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Mini Review

Raman spectroscopy in food safety: A Mini review

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Introduction

Human activities and industrial production inevitably bring many environmental pollutants, which enter human bodies under the ecological cycle. Diseases caused by foodborne pathogens or toxins result in more than 6,000,000 illnesses and 420,000 deaths globally annually [1]. Therefore, detecting and identifying these pollutants is urgent to protect the environment and human health. Standard food safety detections include pesticides, pathogens, heavy metals, and other substances that may be hazardous to human health, for which relatively safe and accurate handling methods are required.

In the past, instrumental analysis methods in food testing have gradually become the significant means of food hygiene inspection, and commonly used instrumental detection methods include spectrophotometry, atomic fluorescence spectrometry, atomic absorption spectrometry, electrochemical processes, gas chromatography (GC), liquid chromatography (LC), and so on [2]. Spectroscopy is a relatively widely used and accurate method but isn't straightforward and requires high instrumental accuracy [3]. Electrochemical processes have the capacity for quick and simple measurement with reasonable detection limits, but they might use expensive reagents that are not environmentally friendly [4]. As for GC and LC, they have highly sensitive and fast performance on detection, but they suffer from some drawbacks, including high-demand pretreatment and complicated operation methods [5]. However, their limitations, such as a high threshold of users, expensive instrument usage, and complex pre-treatment, make them harder to use.

In recent years, Raman spectroscopy, a label-free micro-imaging analytical method, has excellent capability to solve the above problems. Compared to other ways, it has the advantages of rapid detection, inexpensive equipment, no need for professional operation, on-site detection, high sensitivity, and nondestructive to the sample [6], which makes it more suitable for food detection. We can obtain information about the substance's concentration, functional group, structure, and crystallinity by analysing Raman spectroscopy [7].

However, due to the relatively weak Raman scattering effect in Raman spectroscopy, the more sensitive surface enhanced Raman spectroscopy (SERS) has been proposed for detecting toxic and hazardous chemicals in agricultural products. Generally, SERS substrates are classified as label-free and labeled. Label-free SERS directly detects Raman spectral signals, whereas the labeled one achieves this by detecting tags [8]. As for label-free substrates, Lee et al. attempted to identify Tetracycline in animal feeds by preparing gold nanoparticle SERS substrates and detecting tetracycline concentrations below 10mg/kg through machine learning combined with Raman spectroscopy is possible [9]. Wijaya et al. incubated acetamiprid samples from the apples' surfaces with Ag substrates for several minutes, and SERS spectra were obtained directly to attain the acetamiprid concentration for rapid detection [10]. Alsammmariraie, et al. established a SERS system by designing Au substrates as nanorod arrays for detecting carbaryl residues in juice and milk within 10 minutes and quantifying carbaryl as low as 50 ppb in three types of foods [11]. Regarding labeled SERS substrates, Barimah et al. developed a SERS silver (Ag) nanosensor based on 3-Aminobenzeneboronic acid (ABBA) for detecting arsenic in black tea with a detection limit of 0.0273 μg/g [12]. Similarly, Guo et al. designed an Ag-Au alloy SERS sensor with 4-Aminothiophenol labeled to detect mercury in black tea, and its minimum detectable concentration can reach 4.12 × 10-7 μg/mL for Hg2+ standard solutions [13]. Therefore, in the future, more people will choose Raman spectroscopy for food detection, and related methods will be gradually invented and used.

Conclusion

Raman spectroscopy has excellent potential as a rapid, sensitive, and label-free detection method in analysing complex food systems. In the future, with the emergence of more products and rising awareness of food safety, more people would like to choose a fast and accurate method for food safety. Compared with traditional food testing methods, Raman spectroscopy detection is more convenient, safe, and rapid, with a lower user threshold and cheaper equipment. Therefore, the future of Raman spectroscopy-based food testing methods will become the top choice for food safety testing.

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Conflict of Interest

No conflict of interest.

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