ASSESSMENT OF CHEMICALS RELEASED FROM CONSUMER PRODUCTS INTO THE INDOOR ENVIRONMENT

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Reasons for the study

Indoor climate is a high-priority area in the Danish National Strategy for Environment and Health.

Indoor climate is important for the public health, because we reside far the greatest part of our life indoors.

Many studies show that levels of air pollution indoors are much higher than outdoors.

Background for study

FORCE TECHNOLOGY

In the years 2002 to 2007 the Danish Environmental Protection Agency (DEPA) has published more than 60 reports on the study of chemicals in various consumer products. www.mst.dk

About half of these reports contain data and information relevant for the indoor climate but of different aim and character. In some report the focus is only on the content of chemicals in the products, in others emissions into the indoor air is included.

The DEPA-reports focus on each consumer product or product group separately. It is more complex in the real dwelling, where many products may be used simultaneously.

Most of the reports on consumer products published by DEPA conclude that the release of chemicals from one single product in the home give no rise of concern.

However, what about the collective burden of chemicals from all products used indoors in the same room, may be another case?

Examples of emissions from consumer products indoors

CONSUMER PRODUCTS	EMITTED CHEMICALS
Candle lights	Dioxin, Particles, PAH, VOC
Carpets	PBDE, PFAS, VOC
Cigarettes	Cd, CO, particles, tars, VOC
Cosmetics	Aromatic amines, perfume, VOC
Electronics	DBDE, ozone, VOC
Furnitures	Formaldehyde, PBDE, PFAS, VOC
Impregnative products	PFAS, silicone, VOC
Toys	DEHP, VOC
White goods	NO_x , VOC
Wood stoves	CO, dioxin, PAH, particles

Aim of DEPA Project

- Mapping which chemicals could be emitted to the indoor climate from normal use of consumer products at home.

  Emission is: Evaporation, wearing, migration, and primary and secondary formation.

- Assess the importance of consumer products as source of chemical pollution indoor and the exposure of the residents.

- Describe the total chemical impacts of consumer products on the indoor climate various places in the dwelling.

- Evaluate potential health impacts and nuisances from these exposures and advice how risks could be reduced.

Prioritized VOCs for modeling

Based on information in the previous reports a comprehensive substance-product matrix was developed with indication of

- if quantitative emission data existed, and
- if the exposures were short-term or long-term

Eight volatile organic compounds (VOC) with potential adverse effects, and for which there were available exposure data, were prioritized for further modeling

Phenol
Formaldehyde
Acetaldehyde
Benzene
Toluene
Xylenes
Styrene
Limonene

Model assumptions

Potential indoor air concentrations of the 8 VOCs were estimated in

- A Children's room
- A Kitchen/family room
- A Hall/utility room

It was based on pragmatic model calculations with some assumptions and simplifications

- The volume of the children's room and the hall/utility room were set to 17.4 m^3 corresponding to a model room of 7 m^2 floor area and ceiling heights of 2.5 m; The air exchange rate was 0.5 h^{-1}.
- The kitchen/family room had a volume of 52.2 m^3, corresponding to a floor area of 21 m^2 and a ceiling height of 2.5 m. The three model room was equipped with up to 47 consumer products with indoor climate relevance and included in the DEPA reports.

Estimated formaldehyde concentrations

HCHO Product	Model rooms					
	Children's room		Kitchen/family room		Hall/utility room	
	New products	Used products	New products	Used products	New products	Used products
Computer	3.3	3.7				
Printer	0.4	0.9				
Monitor	3.0	2,8				
Playing console	0.8	0.5				
Cooking oven			6,0	8,0		
Hair dryer					0,5	0,7
Iron			1,1	0,0	3,3	0,0
Decorative lamp	19,5	4,9				
Mobil phone with charger	<0,1	<0,1	<0,03	<0,03	<0,1	<0,1
TV-set	1,5	0,3	0,5	0,1		
Charger/transformer	11,1	4,3	3,7	1,41	1,1	4,3
El-panel	<0,1	0,2	<0,03	0,1	<0,1	0,1
El-radiator	0,4	0,4	0,1	0,1	0,4	0,4
Rechargeable batteries	<0,1	<0,1	<0,03	<0,03	<0,1	<0,1
Total concentration in model room (µg/m³)	40,0	18,0	11,4	9,7	15,3	5,5

Assessment of formaldehyde

Formaldehyde levels in indoor air are normally estimated to 10-200 µg/m^3, depending on which sources exist.

In this project the calculated maximum concentration of formaldehyde in indoor air was about 500 µg/m^3, however, typically the concentrations will be below 50 µg/m^3.

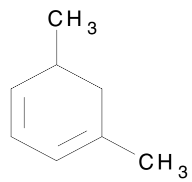
The typical concentration is lower than a recommended indoor air limit value for formaldehyde of 120 µg/m^3 but the worst-case concentration is higher.

