Capturing what others overlook-ion exchange removes short-chain PFAS from drinking water and wastewater

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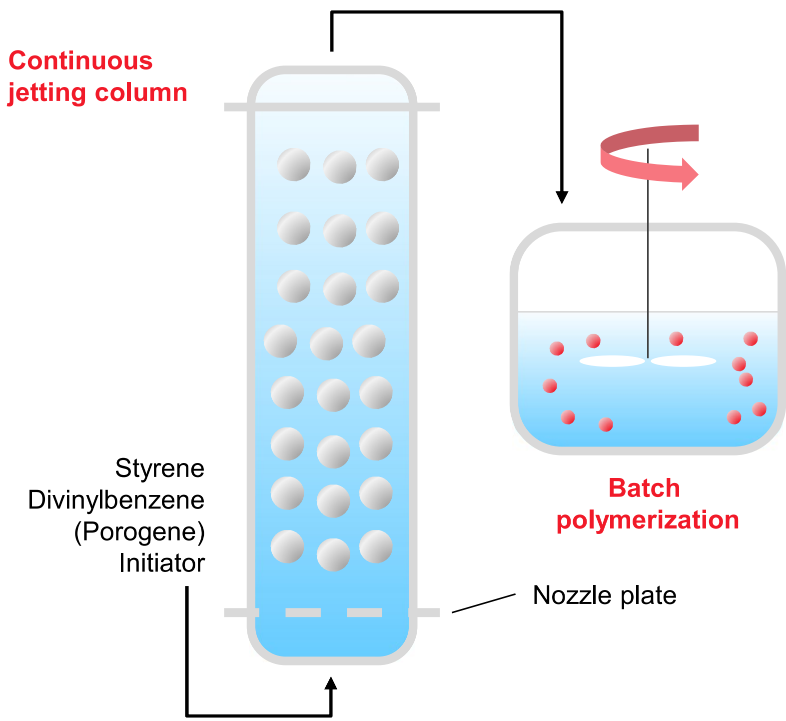
Paris 7th PFAS Conference , Friday June 19th

Monodisperse droplet generation by jetting process

Stable scaffolds for demanding metals processing applications!

Formation of monodisperse droplets



Description

- Continuous process
- Raw materials are fed through a nozzle plate at the bottom of the column
- The resulting monomer jet is chopped into droplets of the same size
- Particle size can be controlled by adjustment of the whole width of the nozzle plate
- The droplets formed at the bottom start to encapsulate as they proceed to the column head
- Polymerization of the monodisperse encapsulated droplets is completed afterwards

Functionality of PFAS Resins

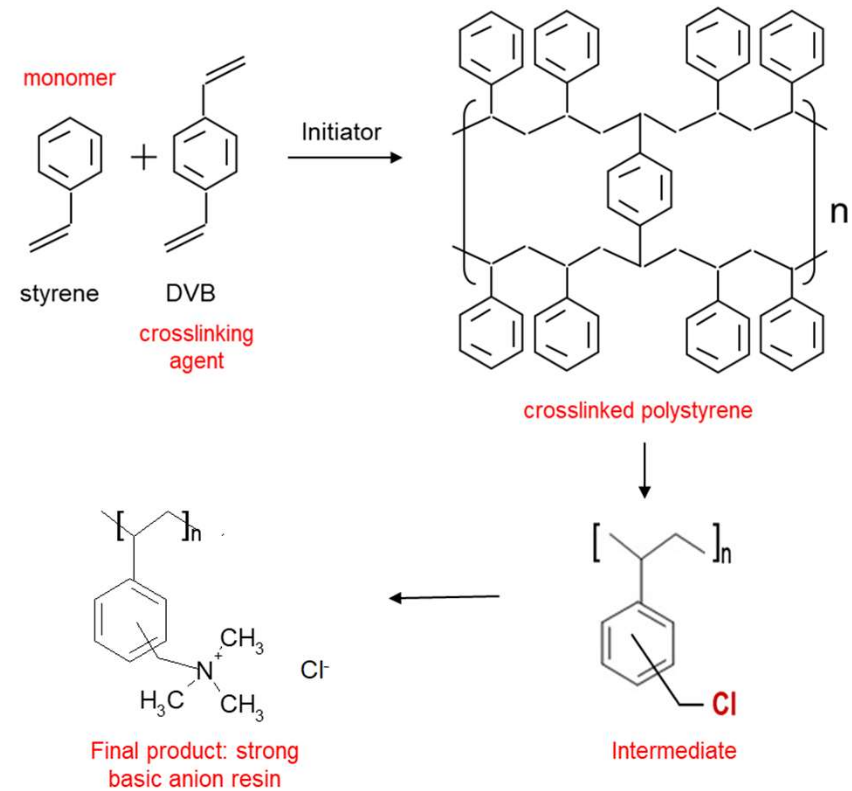
Mechanism

- IX resins for PFAS
  - Strong basic anion resins with a quarternaryamine functional group
  - The alkyl chain in the quarternaryamine functional group could vary:
    - > Trimethyl (C1)
    - > Triethyl (C2)
    - > Tripropyl (C3)
    - > Tributyl (C4)

- **<u>The longer the alkyl chain:</u>**

→ the stronger the hydrophobic bonding

→ the better in capturing PFAS!



