

Introduction

Per and Polyfluorinated alkyl Substances (PFAS) have been identified internationally as a serious environmental and human health risk issue of concern. Extremely low permissible safe concentrations have been established by the USEPA, for the specific regulated PFAS including PFOS/PFHxS), at 70 ng/l and for PFOA 560 ng/l, and these have been applied and largely accepted internationally for drinking water.

These PFAS are predominantly associated with soil and groundwater contamination at airports, military airfields, and fire training locations, where PFAS containing fire retardant chemicals have been historically used for decades in fire training. However, there are also situations where surface waters have also been contaminated from industrial runoff and other contamination mechanisms. The use of these PFAS containing chemicals has since been discontinued, however residual PFAS persisting in these locations have leached into soil and groundwater and have become mobilised and are creating environmental and human health exposure concerns.

MIEX resin is currently used worldwide in the treatment of water to remove anionic dissolved organics (DOC), colour and precursors to disinfection by-products. Anion exchange resins have been shown in research to be useful in removal of PFAS, and are commercially supplied for this application, with various manufacturers offering ion exchange resins for this purpose. These resins are used in fixed ion exchange bed configurations, and in many cases not regenerated, as normally applied for conventional ion exchange systems, but are run to exhaustion and then disposed of.

MIEX resin has been evaluated and shown as being capable of efficient removing of over 99% of a range of PFAS and appears to have significant potential as an alternative technology for removal and management of PFAS contamination in groundwater, as well as surface water.

Preliminary research and laboratory scale evaluations undertaken of the use of MIEX resins for removal of PFAS from a contaminated water sample in 2018, proved very encouraging initially with >99% removal of several PFAS species being achieved in early results. (see Fig 1)

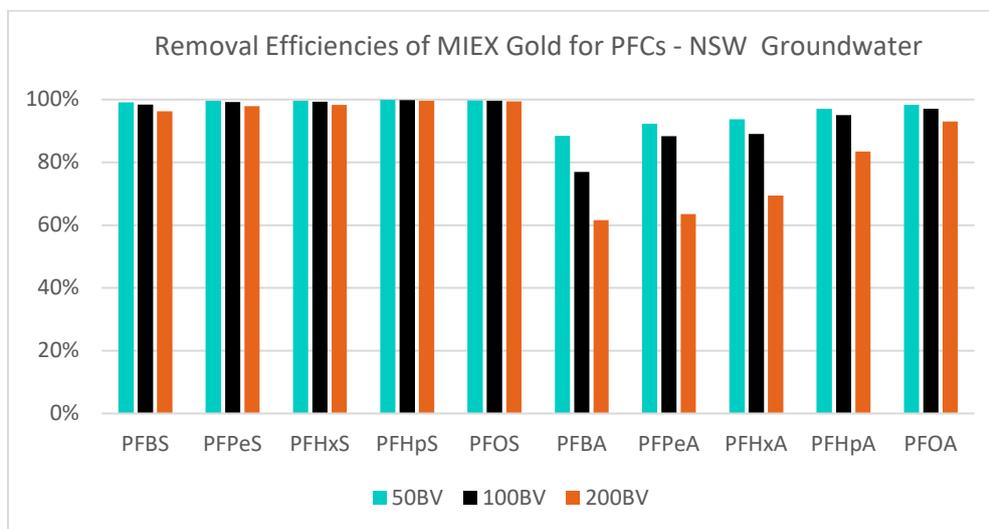


Fig 1. PFAS Removal Efficiencies using MIEX Gold – NSW Groundwater Sample

Research and literature reviews undertaken have indicated that anion exchange resins have been developed and proven as suitable technology and are currently being used already for PFC removal. However, in most cases this is simply run to exhaustion and disposed of as a waste, necessitating stockpiling and/or incineration or other destruction methods to be undertaken for the contaminated resin waste. This is similar to the way in which GAC is used for PFC removal which is one of the already accepted technologies in use.

MIEX technology has several potential technical advantages over fixed bed ion exchange systems currently used:

- MIEX operates in a fluidised bed contactor system, where resin is suspended and mixed with inflow water being treated. This means it is relatively insensitive to suspended solids, which will quickly block a fixed bed ion exchange bed.
- MIEX is a very small bead, typically 160-220 um in diameter so has very high surface area and adsorption kinetics within the fluidised bed contactor.
- MIEX technology continuously regenerates the resin in a side stream unit operation, and can potentially provide unlimited adsorption capacity.

Encouraging results obtained for the preliminary testing undertaken for removal of PFAS from water using MIEX resin has led to a more intensive program of research and investigation of the potential for MIEX to be used as a commercial option for PFAS removal. To further evaluate the effectiveness of MIEX resin in terms of PFAS removal from contaminated water additional work has been conducted with universities who have access to specialised analytical equipment necessary for PFAS analysis. This further work has primarily consisted of:

1. Testing further PFAS contaminated water samples for MIEX removal performance, using standard MIEX jar testing protocols, for various PFAS in contaminated groundwater.
2. Evaluate comparative efficiencies of MIEX resin in relation removal to individual PFAS species.
3. Assess interferences of anionic organics (DOC) and inorganic anionic species on the efficiencies of MIEX removal of PFAS from water.
4. Determine the total PFAS adsorption capacity of MIEX resin.
5. Evaluate regeneration chemistry, capability and efficiencies for MIEX resin.

