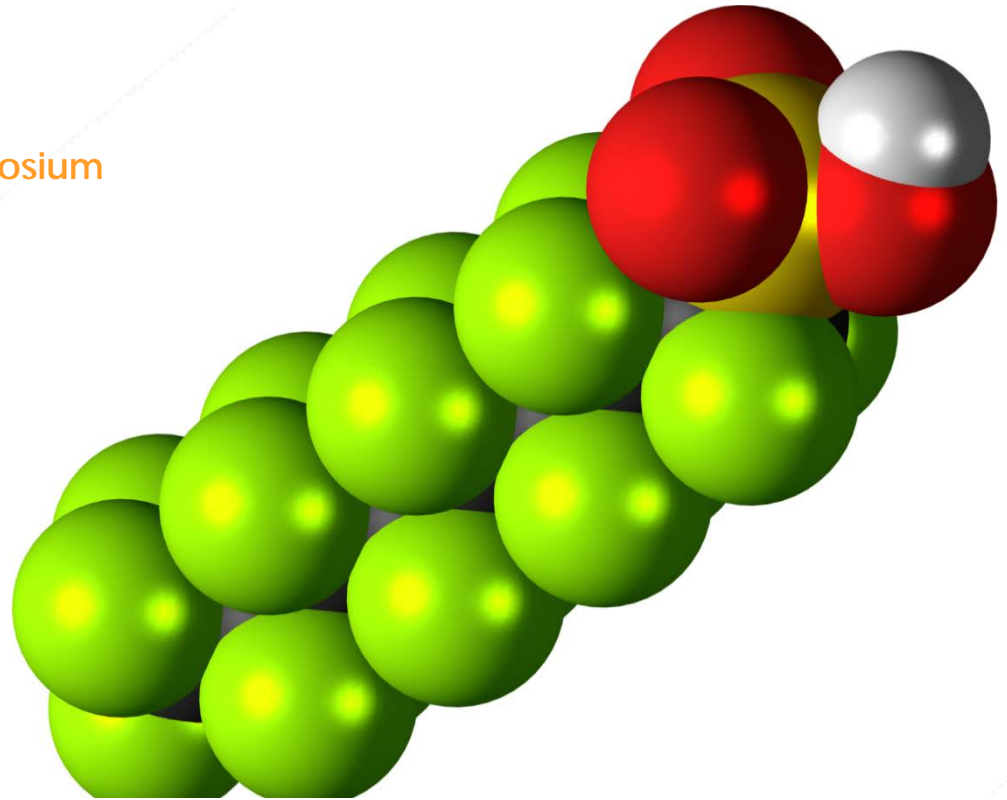


# Bench Scale Trials of Promising Technologies for PFOS Remediation

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# Outline

- 1 Background
- 2 Assessment of PFOS decomposition
- 3 Assessment of PFOS Concentration/Extraction
- 4 Conclusions

# 1 Background

## *PFOS and related compounds*

- Represent a recently-recognized class of environmental contaminants
- Detected in human and animal tissue around the world
- Large quantities of these chemicals still exist at contaminated sites across Canada
- No practical remediation technologies available to remove or destroy them

# Contaminated Sites Issues

*PFOS and related compounds have become contaminants of concern at fire training areas across Canada due to their use in Aqueous Film Forming Foams (AFFF) used for fire suppression.*



# 2 An Assessment of Methods for PFOS Decomposition

- This research was conducted by Dr. Scott McIndoe and his team at the University of Victoria

# Results of Literature Review

- In recent years many oxidative, reductive, photolytic, and pyrolytic methods have been assessed for their ability to decompose PFCs
- From the surveyed literature, the most likely candidates for remediation are :
  1. Persulfate oxidation (using thermal, chemical, or UV activation)
  2. Direct photolysis (by 185nm and 254nm UV irradiation)
  3. Photocatalysis using  $\text{TiO}_2$  (with a hole scavenger such as oxalic acid)

# Bench Scale Testing

- The identified destructive processes were focused to a short list of possibilities.
- Most attractive among these processes was persulfate oxidation:
  - Chemically activated persulfate oxidation and zero-valent iron reduction, (potentially in-situ)
  - Thermally activated persulfate oxidation (ex-situ)

# Experimental Design

- The adsorptive tendencies of PFOS were particularly challenging in the experimental design
- PFOS adsorbs strongly to glass and stainless steel, and is absorbed by polytetrafluoroethylene (PTFE), (three of the most common materials used in laboratory equipment)
- Equipment used had to be carefully chosen to minimize the amount of PFOS adsorption and absorption.
- Polypropylene and polyethylene are considered to exhibit minimal PFOS adsorption, so these plastics were used for experimental work.



