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Incompatible trends - Hazardous Chemical Usage in Building Products Poses Challenges for Functional Circular Construction

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Abstract. Based on a review of 2012 and 2016 data in the Nordic chemical database, SPIN, this paper is an assessment of the usage of REACH's Substances of Very High Concern (SVHC) and Denmark's List over Undesirable Substances (LOUS) chemicals in the building industry in Denmark. The paper is a status update of the 2016 Danish Environmental Agency's report of the usage of hazardous substances in sustainable buildings, based on 2012 data from SPIN. The analysis focuses on change in tonnage of usage of chemicals found in twelve different construction product categories in SPIN, crosschecked with substances from the SVHC and the LOUS lists. The usage of some hazardous substances in certain usage categories has reduced from 2012 to 2016. There is an overall trend indicating an increase of undesirable chemical in construction articles and preparations, which poses serious challenges for a functioning circular built environment. Findings indicate which construction categories and which chemicals are of particular concern for the current construction market in Denmark. The results underscore the essential need for transparency in building product content, in order for design professionals and contractors to make decisions that support the future use of the material or building element.

Keywords: material health, hazardous chemicals, sustainable design, circular built environment

1. Introduction

This paper evaluates the usage of chemicals of very high concern used in the construction industry in Denmark in 2016 and compares the results to a report published by the Danish Environmental Agency's reviewing usage based on 2012 data. [1] This detailed report demonstrated that substances of very high concern were used in the Danish construction industry in 2012, and that the hazards impact all phases of buildings' life cycles, including construction, use and end of life.

An update of this report is highly relevant for the building industry, due to the current intensified focus on recycling, reuse and upcycling of building components. It is strategic to review the usage hazardous substances in construction articles and preparations given the challenges these chemicals



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impose on responsible waste stream management, and given the prognosis that the quantity of hazardous chemical in construction materials is expected to increase in the future. [2]

The original study based on 2012 data evaluated 57 chemicals from two hazard lists which have a high probability of being used in Danish construction, and concluded that 49 chemicals are highly problematic in at least one phase of a building's lifecycle, either in construction, in the use (environmental and/or human exposure) or in the demolition phase. The intent of this study is to track changes of usage of these highly problematic chemicals that are on the EU and Danish hazardous substance lists, in order to highlight the impact these problematic substances may have on initiatives emphasizing circular use of building elements and materials.

As a part of the update of the original study, this study also tracks the usage of substances of very high concern found in construction in Denmark that have been added to REACH's list between July 2015 and July 2018, citing both the usage of these substances in 2012 and in 2016. A final review highlights the 2012 and 2016 usage of REACH Authorization listed substances found in Danish construction that have an expired sunset date.

2. Methodology

The Danish Environmental Agency's report published in 2016 and this paper are based on usage data publicly available in the Nordic Substances in Preparations in Nordic Countries (SPIN) database[3]. The database contains annual import and usage amounts of specific chemicals in four countries, and manufacturers are required to declare the number of preparations as well as the tonnage used for imports greater than 100kg/year. The problematic chemicals under review are those listed in the Danish Environmental Agency's List Over Undesirable Substances, LOUS, 2009 [4] and the June 2018 Substances of Very High Concern (SVHC) for Authorization list published by the European Chemical Agency [5]. Data from the SPIN database links the substances to specific use categories, allowing for an assessment of chemicals used in the construction industry, either as ingredients in liquid construction products, or as a part of a building article. In the original study, the SPIN categorization was collaborated by the usage information found in the LOUS and REACH reports on specific chemicals to verify usage in construction. To track problematic substance usage increases and decreases, the annual tonnage of problematic substances used in construction related categories and declared in Denmark in 2012 is compared with tonnage declared in 2016.

In the original report, a priority hazard screening evaluated the degree of hazard of each substance in each of the four life cycle phases. This ranking (green-yellow-red) is based on hazard and exposure information in the LOUS and REACH reports as well as in the European Union 2008/98/EC Waste Directive[6]; the criteria used to establish the ranking is detailed in the original report[7]. Substances found to have little hazardous impact on the construction, use or end of life have not been reviewed in this status update.

