# THIS VINYL HOUSE

## HAZARDOUS ADDITIVES IN VINYL CONSUMER PRODUCTS AND HOME FURNISHINGS

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## Summary


Greenpeace tested a variety of common polyvinyl chloride (PVC or vinyl) consumer products, with uses from childcare to home furnishing, for phthalate plasticizers and lead, cadmium and organotin stabilizers. In earlier investigations, we detected the presence of hazardous levels of phthalates and cadmium and lead in toys and other PVC products manufactured for children. Toys, however, represent only a small part of the PVC market. On the other hand, construction materials including home furnishings, from hard (e.g., window frames, pipes) to softened (e.g., floor and wall coverings, accessories) products, account for 76% of PVC use. Although the most direct exposure of children to hazardous additives may be expected from toys and childcare items, the wide variety of other vinyl products in the home may also act as significant sources of exposure. Greenpeace therefore expanded its investigations to include materials in the home made of vinyl, such as wallpaper and floor coverings, that children come into contact with on a daily basis.

In this study, we found that:

- All products tested contained detectable levels of phthalates, with a maximum of 39% by weight in a drinking straw. Indeed, some of the highest levels were found in products specifically designed for children's mouths.
- Virtually all of the products contained significant amounts of organotins. Floor tiles, on which children spend a lot of time crawling and playing, and wallpa-

per were the two products containing the highest levels.

- Vinyl products for everyday use, containing larger amounts of hazardous additives than any other plastic, can be readily purchased at popular retail stores in the United States.

Greenpeace is concerned about this widespread availability of vinyl products containing substantial levels of phthalates and organotins since these additives leach from PVC and are untested and/or are associated with a number of serious health effects in animals.

With respect to phthalate plasticizers, scientific studies have shown that:

- Humans have phthalates in our bodies. A recent Centers for Disease Control (CDC) study confirmed the presence of two of the phthalates detected in this study in a test population.
- The offspring of rats fed the three phthalates detected in this study, namely diethyl hexyl-, diisononyl- and benzyl butyl phthalate (DEHP, DINP and BBP, respectively), do not follow normal patterns of sexual development.
- There is reason for concern that DEHP may impair male reproductive system development in human infants and toddlers.
- DINP causes liver tumors and damages the kidneys in rodents.
- The amount of DINP and other phthalates that leach from a product does not always correlate with the amount the product contains.
- DEHP-exposed rats and mice have a higher propensity for liver cancer than non-exposed animals. Furthermore, the Environmental Protection Agency (EPA) and the Department of Health and Human Services (DHHS) consider DEHP to be a probable human carcinogen. That is to say, DEHP may reasonably be considered a cancer causing substance in people.

In the case of metal stabilizers, it is scientifically accepted that:

- Breathing or swallowing organotins can interfere with the nervous system, and even cause death at high levels of exposure.
- Organotins have adverse effects on marine wildlife and rats, including reduced reproduction and developmental problems.
- Organotins build up in the fat of fish, rats and mice.

Greenpeace considers the use of phthalate plasticizers and metal stabilizers in common PVC consumer products unacceptable since it results in our needless and avoidable exposure to hazardous substances - exposure about which most people remain unaware. PVC requires more additives than any other plastic. Eighty-six percent of all phthalates made are used as PVC additives, and that number is expected to climb. It has also been estimated that almost 70% of all organotins are devoted for use in PVC. Clearly, if we replaced PVC with alternate materials that already exist, our direct exposure to phthalates and organotins would drop dramatically.

PVC's need for chemical additives is only part of its hazard - its lifecycle has serious, negative consequences. Dioxin is a confirmed human carcinogen (cancer-causing substance), and one of the most potent toxins known to man. Together, PVC manufacture and disposal represent one of the largest sources of dioxin. For these reasons, Greenpeace advocates the phase-out of all PVC plastics.

This Graco stroller raincover contains DEHP, a phthalate that some manufacturers have voluntarily removed from their products.

## Introduction

### Reasons for conducting this study

The global production of vinyl (also called PVC or polyvinyl chloride) was last estimated at approximately 51 billion pounds per year. (Stringer 2001) PVC takes many forms, being used to produce anything from food wrap, medical devices and children's toys to construction materials. To play all of these roles however, PVC must be mixed with additives since it is a hard, brittle plastic if left untreated. Chemicals known as phthalates are the most commonly used to plasticize PVC. (Bizarri 1996) These chemicals are characteristically oily liquids that soften, but do not bind to PVC when mixed. Because phthalates do not form tight bonds with PVC, they are able to leach out of vinyl products during normal use and after disposal. (Cadogan 1993)

Fueled by the hazards of PVC additives, Greenpeace undertook a study to determine the amount of phthalates present in vinyl products designed for a potentially sensitive and vulnerable population, namely children. That 1997 investigation found up to 40% by weight of phthalates, primarily diisononyl phthalate (DINP), in toys bought in 17 countries from around the world. (Stringer 2000) Toys, however, represent only a small percentage of the PVC market. Construction materials on the other hand, including vinyl siding, pipes, home furnishings and accessories, account for 76% of PVC use. (Chemical Economics Handbook 1997) Greenpeace, therefore, undertook this study of a wider assortment of vinyl products, including wallpaper, floor coverings and childcare items that children are likely to come into contact with in their everyday lives. The descriptions of the products are shown in Table 1 (page 17).

Phthalate plasticizers are only one class of additives that PVC requires. Without additives, PVC is not only brittle but it is also relatively unstable. Stabilizers, often metals, are added to PVC to keep it from breaking down and to give it stability against heat. (DiGangi 1997) Lead and cadmium were widely used for these purposes, but regulations brought on by their known human health hazards have forced manufacturers to replace them with other metals in some products. Organotins have long been used in commerce (Sadiki 1996) and as such, they made attractive candidates for replacements of the known hazardous stabilizers. However, the increased use of organotins as PVC stabilizers does not mean that they have a 'clean bill of health.' In fact, evidence is mounting against them. In the face of emerging reports that organotins also leach from PVC (Sadiki 1999) and are hazardous to humans (Boyer 1989, Champ 2000, ASTDR 1992), Greenpeace also tested the products included in this study for their organotin content. We did not test the leaching of either phthalates or organotins from PVC since it is already established to occur. (Cadogan 1993, Sadiki 1999) Furthermore, leaching rates are dependent upon a variety of factors such as heat, age of the product and friction. (DiGangi 1997)

This Gerber diaper cover and The First Years changing mat contained significant levels of one phthalate, DINP. In addition, the changing mat contained organotins and bisphenol A.

