Feasibility Study on Degradable Plastics for Logistics Packaging

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Abstract: In recent years, the booming development of caller has changed people's shopping way and consumption concept. At the same time, it also leads to the rapid development of logistics express industry, but this development also brings a lot of logistics packaging waste. Under the background of national vigorously advocating carbon neutrality, green and recyclable logistics packaging has gradually become a requirement. This paper introduces some degradable plastics that can be used in logistics packaging. This paper analyzes the advantages and disadvantages of using biodegradable plastics in logistics packaging and tries to provide corresponding countermeasure.

1 INTRODUCTION

Goods can participate in circulation through the means of packaging, packaging is a necessary link of logistics.

Packaging in logistics is also divided into three types, one is the packaging of the goods just produced, this packaging is generally considered to protect and beautify the goods. The second is outsourcing packaging, which generally considers the wholesale problem. Most goods will be sold more than one piece, requiring larger outer packaging for packaging, which is common in the food and beverage industry. Third, express packaging, considering the related problems in logistics transportation, need to add a layer of express packaging, to ensure that goods will not be damaged in logistics transportation, but also need to meet the delivery, sorting, transportation, delivery needs.

In 2020, China's express delivery volume reached 83.36 billion pieces, up 31.2 percent year on year, showing that China has become a global Courier power. With the rapid development of express delivery, the demand for packaging has also increased dramatically. From January to July 2021, a total of 15.01 billion pieces of postal delivery services were delivered, up 1.3 percent year on year. At this rate, express packaging material consumption is expected to reach 41.27 million tons in 2025.Recently, the National Development and Reform Commission and the Ministry of Ecology and Environment issued the "14th Five-year plan for Plastic Pollution Control Action Plan", which has clear requirements for express packaging, e-commerce express should realize secondary packaging, using recyclable packaging instead of traditional packaging.[0]As a new type of green material, degradable plastic has become a trend of large-scale application in e-commerce logistics.

2 DEVELOPMENT PROSPECT OF DEGRADABLE PLASTICS

A biodegradable plastic is a material that can degrade thermodynamically and dynamically over a period of time. There are two kinds of materials that have been applied in logistics packaging on a large scale, one is biodegradable plastic, mainly polylactic acid (PLA), the other is petroleum degradable plastic, also known as thermoplastic biodegradable plastic, mainly polyladipic acid (PBAT). Polylactic acid (PLA) is produced from renewable plants by saccharification to convert it into glucose, fermentation with related strains, and synthesis through complex chemical processes. It can be completely degraded and absorbed by some microorganisms after use, producing carbon dioxide and water that will not cause pollution. It has good thermal stability, good solvent resistance, can be processed in a variety of ways, such as extrusion, spinning, biaxial stretching, injection blow molding. In addition to having good biodegradability,

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polylactic acid also has excellent glossiness, transparency, hand feel and heat resistance. It is a good green logistics packaging material. The current global PLA production capacity exceeds 500,000 tons/year. NatureWorks is the world's largest polylactic acid manufacturer with an annual production capacity of 180,000 tons, accounting for more than 30% of the world's polylactic acid production capacity. The production of PLA is still in the initial stage of development in China. Jiangsu Yunyoucheng production line with annual output of 50,000 tons of PLA is the largest production line in China. In recent years, new entrants have emerged in the industry, mainly because of the promising market prospects of lactic acid and its derivatives lactide and polylactic acid in the field of biodegradable new biological materials. Its development has been successively included in "863", "973", "Torch Plan", "13th Five-Year Plan", "Made in China 2025" and "National Medium and Long Term Science and Technology Development Plan" key research projects.[0]

The production process of polyglycolic acid is synthesized by using adipic acid (AA), terephthalic acid (PTA) and butanediol (BDO) as monomers through esterification or transesterification and polycondensation reaction in a certain proportion. Direct esterification is a widely used production process in China. The advantages of this method are short process, high utilization rate of raw materials, short reaction time and high production efficiency. The disadvantage is that the reaction system is more complex, the relative molecular weight distribution is wide and difficult to control, the reaction conditions are more demanding, the reaction medium is more acidic, part of THE BOD cyclodehydration reaction to form tetrahydrofuran (THF), etc., which have influence on the product quality. In addition, there are separate esterification and series esterification processes, which have the advantages of simple equipment, fewer intermediate substances in the reaction system, narrow distribution of relative molecular weight, easy regulation of product viscosity, and reuse of waste products. The disadvantage is that the product quality may vary from batch to batch. Direct esterification is a widely used production process in China, which has high fracture elongation and toughness, and excellent physical and chemical properties. PBAT biodegradation mainly depends on its chemical structure and degradation of the environment, almost completely biodegradable, some by microbial fermentation is degraded in nature, some can make through chemical hydrolysis and thermal degradation of polymer chain break in depolymerization, there are also some depolymerization intermediates by microbial metabolism.

