

Gliding arc plasma treatment of PFAS-contaminated water: Investigation of the degradation mechanism and scalability

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Abstract: In this contribution, we report that GAP appears to degrade PFAS in water by two major pathways: (1) mineralization at interface via heat, catalyzed by gas phase charged particles, and (2) degradation to unknown organofluorine products in the bulk liquid via e^-_{aq} and potentially other dissolved reactive species. Findings also demonstrate that scalability of this technology is promising at the volumes tested (up to 80 L).

1. Introduction

PFAS are a large class of synthetic organofluorine compounds designated contaminants of emerging concern due to their historical widespread use in tandem with their potential for bioaccumulation and toxicity. One exposure route is via ingestion of contaminated water. Various non-equilibrium plasmas have emerged as promising technologies for the degradation of PFAS in contaminated water. Lewis et al. demonstrated that air gliding arc plasma (GAP) is feasible for this application [1]. Here, we elucidate the mechanism by which air GAP degrades PFAS, specifically looking at the role of gas phase charged particles, temperature, and dissolved reactive species. We also assess the scalability of this technique.

2. Methods

A thermodynamic model was used to assess the role heat and plasma reactive species could play during GAP treatment of PFAS-contaminated water [2]. Two reactors were used to investigate mechanism experimentally: (1) a 200 mL flow-through GAP reactor [3], and (2) a 1 L submerged GAP reactor [2]. To investigate the role of heat, experiments were conducted with varied average plasma gas temperature in the 200 mL reactor. To investigate the role of charged gas particles, they were scavenged via a grounded mesh. This mesh was added to the 1 L reactor so that the submerged plasma jet would pass through it prior to contact with contaminated water. Preliminary tests were conducted to ensure mesh did not significantly affect plasma jet temperature. To investigate the role of dissolved reactive species, various scavengers were tested (sodium nitrate for e^-_{aq} ; methanol, N-acetyl cysteine, sucrose, and tert-Butyl alcohol for RONS). Finally, an 80 L submerged GAP reactor was tested to assess scalability.

3. Results and Discussion

Thermodynamics indicated that PFOA mineralization is endothermic; thus, energy input (e.g. heat) is required, and plasma reactive species may act as catalysts [2]. Experimentally, a higher extent of PFOS mineralization was achieved with higher average plasma gas temperature, supporting the model [3]. **Figure 1** shows that mesh completely inhibited mineralization of the various PFAS

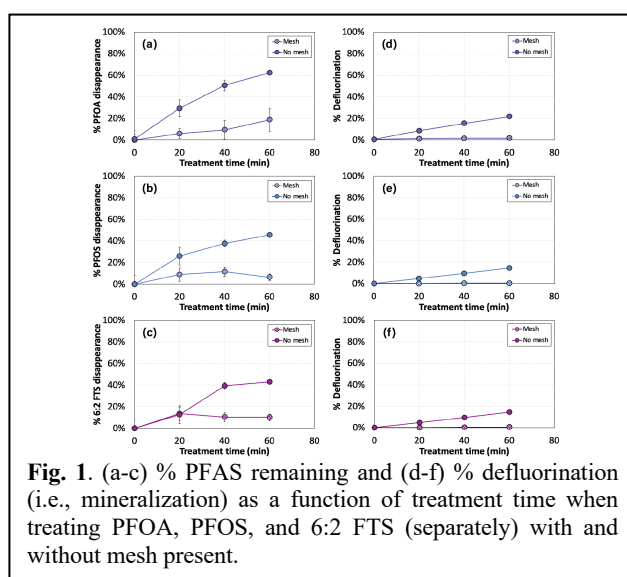


Fig. 1. (a-c) % PFAS remaining and (d-f) % defluorination (i.e., mineralization) as a function of treatment time when treating PFOA, PFOS, and 6:2 FTS (separately) with and without mesh present.

compounds tested, suggesting that gas phase charged particles play an important role in this pathway. Scavengers of dissolved reactive species had no effect on PFOA mineralization, but e^-_{aq} scavenging inhibited degradation. Experiments in the 80 L reactor indicated that PFOA degradation efficiency was retained with scale-up.

4. Conclusion

Results suggest GAP degrades PFAS by two pathways: (1) mineralization via heat, with gas phase charged particles acting as catalysts, and (2) degradation to unquantifiable organofluorine products via e^-_{aq} and potentially other dissolved reactive species. Results also revealed GAP is promising for treatment of larger volumes.

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References

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