Industrial Scale Irradiation Facility for Environmental Remediation of PFAS

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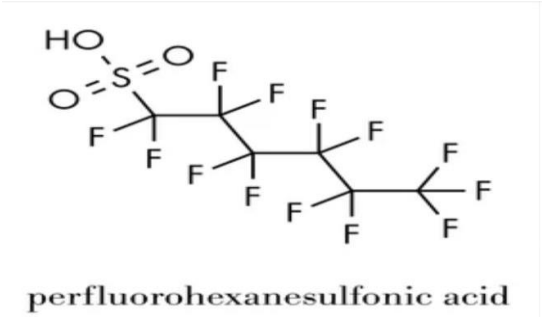
Introduction to PFAS

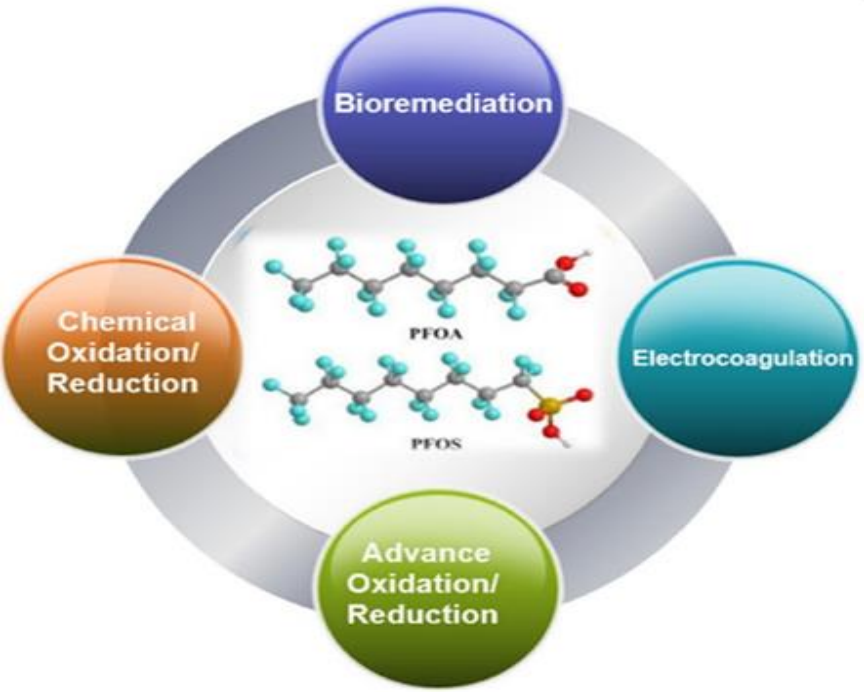
- PFAS are persistent chemicals that do not break down easily in the environment or in living organisms
- The two most studied and regulated are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS)
- PFAS can be found in a wide range of products, including firefighting foam, non-stick cookware, food packaging, water-resistant clothing, and personal care products
- PFAS have been detected in drinking water sources across the United States and many other countries

