Understanding PFAS and their chemical properties for better remediation

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Swedish Chemicals Agency

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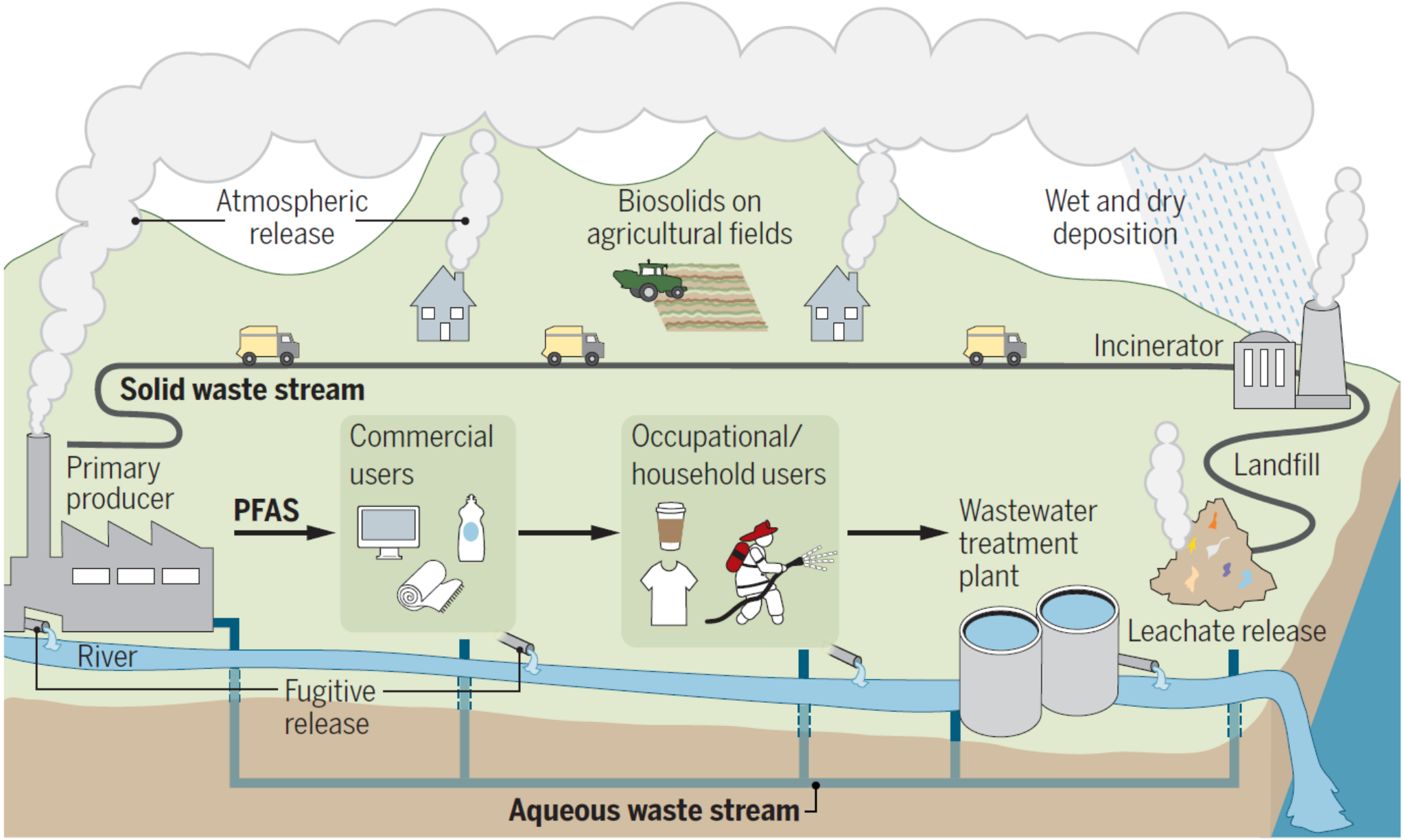
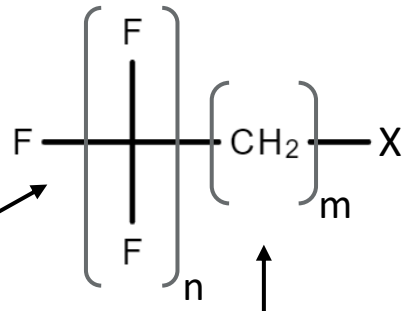
KEMI
Kemikalieinspektionen
Swedish Chemicals Agency

The PFAS life cycle



Evich et al., Science 375, 512 (2022)

