iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: XII Month of publication: December 2025

DOI: https://doi.org/10.22214/ijraset.2025.76330

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XII Dec 2025- Available at www.ijraset.com

A Review Study on: Synthesis of Biodegradable Plastic from Starch

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Abstract: Plastics are a wide range of semisynthetic or synthetic materials composed primarily of polymers, which means they are made by linking chains of molecules (called monomers) together to create a large molecule (a polymer). Most conventional plastics are derived from precious petrochemicals. However, over time, it leads to the depletion of fossil fuels, and traditional plastic is proving to be a major environmental problem. To overcome these issues, 'Biodegradable Plastic' is now widely being considered as an alternative. This research focuses on the synthesis of biodegradable plastic from starch to address environmental pollution from conventional plastics. This study reveals that biodegradable plastic made from starch is strong and eco-friendly, as it completely degrades within a short period of time. So, biodegradable plastic gives a promising solution to environmental problems, and it can be used for various purposes in our day-to-day life.
Keywords: Bioplastics, Biopolymers, Plasticisers, Polymerisation, Soil burial, Starch

I. INTRODUCTION

The modern world is wrapped in Plastic. Plastics have become a significant part of our lives. Plastics include a wide range of synthetic or semisynthetic materials composed primarily of polymers. The plasticity of a polymer is its defining character. It allows them to be moulded, extruded, or pressed into a diverse range of solid forms. They are also lightweight, durable, flexible, chemically resistant, low in toxicity and have low production cost. This has led to widespread use of plastic worldwide. Most plastics are produced from petroleum and natural gas, whereas a growing minority are produced from renewable resources like polylactic acid. Most plastics contain organic polymers. Most of these are formed from chains of carbon atoms, with or without the attachment of oxygen, nitrogen or sulphur atoms. These polymer chains comprise many repeating units (monomers). Each chain can contain several thousand repeating units. The backbone is the part of the chain that is on the main path, linking together many repeat units. To customise the properties of a plastic, different molecular groups called side chains hang from this backbone. These are usually attached to the monomers before the monomers themselves link together to form the polymer chain. These side chains influence the properties of a polymer. Over time, the amount of petroleum used to make plastic contributes to the depletion of fossil fuels. However, traditional plastic is proving to be a major environmental problem because once discarded in landfills and oceans, it takes centuries to degrade, as plastic is non-degradable. Another issue is that conventional plastic is manufactured from non-renewable resources (such as crude oil, natural gas, coal, etc). Plastics are so important in our everyday lives and so versatile in their usage that their use cannot be entirely stopped. Hence, alternative solutions to this problem are being investigated. Thus, biodegradable plastics come into the picture. The term 'Biodegradable Plastic' refers to a plastic that can be broken down biologically into organic substances by the activities of living organisms like fungi, bacteria, or other microorganisms, which completely metabolise them to carbon dioxide and water. Starch or amylum is a polymeric carbohydrate that consists of numerous glucose units connected by glycosidic bonds. Most green plants produce this polysaccharide for storing energy. It is the most common carbohydrate in human diets worldwide and is contained in large amounts in staple foods such as wheat, potatoes, maize (corn), rice, and cassava (manioc). Pure starch powder is white, tasteless and odourless and is insoluble in cold water or alcohol. Starch is a natural polymer. Normally, starch is present in large proportions in cereal plants, rhizome and tuberous plants. Starch is a biodegradable and renewable plant resource. Starch can be processed directly into biodegradable plastic on the addition of plasticiser (like sorbitol, glycerol, etc). Plasticiser impacts the flexibility and mouldability of the plastics and thus, produces a range of different characteristics. Owing to its complete biodegradability, low cost and renewability, starch is considered a reliable plant source for the synthesis of biodegradable plastic. About 50% of the bioplastics used commercially are synthesised from starch. The production of starch-based bioplastics is very simple. They are widely used for packaging applications. The tensile properties of starch are suitable for the production of packing materials, and glycerol is added to the starch as a plasticiser. The required characteristics of the bioplastics are achieved by adjusting the quantities of the additives.

For trade applications, the starch-based plastics are often mixed with eco-friendly polyesters. Human diets also contain this carbohydrate, and it is contained in enormous volumes in primary foods, including rice, cassava, maize (corn), wheat, and potatoes. The most important among them is cassava starch, which contains more than 80% starch in dry mass. Starch is a carbohydrate that contains a great amount of glucose units, combined through glycosidic links. For the residents of tropical regions, cassava starch is the third most essential nutritional source. A biodegradable polymer was developed from cassava starch with different surface treatments for various applications. Researchers have prepared sugar starch-based bioplastic film for packaging applications with a wide variety of reinforcements.

