KLIMA- OG FORURENSNINGS-DIREKTORATET

Hazardous substances in plastic materials

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Prepared by COWI in cooperation with Danish Technological Institute

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Preface

This report is developed within the project of mapping of prioritized hazardous substances in plastic materials. The report presents key information on the most used plastic types and their characteristics and uses, as well as on hazardous substances used in plastics and present on the Norwegian Priority List of hazardous substances ("Prioritetslisten") and/or the Candidate List under REACH, by August 2012.

The aim of the report is to be a brief handbook on plastic types and hazardous substances in plastics providing knowledge on the characteristics and use of different plastic materials and the function, uses, concentration, release patterns, and alternatives of the hazardous substances, allowing the user to use the report as an introduction and overview on the most important hazardous substances in plastics and the plastic types, they primarily are used in.

The development of the report has been supervised by a steering committee consisting of:

Inger-Grethe England, Klima- og Forurensningsdirektoratet (chairman)
Pia Linda Sørensen, Klima- og Forurensningsdirektoratet
Erik Hansen, COWI, Denmark
Nils H. Nilsson, Danish Technological Institute

The report has been prepared by Erik Hansen, COWI-Denmark, Nils H. Nilsson, Danish Technological Institute, Delilah Lithner, COWI-Sweden and Carsten Lassen COWI-Denmark.

Vejle, Denmark, 15. January 2013

Erik Hansen, COWI (project manager)

Content

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English Summary and Conclusions

This report presents information on the most used plastic types and their characteristics and uses as well as on hazardous substances used in plastics.

The first part of this report is focused on 15 selected important groups of plastic materials. They were selected according to frequent use and according to possible content of chemical substances that might give rise to concern.

The second part of the report is focused on 43 chemical substances used in plastics and considered hazardous and thus been adopted on the Norwegian Priority List of hazardous substances or the REACH Candidate list of SVHC-substances.

For the selected plastic materials and hazardous substances important information has been collected and presented.

Regarding plastic materials the following issues have been addressed:

- Main uses;
- Important characteristics covering technical issues as well as price;
- Content of additives which may contain hazadous substances;
- Content of other hazardous substances originination from manufacturing or degradation processes etc.;
- Consumption in EU27/Norway, and
- Whether recycling is possible and the technical potential for good quality materials.

With respect to hazardous substances the following issues have been addressed:

- Technical Function (of the substance);
- Relevant types of plastics (where the substance is used);
- Main articles groups (for which the plastics with the substance are used);
- EU Restrictions of the use in plastics;
- Norwegian regulation of the use in plastics;
- Concentration in plastic materials;
- Chemical binding (of the substance in the plastic - is migration possible?);
- Potential for release;
- Alternatives, and
- Applications for which the substance may still be in use in the society.

The survey process
The information presented has been collected from the scientific literature available including study reports prepared for the Environmental Authorities in the Nordic Coutries as well as information available on the internet. An important source of information has been the Annex XV dossiers/reports available form the European Chemical Agency (ECHA) for almost all substances included on the REACH Candidate list of SVHC-substances. This information has been supplemented by expert assessments by the consultants undertaken this survey.

The plastic materials selected cover all dominating thermoplastics as polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinylchloride (PVC), polyester (PET), and polyurethane (PUR), but also important technical plastics as polycarbonate (PC), acrylonitrile butadiene styrene (ABS) and polyamide (PA - nylon). Furthermore, also the most important thermosetting plastics as epoxies, unsaturated polyester and melamine are described.

Regarding the hazardous substances a screening procedure was undertaken to identify which substances on the Candidate list and Norwegian priority list that are used in plastics. Substances for which there was no indication of use in plastics were listed in annex 1 together with a brief presentation of their uses. All 84 substances on Candidate list and all 30 substances or substance groups on the Norwegian Priority list have been checked for use in plastics.

The study results

The detailed results of the study are presented in section 2.2-2.17 and 3.2-3.44. In the following the attention is focused on a number of important key areas:

Plastic materials represent a very large group of organic based polymers with different technical characteristics, which is reflected in the application of different materials.

For all plastics materials their characteristiscs may be changed and improved by use of additives which may be based on hazardous substances. Important additives in this context are colorants, plasticizers, stabilisers, flame retardants, blowing agents and biocides.

Attention should also be paid to hazardous residues of monomers and degration products present in end products. Examples of such substances include bisphenol A in polycarbonate, mercury in polyurethane and aromatic amines in polyamide.

All thermoplastic plastics as polyethylene etc. can be recycled by so-called mechanical recycling (remelting), with a loss of materials less than 10%, assuming sufficient quantities of good quality materials are available. By good quality materials is to be understood relatively clean materials separated well in different plastics and with a largely uniform content of additives. Difficulties in collection and separation of plastic are not considered in these figures, as such constraint depends heavily on how waste collection is organised in the society.

Thermosetting plastics can only be recycled by so-called feedstock recycling by treating the plastic by processes able to degradate the plastic into its basic monomers or other chemical substances which can then be used for manufacturing of new plastic polymers. This technology is under development. No information is available regarding the material loss by feedstock recycling.

Most hazardous substances used as additives are not chemical bound in plastics, but are able to migrate. Migration is the phenomenon that takes place when chemical substances in the plastic migrate to the surface of the plastic item or to a medium in contact with the item. At the surface the substance may evaporate or be removed by washing or contact with human skin or another medium. Both plasticizers, e.g. phthalates, and flame retardants, e.g.

brominated flame retardants, are substances well-known to migrate, but many other substances migrate too.

The migration rate of chemical substances depends on their size, boiling point, vapour pressure and their solubility in the plastic as well as in the environment or material surrounding the plastic. Migration thus depends heavily on the physical-chemical characteristics of the substance. Small molecules, typically monomers and residual solvents, will migrate fast as they have a low boiling point. Some monomers such as formaldehyde, vinyl chloride, ethylene and butadiene are all gases and have a high tendency to migrate quickly even at ambient temperatures. Larger organic molekyles will migrate more slowly, while inorganic metal salts will not migrate. In all cases migration will decrease with time as the concentration of the migrating substances get lower in the plastic.

The ability to migrate significantly determines the potential for release of substances from plastics. Substances that do not migrate will only be released by wear and tear including degradation by weathering or by chemical attack.

Little precise information is available regarding migration rates. The migration rate of the plasticizer DEHP is likely in the range of 0.1-1% per year or below, while the existing information on release of cadmium by wear and tear does not allow quantification, but is assessed as very little.

For most hazardous substances in plastics alternatives do exist, either as other chemical substances fulfilling the same function as the hazardous substance in question or as other technical solutions that represents another way of fulfilling the same function. It should be noted that for chemical substances it is generally so that perfect substitutes do not exist and selection of alternatives is a trade-off between different characteristics.

It has been assessed whether the substances in question still are present in products in service in the society. The general answer to this question is yes, as for most substances it is possible to identify products with a relatively long in-service life meaning that products containing the substance are still in service in the society.

Sammendrag og konklusjoner

Denne rapporten gir en oversikt over de mest brukte plasttyper, deres egenskaper og bruksområder, og hvilke farlige kjemikalier som brukes i plast.

Den første delen av rapporten gir en oversikt over 15 utvalgte plasttyper. Disse plasttypene er valgt delvis fordi de er mye brukt og delvis fordi de er vesentlige på grunn av et antatt innhold av kjemikalier som kan gi grunn til bekymring.

Den andre delen av rapporten gir oversikt over 43 kjemikalier som brukes i plast og anses som farlige, og derfor er inkludert i den norske prioritetslisten og/eller på EUs kandidatliste for SVHC-kjemikalier under REACH.

For de utvalgte plasttypene og de farlige kjemikaliene er følgende informasjon om følgende emner samlet inn og presentert:

Plasttyper:

- Viktigste bruksområder.
- Viktige egenskaper – som dekker tekniske emner, samt pris.
- Innhold av tilsetningsstoffer som kan inneholde farlige kjemikalier.
- Innhold av andre farlige kjemikalier, som stammer fra fremstillingsprosesser eller nedbrytningsprosesser mv.
- Forbruk i EU27/Norge.
- Om gjenvinning er mulig og det tekniske potensialet for gjenvinning av materialer som er av god kvalitet.

Farlige kjemikalier:

- Teknisk funksjon (av kjemikalie).
- Plasttyper (som kjemikalie brukes i).
- Viktigste produktgrupper (som plast som inneholder kjemikalie brukes til).
- EU restriksjoner av bruken i plast.
- Norsk regulering av bruken i plast.
- Konsentrasjon av kjemikalie i plast.
- Kjemisk binding (av kjemikalie i plast - er migrasjon mulig?).
- Potensial for utlekking av kjemikalie.
- Alternativer.
- Produkter som inneholder kjemikalier og som fortsatt er i bruk i samfunnet.

Undersøkelsen
Informasjonen som presenteres er hentet fra tilgjengelig teknisk litteratur inkludert rapporter utgitt av miljømyndigheter i de nordiske land, dessuten informasjon som er tilgjengelig på internett. En viktig kilde til informasjon for nesten alle kjemikalier på REACH kandidatlisten av SVHC-kjemikalier, har vært Annex XV dossier/rapportene som er tilgjengelig fra det Europeiske kjemikalie byrået (ECHA). Denne kunnskapen er supplert av ekspertvurderinger som er gjort av konsulenter som har utført denne undersøkelsen.
De valgte plasttypene omfatter alle

dominerende typer termoplast som polyetylen (PE), polypropylen (PP), polystyren (PS), polyvinylklorid (PVC), polyester (PET), og polyuretan (PUR), men også viktige tekniske plasttyper så som polykarbonat (PC), akrylnitril butadien styren (ABS) og polyamid (PA - nylon). I tillegg er også de viktigste herdeplasttypene slik som epoxy, umettet polyester og melamin beskrevet.

Med hensyn til farlige kjemikalier er det gjennomført en innledende screeningsvurdering av hvilke kjemikalier på kandidatlisten og den norske prioritetslisten som brukes i plast. Kjemikalier, hvor en ikke kan finne opplysninger om at de brukes i plast, er beskrevet i vedlegg 1 med en kort presentasjon av bruken.

Resultatene fra undersøkelsen
Detaljerte resultater fra undersøkelsen kommer frem i avsnitt 2.2-2.17 og 3.2-3.44. Det er fokusert på følgende viktige problemstillinger:

Plastmaterialer representerer en meget stor gruppe av organiske polymerer med forskjellige tekniske egenskaper, noe som gjenspeiles i bruken av forskjellige plasttyper. For alle plastmaterialer kan deres egenskaper forandres og forbedres gjennom bruken av tilsetningsstoffer som kan være basert på farlige kjemikalier. Viktige tilsetningsstoffer i denne sammenhengen er fargestoffer, myknere, stabilisatorer, flammehemmere, skummidler og biocider.

Imidlertid bør en også være oppmerksom på farlige rester av monomerer og nedbrytningsprodukter, som kan være til stede i ferdigvarer. Eksempel her er bisfenol A i polykarbonat, kvikksølv i polyuretan og aromatiske aminer i polyamid.

Alle termoplaster som polyetylen etc. kan gjenbrukes ved såkalt mekanisk gjenbruk (omsmelting), med et materialetap på mindre enn 10 %, forutsatt at tilstrekkelige mengder av materialer (plastavfall) i god kvalitet er tilstede. Med materialer av god kvalitet mener en relativt rene materialer sortert i forskjellige plasttyper med stor grad av ensartet innhold av tilsetningsstoffer. Disse tallene inkluderer ikke vanskeligheter med innsamling og sortering av plast, da slike vanskeligheter er svært avhengig av hvordan avfallsinnsamlingen er organisert i samfunnet.

Herdeplast kan kun brukes på nytt av såkalt "feedstock recycling", der plasten utsettes for fysisk-kjemiske prosesser som kan bryte ned plasten til de hovedkomponentene (monomerer etc.) som den er bygget opp av. Disse monomerene etc. kan deretter brukes til å produsere ny plast. Det har ikke vært mulig å finne opplysninger om materialtap ved disse prosessene.

De fleste farlige kjemikalier som brukes som tilsetningsstoffer, er ikke kjemisk bundet til plasten, men er i stand til å migrere. Migrasjon betegner virkemåten når kjemikalier i plast kan flytte sig (vandre) til overflaten av plastmaterialet eller til et annet medium i kontakt med plast. Ved overflaten kan kjemikaliet fordampe eller bli fjernet ved vask eller kontakt med hud eller et annet medium. Både myknere, f.eks. ftalater og flammehemmereog bromerte flammehemmere er kjent for å migrere, men det er mange andre kjemikalier som også migrerer.

Migrasjonsrater for kjemikalier avhenger av størrelsen på deres molekyler og deres kokepunkt, damptrykk og oppløselighet både i plast og i det miljø eller medium som plasten er omgitt av.

Migrasjon avhenger sterkt av fysisk-kjemiske egenskaper ved kjemikaliet. Små molekyler, typisk rester av monomerer og løsningsmidler, har et lavt kokepunkt og vil derfor raskt migrere. Enkelte monomerer slik som formaldehyd, vinylklorid, etylen og butadien er alle i gassform og vil migrere raskt selv ved romtemperatur. Store organiske molekyler med høyere kokepunkt vil migrere saktere, mens uorganiske metallsalter slett ikke vil migrere. I alle tilfeller vil migrasjonen avta med tiden i takt med at konsentrasjonen av kjemikaliet avtar i plasten.

Evnen til å migrere har stor betydning for frigivelsen av kjemikalier fra plast. Kjemikalier som ikke migrerer kan kun frigis ved nedbrytning av plasten ved værpåvirkninger (sol, vind, varme og kulde) eller ved kjemiske påvirkninger.

Det finnes kun beskjeden og upresis informasjon om migrasjonsrater. Migrasjonsraten for DEHP er antagelig av størrelsen 0,1-1 % pr år eller mindre, mens den eksisterende informasjon om frigivelsen av kadmium ved slitasje gjør det umulig å kvantifisere frigivelsesraten som generelt vurderes som meget beskjeden.

For de fleste kjemikalier som brukes i plast, finnes alternativer enten i form av andre kjemikalier som oppfyller samme funksjon i plasten, eller i form av andre tekniske løsninger som representerer en annen måte å oppnå den samme funksjonen på. Det skal bemerkes at for kjemikalier er det generelt slik at perfekte erstatninger ikke eksisterer og at valg av alternativ er en handel eller balanse mellom forskjellige egenskaper.

Det er vurdert om de enkelte kjemikalier fortsatt er til stede i produkter som brukes i samfunnet. Det generelle svar til dette spørsmål er ja, fordi for de fleste kjemikalier er det mulig å identifisere i ferdigvarer med relativ lang levetid, noe som betyr at det stadig er produkter i bruk i samfunnet som inneholder det gjeldende kjemikaliet.

1. Introduction

It has been the wish of The Norwegian Environmental Protection Agency (KLIF) to undertake a survey of the prioritized hazardous substances and substances on SVHC (Substances of Very High Concern) Candidate list under REACH present in various plast materials. In this context it has been the objective of KLIF to obtain knowledge on:

- Charateristics and applications of the most used plastic materials
- The potential for recycling for these plastic materials
- The substances on the Norwegian Priority List and on the REACH candidate list that will be present in the different plastic materials
- The function and quantity of these substances in plastics materials
- The potential for leaching of these substances from plastic materials
- Alternatives
- Which substances in which products can be expected to be present in waste

The present report has tried to fulfil these wishes recognizing that they in many ways are covering huge topics and only a brief presentation focusing on key issues are practically possible.

Plastic materials represent a very large group of organic based polymers and many different commercial varieties exist. The first part of this report is focused on selected groups of plastic materials. They were selected according to frequent use and according to possible content of chemical substances that might give rise to concern.

The second part of the report is focused on chemical substances considered hazardous and thus been adopted on the Norwegian Priority List of hazardous substances or the REACH Candidate list of SVHC-substances. For the substances on those lists actually used in plastics and likely to be present in plastic end-products have been compiled the information available on the issues listed above.

1.1 Selection of plastic materials for the survey

In total, 15 different groups of plastics have been selected for the survey of plastic materials, their properties and typical areas of application.

The plastics were selected on the basis of a recent seminar at KLIF where [Sundt 2012] presented the most commonly used plastic materials in Norway and Europe.

There are two types of plastics: thermoplastics and thermosetting plastics. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. Examples include polyethylene, polypropylene, polystyrene, polyvinyl chloride, and polytetrafluoroethylene (PTFE).

Thermosets can melt and take shape once; after they have solidified, they stay solid. In the thermosetting process, a chemical reaction with the establishment of a tight crosslink between the plastic molecules occurs that is irreversible.

This survey covers thermoplastics as well as thermosetting plastics. Elastomers, also named as rubber or syntetic rubber is, however, not covered by the survey.

Some plastic materials with a rather small consumption have been included due to the fact that unwanted toxic chemicals might be released by use, e.g. for food contact applications. This is the case for PTFE and melamine.

1.2 Selection of substances

All 84 substances on Candidate list and all 30 substances or substance groups on the Norwegian Priority list have been checked for use in plastics. In total, 43 different substances and /or groups of substances have been selected for this survey of hazardous substances in plastic materials.

Many of the substances on the Candidate list and the Norwegian priority list are not used in plastic and are assumed not be present in plastic in a quantity relevant to consider. These substances together with a brief presentation of their uses are listed in annex 1.

The methodology for identifying the substances used in plastics is described in section 3.1.

Plastics are taken to include both thermoplastics and thermosetting plastics. Elastomers, also named as rubber or syntetic rubber are not included and substances only used in elastomers are therefore not neceassarily covered by the survey. For some substances, however, the focus are given to elastomers used e.g. for sealants. This is only done in case it is not possible to focus on important other uses in plastic.

Only uses, where the substance is integrated in the plastic by manufacturing, are normally considered. Uses where the substance is only attached to the plastic during miscellaneous finishing processes (as for textiles) or in mixing of preparations (as for paint) is not considered in the survey.

It must be recognised that in several cases it has not been easy to make a correct decisions on whether the substance in question is relevant to consider in detail (a special section 3.x is prepared) or should be dismissed to annex 1. For several substances the use in plastics are a minor use and very scarcely described in literature or the use may be very indirect (e.g. catalyst in production of monomers used for production of special types of plastic). Furthermore, the data available may not be up-to-date, meaning there is a possibility that the use of the substance in plastics may have ceased. For these reasons some of the choices made may well be discussed.

1.3 Additives used in plastics

Plastic materials do not only consist of plastic polymers. In nearly all cases the producer has made a formulary (plastic compound) with different additives to improve the performance and ageing properties as well as the processing properties of the plastic compound for the shaping process (injection moulding, extrusion, blow moulding, vacuum moulding, etc.).

In connection with thermoplastics, the final plastic compound is ready to be processed directly. In connection with thermosetting plastics, a chemical catalysed reaction will take place during moulding in order to establish the plastic polymer chain and the tight crosslink between the formed plastic polymer chains.

In many cases the plastic polymers alone have sufficient properties to “do the job” for a number of applications. Especially for “one time use packaging plastic materials” only small amounts of additives are added e.g. to reduce oxidation and to improve slip properties.

In other applications it is necessary to improve the basic properties of the plastic polymer by using higher amounts of additives. There are a large number of additives which can be used to improve different properties of the plastic. Some are added to prevent degradation of the polymer during processing (typically for PVC), others to improve resistance to fire or to prevent degradation in the environment (UV, temperature, humidity, microorganisms). By use of fibres in the plastic, high mechanical strength can be obtained. It should be observed that some additives are used to reduce the price of the plastic compounds rather than to improve the properties of the plastic.

Additives in plastic can be divided into:

- Functional additives (stabilisers, antistatic agents, flame retardants, plasticizers, lubricants, slip agents, curing agents, foaming agents, biocides, etc.)
- Colorants
- Fillers (mica, talc, kaolin, clay, calcium carbonate, barium sulphate)
- Reinforcements (e.g. glass fibres, carbon fibres).

Important is that additives in plastics in nearly all cases are not chemically bound to the plastic polymer. Only the reactive organic additives e.g. some flame retardants are polymerised with the plastic molecules and are becoming part of the polymer chain.

In the table below a more detailed but still brief description of the most common functional types of additives used in plastics is presented. The substances described in chapter 3 are presented in the table - if relevant - as examples on substances used as additives in plastics. It may be noted that substances used as monomers, intermediates or catalysts in plastic manufacturing are not considered additives and therefore not presented in the table.

Table 1. Additives used in plastics

Type of additive	Typical amount in % w/w	Comments	Substances
Functional additives			
Plasticisers	10-70	Around 80 % used in PVC and the remaining 20 % in cellulose plastic	Short and medium chain chlorinated paraffins (SCCP-MCCP); Diisoheptylphthalat (DIHP); DHNUP; Benzyl butyl phthalate (BBP); Bis (2-ethylhexyl)phthalate (DEHP): Bis(2-methoxyethyl) phthalate (DMEP): Dibutyl phthalate (DBP); Diisobutyl phthalate (DiBP); Tris(2-chloroethyl)phosphate (TCEP);
Flame retardants	12 – 18 (for brominated)	Three groups: organic non- reactive, reactive; inorganics.	Short and medium chain chlorinated paraffins (SCCP-MCCP): Boric acid; Brominated flame retardants; Tris(2-chloroethyl)phosphate (TCEP)
Stabilisers, Antioxidants and UV stabilizers Heat stabilisers	0.05- 3 0.5 -3	Amount depends on chemical structure of additive and of plastic polymer. Phenolic antioxidants are used in low amounts and phosphites in high. Lowest amounts in polyolefins (LLDPE, HDPE), higher in HIPS and ABS Used in PVC. Based on lead, tin, barium, cadmium and zinc compounds. Lead is most efficient and used in the lower amounts.	Bisphenol A (BPA); Cadmium compounds; Lead compounds; Nonylphenol compounds; Octylphenol; 1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)/1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC) Cadmium compounds; Lead compounds; Nonylphenol (barium and calcium salts);

Slip agents	0.1 – 3	Amounts depend on chemical structure of slip agent and plastic polymer type	
Lubricants (internal and external)	0.1 - 3		
Antistatics	0.1-1	Most types are hydrophilic and can migrate to water	
Curing agents	0.1-2	Peroxides and other crosslinkers, catalysts, accelerators	4,4'- Diaminodiphenylmethane (MDA); 2,2'-dichloro-4,4'-methylenedianiline (MOCA); Formaldehyde - reaction products with aniline; Hydrazine; 1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)/1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC)
Blowing agents	Depends on the density of the foam and the potential gas production of the agent	Azodicarbonamide, benzene di-sulphonyl hydrazide (BSH), pentane, CO_2	
Biocides	0.001-1	Soft PVC and foamed polyurethanes are the major consumers of biocides. They are of different chemical structures and include chlorinated nitrogen-sulphur heterocycles and compounds based on tin, mercury, arsenic, copper and antimony, e.g. tributyltin and 10,10´-oxybisphenoarsine	Arsenic compounds; Organic tin compounds; Triclosan;
Colorants			
Soluble (eg. azocolorants)	0.25-5	Migrates easily. Used in highly transparent	

		plastics. They are expensive, have limited light- and heat resistanse. They are used in PS, PMMA and cellulose plastics to give a bright transparent colour.	
Organic pigments	0.001-2.5	Insoluble low migration tendency	Cobalt(II) diacetate
Inorganic pigments	0.01-10	E.g. zinc sulphide, zinc oxide, iron oxide, cadmium-mangane based, chromium based, ultramarine and titanium dioxide	Camium compounds; Chromium compounds; Lead compounds
Special effect	Varies with the effect and substance in question	Aluminium and copper powder, lead carbonate or bismuthoxichloride and substances with fluorescence Substances with fluorescence might migrate, the former not	
Fillers	Up to 50	Calcium carbonate, talk,clay, zinc oxide, glimmer, metal powder, wood powder, asbest, barium sulphate, glass microspheres, silicious earth	
Reinforcements	Glass (15 - 30%)	Glass fibers, carbon fibers, aramide fibers. 15-30% is for glass only due to the high density of glass.	

In addition, other chemical substances can be formed during processing by degradation of the plastic polymer or of some additives or during the use of the plastic materials (ageing). That means that the chemistry of plastics and environmental and health impacts can be difficult to predict.

Furthermore, residues of monomers and reactive compounds may be present in the final products. These residues is a result of that not all monomers/compounds succeeds in reacting during the polymerisation process. Typical concentrations of residues left are 0-2 %.

It is well-known that PVC is one of the cheapest plastics on the marked, but PVC is also a plastic to which a significant amount of additives are added either as stabilizers or as plasticisers.

More than 50 % plasticiser might be added to PVC, and phthalates are still the most popular plasticisers for PVC, as they are inexpensive and have solubility parameters very close to the PVC polymer.

Flame retardants will be added to applications when the law requires that they have to fulfil certain fire standards (e.g. UL 94 class V_0 –V_2 (UL = Underwriters Laboratories). Therefore, flame retardants will typically be found in plastic materials used for trains, ships, airplanes, cars, buses and for buildings, furniture, carpets, cables, television cabinets and in applications where the plastic is exposed to high temperatures (e.g. hair dryers, electric articles and electronics).

1.4 Migration

Migration is the phenomenon that takes place when chemical substances in the plastic migrate to the surface of the plastic item or to a medium in contact with the item.

Migration can in fact be a required property but in most cases it is not. An example of the first requirement is the migration of mould release agents to the surface to give a better slip to the mould or to give antistatic properties. Controlled release of drugs from a plastic matrix for precise dosage to the patients also belongs to the wanted controlled migration.

Unwanted migration is the migration of plasticizers to the surface of a plastic item or the migration and evaporation of flame retardants e.g. from electronic cabinets (televisons, computers).

Migration of chemical substances in plastic packaging for food or medicine are other examples of unwanted migration as some of the migrating substances may be toxic or give an unpleasant taste to the food or finally destroy the medicine or enhance the degradation of the active substances in the medicine.

What can migrate?
The migration rate of organic chemical substances depends on their size. Small molecules, typically monomers and residual solvents, will migrate fast as they have a low boiling point. Some monomers such as formaldehyde, vinyl chloride, ethylene and butadiene are all gases and have a high tendency to migrate quickly even at ambient temperatures and for sure at 100 °C.

The molecular weight of substances used as additives in the plastic are estimated to be in the range of 200 – 2000 g/mol. A high molecular weight means a large molecule and a slow migration rate and visa versa. This rule of thumb is used to design additives with low migration rates by designing them with high molecular weight structures. This trick is used for antioxidants, flame retardants and for plasticizers. However, plasticizers and flame retardants based on this princip are used to a minor extend because of the higher cost of the high molecular additives.

