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Sonolytic and Photocatalytic Degradation of Per- and Polyfluoroalkyl Substances

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ABSTRACT

Per- and polyfluoroalkyl substances (PFAS) are a large group of chemical compounds, categorized by their fluorinated carbon chain. Due to their high chemical stability, they have been widely used in industry and consumer products, such as firefighting foams, non-stick coatings, cosmetics, textiles, and electronics. However, PFAS do not break down naturally due to their high chemical stability, which results in the accumulation of PFAS in the environment. This is very concerning, as there is growing evidence of a link between some PFAS and various diseases, such as diabetes and cancer[1].

There are many techniques that can be used to degrade PFAS, including incineration, sonolysis, electrochemical oxidation, and photocatalysis.[2] However, there are many different issues with each degradation technique. This research investigates sonolytic and photocatalytic degradation of PFAS.

Sonolysis (or ultrasonication) involves the use of an ultrasonic transducer to generate sound waves, which produces cavitation bubbles in the PFAS solution. These bubbles grow is size until they become unstable and collapse. The collapse of these cavitation bubbles generates high temperature (4000 K) and pressure (>100 bar), which is sufficient to break the strong carbon-fluorine bond.[3] The effect of ultrasonic frequency, PFAS type, and gas bubbling are investigated.

Photocatalysis uses light to generate electron-hole pairs from a semiconductor photocatalyst. Provided the redox potential of the photocatalyst is sufficient, these electrons and holes can then degrade the strong carbon-fluorine bonds.[4] Photocatalysis is an attractive degradation technique due to their low environmental impact and energy use. We have investigated the addition of sacrificial donor molecules to increase degradation rate and also create secondary reactive species to enhance the degradation of PFAS.

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KEY WORDS

PFAS, Photocatalysis, Sonolysis, Ultrasonication, Degradation

BIOGRAPHY

Alex graduated from The University of Adelaide in 2020 from his Bachelor of Science (Advanced) (Honours). Following that he worked at Intertek, testing agricultural produce for pesticides, heavy metals and toxins, along with any other tests required.

Alex returned to The University of Adelaide in 2024 to conduct research into upscaling a PFAS remediation process for Enviropacific Services, aiming to capture and completely destroy PFAS from contaminated sites. He enjoyed this research so much, that in 2025, he decided to start his PhD, looking at advanced catalytic reduction processes for the breakdown of PFAS.

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