Beyond Plastic Bermuda

Glossary of Plastic Types and Associated Chemicals

BioPBS A film which is made from corn starch and is commercially compostable.

BioPlastic A poorly defined term which generally means that the plastic was made entirely or partially from a renewable (biological) source. This could mean that the bioplastic is chemically identical to a traditional plastic or, it may be unique and also biodegradable. A bioplastic is theoretically more carbon neutral as it uses less fossil fuel as a starting point. It is important to note that not all items that are made from BioPlastics are biodegradable. It is important to also note that Bio-based/biodegradable materials and conventional plastic are similarly toxic. (Zimmermann et al. 2020)

Biodegradable Should mean that the compound will be naturally degraded over time by living organisms and or oxidation into smaller constituent molecules and eventually to a full extent into carbon dioxide, methane, water and biomass. See 'home compostable' and 'industrially compostable' for further information.

Bisphenol (BPA & BPS) Bisphenol A is an industrial chemical that has been used in the manufacture of certain plastics and resins since the 1950s. BPA is found in polycarbonate plastics and epoxy resins. Polycarbonate plastics are often used in containers that store food and beverages, such as water bottles. They may also be used in other consumer goods. Epoxy resins are used to coat the inside of metal products, such as food cans, bottle tops and water supply lines and may contain bisphenol. Some dental sealants and composites also may contain BPA. Research has shown that BPA can leach into food or beverages from containers that are made with BPA. Exposure to BPA is a concern because of the possible health effects on the brain and prostate gland of fetuses, infants and children. Exposure to bisphenol may affect children's behavior. Additional research suggests a possible link between BPA and increased blood pressure, type 2 diabetes and cardiovascular disease. Bisphenol is restricted in use by many countries, however, the U.S. Food and Drug Administration (FDA) has said that BPA is safe at the very low levels that occur in some foods. BPA has been removed from many products voluntarily due to health concerns. Some products now use BPS or BPF which are other form of the compound and are suspected of being EDCs.

Circular Economy At its core, a circular economy model has the intention of designing out waste. In fact, a circular economy is based on the idea that there is no such thing as waste. In order to achieve this, products are designed to last (good quality materials are used) and optimized for a cycle of disassembly and reuse that will make it easier to handle and transform or renew them.

Dacron fiber based on PET

Endocrine Disrupting Chemical (EDC) An EDC is a chemical that can mimic a hormone in a living organism. Many chemicals, both natural and man-made, can act as an EDC and therefore interfere with the body's hormones, known as the endocrine system. Called endocrine disruptors, these chemicals are linked with developmental, reproductive, brain, immune, and other problems. Endocrine disruptors are found in many everyday products, including some plastic bottles and containers, liners of metal food cans, detergents, flame retardants, food, toys, cosmetics, and pesticides. Some endocrine-disrupting chemicals are slow to break-down in the environment. That characteristic makes them potentially hazardous over a long period. Endocrine disrupting chemicals have been shown to cause adverse effects in animals, but limited scientific information exists on potential health problems in humans. Because people are typically exposed to multiple endocrine disruptors at the same time, assessing public health effects is difficult.
(https://www.niehs.nih.gov/health/topics/agents/endocrine/index.cfm)

Expanded PolyStyrene (EPS), Styrofoam EPS is produced by placing Styrene and isobutene in a reactor and heating them. The result is extruded polystyrene foam, a strong material that is moisture resistant and composed of 98 percent air—so incredibly lightweight and buoyant that it was considered a wonder product. The US Department of Health and Human Services (DHHS), National Toxicology Program (NTP) lists styrene as "reasonably anticipated to be a human carcinogen." The International Agency for Research on Cancer (IARC) has determined that styrene is a possible human carcinogen. EPS becomes brittle with age and oxidation and tends to form microplastics. Waste polystyrene takes hundreds of years to biodegrade and is resistant to photo-oxidation.

High-Density Polyethylene (HDPE) is type 2 on the recycling label. HDPE is a thermoplastic polymer produced from the monomer ethylene. It is sometimes called "alkathene" or "polythene" when used for HDPE pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes and plastic lumber. HDPE is commonly recycled. Often used for sturdy jugs and containers. Reported to be safer than PET, but contaminants in HDPE can act as EDCs.