### Routes of human intake of phthalates

A recent study released by the CDC confirmed that humans have certain phthalates in our bodies. (U.S. CDC 2001) Eating, breathing and skin contact, as well as transfusion, are all ways, either together or alone, that different phthalates make their way into our systems. According to the EPA, eating is probably the main route by which humans are contaminated with diethylhexyl phthalate (DEHP), the most widely used phthalate plasticizer. (U.S. ASTDR 1993) In the same way, we are contaminated with other commonly used phthalates such as diisononyl phthalate (DINP). (Opinion on Phthalate migration 1998, U.S. CPSC 1998a) Children may take in higher than average amounts because their chew toys are made of highly phthalate-softened PVC (e.g., teethers). Indeed, the highest levels of DINP released from teethers and toys exceeded the acceptable daily intake level in studies, conducted in the Netherlands and Denmark, that simulated children's mouthing behavior. (Opinion on Phthalate migration 1998, U.S. CPSC 1998b) Furthermore, a Dutch study confirmed what most of us have observed - children suck or chew their fingers and other things that are not intended to go into their mouths more than chew toys. (Groot 1998) This unintended chewing undoubtedly adds to their overall intake of phthalates.

Transfusion is another route of human phthalate exposure. Phthalates leach from PVC medical devices into solutions that are then fed into the patient. (Rossi 2000, Tickner 1999) People who are ill, especially children whose systems are still developing, may be particularly sensitive to this type of exposure. Concerns have in fact been raised that the developing, but not mature, male genital tract in humans may be adversely affected by high levels of DEHP. (U.S. National Toxicology Program 2001)

Breathing in air and dust containing phthalates that have off-gassed from PVC flooring also adds to the amount of phthalates in our systems. (Cadogan 1993, Rossi 2000) Again, this is of particular concern with respect to children since they spend a lot of time indoors with a breathing range close to the floor.

Although uptake of phthalates through skin contact with PVC would not be expected to play a large role in human contamination, it should be considered when thinking about our cumulative phthalate intake. This is particularly true for children who touch PVC products and then put their fingers into their mouths.

### Regulations on phthalate use

Prompted by the potential of babies to intake dangerous amounts of phthalates and the serious, negative health effects they cause in animal studies, the European Union placed an emergency ban on the use of certain phthalates in toys made for children under the age of three in 1999. (Official Journal of European Communities 1999) This emergency ban was recently renewed for the fifth time. (European Commission 2001) In the United States, the Consumer Product Safety Commission (CPSC) and the Toy Manufacturers of America (TMA) agreed upon a voluntary limit of DEHP at 3% in pacifiers and teethers in 1986. (TMA 1986) Later in 1998, the CPSC responded to Greenpeace calls and asked toy manufacturers to voluntarily withdraw PVC teething rings and rattles containing DINP from the market. (U.S. CPSC 1998c) However, such agreements do not stop the use of, and children's exposure to hazardous or untested additives. DINP is a poorly defined mix of as many 100 chemical variants, and the CPSC states that the composition of DINP in children's products is unknown and was unknown in 1986 when the toy industry began using it after concerns about DEHP came to light. (U.S. CPSC 1998b) In addition, the CPSC states that, "It is conceivable that one or more existing types of DINP for which data are unavailable could also be more toxic and/or carcinogenic," than the types of DINP that have been tested. (U.S. CPSC 1998b)

Regulations are also in place for phthalates in plastics that come into contact with food such as during its processing, transportation and storage. The Food and Drug Administration (FDA) states that butyl benzyl phthalate (BBP) and diisononyl phthalate (DINP) "may be safely used" at levels up to 1% and 43%, respectively. (U.S. FDA 21CFR178.3740 2000) Closer inspection reveals legislative provisions that are very likely to be broken. For example, the regulation states that the plastics should be used "at temperatures not exceeding room temperature." (U.S. FDA 21CFR178.3740 2000) That suggests that eating food from a plastic container at a summer picnic, or warming food wrapped in plastic in a microwave may be considered unsafe. Worse still is that plastic products are often unmarked, leaving consumers unable to make informed decisions.

### Routes of human intake of organotins

Ingestion and inhalation represent the major ways by which we take in organotins, although skin contact may also be a route of contamination. (U.S. ASTDR 1992)

Canadian studies have shown organotins in water from PVC pipes containing organotin stabilizers. (Sadiki 1999) Clearly, drinking tainted water is a route that organotins can make their way into our bodies. In addition, organotins in the environment build up in the fat of fish. (Boyer 1989, U.S. EPA 2001) By eating these fish, we again introduce organotins into our systems.

Because organotins are found in dust (Santillo 2001), perhaps due to their release from plastics and other textiles, breathing is another way that humans are contaminated by organotins. This and previous research conducted by Greenpeace and the Healthy Flooring Network in the United Kingdom confirmed the presence of organotins in vinyl flooring, carpets and wallpaper. (Allsopp 2001, Allsopp 2000)

Although it is not clear whether skin contact with PVC containing organotins adversely effects our health, workers exposed to paint containing tributyltin, or TBT, developed skin inflammation among other symptoms. (Boyer 1989, Champ 2000, U.S. ASTDR 1992)

### Regulations on organotin use

Traditionally, organotins are used as antifouling agents in paint applied to ships to keep the growth of algae and other marine life to a minimum. (Champ 2000) Although organotins are very effective at this task, marine life has unfortunately suffered as a result. In response to this threat, the U.S. Congress made organotins the only chemicals to have exclusive environmental legislation. (Champ 2000) The Organotin Antifouling Paint Act of 1988 prohibits the use of paint containing organotins on water vessels shorter than twenty-five meters. The Act also prohibits the sale of paint containing organotins not certified by the EPA. (Champ 2000) Other countries have even more stringent regulations in effect. Both Austria and Switzerland have banned all use of TBT paints on vessels in freshwater. (Champ 2000) Germany, in addition to having similar restrictions to those in the United States, has regulations that limit TBT to 3.8% in paint and that require organotin-containing paint to be safely disposed. (Champ 2000)

The threat of organotins in products besides paint has also been recognized. In the United States, the FDA limits certain organotins to 3% in plastics that contact food (U.S. FDA 21CFR178.2650 2000). The organotin air limit set by the Occupational Safety and Health Administration (OSHA) is 0.1 milligrams/cubic meter. (U.S. ASTDR 1992) Depending upon the organotin, this number translates to 0.000002% at the very most.

