Plastics Compendium

An overview of common plastics, their applications, critical issues, and the truth in common public criticism.

Version of March 2011

Introduction

- Plastics and their applications actually spread around the world since about 60 years. Plastics are working materials that virtually offer unlimited options for use. They can be modified to provide a wide range of various material properties, and their production is often very economic.

- The first reservations against plastics were expressed in the beginning of the eighties of the 20th century. More critical studies about plastics were published in the beginning of 2000. However, public interest only developed after the launch of movies such as “Plastic Planet” and “Life in Plastic.”

- Currently, most opinion makers only have insufficient superficial knowledge, or they intently combine true facts in a highly sophisticated way to induce misinterpretations while directing public awareness to their publications. In the end, they all have the same objective, to rouse consciousness and to increase awareness.
- Many studies and facts are cited that really give reason for concern, although the relationship between cause and effect mostly is not clear. Due to the complexity of the issue, consumers are provided with “simple” tips suggesting wrong facts, e.g. that all plastics would contain plasticizers, that all recycling code “7” products are basically bad, and that nobody will ever drink from a plastic bottle, as soon as he or she will have sufficient knowledge.

- The answers to the arising questions require knowledge of the backgrounds and interrelationships as an essential prerequisite to eliminate half-truths and scare stories convincingly.

- The “Plastics Compendium” is intended as a reference for all friends of COPLARE, to help them when confronted with plastics issues, to give most current and correct answers to critical questions and to give good advice.

Overview: reasons why consumers increasingly ask about plastics

Movie / DVD + book
"Plastic Planet"
sponsored by BUND and NABU

Reports in public media

Film/DVD
"Life in Plastic"
sponsored by WWF und Greenpeace

Core message: plastics is harmful

- Direct
  - Babies
  - Children
  - Adults
- Indirect
  - By consumption of fish & seafood

Hormone-like substances from sources such as specific plastics are suspected to be hazardous to reproduction and genetic material, to be carcinogenic, or to have other negative effects on the development of humans and animals. This refers in particular to substances such as

1) the three phthalates DEHP, DBP, and BBP. They can escape from soft PVC; however, other sources are perfumes and cosmetics, where they are used as film formers. Other phthalates are considered not harmful to reproduction but are suspected to accumulate in the environment.

2) bisphenol A (BPA). Under certain conditions (contact to liquids at > 70 °C), it can be eluted from plastics such as polycarbonate but also from thermal paper or the epoxide inside lacquer of cans.

3) p-nonylphenol; its sources include not only soft PVC but also textiles, pesticides, dyes, etc., to provide specific properties to these materials.

These hormone-like substances also carry names like "endocrine substances," "phantom hormones," "xerohormones," or "environmental hormones." Today they have been detected in many cases in the environment, i.e. in waters and sediments, also in human blood and various foods and even in mother's milk. Both their sources and the exact pathways how they come into these targets are still unknown today. Among others, significant amounts of such substances are used as plasticizers for PVC and source materials for polycarbonate.
(Excursus: *However, this is not the only source. BPA may not only originate from polycarbonate, but also from epoxide lacquer that protects cans from corrosion or from thermal paper, e.g. used to print sales slips. In addition to soft PVC, phthalates also are present in perfumes and cosmetic products.)*

Therefore, environmentalists and consumer protectors urge industry since years to discontinue the use of such substances to prevent that they will leak into the environment for even more decades and thus will harm humans and animals as discussed above.

Hormone-like substances from sources such as plastics potentially can interfere with reproduction in fishes and seafood

Slow decrease in populations of fishes and marine animals; intermediate to long-term loss of this food resource

Additional stress to the marine eco-system that in many places are stressed anyway by overfishing

Plastic particles floating in the sea become porous and act like a sponge that absorbs and stores environmental toxins from the environment

Minute plastic particles enriched in environmental toxins contaminate food fish via the food chain

Slow uptake of toxic substances into the human metabolism by absorption from food

Baby bottles (made from polycarbonate)

Toys and children clothes (made from soft PVC)

- Food contact to polycarbonate
- Medical devices made from soft PVC

- Beverages from PET bottles
- Products labeled with recycling code "7"

It is not true that PET bottles and all products labeled with recycling code "7" release toxic plasticizers!
(which is frequently assumed)

Sample applications of common plastics

PE

Container
(polyethylene)

Beverage crate
(polyethylene)

Disposable gloves
(polyethylene)

PP

Brace box
(polypropylene)

Sunmilk bottle
(polypropylene)

"Lumibär" lamp
(polypropylene)

PET

Soft drink bottle
(polyethylene
terephthalate)

Fleece jacket
(polyethylene
terephthalate)

Heat protection film
(polyethylene
terephthalate)

PS

Coffee beaker
(polystyrene)

Bathroom tissue holder
polystyrene)

Beaker, crystal-clear
polystyrene)

PC

Compact disc
(polycarbonate)

Beaker, crystal-clear
(polycarbonate)

"Rimova" suitcase
(polycarbonate)

Soft PVC

Inflatable children sofa
(polyvinyl chloride [soft PVC])

Rain protection
(polyvinyl chloride [soft PVC])

Rubber boots
(polyvinyl chloride [soft PVC])

