QUARTERLY PROGRESS REPORT

[February 01, 2021 – April 30, 2021]

PROJECT TITLE: Non-Thermal Plasma Degradation of Per- and Polyfluoroalkyl Substances from Landfill Leachate

PRINCIPAL INVESTIGATORS:

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PROJECT WEBSITE: https://web1.eng.famu.fsu.edu/~ytang/PFAS_in_leachate.html

Work Accomplished during this Reporting Period:

The project has four tasks. We have completed ~10% of Task 1, ~30% of Task 2, ~10% of Task 3, and ~0% of Task 4. The completed work in each task is described below:

<u>Task 1: evaluate the removal of five representative PFAS in addition to PFOA at leachate-relevant PFAS concentrations (µg/L) by the gas-liquid flowing film plasma reactor</u>

We purchased six representative PFAS that have standards or guidance values in place or being developed, including perfluorohexane sulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluorooctanesulfonic acid (PFOS), one typical perfluoropolyether (PFPE), and one representative GenX product. We tested one of these six chemicals (*i.e.*, PFOS) by treating a deionized water spiked with PFOS at ppb level. The reactor configuration and operating conditions was the same as in the preliminary experiments (Bulusu et al., 2020). A schematic diagram of the gas-liquid flowing film plasma reactor is shown in Figure 1. The power supply settings were 16 kV (input voltage), 40 ns (pulse width), and 5 KHz. The flow rate was 2 mL/minute, corresponding to a hydraulic retention time of ~0.2 seconds. Preliminary results show that the PFOS removal is ~75%. Duplicate experiment will be conducted for all the abovementioned PFAS.

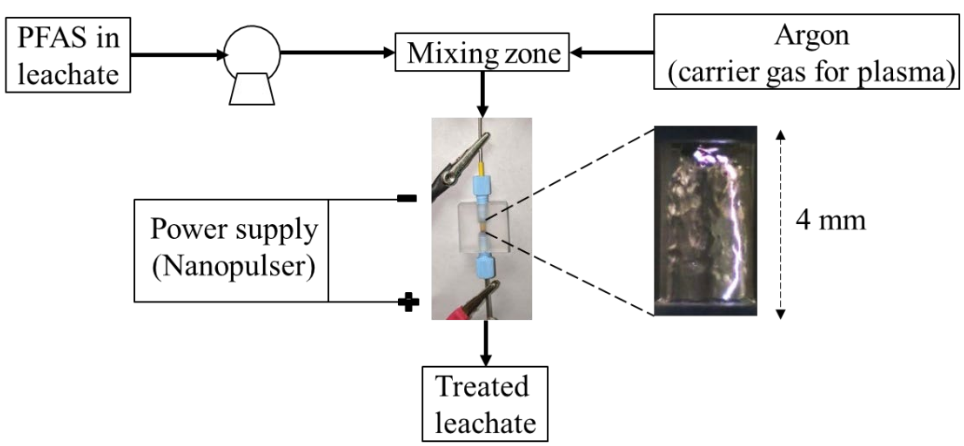

Figure 1. Schematic diagram of the gas-liquid flowing film plasma reactor for leachate treatment. Water flows downward along the wall of the reactor and forms a thin water film on the wall. The carrier gas (*i.e.*, argon) flows downward at the core of the reactor. Pulsed electrical discharge (*i.e.*, plasma) occurs at the interface of water and gas.

<u>Task 2: evaluate the effects of leachate components (e.g., inorganic substances, complex organic substances, simple organic substances, pH, and surfactants) on the removal of one representative PFAS: PFOA.</u>

Using the same reactor and operating conditions as in Task 1, we evaluated the effects of inorganic substances on the removal of PFOA. We used a high PFOA concentration of ~50 ppm so that we can measure the fluoride production in the reactor effluent. The results are shown in Figure 2. While inorganic substances did not affect the mineralization of PFOA, it decreased the energy efficiency. The main reason for the decrease in energy efficiency is the increase in power delivered to the reactor as the conductivity increased above 2 mS/cm. At those very high conductivities some current flow is lost through the liquid solutions. In previous work we have studied the plasma properties up to 38 mS/cm and have shown how the power supply characteristics can affect the plasma generation with solution conductivity (Wang et al., 2019). It is outside of the scope of the present work to design alternative power supplies for those high conductivities, but our work can provide rationale for further work on this topic.

