Ratiometric detection of perfluoroalkyl carboxylic acids using dual fluorescent nanoparticles and a miniaturised microfluidic platform [1]

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Per- and polyfluoroalkyl substances (PFAS) are a group of chemicals with fluorinated carbon chains, including perfluorocarboxylic acids (PFCAs) such as perfluorooctanoic acid (PFOA). Extensive industrial use, particularly in Teflon production, has led to widespread environmental contamination. PFAS are highly persistent, bioaccumulate, and are now found globally in water, soil, and living organisms. Due to their toxicity, PFOA and related compounds were listed as persistent organic pollutants under the Stockholm Convention in 2019, prompting increased monitoring in water sources.[2]
According to the current state of the art, PFAS are predominantly analyzed using chromatography techniques coupled to mass spectrometry, such as GC-MS, HPLC-MS, tandem HPLC-MS/MS, or HRMS.[3] While these methods offer excellent sensitivity down to the ppt range, they are time-consuming, costly, and require laboratory infrastructure and trained personnel, limiting their use for on-site or routine monitoring, for example at industrial sites or wastewater treatment plants. In contrast, fluorescence assays provide a simpler, portable, and cost-effective alternative with rapid response and high sensitivity, particularly when analyte binding enhances probe emission. Integrating such probes with suitable carrier platforms and miniaturized optofluidic devices represents a promising approach for point-of-need PFCA monitoring.
In this study, we present the development of a green-fluorescent guanidine-BODIPY indicator monomer incorporated into a molecularly imprinted polymer (MIP) for the selective detection of perfluorooctanoic acid (PFOA). Analyte binding induces a fluorescence enhancement, enabling sensitive detection. The MIP is deposited as a thin layer on silica nanoparticles doped with tris(bipyridine)ruthenium(II) chloride, which provides an internal orange-emitting reference and improves measurement precision. In combination with a liquid–liquid extraction protocol, the system allows direct detection of PFOA in environmental water samples with a detection limit of 0.11 μM. Integration into an opto-microfluidic platform further enables rapid and user-friendly analysis within 15 minutesn (Figure 1).

Keywords:
Molecularly Imprinted Polymers (MIPs), Fluorescence, Microfluidics, Onsite assay, PFAS

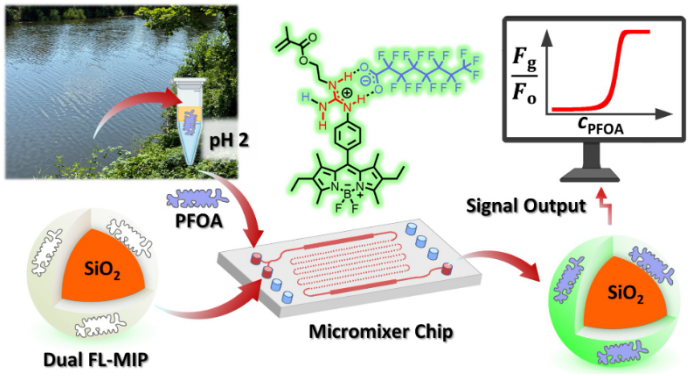

Figure 1: Scheme of miniaturized device for detection of PFOA with MIPs.

References:

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