1. MIEX Removal of PFAS Compounds and Interference Effects

1.1 PFAS Adsorption with MIEX

The primary function of any applicable candidate absorbent is the removal of the PFAS contaminants in the contaminated water and this was evaluated by conducting various laboratory scale adsorption experiments.

For the PFAS adsorption evaluations, initial concentrations of PFAS compounds were established at 1 ppm in the test water. PFAS contaminated water to resin ratio was kept consistent at 50 bed volumes (BV). Methanol washed MIEX resin was mixed with 25 mls of 1 ppm PFAS contaminated water for 30 min at 180 rpm. After 30 min, resins were removed carefully with a rare earth magnet and the treated water was collected for further analysis. Quantitative analysis was performed via mass spectroscopy. Removal efficiency was calculated by using the following equation:

$$\text{Removal efficiency (\%)} = \left(\frac{\text{Initial amount of PFAS compound} - \text{PFAS compound left in Water}}{\text{Initial amount of PFAS compound}} \right) \times 100$$

Furthermore, as MIEX resin and technology was initially developed for dissolved organic compounds (DOC) initial assessment of potential interference of the presence of DOC on PFAS removal was also undertaken. Tannic Acid (TA) and Humic Acid (HA) were selected as common DOC components found in natural waters, and a total of 1 ppm was spiked into PFAS spiked water samples to examine the potential for interference of these typical DOC species on the removal of PFAS by MIEX resin.

1.2 Removal of PFAS Compounds with MIEX and Organics Interference

Removal efficiency of the MIEX resin was initially studied against six different PFAS compounds which included: Perfluorobutanoic acid (PFBA), Perfluorobutanesulfonic acid (PFBS), Perfluorohexanoic acid (PFOA), Perfluorohexanesulfonic acid (PFHxS), Perfluorooctanoic acid (PFOA), and Perfluorooctanesulphonic acid (PFOS).

PFAS Compound	Removal Efficiency (%) no interference	Std (+/-)	Removal Efficiency (%) with 1 ppm Humic and Tannic	Std (+/-)
PFBA	99.21	0.12	99.66	0.02
PFBS	99.82	0.01	99.85	0.03
PFHxA	99.65	0.001	99.78	0.04
PFHxS	>99.99	0	99.94	0.064
PFOA	100	0	>99.99	0
PFOS	>99.99	0	99.94	0

Table 1.1 Removal Efficiencies of PFAS with and without low level Organics Interference

Overall these test results indicated that virtually 100% removal of PFOA, PFOS, and PFHxS was achieved with no DOC in the water. While 99.2%, 99.8%, and 99.7% removal of PFBA, PFBS and PFHxA was achieved also with no DOC present. Comparisons of removals with 1 ppm DOC present did not suggest any significant interference on removal capacity within experimental and analytical errors. (Table 1.1). This is consistent with earlier results obtained for the NSW groundwater samples tested.

These results also suggest that the sulfonic acid group containing PFAS compounds may have more affinity towards the MIEX resin when compared to carboxylic acid group containing PFAS compounds. Higher removals of PFHxS and PFBS were evident when compared to PFHxA and PFBA respectively. Also the longer chain (PFOA has eight carbon atoms) PFAS compounds also appear to have greater affinity for MIEX resin compared to shorter chain (PFBA has a four carbon chain and PFHxA has a six carbon chain structure).

