

BIOPLASTIC CONTRIBUTION IN THE PLASTICS INDUSTRY AND ITS ECONOMIC DEVELOPMENT

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ABSTRACT

Leo Baekeland American - Belgium chemist, formulated and synthesized Bakelite, it had been considered the gift to the society and solution to the many problems. But later on, overuse, imprudent use of the plastics material created the turmoil on the blue planet thereby creating environmental pollution deteriorating the balance of atmosphere. A micro plastic becomes the major threat to the soil contamination, pollution. Over the period of time demand of plastics materials is increasing because of growing population and increased standard of living. Therefore, there has been tremendous research work is in process to generate material i.e., bioplastic which would be appropriately substitute to the present crude oil-based conventional plastics material. Bioplastic have been accepted worldwide because bioplastic is generally environmental; friendly, harmless materials and ultimately in all aspects it has become the need of the time. National governments, policy makers are supporting bioplastic material. This paper reveals the role of bioplastic in the market thereby its economical contribution in the plastic industries. In the world, bioplastic contribution was estimated USD 11.2 billion in 2021 and is increasing gradually will reach around USD 46.1 billion by 2030, CAGR registered of about 17.2% between 2022 to 2030.

Keywords: - Economy, crude oil, bioplastic, environment, market.

INTRODUCTION

Economic development of bioplastic in term of its contribution in the plastic industry. There has been found out a paradigm shifts towards climate change and related attribute [1]. However, in this scenario majorly one of them attribute is found out be a crude oil-based conventional plastic and its leaving behind its carbon footprint and its microparticles everywhere on the blue planet. In this research paper, focus has been kept on the bioplastic, bioplastic would be the great option for crude oil based conventional plastic. In terms of economic development, it is a continuous process of generating and using human, financial, physical and social assets to enhance their economic well-being thereby improving quality of life for society or nation. Therefore, without compromising the quality of life with keeping in mind the goal of “sustainable development”. On every front from economic well-being, employment to the environment sustainability bioplastic found out to be a best solution to the many problems faced by the community in the present scenario [2]. Bioplastic capturing the plastic market at considerable rate, it is happening because of public paradigm shift towards climate change. As a consequences of bioplastic development every section of the community is being benefitted especially farmers and off course it is kind of evolution on the blue planet [3].

HISTORY OF THE CRUDE OIL-BASED PLASTIC

History of the crude oil-based plastic is very interesting to know. It reveals many facts and figures that can be useful for the policy makers, researcher and national governments for their profound work in the field of plastics [4]. There was need of plastic material to replace conventional material such as wood, metals. It was the time when it is considered as the solution for many problems but in the last 60 years of time span plastics industry grown in every dimension and becomes the major part of economic development. The main inventions in the industry of plastics taken place between the World War 1 and World War 2, cellophane had been formulated and synthesized in 1913, then polyvinyl

chloride had been formulated and synthesized in 1927, polystyrene and nylon had been formulated and synthesized in 1938, and polyethylene had been formulated and synthesized in 1942. Plastics are the part of our daily life from simple articles to most sophisticated object. In era of 1950 and 1970, production increased 20 times to more than 25 million metric tons. At the same time, there was attention in the West countries such as 8.1 million metric tons in the only United States of America, 4.1 million metric tons in Japan and England, 1.4 million in the United Kingdom, France and Italy. Union of Soviet Socialist Republics still the world's second largest economy – manufactured only 1.46 million metric tons. During these robust and flourishing years, when the Western countries felt and suffered the Depression of wars, plastics enter efficiently into our everyday routine lives. An Americans standard of living status symbol “American way of life”, such as Tupperware very first introduced in year 1946. The first plastic draining rack was molded in early 1950 by Italian chemist. In the France the plastic bottles had introduced in the year 1968. The world produced 60 million metric tons of plastic in the year 1980. The production of plastics reached 188 million metric tons, then in 2010 it had gone to 266 million tons in 2010 and in year 2017 348 million metric tons. The average growth of plastics is at the rate of 8.5% per annum. In the year 1950 it was 1.5 million metric tons. In the present situation one third of world plastic production is controlled by chine only. Since year 1949, total 8.4 billion metric tons of plastic have been produced in the world market. In a year 2018 study revealed by the International Energy Agency is that production of around 600 million metric tons of plastics by the center of the century [5].

