Defoamer Assisted Electrocatalytic Treatment of PER- and Polyfluorinated Alkyl Substance-Laden Foam

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Outline

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3 Materials and Methods

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5 Key Findings

6 Future work

7 Acknowledgement

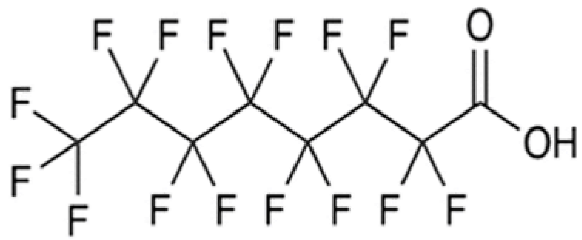
Per- and polyfluoroalkyl substances (PFAS)

❖ Widely used in industrial processes and consumer products.

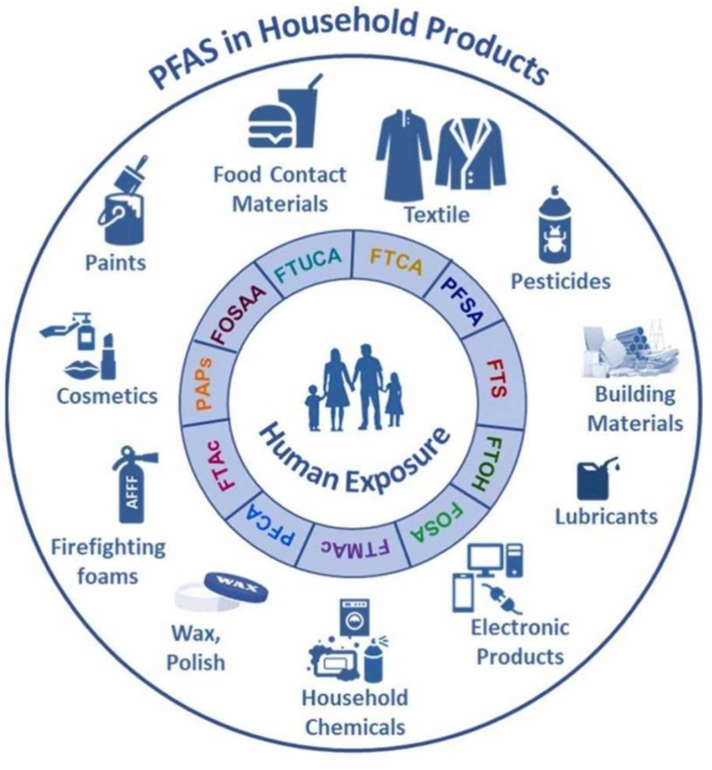
❖ Persistent organic chemicals.

❖ PFAS are found in

- Surface and groundwater
- Urine, blood, and breast milk
- Household and industrial wastewater
- Landfill leachate
- Firefighting foams

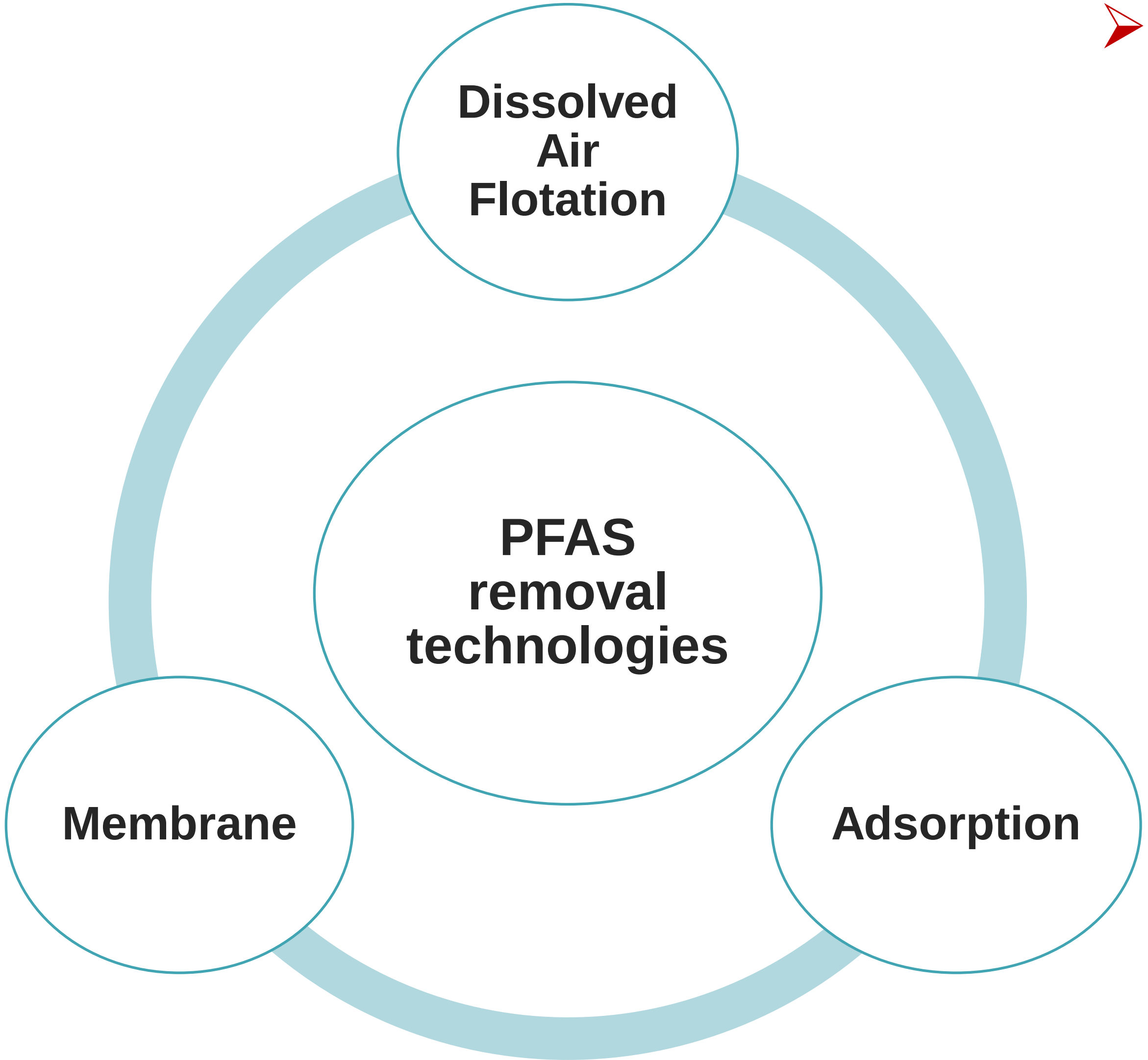


Perfluorooctanoic acid (PFOA)

