# BIOPLASTIC PRODUCTION FROM LIGNOCELLULOSIC BIOMASS TOWARDS SUSTAINABLE FUTURE IN MALAYSIA

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## INTRODUCTION

Plastic usage has ultimate number of consumers globally in every sector. In line with the expanding market demand for eco-friendly green products that have been strongly advocated as alternatives to petroleum-based products had leave the big impacts to many industrial sectors and Malaysia is no exception to it (Mohd Yusof et al., 2015). Based on report by Malaysian Plastics Manufacturers Association's (MPMA, 2016) data, the major market segments for plastic product is in packaging area with 45% while electrical and electronic is 26%, automotive 10%, construction 8%, 5% for household, and the remaining is in other industries. Currently, the Ministry of energy, science, technology, environment, and climate change (MESTECC) has put a lot of efforts to ensure that Malaysia would reduce the usage of plastic especially single-use plastic which cannot be reuse once after use. The single-use plastic products are widely utilized in packaging area as a product plastic wrapper, food packaging as well as carrier shopping bag and so on. Most of plastic materials are made up from petroleum-based known as a non-renewable fossil fuel with huge carbon footprint that leads to the global climate change due to carbon emissions. Environmental awareness has increased tremendously in recent years due to many environmental issues involving animals extinction caused by non-biodegradable plastic disposal into the landfills and in natural habitat like marine debris issues, physical problem to wildlife such as entanglement with plastic besides potential chemical transfer to wildlife (Pei & Schmidt, 2011).

An uprising number of policies and national strategies of implementation as well as development of a bio-based economy have emerged in many countries such as US, EU, Australia, Canada, Sweeden, Malaysia and others since 2008. The policies and strategies are more striving towards eco-efficient and sustainable transformation of natural resources into energy, food or other industrial products (Mohd Yusof et al., 2015). Since Malaysia is listed as the second largest oil palm biomass (OPB) resources producer, it is a great opportunity to employ OPB into bio-based products in order to cater the issues regarding the non-biodegradable plastics. Hence, the replacement of conventional synthetic plastics with biodegradable bioplastic (BP) is one of the good alternatives. BP can refer as i) synthetic biodegradable polymers, e.g. PVA, PBS and PCL; 2) conventional plastics; 3) bio-based, non-biodegradable plastics like polyamides and bio-based PE; 4) bio-based and biodegradable plastics like starch acetate, PLA and PHA. The latter would be a great candidate with amazing properties. Therefore, the focus is more towards polyhydroxyalkanoate (PHA) production from OPB to produce sustainable and eco-friendly BP.

## LIGNOCELLULOSIC BIOMASS

Lignocellulosic biomass is one of the most natural renewable and available resources in almost every country. Major component of lignocellulosic biomass is cellulose which considered as the strongest promising alternative for petroleum-based polymers due to its environmentally friendly properties such as biodegradable, biocompatible as well as renewable besides it is the most abundant resources in the earth. Lignocellulosic biomass also known for its carbon-neutral property that capable to reduce emission of atmospheric pollution and CO2. Based on previous studies, it also has substantial potential for sustainable production of fuels and chemicals. Even from the economic point of view, a lot of lignocellulosic biomass can be produced or growth quickly and cheaper compared to other agricultural feedstocks like soybean, corn, sugar cane, and starch (Isikgor & Becer, 2015).

Malaysia is often known as one of the largest cultivator or contributor for oil palm *(Elaeis guineensis)* plants besides Indonesia with approximately 5.4 million hectares of plantation area (Chiew and Shimada, 2013). The high global demand of oil palm leads to explosive expansion of oil palm plantation which increase the production of lignocellulosic biomass, namely, oil palm trunk (OPT), fronds (OPF) and empty fruit bunch (OPEFB) which expected to reach 110 million tonnes by year 2020 (Wan Rosli et al., 2017). The increasing of oil palm plantation

resulted in the increment of oil palm mill. Malaysia is now among a top world's oil palm exporter for numerous oil palm-based production in line with the large plantation areas and enormous numbers of oil palm mills. As reported by Kong et al. (2014), only about 10% of oil palm produced as oil extraction, while the remaining 90% left as biomass waste. It would be tremendously wasted if this biomass is not exploited to its fullest. This data showed that, the oil palm industry can create many opportunities and social benefits for the locals. In recent years, green, renewable, sustainable, biodegradable, and environmentally friendly materials are receiving explosive interest from both scientific and industrial communities due to several drawbacks from conventional sources such as ecological treats, finite supply and non-renewable petroleum-based sources for bio-based products applications. Cellulose, a biopolymer, which in recent decades have develops into promising value-added end-products (Abdul Khalil et al., 2014; Kargarzadeh et al., 2017).

## BIOPLASTIC DERIVED FROM PHA FROM OIL PALM BIOMASS

Commonly, polymers are produced from petrochemical derivatives which generate large amount of wastes that hard to be treated or dispose. Therefore, a lot of efforts in searching for other potential candidates have been done which particularly focus in eco-friendly material that leads to biopolymer referring to polymer materials derived from renewable biomass resources. Biopolymers also known as bioplastics (BPs) are suitable candidate to replace common polymer due to it physicochemical properties similar to those petroleum-derived material. It is more environmentally-friendly compared to normal polymer due to its biodegradability (Boneberg et al., 2016). As aforementioned, not all BPs are biodegradable. Table 1 shows the commercialize bioplastics and biodegradable plastics. Unlike starch-based polymers and chemically synthesized polymers, PHA is more favorable as its environmentally-friendly, biodegradability and sustainability properties (Khanna & Srivastava 2005; Salehizadeh & Van Loosdrecht, 2004).