3. Discussion - comparison of usage over time

The original study focused on eleven construction usage categories in the SPIN database (UC62 categories) that document usage of SVHC and LOUS substances, which have a high probability of inclusion in Danish construction preparations and articles.

- Construction materials
- Paint, lacquers and varnishes
- Adhesives and binding agents
- Fillers
- Insulation materials
- Impregnation materials
- Corrosion protection
- Solvents
- Foaming agents
- Non-agricultural pesticides and preservatives

This update adds the extra SPIN category Electroplating agents. 2012 usage indicated that the categories with the largest number of problematic substances were Paint & Lacquers, Adhesives, Surface Treatments, Fillers, and Construction materials. This trend is confirmed in 2016 usage data.

3.1. Status of usage category paints, lacquers and varnishes

Paints, lacquers and varnishes is the category with the highest number of problematic substances, and 2016 usage data indicates a reduction of LOUS substances and an increase of SVHC, due to the addition of new substances on REACH's list in the intervening years. Figure 1 depicts the problematic substances with decreased usage, Figure 2 depicts extreme decreases in usage.

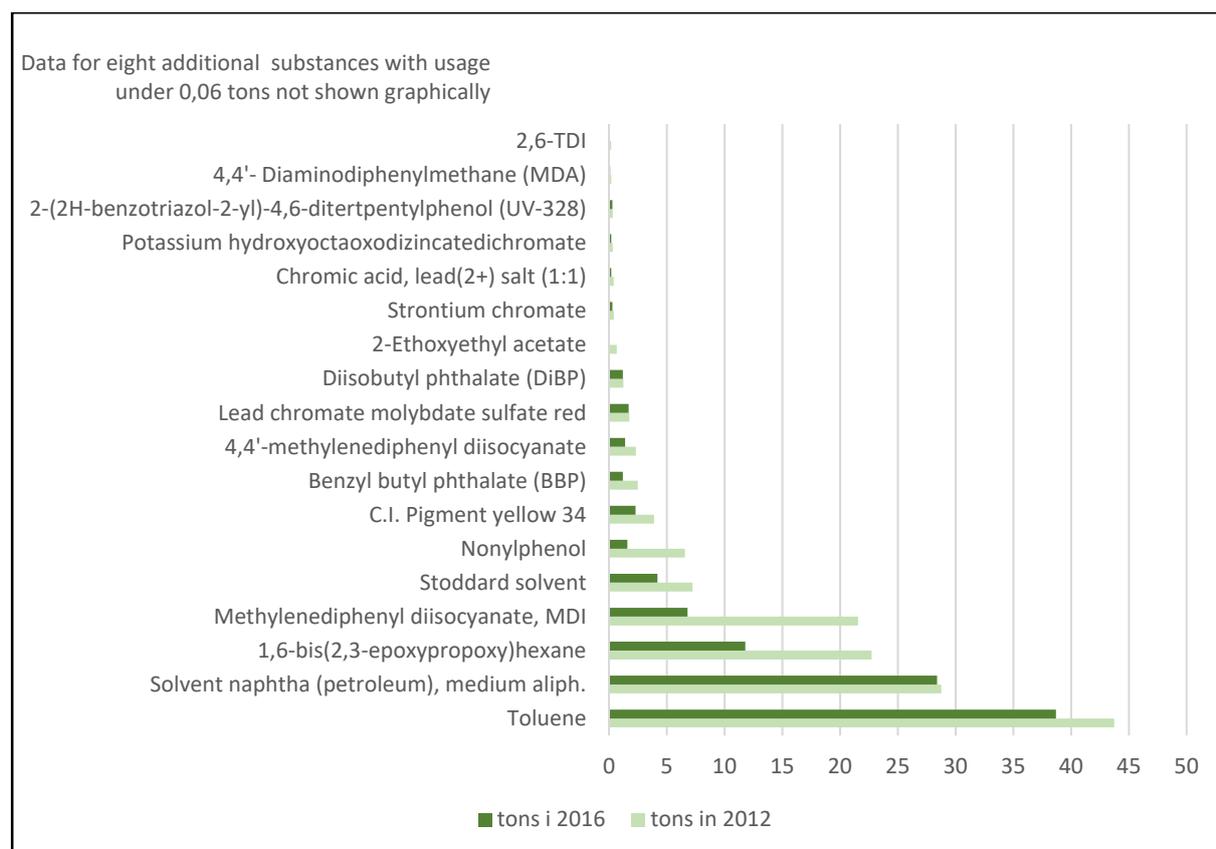


Figure 1. Decreases in Danish use of LOUS & SVHC list chemicals used in paints, lacquers and varnishes in 2012 and in 2016.