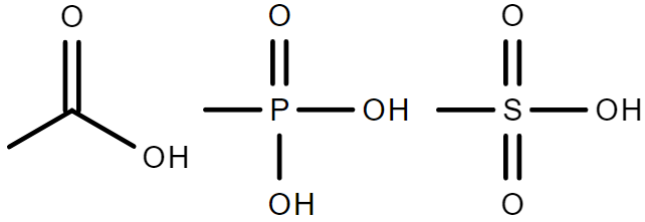
Properties influencing environmental distribution of PFAS



Perfluoroalkyl chain
n = 1-2 -> Ultra-short-chain PFAS
n = 3-6 -> Short-chain PFAS
n ≥ 7 -> Long-chain PFAS

Non-fluorinated alkyl linker
m ≥ 0

Head group -X
Hydrogen, halogen
Polar group, e.g. –OH, –NH2
Ionizable group e.g.



Water solubility

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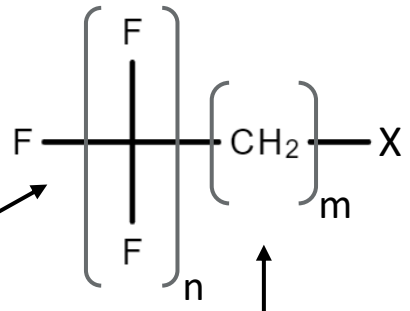

Sorption to organic matters (Log Koc)

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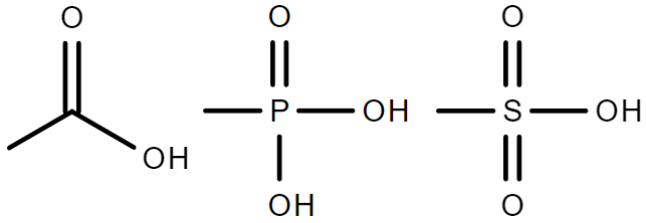

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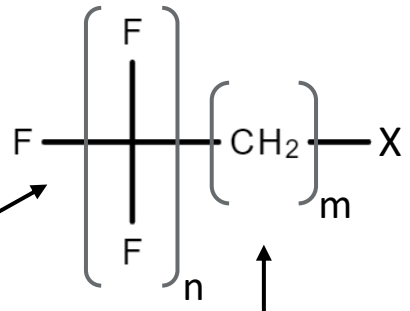

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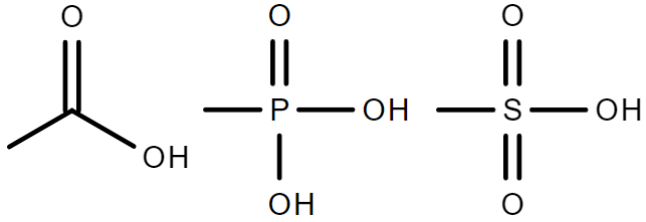

Volatility (Vapour pressure)

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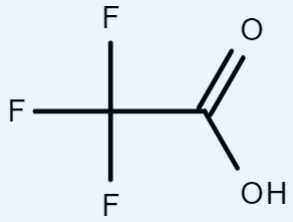
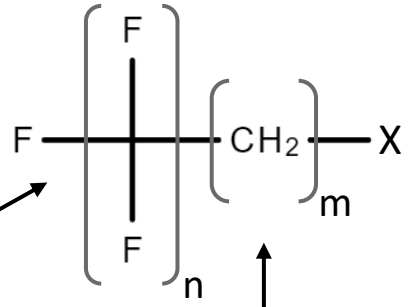


- Very water soluble (anionic)
- **Distributes mainly to water**



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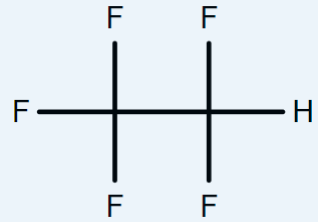
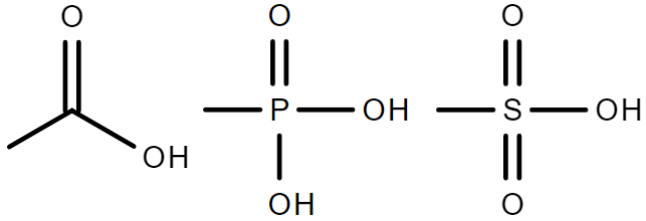
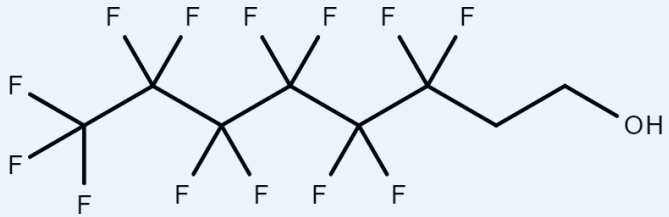


- Very volatile (F-gas)
- **Distributes to atmosphere**

Head group -X
Hydrogen, halogen
Polar group, e.g. –OH, –NH2
Ionizable group e.g.





