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Survey of Bisphenol A and Bisphenol-A- diglycidylether polymer

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Survey of Bisphenol A and Bisphenol-A-diglycidylether polymer

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Preface

The Danish Environmental Protection Agency's List of Undesirable Substances (LOUS) is intended as a guide for enterprises. It indicates substances of specific concern due to the actual consumption in Denmark and for which the use should be reduced or eliminated completely. The first list was published in 1998 and updated versions have been published in 2000, 2004 and 2009. The latest version, LOUS 2009 (Danish EPA, 2012) includes 40 chemical substances and groups of substances which have either been classified as dangerous or identified as problematic due to other concerns.

The criteria employed by the Danish EPA for inclusion of substances on the list include:

- Properties of concern according to the EU "List of hazardous substances";
- Properties of concern identified using computer-based model calculations outlined in the Danish EPA's "Advisory list for self-classification of dangerous substances" (the Self-classification list);
- PBT/vPvB substances as identified by the EU;
- Substances on the EU "Priority list of substances for further evaluation of their role in endocrine disruption"

Furthermore a tonnage threshold has been used. Substances used in quantities exceeding 100 tons per year in Denmark and fulfilling any of the abovementioned criteria have been included in LOUS 2009. For substances which are the subject of special focus in Denmark, the tonnage threshold can however be different.

Over the period 2012-2015 all 40 substances and substance groups on LOUS will be surveyed. The surveys include collection of available information on the use and occurrence of the substances, internationally and in Denmark, information on environmental and health effects, on alternatives to the substances, on existing regulation, on monitoring and exposure and information regarding ongoing activities under REACH among others.

The Danish EPA will on the basis of the surveys assess the need for any further regulation, substitution/phase out, classification and labelling, improved waste management, development of new knowledge or increased dissemination of information.

This survey concerns Bisphenol A and Bisphenol-A-diglycidylether polymer.

The project "Survey of Bisphenol A and Bisphenol-A-diglycidylether polymer" was carried out from June till December 2012.

This report describes the project results and includes surveys on the three CAS Numbers, including information on, uses and exposure, legislation, and environment and health properties and alternatives on the basis of available information.

The project was carried out by DHI Water Environment Health, Denmark.

The project participants were:

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The project was financed by the Danish Environmental Protection Agency.

The report reflects the author's views and opinions, but not necessarily the views of the EPA.

Summary and Conclusion

Bisphenol A (BPA) is one of the industrial chemicals produced in largest volume world-wide. In 2009 the world's consumption of BPA as a monomer in the manufacture of polycarbonates was 2768 kt (kilotonnes). As a precursor or starting material for monomers of certain epoxy resins it was 1093 kt. The European Union (EU) and the United States (US; USA) each make up slightly over 25% of the world's BPA production of 3800 kt. BPA production increased with 64% in the EU from the period 1996/1999 to 2005/2006. Observations from Sweden, Norway, Denmark and Finland showed overall a quite stable use up to about 1000 tonnes/year/country from year 2000 till 2010.

Bisphenol A is an organic chemical compound which functions as the building block for epoxy resins and polycarbonate (PC) plastic. It is primarily used as a **monomer** in the manufacture of **polycarbonates** and as a **monomer, precursor or a starting material for monomers** of certain **epoxy resins** and as such used in a wide variety of consumer products and articles. Over 95% of the world consumption of BPA in 2009 was of PC resins (about 75%) and epoxy resins. PC is a highly versatile, durable, heat- and shatter-resistant and clear thermoplastic that is the material of choice for a wide range of end-user applications. Polycarbonate is used in compact disc manufacture, food and beverage contact containers, medical devices, and in glazing applications and film. Polycarbonate blends are used in the electric and electronics industries and in the automotive industry.

Epoxy resins are used primarily as coatings for consumer and industrial applications. They are used in protective coatings, structural composites, electrical laminates, electrical applications and adhesives. Epoxy-phenolic resins are used as liners in metal cans for foods and beverages and as coatings on metal lids for glass jars and bottles. Epoxy resins are used in automotive electro-coating and in automotive and industrial primer and topcoat applications as well as in coatings (e.g. for water pipes) and dental materials/epoxy adhesives.

BPA is also used in the production of phenoplast, phenolic and unsaturated polyester resins, thermal paper, polyvinylchloride (PVC), alkoxylated bisphenol A and polyols/polyurethane. BPA may be used in the manufacture of modified polyamide, and tetrabromobisphenol A. Other articles that may contain BPA include protective window glazing, building materials, optical lenses and dyes as well as recycled paper.

Bisphenol-A-diglycidylether polymer (BADGE polymer) functions as protective or surface coatings in cans and storage tanks or as bonding and adhesives for repair kits, dental repairs, cars etc. Bisphenol-A-diglycidylether polymer is manufactured from BPA epoxy resins. Epoxy resins are based on BPA and epichlorohydrin, also known as BPA diglycidyl ether epoxy resins (BADGE resins). As mentioned above, the world's consumption of epoxy resins was 1093 kt in 2009. The consumption of epoxy coatings by end use in 2007 in the USA was as follows (% share): protective (or surface) coatings (48%); bonding and adhesives (14%); flooring, paving and construction (8%); composites (9%); electrical and electronic laminates (6%); embedding and tooling (4%); vinyl ester resins (4%) and other (16%) (WHO, 2010). More than one CAS number covers the bisphenol-A-diglycidylether polymer. The focus in this survey was on the bisphenol-A-diglycidylether polymer with the CAS numbers 25036-25-3 and 25068-38-6. At least in Scandinavia and Poland the consumption of the CAS number 25068-38-6 seems to be larger than for 25036-25-3. The consumption of 25036-25-3 was approximately 5000 tonnes in 2010 in Scandinavia (Sweden, Denmark, Finland and Norway; The Nordic SPIN database) and 10 tonnes in Poland in 2011

(Poland Bureau for Chemical Substances, 2012). In comparison the consumption of 25068-38-6 was approximately 40,000 tonnes in 2010 in Scandinavia (Sweden, Denmark, Finland and Norway; The Nordic SPIN database) and 235 tonnes in Poland in 2011 (Poland Bureau for Chemical Substances, 2012). By varying the ratio of epichlorohydrin to BPA, as well as the operating conditions, BADGE epoxy resins of low, medium and high molecular weight can be produced, with molecular weights ranging from as low as 350 (liquid epoxies) to as high as 8000 (solid epoxies). The use of bisphenol-A-diglycidylether polymer has raised concerns due to its release of BPA. This is not only the case for food contact materials, but also for dental treatments. The contained amount of BADGE derivatives in canned food, 2004, was 100 to 600 µg/kg food, which is about 10 times higher than the highest BPA content of 69.9 µg/kg seen in canned food. Many dental composite filling surfaces on teeth may also increase the urinary BPA concentration in children as reported by Chung et al (2012). The concerns about the effects of BPA are described below. From the toxicity data on BADGE and BADGE-containing polymers (CAS 25036-25-3 and CAS 25068-38-6), the main concern is the skin sensitizing property of the substances. EFSA concluded that reproduction studies in rats with BADGE gave no indication of any deleterious effects on fertility, general reproductive parameters, litter data or post-natal development. Developmental toxicity studies in rats and rabbits via the oral route showed no teratogenic effects or adverse effects on embryonal or foetal development. EFSA further concluded that BADGE does not raise concern for genotoxicity or carcinogenicity. A TDI of 0.15 mg/kg bw/day was established from a NOAEL of 15 mg/kg body weight (bw)/day from a two-year chronic/carcinogenicity study; toxic effects on the spleen were observed at higher levels. As BADGE is rapidly and extensively metabolised *in vivo* into the corresponding mono- and bis-diol derivatives, they are included in the TDI as well. For the BADGE chlorohydrins BADGE.2HCl, BADGE.HCl, BADGE.HCl.H₂O, the current restriction of 1 mg/kg of food is considered by EFSA to remain appropriate (EFSA, 2005). Also other BADGE reaction products other than chlorohydrins, with undefined toxicological properties and chemical identity, may be found at low levels in the migrate from epoxy coatings. EFSA (2005) is currently considering a general approach for the assessment of these BADGE reaction products. In general the approach will be for minute amounts of unknown migrants from food contact materials. This is the latest update available. For BADGE, BADGE.H₂O and Badge.2H₂O, the SML (Specific Migration Limit) is 1 mg/kg. For BADGE, BADGE.H₂O and BADGE.2H₂O in total, the SML is 9 mg/kg food (EC 1895/2005 in EUR LEX, 2012A).

BPA and bisphenol-A-diglycidylether polymer. BPA is classified reprotoxic in category 2 (suspected of damaging fertility). However, the French authorities have reported that they will submit in 2012 a proposal for a revised harmonized classification of BPA which will upgrade the classification for reproductive toxicity from “Repr. Category 2” to “Repr. Category 1B, H360F” (may damage fertility) alternatively considering human data in category 1A, H360F (may damage fertility) (ANSES, 2012B).

Due to concern for the endocrine disrupting effects of BPA, several restrictions have been put on BPA. They are often implemented to protect infants and small children because they are the most sensitive group and are highly exposed due to their consumption pattern. Thus, BPA is addressed under several EU Directives and Regulations, e.g. restricted in plastic infant feeding bottles (EC 321/2011 & No 10/2011). In addition, some EU Member States have chosen to strengthen the European regulation for infant feeding bottles (e.g. DK, SE and Austria). Canada and China have restricted BPA in infant feeding bottles.

In connection with the REACH regulation, Germany is presently elaborating a Substance Evaluation on BPA in order to evaluate whether further EU regulatory measures are necessary for ensuring the safe use of BPA.

The BPA exposure is widespread in the general human population. This has been confirmed in biomonitoring studies where BPA and its metabolites have been measured in blood and urine. It is generally believed that consumer exposure to BPA occurs primarily via food in contact with BPA-

containing materials, such as polycarbonate baby bottles, tableware and food containers as well as food and beverage cans lined with epoxy resins.

Based on measurements on BPA migration and on BPA content in food, BPA exposure from food intake has been calculated as the dominant source of BPA exposure. Infants and children in the age group of 1.5-4.5 years are considered to be the most highly exposed, and scenarios with exposure of up to 10 µg BPA/ kg bw/day have been estimated. For adults lower exposure estimates of up to 1.5 µg BPA/ kg bw/day have been estimated. On the other hand biomonitoring data in general indicate considerable lower exposures than have been calculated from scenarios using BPA migration data and data on food intake. The highest exposure in biomonitoring studies has been found for Japanese children where exposures up to 40% of the calculated exposure levels were reported.

Few BPA exposure estimates have been made using BPA migration data from other types of articles than food contact articles. However, the migration of BPA has been measured from a variety of articles.

Recently, it has been shown that BPA can be transferred to the skin from certain types of thermal printing paper, such as some types of cashier's receipts.

At present there are no data from which to evaluate the possible decline in BPA exposure of infants and children due to the recent EU and national restrictions on infant feeding bottles and on certain types of food contact materials. Thus, more studies are needed in order to get an updated and more realistic impression of the various exposures from articles and to get an impression of the sum of the BPA exposures of the different age groups in the population.

Bisphenol A is considered to be a potential endocrine disruptor and can interact with nuclear and membrane-bound oestrogen receptors. The possibility of other effects has also been reported. In adults, elevated urinary BPA concentrations were found associated with obesity and incident coronary artery disease (Trasande et al, 2012). The toxicity of BPA has been studied extensively during the last decades, and new studies of the effects are constantly being released. EFSA mentioned about 30 new research papers each month (Personal communication, 2012).

BPA has recently been subject to many expert evaluations:

The EU risk assessment report on BPA from 2003 was updated in 2010. In the updated version further studies of developmental neurotoxicity were evaluated. However, it was assessed that no new conclusion could be reached from the new studies due to their low confidence and reliability and lack of consistency in results. A new two-generation study with mice confirmed the previous NOAEL value from the EU RAR evaluation 2003 for reproductive toxicity of 50 mg/kg/day. Furthermore it was stated that there was no evidence of adverse effects on the development of the male reproductive tract at lower doses of BPA. Thus, the study resolved the uncertainties of the potential of low doses to produce adverse effects on development. Overall, the EU RAR (2010) confirmed its previous conclusion and also found support in the EFSA (2006) opinion which reached a similar conclusion on the basis of the more recent studies. In the EU RAR it is written: Overall, taking together the low confidence in the reliability of the developmental neurotoxicity studies and the lack of consistency in the results of behavioural testing, no conclusions can be drawn from these studies¹. This opinion is very similar to that of EFSA (2006), who reviewed nine of the developmental neurotoxicity studies.

¹Denmark, Sweden and Norway do not agree with this conclusion. These countries find that some of the studies in the DNT database are sufficiently reliable for regulatory use: Negishi 2004, Carr 2003, Ryan and Vandenberg 2006 and Adriani 2003. The reliability of these studies is judged to be adequate because the behavioural testing has been conducted according to acceptable methods, the group sizes are quite close or equal to those recommended in the OECD TG 426, and the litter has been used as the statistical unit. The effects found in these studies indicate that there is a possible risk for developmental neurotoxicity of BPA at very low exposure levels (0.1-0.25 mg/kg/day). These effects cannot be dismissed based on the other unreliable studies in the DNT database. The above mentioned countries would therefore prefer one of two possible conclusions: 1) the available, but limited data are used for the risk assessment or 2) there is a need for further information (the

In 2010 EFSA also made an update of their 2006 evaluation that set the current Tolerable Daily Intake (TDI) of 0.05 mg BPA/kg bw/day. Again, EFSA included the most recent studies in the evaluation together with a Danish risk assessment that had been basis for the Danish ban of BPA in food contact materials for infants aged 0-3 years. Overall, based on this comprehensive evaluation of recent toxicity data, the Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF) concluded that no new study could be identified, which would call for a revision of the current TDI. This TDI is based on the No-Observed-Adverse-Effect-Level (NOAEL) of 5 mg/kg bw/day from a multi-generation reproductive toxicity study in rats (Tyl et al, 2002), and the application of an uncertainty factor of 100. This factor was regarded as conservative based on all information on BPA toxicokinetics. The Panel noted that some studies conducted on developing animals have suggested other BPA-related effects of possible toxicological relevance, in particular biochemical changes in brain, immune-modulatory effects and enhanced susceptibility to breast tumours. These studies had several shortcomings, but more studies have been released since and EFSA is currently working on an assessment of human health risks associated with BPA. Its new scientific opinion is scheduled for completion in May 2013 (EFSA, 2012).

ANSES in France has recently published a comprehensive report on health effects and uses of BPA (ANSES, 2011) and came out with conclusions on the need to reduce exposure of the sensitive populations based on BPAs effects described below. The report explains that available human and animal data have most often been obtained at doses lower than the NOAEL of 5 mg/kg/day that was used to calculate the TDI currently used by EFSA. The working group recommends for instance to assess the relevance of using toxicity reference values (TRVs) or Tolerable Daily Intakes for substances with non-monotonic dose-response curves. The ANSES report also recommends that some adverse effects should be taken into account in future risk assessment.

These are **in animals**:

- Increased occurrence of ovarian cysts after pre- and postnatal exposures
- Hyperplastic modification of the endometrium after pre- and postnatal exposure
- Early onset of puberty after pre- and postnatal exposures
- Altered sperm production after adult exposure
- Histological changes in neurogenesis following pre- or perinatal exposure
- Effects on lipogenesis after prenatal, perinatal or adult exposure
- Effects on the mammary gland: acceleration of the mammary gland's structural maturation in adulthood and development of intraductal hyperplastic lesions after pre- or perinatal exposure to BPA.

in humans:

- Effects on oocyte maturation in females in infertile couples undergoing ART (Assisted Reproductive Technology).
- Effects on cardiovascular pathologies (coronary diseases) and diabetes (ANSES, 2011).

In 2011, and following the publication of report by ANSES (2011), EFSA was requested by the European Commission to provide scientific advice about the possible divergence between, on the one hand, the report from ANSES and, on the other hand, the conclusions of the previous EFSA scientific opinion on BPA (EFSA, 2011) that is based on ANSES' conclusion on the need to reduce exposure of the sensitive populations. Additional studies have become available, and they indicate effects of BPA in rodents at dose levels below the current NOAEL of 5 mg/kg bw/day. Uncertainties regarding the relevance to humans of these toxicological effects remain to be clarified (EFSA, 2011). The Panel needs more time to review in depth these new studies and hence its new scientific opinion is scheduled for completion in May 2013 (EFSA, 2012).

countries certainly evaluate the database as sufficient to justify a concern warranting further investigation of developmental neurotoxicity), similarly to the proposed conclusion in the final expert panel report on the reproductive and developmental toxicity of BPA performed by NTP, US in November 2007.

In a recent report by Beronius and Hanberg (2012) the current TDI of 50 µg/kg bw/day is challenged by alternative reference doses. The report concluded that although no single study reviewed was considered reliable enough to serve as a key study for the derivation of an alternative reference dose, if the data is considered as a whole, effects are consistently observed at doses well below those which serve as the basis for the current TDI for BPA. This indicates that revising the TDI may be prudent when conducting risk assessment of BPA. Alternative reference doses calculated from the NOAELs/LOAELs ranging from 0.01 to 0.8 µg/kg bw/day thus are considerably lower than the current TDI. How risk assessment on BPA should be undertaken in the future will very much depend on whether the toxicological findings in the low dose studies will be generally accepted as the starting point for a revised TDI derivation. A revised TDI will then be orders of magnitude lower than the current TDI. While the current human exposure to BPA, also in relation to worst case exposures, generally is considered below the current TDI value risk assessment scenarios may change if the TDI in the future is set at a level indicated by the report. If the TDI would be lowered, the exposure to BPA from food contact material would be of primary concern. However, also other types of exposures from various articles may then be of greater concern.

A new Danish study on BPA and other substances with endocrine disrupting properties investigated the risks from combined exposure (exposure from several sources) and risks from exposure to “cocktails” (exposures from several substances with the same effect at the same time), (Andersen et al, 2012). The highest Risk Characterization Ratio (RCR) for bisphenol A in the report was 0.01 from combined BPA exposure in the basis scenario added to the work and transport scenarios. Based on this the combined exposure to BPA alone does not seem to pose a risk to the normal consumer. The study covered many sources of BPA and was considered to allow a realistic evaluation of the exposure of a pregnant woman in Denmark with an average lifestyle. Should the current TDI be lowered, RCR's should be re-calculated.

In the same study (Andersen et al, 2012), simultaneous exposure to several chemicals, including BPA and parabens, were looked at in three scenarios: basis, work and transport. For the sum of these, the RCR was 3.88 for exposure to 11 estrogenic substances, thus a clear risk. This risk was primarily due to propyl- and butylparaben in cosmetics. BPA was the only bisphenol in this calculation.

If the current TDI is changed, then the scenario of the risk assessment must also be changed. Furthermore, the calculated cocktail effect in the work mentioned above includes only 11 substances with estrogenic effect; more substances with that effect certainly exist to which individuals are exposed and many chemicals have not been examined in relation to endocrine disrupting properties.

Some of the alternative substances e.g. other bisphenols that are used as substitutes for BPA probably have effects similar to it. Thus substituting to these bisphenols will probably not reduce the risk.

If the current TDI is lowered it might result in more restrictions on BPA and bisphenol-A-diglycidylether polymers.

Resume og konklusion

Bisphenol A (BPA) er et af de industrikemikalier, der produceres i størst volumen på verdensplan. I 2009 var verdens forbrug af BPA som monomer til fremstilling af polycarbonater 2768 kt (kiloton). Som precursor eller udgangsmateriale til monomerer af visse epoxyharpikser var forbruget 1093 kt. Den Europæiske Union (EU) og USA (US) udgør hver lidt over 25% af verdens samlede BPA produktion på 3800 kt. BPA produktionen steg med 64% i EU fra perioden 1996/1999 til 2005/2006. Sverige, Norge, Danmark og Finland havde en ganske stabil anvendelse på op til omkring 1000 tons/år/land fra år 2000 til 2010.

Bisphenol A er en organisk kemisk forbindelse, der fungerer som byggesten for epoxyharpikser og polycarbonat (PC) plast. Det anvendes primært som en **monomer** i fremstillingen af polycarbonater og som en **monomer, precursor eller et udgangsmateriale** til monomerer af visse **epoxyharpikser** og som sådan anvendes BPA i en lang række af forbrugerprodukter og artikler. Over 95% af verdens forbrug af BPA var i 2009 PC harpiks (ca. 75%) og epoxyharpikser. PC er en meget alsidig, holdbar, varmestabil og splintsikker klar termoplast, der er det foretrukne materiale til en bred vifte af slutbrugerapplikationer. Polycarbonat bruges i compact disc fremstilling, beholdere til mad og drikke, medicinsk udstyr samt i vinduer. Polycarbonat blandinger anvendes i elektriske installationer og elektronik industrien samt i automobil industrien. Epoxyharpikser bruges primært som belægninger til forbruger- og industrielle applikationer. De anvendes i beskyttende belægninger, strukturelle kompositter, elektriske laminater, elektriske applikationer og klæbemidler. Epoxy-phenolharpikser anvendes fx som foringer i metaldåser til fødevarer og drikkevarer, og som belægninger på metallæg til glas og flasker. Epoxyharpikser bruges i bilindustrien i elektrobelægning og i auto- og industritekniske primere og topcoatninger samt i coatninger/belægninger (fx vandrør) og tandmaterialer/epoxy.

BPA anvendes også til fremstilling af phenolplast, phenolharpiks og umættede polyesterharpikser, termisk papir, polyvinylchlorid (PVC), alkoxyleret bisphenol A og polyoler/polyurethan. BPA kan anvendes ved fremstillingen af modificeret polyamid, og tetrabrombisphenol A. Andre artikler, der kan indeholde BPA omfatter beskyttende vinduesglas, byggematerialer, optiske linser og farvestoffer samt genbrugspapir.

Bisphenol-A-diglycidylether polymer (BADGE polymer) fungerer som beskyttende belægninger eller overfladebelægninger i dåser og lagertanke eller som bindemiddel og klæbestoffer til reparationsset, tandreparationer, biler etc. Bisphenol-A-diglycidylether polymer er fremstillet af BPA epoxyharpikser. Epoxyharpikser er baseret på BPA og epichlorhydrin, også kendt som BPA diglycidylether epoxyharpikser (BADGE harpikser). Som nævnt ovenfor var verdens forbrug af epoxyharpikser 1093 kt i 2009. Forbruget af epoxymalinger ved slutanvendelse var i 2007 i USA som følger (% andel): beskyttende (eller overflade) belægninger (48%), limning og lime (14%), gulve, brolægning og anlæg (8%), kompositter (9%), elektriske og elektroniske laminater (6%), indlejring og værktøj (4%), vinylesterharpikser (4%) og andre (16%) (WHO, 2010). Bisphenol-A-diglycidylether polymer har mere end ét CAS-nummer. Fokus i denne undersøgelse var på bisphenol-A-diglycidylether polymer med CAS-numrene 25036-25-3 samt på 25068-38-6. I det mindste i Skandinavien og Polen synes forbruget af CAS-nummeret 25068-38-6 at være større end for 25036-25-3. Forbruget af 25036-25-3 var omkring 5000 tons i 2010 i Skandinavien (Sverige, Danmark, Finland og Norge, Nordisk SPIN database) og 10 tons i Polen i 2011 (Poland Bureau for Chemical Substances, 2012). Til sammenligning var forbruget af 25068-38-6 cirka 40.000 ton i

2010 i Skandinavien (Sverige, Danmark, Finland og Norge, Nordisk SPIN-databasen) og 235 tons i Polen i 2011 (Poland Bureau for Chemical Substances, 2012). Ved at variere forholdet mellem epichlorhydrin og BPA samt driftsbetingelserne, kan BADGE epoxyharpikser med henholdsvis lav, middel og høj molekylvægt fremstilles. De fremstilles med molekylvægte på 350 (flydende epoxyer) til 8000 (faste epoxyer). Anvendelsen af bisphenol-A-diglycidylether polymer har skabt bekymring på grund af polymerens frigivelse af BPA. Dette ses ikke kun ved kontakt med fødevarer, men også fra tandbehandlinger. Mængden af BADGE derivater i dåsemad, 2004, var 100 til 600 µg/kg mad, hvilket er omkring 10 gange højere end det højeste BPA indhold på 69,9 µg/kg målt i dåsemad. Der er også fundet øget BPA koncentrationen i urinen hos børn med mange plastfyldninger på tænderne, som rapporteret af Chung et al (2012). Bekymringerne for BPA's effekter er beskrevet nedenfor. På baggrund af toksicitetsdata for BADGE og BADGE-holdige polymerer (CAS 25036-25-3 og CAS 25068-38-6) ses den største bekymring relateret til stoffernes hudsensibiliserende egenskaber. EFSA konkluderede, at reproduktionsforsøg på rotter med BADGE ikke gav indikation på eventuelle skadelige virkninger på fertilitet, generelle reproduktionsparametre, kuld størrelser eller postnatal udvikling. Udviklingsstudier hos rotter og kaniner via oral indtagelse viste ingen teratogene virkninger eller skadelige virkninger på den embryonale eller føtale udvikling. EFSA konkluderede endvidere, at BADGE ikke gav anledning til bekymring for genotoksicitet eller karcinogenicitet. En TDI på 0,15 mg/kg legemsvægt/dag blev fastsat på baggrund af en NOAEL på 15 mg/kg legemsvægt/dag fra et to-årigt kronisk carcinogenicitet studie. Toksiske virkninger på milten blev observeret ved højere niveauer. Da BADGE metaboliseres hurtigt og ekstensivt *in vivo* til de tilsvarende mono- og bisdiol-derivater, er disse også medtaget i TDI'en. EFSA anser den nuværende grænseværdi på 1 mg/kg fødevarer for at være passende for BADGE chlorhydrinerne BADGE.2HCl, BADGE.HCl og BADGE.HCl.H₂O (EFSA, 2005). Også andre BADGE reaktionsprodukter med udefinerede toksikologiske egenskaber og kemisk identitet end chlorhydriner, kan migrere fra epoxy malinger i lave niveauer. EFSA behandler i øjeblikket (2005) en generel tilgang til vurdering af disse BADGE reaktionsprodukter. Generelt vil EFSA's tilgang dække små mængder af ukendte stoffer som migrerer ud af fødevarekontaktmaterialer. Dette er den senest tilgængelige opdatering. For BADGE, BADGE.H₂O og BADGE.2H₂O, er den specifikke migrationsgrænse på 1 mg/kg. For den samlede mængde BADGE, BADGE.H₂O og BADGE.2H₂O er den specifikke migrationsgrænse på 9 mg/kg levnedsmidler (EC 1895/2005 i EUR LEX, 2012A).

BPA og bisphenol-A-diglycidylether polymer. BPA er klassificeret reproduktionstoksisk i kategori 2 (mistænkes for at skade forplantningsevnen). De franske myndigheder har imidlertid rapporteret, at de i 2012 vil fremlægge et forslag til en revideret harmoniseret klassificering af BPA, der vil opgradere klassificering for reproduktionstoksicitet fra "Repr. Kategori 2 "til" Repr. Kategori 1B, H360F " (Kan skade forplantningsevnen) eller alternativt overveje humane data i kategori 1A, H360F (kan skade forplantningsevnen) (ANSES, 2012B).

På grund af bekymring for BPA's hormonforstyrrende effekter er BPA begrænset ved flere anvendelser. Begrænsningerne er ofte implementeret for at beskytte spædbørn og små børn, fordi de er den mest følsomme gruppe og udsat på grund af deres forbrugsmønster. Således er BPA omfattet af adskillige EU-direktiver og forordninger, fx begrænset i plast til sutteflasker til spædbørn (EC 321/2011 og nr. 10/2011). Nogle EU-medlemsstater har desuden valgt strammere nationale regler end den europæiske forordning for sutteflasker til spædbørn (fx DK, SE og Østrig). Canada og Kina har også begrænset BPA i sutteflasker til spædbørn. I forbindelse med REACH-forordningen, er Tyskland i øjeblikket ved at udarbejde en stofvurdering på BPA med henblik på at vurdere, om yderligere regulering i EU er nødvendig for at sikre en sikker anvendelse af BPA.

Biomoniteringsundersøgelser bekræfter at BPA eksponeringen er generelt udbredt i befolkningen. Der er målt indhold af BPA og dets metabolitter i både blod og urin. Det er en udbredt opfattelse, at forbrugernes eksponering for BPA primært sker via fødevarer i kontakt med BPA-holdige materialer, såsom polycarbonat sutteflasker, service og beholdere til fødevarer samt dåser foret med epoxyharpikser til mad og drikke.

Baseret på målinger af BPA migrationen og koncentrationen i fødevarer, er BPA eksponeringen stammende fra fødeindtagelse beregnet til at udgøre den dominerende kilde til BPA eksponeringen. Spædbørn og børn i aldersgruppen fra 1,5-4,5 år anses for at være den mest udsatte gruppe med estimerede eksponeringer på op til 10 ug BPA/kg legemsvægt/dag. For voksne er eksponeringerne lavere med niveauer på op til 1,5 ug BPA/kg legemsvægt/dag.

På den anden side indikerer bioovervågningsdata generelt betydeligt lavere eksponeringer end der beregnes ud fra scenarier med BPA migration og data for fødeindtagelse. Den højeste eksponering i bioovervågningsundersøgelser er fundet for japanske børn, hvor en eksponering op til 40% af de beregnede eksponeringsniveauer blev rapporteret.

Der foreligger kun enkelte BPA eksponeringsberegninger af BPA migration fra andre typer af artikler end fødevarekontaktmaterialer. Men migrationen af BPA er imidlertid blevet målt fra en række forskellige artikler.

Det er for nylig også blevet påvist, at BPA kan overføres til huden fra visse typer termisk printerpapir, såsom nogle typer af kasseboner.

På nuværende tidspunkt foreligger der ikke data, hvorfra man kan vurdere hvorvidt der en reduktion i BPA eksponeringen af spædbørn og børn som følge af de seneste EU og nationale restriktioner af BPA i spædbørns sutteflasker og andre fødevarekontaktmaterialer. Flere undersøgelser er således nødvendige for at få et aktuelt billede af de forskellige eksponeringer fra artikler samt summen af BPA eksponeringer, som de forskellige aldersgrupper i befolkningen udsættes for.

Bisphenol A anses for at være potentielt hormonforstyrrende og kan interagere med nukleare og membranbundne østrogenreceptorer. Andre mulige effekter er også blevet rapporteret. Hos voksne er forhøjede BPA-koncentrationer i urinprøver fundet at være forbundet med fedme samt tilfælde af koronararteriesygdom, som er forsnævring af arterierne, der fører til hjertet (Trasande et al, 2012). Toksiciteten af BPA er blevet omfattende undersøgt i de seneste årtier, og der kommer hele tiden nye undersøgelser til. EFSA nævnte omkring 30 nye forskningsartikler hver måned (Personal communication, 2012).

På det seneste er der kommet mange ekspertvurderinger på BPA:

EU risikovurderingsrapporten for BPA fra 2003 blev opdateret i 2010. I den opdaterede version er yderligere undersøgelser af udviklingsmæssig neurotoksicitet blevet evalueret. Det blev dog vurderet, at der ikke kunne drages nogen ny konklusion på baggrund af de nye undersøgelser, som følge af studierne begrænsede pålidelighed og manglende konsekvens i resultaterne. Et nyt to-generations studie på mus bekræftede den tidligere NOAEL værdi fra EU RAR evalueringen fra 2003 for reproduktionstoksicitet på 50 mg/kg/dag. Endvidere blev det anført, at der ikke var tegn på uønskede effekter på udviklingen af de mandlige kønsorganer ved lavere doser af BPA. Ydermere blev det fastslået at der ikke var tegn på skadelige påvirkninger af de mandlige kønsorganer ved lave doser af BPA. Samlet set bekræftede EU RAR'en (2010) sin tidligere konklusion fra 2003, som også blev støttet af EFSA's udtalelse (2006), der nåede frem til en lignende konklusion på grundlag af de nyere undersøgelser. I EU RAR'en står skrevet: Samlet set kan der ikke drages konklusioner fra disse studier, som følge af studierne begrænsede pålidelighed af de udviklingsmæssige neurotoksicitetsundersøgelser og manglende konsistens i resultaterne af adfærdsmæssige test². Denne udtalelse stemmer overens med den af EFSA (2006), som vurderede ni af undersøgelserne for udviklingsmæssig neurotoksicitet.