In recent years, China has issued a series of policies to encourage the application and promotion of biodegradable plastics, which has led to the continuous expansion of the market for biodegradable plastics in China. At present, China has become a major producer of biodegradable plastics in the world, and its products are exported abroad, mainly to Europe and North America. It is expected that with the growing demand of the global degradable plastics market, the export and domestic market size of Degradable plastics in China will continue to increase. In 2020, the annual production capacity of China's PBAT and PLA will be about 300,000 tons and 100,000 tons respectively. According to industry estimates, by 2025, the demand for degradable plastics in express packaging, disposable plastic tableware, plastic shopping bags and agricultural mulches will form a total market space of about 2.5 million tons. Accounted for in addition to the two bigger biodegradable plastics, such as starch composite plastic, poly (butyl diacid butyl glycol ester (PBS) and poly hydroxy fatty acid ester (PHA) such other accounts for the relatively small size of the market of biodegradable plastics, through the model forecast, can be expected to 2025 biodegradable plastic future market demand will reach 3.3 million tons, as shown in figure1.It is clear that biodegradable plastics have a promising future.

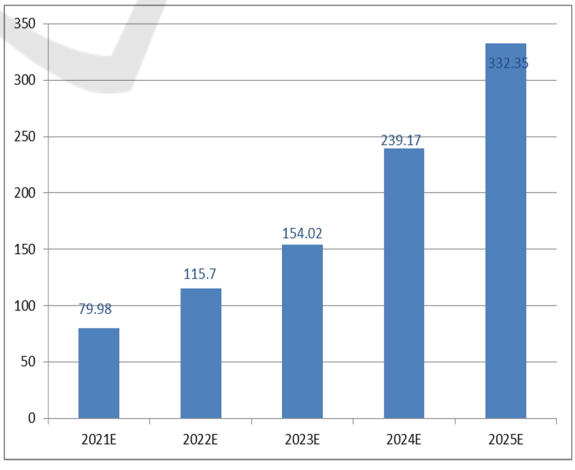

Figure 1: Forecast of future market demand release rhythm of degradable plastics (10k tons).

product	melting point/° C	tensile strength /Mpa	Elongation/%	Degradation rate	Water vapor barrier	Oxygen barrier
PLA	180	40-60	4-10	fast	Average	Average
PBAT	120	18	750	fast	Poor	Poor
LDPE	110	148	148	Non degradable	Good	Poor

Figure 2: Comparative analysis of comprehensive performance of PLA, PBAT and LDPE

3 COMPREHENSIVE COMPARISON BETWEEN DEGRADABLE PLASTICS AND TRADITIONAL PLASTIC PACKAGING

Polyethylene (PE) is a widely used traditional plastic, ethylene by polymerization of a thermoplastic resin, is one of the most common plastics, the annual production of more than 100 million tons of polyethylene resin, accounting for 34% of the total plastic market.PE is a typical crystalline polymer with a melting point of 130℃ ~ 145℃. It is characterized by tasteless, odorless, non-toxic, matte surface and milky waxy particles. It is also a major alternative to biodegradable plastics.PE has excellent crystallinity, water vapor barrier and weather resistance, which can be collectively referred to as "PE characteristics". In fact, currently common biodegradable plastics are aliphatic polyesters, such as PLA and PBS, which can be roughly regarded as PE containing ester bonds. The ester bonds in its molecular chain give it biodegradability, and the aliphatic chain gives it "PE properties". Promising biodegradable plastics need to be both biodegradable and "PE". Therefore, it is necessary to compare the comprehensive properties of biodegradable plastics and polyethylene.

As shown in the figure 2, PLA and PBAT have different performance from PE. Each has its own advantages and disadvantages, but none of them fully possess the "PE characteristics". PBAT and mechanical properties and the melting point of PE, it can cover the basic PE in disposable products industry, the application of PLA and intensity is higher than the melting point of PE, but with significantly lower tensile toughness and crystalline, polymer relative molecular weight distribution of the products is too wide, PLA itself for the linear polymer, it makes the strength of the PLA material often cannot meet the requirements, High brittleness, low thermal deformation temperature (54℃ under 0146MPa load), poor impact resistance, only when it is toughened, crystallization promotion and other modification can basically cover PE in the disposable products industry application. In addition to the basic characteristics of biodegradable plastics, PLA also has its own unique characteristics. Traditional biodegradable plastics are not as strong, transparent and resistant to climate change as ordinary PE.PLA has similar basic physical properties to petrochemical synthetic plastics, which means that it can be used to manufacture a wide range of applications. PLA also has good gloss and transparency, comparable to films made from polystyrene, which cannot be provided by other biodegradable products. PLA film has good air permeability, oxygen permeability and dioxide-carbon permeability. It also has the characteristics of odor isolation. When PLA is incinerated, its combustion heat value is the same as that of incinerated paper, which is half of that of traditional plastics (such as polyethylene), and the incineration of PLA absolutely does not release toxic gases such as nitrogen compounds and sulfides. The body also contains lactic acid as a monomer, indicating the safety of the breakdown product. According to the analysis, theoretically, PLA and PBAT can replace all disposable plastics. In addition, although PLA and PBAT have overlapping application fields, they have different characteristics. For example, PLA belongs to hard plastics, while PBAT belongs to soft plastics, which can be approximately regarded as polypropylene and polyethylene in petrochemical products. Moreover, PLA membrane bags with poor blowing processability are mostly blended with PBAT with good toughness, which can improve the blowing processability without damaging its biodegradability.

