

Experimental Set-Up for the Design of Deep Ultraviolet Raman Spectroscopic Applications for Standoff Detection of Hazardous Substances

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Despite its immediate applications, selective detection of trace quantities of surface adsorbed chemicals, such as explosives, without physically collecting the sample molecules is a challenging task. Standoff spectroscopic techniques offer an ideal method of detecting chemicals without using a sample collection step. Though standoff spectroscopic techniques are capable of providing high selectivity, their demonstrated sensitivities often are poor. Especially, Raman spectroscopy promises highest selectivity, but a number of challenges have to be managed in order to succeed in the detection of tiny amounts of substances [1-3].

In order to manage standoff Raman spectroscopic challenges, i.e. retrieving spectral signatures of traces on an unknown, possibly fluorescent background, measuring in an open, public environment and under deep UV conditions, a basic setup for the standoff detection of trace quantities of surface adsorbed chemicals using deep UV Raman is described and characterized at an excitation wavelength of 264 nm. This set-up promises to be an aid for future, compact UV Raman equipment for standoff applications from ~2 m and above.

EXPERIMENTAL

In order to find best conditions for the design of standoff Raman applications, a flexible set-up has been chosen. The tunable laser (Continuum Sunlite) allows for UV Raman excitation at wavelengths down to 230 nm. The Raman scattering is collected by a 4'' off axis parabolic mirror and guided into the Czerny-Turner spectrometer, with a longpass laser line filter, 2400 g/nm gratings and a nitrogen cooled CCD.

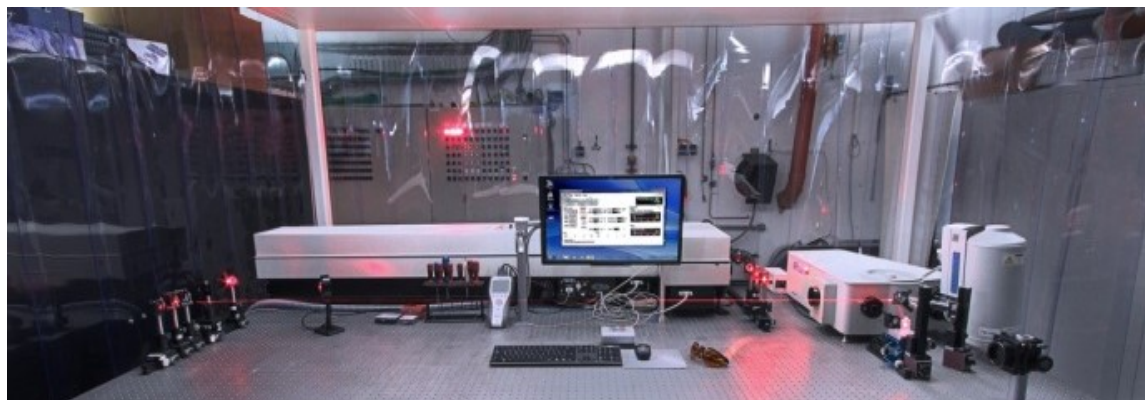


Figure 1 Experimental set-up for deep UV Raman standoff applications with a tunable solid state laser (230-1700 nm)

The selected set-up promises optimum possibilities for the selection of wavelength with sufficient signal quality. It is capable of recording a spectral database for relevant hazardous substances on coloured, possibly fluorescent background material for further application of processing spectral information. It is intended to use the obtained information for the design of Raman standoff applications.

RESULTS

As first demonstration, Raman spectra of pure, dried NaClO_4 ; NaNO_3 ; NH_4NO_3 and urea were recorded at a standoff distance of 60 cm with an excitation at 264 nm.

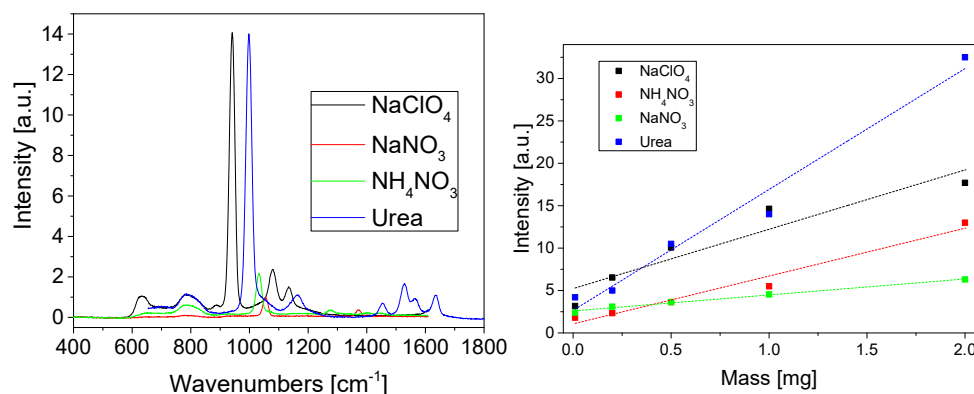


Figure 2 UV Raman spectra of pure NaClO_4 ; NaNO_3 ; NH_4NO_3 and urea (left) and signal intensity of symmetric stretch vibration as a function of surface concentration (right).

The spectra were recorded by accumulating 10 single shot spectra within 3 seconds. With the aim of finding traces of hazardous substance on natural background material (textiles, metals) the spectra represent the basic information for detecting unknown substances. The right panel of Figure 2 contains Raman intensities of vibrational stretch modes of the measured precursors at different concentrations from 2 mg/cm^2 down to less than 250 $\mu\text{g}/\text{cm}^2$.

The presented experimental set-up promises to be a valuable tool for the design of experiments and standoff applications: the overall testing time of max. 3 seconds for each experimental point stays within the limits of required fast detection.

REFERENCES

- [1] K. L. Gares, K. T. Hufziger, S. V. Bykov, S. A. Asher, *Review of explosive detection methodologies and the emergence of standoff deep UV resonance Raman*; Journal of Raman Spectroscopy 47(1):124-141; DOI10.1002/jrs.4868
- [2] Gaft M, Nagli L (2008) *UV gated Raman spectroscopy for standoff detection of explosives*. Opt Mater 30:1739–1746
- [3] A. Ehlerding, I. Johansson, S. Wallin, H. Oestmark, *Resonance-Enhanced Raman Spectroscopy on Explosives Vapor at Standoff Distances*, International Journal of Spectroscopy 2012(3), DOI 10.1155/2012/158715