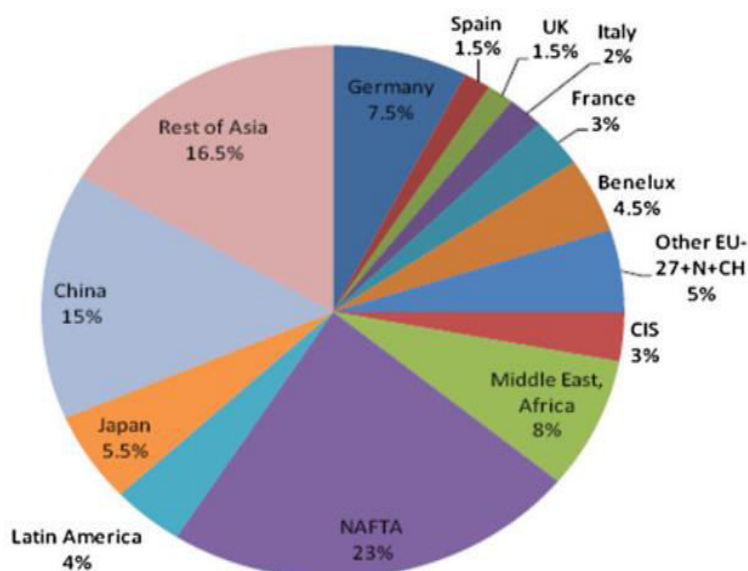


Fig 1.1 Worldwide distribution of crude oil-based plastic production

If we observe trend of using plastic is generally based on applications. Automotive sector is found out be dominating because the plastic product reduces the weight i.e., density ration and thereby vehicle emission. Other sectors such as electrical and electronics, consumer product, packaging, construction and other cutlery like products.

The main market controller of Conventional plastics / crude oil-based plastic market: -

- 1) BASF SE belongs to Germany,
- 2) Covestro belongs to Germany,
- 3) Solvay S. A. belongs to Belgium,
- 4) Celanese Corporation belongs to U.S.
- 5) Du Pont de Nemours and Company belongs to U.S.

- 6) LG Chem Ltd. belongs to South Korea,
- 7) Saudi Basic Industries Corporation belongs to Saudi Arabia,
- 8) Evonik Industries AG belongs to Germany, Lanxess AG belongs to Germany,
- 9) Mitsubishi Engineering-Plastics Corporation belongs to Japan.

Thus, Conventional plastics / crude oil-based plastic has created havoc result is climate change. Climate change has been considered to major threat to the blue planet and for this situation crude oil-based plastic is responsible. Crude oil-based plastic has been creating tremendous pollution much greater than pesticides and fertilizers around the world [6]. It is very difficult to remove micro-plastic from the soil, researcher have forecasted that it may takes more time and could be found major Challenge to coming generation.

Following are the main commercial plastics and their classification based on biodegradability: -

Types	Petrochemical based/ crude oil-based plastic	Partly bio-based	Bio-based
Non-biodegradable	PE, PP, PET, PS, PVC	Bio-PET, PTT	Bio-PE
Biodegradable	PBAT, PBS(A), PCL	Starch blends	PLA, PHA, Cellophane

Table 1.1 classification of plastic based on biodegradability

BIOPLASTIC

May help to reduce catastrophe created by crude oil-based plastic on the blue planet. There are various companies these are carrying out intensive research and development work to innovate and develop new efficient bio-based products [7]. A human now realizes that environmental sustainability can never be compared at the cost of performance. That’s why researcher is adamant that, along with our materials meeting the industry standards for biodegradability, researcher also made sure they’re heat-resistant, of comparable strength with alternative materials and there should not be any major manufacturing hurdles. Bioplastic are made up of bio-based materials that meet industry standards specifically tolerant to heat conditions ranging from moderate to high. There is rare combination of strength, rigidity, flexibility and pliability like properties has been revealed. Bio-based material in European standard it is EN 16575 which is derived from biomass. Bio-based material is also called as renewable feedstock. It is 7th green chemistry principles. The petrochemical based means which is completely derived from petrochemicals such as examples PE, PP, PET, PS; PVC bioplastic material which has been completely broken down by microorganism is generally called as biodegradable plastic materials [8].

