

Are bio-based polymers a viable alternative?

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The aim of this research paper is to provide the reader with an overview of bio-based plastics and challenges that these polymers face on its way to become the alternative to petroleum based polymers.

History of synthetic polymers and problem with disposal

The synthetic polymer (plastics) industry dates back its origins to 1930s but not until World War II the production of polymer-based commercial products started to emerge on the market. Polymers proved to be a good alternative to natural material and they production has been on a steep increase since the mid-twentieth century (Beckman, 2018). It is estimated that around 8.3 billion metric tons of plastic has been manufactured to date. The recycling of plastic is small percentage of overall global production (9% in 2015) and still around 80 % end up in landfills and the environment as litter (Geyer et al, 2017). The widespread use of commodity plastics (plastics used in large volume for wide range of products) created a problem of mind-boggling scale.

Plastic is also present in oceans where garbage patches have formed by gyres (circulating water currents). The largest, the Great Pacific Garbage Patch, is speculated to be twice the size of Texas state. Despite their size, the patches cannot be seen from space as debris resemble more of peppercorns suspended in soup rather than dense piles of

rubbish in landfills. Debris is not uniformly dispersed in water and relatively small in size (5-50mm and smaller). This, however does not mean the problem is negligible. Plastic debris became an integral part of marine environment where they pose risk to wildlife as well as humans, through the food chain pathway (Barnes et al, 2009). The plastic input to oceans is estimated at 4.8 – 12.7 million metric tons annually (Efferth, 2017). First reports of plastic litter in seas began to appear in 1970, and speculations what potential effect the toxic additives in plastics could have on marine life followed (Moore, 2015).



Fig 1. John Cancalosi, *Stork in a bag*.

Monitoring of human blood showed that plastic compounds have made their way to human blood and cells (Efferth, 2017) where they can act as carcinogens, mutagens and endocrine disruptors (Moore, 2015).

Taking into account that plastics biodegrade at very slow pace of 500 to 1000 years (Leblanc, 2016) and even slower in marine environment (Andrady, 2011) the problem is here to stay.

Why do we use plastic packaging and tableware?

There are many reasons why plastics are so popular as packaging material. It is durable and hygienic material. It is safe to use, i.e. does not shatter into dangerous pieces, unlike glass. Plastic is lightweight and can be processed using many different industrial processes. Plastic is energy efficient; less energy is needed to manufacture plastic cup than paper. It is versatile material for packaging, disposable cutlery and tableware. (British Plastics Federation, 2019) These properties made plastic no. 1 choice as packaging material, and also top contributor to plastic waste and environmental garbage.

Does the public care about environment?

Public incentives and pressure on companies and manufacturers forces them to reconsider the use of polymers. The proposals to adopt solutions in order to protect environment were on European Commission's agenda in May 2018 with France and Britain proposing extra measures as citizens urged to tackle problem of single use plastics (Corporate Europe Observatory, 2018). McDonald's, following customer inquiries, committed to switch to fully recyclable packaging by 2025, from c. 50% of recyclable packaging currently. (Keating, 2018)

Bio-based polymers

Synthetic, petroleum-based polymers have wide application. It is difficult to imagine packaging industry without plastics today. While some packaging plastics can be easily substituted with fibre or cellulose based

biodegradable counterparts, some properties of synthetic plastics cannot be replicated with substitutes. The term 'bioplastic' can be confusing. It can be used to describe plastic that is bio-based such as PLA (polylactic Acid) or PHA (Polyhydroxyalkanoate) which are made from plant based resources or petroleum based PBS (Polybutylene succinate) which can also be broken down by microorganisms (Emadian, 2016). PBS can be entirely petroleum based or partially petroleum based and plant based. European Plastics (Association) lists PBS as biobased and biodegradable on their stock photo based website [sic] (European Bioplastics, 2019). Global production of bioplastics in 2014 was 1.7 million tons; with 39 % of this figure accounting for biodegradable and 39 % non-biodegradable bioplastics (Emadian, 2016). This shows that bioplastic may not be what an average consumer think it is – the eco friendly, biodegradable alternative to synthetic polymers. Bioplastics can refer to plastics that are compostable, biodegradable or not. Most of bioplastics are designed to be compostable in industrial plants, under specific conditions. Biodegradation of plastics in various environments have been studied (Emadian, 2016). Not all biodegradable bioplastics are compostable.