Another rule is that the solubility of the additive in the plastic should be high and on the other hand low in a liquid (or food) in contact with the plastic. The initial concentration of the chemical substance in the plastic, the thickness of the plastic item, the crystallinity of the plastic and the surface structure of the plastic item all influence the migration rate in a rather complex way.

As the solubility as well as the mobility of the migrating substance depends on the temperature, the exposure temperature is a very important factor for the migration to a contact media. The types of contact media are also important: gas, liquid or solid. Finally, the contact time determines how much will migrate to the contact media. That depends on the square root of time.

In total, migration is expressed mathematically in Fick´s law:

$$M = C_0 \text{ x } t^{0.5} \text{ x } K \text{ x } EXP(-E/RT)$$

Where M: Migration
C_0: Concentration of the migrant in the polymer
t: Time
K: Constant
T: Temperature
E: Activation energy
R: Gas constant

In practise, the migration of substances from plastics is measured in contact experiments under worst case scenarios. Some methods for food contact materials and for pharmaceuticals are standardised while others have to be set up according to the use of the plastic. Special set ups of migration studies are carried out in projects which aim at protecting the consumers against exposure to toxic chemicals from products.

Health assessments are carried out and based on data from these contact migration studies.

In [KL,2012] it is stated that only the fraction of additives with molecular weigth less than 1000 g/mol is regarded as toxicological relevant as it is very unlikely, that the molecules with more than 1000 g/mol will be absorbed by the gastro- intestinal tract and thus is not considered to present a toxicological risk.Below 600 g/mol most substances are absorbed and the rate absorption is determined by other factors than size and shape of the molecule.

For colourants used in plastics four groups exists:

- Soluble colourants
- Organic pigments
- Inorganic pigments
- Special colourants

The soluble colorants are expensive, have limited light- and heat resistanse and have a low tendency to migrate. They are used in PS, PMMA and cellulose plastics to give a bright transparent colour. They are used in amounts of 0.25–5 % w/w. They are pure organic based compounds e.g. azocolorants and disperse colorants (dyes).

Organic pigments are insoluble and will not easily migrate. They counts alizarin derivatives, phthalocyanines, benzidines, carbon black, and metal- azo complexes. They are used as additives in amounts from 0.001-2.5 %.

Inorganic pigments have no migration tendency and have high temperature and UV/VIS resistens. They counts zinc sulphide, iron oxide, cadmium- manganese based substance, chromium and molybdaenium salts, ultramarine and titan dioxide.

The special colorants use aluminium or cobber powder or lead carbonate or bismuth chloride and combinations with titaniumdioxide and "glimmer". To this group belongs fluorescent colourants.

Flame retardants can migrate from the plastic if they are halogen containing additives. Phosphor acid esters can migrate as well. These two groups of flame retardants can be added in amounts up to 50 %.

Inorganic flame retardants count aluminium trihydrate, antimonium trioxide, zink borate and other borate, barium and phosphorous containing inorganic substances. They will not migrate but can as other inorganic additives be liberated by ageing/ abrasion of the plastic polymer.

It is possible to make a co polymerisation of the plastic with halogen containing reactive monomers, e.g. vinyl bromide, tetrachlorbisphenol A and tetrachlorphthalic acid anhydride.

The copolymer will not migrate, but there might be left residual monomer. They are used for the thermosetting polymers epoxy, unsaturated polyester and PUR.

Summary of rules of thumb for migration

- Additives are not chemical bonded in the plastics, except the rather few reactive which is built in the plastic molecule by co-polymerisation (some flame retardants);
- Small organic molecules likes gasses and solvents with low boiling point and high vapour pressure will migrate fast;
- Molecules which have a low solubility in the plastic will migrate faster than molecules with a high solubility in the plastic;
- Some organometallic substances will migrate due to fairly low boiling points, e.g. organo tin compounds;
- Chemical substances with a molecular weight higher than 600 g/mol will have low tendency to migrate;
- Inorganic pigments, carbon black, fillers and reinforcing fibres will not migrate unless the plastic material is degraded by weathering or chemical attack;
- Migration rate will increase with higher temperatures;
- Migration will occur faster in amorphous regions of semi crystalline plastics because of better space between the plastic polymers in the amorphous regions;
- Migration in amorphous plastics will be slowed down as the glass temperature get higher due to less mobility of the plastic polymer chains;
- Migration rate will increase to a contact medium if the solubility of the migrating substances is high in the contact medium (e.g. phthalate plasticizers to vegetable oils), and;

- The migration will decrease with time as the concentration of the migrating substances get lower in the plastic.

1.5 Degradation of plastic polymers

Plastic materials will slowly degrade during use. How fast depends on the chemical structure of the plastic, the amount of stabilizers and the environment it is exposed to (mechanical wear, weather conditions, chemical attack). Some plastics like polyurethane and polyamide can hydrolyse in contact with water especially if the water is either acidic or basic and if the temperature is high. For building and construction it is not uncommon to demand a functional lifetime of the plastic for 25 – 50 years far longer than any demands for packaging plastics materials.

1.6 Recycling potential of plastic materials

Recycling of plastic materials is complicated for many reasons. Here it is relevant to distinquesh strongly between mechanical recycling versus feedstock recycling as well as between thermoplastics and thermosetting plastics.

Mechanical recycling covers the process in which the plastic is simply washed, cut into small pieces and used as raw materials for new products relevant for the types of plastic and additives in question.

Feedstock recycling means that the plastic are treated by pyrolyse or a similar process (e.g. glycolysis, a method for chemical recycling) able to degradate the plastic into its basic monomers which can then use for manufacturing of new plastic polymers.

Mechanical recycling is easily applied to thermoplastics, in case the plastic materials available are clean, not mixed with other plastics, and contains by and large the same additives.

This kind of recycling takes place at many factories as part of the production process (manufacturing scrap is simply recycled into new products). As examples of recycling of waste may be mentioned HDPE boxes for beer and softwater and PET bottles for softwater. Also packaging foils made of LDPE are normally easy to recycle, as it is normally easy to obtain large quantaties of materials not very dirty and LDPE generally does not contain additivites apart from pigments.

Recycling of thermoplastics becomes complicated when:

- The material is very dirty and it is not possible to remove the dirt by simple washing (e.g. when food or oil residues are attached to the plastic).
- Different plastic types are mixed together (PE, PVC, ABS, PA, PET etc.)
- The materials contain many different additives

A general problem regarding recycling is that recycled plastics may contain additives or blowing agents which now are illegal; however, at the time of production they were not forbidden. An example of this kind is polyurethane foams, which former were blown with

CFC gasses which now have been replaced with pentane or CO_2 blowing agents, but the former can still end up in the waste streams. Other examples are the recent restrictions on brominated flame retardants and pigments or stabilisers based on heavy metals (lead, cadmium).

If a sorting according to processing properties could be done cost-efficiently it might open for a higher degree of recycling and higher prices on recyclate.

Finally regarding recycling of thermoplastics a problem might be degradation caused by ageing. By ageing the polymer plastic chains can be shortened. This means that the degraded platic polymers are less capable, or even incapable of linking with their nabor molecules by hooking together. And the ability to hook together is important for properties of the plastic regarding high strength and toughness. Instead the plastic gets brittle [Brandrup et al, 1996].

Thermosetting plastics cannot be recycled mechanically, but feedstock recycling is possible. However, only a few feedstock recycling plants are actually operating in Europe and this technology is still under development.In many countries energy recovery by incineration has been prioritized as compared to recycling and in particular feedstock recycling.

Recycling of thermosetting materials reinforced with fibres e.g. glas fiber products are more complicated as it is necessary to treat the products by cutting or shredding processes before recycling can take place. By doing this the fibers ar shortened and loosing most of their value as reinforcement material.

The figures stated as recycling rates in this report is figures representing recycling of good quality materials delivered to the recycling plant. By good quality materials is to be understood relatively clean materials separated well in different plastics with a by and large uniform content of additives.

Difficulties in collection and separation of plastic are not considered in these figures, as such constraint depends heavily on how waste collection is organised in the society.

Basically it should be recognised that dealing with thermoplastics, the amount of waste generated by production will optimally be down at 2-3 % of the material employed as raw material.This can be compared to the experiences from recycling of PVC-windows in Germany where a recycling rate of 97.5% is claimed to be obtained [Menges, 1996]. They German experiences thus claim that the material loss by recycling may not exceed the material loss to be obtained by normal production.

Danish experiences are somewhat more conservative. Investigations of the loss of materials by recycling processes have shown a loss of 7.4% at a Danish company (Replast) recycling LDPE packaging foil [Frees 2002]. For HDPE used in Denmark for beer boxes and kept in an almost closed loop cycle it is known, that in the process of recycling old damaged boxes the amount of new plastic added is below 10%, meaning that the amount of HDPE lost by the recycling process is below 10% [Drivsholm et al 2000].

The loss related to recycling of PET bottles is generally assumed to correspond to the loss by recycling LDPE [Schmidt 2005].

Based on these experienced an optimal recycling rate of 90-93% will be assumed in all cases with mechanical recycling of thermoplastics where more specific knowledge is not available.

Regarding feedstock recycling no data of recycling rates are available neither for thermoplastic nor for thermosetting plastics.

2. Important plastic materials, their characteristics and application

2.1 Introduction to the information presented

In the tables below, key information has been listed for the 15 selected types of plastic. The information presented naturally is very brief and the references quoted should be consulted for further details if required.

Main Uses
Typical uses are listed. The uses listed are in no way exhaustive, but should be regarded as illustrative examples.

Important characteristics
Important parameters for plastics are and in connection with amorphous plastics (no tm) the softening point should be considered. These parameters play an important part for the temperature span where the plastic material can be used (upper and lower service temperature).

Other important parameteres to consider for choosing a plastic material are:

- The price of the plastic (not better performance than needed)
- Processing properties (how easy can the material be moulded, extruded etc.)
- Resistance to weathering or chemical attack (oxygen, ozone, light, water, acids/bases , solvents or other chemicals)
- Barrier properties (water vapor, oxygen, nitrogen, carbon dioxide etc.)
- Mechanical performance (tensile strength, fatigue resistance, toughness, creep, hardness, compression properties)
- Density (if low weigth of the plastic product is needed, use of carbon fibres as reinforcement instead of glass)
- Electrical properties and fire resistance.
- The molecular weight (MW) and MW distribution is also important as high molecular weight plastic materials will have better mechanical properties. Low molecular weight will act partly as plasticizer. High molecular weight plastics are more difficult to process because they have high viscosity. High viscosity results in bad flow properties (e.g. filling a mould or extruding a pipe might be difficult).

For the application of different plastic qualities a number of considerations can be important:

- Legal demands (e.g. food contact material, medical devices, difficult to ignite and burn)

- Safety demands (e.g. toys and electronic and electrical equipment))

- Functional demands (e.g. transparent, rigid, stiff, flexible, low abrasion, high impact strength, weather resistant, stable at high temperatures, etc).

Additives
It has been listed, which types of additives should be expected in the different types of plastic materials. Only additives which might contain hazardous substances are listed.

Other substances
Other toxic substances than additives, relevant to pay attention toare listed. It may be residues of monomers and reactive compounds that may be present in the final product or substances that can be formed during processing or by degradation of the plastic polymer etc.

Consumption in EU27/Norway
In the following tables covering the most common thermoplastics, the 2011 consumption in Europe and Norway has been listed according to the different forecasts in [AMI 2011].

The forecast for 2011 is very similar to the known consumption in 2010 and it was made in the second half of 2011 (September) so it is estimated to be very close to the truth. AMI [2011] estimates an increase of 1.7 % for next year in Western Europe and 5% in Central and Eastern Europe for consumption of thermoplastics.

For the Thermosetting plastics [Witten, 2012] has reported the European market for GRP (glas fiber reinforced plastics) in 2012. According to[Witten, 2012] the production volume of GRP in Europe will fall by approx. 4% to 1.01 million tonnes in 2012. For the Nordic countries (Finland, Norway, Sweden and Denmark) the market for glass reinforced products (GRP) was 52 000 tonnes in 2011 and forecast for 2012 is 44 000 tonnes.

For polyurethane plastic the European production volume in Europe is in the order of 4150,000 tonnes. This amount includes elastomers (rubber) which approx. corresponds to 10 % of the total amount [IAL 2011].

Is recycling possible/potential
In the tables are written "Yes", if mechanical recycling is possible. Otherwise is written "only by feedstock recycling" (se section 1.5).

The figures stated as recycling rates is figures representing recycling of good quality materials delivered to the recycling plant. By good quality materials is to be understood relatively clean materials separated well in different plastics with a largely uniform content of additives. Difficulties in collection and separation of plastic are not considered in these figures, as such constraint depends heavily on how waste collection is organised in the society.

An optimal recycling rate of 90-93% will be assumed in all cases with mechanical recycling of thermoplastics where more specific knowledge is not available (se section 1.5).

References
General references are presented in the section of references at the end of the report.

The information presented in the section on "important characteristics" has been extracted from a large number of technical handbooks and other pieces of technical literature.As many handbooks ha been consulted for each information, the choice has been made not to specify the exact references for each information but instead to list all the litterature in a special section i the beginning of the list of reference.

2.2 Polyethylene (PE-LD/PE-LLD)

Material	Polyethylene - Low Density Polyethylene (LDPE) and linear low density (LLDPE)
Main uses	Packaging foils, kitchen tools, toys, bottles, tubes, cable isolation
Important characteristics	Semi-crystalline thermoplastic T_g = -120°C; t_m =+105 – 125 °C LDPE has a high ratio of branches in the polymer chain. That results in low density and low crystallinity. LLDPE has a low ratio of branches and higher crystallinity unless copolymerised with butene or hexene. LDPE and LLDPE are cheap and versatile plastic materials and because the glass transition temperature is so low they are very flexible and there is no plasticisers added to LDPE or LLD. Around 50 % is used for packaging. LLDPE has the highest melting point (125 °C) which means that it can be used in dish washing machines. Normally he use of LDPE and LLDPE will be limited to less than 100 °C as especially LDPE starts to soften around 80° C. LDPE and LLDPE are not resistant to UV radiation. For outdoor application it is needed to ad UV stabilizers or better to add 2 % w/w carbon black if a clear and transparent or bright colours material is not needed. LDPE and LLDPE are very tight against water, but open for diffusion of gasses e.g. oxygen. These last barrier properties are used for transport of living fish. LDPE and LLDPE are very easy to weld. For this reason they are very often used as the inner layer in laminated packagings. LDPE can be used as shrinking foil/wrap for packaging purposes
Additives that may contain hazardous substances	Colorants, flame retardants. Flame retardants are added in few cases, e.g. to cable insulation applications due to fire resistant demands.
Consumption in EU27	8553 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	30 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible/potential	Yes, recycling rate in the range of 92-93 % for good quality materials [Frees 2002].
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2.

	Frees, N. (2002) Miljømæssige fordele og ulemper ved genvinding af plast. Miljøprojekt 657/2002. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.3 Polyethylene HDPE

Material	Polyethylene: HDPE (High Density)
Main uses	Kitchen utensils, transport boxes and crates, protection helmets, pipes and fittings for drinking water, sewage and gas applications, waste containers, technical articles, gasoline tanks, corrosion protection cover (on steel cables etc.)
Important characteristics	Semi-crystalline thermoplastic with crystallinity between 50 – 80% due to high linearity in structure. Density 940 – 965 g/cm^3. Tg= -120˚C Cheap Fairly tough material and with high chemical resistance. As for LDPE the glass transition temperature is very low and there is no need for plasticizers. The upper temperature for use is limited as the crystallites melts around 125 – 135⁰ C and the material starts to soften and creep before the melting point. HDPE is easy to weld which is a benefit for many packaging applications or for plastic membrane and pipe applications
Additives that may contain hazardous substances	Colorants, flame retardants. Flame retardants are added in few cases, e.g. cable applications, electronics in hot temperature applications
Other substances	Chromium oxide is used as catalyst for the polymerisation according to the Phillips-method
Consumption in EU27	5739 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	50 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, recycling rate in the range of 90 % or better for good quality materials [Drivsholm et al 2000]
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Drivsholm T., Maag J., Hansen E., Havelund S., Lassen, C. (2000). Massestrømsanalyse for cadmium. Miljøprojekt nr. 557. Miljøstyrelsen. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.4 Polypropylene (PP)

Material	Polypropylene (PP)
Main uses	Medical containers, packaging for consumer goods, fibres and filaments, foils, pipes, plates, suction tubes, cable insulation, furniture, kitchen utensils, suitcases, closures, containers, toys, battery cases. Boxes of all kinds (e.g. suitcases for tools), parts of washing machines, huge amounts of throw away articles like drinking cups or food contact packaging trays, garden furniture's, toys.
Important characteristics	Semi-crystalline thermoplastics with high stiffness (between PE and ABS), good tensile strength and resistant to acids, bases and solvents. The polymer is not resistant to oxidation and all commercial PP´s are stabilised with antioxidants. Cheap PP is resistant to bacteria and fungi and can be steam sterilized as opposed to PE. T_g= - 10°C and T_m= 165°C. As the glass transition temperature is low PP has flexible properties down to below 0 °C. When the temperature drops below -10 C PP starts to be stiffer and more fragile. There is no need for plasticizers in PP. Density: 900 – 910 g/cm^3.
Additives that may contain hazardous substances	Antioxidants, colorants, flameretardants (in cable applications or electronics in hot temperature areas)
Consumption in EU27	8 800 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	37 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, recycling rate is assumed to correspond to HDPE an be in the range of 90 % or better for good quality materials.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.5 Polystyrene (PS/HIPS)

Material	Polystyrene (PS and HIPS)
Main uses	Standard types for single use packaging for food, pharmaceuticals and cosmetics and disposable tableware, boxes for CD and DVD. HIPS contains 2-15 % by weight of a rubber polymer (butadiene rubber) and is used for electronic, and medical applications and for condensator foils. HIPS is also used for more demanding packaging applications for medical sector and for taste and odour sensitive products. Due to the rubber part the material has a an opaque milky appearance.
Important characteristics	Amorphous thermoplastic, hard, stiff and fairly fragile unless modified with butadiene rubber as HIPS (High Impact PolyStyrene). T_g= 100 °C. Upper temperatures limit for use 80- 90 °C. PS is clear and transparent with a high gloss. Stable against non-oxidizing acids, aliphatic amines, bases, foods, vegetable oils, soaps and detergents. Unstable to hydrocarbons, aromatic amines, aldehydes and ketones and etheric oils. Density 1.04-1.07 g/cm^3 Cheap HIPS is especially well suited for thermoforming.
Additives that may contain hazardous substances	Colorants
Other substances	Residual styrene monomer
Consumption in EU27	2,218,000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	5 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, no certain knowledge of recycling rates - for good quality materials should be assumed a rate of 90% or better.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.6 Expanded Polystyrene (EPS and XPS)

Material	Expanded polystyrene (EPS and XPS))
Main uses	Thermo insulation materials and goods for many purposes (e.g. buildings, shock absorbing packaging, rescue materials (lifebelts etc.). Meat trays and egg cartons and cups.
Important characteristics	T_g = 100 C. Expansion of PS to PS balls is done with a gas (e.g. pentane or CO2: 5-8%). Densities down to 20 kg/m^3 which mean that the weight of PS in the foam only corresponds to 5 % w/w the rest being air. XPS is formed by extrusion and has a closed cell structure. The density of the surface is higher. Due to this structure XPS has a high "impact strength", low water absorption and low flamm ability. Cheap
Additives that may contain hazardous substances	Flameretardants for some applications e.g. insulation for buildings. Colorants are possible but not normal. Expansion gas for XPS was formerly CFC-compounds which impose damage to the ozone layer.
Other substances	Residual styrene monomer
Consumption in EU27	139 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	35 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, by remelting/blowing as well as defragmentation in separate PS balls to be used for insulation or other purposes. Recycling rate estimated to >90% for good quality materials
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.7 Acrylonitrile butadiene styrene (ABS)

Material	Acrylonitrile butadiene styrene (ABS)
Main uses	Cabinets for office machines, television and radios, loudspeakers, telephones, computers, toys (building bricks and other), suitcases, inner liners for refrigerators and frost boxes, cabinets for kitchen machines, pipes, automotive parts, shower heads and door handles, cabinets for tools as drilling machines.
Important characteristics	Amorphous thermoplastics, T_g= 100 – 120 °C. Upper service temperature limit 80 -120 °C depending on ABS type. Types which are antistatic exist. Good electrical insulation. Attractive glossy surface For outdoor applications it is necessary to use weather protecting additives, e.g. by using carbon black to prevent UV degradation. Good impact strength. Can easily be painted or metalized Might successfully be blended with PC, PA, PVC, PBT and PSU so-called plastic alloys to obtain special characteristics
Additives that may contain hazardous substances	Colorants, flame retardants e.g. in electric and electronic equipment.
Other substances	Residual styrene monomer, UV-stabilizers
Consumption in EU27	813 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	2 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, no certain knowledge of recycling rates - for good quality materials should be assumed a rate of 90% or better.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.8 Polyvinylchloride (PVC)

Material	Polyvinylchloride (PVC)
Main uses	PVC is one of the most frequently used plastic materials as it is one of the cheapest plastic polymers. Rigid PVC is typically used for pipes, panels for buildings, window frames, profiles, gutters and conduits. In thermal insulation applications where demands exist for flame retardant properties, e.g. electrical cables or blown sandwich panels, bottles and containers. Soft PVC is used for packaging, hoses, membranes for swimming pools, sealing lists, artificial leather, cable insulation, fittings, balls, dolls, swimming finnes??, toys, mats, plastic covers, flooring and wall panels.
Important characteristics	Amorphous thermoplastics with T_g= 82 ºC for the rigid PVC. Density: 1.38 - 1.53 g/cm^3 depending on the chlorine content. As for all amorphous thermoplastics rigid PVC has high dimension stability. For the soft PVC, T_g depends on the amount of plasticizer added, the higher the amount the lower the T_g and hardness. With a high content of plasticisers T_g can be moved to -50°C. PVC has a upper temperature limit in the range of 55- 80°C. The polymer is transparent but can easily be coloured according to request (soft PVC can be highly transparent and difficult to distinguish from PET foils). PVC is attacked by ketones and chlorinated solvents. PVC has very good barrier properties towards oxygen, nitrogen and water. PVC is very easy to weld, and thus appropriate for applications where water tightness is required, e.g. flooring in bathrooms
Additives that may contain hazardous substances	Colorants, plasticizers, stabilizers, flame retardants (not common as PVC in itselv has flame retardants properperties)
Consumption in EU27	5237 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	22 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes for rigid PVC. Recycling rates may be up to 97,5% (for good quality materials) [Menges 1996]. Yes, for soft/flexible PVC - no certain knowledge of recycling rates - for good quality materials should be assumed a rate of 90% or better.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report,

	Applied Market Information LTD, ISBN 978-1-907559-08-2. Menges G. (1996). PVC recycling management *Pure* & *Appl. Chem.*. Vol. 68, No. 9, pp. 1 &O9-1822, 1996. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.9 Polyester (PET)

Material	Polyester (Polyethylene terephthalate - PET)
Main uses	Amorphous PET A is used for carbonated drink bottles due to transparency, very good chemical resistance and gas barrier properties to both carbon dioxide and oxygen. Semi-crystalline PET C is mostly used for reinforcing textiles e.g. in tyres and belts. PET- A is used for blister packaging and blown PET-C for fast food packaging
Important characteristics	Thermoplastic in both amorphous (transparent) and semi-crystalline (opaque and white) versions. Amorphous PET is highly transparent, tough and resistant to stress cracking. T_g = 80°C; T_m= 265°C. Good abrasion, chemical and weather resistance, low friction, low water absorption, hard and stiff. Good dielectric properties. Can be used at low and high temperatures (continuously at 100 -120 ˚C). Density: 1.33 - 1.4 g/cm^3
Additives that may contain hazardous substances	Colorants
Consumption in EU27	3050 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	4 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes. recycling rate are assumed to equal LDPE (92-93 %) for good quality materials [Schmidt]
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.10 Polymethyl methacrylate (PMMA)

Material	Polymethyl methacrylate (PMMA)
Main uses	Window glass, protection of rear lights of cars, signs, lamps for indoor and outdoor applications, protection glass for instruments, spectacle lenses.
Important characteristics	Amorphous thermoplastic, T_g = 105 C, High gloss/ optical properties, excellent weather resistance, good electrical properties. High hardness and stiffness. Most common plastic for metallisation, resistant to basic solutions, dilutes acids and oils but is attacked by strong acids, alcohol, acetone and chlorinated hydrocarbons. Density: 1.17-1.2 g/cm^3
Additives that may contain hazardous substances	Colorants
Consumption in EU27	289 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	Unknown
Is recycling possible	Yes, no certain knowledge of recycling rates - for good quality materials should be assumed a rate of 90% or better.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.11 Polycarbonate (PC)

Material	Polycarbonate (PC)
Main uses	Security glass for windows, fittings for power currents, protective glass for rear lights for cars, pump wheels, propellers, cycling helmets, hair dryers, food containers.
Important characteristics	Amorphous thermoplastic, T_g = 150°C, high impact strength, dimension stability, Resistant to weak acids, aliphatic hydrocarbons, paraffin, alcohol (except methanol), animal and vegetable oils, but not to oxidation acids, bases including ammonia, aromatic and chlorinated hydrocarbons Good weathering resistance, High melt viscosity makes it difficult to process. Density: 1.2 g/cm^3
Additives that may contain hazardous substances	Colorants
Other hazardous substances	Bisphenol A residues (polycarbonate monomer)
Consumption in EU27	671 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	4 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, recycling rate is assumed to correspond to HDPE an be in the range of 90 % or better for good quality materials.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel.

