**Material  Biopolymers**

Biopolymers are polymers that are generated from renewable natural sources, are often biodegradable, and not toxic to produce.

They can be produced by biological systems (i.e. micro-organisms, plants and animals), or chemically synthesized from biological starting materials (e.g. sugars, starch, natural fats or oils, etc.).

Biopolymers are an alternative to petroleum-based polymers (traditional plastics). (Bio)polyesters have properties similar to traditional polyesters. Starch-based polymers are often a blend of starch and other plastics (e.g PE), which allows for enhanced environmental properties.

<table>
<thead>
<tr>
<th>Biopolymer type</th>
<th>Price (DKK/kg)</th>
<th>Density (kg/liter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aliphatic-aromatic copolymer</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aliphatic polyesters</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CPLA</td>
<td>25-50</td>
<td>1.25</td>
</tr>
<tr>
<td>PCL</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PHA</td>
<td>15-60</td>
<td>1.25</td>
</tr>
<tr>
<td>PLA</td>
<td>30-70</td>
<td>1.26</td>
</tr>
</tbody>
</table>
### Starch-based polymers

<table>
<thead>
<tr>
<th>Biopolymer type</th>
<th>Price (DKK/kg)</th>
<th>Density (kg/liter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 % Starch</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50 % Starch</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>90 % Starch</td>
<td>20-40</td>
<td>-</td>
</tr>
<tr>
<td>Foamed starch</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Others

<table>
<thead>
<tr>
<th>Biopolymer type</th>
<th>Price (DKK/kg)</th>
<th>Density (kg/liter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein formaldehyde</td>
<td>-</td>
<td>1.33</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Horn</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Environmental notes

Some polymers degrade in only a few weeks, while others take several months. Biodegradability and other plastic properties strongly depend on the polymer structure. By changing the structure, these properties can be altered.

### Price

The above-mentioned prices are from December 1997.

The price of biopolymers is still fairly high compared to oil-based polymers. This is due to lower production-volumes than petroleum-based polymers.

However, the growing environmental consciousness and the application of life-cycle evaluations in the material circuit may help biomass-based raw materials to become mass-produced and cheaper, replacing traditional plastics in a number of applications.

Significant price reductions can be expected within the next two years.
protein found in skin, horn, ...

Horn

Return to materials description
**Material** *Aliphatic-aromatic copolymer*

This copolymer combines the excellent material properties of aromatic PET, and the biodegradability of aliphatic polyesters. It is soft, pliable (producing low noise) and has a good touch. Melting-points are high for a degradable material (around 200°C).

Depending on the application, up to three aliphatic monomers are incorporated into the PET structure. The monomers create weak spots in the polymeric chains, thereby making them susceptible to degradation through hydrolysis.

Applications include disposal bags, diapers and eating utensils. It can be used to create geo-textiles and plant pots, and it is suitable for thermoformed blown bottles and injection moulded objects.

**Category**

Biopolymers

**Processes**

Blow moulding
Injection moulding
Extrusion

**References**

Dupont
GBF - Enviromental Biochemical Engineering

**Price**

It is only marginally more expensive to produce than PET itself because it can be manufactured with existing equipment using existing bulk monomers. Currently available degradable materials can cost twice as much.
Environmental notes

Disposal: It can be recycled, incinerated or landfilled, but is intended mainly for disposal composting and in-soil degradation. If properly disposed, it degrades in eight weeks. The large polymer molecules are cleaved by moisture into smaller molecules, which are then consumed by naturally occurring microbes and converted to carbon dioxide and water.

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**Material**  *Aliphatic polyesters*

Aliphatic polyesters have properties similar to those of PE and PP. They are odorless and can be used for trash bags, diapers, and cosmetic and beverage bottles.

They can be processed on conventional processing equipment at 140-260 °C, in blown and extruded films, foams, and injection moulded products.

Aliphatic polyesters are biodegradable but often lack in good thermal and mechanical properties. Vice versa, aromatic polyesters, like PET, have excellent material properties, but are resistant to microbial attack.

