Application And Research of Biodegradable Plastics in China and The United States

Kehan Mou *

School of Economics and Management, Wuhan University, Wuhan, 430072, China

* Corresponding Author Email: 2022301051165@whu.edu.cn

Abstract. In this era of continuous economic growth, an increasing number of people have shifted their focus towards acquiring more convenience and benefits, thereby reducing their level of concern for the environment, ultimately giving rise to various forms of environmental pollution. Among these pollutants, the closest to us is "white pollution," which refers to a series of harms caused by non-degradable plastics. As one of the most essential materials in people's daily lives, plastics are virtually irreplaceable by other materials. Therefore, this paper will delve into the necessity and feasibility of using biodegradable plastics. It will further compare and analyze China and the United States' attitudes, specific policies, and industrial manufacturing status regarding biodegradable plastics. This paper, through an examination of relevant literature, national laws, policies, and data collection and analysis, identifies the differences between China and the United States in their attitudes and policies towards biodegradable plastics. It also analyzes the strengths and weaknesses of both countries in the biodegradable plastics market and production technology. Finally, it briefly assesses the prospects and outlook for both countries in the field of biodegradable plastics and environmental governance.

Keywords: Biodegradable plastics; China; the United States.

1. Introduction

As is well-known, with the continuous advancement of industrialization, carbon emissions have been steadily increasing. Driven by certain vested interests, we sometimes find ourselves making choices that harm the environment. However, over time, both the government and the people have come to realize the dangers posed by environmental destruction. The main cause of environmental pollution is the improper disposal of plastic waste. Currently, there are two primary methods for plastic waste disposal: landfilling and incineration. Landfilling can lead to the erosion of soil by certain components of plastic, while also contaminating groundwater. On the other hand, incineration produces a significant amount of black smoke from plastics and releases a considerable quantity of harmful gases and residues. These gases can contribute to air pollution in our atmosphere, and the residues take a long time to gradually decompose once they enter the soil. This can result in them entering the food chain through crops, ultimately impacting our health. The significance of this study lies in comparing the attitudes and current state of relevant manufacturing enterprises towards the application of biodegradable plastics in China and the United States. This comparison aims to assess the degree of importance both countries place on the environment and the issue of plastic pollution. Additionally, it enables a comparison of the technological advancements and actual investments made by China and the United States in environmentally related industries. In Hunan Province, China, the "Clean Beach 100 Square Meters" campaign has collected around 77,738 square meters of riverbank garbage, mostly from the Xiangjiang River basin. According to 69 valid surveys, plastic bags rank second among the top ten types of garbage, with cigarette butts being the most prevalent. Dealing with plastic bags currently involves two main methods: landfill and incineration. Both methods pose significant environmental risks. Landfilling may take decades or even hundreds of years for plastic bags to degrade, leading to soil and groundwater pollution due to polyvinyl chloride content. Incineration, on the other hand, generates harmful dioxins and affects the soil, plants, crops, and human health when entering the food chain, causing liver disease and cancer. [1] The main issues addressed in this study include the industrial manufacturing of plastic products and their relevance to

daily life, the policies and attitudes of both China and the United States towards biodegradable plastics and plastic pollution, as well as the necessity of utilizing biodegradable plastics. The aim of this study is to conduct a thorough analysis of these issues, considering relevant data comprehensively, and ultimately arrive at relatively reliable conclusions. By closely examining and meticulously assessing aspects such as the industrial manufacturing and application of plastic products, the policies and attitudes towards biodegradable plastics and plastic pollution in both China and the United States, as well as the necessity of employing biodegradable plastics, this research seeks to offer valuable insights and provide guidance for pertinent decision-making and actions. Through this study, we aspire to gain a deeper understanding of these facets and contribute substantial insights to the discourse on plastic-related topics. This paper will begin by conducting a relevant analysis of the prospects for the application of biodegradable plastics, such as highlighting the harms of conventional plastics and the benefits of biodegradable alternatives. In the industrial analysis section, an overview and analysis of the biodegradable plastics manufacturing industries in both the United States and China will be provided, accompanied by detailed comparisons between them. Concerning policies, this paper will outline select policies from China and the United States, while aiming to identify commonalities and differences between the two and progressively deriving relevant conclusions. Within various industrial sectors, competitiveness often serves as a reflection of industrial strength. This paper will enumerate some advantages China and the United States possess in these industries, while also analyzing their contributions to industrial prowess.