2.12 Polytetrafluoroethylene (PTFE)

Material	Polytetrafluoroethylene (PTFE, teflon)
Main uses	In applications with high demand for chemical, electrical and thermal properties and with low coefficient of friction. E.g. electrical applications in airplanes and robots, seals, filters, self-lubricating bearings, non-slip kitchen pans, foils, surface coating in chemical apparatuses. Artificial blood vessels and other implants.
Important characteristics	Tg= 125-130 ˚C; T_m=325 ˚C, High melt viscosity, low abrasion resistance, limited mechanical properties. Difficult to process. Sintering is the most common process. It is carried out at high pressure of granulate or powder at high temperatures (370°C) PTFE has high resistance towards high temperatures to 260^o C but even higher (500 ^{o}C) has been recorded. High resistance towards chemicals, high weather resistance and low water absorption. PTFE has very low coefficient of friction and good electrical properties. Can be used to very low temperatures and is tough at low temperatures. PTFE is resistant towards fire due to the high amount of fluorine in the polymer. PTFE are used in natural or grey colour. Density: 2.15 g/cm^3
Additives that may contain hazardous substances	Processing aid substances (PFOA)
Consumption in EU27	Unknown but low due to high price [Nilsson ,2012].
Consumption in Norway	Unknown
Is recycling possible	Yes, in theory but normally not practised as PTFE often is used as coating on other materials (iron, steel, aluminium for cooking equipment).
References	Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

2.13 Polyamides (PA)

Material	Polyamides (PA 6, PA 66,)
Main uses	Gears, bearings, kitchen machines and utensils for high temperature applications (palette knifes), fishing nets and lines, cabinets and buttons for electronic devices, fuel tanks. Bottles and foils for special packaging applications
Important characteristics	Important technical thermoplast. Semi-crystalline, crystallinity of PA6 50% and of PA66 50%. PA6: T_g=75 ˚C, T_m= 233 ˚C PA66: T_g= 50 ˚C, T_m= 272 ˚C High strength and stiffness. Resistant to heat, abrasion and many solvents. Not stable to acids and bases due to hydrolysis. Absorbs water: PA 66 has a higher melting point, lower creep and higher stiffness than PA6. Density (PA6): 1.12 - 1.15 g/cm^3 Density (PA66): 1.13 - 1.16 g/cm^3
Additives that may contain hazardous substances	Colorants.
Other substances	Aromatic amines - decomposition residues - may be present if aromatic diisocyanates have been used in the manufacturing of the PA´s or if azocolorants have been used [Trier et al 2010].
Consumption in EU27	716 000 t [AMI, 2011; Plastics Europe 2012].
Consumption in Norway	2 000 t [AMI, 2011; Plastics Europe 2012].
Is recycling possible	Yes, recycling rate is assumed to correspond to HDPE and be in the range of 90 % or better for good quality materials.
References	AMI (2011). AMI´s 2011 European Plastics Industry Report, Applied Market Information LTD, ISBN 978-1-907559-08-2. Plastic Europe (2012). Plastics-the Facts 2012- An analysis of European plastics production, demand and waste data for 2012. Plastics Europe, Brussel. Trier X. et al. (2010). Food Additives and Contaminants Vol. 27, No.9, 2010, 1325-1335

2.14 Polyurethanes (PUR)

Material	Polyurethane (PUR)
Main uses	Insulation foam for district heating pipes, refrigerators and freezers, insulating sandwich panels for gates and doors. Soft foam for furniture, matresses, flooring, shoesoles etc. Rigid foam for automotive parts (e.g. bumper) etc. In most cases PUR is used in foamed versions. The foam can be open cell or closed cell types and foamed PUR can be flexible or semi stiff to stiff.
Important characteristics	PUR can be used as a thermoplastic or thermosetting material. Mostly used as thermosetting material. PUR is based on the reaction between polyols and di- or multifunctional isocyanates. Most used isocyanate is MDI. PUR has adhesive properties and will when foamed between other materials (e.g. plast and metal as in freezers) keep these materials together.
Additives that may contain hazardous substances	Flame retardants (not common except in Great Britain which has special rules for fire resistance for furnitures) and biocides
Other substances	Methyl fumarate has been found in furnitures from China as a biocide with a high risk for allergic reactions [Pedersen 2012] Mercury used as catalyst in manufacturing of PU-polymers may be present as contaminant
Consumption in EU27	1,085,435 tonnes in 2009. Sandwich panels in highest amounts (358,960 tonnes)
Consumption in Norway	Unknown
Is recycling possible	Only by feedstock recycling.
References	Pedersen E. (2012). Personal communication with Eva Pedersen, Danish Technological Institute, Tåstrup, Nov. 2012.

2.15 Epoxies

Material	Epoxies
Main uses	Non-reinforced: Molten metal e.g. putty, wear and corrosion resistant surface coating especially on steel and concrete. Fibre reinforced (glass, aramid or carbon fibres): As parts in cars, boats and airplanes, fuel tanks, flooring, as insulating part in electronic print cards.
Important characteristics	Epoxy is a thermosetting plastic. EP has high resistance to solvents and bases. The adhesion to other materials is from good to excellent. Good abrasion resistance and dimension stability. Good electric and mechanical properties e.g. stiffness and high module. For glass fibre reinforced epoxy the E-Modul is 10- 25 GPa and the density is 1.61-2.10 g/cm3. Can be used at high temperatures. 100 – 180 °C without reinforcement and 100 – 280°C with reinforcement. Standard quality epoxies are manufactured from epichlorhydrin and bisphenol A, but more complex chemical structures exist.
Additives that may contain hazardous substances	Colorants
Other hazardous substances	Bisphenol A residues (epoxy monomer)
Consumption in EU27	GRP = 1.01 million tonnes 2012 [Witten, 2012].
Consumption in Norway	GRP in Nordic countries 44000 tonnes [Witten, 2012].
Is recycling possible	Only by feedstock recycling.
References	Witten E. (2012). Composites Market Report 2012 – Market developments, trends, challenges and opportunities, The European GRP market,(AVK) October 2012. Epoxies 2.16

2.16 Unsaturated polyesters (UP)

Material	Unsaturated polyesters (UP)
Main uses	Transport sector: naval vessels, yachts, car bodies, airplanes and airplane components, tanks, trailers, components for trains, containers, transport crates, vessels. Construction: Moulds for concrete, bathrooms, facing, plates and domes for skylights, ventilation ducts, liners in the chemical industry. Energy sector: wind turbine wings, generator houses. Equipment: seats, chairs and benches, bath tubs Chemical Industry: process plants, acid tubs, tanks, flue gas ducts, chimney lining, coatings on steel and concrete surfaces. Electro industry: outdoor lighting fixtures, plates for printed circuits. Sports: Fishing rods, skis, biking helmets, golf club handles.
Important characteristics	Unsaturated polyester is a very versatile plastic material. They are in most cases combined with glass fibres (GUP). The glass fibres deliver the mechanical properties and the polyester together with additives the thermic and chemical properties of the composite. The unsaturated polyester is formed by polycondensation of a dibasic acid and a glycol. Common monomers used are the three aromatic isomeric phthalic acids, fumaric- or maleinic acid (both unsaturated) and ethylene glycol or propylene glycol. At this stage the polyester is still thermoplastic and highly viscous. The next step is the crosslinking process. In this step styrene acts both as a reactive monomer and a solvent. To initiate the crosslinking process an initiator is added. Typically organic peroxide. If the reaction is carried out at room temperature an accelerator is needed. This is often a cobalt salt of organic acids. Crosslinking at high temperature is not needed but special peroxides are used. As many different combinations of the monomers in the “tool box” are possible one can really tailor-made polyesters for special purposes. Due to the chemical structure (an ester) UP can hydrolyse. For this reason the highest temperature in contact with water, weak bases or acids is below 110 C. Otherwise the upper temperature in use is somewhat higher than 100 C and for special types around 170 C.

	The weather resistance is good and the water absorption low.
Additives that may contain hazardous substances	Flame retardants (life-saving boats, fire alarm boxes). Colorants
Others	Residual styrene monomer
Consumption in EU27	GRP = 1.01 million tonnes 2012 [Witten, 2012].
Consumption in Norway	GRP in Nordic countries 44000 tonnes [Witten, 2012].
Is recycling possible	Only by feedstock recycling.
References	Witten E. (2012). Composites Market Report 2012 – Market developments, trends, challenges and opportunities, The European GRP market,(AVK) October 2012. Epoxies 2.16

2.17 Melamine (MF)

Material	Melamine-formaldehyde (MF)
Main uses	Laminated surface on chipboards used for cupboards, cabinets, shelves, doors, table tops and worktops etc. Kitchen items such as bowls, casserole spoons and trays.
Important characteristics	Thermosetting plastic made by polycondensation between melamine and formaldehyde at 120 – 165°C. Hard, stiff and fragile MF is resistant to weather, solvents and weak bases and acids, but not resistant to strong acids and bases. Highest temperature of use for standard MF is 120 – 130°C, but somewhat higher if reinforced with glass fibres. Due to the high content of nitrogen in melamine, it will not promote fire and is in fact used as flame retardant due to the high content of nitrogen in the polymer
Additives that may contain hazardous substances	Colorants
Other substances of concern	2,4,6-triamino-1,3,5-triazin (melamin monomer)
Consumption in EU27	Estimated to be low [Nilsson ,2012].
Consumption in Norway	Estimated to be low [Nilsson ,2012].
Is recycling possible	Only by feedstock recycling.
References	Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

3. Prioritized substances in plastics

In this chapter substances on the Candidate list (August 2012) and Norwegian priority list which are used in plastics are listed and described. The description is aimed at providing key information on each of the substances regarding their use in plastic.

The key information is in this context limited to the following:

CAS number
Justification (is the substance included on the Candidate list and/or the Norwegian priority list?)
The function of the substance
Types of plastics where the substance is used
Main articles groups for which the plastics with the substance are used
EU restrictions of the use of the substance in plastics/ Norwegian regulations on the use in plastics
The concentration of the substance in plastic materials
The chemical binding of the substance in plastics
Potential for release inclusive leaching or evaporation of the substance from plastics
Alternatives
Applications for which the individual substances may still be in use in the society

This information, to the extend it is available, is presented in the following sections 3.3- 3.44. A section has been designated to each substance assumed to be present in plastics and relevant to consider.

Selection of substances
The substances on the Candidate list and the Norwegian priority list used in plastic, have been identified by a screening process in which the following sources of information has been utilized: .

- EU Annex XV reports
- eChemPortal – EU risk assessment reports and other risk assessments made by non-EU countries, and SIDS/SIAR
- Article guide (Swedish Chemicals Inspectorate) "Varuguiden" for plastic and plastic products
- Polymer and additive literature
- Google books searches on keywords
- Various internet sources accessed by google searches
- Chemical suppliers' information on the web.
- Reports from KLIF

The substances assessed not to be used in plastics to any significant extent are together with a brief presentation of their uses listed in annex 1.

3.1 Introduction to the information presented

Regarding the information presented in the following sections 3.3- 3.44 the following considerations applies:

Function (of the substance)
The relevant function(s) of the substance in plastic is indicated. As described in section 2.1 typical functions of additives in plastics include stabilizers, flame retardants, plasticisers, foaming agents, biocides, pigments (colorants). To this may be added the functions of intermediate or catalysts in production of plastics, both of which may lead to the presence of residues in end products.

Relevant types of plastics (where the substance is used)
The relevant types of plastics are listed. As stated above relevant thermoplastics and thermosetting plastics are included while elastomers (rubber) normally not are listed.

Main articles groups (for which the plastics with the substance are used)
The main articles groups are stated to the extent, they are known.

EU Restrictions of the use in plastics
Only restrictions having reference to the use of the substance in plastics is stated. Relevant restrictions typically include the following regulations:

- REACH (noted if the substance is included in the REACH-procedure as the case is for candidate substances)
- REACH annex XIV and XVII is stated if the substance are subject to Authorisation under REACH (Annex XIV) or special restrictions (import, use or marketing) is stated in annex XVII to the REACH directive.
  It is noted that all CMR-substances are covered by Annex XVII (item 28-30) requiring that use of such substances inclusive mixtures are restricted to professional users.
- CLP (noted if a harmonised classification has been established for the substance)
- Directive 2009/48/EC relating to toy safety (use of CMR-substances are not allowed)
- Directive 2005/90/EC on the marketing and use of certain dangerous substances and preparations (substances classified as carcinogenic, mutagenic or toxic to reproduction — c/m/r)
- Directive 2005/84/EC on the marketing and use of certain dangerous substances and preparations (phthalates in toys and childcare articles)
- Directive 93/42/EEC on medical devices
- Directive 2002/72/EC relating to plastic materials in contact with food (unless a substance is authorized to be used without restrictions, the substance is restricted)
- Directive 2000/53/EC on End of Live Vehicles (ELV)
- Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
- Directive 94/62/EC of 20 December 1994 on packaging and packaging waste.

For group of substances (e.g. nonylphenol and its ethoxylates) the strongest restriction or classification is stated, no matter whether this only applies to one or few members of the group.

Norwegian regulation of the use in plastics.
For substances and /or substance groups included on the Norwegian priority list and for which specific Norwegian regulation relevant to the use of the substance in plastics applies, the

relevant regulation is stated. Relevant regulation typically include:

- Regulations relating to restrictions on the manufacture, import, export, sale and use of chemicals and other products hazardous to health and the environment (Product Regulations)
- Regulation on toy safety

Concentration in plastic materials
The concentrations stated will be typical concentrations used in relevant plastic materials. If exact knowledge regarding the substance in question is not available typical concentrations for the relevant type of additives as stated in table 1 is presented.

Chemical binding
Chemical binding is assessed as stated in section 3.2 regarding rules of thump regarding chemical binding and migration of substances Regarding the chemical binding, emphasis is put on whether the substance is solid bound in the plastic material or the substance is available for migration and thereby to leach or evaporate from the material.

Potential for release
Only potential release during the use phase is taken into account. Release mechanisms during the use phase includes, apart from leaching or evaporation, also simple wear and tear caused by e.g. weathering. Thise mechanisms depends primarily on the actual applications in question.

Information on actual leaching or evaporation rates are difficult to find and is, therefore, seldom stated.

Alternatives
Alternatives includes in principle:
- Other chemical substances fulfilling the same function as the hazardous substance in question
- Alternative technical solutions that represents another way of fulfilling the same function.

In this survey the focus has been given other chemical substances. The main issue is, however, whether it is possible to point at alternatives or not. For chemical substances it is generally so that perfect substitutes do not exist and selection of alternatives is a trade-off between different characteristics. In reality it will normally be necessesary to test several alternatives and maybe also adjust on the content of other additives in order to obtain satisfying alternative solutions.

Applications for which the individual substances may **still** be **in use in the society.**
The objective is to present existing information on the historical
uses of the substances identified focusing on identifying applications for which the individual substances may still be in use in the society. For substances still in use and used in products with a relative short in-service life, information on historical uses are, however, considered irrelevant.

References

For each substance and/or group of substances for which information is presented in section 3.2 - 3.43 the relevant references has been stated in the bottom row of the table. The references have, furthermore, been organised into the general list of references presented at the end of the report.

However, the REACH Annex XV reports or dossiers, which for all candidate substances have been an important source of information are only listed under the relevant tables and not included in the the general list of references. All these reports are available from ECHA on the internet.

3.2 Acrylamide

Substance	Acrylamide
CAS Number	79-06-1
Justification	Candidate list
Function	Intermediate - Comonomer [Kostikov, 1995; Echa 2009]
Relevant types of plastics	Polyacrylamide [ECHA 2009a] Polyacrylonitrile copolymer [Kostikov, 1995].
Main article groups	Acrylamide is almost exclusively (France 2005: 99,54%) used for the synthesis of polyacrylamides, which are used as flocculating agent, in particular in waste water treatment and paper processing. Minor uses include soft contact lenses, cosmetics and comonomer for acrylic fibres [ECHA 2009; NICNAS 2002; Kostikov, 1995]. Other uses of acrylamide includes the preparation of polyacrylamide gels for research purposes, grouting agent in civil engineering and the production of acrylic/acrylamide resins used in household appliances and in automotive engineering (for covering and coating of automotive parts)
EU restrictions of the use in plastics	REACHAnnex XVII CLP-regulation Directive 2009/48/EC relating to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Residual acrylamide monomer in polyacrylamide products are usually below 0.1 %, but residuals up to 2% monomer has been reported [NICNAS 2002]
Chemical binding in plastics	Residual monomer is not chemically bound to the polymer and will migrate.
Potential for release from plastics	Besides residual monomer from production, monomers may be released by weathering processes (hydrolysis). All monomers present may migrate. [Nilsson, 2008]
Alternatives	Alternatives for grout applications include: - acrylics and acrylates not containing N-methylolacrylamide(NMA); - polyurethanes; - silicates; and - formaldehydes. Agarose gels can be used as an alternative for polyacrylamide gel in certain applications. [Annex XV dossier]
Applications in use in society	No information - Uses presented under "main article group" should be assumed still to take place
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_netherlands_cmr_acrylamide_20090831_en.pdf ECHA (2009a). COMMENTS AND RESPONSE TO COMMENTS ON ANNEX XV SVHC for Acrylamide - CAS number: 79-06-1

	http://echa.europa.eu/documents/10162/13638/rcom_final_cc009698-48_acrylamide_nonconf_12112009_en.pdf (Nov. 2012) Kostikov, V.I. (ed) (1995). Fibre science and technology. Chapman and Hall, London. NICNAS (2002). Acrylamide. Priority Existing Chemical Assessment Report No. 23. National Industrial Chemicals Notification and Asessment Scheme. Australia 2002. Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

3.3 Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins-SCCP)

Substance	Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins-SCCP)
CAS Number	85535-84-8; 108171-26-2
Justification	Candidate list and Norwegian priority list
Function	Secondary plasticiser and flame retardant [US EPA, 2009a]
Relevant types of plastics	In USA use in PVC is important [US EPA 2009a]. According to [POPRC, 2007] it it not used in PVC in Europe, but primarily in rubber and elastomers (sealants etc.). Use in textile fibres cover cellulosic textiles and in other polymers.
Main article groups	Polyurethane and acrylic sealants. Fire proofing of cellulosic textiles and in other polymers.[POPRC, 2007]
EU restrictions of the use in plastics	REACH- and CLP-regulations Directive 2002/72/EC relating to plastic materials in contact with food.
Norwegian regulation on the use in plastics	Product Regulations, § 2-4.
Concentration in plastic materials	10–15% by weight for sealants (new sealants)
Chemical binding in plastics	Will not bind to the polymer matrx. Will migrate and leach/evaporate from plastic.
Potential for release from plastics	A release factor for medium chained CPs to water for outdoor use in sealants of 0.15% per year over the 20-to 30-year lifetime of sealants is assumed [POPRC, 2007]. A higher release factor must be assumed for short chained CP. Wear and tear will cause release also.
Alternatives	Alternatives to short chained CPs in plastics include: Long chained CPs and phthalates for e.g sealants. Antimony trioxide, aluminium hydroxide, acrylic polymers and phosphate compounds for flame retardants in textiles and PVC [OSPAR 2009].
Applications in use in society	CP's became important as substitutes for PCB's in paint and sealants back in the 1980'ties. Initiatives to reduce the consumption were introduced during the 1990'ties. The EU's ban of SCCPs for metal and leather working was applied in January 2004. [OSPAR 2009b] Will still be present in the society in many countries as plasticizer in sealants in buildings etc.
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_uk_pbt_sccp_20083006_en.pdf OSPAR (2009b). Background Document on short chain chlorinated paraffins. OSPAR Commission. http://www.ospar.org/documents/dbase/publications/p00397_sccp%20update2.pdf POPRC - Persistent Organic Pollutants Review Committee (2007). Draft risk profile for Short-chained chlorinated paraffins. http://www.pops.int/documents/meetings/poprc/drprofile/drp/DraftRi

	skProfile_SCCP.pdf US EPA (2009a). Short-Chain Chlorinated Paraffins Action Plan. http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/sccps_ap_2009_1230_final.pdf

3.4 Arsenic and arsenic compounds

Substance	Arsenic and arsenic compounds
CAS Number	7440-38-2; 7778-39-4; 58-36-6; 1303-28-2;1327-53-3; 7784-40-9; 7784-42-1; 15606-95-8
Justification	Norwigian priority list
Function	Is used to make 10,10'-oxybisphenoxarsine (OBPA) which is a antimicrobial (accounting for 70 % of the demand for antimicrobials in plastics) [Zweifel et al, 2009].
Relevant types of plastics	Plasticised PVC (have a particular susceptibility to microbial attack and is by far the main plastic in which biostabilisers are incorporated), followed by polyurethane, and then LDPE and polyesters [Zweifel, 2001].
Main article groups	Examples include: shower curtains, floor coverings, wall coverings, coated fabrics, marine upholstery, automotive vinyl trim, vinyl molding, tarpaulins, awnings, gaskets, weather stripping, caulking, ditch liners and swimming pool liners, and textiles [US EPA, 2009b].
EU restrictions of the use in plastics	REACH Annex XIV (diarsenic trioxide and pentaoxide) and Annex XVII CLP-regulations Directive 2009/48/EC on the safety of toys. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food.
Norwegian regulation on the use in plastics	Regulation on toy safety.
Concentration in plastic materials	In most cases, biostabilisers are formulated with a carrier, usually a plasticiser, at a concentration of 2 to 20 % active ingredient. In some cases the biostabiliser is incorporated into a resin concentrate such as PVC/PVA copolymer or polystyrene [Zweifel, 2001]. For OBPA is recommended a concentration of 0.0300-0.05 % by weight for plastics [US EPA 1993]
Chemical binding in plastics	OBPA will likely remain bound without significant migration in the plastics (molecular weight: 502; very low vapour pressure) [US EPA 1993]
Potential for release from plastics	By wear and tear mainly
Alternatives	No information
Applications in use in society	OBPA has been used as antimicrobial in plastics for at least 20 years. A number of the PVC products in question (in particular floor and wall covering) will have an in-service life of 10-25 years and thus still be in use in the society.
References	US EPA (1993). 10,10'-Oxybisphenoxarsine (OBPA) Reregistration Eligibility Document. National Service Center for Environmental Publications (NSCEP)

	US EPA (2009b). 10,10'-Oxybisphenoxarsine (OBPA) Summary Document: Registration Review. Document ID: EPA-HQ-OPP-2009-0618-0004 Zweifel, H. (2001). Plastics additives handbook. 5th edition. Carl Hanser Verlag, Munich. Zweifel, H., Maier, R.D., Schiller, M. (2009). Plastics additives handbook. Carl Hanser Verlag, Munich.

3.5 1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich (DIHP)

Substance	1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich - Diisoheptylphthalat (DIHP)
CAS Number	71888-89-6
Justification	Candidate list
Function	Plasticiser [Annex XV dossier].
Relevant types of plastics	PVC, one-component polyurethanes and acrylics [Annex XV report].
Main article groups	Plasticiser in PVC: vinyl flooring, tile and carpet backing; moulding and coating plastisols (e.g. coating of textiles or other materials); partial replacement for other low molecular weight plasticizers (e.g. DEHP) in extrusion, injection moulding and calendering applications requiring improved processability. Plasticiser in sealants e.g. one-component polyurethanes and acrylics [Annex XV dossier].
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC relating to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	10-40% by weight
Chemical binding in plastics	Not chemically bound. Will migrate
Potential for release from plastics	Release rates by migration are probably in the range of 0.1-1% per year or below (analogy considerations to DEHP). Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternative plasticiser systems for key applications as flooring include [Annex XV]: • A blend of DINP and isodecyl benzoate (IDB). • A blend of the terephthalates DEHT and DBT. • DINP alone (production conditions must be adjusted). • Dibenzoates
Applications in use in society	It is not clear when DIHP was first introduced on the market. It has been marketed as a substitute for a blend of BBP and DEHP used for vinyl flooring and a range of other applications [Hansen et al, 2008]. It is known that up to about 1995-2000 the dominating plasticisers for flooring in Denmark was DEHP, BBP and DBP, while from 1995 DINP and DIDP slowly took over [Hansen et al, 2008]. DIHP has not been used significantly on the Danish market, but may have substituted DEHP, BBP etc. in other European countries.

	The use of DIHP ceased about 2008-2010 in Europe and USA. DIHP has never been marketed by Asian manufacturers, and it is therefore not so likely it will be present in mixtures and articles imported from Asia. The in-service life of flooring and sealants may probably be in the range of 10-25 years.
References (all)	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_echa_cmr_dihp_en.pdf Hansen E., Christensen C.L., Høibye L. (2008). Forbrug af ftalater i Danmark i historisk perspektiv. Miljøstyrelsen, Danmark.

3.6 1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear alkyl esters

Substance	1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear alkyl esters (DHNUP)
CAS Number	68515-42-4
Justification	Candidate list
Function	Plasticiser (mainly) [Annex XV dossier].
Relevant types of plastics	PVC (mainly), foam and urethane.
Main article groups	Electrical and communication wire insulation (mainly) [Annex XV dossier] dossier.
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC relating to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	No data - typical concentration of 10-40 % by weight should be assumed as for other phthalates used as plasticisers
Chemical binding in plastics	Molecular weigt range: 362 – 474 D. Will migrate.
Potential for release from plastics	DHNUP should be regarded as semivolatile (molecular weight: 362-474 g/mol, boiling point: 235-278 °C at 7 hPa). Release rates by migration are probably in the range of 0.1-1% per year or below (analogy considerations to DEHP). Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternative plasticiser systems for key applications as electrical an communications wires include [Annex XV dossier]: DIDP, DINP and DTDP
Applications in use in society	It is not clear when DHNUP was first introduced on the market. Based on information from European manufacturers of phthalates and The European Council for Plasticisers and Intermediates (ECPI), the substance seems not (anymore) to be manufactured in the EU or imported to the EU [Annex XV dossier]. Most likely DHNUP has never been a dominant plasticiser in Europe. It is not known to have been used in Denmark. The in-service life of electrical cables are often high (10-30 years), and products with plasticisers could still be present, to the extent these plasticisers has been used in Norway.
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_dk_cmr_dhnup_en.pdf Hansen E., Maag J., Høibye L. (2010). Background data for Annex XV dossier - DEHP, BBP, DBP and DIBP. Environmental report No. 1362/2011. Danish Environmental Protection Agency

3.7 Benzyl butyl phthalate (BBP)

Substance	Benzyl butyl phthalate (BBP)
CAS Number	85-68-7
Justification	Candidate list
Function	Plasticiser [Annex XV]
Relevant types of plastics	BBP is or has been widely used in PVC (60% of all BBP use) [Annex XV]. Other plastics include polymetamethylacrylate (PMMA), polyamide, and thermoplastic polyester [Swedish Chemicals Agency, 2007]
Main article groups	PVC flooring (largest single use category, 41% of the total use volume); Also tablecloth, curtains, shower curtains and other uses. Also sealants (based on polyurethane based or acrylic-based); and other products. [Annex XV].
EU restrictions of the use in plastics	REACH Annex XIV and XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing and use of certain dangerous substances and preparations (substances classified as carcinogenic, mutagenic or toxic to reproduction — c/m/r) Directive 2005/84/EC on the marketing and use of certain dangerous substances and preparations (phthalates in toys and childcare articles) Directive 93/42/EEC on medical devices Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Typically 10-30% by weight. BBP is typically used together with other phthalates [Hansen et al, 2010]
Chemical binding in plastics	Not chemically bound. Will migrate
Potential for release from plastics	Release rates by migration are probably in the range of 0.1-1% per year or below (analogy considerations to DEHP). Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternatives may include alternative as plasticisers, other flexible polymers without or completely different materials. Product specific application conditions must be taken into account. Alternative plasticisers include other phthalates and other plasticisers as adipates, e.g. di (ethylhexyl) adipate (DEHA), diisononyl adipate (DINA), citrates, e.g. acetyl tributyl citrate (ATBC), cyclohexanedicarboxylic acid esters, e.g. di-(isononyl)-cyclohexane-1,2-dicarboxylate (DINCH), terephthalic acid, bis(2-ethylhexyl)ester (DEHT), organic phosphates, castor oil derivatives (COMGHA), etc. Other flexible polymers include polypropylene, polyethylene, ethylene-vinylacetate copolymers (EVA), ethylene propylene diene terpolymers (EPDM), polyurethane (PU) and

	thermoplastic elastomers. [Hansen et al 2010, analogy to DiBP]
Applications in use in society	BBP is known to be used in flooring from medio 1990'ties and probably also before. In Denmark the use of BBP was phased out about year 2000.[Hansen et al 2008] The use of BBP for flloring in Europe has decresed significantly during since year 2000. [Hansen et al, 2010] The in-service life of flooring and sealants may probably be in the range of 10-25 years.
References	Annex XV report http://echa.europa.eu/documents/10162/13640/svhc_axvrep_austria_cmr_bbp_20083006_en.pdf Hansen E., Christensen C.L., Høibye L. (2008). Forbrug af ftalater i Danmark i historisk perspektiv. Miljøstyrelsen, Danmark. Hansen E., Maag J., Høibye L. (2010). Background data for Annex XV dossier - DEHP, BBP, DBP and DIBP. Environmental report No. 1362/2011. Danish Environmental Protection Agency Swedish Chemicals Agency (2007). Varuguiden. (Article guide) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx.

