एआईई संवेदक का उपयोग करते हुए ट्रेस थोरियम (IV) हेतु सरल क्यूवेट-आधारित प्रतिदीप्ति विवरण

थोरियम के लिए जल-विलेय प्रतिदीप्ति संवेदक

Simple Cuvette-Based Fluorescence Readout for Trace Thorium(IV) Using an AIE Sensor

Water-Soluble Fluorescence Sensor for Thorium

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Thorium (Th) is a naturally occurring element of strategic relevance to India's nuclear energy programme, therefore, accurate Th(IV) detection in water underpins radiation surveillance, environmental stewardship, public health assurance, and the safe, sustainable utilisation of thorium within the Department of Atomic Energy's initiatives. While techniques such as ICP-MS provide excellent sensitivity, they are infrastructure-intensive and less suited to rapid, on-site screening.

In our newly published study, we report a dicarboxylated tetraphenylethylene probe (TPE-DCA) that enables selective, "turn-on" detection of Th^{4+} directly in 100% water via aggregation-induced emission (AIE). TPE-DCA is weakly emissive when molecularly dispersed. Upon Th^{4+} coordination to its carboxylate groups, charge neutralization and coordination-driven cross-linking trigger aggregation, restrict intramolecular motion, and switch the fluorescence "on". This produces an ≈180-fold emission enhancement at 490 nm. The sensor operates near neutral pH (≈5–6) and achieves a detection limit of 11 nM (≈3 ppb), well below the WHO guideline value for drinking water (245 ppb).

The probe shows negligible interference from competing ions, including lanthanides and uranium, and performs robustly in tap water, lake water, and undiluted seawater. Mechanistic validation using steady-state and time-resolved fluorescence, UV–vis absorption, FTIR, dynamic light scattering, SEM-EDS, and DFT calculations confirms Th–carboxylate coordination and nanoscale aggregate formation. Overall, this water-only AIE platform provides a simple, field-relevant strategy for routine thorium monitoring and a transferable design principle for actinide sensing in complex aqueous matrices. Because the response is a clean fluorescence turn-on in a cuvette-friendly format, it is readily compatible with compact fluorimeters or mini-spectrometers for on-site screening.

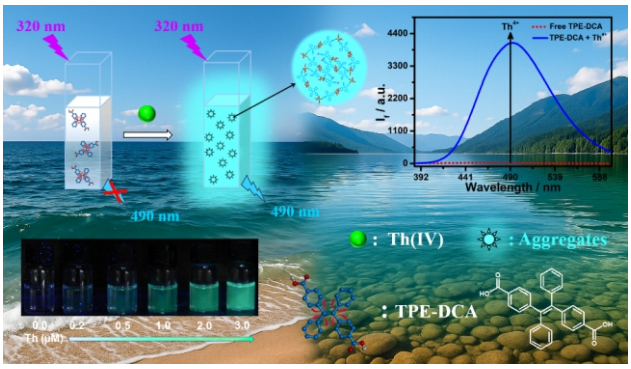

Figure: Schematic representation of Th(IV)-induced aggregation of TPE-DCA and the molecular structure of TPE-DCA (Small, 2025, DOI: 10.1002/smll.202508399).

Reference:

M. Ghosh, S. S. Kadlag, K. K. Swain, A. Ghosh, A. K. Sahu, P. K. Singh*, "Bright and Selective: A Dicarboxylate-Functionalized AIE Sensor for Th^{4+} in 100% Water with a Sub-ppm Level Sensitivity", Small (2025), DOI: 10.1002/smll.202508399.

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