Overview: plastics and their fields of application

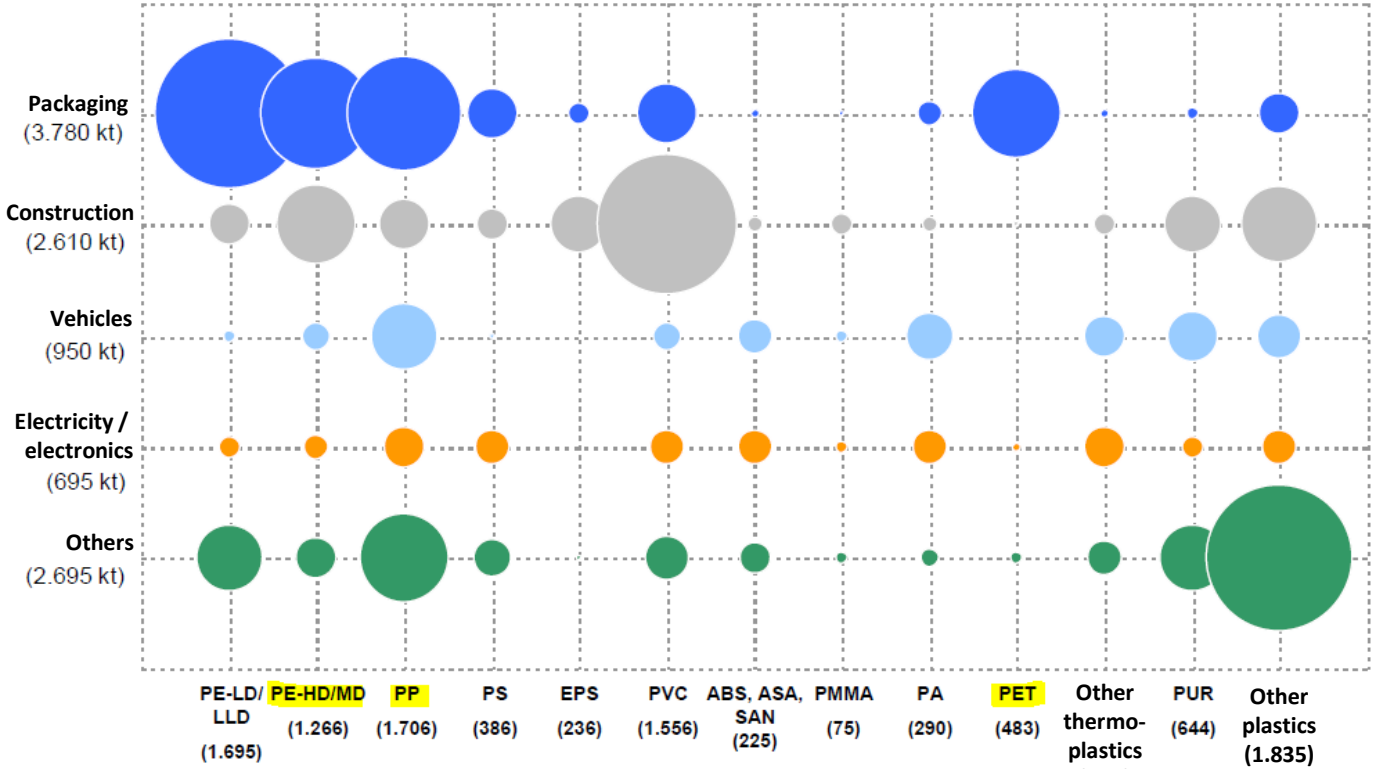
Processing of plastics

Plastics and their fields of application

Structure of the processed plastics within the industries - overview

Industries in 2009: packaging, construction, vehicles, electricity/electronics, and others

(figures specified in kilotons)



Definitions of various plastic types

Durable plastics, e.g. all conventional plastics such as PE, PET, PVC … which do not biodegrade.

Recyclable plastics allow the generation of new products from used plastics by mechanical recycling. Most of the conventional plastics can be recycled mechanically, but recycling facilities are not installed in all countries and regions for all sorts of plastics.

Bioplastics are generally understood to be either:
- biomass-based plastics made from renewable raw materials (converted to biodegradable or non-biodegradable products) or
- biodegradable plastics made from either renewable or fossil raw materials.

- "Generation 1" bioplastics should not be mixed with traditional plastics in recycling facilities, but lately first "generation 2" bio-plastics were launched, which have identical material properties as conventional plastics and can be recycled together with them.
- Some bioplastics, e.g. those derived from corn grown in North America, are based on genetically modified raw materials. However, others are not.

Biodegradable plastics degrade because of cell-mediated phenomena (by microorganisms, enzymes, fungi, bacteria). A material is biodegradable, when the degradation is the result of the action of microorganisms and the material is ultimately converted to water, carbon dioxide, methane, and biomass. Please note that during biodegradation no valuable micro-nutrients are returned to nature from biodegradable plastics.

Compostable plastics are degradable because of biological processes occurring during composting and are converted into carbon dioxide, water, and biomass. There are no toxic side-effects like toxic residue for water, soil, plants, or other living organisms. They comply with EN 13432, but need separated waste collection. Many products which meet EN13432 in industrial / commercial composting facilities will not do so in home composters. Please note that during biodegradation no valuable micro-nutrients are returned to nature from compostable plastics.

Photodegradable plastics are conventional plastics containing an additive which causes the plastic to degrade under exposure to ultraviolet light and oxygen.

