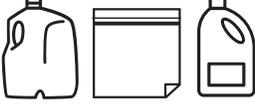
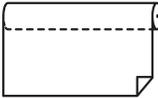
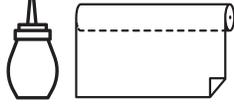
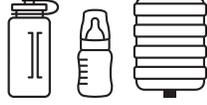


PLASTIC and FOOD PACKAGING

RESIN TYPE	TYPICAL PACKAGING PRODUCTS	
 PE	Freezer bags, frozen meat bags, prepackaged fresh produce, food storage containers, shrink and stretch wrap, bags, pouches and sachets, laminated with paperboard to make liquid packing cartons	
 PE	Water and soft drink bottles, fruit juice containers, domes or covers for prepared meals, cookie/biscuit trays, condiment bottles, peanut butter containers, cooking oil bottles	
 HDPE	Milk bottles, freezer bags, ice cream containers, juice bottles	
 PVC	Cling wrap, food foils, trays for sweets, seal on metal lids	
 LDPE	Squeeze bottles, cling wrap, shrink wrap	
 PP	Microwave dishes, yogurt and ice cream tubs, chip bags	
 PS	Water station cups, plastic cutlery	
 OTHER	Polycarbonate plastic Nalgene™ bottles, baby bottles, water cooler jugs, PLA, multi-material packaging	

The most common plastics used in food packaging include:

- Polyethylene #1
- Polyethylene terephthalate #1
- Polyvinyl chloride #3
- Polypropylene #5
- Polystyrene #6

Less common, but also used (all grouped into #7):

- Polycarbonate
- Polyamides
- Polylactic acid
- Acrylics

Chemicals of Concern by Packaging Type

METAL

Aluminum
Manganese
Sodium chromate
Potassium dichromate
Bisphenol B
Bisphenol A
Bisphenol S
Diphenolic acid
Bisphenol F
6:2 Fluorotelomer Alcohol
8:2 Fluorotelomer Alcohol
2-Chlorobuta-1,3-diene

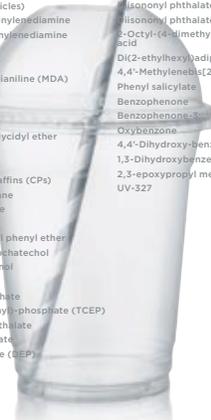
PAPER

Perfluorooctanoic acid, ammonium salt
2,3-Epoxypropyl-trimethylammonium chloride
Pentachlorophenol
2,3,4,5-Tetrachlorophenol anthraquinone
Boric acid
4-Nonylphenol
Ethyleneimine
Methylloxirane
Perfluorobutane sulfonic acid (PFBS)
Perfluoropentane sulfonic acid (PFPeS)
Perfluorohexane sulfonic acid (PFHxS)
Perfluoroheptane sulfonic acid (PFHpS)
Perfluorooctane sulfonic acid (PFOS) (3)
Perfluorobutanoic acid (PFBA)
Perfluoropentanoic acid (PFPeA)
Perfluorohexanoic acid (PFHxA)
Perfluoroheptanoic acid (PFHpA)
Perfluorooctanoic acid (PFOA) (5)
Perfluorononanoic acid (PFNA)

PLASTIC

Vinyl chloride
Sodium perchlorate
2,3-Epoxypropyl-trimethylammonium chloride (TBTO)
Tributyltin acetate
Dibutyltin (dilatrate)
Dibutyltin dichloride
Antimony trioxide
Silver (nanoparticles)
4-Methyl-m-phenylenediamine
Diphenyl-p-phenylenediamine
Acrylamide
Styrene
4,4'-Methylenedianiline (MDA)
Buta-1,3-diene
Vinyl acetate
Melamine
Bisphenol A diglycidyl ether
Chloroethylene
Isoprene
Chlorinated paraffins (CPs)
1,2-Dichloroethane
Dichloromethane
Styrene oxide
2,3-Epoxypropyl phenyl ether
4-tert-Butylpyrocatechol
4-tert-Butylphenol
p-Cresol
Triphenyl Phosphate
Tris(2-Chloroethyl) phosphate (TCEP)
Dicyclohexyl phthalate
Diphenyl phthalate
Diethyl phthalate (DEP)