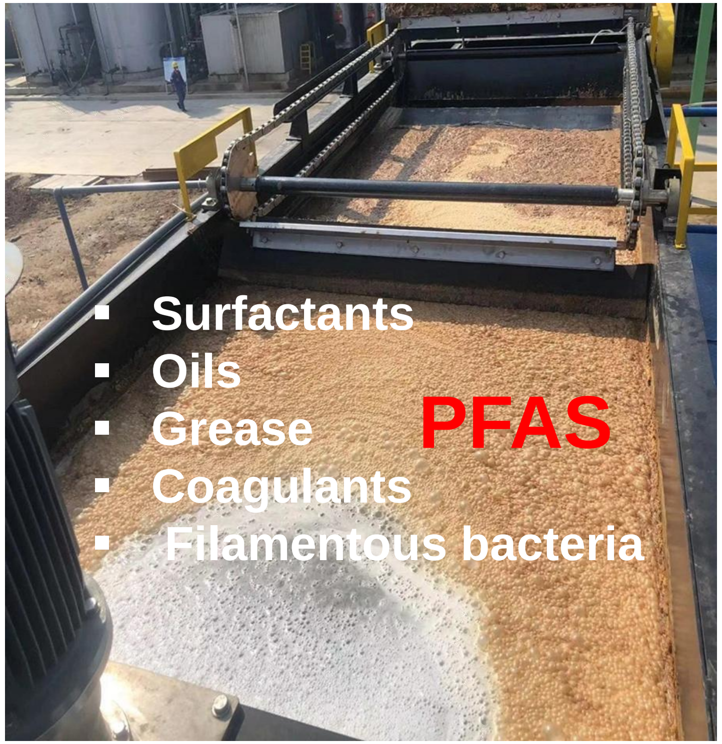


Pradeep et.al., J. Hazard. Mater, 2023

Non-destructive Technologies



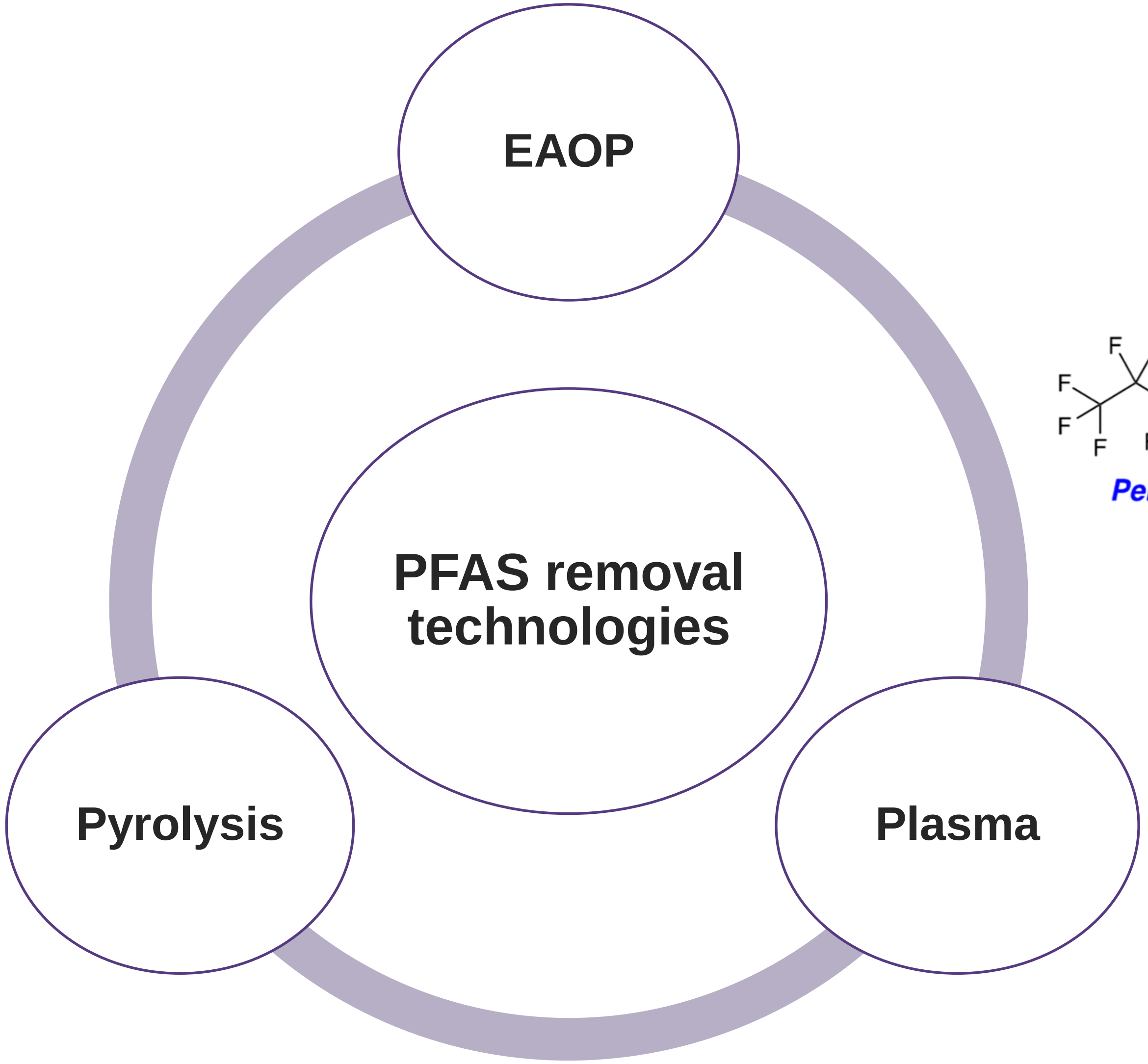
- **These technologies are non-destructive, which are leading to the generation of PFAS-laden brine and foam.**



