Bio-polymers are not a miracle solution against plastic waste

By Olivia Jeanne, Benjamin Leflon and Sophie Seidenschwang

Introduction

Today, we are becoming increasingly aware of our impact on the environment. One of the most visible and systematic human-made pollution is plastic pollution. In order to solve this problem, bio-plastics, engineered from bio-polymers are emerging, and are considered by many as an alternative to plastic made from fossil fuel. But do bio-polymers truly represent a green solution? Below, we answer some common questions and misconceptions shrouding bio-polymers.

What is a Bio-Polymer ?

Also called bio-sourced polymer, it is a polymer created by **living organisms**, or polymers **synthesized from renewable products**, the polymer being produced from a bio-based monomer.
Often used as an alternative to oil-based polymers used in plastics.

Common examples: DNA, starch, PLA (PolyLactic Acid)...

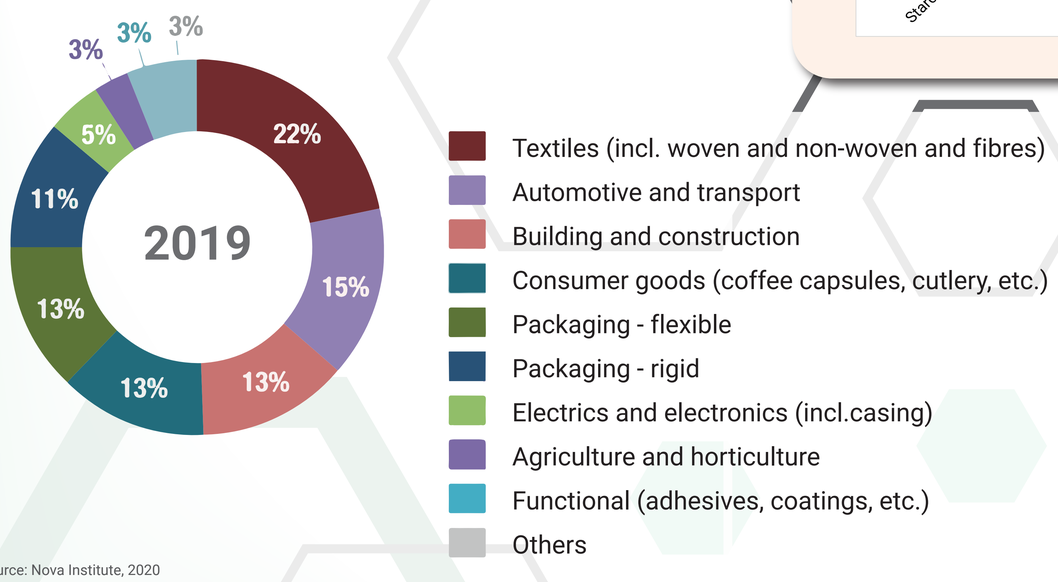
In the industry:
- No official definition of a bio-plastic
- Some «bio-plastics» are composed only of 40% of bio-polymers

What is biodegradability?

Biodegradable materials, according to the EN NF 1343 norm, is a material that can be broken down and degraded by micro-organisms, and form H_2O, CO_2 and residues which are environmentally safe (methane is considered as such, even though it has a green-house effect).
A material's biodegradability depends on the environment it is put in (with or without air, water, sunlight...).

Bio-polymer ≠ Biodegradable polymer
A bio-polymer can be non-biodegradable (Polyamide 11) and an oil-based polymer can be biodegradable (PCL).

Shares of produced bio-based polymers



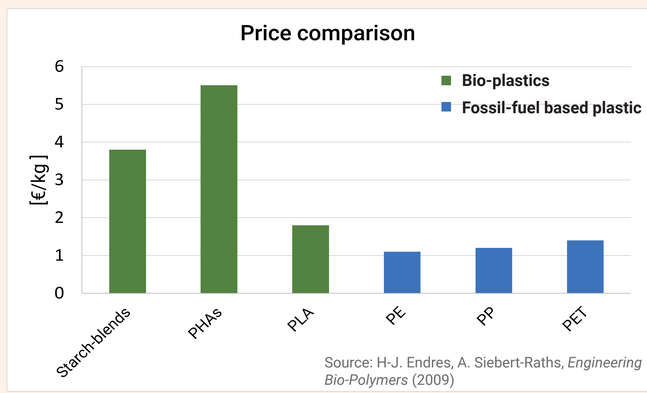
Source: Nova Institute, 2020

Properties of bio-polymers

Advantages of biopolymers:
- Medicine: Most are bio-compatible and degrade naturally in the body without releasing toxic agents, they are used for surgical sutures, protective membranes to cover wounds...
- Packaging: Some bio-plastics (PLA) are edible so do not pose a problem if part of it is eaten, and they act as excellent oxygen and moisture barriers.

Mechanical properties:
They offer a wide range of mechanical properties for everyday use (packaging, textiles...).
BUT: Cannot replace high performance polymers.
They generally degrade faster than petroleum-based polymers (more sensitive to heat, UV exposition and air).

Biggest drawbacks:
- **Lack of clear and precise data** on creep resistance, fatigue, and generally on their performances
- **Price: several times more expensive** than most commonly used polymers

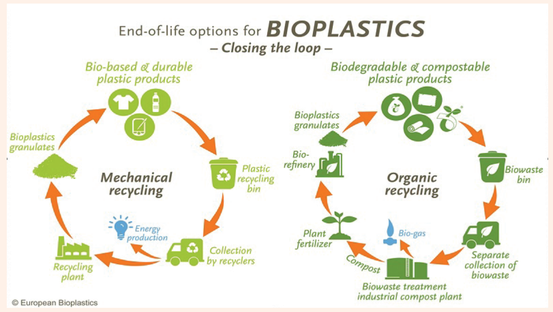


Source: H-J. Endres, A. Siebert-Raths, *Engineering Bio-Polymers* (2009)

Are they good for the environment?

Bio-polymers are often presented with that type of diagram:

Misleading content



Why is it misleading?
1. Non biodegradable bioplastics present the same challenges as petroleum-based plastics:
   - Difficulty in separating the different plastics
   - Partial loss of mechanical properties
   - Countries use more plastic than they can recycle.

2. These diagrams do **not take into account** the amount of land, water and phytosanitary products used to grow the plants used for these plastics.

Some studies (Tabone 2010) show that bio-sourced plastics could use more energy and create more green-house gas emissions than fossil-fuel-based PP and PE.

3. Life cycle analyses taking into account the **acidification** of ecosystems show that **polymers perform better than biopolymers** in this regard. Only corned-based bio-polymers seem to have a positive impact. Madival (2009) even concluded that PS (polystyrene) is to be prefered compared to PLA regarding the eutrophication of ecosystems and the damage done to the ozone layer.

Conclusion

Bio-polymers and bio-plastics are as varied as their petroleum-based cousins. They come in many forms and from different sources (starch, corn, unused organic matter...). However, hailing them as an the new «miracle solution» to conventional plastic is a mistake.
Some of these bio-polymers **only add to the current pollution** as they are not degradable, and most cannot compete against conventionnal plastics' superior mechanical properties and reduced costs.
Traditional plastic production represents only **5% of annual oil consumption**, ridiculously low compared to transport (45% of total consumption).
Currently, bio-polymers are only **1% of the total annual plastic produced**, very far from replacing petroleum-based plastic.

But might we add that bio-polymers are still in development and that further research might change these aspects, and make bio-polymers as essential to our society as conventionnal polymers are.

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Sources

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