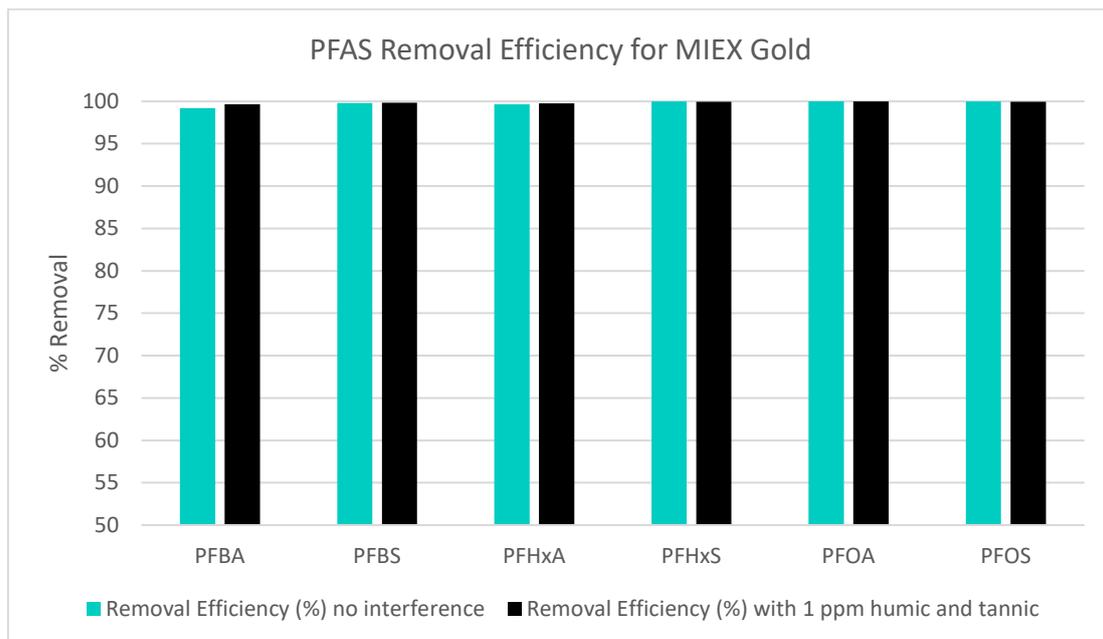
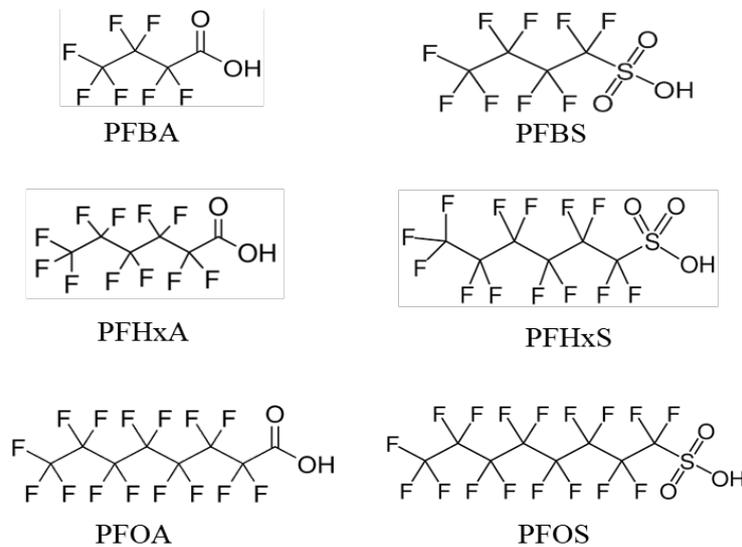


Figure 1.1: Removal Efficiency of MIEX Resin for PFBA, PFBS, PFHxA, PFHxS, PFOA and PFOS

1.3 Further Assessment of Organic and Inorganic Interferences on PFAS Adsorption

Removal efficiencies and interferences of organics and inorganic species for MIEX resin were further assessed for three selected PFAS compounds - Perfluorohexanesulfonic acid (PFHxS), Perfluorooctanoic acid (PFOA), and Perfluorooctanesulphonic acid (PFOS), which are the currently USEPA and NEPM regulated species in Australia. Nitrate and sulphate anions were selected to assess the interference of inorganic matter on the removal of PFAS compounds by MIEX resin. Tannic Acid (TA) and Humic Acid (HA) were chosen to assess the interference of dissolved organic matter (DOC) on removal of PFAS compounds by MIEX resin.

Experimental conditions were kept consistent and a higher levels of DOC used at a 10 ppm concentration, which is a level more typically seen in raw waters. This was done by adding Humic and Tannic acid in equal proportions resulting in each sample of tested water contained 1 ppm PFAS compound (either PFOS, PFOA or PFHxS) and additionally 10 ppm as DOC (as a 5 ppm Tannic Acid and 5 ppm Humic Acid mixture).

Interference of inorganic matter was also assessed following similar test protocols where PFAS concentration was kept at 1 ppm and a total concentrations of inorganics was added to 25 ppm (5 ppm nitrate, and 20 ppm sulphate), simulating typical inorganics levels in raw waters.

Furthermore, interference effects were also evaluated using very high concentrations of organics and inorganics by following the same protocol with PFAS concentrations at 1 ppm. Interference was assessed by using concentrations of DOC at 100 ppm (50 ppm Humic Acid plus 50 ppm Tannic Acid), and a total concentration of inorganics at 500 ppm (250 ppm Sulphate plus 250 ppm Nitrate)*.

PFAS Compound	Removal efficiency (%) no interference	Std (±)	Removal efficiency (%) with sulphates and nitrates - 25 ppm	Std (±)	Removal efficiency (%) with humic and tannic acid - 10 ppm	Std (±)	Removal efficiency (%) with inorganic and DOC (*high conc)
PFHxS	100	0	99.88	0.09	99.82	0.02	91
PFOA	99.91	0.04	99.50	0.09	99.79	0.01	67.42
PFOS	100	0	98.40	1.0	99.94	0.9	94.35

*N.B. High interference data is based on commercial lab analysis.