PFAS concentration in the foam is between 3-6 g/L

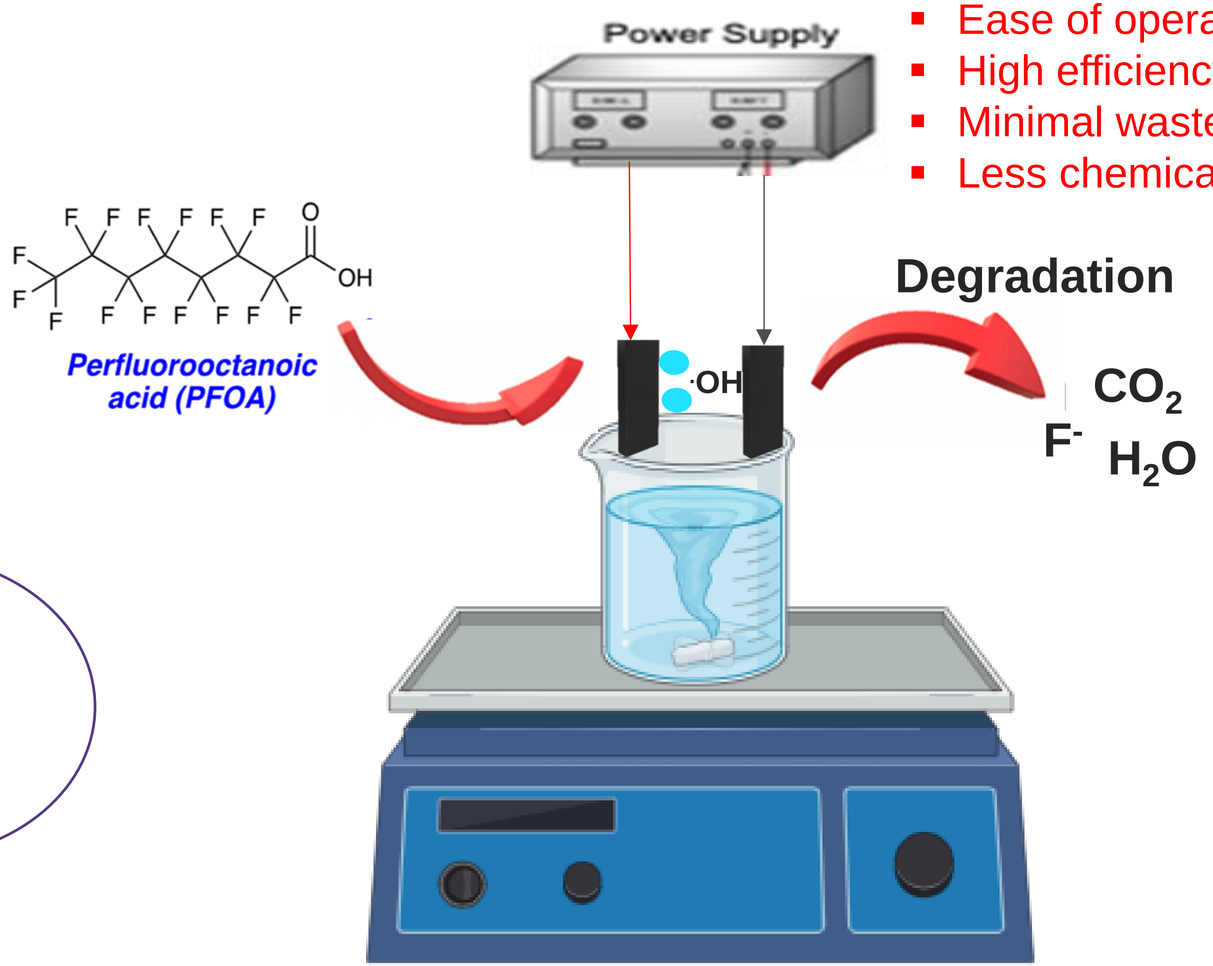
(Meng et.al., J. Chemosphere, 2018)

Destructive Technologies



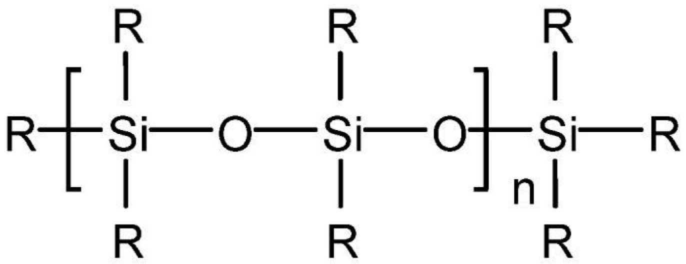
EAOP technology

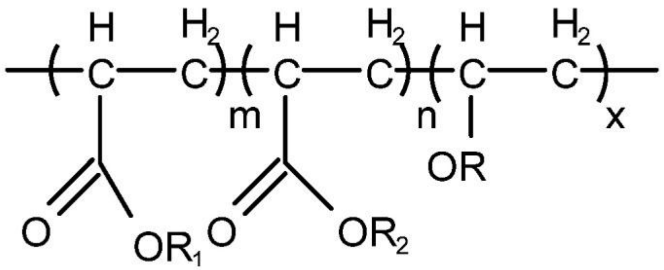
- Ease of operation
- High efficiency
- Minimal waste
- Less chemical requirements



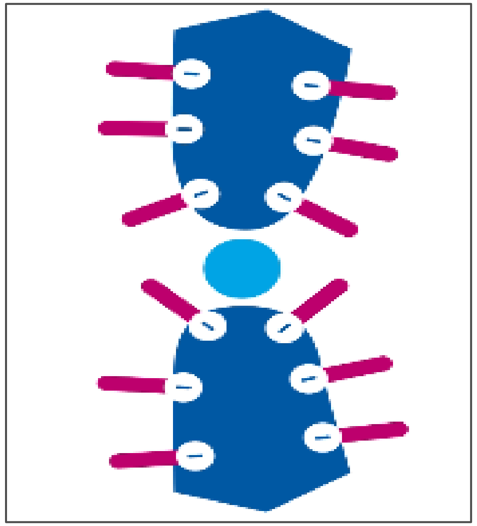
What is a Defoamer?

- ❖ Chemical additive that reduces the formation of foam.
- ❖ Have two categories: Silicone and Non-Silicone defoamers.
- ❖ Defoamers have a low surface tension and spread rapidly along the gas-liquid interface.

