

Biodegradable plastic formation from corn starch

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Abstract

Increasing use of Petroleum – based Plastic poses environmental challenges Prompting researchers to seek alternative like biodegradable plastic. Starch serves as a natural & renewable alternative to Synthetic polymer in biodegradable plastic production. This research focuses on Creating biodegradable plastic From Corn starch to address various pollution issue As a workable solution to lessen environmental pollution, biodegradable plastics show promise as a substitute for conventional plastics. The natural environment's microorganisms are essential to the biodegradation of biodegradable polymers. Since starch is widely available, inexpensive, fully biodegradable, highly biocompatible, and has good film-forming qualities, it is seen as a good alternative to synthetic polymers. This work compiles the methods and a potential plan for starch modification to improve the mechanical and barrier properties of starch-based films. Here, we go over how starch-based biodegradable plastics are made, the obstacles to mass production, and some advantages and disadvantage. Starch is regarded as a promising substitute for synthetic polymers since it is widely accessible, reasonably priced, completely biodegradable, highly biocompatible, and has good film-forming properties.

Keywords: *corn starch, Biodegradable plastic , coplasticizers,Glycerol etc.*

Introduction:

Plastic pollution is a critical environmental issue leading to extensive ecological damage and posing health risk due to the using of petrochemical - derived plastic. Biodegradable Plastic particularly derived From renewable resource like corn starch offer a promising solution to this issue.[1] Plastic cause several type of pollution:

- 1)Air pollution
- 2)water pollution
- 3)soil and Marine pollution
- 4) chemical pollution

1) Air pollution

Hazardous compound, and persistent organic pollutants are released into the atmosphere. When plastic is burned, heavy metals,benzene,toluene,ethylbenzene,ozone,xylene.[2]

•Air pollution by plastic can cause several harmful effect on human life. Burning of plastic and toxins such as micro plastic,bisphenol and phthalates are released into the atmosphere when plastic garbage is burned.

These poisons are capable of:

Interfere with reproductive, endocrine, and neurodevelopmental processes. Raise the risk of respiratory conditions and cardiovascular disorders, Damage the nerve system.[3] 2) water pollution

The disintegration of plastic debris from both marine and terrestrial source into water bodies is known as plastic water pollution. Marine debris originates on land and is caused by storm drain and rain water runoff. There is a possibility of marine plastic contamination in lakes, rivers, streams, and open water.[4]

- The main cause of water pollution;

Global warming. The increase in global temperature caused by carbon dioxide emissions warm water, reducing its oxygen content-Deforestation, Industry, waste disposal and faecal water, marine traffic and fuel spill.[5]

- water pollution by plastic can cause several harmful effect on human Life; The assessment of the degree of pollution of the aquatic environment must take into account it's chemical characteristics that have possible toxic effects and allow an integrated assessment of it's effect on the population of the aquatic system. In recent decades, much attention has been paid to the possible risks of heavy metal poisoning in human due to the consumption of contaminated fish.

Industrial and agricultural discharges, such as coal and oil combustion, phosphate fertilizers, plastics and pesticides are considered to be the main source.[6] Chemical in plastic can leach into water and other products and enter the human body. These chemicals can cause series health problems, including endocrine disorder, Insulin resistance,cancer,weight gain etc.

- plastic can contain toxins like lead cadmium and mercury, which can accumulate in fish and be consumed by humans. Plastic can also contain diethylhexyl phthalate .a toxic carcinogen. Other toxic in plastic can cause birth defects, immune system, problem and childhood development issues.

3)soil and Marine pollution

Plastic can decompose into tiny particles called microplastics,which can penetrate into the soil and alter the physical composition and water-holding capacity. Plant that are exposed to microplastics may also experience reduced root development and nutrient uptake. Hazardous chemical released by chlorinated plastic have the potential to leach into the soil and eventually into groundwater and other water sources.[7][8]

Ocean plastic contamination can include the following; a)ocean plastic pollution every year 19-23 million tonnes of plastic trash are through to seep into aquatic ecosystems?) garbage patches, plastic debris group up in garbage patches, plastic accumulation zones, in the heart of the ocean resuscitated between Hawali and California the great Pacific garbage patch is the largest.[9]

- marine pollution; harm to human being:

As previously mentioned, microplastics can now be detected in drinking water, beer, salt & the soil where crops are grown. They have even entered the food Chain. IN addition to being Carcinogenic, plastic materials can disrupt the body's endocrine system, leading to Immunological, neurological developmental and reproductive problems hazardous

Pollutants that frequently build up on the surface of plastic also pose a health Risk to people when they are consumed though seafood.(9)

4)Substance found in plastic - plastic are linked to More than 13,000 Compound including;

Flame retardants : may have an impact on hormone balance & the nervous system. Phthalates :Softeners that may interfere with Reproduction by upsetting the endocrine System.

