# Explosives Detection
## using the D3 Klarite® SERS technology

Application Note


### SUMMARY
Detection of the presence of explosives requires trace level sensitivity and, ideally, the ability to make the measurements without direct contact with the suspect material. Recently developed D3 Technologies Klarite® SERS substrates were used to collect Surface-Enhanced Raman Spectroscopy (SERS) data from three common explosive compounds evaporated from dilute solutions, as well as in the vapor phase.


### EXPERIMENTAL
SERS and bulk Raman spectra were measured using a low power density Raman system with a 785 nm laser (250 mW, 130 µm diameter illumination).

Figure 1 – The D3 Technologies Klarite SERS substrates

Samples were prepared from the following commercially available solutions: nitroglycerin in methanol and TNT and RDX in acetonitrile (all 1 mg/ml; Thames Restek UK Ltd, catalogue numbers 31498, 31669 and 31665).

Evaporated films were prepared by pipetting 1.5µl of each explosive onto the active area of Klarite gold SERS substrates. Vapor phase measurements were made using a low volume, sealed system incorporating a Klarite substrate as the sensing surface. Microlitre volumes of explosive material were pipetted into reservoirs distal from (i.e. not in direct contact with) the Klarite surface.

### RESULTS
Figure 2 shows the SERS spectra of evaporated films of explosive material on the Klarite substrate, each at a concentration of 1 mg/ml. The trace for each explosive shows a series of unique, intense peaks, with a clear differentiation between each of the substances. This allows identification of the materials applied to the Klarite substrate in addition to trace level detection of the explosive material.

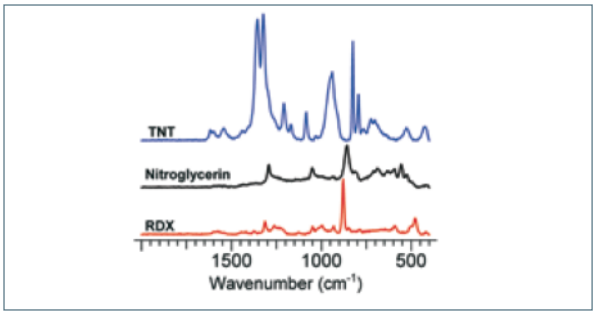


Figure 2 – SERS spectra of evaporated films from 1mg/ml solutions of TNT, nitroglycerin and RDX

Figure 3 shows SERS spectra of evaporated films from diluted samples of each explosive. The concentration of the explosive material pipetted onto the Klarite surface is given in the legend. Owing to the volatility of the solvents used as the vehicles for the explosives, the pipetted solutions spread to cover an area of at least 4mm$^2$ (the active area of the Klarite substrate). Approximate calculation of the mass of explosive under the laser spot (130 µm) at each concentration shown in figure 3 is ~12 pg for TNT, ~120 pg for Nitroglycerin and ~1.2 pg for RDX. Further work is underway to accurately determine the absolute limit of detection level for explosive materials on Klarite. However, these data indicate that the Klarite surface provides a sensitive detection system for explosive materials deposited using evaporated films.

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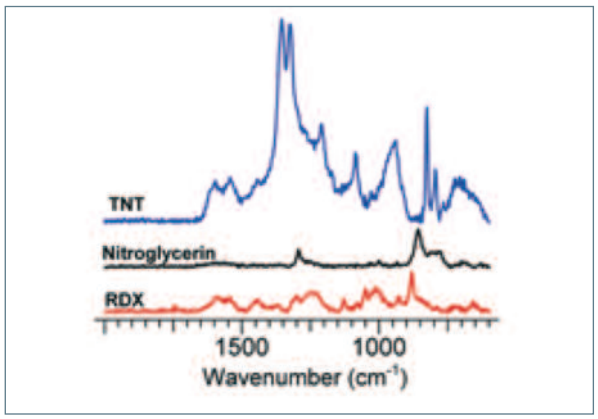


Figure 3 – SERS spectra of evaporated films from diluted solutions of TNT (10 µg/ml or 10 ppm), Nitroglycerin (100 µg/ml or 100 ppm) and RDX (1 µg/ml or 1 ppm)

Figures 4 and 5 show the vapor phase SERS spectra of TNT and nitroglycerin respectively. These data demonstrate that the vapor phase spectra are similar to the spectra obtained from an evaporated film deposit (reference trace). Furthermore, the data shows that the detection is rapid, with a strong signal detected for each explosive in the timescale of a few minutes even without a special sampling system. This demonstrates the feasibility of using the Klarite substrate for rapid detection of explosive vapors.

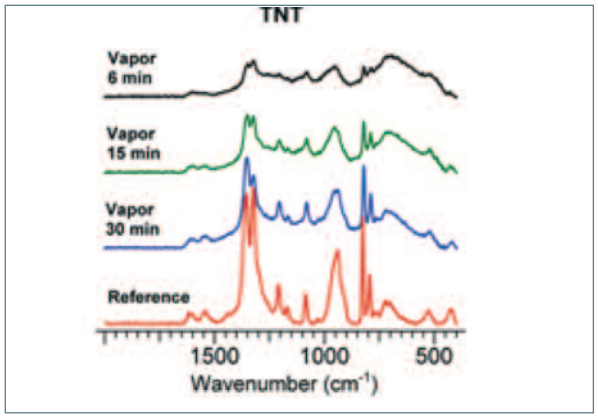


Figure 4 – SERS spectra of vapor phase samples of TNT after 6, 15 and 30 minutes. A reference evaporated film spectrum is also shown

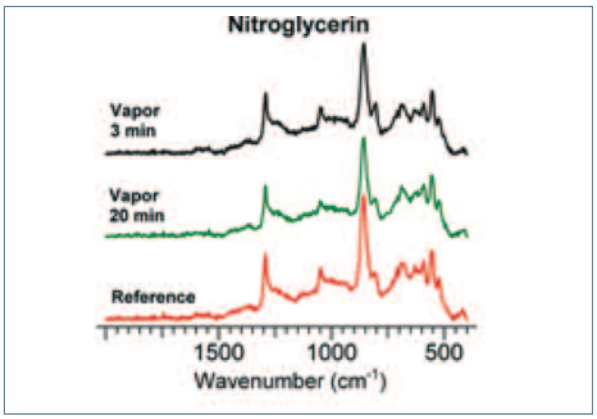


Figure 5 – SERS spectra of vapor phase samples of nitroglycerin after 3 minutes and 20 minutes. A reference evaporated film spectrum is also shown

### CONCLUSION

We have demonstrated the feasibility of using the D3 Technologies Klarite SERS substrates to detect and identify explosives in both evaporated films and in the vapor phase. With further development and refinement, the Klarite technology has the potential to become a rapid and sensitive screening tool for the presence of explosives on personnel, property and within the environment.

* Legal notice: All statements, information and recommendations related to products herein are based upon information believed to be reliable or accurate. However the accuracy or completeness is not guaranteed and no responsibility is assumed for inaccuracies.

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