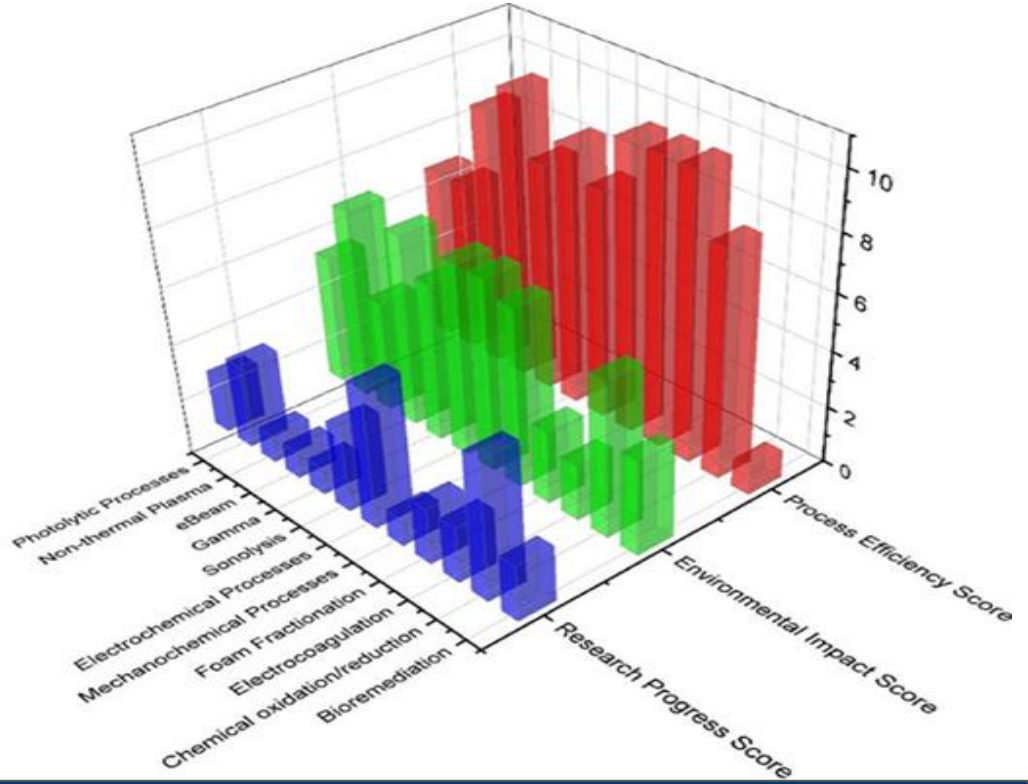


Negative Effects of PFAS

- Exposure to PFAS has been linked to a range of health problems, including liver damage, thyroid disease, decreased fertility, and certain types of cancer.
- PFAS can contaminate water supplies and harm wildlife, including fish and birds.
- PFAS can persist in the environment for decades or even centuries, leading to long-term contamination and exposure risks.

Competing technologies for PFAS



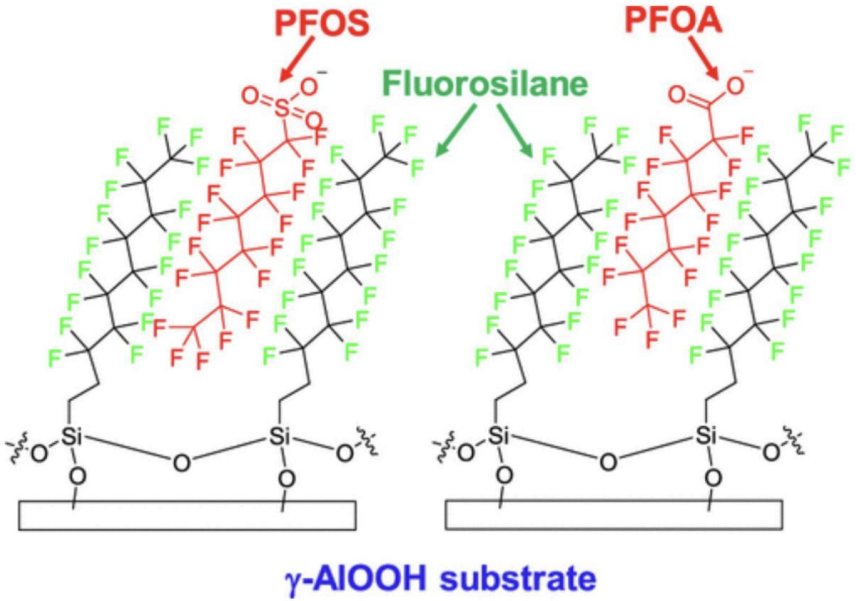


Current Status of PFAS in the Environment

- There are no widely accepted water or solid media treatment technologies that address the full range of PFASs (precursors and PFAAs)
- Treatment of PFASs involves the use of adsorptive or separation technologies to create a lower volume concentrated waste stream for energy intensive destruction (thermal or chemical reduction).
- The current commercially available PFAS water treatment technologies:
  - granular activated carbon (GAC)
  - anion exchange (AIX)
  - reverse osmosis/nanofiltration (RO/NF)
  - incineration
- In 2019, the U.S. Environmental Protection Agency (EPA) set a lifetime health advisory level for PFAS in drinking water of 70 parts per trillion (ppt) for the combined concentration of PFOA and PFOS.
- Some states have set their own, lower regulatory standards for PFAS in drinking water and other sources.
- The European Union has set a limit of 100 ng/L for PFOS in drinking water, and is considering a similar limit for PFOA.