General Removal Mechanism PFAS

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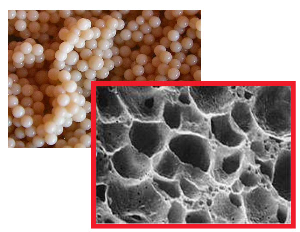
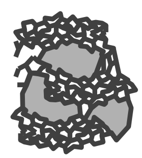
- Resin polymer chain
- Resin crosslinkage
- Fixed positively charged sites of resin
- Exchangeable negatively charged ions of resin

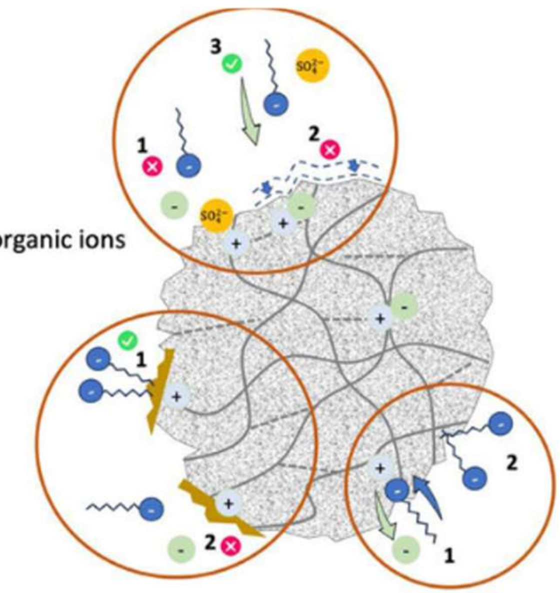
- PFAS
- Organic matter
- Inorganic Matter

Promotive effect

Prohibitive effect







Negative Impact of Organics & Inorganic Ions on Resin Capacity

Interactions of PFAS with anion exchange resins

Strongest interaction between Lewatit® TP 108 DW and long chain PFAS

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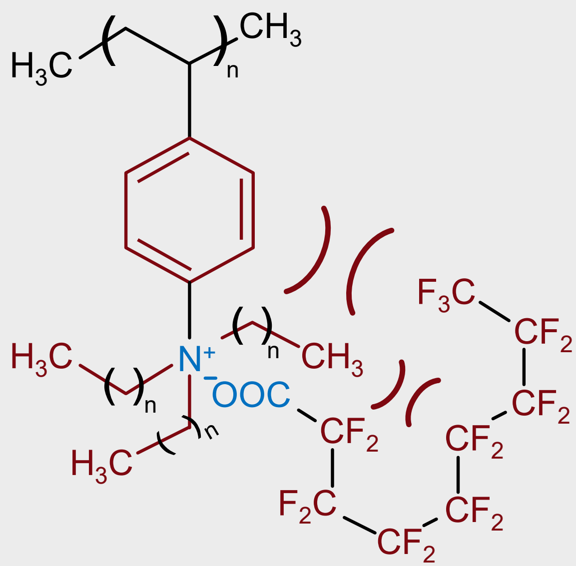
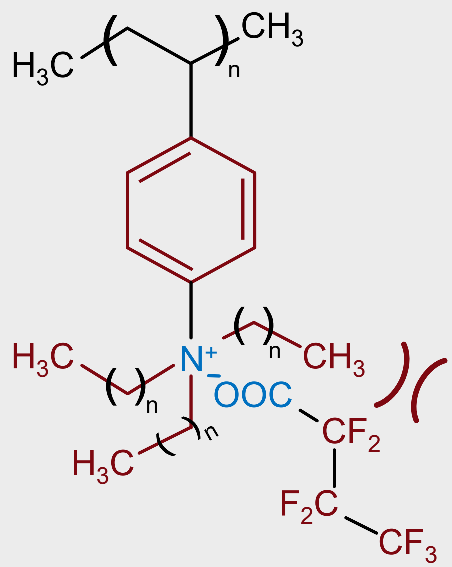
Strong interactions between Lewatit® TP 108 DW and PFNA



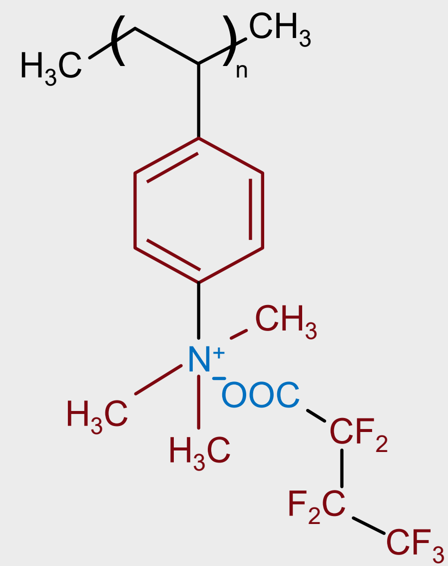
)(Hydrophobic interaction

Medium interactions between Lewatit® TP 108 DW and PFBA



n > 1

Weak interaction between Lewatit® K 6362 and PFBA



Ionic interaction

Selectivity of Ultra Short Chain PFAS

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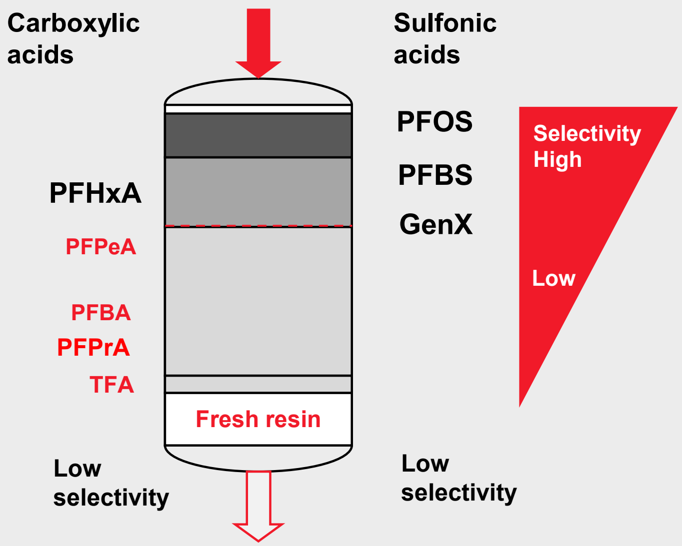
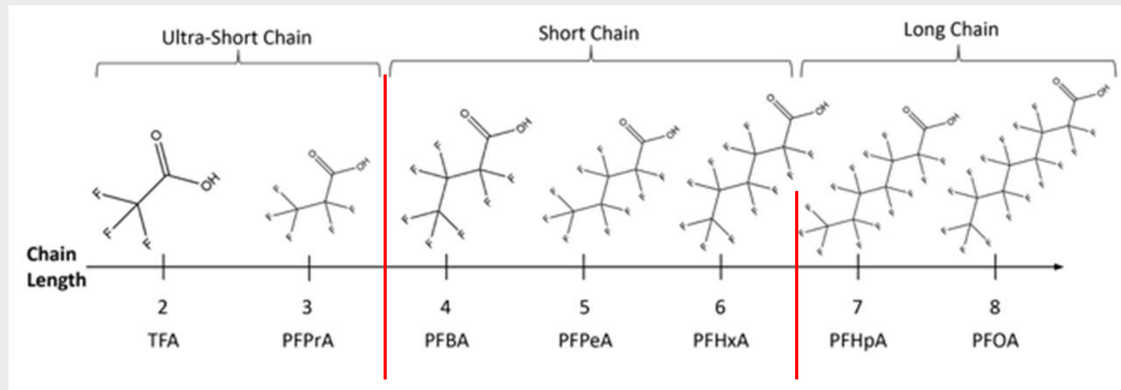
Breakthrough Profile – Carboxylic acids break through first



