Forensic Science International: Synergy 2 (2020) 670–700

Contents lists available at ScienceDirect

Forensic Science International: Synergy

journal homepage: https://www.journals.elsevier.com/forensic-science-international-synergy/

Interpol review of detection and characterization of explosives and explosives residues 2016-2019☆

Douglas J. Klapec*, Greg Czarnopys, Julie Pannuto

United States Department of Justice, Bureau of Alcohol, Tobacco, Firearms and Explosives, Forensic Science Laboratory, 6000 Ammendale Road, Ammendale, MD, 20705, USA

ARTICLE INFO

Article history:
Received 6 January 2020
Accepted 23 January 2020
Available online 17 June 2020

ABSTRACT

This review paper covers the forensic-relevant literature for the analysis and detection of explosives and explosives residues from 2016-2019 as a part of the 19th Interpol International Forensic Science Managers Symposium. The review papers are also available at the Interpol website at: https://www.interpol.int/Resources/Documents#Publications

1. Introduction and coverage of the literature

This review starts with a recommendation to read the previous three papers covering explosives analysis from 2007 to 2010 presented in 2010 by Richard Strobel and our previous reviews from 2013 to 2016 [13,14,26]. This review is less broad than the previous papers for several reasons including the filtering out of repetitive research. An example would be several papers on a single type of nanotechnology for a single analyte that already is already relatively easy to detect. That said, it is also highly recommended that practitioners in the field of forensic analysis and those on the cutting edge of developing new explosive security measures, peruse the references and determine what may be of use in future real life applications.

As Allied war efforts in regions that have seen many bombings have slowed even more in the past three years than in the last iteration of this topic, we have seen a decrease or flatlining in funding among some governments and even in private companies' research. However, civil wars are still ongoing in countries like Yemen, Syria, Iraq, Libya and Afghanistan, and major bombings are still prevalent, targeting combatants and civilians alike. Manchester, England was the site of a major terrorist bombing in May 2017, which killed 22 people. Large bombings are still prevalent in the Philippines, as one example, and in other nations not involved in a civil war. Other modes of terrorism also have the attention of forensic practitioners and security experts. These include mass shootings and vehicular attacks, arson and knife attacks. However, the overall threat from explosives, especially in domestic settings, has remained important.

One of the most important yet difficult areas for the past ten to twenty years for the explosive analyst is the ever-changing type of explosives employed by the criminal bomber and terrorists. Restrictions on widely used commercial and military high explosives are often circumvented by the illicit production of homemade explosives. While there have been attempts to restrict chemical precursors and some oxidizers and fuels, criminal and terrorist bombings are still frequently using homemade explosives. Some of these explosive formulations are difficult to detect in a chaotic and contaminated scenes, with matrices that are additionally problematic. The two biggest reasons for failure to identify a post-blast homemade explosive in some of these cases are the failure to collect samples in a timely manner and the failure to properly extract the analytes from difficult samples. While training of first responders and others may help with the first issue, the second issue falls mostly on the explosives forensic community. There is not a lot of research in this area, but a few referenced papers do address this second issue.

As stated in our 2016 paper, "The forensic explosive analyst should regularly review literature in the wider scientific community with an emphasis on suitability for employing new techniques in the scheme of analysis. These include both applied and theoretical published research. It helps to get an early start in researching these techniques because of the increasingly stringent accrediting requirements for any new technique" [14]. We are hopeful this review

☆ 19th International ICPO – INTERPOL Forensic Science Symposium, Lyon, France, October 2019.

* Corresponding author. United States Department of Justice, Bureau of Alcohol, Tobacco, Firearms and Explosives, Forensic Science Laboratory, Washington, USA.
E-mail address: doug.klapec@atf.gov (D.J. Klapec).

https://doi.org/10.1016/j.fsisyn.2020.01.020

will provide additional references and resources to kick start more applied research for the forensic practitioner.

There are increasing scientific and accrediting body requirements to make the transition from research to casework use in the forensic laboratory. More laboratories are requiring vigorous validation before putting any given method into use. As one example, although most forensic explosives chemistry protocols do not require quantitation (the verified detection of an analyte is normally enough to report it) and nor is the amount detected useful in most post-blast analysis, nevertheless, limits of detection may be required for full validation of a technique. There are several reasons for this but include monitoring any given system for performance over time. These issues should not dissuade analysts from attempting to introduce new or improved techniques into their schemes of analysis.

The review of the literature presented here shows that there are many applications in the wider world of explosives that could be of interest to the forensic explosive chemist. The authors, with help of a competent research librarian and hundreds of hours of reviewing abstracts by a team of forensic explosive chemists, have looked for anything to do with explosive manufacturing, theoretical and commercial, explosive detection using any technology, explosive performance and physics, sampling improvements, as well as new or improved analytical techniques for the identification of explosives. The field of explosives detection is still the fastest growing area from which forensics can draw. There are still dozens of references in this area, ranging from theoretical research to applied systems that are already in field use.

There are 1005 references in this review. Each reference has a hyperlink to the abstract or full text article where available. Additionally, the categories in the reference list can be easily accessed using the Navigation page in Microsoft Word. This will aid the navigation of the bibliography section, starting on page 26 of this document. Many of these references could fall into two or even three categories. They will not be presented in multiple places, so it would be advantageous for the reader to peruse all of the sections. The organization of this paper follows the same pattern as the previous reviews.

2. Review articles

This three-year cycle included several review publications. Some are broad schemes of analysis, while many are reviews of a specific class of instrumentation. Still others are self-described as reviews. Review papers are useful to give a broad overview of advances in particular aspects or categories of forensic explosive analysis. We will be dividing this section into forensic applications versus detection and security applications.

In the area of general overviews, Goodpaster reviewed the current status of explosives analysis from the forensic practitioner standpoint. He reviewed methods including types of spectroscopy, chromatography, and elemental analysis, as well as mass spectrometry [9].

Similarily, Brown et al., in a two part discussion, reviewed the current state of explosives detection. They "… review and critically evaluate the latest (the past five years) important advances in explosives detection, with details of the improvements over previous methods, and suggest possible avenues towards further advances in, e.g., stand-off distance, detection limit, selectivity, and penetration through camouflage or packaging. The review consists of two parts. This part, Part I, reviewed methods based on animals, chemicals (including colorimetry, molecularly imprinted polymers, electrochemistry, and immunochemistry), ions (both ion-mobility spectrometry and mass spectrometry), and mechanical devices" [2].

Peacock, P., et al., comprehensively reviewed the advances in ionization technology from January 2015 to September 2016 [21]. Their work should provide a guide for those working on new techniques to improve mass spectroscopy. Primarily focused towards researchers, the newer ionization techniques here in this paper could be seen commercially or even used directly by enterprising forensic chemists.

Gooch, J., et al. have an interesting review on the use of unique taggants that could be used in countries where taggants are mandated or even by companies interested in tagging their products. With nanotechnologies advancing at an increased pace, "… continuing advances in portable in-field analysis, nanotechnology and material science should have allowed for the development of new and improved forensic marking agents. However, the limited amount of recent research in this area suggests that this is not the case" [8].

Saini, R., has an excellent primer on the latest technologies being investigated for explosives detection [24].

Forbes, T. and Sisco, E. looked at recent advances in ambient mass spectrometry of trace explosives. They write, "These techniques have enabled real-time detection of target analytes in an open environment with no sample preparation and can be coupled to any mass analyzer with an atmospheric pressure interface" [6]. Mostly applicable to security purposes, these are also finding their way into the forensic analysis environment.

Although this paper could be placed in nanotechnology or even novel explosives, Go, B., Qiao, Z., & Yang, G. reviewed the rapidly growing interest in nano-explosives, dividing them into nano-individual explosives, nanocomposites, and nano-cocrystals [7].

Huri, M., Ahmad, U., Ibrahim, R., and Omar, M. presented a nice comprehensive overview of three aspects of explosive residue detection: screening techniques, extraction techniques, and instrumental techniques. Extraction methods include swabbing techniques, solid phase extractions, and solid phase microextractions. Additionally, "Instrumental techniques covered in this review included gas chromatography, high performance liquid chromatography, ion chromatography and capillary electrophoresis" [10].

de Araujo, W.R., et al., presented a review of portable on-site instrumentation and methods to include explosives. They review "A wide range of approaches including electrochemical sensors, microchip electrophoresis, ambient ionization on portable mass spectrometers, handheld Raman and NIR instruments as well as and point-of-need devices, like paper-based platforms" [5].

Zhang, W., et al. reviewed recent developments in spectroscopic techniques for trace explosives detection in the field using terahertz (THz) spectroscopy; laser-induced breakdown spectroscopy (LIBS), Raman spectroscopy; and ion mobility spectrometry (IMS) [32].

3. Explosive standards and references, laboratory quality control, contamination prevention

Lees, H., Zapata, F., Vaher, M., and Garcia-Ruiz, C. looked at the transfer of nine different explosive residues (ANFO, dynamite, black powder, TNT, HMTD, PETN, NH_4NO_3, KNO_3, $NaClO_3$) to evaluate cross-contamination through fingerprint transfers and other modalities encountered at busy security checkpoints. Some results included, "… that transfer of explosive residues frequently occurred with certain differences among materials. Generally, the amount of explosive particles adhered to the finger decreased in the following order: skin > latex > nitrile, while the transfer of particles from the finger to another surface was the opposite. The adhesion of explosive residues from polycarbonate to the finger was found to be better compared to cotton, while the amount of particles transferred to cotton was higher" [34].

Pawłowski, W., Matyjasek, Ł., Cieślak, K. and Karpińska, M. studied contamination in the laboratory with some common explosives, looking at what stage of an analytical procedure would most likely result in contamination and with what type of explosive. The results are surprising given the static adhesion energy of PETN is well known and that NG, although volatile, can re-absorb on any number of substrates [36].

4. Sampling and concentration of explosive traces

Sampling and concentration of explosives is an important step in explosives analysis and detection. In many post-blast samples, the analytes are present in extremely low quantities or part of difficult matrices, or both. This aspect of explosive analysis is ripe for exploration and research.

A validated solid phase extraction cleanup procedure with Bond Elut NEXUS co-polymeric cartridges was used for soil and swab samples containing pre- and post-blast residues of nitro-organic explosives and reported by Thomas, J., Donnelly, C., Lloyd, E., Mothershead, R., Miller, J., McCollam, D. and Miller, M [69]. They report "The expected explosives were detected in 97% of cases after processing through SPE and analysis by GC/ECD." And "The results from these matrices were compared to results obtained by syringe filtration. SPE produced equal or better results than syringe filtration in both the ECD screening and MS confirmation tests …" They report the successful application of the cleanup of organic explosive residues in complex matrices. This was also reported in a separate journal [68].

Chouyyok, W., et al., "… compared the analyte-release performance of standard muslin sampling swipes to that of rationally assembled fiberglass cloth, and used thermal-desorption ion mobility spectroscopy for detection. The fiberglass cloth was chemically modified by covalently bonding phenyl-functional groups to the surface. The rationally assembled sampling materials provide significantly performance improvements over standard muslin sampling materials for detection of TNT, NG, RDX, TATP, and PETN." For example, phenyl-functionalized fiberglass resulted in over 10 times greater TNT release, compared to muslin cloth, as well as improved response and repeatability after multiple uses of the same swipe [44].

Laster, J. presented novel sampling swabs for the collection of trace explosive residues. Microstructured polypyrrole (PPy) films displayed enhanced particle removal abilities compared to PPy non-structured and current commercial films for IMS detection [54].

Temple, T., Goodwin, C., Ladyman, M., Mai, N., and Coulon, F. reported "Optimised accelerated solvent extraction of Hexahydro-1,3,5-Trinitro-1,3,5 Triazine (RDX) from polymer bonded explosives" [67].

Daeid, N., Holly, A., and Beardah, M. reported that a 2007 European Network of Forensic Science Institutes (ENFSI) Expert Working Group proficiency test with TNT spiked swabs revealed that some laboratories did not detect the analyte. This paper reports on loss of TNT over time and various environmental conditions. "Overall, the cotton swabs stored at room temperature and exposed to daylight showed a very rapid loss of TNT over time, whereas cotton swabs stored in the freezer, and all simulated swab extracts, gave high recoveries over time" [46].

Bors, D., and Goodpaster, J. mapped smokeless powder residues using total vaporisation solid phase microextraction gas chromatography mass spectrometry (TV-SPME/GC/MS) to quantify residues of double-base smokeless powder (nitroglycerin (NG), diphenylamine (DPA), and ethyl centralite (EC)) on post-blast PVC pipe bomb fragments. They report "The analytical method could separate the three constituents in under 5 min with a detection limit under 1 ppb, which demonstrates high throughput while maintaining high sensitivity. The method was optimised for nitroglycerin, as it is the most indicative of DBSP (double base smokeless powder)" [41].

Abdul-Karim, N., et al., looked at post blast particle morphology in an attempt to aid in collection and recovery. Particles were collected from the detonations of aluminized ammonium nitrate and RDX-based explosive utilizing SEM stubs. They report "Spheroidal particles (10–210 μm) with microsurface features recovered following inorganic charge detonations were dissimilar to the irregularly shaped particles (5–100 μm) recovered following organic charge firings" [38].

Zapata, F., and García-Ruiz, C. used "a wide variety of materials such as glass, steel, plywood, plastic bag, brick, cardboard or cotton subjected to open-air explosions were examined using confocal Raman microscopy, aiming to detect the inorganic oxidizing salts contained in explosives as black powder, chloratite, dynamite, ammonium nitrate fuel oil and ammonal. Post-blast residues were detected through microscopic examination of materials surfaces. In general, the more homogeneous and smoother the surface was, the less difficulties and better results in terms of identification were obtained" [72].

Fisher, D., Zach, R., Matana, Y., Elia, P., Shustack, S., Sharon, Y., et al. examined what types of swabs are best suited for recovery of explosives in the oft-used IMS detection setting. They report, "The adhesion of explosive particles to three typical materials, plastic, metal and glass, were measured using atomic force microscopy (AFM). We found that a strong contribution of capillary forces to adhesion on glass and metal surfaces renders these substrates more promising materials upon which to find and collect explosive residues" [48].

Taudte, R., Roux, C. and Beavis, A. investigated the degradation of compounds from smokeless powders and report that "energetic compounds were generally found to be more stable than smokeless powder additives such as stabilisers including diphenylamine and ethyl centralite, which might be problematic considering that these compounds are common targets for OGSR (*organic gunshot residues*)" [66].

5. Identification of explosives, explosive residues and explosive properties

There are some reports on the properties of explosives and theoretical modeling of explosive behavior. Also of great interest is the area of novel explosives and proposed improvements to existing commercial and military explosives. Some of these articles also describe analytical techniques.

5.1. Commercial explosives

Elbasuney, S., Fahd, A., Mostafa, H., Mostafa, S. and Sadek, R. reported on modified double base propellants with additions of oxidizer-metal fuel (Ammonium perchlorate/Aluminum), and energetic nitramines. The study evaluates the impact of these energetic additives on thermal behavior, chemical stability, and shelf life [83].

Dennis, D., Williams, M., & Sigman, M. utilized "a Bayesian network for inference of the powder manufacturer." They looked at chemical characteristics of 169 smokeless powders using the most intense ions in their total ion spectra from gas chromatography-electron ionization-mass spectrometry and physical characteristics such as diameter and length, shape, color, luster, bias cut and whether the particles were perforated. The sensitivity and specificity of the fully instantiated network was examined for each manufacturer. They reported, "The PPV ranged from 0.59 to 0.81 for

individual manufacturers when all nodes of the network were instantiated. The NPV for fully instantiated networks ranged from 0.82 to 0.99 for individual manufacturers" [81].

Dennis, D., Williams, M., and Sigman, M. used "Gas chro matography–electron ionization–mass spectrometry (GC–EI–MS) and physical characteristics data for 726 smokeless reloading powders were analyzed by pairwise comparisons of samples comprising the same product and different products." They looked at 13 organic components/constituents of smokeless powders Interestingly they reported, "In the discrete and continuous data comparisons, the likelihood ratios for probabilities conditioned on same shape, color, presence/absence of perforation and size were found to provide relatively limited support for either the proposition of same product or different product" [80].

Xu, C., An, C., Li, Q., Xu, S., Wang, S., Guo, H., and Wang, J. have a unique and timely paper on using direct ink writing (DIW) to manufacture pentaerythrite tetranitrate-based composites. The energetic materials were producting using DIW, and "scanning electron microscopy, energy-dispersive x-ray spectroscopy, X-ray diffraction, differential scanning calorimetry, and nanoindentation were used to characterize the printed samples" [111].

While this could be included in the safety section of this paper, Xu, S., Tan, L., Liu, J., Chen, X., Jiang, W., Chen, Y., et al., investigated an accidental event with emulsion explosives and concluded, "The investigation of the accident showed that the reaction between crystalloid sodium nitrite and ammonium nitrate (AN) was likely the cause of the spontaneous burning" [112].

5.2. Military explosives

Mao, X., Jiang, L., Zhu, C., and Wang, X. looked at the "Effects of aluminum powder on ignition performance of RDX, HMX, and CL-20 explosives" in *Advances in Materials Science and Engineering*. They showed, interestingly that, "… the energy release of the HMX/Al composite explosive with 10 wt%, 20 wt%, and 30 wt% aluminum powder was only equivalent to 80%, 65%, and 36% of pure HMX, respectively. It was similar to RDX/Al and CL-20/Al composite explosives, except the CL-20/Al mixture with 10% aluminum powder." Aluminum does not seem to play much of a role except at ignition [131].

5.3. Homemade explosives

The area of Homemade Explosives (HME) is still of tremendous interest to the forensic explosives analyst. Sometimes called Improvised Explosives (as opposed to an Improvised Explosive *Device* that may or may not use HME), these explosives can, in general terms, be defined as non-factory manufactured explosives. It is uncommon, but not unheard of, however, that makers of HME will attempt to make a "commercial" type of explosive. Such cases are more likely to include improvised black powder or flash powder than processes such as the nitration of toluene.

The actual usage of HME is constantly changing and it is difficult for forensic laboratories to have adequate protocols for every possibility. Some HMEs or components therein are difficult to detect post-blast unless samples are taken immediately, stored properly, and analyzed quickly. In other instances, a component of the HME might be present in the environment of the explosion (say gasoline used as a fuel in an AN-gasoline mixture used in a car bomb).

In the area of primarily low explosives, many of which can be improvised, Conkling, J.A. & Mocella, C. have published the 3rd edition of *Chemistry of Pyrotechnics: Basic Principles and Theory.* This book is an excellent primer for the forensic analyst wishing to understand behavior of pyrotechnic mixtures and of low explosives, and for understanding the area of Homemade Explosives [149].

DeGreeff, L. and Johnson, K. looked at how vapor detection of Homemade Explosives differs from traditional explosive vapor detection. Specifically, they looked at ammonium nitrate mixtures and organic peroxides [150].

Härtel, M., Klapötke, T., Stiasny, B., and Stierstorfer, J. re-examined the gas phase concentration parameters of the explosives triacetone triperoxide (TATP) and diacetone diperoxide (DADP) [154].

Fraga, C., Mitroshkov, A., Mirjankar, N., Dockendorff, B., and Melville, A. presented a study titled *Elemental source attribution signatures for calcium ammonium nitrate (CAN) fertilizers used in homemade explosives.* They used inductively coupled plasma-mass spectrometry (ICP-MS) to "determine the concentrations of 64 elements in 125 samples from 11 CAN stocks from 6 different CAN factories." They looked at the elements Na, V, Mn, Cu, Ga, Sr, Ba and U. Partial least squares discriminant analysis was then used to develop a classification model. They report that "for pristine CAN samples, i.e., unadulterated prills, 73% of the test samples were matched to their correct factory group with the remaining 27% undetermined using strict classification." They then used various fuels in mixtures and still found similar but not the exact results. This is a promising approach to discriminate among CAN samples, especially in those areas where terrorists are frequently using unadulterated CAN as the oxidizer [153].

Newsome, G., Steinkamp, F., and Giordano, B. reported on analyzing bulk ammonium nitrate by using ambient ionization mass spectrometry and a tungsten oxide layer, which absorbs both species and thermally desorbs NH3 and NO2. They report that "ammonia was detected successfully, but the pre-concentrator reduced nitric acid to compounds smaller than NO2, including N2, that could not be detected apart from background" [159].

Kotrlý, M., Turková, I., Beroun, I., and Mares, B. presented Methods for characterization of home-made and non-standard explosives in forensic science which is basically a working scheme of analysis for Homemade Explosives. A later presentation will be explored next but here they present the types of techniques they used and include GC-MSD, GC-ECD, EDS, and imaging by SEM. It is well worth the time to read this [156].

Kotrly, M., Wolker, J., Turkoba, I., and Beroun, I. presented a the first version of an HME database based on a two year running project to "… prepare some of these substances and carry out experimental explosions and tests, and map analyses possibilities using a wide range of available analytical techniques in forensic labs. Samples of primary substances, prepared explosives and post-blast residues are analyzed in a complex way in terms of organic and inorganic components. All data obtained, including visual documentation, are stored in a specialized database for security forces and their expert workplaces." Again, it is another resource for laboratories attempting to analyze HME [157].

Bannister, W. and Oxley, J. reported on detection issues when dealing with non-nitrogen based explosives. These "include peroxides (used in both monergolic and hypergolic applications); acetylene precursors; and fuel/air bomb systems involving use of olefin oxides, acetylene, other hydrocarbons, and similar high energy agents." They additionally look at precursors and preparation of these energetic materials. Next they deal with numerous composite explosives in the form of intimate mixtures of fuels and oxidizers such as those that use perchlorate, chlorate or hypochlorite salts as oxidizers. Finally and interestingly they discuss "… self-igniting systems such as boranes, phosphorus and alkali metals" [147].

DeGreeff, L., Cerreta, M., and Katilie, C. looked at degredation products of HMTD for detection and noted variances in detection based upon synthesis method, precursors, storage time, and storage environment. The composition and quantity of these volatiles

were compared across these variables. They did this through headspace analysis of bulk HMTD samples and used solid phase microextraction (SPME) with gas chromatography/mass spectrometry (GC/MS). They also monitored decomposition of HMTD by gravimetric analysis. Two results reported were "… that formic acid is the most abundant decomposition product while formaldehyde is the most commonly detected across all variables" [151].

In a similar report, Steinkamp, F., DeGreeff, L., Collins, G., and Rose-Pehrsson, S. completed a kinetic study of HMTD decomposition in solution (water). They also report a "correlation between degradation rate and the presence of decomposition species identified in the headspace …" [164].

One interesting paper by Vodochodský, O., Jalový, Z., Matyáš, R. and Novotná, M. reported on using FTIR to do quantitative analysis of triacetone triperoxide (TATP) and hexamethylene triperoxide diamine (HMTD) on different substrates. They tried polymer, plastic, and cellulose matrices. Reporting (in the abstract): "It is based on dissolving, or extraction of, peroxide in the solvent and measurement in cuvettes using the Fourier transform infrared technique. These methods may be useful in analytical techniques of explosive detection and determination" [165].

Lease, N., Kay, L., Chavez, D., Robbins, D. and Manner, V. reported that molten ETN is more sensitive than cast ETN [158].

5.4. Other explosives including novel or new explosives

It was stated in our 2016 paper and still is true now, "Two types of advances in the production of novel explosives are reported here. As in the last review, there are many nanoparticle investigations. Additionally, the need for stability in harsh environments and a push toward environmentally friendlier explosives drive development of new military explosives. Also included are some recently declassified materials" [14].

While this could be seen as an improvement for a well-established technology for commercial explosives, we have included it here under novel explosives. Wang, Y., Ma, H., Shen, Z., Wang, B., Xue, B., & Ren, L. examined the detonation characteristics of emulsion explosives sensitized by hydrogen-storage glass microballoons instead of neutral or air filled microspheres. They reported, "Brisance testing and underwater explosion experiments showed that, compared with traditional emulsion explosives, the shock impulse and specific total energy of hydrogen-storage glass microballoons sensitized emulsion explosives are improved significantly. The brisance (compression of lead block) of hydrogen-storage emulsion explosives is 23.0 mm, 3.2 mm more than that of traditional emulsion explosives." It is unknown if this is a feasible alternative for traditional glass or polymer microballoon for commercial production due to the increased danger in working with hydrogen filled microballoons [244].

Singh, A., Soni, P., Sarkar, C. and Mukherjee, N. discussed reactivity of aluminized polymer-bonded explosives with non-isothermal thermogravimetry and calorimetry. They reported, "Results revealed that the thermal decomposition behavior has been significantly influenced in the presence of Al and HTPB matrix, especially reducing the thermal stability than that of neat HMX" [228].

Abd-Elghany, M., Klapotke, T., and Elbeih, A. studied a new green propellant formulation of a chlorine-free high energy dense oxidizer (HEDO) 2,2,2-trinitroethyl-formate (TNEF) and hydroxyl-terminated polybutadiene (HTPB) as a binder. They characterized the new oxidizer TNEF by nuclear magnetic resonance (NMR) and FTIR and scanning electron microscopy (SEM). They reported, "The results proved that the new oxidizer and its formulation based on HTPB have chlorine-free decomposition products and have higher performance characteristics than the traditional propellants" [169].

In a very interesting article, Gottfried, J., Smith, D., Wu, C. and Pantoya, M. explored coating aluminum particles with aluminum iodate hexahydrate (AIH) to replace the Al_2O_3 layer on Al particles that limits Al oxidation. They stated, "Estimates of the detonation velocity for TNT-AIH composites suggest an enhancement of up to 30% may be achievable over pure TNT detonation velocities. Replacement of Al_2O_3 with AIH allows Al to react on similar time-scales as detonation waves." Again, it is unknown if this could be used on an industrial scale [189].

6. Instrumental analysis of explosives

6.1. LC/HPLC/UPLC

Forensic explosive examiners utilize dozens of instrumental techniques to identify trace amounts of explosives. Liquid chromatography (LC), high performance liquid chromatography (HPLC), and ultra-high performance liquid chromatography (UHPLC) are all excellent separation techniques and have the advantage of being less destructive to thermally sensitive high explosives than gas chromatography techniques.

Şener, H., Anilanmert, B., and Cengiz, S. presented a paper on one of the most popular and newer techniques for ionization with LC systems, that of atmospheric pressure chemical ionization mass spectrometry (LC–APCI–MS/MS). In this presentation they used a fast screening method and examined trace amounts of TNT (trinitrotoluene), RDX (1,3,5-trinitroperhydro-1,3,5-triazine), HMX (cyclotetramethylene-tetranitramine), PETN (pentaerythritoltetranitrate), tetryl (2,4,6-trinitrophenyl-N-methylnitramine), picric acid (2,4,6 trinitrophenol), 2,6-DNT (2,6-dinitrotoluene), and TMETN (trimethylolethane-trinitrate). They used "a gradient of 2.00 mM ammonium nitrate aqueous solution-methanol mobile system, C18 column, and atmospheric pressure chemical ionization (APCI) (−) ionization mode was used after a single-step solid–liquid extraction procedure from soil matrix." And reported "Limit of detection (LOD) and limit of quantification (LOQ) values obtained from the analysis of the soil samples including explosive mix were between 8.9–161.2 and 13.2–241.5 ngg−1, respectively" [266].

Similarly, using tandem mass spectrometry, Avci, G., Anilanmert, B. and Cengiz, S. proposed "A fast and a selective determination method with high recovery was developed for the common explosives 2,4,6-trinitrotoluene (TNT), 3,5-trinitro-1,3,5-triazacyclohexane (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) in soil …" [263].

6.2. Ion chromatography

The technique of ion chromatography (IC) is used in forensic post-blast analysis for the analysis of mostly inorganic but also some organic explosives. The mass spectrometer is the detector of choice even for simple ions, but other detectors are still used as well. Ion chromatography has the advantage over other inorganic characterization methods such as X-ray diffraction and SEM/EDS in that physical particle recovery is not required and, perhaps more importantly, a relative profile of all anions or cations in a sample can be ascertained and judged against known post-blast or post-combustion profiles.

Often, the anionic profile of post-blast residues proves to be most probative. However, in many laboratories, the authors' laboratories included, thiocyanate and perchlorate anions are examined with a separate method from the other typical anions found in post-blast inorganic samples. Here, Gan, Z., Liu, J. and Tang, S. presented a novel method for the simultaneous determination of nine anions (Cl-, NO_2-, ClO_3-, NO_3-, CO_3^{2-}, SO_4^{2-}, $S2O_3^{2-}$, SCN-and

ClO_4-) in explosive residues by ion chromatography using a high capacity anion-exchange IonPac AS20 column (250 mm × 4 mm) [267].

6.3. Gas chromatography

As an alternative to, or as an orthogonal technique, for traditional IC detection and identification of anions, Pagliano, E., Campanella, B., D'Ulivo, A. and Mester, Z. reviewed gas chromatography GC) methods for the determination of inorganic anions after derivatization The review explores many inorganic anions and their derivatives (already published). They stated, "In this review, most derivatization chemistries employed for anions are discussed with attention to molecular aspects of the conversion, experimental conditions, applications to complex sample matrices, and figure of merits" [275]. It seems useful to have this review available for those who do inorganic ion identifications in post-blast explosives analysis.

Marder, D., Tzanani, N., Prihed, H. and Gura, S. used a splitless programmed temperature vaporizing (PTV)-large volume injection (LVI)-GC-MS-negative chemical ionization (NCI). They improve traditional LVI and the issue of having trouble detecting too many analytes in one sample by having "a unique double-column configuration setup developed for the efficient removal of excess solvent through a flame detector before reaching the MS, with the precise timing of carrier-gas flows and the heating program" [274].

For a method to possibly source plastic explosives, Tsai, C., Milam, S. and Tipple, C. used a comprehensive two dimensional gas chromatography-mass spectrometer (GC × GC—MS) with a statistical approach. The MS was a Time of Flight detector and principal component analysis was done. They report, "This demonstrates accurate classification of PE samples into production lots using these data treatment steps" [277].

Chajistamatious, A. and Bakeas, E. presented unique research into analyzing nitrocellulose (NC) by Gas Chromatography—Electron Ionization—Mass Spectrometry (GC—EI—MS). A rapid method for the identification of NC in bulk explosives using GC—EI—MS was developed. They write, "Results showed that NC was detected, by its trimethylsilyl (TMS) derivatives, in all the explosive mixtures analyzed and no false positives were observed" [270].