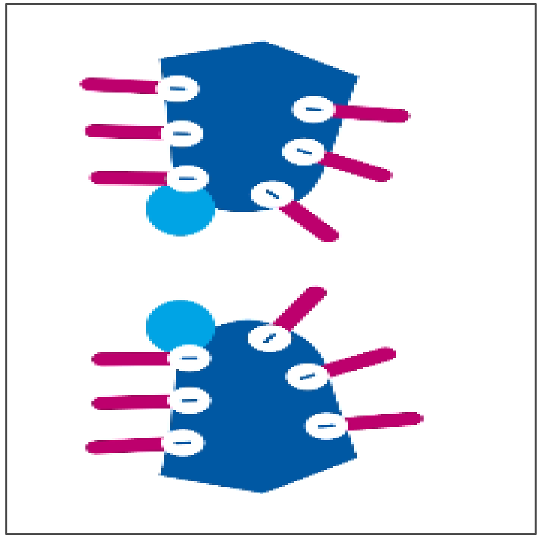




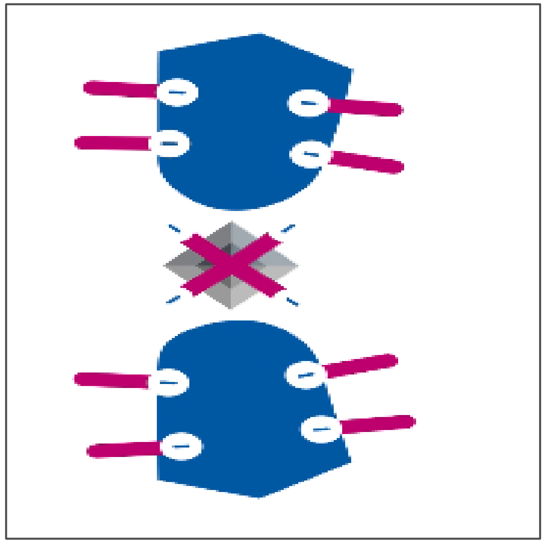
Ren et al., J.MDPI, 2023

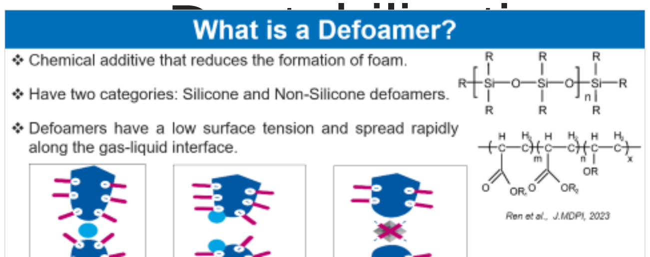


Dewetting



Stretching (Marangoni effect)





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Ren et al., J.MDPI, 2023

Objectives

The main goal of this study is to understand the influence of defoamers on the degradation efficiency of PFAS-laden foam using Electrochemical Advanced oxidation process (EAOP).

The specific objectives are to:

- **Objective #1:** Examine the impact of defoamer type (hydrophilic vs hydrophobic) on the degradation efficiency of PFOA during EAOP.
- **Objective #2:** Investigate the influence of operational parameters such as (a) defoamer dose, (b) electrolyte concentration, and (c) pH on the degradation efficiency of PFOA during EAOP.
- **Objective #3:** Investigate the impact of defoamers on the degradation kinetics of PFOA during EAOP.

