DEVELOPMENT POTENTIAL OF BIOPLASTICS PRODUCTION

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ABSTRACT

Plastic is a low-cost synthetic polymer, which has numerous uses, from food packaging to pharmaceutical materials. Since 1950, its production has grown exponentially, in an attempt to keep up with population growth and unrestrained industry consumption, generating more and more waste that is inappropriately disposed of in the environment. The slow and partial decomposition of this waste creates small particles known as microplastics that contaminate various ecosystems, reaching the human food chain and causing numerous health problems. Searching for a sustainable solution, in recent decades research in the area of bioplastics has been intensified in an attempt to offer solutions for the use of common plastics and mitigate the problems generated by their inadequate disposal. Bioplastics are polymers derived from renewable sources, such as starch and cellulose, with high degradability in both aerobic and anaerobic conditions. Despite the high production cost, bioplastics have been gaining ground in the sustainable products market, as they offer the same advantages as some synthetic products and with less environmental impact. But, despite the increase in its production and industrial use, there is a clear need to develop technologies that reduce production costs and improve their physical-chemical properties, making bioplastics a product more similar to traditional plastic and even more sustainable. The objective of this research was to gather material on the proposed topic and evaluate the situation of manufacturing and use of bioplastics in recent years.

Keywords: Biomass. Polymer. Renewable sources.

1 INTRODUCTION

Since their creation in 1907, plastics have been used in countless ways to meet man's diverse needs in a variety of areas, replacing materials such as glass, metals and wood. Data shows that in 2022 Brazil produced 81.8 million pieces of waste in urban areas, 30-40% of which was plastic. By 2050, the production of plastic materials could reach 1100 tons/year, causing a major environmental impact.[1] The long decomposition process, the lack of management of discarded waste and disregard for incentives to recycle means that the amount of plastic waste is growing considerably, causing numerous health problems for humans, from respiratory and cardiovascular problems to cancer.[2,3] Therefore, with the growing global sustainability movement, it is necessary to create products that degrade quickly and do not contaminate the environment. Bioplastics generated from natural and renewable resources have been the focus of the scientific community.[4]

2 PLASTICS

The first 100% synthetic plastic produced from the reaction between phenol and formaldehyde was called Brakeline, withstanding temperatures of over 300 °C, resistant to numerous chemicals and a perfect electrical insulator. The vast majority of plastics are derived from fossil fuels and formed from the union of macromolecules, called polymers.[5] Due to its mechanical qualities, durability and low production costs, its consumption has been increasing on a large scale and it is replacing various materials such as glass, metals and paper in different areas of industry. In an attempt to keep up with population growth, more than 0.3 billion tons of plastic are produced worldwide every year, of which only 1/5 are recycled or incinerated, while the rest goes back into the environment as waste, proving to be a problem on a global scale. The lack of management of plastic waste leads to the contamination of ecosystems, piling up in landfills, dumps and oceans.[1]

Of the world's plastic, only 9% is recycled, 12% is burned, contributing to CO2 emissions, and the remaining 79% is found in the oceans and landfills, threatening life on earth. During the combustion of plastic material, contaminants harmful to health are released, including volatile organic carbons, furans, hydrocarbons and dioxins, substances that can cause cancer, respiratory and cardiovascular diseases.[6] In nature, plastics are degraded by weathering, UV rays, temperature variations and physical abrasion, being reduced to smaller particles of <5 mm (microplastics) and <0,001 mm (nanoplastics), posing a danger to humans and animals. There are numerous health risks associated with the various harmful substances present in plastics, which, once present in the environment, cause physical and toxicological effects.[7]

Humans ingest around 0.1 to 0.5g of microplastics every week, both in the environment and in food sources such as fish. The ingestion of microplastics can cause damage such as false satiety, digestive blockages and lesions in the gastrointestinal tract. The toxicological effects are related to the release of chemicals that are endocrine disruptors, such as bisphenol A and phthalates, present in plastic particles, which affect the immune system, metabolism and reproductive health.[8] It is estimated that the world's production of plastic materials amounts to 250 million tons, with Brazil's production standing at around 6.5 million tons, less than 3% of world production. The lack of management of plastic materials causes environmental and economic damage, with annual losses exceeding US$ 2.00 billion according to IPEA (2012).[9] In an attempt to mitigate these problems, new technologies have been developed as an alternative to replace conventional plastic materials. Greener solutions that have a shorter degradation time and are made from biodegradable materials from renewable sources.

