ISSN 2616-5880 Vol. 4, Issue 7: 38-43, DOI: 10.25236/AJMC.2023.040707

# Development Trend of Biodiesel in China

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***Abstract:*** *Biodiesel is a clean and renewable resource, known as "green diesel". With the development of two generations of technology, its quality is guaranteed and its performance is superior. It has been widely promoted and applied in European and American countries. At present, the capacity utilization rate of China's biodiesel industry is relatively low, with a production capacity of only 1.5 million tons in 2021, among which 1.2 million tons are exported to EU countries. Compared to the European Union and the United States, there is still significant room for development in China's biodiesel industry. Against the backdrop of the "dual carbon" strategy and a new round of rising prices in the petrochemical industry, it is urgent and realistic to vigorously develop biodiesel. This article proposes reasonable suggestions from the point of strengthening departmental coordination, improving fiscal and tax policies, and deepening publicity and promotion.*

***Keywords:*** *Biodiesel; Technological development; Market situation; Existing problems; Policy suggestion*

## 1. Introduction

In order to address climate change and promote high-quality economic development, China has proposed a "dual carbon" strategy, which aims to peak carbon dioxide emissions by 2030 and strive to achieve carbon neutrality by 2060. Biodiesel, with its excellent performance such as environmental protection, strong regeneration ability, high oxygen content, and sufficient combustion, is increasingly receiving attention from domestic and foreign governments and manufacturers. Against the backdrop of China's active promotion of the "dual carbon" strategy and the drastic changes in the international crude oil supply and demand pattern, it is of great urgency and practical significance to conduct in-depth research on the development trend and trend of biodiesel, and take measures to vigorously develop biodiesel.

## 2. Biodiesel technology and maturity level

Biodiesel is a renewable diesel fuel made from oil crops such as soybeans, rapeseed, cotton, palm, aquatic plant oils such as wild oil plants and engineering microalgae, as well as animal fats and catering waste oils, through ester exchange or thermochemical processes, which can replace petrochemical diesel. Biodiesel technology is not an emerging technology, with a history of over a hundred years. The technology is mature and stable, with guaranteed product quality and superior performance[1]. It has been widely applied and promoted in developed countries such as Europe and America.

Biodiesel was first proposed by German engineer Dr. Rudolf Diesel. He developed a new type of compression ignition internal combustion engine in 1892, using kerosene, peanut oil, and other fuels. After further research, the concept of biodiesel was proposed in 1893. In 1895, he began using animal or plant fats as raw materials to produce fuel for internal combustion engines through esterification reactions of alcohol compounds. After a series of theoretical research and practice, engines powered by peanut oil officially emerged in 1900.

Nowadays, the production technology of biodiesel has undergone two generations of development. The first generation of biodiesel is a type of fatty acid ester compound produced through ester exchange method using natural oils, including vegetable oils, animal oils, and microbial oils, typically fatty acid methyl esters. According to the characteristics of the reaction, it can be divided into acid or base catalyzed method, biological enzyme method, and supercritical method[2]. Currently, acid or base catalyzed method is commonly used. The first generation of biodiesel has certain drawbacks, such as poor long-term storage stability; Poor compatibility with the engine, narrow boiling range, and volume mixing ratio with

ISSN 2616-5880 Vol. 4, Issue 7: 38-43, DOI: 10.25236/AJMC.2023.040707

petrochemical diesel oil cannot exceed 20% -30%; The high freezing point and inability to use in areas with low temperatures limit its potential for use.

In order to improve the first generation of biodiesel, people have shifted their research focus to changing the molecular structure of carboxyl functional groups in oils and fats, removing oxygen-containing groups and transforming them into corresponding alkanes. Through isomerization, the pour point is reduced to improve its fluidity, gradually forming the second generation of biodiesel preparation technology with catalytic hydrogenation as the main technology, including hydrogenation catalysts and isomerization catalysts.