In a very important study, Sauzier, G., Bors, D., Ash, J., Goodpaster, J., and Lewis, S. attempt "… a central composite design was used to determine statistically validated optimum recovery parameters for double-base smokeless powder residues on steel, analyzed using total vaporisation (TV) SPME/GC-MS." Importantly, they reported that maximum recovery was by using "… isopropanol-wetted swabs stored under refrigerated conditions, then extracted for 15 min into acetone on the same day as sample collection." It will be interesting to see if this finding translates to other post blast explosives [276].

Katilie, C., Simon, A. and DeGreeff, L. reported an ammonia derivatization in the GC inlet with butyl chloroformate to produce butyl carbamate, a compound that can be used on GC and is compatible with standard GC-MS analysis. The inlet was also cooled. They state, "This method was then used to quantify the ammonia headspace vapor concentration produced from the dissociation of bulk ammonium nitrate as well as from mixtures with aluminum and petroleum jelly, which are fuels commonly used in homemade explosives (HMEs)" [272]. It is unknown how long ammonia stays in the environment in most post-blast scenes but this is interesting work.

Chajistamatiou, A. and Bakeas, E. derivatize thiocyanate and run GC-MS. They correctly assume that SCN is a product of black powder combustion and, while present in most BP post-combustion samples, there are indications this doesn't happen in all post-combustion scenarios. They report, "In this study, a simple experimental protocol has been developed towards black powder residues identification, using GC—MS. Derivatization of thiocyanates coming from BP deflagration and identification of the relative derivative (PBF—SCN) was achieved by monitoring ions m/z 239, 181 and 161." In addition, they observed, "This protocol may be applied directly and without previous preparation to evidence coming from cases of explosions, thus practically contributing in BP residues identification" [269].

6.4. Capillary electrophoresis

Capillary electrophoresis (CE) is a powerful analytical technique for separating analytes. Coupled with mass spectrometry it can identify many species, organic or inorganic, of interest to the forensic explosives chemist.

6.5. General spectroscopy: Fluorescence, luminescence, Spectrophotometric, UV, chemiluminescence

There are hundreds of research papers and reports in this area. They are varied in their practical application to forensic and/or security work. Some could eventually be used in commercial, military, security and law enforcement applications. Still others will prove to be too costly and are too focused on one class of explosives or even a single explosive. There are a few papers the authors wish to highlight.

Cruse, C. and Goodpaster, J. proposed coupling of a GC to vacuum ultraviolet (VUV) spectroscopy to possibly increase detection specificity. GC/VUV has already been used for "the analysis of volatile organic compounds, petroleum products, aroma compounds, pharmaceuticals, illegal drugs, and lipids." [297]. Here, they reported on the utility of GC/VUV for explosives analysis, and on thermal degradation within the VUV cell and whether it can be useful. They report, "The general figures of merit and performance of GC/VUV were evaluated with authentic standards of nitrate ester explosives (e.g., nitroglycerine (NG), ethylene glycol dinitrate (EGDN), pentaerythritol tetranitrate (PETN), and erythritol tetranitrate (ETN))" and that "the explosive analytes were thermally degraded in the VUV cell, yielding reproducible, complex and characteristic mixtures of gas phase products (e.g., nitric oxide, carbon monoxide, and formaldehyde)" [297].

Valdes, E. and Hoang, K. looked at the application of X-ray fluorescence spectroscopy (XRF) to analysis of potential explosives via the Primini X-ray fluorescence spectrometer (Rigaku Corporation; Tokyo). They looked at plastic explosives, ammonium nitrate, and calcium ammonium nitrate. XRF is an established technique for elemental analysis in forensic laboratories doing explosives analysis [364].

Pacheco-Londoño, L., Aparicio-Bolaño, J., Galán-Freyle, N., Román-Ospino, A., Ruiz-Caballero, J. and Hernandez, S. used classical Least Squares-Assisted MIR Laser Spectroscopy Detection of High Explosives on Fabrics [342].

6.6. Mass spectrometry

Mass spectrometry continues to be the widest used technique for forensic explosives analysis, especially for post-blast analysis, or for trace detection in security settings. It also is one of the most researched areas in explosives analysis. There are hundreds of applications for mass spectrometry. In many cases, a positive nearly unambiguous identification of an analyte can be achieved. In other cases, orthogonal methods must still be used. Any mass spectrometry technique that does not employ any chromatography or other mode of separation on the front end will almost always trade

some point of identification (i.e. retention time) for speed of use. That said, softer ionization or using chemical adducts can alleviate that potential problem, even for smaller thermally labile explosive compounds.

One of the most researched and promising areas of mass spectrometry for explosives analysis is that of direct analysis in real time mass spectrometry (DART-MS). Williamson, R., Gura, S., Tarifa, A. and Almirall, J. couple capillary microextraction of volatiles with DART for the trace detection and characterization of organic compounds found in smokeless powders and in organic gunshot residues. The analytes are those typically seen in the suite of chemicals in smokeless powders (nitroglycerin (NG), diphenylamine (DPA), ethyl centralite (EC), 2,4-dinitrotoluenes (2,4-DNT), methyl centralite (MC), 2,4,6-trinitrotoluene (2,4,6-TNT) and various derivatives of DPA) [426].

Correa, D., Melendez-Perez, J., Zacca, J., Borges, R., Schmidt, E., Eberlin, M., et al. used DART for looking for TATP on recovered bank notes from an ATM theft. They reported, "Easy ambient sonic-spray ionization mass spectrometry (EASI-MS) is shown to be a simple and selective screening tool to identify peroxide explosives on real banknotes collected from ATM explosion. Analyses were carried out directly on the banknotes surfaces without any sample preparation, identifying triacetone triperoxide (TATP) and diacetone diperoxide (DADP). EASI source coupled to a single quadrupole mass spectrometer provides an intelligent and simple way to identify the explosives TATP, DADP and its domestic synthesis markers" [396].

In another application of DART, Forbes, T., Sisco, E., & Staymates, M. coupled Infrared thermal desorption (IRTD) with (DART-MS) for "the detection of both inorganic and organic explosives from wipe collected samples." The abstract reported, "IRTD-DART-MS demonstrated the thermal desorption and detection of refractory potassium chlorate and potassium perchlorate oxidizers, compounds difficult to desorb with traditional moderate-temperature resistance-based thermal desorbers. Nanogram to sub-nanogram sensitivities were established for analysis of a range of organic and inorganic oxidizer-based explosive compounds …" and "The thermal desorption and ionization characteristics of the IRTD-DART technique resulted in optimal sensitivity for the formation of nitrate adducts with both organic and inorganic species" [402].

Forbes, T., Sisco, E., Staymates, M. and Gillen, G. reported on a mass spectrometry (MS) platform coupling resistive Joule heating thermal desorption (JHTD) and direct analysis in real time (DART) for the analysis of inorganic nitrite, nitrate, chlorate, and perchlorate oxidizers. They stated, "JHTD enhanced the utility and capabilities of traditional DART-MS for the trace detection of previously difficult to detect inorganic compounds" [403]. The use of DART-MS for inorganic compounds creates, at a minimum, an orthogonal technique to ion chromatography or capillary electrophoresis.

Also effectively using DART-MS with a unique sample introduction method, Li, F., Tice, J., Musselman, B., and Hall, A. "designed a qualitative analytical approach that utilizes novel sorbent-coated wire mesh and dynamic headspace concentration to permit the generation of information rich chemical attribute signatures (CAS) for trace energetic materials in smokeless powder with DART-MS. Sorbent-coated wire mesh improves the overall efficiency of capturing trace energetic materials in comparison to swabbing or vacuuming." Constituents of smokeless powders, including nitroglycerin, "… were rapidly and efficiently captured by the Carbopack X wire mesh, followed by detection and identification using DART-MS." This reduces the analysis time compared to traditional GC-MS approaches as all of the "components that can be detected by GC-MS, were detected by DART-MS in less than a minute" [411].

Bridoux, M., Schwarzenberg, A., Schramm, S., and Cole, R. have a unique approach on the use of Direct Analysis in Real Time (DART™) high-resolution Orbitrap™ mass spectrometry (HRMS) in combination with Raman microscopy. They used this combination on actual explosives including plastic explosives, which have "complex matrix of binders, plasticizers, polymers, and other possible organic additives." Swabbed particles were "characterized using micro-Raman spectroscopy followed by DART-HRMS providing fingerprint signatures of orthogonal nature." And "When the polarity was switched to positive mode, DART-HRMS revealed a very complex distribution of polymeric binders (mainly polyethylene glycols and polypropylene glycols), plasticizers (e.g., dioctyl sebacate, tributyl phosphate) …" [391].

Lising, A. completed a thesis where DART-MS was used on smokeless powder samples in potential matrices that may be encountered in real life samples. DART-MS has been reportedly successful in relatively clean matrices but here smokeless powder was mixed in with motor oil and tested. However, the author reported, "Effective separation was not achieved using the various LLE methods tested. Further testing would be required in order to evaluate the feasibility of implementing the technique as a sample preparation approach prior to analysis by DART-MS." This is exactly the type or research and reporting that helps forensic laboratories evaluate whether a technique is feasible for (some) real world type samples [412].

Lennert, E. and Bridge, C. have two papers looking at DART-HRMS with smokeless powders [409].

Forbes, T. and Verkouteren, J. reported on the *Forensic Analysis and Differentiation of Black Powder and Black Powder Substitute Chemical Signatures by Infrared Thermal Desorption–DART-MS*. As reported in their abstract, "The trace detection and forensic analysis of black powders and black powder substitutes, directly from wipe-based sample collections, was demonstrated using infrared thermal desorption (IRTD) coupled with direct analysis in real time mass spectrometry (DART-MS)" [401].

Another area for practical scene application is the miniaturization of Mass Spectrometry. Hashimoto, Y. reported on recent developments in this area. He reported, "… on the recent results related to the detection of explosive materials where automated particle sampling using a cyclone concentrator permitted the inspection time to be successfully reduced to 3 s" [408].

One of the mass spectrometry methods and systems that have the most promise for explosives analysis application is the LC coupled with an exact mass detector. Here, Dunn, L., Obaidly, H., and Khalil, S. reported on two semi-quantitative, fast liquid chromatography-mass spectrometry methods. They use an atmospheric pressure chemical ionization source with an accurate mass detector (LC-APCI-QToF-MS) for the analysis of peroxide explosives, namely hexamethylene triperoxide diamine (HMTD) and triacetone triperoxide (TATP). They report, "The limits of detection (LOD) for HMTD and TATP using these methods were determined to be 0.5 ng and 10 ng on column, respectively. The high mass accuracy and narrow mass detection window offer high selectivity with <2 ppm mass difference between measured and calculated values for HMTD" [397].

Ewing, R., Valenzuela, B., Atkinson, D., and Freeburg, E. reported using a commercial mass spectrometer with an atmospheric flow tube (AFT) for inorganic oxidizers in homemade explosives at picogram levels. Specifically, they analyze the thermal desorption of nitrate, chlorate and perchlorate salts [398].

Reese, K., Jones, A. & Smith, R. have a paper titled, *Characterization of smokeless powders using multiplexed collision-induced dissociation mass spectrometry and chemometric procedures.* They compared unburned powders to corresponding fired residues and analyzed them by liquid chromatography–atmospheric pressure chemical ionization-time-of-flight mass spectrometry (LC–APCI-TOFMS). They report "Multivariate statistical procedures were performed to first investigate association and discrimination of the

unburned powders. Principal components analysis (PCA) of the chemical profiles suggested nine distinct groups of powders, according to the dominant organic compounds present. The clusters formed in hierarchical cluster analysis (HCA) were mostly in agreement with PCA groupings although HCA provided a metric to quantify the similarity." They also caution, "… association of the fired residue (sic) to the corresponding unburned powder was possible although the success was highly dependent on the composition of the unburned powder and the extent of compound depletion as a result of firing" [421].

6.7. Isotope ratio mass spectroscopy, IRMS

Isotope ratio mass spectroscopy is an elusive but still promising technique to source discriminate almost anything. Well established in some drug and agricultural products analysis, it is still in a nascent stage when it comes to practical applications for explosives analysis. Often its utility is in intelligence gathering rather than being reliable for judicial proceedings.

Chesson, L., Howa, J., Lott, M. & Ehleringer, J looked at samples containing RDX, HMX, PETN, TNT, AN, and NC (nitrocellulose) and binders, plasticizers and additives to prepare these different explosive components for stable isotope analysis. They write, "This paper describes the theory and processes used to develop a component-specific approach to prepare explosives samples for isotope ratio analysis, focusing specifically on optimization of solvent extraction methods" [431].

One of the most popular and easily synthesized homemade explosives is TATP. Here, Howa, J., Barnette, J., Chesson, L., Lott, M. and Ehleringer, J. measured the carbon (13C/12C) and hydrogen (2H/1H) isotope ratios of the TATP, and one of its precursors, acetone. Acetone is the only source of carbon and hydrogen in TATP. They conducted a survey of acetone from 12 countries to see how much variation there was of 13C/12C and 2H/1H. They reported, "We observed greater ranges in both C and H isotope ratios of acetone than previously published; we also found that country-of-purchase was a large contributing factor to the observed variation, larger than acetone grade and brand. Following clandestine production methods, we observed that the stable isotope ratios of TATP retained the stable isotope signatures of acetone used in synthesis" [433].

6.8. FTIR

Fourier Transform Infrared Spectroscopy (FTIR) is a workhorse instrument in forensic explosives analysis. Some useful papers are commented upon, below. Many commercial platforms and sampling devices are available [14].

Alvarez, A., Yanez, J., Contreras, D., Saavedra, R., Saez, P., & Amarasiriwardena, D. looked at four propellant brands and characterized them by Fourier-transform infrared photoacoustic spectroscopy (FTIR-PAS). As expected, "Spectra shows characteristic signals of typical compounds in the propellants, such as nitrocellulose, nitroglycerin, guanidine, diphenylamine, etc." However, they then applied chemometric methods of classification, namely principal component analysis (PCA) and soft independent modelling of class analogy (SIMCA). They state, "Our results show the ability of FTIR-PAS combined with chemometric analysis to identify and differentiate propellant brands in different explosive formulations of IED" [436]. It is unclear if the sample set was vastly increased, whether this technique would work for discrimination but it would be a relatively quick way to do so.

6.9. Raman spectroscopy

Raman spectroscopy has seen increased usage not only on scene, but also in forensic explosive laboratories in the last ten years. It is fast, discriminatory, non-destructive and vetted for legal proceedings. There are still two basic types, stand-off or near stand-off detection, and targeted analysis, sometimes with portable hand-held units.

Elbasuney, S., and El-Sherif, A. introduced a study on instant and standoff identification of concealed explosive-related compounds using a customized Raman technique. They reported, "Stokes Raman spectra of common explosive-related compounds were generated and spectrally resolved to create characteristic finger print spectra." As expected they demonstrated "… that the two vibrational spectroscopic techniques were opposite and completing each other" [449].

Almeida, M., Logrado, L., Zacca, J., Correa, D., and Poppi, R. reported using "Raman hyperspectral imaging, in conjunction with independent component analysis" as a "methodology to detect an ammonium nitrate fuel oil (ANFO) explosive in banknotes after an ATM explosion experiment" [441].

Almaviva, S., Palucci, A., Botti, S., Puiu, A., and Rufoloni, A. reported on using surface-enhanced Raman spectroscopy (SERS) measurements of common trace amounts of military explosives with a micro-Raman system integrated with a Serstech R785 miniaturized device, comprising a spectrometer and detector for near-infrared (NIR) laser excitation (785 nm). They report that "SERS spectra were obtained, exciting samples in *picogram* quantities on specific substrates …" [440] *Italics added.*

Zapata, F. and Garcia-Ruiz, C. used vibrational spectroscopy, including both IR and Raman, to study some 72 nitrate, perchlorate and chlorate salts in a non-destructive, non-disassociated (like ion chromatography) manner. They tested whether every salt can be unequivocally identified by IR and Raman. They reported that, "Besides the visual spectra comparison by assigning every band with the corresponding molecular vibrational mode, a statistical analysis based on Pearson correlation was performed to ensure an objective identification, either using Raman, IR or both." Also, that "Positively, 25 salts (out of 72) were unequivocally identified using Raman, 30 salts when using IR and 44 when combining both techniques" [479]. This is not surprising since many low molecular weight inorganic salts have spectra reflecting the anionic portion of the salt.

6.10. DSC, Thermal analysis, TG

Kohga, M. and Handa, S. analyzed the thermal decomposition behaviors and burning characteristics of propellants with ammonium perchlorate (AP)/ammonium nitrate (AN) particles. It is reported that these greatly depended on the AN content (χ) of the AP/AN sample [485].

7. Nanotechnology

As stated in our previous two reviews, "one of the most exciting aspects in explosives in the last decade has been the development of nanotechnology" [14]. Nanotechnology allows for the miniaturization of instrumentation allowing for very powerful portable analytical use. Another aspect of nanotechnology is the miniaturization of particles in explosives themselves.

Gao, B., Qiao, Z. and Yang, G. presented a review of nano-explosive materials since the 1990's. They write, "Nanotechnology has proved to be a remarkable and indispensable strategy to achieve high-performance nanomaterials for applications. This chapter provides an overview of the main developments of the three types of nanoexplosives (nano-individual explosives, nanocomposites,

and nano-cocrystals) from preparation and characterization of properties, using a comparison of different approaches for preparing nanoexplosives." This paper is an excellent primer for forensic explosive analysts who will be encountering these types of explosives in criminal or terrorist bombings in the near future (if they have not already) [516].

8. General detection

Mochan, W. and Ramirez-Solis, A. reported that "The GT200 device has been extensively used by the Mexican armed forces to remotely detect and identify substances such as drugs and explosives. A double blind experiment was performed to test its efficacy. In seventeen out of twenty attempts, the GT200 failed in the hands of certified operators to find more than 1600 amphetamine pills and four bullets hidden in a randomly chosen cardboard box out of eight identical boxes distributed within a 90 m × 20 m ballroom. This result is compatible with the 1/8 efficacy expected for a useless device, and is incompatible with even a moderately effective working one" [607]. This is not surprising since the UK Government banned their use in Iraq and Afghanistan in 2010 and the owner of the company, Gary Bolton, was convicted on 26 July 2013 on two charges of fraud relating to the sale and manufacture of the GT200 and sentenced to seven years in prison [564,565,and584]].

Seman, J., Johnson, C. and Giraldo, C. proposed the creation of an identification taggant that survives detonation and can easily be recovered. "This paper shows that traces of two elements, samarium (Sm) and holmium (Ho), can be identified from explosive post-blast residue". Post-blast residue was analyzed by neutron activation analysis (NAA) and the two elements were detected. The approach is not clear as to whether ratioing or another method would be employed for the thousands of "codes" needed for an identification taggant [622].

A) Canine Explosives Detection

MacCrehan, W., Young, M., and Schantz, M. employed a "novel solid-phase microextraction with externally-sampled internal standard (SPME-ESIS) vapor-time measurements of two volatile compounds associated with canine detection of plastic explosives, 2-ethyl-1-hexanol and cyclohexanone." They used a polydimethylsiloxane (PDMS)-based material for use as canine training aids [656].

Hall, N. and Wynne, C.D.L. looked at complex odor mixtures with oxidizers and oxidizers alone for canine detection capabilities. They "… evaluated the effect of two training procedures on dogs' ability to identify the presence of a critical oxidizer in complex odor mixtures." Some dogs "received odor mixtures that varied from trial to trial with and without an oxidizer." Moreover, some were trained on solely the oxidizer. Their results were that the dogs who were trained on mixtures had "above chance discrimination of the oxidizer from variable backgrounds and dogs were able to readily generalize performance, with no decrement, to mixtures containing novel odorants." They also reported that dogs trained on oxidizers alone "… led to a precipitous drop in hit rate when the oxidizer was presented in a mixture background containing either familiar and/or novel odorants" [653].

Colizza, K., Gonsalves, M., McLennan, L., Smith, J. and Oxley, J. studied, in depth, the metabolites of triacetone triperoxide (TATP) and compare those to methyl ethyl ketone peroxides (MEKP) in canines to determine possible toxicity of these materials to canines [648].

DeGreeff, L.E., Peranich, K., & Simon, A. looked at "the capability of canines to generalize or discriminate between related target odors including single target odors and binary mixtures" [650].

Ong, T., Mendum, T., Geurtsen, G., Kelley, J., Ostrinskaya, A., and Kunz, R. used a sensitive, real-time vapor analysis mass spectrometer, with a "detection library of nine explosives and explosive-related materials consisting of 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 2,4,6-trinitrotoluene (TNT), nitroglycerin (NG), 1,3,5-trinitroperhydro-1,3,5-triazine (RDX), pentaerythritol tetranitrate (PETN), triacetone triperoxide (TATP), hexamethylene triperoxide diamine (HMTD), and cyclohexanone, with detection limits in the parts-per-trillion to parts-per-quadrillion range by volume." They found areas of improvement for canine training [657].

B) LIBS Detection

Rezaei, A., Keshavarz, M., Tehrani, M., and Darbani, S. using LIBS, reported how aluminum affected PBX. They reported, "this work introduces a new method on the basis of the laser-induced breakdown spectroscopy (LIBS) technique in air and argon atmospheres to investigate the determination of aluminum content and detonation performance of aluminized PBXs." They also stated, "By using the LIBS method and the measured intensity ratio of CN/C, an Al content of 15% is found to be the optimum value in terms of velocity of detonation of the RDX/Al/HTPB standard samples" [669].

C) Neutron

Kulcinski, G., Santarius, J., Johnson, K., Megahed, A. and Bonomo, R wrote about using a system to detect landmines or IEDs by the use of small DD or DT neutron sources carried by a drone [679].

D) Terahertz
E) Nuclear Techniques
F) X-Ray
G) Ion Mobility Spectroscopy

Chaffee-Cipich, M., Hoss, D., Sweat, M., and Beaudoin, S. explored the formation of "traps" and malleable surfaces for explosives in IMS sampling in a security setting. Their sampling methods may help in a forensic setting [704].

In a similar fashion Kuzishchin, Y., Kotkovskii, G., Martynov, I., Dovzhenko, D., & Chistyakov, A. reported on a method for detection of ultralow concentration of explosives coupling ion mobility spectrometry (IMS) and laser desorption/ionization on silicon (DIOS). "The DIOS is widely used in mass spectrometry due to the possibility of small molecule detection and high sensitivity" [710].

H) Novel Detection

The references cited in this section are varied. Some are not necessarily completely novel but have a reported significant variation from the standard technology on which they are based.

El-Sharkawy, Y. and Elbasuney, S. used Laser photoacoustic spectroscopy (LPAS). They claimed that theirs is "a novel LPAS technique that offers instant and standoff detection capabilities of trace explosives." They used this "customized LPAS technique … for instantaneous trace detection of three main different high explosive materials including TNT, RDX, and HMX" [734].

Adlin, A. and Kumar, K.M. proposed explosive detection by using printed antennas with substrates that can detect explosives based on the E-field excitation value [718].

Zhang, A., Fu, D., Xuan, Y., & Ma, H. introduced a multi-channel system for explosive and drug detection. They reported that they "have developed a new synthetic conjugated polymer with single molecule layer and coated on porous silicon with large surface area to increase quenching signal at least one order, based on this new

film a small handheld explosive detector with sensitivities of 0.1 pg for TNT and 0.1 ng for black gun powder are obtained." They claimed that "Last year, after face to face competition, our device was selected as the only security detector for the G20 summit held in Hangzhou, China" [808].

Gillanders, R., Samuel, I., & Turnbull, G. "… present a portable photoluminescence-based sensor for nitroaromatic vapours based on the conjugated polymer Super Yellow integrated into an instrument comprising an excitation LED, photodiode, Arduino microprocessor and pumping mechanics for vapor delivery" [739].

A cheap field instrument is reported by Erickson, J., Shriver-Lake, l., Zabetakis, D., Stenger, D. & Trammell, S. using an inexpensive electrochemical assay, with a hand-held "potentiostat for the identification of explosives." They claimed, "The prototype instrument designed to run the assay is capable of performing time-resolved electrochemical measurements including cyclic square wave voltammetry using an embedded microcontroller with parts costing roughly $250 USD. We generated an example library of cyclic square wave voltammograms of 12 compounds including 10 nitroaromatics, a nitramine (RDX), and a nitrate ester (nitroglycerine), and designed a simple discrimination algorithm based on this library data for identification" [735].

I) Stand Off

Cole, P., Cal, C.J., Jean, D. R., & Fell N. F. Looked at UV Raman spectroscopy to "determine the effect of additional colors of vehicle paints (*besides white, black and bare metal*) with Clearcoat on the ability of UV Raman to detect explosives on these surfaces." They reported, "The results clearly show a strong luminescent background in all of the visible Raman spectra and only a weak Raman background signal in the case of UV Raman spectra with 150 backscattering at all 3 UV excitation wavelengths and the onset of luminescence between 1,400 and 1,500 cm^1 with 180 backscattering at 257.23-nm excitation" [824].

Kuzovnikova, L., Maksimenko, E., Vorozhtsov, A., Pavlenko, A., Didenko, A. and Titov, S. used an optical-electronic laser complex for the standoff detection of traces explosives. They used Active Spectral Imaging. They reported the results as "Experimental researches in detection of traces of various types of explosives on different substrates were carried out. On average, the probability of detection was 89% and the probability of identification was 91%" [852].

Holthoff, E., Marcus, L., and Pellegrino, P. write on using photoacoustic spectroscopy (PAS), employed in a sensor format. They explained, "PAS is one of the more flexible IR spectroscopy variants, and that flexibility allows for the construction of sensors that are designed for specific tasks. PAS is well suited for trace detection of gaseous and condensed media" [845].

9. Environmental

Environmental scientists and chemists have long sought to test and eventually remediate explosives in environmental samples. Some of these methods can be directly borrowed from this field for use in forensic laboratories. Still other research, such as degradation studies, may assist the analyst in background knowledge of the explosive in certain matrices, especially soils.

Ha, Y., Daeid, N.N., Dawson, L.A., DeTate, D., & Lewis, S.W. in an interesting study, looked at explosives that were spiked into soil samples versus actual residues from the detonation of those explosives. They showed how detonations, when examined by scanning electron microscopy, "… reveal that detonations result in newly-fractured planes within the soil aggregates …", They also stated that "We demonstrate that detonations cause an increase in soil porosity, and this correlates to an increased rate of TNT transformation and loss within the detonated soils, compared to spiked pristine soils" [876].

Chatterjee, S., Deb, U., Datta, S., Walther, C., and Gupta, D. demonstrated a review of explosive materials in soils that are contaminated either due to "manufacturing operations, military activities, conflicts of different levels, open burning/open detonation (OB/OD), dumping of munitions etc.". The review seeks to emphasize the appropriate practices to remediate the contamination [871].

Yu, H., DeTata, D., Lewis, S., and Daeid, N. studied storage effects of explosives in soil. They explain, "in this work, three different soils were spiked with solutions of TNT, RDX and PETN and stored either at room temperature, refrigerated or frozen. Samples were extracted over 6 weeks, with additional samples gamma-irradiated or nitrogen purged prior to storage. Experimental results indicate that TNT underwent very rapid degradation at room temperature, attributed to microbial action, whereas PETN and RDX proved to be more stable" [888].

10. Other (safety, definitions, etc.)

Sisco, E., Najarro, M., Samarov, D. & Lawrence, J. reported on the stability of trace amounts of explosives over time and environmental conditions. Six "explosives were inkjet printed directly onto substrates and exposed to one of seven environmental conditions (Laboratory, −4 °C, 30 °C, 47 °C, 90% relative humidity, UV light, and ozone) up to 42 days." At various intervals, samples were extracted and quantified using electrospray ionization mass spectrometry (ESI-MS). The results were, "… compound dependent with minimal sample losses observed for HMX, RDX, and PETN while substantial and rapid losses were observed in all conditions except −4 °C for ETN and TNT and in all conditions for tetryl." These are quite interesting results for the authors [957].

Verolme, E., Van der Voort, M., Weerhejim, J., Koh, Y., & Kang, K. tried to extrapolate backwards to see if damage on a post-blast scene can be applied to determine the strength of the original explosion [966].

Of interest for EOD Techs and perhaps other responders, Reid, D., Riches, B., Rowan, A. and Logan, M. proposed a "A new field portable approach using high temperature combustion has been developed and tested to destroy organic peroxides especially TATP. This approach provides a viable alternative to destruction of organic peroxides using explosives, or chemical neutralization. The apparatus is made of commonly available parts, and does not require specialist expertise to safely operate" [944].

Oxley, J., Smith, J., Bernier, E., Sandstrom, F., Weiss, G., Recht, B., and Schatzer, B. mapped pipe fragments for bombs made of steel and PVC. They described pipe fragmentation patterns by fragment weight or surface-area distribution mapping (FWDM) or (FSADM). They make a distinction of presumably steel pipe with cast iron end caps when concluding, "When fillers detonated, detonation velocities of ~4.4 mm/μs were measured. In such cases, side-walls of the pipe were thrown first; the average fragment velocity was ~1000 km/s*[1]. In deflagrations, the end cap was first thrown; fragment velocities were only ~240 km/s*" [938].

In a macabre paper, Zwirner, J., Bayer, R., Japes, A., Eplinius, F., Dessler, J., & Ondruschka, B. looked at suicide by "the intraoral blast of firecrackers-experimental simulation using a skull simulation." They stated, "We here report two cases of suicide committed by an intraoral placement of firecrackers, resulting in similar patterns of

[1] Unit of measurement should be m/s and not km/s as reported by the authors in the original paper.

skull injury. As it was first unknown whether black powder firecrackers can potentially cause serious skull injury, we compared the potential of destruction using black powder and flash powder firecrackers in a standardized skull simulant model (Synbone, Malans, Switzerland). This was the first experiment to date simulating the impacts resulting from an intraoral burst in a skull simulant model. The intraoral burst of a "D-Böller" (an example of one of the most powerful black powder firecrackers in Germany) did not lead to any injuries of the osseous skull. In contrast, the "La Bomba" (an example of the weakest known flash powder firecrackers) caused complex fractures of both the viscero- and neurocranium. The results obtained from this experimental study indicate that black powder firecrackers are less likely to cause severe injuries as a consequence of intraoral explosions, whereas flash powder-based crackers may lead to massive life-threatening craniofacial destructions and potentially death" [975]. The authors of this paper note that black powder is known to have less velocity upon exploding than typical perchlorate or chlorate-based flash powders.