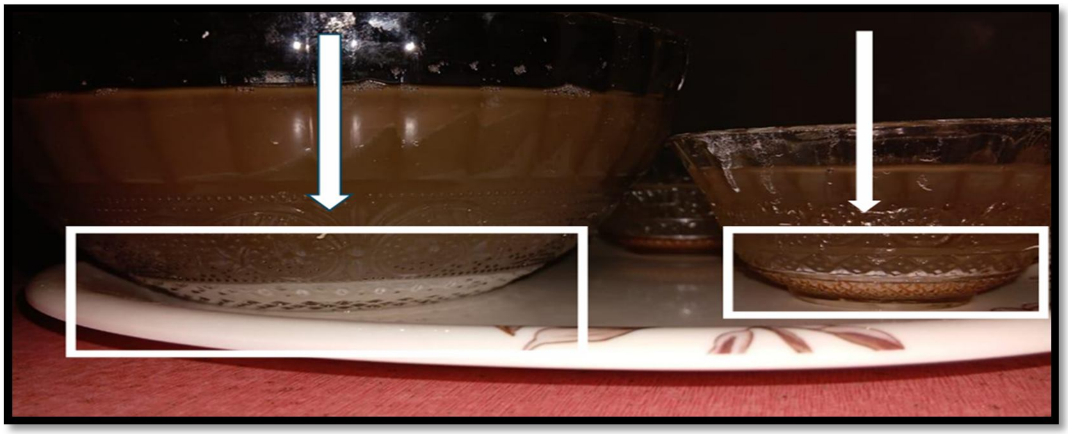
One of the well-known starch-rich sources is the potato, belonging to the family of Solanaceae. It is an herbaceous plant that can grow to 0.4 - 1.4m tall. Potato stems are nearly hairless to densely hairy and may be green or purple. Its leaves are pinnate. Potato starch consists of typical large oval spherical granules that can range from 5 to 100 µm in size. Potato starch is a type of refined starch that contains minimal protein or fat. The powder has a clear white colour, and the typical characteristics of cooked starch - neutral taste, good clarity, high binding strength, long texture, and minimal tendency to foaming or yellowing of the solution. India, France, Germany, the Netherlands, China, Japan, Denmark, Poland, Sweden and Canada are the main centres of potato cultivation across the world. Rice is a complex carbohydrate that has a smooth texture, neutral taste, and can be used as a substitute for other starches like cornstarch. Rice starch shows greater diversity compared to other cereal grains, which is significant as it enables the isolation of starch with a variety of functionalities. New rice cultivars are regularly being developed, with the total number now exceeding 2000 worldwide. The optimised composition of rice starch is responsible for its smooth texture, favourable amylose-to-amylopectin ratio, mild flavour, white colour, hypoallergenic properties, high digestibility, strong consumer acceptance, small granules and high acid resistance.

II. METHODOLOGY

1) Materials Required: Potato and rice starch, glycerol or Glycerine, Vinegar, Water, Heating source, Beaker.
2) Starch Extraction from potato: First, crush the potatoes to break down the cells, which releases the starch granules. The resulting pulp is then mixed with water, and the starch is separated through a process of washing, filtering, and settling. The settled starch is then repeatedly washed to remove impurities.
3) Starch Extraction from Rice: Rinse the rice with water until the water runs clear to remove surface starch. The rice is then soaked in water for about 30 minutes to soften it. Blend the softened rice with fresh water until very smooth to create a milky slurry. Strain the mixture through a fine-mesh cloth to separate the liquid from the rice solids. Allow the liquid to settle, then pour off the water.

A. Procedure

1) Mix 10g to 20g starch in 5ml of glycerol in 100ml of water in a beaker.
2) Heat the mixture slowly while stirring.
3) Add 5ml of vinegar to catalyse gelatinisation.
4) Continue heating until a thick gel-like solution is formed.
5) Pour it onto a flat tray and let it dry to harden.



(a) (b)

Fig 1: Extraction of Starch from (a) potato and (b) rice.

