

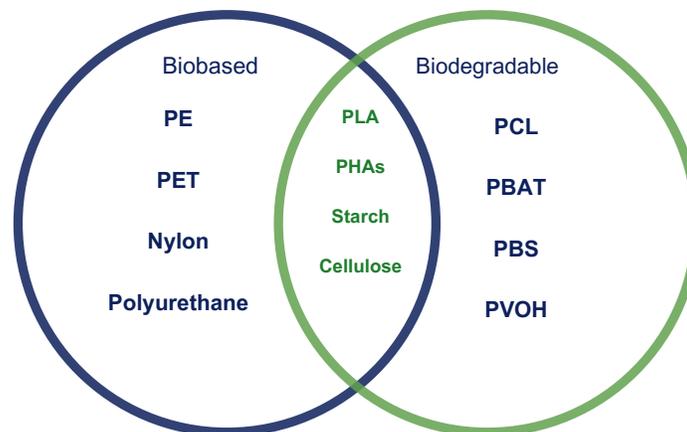
# Ingenia Extrusion Brief

## Biopolymers

### Biopolymers – What are they?

Most plastic products are currently derived from fossil-based compounds. Regulatory pressure and societal concerns surrounding plastic waste accumulation, their environmental persistence and non-renewable sourcing of petroleum based plastics has increased over the past few decades. Research and interest in biopolymers is growing, and more industries and companies are turning their attention to biopolymers.

Biopolymers are materials that can be biobased (produced from biomass feedstocks, such as waste food or agricultural products), biodegradable (broken down by bacteria and microorganisms under certain conditions into CO<sub>2</sub>, water and biomass) or both. There are a few conventionally petroleum based plastics such as polyethylene (PE) and polyethylene terephthalate (PET) that can be produced from renewable feedstock. The material properties and end of life fate remains the same as their fossil-sourced counterparts.



### Biodegradable vs Compostable

Biodegradability refers to the general process and mechanisms of degradation, while compostability has specific standardized conditions at which the product or neat resin is tested. For a material to be compostable it must undergo a fixed amount of degradation after a standardized time period.

Biodegradable is not a regulated term while compostable is, and there are various organizations such as TÜV Austria in Europe or BPI in North America that monitor and certify compostability.

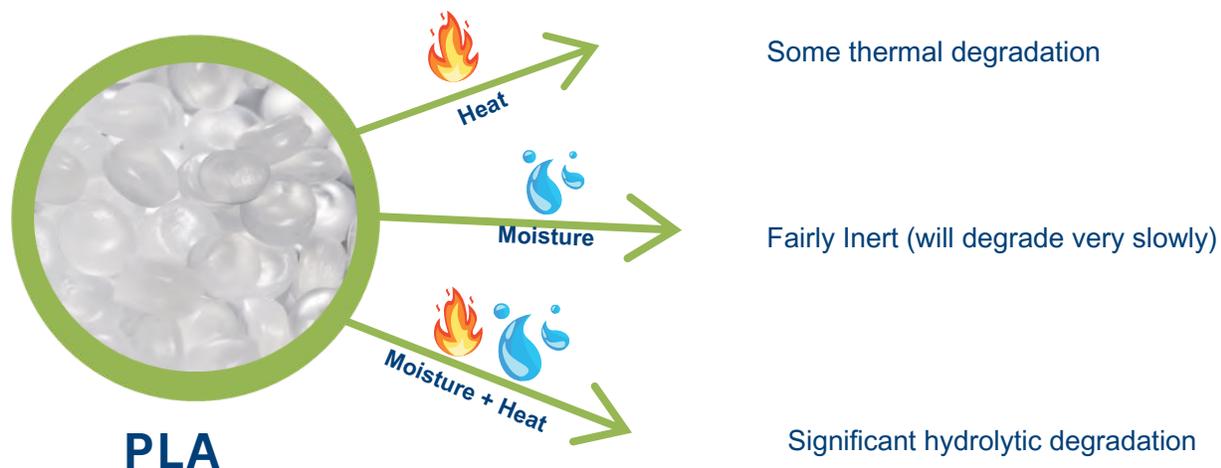
Biodegradable materials undergo distinct degradation mechanisms in different environments. Certain environments may be more challenging for biopolymers to degrade. For example, PLA degrades faster under industrial compost conditions compared to a marine environment.

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### Challenges in Processing Biopolymers

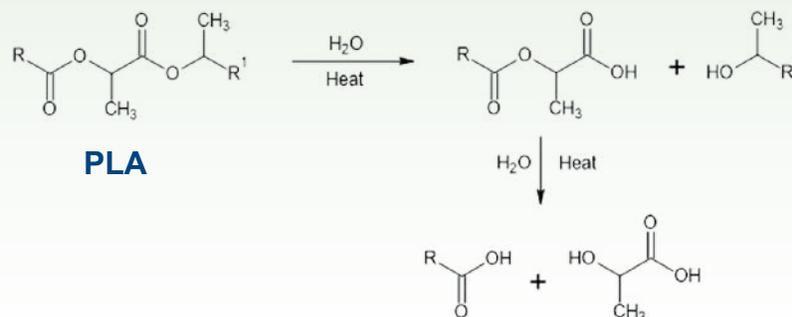
The chemical characteristics that allow biopolymers to degrade, also present challenges during compounding, storage and in the final use application. Polyolefins have been used for decades to package food. As such, many additives compounded into polyolefins have secured regulatory approvals for use in food contact applications. These additives often require additional approvals in biopolyesters. Furthermore, the impact plastic additives have on the biodegradation rate of the plastic product and the final soil toxicity are important considerations that need to be addressed when designing alternatives to petroleum-based plastic packaging.



The processing concerns of biopolymers are abundant. The most significant and well documented is hydrolysis during processing which shortens polymer chains and reduces melt strength. Hydrolysis occurs when the ester bonds in the polymer backbone are cleaved in the presence of water at the elevated processing temperatures ( $>150\text{ }^{\circ}\text{C}$ ). Hydrolysis is catalyzed by acid and so hydrolysis in polyesters is autocatalytic – as more ester bonds are cleaved more carboxylic acid groups are formed catalyzing subsequent hydrolysis. PLA (polylactic acid) exhibits the most significant sensitivity to hydrolysis, however care to ensure all biopolymers are dry before processing is important.

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### Hydrolysis reaction

Biopolyesters are hygroscopic (especially PLA) meaning they readily absorb atmospheric moisture. To reduce hydrolysis during processing, resins must have low moisture (ideally <250 ppm in PLA). Processors can avoid moisture uptake by storing resin in sealed foil liners. Resin should also be dried before compounding to reduce hydrolytic degradation – in-line dryers are ideal when processing biopolymers.

PHAs (polyhydroxyalkanoates, made from the fat storages of bacteria) are another example of biopolymers with processing challenges. PHAs have high shear sensitivity and low thermal degradation temperatures. When PHAs undergo thermal degradation, the result is an off-color part with poor mechanical properties.

Processing Challenges in Biopolymers	Actions to Ease Processing
Reduction in melt strength from hydrolysis	Ensure resin is dried to suppliers specification before processing
High shear sensitivity	Low shear screw design
Narrow processing window	Avoid high processing temperatures, keep temperatures below the resin's thermal degradation temperature

### IN SUMMARY

Although there are challenges associated with processing biopolymers, there are additive technologies that can help. The key advantage of biopolymers is that they can undergo biodegradation and be used in the development of compostable packaging and other products, helping brand owners provide consumers with additional sustainable options.