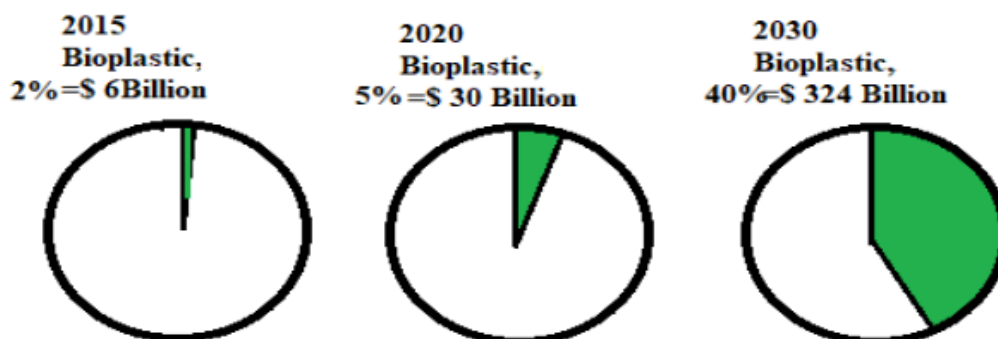


Fig 1.2 World Bioplastic market

The main market controller of bioplastic / bio-based plastic market: -

- 1) Plantic Technologies Limited Altona, 3018, Victoria, Australia
- 2) Mitsubishi Chemical Holdings Corporation (Japan)
- 3) DuPont de Nemours, Inc. (U.S.)
- 4) PTT Global Chemical Public Company Limited (Thailand)
- 5) FUTERRO SA (subsidiary of Galactic Group)
- 6) Biome Bioplastics Limited (subsidiary of Biome Technologies plc)
- 7) Total Corbion PLA (Netherlands)
- 8) BASF SE (Germany)

In the Food packaging, disposable cutlery and other single-use articles which associated with food and other perishable products is a particular target for compostable plastics. Product applications for bioplastic are not just confined to condition where they are single-use or disposable [9]. In some cases, biodegradability lends a product a distinct functional advantage. This is often true in gardening and agricultural applications where a product may need to lend short-term support or to act as a temporary barrier [10]. Mulch films and plant pots are examples of such products. There are some common companies, these companies have initiated to produce bioplastic, government and company management have mutually taken decision keeping market sentiments in their mind that bioplastic is the first preference over crude oil-based plastic [11].

Starch [$\text{amylum (C}_6\text{H}_{10}\text{O}_5)_n + (\text{H}_2\text{O})$]: Are an organic compound, polymeric carbohydrate, chief source and part of human foods. Starch is easily available, abundant in quantity and inexpensive. The starch is main ingredient of bioplastic and it is produced from food crop such as maize, corn cassava, wheat, rice, potato etc. Starch is a polysaccharide containing glycoside bond and is made up of a D-glucose unit linked in a long polymeric chain. Two major components of the starch structures are amylose and amylopectin, amylose possesses linear chain of glucose monomers and amylopectin possesses highly branched chain of glucose monomers. Starch is available in the form of white powder [12]. Starch is basically sensitive to the water molecules highly brittle and possesses low thermal, mechanical properties but these properties can be reduced by hydrophobic modification Acetalization of starch i.e., addition of plasticizers and impregnation of suitable ingredients. Starch has unique qualities due to its structure, chemical formula $(\text{C}_6\text{H}_{10}\text{O}_5)_n + (\text{H}_2\text{O})$, it is tasteless, odorless, white in color, when mixed with water forms a white paste which can be used as a gluing agent, thickening agent and mostly it has been used in paper industries. It is degradable, environment friendly; harmless, nontoxic and for degradation it takes its own time period subject to working conditions. Starch molar mass is variable subject to formulating conditions [13]. Starch auto ignition temperature is almost 4100 Celsius. Starch is the chief source of biomass or biofuels such as ethanol. It is also used in the manufacturing of beer, whiskey. Starch contains different proportional ratios of amylose and amylopectin ranges from about 10–20% amylose to 80–90% amylopectin and it completely depends on the source. Amylose is generally soluble in H_2O and forms a helical like structures [14].

