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Real time recognition of explosophorous group and explosive material using laser induced photoacoustic spectroscopy associated with novel algorithm for time and frequency domain analysis

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Abstract

Energy-rich bonds such as nitrates (NO_3^-) and percholorates (ClO_4^-) have an explosive nature; they are frequently encountered in high energy materials. These bonds encompass two highly electronegative atoms competing for electrons. Common explosive materials including urea nitrate, ammonium nitrate, and ammonium percholorates were subjected to photoacoustic spectroscopy. The captured signal was processed using novel digital algorithm designed for time and frequency domain analysis. Frequency domain analysis offered not only characteristic frequencies for NO_3^- and ClO_4^- groups; but also characteristic fingerprint spectra (based on thermal, acoustical, and optical properties) for different materials. The main outcome of this study is that phase-shift domain analysis offered an outstanding signature for each explosive material, with novel discrimination between explosive and similar non-explosive material. Photoacoustic spectroscopy offered different characteristic signatures that can be employed for real time detection with stand-off capabilities. There is no two materials could have the same optical, thermal, and acoustical properties.

Keywords: Explosives, Instant detection, Photoacoustic response, Spectroscopy, Laser, Optical properties, Forensic analysis.

1. Introduction

Traditional security measures including X-ray technique cannot provide any information about the chemical structure of explosive materials [1-2]. Some functional groups such as NO_3^- and ClO_4^- have an explosive nature; as they have two highly electronegative atoms competing for electrons. The oxidation state of nitrogen and chlorine is +5 and +7 respectively; this is unstable state for highly electronegative