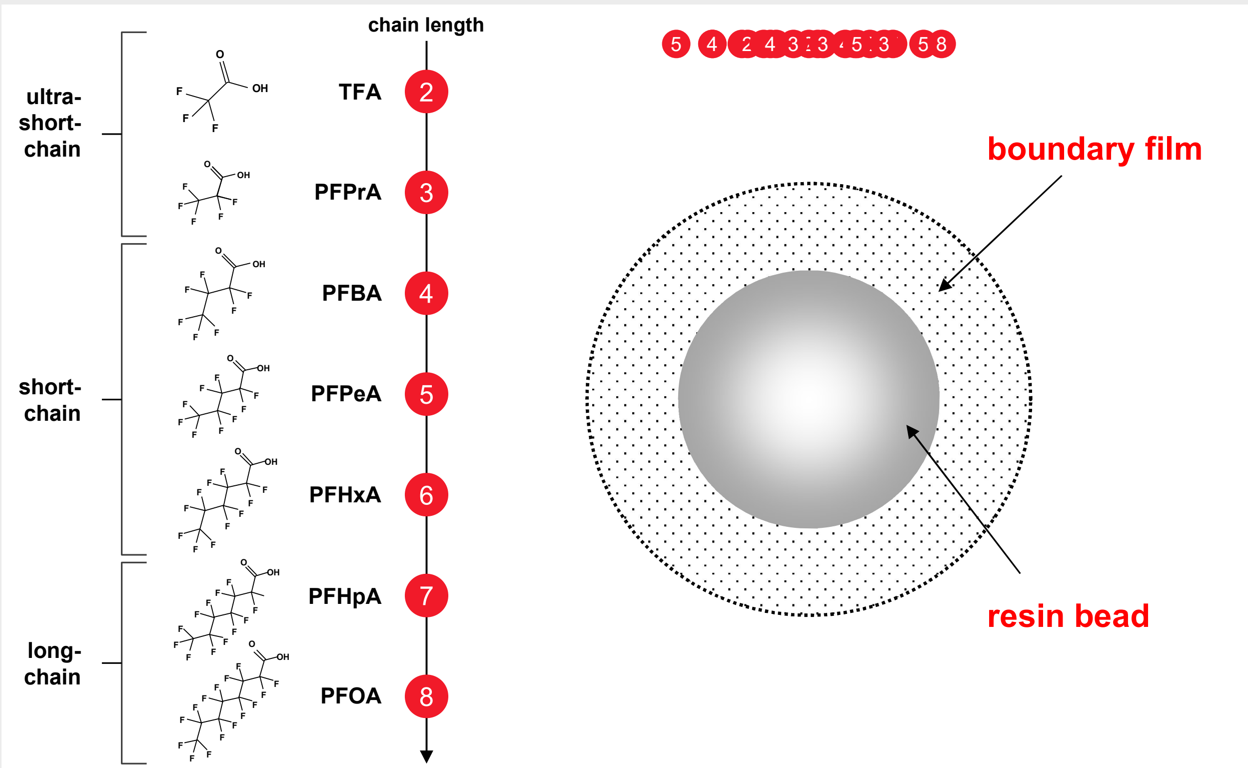


Low capacity	>	Good capacity	>	Very high capacity
Trifluoroacetic acid (TFA) MW = 114 g/mol		**Perfluorobutanoic acid (PFBA)** MW = 214 g/mol		**Perfluoroheptanoic acid (PFHpA)** MW = 364 g/mol