3.8 Bis (2-ethylhexyl)phthalate (DEHP)

Substance	Bis (2-ethylhexyl)phthalate (DEHP)
CAS Number	117-81-7
Justification	Candidate list and Norwegian priority list
Function	Plasticiser [Annex XV dossier]
Relevant types of plastics	PVC (mainly), but also other polymer products [Annex XV] e.g. polymetamethylacrylate (PMMA), acrylonitrile-butadiene-styrene (ABS) (0-5 %), polyamide, polystyrene (0-5 %), PVC (0-50 %) and thermoplastic polyester [Swedish Chemicals Agency, 2007].
Main article groups	DEHP has for many years been one of the dominant plasticisers for flexible PVC and used in almost all kind of products made of flexible PVC. DEHP is used for producing flexible plastics that are part of many products for both industrial and consumer use. These include building products (insulation of cables and wires, tubes and profiles, flooring, wallpapers, out-door wall- and roof covering, sealants and insulations), certain children's products, clothing (footwear, outwear and rainwear), car products (e.g. car under-coating, car seats made of imitation leather), articles like prams, shower curtains and textile prints [Annex XV dossier].
EU restrictions of the use in plastics	REACH Annex XIV and XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing and use of certain dangerous substances and preparations (substances classified as carcinogenic, mutagenic or toxic to reproduction — c/m/r) Directive 2005/84/EC on the marketing and use of certain dangerous substances and preparations (phthalates in toys and childcare articles) Directive 93/42/EEC on medical devices Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	The content of DEHP in flexible polymer materials varies significantly and DEHP is often used together with other plasticisers. Normally is assumed a typical concentration about 30% (w/w) in flexible PVC, but a concentration as high as 61% has been reported for sextoys and up to 54% for erasers and 46% for sandals [Annex XVdossier; Lassen and Brandt 2012]. The concentrations in the following plastics are: 0-5 % in acrylonitrile-butadiene-styrene (ABS), 0-5 % in polystyrene and 0-50 % in [Swedish Chemicals Agency, 2007].
Chemical binding in plastics	Not chemically bound. Will migrate.
Potential for release from plastics	Release rates by migration are probably in the range of 0.1-1% per year or below (estimate based on [ECB 2008]). Given sufficient time, a significant part of the substance will probably be realeased by leaching

	to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternatives may include alternative as plasticisers, other flexible polymers without or completely different materials. Product specific application conditions must be taken into account. Alternative plasticisers include other phthalates and other plasticisers as adipates, e.g. di (ethylhexyl) adipate (DEHA), diisononyl adipate (DINA), citrates, e.g. acetyl tributyl citrate (ATBC), cyclohexanedicarboxylic acid esters, e.g. di-(isononyl)-cyclohexane-1,2-dicarboxylate (DINCH), terephthalic acid, bis(2-ethylhexyl)ester (DEHT), organic phosphates, castor oil derivatives (COMGHA), etc. Other flexible polymers include polypropylene, polyethylene, ethylene-vinylacetate copolymers (EVA), ethylene propylene diene terpolymers (EPDM), polyurethane (PU) and thermoplastic elastomers. [Hansen et al 2010, analogy to DiBP]
Applications in use in society	DEHP has been used from about 1960 and has for PVC products been the default plasticiser (together with DBP) due to its efficiency and cheapness. Although use and consumption has decrased after year 2000 it is still available on the market in many products. [Hansen et al, 2008]
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_sweden_cmr_dehp_20083006_en.pdf ECB (2008). EU Risk Assessment Report - bis(2-ethylhexyl)phthalate (DEHP). European Chemicals Bureau (ECB). Hansen E., Christensen C.L., Høibye L. (2008). Forbrug af ftalater i Danmark i historisk perspektiv. Miljøstyrelsen, Danmark. Hansen E., Maag J., Høibye L. (2010). Background data for Annex XV dossier - DEHP, BBP, DBP and DIBP. Environmental report No. 1362/2011. Danish Environmental Protection Agency Lassen C., Brandt U.K. (2012). Survey of the phthalate DEHP in articles imported to Norway. Klima- og forurensningsinspektoratet TA 2845/2011. Oslo. Swedish Chemicals Agency (2007). Varuguiden.(Article guide) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx.

3.9 Bisphenol A (BPA)

Substance	Bisphenol A (BPA)
CAS Number	80-05-7
Justification	Norwegian priority list
Function	Monomer (polycarbonate, epoxy resin, unsaturated polyester resin), used in processing (not further specified, of phenoplast cast resin), antioxidant (in PVC processing and in production of plasticisers for PVC), ingredient in PVC additive package, crosslinking agent (rigid polyurethane foam), unspecified function (modified polyamide) [EU, 2010] *Note:* The use in PVC manufacture is being phased out [EU RAR, 2010].
Relevant types of plastics	Polycarbonate, epoxy resins, phenoplast cast resin, PVC, rigid polyurethane foam, modified polyamide, unsaturated polyester resin
Main article groups	All polycarbonate plastics, and many epoxy resins, some phenoplast e.g. phenoplast high pressure laminate compact panels, and PVC articles (groups not specified).
EU restrictions of the use in plastics	REACH Annex XIV (Diarsenic trioxide) and Annex XVII CLP-regulation Directive 2009/48/EC on the safety of toys. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials into contact with foodstuffs Regulation (EU) No 321/2011 amending Regulation (EU) No 10/2011 as regards the restriction of use of Bisphenol A in plastic infant feeding bottles Regulation (EC) No 1895/2005 on the restriction of use of certain epoxy derivatives in materials and articles into contact with food
Concentration in plastic materials	Polycarbonate: The residual content in baby bottles purchased in Singapore has been reported to range from < 3 to 141 mg/kg [Wong et al 2005], which correstponds to 0.0003 - 0.0141 %. Bottles purchased in Washington ranged from 7 to 58 mg/kg [Biles et al, 1997], corresponding to 0.0007 - 0.0058 %. Phenoplast resin: 0.2 % on a molar basis PVC (0.2% in plasticiser constituting 30%) estimated 0.0006 % PVC (when BPA is used as an antioxidant) estimated 0.2% [EU, 2010]. No information available for the other plastic materials.
Chemical binding in plastics	Based on the chemical properties of bisphenol A (molocular weight. 228 g/mol; boiling point: 288˚C) it should be regarded as a semi-volatile compound able out migrate out of plastics.
Potential for release from plastics	Given sufficient time, the major part of the substance will probably be realeased by leaching to the surface followed by evaporation or

	removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Several alternative plastics and other materials can be used instead of plastics based on or containing BPA. [Oregon 2012] points e.g. at glass, aluminium, HDPE, PET, PP.
Applications in use in society	BPA has been used for plastics since before 1960. As a monomer in production of in particular PC and epoxy, BPA is widespread in the modern society.
References	Biles, J.E., McNeal, T.P., Begley, T.H., Hollifield, H.C. (1997). Determination of bisphenol A in reusable polycarbonate food-contact plastics and migration to food-simulating liquids.Journal of Agricultural and Food Chemistry 45:3541–3544. EU (2010). European Union Risk Assessment report 4,4'-Isopropylidenediphenol (Bisphenol-A) CAS No: 80-05-7. EINECS No: 201-245-8. RISK ASSESSMENT. http://esis.jrc.ec.europa.eu/doc/risk_assessment/REPORT/bisphenolareport325.pdf Oregon (2012). Safer alternatives to Bisphenol A (BPA) http://www.oeconline.org/our-work/healthier-lives/tinyfootprints/toxic-prevention/safer-alternatives-to-bisphenol-a-bpa Wong, K.O., Leo L.W., Seah, H.L. (2005). Dietary exposure assessment of infants to bisphenol A from the use of polycarbonate baby milk bottles. Food Additives and Contaminants 22:280–288.

3.10 Bis(2-methoxyethyl) phthalate

Substance	Bis(2-methoxyethyl) phthalate (DMEP)
CAS Number	117-82-8
Justification	Candidate list
Function	Plasticiser [Annex XV dossier]
Relevant types of plastics	Nitrocellulose, acetyl cellulose, polyvinyl acetate, polyvinyl chloride and polyvinylidene chloride (globally) [Annex XV].
Main article groups	Uses that have been reported include material to cover floors, balls for playing and exercise, hoppers and children's toys (e.g. as inflatable water products), cellulose acetate lamination films and laminated documents .There is no information whether the substance is still in use in articles on the EU market .[Annex XV dossier]
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	The Danish Product Register records DMEP as a plasticiser in the concentration range 0.1–1% in a material used to cover floors. Cellulose acetate lamination films typically contain 20–30% plasticisers by weight [Annex XV dossier].
Chemical binding in plastics	Not chemically bound. Will migrate.
Potential for release from plastics	Release rates by migration are probably in the range of 0.1-1% per year or below (estimated based on [ECB 2008]). Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternatives relevant for DEHP will also be relevant for DMEP [Annex XV dossier].
Applications in use in society	No knowledge
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_cmr_bis2-methocxyethylphthalate_20110829_en.pdf

3.11 Bis(tributyltin)oxide (TBTO)

Substance	Bis(tributyltin)oxide (TBTO) - see also section 3.35.
CAS Number	56-35-9
Justification	Candidate list and Norwegian priority list
Function	Antimicrobial agent, intermediate
Relevant types of plastics	Polyurethane (foam), impurities in mono- and dibutyltin stabilisers for plastic, other unspecified. [Annex XV dossier] Are today according to [ECHA 2009b] only used as intermediate.
Main article groups	Polyurethane foam; polymers used in products such as flooring, tiles and carpeting [Annex XV dossier]. Are today according to [ECHA 2009b] only used as intermediate.
EU restrictions of the use in plastics	REACH Annex XVII Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	According to RPA [2007] antimicrobial products are produced based on tributyltin oxide and tributyltin maleate (formulated at concentrations around 1% and 25% respectively and generally further diluted by mixing with other ingredients). These can be used in products such as polymers used flooring, tiles and carpeting; Tributyltins can be present as impurities in mono- and dibutyltin stabilisers for plastics (up to 1% [COHIBA 2011]), but their content is voluntarily controlled by industry to ≤ 0.67 % (as tin) [Annex XV dossier]. From 1.July 2010 new products with >0.1% (as tin) are banned.
Chemical binding in plastics	Assessed as a volatile compound. Not solid bound and will migrate. [Nilsson, 2012]
Potential for release from plastics	Migration and by wear and tear. Given sufficient time, a significant part of the substance will probably be realeased. [Nilsson, 2012]
Alternatives	No information
Applications in use in society	TBTO among other triorganostannic compounds have been formerly used as biocides in antifouling paints and coatings and for other biocidal uses [Annex XV dossier]. Use of the substance is today restricted and deliberate consumption is decreasing [ECHA 2009b]. Substance has been on the"Candidate List" since 28 October 2010 but had not been prioritised by ECHA for its first recommendation. Many of the uses listed under "main article groups" may, however, have a relative long in-service life and still be ind use in the society.
References	Annex XV dossier reporthttp://echa.europa.eu/documents/10162/13640/svhc_axvrep_norway_pbt_tbto_20083006_en.pdf COHIBA (2011). Measures for emission reduction of Tributyl (TBT) and Triphenyltin (TPHT) in the Baltic Sea Area. Guidance Document No.2. COHIBA (Control of Hazardous Substances in the Baltic Sea Region). Finnish Environment Institute SYKE. Helsinki ECHA (2009b). Background document for bis(tributyltin) oxide

	(TBTO). Document developed in the context of ECHA's first Recommendation for the inclusion of substances in Annex XIV. ECHA 1 June 2009 Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012 RPA (2007). Impact Assessment of Potential Restrictions on the Marketing and Use of Certain Organotin Compounds. European Commission, Directorate-General Enterprise and Industry. Brussel. http://ec.europa.eu/enterprise/sectors/chemicals/files/studies/organotins_en.pdf

3.12 Boric acid

Substance	Boric acid
CAS Number	10043-35-3, 11113-50-1
Justification	Candidate list
Function	Boric acid can be used as flame retardant for polystyrene beads [Weil and Levchik, 2009]. Component (39-48 %) in zink borate flame retardant [Murphy, 2001]. Component (not further defined) in silly putty toys [Annex XV dossier].
Relevant types of plastics	Polystyrene beads [Weil and Levchik, 2009], PVC [Murphy, 2001], Silly putty (synthetic rubber) [Silly putty 2012]
Main article groups	Polystyrene beads expanded to polystyrene foam [Weil and Levchik, 2009]; PVC leather cloth, foil, calendaring film and cable [Murphy, 2001], and Silly putty toy [Annex XVdossier].
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials etc. in contact with food
Concentration in plastic materials	Up to 8% in silly putty [Annex XV dossier]. No information on flame retardants.
Chemical binding in plastics	Depends on the application. Zinc borates will be solid bound, while boric acid may migrate. Not solid bound in silly putty, will migrate at least partly. [Nilsson, 2012]
Potential for release from plastics	Depends on the application. See above.
Alternatives	No information
Applications in use in society	No information - Uses presented under "main article group" should be assumed still to take place
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_cmr_boric_acid_en.pdf Murphy, J.(2001). Additives for plastics handbook. Elsevier Science Ltd. oxford, New York, Tokyo. Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012. Silly putty (2012). http://www.chem.umn.edu/outreach/Sillyputty.html (Dec 2012). Wiel, E.D., Levchik, S.V. (2009). Flame retardants for plastics and textiles. Practical applications. Carl Hanser Verlag, Munich.

3.13 Brominated flame retardants

Substance	Brominated flame retardants - see also section 3.24
CAS Number	32534-81-9 (PeBDE), 32536-52-0 (OBDE), 1163-19-5 (DBDE), 25637-99-4 (HBCDD); 79-94-7(TBBPA), 3194-55-6, 134-51-7, 134237-52-8, etc.
Justification	Norwegian priority list
Function	Flame retardant [Zweifel, 2001].
Relevant types of plastics	ABS, EPA, HIPS, polyamides, PBT, polyethylene, polypropylene, epoxy, unsaturated polyester, polyurethane [Zweifel, 2001].
Main article groups	Brominated flame retardants are frequently used in: • 'brown' goods such as television sets, computer hardware housings and monitors, etc. • in polystyrene foams (e.g. see also hexabromocyclododecane(HBCDD)) • EPS and XPS: Insulation boards in buildings, against frost heaves of road and railway embankments, in transport vehicles EPS: Packaging material (minor use and not in food packaging). HIPS: Electric housings for VCR, Electrical and electronic equipment e.g. distribution boxes for electrical lines Video cassette housing Polymer dispersions in textile coating: Upholstery fabric Bed mattress ticking Flat and pile upholstered furniture (residential and commercial furniture), Upholstery seatings in transportation, draperies, and wall coverings, Interior textiles e.g. roller blinds Automobile interior textiles [Annex XV].
EU restrictions of the use in plastics	REACH Annex XIV (HBCDD) and Annex XVII (PeBDE, OBDE etc.) CLP-regulation (OBDE and TBBPA) Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
Norwegian regulation of the use in plastics	Product Regulations§ 2-7.
Concentration in plastic materials	2-28 wt% [Zweifel, 2001].

	PeBDE and OBDE is banned for all applications with a threshold of 0,1 % (w/w).
Chemical binding in plastics	Flame retardants can be either reactive (chemically bound in the material) or additive (not chemically bound in the material) [Zweifel, 2001]. While TBBPA generally are used as a reactive flameretardant, the other bromminated flameredardants focused on here are additive flameretardants [Lassen et al 1999]. Additive flameretardants will migrate. For thermoplastics non-reactive flame retardants (additive) are usually used, while reactive flameretardants are normally used for thermosetting plastics (epoxy, unsaturated polyester and polyurethane) [Frisk et al, 2003; Zweifel, 2001].
Potential for release from plastics	Additive flame retardants can be released from the plastic material since they are not chemically bound. For the reactive flame retardant release is limited since they are chemically bound within the polymer. [Frisk et al, 2003].
Alternatives	Alternatives vary with application. Based on [Lassen et al, 1999] an overview is as follows - (M) stands for alternative material: • Epoxy: Reactive nitrogen and phosphorus constituents, Ammonium polyphosphate and aluminium trihydroxide • Phenolic resins: Nitrogen- and phosphorus compounds, Aluminium trihydroxide • Unsaturated polyester: Ammonium polyphosphate and aluminium trihydroxide • ABS: (M) PC/ABS blends or PPE/PS blends with organic phosphorus compounds • HIPS: Organic phosphorus compounds, (M) Polyethylene with magnesium hydroxide • PBT/PET: (M - some applications) polyamide, polyketone, ceramics, selfextinguishing plastics • Polyamide: Magnesium hydroxide, red phosphorus, melamine cyanurate, melamine polyphosphate • Polycarbonate: Organic phosphorus compounds • Polypropylene: Ammonium polyphosphate • EPS:No alternatives • Rigid polyurethane foam: Ammonium polyphosphate and red phosphorus,(M- some applications) mineral wool • Soft polyurethane foam: Ammonium polyphosphate, melamine, reactive phosphorus polyols
Applications in use in society	Most of the uses listed under "main article groups" will have in-service life in the range of 10 years or more. For building and road insulation the in-service will be significantly longer. As the use of TBBPA is not restricted, this flameretardant will be present in products for many years ahead.

References	Frisk, P.R., Girling, A.E., Widely, R.J. (2003). Prioritisation of flame retardants for environmental risk assessment. UK EPA. http://ec.europa.eu/environment/waste/stakeholders/industry_assoc/ebfrip/annex2.pdf Lassen C., Løkke S.,Andersen L.I. (1999). Brominated Flame Retardants - Substance Flow Analysis and Assessment of Alternatives Environmental Project **Nr. 494/**1999. The Danish Environmental Protection Agency Zweifel, H. (2001). Plastics additives handbook. 5th edition. Carl Hanser Verlag, Munich.

3.14 Cadmium and cadmium compounds

Substance	Cadmium and cadmium compounds
Cas No.	7440-43-9, 10108-64-2, 542-83-6, 7790-79-6, 4464-23-7, 7790-80-9, 17010-21-8, 1306-19-0, 10124-36-4, 1306-23-6 etc.
Justification	Norwegian priority list
Function	Pigment - colours include yellow, orange, red and in principle all others colours as green, brown, beige etc. that may be based on yellow and red. Cadmium sulfide and cadmium selenide are the main substances used as pigments. [MST 1980] Heat and UV stabilizer in PVC and similar materials [MST 1980] The starting material is cadmium oxide for pigments and PVC stabilisers, but also the cadmium metal can be used for making the stabiliser [EU, 2007].
Relevant types of plastics	Cadmium pigments may be used in all types of plastics being coloured. Cadmium stabilizers are used mainly in PVC
Main article groups	Cadmium pigments are/were used mainly in quality products with a long lifetime. Cadmium pigments are/were used anywhere the colours in question are needed, and in particular for safety purposes. [Hansen et al 2005]. Cadmium stabilizers was used mainly for outdoor purposes (doors, windows, crystal clear roof windows) [Hansen et al 2005]
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulations Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS) Directive 94/62/EC of 20 December 1994 on packaging and packaging waste
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment (EE products) – product requirements. Regulation on toy safety.
Concentration in plastic materials	As pigment: ~0.01-1% (low figure for e.g. light beige, high figure for e.g. clear warm yellow) [Hansen et al, 2005] As stabilizer: ~0.1% [Hansen et al, 2005]
Chemical binding in	Solid bound

plastics	
Potential for release from plastics	Release is related to wear and tear of products (e.g. if a plastic window is grinded before painting). Existing information does not allow quantification. However, the quantity released can be assessed as small compared to the quantity present in the product.
Alternatives	Regarding pigments many alternatives are available on the market covering organic as well as inorganic pigments. Ultimately, the choice is a matter of costs versus colour and other characteristics like weather resistance, torsion stability and brilliance. Costs may be lower or higher depending on the substitute selected. Regarding stabilizers both Ca/Zn-systems and organotin compounds are well established on the market (tin compounds are partly banned in PVC from 1. January 2012 - REACH Annex VII). Other alternatives as organic stabilizers are also being developed.
Applications in use in society	Cadmium pigments and stabilizers were in widespread use before 1980. The use was strongly limited by the cadmium ban introduced in Sweden in 1982, in Denmark in 1983 and in the EU in 1991. The ban was, however, improved with EU regulation 494/2011. Many products containing cadmium will still be in use in society e.g.: • Lego building bricks - cadmium was used up to about 1980, but these bricks are saved from generation to generation and the real in service life seems so far to be "almost" unlimited.. • Safety signs/materials - due to very high light and weather resistance cadmium is typically used for such materials. The use was allowed in EU until 2011 • Buttons and housing/casings made of technical plastics as PA or ABS. The use was allowed in EU until 2011. • PVC door and windows. The use of cadmium continued to about 1990/1991. The in service life of such products may reach 40 years or more. Furthermore, recycling of such product may significantly increase the in service life of cadmium stabilizers. Discussion in EU on this issue is on-going
References	EU (2007). European Union Risk Assessment Report. Cadmium metal. http://esis.jrc.ec.europa.eu/doc/risk_assessment/REPORT/cdmetalreport303.pdf Hansen, E.; Lassen, C.; Stuer-Lauridsen, F.; Kjølholt, J. (2002). Heavy metals in waste. EU Commission, DG Environment, Brussels 2002. Hansen, E.; Lassen, C.; Maxson, P. (2005). RoHS substances (Hg, Pb, Cr(VI), Cd, PBB and PBDE) in electronic equipment in Belgium. Directorate-General Environment. Federal Public Service Health, Food Chain Safety and Environment. Belgium MST (1980). Cadmiumforurening. En redegørelse om anvendelse, forekomst og skadevirkninger af cadmium i Danmark. Miljøstyrelsen, København.

3.15 Chromium and chromium compounds

Substance	Chromium and chromium compounds - see also section 3.17, 3.27-3.29, and 3.38
CAS Number	1333-82-0, 7778-50-9, 7789-09-5, 10588-01-9, 7789-00-6, 13765-19-0, 7789-06-2, 24613-89-6, 12656-85-8, 1344-37-2, 1308-38-9, 7738-94-5, 7758-97-6, 7775-11-3, 7789-12-0, 7789-09-5, 10294-40-3, 13530-68-2, 13530-65-9,14977-61-8, 37300-23-5, 11103-86-9 etc.
Justification	Norwegian priority list
Function	Catalyst for production of plastics (chromium trioxide - see section 3.16), component in pigments (yellow, red and green colours - see section 3.25-3.28) [Annex XVreport; Hoffmann et al 2002]
Relevant types of plastics	PVC, polyethylene, polypropylene and other non-specified plastics [Annex XV report; Hofmann et al 2002].
Main article groups	All articles, where a need for yellow, red and green colors exist.
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS) Directive 94/62/EC of 20 December 1994 on packaging and packaging waste
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	For pigments concentrations in the range of 0.01 - 0.29 has been registered [Hofmann et al 2002]. Swedish Chemicals Inspectorate [2007] estimates 0-5 %. No data on residues coming from use of chromium compounds as catalysts.
Chemical binding in plastics	Solid bound
Potential for release from plastics	Release is related to wear and tear of products (e.g. if a plastic window is grinded before painting). Existing information does not allow quantification. However, the quantity released can be assessed as small compared to the quantity present in the product.
Alternatives	Regarding pigments many alternatives are available on the market covering organic as well as inorganic pigments. Ultimately, the

	choice is a matter of costs versus colour and other characteristics like weather resistance, torsion stability and brilliance. Costs may be lower or higher depending on the substitute selected. In Denmark the use of lead chromates as pigments in plastic was substituted by organic pigments with regard to Danish production [Hofmann et al 2002]
Applications in use in society	In many years lead chromates has been widespread as pigments in plastics. The Danish ban on lead and later on after year 2000 the ELV and RoHS directives may have promoted alternatives as organic pigments. The consumption of lead chromate pigments is, however, still significant [Annex XVreport]
References	Annex XV report. Proposal for a restriction. http://echa.europa.eu/documents/10162/4d88d444-4b8b-48ab-9c11-6e74819e047c Hoffmann L., Grinderslev M., Helweg C., Rasmussen J.O. (2002). Massestrømsanalyse af chrom og chromforbindelser. Miljøprojekt Nr. 738. Miljøstyrelsen. Swedish Chemicals Agency. (2007). Varuguiden. (Guide for articles) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx.

3.16 Chromium trioxide

Substance	Chromium trioxide - see also section 3.16
CAS Number	1333-82-0
Justification	Candidate list and Norwegian priority list
Function	Catalyst for production of plastics. Intermediate for pigment manufacture [Annex XV report]
Relevant types of plastics	Polyethylene and other plastics [Annex XV report].
Main article groups	Not specified - probably many different products
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	Only as residues from use of catalysts/intermediates. Likely insignificant.
Chemical binding in plastics	Probably solid bound
Potential for release from plastics	Only by wear and tear
Alternatives	No information on catalysts - many alternative pigments to chromium pigments are available
Applications in use in society	No precise information - relevant applications will likely still be in use
References	Annex XV report. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_cmr_chromium-trioxide_en.pdf.

