Pulsed Spark Discharge In-situ Spectral Detection of Perfluorinated Compounds (PFCs) in Water, on Filter Material, and in Soil

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Abstract: Perfluorinated compounds (PFCs) are globally-distributed, persistent [1-5], bio-accumulative chemicals with the properties including hydrophobicity and oleophobicity [2]. Detecting PFCs in the water, on filter materials, and in soils usually requires multiple complicated steps. Here we report a relatively simple and inexpensive method to detect the presence of fluorinated compounds in water, signaling for the need of a more precise diagnostic step. We use granular activated carbon (GAC) to capture PFCs in water. After filtering the potential PFCs-contained water with GAC, we use optical emission from pulsed spark discharge over the contaminated GAC sample to evaluate it for presence of fluorine atoms. This method can be used as an alternate economical method of detecting PFCs in potable water, soil samples, etc.

Introduction

Perfluorinated compounds (PFCs) have been widely utilized in industry since 1950s. The persistence of the PFCs led them to saturate our environment, globally: soil[6], water[4], and animal [7] and plant tissues [6, 8]. Instead of using traditional methods, which are more time-consuming and expensive, of detecting the PFC molecules, the purpose of this study is to devise a fast method for detection of fluorine presence in water, necessitating later detailed analysis. The technique applied in this study includes two major parts: spark pulsed discharge generation over the contaminated granular activated carbon (GAC) sample, follow by the optical emission spectroscopy (OES) analysis.

In this study, pure GAC and pure perfluorooctanoic acid (PFOA) powder are tested by Avantes Enlightening OES spectrometer. The experiment aims to identify the discrepancies between two graphs and obtain a fluorine-existing result.

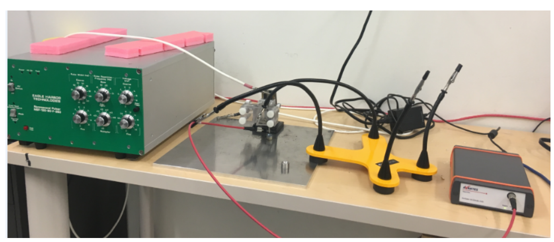

Figure 1. Experimental setup: Nanosecond pulse generator, spark pulsed discharge chamber, Quadhand holder, and Avanted OES spectrometer.

Materials & Method

The experimental setup (Figure 1) includes three parts: nanosecond pulse generator (NSP-100, Eagle Harbor Tech, Seattle, WA), sparked plasma needle, and the OES spectrometer. Here we use the pulse width of 200 ns, repetition frequency of 1k Hz and the pulse amplitude of 11 kV. Photograph of the spark discharge over the GAC sample is shown in Figure 2. To keep powder from escaping the discharge zone quickly we pelletize the GAC and the PFOA samples before treatment (Grindhouse T-Press Stainless Steel Pollen Press). After the spectra is collected, we import the data from Avantes's proprietary software to the *Spectrum Analyzer 1.8* [9] for atomic peak identification. By comparing the OES of pure PFOA sample with that of GAC we observe strong signals from fluorine atoms which are absent in GAC samples (see Figure 3 and zoomed-in scan in Figure 4).

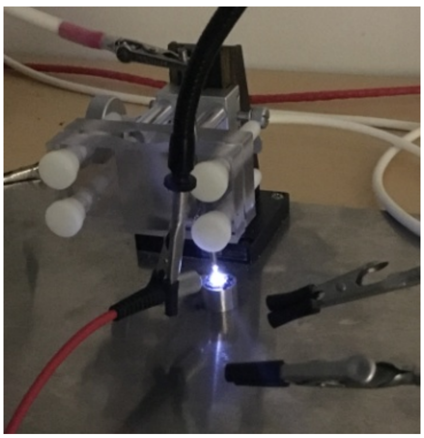

Figure 2. Photograph of the pulsed spark discharge over the sample with contaminated GAC.

Results & Discussion

Figure 4 shows an abundance of fluorine atomic peaks. Fluorine is detected at around 230, 250, 290, 320, 350, 390, 430, 450, and 540 nm. Among these regions, 320, 350, and 540 nm regions have the strongest atomic fluorine peaks and show significant difference with pure GAC samples.

Conclusion

The presented work is preliminary. While we observe a pronounced difference between pure PFOA and pure GAC samples, in the real environment the situation will be drastically different. We typically anticipate parts per billion (PPB) or lower concentration of PFCs in river water [4]; and even when it is concentrated on GAC we will still have significantly lower concentration of PFCs than what we have thus-far presented.

The method presented in this work utilized GAC filter material; however, this approach can be used for detection of fluorine directly in water, in soil samples, and in landfill leachate.

This research effort is ongoing, and we anticipate showing a significant progress by the time the 24th International Symposium on Plasma Chemistry approaches.