A high-performance ion exchange resin required in order to remove mixture PFAS

Animations on click

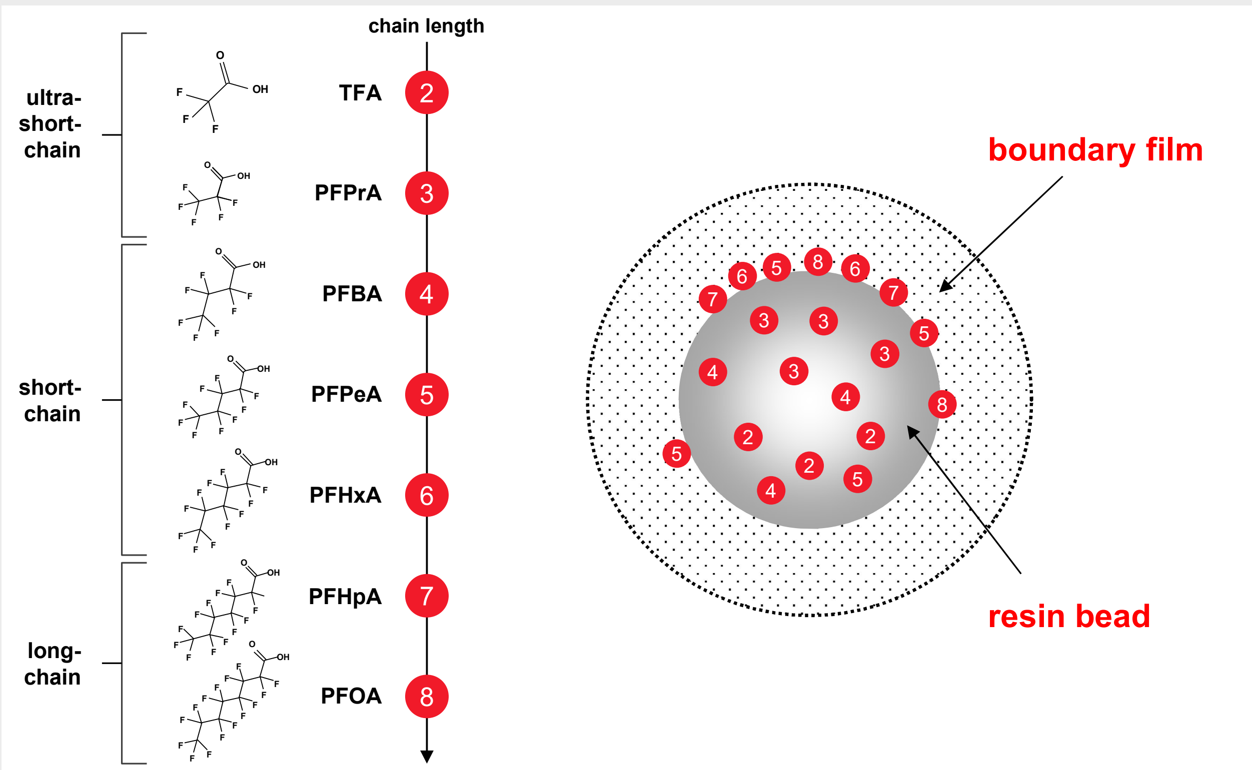
Highest removal capacity for short- and long-chain PFAS with selective Lewatit® ion exchange resins



- For water treatment systems with a variety of different PFAS contaminants our selective ion exchange resin Lewatit® TP 108 DW has best in class removal performance
- Removes ultra-short-chain & short-chain PFAS since the **PFAS is diffusing into the high-capacity resin bead** (C2-C5)
- **Gel type structure allows highest amounts of functional groups** to remove short chain PFAS with longest cycle times
- Our **highly selective functional groups** capture long chain PFAS (C6-C8) on the surface area irreversibly

Static slide for print

Highest removal capacity for short- and long-chain PFAS with selective Lewatit® ion exchange resins



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Required resins and filter arrangements

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Wastewater leachates from hot spots
(PFAS influent: ppm-ppb)

1

Activated carbon removal of natural organic matter

↓

Macroporous regenerable:
Lewatit® MP 62 WS and
Lewatit® MonoPlus TP 109
Regenerable working filter

↓

PFAS selective Lewatit® TP 108 and Lewatit® K 6362 polishing, especially short chain PFAS

↓

Purified water

2

RO unit → Selective Lewatit® TP 108 Polishing

concentrate

↓

Lewatit TP 108 single use or Lewatit® MonoPlus TP 109 Regenerable

Ground water
(PFAS influent: ppt)

Activated carbon removal of natural organic matter

↓

Selective Lewatit® TP 108
Polishing, longest cycle time
lowest leakage

↓

Purified water

Lewatit® TP 108 DW – Surface Water Treatment

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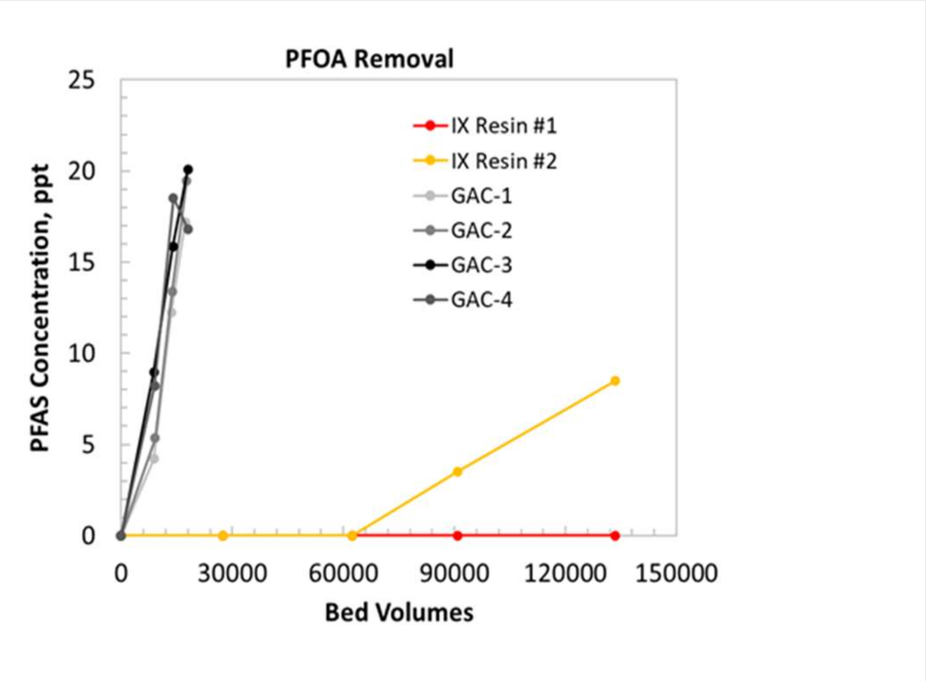
Surface Water Treatment Plant, USA