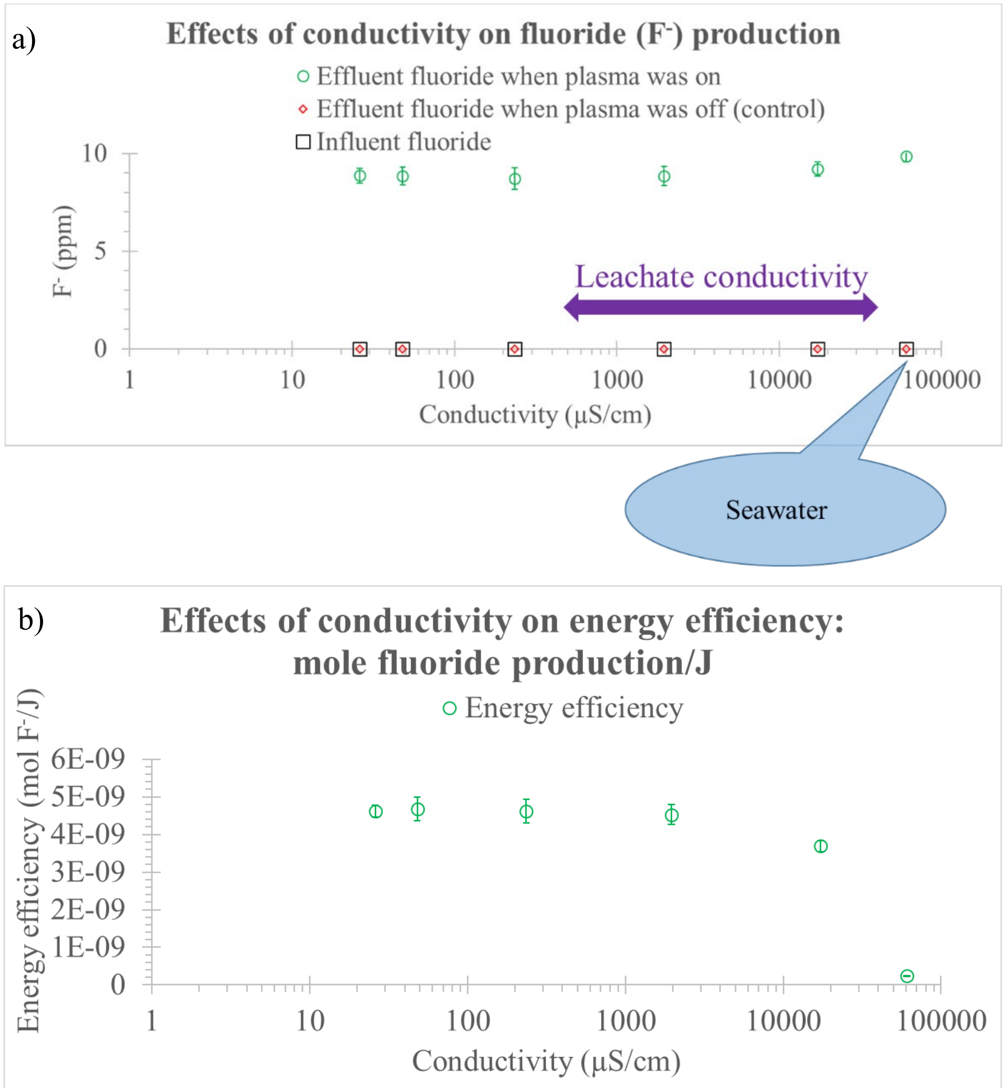

Figure 2. The effects of inorganic substances, represented by NaCl and measured by conductivity, on a) fluoride production and b) energy efficiency.

Task 3: determine the degradation intermediates found in the liquid and gas phases from PFOA

We are currently developing methods for measuring the degradation intermediates in both gas and liquid phases.