Biphenyl A (BPA) : Occurs in bottles, medical equipment & Packaging, it mimics oestrogen.

Polybrominated diphenyl ethers: Added to polymers as a flame retardant ,It disrupts thyroid hormone.

Substance emitted From plastics, Plastics Can release chemical into the air & water - Pollutant -binding plastics Environmental CPHI Phthalates & Softeners that may inter Fore wit Reproduction by upsetting the endocrine System

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Substance emitted From plastics, Plastics Can release chemical into the air & water Pollutant -binding plastics Environmental Contaminants that Plastic Can bind to

Include: Polychlorinated biphenyls or Dioxins, Mercury burning trash made of Plastic Burning garbage can lead to headache, rashes, nausea and increased risk of heart disease and Respiratory Condition.[10] All the above problems are reduced using corn starch biodegradable plastic. As an agricultural resource, Corn Starch provides a sustainable substitute for conventional plastic made from Fossil Fuels.[11]The annual production of petroleum - based Plastic has been recorded at more than 300 million tons since 2015. during the production of plastic bags, the emission of carbon and many other dangerous gases raises environmental Concerns. Therefore, Biodegradable plastic is more suitable and decomposable plastic is widely used in a Variety of Product where plastic recycling is encouraged.[12]

Elements including carbon, hydrogen, nitrogen, oxygen, chlorine & bromine are Found in plastic every one of them is bad For the environment. The use of plastic Increase every year in all aspects of life and technology .The most commonly used plastic are polyethylene, polystyrene, polyvinyl chloride, polypropylene & Polyethylene terephthalate. [13]

This review examines the various methods For producing biodegradable plastic using Com Starch, also their benefits and drawbacks as well as the processes for extracting natural polymer From Plant biomass. like Starch powder, white vinegar distilled water, & glycerine etc.[14]the demand for biodegradable plastic is Increasing & they are used in a variety of applications For example, Consumer goods, Packaging, textiles, automobiles electronics, Construction, agriculture etc. The use of bio-based polymers instead of Synthetic polymers has many advantages For example, they are Non-toxic, biodegradable and renewable & therefore a good Substitute for product plastic.[15] Microbes have little trouble breaking down. bioplastics, and the process happens quickly. One of the most popular basic Sources For creating bioplastic that replace plastic polymers is starch. The biodegradable plastic made from corn starch break down in the soil very quickly, owing to its great biodegradability ,Moreover, Starch is widely accessible & reasonably priced in agricultural nations like Indonesia. There are numerous recorded studies on the effective production of bioplastic from starch.[16]

The current study is part of larger investigation into the creation of affordable readily available bio sourced and biodegradable plastic than can truly replace the synthetic polymers produced by petro chemistry in Cote d'Ivoire[17]

Three different co-plasticizer combination -glycerol-urea, glycerol-citric acid & glycerol -Succinic anhydride - as well as the commercial plasticizer glycerol-were Selected for this study's analysis of their effect on environment during the extraction process of plasticized corn starch. Before processing bioplastic, the project will assess the effect of producing plasticizers exclusively in a lab setting. By enabling enterprises to select a starch Plasticizer that is more environmentally Friendly than glycerine, carrying out this life cycle assessment (LCA) Study will be advantageous. Additionally, the environmental impacts of using different plasticizers in the production of plasticized starch for TPS have not been adequately addressed in earlier studies. Furthermore, there is a dearth of information regarding these material end-of-life effect.[18]

Method:

Biodegradable plastic;

Plastic that can be broken down by microbes Into CO₂, CH₄,and microbial biomass are known as biodegradable plastic .Microorganisms assimilate carbon and obtain energy from the carbon substrate found in plastic polymers.

