wjert, 2019, Vol. 5, Issue 3, 272-283. *Original Article* ISSN 2454-695X

World Journal of Engineering Research and Technology
WJERT
www.wjert.org SJIF Impact Factor: 5.218

BIODEGRADABLE FABRIC DEVELOPMENT AND TESTING

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Article Received on 23/03/2019 Article Revised on 13/04/2019 Article Accepted on 03/05/2019

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ABSTRACT

Synthetic polymers are important in many branches of industry, particularly in the packaging industry. However, it has an undesirable influence on the environment and causes problems with deposition of waste and consumption. Therefore, there is a tendency to replace the polymer with biodegradable polymer that undergoes a process. Some biodegradable plastics that have been commercialized are starch based plastics, bacteria based plastics, soy based plastics, cellulose based plastics, lignin based plastics and natural fiber reinforced plastics. Production of this kind of material and its introduction to the market is important for the natural environmental. The starch based and starch mixed with agar showed more elasticity, strength, compatibility and stiffness by appearance. The starch with sodium alginate also showed the more elasticity compared to single starch used fabrics. The fabric was degraded when it is exposed to heat or above 70^{O} C temperature. The fabric was degraded by the Gram negative microorganisms.

INTRODUCTION

Today's consumer driven society demands plastic for the manufacture of millions of products. Packaging materials largely contribute to the high demand for plastics. Our fast paced lifestyles demand convenience and single serving, pre- packaged foods. The manufacture of cost effective packaging that adequately protects the product is made possible by plastic. Plastic is made from crude oil, a nonrenewable resource. Although the plastic we use can be recycled, the amount of solid waste generated by plastic is becoming a problem.

Bioplastic is a better option for the environment and, in turn, everyone in the world. The amount of plastic we are using is not only harmful to the environment but we are killing a number of species as well. Marine animals can get caught up in the waste, making it so that the animal is unable to eat or swim.

Fig. 1: Wasted plastics.

Using biodegradable plastics could cut down on the amount of space taken up in landfills and reduce the impact that litter has on the environment Also, the majority of bioplastic is made from renewable resources, such as corn or other plant material, and it can be reproduced fast enough to keep up with our needs.

With thoughtful development, redesign could have an impact at all levels of the hierarchy established by the European Waste Framework Directive: prevention, re-use, recycle, recovery and disposal. The future brief explores current research into the redesign of plastics and developments in biodegradable plastics. It considers the implications of redesign and increased use of biodegradable plastics, as well as policy options to maximize benefits and minimize risks.

Polymers synthesized from monomers derived from renewable resources. For example, PLA (polylactic acid) is a polymer of lactic acid that is produced by the fermentation of starch, corn or sugar. Polymers produced by microorganisms, for example, PHA (polyhydroxyalkanoate) is produced by bacteria through fermentation of sugar or lipids.

Biodegradable: Plastics decompose from the action of biological agents, usually bacteria.

Compostable: Plastics are biodegradable and meet certain criteria, such as rate of biodegradation and impact on the environment.

Degradable: Includes biodegradable and compostable plastics, but also plastics that degrade by chemical and physical processes, for example, with the action of sunlight.

Decomposition generally begins with fragmentation, i.e. the material that is exposed to living or non-living factors undergoes a chemical decomposition of the polymer and therefore decomposes mechanically (fragments). In the next phase, the products of this decomposition are mineralized by microorganisms. This second phase is a necessary step that characterizes this process as biodegradation, because the partially degraded polymers (fragments) are hereby metabolized into end products. There are other cases (oxo- degradable materials) where the material undergoes a quick fragmentation under the influence of heat and UV light but the mineralization stage is very slow, which means that the relatively inert micro particles of the plastic material remain that have a poor susceptibility to biodegradation.The common materials used for the biodegradable plastics are

1. Starch based plastics
2. Agricultural waste based plastic
3. Biodegradable polyesters (PHA, PLA, PHB)

Plastics derived from petroleum are made from synthetic polymers. However, polymer chains are also found in nature. These chains are common in cellulose, lignin, and starch. Cellulose is abundant in all plants, although some plants produce more than others. Lignin is typically found in wood, and starch is common in plants such as corn, potatoes, and wheat. Plants, wood, corn, potatoes, and wheat are all raw materials that are renewable and readily available. The major difference between synthetic polymers and polymers found in nature is that the natural polymers contain oxygen and nitrogen. The oxygen and nitrogen in the polymer structure permit the polymer to biodegrade.

