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Detecting Environmental Chemicals with Novel Immunoassay Technology

A new low-cost portable device uses a smart phone to detect the presence and concentrations of BDE-47 (2,2',4,4'-tetrabromodiphenyl ether), a type of flame retardant and widespread environmental contaminant. The device uses a lab-on-a-chip (LOC) platform to perform microscale enzyme-linked immunosorbent assays (ELISA), a popular lab technique that uses antibodies designed to measure a specific substance in a sample. The LOC platform performed comparably to the standard ELISA laboratory protocol, but in much less time and with much smaller sample sizes.

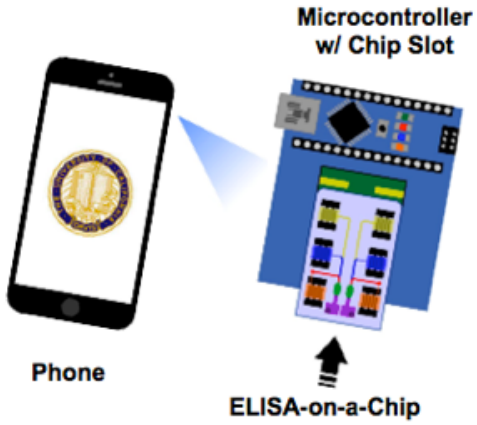
The system, developed by researchers led by Tingrui Pan, Ph.D., at the University of California (UC) Davis Superfund Research Program, is cost-effective, easy-to-use, and widely accessible. It can be used to detect levels of BDE-47 in human samples, such as blood, as well as in liquid samples from the environment. It can also be applied to other chemicals, facilitating mobile detection of health and environmental contaminants in rural or less developed regions.

The Innovative LOC Device

The device consists of a hand-held microcontroller, which is powered by a smartphone. The microcontroller has a printed circuit board designed to perform ELISA operations and contains a slot in which the user can insert a chip specific to the chemical being detected.

In this study, the researchers developed an ELISA chip to detect BDE-47 using variable domains derived from heavy chain antibodies (VHH). These VHH antibodies, which are found in alpacas, can be easily manipulated using molecular biology to bind specifically to chemicals such as BDE-47 in the lab.

The chip contains electrodes and pumping mechanisms that replicate an ELISA procedure on a microscale. Carbon black was mixed with polydimethylsiloxane to create the electrodes. These electrodes are in contact with copper electrodes on the device to power the electrolysis micropumps that transport BDE-47 through the system for detection. Carbon black composite electrodes allow the device to be low-cost, low-power, disposable, and less susceptible to electrochemical degradation than traditional metal electrodes.



The integrated mobile-interfaced point-of-care system includes the smartphone, a microcontroller with a chip slot, and the ELISA-on-a-chip. The smartphone not only powers the microcontroller, but is also used to record the image of the ELISA reaction. (Photo courtesy of Arnold Chen, UC Davis)

The ELISA reaction produces a visible signal that indicates the quantity of the chemical in the sample. The smartphone captures an image of the signal, which is then wirelessly transferred to a computer for processing.

Improving Efficiency and Ease of Use

With a readout time of 15 minutes, the LOC system not only measures chemicals in the field in human and environmental samples, it does so much faster than the traditional ELISA protocol, which typically takes at least 2 hours. The sample volume is also greatly reduced, from 50 microliters for laboratory ELISA to only 2 microliters in the LOC device. Using VHH, the researchers achieved comparable performance to the standard ELISA protocol and a detection range of 0.001 to 10,000 microliters of BDE-47 per liter, well within relevant levels in humans and the environment.

The device is not limited to BDE-47 and can be applied to a wide range of environmental contaminants by substituting different immunoassay antigen proteins on the removable chip. The low cost and mobility of the LOC allows point-of-care health diagnosis and environmental safety monitoring that may be widely and easily used. According to the authors, the potential impact in mobile detection of health and environmental contaminants will prove beneficial to our community and low-resource environments.

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For more information, please refer to the following source:

Chen A, Wang R, Bever CRS, Xing S, Hammock BD, Pan TR. 2014. Smartphone-interfaced lab-on-a-chip devices for field-deployable enzyme-linked immunosorbent assay. Biomicrofluidics 8: 064101. doi: 10.1063/1.4901348