

PFAS Foam Waste Management

Principal Advisor Incident Management
Incident Response Unit
Department of Environment and Science



PFAS waste management

Key issues for PFAS waste management

- Regulator requirements for PFAS wastes
- **PFAS cleanout & wastewater issues**
- Waste disposal planning & implementation
- **Inappropriate disposal & liability**
- PFAS destruction difficulties
- **Available destruction technologies**



PFAS foams waste management

PRACTICALITIES

- **PFAS foam concentrates** – Removal of foam from systems, repackaging, storage and disposal.
- **System testing/cleanout** – Generation of large volumes of wastewater for treatment and disposal.
- **Contaminated equipment** – PFAS adsorbed to bladders, pipework, fittings, seals, valves, etc.
- **Specialist waste disposal** – PFAS require specialised handling, transport, treatment and disposal as regulated waste.



PFAS cleanout options

SIMPLE SYSTEMS (Limited size tank and pipework)

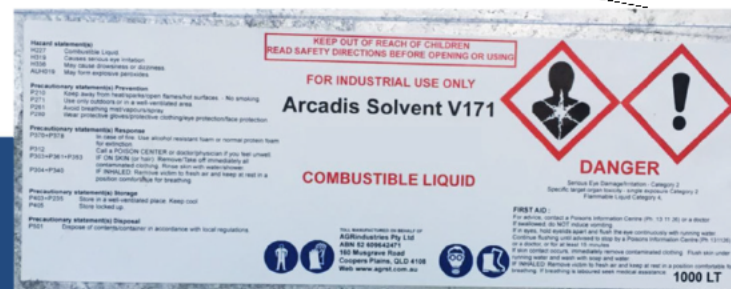
Aggressive detergents, hot water, recirculation and pressure washing.

COMPLEX SYSTEMS (Large fixed systems)

Solvents and/or detergents emulating chemicals used to keep PFAS in suspension in foams.

CO-CONTAMINATED SYSTEMS (e.g., sewers)

Specialised solvent combinations to separate PFAS plus concentration mechanism to minimise waste volumes.



PFAS cleanout problems

ABSORPTION INTO SURFACES

Rubber bladders, seals, stainless steel, rusty steel.

AFFINITY FOR MATERIALS

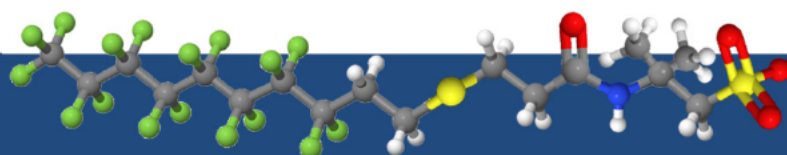
PFAS adsorb to surfaces – later released into new foam.

PRECIPITATES AND SLUDGES

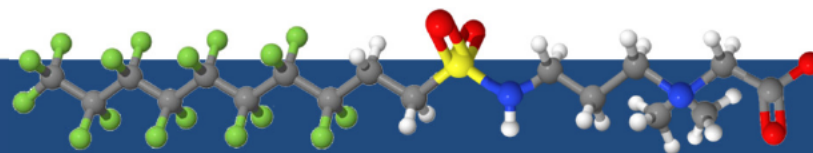
Precipitation in tanks, pipework, valves and fittings.

CO-CONTAMINANTS

Incorporation with other contaminants that bind with PFAS or interfere with removal (e.g., sewage).



8:2FtTAoS



8:2FtTAB

PFAS waste disposal plan

Queensland Policy waste disposal plan advisory:

- **Guides disposal planning** for handling, storage, security, responsibilities, transport and disposal.
- **Staged disposal** allowed for to meet operational and budgetary constraints.

Department of Environment and Science

Environmental Management of Firefighting Foam Policy

Waste disposal plan advisory (Fluorinated organic compounds)

This advisory provides guidance on how to manage the disposal of firefighting foam wastes and the development of a disposal plan for waste fluorinated foam concentrate as required by the Environmental Management of Firefighting Foam Operational Policy

1 BACKGROUND

The *Operational Policy on the Environmental Management of Firefighting Foam* requires that firefighting foam wastes be managed appropriately as regulated wastes as required under the provisions of the *Environmental Protection Act 1994* and *Environmental Protection Regulation 2008* (Schedule 7, organohalogens). Firefighting foam wastes include foam concentrates, firewater and any other wash-waters or wastewaters containing firefighting foam or residues from mobile, fixed or hand-held systems.