2. Industry Background

2.1. Industry Development

In the 1970s, scientists discovered Polyhydroxyalkanoates (PHA), a type of biodegradable plastic that can be produced by microorganisms through fermentation and has good degradability and biocompatibility. PHAs are regarded as the bioplastics of the future, possessing all the attributes that define green plastics: they are derived from biological sources, synthesized through biological processes, capable of natural biodegradation, compostable, and compatible with living organisms [2]. In the 1980s, commercial production of biodegradable plastics began. Some PHA-based bioplastics have entered the market and are used in fields such as medical devices and disposables. Development of PLA. In the 1990s, Polylactic Acid (PLA), as an important biodegradable plastic, received widespread attention. PLA is made by fermenting plant raw materials such as corn or sugar cane, and has good degradability and biocompatibility.With advances in biopolymer research, polylactic acid (PLA) has been considered as a potential alternative to petroleum-based materials. [3]At the beginning of the 21st century, the preparation technology of biodegradable plastics continued to improve, and various new bioplastics such as PHA, PLA, PBS (polybutylene succinate), etc. were widely developed and used in food packaging, agricultural films, disposable Tableware, medical equipment and other fields.

2.2. Industry Overview in China

As Asia's most populous country, China is a major consumer of plastics, and biodegradable plastics are considered an effective way to solve the problem of pollution from single-use plastic waste. China is experiencing rapid growth in the market value of biodegradable plastics, arriving at an estimated RMB 23.072 billion in 2023 from RMB 4.056 billion in 2018. In 2021, China's trade of biodegradable plastic-related products saw significant growth. The country's exports reached 136,900 tons valued at 3.96 billion yuan ($591.90 million), with a 27.88% year-on-year increase. Additionally, imports amounted to 8,500 tons valued at 1.96 billion yuan ($293.04 million), showing a remarkable 64.87% year-on-year increase, resulting in a trade surplus of about 2 billion yuan (nearly $300 million) [4]. This data highlights China's strong performance in the international market for biodegradable plastics. The increase in exports demonstrates the competitiveness of China's biodegradable plastic products,

while the rising imports indicate a growing domestic demand. The trade surplus indicates China's export advantage in this sector, driving the development of the domestic industry.

2.3. Industry Overview in the United States

The biodegradable plastics market in the United States is anticipated to experience significant expansion, reaching a value of USD 2.18 billion by 2028. This growth is projected to occur at a Compound Annual Growth Rate (CAGR) of 13.68% from 2022 to 2028. It is indicative of the ongoing progress in the plastics sector, with biodegradable packaging playing a pivotal role in this development. [5] Components of the Global Packaging Market. As environmental concerns grow, biodegradable plastics are increasingly seen as a sustainable solution that can help transform the industry and meet the demand for environmentally friendly alternatives.

Being a major country in North America, where the penetration of degradable plastics is relatively small, the U.S. Degradable Plastics Industry Market value is expected to reach a level of 1,378.6 million Dollars by 2023 and continue to rise steadily but remain at a relatively small rate of increase.

2.4. Comparison

China, as the main country in Asia researching biodegradable plastics, is likely to have a larger share of the 49.9% of biodegradable plastics production in the Asian region in 2021. The U.S., on the other hand, has more limited production capacity in the biodegradable plastics industry and is likely to rank behind Asia and Europe. The Chinese government has been committed to promoting environmental protection and sustainable development, which includes supporting the development of the biodegradable plastics industry. Government policy support and investment may have contributed to the rapid growth of the biodegradable plastics industry in China. China has advantages over the United States in manufacturing, which helps China to have a relatively high market value growth. While the growth in the United States is relatively slow, the overall biodegradable plastics industry in both countries is growing steadily.