Oxo-degradable plastics are conventional plastics containing an additive which initiates degradation under specific conditions of temperature and humidity. The degradation process is not initiated by microbial action and does not comply with the EN 13432 standard.

EN 13432 tests (for packaging) or ISO14855 -1 (for plastic materials) and the corresponding product certification assure the compostability in industrial/ municipal composting units based on scientific evidence. There are petroleum-based and biomass-based plastics which fulfill the test standard.

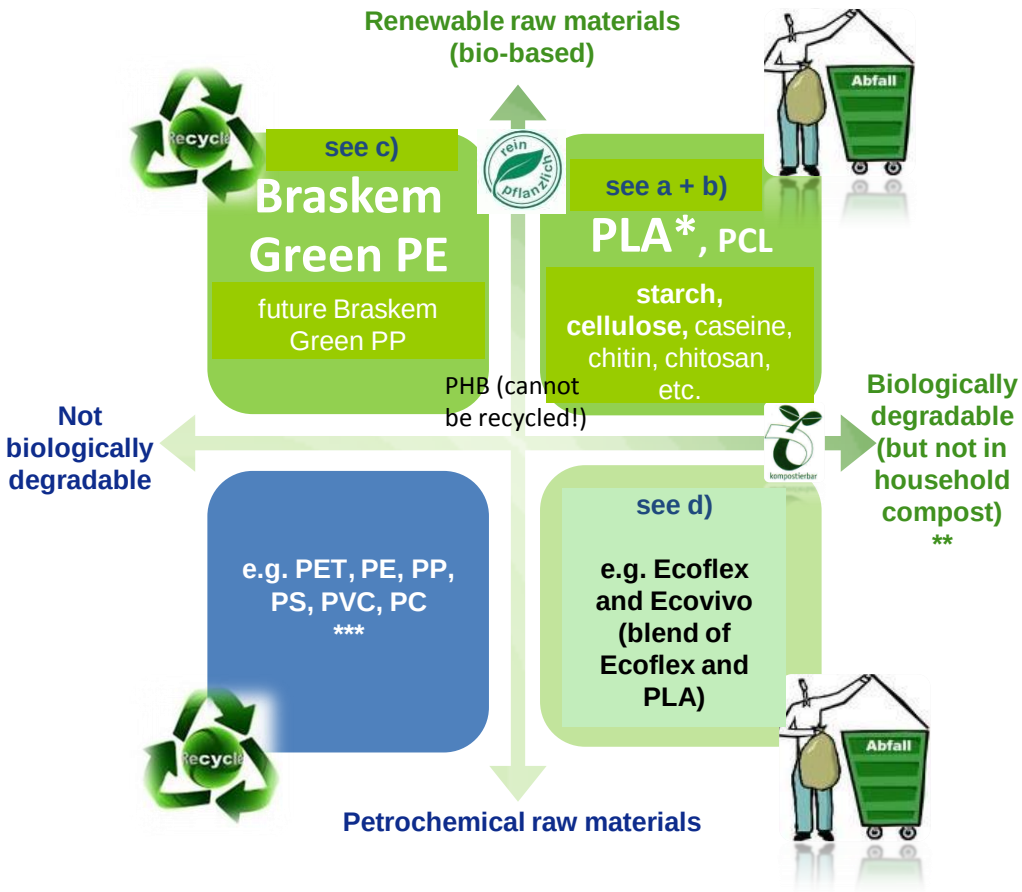
Conventional plastics I	PE – polyethylene (thermoplastic, polyolefin)	PP – polypropylene (thermoplastic, polyolefin)
Interesting facts	Most important thermoplastic plastic. Available as LD-PE, HD-PE, and LLD-PE (low/high/linear low density PE). Petrochemically manufactured from ethylene gas and (recently) biochemically from ethanol (see bioplastics section).	Many PP varieties exist; they can largely vary with respect to their specific parameters and properties. It is produced from propene gas from petroleum or natural gas.
Properties	Soft, flexible (LD-PE) to rigid, unbreakable (HD-PE), opaque (only thin films are clear). Odorless, waxy to the touch and scorable with fingernails. HD-PE cannot be readily glued or printed. Compatible to skin, free from odor and taste.	Many properties similar to HD-PE; however, PP is lighter, harder, and less elastic. PP is compatible to skin, free from odor and taste. PP is also long-term bending resistant. 10 millions of bendings do not deteriorate the material; it therefore allows the production of so-called "film hinges."
Typical applications	HD-PE: plastic bottles, shampoo bottles, cream tins, plastic tubing, garbage cans, beverage crates, plastic barrels, artificial wood, and thin, rustling bags with handles (made from stretched HD-PE). LD-PE: plastic bags, plastic tubes, shrink wrap, garbage bags	Extremely versatile: e.g. used in food industry, household, and packaging technology for yoghurt cups, bottle stoppers, coffee machines, films, tubing, plates, toys for children, heat preservation containers (EPP), straws, sportswear, health products… Also used for bottle caps.
Criticized issues in public discussion	None, considered physiologically safe. (Even Plastic Planet expresses no reservations against PE.)	None, considered physiologically safe. Suited for food and pharmaceutical applications.
Criticized ingredients	No plasticizers needed.	Use of plasticizers uncommon.
How many recycling cycles are possible?	4 to 5; no more recycling cycles possible due to the decreasing chain length of the polymer molecules. Currently, many countries do not recycle PE; however, the tendency is increasing, also due to the increasing demand for recycled PE (mostly in the U.S.A and in the UK).	PP can be recycled, but this is (still) rarely done. Melting of PP results in a mixture of the properties of the various PP types and therefore to an inferior quality recycling product.
CO_2 saving by recycling process:	Recycling forms 70% less CO_2 than the production of new PE. (source: Interseroh)	n.a.
What happens during (waste) combustion?	Burns without residues. Combustion products: $CO_2 + H_2O$. No toxic combustion gases are formed from pure PE. However, when the PE contains flame retardants, the combustion can lead to halogen-containing residues to be deposited. On the other hand, the most relevant flame retardants with respect to amounts used in polyolefin processing are aluminum oxide hydrates which are considered to be toxicologically safe.	Burns without residues. Combustion products: $CO_2 + H_2O$. No toxic combustion gases are formed from pure PP. However, when the PE contains flame retardants, the combustion can lead to halogen-containing residues to be deposited. On the other hand, the most relevant flame retardants with respect to amounts used in polyolefin processing are aluminum oxide hydrates considered toxicologically safe.
Recommendations	Disposal by recyclable waste system, if existing.	Disposal by recyclable waste system, if existing.

