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The Porous Extraction Paddle: A Non-Targeted Sampling Device to Detect Contaminants in Urine

A new tool and accompanying method provides an easy way to extract substances from urine, even where resources are limited. The non-targeted technique, developed by researchers at the Northeastern University Superfund Research Program (Northeastern SRP), can reveal large numbers of exposures to substances foreign to the body, called xenobiotics, from a sample of urine.

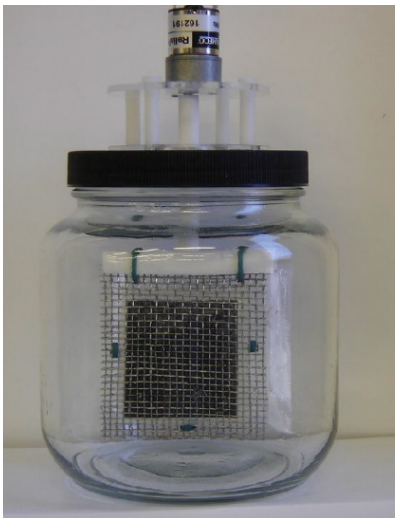
Researchers led by Roger Giese, Ph.D., developed a porous extraction paddle (PEP) for simple solid-phase extraction of urine samples. They also applied their new method to analyze a wide range of compounds in urine that are most likely to affect the human body. According to the researchers, this technique will be helpful in conducting metabolomics studies, or studies of the chemical fingerprints left behind after the body metabolizes compounds. Identifying these metabolites and linking them to xenobiotic exposure may improve our understanding of the exposome, which is the measure of a person's lifelong exposure to all xenobiotics.

Developing a Tool to Analyze Chemicals Offsite

As part of the Northeastern SRP Puerto Rico Testsite for Exploring Contamination Threats (PROTECT) Center, researchers were confronted with the challenge of identifying environmental chemicals that pregnant women are exposed to in a Puerto Rico cohort. To do this, they needed to identify xenobiotics in urine samples from the women. Because storage and shipment of large volumes of urine from Puerto Rico to their lab was unrealistic, they developed the PEP for simple solid-phase extraction outside of the lab.

To assemble the PEP, a porous bag, much like a tea bag, is filled with solid-phase extraction particles and then flattened and immobilized between two pieces of stainless steel mesh to form the "paddle." This paddle is attached to a stirring motor, and the assembly is screwed onto a jar containing the urine sample and plugged into an electrical outlet. As the apparatus with the motor stirs the paddle in the sample, a wide range of compounds move from the urine into the PEP bag. The compounds collected in the small bag can then easily be shipped to the laboratory for analysis, making it easy to use away from the lab, such as at clinics and during in-home visits.

In the lab, scientists can easily elute the compounds from the PEP so they can be analyzed by a laboratory mass spectrometry method or stored for later analysis. Researchers reported that they were able to extract a diversity of compounds that are at least partly nonpolar in urine, a property shared by many xenobiotics.



The PEP assembly includes a small bag (6 x 6.5 cm) containing particles that adsorb nonpolar xenobiotics, which is wedged between two pieces of stainless steel mesh to facilitate stirring. The PEP assembly can be screwed onto a half-gallon jar containing urine. The stirring motor stirs the PEP in the urine, which collects xenobiotics from the sample. (Photo courtesy of Roger Giese)

Applying the Technique to Facilitate Exposome Research

When nonpolar xenobiotics enter the body, they are likely to enter cells and are often partly metabolized into sulfates that are excreted in the urine. Because of this, testing the urine nonpolar sulfateome can enable discovery of contaminants to which a person was exposed. Using the PEP, the researchers developed a method to extract and measure the broad range of sulfates in urine.

From a collection of urine samples from six pregnant women, the researchers measured 1,129 sulfate compounds. Using a database, they determined candidate compounds associated with these sulfates for 35 xenobiotic contaminants, along with a number of steroids and flavonoids. The contaminant compounds included phthalates, herbicides, and pesticides.

According to the researchers, the method provides a strategy to discover the wide range of nonpolar xenobiotics to which humans are exposed, providing a pathway to understand some of the nonpolar xenobiotic exposome. By measuring the wide range of exposures in a non-targeted way and collecting subsequent health data, researchers may be able to find new associations between exposures and health outcomes. In the PROTECT study, the researchers are currently using this method to collect samples from pregnant women in Puerto Rico, with the long-term goal of discovering xenobiotics that contribute to preterm birth. They are also using the technique similarly to extract groundwater samples in Puerto Rico, toward the goal of discovering Superfund contaminants to which pregnant women are exposed.

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To learn more about this research, please refer to the following source:

Shao G, MacNeil M, Yao Y, Giese RW. 2016. Porous extraction paddle: a solid phase extraction technique for studying the urine metabolome. Rapid Commun Mass Spectrom 30(23):2462-2470. doi: 10.1002/rcm.7739 PMID: 27624170

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