3. Policy

3.1. Chinese Key Policy

China has made several revisions to the policy for the domestic plastics industry. The establishment of first policy to the plastics industry went into effect in June 2008, effectively prohibiting the manufacturing sector from producing plastic bags smaller than 0.025 mm and limiting the availability for free usage to citizens. [5] The State Council did not upgrade the prohibition to limit the use of non-biodegradable plastics until July 2020. In accordance with Article 106 of the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes. This law imposes penalties for the utilization of non-biodegradable plastics and prohibits the use of disposable plastic tableware in the catering industry. Moreover,by 2025, all single-use plastic dinnerware and medical waste-derived plastic goods will be banned on recycling and accessing. Furthermore, the People's Republic of China's Ministry of Commerce published a policy in June 2023 outlawing the use of single-use, non-biodegradable plastics in the commercial sector. At the international level, policies have been set up in response to plastic imports from abroad, and as of the beginning of 2018, China has started implementing a permanent ban on imports of waste plastic [6].

3.2. American Key Policy

Similarly, the American Federal government also implemented a policy, which is the Break Free from Plastic Pollution Act of 2021, to restrict plastic industry behavior. The political content refers to the reduction of the production of plastic-containing goods and the scaling up of recycled plastic products and materials. The act was also put into effect in January 2023. It includes a fee on carry-on plastic bags in addition to refunds on recycling the regular plastic products, and to encourage

consumers to use fewer single-use plastic products. [7] California is one of the most populous states in the United States and is a cluster of high-tech companies. The production of plastic waste is high, and the government is very serious about the problem of plastic pollution. So, take California as an example, the state government made more efforts on controlling plastic pollution than other states did. For instance, the SB 54, a bill act established for preventing the plastic pollution. The bill outlines the consequences for violating the limitations on the manufacture, recycling, and export of plastics. Specifically, the usage of plastics will be cut in half over the following ten years, with an immediate recycling of 65% of single-use plastic packaging, and some types of plastic packaging are required to be recyclable and compostable as of the implementation date [8].

3.3. Discussion and Comparison

The plastics supply chain may suffer negative economic effects as a result of Chinese and American regulations affecting the plastics industry. Chinese policies are carried out via a top-down approach.The General Office of the State Council adopts and releases policies in the form of documents, which are then implemented by local governments in accordance with their particular local circumstances. Generally, it is evident from the rules that China takes a more serious attitude on the use of non-biodegradable plastics. This contrasts sharply with the euphemistic approach of the US government to the execution of national-level programs, such as those that are supported with incentives and taxes on usage. In comparison to China, this is a considerably milder policy. Further, the policy has provided avenues for the manufacture and recycling of plastics. Especially in California, the plastic policy provides protection on the plastics sector and supply chain.

Finally, in order to prevent regulatory corruption and carelessness from occurring, administrative sanctions are also implemented in China and the US.

4. Evaluation of Industrial Competitiveness

4.1. Chinese Market

The biodegradable plastics markets in China and the United States vary in size. Prior to 2019, China's biodegradable plastics industry experienced sluggish growth. However, following the implementation of the plastic ban policy, China's biodegradable plastics sector began to expand rapidly. Currently, China boasts a larger biodegradable plastics market compared to the United States. According to Statista data, the market value of the biodegradable plastics industry in the United States was $1,196.5 million in 2022. [9]. In contrast, the biodegradable plastics market value of China was 2244.8 million dollars, which is more than that in the United States. China is the biggest producer of biodegradable plastic with the market volume of 162, 000 tons [10]. During the pandemic years, the structure of plastic use had a big change. Because of the lockdown policy, economic activity changed a lot, for example, from in-store eating to take away food and food delivery, and from going to the shopping malls to visiting online shopping platforms like Amazon. In 2021, online purchases in the United States increased 32.2% from 2019 and totaled an all-time high of $188.2 billion [11] In contrast, China reached 229.7 billion e-commerce sales in 2020 with an increase rate of 27.5%[12] The shift in economic activity requests more amount of packaging material, which causes the rapidly increasing demand of biodegradable plastics in China and the United States. Based on the data in the Statistics, in 2019, China and America were the main e-commerce polluters because of plastic packaging waste. The Chinese e-commerce industry produced 221.5 million kg of plastic packaging waste, while 212.7 million kg of plastic packaging waste was produced by the US [9]. The big amount of plastic pollution boosts the development of the bioplastics industry and the innovation of new biodegradable plastics in both the US and China. Since China’s total amount of plastic consumption along with the plastic waste is bigger than that in the US, plastic manufacturing companies have a higher incentive to innovate eco-friendly plastics to meet the request of the government. As a result, the bioplastic industry in China has been promoted due to the environmental protection pressure.