² Danmark, Sverige og Norge er ikke enige i denne konklusion. Disse lande finder, at nogle af undersøgelserne i DNT databasen er tilstrækkeligt pålidelige til at anvende regulatorisk: Negishi 2004, Carr 2003, Ryan og Vandenberg 2006 og Adriani 2003. Pålideligheden af disse undersøgelser vurderes til at være tilstrækkelige, fordi adfærdsmæssige test er blevet gennemført i henhold til acceptable metoder, gruppens størrelse er ganske tæt på eller lig med de som anbefales i OECD TG 426, og kuldet er blevet brugt som den statistiske enhed. Effekterne, som er fundet i disse undersøgelser viser, at der er en mulig risiko for udviklingsmæssig neurotoksicitet ved meget lave BPA eksponeringsniveauer (0,1 til 0,25 mg/kg/dag). Disse effekter kan ikke

EFSA udførte også i 2010 en opdatering af deres 2006 evaluering, som fastsatte den aktuelle tolerable daglige indtagelse (TDI) til 0,05 mg BPA/kg legemsvægt/dag. EFSA inkluderede igen de seneste undersøgelser i vurderingen sammen med en dansk risikovurdering, som var grundlag for det danske forbud af BPA i fødevarerkontaktmaterialer til spædbørn i alderen 0-3 år. Baseret på denne omfattende evaluering af de seneste toksicitetsdata, konkluderede panelet for kontakt med fødevarer, enzymer, smagsstoffer og hjælpestoffer (CEF) samlet set, at der ikke kunne identificeres nye undersøgelser, som ville kræve en revision af den nuværende TDI. Denne TDI er baseret på NOAEL (No-Observed-Adverse-Effect-Level) på 5 mg/kg legemsvægt/dag stammende fra et multi-generations studie af reproduktionstoksicitet i rotter (Tyl et al, 2002) med anvendelsen af en usikkerhedsfaktor på 100. Denne faktor betragtes som konservativ baseret på al tilgængelig information om BPA's toksikokinetik. Panelet bemærkede, at nogle studier af dyrs udvikling viser tegn på andre BPA-relaterede effekter af mulig toksikologisk relevans, især biokemiske forandringer i hjernen, immun-modulerende effekter og øget modtagelighed for brysttumorer. Disse undersøgelser havde flere mangler, men flere undersøgelser er siden kommet til og EFSA arbejder i øjeblikket på en vurdering af sundhedsrisici forbundet med BPA. Deres nye videnskabelige udtalelse forventes i maj 2013 (EFSA, 2012).

ANSES i Frankrig har for nylig offentliggjort en omfattende rapport om helbredseffekter og anvendelser af BPA (ANSES, 2011) og konkluderede, at der er behov for at reducere eksponeringen af følsomme befolkningsgrupper baseret på BPAs effekter, som beskrevet nedenfor. Rapporten forklarer, at de data der foreligger for mennesker og dyr oftest er opnået ved lavere doser end den NOAEL på 5 mg/kg/dag, der blev brugt til at beregne TDI'en, som i øjeblikket anvendes af EFSA. Arbejdsgruppen anbefaler bl.a. at vurdere om toksicitet referenceværdier (TRVs) eller tolerable daglige indtag for stoffer med ikke-monotone dosisresponskurver alternativt kan anvendes. Rapporten fra ANSES anbefaler også, at flere uønskede effekter inddrages i fremtidige risikovurdering.

Disse er **i dyr**:

- Øget forekomst af cyster på æggestokkene efter præ-og postnatal eksponering
- hyperplastisk modifikation af endometriet efter præ-og postnatal eksponering
- Tidlig pubertet efter præ-og postnatal eksponering
- Ændret sædproduktion efter eksponering som voksen
- Histologiske ændringer i neurogenesen efter præ-eller perinatal eksponering
- Effekter på lipogenesen efter prænatal, perinatal eksponering eller eksponering som voksen
- Effekter på brystkirtlen: acceleration af strukturel modning af mælkekirtlen i voksenalderen og udvikling af intraductal hyperplastiske læsioner efter præ-eller perinatal eksponering for BPA.

hos mennesker:

- Effekter på oocytmodning i kvinder hos barnløse par i ART behandling (Assisted reproduktiv teknologi).
- Virkninger på hjerte-kar-sygdomme og diabetes (ANSES, 2011).

Efter offentliggørelsen af rapporten fra ANSES i 2011, som konkluderede at der er behov for at reducere eksponeringen af følsomme befolkningsgrupper (ANSES, 2011) anmodede Europa-Kommissionen EFSA om at yde videnskabelig rådgivning om den mulige divergens mellem rapporten fra ANSES og EFSA panelets tidligere videnskabelige udtalelse om BPA (EFSA, 2011). Yderligere nye undersøgelser viser effekter af BPA hos gnavere ved dosisniveauer under den nuværende NOAEL på 5 mg/kg legemsvægt/dag, men det er ikke afklaret hvorvidt disse toksikologiske effekter har relevans for effekter på mennesker (EFSA, 2011). Panelet har behov for

afvises på grundlag af de øvrige upålidelige undersøgelser i DNT databasen. De ovennævnte lande vil derfor foretrække en af to mulige konklusioner: 1) tilgængelige, men begrænsede data anvendes til risikovurdering eller 2) der er behov for yderligere oplysninger (landene evaluerer bestemt databasen som tilstrækkeligt til at begrunde en bekymring, som berettiger til en yderligere undersøgelse af udviklingsmæssige neurotoksicitet), i lighed med den foreslåede konklusion i den endelige rapport fra ekspertpanelet om reproduktions-og udviklingstoksicitet af BPA udført af NTP, USA i november 2007.

mere tid til at gennemgå disse nye undersøgelser i dybden og deres nye videnskabelige udtalelse er derfor planlagt til at være færdig i maj 2013 (EFSA, 2012).

Den nuværende TDI på 50 µg/kg lgv/dag udfordres også af alternative reference-doser i en ny rapport fra Beronius og Hanberg (2012). Rapporten konkluderede, at selv om der ikke er et enkelt af de gennemgåede studier, som i sig selv kunne anses for at være pålideligt nok som grundlag for en alternativ grænseværdi, så når data betragtes som en helhed ses der konsekvent effekter ved doser langt under de, der danner grundlag for den nuværende TDI for BPA. Dette indikerer, at der bør udvises forsigtighed når TDI'en revideres i forbindelse med risikovurdering af BPA. Alternative referencedoser beregnet ud fra NOAEL/LOAELs spænder fra 0,01 til 0,8 mg/kg legemsvægt/dag og er således betydeligt lavere end den nuværende TDI. Fremtidige risikovurderinger af BPA, vil i høj grad afhænge af, om de toksikologiske lav-dosis effekter bliver alment accepteret som udgangspunkt for en revideret TDI. En revideret TDI vil så blive størrelsesordener lavere end den nuværende TDI. Mens den aktuelle BPA eksponering af mennesker, også i forhold til worst case-eksponeringer, generelt anses for at ligge under den nuværende TDI, så kan risikovurderingsscenarierne ændre sig, hvis TDI'en i fremtiden reduceres til det niveau, der lægges op til i rapporten. Hvis TDI'en sænkes, vil BPA eksponeringen fra fødevarekontaktmaterialer stadig udgøre den primære bekymring, men også eksponeringer fra andre artikler kan så vise sig at være meget betydningsfulde.

En ny dansk undersøgelse af BPA og andre hormonforstyrrende stoffer undersøgte kombineret eksponering (samtidig udsættelse fra flere kilder) og risiko for "cocktaileffekter" (effekter fra udsættelse for flere stoffer med samme virkning på samme tidspunkt), (Andersen et al, 2012). Rapportens højeste risiko karakteriserings ratio (RCR) for bisphenol A var 0,01 beregnet fra kombineret BPA eksponering i basis scenariet lagt sammen med arbejds- og transportsценarierne. Beregningerne viser at kombineret eksponering for BPA alene ikke udgør en risiko for den normale forbruger. Der var mange BPA kilder omfattet af undersøgelsen, og den anses for at give et realistisk billede af BPA eksponeringen hos en gravid dansk kvinde med en gennemsnitlig livsstil, men i tilfælde af at den nuværende TDI sænkes, skal RCR værdierne revideres.

Samtidig eksponering for forskellige kemikalier, herunder BPA og parabener, i tre scenarier (basis, arbejde og transport) blev omfattet i den samme undersøgelse (Andersen et al, 2012). Her var RCR 3,88 for eksponeringen af 11 østrogene stoffer tilsammen, som dermed viser en klar risiko. Risikoen skyldes primært propyl- og butylparabens forekomst i kosmetik. BPA var den eneste bisphenol, som var omfattet af beregningen.

Såfremt den nuværende TDI ændres vil risikovurderingsscenariet her også skulle ændres. Endvidere omfatter undersøgelsens beregnede cocktaileffekt kun 11 stoffer med østrogen effekt, som ikke udgør alle de østrogene stoffer som enkeltpersoner kan udsættes for, og dertil kommer at mange kemiske stoffer endnu ikke er blevet undersøgt i forhold til deres hormonforstyrrende egenskaber.

Nogle af de alternative stoffer fx andre bisphenoler, der anvendes som erstatning for BPA har sandsynligvis lignende effekter. Man vil således sandsynligvis ikke reducere risikoen ved at erstatte BPA med disse bisphenoler.

Hvis den aktuelle TDI sænkes det kan medføre, at der kommer flere begrænsninger i brugen af BPA og bisphenol-A-diglycidylether polymerer.

1. Introduction

As part of a strengthened Danish effort in relation to chemicals, the Danish Environmental Protection Agency (Danish EPA) is making surveys of substances on the Danish EPA's list of undesirable substances (LOUS). Based on these surveys, the Danish EPA will, for each substance or substance group, evaluate the need for possible further risk management. For the LOUS substances, a systematic survey is being made, consisting of collection of all available knowledge and experience regarding application and occurrence of the substances or substance groups both internationally and in Denmark, and environmental and health effects, alternatives to the substances, and existing restrictions and ongoing efforts in relation to i.e. REACH.

DHI has been contracted by Danish EPA to collect and provide background information on the markets, uses, releases of and alternatives for bisphenol A (BPA) and bisphenol-A-diglycidylether polymer. Bisphenol-A-diglycidylether polymer functions e.g. as protective or surface coatings in cans and storage tanks or as bonding and adhesives for repair kits or dental repairs. It is manufactured from BPA epoxy resins.

BPA has been identified as an endocrine disrupting chemical with health effects that include adverse impacts to development, metabolism and the reproductive system. In addition also neurobehavioral changes are under discussion and obesity and incident coronary artery disease were seen associated with elevated urinary BPA concentrations. BPA is an organic chemical compound which functions as the building block for polycarbonate plastic (PC) and many epoxy coatings, lacquers and adhesives. Exposures to consumers are e.g. from the paint on the inside of cans, lids for glass jars, receipts, PC as well as production and industrial contact with the working environment. The exposure has been shown to occur both orally (food contact materials, PC shield pacifiers, etc.), dermal (contact with receipts, etc.) and by inhalation (indoor dust, etc.) in e.g. a study on pregnant women's exposure to endocrine disruptors. Exposure is also confirmed in a biomonitoring study of urine samples from pregnant Danish women. Oral exposure via food is the main source. Many countries have banned e.g. bisphenol A in food contact materials for 0-3 year olds. Exposure to bisphenol A may pose a risk together with other endocrine disruptors as well. The study of exposure of pregnant consumers to suspected endocrine disruptors show cocktail effects with other endocrine disruptors using the dose-addition method.

The survey has its main focus on bisphenol A (BPA) and the BPA monomers/residues migrating from BPA based polymers used in different applications. Danish EPA has specified two CAS numbers on the bisphenol-A-diglycidylether polymer, which should be included in the survey in order to address the BPA exposure from the bisphenol-A-diglycidylether polymers as well.

Therefore this survey includes bisphenol A and bisphenol-A-diglycidylether polymer:

Bisphenol A:	EC NUMBER 201-245-8, CAS NUMBER: 00080-05-7
Bisphenol-A-diglycidylether polymer:	EC NUMBER (not given), CAS NUMBER: 25036-25-3
Bisphenol-A-diglycidylether polymer:	EC NUMBER 500-033-5, CAS NUMBER: 25068-38-6.

The bisphenol-A-diglycidylether polymer with the CAS no. 25036-25-3 is included on the LOUS list as well and with further reference to the description under BPA.

To gather information on manufacture and use of BPA and bisphenol-A-diglycidylether polymer questionnaires were send out. One kind of questionnaire was prepared for the industry and another kind for the authorities.

For the industry part industrial companies was selected among those who have reported notifications to ECHA on all or 2 of the substances. They covered many different sectors, countries and were mainly larger industries but also some smaller. About 50 different industrial companies have received a questionnaire. No answers did return, but one did take initiative to collect data among other industries in his network. Several of these industries in his network group had received the questionnaire and they discussed the possibility to generate coordinated answers on the non-confidential part of it. However, at the end no answers were sent in.

For the authority part, countries hosting companies selected above were prioritized. 13 countries received the questionnaire (Australia, Canada, Finland, France, Germany, Italy, Netherlands, Norway, Poland, Spain, Sweden, Turkey, and United Kingdom). 4 of them returned with useful data, e.g. amounts of the substances used as referred in chapter 4.

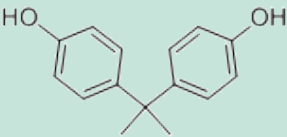
Along with that some Danish industrial organizations, Danish EPA, the Danish Food Agency, the Danish Food Institute and other contact persons have provided data to this present survey on BPA and bisphenol-A-diglycidylether polymers.

2. Identity of the substances

2.1 Name, identity and composition of the substances

The name, identity and composition of BPA and the bisphenol-A-diglycidylether polymer CAS numbers are given in the following tables.

TABLE 2.1
NAME, IDENTITY AND COMPOSITION OF BISPHENOL A

EC number	201-245-8
EC name	4,4'-isopropylidenediphenol
CAS number	80-05-7
IUPAC name	2,2-bis(4-hydroxyphenyl)propane
Other names and explanations	Bisphenol A (BPA), 4,4'-(1-methylethylidene)bisphenol 4,4'-Isopropylidenediphenol
Molecular formula	C ₁₅ H ₁₆ O ₂
Molecular weight	228.29
Concentration range (% w/w)	99 – 99.8 (Impurities typically include phenol (<0.06%), ortho and para isomers of bisphenol-A (<0.2%) and water (<0.2%).)
Structure	

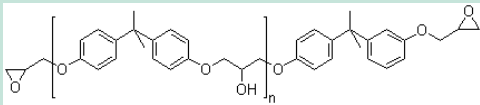
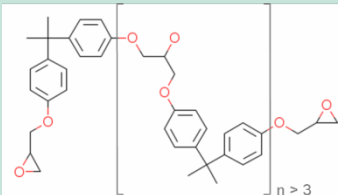
Included in the survey are also BPA derived substances based on bisphenol-A-diglycidylether polymers covering two different CAS numbers mentioned in table 2.2 below. The abbreviations for the bisphenol-A-diglycidylether are BADGE, BPADGE and DGE BPA, as explained in the table. These substances are *not* to be confused with other related bisphenol substances also present on the market, e.g. Bisphenol F (BPF) and Bisphenol-F-diglycidylether (BFGDE).

As explained in the table in the row with monomers the bisphenol-A-diglycidyl ether polymer with the CAS no. 25068-38-6 consists of a BPA monomer and an epichlorhydrin monomer unit, which in reaction forms the bisphenol-A-diglycidyl ether (BADGE) unit. The 25068-38-6 polymer is obtained in a polymerisation of BADGE resins.

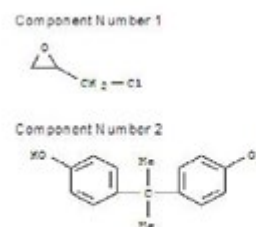
The bisphenol-A-diglycidyl ether polymer with the CAS no. 25036-25-3 consists of the BPA monomer and BADGE resin. The 25036-25-3 polymer is obtained by a polymerization of BADGE resins and BPA monomers.

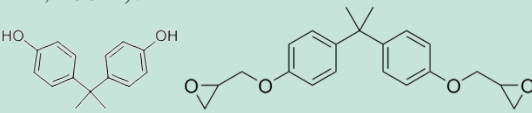
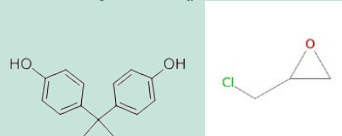
TABLE 2.2
NAME, IDENTITY AND COMPOSITION OF BISPHENOL-A-DIGLYCIDYLETHER POLYMERS

CAS number	25036-25-3	25068-38-6
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CAS number	25036-25-3	25068-38-6
EC number	-	500-033-5
EC name	-	4,4'-Isopropylidenediphenol, oligomeric reaction products with 1-chloro-2,3-epoxypropane
IUPAC name	Not available, but one chemical name is: <i>2,2'-bis(2-(2,3-epoxypropoxy) phenyl)propane</i>	2-(chloromethyl)oxirane; 4-[2-(4-hydroxyphenyl)propan-2-yl]phenol
Other names and explanations	4,4'-(1-methylethylidene)bisphenol (BPA) polymer with 2,2'-[(1-methylethylidene)bis(4,1-phenyleneoxymethylene)]bis[oxirane] (Bisphenol A diglycidyl ether), (Dow, 2012) 2,2'-bis(2-(2,3-epoxypropoxy) phenyl)propane , which is a polymer of BPA and BPA-diglycidylether (Danish EPA, 2012) Bisphenol A diglycidyl ether bisphenol A polymer (NLM, 2012) 2,2-bis(4-(2,3-epoxypropoxy)phenyl)propane (EC DG ENV, 2002)	4,4'-(1-methylethylidene)bisphenol (BPA) polymer with 2-(chloromethyl)oxirane (epichlorhydrin) (Dow, 2012) Polymer of 4,4'-isopropylidenediphenol (BPA) and 1-chloro-2,3-epoxypropane (epichlorohydrin), (PRTR No of Japan: 30) bisphenol A diglycidyl ether (BADGE; BPADGE) is part of the polymer (PRTR No of Japan: 30)
Molecular formula	(C ₂₁ H ₂₄ O ₄ .C ₁₅ H ₁₆ O ₂) _x -	(C ₁₅ H ₁₆ O ₂ .C ₃ H ₅ ClO) _x -
Molecular weight	(340.42 for the BADGE resin) See also table 2.3	≤ 700 (Danish Coatings and Adhesives Association, 2012) (320.81 for the unit part) See also table 2.3
Concentration range (% w/w)	Up to 20 % BADGE residue monomer (CAS No. 1675-54-3), (US EPA, 2001B)	Up to 20 % BADGE residue monomer, (US EPA, 2001B)
Structure		

Structure (alternative)



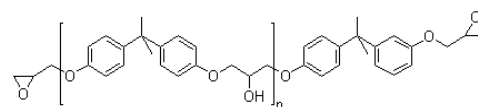
CAS number	25036-25-3	25068-38-6
The monomers	BPA & bis(2,3-epoxypropyl)ether (CAS No. 1675-54-3); Bisphenol A diglycidyl ether (BADGE; BPADGE); Diglycidyl ether of bisphenol A (DGEBA), (US EPA, 2001B):	BPA & epichlorhydrin (CAS No. 106-89-8)
	 BADGE from BPA & epichlorhydrin (Dow, 2012):	

Depending on the number of repeating units in the bisphenol-A-diglycidylether polymer the molecular weight differ as shown in table 2.3. The substance part of 25068-38-6 with molecular weight less than 700 is for instance no longer a polymer and has been registered for REACH as a substance (Goodson, 2012).

TABLE 2.3
OVERVIEW OF EPOXY RESINS, ALSO COVERING 25036-25-3 AND 25068-38-6), (US EPA, 2001B)

Epoxy resin	n*	Epoxide Equivalent Weight (EEW)	Mol Weight (M _n)
Liquid epoxy resin	0	170	340 (BADGE)
Semisolid epoxy resin	1	312	625
Low molecular weight solid epoxy resin	2-6	450-1000	900-2000
High molecular weight epoxy resin	10-30	1600-4500	3200-9000
Ultra high molecular weight epoxy resin	> 50	> 15000	> 30000

*) n= the number of repeating units in the molecule. The unit equals the one marked with “n” in the table 2.2 above in the structure under 25036-25-3:



In additions to the above, other similar bisphenol A containing polymers are on the marked like the epoxy resin homopolymer 2,2'-[(1-methylethylidene)bis(4,1-phenyleneoxymethylene)]bisoxirane (CAS no. 25085-99-8), (Dow, 2012). Also alternative CAS numbers were available for bisphenol A diglycidyl ether (BADGE). These are 116161-20-7, 170962-54-6, 47424-12-4, 85101-00-4 (NTP, 2012). BPA occurs as monomer in these substances as well, but they are not further specifically covered in this survey.

2.2 Physico-chemical properties

Bisphenol A is a white solid with a mild phenolic odor, but is not volatile and it has a low vapor pressure at ambient temperature conditions. It is soluble in organic solvents, but poorly soluble in water and its bioconcentration potential is low. Bisphenol-A-diglycidylether polymer consists of BPA and BADGE. BADGE is a pale yellow or colorless transparent solid, which has low volatility at

room temperature and it has a moderate bioconcentration potential. The physico-chemical properties on bisphenol A and the bisphenol-A-diglycidylether polymer CAS numbers is given in the tables below.

TABLE 2.4
BISPHENOL A (4,4'-ISOPROPYLIDENEDIPHENOL), PHYSICO-CHEMICAL PROPERTIES

Property	Value	Comment/reference
Physical state at 20 C and 101.3 KPa	White solid flakes or powder	Depends on manufacturing process (UK, 2008)
Melting/freezing point	155-157°C	Depends on manufacturing process (UK, 2008)
Boiling point	360°C at 101.3 kPa	Decomposition is also likely (UK, 2008)
Relative density	Approx. 1.1-1.2 kg/m ³ at 25°C	(UK, 2008)
Vapour pressure	4.1×10 ⁻¹⁰ kPa and 5.3×10 ⁻⁹ kPa at 25°C	(UK, 2008)
Surface tension	Not available	(UK, 2008)
Water solubility (mg/L)	300 mg/l	(UK, 2008)
Partition coefficient n-octanol/water (log value)	Log K _{ow} circa 3.3-3.5	(UK, 2008)
Flash point	circa 207°C	(UK, 2008)
Flammability	circa 532°C	(UK, 2008)
Explosive properties	Minimum explosive concentration 0.012 g/l with oxygen > 5%	(UK, 2008)
Self-ignition temperature	510°C	(UK, 2008)
Oxidising properties	Not an oxidising agent	(UK, 2008)
Granulometry	Not available	(UK, 2008)
Stability in organic solvents and identity of relevant degradation products	Not available	(UK, 2008)
Dissociation constant	Not available	(UK, 2008)
Viscosity	Not applicable	(UK, 2008)
Auto flammability	Circa 532°C	Decomposition is likely before these temperatures are reached (UK, 2008).
Reactivity towards container material	Not available	(UK, 2008)
Thermal stability	Not available	(UK, 2008)

TABLE 2.5
BISPHENOL A-DIGLYCIDYLETHER POLYMER (25036-25-3), PHYSICO-CHEMICAL PROPERTIES

Property	Value	Comment/reference
Physical state at 20 C and 101.3 KPa	Not available	Colorless viscous liquid. (Look Chem, 2012)
Melting/freezing point	88-95 °C	(Look Chem, 2012)
Boiling point	Not available	(Look Chem, 2012)
Relative density	1.169 g/mL (25 °C)	(Look Chem, 2012)
Vapour pressure	1.08 x 10 ⁻⁷ mmHg (25 °C)	(EC DG ENV, 2002)
Surface tension	Not available	
Water solubility (mg/L)	3.685 mg/L (25 °C)	(EC DG ENV, 2002)
Partition coefficient n-octanol/water (log value)	3.84	(EC DG ENV, 2002)
Flash point	113°C	(Look Chem, 2012)
Flammability	Not available	
Explosive properties	Not available	
Self-ignition temperature	Not available	
Oxidising properties	Not available	
Granulometry	Not available	
Stability in organic solvents and identity of relevant degradation products	Not available	
Dissociation constant	Not available	
Viscosity	Not available	
Auto flammability	Not available	
Reactivity towards container material	Not available	
Thermal stability	Not available	

TABLE 2.6
BISPHENOL A-DIGLYCIDYLETHER POLYMER (25068-38-6), PHYSICO-CHEMICAL PROPERTIES

Property	Value	Comment/reference
Physical state at 20 C and 101.3 KPa	Yellow liquid (10.8 Pa.s ; 25°C)	ECHA public dossier (2012 A)
Melting/freezing point	ca. -16 °C	ECHA public dossier (2012 A)
Boiling point (A.2)	ca. 320 °C	ECHA public dossier (2012 A)
Relative density	1.16 g/cm ³ at 25°C	ECHA public dossier (2012 A)
Vapour pressure	4.6E-08 (Pa, 25 °C)	ECHA public dossier (2012 A)
Surface tension	58.7 - 58.9 mN/m (20 °C)	As the surface tension is lower than 60 mN/m, test substance should be regarded as a

Property	Value	Comment/reference
		surface-active material. ECHA public dossier (2012 A)
Water solubility (mg/L)	6.9+/-1.5 (20°C) 3.6 (20°C) ca. 5.87 (25°C)	ECHA public dossier (2012 A)
Partition coefficient n-octanol/water (log value)	3.26 +/- 0.52 (25°C; pH 7) 3.242 +/- 0.324 (25 °C, pH 7.1)	ECHA public dossier (2012 A)
Flash point	266 +/- 2°C	ECHA public dossier (2012 A)
Flammability	Not available	ECHA public dossier (2012 A)
Explosive properties	Non explosive	ECHA public dossier (2012 A)
Self-ignition temperature	Not available	
Oxidising properties	Considered not to be an oxidizer	ECHA public dossier (2012 A)
Granulometry	Not available	
Stability in organic solvents and identity of relevant degradation products	Stable in the solvent dimethyl sulfoxide. Soluble and stable in the organic solvent xylene. Also stable in solvents such as acetone and methyl ethyl ketone.	ECHA public dossier (2012 A)
Dissociation constant	Not available	ECHA public dossier (2012 A)
Viscosity	10 800 mPa.s. (25°C) 8 400 cPs (25°C) 11 100 cPs (25°C) 4 859 cPs (25°C) 9 258 cPs (25°C)	ECHA public dossier (2012 A)
Auto flammability	Not available	ECHA public dossier (2012 A)
Reactivity towards container material	Not available	
Thermal stability	Not available	

3. Regulatory framework

Summary:

There are specific restrictions on BPA both in EU and other continents as well as in some countries. The restrictions and bans are in general implemented to protect infants and small children, as these age groups are considered to be the most sensitive as well as the most highly exposed groups due to their consumption pattern.

BPA is addressed under several EU Directives and Regulations, e.g. restricted in plastic infant feeding bottles (EC 321/2011 & No 10/2011). In addition to this some Member States have chosen to strengthen the European regulation (e.g. DK, SE and Austria). Thus, within EU there is no overall harmonisation of the BPA regulation as several countries have implemented national restrictions on the use of BPA. Also in other parts of the world, Canada and China have restricted BPA in infant feeding bottles.

Before March 2013 the German authorities will in connection with the REACH regulation finalize a substance evaluation report on BPA from which it should be concluded whether further regulatory steps are considered necessary for controlling the safe use of BPA (BAUA, 2012).

The French authorities have reported that they within 2012 will submit a proposal for a revised harmonized classification of BPA with respect to an upgraded classification for reproductive toxicity from "Repr. Category 2" to "Repr. Category 1B, H360F" (may damage fertility) alternatively considering human data in category 1A, H360F (may damage fertility) (ANSES, 2012B).

Furthermore bisphenol-A-diglycidylether polymer (25068-38-6) is mentioned under ECHA's CoRAP, part (Community Rolling Action Plan), as a substance for evaluation by Denmark in 2015 as there is a suspicion that its use could pose a risk to human health or the environment (ECHA, 2012C).

3.1 Classification

3.1.1 Classification in Annex VI of the Classification and Labelling of Products (CLP) regulation

The harmonized classification of the substances is according to Regulation (EC) No 1272/2008 as amended by Regulation (EC) No 790/2009 (Annex VI, part 3, Table 3.1) are presented in Table 3.1. However, the French authorities have announced that they within 2012 for BPA will submit a proposal for an upgraded harmonized classification for reproductive toxicity from Repr. Category 2 to Repr. Category 1B, alternatively category 1A (ANSES, 2012B).

TABEL 3.1

CLASSIFICATION OF BISPHENOL A & BISPHENOL-A-DIGLYCIDYLETHER TO ANNEX VI, PART 3, TABLE 3.1 OF REGULATION (EC) NO. 1272/2008 AMENDED BY REGULATION (EC) NO 790/2009

Substance	CAS No.	Classification Hazard Class and Category Code(s)	Classification Hazard statement Code(s) and sentence	Specific Cons Limits M-factors
Bisphenol A	80-05-7	Skin Sens 1 Eye Dam. 1 STOT SE 3 Repr. 2	H317; May cause an allergic skin reaction H318; Causes serious eye damage H335; May cause respiratory irritation H361f; Suspected of damaging fertility	
Bisphenol A-diglycidylether polymer	25036-25-3	Not classified	Not classified	
Bisphenol A-diglycidylether polymer	25068-38-6	Skin Irrit. 2 Skin Sens 1 Eye Irrit.2 Aquatic Chronic 2	H315; Causes skin irritation H317; May cause an allergic skin reaction H319; Causes serious eye irritation H411; Toxic to aquatic life with long lasting effects	C≥5% C≥5%

3.1.2 Selfclassification

The bisphenol-A-diglycidylether polymer 25036-25-3 has no harmonized classification in ECHA. However 724 notifiers have notified classification of the substance using one or more of the indicated hazard classes, reported by October 24 2012 and presented in Table 3.2. In addition to the harmonized classifications on BPA and the BADGE polymer 25068-38-6 the other classifications from the selfclassification is also given in table 3.2. The classifications include also some that is not as strong as the harmonized and some only notified by a single notifier. These should not be considered as valid as the others.

TABEL 3.2

SELFCLASSIFICATION OF BISPHEENOL-A-DIGLYCIDYLEETHER (25036-25-3) + ADDINGS TO THE HARMONIZED CLASSIFICATION FOR BPA AND BISPHEENOL-A-DIGLYCIDYLEETHER (25068-38-6). THE NUMBER OF NOTIFIERS IS GIVEN UNDER REMARS. JOINT MEANS THE NUMBER NOTIFIED THROUGH JOINT ENTRIES.

Substance	CAS No.	Classification Hazard Class and Category Code(s)	Classification Hazard statement Code(s) and sentence	Remarks
Bisphenol A-diglycidylether polymer	25036-25-3	<i>Skin Irrit. 2</i>	<i>H315; Causes skin irritation</i>	Each hazard code is addressed by 18 to several hundred notifiers in different combinations.
		<i>Skin Sens 1</i>	<i>H317; May cause an allergic skin reaction</i>	
		<i>Eye Irrit.2</i>	<i>H319; Causes serious eye irritation</i>	
		<i>Aquatic Chronic 2</i>	<i>H411; Toxic to aquatic life with long lasting effects</i>	
		<i>STOT SE 3</i>	<i>H335; May cause respiratory irritation</i>	
		<i>Acute tox. 4</i>	<i>H332; Harmful if inhaled</i>	
Bisphenol A	80-05-7	Skin Sens 1	H317; May cause an allergic skin reaction	Harmonized classification part > 1116
		Eye Dam. 1	H318; Causes serious eye damage	
		STOT SE 3	H335; May cause respiratory irritation	
		Repr. 2	H361f; Suspected of damaging fertility	
		STOT SE 3	H370; Cause damage to organs	
	Aquatic Chronic 2	H411; Toxic to aquatic life with long lasting effects	Add to harmonized; 38 joint + 28	
	Aquatic Chronic 3	H412; Harmful to aquatic life with long lasting effects	18	
Bisphenol A-diglycidylether polymer	25068-38-6	Skin Irrit. 2	H315; Causes skin irritation	Harmonized classification part 910 joint
		Skin Sens 1	H317; May cause an allergic skin reaction	
		Eye Irrit.2	H319; Causes serious eye irritation	
		Aquatic Chronic 2	H411; Toxic to aquatic life with long lasting effects	
		Aquatic Acute 1	H400; Very toxic to aquatic life	1
		Aquatic Chronic 1	H410; Very toxic to aquatic life with long lasting effects	1
		Aquatic Chronic 3	H412; Harmful to aquatic life with long lasting effects	1
Aquatic Chronic 4	H413; May cause long lasting harmful effects to aquatic life	1		

3.2 Restrictions and initiatives in continents and regions (EU, US etc.)

The tables below inform about the restrictions and initiatives given. Where specific limits were found, they are given in the tables, e.g. a specific migration limit.

TABEL 3.3

OVERVIEW OF CENTRAL RESTRICTIONS AND INITIATIVES OF **BPA** IN EU, US AND OTHER PARTS OF THE WORLD

Restriction	Bisphenol A (80-05-7)
<i>Food Contact Materials (FCM)</i>	
EU, Sale of infant feeding bottles.	Sale of plastic infant feeding bottles with BPA not allowed from 1. June 2010. Effect from 1 March, 2011. EU Commission Regulation No 321/2011 amending Regulation (EU) No 10/2011 BPA is still authorized as additive or monomer in the manufacture of other plastic materials and articles in contact with food and water, with a specific migration limit of 0.6 mg/kg .
USA, FCM for children aged 0-3	BPA restricted in 15 states. Vermont banned BPA in baby food, formula and bottles. In force. New York state banned BPA in bottles, sippy cups, pacifiers and drinking straws beginning December 2010. In force (World Press, 2012).
USA, FCM all ages	Vermont to restrict BPA in cans from 2014. Coming (World Press, 2012).
Canada, Sale of infant feeding bottles.	BPA not allowed in sale of infant feeding bottles. In force from spring 2008 (KemI, 2012E).
China, Production of infant feeding bottles of polycarbonate (PC) or with content of BPA.	BPA not allowed in production of infant feeding bottles (from June 2011). Import and sale of PC infant feeding bottle and other infant feeding bottles that contain BPA (from Sept. 2011). In force (HKTDC, 2012).
Australia, Infant products	Have initiated voluntary bans of BPA in infant feeding bottles. Coming (Food Safety News, 2012).
Japan, Infant products	BPA is banned in infant products in Japan. In force (AU news, 2012).
<i>Other uses</i>	
EU, Cosmetic products	Bisphenol A is prohibited in cosmetic products. REGULATION (EC) No 1223/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 November 2009 on cosmetic products. ANNEX II, LIST OF SUBSTANCES PROHIBITED IN COSMETIC PRODUCTS. (EUR LEX, 2012B).
EU, Toys Safety	CMR substances (cat. 1A, 1B or 2) are banned or restricted in toys and parts of toys (in concentrations above the specific classification limit). As BPA is reprotoxic cat. 2 it is covered by the Directive 2009/48/EC (EUR LEX, 2012E).
EU, Occupational work environment	BPA, occupational exposure limit value 10 mg/m³ (8h-TWA) for inhalable dust of BPA. For Austria, Germany and Switzerland, the OIELV for inhalable fraction is 5 mg/m³ (8h-TWA), (Commission Directive 2009/161/EU of 17 December 2009; EUR LEX, 2012D).
EU, young people at work	Young people must not be in contact with BPA, as it is classified as irritant (STOT SE 3) and sensitizer (Skin Sens.1) and thus fulfills the criteria specified in Annex I.3 (a-c) of EU Directive 94/33/EC on young people at work.

