InnProBio
FORUM FOR BIO-BASED INNOVATION IN PUBLIC PROCUREMENT

Factsheet No. 3

Biodegradability: Exposing some of the myths and facts

Sometimes it seems that being "biodegradable" is all the rage for bio-based and other materials. It sounds so good: at the end of its life, a product will decompose and go back to where it came from. That is, decompose back into the natural environment and reduce littering. However, looking a bit more deeply into the issue, it becomes clear that many misunderstandings, myths and confusion govern the discussion. Here is our contribution to a bit more clarity.

MYTH #1: All biodegradable products are made from bio-based materials

FACT: While biodegradability is a property inherent to many bio-based products (products made from renewable feedstocks – see *Factsheet #1 on What are bio-based products?*), there are also quite a few fossil-based chemicals and polymers on the market that are completely biodegradable. Examples of these are the fossil-based polymers polybutylene adipate-co-terephthalate (PBAT) or polycaprolactam (PCL) that degrade completely, too.

Not all biodegradable products are made from renewable resources. And vice versa, not all bio-based products are biodegradable.

MYTH #2: All bio-based products are biodegradable

FACT: While biodegradability is a property inherent to some bio-based products, many of them are durable (which means they will not biodegrade in any case). This is in fact the case for bio-based versions of traditional fossil-based plastics (such as bio-based polyethylene (BioPE) or polyethylene-terephthalate (BioPET)). These bio-based materials are chemically identical to the fossil-based ones, so they carry the same properties. They are also called drop-in solutions. But there are also novel bio-based polymers that are durable, such as bio-based polyethylene furanoate (PEF), which is expected to enter the market in 2017. PEF is primarily aimed for bottle production and is said to have better barrier properties than PET, which is commonly used for bottle production.

Biodegradation is a chemical process, disintegration is a physical process. Both have to occur together, for a product to decompose completely.

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MYTH #3: If a product is biodegradable, I can throw it into the environment and it will disappear, almost like magic

FACT: Now it gets complicated. Firstly, throwing waste into the environment is never a good idea. Secondly, biodegradability is a very broad term and does not automatically mean that a product will degrade in any environment. Degradation is dependent on factors such as temperature, time and the presence of bacteria and fungi in the specific environment. Below is a list of the most used and misused terms and a picture that gives an overview of the different environments that determine the biodegradability of different polymers. In most cases, biodegradability means that these products will only degrade under specific conditions and not in the open environment. And on top of that, the biodegradability of the final product is not just determined by the properties of its polymer, but also by additives or organic fillers etc. that are added for final consumer products. As said before, it is complicated.

Biodegradation is not always biodegradation – details are important. Time is key, and also the temperature and presence of microorganisms in the specific environment.

MYTH #4: Biodegradability is a quick solution

FACT: Biodegradation takes quite a bit of time. How much exactly, is very dependent on the environment. In industrial composting (see below), materials need to biodegrade within six months, but in open environments, it will take much longer, often at least a year or several years. And if you wait for hundreds of years, even "durable" goods will start to degrade.

Home composting and industrial composting are not the same. Higher temperatures and controlled conditions make industrial composting the much easier environment for plastics to decompose.