Final Notes

Papers that were not referenced above can be found in the extensive bibliography. Many of these seem promising as technology advances.

Disclaimer

This is a republication in journal form of a conference proceeding that was produced for the 19th Interpol Forensic Science Managers Symposium in 2019 and was originally published online at the Interpol website: https://www.interpol.int/content/download/14458/file/InterpolReview Papers2019.pdf. The publication process was coordinated for the Symposium by the Interpol Organizing Committee and the proceeding was not individually commissioned or externally reviewed by the journal. The article provides a summation of published literature from the previous 3 years (2016-2019) in the detection of explosives and explosive residues and does not contain any experimental data. Any opinions expressed are solely those of the authors and do not necessarily represent those of their agencies, institutions, governments, Interpol, or the journal.

Declaration of Competing Interests

The authors have no competing interests to declare.

Acknowledgements

The authors would like to express our deepest gratitude to Ms. Logan Tapscott, Librarian for the Bureau of Alcohol, Tobacco, Firearms and Explosives Laboratory. Additionally, the tireless work of the staff of the Arson and Explosives Sections at the ATF Forensic Science Laboratory, Washington, especially Malinda Durand, Delonn Ng, Dr. Kelley Peters, and Dr. Michelle Clarke, have been invaluable.

References

Review Articles

[2] K. Brown, M. Greenfield, S. McGrane, D. Moore, Advances in explosives analysis—part 1: animal, chemical, ion, and mechanical methods, Anal. Bioanal. Chem. 408 (1) (2016) 35–47.
[5] W. de Araujo, T. Cardoso, R. da Rocha, M. Santana, R. Munoz, E. Richter, et al., Portable analytical platforms for forensic chemistry: a review, Anal. Chim. Acta 1034 (2018) 1–21.
[6] T. Forbes, E. Sisco, Recent advances in ambient mass spectrometry of trace explosives, Analyst 143 (9) (2018). April 2018.
[7] B. Go, Z. Qiao, G. Yang, Review on nanoexplosive materials, in: Q. Yan, G. He, P. Liu, M. Gozin (Eds.), Nanomaterials in Rocket Propulsion Systems, Elsevier, Amsterdam, Netherlands, 2019, pp. 31–79.
[8] J. Gooch, B. Daniel, V. Abbate, N. Frascione, Taggant materials in forensic science: a review, Trac. Trends Anal. Chem. 83 (2016) 49–54.
[9] J. Goodpaster, Forensic sciences—explosives, in: P. Worsfold, C. Poole, A. Townshend, M. Miró (Eds.), Encyclopedia of Analytical Science. 3rd Edn, Reference Module in Chemistry, Molecular Sciences and Chemical Engineering, Elsevier, 2019, pp. 23–27.
[10] M. Huri, U. Ahmad, R. Ibrahim, M. Omar, A review of explosive residue detection from forensic chemistry perspective, Malays. J. Anal. Sci. 21 (2) (2017) 267–282.
[13] D.J. Klapec, G. Czarnopys, Analysis and detection of explosives and explosives residues review: 2010 to 2013, in: 17th Interpol International Forensic Science Managers Symposium, Lyon 8th-10th October 2013, 526, 2013, pp. 280–435.
[14] D.J. Klapec, G. Czarnopys, Analysis and detection of explosives and explosives residues review: 2013 to 2016, in: 18th Interpol International Forensic Science Managers Symposium, Lyon 11th-13th October 2016, 2016, pp. 194–261.
[21] P. Peacock, W. Zhang, W. Zhang, S. Trimpin, Advances in ionization for mass spectrometry, Anal. Chem. 89 (1) (2016), 372-288.
[24] R. Saini, Recent developments in the methods for detection of explosives, Int. J. Biomed. Adv. Res. 8 (3) (2018) 240–253.
[26] R. Strobel, G. Czarnopys, Analysis and detection of explosives and explosives residues, in: N.N. Daeid, M.M. Houck (Eds.), Interpol's Forensic Science Review 2010, CRC Press, Boca Raton, Florida, 2010, pp. 453–523.
[32] W. Zhang, Y. Tang, A. Shi, L. Bao, Y. Shen, R. Shen, et al., Recent developments in spectroscopic techniques for the detection of explosives, Materials 11 (8) (2018) 1364.

Explosive Standards and References, Laboratory Quality Control, Contamination Prevention

[1] R. Bogue, Remote chemical sensing: a review of techniques and recent developments, Sens. Rev. 38 (4) (2018) 453–457.
[3] S. Carter, A. Fisher, R. Garcia, B. Gibson, J. Marshall, I. Whiteside, Atomic spectrometry update: review of advances in the analysis of metals, chemicals and functional materials, J. Anal. Atomic Spectrom. 31 (11) (2016) 2114–2164.
[4] Z. Chen, C. Xiao, W. Xiao, M. Qin, X. Liu, A review on several key problems of standoff trace explosives detection by optical-related technology, in: Proceedings of the International Society for Optics and Photonics 10244, International Conference on Optoelectronics and Microelectronics Technology and Application, 2017, p. 10244.
[11] M. Joshi, Ion mobility spectrometry in forensic science, in: R.A. Meyers (Ed.), Encyclopedia of Analytical Chemistry, 2017, pp. 1–22.
[12] M. Kangas, R. Burks, J. Atwater, R. Lukowicz, P. Williams, A. Holmes, Colorimetric sensor arrays for the detection and identification of chemical weapons and explosives, Crit. Rev. Anal. Chem. 47 (2) (2017) 138–153.
[15] P. Lehr, Detection: scanning and 'sniffing' technologies, in: Counter-Terrorism Technologies: A Critical Assessment, Cham Springer, 2018, pp. 101–114.
[16] L. Liu, S. Ye, W. Huang, Advances on fluorescent sensors for detection of explosives, Chin. J. Appl. Chem. 34 (1) (2017) 1–24.
[17] A. Marchisio, J. Tulliani, Semiconducting metal oxides nanocomposites for enhanced detection of explosive vapors, Ceramics 1 (1) (2018) 98–119.
[18] M. Moini, Applications of liquid-based separation in conjunction with mass spectrometry to the analysis of forensic evidence, Electrophoresis 39 (9–10) (2018) 1249–1275.
[19] S. Nabiev, L. Palkina, Modern technologies for detection and identification of explosive agents and devices, Russ. J. Phys. Chem. B 11 (5) (2017) 729–776.
[20] G. Pandey, M. Tharmavaram, D. Rawtani, S. Kumar, Y. Agrawal, Multifarious applications of atomic force microscopy in forensic science investigations, Forensic Sci. Int. 273 (2017) 53–63.
[22] P. Rae, *Some Observations Regarding the Detonation of Nitromethane* (Report No. LA-UR-17-22540), Los Alamos National Laboratory, 2017, pp. 1–21.
[23] M. Rieger, M. Wittek, P. Scherer, S. Lobbecke, K. Muller-Buschbaum, Preconcentration of nitroalkanes with archetype metal–organic frameworks (MOFs) as concept for a sensitive sensing of explosives in the gas phase, Adv. Funct. Mater. 28 (2) (2018) article no. 1704250.
[25] P. Pallister, T. D'Souza, C. Black, N. Hearns, J.C. Smith, Explosive detection strategies for security screening at airports, in: J. Banoub, R. Caprioli (Eds.), *Molecular Technologies For Detection Of Chemical And Biological Agents*. NATO Science for Peace and Security Series A: Chemistry and Biology, Springer, Dordrech, Netherlands, 2017, pp. 243–251.
[27] L. Türker, Thermobaric and enhanced blast explosives (TBX and EBX), Defence Technol 12 (6) (2016) 423–445.
[28] A. van der Heijden, Developments and challenges in the manufacturing, characterization and scale-up of energetic nanomaterials, Chem. Eng. J. 350 (2018) 939–948.
[29] D. Viswanath, T. Ghosh, V. Boddu, Emerging Energetic Materials: Synthesis,

Physicochemical, and Detonation Properties, Springer, New York, 2018.
[30] L. Wilson, M. Gahan, C. Lennard, J. Robertson, The black sheep of forensic science: military forensic and technical exploitation, Aust. J. Forensic Sci. (2018) 1–13.
[31] H. Yu, D.A. DeTata, S.W. Lewis, D.S. Silvester, Recent developments in the electrochemical detection of explosives: towards field-deployable devices for forensic science, Trends Anal. Chem. 97 (2017) 374–384.
[33] F. Lederle, J. Namyslo, E. Huebner, Protocol for the full quantitative analysis of flash compositions, J. Pyrotechnics 35 (2017) 9–14.
[34] H. Lees, F. Zapata, M. Vaher, C. Garcia-Ruiz, Study of the adhesion of explosive residues to the finger and transfer to clothing and luggage, Sci. Justice 58 (6) (2018) 415–424.
[35] I. Oluwoye, B. Dlugogorski, J. Gore, H. Oskierski, M. Altarawneh, Review article: atmospheric emission of NOx from mining explosives: a critical review, Atmos. Environ. 167 (2017) 81–96.
[36] W. Pawłowski, Ł. Matyjasek, K. Cieślak, M. Karpińska, Contamination with explosives in analytical laboratory procedure, Forensic Sci. Int. 281 (2017) 13–17.
[37] M. Wittek, D. Roseling, F. Schnurer, T. Heintz, A. Dresel, T. Wegener, M. Schmah, Reproducible generation of explosive traces for detection system testing, in: Proceedings of the International Society for Optics and Photonics 10802, Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies II. 10802, 2018.

Sampling and Concentration of Explosive Traces

[38] N. Abdul-Karim, C. Blackman, P. Gill, R. Morgan, L. Matjacic, R. Webb, et al., Morphological variations of explosive residue particles and implications for understanding detonation mechanisms, Anal. Chem. 88 (7) (2016) 3899–3908.
[39] A. Akmalov, A. Chistyakov, G. Kotkovskii, Effectiveness of laser sources for contactless sampling of explosives, in: Proceedings of the International Society for Optics and Photonics 9823, Detection and Sensing of Mines, Explosives Objects, and Obscured Targets, XXI, 2016, p. 982311.
[40] V. Babrauskas, The West, Texas, ammonium nitrate explosion: a failure of regulation, J. Fire Sci. 35 (5) (2017) 396–414.
[41] D. Bors, J. Goodpaster, Mapping smokeless powder residue on PVC pipe bomb fragments using total vaporization solid phase microextraction, Forensic Sci. Int. 276 (2017) 71–76.
[42] S. Choi, C.E. Son, Testing method for on-site measurement of explosive materials contaminated on travel luggage bag and backpack using ion mobility spectrometry, Bull. Kor. Chem. Soc. 39 (1) (2017) 45–51.
[43] S. Choi, C. Son, Analytical method for the estimation of transfer and detection efficiencies of solid state explosives using ion mobility spectrometry and smear matrix, Anal. Methods 9 (17) (2017) 2505–2510.
[44] W. Chouyyok, J. Bays, A. Gerasimenko, A. Cinson, R. Ewing, D. Atkinson, R. Addleman, Improved explosive collection and detection with rationally assembled surface sampling materials, RSC Adv. 6 (97) (2016) 94476–94485.
[45] G. Collins, M. Malito, C. Tamanaha, M. Hammond, B. Giordano, A. Lubrano, et al., Trace explosives sensor testbed (TESTbed), Rev. Sci. Instrum. 88 (3) (2017), 034104.
[46] N. Daeid, A. Holly, M. Beardah, Investigating TNT loss between sample collection and analysis, Sci. Justice 57 (2) (2017) 95–100.
[47] L. DeGreeff, H. Liddell, W. Pogue, M. Merrill, K. Johnson, Effect of re-use of surface sampling traps on surface structure and collection efficency for trace explosive residues, Forensic Sci. Int. 297 (2019) 254–264.
[48] D. Fisher, R. Zach, Y. Matana, P. Elia, S. Shustack, Y. Sharon, et al., Bomb swab: can trace explosive particle sampling and detection be improved? Talanta 174 (2017) 92–99.
[49] T. Forbes, M. Staymates, E. Sisco, Broad spectrum infrared thermal desorption of wipe-based explosive and narcotic samples for trace mass spectrometric detection, Analyst 142 (16) (2017) 3002–3010.
[50] S. Gamble, Forensic Detection of Explosives in the Wastewater System: Implications for Intelligence Gathering, Ph.D. University College London, 2016.
[51] R. Gillanders, J. Glackin, J. Filipi, N. Kezic, I. Samuel, G. Turnbull, Preconcentration techniques for trace explosive sensing, Sci. Total Environ. 658 (2019) 650–658.
[52] A. Hohnholz, V. Schutz, D. Albrecht, J. Koch, O. Suttmann, L. Overmeyer, Simulation of an efficient particle extraction for the detection of explosive materials, J. Laser Appl. 30 (3) (2018), 032201.
[53] K. Kottapalli, Aerodynamic Removal and Characterization of Particulate Trace Residues on Model Surfaces, PhD. University of Washington, 2017.
[54] J. Laster, Design of Microstructured Conducting Polymer Films for Enhanced Trace Explosives Detection, PhD. Purdue University, 2017.
[55] H. Lees, F. Zapata, M. Vaher, C. García-Ruiz, Simple multispectral imaging approach for determining the transfer of explosive residues in consecutive fingerprints, Talanta 184 (2018) 437–445.
[56] G. McEneff, B. Murphy, T. Webb, D. Wood, R. Irlam, J. Mills, D. Green, L. Barron, Sorbent film-coated passive samplers for explosives vapour detection Part A: materials optimisation and integration with analytical technologies, Sci. Rep. 8 (2018) 5815.
[57] G. McEneff, A. Richardson, T. Webb, D. Wood, B. Murphy, R. Irlam, J. Mills, D. Green, L. Barron, Sorbent film-coated passive samplers for explosives vapour detection Part B: deployment in semi-operational environments and alternative applications, Sci. Rep. 8 (2018) 5816.
[58] M. Papantonakis, V. Nguyen, T. Fischer, A. Howard, K. Adams, R. McGill, Persistence of explosives under real world conditions, in: Proceedings of the International Society for Optics and Photonics 9824, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII, 2016, p. 982419.
[59] M. Papantonakis, V. Nguyen, R. Furstenberg, C. White, M. Shuey, C. Kendziora, et al., Physical and environmental factors affecting the persistence of explosives particles (Conference Presentation), in: Proceedings of the International Society for Optics and Photonics 10183, Chemical, Biological, Radiological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII, 101830F, 2017.
[60] W. Pawłowski, Ł. Matyjasek, M. Karpińska, Detection of contact traces of powdery substances, J. Forensic Sci. 62 (4) (2017) 1028–1032.
[61] T. Phetchakul, P. Phuvanatai, A study on 2, 4, 6-trinitrotolurene (TNT) vapor detection by using a quartz crystal microbalance with 18-crown-6 ether film, in: AIP Conference Proceedings, 1858, AIP Publishing, 2017, 020004, 1.
[62] H. Rapp-Wright, G. McEneff, B. Murphy, S. Gamble, R. Morgan, M. Beardah, L. Barron, Suspect screening and quantification of trace organic explosives in wastewater using solid phase extraction and liquid chromatography-high resolution accurate mass spectrometry, J. Hazard Mater. 329 (2017) 11–21.
[63] E. Robinson, E. Sisco, M. Staymates, J. Lawrence, A new wipe-sampling instrument for measuring the collection efficiency of trace explosives residues, Anal. Methods 10 (2) (2018) 204–213.
[64] M. Sweat, A. Parker, S. Beaudoin, Compressive behavior of idealized granules for the simulation of composition C-4, Propellants, Explos. Pyrotech. 41 (5) (2016) 855–863.
[65] A. Tarifa, N. Kreitals, J. Mulloor, S. Gura, J. Almirall, Cryofocusing capillary microextraction of volatiles (Cryo-CMV) as a novel headspace extraction device for the analysis of volatile organic compounds and smokeless powders, Forensic. Chem 3 (2017) 81–89.
[66] R. Taudte, C. Roux, A. Beavis, Stability of smokeless powder compounds on collection devices, Forensic Sci. Int. 270 (2017) 55–60.
[67] T. Temple, C. Goodwin, M. Ladyman, N. Mai, F. Coulon, Optimised accelerated solvent extraction of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) from polymer bonded explosives, Propellants, Explos. Pyrotech. 43 (11) (2018) 1171–1177.
[68] J. Thomas, C. Donnelly, E. Lloyd, R. Mothershead, M. Miller, Development and validation of a solid phase extraction sample cleanup procedure for the recovery of trace levels of nitro-organic explosives in soil, Forensic Sci. Int. 284 (2018) 65–77.
[69] J. Thomas, C. Donnelly, E. Lloyd, R. Mothershead, J. Miller, D. McCollam, M. Miller, Application of a co-polymeric solid phase extraction cartridge to residues containing nitro-organic explosives, Forensic. Chem 11 (2018) 38–46.
[70] J. Verkouteren, E. Sisco, Microscopy to support trace screening of contraband, including explosives and illicit drugs, Microsc. Microanal. 24 (S1) (2018) 1170–1171.
[71] J. Wang, Z. Meng, M. Xue, L. Qiu, X. Dong, Z. Xu, et al., Simultaneous selective extraction of nitramine explosives using molecularly imprinted polymer hollow spheres from post blast samples, New J. Chem. 41 (3) (2017) 1129–1136.
[72] F. Zapata, C. García-Ruiz, Analysis of different materials subjected to open-air explosions in search of explosive traces by Raman microscopy, Forensic Sci. Int. 275 (2017) 57–64.

Commercial Explosives

[73] T. An, F. Zhao, Q. Yan, Y. Yang, Y. Luo, J. Yi, W. Hong, Preparation and evaluation of effective combustion catalysts based on Cu(I)/Pb(II) or Cu(II)/Bi(II) nanocomposites carried by graphene oxide (GO), Propellants, Explos. Pyrotech. 43 (11) (2018) 1087–1095.
[74] K. Bezemer, R. Woortmeijer, M. Koeberg, W. Wiarda, P. Schoenmakers, A. van Asten, Multicomponent characterization and differentiation of flash bangers — Part II: elemental profiling of plastic caps, Forensic Sci. Int. 290 (2018) 336–348.
[75] H. Cao, L. Jiang, Q. Duan, D. Zhang, H. Chen, J. Sun, An experimental and theoretical study of optimized selection and model reconstruction for ammonium nitrate pyrolysis, J. Hazard Mater. 364 (2019) 539–547.
[76] P. Chen, B. Yuan, R. Chen, K. Qu, Compression and shear experimental study of PBX explosive, Propellants, Explos. Pyrotech. 43 (12) (2018) 1245–1250.
[77] M. Comet, C. Martin, F. Schnell, D. Spitzer, Nanothermites: a short review. Factsheet for experimenters, present and future challenges, Propellants, Explos. Pyrotech. 44 (1) (2018) 18–36.
[78] N. Cummock, J. Mares, I. Gunduz, S. Son, Relating a small-scale shock sensitivity experiment to large-scale failure diameter in an aluminized ammonium nitrate non-ideal explosive, Combust. Flame 194 (2018) 271–277.
[79] J. Dai, C. Ru, J. Xu, C. Wang, W. Zhang, Y. Ye, et al., Ammonium perchlorate as an effective additive for enhancing the combustion and propulsion performance of Al/CuO nanothermites, J. Phys. Chem. C 122 (18) (2018) 10240–10247.
[80] D. Dennis, M. Williams, M. Sigman, Assessing the evidentiary value of smokeless powder comparisons, Forensic Sci. Int. 259 (2016) 179–187.
[81] D. Dennis, M. Williams, M. Sigman, Investigative probabilistic inferences of smokeless powder manufacturers utilizing a Bayesian network, Forensic. Chem 3 (2017) 41–51.

[82] A. Dolgoborodov, A. Streletskii, A. Shevchenko, G. Vorobieva, G. Val'yano, Thermal decomposition of mechanoactivated ammonium perchlorate, Thermochim. Acta 669 (2018) 60–65.
[83] S. Elbasuney, A. Fahd, H. Mostafa, S. Mostafa, R. Sadek, Chemical stability, thermal behavior, and shelf life assessment of extruded modified double-base propellants, Defence Technol 14 (1) (2018) 70–76.
[84] Y. Guo, N. Zhao, T. Zhang, H. Gong, H. Ma, T. An, F. Zhao, R. Hu, Compatibility and thermal decomposition mechanism of nitrocellulose/Cr2O3 nanoparticles studied using DSC and TG-FTIR, RSC Adv. 9 (7) (2019) 3927–3937.
[85] G. Hang, W. Yu, T. Wang, J. Wang, Theoretical investigations into effects of adulteration crystal defect on properties of CL-20/TNT cocrystal explosive, Comput. Mater. Sci. 156 (2019) 77–83.
[86] G. Hang, W. Yu, T. Wang, J. Wang, Z. Li, Theoretical investigations on stabilities, sensitivity, energetic performance and mechanical properties of CL-20/NTO cocrystal explosives by molecular dynamics simulation, Theor. Chem. Acco 137 (8) (2018).
[87] R. Harrison, A thermal study of a simple Al–CuO pyrotechnic crackle composition, Propellants, Explos. Pyrotech. 44 (6) (2019) 733–743.
[88] G. He, J. Liu, F. Gong, C. Lin, Z. Yang, Bioinspired mechanical and thermal conductivity reinforcement of highly explosive-filled polymer composites, Compos. Appl. Sci. Manuf. 107 (2018) 1–9.
[89] A. Higgins, J. Loiseau, X. Mi, Detonation velocity/diameter relation in gelled explosive with inert inclusions, in: AIP Conference Proceedings, 1979, 2018, p. 100019 (1).
[90] X. Hong, W. Li, X. Wang, W. Li, R. Li, Explosion temperature and dispersion characteristics of composite charges based on different non-detonative materials, Propellants, Explos. Pyrotech. 43 (12) (2018) 1251–1262.
[91] S. Jackson, The dependence of Ammonium-Nitrate Fuel-Oil (ANFO) detonation on confinement, in: V. Sick, A. Tomlin (Eds.), Proceedings of the Combustion Institute, 36, 2017, pp. 2791–2798, 2017, 2.
[92] D. Ji, X. Wei, P. Du, G. Zhang, Z. Wang, Effect of boron-containing hydrogen-storage-alloy (Mg(BHx)y) on thermal decomposition behavior and thermal hazards of nitrate explosives, Propellants, Explos. Pyrotech. 43 (4) (2018) 413–419.
[93] L. Kang, S. Li, B. Wang, X. Li, Q. Zeng, Exploration of the energetic material ammonium perchlorate at high pressures: combined Raman spectroscopy and x-ray diffraction study, J. Phys. Chem. C 122 (28) (2018) 15937–15944.
[94] K. Kim, J. Lee, S. Choi, G. Ahn, J. Paik, B. Ryu, Y. Kim, Y. Won, A combined study of TEM-EDS/XPS and molecular modeling on the aging of THPP, ZPP, and BKNO3 explosive charges in PMDs under accelerated aging conditions, Energies 12 (1) (2019) 151.
[95] E. Koch, Insensitive high explosives: III. Nitroguanidine - synthesis - structure - spectroscopy - sensitiveness, Propellants, Explos. Pyrotech. 44 (3) (2019) 267–292.
[96] L. Liu, J. Li, L. Zhang, S. Tian, Effects of magnesium-based hydrogen storage materials on the thermal decomposition, burning rate, and explosive heat of ammonium perchlorate-based composite solid propellant, J. Hazard Mater. 342 (2018) 477–481.
[97] Q. Luo, T. Ren, H. Shen, J. Zhang, D. Liang, The thermal properties of nitrocellulose: from thermal decomposition to thermal explosion, Combust. Sci. Technol. 190 (4) (2017) 579–590.
[98] F. Maggi, P. Garg, Fragmentation of ammonium nitrate particles under thermal cycling, Propellants, Explos. Pyrotech. 43 (3) (2018) 315–319.
[99] A. Makishima, Decomposing explosives and reduction of perchlorate and nitrate, in: Biochemistry for Material Science: Catalysts, Complexes, and Proteins, Elseveir, Amsterdam, Netherlands, 2019, pp. 203–210.
[100] V. Manner, M. Cawkwell, E. Kober, T. Myers, G. Brown, H. Tian, C. Snyder, R. Perriot, D. Preston, Examining the chemical and structural properties that influence the sensitivity of energetic nitrate esters, Chem. Sci. 9 (2018) 3649–3663.
[101] F. Mauricio, A. Pralon, M. Talhavini, M. Rodrigues, I. Weber, Identification of ANFO: use of luminescent taggants in post-blast residues, Forensic Sci. Int. 275 (2017) 8–13.
[102] V. Medvedev, E. Forat, V. Tsipilev, A. Yakovlev, The effect of aluminum particles dispersity on characteristics of ammonium perchlorate—aluminum composition laser ignition, in: Journal of Physics: Conference Series, 830, IOP Publishing, 2017, 012146, 1.
[103] P. Mertuszka, B. Cenian, B. Kramarczyk, W. Pytel, Influence of explosive charge diameter on the detonation velocity based on emulinit 7L and 8L bulk emulsion explosives, Cent. Eur. J. Energy. Mater 15 (2) (2018) 351–363.
[104] M. Nakashima, T. Itaura, H. Matsunaga, E. Higashi, S. Takagi, K. Katoh, A fundamental study on the thermal decomposition and combustion behaviors of guanidine nitrate and basic copper nitrate mixture, J. Therm. Anal. Calorim. 131 (1) (2017) 95–100.
[105] W. Pang, J. Li, K. Wang, X. Fan, L. De Luca, F. Bi, H. Li, Effects of dihydroxylammonium 5,5′-bistetrazole-1,1′-diolate on the properties of HTPB based composite solid propellant, Propellants, Explos. Pyrotech. 43 (10) (2018) 1013–1022.
[106] S. Ravindran, A. Tessema, A. Kidane, On the response of polymer bonded explosives at different impact velocities, in: J. Kimberley, L. Lamberson, S. Mates (Eds.), Dynamic Behavior of Materials, Volume 1. Conference Proceedings of the Society for Experimental Mechanics Series, Springer, Cham, 2019, pp. 219–224.
[107] Y. Shu, S. Zhang, Y. Shu, N. Liu, Y. Yi, J. Huo, X. Ding, Interactions and physical properties of energetic poly-(phthalazinone ether sulfone ketones) (PPESKs) and ε-hexanitrohexaazaisowurtzitane (ε-CL-20) based polymer bonded explosives: a molecular dynamics simulations, Struct. Chem. 30 (3) (2018) 1041–1055.
[108] S. Valluri, M. Schoenitz, E. Dreizin, Fluorine-containing oxidizers for metal fuels in energetic formulations, Defence Technol 15 (1) (2019) 1–22.
[109] H. Wang, D. Kline, M. Rehwoldt, M. Zachariah, Ignition and combustion characterization of Ca(IO3)2-based pyrotechnic composites with B, Al, and Ti, Propellants, Explos. Pyrotech. 43 (10) (2018) 977–985.
[110] Y. Xiao, Y. Sun, Y. Zhen, L. Guo, L. Yao, Characterization, modeling and simulation of the impact damage for polymer bonded explosives, Int. J. Impact Eng. 103 (2017) 149–158.
[111] C. Xu, C. An, Q. Li, S. Xu, S. Wang, H. Guo, J. Wang, Preparation and performance of pentaerythrite tetranitrate-based composites by direct ink writing, Propellants, Explos. Pyrotech. 43 (11) (2018) 1149–1156.
[112] S. Xu, L. Tan, J. Liu, X. Chen, W. Jiang, Y. Chen, et al., Cause analysis of spontaneous combustion in an ammonium nitrate emulsion explosive, J. Loss Prev. Process. Ind. 43 (2016) 181–188.
[113] Z. Yang, F. Gong, L. Ding, Y. Li, G. Yang, F. Nie, Efficient sensitivity reducing and hygroscopicity preventing of ultra-fine ammonium perchlorate for high burning-rate propellants, Propellants, Explos. Pyrotech. 42 (7) (2017) 809–815.
[114] S. Zeman, A. Elbeih, A. Hussein, T. Elshenawy, M. Jungova, Q. Yan, A modified vacuum stability test in the study of initiation reactivity of nitramine explosives, Thermochim. Acta 656 (2017) 16–24.
[115] T. Zhang, J. Zhao, Z. Gao, X. Wu, H. He, Y. Gu, Shock initiation of the triaminotrinitrobenzene-based explosive JBO-9021 measured with a photon Doppler velocimeter, Propellants, Explos. Pyrotech. 43 (12) (2018) 1227–1235.