BPA has in relation to the REACH regulation been prioritized for substance evaluation. Thus the German authorities have taken the task before March 2013 to finalize a report analyzing whether the environmental exposure and risks to consumers in connection to the use of BPA are adequately controlled. From this report it should be clarified whether sufficient data is available to conclude that the current use of BPA is safe or whether sufficient data is available in order to introduce further regulatory measures (e.g. a revised harmonized classification and possible inclusion on the

candidate list for authorization or proposals for use restrictions). A third possibility would be to conclude that sufficient information is not available to make a final assessment and to ask the registrant(s) of the substance for more specific information from which a conclusion can be made (BAUA, 2012; FFW, 2012).

TABEL 3.4
OVERVIEW OF CENTRAL RESTRICTIONS AND INITIATIVES REGARDING **BISPHENOL A-DIGLYCIDYLETHER**
POLYMER IN EU, US AND OTHER PARTS OF THE WORLD

Restriction	Bisphenol A-diglycidylether polymer (25036-25-3 & 25068-38-6)
EU, Silos and storage tanks for food, etc., e.g. Sugar silos.	<p>COMMISSION REGULATION (EU) No 10/2011 of 14 January 2011 and COMMISSION REGULATION (EC) No 1895/2005 of 18 November 2005 on the restriction of use of certain epoxy derivatives in materials and articles intended to come into contact with food.</p> <p>For BADGE, BADGE.H2O and BADGE.2H2O³ the specific migration limit is 1 mg/kg.</p> <p>The sum of the migration levels of the substances:</p> <p>a) BADGE (CAS No. 1675-54-3) b) BADGE.H2O (CAS No. 76002-91-0) c) BADGE.2H2O (CAS No. 5581-32-8)</p> <p>must not exceed the following limits:</p> <p>- 9 mg/kg of food or food simulants or - 9 mg/6 dm² (EUR LEX, 2012A)</p>
US, epoxy-coating in food contact materials	BPA polymers are allowed with restrictions by FDA Regulations Title 21 Part 175.300 "Indirect Food Additives; additives and components of coatings, resinous and polymeric coatings" and 21 Part 175.105 "Adhesives" (US FDA, 2012).
Evaluation by DK, 2015.	Bisphenol-A-diglycidylether polymer (25068-38-6) is mentioned under ECHA's CoRAP, part (Community Rolling Action Plan), as a substance for evaluation by Denmark in 2015 as there is a suspicion that its use could pose a risk to human health or the environment (ECHA, 2012C).

3.3 Additional national initiatives

TABEL 3.5
OVERVIEW OF RESTRICTIONS AND INITIATIVES ON **BPA** IN DENMARK

Restriction	Bisphenol A (80-05-7)
Denmark, FCM for children aged 0-3 (e.g. infant feeding bottles, feeding cups and packaging for baby food)	BPA not allowed in FCM In force from March 2010 (Executive Order No. 579 June 1 th 2011), (FVM, 2012).
Denmark, Migration from drinking water installations, e.g. PC (polycarbonate), epoxy-coating	Endocrine disrupting substances may not migrate from drinking water installations. If BPA migration identified, no VA-approval is obtained (Miljøstyrelsen, 2004).
Denmark, water quality criterion, BPA, marine areas.	BPA, water quality criterion for marine areas is 0.01 µg /l . It is proposed to the EU. The criterion is implemented as a national requirements of the Statutory Order on environmental quality standards for water bodies and requirements for emissions of pollutants into rivers, lakes or the sea (Statutory Order 1669, 2006) from the Danish EPA.

³ In aqueous and acidic foodstuffs **BADGE** readily hydrolyses into mono- and dihydrolysed products (**BADGE.H2O** and **BADGE.2H2O**).

Denmark, Occupational work environment	BPA, occupational exposure limit value 3 mg/m³ (8h-TWA) for inhalable dust of BPA.
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TABEL 3.6
OVERVIEW OF RESTRICTIONS AND INITIATIVES ON **BPA** IN COUNTRIES OTHER THAN DENMARK

Restriction	Bisphenol A (80-05-7)
<i>Food Contact Materials (FCM)</i>	
Sweden, Sale of infant feeding bottles. (The restriction covers BPA in food contact materials for 0-3 year olds. I.e. including bottles).	Sale of infant feeding bottles with BPA not allowed (effect from April 2012), (KemI, 2012E).
Sweden, Baby food jars. (The regulation covers BPA in food contact materials for 0-3 year olds. I.e. including bottles).	Sale of baby food jars with BPA not allowed (effect from April 2012), (KemI, 2012E).
France, All FCM.	BPA not allowed in FCM. For FCM for children aged 0-3 in force from January 1 st , 2013. For FCM for all ages in force from July 1 st , 2015 (GAIN, 2012; KemI, 2012E).
Belgium, FCM for children aged 0-3	BPA not allowed in FCM. In force from January 2013 (KemI, 2012E).
Netherlands, SML on food	The Dutch Packaging and Food-Utensils Regulation (Food and Commodities Act). The migration limit is 15 mg BPA/kg. The Specific Migration Limit is 0.6 mg BPA/kg as set by the Scientific Committee on Food, based on a temporary Tolerable Daily Intake (tTDI). (RIVM, 2012).
<i>Drinking water installations</i>	
Sweden, BPA and epoxy-coating of drinking water installations	Report from Sweden to identify, by December 2013, the extent to which BPA could be released from relining of pipes and, if necessary, propose measures to reduce the exposure (KemI, 2012E).
<i>Other uses</i>	
Austria, pacifiers and teething rings	Ban BPA in pacifiers and teething rings. Austria implemented the law in October 2011. In Force (Bisphenol A Europe, 2012).
Sweden, Thermal paper	The Swedish Chemicals Agency (KemI) has June 29 th 2012 presented a proposal to the Swedish Government for a national ban on bisphenol A in thermal paper used, for example, in cash receipts and tickets (KemI, 2012A & 2012E).
France, Medical devices	France suspends medical devices containing BPA or other endocrinal disruptors by July 1 st , 2015 (GAIN, 2012).

TABLE 3.7
OVERVIEW OF RESTRICTIONS AND INITIATIVES ON **BISPHENOL A-DIGLYCIDYLETHER POLYMER** IN COUNTRIES

Bisphenol A-diglycidylether polymer (25036-25-3/ 25068-38-6)	
<i>Drinking water installations</i>	
Denmark, Migration from drinking water installations, e.g. PC, epoxy-coating	Migration is not tolerated above accept limit in drinking water installations. If migration is analyzed in concentrations above the accept limit, no VA-approval is obtained (ETA Danmark, 2012).
Sweden, BPA and epoxy-coating of drinking water installations	Report from Sweden to identify, by December 2013, the extent to which BPA could be released from relining of pipes and, if necessary, propose measures to reduce the exposure (KemI, 2012E).
<i>Other uses</i>	
France, Medical devices	France suspends medical devices containing BPA or other endocrinal disruptors by July 1 st , 2015 (GAIN, 2012).
Denmark, Occupational exposure from epoxy resins and isocyanates.	<p>It must appear on the label if the product contains epoxy compounds, if the epoxy compounds have an average molecular weight of less than or equal to 700. The label must have this inscription: "Contains epoxy constituents. See manufacturer's information."</p> <p>The label may occur names such as:</p> <ul style="list-style-type: none"> • 2,2-bis (p-(2,3-epoxypropoxy) phenyl) propane • bisphenol-A-diglycidylether • 1,4-butanediol diglycidyl ether. <p>Annex III - Working with epoxy resins and isocyanates: Annex to the Executive Order No. 292 of 26 April 2001 on work with substances and materials (chemical agents), (Statutory Order 292, 2001). In Force.</p>

3.4 Other regulatory aspects

BPA is a substance subject to review for priority substance or priority hazardous substance (Annex III) in DIRECTIVE 2008/105/EC (on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives), (EUR LEX, 2012C).

Based on endocrine disrupting properties of BPA in the environment, Danish EPA has made a water quality criterion for marine areas of 0.01 µg /l, which is proposed to the EU. The criterion is implemented as a national requirements of the Statutory Order on environmental quality standards for water bodies and requirements for emissions of pollutants into rivers, lakes or the sea (Statutory Order 1669, 2006).

4. Manufacture, import, export and use

Summary:

The world's consumption in 2009 of BPA as a monomer in the manufacture of polycarbonates was 2768 kt (kilotonne) and as a precursor or a starting material for monomers of certain epoxy resins it was 1093 kt. Of the world's BPA production of 3800 kt, EU and US each covers slightly over 25%. The BPA production *increased* with 64% in EU from the years 1996/1999 to 2005/2006. Observation from Sweden, Norway, Denmark and Finland showed an overall quite stable use up to about 1000 tonnes/year/country from year 2000 till 2010.

The main use of BPA is in polycarbonate (PC). PC is used in compact disc manufacture, food and beverage contact containers, medical devices, and in glazing applications and film. Polycarbonate blends find application in the electric and electronics industry and the automotive industry. About 75% of the BPA amount used is used for PC products. Bisphenol A is also used in the production of phenoplast, phenolic and unsaturated polyester resins, thermal paper, polyvinylchloride (PVC), alkoxyated bisphenol A and polyols/polyurethane. Bisphenol A may be used in the manufacture of modified polyamide, and tetrabromobisphenol A. Other products/articles that may contain bisphenol A include protective window glazing, building materials, optical lenses and dyes (Environment Canada, 2012). Thus Bisphenol A is sometimes also found in PVC products/articles. In a study 5 out of 48 PVC sub samples in toys (approximately 10%) BPA was detected. It was probably used as chain-terminator to end the polymerisation of PVC or as an antioxidant for polymers or plasticisers (Voedsel en Waren Autoriteit, 2005). BPA is also present in recycled paper (WHO, 2010).

Epoxy resins are used in protective coatings, structural composites, electrical laminates, electrical applications and adhesives. Epoxy-phenolic resins are used as liners in metal cans for foods and beverages and as coatings on metal lids for glass jars and bottles. Epoxy resins are used in automotive electro-coating and in automotive and industrial primer and topcoat applications. Also the epoxy-phenolic resin part of the epoxy resins contains BPA and BADGE.

4.1 Manufacturing

Information received as response from the questionnaires (see chapter 1) from industrial organizations and national authorities (Poland, Finland, Canada and Denmark) is mentioned in addition to the figures from the WHO and EU reports, etc.

4.1.1 Manufacturing sites & volumes

4.1.1.1 Bisphenol A

Four companies within the EU manufacture BPA. There are a total of six production sites based in Germany, The Netherlands, Belgium and Spain. The total amount of BPA manufactured within the EU, based upon submissions to CEFIC by the manufacturers, is estimated at approximately 1,150,000 tonnes/year (taken from 2005/06 data). From the data submitted by the EU manufacturers net exports are in the region of 65,000 tonnes/year for 2005/06. However, other manufacturers exist who are not members of CEFIC and so have not supplied information, so these tonnage figures may be an underestimate (UK, 2008).

The manufactured BPA is used for a) polycarbonate resins, b) epoxy resins, c) Polyvinyl chloride and thermal paper and d) others, including flame retardants.

Received additional questionnaire information on manufacturing volumes from individual countries, BPA:

- Finland (Finnish Safety and Chemicals Agency, 2012): 27 tonnes (2011)
- Canada (Environment Canada, 2012): 0.1 tonnes or less/company (2006)*

*) : “Based on a survey conducted under section 71 of CEPA 1999, no bisphenol A was manufactured in Canada in 2006 at quantities greater than or equal to 100 kg. However, 25 companies reported importing approximately 0.5 million kg of bisphenol A in Canada and 5 companies reported using 0.1 to 1 million kg of bisphenol A in Canada either alone, in a product, in a mixture or in a manufactured item” (Environment Canada, 2012).

4.1.1.2 Bisphenol-A-diglycidylether polymer

The second largest end use for BPA is in epoxy resins, accounting for about 22% of demand in 2009 in both the USA and Western Europe. Epoxy resins based on BPA and epichlorohydrin also known as BPA diglycidyl ether epoxy resins (BADGE resins), account for 90–95% of production in the USA. By varying the ratio of epichlorohydrin to BPA, as well as the operating conditions, BADGE epoxy resins of low, medium and high molecular weight can be produced, with molecular weights ranging from as low as 350 (liquid epoxies) to as high as 8000 (solid epoxies), see also table 2.3. Liquid resins consist of 80–90% BADGE, with the remaining 10–20% composed of higher molecular weight oligomers. The consumption of epoxy coatings by end use for 2007 in the USA was as follows (% share): protective (or surface) coatings (48%), bonding and adhesives (14%), flooring, paving and construction (8%), composites (9%), electrical and electronic laminates (6%), embedding and tooling (4%), vinyl ester resins (4%) and other (16%), (WHO, 2010).

Received additional questionnaire information on manufacturing volumes from individual countries, 25036-25-3:

- Finland (Finnish Safety and Chemicals Agency, 2012): 2770 tonnes (2011)

Received additional questionnaire information on manufacturing volumes from individual countries, 25068-38-6:

- Finland (Finnish Safety and Chemicals Agency, 2012): 4570 tonnes (2011)

4.2 Import and export volumes

Received additional questionnaire information on import volumes from individual countries, BPA:

- Finland (Finnish Safety and Chemicals Agency, 2012): 514 tonnes (2011)
- Canada (Environment Canada, 2012): 100-1000 tonnes (2006) either alone, in a product, in a mixture or in a manufactured item.*

Received additional questionnaire information on import volumes from individual countries, 25036-25-3:

- Finland (Finnish Safety and Chemicals Agency, 2012): 23 tonnes (2011)

Received additional questionnaire information on import volumes from individual countries, 25068-38-6:

- Finland (Finnish Safety and Chemicals Agency, 2012): 2376 tonnes (2011)

4.3 Information on uses

Bisphenol A is a monomer used primarily in the production of polycarbonate (PC) resins and epoxy resins, with “other” uses that include flame retardants, unsaturated polyester resins, polysulfone (PS) resins and polyetherimides (PEIs).

Polycarbonate (PC) is used in a wide range of different articles as compact disc manufacture, food and beverage contact containers, medical devices, and in glazing applications and film.

Polycarbonate blends find application in the electric and electronics industry and the automotive industry. About 75% of the BPA amount used is used for PC products.

Epoxy resins are used in protective coatings, structural composites, electrical laminates, electrical applications and adhesives. Epoxy-phenolic resins are used as liners in metal cans for foods and beverages and as coatings on metal lids for glass jars and bottles. Epoxy resins are used in automotive electro-coating and in automotive and industrial primer and topcoat applications.

Bisphenol A is also used in the production of phenoplast, phenolic and unsaturated polyester resins, thermal paper, polyvinylchloride (PVC), alkoxyated bisphenol A and polyols/polyurethane. Bisphenol A may be used in the manufacture of modified polyamide, and tetrabromobisphenol A.

Other products/articles that may contain bisphenol A include protective window glazing, building materials, optical lenses and dyes (Environment Canada, 2012). Thus Bisphenol A is sometimes also found in PVC products/articles. In a study 5 out of 48 PVC sub samples in toys (approximately 10%) BPA was detected. It was probably used as chain-terminator to end the polymerisation of PVC or as an antioxidant for polymers or plasticisers (Voedsel en Waren Autoriteit, 2005). BPA is also present in recycled paper (WHO, 2010).

4.3.1 Use volumes, BPA

BPA is used worldwide and with many different uses as seen in the list and tables below. The uses covers e.g. use as a monomer in the manufacture of polycarbonates and as a precursor or a starting material for monomers of certain epoxy resins for a lot of different product categories.

The world consumption of BPA in 2009 by end use was as follows:

- PC resins, 2768 kt;
- epoxy resins, 1093 kt; and
- “other”, 180 kt.

Thus, over 95% of the world consumption of BPA in 2009 was for PC resins and epoxy resins (WHO, 2010). As BPA is used to produce the bisphenol-A-diglycidylether polymers, the consumption for this use is covered under the epoxy resin production, can coating manufacture, etc. figures.

Of the world's BPA production of 3800 kt, EU and US each covers slightly over 25%, and thus together over half of world BPA consumption. The figures and many different uses of BPA are seen in the table below. The figures are from the EU RAR (2010), but not updated later than 2006.

TABLE 4.1

BISPHENOL A, (BPA) CONSUMPTION FIGURES (RECAST AFTER EU RAR, 2010). GROUP TOTALS IN BOLD (FOR INSTANCE 66% + 30% + 2% + 2% EQUALS 100%). PERCENTAGES IN BRACKETS FOLLOWING A GROUP BELONG TO THE GROUP IN BOLD.

Use	EU Tonnes/ year, 2005/2006 (EU RAR, 2010)	EU %, 2005/2006 (EU RAR, 2010)	Global, Tonnes in 2006 (Plastics Europe, 2007)	Global % in 2006 (Plastics Europe, 2007)
BPA production	1,150,000 (US: 1,089,000 tonnes, 2007)		3,800,000	
Polycarbonate production	865,000	75.2	Approx. 2,900,000	66
- Optical Media (<i>Discs, CD-ROM's, etc.</i>)	-	-	-	(32)
- Electrical & Electronics (<i>TVs, monitors, PCs, telephones, Electrical kettles, mixers, switches, lamp holders, etc.</i>)	-	-	-	(23)
- Blends**	-	-	-	(15)
- Construction (<i>Greenhouse glazing, noise reduction walls, road signs, etc.</i>)	-	-	-	(13)
- Automotive (<i>Fixed side windows, foglamps, rear windows, radiator grills, etc.</i>)	-	-	-	(9)
- Bottles and Packaging (<i>Reusable bottles, glasses, bowls, etc.</i>)	-	-	-	(3)
- Medical & Healthcare (<i>Dialysers, breastpumps, medical packaging film, etc.</i>)	-	-	-	(3)
- Others (<i>safety & ski goggles, sun glasses, motorbike and cycle helmets, Suitcase shells, etc.</i>)	-	-	-	(2)
Epoxy resin production	191,520	16.7	2005 Approx. 1,600,000	30
- Marine and Protective Coatings (<i>Water ballast tanks, sea containers, Steel bridges, storage tanks and drinking water pipes of metal and concrete etc.</i>)	-	-	-	(20)
- Powder coatings (<i>Steel furniture, pipes, valves & fittings, shelves, etc.</i>)	-	-	-	(18)
- Electrical & Electronics (<i>Potting/encapsulation electronic parts (trans-formers, inductors), printed circuit boards, etc.</i>)	-	-	-	(16)
- Civil Engineering (<i>Flooring, fillers, crack repair, seal against water and de-icing on concrete bridges, Anti-skid coatings for park decks, etc.</i>)	-	-	-	(15)

Use	EU Tonnes/ year, 2005/20 06 (EU RAR, 2010)	EU %, 2005/ 2006 (EU RAR, 2010)	Global, Tonnes in 2006 (Plastics Europe, 2007)	Global % in 2006 (Plastics Europe, 2007)
- Can and Coil coatings (<i>Food & drink cans, caps, collapsible tubes (toothpaste, cream), dishwashers, fridges, etc.</i>)	-	-	-	(11)
- Automotive coatings (<i>Waterborne primers for cars, buses, railcars, etc.</i>)	-	-	-	(9)
- Composites (<i>Rackets (tennis, etc.), snowboards, canoes, helmets, windmill blades, pipes, boats, aircraft, etc.</i>)	-	-	-	(5)
- Adhesives (<i>Repair kits, adhesives for buildings, cars, boats, etc.</i>)	-	-	-	(4)
- Photocure (<i>Printing inks, wood coating, paper varnish, incl food packaging, coating for plastics and primed metals, etc.</i>)	-	-	-	(2)
Can coating manufacture	2,755	0.23	-	-
Ethoxylated BPA	2,260	0.20	-	-
Phenoplast cast resin processing	8,800	0.77	-	-
Unsaturated polyester resin production	3,600	0.31	-	-
Other resins*	-	-	-	2
TBBA*,**	-	-	-	2
Thermal paper manufacture	1,890	0.16	-	-
Use PVC production and processing	0	-	-	-
- stabilizer packages	450	-	-	-
- phthalate plasticizers	900	-	-	-
- direct stabilization	450	-	-	-
Polyols/Polyurethane manufacture	-	-	-	-
Modified polyamide production	-	-	-	-
Tyre manufacture	-	-	-	-
Brake fluid	-	-	-	-
Minor uses	-	-	-	-
Others	7,245	0.63	-	-
Net exports	65,000	5.65	-	-
Total consumption	1,149,870	-	-	-

-): Information not available.

(): % of the above percent part (e.g. % of polycarbonate)

*) : These data uses other categorization than the figures from EU (2010) and thus may overlap with other figures from EU (2010).

**) : Mainly used in Automotive and Electrical & Electronics

**) : Bisphenol-A is used in the production of tetrabromobisphenol-A (TBBPA), but the production of TBBPA takes since 1998 no longer place in the EU (EU, 2010). TBBPA belongs to the group of the TBBA's (tetrabrominated flame retardants).

US: BPA is a high production volume chemical with a U.S. volume estimated at 2.4 billion pounds (approx. 1 089 000 tonnes) in 2007. It is a monomer used in manufacturing most or all polycarbonate plastics, the majority of epoxy resins, and certain other products such as flame retardants, see Table 4.2 (US EPA, 2012).

TABLE 4.2
BISPHENOL-A, THE U.S. VOLUME AT 2.4 BILLION POUNDS IN 2007 DIVIDED INTO THESE CATEGORIES (US EPA, 2012)

Product type	Percent of BPA U.S. 2007 Consumption
Polycarbonate resins	74%
Epoxy resins	20%
Flame retardants; Polyetherimides/ Polyarylates; Polysulfone resins; Unsaturated polyester resins	6%
Total	100%

Information on use volumes obtained from individual countries, BPA:

Figure 1 and 2 below show the total amount of bisphenol A in Sweden, Denmark, Finland and Norway from 1999 till 2010. All four countries have uses below 1000 tonnes in the period from 2000 until 2010, except from Norway with a peak of 9000 tonnes in 2002. It also shows that Denmark has twice as many preparations containing BPA as the other 3 Nordic countries. No explanation to the high top in Norway in 2002 was given.

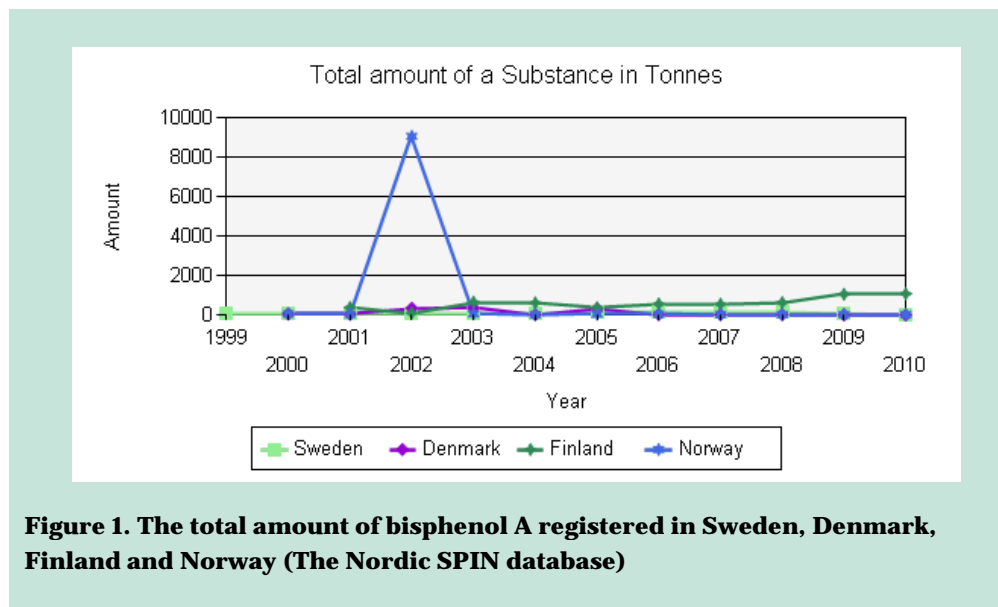


Figure 1. The total amount of bisphenol A registered in Sweden, Denmark, Finland and Norway (The Nordic SPIN database)

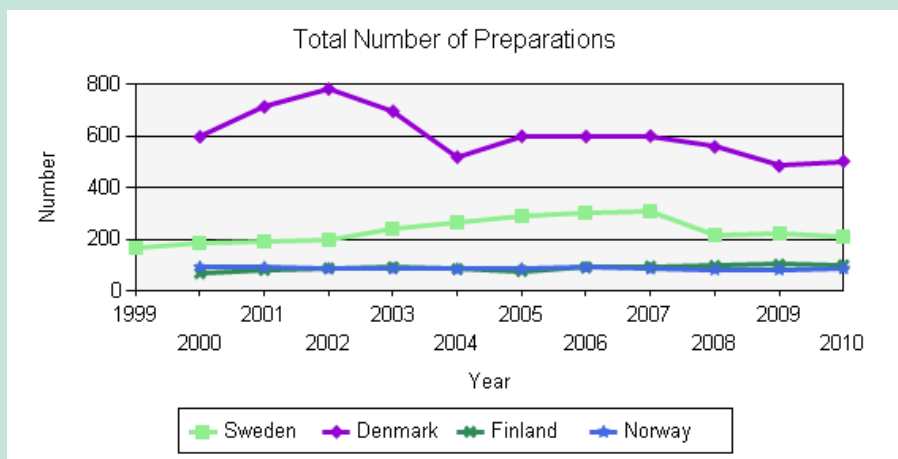


Figure 2. The amount of preparations with bisphenol A registered in Sweden, Denmark, Finland and Norway (The Nordic SPIN database)

Information received through questionnaire from Poland:

Amount of mixtures placing on the Polish market that contain **BPA** (Poland Bureau for Chemical Substances, 2012):

- 21 tonnes in 2011
- 36 tonnes in 2010
- 18 tonnes in 2009

4.3.2 Use volumes, Bisphenol-A-diglycidylether polymer

Bisphenol-A-diglycidylether polymer is known to be used as e.g. coatings (can and coil coatings, etc.) and adhesives (for dental repairs) and also dental fissure sealants. Available information on use volumes of bisphenol-A-diglycidylether polymer 25036-25-3 and 25068-38-6 is sparse, but based on the data from national authorities given below; at least in Poland and Denmark, 25068-38-6 seems to be used in larger amounts than 25036-25-3.

4.3.2.1 Information on use volumes from individual countries, 25036-25-3:

Figure 3 and 4 below show the total amount of the bisphenol-A-diglycidylether polymer 25036-25-3 in Sweden, Denmark, Finland and Norway from 1999 till 2010. In the period from 2005 until 2010 both the used amounts and the number of preparations containing the polymer have been quite stable in all 4 countries. No explanation to the high top in Norway in 2002 was given.

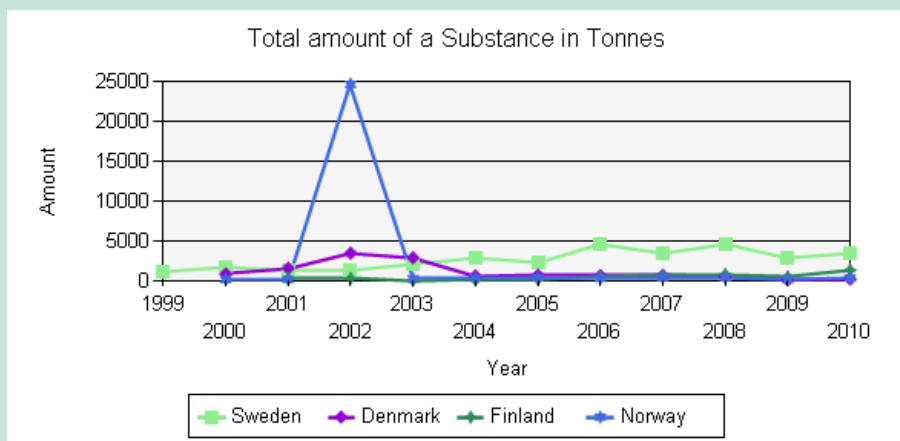


Figure 3. The total amount of bisphenol-A-diglycidylether polymer, 25036-25-3 registered in Sweden, Denmark, Finland and Norway (The Nordic SPIN database)

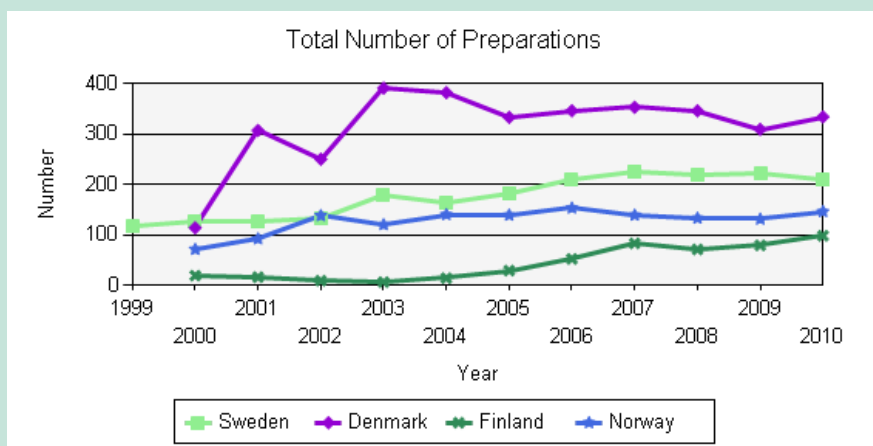


Figure 4. The amount of preparations with bisphenol-A-diglycidylether polymer, 25036-25-3 registered in Sweden, Denmark, Finland and Norway (The Nordic SPIN database)

Information received through questionnaire from Poland:

PL; Amount of mixtures placing on the **Polish market** that contain Bisphenol-A-diglycidylether polymer, **25036-25-3** (Poland Bureau for Chemical Substances, 2012):

- 10 tonnes in 2011
- 79 tonnes in 2010
- 88 tonnes in 2009

DK; There are no uses of 25036-25-3 in binders, hardeners, paints, adhesives and jointing materials category in Denmark (Danish Coatings and Adhesives Association, 2012).

4.3.2.2 Information on use volumes from individual countries, 25068-38-6:

Figure 5 and 6 below show the total amount of the bisphenol-A-diglycidylether polymer 25068-38-6 in Sweden, Denmark, Finland and Norway from 1999 till 2010. In the period from 2000 until 2010 both the used amounts and the number of preparations containing the polymer have been quite stable in all Sweden and Finland. In Denmark there is a peak from 2002 to 2003 and again in

2007, but no explanation was given. In Norway it has been stable at an amount of about 2000 tonnes/ year from 2000 till 2009, but increased to above 20,000 tonnes in 2010.

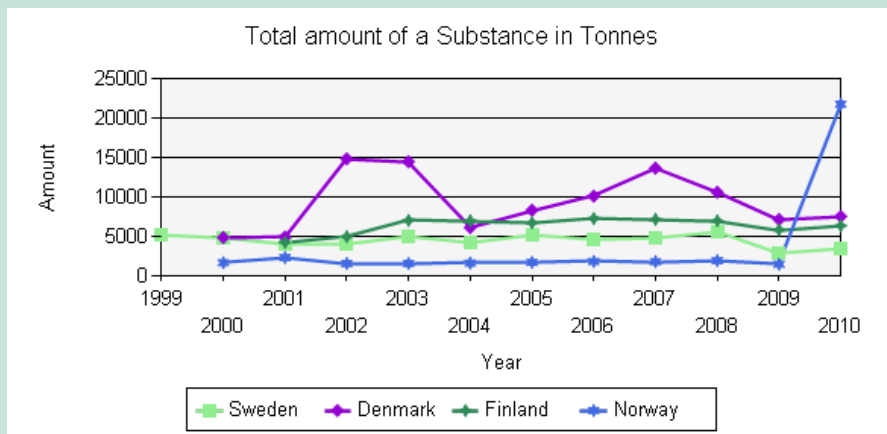


Figure 5. The total amount of bisphenol-A-diglycidylether polymer, 25068-38-6 registered in Sweden, Denmark, Finland and Norway (The Nordic SPIN database)

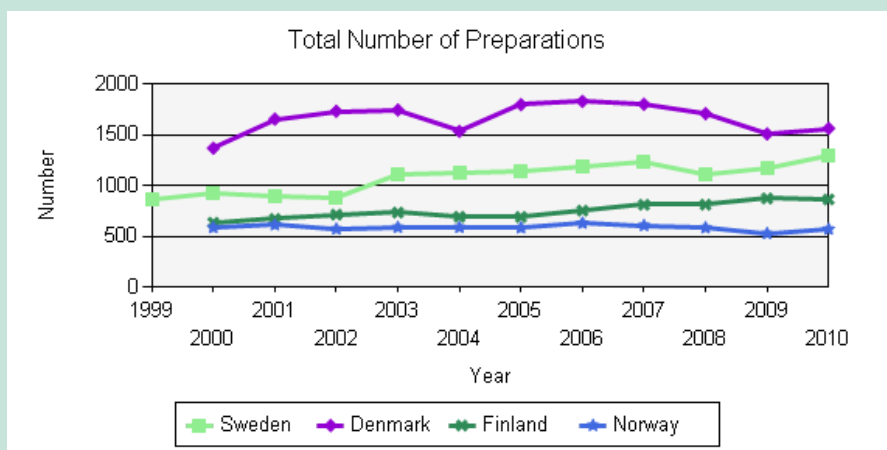


Figure 6. The amount of preparations with bisphenol-A-diglycidylether polymer, 25036-25-3 registered in Sweden, Denmark, Finland and Norway (The Nordic SPIN database)

Information received through questionnaires and other input:

PL; Amount of mixtures placing on the Polish market that contain Bisphenol-A-diglycidylether polymer, 25068-38-6 (Poland Bureau for Chemical Substances, 2012):

- 235 tonnes in 2011
- 506 tonnes in 2010
- 409 tonnes in 2009

DK; There are some uses of 25068-38-6 in binders, hardeners, paints, adhesives and jointing materials category in Denmark. No amount reported (Danish Coatings and Adhesives Association, 2012).

