

## Potential Hazardous Chemicals in Plastics

### สารเคมีอันตรายในพลาสติก

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### Abstract

Typically, plastics are polymers of high molecular mass and may contain some other substances to improve material performance and/or reduce cost of production. Some monomers of plastic are either hazardous or none-hazardous organic compounds. The objective of this article is to provide information on the safety of plastics used in daily living. Since plastics often contain a variety of toxic additives, this article also addresses toxicity of some hazardous substances associated with plastics. PVC plastic seems to be one of the most hazardous plastic in the modern world. Some chlorine-free plastics are safer than others, such as high density polyethylene (HDPE) and low density polyethylene (LDPE). Finally, this article suggests some tips for protection from hazards associated with plastics.

**Keywords:** Hazardous chemicals; Toxicity; Protection; Plastics

### บทคัดย่อ

พลาสติกคือโพลิเมอร์ที่มีโมเลกุลขนาดใหญ่และมีส่วนผสมอื่น เพื่อช่วยเพิ่มคุณภาพและ/หรือลดต้นทุนการผลิต โมนเมอร์ที่เป็นสารอินทรีย์ในพลาสติก มีทั้งที่มีพิษและไม่มีพิษ บทความนี้มีวัตถุประสงค์เพื่อเผยแพร่ความปลอดภัยของพลาสติกชนิดต่างๆ ที่ใช้ในชีวิตประจำวัน เนื่องจากพลาสติกมักมีสารเติมแต่งนานาชนิดที่เป็นพิษ บทความนี้จึงได้นำเสนอความเป็นพิษของสารเติมแต่งต่างๆ ด้วย พลาสติกพีวีซีจัดเป็นพลาสติกที่มีอันตรายสูงสุดในบรรดาพลาสติกทั้งหลาย ส่วนพลาสติกที่ปลอดภัยกว่าหลายชนิดจะปราศจากโมเลกุลของคลอรีน เช่น พลาสติกประเภทโพลิเอทิลีน บทความนี้ได้เสนอวิธีการต่างๆ เพื่อป้องกันภัยจากสารอันตรายในพลาสติกด้วย

**คำสำคัญ:** สารเคมีอันตราย; ความเป็นพิษ; การป้องกัน; พลาสติก

## Introduction

Plastic is a product of the petrochemical industry. In Thailand, a plastic material is produced from both natural gas and oil. Monomers of plastic are synthetic organic compounds. Plastic products are made of various types of plastics in the form of polymers of high molecular mass, and may contain some additives to improve performance and/or reduce costs. The objective of this article is to provide some information on the safety of plastics used in daily living.

Macmillan English Dictionary provides the definition of plastic as “a very common light, strong substance produced by a chemical process and used for making many different things (Macmillan Education, 2006).” The word “plastic” is used as an adjective of many nouns such as plastic arts (a sculpture that is produced from materials such as clay, stone, or wood), plastic bullet (a bullet made of plastic used for controlling large violent crowds without killing people), plastic explosive (a soft substance that can explode, or a bomb made from this substance), plastic surgery (medical operations to improve the appearance of a part of someone’s body, either to repair an injury or to make them more attractive), and plastic wrap (clingfilm). Thus, the common word “plastic” should not be confused with the technical adjective as mentioned here.

Plastics in the early stage of development are natural compounds such as chewing gum, shellac, rubber and so on. Most plastics used in our daily living are synthetic materials such as polyvinyl chloride (PVC), polyethylene (PE), polystyrene (PS), polypropylene (PP), high density polyethylene (HDPE), low density polyethylene (LDPE), Teflon and melamine resin, etc.

Nowadays, plastics are essential to one’s lifestyle. One must acknowledge today’s extreme dependence on plastics. They are pervasive, cheap and effective. If a product or solid material is not clearly wood or metal, chances are it is plastic. Computers, telephones, cars, boats, Teflon cookery, toys, packaging, kitchen appliances and tools, and imitations of a multitude of natural items, are but part of the world of plastics. Living without them would seem unthinkable, however, plastic becomes toxic trash after being used and the resulting waste can no longer be simply ignored. It should be managed properly.