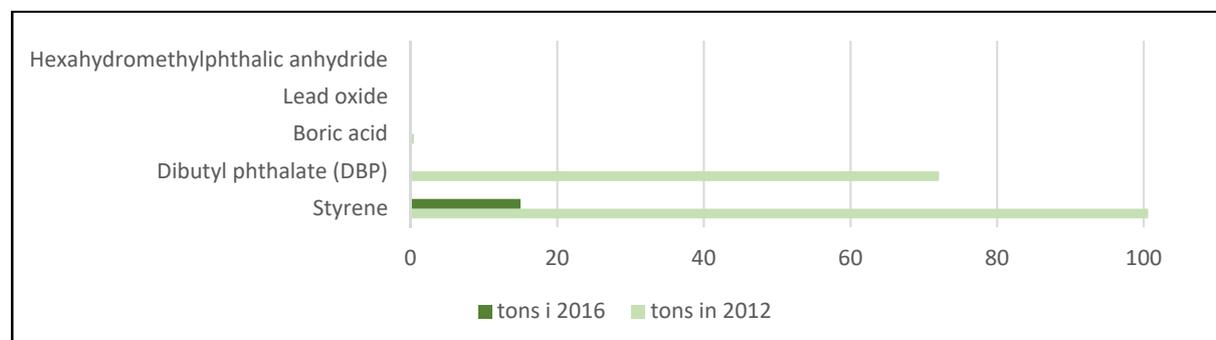


Figure 2. Extreme decreases in Danish use of LOUS & SVHC list chemicals used in paints, lacquers and varnishes in 2012 and in 2016.

There are 49 problematic substances in the paint usage category, of these 33 show a decrease of usage, including three that are not used in 2016. The 16 problematic substances indicating an increase in usage are shown in Figure 3 and 4. Notably, the increases are much greater in actual tonnage than the decreases, resulting overall in a 47% increase of usage in this category.