4.3.3 Estimated trends in use

Based on the figures below and above the trends show an increase of BPA production in EU from the periods 1996/1999 to 2005/2006 of 64%. The increase cover polycarbonate production (+78%), epoxy resin production (+12%), can coating manufacture (+12%) and thermal paper manufacture (+35%). The decrease covers use in PVC production and processing (-30%).

TABLE 4.4
BISPHENOL-A, CONSUMPTION AND TRENDS (RECAST AFTER EU RAR, 2010)

Use	Tonnes/ year, 1996- 1999	% EU consump tion, 1996- 1999	Tonnes/ year, 2005/2006	% EU con- sumption change since 1996-1999
BPA production	-	-	1,150,000	+64
Polycarbonate production	486,880	71.1	865,000	+78
- Manufacture of articles from polycarbonate	(400)*	(0.05)*	-	-
Epoxy resin production	171,095	25.0	191,520	+12
Can coating manufacture	2,460	0.4	2,755	+12
- Alkyloxyated bisphenol-A manufacture	2,020	0.3	-	-
- ethoxylated BPA	-	-	2,260	+12
Phenoplast cast resin processing	8,800	1.3	8,800	
Unsaturated polyester resin production	3,000	0.4	3,600	
Thermal paper manufacture	1,400	0.2	1,890	+35
Use PVC production and processing	2,250	0.3	0	
- stabilizer packages	-	-	450	-10
- phthalate plasticizers	-	-	900	-10
- direct stabilization	-	-	450	-10
Polyols/Polyurethane manufacture	950	0.1	-	-
Modified polyamide production	150	<0.1	-	-
Tyre manufacture	110	<0.1	-	-
Brake fluid	45	<0.1	-	-
Minor uses**	5,990	0.9	-	-
- Manufacture of tin-plating additive	(2,460)*	(0.4)*	-	-
Others	-	-	7,245	-
Net exports	-	-	65,000	-
Total consumption	685,000	-	1,149,870	+68

-): Information not available.

*) : Data from UK (2008).

**): Minor uses include sales to chemical merchants and minor sales. The uses of these minor sales are not expected to be different from those mentioned above.

The overall picture from Norway, Sweden, Finland and Denmark is given above and show a quite stable level from 2000 till 2010. But with the more detailed figures from Sweden below it show a slight to clear decrease in the use of Bisphenol A in Sweden in the periods 1997/1999 to 2006/2009. BPA is not manufactured in Sweden, but imported and used in manufactured products. The imported amount of BPA decreases from about 140 tonne in 1997 to about 25 tonne in 2009.

TABLE 4.5
BISPHENOL A. TRENDS; IMPORTED AMOUNTS IN CHEMICAL PRODUCTS WITHIN SWEDEN IN TONNE PURE BPA/YEAR (KEMI, 2012D)

Product type	1994	1997	1999	2001	2004	2006	2008	2009
Raw material for plastics, Softeners	2	39	19	8	8	16	19	8
Binders, hardeners, paints, adhesives and jointing materials	7	98	51	17	18	16	25	11
Stabilizers	26	-	8	7	7	8	7	6
Brake fluid	-	-	-	-	-	1	< 1	< 1
Other types of products	-	5	4	5	3	< 1	< 1	< 1

TABLE 4.6
BISPHENOL A. TRENDS; MANUFACTURED AMOUNTS OF PRODUCTS WITH BPA CONTENT WITHIN SWEDEN IN TONNE PURE BPA/YEAR (KEMI, 2012D)

Product type	1994	1997	1999	2001	2004	2006	2008	2009
Raw material for plastics, Softeners	-	11	8	3	10	9	12	9
Binders, hardeners, paints, adhesives and jointing materials	2	6	19	17	4	4	4	5
Stabilizers	1	-	1	< 1	< 1	-	-	-
Brake fluid	-	-	-	-	-	-	-	-
Other types of products	< 1	< 1	1	2	< 0.1	-	-	-

5. Exposure

Summary:

BPA Environmental releases of BPA may occur during production, processing, use or disposal of the substance or products/articles containing it. BPA may enter the environment through physical and chemical degradation of end products during disposal and recycling operations. Releases is primarily to soil (145,800 kg/year in EU), and to a lesser extent, to water (21,260 kg/year in EU) and air (14,449 kg/year in EU). BPA has been identified in groundwater samples collected in the vicinity of municipal landfills. Soil and groundwater exposure may also occur through weathering and breakdown of end products, particularly those with outdoor applications. BPA present in wastewater sludge can also be released into the soil compartment through application of sludge biosolids to agricultural and pasture lands.

With respect to human exposure measured concentrations of BPA in human blood, urine and other tissues confirm that exposure is widespread in the general human population. Migration of BPA to food from food contact materials such as epoxy-based coatings for food and beverage cans and PC resins for food service items such as sports bottles, baby bottles, pitchers, tumblers, home food containers and flatware has been quite thoroughly examined. Based on these data and assumptions on intake of the food items the BPA exposure from food intake can be calculated as the dominant source to BPA exposure. Infants and children in the age group of 1.5-4.5 years are considered to be the most highly exposed and scenarios with BPA exposure from food contact materials of up to 10 µg BPA/ kg bw/day have been estimated. For adults lower exposure estimates of up to 1.5 µg BPA/ kg bw/day have been estimated.

In general biomonitoring data indicate considerable lower exposures compared to what have been calculated from scenarios using BPA migration data and data on food intake. However, some Japanese urine data indicate measured exposure of children of up to 40% compared to the most conservative calculated BPA exposures.

Few BPA exposure estimates have been found from BPA migration data from other types of articles than food contact materials with the exception to BPA exposure of infants from dummies leaching BPA and the dermal exposure to BPA from cashier's receipts. Also, additional oral exposure to BPA may result from the use of BPA-containing resins in dentistry. BPA exposure from unexpected source has also been reported. Bisphenol A was released from baby bottles made of polyamide, although the bottles were labelled bisphenol A-free and the source was not detected.

BPA exposure via the ambient air, indoor air, drinking water, soil and house dust is expected to be low compared with the exposure from food contact materials.

At present there is no data from which to evaluate the possible decline in BPA exposure of infants and children due to the recent EU and national restrictions on infant feeding bottles and on certain types of food contact materials. Thus, more studies including biomonitoring and exposure estimations from articles would be needed in order to get an updated and more realistic impression of the sum of the BPA exposures of the various age groups in the population.

Bisphenol-A-diglycidylether polymer measured concentrations in wastewater or in the air were not seen. Release of BADGE to the environment through manufacturing sites is expected to be low because they are used in a closed system. An environmental release of BADGE from end-use application is unlikely to occur as epoxy resins are reacted with hardeners/curing agents into cross linked systems which are stable against thermal and hydrolytic breakdown. But the use of bisphenol-A-diglycidylether polymer has raised concerns due to its release of BPA. This is not only the case for food contact materials, but also for dental treatments. The contained amount of BADGE derivatives in canned food, 2004, was 100 to 600 µg/kg food, which is about 10 times higher than the highest BPA content of 69.9 µg/kg seen in canned food. Many dental composite filling surfaces on teeth may also increase the urinary BPA concentration in children.

5.1 Environmental exposure, BPA

There are no known natural sources of BPA and potential releases to the environment are restricted to those associated with human activities (Environment Canada, 2012).

BPA has been identified in groundwater samples collected in the vicinity of municipal landfills. Environmental releases of BPA may occur during production, processing, use or disposal of the substance or products/articles containing it. BPA may enter the environment through physical and chemical degradation of end products during disposal and recycling operations. Releases is primarily to soil (145,800 kg/year in EU), and to a lesser extent, to water (21,260 kg/year in EU) and air (14,449 kg/year in EU) (EU RAR, 2010). Soil and groundwater exposure may also occur through weathering and breakdown of end products, particularly those with outdoor applications. BPA present in wastewater sludge can be released into the soil compartment through application of sludge biosolids to agricultural and pasture lands. Environmental releases to wastewaters were reported in the EU RAR (2010) with flow rates to the receiving water of 8.64×10^6 to 6.1×10^8 m³/day from 6 BPA production sites.

Unintentional release of dust from closed systems during handling and transportation of the substance may also occur. Elevated temperatures that occur during some processing operations could lead to possible emission of gaseous BPA from manufacturing facilities or during heating of end products (Environment Canada, 2012 and EU RAR, 2010).

The emissions of industrial effluents from industries are from recycling of thermal paper (70%), production of PVC (17%) and emissions from the use of PVC items by European households (12%). All the investigated waste water treatment plants had detectable levels of BPA (INERIS, 2010).

In Europe measured levels of BPA in effluents (after wastewater treatment) range from 3.13 µg/l and up to 45 µg/l. Releases of BPA from production sites to effluent (after wastewater treatment) range from 6.8 to 113 kg/year, with water flow rates to the receiving water of 8.64×10^6 to 6.1×10^8 m³/day (EU RAR, 2010). Average concentrations of BPA in household wastewater at 2 locations in Denmark range from 1.5 to 1.9 µg/l, while average concentrations of BPA in surface water at two other locations in Denmark range from 0,17 to 0,19 µg/l. Even though there is no production of BPA in Denmark, the highest concentrations were seen in industrial waste water with average concentrations at two locations of 3.2 to 7.8 µg/l and with the highest concentration of 13 µg/l (Lynettefællesskabet I/S, 2007).

More figures on releases to the environment from human activity are given in appendix 1, table A1.1. Furthermore environmental fate and predicted environmental concentrations (PECs) are given in appendix 1, table A1.2, A1.3 and A1.4.

5.2 Exposure to humans, BPA

5.2.1 Consumer exposure

BPA content in food and beverages: An updated evaluation on the current levels of BPA in food and beverages is given by WHO (2010), see also appendix 1, table A1.7. Liquid milk formula showed an overall average level of BPA content of 3.5 µg BPA/kg with a maximum level of 11 µg BPA/kg (whereas human breast milk had an average and maximum content of 1.9 and 7.3 µg BPA/kg, respectively). The highest BPA content was found in canned meat with an average content of 69.6 µg BPA/kg.

BPA exposure from food/ food contact materials: In 2010 the EU RAR on BPA was updated and more recent data including the exposure data from the EFSA (2006) opinion was included. According to the EU RAR on BPA the articles that are likely to have the potential for the highest exposure of consumers to BPA are those that are used in applications which involve direct contact with foodstuff. These include food and beverage containers which have epoxy resin internal coatings, and polycarbonate tableware and bottles, such as those used for infant formula milk. Exposure to BPA arising from use of these articles is determined by the migration of BPA from the polymer into the food with which it is in contact, under the particular conditions of use. Migration of BPA from these articles into food or beverages stored in them may occur if conditions are created which allow hydrolysis of the polymer during food or beverage storage or if there is residual monomer in the polymer. Consumption of the food or beverage will then result in ingestion of BPA. EU RAR (2010) recalculated the exposure estimates building on the data from EFSA (2006) and found the highest exposure to be 0.01 mg BPA/kg bw day for children (1.5-4.5 years) in relation to an exposure scenario with ingestion of canned food+ use of polycarbonate tableware. For adults with a scenario with canned food ingestion + beverage and wine + use of polycarbonate tableware a daily exposure of 0.0015 mg BPA/kg bw day was calculated (see also appendix 1, table A1.5 and A1.7).

Other exposure sources: Other relatively minor sources of consumer exposure to BPA arise from its use in dental fissure sealants and in epoxy-based surface coatings and adhesives. The use of BPA in dental fissure sealants and dental composites will result in oral exposure. In a study, urine samples on a total of 495 children aged 8-9 years showed BPA concentrations higher in children with 11 or more surfaces restored with sealants and resin composites than in those with zero restored surfaces, although no difference was seen in the group with 1-10 surfaces. After adjusting for gender and age, the urinary BPA concentration in children with 11 or more resin composite surfaces was 2.67 µg/g creatinine, which was higher than the concentration found in those with no filling surfaces ($P < 0.01$) (Chung et al, 2012) (see appendix 1, table A1.8).

For epoxy-based surface coatings and adhesives, the main route of exposure is dermal.

In addition to the above mentioned exposure to BPA exposures from other types of articles may occur. This might for instance be through dermal contact with articles of PC, e.g. protecting glasses. Newer data on *BPA migrating from articles* have been collected and are given in appendix 1, table A1.8 in order to give an impression of the potential for exposure. The examples cover about 8 studies from 2009 to 2012, e.g. dummies, baby bottles, thermal paper and toys. Migration ranges from 0.12 mg BPA/kg in dummy shield to 50 mg BPA/kg in paper board were seen (Lassen et al, 2011), (RIVM, 2012). Measured BPA migration from toys was found to be in the range of <0.1 to 2.1 µg BPA/l, which was considered as a low level of exposure (KEMI, 2012B).

Other uses of BPA, such as in printing inks and thermal paper, are considered to result in negligible potential for consumer exposure in comparison with the other sources considered (EU RAR, 2010).

New estimates have been given on exposure to BPA migration from cash receipts.

In a report from KemI it is reported that BPA can be released from the cash receipts and up to 660 µg BPA were evaluated to be released to the skin. Considering the absorption rate from the skin this may lead to an internal BPA worst case exposure of 1 µg BPA/ kg bw day (KemI, 2012A).

In a Danish report, the BPA worst case exposure from cash receipts was calculated based on Danish measurements to 8 µg/kg bw /day (corresponding to an absorbed intern dose of 0.8 –4 µg/kg bw day) for consumers and to 43 µg/kg bw day (corresponding to an absorbed dose of 4.3-20µg/kg bw day) for cashiers (Lassen et al, 2011).

Infants exposure to BPA migration from dummies has based on migration data been calculated to 0.23 µg/kg bw day (corresponding to an absorbed intern dose of 0.023 – 0.12 µg/kg bw day) for dermal exposure and to 0.03-0.08 µg/kg bw day for oral exposure (Lassen et al, 2011).

BPA exposure from unexpected source: A study of **baby bottles** in the EU from November 2011 has shown that BPA was released from baby bottles made of **polyamide**, although the bottles were labelled bisphenol A-free (Simoneau et al, 2012).

5.2.2 Human exposure via the environment

In EU, human exposure via the environment was calculated with EUSES. It shows that the daily human intake via the environment at the regional level is 9.1×10^{-3} µg/kg/day. The highest local exposure in relation to a BPA production site was estimated to 41 µg/kg/day (EU RAR, 2010).

In relation to indoor BPA exposure from dust appendix 1, table A1.9 show examples of measured BPA amounts *in indoor dust* (4 studies from 2003 to 2012). The highest concentration was 39.1 µg BPA/g from a study with 158 indoor dust samples collected in US and several Asian countries ranged from below the limits of quantification (<LOQ) to 39.1 µg/g (Wang et al, 2012). Data from Belgium indicate levels of 0.5 – 9.7 µg BPA/g. A level of 9.7 µg BPA/g would lead to an exposure of approximately 0.1 µg BPA/kg bw day for a child (10 kg) that ingest 100 mg dust/day.

In Canada, human exposure via the environmental media was low. This might well be the picture in the world in general. The environmental media covers BPA present in ambient air, indoor air, drinking water, soil and house dust (Environment Canada, 2012).

5.2.3 Occupational exposure

Occupational contact with BPA occurs from about 9 different activities. Among them are manufacture of BPA, of polycarbonates (PC), of articles from PC, of epoxy resins (and moderated resins), of liquid epoxy paints/lacquers/powder coatings and use of BPA in PVC manufacture. Reasonable worst case exposure estimates in relation to manufacture of epoxy resins were calculated to 700 µg BPA /m³ (8-hr TWA) for long-term inhalation and to 12000 µg BPA/kg/day for long-term dermal exposure. The data background is partly from EU RAR (mainly 2003) and partly from information from the industry given in 2008 (UK, 2008).

5.3 Combined exposure, BPA

In a Danish report estimating chemical exposures to pregnant women the **combined exposure** (exposure from several sources) was investigated. **BPA exposure from consumer products/articles, indoor air and food** sources was estimated (Andersen et al, 2012). Many sources to BPA were covered, possibly not all, but the study was intended to give a realistic level on the present BPA exposure to an average pregnant Danish women. The exposure was 2.3 µg/kg bw/day in the basis scenario and thus at approximately the same level as found in the EU report of 1.45 µg/kg bw/day shown in appendix 1, table A1.11.

5.4 BPA exposure, concentrations in humans measured by biomonitoring studies

Bisphenol A and its metabolites can be measured in blood and urine and from the amounts excreted in urine during a course of a day the daily exposure of BPA may be estimated. In relation to the available studies of biomonitoring of BPA EFSA (2006) noted that BPA exposure assessed from urinary excretion measured in groups of subjects from the general population in the USA, Japan and Korea could be used to assess the order of magnitude of overall average BPA exposure (EU RAR, 2010).

The studies on human urinary concentrations of BPA metabolites show peak levels of 15 µg/l and confirm that BPA is mainly present as BPA glucuronide in urine. Mean urinary (total) BPA concentrations in the USA and in Japan are reported to range from 1.2 to 3.5 µg/l, while samples from a cohort in Germany did not contain detectable concentrations of BPA with a detection limit of 1.1 µg/l. A Japanese assessment from 2006 of BPA exposure of the general population used urinary excretion data and estimated (95 % confidence interval) daily BPA exposure as 0.037 to 0.064 µg/kg bw/day for male and 0.043 – 0.075 µg/kg bw/day for female adults. Japanese children in the age of 1 to 6 years showed the highest exposure of 3.9 µg BPA /kg bw/day for boys and 4.1 µg BPA /kg bw/day for girls.

In a Danish study Bisphenol A (among other substances) was measured in urine samples from 50 pregnant women. The samples were collected in Denmark in the period between 1 February and 7th June 2011. The concentration reported corresponded to a daily exposure of 0.0140 µg BPA/kg bw/day as an average exposure and 0.0791 µg BPA/kg bw/day as a maximum exposure. The measured BPA-levels in Denmark are at the same level as in a Dutch study (samples 2004-2006), slightly lower than in a Spanish study (samples 2004-2008) and much lower than in a Norwegian study (samples from 2004), (Andersen et al, 2012).

As mentioned in chapter 7 (Alternatives), also another bisphenol, bisphenol S (**BPS**) used as an alternative to BPA were found in urine samples. 315 urine samples from people in the U.S., China, India, Japan, Korea, Kuwait, Malaysia and Vietnam were analyzed for content of bisphenol S. The substance was found in 81% of the samples. The content varied from below the detection limit to 21 nanograms / millilitre. People in Japan had the most bisphenol S in urine, followed by people from USA and China. The median estimated daily intake of BPS was 0.009 and 0.004 µg/kg bw/day for children and adults (based on nominal body weights of 30 and 60 kg), respectively (Liao et al, 2012 a).

5.5 Bisphenol-A-diglycidylether polymer exposure

A number of exposures related to the content of bisphenol-A-diglycidylether polymer, mainly measured as the BADGE content are available, see appendix 1, table A1.10. The estimated daily intake for BADGEs was 0.0065 µg/kg bw/day through dust ingestion, which is much lower than the levels estimated for BPA of approximately 0.1 µg BPA/kg bw day for a child (10 kg bw child that ingest 100 mg dust/day). 158 indoor dust samples were collected from the U.S., China, Korea, and Japan, (Wang et al, 2012).

The contained amount of BADGE derivatives in canned food, 2004, was 100 to 600 µg/kg food, which is about 10 times higher than the highest BPA content of 69.9 µg/kg seen in canned food. These BADGE polymers contributions to the body content should not be seen isolated, but also as the BADGE polymers contribution to the overall exposure to BPA. Like reported by Chung et al (2012), who concluded that many dental composite filling surfaces on teeth may increase the urinary BPA concentration in children, the exposure to BADGE polymers contribute to the body content of BPA.

A Canadian study determined the content of BADGE and BFDGE in liquid infant formula (Cao et al. 2009). BADGE was found in all of the 21 samples in the range of 2.4 – 262 ng/g. The maximum intake of BADGE for 12-18 months infants was calculated to 0.022 mg BADGE/kg bw/d.

Measurements of bisphenol-A-diglycidylether polymer concentrations in wastewater or in the air were not seen. Release of BADGE to the environment through manufacturing sites is expected to be low because they are used in a closed system. Furthermore an environmental release of BADGE from end-use application is unlikely to occur as epoxy resins are reacted with hardeners/curing agents into cross linked systems which are stable against thermal and hydrolytic breakdown (EC DG ENV, 2002 and appendix 2 table A2.5).

6. Environmental hazard assessment

Summary:

BPA has been shown to have effects on the endocrine system of a number of organisms. Thus, it is considered to meet the criterion for toxicity (T) but not the persistence (P) or bioaccumulation (B) criteria and therefore BPA is not considered to be a PBT or vPvB substance. Effects at levels below 0.01 mg/l have been observed, and no reliable chronic NOEC values have been identified for BPA. (EU RAR, 2010).

It is further concluded that there is a need for further information and/or testing regarding the freshwater and marine aquatic compartments, including sediment. Although no risks are indicated using the freshwater and marine PNEC for any scenario, there are still some uncertainties concerning effects of bisphenol A on snails, despite the thorough testing.

Regarding the terrestrial and atmospheric compartments and secondary poisoning through the aquatic, terrestrial and marine food chains, the EU RAR (2010) concluded that there is at present no need for further information and/or testing. This also applies to the risks to wastewater treatment plant microorganisms (EU RAR, 2010).

The BADGE polymer is not as well investigated as BPA, but data indicate that BADGE is biodegradable and not bioaccumulative.

6.1 Environmental persistence

BPA is considered readily biodegradable in the aquatic environment (natural fresh surface waters) as well as in the terrestrial environment (soil). It is likely to be moderately adsorbed to solids upon release to the environment. Volatilization is not considered to be a significant removal mechanism for BPA from water. Removal of BPA in rainwater is also considered to be negligible (EU RAR, 2010).

Aquatic: A number of different studies are available which all together show that bisphenol A is readily biodegradable in natural fresh surface waters (EU RAR, 2010). The studies cover e.g. a manometric respirometry test (OECD 301F) on BPA. The average percent removal by BOD was 89%, and no parent compound could be detected by HPLC after 28 days. The 10-day window was met in this test (CERI, 2004 reported in EU RAR, 2010).

A measured concentration of BPA in 24-hour composite samples of the influent and effluent from five municipal sewage treatment plants in Tokyo. All five plants used primary and secondary treatment with activated sludge. BPA levels in the influent were between 100 and 1000 ng/l; removal of BPA was >92% on average (Nakada et al, 2006 reported in EU RAR, 2010).

In a continuous activated sludge (CAS) simulation test according to the OECD 303A guideline 14C radiolabelled BPA was used to determine the mass balance. BPA was determined in the influent, effluent, waste sludge and in CO₂ traps. Recovery of the dosed radioactivity was 94-99%. Average removal of 14C-BPA was 99.1% (TNO, 2001 reported in EU RAR, 2010).

Terrestrial: Different studies available show all together that BPA is readily biodegradable in soil (EU RAR, 2010). Among these is a study of the adsorption and degradation of BPA in soils from Germany: three soils from North-Rhine Westphalia and one from Rhineland Palatinate. The adsorption-desorption studies were carried out according to the OECD Guideline 106, the soil degradation studies according to a SETAC design. For the degradation study, twelve test systems were set up for each soil type. BPA (uniformly labelled with ^{14}C) was applied at $6\ \mu\text{g}/100\ \text{g}$ soil. Experiments were continued for 120 days. The test systems were analyzed at intervals for the amount of extractable, non-extractable and volatile radioactivity (volatiles captured in soda lime trap for CO_2 and oil-wetted quartz wool for VOCs), as well as how much BPA remained in the system. BPA rapidly formed bound residues in soil. After one hour, 19-59% of the applied radioactivity was non-extractable under normal conditions (methanol plus 5% acetic acid). After three days, 84.7 – 88.6% was not extractable. Following hot flux extraction, only a further 2.8% was removed, so that less than 7.4% was extractable using both techniques combined. At the end of the 120 days exposure, less than 2% of the applied radioactivity was extractable. Depending on the soil, 13.1 – 19.3% of the label was recovered as CO_2 after the incubation period. No other volatile radioactive species were found. In one soil, after 1-2 hours, 49.2% of the BPA applied could be recovered, with 33% as other extractable species (up to five different metabolites). After three days the amount was less than the detection limit ($1\ \mu\text{g}/\text{kg}$). No significant metabolites could be found after three days. The authors comment that forming bound residues is common behaviour for phenols and anilines. Rapid transformation to transient metabolites suggests that most of the bound residues are in fact transformation products (Fent et al, 2003 reported in EU RAR, 2010).

In another study BPA was added to 5 g of sandy loam soil from a depth of 0-15 cm soil to give a concentration of $1\ \mu\text{g}/\text{g}$, and incubated at 20°C for 70 days. Degradation was rapid, with a half-life of seven days calculated from the results. Little or no degradation was seen in sterilized soil samples. When the soil was mixed with an equal amount of river water and allowed to attain anaerobic conditions before addition of the BPA, no degradation was seen (Ying and Kookana, 2005 reported in EU RAR, 2010).

Distribution: BPA is considered likely to be moderately adsorbed to solids upon release to the environment. Volatilization is not considered to be a significant removal mechanism for BPA from water. Removal of BPA in rainwater is also considered to be negligible. This is based on a number of studies assessed in the EU RAR (2010). Among these is a study on BPA in German soils in where the adsorption of BPA in four soils using the OECD 106 Guideline were measured. Degradation as well as binding was seen in the adsorption studies (rapid removal was seen in the degradation studies). In studies to measure the Koc values a biocide was employed to reduce the degree of degradation in the experiments. The mean Koc value obtained was 795.9 (mean Kd value 11.01).

6.2 Potential for bioaccumulation

Based on measured data BPA has a low potential for bioaccumulation in fish (BCF of 67) and a slightly higher measured bioconcentration in freshwater clams (BCF up to 144). The BCF of 67 for fish was used in risk assessment, and the accumulation in clams was considered in the risk characterization. A bioconcentration factor for earthworms of $7.9\ \text{kg}/\text{kg}$ was estimated using QSARs (EU RAR, 2010).

6.3 Potential to Cause Ecological Harm

Evidence of **disruption to reproductive and developmental processes** following exposure to BPA at concentrations below those causing acute effects has been **reported in fish, aquatic invertebrates, amphibians and reptiles**. A selection of reported endpoint values relevant to potential endocrine disruption is presented in table 7c in Environment and Health Canada (2008). While there is a widespread variation in reported lowest effect values, many fall in the range of

0.001 to 1 mg/l. In addition, differing sensitivities are evident between groups of organisms, with endpoint values for fish generally higher than those for aquatic invertebrates. Considered together, the data provide strong evidence that BPA is capable of eliciting adverse effects: (1) following prolonged exposure at levels below those usually seen to elicit effects in standard toxicity tests (i.e., tests based on recognized methods which evaluate endpoints such as survival, reproduction and growth); (2) following brief low-dose exposure, particularly at sensitive developmental stages, with effects apparent later in the life cycle; (3) on filial generations following parental exposure; and (4) using more than one mode of action (Environment and Health Canada, 2008).

The EU RAR (2010) concluded that no reliable chronic NOEC values could be identified as some data although not fully reliable indicated effects below 0.01 mg/l. BPA has shown effects on the endocrine systems of a number of organisms. It is therefore considered to be toxic and meet the T criterion (EU RAR, 2010). Modelled and experimental evidence that bisphenol A causes harm to aquatic organisms at relatively low concentrations can be seen in appendix 2, table A2.1 to A2.4.

6.4 Risk Characterization

The EU RAR (2010) made the following conclusions for BPA in relation to the predicted levels in the environment:

6.4.1 Aquatic compartment

Freshwater: All the calculated PEC/PNEC ratios are below one (i.e. no risk can be identified) for the freshwater compartment for any life cycle stage. Nevertheless, there remains a possibility that the PNEC_{water} does not take full account of the potential effects of bisphenol A on snails. Recent results from studies, funded by UK government, in snails were inconclusive. There is therefore a residual concern that the PNEC_{water} might be too high, despite the thorough testing.

The conclusion is therefore that there is a need for further information, or testing.

Marine waters: As the considerations on the toxicity to snails are also relevant for the marine environment, the conclusion is therefore that there is a need for further information or testing also for the marine environment.

Sediment: The sediment PNEC and the sediment PEC values are obtained through the equilibrium partition method, and so the risk characterization ratios are the same as for the freshwater and marine compartments and there is a need for further information or testing also for the sediment (EU RAR, 2010).

6.4.2 Terrestrial compartment

All the calculated PEC/PNEC ratios are below 1 (i.e. no risk can be identified). The conclusion is therefore that there is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

6.4.2.1 Secondary poisoning

The PNEC_{oral} was based on the mammalian data reviewed in the human health risk assessment. A NOAEL of 50 mg/kg bw/day was used (related to reduction in litter size in a three-generation feeding study with rats). A recent study in CD-1 mice gave rise to a similar NOAEL at 50 mg/kg bw/day for both general and reproductive toxicity. In another recent study on Chicks *Gallus domesticus*, a NOAEL was derived to 10 mg/kg/day, based on delayed development of comb, wattle and testes (Furuya et al, 2006 reported in EU RAR, 2010).

In conclusion BPA is readily biodegradable and has a low bioaccumulation potential, the existing study addressed several relevant end points but the PEC/PNEC ratios are all significantly below 1.

Thus there are no risks for secondary poisoning from the current production and uses of BPA based on those findings (EU RAR, 2010).

6.4.2.2 PBT assessment

Persistence: As mentioned above BPA is readily biodegradable, and so does not meet the P criterion.

Bioaccumulation: The measured BCF values in fish for BPA are in the range 30-75, with slightly higher values for other aquatic organisms (tadpoles, clams). These values are well below the threshold, and so BPA does not meet the B criterion as also mentioned above (EU RAR, 2010).

Toxicity: There are no reliable chronic NOEC values below 0.01 mg/l, although there are some less reliable values and indications of possible effects at this level. BPA has been shown to have effects on the endocrine systems of a number of organisms. It is therefore considered to meet the T criterion (EU RAR, 2010).

PBT-conclusion: Bisphenol A is not a PBT or vPvB substance; it meets the T criterion but not the P or B criteria (EU RAR, 2010).

6.4.2.3 Uncertainties

The PNEC_{water} can be derived in several ways, depending on how the data on the snails *Marisa cornuarietis* data are viewed. The interpretation is complicated strain differences in the snail stocks used in the different laboratories, and it is also possible that the role of seasonality was not sufficiently investigated. Differences in exposure regimes might also have an influence if metabolites are more potent than the parent substance (though there is no evidence for this). It is also apparent that reproductive effects have been observed at apparently low concentrations in more than one aquatic snail species (*Nucella lapillus* and *Potamopyrgus antipodarum*), although the available data are not sufficiently robust for direct use in the PNEC derivation. Whilst some of these effects might be an artifact of the experimental design, histopathological changes are difficult to dismiss in this way (although these are not necessarily directly related to effects that could influence population growth), (EU RAR, 2010).

There therefore remains a possibility that the PNEC_{water} does not take full account of the potential effects of bisphenol A on snails. The implications for other endocrine active compounds will also need to be considered at the same time.

The PNEC for the marine compartment should also be considered as provisional for the same reasons as for freshwater; it is noted that effects of bisphenol A on marine molluscs have been recorded. If the aquatic PNEC is revised, then the sediment ratios would also change (EU RAR, 2010).

6.5 Bisphenol-A-diglycidylether polymer

The BADGE polymer is not as well investigated as BPA. In an investigation of the BADGE polymer 25036-25-3 and BADGE, DG ENV concludes that data indicate that BADGE is biodegradable and not bioaccumulative (EC DG ENV, 2002 and appendix 2 table A2.5). If released to air, BADGE is expected to solely exist in the vapour phase. It has low volatility and is removed from atmosphere through wet or dry deposition. When released to water, it is assumed to absorb to particulate matter and sediment. Absorption to the humic fraction is suspected, when released to soil (EC DG ENV, 2002).