4 EXISTING PROBLEMS AND IMPROVEMENT MEASURES OF DEGRADABLE PLASTIC PACKAGING

Although biodegradable plastic packaging has a promising development prospect, it is difficult to be applied on a large scale in real life. The existing reasons are three, one is that the development of degradable plastic is not mature enough, a large part of the main body involved in logistics is difficult to

accept this kind of emerging products. The solution should be for the government to raise people's awareness of environmental protection and change people's view of degradable plastics through relevant policies or publicity. The second reason is the low bearing capacity of degradable plastic bags, which to a large extent cannot meet the requirements of logistics for multiple loading and repeated use. The third and most important point is the cost factor. Enterprises generally take maximizing profits as the premise. According to relevant data, the price of PLA and PBAT is 3-4 times that of mainstream plastic PE, so using degradable plastic packaging will compress the profit of logistics enterprises on the premise of maximizing profits. If this kind of excess expenditure is added to the logistics demander, it may lead to the decline of the competitiveness of similar products in the market. Nowadays, the effective way to improve these two reasons is to blend and modify them to improve their physical and chemical properties and reduce the cost of materials. Using other materials with lower cost to blend and modify them can effectively reduce the production cost of degradable plastics.

Several common blend modification, such as the blend modification of PBAT and PLA, PBAT has low tensile strength and modulus. PLA has the characteristics of high strength and high modulus. However, due to its inherent brittleness, low elongation at break, low impact strength and easy bending deformation, PBAT and PLA are blended. The toughness of the material is improved while maintaining its degradability. It solves the problem of packaging damage caused by insufficient hardness in logistics packaging.[0]PBAT can and starch blend modification of polymer materials, starch sources, cheap, can be completely biodegradable, but its itself does not have thermoplastic, and easy bibulous, not easy processing, will join the rest of the PBAT matrix modified starch, can greatly reduce cost and accelerate the degradation rate of PBAT, to reduce cost and solve the problem of resource shortage and environment pollution. PBAT can also be filled and modified with inorganic CaCO3. Nano CaCO3 has the characteristics of small particle size and high activity, and has a strong interface binding force with the polymer.[0]It is usually used as a filler in different polymers. Therefore, adding it into PBAT to prepare degradable composite materials can improve the performance of PBAT and greatly reduce the cost.

For the production of biodegradable plastics producers, there are a lot of technical barriers, PLA exist two kinds of preparation methods, one is the lactide ring-opening polymerization and direct polycondensation method, the lactide ring-opening polymerization is of the methods used by the majority of enterprises, and this method the required conditions are harsh, many domestic enterprises subject to the technical level and production scale, etc. There is no way to expand further. Another reason is the lack of strong policy or legal support. In foreign countries, the government set up a special development fund, tax incentives and other policy support the development of biodegradable plastics industry, at present China in this respect, the support to strengthen gradually, macroscopic policy support more and more, although issued the "difference" plastic pollution administrative action ", but the lack of detailed rules, against the development of production-oriented enterprises. Insufficient funds and financing difficulties of enterprises. The scale of Chinese biodegradable plastics enterprises is not large enough, and the return cycle of biodegradable plastics industry exceeds the expected design, resulting in insufficient funds and financing difficulties for enterprises. The evaluation system is not perfect. Biodegradable plastics is a new industry, many materials and products developed, there is no product standards, to trade a lot of inconvenience and disputes. Therefore, countries should be legally clear biodegradable plastics in modern circular economy system, the status and importance to give strong support on policy, on the application and development of biodegradable plastic products subsidy policy, refine on tax preferential measures, and to set up special national development fund, lead into the various funds, to promote the development of degradable plastics industry. Relevant government departments assist enterprises and scientific research institutions in technological innovation and promote the research, development and popularization of mature technologies; Actively develop cheap and widely sourced raw materials, using mature technology and processing processes; In order to reduce the production cost, it is necessary to find efficient strains and low-cost media, develop the best fermentation process and molding process equipment. Strengthen investment in biodegradable plastics standards, testing technology and other aspects, improve product standards.

Figure 3: An illustration of a fully biodegradable plastic bag.

5 CONCLUSION

As policies continue to increase, it has gradually become a requirement that biodegradable plastics replace traditional plastics as logistics packaging. Relying on its environmental protection, energy saving, recyclability and other properties, biodegradable packaging perfectly conforms to modern people's green and environmental ideology, and also conforms to my country's sustainable development strategy, and its future market is very broad. Although the development of degradable plastics is not yet mature enough, and related technologies are not fully mastered, as the global demand for degradable plastics continues to expand, the degradable plastics industry will be forced to further develop and improve. The emergence of degradable packaging materials not only conforms to the development theme of green and environmental protection, but is also a new trend in the development of logistics packaging materials, and also has a profound impact on green logistics.

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