LaserScan™: QCL Based IR Reflection Spectroscopy System for Detection of Explosives

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Abstract

New technologies based on infrared spectroscopies such as the LaserScan™ (Block Engineering) provide rapid, precise detection and identification in real-time without sample preparation of compounds deposited on surfaces (as glass, plastics and metals) and present at trace level as contaminants. These new system are able to detect different hazardous compounds employed by terrorist such as highly energetic materials (HME), homemade explosives (HME) and other threat chemical and biological agents as well as Toxic Industrial Compounds and Materials (TICs/TIMs).

Relevance

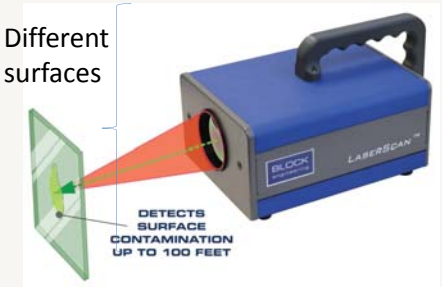
The **LaserScan™** employs a quantum cascade laser (QCL) as source, which operates in the mid IR (MIR) region. QCLs have revolutionized many areas of research and development in defense and security applications.

The most relevant features of these new IR reflectance systems is their portability. Furthermore, the MIR laser-based spectrometers can detect analytes deposited on various types of several substrates *in situ* such as glass, metals and plastics, significantly reducing the potential caused by exposure to chemical hazards to the operator as well as prevent cross contamination of forensic evidence.

In this project the UPRM ALERT research team will work in testing a spectroscopic system for sensing of highly energetic materials and Northeastern will develop algorithms that will enhance the LaserScan

Technical Approach

QCL based LaserScan™



We have evaluated a widely-tunable QCL scanner (1000–1600 cm^{-1}) for detection and quantification of HEM/HME deposited on substrates. Figures 1 and 2 show some of the results obtained for experiments using RDX, TNT, PETN and Semtex-H deposited on Al.

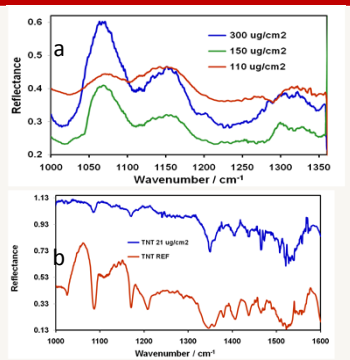


Figure 1. (a) QCL spectra RDX deposited on Al substrate at 110, 150 and 300 μg/cm² loadings. (b) Reference micro-FTIR spectrum of TNT and the corresponding QCL excited reflectance spectrum on aluminum plate.

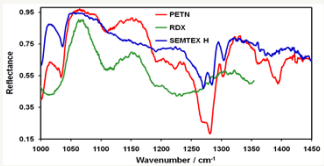


Figure 2. QCL spectra of PETN, RDX and SEMTEX-H formulation: 40.9% PETN and 41.2% RDX

A selected list of 15 organic compounds considered highly energetic materials have been studied so far. Energetic substances samples deposited on sandblasted aluminum plates were detected using this method. The samples analyzed were placed at 6 in. of distance for the active mode experiments. All experiments were carried out at room temperature. Surface concentrations (60 to 80 μg/cm²) were used. Results were compared with a bench FTIR to characterize the vibrational signatures. Figure 3 show some results.

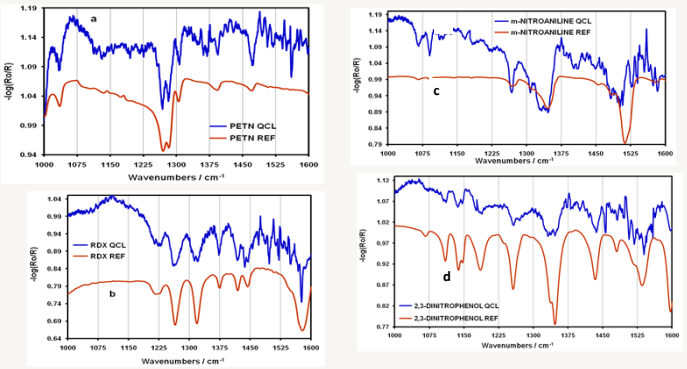


Figure 3. QCL spectra compared to reference spectra: (a) PETN; (b) RDX; (c) m-nitroaniline; (d) 2,3-dinitrophenol.

Future Work

- Continue generating a IR Spectral Database of HEM/HME and other common threat chemicals.
- Design and development chemometric models for discrimination and quantifications analysis.
- Testing the unit performance in terms of vibrational signatures of HEM/HME
- Determining low limits of detection of HEM/HME
- Study substrate effects on spectral response
- Perform study of interference/matrix effects
- Perform quantification/discrimination studies

LaserScan™ system will be useful for defense and security applications, for monitoring HEM/HME. These system can be work together with the existent instrument employed by TSA in airports

Opportunities for Transition

Efforts of the University of Puerto Rico and Northeastern University under this program represent an initial step towards optimization of a new portable MIR laser based instrument useful for threat detection. Optimization will include development of new algorithms, which will increase the market potential for the LaserScan™ and the ultimate number of customers. The increased sales will directly benefit the Massachusetts economy, where the instrument is manufactured. Benefits to ALERT COE is the value added will be licensed by Block Engineering and ALERT will then receive a residual on the sales of the LaserScan™ that include the improved detection/discrimination algorithms

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- S.P. Hernández-Rivera, J.R. Castro-Suarez, L.C. Pacheco-Londoño, O.M. Primera-Pedrozo, N. Rey-Villamizar, M. Vélez-Reyes and M. Diem, "MID-Infrared Vibrational Spectroscopy Standoff Detection of Highly Energetic Materials: New Developments", *Spectroscopy*, Defense and Homeland Security Issue, April, 2011, 34-41 Ortiz-Rivera, W; Pacheco-Londoño, L.C.; Hernández-Rivera, S. P. Remote Continuous Wave and Pulsed Laser Raman Detection of Chemical Warfare Agents Simulants and Toxic Industrial Compounds. Sensing and Imaging: An International Journal, **(2010),** 11 (3): 131-145.
- Pacheco-Londoño, L., Ortiz-Rivera W., (**2009**). "Vibrational spectroscopy standoff detection of explosives." Analytical and Bioanalytical Chemistry 395(2): 323-335.

Other References

For more information, please go to:
http://academic.uprm.edu/ccsde/

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