## Findings

### All PVC products tested contain detectable levels of phthalates

Twenty common, vinyl consumer products were tested for phthalate plasticizers, and the results of the tests are summarized in Table 1 (page 17). They show that diethylhexyl phthalate (DEHP), diisononyl phthalate (DINP) and butyl benzyl phthalate (BBP) are found in childcare products and vinyl home furnishings that children come into contact with in their daily lives. Taken together, the results reveal that:

- All products tested contained detectable levels of phthalates, with a maximum of 39% by weight in a straw from a child's drinking cup. Indeed, some of the highest levels were found in products specifically designed for children's mouths.
- Seven out of 20 products contained DEHP above a 3% voluntary cap set for pacifiers and teethers. Some of these products, although not intended for children's mouths, are very likely to be chewed by children.
- Two teethers contained over 20% by weight DINP.
- BBP is found in home furnishings at concentrations up to 1.7% by weight. A 1% limit on BBP in plastic that contacts food is currently in effect in the U.S.
- Vinyl products for everyday children's use containing hazardous levels of phthalates can be readily purchased at popular retail stores throughout the United States.

In 1999, the European Union approved an emergency ban on the use of six phthalates in toys made for children under the age of three. (Official Journal of European Communities 1999) That emergency ban was recently extended for the fifth time. (European Commission 2001) In the United States however, a voluntary limit of 3% DEHP is the only recommendation on phthalate use in pacifiers and teethers. This inadequate regulation does not stop the use of high levels of phthalates besides DEHP in teethers, as illustrated by the over 20% DINP content that we found in teethers tested in this study.

Clothing for children, such as these sandals and winter hat tested by Greenpeace, is often made of vinyl.

The home furnishings we tested had an overall lower phthalate content than the children's products, although a carpet protector did contain phthalates up to 24.7% by weight. This result should not be taken to suggest that products for the home do not act as significant sources of chemical exposure to children. Because wallpaper and floor tiles are not designed to be as soft and flexible as chewable toys, they do not require as large amounts of phthalates. However, they have other requirements that products such as teethers do not, namely considerable stability against heat and decomposition. For these reasons, they would be expected to contain high levels of metal stabilizers, and the results of this study confirm that to be the case.

Although the chemical additive bisphenol A was not a focus of this study, it was also detected in two of the 20 items we tested. Bisphenol A is used in glue production, and can be found in a wide variety of products ranging from car parts to drinking bottles. (WWF 2000) It is also used in PVC production and processing, and similar to phthalates, bisphenol A is known to leach from plastic and other materials and subsequently contaminate humans. (ADA 1998, WWF 2000) Leaching of bisphenol A from dental sealants at 5 ppb (parts per billion) prompted the American Dental Association to contact the manufacturer of the sealant to change its manufacturing process. (ADA 1998) In this study, bisphenol A was detected at 139,000 ppb in a Safety 1st Deluxe RollerShade sunscreen carblind from Toys R Us, and at 142,000 ppb in a changing pad made by The First Years bought at Target. This is of concern since bisphenol A affects the hormone system, and causes toxic effects such as reduced sperm production and increased prostate, kidney and liver weights in some animals. (U.S. National Toxicology Program 2000, WWF 2000)

(See Table, page 17)

**Metal stabilizers detected in all but one product tested**

All 20 PVC items in this study were tested for lead and cadmium stabilizers, whereas just 15 were tested for organotins. Five items were eliminated from the organotin tests based upon the high cost of the procedure and the fact that a similar item was being tested. The results of the metal tests are shown in Table 1 (page 17). They reveal that:

- Fourteen out of 15 products contained detectable amounts of organotins. Floor tiles, on which children spend a lot of time crawling and playing, and wallpaper were the two products containing the highest levels.
- Two of the products tested contained cadmium in amounts exceeding the California Proposition 65 regulated level.
- Eleven of the products tested contained lead above the detection limit, although none at levels exceeding the regulated limit for vinyl. (DiGangi 1997)

Current limits of organotins in air set by OSHA do not exceed 20 ppb (parts per billion). (U.S. ASTDR 1992) Our results show that a wallpaper sample contained 776,508 ppb total organotins. It is alarming that a product containing that amount of organotins is readily available given the lack of information about organotins being released from PVC products by off-gassing and normal wear and tear.
In 1988, the Washington State Department of Health issued an advisory against the use of tributyltin (TBT) in interior paint since it released into the air and caused illness in humans. (Epidemiologic Notes and Reports 1991) In addition, organotins were found in the dusts from parliament buildings in Europe, a clear demonstration that organotins are found in our daily environment. (Santillo 2001) This study confirmed the presence of organotins in vinyl floor tiles and wallpaper. Earlier work by Greenpeace also found significant quantities of organotins in vinyl flooring in addition to carpets. (Allsopp 2001, Allsopp 2000) A possible route by which they make their way into the air we breathe is through off-gassing from PVC building materials and other organotin-containing textiles.

## Discussion

In this report, we have demonstrated that widely used PVC products, including children's items, wallpaper and floor coverings, contain high levels of hazardous additives. These additives, namely phthalate plasticizers and metal stabilizers, are needed to soften PVC and to keep it from degrading. (Bizarri 1996, DiGangi 1997) Diethylhexyl phthalate (DEHP), diisnonyl phthalate (DINP) and butyl benzyl phthalate (BBP), were detected in the products tested in this study at combined levels up to 39% by weight of the product. The metal stabilizers lead and cadmium were also found in some of the products, but organotins were present in all but one of the items, often at high concentrations. Concerns surrounding the use of phthalate and organotin additives in commonly used PVC products are discussed below.

### Humans are contaminated with phthalates

A recent study conducted by the CDC confirmed that we have phthalates in our bodies. (U.S. CDC 2001) Levels of the metabolites, or breakdown products, of seven phthalates were found in the urine of at least 1,020 people ages six and above. With respect to the phthalates detected in our work, the CDC study confirmed the presence of DEHP and BBP metabolites in human urine. Conversely, DINP metabolites were not found in that study. This may simply reflect, however, the difficulty in identifying DINP breakdown products since DINP is a complex mixture of as many as 100 isomers, or chemical variants.

The observation that the metabolites of BBP and diethyl-, and dibutyl phthalate (DEP and DBP) were detected in urine at a higher concentration than DEHP metabolites does not necessarily mean that human contamination by DEHP is lower than that of BBP, DBP or DEP. Alternatively, the results may reflect differences in the efficiency with which different phthalates are metabolized. In a study comparing the metabolism of the same amount of DEHP and DBP, 80% of DBP was metabolized versus only 20% of DEHP under the same conditions. (Kluwe 1982) However the results are interpreted, they clearly show that humans are contaminated with DEHP, BBP, DBP and DEP.

### Routes of human intake of phthalates

As discussed earlier, children may take in particularly high levels of phthalates from teethers and other childcare items made of highly phthalate-softened PVC. In this study, a Prince Lionheart crib rail teether purchased at Babies R Us, and a hand-held General Mills Cheerios teether from the Burlington Coat Factory containing 20.8% and 21.7% DEHP by weight, respectively serve as good examples. Other items in this study that could very likely be chewed by youngsters include a child's hat and a Liz Claiborne handbag. These products are made up of over 20% DEHP.