For example, some airlines have banned plastic bags on every flight. Some Thai NGOs have campaigned to ban plastic bags and to promote cloth bags and other natural compostable material bags. In the United States, grocery shoppers in San Francisco may start paying a fee of 17 cents per bag. Fees for each plastic bag have been collected for many years in Seoul, Korea. Those fees are the cost that the citizenry is already paying in general taxes for some of the costs associated with plastic bag trash, such as cleaning up the litter and unclogging the waste system.

There are several types of plastics used in the world as shown in Table 1.

Table 1 Classification, Identification Codes, and Uses of Common Plastics

Material	Code	Original uses	Percent of total used for packaging
Polyethylene Terephthalate	1 PETE	Carbonated soft drink bottles; Food containers	7
High Density Polyethylene	2 HDPE	Milk bottles; Detergent bottles; Film products, such as produce bags	31
Polyvinyl Chloride	3 PVC	Household and food product containers; Pipe	5
Low Density Polyethylene	4 LDPE	Thin film packaging and wraps; Other film materials	33
Polypropylene	5 PP	Crates; Cases; Closures; Labels	10
Polystyrene	6 PS	Foamed cup and plats; Injection molded items	10
All others	7 Other	Polycarbonate plastics and others	4

Exposure to additives or combustion products of plastics may be hazardous to health. The possible health problems may be asthma, birth defects, cancer, chronic bronchitis and so on.

The hazard of each type of plastic is different, depending on the toxic materials released from it, as shown in Table 2.

Table 2 Hazard of Each Type of Plastics

Plastic type	Related toxic substances	Health effects
1. PET/ PETE (Polyethylene Terephthalate)	(1) DEHA (Diethyl hydroxylamine) (2) Phthalates (plasticizers)	(1) Toxic to reproductive system (2) Endocrine disruptors
2. HDPE (High Density Polyethylene)	(1) Incomplete burning can produce CO (2) Persistent	(1) Blue baby (2) Ingested by sea creatures
3. PVC (Polyvinyl Chloride)	(1) Dioxin(TCDD) from incineration and open burning (2) Phthalates (plasticizers)	(1) Human carcinogen and mutagen (2) Endocrine disruptors
4. LDPE (Low Density Polyethylene)	(1) Incomplete burning can produce CO (2) Persistent	(1) Blue baby (2) Ingested by sea creatures
5. PP (Polypropylene)	(1) Incomplete Burning can produce CO (2) Very persistent (3) BHA and BHT	(1) Blue baby (2) Ingested by sea creatures (3) Mimic hormone estrogen

6. PS (Polystyrene)	(1) Incomplete Burning can produce CO (2) Solid particle is irritant (3) Hot PS can release styrene vaporizes	(1) Blue baby (2) Irritation (3) Neurotoxin, suspected endocrine disruptor and chromosomal damage
7. Others: (1) Polycarbonate	BPA (Bisphenol A)	Mimic the natural female sex hormone (estradiol) being linked to cancer
(2) Melamine	Melamine powder	Kidney stone
(3) Teflon	Perfluorooctanoic acid (PFOA)	Birth defects in humans
(4) Clear plastic food wrap	DEHP (di-2-ethylhexyl phthalate)	Possible human carcinogen

As seen in Table 2, safe plastics are HDPE and LDPE. Hazardous plastics are PET, PVC, PP, PS Polycarbonate, Melamine, Teflon and clear plastic food wrap. Thus, some plastics used in daily living are likely to be safe (see also Table 1.)

## Significant Toxic Substances in Plastics

### BPA (Bisphenol A)

Bisphenol A or BPA is used as an additive in polycarbonate plastic and epoxy resins. Approximate 6 billion pounds of this chemical are produced each year. BPA can be detected in urine, but it cannot be detected in children under 6 years old (Medicine Network, 2010).

BPA was first synthesized in 1891 and almost 45 years later it was discovered to be a hazardous substance as estrogen mimicry or female hormone. In a study on rats, BPA was found to decrease sperm count. This finding has called attention to the potential health risks of this substance (Biello, 2008a).

BPA may rapidly leak out of plastic bottles when hot liquid is applied. To prevent health risks to babies fed with plastic bottles, the Canadian Government proposed a ban on BPA in baby bottles (Biello, 2008b). Additionally, BPA used in the production of metal food containers and water supply pipes may leak out of those food containers and pipes into beverages or food and also drinking water (Heartspring Network, 2010).