Home Compostable A term that indicates a product will biodegrade completely in normal temperatures (20 degrees C) in a home compost pile in a short period of time (60 -120 days). However, use of this term can be misconstrued if not accompanied by a defined certification such as by TUV Austria or Quebec Bureau de normalisation (BNQ). There are European standards such as EN 13432 that may also be referenced. The US ASTM does **not** have a home compostable standard.

Note that the TUV Home documentation also states "OK compost HOME certification of a product may not be used to make a claim of (bio)degradation in the soil, (bio)degradation in water or renewability. Formal certification to a separate standard

such as OK biodegradable SOIL, OK biodegradable WATER or OK biobased is required in order to make such a claim."

Industrially Compostable A term that indicates that a product will biodegrade completely in an industrial compost pile. An industrial compost pile requires high temperatures. Items labeled as certified industrially compostable means they have passed a certification such as BPI or TUV. These items require the controlled environment of a composting facility to biodegrade, so they usually will not biodegrade in a home compost environment. Biodegradation takes a defined time depending on the standard (usually 120 days). Bermuda does not have an industrial compost facility and such waste would require that a separate waste stream be created. It should be noted that bioplastic does not produce a material that is high quality and it is often contaminated with undegraded materials.

ISLA® A more eco-friendly water-based nonPlastic barrier coat product that can be used on fibre-based containers to repel water and grease. Produced by Kotkamills' in Finland. Kotkamills' recyclable and biodegradable ISLA® Duo barrier board has received the Seedling and DIN-Geprüft certifications for industrial compostability and reports state they are working on a home compostable version. Cups made from the paperboard are available.

Low-density polyethylene (LDPE) Type 4 on the recycling label though not normally recycled. Used as barrier coat, for bags and films. Considered less dangerous than other plastics but still may contain diethylhexyl adipate (DEHA), another potential endocrine disruptor that has been linked to breast cancer in women and low sperm counts in men.

Microplastics are tiny plastic particles measuring less than 5mm that result from both commercial product development and the breakdown of larger plastics. As a pollutant, microplastics can be harmful to the environment and animal health. They have been found everywhere from freshly fallen snow in Antarctica to the depths of the ocean and can be toxic for animals and plants.

Oxo-degradable plastics Plastic materials that include additives which may include plastic that through oxidation, lead to the fragmentation of the plastic material into micro-fragments or to chemical decomposition. Some oxo-degradable products are often more damaging to the environment than traditional plastic. Oxo-degradable is not the same as biodegradable or compostable.

Per- and polyfluoroalkyl substances (PFAS) Are a group of man-made chemicals that includes PFOA, PFOS, GenX, and many other chemicals. PFAS have been manufactured and used in a variety of industries around the globe since the 1940s. PFOA and PFOS have been the most extensively produced and studied of these chemicals. Both chemicals are very persistent in the environment and in the human body – meaning they don't break down and they can accumulate over time. There is

evidence that exposure to PFAS can lead to adverse human health effects. Part of a group of chemicals called ‘forever chemicals’.

Phthalates Are a group of chemicals used to make plastics more durable. They are often called plasticizers. Some phthalates are used to help dissolve other materials. Phthalates are in hundreds of products, such as vinyl flooring, lubricating oils, and personal-care products (soaps, shampoos, hair sprays). Phthalates are in polyvinyl chloride plastics, which are used to make products such as plastic packaging, garden hoses, and medical tubing.People can be exposed to phthalates by eating and drinking foods that have contacted products containing phthalates. Some exposure can occur from breathing phthalate particles in the air. Children can be exposed in crawling or touching things and then putting their hands in their mouths. Because of that hand-to-mouth behavior, phthalate particles in dust might be a greater risk for children than for adults. Inside a person’s body, phthalates are converted into breakdown products (metabolites) that quickly leave the body in urine. Some types of phthalates have affected the reproductive system in animals. More research is needed to assess the human health effects of exposure to phthalates. Certain phthalates are considered to be EDCs.