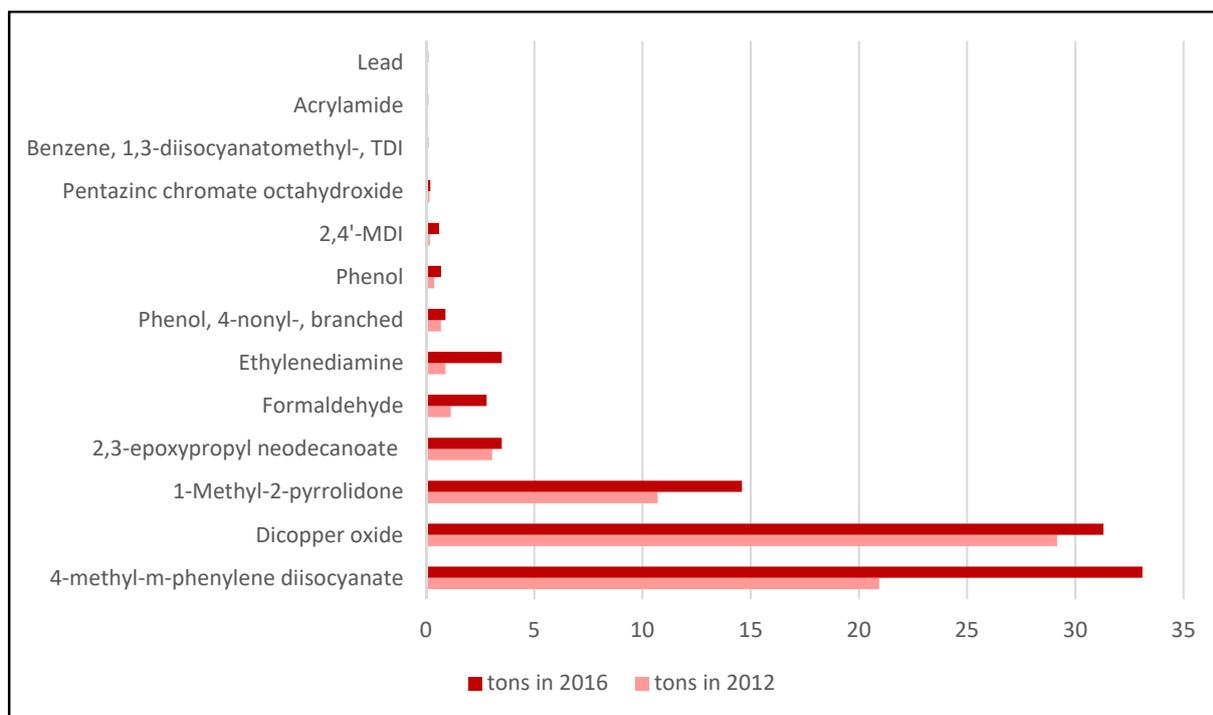


Figure 3. Increases in Danish use of LOUS & SVHC list chemicals used in paints, lacquers and varnishes in 2012 and in 2016.

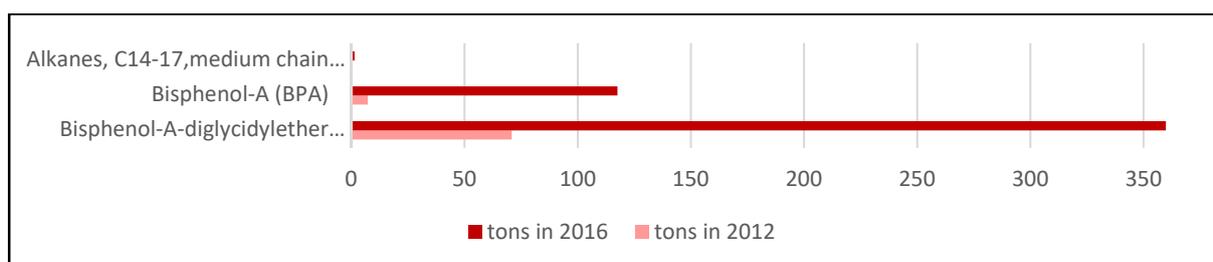


Figure 4. Extreme increases in Danish use of LOUS & SVHC list chemicals used in paints, lacquers and varnishes in 2012 and in 2016.

3.2. Status of usage category construction materials

The SPIN database category “Construction Materials” includes substances and materials used as building materials and constructional articles, such as wall construction materials, road surface materials, ceramic, metal, plastic and wooden construction materials, and molding materials. Substances declared in the category “Construction materials” have the highest probability of being used exclusively in the construction industry. Three problematic substances indicate no usage in 2016, four others have reduced usage to under 100kg/year, and six have reduced usage, see Figure 5 and 6. The category had a total of nine problematic substances with notable increases in tonnages used, contributing to an overall tonnage increase of 217% for this category.

