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PolyQA-Osorb®: A Superior Adsorbent for PFAS Contaminants

PolyQA-Osorb® is a novel adsorbent that will remediate PFAS compounds to the most stringent levels eventually required by the US and State EPAs at a lower total cost than other remediation alternatives.

What are PFAS compounds?

Per- and polyfluoroalkyl substances (PFAS) are a class of widely used and extremely stable man-made chemicals that are ubiquitous in the environment. PFAS are called "forever chemicals" because the carbon-fluorine bond (C-F) is one of the shortest and strongest bonds in chemistry. Most PFAS are stable, persistent, bio-accumulative, and not biodegradable. According to the US EPA, "there is evidence that exposure to PFAS can lead to adverse health outcomes in humans."[1] Perhaps of most concern is when PFAS enter the supply of potable water.

Can PFAS be removed from the environment today?

Yes. Historically, they have been removed from water using Granulated Activated Carbon (GAC) filters. GAC works by capturing PFAS chemicals in its very small pores (very high surface area). GAC is inexpensive on a dollar-per-pound basis, but effective remediation requires large vessels with very large quantities of carbon media, and relatively frequent changeouts. Eventually, the carbon and captured PFAS are incinerated and converted into greenhouse gases. Finally, GAC is less effective against the smaller-chain PFAS varieties that have become more common recently.

As awareness of and concern about PFAS has grown, Anion Exchange (AIX) Resins have been developed to improve upon GAC. AIX resins work by using a molecule with a positively charged side to attract the negatively charged parts of some PFAS molecules. Typically, AIX resin costs more per-pound than GAC, but AIX also requires smaller vessels, fewer changeouts, and does a better (but not perfect) job against the smaller-chain PFAS. Spent AIX resins are also typically incinerated.

How does PolyQA-Osorb® compare to GAC and AIX?

The table below compares the performance of GAC, AIX and PolyQA-Osorb® in PFAS remediation along the most critical dimensions for evaluating options to remediate PFAS.[2] All of these options can reduce PFAS to safe levels.

Performance Dimension	GAC	AIX	PolyQA-Osorb®
Familiarity	Established	Growing	Novel
Slow vs. Fast	Slowest	Medium	Fastest
• Typical bed contact time	~10 min	~3 min	~1 min
Capacity	Lowest	Medium	High
• Bed volumes to breakthrough	50k – 120k	250k – 300k	500k – 750k
Effective against small-chain PFAS	Least	Medium	Best
Regeneration /reactivation	Few/None	Few/None	Many times
Cost per kg of media	Lowest	Medium	Highest
Total cost of remediation	Higher	Medium	Expect lowest

[1] https://www.epa.gov/pfas/basic-information-pfas

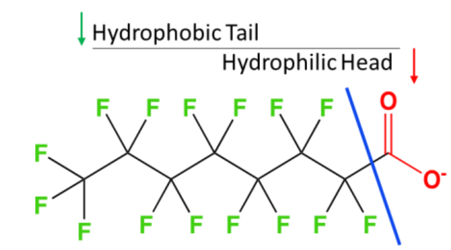
[2] Data taken from Dora Chiang, Ph.D., PE; Ji Im, PE "PFAS Cleanup Approaches – GAC vs Anion Exchange Resin" March 2019. https://www.cdmsmith.com/-/media/Insights/PFAS-Treatment-Options/PFAS-March-Newsletterdocx.pdf and from Edmiston, P., forthcoming.

The combination of the fastest kinetics, the highest capacity, efficacy against the full range of PFAS, and the ability to regenerate PolyQA-Osorb® tens to hundreds of times give us very strong reason to believe that PolyQA-Osorb® will result in the lowest overall cost of remediating PFAS in many applications, even without counting the time and coordination costs of many and frequent media changeouts. We are currently developing the best commercialization configurations for different commercial applications.

How does PolyQA-Osorb® remove PFAS from water?

PolyQA-Osorb® is the brand name for one of ABS Materials' patented Swellable Organically Modified Silicas (SOMS). Different contaminants, when dissolved in water, will have a lesser or stronger affinity for staying in solution, which can be measured by the partition coefficient. Contaminants with higher partition coefficients are, to some degree, "hydrophobic". When contaminated water passes through SOMS media, solutes with higher partition coefficients will prefer to leave solution and remain in the SOMS media. SOMS are highly hydrophobic matrices that swell as they adsorb. As it adsorbs solutes, the hydrophobic SOMS matrix expands up to several times its volume, accounting for its great capacity.[3]

Most PFAS compounds such as perfluorooctanoate (PFOA, right) have both a hydrophobic tail <u>and</u> a hydrophilic anionic group. PolyQA-Osorb® is made by treating hydrophobic Osorb® with a cationic quaternary amine (QA) polymer. The resulting material provides two mechanisms for adsorption.



Perfluorooctanoate (PFOA)

PolyQA-Osorb® uses a combination of cationic groups in hydrophobic pores to capture both long-chain PFAS such as PFOA and harder-to-treat short-chain compounds such as perfluorobutanoic acid (PFBA). PolyQA-Osorb® has been identified as an emerging technology in PFAS treatment.[4]

Among the most interesting characteristics of PolyQA-Osorb® is that, like most SOMS, it can be regenerated by flushing with a solvent (fluid or gas), pulling the PFAS from the matrix, and restoring the PolyQA-Osorb® media to full functionality. The contaminant PFAS can then be separated from the solvent, minimizing both the cost and the resource requirements of ultimate disposal.

What are the markets for PolyQA-Osorb®?

Although we are still developing the most effective commercial configurations, we are confident that the far smaller footprint, less frequent media changeouts, effectiveness against the full range of PFAS contaminants and ability to regenerate the media will make PolyQA-Osorb® media systems both exceptionally effective and cost-effective in the following markets:

- **Point of Entry Treatment (POET) and Point of Use Treatment (POUT);**
- **Groundwater PFAS Remediation; and**
- **Industrial PFAS Remediation.**

Patent Portfolio

ABS Materials has 11 granted patents including composition of matter and applications. Grated patents regarding the use for PFAS include: 7,790,830; 8,119,759; and 9,144,784

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[3] Stebel, E.K., Pike, K.A., Nguyen, H., Hartmann, H.A., Klonowski, M.J., Lawrence, M.G., Collins, R.M., Hefner, C.E. and Edmiston, P.L., 2019. Absorption of short-chain to long-chain perfluoroalkyl substances using swellable organically modified silica. *Environmental Science: Water Research & Technology*, *5*(11), pp.1854-1866.

[4] Ross, Ian, Jeffrey McDonough, Jonathan Miles, Peter Storch, Parvathy Thelakkat Kochunarayanan, Erica Kalve, Jake Hurst, Soumitri S. Dasgupta, and Jeff Burdick. "A review of emerging technologies for remediation of PFASs." *Remediation Journal* 28, no. 2 (2018): 101-126.