Military Explosives

[116] D. Badgujar, M. Talawar, Thermokinetic decomposition and sensitivity studies of 4,4′-diamino-3,3′-azoxy furazan (DAAF)-based melt cast explosive formulations, J. Energetic Mater. 36 (3) (2018) 316–324.
[117] J. Bennion, I. Batyrev, J. Ciezak-Jenkins, The high-pressure characterization of melt-castable energetic materials: 3,3′-bis-oxadiazole-5,5′-bis-methylene dinitrate. *Propellants, explosives*, Pyrotechnics 44 (2) (2018) 160–165.
[118] T. Chen, B. Gou, G. Hao, H. Gao, L. Xiao, X. Ke, S. Guo, W. Jiang, Preparation, characterization of RDX/GAP nanocomposites, and study on the thermal decomposition behavior, J. Energetic Mater. 37 (1) (2018) 80–89.
[119] G. Chu, Z. Yang, T. Xi, J. Xin, Y. Zhao, W. He, et al., Relaxed structure of typical nitro explosives in the excited state: observation, implication and application, Chem. Phys. Lett. 698 (2018) 200–205.
[120] S. Cudziło, W. Trzciński, J. Paszula, M. Szala, Z. Chyłek, Effect of titanium and zirconium hydrides on the detonation heat of RDX-based explosives - a comparison to aluminium, Propellants, Explos. Pyrotech. 43 (3) (2018) 280–285.
[121] J. Gottfried, R. Pesce-Rodriguez, D. Farrow, J. Dellinger, Laboratory-scale investigation of the influence of ageing on the performance and sensitivity of an explosive containing ε-CL-20, Propellants, Explos. Pyrotech. 43 (6) (2018) 616–625.
[122] L. Gutowski, W. Trzcinski, M. Szala, 5,5′,6,6′-Tetranitro-2,2′-bibenzimidazole: a thermally stable and insensitive energetic compound, ChemPlusChem 83 (2) (2018) 87–91.
[123] G. He, Z. Yang, X. Zhou, J. Zhang, L. Pan, S. Liu, Polymer bonded explosives (PBXs) with reduced thermal stress and sensitivity by thermal conductivity enhancement with graphene nanoplatelets, Compos. Sci. Technol. 131 (2016) 22–31.
[124] M. Hobbs, M. Kaneshige, C.D. Yarrington, Large deformation and gas retention during cookoff of a plastic bonded explosive, Combust. Flame 198 (2018) 278–289.
[125] D. Hoffman, Infrared properties of three plastic bonded explosive binders, Int. J. Polym. Anal. Char. 22 (6) (2017) 545–556.
[126] S. Jackson, E. Anderson, L. Hill, Direct measurement of energy loss due to aging effects in the condensed phase explosive PBX 9404, Proc. Combust. Inst. 37 (3) (2019) 3645–3652.
[127] X. Jia, J. Wang, C. Hou, Y. Tan, Y. Zhang, Effective insensitiveness of melamine urea-formaldehyde resin via interfacial polymerization on nitramine explosives, Nanoscale Res. Letts 13 (402) (2018).
[128] A. Keyhani, S. Kim, Y. Horie, M. Zhou, Energy dissipation in polymer-bonded explosives with various levels of constituent plasticity and internal friction, Comput. Mater. Sci. 159 (2019) 136–149.
[129] M. Klaumunzer, F. Pessina, D. Spitzer, Indicating inconsistency of desensitizing high explosives against impact through recrystallization at the nanoscale, J. Energetic Mater. 35 (4) (2017) 375–384.
[130] W. Li, Y. Xu, X. Qing, Z. Yang, Quantitative imaging of surface cracks in polymer bonded explosives by surface wave tomographic approach, Polym. Test. 74 (2019) 63–71.
[131] X. Mao, L. Jiang, C. Zhu, X. Wang, Effects of aluminum powder on ignition performance of RDX, HMX, and CL-20 explosives, Adv. Mater. Sci. Eng (2018) 1–8, 2018.
[132] Z. Men, K. Suslick, D. Dlott, Thermal explosions of polymer-bonded explosives with high time and space resolution, J. Phys. Chem. C 122 (26) (2018) 14289–14295.

[133] S. Qin, X. Zhang, J. Liu, Z. Yu, F. Zhao, R. Zhang, B. Zhong, Use of a reverberation technique to determine grüneisen parameter of unreacted plastic bonded explosive, Propellants, Explos. Pyrotech. 44 (2) (2018) 166–174.
[134] K. Rao, D. Ganesh, F. Yehya, A. Chaudhary, A comparative study of thermal stability of TNT, RDX, CL20 and ANTA explosives using UV 266 nm-time resolved photoacoustic pyrolysis technique, Spectrochim. Acta Mol. Biomol. Spectrosc. 211 (2019) 212–220.
[135] M. Shin, M. Kim, G. Kim, B. Kang, J. Chae, S. Haam, Highly energetic materials-hosted 3D inverse opal-like porous carbon: stabilization/desensitization of explosives, ACS Appl. Mater. Interfaces 10 (50) (2018) 43857–43864.
[136] N.T. Toan, P.D. Nhan, D.C. Hung, V.H. Phuong, Thermal decomposition behavior and shelf-life of polymer-bonded explosives and hexogen, Vietnam J. Chem 56 (5) (2018) 654–659.
[137] A. van der Heijden, R.H. Bouma, Confocal scanning laser microscopic study of the RDX defect structure in deformed polymer-bonded explosives, Propellants, Explos. Pyrotech. 41 (5) (2016) 875–882.
[138] K. Vandersall, A. Jones, J. Curtis, *Computer Simulations to Study the Post-ignition Violence of HMX Explosives in the Steven Test* (LLNL-CONF-760507), United States: 2018, 2018.
[139] C. Wu, S. Zhang, R. Gou, F. Ren, G. Han, S. Zhu, Theoretical insight into the effect of solvent polarity on the formation and morphology of 2,4,6,8,10,12-hexanitrohexaazaisowurtzitane (CL-20)/2,4,6-trinitro-toluene(TNT) cocrystal explosive, Comput. Theor. Chem. 1127 (2018) 22–30.
[140] Y. Wu, H. Guo, F. Huang, X. Bao, Effects of large-sized granules on ignition and burning of powdery explosives under drop-weight impacts, Combust. Sci. Technol. (2018) 1–9.
[141] X. Xing, S. Zhao, X. Wang, W. Zhang, X. Diao, W. Fang, W. Li, The detonation properties research on TKX-50 in high explosives, Propellants, Explos. Pyrotech. 44 (4) (2019) 408–412.
[142] S. Zeman, A. Hussein, M. Jungova, A. Elbeih, Effect of Energy Content of the Nitraminic Plastic Bonded Explosives on Their Performance and Sensitivity Characteristics, Defence Technology, 2018.
[143] M. Zhang, J. Li, J. Chen, K. Li, F. Zhao, S. Bai, Study on compression–expansion behaviour of PBXs substitutive materials, Plast., Rubber Compos. 48 (4) (2019) 137–148.
[144] Y. Zhang, Z. Xu, J. Ruan, X. Wang, L. Zhang, J. Luo, A stepwise strategy for the synthesis of HMX from 3,7-Dipropionyl-1,3,5,7-Tetraazabicyclo[3.3.1]Nonane, Propellants, Explos. Pyrotech. 43 (12) (2018) 1287–1295.
[145] Z. Zhou, J. Chen, H. Yuan, J. Nie, The role of Al reaction rate in the damage effect and energy output of RDX-based aluminized explosives in concrete, Propellants, Explos. Pyrotech. 44 (3) (2019) 319–326.

Homemade Explosives

[146] M. Atamanov, I. Noboru, T. Shotaro, R. Amrousse, M.Y. Tulepov, A. Kerimkulova, et al., Investigation of combustion and thermal analysis of ammonium nitrate with carbonaceous materials, Combust. Sci. Technol. 188 (11–12) (2016) 2003–2011.
[147] W. Bannister, J. Oxley, Potential detection problems: nonnitrogen-based explosives, in: Proceedings of the International Society for Optics and Photonics 10264 the Aviation Security Problem and Related Technologies: A Critical Review, Critical Review Collection, 2017, p. 1026402.
[148] A. Brown, Improvised Explosives: X-Ray Detection & Euthectics of Erythritol Tetranitrate, PhD. University of Rhode Island, 2017.
[149] J.A. Conkling, C. Mocella, Chemistry of Pyrotechnics: Basic Principles and Theory, third ed., CRC Press, Boca Raton, FL, 2019.
[150] L. DeGreeff, K. Johnson, Considerations in the vapor analysis of traditional vs. homemade explosives, in: ISOCS/IEEE International Symposium on Olfaction and Electronic Nose/Institute of Electrical and Electronics Engineeers. Montreal QC, Canada, IEEE, 2017, pp. 1–3.
[151] L. DeGreeff, M. Cerreta, C. Katilie, Variation in the headspace of bulk hexamethylene triperoxide diamine (HMTD) with time, environment, and formulation, Forensic. Chem 4 (2017) 41–50.
[152] L. DeGreeff, S. Rose-Pehrsson, M. Malito, A novel odor delivery device for homemade explosive analysis. ISOCS/IEEE International Symposium on Olfaction and Electronic Nose/Institute of Electrical and Electronics Engineeers, IEEE, Montreal, 2017, pp. 1–3.
[153] C. Fraga, A. Mitroshkov, N. Mirjankar, B. Dockendorff, A. Melville, Elemental source attribution signatures for calcium ammonium nitrate (CAN) fertilizers used in homemade explosives, Talanta 174 (2017) 131–138.
[154] M. Härtel, T. Klapötke, B. Stiasny, J. Stierstorfer, Gas-phase concentration of triacetone triperoxide (TATP) and diacetone diperoxide (DADP). *Propellants, Explosives*, Pyrotechnics 42 (6) (2017) 623–634.
[155] M. Kotrlý, B. Mareš, I. Turková, I. Beroun, May). Identification of improvised explosives residues using physical-chemical analytical methods under real conditions after an explosion, in: Proceedings of the International Society for Optics and Photonics 9823, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets, XXI, 2016, p. 98230S.
[156] M. Kotrlý, I. Turková, I. Beroun, B. Mares, Methods for characterization of home-made and non-standard explosives in forensic science (Conference Presentation), in: Proceedings of the International Society for Optics and Photonics 10182, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets, XXII, 2017, p. 1018209.
[157] M. Kotrly, J. Wolker, I. Turkoba, I. Beroun, Forensic database of homemade and nonstandard explosives, in: Proceedings of the International Society for Optics and Photonics 10628, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets, XXIII, 2018, p. 1062806.
[158] N. Lease, L. Kay, D. Chavez, D. Robbins, V. Manner, Increased handling sensitivity of molten erythritol tetranitrate (ETN), J. Hazard Mater. 367 (2019) 546–549.
[159] G. Newsome, F. Steinkamp, B. Giordano, Headspace Analysis of Ammonium Nitrate, Naval Research Laboratory, Washington, D.C, 2017. Technical Report.
[160] A. Osmont, M. Genetier, G. Baudin, Ability of thermochemical calculation to treat organic peroxides, in: AIP Conference Proceedings, 2018, p. 150030, 1979.
[161] R. Rettinger, Examination of Non-ideal Explosives, PhD dissertation, University of Rhode Island, 2019.
[162] M. Schmitt, P. Bowden, B. Tappan, D. Henneke, Steady-state shock-driven reactions in mixtures of nano-sized aluminum and dilute hydrogen peroxide, J. Energetic Mater. 36 (3) (2018) 266–277.
[163] G. Shiue, A. Huang, J. Chen, Thermal decomposition of triacetone triperoxide by differential scanning calorimetry, J. Therm. Anal. Calorim. 133 (1) (2018) 745–751.
[164] F. Steinkamp, L. DeGreeff, G. Collins, S. Rose-Pehrsson, Factors affecting the intramolecular decomposition of hexamethylene triperoxide diamine and implications for detection, J. Chromatogr. A 1451 (2016) 83–90.
[165] O. Vodochodský, Z. Jalový, R. Matyáš, M. Novotná, Determination of triacetone triperoxide and hexamethylene triperoxide diamine in various matrices using infrared spectroscopy, Appl. Spectrosc. 73 (2) (2018) 195–202.
[166] O. Vodochodsky, Z. Jalovy, R. Matyas, M. Novotna, Comparison of the efficacy of homemade and industrially made ANFO explosives as an improvised explosive device charge, Commun- Sci. Lett. Univ. Zilina 20 (2) (2018) 23–27.
[167] A. Zygmunt, K. Gańczyk, A. Kasztankiewicz, K. Cieślak, T. Gołofit, Application and properties of aluminum in primary and secondary explosives, J. Elementol 22 (2) (2017) 747–756.

Other Explosives including Novel or New Explosives

[168] M. Abd-Elghany, A. Elbeih, T.M. Klapotke, Thermo-analytical study of 2,2,2-trinitroethyl-formate as a new oxidizer and its propellant based on a GAP matrix in comparison with ammonium dinitramide, J. Anal. Appl. Pyrol. 133 (2018) 30–38.
[169] M. Abd-Elghany, T. Klapotke, A. Elbeih, Investigation of 2,2,2-trinitroethyl-nitrocarbamate as a high energy dense oxidizer and its mixture with Nitrocellulose (thermal behavior and decomposition kinetics), J. Anal. Appl. Pyrol. 128 (2017) 397–404.
[170] M. Abd-Elghany, T. Klapötke, A. Elbeih, Environmentally safe (chlorine-free): new green propellant formulation based on 2,2,2-trinitroethyl-formate and HTPB, RSC Adv. 8 (21) (2018) 11771–11777.
[171] B. Abraham, J. Kumar, G. Vaitheeswaran, High-pressure studies of hydrogen-bonded energetic material 3,6-Dihydrazino-s-tetrazine using DFT, ACS Omega 3 (8) (2018) 9388–9399.
[172] P. Anderson, How and when metals react in high performance explosives, in: AIP Conference Proceedings, 1979, 2018, p. 150002.
[173] T. Aslam, Shock temperature dependent rate law for plastic bonded explosives, J. Appl. Phys. 123 (14) (2018) 145901.
[174] P. Bowden, J. Yeager, D. Guildenbecher, J. Olles, J. Hashen, A. Schmalzer, Characterizing the propensity of hypervelocity metal fragments to initiate plastic bonded explosives, AIP Con. Proc 1979 (1) (2018) 100006.
[175] X. Cao, Y. Guan, L. Yang, M. Yan, Q. Ma, G. Fan, S. Huang, An energetic derivative of 2,2′,4,4′,6,6′-hexanitrostilbene (HNS) and its DMF solvate crystallized from HNS solution with tertiary amine additives, J. Energetic Mater. 37 (1) (2018) 90–97.
[176] L. Catoire, Detailed chemical kinetic models for nanothermites combustion, Propellants, Explos. Pyrotech. 44 (1) (2018) 41–46.
[177] Z. Chai, B. Jin, W. Gong, R. Peng, S. Chu, Synthesis and thermal performance study of C60-polyglycidyl nitrate (C60-PGN) maleic acid copolymer lead salts, Fullerenes, Nanotub. Carbon Nanostruct. 26 (12) (2018) 880–886.
[178] C. Chapman, L. Groven, Evaluation of a CL-20/TATB energetic Co-crystal, Propellants, Explos. Pyrotech. 44 (3) (2019) 293–300.
[179] D. Chen, H. Yang, Z. Yi, H. Xiong, L. Zhang, S. Zhu, G. Cheng, C8N26H4: an environmentally friendly primary explosive with high heat of formation, Angew. Chem. Int. Ed. 57 (8) (2018) 2080–2084.
[180] S. Chen, W. He, C. Luo, T. An, J. Chen, Y. Yang, P. Liu, Q. Yan, Thermal behavior of graphene oxide and its stabilization effects on transition metal complexes of triaminoguanidine, J. Hazard Mater. 368 (2019) 404–411.
[181] T. Chen, W. Li, W. Jiang, G. Hao, L. Xiao, X. Ke, J. Liu, H. Gao, Preparation and characterization of RDX/BAMO-THF energetic nanocomposites, J. Energetic Mater. 36 (4) (2018) 424–434.
[182] A. Elghafour, M. Radwan, A. Fahd, H. Mostafa, S. Elbasuney, Novel approach to quantify the chemical stability and shelf life of modified double-base propellants, Defence Technol 14 (6) (2018) 720–724.
[183] D. Fischer, J. Gottfried, T. Klapötke, K. Karaghiosoff, J. Stierstorfer, T. Witkowski, Synthesis and Investigation of advanced energetic materials based on bispyrazolylmethanes, Angew. Chem. Int. Ed. 55 (52) (2016) 16132–16135.
[184] W. Focke, S. Tichapondwa, Y. Montgomery, J. Grobler, M. Kalombo, Review of

gasless pyrotechnic time delays, Propellants, Explos. Pyrotech. 44 (1) (2018) 55–93.
[185] E. Francois, D. Tasker, R. Burritt, P. Bowden, Initiation of insensitive high explosives using multiple wave interactions, AIP Con. Proc 1979 (1) (2018) 160009.
[186] H. Ghayeni, R. Razeghi, A. Olyaei, An efficient synthesis, evaluation of parameters and characterization of nitro-hydroxyl-terminated polybutadiene (Nitro-HTPB), Propellants, Explos. Pyrotech. 43 (6) (2018) 574–582.
[187] T. Golofit, Thermal behaviour and safety of 1,3,7,9-tetranitrodibenzo-1,3a,4,6a-tetraazapentalen (z-TACOT), Thermochim. Acta 667 (2018) 59–64.
[188] T. Golofit, M. Szala, L. Gutowski, M. Zybert, Studies on the thermal behaviour and safety of a novel thermostable explosive 5,5′,6,6′-tetranitro-2,2′-bibenzimidazole, Thermochim. Acta 668 (2018) 126–131.
[189] J. Gottfried, D. Smith, C. Wu, M. Pantoya, Improving the explosive performance of aluminum nanoparticles with aluminum iodate hexahydrate (AIH), Sci. Rep. 8 (1) (2018).
[190] X. Guo, J. Wang, J. Ran, L. Zhao, Y. Han, W. Cao, Shock initiation of nano-TATB explosives under short-duration pulses, Propellants, Explos. Pyrotech. 44 (2) (2019) 138–143.
[191] C. Hou, Y. Zhang, Y. Chen, X. Jia, S. Zhang, Y. Tan, Fabrication of ultra-fine TATB/HMX cocrystal using a compound solvent, Propellants, Explos. Pyrotech. 43 (9) (2018) 916–922.
[192] X. Hou, Z. Guo, L. Yang, H. Ma, Four three-dimensional metal–organic frameworks assembled from 1H-tetrazole: synthesis, crystal structures and thermal properties, Polyhedron 160 (2019) 198–206.
[193] X. Huang, Z. Huang, J. Lai, L. Li, G. Yang, C. Li, Self-healing improves the stability and safety of polymer bonded explosives, Compos. Sci. Technol. 167 (2018) 346–354.
[194] A. Hussein, A. Elbeih, S. Zeman, Thermal decomposition kinetics and explosive properties of a mixture based on cis -1,3,4,6-tetranitrooctahydroimidazo-[4,5-d]imidazole and 3-nitro-1,2,4-triazol-5-one (BCHMX/NTO), Thermochim. Acta 655 (2017) 292–301.
[195] A. Hussein, A. Elbeih, S. Zeman, Thermo-analytical study of a melt cast composition based on cis -1,3,4,6-tetranitrooctahydroimidazo-[4,5 d]imidazole (BCHMX)/trinitrotoluene (TNT) compared with traditional compositions, Thermochim. Acta 666 (2018) 91–102.
[196] A. Hussein, S. Zeman, A. Elbeih, Thermo-analytical study of glycidyl azide polymer and its effect on different cyclic nitramines, Thermochim. Acta 660 (2018) 110–123.
[197] A. Hussein, S. Zeman, A. Elbeih, Synthesis, performance, and thermal behavior of a novel insensitive EDNA/DAT co-crystal, Zeitschrift fur anaorganische und allgemeine Chemie 644 (8–9) (2018) 430–437.
[198] A.K. Hussein, A. Elbeih, M. Jungova, S. Zeman, Explosive properties of a high explosive composition based on cis-1,3,4,6-tetranitrooctahydroimidazo-[4,5-d]imidazole and 1,1-Diamino-2,2-dinitroethene (BCHMX/FOX-7). *Propellants, explosives*, Pyrotechnics 43 (5) (2018) 472–478.
[199] M. Ilyushin, V. Tselinsky, I. Shugalei, Eco-friendly energetic substances for initiation devices, Cent. Eur. J. Energy. Mater 9 (4) (2017) 293–327.
[200] K. Jeong, New theoretically predicted RDX- and β-HMX-based high-energy-density molecules, Int. J. Quant. Chem. 118 (6) (2017), e25528.
[201] E. Johnson, J. Sabatini, D. Chavez, R. Sausa, E. Byrd, L. Wingard, et al., Bis(1,2,4-oxadiazole)bis(methylene) Dinitrate: a high-energy melt-castable explosive and energetic propellant plasticizing ingredient, Org. Process Res. Dev. 22 (6) (2018) 736–740.
[202] T. Klapötke, B. Krumm, T. Reith, Dihydrazinium nitrates derived from malonic and iminodiacetic acid, Propellants, Explos. Pyrotech. 43 (7) (2018) 685–693.
[203] T. Klapötke, B. Krumm, A. Widera, Synthesis and properties of tetranitro-substituted adamantane derivatives, ChemPlusChem 83 (1) (2018) 61–69.
[204] D. Kumar, Y. Tang, C. He, G. Imler, D. Parrish, J. Shreeve, Multipurpose energetic materials by shuffling nitro groups on a 3,3′-bipyrazole moiety, Chem. Eur J. 24 (65) (2018) 17220–17224.
[205] J. Lavoie, C. Petre, C. Dubois, Erosivity and performance of nitrogen-rich propellants, Propellants, Explos. Pyrotech. 48 (9) (2018) 879–892.
[206] P. Leonard, P. Bowden, M. Shorty, M. Schmitt, Synthesis and evaluation of 3-picrylamino-1,2,4-triazole (PATO) formulations, Propellants, Explos. Pyrotech. 44 (2) (2018) 203–206.
[207] P. Leonard, D. Chavez, P. Bowden, E. Francois, Nitrate salt based melt cast materials, Propellants, Explos. Pyrotech. 43 (1) (2018) 11–14.
[208] G. Li, Z. Ni, Y. Liu, M. Xia, Thermal performance and decomposition kinetics of RDX/AP/SiO2 intermolecular explosive, J. Therm. Anal. Calorim. 132 (3) (2018) 1969–1978.
[209] H. Li, J. Pan, W. Wang, R. Pan, W. Zhu, Preparation, characterization and compatibility studies of poly(DFAMO/AMMO), J. Macromol. Sci., Part A 55 (2) (2017) 135–141.
[210] H. Li, Y. Yang, J. Pan, W. Wang, R. Pan, W. Zhu, Synthesis, characterization and compatibility studies of Poly(DFAMO/NIMMO) with propellant and PBX ingredients, Cent. Eur. J. Energy. Mater 15 (1) (2018) 85–99.
[211] Q. Li, C. An, X. Han, C. Xu, C. Song, B. Ye, B. Wu, J. Wang, CL-20 based explosive ink of emulsion binder system for direct ink writing, Propellants, Explos. Pyrotech. 43 (6) (2018) 533–537.
[212] X. Li, Y. Sun, H. Zhao, Y. Xiao, X. Cai, A systematic method to determine and test the ignition and growth reactive flow model parameters of a newly designed polymer-bonded explosive, Propellants, Explos. Pyrotech. 43 (9) (2018) 948–954.
[213] R. Liu, P.W. Chen, Modeling ignition prediction of HMX-based polymer bonded explosives under low velocity impact, Mech. Mater. 124 (2018) 106–117.
[214] W. Liu, Y. Cheng, X. Meng, H. Ma, C. Shu, H. Fang, S. Song, Z. Shen, Synthesis of multicore energetic hollow microspheres with an improved suspension polymerization-thermal expansion method, Powder Technol. 343 (2019) 326–329.
[215] Y. Liu, J. Zhang, K. Wang, J. Li, Q. Zhang, J. Shreeve, Bis (4-nitraminofurazanyl-3-azoxy) azofurazan and derivatives: 1, 2, 5-oxadiazole structures and high-performance energetic materials, Angew. Chem. Int. Ed. 55 (38) (2016) 11548–11551.
[216] Y. Lu, Y. Zhu, P. Xu, P. Ye, B. Gao, Y. Sun, et al., In situ synthesis of cobalt alginate/ammonium perchlorate composite and its low temperature decomposition performance, J. Solid State Chem. 258 (2018) 718–721.
[217] F. Luppi, H. Cavaye, E. Dossi, Nitrated cross-linked β-Cyclodextrin binders exhibiting low glass transition temperatures, Propellants, Explos. Pyrotech. 43 (10) (2018) 1023–1031.
[218] A. Ma, J. Wu, Y. Han, F. Chen, B. Li, S. Cai, et al., Rational synthesis of a luminescent uncommon (3,4,6)-c connected Zn(ii) MOF: a dual channel sensor for the detection of nitroaromatics and ferric ions, Dalton Trans.: Int. J. Integrated Care 47 (29) (2018) 9627–9633.
[219] P. Ma, Y. Pan, J. Jiang, S. Zhu, Molecular dynamic simulation and density functional theory insight into the nitrogen rich explosive 1,5-diaminotetrazole(DAT), Procedia Eng 211 (2018) 546–554.
[220] M. Makhov, Acceleration ability of aluminum-containing explosive compositions, Russ. J. Phys. Chem. B 12 (2) (2018) 258–265.
[221] R. Matyas, J. Selesovsky, V. Pelikan, M. Szala, S. Cudzilo, W. Trzcinski, M. Gozin, Explosive properties and thermal stability of urea-hydrogen peroxide adduct, Propellants, Explos. Pyrotech. 42 (2) (2017) 198–203.
[222] B. Nassim, Q. Zhang, Thermal stability of explosive mixture with additives at different ambient temperatures, Propellants, Explos. Pyrotech. 43 (2) (2018) 177–187.
[223] H. Niu, S. Chen, S. Jin, B. Li, X. Li, J. Wang, et al., Preparation, nonisothermal decomposition kinetics, heat capacity, and safety parameters of TKX-50-based PBX, J. Therm. Anal. Calorim. 131 (3) (2018) 3193–3199.
[224] E. Pasquinet, N. Pin, A. Forzy, P. Palmas, J. Rideau, A. Beaucamp, E. Lalière, M. Perdrigeat, S. Quéré, C. Barthet, A. Wuillaume, DAPO-LLM-105: improving the particle morphology and thermal stability, Propellants, Explos. Pyrotech. 44 (6) (2019) 785–791.
[225] E. Robertson, D. Hoffman, P. Pagoria, New polycarbonate-based thermoplastic polyurethane binder for HMX based explosives, in: Insensitive Munitions and Energetic Materials Technology Symposium. United States, 2018.
[226] M. Satya Bharati, B. Chandu, S. Rao, Explosives sensing using Ag–Cu alloy nanoparticles synthesized by femtosecond laser ablation and irradiation, RSC Adv. 9 (3) (2019) 1517–1525.
[227] A. Sergienko, E. Popenko, K. Slyusarsky, K. Larionov, E. Dzidziguri, E. Kondratyeva, A. Gromov, Burning characteristics of the HMX/CL-20/AP/polyvinyltetrazole binder/Al solid propellants loaded with nanometals, Propellants, Explos. Pyrotech. 44 (2) (2018) 217–223.
[228] A. Singh, P. Soni, C. Sarkar, N. Mukherjee, Thermal reactivity of aluminized polymer-bonded explosives based on non-isothermal thermogravimetry and calorimetry measurements, J. Therm. Anal. Calorim. 136 (3) (2018) 1021–1035.
[229] X. Song, Y. Wang, C. An, Thermochemical properties of nanometer CL-20 and PETN fabricated using a mechanical milling method, AIP Adv. 8 (2018), 065009.
[230] X. Song, Y. Wang, S. Zhao, C. An, J. Wang, J. Zhang, Characterization and thermal decomposition of nanometer 2,2′, 4,4′, 6,6′-hexanitro-stilbene and 1,3,5-triamino-2,4,6-trinitrobenzene fabricated by a mechanical milling method, J. Energetic Mater. 36 (2) (2018) 179–190.
[231] S.B. Sopaci, H. Nazir, E. Emir, O. Atakol, S. Oz, Thermal kinetic analysis, theoretical thermodynamic calculations and antimicrobial activity of three new energetic materials, J. Therm. Anal. Calorim. 131 (3) (2018) 3105–3120.
[232] V. Sosikov, S. Torunov, A. Utkin, V. Mochalova, D. Rapota, Experimental investigation of detonation waves instabilities in liquid high explosives, J. Phys. Conf. 946 (2018), 012058.
[233] N. Szimhardt, M. Gruhne, M. Lommel, A. Hess, M. Wurzenberger, T. Klapötke, J. Stierstorfer, 2,2-Bis(5-tetrazolyl)propane as ligand in energetic 3d transition metal complexes, Z. Anorg. Allg. Chem. 645 (3) (2018) 354–361.
[234] N. Szimhardt, M. Wurzenberger, P. Spieß, T. Klapötke, J. Stierstorfer, Potassium N -nitramino-5 H -tetrazolates – powerful green primary explosives with high initiation capabilities, Propellants, Explos. Pyrotech. 43 (12) (2018) 1203–1209.
[235] N. Szimhardt, M. Wurzenberger, L. Zeisel, M. Gruhne, M. Lommel, T. Klapötke, J. Stierstorfer, 1-AminoTriazole transition-metal complexes as laser-ignitable and lead-free primary explosives, Chem. Eur J. 25 (8) (2018) 1963–1974.
[236] L. Türker, On the possibility of endohedrally helium-doped TEX - a DFT treatment, Z. Anorg. Allg. Chem. 644 (18) (2018) 1096–1102.
[237] A. Utkin, V. Mochalova, Non-classical detonation regimes of liquid high explosives, J. Phys. Conf. 946 (2018), 012056.
[238] V. Vuppuluri, P. Samuels, K. Caflin, I. Gunduz, S. Son, Detonation performance characterization of a novel CL-20 cocrystal using microwave interferometry, Propellants, Explos. Pyrotech. 43 (1) (2018) 38–47.
[239] Z. Wan, A. Cruz, Y. Li, Y. Li, Y. Ye, S. Zhu, L. Zhang, Facile production of NaIO4-

