

BIO-DEGRADABLE FILMS

The growing use of plastics in agriculture has enabled farmers to increase their crop production. One major drawback of most polymers used in agriculture is the problem with their disposal, following their useful lifetime. Non-degradable polymers, being resistive to degradation (depending on the polymer, additives, conditions etc. tend to accumulate as plastic waste, creating a serious problem of plastic waste management.

Ideally, a degradable polymer should be fully biodegradable leaving no harmful substances in the environment. Most experts and acceptable standards define a fully biodegradable polymer as a polymer that is completely converted by microorganisms to carbon dioxide, water, mineral and biomass, with no negative environmental impact or ecotoxicity. Biodegradable materials are materials that can be broken down by microorganisms (bacteria or fungi) into water, naturally occurring gases like carbon dioxide (CO₂) and methane (CH₄) and biomass (e.g. growth of the microorganism population). Biodegradability depends strongly on the environmental conditions: temperature, presence of microorganisms, presence of oxygen and water. So both the biodegradability and the degradation rate of a biodegradable plastic product may be different in the soil, on the soil, in humid or dry climate, in surface water, in marine water, or in human made systems like home composting, industrial composting or anaerobic digestion.

A. (Biodegradable) Starch based plastics

Starch based plastics are complex blends of starch with compostable polyesters (such as PLA (Polylactic Acid), PBAT (Polybutylene adipate terephthalate), PBS (Polybutylene succinate), PCL (Polycaprolactone) and PHA (Polyhydroxy Alkanoates) and additives like plasticisers and compatibilisers. Blending of starch with polyesters is necessary to improve water resistance, processing properties and mechanical properties. Commonly the starch content of starch based plastics is lower than 50% and the overall bio-based content of these materials depends on the nature of the other components. Starch based plastics are used in applications where biodegradability is an advantage like agricultural products (mulching films), service ware, garbage bags for green waste and carrier bags. The advantage is that these products can be composted together with the organic waste. Starch blends are generally compostable and various materials (depending on the other blend components) are also biodegradable in soil, anaerobic digestion installations, fresh water or marine environment. Not all starch blends are allowed for food contact applications and this depends on the presence of blend components that can potentially migrate out of the starch blend.

1. Starch based films

Starch based films can be translucent (not transparent) and are used in packaging materials as a mono layer and as laminates (for example barrier films in combination with cellulose). They are used in applications where transparency is not required. Starch films can be highly flexible when they contain flexible polyesters like PBAT (Polybutylene adipate terephthalate). These materials are suitable for packaging of products like potatoes and carrots and also for grocery bags. In these applications the starch based films replace (perforated) PE and barrier properties are not important. New is the starch based candy

wrapping of Mars that replaces BOPP (Biaxially oriented Polypropylene). In this application starch based films are combined with PLA (Polylactic Acid) films as an outer layer. Starch based films are frequently used in cellophane based barrier laminates to allow heat sealing. These types of laminates are used in pouches for products like cereals and cookies.

Starch based trays (rigid or foamed) can be used to pack fruits and vegetables. Starch based trays are not transparent. Barrier properties are not important in this application so functionality is based on the mechanical properties and the end-of-life options. Since materials for thermoformed products need to be rigid, PLA can be used in the blend composition, whereas in films highly flexible fossil-based biodegradable polyesters are used. Since PLA is 100% bio-based in this application the overall bio-content of starch blends is higher than in films. A specific type of foamed starch tray is PaperfoamTM. Paperfoam is mainly used in packaging applications where product protection is important, for example in egg boxes but also in packaging of electronic devices. Paperfoam is certified compostable and is also allowed in paper recycling. Other packaging products of starch based materials are frequently used in loose fill foams for transport packaging. Another application is in service ware (cups, plates and cutlery).

B. Biodegradable (and bio-based) films

A variety of biodegradable polyesters has been developed in the eighties of the previous century. These biodegradable polyesters are predominantly based on fossil fuels. These materials are mainly used in combination with bio-based polymers like starch and PLA. The most frequently used biodegradable polyesters are PBAT, PCL (Polycaprolactone) and PBS(A). Partly bio-based PBS (Polybutylene succinate) is commercially available.

1. Flexible films based on biodegradable polyesters

A large product group containing biodegradable polyesters are flexible films. Applications range from shopping bags, food packaging films, waste bags to mulching films. The predominantly fossil-based biodegradable polyesters are often combined with bio-based materials. Examples are:

- Starch based flexible films containing polyesters like PBAT to improve processability, water resistance and tear strength. The content of biodegradable polyesters is commonly 50% or more.
- PLA based flexible films containing polyesters like PBAT, PBS and PCL to reduce stiffness and improve tear strength. Again the content of biodegradable polyester is usually high (> 50%).

2. Trays and other thermoformed products (Bio-Based)

Biodegradable polyesters are used as a blend component in trays and thermoformed products, most commonly in combination with PLA. These products are non-transparent and the amount of biodegradable polyester used is considerably lower than in films.

3. Other packaging products (Bio-Based)

Biodegradable polyesters and blends are also used in coated paperboard for the production of plates, cups and other compostable paper-based packaging products. Moreover they can be found in other disposables like cutlery, straws, lids for coffee cups etc. For the

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packaging of vegetables and fruits compostable nets are available on the market. Coffee capsules are based on/or contain biodegradable polyesters for example in combination with PLA. New on the market is PLA/PBAT based particle foam for protective (heat and impact) packaging of various products.