

Original Research Article

EVALUATION OF BIOPLASTIC DEVELOPED FROM CORN STARCH AND *Euphorbiaantiquorum*LATEX

ABSTRACT

Traditional plastic materials have a negative environmental impact and one potential strategy to reduce this rising plastic pollution is to use compostable materials like bioplastic. An experiment was conducted at RVS School of Engineering and Technology, Dindigul to synthesize bioplastic from agricultural products like corn starch, latex of *Euphorbia antiquorum* and polyvinyl alcohol (PVA). Two sets of blend bioplastic film samples were prepared using solution casting method; Sample A (corn starch + latex of *Euphorbia antiquorum*) and Sample B (corn starch + latex of *Euphorbia antiquorum* + PVA). The biodegradability of the samples was investigated by burying in soil and compost method. Based on this study, the Sample A film without PVA was found to be highly biodegradable as compared to Sample B. The solubility and swelling tests were performed using organic solvents; ammonia, acetic acid, methanol and water. The swelling property of Sample B film showed less percentage of swelling. The solubility test showed that none of the bioplastic samples were completely soluble in any of the organic solvents. Result of this research work indicated that the bioplastic with incorporation of PVA is a better alternative to conventional plastic films.

Keywords: Bioplastic, Euphorbia antiquorum, corn starch, polyvinyl alcohol, PVA, biodegradability, swelling

1. INTRODUCTION

Plastics, which are synthetic organic polymers derived from petrochemicals. Plastics take over a century to degrade, causing plastic pollution. Due to their low cost and durability, humans produce a significant amount of plastic. Their chemical structure makes them resistant to natural degradation, taking millions of years to break down. Fossil fuel-based plastics also produce more greenhouse gases compared to bio-based polymers. These factors contribute to the prevalent issue of plastic pollution in the environment.

Single-use plastics persist in the environment, contributing to a significant carbon footprint and causing harm by leaching into food, disrupting hormones, contaminating the ocean, and threatening marine life and vegetation. Additionally, they hinder rainwater from percolating into deep wells. Dumped plastic waste in water bodies has even altered aquatic ecosystems, becoming a new food source for aquatic animals. This poses a severe environmental tragedy [1].

Traditional plastics are currently under blaze from the public due to their negative impact on the well-being of people and the environment. To keep this market afloat, the industry is searching for new plastics or raw materials. In this context, the key phrases are "bio-based" and "biodegradable" [2]. Biodegradability is defined as the decay of organic material under aerobic or anaerobic conditions by the use of microorganisms to produce CO₂ / methane, water, mineral salts, and biomass [3]. When compared to conventional plastics, bioplastics disintegrate within 20-45 days provided there is sufficient soil moisture, oxygen, and number of microorganisms, which might be encountered in organic landfills or manure [4]. Biodegradable plastics are developed by formulating natural organic substances such as polysaccharides, proteins, and lipids. Among the above mentioned plastic sources, starch-based bioplastics remain as a promising substitute as they are available in abundant, renewable and sustainable [5]. Biodegradable plastics are obtained from biomass feed stocks which have biodegradation property [6].

Starch is a widely recognized carbohydrate polymer whose plant source is grown in all temperate zone. Corn, wheat, potato, and rice are the world's leading crops, which accounts for 84%, 7%, 4%, and 1% of total production [7]. The thermoplastic starch films made from the starches can display a wide range of chemical, physical, and mechanical properties due to their different film-forming

properties [8]. Loose-fill packaging, various types of bags and sacks, flexible and rigid packaging, agriculture and horticulture applications, and hygiene and cosmetics products are all made from starch [6]. Proteins, enzymes, alkaloids, glycosides, cardenolides, terpenoids, furanocoumarins, and starch are just a few of the bioactive substances that can be found in the latex of different plant species. [9]. Different species of the Euphorbiaceae family's latex have been utilized as an impact modifier and secondary plasticizer for polyvinyl chloride (PVC), as adhesive for glass joints, and in paint formulations[10]. The white latex of *E. antiquorum* is a versatile material which offers the potential for creating biodegradable composites and can be used as a biopolymer in the production of bioplastics. Polyvinylalcohol (PVA) is a biodegradable polymer which is water soluble and they release their component into cold or warm solution. PVA hydrolyzes quickly and is a bio inert, so protein and cell attachment are confined on the pure substance [11]. Starch or chitosan blend along with PVA macromolecules provides film flexibility; furthermore, it also works on improving water-related properties [12]. Hence, an attempt has been made in this study to prepare bioplastic from corn starch, latex of *Euphorbia antiquorum* and PVA.

