Hello, this is Kevin O'Donovan, and I'd like to welcome you to the National Institute of Environmental Health Sciences Superfund Research Program monthly Research Brief podcast.

This month, we're discussing a new highly sensitive on-chip nanoparticle immunoassay.

The Research Brief, Number 216, was released on December 5, 2012, and was written by SRP contractor Marisa Naujokas in conjunction with SRP-supported researcher Ian Kennedy.

A breakthrough in bioassay technology allows detection of attomolar concentrations of biomolecules on a microchip. This concentration (10^{-15} mol/m^3) is equivalent to measuring grains of salt in 10 tons of potato chips. This new nanotechnology approach to detecting proteins and other compounds increases sensitivity more than 1,000-fold over conventional assays, and yet is affordable and easy to use. Developed by researchers at the University of California – Davis Superfund Research Program, the assay could have a transformative impact on investigations in environmental health, food sciences, and medicine.

Immunoassays are a type of bioassay that use antibodies (proteins produced by the immune system) that serve as tags by binding to the molecule or analyte of interest with a high degree of specificity. Concentrations of analytes are measured by the release of light-emitting photons from fluorescent dyes. Immunoassays were taken to a much smaller scale – the nanoscale – in a new system developed by Ian Kennedy, Ph.D., and his engineering team together with immunoassay biologists in the lab of Bruce Hammock, Ph.D., both at UC Davis. A collection or array of nanoscale wells, each containing a single antibody-coated nanoparticle, was used to detect analytes, and the number of photons emitted per second was measured one photon at a time. The optimum nanoparticle size was 40-100 nm for use with visible wavelengths of fluorescence. For a sense of scale, a strand of human DNA is 2.5 nm in diameter (1 nm = 10^{-9} meters, or 1 billionth of a meter).

As presented in the November 2012 issue of ACS NANO, Jin-Hee Han, Ph.D., a postdoctoral fellow in Kennedy's lab, developed the nanoparticle platform by using an electric field to drive antibody-coated nanoparticles into nanowells, creating a 2-dimensional array on a microchip that behaves as a photonic crystal. Photonic crystals are 3-dimensional structures that can manipulate the flow of light, or more specifically, photons, and enhance sensitivity. The nanoparticles in the new platform provide small, highly effective solid supports that overcome many shortcomings of other photonic crystal assays.

Even with nanoparticle advantages, the key challenge was to reduce background signals. Han and Lakshmana Sudheendra, Ph.D., now Associate Specialist at the UC Davis SRP, maximized sensitivity by matching the size of the particle to the size of the well, and optimizing the distance between wells for a given light source/dye/wavelength combination. The new assay detected human epidermal growth factor receptor 2, a breast cancer biomarker, at concentrations at least 1,000 times less than those measured in a conventional immunoassay.

This affordable, fast, easy-to-use immunoassay technology holds promise for a wide range of applications. The UC Davis team has several patents pending as they look toward commercializing the technology, as it could be a powerful tool for detecting a variety of analytes. Currently, immunoassays in development can detect Staphylococcal enterotoxin as well as Salmonella and E. coli in food, metabolites of pesticides in humans, and several live infectious disease pathogens.

This project highlights how successes can arise from engineers and biologists working closely to tackle challenges. “SRP does a great job of bringing engineers and biologists together in interdisciplinary research,” said Kennedy. “In this example, it really works.”

If you’d like to learn more about this research, visit the Superfund Research Program website at www.niehs.nih.gov/srp. From there, click on “Who We Fund” and follow the links to the University of California – Davis research summary. If you have any questions or comments about this month’s podcast or if you have ideas for future podcasts, contact Maureen Avakian at avakian@niehs.nih.gov.

Join us next month as we discuss more exciting research and technology developments from the Superfund Research Program.