Both anaerobic and aerobic circumstances can support this activity, although the aerobic method gains energy more efficiently. In common laboratory tests, the amount of CO₂ released as a function of time can be used to calculate the rate of biodegradation.[19] The section examines various methods for producing starch Films, with an emphasis on the difficulties involved with each. There are two type of techniques for making starch - based films: Wet & dry. The dry procedure can be helpful in an industrial Setting, but the wet process is more often used in scientific Settings due to its lengthy duration.[20]

Type of Biodegradable plastic:

A biodegradable polymer derived from sustainable biomass sources like called polylactic corn(PLA). Compared to conventional polymers PLA is less carbon intensive, compostable, and environmentally benign.[21]

a) Polycaprolactone: An increasingly popular biodegradable, polymer on a global scale

b) Polynhydroxyalkanoats(PHA): An extremely eco-friendly and biodegradable polymer.[22]

c) Starch-based bioplastic:

Biodegradable and compostable polymers derived From renewable resources including corn starch, are known as starch based bioplastics.

d) Polybutylene adipate terephthalate (PBAT) is a biodegradable plastic that is strong and easy to work with.

e) Polybutylene succinate : It is a thermoplastic that breaks down organically into carbon dioxide & water.[23]

Preparation method of biodegradable plastic:

a) Casting of solvent: Dissolve plastic pellets in a solvent, add protected enzymes, mix, and drop cast onto a smooth surface to dry.[24]

b) Glycerol and starch Combine starch and glycerol, add distilled water, boil and stir, and then place on glass or petri plates to chill.[25]

c) Paper-oriented; Raw paper is first dried in an oven, then it is dipped in a solution containing zinc chloride, allowed to age in the air, then it is dipped in distilled water and finally placed in a plasticizer solution.[26]

d) Corn-starch Melt ;the corn starch in an airtight container, then mix in the phthalic acid ester and water. Extrude and granulate the mixture.[27]

e) Made at Home; In a pot, combine the corn starch, water, glycerine, and vinegar; simmer over medium heat, then strain out any excess liquid. Made at Home In a pot, combine the corn starch, water, glycerine, and vinegar; simmer over medium heat, then strain out any excess liquid.[28]

Compared to traditional plastics, biodegradable plastics may be a more environmentally friendly option.

Advantages of biodegradable plastic:

(1) Decreased carbon dioxide emissions: One metric ton of bio- Between 0.8 to 3.2 metric tons of carbon dioxide are produced by plastics compared to one metric ton of petroleum-based plastics.

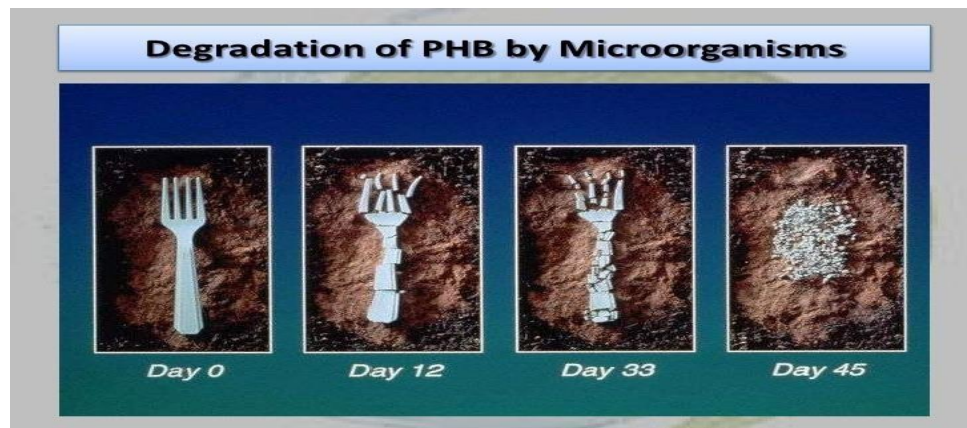
(1) Less expensive option: As a result of the fluctuations in oil costs, bio-plastics are starting to show promise.

(ii) Waste: Bio-plastics lower the quantity of harmful runoff generated by the oil-based alternatives.

(iv) Advantage for the rural economy: As nations search for oil substitutes to protect the environment and achieve energy security, the price of crops, including maize, has increased dramatically. This is due to the increased interest in producing biofuels and bioplastics globally.

(v) Less carbon footprint: Fossil fuel is a necessary raw element for oil-based polymers.[29] Furthermore, compared to bio-plastics, oil-based polymers like PS and PP demand more energy throughout the plastic synthesis process. A Life Cycle

Analysis for a typical PP or PS plastics shows a carbon footprint of roughly 2.0 kg CO₂e, equivalents per kg of plastic (from cradle to factory gate). The carbon emissions from this resin are four times more than those from polylactic acid (PLA) resin. (vi) Various end-of-life options: the negative environmental impact of used plastic items can be significantly reduced, if not completely eliminated, and valuable raw materials can be recovered and repurposed into new products, decreasing the demand for new virgin material..