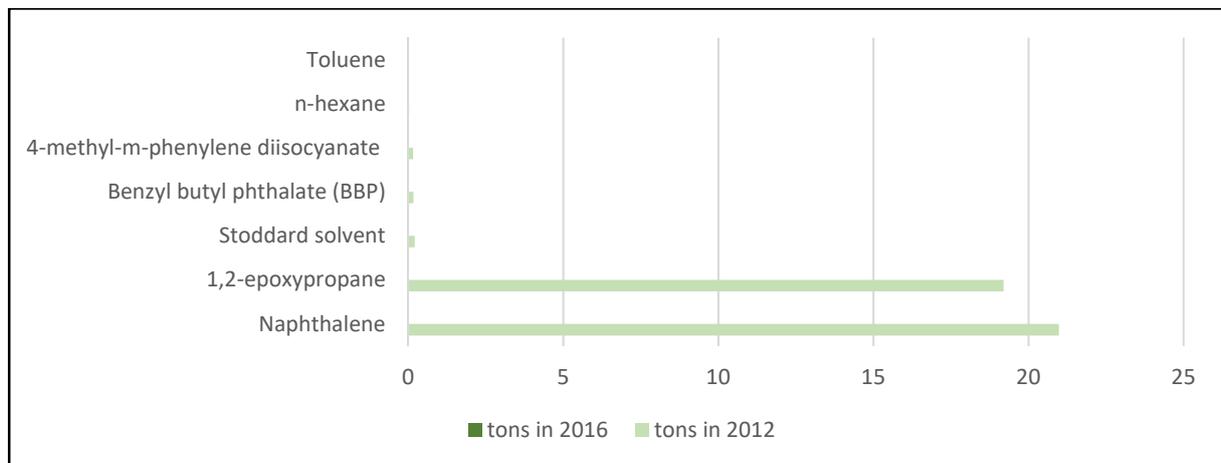


Figure 5. Decreases to under 100kg/ year in Danish use of LOUS & SVHC list chemicals used in construction materials in 2012 and in 2016.

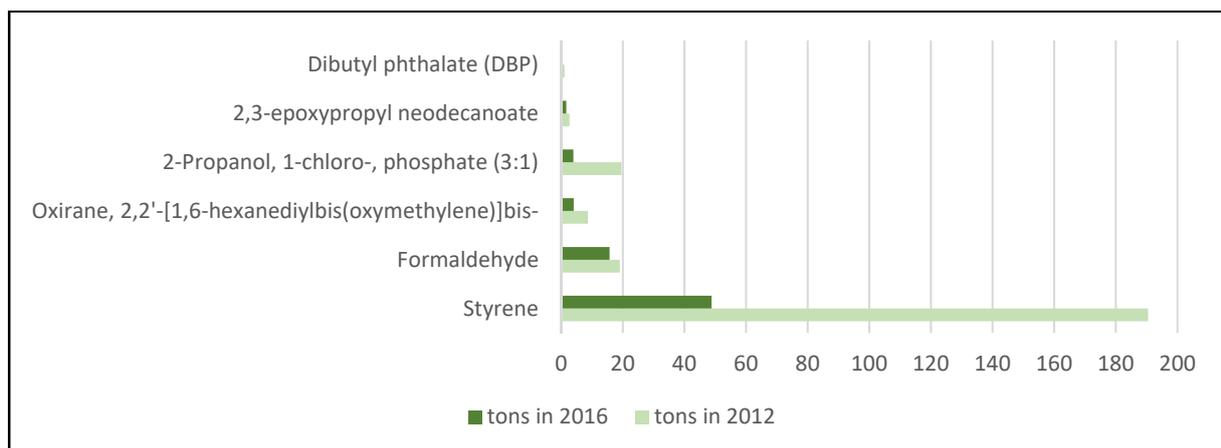


Figure 6. Decreases in Danish use of LOUS & SVHC list chemicals used in construction materials in 2012 and in 2016.

