Technospex

Application of uRaman for Surface Enhanced Raman Scattering

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Introduction

Raman signals are inherently weak and investigation of low concentration chemicals are usually carried out with expensive research-grade Raman micro-spectroscopy system. Surface-Enhanced Raman Spectroscopy or Surface-Enhanced Raman Scattering (SERS) is an amplification technique that enhances Raman scattering by molecules absorbed on rough metal surfaces typically made of Gold (Au) or Silver (Ag). The enhancement factor can be as much as 10^{10} to 10^{11}, thus enabling even single molecule detection using Raman. By using SERS, the criteria for Raman micro-spectroscopy system becomes more relax, thereby allowing users to use less expensive Raman spectroscopy system for low concentration material detection. The objective of this application note is to demonstrate the capability of our economically priced uRaman micro-spectroscopy system works with SERS substrates and SERS Gold Nanostars colloidal solution to detect low concentration materials.

Experiment

Two separate SERS experiments were performed with uRaman system (Figure 1) that is equipped with a frequency-stabilized 785 nm laser. The sample stage can either be manual or motorized. The latter will be useful for imaging multiple well SERS chips. To measure liquid sample, a cuvette holder attachment can be mounted easily onto the nose piece of the microscope.

Figure 1. uRaman-785-Ci-T-MAP uRaman / uSight micro-spectroscopy system equipped with motorized stage and several objective lens.

In the first experiment, we evaluate the system capability working with SERS colloidal solution. The test sample used is Crystal Violet (CV), as CV has been sought to monitor its illicit use in aqua culture industry as an antimicrobial agent in spite of its toxicity and mutagenicity to mammalian cells. The gold Nanostars SERS colloidal solution is provided by National University of Singapore.

To evaluate the detection capability of the uRaman system, we prepared two CV bulk solutions, each with different concentration of 10 mM and 1 µM respectively. The solutions were then imaged with the uRaman system, through the cuvette holder, at an integration time of 10 seconds. Lastly, the test was repeated by mixing 1 µM of CV solution with Gold Nanostars colloidal solution. The spectra were also acquired with 10 seconds integration time.

The second set of experiment evaluates uRaman with SERS substrate. We prepared a mixed solution of 1mM concentration of 1-Napthalenethiol with hexane and then incubate the solution onto the SERS substrate. The choice of 1-naphthalenethiol was guided by our interests to detect polycyclic aromatic hydrocarbons (PAH) at low concentration, of which naphthalene shares close similarities. PAHs are identified as toxic environmental pollutants by environmental agencies of the United States.

The SERS substrates were provided by Institute of Materials Research and Engineering – A*Star Singapore. The uRaman system used in this experiment used a 20X 0.75NA objective lens that has good transmission (80%) in the NIR range from 700 nm to 1100 nm. The spectra were acquired with 5 seconds integration time.

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Results

Gold Nanostars colloidal solution test

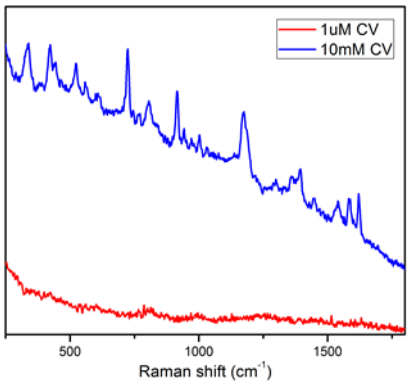

Figure 2 plots out the pure CV Raman spectra at different concentrations, 10 mM (blue) and 1 µM (red). As can been seen in figure 2 that the uRaman system is sensitive to pick up signal at 10 mM concentration but is not able to do so when the CV concentration drops to 1 µM.

Figure 2. Raman spectra of pure CV, acquired over 10 second integration time, of different concentration, 10 mM (red graph) and 1 µM (blue graph)

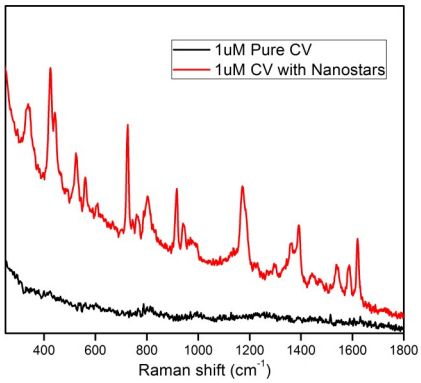

Figure 3 shows the Raman spectrum (red) obtained with 1 µM concentration CV mixed with gold Nanostars colloidal solution. The Raman spectrum of 1 µM concentration pure CV is included for comparison purpose. It is evident that the Gold Nanostars provide strong Raman signal amplification of the low concentration CV solution that can be easily be detected with the uRaman system.

Figure 3. Raman spectra of 1 µM concentration CV mixed with gold Nanostars (blue) shows huge Raman signal amplification as compared to pure CV solution

SERS substrate test

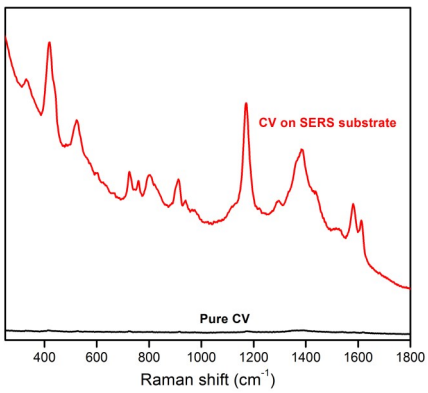

Figure 4 shows the Raman spectra of CV on SERS substrate and pure CV. It is obvious from the results in figure 4 that the SERS substrate offers an excellent platform for amplifying weak Raman signals. Using the SERS substrate together with the uRaman system enables low cost rapid testing of substances, making this combined technique very attractive for both academics and industries.

Figure 4. Raman spectra of 1 mM concentration 1-Napthalenethiol incubated on SERS substrate (red). The blue graph is the Raman spectrum from 1 mM concentration 1-Napthalenethiol bulk solution.

Conclusion

In conclusion, the SERS results obtained with uRaman micro-spectroscopy system demonstrates the capability of commercial-grade for many potential applications, including biomedical. The affordability, small footprint and multimodality imaging capability of the uRaman system will find numerous uses in industries and in both academics teaching and research labs.

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