MATERIALS AND METHODS

A. Materials

Potato starch, corn starch, agar, vinegar, glycerine, sodium alginate, water, microwave and glass plates.

B. Methods

Potato starch based plastic: 10 g of starch (potato) powder was taken in 500 mL beaker. Then 50 mL of water was added, the suspension was mixed well to get the clear solution. Then 10 mL of vinegar and 10 mL of glycerin was added to solution, stirred solution well. Then the suspension was heated under the Bunsen burner until the sticky precipitate forms. After that, the precipitated suspension was spread over flat the glass plate. The glass plate was kept in oven for 30 min at 45^{o} C or keeps the glass plate at room temperate for 24 hrs.

Next day the produced fabric was observed.

Fig. 2: Potato starch based fabric.

Corn starch based plastic: 10 g of starch (corn) powder was taken in 500 mL beaker. Then 50 mL of water was added, the suspension was mixed well to get the clear solution. Then 10 mL of vinegar and 10 mL of glycerin was added to solution, stirred solution well. Then the suspension was heated under the Bunsen burner until the sticky precipitate forms. After that, the precipitated suspension was spread over flat the glass plate. The glass plate was kept in oven for 30 min at 45^{o} C or keeps the glass plate at room temperate for 24 hrs.

Fig. 3: Corn starch based fabric.

Potato and corn starch based: In this procedure the mixture of both corn and potato starch were used. Equal quantity of both starches were added i.e. 5 gm of potato starch and 5gm of corn starch. Then 50 mL of water was added to mix the starch powder completely and added 10 ml of vinegar and 10 mL of glycerin and stirred well. Then heat the suspension under the Bunsen burner until the sticky precipitate forms. After the heating process, the precipitate was spread to a glass plate and kept in oven for 30min at 45^{o} C or keep the glass plate at room temperature for one day. After one day the glass plate was observed.

Fig. 4: Potato starch and corn starch based fabric.

Potato starch and Agar mixture: In order to get the thickness of fabric, 5 gm of agar was added to the 5 gm of potato starch. Here agar acts as thickener. Then processed with the same protocol i.e. to the mixture of starch and agar, 50mL of water, 10 ml of vinegar and 10 ml of glycerin were added. Then suspensions was mixed well until the clear solution forms, after that heat the clear solution under the Bunsen burner until the sticky precipitate forms. The formed precipitate was spread over the glass plate and kept for one day at room temperature or at 45^{o}C in oven for 30 min. After next day glass plate was observed.

Fig. 5: Potato starch and agar mixed fabric.

Potato starch and sodium alginate based plastic: Sodium alginate also a biomaterial and also showed elasticity to the fabrics therefore sodium alginate used to develop the biodegradable plastics. 10 g of starch (potato) powder was taken in 500 mL beaker. Then 30 mL of RO water was added, 20 mL of sodium alginate solution was added to beaker. Then the suspension was mixed well to get the clear solution. Then 10 mL of vinegar and 10 mL of glycerin was added to solution, stirred solution well. Then the suspension was heated under the Bunsen burner until the sticky precipitate forms. After that, the precipitated suspension was spread over flat the glass plate. The glass plate was kept in oven for 30 min at 45^{o}C (Fig. 6).

Fig. 6: Starch and sodium alginate fabric.

Testing for Characterization

1) Solubility testing

Produced fabrics were made into 2 g of five pieces. Then those fabrics were kept in 100 mL water (RO) containing beaker i.e. each of 2 g fabric were kept in separate beaker for testing of solubility from the 1st day to 5th day. Then after 1st day the fabric was taken out weighed to test solubility. In the same way up to 5th day the process was processed. The fabrics were observed after every day and weighed and tested. The fabrics were unable to show the solubility. This observation was showed positive result because the fabric was not soluble in water so that produced fabrics helps to make the bottle to carry the water.