2. MATERIALS AND METHODS

An experiment was conducted to prepare bioplastic from agricultural products such as corn starch, latex of *Euphorbia antiquorum* and Polyvinyl alcohol (PVA) at Agricultural practices laboratory, RVS Educational Trust Group of Institutions, Dindigul in 2019. Commercial corn starch (Fig. 1) was purchased from the local grocery market. Latex of *Euphorbia antiquorum* (Fig. 3) was extracted from plants (Fig. 2) obtained in local regions of Dindigul, Tamilnadu. The analytical grade Glycerol and Polyvinyl alcohol was purchased from S. P. R. M. Chemicals. Other chemicals like Methanol, Acetic acid, Ammonia, Sodium meta bisulphate ($\text{Na}_2\text{S}_2\text{O}_5$) were utilized from the laboratory in the Institution.

2.1 Treatment details

Two treatments were followed for preparing bioplastic film.

Sample A: Bioplastic film without PVA (corn starch + latex of *Euphorbia antiquorum*)

Sample B: Bioplastic film with addition of PVA (corn starch + latex of *Euphorbia antiquorum* + Polyvinyl Alcohol)

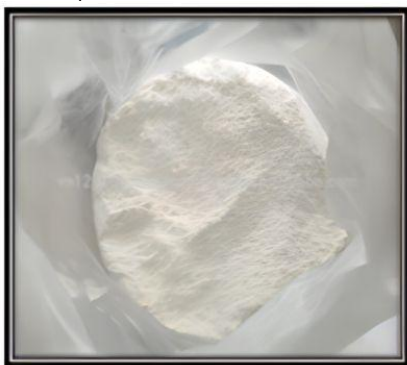


Fig.1. Corn Starch



Fig.2. *Euphorbia antiquorum*



Fig.3.Latex of *Euphorbia antiquorum*

2.2 Preparation of Bio-plastic film

2.2.1Preparation of Sample A (Bio-plastic without PVA)

Initially 2.5 g of corn starch was added to 25 ml of distilled water and mixed with 3 ml of 0.1N hydrochloric acid and 2 ml of propane-1, 2, 3-triol (glycerol). About 2 ml latex of *E. antiquorum* was added to this sample. The mixture was heated carefully for 15 minutes. Enough sodium hydroxide solution was added to neutralize the mixture. Then this sample was poured on a labeled petridish or white tile and spread with glass rod to get an even thickness (Fig. 4). The sample was left for drying in oven at 40°C for 24 hours and taken for further analysis.

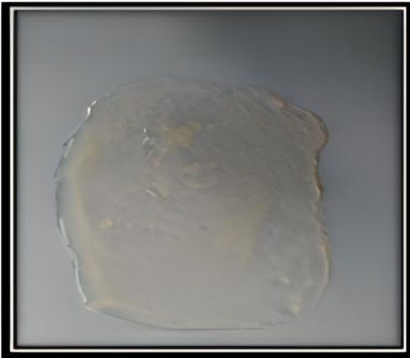


Fig.4. Bio plastic film for drying

2.2.2 Preparation of Sample B (Bio-plastic with PVA)

Initially 2.5 g of corn starch was added to 25 ml of distilled water and mixed with 3 ml of 0.1N hydrochloric acid, 2 ml of propane-1, 2, 3-triol (glycerol) and 6ml of PVA. About 2 ml latex of *E. antiquorum* was added to this sample. The mixture was heated carefully for 15 minutes. Enough sodium hydroxide solution was added to neutralize the mixture. The mixture was poured onto a labeled petridish or white tile and spread with glass rod to obtain even covering. The sample was left for drying in oven 40°C for 24 hours and taken for further analysis.

2.3 Testing of developed bio-plastic samples

2.3.1 Biodegradability test

Two different trials were carried out for each of sample A and sample B. In trial 1; sample A and sample B were treated with 0.5% $\text{Na}_2\text{S}_2\text{O}_5$. Samples of trial 1 are A1 and B1. In trial 2, sample A and B were kept untreated and they are samples A2 and B2 respectively. Two 400ml beakers and 0.3 g of each treated and untreated bio-plastic samples were taken. The samples were placed in the beaker containing soil at a depth of 5 cm from the surface. Some water was sprinkled on the soil so that