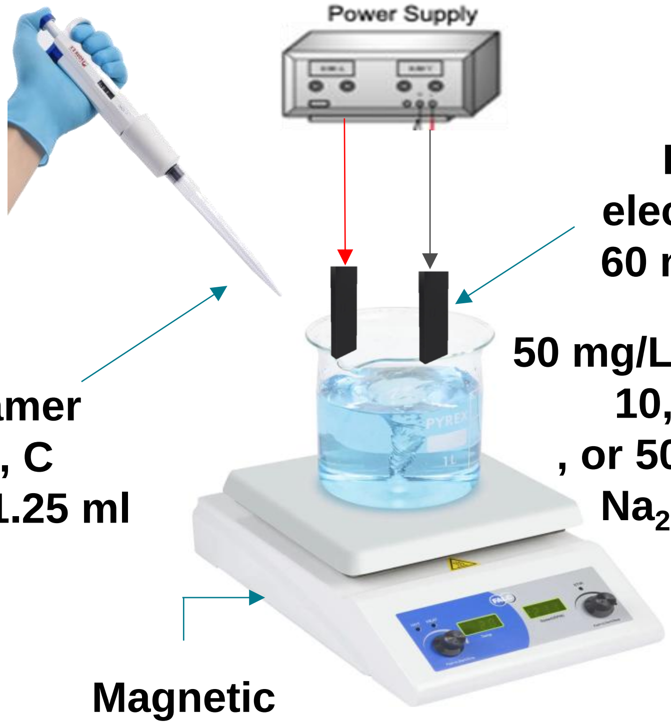
Materials and Methods

Less

More

Hydrophobicity

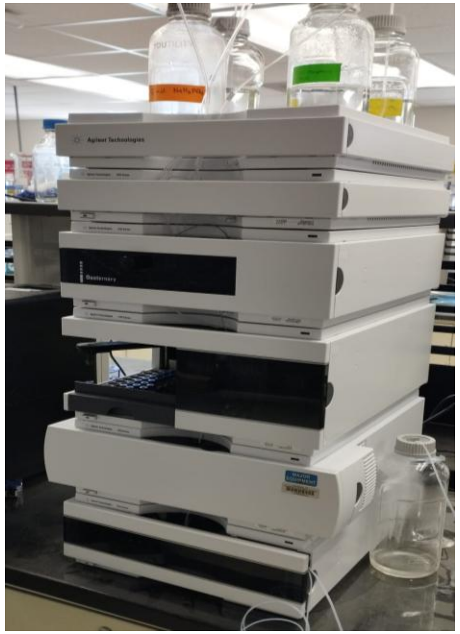
Defoamer
A, B, C
0.25 or 1.25 ml



BDD
electrodes
60 mA/cm^2

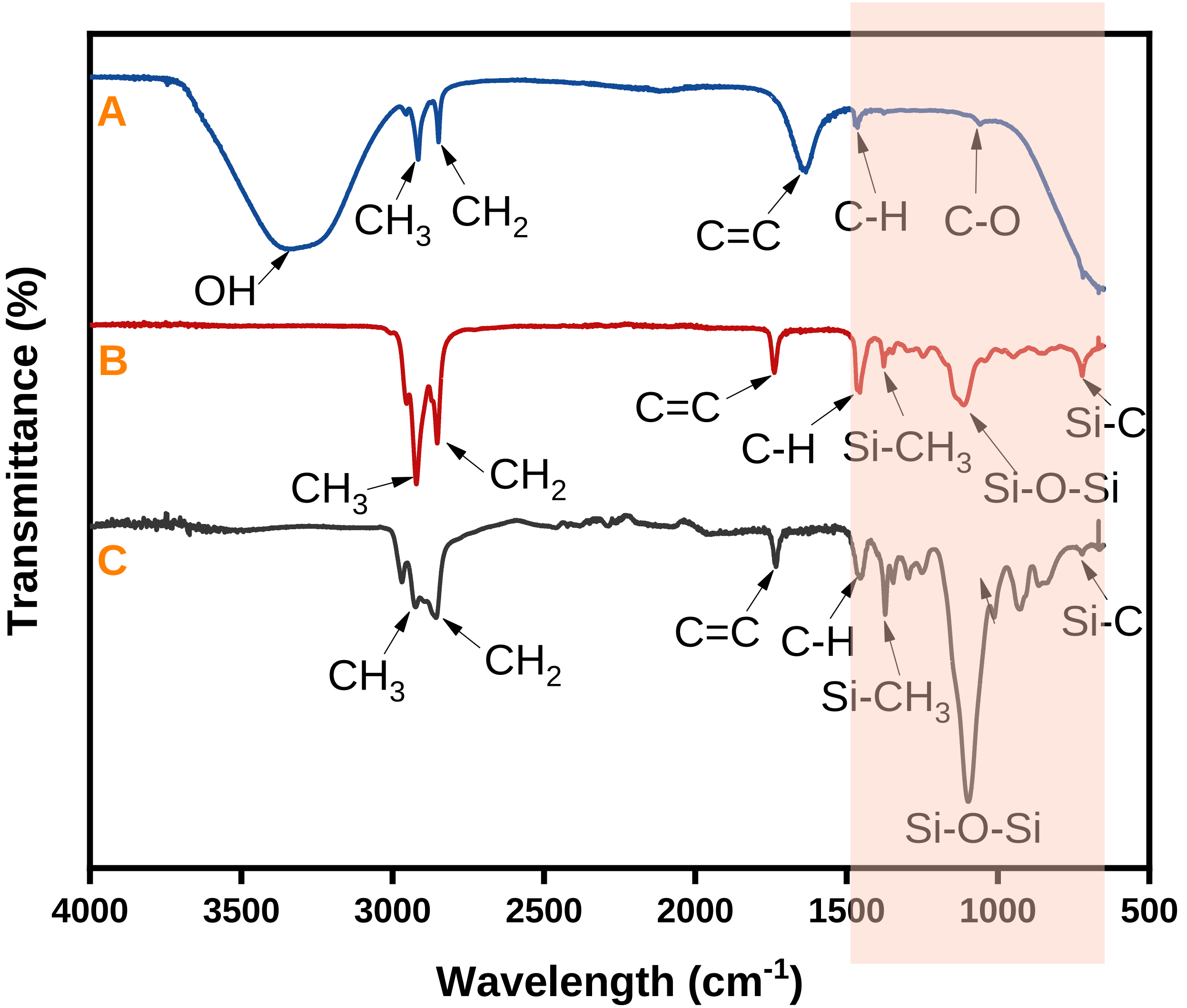
50 mg/L PFOA +
10, 50
, or 500 mM
Na_2SO_4

Magnetic
Stirrer
700 rpm

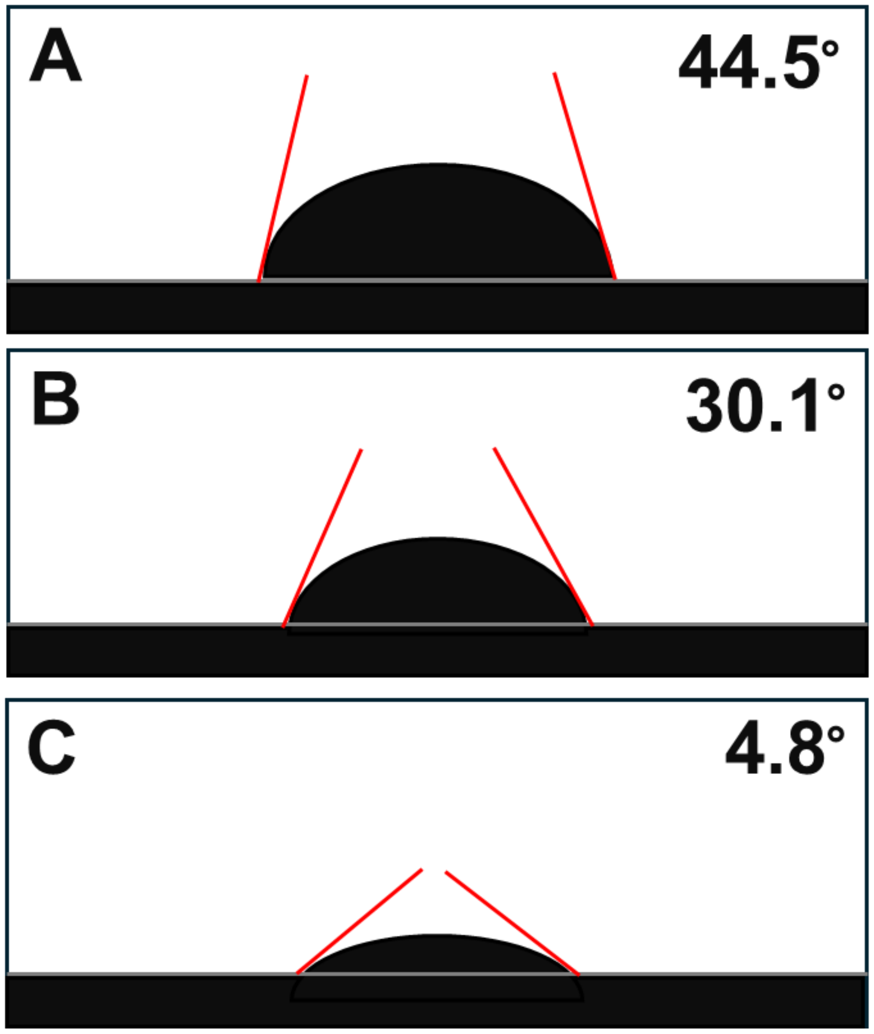


High-Pressure Liquid
Chromatography
Analysis (HPLC)