APPLICATIONS INCLUDE

- 1) Packaging for food stuffs and other perishable products
- 2) Single use articles.
- 3) Especially in organic waste containers
- 4) Agricultural, Gardening and other applications
- 5) A wide range of variety of injection-molded articles
- 6) Coating Sheets and Film applications [15]

In the food packaging applications starch-based film has a drawback of smell becomes the problem emitted by starch-based coating film, researcher suggested to inculcate the oil during formulation of

starch-based Bioplastics because oil has antiseptic, antifungal properties particularly clove oil. Starch is susceptible to moisture and humidity, possesses poor mechanical properties, thermal stability and has lacks in physical characteristics such as low softening point, fragile structure, and brittleness. However, if it is being inculcated with plasticizers, lubricants, biopolymers and essential fillers, the mechanical and chemical characteristics of starch-based biopolymers can be enhanced. Furthermore, to raise the properties, advanced research has been conducted to use nano-materials, nano-reinforced materials [16]. Once it is inculcated with natural or synthetic polymers, starch-based bioplastic has huge demand and applications in food packaging sector, biomedical and pharmaceutical industry. Because of awareness Starch-based coatings on fruits and vegetables has been considered a good practice and become popular. Because it protects the flavor, moisture and decreases the ripening /rotting.

Cellulose ($C_6H_{10}O_5$)_n: Research work shows that cellulose would be the major part of the Bioplastic materials. In nature or earth cellulose is most easily available and abundant in quantity biomass. Cellulose is a homo-polymer polysaccharides organic compound. Its structure consists of a β (1→4) linkage. It is thermoplastics in nature. It is transparent, amorphous, fairly rigid thermoplastics. It has glossy finish, reasonably chemical and UV resistant. Generally it is available in the white color. Density is almost 1.5 g/cm³. Molecular Weight/ Molar Mass: 162.1406 g/mol and melting point 250^o Celsius to 260^o Celsius [17].

COMPARATIVE STUDY

Bioplastic is being utilized in various sectors such as packaging, consumer goods, Agriculture, Textile, building construction and others. Even with a minor fall in plastic production worldwide, the market for bioplastic has been evolved gradually. This type of growth is being accelerated by rising demand of more sophisticated applications-based products. Worldwide bioplastic manufacturing capacity are expected to increase from approximately 2.42 million tons in 2021 to over 7.59 million tons in 2026, according to the most recent market statistics data collection and evaluation in collaboration with the nova-Institute [18]. Subsequently, for the first time, the percentage proportion of bioplastic globally manufacturing will surpass by 2%. Packaging will continue to be the largest bioplastic market category, accounting for 48 % (1.15 million tons) of an entire bioplastic market in 2021. However, the applications of a portfolio continue to diversify. With increasing functional polymer capabilities, segments such as automotives and transportation and building and construction continue to increase [19].

