New developments in Surface Enhanced Raman Spectroscopy – A review
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Abstract

The aim of this review was to provide an overview of the latest developments of novel substrates with respect to Surface-Enhanced Raman Spectroscopy (SERS). The topics discussed in this review are new developments in single-composition colloidal nanomaterials, multiple-composition colloidal nanomaterials, planar substrates, composite-metal substrates, SERS based sensors and hyphenated SERS methods.

Single-composition colloidal nanomaterial developments recently focus on new morphologies to achieve a higher sensitivity, the control of aggregation by adding reducing and stabilizing agents and improving the repeatability of the analysis. Nanorods offer a higher sensitivity compared to spherical nanoparticles. Recently, new morphologies proposed are nanostars and nanourchins. New reducing and stabilizing agents proposed are based on citrate complexes for novel applications and nanocrystalline cellulose (NCC). To achieve a higher repeatability, it is proposed to employ screen printing or inkjet printing, which is particularly attractive to use for industrial purposes.

Multiple-composition colloidal nanomaterials are a novel concept, with its most recent development (2010) being Shell-isolated nanoparticle-enhanced Raman spectroscopy (SHINERS). Compared to single-composition colloidal nanomaterials, SHINERS offers more substrate flexibility and prevents the core from oxidizing, increasing the stability of the substrate. The tuneable core-shell particles have been shown to be particularly useful for drug delivery applications, as the shell may exhibit drug-release features with a lower toxicity than previously used drug-release molecules.

Planar substrates are one of the first SERS substrates and are mainly used today to improve the ease of application. A recyclable method was proposed using photocatalytic degradation of the adsorbed analytes, followed by a self-cleaning method centrifuging the nanocomposite and washing the substrate with deionized water to remove the residual molecules and ions.

Composite-metal substrates are known to be more uniform and reproducible than colloidal solutions. Recent developments concentrate on novel morphologies for improved hot spot detection for multiple purposes. New morphologies proposed are gold hexagonal-packed nanorod arrays, tuneable nanodomes, large surface nanopyramids and gecko-inspired nanotentacles for press and peeled-off pesticide detection.

SERS based sensors have been developed to use for more convenient purposes for industry. New affinity-based SERS sensors were evaluated for the detection of mercury and Salmonella Typhimurium. Also, novel drug-delivery colloidal trackers are explored for cancer therapy and the treatment of schizophrenia, mainly consisting of core-shell particles.

Microfluidics is a novel and interesting field for SERS due to effective dissipation of heat and allowing the removal of photodamaged analyte molecules from the detection volume when using a high-power laser excitation. Furthermore, the recent progress of Lab-On-A-Chip (LoC) allows gene
distinction for mutation analysis. Combined with portable Raman systems and more sensitive equipment, it may provide a promising development for more accessibility. A LC-SERS application is demonstrated allowing a gradient elution mode for a more selective SERS detection in samples with a higher structural complexity.

Overall, new morphologies for substrates have been employed as well as improvement of enhancement limiting parameters to gain more sensitivity, in some cases almost reaching single-molecule level. Also, more robust composite-metal substrates and several tuneable, facile and re-usable substrates have been employed. These developments promise a wide range of study perspectives for fundamental and industrial purposes.