DHS Science and Technology Directorate

Wearable Smart Chemical Sensor—Small, Rugged Monitor Warns First Responders of Toxic Exposure

Developing a Low-maintenance, Low-cost Sensor is Key to Protecting Responders from Exposure

Toxic industrial chemicals (TICs) are substances that produce toxic effects if encountered in sufficient quantities and/or for long durations. TICs are a great concern for the U.S. Department of Homeland Security (DHS) since they can be easier for terrorists to obtain and use than chemical warfare agents. First responders need a small, rugged, wearable monitor that can tell them when they encounter TICs, which substance is present and at what levels.

Commercially-available color-changing badges and tubes provide trace detection of many TICs of interest at low cost ($5-10), but they often involve extensive hands-on manipulation and chart read-outs. Some monitors exist that can detect multiple TICs; however, the cost is prohibitively high (more than $500). Hence, there is a need for a multi-gas sensor in wearable form that costs less than $50.

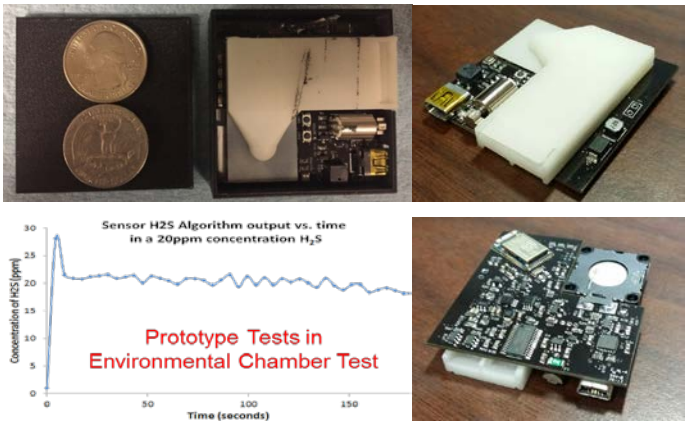
The DHS Science and Technology Directorate (S&T) is working with TDA Research, Inc. (TDA) through a Small Business Innovation Research (SBIR) award to develop a simple, inexpensive, wearable smart chemical sensor badge that has high sensitivity and selectivity to multiple TICs at trace (low parts per million or ppm) concentrations, and that triggers alarms at permissible exposure limits, short-term exposure limits and time weighted average concentrations.

As responders can easily be the first to encounter these materials, this new sensor will alert them to the presence, nature and magnitude of the threat.

Sensors are Applicable across the Homeland Security Enterprise and Private Sector

The wearable smart sensor badge uses a lab-on-a-chip (LOC), is smaller than 2” x 2” x 0.5”, can detect multiple TICs of interest and has a low rate of false alarms, so that easy and widespread deployment can be achieved.

In SBIR Phase I, S&T and TDA demonstrated the detection of hydrogen sulfide (H_2S) and ammonia (NH_3) (from ppm levels and responses that can be quantified) in a fully integrated prototype chemical sensor badge containing field replaceable media cartridges. Performance data included results for these two TICs, both separately and together in the presence of other contaminants, such as carbon monoxide and smoke.



TDA’s wearable chemical badge sensor prototype, fabricated during SBIR Phase I, successfully demonstrated detection of H_2S and NH_3 in the presence of other contaminants.

The sensor was able to identify and predict TIC concentration within 20 seconds with an accuracy of ±2 ppm. S&T and TDA also carried out a detailed design of the sensor badge, generated 3-D models and assessed the techno-economic merits of a four-six gas sensor.

Further research will yield a robust, multimodal wearable smart sensor badge for trace detection of a wide range of TICs. This capability can be transitioned to applications in homeland security and law enforcement agencies for wide use. The target commercial space can also be extended to include personal monitors for industries to enforce worker safety and workplace exposure limits.

What’s Next? Phase II of Sensor Development

In SBIR Phase II, TDA will improve sensor selectivity and fabricate at least six prototype LOC chemical sensor badges, each of which can detect at least four target TICs.

TDA will collaborate with Texas Tech University for the design and fabrication of the media cartridges with up to 10 channels to enable detection of four or more TICs using TDA’s sensing media.

TDA will also complete an engineering analysis of anticipated risks and mitigation strategies, as well as strategies for commercialization. Finally, TDA will complete a detailed techno-economic assessment of the sensor technology.

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To learn more about the Wearable Smart Chemical Sensor, contact first.responder@hq.dhs.gov.

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