- Low water solubility / relatively high sorption
- **Distributes mainly to soil/sediment**
- Relatively volatile
- Transport via atmosphere

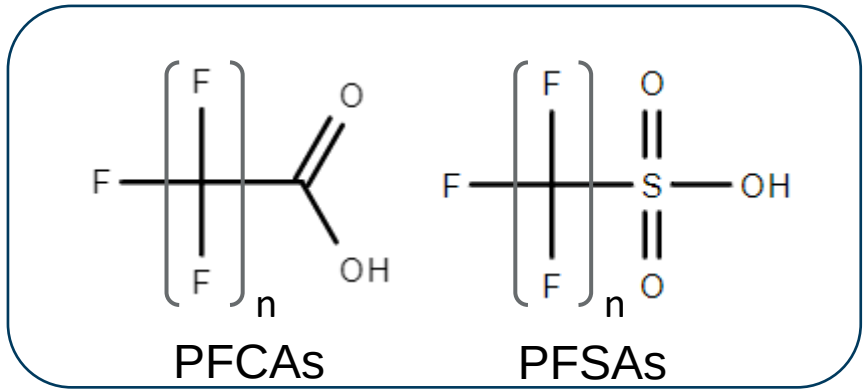
PFAS degradation in environment

Precursors

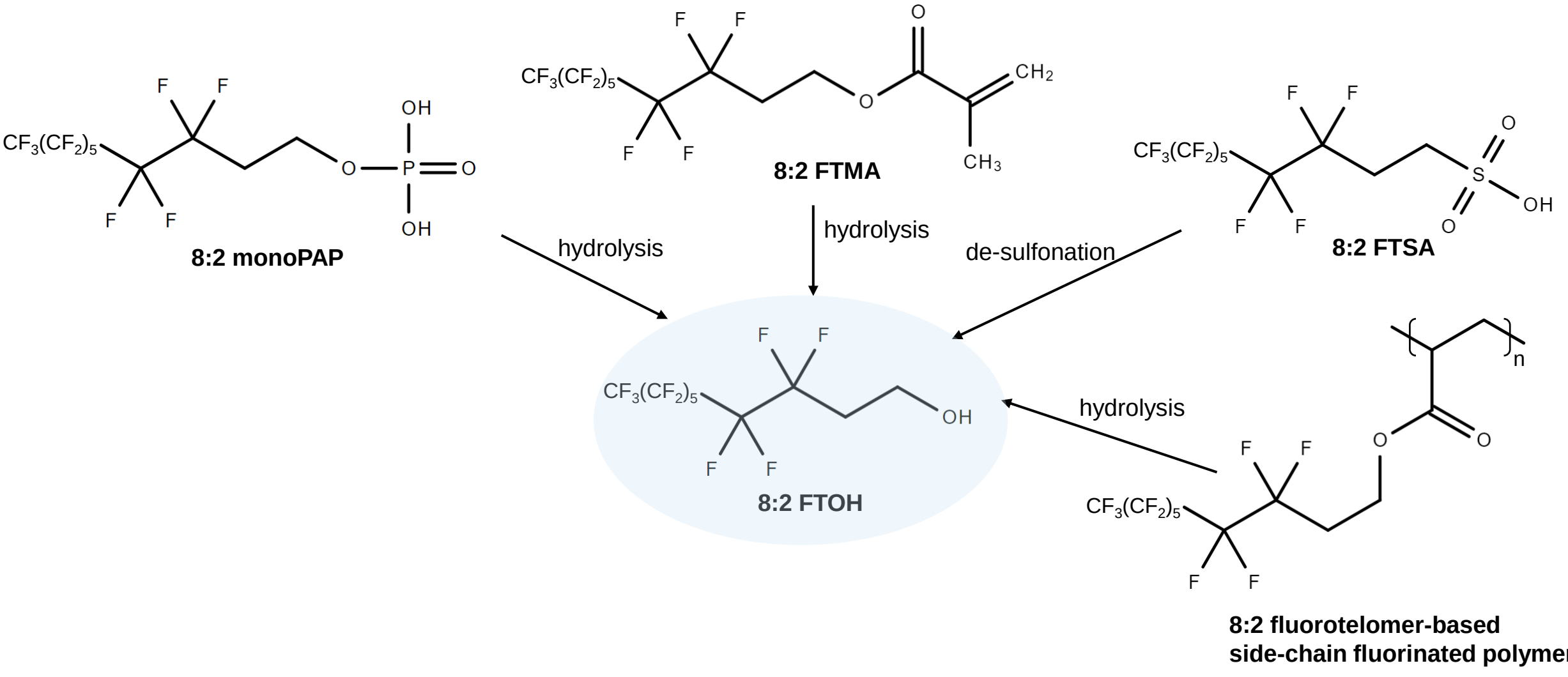
Environmental degradation