A child will typically daily inhale 72 µg formaldehyde/kg bw and 700 µg/kg bw in the worst case.

Thus, the USEPA "Reference dose" of 200 µg/kg bw/d will be easily complied with for a child in the typical case but not in the worst case adding up all sources working simultaneously in the children's room.

Formaldehyde is a potent carcinogen, thus all unnecessary exposure to formaldehyde should be avoided.

Estimated xylene concentrations

 oduct	Model rooms					
	Children's room		Kitchen/family room		Hall/utility room	
	New products	Used products	New products	Used products	New products	Used products
mputer	10.5	8.6				
onitor	24.2	7.9				
aying console	0.7	0.0				
oking oven			0.3	<0.33		
ir dryer					1.3	1.7
ecorative lamp	23.0	4.7				
obil phone with charger	0.1	<0.1	0.0	<0.03	0.1	<0.1
/-set	1.8	2.0	0.6	0.7		
arger/transformer	25.6	15.2	8.5	5.1	25.6	15.2
echargeable batteries	19.5	5.3	6.5	1.81	9.5	5.3
tal concentration in model om (µg/m³)	105.4	43.7	16.0	7.5	46.5	22.2

Assessment of xylenes

The highest concentrations of xylenes occur in the children's room, where the concentration is 105 µg/m^3 for new electronic products and 44 µg/m^3 for used products.

In the utility room/hall the concentration is 47 µg/m^3 for new products.

To this should be added a possible contribution from other sources of up to 476 µg/m^3 (or 51,000 µg/m^3 with spray paint).

The Reference Concentration is 0.1 mg/m^3, which alone compare to the contribution from electronics in the children's room.

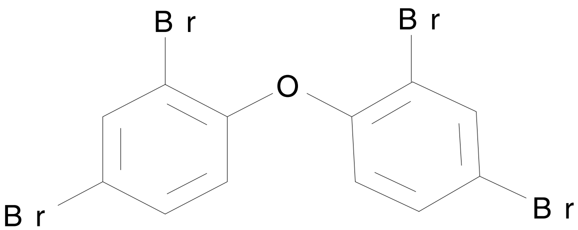
In case of spray painting the concentrations are so high that direct health damage may occur

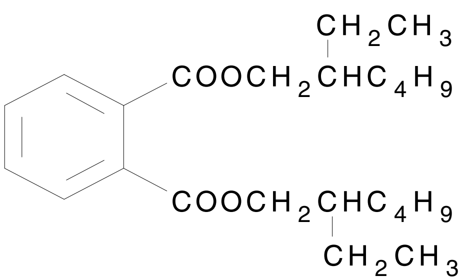
The Reference dose for xylenes is 0.2 mg/kg bw/d.

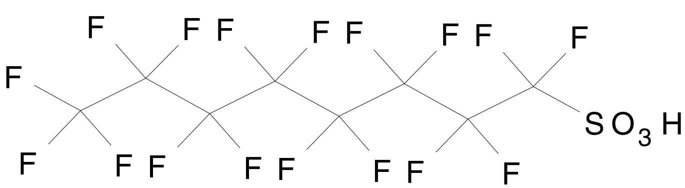
Six hours exposures to 100 µg/m^3 correspond to a child intake of xylenes of 360 µg/kg bw/d.

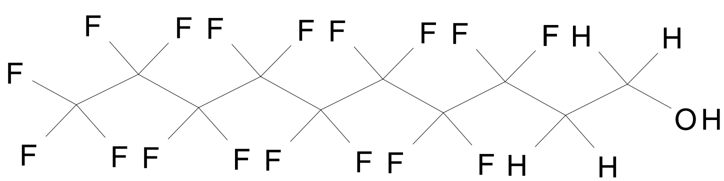
Thus, alone the electronics generate too high exposures compared to Reference Dose. A further 10-100 times enhanced exposure, which is likely with contributions from other sources, may be seen as completely unacceptable.

Less volatile chemicals in house dusts









Studies in the scientific literature on release of chemicals from consumer products and contamination of house dusts were reviewed with focus on exposure of a crawling infant to

- the less volatile brominated flame retardants (PBDE) often used in electronics, textiles and furniture foam,
- phthalate plasticizers used in vinyl floors, vinyl wallpaper and toys,
- the water-oil-dirt repellant perfluoroalkylated compounds (PFAS) added to carpets, textiles and outdoor clothes.

It is all hazardous substances, which only in a few cases have been included in the DEPA reports but other studies have reported significant exposure indoors.

Assessment of brominated flame retardants

The levels of brominated flame retardants (PBDE) in indoor air and house dusts are very variable but, generally, PBDE occur in concentrations one order of magnitude lower than for phthalates.

Maximum concentration may be >20,000 ng PBDE/g dust.