<table>
<thead>
<tr>
<th>Category</th>
<th>Biopolymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td>Pot for plants</td>
</tr>
<tr>
<td>Processes</td>
<td>Blow moulding</td>
</tr>
<tr>
<td></td>
<td>Injection moulding</td>
</tr>
<tr>
<td></td>
<td>Extrusion</td>
</tr>
<tr>
<td>Similar</td>
<td>PET (aromatic polyester)</td>
</tr>
<tr>
<td>materials</td>
<td></td>
</tr>
<tr>
<td>References</td>
<td>Showa Highpolymer Co. Ltd. (Bionolle®)</td>
</tr>
</tbody>
</table>
Environmental notes

**Creation:** Made from polycondensation reaction of glycol and aliphatic dicarboxylic acids. Both components can be obtained from renewable resources (e.g. glycol from glycerol by fermentation).

**Disposal:** It biodegrades to water and carbon dioxide in soil as well as fresh and ocean water areas. The rate of degradation depends on grade, shape of the product, and level of microbiological activity. Typically, degradation of a 0.04 mm thick film takes two months. When coated with coconut-shell powder, and buried in soil, it decomposes within five days. In fact, coconut-shell powder absorbs water and swells, helping microorganisms to live on the biodegradable film.

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**Material**  **CPLA - Polylactide aliphatic copolymer**

Biodegradable CPLA is a mixture of lactide and aliphatic polyesters. It can be either a hard plastic (similar to PS) or a soft flexible one (similar to PP) depending on the amount of aliphatic polyester present in the mixture.

Possible applications will include compost bags, cushioning materials, food wrapping materials, fishing nets, etc. It is easy to process with stability up to 200 °C.

<table>
<thead>
<tr>
<th>Category</th>
<th>Biopolymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processes</td>
<td>Most conventional plastic processes like:</td>
</tr>
<tr>
<td></td>
<td>Blow moulding</td>
</tr>
<tr>
<td></td>
<td>Injection moulding</td>
</tr>
<tr>
<td></td>
<td>Extrusion</td>
</tr>
<tr>
<td></td>
<td>Vacuum forming</td>
</tr>
<tr>
<td></td>
<td>Fibre spinning</td>
</tr>
<tr>
<td>Similar materials</td>
<td>Aliphatic polyesters</td>
</tr>
<tr>
<td>References</td>
<td>Dainippon Ink and Chemicals Inc. (DIC)</td>
</tr>
<tr>
<td>Price</td>
<td>DIC plans to produce several tons per year at a price ranging from 25 to 50 DKK/kg.</td>
</tr>
</tbody>
</table>

**Environmental notes**

*Creation:* CPLA is made by copolymerising lactide (made by fermenting cornstarch, cheese whey, etc.) with aliphatic polyester (e.g. dicarboxylic acid or glycol made from fermentation of glycerol). All are renewable resources.

*Disposal:* If incinerated, no toxic substances are generated. The heating value and carbon dioxide generated during combustion are lower, by almost half the level, of that generated by PE or PS.

Although CPLA has a high molecular weight and
high melting-point, it begins breaking down into a low-molecular weight polymer, in natural environments, after 5-6 months. Complete decomposition after 12 months. When composted with food garbage, it begins breaking down into a low-molecular weight after 2 weeks.

Additional Info
CPLA does not dissolve in alcoholic solvents, oils, and diluted solution of strong acids. It does dissolve in aromatic hydrocarbon, concentrated acids, and caustic soda.

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**Material** PCL - Polycaprolactone

Polycaprolactone is a biodegradable thermoplastic polymer derived from the chemical synthesis of crude oil. Although not produced from renewable raw materials, it is fully biodegradable.

Polycaprolactone has good water, oil, solvent and chlorine resistance. It has a low melting-point (58-60 °C) and low viscosity, and it is easy to process.

It is used mainly in thermoplastic polyurethanes, resins for surface coatings, adhesives and synthetic leather and fabrics. It also serves to make stiffeners for shoes and orthopedic splints, and fully biodegradable compostable bags, sutures, and fibres.

**Category** Biopolymers

**References**
Solvay Caprolactones (CAPA®)
Union Carbide Corp. (Tone)

**Environmental notes**

Disposal: Fully biodegradable.

The low melting-point makes the material suited for composting as a means of disposal, due to the temperature obtained during composting routinely exceeding 60 °C.

Degradation time is very short. In Sweden there has been an attempt to produce PCL bags, but they degraded before reaching the customers.