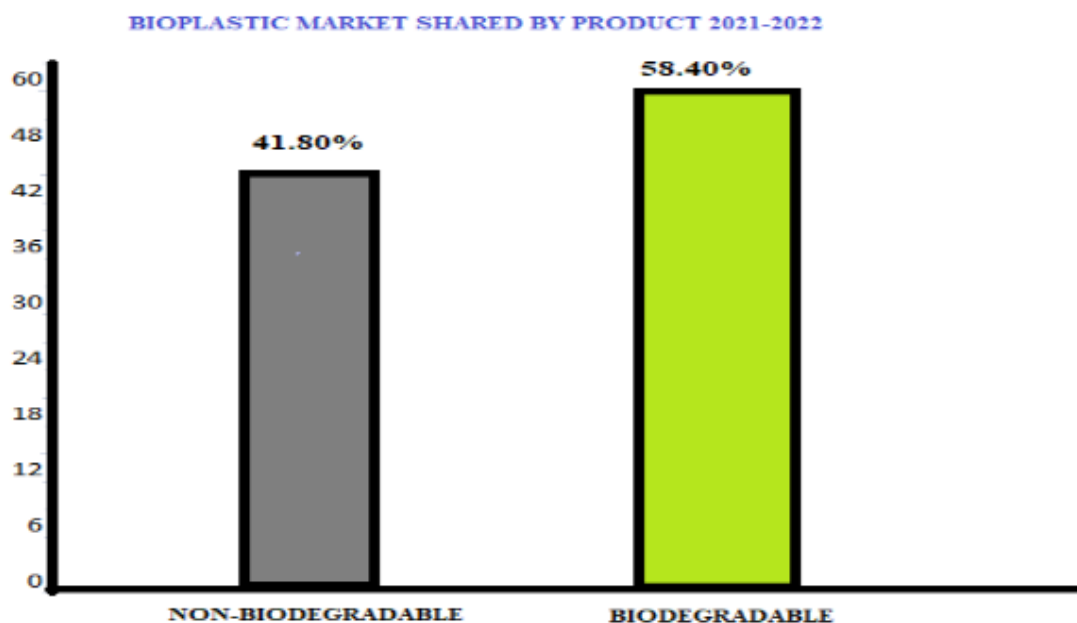


Fig 1.3 Bioplastic market shared by product in 2021-2011

Packaging application is more dominating which account for the 63% of revenue

Regions	Revenue share in 2021-2022
North America	28.40 %
Asia pacific	19.60 %
Europe	24.50 %
Latin America	5.0 %
MEA	3.50 %

Table 1.2 Revenue share region and year wise.

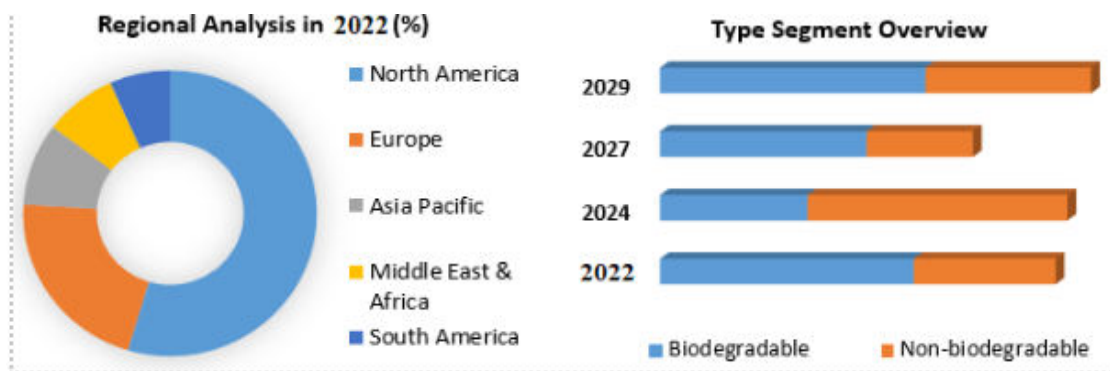


Fig 1.4 Worldwide production of bioplastic and crude oil-based plastics

Plastics and packaging is major product of European union Commission's for the "Circular Economy Action Plan," which has released in spring 2020 and it is a part of the "Green Deal." To combat the garbage creator society thereby minimize the waste, The European union Commission has planned and executed a plastic tax, limitations and control on micro plastics, and encouragement of plastic recycling. A new "framework law for bio-based, biodegradable, and compostable plastics" is being in placed at the end of 2021, Biobased plastics should be utilized if they provide actual environmental benefits over fossil plastics and do not conflict with food production [20].

Data collection / Report	Details / Evaluation
Market size in 2022	USD 13.11 Billion
Market size by 2030	USD 46.1 Billion
Growth rate by 2022 to 2030	CAGR of 17.02%
Base period	2021
Forecast period	2022 to 2030
Segments covered	Product, Application and Geography
Companies mentioned	TEIJIN LIMITED, TORAY INDUSTRIES, INC., Toyota Tsusho Corporation, Avantium, PTT MCC Bio-Chem Co., Ltd., A Phat Holdings, NatureWorks LLC, SABIC, BASF SE, Futerro, Trinseo S.A., Braskem, Total Corbion PLAIR, SUPLA (JIANGSU SUPLA BIOPLASTICS CO., LTD.), Solvay.

Table 1.3 Bioplastics Market size, Growth report, 2022 – 2030

Market size and growth rate can be evaluated using the data thereby one can understand the profound importance of bioplastic.