Children may also intake more phthalates than adults through breathing. An initial study conducted in Norway reported a higher incidence of bronchial obstruction in children living in houses with PVC, as opposed to wooden, floors. (Allsopp 2000, Jaakola 1999) Phthalates being released into the air could provide a possible link between these two observations since phthalates are known to leach from PVC into the surrounding air. (Cadogan 1993, Rossi 2000) Off-gassing of DEHP from vinyl flooring can result in exposure levels that exceed the highest estimates of our daily intake by almost three times. (Rossi 2000) In this study, a Tenex carpet protector was determined to be 24.7% by weight DEHP, indicating that we can be exposed to phthalates in our homes and offices through everyday activity. This is of more concern with respect to children since they spend a lot of time indoors with a breathing range closer to the floor than adults. In addition, children may ingest phthalates by coming into contact with home furnishings since they are very likely to crawl on PVC flooring, for example, and then put their fingers into their mouths.

**Toxic effects associated with phthalates**

The offspring of rats fed the three phthalates detected in the products Greenpeace tested here, namely DEHP, DINP and BBP do not follow normal patterns of sexual development. (Gray 2000) In the case of DEHP-fed and BBP-fed rats, the weight of the offspring was also reduced. Other studies also report subtle effects of DEHP in the testes of young rats at levels below the accepted no-observed-adverse-effect level (NOAEL). (Gray 2000) Recently, the National Toxicology Program (NTP) expressed concern over the adverse development of babies born to pregnant women who take in DEHP at the exposure levels estimated for an adult. (U.S. National Toxicology Program 2001) They also expressed concern that male infants and toddlers who substantially exceed adult DEHP exposure estimates could suffer problems in their reproductive system development.

Rats and mice fed DEHP and DINP also showed an increase in liver cancers over animals that had not been fed DEHP. (U.S. ASTDR 1993, U.S. CPSC 1998c) Furthermore, DEHP has been classified as a "probable human carcinogen" by the EPA. The Department of Health and Human Services has also classified DEHP as a potential carcinogen. (U.S. ASTDR 1993) That is to say, DEHP may reasonably be considered a cancer causing substance in humans. A retrospective study conducted in Sweden found an increase in testicular cancer in workers who were exposed to PVC (Ohlson 2000), although additional studies are needed to determine whether phthalates are responsible.

Small children chew on everything. It is part of their learning process!

### Routes of human intake of organotins

Ingestion of organotin-tainted foods and drink, and inhalation of organotin-laden dust are the main ways that humans become contaminated with these metal stabilizers. (U.S. ASTDR 1992) Tests of drinking water found organotins in water from PVC pipes, but not in water from polyethylene pipes. (Sadiki 1999, Sadiki 1996) This finding demonstrates that organotins leach from PVC, and points out a source of our exposure. Organotins are also used as stabilizers in PVC plastics used to protect food. (Kawamura 2000) Similar to the phthalate plasticizers, it is conceivable that they make their way from plastic containers and wraps into food we subsequently eat.

Although not from a PVC source, yet another way organotins make their way into our diets is through leaching from paint on marine vessels and building up in the fat of fish that we eat. (Boyer 1989, Champ 2000, Jacobson 2000, U.S. EPA 2001)

A recent study found organotins in dusts collected from parliament buildings in Europe. (Santillo 2001) This finding provides us with clear evidence that organotins have made their way into our environment, perhaps from organotin-containing textiles, and also a better understanding of where we might be exposed.


This Prince Lionheart crib rail teether contained over 20% phthalates.

### Concerns about organotin stabilizers

Organotins, especially tributyltin (TBT), are most widely recognized for their use as anti-foulants in the paint on marine vessels. (Champ 2000, Jacobson 2000) Fouling is the growth of marine life including bacteria, fungus, barnacles and algae on boats. While organotins are very effective as anti-fouling agents, they cause adverse effects on the environment by leaching from ships into the water where they can remain for several months. Organotins also concentrate in sediments where they have a half-life of over 20 months. (Jacobson 2000, U.S. EPA 2001) Concentrations of TBT as low as 1 parts per trillion (ppt), or 0.0000000001%, have been associated with reduced reproduction in snails (U.S. EPA 2001), and TBT at 7 ppt causes malformations in oysters (Jacobson 2000). Organotins also cause rats and mice to have problems with reproduction and the birth of normal offspring. (Kergosian 1998, U.S. ASTDR 1992) In humans, shipyard workers exposed to TBT-containing paint developed symptoms such as breathing problems, chronic skin inflammation, dizziness and a weakened ability to ward off colds and flu. (Champ 2000)

## Recommendations

In this study, we have shown the presence of hazardous phthalate plasticizers and organotin stabilizers in common PVC consumer products. Earlier Greenpeace investigations of phthalates (Stringer 2000) and cadmium and lead (DiGangi 1997) in toys and other children's items identified products that expose children to hazardous PVC additives. In this study, we have extended the list to include childcare products and other materials used for decorating around the home.

Although debate still remains surrounding the hazards that PVC additives pose to human health, we advocate using precaution in assessing chemicals for their use in commerce especially where safe alternatives that do not require additives exist. Unequivocal scientific proof that a given chemical causes a particular effect should not be necessary to start the regulatory process to remove hazardous chemicals from consumer products in order to avoid long-term or irreversible harm.

Inadequate regulations on only some PVC plasticizers and stabilizers have led to the use other hazardous substitutes. Policy loopholes that allow 'guilty' chemicals to be replaced with untested or insufficiently tested ones are unacceptable. This is particularly true in the case of phthalate plasticizers and organotin stabilizers since PVC accounts for the bulk of their use in industry, and since it requires more hazardous additives than any other plastic.

Hazardous additives are only part of the threat that we face from using common PVC products. The bulk of PVC waste is not recycled, but ends up in landfills and incinerators. PVC in landfills is of great concern because its hazardous additives leach from the plastic and cannot be contained. (Van der Naald 1998) Furthermore, the burning of PVC in accidental landfill fires adds to the global burden of dioxin, a potent toxin and cancer-causing substance. (Costner 2000) Dioxin formation is also the main cause of concern around burning PVC in incinerators.

In order to stop the needless exposure of people, especially children, to the hazards of PVC, Greenpeace recommends that:

- The Consumer Product Safety Commission (CPSC) should regulate vinyl as a material. It should further prohibit the use of phthalates, lead, cadmium, organotins and other toxic or untested additives in consumer products. If necessary, the CPSC should seek new legislation in Congress to give them the authority to do this.
- Manufacturers of products designed for children or the home should disclose all of the chemical ingredients in their products.
- Manufacturers should commit to immediately eliminating soft vinyl from their products and establish a rigorous schedule for the elimination of hard vinyl.
- Retailers and distributors should remove vinyl products from the market.
- Parents should not purchase vinyl products to which children might be exposed such as toys, childcare items, clothing, school supplies, handbags, sports equipment or items for the home. Vinyl products should be returned to the manufacturer or retailer for a full refund.