bacterial enzymatic activities could be activated. These samples were kept in beaker for about seven days and observations were taken at two days interval. The decrease in the weight of the bio-plastic samples were taken and recorded accordingly. Each test was done in triplicate in order to ensure the results [13]. The amount of bio degradation occurred was calculated by following equation,

$$\text{Soil degradation (\%)} = \frac{w-w_0}{w_0} \times 100 \quad (1)$$

Where,

w_0 - Initial weight of sample, g
 w - Final weight of the sample, g

2.3.2 Swelling test

The swelling behaviour of the developed bioplastics was studied by immersing the bioplastic samples in water and methanol for about 2 hours. The increase in weight of the sample indicated the quantity of water or methanol penetrated into them which give a measure of swelling percentage [13]. The percentage swelling was calculated by using the following equation,

$$\text{Percentage Swelling (\%)} = \frac{w-w_0}{w_0} \times 100 \quad (2)$$

Where,

w_0 - Initial weight of sample, g
 w - Final weight of the sample, g

2.3.3 Solubility test

Three replications of bioplastic samples were prepared and the solubility studies were conducted to check the persistence of these bioplastic materials. The samples of bioplastics taken for conducting the solubility test were A1, B1 (treated with $\text{Na}_2\text{S}_2\text{O}_5$) and A2, B2 (untreated). The samples (2 x 2 cm) treated with $\text{Na}_2\text{S}_2\text{O}_5$ and untreated were immersed in different solvents like ammonia, acetic acid, methanol and water for one hour in separate test tubes. The solubility of the prepared samples in these solvents was observed and recorded accordingly [13].

3. RESULTS AND DISCUSSION

3.1 Biodegradability test

The test for biodegradability of developed bioplastic samples were conducted as per the procedure. The samples were weighed at regular intervals and the percentage biodegradation of bioplastic samples taken was computed. The observations taken are shown in the Table 1. From the results obtained, sample A2 indicated 50% biodegradation and sample B1 showed 36% biodegradation. The percentage of biodegradation was observed higher in bioplastic sample A which is untreated and lower in sample B which is treated with $\text{Na}_2\text{S}_2\text{O}_5$.

Table1. Percentage of biodegradation of synthesized bioplastic material

Bioplastic sample	Treatment of Samples	Initial weight (g)	Final weight (g)	Percentage of Biodegradation, %
Sample A (Corn starch + Latex)	Treated with $\text{Na}_2\text{S}_2\text{O}_5$ (A1)	0.3	0.18	40
	Untreated (A2)	0.3	0.15	50
Sample B (Corn starch + Latex + PVA)	Treated with $\text{Na}_2\text{S}_2\text{O}_5$ (B1)	0.3	0.19	36
	Untreated (B2)	0.3	0.16	46

A reduction in the weight of bioplastic made from corn starch, latex of *Euphorbia antiquorum* and PVA were observed because glycerol was readily soluble in water as well as the addition of PVA to starch might have increased hydrophilic property of glycerol [14]. Although PVA is a water soluble polymer, it contributed high strength, chemical and thermal stability to the prepared bioplastic material. The

sample treated with $\text{Na}_2\text{S}_2\text{O}_5$ inhibited the growth of microorganisms, resulting in less deterioration than the untreated samples. The starch content was consumed by soil micro-organisms and they cause the biodegradation. The micro-organisms will utilize the bioplastic sample as a carbon source by degrading their polymeric structure.

3.2 Swelling test

Table 2 shows the results obtained from swelling test done in bioplastic samples. The swelling percentage of all the bioplastic samples was computed and there were no much change in the integrity of bioplastic when samples soaked in methanol. However, a slight increase in the weight of the bioplastic material when soaked in water for 2 hours was observed as compared to samples soaked in methanol.

Table 2. Percentage of swelling of the developed bio plastic samples

Bioplastic sample	Solvent medium	Quantity (ml)	Initial weigh (g)	Final weight (g)	Difference (g)	Percentage of swelling, %
Sample A (Corn starch + Latex)	Water	20	0.3	0.47	0.17	56
	Methanol	5	0.3	0.38	0.08	26
Sample B (Corn starch + Latex + PVA)	Water	20	0.3	0.43	0.13	43
	Methanol	5	0.3	0.36	0.06	20

The bioplastic sample A exhibited higher percentage of swelling which is 50% when soaked in water. Lower swelling percentage of 20% was observed in bioplastic sample B soaked in methanol. The lower percentage of swelling indicates higher resistant property of bioplastic material which means the capacity to absorb water will be less [13]. Therefore it will be harder for water to penetrate into the bioplastic sample. As per the results obtained (Table 2), less extent of swelling was observed in the prepared bioplastic material soaked in methanol medium, but swells a little higher in water medium. This is a desirable result because most of the additives are prepared by using organic solvents; certainly it will help in stabilizing the product synthesis and development.