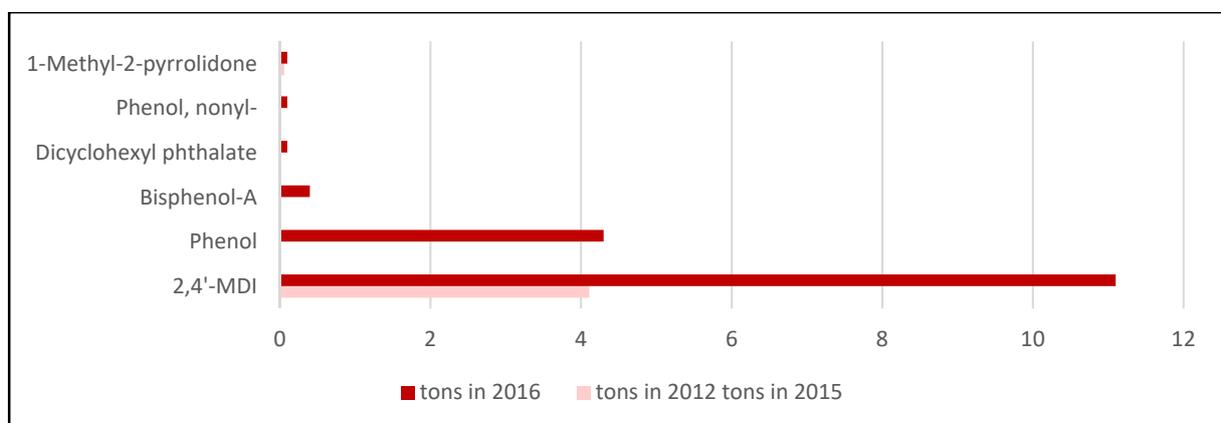


Figure 7. Increases in Danish use of LOUS & SVHC list chemicals used in construction materials in 2012 and in 2016.

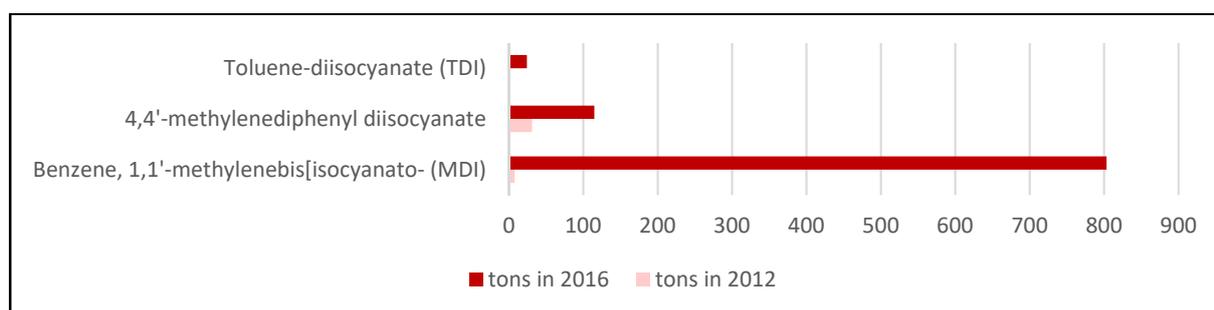


Figure 8. Extreme increases in Danish use of LOUS & SVHC list chemicals used in construction materials in 2012 and in 2016.

3.3. Status of usage – general discussion

The change in usage of hazardous substances in Danish construction products and preparations from 2012 to 2016 shows increases in the categories with the largest number of hazardous substances. Reviewing changes in tonnage usage of problematic substances in 2012 and in 2016, seven construction categories indicate decreases in usage. Five categories indicate increases, four of these are substantial increases, see Table 1.

Table 1. Usage of problematic substances from LOUS and SVHC lists marketed in Danish construction products in 2012 and in 2016.

Usage categories	2012 USAGE			2016 USAGE		
	LOUS	REACH's 2015 SVHC	LOUS & SVHC	LOUS	REACH's 2018 SVHC	LOUS & SVHC
Source: SPIN database, usage in Denmark	number of substances	number of substances	total tonnage	number of substances	number of substances	total tonnage
Building materials (incl. flooring)	22	4	326	19	6	1034
Paints, lacquers & varnishes	35	21	466	32	23	686
Surface Treatments	21	7	62	21	12	85
Adhesives, binding agents	25	7	3644	21	11	2467
Fillers	24	5	333	22	9	291
Insulation	3	0	30	2	0	8
Impregnation	5	0	93	4	0	89
Corrosion protection	7	1	4	6	1	3
Solvents	8	2	8906	5	1	7893
Foaming agents	1	0	2,5	0	0	0
Non-agricultural pesticides	11	4	349	8	2	9947
Electroplating agents	0	1	1,6	0	1	3,1

REACH's Authorization list of July 2018[8] consists of 43 substances, twelve of which are categorized in SPIN as marketed in the Danish construction industry in 2012 and in 2016 and evaluated in the Danish Environmental Report as critically hazardous in one of the building's use phases. Eight of these substance reached their sunset date before 2016, any usage after this date is dependent on an authorization application approved by European Chemical Agency. Nevertheless, all eight are registered with construction affiliated usage in Denmark in 2016 (SPIN data). Of the twelve, two have increased usage quantities from 2012 to 2016, see Table 2.