**Additional Info**

Polycaprolactone is often mixed with starch to obtain a good biodegradable material at a low price (~20 DKK/kg lower than other aliphatic polyesters). The mix has been successfully used for making trash bags in Korea (Yukong Company).

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PHAs - Polyhydroxyalkanoates

PHAs are linear polyesters produced in nature by bacterial fermentation of sugar or lipids. More than 100 different monomers can be combined within this family to give materials with extremely different properties.

They can be either thermoplastic or elastomeric materials, with melting-points ranging from 40 to 180°C. The most common type of PHAs is PHB (poly-beta-hydroxybutyrate). PHB has properties similar to those of PP, however it is stiffer and more brittle.

A PHB copolymer called PHBV (polyhydroxybutyrate-valerate) is less stiff and tougher, and it is used as packaging material.

Category
Biopolymers

Products
Bone plate
Razor, biodegradable (PHA)
Shampoo bottle, biodegradable (PHBV)
Surgical sutures

Processes
Blow moulding
Injection moulding
Extrusion

Keywords
PHB
PHBV

References
Monsanto Company (Biopol®)
PHB production
Price
The price (1997: 15-60 DKK/kg) is very high compared to other oil-derived polymers. Prices are thus falling down (1993: 100-140 DKK/kg) and, in a couple of years they could reach a level which would enable mass-production (2-6 DKK/kg).

Environmental notes

Creation: Made from renewable natural sources like sugar.

Use: It is biocompatible and therefore can be implanted in the body without causing inflammations. The producer claims that is not toxic.

Disposal: It biodegrades in microbially active environments in 5-6 weeks. The action of some enzymes produced by microbes solubilises PHB which is then absorbed through the cell wall and metabolised.

PHB is normally broken down to carbon dioxide and water when degraded in aerobic conditions. In absence of oxygen the degradation is faster, and methane is also produced.

PHB is not degraded in biologically inactive systems such as sanitary landfills.

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**Material**  
**PLA - Polylactide**

PLA is a biodegradable thermoplastic derived from lactic acid.

It resembles clear polystyrene, provides good aesthetics (gloss and clarity), but it is stiff and brittle and needs modifications for most practical applications (i.e. plasticizers increase its flexibility).

It can be processed like most thermoplastics into fibres, films, thermoformed or injection moulded. Used for compost bags, plant pots, diapers and packaging.

**Category**  
Biopolymers

**Products**  
Compostable bag

**Processes**  
Most conventional plastic processes like:  
- Blow moulding  
- Injection moulding  
- Extrusion  
- Vacuum forming  
- Fibre spinning

**References**  
Neste Corporate Technology  
Cargill Dow Polymers LLC

**Price**  
Current prices (1997) are between 40 and 70 DKK/kg.
Environmental notes

*Creation:* Lactic acid can be obtained on the basis of renewable starch containing resources (e.g. corn, wheat or sugar beet) by fermentation, or by chemical synthesis of non-renewable resources.

*Disposal:* If composted properly it takes 3-4 weeks for complete degradation. The first stage of degradation (two weeks) is a hydrolisis to water soluble oligomers and lactic acid. The latter, as a naturally occurring substance, is a rapid metabolisation into CO2, water and biomass by a variety of micro-organisms.

Additional Info

The future tendency is towards a sharp decrease of the price, thanks to the introduction of plants capable to mass-produce the material. Future prices are expected to fall to few times the price of PP (15-20 DKK/kg).

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Material 10% Starch

Starch can be used as biodegradable additive or replacement material in traditional oil-based commodity plastics. If starch is added to petroleum derived polymers (e.g. PE), it allows disintegration of the blend, but not its biodegradability.

Category Biopolymers
Products Compostable bags
Environmental notes

Disposal: Starch can in theory accelerate the disintegration or fragmentation of the synthetic polymer chains. Microbial action consumes the starch, thereby creating pores in the material, which weaken it and enable it to break apart.

Disintegration of starch-plastic blends is not the same as biodegradation. Their breakdown, also under optimal conditions, is quite slow. Starch content needs to exceed 60% before significant material breakdown occurs.

