LOCALIZING CHEMICAL AND BIOLOGICAL THREAT DETECTION

Fast Bioaerosol Warning Sensor Using Single Particle Differential Circular Polarization Scattering (CIDS)

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The developed fast bioaerosol warning sensor for harmful bacteria, virus is mainly based on fluorescence, elastic scattering etc. optical methods, but they are limited by the prevalence of interferents and significant costs, particularly the optical signatures vary with environmental conditions. These inadequacies inspired further exploration for more accurate but lower cost biosensor.

It was reported that DNA or RNA helical structures in biological molecules produce non-zero circular intensity differential scattering (CIDS, normalized Mueller matrix element -S14/S11), but zero CIDS for molecules without helical or spiral structures. Traditionally, CIDS phase function was measured from a group of particles using a polarization modulator, lock-in amplifier, and rotating detector due to its ultra-weak signals (10-3-10-6). Such complex instrumentation is not suitable outside a laboratory for the usage as a biosensor.

We report an advanced method for measuring CIDS phase function from single individual flowing through particles without any moving parts or modulator. An elliptical reflector is used to project scattering light at different angles onto a 32-anode PMT for scattering phase functions illuminated by left- and right-circular polarization beam, respectively, while the individual single particle is moving through the focal point of the reflector. This innovative setup, significantly, shortens a complete measurement from tens of minutes to 17 ms (>50,000 particles/sec). CIDS phase functions from single particles of B. subtilis, E. coli spores, MS2 bacteriophage, Yersinia rohdei, DNA-tagged polystyrene (PSL) microsphere, tryptophan, PSL microsphere, atmospheric aerosol particles are carried out using this system. The results showed all bioaerosol particles have at least 3 times stronger CIDS signals than non-bioaerosol particles. Especially, the signature was tested to be no changes with various ambient conditions (relative humidity, ozone concentration, UV exposure). This new technology gives promise for new rapid biosensor with low cost and reduced false alarm rate from potential interferents.

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