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Fabrication and Evaluation of Biodegradable Plastics Based on Corn and Potato Starch

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Abstract: The increasing environmental concerns related to synthetic plastics have spurred interest in biodegradable alternatives derived from renewable sources. This study focuses on the preparation and comparative analysis of biodegradable plastics synthesized from corn and potato starches. The bioplastics were developed through plasticization with glycerol and crosslinking with acetic acid. Their mechanical, thermal, and degradation properties were tested and analyzed. Results indicated that corn starch-based plastic exhibited superior solubility (11.6%) and biodegradability (complete degradation within 15 days), while potato starch-based plastic showed higher thermal resistance. these findings indicate the potential of this material as a viable alternative to low-density polyethylene (LDPE) for various packaging applications.

Key words: Biodegradable plastics, Starch-based polymers; Corn starch; Potato starch, Glycerol, Acetic acid, Plasticizer, Cross linker, Sustainable materials, Bio-based plastics, Green packaging.

I. Introduction

The global dependence on synthetic plastics, primarily derived from petrochemicals, poses significant environmental challenges due to their non-biodegradable nature. In 2007 alone, plastic consumption reached an estimated 260 million tonnes, reflecting an unsustainable reliance on finite fossil fuel resources. Despite widespread recycling initiatives, only a minor fraction of plastic waste is truly repurposed; the majority is incinerated or landfilled, contributing to pollution and greenhouse gas emissions. To mitigate these issues, researchers and industries have turned their focus toward biodegradable alternatives that are sustainable, cost-effective, and environmentally benign. Among the various candidates for bio-based plastic production, starch—a naturally occurring polysaccharide found in many plants—has emerged as a promising raw material. However, native starch lacks the mechanical and thermal robustness required for practical applications. Thus, it is often combined with plasticizers such as glycerol and crosslinkers like acetic acid to enhance its properties and processability. Biodegradable plastics derived from starch sources, such as corn and potato, offer multiple advantages including lower carbon emissions, enhanced degradability, and reduced reliance on petroleum-based inputs. This study aims to synthesize biodegradable plastics using corn and potato starches, and to evaluate their mechanical, thermal, and environmental characteristics. The ultimate goal is to explore their potential as substitutes for conventional low-density and high-density polyethylene materials used in packaging.

II. Materials and Methods

Materials

- Starch Sources: Corn starch (commercial grade) and potato starch (extracted in-lab)
- Plasticizer: Glycerin (Propan-1,2,3-triol)
- Crosslinking Agent: Vinegar (6% acetic acid solution)
- Solvent: Distilled water

Extraction of Potato Starch

Fresh potatoes were washed, peeled, and grated. The grated mass was submerged in warm water, agitated, and strained through cheesecloth to separate the starch. This washing and filtration process was repeated until the rinsing water appeared clear. The starch was allowed to settle, after which the supernatant was carefully decanted. The recovered starch was then dried using different methods. The dried starch was then ground into fine powder and stored in airtight containers.

Preparation of Biodegradable Plastics

A standard formulation was used for both starch types. A mixture of 20 g starch, 40 mL distilled water, 10 mL vinegar, and 10 mL glycerin was heated with constant stirring. Once the mixture thickened and reached boiling, it was allowed to cook for five additional minutes to ensure homogeneity. The resulting viscous material was poured into molds or cast on aluminum foil and dried at ambient conditions or in an oven at 150°F for 1–2 hours.

Characterization and Testing

Tensile Strength Test:

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Strips of bioplastic were subjected to tension using a retort stand. By applied force on sample to rupture the strip, reading of tensile strength noted from UTM machine

Thermal Resistance Test

Plastic samples were immersed in water heated from 40°C to 100°C in 20°C intervals. Softening was visually observed after 10 minutes at each temperature.

Solubility Test

Samples were weighed and submerged in water for 7 days. After 7 days Final weights were recorded and calculate solubility of each sample

Degradability Test:

Samples were buried in nitrogen-rich soil for 15 days. After the time period take the sample, how much mass degradation done were analyzed by visual appearance

III. Results and Discussion

Mechanical Properties

Corn starch-based plastic exhibited higher tensile strength (2.4×10^{-8} kgf/cm²) compared to the potato starch-based variant (1.18×10^{-8} kgf/cm²). This suggests that the corn-derived polymer matrix provides better cohesion and structural integrity, making it more suitable for applications requiring moderate strength.

Solubility Analysis

The water solubility of the corn starch plastic was 11.6%, higher than the 8.3% measured for the potato starch sample, suggesting better compatibility with aqueous environments. However, increased solubility could also imply reduced resistance to water for certain packaging applications.

Thermal Behavior

The potato starch-based bioplastic began to soften at 60°C, whereas the corn starch sample retained its form until temperatures exceeded 60°C. This indicates superior heat resistance for the corn-based plastic, potentially making it more viable for applications exposed to elevated temperatures.

Biodegradation Potential

After 15 days of burial in soil, the corn starch plastic had completely decomposed, while the potato starch plastic showed partial degradation. The higher biodegradability of the corn-based plastic may be attributed to its more accessible polymer chains and the efficiency of microbial breakdown pathways.

Table 1. Mechanical Properties of Bioplastics

Property	Corn Starch	Potato Starch
Tensile Strength (kgf/cm²)	2.4×10^{-8}	1.18×10^{-8}
Solubility (%)	11.6	8.3
Degradability (15 days)	Complete	Partial
Thermal Softening (°C)	>60	60

IV. Conclusion

The bioplastics developed using corn and potato starches demonstrate promising characteristics for eco-friendly packaging applications. Corn starch-based plastic outperforms potato starch in terms of solubility, tensile strength, and biodegradability. However, potato starch provides superior heat resistance. These findings support the feasibility of starch-derived bioplastics as alternatives to conventional LDPE and HDPE plastics, particularly in single-use applications. Further research into hybrid formulations with other natural or synthetic biodegradable polymers could enhance mechanical and barrier properties.

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