Molecularly Imprinted Polymer (MIP)-Based Electrochemical Sensor for Rapid Detection of PFAS on Site

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Background. Poly- and per-fluorinated alkyl substances (PFAS) are a human health concern that have been found in water supplies around the world. The current testing paradigm is to collect samples of water and send them to third-party laboratories for liquid chromatograph-tandem mass spectrometry (LC-MS/MS) analysis. This testing is costly and the turnaround time for results can be weeks to months. Thus, there is great need for a low-cost, rapid, in-field screening sensor for PFAS. A sensor would enable targeted screening to reduce the number of samples sent for LC-MS/MS analysis, inform destructive remediation technologies of their progress on site, and alert water treatment plants when PFAS escapes their granular activated carbon (GAC) or ion exchange resin (IX) systems.

Approach. Molecularly imprinted polymers (MIPs) are polymers created in the presence of a specific analyte, known as a template. The template and polymer monomers establish attractive intermolecular forces that are maintained during the polymerization, creating sites with high specificity towards the template. The template is then removed through washing, resulting in a material with a lock-and-key binding mechanism for the chosen template. These polymers can be controllably generated on an electrode surface via electropolymerization. The templated MIP acts as an insulator, limiting current at the electrode surface. When the template is removed, the current increases because an electron mediator can access the electrode through the empty binding sites. When the MIP encounters the template molecule (e.g., PFOS), sites in the MIP become occupied, blocking access to the electrode surface and decreasing the current sigmoidally with concentration. However, when a group of molecules share similar chemical properties, such as PFAS carboxylic acids and sulfonic acids, the MIP will interact with the whole family of compounds instead of the individual template. This has led to a prototype sensor capable of detecting PFOS and PFOA in simulated water samples as a preliminary step towards developing a total PFAS sensor for near real-time, on-site testing.

Results. Currently, several sets of data have been generated showing the sensors' response to part-per-trillion (ppt) concentrations of PFOS in electrolyte heavy water. Additional tests have shown that the sensor responds equally to PFOA. Preliminary data comparing the sensor's response to validated PFAS containing samples from Cape Cod has also been demonstrated. By the time of the conference, we expect to have additional data with PFOA, a simulated "total" PFAS reading based on PFOA and PFOS, and additional validation of the sensor against real-world samples.