Currently, most hydrogenation and deoxidation catalysts have been developed based on hydrodesulfurization catalysts. Common catalyst active components include Mo, Ni, Co, W, Pt, Pb, Rh, Ir, Ru, and composite active metals. Common catalyst carriers are γ- Al2O3, molecular sieve, activated carbon, SiO2, Zr O2, Ti O2, etc. Different catalysts have different hydrogenation activities, reaction selectivity, and raw material adaptability. For example, using rapeseed oil as raw material, Ni, Mo, and 0.3NiMo (n (Ni): n (Mo)=3:7) loaded with Al2O3 were used in a fixed bed reactor. Under the conditions of reaction temperature of 260 ℃ -280 ℃, hydrogen pressure of 3.5 MPa, and mass space velocity (WHSV) of 0.25-4.00h-1, the experimental results showed that the activity order of hydrogenation deoxygenation was 0.3NiMo/Al2O3>Mo/Al2O3>Ni/Al2O3. The current representative domestic and foreign enterprise technology processes through hydrogenation deoxygenation catalysis are shown in Table 1. Isomerization catalysts mainly consist of precious metal catalysts, such as those prepared by Neste OiL Company using molecular sieves such as SAPO-11-$Al_2O_3$,, ZSM-23-$Al_2O_3$, and other Pt supported catalysts; UOP company and Italian Eni company use catalysts prepared by loading Pt on molecular sieves such as SAPO-11, SAPO-31, ZSM-12, etc[3]. The catalyst prepared by Topsoe Company using acidic support supported Ni-W is shown in Table 1.

*Table 1: Basic Technology for Producing Biodiesel with Hydrogenation Catalysts*

| Company | raw material | hydrogenation catalyst | reactor |
|---|---|---|---|
| Neste Oil | Vegetable oil, animal oil, waste oil | Ni/Co-Mo/$Al_2O_3$ | fixed bed |
| UOP+ENI | Soybean oil or crude tall oil | Ni-Mo,Co-Mo | fixed bed |
| Topsoe | Light gas oil | Mo/$Al_2O_3$,Ni-Mo/$Al_2O_3$ | fixed bed |
| Yigao Biotechnology | waste oil | Metal supported catalyst | Suspended bed |
| Trimeric environmental protection | Waste animal and vegetable fats and oils | Composite catalyst | fixed bed |

The second-generation biodiesel production technology has now matured, with most using fixed bed hydrogenation processes and a few using suspended bed hydrogenation processes. Representative commercial production processes abroad include the NExBTL (Next generation biomass to liquid) process of Neste oil in Finland, the Ecofining process of UOP and Eni, the H-BIO process of Petrobras, and the Haldor Topsoe process of Topsoe; Representative commercial production processes in China include the MCT-B process of San Environmental Protection[4]. The second generation of biodiesel has a structure and performance closer to that of petrochemical diesel. It uses waste oils as raw materials and uses suspension bed hydrogenation technology to obtain advanced biofuels through hydrogenation, deoxidation, cracking, and isomerization, which can achieve higher carbon emission reduction goals and achieve better oil quality. Its cetane number is high, sulfur content is low, density is low, stability is good, and low-temperature flowability is good. It can be added to petrochemical petroleum in a larger proportion, and can also be used to produce high-end solvent oil, bioplastics, bioplasticizers, bio wax oil, biomass additives, biosurfactants, and etc.

## 3. Advantages of biodiesel and corresponding policy guarantees

### *3.1 Analysis of the Advantages of Biodiesel*

Biodiesel is a clean and renewable resource, known as "green diesel". Its performance is very similar to that of petrochemical diesel, and it is a high-quality substitute for petrochemical fuels. Petrochemical diesel contains high components of harmful elements such as sulfur and benzene, which release harmful substances into the air during combustion, causing significant environmental pollution; However, the content of aromatic alkanes and sulfur lead in biodiesel is low, and the particulate matter content and CO emissions in the exhaust are about 20% of that of petrochemical diesel, respectively. After combustion, the harmful substances emitted can be reduced by 30% compared to petrochemical diesel. Under the catalysis of catalysts, the pollutant emissions of biodiesel can even be reduced by more than 60%.