Plastic Any of the numerous organic synthetic or processed materials that are composed of polymers of high molecular weight whether the starting compounds are plants or petrochemical based and which can be made into objects, films, or filaments and which are not biodegradable in a reasonable time frame in terrestrial, aqueous or marine environments.

Polybutylene Adipate Terephthalate (PBAT)
Is a type of fossil fuel based plastic polymer used in various applications, including packaging, consumer goods, and industrial products. It is known for its versatility, high-temperature resistance, and biodegradability. PBAT is often blended with other polymers such as polyethylene (PE) or starch to improve its properties. It is a common component of biodegradable plastics, as it helps improve their performance while retaining biodegradability. It has been suggested that PBAT may degraded by microorganisms to produce chemicals that are highly toxic to plants (J. Liu, et al. 2022)

Polybutylene succinate (PBS) PBS is a biodegradable, semi-crystalline thermoplastic polyester synthesized through polycondensation of **succinic acid and 1-4-butanediol**. Both building blocks can be produced either from renewable feedstock such as glucose and sucrose via fermentation or from petroleum-based feedstock. PBS has physical properties comparable to propylene. It is used in packaging films for food and cosmetics. In the agricultural field, PBS is used as a biodegradable mulching film PBS can be degraded by the bacterias *Amycolatopsis* sp. HT-6 and *Penicillium* sp. strain 14-3. In addition, *Microbispora rosea*, *Excellospora japonica* and *E. viridilutea* have been shown to consume samples of emulsified PBS.

Polycarbonate are a group of thermoplastic polymers containing carbonate groups in their chemical structures. Polycarbonates used in engineering are strong, tough materials, and some grades are optically transparent. They are easily worked, molded, and thermoformed. Because of these properties, polycarbonates find many applications. Polycarbonates do not have a unique resin identification code (RIC) and are identified as "Other", 7 on the recycling list. Products made from polycarbonate can contain bisphenol A (BPA) which can be released under certain conditions.

Polyethylene (PE) See HDPE High Density Polyethylene and LDPE Low Density Polyethylene

Polyethylene terephthalate (PET) Number 1 on the recycling type label. PET is the most common thermoplastic polymer resin of the polyester family and is used in fibres for clothing, containers for liquids and foods, and thermoforming for manufacturing, and in combination with glass fibre for engineering resins. PET is the most commonly used plastic for water bottles and is the most widely recycled plastic. **Bio-PET** is the bio-based counterpart of PET. Antimony and Bromine compounds are often contaminants.

Polyhydroxyalkanoates (PHA) Are a class of biodegradable, biocompatible plastics comprised of polyesters of *R*-hydroxyalkanoic acids.PHA producing organisms can be classified into two groups, ones that produce PHAs during their growth and others that produce PHAs when grown in a nutrient-limiting condition. PHAs demonstrate a wide range of physical and mechanical properties depending on the number of carbon atoms in the constituent monomer units of the polymer chain. Blending two different types of PHAs or PHAs with synthetic or other natural polymers have generated novel biomaterials to suit specific biomedical applications. Due to their environmentally friendly nature and favorable properties, PHAs have gained immense attention for industrial applications as replacements for conventional non-biodegradable plastics. Due to the relatively high costs associated with PHA production and downstream processing so far, the use of PHAs as industrial plastics is still limited. However, with increasing research and development pertaining to large-scale production and optimisation of PHA production costs, the use of PHAs is likely to expand.

Polylactic Acid (PLA) is a so called bioplastic which can be made from starch or sugars which have a plant based source. It is engineered to biodegrade, but requires an industrial facility which uses high temperatures to achieve this. In the natural environment this plastic could take eighty years or more to degrade. While PLA is considered Food Safe by the US FDA, there have been studies that questioned whether the final products are any less toxic than other fossil fuel based plastics. This is due to the additives used in the manufacturing processes to achieve particular product qualities. It is also unclear that biobased plastics such as PLA are less damaging from the greenhouse gas emissions perspective when examined in lifecycle analyses.