- **Figure: shows Bio- degradation of bio-plastic**

(7)Eco-Friendly Disposable Solution:

Biodegradable plastics require composting or recycling to ensure proper breakdown of the plastic pieces to enable the natural composting process. The requirement to properly dispose of and process biodegradable plastic products automatically reduces the amount of waste that would otherwise be sent to landfills. [30] **Disadvantages:**

Although biodegradable plastics have many benefits,

- 1)their main disadvantage is that they can get polluted if improperly disposed of and mixed with other plastics.
- 2)Most likely, customers will simply recycle corn starch plastics instead of properly composting them. This can taint the recycling process.
- 3) 3. Because PLA contains a polymer that makes typical compost more acidic, composting PLA in big amounts could compromise traditional composting. [31] 4)Short shelf life: Cornstarch food packaging may lose its integrity if improperly stored due to its biodegradability. could have an impact on food production: Since cornstarch is a staple crop, using it excessively could upset the world's food supply system. [32]

Physical & mechanical properties of biodegradable plastic made from corn starch:

1)moisture content

The film was weighed before & after conditioning in an oven for 24h or until a constant weight was obtained at 50°C. The moisture content of the film was calculated with following equation.

• Moisture content (%) = $\frac{\text{Before weight} - \text{after weight}}{\text{Before weight}} \times 100\%$ [33]

2)Permeability test for water vapour

A 1-by-2 cm bioplastic sheet was positioned over the mouth of a 7 cm diameter, 2-cm- deep porcelain dish that contained 10 grams. 0.7 silica gel use glue to secure the porcelain dishes & Film's edges together. Place the

porcelain cup in a 40%NaCl(w/v) solution. Every the film changes were computed until the weight remained constant. The water vapour permeability was determined using equation,

$WVP = \text{linear slope for the Jar's weight change (g/hr)} \div \text{surface area. [34]}$

It also include;

a) Tensile power:

Bioplastic derived from corn starch have a Maximum tensile Strength of 12.5 MPa.

b) Absorption of water:

As the concentration of glycerol & corn starch rises, so does the rate at which the bioplastic based on corn starch absorb water. c) Flexibility / Adaptability :

20% maize starch and 20% glycerol films are rigid and have a high tensile strength, but they are not Flexible. d) Biodegradability

Bioplastic derived From corn and rice Starch may decompose more quickly than current plastics. e) duration of self life bioplastics based on corn starch may have a longer shelf life if citric acid added.

Method use for decomposition of biodegradable plastic:

1) Microbiological activity in natural environment; Microorganisms are minuscule, single-celled creatures that can only be seen under a microscope. In the natural world, they can be found in soil, water, and air as well as inside living things. In order to keep the environment clean, microorganisms are essential for breaking down organic materials. By utilizing enzymes to cleave organic molecules into smaller, more absorbable ones, microorganisms decompose organic materials. Microorganisms then use these smaller molecules as food and energy sources.

2) Biodegradation of soil;

Microbial activity in soil can cause biodegradable polymers to break down. There are several steps in the biological breakdown process in soil. Microorganisms produce enzymes to break down plastic molecules into smaller ones during the biological response step. These tiny molecules could be monomers or oligomers. Microorganisms use the plastic's smaller molecules as food and fuel during the homogenization stage. These smaller molecules are broken down by microorganisms to produce end products like biomass, CO₂, and H₂O.

3) Marine environment;

Microbial activity in the marine environment can potentially cause biodegradable polymers to break down. The biological breakdown of biodegradable plastics in the ocean is comparable to that which occurs in soil. Biodegradable plastics' marine biological decomposition time is influenced by the same variables that affect the biological decomposition time of soil. But because the pH of the sea environment is typically higher than that of the soil, it takes longer for biodegradable plastics to break down biologically in the marine environment than it does in the soil.

• In many locations where petroleum-based plastics are used, bioplastics and biocomposites are permitted and can play a potential role in meeting such needs. They are able to satisfy the growing market for biodegradable goods. [35]

Conclusion:

In conclusion As we've seen, creating biodegradable plastics from starch is a more complicated and challenging process than creating conventional polymers based on petroleum. In order to address the difficulties in processing polymer starch, changes to conventional processing methods and the assessment of processing parameters have been investigated. This study examined the main processes used in the creation of biodegradable polymers based on starch. Despite the fact that the majority of research in this area

Biodegradable plastics emerge as a potential alternative to traditional plastics, serving as a practical measure to reduce environmental pollution. The biodegradation process of Biodegradable plastics relies on microorganisms in the natural environment. By utilizing new preparation methods and other biopolymers or additives, the functional performance of starch-based biodegradable products can be increased or prolonged. However, there are

still obstacles to overcome before high-performance starch-based biodegradable polymers can be produced economically on a wide scale, and further study is needed in this field.

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