ISSN 2616-5880 Vol. 4, Issue 7: 38-43, DOI: 10.25236/AJMC.2023.040707

According to industry testing data, 1 ton of biodiesel can achieve a carbon reduction of 2.83 tons[5]. In addition, the cetane number of biodiesel is higher than that of petrochemical diesel. The cetane number is an important indicator for judging the anti knock performance of diesel combustion. The higher the cetane number, the more complete the combustion and the better the anti knock performance. From the perspective of flash point, flash point is an important performance indicator of combustible gases, used to describe the minimum temperature at which the ignition source can cause a liquid to ignite. The flash point of biodiesel is higher than 100 ℃, which is much higher than that of petrochemical diesel. Therefore, the high flash point of biodiesel ensures higher safety during transportation, storage, and use than petrochemical diesel. In terms of lubrication performance, the magnitude of kinematic viscosity has important reference value for the judgment of liquid fuel flow performance. The kinematic viscosity of biodiesel is higher than that of petrochemical diesel, and its good lubricity ensures that biodiesel can greatly reduce wear and tear on machines during use, extend machine service life, and reduce production and maintenance costs[6]. The global distribution of petrochemical oil deposits is uneven, non renewable, and affected by geopolitical and other uncertain factors, resulting in poor safety and security. Biodiesel has a wide range of sources, including plant raw materials such as soybeans, rapeseed, jatropha, rubber seeds, as well as waste oils and fats from the catering industry, leftovers from oil mills, and waste animal fats. These renewable animal and plant resources provide a rich source for biodiesel production and can largely replace petroleum resources. In the current global production of biodiesel raw materials, genetically modified soybean oil accounts for 30%, double low rapeseed oil accounts for 25%, palm oil accounts for 18%, catering waste oil accounts for 10%, animal oil accounts for 6%, and other oils account for 11%[7]. It can be seen that genetically modified soybean oil, double low rapeseed oil, and palm oil are currently the main biodiesel raw materials worldwide.

### *3.2 Supporting Policies for the Development of Biodiesel Abroad*

Biodiesel, with its excellent performance, has alleviated the problems of oil resource scarcity and severe environmental pollution in various countries, and has become a target of vigorous development in various countries. At present, the main producing countries and regions of biodiesel attach great importance to the promotion and utilization of biodiesel. On the premise of implementing corresponding preferential tax policies, a quota system is established, and the goal of blending proportions is set and enforced to promote the development of biodiesel.

The EU aims to encourage the production of biodiesel by exempting it from 90% of taxes and proposing legislative support, differential taxation, and subsidies for oilseed production for alternative fuels. Before 2008, EU member states were exempt from tariffs on imports and exports of biodiesel, and imposed a 6.5% tariff on imports of biodiesel from other countries. The European Union passed the Biofuels Directive (BD) in 2003 and the Renewable Energy Directive (RED) in 2009. Two legal directives mandate the use of biofuels in the transportation sector, requiring renewable energy to account for 20% of energy by 2020 and 10% for the transportation sector. Subsequently, in the Renewable Energy Directive 2 (RED II) issued in 2018 and the Renewable Energy Directive (2021 Edition) issued in 2021, the EU was required to increase the overall share of renewable energy in total final energy consumption from 32% to 40% by 2030, the share of renewable fuels in final energy consumption in the transportation sector from 14% to 26%, and the greenhouse gas emission reduction target from 40% to 55%. At the same time, the sources of raw materials for biofuels are divided into two categories: the first category is traditional biofuels, including biodiesel produced from economic crops such as grain and oil; The second type is advanced biofuels, which use non grain as raw materials and are specifically divided into two types: PART-A and PART-B, with greater policy incentives. Further demands that EU member states no longer include palm oil biofuels in their renewable energy and climate targets, and that palm oil will gradually be completely phased out from the EU's raw materials for firewood starting from 2023; It is required that the proportion of bioenergy products using food crops as raw materials should not exceed 7%, the proportion of non grain and other advanced biofuels should be increased from 0.2% in 2022 to 2.2%, and the proportion of non bio based renewable fuels should not be less than 2.6%. For more sustainable biofuels such as biodiesel produced from "gutter oil", the "dual point" policy established by the Renewable Energy Directive (2018 version) can be implemented, which means using "gutter oil" to produce equivalent 1 liter of biodiesel and writing off 2 liters of traditional biodiesel (such as biodiesel from rapeseed oil)[8]. In the future, waste oil and rapeseed oil will replace palm oil as the main raw material.

