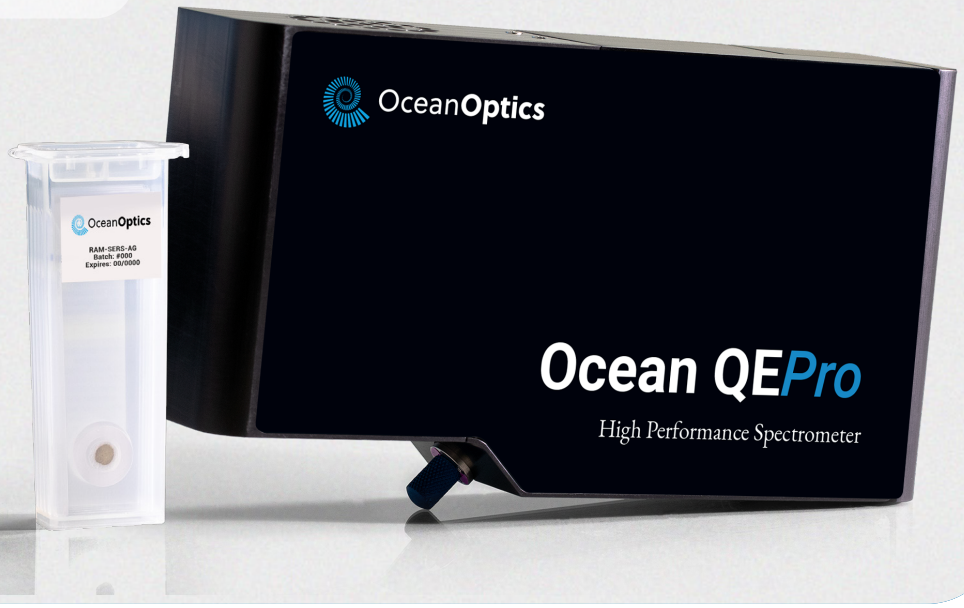
Identifying Illicit Drugs using SERS

Application Note



KEYWORDS

- Illicit drugs
- SERS
- Nanoparticles

TECHNIQUES

- Raman

APPLICATIONS

- Security screening
- Substance identification

Surface Enhanced Raman Spectroscopy (SERS) is an extension of Raman spectroscopy in which gold or silver nanoparticles amplify the Raman signals. The technique works via an electromagnetic effect where molecules come into proximity with gold or silver particles. When incident laser light strikes the nanoparticulate surface, localized surface plasmons can be excited, greatly enhancing Raman signals. The enhancement can be significant, making SERS well-suited to trace level detection of illicit drugs such as cocaine, heroin, methamphetamine and tetrahydrocannabinol (THC).

Introduction

To test how well Ocean Optics SERS technology can detect trace drugs, measurements were performed using gold nanoparticles with an Ocean Optics modular Raman setup. As we discovered, detection of several illicit drugs using gold nanoparticles is a rapid, reliable technique that requires only a few milliwatts of laser power.

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Sample Preparation

Heroin hydrochloride, cocaine hydrochloride, Δ9-tetrahydrocannabinol and (±)-methamphetamine were prepared in 100 ppm, 10 ppm and 1 ppm solutions in methanol.

For the Ocean Optics SERS technology, which comprises analyte-sensitive nanoparticle chemistries, we used 50 µL of 100 ppm, 10 ppm and 1 ppm solutions of several illicit drugs. We tested these concentrations to determine feasibility, although results suggest lower concentrations are possible.

Experimental Setup

For measurements with the gold nanoparticles, we used a modular Raman system comprising the QE *Pro*-Raman+ high-sensitivity spectrometer, a 785 nm laser for Raman excitation and sampling optics. The 785 nm excitation produces excellent Raman spectra for most chemicals, with limited interference from fluorescence. These systems also offer very good spectral resolution, making them a preferred wavelength choice for Raman spectroscopy of chemicals and organic materials.

As demonstrated in the spectra, SERS methods utilizing Ocean Optics nanoparticles can detect ppm levels of illicit drugs, which Raman techniques alone would not be able to accomplish.

Also, certain peaks have higher Raman cross-sections, and each peak is enhanced by the gold nanoparticles differently depending on how the molecule is oriented with respect to the gold surface. Here are the experiment results:

Cocaine

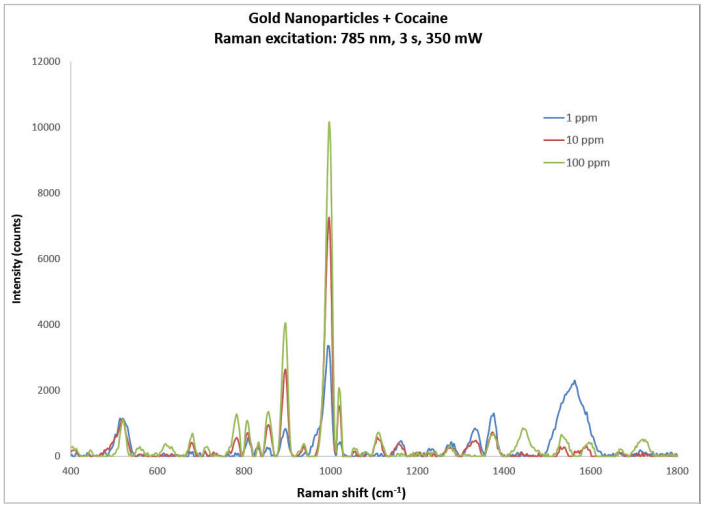

Figure 1. The enhanced Raman spectrum of cocaine.