### Dioxin (2, 3, 7, 8-tetrachlorodibenzo dioxin: TCDD)

In 1989, it was discovered that dioxins were generated in the process of manufacturing PVC. The production of PVC powder involves the transport of dangerous explosive materials such as vinyl chloride monomer (VCM), and the creation of toxic waste, notably ethylene dichloride (EDC) tars. Tar wastes, in particular, contain huge quantities of dioxin that are further incinerated or dumped, spreading dioxins into the wider environment. Dioxins are now present throughout

the environment and the food chain; everyone is exposed to them in their diet, particularly through fatty foods such as dairy, meat, fish and eggs. TCDD, as shown in Figure 1, the most lethal form of the dioxin family, is a known human carcinogen and hormone disrupter and is recognized as the most toxic synthetic compound ever produced. All humans and animals now carry body burdens of TCDD and other dioxins.

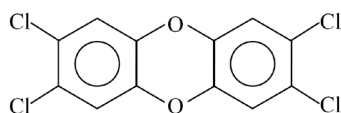


Figure 1 Dioxin Molecule

Source: Greenpeace Organization (2010)

In the summer of 1997 in Hamilton, Canada an accidental fire at a PVC car scrap recycling site caused the evacuation of hundreds of people due to dioxin contamination in the wastes on and around the site. Residents were advised not to eat local garden produce or allow their children to play on the grass. Some environmentalists have recommended that eventually, PVC products should be substituted by other materials in all areas where the potential dioxin and hydrogen chloride formation, in case of fire, poses a substantial risk to human health and the environment (Greenpeace Organization, 2010).

Another cause for concern is that children's toys feature rampant use of PVC. A child chewing on his rubber ducky in the bath is being exposed to levels of cancer-causing chemicals which have led to such items being banned in many European countries. Yet, here in Thailand, people are not informed that the toys their children play with, the shower curtain in their bathroom, or the pipes under their houses contain PVC. This plastic causes cancer and kidney damage, and when burned, it results in long term respiratory damage (Conscientious Home Network, 2010).

PVC is also the most problematic for the environment because it is one of the world's largest dioxin sources.

PVC production began rising rapidly in the 1960s, particularly in Asia and Latin America. Today more than 30 percent of the world's chlorine production is used to make PVC. This plastic has replaced less problematic materials such as glass, metal, paper, wood, ceramics, etc. A wide range of products are made up of PVC, such as building materials, consumer articles, office furniture, car underseal, wire and cable insulation, imitation leather and garden furniture (Greenpeace Organization, 2010).

Vinythai Public Company Limited is a biggest producer of VCM and PVC in Thailand. The production facility is located in Mab Ta Phut Industrial Estate. The company focuses on the supply of PVC (suspension and emulsion resins), VCM and caustic soda in South-East Asia. It has doubled the production since 2004 (Solvay Plastics Company, 2010).

### DEHA (Diethyl hydroxylamine)

DEHA or Bis (2-ethylhexyl) adipate is a colorless plasticizer. It is sometimes called dioctyl adipate or diisooctyl adipate. DEHA has been demonstrated to induce liver carcinomas in mice but not in rats. According to International Agency for Research on Cancer (2008), it is not classifiable as to its carcinogenicity to humans. DEHA is used as an ingredient in plastic wrap and other plastics such as PET and PVC. Plasticizers give hard plastics like PVC and PET desired flexibility and durability (Wikipedia, 2010).

PET (Polyethylene Terephthalate) used in water or soft drink beverage containers contains potentially carcinogenic elements such as DEHA and reuse of these bottles can cause the plastic to break down and the carcinogen can leak into the water or soft drinks that people are drinking (Mind Chimes Network, 2010).

### Phthalate or DEHP (di-2-ethylhexyl phthalate)

Phthalates are used as plasticizers to soften PVC. They have been used in the PVC industry for more than 80 years. They can easily leak out as the plastic ages and breaks down. In general, they do not persist in the outdoor environment (Perovich & Rudel, 2008). The general chemical structure of phthalates is shown in Figure 2.

People are commonly exposed to the colorless, odorless and clear liquid of phthalates. Most Americans tested by the Center for Disease Control and Prevention have metabolites of multiple phthalates in their urine. Phthalate in plastics can easily leak and evaporate into food. Diet is believed to be the main source of phthalates in the general population, with fatty foods such as milk, butter and meats being the major carriers (Heudorf, Mersch-Sundermann & Angerer, 2007).