In 1993 LDPE-starch blends were commercialized under the trade name Ecostar®

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Material 50% Starch

Also called plastified starch materials. They exhibit mechanical properties similar to conventional plastics such as PP, and are generally resistant to oils and alcohols, however, they degrade when exposed to hot water.

Properties of these materials can be varied as the content of starch and other materials changes. They are fully biodegradable and compostable, and they can replace traditional plastics in food service, food packaging, personal health care, etc.

Their basic content (40-80%) is corn starch, a renewable natural material. The rest is performance-enhancing additives and other biodegradable materials.

Category Biopolymers

Products Pen, biodegradable
Golf tees
Trash bags

Processes Most conventional plastic processes like:
Blow moulding
Injection moulding
Extrusion
Thermoforming

References Novamont S.p.A. (Mater-Bi®)
Environmen-
tal notes

Creation: Made of renewable natural sources (starch).

Disposal: When disposed in biologically active environments such as compost facilities and wastewater treatments systems, they display degradation characteristics similar to leaves, wood chips and paper.

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Material 90 % Starch

Usually referred to as thermoplastic starch. They are stable in oils and fats, however, depending on the type, they can vary from stable to unstable in hot/cold water. They can be processed by traditional techniques for plastics.

These materials consist mainly (>90%) of starch obtained from renewable natural sources. Colouring and flame retardant additives are possible.

Category Biopolymers

Products Starch-based tube
Degradeable compost bags
Agricultural mulch film
Golf tees

Processes Most conventional plastic processes like:
Blow moulding
Injection moulding
Extrusion
Thermoforming

References Biotec GmbH (Bioplast®)
NOVON International (NOVON®)

Price Prices vary from 20 to 40 DKK/kg

Environmental notes
Creation: Made of renewable natural sources.
Disposal: Depending on the grade, thermoplastic starch can degrade completely within five days in aqueous aerobic testing and in 45 days in a controlled compost, or can even decompose in water.

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**Material** Foamed starch

Starch can be environmentally friendly blown into a foamed material using water steam.

Foamed starch is antistatic, insulating and shock absorbing, therefore a good replacement for polystyrene foam.

It can be used as packaging material or can be pressed into starch-based sheet for thin-walled products, such as trays, disposable dishes etc.

<table>
<thead>
<tr>
<th>Category</th>
<th>Biopolymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td>Loose-fill</td>
</tr>
<tr>
<td></td>
<td>Disposable cup</td>
</tr>
<tr>
<td>Processes</td>
<td>Water steam foaming</td>
</tr>
<tr>
<td></td>
<td>Extrusion</td>
</tr>
<tr>
<td></td>
<td>Cutting</td>
</tr>
<tr>
<td></td>
<td>Moulding</td>
</tr>
</tbody>
</table>

**Similar materials** Foamed PS

**References**
- Biotec GmbH (Biopur®)
- National Starch & Chemical (Eco-Foam®)
- Norel (Envirofill™)

**Environmental notes**

*Creation:* Foamed starch is 99% starch, which is a renewable resource found in corn, wheat, rice, potatoes, etc. Foaming is performed using water steam instead of hydrocarbon-based blowing agents used for blowing PS.

*Disposal:* It dissolves when soaked with water leaving just a dilute corn starch solution. The solution is not toxic and is consumed by microbial life in about ten days, leaving only carbon dioxide and water.
It can also be re-used, recycled, incinerated, or composted along with other organic materials, since it decomposes very quickly.

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Casein formaldehyde is a plastic of natural protein origin, made from organic substances such as milk, horn or vegetable products such as soy beans, wheat, etc.

It can be made to look like celluloid, ivory, or artificial horn. It is odourless, insoluble in water, and only with difficulty inflammable.

In the first decades of this century, casein formaldehyde was used to make buttons, pins, cigarette-cases, fountain pens, umbrella handles and radio cabinets.

**Category** Biopolymers
**Products** Button for clothes, Gramophone box
**References** Plastic museum
**Environmental notes** 
*Creation*: Made from chemical modification of casein, which is a natural renewable resource.
**Additional Info** Casein formaldehyde was commercialised under the trade names Galalith and Erinoid.
**Photo** Thomas Nissen (Computer graphics)
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Material CA - cellulose acetate

Cellulose acetate (CA) is used for transparent, translucent and opaque objects (e.g. typewriter keys, calculators, switches, car wheel coverings).