Table 2. Substances from REACHs Authorization List (as of July 2018) marketed in Denmark in 2012 and 2016 (SPIN data).

Substance name	CAS No.	Sunset Date	Tons in 2012	Tons in 2016	SPIN usage category
4,4'- Diaminodiphenylmethane (MDA)	101-77-9	21/08/2014	0,2	0,1	Paints & Lacquers Fillers
Bis(2-ethylhexyl) phthalate (DEHP)	117-81-7	21/02/2015	0,3	0,5	Paints & Lacquers Fillers
Benzyl butyl phthalate (BBP)	85-68-7	21/02/2015	3,5	1,3	Paints & Lacquers Construction Materials Paints & Lacquers Surface treatments
Dibutyl phthalate (DBP)	84-74-2	21/02/2015	74,1	0,5	Fillers Fillers
Diisobutyl phthalate (DIBP)	84-69-5	21/02/2015	2,2	2	Paints & Lacquers
Lead chromate	7758-97-6	21/05/2015	0,4	0,2	Paints & Lacquers
Lead sulfochromate yellow	1344-37-2	21/05/2015	3,9	2,3	Paints & Lacquers
Lead chromate molybdate sulfate red	12656-85-8	21/05/2015	1,8	1,7	Paints & Lacquers Surface Treatments
Chromium trioxide	1333-82-0	21/09/2017	7,1	8,9	Electroplating Agents
Strontium chromate	7789-06-2	22/01/2019	0,4	0,3	Paints & Lacquers
Potassium hydroxyoctaoxidizincatedichromate	11103-86-9	22/01/2019	0,3	0,2	Paints & Lacquers
Pentazinc chromate octahydroxide	49663-84-5	22/01/2019	0,2	0,2	Paints & Lacquers

4. Conclusion

Of the 49 substances flagged in the original study as highly problematic in one or more of four life cycle phases, 48 are documented in use in Denmark in the year 2016. Of these 48 substances, 50% are screened as highly problematic in the demolition (type HP7 or HP10 hazardous waste) phase. [9] These chemicals are declared in the SPIN database in a range of different usage categories, categories with a high probability of being part of the built environment. Individual substance review based on LOUS and REACH reports confirms the substance's use in specific areas of construction, [10] and 2016 data from SPIN confirms declared usage of the substances in Denmark.

In the twelve SPIN categories related to construction, there are small increases and decreases in the number of problematic substances used in 2012 and in 2016. In three categories with a high number of problematic substances, the tonnage usage has increased substantially. This could be due to an increase in building activity in Denmark in this time period. This increase, in particular in the categories of construction articles, paint, surface treatments, is problematic for healthy and environmentally sustainable construction.

Declared usage of Authorization list substances in construction articles and preparations are another challenge for sustainable construction. Of the eight authorization list substances that have an expired sunset date and are declared in Danish 2016 construction usage, seven of these substances are screened in the original report to be have high hazard and exposure in all four life cycle phases including the final life cycle phase, the demolition phase. This poses challenges for new construction as well as for recycling and reuse of building elements in the future.

In order to minimize health and environmental damages from the building industry, it is necessary to eliminate the use of the most problematic substances from all phases of the building's life cycle. One of the obstacles in this process is the difficulty of finding transparent information regarding construction material content, in particular construction articles are difficult to assess. Consultants and contractors should have ready access to complete ingredient reports in order to screen for harmful substances. Building declarations or material passes need to include declarations of chemical content with CAS numbers for proper identification. Easy access to content information allows for choices for new construction that are healthier for the immediate surroundings in the construction and the use phases, minimize unhealthy exposure to the users and enable reuse of material in the future unhampered by costly hazard screenings and waste treatments. Transparency and the elimination of hazardous substances in building products are essential for effective implementation of resource conscious trends in the building industry.

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- [10] The Danish Environmental Protection Agency 2016 "Uønsket Kemi i Bæredygtigt Byggeri" Environmental project No. 1882 Table 27 pp. 73 - 82

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