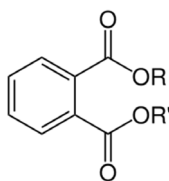


Figure 2 General chemical structure of phthalates

Source: Wikipedia (2010)

In general, infants and toddlers are at the greatest risk of exposure to phthalates due to their mouthing behavior, while body care products containing phthalates are also a source of exposure for infants. There is a report that use of infant lotion, infant powder, and infant shampoo was associated with increased infant urine concentrations of phthalate metabolites. This association is strongest in younger infants. These findings suggest that dermal exposures may contribute significantly to phthalate body burden in the population. Young infants are more vulnerable to the potential adverse health effects of phthalates, given their increased dosage per unit body surface

area, metabolic capabilities, and developing endocrine and reproductive system (Sathyanarayana, Kerr & Lozano, 2008).

Additionally, phthalates can affect pregnancy in woman. Researchers at the University of Michigan, School of Public Health, found that women who deliver prematurely have, on average, up to three times the phthalate level in their urine compared to women who carry to term (Wikipedia, 2010).

Hypospadias is one of the most common birth defects among baby boys. It is a condition in which the urethra opening is on the underside of the penis rather than the tip. This occurs in roughly one of every 250 male births. Surgery is normally required or the condition can lead to infertility (Cone, 2009). However, hypospadias is apparently not on the rise in the U.S., casting doubt on claims that phthalate and other endocrine disruptors cause reproductive abnormalities in humans.

Restricted uses of phthalate in children's products such as toys and child care articles have been legalized in some countries. The European Union has restricted use of some phthalates in children's toys since 1999. The United States Congress passed and President Bush signed the Consumer Product Safety Improvement Act in August 2008. This law states that it shall be unlawful for any person to manufacture for sale, offer for sale, distribute in commerce, or import into the United States any children's toys or child care articles that contain concentrations of more than 0.1 percent of phthalate (American Chemistry, 2010).

#### **BHA (Butylated hydroxyanisole) and BHT (Butylated hydroxytoluene)**

Both BHA and BHT are additives used as antioxidants to protect the structure of plastic. They are designed to react quickly with oxygen, sacrificing themselves to protect the polymer chemical chain.

Though both BHA and BHT have known health effects, they are used in many products including food, cosmetics, plastics and lubricants. BHT has been shown to cause mutations, tumors and endocrine effects in test animals, whereas BHA can also mimic the female hormone estrogen (Reingruber, Himmelsbach, Sauer & Buchberger, 2010). Another study found that both BHA and BHT cause liver toxicity (Ecology Center, 2010).

#### **Teflon (PFOA – Perfluorooctanoic acid)**

Teflon was first used after World War II as a coating material for non-stick pans. Today, it is considered to be a health risk substance, linked to birth defects. Moreover, Teflon exposed to heat above 340 degree Celsius can release carcinogens. However, use of Teflon kitchenware is safe because normal usage temperatures are much lower than the 340 degrees stated here (Scoop, 2010; High Country Conservation Organization, 2003).

Even considering this, for consumer's safety, alternatives to Teflon, such as stainless steel,

cast iron, porcelain enameled surfaces or ceramic titanium surfaces, should be considered. If consumers can afford to replace old non-stick cookware, they are advised to do so.

### Melamine resin (Melamine formaldehyde)

While melamine resin is safe to be used in kitchen utensils, plates and bowls, it should not be put in a microwave without a label stating that it is safe for microwave use. A weak point of its use is recycling because melamine resin cannot be melted (Wikipedia, 2010).

Melamine is an organic based chemical most commonly found in the form of white crystals rich in nitrogen, as shown in Figure 3

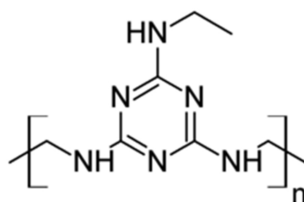


Figure 3: Structure of melamine resin

Source: Wikipedia (2010)

The addition of melamine to food is not approved by Food Standard Commission or by any national authorities. Melamine can form crystals that can raise the risk of kidney stones (World Health Organization, 2010). Adding melamine to food is prohibited worldwide. The addition of melamine to food can increase nitrogen content, which is also an important indicator of protein quality of milk products. Some imported milk products were found the addition of melamine and were banned from store shelves for consumer safety.

