch. And water absorption and water solubility were reduced. On the basis of result, the best sample was analyzed for biodegradability test, thickness, moisture content, sealing properties of plastic. The results show the suitability of rice and corn based thermoplastic starch for various applications.

Keywords: Corn Starch, Rice Starch, Glycerol, Citric Acid, Gelatin, Biodegradability, Moisture Content

I. Introduction

Plastics play a vital role today in both industrial and household applications. Plastics are widely used for various applications, such as hand bagged, cool drink bottles, toys, containers of electronic equipment, modules of vehicles, furniture, food packages etc. The annual production of petroleum based plastic was recorded as more than 350 million metric tons until 2018.[1] But some plastics are not recyclable, the recycling option faces additional problems of high energy consumption and difficulties arising from contaminates and fiber reinforcements. Molecular structure of polyethylene contains a large chain of numbers of ethylene molecules so it's called polyethylene and that why plastics are no degradable. Main reason of no degradability is chemical formula of plastic contain strong bond between C atom with H atom, and also each and every carbon atom bond with other carbon atom. So degradation of plastic doesn't do with naturally by bacteria and other organisms because they didn't broke chain of carbon atoms. During the manufacturing of plastic bags, the emission of carbon and many other dangerous gases causes environmental concerns. Generally, polyethylene plastic films, such as low-density polyethylene (LDPE) and high-density polyethylene (HDPE), are being used to produce a variety of polyethylene plastic films, and the drawback of this plastic is its non-degradability. Over 1000 million tons of plastic were predisposed of as unwanted elements, and they might take several hundreds of years to decay. The percentage of plastics in municipal solid waste continues to grow rapidly.[2] When plastic wastes are dumped in landfills, they interact with water and form hazardous chemicals, and the quality of drinking water may also be affected. Hence, efforts are taken to reduce the use of synthetic plastics and to promote bioplastics. Starch polymers contain amylose and amylopectin so that easily degradable naturally and also this type of plastic made out from natural sources.

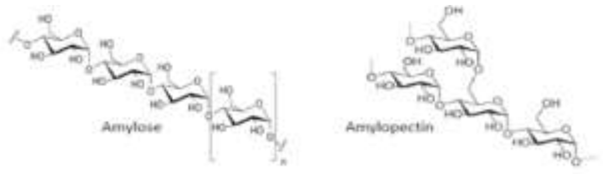


Figure 1. Starch Polymers

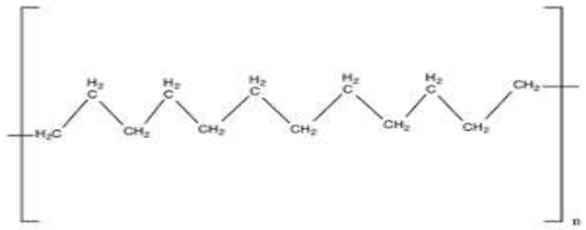


Fig. 1: Molecular structure of polyethylene

II. Experimental Process

A. Materials

1) Starch

Pure starch is white in color. The starch powder does not possess any specific taste or odor. Furthermore, pure starch cannot be dissolved in cold water or alcohol. It is non-toxic, biologically absorbable, and semi-permeable to carbon dioxide. The linear and helical amylose and the branched amylopectin are the two types of molecules present in starch [3]. The amylose content may vary from 20 to 25%, while the amylopectin content varies from 75 to 80% by weight, depending on the type of plant. Amylopectin is a far greater molecule than amylose. If heated, starch would become soluble in water, and the grains swell and burst. Due to this, the semi-crystalline arrangement is also lost, and the minor amylose particles begin percolating out of the granule, forming a network. This network compresses water and increases the mixture's viscosity. This procedure is known as starch gelatinization.

Source	Amylose(%)	Amylosepectin(%)
Arrowroot	20.5	79.5
Banana	17	83
Cassava	18.6	81.4
Corn	28	72
Potato	17.8	82.2
Rice	35	65
Tapioca	16.7	83.3
Wheat	20	80

The tensile properties of the bioplastics would rise when the amylose content was increased [24]. As rice and corn starches have a higher concentration of amylose content, the present work concentrates on this.

2) Citric acid

As rice and corn starches have a higher concentration of amylose content, the present work investigation the films produced from pure starch and concluded that these films were brittle and difficult to handle. The problem was solving by adding citric acid with varying concentration.

3) Glycerol

Bio plastics conclude that mechanical properties and tensile strength is increasing with concentration of glycerol adding in the process as a plasticizer. Increase in the concentration of plasticizer would lead to increase in the tensile strength. We concluded that the increases in temperature would decrease the water absorption values when the rice protein-based bioplastics were plasticized with glycerol.

4) Water

It is provide liquid medium for mixing of raw materials.

B. Process Description

The process of making Bio plastic contains the following sequences of steps as mention below.

1) Measuring and Mixing

Take 100 ml of water. And then 10 gm of starch(corn + rice) add into water. Then measure 1 gm of citric acid and also dissolved in the solution. Mixed them proper and 3 ml of glycerol.

