Poly- and Perfluorinated Alkyl Substances (PFASs): Scientific Evidence

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Overview

- Information needs for environmental hazard assessment and risk assessment
- Long-chain PFASs
- Fluorinated alternatives
- Persistence of perfluorinated alkyl substances
- Conclusions

Reference:
Synthesis Paper on Per- and Polyfluorinated Chemicals (PFCs), OECD 2013
What Evidence Do We Need?

chemical identity
chemical properties

production
uses
disposal

emissions
(amount/rate, place, time)

environmental fate
environmental exposure
human exposure
adverse effects

risk assessment:
ratio of exposure to no-effect thresholds

persistence, P
bioaccumulation potential, B
toxicity, T

environmental hazard assessment
Long-Chain Perfluorinated Alkyl Acids

PFOS

production → uses → disposal

emissions (amount/rate, place, time)

environmental fate

environmental exposure

human exposure

adverse effects

Many components of hazard and risk assessment (relatively) well known

Regional and global regulation; voluntary phase-out
Long-Chain Perfluorinated Alkyl Acids: Regulation

- Stockholm Convention on POPs: PFOS and precursors included in Annex B in 2009 because of P, B, T and LRTP

- European Union:
  - long-chain PFCAs (C_{11–C_{14}}) are Substances of Very High Concern because of vPvB properties
  - APFO/PFOA are Substances of Very High Concern because of PBT properties

- US EPA 2010/15 PFOA Stewardship Program: voluntary phase-out of PFOA, precursors, and higher homologues
Replacements of Long-Chain PFASs

- 6:2 FTOH-based substances
- PBSF-based substances, to some extent also PHxSF-based
- Mono- and polyfluorinated ether-based substances, such as polyfluoroalkyl ether carboxylic acids
- Fluorinated oxetanes and other fluorinated polymers with „short“ fluorinated side-chains

References:
Synthesis Paper on Per- and Polyfluorinated Chemicals (PFCs), OECD 2013
http://www.miteni.com/Products/perfluorinatedde.html
What Do We Know?

6:2 FTSA

F₃C

CF₂

CF₂

CF₂

CH₂

SO₃⁻

chemical identity

chemical properties

production

uses

disposal

emissions (amount/rate, place, time)

environmental fate

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adverse effects

persistence, P

bioaccumulation potential, B

toxicity, T
What Do We Know?

- Basic information: identity and use
- (uncertain) estimates of properties derived from structure
- (uncertain) estimates of environmental fate
Implications of the Available Evidence

- Perfluorinated chain is very persistent.
- Ultimate degradation of alternative PFASs will be slow.
- Perfluorinated carboxylic acids (PFCAs) and perfluorinated sulfonic acids (PFSAs) are *terminal transformation products.*
Persistence of the Perfluorinated Chain

- Degradation half-lives of decades or centuries under environmental conditions
  - anaerobic defluorination (Liou et al. 2010) does not take place
  - direct photolysis (Taniyasu et al. 2013) not possible
  - indirect photolysis (Vaalgamaa et al. 2011, Liu et al. 2013) very slow; requires high Fe(III) concentration, light, and low pH

J.S.-C. Liou et al., Chemosphere 80 (2010) 176–183
S. Taniyasu et al., Chemosphere 90 (2013) 1686–1692
Extended Risk Assessment

- PFCAs and PFSAs as terminal degradation products need to be included in risk assessment of precursors

- This is consistent with
  - the regulation of PFOS under the Stockholm Convention
  - the treatment of PFCA and PFSA precursors in the PBT screening study by Strempel et al. (2012), ES&T 46, 5680–5687
Long-Range Transport

Environmental exposure:

- long-lasting
- large-scale
- cannot be controlled once the chemicals have been released
- long-range transport is a concern in itself

Long-Term Implications

- Continuing emissions will lead to increasing levels and, thereby, increasing risk.

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\text{risk} = \frac{\text{environmental concentration}}{\text{no-effect threshold}}
\]
Long-Term Implications

✦ Continuing emissions will lead to **increasing levels** and, thereby, **increasing risk**.

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\text{risk} = \frac{\text{environmental concentration}}{\text{no-effect threshold}}
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Long-Term Implications

✧ Continuing emissions will lead to increasing levels and, thereby, increasing risk.

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\text{risk} = \frac{\text{environmental concentration}}{\text{no-effect threshold}}
\]
Long-Term Implications

✈ Continuing emissions will lead to increasing levels and, thereby, increasing risk.

\[
\text{risk} = \frac{\text{environmental concentration}}{\text{no-effect threshold}}
\]
Conclusions (I)

- Phase-out of long-chain PFASs under way
- Fluorinated alternatives being developed and commercialized
- Current evidence on fluorinated alternatives:
  - information in the public domain: in many cases\(^1\), insufficient for hazard and risk assessments (emissions, properties, exposure levels, effect thresholds not known)
  - manufacturers often have additional information
  - new dialogue about information sharing

\(^1\) For 26 of 30 fluorinated alternatives discussed by Z. Wang et al., *Environment International* 60 (2013), 242–248, no information on properties or toxicity was available in the 25 databases accessible via eChemPortal, www.echemportal.org, in November 2013.
Conclusions (II): PBT Properties?

✦ Current evidence does indicate potential for serious environmental impacts:
  ➤ High persistence implies large-scale and long-term exposure; levels will be increasing
Conclusions (II): PBT Properties?

- Current evidence does indicate potential for serious environmental impacts:
  - High persistence implies large-scale and long-term exposure; levels will be increasing

- In many cases: B and T not sufficiently well known, but this does not imply absence of any B and T properties

Absence of evidence is not evidence of absence

Hansson and Rudén, Toxicological Sciences 90 (2006), 304–308
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