Furthermore, it is especially suitable for coatings applications requiring high melting-point, toughness, clarity, and good resistance to ultraviolet light, chemicals, oils, and greases.

Cellulose acetate is an amorphous thermoplastic material belonging to the cellulosic resin family. It is obtained by introducing the acetyl radical of acetic acid into cellulose (as cotton or wood fibres) to produce a tough plastic material.

Danish Name CA - celluloseacetat

Category Biopolymers

Products Knife-handle
Shoe-heel
Lamp shade
Pen
Umbrella handle

References Plast og gummi ståbi

Environmental notes

Creation: Made from chemical modification of cellulose, which is one of the most diffuse organic substances in nature.

Use: Cellulose acetate is inflammable and burns with a yellowish flame producing a smelling smoke. Additive are often used to decrease its inflammability and to give the material self-extinguishing properties.
Additional Info
First plastic to be injection moulded.
Cellulose acetate becomes brittle at temperature under the freezing point.
It is an insulator material and shows only a little tendency to electrostatic charging.

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**Material** Horn

It is an organic material containing 80% keratin. It is thermoplastic and can be worked after dry heating or immersion in boiling water or alkaline solutions.

After softening it can be pressed obtaining objects and various laminas, such as tobacco containers, boxes, buttons, pens and combs. It was successfully applied, especially in England, before the advent of plastics.

**Danish Name** Horn

**Category** Biopolymers

**Environmental notes**

*Creation:* Horn is natural organic material.

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Aliphatic-aromatic copolymer

Return to materials description
Aliphatic polyesters

Return to materials description
CPLA - Polylactide aliphatic copolymer

Return to materials description
PCL - Polycaprolactone

Return to materials description
PHAs - Polyhydroxyalkanoates

Return to materials description
Starch-based biopolymers (5-10\% starch)

Return to materials description
Starch-based biopolymers
(40-80 % starch)

Return to
materials description
Starch-based biopolymers (>90% starch)

Return to materials description
Foamed starch

Return to materials description
Casein formaldehyde

Return to materials description
CA - cellulose acetate

Return to materials description
Biopolymers are usually produced from plants and are often biodegradable.
**Products**  
**Compostable bag**

This compostable lawn and leaf bag is made of PLA. It is designed expressly for collecting yard waste as part of municipal composting programmes, and offers an alternative to kraft paper collection bags.

Like kraft paper lawn and leaf bags, the biopolymer bags eliminate the need to separate bags from their contents at compost sites. Both degrade and are easy to print on.

Compared to paper bags advantages are: improved wet strength, better puncture resistance, visibility of content, ease of handling and closing, as well as compactness which minimises storage requirements.

**Category**  
Outdoor equipment

**Materials**  
PLA

**Processes**  
Blow moulding

**References**  
Cargill Dow Polymers LLC

**Keywords**  
Biopolymer  
Biodegradable  
Composting  
Transparent

**Price**  
Competitive with the price of paper bags.

**Environmental notes**  
*Use*: Bags designed only for degradation through composting, and only for carrying leaves, grass etc. They should not be used for waste such as ashes etc.

*Disposal*: The bag biodegrades along with the leaves, grass and wood chips inside it to create a rich, organic humus that can be used as a soil nutrient.
**Process** Blow moulding

Used for hollow parts of all sizes. A tube of molten plastics is extruded into an open mould. The mould closes and thereby the bottom of the part welds.

Hot air is blown into the tube and it is blown up until it fills out the mould cavity.

Parts can be produced in small and large quantities, since setup cost is low and tools/moulds are often made of aluminium and cheap.

### Danish

Blæsestøbning

### Category

Mass conserving processes, Plastic moulding

### Materials

PS ABS SAN PVC PC PE PP

### Typical products

- Bottle for motor oil
- Bottle for organic solvents
- Tubing for a car

### Competing processes

Injection blow moulding

### References

- Dudek Plast A/S
- Gravenhorst Plast A/S
- Kornerup Plast Trading ApS
- Rosti A/S

### Price notes

Moulds can be produced at a relative low price. Setup times are low.

### Photo

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### Copyright

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**Process** *Injection moulding*

For parts of all sizes which require accurate and complex geometry. Granular plastic or pellets are melted by friction with a rotating screw and actual heating, and then injected into the mould.