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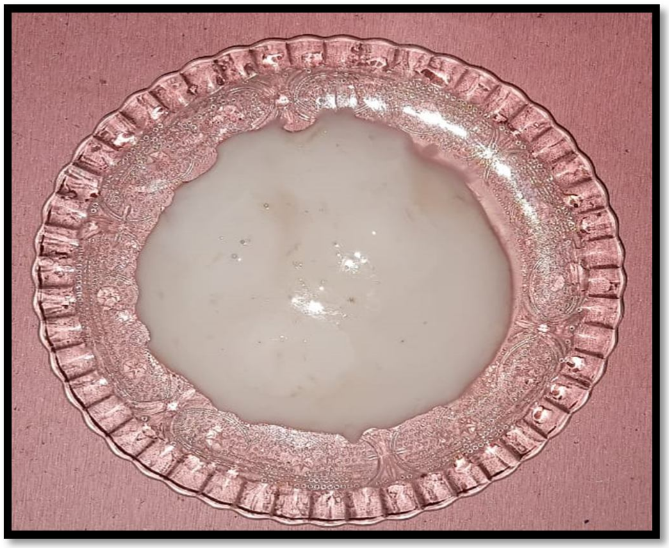
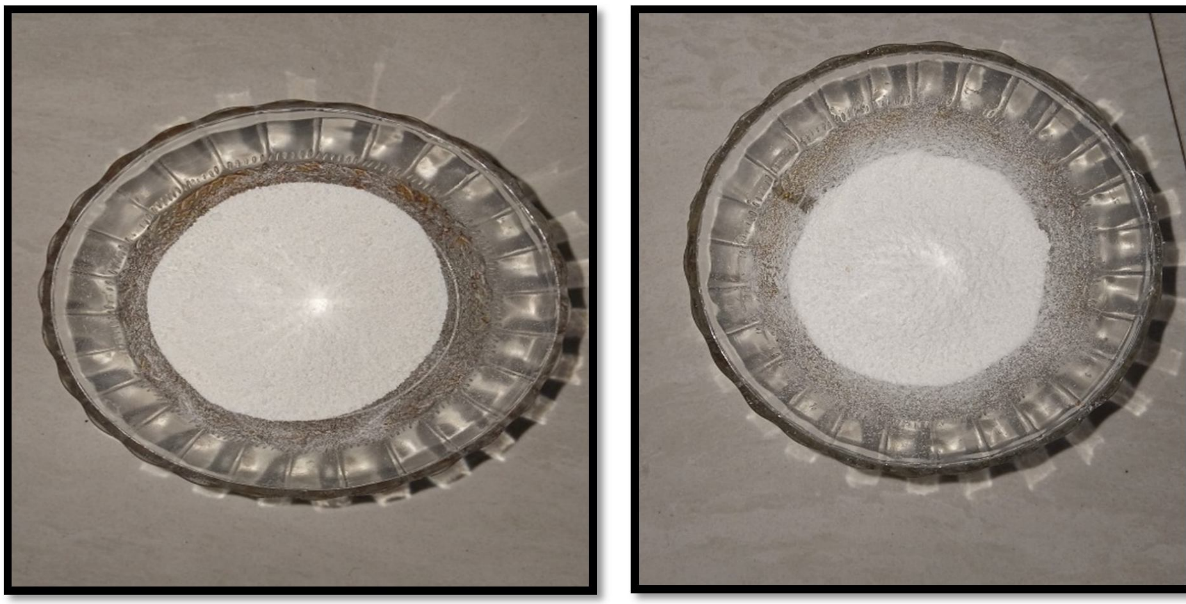


Fig 2: Potato Starch.



(a) (b)

Fig 3: (a) Potato Starch and (b) Rice Starch.

Fig 4: Corn Starch.

Fig 5: Mixture of Potato and Rice Starch Plastic (under sunlight).

Fig 6: Mixture of Rice and Potato Starch Plastic (after drying).

Fig 7: Corn Starch Plastic.

III. RESULT & CONCLUSION

Biodegradable plastics offer a promising alternative to conventional plastics by decomposing into natural elements like water and carbon dioxide with the help of microorganisms. But their effectiveness depends on proper disposal and environmental conditions. While they can reduce plastic pollution and reliance on fossil fuels, challenges such as ensuring proper waste management, differentiating them from degradable plastics (which may fragment but not fully decompose), and improving their performance and affordability remain. Therefore, while biodegradable plastics have the potential for a more sustainable future, they are not a universal solution and would require careful application and management to be truly beneficial.

IV. APPLICATIONS

1) Packaging
    - Disposable food service items like plates, cups, and cutlery
    - Food packaging films, trays, and containers
    - Edible packaging and films
    - Retail and garbage bags
2) Agriculture and forestry
    - Seedling pots
    - Water retention sheets
    - Mulch films
3) Medical
    - Surgical sutures and bone fracture fixation materials
    - Controlled drug delivery and release systems
    - Tissue engineering scaffolding
    - Medical implants (e.g., for PLA)
4) Consumer and industrial goods
    - Textile: Fibres for clothing and other applications
    - Office supplies: Pens and razors
    - Electronics: Making cases for electronic devices such as phones, keyboards, and loudspeakers.
    - Sanitary products: Diapers
    - Home goods: Furniture components, carpets, and vacuum cleaner parts.
5) Construction and civil engineering
    - Formwork and sandbags
    - Tiling and flooring materials
    - Additives for concrete
    - Insulation

V. BENEFITS

Biodegradable plastics offer various advantages over conventional plastics, such as:

1) Environmental: They decompose into natural byproducts like water, carbon dioxide, and biomass, with minimal or no toxic residue. They decrease fossil fuel dependency, since many biodegradable plastics are produced from renewable resources like corn starch or sugarcane, reducing reliance on petroleum.
2) Economical: Biodegradable plastics can be synthesised from renewable resources, which helps reduce the cost of producing plastic. They can also be used to make various products that are designed to be composted, which can create new markets for such products.
3) Performance: Biodegradable plastics offer performance characteristics similar to those of conventional plastics. For example, PLA can be used to make clear food packaging, and it is just as strong and durable as conventional plastic used for food packaging.
4) Enhances brand image: Companies can improve their brand image by adopting sustainable practices that include using biodegradable materials.