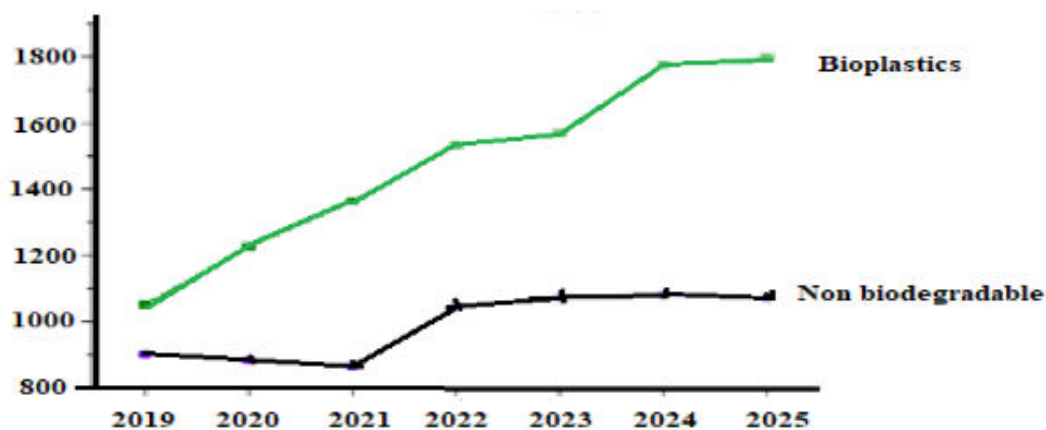


Fig 1.5 Trend set up for Bioplastics

Continuous fluctuation of crude oil prices has no effect on bioplastic production and expansion. The bioplastic reduces the carbon footprints approximately by 42.1%. Hence, key manufacturer in the market such as Ford, Nestle, Nike, and Coca-Cola are encouraging research and development work in the manufacturing of bioplastic for capacious, broad range of applications [21]. Bioplastic is also a best material for organic farming; it does not have toxicity, readily decomposable, eco-friendly [22].

RESULT

The contribution of Bioplastics has been increased and it is being increasing. This research work showing the result that comparative contribution and share of bioplastic and conventional plastic in whole plastic market. The demand and supply ratio of plastics is raising its number due to exponentially increasing population; comfortable human's lifestyle required various plastics product from simple daily used article to super advanced electronic gadgets. People are not ready to compromise their comfortable lifestyle by sacrificing crude oil-based plastics due to its carbon footprint but they may have optionally selected the bioplastic. Therefore, I would like to share my view through this paper bioplastic would be the solution for problem created by conventional crude oil-based plastic materials. The bioplastic has shown the result therefore its demand is in full swing in the market. it is estimated that in comparison to plastic. This paper reveals the role of bioplastic in the market thereby its economical contribution in the plastic industries. In the world, bioplastic contribution was estimated USD 11.2 billion in 2021 and is increasing gradually will reach around USD 46.1 billion by 2030, CAGR registered of about 17.2% between 2022 to 2030.

CONCLUSION

It has been understood that the bioplastic contribution or share has been increasing generously in the plastic market thereby considering the present and future demand of the bioplastic due to its awareness among people and that the sense of responsibility towards environment and climate change. Therefore, it is gaining continuous momentum throughout the developed and developing countries that conventional plastic is leaving behind carbon footprint which is difficult to eradicate from the environment and it would take many years for coming generations. Therefore, there is need of tremendous research & development work on the formulation and synthesis of bio-based plastics, which would be ultimately considered as the environmentally friendly, harmless to the ecosystems and may be appropriately substitute to the conventional crude oil-based plastic materials. Bioplastic development has been supporting directly to the farmers in terms of their economic development thereby accelerating their hopes for prosperous lifestyle. The basic ingredients required for the production of Bioplastics are starch, cellulose and glycerol. The maize or potatoes are in full demand for production of starch. Demand and supply of the food grains required for the production of bioplastic has been balanced with the food grains required for the people, care has been taken that food grain price should not increase and their scarcity should not happen due to production of

bioplastic. Furthermore, Continuous fluctuating crude oil prices does not impact, influence directly on production of bioplastic.

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