Defoamer Characterizations



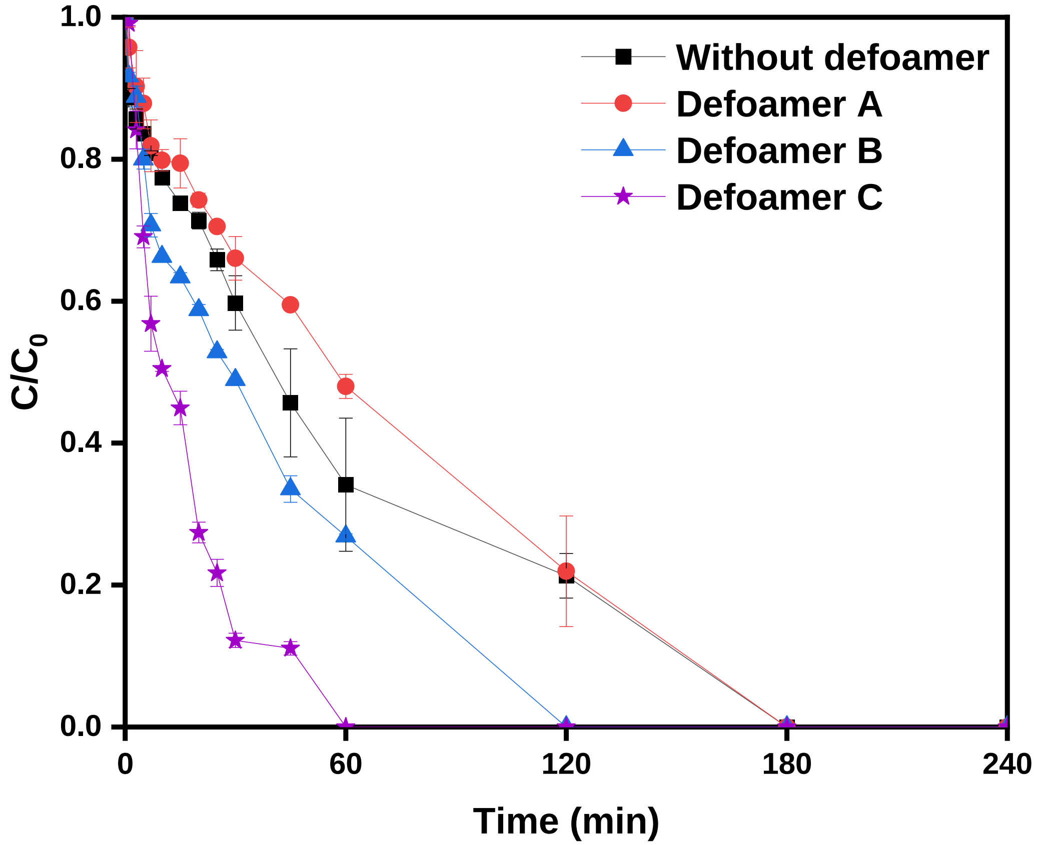
➤ FT-IR spectrum for the selected defoamers



➤ Surface contact angle for the selected defoamers

Results and Discussions

➢ **Objective #1:** Examine the impact of **defoamer type** (hydrophilic vs hydrophobic) on the degradation efficiency of PFOA during EAOP.



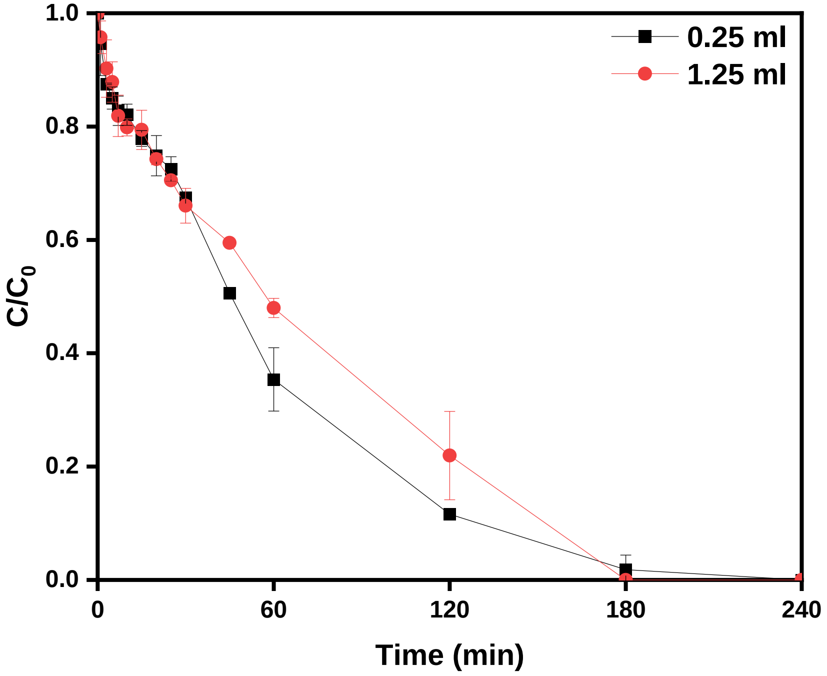
➢ **Defoamer C** (more hydrophobic) facilitated the degradation of PFOA

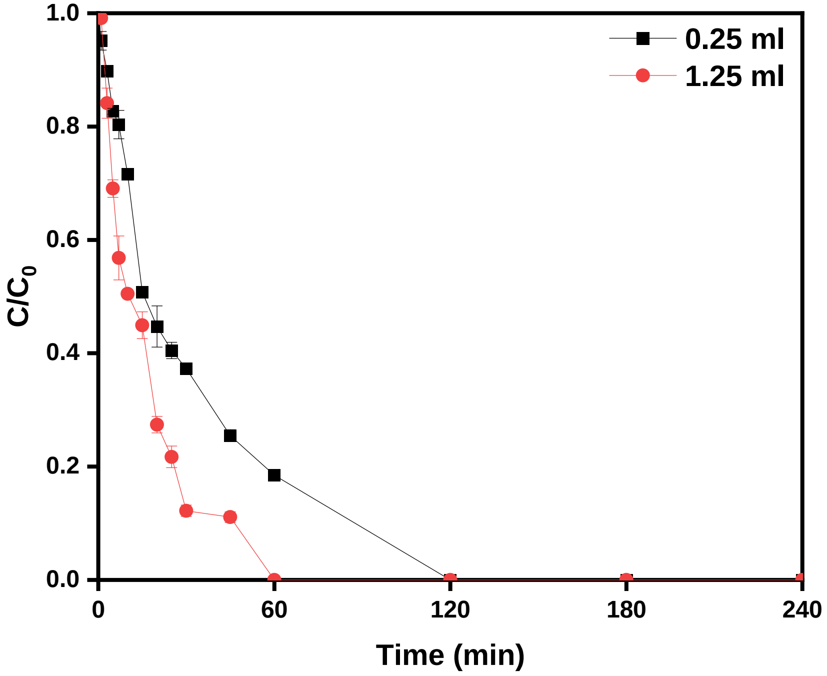
Results and Discussions

- **Objective #2-a:** Investigate the influence of **operational parameters** on the degradation efficiency of PFOA during EAOP.

