Identification and prioritization of chemicals associated with plastic packaging

Ksenia Groh
Food Packaging Forum
HCPP Project final event
Gothenburg, 12 September 2019
Global plastics production: 380 Mt in 2015

Plastic packaging is ...

- (relatively) cheap
- lightweight
- durable
- versatile, allowing for a multitude of applications

BUT

- persisting in the environment
- leaching chemicals, some of which could be hazardous
High exposure potential for humans and environment

Direct contact with food

Environmental pollution

- Top 10 single-use plastic items found on seashores
  - Drink bottles, caps, lids
  - Cigarette butts
  - Cotton bud sticks
  - Crisps and sweets packets and wrappers
  - Sanitary applications
  - Plastic bags
  - Cutlery, straws, stirrers
  - Drink cups, cup lids
  - Balloons and balloon sticks
  - Food containers, incl. fast food packaging

High proportion among marine litter


Hazardous chemicals in plastic packaging?

- bisphenols
- phthalates
- nonylphenols
- Cd, Pb ..
- ...
- ...
- ...
- ...

? . ? . ?
Hazardous chemicals in plastic packaging: State of the art, prioritization, and assessment

• HCPP: multi-partner project led by FPF, 2017-2019

• Aims
  • raise awareness for chemicals in plastic packaging
  • identify chemicals associated with plastic packaging
  • assess their hazards and identify candidates for substitution
  • human health and environmental assessment for selected substances
Chemical composition of plastics

IAS: intentionally added substances
- monomers
- additives
- processing aids e.g. solvents

NIAS: non-intentionally added substances
- impurities and contaminants
- oligomers
- reaction by-products and side products, breakdown products, neoformed products

Dossier – Non-intentionally added substances (NIAS)
June 2018, 2nd edition
DOI: 10.5281/zenodo.1265331
Birgit Geueke
Material constituents of plastic packaging

Final compounded plastic polymers, single or in combination

+ other components such as printing inks, adhesives, foils, coatings . . .
Database of Chemicals associated with Plastic Packaging (CPPdb)

- compilation of publicly available information sources
- covering both food and non-food packaging

CPPdb: 4255 chemicals

List A: LIKELY associated with plastic packaging 902 chemicals

List B: POSSIBLY associated with plastic packaging 3353 chemicals

Challenge: insufficient transparency and lack of information on the actual use and levels of chemicals in plastic packaging

Current database version can be downloaded at https://doi.org/10.5281/zenodo.1287773

Hazardous chemicals associated with plastic packaging

List A: **LIKELY** associated with plastic packaging
902 chemicals

% chemicals with CLP classifications available:
~13% on environmental hazards
~27% on human health hazards

+ EDC identification, REACH/UNEP
+ PBT/vPvB identification, EU

List of 148 top hazardous chemicals likely associated with plastic packaging, including (with overlaps):

Food contact chemicals among CPPdb chemicals

<table>
<thead>
<tr>
<th>CPPdb sublist</th>
<th>Total number of chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>ListA – likely associated with plastic food packaging</td>
<td>902</td>
</tr>
<tr>
<td>Top hazardous for human health based on harmonized classifications</td>
<td>63</td>
</tr>
<tr>
<td>Top hazardous for the environment based on harmonized classifications</td>
<td>68</td>
</tr>
<tr>
<td>PBT/vPvB classified (EU)</td>
<td>7</td>
</tr>
<tr>
<td>Conservatively identified EDCs</td>
<td>35</td>
</tr>
</tbody>
</table>

- the majority of top hazardous chemicals associated with plastic packaging have indications of food contact use
Lack of harmonized hazard data for many CPPdb chemicals

<table>
<thead>
<tr>
<th>CPPdb sublist</th>
<th>Total number of chemicals</th>
<th>Of them, chemicals used in food contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>ListA – likely associated with plastic food packaging</td>
<td>902</td>
<td>788 (87.4%)</td>
</tr>
<tr>
<td>Top hazardous for human health based on <strong>harmonized</strong> classifications</td>
<td>63</td>
<td>55 (87.3%)</td>
</tr>
<tr>
<td>Top hazardous for the environment based on harmonized classifications</td>
<td>68</td>
<td>45 (66.2%)</td>
</tr>
<tr>
<td>PBT/vPvB classified (EU)</td>
<td>7</td>
<td>6 (85.7%)</td>
</tr>
<tr>
<td>Conservatively identified EDCs</td>
<td>35</td>
<td>35 (100%)</td>
</tr>
<tr>
<td>**Top hazardous for human health based on <strong>advisory</strong> <strong>classifications</strong></td>
<td>102</td>
<td>97 (95.1%)</td>
</tr>
</tbody>
</table>