VI. ACKNOWLEDGEMENT

I extend my heartfelt gratitude for the assistance, suggestions, and encouragement provided by my mentors. Their contributions have significantly strengthened the quality of this manuscript. I am thankful to The Pimpri Chinchwad College of Engineering, AS&H department, for the provision of required chemicals and lab for experimental work and for their timely help and technical support. My sincere thanks also go to my peers for their valuable inputs and constructive discussions.

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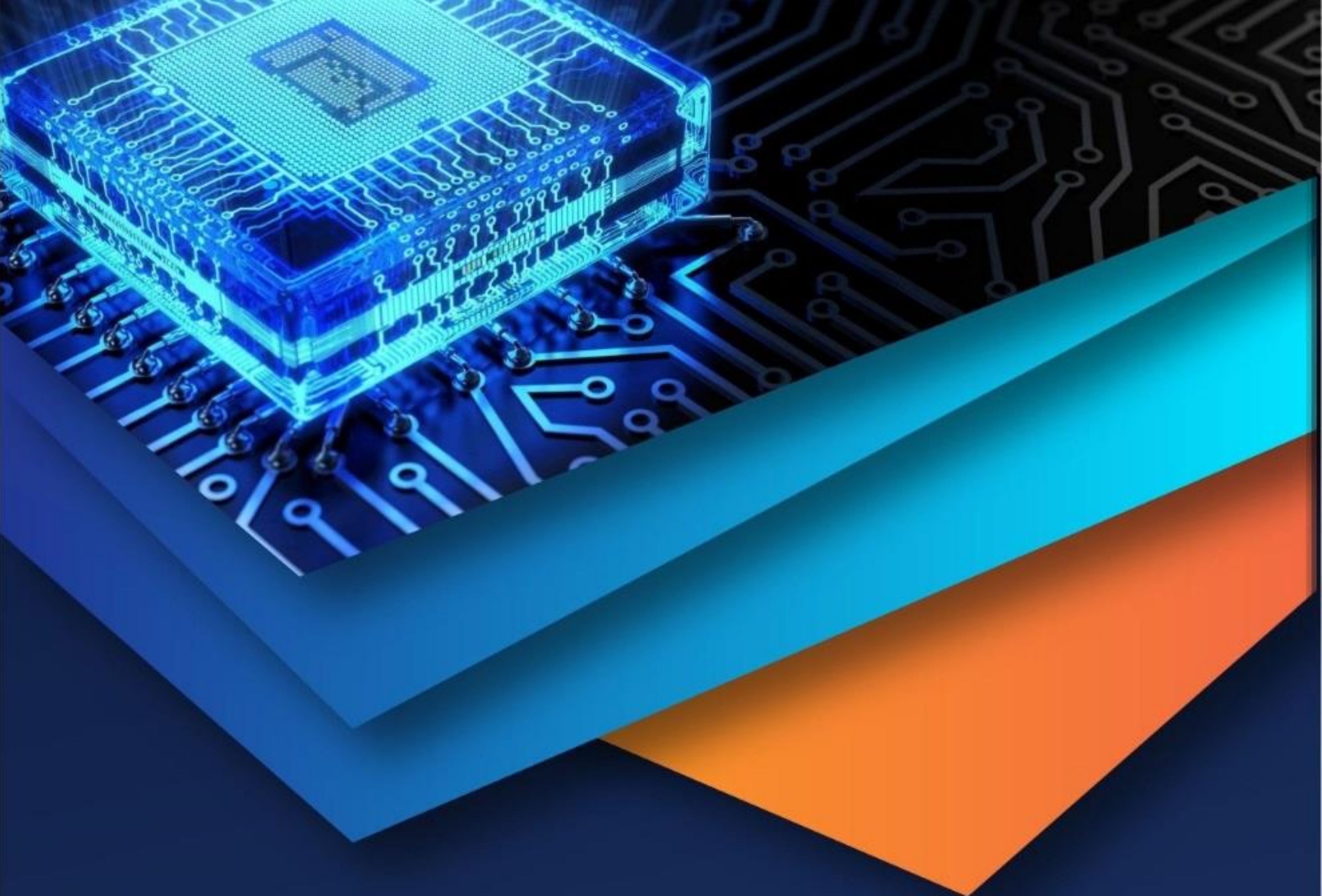

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