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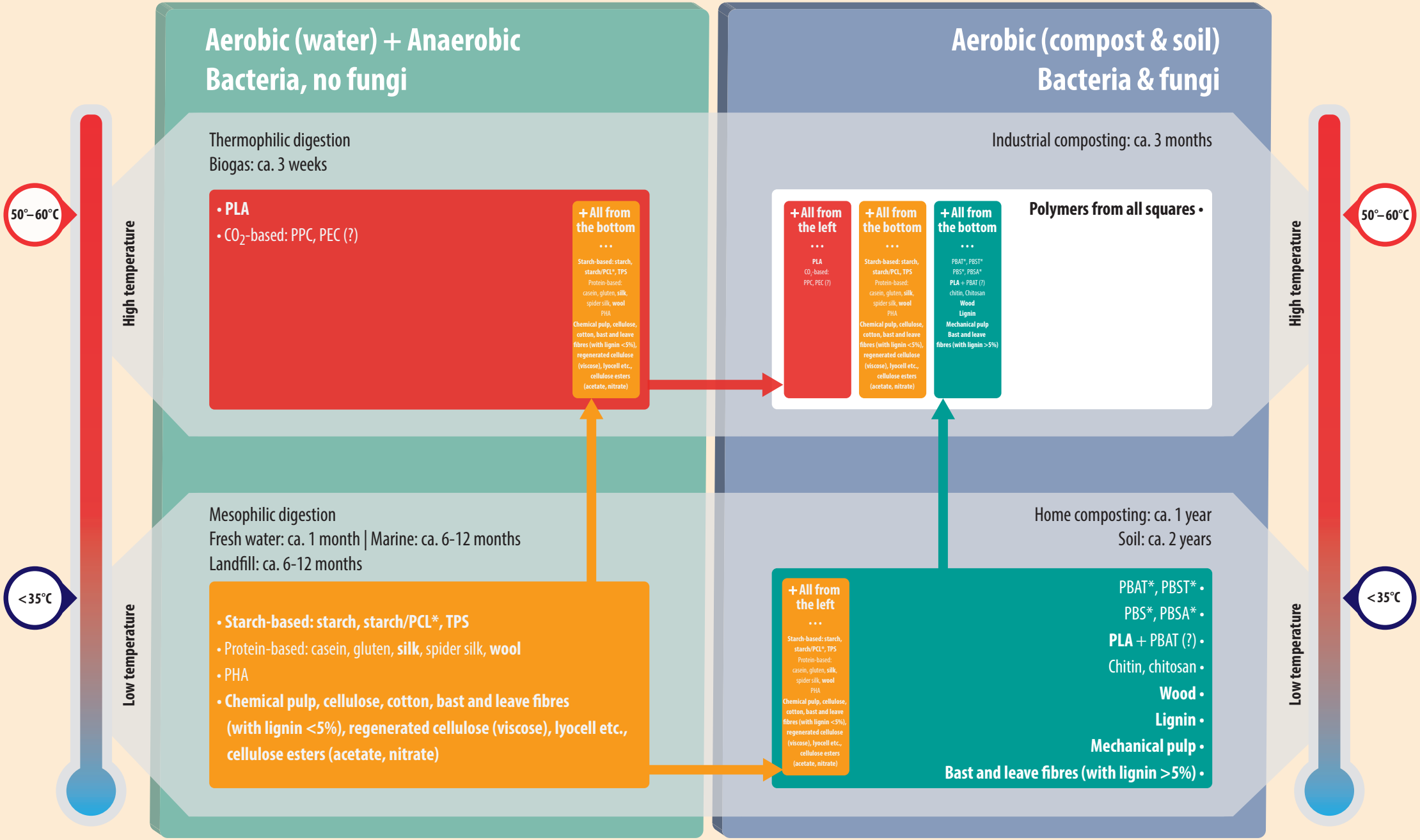
The most important terms around biodegradability and what they actually mean*

Term	End result	How	Remarks
Biodegradation	Carbon dioxide, methane and biomass	Chemical process; micro-organisms break down the material to CO_2, methane and biomass, using oxygen and biomass	Biodegradation and disintegration have to occur together for a material to decompose completely
Disintegration	Little – sometimes even microscopic – pieces of material	Physical process; break down of material caused by multiple factors like wind and weather, tear force, UV radiation, microbial activity, etc.	
Oxo-biodegradability/ Oxo-degradability/ Oxo-fragmentability	Microscopic plastic particles remain	Oxo-degradable materials only disintegrate (= break down), no chemical conversion takes place	"Oxo-biodegradability" is a misleading term (because there is no real degradation, only disintegration, and microplastics remain in the environment); huge opposition to this term from science, society and policy. Now frequently called "oxo-fragmentability"
Compostability	Carbon dioxide, methane and biomass which can be used as compost	Biodegradation and disintegration take place to produce compost	See the difference between industrial composting and home composting
Industrial composting	Carbon dioxide, methane and biomass which can be used as compost	Biodegradation and disintegration take place in an industrial facility to produce compost; controlled environment, high temperatures	Due to high temperatures, this is much quicker than home composting; standardised in norm EN 13432
Home composting	Carbon dioxide, methane and biomass which can be used as compost	Biodegradation and disintegration take place in, i.e. a garden to produce compost; changing environment, lower temperatures (depending on region)	Takes much longer than industrial composting; some bio-based materials need higher temperatures to biodegrade than home composting can achieve. So if a bio-based plastic is labelled "compostable" according to EN 13432, it does not mean it will also be home compostable
Biodegradation in soil, fresh water or sea water	Carbon dioxide, methane and biomass	Biodegradation and disintegration take place in open environment; changing conditions, sometimes very low temperatures; low population of micro-organisms like bacteria and fungi (which are needed for the process)	Open environment is the most difficult condition for biodegradation; especially the cold sea water with low population of micro-organisms makes it hard for materials to decompose

* For more detailed explanations, please see the text on page 5.