Conventional plastics II	PET– polyethylene therephthalate (thermoplastic, polyester)	PE-PET film bags (thermoplastic, composite material)
Interesting facts	Used PET is available according to type by organized large-scale collecting systems for PET beverage bottles.	Composite films are multiple layer packaging films. The individual film layers are laminated or coated.
Properties	Light, rigid, stable shape, weather-resistant, highly transparent, shiny, dyeable, printable. Excellent temperature resistance, fire-resistant. Excellent mechanical properties, scratch-resistant. Almost unlimited shapeability under heat, with the exception of bottles with handle.	The properties of composite films depend on the carrier material. PET represents a good barrier with respect to gases, steam, and aromas. However, this barrier function is not sufficient to allow the use of PET only as a barrier film. However, PET is excellently suited to be used in composite materials, preferentially in combination with PE.
Typical applications	Soft drink bottles, polyester textiles and very thin films, e.g. for aroma-proof food packaging, furniture films, magnetic tapes, etc., machine parts and medical implants, e.g. vascular grafts. Well-known: detergent bottles, toilet cleaner bottles, glass cleaner bottles. etc.	Composite films are preferentially used by the food industry, but also by some detergent manufacturers for refill pouches.
Criticized issues in public discussion	So far only criticized in the context of foods: 1) traces of antimony and acetaldehyde in beverages from PET bottles have been detects (acetaldehyde is not hazardous to health; It is only a matter of taste but has been meanwhile resolved). 2) in 2009, the Frankfurt university detected in mineral waters filled into PET twice the level of hormone-like substances than in glass; However, the researchers admit that the study design does not allow conclusions on the cause. 3) Plastic Planet complains that the composition of recycled plastics is often is handled as a company secret by the manufacturer. In the case of W&M this is not true.	Composite films are recently often confused with polycarbonate (PC), because both materials are labeled with recycling code “7.” The two materials PC and PE-PET films have only in common that they cannot be assigned to the recycling codes “1” to “6.”. Code “7” is used to label all other recyclable plastic. Thus, “7” is a pool group not allowing conclusions on the used material or its properties. Consumers need deeper knowledge in plastics recycling to know this.
Criticized ingredients	**None. PET contains no plasticizers**. In contrast to phthalates, the terephthalates in PET are not volatile but permanently chemically bonded.	None.
How many recycling cycles are possible?	Up to 8 recycling runs. About 2/3 of recycled PET is used for textiles (fleece), the other material for new films, bottles, etc.	n.a. Currently, many countries do not recycle composite materials.
CO_2 saving by recycling process:	Recycling forms 82% less CO_2 than the production of new PET (even including the far transport distances to Asia).	n.a.
What happens during (waste) combustion ?	Burns without residues. Products without flame retardants burn to CO_2 and H_2O only.	Burns without residues. Products without flame retardants burn to CO_2 and H_2O only.
Recommendations for consumers	PET is returned to recycling by deposit-based collection systems. Alternative: recyclable waste system.	Disposal by recyclable waste system, if existing.

