REVOLUTIONARY DIAGNOSTICS – NONTRADITIONAL APPROACHES FOR DEVELOPING BREAKTHROUGH CAPABILITIES AGAINST EMERGING THREATS

Portable Biogenic Volatile Organic Compound Analyzer

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Biogenic volatile organic compounds (VOC) continue to be discovered as biomarkers indicative of disease states in humans and can arise prior to symptom onset. These biomarkers were originally identified via empirical observations when an odor could be attributed to a change in physiological state. Over several years, the scientific community has found numerous examples across a range of diseases, alignments, and emerging pathogens that produce unique volatiles. These compounds can be easily accessed in breath, skin, waste (e.g. feces, urine), or saliva, and present biochemical information from a multitude of organ systems simply by changing the sample collection location. While the appeal of these compounds as a diagnostic source is widely growing due to their accessibility, the challenge of realizing their use in the field stems from the difficulty of creating a portable device capable of analyzing complex chemical mixtures. Traditionally, VOCs are analyzed with a bench top gas chromatography (GC) system coupled to a mass spectrometer. This system can identify tens of thousands of compounds, but requires an enormous amount of energy, consumables (e.g. compressed gases), and secondary compounds known to be difficult to miniaturize (e.g. vacuum pump).

Our team approaches the portable VOC detection problem using a 'system' approach that mimics the process of a benchtop unit, but employs miniaturized components to reduce SWAP (size, weight, and power). VOCs are first collected and concentrated on a microfabricated pre-concentrator (PC) which is a component that collects and enriches VOCs in a solid phase sorbent and thus significantly increases system limits of detection. VOC separation is then performed using a microfabricated two-dimensional GC (GCxGC) system that can separate VOCs against both a polar and non-polar phase for improved chemical separation. Lastly, we utilize a SNL-developed miniaturized drift tube ion mobility spectrometer (IMS) for VOC analysis at atmospheric pressure, thus greatly reducing detector SWAP demands compared to traditional mass spectrometers. Coupling the VOC peak capacity of the micro GCxGC (~500) with the resolving power of the miniature IMS (~20-30) produces a theoretical VOC detection limit of 10,000 to 15,000 compounds. Hundreds to thousands of biogenic VOCs have been identified in the literature and our portable VOC module has been demonstrated to be well-suited for identifying this complex range of chemicals. Due to the size of these components, our system only weight 1.3lbs with dimensions (~8" x 8" x 4"), which is reasonable for both portable and wearable deployment. Our team has already delivered four instruments with semi-autonomous functionality and prototype peak identifying software to a customer for breath analysis. In addition to our instrumentation development, our team has efforts studying new biogenic VOC biomarkers and can recruit human subjects for VOC collection and portable VOC sensor testing. Recent results identified unique volatiles emitting from human lung cell cultures infected with either coronavirus 229E, rhinovirus, or dengue 2. We expect our VOC analyzer module and ongoing VOC biomarker discovery efforts can continue to be deployed and aid the warfighter in reducing exposure and severity of biological threats.

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