# Surface Enhanced Raman Spectroscopy (SERS) – A new solution for food quality and safety analysis

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Surface-enhanced Raman spectroscopy (SERS) is an emerging technology in environmental, agricultural, food, and medical applications.[1–7] In **Figure 1** (a), Raman spectroscopy provides a signature profile of an analyte according to its chemical structure, and with the attachment of nanometallic structures, Raman scattering can be dramatically enhanced. Compared to the standard analytical methods (e.g., HPLC, GC-MS, etc.), SERS showed advantages in simpler sample preparation, faster detection, easier operation, less instrumental complexity, and relative less expensive cost. Additionally, a handled or portable Raman instrument allows SERS to be an on-site solution for the field test.

## SERS substrates

### *Colloidal nanoparticles*

Colloidal silver and gold nanoparticles are commercially available and can also be easily fabricated in a lab. Sample preparation can be facilely done by mix a few drops of sample with colloidal nanoparticles and air-dried on solid surfaces for measurement. The biggest concern towards the colloidal nanoparticles is the "coffee ring" that can cause a huge variation.

### *Solid based substrates*

As shown in **Figure 1** (c), nanoparticles can be driven by a "mediating solvent" to self-assembly a monolayer mirror substrate, which features a better signal consistency and an improved quantitative ability. It can be either fabricated with the targets in the solvent or preformed as a dried SERS active platform for sample immersing. In **Figure 1** (b), nanoparticles can also be deposited to targets concentrated on a Nitrocellulose Millipore® membrane. This providing a fast detection of low concentrations of pathogens and contaminants without pre-enrichment.

## Application of SERS in food analysis

### *Pesticides detection*

SERS is known for its sensitive and fast detection of many kinds of pesticides in different food or agricultural matricees, with a limit of detection lower than the regulation requirement.[10] In my project, the mirror substrate can detect fonofos pesticide in beverages at a low concentration (i.e. 0.5 ppm) with good recoveries (i.e. 99-106 %), which illustrated the reliability of mirror and SERS in pesticides detection.[8] SERS is also suitable to monitor the distribution and penetration of pesticides on plants (**Figure 1** (d)), also the efficacy of pesticides removal from fruits.[12]

### *Colorants and adulterants analysis*[5]

A SERS database was developed including a wide variety of artificial and natural food coloring agents currently approved or banned in the United States. All colorants showed discriminative SERS signals and can be differentiated or quantified in commercial products.

### *Wine analysis*

By forming the mirror substrate with the red wine extracts in the "mediating solvent", signature peaks in the spectra were successfully matched with condensed tannin, resveratrol, anthocyanins, gallic acid, and catechin, and the unique chemical information creates a specific bar code that could be beneficial for red wine quality assessment and authentication.

### *Bacteria detection*[9,13]

Using the Millipore® filter membrane substrate, we developed a rapid bacteria screening method using SERS to successfully detect Escherichia coli, Salmonella enterica, and Listeria monocytogenes in 80 min in pond water and vegetable rinse water with reliable quantification (i.e. $R^2$ = 92 %) to a concentration as low as 10 CFU/mL.

**References**

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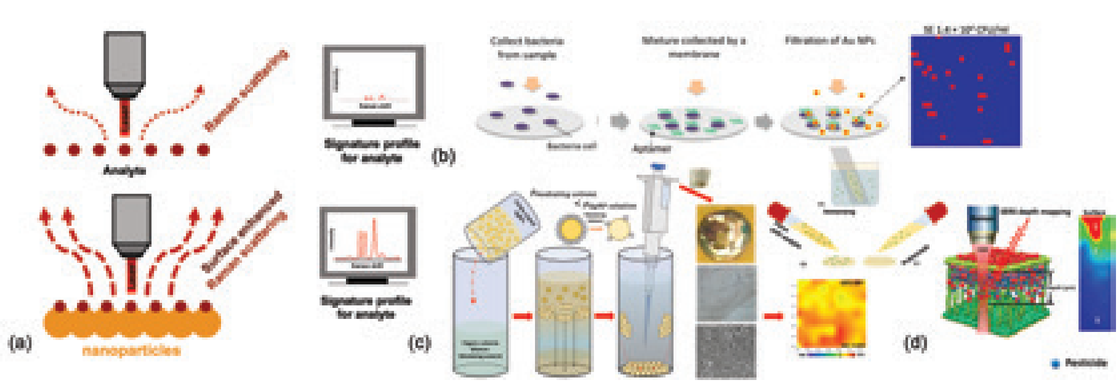

**Figure 1**. (a) Mechanism of SERS (b) Millipore® membrane substrate for bacterial detection (c) Mirror substrate (d) Monitoring of pesticide penetration using SERS mapping technique.