

NEXT-GENERATION BIOAEROSOL DETECTION & IDENTIFICATION

Detection And Identification Of Bioaerosol Species By Miniaturized Dual Frequency Combs Based Waveguide Enhanced Coherent Raman Spectroscopy (dc-wecrs)

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The need to efficiently collect and identify biological and chemical species in aerosols in real-time remains imperative to biological chemical defense and security, among others. There are a variety compelling reasons to develop methods for the rapid on-site, remote detection of bioaerosol species at trace levels with high sensitivity and specificity. Performing bioaerosol analysis in situ without the necessity to deliver samples to the off-site analytical laboratory is advantageous in many areas of bioaerosol threat analysis and predictions. Warfighters are in the need of systems able to perform rapid, sensitive, and definitive identification of traditional and newly developed toxin threat agents to support early warning and prepare for the unknown.

Most of the currently available detectors for bioaerosol detection technologies tend to be too large and cumbersome for field-deployment or require expert users to analyze and interpret results. In addition, many devices for biological detection, collection, and identification are not modular in design, which makes remote and field-deployment difficult or impossible.

This paper will present an instrument that is a novel, revolutionary optical spectroscopy technique, which can be miniaturized as well as relatively straightforward to implement, compare to that of complicated bioassays, or mass spectrometry based techniques such as GC-MS or Time of Flight (TOF), et al.. We present a nonlinear optical spectrometer based on dual ultrafast mode-locked lasers (Dual Frequency Combs) enabled Fourier Transformed Coherent Anti-Stokes Raman Spectroscopy (DC-FT-CARS), which offers unprecedented sensitivity and speed, in conjunction with a semiconductor waveguide enhanced sampling chip for further sensitivity enhancements on toxins from bioaerosols, which possibly enhance the toxin detection sensitivity to trace level.

The instrument construction is highly portable and integrated, e.g. the entire instrument with optical system and control electronics of the DC-FT-CARS can be packed into a box of the size of $\sim 0.015\text{m}^3=15\text{L}$, which including control electronics, miniature vacuum pumps for fluidic controls(for sample collection), power supply, and battery, et. al. The integrated instrument is estimated weight of 25 lbs (12 kg). It is feasible to build a portable dual comb coherent spectroscopic device with bioaerosol detection sensitivity estimated concentration of 10-20 ng/mL, on all types of the bio-species of interest, as well as the instrument's multiplexing feature allows detecting multiple species simultaneously. The response time will be less than 60-90 seconds depending on environmental conditions and toxins under detection. It is an integrated solutions combining detection, collection, and identification of bioaerosols which contains a variety of agents such as bacterial, viral, toxin, et al.