# Selected Treatments

Tested treatments included:

- Potassium persulfate ( $1 \times 10^5$  mole percent at  $80^\circ\text{C}$ , and  $2 \times 10^6$  mole percent at  $50^\circ\text{C}$ )
- Iron powder ( $1 \times 10^5$  mole percent at  $80^\circ\text{C}$ )
- Iron sulfate and potassium persulfate ( $1 \times 10^5$  mole percent each at both  $50^\circ\text{C}$  and  $20^\circ\text{C}$ )
- A control with no chemical treatment at  $80^\circ\text{C}$

# 3 Conclusions Regarding the Decomposition of PFOS

- The results indicate that neither iron reduction, nor persulfate oxidation are effective in the destruction of PFOS.
- Other non-pyrolytic techniques may be effective but it seem that even powerful oxidative conditions were unsuccessful at breaking down this molecule.
- Observations regarding the propensity of PFOS to appear to disappear on its own (through adsorption) suggests that literature methods conducted in the absence of careful controls need to be treated with some skepticism.
- The results of this study suggest that chemical treatment of PFOS (in-situ or otherwise) using known methods appears difficult.



# 4 Assessment of PFOS Concentration/Extraction

This research was conducted by Dr. Tom Fyles and his team at the University of Victoria.

# Results of Literature Review

The literature review for PFOS Concentration/Extraction technologies considered the following approaches:

- Activated carbon
- Ion-exchange resins
- Reverse osmosis
- Pressure-driven electro dialysis
- Phyto-remediation
- Foam Fractionation

# Charcoal Adsorption

- The majority of reports focus on sorbents such as granular activated charcoal and powdered activated charcoal.
- Can be effective, but the efficiency of recovery appears to fall as the source concentration decreases.

# Ion Exchange Resins

- More efficient sorbent
- PFOS is very effectively bound into the resin
- Requires a mixed solvent / salt wash to remove

# Reverse Osmosis

- PFOS is effectively retained by reverse osmosis membranes
- Flux reduction due to sorption of PFOS and other foulants (e.g., humic substances, natural organic matter)



# Electrodialysis

- A novel pressure-driven electrodialysis-like process has demonstrated effective removal of PFOS from spiked ground water on the lab scale.
- This type of process is potentially low fouling.
- Scale-up potential of the process is not known.

# Phyto-remediation

- Although no record of phytoremediation of PFCs has been found in the literature, several authors have investigated PFC removal from soil by various plants in order to assess human exposure by ingestion of plants grown using contaminated water or soil.

# Foam Fractionation

- Ample physico-chemical evidence to suggest that foam fractionation should be possible
- Has not yet been demonstrated experimentally

# Literature Review Conclusions

- Direct electro dialysis or direct foam fraction of PFOS-containing solutions has not been reported.
- There is good precedent for recovery of low-level surfactants by foam fractionation.