- 20 BV/Hour;
- EBCT = 3 min
- Average TOC ~ 2 ppm
- **TP 108 DW outperformed competitor's IER**
- **TP 108 DW performs excellent for surface water**
- **TP 108 DW effectively removes both short & long chain PFAS compounds**

Raw Water PFAS Concentration

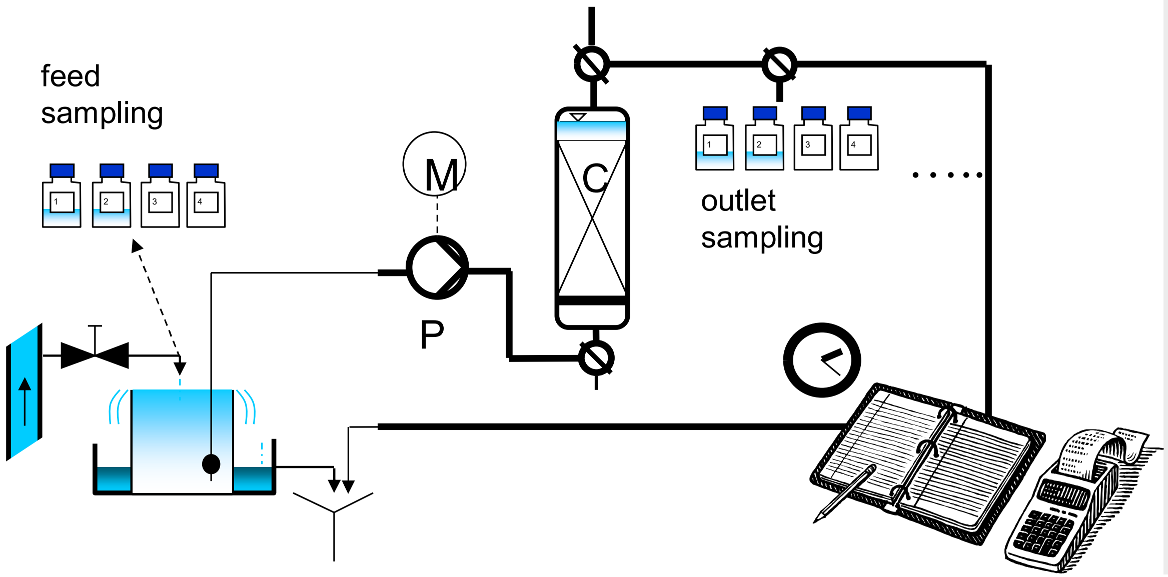
PFOS ppt	PFOA ppt	PFBS ppt	PFHxS ppt	PFNA ppt	GenX ppt	PFHxA ppt	PFHpA ppt
17.3	19.1	5.6	8.6	4.9	33.6	53.1	35.4

PFAS Removal Performance



Pilot testing – Single Resin

Filtration Test Run (3-4 months to see impact of critical impurities)

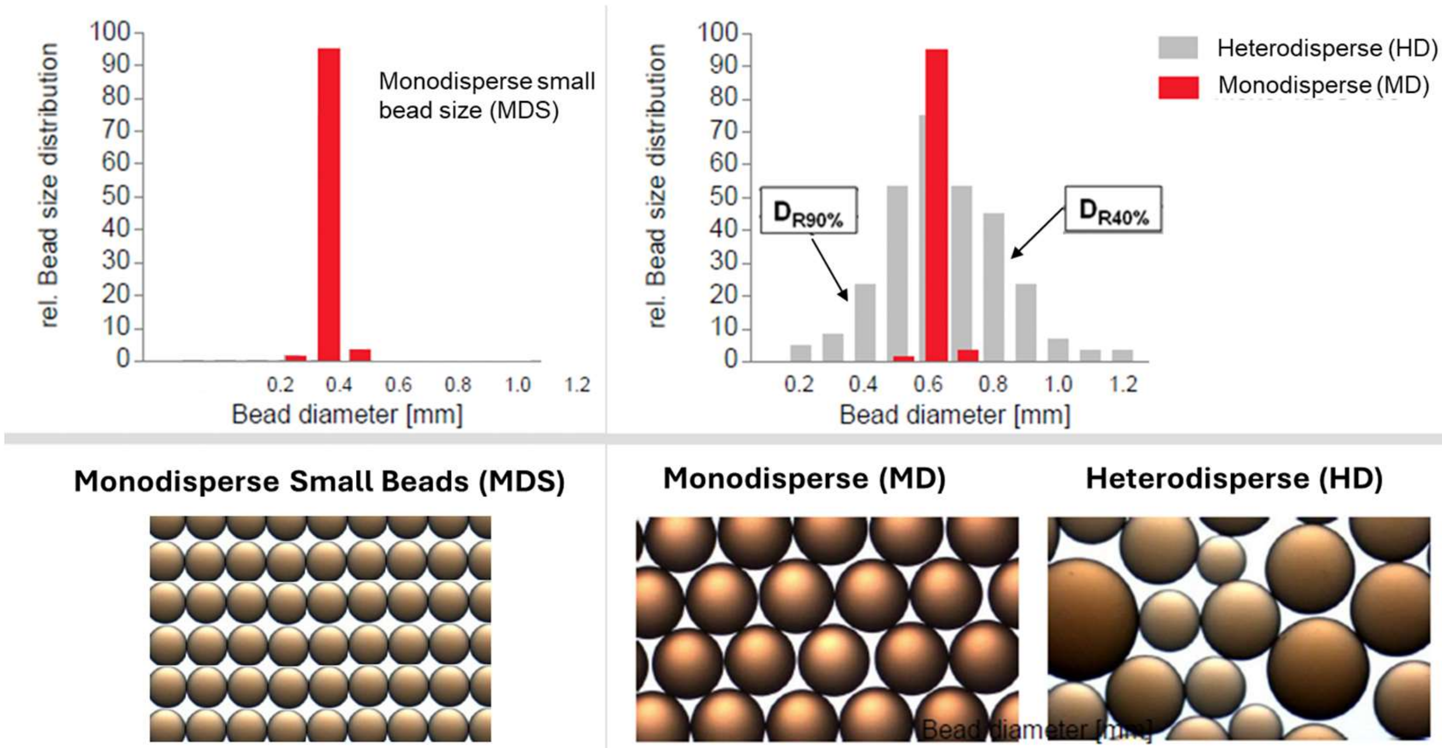


- start the filtration run (20 BV/h)
- take **samples in regular periods** and make notes
- check **flow rate** and readjust flow if required
- check pH in samples for orientation
- **Do you see air bubbles** ? (CO2)
- measure resin bed depth
- check source tank overflow
- check color of resin (did it filter iron out)