Polymethylmethacrylate (PMMA) belongs to a group of materials called engineering plastics. It is a transparent thermoplastic. PMMA is also known as **acrylic**, acrylic glass, as well as by the trade names and brands such as Crylux, Plexiglas, Acrylite, Astarlas,

Lucite, Perclax, and Perspex, among several others. This plastic is often used in sheet form as a lightweight or shatter-resistant alternative to glass. It can also be used as a casting resin, in inks and coatings, and for many other purposes. Common uses include lenses, acrylic nails, paint, security barriers, medical devices, LCD screens, and furniture. Because of its clarity, it is also often used for windows, tanks, and enclosures around exhibits. Similar to Polycarbonate, but differing in that Acrylic doesn't contain the potentially harmful substance bisphenol-A (BPA) and Polycarbonate tends to have higher impact strength

Polypropylene (PP) Type 5 on the recycling label. PP is a thermoplastic polymer used in a wide variety of applications. Its properties are similar to polyethylene, but it is slightly harder and more heat resistant. It is a white, mechanically rugged material and has a high chemical resistance. Bio-PP is the bio-based counterpart of polypropylene. Polypropylene is the second-most widely produced commodity plastic (after polyethylene). The sales of this material are forecast to grow at a rate of 5.8% per year until 2021. Commonly used for bottles, food trays, heavy duty bags, and bottle tops.Though a safer alternative in food contact uses because it can withstand heat better, it still can leech EDCs. PP can also shed microplastics. Not often recycled.

Polystyrene (PS) Type 6 on the recycling label. Polystyrene is one of the most widely used plastics, the scale of its production being several million tonnes per year. Uses include jewel cases used for storage of optical discs, containers, lids, bottles, trays, tumblers, disposable cutlery and in the making of models. As a thermoplastic polymer, polystyrene is in a solid (glassy) state at room temperature but flows if heated above about 100 °C, its glass transition temperature. It becomes rigid again when cooled. This temperature behaviour is exploited for extrusion as in Styrofoam or **Expanded Polystyrene (EPS**) and also for molding and vacuum forming, since it can be cast into molds with fine detail. PS is recycled, but at a low rate. Styrene itself is a suspected carcinogen and can leech at various rates from containers.

Polyurethane (often abbreviated **PUR** and **PU**) is a commonly encountered polymer composed of organic units joined by carbamate (urethane) links. In contrast to other common polymers such as polyethylene and polystyrene, polyurethane is produced from a wide range of starting materials (monomers) and is therefore a class of polymers, rather than a distinct compound. This chemical variety allows for polyurethanes with very different physical properties, leading to an equally wide range of different applications including: rigid and flexible foams, varnishes and coatings, adhesives, electrical potting compounds, and fibres such as spandex and PUL. Of these, foams are the largest single application, accounting for 67% of all polyurethane produced in 2016. Generally considered less toxic than other compounds. However The flame retardant HBCD that is released from polyurethane foam negatively affects the survival and reproductive health of many aquatic animals. HBCD has been shown to harm the survival and reproduction of algae, daphnids and annelid worms. In fish, HBCD alters hormonal status and affects liver enzymes and it has been reported to alter thyroid hormones in salmon. HBCD can last for months in the air or for days in the soil. In water, HBCD is believed to have a half-life greater than 182 days

Poly(vinyl alcohol) (**PVOH**, **PVA**, or **PVAl**) Is a water-soluble synthetic polymer and has the idealized formula $[CH_2CH(OH)]_n$. As a polymer, it is a type of plastic. PVA is a vinyl polymer joined by only carbon–carbon linkages. The linkage is the same as those of typical plastics such as polyethylene, polypropylene, and polystyrene, and of water-soluble polymers such as polyacrylamide and polyacrylic acid. PVA can re-crystallize into microplastic particles under certain environmental conditions. While most toxicity tests report limited biological activity, it is one of the least studied forms of microplastic, despite its high industrial use and abundance in the environment. Additionally, PVA is reported to have a short environmental half-life, however due to its high concentrations in the environment it must either be more persistent than previously thought or is released at high, consistent rates. It is used in papermaking, textile warp sizing, as a thickener and emulsion stabilizer in PVAc adhesive formulations, in a variety of coatings, and 3D printing. It is colourless (white) and odorless. It is commonly supplied as beads or as solutions in water Without an externally added crosslinking agent, PVA solution can be gelled through repeated freezing-thawing, yielding highly strong, ultrapure, biocompatible hydrogels which have been used for a variety of applications such as vascular stents, cartilages, and contact lenses.

