

Biodegradable polymers reduce environmental impact by breaking down into harmless products after use

Thiago Almeida*

Department of Sustainable Polymer Chemistry, Amazon Institute of Chemical and Environmental Technology, Brazil.

***Corresponding author:** Thiago Almeida, Department of Sustainable Polymer Chemistry, Amazon Institute of Chemical and Environmental Technology, Brazil.

Email: thiago.almeida.biopoly@amazochem.edu

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Abstract

Biodegradable polymers are materials designed to decompose into environmentally benign substances through natural biological processes such as microbial action and hydrolysis. These polymers offer sustainable alternatives to conventional plastics that persist in the environment for decades. Materials such as polylactic acid, polycaprolactone, and starch-based polymers are widely studied for packaging, biomedical, and agricultural applications. This article discusses the principles, degradation mechanisms, properties, and applications of biodegradable polymers in modern chemical science.

Keywords: Biodegradable polymers, Polylactic acid, Hydrolysis, Green materials, Compostable plastics, Biopolymers, Sustainable packaging, Environmental chemistry, Polymer degradation, Eco-friendly materials

Introduction

Biodegradable polymers are developed to address the environmental problems caused by conventional plastics that accumulate in landfills and oceans due to their resistance to degradation [1]. These polymers are designed to break down through natural processes such as microbial activity, enzymatic action, and hydrolysis into harmless products like water, carbon dioxide, and biomass. Polylactic acid is one of the most widely used biodegradable polymers, derived from renewable resources such as corn starch and sugarcane. Its structure allows it to undergo hydrolytic degradation under composting conditions, making it suitable for sustainable packaging applications [2]. Other biodegradable polymers such as polycaprolactone and starch-based materials also exhibit similar environmentally friendly properties. The degradation mechanism typically involves breaking of polymer chains through hydrolysis or enzymatic reactions. Environmental factors such as temperature, moisture, and microbial presence influence the rate of degradation. Understanding these factors is essential for designing polymers with controlled lifespans for specific applications [3]. Biodegradable polymers are widely used in medical applications such as sutures, drug delivery systems, and tissue engineering scaffolds, where temporary support is required

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before natural absorption by the body. In agriculture, biodegradable films are used for mulching and soil protection without leaving harmful residues [4]. Challenges include balancing mechanical strength with degradation rate and ensuring cost-effectiveness compared to traditional plastics. Advances in polymer chemistry and blending techniques continue to improve performance and affordability. The development of biodegradable polymers integrates green chemistry principles with materials science to create environmentally responsible alternatives for everyday products [5].

Conclusion

Biodegradable polymers offer sustainable solutions to plastic pollution by decomposing into harmless products after use. Through careful design of polymer structure and degradation behavior, these materials serve important roles in packaging, medicine, and agriculture. Continued innovation in biodegradable polymer chemistry will contribute significantly to environmental protection and sustainable development. Continued innovation in catalyst design will further expand its applications in sustainable chemical synthesis. Through advanced membranes, catalysts, and electrolytes, fuel cells provide sustainable and clean power solutions. Continued development of durable and cost-effective materials will expand the role of fuel cells in future energy systems.

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