2) Heat testing

Heating test was carried out by two processes i.e. by direct heating and indirect heating the fabrics. The 5 g of fabrics were made into pieces. Then the fabric was kept on current coil (direct). In 5-7 min the fabric was start burning, within 10 min it completely burns by exposing to heat (fig. 7). Then tested for indirect heating i.e. the weighed fabrics were kept in 250 mL water containing beaker, maintained the different temperature from 40^o C to 100^o C (shown in results). After every heating process the fabrics were again weighed to test heating and observed the fabrics.

Fig. 7: Direct heating and indirect heating.

3) Degradability testing

5 g of produced fabrics were buried in the 2 different soils contacting places i.e. one in the pot and another one in the garden land and left for biodegradation processing. After the five days of processing the fabrics were taken out from both places, weighed and tested for characterization. After the five days biodegradation the fabrics were observed and soil the around the fabrics was taken and processed with serial dilution identify the type of the microorganisms which helps in biodegradation process microbes were showed the pink in color and identified as gram negative microorganisms because of their color (Fig. 9).

Fig. 8: Degradation of produced fabric in soil and pot.

RESULTS AND DISCUSSION

4) Identification of microorganisms

The 5 g of soil taken from garden area where the fabrics were buried, then from that 1 g of soil and 9 mL of water taken in test tube and labeled 1^{st} dilution. Then from 1^{st} dilution took the 1 mL of soil water and added 9 mL of RO water. In the same way the 6^{th} dilution ware made kept aside for while. The 2.5g nutrient broth was weighed and added 1.5 g of agar to produce the platform to grow the microorganisms in the Petri plate. The broth containing conical flask, pipettes, Petri plates were autoclaved in cooker for 20 min. Then all of these were taken out from cooker and placed in laminar air flow chamber. The broth was poured to the 2 Petri plates and made two compartments in each Petri plate. A loop of suspension of soil took from 2^{nd} to 5^{th} dilution of serial diluted and streaked out over the broth media in Petri plate.

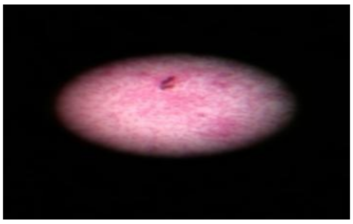

Fig. 9: Gram negative bacteria.

After streaking of soil suspension on Petri plate left for 24 hrs to grow the microbes and after 1 day the microorganisms colonies were observed and took a colony of microbe on the slide, then slide was processed with staining procedure. On the microbe culture the stains were added i.e. 1 drop of crystalline violet and left for 1 min and washed the stain. Then added saffron stain and left for 1 min and washed again. After that 1 drop of alcohol was added to culture slide. Then the slide was observed under the microscope to identify the type of the microorganisms. After visualization under the microscope the To make plastic from natural sources, the polymers are isolated from the raw material. Depending on the material used, different technologies are required to produce plastic. Typically, the polymers are synthesized using chemicals or by fermenting the sugars. When using corn to produce plastic, the lactic acid is extracted from the corn. Through purification processes, the starches in the corn are broken down into sugars. The sugar is fermented and the carbons in the sugar are removed.

Solubility inference Table I: Solubility testing

Methods	Days	Weight of the fabric	
		Before placing in water	After placing in water
Potato starch + Corn starch	1	2	2
	2	2	2
	3	2	2
	4	2	2
	5	2	2
Potato starch + agar	1	2	2
	2	2	2
	3	2	2
	4	2	2
	5	2	2
Potato starch + Sodium alginate	1	2	2
	2	2	2
	3	2	2
	4	2	2
	5	2	2

The above table showed that, the different fabrics were produced with different biomaterials were tested for solubility. Those produced fabrics were weighed before placing in water beaker for days and again weighed after the solubility. All the different materials methods were showed that fabrics unable to soluble in the water. Therefore these produced fabrics may help in help formation bottle structure.

Temperature effects on produced starch fabric

The Table II shows that, the produced fabrics with different biomaterial were tested for heat test. For single methods from 40-100^{O}C temperature water was maintained and kept for 10 min and observed (Fig.10). As shown in table the readings of starch with agar and starch with sodium alginate biomaterial fabrics were more strength and compatibility. The single starch used material fabrics were showing less compatibility and elasticity.