3 BIOPLASTICS

The main advantage of biodegradable polymers is their ecological impact due to their high degradability, decomposing into carbon dioxide (CO_2), water, minerals and biomass.13,14 They can be used as packaging or to coat the surface. of food. They must have mechanical properties characteristic of common plastics, microbiological stability, be free of toxic agents, help with the shelf life of food, among other things.[15] According to European Bioplastics, 2.18 million tons of bioplastics were produced worldwide in 2023, which is expected to grow by approximately 68% per year, and could reach a production of 7.43 million tons by 2028.[17]

One worrying factor is the lack of management of the waste generated, because even though they are biodegradable, bioplastics need specific collection and recycling technology. Studies show that mechanical recycling and reuse are the most suitable methods for disposing of biobased and biodegradable plastics, which are reused until their physical and chemical qualities are no longer efficient, and then sent for chemical recycling treatment.[18] The global trend is towards sustainability, with a gradual and growing shift from the use of fossil-based plastics to bio-based plastics, but it is notable that thought does not accompany action. Commitment to recycling plastic products and using biodegradable plastics is correlated with cultural differences and education levels.[19]

4 TYPES OF BIOPLASTICS

Bioplastics can be classified into plastics derived from bio-based materials and those derived from biodegradable materials. Those formed from a biological basis are made up entirely or partially of renewable materials, such as agricultural products made up of starch, cellulose and lipids. Derivatives of biodegradable materials are those made up of materials that completely decompose after contact with water, CO_2, methane and microorganisms.[16] Biodegradable plastics are divided into 4 groups based on the source of the polymer, as shown in Table 1. [12,16,20]

Table 1 Classification of Biodegradable Plastics.

Biodegradable Plastics		
Type	**Source**	
Agro-Polymers	Polysaccharides	Starches: wheat, potatoes, corn, etc.
		Lignocellulosics: wood, straw, etc.
		Others: pectins, gums, chitosan
	Proteins/Lipids	Animal: casein and collagen
		Vegetable: gluten
Microorganisms	Polyhydroxyalkanoates and Polyhydroxybutyrates (PHA)	
Biotechnology	Polylactides (Polylactide Ac. – PLA)	
Petrochemical	Polycaprolactone	
	Polyesteramides	
	Aliphatic Co-Polyesters	
	Aromatic Co-Polyesters	

PLA is composed of lactic acid produced from the fermentation of polysaccharides such as sugar cane, corn starch and others, and is considered the most promising biodegradable polymer to replace common plastics, due to its physicochemical characteristics and numerous applications. such as food packaging, agriculture, engineering, fabrics, automotive parts, in the medical and pharmaceutical field, among others. From 2011 to 2020, its global production quadrupled, going from 200 kt/year to 800 kt/year [22, 23, 24]. PHA is produced from the bacterial fermentation of organic substrates such as agro-industry effluents, vegetable oils, fatty acids and others. Despite the high cost, its production increased from 5.3 million tons to 17.0 million tons from 2013 to 2020, showing promise as it has characteristics comparable to petroleum-derived plastics, such as elasticity, flexibility and thermoplasticity, being used in various areas of the food, medical, engineering and agricultural industries [25, 26, 27]. As a fossil-based biodegradable plastic, PBAT has properties similar to low-density polyethylene, however, with low resistance. It is among the most used bioplastics for the manufacture of shopping/trash bags and plastic films, with China being the world's largest producer with a production of 370 thousand tons [28, 29]. PBS is produced from petroleum-based monomers and is used in the manufacture of utensils that require the ability to tolerate high temperatures, up to 200ºC [30].

The use of nanoengineering, with the addition of nanoparticles in the production of new bioplastics has brought more physical and mechanical resistance to materials, as well as bioengineering, with genetic modification being used to create bioplastics with ideal properties [21]In addition, the infrastructure for the production and processing of bioplastics needs to be improved. This includes investments in production facilities and processing technologies that enable the efficient and high-quality manufacture of bioplastics. It is also important to develop more sustainable production methods with a low environmental impact, with a view to reducing water and energy consumption, as well as minimizing waste and emissions. Brazilian sources such as academic studies, reports from research institutions and articles from government organizations can provide valuable insights into the specific challenges faced by the bioplastics industry in Brazil. For example, the Packaging Technology Center (CETEA) of the Food Technology Institute (ITAL) and the Chemistry Institute of the University of São Paulo (IQ-USP) are important research centers that have contributed relevant knowledge about the production of bioplastics in Brazil.[30,31,32]

5 CONCLUSION

In recent years, research has evolved with a focus on the development of bioplastics derived from renewable resources, in an attempt to reduce dependence on oil and mitigate environmental pollution from plastic waste. Highlighting its high degradability, which facilitates disposal and contributes to environmental preservation. New technologies show promise in the search for increased production and improved quality of bioplastics, in addition to constant attempts to reduce costs, using innovative methodologies such as fermentation, chemical-enzymatic polymerization, nanoengineering and genetic engineering. However, despite the intensification in the production and development of new and improved bioplastics, there is a clear need for public policies aimed at sustainable education for the population. Encouraging the use of biodegradable materials will help reduce plastic waste discarded irregularly in the environment, and encourage the scientific community to expand its research in the area, in an attempt to bring a quality, biodegradable product to the end consumer, and resistance similar to common plastic.

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