Project proposal by Dr Tapas Sen for the application of summer internship 2024 Miss Ashley Jane

Title of the project: A photocatalytic decomposition study of C-F bonds presence in "Forever Chemicals" using functionalised titanium dioxide conjugated magnetic iron oxide nanocomposites

Background and importance: "Forever Chemicals" are mainly per-and polyfluoroalkyl substances (PFAS), which are highly toxic. They are called forever chemicals as they don't degrade or breakdown in natural environment and / or in our body. Therefore, they can stay forever and pose serious health risks including cancer, thyroid disease, and fertility problems as well as developmental defects in unborn children. These chemicals are widely used in our daily commodities such as cosmetics, food packaging, household paints, cookware to almost all non-strain waterproof products. Once they enter our environment via landfill waste, they spread through air and water. Their presence has been detected in food, soil, marine products and drinking water in all over the world. The current acceptable limit of PFAS in UK drinking water is 100 ng/L, with levels below 10 ng/L considered low risk. The EU maintains a collective PFAS limit of 100 ng/L, while the USA has set a limit of 4 ng/L for individual PFAS components, following extensive research and considering public health implications. In response to the higher acceptable limits of specific PFAS in drinking water in UK, Royal Society of Chemistry has raised a public awareness about the need for a new PFAS limit in UK[1] in a report "Forever Chemicals in Water- New PFAS limit needed to protect our health". This call for change comes in response to recent analysis which has revealed that 35 and 37 percent of water courses tested in England and Wales contain medium or high-risk levels of most common PFAS such as perfluoro octane sulphonic acid (PFOS) and perfluoro octanoic acid (PFOA).

In the **proposed project**, the student will use titanium dioxide conjugated magnetic iron oxide nanocomposites as photocatalyst under the exposure of UV light to decompose C-F bonds presence in perfluoro octanoic acid (PFOA) both in water and in surface adsorbed states followed by magnetic separation (see Figure 1). The magnetic nanomaterials can then be reused instead of being discarded as solid waste, which helps prevent environmental pollution.

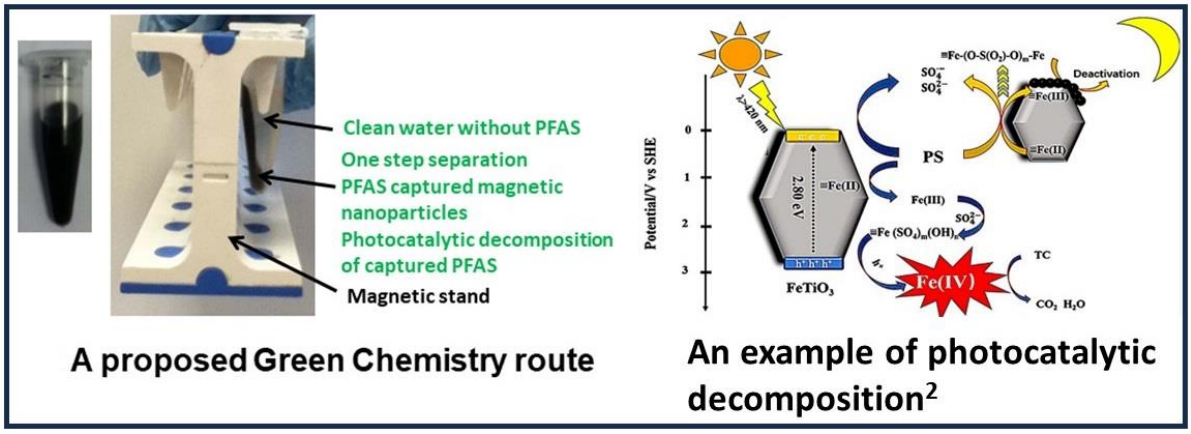

Figure 1. A green chemistry route for the separation and decomposition of C-F bonds of Forever Chemicals

The proposed project has built upon our recent research on photocatalytic decomposition of organic pollutants from water[2,3] as a part of our long-standing collaboration with China and India, funded by British Council Going Global programme. Currently, this project will run alongside with our two ongoing projects and one recently funded project with India and China. An experienced research assistant (Mrs Faryal Mehr) is currently working in our on-going projects involving functional magnetic nanomaterials for wastewater treatment who will be supporting the student during the summer if successful.

