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STUDY ON PRODUCTION OF BIOPLASTIC

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***Abstract**:* The accumulation of plastic garbage has emerged as a critical global concern, spurring research into methods designed to lessen the environmental effects of petroleum-based items. In-depth research on the benefits and drawbacks of producing bioplastics from lignocellulosic feedstock is conducted in this work. Bioplastics made from lignocellulosic biomass show great potential as environmentally acceptable substitutes for traditional clear plastic, which is mostly made of corn starch. Extensive testing, including thickness, tensile, thermal, friction, flame, and recycling tests, are used in experimental validation. The outcomes are compared to those of standard plastics. The threshold temperature for bioplastics, as determined by thermal tests, is marginally lower than the range noted for conventional plastics. The flame test, in particular, shows that bioplastics don't produce any dangerous smoke, in contrast to conventional plastic. In addition to providing a practical substitute for conventional plastics, the manufacturing of bioplastics from plant biomass serves as a model for waste management and recycling that has a good impact on the environment.

Index Terms – Bioplastic, Corn starch, Characterization, Sustainability

I Introduction

Bioplastics represent a category of plastic materials crafted from renewable sources like vegetable oils, corn starch, wood chips, and recycled food waste. They can be derived directly from natural biopolymers such as starch, cellulose, chitosan, alginate, and proteins like soy protein and gelatin. Additionally, they can be chemically synthesized from sugar derivatives like lactic acid and lipids from plants or animals, or through the fermentation of biologically produced sugars or lipids. This stands in contrast to conventional plastics, which are typically derived from fossil fuels like oil or natural gas.

One notable advantage of bioplastics lies in their independence from fossil fuels, a resource that is both limited and unevenly distributed globally, with significant ties to oil policies and environmental impacts. Life cycle analyses have demonstrated that certain bioplastics can be manufactured with a smaller carbon footprint compared to their fossil-based counterparts, especially when biomass serves as the primary raw material and for energy production. However, it's worth noting that some bioplastic processes may be less efficient and result in a larger carbon footprint than traditional fossil-based plastics [Paramanandham and Ross, 2015].

Lignocellulose, the biomass of plants, is a vital resource for bioplastic production due to its widespread availability. It comprises two carbohydrate polymers; cellulose and hemicellulose, along with lignin, an aromatic-rich polymer. Each component exhibits distinct chemical behaviors, making lignocellulose a complex material. Its resistance to degradation or separation, termed recalcitrance, poses challenges. To harness its potential for valuable products, a combination of heat, chemicals, enzymes, and microorganisms is required. These polymers, rich in carbohydrates, encompass various sugar monomers and are intricately linked to lignin. Despite its complexity, lignocellulose holds three components viz. lignin, hemicellulose and cellulose.

Lignin, akin to phenolic formaldehyde resins, is a complex and densely cross-linked polymer. It originates from three to four monomers, with varying ratios among different plant species. Its extensive cross-linking renders it highly heterogeneous. Due to its abundance in aromatics, lignin exhibits hydrophobic properties and considerable rigidity, providing plants with structural support. However, its heterogeneous in nature and resistance to degradation limit its utility, primarily valuing it as a fuel source.

Hemicellulose, comprising branched polysaccharides, presents its own challenges. Its covalent attachment to lignin, typically via ferulic acid, poses a particular obstacle. On the other hand, cellulose, a glucose homopolymer, displays minimal solubility in most solvents. Although cellulose fibers intertwine with the lignin-hemicellulose matrix, they are not covalently bonded to it [Varghese et al.2022].

II Materials and Methods

Materials

Corn starch, sodium hydroxide, water, lignin (lignocellulose), vinegar, glycerol

Methodology

Bioplastic can be synthesized using lignin regeneration approach directly from corn starch. Precipitate is prepared by adding corn-starch, lignin rich water, glycerol and vinegar in the ratio of 2:3:1:1 respectively and were continuously stirred for 2-5 hours and melted at 150 °C until a homogeneous and transparent liquid was obtained. With this high solid-content slurry, we can fabricate lignocellulosic bioplastic films via a simple casting process that can be conducted by placing the product on the flat board and apply pressure on it using the roller to make it flat and uniformly thin according to the requirements. The mixture was cooled to room temperature and then used [Xia et al, 2021]

III Characterization

Thermal Testing: The ability of a material to function safely at various temperatures is determined by thermal testing. The product's users can comprehend its safe working limitations and learn more about the general properties of the material by using the findings of the thermal testing. In this test, the specimen is tested under various temperature conditions, to conclude the upper and lower temperature limits of the product, so as to make the consumer aware of the threshold temperature values [Marichelvam et al,2019].

Friction Testing: The friction testing is used to measure the static coefficient of friction and dynamic coefficient of friction. In this test the specimen is attached to a sled of specified weight. The sled is pulled across a second surface at a speed of 150 mm/min. The force to get the sled started is the static friction and the force required to maintain the motion is dynamic friction.

(a) Static Friction: The initial force to make two surfaces slip against each other.

(b) Dynamic Friction: Force required maintaining movement between two surfaces.

Tensile Testing: Measure the force required to break a plastic sample specimen and the extent to which the specimen stretches or elongates to that breaking point. It measures the physical properties of the specimen. It measures the force required to break four sheets of specimen piled together. In this testing process the specimen to be tested is held between two clippers / tongs. One end of the specimen is fixed at a point and the other end is being pulled by a force until failure. The force at which the specimen breaks is determined as the tensile strength of that product. It is calculated as the product of the maximum force and the original cross-sectional area [Shah ,2017].