Melamine formaldehyde plastic may also release formaldehyde when heated or burned at high temperatures. While formaldehyde is a human carcinogen, there is not enough information to confirm that melamine utensils and bowls used at normal cooking temperatures are unsafe.

## Protection from hazards associated with plastics

There are a number of steps that can be taken to protect users from hazards associated with plastics, as follows (International Air Quality Resource Center, 2010):

- One should attempt to find and use natural substitutes for plastic products. For example, instead of plastic shelves, solid wood shelves should be used. Also, plastic grocery bags could be substituted for cloth bags.
- In the kitchen, one should use glass containers with lids or ceramic cookware. For pets, use stainless steel or ceramic food bowls.
- Food in containers, such as margarine tubs, cottage cheese cartons, or deli containers,



should never be microwaved. When people microwave these light-weight, throwaway containers, the containers warp from contact with hot food and molecules of plasticizers and other chemicals are released and migrate into the food. Long-term exposure to low levels of these chemicals could be harmful, since they were not meant to be consumed.

- Several plastic manufacturers have containers that are designed to go from the freezer to the microwave, to the top rack of the dishwasher. While these lightweight plastic products are reusable, they are not meant to be used forever.

- If people do microwave food in plastic containers, they should make sure that container is marked microwave-safe.

- Plastic trays or containers from frozen foods should not be reused.

- Foods in their retail containers should not be microwaved or defrosted.

- Plastic wrap should not be allowed to touch food when it is cooked in a microwave.

- Meat should be purchased from a butcher and wrapped in paper.

- Cheese should be purchased from a wheel and wrapped in paper before being placed in a plastic bag.

- One should use plastic wrap made of safer plastics which do not contain plasticizers, such as polystyrene rather than PVC.

- One should avoid the use of PVC plastics. HDPE and LDPE are safer, since they are chlorine free.

- For margarine or other fatty foods wrapped in clingwrap, the outer layer should be removed to prevent the leakage of plasticizers into the food.

- Clay pipe should be used as a safer substitute for PVC pipe.

- A plastic derived from corn and wheat has been introduced. It can someday be used to make packaging and containers.

- Safer plasticizers and antioxidants should be initiatively substituted the hazardous ones.

## Microwaving food in plastic

When food is wrapped in plastic or placed in a plastic container and microwaved, plasticizers may leak into the food (Harvard Medical School, 2006). Thus, Food and Drug Administration (FDA) requires that manufacturers test plastic containers. Additionally, it reviews the test data before approving a container. Only containers that pass the test can display a microwave-safe label. However, a container that is not labeled safe for microwave use is not necessarily unsafe; the FDA simply has not yet determined whether it is or is not.

Here are some things to keep in mind when using the microwave:

- Most takeout containers, water bottles and plastic jars made to hold margarine, yogurt,

whipped topping, cream cheese, mayonnaise and mustard are not microwave-safe.

- Microwave takeout dinner trays are formulated for one-time use only.
- Plastic storage bags or plastic bags from grocery stores should not be put in a microwave.
- Before microwaving food, one should be sure to vent the container, leave the lid ajar, or lift the edge of the cover.
- Plastic wrap should not be allowed to touch food during microwaving because it may melt.
- If one is concerned about plastic wrap or containers in the microwave, one should transfer food to glass or ceramic containers labeled for microwave oven use.

## Conclusion

Some plastics are safer than others. PVC is the most hazardous material. Most plastics used in daily living are safe for the right application. Many hazardous substances, such as plasticizers and antioxidants in plastics, may reach into foods and cause chronic health effects to consumers. Some plastic materials are hazardous by themselves, such as styrene vapor, melamine powder and Teflon. However, there are many ways to protect consumers from the adverse health effects of plastics in daily living.

The question which needs to be answered by future epidemiological research is whether there is a correlation between hazardous substances in a specific plastic, and chronic health effects in human, such as cancer, birth defects, sex deviation in males and kidney stone.