Biodegradable, bio-based polymers in various environments



Plastics derived from these biodegradable polymers only keep this property if also all additives and fillers are biodegradable, too.

BOLD: Bio-based polymers with relevant production volumes in 2014 (>10,000 t/year) **?:** Not finally confirmed, further testing necessary.

*: PBS, PBST, PBSA and PBAT so far mainly petro-based, but in the future bio-based; PCL so far only petro-based.

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Biodegradation vs. disintegration

Biodegradation means that a material goes through a chemical reaction in which it uses oxygen (O_2) and hydrogen (H) from the material itself or from its environment and then dissolves into water (H_2O) and gases such as carbon dioxide (CO_2) and methane (CH_4) or also new biomass. For this reaction to take place, micro-organisms also need to be in place. This means that – in the ideal chemical process – nothing remains of the original material. **Disintegration** means that materials break down physically into little – sometimes even microscopic – pieces. This can be caused by a multitude of factors, such as wind and weather, tear force, UV radiation, microbial activity, etc. Even though the remaining pieces might not be visible to the naked eye after this process, they are still there. If a material biodegrades, both processes usually take place: the material first breaks down into smaller pieces, and later, the real biodegradation starts after which, only water, CO_2 and biomass are left.

Oxo-biodegradability, oxo-degradability, oxo-fragmentability

Now it gets tricky. **Oxo-degradability** is a term invented by plastics manufacturers that is clearly misleading. As opposed to being really biodegradable (that is, going through the reaction described above), oxo-degradable materials only disintegrate into microscopic pieces when exposed to sunlight and oxygen. Which means, they do not disappear, but stay in the environment for a very long time, often as microparticles (also called "microplastics"). There has been more and more opposition to this term from society and science and these materials are now frequently called **oxo-fragmentable** to make clear that they only fragment (that is, fall apart into smaller pieces) and do not properly degrade.

Compostability

Compostability is a term used for products which are suitable for organic recycling (i.e. compostable in an industrial composting plant). This means it is one kind of biodegradation in a specific environment, but in order for a product to be called "compostable", it also needs to fulfil other requirements, such as disintegration in a defined time, no harmful substances or ecotoxicity. These requirements are laid down in European standard EN 13432 Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of packaging (2000).

Home composting vs. industrial composting

If a material is compostable, it does not automatically mean that you can add it to your garden compost to begin composting. Usually a distinction is made between **home compostability and industrial compostability**. In the garden, temperatures and volumes are a lot lower than those in industrial composting facilities, and conditions are less stable. Consequently, the process also works slower under home composting conditions. Products labelled as "home compostable" need to demonstrate at least 90% biodegradation within a year at temperatures of below 30°C and at least 90% disintegration within six months. In an industrial composting facility, conditions are controlled and constant. There are usually temperatures of over 50°C, in which industrially compostable materials degrade in approximately three to six months. Products that need a thermal trigger to start degrading (for example PLA) will be compostable in an industrial composting facility, but will remain intact under home composting conditions.

Biodegradation in our natural environment – soil, fresh water or salt water

For a few materials, it is actually true that they will degrade in specific open environments, such as in **soil, fresh water or salt water**. This is still not an excuse for littering – but it might be a good idea for products that typically end up in these environments (i.e. agricultural mulch films for soil, fishing nets for the ocean). However, again the problem is in the details: soil, fresh water and salt water are very different environments and make biodegradation harder or easier, depending on a number of different factors. What these environments have in common is that temperatures are below 35°C. The differences are mostly the presence of bacteria and fungi. In water, there are no fungi, which are helpers for biodegradation. That means that the cold, fungi-free ocean is actually the hardest place for materials to biodegrade, whereas it is much easier in soil. The conditions in soil are comparable to those in home composting, however, the time required is a lot longer. There are different test methods that can verify the biodegradability of materials in these very specific conditions, but research on their validity and optimisation is still going on.

InnProBio seeks to build a community of public procurement practitioners interested in the procurement of bio-based products and their associated services. This factsheet series aims to provide concise information on topics of relevance to public procurement of bio-based products and services.

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