QUANTUM TECHNOLOGIES, METAMATERIALS, AND THE FUTURE OF CB SENSING

XPCR: An Ultra-rapid And Portable Sensor For Automated Biothreat Surveillance

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Existing gold-standard biological identification technologies require considerable amounts of time for a positive result and are thus limited to 'detect-to-treat'scenarios. Recent advances in plasmonic PCR have pushed the speed envelope enough to begin exploring 'detect-to-warn' scenarios. Ultra-rapid biological identification is essential for rapid response to aerosolized biothreats to reduce exposure, alter operations, and identify when a threat has passed. While optical trigger sensors have been developed to identify potential biothreats, only DNA-based analysis provides sufficient confidence to take high-regret actions. High-confidence biological identification has been traditionally limited by the biochemical activity of the enzymes used in polymerase chain reactions (PCR) which requires repeated cycles of heating and cooling to amplify the unique DNA sequence of a targeted biothreat agent. Recent publications have debuted a new type of PCR that can identify bioagents under a minute (Farrar, J. S. and Wittwer, C. T. "Extreme PCR: efficient and specific DNA amplification in 15-60 seconds" Clin. Chem. 2015). By using ten- to 20-fold increases in primer and polymerase concentrations, as well as heating cycles of 0.4 to 2 seconds, specific, high-yield amplification of DNA is capable under a minute. Extreme PCR (xPCR) paired with integrated sample collection, sample preparation, and signal readout would enable a total system sample-to-answer in approximately five minutes.

Our team has developed an inegrated prototype of an ultra-rapid, high-confidence, low-SWaP (size, weight, and power), and fully-automated biosurveillance system capable of air sample collection, sample preparation, and rapid analysis. This xPCR system is designed to enable rapid detection of known biothreats in any environment, thus informing and accelerating key operational decisions (e.g., more efficient mask-on and mask-off time in field-forward bases). The low SWaP of the device (weight < 5 lbs with a low-voltage battery supply) makes it compatible with a broad range of platforms and deployments, such as unmanned aerial and ground vehicles (UAVs and UGVs). Near real-time analysis of data for identification and quantification of threats can be handled by the onboard microprocessor, and results are transmitted wirelessly. This prototype, which is still being optimized, is intended to achieve high-confidence rapid bio-ID by amplifying DNA sequences by leveraging recent advances in plasmonic PCR as described in the literature as "extreme" PCR.

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