Defoamer Dose Effect

Defoamer A vs. **Defoamer C**



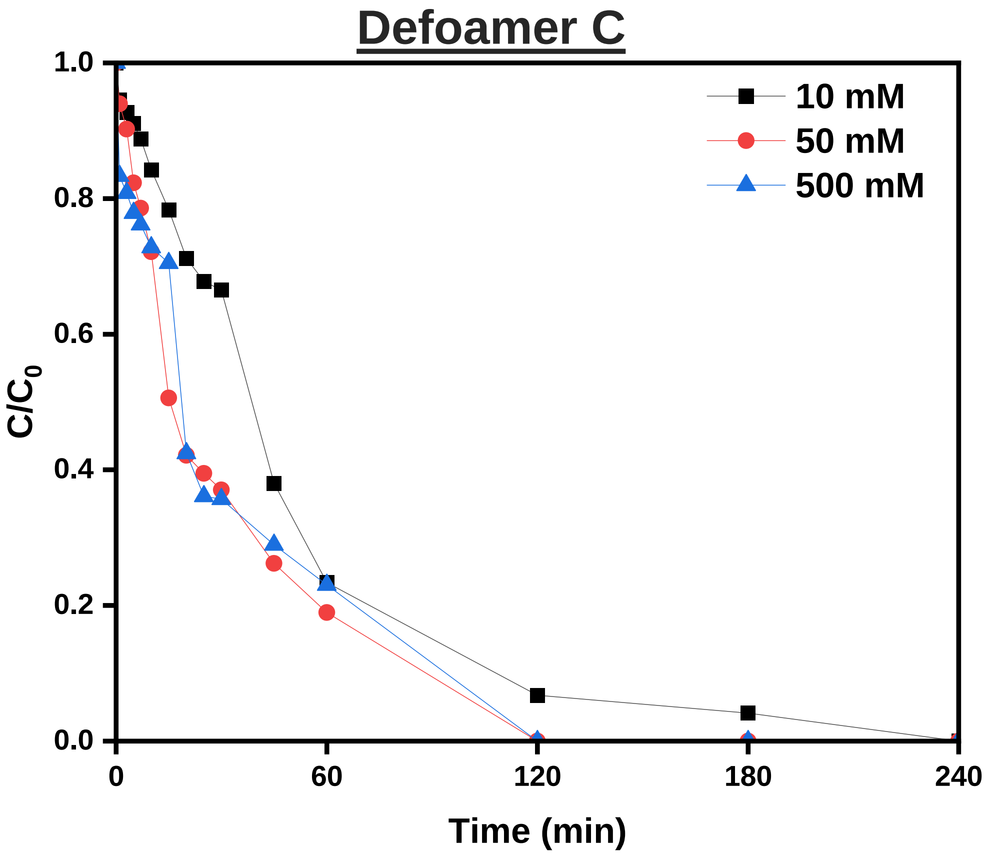


- There is no or little impact of increasing Defoamer A (***less hydrophobic***) dose on PFOA degradation
- Defoamer C (***more hydrophobic***) shows a higher efficiency for the degradation of PFOA under its high dose

Results and Discussions

➢ **Objective #2-b:** Investigate the influence of **operational parameters** on the degradation efficiency of PFOA during EAOP.

Electrolyte *Dose Effect*



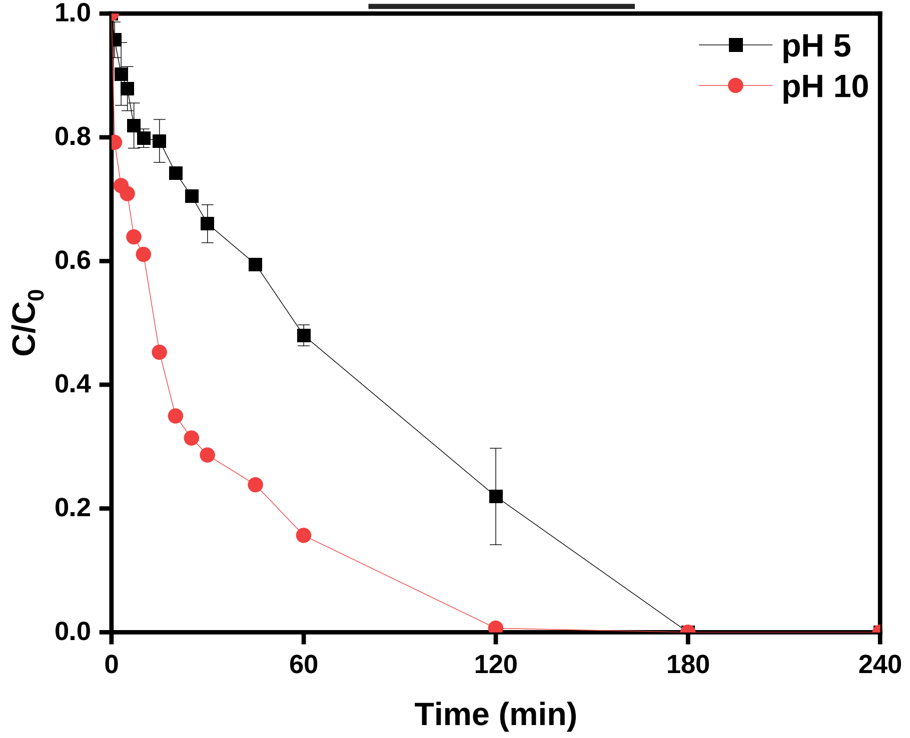
➢ **Increasing the electrolyte concentration** increased the degradation efficiency of PFOA