**TABLE 1. Hazardous phthalates or organotins found in all products tested.**
(Continued on next page)

| **Product** | Prince Lionheart crib rail teether | Graco stroller rain cover | Goldbug sandles, size 2 | General Mills Cheerios teether | Gerber pull-on vinyl pants, XL | Carter's waterproof mattress pad | Basics magnetic shower curtain liner | Babycare changing mat | Liz Claiborne handbag | Babyplace "fur" lined hat |
|---|---|---|---|---|---|---|---|---|---|---|
| **Store** | Babies R Us | Babies R Us | Babies R Us | Burlington Coat Factory | Burlington Coat Factory | Burlington Coat Factory | Walmart | Walmart | Macy's | Children's Place |
| **State** | Massachusetts | Massachusetts | Massachusetts | Michigan | Michigan | Michigan | Louisiana | Louisiana | DC | DC |
| | | | | | | | | | | |
| **DEHP** | 0.026% | 18.70% | 0% | 0.02% | 0.31% | 0.02% | 22.10% | 0.66% | 21.70% | 20.30% |
| **DINP** | 20.80% | 0.90% | 14.90% | 28.7% | 21.70% | 6.88% | 0% | 6.72% | 0% | 0% |
| **BBP** | 0% | 0.02% | 0% | 0% | 0% | 0% | 0% | 0.03% | 0% | 0% |
| **Phthalate Total** | **20.83%** | **19.62%** | **14.90%** | **28.72%** | **22.01%** | **6.90%** | **22.10%** | **7.41%** | **21.70%** | **20.30%** |
| | | | | | | | | | | |
| **Bisphenol A** | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm |
| | | | | | | | | | | |
| **MBT** | <0.3 ppb | 2.1 ppb | 13.1 ppb | NT | NT | NT | NT | 173 ppb | 102 ppb | 6.4 ppb |
| **DBT** | <0.3 ppb | 2.2 ppb | 64.4 ppb | NT | NT | NT | NT | 73.3 ppb | 2,250 ppb | 55.4 ppb |
| **TBT** | <0.3 ppb | 0.4 ppb | 0.6 ppb | NT | NT | NT | NT | 4,120 ppb | 5.6 ppb | 2.6 ppb |
| **TeBT** | <0.4 ppb | <0.3 ppb | 0.8 ppb | NT | NT | NT | NT | 6.4 ppb | <0.3 ppb | <0.3 ppb |
| **MOT** | <0.4 ppb | 1.9 ppb | 2,860 ppb | NT | NT | NT | NT | <0.4 ppb | 278 ppb | 5.1 ppb |
| **DOT** | <0.4 ppb | 1.6 ppb | 5,860 ppb | NT | NT | NT | NT | <0.4 ppb | 410 ppb | 16.6 ppb |
| **Organotin Total** | **<0.3 ppb** | **8.2 ppb** | **8778.9 ppb** | NT | NT | NT | NT | **4372.7 ppb** | **2945.6 ppb** | **86.1 ppb** |
| | | | | | | | | | | |
| **Cadmium** | <0.5 ppm | 1.09 ppm | 0.7 ppm | <0.5 ppm | <0.5 ppm | 83.3 ppm | 3.7 ppm | <0.5 ppm | 32.9 ppm | 0.8 ppm |
| **Lead** | <0.5 ppm | 1.03 ppm | 9.8 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | 17.4 ppm | <0.5 ppm | 5.57 ppm | 3.6 ppm |

Abbreviations: **DEHP**, diethylhexyl phthalate; **DINP**, diisononyl phthalate; **BBP**, benzyl butyl phthalate; **MBT**, monobutyltin; **DBT**, dibutyltin; **TBT**, tributyltin; **TeBT**, tetrabutyltin, **MOT**, monooctyltin; **DOT**, dioctyltin; **ppm**, parts per million (1 ppm=0.0001%); **ppb**, parts per billion (1 ppb=0.0000001%); **NT**, not tested.

The Toy Manufacturers of America's and Consumer Product Safety Commission's voluntary limit of DEHP is 3% in pacifiers and teethers. The National Pollution Discharge Elimination Standard (NPDES) permits TBT in state waters at 0.05 ppb.

**TABLE 1…**

| **Product** | Tenex Corp. deep pile carpet cover | K.C Products Inc. drawer liner | Mannington floor tile; black, mottled | Safety 1st Deluxe RollerShade sun screen car blind | The 1st Years changing pad; 3-in-1 changing kit #4087 | Podee; straw to hands-free cup | Graham & Brown Blackburn vinyl border wallpaper #97264 | FSC Wallcoverings, village solid vinyl wallpaper #58125 | Armstrong, Themes Collection self-stick urethane tile #21126 | Armstrong, Self Stik II vinyl tile #26225 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Store** | Bed, Bath and Beyond | Bed, Bath and Beyond | Floorcraft | Toys R Us | Target | Toys R Us | Home Depot | Home Depot | Home Depot | Home Depot |
| **State** | New York | New York | California | Illinois | Illinois | Illinois | Illinois | Illinois | Illinois | Illinois |
| | | | | | | | | | | |
| **DEHP** | 24.70% | 2.24% | 1.66% | 0.20% | 0% | 6.00% | 8.24% | 0.05% | 0.04% | 0.06% |
| **DINP** | 0% | 9.72% | 1.23% | 20.00% | 25.00% | 33.00% | 0% | 12.00% | 3.37% | 3.55% |
| **BBP** | 0% | 0.04% | 0% | 0% | 0% | 0% | 0% | 0% | 1.13% | 1.56% |
| **Phthalate Total** | **24.70%** | **12.00%** | **2.89%** | **20.20%** | **25.00%** | **39.00%** | **8.24%** | **12.05%** | **4.54%** | **5.17%** |
| | | | | | | | | | | |
| **Bisphenol A** | <100 ppm | <100 ppm | <100 ppm | 139 ppm | 142 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm | <100 ppm |
| | | | | | | | | | | |
| **MBT** | 3.2 ppb | NT | 440 ppb | 56.5 ppb | 258 ppb | 9.1 ppb | 56,500 ppb | 4.3 ppb | 16,600 ppb | 11.8 ppb |
| **DBT** | 0.8 ppb | NT | 3,160 ppb | 143 ppb | 3,230 ppb | 134 ppb | 719,000 ppb | 38.5 ppb | 46,800 ppb | 32.6 ppb |
| **TBT** | 1.1 ppb | NT | 27.4 ppb | 38.3 ppb | 196 ppb | 30.7 ppb | 300 ppb | 96.9 ppb | 679 ppb | <0.3 ppb |
| **TeBT** | <0.3 ppb | NT | 7.3 ppb | <0.3 ppb | <0.3 ppb | <0.3 ppb | <0.3 ppb | <0.3 ppb | <0.3 ppb | <0.3 ppb |
| **MOT** | 2.8 ppb | NT | 8.1 ppb | 4.3 ppb | 12 ppb | <0.4 ppb | 76.6 ppb | <0.4 ppb | 10,800 ppb | 7,300 ppb |
| **DOT** | 9.2 ppb | NT | 34.8 ppb | 2.8 ppb | 11.4 ppb | <0.4 ppb | 632 ppb | <0.4 ppb | 43,400 ppb | 25,800 ppb |
| **Organotin Total** | **17.1 ppb** | NT | **3,677.6 ppb** | **244.9 ppb** | **3,707.4 ppb** | **173.8 ppb** | **776,508.6 ppb** | **139.7 ppb** | **118,179 ppb** | **33,144.4 ppb** |
| | | | | | | | | | | |
| **Cadmium** | <0.5 ppm | 230 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm |
| **Lead** | <0.5 ppm | 15.1 ppm | 0.77 ppm | <0.5 ppm | <0.5 ppm | <0.5 ppm | 3.89 ppm | 73.82 ppm | 3.82 ppm | 0.67 ppm |