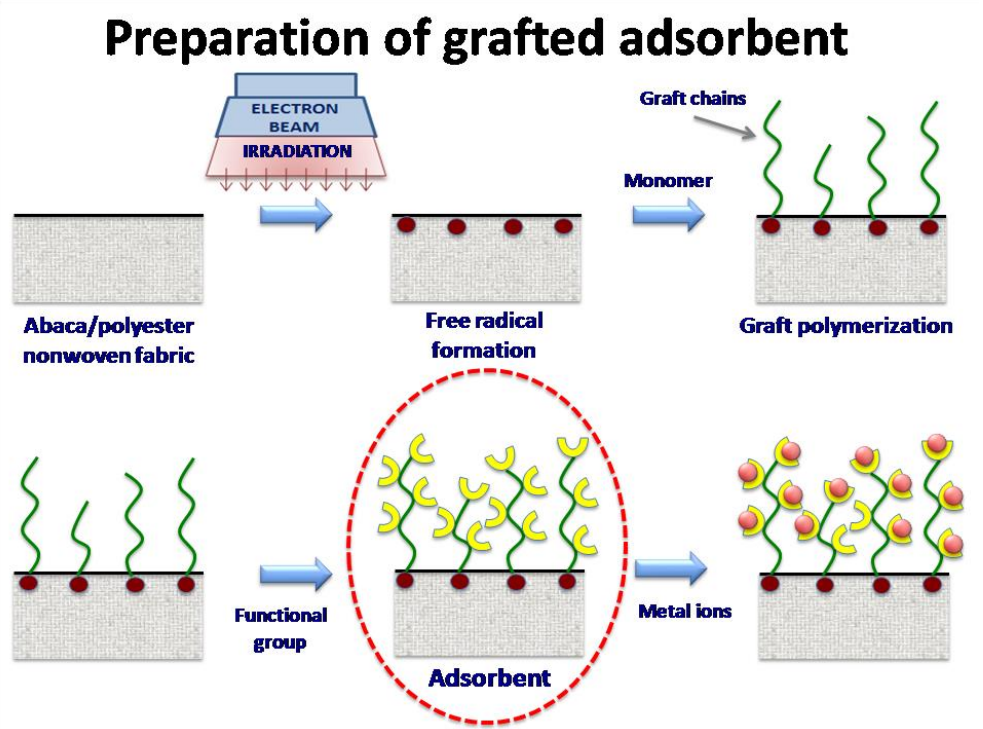
Radiation-grafted adsorbent for PFAS: Potential functional groups

- Methods for removing PFOS and PFOA from drinking water by linear fluorinated silane-functionalized aluminum oxide hydroxide (γ-AlOOH) nanowhiskers
- Linear fluorinated silanes with appended hydrophilic poly(ethylene glycol) units
- Added modified amphiphilic silanes
- 99.9% reduction in PFOS and PFOA
- Treatment at very high flux of 1223 L/m2·h



Retrieved from: Johnson, J. K., Hoffman, C. M., Smith, D. A., & Xia, Z. (2019). Advanced filtration membranes for the removal of perfluoroalkyl species from water. ACS Omega, 4(5), 8001–8006. https://doi.org/10.1021/acsomega.9b00314