**Table 1.** Types of bioplastics and biodegradable plastics

| | Biodegradable | Non-biodegradable |
|---|---|---|
| **Bioplastics (BPs)** | - Polyhydroxyalkanoate (PHA)<br>- Polylactic acid (PLA)<br>- Starch-based plastics | - Polyamide 11 (PA11)<br>- Bio-derived polyethylene |
| **Petroleum-based plastics** | - Polycaprolactone (PCL)<br>- Polyesteramide<br>- Polybutylene succinate adipate (PBSA) | - Polypropylene (PP)<br>- Polyethylene (PE)<br>- Polyethylene terephthalate (PET)<br>- Polystyrene (PS) |

Source: Hassan et al. 2013

PHA is naturally accumulated in bacteria through fermentation with materials like sugar, vegetable oils or industrial waste in culture medium and also 100% biodegradable polymer. It is produced under imbalanced growth conditions by bacteria and some of the bacteria are able to produce PHA up to 90% (w/w) of dry cells. Simple fermentation method is utilized in commercial production of PHA to fulfill the BPs criteria. The common industrial microbes that have been used in the process are *Aeromonas hydrophila, Alcaligenes latus*, Recombinant *E.coli*, *Pseudomonas putida*, and *Bacillus* spp. (Varsha & Savitha, 2015). The PHA production cost is expensive compared to synthetic plastics (PE & PP). The carbon substrate contributes almost half in PHA production price. Therefore, renewable biomass material as a carbon source will be an excellent alternative in reducing the PHA production cost substantially and capable to minimize the industrial waste disposal cost (Hassan et al., 2013). Previously reported by Reddy and co-workers (2003), the OPB and its related products are suitable as substrates for PHA production by a different of PHA producers which at least from 75 variety genera has been listed. For OPB, the regular component that always been used are pall oil mill effluent (POME) and OPEFB which are the most abundant residues for OPB. POME will undergo anaerobic treatment to produce organic acids which become a carbon sources for PHA production in bacterial cells (Hong et al., 2009). While, there are two types of pretreatment for OPEFB which are acid hydrolysis and enzymatic saccharification to convert OPEFB into fermentable carbohydrates and subsequently turns it to fermented broth via microbial fermentation, hence it is viable for PHA production. Both of these methods could be an effective way to dispose the POME and OPEFB residues instead of being discharged into the environment as a harmful wastewater or being burned without proper usage, respectively, which will cause greenhouse gas emission (Hassan et al., 2013).

## GLOBAL MARKET CHALLENGES IN BIOPLASTIC INDUSTRY

BPs worldwide market is mostly in packaging sector which gradually growth to date. In recent year, with a soaring price in natural gas and crude oil indirectly cause an increment in petroleum-based plastics price. Thus, bio-based plastics are one of the promising alternatives to replace petroleum-based plastics. The most challenging in developing a sustainable BPs industry is that of price competition. Even in the high rank country like United State cannot give lower than five folds prices compared to common thermoplastics. BRICs countries or

known as Brazil, Russia, India and China countries are emerging countries where the BPs sectors get a higher demand due to their changing lifestyle, increasing foreign investments in pharmaceutical industry, growth of domestic electronics as well as food and beverage industries which amplifies the market interest for BPs packaging. While in Europe countries, the government has set a few policies like Europe 2020 strategy that promote bio-economy. This policy has reduces taxes for bio-based products and encourage public authorities to support preference towards procurement of bio-based products (Ahmad Saffian & Abdan, 2015).

As some of developing countries like Thailand, Indonesia and Malaysia are putting more efforts in BPs industry and try to improve in terms of its quality and production cost with utilization of renewable biomass. A lot of countries get the government support with this eco-friendly replacement via various types of fund in order to generate a better product and raising awareness among the private sectors and public users. Moreover, oil palm industry will break the country's dependence on fossil fuel. Usually, as fossil fuel cost increase, a substantial proportion of the products related to it will also increase. Unlike the fossil fuel-based products, BPs which is from non-fossil fuel will not be related to fluctuation of the market price like conventional synthetic plastic. The generated bio-based BPs will decrease the dependence on fossil fuel. Thus, automatically can preserve and balance our minerals source in earth. However, the overall cost for commercialization will involve many factors besides the raw materials used. This still need a deep evaluation and studies in order to improve the BPs sustainability (Hassan et al., 2013).

## CONCLUSION

Plastic usage is indispensable in many sectors by numerous industries and consumers. Besides, the petroleum-based sources might be depleted in a few centuries as it is not renewable materials and it causes many environmental issues in a long run. Therefore, other potential alternatives should be employed and improved in line with government attempts in this issue. In recent years, BPs production from biorenewable sources came into limelight and it is ensured that the emerging sustainability, biodegradability, and renewability issues can be catered well with improved research development. Last but not least, the products criteria must meet the consumers and manufacturers demand to advance them as a useful material globally.

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