INNOVATING CROSS-DOMAIN SOLUTIONS TO DETECT EMERGING BIOLOGICAL THREATS

The Bio-inspired Nose-on-a-chip For Mobile Sensing And Breath-based Diagnostics

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Background: A dog's nose is a valuable battlefield sensor, whether assessing environmental chemical threats or the health of friendly warfighters. However, the cost of canine and handler training and deployment are prohibitive to widespread use, and conventional eNoses lack the sensitivity and selectivity needed to duplicate canine olfaction. A volatile organic compound (VOC) sensor that exceeds the performance of olfactory systems could provide widespread, affordable detection of infectious agents, chemical weapons, and diseases, whether weaponized or incidental, on the battlefield or at home.
Purpose: A parts-per-billion-sensitive portable eNose could provide environmental monitoring for threats (ordnance, chemical, and biological) or serve as a rapid and non-invasive diagnostic tool by monitoring volatile organic compounds (VOCs) in human breath.
Objective: The University of Washington and Odo Labs are developing a molecular probe-based "nose-on-a-chip," a compact, multiplexed sensor to detect and rapidly diagnose existing and emerging diseases, toxins, and biomarkers in breath or the environment.
Rationale: The biohybrid sensor mimics the binding specificity of an olfactory neuron while taking advantage of the low SWaP-C and high sensitivity of a microscale transistor. It combines engineered biomolecular probes with a multiplex of carbon nanotube (CNT) transistors for signal transduction. Selective, compact, and customizable, the VOC-sensing platform identifies chemical agents directly or quantifies the human body's response to exposure or illness.
Relationship to other areas of study: Sensor design depends on "breathomics" to identify the breath fingerprints of many diseases using mass spectrometry. Its compact form is a natural fit for wearable and mobile platforms. The sensor design process combines bioinformatics, protein design, CNT device engineering, and machine learning for signal processing.
Methods: VOC-binding peptides are extracted from wild-type olfactory protein structures. These multifunctional molecules bind to specific analytes and sensor surfaces comprising multiplexes patterned CNT-based transistors. Machine learning (ML) analysis of the signal output from a multi-functionalized sensor array identifies target compounds or diseases.
Results: Peptide probes have achieved targeted binding and detection of VOCs indicative of COVID-19 infection. Sensors demonstrate sensitivity in simulated and natural human breath to VOCs at concentrations from

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