Lasers help speed up the detection of bacterial growth in packaged food

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It's important to know how microorganisms—particularly pathogenic microbes—grow under various conditions. Certain bacteria can cause food poisoning when eaten and bacterial growth in medical blood supplies, while rare, might necessitate discarding the blood.

Now a group of researchers from Zhejiang Normal University in China and Umeå University in Sweden report a fast, accurate, and noninvasive technique for monitoring bacterial growth. They report the results in *Applied Optics*.

Microorganism growth is driven by many factors, which make it far from easy to accurately estimate the amount of bacteria within food containers or blood samples at any given time.

To avoid the risk that any particular packaged food item will go bad and cause illness, it's given an unnecessarily short shelf life. In short, a better understanding of the growth process of microorganisms could reduce food waste and prevent people from being sickened by food poisoning—or both.

Within the medical realm, it's critical to be able to assess the quality of blood samples quickly and accurately. Without this ability, samples might need to be discarded or, alternatively, result in or worsen illnesses. Although bacterial blood contamination is rare, it does occur and has led to deaths. A rapid screening method could mean that a larger percentage of blood could be directly tested for bacteria.

"Microorganism growth is always associated with the production of carbon dioxide (CO_2)," said Jie Shao, associate professor at the Institute of Information Optics, Zhejiang Normal University, Jinhua, China. "By assessing the level of CO_2 within a given closed compartment—bottle or bag—it's possible to assess the microbial growth."

Several detection techniques are currently capable of rapid and accurate measurements of gas compositions. Those based on optical spectrometry are most appealing because they're noninvasive, boast high sensitivity, provide instant responses, and are potentially useful for assessment of bacterial growth.

"A technique referred to as 'tunable diode laser absorption spectroscopy' (TDLAS) is particularly suitable because it combines all of these properties with an ease of use and low cost," Shao said.

So the group decided to develop an easy-to-use instrument based on TDLAS to assess bacterial growth of various types of samples under a variety of conditions.

TDLAS is by far the most common laser-based absorption technique for quantitative assessments of species within a gas phase. It can be used to measure the concentration of specific gaseous species—carbon monoxide, CO_2, water, or methane, to name a handful—within gaseous mixtures by using absorption spectrometry based on tunable diode lasers.

"One major advantage TDLAS offers is its ability to achieve very low detection limits, on the order of parts per billion," Shao said. "Apart from concentration, it's also possible to determine other properties of the gas under observation—temperature, pressure, velocity and mass flux."

The group's basic setup simply involves a tunable diode laser as the light source, beam shaping optics, a sample to be investigated, receiving optics, and one or more detectors.

"The emission wavelength of the laser is tuned over a characteristic absorption line transition—of the species within the gas being assessed," Shao explained. "This causes a reduction of the measured signal intensity, which we can use to determine the gas concentration."

When the wavelength is rapidly tuned across the transition in a specific manner, it can be combined with a modulation technique called "wavelength modulation" (WM), which gives the TDLAS technique an enhanced sensitivity. It's referred to as "WM-TDLAS."

By applying the technique to transparent containers of organic substances such as food items or medical samples, bacterial growth can be quickly evaluated. "Although we anticipated that the WM-TDLAS technique would be suitable for assessing bacterial growth, we didn't expect this level of accuracy," Shao noted.

In contrast with conventional and more invasive techniques that require contact with the tested items, the WM-TDLAS method is truly noninvasive, making it ideal for monitoring the status of food and medical supplies, or as a tool to determine under which environmental conditions bacterial growth is expected to be severe. "It can provide real-time analysis," Shao said.

Next, the researchers plan to enhance the technique to "allow for assessments of microbial growth in a large variety of samples—expanding beyond food items and medical supplies," Shao added.

More information: Jie Shao, Jindong Xiang, Ove Axner, and Chaofu Ying, "Wavelength-modulated tunable diode-laser absorption spectrometry for real-time monitoring of microbial growth," *Appl. Opt.*

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