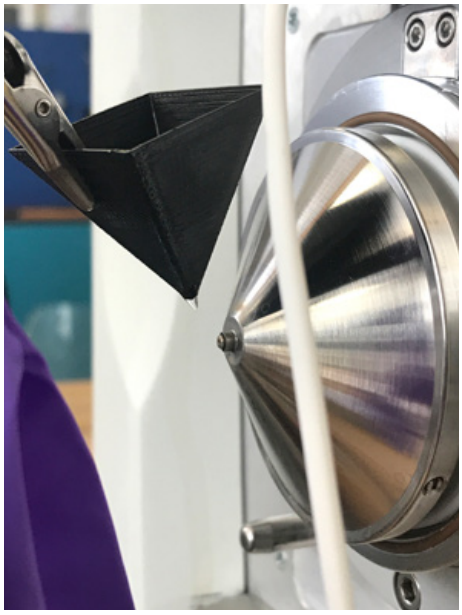
PROJECT ID:
605

3D Printed Cone Spray Ionization Mass Spectrometry for the Rapid, Low-Cost, and In Situ Detection and Mapping of PFAS in Soil



Analysis of PFAS in bulk soil by 3D-printed cone spray ionization mass spectrometry.
(Photo Credit: Patrick Fedick)

OBJECTIVE

This project has four objectives: to compare 3D printed cone spray ionization mass spectrometry (3D PCSI-MS) to traditional liquid chromatography mass spectrometry (LC-MS) methods, to develop an autosampler for easier sampling, to field test the new methodology and develop a robust standard operating procedure (SOP).

PROBLEM STATEMENT

Per and polyfluoroalkyl substances (PFAS) are a group of chemicals that have become widespread and persistent compounds at Department of Defense sites primarily due to their use in aqueous film-forming firefighting foams. Traditional analysis methods for PFAS detection utilize time-consuming extraction methods followed by lengthy chromatographic separations with mass spectrometry detection. To overcome these issues, cone spray ionization (CSI) consisting of a three-dimensional cone fabricated by folding filter paper, allows solid samples to be placed within the hollowed compartment. Solvent is applied to the solid sample, where liquid extraction occurs. At the tip of the cone a small hole allows the passage of the PFAS while retaining the soil. A high voltage is applied to ionize the analyte, which is then analyzed by the mass spectrometer (MS). While traditional CSI excels at analyzing solids, reproducibility can be a limitation due to variability of the manual cone construction.

DESCRIPTION

To increase ease of analysis and reproducibility, this team is using a 3D printed CSI (3D-PCSI) which incorporates a 3D printer to create rigid plastic cones. The mechanism of ionization for 3D PCSI-MS is identical to the paper CSI-MS technique, but the addition of the rigid cone eliminates the time-consuming construction of a paper cone.

This project will apply 3D PCSI-MS for infield sampling across three naval installations, all with varying soil compositions, environment conditions, and PFAS origin. The process will be improved through the construction of an autosampler, using commercial

off-the-shelf (COTS) parts and a custom 3D printed platform to hold 6-8 cones at a time. While the first cone in the spray position is analyzed, a COTS syringe pump will dispense the proper volume of extraction and spray solvent. Once dispensed, the spraying cone will rotate to the right and can be removed. The autosampler should not only mitigate any alignment issues but also increase the overall throughput of 3D PCSI-MS.

A second overall improvement will be expanding the types of analyses 3D PCSI-MS can perform through the addition of a triple quadrupole mass spectrometer, which is ideal for quantitation. When complete, the 3D PCSI-MS will be compared to traditional LCMS analysis.

RETURN ON INVESTMENT

Traditionally, each sample could cost upwards of $500.00 and the turnaround time can be weeks. The throughput of 3D PCSI-MS is at minimum 30 times faster than traditional chromatography MS. This is a major return on investment as labor costs and analysis times are typically the largest long-term cost.

The lack of chromatography makes the portable MS cheaper and easier to maintain, and it can be transported from site to site as needed, whereas traditional methods are stationary. The remaining consumables, 3D printer and analysis software are minimal, making the real initial investment the instrumentation followed by labor costs.

NAVY BENEFITS

The rapid sampling and analysis afforded by 3D PCSI-MS enables multiple sites, across multiple bases and services to be screened in minimal time on one single device. MS techniques are the gold standard for many environmental analyses and 3D PCSI-MS will not only be able to perform the proposed PFAS analysis but could also be utilized for other environmental evaluations, with new and emerging compounds added to the database for easy postprocessing and identification.

TRANSITION DESCRIPTION

At the end of the third year, a full SOP will be published to instruct operators on the proper sampling technique, solvent addition, and analysis. The SOP detailing simple construction, user-friendly operation, and evaluation will be readily disseminated and designed for individuals who are not trained in ambient ionization to easily incorporate 3DPCSIME into their analytical workflow.

Primary Navy users include ports, airfields, remediation sites where AFFF has beensprayed, as well as AFFF test facilities.

CONTACT

For more specific information about this project, contact the Principal Investigator at 760-939-1590.

ABOUT THE NESDI PROGRAM

The Navy Environmental Sustainability Development to Integration (NESDI) program is the Navy's environmental research and development demonstration and validation program, sponsored by OPNAV N4I Installations Division and managed by the Naval Facilities Engineering Systems Command from the Engineering and Expeditionary Warfare Center in Port Hueneme, CA. The mission of the program is to provide solutions by demonstrating, validating and integrating innovative technologies, processes and materials and by filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring Navy readiness and lethality.

For more information, visit the program's web site at www.navfac.navy.mil/nesdi or contact Ken Kaempffe, the NESDI Program Manager at 805-982-4893, DSN: 551-4893 or kenneth.c.kaempffe.civ@us.navy.mil.