7. Human health hazard assessment

Summary:

The exposure to **BPA** may cause eye irritation, respiratory tract irritation, skin sensitization, repeated dose local effects to the respiratory tract, systemic effects following repeated exposure and reproductive toxicity (effects on fertility and on development) (EU RAR, 2010).

The current Tolerable Daily Intake (TDI) of 0.05 mg BPA/kg body weight (bw)/day was set by EFSA in 2006 (EFSA, 2010 & 2011). It is based on the NOAEL of 5 mg/kg bw/day from a multi-generation reproductive toxicity study in rats, and by the application of an uncertainty factor of 100. This factor is by EFSA regarded as conservative based on all information on BPA toxicokinetics.

Also obesity and incident coronary artery disease were seen associated with elevated urinary BPA concentrations. However, with respect to reproductive toxicity and endocrine disruption it has been intensively debated to which extent data from experimental animal studies observing neurobehavioral changes and effects on the reproductive system in offspring at very low BPA dose levels were sufficient reliable for use in the TDI derivation. The exposure levels at which effects were observed in these studies were orders of magnitudes lower than the no adverse effect observed levels (NOAELs) concluded by the EU-RAR (2010) and by EFSA (2010).

In the EU this has especially been addressed by authorities and scientific institutions in France, Sweden and Denmark. Thus a Swedish report identified NOAELs and LOAELs in the range of 2-500 µg/kg bw/day for different effects at low doses and discussed how these values could be used as basis for derivation of an alternative reference dose for BPA and to what extent this reference dose would deviate from the current tolerable daily intake (TDI) for BPA (Beronius and Hanberg, 2012). From this evaluation alternative reference doses (TDIs) between 0.01 and 0.8 µg/kg bw/day were estimated, which are values considerably lower than the current TDI of 50 µg/kg bw/day.

Thus, how risk assessment on BPA should be undertaken in future will very much depend on whether the toxicological findings in the low dose studies with NOAEL/LOAEL values in the range of 2-500 µg/kg bw/day will generally be accepted as the starting point for a revised TDI derivation, as such a revised TDI may then be considerable lower than the current TDI. Currently, a new opinion from EFSA on these questions is expected in May 2013.

The current human exposure to BPA, also in relation to worst case exposures, is generally considered below the current TDI value. This risk assessment scenario may change if the TDI in future should be set at a level as indicated by the Swedish report. If the TDI would be lowered the exposure from BPA from food contact material would be of primary concern, however, also other types of exposures from various articles - which today are considered rather negligible - may then be of greater concern.

A possible revised TDI for BPA will also influence risk assessments using the cocktail effect approach in which the risk characterization ratios from various chemical acting with same

endocrine mechanisms are added as the exposure contribution from BPA then will result in a considerable higher risk characterization ratio than to day.

The main concern for the **BADGE polymers** has been the potential for genotoxic and carcinogenic effects of the epoxy-monomer BADGE. In 2004 EFSA evaluated new data on genotoxicity and carcinogenicity and from these data concluded that BADGE does not raise concern for neither genotoxicity nor carcinogenicity. A TDI of 0.15 mg/kg bw/day was established from a NOAEL of 15 mg/kg bw/day from a two year chronic/carcinogenicity study as toxic effects on the spleen was observed at higher levels. Studies examining effects on fertility and development did not indicate concerns for these end-points. The possible content of BPA and the toxicological implication of this were not addressed by EFSA as it was not the task of EFSA to evaluate impurities and other reaction products present at low levels in the BADGE polymer. However, in relation to endocrine disruption the toxicity of BADGE polymers should not be seen in an isolated context but also in the context of BPA toxicity and to which extent the BADGE polymers contribute to the overall exposure to BPA.

7.1 Bisphenol A

7.1.1 Toxicokinetics

In humans BPA is rapidly absorbed from the gastrointestinal tract after oral exposure. The EU RAR assume an uptake from the gastrointestinal tract of 100%, however the systemic bioavailability of BPA is much lower as first-pass metabolism leading to BPA-glucuronide occur to a great extent.

Limited dermal absorption of BPA was concluded based on an *in vitro* dermal absorption study with human skin found and from these data an absorption rate of 10% was concluded for use in risk assessments (EU RAR, 2010).

Later this figure has been challenged as a French *in vitro* study using pig ear skin and viable human skin explants found a considerable higher absorption and from this an absorption rate of 50% was suggested (Lassen et al, 2011).

No specific data on absorption from the inhalational route is available but an absorption rate of 100% was considered reasonable due to the physicochemical properties of the substance and the evidence from absorption and toxic effects in inhalational studies (EU RAR, 2010).

After oral dosing to rats with radiolabeled BPA the radioactivity was found to be distributed to liver, kidney and carcass with the lowest concentration in brain and testes. Only limited distribution to fetus occurred and to lactating neonates after oral exposure but in connection with intravenous exposure, however, significant amounts of radioactivity were distributed to placenta and the fetus (EFSA, 2006).

Due to rapid biotransformation and urinary excretion in humans (with a half-life < 6 hours) and high degree of protein binding free BPA concentrations available for receptor binding are very low in humans whereas higher levels of free BPA occur in rats due to lower degree of protein binding and also due to re-uptake from the gastrointestinal tract by enterohepatic circulation (EFSA, 2006). In addition, new findings in non-human primates (both adults and newborns) further strengthen the view that BPA is eliminated faster in humans than in rodents. Even human premature infants can metabolise and excrete BPA efficiently (via glucuronidation and sulfation); this is supported by recent human data and data in young monkeys (EFSA, 2010).

7.1.2 Acute toxicity

Current data indicate that BPA is of low acute toxicity as oral and dermal LD₅₀ values in experimental animals are beyond 2000 mg/kg bw. Slight tissue damage in the nasal tract was however noted in a 6-h inhalation study at 170 mg BPA/ m³ (EU RAR, 2010).

7.1.3 Irritation

Recent animal studies indicate that BPA is not a skin irritant, however BPA is from human and animal data considered to cause serious damage to the eyes and also to cause respiratory tract irritation (EU RAR, 2010).

7.1.4 Skin sensitization

Based on overall human and animal data BPA is considered as a skin sensitizer (EU RAR, 2010).

7.1.5 Genotoxicity and carcinogenicity

BPA is not considered to be genotoxic in bacteria and in mammalian cells, and has not been shown to increase the incidence of tumours in rats exposed for life to high doses of BPA by dietary administration. A number of reviews have concluded that BPA is not genotoxic or carcinogenic (EFSA, 2006; EU RAR, 2010).

7.1.6 Reproductive toxicity

In 2003 the EU RAR concluded the following in relation to reproductive toxicity:

‘ BPA has been shown to have endocrine modulating activity in a number of *in vitro* and *in vivo* screening assays, with a potency generally ranged from 3 to 5 orders of magnitude less than that of estradiol. Although a number of studies reported to have detected a BPA-related effect on development, no firm conclusions could be drawn about developmental neurotoxicity because of a low level of confidence in the reliability of the studies and a lack of consistency in the results. In the EU RAR it is written: “Overall, taking together the low confidence in the reliability of the developmental neurotoxicity studies and the lack of consistency in the results of behavioural testing, no conclusions can be drawn from these studies⁴”. This opinion is very similar to that of EFSA (2006), who reviewed nine of the developmental neurotoxicity studies.

Overall, in standard developmental studies in rodents, there is no convincing evidence that BPA is a developmental toxicant as mentioned in the EU RAR. However, the available and apparently conflicting data from studies conducted using low doses (in the µg/kg range) do raise uncertainties, which the majority of EU member states felt could not be dismissed, but disagreed on how these studies should be used, if at all, in the risk characterization for this endpoint. It was agreed that a provisional **NOAEL of 50 mg/kg/day** for developmental effects, derived from the rat multi-generation study, should be used in the risk characterization in the interim, whilst awaiting the outcome of further testing ‘ .

In the updated 2010 version of the EU RAR further studies regarding developmental neurotoxicity were evaluated, however, it was assessed that no conclusion could be made from these studies due to low confidence and reliability of the studies and the lack of consistency in the results.

Also from a new 2-generation study with mice it was concluded that a NOAEL for reproductive toxicity of 50 mg/kg/day could be identified. As there was no evidence of an adverse effect on the development of the male reproductive tract at µg/kg bw/day doses of BPA, the study resolves the uncertainties surrounding the potential to produce adverse effects on development at low doses.

⁴Denmark, Sweden and Norway do not agree with this conclusion. These countries find that some of the studies in the DNT database are sufficiently reliable for regulatory use: Negishi 2004, Carr 2003, Ryan and Vandenberg 2006 and Adriani 2003. The reliability of these studies is judged to be adequate because the behavioural testing has been conducted according to acceptable methods, the group sizes are quite close or equal to those recommended in the OECD TG 426, and the litter has been used as the statistical unit. The effects found in these studies indicate that there is a possible risk for developmental neurotoxicity of BPA at very low exposure levels (0.1-0.25 mg/kg/d). These effects cannot be dismissed based on the other unreliable studies in the DNT database. The above mentioned countries would therefore prefer one of two possible conclusions: 1) the available, but limited data are used for the risk assessment or 2) there is a need for further information (the countries certainly evaluate the database as sufficient to justify a concern warranting further investigation of developmental neurotoxicity), similarly to the proposed conclusion in the final expert panel report on the reproductive and developmental toxicity of BPA performed by NTP, US in November 2007.

Thus, a NOAEL of 50 mg/kg/day for reproductive toxicity, which was a provisional position in the original risk assessment report, should be used in the risk assessment. So overall, EU RAR (2010) confirmed its previous conclusion and also supported the EFSA (2006) opinion which came with a similar conclusion on the recent studies.

The current Tolerable Daily Intake (TDI) of 0.05 mg BPA/kg body weight (bw)/day was set by EFSA in 2006 (EFSA, 2010 & 2011). It is based on the No-Observed-Adverse-Effect-Level (NOAEL) of 5 mg/kg bw/day from a multi-generation reproductive toxicity study in rats based on liver toxicity (NOAEL for developmental toxicity was set at 50 mg/kg bw d), and the application of an uncertainty factor of 100. This factor is by EFSA regarded as conservative based on all information on BPA toxicokinetics.

7.1.6.1 Reproductive toxicity, low-dose effects

Bisphenol A is considered as a potential endocrine disruptor and can interact with nuclear and membranebound estrogen receptors. This has been extensively studied during the last decades and new studies on the endocrine effects are constantly being released.

Based on this it has been intensively debated to which extent data from experimental animal studies observing neurobehavioral changes and effects on the reproductive system in offspring at very low dose levels (i.e. exposures at orders of magnitudes lower than the no adverse effect observed levels (NAEOLs) concluded by the EU-RAR (2010) and by EFSA (2010) were sufficient reliable to be used for the TDI derivation. The need to consider these findings have been expressed in a foot note to the EU risk assessment (EU RAR, 2010) and in a minority statement in the EFSA (2010) opinion, as well as in publications and statements from authorities and scientific institutes from France, Sweden and Denmark (ANSES, 2011; Beronius and Hanberg, 2012; DTU Food, 2010).

The National Food institute, Technical University of Denmark (DTU FOOD) evaluated in 2010 a new developmental neurotoxicity study on BPA conducted by Stump et al, which followed the OECD TG 426 (Test guideline: Developmental Neurotoxicity Study). They concluded "that the new study does not clarify or change the uncertainties and possible concerns for effects of bisphenol A on brain development and behaviour in rodents exposed to low doses of bisphenol A and the results in the study cannot be used for setting a robust NOAEL for the effects of bisphenol A on brain development and behavior" (DTU Food, 2010). It was concluded that uncertainty still remains due to some findings at the lowest dose level in the study and also it was noted that the dose levels used was not adequate for examining the possible low dose effects of BPA. Furthermore, seven other studies published since 2003 was mentioned to add to the concern regarding neurobehavioral effects at low dose levels (DTU Food, 2010). Both the Stump et al study and the evaluation of the Danish National Food Institute was assessed and included in the EFSA 2010 opinion. However EFSA concluded that "With respect to the learning and memory endpoint of the Stump study, as examined in the Biel Maze test, the Panel concluded that the influence of BPA on learning and memory behaviour cannot be evaluated. Regarding this endpoint, the study is inconclusive and cannot be used for the risk assessment of BPA" (EFSA, 2010).

ANSES in France has recently published a comprehensive report on health effects and uses of BPA (ANSES, 2011) and came out with conclusions on the need to reduce exposure of the sensitive populations based on these effects. The report explains that available human and animal data have most often been obtained at doses lower than the NOAEL of 5 mg/kg/day that was used to calculate the TDI currently used by EFSA. The working group recommends for instance to assess the relevance of using toxicity reference values (TRVs) or Tolerable Daily Intakes for substances with non-monotonic dose-response curves. The ANSES report also recommends that some adverse effects should be taken into account in future risk assessment.

These are

in animals:

- Increased occurrence of ovarian cysts after pre- and postnatal exposures
- Hyperplastic modification of the endometrium after pre- and postnatal exposure
- Early onset of puberty after pre- and postnatal exposures
- Altered sperm production after adult exposure
- Histological changes in neurogenesis following pre- or perinatal exposure
- Effects on lipogenesis after prenatal, perinatal or adult exposure
- Effects on the mammary gland: acceleration of the mammary gland's structural maturation in adulthood and development of intraductal hyperplastic lesions after pre- or perinatal exposure to BPA.

in humans:

- Effects on oocyte maturation in females in infertile couples undergoing ART (Assisted Reproductive Technology).

It was also recommended further to explore the toxicokinetic similarities and differences between experimental animals and humans for better predicting bioequivalent doses of BPA (ANSES, 2011).

In 2011, and following the publication of reports by ANSES (2011), EFSA was requested by the European Commission to provide scientific advice about the possible divergence between the report from ANSES and the conclusions of the previous EFSA scientific opinion on BPA (EFSA, 2011) based on ANSES conclusion on the need to reduce exposure of the sensitive populations. Additional studies have become available, indicating effects of BPA in rodents at dose levels below the current NOAEL of 5 mg/kg bw/day. Uncertainties regarding the relevance to humans of these toxicological effects remain to be clarified. The EFSA Panel would need more time to review in depth these new studies. The Panel will reconsider its opinion following further evaluations of new studies and of new data from ongoing low dose studies (EFSA, 2011). According to news from EFSA 29 October 2012 the opinion is scheduled for completion in May 2013 (EFSA, 2012).

The recent report from Sweden (Beronius and Hanberg, 2012) presents a review and summary of studies investigating the effects of developmental exposure to BPA in regard to developmental neurotoxicity, as well as effects on the development of the mammary gland, the female reproductive system and lipogenesis.

The purpose was to identify a no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) for these different effects as well as to discuss how these NOAEL/LOAEL could be used as points of departure for the derivation of an alternative reference dose for BPA and to what extent this reference dose would deviate from the current tolerable daily intake (TDI) for BPA. The current TDI is based on the results of rodent studies that were conducted according to standardized toxicity test guidelines. In these studies effects on offspring body and organ weights were observed at doses above a NOAEL of 5 mg/kg bw/day. However, a large number of research studies conducted during the last decade have reported effects of BPA in animals at doses well below 5 mg/kg bw/day. But these data have so far not been considered relevant or reliable enough by regulatory bodies to affect the TDI or other health-based guidance values for BPA.

In the report studies using BPA-administration via the oral route to pregnant and/or lactating females or directly to neonatal offspring were primarily considered since these scenarios reflect relevant exposure scenarios in the general population.

No single study was considered reliable enough to serve as a key study for the identification of a NOAEL or LOAEL. The approach was instead to consider the data as a whole and to identify several NOAELs or LOAELs for each type of effect from different studies that were considered to be most reliable and relevant. In general, the selected NOAELs range from 2 to 50 µg/kg bw/day, which are 2 to 3 orders of magnitude lower than the NOAEL on which the current TDI is based. LOAELs range from 40 to 500 µg/kg bw/day. Alternative reference doses calculated from these NOAELs/LOAELs

range between 0.01 and 0.8 µg/kg bw/day and are considerably lower than the current TDI of 50 µg/kg bw/day. The lowest reference doses were calculated for developmental neurotoxicity. Overall, it was concluded that although no single study reviewed here was considered reliable enough to serve as a key study for the derivation of an alternative reference dose, if the data is considered as a whole, effects are consistently observed at doses well below those which serve as the basis for the current TDI for BPA. This indicates that a revised TDI may be prudent when conducting risk assessment of BPA (Beronius and Hanberg, 2012).

7.1.7 Other effects

Possibility of other effects has been reported as well. In adults, elevated urinary BPA concentrations were found associated with obesity and incident coronary artery disease (Trasande et al, 2012).

7.2 BADGE polymers (CAS 25036-25-3 and CAS 25068-38-6)

From the toxicity data on BADGE (CAS 1675-54-3) and BADGE containing polymers (CAS 25036-25-3 and CAS 25068-38-6) the main concern is the skin sensitizing property of the substances. EFSA (2004) concluded that reproduction studies in rats with BADGE gave no indication of any deleterious effects on fertility, general reproductive parameters, litter data and post-natal development. Oral developmental toxicity studies in rats and rabbits showed no teratogenic effects or adverse effects on embryonal and foetal development.

EFSA (2005) further concluded that BADGE does not raise concern for carcinogenicity and genotoxicity *in vivo*. Based on a NOAEL of 15 mg/kg bw/day (atrophy and decrease in spleen weight at higher doses) observed in an oral chronic toxicity/carcinogenicity study in the rats exposed to BADGE, and applying an uncertainty factor of 100, a TDI of 0.15 mg/kg bw was established for BADGE and its hydrolysis products.

It was not the task of EFSA to evaluate impurities and other reaction products present at low levels in the BADGE polymer. Thus the possible content of BPA and the implication of this were not addressed by EFSA.

No indications were found in relation to reproductive toxicity from BADGE. However, in relation to endocrine disruption the toxicity of BADGE polymers should not be seen in an isolated context but also in the context of the endocrine effects of BPA as the BADGE polymers due to residual levels of BPA may contribute to the overall exposure to BPA.

7.2.1 Human health assessment, BADGE polymer 25036-25-3

The 25036-25-3 polymer contains up to 20% BADGE monomer.

Irritation: A moderate eye irritant; May cause skin and respiratory sensitization after prolonged contact; May cause irritation (NLM, 2012).

Sensitisation: May cause skin sensitization. A completely cured epoxy resin contains no free monomer or hardener and is nonsensitizing). However, CAS 25036-25-3 polymers with an average molecular weight of approximately 1000 produced allergic contact dermatitis in guinea pigs. As it contain up to 20% BADGE monomer and BADGE is a known skin sensitizing substance this result is not unexpected (US EPA, 2001B). Allergy to epoxy resin is also reported by Dermnetnz (2012).

Carcinogenicity: Not Classifiable as an IARC Carcinogen (NLM, 2012).

7.2.2 Human health assessment, BADGE polymer 25068-38-6

The 25068-38-6 polymer contains up to 20% BADGE monomer. The common used polymer (at least in Denmark) has a molecular weight ≤ 700 (Danish Coatings and Adhesives Association, 2012).

Sensitisation: 25068-38-6 polymers with an average molecular weight of approximately 1000 produced allergic contact dermatitis in guinea pigs. As it contain up to 20% BADGE monomer and BADGE is a known skin sensitizing substance this result is not unexpected (US EPA, 2001B). Allergy to epoxy resin is also reported by Dermnetnz (2012).

7.2.3 Human health assessment, BADGE (1675-54-3)

In 2004 EFSA evaluated BADGE as pure BADGE and as BADGE in connection with technical grades of BADGE containing resins (EFSA, 2005).

Acute toxicity: BADGE is considered to be of low acute toxicity in relation to oral and dermal exposure. No data of inhalational acute toxicity is available.

Irritation: Based on the available data BADGE is considered to be a slight dermal and eye irritant.

Sensitisation: In guinea pig maximization test pure and especially technical BADGE resulted in positive sensitizing response. Resins with molecular weight of 1850 and above are non-sensitizing. Also human data confirm that resins with BADGE may cause skin sensitization. Most positive reactions have been found with the presence of BADGE monomer content as an impurity in the resins.

Repeated dose toxicity: Oral subchronic administration of pure BADGE produced alterations in haematology, clinical chemistry, urinalysis, and organ weights parameters, especially in males, at doses from 250 mg/kg bw upwards. Some clinical chemistry and urinalysis alterations were indicative of renal toxicity.

No histopathological changes were observed in oral and dermal rat and mouse subchronic studies.

Reproductive toxicity: Reproduction studies in rats with BADGE gave no indication of any deleterious effects on fertility, general reproductive parameters, litter data and post-natal development. Oral developmental toxicity studies in rats and rabbits showed no teratogenic effects or adverse effects on embryonal and foetal development. The NOELs for systemic effects on adults (organ and body weight reductions) derived from reproduction and teratogenicity studies were in the range of 20-60 mg/kg bw.

Mutagenicity: Genotoxicity studies show that BADGE is a direct-acting mutagen *in vitro* in test systems covering different genetic endpoints. Several *in vivo* studies show that BADGE does not induce chromosome damage in rodent bone marrow and germ cells nor DNA strand breaks in liver cells. It is concluded that BADGE is not genotoxic *in vivo* in these tissues.

Low but detectable covalent binding to DNA was detected in mouse skin after topical application of BADGE. The biological significance of the low DNA binding activity of BADGE is unclear, but it raised concern for possible genotoxic effects of BADGE at the site of contact.

Mutagenicity studies with BADGE.2HCl indicate that the bis-chlorohydrin is unable to induce gene mutations and structural chromosomal aberrations *in vitro*. A weak positive response was observed in the *in vitro* micronucleus assay, only in the absence of exogenous metabolic system.

Carcinogenicity: In a 2-year carcinogenicity study with rats BADGE did not show oncogenic potential. Based on the effect on spleen weight observed at 100 mg/kg bw, the NOAEL was set at 15 mg/kg bw/day.

Overall: EFSA (2005) concluded that BADGE does not raise concern for carcinogenicity and genotoxicity *in vivo*. On the basis of the available experimental data, a TDI was established for BADGE and its hydrolysis products. Considering the NOAEL of 15 mg/kg bw/day observed in the oral chronic toxicity/carcinogenicity study in the rat with BADGE, and applying an uncertainty factor of 100, a TDI of 0.15 mg/kg bw was established for BADGE. As BADGE is rapidly and extensively metabolised *in vivo* into the corresponding mono- and bis-diol derivatives, the Panel includes these in the TDI.

7.3 Risk assessments

7.3.1 BPA

EFSA (2006) concluded that even conservative exposure estimates based on conservative migration values of BPA and 95-percentile intake of food items never exceeded 30% of the TDI of 50 µg/kg bw/day for any groups in the population groups studied (this corresponds to risk characterisation ratios < 0.3). Thus no risk could be identified by EFSA in relation to the estimated BPA exposure of the population.

The EU RAR (2010) concluded that the current BPA exposures in relation to consumers and the general public did not give raise to concern: For eye and respiratory tract irritation, for repeated dose local effects on the respiratory tract and for skin sensitization, exposure is very low and it is concluded that there is no concern for these effects. For systemic effects following repeated exposure and for reproductive toxicity, the conclusion is that at present there is no need for further information and/or testing or for risk reduction measures beyond those which are being applied already. The same conclusion can be applied for consumers exposed via the environment, for both regional and local levels, due to the low exposure.

A risk characterisation ratio of 0.1 can be calculated when comparing the highest exposure from food contact material of 0.01 mg/kg bw/d for 1.5-4.5 year old children with the current TDI value of 50 µg/kg bw/day.

A Danish report measured the migration of BPA from cash receipts and from dummies (pacifiers) made by polycarbonate. Exposure estimates were made for consumers and cashiers in relation to the cash receipts and for infants/children in relation to the dummies. Based on these estimates, risk characterization ratios (RCRs) of 0.08-0.19 were calculated for consumers and RCRs of 0.15-0.74 were calculated for cashiers exposed to BPA from receipts or the exposure to cashiers. For infants and BPA exposure from dummies RCRs in the range of 0.0034-0.0046 were calculated. Thus the report concluded that no immediate risk could be identified in relation to the exposure scenarios for BPA (Lassen et al, 2011).

Thus, the current human exposure to BPA, also in relation to worst case exposures, is generally considered below the current TDI value. This risk assessment scenario may change if the TDI in future should be set on the basis of effects from the low-dose studies at a level of 0.01 and 0.8 µg BPA /kg bw/day as indicated by the Swedish report by Beronius and Hanberg (2012). If the TDI would be lowered the exposure from BPA from food contact material would be of primary concern, however, also other types of exposures from various articles - which today are considered rather negligible - may then be of greater concern.

7.3.1.1 BPA and Cocktail effects

As mentioned under the combined exposure a new Danish report on cocktail effects from consumer products/articles, indoor air and food sources showed that the highest Risk Characterization Ratio (RCR) for bisphenol A in the study was 0.01 from combined BPA exposure in the basis scenario added to the work and transport scenarios. The exposure to multiple chemicals, including BPA and parabens, were investigated among the 11 substances in the estrogenic group. A total of 31 different endocrine disrupting substances were covered in the study. The calculated risks from cocktails in the study showed a RCR on 3.88 for the combined scenarios with basis, work and transport from 11 estrogenic substances including BPA – and hence a clear risk. This risk was primarily due to propyl- and butylparaben in cosmetics (Andersen et al, 2012).

The resulting RCR was 0.0046 using a derived no-effect level for estrogenic mode of action (DNELEstrogen) on 500 µg/kg bw/day. The DNELE was based on a NOAEL on 50 mg/kg bw/day for reproductive effects for estrogenic mode of action (reduced fertility, delayed puberty, and testis changes) in a multigeneration study on rats and a two-generation study in mouse (Tyl et al, 2002;

Tyl et al, 2008). This DNEL is 10 times higher than the current TDI from EFSA. The reason for choosing this 10 fold higher DNEL was that the aim of that study was to calculate the cocktail effects for endocrine disruption. The highest RCR for bisphenol A in the report was 0.01 from combined BPA exposure in the basis scenario added to the work and transport scenarios. The transport scenario covered short time daily transport to and from work and the work scenario covered a normal consumer not especially exposed to BPA as 31 different endocrine disrupting substances were covered in the study.

No other BPA-like substances was included, thus e.g. addings from other bisphenols, with similar effects. Thus based on this the combined exposure to BPA alone does not seem to pose a risk to the normal consumer at the used TDI and also not with the current TDI (resulting in a 10 time higher risk, which is RCR on 0.1). The study covered many sources to BPA, possibly not all, but the study was considered to give a realistic level on the present BPA exposure of a pregnant Danish woman with an average lifestyle in 2011. If the current TDI be lowered in the future this RCR might needs to be reconsidered. Furthermore the calculated cocktail effect covers a group of 11 substances with estrogenic effect, but more substances with that effect exists, to which individuals may be exposed.

A possible revised TDI for BPA will also influence risk assessments using the cocktail effect approach in which the risk characterization ratios from various chemical acting with same endocrine mechanisms are added as the exposure contribution from BPA then will result in a considerable higher risk characterization ratio than to day.

7.3.2 BADGE

No recent risk assessment on BADGE has been found.

In a Canadian study a maximum intake of BADGE for 12-18 months infants was calculated to 0.022 mg BADGE/kg bw/day from intake of liquid infant formula. As for BPA a scenario with infants exposed via food / food contact material may be considered as a worst case scenario for BADGE as well. Comparing this scenario with the current TDI of 0.15 mg BADGE/ kg bw/day would result in a risk characterization ratio of 0.15. However, it is uncertain to which extent this scenario from a single study is representative for a realistic BADGE exposure to day in the EU.

8. Information on alternatives

Summary:

Different alternatives to BPA are available. Polyether sulfone among others might replace *polycarbonates* e.g. for watering pitchers and for other uses where hard, unbreakable and transparent plastic is requested. Other possibilities can be polystyrene, high impact polystyrene, PMMA (polymethyl methacrylate, Plexiglas), ABS (Acrylonitrile butadiene styrene) and polyester (e.g. PET: polyethylene terephthalate), but these materials have difficulties for some uses, e.g. lower strength and shorter life. There are alternative options to polycarbonate baby bottles, such as baby bottle made of polyethylene (PE), polypropylene (PP) or glass. BPA-free alternatives might be used in *thermal paper*, but most contain other bisphenols, such as bisphenol S (BPS). 19 alternatives was mentioned for *epoxy resin uses*, among those polyesters, vinyl and glass, but whether an alternative is suitable for an application depends also on technical requirements, so an alternative would only be suitable for some applications.

Except for the use in baby bottles and similar products, BPA is often replaced by other bisphenols, but due to the uncertainties and their possibly endocrine disruption effects these aspects have to be clarified before decision can be made whether these bisphenols are suitable alternatives.

In general information on effects of the alternatives were scarce and not fully covered, thus no effects mentioned cannot be taken to mean that the alternative can be considered as a safe alternative to BPA.

Replacements of PC in food contact seem possible within a short period – and some did already replace e.g. PC infant bottles with alternatives. On the other hand the substitution of BPA in thermal paper seems possible, but might have some technical difficulties and replacing BPA-based can coatings with others not bisphenol containing parts seems to be about 4-7 years ahead.

8.1 Alternatives identified for polycarbonates

Use: Polyether sulfone is like polycarbonate a type of plastic suitable for beverage cans and other containers because the plastic is hard, unbreakable and transparent. But it contains BPS, which can be released from polyether sulfone, like BPA can from polycarbonate (Simoneau et al, 2012).

Besides the alternatives mentioned in appendix 3, table A3.1 **bisphenol AF (BPAF)** is a fluorinated derivative of BPA, which is used in polycarbonate copolymers in high-temperature composites, electronic materials, gas-permeable membranes, and specialty polymer applications (Li et al, 2012).

Alternatives to transparent polycarbonate can be **polystyrene**, high impact polystyrene, **PMMA** (polymethyl methacrylate, Plexiglas), **ABS** (Acrylonitrile butadiene styrene) and polyester (e.g. **PET**: polyethylene terephthalate). However, all these materials have lower strength and shorter life. PMMA is used as glass in many applications in society and could be able to replace polycarbonate pretending glass. The disadvantage of PMMA is it like glass has sharp edges when broken (KemI, 2012B).

There are a number of alternative options to polycarbonate baby bottles, including: baby bottles or baby bottle liners (flexible plastic inserts) made of **polyethylene (PE)** or **polypropylene (PP)** or other plastics not made with bisphenol A monomer, and **glass** baby bottles (Environment Canada,

2012). In addition also **pyrex glass** is seen to be used e.g. as a food contact material. The alternatives are given in appendix 3, table A3.1.

Remarks on risks: Bisphenol AF (**BPAF**) is a fluorinated derivative of BPA used in polycarbonate copolymers in high-temperature composites, electronic materials, gas-permeable membranes, and specialty polymer applications. A research on the oestrogenic actions of the endocrine disrupting chemicals BPA, bisphenol AF (BPAF), and zearalenone showing that all three substances act as strong agonists of an oestrogen receptor. The researchers used three human cell lines from the cervix, liver and uterus to evaluate the promoter activity of the chemicals on two oestrogen receptors. They found that all three chemicals showed strong oestrogenic activity via one type of receptor in a dose-dependent manner. At lower concentrations, BPA acted as an antagonist for the receptor in one cell type and BPAF acted as an antagonist for another receptor in another cell. They also found evidence of activation of specific genes and signalling pathways downstream of one of the receptors. They conclude their results show that BPA and BPAF can function as endocrine disrupting chemicals via different mechanisms in certain cell types, which demonstrates the mechanistic importance of considering cell type specificity in evaluating endocrine disrupting activities (Li et al, 2012).

BPS is discussed below, due to its use also in thermal papers. No further information on effects was given on the other alternatives, see appendix 3, table A3.1.

8.2 Alternatives identified for use in thermal papers

Use: Under ECHA CoRAP, part (Community Rolling Action Plan), (ECHA, 2012B) KemI, Sweden, has identified 17 different chemicals which can replace BPA in thermal paper. It has been confirmed that five of these are available on the Swedish market. There are classifications data available for twelve of them. Several of the alternatives are classified as hazardous to human health or the environment. Suppliers and manufacturer of thermal paper speaks of BPA-free and bisphenol-free paper. BPA is usually replaced by bisphenol S (BPS), which possibly also has endocrine disrupting effects. Others contain neither BPA nor BPS, but usually Pergafast 201. The manufacturers who were willing to provide chemicals information to the alternative which uses the color developer has confirmed that there are BPA-free alternatives available on the Swedish market. One reported that the BPA-free paper contain urea-based materials instead of phenols (KemI's remark: Pergafast 201, BTUM and Urea Urethane Compound are based on urea) (KemI, 2012A). No information regarding reproductive toxicity was available in REACH on the urea containing compounds appendix 3, table A3.3. The study has only been able to confirm that two of the alternative color developers to BPA are used in the cash receipts for the Swedish market (BPS and Pergafast 201). Thus only 2 of the five alternatives available on the Swedish market were clearly marked in the report from KemI. If BTUM and Urea Urethane Compound are among the other 3 is not clear. The alternatives are given in appendix 3, table A3.2 and A3.3.

Further remarks on risks: **BPS** as an alternative to BPA has not been investigated to the same extent as BPA. However, a number of studies show that the BPS has endocrine disrupting effects. Other studies have studied the degradation of BPS. These show that the BPS is more persistence in the environment than BPA, both in freshwater and seawater KemI, (2012A).