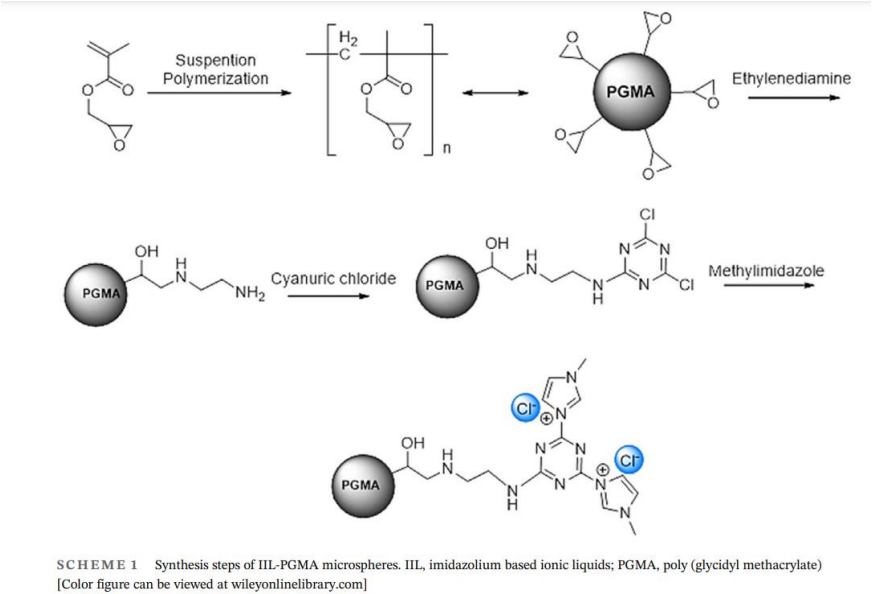
Treatment Solutions



Radiation-grafted adsorbent for PFAS: Potential functional groups

Advantages of radiation-grafted adsorbents over other existing resins or technologies:

1. High adsorption capacity (presence of functional groups with high selectivity to target chemical species)
2. Faster adsorption kinetics
3. Tunable properties (dose needed to produce optimized grafted adsorbent is ≤ 50 kGy (<< 2000 kGy needed to treat PFAS!!!)
4. Regenerable/reusable
5. Adsorb pollutants are recoverable (using acidic pH)



SCHEME 1 Synthesis steps of IIL-PGMA microspheres. IIL, imidazolium based ionic liquids; PGMA, poly (glycidyl methacrylate)
[Color figure can be viewed at wileyonlinelibrary.com]

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Potential Challenges along adoption	***Current Milestone***
1. Cost: capital for EB irradiator, materials for radiation grafting, equipment and engineering.	• On-going IAEA Project RAS1023: Developing and Upscaling of Radiation grafted adsorbent for environmental remediation. • Radiation grafted adsorbents can be tailored to capture precious metals (gold), rare earth metals (Scandium), organic pollutants (dyes, pharmaceutical compounds), and toxic heavy metals (Cs, As, Cr). [Can be offered to different industries, not only limited for environmental remidiation]
2. Upscaling and streamlining of production	
3. Evaluation of cost-benefit analysis	

Market Analysis

SWOT ANALYSIS

Strength

- The use radiation grafted filters/absorbents in treating contaminant such PFAS is environment safe and friendly. Since it does not leave residues in the environment as compared to other forms of remediations.
- It is a versatile technology. Eg.Precious metals, toxic heavy metals, and any contaminants

Weakness

- It is relatively new technology is not well known and it is being developed.

Opportunity

- It is a viable business. IAEA Technical Cooperation Project
- It is economically feasible ie marketable and less expensive

Threats

- No binding legislation in place ensure that producers and users are regulated.
- Alternative remediation technologies available

Roadmap for business plan to Implementation

1) Education or engagement of stakeholders.
2) Market analysis
3) Technology and equipment
4) Facility location and design
5) Operations and maintenance
6) Financials

Conclusion

RGA is a state of the art-of-the-technology which can reduce PFAS contamination to acceptable level. It can be very versatile and useful in solving other environmental related issues.

Laboration formulation of RGA and it optimization is the prerequisite

The success of this project hedges on the detailed legislation and enforcement.

Works Cited

Johnson, J. K., Hoffman, C. M., Smith, D. A., & Xia, Z. (2019). Advanced filtration membranes for the removal of perfluoroalkyl species from water. ACS Omega, 4(5), 8001–8006. https://doi.org/10.1021/acsomega.9b00314

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