The US Environmental Protection Agency (EPA) has also developed the Renewable Fuel Standards Program (RFS) to promote the use of alternative fuels, requiring US refineries to mix 20.09 billion gallons of renewable fuel in gasoline and diesel by 2020, accounting for 10.97% of the national

ISSN 2616-5880 Vol. 4, Issue 7: 38-43, DOI: 10.25236/AJMC.2023.040707

transportation fuel supply. The US Department of Agriculture announced in February 2020 that it will achieve a 15% blending rate target for biofuels in the transportation industry by 2030, driven by the market, and a 30% blending rate target by 2050.

### *3.3 Policies for Developing Biodiesel in China*

China's biodiesel industry started later than developed countries and regions such as Europe and America. In 2001, Hainan Zhenghe Bioenergy Co., Ltd. invested in the construction of China's first biodiesel factory in Wu'an, Hebei, marking the beginning of the industrialization process of biodiesel in China. Due to the small per capita arable land area and the need for a large amount of imported edible oil, China has embarked on a path of developing biodiesel with Chinese characteristics, mainly using waste oil as the main raw material.

Starting from January 1, 2006, China officially implemented the Renewable Energy Law of the People's Republic of China. Subsequently, the country successively introduced corresponding legal plans, industrial policies, fiscal and tax policies, and product standards to support the development of renewable energy, including biodiesel. Especially the promulgation of the Renewable Energy Law of the People's Republic of China revised in 2009 and the Biodiesel Industry Development Policy in 2014 played an important role in guiding and promoting the development of the biodiesel industry[9]. The Ministry of Finance and the State Administration of Taxation have issued multiple documents clarifying the preferential tax policies for biodiesel, and implementing exemption from consumption tax and a 70% value-added tax refund policy for biodiesel products that meet national standards. Compared to petrochemical diesel, each ton is equivalent to a tax reduction of approximately 1900 yuan. At the same time, the urban pilot work of "resource utilization and harmless treatment of kitchen waste" initiated by the National Development and Reform Commission has further brought new development opportunities for biodiesel enterprises.

In 2007, China's first biodiesel standard was "Biodiesel for Diesel Fuel Blending (BDl00)", which was based on the American Society for Testing and Materials standard ASTM D 6751-03a "Biodiesel for Distillate Fuel Blending (BD100). Although this standard serves as a blending component for biodiesel, biodiesel that meets this standard cannot be directly used as a fuel, but can only be used as a substitute for diesel after blending with petrochemical diesel. At the same time, considering that China's emission regulations are similar to those of the European Union, and diesel cars are increasingly valued, some indicators in the biodiesel standards have also appropriately referred to the relevant indicators and limits of the European Union standards. However, GB/T 20828-2007 lacks three main analysis indicators: phosphorus content, methanol content, and metal content. Therefore, in 2014, China changed the biodiesel standard to GB/T 20828-2014 "Biodiesel for Diesel Engine Fuel Blending". This standard is based on ASTM D6751-11b "Biodiesel for Distillate Fuel Blending" and includes control indicators and requirements for methanol, ester content, and monovalent metal (Na+K) content; Modified flash point and acid value indicators, and changed 10% residual carbon from steam residue to residual carbon indicator. The second revised biodiesel standard in 2015 added the content of monoglycerides, phosphorus, and divalent metals (Ca+Mg), and removed the S350 category from the classification. In 2017, GB25199-2017 "B5 Diesel" was issued, which replaced GB/T 20828-2015 and GB 5199-2015. In addition, provinces such as Yunnan and Guangdong, which are key areas of national development for biodiesel, have also formulated corresponding local standards.