Task 4: determine the toxicity of the degradation intermediates of PFOA by an EPA recommended method

We have reviewed the literature for this task, but has not started the experiment.

TAG Meetings #1:

• Date of the meeting – April 27, 2021

• Names/title/emails of all participants – See Table below

• List of TAG members who were unable to attend this meeting – See Table below

Attendants and title	Email	Attended?
Bruce Locke, co-PI	locke@eng.famu.fsu.edu	yes
Bruce Marvin, TAG member	BMarvin@Geosyntec.com	yes
Chao Zhou, TAG member	chaozhou.asu@gmail.com	yes
Claudia Mark, TAG member	CMack@Geosyntec.com	yes
Huan Chen, co-PI	huan.chen@magnet.fsu.edu	yes
Joseph Dertien, TAG member	joseph.dertien@dep.state.fl.us	yes
John Schert, program director	jschert@ufl.edu	yes
Karam Eeso, undergraduate research assistant	kfe18b@my.fsu.edu	yes
Kerry Tate, TAG member	kerry.tate@dep.state.fl.us	no
Kevin Warner, TAG member	KWarner@Geosyntec.com	yes
Lauren J. Coleman, TAG member	lauren.coleman@floridadep.gov	no
Owete S. Owete, TAG member	owete.owete@dep.state.fl.us	yes
Rachel Gallen, graduate research assistant	rog15b@my.fsu.edu	yes
Radha Krishna Bulusu Raja, technical support to this project	rb16j@my.fsu.edu	yes
Robert Wandell, technical support to this project	rwandell@eng.famu.fsu.edu	yes
Ryan Barker, TAG member	Ryan.M.Barker@FloridaDEP.gov	yes
Shanin Speas-Frost, TAG member	shanin.speasfrost@dep.state.fl.us	yes
Stephanie Sanchez, TAG member	ssanchez@geosyntec.com	yes
Sterling Carrol, TAG member	sterling.carroll@frwa.net	yes
Tarek Abichou, co-PI	abichou@eng.famu.fsu.edu	yes
Terry Johnson, TAG member	tjohnson8@wm.com	yes
Walsta Jean-Babtiste, TAG member	walsta.jeanbaptiste@dep.state.fl.us	yes
Youneng Tang, PI	ytang@eng.famu.fsu.edu	yes
Zeljka Popovic, technical support to this project	zp17@my.fsu.edu	yes

• Link to the video recording/presentation slides of the TAG meeting:
https://web1.eng.famu.fsu.edu/~ytang/PFAS_in_leachate.html

References:

Bulusu, R.K.M.; Wandell, R.J.; Zhang, Z.; Farahani, M.; Tang, Y.; Locke, B.R. Degradation of PFOA with a nanosecond-pulsed plasma gas–liquid flowing film reactor. *Plasma Processes and Polymers*, 2020, 17(8), 2000074.

Wang, H.H.; Wandell, R.J.; Tachibana, K.; Vorac, J.; Locke, B.R. The influence of liquid conductivity on electrical breakdown and hydrogen peroxide production in a nanosecond pulsed plasma discharge generated in a water-film plasma reactor, *Journal of Physics D: Applied Physics*, 2019, 52, 075201.

Metrics:

1. List research publications resulting from THIS Hinkley Center project.

None.

2. List research presentations resulting from (or about) THIS Hinkley Center project.

Gas-Liquid Water Plasma Reactors for PFAS Degradation, Bruce R. Locke, PFAS Forum: April 2021, Tampa, FL, https://vimeo.com/538786432.

3. List who has referenced or cited your publications from this project.

None.

4. How have the research results from THIS Hinkley Center project been leveraged to secure additional research funding? What additional sources of funding are you seeking or have you sought?

We have obtained seed funding from NSF, FSU, and Geosyntec consultants/Redhill Scientific to do PFAS research.

5. What new collaborations were initiated based on THIS Hinkley Center project?

There is a collaborative effort among FSU, Geosyntec Consultants and Redhill Scientific on PFAS removal

6. How have the results from THIS Hinkley Center funded project been used (not will be used) by the FDEP or other stakeholders?

None.

Pictures:

We will report them in the next quarterly report.