20-30 ^{O} C

40 – 70^{O} C

80 ^{O} C

100 ^{O}C

Fig. 10: Effect of temperature on fabric.

Biodegradation inference

Biodegradation or biotic degradation is a specific property of certain plastic materials - that is, of the polymers these materials are made of. It is a process by which a polymer material decomposes under the influence of biotic components (living organisms). Microorganisms (bacteria, fungi, algae) recognize polymers as a source of organic compounds (e.g. simple monosaccharides, amino acids, etc.) and energy that The potato starch and corn starch used fabric was kept in refrigerator for 2 days to test the freezing condition of the biomaterial fabric. The result of this fabric showed positive that is the biomaterial can store in refrigerator by making water carrying bottles.

Table II: Effect of temperature on produced fabric.

Methods	**Temperature (^{o}C)**	**Weight of the fabric**		**Timings (min)**
		Before heating (g)	**After heating (g)**	
Potato starch + Corn starch	40	5	5	5
	50	5	5	5
	60	5	5	5
	70	5	5	5
	80	5	4.50	5
	90	5	4.15	5
	100	5	3.85	5
	Refrigerator	Weight of fabric		Days
		Before	After	

		incubation	incubation	
Potato starch + agar	40	5	5	5
	50	5	5	5
	60	5	5	5
	70	5	5	5
	75	5	4.92	5
	80	5	4.85	5
Potato starch + sodium alginate	40	5	5	5
	50	5	5	5
	60	5	5	5
	70	5	5	5
	75	5	4.72	5
	80	5	4.80	5

Sustain them. In other words, biodegradable polymers are their food. Under the influence of intracellular and extracellular enzymes (endo- and exoenzymes) the polymer undergoes chemical reactions and the polymer degrades by the process of scission of the polymer chain, oxidation, etc.

Fig. 11: Biodegraded fabric in soil.

Decomposition generally begins with fragmentation, i.e. the material that is exposed to living or non-living factors undergoes a chemical decomposition of the polymer and therefore decomposes mechanically (fragments). In the next phase, the products of this decomposition are mineralized by microorganisms. This second phase is a necessary step that characterizes this process as biodegradation, because the partially degraded polymers (fragments) are hereby metabolized into end products. There are other cases (oxo- degradable materials) where the material undergoes a quick fragmentation under the influence of heat and UV light but the mineralization stage is very slow, which means that the relatively inert micro particles of the plastic material remain that have a poor susceptibility to biodegradation.

CONCLUSION

Technical and economic problems associated with recycling materials have prompted researchers to look for new materials that can be recycled organically. The negative impact of synthetic polymers on the natural environment creates a lot of problems with deposition of waste and consumption. Biodegradable polymer based sources that are renewable are the most desirable. The main advantage of biodegradable polymers is that they can be composted with organic waste and release back to enrich the soil. Their use will not only reduce threats to wildlife caused by dumping conventional plastic but will also reduce the cost of labor for removal of plastic waste in the environment because they are parsed by nature.

Decomposition will help increase the longevity and stability of the landfills by reducing the amount of waste, which can be recycled to useful monomers and oligomers by microbial and enzyme treatments. Using biodegradable polymers in a variety of industries instead of synthetic materials can significantly help to protect the natural environment.From the different starch sources, the biodegradable fabrics were developed and tested. By the obtained results the following conclusions can be drawn:

- The biomaterials used for making the biodegradable plastics were starch based materials i.e. potato starch, corn starch, agar and sodium alginate.
- The starch mixed with agar showed more elasticity, strength, compatibility and stiffness by appearance.
- The starch with sodium alginate also showed the more elasticity compared to single starch used fabrics.
- The fabric was degraded when it is exposed to heat or above 70^{O} C temperature.
- The fabric was degraded by the Gram negative microorganisms.

ACKNOWLEDGMENT

I would like to thank Dr. G. N Rameshaiah Ph. D. (IITM) for providing immense support during the project. We would also like to thank Department of Chemical Engineering, B.M.S College of Engineering and faculty members for providing facility to conduct experiments. Also like to thank my parents and my friends for moral support.

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