Extremely persistent!
No further degradation in environment

Arrowheads



Example of PFCA-precursors – Fluorotelomer derivatives



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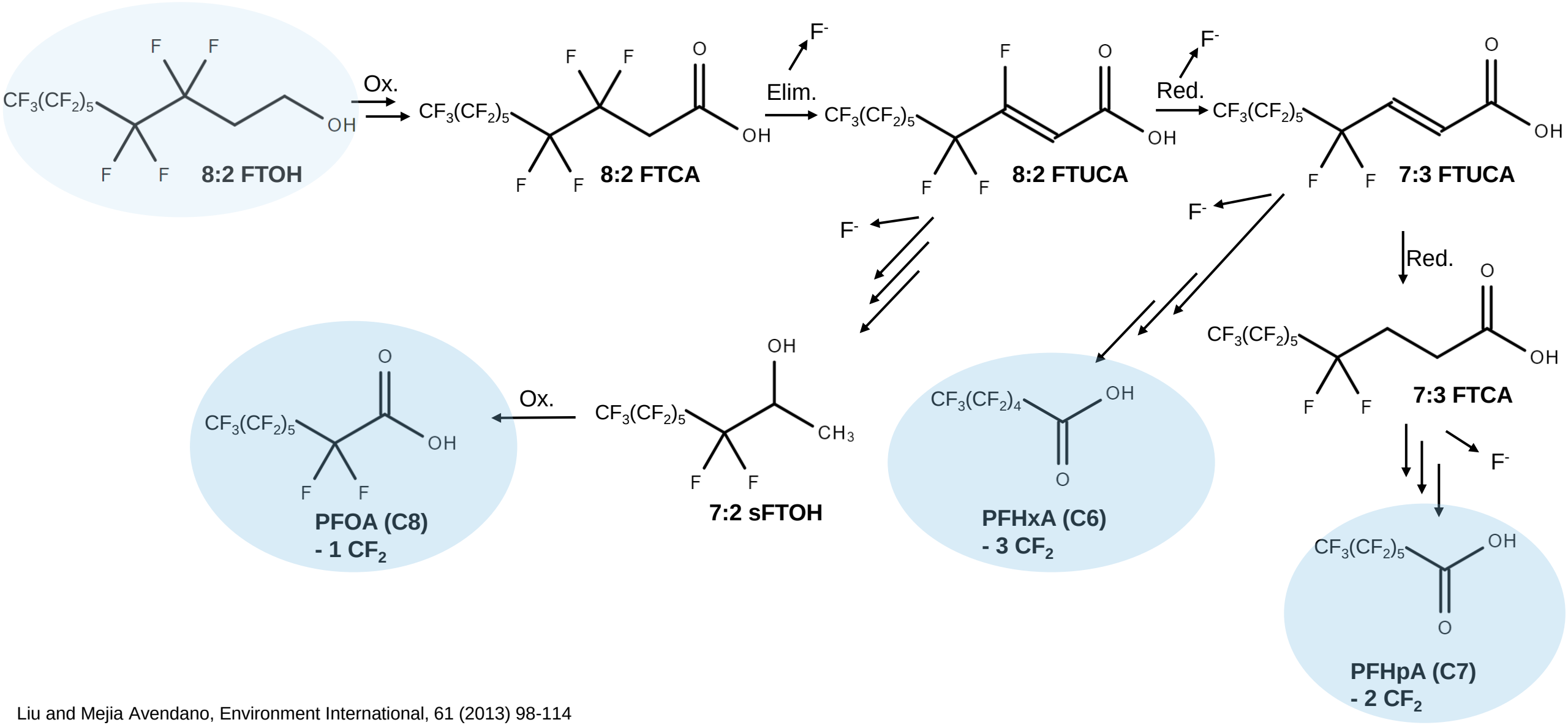
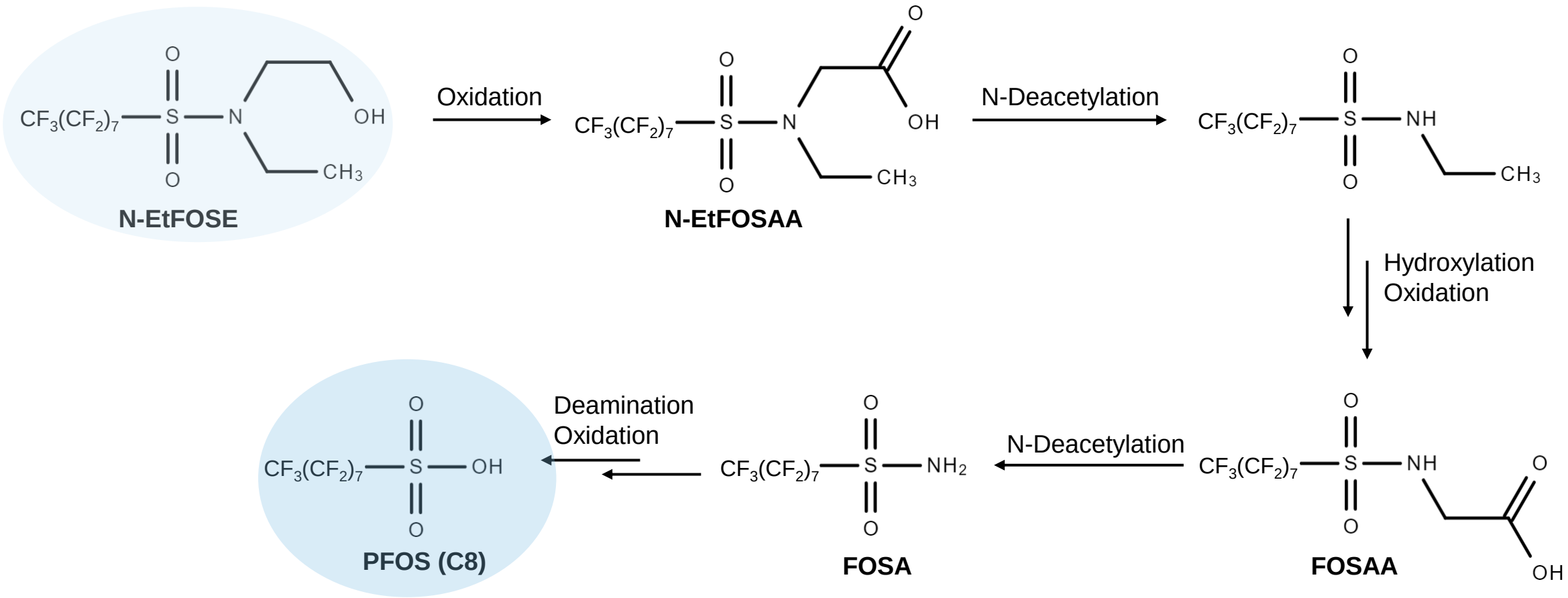