Thickness Testing: It is the measure of the thickness of the plastic specimen. It gives the conclusion of the surface uniformity and also of the presence of corrosion or any foreign material on the surface [Shah, 2017]. This test is done using a micrometer. The analysis of the thickness of the specimen is also useful for the visual appeal of the product.

Surface Resistance Testing: It is the surface resistance test for a product. Surface Resistance is the resistance to the flow of the electric current across the surface. The resistance to an electrical current is measured by electrodes on the same surface. This test gives the conclusion of the electrical conductivity of the product; which is very necessary in the case of plastics, as they are one of the best insulators. Hence the product should have good value of surface resistance [Shah, 2017].

Recycling: The produced bio-plastic undergoes recycling at a simpler way compared to the normal plastic. This process includes heating the specimen above its reaction temperature i.e. 160 ℃. At this temperature, the specimen starts softening. Further on increasing the temperature, at near 180 ℃, the specimen turns into the precipitate, which is the starting point of the manufacturing process. Then the specimen can undergo changes in its composition and is again ready for the manufacturing. For this testing the specimen is dipped into hot bath and then the temperature is varied accordingly

Flame Test: This test is done to check the smoke emitted by the bio-plastic produces compared to the smoke emitted by the normal plastic. Upon holding the normal plastic over a flame, it starts to emit smoke with unpleasant odor, making it difficult to breathe. Also, the smoke emitted by normal plastic during burning consists of harmful heavy metals and toxic chemicals like dioxin, nitrogen oxides, sulfur dioxide and various other volatile organic compounds. These elements are not only harmful for the environment, but also dangerous for human health; causing nervous system damage, liver, kidney damage, lung damage and many other acute and chronic disorders.

IV Results and Discussion

The bioplastics produced by following the procedure as stated in the methodology section. The following Image 1 shows the transparent bioplastic produced in laboratory from the corn starch.

Image 1:. Transparent bioplastic

The produced bioplastics is compared with the normal plastic as shown in Table 1 for different characterization tests. The characterization study of bioplastic shows that the thermal test, friction test, thickness test values are matching with the normal plastic values. The flame test signifies that our produced bio-plastic does not emits any smoke. Instead, it starts softening after a specific temperature and eventually, turns into precipitate again. Thus, making it safer for humans as well as for environment.

Table 1 Comparison between laboratory produced bioplastic and normal plastic

Name of test	Bio plastic	Normal plastic
Thermal test	172 ℃	180-220 ℃
Friction test Static friction Dynamic friction	 0.524 0.117	 0.6 0.2
Tensile test	8.063 MPa	10-15 MPa
Thickness Test	Slight rough surface with pores	Smooth surface
Surface Resistance Test	8^{10} Ohm	10^{10} Ohm
Recycling Test	Recycle easily	Very hard to recycle
Flame test	Does not emit any smoke	Emits harmful smoke

Image 2: Normal Plastic v/s Bio-Plastic (produced) after 10 weeks of decomposition

The image 2 shows that produced bioplastic from the corn starch decompose easily after approximately ten weeks while normal plastic may take longer time or remains as it is [Onen Cinar et al, 2020; Mujtaba et al 2023]. The bioplastic does not affect soil fertility also [Mandavgane et al, 2006].

Conclusion

The agricultural byproducts containing lignocellulose are very important for world economy, sustainability and preservation of environment. The study shows that degradable bioplastic can be produced from the corn starch. The characterization of the obtained product revealed that it closely resembles to normal plastic. According to the results of the thermal test, the threshold temperature for bioplastic is 172 °C, while the threshold temperature for conventional plastic ranges from 180 °C to 220 °C. The results of a flame test indicate that bioplastic does not emit smoke, while regular plastic does emit toxic smoke. Bioplastic can be easily recycled. Thus, the production of bioplastics approaches towards the environment sustainability.

References

1.Mandavgane, S. A., Paradkar, G. D., & Subramanian, D. (2006). Desilication of agro based black liquor using bubble column reactor.

2.Marichelvam, M. K., Jawaid, M., & Asim, M. (2019). Corn and rice starch-based bio-plastics as alternative packaging materials. Fibers, 7(4), 32.

3.Mujtaba, M., Fraceto, L., Fazeli, M., Mukherjee, S., Savassa, S. M., de Medeiros, G. A. & Vilaplana, F. (2023). Lignocellulosic biomass from agricultural waste to the circular economy: A review with focus on biofuels, biocomposites and bioplastics. Journal of Cleaner Production, 136815.

4.Onen Cinar, S., Chong, Z. K., Kucuker, M. A., Wieczorek, N., Cengiz, U., & Kuchta, K. (2020). Bioplastic production from microalgae: a review. International journal of environmental research and public health, 17(11), 3842.

5.Paramanandham, J., & Ronald Ross, P. (2015). Lignin and cellulose content in coir waste on subject to sequential washing. Journal of Chemistry and Chemical Research (India) Volume, 1(1), 10-13.

6.Shah, M. A., Schmid, M., Aggarwal, A., & Wani, A. A. (2017). Testing and Quality Assurance of Bioplastics. Food Packaging Materials: Testing & Quality Assurance, 201.

7.Varghese, S., Dhanraj, N. D., Rebello, S., Sindhu, R., Binod, P., Pandey, A., ... & Awasthi, M. K. (2022). Leads and hurdles to sustainable microbial bioplastic production. Chemosphere, 305, 135390.

8.Xia, Q., Chen, C., Yao, Y., Li, J., He, S., Zhou, Y., ... & Hu, L. (2021). A strong, biodegradable and recyclable lignocellulosic bioplastic. Nature Sustainability, 4(7), 627-635.