



# Use of strong anion exchange resins for the removal of perfluoroalkylated substances from contaminated drinking water in batch and continuous pilot plants



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## ABSTRACT

In recent years abnormally high levels of perfluoroalkylated substances (PFAS) have been detected both in surface and underground water sampled in an area covering approximately 150 square kilometers in the Veneto region (Italy) indicating the presence of a pollution point source (fluorochemicals production plant). Adsorption on granular activated carbon is an emergency measure which is poorly effective requiring frequent replacement. This work focuses on the application of three strong anion exchange resins (Purolite® A520E, A600E and A532E) for the removal of traces of PFOA, PFOS, PFBA and PFBS (concentration of hundreds of  $\text{ng L}^{-1}$ ) from drinking water. This technology is attractive for the possibility of reusing resins after an in-situ regeneration step.

A strong relationship between the hydrophobicity of the exchange functional group of the resin and its capacity in removing PFAS exists. A600E (non hydrophobic) and A520E (fairly hydrophobic) show a reduced sorption capacity compared to A532E (highly hydrophobic). While A600E and A520E can be regenerated with solvent-less dilute solutions of non-toxic  $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{OH}$ , A532E requires concentrated solutions of methanol or ethanol and 1%  $\text{NH}_4\text{Cl}$  and for the sake of this work it was regarded as non-regenerable. The volume of regeneration effluents requiring incineration can be efficiently reduced by more than 96.5% by using reverse osmosis coupled with under-vacuum evaporation.

Transmission electron analysis on saturated resins showed that large molecular macro-aggregates of PFAS can form in the intraparticle pores of resin indicating that ion exchange is not the only mechanism involved in PFAS removal.

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## 1. Introduction

The term “PerFluoroAlkylated Substances” or PFAS indicates a broad group of anthropogenic compounds comprising a per-fluoroalkyl backbone and a terminal functional group.

In the last six decades these substances have been incorporated into a wide range of industrial and commercial products used in more than 200 applications: surfactants (Kissa, 2001), medical applications (Krafft and Reiss, 2007), surface protecting agents (Kostov et al., 2009), fire fighting foams (Magrabi, 2002), mist suppressor (Nishiyama and Ishikawa, 1979). Because of their past

and present widespread use, PFAS are ubiquitous micro pollutants found both in underground and surface water with concentration ranging from detection limits ( $<1 \text{ ng L}^{-1}$ ) to several tens of  $\text{ng L}^{-1}$ .

Perfluoroalkylated substances have unique physico-chemical properties such as simultaneous hydro and oleophobicity, chemical, radiation and biological stability and extremely low surface tension.

All these properties are attributable to fluorine atoms which shield carbon–carbon bonds of the molecular backbone from physical and chemical attacks. Further, fluorination stiffens alkyl chains which self assemble at interface packing close together. This characteristic structure called “molecular-brush” forms a dense layer of trifluoromethyl groups which repels both water and oil. The number of completely fluorinated carbon atoms is the key factor in determining the degree of molecular packing: the longer the

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