Diisobutyl phthalate
Dibutyl phthalate (DBP)
Diethyl phthalate
Benzyl butyl phthalate
Bis(2-ethylhexyl) phthalate
Dicyl phthalate
Diosodecyl phthalate
Isodecyl phthalate
Isodecyl phthalate
3-Octyl-(4-methyl-amino)benzoic acid
Di(2-ethylhexyl)adipate
4,4'-Methylenbis[2-chloroaniline]
Phenyl salicylate
Benzophenone
Benzophenone-3
Oxybenzone
4,4'-Dihydroxybenzophenone
1,3-Dihydroxybenzene
2,3-epoxypropyl methacrylate
UV-327



GLOSSARY

Food Contact Article (FCA):

Yogurt cup



Food Contact Materials (FCMs):

- plastic(s)
- aluminum
- coating
- adhesives
- printing inks

Food Contact Chemicals (FCCs):

- monomers
- polymers
- oligomers
- additives
- pigments
- metals
- impurities
- reaction by-products
- degradation products

Food Contact Articles (FCAs) are combinations of different **Food Contact Materials (FCMs)**, which consist of **Food Contact Chemicals (FCCs)**.

Muncke, J., Backhaus, T., Geueke, B., Maffini, M. V., Martin, O. V., Myers, J. P., Soto, A.M., Trasande, L., Trier, X., Scheringer, M. (2017). Scientific Challenges in the Risk Assessment of Food Contact Materials. *Environmental Health Perspectives*, 125(9), [095001]. <https://doi.org/10.1289/EHP644>

Food Contact Material (FCM) – are all materials and articles intended to come into contact with food, such as packaging and containers, kitchen equipment, cutlery and dishes. These can be made from a variety of materials including plastics, rubber, paper and metal. They also include materials used in processing equipment, such as coffee makers or production machinery as well as containers used for transport. FCMs are made with the FCS and (usually) other substances. They are often (but not necessarily) a mixture, such as an antioxidant in a polymer. The composition may be variable. Food Contact Article is the finished film, bottle, dough hook, tray, or whatever that is formed out of the FCM.

Food Contact Substance (FCS) – in the U.S. means any substance that is intended for use as a component of materials used in manufacturing, packing, packaging, transporting, or holding food if such use of the substance is not intended to have any technical effect in such food. The Food Contact Substance is a single substance, such as a polymer or an antioxidant in a polymer. As a substance, it is reasonably pure (the Chemist's definition of substance). Even though a polymer may be composed of several monomers, it still has a well-defined composition.

Food Additive – any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food, including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and radiation sources. Exceptions include GRAS substances, a pesticide chemical residue, a pesticide chemical; a color additive; any substance used prior to September 6, 1958, a new animal drug; or or intended for use in a dietary supplement. Food additives include “indirect food additives” or “food contact substances” and thousands of substances used in food packaging and on the equipment used for processing and storing food.

1. **Direct Food Additives** – Additives that are added to a food for a specific purpose are known as direct additives. For example, the low calorie sweetener, aspartame, is a direct additive that is added to puddings, soft drinks, yogurt, and many other foods. Direct additives are identified on a food's ingredient label.
2. **Indirect Food Additives** – In general, these are food additives that come into contact with food as part of packaging, holding, or processing, but are not intended to be added directly to, become

GLOSSARY *continued*

a component, or have a technical effect in or on the food. In the U.S., these include adhesives and components of coatings, paper and paperboard components, polymers, and adjuvants and production aids.

Endocrine disrupting chemicals – are chemicals that can interfere with endocrine (or hormone) systems at certain doses (usually very low one). These disruptions can cause cancerous tumors, birth defects, and other developmental disorders. Some chemicals mimic a natural hormone, fooling the body into over-responding to the stimulus (e.g., a growth hormone that results in increased muscle mass), or responding at inappropriate times (e.g., producing insulin when it is not needed). Other endocrine disruptors block the effects of a hormone from certain receptors (e.g. growth hormones required for normal development). Still others directly stimulate or inhibit the endocrine system and cause overproduction or underproduction of hormones (e.g. an over or underactive thyroid).

GRAS – “GRAS” is an acronym for the phrase Generally Recognized As Safe. Regulated in the U.S. by the Food and Drug Administration, GRAS substances are a form of self determination of safety in which the manufacturer determines that the chemical would be considered safe according to standards of the scientific community, using no information needs to be submitted to the FDA regarding the use or existence of the chemical, or the basis of the GRAS determination of safety.