Conventional plastics III	**PS – polysterene** (thermoplastic, styrene)	**PVC – polyvinyl chloride** (thermoplastic, vinyl, chlorinated polymer)
Interesting facts	Very common bulk plastic. Foamed PS is called EPS (expanded polystyrene). Well-known EPS: Styropor® As the demand for PS decreased, both BASF and Dow Chemicals intend to withdraw from the styrene market.	Plasticizers allow large variations in the hardness and viscosity of PV. Soft PVC even contains a plasticizer portion as high as 30-35%!
Properties	Pure PS: hard, rigid; shiny; does neither taste nor small; UV-sensitive; easily flammable; very limited heat resistance; sensitive to organic solvents; recognizable by the metallic-rustling sound. EPS: noise and heat insulation	Hard PVC: stiff, rigid; very smooth surface; resistant to oils, fats, bases, and acids; flame-resistant; little temperature resistance (permanently only up to 65 °C); tends to stress whitening Soft PVC: abrasion-resistant, rubber-elastic, leather-like
Typical applications	Packaging materials: foam polystyrene, packaging films, yoghurt cups, etc. Also many commodity goods are made from PS, for example hangers, clothespins, and CD boxes.	Hard PVC: drain pipes, window profiles, credit cards Soft PVC: toys for children, rainwear, imitation leather, shower curtains, floor coverings, tubing, seals, films, etc.
Criticized issues in public discussion	The **production process** involves **carcinogenic styrene** and **benzene**. The **processing** of PS involves the **release of carcinogenic styrene oxide.** Styrene also has been demonstrated to damage the reproductive system. PS is readily flammable (PS has played a decisive role in starting the fire in the fire disaster in the Düsseldorf airport in 1996).	Due to its high chlorine content and the resulting by-products (see below) formed during **burning**, PVC is considered very harmful to the environment. The **vinyl chloride** used in its production is **carcinogenic**. In addition **soft PVC** unavoidably **releases plasticizers**, mostly **phthalates**, including **DEHP**, DBP, and BBP considered **harmful to reproduction**.
Criticized ingredients	According to Plastic Planet, **p-nonylphenol** is sometimes used as a stabilizer for PS; this substance acts as a phantom estrogen.	**Yes**, mostly **phthalates**, but sometimes also p-nonylphenol and BPA, which are other so-called endocrine disruptors (hormone-like substances).
Recycling	Possible but rarely performed. PS can be converted to its starting material styrene by heating. Alternatively, styrene beads can be used in other applications.	The German PVC-processing industry provides exhaustive collection systems for PVC construction materials such as tubing and windows (hard PVC); incorporation of recycled material is possible up to 70%.
CO_2 saving by recycling:	n.a.	n.a.
What happens during (waste) combustion ?	PS without chemical contaminants (e.g. flame retardants) is rare. Therefore, its **steams** often have a pungent smell and **may be hazardous to health**. Therefore, they should not be inhaled.	Forms **caustic** hydrogen chloride gas that forms **hydrochloric acid** together with water or humidity. It is neutralized in waste incineration plants with lime in the exhausts. Highly toxic **dioxins** are formed during PVC combustion. They burn incompletely leading to soot formation; smoke and soot contain **highly toxic and carcinogenic** polycondensed **aromatic compounds**.
Recommendations for consumers	Yoghurt should preferably purchased in glasses. Disposable beverage cups and party dishes are better replaced by cardboard cups and plates. Disposal by recyclable waste system, if existing.	Avoid PVC, in particular soft PVC, especially in households with children. Avoid soft PVC as well for fat-containing foods, because plasticizers are **well absorbed** by fat.

“Bio” plastics

- “Bio” plastics represent a comparably new compound class; they have much in common with conventional plastics. Criteria allowing to differentiate between the different bioplastic types are
  - the use of renewable raw materials in production and/or
  - biological degradability and compostability.
- **“Bio-based” plastics** are formed from bio-polymers sourced from renewable raw materials. Another definition says that “bioplastics” are all biologically degradable plastics, independent from their raw material source (**“bio-degradable plastics”**).
- The first definition includes non-degradable (or persistent) raw materials based on sustainable raw materials that are excluded by the second definition; on the other hand it includes biologically degradable plastics based on petroleum.



- It is theoretically possible to recycle PLA chemically and to process it to new PLA. However, this would require separated collection according to type that currently nowhere has been established. The addition of shredded PLA to conventional recyclate (PET, PE, PP, etc.) can render this useless.

** So far, biological decomposition of all “bioplastics marketed as compostable” is only possible in industrial composting plants, i.e. neither in household compost nor via the “bio-trash can” (see WWF statements and UBA leaflet).