Normally, the process is reserved to thermoplastics, but it can be used for shaping fibre reinforced thermoplastics or thermosettings.

When shaping composites, parts with good mechanical properties cannot be produced as the content of fibres must be limited. Production volumes are medium to large, and the cycle time per part is very short.

**Danish Name** Sprøjtestøbning

**Category** Mass conserving processes, Plastic injection moulding

**Materials**
- Plastics
- Composites

**Typical products**
- Disposable drinking glass
- Hedge cutter
- Milestone
- Razor, biodegradable
- Razor, ordinary
- Shaver, rechargeable
- Spoon, clasp type
- Satellite box
- Washing machine drum
- Gear
- Hinge for gramophone lid
- Video front-panel

**Competing processes**
- Extrusion
- Gas assisted injection moulding
The injection machine and the shaping mould are very expensive.

Possible to achieve good dimensional accuracy and surface finish.

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Process **Extrusion**

Profiles of all shapes can be produced. In an extruder the material is heated and continuously pushed by a rotating screw through a die with the shape of the profile. After the die, the profile is cooled by air or water and cut into desired lengths.

Production volumes are normally high.

**Danish Name**
Ekstrudering

**Category**
Mass conserving processes, 2d plastic processes

**Materials**
Most plastics

**Typical products**
- Garden hose
- Tubes
- Metal sheet edge protection
- Railings
- Ice cube plastic bag
- Potholder

**Competing processes**
- Injection moulding
- Blow moulding
- Pultrusion
- Calandering

**References**
- DKI Plast A/S
- Vestfos Plast A/S
- Glim Plastic Industri ApS

**Photo**
Thomas Nissen (Computer graphics)

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### Products

**Pot for plants**

This pot for plants is made of aliphatic polyesters (Bionolle®)

Its biodegradability allows the plant to be planted in soil with no need to extract it from its pot.

<table>
<thead>
<tr>
<th>Category</th>
<th>Outdoor equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>Aliphatic polyesters</td>
</tr>
<tr>
<td>References</td>
<td>Showa Highpolymer Co. Ltd.</td>
</tr>
<tr>
<td>Keywords</td>
<td>Biopolymer, Biodegradable, Outdoor, Renewable resources</td>
</tr>
</tbody>
</table>

See aliphatic polyesters

### Similar products

- Compostable bag

### Photo

Showa Highpolymer Co. Ltd.

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**Process** Vacuum forming

Well suited for larger plastic parts since tools investments are low. Also used for high volume production of e.g. disposable cups and chocolate packaging. The surface facing the mould has the best quality. Material thickness is difficult to control.

A sheet of thermoplastic material is heated to the softening point. The sheet is positioned over a mould with small air canals, and a vacuum pulls the sheet into the mould.

Vacuum is normally sufficient due to the low strength in the material being formed, but for a more complex geometry, additional air or mechanical pressure can be applied.

- **Danish Name:** Vacuum formning
- **Category:** Mass conserving processes. Plastic shaping
- **Materials:** Most thermoplastics e.g. ABS, PC, PP, PS, PE
- **Typical products:** Dolphin, bicycle trailer base part, KindBox suitcase, Appliance housing, Disposable cups, Commercial sign, Shaped packaging, Refrigerator inside panels
- **Competing processes:** Rotation moulding, Blow moulding, Injection moulding
- **Price notes:** Low tooling costs
Difficult to produce small details

Photo
Thomas Nissen (Computer graphics)

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**Products** **Razor, biodegradable**

A double-bladed razor with replaceable head. Handle and razor heads are made of biodegradable plastic.

**Danish Name**
Barberhøvl, bionedbrydelig

**Category**
Personal items, Personal care

**Materials**
PHA (handle and razor head)
Stainless steel (blades)
PS and paper (packaging)

**Processes**
Injection moulding (handle)
Insert moulding (razor head)
Packaging:
Extrusion
Vacuum forming

**References**
Kay Razor

**Keywords**
Personal accessories
Cutting function
Shave
Biodegradable
Plastic

**Price**
Retail price, for 1 handle with 5 razor heads (9/95)
DKK 30,-

**Environmental notes**
Materials / Production: The plastic is made from renewable resources.
Use / Transport: The razor itself does not use energy, but use require water, soap and energy for heating water.
Disposal: putrification or incineration.

