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WHITE PAPER 06/2017

WHY 2017 IS THE 'RIGHT' TIME FOR BIOPLASTICS

During Interpack 2017 we were asked to provide some background on the bioplastics market, and to explain why we believe that the time is 'right' for bioplastics. This whitepaper provides general context, outlines bioplastics' conundrum, gives a market overview, and compares available materials. In addition, we share how we can solve bioplastics' conundrum by bringing to market an innovative bioplastic at a competitive price, based on a reliable supply chain.

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01 | General context

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In 2015, mankind consumed a staggering 322 million tonnes[1] of plastics. No surprise as plastics keep our food fresh and us healthy, protect us from the environment as fibres in our clothing, keep us warm as part of our homes' insulation, or form an integral part of our different modes of transport. Plastic products are everywhere, and – undoubtedly – they make our lives easier and more comfortable. But there are several problems associated with petroleum-based plastics (or also called "conventional plastics"):

ISSUES WITH CONVENTIONAL PLASTICS

- Worldwide plastic demand **equated to 4-6% of global oil consumption**[2]
- Converting oil and gas into plastics **releases "black carbon"**
- **32% of all plastic packaging pollute the environment**[3]
- **Plastics stays around "forever"** (e.g. plastic bag takes 1,000 years to degrade)

On a global scale, the problem is mostly visible in form of large garbage patches floating in our oceans, which consist mainly of small plastic particles suspended at or just below the surface. The Great Garbage Patch in the Pacific Ocean (also referred to as the "Pacific Trash Vortex") is probably the the largest one with size estimates ranging from 270k square miles (the size of Texas) to 5.8m square miles (twice the size of the continental United States).[4] **Apart from the pollution, studies show that the small plastic particles not only kill animals but also have entered the human food chain.**[5]

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Today's end-consumers' attitude of "one-use and throw-away" is only changing slowly in the Western world and each year millions of new consumers in the emerging markets want to enjoy the convenience of plastics too. That's why we need to create closed loops for plastics. And for areas, where plastic could end-up polluting the environment, bioplastics offer an alternative. But there are three reasons why bioplastics hasn't gone mainstream yet, namely:

BIOPLASTICS' CONUNDRUM

WHAT IS HOLDING BIOPLASTICS BACK

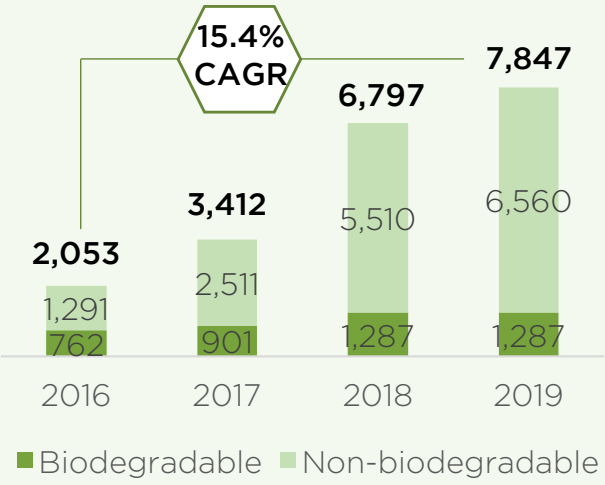
1. **Lack of functionality**: First bioplastics weren't fit for the job and still lack functionality today
2. **Higher costs**: Bioplastics are 2.5x to 10x more expensive than normal plastics.[6)]
3. **Unreliable supply chain**: Bioplastics are only available in small quantities from single suppliers

The EU identified the negative environmental impact of plastics, mainly packaging. Despite major recycling efforts over the last years, only 14% of all plastic packaging gets recycled, while 40% ends up in landfill and 14% gets incinerated. A staggering 32% or 25 million tonnes end-up polluting the environment.[3)] The European Commission realised that change isn't happening fast enough, and therefore intervened with the "Directive 94/62/EC on Packaging and Packaging Waste" in 2014. While member states are translating the EU's directive into national law: Italy has been, since 2009, with 90kt the world's largest bioplastics market, when it made biodegradation obligatory for shopping bags. Since then countries like UK, Germany, and Portugal introduced bag charges. Though this resulted mainly in getting rid off thin single-use bags and shifted volumes to thicker multi-use bags. Since 2016, France is leading the way: It introduced legislation that over time bans conventional plastics in certain applications and enforces stricter biodegradation standards. **At the 2017 World Economic Forum, 40 industry leaders agreed to increase the plastic packaging recycling rate from 14% to 70%.**