- many chemicals lacking harmonized hazard data could actually be hazardous as well
Prioritizing for substitution: Environment

<table>
<thead>
<tr>
<th>Criterium</th>
<th>N chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest CLP sum hazard score (1100) for the environment</td>
<td>68</td>
</tr>
<tr>
<td>Any data available in ECOTOX database</td>
<td>54</td>
</tr>
<tr>
<td>ECOTOX data available for Standard Test Species</td>
<td>29</td>
</tr>
<tr>
<td>Not containing metals or metal groups</td>
<td>15</td>
</tr>
<tr>
<td>Use in plastic packaging confirmed by additional primary literature searches</td>
<td>6</td>
</tr>
<tr>
<td>Consideration of data on exposure and environment-relevant effects</td>
<td>1*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>CAS number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzyl butyl phthalate (BBP)</td>
<td>85-68-7</td>
</tr>
<tr>
<td>Diphenylamine</td>
<td>122-39-4</td>
</tr>
<tr>
<td>Nonylphenol</td>
<td>25154-52-3</td>
</tr>
<tr>
<td>4-tert-Octylphenol</td>
<td>140-66-9</td>
</tr>
<tr>
<td>2,2',6,6'-Tetrabromobisphenol A</td>
<td>79-94-7</td>
</tr>
<tr>
<td>Triclosan</td>
<td>3380-34-5</td>
</tr>
</tbody>
</table>

Prioritizing for substitution
Human Health

<table>
<thead>
<tr>
<th>Criterium</th>
<th>N chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest CLP sum hazard score (&gt;10,000) for human health</td>
<td>63</td>
</tr>
<tr>
<td>NHANES biomonitoring data available (indication of human exposure)</td>
<td>16</td>
</tr>
<tr>
<td>Consideration of regulatory status under REACH and endocrine disrupting properties for human health</td>
<td>5*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>CAS No</th>
<th>CLP hazard score for human health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzyl butyl phthalate (BBP)</td>
<td>85-68-7</td>
<td>10000</td>
</tr>
<tr>
<td>Bis(2-ethylhexyl) phthalate (DEHP)</td>
<td>117-81-7</td>
<td>10000</td>
</tr>
<tr>
<td>Di(nbutyl phthalate (DBP)</td>
<td>84-74-2</td>
<td>10000</td>
</tr>
<tr>
<td>Diisobutyl phthalate (DiBP)</td>
<td>84-69-5</td>
<td>10000</td>
</tr>
<tr>
<td>Dicyclohexyl phthalate (DCHP)</td>
<td>84-61-7</td>
<td>11000</td>
</tr>
</tbody>
</table>

Geueke B. et al. (2018) Prioritization approaches for hazardous chemicals associated with plastic packaging. *Food Packaging Forum*
https://doi.org/10.5281/zenodo.14364425
Take-home messages

• Numerous hazardous chemicals associated with plastic packaging

• (Harmonized) hazard data missing for many more substances

• High complexity and lack of transparency hinder comprehensive overview and risk assessment

• Phthalates highlighted as candidates for substitution. Are there other important chemicals we should be looking at?

• Non-intentionally added substances pose unique challenges for systematic identification, toxicity testing, risk assessment
Hazardous Chemicals in Plastic Packaging (HCPP)

Funding: MAVA foundation

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Healthy Buildings Network

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Food Packaging Forum Foundation (FPF)

Final Event HCPP project, 12 September 2019, Gothenburg
Thank you for your attention!

www.foodpackagingforum.org

Save the date: 24 October 2019
Improving the chemical safety of food contact articles:
accelerating science and innovation
7th FPF workshop, Zurich, Switzerland
Overview of information sources (dashed-line boxes) and approaches/workflow (solid-line boxes) followed to (A) compile the database of chemicals associated with plastic packaging (CPPdb) and (B) split the full CPPdb into the two lists according to the assigned likely (CPPdb_ListA) or possible (CPPdb_ListB) association with plastic packaging.
Comparison to ECHA’s database of plastic additives