PFAS waste disposal plan

Key elements in waste management planning:

- **Waste generator liable** up to the point of final disposal.
- **Foam/waste type and quantities** documented, appropriate containers, labelled and securely stored.
- **Responsible persons** designated to manage wastes, track and document handling and disposal.



PFAS waste disposal plan

Key elements in waste management planning:

- **Identify and budget** for approved and licensed pathways/methods for final destruction (✗**SDS**).
- **Define stages and timeframes** for collection, storage and disposal.
- **Prevent** disposal by “repurposing”, “donation” or “testing”.

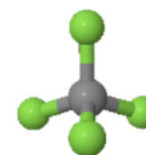


PFAS disposal options

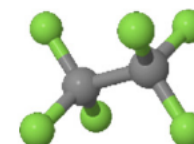
PFAS ARE HIGHLY PROBLEMATIC

- **NOT Sewage treatment plants** – PFAS pass straight through to release.
- **NOT Composting** – PFAS do not biodegrade and are taken up by crops.
- **NOT Landfills** – PFAS outlast the life of the containment and are released.
- **NOT Domestic incineration** – Temperatures are too low for destruction with PFAS releases to air →

NEED TO MANAGE WASTES RESPONSIBLY



Perfluoromethane



Hexafluoroethane

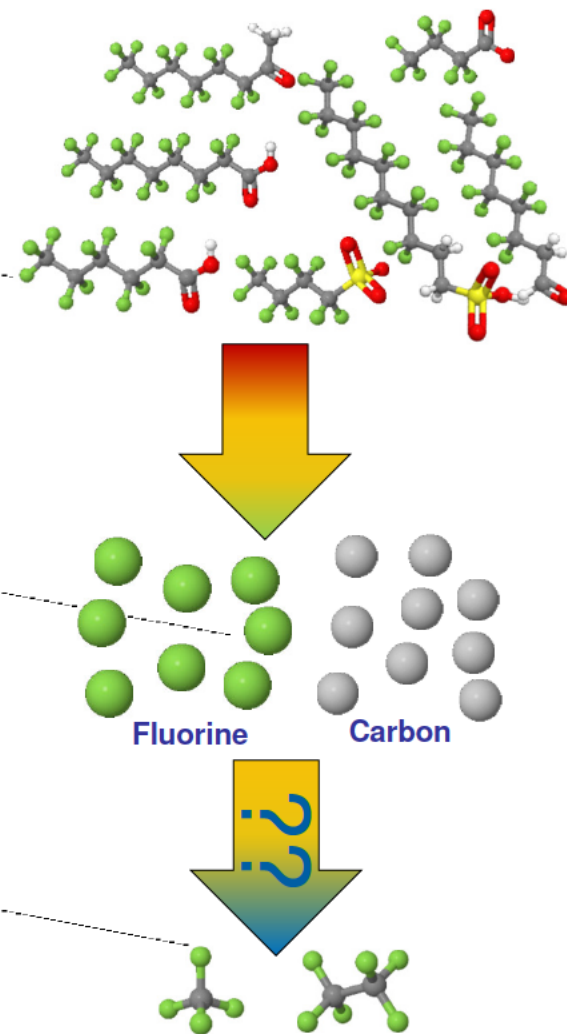
Potent greenhouse gasses

1/2 -life ~50,000y.

PFAS waste destruction

PFAS ARE HIGHLY PROBLEMATIC

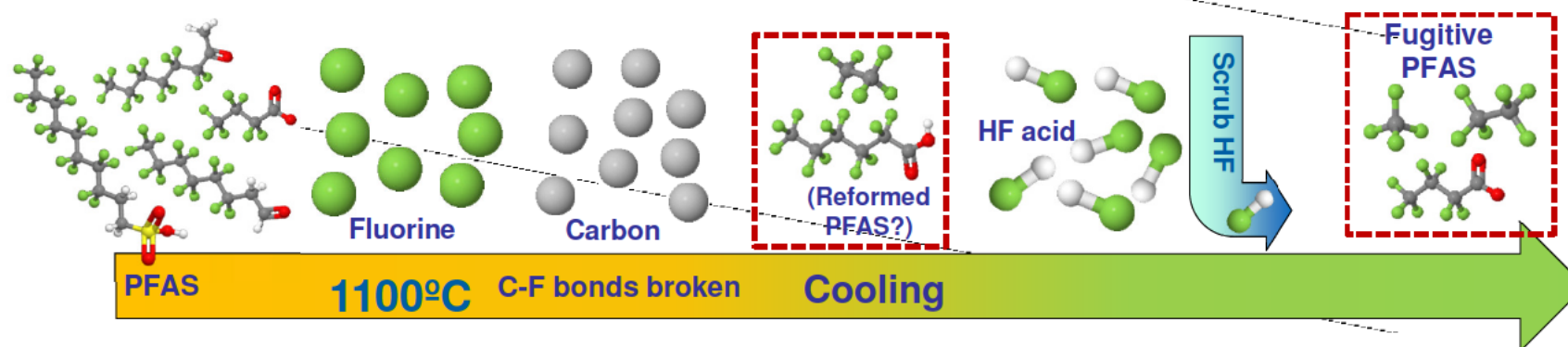
- **High temperatures** to break the carbon-fluorine bonds.
- **Residence time** at high temperature to ensure all C-F bonds are broken.
- **Prevention of reformation** of PFAS from C+F as the gases cool.
- **Capture of fluorine** and convert to inert material (gasses scrubbing and neutralisation).