Table 1.3 Removal of PFAS compound with and without Organics and Inorganics

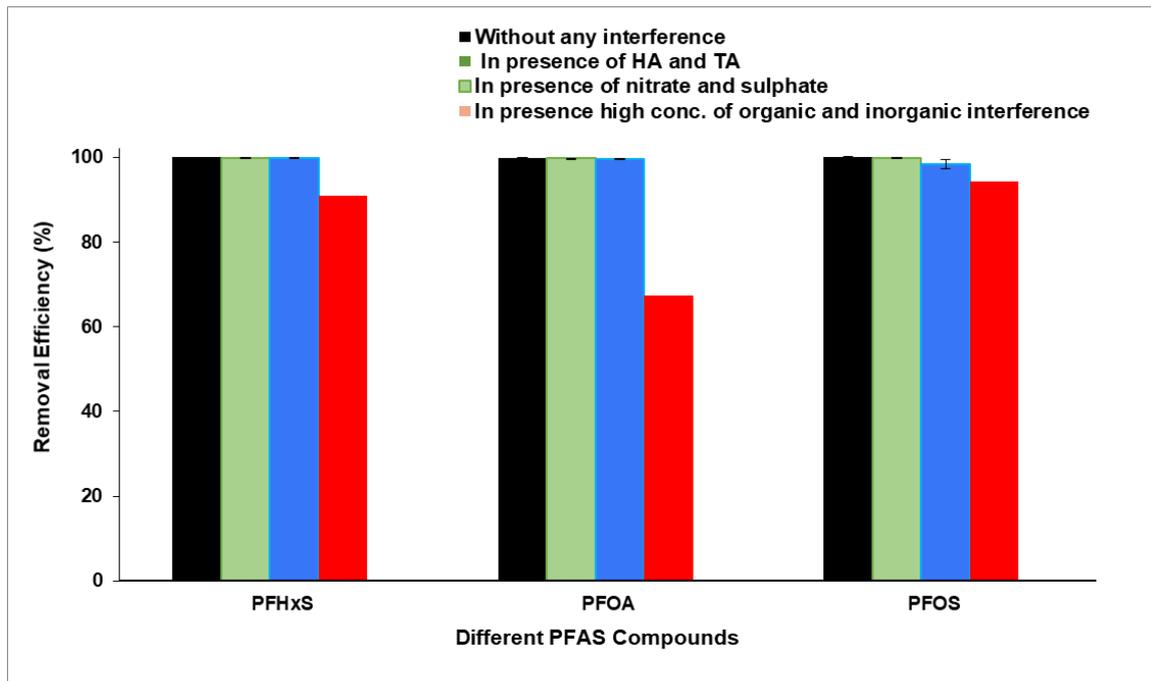


Figure 1.3 Interference of Inorganic and Organics in PFAS Removal by MIEX

The presence of DOC at a total of 10 ppm (5 ppm tannic acid, and 5 ppm humic acid) and inorganic matter at 25 ppm (5 ppm nitrate, and 20 ppm sulphate) did not suggest significant interferences on removal of PFAS compounds using MIEX resin. Removal efficiency was also examined at extremely high concentrations of DOC and (50 ppm tannic acid, and 50 ppm humic acid, totalling 100ppm) and inorganic matter (i.e. 250 ppm nitrate and 250 ppm sulphate, totalling 500 ppm). A significant decrease in the removal efficiency was evident at these high levels of DOC, sulphate and nitrate. Removal achieved were 67%, 94%, and 91% removal of PFOA, PFOS, and PFHxS respectively were observed in the presence of 100 ppm DOC and a 500 ppm sulphate and nitrate mix.

Overall it appears there is negligible interference of DOC or inorganics in the form of nitrate and sulphate, on PFAS adsorption onto MIEX resin at lower concentrations which are considered typical and more likely found in various natural waters. However, at higher and more extreme concentrations of DOC and inorganics, we do see significant interferences, and more so with carboxylic PFAS. This may be more of a problem if treating wastewaters and effluents which may have high organics and inorganics levels.

As has been seen in previous results the sulfonic acid group containing PFAS compounds generally show more affinity towards adsorption onto MIEX resin, and hence shows less interference, when compared to the carboxylic acid group containing PFAS compounds. This is evident as seen in the higher removals still achieved of PFHxS and PFOS compared to PFOA respectively.

However, the PFAS removal results using MIEX continue to be very encouraging, particularly for the sulphonic acid and longer chain PFAS species, with removal interferences seen only in waters with unusually high DOC or inorganic loads. Each candidate water would need to be fully assessed and removals characterised when MIEX was intended for use as a removal technology.

2. Regeneration Evaluation of PFAS Loaded MIEX Resin

Following use of MIEX to remove PFAS from water, the loaded MIEX resin needs to be able to be effectively regenerated to provide a technically viable, highly efficient and cost effective technology for sustainable PFAS removal from water. One of the key benefits that an ion exchange process offers in normal applications is the ability of the resin to be recycled by being regenerated for ongoing reuse for ion exchange and potentially also for PFAS removal.