3.17 Cobalt(II) diacetate

Substance	Cobalt(II) diacetate
CAS Number	71-48-7
Justification	Candidate list
Function	Pigment for tinting PET a light blue colour [Annex XV report] Note: This use is being phased out according to information from the Committee of PET manufacturers in Europe [ECHA, 2011]. *Other plastic related function:* Catalyst e.g. in the production of Purified Teraphthalate Acid (an intermediate for the manufacture of polyester fiber) – by far the main use [Annex XV report].
Relevant types of plastics	Polyester (PET)
Main article groups	PET bottles
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Probably <1% from pigments (cobalt pigments are expensive). No information regarding potential residues from use of catalysts is available. [Nilsson, 2012]
Chemical binding in plastics	Probably solid - the pigment should not be assumed to migrate
Potential for release from plastics	Only by wear and tear of plastic materials. Likely insignificant
Alternatives	No information
Applications in use in society	In-service life of PET containers is rather short and this application will likely disappear within a few years.
References	Annex XV report. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_netherlands_cmr_co-diacetate_en.pdf ECHA (2011). Background document for cobalt(II) diacetate. http://echa.europa.eu/documents/10162/e8682070-93db-40d4-846b-214daf89719e Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

3.18 4,4'- Diaminodiphenylmethane (MDA)

Substance	4,4'- Diaminodiphenylmethane (MDA)
CAS Number	101-77-9
Justification	Candidate list
Function	Hardener for epoxy resins, intermediate in the manufacture of high-performance polymers [Annex XV]dossier e.g. building block for polyether ether ketone (PEEK) [BASF, 2012].
Relevant types of plastics	Epoxy coatings and composites, and the high-performance polymer polyether ether ketone (PEEK) [BASF, 2012].
Main article groups	Mainly used in epoxy coatings and composites and PEEK [BASF, 2012]. The uses is described as "open use in the skilled trade area" [Annex XV dossier].
EU restrictions of the use in plastics	REACHAnnex XIV and Annex XVII CLP-regulation Directive 2009/48/EC relating to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Low, but in a level of concern. Unreacted residues will be <0.1% [Nilsson, 2012].
Chemical binding in plastics	Depends on the application - will e.g. be solid bound in epoxydue to crosslinking (reactive) behaveour. If present as unreacted residues or due to degradation of colorants or polymers migration should be expected to take place. [Nilsson, 2012]
Potential for relea-se from plastics	Mainly by wear and tear
Alternatives	No information
Applications in use in society	No information - the uses described under "main article groups" should be assumed still to take place.
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_cmr_mda_public_20083006_en.pdf BASF (2012). Webpage: http://www.basf.com/group/corporate/en/brand/4_4_DIAMINODIPHENYLMETHANE_MOL Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

3.19 Dibutyl phthalate (DBP)

Substance	Dibutyl phthalate (DBP)
CAS Number	84-74-2
Justification	Candidate list
Function	Plasticiser [Annex XV], component in catalyst for PP (several internet sources).
Relevant types of plastics	PVC (plasticiser) [Annex XV], PP (catalyst) Today extensively used to plasticise PVA-based adhesives and as plasticiser-solvent for nitrocellulose lacquers and similar [Gooch 2010, DBP Information Centre 2012]
Main article groups	DBP has for many years been one of the dominant plasticisers for flexible PVC and used in many products made of flexible PVC. DBP is used for producing flexible plastics that are part of many products for both industrial and consumer use. These include flooring, balls, products, footwear, articles like tablecloth, shower curtains etc. [Hansen et al, 2010].
EU restrictions of the use in plastics	REACH Annex XIV and XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing and use of certain dangerous substances and preparations (substances classified as carcinogenic, mutagenic or toxic to reproduction — CMR) Directive 2005/84/EC on the marketing and use of certain dangerous substances and preparations (phthalates in toys and childcare articles) Directive 93/42/EEC on medical devices Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	DBP is never used alone but always in combination with other phthalate plasticisers. While the total amount of phthalates typically is about 30% (w/w) in PVC, the content of DBP will typically be below 10% [Annex XV dossier, Hansen et al, 2010].
Chemical binding in plastics	Not chemically bound. Will migrate
Potential for release from plastics	Release rates by migration are probably in the range of 0.1-1% per year or below (analogy considerations to DEHP). Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternatives may include alternative as plasticisers, other flexible polymers without or completely different materials. Product specific application conditions must be taken into account. Alternative plasticisers include other phthalates and other plasticisers as adipates, e.g. di (ethylhexyl) adipate (DEHA), diisononyl adipate (DINA), citrates, e.g. acetyl tributyl citrate (ATBC),

	cyclohexanedicarboxylic acid esters, e.g. di-(isononyl)-cyclohexane-1,2-dicarboxylate (DINCH), terephthalic acid, bis(2-ethylhexyl)ester (DEHT), organic phosphates, castor oil derivatives (COMGHA), etc. Other flexible polymers include polypropylene, polyethylene, ethylene-vinylacetate copolymers (EVA), ethylene propylene diene terpolymers (EPDM), polyurethane (PU) and thermoplastic elastomers. [Hansen et al, 2010, analogy to DiBP]
Applications in use in society	DBP has been used from about 1960 and has for PVC products been a default plasticiser (together with DEHP) due to its efficiency and cheapness. Although use and consumption has decrased after year 2000 it is still available on the market in many products.[Hansen et al, 2008]
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_austria_cmr_dbp_20083006_en.pdf DBP information Centre (2012). DBP-A speciality stabilizer. DBP - A speciality plasticiser. http://www.dbp-facts.com/index.asp?page=1 (Nov. 2012) Gooch, J.W. (2010). Encyclopedic Dictionary of Polymers, Volume 1, 2nd edition, Springer. Hansen E., Maag J., Høibye L. (2010). Background data for Annex XV dossier - DEHP, BBP, DBP and DIBP. Environmental report No. 1362/2011. Danish Environmental Protection Agency Hansen E., Christensen C.L., Høibye L. (2008). Forbrug af ftalater i Danmark i historisk perspektiv. Miljøstyrelsen, Danmark.

3.20 2,2'-dichloro-4,4'-methylenedianiline (MOCA)

Substance	2,2'-dichloro-4,4'-methylenedianiline (MOCA)
CAS Number	101-14-4
Justification	Candidate list
Function	Curing agent (for polyurethane resins, epoxy resins and epoxy urethane reins, polystyrene and poly(methylmethacrylate) (PMMA), cross-linker (for polyurethane), chain extender (for polyurethane) or prepolymer [Annex XVdossier].
Relevant types of plastics	Mainly polyurethane (PU) [Annex XV dossier].
Main article groups	PU used in construction, for wheels, cars, electric wire coating, safety belts and recently also in biomaterials such as pace makers and implants, polyurethane coatings, castable urethane (curing agent). Polyurethanes with crosslinking agent can be used in the production of machines, buildings, automobiles, airplanes, mining and sport equipment. [Annex XVdossier]
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC relating to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	The amount of un-reacted MOCA is estimated to be in the range of 0.01 % and 4 % [Annex XV dossier].
Chemical binding in plastics	Solid bound due to reactive behaviour. Unreacted MOCA will, however, migrate.
Potential for release from plastics	Migration of un-reacted MOCA. Degradation of azocolourants used in plastics
Alternatives	The following substances are potential alternatives to MOCA [Annex XV dosier]: 3,5-diamino-4-chlorobenzoacid isobutylester (CAS No 32961-44-7) Dimethylthiotoluenediamine (DMTDA) (isomers) (CAS No 106264-79-3) DETDA-80 (isomers) (CAS No 68479-98-1) MCDEA (CAS No 106246-33-7)
Applications in use in society	MOCA has been used for the products listed for 30-40 years. Concern on release of MOCA however should be limited to new products with un-reacted MOCA and miscellaneous other plastic products in which azocolourants are used.
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_echa_cmr_moca_20110829_en.pdf

3.21 Diisobutyl phthalate (DIBP)

Substance	Diisobutyl phthalate (DiBP)
CAS Number	84-69-5
Justification	Candidate list
Function	Specialist plasticiser, gelling aid in combination with other plasticisers, plasticiser for nitrocellulose, cellulose ether (which are cellulosic plastic) and polyacrylate and polyacetate dispersions [Annex XV].
Relevant types of plastics	PVC, polystyrene [Gooch, 2010], nitrocellulose, cellulose ether (which are cellulosic plastic) and polyacrylate and polyacetate dispersions [Annex XV dossier].
Main article groups	DiBP has application properties similar to DBP, and may thus be used in all products, where DBP is used. DiBP has registered in products like crayons, bar ends of run bikes, erasers, school bags, plastic spoons and forks, boxes for microwave ovens, milk package bags, spoons, cups, plates and bowls [Annex XV dossier]. In many products DiBP may not be used intentedly and be present due to contamination.
EU restrictions of the use in plastics	REACH Annex XIV and Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food.
Concentration in plastic materials	DiBP is never used alone but always in combination with other phthalate plasticisers. DiBP is registered in concentrations up to 0.2%. DiBP is in several products registered in concentrations down to below 0.001%. [Annex XV dossier].
Chemical binding in plastics	Not chemically bound. Will migrate
Potential for release from plastics	Release rates by migration are probably in the range of 0.1-1% per year or below (analogy considerations to DEHP). Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	Alternatives may include alternative as plasticisers, other flexible polymers without or completely different materials. Product specific application conditions must be taken into account. Alternative plasticisers include other phthalates and other plasticisers as adipates, e.g. di (ethylhexyl) adipate (DEHA), diisononyl adipate (DINA), citrates, e.g. acetyl tributyl citrate (ATBC), cyclohexanedicarboxylic acid esters, e.g. di-(isononyl)-cyclohexane-1,2-dicarboxylate (DINCH), terephthalic acid, bis(2-ethylhexyl)ester (DEHT), organic phosphates etc. Other flexible polymers include polypropylene, polyethylene, ethylene-vinylacetate copolymers (EVA), ethylene propylene diene terpolymers (EPDM), polyurethane (PU) and thermoplastic elastomers [Annex XV dossier].
Applications in use in society	No information - it must be assumed that DiBP is still is use for the uses listed above as "main article groups".

References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_cmr_diisobutylphthalate_20090831_en.pdf Gooch, J.W. (2010). Encyclopedic Dictionary of Polymers, Volume 1, 2nd edition, Springer.

3.22 Disodium tetraborate, anhydrous

Substance	Disodium tetraborate, anhydrous
CAS Number	1303-96-4, 1330-43-4, 12179-04-3
Justification	Candidate list
Function	Sodium tetraborate decahydrate (1303-96-4) used as buffering agent (in formaldehyde resins). Sodium tetraborate pentahydrate (CAS 12179-04-3) used for production of plastics, resins, nylon. [Annex XV dossier]
Relevant types of plastics	Formaldehyde resins (not further specified) - no further data [Annex XV dossier]
Main article groups	Formaldehyde resins (not further specified) - no further data [Annex XV dossier]
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	No information
Chemical binding in plastics	No information
Potential for release from plastics	No information
Alternatives	No information
Applications in use in society	No information
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_denmark_cmr_tetraboron_disodium_en.pdf

3.23 Formaldehyde, oligomeric reaction products with aniline

Substance	Formaldehyde, oligomeric reaction products with aniline
CAS Number	25214-70-4
Justification	Candidate list
Function	Intermediate for selected high performance polymers, hardener for epoxy resins. Dominant application is intermediate for methylene diphenyldiisocyanate (MDI). [Annex XV dossier]
Relevant types of plastics	Epoxy resins, high performance polymers (not specified) [Annex XVdossier].
Main article groups	Epoxy: rolls with composite cover, chemically resistant pipes, moulds [Annex XVdossier]
EU restrictions of the use in plastics	REACH Directive 2002/72/EC relating to plastic materials in contact with food.
Concentration in plastic materials	No data
Chemical binding in plastics	Hardeners in epoxy will react with other substances and create chemical bindings. No data on reaction residues in other polymers are available
Potential for release from plastics	Only by wear and tear
Alternatives	No information
Applications in use in society	No information - it must be assumed that formaldehyde is still in use for the uses listed above as "main article groups".
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_cmr_techmda_20110829_en.pdf

3.24 Hexabromocyclododecane (HBCDD) and all major diastereoisomers

Substance	Hexabromocyclododecane (HBCDD) and all major diastereoisomers identified - Alpha-hexabromocyclododecane, Beta-hexabromocyclododecane, Gamma-hexabromocyclododecane - see also section 3.13)
CAS Number	25637-99-4; 3194-55-6; 134237-50-6; 134237-51-7; 134237-52-8
Justification	Candidate list and Norwegian priority list
Function	Flame retardant
Relevant types of plastics	Expandable polystyrene (EPS), extruded polystyrene (XPS), High impact polystyrene (HIPS), polymer dispersions on cotton or cotton/synthetic blends [Annex XVdossier].
Main article groups	EPS and XPS: • Insulation boards in building constructions e.g. houses' walls, cellars and indoor ceilings and "inverted roofs" (outdoor) – main use • Insulation boards against frost heaves of road and railway embankments – main use • Insulation boards (against cold or warm) of transport vehicles e.g. lorries and caravans EPS: Packaging material (minor use and not in food packaging). HIPS: • Electric housings for VCR, • Electrical and electronic equipment e.g. distribution boxes for electrical lines • Video cassette housing Polymer dispersions in textile coating: • Upholstery fabric • Bed mattress ticking • Flat and pile upholstered furniture (residential and commercial • furniture), • Upholstery seatings in transportation, draperies, and wall coverings, • Interior textiles e.g. roller blinds • Automobile interior textiles [Annex XVdossier].
EU restrictions of the use in plastics	REACH Annex XIV Directive 2002/72/EC relating to plastic materials in contact with food.
Norwegian regulation of the use in plastics	Product Regulations § 2-7.

Concentration in plastic materials	• Formulation of flame-retarded EPS beads 0.7% • Formulation of flame-retarded PS compound for XPS 40 % (in the dispersion) • Formulation of polymer dispersion for textile backcoating 10-15 % (in the dispersion) Industrial use of EPS beads to produce flame retarded EPS (in the EPS) Industrial use of HBCDD in PS compound to produce flame-retarded HIPS 1-3 % (in the HIPS) • Industrial use of HBCDD in PS compound to produce flame-retarded XPS 1-3 % (in the XPS) • Industrial use of HBCDD as powder to produce flame retarded XPS 0.5-3 % Industrial use of HBCDD in polymer dispersion for textile back-coating 25 % or 6 to 15 % (in final layer) (the lower span is if used together with antimony trioxide) [Annex XVdossier]
Chemical binding in plastics	Not solid bound. Will migrate
Potential for release from plastics	Given sufficient time, a significant part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place.
Alternatives	XPS and EPS No information that alternatives are available HIPS Un-classified alternatives include: Triphenylphosphate, resorcinol bis (diphenyl phosphate)/Tetraphenyl m-phenylenebis(phosphate), bisphenol A bis (biphenyl phosphate) and polymeric biphenyl phosphate Textiles Un-classified alternatives include: Ammonium polyphosphate, ammonium phosphate, reactive phosphorous constituents
Applications in use in society	The service time for many products containing HBCDD is long. Insulation under roads and railways may last up to 100 years and insulation in buildings typically 30 to 100 years.
References	Annex XV report http://echa.europa.eu/documents/10162/3f5de199-8732-4881-aec6-730bf9499a36

3.25 Hydrazine

Substance	Hydrazine
CAS Number	302-01-2; 7803-57-8
Justification	Candidate list
Function	Crosslinker, chain extender in polyurethane Intermediate in production of blowing agents in thermoplastics, polymerization initiators for acrylic and vinyl, flame retardants for nylon and smoke suppressant additives for polyurethane foam [Annex XV report].
Relevant types of plastics	Polyurethane [Annex XV report].
Main article groups	Polyurethane coatings End-applications for blowing agents include wind turbine blades, isolation panels, flotation devices, boat structures and seat foams, etc. [Annex XV report].
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food.
Concentration in plastic materials	No information
Chemical binding in plastics	Solid bound due to reactive behaviour in PU. Very reactive substance.Therefore most likely no intermediate residues in the endl products. Residues will migrate. [Nilsson, 2012]
Potential for release from plastics	Probably only by wear and tear.
Alternatives	No information for the applications stated above
Applications in use in society	Actual uses have been known for at least 10 years [Annex XV report].
References	Annex XV report. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_echa_cmr_hydrazine_en.pdf Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

3.26 Lead and lead compounds

Substance	Lead and lead compounds - see also section 3.27-3.29.
CAS Number	75-74-1, 78-00-2, 301-04-2, 1072-35-1, 1314-41-6, 1317-36-8, 1319-46-6, 1335-32-6, 1344-37-2, 6838-85-3, 7428-48-0, 7439-92-1, 7446-14-2, 7446-27-7, 7758-95-4, 7758-97-6, 12141-20-7, 12656-85-8, 13424-46-9, 13453-65-1, 15245-44-0, 16038-76-9,16183-12-3, 17570-76-2, 24824-71-3, 25808-74-6, 53807-64-0, 61790-14-5, etc.
Justification	Norwegian priority list
Function	Heat and UV stabiliser for PVC (50% of all stabilisers used for PVC), pigments [Hansen et al, 2005; PVC, 2012]
Relevant types of plastics	Lead pigments may be used in all types of plastics being coloured. Lead stabilizers are used in PVC
Main article groups	Lead pigments may be used in all products where the colours provided are required. The colours available include yellow (lead chromates), orange, and red (mixtures of lead chromates/molybdates) and in fact all other colours like green, brown, beige, etc. that may be based on yellow or red. [Hansen et al 2005]. Lead stabilisers are dominantly used for pipes, gutters, outdoor products inclusive of roofs, windows and doors besides electrical cables and wires [Hansen et al 2005].
EU restrictions of the use in plastics	REACH Annex XIV and Annex XVII CLP-regulations Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS) Directive 94/62/EC of 20 December 1994 on packaging and packaging waste
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	Lead chromate moybdate sulfate can be used in polyethylene, and PVC both rigid and plasticised in rough estimates of 0-5 % [Swedish Chemicals Inspectorate, 2007]. According to Danish experiences plast colored with lead pigments will typically contain 1-3% lead, while stabilised PVC will contain about 2% lead [Hansen et al 2005]
Chemical binding in plastics	Solid bound
Potential for release from	Release is related to wear and tear of products (e.g. if a plastic window is grinded before painting). Existing information does not allow

plastics	quantification. However, the quantity released can be assessed as small compared to the quantity present in the product.
Alternatives	Regarding pigments many alternatives are available on the market covering organic as well as inorganic pigments. Ultimately, the choice is a matter of costs versus colour and other characteristics like weather resistance, torsion stability and brilliance. Costs may be lower or higher depending on the substitute selected. [Hansen et al 2002] Regarding stabilizers both Ca/Zn-systems and organotin compounds are well established on the market (tin compounds are partly banned in PVC from 1. January 2012 - REACH Annex VII). Other alternatives as organic stabilizers are also being developed.[Hansen et al 2002]
Applications in use in society	Lead pigments and stabilizers were in widespread use before 1980. Lead stabilisers and pigments partly substituted cadmium compounds after the ban on cadmium introduced in Sweden, Denmark and later EU. Use of lead compounds were widespread in the EU until the RoHS Directive was established in 2002. This Directive in generally regarded as a as ban on lead and has initiated a slow process in EU of phase of lead stabilisers and pigments. Under the terms of the PVC Industry Voluntary Commitment, sales of lead stabilisers will be reduced in stages and ended by 2015. The use of lead stabilisers for potable water piping has been voluntarily discontinued end 2005 by the pipe producers members of the European association TEPPFA, which is a partner of Vinyl 2010 [PVC, 2012] Many products containing cadmium will still be in use in society e.g.: • Lego building bricks - lead was used up to about 1980, but these bricks are saved from generation to generation and the real in service life seems so far to be "almost" unlimited.. • PVC pipes, gutters etc., door and windows. Internationally lead stabilizers are still used. The in service life of such products may reach 40 years or more. Furthermore, recycling of such product may significantly increase the in service life of lead stabilizers. Discussion in EU on this issue is on-going
References	Hansen, E.; Lassen, C.; Stuer-Lauridsen, F.; Kjølholt, J. (2002). Heavy metals in waste. EU Commission, DG Environment, Brussels 2002. Hansen, E.; Lassen, C.; Maxson, P. (2005). RoHS substances (Hg, Pb, Cr(VI), Cd, PBB and PBDE) in electronic equipment in Belgium. Directorate-General Environment. Federal Public Service Health, Food Chain Safety and Environment. Belgium PVC (2012). Lead stabilisers. webpage: http://www.pvc.org/en/p/lead-stabilisers Swedish Chemicals Agency. (2007). Varuguiden. (Guide for articles) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx.

3.27 Lead chromate

Substance	Lead chromate - see also section 3.16 and 3.26
CAS Number	7758-97-6
Justification	Candidate list and Norwegian priority list
Function	Pigment/used in manufacturing of other lead chromate pigments [Annex XV report; Zweifel, 2001]. Provides green-yellow to red-yellow colors [Annex XV report].
Relevant types of plastics	Used in plastic in all kinds of application [Zweifel, 2001].
Main article groups	Used in plastic in all kinds of application [Zweifel, 2001].
EU restrictions of the use in plastics	REACHAnnex XIV and Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	Less than 5% [Swedish Chemicals Agency, 2007].
Chemical binding in plastics	Solid bound. Will not migrate.
Potential for release from plastics	Only release by wear and tear.
Alternatives	Many pigments are available. Ultimately it is a question of the color accepted
Applications in use in society	According to the European colourants industry pure lead chromate was never of important technical use and only the two lead chromate pigments (C.I. Pigment Yellow 34 and Red 104 - see section 3.26-3.27) have been used commercially for several decades [Annex XV report].
References	Annex XV report. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_france_cmr_lead_chromate_20090831_en.pdf Zweifel, H. (2001). Plastics additives handbook. 5th edition. Carl Hanser Verlag, Munich.

3.28 Lead chromate molybdate sulphate red (C.I. Pigment Red 104)

Substance	Lead chromate molybdate sulphate red (C.I. Pigment Red 104) - (see also section 3.16 and 3.26)
CAS Number	12656-85-8
Justification	Candidate list and Norwegian priority list
Function	Pigment (red). The plastic industry is the largest consumer of C.I. Pigment Red 104 [Annex XVdossier].
Relevant types of plastics	All types of plastics, where red pigments are used.
Main article groups	All types of plastic products, where red pigments are used
EU restrictions of the use in plastics	REACHAnnex XIV and Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	Less than 5% [Swedish Chemicals Agency, 2007].
Chemical binding in plastics	Solid bound. Will not migrate.
Potential for release from plastics	Only release by wear and tear.
Alternatives	Many pigments are available. Ultimately it is a question of the color accepted
Applications in use in society	The pigment has been known and used in plastic for decades. At the EU level lead pigments are only banned in plastics in contact with food, besides vehicles and electronic/electrical products (ELV and RoHS directives). Unless national restrictions on the use in plastic exist the pigments must be assumed still to be present in consumer goods.
References	Annex XV dossier http://echa.europa.eu/documents/10162/13640/svhc_axvrep_france_cmr_lead_chromate_sulfate_red_20090831_en.pdf Swedish Chemicals Agency (2007). Varuguiden.(Article guide) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx.

3.29 Lead sulfochromate yellow (C.I. Pigment Yellow 34)

Substance	Lead sulfochromate yellow (C.I. Pigment Yellow 34) - (see also section 3.16 and 3.26)
CAS Number	1344-37-2
Justification	Candidate list and Norwegian priority list
Function	Pigment (yellow)
Relevant types of plastics	Mainly HDPE, LDPE, PVC [Zweifel, 2001], cellulose acetate [Annex XV] and polypropylene [Swedish Chemicals Agency, 2007]. In reality all types of plastics, where yellow pigments are used.
Main articles	In reality types of plastics, where yellow pigments are used.
EU restrictions of the use in plastics	REACH Annex XIV and Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing and use of certain dangerous substances and preparations (substances classified as carcinogenic, mutagenic or toxic to reproduction — c/m/r) Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	Less than 5% [Swedish Chemicals Agency, 2007].
Chemical binding in plastics	Solid bound. Will not migrate.
Potential for release from plastics	Only release by wear and tear.
Alternatives	Many pigments are available. Ultimately it is a question of the color accepted
Applications in use in society	The pigment has been known and used in plastic for decades. At the EU level lead pigments are only banned in plastics in contact with food, besides vehicles and electronic/electrical products (ELV and RoHS directives). Unless national restrictions on the use in plastic exist, the pigments must be assumed still to be present in consumer goods.
References	Annex XV dossier http://echa.europa.eu/documents/10162/13640/svhc_axvrep_france_cmr_lead_sulfochromate_yellow_20090831_en.pdf Swedish Chemicals Agency (2007). Varuguiden.(Article guide) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx. Zweifel, H. (2001). Plastics additives handbook. 5th edition. Carl Hanser Verlag, Munich.