Water should be pretreated to simulate real system conditions

Wastewater

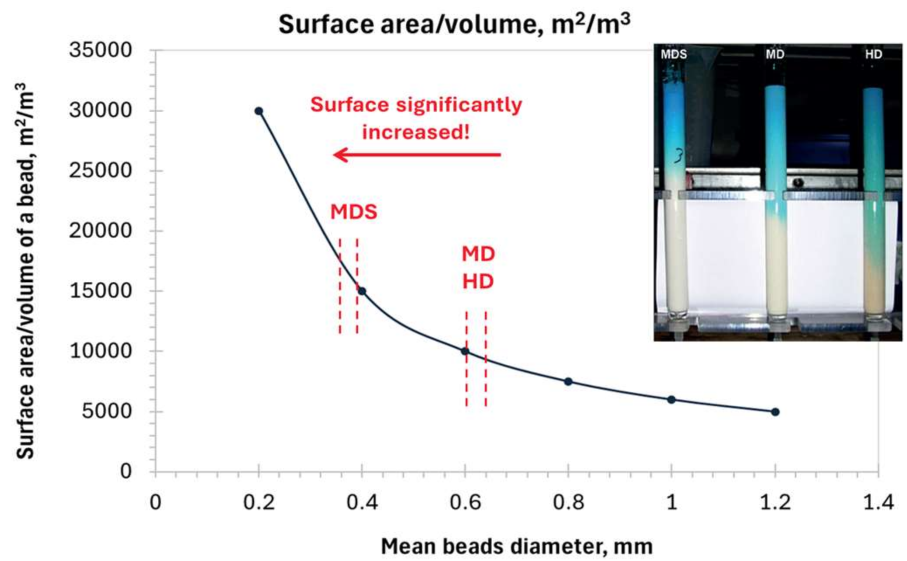
Development of a Novel IX resin-MDS TP 108



Lewatit MDS TP 108

Advantages

- Better kinetics
- Bigger surface area
- Monodisperse
- Higher Capacity

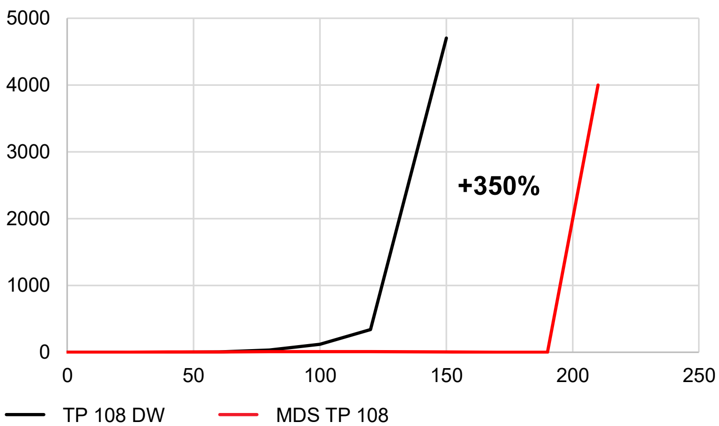


Excellent Results

Ultra Short Chain PFAS selective Resin capacity

New LEWATIT MDS TP 108 better results

PFPrA [ppb]



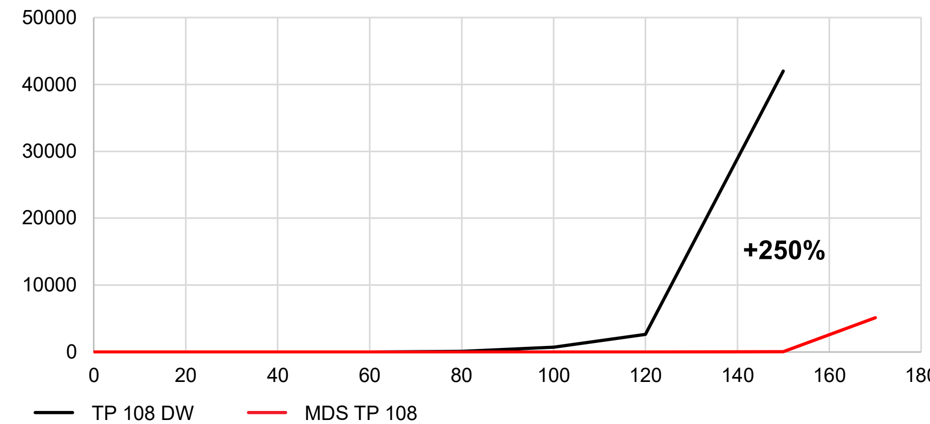
20 BV/h

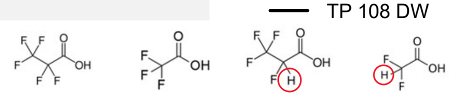
110 ppm DFA,
150 ppm TFPrA
140 ppm TFA
140 ppm PFPrA

194 ppm chloride,
194 ppm sulfate,
97 ppm nitrate
388 ppm HCO3-

Breakthrough colomn tests

TFA [ppb]