encapsulated nanoAl microsphere as green primary explosive and its thermodynamic research, Chem. Eng. J. 360 (2019) 778–787.
[240] F. Wang, L. Chen, D. Geng, J. Wu, J. Lu, C. Wang, Thermal decomposition mechanism of CL-20 at different temperatures by ReaxFF reactive molecular dynamics simulations, J. Phys. Chem. 122 (16) (2018) 3971–3979.
[241] J. Wang, Y. Qu, Y. Wang, L. Zhang, Z. Qiao, Preparation of Nano-DAAF explosive with improved initiation sensitivity, Propellants, Explos. Pyrotech. 43 (10) (2018) 1060–1064.
[242] K. Wang, D. Liu, P. Wu, X. Yu, L. Cheng, J. Zhang, How hydrogen-storage material affects the decomposition of nitramine explosive: CPMD investigations of LAB-doped CL20, Int. J. Hydrogen Energy 43 (43) (2018) 19825–19840.
[243] Q. Wang, J. Han, Y. Zhang, Z. Yan, E. Velasco, L. Yang, B. Wang, S. Zang, Fabrication of copper azide film through metal–organic framework for micro-initiator applications, ACS Appl. Mater. Interfaces 11 (8) (2019) 8081–8088.
[244] Y. Wang, H. Ma, Z. Shen, B. Wang, B. Xue, L. Ren, Detonation characteristics of emulsion explosives sensitized by hydrogen-storage glass microballoons, Propellants, Explos. Pyrotech. 43 (9) (2018) 939–947.
[245] R. Wei, S. Huang, Z. Wang, X. Wang, C. Ding, R. Yuen, J. Wang, Thermal behavior of nitrocellulose with different aging periods, J. Therm. Anal. Calorim. 136 (2) (2018) 651–660.
[246] M. Wurzenberger, N. Szimhardt, J. Stierstorfer, Nitrogen-rich copper(II) bromate complexes: an exotic class of primary explosives, Inorg. Chem. 57 (13) (2018) 7940–7949.
[247] J. Xu, C. Sun, M. Zhang, B. Liu, X. Li, J. Lu, et al., Coordination polymerization of metal azides and powerful nitrogen-rich ligand toward primary explosives with excellent energetic performances, Chem. Mater. 29 (22) (2017) 9725–9733.
[248] B. Yan, H. Li, H. Ma, F. Zhao, Y. Ma, Z. Zhang, Y. Zhang, Z. Zhang, Thermal behavior and detonation characterization of 3,3-dinitroazetidinium salicylate, Propellants, Explos. Pyrotech. 44 (2) (2018) 175–180.
[249] L. Yang, J. Wu, D. Geng, F. Wang, Y. Huang, L. Chen, Reactive molecular dynamics simulation of the thermal decomposition mechanisms of 4,10-dinitro-2,6,8,12-tetraoxa-4,10-diazatetracyclo[5.5.0.05,9.03,11]dodecane (TEX), Combust. Flame 202 (2019) 303–317.
[250] S. Zeman, A. Hussein, A. Elbeih, M. Jungova, cis-1,3,4,6-Tetranitrooctahydroimidazo-[4,5-d]imidazole (BCHMX) as a part of explosive mixtures, Defence Technol 14 (5) (2018) 380–384.
[251] T. Zhang, Y. Guo, J. Li, Y. Guan, Z. Guo, H. Ma, High catalytic activity of nitrogen-doped graphene on the thermal decomposition of CL-20, Propellants, Explos. Pyrotech. 43 (12) (2018) 1263–1269.
[252] W. Zhang, H. Ren, Y. Sun, S. Yan, Q. Jiao, Effects of ester-terminated glycidyl azide polymer on the thermal stability and decomposition of GAP by TG-DSC-MS-FTIR and VST, J. Therm. Anal. Calorim. 132 (3) (2018) 1883–1892.
[253] Z. Zhang, J. Ma, Q. Zhou, W. Hu, X. Zhang, 2-Fluoro-1,3-diamino-4,6-dinitrobenzene (ZXC-7) and 2-Fluoro-1,3,5-triamino-4,6-dinitrobenzene (ZXC-8): thermally stable explosives with outstanding properties, ChemPlusChem 84 (1) (2019) 119–122.
[254] L. Zhao, Y. Yin, H. Sui, Q. Yu, S. Sun, H. Zhang, S. Wang, L. Chen, J. Sun, Kinetic model of thermal decomposition of CL-20/HMX co-crystal for thermal safety prediction, Thermochim. Acta 674 (2019) 44–51.
[255] Y. Zhao, Z. Chai, S. Ye, Y. Xiao, Q. Zhang, B. Jin, R. Peng, Synthesis, characterization and thermal decomposition performance of polyaminofullerene nitrate, Thermochim. Acta 663 (2018) 110–117.
[256] F. Zhen, X. Zhou, L. Wang, R. Yang, F. Huang, Study on burning and thermal decomposition properties of HTPB propellant containing synthesized micro-nano ferric perfluorooctanoate, Propellants, Explos. Pyrotech. 44 (3) (2019) 362–368.
[257] J. Zhou, L. Ding, J. An, Y. Zhu, Y. Liang, Study on the thermal behaviors of nano-Al based fuel air explosive, J. Therm. Anal. Calorim. 130 (2) (2017) 1111–1116.
[258] J. Zhou, L. Ding, F. Bi, B. Wang, J. Zhang, Research on the thermal behavior of novel heat resistance explosive 5,5′-bis(2,4,6-trinitrophenyl)-2,2′-bi(1,3,4-oxadiazole), J. Anal. Appl. Pyrol. 129 (2018) 189–194.
[259] M. Zhou, S. Chen, D. Wang, Y. Yu, J. Wang, J. Li, N. Wang, M. Chen, A comparative study of performance between TKX-50-based composite explosives and other composite explosives, J. Energetic Mater. 37 (2) (2018) 162–173.
[260] C. Zhu, P. Song, L. Qiu, Y. Liu, Z. Xu, Z. Meng, Synthesis and characterization of the guanidine salt based on 1,1,2,2-tetranitraminoethane (TNAE). *Propellants, explosives*, Pyrotechnics 43 (12) (2018) 1296–1301.
[261] J. Zhu, S. Fu, K. Li, X. Zeng, S. Chen, Thermal stability assessment of a new energetic Ca(II) compound with ZTO ligand by DSC and ARC, J. Therm. Anal. Calorim. 134 (3) (2018) 1873–1882.
[262] Q. Zhu, C. Xiao, X. Xie, B. Zheng, S. Li, G. Luo, Thermal Decomposition Enhancement of HMX by Bonding with TiO 2 Nanoparticles, Propellants, Explosives, Pyrotechnics 44 (4) (2019) 438–446.

Instrumental Analysis of Explosives

LC/HPLC/UPLC

[263] G. Avci, B. Anilanmert, S. Cengiz, Rapid and simple analysis of trace levels of three explosives in soil by liquid chromatography—tandem mass spectrometry, Acta Chromatogr. 29 (1) (2017) 45–56.
[264] S. Gamble, L. Campos, R. Morgan, Detection of trace peroxide explosives in environmental samples using solid phase extraction and liquid chromatography mass spectrometry, Environ. Forensics 18 (1) (2017) 50–61.
[265] C. Liu, B. Kuo, M. Liu, Y. Huang, C. Chen, Computer simulation for the study of the liquid chromatographic separation of explosive molecules, J. Mol. Graph. Model. 85 (2018) 331–339.
[266] H. Şener, B. Anilanmert, S. Cengiz, A fast method for monitoring of organic explosives in soil: a gas temperature gradient approach in LC–APCI/MS/MS, Chem. Pap. 71 (5) (2017) 971–979.

Ion Chromatography

[267] Z. Gan, J. Liu, S. Tang, Simultaneous determination of nine typical anions in fire explosive residues by ion chromatography, Chin. J. Chromatogr. 36 (3) (2018) 299–302.

Gas Chromatography

[268] A. Boggess, S. Crump, C. Gregory, J. Young, G. Kessinger, Analytical method for nitroaromatic explosives in radiologically contaminated soil for ISO/IEC 17025 accreditation, Forensic. Chem 7 (2018) 26–32.
[269] A. Chajistamatiou, E. Bakeas, Identification of thiocyanates by Gas Chromatography – mass Spectrometry in explosive residues used as a possible marker to indicate black powder usage, Talanta 195 (2019) 456–462.
[270] A. Chajistamatious, E. Bakeas, A rapid for the identification of nitrocellulose in high explosives and smokeless powders using GC-EI-MS, Talanta 151 (2016) 192–201.
[271] J. Du, X. Zhang, C. Li, J. Gao, J. Hou, X. Jing, Y. Mu, L. Li, A bi-functional luminescent Zn(II)-MOF for detection of nitroaromatic explosives and Fe3+ ions, Sensor. Actuator. B Chem. 257 (2018) 207–213.
[272] C. Katilie, A. Simon, L. DeGreeff, Quantitative analysis of vaporous ammonia by online derivatization with gas chromatography - mass spectrometry with applications to ammonium nitrate-based explosives, Talanta 193 (2019) 87–92.
[273] J. Leppert, M. Hartel, T. Klapotke, P. Boeker, Hyperfast flow-field thermal gradient GC/MS of explosives with reduced elution temperatures, Anal. Chem. 90 (14) (2018) 8404–8411.
[274] D. Marder, N. Tzanani, H. Prihed, S. Gura, Trace detection of explosives with a unique large volume injection gas chromatography-mass spectrometry (LVI-GC-MS) method, Anal. Methods 10 (23) (2018) 2712–2721.
[275] E. Pagliano, B. Campanella, A. D'Ulivo, Z. Mester, Derivatization chemistries for the determination of inorganic anions and structurally related compounds by gas chromatography - a review, Anal. Chim. Acta 1025 (2018) 12–40.
[276] G. Sauzier, D. Bors, J. Ash, J. Goodpaster, S. Lewis, September) Optimisation of recovery protocols for double-base smokeless powder residues analysed by total vaporisation (TV) SPME/GC-MS, Talanta (158) (2016) 368–374.
[277] C. Tsai, S. Milam, C. Tipple, Exploring the analysis and differentiation of plastic explosives by comprehensive multidimensional gas chromatography-mass spectrometry (GC × GC–MS) with a statistical approach, Forensic. Chem 6 (2017) 10–18.

Capillary Electrophoresis

[278] L. Jones, M. Breadmore, Separation of small-mass ions, in: C.F. Poole (Ed.), Capillary Electromigration Separation Methods, *first ed.*, Elsevier, Amsterdam, Netherlands, 2018, pp. 353–372.
[279] K. Pinheiro, R. Moreira, K. Rezende, M. Talhavini, L. Lograd, J. Baio, M. Lanza, W. Coltro, Rapid separation of post-blast explosive residues on glass electrophoresis microchips, Electrophoresis 40 (3) (2018) 462–468.
[280] H. Zhou, Z. Liu, Y. Sun, L. Zeng, H. Mei, J. Xu, H. Hao, Detection of three common organic explosives using capillary electrophoresis, J. Mater. Sci. Chem. Eng. 4 (6) (2016) 17.

General Spectroscopy: Fluorescence, Luminescence, Spectrophotometric, UV, Chemiluminescence

[281] Y. An, X. Xu, K. Liu, X. An, C. Shang, G. Wang, T. Liu, H. Li, H. Peng, Y. Fang, Fast, sensitive, selective and reversible fluorescence monitoring of TATP in a vapor phase, Chem. Commun. 55 (7) (2019) 941–944.
[282] J. Andrasko, L. Lagesson-Andrasko, J. Dahlén, B. Jonsson, Analysis of explosives by GC-UV, J. Forensic Sci. 62 (4) (2017) 1022–1027.
[283] I. Anthony, M. Brantley, C. Gaw, A. Floyd, T. Solouki, Vacuum ultraviolet spectroscopy and mass spectrometry: a tandem detection approach for improved identification of gas chromatography-eluting compounds, Anal. Chem. 90 (7) (2018) 4878–4885.
[284] W. Asher, Determining the Binding Mechanisms of Nitro Group Containing Explosives on Metal Oxide Semiconductor Surfaces, Technical Report, University of Washington, Seattle, Washington, 2018.
[285] N. Bolse, R. Eckstein, M. Schend, A. Habermehl, C. Eschenbaum,

G. Hernandez-Sosa, et al., A digitally printed optoelectronic nose for the selective trace detection of nitroaromatic explosive vapours using fluorescence quenching, Flexible and Printed Electronics 2 (2) (2017), 024001.
[286] N. Bolse, R. Eckstein, M. Schend, A. Habermehl, G. Hernandez-Sosa, C. Eschenbaum, et al., Discrimination of trace nitroaromatics using linear discriminant analysis on aerosol jet printed fluorescent sensor arrays, in: Proceedings of the International Society for Optics and Photonics Optics+ Optoelectronics, 2017, p. 102310R.
[287] M. Boonsri, K. Vongnam, S. Namuangruk, M. Sukwattanasinitt, P. Rashatasakhon, Pyrenyl benzimidazole-isoquinolinones: aggregation-induced emission enhancement property and application as TNT fluorescent sensor, Sensor. Actuator. B Chem. 248 (2017) 665–672.
[288] J. Brady, B. Argirakis, A. Gordon, R. Lareau, B. Smith, Polymorphic phase control of RDX-Based explosives, Appl. Spectrosc. 72 (1) (2018) 28–36.
[289] S. Chakiroy, T. Kundu, V. Rao, T. Thundat, On-chip integration of photodetector and sensor: a multimodal photonic device for sensing applications, IEEE Sensor. J. 17 (15) (2017) 4773–4780.
[290] M. Chapman, Development of Rhodamine G6 Thin Film as a Fluorescent Sensor for Explosive Vapor Detection, PhD. University of Rhode Island, 2017.
[291] S. Chaudhary, S. Ninsawat, T. Nakamura, Non-destructive trace detection of explosives using pushbroom scanning hyperspectral imaging system, Sensors 19 (1) (2018) 97.
[292] H. Chen, X. Yang, D. Jiang, D. Schipper, R. Jones, NIR luminescence for the detection of metal ions and nitro explosives based on a grape-like nine-nuclear Nd(iii) nanocluster, Inorg. Chem. Front 6 (2) (2019) 550–555.
[293] X. Chen, X. Liu, J. Lei, L. Xu, Z. Zhao, F. Kausar, X. Xie, X. Zhu, Y. Zhang, W. Yuan, Synthesis, clustering-triggered emission, explosive detection and cell imaging of nonaromatic polyurethanes, Mol. Syst. Des. Eng. 3 (2) (2018) 364–375.
[294] F. Chu, F. Cheng, Z. Bian, G. Li, W. Jiang, X. Song, Explosive sensing by using polymer tip on the end of optical fiber, Optik-Int. J. Light. Electron Optics 141 (2017) 10–15.
[295] M. Chua, H. Zhou, T. Lin, J. Wu, J. Xu, Aggregation-induced emission active 3,6-bis(1,2,2-triphenylvinyl)carbazole and bis(4-(1,2,2-triphenylvinyl) phenyl)amine-based poly(acrylates) for explosive detection, J. Polym. Sci. Polym. Chem. 55 (4) (2017) 672–681.
[296] C. Copper, K. Brensigner, C. Rollman, A. Clark, M. Perez, A. Genzman, J. Rine, M. Moini, MEKC-UV as an effective tool for the separation and identification of explosives, high explosives, and their degradation products in environmental samples, Electrophoresis 37 (19) (2016) 2554–2557.
[297] C. Cruse, J. Goodpaster, Generating highly specific spectra and identifying thermal decomposition products via Gas Chromatography/Vacuum Ultraviolet Spectroscopy (GC/VUV): application to nitrate ester explosives, Talanta 195 (2019) 580–586.
[298] M. Cui, Y. Zhuang, G. Zou, B. Zhu, Q. Zhang, Fabrication of composite optical fiber taper through “click” polymerization initiated by evanescent field for sensing, Sensor. Actuator. B Chem. 284 (2019) 243–249.
[299] Dandan, M. Doganci, S. Bayir, E. Doganci, M. Gorur, F. Yilmaz, Nitroaromatic compound sensing application of hexa-armed dansyl end-capped poly (epsilon-caprolactone) star polymer with phosphazene core, J. Turkish Chem. Soc. Sec A: Chemistry 3 (3) (2016) 501–514.
[300] D. Das, K. Biradha, Luminescent coordination polymers of naphthalene based diamide with rigid and flexible dicarboxylates: sensing of nitro explosives, Fe(III) ion, and dyes, Cryst. Growth Des. 18 (6) (2018) 3683–3692.
[301] S. Dong, J. Hu, X. Zhang, M. Zheng, A bifunctional Zn(II)-MOF as recyclable luminescent sensor for detecting TNT and Fe3+ with high selectivity and sensitivity, Inorg. Chem. Commun. 97 (2018) 180–186.
[302] W. Dong, Z. Ma, P. Chen, Q. Duan, Carbazole and tetraphenylethylene based AIE-active conjugated polymer for highly sensitive TNT detection, Mater. Lett. 236 (2019) 480–482.
[303] J. Du, C. Li, J. Gao, X. Zhang, X. Jing, Y. Mu, L. Li, Zn(II) and Cd(II) coordination networks based on N-donor ligands: synthesis, crystal structures, and sensing of nitroaromatic explosives, RSC Adv. 6 (103) (2016) 101380–101388.
[304] J. Du, J. Liu, Y. Ren, C. Wang, F. Bai, H. Hao, Rapid detection of TNP based on a commercial fluorescent probe, Spectrochim. Acta Mol. Biomol. Spectrosc. 211 (2019) 287–290.
[305] Y. El-Sharkawy, S. Elbasuney, Real time recognition of explosophorous group and explosive material using laser induced photoacoustic spectroscopy associated with novel algorithm for time and frequency domain analysis, Spectrochim. Acta Mol. Biomol. Spectrosc. 204 (2018) 25–32.
[306] M. Fan, J. Wu, G. Deng, W. Zhang, K. Chen, Y. Gong, Donor-acceptor-donor organic dye-based optofluidic laser for sensitive explosive detection with a large dynamic range, in: 17th International Conference on Optical Communications and Networks, 2019, p. 11048.
[307] S. Fan, J. Lai, P. Burn, P. Shaw, Solid-state fluorescence-based sensing of TATP via hydrogen peroxide detection, ACS Sens. 4 (1) (2019) 134–142.
[308] C. Frenois, T. Caron, E. Pasquinet, P. Palmas, F. Pereira, R. Rousier, Experimentation of dioxazaborocane derivative as fluorescent material: application to the trace detection of hydrogen peroxide, IEEE Sens (2016) 1–3.
[309] T. Geng, Z. Zhu, W. Zhang, Y. Wang, A nitrogen-rich fluorescent conjugated microporous polymer with triazine and triphenylamine units for high iodine capture and nitro aromatic compound detection, J. Mater. Chem. 5 (16) (2017) 7612–7617.
[310] T. Ghorpade, A. Palai, S. Rath, S. Sharma, K. Sudarshan, P. Pujari, et al., Pentiptycene-butylpyrene based poly(arylene-ethynylene)s: highly sensitive and selective TNT sensor in aqueous as well as vapor phase, Sensor. Actuator. B Chem. 252 (2017) 901–911.
[311] P. Ghosh, P. Banerjee, Small molecular probe as selective tritopic sensor of Al 3+, F– and TNP: fabrication of portable prototype for onsite detection of explosive TNP, Anal. Chim. Acta 965 (2017) 111–122.
[312] P. Ghosh, S. Paul, P. Banerjee, How explosive TNP interacts with a small tritopic receptor: a combined crystallographic and thermodynamic approach, CrystEngComm 19 (44) (2017) 6703–6710.
[313] N. Goel, N. Kumar, A stable nonanuclear Tb (III) cluster for selective sensing of picric acid, Inorg. Chim. Acta. 463 (2017) 14–19.
[314] S. Halder, P. Ghosh, A. Hazra, P. Banerjee, P. Roy, A quinoline-based compound for explosive 2,4,6-trinitrophenol sensing: experimental and DFT-D3 studies, New J. Chem. 42 (11) (2018) 8408–8414.
[315] M. Han, S. Wang, Z. Li, Z. Zhou, D. Li, L. Ma, et al., Significant centre metallic effects on the sensing properties of two isostructural lanthanide metal-organic frameworks, Inorg. Chem. Commun. 79 (2017) 12–16.
[316] Y. Han, Y. Chen, J. Feng, J. Liu, S. Ma, X. Chen, One-pot synthesis of fluorescent silicon nanoparticles for sensitive and selective determination of 2, 4, 6-trinitrophenol in aqueous solution, Anal. Chem. 89 (5) (2017) 3001–3008.
[317] J. Hassanzadeh, A. Khataee, Y. Mosaei Oskoei, H. Fattahi, N. Bagheri, Selective chemiluminescence method for the determination of trinitrotoluene based on molecularly imprinted polymer-capped ZnO quantum dots, New J. Chem. 41 (19) (2017) 10659–10667.
[318] N. He, M. Gao, D. Shen, H. Li, Z. Han, P. Zhao, Rapid visual detection of nitroaromatic explosives using a luminescent europium-organic framework material, Forensic Sci. Int. 297 (2019) 1–7.
[319] X.J. Hong, Q. Wei, Y.P. Cai, S.R. Zheng, Y. Yu, Y.Z. Fan, et al., 2-Fold interpenetrating bifunctional Cd-metal–organic frameworks: highly selective adsorption for CO2 and sensitive luminescent sensing of nitro aromatic 2,4,6-trinitrophenol, ACS Appl. Mater. Interfaces 9 (5) (2017) 4701–4708.
[320] T. Hu, W. Sang, K. Chen, H. Gu, Z. Ni, S. Liu, Simple and sensitive colorimetric detection of a trace amount of 2,4,6-trinitrotoluene (TNT) with QD multilayer-modified microchannel assays, Mater. Chem. Front 3 (2) (2019) 193–198.
[321] X.L. Hu, X.X. Yang, X.Q. He, Z.M. Su, Synthesis, structure and photoluminescent properties for sensing nitro explosives of two new Zn (II) coordination polymers based on mixed tetrazolate and carboxylate ligands, Inorg. Chem. Commun. 77 (2017) 35–39.
[322] V. Kachwal, M. Joshi, V. Mittal, A. Choudhury, I. Laskar, Strategic design and synthesis of AIEE (Aggregation Induced Enhanced Emission) active push-pull type pyrene derivatives for the ultrasensitive detection of explosives, Sens. Bio-Sens. Res 23 (2019) 100267.
[323] M. Kaur, S.K. Mehta, S.K. Kansal, Nitrogen doped graphene quantum dots: efficient fluorescent chemosensor for the selective and sensitive detection of 2,4,6-trinitrophenol, Sensor. Actuator. B Chem. 245 (2017) 938–945.
[324] A. Khasanov, D. Kopchuk, I. Kovalev, O. Taniya, K. Giri, P. Slepukhin, et al., Extended cavity pyrene-based iptycenes for the turn-off fluorescence detection of RDX and common nitroaromatic explosives, New J. Chem. 41 (6) (2017) 2309–2320.
[325] S. Knapp, S. Kelzenberg, A. Raab, E. Roth, V. Weiser, Emission spectroscopy of the combustion flame of aluminium/copper oxide thermite, Propellants, Explos. Pyrotech. 44 (1) (2018) 9–17.
[326] S. Krishnan, C. Suneesh, Fluorene – triazine conjugated porous organic polymer framework for superamplified sensing of nitroaromatic explosives, J. Photochem. Photobiol. Chem. 371 (2019) 414–422.
[327] S. Kumar, R. Kishan, P. Kumar, S. Paschisia, R. Gupta, Size-selective detection of picric acid by fluorescent palladium macrocycles, Inorg. Chem. 57 (4) (2018) 1693–1697.
[328] B. Li, J. Chen, Y. Xiong, X. Yang, C. Zhao, J. Sun, Development of turn-on fluorescent probes for the detection of H 2 O 2 vapor with high selectivity and sensitivity, Sensor. Actuator. B Chem. 268 (2018) 475–484.
[329] X. Li, L. Zhou, L. Yan, D. Yuan, C. Lin, Q. Sun, Evolution of luminescent supramolecular lanthanide M2nL3n complexes from helicates, tetrahedra, to cubes, J. Am. Chem. Soc. 139 (24) (2017) 8237–8244.
[330] A. Liu, H. Liu, X. Peng, Y. Jia Fu, Q. He, H. Cao, et al., Direct and ultrasensitive fluorescence detection of PETN vapor based on a fuorene-dimer probe via a synergic backbone and side-chain tuning, Anal. Methods 10 (22) (2018) 2567–2574.
[331] R. Liu, Y. Ma, J. Liu, Y. Yang, T. Chu, New perspective on the fluorescence and sensing mechanism of TNP chemosensor 2-(4,5-bis(4-chlorophenyl)-1H-imidazole-2-yl)-4-chlorolphenol, Spectrochim. Acta Mol. Biomol. Spectrosc. 213 (2019) 309–317.
[332] Q. Lu, W. Cai, X. Zhang, C. Yang, H. Ge, Y. Chen, H. Niu, W. Wang, Multifunctional polymers for electrochromic, memory device, explosive detection and photodetector: donor-acceptor conjugated isoindigo derivatives with strong fluorescence, Eur. Polym. J. 108 (2018) 124–137.
[333] W. Lu, X. Dong, L. Qiu, Z. Yan, Z. Meng, M. Xue, X. He, X. Liu, Colorimetric sensor arrays based on pattern recognition for the detection of nitroaromatic molecules, J. Hazard Mater. 326 (2017) 130–137.
[334] X. Ma, F. Tao, Y. Zhang, T. Li, F.M. Raymo, Y. Cui, Detection of nitroaromatic explosives by 3D hyperbranched σ-π conjugate polymer on the basis of the POSS scaffold, J. Mater. Chem. 5 (2017) 14343–14354.
[335] H. Ma, F. Li, Z. Zhang, M. Zhang, Rapid DNT fluorescent films detection with high sensitivity and selectivity, Sensor. Actuator. B Chem. 244 (2017)