3.30 Medium-chain chlorinated paraffins (MCCP)

Substance	Medium-chain chlorinated paraffins (MCCP)
CAS Number	85535-85-9
Justification	Norwegian priority list
Function	Plasticiser, flame retardant [KLIF, 2010].
Relevant types of plastics	Soft plastic, PVC, and polyester [KLIF, 2010].
Main article groups	Polyester e.g.in lifeboats PVC - mainly wallpapers, floor coverings, cables, leisure and travel articles, [KLIF, 2010; NG 2010]
EU restrictions of the use in plastics	REACH- and CLP-regulation Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	9-13% [Annex XV report]
Chemical binding in plastics	Not chemically bound. Will migrate.
Potential for release from plastics	In a risk assessment it is estimated that significant release will take place during in-service life of MCCP in plastics [Annex XV report] .
Alternatives	Alternatives to MCCP as plasticizer covers: • other plasticisers (e.g. DINP] as phthalates, adipates, citrates and organophosphates and • other materials as polyethylene (PE) and polypropylene (PP) and ethyl vinyl acetate (EVA). Alternatives to MCCP as flame retardant cover other substances as e.g. trialkyl phosphate, aluminium trioxide in combination with antimony trioxide (for cable sheathing). [NG 2010]
Applications in use in society	Use of MCCP seems to be decreasing partly due to reduced use of DEHP since MCCP are working technically better with DEHP than alternatives as DINP [Annex XVreport]. Still use of MCCP seems to be widespread.
References	Annex XV Restriction Report echa.europa.eu/documents/10162/13630/trd_uk_mccp_en.rtf KLIF (2010). Prioriterte miljøgifter i produkter - data for 2008. Klima- och forurensningsdirektoratet. Oslo. http://www.klif.no/publikasjoner/2743/ta2743.pdf NG (2010). Impact assessment of regulation of medium-chain chlorinated paraffins C_{14}-$_{17}$ (MCCPs) in consumer products. http://www.eftasurv.int/media/notification-of-dtr/2010-9018-en.pdf

3.31 Mercury and mercury compounds

Substance	Mercury and mercury compounds
CAS Number	55-68-5, 62-38-4, 100-57-2, 123-88-6, 593-74-8, 627-44-1, 628-86-4, 1335-31-5, 1344-48-5, 7439-97-6, 7487-94-7, 7546-30-7, 7783-35-9, 8003-05-2, 10112-91-1
Justification	Norwegian priority list
Function	Catalyst [UNEP, 2011]
Relevant types of plastics	Polyurethane [UNEP, 2011]
Main article groups	Examples of mercury catalyst based polyurethanes in use today, for example in gaskets and seals, as encapsulant for electronic assemblies, in film and television props, in vibration dampers, for clear polyurethane on labels, water resistant coatings and concrete sealants, for boat repair and repair on conveyor belts, in rollers on swivel chairs and roller skates and in shoe soles. It has also been used in flooring [UNEP, 2011].
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS) Directive 94/62/EC of 20 December 1994 on packaging and packaging waste.
Norwegian regulation on the use in plastics	Product Regulations), § 2-3. Mercury Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	New products will typically contain 0.1-0.3% mercury [Lassen et al, 2008]. Example 0.1 - 0.2 % mercury in polyurethane floor installed in the US between 1960s-1980s [Weinberg, 2010]
Chemical binding in plastics	Is not bound. Will migrate.
Potential for release from plastics	Elemental mercury will vaporise from the plastic material, e.g. flooring [Lassen et al ,2008]
Alternatives	Alternatives to mecury as catalyst includes tin and amine catalysts, titanium and zirconium compounds as well as compounds of bismuth, zinc, platinum, palladium, hafnium, etc.. Optimal alternative will depend on application. [Lassen et al, 2008]
Applications in use in society	Mercury based biostabilisers were among the first antimicrobials used in plastics [Zweifel et al, 2009]. The use

	today has not been confimed. The use of mercury catalysts is ongoing. [Lassen et al, 2008]
References	Lassen C., Andersen B.H., Maag J., Maxson P. (2008). Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. European Commission Directorate-General Environment, Brussel. UNEP. 2011. Intergovernmental negotiating committee to prepare a global legally binding instrument on mercury. Third session Nairobi, 31 October–4 November 2011. Submission by the Government of Norway on processes using mercury, particularly catalysts in the production of polymers and chemicals. http://www.zeromercury.org/phocadownload/Developments_at_UNEP_level/INC3/CRP8_Norway_processes.pdf Weinberg, J. (2010). An NGO introduction to mercury pollution. International POPs Elimination Network (IPEN). http://www.ipen.org/ipenweb/documents/book/ipen%20mercury%20booklet_s.pdf

3.32 2-Methoxyethanol

Substance	2-Methoxyethanol
CAS Number	109-86-4
Justification	Candidate list
Function	Solvent, chemical intermediate and solvent coupler of mixtures and water-based formulations [Annex XVreport]. Solvent in epoxy resins and polyvinylacetate [Chemindustry.ru, 2000-2010; OSHA, 2012].
Relevant types of plastics	Epoxy resins and polyvinylacetate. The knowledge available is poor.
Main article groups	Not specified. Plastic products made of epoxy or polyvinylacetate. Emissions from new carpets have been registered. The knowledge available is poor.
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	<0.1% [Nilsson, 2012]
Chemical binding in plastics	Is not chemical bound (a solvent) and will migrate.
Potential for release from plastics	The substance is volatile (molecular weight: 76.09 g/mol, boiling point: 123.5 – 125.5 °C at 1013 hPa) and will likely migrate easily.
Alternatives	Possible substitutes for methoxyethanol, ethoxyethanol and their acetates include 1-methoxy-2-propanol (PGME), 1-methoxy-2-propyl acetate (PGMEA), 2-butoxyethanol (EGBE), 2-butoxyethyl acetate (EGBEA), and ethyl-3-ethoxypropionate (EEP) and ethylene glycol butyl ethers, and propylene glycol ethers [Annex XV report]
Applications in use in society	No data - has likely been used for many years.
References	Annex XV report 2010. http://echa.europa.eu/documents/10162/b6b959c2-14c8-4612-9e91-cf181a867dd2 Chemindustry.ru. 2000-2010. 2-methoxyethanol.(Webpage). http://chemindustry.ru/Methyl_Cellosolve.php Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012. OSHA, Occupational Safety and Health Adminitration. 2012. http://www.osha.gov/SLTC/healthguidelines/2-ethoxyethanol/recognition.html

3.33 Nonylphenol and its etoxylates

Substance	Nonylphenol and its etoxylates
CAS Number	104-40-5, 7311-27-5, 9014-90-8, 9016-45-9, 9040-65-7, 9051-57-4, 9081-17-8, 11096-42-7, 25154-52-3, 26027-38-3, 26571-11-9, 27177-03-3, 27177-05-5, 27177-08-8, 27986-36-3, 28987-17-9, 37205-87-1, 51811-79-1, 52503-15-8, 66197-78-2, 68412-54-4, 68584-47-4, 68891-21-4, 72580-36-0, 84852-15-3, 127087-87-0
Justification	Norwegian priority list
Function	Nonylphenol: Monomer (for phenol/formaldehyde reins), catalyst (in the curing of epoxy resins) [EU Commission, 2003]. Nonylphenol can be reacted to form tris(4-nonyl-phenyl) phosphite (TNPP) an antioxidant (for vinyl, polyolefins, and polystyrenics). TNPP is also used as a stabilizer in plastic food packaging. [US EPA, 2010]. Barium and calcium salts of NP are used as heat stabilizers for poly vinyl chloride (PVC). [US EPA, 2010]. Nonylphenol etoxylates has no use related to plastics. More than half of the tonnage of nonylphenol is used to produce nonylphenol ethoxylates surfactants [EU Commission, 2003].
Relevant types of plastics	Phenol/formaldehyde plastic, epoxy [EU Commission, 2003]. Polyurethane foam (emulsifier), PVC.
Main article groups	No information
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	No information
Chemical binding in plastics	Not chemically bound. Will migrate
Potential for release from plastics	Although it does contain residual NP, TNPP has been approved for use in food packaging by the Food and Drug Administration [US EPA 2010].
Alternatives	Information on alternatives for NP is scarce. The only alternatives suggested as suitable are other alkylphenol compounds, particularly octylphenols [RPA 1999, OSPAR 2009].
Applications in use in society	No information
References	EU Commission (2003). Recommendation from the Scientific Committee on Occupational Exposure Limits for commercial

	nonylphenol. SCOEL/SUM/103. OSPAR (2009). Background Document on nonylphenol/nonylphenol ethoxylates. http://www.ospar.org/documents/dbase/publications/p00396_npnpe%20update.pdf RPA (1999). Nonylphenol Risk Reduction Strategy. http://archive.defra.gov.uk/environment/quality/chemicals/documents/nonylphenol_rrs.pdf US EPA (2010). Nonylphenol (NP) and Nonylphenol Ethoxylates (NPEs) Action Plan http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/RIN2070-ZA09_NP-NPEs%20Action%20Plan_Final_2010-08-09.pdf

3.34 Octylphenol and its ethoxylates

Substance	Octylphenol and its ethoxylates - see also section 3.39
CAS Number	140-66-9, 1806-26-4, 9004-87-9, 9036-19-5, 9063-89-2, 11081-15-5, 68987-90-6, 69011-84-3
Justification	Norwegian priority list
Function	Octylphenol: Monomer (for phenol formaldehyde resin) - (major use) [UK Environment Agency, 2005]. Antioxidant in stabilizers- (minor use) [RPA 2006] Octylphenol ethoxylate: Emulsifiers in finishing agents (mainly styrene-butadiene copolymers and PTFE) that cover textiles and leather with a thin film [UK Environment Agency, 2005].
Relevant types of plastics	Phenol formaldehyde resin, PVC, styrene-butadiene copolymer,
Main article groups	OP-based resins are used for secundary insulation of electrical windings (e.g. in motors and transformers) to improve insulation and bond windings together [RPA, 2006]. Articles made of phenol, a polymer finishing that can cover textiles and leather [UK Environment Agency, 2005]. Antioxidant in stabilisers for PVC cable jacketing
EU restrictions of the use in plastics	REACH- and CLP-regulation Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	The resins may also contain a small proportion (~3-4%) of unreacted 4-tert-octylphenol [UK Environment Agency, 2005].
Chemical binding in plastics	Most of the 4-tert-octylphenol in the resins is chemically bound and cannot be released even on subsequent chemical or biological degradation, but the resins may also contain a small proportion (~3-4%) of unreacted 4-tert-octylphenol [UK Environment Agency, 2005]. The octylphenol ethoxylate is physically bound in the polymer matrix [UK Environment Agency, 2005].
Potential for release from plastics	The unreacted 4-tert-octylphenol may be released [UK Environment Agency, 2005]. (Molecular weight 206.33 g/mol boiling point 281.5˚C)
Alternatives	The main alternative for phenolic resins for insulating varnishes is epoxy resins [RPA 2006]. For formulation of PTFE emulsions OP may be substituted by fatty

	alcohol ethoxylates and similar compounds (CAS no 61725-89-1, 65150-81-4 and 25322-68-3 etc.)[RPA 2006] OP as antioxidant are being replaced by other phenol compounds [RPA 2006]
Applications in use in society	4-*tert*-octylphenol (CAS No. 140-66-9) is the only octylphenol commercially available in Europe [RPA 2006]. All applications described above are still in use.
References	RPA (2006). 4-*tert*-Octylphenol Risk Reduction Strategy and Analysis of Advantages and Drawbacks. http://archive.defra.gov.uk/environment/quality/chemicals/documents/op-rrs-aad-report.pdf UK Environment Agency (2005). Environmental Risk Evaluation, Report: 4-tert-Octylphenol http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho0405biyz-e-e.pdf

3.35 Organic tin compounds (tributyltin, trifenyltin)

Substance	Organic tin compounds (tributyltin, trifenyltin) - see also section 3.11
CAS Number	76-63-1, 76-87-9, 379-52-2, 639-58-7, 76-87-9, 900-95-8, 56-35-9, 1461-22-9, 2155-70-6, 26354-18-7, 688-73-3
Justification	Norwegian priority list
Function	Biocide (trisubstituted tin compounds - tributyltin, trifenyltin) Impurity in e.g. disubstituted tin compounds used as stabiilizers in PVC and catalyst in production of polyurethane foams.
Relevant types of plastics	Polyurethane foam, PVC
Main article groups	Dibutyltin compounds are used preferablyas stabilizers in colourless and/or transparent PVC plastic articles.[KEMI 2012]. Examples on transparent PVC products include roof panels/windows, transparent partitions for clean rooms, packaging (blisters), containers, bottles, films (wrapping). Tributyltin: Polyurethane foam used in furniture; fibrefill polymers used in products such as flooring, carpeting; back-coating of textiles used in upholstery, fabrics treated with a coating (e.g. PVC) containing tributyl tin [Annex XVdossier; US EPA, 2008].
EU restrictions of the use in plastics	REACH Annex XVII (dibutyltin, tributyltin, triphenyltin and dioctyltin etc.) CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	For dibutyltin used as stabiliser normally 0.001 to 1% is added [KEMI 2012]. For dibutyltin used as catalyst normal residue concentrations in polyurethanes are 0.05 - 0.3 % by weight.[KEMI 2012] From 1. January 2012 some new products with >0.1% dibutyltin (as tin) are banned. All products have to comply with the threshold from 1. January 2015. Antimicrobial products based on tributyltin oxide and tributyltin maleate are formulated at concentrations around 1% and 25% respectively and generally further diluted by mixing with other ingredients [RPA 2007]. Tributyltins can be present as impurities in mono- and dibutyltin stabilisers for plastics (up to 1% [COHIBA 2011]), but their content is voluntarily controlled by industry to ≤ 0.67 % (as tin) [Annex XV

	dossier]. From 1.July 2010 new products with >0.1% tributyltin (as tin) are banned.
Chemical binding in plastics	Assessed as a volatile compound. Not solid bound and will migrate. [Nilsson, 2012]
Potential for release from plastics	Migration and by wear and tear. Given sufficient time, a significant part of the substance will probably be realeased. [Nilsson, 2012]
Alternatives	Dibutyltin compounds as stabilizer in PVC may be substituted by Ca/Zn-systems. Organic stabilizers are also being developed. Information on alternatives tributyltin or triphenyltin compounds are not available
Applications in use in society	Dibutyltin compounds have been in use for many years, but are now being restricted (see above). Some uses (e.g. roof panels/windows etc.) will remain in use for many years. Triorganostannic compounds have been formerly used as biocides in antifouling paints and coatings and for other biocidal uses [Annex XV dossier]. Use of the substance is today restricted and deliberate consumption is decreasing [ECHA 2009c]. Many of the uses listed under "main article groups" may, however, have a relative long in-service life and still be ind use in the society.
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_norway_pbt_tbto_20083006_en.pdf COHIBA (2011). Measures for emission reduction of Tributyl (TBT) and Triphenyltin (TPHT) in the Baltic Sea Area. Guidance Document No.2. COHIBA (Control of Hazardous Substances in the Baltic Sea Region). Finnish Environment Institute SYKE. Helsinki ECHA (2009c). Background document for bis(tributyltin) oxide (TBTO). Document developed in the context of ECHA's first Recommendation for the inclusion of substances in Annex XIV. ECHA 1 June 2009 KEMI (2012). Dibutyltin compounds. http://apps.kemi.se/flodessok/floden/kemamne_eng/dibutyltennforeningar_eng.htm (Nov.2012) Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012 RPA (2007). Impact Assessment of Potential Restrictions on the Marketing and Use of Certain Organotin Compounds. European Commission, Directorate-General Enterprise and Industry. Brussel. http://ec.europa.eu/enterprise/sectors/chemicals/files/studies/organotins_en.pdf US EPA (2008). Reregistration Eligibility Decision for

	the Tributyltin Compounds: Bis(tributyltin) oxide, Tributyltin benzoate, and Tributyltin maleate (Case 2620) http://www.epa.gov/oppsrrd1/REDs/tbt-compounds-red.pdf

3.36 Perfluorooctanoic acid (PFOA) and similar compounds

Substance	Perfluorooctanoic acid (PFOA) and similar compounds
CAS Number	15166-06-0, 2395-00-8, 24216-05-5, 3108-24-5, 33496-48-9, 335-64-8, 335-66-0, 335-67-1, 335-93-3, 335-95-5, 376-27-2, 3825-26-1, 39186-68-0, 41358-63-8, 423-54-1, 53517-98-9, 68141-02-6, 68333-92-6, 69278-80-4, 72623-77-9, 72968-38-8, 85938-56-3, 89685-61-0, 90179-39-8, 90480-55-0, 90480-56-1, 90480-57-2, 91032-01-8, 93480-00-3
Justification	Norwegian priority list
Function	Dispersing agent (for production of special plastics e.g. PTFE)
Relevant types of plastics	Polytetrafluorethylene (PTFE) and fluoroethylene propylene (FEP). Polyvinylidene fluoride (PVDF)
Main article groups	PTFE is used as coating of metals, e.g. for non-stick cookware; in ceals, gaskets, packings, valve and pump parts and laboratory equipment; in wire and cable insulation, molded electrical components, insulated transformers, hermetic seals for condensers, and laminates for printed circuitry [Chanda and Roy, 2008]. PVDF is commonly used as e.g. insulation in certain electrical wires (e.g. in computers and in airplanes, and in the chemical industry to make pipes and bottles and such that hold chemicals [Polymer science learning center. 2005].
EU restrictions of the use in plastics	Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Trace amounts [Jarnberg et al, 2006]
Chemical binding in plastics	Not chemically bound. Will migrate
Potential for release from plastics	Experiments with heated Teflon® (Du Pont PTFE) frying pans indicate release of perfluorocarboxylic acids (i.e. PFOA) at temperatures of 360 °C (a PTFE-coated pan can reach 400 °C) [Järnberg et al, 2006].
Alternatives	DuPont has been searching for alternatives for PFOA in the the last 30 years. The conclusion so far is that there are no viable alternatives to PFOA. [Poulsen et al, 2005]
Applications in use in society	The uses listed under "main article groups" will still be in place.
References	Chanda, M., Roy, S.K., (2008). Industrial Polymers, Specialty Polymers and Their Applications. Plastics Engineering Series. CRC Press, Taylor & Francis Group, Boca Raton Järnberg, U., Holmström, K. van Bavel, B., Kärrman, A. (2006). Perfluoroalkylated acids and related compounds (PFAS) in the Swedish environment http://www.swedishepa.se/upload/02_tillstandet_i_miljon/Miljooverva kning/rapporter/miljogift/PFAS_ITMreport_06oct.pdf

	Lithner, D, Larsson, Å. Dave, G. (2011). Supplementary appendix in: Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Science of the total environment, 409: 3309-3324. Polymer science learning center. (2005). Polyvinylidene fluoride). http://www.pslc.ws/macrog/pvdf.htm Poulsen P.B., Jensen A.A., Wallström E. (2005). More environmentally friendly alternatives to PFOS-compounds and PFOA. Environmental Project No. 1013/2005. The Danish Environmental Protection Agency.

3.37 Polyaromatic Hydrocarbons (PAHs)

Substance	PolyAromatic Hydrocarbons (PAHs)
CAS Number	50-32-8, 56-55-3, 120-12-7, 192-97-2, 193-39-5, 205-82-3, 205-99-2, 207-08-9, 218-01-9, 65996-93-2, 90640-80-5, 90640-81-6, 90640-82-7, 90640-86-1, 91995-15-2, 91995-17-4, etc. PAHs are usually present as a complex mixture of several hundred congeners.
Justification	Norwegian priority list
Function	Impurity in plasticisers (e.g. mineral oil and coal based extender oils) and carbon black [BfR, 2010].
Relevant types of plastics	Soft plasticised plastics, and other plastic types such as acrylonitrile-butadiene-styrene (ABS) and polypropylene (PP) [Central Experience Exchange Committee, 2008]. All plastics colored black.
Main article groups	E.g. tool handles, bicycle handlebars, slippers, flip-flops, beach sandals, diver equipment, toy car tyres or clay pigeons used in skeet shooting. PAHs may also be contained in synthetic turf or in materials used for construction work, e.g. flooring material.e.g. plastic handles [BfR, 2010]. Furthermore, all plastic products colored black might contain PAH.
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	In Germany has in various products (about 5000 samples) been registered up to 530 mg/kg for BaP, up to 9300 mg/kg for sum of 16 PAHs (USEPAs PAH list), and up to 2483 mg/kg for the sum of BaP, BaA, CHR, BbF, BkF, DBAhA [BfR, 2010]. Measurements of tyres are not indcluded i these figures. In a clear majority of analysed products, PAHs were non-detectable or present only to a very low degree. [BfR, 2010].
Chemical binding in plastics - potential for release from plastics	Migration and release of PAHs from plastics etc. are discussed by [BrF, 2010]. The conclusion is that for some products significant release and thereby dermal exposure to humans can be expected.
Alternatives	Extender oils (secondary plasticisers) can be avoided and carbon black can be replaced by other pigments. However, in EU the efforts seem focused on restricting the content of PAHs in these products rather than developing alternatives. Thus no detailed knowledge on alternatives has been published.
Applications in use in society	The uses listed under "main article groups" will still be in place.
References	BfR (2010). Carcinogenic polycyclic aromatic hydrocarbons (PAHs) in consumer products to be regulated by the EU - risk

	assessment by BfR in the context of a restriction proposal under REACH. BfR Opinion Nr. 032/2010, 26 July 2010. The Federal Institute for Risk Assessment. Germany http://www.bfr.bund.de/cm/349/carcinogenic_polycyclic_aromatic_hydrocarbons_pahs_in_consumer_products_to_be_regulated_by_the_eu.pdf Central Experience Exchange Committee (2008). Testing and Validation of Polycyclic Aromatic Hydrocarbons (PAH) in the course of GS-Mark Certification. Not authorized translation of original document. http://www.cnqa.org/upimg/20092167421780.pdf

3.38 Potassium hydroxyoctaoxodizincatedichromate

Substance	Potassium hydroxyoctaoxodizincatedichromate -see also section 3.16
CAS Number	11103-86-9
Justification	Candidate list and Norwegian priority list
Function	Corrosion inhibition (in plastic resins for primers, coating an sealants) to metal substrates (iron, steel, galvanized steel, zinc, aluminum and aluminum alloys)
Relevant types of plastics	epoxy, polyurethane, alkyd, isocyanate-cured polyester, acrylic resins containing pigments are used as topcoats and primers [Annex XVreport]
Main article groups	e.g. Coatings in the aeronautic/aeropace sector and the automotive sector (heavy duty vehicles and trucks, military vehicles, agricultural equipments) [Annex XVreport]
EU restrictions of the use in plastics	REACH Directive 2002/72/EC relating to plastic materials in contact with food Directive 2000/53/EC on End of Live Vehicles (ELV) Directive 2002/95/EC on Restriction of Hazardous Substances (RoHS)
Norwegian regulation on the use in plastics	Product Regulations, § 2-15. Heavy metals in packaging. Product Regulations, § 2-19. Vehicles – phasing out of components, labelling and information obligation. Product Regulations, § 2-22. Electrical and electronic products and equipment – product requirements. Regulation on toy safety.
Concentration in plastic materials	No information.
Chemical binding in plastics	Solid bound. Will not migrate.
Potential for release from plastics	Only release by wear and tear - significant release (as dust) may take by sandgrinding of surfaces before maintenance.
Alternatives	For the automotive sector, efficient substitutes are already on the market. Currently, there are about 30 different alternatives for chromium (VI) coating systems available on the market [Annex XV]. For the aeropace sector the situation is more complicated. Some alternatives are available. However, maintenance standards may often prohibit or constrain use of alternatives for safety reasons. [Anne XV].
Applications in use in society	Has been used for many years. As many of the relevant products have a significant in service life (10-20 years for vehicles etc. and up to 30 years for aeroplanes) many products containing the substance will still be in use.
References	Annex XV report http://echa.europa.eu/documents/10162/13640/svhc_axvrep_france_cmr_potassium_hydroxyoctaoxodizinccatedichromate_20110829_en.pdf

3.39 4-(1,1,3,3-tetramethylbutyl)phenol, (4-tert-Octylphenol)

Substance	4-(1,1,3,3-tetramethylbutyl)phenol, (4-tert-Octylphenol) - see also section 3.34.
CAS Number	140-66-9
Justification	Candidate list and Norwegian priority list
Function	As a monomer for polymer preparations As an intermediate for manufacture of ethoxylates As a component in phenolic resins used in the formulation of adhesives As a component in coatings, incl. insulation of electric windings (e.g. in motors and transformers) to improve insulation and to bond windings together [Annex XV dossier; DEFRA 2008]
Relevant types of plastics	Phenol resins [UK Environment Agency, 2005].
Main article groups	98% used as an intermediate for the production of phenolic resins (mainly for rubber) and 2% used for octylphenol ethoxylates [Annex XV dossier]. No other information is available
EU restrictions of the use in plastics	REACH- and CLP-regulation Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	The resins may contain a small proportion (~3-4%) of unreacted 4-tert-Octylphenol [DEFRA, 2008].
Chemical binding in plastics	Most of the 4-tert-octylphenol in the resins is chemically bound and cannot be released even on subsequent chemical or biological degradation, but the resins may also contain a small proportion (~3-4%) of unreacted substance that may migrate out of the resin.
Potential for relea-se from plastics	Wear and tear besides migration of unreacted substance
Alternatives	Alternatives for insulating varnishes are described as: Epoxy resins based on bisphenol A or urethane modified epoxies, rubber modified epoxies and novolac epoxies. It is noted that 4-tert-octylphenol may be application critical and alternatives may not be suitable [DEFRA 2008]
Application in a historical perspective	No certain knowledge is available. 4-tert-octylphenol is still used. The applications listed should be assumed to have an in-service life of 5-15 years.
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_germany_equivalent_concern_4-tert-octylphenol_20110829_en.pdf DEFRA (2008). 4-tert-Octylphenol Risk Reduction Strategy and Analysis of Advantages and Drawbacks. Department for Environment, Food and Rural Affairs. UK http://archive.defra.gov.uk/environment/quality/chemicals/documents/op-rrs-aad-report.pdf UK Environment Agency (2005). Environmental Risk Evaluation Report: 4-tert-Octylphenol. http://cdn.environment-agency.gov.uk/scho0405biyz-e-e.pdf

3.40 Trichloroethylene

Substance	Trichloroethylene
CAS Number	79-01-6
Justification	Candidate list and Norwegian priority list
Function	Intermediate or chain transfer agent for controlling molecular weight in the manufacture of PVC [Hocking 2005; Annex XV report]. According to the EU [2004] Risk assessment report it is "apparently" no longer used as a chain transfer agent (however no information to confirm this statement has been found).
Relevant types of plastics	PVC
Main article groups	Not specified - probably all product types
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	No data - probably insignificant concentrations - Directive 2003/36/EC restricts the concentration to <0.1% w/w.
Chemical binding in plastics	Very volatile. Will easily migrate and evaporate.
Potential for release from plastics	Most of the substance will likely disappear from the products, when they still are new.
Alternatives	No information
Applications in use in society	Trichloroethylene has been used worldwide for more than 70 year for the application described above. Trichloroethylene will most likely have evaporated and not be a problem related to products discarded as waste.
References	Annex XV report http://echa.europa.eu/documents/10162/13640/svhc_axvrep_france_cmr_trichloroethylene_en.pdf EU (2004). European risk assessment report. Trichloroethylene CAS no. 79-01-6. http://esis.jrc.ec.europa.eu/doc/risk_assessment/REPORT/trichloroethylenereport018.pdf Hocking (2005). Handbook of Chemical Technology and Pollution Control, 3rd Edition, Accademic press, San Diego.

3.41 1,2,3-Trichloropropane

Substance	1,2,3-Trichloropropane
CAS Number	96-18-4
Justification	Candidate list
Function	Intermediate - Crosslinking agent [Annex XVdossier].
Relevant types of plastics	Hexafluoropropylene [Annex XV dossier] which is used as a copolymer with e.g. tetrafluoroethylene and polyvinylidenefluoride (elastomer)
Main article groups	Tetrafluoroethylene-Hexafluoropropylene-Copolymer (FEP) is used: • for the manufacture of heating cables for chemical platoon • for the manufacture of heating tapes • foils • in filaments and cables at communications • injection moulded components • coating for valves, tubes, vessels and tanks [Mecadi, GmbH, 2012]
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Not relevant for intermediates - crosslinking agents - content of intermediate residues <0.1% [Nilsson, 2012]
Chemical binding in plastics	Solid bound due to crosslinking (reactive) behaveour. Residues (Molecular weight:147.4 g/mol; Boiling point: 157 °C at 1013 hPa - Volatile) will migrate and slowly evaporate from the plastic.
Potential for release from plastics	Potential corresponds to the amount of residues present - all residues will evaporate.
Alternatives	No knowledge
Applications in use in society	No knowledge
References	Annex XV dossier. http://echa.europa.eu/documents/10162/13640/svhc_axvrep_echa_cmr_123-tcp_publ_en.pdf Mecadi GmbH. (2012). webpage: http://www.mecadi.com/en/literature_tools/encyclopedia/categorial/Thermoplastic/Tetrafluoroethylene-Hexafluoropropylene-Copolymer_FEP/ Nilsson N. (2012). Expert assessment by Nils Nilsson, Danish Technological Institute, Århus, Dec. 2012.