Intentionally Added Food Substances – are intentionally added to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food.

Non-Intentionally Added Substances – substances whose use may reasonably be expected to result in them becoming a component of food, even if the manufacturer does not intend for them to become part of the food- these can include thousands of substances used in food packaging and on the equipment used for processing and storing food.

Monomer – is a molecule that can be bonded to other identical molecules to form a polymer.

Oligomer – a polymer whose molecules consist of relatively few repeating units.

Phenol – Phenol is an aromatic organic compound with the molecular formula C₆H₅OH. It is a white crystalline solid that is volatile. The molecule consists of a phenyl group (–C₆H₅) bonded to a hydroxy group (–OH). It is mildly acidic and requires careful handling due to its propensity for causing chemical burns. Phenol is produced from petroleum. It is an important industrial commodity as a precursor to many materials and useful compounds. It is primarily used to synthesize plastics and related materials. Phenol and its chemical derivatives are essential for production of polycarbonates, epoxies, Bakelite, nylon, detergents, herbicides, and numerous pharmaceutical drugs.

Polymer – a substance that has a molecular structure consisting chiefly or entirely of a large number of similar molecular units bonded together, e.g., many synthetic organic materials used as plastics and resins.

Thermoset Plastics – A thermoset is a polymer that solidifies or “sets” irreversibly when heated. They are useful for their durability and strength, and are therefore used primarily in automobiles and construction applications. Other uses are adhesives, inks, and coatings.

Thermoplastics – A thermoplastic is a polymer in which the molecules are held together by weak bonds, creating plastics that soften when exposed to heat and return to original condition at room temperature. Thermoplastics can easily be shaped and molded into products such as milk jugs, floor coverings, credit cards, and carpet fibers.

SUMMARY OF PRIORITY CHEMICALS OF CONCERN

BISPHENOL A¹

Bisphenol A (BPA) is best known as the monomer building block of polycarbonate plastics. It is frequently used as an additive to other plastics such as polyvinyl chloride (PVC). Because the polymerization of BPA leaves some monomers unbound, BPA molecules can be released from beverage and food containers into drink and food over time. BPA is used in reusable water bottles, baby bottles, and the inner linings of food cans, where leaching is accelerated at elevated temperatures. It is also used to coat thermal paper receipts. Monomeric BPA is an endocrine disrupter.

In its determination of an exposure limit for humans, the U.S. EPA arrived at a value of 50 µg per kg per day. Scientists have argued that neither the EPA limit for BPA nor the typical risk assessment approach are suitable for evaluating BPA's health risks, as many peer-reviewed studies have reported adverse effects of BPA at very low doses (at or below the current EPA limit). Such effects include for males: decreased testosterone, increased prostate size, decreased sperm production and fertility. Low doses in females cause early puberty, increased mortality of embryos, disruption of adult estrous cycles, alterations in immune function. And generally BPA causes behavioral effects such as hyperactivity, increased aggressiveness, alterations in response to pain and threat stressors, reversal of normal sex differences and elimination of differences between the sexes in behavior, and decreases in maternal behavior. New studies also indicate BPA contributes to obesity, endometrial hyperplasia, recurrent miscarriages, sterility, and polycystic ovarian syndrome. Recent studies indicate that substitute bisphenols (BPS and BPH) may cause similar harm.

PHTHALATES

Phthalates are widely used in commercial and industrial production of plastics, household items, paints, medical devices, children's toys, and personal care products. More than 25 different phthalate esters exist. Phthalates impart flexibility, pliability, and elasticity to otherwise rigid polymers, such as PVC. They comprise 70% of the U.S. plasticizer market. Unlike BPA monomers in polycarbonate plastics, phthalates are not covalently bound to the polymer matrix, which means they migrate easily from packaging into food and beverages. Phthalates are contained in plastics at surprisingly high percentages. Di(2-ethylhexyl) phthalate (DEHP) is one of the principal phthalates causing human health concerns. Important other phthalate additives include di-isononyl phthalate (DINP), dibutyl phthalate (DBP), butylbenzyl phthalate (BBP), di-isododecyl phthalate (DIDP), di-n-octyl phthalate (DnOP), and di-n-hexyl phthalate (DnHP).