## 4. Current Development Status of Biodiesel Market

### *4.1 Development of the Global Biodiesel Market*

The global production of biodiesel has grown from less than 10 million tons in 2006 to 42.9 million tons in 2020. In the past decade, the compound growth rate of global demand has reached 10%, and it is expected to reach 80 million tons by 2030. From the perspective of origin, the European Union is the world's largest producer of biodiesel, accounting for approximately 30% of its production; Indonesia is the world's largest producer, accounting for approximately 19% of production. From the perspective of raw material structure, palm oil is the largest source of biodiesel, accounting for about 39%, while soybean oil and rapeseed oil account for 25% and 15% respectively. The production of biodiesel from waste oils only accounts for 10%. From the perspective of consumption regions, it is mainly concentrated in Europe, the Americas, Southeast Asia and other regions, with European biodiesel consumption accounting for 47% of the global total consumption.

ISSN 2616-5880 Vol. 4, Issue 7: 38-43, DOI: 10.25236/AJMC.2023.040707

### *4.2 Development of Biodiesel Market in China*

Biodiesel in China mainly uses waste oil as the raw material. At present, the collection and utilization of gutter oil in China is about 2.4 to 3 million tons/year, of which about 700000 tons/year are used to produce biodiesel. On average, 12000 tons of gutter oil can produce 1 ton of biodiesel. In 2021, China's biodiesel production was approximately 1.5 million tons, a year-on-year increase of 16.8%; Export of approximately 1.1 million tons, a year-on-year increase of 18.0%, almost all of which are exported to Europe. Since 2021, the price of domestic biodiesel has increased from 7000 yuan/ton to 10500 yuan/ton, with an average annual selling price of 8900 yuan/ton, a year-on-year increase of 35.2%; The average export price has increased from $1050/ton to $1572/ton, with an average annual selling price of $1340/ton, a year-on-year increase of 9.0%. According to data from Zhuochuang Information, since the second half of 2021, the average profit of biodiesel has been 972 yuan/ton, an increase of 101.7% year-on-year and 143.3% month on month. Currently, the profit per ton is around 1200 yuan/ton. The increase in profit per ton can greatly stimulate manufacturers' enthusiasm for production. At present, the main enterprises producing biodiesel are private enterprises, mostly distributed in provinces and cities such as Hebei, Hubei, Shandong, Sichuan, Zhejiang, Chongqing, etc. The largest production is in Hebei, followed by Fujian and Zhejiang.

## 5. Suggestions for Developing Biodiesel in China

The future prospects of China's biodiesel market are broad. One reason is that there is still a significant gap in China's current production compared to advanced countries. In 2020, the global level of biodiesel production and sales remained stable, reaching 46.8 billion liters. The European Union, Indonesia, the United States, and Brazil are the main biodiesel production areas, accounting for 31%, 17%, 15%, and 14% of the global total production, respectively, while China only accounts for 2%. The second is that the EU policy adjustment will bring significant benefits. Biodiesel in China is mainly processed from discarded animal and plant fats, and is mainly exported to the European Union. The Renewable Energy Directive issued by the European Union in July 2021 points out that not only should biodiesel be vigorously developed, but also the raw materials for biodiesel should be improved, limiting grain crops and palm oil, and encouraging the use of waste fats and rapeseed oil. According to the calculations of the European Union Environmental Protection Commission, by 2030, the annual UCOME firewood shortage in the EU will reach 3-3.3 million tons. Thirdly, China needs to change the situation of high dependence on foreign oil. In 2021, China imported 513 million tons of crude oil, with an external dependence rate of up to 72%. Such a high import volume and external dependence will bring significant risks and hidden dangers to China's energy security.