3.42 Triclosan

Substance	Triclosan
CAS Number	3380-34-5
Justification	Norwegian priority list
Function	Biocide [NICNAS, 2009]
Relevant types of plastics	Polyethylene, polypropylene and PVC, polyester and polyamide fibres [NICNAS, 2009].
Main article groups	Polyethylene and polypropylene: injection moulded and blow moulded plastic products PVC: calendered film and cast PVC plastisol [NICNAS, 2009]. Polyester and polyamide fabrics [NICNAS, 2009]. Plastic end products using triclosan additives include various household moulded plastic products including: · Food storage containers · Wheelie bins · Toilet seats · Toilet tidy sets · PVC carpet backing · Swimming pool liners · Toothbrushes, and · Pet accessories such as litter trays, food bowls, and Frisbees. [NINCAS, 2009].
EU restrictions of the use in plastics	REACH- and CLP-regulation Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Product in use in Australia us known to contain up to 0.3 % Triclosan [NICNAS, 2009].
Chemical binding in plastics	The substance is not chemically bound, but is assessed as semivolatile (Molecular weight: 290 g/mol; vapour pressure: 4×10^{-6} mm Hg (4×10^{-4} Pa) at 20°C) and should be assumed to migrate.
Potential for release from plastics	No data on leaching rates are available [NICNAS, 2009].
Alternatives	No data.
Applications in use in society	No data - The uses listed under "main article groups" should be expected still to take place.
References	NICNAS (2009). Triclosan. Priority existing chemical, Assessment report no. 30. National industrial chemicals notification and assessment scheme. Australian Government. http://www.nicnas.gov.au/publications/car/pec/pec30/pec_30_full_report_pdf.pdf

3.43 Tris(2-chloroethyl)phosphate

Substance	Tris(2-chloroethyl)phosphate (TCEP)
CAS Number	115-96-8
Justification	Candidate list and Norwegian priority list
Function	Plasticiser and viscosity regulator with flame retardant properties (for polyurethane, polyesters, polyvinyl chloride and other polymers), secondary plasticiser (for PVC), flame retardant (for paint and varnishes containing e.g. polyvinyl acetate) [Annex XV report].
Relevant types of plastics	Polyurethane, polyester, PVC, polyvinyl acetate [Annex XV], polymetamethylacrylate (PMMA), epoxy, polyamide, polycarbonate, polyurethane, thermoplastic polyester and unsaturated polyester [Swedish Chemicals Agency, 2007]. The main use of today is in the production of unsaturated polyester resins (80 %). Other fields of application are acrylic resins, adhesives and coatings. [EU, 2008].
Main article groups	Main industrial branches include furniture, the textile and the building industry (roof insulation); it is also used in the manufacture of cars, railways and aircrafts, and in paint and varnishes [Annex XVreport; EU, 2008].
EU restrictions of the use in plastics	REACH Annex XIV and Annex XVII CLP-regulation Directive 2009/48/EC related to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food.
Concentration in plastic materials	The following typical concentrations are estimated: 1-10 % in polymetamethylacrylate (PMMA), 1-10 % in polyamide, 0-6 % in polyurethane and 0-20 % in unsaturated polyester [Swedish Chemicals Agency, 2007].
Chemical binding in plastics	The compound is not chemically bound and may be regarded as semi-volatile (Molecular Weight: 285.49 g/mol; No boiling point but decomposition at 320°C .Vapour pressure 43 Pa at 136.9 °C 0.00114 Pa at 20°C (extrapolated)). Will slowly migrate
Potential for release from plastics	Given sufficient time, the major part of the substance will probably be realeased by leaching to the surface followed by evaporation or removal by washing. Tear and wear will also take place but be of minor importance.
Alternatives	As a flame retardant TCEP can be substituted with Tris(2-chlorpropyl)phosphat (TCPP) [Annex XV report]. No other information is available.
Applications in use in society	The substance has been in use for decades. Some changes in application have taken place in the last 15 years. Many of the current uses are application with long in service life (furniture, roof insulation, cars, railways and aircrafts) and thus still in use

References	Annex XV report http://echa.europa.eu/documents/10162/13640/svhc_axvrep_austria_cmr_tcep_20090831_en.pdf EU (2008). EU Risk Assessment Report. Tris(2-chloroethyl) phoshate, TCEP. CAS-No.: 115-96-8 http://esis.jrc.ec.europa.eu/doc/risk_assessment/REPORT/tceprepor t068.pdf Swedish Chemicals Agency (2007). Varuguiden.(Article guide) Database. https://webapps.kemi.se/varuguiden/VarugrupperAmne.aspx.

3.44 1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC) & 1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC)

Substance	1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC) [1)] 1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC) [2)] [1)] contains a combination of isomers 90% α and 10% β isomer. [2)] exist and is used only as a part of TGIC (mixture of isomers, 90% α and 10% β isomer) [Annex XV dossier]
CAS Number	2451-62-9; 59653-74-6
Justification	Candidate list
Function	Main function is as a three-dimensional cross-linking or curing agent (in polyester powder coatings). Also used as stabiliser in plastics [Annex XV dossier].
Relevant types of plastics	Polyester. TGIC is an epoxy compound [Annex XV dossier]
Main article groups	The main use is in polyester powder coatings for metal finishing for coated articles (in particular articles for exterior use) such as steel garden furniture, car parts, metal fencing, window and door frames, electrical equipment, refrigerators, washing machines and ovens [Annex XV dossier].
EU restrictions of the use in plastics	REACH Annex XVII CLP-regulation Directive 2009/48/EC relating to toy safety. Directive 2005/90/EC on the marketing/use of certain dangerous substances and preparations. Directive 2002/72/EC relating to plastic materials in contact with food
Concentration in plastic materials	Polyester powder coatings contain between 4-10 % TGIC [Annex XV dossier].
Chemical binding in plastics	Solid bound due to crosslinking (reactive) behaviour.
Potential for release from plastics	Mainly by wear and tear
Alternatives	Beta-hydroxyl alkylamide and glycidylesters are the mostly used alternative cross linkers to TGIC. Using alternatively both technologies, almost all TGIC formulations have been replaced on the European market after 1990 [Annex XV dossier] .
Applications in use in society	In Europe it is has been used in weather-resistant powder coatings since the 1970 [Annex XV dossier]. Many applications have a long in-service life and may still contain the coating in question
References	Annex XV dossier. thttp://echa.europa.eu/documents/10162/13638/svhc_axvrep_tgic_combinationisomers_en.pdf

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Abbreviations and acronyms

ABS	Acrylonitrile butadiene styrene
ATBC	acetyl tributyl citrate
BaA	Benzo[a]antracene
BaP	Benzo[a]pyrene
BbF	benzo[b]fluoranthene
BeP	Benzo[e]pyrene
BjF	benzo[j]fluoranthene
BkF	benzo[k]fluoranthene
BBP	Benzyl butyl phthalate
BPA	Bisphenol A
BSH	Benzene di-sulphonyl hydrazid
CAS	Chemical Abstracts Service
Ca/Zn	Calcium/Zinc
CD	Compact disc
CFC	Chloro fluoro carbon
CHR	Chrysene
C.I.	Colour Index
CLP	Classification, labelling and packaging of substances and mixtures (EU regulation)
CMR	Carcinogenic, Mutagenic or toxic to Reproduction
CO_2	Carbon dioxide
COMGHA	Castor oil derivatives
DBAhA	dibenzo[a,h]antracene
DBP	Dibutyl phthalate
DBT	di-n-butyl terephthalate
DEHA	Di (ethylhexyl) adipate
DEHP	Bis (2-ethylhexyl)phthalate
DEHT	Bis(2-ethylhexyl)ester
DHNUP	1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear alkyl esters
DIBP	Diisobutyl phthalate
DIHP	Diisoheptylphthalat
DINA	Diisononyl adipate
DINCH	Di-(isononyl)-cyclohexane-1,2-dicarboxylate
DINP	Diisononyl phthalate
DMEP	Bis(2-methoxyethyl) phthalate
DVD	Digital video disc
EC	European Community
ECHA	European Chemicals Agency
EEC	European Economic Community
EEP	Ethyl-3-ethoxypropionate

EGBE	2-Butoxyethanol
EGBEA	2-Butoxyethyl acetate
ELV	End of Life Vehicles (EU regulation)
E-Modul	Elasticity module
EPA	Environmental Protection Agency
EPDM	Ethylene propylene diene terpolymers
EPS	Expanded PolyStyrene
EU	European Union
EU27	European Union med 27 member states
EVA	Ethylene-vinylacetate copolymers
FEP	Fluoroethylene propylene
GPa	Gigapascale
GRP	Glass fiber reinforced plastics
HBCDD	Hexabromocyclododecane
HDPE	PolyEthylene - High Density
Hg	Mercury
HIPS	High Impact PolyStyrene
hPa	Hectopascal
IDB	Isodecyl benzoate
KLIF	The Norwegian Environmental Protection Agency
LDPE	PolyEthylene - Low Density
LLDPE	PolyEthylene - Linear Low Density
MCCP	Medium-chain chlorinated paraffins
MDA	4,4'- Diaminodiphenylmethane
MDI	Methylene diphenyldiisocyanate
MF	Melamine
MOCA	2,2'-dichloro-4,4'-methylenedianiline
MW	Molecular weight
NMA	N-methylolacrylamide
NP	Nonylphenol
OBPA	10,10'-oxybisphenoxarsine
OBDE	Octabromodiphenyl ether
OP	Octylphenol
PA	Polyamides (nylon)
Pa	Pascal
PAH	Polyaromatic hydrocarbons
PBT	Polybutylene terephthalate
PC	Polycarbonate
PE	Polyethylene
PEK	Polyetherketone
PEEK	Polyetheretherketone
PeBDE	Pentabromodiphenyl ether
PET	Polyethylene terephthalate (polyester)
PFOA	Perfluorooctanoic acid
PGME	1-Methoxy-2-propanol
PGMEA	1-Methoxy-2-propyl acetate
PMMA	Polymethyl methacrylate
PP	Polypropylene

PPE	Polyphenylen ether
PS	Polystyrene
PSU	Polysulphone
PTFE	Polytetrafluoroethylene (teflon)
PUR	Polyurethane
PVA	Polyvinylacetate
PVC	Polyvinyl chloride
PVDF	Polyvinylidene fluoride
R&D	Research and development
REACH	REACH is the European Community Regulation on chemicals and their safe use. It deals with the **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances
RoHS	Restriction of Hazardous Substances (EU regulation)
SCCP	Short Chain Chlorinated Paraffins
SIAR	OECD SIDS Initial Assessment Report
SIDS	OECDs Screening Information Dataset
SPIN	Substances in Products in Nordic Countries (a database)
SVHC	Substances of Very High Concern
TBBPA	Tetrabromobisphenol A
TBTO	Bis(tributyltin)oxide
TCEP	Tris(2-chloroethyl)phosphate
TCPP	Tris(2-chlorpropyl)phosphate
Tg	The glass transition temperature. Below Tg, the plastic becomes brittle.
TGIC	1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione
β-TGIC	1,3,5-Tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione
Tm	Melting temperature of plastics containing crystalline domains
TNPP	Tris(4-nonyl-phenyl) phosphate
TNT	2,4,6-trinitrotoluene
UL	Underwriters Laboratories
UP	Unsaturated polyesters
US EPA	United States Environmental Protection Agency
UV	Ultraviolet (light)
UV/VIS	Ultraviolet/visible
XPS	Extruded PolyStyrene
VCR	Videocassette recorder
w/w	By weight

Annex 1 Prioritised substances not likely to be used in plastics

In this annex the substances not likely to be used in plastics are presented. First are presented substances belonging to the EU Candidate list (August 2012), then substances or substance groups on the Norwegian priority list.

For most of the substances there is not a complete coverage in the available literature of all uses for a substance, and in some cases the information is very scarce. It is, therefore, not possible to conclude with certainty that the substance is not in any applications used in plastics. The list could, therefore, include substances which in some minor applications are used in plastics. When there is a significant uncertainty the following statement is made "to the best of knowledge this substance is not used to any significant extent in plastics".

In some cases the substance is associated with plastics but is not an intentional ingredient in the plastic material. This is for instance with an intermediate used in the synthesis of a monomer for plastics, or a solvent used in the production of the plastic polymer, or a component added after the plastic material has been produced. This is noted in the column "Use associated with plastics".

The method for screening the substances and main sources that have been checked are described in the introduction of chapter 3.

Substance [CAS No.]	**Uses**	**Use associated with plastic**
Substances on the EU CANDIDATE LIST		
Acids generated from chromium trioxide and their oligomers. Names of the acids and their oligomers: Chromic acid, Dichromic acid, Oligomers of chromic acid and dichromic acid. [7738-94-5, 13530-68-2] Candidate list	Chromic acid is used: • in manufacture of chemicals (chromates, oxidizing agents, catalysts) • in manufacture of medicines • in process engraving, anodizing, ceramic glazes, coloured glass, metal cleaning, inks, tanning, paints, **textile mordants, etchant for plastics** [Milne, 2005].	Used with sulfuric acid as an etchant for plastics such as ABS, modified polypropylene, polysulfone [Muccio, 1991]
Aluminosilicate Refractory Ceramic Fibres… Candidate list	Are amorphous synthetic vitreous fibres produced from melting and spinning/blowing calcined kaolin or a mixture of alumina and silica. The largest single use (approximately 67 %) is for furnace linings and related applications [Annex XV].	No
Ammonium dichromate	Crosslinking [Grimm et al, 1982]	Preparation and

[7789-09-5] Candidate list	Is mainly used in/as: - Oxidising agent - Laboratory reagents and chemicals. - Photosensitive films manufacturing - Tanning and dressing of leather: - Manufacture of textile: in preparation and spinning of textile fibres as a textile mordant (fixing agent) and oxidizing agent for dyes, Other potential uses: manufacture of pigments, manufacture of alizarin, manufacture of chrome alum, manufacture of magnetic tape, oil purification, pickling, manufacture of catalysts, synthetic perfumes, process engraving and lithography (sensitizer for photo- chemical insolubilization of albumin, etc.), etc. [Annex XV report]. [Grimm et al, 1982] claims use for crosslinking of polyvinyl alcohol, but the reference ie rather old.	spinning of textile fibres. Crosslinking of PVA
[4-[[4-anilino-1-naphthyl][4-(dimethylamino)phenyl]methylene]cyclohexa-2,5-dien-1-ylidene] dimethylammonium chloride (C.I. Basic Blue 26) [with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)] [2580-56-5] Candidate list	Is used in inks, dyes, paints, and **pigments.** The uses/applications include: • Production of various inks (formulation steps may also include mixing with other basic dyes) • Cleaners (e.g. printing plate cleaner and water tank cleaner, for use in the lithographic printing industry) • Coating applications • **Dyeing** of various paper and **plastic** products (e.g. paper towel wipes , low grade paper and paper food trays, and other products) • Dyeing or painting of other articles • Cosmetic procucts (e.g. hair products, cayons and soaps). • Diagnostic, analytical, and research and development applications, such as biological stain [Annex XV].	Dyeing of various paper and plastic products [Annex XV].
Anthracene [120-12-7] Candidate list	Is mainly used as a basic material for the production of dyes (especially anthraquinone dyes) [Annex XV]. Plastics such as **polyvinyltoluene** can be **doped** with anthracene to produce a plastic scintillator that can be used in radiation therapy dosimetry [Several internet sources, 2012].	Doping agent for polyvinyltoluene to produce a plastic scintillator. [Several internet sources, 2012].

	Note: Limited data on uses. To the best of knowledge not used in plastics.	
Anthracene oil [90640-80-5] Candidate list	Is mainly used as an intermediate in the production of pure anthracene, which is intensively used in the production of artificial dyes. It is also used in the following applications: • Component in technical tar oils • Production of basic chemicals • Intermediate for phyto-pharmaceutical and human-pharmaceutical products. • Impregnation agent (mostly as wood preservative, sometimes for ropes and • sailcloth) • Component in tar paints for special application • Component of waterproof membranes for roofing and other sealing purposes • Component of asphalt used for road construction • Supplementary blast furnace reducing agent • Industrial viscosity modifier [Annex XV].	No
Anthracene oil, anthracene paste [90640-81-6] Candidate list	Same as antracene oil (above)	No
Anthracene oil, anthracene paste, anthracene fraction [91995-15-2] Candidate list	Same as antracene oil (above)	No
Anthracene oil, anthracene paste,distn. lights [91995-17-4] Candidate list	Same as antracene oil (above)	No
Anthracene oil, anthracene-low [90640-82-7]	Same as antracene oil (above)	No

Candidate list		
Arsenic acid [7778-39-4] Candidate list	Is used in the manufacturing of ceramic glass as a fining agent to remove bubbles from the glass melt, and as decolourising agents in glass and enamels. Arsenic acid is not used as a biocide in the EU. Outside the EU chromium, copper, arsenic-concentrates with arsenic acid are marketed, and wood treated outside the EU may be imported for the specific, exempted uses [Annex XV].	No
[4-[4,4'-bis(dimethylamino) benzhydrylidene]cyclohexa-2,5-dien-1-ylidene]dimethylammonium chloride (C.I. Basic Violet 3) [with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)] [548-62-9] Candidate list	The main uses of C.I. Basic Violet 3 are as a dye in ink applied in cartridges for printers and in ball pens and as dyestuff for paper colouring. Other minor uses are: • in carbon papers (where dyestuff is suspended in wax and applied to a thin impregnated paper) • staining of dried flowers/plants (dried plants dyed by immersion in a hot water solution of the dyestuff) • as a marker (i.e. where dyestuff is used to improve the visibility of a liquid). • in microbial and clinical laboratories (e.g. as stain to distinguish gram negative from gram positive bacteria) in presumably thousands of laboratories and teaching institutions around Europe • as a component of navy blue and black **dyes** for **polyacylonitrile fibers** [Annex XV].	A component of navy blue and black dyes for polyacylonitrile fibers [Annex XV].
4,4'-bis(dimethylamino)benzophenone (Michler's ketone) [90-94-8] Candidate list	Intermediate in the manufacture of triphenylmethane dyes [Annex XV].	No
4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol [with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)] [561-41-1]	Is used in the production of writing inks and potentially in the production of other inks, as well as for dyeing of a variety of materials [ECHA, 2012]. Some companies indicated that "Solvent Violet 8" is a synonym to 4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol), however the CAS	*Note:* Uncertainty if it is the same as pigment Solvent Violet 8 which could be used in dyes for polyacrylonitrile materials [Annex XV].

	no do not match. Solvent Violet 8 (/its products) are also used dyeing a variety of materials: In Colour Index the materials listed include plastics. The usese in black dyes for polyacrylonitrile materials [Annex XV]. *Note*: Limited data on uses.	
Bis(2-methoxyethyl) ether [111-96-6] Candidate list	Is used primarily as a **solvent** in a wide variety of applications (e.g. reaction solvent for Grignard-reactions, reduction-reactions, alkylation-reaction, organo-metallic reactions, battery electrolytes). Other uses include: • application as entrainer for azeotropic distillations • use in reactions involving alkali metals such as lithium, sodium and potassium and can dissolve sodium/potassium alloy. • use as active pharmaceutical ingredient, • as additive for diesel fuels10, • for photolithography and for the manufacture of semiconductor chips. • uses in sealants and adhesives, automotive care products and paints and coatings are indicated [Annex XV].	Used as a solvent for PVC/PVA copolymer and polymethyl methacrylate [Milne, 2005]. Used for purification and solvent in production of magnetic polystyrene beads [Annex XV].
α,α-Bis[4-(dimethylamino)phenyl]-4 (phenylamino)naphthalene -1-methanol (C.I. Solvent Blue 4) [with ≥ 0.1% of Michler's ketone (EC No. 202-027-5) or Michler's base (EC No. 202-959-2)] [6786-83-0] Candidate list	Solvent Blue 4 is used in **inks and dyes**. Among potential uses registered by companies in the Colour Index (2012)7, for products (dyestuff) containing Solvent Blue 4 are printing inks (such as rotogravure inks, typewriter ribbons, computer cartridge, etc.), ball point pen inks, and stamping inks. Furthermore, according to Colour Index (2012) Solvent Blue 4 or its products are used for **dyeing a variety of materials**, such as paper (e.g. carbon paper), distemper, wood, lacquers, feathers, and plastic. [Annex XV]	Is used for dying of plastics [Annex XV]
1,2-bis(2-methoxyethoxy)ethane (TEGDME; triglyme) [112-49-2] Candidate list	It is registered for industrial use as a solvent or as a process chemical. It is used as: • an inert solvent for grignard-, reduction- and alkylation-reactions. • an inert solvent for reduction reactions using Sodium borohydride and used as a solvent to carry out methylation	Substance in etchant formulation [Annex XV] used to make fluoropolymers bondable to a wide variety of articles.

<table>
<tr><td></td><td>reactions using dimethyl carbonate (and other dialkyl carbonates)
part of absorbing liquids in the industrial cleaning of gases (gas scrubber)
a substance in etchant formulation used to make fluoropolymers bondable to a wide variety of articles [Annex XV].
It can also possibly be used as a catalyst for certain phase –transfer reactions, and used in the formulation of electrolyte systems for lithium batteries and in brake fluids [Annex XV].

Note: There is only limited information on the current use of the substance [Annex XV].</td><td></td></tr>
<tr><td>Calcium arsenate

[7778-44-1]

Candidate list</td><td>Is used as a precipitating agent in copper smelting and in the manufacturing of diarsenic trioxide [Annex XV].

According to several internet sources [e.g. State of New Jersey, 2008] calcium arsenate is used as a herbicide, insecticide, molluscicide and fungicide. It is also used in weather resistant wood-treatment.</td><td></td></tr>
<tr><td>Cobalt(II) carbonate

[513-79-1]

Candidate list</td><td>Is used:
in the manufacture of catalysts (homogenous, hydrotreating and Fischer Tropsch),
in the production of animal food supplement, production of pigments,
in ground frit (i.e. the key ingredient for enamel),
as an additive to soils/fertilizer,
in veterinary medication,
in temperature indicator.
as a catalyst in the production (liquid-phase oxidations) of e.g. p-xylene to terephthalic acid (monomer for PET) [Annex XV].</td><td>Catalyst in the production of p-xylene to terephthalic acid (which is a monomer for PET) [Annex XV].</td></tr>
<tr><td>Cobalt dichloride

[7646-79-9]

Candidate list</td><td>The main use (88%) is thought to be as intermediate in the synthesis of other inorganic cobalt compounds (e.g. cobalt dihydroxide, cobalt oxalate).

Examples of other uses include:</td><td>No</td></tr>
</table>

	• synthesis of B12 (>1 % of tonnage) electroplating • Use in the synthesis of pigments, • animal food and veterinary products [Annex XV]. • use in humidity Indicators [Entec, year unknown]. • dye mordant, • in manufacturing solid lubricants, additive to fertilisers, • as a chemical reagent in laboratories, • as an absorbent in gas masks and in electroplating [Krebs, 2006]. Cobalt chloride or sulfate may also be used as the cobalt source in storage batteries, porcelain pigments, glazes and ink driers, but will because of thermally decomposition or calcination not be present in the final product [Environment Canada, 2011] .	
Cobalt(II) dinitrate [10141-05-6] Candidate list	The main use is in the manufacture of catalysts and production of intermediate chemicals. Cobalt dinitrate is consumed in the course of the catalyst manufacturing process and is not present in the final catalyst according to industry. It is also used: • in the production of other chemicals (intermediates), • surface treatments (Anodizing, Electro-deposition, Non-electro deposition), • in the manufacture of nickelbased electrodes of several alkaline rechargeable battery technologies, • in pigment production in ceramic industry, sympathetic (invisible) inks and hair dyes [Annex XV].	No
Cobalt(II) sulphate [10124-43-3] Candidate list	Is used in: • production of other chemicals; • manufacture of drier for lithographic inks; • drier for paints and linoleum; • manufacture of catalysts; • surface treatments; • corrosion protection agent; • Li ion batteries for automotive market and storage applications;	Used in organic textile dyes (cobalt complexes of azo-dye derivates) which could be used in synthetic textiles.