Heroin

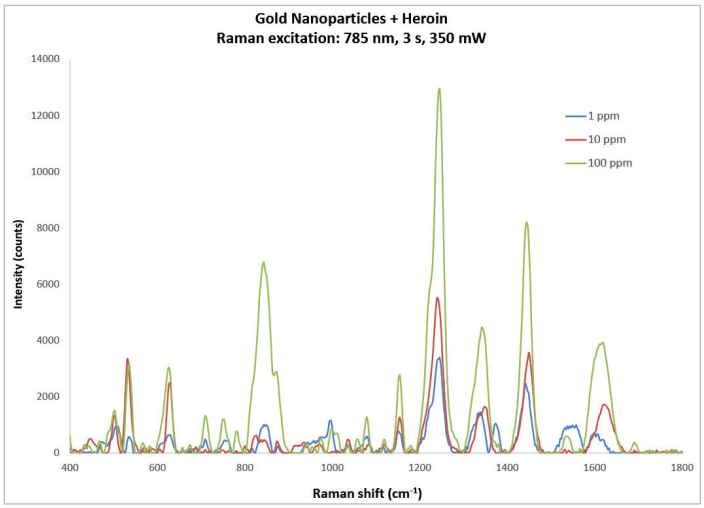

Figure 2. The enhanced Raman signal of heroin reveals distinct spectral features.

Methamphetamine

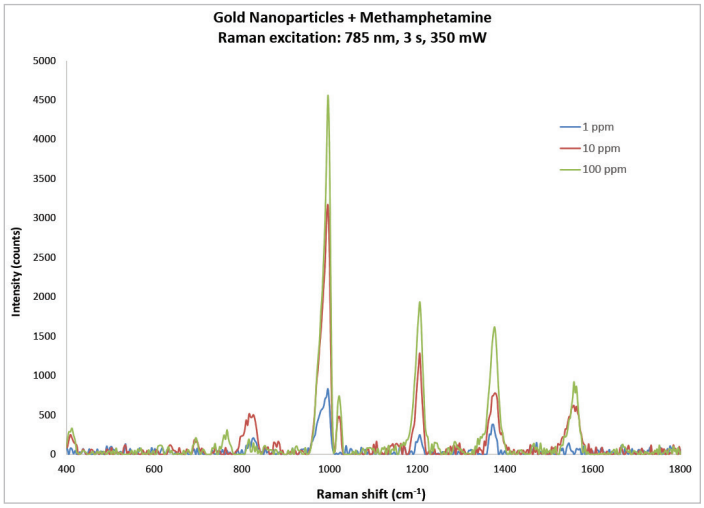

Figure 3. The enhanced Raman signal of methamphetamine shows a strong peak near 1000 cm^{-1}.

THC

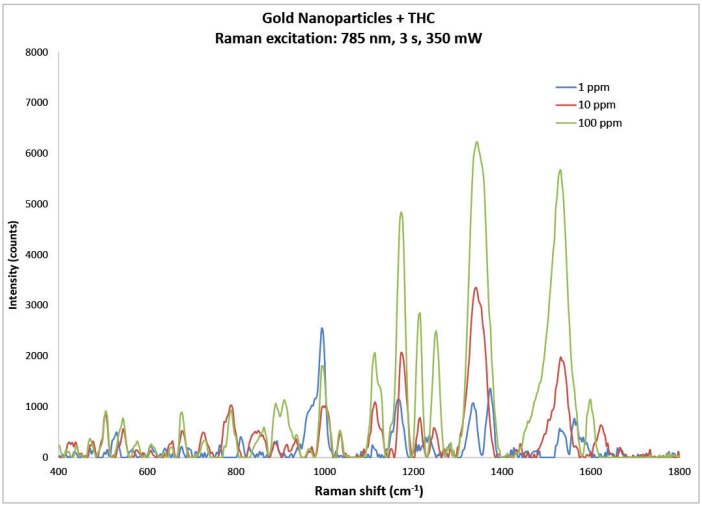

Figure 4. Strong Raman response is observed in THC despite the potential for interference from fluorescence.

Conclusions

When compared with other SERS substrates on the market, the Ocean Optics nanoparticles show better sensitivity for a wide range of low concentrations of commonly used molecules for benchmarking SERS performance. Additionally, Ocean Optics nanoparticles are far more robust and simpler to use, with sample preparation and measurement taking seconds as opposed to minutes or hours.