1080–1084.
[336] V. Mahendran, K. Pasumpon, S. Thimmarayaperumal, P. Thilagar, S. Shanmugam, Tetraphenylethene–2-Pyrone conjugate: aggregation-induced emission study and explosives sensor, J. Org. Chem. 81 (9) (2016) 3597–3602.
[337] P. Maity, A. Bhatt, B. Agrawal, A. Jana, Pt (II) C∧ N∧ N-based luminophore–micelle adducts for sensing nitroaromatic explosives, Langmuir 33 (17) (2017) 4291–4300.
[338] A. Mani-Varnosfaderani, M. Soleimani, N. Alizadeh, Least absolute shrinkage and selection operator as a multivariate calibration tool for simultaneous determination of diphenylamine and its nitro derivatives in propellants, Propellants, Explos. Pyrotech. 43 (4) (2018) 379–389.
[339] L. Martelo, T. das Neves, J. Figueiredo, L. Marques, A. Fedorov, A. Charas, et al., Towards the development of a low-cost device for the detection of explosives vapors by fluorescence quenching of conjugated polymers in solid matrices, Sensors 17 (12) (2017) 2532–2545.
[340] V. Mehta, M. Athar, P. Jha, A. Kongor, M. Panchal, V. Jain, A turn-off fluorescence sensor for insensitive munition using anthraquinone-appended oxacalix [4] arene and its computational studies, New J. Chem. 41 (2017) 5125–5132.
[341] H. Mi, J. Liu, M. Guan, Q. Liu, Z. Zhang, G. Feng, Fluorescence chemical sensor for determining trace levels of nitroaromatic explosives in water based on conjugated polymer with guanidinium side groups, Talanta 187 (2018) 314–320.
[342] L. Pacheco-Londoño, J. Aparicio-Bolaño, N. Galán-Freyle, A. Román-Ospino, J. Ruiz-Caballero, S. Hernandez, EXPRESS: Classical Least Squares-Assisted MIR Laser Spectroscopy Detection of High Explosives on Fabrics, Applied Spectroscopy, 2018, 000370281878041.
[343] A. Palma-Cando, D. Woitassek, G. Brunklaus, U. Scherf, Luminescent tetraphenylethene-cored, carbazole- and thiophene-based microporous polymer films for the chemosensing of nitroaromatic analytes, Mater. Chem. Front 1 (6) (2017) 1118–1124.
[344] X. Qiao, Y. Han, D. Tian, Z. Yang, J. Li, S. Zhao, MOF matrix doped with rare earth ions to realize ratiometric fluorescent sensing of 2,4,6-trinitrophenol: synthesis, characterization and performance, Sensor. Actuator. B Chem. 286 (2019) 1–8.
[345] Z. Qu, X. Chen, X. Huo, X. Zheng, D. Wang, L. Ji, et al., Soluble graphene composite with aggregation-induced emission feature: the non-covalent functionalization and application in explosive detection, J. Mater. Chem. C 5 (2017) 6216–6223.
[346] J. Ramakrishna, P. Venkatakrishnan, Bigger and brighter fluorenes: facile π-expansion, brilliant emission and sensing of nitroaromatics, Chem. Asian J. 12 (2) (2017) 181–189.
[347] A. Rana, S. Sahoo, P. Panda, β-Octaalkoxyporphyrins: versatile fluorometric sensors towards nitrated explosives, J. Porphyr. Phthalocyanines 23 (3) (2019) 287–295.
[348] M.R. Rao, Y. Fang, S. De Feyter, D.F. Perepichka, Conjugated covalent organic frameworks via michael addition–elimination, J. Am. Chem. Soc. 139 (6) (2017) 2421–2427.
[349] A. Rizzo, C. Telloli, P. Bartolomei, F. Manassero, δ13C analysis to screen out explosive precursors by using cavity ring down laser spectroscopy, Eur. Phys. J. Plus 133 (2018) 292.
[350] X. Shan, S. Zhang, M. Zhou, T. Geske, M. Davis, A. Hao, H. Wang, Z. Yu, Porous halide perovskite–polymer nanocomposites for explosive detection with a high sensitivity, Adv. Mater. Interfaces (2018) 1801686.
[351] S. Shanmugaraju, C. Dabadie, K. Byrne, A. Savyasachi, D. Umadevi, W. Schmitt, et al., A supramolecular Tröger's base derived coordination zinc polymer for fluorescent sensing of phenolic-nitroaromatic explosives in water, Chem. Sci. 8 (2) (2017) 1535–1546.
[352] R. Sharma, S. Kumar, S. Gautam, S. Gupta, H. Srivastava, Photoacoustic sensor for trace detection of post-blast explosive and hazardous molecules, Sensor. Actuator. B Chem. 243 (2017) 59–63.
[353] S. Shoaee, S. Fan, P. Burn, P. Shaw, Photophysics of detection of explosive vapours via luminescence quenching of thin films: impact of inter-molecular interactions, Phys. Chem. Chem. Phys. 18 (37) (2016) 25861–25868.
[354] S. Shoaee, S. Fan, P. Burn, P. Shaw, Photophysics of detection of explosive vapours via luminescence quenching of thin films: impact of inter-molecular interactions, Phys. Chem. Chem. Phys. 18 (37) (2016) 25861–25868.
[355] T. Smijs, F. Galli, A. Van Asten, Forensic potential of atomic force microscopy, Forensic. Chem 2 (2016) 93–104.
[356] R. Sodkhomkhum, M. Masik, S. Watchasit, C. Suksai, J. Boonmak, S. Youngme, et al., Imidazolylmethylpyrene sensor for dual optical detection of explosive chemical: 2,4,6-Trinitrophenol, Sensor. Actuator. B Chem. 245 (2017) 665–673.
[357] W. Song, X. Cui, Z. Liu, E. Yang, X. Zhao, Light-triggered supramolecular isomerism in a self-catenated Zn(II)-organic framework: dynamic photo-switching CO2 uptake and detection of nitroaromatics, Sci. Rep. 6 (1) (2016) 34870.
[358] X. Tan, T. Zhang, W. Zeng, S. He, X. Liu, H. Tian, J. Shi, T. Cao, A fluorescence sensing determination of 2, 4, 6-trinitrophenol based on cationic water-soluble pillar[6]arene graphene nanocomposite, Sensors 19 (1) (2018) 91.
[359] O. Taniya, L. Sadieva, I. Kovalev, G. Zyryanov, D. Kopchuk, V. Rusinov, O. Chupakhin, Detection of nitroaromatic explosives by 2-amino-3-ethoxycarbonyl-6-(1-methylindol-3-yl)-5-(4-chlorophenyl)-pyrazine and its derivatives, AIP Con. Proc 2063 (1) (2019), 040058.
[360] S. Tawfik, M. Sharipov, S. Kakhkhorov, M. Elmasry, Y. Lee, Multiple emitting amphiphilic conjugated polythiophenes-coated CdTe QDs for picogram detection of trinitrophenol explosive and application using chitosan film and paper-based sensor coupled with smartphone, Adv. Sci 6 (2) (2018) 1801467.
[361] N. Tripathi, R. Kumar, P. Singh, S. Kumar, Ratiometric fluorescence "Turn On" probe for fast and selective detection of TNT in solution, solid and vapour, Sensor. Actuator. B Chem. 246 (2017) 1001–1010.
[362] N. Trpathi, P. Singh, S. Kumar, Dynamic fluorescence quenching by 2, 4, 6-trinitrophenol in voids of aggregation induced emission based fluorescent probe, New J. Chem. 41 (2017) 8739–8747.
[363] A. Üzer, S. Durmazel, E. Erçağ, R. Apak, Determination of hydrogen peroxide and triacetone triperoxide (TATP) with a silver nanoparticles—based turn-on colorimetric sensor, Sensor. Actuator. B Chem. 247 (2017) 98–107.
[364] E. Valdes, K. Hoang, X-ray Fluorescence Spectroscopy for Analysis of Explosive-Related Materials and Unknowns. ECBC-TR-1455, Aberdeen Proving Ground, M.D, Edgewood Chemical Biological Center, 2017.
[365] E. Verbitskiy, E. Cheprakova, A. Baranova, K. Khokhlov, K. Lugovik, G. Rusinov, et al., Microwave-assisted synthesis of 4-(2,2'-bithiophen-5-yl)-5-phenylpyrimidine derivatives as sensors for detection of nitroaromatic explosives, Chem. Heterocycl. Compd. 52 (11) (2016) 904–909.
[366] W. Wan, D. Tian, Y. Jing, X. Zhang, W. Wu, H. Ren, H. Bao, NBN-Doped conjugated polycyclic aromatic hydrocarbons as an AIEgen class for extremely sensitive detection of explosives, Angew. Chem. 130 (47) (2018) 15736–15742.
[367] C. Wang, H. Huang, B. Bunes, N. Wu, M. Xu, X. Yang, L. Zang, Trace detection of RDX, HMX and PETN explosives using a fluorescence spot sensor, Sci. Rep. 6 (2016) 25015.
[368] C. Wang, L. Tian, W. Zhu, S. Wang, P. Wang, Y. Liang, et al., Dye@ bio-MOF-1 composite as a dual-emitting platform for enhanced detection of a wide range of explosive molecules, ACS Appl. Mater. Interfaces 9 (23) (2017) 20076–20085.
[369] K. Wang, X. Tian, Y. Jin, J. Sun, Q. Zhang, Heterometallic hybrid open frameworks: synthesis and application for selective detection of nitro explosives, Cryst. Growth Des. 17 (4) (2017) 1836–1842.
[370] Q. Wang, D. Liu, L. Cui, X. Hu, X. Wang, Z. Su, A 3D pillared-layer metal–organic framework with fluorescence property for detection of nitroaromatic explosives, New J. Chem. 43 (2) (2019) 963–969.
[371] Y. Wang, W. Jia, R. Chen, X. Zhao, Z. Wang, Guest-induced SC–SC transformation within the first K/Cd heterodimetallic triazole complex: a luminescent sensor for high-explosives and cyano molecules, Chem. Commun. 53 (3) (2017) 636–639.
[372] Z. Wang, L. Qin, J. Chen, H. Zheng, H-bonding interactions induced two isostructural Cd(II) metal–organic frameworks showing different selective detection of nitroaromatic explosives, Inorg. Chem. 55 (21) (2016) 10999–11005.
[373] Y. Wu, S. Luo, L. Cao, K. Jiang, L. Wang, J. Xie, et al., Self-assembled structures of N-alkylated bisbenzimidazolyl naphthalene in aqueous media for highly sensitive detection of picric acid, Anal. Chim. Acta 976 (2017) 74–83.
[374] Z. Wu, L. Gong, X. Huang, A Mg-CP with in situ encapsulated photochromic guest as sensitive fluorescence sensor for Fe3+/Cr3+ ions and nitro-explosives, Inorg. Chem. 56 (13) (2017) 7397–7403.
[375] W. Xiong, X. Liu, T. Wang, Y. Zhang, Y. Che, J. Zhao, Fluorescence detection of a broad class of explosives with one zinc (II)-coordination nanofiber, Anal. Chem. 88 (22) (2016) 10826–10830.
[376] Y. Xu, X. Wu, Y. Chen, H. Hang, H. Tong, L. Wang, Star-shaped triazatruxene derivatives for rapid fluorescence fiber-optic detection of nitroaromatic explosive vapors, RSC Adv. 6 (38) (2016) 31915–31918.
[377] S.-Y. Yin, S.-S. Sun, M. Pan, L. Chen, Z. Wang, Y.-J. Hou, et al., An imidazole based ESIPT molecule for fluorescent detection of explosives, J. Photochem. Photobiol. Chem. 355 (2018) 377–381.
[378] F. Zapata, M. Ferreiro-González, C. García-Ruiz, Interpreting the near infrared region of explosives, Spectrochim. Acta Mol. Biomol. Spectrosc. 204 (2018) 81–87.
[379] X. Zeng, H. Xu, Y. Xu, X. Li, Z. Nie, S. Gao, D. Xiao, A series of porous interpenetrating metal–organic frameworks based on fluorescent ligands for nitroaromatic explosive detection, Inorg. Chem. Front 5 (7) (2018) 1622–1632.
[380] F. Zhang, Y. Wang, T. Chu, Z. Wang, W. Li, Y. Yang, A facile fabrication of electrodeposited luminescent MOF thin films for selective and recyclable sensing of nitroaromatic explosives, Analyst 141 (14) (2016) 4502–4510.
[381] F. Zhang, G. Zhang, H. Yao, Y. Wang, T. Chu, Y. Yang, A europium (III) based nano-flake MOF film for efficient fluorescent sensing of picric acid, Microchimica Acta 184 (4) (2017) 1207–1213.
[382] X. Zhang, Y. Duan, N. Zhang, L. Zhao, X. Luo, J. Wu, X. Yu, Highly selective and sensitive detection of nitroaromatic compounds and metal ions by supramolecular assemblies of 3,3',5,5'-azobenzenetetracarboxylic acid and 4,4'-bipyridine, J. Fluoresc. 27 (1) (2016) 281–286.
[383] X. Zhang, J. Hu, J. Li, T. Liu, J. Wang, X. Ma, A bifunctional luminescent coordination polymer as recyclable sensor for detecting TNP and Fe3+ with high selectivity and sensitivity, Inorg. Chim. Acta. 486 (2019) 556–561.
[384] X. Zhang, J. Hu, B. Wang, Z. Li, S. Xu, Y. chen, X. Ma, A chiral zinc(II) metal-organic framework as high selective luminescent sensor for detecting trace nitro explosives picric acid and Fe3+ ion, J. Solid State Chem. 269 (2019) 459–464.

[385] X. Zhang, D. Zhu, Y. Fu, Q. He, H. Cao, W. Li, et al., Enhanced fluorescence of functionalized silica microsphere based on whispering gallery mode for nitrate ester explosives and hexogen vapour detection, J. Mater. Chem. C 5 (8) (2017) 2114–2122.
[386] Y. Zhang, Z. Jiao, W. Xu, Y. Fu, D. Zhu, J. Xu, et al., Design, synthesis and properties of a reactive chromophoric/fluorometric probe for hydrogen peroxide detection, New J. Chem. 41 (10) (2017) 3790–3797.
[387] Z. Zhang, S. Chen, R. Shi, J. Ji, D. Wang, S. Jin, et al., A single molecular fluorescent probe for selective and sensitive detection of nitroaromatic explosives: a new strategy for the mask-free discrimination of TNT and TNP within same sample, Talanta 166 (2017) 228–233.
[388] M. Zhao, H. Yu, Y. He, A dynamic multichannel colorimetric sensor array for highly effective discrimination of ten explosives, Sensor. Actuator. B Chem. 283 (2019) 329–333.
[389] B. Zheng, Y. Li, F. Tao, Y. Cui, T. Li, Enhanced superquenching of the hyperbranched conjugated polymer for the detection of nitroaromatic explosives, Sensor. Actuator. B Chem. 241 (2017) 357–363.

Mass Spectrometry

[390] R. Bain, P. Fedick, J. Dilger, R. Crooks, Analysis of residual explosives by swab touch spray ionization mass spectrometry, Propellants, Explos. Pyrotech. 43 (11) (2018) 1139–1144.
[391] M. Bridoux, A. Schwarzenberg, S. Schramm, R. Cole, Combined use of direct analysis in real-time/Orbitrap mass spectrometry and micro-Raman spectroscopy for the comprehensive characterization of real explosive samples, Anal. Bioanal. Chem. 408 (21) (2016) 5677–5687.
[392] H. Byliński, J. Gębicki, T. Dymerski, J. Namieśnik, Direct analysis of samples of various origin and composition using specific types of mass spectrometry, Crit. Rev. Anal. Chem. 47 (4) (2017) 340–358.
[393] K. Colizza, Metabolism and Gas Phase Reactions of Peroxide Explosives Using Atmospheric Pressure Ionization Mass Spectrometry, PhD. University of Rhode Island, 2018.
[394] K. Colizza, A. Yevdokimov, L. McLennan, J. Smith, J. Oxley, Reactions of organic peroxides with alcohols in atmospheric pressure chemical ionization—the pitfalls of quantifying triacetone triperoxide (TATP), J. Am. Soc. Mass Spectrom. 29 (2) (2018) 393–404.
[395] I. Corbin, Analysis of Improvised Explosives by Electrospray Ionization - Mass Spectrometry and Microfluidic Techniques, PhD, Florida International University, 2016.
[396] D. Correa, J. Melendez-Perez, J. Zacca, R. Borges, E. Schmidt, M. Eberlin, et al., Direct detection of triacetone triperoxide (TATP) in real banknotes from ATM explosion by EASI-MS, Propellants, Explos. Pyrotech. 42 (4) (2017) 370–375.
[397] L. Dunn, H. Obaidly, S. Khalil, Development and validation of fast liquid chromatography high-resolution mass spectrometric (LC-APCI-QToF-MS) methods for the analysis of hexamethylene triperoxide diamine (HMTD) and triacetone triperoxide (TATP), Forensic. Chem 10 (2018) 5–14.
[398] R. Ewing, B. Valenzuela, D. Atkinson, E. Freeburg, Detection of inorganic salt-based homemade explosives (HME) by atmospheric flow tube-mass spectrometry, Anal. Chem. 90 (13) (2018) 8086–8092.
[399] M.E. Fajardo, C.D. Molek, E.C. Fossum, Time-of-flight mass spectrometry of laser exploding foil initiated PETN samples, Am. Inst. Phys. Conf. Proc. 1793 (1) (2017), 030024.
[400] C. Fletcher, R. Sleeman, J. Luke, P. Luke, J. Bradley, Explosive detection using a novel dielectric barrier discharge ionisation source of mass spectrometry, J. Mass Spectrom. 53 (3) (2018) 214–222.
[401] T. Forbes, J. Verkouteren, Forensic analysis and differentiation of black powder and black powder substitute chemical signatures by infrared thermal desorption–DART-MS, Anal. Chem. 91 (1) (2018) 1089–1097.
[402] T. Forbes, E. Sisco, M. Staymates, Detection of nonvolatile inorganic oxidizer-based explosives from wipe collections by infrared thermal desorption-direct analysis in real time mass spectrometry, Anal. Chem. 90 (11) (2018) 6419–6425.
[403] T. Forbes, E. Sisco, M. Staymates, G. Gillen, DART-MS analysis of inorganic explosives using high temperature thermal desorption, Anal. Methods 9 (34) (2017) 4988–4996.
[404] B. Gaiffe, M. Bridoux, C. Costanza, R. Cole, A systematic tandem mass spectrometric study of anion attachment for improved detection and acidity evaluation of nitrogen-rich energetic compounds, J. Mass Spectrom. 53 (1) (2018) 21–29.
[405] S. Gobi, L. Zhao, B. Xu, U. Ablikim, M. Ahmed, R. Kaiser, A vacuum ultraviolet photoionization study on the thermal decomposition of ammonium perchlorate, Chem. Phys. Lett. 691 (2018) 250–257.
[406] N. Hagan, I. Goldberg, A. Graichen, A. St Jean, C. Wu, D. Lawrence, P. Demirev, Ion mobility spectrometry-high resolution LTQ-Orbitrap mass spectrometry for analysis of homemade explosives, J. Am. Soc. Mass Spectrom. 28 (8) (2017) 1531–1539.
[407] S. Hagenhoff, J. Franzke, H. Hayen, Determination of peroxide explosive TATP and related compounds by dielectric barrier discharge ionization-mass spectrometry (DBDI-MS), Anal. Chem. 89 (7) (2017) 4210–4215.
[408] Y. Hashimoto, Development of a miniature mass spectrometer and an automated detector for sampling explosive materials, Mass Spectrom. 6 (1) (2017) A0054.
[409] E. Lennert, C. Bridge, Analysis and classification of smokeless powders by GC–MS and DART-TOFMS, Forensic Sci. Int. 292 (2018) 11–22.
[410] E. Lennert, C. Bridge, Rapid screening for smokeless powders using DART-HRMS and thermal desorption DART-HRMS, Forensic. Chem 13 (2019) 100148.
[411] F. Li, J. Tice, B. Musselman, A. Hall, September) A method for rapid sampling and characterization of smokeless powder using sorbent-coated wire mesh and direct analysis in real time - mass spectrometry (DART-MS), Sci. Justice 56 (5) (2016) 321–328.
[412] A. Lising, Evaluating The Feasibility of Implementing Direct Analysis in Real Time - Mass Spectrometry for the Forensic Examination of Post-blast Debris, Master of Science, Boston University, 2017.
[413] Z. Liu, B. Xu, Z. Sun, Y. Sun, H. Zhou, J. Zhu, J. Xu, X. Duan, C. Liu, Identification of nitro explosives by direct analysis in real-time time-of-flight mass spectrometry, Anal. Lett. 50 (14) (2017) 2234–2245.
[414] A. Lubrano, B. Andrews, M. Hammond, G. Collins, S. Rose-Pehrsson, Analysis of ammonium nitrate headspace by on-fiber solid phase microextraction derivatization with gas chromatography mass spectrometry, J. Chromatogr. A 1429 (2016) 8–12.
[415] S. Martínez-Jarquín, R. Winkler, Low-temperature plasma (LTP) jets for mass spectrometry (MS): ion processes, instrumental set-ups, and application examples, Trac. Trends Anal. Chem. 89 (2017) 133–145.
[416] A. Ostrinskaya, R. Kunz, M. Clarke, R. Kingsborough, T. Ong, Rapid quantitative analysis of multiple explosive compound classes on a single instrument via flow-injection analysis tandem mass spectrometry, J. Forensic Sci. 64 (1) (2019) 223–230.
[417] J. Perez, Elucidating the Fundamentals of Laser Electrospray Mass Spectrometry and Characterization of Composite Explosives and Classification of Smokeless Powder and its Residue Using Multivariate Statistical Analysis, Doctoral Dissertation, Temple University, 2016.
[418] V. Pervukhin, D. Sheven, Semi-quantitative analysis of samples in solutions using Aerodynamic Breakup Droplet ionization (ABDI) mass spectrometry, Talanta 196 (2019) 449–455.
[419] M. Poltash, J. McCabe, J. Patrick, A. Laganowsky, D. Russell, Development and evaluation of a reverse-entry ion source Orbitrap mass spectrometer, J. Am. Soc. Mass Spectrom. 30 (1) (2018) 192–198.
[420] M. Rahman, T. Jiang, Y. Tang, W. Xu, A simple desorption atmospheric pressure chemical ionization method for enhanced non-volatile sample analysis, Anal. Chim. Acta 1002 (2018) 62–69.
[421] K. Reese, A. Jones, R. Smith, Characterization of smokeless powders using multiplexed collision-induced dissociation mass spectrometry and chemometric procedures, Forensic Sci. Int. 272 (2017) 16–27.
[422] R. Reiss, S. Ehlert, J. Heide, M. Putz, T. Forster, R. Zimmermann, Ambient pressure laser desorption—chemical ionization mass spectrometry for fast and reliable detection of explosives, drugs, and their precursors, Appl. Sci. 8 (6) (2018) 933.
[423] C. Tsai, A. Midey, C. Wu, R. Yost, Analysis of ammonium nitrate/urea nitrate with crown ethers and sugars as modifiers by electrospray ionization-mass spectrometry and ion mobility spectrometry, Anal. Chem. 88 (19) (2016) 9435–9442.
[424] C. Tsai, C. Tipple, R. Yost, Application of paper spray ionization for explosives analysis, Rapid Commun. Mass Spectrom. 31 (19) (2017) 1565–1572.
[425] D. Usmanov, S. Ninomiya, L. Chen, S. Saha, M. Mandal, Y. Sakai, et al., Desorption in mass spectrometry, Mass Spectrom. 6 (2) (2017) S0059.
[426] R. Williamson, S. Gura, A. Tarifa, J. Almirall, The coupling of capillary microextraction of volatiles (CMV) dynamic air sampling device with DART-MS analysis for the detection of gunshot residues, Forensic. Chem 8 (2018) 49–56.
[427] M. Young, M. Schantz, W. MacCrehan, July) Improvements in the vapor-time profile analysis of explosive odorants using solid-phase microextraction, J. Chromatogr. A (1455) (2016) 1–8.
[428] Q. Zhao, J. Liu, B. Wang, X. Zhang, G. Huang, W. Xu, Rapid screening of explosives in ambient environment by aerodynamic assisted thermos desorption mass spectrometry, J. Mass Spectrom. 52 (1) (2017) 1–6.

Isotope Ratio Mass Spectroscopy, IRMS

[429] C. Aikaterini, A. Yiannis, K. Polyxeni, T. Maria, B. Evangelos, Discrimination of tetryl samples by gas chromatography - isotope ratio mass spectrometry, Forensic. Chem 12 (2018) 42–45.
[430] K. Bezemer, M. Koeber, E. Heijden Antonie, C. Driel, C. Blaga, J. Bruinsma, A. Asten, The potential of isotope ratio mass spectrometry (IRMS) and gas chromatography-IRMS analysis of triacetone triperoxide in forensic explosives investigations, J. Forensic Sci. 61 (5) (2016) 1198–1207.
[431] L. Chesson, J. Howa, M. Lott, J. Ehleringer, Development of a methodological framework for applying isotope ratio mass spectrometry to explosive components, Forensic. Chem 2 (2016) 9–14.
[432] B. Grimm, L. Stern, A. Lowe, Forensic utility of a nitrogen and oxygen isotope ratio time series of ammonium nitrate and its isolated ions, Talanta 178 (2018) 94–101.
[433] J. Howa, J. Barnette, L. Chesson, M. Lott, J. Ehleringer, TATP isotope ratios as influenced by worldwide acetone variation, Talanta 181 (2018) 125–131.
[434] J. Howa, M. Lott, L. Chesson, J. Ehleringer, Isolation of components of plastic explosives for isotope ratio mass spectrometry, Forensic. Chem 1 (2016) 6–12.

[435] M. Rahman, P. McCutcheon, C. Gillan, S. Bell, Vibrational spectroscopy for identification and discrimination of explosives and common household materials, J. Def. Sec. Technol 1 (1) (2017) 0–n.

FTIR

[436] A. Alvarez, J. Yanez, D. Contreras, R. Saavedra, P. Saez, D. Amarasiriwardena, Propellant's differentiation using FTIR-photoacoustic detection for forensic studies of improvised explosive devices, Forensic Sci. Int. 280 (2017) 169–175.
[437] K. Banas, A. Banas, S. Heussler, M. Breese, Influence of spectral resolution, spectral range and signal-to-noise ratio of Fourier transform infra-red spectra on identification of high explosive substances, Spectrochim. Acta Mol. Biomol. Spectrosc. 188 (2018) 106–112.
[438] J. Ostrander, R. Knepper, A. Tappan, J. Kay, M. Zanni, D. Farrow, Energy transfer between coherently delocalized states in thin films of the explosive Pentaerythritol Tetranitrate (PETN) revealed by two-dimensional infrared spectroscopy, J. Phys. Chem. B 121 (6) (2017) 1352–1361.
[439] R. Risoluti, A. Gregori, S. Schiavone, S. Materazzi, Click and screen" technology for the detection of explosives on human hands by a portable MicroNIR-Chemometrics platform, Anal. Chem. 90 (7) (2018) 4288–4292.

Raman Spectroscopy

[440] S. Almaviva, A. Palucci, S. Botti, A. Puiu, A. Rufoloni, Validation of a miniaturized spectrometer for trace detection of explosives by Surface-Enhanced Raman Spectroscopy, Challenges 7 (2) (2016) 14.
[441] M. Almeida, L. Lograd, J. Zacca, D. Correa, R. Poppi, Raman hyperspectral imaging in conjunction with independent component analysis as a forensic tool for explosive analysis: the case of an ATM explosion, Talanta 174 (2017) 628–632.
[442] S. Ben-Jaber, W. Peveler, R. Quesada-Cabrera, E. Cortés, C. Sotelo-Vazquez, N. Abdul-Karim, I. Parkin, et al., Photo-induced enhanced Raman spectroscopy for universal ultra-trace detection of explosives, pollutants and biomolecules, Nat. Commun. 7 (1) (2016) 12189.
[443] S. Ben-Jaber, W. Peveler, R. Quesada-Cabrera, C. Sol, I. Papakonstantinou, I. Parkin, Sensitive and specific detection of explosives in solution and vapour by surface-enhanced Raman spectroscopy on silver nanocubes, Nanoscale 9 (42) (2017) 16459–16466.
[444] C. Byram, S. Moram, A. Shaik, V. Soma, Versatile gold based SERS substrates fabricated by ultrafast laser ablation for sensing picric acid and ammonium nitrate, Chem. Phys. Lett. 685 (2017) 103–107.
[445] N. Chen, P. Ding, Y. Shi, T. Jin, Y. Su, H. Wang, Y. He, Portable and reliable surface-enhanced Raman scattering silicon chip for signal-on detection of trace trinitrotoluene explosive in real systems, Anal. Chem. 89 (9) (2017) 5072–5078.
[446] S. Christesen, J. Guicheteau, J. Curtiss, A. Fountain, Handheld dual-wavelength Raman instrument for the detection of chemical agents and explosives, Opt. Eng. 55 (7) (2016), 074103.
[447] A. Dowgiallo, A. Branham, D. Guenther, Trace-level detection of explosives using sputtered SERS substrates, Spectroscopy 32 (6) (2017) 8–17.
[448] P. Wilcox, E. Emmons, I. Pardoe, Raman Spectra and Cross Sections of Chemical Warfare Agents, Agent Simulants, and Explosives Using 213 Nm Deep-Ultraviolet Laser Excitation (ECBC-TR-1512). Edgewood Chemical Biological Center, U.S. Army Research, Development and Engineering Command, 2019.
[449] S. Elbasuney, A. El-Sherif, Instant detection and identification of concealed explosive-related compounds: induced Stokes Raman versus infrared, Forensic Sci. Int. 270 (2017) 83–90.
[450] F. Gao, W. Liu, Z. Meng, P. Su, Z. Li, M. Wang, A rapid and sensitive quantitative analysis method for TNT using Raman spectroscopy, Propellants, Explos. Pyrotech. 44 (3) (2019) 337–344.
[451] K. Gares, UV Resonance Raman Investigation of Explosives' UV Photochemistry, PhD. University of Pittsburgh, 2017.
[452] R. Gillibert, J. Huang, Y. Zhang, W. Fu, M.L. de la Chapelle, Explosive detection by surface enhanced Raman scattering, Trends Anal. Chem. 105 (2018) 166–172.
[453] M. Greenfield, S. McGrane, D. Moore, Selective detection using the gerchberg-saxton algorithm and optimal coherent anti-Stokes Raman spectroscopy, in: Imaging and Applied Optics 2016, Optical Society of America, 2016. LT2G-1.
[454] S. Gulia, K. Gulati, V. Gambhir, R. Sharma, M. Reddy, Trace detection of explosives and their derivatives in stand-off mode using time gated Raman spectroscopy, Vib. Spectrosc. 87 (2016) 207–214.
[455] B. Guven, M. Eryilmaz, A. Üzer, I. Boyaci, U. Tamer, R. Apak, Surface-enhanced Raman spectroscopy combined with gold nanorods for the simultaneous quantification of nitramine energetic materials, RSC Adv. 7 (59) (2017) 37039–37047.
[456] A. Hakonen, K. Wu, M. Schmidt, P. Andersson, A. Boisen, T. Rindzevicius, Detecting forensic substances using commercially available SERS substrates and handheld Raman spectrometers, Talanta 189 (2018) 649–652.
[457] X. He, Y. Liu, X. Xue, J. Liu, Y. Liu, Z. Li, Ultrasensitive detection of explosives via hydrophobic condensation effect on biomimetic SERS platforms, J. Mater. Chem. C 5 (47) (2017) 12384–12392.
[458] A. Hopkins, J. Cooper, L. Profeta, A. Ford, Portable deep-ultraviolet (DUV) Raman for standoff detection, Appl. Spectrosc. 70 (5) (2016) 861–873.
[459] L. Hu, Y. Liu, S. Xu, Z. Li, J. Guo, S. Gao, Z. Lu, H. Si, S. Jiang, S. Wang, Facile and low-cost fabrication of Ag-Cu substrates via replacement reaction for highly sensitive SERS applications, Chem. Phys. Lett. 667 (2017) 351–356.
[460] S. Khandasammy, M. Fikiet, E. Mistek, Y. Ahmed, L. Halámková, J. Bueno, I. Lednev, Bloodstains, paintings, and drugs: Raman spectroscopy applications in forensic science, Forensic. Chem 8 (2018) 111–133.
[461] X. Kong, Y. Xi, P. Duff, X. Chong, E. Li, F. Ren, A. Wang, Detecting explosive molecules from nanoliter solution: a new paradigm of SERS sensing on hydrophilic photonic crystal biosilica, Biosens. Bioelectron. 88 (2017) 63–70.
[462] B. Leigh, K. Monson, J. Kim, Visible and UV resonance Raman spectroscopy of the peroxide-based explosive HMTD and its photoproducts, Forensic. Chem 2 (2016) 22–28.
[463] J.M. Leonard, The Advanced Spectroscopic Analysis of Organic Gunshot Residue and Explosives, Doctoral Dissertation, City University of, New York, 2017.
[464] Y. Liu, R. Perkins, Y. Liu, N. Tzeng, Normal mode and experimental analysis of TNT Raman spectrum, J. Mol. Struct. 1133 (2017) 217–225.
[465] Y. Liu, N. Tzeng, Y. Liu, T. Junk, Normal mode analysis of isotopic shifts in Raman spectrum of TNT-d5, J. Mol. Struct. 1143 (2017) 438–443.
[466] T. Liyanage, A. Rael, S. Shaffer, S. Zaidi, J. Goodpaster, R. Sardar, Fabrication of a self-assembled and flexible SERS nanosensor for explosive detection at parts-per-quadrillion levels from fingerprints, Analyst 143 (9) (2018) 2012–2022.
[467] P. Loeffen, G. Maskall, M. Bloomfield, C. Tombling, P. Matousek, The performance of spatially offset Raman spectroscopy for liquid explosive detection, in: Proceedings of the International Society for Optics and Photonics 9995, Optics and Photonics for Counterterrorism, Crime Fighting, and Defence XII. Edinburgh, United Kingdom, 2016, p. 99950D.
[468] C.D. Meinhard, M. Moskovits, A.W. Fountain, N.D. Kline, Rapid Detection of Drugs and Explosives for Forensic Analysis (Accession No. AD1065041), Edgewood Chemical Biological Center, Aberdenn Proving Ground, MD, 2018.
[469] S. Pilkington, S. Roberson, P. Pellegrino, Multiplex coherent anti-Stokes Raman scattering spectroscopy for trace chemical detection, Appl. Optic. 56 (3) (2017) B159.
[470] K. Rao, A. Chaudhary, Raman and time-resolved pulsed photoacoustic spectroscopy of solid trinitrotoluene in graphite mixture: for identification of double resonant optical phonon signatures, Optic Laser. Technol. 109 (2019) 149–156.
[471] V.R. Soma, G.K. Podagatlapalli, H. Syed, Femtomolar detection of explosive molecules using laser ablated targets and SERS, in: 13th International Conference on Fiber Optics and Photonics, Optical Society of America Technical Digest, 2016, pp. Th4D–2.
[472] R.J. Stokes, M. Bailey, S. Bonthron, T. Stone, G. Maskall, O. Presly, et al., New capability for hazardous materials ID within sealed containers using a portable spatially offset Raman spectroscopy (SORS) device, in: Proceedings of the International Society for Optics and Photonics 9995 Optics and Photonics for Counterterrorism, Crime Fighting, and Defence XII. Edinburgh, United Kingdom, 2016, p. 999506.
[473] M. Svanqvist, M. Glimtoft, M. Ågren, M. Nordberg, H. Östmark, May). Standoff detection of explosives and precursors using compressive sensing Raman spectroscopy, in: Proceedings of the International Society for Optics and Photonic 9824, Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) Sensing XVII. Edinburgh, United Kingdom, 2016, p. 98240C.
[474] C. Tao, R. Chen, J. Li, Photonic crystal fiber sensor based on surface-enhanced Raman scattering for explosives detection, in: Proceedings of the International Society for Optics and Photonics 10025, Advanced Sensor Systems and Applications VII. Beijing, China, 2016, p. 100251H.
[475] J. Verkouteren, J. Lawerence, T. Brewer, E. Sisco, New particle-based trace explosive test material produced by drop-on-demand inkjet printing for quantitative wipe-sampling studies, Anal. Methods 9 (23) (2017) 3441–3449.
[476] D. Videira-Quintela, F. Zapata, C. Garcia-Ruiz, Detection of microscopic traces of explosive residues on textile fabrics by Raman spectroscopy, J. Raman Spectrosc. 49 (10) (2018) 1668–1677.
[477] K. Willets, K. Mayer, Surface-enhanced Raman scattering (SERS) as a characterization method for metal-organic interactions, in: O. Ostroverkhova (Ed.), Handbook of Organic Materials for Electronic and Photonic Devices, Woodhead Publishing, Sawston, United Kingdom, 2019, pp. 551–577.
[478] C. Xiao, Z. Checn, M. Qin, D. Zhang, L. Fan, Composite sinusoidal nanograting with long-range SERS effect for label-free TNT detection, Photonic Sensors 8 (3) (2018) 278–288.
[479] F. Zapata, C. Garcia-Ruiz, The discrimination of 72 nitrate, chlorate and perchlorate salts using IR and Raman spectroscopy, Spectrochim. Acta Mol. Biomol. Spectrosc. 189 (2018) 535–542.