Liu and Mejia Avendano, Environment International, 61 (2013) 98-114

Example of PFSA-precursors – FASAs



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Remediation of PFAS arrowheads PFCAs & PFSAs in water

- Conventional water treatment techniques cannot remove PFCAs and PFSAs. In wastewater treatment plants PFCAs and PFSAs can even be found in higher concentration in effluent water due to degradation of precursor PFASs.
- Granular activated carbon (GAC) and powdered activated carbon (PAC) filtration: Longer chain PFCAs & PFSAs can be removed. Higher efficiency removal for PFSAs compared to PFCAs. Shorter chain PFCAs & PFSAs cannot be effectively removed. This correlates to water solubility / sorption potential.
- Ion exchange resin (IXR) filtration: Requires an ionizable group. Longer chain PFCAs & PFSAs can be removed. Higher efficiency removal for PFSAs compared to PFCAs. Shorter chain PFCAs & PFSAs cannot be effectively removed.
- High pressure membrane systems: Effective removal of ≥C4 PFCAs and ≥C4 PFSAs.
- The above separation techniques requires subsequent destruction due to the extreme persistence of PFASs: Thermal degradation/incineration, electrochemical oxidation, sonolysis, photocatalysis, supercritical water oxidation

THANK YOU FOR LISTENING!