PFPrA → TFA → TFPrA

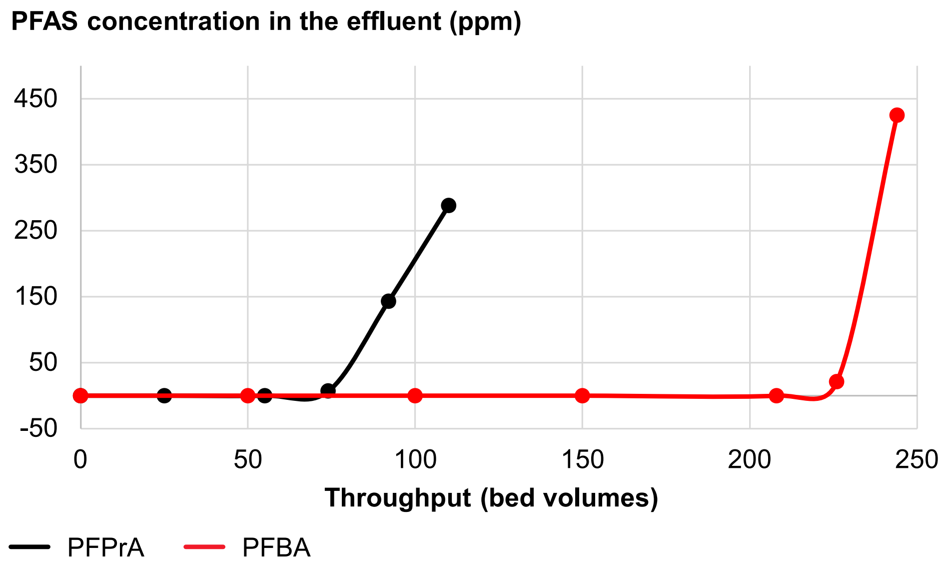
New LEWATIT MDS TP 108 outperforms standard PFAS selective resin

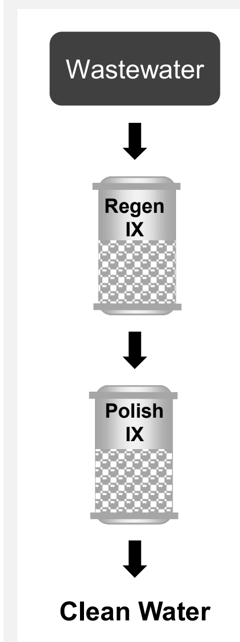
PFPrA[1)] and PFBA[2)] removal from process stream

Lewatit® MP 62 WS outperforms with high loading capacity and efficient regeneration using 4% NaOH

Operating conditions	
applied form	**free base form**
$PFPrA_{feed}$	103 ppm
$PFPrA_{loading\ capacity}$	10.3 g/L
$PFBA_{feed}$	602 ppm
$PFBA_{loading\ capacity}$	145 g/L
Volume	900 L
pH	2
SV	2 BV/h
Reg.	4% NaOH, 3-4 BV
Configuration	merry-go-round

PFPrA and PFBA removal by Lewatit® MP 62 WS





[1] Perfluoropropanoic acid [2] Perfluorobutanoic acid

Reliable and efficient PFAS removal for several years at waste water plant in Germany

USC PFAS removal from process-water at Chemours Netherlands

With Lewatit® MDS TP 108 resin consumption can be reduced more than factor 5!

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Lewatit® MDS TP 108 in Dordrecht

Plant configuration

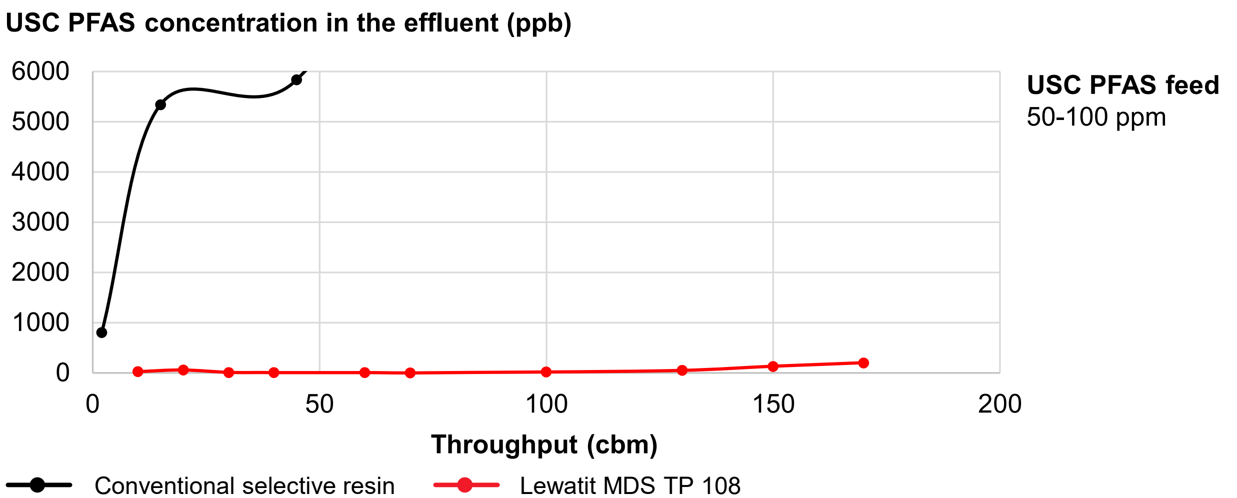
- Concentration by reverse osmosis (RO) followed by activated carbon (AC)
- 2 cbm Lewatit MDS TP 108 per filter
- 3 filters in series: 1st working filter removing most ultra short-chain (USC) PFAS, 2nd and 3rd polisher
- Breakthrough after appr. 75 BV
- Unique composition of process-water. Feasibility for other streams needs to be tested

Innovative Lewatit MDS TP 108 technology leads to improved efficiency in USC PFAS abatement.

USC PFAS removal from process-water at Chemours Netherlands

With Lewatit® MDS TP 108 resin consumption can be reduced more than half!