DSC, Thermal Analysis, TG

[481] K. Bonnot, L. Schlur, D. Spitzer, Investigation of the co-identification of hexogen and pentrite as particles and co-adsorbed on copper oxide nanoparticles by using nanocalorimetry, Anal. Methods 8 (40) (2016) 7306–7311.
[482] M. Chen, M. Zikry, M. Steer, Microwave excitation of crystalline energetic

composites, IEEE Access 6 (2018) 24596–24605.
[483] H. Dong, W. Zan, T. Hong, X. Zhang, Numerical simulation of deflagration to detonation transition in granular HMX explosives under thermal ignition, J. Therm. Anal. Calorim. 127 (1) (2017) 975–981.
[484] J. Dong, Q. Yan, P. Liu, W. He, X. Qi, S. Zeman, The correlations among detonation velocity, heat of combustion, thermal stability and decomposition kinetics of nitric esters, J. Therm. Anal. Calorim. 131 (2) (2018) 1391–1403.
[485] M. Kohga, S. Handa, Thermal decomposition behaviors and burning characteristics of composite propellants prepared using combined ammonium perchlorate/ammonium nitrate particles, J. Energetic Mater. 36 (1) (2018) 93–110.
[486] X. Li, Y. Qin, L. Zhu, B. Wang, Investigation on compatibility and thermal stability of CL-20 with several plasticizers, Int. J. Energ. Mater. Chem. Propuls. 17 (1) (2018) 359–366.
[487] A. Pivkina, N. Muravyev, K. Monogarov, V. Ostrovsky, I. Fomenkov, Y. Milyokhin, et al., Synergistic effect of ammonium perchlorate on HMX: from thermal analysis to combustion, in: Chemical Rocket Propulsion, Springer International Publishing, 2017, pp. 365–381.
[488] A.S. Rossi, Metal Oxide Catalysts for the Detection of Explosives: Methodology and Mechanism, Master's thesis. University of Rhode Island, 2018.
[489] A. Singh, T. Sharma, M. Kumar, J. Narang, P. Kishore, A. Srivastava, Thermal decomposition and kinetics of plastic bonded explosives based on mixture of HMX and TATB with polymer matrices, Defence Technol 13 (1) (2017) 22–32.
[490] A. Singh, S. Singh, T. Sharma, P. Kishore, Physicochemical properties and kinetic analysis for some fluoropolymers by differential scanning calorimetry, Polym. Bull. 75 (6) (2017) 2315–2338.
[491] L. Tan, D. Liu, Q. Wu, S. Xu, Effect of potassium chloride on thermal stability of ammonium nitrate under acidic conditions, J. Therm. Anal. Calorim. 131 (3) (2018) 2719–2728.
[492] G. Wang, Y. Wang, Q. Wen, L. Yan, Numerical study of countermeasure against thermal stimuli for HMX-based polymer-bonded explosives, J. Energetic Mater. 36 (4) (2018) 435–453.
[493] K. Wang, J. Wang, W. Wang, D. Liu, Research on the thermal decomposition kinetics and the isothermal stability of HMX, J. Therm. Anal. Calorim. 135 (4) (2019) 2513–2518.
[494] Q. Wu, L. Tan, S. Xu, D. Liu, L. Min, Study on thermal decomposition characteristics of ammonium nitrate emulsion explosive in different scales, J. Energetic Mater. 36 (2) (2018) 202–210.
[495] M. Yang, X. Chen, B. Yuan, Y. Wang, A. Rangwala, H. Cao, Y. Niu, Y. Zhang, A. Fan, S. Yin, Inhibition effect of ammonium dihydrogen phosphate on the thermal decomposition characteristics and thermal sensitivity of ammonium nitrate, J. Anal. Appl. Pyrol. 134 (2018) 195–201.
[496] D. Ze, C. Yingying, C. Liping, C. Wanghua, Z. Jun, X. Beibei, Evaluation of isothermal kinetics of the thermal decomposition of guanidine nitrate in constant volume, J. Energetic Mater. 36 (4) (2018) 412–423.
[497] C. Zhang, S. Jin, J. Ji, F. Bao, G. Zhang, Q. Shu, Thermal hazard assessment of TNT and DNAN under adiabatic condition by using accelerating rate calorimeter (ARC), J. Therm. Anal. Calorim. 131 (1) (2018) 89–93.
[498] J. Zhang, X. Guo, Q. Jiao, H. Zhang, H. Li, Analysis of the thermal behaviour of CL-20, potassium perchlorate, lithium perchlorate and their admixtures by DSC and TG, Cent. Eur. J. Energy. Mater 15 (1) (2017) 115–130.
[499] A. Zuck, S. Kendler, Visual study of explosive particles during fast thermal analysis, Sensor Actuator Phys. 283 (2018) 330–339.

Nanotechnology

[500] X. Bai, S. Xu, G. Hu, L. Wang, Surface plasmon resonance-enhanced photothermal nanosensor for sensitive and selective visual detection of 2,4,6-trinitrotoluene, Sensor. Actuator. B Chem. 237 (2016) 224–229.
[501] P. Bairagi, G. Gupta, N. Verma, Fe-enriched clay-coated and reduced graphene oxide-modified N-doped polymer nanocomposite: a natural recognition element-based sensing electrode for DNT, Electroanalysis 31 (3) (2018) 535–544.
[502] L. Bastatas, E. Echeverria-Mora, P. Wagle, P. Mainali, A. Austin, D. Mcllroy, Emergent electrical properties of ensembles of 1D nanostructures and its impact on room temperature electrical sensing of ammonium nitrate vapor, ACS Sens. 3 (11) (2018) 2367–2374.
[503] M. Bharati, C. Byram, V. Soma, Femtosecond laser fabricated Ag@Au and Cu@Au alloy nanoparticles for surface enhanced Raman spectroscopy based trace explosives detection, Front. Phys 6 (2018).
[504] J. Boken, P. Khurana, S. Thatai, D. Kumar, S. Prasad, Plasmonic nanoparticles and their analytical applications: a review, Appl. Spectrosc. Rev. 52 (9) (2017) 774–820.
[505] M. Burton, B. Gorbunov, NMT – a new individual ion counting method: comparison to a Faraday cup, Chem. Phys. 502 (2018) 60–65.
[506] C. Byram, S.S.B. Moram, V.R. Soma, Gold-silver nanostructures prepared by femtosecond ablation for picric acid detection, in: 13th International Conference on Fiber Optics and Photonics, *Optical Society of America Technical Digest* (online), 2016. Tu4A-44.
[507] R. Chandiramouli, Antimonene nanosheet device for detection of explosive vapors – a first-principles inspection, Chem. Phys. Lett. 708 (2018) 130–137.
[508] S. Chaudhary, A. Umar, K. Bhasin, S. Baskoutas, Chemical sensing applications of ZnO nanomaterials, Materials 11 (287) (2018) 1–38, 1996-1944.
[509] Z. Chen, Z. Tao, S. Cong, J. Hou, D. Zhang, F. Geng, Z. Zhao, Fast preparation of ultrafine monolayered transition-metal dichalcogenide quantum dots using electrochemical shock for explosive detection, Chem. Commun. 52 (76) (2016) 11442–11445.
[510] E. De Geer, Detection of Gunshot Residue and Explosives Using Hybrid Graphene Quantum Dot Based Sensors (2017). Master's Thesis, Lund University, 2017.
[511] S. Elbasuney, Novel colloidal molybdenum hydrogen bronze (MHB) for instant detection and neutralization of hazardous peroxides, Trac. Trends Anal. Chem. 102 (2018) 272–279.
[512] M. Eslami, N. Alizadeh, Ultrasensitive and selective QCM sensor for detection of trace amounts of nitroexplosive vapors in ambient air based on polypyrrole—bromophenol blue nanostructure, Sensor. Actuator. B Chem. 278 (2019) 55–63.
[513] E.P. Fahrenthold, J. Zhang, Simulation for explosive sensing materials design, in: 58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, AIAA SciTech Forum, 2017, p. 1364.
[514] M. Faraz, M. Shakir, N. Khare, Highly sensitive and selective detection of picric acid using one pot biomolecule inspired polyindole/CdS nanocomposite, New J. Chem. 41 (2017) 5784–5793.
[515] B. Firtat, C. Moldovan, C. Brasoveanu, G. Muscalu, M. Gartner, M. Zaharescu, I. Stan, Miniaturised MOX based sensors for pollutant and explosive gases detection, Sensor. Actuator. B Chem. 249 (2017) 647–655.
[516] B. Gao, Z. Qiao, G. Yang, Review on nanoexplosive materials, in: Q. Yan, G. He, P. Liu, M. Gozin (Eds.), Nanomaterials in Rocket Propulsion Systems, Elsevier, 2019, pp. 31–79.
[517] Y. Ge, Z. Wei, Y. Li, J. Qu, B. Zu, X. Dou, Highly sensitive and rapid chemiresistive sensor towards trace nitro-explosive vapors based on oxygen vacancy-rich and defective crystallized In-doped ZnO, Sensor. Actuator. B Chem. 244 (2017) 983–991.
[518] L. Guo, Z. Yang, X. Dou, Artificial olfactory system for trace identification of explosive vapors realized by optoelectronic Schottky sensing, Adv. Mater. 29 (5) (2017) 1604528.
[519] S. Guthe, R. Mudhalwadkar, Thin film sensors for nitro aromatic explosive detection, Mater. Today: Proceedings 4 (9) (2017) 10324–10327.
[520] Y. He, Y. Cheng, A visual assay and spectrophotometric determination of LLM-105 explosive using detection of gold nanoparticle aggregation at two pH values, Anal. Bioanal. Chem. 408 (20) (2016) 5551–5556.
[521] J. Hu, C. Wang, R. Liu, Y. Su, Y. Lv, Poly(thymine)-CuNPs: bimodal methodology for accurate and selective detection of TNT at sub-PPT levels, Anal. Chem. 90 (24) (2018) 14469–14474.
[522] D. Jiang, X. Yang, X. Zheng, L. Bo, T. Zhu, H. Chen, L. Zhang, S. Huang, Self-assembly of luminescent 12-metal Zn–Ln planar nanoclusters with sensing properties towards nitro explosives, J. Mater. Chem. C 6 (31) (2018) 8513–8521.
[523] S. Kaur, A. Kumar, J. Rajput, P. Arora, H. Singh, SnO2—glycine functionalized carbon nanotubes based electronic nose for detection of explosive materials, Sens. Lett. 14 (7) (2016) 733–739.
[524] J. Kim, M. Cho, K. Kim, S. Kim, Laser ignition and controlled explosion of nanoenergetic materials: the role of multi-walled carbon nanotubes, Carbon 118 (2017) 268–277.
[525] M. Koudehi, S. Pourmortazavi, Synthesis and application of carbowax/polypyrrole nanocomposite for fabrication of electrochemical sensor to detect 2, 4-DNT vapor, Mater. Res. Express 4 (8) (2017), 086303.
[526] G. Kubas, Detection of PETN Using Peptide Based Biologically Modified Carbon Nanotubes, Doctoral Dissertation, Youngstown State University, 2017.
[527] G. LeCroy, K. Fernando, C. Bunker, P. Wang, N. Tomlinson, Y.-P. Sun, Steady-state and time-resolved fluorescence studies on interactions of carbon "quantum" dots with nitrotoluenes, Inorg. Chim. Acta. 468 (2017) 300–307.
[528] D. Lee, S. Choi, Y.T. Byun, Room temperature monitoring of hydrogen peroxide vapor using platinum nanoparticles-decorated single-walled carbon nanotube networks, Sensor. Actuator. B Chem. 256 (2018) 744–750.
[529] Y. Li, X. Jia, L. Wang, B. Zhou, R. Shen, Research on the electro-explosive behaviors and the ignition performances of energetic igniters, J. Energetic Mater. 36 (1) (2018) 1–12.
[530] H. Ma, F. Li, Y. Zhang, X. Li, T. Li, F. Shen, M. Zhang, Supramolecular self-assembly carbazolyl radicals nanospheres triggered by ultraviolet light for explosives sensing, Talanta 160 (2016) 133–137.
[531] S.S.B. Moram, C. Byram, S.N. Shibu, B.M. Chilukamarri, V.R. Soma, Ag/Au nanoparticle-loaded paper-based versatile surface-enhanced Raman spectroscopy substrates for multiple explosives detection, ACS Omega 3 (7) (2018) 8190–8201.
[532] M. Moronshing, C. Subramaniam, Room temperature, multiphasic detection of explosives, and volatile organic compounds using thermodiffusion driven soret colloids, ACS Sustain. Chem. Eng. 6 (7) (2018) 9470–9479.
[533] V. Nagarajan, R. Chandiramouli, Investigation on probing explosive nitroaromatic compound vapors using graphyne nanosheet: a first-principle study, Struct. Chem. 30 (3) (2018) 657–667.
[534] R. Norman, Simultaneous Detection of Multiple Explosives Using Surface Enhanced Raman Scattering, Doctoral Dissertation, University of Strathclyde, 2016.
[535] H. Pandas, M. Fazli, Preparation and application of La2O3 and CuO nano particles as catalysts for ammonium perchlorate thermal decomposition,

Propellants, Explos. Pyrotech. 43 (11) (2018) 1096–1104.
[536] A. Pandya, R. Shukla, New perspective of nanotechnology: role in preventive forensic, Egypt. J. Food Sci. 8 (1) (2018) 57–68.
[537] W. Peveler, S. Jaber, I. Parkin, Nanoparticles in explosives detection – the state-of-the-art and future directions, Forensic Sci. Med. Pathol. 13 (4) (2017) 490–494.
[538] V. Pichot, A. Seve, J. Berthe, F. Schnell, D. Spitzer, Study of the elaboration of HMX and HMX composites by the spray flash evaporation process, Propellants, Explos. Pyrotech. 42 (12) (2017) 1418–1423, https://doi.org/10.1002/prep.201700171.
[539] J. Qian, M. Hua, C. Wang, K. Wang, Q. Liu, N. Hao, K. Wang, Fabrication of l -cysteine-capped CdTe quantum dots based ratiometric fluorescence nanosensor for onsite visual determination of trace TNT explosive, Anal. Chim. Acta 946 (2016) 80–87.
[540] Ş. Sağlam, A. Üzer, E. Erçağ, R. Apak, Electrochemical determination of TNT, DNT, RDX, and HMX with gold nanoparticles/poly(carbazole-aniline) film–modified glassy carbon sensor electrodes imprinted for molecular recognition of nitroaromatics and nitramines, Anal. Chem. 90 (12) (2018) 7364–7370.
[541] F. Shahdost-fard, M. Roushani, Impedimetric detection of trinitrotoluene by using a glassy carbon electrode modified with a gold nanoparticle@ fullerene composite and an aptamer-imprinted polydopamine, Microchimica Acta 184 (10) (2017) 3997–4006.
[542] B. Shin, H. Sohn, Enhanced explosive sensing based on bis(methyltetraphenyl)silole nanoaggregate, J. Kor. Phys. Soc. 72 (2) (2018) 234–237.
[543] S. Singh, V. Meena, B. Mizaikoff, S. Singh, C. Suri, Electrochemical sensing of nitro-aromatic explosive compounds using silver nanoparticles modified electrochips, Anal. Methods 8 (39) (2016) 7158–7169.
[544] D. Singha, P. Mahata, Coordination polymer derived nano-sized zinc ferrite with excellent performance in nitro-explosives detection, Dalton Trans. 46 (34) (2017) 11344–11354.
[545] B. Soundiraraju, B. George, Two-dimensional Titanium Nitride (Ti2N) MXene: synthesis, characterization, and potential application as surface-enhanced Raman scattering substrate, ACS Nano 11 (9) (2017) 8892–8900.
[546] V. Srinivasan, M.A. Jhonsi, M. Kathiresan, A. Kathiravan, Nanostructured graphene oxide dots: synthesis, characterization, photoinduced electron transfer studies, and detection of explosives/biomolecules, ACS Omega 3 (8) (2018) 9096–9104.
[547] D. Tomeček, P. Fitl, E. Marešová, J. Vlček, J. Hofmann, M. Vrňata, Silver phthalocyanine thin films carrying gold, palladium and silver nanoparticles for detection of taggants in explosives, Thin Solid Films 630 (2017) 31–37.
[548] N. Ular, A. Uzer, S. Durmazel, E. Ercag, R. Apak, Diaminocyclohexane-Functionalized/Thioglycolic acid-modified gold nanoparticle-based colorimetric sensing of Trinitrotoluene and Tetryl, ACS Sens. 3 (11) (2018) 2335–2342.
[549] J. Wang, Near infrared optical biosensor based on peptide functionalized single-walled carbon nanotubes hybrids for 2,4,6-trinitrotoluene (TNT) explosive detection, Anal. Biochem. 550 (2018) 49–53.
[550] Z. Wu, H. Duan, Z. Li, J. Guo, F. Zhong, Y. Cao, D. Jia, Multichannel discriminative detection of explosive vapors with an array of nanofibrous membranes loaded with quantum dots, Sensors 17 (11) (2017) 2676–2689.
[551] K. Xiang, Y. Li, C. Xu, S. Li, POSS-based organic–inorganic hybrid nanomaterials: aggregation-enhanced emission, and highly sensitive and selective detection of nitroaromatic explosives in aqueous media, J. Mater. Chem. C (2016) 5578–5583.
[552] W. Xiong, Q. Zhu, Y. Gong, C. Wang, Y. Che, J. Zhao, Interpenetrated binary supramolecular nanofibers for sensitive fluorescence detection of six classes of explosives, Anal. Chem. 90 (7) (2018) 4273–4276.
[553] S. Yang, X. Sun, Y. Chen, A novel fluorescence enhancement probe based on L-cystine modified copper nanoclusters for the detection of 2,4,6-trinitrotoluene, Mater. Lett. 194 (2017) 5–8.
[554] T. Yang, R. Yu, H. Chen, R. Yang, S. Wang, X. Luo, K. Jiao, Electrochemical preparation of thin-layered molybdenum disulfide-poly (m-aminobenzenesulfonic acid) nanocomposite for TNT detection, J. Electroanal. Chem. 781 (2016) 70–75.
[555] W. Zeng, D. Manoj, H. Sun, R. Yi, X. Huang, Y. Sun, One-pot synthesis of high-density Pd nanoflowers decorated 3D carbon nanotube-graphene network modified on printed electrode as portable electrochemical sensing platform for sensitive detection of nitroaromatic explosives, J. Electroanal. Chem. 833 (2019) 527–535.
[556] R. Zhang, C. Zhang, F. Zheng, X. Li, C. Sun, W. Chen, Nitrogen and sulfur co-doped graphene nanoribbons: a novel metal-free catalyst for high performance electrochemical detection of 2, 4, 6-trinitrotoluene (TNT), Carbon 126 (2018) 328–337.
[557] P. Zhao, Y. Wu, C. Feng, L. Wang, Y. Ding, A. Hu, Conjugated polymer nanoparticles based fluorescent electronic nose for the identification of volatile compounds, Anal. Chem. 90 (7) (2018) 4815–4822.
[558] C. Zhou, Z. Wu, Y. Guo, Y. Li, H. Cao, X. Zheng, et al., Ultrasensitive, real-time and discriminative detection of Improvised explosives by chemiresistive thin-film sensory array of Mn2+ tailored hierarchical ZnS, Sci. Rep. 6 (2016) 25588.
[559] H. Zhou, X. Wang, T. Lin, J. Song, B. Tang, J. Xu, Poly (triphenyl ethene) and poly (tetraphenyl ethene): synthesis, aggregation-induced emission property and application as paper sensors for effective nitro-compounds detection, Polym. Chem. 7 (41) (2016) 6309–6317.

Detection

[560] A. AL-Mousawi, H.K. AL-Hassani, A survey in wireless sensor network for explosives detection, Comput. Electr. Eng. 72 (2017) 682–701.
[561] C. Ambard, N. Duée, F. Pereira, D. Portehault, C. Méthivier, C. Pradier, C. Sanchez, Improvements in photostability and sensing properties of EuVO4 nanoparticles by microwave-assisted sol–gel route for detection of H2O2 vapors, J. Sol. Gel Sci. Technol. 79 (2) (2016) 381–388.
[562] R. Aparna, J. Anjali Devi, P. Sachidanandan, S. George, Polyethylene imine capped copper nanoclusters-fluorescent and colorimetric onsite sensor for the trace level detection of TNT, Sensor. Actuator. B Chem. 254 (2018) 811–819.
[563] P. Balaz, M. Balaz, M. Sayagues, A. Eliyas, N. Kostova, M. Kannuchova, E. Dutkova, A. Zorkovska, Chalcogenide quaternary Cu2FeSnS4 nanocrystals for solar cells: explosive character of mechanochemical synthesis and environmental challenge, Crystals 7 (12) (2017) 367.
[564] Bbc News, Businessman Gary Bolton Jailed over Fake Bomb Detectors, BBC News, 2013.
[565] Bbc News, Gary Bolton Guilty of Selling Fake Bomb Detectors, BBC News, 2013.
[566] Blue, R., Thomson, N., Taylor, S., Fletcher, A., Skabara, P., and Uttamchandani, D. Miniature nitro and peroxide vapor sensors using nanoporous thin films. IEEE Sensor. J., 16(24), pp. 8767-8774.
[567] N. Bolse, A. Habermehl, C. Eschenbaum, U. Lemmer, Fluorescence quenching sensor arrays for the discrimination of nitroaromatic vapors, in: Y. Albastaki, F. Albalooshi (Eds.), Electronic Nose Technologies and Advances in Machine Olfaction, IGI Global, Hershey, PA, 2018, pp. 58–93.
[568] X. Cao, N. Zhao, H. Lv, Q. Ding, A. Gao, Q. Jing, T. Yi, Strong blue emissive supramolecular self-assembly system based on naphthalimide derivatives and its ability of detection and removal of 2, 4, 6-trinitrophenol, Langmuir 33 (31) (2017) 7788–7798.
[569] K. Chabaud, J. Thomas, M. Torres, S. Oliveria, B. McCord, Simultaneous colorimetric detection of metallic salts contained in low explosives residue using a microfluidic paper-based analytical device (μPAD), Forensic. Chem 9 (2018) 35–41.
[570] C. Chakravarty, B. Mandal, P. Sarkar, Multifunctionalities of an azine-linked covalent organic framework: from nanoelectronics to nitroexplosive detection and conductance switching, J. Phys. Chem. C 6 (2018) 3245–3255.
[571] S. Chakravarty, N. Bhardwaj, B. Mandal, N. Sarma, Silk fibroin–carbon nanoparticle composite scaffolds: a cost effective supramolecular 'turn off'-chemiresistor for nitroaromatic explosive vapours, J. Mater. Chem. C 4 (38) (2016) 8920–8929.
[572] J. Chen, Y. Shi, M. Zhang, J. Zhan, Diethyldithiocarbamate (DDTC) induced formation of positively charged silver nanoparticles for rapid in situ identification of inorganic explosives by surface enhanced Raman spectroscopy, RSC Adv. 6 (57) (2016) 51823–51829.
[573] A. Chowdhury, P. Howlader, P. Mukherjee, Aggregation-induced emission of platinum (II) metallacycles and their ability to detect nitroaromatics, Chem–A Eur. J 22 (22) (2016) 7468–7478.
[574] M. Deenadayalan, N. Sharma, P. Verma, C. Nagaraja, Visible-light-Assisted photocatalytic reduction of nitroaromatics by recyclable Ni (II)-Porphyrin metal–organic framework (MOF) at RT, Inorg. Chem. 55 (11) (2016) 5320–5327.
[575] W. Dong, T. Fei, U. Scherf, Conjugated polymers containing tetraphenylethylene in the backbones and side-chains for highly sensitive TNT detection, RSC Adv. 8 (11) (2018) 5760–5767.
[576] J. Essner, X. Chen, T. Wood, G. Baker, Tandem copper and gold nanoclusters for two-color ratiometric explosives detection, Analyst 143 (5) (2018) 1036–1041.
[577] R. Fu, S. Hu, X. Wu, Rapid and sensitive detection of nitroaromatic explosives by using new 3D lanthanide phosphonates, J. Mater. Chem. 5 (2017) 1952–1956.
[578] J. Garica-Calvo, P. Calvo-Gredillia, M. Ibanez-Llorente, D. Romero, J. Cuevas, G. Garcia-Herbosa, M. Avella, T. Torroba, Surface functionalized silica nanoparticles for the off–on fluorogenic detection of an improvised explosive, TATP, in a vapour flow, J. Mater. Chem. 6 (10) (2018) 4416–4423.
[579] A. Ghoorchian, N. Alizadeh, Research Paper: chemiresistor gas sensor based on sulfonated dye-doped modified conducting polypyrrole film for high sensitive detection of 2,4,6-trinitrotoluene in air, Sensor. Actuator. B Chem. 255 (1) (2018) 826–838.
[580] D. Ghosh, U. Dutta, A. Haque, N. Mordvinova, O. Lebedev, K. Pal, A. Gayen, M. Seikh, P. Mahata, Ultra-high sensitivity of luminescent ZnCr2O4 nanoparticles toward nitroaromatic explosives sensing, Dalton Trans. 47 (14) (2018) 5011–5018.
[581] R. Gillander, J. Glackin, I. Campbell, I. Samuel, G. Turnbull, Advances in optical sensing of explosive vapours, in: Proceedings of the 6th International Conference on Phtotonics Optics and Laser Technology (PHOTOPTICS 2018, 2018, pp. 323–327.
[582] N. Goel, N. Kumar, A dual-functional luminescent Tb(iii) metal–organic framework for the selective sensing of acetone and TNP in water, RSC Adv. 8 (20) (2018) 10746–10755.
[583] H. Hao, Y. Wang, S. Yuan, D. Chen, D. Li, J. Dou, Two Zn(II)-based metal-organic frameworks for selective detection of nitroaromatic explosives and Fe3+ ion, Inorg. Chem. Commun. 98 (2018) 120–126.