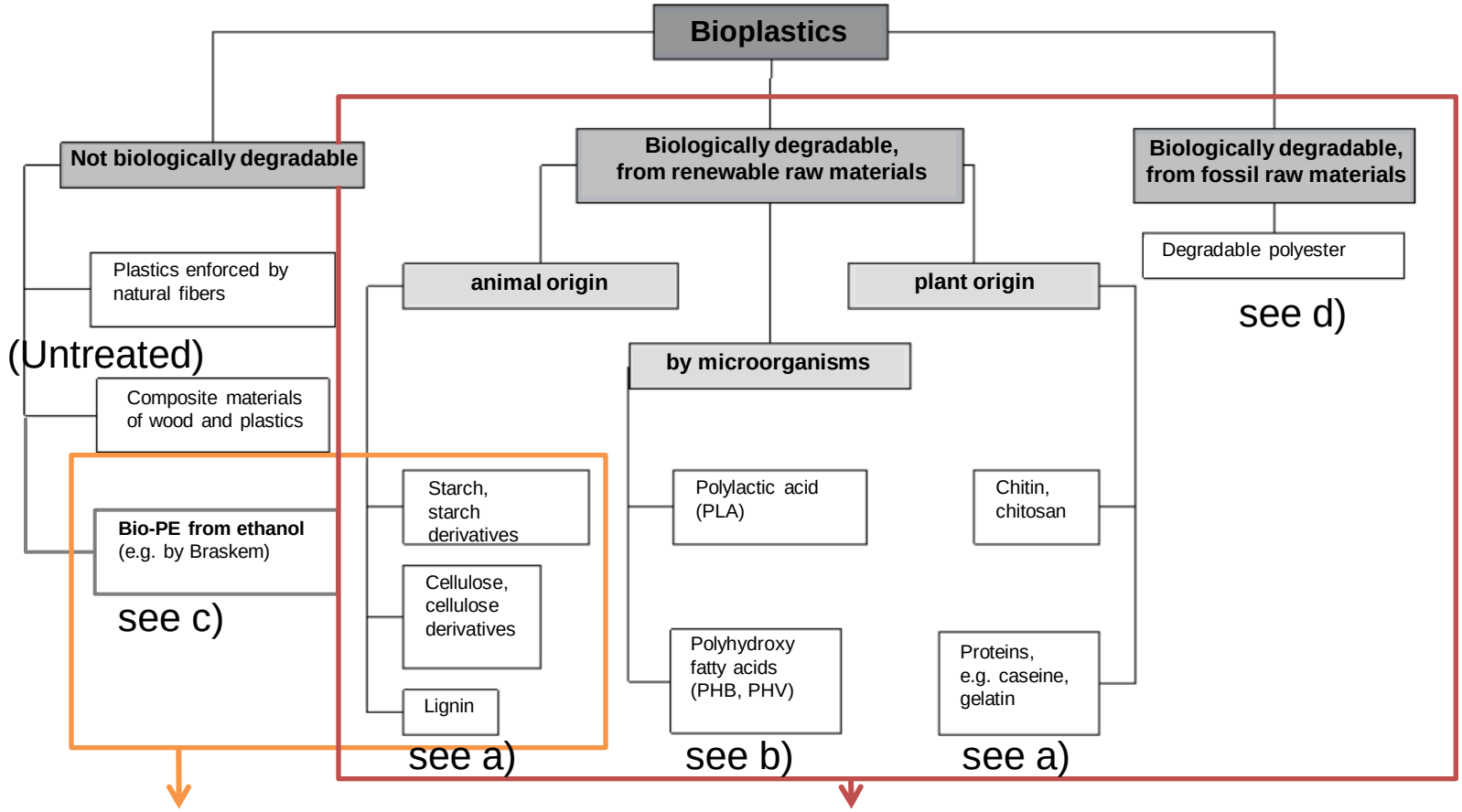
***The addition of specific harmless additives makes conventional plastics biologically degradable.

“Bio” plastics

- **Thermoplastic starch** has a market share of about 80% and therefore is the most common bioplastic. The basic raw material is normally starch from maize, wheat, or potatoes.
- Applications from **polylactide (PLA, lactic acid)** can be either manufactured highly transparent or in a large variety of colors. PLA is similar to conventional thermoplastic mass plastics and can be processed in various processes. PLA is suited for the production of products such as films, moldings, and bottles.
- The biopolymer **polyhydroxy butyric acid (PHB, fatty acid)** is a biopolyester produced by fermentation. Its properties resemble the petrochemically produced plastic polypropylene. The properties of PHB blends range from adhesives to vulcanite.

- 225 millions of plastics are used worldwide every year. Therefore, the share of materials from renewable raw materials (about 250,000 tons) is currently rather low (0.1 percent). However, tremendous future gains in market share are forecasted for bioplastics. Experts estimate that depending on the conditions about 10% of the total plastics production or about 70% of plastic packaging could be replaced by bioplastic products.

Classification of “bio” plastics



Potential area competition to foods unless produced from agricultural waste.

- They cannot be composted in gardens and therefore are waste there.
- They are also not well accepted in industrial composting plants, because they do not form valuable compost ingredients but only water and CO_2.
- They interfere with the recycling of conventional plastics; they deteriorate the product quality of the plastic recyclates and increase processing expenses.
- According to a UBA recommendation, they should be disposed of with residual waste, if possible, and undergo thermal exploitation, unless they can be supplied to closed recycling.

The UBA (German Federal Environmental Agency) requires that no advertising should be made based on positive environmental statements relating to biologically degradable plastics, unless their benefit to the environment has been actually demonstrated by scientific studies! The major benefit of bioplastics based on renewable raw materials is their neutral CO_2 balance. On the other hand, they may cause problems by eutrophication of waters by plant fertilizers and potentially problems arising from artificial irrigation.

Sample applications of “bio” plastics made from

…starch
(natural bio-polymer)

Mobile phone
made from maize starch

Plastic bag
made from maize starch

Disposable cutlery
made from maize starch

Plastic chips
made from maize starch

…cellulose
(natural biopolymer)

Printed cellophane bag
and clear cellophane film

Transparent cubes
made from cellulose acetate (CA)

Packaging
made from cellulose acetate (CA)

Cosmetic pencil
made from cellulose acetate (CA)

…polylactic acid
(synthetic biopolymer)

Highly transparent PLA bottle
(right) compared to PET and PP

Food packaging lid
made from PLA

Leman juice
bottle
made from PLA

Computer housing
made from PLA

Ballpoint pen
made from PLA

Clothing
made from PLA

Correction roller
made from PLA

…“Ecovio®”

Bag made from Ecovio, a blend of
petroleum-based but biologically
degradable Ecoflex and PLA
from renewable raw materials