With our BIOPAR® Technology replacing polyethylene applications, we've used the global polyethylene market as a reference. With 84.7 millions tonnes, in 2015, it is the world's most important plastic market. It is a mature market and is expected to grow with a CAGR of 3.2% over the next couple of years (mainly driven by growing economies in the Far East) and is expected to reach 119 million tonnes in 2026.[7)]

BIOPLASTICS MARKET SIZE [IN KT][8)]

In contrast, the **global bioplastic market with less than 3.5 million tonnes**, in 2017, is still in its infancy. But it is expected to grow each year 15.4%, and reach 7.8 million tonnes in 2022 – **doubling in next 2 years**.



The above European Bioplastics' market figures are always quoted when people talk about the bioplastics' market size. But the numbers have to be interpreted correctly. Like in the early stages of the oil and gas industry, the above figures are based purely on press releases announcing installed or planned capacities, and not real production. When key market players met in Oct 2016 at K-Messe (the world's largest plastic/rubber trade fair), the consensus was that only 50% of the above production capacity is used. This means: In 2016, the bioplastics market was less than 1.0mt, of which only roughly a third was biodegradable. To date bioplastics, due to a lack of functionality and higher costs, relied heavily on legislation to create markets, such as biodegradable shopping, garbage, and vegetable bags. The majority of today's bioplastics are bio-based material: Bio-PET used for bottles and Braskem's GreenPE®. **Our GuiltfreePlastics® underpin the above forecasted growth as they open-up new applications, achieve price parity in complex packaging, and provide brand owners with a reliable and scalable supply chain.**

04 Material comparison

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Over the last couple of years, lots of innovation has happened in the field of bioplastics. Though most materials were developed for specific applications, which means they have limited functionalities. Moreover, most materials (with the exception of Braskem's GreenPE® and Novamont's MaterBi®) are only available in small quantities – meaning high prices. Unlike with conventional plastics, different bioplastics can't be easily mixed – resulting in single sourcing.

MATERIAL COMPARISON[9)]

GreenPE®	Starch-based: PLA	Starch-based: Disperse Methods	Starch-based: BIOPAR® Technology
Braskem's proprietary technology where sugar cane, using high amounts of energy, is first converted into a monomer and then back into a polymer. GreenPE® is sold as a 100% bio-based material. Its biggest advantage are its price (relative small premium above PE prices) and it behaving like normal PE; but it does not biodegrade.	Again, subject to high energy consumption, starch or biomass is converted into PLA, and then blended with biodegradable PBAT. Challenges are on pricing and biodegradability of the finished products. Advantages are in the transparency of the film; on the downside products tend to be more brittle, and have shorter shelf-lives.	Here starch is being used purely as a filler. The lower starch loadings mean higher costs as more co-polymer has to be used. With the starch molecules being disperse, any film made is always opaque. Films also suffer from retro-gradation and poor mechanical properties (both low tear as well as punch resistance).	With BIOPAR® Technology the starch, used as a polymer, becomes an integral part of the finished product. Higher starch loadings (up to 70%) reduce costs significantly. The proprietary bi-co-continuous phase structure adds functional properties (e.g. barrier) and enhances mechanical properties significantly.
Players: Braskem	**Players**: BASF, Natureworks	**Players**: Biotec/Sphere, Novamont, Jinhui	**Players**: United Biopolymers (and its licensees)
Evaluation:	**Evaluation:**	**Evaluation:**	**Evaluation:**
Economics ●●○○○	Economics ●●●○○	Economics ●●●○○	Economics ●●●●●
Energy balance ●●○○○	Energy balance ●●○○○	Energy balance ●●●○○	Energy balance ●●●●●
Functionalities ●●●●○	Functionalities ●●●○○	Functionalities ●●○○○	Functionalities ●●●●○
Renewable content ●●●●●	Renewable content ●●●○○	Renewable content ●●●○○	Renewable content ●●●●○
Recyclability ●●●●●	Recyclability ○○○○○	Recyclability ●●○○○	Recyclability ●●●●●
Biodegradability ○○○○○	Biodegradability ●●●○○	Biodegradability ●●●●●	Biodegradability ●●●●●