Abbreviations: **DEHP**, diethylhexyl phthalate; **DINP**, diisononyl phthalate; **BBP**, benzyl butyl phthalate; **MBT**, monobutyltin; **DBT**, dibutyltin; **TBT**, tributyltin; **TeBT**, tetrabutyltin, **MOT**, monooctyltin; **DOT**, dioctyltin; **ppm**, parts per million (1 ppm=0.0001%); **ppb**, parts per billion (1 ppb=0.0000001%); **NT**, not tested.

The Toy Manufacturers of America's and Consumer Product Safety Commission's voluntary limit of DEHP is 3% in pacifiers and teethers. The National Pollution Discharge Elimination Standard (NPDES) permits TBT in state waters at 0.05 ppb.

## Appendix I

### Health Effects Associated with Phthalates and Organotins

| Chemical | Health Effects |
| --- | --- |
| Diethylhexyl phthalate (DEHP) | Probable human carcinogen, and potentially detrimental to immature male reproductive system. Animal studies show liver cancer and altered patterns of sexual development. |
| Diisononyl phthalate (DINP) | Causes liver tumors and damages the kidneys in rodents. Alters sexual development in rats. |
| Benzyl butyl phthalate (BBP) | Alters sexual development in rats. |
| Tributyltin (TBT) | Interferes with nervous system and causes death at high levels in humans. Causes reduced reproduction and developmental problems in marine wildlife and rats. |

## Appendix II

### Major U.S. Producers of PVC, Phthalates and Organotins

| Company Name and Location | Chemical |
|---|---|
| Borden Chemicals and Plastics Operating Limited Partnership<br>*Addis, Louisiana*<br>*Geismar, Louisiana*<br>*Illiopolis, Illinois* | PVC |
| Certain Teed Corporation<br>*Lake Charles, Louisiana* | PVC |
| Colorite Polymers<br>*Burlington, New Jersey* | PVC |
| Formosa Plastics Corporation, U.S.A.<br>*Baton Rouge, Louisiana*<br>*Delaware City, Delaware*<br>*Point Comfort, Texas* | PVC |
| The Geon Company<br>*Henry, Illinois* | PVC |
| Georgia Gulf Corporation<br>*Aberdeen, Mississippi*<br>*Oklahoma City, Oklahoma*<br>*Plaquemine, Louisiana* | PVC |
| Kaneka Delaware Corp.<br>*Delaware City, Delaware* | PVC |
| Keysor-Century Corporation<br>*Saugus, California* | PVC |

| **Company Name and Location** | **Chemical** |
|---|---|
| OxyVinyls LP<br>*Deer Park, Texas*<br>*Louisville, Kentucky*<br>*Pasadena, Texas*<br>*Pedricktown, New Jersey*<br>*Pottstown, Pennsylvania* | PVC |
| Shintech Incorporated<br>*Freeport, Texas* | PVC |
| Union Carbide Corporation<br>*Texas City, Texas* | PVC |
| Westlake PVC Corporation<br>*Calvert City, Kentucky* | PVC |
| Solutia Inc.<br>*Bridgeport, New Jersey* | BBP |
| Aristech Chemical Corporation<br>Chemicals Division<br>*Neville Island, Pennsylvania* | DEHP, DINP |
| Eastman Chemical Company<br>Tennessee Eastman Division<br>*Kingsport, Tennessee* | DEHP |
| Velsicol Chemical Corporation<br>*Chestertown, Maryland* | DEHP |
| ExxonMobil Chemical Company<br>*Baton Rouge, Louisiana* | DINP |
| Elf Atochem North America, Inc.<br>Specialty Chemicals Division<br>*Carrollton, Kentucky*<br>*Axis, Alabama* | DBT, TBT compounds |

| Company Name and Location | Chemical |
|---|---|
| Gelest, Inc.<br>*Tullytown, Pennsylvania* | DBT compounds |
| Cardinal Companies, L.P.<br>*Columbia, South Carolina* | DBT compounds |
| Ferro Corporation<br>Performance and Fine Chemicals Group<br>Polymer Additives Division<br>*Walton Hills, Ohio* | DBT compounds |
| Atotech USA Inc.<br>*Rock Hill, South Carolina* | DBT compounds |
| Johnson Matthey, Inc.<br>Alfa Aesar<br>*Ward Hill, Massachusetts* | DBT, TBT compounds |
| Aldrich Chemical Company, Inc.<br>*(Location not specified)* | TBT compounds |

Abbreviations: PVC, polyvinyl chloride; BBP, benzyl butyl phthalate; DEHP, diethylhexyl phthalate; DINP, diisononyl phthalate; DBT, dibutyltin; TBT, tributyltin.

Source: Directory of Chemical Producers: United States. 2000. SRI International.

## Appendix III

**PVC in Your Home**

Consumers should beware of PVC products available for the home. Here's a list of the most common products on the market today. Go to the Greenpeace website for a virtual house that will show you how to find products not made from PVC. We also offer an online searchable database of alternatives for PVC used in construction. Over 200 companies are featured on the database.

**Visit the virtual home at: http://www.greenpeaceusa.org/toxics/house.htm**

**Search the online database for alternatives to PVC in construction: www.greenpeace.org.au/pvc/**

Some other tips to be a PVC detective include:

- Look for packaging with the #3 recycling symbol on it. That means it is PVC and rarely recycled.
- Often, PVC products are labeled "non-toxic vinyl," or "washable vinyl." The words vinyl and PVC are used synonymously.
- Plastic products that are soft and flexible and have a distinct odor are often PVC. If you are not sure, don't buy it. When you get home, call the product manufacturer and demand information about materials used in the product.