MIEX resin used for DOC removal is typically regenerated using a saturated brine (NaCl) solution, however this has been shown as not effective regeneration chemistry to remove PFAS from the resin. The adsorption mechanism of PFAS has been proposed as a combination of both ion exchange and organic chain adsorption onto the resin matrix, requiring both ionic exchange and solvent desorption to occur simultaneously for effective regeneration. Research reviewed to date has suggested mixtures of approximately 70% alcohol solution and sodium chloride have proven effective for other commercially available ion exchange resins used for PFAS removal.

These studies (see Fig 2. below) have suggested very high regenerations efficiencies approaching 100% are feasible for PFOS and PFOA. However, this needs to be evaluated for MIEX as an acrylic resin, as much of this work was using Styrene based resins, and also for multiple PFAS species. Adopting this type of chemistry, review and evaluation of MIEX resin regeneration options, chemistry and efficiency was undertaken to assess the feasibility of regeneration of MIEX resin in support of it being an effective technology for PFAS removal.

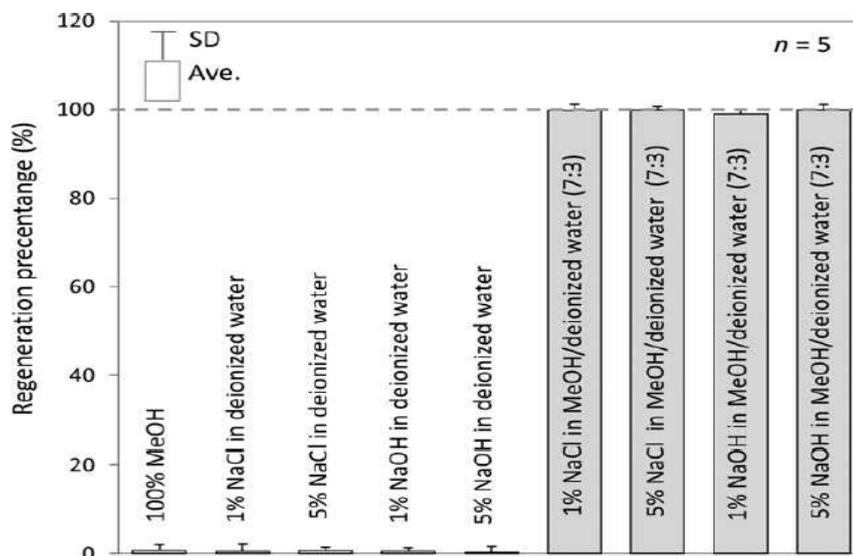


Figure 2. Regeneration percentage of PFA300 by different regeneration solutions after 48 h.

**Extracted from Chularuagaksorn 2013 – Journal of Polymer Science*

Regeneration efficiencies or PFAS desorption from MIEX resin was initially studied for only PFOA and PFBA, and used UV spectroscopy for quantification. PFOA and PFBA were loaded onto MIEX resin using initial concentrations of the PFAS compounds of 100 ppm. The PFAS adsorbed resins were collected carefully and used for the regeneration evaluations. Then 0.5 ml PFOA or PFBA adsorbed resin was added into 3 times the volume of regenerant and mixed for 1 hour at 180 rpm (i.e. 1.5 ml regenerant used for 0.5 mL PFAS loaded resin that provided 3 BV). Then resin was separated carefully and this step was repeated for 2 more times with fresh regenerant. Finally, 1 BV regenerant (0.5 ml) was added to the resin and mixed for 1 hour. All regenerants were collected at the end of each cycle and combined together (i.e. total 10 BV). This combined solution was analysed via UV Spectroscopy for quantitative analysis. Regeneration efficiency of resin was calculated by quantifying the percentage of desorbed PFAS compound from resin with following equation.

$$\text{Regeneration (\%)} = \left(\frac{\text{Total adsorbed PFAS in resin} - \text{total desorbed PFAS in regenerant}}{\text{Total adsorbed PFAS in resin}} \right) \times 100$$

Four different regenerant chemistries were used for each PFAS compound, namely:

- (i) 60% methanol with saturated NaCl,
- (ii) 60% methanol with saturated NH₄Cl,
- (iii) 60% methanol with 0.0012% NaOH (pH 9.8), and
- (iv) 60% ethanol with saturated NaCl.

Regeneration of MIEX resin to remove PFBA and PFOA adsorbed resin was undertaken by using four different regenerant chemistries as described.

Regenerant Chemistry	Desorption (%) of PFBA	Std.	Desorption of PFOA (%)	Std.
60% MtOH with saturated NaCl	102.0	15.1	84.9	14.3
60% EtOH with saturated NaCl	74.0	9.8	42.1	2.6
60% MtOH with saturated NH ₄ Cl	91.9	5.0	68.1	15.9
60% MtOH with 0.001% NaOH	Undetectable		Undetectable	

Table 2.1 Regeneration Efficiency for MIEX Resin with Different Regenerants (PFBA and PFOA)

Of the four differing regenerant options used approximately 100% and 85% desorption of PFBA and PFOA respectively was estimated using 60% methanol (MtOH) with saturated NaCl, and appeared the most effective of the regenerants tested. The 60% methanol (MtOH) with saturated NH₄Cl regenerant achieved approximately 92% and 68% desorption of PFBA and PFOA respectively and suggests that the NaCl:methanol mixture seems to provide better regeneration efficiencies of the MIEX resin compared to the NH₄Cl:methanol mixture.