**Similar products**
Razor, ordinary
Shaver, rechargeable

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**Products**  *Shampoo bottle, biodegradable*

This shampoo bottle is manufactured from biodegradable PHBV plastic (commercially named Biopol™).

The biodegradable shampoo bottle is the first major product to be produced using this material.

The closure is injection moulded and the bottle is blow moulded.

**Category**  Personal items, Personal care

**Materials**  PHBV

**Processes**
- Injection moulding (closure)
- Blow moulding (bottle)

**References**
- Monsanto Company
- Wella

**Keywords**
- Bottle
- Biodegradable
- Biopolymer
- PHBV
- Biopol™

**Price**  Approximately 4 DKK/bottle (retail, 1995)

**Environmental notes**
- Creation: The plastic is made from renewable resources using traditional production methods.
- Disposal: The bottle will degrade through composting.

**Similar products**
- Razor, biodegradable

**Photo**  Monsanto Company

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**Products**  *Pen, biodegradable*

This “green pen”, with the exception of the ink refill, is made from the corn starch based material Mater-Bi®.

It is very similar to an ordinary plastic pen, but degrades when disposed in a composting site or in natural environment.

**Category**  
Dwelling & office appliances, office equipment

**Materials**  
Starch-based biopolymer (Mater-Bi®)

**Processes**  
Injection moulding

**References**  
Novamont S.p.A.

Enpac

**Keywords**  
Biopolymer

Biodegradable

Pen

Office equipment

**Price**  
Approximately 11 DKK (retail, 1997)

**Environmental notes**  
*Creation:* The pen is made from renewable resources using traditional production methods.

*Disposal:* The pen will disintegrate in about 12 months after being disposed.

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**Products**  
*Starch-based tube*

This tube is made of corn starch, is environment-friendly and is designed to decompose in water.

The tube is a direct alternative to conventional spiral-wound tube packaging, including flexible plastics and corrugated paper. The product can also be made in a variety of vibrant colours.

**Category**  
Dwelling & office appliances, office equipment

**Materials**  
Thermoplastic starch

**References**  
American Excelsior Company

**Keywords**  
Biopolymer  
Biodegradable  
Starch  
Packaging  
Water-soluble

**Environmental notes**  
*Creation:* The tube is made from renewable resources using traditional production methods.  
*Disposal:* The tube is designed to dissolve in water after use.

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Products **Loose-fill**

This loose-fill for packaging industry is made of foamed starch.

It offers numerous disposal alternatives and can be a good substitute of CFCs-blown PS.

**Category** Packaging

**Materials** Foamed starch

**Processes** Water steam foaming

**References**
- National Starch & Chemical
- American Excelsior Company

**Keywords**
- Biopolymer
- Biodegradable
- Starch
- Packaging
- Water-soluble

**Environmental notes**

*Creation*: Made from renewable materials.
*Environment-friendly foaming process.*

*Disposal*: See foamed starch.

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Products Disposable cup

The cup shown appears very similar to normal PS disposable cups, and displays similar characteristics as far as thermal insulation and resistance to fluids are concerned.

Category Food, Food equipment
Materials Foamed starch
Processes Water steam foaming
Pressing
References Biotec Gmbh
Keywords Biopolymer
Biodegradable
Starch
Packaging

Environmental notes
Creation: Made from renewable materials.
Environment-friendly foaming process.
Disposal: Once disregarded, the cup will completely decompose into useful compost.

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Products Button for clothes

This buttons are made of casein formaldehyde. They show the different decoration possibilities that this material can give.

Category Personal items, Clothes
Materials Casein formaldehyde
References Bottonificio Ontano
Keywords Biopolymer
Decoration
3D decoration
Clothes

Creation: See casein formaldehyde.

Environmental notes

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Products Gramophone box

The box housing this gramophone is coated with a layer of casein formaldehyde.

The antique gramophone from 1950 shows how casein formaldehyde can give a beautiful surface appearance.

Category Dwelling & office appliances, Home electronics

Materials Casein formaldehyde

References Plastic museum

Keywords Biopolymer
Decoration
Home electronics

Environmental notes Creation: See casein formaldehyde.

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