Ecovio-coated cardbox beaker
and shrink film made from Ecovio

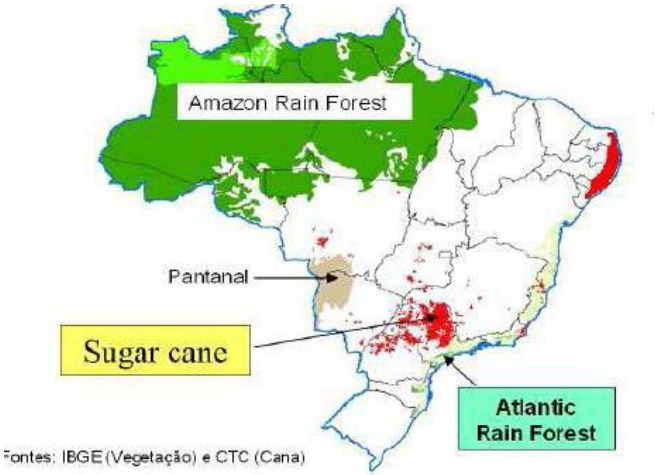
…“Ecoflex®”

Bag made from petroleum-based but
biologically completely degradable Ecoflex

Bioplastics	a) "Bioplastics" from natural biopolymers, compostable	b) "Bioplastics" from synthetically produced bio-polymers, e.g. PLA (polylactide), compostable
Interesting facts	**Biopolymers of raw materials of plant** (starch, cellulose, lignin, proteins) **or animal origin** (chitin, PHB, PHV, chitosan) **are formed in nature.** The first factory producing celluloid, a thermoplastic made from cellulose, was already established in 1869.	Plant monomers can be also synthetically converted to biopoly-mers, e.g. by artificial polymerization of lactic acid (formed by lactic acid bacteria as a fermentation product of sugar and starch).
Properties	Biopolymers resemble the basic products of conventional plastics; however, their, processing is somewhat more sophisticated, and they are not as stable a plastics. Thermoplastic starch absorbs water and is therefore normally only a partial component in the production of bioplastics. The second basic component is represented by water-repellant biologically degradable polymers. In the extruder, the water-soluble, disperse starch phase and the water-insoluble, continuous plastics phase combine to a water-resistant starch plastic. Cellulose acetate is transparent and flame-resistant; it can be readily stained and thermoplastically shaped at 180 to 200 °C.	The mechanical properties of pure PLA are very similar to those of PET. In particular due to its transparence and low migration specifications, PLA is ideal for food packaging applications. However, compared to PET, its permeability for CO2, oxygen and humidity is much higher. The benefits provided by PLA are the wide diversity of bioplastics that can be designed either for quick biological decomposition or for yearlong duration, high solidity, thermoplasticity, and good processability by existing industrial plants. However, it is a disadvantage of PLA and PLA blends that they become very soft at temperatures above 50 °C.
Typical applications	Starch blends: carrying bags, yoghurt/drinking cups, planter pots, cutlery, diaper film, coated paper and cardboard. Cellulose acetate: textiles (acetate = artificial silk), spectacle frames, ballpoint pens, telephones, toys, packaging film, etc.	PLA provides potential for films, molded parts, cans, cups, bottles, and other commodity goods for exhaustible packaging films or deep-drawing products (such as drinking or yoghurt cups, dishes for fruits, vegetables, and meat), in particular, when collection in closed systems is possible (e.g. by large-scale catering).
Criticized issues in public discussion	Few! The threat that genetic engineered agricultural raw materials would be grown as the source for bioplastics and the dilemma of area competition with foods. The latter can be avoided by using agricultural wastes.	
Criticized ingredients	Cannot be excluded in "bioplastics"	
Biological degradability	Compostable, however, only in specialized industrial plants requiring supply of heat and water and mechanical support. Biological decomposition in a natural environment is normally very slow; not suited for household compost,	
CO_2 by replacement of raw oil:	**Bioplastics burn and are recycled with a neutral CO2 balance**, because they consist of renewable raw materials.	
What happens during (waste) combustion ?	Depends on potential additives. Pure bioplastics are no source of toxic substances.	
Recommendations for consumers	No separate collection system exists for composting of bioplastics. Therefore, they should be disposed of as residual waste but not in the yellow plastic collection bag or in the green bin! There they would be rather harmful then useful, because current waste sorting plants cannot isolate them. For the time being, they require residual waste collection!	

