Fluorescence spectra from individual microsized bioaerosols excited by a sequentially fired UV-LED linear array

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Abstract: A low-cost, very compact optical spectroscopic system demonstrates the ability for detecting fluorescence spectrum from single flowing bioaerosols excited by pulsed-sequentially firing UV LED linear array.

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Laser-induced-fluorescence spectroscopy has shown to be useful for classifying or discriminating, in real-time and in-situ, bioaerosols from nonbioaerosols. The point sensor based on this principal provides rapid analysis of the detected aerosols and give early warning of the presence of suspicious bioaerosols in the ambient air. Most systems these days use pulsed-high-power harmonic output of Q-switched laser. As a very efficiency, economical, and very compact light source, UV semiconductor light-emitting diode (UV LED) is a good selection for system miniaturization, as well as optimized wavelength for the excitation of bioaerosols.

Here, we present a particular configuration composed of a linear array of UV LEDs that gives a new feasible optical biosensor system based on the detection of fluorescence spectrum from single, with a straight trajectory flowing bioaerosol. The insufficient emitting intensity from a single LED is overcome by using 32 LEDs manufactured in a linear array. Driving the LED in a pulsed mode allow an increase in the peak intensity without increasing the heat generated in continuously running mode. Furthermore, sequentially driving the LEDs to emit one-by-one, matching the flow velocity of the aerosol within 3 mm helps reduce the scattering background and their energy consumption, in comparison to the case when all the LEDs emit simultaneously once the aerosol passing through the whole sampling volume. For achieving higher power from the AlGaN based UV LED, a hemispherical quartz lens was attached to the flip-chip LED, then a pair of aspherical lenses for transferring the LED emission to the flowing aerosols. This optical coupling configuration has been optimized by using a ray-trace program (TracePro from Lambda Research) via comparing different combinations of the commercially available lenses and mirrors.

The 50µm water droplets containing 1% concentration of NADH, which were produced by a piezo-driven aerosol generator, have been used for the sensitivity test of the system. The system is capable of collecting the spectra at a rate more than 10 KHz. The fluorescence from the flowing droplet was collected by another aspherical lens, and focused onto a spectrograph with a concave grating. The dispersed fluorescence spectra were recorded by a 32-anode PMT array. Figure 1 shows 20 successive fluorescence spectra from single flowing 50 micron NADH (1% in water) droplet excited by sequentially emit 370 nm UV-LED array. The fluorescence is collected within 1 ms, which equals to a emitting cycle of the whole LED array as well as the flowing time of the aerosol bathed in the illuminated volume. The aerosol, the detector, and each emitting cycle of the LED array are synchronized to run at 10 Hz to assure the spectra we collected are from single aerosol. The test results show that such a system can detect (with sufficient S/N ratio) fluorescence spectrum from single flowing aerosols. LED-induced-fluorescence provides a potential instrumentation for use in the biosensor fields.
Fig.1 20 successive fluorescence spectra from single flowing 50 micron NADH (1% in water) droplet excited by sequentially emit 370 nm UV-32-LED array.