	• additive to soils/ fertilizer; • veterinary medication to prevent and treat cobalt deficiency; • magnetic recording materials; • pigments for decorating porcelains; manufacture of organic textile dyes (cobalt complexes of azo-dye derivates), • additive mineral supplement in animal feed [Annex XV].	
Diarsenic pentoxide [1303-28-2] Candidate list	Is used in the dying industry, metallurgy (to harden copper, lead or gold in alloys), for manufacturing special glass and in wood preservatives [Annex XV]. Diarsenic pentoxide is to the best of knowledge not used in plastics.	May be used in dyes for plastics or synthethetic textiles. However this use was not included in ECHA's (2009) background document and the other searched sources have not either indicated this.
Diarsenic trioxide [1327-53-3] Candidate list	Is used: • as decolorizing agent for glass and enamels; refining and oxidizing agent for manufacturing special glass and lead crystal formulations; • a hydrogen recombination poison for metallurgical studies; • a starting point for the preparation of elemental arsenic, • in arsenic alloys and arsenide semiconductors; as a cytostatic in the treatment of refractory promyelocytic (M3) subtype of acute myeloid leukemia [Annex XV]	
Diboron trioxide [1303-86-2] Candidate list	Is used in the following product categories: • detergents, cleaners and adhesives (air care products, polishes and wax blends, **textile dyes**, finishing and impregnating products, washing and cleaning products); • industrial fluids (anti-freeze and de-icingproducts, heat transfer fluids, lubricants, greases, release products, metal working fluids, water treatment chemicals); • agriculture (fertilisers); • construction materials (fillers, putties,	May be use used in dyes for synthetic textiles, but no detailed information has been found.

	plasters, modelling clay) • reagent chemicals (intermediate, products such as pH-regulators, flocculants, precipitants, neutralisation agents, laboratory chemicals, photo-chemicals, water treatment chemicals); • ink/paints (paints, lacquers and varnishes; glazing materials); • welding and soldering agents; • fireproof cement; • protective chemicals; • photo-chemicals [Annex XV].	
1,2-Dichloroethane [107-06-2] Candidate list	**Intermediate** – (main ingredient) in the production of vinyl chloride monomer (main use) for the production of PVC [Annex XV]. Over 95% of 1,2-Dichloroethane in 2009 was consumed in the production of vinyl chloride monomer [Annex XV]. Other very small uses of 1,2-Dichloroethane include chlorinated extraction and cleaning solvents, manufacture of ethyleneamines and vinylidene chloride [Annex XV].	Precursor in the production of vinyl chloride monomer for the production of PVC, (an alternative route exists). Will easily evaporate - will to the best of knowledge not be present in the plastic material
Dichromium tris(chromate) [24613-89-6] Candidate list	Identified uses include: • formulation of metal treatment products; industrial surface treatment of metals- reactive anti-corrosion primer for steel and aluminium;' laboratory reagent; • surface treatment; • corrosion inhibitors (minor use) [Annex XV].	No
1,2-dimethoxyethane; ethylene glycol dimethyl ether (EGDME) [110-71-4] Candidate list	It is mainly used as an inert special solvent for grignard-, reduction- and alkylation-reactions. It is also used: • as an inert solvent for organo metallic reactions in general, e.g. reactions involving alkali metals. • as solvent a for electrolytes of lithium batteries and as a process solvent for the recycling of Li-batteries (It has one confirmed use in a consumer product, as an electrolyte solvent (1-5%) in sealed lithium ion batteries) • in a process for the surface treatment of aluminium	Processing aid for Fluoropolymer Etchant formulation, which is used to make fluoropolymers bondable to a wide variety of articles, i.e., Teflon [Annex XV]

	• as asolvent in the production of Lithium batteries. • as an industrial reaction solvent • as cleaning solvent and within solder fluxes within the microelectronics industry. • as a constituent within flexo gravure water-solvent based inks, lithographic plate developers and glass cleaning solvents • Processing aid (for Fluoropolymer Etchant formulation), which is used to make fluoropolymers bondable to a wide variety of articles, i.e., Teflon [Annex XV].	
N,N-dimethylacetamide (DMAC) [127-19-5] Candidate list	65-70% of N,N-dimethylacetamide is used as process solvent in the synthesis of active agrochemical and pharmaceutical substances. 25-30 % of the total use of N,N-dimethylacetamide is used in the spinning of fibres. The largest application for these fibres are textiles mainly for clothing, but to some extent also technical textiles (e.g. for reinforcement). < 2 % of the total use of N,N-dimethylacetamide is used solvent in the production of polyimide and polysulfone films. The polyimide films are used in a range of industries including consumer electronics, solar photovoltaic and wind energy, aerospace, automotive and industrial applications. 3-5 % of the total use is used as a solvent in coatings e.g. polyamide-imide enamels (varnishes) used for electrical wire insulation. [Annex XV]	Spinning of textile fibres [Annex XV]
2,4-Dinitrotoluene [121-14-2] Candidate list	About 99 % of 2,4-Dinitrotoluene are used for making toluylenediamine which is in intermediate for toluylenediisocyanate [OECD, 2004], which is mainly used, together with polyether polyols, for the **production of flexible PU foams** for furnishings, packaging foam, mattresses and car seats [Evonik Industries, 2012].	Used to make the Intermediate for TDI which is used for making flexible polyurethane foam.

	Other small applications include the manufacturing of TNT and propellants, and as an intermediate in the production of dyes and for staining of refractory bricks [OECD, 2004].	
2-Ethoxyethanol [110-80-5] Candidate list	The main proportion (80 %) is processed to intermediates such as the 2-ethoxyethanol tert-butyl ether in chemical industry. The smaller part (20 %) is used as industrial solvent [Annex XV]. Other uses include: • solvent for nitrocellulose, epoxy coatings, alkyd resins • solvent for surface coatings, lacquers, lacquer thinners, varnish removers, cleaning solutions, adhesives, cosmetics, and pharmaceuticals, • intermediate for 2-ethoxyethyl acetate • ying and printing textiles • in dye baths • leather treatment • emulsion stabilizer • anti-icing additive for aviation fuels • diluent in food colorants etc [Ash and Ash, 2007]. Use categories notified in the SPIN database include paints, lacquers and varnishes, adhesives, binding agents, laboratory chemicals, pharmaceuticals, others [Annex XV].	Solvent for epoxy coatings.
2-Ethoxyethyl acetate [111-15-9] Candidate list	It is used as solvent and for the formulation of paints, lacquers and varnished for professional use exclusively (at very low volumes). These remaining uses are probably very specific e.g. building and repairing of ships and boats, manufacture of aircraft and spacecraft. It is reported for use in the sector of rubber and plastic industry (France and Sweden <100 kg), [Annex XV] but no other information to confirm this has been found.	It is reported in the sector of rubber and plastic industry [Annex XV], but no other information to confirm this has been found. *Note:* To the best of knowledge it is not used to any significant extent in plastics.
Formamide [75-12-7] Candidate list	It can be used: • in the agrochemical and pharmaceutical industries, • in the production of vitamins and pyrimidines,	Solvent (for synthetic leather)*, by-product in the processing of foam (EVA) [Annex XV].

	- in hydrogen cyanide production, - as an intermediate for paper finishing - as a **solvent** for example in the production of **synthetic leather** and inks. - as a building block used to make triazoles as starting materials for crop protection products - as a solvent and plasticizer in consumer products - as an ingredient as softener for paper, animal glues, water soluble glues and wood stains [Annex XV]. - as a **solvent** for polymers such as PVC and polyacrylonitrile [Swedish Chemicals Agency, 2010] It is formed as a by-product in the production of EVA foam and has been measured in foam puzzle mats as well as in fitness and exercise mats which are made of ethylene vinyl acetate (EVA) [Annex XV].	* Besides in the Annex XV report there is no information that formamide is used in the production of synthetic leather. However dimethyl formamide (DMF) is [Several internet resources].
Lead(II) bis(methanesulfonate) [17570-76-2] Candidate list	Solutions of the substance are used in plating (both electrolytic and electroless) [Annex XV] causing a metallic layer to be deposited on a surface.	No
Lead diazide, Lead azide [13424-46-9] Candidate list	Is used in the manufacture of initiation devices such as civil detonators or defence products, including use: - as an initiator or booster in blasting caps/ detonators, for example in the ASA (lead diazide, lead styphnate and aluminium) mixtures, used for both civilian and military uses; - in pyrotechnic devices used in military munitions; - as a primer in cartridge actuated devices for aerospace/defence/safety applications; - as an initiator in primers for percussion caps for small calibre and rifle ammunition; - as a micro-explosive to produce shock waves for medical applications [Annex XV].	No

Lead dipicrate [6477-64-1] Candidate list	It seems that because of its extreme sensitivity to impact lead dipicrate has now been replaced by easier to handle superior explosives, such as lead diazide and lead styphnate. However, due to its explosive properties, lead dipicrate could in some cases be considered as a replacement for lead diazide and lead styphnate [Annex XV].	No
Lead hydrogen arsenate [7784-40-9] Candidate list	It is no longer in use either in the EU or the US. Lead hydrogen arsenate has previously been used as a pesticide [ECHA, 2009]. No quantities have been reported in the SPIN database [Annex XV].	No
Lead styphnate [15245-44-0] Candidate list	Is used: • as an initiator in primers for percussion caps for small calibre and rifle ammunition; • as an initiator in detonators for civilian and military use; • in pyrotechnic igniters used in military munitions (fuzes); • as a primer in cartridge actuated devices both for aerospace/defence/safety • applications but also for cartridges used in fastening power tools; and • as an initiator in pyrotechnics including automotive airbag inflators and seat belt pretensioners • as a primer in cattle killer cartridges [Annex XV].	No
2-Methoxyaniline o-Anisidine [90-04-0] Candidate list	It is used for manufacture of dyes and as a processing aid [Annex XV]. In the EU the main part of manufactured and imported o-anisidine was (according to the EU risk assessment report, 2002) processed to **azo pigments**. These were mainly used in **printing inks** for packing materials such as paper, cardboard, **polyme**r and aluminum foil. In colorants for tattooing, o-anisidine can be an impurity or a cleavage product of the corresponding organic pigments [Annex XV]. Outside the EU, it may be also used for the manufacture of guaiacol and vanillin [Annex XV].	Component of azo and naphtol pigments and dyes used in dyed and printed polymers especially in printed packing foils [Annex XV].
1-Methyl-2-pyrrolidone	Is used in:	Spinning agent (for

(NMP) [872-50-4] Candidate list	• Coatings: High temperature coating, urethane dispersions, acrylic and styrene latexes • Industrial and consumer cleaners : Paint removers, floor strippers, graffiti remover, industrial degreasing, injection head and cast-molding equipment cleaning • Agricultural chemicals: Solvent for herbicide, pesticide and fungicide formulations • Electronics: Cleaning, de-fluxing, edge bead removal, photoresist stripping • Petrochemical processing: Lube oil processing, natural and synthetic gas purification • Pharmaceuticals: Solvent • Other uses: e.g. spinning agent for PVC and PU topcoat [Annex XV]	PVC); binder in waterborne PU topcoat, solvent [Annex XV].
Pentazinc chromate octahydroxide [49663-84-5] Candidate list	Is used as: • anti-corrosive agent for the formulation of wash primers/etch primers and shop primers, particularly two pack primers (poly(vinyl butyryl) PVB wash primers), • colouring and hiding agent in paints and coatings, • anti-scaling agent in paints and coatings [Annex XV]. It is used by four industrial activity sectors: • formulation of liquid mixtures (coatings such as primer paints and wash primers, thinners, • paint removers , etc.), • industrial use of mixtures in the aeronautic/aerospace sector, • industrial use of mixtures in the vehicle coating sector, • laboratory uses (analysis, R&D, etc.) in very small quantities, no more developed hereafter [Annex XV].	No
Phenolphthalein [77-09-8] Candidate list	It is used: • as a pH indicator in solution for determining acid/alkali conditions via titration methods in chemical analysis. • in disappearing or colour-changing inks	No

	or dyes are reported. (The dye changes colour in • the presence of an acid or a base.) • in laboratory indicator test paper. • as an active ingredient in contact laxative products. In addition it is approved for use as an excipient (i.e. a carrier for active ingredients) in medications. However, there is no evidence that this is a current use [Annex XV].	
Pitch, coal tar, high temp. [65996-93-2] Candidate list	Is mainly used as a binding agent (ca. 95 %) in: • the production of electrodes • refractories to hold the various aggregates and matrix particles together • coal briquettes, "clay pigeons" • road construction and paving applications (is now very limited) [Annex XV]. Examples of other uses are: • raw material in the production of activated carbon • heavy duty **corrosion protection agent in paint and coatings** • impregnating, coating and adhesive agent, mainly for waterproofing purposes [Annex XV].	Anti-corrosion protection in coatings such as as pitch-polymer combinations consisting of two-pack systems with epoxy or polyurethane, and pitch paints with mixed with PVC, polyacrylonitrile, or polystyrene (4-8 wt % of polymer) [Annex XV].
Potassium chromate [7789-00-6] Candidate list	Can be used: • in preparation and **spinning** of t**extile fibres** • as a **textile mordant** (fixing agent) (this use is being replaced in the EU) • as an oxidizing agent for dyes • treatment and coating of metals • metallurgy of non-ferrous metals • manufacture of reagents and chemicals (such as for analysis, routine checks) • colouring agent in ceramics • tanning and dressing of leather • manufacture of pigments/inks • manufacture of paper and paperboard • analytical reagent in laboratory applications [Annex XV].	In spinning of texile fibres, mordant (fixing agent) in synthetic textiles [Annex XV].
Potassium dichromate	Has many uses, e.g.:	Mordant (fixing

[7778-50-9] Candidate list	• in chrome metal manufacturing • in treatment and coating of metals • sealing of pores in the anodized coatings of aluminum • used to prepare chromic acid • as an ingredient in cement • for manufacturing chromate containing reagents and chemicals • analytical reagent, oxidising agent and inorganic chemical reagent in various • laboratory applications • determination of ethanol concentration in a sample • tanning and dressing of leather • preparation and **spinning of textile fibres** as a **textile mordant (fixing agent**) • oxidizing agent for dyes [Annex XV].	agent) in synthetic textiles and spinning of textile fibres [Annex XV]. Used in PMMA, polyamide and thermoplastic polyester [Swedish Chemicals Agency, 2007].
Sodium chromate [7775-11-03] Candidate list	Is used: • in conversion coatings and as a corrosion inhibitor in cooling systems. • chemical **intermediate for pigments* and catalysts** • corrosion inhibitor (sealed water in cooling systems, oil-well drilling muds, protection of • iron), • mordant for dyes, dying paint pigment • drilling mud additive, • component of cells for chlorate manufacture, • leather tanning, • in specific pharmaceuticals • aluminium etchant ingredient • analytical reagent in laboratories [Annex XV]. *It can be used as an ingredient in the production of lead chromates and lead molybdates which can be used as pigments in plastics [Charvat, 2003]. *Note:* Sodium chromate is to the best of knowledge not used in any significant extent in plastics.	It can be used as An ingredient in the production of lead chromates and lead molybdates which can be used as pigments in plastics [Charvat, 2003]
Sodium dichromate	It is used:	Used in manufacture

[7789-12-0, 10588-01-9] Candidate list	• in manufacture of other chromium compounds as chromium sulfate. • in manufacture of inorganic chromate pigments: associated to lead, strontium, barium, zinc, bore for paints and **plastic coloration**. • for metal finishing, aiding corrosion resistance: the main process is chrome plating-, electroplating-, in conversion coatings - passivating and anodising - and in • brightening. • in vitamin K manufactures. • for preparation of coloured glass and ceramic glazes. • as **mordant in dyeing** • for manufacture of essential oil and perfumes [Annex XV].	of pigments for plastic coloration, and as a mordant in dying (perhaps synthetix textiles) [Annex XV]. According the Swedish Chemicals Agency's [2007] guide on articles sodium dichromate can be used in polymetamethylacrylate (PMMA), polyamide, and thermoplastic polyester.
Strontium chromate [7789-06-2] Candidate list	Is used as rust- and corrosion-resistant pigment in paints, varnishes and oil colours. It is also used in water based wash primers, metal conditioners or in aluminium flake coatings, either alone or in combination with basic zinc chromate (solvent and vinyl based wash primer). Strontium chromate has also been used as an additive to control the sulfate content of solutions in electrochemical processes [Chemicalland21, 2012]. According to ECHA's registration information on identified uses related to article categories it is used in coil coating of metal articles and, aerospace and vehicle coating.	No
5-tert-butyl-2,4,6-trinitro-m-xylene (musk xylene) [81-15-2] Candidate list	Are used in fragrance formulation, helping to 'fix' aromas and ensure persistence in a range of household products (such as detergents, fabric softeners, fabric conditioners, cleaning agents, air fresheners, etc) and cosmetic products (such as soaps, shampoos, perfumes, etc) [EU, ≥2008]	No
Tetraboron disodium heptaoxide, hydrate [12267-73-1] Candidate list	The main industrial uses include glass, ceramics, detergents, wood treatment, insulation fibreglass and various unspecified uses such as production of other borate compounds [Annex XV]. *Note:* Lack of data for this substance, but to the	No

	best of knowledge this substance is not used to any significant extent in plastics.	
N,N,N',N'-tetramethyl-4,4'-methylenedianiline (Michler's base) [101-61-1] Candidate list	Is used as chemical intermediate in the manufacture of dyes and pigments (including Methylene red, C.I. Basic Yellow 2, Basic Orange 14, Solvent Orange 15, and Solvent Yellow 34 and C.I. Basic Violet 3 [Annex XV]. It is also used as chemical intermediate in the manufacture of its hydrochloric salt [Annex XV].	Information on whether these pigments are used in plastics/fibres has not been found.
Triethyl aresenate [15606-95-8] Candidate list	It may potentially be used in the fabrication of integrated circuits [Annex XV], and has been developed for use in specialised doping applications used in fabricating semiconductor devices [ECHA, 2009b] *Note:* No other information on use is described. To the best of knowledge this substance is not used to any significant extent in plastics.	
Trilead diarsenate [3687-31-8] Candidate list	Is used as an intermediate in the production of diarsenic trioxide. Triethyl arsenate may potentially be used in the fabrication of integrated circuits [Annex XV].	No
Zirconia Aluminosilicate Refractory Ceramic Fibres… [index number 650-017-00-8] Candidate list	Is a high-temperature insulating fibre sold chiefly for industrial applications: • as insulation for industrial furnaces (approximately 67 % of consumption), pipes, ducts, and cables, • as fire protection for buildings and industrial process equipment, • as aircraft/aerospace heat shields, • in automotive uses, such as catalytic converters, metal reinforcements, heat shields, brake pads, and air bags [Annex XV].	No
Substances on the NORWEGIAN PRIORITY LIST		
1,2-Dichloroethane [107-06-2] Norwegian priority list	**Intermediate** – (main ingredient) in the production of vinyl chloride monomer (main use) for the production of PVC [Annex XV]. Over 95% of 1,2-Dichloroethane in 2009 was consumed in the production of vinyl chloride monomer [Annex XV].	Precursor in the production of vinyl chloride monomer for the production of PVC, (an alternative route exists).

	Other very small uses for 1,2-Dichloroethane include chlorinated extraction and cleaning solvents, manufacture of ethyleneamines and vinylidene chloride [Annex XV].	Will easily evaporate - will to the best of knowledge not be present in the plastic material
Certain surfactants (DHTDMAC, DSDMAC, DTDMAC) Norwegian priority list	Ditallowdimethylammonium chloride (DTDMAC) was previously mainly used as a fabric softening agent, has almost (2003) been replaced by other more environmentally friendly alternatives [Knepper et al, 2003]. Use in polybutulene terephtaltate nanocomposites has been mentioned [McLauchlin et al, 2011] Dihydrogenated tallow dimethyl ammonium chloride (DHTDMAC) is used as fabric softener, as additive in car washing agents and cosmetics, and to activate organic clays (bentonites) [OECD, 1996].. Dimethyldioctadecylammonium chloride (DSDMAC), Is an isolated substance which is one of the active component of the technical product ditallowdimethylammonium chloride (DHTDMAC) above [EU, 2009].	According to one article by McLauchlin et al, [2011] DTDMAC can be used to modify clay mineral (giving a dual surfactant organoclay), which can be used (in amounts of 4 %) in the production of poly(butylene terephthalate (PBT) nanocomposites [McLauchlin et al, 2011] This not been confirmed by other sources.
Dioxins and furans Norwegian priority list	Dioxins and furans (PCDD/PCDF) are formed as unwanted by-products in many industrial and combustion processes. [UNEP, 1999] UNEP.1999.	Dioxins may form during combustion of chlorinated material, e.g. PVC.
Chlorinated alkylbenzenes e.g. [85117-42-6] Norwegian priority list	Almost no information is available. Information available on the internate indicates that chlorinated alkylbenzenes may be used as chemical intermediates for the preparation of monomers and plasticizers etc. They may also be as result of degradation or combustion processes.	?
Hexachlorobenzene [118-74-1] Norwegian priority list	HCB is no longer directly used, but it is still found in our environment as a by-product of certain activities and because of past use. It was e.g. commonly used as a pesticide until 1965. [US EPA, 2011].	No
Muskxylenes Norwegian priority list	Are used in fragrance formulation, helping to ‘fix’ aromas and ensure persistence in a range of household products (such as detergents, fabric softeners, fabric conditioners, cleaning agents, air fresheners, etc) and cosmetic products (such as soaps, shampoos, perfumes,	No

	etc) [EU, ≥2008]	
Pentachlorophenol Norwegian priority list	Is a general biocide which is mainly used as a wood preservative [US EPA, 2008]. Pentachlorophenol may also be used as a **biocide** for transportation and or storage of **textiles** in humid conditions [Texanlab, 2008 or 2006].	Biocide in textiles Can be used in thermoplastic polyester in roughly estimated amounts of (0.1-1 %) [Swedish Chemicals Agency, 2007]
PFOS (Perfluorooctanesulfonic acid or perfluorooctane sulfonate) Norwegian priority list	Is used in fire fighting foams, photographic industry, photolithography and semiconductors, hydraulic fluids and in metal plating industry2. [UNECE, 2006] In the past was to provide soil, oil and water resistance to textiles, apparels, home furnishings and upholstery, carpets and leather products [UNECE, 2006]	
Polychlorinated biphenyls (PCBs) Norwegian priority list	In most countries, commercial PCBs and products containing PCBs are no longer produced anymore. [Breivik, 2005]. PCBs were used both for closed applications (e.g., capacitor and transformers, heat transfer and hydraulic fluids) and in open-end applications (e.g., flame retardants, inks, adhesives, microencapsulation of dyes for carbonless duplicating paper, paints, pesticide extenders, **plasticizers, polyolefin catalyst carriers**, slide-mounting mediums for microscopes, surface coatings, wire insulators and metal coatings. Dielectric insulating material in electrical equipment such as capacitors and transformers has been the main use [Breivik, 2005]	Previously used as plasticisers and polyolefin catalysts [Breivik, 2005]. According the Swedish Chemicals Agency's guide on articles PBC can be used in thermoplastic polyester in roughly estimated amounts of (0.1-1 %) [Swedish Chemicals Agency, 2007]. No other information has been found to confirm this.
Siloxanes Decamethylcyclopentasilo xan (D5) [541-02-6] Octamethylcyclotetrasilox an (D4) [556-67-2] Norwegian priority list	It is mainly used in blending and formulating personal-care products and cosmetics, including deodorants, antiperspirants, cosmetics, shampoos, and body lotions. [Fishlock, 2012; Environment Canada, 2012]. It is also an intermediate in the production of polydimethylsiloxane silicone polymers. [Fishlock, 2011]. Examples of uses in plastics have not been found.	No

Tetrachloroethene (PER) [127-18-4] Norwegian priority list	The major uses are as a chemical intermediate and a dry cleaning solvent. Other uses include in metal cleaning and extraction processes. Some minor uses are use as a textile scouring solvent, fumigant, stain remover, paint remover and heat transfer media ingredient. During the production of **textile fabrics** (synthetic and natural) sources, tetrachloroethylene is usually used to **remove lubricants** added facilitate the knitting or weaving of yarns. Other non-plastic related minor uses exists [EU, 2005].	Added to remove lubricants in knitted or weaved synthetic fabrics.
Trichlorobenzene [120-82-1] Norwegian priority list	Is predominantly used as an intermediate in the manufacture of pesticides and is further used as a process solvent in closed systems. Several minor uses are e.g.: as a process regulator, an additive, a **dye carrier**, a corrosion inhibitor, etc [EU, 2003] Considerable amounts of 1,2,4-TCB are likely to occur in existing electrical equipment, since it previously was used as a dielectricfluid Previous wide dispersive use types (e.g. as solvents) have significantly decreased during the last decade [EU, 2003].	As a dye carrier (mixed with a levelling agent) applied mainly to polyester materials [EU, 2003].
2,4,6 Tri-tert-butylphenol [732-26-3] Norwegian priority list	It is an antioxidant which can be used as a fuel, oil, gasoline or lubricant additive. The only use in Canada is as an antioxidant in hydrocarbon fluids such as gasoline, diesel fuel and jet fuel [Environment Canada, 2011b]. In Norway use as a lubricant additive has also been registred [OSPAR, 2006]. Other possible applications in the EU could be: as a chemical **intermediate** in the production of **antioxidants** used in rubber and **plastic**, as a lubricating agent in the transport sector as a by-product in the production of 4-tert-butylphenol, as an additive for gasoline and fuel oil distillate, and use in the offshore sector [Environment Canada, 2008]	Maybe used as an intermediate in the production of antioxidants for plastics [Environment Canada 2008] According the Swedish Chemicals Agency [2007] it can be used in thermoplastic polyester in roughly estimated amounts of (0.1-1 %) .

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KLIMA- OG FORURENSNINGS-DIREKTORATET

Klima- og forurensningsdirektoratet
Postboks 8100 Dep, 0032 Oslo
Besøksadresse: Strømsveien 96
Telefon: 22 57 34 00
Telefaks: 22 67 67 06
E-post: postmottak@klif.no
Internett: www.klif.no

<table>
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COWI- Danmark og Teknologisk institutt, Danmark</td><td>ISBN-nummer
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Inger Grethe England</td><td>TA-nummer
3017/2013</td></tr>
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Forfatter(e)

Erik Hansen, COWI-Danmark, Nils H. Nilsson, Teknologisk institutt, Danmark, Delilah Lithner, COWI-Sverige and Carsten Lassen COWI-Danmark.

Tittel - norsk og engelsk

Helse- og miljøskadelige stoffer i plastmaterialer
Hazardous substances in plastic materials

Sammendrag – summary

Rapporten gir en oversikt over de mest brukte plasttyper, deres egenskaper og bruksområder, og hvilke farlige kjemikalier som brukes i plast. Den første delen av rapporten gir en oversikt over 15 utvalgte plasttyper. Disse er valgt delvis fordi de er mye brukt og delvis fordi de er vesentlige på grunn av et antatt innhold av kjemikalier som kan gi grunn til bekymring. Den andre delen av rapporten gir oversikt over 43 kjemikalier som brukes i plast og anses som farlige, og derfor er inkludert i den norske prioritetslisten og/eller på EUs kandidatliste for SVHC-kjemikalier under REACH.

The report presents information on the most used plastic types and their characteristics and uses as well as on hazardous substances used in plastics. The first part of this report is focused on 15 selected important groups of plastic materials. They were selected according to frequent use and according to possible content of chemical substances that might give rise to concern. The second part of the report is focused on 43 chemical substances used in plastics and considered hazardous and thus been adopted on the Norwegian Priority List of hazardous substances or the REACH Candidate list of SVHC-substances.

4 emneord	4 subject words
Plastmaterialer, prioriterte miljøgifter, kandidatlisten, oversikt	Plastic materials, hazardous substances, candidate list, synopsis

Klima- og forurensningsdirektoratet
Postboks 8100 Dep,
0032 Oslo
Besøksadresse: Strømsveien 96

Telefon: 22 57 34 00
Telefaks: 22 67 67 06
E-post: postmottak@klif.no
www.klif.no

Om Klima- og forurensningsdirektoratet

Klima- og forurensningsdirektoratet (Klif) er fra 2010 det nye navnet på Statens forurensningstilsyn. Vi er et direktorat under Miljøverndepartementet med 325 ansatte på Helsfyr i Oslo. Direktoratet arbeider for en forurensningsfri framtid. Vi iverksetter forurensningspolitikken og er veiviser, vokter og forvalter for et bedre miljø.

Våre hovedoppgaver er å:

- redusere klimagassutslippene
- redusere spredning av helse- og miljøfarlige stoffer
- oppnå en helhetlig og økosystembasert hav- og vannforvaltning
- øke gjenvinningen og redusere utslippene fra avfall
- redusere skadevirkningene av luftforurensning og støy

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