## References

- American Chemistry. (2010). *Phthalates and Children's Toys*. Retrieved September 28, 2010, from <http://phthalates.americanchemistry.com/Phthalates-Basics/Toys/default.aspx>
- Biello, D. (2008a). Plastic (Not) Fantastic: Food Containers Leach a Potentially Harmful Chemical. *Scientific American*. Retrieved September 16, 2010, from <http://www.scientificamerican.com/article.cfm?id=plastic-not-fantastic-with-bisphenol-a>
- Biello, D. (2008b). Consumer Alert: Plastic in Baby Bottles May Pose Health Risk. *Scientific American*. Retrieved September 16, 2010, from <http://www.scientificamerican.com/article.cfm?id=plastics-in-baby-bottles-may-pose-health-risk>
- Conscientious Home Network. (2010). *Toxic Plastic 3 – Turn Over the Bottle and Look!*. Retrieved September 27, 2010 from [http://www.theconscientioushome.net/articles.php?con\\_id=183](http://www.theconscientioushome.net/articles.php?con_id=183)
- Cone, M. (2009). Birth Defect Study Casts Doubt on Phthalate on Fears. *Scientific American*. Retrieved September 29, 2010, from <http://www.scientificamerican.com/article.cfm?id=phthalate-fears-questioned>

- Ecology Center. (2010). *Adverse Health Effects of Plastics*. Retrieved September 21, 2010, from [www.ecologycenter.org/factsheet](http://www.ecologycenter.org/factsheet)
- Greenpeace Organization. (2010). *PVC – the Poison Plastic*. Retrieved September 28, 2010, from <http://archive.greenpeace.org/toxics/html/content/pvc1.html>
- Harvard Medical School. (2006). *Microwaving Food in Plastic: Dangerous or Not?*. Retrieved October 2, 2010, from <http://www.health.harvard.edu/fhg/updates/update0706a.shtml>
- Heartspring Network. (2010). *Study and Controversy Remain over Plastic Safety*. Retrieved September 13, 2010, from [http://heartspring.net/plastic\\_safety\\_bisphenol\\_a\\_phthalates.html](http://heartspring.net/plastic_safety_bisphenol_a_phthalates.html)
- Heudorf, U., Mersch-Sundermann, V. & Angerer, J. (2007). Phthalate: Toxicology and Exposure. *International Journal of Hygiene and Environmental Health*, 210(5), 623-634.
- High Country Conservation Organization. (2003). *Toxic Teflon*. Retrieved September 16, 2010, from [www.highcountryconservation.org/teflon](http://www.highcountryconservation.org/teflon)
- International Agency for Research on Cancer (IARC). (2008). *Bottle Royale*. Retrieved September 16, 2010, from <http://www.snopes.com/medical/toxins/plasticbottles.asp>
- International Air Quality Resource Center. (2010). *Plastics*. Retrieved October 3, 2010, from [www.aerias.org](http://www.aerias.org)
- Macmillan Education. (2006). *Macmillan English Dictionary*. Malaysia: Bloomsbury Publishing.
- Medicine Network. (2010). *Plastic*. Retrieved September 20, 2010, from [www.medicinenet.com](http://www.medicinenet.com)
- Mind Chimes Network. (2010). *Are PET Bottles Hazardous to Health?* Retrieve September 17, 2010, from <http://mindchimes.net/2007/04/07/are-pet-bottles-hazardous-to-health>
- Perovich, L. & Rudel, R. (2008). Endocrine Disrupting Chemicals in Indoor and Outdoor Air. *Atmospheric Environment*, 43(1), 170-181.
- Reingruber, E., Himmelsbach, M., Sauer, C. & Buchberger, W. (2010). Identification of Degradation Products of Antioxidants in Polyolefins by Liquid Chromatography Combined with Atmospheric Pressure Photoionisation Mass Spectrometry. *Polymer Degradation and Stability*, 95(5), 740 – 745.
- Sathyanarayana, S., Kerr, C. J. & Lozano, P. (2008). Baby Care Product: Possible Sources of Phthalate Exposure. *Pediatrics*, 121(2), 260-268.
- Scoop. (2010). *Teflon Health hazard*. Retrieved September 20, 2010, from <http://teflonhealthhazard.com>
- Solvay Plastics Company. (2010). *Who we are Vinythai*. Retrieved September 20, 2010, from <http://www.solvayplastics.com>
- World Health Organization (2010). *Questions and Answers on Melamine*. Retrieved October 1, 2010, from <http://www.who.int/csr/media/faq/QAmelamine/en/index.html>
- Wikipedia (2010). *Plastics*. Retrieved September 13, 2010, from <http://en.wikipedia.org/wiki/Plastic>