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Innovative Raman Measurement Technique with a Uniform Line Focus for LFT readout

Several spectroscopic methods are available for reading the test and control lines of Lateral Flow Tests (LFTs). Raman spectroscopy stands out due to its ability to provide distinct molecular bands, clearly separated from the background spectrum. This characteristic allows for more reliable identification of markers at the test and control lines, resulting in tests that are both more specific and sensitive, offering improved quantification of analytes [1]. Although pure Raman scattering suffers from a low quantum yield, this limitation can be overcome by using marker particles that enhance the Raman scattering cross-section via plasmonic effects, a technique known as Surface Enhanced Raman Spectroscopy (SERS). SERS enables ultrasensitive and rapid quantification of analytes, such as viral particles, even in complex environmental samples [2].

However, a key challenge in Raman spectroscopy is balancing maximum quantum yield with the risk of thermal damage to the LFT. To mitigate this risk, it is preferable to use a line focus rather than a conventional point focus for the excitation laser. This can be achieved using a cylindrical lens to form the line focus. Yet, even without further beam shaping, there tends to be a peak in intensity at the center of the line. This study aimed to develop a Raman measurement technique that produces a uniform line focus, enabling non-destructive analysis of LFTs without causing thermal damage or overheating. Two approaches were explored: the first involved using a beam-shaping lens, which delivered stable and reproducible measurements but required additional optical components and increased the distance between the Raman probe and the sample, leading to significant signal attenuation. The second approach utilized a rectangular fiber in conjunction with a cylindrical lens to produce a uniform line focus, resulting in a homogeneous output beam without the need for additional optical elements. This novel solution proved to be the more effective method. Here, we present our findings based on newly developed multiplex LFTs for veterinary applications.

References

[1] B. Khlebtsov, N. Khlebtsov, Nanomaterials, 10 (2020) 2228. DOI: 10.3390/nano10112228.
[2] W. Wang, S. Srivastava, A. Garg, C. Xiao, S. Hawks, J. Pan, N. Duggal, G. Isaacman-VanWertz, W. Zhou, L.C. Marr, P.J. Vikesland, Environ. Sci. Technol., 58 (2024) 4926-4936. DOI: 10.1021/acs.est.3c10311.

Figures

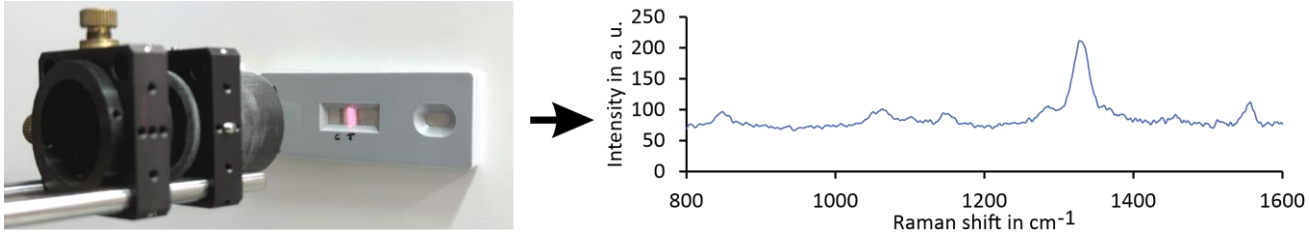

Figure 1: Creating a uniform line focus using a rectangle fiber to generate Rama spectra of the test and control line.