**APPLIANCES:**

**Electronics** - TV, Video, Hi-Fi. In electrical and electronic products, plastics are mainly found in casings and cable sheathings. They are also found in circuit cards, component capsules, mechanical bearing parts and moving mechanical components, such as wheels and stub shafts.

**White Goods** - These include washing machines, dishwashers, refrigerators, and freezers. PVC is commonly found in cables, shelving and door gaskets.

**BUILDING MATERIALS:**

**Home Siding** - PVC siding is widely used in the USA as a replacement for timber.

**Insulation** - The use of PVC profiles in cavity closure is increasing.

**Roofing Membranes** - Roofing film made of soft PVC is used on the insides of roofs as shielding and flashing against water.

**Pipes** - Rainwater guttering and drainpipes, water supply pipes, sewage and drainage pipes, protective pipes for cables.

**Electrical Cables and Wires** – Electricity cables, telephone and data cables, lighting cables and fittings – PVC coating is commonly used on cables and lines for the transfer of electricity and information.

**Door and Window Frames** – Door and window frames made from PVC-u (which stands for unplasticized PVC) are being heavily promoted by the industry as replacement windows and doors.

**CARS:**

**Interiors** – Some cars still contain PVC interiors, including seat upholstery and dashboards, although many companies are eliminating PVC.

**Undersealing** – Soft PVC is used in undersealing to prevent rust, and some car manufacturers have already eliminated its use.

**CHILDCARE PRODUCTS:**

**Mattress Covers** – Crib and bed mattress covers with a waterproof coating of PVC are commonly sold.

**Diaper Covers for Cloth Diapers** – Diaper covers are available in vinyl, and also in nylon and rubber.

**Bibs** – Many bibs are cotton or polyester coated with vinyl for waterproofing.

**Car Seats and Strollers** – Clear PVC is used for transparent covers to protect strollers from rain. The linings of some car seats are also made of vinyl.

**Toys** – Teethers, squeeze toys, inflatable toys and dolls are often made from PVC to make them soft and more marketable.

**CLOTHING:**

**Aprons** – PVC laminated textile is often used as a water-resistant material for aprons.

**Shoes** – Soft PVC is used in shoes and parts of shoes, such as soles, labels for logo imprints, upper parts made from vinyl imitation leather of PVC coatings.

**Boots and Waders** – 'Rubber' boots are sometimes made from PVC.

**Carrying Bags** – Sports bags, school bags, etc. are often made from nylon with a PVC coating as waterproofing.

**Luggage** – Soft PVC is often used as a surface coating, inner coating or for parts of products in bags, suitcases and other luggage.

**Clothes** – T-shirts with PVC prints (usually shiny), pants and raincoats (for waterproofing).

**HOME FURNISHINGS:**

**Vinyl Floor and Vinyl Wall Coverings** – Vinyl flooring is made of soft PVC, and other materials such as cork tiles may have a PVC coating. Cushion vinyl, sheet vinyl and vinyl tiles all represent types of vinyl flooring.

**Furniture** – Imitation leather and furniture film are made from soft PVC.

**Inflatable Furniture and Water Beds** – This furniture, which is often designed for a short life, is made of soft PVC.

**Venetian Blinds** – Venetian blinds are sometimes made of unplasticized PVC (PVC-u).

**Dish and Clothes Racks** – PVC is used to coat metal dish and clothes racks against rusting.

**Tablecloths** – Tablecloths are often vinyl, but also available in cotton, linen or polyester.

**Shower Curtains** – Shower curtains are often made of soft PVC, but are also available in nylon, cotton and polyester or a blend.

**GARDEN FURNITURE AND PRODUCTS:**

**Hoses** – Garden hoses are sometimes made of PVC though you can find some made of rubber.

**Tables and Chairs** – The least expensive garden furniture is usually u-PVC.

**Tarps** – Tarps are used for covering purposes, for example, over garden furniture and within the building sector, for trucks and storage tents. They are made from nylon or polyester, with a soft PVC coating.

**Swimming Pools** – Inflatable and non-inflatable children's pools are made of soft PVC, as well as swimming wings and rings.

**Lawnmower** – PVC will be found in cables for lawnmowers and other garden machinery.

**Greenhouses and Cold frames** - Corrugated PVC sheeting is often used as a cheaper alternative to glass for greenhouses and cold frames.

**Membrane pond liners** – PVC is sometimes used as a pond liner.

**MEDICAL PRODUCTS:**

**Medical Devices** – This product group is made up of products that are used directly in the treatment of patients. Soft PVC products include colostomy bags, catheters, urine bags, infusion sets and bloodbags. Other medical products include certain gloves, curtains, sheets, and shoe covers made from soft PVC.

**OFFICE EQUIPMENT AND SUPPLIES:**

**Equipment** - In items such as computers and fax/printers PVC is usually found in the cabling.

**Supplies** – Ring binders, folders, letter organizers, writing pads, clipboards, tape and calendars are often made of soft PVC.

**PACKAGING:**

**Packaging** - PVC in packaging includes disposable bottles (for oil, mineral water, vinegar etc.), food wrap, trays and boxes, bottles and jars, blister packaging and transportation packaging.

**SPORTS EQUIPMENT:**

**Weights** – Hand weights are often covered with brightly colored PVC coatings.

**Balls** – Many inexpensive balls, such as those used for soccer, are often vinyl, but leather and other types of plastic balls are also available.

## Appendix IV

### Alternatives to PVC

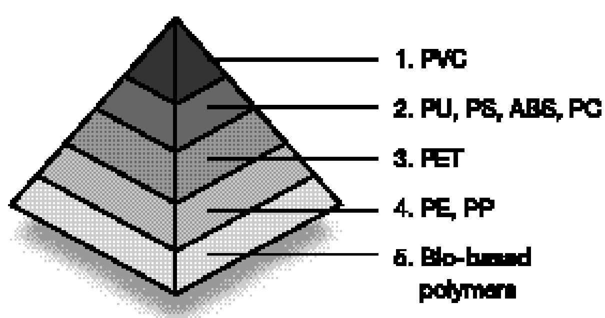
For virtually all PVC applications, safer alternatives exist, using more sustainable, traditional materials - such as paper, wood or local materials. PVC can also be replaced by a variety of other, less environmentally damaging plastics, although most plastics pose some risk to the environment and contribute to the global waste crisis.

Greenpeace has developed a pyramid of plastics to assist those making material selection to avoid PVC use. The guidance focuses on the toxic characteristics of the potential alternative materials. It provides a qualitative ranking based on environmental and health problems of PVC, addressing the production, additives and product emissions during use, disposal and recycling.