In a preliminary QSAR study both **BPF** and **BPS** are predicted to be very biologically active with respect to enzymatic systems and metabolism. Both BPS and BPF are experimentally tested positive for estrogen *in vitro* binding and reporter gene and the data is part of the training sets of the models. BPF has also been tested positive for androgen receptor antagonism and BPS is predicted negative for this endpoint. A few weak positive flags, but no clear positive predictions for BPF and BPS were obtained in a number of models related to reproductive toxicity. However, BPF was predicted positive in a model for *Drosophila* sex-linked recessive lethal *in vivo* effect, which detects mutations in the germ line of the insect. Furthermore, BPF was predicted active in genotoxicity models for *in vitro* chromosomal aberrations (in Chinese hamster lung) and UDS (unscheduled DNA synthesis), but the substance was predicted negative in models for Ames, Ashby fragments, and a number of other *in vitro* and *in vivo* genotoxicity endpoints. BPS was predicted negative or

equivocal in all models for genotoxicity and tested negative experimentally for Ames (DTU FOOD, 2012, personal communication).

In 3 tests of *in vitro* testing for estrogenic effect used 3 different *in vitro* test systems the results indicate broadly similar estrogenic potential for both BPS and BPF as for BPA. Based on the overall preliminary information available the other **BPs** should not be recommended as alternatives to BPA (DTU FOOD, 2011).

These are the main conclusions, but further data are given on the substances in appendix 3, table A3.6.

8.3 Alternatives identified for epoxy resin uses

19 alternatives was mentioned by ANSES (2012) for epoxy resin uses, among those polyesters, vinyl and glass, but whether an alternative is suitable for an application depends also on technical requirements, so a mentioned alternative would only be suitable for some applications. The 19 alternatives are given in appendix 3, table A3.4.

In addition to the mentioned substances above other substances (Propoxylated bisphenol A and BFDGE) is mentioned as a possible alternative for BPA in toners and inks. One is Propoxylated bisphenol A, which is mentioned under ECHA's CoRAP, part (Community Rolling Action Plan), as a substance for evaluation in the future as there is a suspicion that its use could pose a risk to human health or the environment (ECHA, 2012C), see appendix 3, table A3.5. Substituting with these 2 substances may not solve the problem according to endocrine risks from migration of monomers as they are also bisphenols, which might have the similar effects like BPA.

8.4 Exposure example, biomonitoring of alternative to BPA.

BPS: 315 urine samples from people in the U.S., China, India, Japan, Korea, Kuwait, Malaysia and Vietnam were analyzed for content of bisphenol S. The substance was found in 81% of the samples. The content varied from below the detection limit to 21 nanograms / millilitre. People in Japan had the most bisphenol S in urine, followed by people from USA and China (Liao et al 2012 a). The results indicate that human exposure to BPS is ubiquitous. Relatively higher concentrations of BPS found in urine samples from Japan and the U.S. than in other countries suggest widespread use of BPS as a replacement for BPA in various applications in these countries. The median estimated daily intake of BPS was 0.009 and 0.004 µg/kg bw/day for children and adults (based on nominal body weights of 30 and 60 kg), respectively, which is below the reference dose of 50 µg/kg bw/day set for BPA by several environmental organizations, including the U.S. EPA (Liao et al 2012 a). BPS is used e.g. in thermal paper for receipts, bills and paper for food contact (Liao et al 2012 b). The sources for the BPS exposure may be many. Receipts are expected to be the largest source of BPS and it is believed that people will increasingly be exposed to it, as it substitutes for bisphenol A (Liao et al 2012 b).

These findings indicate that BPA is often replaced by other bisphenols, but due to the uncertainties and their possibly endocrine disrupting effects it does not seem to be replacements reducing the risks remarkable.

8.5 Examples of economic, etc. consequences on substitution and use of alternatives

Remarks received from the industry and available in the literature are mainly on the difficulties replacing BPA in can coatings. Any potential substitutes require a lengthy process of testing and validation, for each food type, through the whole supply chain and must prove that the required shelf life (typically three years) can be achieved. There is no single formulation that can be used with all different types of food and drink, which is why there are so many specifications in existence (Campbell Soup, 2012). It takes 4 to 7 years to meet the requirements and there is no readily available, suitable alternative to BPA-based can coatings that meets the essential safety and performance requirements for the broadest spectrum of foods now packaged in metal containers

(LaKind, 2012; Nampa, 2012 and Empac, 2012). These are the main parts, but further information is given in appendix 3, table A3.7.

Socio-economic factors discussed by the authority in Canada, report that several retailers have voluntarily removed PC plastic baby bottles containing bisphenol A from their store shelves. Substitutes that exist for PC plastic baby bottles include bottles or bottle liners made of polyethylene (PE) or polypropylene (PP) or other plastics not made with bisphenol A monomer, and glass baby bottles. The retail price of baby bottles varies significantly and the glass bottles is often more expensive than the plastic bottles (Environment Canada, 2012).

Different other comments on the process are available to given in appendix 3, table A3.8.

Based on these remarks, replacements of PC in food contact seems doable within a short period – and some did already replace e.g. PC infant bottles with alternatives. The substitution of BPA in thermal paper seems possible according to KemI (2012B), but according to INERIS (2010) it has some technical difficulties. In the other end replacing BPA-based can coatings with others not bisphenol containing parts seems to be about 4-7 years ahead.

9. Overall conclusions

BPA, have been extensively studied. Both its environmental and human health effects are well investigated. Exposure assessments, migration data and biomonitoring studies are also to a great extent available. However, huge amounts of BPA are used worldwide each year and the population is being exposed from many sources during their daily lives, including from food contact materials, toys, goggles, PC-discs, cash receipts and recycled paper among others.

BPA migration to food from food contact materials has been thoroughly examined and based on data and assumptions on intake of the food items BPA exposure from food intake is the dominant source to BPA exposure. Infants and children in the age group of 1.5-4.5 years are considered to be the most highly exposed group. On the other hand biomonitoring data in general indicate considerable lower exposures than have been calculated from scenarios using BPA migration data and data on food intake. The highest exposure in biomonitoring studies has been found for Japanese children where exposures up to 40% of the calculated exposure levels were reported.

Few studies are available from BPA exposure from other articles and in the literature there was no collection of measured BPA migration from articles. Therefore, in this survey the studies have been collected especially with focus on recent studies from 2011 and 2012. The total collection is shown in appendix 1, table A1.8. Overall, the BPA-exposure from articles is less well defined compared to exposure from food contact material, and although exposures from the various articles may be lower, they may become more relevant if the TDI value in future should be lowered.

Risk assessment based on the current human exposure to BPA, also in relation to worst case exposures indicate no concern as the exposure is considered well below the current TDI value of 50 µg BPA/kg bw/day.

However, the basis for this TDI value has been intensively debated among experts and authorities, as this value does not take into account experimental animal studies observing neurobehavioral changes and effects on the reproductive system in offspring at very low dose levels. The need to consider these findings have been expressed in a foot note to the EU risk assessment (EU RAR, 2010) and in a minority statement in the EFSA (2010) opinion, as well as in publications and statements from authorities and scientific institutes from France, Sweden and Denmark (ANSES, 2011; Beronius and Hanberg, 2012; DTU Food, 2010).

Therefore the risk assessment scenario may change if the TDI in future should be set on the basis of effects from the low-dose studies e.g. at a level of 0.01 and 0.8 µg BPA/kg bw/day as indicated by the Swedish report by Beronius and Hanberg (2012). If the TDI would be lowered the exposure from BPA from food contact material would still be of primary concern, but also exposures from other types of articles - which today are considered rather negligible - may then be of greater concern.

It is uncertain to which extent recent restrictions to BPA in food contact material have influenced the current exposure. Therefore, to get a more updated and realistic impression of the overall BPA exposure of the different age groups and especially small children more biomonitoring studies is needed. In order to target specific exposures reliable exposure scenarios have to be generated using

BPA migration data and realistic exposure assumptions for the various exposure sources e.g. the broad variety of articles.

Investigation on alternatives finds that BPA is often replaced by other bisphenols. Adequately information on their toxicological properties is lacking, but due to their possibly endocrine disrupting effects they do not seem to be suitable alternatives.

It seems that replacements of PC in food contact materials are possible within a short period – and some have already replaced e.g. PC infant bottles with glass or plastic alternatives without bisphenol.

The substitution of BPA in thermal paper seems possible according to KemI (2012B), but according to INERIS (2010) it has some technical difficulties.

Replacing BPA-based can coatings with non bisphenol containing alternatives seems to be about 4-7 years away.

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Abbreviations

ABS	Acrylonitrile butadiene styrene
ADI	Acceptable Daily Intake
AF	Assessment Factor
ART	Assisted Reproductive Technology
B	Bioaccumulation
BADGE	Bisphenol-A-diglycidylether
BCF	Bioconcentration Factor
BMC	Benchmark Concentration
BMD	Benchmark Dose
BMF	Biomagnification Factor
BOD	Biochemical Oxygen Demand
BP	Bisphenol
BPA	Bisphenol A
BPAF	Bisphenol AF
BPF	Bisphenol F
BPS	Bisphenol S
bw	body weight / Bw, bw
CA	Chromosome Aberration
CA	Competent Authority
CAS	Chemical Abstract Services
CAS	Continuous Activated Sludge
CEN	European Standards Organisation / European Committee for Normalisation
CEF	Panel on food contact materials, enzymes, flavourings and processing aids
CMR	Carcinogenic, Mutagenic and toxic to Reproduction
CNS	Central Nervous System
CoRAP	Community Rolling Action Plan
dw	dry weight / dw
DG	Directorate General
DIN	Deutsche Industrie Norm (German norm)
DNA	Deoxyribo Nucleic Acid
DNEL	Derived No-Effect Level
EC	European Communities
EC10	Effect Concentration measured as 10% effect
EC50	median Effect Concentration
ECB	European Chemicals Bureau
ECETO	European Centre for Ecotoxicology and Toxicology of Chemicals
ECHA	European Chemicals Agency
EDC	Endocrine Disrupting Chemical
EEC	European Economic Communities
EFSA	European Food Safety Authority
EINECS	European Inventory of Existing Commercial Chemical Substances
ELINCS	European List of New Chemical Substances
EN	European Norm
EPA	Environmental Protection Agency (USA)

EPDM	Ethylene/Propylene Dimer
EU	European Union
EUSES	European Union System for the Evaluation of Substances [software tool in support of the Technical Guidance Document on risk assessment]
EVA	Ethylene Vinyl Acetate
FAO	Food and Agriculture Organisation of the United Nations
FCM	Food Contact Material
HPLC	High Pressure Liquid Chromatography
IARC	International Agency for Research on Cancer
IC	Industrial Category
IC50	median Immobilisation Concentration or median Inhibitory Concentration
IUCLID	International Uniform Chemical Information Database (existing substances)
IUPAC	International Union for Pure and Applied Chemistry
Koc	organic carbon normalised distribution coefficient
Kow	octanol/water partition coefficient
Kp	solids-water partition coefficient
L(E)C50	median Lethal (Effect) Concentration
LC50	median Lethal Concentration
LD50	median Lethal Dose
LEV	Local Exhaust Ventilation
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observed Effect Level
LOQ	Limits Of Quantification
MOE	Margin of Exposure
MOS	Margin of Safety
MW	Molecular Weight
N	Dangerous for the environment (Symbols and indications of danger for dangerous substances and preparations according to Annex II of Directive 67/548/EEC)
n	Number (and here the number of repeating units in the molecule)
NAEL	No Adverse Effect Level
NAEOL	No Adverse Effect Observed level
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NOEC	No Observed Effect Concentration
NTP	National Toxicology Program (USA)
O	Oxidizing (Symbols and indications of danger for dangerous substances and preparations according to Annex II of Directive 67/548/EEC)
OC	Organic Carbon content
OECD	Organisation for Economic Cooperation and Development
OEL	Occupational Exposure Limit
OJ	Official Journal
P	Persistent
PBT	Persistent, Bioaccumulative and Toxic
PBT	Polybutylene Terephthalate
PC	Polycarbonate (a plast material)
PEC	Predicted Environmental Concentration
PET	Polyethylene Terephthalate
pH	Logarithm (to the base 10) (of the hydrogen ion concentration {H ⁺ })
PMMA	Polymethyl Methacrylate (also known as Plexiglas)
PNEC	Predicted No Effect Concentration
PP	Polypropylene

PVC	Polyvinylchloride (a plast material)
QSAR	(Quantitative) Structure-Activity Relationship
R phrases	Risk phrases according to Annex III of Directive 67/548/EEC
RAR	Risk Assessment Report
RC	Risk Characterization
RCR	Risk Characterization Ratio
RfD	Reference Dose
S phrases	Safety phrases according to Annex IV of Directive 67/548/EEC
SAR	Structure-Activity Relationships
SETAC	Society of Environmental Toxicology And Chemistry
SML	Specific Migration Limit
SSD	Species Sensitivity Distribution
STP	Sewage Treatment Plant
T	Toxic (Symbols and indications of danger for dangerous substances and preparations according to Annex II of Directive 67/548/EEC)
TDI	Tolerable Daily Intake
TG	Test Guideline
TGD	Technical Guidance Document
TNO	The Netherlands Organisation for Applied Scientific Research
TRV	Toxicity Reference Values
UC	Use Category
UDS	Unscheduled DNA Synthesis
UN	United Nations
UNEP	United Nations Environment Programme
US EPA	Environmental Protection Agency, USA
UV	Ultraviolet Region of Spectrum
vB	very Bioaccumulative
VOC	Volatile Organic Compound
vP	very Persistent
vPvB	very Persistent and very Bioaccumulative v/v volume per volume ratio
w/w	weight per weight ratio
WHO	World Health Organization
WWTP	Waste Water Treatment Plant
Xi	Irritant (Symbols and indications of danger for dangerous substances and preparations according to Annex II of Directive 67/548/EEC)

Appendix 1; Exposure

TABLE A1.1
RELEASES TO THE ENVIRONMENT, BPA.

Country and reference	Information and comments
EU EU (2010). RAR,	<p>Figures on EU-part:</p> <p><u>Total continental environmental releases (all BPA processes included):</u></p> <ul style="list-style-type: none"> • Air: 14,449 kg/year • Emission to wastewater treatment plants: 1,594 kg/year • Emission to receiving waters: 21,260 kg/year • Releases to soil: 145,800 kg/year <p><u>Environmental releases from bisphenol-A production sites (ranges from 6 sites):</u></p> <ul style="list-style-type: none"> • To air (dust included): 0.0605 to 575 kg/year • To effluent (After wastewater treatment): 6.8 to 113 kg/year • With flow rates to the receiving water of: 8.64 x 10⁶ to 6.1 x 10⁸ m³/day <p><u>Other releases to the environment from raw material handling and compounding:</u></p> <ul style="list-style-type: none"> • A loss during raw material handling of 0.01% of solid waste as residue in bags will also occur. • Losses during compounding: initial losses will be to atmosphere, but ultimately particulates will be removed or will settle, and vapours will condense, resulting in losses to both solid waste and aqueous washings. For powders of particle size > 40 µm losses to solid waste/water of 0.01% are estimated. For low volatility compounds losses of 0.002% are estimated.
Canada Environment Canada (2012).	<p>Releases of bisphenol A may occur during production, processing, use or disposal of the substance or products containing it. Unintentional release of fugitive dust from closed systems during handling and transportation of the substance may also occur. Elevated temperatures that occur during some processing operations could lead to possible emission of gaseous bisphenol A from manufacturing facilities or during heating of end products. The National Pollutant Release Inventory (NPRI) indicates that where information was provided, on-site industrial releases of bisphenol A in Canada were solely to air. However, based on its physical and chemical properties and compartments to which it is released, the results of Level III fugacity modelling suggest that bisphenol A is expected to partition predominantly to soil or water.</p> <p>The industrial sectors that did report emissions and disposals of bisphenol A to the NPRI included the manufacturers of motor vehicles, coatings, plastic products, resins, synthetic rubber and fiber and filaments, basic chemical manufacturing and foundries. Air releases reported to NPRI ranged from 0.04 to 8.77 tonnes annually, over the period of 1999 to 2006; although there is no temporal trend in emissions. The 2006 data indicated that only two companies released a total of 159 kg to air from a stack or point source. Off-site disposals of bisphenol A reported to the NPRI ranged from 1.2 to 14 tonnes, with no temporal trend, over the same years, with 2.9 tonnes being reported for year 2006.</p> <p>The NPRI reporting criteria for bisphenol A are 10 tonnes manufacture, process or otherwise used, with an equal to or greater than 1% by weight concentration, and ten full-time employees at that facility for a given calendar year. It is important to note that once a reporting facility meets all of the criteria noted above, they are obligated under CEPA 1999 to report all on-site releases (air, water,</p>

Country and reference	Information and comments
	<p>and land), on-site and off-site disposals, and transfers off-site for recycling. Based on information obtained from the NPRI, many facilities that reported for bisphenol A reported releases on site to air, but did not report any releases to water. This was mainly due to the fact that facilities which reported for this substance either do not have on-site releases of this substance to water or the quantity of releases to water were less than 1 kg (the current reporting system only allows reporting to this amount).</p> <p>Based on its moderate water solubility and low vapour pressure, wastewaters and washing residue generated during production and processing of application materials such as polycarbonates and epoxy resins are the most likely sources of release of bisphenol A into the Canadian environment. Release over the service life of end products may occur through volatilization or leaching. The majority of bisphenol A appears to be effectively retained within the polymer matrix of materials such as polycarbonates and therefore losses through leaching from the product surface are expected to be limited. As well, the low vapour pressure suggests bisphenol A will have little tendency to volatilize from products at normal environmental temperatures. Some losses could occur at elevated temperatures.</p> <p>Bisphenol A may enter the environment through physical and chemical degradation of end products during disposal and recycling operations. Releases would be primarily to soil, and to a lesser extent, to water and air. Bisphenol A has been identified in groundwater samples collected in the vicinity of municipal landfills. Soil and groundwater exposure may also occur through weathering and breakdown of end products, particularly those with outdoor applications. Bisphenol A present in wastewater sludge could be released into the soil compartment through application of sludge biosolids to agricultural and pasture lands.</p>

TABLE A1.2
ENVIRONMENTAL FATE, BPA.

Subject	Information and comments
Abiotic degradation	The physical and chemical properties of BPA suggest that hydrolysis and photolysis are likely to be negligible. A short atmospheric half-life of 0.2 days is calculated for the reaction of BPA with hydroxyl radicals (EU RAR, 2010).
Biodegradation	<p>Fresh surface waters: It is concluded that BPA is readily biodegradable in natural fresh surface waters.</p> <p>Soil: It is concluded that BPA is readily biodegradable in soil (EU RAR, 2010).</p>
Distribution	BPA is likely to be moderately adsorbed to solids upon release to the environment. Volatilisation is not considered to be a significant removal mechanism for BPA from water. Removal of BPA in rainwater is also considered to be negligible (EU RAR, 2010).
Akkumulation and metabolism	<p>Fish: The data suggested that BPA has a low potential for bioaccumulation in fish, in contrast to the moderate potential indicated by the log Kow value. A BCF of 67 for fish was used in the risk assessment.</p> <p>Clams: A slightly higher potential was indicated by the measured bioconcentration in freshwater clams (up to 144), and this accumulation in clams was considered in the risk characterisation.</p> <p>Earthworms: A bioconcentration factor for earthworms of 7.9 kg/kg was estimated using QSARs (EU RAR, 2010).</p>

TABLE A1.3
PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC'S), BPA.

Subject	Information and comments
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Subject	Information and comments
Surface water	PEC _{Freshwater} range from 0.032 (4 different sites) to 1.47 µg/l (phenoplast cast resin processing site).
Marine water	PEC _{Marinewater} range from 0.032 (4 different sites) to 1.2 µg/l (phenoplast cast resin processing site).
Sediment	PEC _{sediment} range from (1.23-1.7) x 10 ⁻⁶ (processing of epoxy resins) to (5.75-7.9) x 10 ⁻³ mg/kg wwt (Acrylonitrile butadiene styrene (ABS) compounding). WWT stands for waste water Treatment.
Terrestrial compartment	PEC _{soil} range from 0.1 (PVC additive package site) to 880 µg/kg wwt (thermal paper recycling site with deinking).
Microorganisms and air	There are no PEC values for microorganisms (PEC _{microorganisms}) and for air, as there were no risks for either of these compartments (EU RAR, 2010).

TABLE A1.4
PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC'S), BPA.

Subject	Information and comments
freshwater	PEC _{Fish} range from 2.2 (BPA production site) to 36 µg/kg (phenoplast cast resin processing site).
Marine water	PEC _{Predator} range from 0.2 (3 sites) to 28 µg/kg (phenoplast cast resin processing site).
Soil	PEC _{worms} range from 1.2 (PVC – antioxidant site during processing) to 237 µg/kg (paper sludge at thermal paper recycling site with deinking), (EU RAR, 2010).

TABLE A1.5
ESTIMATES OF DAILY INGESTION OF BPA FROM FOOD CONTACT APPLICATIONS OF EPOXY-RESINS (EU RAR, 2010).
UPDATED ESTIMATES BASED ON DATA FROM THE EFSA (2006).

Source of exposure	Daily intake of wine (l) or canned food	Concentration of BPA in wine	Daily ingestion of BPA (µg/day)
Wine	0.75	10	7.5
Canned beverages (adult)	2	10	20
Canned food (adult)	1.0	50	50
Canned food + beverages (adult)	1 kg food	50 µg/kg food	70
	2 l beverages (including	10 µg/l beverages	
Canned food and beverages (infant 6-12 months)	0.375	100	37.5
Canned food and beverages (young child 1.5-4.5 years)	2	50	100

TABLE A1.6

LEVELS OF BPA IN FOOD CONTACT MATERIALS TAKEN FORWARD TO THE RISK CHARACTERIZATION IN THE EU ASSESSMENT (EU RAR, 2010). UPDATED ESTIMATES BASED ON DATA FROM THE EFSA (2006).

Source of exposure	Daily ingestion of BPA (mg/day)	Estimated body burden (mg/kg/day)
Infant feeding bottles (1-2 month baby)	0.035	0.008
Infant feeding bottles (4-6 month baby)	0.050	0.007
Canned food and beverages (infant 6-12 months)	0.0375	0.0043
Canned food and beverages (young child 1.5-4.5 years)	0.100	0.009
Canned food (adult)	0.050	8x10 ⁻⁴
Canned beverages (adult)	0.020	3x10 ⁻⁴
Wine (adult)	0.010	1.7x10 ⁻⁴
Canned food and beverages including wine (adult)	0.070	0.00125
Polycarbonate tableware (young child, 1.5-4.5 years)	0.010	9x10 ⁻⁴
Polycarbonate tableware (adult)	0.015	2.5x10 ⁻⁴
Canned food and beverages + polycarbonate tableware (young child, 1.5-4.5 years)	0.110	0.01
Canned food and beverages + polycarbonate tableware (adult)	0.085	0.00150

TABLE A1.7

OCCURRENCE DATA FOR BPA IN FOOD AND BEVERAGES (TABLE 19; WHO, 2010).

Matrix / Reference	Concentration (µg/l or µg/kg)		Number of samples
	Average	Maximum	
Human breast milk (Ye et al., 2006)	1.9	7.3	20
Liquid milk formula, ready to feed^a			
Cao et al. (2008)	5.1	10.2	3
Ackerman et al. (2010)	5.05	10	39
Goodson, Summerfield & Cooper (2002)	<2	<2	4
<i>Overall</i>	4	10	46
Liquid milk formula, concentrate^a			
Ackerman et al. (2010)	5.71	11	38
Biles, McNeal & Begley (1997)	2.6	6.1	14
EWG (2007)	1.2	8.5	6
Cao et al. (2008)	2.6	5.1	18
<i>Overall</i>	3.0	11	74
Liquid milk formula, overall^a	3.5	11	120
Powdered milk formula^a (Ackerman et al., 2010)	0.09	0.4	26
Infant food, glass jars (Cao et al., 2009)			
Desserts	0.38	0.83	9

Fruits	0.6	3.7	26
Meats	1.1	7.2	25
Vegetables	1.2	7.2	39
<i>Overall</i>	0.82	7.2	99
Canned food, solid^b			
Fruits	9.8	—	70
Vegetables	32.4	—	305
Grains	42.7	—	22
Meat (no soups or seafood)	69.6	—	70
Soups	49.1	—	66
Seafood	26.6	—	166
Desserts	26.7	—	11
<i>Overall</i>	36.7	—	710
Canned food, liquid^b			
Drinks, carbonated (cola, beer, soda, tonic)	1.0	—	128
Drinks, non-carbonated (tea, coffee, other)	23.2	—	131
Migration from PC			
Baby bottles (Maragou et al., 2008)	—	15	6
Tableware (Kawamura et al., 1998)	—	2	3
Tap water and bottled water^c			
	—	1	>100

^a Expressed as consumed.

^b Brotons et al. (1995); Horie et al. (1999); Kawamura, Sano & Yamada (1999); Imanaka et al. (2001); Yoshida et al. (2001); Goodson, Summerfield & Cooper (2002); Kataoka, Ise & Narimatsu (2002); Kang & Kondo (2003); Braunrath et al. (2005); Munguia-Lopez et al. (2005); Thomson & Grounds (2005); Maragou et al. (2006); Sun et al. (2006); EWG (2007); Podlipna & Cichna-Markl (2007); Poustka et al. (2007); Sajiki et al. (2007); Shao et al. (2007); Garcia-Prieto et al. (2008); Grumetto et al. (2008); Yonekubo, Hayakawa & Sajiki (2008); Bendito et al. (2009); Cao, Corriveau & Popovic (2009a, 2010a,b); Consumers Union (2009); Rastkari et al. (2010); Vinas et al. (2010).

^c Biles et al. (1997); Ghijsen & Hoogenboezem (2000); Kuch & Ballschmiter (2001); Inoue et al. (2002); Boyd et al. (2003); Casajuana & Lacorte (2003); Rodriguez-Mozaz, López De Alda & Barceló (2004); Stackelberg et al. (2004); Szymanski & Wasiak (2004); Rykowska, Shao et al. (2005); Jiang et al. (2006); Szymanski, Rykowska & Wasiak (2006); Loos et al. (2007); Cao & Corriveau (2008c); L. Li et al. (2008); X. Li et al. (2010); Sodré, Locatelli & Jardim (2010); Wang & Schnute (2010); Amiridou & Voutsas (2011).

TABLE A1.8
EXAMPLES OF MEASURED BPA AMOUNTS IN ARTICLES.

Product reference	Measured amount in material	Migrated amount from material	Information and comments
Baby Bottles (RIVM, 2012)	-	BPA traces (below 0.0050 mg/L).	Netherlands: New and used baby bottles were investigated on the migration of BPA in distilled water and 3% acetic acid (2005 or before). For all new and nearly all used baby bottles no migration of BPA was detectable in distilled water as well as in 3% acetic acid. In 4 used bottles traces migration of BPA were detected in distilled water. The migration of BPA from these baby bottles was far below the present and future specific migration limit (respectively 3 mg/kg and 0.6 mg/kg). The migration was also tenfold lower than the SML of the European standard EN 14350-2.
Paper and board (RIVM, 2012)	-	<0.03 to 1.8 mg/kg	Netherlands: Analysis of different types of paper and board showed BPA was present at various levels. The samples were of different types, e.g. cake cases, chocolate boxes, sugar bags, meat savers and egg cases (2003 or before). The content of BPA varied from not detectable (<0.03 mg/kg) up to 50 mg/kg with an average of 1.8 mg/kg. The amounts of BPA found in the samples are not

Product reference	Measured amount in material	Migrated amount from material	Information and comments
			likely to exceed the migration limit (15 mg/kg) as regulated in the Dutch Packaging and Food-Utensils Regulation (Food and Commodities Act). The Specific Migration Limit (0.6 mg/kg) as set by the Scientific Committee on Food, based on a temporary Tolerable Daily Intake (tTDI) for BPA, was exceeded. Paperboard manufactured from recycled fibres contained significantly more BPA than paperboards manufactured from virgin fibres.
18 dummies ("rubber part") BfR (2009).	-	0.2 µg bisphenol A/dummy/hour (In 1 out of 18)	German market: 18 dummies from various manufacturers and brands made of latex and silicone were examined for bisphenol A. The release of 4 µg/l BPA (which equals 0.2 µg BPA per dummy and hour) was detected in one dummy, only. None of the other 17 dummies released any BPA. According to BfR estimates, the dummies examined cover around 70 % of the manufacturers on the German market. As, according to information from the manufacturers, no BPA is used in the production of latex and silicone dummies, the presence of BPA in the soft parts of the dummy is unexpected. The levels of BPA in the dummy mouth shields do not correspond to the available data either.
Dummy shield (PC) Tønning et al (2009)	106-280 mg/kg	0-7 mg/kg	Danish market: BPA content was found in PC shields in 5 dummies (screening analyze). 2 shields with high content were selected for migration analyzes in sweat and saliva. The lowest (n.d. mg BPA/kg shield) was seen in saliva and sweat. The highest (7 mg BPA/kg shield) was seen in sweat.
Dummy Shield (PC) Lassen et al (2011)	-	0.12-0.49 mg/kg	Danish market: Migration of BPA from PC shields in 8 dummies was analyzed in sweat and saliva. BPA migration was seen in 2 shields. The lowest (0.12 mg BPA/kg shield) was seen in saliva. The highest (0.49 mg BPA/kg shield) was seen in sweat.
Thermo paper (cash receipts) Lassen et al (2011)	37-17000 mg/kg	7-21 µg/cm ² /5 sec	Danish market: Migration of BPA from 13 cash receipts was analyzed in sweat. BPA content and migration was found in 9 receipts.
Ear pad in headset (EVA-foam) Receiver house w. loudspeaker (PC/PBT)	0.13 mg/kg	-	Danish market: Migration of BPA from headphones and hearing protection aids. Only the BPA content the materials were analyzed. BPA was found in these 5 parts listed here. The material parts mentioned refers to: ABS (acrylonitrile-butadiene-styrene), EPDM (ethylene/propylene dimer), EVA (ethylene vinyl acetate) PBT (polybutylene terephthalate), PP (polypropylene) Schmidt et al (2008).
Ear pad in headset (EVA-foam)	3.2 mg/kg	-	
Earpiece (ABS)	0.9 mg/kg	-	
	1.9 mg/kg	-	

Product reference	Measured amount in material	Migrated amount from material	Information and comments
Ear hook/spring band, soft (PP/EPDM)	6.4 mg/kg	-	
BPA in toys and child care articles (KemI, 2012B)			
CD-disc (PC)	350 mg/kg	n.d. (ng/cm ²)	Sweden: BPA content was measured in 24 articles, mainly in polycarbonate (PC) but some also in epoxy. These first 14 parts with BPA were measured by the laboratory SP (Sveriges Tekniska Provningsinstitut). The material type was indicated. No migration was detected.
Sword (PUR)	15 mg/kg	n.d. (ng/cm ²)	
Water Bottle (PC)	600 mg/kg	n.d. (ng/cm ²)	
Sticker (Epoxy)	280 mg/kg	n.d. (ng/cm ²)	
Sticker (Epoxy)	50 mg/kg	n.d. (ng/cm ²)	
Goggles (PC)	590 mg/kg	n.d. (ng/cm ²)	
Block (PC)	600 mg/kg	n.d. (ng/cm ²)	
Kit Parts (PC)	260 mg/kg	n.d. (ng/cm ²)	
Window (PC)	350 mg/kg	n.d. (ng/cm ²)	
Astronauts Visor (PC)	190 mg/kg	n.d. (ng/cm ²)	
Police Visor (PC)	190 mg/kg	n.d. (ng/cm ²)	
Motorcycle Windshield (PC)	190 mg/kg	n.d. (ng/cm ²)	
Helmet Visors (PC)	600 mg/kg	n.d. (ng/cm ²)	
Kits Parts (PC)	500 mg/kg	n.d. (ng/cm ²)	
Pacifier	1,1 mg/kg	< 0,10 (µg/l)	At the laboratory ALS Scandinavia AB, 24 products were analyzed for content and migration of BPA. In these ten of the 24 products content and/or migration of BPA were seen. The material type was not indicated in these samples.
Rattle	< 1,0 mg/kg	0,14 (µg/l)	
Cyclops	27 mg/kg	1,1 (µg/l)	
Police Motorcycle	40 mg/kg	< 0,45 (µg/l)	
Police Motorcycle	160 mg/kg	0,77 (µg/l)	
Rattle	200 mg/kg	2,1 (µg/l)	
Goggles	82 mg/kg	0,38 (µg/l)	

Product reference	Measured amount in material	Migrated amount from material	Information and comments
Goggles	1,1 mg/kg	< 0,10 (µg/l)	
Pacifier	21 mg/kg	2,1 (µg/l)	
Rattle	< 1,0 mg/kg	0,14 (µg/l)	
Paper & board	<0.03 – 50 mg/kg		<p>Netherlands:</p> <p>Analysis of different types of paper and board showed BPA was present at various levels. The content of BPA varied from not detectable (<0.03 mg/kg) up to 50 mg/kg with an average of 1.8 mg/kg. The amounts of BPA found in the samples are not likely to exceed the migration limit (15 mg/kg) as regulated in the Dutch Packaging and Food-Utensils Regulation (Food and Commodities Act). The Specific Migration Limit (0.6 mg/kg) as set by the Scientific Committee on Food, based on a temporary Tolerable Daily Intake (tTDI) for BPA, was exceeded. Paperboard manufactured from recycled fibres contained significantly more Bisphenol-A than paperboards manufactured from virgin fibres (RIVM, 2012).</p>

TABLE A1.9
EXAMPLES OF MEASURED BPA AMOUNTS IN INDOOR DUST.