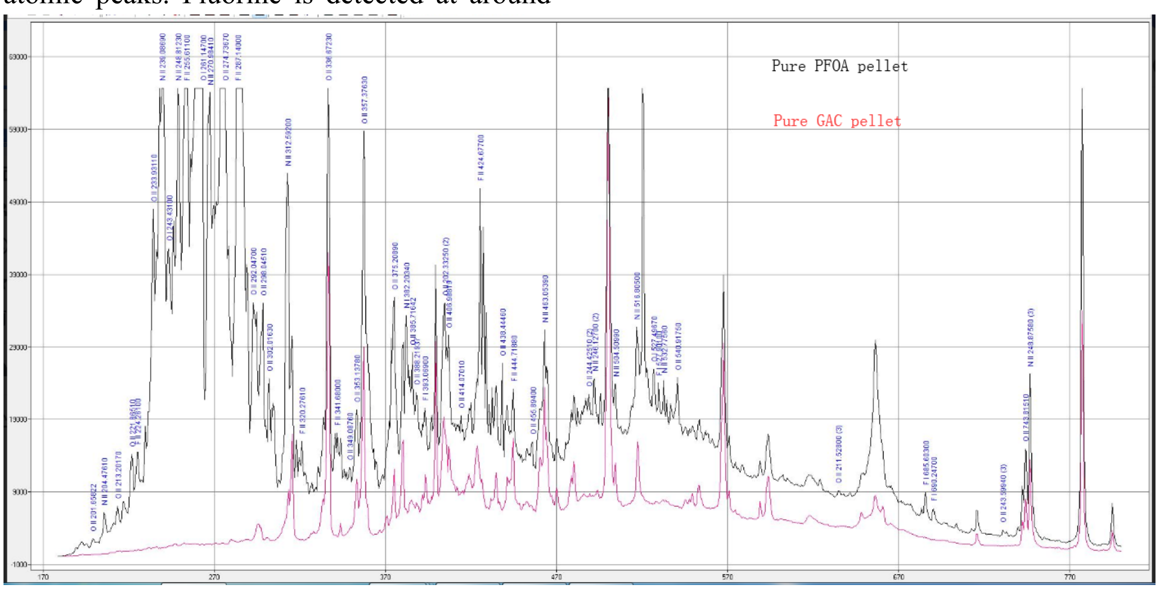

Figure 3. OES of spark discharge over the pure PFOA pellet sample, compared with pure GAC pellet sample.

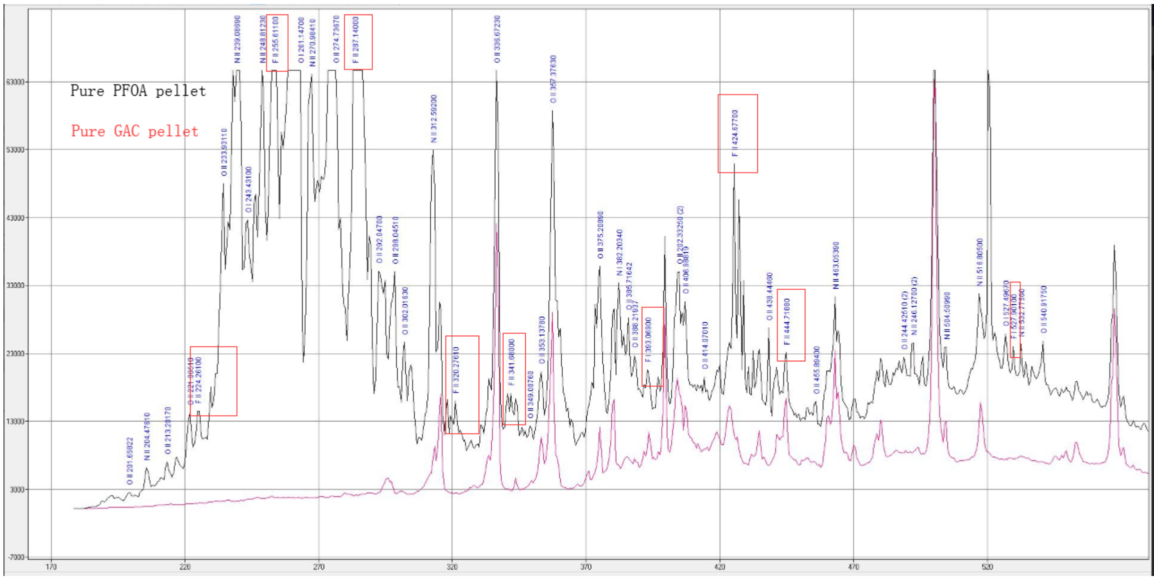

Figure 4. The zoom-in of the OES of spark discharge over the pure PFOA pellet sample, compared with pure GAC pellet sample.

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