# Quantitative Surface Enhanced Raman of Nicotine at PPB Concentrations

Key Words
- SERS
- NICOTINE
- PYRIDINE

APPLICATION NOTE

## INTRODUCTION

Surfaced Enhanced Raman Spectroscopy (SERS) is an effect in which nanoscale silver and gold can be used to amplify the intensity of Raman spectra, Resonance Raman can be used in conjunction with SERS to yield enhancement by Surfaced Enhanced Resonance Raman Spectroscopy (SERRS). Enhancement factors of $10^7$ are routine for SER(R)S, and materials at femtomol concentrations can be routinely analysed. For further information on the theory of SER(R)S please see our SER(R)S Tech Note.

Nicotine is commonly used in smoking cessation therapies, these typically take the form of patches, chewing gum or lozenges. These products are effectively drug delivery devices for a potent and potentially toxic API, so the ability to make quantitiative measurements of nicotine concentrations is important.

As shown in Figure 1, nicotine is based on a substuted hetrocyclic (pyridine) ring. The nitrogen in the ring is in a sterically unhindered position and is ideal for binding to a SERS surface in much the same way as the pyridine parent compound which is well known to be SERS active.

Quantitative analysis using SERS is difficult, because slight differences in SERS surface preparation can dramatically alter enhancement

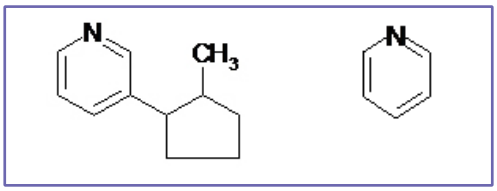


**Figure 1: Chemical structures of nicotine and pyridine**

factors. In addition to this, the absolute SERS intensity depends on simple experimental parameters such as sample focus.

A good way to work around this variability is to use an internal standard and to measure peak intensities relative to the intensity of the standard rather than absolute values. Choosing an internal standard is not a simple matter of selecting a species whose bands do not overlap with the analyte. In SERS the enhancement is only observed from materials which are adsorbed onto the SERS surface so it is important to find a standard which does not compete for surface sites, and preferably one which adsorbs in a similar manner to the analyte of interest.

Since nicotine has a pyridine-like core it would be obvious to use pyridine as an internal standard. However, there is some overlap between the pyridine ring breathing mode at *ca.* 1000 $cm^{-1}$, and the strongest nicotine band which arises from the equivalent breathing mode of the sunstituted pyridine ring in nicotine. This problem can be circumvented by use of deuterated pyridine as an internal standard since deuteration gives a useful downshift in this ring breathing band. This is a cost-effective solution since deuterated pyridine is wdiely available due to its use as a solvent for NMR studies.

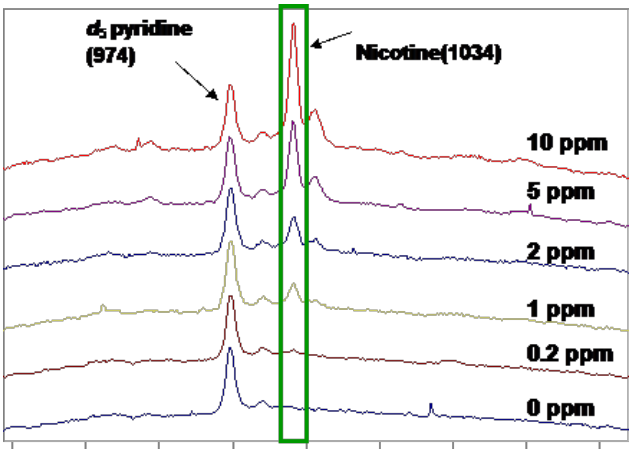


**Figure 2: SERS spectra of nicotine at various concentrations relative to fixed concentration of $d_5$ pyridine.**

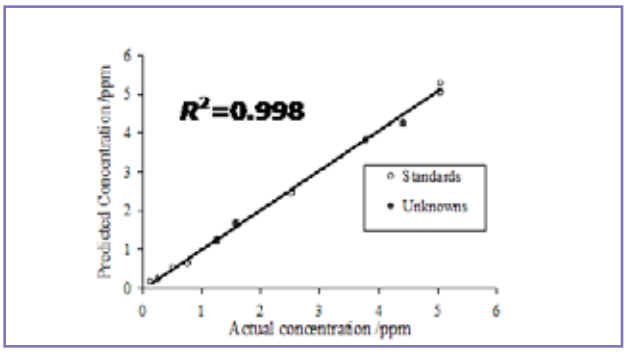


**Figure 3: Linear calibration graph of nicotine concentration derived from peak intensities shown in Figure 2.**

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