Product & substance	Information and comments
Indoor dust BPA	<p>US and several asian countries (indoor dust samples):</p> <p>Concentrations of BPA in 158 dust samples ranged from below the limits of quantification (<LOQ) to 39100 ng/g (Wang et al., 2012).</p>
Indoor dust BPA	<p>US (indoor dust samples):</p> <p>< 0,2 – 17,6 µg BPA/g (median = 0,821 µg BPA/g). 120 U.S. homes measured in 1999-2001. The dust sample is collected through a vacuum cleaner from 4-5 of the most used rooms in the home (Rudel et al., 2003).</p>
Indoor dust BPA	<p>Belgium (indoor dust samples):</p> <p>0.535– 9.729 µg BPA/g (median = 1.461 µg BPA/g). 18 homes and 2 offices measured in 2008. The dust sample is dust collected from living room, bedroom and kitchen. The concentration in the offices were 4.685 – 8.380 µg BPA/g (Geens et al., 2009).</p>
Indoor dust BPA	<p>12 countries around the world (indoor dust samples):</p> <p>South Africa, Tanzania, Kenya, Uganda, the Philippines, Malaysia, Sweden, Belgium, Germany, Czech Republic, Hungary and Italy. It is not indicated when the samples was taken. The highest concentration was 0.0247 µg BPA/g and was taken in Philippines (Reported in Andersen et al., 2012).</p>

TABLE A1.10
EXAMPLES OF MEASURED BISPHENOL-A-DIGLYCIDYLETHER POLYMER AND MONOMERS AMOUNTS.

Product & substance	Migrated amount from material	Information and comments
Can coatings BADGE	Approx. 0.1 mg/kg	<p>Netherlands:</p> <p>In 2004 the market surveillance was repeated on the migration of bisphenol-A-diglycidyl ether (BADGE) and bisphenol-F-diglycidyl ether (BFDGE) derivatives from can coatings to fish. These epoxy derivatives are being used in can coatings, both as starting substance as well as</p>

Product & substance	Migrated amount from material	Information and comments
		<p>additive. The method was suitable to determine these substances in fish in oil and fish in aqueous sauces. A total of 64 cans of fish was samples and analysed. All samples complied with the migration limit of 1 mg/kg food. In 9 cans epoxy derivatives were detected: 6 cans contained BADGE derivatives in amount of approximately 0.1 mg/kg; 3 cans contained BFDGE derivatives up to 0.6 mg/kg. This market surveillance was also performed in 2001 and 2002. The number of samples was small in all surveillances; therefore it is not possible to draw hard conclusions on a change in market situation. However, a trend is visible that all cans now comply with the legal migration limits (RIVM, 2012).</p>
Indoor dust BADGE		<p>US, China, Korea and Japan (Indoor dust samples): Bisphenol A diglycidyl ether (BADGE) is widely present in food packages and material coatings, but little is known about the occurrence of the compound in indoor dust. 158 indoor dust samples were collected from the U.S., China, Korea, and Japan and the concentrations of BADGE and its three hydrolysis products (BADGE·H₂O, BADGE·2H₂O, and BADGE·HCl·H₂O) were determined. All of the target compounds were found in dust samples from four countries. Geometric mean concentrations of BADGEs in dust ranged from 1300 to 2890 ng/g among four countries. BADGE·2H₂O, and BADGE·HCl·H₂O were the predominant BADGE compounds found in dust samples. This is the first report of BADGE and its hydrolysis products (BADGEs) in indoor dust samples. The estimated daily intake for BADGEs was 6.5 ng/kg-bw/day through dust ingestion (Wang et al., 2012).</p>
Dental sealants Bisphenol-A-diglycidylether BPA		<p>Resin Dental Sealants and Bisphenol A Oral Exposure. In 1996, Nicolas Olea and coworkers at the University of Granada in Spain reported detectable levels of bisphenol A (BPA) in the saliva of patients treated with dental sealants.</p> <p><u>What is the Source of BPA in Dental Sealants?:</u> Composite resins are formulated from a mixture of monomers and are most commonly based on bisphenol A glycidyl methacrylate, Dental sealants typically contain monomers that are derived from BPA, such as bis-GMA and bis-DMA, but there is no known use of BPA itself in dental sealants. Since it is known that these monomers may leach from dental sealants, the stability of the monomers has been studied under a variety of conditions, including in saliva, to determine if they may hydrolyze to form BPA. Bis-GMA, the base monomer for many composite resins, has been found to be stable to various hydrolytic conditions (origin from Schmalz et al, 1999 reported in Bisphenol A org., 2012). However, two researchers have reported that bis-DMA is hydrolyzed to BPA, which likely accounts for the BPA detected in extracts from certain sealants (origin from Schmalz et al, 1999; Atkinson et al, 2002 reported in Bisphenol A org., 2012).</p> <p>The highest amount of BPA reported in saliva by Olea, 931 µg, forms the basis for the calculation of potential exposure and margin of safety. This quantity was reported in saliva after the application of one brand of dental sealant in one individual in a single study. Further studies by other researchers have reported much lower levels of BPA and have suggested that BPA may have been misidentified in the Olea study due to interferences in the analytical method. In addition, no detectable amounts of BPA were found in the blood, indicating that while some BPA may leach into saliva, systemic exposure does not occur (Bisphenol A org., 2012).</p>
Dental sealants		<p>BPA can become part of dental composites or sealants in three ways: as a direct ingredient, as a by-product of other ingredients in dental composites or sealants that may have</p>

Product & substance	Migrated amount from material	Information and comments
Bisphenol-A-diglycidylether BPA		<p>degraded, and as a trace material left-over from the manufacture of other ingredients used in dental composites or sealants. E.g. Bis-DMA-containing materials can release very small quantities of BPA because bis-DMA is subject to degradation by salivary enzymes.</p> <p>To put the exposure from dental materials into perspective, consider the exposure that occurs from the placement of six dental sealants containing bis-GMA in a child (7 to 14 years of age). The estimated one time exposure (upon sealant placement) for a male child of median body weight (51 to 112 pounds) is approximately 5.5 micrograms, which is two to five times lower than the estimated daily exposure from food and environmental sources. ADA (2012).</p>
Dental composites BPA-based		<p>Bisphenol A (BPA)-based dental composites have commonly been used to fill dental cavities or seal pits and fissures on teeth. However, epidemiological evidence with regard to the BPA exposure from dental composites among children has rarely been reported. This study investigated whether there is a relationship between the BPA concentration in urine and the presence of composite restorations and sealants among South Korean children. Oral examinations and urine sample analyses were conducted on a total of 495 children aged 8-9 years. We classified the participants into four groups by the number of resin composites and sealant surfaces (0, 1-5, 6-10 and 11+).</p> <p>BPA concentrations in urine were higher in children with 11 or more surfaces restored with sealants and resin composites than in those with zero restored surfaces, although no difference was seen in the group with 1-10 surfaces. After adjusting for gender and age, the urinary BPA concentration in children with 11 or more resin composite surfaces was 2.67 µg/g creatinine, which was higher than the concentration found in those with no filling surfaces (P < 0.01). Conclusion: Having many dental composite filling surfaces on teeth may increase the urinary BPA concentration in children (Chung et al. 2012).</p>

TABLE A1.11
COMPONENTS OF COMBINED EXPOSURE, **BPA** PROVIDED FOR WORST CASE COMBINED EXPOSURE (EU RAR, 2010).

Source of exposure	Exposure (µg/kg bw/day)
As a consumer (oral exposure from canned food and canned beverages and from polycarbonate tableware and storage containers)	1.45
<u>Indirect exposure via the environment:</u>	
Regional	9.1 x 10 ⁻³
Local	41
Total, Regional	1.45
Total, Local	43

Appendix 2; Environmental hazard

TABLE A2.1

ENVIRONMENTAL EFFECTS; **MICROORGANISMS**; AQUATIC COMPARTMENT; **BPA** (EU RAR, 2010).

Species	Effect conc.	Endpoint	Source
<i>Pseudomonas putida</i>	320 mg/l	Growth(NOEC)(18h)	DOW, 1988
<i>Pseudomonas fluorescens</i>	52 mg/l	Growth(IC ₅₀)	Stone and Watkinson (1983)

TABLE A2.2

ENVIRONMENTAL EFFECTS; **PRIMARY PRODUCERS**; AQUATIC COMPARTMENT; **BPA** (EU RAR, 2010)..

Species (Freshwater)	Effect conc.	Endpoint	Source
<i>Pseudokirchneriella subcapitata</i>	2.73 mg/l	Growth(EC ₅₀)(96h)(cell count)	Alexander et al. (1985b)
<i>Pseudokirchneriella subcapitata</i>	3.10 mg/l	Growth(EC ₅₀)(96h)(cell volume)	Alexander et al. (1988)
<i>Pseudokirchneriella subcapitata</i>	2.50 mg/l	Growth(EC ₅₀)(96h)(cell count)	Stevenson (1983)
<i>Lemna gibba</i>	7.8 mg/l	frond density, biomass and growth rate(NOEC)(7d)	Putt (2003)

Species (Marine)	Effect conc.	Endpoint	Source
<i>Skeletonema costatum</i>	1.0 mg/l	Growth(EC ₅₀)(96h)(cell count)	Springborn Bionomics Inc. (1985c)
<i>Skeletonema costatum</i>	1.8 mg/l	Growth(EC ₅₀)(96h)(chlorophyll content)	Springborn Bionomics Inc. (1985c)
<i>Nannochloropsis oculata</i>	3.00 mg/l	Growth(NOEC)(12d)(cell count)	Ishii et al. (2003)

TABLE A2.3

ENVIRONMENTAL EFFECTS; FRESHWATER SPECIES; AQUATIC COMPARTMENT; BPA (EU RAR, 2010).

Species (Freshwater)	Effect conc.	Endpoint	Source
<i>Heteromyenia</i> sp. (porifera)	1.6 mg/l	Growth(NOEC) (9d)	Hill <i>et al.</i> (2002)
<i>Heteromyenia</i> sp. (porifera)	16.0 mg/l	Growth(LOEC) (9d)	Hill <i>et al.</i> (2002)
<i>Hydra vulgaris</i> (cnidaria)	6.90 mg/l	Mortality(LC ₅₀) (96h)	Pascoe <i>et al.</i> (2002)
<i>Hydra vulgaris</i>	42 µg/l	(NOEC) (6 week) (polyp structure)	Pascoe <i>et al.</i> (2002)
<i>Brachionus calyciflorus</i> (rotifera)	1.8 mg/l	Reproduction(NOEC) (48h)	Springborn Smithers, 2006a
<i>Marisa cornuarietis</i> (Gastropoda)	25 µg/l (25-640 µg/l)	Growth(NOEC) (60d)	Warbritton <i>et al.</i> , 2007b
<i>Potamopyrgus antipodarum</i>	100 µg/l	Growth and embryo production(NOEC) (90d)	Jobling <i>et al.</i> (2004)
<i>Daphnia magna</i>	3.9 mg/l	Immobilization(EC50) (48h)	Stephenson (1983)
<i>Daphnia magna</i>	10.0 mg/l	Immobilization(EC50) (48h)	Chen <i>et al.</i> (2002)
<i>Daphnia magna</i>	12.8 mg/l	Immobilization(EC50) (48h)	Hirano <i>et al.</i> (2004)
<i>Daphnia magna</i>	≥3.15 mg/l	Reproduction(NOEC) (21d)	Bayer AG (1996)
<i>Daphnia magna</i>	1.3 mg/l	Female fecundity(NOEC) (21d)	Mu <i>et al.</i> (2005)
<i>Daphnia magna</i>	0.2 mg/l	Mortality(EC10) (21d)	Brennan <i>et al.</i> (2006)
<i>Gammarus pulex</i> (amphipoda)	1.5 mg/l	Mortality(LC50) (120h)	Watts <i>et al.</i> (2001a)
<i>Hyalella azteca</i> (amphipoda)	0.49 mg/l	No of offspring(NOEC) (42d)	Springborn Smithers (2006b)
<i>Cyprinus carpio</i> (teleost)	100 µg/l	Growth(NOEC) (49d)	Bowmer and Gimeno (2001)
<i>Danio rerio</i> (teleost)	0.76 mg/l	Fertilization rate(NOEC) (life-cycle)	Schäfers <i>et al.</i> (2001)
<i>Danio rerio</i> (teleost)	750 µg/l	Growth, Behavior and Fertilization success (NOEC) (life-cycle)	Segner <i>et al.</i> (2003a)
<i>Oncorhynchus mykiss</i> (teleost)	3.64 mg/l	Growth(NOEC) (28d)	Bayer AG (1999b)
<i>Oncorhynchus mykiss</i> (teleost)	11.0 mg/l	Growth(LOEC) (28d)	Bayer AG (1999b)
<i>Oryzia latipez</i> (teleost)	247 µg/l	Multiple endpoints(NOEC) (life-cycle)	Japanese Ministry of the Environment (2006)
<i>Pimephales promelas</i> (teleost)	16 µg/l	Hatchability(NOEC) (life-cycle)	Sumpter <i>et al.</i> (2001) (Rhodes <i>et al.</i> , 2007).
<i>Xenopus laevis</i> (Amphibia)	500 µg/l	Larval survival(NOEC) (90d)	Pickford <i>et al.</i> (2003)

TABLE A2.4
ENVIRONMENTAL EFFECTS; **MARINE SPECIES**; AQUATIC COMPARTMENT; **BPA** (EU RAR, 2010).

Species (Marine)	Effect conc.	Endpoint	Source
<i>Capitella sp.</i> (Annelida)	11.5 µg/l	Settlement and metamorphosis(EC50)(1h)	Biggers and Laufer (2004)
<i>Nucella lapillus</i> (Gastropoda)	1 µg/l	Endocrine disruption(LOEC)(3 months)	Oehlmann <i>et al.</i> , 2000
<i>Acartia tonsa</i> (Crustacea)	3.4-5.0 mg/l	Immobilization(EC50)(48h)	Andersen <i>et al.</i> (1999)
<i>Americamysis bahia</i> (Crustacea)	1.1 mg/l	Mortality(LC50)(96h)	Springborn Bionomics, (1985b; Alexander <i>et al.</i> , (1988)
<i>Americamysis bahia</i>	0.51 mg/l	Mortality(NOEC)(96h)	As above
<i>Strongylocentrotus purpuratus</i> (Echinodermata)	0.23 mg/l	Embryonal development(EC50)(96h)	Roepke <i>et al.</i> (2005)
<i>Strongylocentrotus nudus</i> (Echinodermata)	0.71 mg/l	Embryonal development(NOEC)(96h)	Kiyomoto <i>et al.</i> (2006)

TABLE A2.5
EXAMPLES OF ENVIRONMENTAL ASSESSMENTS OF BISPHENOL-A-DIGLYCIDYLETHER POLYMER 25036-25-3 (INCL. BADGE)

Examples of environmental assessments

BADGE is an isomer of the polymer 25036-25-3. Data taken up in this profile are based on BADGE (EC DG ENV, 2002) :

Abiotic degradation: When released to the atmosphere BADGE might be degraded by photochemically activated hydroxyl radicals. Atmospheric half-life is expected to be 1.92 hours. Furthermore, BADGE is very stable against thermal and hydrolytic breakdown.

Biotic degradation: BADGE is assumed to be inherently biodegradable.

Bioconcentration: Based on a BCF value of 182.1, BADGE has the ability to accumulate in organisms. However, due to the fact that BADGE (and hence 25036-25-3 probably as well) is inherently biodegradable, the concern about bioaccumulation is low.

Use, exposure and emissions: BADGE is solely used in closed systems, however, workers involved in manufacturing and industrial application might be exposed through skin or through inhalation of dust e.g. during bag filling and charging of epoxy resins from bags in the manufacturing process of paint. Assumed is that workers take the precautions needed to prevent exposure.

During in-house measurements for epoxy powder applications carried out by the United Kingdom powder manufacturing industry, the range of personal exposure across four companies for all activities was 0.3 – 10 mg/m³, as 8h time weighted average, for all activities. Based on the assumption that epoxy powder paints typically contain 25-30% of epoxy resins and that powder coating grade epoxy resins contain between 5-10% BADGE, this would correspond to a typical BADGE exposure of 0.0009-0.3 mg/m³.

Exposure of the general public might occur as a consequence of BADGE containing consumer goods. The major consumer exposure to BADGE is from food and drink cans lined with epoxy based coatings while

Examples of environmental assessments

minor volumes of liquid epoxy resins are used in two-component epoxy glues sold to public in retailer shops. A number of studies have investigated the migration of BADGE from coated food and drink cans. In 2001 the United Kingdom Food Standards Agency (FSA) conducted a marker survey of BADGE in canned food. Migration levels of BADGE detected in the canned foodstuff were 0.1 mg/kg food. Using information on European consumption pattern for canned food, the total surface areas of cans and the UK FSA survey data, 2002, calculated per capita exposure to BADGE is 3.0-8.0 µg per person per day, hence 0.05-0.13 µg/kg body weight (assumed a standard person weighs 60 kg). The major sources of exposure appear to arise from canned vegetables (48%), canned fish (18%) and ready meals (5%). Other studies, 2001, using a Monte Carlo Simulation estimated an average exposure of 0.004 µg/kg bodyweight per person per day. With a maximum of 0.19 µg/kg bodyweight per person per day.

Summary of environmental fate: If released to air, BADGE is expected to solely exist in the vapour phase. It has low volatility and is removed from atmosphere through wet or dry deposition. When released to water, 25036-25-3 is assumed to absorb particulate matter and sediment. When released to soil, absorption to the humic fraction is suspected. Leaching to the groundwater compartment is not expected.

Vulnerable groups and vulnerable use: Workers involved in the manufacturing and industrial application might be exposed to 25036-25-3 through skin contact or through inhalation of dust (e.g. bag filling). General public might be exposed as a consequence of the use of BADGE in and on consumer goods, especially through food packages.

Environmental concentrations: No measured environmental (aquatic, terrestrial or aerial) exposure data have been obtained on searches of the COMMPS database and literature sources. Release of BADGE to the environment through manufacturing sites is expected to be low because they are used in a closed system. Furthermore an environmental release of BADGE (and hence 25036-25-3 as well) from end-use application is unlikely to occur as epoxy resins are reacted with hardeners/curing agents into cross linked systems which are stable against thermal and hydrolytic breakdown. This taken with the fact that BADGE is inherently biodegradable reduces concern about any possible environmental accumulation.

Conclusions: The use or origin of 25036-25-3 remains a bit uncertain. It is supposed to be inherently biodegradable but not bioaccumulative. Human exposure is expected through food (leaching from food packaging) and through other consumer goods like baby toys etc. 25036-25-3 is categorized as a high exposure concern compound.

Appendix 3; Alternatives

TABLE A 3.1
POTENTIAL ALTERNATIVES TO BPA-BASED POLYCARBONATE AND AVAILABLE TOXICOLOGICAL DATA (RECAST AND TRANSLATED VERSION AFTER ANSES, 2012A).

Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI S	NT P	US EPA	
Polyphenylsulfone	-	-	-	-	-	-	-
Polyethersulfone	-	-	-	-	-	-	-
Polyamide 6,6	-	-	-	-	-	-	-
Polyamide 11	-	-	-	-	-	-	-
Polyamide 12	-	-	-	-	-	-	-
High density polyethylene	-	-	-	-	-	-	-
Low density polyethylene	-	-	-	-	-	-	-
Polypropylene	-	-	-	-	-	-	-
Copolyester Tritan®	-	-	-	-	-	-	-
Polyethylene terephthalate (PET)	-	-	-	-	-	-	-
Isosorbide	652-67-5	NC	Absence of detailed studies, only a summary of toxicological studies is available	No	No	No	No
Ecozen®	-	-	-	-	-	-	-
Polyetherimide	-	-	-	-	-	-	-
Polylactic acid/poly lactide (PLA)	-	-	-	-	-	-	-
TOPAS IT X1	-	-	-	-	-	-	-

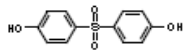
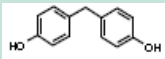
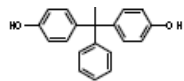
Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI	NT	US	
				S	P	EP	A
Melamine	108-78-1	NC	OECD-test 414 + reproduction (1-generation) and development Studies	IUC LID 200 0	Yes	No	No
Acrylonitrile butadiene styrene (ABS)	-	-	-	-	-	-	-
Glass	-	-	-	-	-	-	-
Stainless steel	-	-	-	-	-	-	-
Silicone	-	-	-	-	-	-	-
Ceramic	-	-	-	-	-	-	-

-): Information not available due to no CAS number.

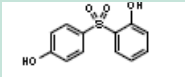
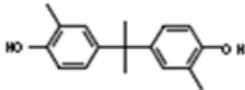
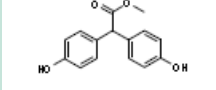
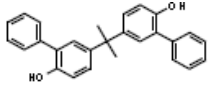
NC: No classification available.

TABLE A3.2

BPA ALTERNATIVES **FOR USE IN THERMAL PAPERS**. POSSIBLE COLOR DEVELOPER IN THERMAL PAPER (REVISED FROM THE LIST PUBLISHED ON SWEDEN EPA'S WEBSITE IN NOVEMBER 2011). THE 2 KNOWN ALTERNATIVES AVAILABLE ON THE SWEDISH MARKET IN BOLD. CLASSIFICATION INCLUDED (RECAST AND TRANSLATED VERSION AFTER KEMI, 2012A).

Alternative substance	CAS No.	Molecular formula	Classification	Explanation	Structure formula
Bisphenol S	80-09-1	C ₁₂ H ₁₀ O ₄ S	H319 H412	Causes serious eye irritation Harmful to aquatic life with long lasting effects	
Bisphenol F (para)	620-92-8	C ₁₃ H ₁₂ O ₂	H315 H317 H319 H335 H412	Causes skin irritation May cause an allergic skin reaction Causes serious eye irritation May cause respiratory irritation Harmful to aquatic life with long lasting effects	
Bisphenol AP	1571-75-1	C ₂₀ H ₁₈ O ₂	-	-	

Alternative substance	CAS No.	Molecular formula	Classification	Explanation	Structure formula
2,2'-diallyl-4,4'-sulfonyldiphenol (TGSA)	41481-66-7	C ₁₈ H ₁₈ O ₄ S	H317 H411	May cause an allergic skin reaction Toxic to aquatic life with long lasting effects	
4-(4-isopropoxyphenylsulfonyl)phenol (D8)	95235-30-6	C ₁₅ H ₁₆ O ₄ S	H411	Toxic to aquatic life with long lasting effects	
Phenol, 4-[[4-(2-propen-1-yloxy)phenyl]sulfonyl] (BPS-MAE)	97042-18-7	C ₁₄ H ₁₂ O ₄ S	-	-	
4,4'-methylenebis-(oxyethylenethio)diphenol	93589-69-6	C ₁₇ H ₂₀ O ₄ S ₂	H411	Toxic to aquatic life with long lasting effects	
Phenol, 4,4'-sulfonylbis-, polymer with 1,1'-oxybis[2-chloroethane] (D90)	191680-83-8	N=2; C ₄₄ H ₄₂ O ₁₄ S ₃	-	-	
4-hydroxy benzoate benzyl (PHBB; Bensyl-paraben)	94-18-8	C ₁₄ H ₁₂ O ₃	H315 H319 H335 H411	Causes skin irritation Causes serious eye irritation May cause respiratory irritation Toxic to aquatic life with long lasting effects	
N-(p-toluene sulfonyl)-N'-(3 p-toluenesulfonyloxyphenyl) urea (Pergafast 201)	232938-43-1	C ₂₁ H ₂₀ N ₂ O ₆ S	H411	Toxic to aquatic life with long lasting effects	
p-[[p-benzyloxy phenyl]sulfonyl]phenol (BPS-MPE)	63134-33-8	C ₁₉ H ₁₆ O ₄ S	H302 H312 H315 H319 H332	Harmful if swallowed Harmful in contact with skin Causes skin irritation Causes serious eye irritation Harmful if inhaled	
Urea Urethane Compound	321860-75-7	C ₄₂ H ₃₆ N ₆ O ₈ S	-	-	
4,4'-bis(N-carbamoyl-4-methylbenzenesulfonamide)diphenylmethane (BTUM)	151882-81-4	C ₂₇ H ₂₄ N ₄ O ₆ S ₂	H351	Suspected of causing cancer	

Alternative substance	CAS No.	Molecular formula	Classification	Explanation	Structure formula
o-[(4-hydroxyphenyl)sulfonyl]phenol	5397-34-2	C ₁₂ H ₁₀ O ₄ S	H302 H312 H314 H332 H341	Harmful if swallowed Harmful in contact with skin Causes severe skin burns and eye damage Harmful if inhaled Suspected of causing genetic defects	
4,4'-isopropylidenedi-ocresol (Bisphenol C)	79-97-0	C ₁₇ H ₂₀ O ₂	H315 H319 H335 H341 H373	Causes skin irritation Causes serious eye irritation May cause respiratory irritation Suspected of causing genetic defects May cause damage to organs through prolonged or repeated exposure	
bis(4-hydroxyphenyl) acetate de methyle (MBHA)	5129-00-0	C ₁₅ H ₁₄ O ₄	-	-	
4,4'-Isopropylidene bis(2-phenylphenol) (Bis-OPP-A)	24038-68-4	C ₂₇ H ₂₄ O ₂	H315 H319	Causes skin irritation Causes serious eye irritation	

-): Information not available.

TABLE A3.3
POTENTIAL ALTERNATIVES TO BPA IN **THERMAL PAPERS** AND AVAILABLE TOXICOLOGICAL DATA (RECAST AND TRANSLATED VERSION AFTER ANSES, 2012A). 13 ALTERNATIVES NOT INCLUDED IN KEMI (2012A) MARKET IN **BOLD**.

Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI S	NT P	US EPA	
Bisphenol S	80-09-1	NC	1 test OECD 421	No	No	Yes	Yes (24/06/2011)
Bisphenol F (para)	620-92-8	NC	No	No	No	Yes	Yes (15/07/2011)
Bisphenol F (ortho)	2467-02-9	NC	No	No	No	No	No
Bisphenol AP	1571-75-1	H400 H410	No	No	No	Yes	Yes (03/02/2012)
2,2'-diallyl-4,4'-sulfonyldiphenol (TGSA)	41481-66-7	H317 H411	No	No	No	Yes	No
4-(4-isopropoxy-	95235-30-	H411	No	No	No	Yes	No

Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI S	NT P	US EPA	
phenylsulfonyl)phenol (D8)	6						
Phenol, 4-[[4-(2-propen-1yloxy)phenyl]sulfonyl] (BPSMAE)	97042-18-7	NC	No	No	No	Yes	No
4-4'-methylenebis-(oxyethylenethio)diphenol	93589-69-6	H411	No	No	No	Yes	No
Phenol, 4,4'-sulfonylbis-, polymer with 1,1'-oxybis[2-chloroethane] (D90)	191680-83-8	NC	No	No	No	Yes	No
p-phenylphenol	92-69-3	NC	No	No	No	No	No
4,4'-thiobisphenol	2664-63-3	NC	No	No	No	Yes (utero-trophic test)	No
p-tert-butylphenol	98-54-4	NC	OECD tests 414, 416 and 422 + a study of 3 generations	EU RA R (2008); IUC LID (2000)	No	Yes	In Progress
4-hydroxy benzoate benzyl	94-18-8	NC	No	No	No	Yes	No
Ethyl 4-hydroxy benzoate	120-47-8	NC	No	No	No	Yes (utero-trophic test)	No
4-hydroxyphtalate dimethyl (DMP-OH)	22479-95-4	NC	No	No	No	No	No
3,5-Bis-tert-butylsalicylic acid	19715-19-6	NC	No	No	No	No	No
3,5-bis-α methyl benzylsalicylic acid	-	-	-	-	-	-	-
N-(p-toluene sulfonyl)-N'-(3 p-toluenesulfonylox	232938-43-1	H411	No	No	No	Yes	No

Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI S	NT P	US EPA	
phenyl) urea							
p-[[p-benzyloxy phenyl] sulfonyl]phenol	63134-33-8	NC	No	No	No	Yes	No
Urea Urethane Compound	321860-75-7	NC	No	No	No	Yes	No
4,4'-bis(N-carbamoyl-4-methylbenzenesulfonamide)diphenylmethane	151882-81-4	H351	No	No	No	Yes	No
o-[(4-hydroxyphenyl) sulfonyl]phenol	5397-34-2	NC	No	No	No	Yes	No
4,4'-isopropylidenedi-cresol	79-97-0	NC	No	No	No	Yes	No
bis(4-hydroxyphenyl) acetate de methyle (MBHA)	5129-00-0	NC	No	No	No	Yes	No
4,4'-Isopropylidenebis (2 phenylphenol)	24038-68-4	NC	No	No	No	Yes	No
6,6'-di-tert-butyl-4,4'-butylidenedi-m-cresol	85-60-9	NC	No	No	No	Yes	No
2,6-di-tert-butyl-p-cresol	128-37-0	NC	OECD 414 tests and 416 + studies on development of a generation of 2 generation, 3 generations and fertility	IUC LID (2000)	Yes	Yes	No
Octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate	2082-79-3	NC	OECD 414 tests and 416	IUC LID (2000)	No	Yes	No
pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate)	6683-19-8	NC	OECD 414 tests and 416	IUC LID (2000)	No	Yes	No
4,4',4''-(1-methyl-1-	1843-03-	NC	No	No	No	Yes (utero-trophic	No

Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI S	NT P	US EPA	
propanyl-3-ylidene)tris[6-tert-butyl-m-Cresol	4					test)	
1,2-diphenoxyethane	104-66-5	NC	No	No	No	No	No

-): Information not available due to no CAS number.

NC: No classification available.

H317: May cause an allergic skin reaction

H351: Suspected of causing cancer

H400: Very toxic to aquatic life

H410: Very toxic to aquatic life with long lasting effects

H411: Toxic to aquatic life with long lasting effects

OECD 414: Prenatal Developmental Toxicity Study

OECD 416: Two-Generation Reproduction Toxicity

OECD 421: Reproduction/Developmental Toxicity Screening Test

OECD 422: Combined Repeated Dose Toxicity Study with the Reproduction/Developmental Toxicity Screening Test

TABLE A3.4

POTENTIAL ALTERNATIVES TO **EPOXY RESINS** AND AVAILABLE TOXICOLOGICAL DATA (RECAST AND TRANSLATED VERSION AFTER ANSES, 2012A).

Alternative substance	CAS No.	Classification CLP	Reproductive toxicity data available in REACH	Toxicological evaluations existing.			Toxicological Profile from ANSES
				ESI S	NT P	US EP A	
Polyesters	-	-	-	-	-	-	-
Polykoat®	-	-	-	-	-	-	-
Polypropylene carbonate	-	-	-	-	-	-	-
oleoresins	-	-	-	-	-	-	-
Resin ChemSuD	-	-	-	-	-	-	-
Biolignin	-	-	-	-	-	-	-
Souplethane WP	-	-	-	-	-	-	-
Verdanol	-	-	-	-	-	-	-
UV-L Eco-Resin	-	-	-	-	-	-	-
Resin SPR	-	-	-	-	-	-	-
Isosorbide	652-67-5	NC	Absence of detailed studies, only a summary of toxicological studies is available	No	No	No	No
Polyacrylates	-	-	-	-	-	-	-
Polyethylene terephthalate (PET)	-	-	-	-	-	-	-
acrylic	-	-	-	-	-	-	-
Vinyl	-	-	-	-	-	-	-
Glass	-	-	-	-	-	-	-
TetraPack®	-	-	-	-	-	-	-
Doypack®	-	-	-	-	-	-	-
Reduced migration of BPA	-	-	-	-	-	-	-

-): Information not available due to no CAS number.

NC: No classification available.

TABLE A3.5
OTHER BPA ALTERNATIVES; EPOXY RESINS

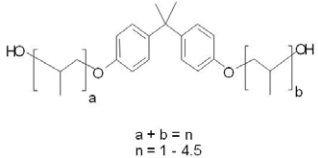
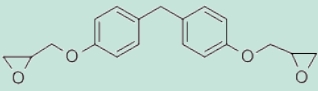
Alternative substance	CAS No.	Comment	Structure formula
'4,4'-Propane-2,2-diyl diphenol, polymer with 2-methyloxirane. (Propoxylated bisphenol A)	37353-75-6	CoRAP, ECHA. Substances for evaluation (ECHA, 2012C). Used in unsaturated polyester resins for glass fiber reinforcement, glass sizing and corrosion resistance, Toner resins, Electro deposition coatings, Epoxy Resins, Epoxy based coating according to different internet pages.	
Bisphenol F diglycidyl ether (BFDGE)		Both Bisphenol A diglycidyl ether (BADGE) and bisphenol F diglycidyl ether (BFDGE) is used as epoxide monomers in dental root canal filling cones (Klee, 2009).	

TABLE A3.6
REMARKS ON RISKS REGARDING ALTERNATIVES IN THERMAL PAPERS.