Results and Discussions

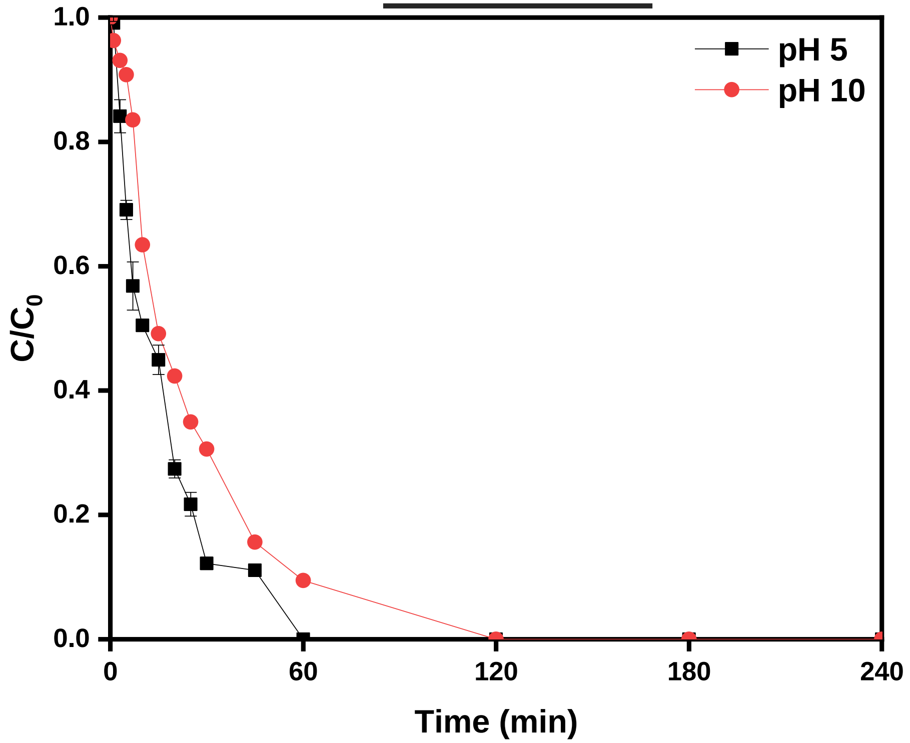
➢ **Objective #2-c:** Investigate the influence of **operational parameters** on the degradation efficiency of PFOA during EAOP.

pH *Effect*

Defoamer A



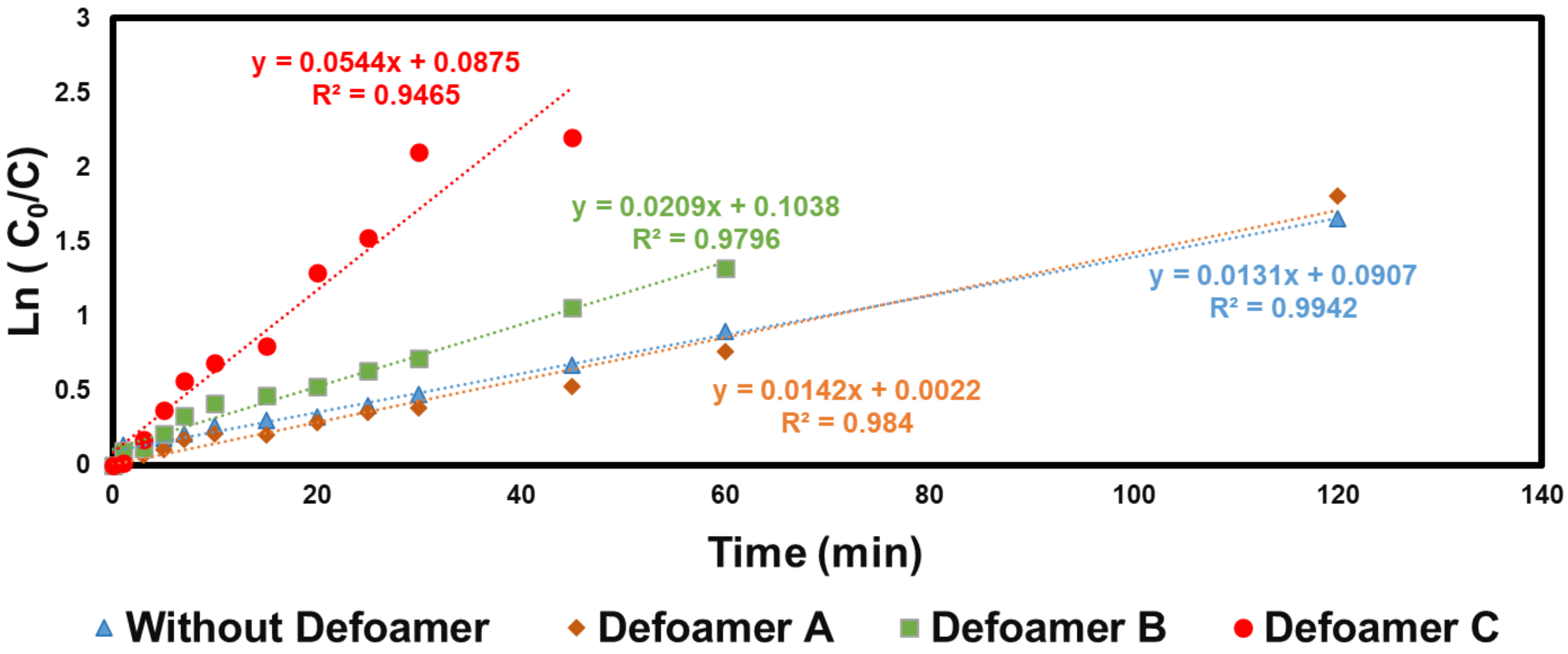
Defoamer C



➢ **In the presence of Defoamer C (hydrophobic), decreasing pH increased the degradation efficiency compared to Defoamer A (relatively hydrophilic).**

Results and Discussions

➢ **Objective #3:** Investigate the impact of defoamers on the **degradation kinetics** of PFOA during EAOP.



Without Defoamer	Defoamer A	Defoamer B	Defoamer C
K_1 = 2.2x10^{-4} s^{-1}	K_1 = 2.4 x10^{-4} s^{-1}	K_1 = 3.5 x10^{-4} s^{-1}	K_1 = 9.1 x10^{-4} s^{-1}
49 kWh/m³			**11 kWh/m³**

➢ **PFOA degradation kinetics fit pseudo-first order, which were followed Defoamer C>B>A=without defoamer**

Key Findings

- In the presence of defoamers, complete degradation of PFOA were achieved within 1-3 hrs. of operating time. Defoamer C (more hydrophobic) facilitated EAOP destruction of PFOA.
- Increasing Defoamer C (hydrophobic) dosage, increased the degradation efficiency compared to Defoamer A (relatively hydrophilic).
- Increasing the electrolyte concentration increased the degradation efficiency of PFOA.
- In the presence of Defoamer C (hydrophobic), decreasing pH increased the degradation efficiency compared to Defoamer A (relatively hydrophilic).
- PFOA degradation kinetics fitted pseudo-first order model, which were followed Defoamer C>B>A=without defoamer.
- The calculated electrical energy consumption for PFOA degradation in the presence of Defoamer C was found to be 11 kWh/m^3 , compared to 49 kWh/m^3 in the absence of defoamer, indicating that this study offers a promising and energy-sufficient strategy for the treatment of PFAS-laden foam.

Future road map

- Conduct experiments in multi solute systems (in the presence of competing organics and inorganics).
- Conduct experiments with real foam fractionation waste obtained from wastewater treatment plants.

Epocenviro.com

Acknowledgement

Ersan Research Lab

American Water Works Association

Questions?

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