USC PFAS removal by Lewatit® MDS TP 108



In courtesy to Chemours Netherlands and Logisticon Water Treatment to provide the data and support for successful product innovation

USC PFAS treatment summary

- Lewatit MDS TP 108 has more than 5 times longer lifetime than conventional resins
- Resin- and incineration costs can be reduced
- Reduction of carbon footprint by halfling resin consumption and incineration
- Low plant footprint
- Conventional technologies like adsorption by activated carbon is less efficient for short chain (USC) PFAS

Lewatit® MDS TP 108 reduces USC PFAS > 99 %. Conventional selective resin is less efficient

Lewatit MDS TP 108 outperforms main competitors

Exceptional performance along with consistently high quality!

Unique selling points wastewater

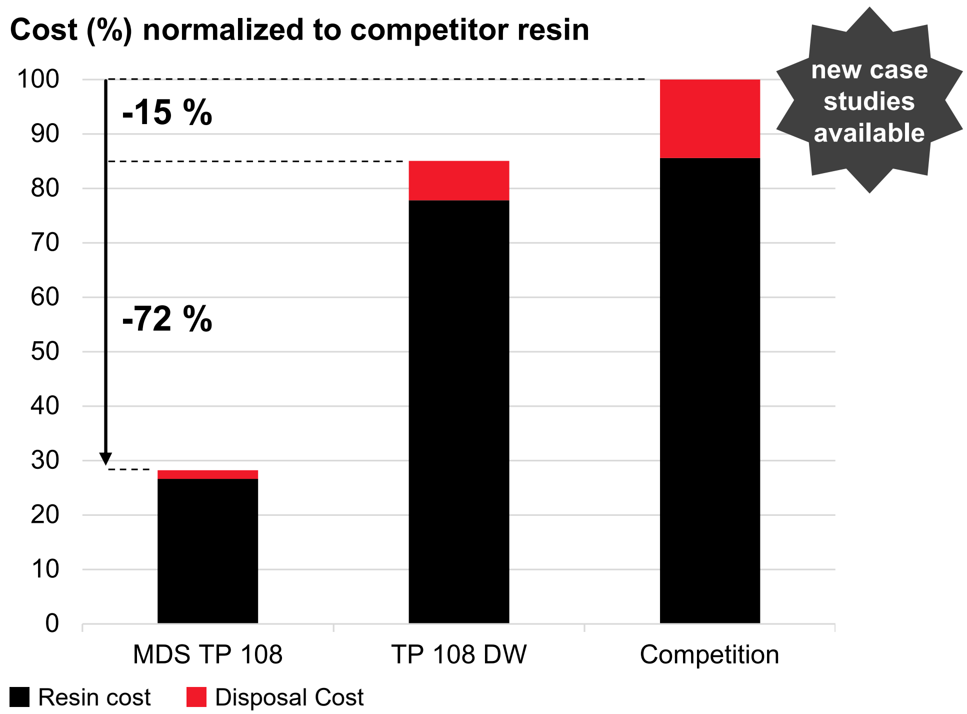
- Lab and plant data at customer site: **Lewatit MDS TP 108 showed 5x longer cycle time** compared to standard PFAS selective resins. (capacity depends on feed composition)
- Cost advantage in high concentration ultrashort chain PFAS feed (very frequent annual change out & disposal)
- **Annual Disposal cost** (incineration) < 80% vs competition

Outlook

- **Exploring ideas** for next generation single use resin for major PFAS producers and DW resin to attack activated carbon
- Pilot tests @ drinking water facilities for capacity evaluation (20 BV/h, 30 BV/h)

Ultrashort chain PFAS wastewater (ppm)

Cost (%) normalized to competitor resin



Overview of LANXESS resins and adsorbers for wastewater applications

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Portfolio of selected LANXESS Lewatit® products

Pollutant		Chelating resin		Strong base anion resin (SBA)		Weak base anion resin (WBA)	Ferric hydroxide adsorber	Polymer adsorber
		MonoPlus TP 207	MonoPlusTP 214	K 6362	TP 108 DW MDS TP 108 MonoPlusTP 109	MP 62 WS	Bayoxide® E IN 20 / E IN 30	VP OC 1064 MD PH
Heavy metals	HM	■						
Mercury	Hg^{2+}		■					
Molybdate, Vanadate	MoO_4^{2-} VO_4^{3-}			■		■		
PFAS					■	■		
Arsenic	AsO_4^{3-}						■	
Phosphate	PO_4^{3-}						■	
Micropollutants								■

Lewatit® PFAS Resins

A versatile product portfolio for critical PFAS separation challenges!

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Lewatit® MDS TP 108 New	▪ **Very high selectivity to PFAS** ▪ Especially effective against short-chains, e.g., TFA types ▪ Not recommended for regeneration ▪ Up to 2 times longer cycle times compared to conventional resins
Lewatit® TP 108 DW NSF 61	▪ **Very high selectivity to PFAS** ▪ Especially effective against short-chains, e.g., PFBA types ▪ Not recommended for regeneration ▪ NSF 61 Certified for drinking water application
Lewatit® MonoPlus TP 109	▪ **High selectivity to PFAS species** ▪ Macroporous structure for improved kinetics, **fouling resistance and easier regeneration** ▪ **Monodisperse resin bead size** for improved hydraulics ▪ Optimum functional group hydrocarbon chain length for balance PFAS removal and regeneration ▪ High regeneration efficiency 70% methanol + 1% NaCl[1]
Lewatit® MP 62 WS	▪ Suitable for highly PFAS-contaminated waters such as point sources or aquifers ▪ Weak Basic Anion, short chains **regenerated NaOH** ▪ A high operating capacity and total capacity (≥1.7 eq/l), ideal as a pretreatment resin

[1] Deng et al. Water Research 2010, 44, 5188

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Energizing Chemistry