PFAS waste destruction

Standard High Temperature Incineration (1100 °C)

- Potential release of hydrofluoric acid in flue gasses.
- Potential for C+F to reform PFAS.
- Residual PFAS emitted to air.
- Strict process control required, slow throughput, \$\$\$/€€€/£££ cost (fuel and gasses scrubbing).



Possible fugitive PFAS and HF in flue gases and scrubber wastes

PFAS waste destruction

PFAS destruction catalysed by calcium

- PFAS in isolation decomposes at $\sim 900\text{--}1100^\circ\text{C}$.
- Calcium catalyses PFAS destruction at lower temperatures.
- PFOS decomposes from 350°C with calcium catalyst (e.g. lime).
- Calcium scavenges fluorine to form inert CaF_2 .

ENVIRONMENTAL
Science & Technology

Article

pubsacs.org/est

Effectiveness and Mechanisms of Defluorination of Perfluorinated Alkyl Substances by Calcium Compounds during Waste Thermal Treatment

Fei Wang,^{†,‡} Xingwen Lu,[†] Xiao-yan Li,^{*,†} and Kaimin Shih[†]

[†]Department of Civil Engineering, The University of Hong Kong, Pokfulam, Hong Kong

[‡]School of Environment, Jinan University, Guangzhou, Guangdong 510632, People's Republic of China

 Supporting Information

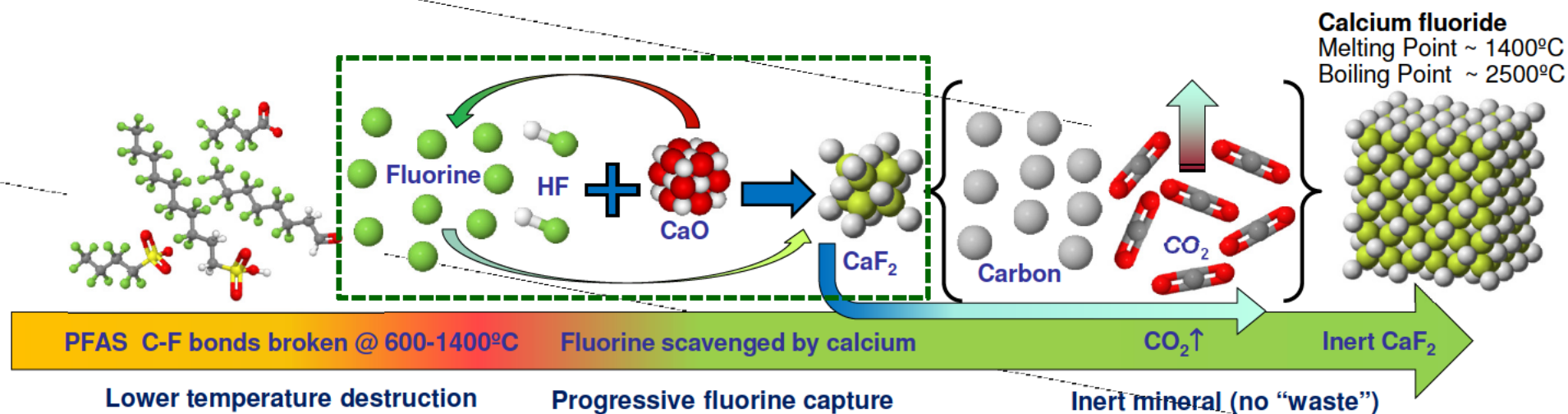
Environ. Sci. Technol. 2015, 49, 5672–5680