Overall aims: The primary goal of this project is to find a cost-efficient laboratory sustainable **Green Chemistry** route for the **breaking down** of C-F bonds in Forever Chemicals from our environment using nanotechnology and **mitigate the risk of their exposure** to living bodies with extreme health hazards.

The **main objective** of the proposed project is to test the **photochemical decomposition of C-F bonds** of PFOA in water of known concentrations under UV light involving previously developed titanium dioxide (TiO_2) conjugated magnetic iron oxide nanoparticles (Fe_3O_4) in our laboratory.

Methodology: The research methodology involved C-F bonds cleavage of PFOA from contaminated water of concentration 100 ppb using already developed TiO_2 conjugate Fe_3O_4 nanocomposites. The project work has been divided into four important tasks.

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Task1: Health, Safety and Risk assessment training
Task 2: Photocatalytic decomposition of captured PFAS by UV light (λ_{max} of 387 to 450 nm) at variable times of exposure
Task 3: Analyse the fluoride ions concentration in water by recently purchased fluorometer (Fisher Scientific) as a part of our on-going Going Global UCLan-China project.
Task 4: An oral presentation and a short report

Project timeline

Task description	**Week number**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Task 1: Health, Safety and Risk assessment training								
Task 1: Photocatalytic decomposition of C-F bond presence in PFOA								
Task 2: Fluoride ion analysis is solution following task 2 after magnetic separation								
Task 4: An oral presentation and a short report								

Indicate task active

How the intern will support:
The intern will support our team as a part of our ongoing projects working alongside a research assistant, a PhD student, and a senior research associate. The results from this proposed project will help us to verify the proof of concept and may help us to submit a manuscript in a Peer-Review journal.

How the intern will be supported:

- One-to-one meeting (Friday morning 1 hr, every week) to discuss project progress and planning for next week. Intern will be asked to write the work plan, experimental details, experimental observation with full integrity in a laboratory notebook. Regular feedback will be given based on the ability to maintain accurate and comprehensive records of the work undertaken, analysis of data and follow-up plan.
- Informal laboratory meetings and discussion with laboratory members
- Training on Fluorometer by Mrs Faryal in the research laboratory, located in J B Firth Building, room JBF309
- To develop skills such as (a) *presentation skill* at week 8 (b) *team working and communication skill* by working with other team members (c) *networking skill* by attending an international workshop on 3rd July 2024 at the university of Central Lancashire as a part of our ongoing projects (d) scientific *writing skill* by providing feedback to final report (e) *computing and IT skill* by attending online Library and Information services (LIS) courses such as Web of Science and Endnote.
- Pastoral and other issues such as (a) to follow university health and safety as a maximum priority (b) to exercise professionalism and to be sensitive to the needs of colleagues with whom facilities are shared (c) to communicate in a professional manner with any sponsors and acknowledge appropriately (d) to respect confidentiality (both professional and commercial) while pursuing the research using absolute discretion and integrity.

Expected outcome:

- A poster presentation in an international workshop “Beyond Boundaries: An International Workshop on Global Policy for pollutants in water including forever chemicals” on 3rd July 2024, organising by Dr Tapas Sen at the University of Central Lancashire, Preston as a part of 3 international projects with China and India along with policy makers from Royal Society of Chemistry and UK Government agencies.
- A partial contribution to submit a Peer-Review journal article
- A partial contribution to a proposed impact case study for REF 2029

Current Funding: Laboratory consumables and equipment running cost (~ £1500) will be covered from our 2 on-going international projects and a recently granted project by British Council Going Global programme.

References:

1. https://www.rsc.org/policy-evidence-campaigns/environmental-sustainability/sustainability-reports-surveys-and-campaigns/cleaning-up-uk-drinking-water?utm_campaign=pfas&utm_source=maxemail&utm_medium=email&utm_content=tgroup_members;
2. Pan L, Shi W, Sen T, Wang L, Zhang J, “Visible light-driven selective organic degradation by FeTiO3/persulfate system: the formation and effect of high valent Fe (IV)” ***Applied Catalysis B: Environmental***, 280, 119414, 2021 **(IF: 21.2)**
3. Lu L, Teng F, Sen T, Qi D, Wang L, Zhang J, “Synthesis of Visible-Light Driven CrxOy-TiO2 Binary Photocatalyst Based on Hierarchical Macro-Mesoporous Silica” ***Applied Catalysis B: Environmental*** 163, 9-15, 2015 **(IF: 21.2)**