3.3 Solubility test

The results from solubility test indicated that none of the samples were completely soluble in the different media used (ammonia, acetic acid, methanol and water). The natural rubber component of *E. antiquorum*'s latex may have given the produced bioplastic material its non-soluble chain flexibility. These are the desired results for preparation of bioplastic based products to compete with the traditionally used plastic. Solubility is an important characteristic feature, where it is essential to have bioplastic material which is less soluble in water than any other organic solvents.

4. CONCLUSION

From this study it is concluded that starch based bio plastic has been successfully synthesized from corn starch, latex of *E. antiquorum* and Polyvinyl alcohol. The current report has made an effort towards the synthesis of natural polymeric material. The bio plastic material prepared could be substantial and the bio degradability was one of the main challenges in developing them. These products have exceptionally high bio degradability property with decent solubility and swelling property which make them as a suitable alternative for the existing conventional plastic. Furthermore, starch and latex of *E. antiquorum* are cheap and can be easily modified. This means someday it is unnecessary to rely on petroleum to prepare polymers, people may 'plant' polymers of suitable performance from the earth and the environmental problems will be no longer as severe as today. Certainly, there is a long way to go in terms of research for both economical and environmentally friendly items made from bioplastics or biopolymers.

REFERENCES

1. Mihai FC, Gundogdu S, Markley LA, Olivelli A, Khan FR, Gwinnett C, et al. Plastic pollution, waste management issues, and circular economy opportunities in rural communities. *Sustainability*. 2021;14(1):20.
2. Filiciotto L and Rothenberg G. Biodegradable plastics: Standards, policies, and impacts. *ChemSusChem*. 2021;14(1):56-72.
3. Elvers D, Song CH, Steinbuechel A and Leker J. Technology Trends in Biodegradable Polymers—Evidence from Patent Analysis. *Polymer Reviews*. 2016;56.
4. Moshood TD, Nawanir G, Mahmud F, Mohamad F, Ahmad M and Abdul Ghani A. Sustainability of biodegradable plastics: New problem or solution to solve the global plastic pollution?. *Current Research in Green and Sustainable Chemistry*. 2022;100273.
5. Shafqat A, Tahir A, Mahmood A and Pugazhendhi A. A review on environmental significance carbon foot prints of starch based bio-plastic: A substitute of conventional plastics. *Biocatalysis and Agricultural Biotechnology*. 2020;27:101540.
6. Havstad MR. Biodegradable plastics. pp 97–129. In: Trevor M. Letcher editors. *Plastic Waste and Recycling*. 1st ed. Elsevier, Academic Press; 2020.
7. Basiak E, Lenart A and Debeaufort F. Effect of starch type on the physical chemical properties of edible films. *International journal of biological macromolecules*. 2017;98:348-356.
8. Domene-Lopez D, Garcia-Quesada J, Martin-Gullon I and Montalbán MG. Influence of starch composition and molecular weight on physicochemical properties of biodegradable films. *Polymers*. 2019;11(7):1084.
9. Konno K. Plant latex and other exudates as plant defense systems: roles of various defense chemicals and proteins contained therein. *Phytochemistry*. 2011;72:1510–1530.
10. Nigam JK, Dabholkar DA, Kaicker PK, Sikri HK and Diwan RK. IUPAC, Intl. Symp. Polym. Adv. Technol. Israel. 1987;16-21.
11. Platt DK. *Biodegradable polymers: market report*. Smithers Rapra Publishing; 2006.
12. Kochkina NE and Lukin ND. Structure and properties of biodegradable maize starch/chitosan composite films as affected by PVA additions. *International journal of biological macromolecules*. 2020;157:377-384.
13. Yaradoddi J, Patil V, Ganachari S, Banapurmath N, Hunashyal A, Shettar A and Yaradoddi JS. Biodegradable plastic production from fruit waste material and its sustainable use for green applications. *International Journal of Pharmaceutical Research and Allied Sciences*. 2016;5(4):72-81.
14. Lusiana S, Putri D and Nurazizah IZ. Bioplastic properties of sago-PVA starch with glycerol and sorbitol plasticizers. *Journal of Physics: Conference Series*. 2019;1351(1):012102.