Phthalates are endocrine disruptors. They are associated with adverse reproductive outcomes, including: malformations of the male reproductive system, including cryptorchidism (failure of testes to descend), male feminization evidenced by reduced anogenital distance (AGD), which is linked to reduced semen volume and sperm count.² Such abnormalities can develop into testicular cancer. In young girls, phthalates — DMP, DEP, DBP, and DEHP — can lead to early onset puberty. DEHP is linked to increased waist circumference as well as an inverse association of phthalate levels with insulin resistance.

PERCHLORATE³

Perchlorate is a naturally occurring and man-made chemical that quickly dissolves in water and organic solvents and persists in the environment. It has been found in the urine of all Americans tested. While it leaves the body quickly, perchlorate persists in the environment for many years and there is evidence that it is widespread in the environment, including drinking water. The FDA has approved perchlorate's use as a food contact substance twice. The first time was in 1963 for its use in sealing gaskets

for food containers; and then, in 2005, it was approved for use as a conductivity enhancer or antistatic agent in dry food packaging.

Drinking water in the U.S. is widely contaminated with perchlorate. Perchlorate contaminates food through two primary uses: as an antistatic agent in any plastic material that contacts dry food, and as a contaminant associated with bleach. Bleach is widely used to sanitize food surfaces in food-manufacturing and processing facilities.

Perchlorate primarily affects the normal functioning of the thyroid gland by inhibiting the transport of iodine from the blood into the organ. Iodine is an essential element needed to produce thyroid hormone — which plays an important role in controlling metabolism and is critical in regulating fetal and infant brain development. Because perchlorate is such a strong inhibitor of iodine transport, pregnant women, infants, and children with inadequate iodine consumption are the most vulnerable, and exposure to the chemical greatly increases the risk of impaired neurodevelopment.

PER- and POLYFLUOROALKYL SUBSTANCES (PFAS)

These are highly persistent, mobile, and toxic chemicals used in food packaging, fire fighting foam, stain-resistant coatings for carpets, clothing, and many other industrial applications. In food packaging, PFAS is used to create moisture and grease-proof barriers for paper and fiberboard products. Some sandwich wrappers, french-fry boxes, compostable fiberware boxes, and bakery bags have been found to contain PFAS. Since the chemicals can migrate into food, and contaminate landfills and compost after disposal, the use of PFAS to treat food packaging can lead to unnecessary long-term exposure to harmful chemicals. Some PFAS are so persistent that they don't degrade at all in the environment — so levels will only get higher over time if their use continues. Exposure has been associated with liver damage, harm to the immune system, developmental toxicity, and cancer. People are exposed to PFAS from multiple sources, including the uses named above, and through multiple routes, including food, dust, air, and water.

FLAME RETARDANTS

Brominated flame retardants (BFRs) used in electronics and electrical equipment are being recycled into black food packaging. Containers, stirrers, straws, and other plastic foodware have demonstrated high levels of BFRs. Meanwhile, increasing numbers of national, state and local laws are calling for the increased use of recycled material. BFRs including PBDEs, HBCDs and TBBP-A have induced endocrine-, reproductive- and behavior effects in laboratory animals. Furthermore, recent human epidemiological data demonstrated association between exposure to BFRs and similar adverse effects as observed in animal studies.

ANTIMICROBIALS

With the advent of "active packaging," antimicrobial agents are integrated either directly into food in the packaging material where it is released over a period of time to maintain the products quality, as well as its extended shelf life. Some antimicrobials, such as polychlorinated hydrocarbons, Triclosan (TCS) and Triclocarban (TCC) are an emerging toxic hazard to public health, in the form of endocrine disruption, and to the environment. TCS and TCC interfere with essential signaling systems in animals and humans, thereby adversely affecting development, sexual maturation, metabolism, and behavior. Of particular for human health are the adverse effects of TCS on thyroid homeostasis and of TCC on reproductive health. In the environment, TCS and TCC rank in the list of top contaminants of concern worldwide. It is suspected that they make bacteria resistant to antibiotics.

1 Rolph U. Halden, (2010) Plastics and Health Risks, *Annual Review of Public Health*, 31:179-194

2 Swan SH, Sathyanarayana S, Barrett ES, Janssen S, Liu F, Nguyen RH, Redmon JB, TIDES Study Team (April 2015). "First trimester phthalate exposure and anogenital distance in newborns". *Human Reproduction*. 30 (4): 963–972

3 M. Maffini, T.G. Neltner, S. Vogel (2017) We are what we eat: Regulatory gaps in the United States that put our health at risk, *PLoS Biol* 15(12): e2003578