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Hybrid fs/ps-CARS microscopy for identification of simi-explosive powders

In the past years, intense efforts in Raman based CBRN sensing have been devoted to the detection and identification of trace amounts of hazardous chemicals [1,2] or biological agents [3]. This goal requires high sensitivity as well as the ability to differentiate between compounds very similar in molecular composition but very different in threat. In that purpose, hyperspectral microscopy appears as a very powerful tool since it combines molecular information with morphological details, which are required for precise identification of threat agents, in samples such as bacterial and spores. In this work, hybrid fs/ps-CARS microscopy is applied to the study of nitroaromatic explosives. A spectroscopic study was carried out on two TNT substitutes having very similar chemical formula, namely DNT and DNB, inside their specific spectral windows (symmetrical elongation mode of NO₂ at 1350 cm⁻¹, C-N bond at 1600 cm⁻¹, and C-H bond at 2900 cm⁻¹). We show that a single peculiar spectral window, 200 cm⁻¹ in width, centered at 1350 cm⁻¹ for the NO₂ elongation mode, although traditionally known to be intense but lacking of specificity [4], definitely allows for accurate identification of DNT and DNB, thanks to the good spectral resolution (<8 cm⁻¹) offered by our hybrid fs/ps-CARS setup. Between 80% and 90% positive identification have indeed been demonstrated using supervised (correlation with reference spectra) or unsupervised (PCA + agglomerative clustering) methods in this single spectral window.

References

- [1] Katz et al, Appl. Phys. Lett. 92 (2008) 171116
- [2] Dogariu et al, 2013 Conference on Lasers and Electro-Optics (2013) AF2H.2
- [3] Coluccelli et al, J Scientific Reports, 13 (2023) 2634
- [4] Bremer et al, Proc. SPIE 8358 (CBRNE) Sensing XIII (2012) 835818

Figures

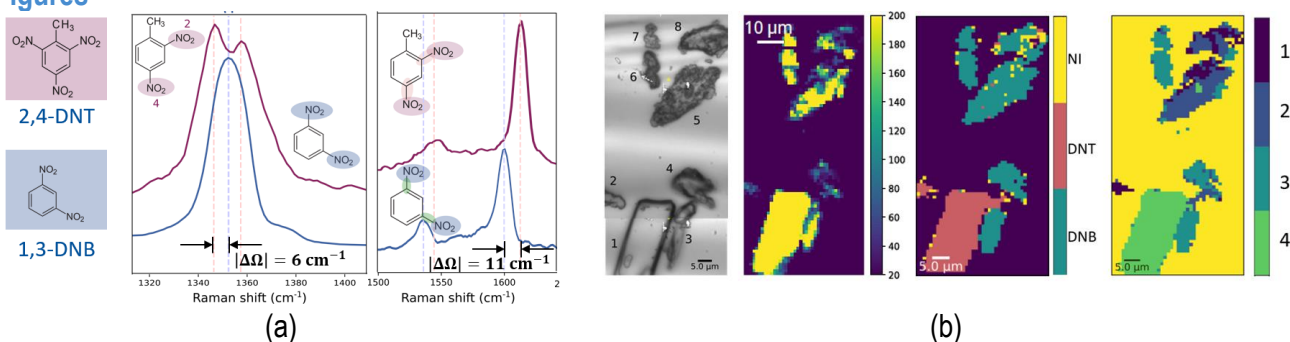


Figure 1: (a) Spectrum of DNT and DNB on the NO₂ and CN bounds (b) White light image, CARS image at 1350 cm⁻¹, clustering using supervised and unsupervised method.