We are obviously biased: Believing that it does not make sense, neither economical nor environmentally, to convert starch into a monomer to afterwards reassemble it back into a polymer – while starch is already a polymer in the first place. With this in mind, **our BIOPAR® Technology is the most efficient and most economical method to produce bioplastics.**

05 | Competitive material

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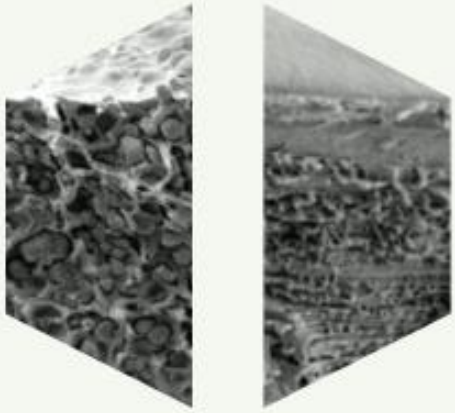
With starch-based bioplastics still being the most efficient and most economical production method for bioplastics, we'd like to compare in more detail the currently available Disperse Methods and our proprietary BIOPAR® Technology, see below:

TECHNOLOGY COMPARISON[9)]

Today's Disperse Methods use starch purely as a filler, which is held in place by the PBAT matrix. The film's cross section shows voids, and the surface is "hilly", meaning the film is opaque.



In contrast, **with BIOPAR® Technology the starch becomes an integral part**, indicated by the bi-co-continuous phase structure. The film's surface is smooth, making the film transparent.

Technical advantages	Functional advantages	Economic advantages
o Better processing capabilities o No need for new machines as it works on existing twin-screw extruders o Simplified production process with all ingredients added in one step and no need for side-extruders	o Transparent films rather than hazy ones o More flexible and softer touch o Gas barrier and adjustable vapour transmission o Higher water and vapour resistance	o Substantially higher throughput rates o 20% down-gauging potential o 33% lower energy consumption o More than 50% reduction of carbon dioxide emissions

Bioplastics made using BIOPAR® Technology offer technical, functional, as well as economic advantages. And our BIOPAR® FG 1000-1030 P range is ideal for the current applications: You can produce strong shopping bags with even colour dispersion; transparent 12-micron thin vegetable bags that hold 6kg without any problem; or transparent/coloured garbage bags that hold liquids and don't melt when exposed to hot tea bags / coffee. But GuiltfreePlastics® can do more than that. **Thanks to our bi-co-continuous phase structure GuiltfreePlastics® have varying barrier properties, which open-up new applications for bioplastics outside the current ones, such as compostable and recyclable food packaging.**

06 | Reliable supply

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To date, bioplastics are only available in relative small quantities. Moreover, there is no real standard, meaning that one can only buy a specific bioplastic from one supplier. With GuiltfreePlastics® opening-up new applications for bioplastics, we need to create a more reliable and scalable supply chain. That's why we decided to license our BIOPAR® Technology instead of becoming a compounder ourselves. Our licensees produce GuiltfreePlastics® based on our proven product formulations, and proven product formulations, and then market them under their own brands. This way, we not only create quickly a sizeable and highly scalable supply chain, but also enable converters and brand owners to multi-source. **Our goal is to make BIOPAR® Technology the new standard for bioplastics. And we'd love for you - whether you're a compounder, converter, or brand owner – to join us on this exciting journey. Get in touch!**

TYPES OF LICENSES

You have the choice between two types pf licenses:
A BIOPAR® Compounding License or a BIOPAR® Technology License.
It really depends on who you are, what you want to do (only produce or also innovate), and naturally your investment appetite.

Items included	BIOPAR® Compounding License	BIOPAR® Technology License
Know-how transfer: Production methodology	⬢	⬢
Know-how transfer: Concept + technology	⬡	⬢
Training courses + materials	⬢	⬢
Marketing support	⬢	⬢
Fast track to biodegradation certificates	⬢	⬢
Access to BIOPAR® Innovation Centre	⬡	⬢

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United Biopolymers, S.A.
Parque Empresarial e
Industrial da Figueira da Foz
Praça das Oliveiras, Lote 126
3090-451 Figueira da Foz
Portugal

+351-300-509-183
www.unitedbiopolymers.com