4.2. Technology

The United States, China, Europe, and Japan are the main contributors to the innovation of biodegradable plastics. In terms of the source of technology, the United States has the largest number of patents, accounting for 36%, while China ranks second, accounting for 19.5% of the world, which is shown in the chart below. Among the world's top 20 bioplastics patentees, the top 11 are from US institutions, compared with only two from China, which are Changchun Institution of Applied Chemistry and Zhejiang University [13]. China is the biggest biodegradable market in the world. Poly lactic acid (PLA) and poly butylene-adipate-co-terephtalate (PBAT), which are the polymers in plastic manufacturing, are the mainstream degradable plastics on the Chinese market. The production capacity of PBAT accounts for about 79% of all plastic types, making it highly competitive in China. However, because of problems like the high cost of raw materials and complicated technology, PLA plastic has always been unable to achieve large-scale high-quality production, and now only a few enterprises such as Fengyuan Company. American biodegradable plastics companies are more advanced than Chinese ones. In the list of the top 10 best bioplastics companies in 2021, Eastman and Nature Works are two US companies that are in this list. [14] Eastman is a specialty materials company focusing on bioplastic and recycling, which applies biodegradable plastic materials in mobile phone cases, glasses, textiles, and other household products. Nature Works, which is a joint venture between US and Thai, is the first company that produces PLA biopolymers at a commercial scale and owns the largest PLA manufacturing factory in the world. In June 2022, Nature Works began the new biopolymer manufacturing plant in Thailand, which is the first fully integrated PLA biopolymer manufacturing plant with an annual capacity expectation of 75,000 tons [11]. Compared to the weakness of PLA production in China, the United States has a great competitive advantage over PLA production [15].

5. Conclusion

American companies have invested significant resources and money in innovation in bioplastics. According to the U.S. Department of Energy, 13.4 million dollars are provided to support the development of the technology of biodegradable plastics in the United States to reduce the carbon emissions of traditional plastics. This investment significantly accelerates the process of achieving zero carbon emissions in the United States by 2050. Moreover, The United States grants a large number of award funds to universities and companies for research and innovation projects, which gives researchers greater motivation. According to the Department of Energy, the "infinitely recyclable single-polymer chemistry nip-based multilayer films" technology of Braskem and the "infinitely recyclable and biodegradable films for improved food packaging" technology of TDA Research Inc. are examples of the seven projects that will develop in the future. Although China did a great job in establishing policies to motivate the innovation of biodegradable plastics and restricting the use of polluting plastics, the direct financial support is relatively weaker compared to that in the United States. The United States has a more biologically based economy. In 2012, Obama announced the National Bioeconomy Plan, which planned to aid the biomass research of the United States Department of Agriculture, Department of Energy, and The Advanced Research Projects Agency-Energy financially. Additionally, this plan also improved the regulatory model and lower the cost of production. Aside from this plan and other financial support, the US also established the Biomass Research and Development Board and a Techical Advisory Committee based on the Biomass Research and Development Act of 2000. After conducting a comparative analysis of the biodegradable plastics industry in the United States and China, several key conclusions emerge. The United States demonstrates a higher level of technological advancement and innovation in the development and production of biodegradable plastics. The U.S. industry benefits from significant research investments and a robust infrastructure, resulting in a wider range of advanced bioplastics with enhanced properties. China excels in manufacturing capabilities and cost-efficiency, enabling the country to produce biodegradable plastics at a more competitive price. This has led to increased

adoption of such materials in various sectors, promoting sustainable practices. Both countries face regulatory challenges and consumer awareness issues. The lack of consistent global standards and confusion surrounding labeling and certification hinder the growth of biodegradable plastics adoption. In conclusion, while the U.S. leads in innovation, China's manufacturing prowess and cost-effectiveness create a competitive advantage. Addressing regulatory and awareness challenges, and fostering cross-country collaboration, can accelerate the growth of biodegradable plastics, contributing to a more sustainable future for both nations and the world.