It does not include raw materials and energy inputs and therefore does not address all criteria of a life cycle analysis. It provides guidance for interim steps on the route to clean production. Ultimately, we should ask why we are using these materials and whether or not they are necessary.

### Pyramid of Plastics

The pyramid of plastics is a ranking of plastics according to their hazardous characteristics. PVC, the most problematic plastic, is at the top of the pyramid, and bio-based plastics, the least polluting of the plastics, are at the pyramid's base. It represents an ongoing process to qualify the main plastics in the economy. More plastics can be added as necessary, and qualifications may change depending upon new information on the material, such as in production processes or the use of toxic additives.




1) Polyvinyl chloride (PVC) and other halogenated plastics
2) Polyurethane (PU), Polystyrene (PS), Acrylonitrile-butadiene-styrene (ABS), Polycarbonate (PC)
3) Polyethylene-terephthalate (PET)
4) Polyolefins (PE, PP, etc.)
5) Bio-based plastics

Notes:

- Metallocene technology is a new way to widen the range of properties and applications of polyolefins. This will in turn help replace many rigid and soft PVC applications.
- TPE's are thermoplastic elastomers that can be made from many different mixes of different plastic monomers/short polymer chains. Currently most of the building blocks are polyolefins, but can also contain other polymers such as polyurethane. Therefore, TPE's can not be generally ranked in the pyramid of plastics.

**Additives**

The addition of toxic additives can significantly change the environmental impacts of a plastic. For example, chloroparaffins or brominated flame retardants in polyolefins or bio-based plastic products with heavy metal stabilizers would significantly increase the hazard level of the plastic, and therefore change its position on the pyramid of plastics. Furthermore, many additives are persistent organic pollutants (POPs) and can cause serious environmental damage.

**Genetically Modified Organisms (GMOs)**

It is essential that the production of bio-based plastics does not involve the use of genetically modified organisms (GMOs) or allow the patenting of life.

**Polyvinyl chloride (PVC)** is unique in its high chlorine and additives content, which makes it an environmental poison throughout its life cycle. Vinyl chloride is a known human carcinogen. PVC releases dioxin and other persistent organic pollutants during its manufacture and disposal and cannot be readily recycled due to its chlorine and additive content. Furthermore, additives are not bound to the plastic and leach out.

**Polyurethane (PU)** is mainly used in insulation and soft/foamed products like carpet underlay. It uses several hazardous intermediates and creates numerous hazardous byproducts. These include phosgene, isocyanates, toluene, diamines, and the ozone-depleting gases methylene chloride and CFCs, as well as halogenated flame retardants and pigments. The burning of PU releases numerous hazardous chemicals such as isocyanates, carbon dioxide, hydrogen cyanide, PAHs and dioxins.

**Polystyrene (PS)** is widely used for foam insulation and also for hard applications like cups and toys. Its production involves the use of known (benzene) and suspected human carcinogenic substances, such as styrene and 1,3-butadiene. Styrene is also known to be toxic to the reproductive system. PS can be technically recycled, but recycling rates are low, although still higher than for PVC.

**Acrylonitrile-Butadiene-Styrene (ABS)** is used as a hard plastic in many applications like pipes, car bumpers and toys (hard building blocks). ABS uses a number of hazardous chemicals. These include butadiene and styrene (see above )and acrylonitrile. Acrylonitrile is highly toxic and readily absorbed by humans by inhalation and directly through the skin. Both the liquid and its vapor are highly toxic. Acrylonitrile is classified as a probable human carcinogen as are styrene and butadiene.

**Polycarbonate (PC)** is used for products like CDs and refillable milk bottles and is usually made with the highly toxic phosgene, which is derived from chlorine gas. PC does not need additives but does need solvents for its production, such as methylene chloride, a carcinogen. Other solvents used may include chloroform, 1,2-dichloroethylene, tetrachloroethane and chlorobenzene. A number of processes have been developed to reclaim polycarbonate from compact discs and PC milk and water bottles, for downcycling into lower quality products such as crates or building applications, or for mixing in small quantities with virgin material for higher grade products such as bottles.

**Polyethylene-Terephthalate (PET)** is made from ethylene glycol and dimethyl terephthalate. PET is generally used in packaging (e.g. bottles) and often contains additives such as UV stabilizers and flame retardants. PET recycling rates are high compared to other plastics.

**Polyolefins such as Polyethylene (PE) and Polypropylene (PP)** are simpler polymer structures that do not need plasticizers, although they do use additives such as UV and heat stabilizers, antioxidants and in some applications, flame retardants. The polyolefins pose fewer risks and have the highest potential for mechanical recycling. Both PE and PP are versatile and cheap, and can be designed to replace almost all PVC applications. PE can be made either hard, or very flexible, without the use of plasticizers. PP is easy to mold and can also be used in a wide range of applications.

In comparison with PVC, PE and PP contain fewer problematic additives, have reduced leaching potential in landfills, reduced potential for dioxin formation during burning (provided that brominated/chlorinated flame retardants are not used), and reduced technical problems and costs during recycling.

**Bio-based Polymers** Biodegradable plastics from renewable sources (bio-based) are seen as a promising alternative for plastic products which have a short life cycle or are impractical to recycle, such as food packaging, agricultural plastics and other disposables. Bio-based plastics can be made out of products obtained from raw materials produced by natural living or growing systems, such as starch and cellulose. The advantage of bio-polymers is that they readily degrade and can be composted. Natural polymers include cellulose (from wood, cotton), horn (hardened protein) and raw rubber. Converted natural polymers include vulcanized rubber, vulcanized fiber, celluloid and casein protein.

# Appendix V

## Materials and Methods

### Tests for Phthalates

The PVC products described in Table 1 were sent to STAT Analysis (AIHA proficient, NIST/NVLAP accredited) in Chicago, Illinois to be tested for the following phthalates: diethylhexyl phthalate (DEHP), benzyl butyl phthalate (BBP), dibutyl phthalate (DBP), diethyl phthalate (DEP), and diisononyl phthalate (DINP). The items were also tested for bisphenol A. All the samples were prepared and analyzed essentially according to EPA Methods 3550M and 8270M, respectively, as previously described. (DiGangi 1999)

### Measurements of Metal Stabilizers

The levels of cadmium and lead contained in the PVC products studied here were also determined at STAT Analysis in Chicago according to a procedure as detailed before. (DiGangi 1997) Organotin analysis was conducted at GALAB laboratories in Geestacht, Germany by accredited methods after DIN EN 17025 to monitor the following organotins: mono-, di-, tri- and tetrabutyltin, mono- and di-octyltin, tricyclohexyltin and triphenyltin.

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