At the same time, it should also be noted that the development of biodiesel in China still faces multiple constraints. One is a technical issue. Although multiple companies in China have achieved industrial production of biodiesel, there are generally problems such as low production capacity, high energy consumption, and low quality. Most enterprises adopt fixed bed processes, and fixed bed catalysts are easily affected by metal ions, reaction coking, and other factors, making it difficult to achieve long-term operation; At the same time, bio fats themselves have seasonal and regional differences, and their properties are unstable. Fixed bed technology requires high stability of raw material properties, so a large amount of material and financial resources need to be invested in the early stage of raw material pretreatment to ensure the stability of the feed. In addition, the recovery of esterification products is difficult and costly, and the waste acid and alkali generated during the generation also have secondary pollution. The water and free fatty acids in the raw materials can also seriously affect the production and quality of biodiesel. The second is economic issues. Related studies have shown that in the preparation cost of biodiesel, the raw material cost accounts for about 75%. China mainly develops biodiesel based on waste oils and herbal oils (excluding edible ones), but the insufficient supply of raw materials has led to high prices of biodiesel. Not only in China, the production cost of biodiesel (with a conversion rate of approximately 0.9) worldwide is generally higher than that of petrochemical diesel (the export price of Sinopec diesel in 2019 was $574.4 per ton). The third is the issue of supporting policies. The National Energy Administration issued the "Biodiesel Industry Development Policy" in 2014, but due to the lack of relevant implementation rules, the implementation of the policy is difficult. At the same time, the scale of biodiesel production enterprises in China is generally small, making it difficult to obtain qualifications for blending and sales according to the 500000 tons/year production scale required by the "Management Measures for Finished Oil Market". In 2015, the Ministry of Finance issued a policy on value-added tax for biodiesel production enterprises, which was adjusted from 100% first collected and then refunded to 70% immediately collected and refunded; In 2017, the national tax system gradually implemented the

ISSN 2616-5880 Vol. 4, Issue 7: 38-43, DOI: 10.25236/AJMC.2023.040707

reform of business tax to value-added tax, making it difficult for biodiesel enterprises to obtain raw material input invoices. In addition, there is a lack of subsidies and inclusion in carbon trading policies.

Against the backdrop of the "dual carbon" strategy and the new cycle of rising prices for petrochemical oil, facing the severe situation of over 70% dependence on foreign oil, China should effectively improve the development of biodiesel. The key is to focus on the "two limits": firstly, to restrict the flow of gutter oil, which can only be collected, transported, and processed by qualified enterprises; The second is to limit prices. The government's price management department, in conjunction with the catering industry association, has proposed guidelines and maximum prices for gutter oil to prevent it from flowing to profiteering ends and ensure the supply of raw materials for biodiesel production enterprises. Through pilot projects, petrochemical enterprises are required to purchase biodiesel indicators for carbon trading. Fourthly, government funds are leading the establishment of an equity investment fund for the biodiesel industry to support leading enterprises in mergers and technological innovation.

## 6. Conclusions

At present, China's biodiesel is mainly exported, and the proportion of domestic consumption is very low. The policy support for promoting biodiesel in various countries around the world mainly includes mandatory consumption ratios or quantities (unified market

Liberalizing prices, financial subsidies, and controlling the entire industry chain. At present, China has certain basic conditions for promoting the application of biodiesel, such as Shanghai, which has started promoting the use of diesel. It is recommended to continue promoting pilot work and support 3-5 leading biodiesel production enterprises to obtain the qualification for product oil sales. By utilizing channels such as television, newspapers, and the internet, we will increase the promotion of the principles, technological maturity, product quality, and superior performance of biodiesel, in order to increase consumer recognition of biodiesel.

## Acknowledgments

This work was supported by grants from institute-level scientific research projects of Nanjing Vocational Institute of Transport Technology (No:JZ2018), high level Scientific Research Foundation for the ntroduction of talent in Nanjing Vocational Institute of Transport Technology and college Student Innovation and Entrepreneurship Project in Jiangsu province, China (No:202112804028Y) .

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