2) Heating

Place the mixture on hot plate at 90 to 100’c with continuous stirring till 50 to 60 min.

3) Spreading

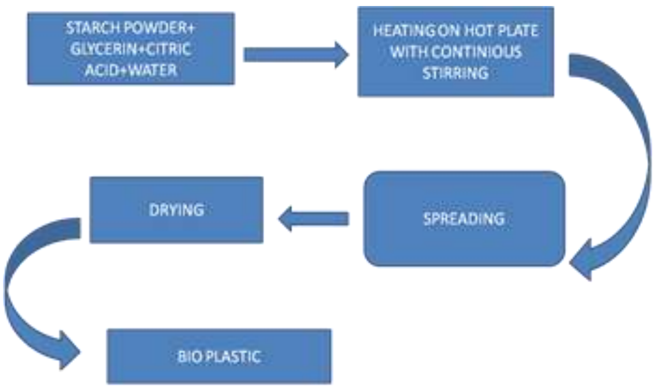
After heating we get gel type solution and we spread it on plate of stainless steel which is greeced by peanut oil for easy removal of plastic after drying.

4) Drying

In drying we put the spreaded plastic under the sunlight for 1 day.

Starch	Rice Starch	Corn Starch	Glycerol	Citric Acid	Water
S1	6.5 gm	6.5gm	5ml	5gm	100ml
S2	8gm	5gm	5ml	5gm	100ml
S3	9gm	4gm	5ml	5gm	100ml

III. Flow Diagram of Process:



IV. Test:

A. Test for moisture content:

By measuring the weight loss of films, the moisture content was estimated. The TPS samples were cut into square pieces of 2.0 cm^2. The samples were weighed accurately. The dry film mass was recorded upon drying in an oven at 110°C until a fixed dry weight was acquired [43]. Each film treatment was used with five replications, and the moisture content was measured:

$$\text{moisture Content in } (\%) = [(W_i - W_f)/W_i] \times 100$$

B. Water solubility test:-

The film samples were cut into square sections of 2.0 cm^2, and the dry film mass was weighed accurately and recorded. The samples remained immersed in 100 ml distilled water. They were then dries in a hot air oven at 110’C until an ultimate fixed weight was found. Glycerol has a good water solubility range from 18% to 25%. The percentage of total soluble matter was calculated as

$$WS(\%) = [(Wo - W_f)/Wo]*100$$

Where WS is solubility in water Wo is the weight at the beginning of the bioplastic and W_f is the final weight of the bioplastic.

C. Bio degradability test:-

The sample was cut in spices of 4 cm$^{2.}$ Found near the roots of plants which are reach in nitrogenous bacteria 5 gm of soil was collected and stored in container. Samples was buried in side the soil at a depth of 2 cm for 15 days under the condition of the room.

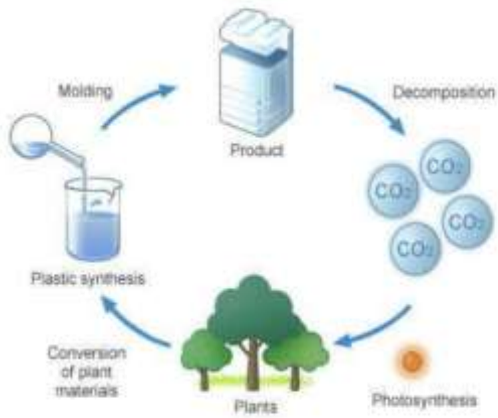
$$\text{Weight Loss } (\%) = [(Wo - W)/Wo] \times 100,$$

where Wo and W are the weights of samples before and after the test.

V. Merits and Demerits

1) It is produced from renewable resources.
2) It does not contain toxins.
3) Much less GHGs emission than conventional plastic production (reduction 86%).
4) 65% less energy needed to produce bio-plastic than conventional plastic.
5) PLA plastic is competitive with conventional plastic.
6) There is no longer danger of explosion in its production.
7) PLA is compostable, but there are very few facilities where these can actually be done.
8) Consumers will not compost starch based plastic properly.
9) Polymer contain in corn based plastic makes regular compost more acidic.
10) Some data used within the project was based on a series of assumptions and estimates.

VI. Life Cycle of Bio Plastic



VII. RESULT

Sample	S1	S2	S3
Water solubility	Medium	High	Low
Moisture content	Medium	High	Low
Elasticity	Less	Medium	high
Temp.of sol.thicking	100'C	97'C	94'C
Bio degradability(days)	14 to 16	17 to 19	13 to 15

VIII. CONCLUSION

The results showed that the samples prepared from the corn and rice starches have better biodegradability than the existing plastic materials. The citric acid addition improves the self-life of the material and improves the mechanical properties. The average thickness of the bioplastic is 0.25 mm(250 microns).

The average moisture content is 13.2%. The solubility in water is 11.9%. The biodegradability of the sample is 48.7% and it is achieved in 15 days. From the above test results, it can be concluded that bio plastic can be used to obtained properties of bio plastic it would be interesting to prepare polybags using this bio plastic with other bio materials, and with different plasticizer, would be an interesting scope for this research.

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