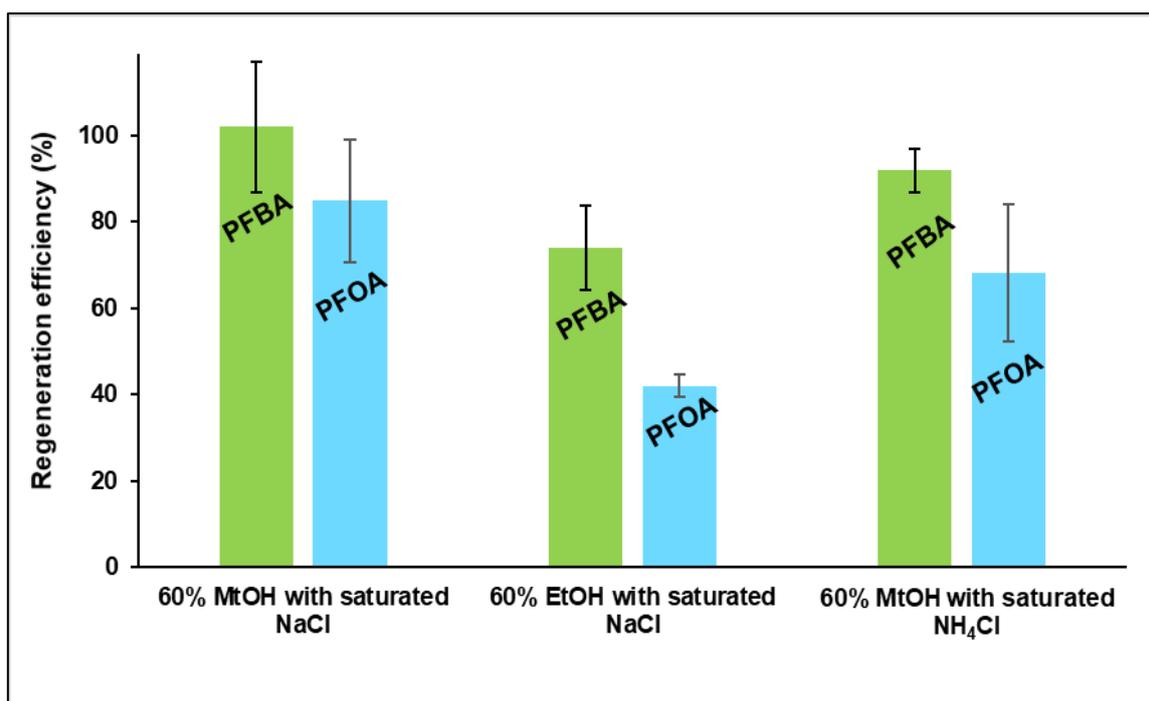


Figure 2.1 Regeneration Efficiency of MIEX resin with Different Regenerants (PFBA and PFOA)

Regeneration of MIEX resin was also evaluated using a 60% ethanol (EtOH) saturated NaCl mixture. This chemistry achieved approximately 74% and 42% desorption of PFBA and PFOA, respectively. This suggests that a methanol and salt mixture is more efficient than the ethanol salt combination in the regeneration of PFAS adsorbed resin.

An alkaline chemistry using 60% methanol (MtOH) with 0.001% NaOH was also evaluated at a pH of 9.8 however no significant desorption of PFBA and PFOA was achieved. The low ionic strength of this particular regenerant combination may be the reason for the low regeneration, as the previous overseas studies show that methanol alone does not regenerate the resin. A pH adjusted saturated methanolic brine is a potential candidate for future investigation.

Based on these initial results the 60% MtOH with saturated NaCl was identified as the best regenerant of those tested.

Regeneration of resin was then further evaluated for PFOA, PFOS, and PFHxS loaded MIEX resin and using LCMS analysis for more accurate quantification of results. PFOA, PFOS, and PFHxS were similarly loaded onto MIEX resin following similar protocols as used previously. Resin with PFAS adsorbed onto it was collected and used for the regeneration or desorption testing. A volume of 0.5 mL resin was added to an equivalent to 3 BV of regenerant solution (methanol 70:30 saturated NaCl mixture) and mixed for 1 hour at 180 rpm (1.5 mL regenerant used for 0.5 mL PFAS loaded resin to provide 3 BV regeneration volume). Treated resin was then separated and this step was repeated for 2 more times with fresh regenerant. Finally, 1 BV regenerant (0.5 mL) was added to the resin and mixed for 1 hour. All regenerants were collected at the end of each cycle and combined together (total 10 BV). This combined solution was analysed using LCMS for quantitative analysis of desorbed PFAS. Regeneration efficiency of resin was calculated by quantifying the percentage of desorbed PFAS compound from resin with following equation.

$$\text{Regeneration efficiency}(\%) = \left(\frac{\text{Total desorbed PFAS in regenerant}}{\text{Total adsorbed PFAS in resin}} \right) \times 100$$

Desorption of PFOA, PFOS and PFHxS from MIEX resin performed by using a mixture of 70% methanol with 30% by volume saturated NaCl. The resin was washed with 100% methanol prior to adsorption of the PFAS to avoid the interference of trace residual organic chemicals during the analysis. Quantification was performed using LCMS.