The exposure to PBDE via house dust is in the same order of magnitude as in food. This is surprising for persistent organic pollutants, for which the food normally account for approximately 90% of human exposure.

If the estimated intake of dust is 100 mg/day a child can have an intake of 30 ng PBDE/day and in seldom cases up to 2000 ng PBDE/day.

This should be compared with an average intake from the food of 40-150 ng/day and about 2000 ng/day for nursing infants, because human milk contains relatively high levels of PBDE. The maximum child intake will be <5 µg/day.

Comparison with the Reference Dose of 2, 3 and 10 µg/kg bw/d for penta-, octa and deca-BDEs, respectively, shows that only nursing infants may come close to the Reference dose.

Therefore, with the present knowledge, the indoor exposure alone will be of no acute health risks for the crawling infant.

Assessment of phthalates

Di(2-ethylhexyl) phthalate (DEHP) is the most abundant phthalate indoors.

The typical daily child intake of DEHP from all indoor sources will be 10-20 µg/kg bw/d or 100-200 µg/day.

In the worst case: a child playing on a PVC floor the exposure may be 50-250 µg/kg bw/d or 0.5-2.5 mg/day.

To be added is intake of DEHP with the food, which is estimated to 18 µg/kg bw/d or 180 µg/day for a child.

Thus, food exposure is in the same order of magnitude as the ”normal” indoor exposure.

The no-adverse-effect level of DEHP in animal feeding experiments with rats is 3.7 mg/kg bw/d or 37 mg/day for a child.

If rats and crawling children do have a similar susceptibility for DEHP, the safety factor is rather narrow for the mostly exposed children, even without exposure to other phthalates.

Assessment of perfluorinated compounds

Perfluoroalkylated compounds (PFAS) are not lipophile. Thus intake of animal fat and food in general will not be so important an exposure source as for the lipophile persistent organic pollutants (POP).

Indoor climate seems to be the major source of exposure to these substances. If the daily intakes of house dust are set to 100 mg/day, the daily average exposure of a 10 kg child will be 200-2,000 ng PFAS and the maximum 8-50 µg PFAS/day or 0.8-5 µg PFAS/kg bw/d.

The Acceptable Daily Intake for perfluoroalkylated compounds is 3 µg/kg bw/day, which corresponds to the no-effect level for reproductive effects with a safety factor of 1,000. Only in the case of maximum exposure the intake will be unacceptable with the present knowledge about the toxicology of PFAS.

Conclusions

- Consumer products may emit to the indoor climate many different toxic substances and in a complex mixture with different emission patterns.
- Some products emit toxic substances over longer time, others have a shorter release.
- New product often release more chemicals to the air than used products.
- Use of incense and some spray products indoors are the most polluting of the studied products and activities.
- The highest concentrations in a home are likely to occur in the children's room because
  - It is normally smaller than most other rooms in the home,
  - ventilation may be limited, and
  - it contains normally many products, which may release chemicals to the air.
- In the worst case the total burden to VOC from all sources may approach or exceed the highest tolerable concentrations for children.
- The safety factor for a crawling infant exposed to less volatile chemicals in house dust was rather narrow, especially for highly phthalate-exposed children.
- Children staying indoors are exposed to many substances simultaneously but health assessments are mainly based on one substance a time.

Recommendation of measures

It is prudent to use the Precautionary Principle regards children's exposure to potential toxic chemicals.

Children's exposure to dangerous chemicals in the indoor climate should be prevented by sufficient cleaning and ventilation.

Use of dangerous substances in consumer products, which may be emitted indoors and expose children for a risk, should be terminated by voluntary agreements or bans.

If feasible, building materials and consumer products containing phthalate plasticizers, especially DEHP, should not be used in children's rooms.

Indoor use of incense is the most polluting and dangerous of all studied activities, and it should be avoided or diminished.

Indoor use of spray products is also an extreme pollution source, which should be avoided or al least be limited as much as possible. As a minimum breathing mask and extra ventilation should be applied.

Research recommendations

Studies to initiate in order to establish a more true/credible basis for assessing the state of health in a dwelling:

- Measurements of selected indicator substances, emitted from consumer products into indoor air and dust, should be initiated at a large number of randomly chosen occupied dwellings.
- Field measurements of indoor air in a dwelling, where rooms are furnished as a realistic worst-case condition.
- An important situation to study could e.g. be a newly furnished children's room with a selection of new building materials, equipments and consumer products.
- It could be interesting to make the study also at low ventilation rate, as occurring at winter time.
- The selected chemicals to be analyzed should have potential adverse effects on health or comfort, including substances originated from secondary chemical reactions.

Thank You for listening!

Reference:

Jensen AA, Knudsen HK. Total health assessment of chemicals in indoor climate from various consumer products. Danish Environmental Protection Agency: Survey of Chemical Substances in Consumer Products No. 75, 2006. www.mst.dk