# PFOS Extraction Bench Scale Testing

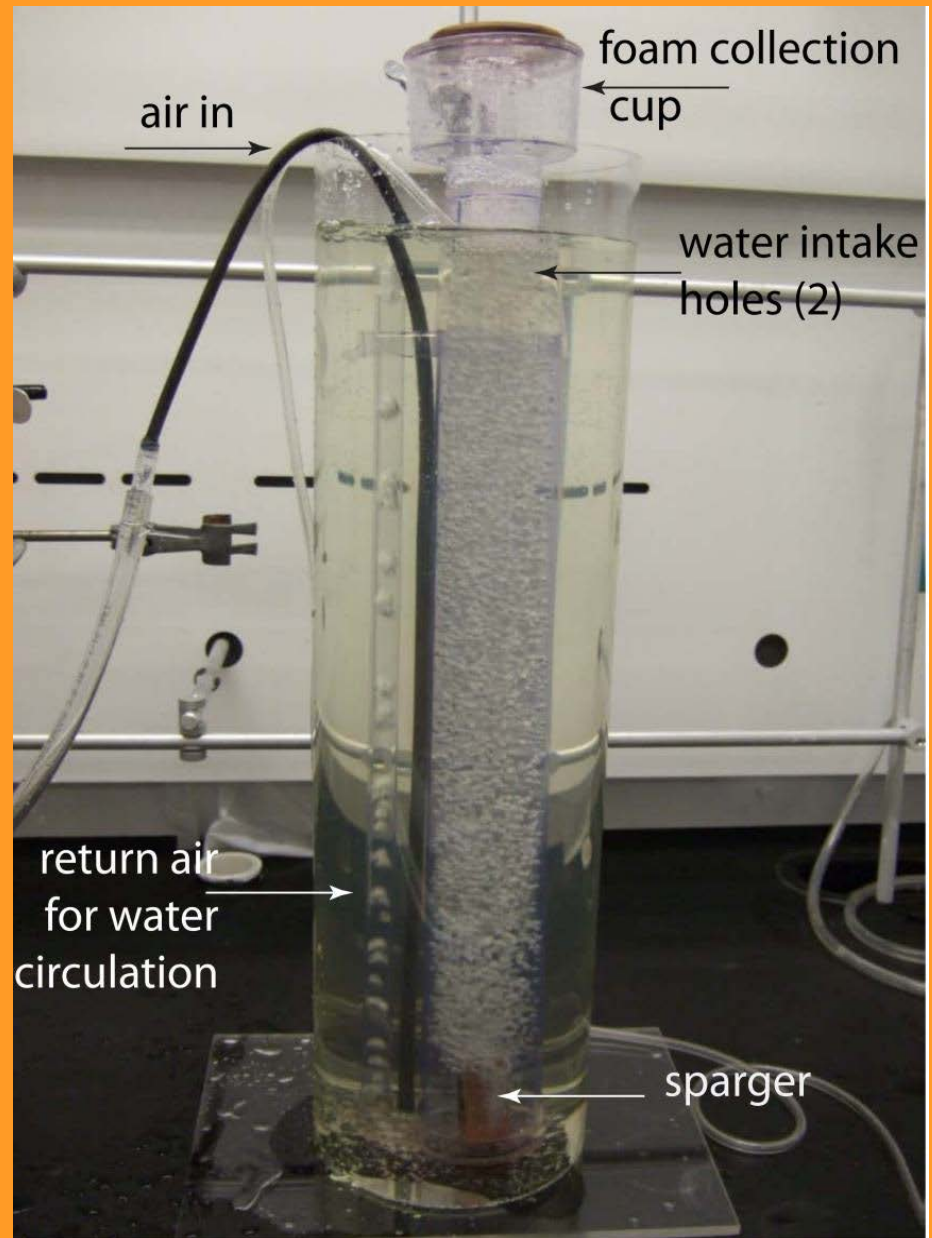
Two extraction technologies were evaluated for the recovery and concentration PFOS from dilute aqueous solution were evaluated.

- Foam Fractionation
- Electrodialysis

# Foam Fractionation

- Achieved concentration factors of 60-70 fold from either PFOS-spiked water
- Extraction is rapid ( $t_{1/2} \sim 3$  minutes)
- The ultimate performance of the extraction could not be assessed

# Foam Fractionation Bench Test Apparatus



# Electrodialysis

- Rapid uptake of PFOS
- No direct through flux of PFOS
- PFOS release from was demonstrated



# 5 Concentration/Extraction Conclusions

- Literature and selected bench scale testing of known PFOS Decomposition technologies indicates a very low probability of field scale success.
- Two potential technologies have been confirmed at a bench scale for PFOS Extraction/Concentration.

# Questions?