<table>
<thead>
<tr>
<th>Function as identified by ECHA</th>
<th>N substances listed by ECHA</th>
<th>N substances (% of total in this category)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>on CPPdb_ListA</td>
<td>on CPPdb_ListB</td>
</tr>
<tr>
<td>Antioxidants</td>
<td>25</td>
<td>18 (72%)</td>
</tr>
<tr>
<td>Antistatic agents</td>
<td>15</td>
<td>9 (60%)</td>
</tr>
<tr>
<td>Flame retardants</td>
<td>36</td>
<td>9 (25%)</td>
</tr>
<tr>
<td>Heat stabilizers</td>
<td>27</td>
<td>12 (44%)</td>
</tr>
<tr>
<td>Light stabilizers</td>
<td>15</td>
<td>6 (40%)</td>
</tr>
<tr>
<td>Other stabilizers</td>
<td>20</td>
<td>6 (30%)</td>
</tr>
<tr>
<td>Other functions*</td>
<td>72</td>
<td>16 (22%)</td>
</tr>
<tr>
<td>Pigments agents</td>
<td>126</td>
<td>57 (45%)</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>56</td>
<td>26 (46%)</td>
</tr>
<tr>
<td>All identified **</td>
<td>392</td>
<td>159 (41%)</td>
</tr>
</tbody>
</table>

*including nucleating agents  
**based on CAS availability
Food Packaging Forum (FPF) foundation

Science communication and research

Food contact materials/chemicals, migration, health effects

Founded in 2012 in Zürich

Non-profit, funded by unconditional donations

For scientists, industry and policy experts, communicators
ALL INFORMATION FREELY ACCESSIBLE: www.foodpackagingforum.org
Plastics’ share among food packaging materials

- Flexible plastics 33%
- Rigid plastics 19%
- Foil 11%
- Paper container 10%
- Metal 9%
- Glass 8%
- Paper 5%
- Other 5%

Plastics recycling: Chemical safety aspects

Review

Food packaging in the circular economy: Overview of chemical safety aspects for commonly used materials

Birgit Geueke*, Ksenia Groh, Jane Muncke

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Abstract

Food packaging facilitates storage, handling, transport, and preservation of food and is essential for preventing food waste. Besides these beneficial properties, food packaging causes rising concern for the environment due to its high production volume, often short usage time, and problems related to waste management and littering. Reduction, reuse, and recycling, but also redesign support the aims of the circular economy. These tools also have the potential to decrease the environmental impact of food packaging.

In this article, we focus on chemical safety aspects of recycled food packaging, as recycling is currently seen as an important measure to manage packaging waste. However, recycling may increase the levels of chemical contaminants.

https://doi.org/10.1016/j.jclepro.2018.05.005

- Metals and glass are ‘permanent’ materials with theoretically unlimited recycling

- Plastics and paper are ‘non-permanent’ materials that degrade during (mechanical) recycling, thus requiring addition of virgin material during each recycling round
Mechanical recycling processes for plastic FCMs

Favorable opinions on plastics recycling published by EFSA and the US FDA (March 2018)


## Typical contaminants in recycled plastics

<table>
<thead>
<tr>
<th>Possible origin</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavor, aroma, odor compounds</td>
<td>Previous food and non-food applications</td>
</tr>
<tr>
<td></td>
<td>Limonene, p-cymene</td>
</tr>
<tr>
<td>Oligomers, monomers and derivatives</td>
<td>Production of virgin materials; degradation during use and recycling</td>
</tr>
<tr>
<td></td>
<td>Linear and cyclic oligomers, acetophenone, benzaldehyde</td>
</tr>
<tr>
<td>Additives and their degradation products</td>
<td>Production of virgin materials; degradation during use and recycling; cross-contaminations</td>
</tr>
<tr>
<td></td>
<td>UV absorbers, antioxidants, plasticizers, other additives</td>
</tr>
<tr>
<td>Contamination by non-food grade hazardous substances</td>
<td>Mixed collection of non-food grade plastics; adulteration; consumer misuse</td>
</tr>
<tr>
<td></td>
<td>Brominated flame retardants, dioxin-like compounds, sulfuric compounds</td>
</tr>
<tr>
<td>Inorganic elements</td>
<td>Catalysts; environmental origin; recycling infrastructure</td>
</tr>
<tr>
<td></td>
<td>Heavy metals</td>
</tr>
</tbody>
</table>

- need to ensure that recycling does not compromise FCM’s safety