PFAS waste destruction

Catalysed Progressive-Capture Destruction

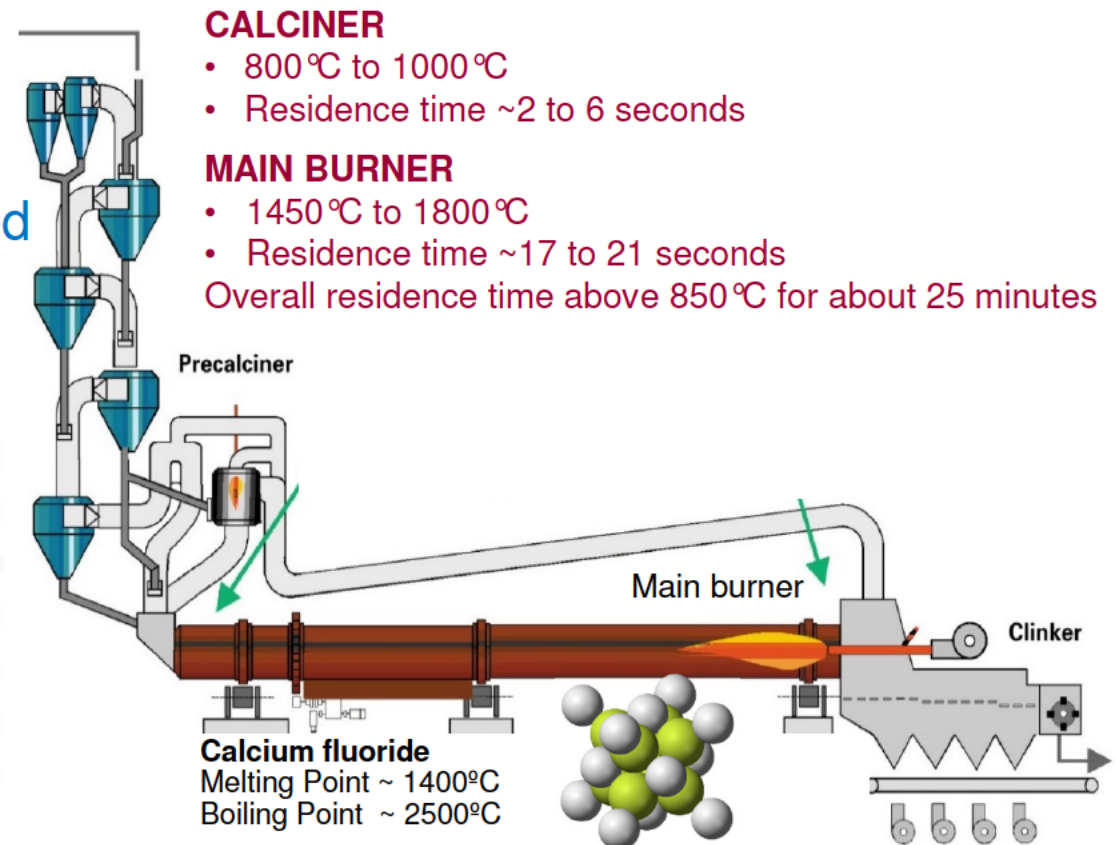
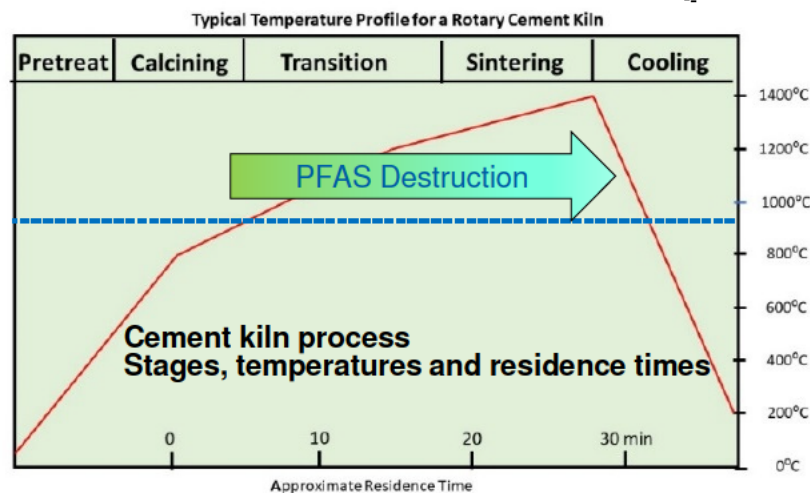
- Calcium catalyses de-fluorination from $\sim 350^\circ\text{C}$ (PFOS).
- Calcium content strips out free fluorine.
- Fluorine captured as inert, insoluble, non-toxic calcium-fluorine minerals.