Substance and reference	Information and comments
Other bisphenols compared with BPA. (BPF & BPS). DTU FOOD (2011) and Personal communication with DTU FOOD (2012)	<p>Preliminary results from a QSAR study on BPF and BPS compared with BPA show:</p> <p>BPF is tested experimentally to be positive for binding to the estrogen receptor and for estrogen reporter gene activation as well as for androgen receptor antagonism, and the substance is part of the training sets of these models. This is in accordance with Bisphenol A, which has been tested positive for these three endpoints. BPF has a positive prediction for skin sensitization (BPA is tested positive). Although negative in the Ames and several other genotoxicity models, BPF was predicted to be active in some genotoxicity models (<i>in vitro</i> chromosomal aberration CHL and UDS rat hepatocytes and <i>in vivo</i> Drosophila melanogaster SLRL). BPF was predicted negative in models for male and female rats, positive for female mice and inconclusive for male mice.</p> <p>BPF is predicted to influence many enzymatic systems as well as several metabolic pathways, including predictions that the substance is a substrate and / or inhibitor of many CYP P450 enzymes. BPS is experimentally tested positive for <i>in vitro</i> estrogen binding and reporter gene activation, like BPA. BPS is predicted negative for <i>in vitro</i> antiandrogenicity. BPS has a positive prediction for skin sensitization (Bisphenol A is tested positive). BPS has negative or unclear ("equivocal") predictions in models for genotoxicity, both <i>in vitro</i> and <i>in vivo</i>. An experimental negative test is included in the model for Ames mutagenicity. Negative predictions of cancer in rats and mice in both males and females. No strong QSAR indications of developmental or reproductive effects. BPS is predicted to be a modulator of cholesterol synthesis. There were slight indications of adverse effects on the kidney and liver based on two different QSAR systems. The substance is predicted to influence many enzymatic systems as well as several metabolic pathways, including predictions that the substance is a substrate and / or inhibitor of many CYP P450 enzymes (DTU FOOD, 2012; Personal communication).</p> <p>In 3 tests of <i>in vitro</i> testing for estrogenic effect used 3 different <i>in vitro</i> test systems. Results indicate broadly similar estrogenic potential for both BPS and BPF as for BPA. One of the references investigated also acute toxicity in Daphnia and mutagenicity of 7 different BPs incl. BPA. There has been slight to moderate toxicity in Daphnia and no mutagenicity.</p> <p>Both Bisphenol F and S are in line with Bisphenol A being very biologically active with respect to enzymatic systems and metabolism. BPS is experimentally tested positive for estrogen <i>in vitro</i> binding and reporter gene. BPF has indications of effects in relation to sensitive developmental parameters. Unlike</p>

Substance and reference	Information and comments
	<p>BPA very few experimental test information are available on the substances on which to base hazard and risk assessments.</p> <p>Generally no studies were found concerning adverse effects such as endocrine disrupting effects on fetal development in experimental animals or toxicity studies. Based on the preliminary information available the other BPs should not be recommended as alternatives to BPA (DTU FOOD, 2011).</p>
<p>Bisphenol S (BPS) KemI, (2012A).</p>	<p>BPS is classified H319 (Causes serious eye irritation) and H412 (Harmful to aquatic life with long lasting effects). BPS has not been investigated to the same extent as BPA. However, a number of studies show that the BPS has endocrine disrupting effects. Other studies have studied the degradation of BPS. These show that the BPS is more persistence in the environment than BPA, both in freshwater and seawater.</p>
<p>Pergafast 201 KemI, (2012A). BASF (2011).</p>	<p>Pergafast 201 is classified H411 (toxic to aquatic life with long lasting effects). According to an assessment carried out by the Australian authorities in 2004 Pergafast 201 is toxic to aquatic organisms and not rapidly degradable in the environment. However, there is no indication that Pergafast 201 would be stored in the fatty tissues of animals. Pergafast 201 is not classified with health properties (KemI, 2012A). BASF has reported a summary of a Reproduction/Developmental Toxicity Screening Test in rats to US-EPA. Reproduction appears to be unaffected, but effects on liver and kidney of the adult animals are seen, and a lower body weight in the offspring (BASF, 2011).</p>
<p>US EPA (2012)</p>	<p>July 31, 2012 – Through its DfE program, EPA has released for comment the draft alternatives assessment "Bisphenol A (BPA) Alternatives in Thermal Paper", but marked with "DO NOT CITE OR QUOTE". The draft report was available for comment until October 1, 2012. On October 20th 2012 still no further information available.</p>

TABLE A3.7
REMARKS ON **SUBSTITUTION AND USE OF ALTERNATIVES: OPINOINS FROM INDUSTRIES**

From industries	Examples of comments
<p>Campbell Soup (2012)</p>	<p>"There are more than 1700 coating specifications in USA and more than 1000 in Europe that are used with a wide variety of foods and drinks. Any potential substitutes require a lengthy process of testing and validation, for each food type, through the whole supply chain and must prove that the required shelf life (typically three years) can be achieved. Campbell Soup state that substitutes will comply with international food safety regulations. These regulations are of course the same that already approve BPA. Coatings companies and can makers have tested hundreds of formulations and those that have shown signs of promise have been taken to industrial trials. It takes three years however to demonstrate that a three year shelf life can be achieved. Some of the industrial trials have failed to show that the required shelf life can be achieved. In such cases new trials with adjusted formulations must be started from the beginning. There is no single formulation that can be used with all different types of food and drink. That is why there are so many specifications in existence. It is highly misleading, in fact plain wrong, for campaigners to suggest that everything can be substituted now. "</p>
<p>Nampa (2012)</p>	<p>Nampa address difficulties related to the substitution of substances in can coatings and mention that it takes 4 to 7 years to meet the requirements. Similar period is also reported by LaKind (2012). "Currently, epoxy is used in one or more components of >90% of the metal packages produced in North America". "There is no readily available, suitable alternative to BPA-based can coatings that meets the essential safety and performance requirements for the broadest spectrum of foods now packaged in metal containers."</p>
<p>Empac (2012)</p>	<p>Empac address also difficulties related to the substitution of substances in can coatings and mention "Development and full performance and safety evaluation of alternatives through all the necessary stages from concept to proven commercial product can take many years – 5 years being typical,</p>

From industries	Examples of comments
	<p>even without failure at any stage.”; “For many products, risk assessment in combination with additional precautionary measures (e.g. reduced shelf life) shall continue for the coming years until alternatives are proven to be fully safe over the entire food product shelf life”.</p>

TABLE A3.8
REMARKS ON **SUBSTITUTION AND USE OF ALTERNATIVES: OPINOINS FROM AUTHORITIES**

From Authorities	Examples of comments
<p>Sweden KemI (2012A)</p>	<p>“The exposure of BPA from cash receipts is not adequately controlled and should therefore be regulated. However, a national ban on BPA would not limit the use of other chemical substances which may have an adverse impact on human health or the environment in cash receipts. Current knowledge of the alternatives is limited. It is therefore not possible to conclude that a regulation would lead to improved safety for human health.</p> <p>Without further measures, BPA would still be used in cash receipts and the knowledge of the exposure would remain uncertain. In KemI’s opinion, a regulation would facilitate and improve the information regarding which colour developers that are used in cash receipts. A national regulation may also motivate further product development and substitution as well as speed up the transition to electronic solutions. This may lead to safer products and use in business activities. A national regulation may also contribute to a European regulation and/or other national regulations.”</p>
<p>Canada Environment Canada (2012)</p>	<p>Socio-economic factors have been considered in the selection process for a regulation and/or instrument respecting preventive or control actions, and in the development of the risk management objective(s). Bisphenol A is not manufactured in Canada, however, Canadian firms reported import and use of bisphenol A in 2006, either alone, in a product, in a mixture or in a manufactured item.</p> <p>Preliminary analysis suggests that the revenue of the plastic bottle manufacturing industry was in excess of \$865 million in 2006, employing approximately 2800 persons in production, and almost 700 persons in non-manufacturing positions. A portion of this industry may manufacture repeat-use polycarbonate bottles, including baby bottles according to Statistics Canada, 2008.</p> <p>Several retailers have voluntarily removed polycarbonate plastic baby bottles containing bisphenol A from store shelves. Repeat-use polycarbonate bottles intended for other uses have also been removed by some retailers. Substitutes that exist for polycarbonate plastic baby bottles include bottles or bottle liners made of polyethylene (PE) or polypropylene (PP) or other plastics not made with bisphenol A monomer, and glass baby bottles. The retail price of baby bottles varies significantly; recent prices on one retailer's website indicate that the price of an 8-ounce polypropylene plastic baby bottle varies from \$1.29/bottle to \$9.99/bottle, and the price of an 8-ounce glass baby bottle varies from \$3.79/bottle to \$14.99/bottle. Baby formula (fresh, processed and bottled) manufacturing, and infants' formula manufacturing are included in the relatively large butter, cheese, and dry and condensed dairy products manufacturing industry. A portion of these sectors involve the use of infant formula cans which contain bisphenol A. Other industries on which the proposed risk management actions may have an economic impact include, but are not limited to: resin and synthetic rubber manufacturing, metal can manufacturing, and the fruit and vegetable canning, pickling and drying industry.</p> <p>An economic analysis will be conducted as part of instrument development. Where information is available, this analysis will identify economic factors as they relate to bisphenol A use and manufacture in Canada, including employment, and regional dispersion of industries that use bisphenol A in the manufacturing process. The analysis will also, where possible, identify potential replacements, the relative cost of these replacements, and the effect on Canadian industries of potential alternatives. Finally, the benefits of pursuing regulatory action will be identified, with a valuation of benefits conducted where possible.</p>

Appendix 4; Overview of risk managements

Many considerations and remarks are available on uses, risks, regulation and risk management of BPA and Bisphenol-A-diglycidylether polymer. A broad range over the world is given in table A4.1 below, but with priority on considerations from EU and US and national countries in front with legislation on BPA like Canada and Sweden.

Some main information is:

- BPA is considered as a substance that may be entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health. The basis of this conclusion is that the neurodevelopmental and behavioural dataset in rodents, is suggestive of potential effects at doses at the same order of magnitude to 1-2 orders of magnitude higher than exposures. Given that toxicokinetic and metabolism data indicate potential sensitivity to the pregnant woman/fetus and infant; and that animal studies suggest a trend towards heightened susceptibility during stages of development in rodents, it is considered appropriate to apply a precautionary approach when characterizing risk.
- BPA is entering or may be entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term effect on the environment or its biological diversity.
- BPA meets the criteria for persistence but does not meet the criteria for bioaccumulation as defined by the Persistence and Bioaccumulation Regulations made under CEPA 1999 (Environment Canada, 2012).
- Based on limited studies in laboratory animals, the pregnant woman/fetus and infant are potentially vulnerable subpopulations due to potential differences in the toxicokinetics and metabolism of bisphenol A. Based on the exposure estimates, infants were the most highly exposed subpopulation. This combination of both highest potential exposure and potential vulnerability led to the focus of risk management on decreasing exposures to newborns and infants under 18 months old (i.e., infant formula cans and some types of baby bottles), (Environment Canada, 2012). **A ban of BPA in sale of infant feeding bottles has been into force since 2008.**
- The EU ban on BPA in feeding bottles has resulted in a considerable reduction of exposure of small children to BPA. In addition, a switch to material free of BPA has started within different parts of the food sector (lids to baby food cans, beverage bottles and other household articles) and the fact that large users of thermo paper in the everyday commerce have **begun to switch to receipts without BPA**. Since alternative plastic materials as well as alternative antioxidants and stabilisers are available, there seems to be **no strong reasons for companies to return using BPA in toys and child care articles if they have discontinued doing so**. Humans are, however, still exposed to continuous exposure of BPA from, in many cases, unknown sources (KemI, 2012B).
- BPA can detach from the cash receipts and is absorbed into the body through the skin. Based on studies of dermal uptake of BPA and the measured amount of BPA in cash register receipts

KemI have calculated that a consumer can be expected to be exposed to **1µg BPA/ kg bw/day** (KemI, 2012A).

- ANSES proposes a new EU harmonized classification for BPA as reprotoxic for humans (Category 1B, H360F) and with a discussion of category 1A, (ANSES, 2012B).
- A recent report was used as a basis for KemI s investigation of risks from the use of BPA in cash register **receipts, toys and children's products/articles** as well as **in re-lining of water pipes**, which was conducted during summer 2012 on commission by the Swedish Government. The purpose of the report was to review and summarize animal studies that have examined the effects of exposure to low doses of bisphenol A (BPA) during early development and to identify at what doses these effects occur. The report also discusses how alternative reference doses of BPA can be calculated based on these data. Overall, the report concluded that although no single study reviewed here was considered reliable enough to serve as a key study for the derivation of an alternative reference dose, if the data is considered as a whole, effects are consistently observed at doses well below those which serve as the basis for the current TDI for BPA. Alternative reference doses calculated from the NOAELs/LOAELs range between **0.01 and 0.8 µg/kg bw/day** and are considerably lower than the current TDI of **50 µg/kg bw/day**. The lowest reference doses were calculated for developmental neurotoxicity. Even if confidence in a specific alternative reference dose based on this data material is low the results from this review indicate that considering a lower reference dose than the current TDI when conducting risk assessment of BPA may be prudent (Beronius and Hanberg, 2012).

Overview of status as present September, 2012

At present different countries and continental organisations are considering their future regulations on BPA and Bisphenol-A-diglycidylether polymers.

BPA is one of the most highly produced industrial chemicals globally and used e.g. for the manufacture of polycarbonate plastic and epoxy resins and as such used in a wide variety of consumer products/articles. Measured concentrations of BPA in human blood, urine and other tissues confirm that exposure is widespread in the general human population. It is generally believed that consumer exposure to BPA occurs primarily via food in contact with BPA-containing materials, such as polycarbonate baby bottles, tableware and food containers as well as food and beverage cans lined with epoxy resins. Recently, it has also been shown that BPA can be transferred to the skin from certain types of thermal printing paper, such as some types of cashier's receipts, in significant amounts (Biedermann et al., 2010, reported in KemI, 2012A).

Based on the wide variety of exposures from consumer products/articles and the fact that BPA is measured in the human body challenge countries and continental organisations over the world to take the right risk management actions in order to protect their population from possible risks posed by the exposure to BPA. The exposure includes residues of BPA monomers from Bisphenol-A-diglycidylether polymers as well, e.g. epoxy resins for lined cans, coatings (water pipes, etc.) and dental materials/epoxy adhesives.

Therefore many actions has been taken, e.g. ban of BPA in infant bottles (EU, some US states, Canada, China, Japan among others) and survey's about the BPA exposure to consumers is ongoing (e.g. from Sweden the extent to which BPA could be released from relining of pipes, expected by December 2013). And this survey has revealed that some countries are underway with some actions and evaluations, for example:

- US, FDA are seeking further public comment and external input on the science surrounding BPA (US FDA, 2012).
- Canada, research on the mechanism of action of bisphenol A and potential foetal exposures (Environment Canada, 2012).

- Canada, Environmental monitoring of bisphenol A in wastewater, landfill leachate, wildlife, fish and receiving waters (Environment Canada, 2012).
- Germany will publish its substance evaluation of bisphenol A in 2013 (BAUA, 2012).

New studies on the effect of BPA are constantly being released. About 10 studies with NOAEL or LOAEL values only from the period of 2011 to first half of 2012 was reported by Beronius and Hanberg (2012) and EFSA mentioned that about 30 BPA studies are released each months (Personal communication, 2012). Some governments consider new restrictions on BPA. For instance in April 2012 the Swedish Chemicals Agency was instructed by the Government to propose a ban on bisphenol A in thermal paper in a report on 29 June 2012 and to carry out a survey of the use of bisphenol A in toys and articles for children by September 2012.

If the new studies available, indicating effects of BPA in rodents at dose levels below the NOAEL of 5 mg/kg bw/day, results in a change of the current TDI to a lower TDI, the risk assessment scenario may change – and also for exposure which today are considered very low.

TABLE A4.1
REMARKS ON USE, RISKS, REGULATION AND RISK MANAGEMENT: BPA AND BISPHENOL-A-DIGLYCIDYLETHER POLYMER.

Substance and continent/country	Information and comments
Bisphenol A (BPA) EU	<p>Existing Risk Management:</p> <p>Food: In 2002, the European Scientific Committee on Food set a temporary tolerable daily intake of 10 µg/kg bw/day, (SCF, 2002). A re-evaluation in 2006 by the European Scientific Panel on food additives, flavourings, processing aids and materials in contact with foods set a tolerable daily intake of 50 µg/kg bw/day based on newer data and this TDI was reconfirmed in a later scientific opinion in 2008, (EFSA, 2008). Under The 2006 Plastic Materials and Articles in Contact with Food (England) Regulations, the amount of bisphenol A permitted to migrate from food contact materials into food was set at 0.6 mg/kg, (Food Standards Agency, 2007 seen in Environment Canada, 2012). For BADGE BADGE.H2O and Badge.2H2O the specific migration limit is 1 mg/kg (EUR LEX, 2012A).</p> <p>Cosmetics: Bisphenol A is listed in the EU Cosmetic Directive Annex II, a list of substances which must not form part of the composition of cosmetic products.</p>
Bisphenol A (BPA) US	<p>Food Contact Applications: FDA's Current Perspective on BPA: At this interim stage, FDA shares the perspective of the National Toxicology Program that recent studies provide reason for some concern about the potential effects of BPA on the brain, behaviour, and prostate gland of fetuses, infants and children. FDA also recognizes substantial uncertainties with respect to the overall interpretation of these studies and their potential implications for human health effects of BPA exposure. These uncertainties relate to issues such as the routes of exposure employed, the lack of consistency among some of the measured endpoints or results between studies, the relevance of some animal models to human health, differences in the metabolism (and detoxification) of and responses to BPA both at different ages and in different species, and limited or absent dose response information for some studies.</p> <p>FDA is pursuing additional studies to address the uncertainties in the findings, seeking public input and input from other expert agencies, and supporting a shift to a more robust regulatory framework for oversight of BPA to be able to respond quickly, if necessary, to protect the public.</p> <p>In addition, FDA is supporting reasonable steps to reduce human exposure to BPA, including actions by industry and recommendations to consumers on food preparation. At this time, FDA is not recommending that families change the use of infant formula or foods, as the benefit of a stable source of good nutrition outweighs the potential risk of BPA exposure (US FDA, 2012).</p>

Substance and continent/country	Information and comments
	<p>Existing Risk Management:</p> <p>Food: From Food and Drug Act (FDA): FDA is taking steps to reduce human exposure to BPA in the food supply. These steps include:</p> <ul style="list-style-type: none"> • supporting the industry's actions to stop producing BPA-containing baby bottles and infant feeding cups for the U.S. market • facilitating the development of alternatives to BPA for the linings of infant formula cans; and • supporting efforts to replace BPA or minimize BPA levels in other food can linings. • FDA is supporting a shift to a more robust regulatory framework for oversight of BPA. • FDA is seeking further public comment and external input on the science surrounding BPA (US FDA, 2012). <p>Releases: From Emergency Planning and Community Right-to-know Act (EPCRA): Annual releases of bisphenol A must be reported if it is manufactured, imported or otherwise used at a level greater than one percent, (US EPA, 2001A). Release data are available through the toxic release inventory (TRI), (US EPA, 2006), (US EPA, 2012).</p>
<p>Bisphenol A (BPA)</p> <p>Canada</p>	<p>The screening assessment report concluded that BPA be considered as a substance that may be entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health. The basis of this conclusion is that the neurodevelopmental and behavioural dataset in rodents, though highly uncertain, is suggestive of potential effects at doses at the same order of magnitude to 1-2 orders of magnitude higher than exposures. Given that toxicokinetic and metabolism data indicate potential sensitivity to the pregnant woman/fetus and infant; and that animal studies suggest a trend towards heightened susceptibility during stages of development in rodents, it is considered appropriate to apply a precautionary approach when characterizing risk.</p> <p>The screening assessment report also states that BPA is entering or may be entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term effect on the environment or its biological diversity.</p> <p>Additionally, the screening assessment report states that BPA meets the criteria for persistence but does not meet the criteria for bioaccumulation as defined by the Persistence and Bioaccumulation Regulations made under CEPA 1999 (Environment Canada, 2012).</p> <p>Existing Canadian Risk Management</p> <p>Water recipients: The Ontario Ministry of Environment has established a provisional water quality objective of 5 µg/L. The water quality objectives are used to provide guidance when making water quality management decisions. They are often a starting point in the development of site-specific acceptable wastewater limits (Ontario Ministry of the Environment and Energy, 1994).</p> <p>Drinking water: Health Canada strongly recommends that consumers look for a mark or label indicating that products and materials that come into contact with drinking water be certified, by an accredited certification body, as meeting the health-based standards developed by NSF International (Health Canada, 2008). Products and materials certified as meeting NSF International/ANSI Standard 53 and/or 61, are tested for indirect additives, including bisphenol A, which can result from contact with drinking water. These standards indicate that the total allowable concentration of bisphenol A in resultant drinking water is 0.1 mg/L from 2008. A recent survey performed by Health Canada found that NSF/ANSI Standard 61 has been adopted by all the provinces and the Northwest Territories in Canada (Environment Canada, 2012).</p> <p>Food: A provisional tolerable daily intake (PTDI) for bisphenol A of 25 µg/kg bw/day was established in 1996 by the Food Directorate of Health Canada; this TDI was reaffirmed for the general population in 2008.</p> <p>Polycarbonate is on the list of acceptable polymers for use in food packaging in Canada, (Health</p>

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Canada, 2005).

The use of bisphenol A-based products in food packaging materials may be regulated under provisions of the Food and Drug Regulations which provide that no person shall sell any food in a package that may yield to its contents any substance that may be injurious to the health of a consumer of the food. Health Canada may conduct health safety evaluations of food packaging materials to assess if the packaging material constitutes a health risk to consumers (Environment Canada, 2012).

Products intended for use in the workplace: The Controlled Products Regulations established under the Hazardous Products Act (HPA) stipulate that any supplier who imports or sells a chemical product that contains a listed substance in a concentration that is equal to or greater than the concentration denoted on the Ingredient Disclosure List (IDL) must supply a Material Safety Data Sheet disclosing that information. Bisphenol A is listed on the IDL with a concentration of 1% weight/weight. The IDL applies only to occupational settings with workplace chemicals and does not include consumer products available to the general public (Environment Canada, 2012).

Releases: The National Pollutant Release Inventory (NPRI) was established in 1992 and legislated under CEPA 1999. The NPRI requires companies to report information on releases and on-site and off-site disposal of pollutants to the Government of Canada on an annual basis. Environment Canada makes the information available to Canadians in an annual public report, and maintains a detailed inventory that can be accessed and searched through an on-line database. Through this system, bisphenol A releases have been reported by industry annually (Environment Canada, 2012).

Risk assessment consideration:

Based on limited studies in laboratory animals, the pregnant woman/fetus and infant are potentially vulnerable subpopulations due to potential differences in the toxicokinetics and metabolism of bisphenol A. Based on the exposure estimates, infants were the most highly exposed subpopulation. This combination of both highest potential exposure and potential vulnerability led to the focus of risk management on decreasing exposures to newborns and infants under 18 months old (i.e., infant formula cans and some types of baby bottles), (Environment Canada, 2012). **A ban of BPA in sale of infant feeding bottles has been into force since 2008.**

Examples of Risk Management Actions (Environment Canada, 2012):

- **Hazardous Products Act:** Prohibit the importation, sale and advertising of polycarbonate baby bottles that contain bisphenol A (since 2008).
- **Cosmetics:** Addition to the Cosmetic Ingredient Hotlist (since 2011).
- **Medical devices:** Survey all currently licensed Class II, III and IV medical devices that contain bisphenol A that come into contact with the patient or the patient fluids (underway).
- **Foods:** Evaluation of pre-market submissions for infant formula to ensure the lowest levels of bisphenol A in the food packaging for these products (since 2008).
- **Foods:** Facilitate the assessment of proposed industry alternatives to bisphenol A used in can linings (since 2008).
- **Foods:** Develop stringent migration targets for bisphenol A in infant formula cans (in development).
- **Foods:** Support industry in the development and implementation of codes of practice to reduce, to as low as reasonably achievable, the levels of bisphenol A in existing food packaging for canned infant formula (underway).
- **Environment:** Environmental monitoring of bisphenol A in wastewater, landfill leachate, wildlife, fish and receiving waters (since 2008).

BPA	and No alternatives to BPA were identified in Canada voluntary Challenge Questionnaire
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Bisphenol-A-diglycidylether polymer Canada	submissions. Bisphenol-A-diglycidylether polymer (CAS 25036-25-3 and 25068-38-6) has not yet been assessed but will be covered under Canada's polymer approach. The start of polymer specific surveys will take place in 2014/2015 (Environment Canada, 2012).
Bisphenol A (BPA) Sweden	<p>The Swedish Chemicals Agency (KemI) conduct a survey of the extent to which bisphenol A (BPA) was included in and migrates from toys and childcare articles. BPA was measured in 24 articles, mainly in polycarbonate (PC) but some also in epoxy. The exposure to small children through breastfeeding has been estimated to be about 200 times higher than the exposure to the products analyzed in this study could give rise to in the worst case scenario. Judging from results of chemical analyses of BPA in toys and child care articles, no risk could be identified applying the risk assessment method used within the scope of REACH. At the present time, the Swedish Chemicals Agency therefore does not propose any restrictions to reduce the exposure of children to BPA in toys and childcare articles.</p> <p>The EU ban on BPA in feeding bottles has resulted in a considerable reduction of exposure of small children to BPA. In addition, a switch to material free of BPA has started within different parts of the food sector (lids to baby food cans, beverage bottles and other household articles) and the fact that large users of thermo paper in the everyday commerce have begun to switch to receipts without BPA. Since alternative plastic materials as well as alternative antioxidants and stabilisers are available, there seems to be no strong reasons for companies to return using BPA in toys and child care articles if they have discontinued doing so.</p> <p>Humans are, however, still exposed to continuous exposure of BPA from, in many cases, unknown sources.</p> <p>Since small children are a sensitive group when it comes to chemical exposure it is essential to identify all sources where children may be exposed to BPA. The Swedish Chemicals Agency therefore considers it very important to actively monitor developments in the health risks of children after exposure to BPA. It is also vital to follow the development of alternative materials and their possible harmful effects to human beings and the environment (KemI, 2012B).</p> <p>BPA can detach from the cash receipts and is absorbed into the body through the skin. Based on studies of dermal uptake of BPA and the measured amount of BPA in cash register receipts KemI have calculated that a consumer can be expected to be exposed to 1µg BPA/ kg bw/day (KemI, 2012A).</p> <p>A recent report was used as a basis for KemI's investigation of risks from the use of BPA in cash register receipts, toys and children's products as well as in re-lining of water pipes, which was conducted during summer 2012 on commission by the Swedish Government. The purpose of the report was to review and summarize animal studies that have examined the effects of exposure to low doses of bisphenol A (BPA) during early development and to identify at what doses these effects occur. The report also discusses how alternative reference doses of BPA can be calculated based on these data.</p> <p>Overall, it concluded that although no single study reviewed here was considered reliable enough to serve as a key study for the derivation of an alternative reference dose, if the data is considered as a whole, effects are consistently observed at doses well below those which serve as the basis for the current TDI for BPA. Alternative reference doses calculated from the NOAELs/LOAELs range between 0.01 and 0.8 µg/kg bw/day and are considerably lower than the current TDI of 50 µg/kg bw/day. The lowest reference doses were calculated for developmental neurotoxicity. Even if confidence in a specific alternative reference dose based on</p>

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this data material is low the results from this review indicate that considering a lower reference dose than the current TDI when conducting risk assessment of BPA may be prudent (Beronius and Hanberg, 2012).

Bisphenol A (BPA) Sweden	<p>A project will find out whether Bisphenol A is released in drinking water from relined pipes. Relining is an alternative to traditional change of pipelines. Relining is a method with which the pipe is given a plastic interior. BPA might be included as a component in these plastic products.</p> <p>The work includes:</p> <ul style="list-style-type: none"> •Mapping of the kind of products used for relining (the Swedish Chemicals Agency), •Historical use of relining as a method (the National Board of Housing, Building and Planning) •Chemical analyses of drinking water (the National Food Agency). <p>These projects are to be achieved before the turn of the year 2012/2013, but the results of the analyses may be compiled later in 2013. A risk assessment will be made after that.</p> <p>If it should turn out that restrictions are required in any area, work will start to elaborate rules and to make a consequence analysis. The assignment is to be reported to the Swedish Government (Ministry of the Environment) no later than 15 December 2013 (KemI, 2012C).</p>
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Bisphenol A (BPA) Germany	<p>18 dummies from various manufacturers and brands made of latex and silicone were examined for bisphenol A. 17 dummies did not release any BPA .The release of 4 µg/l BPA (which equals 0.2 µg BPA per dummy and hour) was detected in one dummy. This level is deemed to be safe, but it must be clarified how BPA might reach the baby dummies. In the opinion of BfR, BPA is generally undesirable in dummies and also avoidable. According to BfR estimates, the dummies examined cover around 70 % of the manufacturers on the German market (BfR, 2009).</p> <p>There was no release of bisphenol A from the shields. In 2013 Germany will publish its substance evaluation of bisphenol A (BAUA, 2012).</p>
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Bisphenol A (BPA) UK	<p>Existing Risk Management:</p> <p>A 2002 draft environmental risk assessment by the Environment Agency for England and Wales and the UK Health and Safety Executive identified a need to limit the risk of exposure from thermal paper recycling and the use of bisphenol A as an inhibitor in PVC production. Bisphenol A use as an inhibitor was voluntarily phased out of PVC production in all European Council Vinyl Manufacturers (ECVM) member companies by 2001 (Risk & Policy Analysts Limited, 2003).</p>
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Bisphenol A (BPA) F	<p>BPA-emissions to the environment:</p> <p>The main European emissions of BPA in the environment are to the water. The emissions of industrial effluents from industries are from recycling of thermal paper (70%), production of PVC (17%) and emissions from the use of PVC items by European households (12%). All the investigated waste water treatment plants had detectable levels of BPA. In order to reduce emissions of BPA into the water the substitution of BPA in thermal paper was suggested but it has technical difficulties (INERIS, 2010).</p>
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Health effects of Bisphenol A (a collective expert report):

The report explain that the conclusions are based on the results of available human and animal data, which have most often been obtained at doses lower than the NOAEL of 5 mg/kg/day that was used to calculate the TDI currently used by EFSA. The working group recommends for instance to assess the relevance of using toxicity reference values (TRVs) or Tolerable Daily Intakes for substances with non-monotonic dose-response curves. It also recommends some adverse effects to be taken into account for future risk assessment. These are,

From recognised effects in animals:

- Increase occurrence of ovarian cysts after pre- and postnatal exposures
- Hyperplastic modification of the endometrium after pre- and postnatal exposure

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	<ul style="list-style-type: none"> - Early onset of puberty after pre- and postnatal exposures - Altered sperm production after adult exposure - Histological changes in neurogenesis following pre- or perinatal exposure - Effects on lipogenesis after prenatal, perinatal or adult exposure - Effects on the mammary gland: acceleration of the mammary gland's structural maturation in adulthood and development of intraductal hyperplastic lesions after pre- or perinatal exposure to BPA. <p>And from “suspected” effects in humans:</p> <ul style="list-style-type: none"> - Effects on oocyte maturation in females in infertile couples undergoing ART (Assisted Reproductive Technology). - Effects on cardiovascular pathologies (coronary diseases) and diabetes (ANSES, 2011). <p>In France BPA is not allowed in food contact materials from: For children aged 0-3 in force from January 1st, 2013. For all ages in force from July 1st, 2015, And in medical devices from: The bill also suspends medical devices containing BPA or other endocrinal disruptors by July 1st, 2015. From the French Senate, who voted unanimously on October 9, 2012 (GAIN, 2012).</p>
Bisphenol A (BPA) Japan	<p>Existing Risk Management:</p> <p>Food: In 2007, a Japanese human health and ecological risk assessment concluded that the risks posed by bisphenol A were below the levels of concern; however, several voluntary risk reduction measures were examined. The substitution of polycarbonate tableware used for school lunches was estimated to have potentially reduced daily bisphenol A intake by 0.2-0.3 µg/kg bw/day. The modification of the inner surface of drink cans to polyethylene terephthalate film lamination or epoxy resin paint was estimated to have minimal costs and to have potentially reduced daily bisphenol A intake by 0.1-0.2 µg/kg bw/day for average exposure individuals and 0.2-0.6 µg/kg bw/day for high exposure individuals (AIST, 2007). Under the Food Sanitation Law in Japan, a migration limit in food-contact polycarbonate plastic is specified as 2.5 ppm (AIST, 2007).</p> <p>Exposure in Japanese individuals: On the homepage (2012) an abstract of an updated Hazard Assessment of Bisphenol A is available (AIST-RISS, 2012). The BPA exposure estimate in Japanese people is found to be the highest for the 1 to 6 year old children (3.9 µg/kg bw/day (boys) and 4.1 µg/kg bw/day (girls). In addition, the value of BPA intake estimated from the amount of BPA excreted in 24-hour urine in adults was 0.037 to 0.064 µg/kg bw/ day (men) and 0.043 to 0.075 µg/kg bw/day (women). The calculated Margin Of Exposure (MOE) was 730 to 770 in 1 to 6 year-olds, and it was 40 000 to 81 000 for adults. The risk of BPA was believed to be very small.</p>

Survey of Bisphenol A and Bisphenol-A-diglycidylether polymer

This survey is part of the Danish EPA's review of the substances on the List of Undesirable Substances (LOUS). This report includes surveys on the substances, including information on, uses and exposure internationally and in Denmark, legislation, environment and health properties and alternatives on the basis of available information.

Kortlægning af Bisphenol A og Bisphenol-A-diglycidylether polymer

Denne kortlægning er et led i Miljøstyrelsens kortlægninger af stofferne på Listen Over Uønskede Stoffer (LOUS). Rapporten indeholder blandt andet en beskrivelse af brugen og forekomsten af Bisphenol A og Bisphenol-A-diglycidylether polymer internationalt og i Danmark, regulering, beskrivelse af miljø- og sundhedseffekter og viden om alternativer.



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