References

[1] Han Shu. Eliminating Environmental Pollution: Calling for Biodegradable Plastics. Green Packaging, 2022, 12(65): 69-72.

[2] Martin Koller, Lukáš Maršálek, Miguel Miranda de Sousa Dias, Gerhart Braunegg. Producing microbial polyhydroxyalkanoate (PHA) biopolyesters in a sustainable manner. New Biotechnology, 2017, 37(1): 24-38.

[3] Siti Baidurah, Takaomi Kobayashi, Azniwati Abd Aziz. PLA Based Plastics for Enhanced Sustainability of the Environment, Encyclopedia of Materials. Plastics and Polymers. 2022, 21(32): 511-519.

[4] Barry van Wyk. The rise of China's biodegradable plastics industry. [EB/OL]. (2022-06-27) [2023-08-25]. https://thechinaproject.com/2022/06/27/the-rise-of-chinas-biodegradable-plastics-industry/

[5] globenewswire. United States Biodegradable Plastics Industry 2023 to 2028: Key Players Include BASF, Dow Chemicals, DuPoint, Eastman Chemical, Green Dot Bioplastics, Novamont, Toray Industries andWestrock. [EB/OL]. (2023-03-27) [2023-08-24]. https://www.globenewswire.com/en/news-release/2023/03/07/2622356/28124/en/United-States-Biodegradable-Plastics-Industry-2023-to-2028-Key-Players-Include-BASF-Dow-Chemicals-DuPoint-Eastman-Chemical-Green-Dot-Bioplastics-Novamont-Toray-Industries-and-Westr.h

[6] Jianli Liu, Yunfei Yang, Lihui An, Qiang Liu, Jiannan Ding. The Value of China's Legislation on Plastic Pollution Prevention in 2020. Bulletin of Environmental Contamination and Toxicology, 2022, 108(67): 601-608.

[7] 117th Congress (2021-2022). S.984 - Break Free From Plastic Pollution Act of 2021.[EB/OL]. (2021) [2023-08-24]. https://www.congress.gov/bill/117th-congress/senate-bill/984

[8] California Senate Bill 54. [EB/OL]. (2022-06-30) [2023-08-24]. https://legiscan.com/CA/text/SB54/id/2600075

[9] Statista. E-commerce plastic packaging waste 2019, by country. [EB/OL]. (2023-03-24) [2023-08-24]. https://www.statista.com/statistics/1262381/e-commerce-plastic-packaging-waste-by-country/

[10] GlobalData. Market Size of Bioplastics in China (2017 – 2021). [EB/OL]. (2023-06-22) [2023-08-24]. https://www.globaldata.com/data-insights/packaging/market-size-of-bioplastics-in-china-2017-2021/

[11] Mordorintelligence. UNITED STATES PLASTIC PACKAGING MARKET SIZE & SHARE ANALYSIS - GROWTH TRENDS & FORECASTS (2023 - 2028). [EB/OL]. (2023-04-06) [2023-08-24]. https://www.mordorintelligence.com/industry-reports/us-plastic-packaging-market

[12] International Trade Administration. China - Country Commercial Guide. [EB/OL]. (2023-04-07) [2023-08-24]. https://www.trade.gov/country-commercial-guides/china-ecommerce

[13] Zhou Qingqing, Zou Qifeng, Xia Ru. Research on China's degradable plastics industry under global competition – Based on patent analysis. Journal of Beijing City University. 2023, 35(02): 68-73.

[14] AXEL BARRETT. TOP 10 Best Bioplastics Companies 2021 (FREE). [EB/OL]. (2022-01-05) [2023-08-24]. https://bioplasticsnews.com/2022/01/05/top-10-best-bioplastics-companies-ranking-2021

[15] OECD. Policies for Bioplastics in the Context of a Bioeconomy, OECD Science, Technology and Industry Policy Papers.2023. [EB/OL]. (2013-10-28) [2023-08-24]. https://doi.org/10.1787/5k3xpf9rrw6d-en