Bioplastics	c) Biologically not degradable but recyclable plastics from renewable raw materials	d) Biologically degradable plastics from petroleum
Interesting facts	The Brazil company Braskem developed a method for the production of **polyethylene** from **bioethanol** from sugar cane produced by fermentation; it has the same chemical composition and thus the same properties as polyethylene synthesized from petroleum. Süd-Chemie currently builds a demonstration plant in Germany to be completed until the end of 2011 to produce ethanol from cellulose; it will have a capacity of 2,000 tons per year. Braskem currently can produce 200.000 tons of "green PE" per year. PP from sugar cane is in development.	With Ecoflex® and Ecovio®, BASF offers since years fully synthetic but biologically degradable and compostable plastics (polyesters) for the production of mulch films and other applications. It is intended to increase the capacity of the Ecoflex plant in Ludwigshafen for 60,000 tons per year by the end of 2010. Currently, biologically degradable plastics from crude oil cannot be recycled in contrast to conventional plastics.
Properties	See polyethylene	Ecovio, a blend of Ecoflex and PLA makes food packaging from starch or paper water and fat resistant.
Typical applications	Automotive industry, packing industry, etc. Customers are e.g. P&G (for Pantene, Max Factor, Cover Girl), Johnson & Johnson (for Sundown), Tetrapack, Shiseido, and Ecover.	Ecoflex: mostly agricultural films, food packaging, and biological waste bags. Ecovio: cardboard cup coatings and shrink films (initial applications).
Criticized issues in public discussion	A definitive disadvantage for "I'm green PE" is the current E10 discussion in Germany. However, it will show in the end that only few actual facts conflict with sugar cane based ethanol. The dilemma of area competition with foods related to sugar cane is by far lower than realted to maize, wheat, or potatoes. A requirement still to be considered is that less fertilizers and pesticides should be used in sugar cane cultivation.	None known.
Criticized ingredients	None. (Also in production, the only waste formed is water.)	None.
Biological degradability	Not biologically degradable, but can be recycled like conventional PE. (see polyethylene)	Under well-defined conditions, biodegradable plastics completely degrade to water, CO_2, and biomass.
CO_2 by replacement of raw oil:	Instead of releasing CO_2, the production of one ton of the green, recyclable bioplastic even binds 2,1 to 2.5 tons of this greenhouse gas.	Petroleum-based biologically degradable plastics **do not have a neutral CO_2 balance**. (see a+b)
What happens during (waste) combustion ?	Combustion without residues. Combustion products: $CO_2 + H_2O$. Pure PE forms no toxic combustion gases.	CO_2 previously bound to petroleum is released again; **therefore, the combustion is climate-damaging, composting as well**.
Recommendations for consumers	Disposal by conventional recyclable waste system possible!	To be disposed of as residual waste!

Supplement to c): 100% plant-based “I’m green” PE (Braskem)



Customers: I’m green Plastic Renewable source Carbon reduction Braskem

From 2011: P&G, SHISEIDO, Johnson & Johnson, Tetra Pak

From 2012: ECOVER POWERED BY NATURE

Supplement to b): e.g. Nature Works “Ingeo” PLA

Pritt ECOmfort Correction Roller, Henkel

The latest innovation to its Correction Roller assortment is the high performance Pritt ECOmfort Correction roller. The solvent-free correction roller is the first in the world with a shell made from 89% Ingeo biopolymer. Read more.

"Nucycle", NEC

The "Nucycle" plant based formulation illustrates the NEC Group's unique material development technology and capabilities. Nucycle significantly expands the application of Ingeo PLA bioplastics into products where performance features such as durability, safety, and high levels of flame retardancy are of paramount importance. Read more.

In-Flight Cold Drink Cups, Avianca

Colombia-based airline Avianca, with a history of over 90 years, was the first commercial airline founded in the Americas and the second in the world. Now Avianca's passengers enjoy cold drinks served from attractive Ingeo cups. Read more.

s-bag® GREEN, Electrolux

s-bag is a high-tech innovation and the first dust bag in the world using Ingeo biopolymer. s-bag GREEN is made from completely renewable sources, with Ingeo fibers from plants not oil, natural rubber, and recycled cardboard. Read more.

Urara Personal Care, Shiseido

Shiseido, a major Japanese and international cosmetics company, launched last year in China its URARA branded shampoo, conditioner, body soap and other personal care products packaged in new Ingeo natural plastic bottles. Read more.

Organic Yogurt Multipack Cups, Stonyfield Farm

Global organic yogurt leader Stonyfield Farm has replaced all of its petroleum- based multipack yogurt cups with cups made from plant-based Ingeo. A first for the dairy industry, these cups reduce the package's greenhouse gas emissions by 48%. Read more.

Bottles

In the first European commercial introduction of an extrusion blow molded bottle, **Polenghi**, the Italian company known for lemon juice and dressings, will switch from polyolefin resin to Ingeo bioplastic for its organic lemon juice.

Read more >

Amazing application, because all information available up-to-date on the properties of PLA indicate that this should not be possible (liquid/hydrophilic, acidic, no internal pressure)

Other plastics claimed as being particularly environmentally friendly

Coca Cola "Plant Bottle"
(also used for Heinz Ketchup)

- PET consists of the components PTA and MEG.
- MEG is a simple molecule; it can be either produced from petroleum or from a number of other, including plant-based, raw materials.
- Coca-Cola used plant MEG since 2009 and markets since that time plastic bottles containing a portion of 30% originating from plant raw materials with the claim "plant bottles."
- Alpla produces in Mexico with this material for Coca-Cola. Coca-Cola grants licenses for the PlantBottle. Alpla can mediate. (current as of March 2011)

Bio-based PET – Coca Cola's plantbottle

- **Available in seven countries worldwide – Brazil, Denmark, Japan, Canada, Mexico, Norway, and the U.S.A.**
- **Mixtures depending on the market of fossil-based, bio-based, and R-PET**

„The PlantBottle is recognized by the 2010 Greener Package Awards for its current innovation and future potential."

www.greenerpackage.com, August 30, 2010

Danone's "45% Öko-PET bottle"

- As a competition to Coca-Cola, Danone tries to offer an even more environmentally friendly PET bottle by using 25% of recycled material in addition to the plant MEG.
- The results in the following balance:

– **25 % recycled PET**	**25% "eco-component 1"**
– **75% normal PET x 27% plant MEG**	**<u>20% "eco-component 1"</u>**
	45% eco portion in the PET

- Currently, only the 500 ml bottle size is available as a 45% "Öko-PET" bottle, but it is intended to add more bottle formats in 2011.

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