PFAS waste destruction

Cement kiln suitability

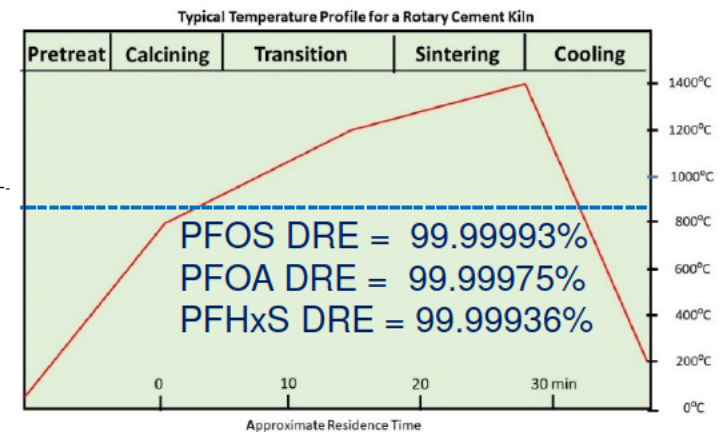
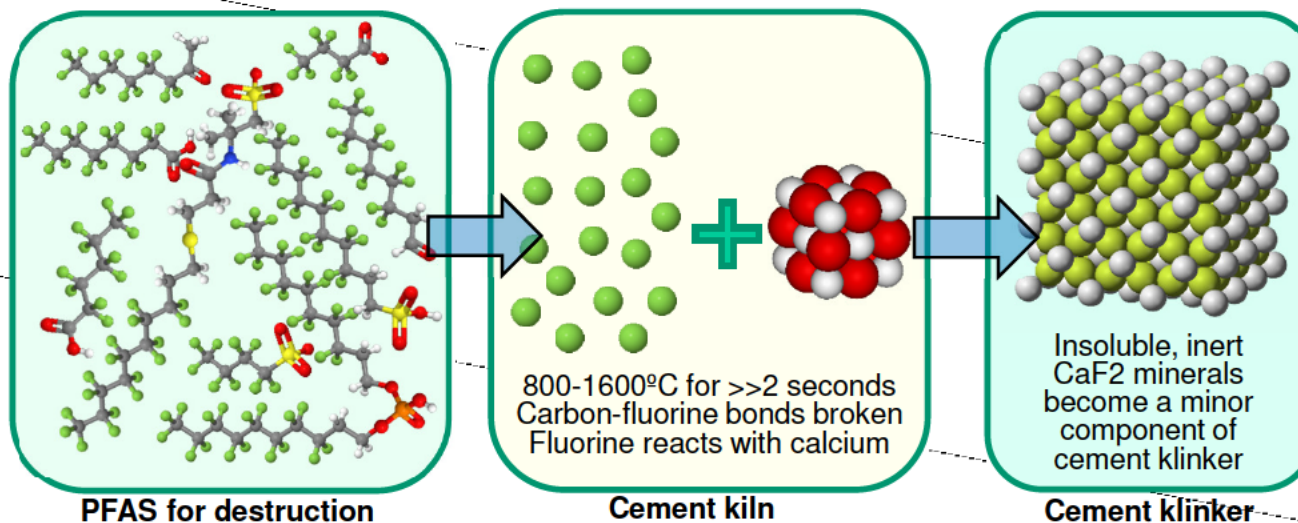
- ✓ High temperatures
- ✓ Very high calcium content
- ✓ Long residence times
- ✓ No additional energy required
- ✓ No ash or waste



PFAS waste destruction

Cement kiln PFAS destruction (calcium catalysed)

- High temperatures, long residence times, fluorine stripping.
- **Quality control of production exceeds destruction control requirements.**
- Cement Australia (Qld) licensed for PFAS destruction since 2018.



Cement kiln process
Stages, temperatures and residence times

Main components of PFAS destruction and fluorine capture by cement kilns

High temperatures – Long residence times – Excess calcium to fluorine ratio

PFAS waste management

- Plan waste management stages, timelines and budgets carefully
- **Standard disposal methods**
 - ☒ Domestic incineration is not suitable.
 - ☒ Biodegradation methods are not suitable.
- **Destruction to inorganic form** is needed to ensure risk is reduced to acceptable levels.
- **Hazmat incinerators** need very strict controls.
- **Calcium catalysed destruction** is currently best practice.

PFAS Foam Waste Management