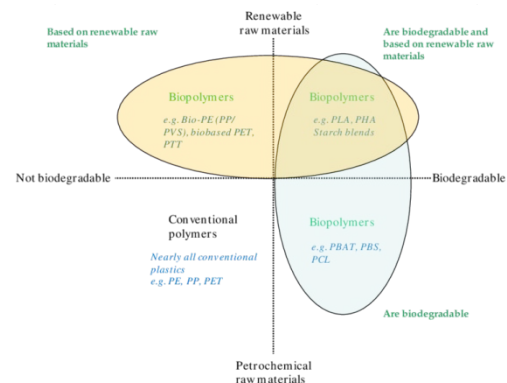


Fig2. Types of bioplastics, both biodegradable and non-biodegradable (Philip, 2013)

Bioplastics that substitute for synthetic plastics have to be durable and therefore do not easily break down in garden compost bins. They usually require higher temperatures to biodegrade in manageable timescale. According to British standard directive BS EN 13432 compostable bioplastic has to comply with certain criteria, such as level of disintegration under specified composting conditions, absence of heavy metals and cannot adversely affect the chemical and physical composition of resulting compost (British Plastics Federation, 2019). Countrystyle Recycling managing director Chris Howards points out that compostable bioplastics do not add any nutrients to compost. Composting is the end of life for these products, and energy used in manufacturing is lost once they enter the composting process. This in turn makes compostable bioplastics – a single use product while large part of bioplastics still remains non-biodegradable. Starch-based bioplastics (as used, for example for kitchen food bin liner) can easily degrade in home composting bins. However this type of bioplastic lacks resistance to moisture and would start breaking up when wet (Axion, 2018)

Garbage collectors are faced with the dilemma whether those bioplastic will deliver the end-of-life value in order to generate the market for collection. The story is different for synthetic polymer plastics – these can be recovered and processed into new products. Compostable bioplastics cost more and does give nothing back to the soil once composted. Does it make sense to force industry to rely on materials that cannot be recycled and no energy can be retrieved from them once those products are no longer needed? Shall we look elsewhere to find a solution?

Although the public does not see the whole picture of bioplastics, they are aware that synthetic polymers has become a bane

of our times. So long as there is public will to participate in the resolving of this burning issue, there is hope.

What can we do to alleviate the problem of excessive plastic being generated?

Changing everyday habits to reduce the proliferation of single-use plastics whether they are synthetic or biobased can have far greater positive impact than switching to alternative plastic. Carrying a reusable water bottle, using reusable shopping bag (lessplastic.co.uk, 2019) or simply choosing products that do not use plastic are just a few from many habit changes that can be adopted by anyone, a person who cares about environment, and welfare of other humans and living beings. Thirteen year old girls conducted a survey on plastics in Canada and found that 99 out of 124 participants use the same plastics daily (Shultz 2017). Those plastics products became a part of their lives and there lay the possible solution to the problem. If they could stop using those and substitute with alternatives, the solution would be within the reach of hand. We must however recognize the problem and stop making the same mistake again and change the way we negotiate our everyday life with the use of plastic products. According to Hanegraaf, CEO of Oerleams Packaging in Netherlands there is only one solution to problem of plastics – law enforcement. (Bruggink, 2017). Company sell bioplastics for over twenty years yet they make only about one percent of the market.

Conclusions

The bioplastics have existed for as long as synthetic ones but only in the recent time they have gained more popularity, thanks to public awareness, and sadly because of the problems that

arose from widespread use of synthetic plastics. Synthetic plastics are to stay with us in the future despite problems with disposal and negative environmental impact that affects biosphere. The biobased plastics may sound as an ideal replacement to conventional polymers. However, as this research have found, both types of plastics have their advantages and disadvantages. What made synthetic plastics so popular (low cost, durability) also paved the way to seek better alternatives for them. Bioplastics are not without the flaws. The available range is very limited, durability compromised and they are inherently single use plastics that energy used in production cannot be recovered. There is public misconception that bioplastics or bio-based plastic are eco-friendly is not

entirely correct. Not all bioplastics can biodegrade and even fewer can be compostable. The new legislation is routinely being placed in order to encourage the use of recyclable and biodegradable materials and dissuade or even ban the use of disposable plastic products such as tableware or bags. As society we need to keep looking for alternative products to synthetic polymers. If we do not change our habits for use of disposable plastics, and live in erroneous belief that one day someone will find a perfect material, we will never find solution to this urging problem.

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