PFAS Compound	Desorption (%)	Std.
PFOA	43.3	1.9
PFOS	100%	na
PFHxS	98.3	0.5

Table 2.2 Regeneration Efficiency of MIEX resin for PFOA, PFOS and PFHxS

Desorption of PFHxS from the MIEX resin was found to be 98.3 % whereas that of PFOA was only 43.3%. Regeneration of PFOA was repeated for verification, but no increase in efficiency was determined, but appear inconsistent with previous results and other research which has suggested PFOA can be desorbed effectively. PFOS regeneration efficiency was found to be complete at 100%. Based on these results it is appears that regeneration of MIEX resin is very effective using a 70:30 methanol:NaCl regenerant solution for the two sulphonic acid group containing PFAS species (PFOS and PFHxS), but may be significantly less so for the carboxylic acid containing PFAS compound (PFOA).

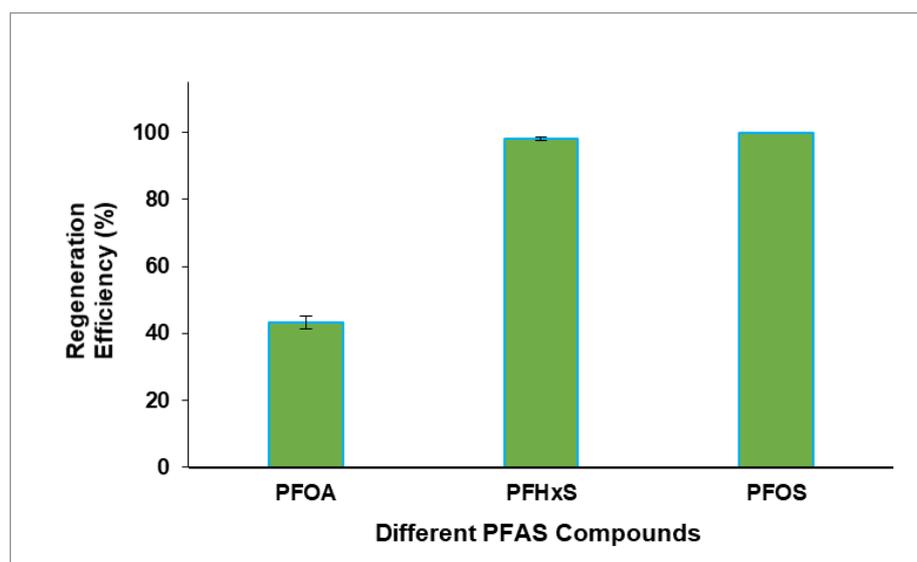


Figure 1.2 Regeneration efficiency of MIEX resin for PFOA, PFOS, and PFHxS

Regeneration of MIEX resin has been shown to be feasible and potentially highly efficient for PFOS and PFHxS, however some results suggest this may be less effective for PFOA. However, other independent studies have suggested that PFOA can be desorbed effectively and this needs further assessment for MIEX resins. Logically, it would be expected that PFOA being less strongly adsorbed onto MIEX should in fact be more easily desorbed. Further evaluations of regeneration chemistry, processes and conditions are required to determine potential for PFOA desorption from MIEX resin.

3.0 Capacity of MIEX Resin for PFAS Adsorption

The total capacity of MIEX resin to remove or adsorb PFAS was assessed to determine potential removal capacity that the resin has. This evaluation was undertaken initially for PFHxS and was carried out by adding 0.5 mL resin to a PFHxS solution containing 0.121 g PFHxS. The MIEX resin was then mixed with the PFHxS solution at 180 rpm overnight. The resin was separated by using a rare earth magnet and the solution was collected for analysis using LCMS.

This study was repeated at 10 times larger scale by adding 5 mL resin to a solution containing 1.23 g PFHxS. Subsequent analytical results indicated a capacity of 0.96 g PFHxS adsorption per dry gram of resin.

Capacity of MIEX resin to adsorb PFOA was also evaluated by similarly adding 0.5 mL resin to a PFOA solution containing 0.11g of PFOA. The Swinburne University LCMS indicated 1.05 g PFOA adsorption per dry gram of resin. Cross-checking using a commercial laboratory analysis indicated 0.99 g of PFOA adsorption per dry gram of resin, so was consistent with the Swinburne results.

Capacity testing of the MIEX resin indicated that the MIEX resin had a total of approximately 1 g of PFHxS adsorption capacity per dry gram of resin, and for PFOA the MIEX resin also had an adsorption capacity of approximately 1 g of PFOA per dry gram of resin.