Among the vinyl polymers produced industrially, PVA is the only one known to be mineralized by microorganisms. PVA is water soluble and biodegradable; hence it is used to make water-soluble and biodegradable carriers, which may be useful in the manufacture of delivery systems for chemicals such as fertilizers, pesticides, and herbicides.

PVA is completely degraded and utilized by a bacterial strain, *Pseudomonas* O-3, as a sole source of carbon and energy. However, PVA-degrading microorganisms are not ubiquitous within the environment. Almost all the degrading strains belong to the genus *Pseudomonas,* although some do belong to other genera (Chielliniet et al., 2003). Among the PVA-degrading bacteria reported so far, a few strains showed no requirement for pyrroloquinoline quinone (PQQ). From a PVA-utilizing mixed culture, *Pseudomonas* sp. VM15C and *P. putida* VM15A were isolated. Their symbiosis is based on a syntrophic interaction. VM15C is a PVA-degrading strain that degrades and metabolizes PVA, while VM15A excretes a growth factor that VM15C requires for PVA utilization.

Some organizations have called for PVa to be removed from the EPA's Safer Chemicals Ingredients List and for the US EPA to regulate this chemical.

See: https://www.sustainablejungle.com/sustainable-living/what-is-pva/

PVC Polyvinyl Chloride Type 3 on the recycling label. PVC is the world's third-most widely produced synthetic plastic polymer (after polyethylene and polypropylene). About 40 million tons of PVC are produced each year. PVC comes in two basic forms: rigid (sometimes abbreviated as RPVC) and flexible. The rigid form of PVC is used in construction for pipes and in profile applications such as doors and windows. It is also used in making bottles, non-food packaging, food-covering sheets, and cards (such as bank or membership cards). It can be made softer and more flexible by the addition of

plasticizers, the most widely used being phthalates. In this form, it is also used in plumbing, electrical cable insulation, imitation leather, flooring, signage, phonograph records, inflatable products, and many applications where it replaces rubber. With cotton or linen, it is used in the production of canvas. Possibly the most dangerous plastic as it has been known to leech bisphenols, phthalates, metals and other compounds throughout its life**.** PVC is rarely recycled.

PVDC polyvinylidene chloride Plastic used to make thin flexible wraps for food store and other uses.

Post Consumer Resin (PCR) Is usually made from recycled PET, HDPE and PP. The recycled material is cleaned, processed and pelletized. The PCR can then be used to form new plastics such as bottles, food containers or other plastic items. Some plastics manufactured with PCR have been approved for food contact applications by various regulatory agencies. However, concern has been raised over the leaching of contaminants from PCR into food. There is pressure to increase the levels of PCR plastic in new material as a method of increasing the circularity and sustainability of plastic. Specific to food contact issues with PCR a 2021 Canadian report can be found here
http://www.plasticsmarkets.org/jsfcode/upload/wd_492/20211201120602_9_jsfwd_492_q2_1.pdf

Silicone or siloxanes, as they are also known—are something of a hybrid between synthetic rubbers and synthetic plastic polymers. They can take on different forms and be used to make malleable rubberlike items, hard plasticlike resins, and thick spreadable fluids.

Starch blends Starch blends are thermoplastic polymers produced by blending natural starches with plasticizers. Because starch polymers on their own are brittle at room temperature, plasticizers are added in a process called starch gelatinization to augment its crystallization. While all starches are biodegradable, not all plasticizers are. Thus, the biodegradability of the plasticizer determines the biodegradability of the starch blend. Biodegradable starch blends include starch/polylactic acid, starch/polycaprolactone and starch/polybutylene-adipate-co-terephthalate. Others blends such as starch/polyolefin are not biodegradable. Some starch blends are certified as home compostable.

Sustainable Broadly**,** sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs. In addition to natural resources, we also need social and economic resources. Embedded in most definitions of sustainability we also find concerns for social equity and economic development.

References

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