4. Summary and Conclusions

4.1 MIEX Removal of PFAS Compounds

Effective removal of several PFAS compounds from PFAS spiked water samples was successfully demonstrated utilising MIEX resin. Virtually 100% removals of PFOA, PFOS, and PFHxS were achieved, and >99% removals of PFBA, PFBS and PFHxA were also determined.

Longer chain PFAS appeared to show more affinity for MIEX resin compared to shorter chain PFAS, and sulphonic acid containing PFAS also appeared to be more effectively removed using MIEX resin when compared to the carboxylic acid containing PFAS compounds evaluated.

4.2 Interferences in Removal of PFAS Compounds by DOC and Inorganic Anions

Minimal interferences of DOC (Tannic and Humic acid mix) or inorganic anions as nitrate and sulphate were observed in the removal of PFAS compound at concentrations of DOC up to 10ppm or inorganic anions as sulphate and nitrate up to 25ppm. Greater than 99% removals of PFOA, PFOS, and PFHxS was still achieved with these levels of organic and inorganics in tested waters containing up to 1 ppm of PFAS.

Only at very high concentrations of DOC (~100 ppm) and inorganic anions (~500 ppm) as nitrate and sulphate, was there a significant decrease in PFAS removal efficiencies of 67%, 94% and 91% for PFOA, PFOS, and PFHxS respectively. The interference appears more pronounced for the carboxylic acid group containing PFAS compounds (PFOA) compared to sulphonic acid group containing PFAS (PFOS and PFHxS), which also aligns with the apparent stronger affinity for sulphonic PFAS to MIEX resin.

4.3 PFAS Regeneration Efficiency for MIEX Resin

Initial evaluations using UV Spectroscopic analysis estimated that regeneration efficiencies were most effective using 60% methanol (MtOH) and saturated NaCl mixtures as the regenerant solution. This achieved approximately 100% and 85% desorption (regeneration) of PFBA and PFOA respectively. This was then followed in efficiency by 92% and 68% desorption of PFBA and PFOA respectively, with a 60% methanol (MtOH) saturated NH₄Cl mixture, and then finally 74% and 42% desorption of PFBA and PFOA using 60% ethanol (EtOH) and saturated NaCl mixture.

Alkaline regenerant using 60% methanol (MtOH) with saturated NaOH (pH 9.8) achieved no measurable desorption of PFOA and PFBA from the resin.

Therefore, 60% methanol (MtOH) with saturated NaCl was indicated as the optimum chemistry tested for desorption of PFAS compounds from MIEX resin. Furthermore, the desorption of shorter chain PFAS (PFBA) appeared more effective when compared to the longer chain PFAS (PFOA).

Further assessment of regeneration efficiencies using LCMS analysis indicated approximately 98.3 %, 43.3%, and 100% regeneration efficiency of PFHxS, PFOA, PFOS respectively were achieved using a 70% methanol and 30% saturated NaCl regenerant mixture.

Regeneration was overall shown to be potentially efficient if the regenerant chemistry is optimised, and was most effective for PFOS and PFHxS, which have sulphonic acid functional groups, while less so for PFOA with carboxylic acid functional groups. Further work is needed to better evaluate PFOA regeneration as other studies have suggested PFOA can be desorbed efficiently also. Given PFOA

appears to be adsorbed less strongly onto MIEX resin it is logical that it should be more readily desorbed, but possibly further refinements in regenerant chemistry or the regeneration process is required.

In summary the work undertaken to date has indicated that MIEX is potentially an effective technology for PFAS removal, with very high removal efficiencies able to be achieved, and regeneration of the resin appearing to be feasible for PFOS and PFHxS although may be less so for PFOA.

4.3 Capacity of MIEX Resin for PFAS Adsorption

PFAS adsorption capacity testing of MIEX resin indicated that the MIEX resin had a total capacity of approximately 1 g of PFHxS adsorption capacity per dry gram of resin, and also similarly for PFOA the MIEX resin also had an adsorption capacity of approximately 1 g of PFOA per dry gram of resin.

This suggests a high capacity for adsorption is potentially available for MIEX resin and notwithstanding reaction kinetics in the fluidised bed contactors normally utilised in MIEX systems, should provide considerable removal capability for PFAS from various water streams.

In practical terms, this suggests that 1 kilolitre of MIEX resin (wet) as a 200 kg dry equivalent can potentially remove a maximum total of 200kg of PFAS. And for an assumed 1 ppm of PFAS contaminated water could potentially remove 1 ppm of PFAS from up to 200 ML of water depending on adsorption kinetics, which equates to a potential theoretical maximum removal capacity of 200,000 BV.

Further work is required to examine adsorption kinetics versus theoretical capacity to establish practical removal capacity and efficiency in terms of both actual breakthrough of PFAS, as well as regeneration frequencies required in actual PFAS removal scenarios. This further highlights the need for every candidate PFAS contaminated water, an evaluation of removal performance and behaviours as well as regeneration efficiencies will be required, similarly to that undertaken when MIEX is proposed for DOC removals in a drinking water or wastewater application.

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