[584] C. Hawley, M. Jones, Government Statement on 'bomb Detectors' Export Ban, BBC News, 2010.
[585] W. Huang, E. Smarsly, J. Han, M. Bender, K. Seehafer, I. Wacker, R. Schroder, U. Bunz, Truxene-based hyperbranched conjugated polymers: fluorescent micelles detect explosives in water, ACS Appl. Mater. Interfaces 9 (3) (2017) 3068–3074.
[586] M. Hussain, A. Nafady, S. Sherazi, M. Shah, A. Alsalme, M. Kalhoro, S. Siddiqui, et al., Cefuroxime derived copper nanoparticles and their application as a colorimetric sensor for trace level detection of picric acid, RSC Adv. 6 (86) (2016) 82882–82889.
[587] N. Idros, M. Ho, V. Kamboj, H. Xu, Z. Gu, H. Beere, D. Ritchie, D. Chu, Using transmissive photonic band edge shift to detect explosives: a study with 2,4,6-trinitrotoluene (TNT), ACS Photonics 4 (2) (2017) 384–395.
[588] T. Kaneta, W. Alahmad, P. Varanusupakul, Microfluidic paper-based analytical devices with instrument-free detection and miniaturized portable detectors, Appl. Spectrosc. Rev. 54 (2) (2018) 117–141.
[589] S. Khanniche, D. Mathieu, F. Pereira, C. Frenois, D. Colin, C. Barthet, et al., Quantitative evaluation of the responses of a gravimetric gas sensor based on mesoporous functionalized silica: application to 2, 4-DNT and TNT detection, Sensor. Actuator. B Chem. 248 (2017) 470–480.
[590] K. Konstantynovski, G. Njio, F. Borner, A. Lepacha, T. Fischer, G. Holl, S. Mathur, Bulk detection of explosives and development of customized metal oxide semiconductor gas sensors for the identification of energetic materials, Sensor. Actuator. B Chem. 258 (2018) 1252–1266.
[591] M. Koudehi, S. Pourmortazavi, Polyvinyl Alcohol/Polypyrrole/Molecularly imprinted polymer nanocomposite as highly selective chemiresistor sensor for 2,4-DNT vapor recognition, Electroanalysis 30 (10) (2018) 2302–2310.
[592] D. Kumar, D. Ghai, R. Soni, Ultrasonic photoacoustic spectroscopy of trace hazardous chemicals using quantum cascade laser, Optic Commun. 381 (2016) 271–276.
[593] K. Kunduru, A. Basu, E. Abtew, T. Tsach, A. Domb, Polymeric sensors containing P-dimethylaminocinnamaldehyde: colorimetric detection of urea nitrate, Sensor. Actuator. B Chem. 238 (2017) 387–391.
[594] B. Li, J. Wu, J. Liu, C. Gu, J. Xu, M. Luo, S. Batten, et al., A luminescent zinc (II) metal–organic framework for selective detection of nitroaromatics, Fe3+ and CrO42−: a versatile threefold fluorescent sensor, ChemPlusChem 81 (8) (2016) 885–892.
[595] D. Li, X. Yu, Mesoporous aluminium organophosphonates: a reusable chemsensor for the detection of explosives, J. Solid State Chem. 239 (2016) 17–22.
[596] Q. Li, Z. Ma, W. Zhang, J. Xu, W. Wei, H. Lu, X. Wang, et al., AIE-active tetraphenylethene functionalized metal–organic framework for selective detection of nitroaromatic explosives and organic photocatalysis, Chem. Commun. 52 (75) (2016) 11284–11287.
[597] X. Lin, J. Niu, J. Lin, L. Hu, G. Zhang, Y. Cai, A luminescent Tb (III)-MOF based on pyridine-3, 5-dicarboxylic acid for detection of nitroaromatic explosives, Inorg. Chem. Commun. 72 (2016) 69–72.
[598] M. Liu, B. Chen, Z. Liu, C. Huang, Highly selective and sensitive detection of 2, 4, 6-trinitrophenol by using newly developed blue–green photoluminescent carbon nanodots, Talanta 161 (2016) 875–880.
[599] X. Liu, C. Tao, B. Chen, Z. Liu, G. Zhu, Z. Zhao, L. Shen, B.Z. Tang, A new luminescent metal–organic framework based on dicarboxyl-substituted tetraphenylethene for efficient detection of nitro-containing explosives and antibiotics in aqueous media, J. Mater. Chem. C 6 (12) (2018) 2983–2988.
[600] N. López-Ruiz, M. Erenas, I. de Orbe-Payá, L. Capitán-Vallvey, A. Palma, A. Martínez-Olmos, Computer vision-based portable system for nitroaromatics discrimination, J. Sens (2016) 1–10, 2016.
[601] M. Lu, P. Zhou, Y. Ma, Z. Tang, Y. Yang, K. Han, Reconsideration of the detection and fluorescence mechanism of a pyrene-based chemosensor for TNT, J. Phys. Chem. 122 (5) (2018) 1400–1405.
[602] W. Lu, S. Asher, Z. Meng, Z. Yan, M. Xue, L. Qiu, D. Yi, October). Visual detection of 2,4,6-trinitrotolune by molecularly imprinted colloidal array photonic crystal, J. Hazard Mater. 316 (2016) 87–93.
[603] B. Ma, J. Xu, H. Qi, J. Sun, J. Chai, J. Jia, S. Jing, Y. Fan, L. Wang, Two 3D metal–organic frameworks as multi-functional materials to detect Fe3+ ions and nitroaromatic explosives and to encapsulate Ln3+ ions for white-light emission, J. Solid State Chem. 258 (2018) 42–48.
[604] H. Ma, F. Li, L. Yao, Y. Feng, Z. Zhang, M. Zhang, Dual-emissive electropolymerization films for the ratiometric fluorescence detection of TNT and TNP with high sensitivity and selectivity, Sensor. Actuator. B Chem. 259 (2018) 380–386.
[605] C. Madhu, B. Roy, P. Makan, T. Govindaraju, Bicomponent β-sheet assembly of dipeptide fluorophores of opposite polarity and sensitive detection of nitro-explosives, Chem. Commun. 54 (18) (2018) 2280–2283.
[606] S. Masoumi, S. Masoumi, H. Hajghassem, H. Hajghassem, A. Erfanian, A. Erfanian, A. Molaei Rad, et al., Design and manufacture of TNT explosives detector sensors based on CNTFET, Sens. Rev. 36 (4) (2016) 414–420.
[607] W. Mochan, A. Ramirez-Solis, How a drug and explosives detector proved useless: military use of the GT200, IEEE Technol. Soc. Mag. 36 (2) (2017) 76–82.
[608] S. Mondal, P. Bairi, S. Das, A. Nandi, Triarylamine-cored dendritic molecular gel for efficient colorometric, fluorometric, and impedometeric detection of picric acid, Chem. Eur J. 24 (21) (2018) 5591–5600.
[609] Y. Mu, Y. Ran, J. Du, X. Wu, W. Nie, J. Zhang, Y. Zhao, H. Liu, A fluorescent lanthanide-organic framework for highly sensitive detection of nitroaromatic explosives, Polyhedron 124 (2017) 125–130.
[610] T. Myers, C. Snyder, D. Chavez, R. Scharff, J. Veauthier, Synthesis and electrochemical behavior of electron-rich s-tetrazine and triazolo-tetrazine nitrate esters, Chem-A Eur. J 22 (30) (2016) 10590–10596.
[611] B. Necioglu, W. Su, J. Rhodes, S. O'Donnell, M. Taczak, S. Guharay, Algorithm-aided performance enhancement of a trace explosives sensor, Sensor. Actuator. B Chem. 259 (2018) 935–944.
[612] T. Ozturk, Classification of measured unsafe liquids using microwave spectroscopy system by multivariate data analysis techniques, J. Hazard Mater. 363 (2019) 309–315.
[613] S. Pan, L. Wang, X. Chen, Y. Tang, Y. Chen, Y. Sun, X. Yang, P. Wan, June) Enhanced electrochemical sensing of nitroaromatic compounds based on hydroxyl modified carbon submicroparticles, Electrochim. Acta 203 (2016) 301–308.
[614] X. Peng, H. Liu, A. Liu, W. Xu, Y. Fu, Q. He, H. Cao, J. Cheng, Ultrasensitive and direct fluorescence detection of RDX explosive vapor via side-chain terminal functionalization of a polyfluorene probe, Anal. Methods 10 (15) (2018) 1695–1702.
[615] Z. Qin, W. Dong, J. Zhao, Y. Wu, Q. Zhang, D. Li, A water-stable Tb(iii)-based metal–organic gel (MOG) for detection of antibiotics and explosives, Inorg. Chem. Front 5 (1) (2018) 120–126.
[616] X. Ran, Q. Qu, X. Qian, W. Xie, S. Li, L. Li, L. Yang, Water-soluble pillar[6]arene functionalized nitrogen-doped carbon quantum dots with excellent supramolecular recognition capability and superior electrochemical sensing performance towards TNT, Sensor. Actuator. B Chem. 257 (2018) 362–371.
[617] A. Räupke, A. Palma-Cando, E. Shkura, P. Teckhausen, A. Polywka, P. Görrn, T. Riedl, et al., Highly sensitive gas-phase explosive detection by luminescent microporous polymer networks, Sci. Rep. 6 (2016) 29118.
[618] K. Reddy, A. Kumar, A. Dhir, V. Krishnan, Selective and sensitive fluorescent detection of picric acid by new pyrene and anthracene based copper complexes, J. Fluoresc. 26 (6) (2016) 2041–2046.
[619] A. Roucou, I. Kleiner, M. Goubet, S. Bteich, G. Mouret, R. Bocquet, F. Hindle, W.L. Meerts, A. Cuisset, Towards the detection of explosive taggants: microwave and millimetre-wave gas-phase spectroscopies of 3-nitrotoluene, Chemphschem 9 (19) (2018) 1056–1067.
[620] J. Sahoo, S. Waghmode, P. Subramanian, M. Albrecht, Specific detection of picric acid and nitrite in aqueous medium using flexible Eu (III)-Based luminescent probe, Chemistry 1 (9) (2016) 1943–1948.
[621] V. Sathish, A. Ramdass, K. Lu, P. Thanasekaran, S. Rajagopal, Development of luminescent sensors based on transition metal complexes for the detection of nitroexplosives, Dalton Trans: Int. J. Integrated Care 46 (48) (2017) 16738–16769.
[622] J. Seman, C. Johnson, C. Giraldo, Holmium and samarium detectability in post-blast residue, AIP Con. Proc 1979 (1) (2018) 150034.
[623] V. Sharma, D. De, S. Pal, P. Saha, P. Bharadwaj, A 2D coordination network hat detects nitro explosives in water, catalyzes baylis–hillman reactions, and undergoes unusual 2D→ 3D single-crystal to single-crystal transformation, Inorg. Chem. 56 (15) (2017) 8847–8855.
[624] P. Shaw, P. Burn, Real-time fluorescence quenching-based detection of nitro-containing explosive vapours: what are the key processes? Phys. Chem. Chem. Phys. 19 (44) (2017) 29714–29730.
[625] S. Shoaee, S. Chen, H. Cavaye, A. Smith, P. Burn, I. Gentle, P. Shaw, et al., Assessing the sensing limits of fluorescent dendrimer thin films for the detection of explosive vapors, Sensor. Actuator. B Chem. 239 (2017) 727–733.
[626] R. Sun, X. Huo, H. Lu, S. Feng, D. Wang, H. Liu, Recyclable fluorescent paper sensor for visual detection of nitroaromatic explosives, Sensor. Actuator. B Chem. 265 (2018) 476–487.
[627] S. Surya, S. Smaji, P. Dhamini, B. Ganne, P. Sonar, V. Rao, A spectroscopy and microscopy study of parylene-C OFETs FOR Explsoive Sensing, IEEE Sensor. J. 18 (4) (2018) 1364–1372.
[628] S. Tang, N. Vinerot, D. Fisher, V. Bulatov, Y. Yavetz-Chen, I. Schechter, Detection and mapping of trace explosives on surfaces under ambient conditions using multiphoton electron extraction spectroscopy (MEES), Talanta 155 (2016, August)) 235–244.
[629] A. Tanwar, S. Hussain, A. Malik, M. Afroz, P. Iyer, Inner filter effect based selective detection of nitroexplosive-picric acid in aqueous solution and solid support using conjugated polymer, ACS Sens. 1 (8) (2016) 1070–1077.
[630] X. Tian, H. Peng, Y. Li, C. Yang, Z. Zhou, Y. Wang, Highly sensitive and selective paper sensor based on carbon quantum dots for visual detection of TNT residues in groundwater, Sensor. Actuator. B Chem. 243 (2017) 1002–1009.
[631] S. Trammell, S. Hernández, R. Myers-Ward, D. Zabetakis, D. Stenger, D. Gaskill, S. Walton, Plasma-modified, epitaxial fabricated graphene on SiC for the electrochemical detection of TNT, Sensors 16 (8) (2016) 1281.
[632] E. Verbitskiy, A. Baranova, K. Lugovik, K. Khokhlov, E. Cheprakova, G. Rusinov, V. Charushin, et al., New V-shaped push-pull systems based on 4, 5-di (hetero) aryl substituted pyrimidines: their synthesis and application to the detection of nitroaromatic explosives, ARKIVOC 3 (2016) 360–373.
[633] E. Verbitskiy, A. Baranova, K. Lugovik, K. Knokhlov, E. Cheprakova, M. Shafikow, G. Rusinov, O. Chupakhin, V. Charushin, New 4,5-di(hetero) arylpyrimidines as sensing elements for detection of nitroaromatic explosives in vapor phase, Dyes Pigments 137 (2017) 360–371.
[634] B. Wang, J. Han, M. Bender, K. Seehafer, U. Bunz, Array-based sensing of explosives by water-soluble poly(p-phenyleneethynylene)s,

Macromolecules 50 (11) (2017) 4126–4131.
[635] E. Wang, D. Sun, H. Li, X. Sun, J. Liu, Z. Ren, S. Yan, High efficiency organosilicon-containing polymer sensors for the detection of trinitrotoluene and dinitrotoluene, J. Mater. Chem. C 4 (28) (2016) 6756–6760.
[636] K. Wang, T. Liu, Y. Liu, X. Tian, J. Sun, Q. Zhang, Fluorescent heterometallic MOFs: tunable framework charges and application for explosives detection, CrystEngComm 18 (42) (2016) 8301–8308.
[637] P. Wang, X. Song, Z. Zhao, L. Liu, W. Mu, C. Hao, Role of the electronic excited-state hydrogen bonding in the nitro-explosives detection by [Zn 2 (oba) 2 (bpy)], Chem. Phys. Lett. 661 (2016) 257–262.
[638] Y. Wu, Y. Li, X. Wu, M. Luo, L. Zou, Q. Xu, S. Cai, An uncommon 3D (3,8)-connected metal-organic framework: luminescence sensing and photocatalytic properties, J. Solid State Chem. 262 (2018) 256–263.
[639] Z. Wu, C. Zhou, B. Zu, Y. Li, X. Dou, Contactless and rapid discrimination of improvised explosives realized by Mn2+ doping tailored ZnS nanocrystals, Adv. Funct. Mater. 26 (25) (2016) 4578–4586.
[640] J. Xiong, H. Feng, J. Wang, C. Zhang, B. Li, Y. Zheng, Tetraphenylethylene foldamers with double hairpin-turn linkers, TNT-binding mode and detection of highly diluted TNT vapor, Chem-A Eur. J 24 (8) (2018) 2004–2012.
[641] L. Yang, X. Li, C. Qin, K. Shao, Z. Su, A fluorescent sensor for highly selective sensing of nitro explosives and Hg (ii) ions based on a 3D porous layer metal–organic framework, CrystEngComm 18 (2016) 4765–4771.
[642] Q. Yang, B. Wang, S. Sheng, H. Xian, Y. Xie, A pillar-layered Cd(II) metal-organic framework for selective detection of organic explosives, J. CoordiChem 70 (14) (2017) 2541–2550.
[643] S. Yao, S. Liu, C. Cao, X. Tian, M. Bao, T. Zheng, Temperature- and solvent-dependent structures of three zinc(II) metal-organic frameworks for nitro-aromatic explosives detection, J. Solid State Chem. 269 (2019) 195–202.
[644] X. Zhang, L. Zheng, Y. He, Creatinine-Modified Gold Nanoparticles for Highly Sensitive Colorimetric Sensing of Nitroguanidine Explosive, Plasmonics, 2016, pp. 1–6.
[645] Y. Zhang, P. Shen, B. He, W. Luo, Z. Zhao, B. Tang, New fluorescent through-space conjugated polymers: synthesis, optical properties and explosive detection, Polym. Chem. 9 (5) (2018) 558–564.
[646] Z. Zhao, X. Song, L. Liu, G. Li, S. Shah, C. Hao, A recognition mechanism study: luminescent metal-organic framework for the detection of nitro-explosives, J. Mol. Graph. Model. 80 (2018) 132–137.
[647] M. Zwijnenburg, E. Berardo, W. Peveler, K. Jelfs, Amine molecular cages as supramolecular fluorescent explosive sensors; a computational perspective, J. Phys. Chem. B 120 (2016) 5063–5072.

Canine Explosives Detectio

[648] K. Colizza, M. Gonsalves, L. McLennan, J. Smith, J. Oxley, Metabolism of triacetone triperoxide (TATP) by canine cytochrome P450 2B11, Forensic Toxicol. 37 (1) (2018) 174–185.
[649] L. DeGreeff, M. Malito, C. Katilie, A. Brandon, M. Conroy, K. Peranich, et al., Passive delivery of mixed explosives vapor from separated components, Forensic. Chem 4 (2017) 19–31.
[650] L. DeGreeff, K. Peranich, A. Simon, Detection of Ammonium Nitrate Variants by Canine: a Study of Generalization between like Substances, Naval Research Laboratory, Washington, D.C., 2018.
[651] R. Gerritsen, R. Haak, K9 Explosive and Mine Detection: A Manual for Training and Operations, Dog Training Press, 2017.
[652] N. Hall, C.D.L. Wynne, Odor mixture training enhances dogs' olfactory detection of home-made explosive precursors, Heliyon 4 (12) (2018), e00947.
[653] J. Heyes, P. McGreevy, S. Forbes, G. Laing, R.(Stuetz, Critical review of dog detection and the influences of physiology, training, and analytical methodologies, Talanta 185 (2018) 499–512.
[654] L. Lazarowski, P. Haney, J. Brock, T. Fischer, B. Rogers, C. Angle, J. Katz, L. Waggoner, Investigation of the behavioral characteristics of dogs purpose-bred and prepared to perform vapor Wake® detection of person-borne explosives, Front. Vet. Sci 5 (2018) 50.
[655] W. MacCrehan, M. Young, M. Schantz, Measurements of vapor capture-and-release behavior of PDMS-based canine training aids for explosive odorants, Forensic. Chem 11 (2018) 58–64.
[656] Naval Research Laboratory, Development of an Alternative Mixed Odor Delivery Device (MODD) for Canine Training, Defense Technical Information Center, Washington D.C, 2017, pp. 1–34.
[657] T. Ong, T. Mendum, G. Geurtsen, J. Kelley, A. Ostrinskaya, R. Kunz, Use of mass spectrometric vapor analysis to improve canine explosive detection efficiency, Anal. Chem. 89 (12) (2017) 6482–6490.
[658] J. Pearce, P. Waggoner, J. Brock, T. Baird, D. Baffa, D. McAfee, et al., Dynamic Canine Tracking Method for Hazardous and Illicit Substances (US2018/0007866A1), Auburn University, Alabama, 2018.

LIBS Detection

[659] S. Ahmadi, M. Keshavarz, H. Atabak, Correlations between laser induced breakdown spectroscopy (LIBS) and dynamical mechanical analysis (DMA) for assessment of aging effect on plastic bonded explosives (PBX), Z. Anorg. Allg. Chem. 645 (2) (2018) 120–125.
[660] S. Ahmadi, M. Keshavarz, H. Hafizi Atabak, Introducing laser induced breakdown spectroscopy (LIBS) as a novel, cheap and non-destructive method to study the changes of mechanical properties of plastic bonded explosives (PBX), Z. Anorg. Allg. Chem. 644 (23) (2018) 1667–1673.
[661] K. Bhavsar, K. Eseller, R. Prahbu, Design optimization of cassegrain telescope for remote explosive trace detection, in: Proceedings of the International Society for Optics and Photonics Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies. Warsaw, Poland, 2017, p. 1044103.
[662] L. Fambro, D. Vandenbos, M. Rosenberg, C. Dockery, Laser-induced breakdown spectroscopy for the rapid characterization of lead-free gunshot residues, Appl. Spectrosc. 7 (1) (2017) 699–708.
[663] G. Guo, K. Liu, J. Wang, S. Wang, Q. Lin, Y. Ding, D. Tian, Y. Duan, Integrated instrumentation for combined laser-induced breakdown and Raman spectroscopy, Instrum. Sci. Technol. 47 (4) (2019) 355–373.
[664] F. Jin, S. Trivedi, C. Yang, E. Brown, E. Kumi-Barimah, U. Hommerich, A. Samuels, May). Chemical and explosive detection with long-wave infrared laser induced breakdown spectroscopy, in: Proceedings of the International Society for Optics and Photonics 9824, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII. Baltimore, Maryland, 2016, p. 98240Q.
[665] L. Jolivet, M. Leprince, S. Moncayo, L. Sorbier, C. Lienemann, V. Motto-Ros, Review of the recent advances and applications of LIBS-based imaging, Spectrochim. Acta B Atom Spectrosc. 151 (2019) 41–53.
[666] W. Li, X. Li, X. Li, Z. Hao, Y. Lu, X. Zeng, A review of remote laser-induced breakdown spectroscopy, Appl. Spectrosc. Rev. 55 (1) (2018).
[667] M. O'Neil, N. Niemiec, A. Demko, E. Petersen, W. Kulatilaka, Laser-induced-breakdown-spectroscopy-based detection of metal particles released into the air during combustion of solid propellants, Appl. Optic. 57 (8) (2018) 1910.
[668] M. O'Neil, N. Niemiec, A. Demko, E.L. Petersen, W.D. Kulatilaka, Characterization of emissions from metalized energetic forumulations using laser-induced breakdown spectroscopy, in: 58th AIAA Aerospace Sciences Meeting, AIAA SciTech, 2017, 0385.
[669] A. Rezaei, M. Keshavarz, M. Tehrani, S. Darbani, Quantitative analysis for the determination of aluminum percentage and detonation performance of aluminized plastic bonded explosives by laser-induced breakdown spectroscopy, Laser Phys. 28 (6) (2018), 065605.
[670] A. Shaik, N. Epuru, H. Syed, C. Byram, V. Soma, Femtosecond laser induced breakdown spectroscopy based standoff detection of explosives and discrimination using principal component analysis, Optic Express 26 (7) (2018) 8069.
[671] Q. Wang, L. He, Y. Zhao, Z. Peng, L. Liu, Study of cluster analysis used in explosives classification with laser-induced breakdown spectroscopy, Laser Phys. 26 (6) (2016), 065605.
[672] Q. Wang, G. Teng, C. Li, Y. Zhao, Z. Peng, Identification and classification of explosives using semi-supervised learning and laser-induced breakdown spectroscopy, J. Hazard Mater. 369 (2019) 423–429.
[673] C. Yang, F. Jin, S. Trivedi, E. Brown, U. Hommerich, A. Tripathi, et al., Long-wave infrared (LWIR) molecular laser-induced breakdown spectroscopy (LIBS) emissions of thin solid explosive powder films deposited on aluminum substrates, Appl. Spectrosc. 71 (4) (2017) 728–734.

Neutron

[674] S. Bishnoi, R. Thomas, A. Sarkar, P. Sarkar, A. Sinha, A. Saxena, S. Gadkari, Modeling of tagged neutron method for explosive detection using GEANT4, Nucl. Instrum. Methods Phys. Res. Sect. A Accel. Spectrom. Detect. Assoc. Equip. 923 (2019) 26–33.
[675] L. Cevallos Robalino, Garcia, G. Fernandez, E. Gallego, K. Guzman-Garcia, H. Vega-Carrillo, Study by Monte Carlo methods of an explosives detection system made up with a D-D neutron generator and NaI(Tl) gamma detectors, Appl. Radiat. Isot. 141 (2018) 167–175.
[676] S. Dolya, Detection of Explosives by Using a Neutron Source Based on a Proton Linac, 2016 arXiv:1606.07468.
[677] E. Espinosa-Fuentes, E. Meza-Fuentes, F. Colpas-Castillo, J. Castro-Suarez, G. Chiquillo-Correa, M. Mora, Verification of the vibrational theoretical assignment of the DADP using isotopic labelling, Dyna 85 (205) (2018) 64–68.
[678] P. Hernández-Adame, D. Medina-Castro, J. Rodriguez-Ibarra, M. Salas-Luevano, H. Vega-Carrillo, November). Design of an explosive detection system using Monte Carlo method, Appl. Radiat. Isot. 117 (2016) 27–31.
[679] G. Kulcinski, J. Santarius, K. Johnson, A. Megahed, R. Bonomo, Identification of landmines and IEDs using compact fusion neutron sources on drones, Fusion Sci. Technol. 72 (3) (2017) 455–460.
[680] M. Michalak, *Increasing The High Voltage Capabilities and Exploring Parameter Space of an Inertial Electrostatic Confinement Fusion Neutron Source for the Detection of Chemical Explosives* PhD, University of Wisconsin, Madison, 2017.
[681] M. Pahlavani, A. Mostaar, J. Nadali-Varkani, Configuration of gamma detectors in a neutron interrogation system for detection of explosives, Appl. Radiat. Isot. 132 (2018) 18–23.
[682] Z. Whetstone, M. Flaska, K. Kearfott, Experimental verification of a method to create a variable energy neutron beam from a monoenergetic, isotropic source using neutron elastic scatter and time of flight, Nucl. Instrum. Methods Phys. Res. Sect. A Accel. Spectrom. Detect. Assoc. Equip. 827 (2016)

95–101.

Terahertz

[683] M. Klymenko, O. Shulika, I. Sukhoivanov, Semiconductor THz lasers and their applications in spectroscopy of explosives, in: J. Uddin (Ed.), *Terahertz Spectroscopy-A Cutting Edge Technology* in *Terahertz Spectroscopy-A Cutting Edge Technology*, first ed., InTech, Rijjeka, 2017, pp. 231–246.
[684] B. Rameev, B. Aktaş, June). NMR & MW techniques for detection of explosive and illicit materials, in: Physics and Engineering of Microwaves, Millimeter and Submillimeter Waves (MSMW), 2016 9th International Kharkiv Symposium, IEEE, 2016, pp. 1–3.
[685] M. Razeghi, Q.Y. Lu, September). RT-CW: widely tunable semiconductor THz QCL sources, in: Proceedings of the International Society for Optics and Photonics 9934 Terahertz Emitters, Receivers, and Applications VII, 993406. San Diego, California, 2016, p. 993406.
[686] M. Shur, May). Recent developments in terahertz sensing technology, in: Proceedings of the International Society for Optics and Photonics 836, Micro- and Nanotechnology Sensors, Systems, and Applications VII. Baltimore, Maryland, 2016, p. 98362Q.
[687] V. Sirkeli, O. Yilmazoglu, S. Preu, F. Kuppers, H. Hartnagel, Proposal for a monolithic broadband terahertz quantum cascade laser array tailored to detection of explosive materials, Sens. Lett. 16 (1) (2018) 1–7.
[688] D. Talbayev, J. Zhou, S. Lin, K. Bhattarai, Grating-coupled surface plasmons on InSb: a versatile platform for terahertz plasmonic sensing (Conference Presentation), in: Proceedings of the International Society for Optics and Photonics10210, Next-Generation Spectroscopic Technologies X, Anaheim, California, 2017, p. 102100X.
[689] V. TRofimov, S. Varentsova, High effective time-dependent THz spectroscopy method for the detection and identification of substances with inhomogeneous surface, PloS One 13 (8) (2018) 1–28.
[690] V. Trofimov, S. Varentsova, V. Tikhomirov, V. Trofimov, May). High effective THz-TDS method for the detection and identification of substances in real conditions, in: Proceedings of the International Society for Optics and Photonics SPIE 9836, Micro- and Nanotechnology Sensors, Systems, and Applications VIII. Baltimore, Maryland, 2016, p. 98362U.
[691] V. Trofimov, D. Zagursky, I. Zakharova, Influence of disordered cover on cascade mechanism of medium response spectrum broadening at THz-TDS of substance, in: Proceedings of the International Society for Optics and Photonics 9934, Terahertz Emitters, Receivers, and Applications VII. San Diego, California, 2016, p. 993409.
[692] V. Vaks, E. Domracheva, M. Chernyaeva, S. Pripolzin, L. Revin, I. Tretyakov, et al., On the possibility of studying the reactions of the thermal decomposition of energy substances by the methods of high-resolution terahertz spectroscopy, Radiophys. Quantum Electron. 60 (9) (2018) 750–760.

Nuclear Techniques

[693] R. Cooper, B. Mark, D. Prescott, K. Sauer, Improving the design of atomic magnetometer arrays for RF interference mitigation in NQR detection of explosives, in: Proceedings of the International Society for Optics and Photonics 10182, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XXII, Anaheim, California, 2017, pp. 403–407, 1018208. Elsheikh, N. (2018). Monte Carlo modelling of a neutron-induced gamma-ray sensor for landmine or explosive detection. Journal of Radiation Research and Applied Sciences, 11(4).
[694] M. Gierlik, S. Borsuk, Z. Guzik, J. Iwanowska, L. Kazmierczak, S. Koroloczuk, T. Kozlowski, T. Krakaoski, R. Macinkowski, L. Swiderski, M. Szeptycka, J. Szewinski, A. Urban, SWAN - detection of explosives by means of fast neutron activation analysis, Nucl. Instrum. Methods Phys. Res.: Accel. Spectrom. Detect. Assoc. Equip. 834 (2016) 16–23.
[695] M. Huang, J. Zhu, J. Wu, R. Li, Element analysis method of concealed explosive based on TNA, Nucl. Sci. Tech. 30 (1) (2019).
[696] H. Meng, Z. Jianyu, W. Jun, L. Rui, Determining age of high-explosive to support nuclear warhead dismantlement verification, Appl. Radiat. Isot. 143 (2019) 11–17.
[697] A. Santos, L. Dutra, L. Menezes, M. Santos, A. Barison, Forensic NMR spectroscopy: just a beginning of a promising partnership, Trac. Trends Anal. Chem. 107 (2018) 31–42.
[698] M. Yucel, A. Bayrak, E. Yucel, C. Ozben, Simulations of Si-PIN photodiode based detectors for underground explosives enhanced by ammonium nitrate, Nucl. Instrum. Methods Phys. Res. Sect. A Accel. Spectrom. Detect. Assoc. Equip. 880 (2018) 152–157.

X-Ray

[699] C. Chan, A. Ferworn, L. Chin, Towards determining relative densities for common unknown explosives in improvised explosive devices, in: 2017 IEEE Canada International Humanitarian Technology Conference, IEEE, Toronto, 2017, pp. 55–60.
[700] J. Kehres, M. Lyksborg, U. Olsen, Threat detection of liquid explosives and precursors from their x-ray scattering pattern using energy dispersive detector technology, in: Proceedings of the International Society for Optics and Photonics Proceedings Volume 10393: Radiation Detectors in Medicine, Industry, and National Security XVIII, San Diego, California, 2017, p. 1039302.
[701] E. Wainwright, S. Lakshman, A. Leong, A. Kinsey, J. Gibbins, S. Arlington, T. Sun, K. Fezzaa, T. Hufnagel, T. Weihs, Viewing internal bubbling and microexplosions in combusting metal particles via x-ray phase contrast imaging, Combust. Flame 199 (2019) 194–203.

Ion Mobility Spectroscopy

[702] A. Akmalov, A. Chistyakov, G. Kotkovskii, I. Martynov, E. Spitsin, Laser ion mobility spectrometry in the detection of ultra-low quantities of explosives, Eur. J. Mass Spectrom. 23 (4) (2017) 140–145.
[703] A.E. Akmalov, G.E. Kotkovskii, A.A. Chistyakov, Laser desorption of traces of explosives in ion mobility spectrometry, KnE Energy & Phys Int. Con. Photo. Info. Optics 8 (2018) 287–296.
[704] M. Chaffee-Cipich, D. Hoss, M. Sweat, S. Beaudoin, Contact between traps and surfaces during contact sampling of explosives in security settings, Forensic Sci. Int. 260 (2016) 85–94.
[705] U. Chiluwal, G. Lee, M. Rajapakse, T. Willy, S. Lukow, H. Schmidt, G. Eiceman, Tandem ion mobility spectrometry at ambient pressure and field decomposition of mobility selected ions of explosives and interferences, Analyst 144 (6) (2019) 2052–2061.
[706] G. Cook, Improving Ion Mobility Spectrometry Detection Methods for Trace Forensics and Military Field Applications, PhD, Uniformed Services University of The Health Sciences Bethesda United States, 2016.
[707] Z. Du, J. Sun, D. Wang, Z. Zhang, W. Yu, Development of a plug-type IMS-MS instrument and its applications in resolving problems existing in in-situ detection of illicit drugs and explosives by IMS, Talanta 184 (2018) 65–72.
[708] B. Hauck, W. Siems, C. Harden, V. McHugh, H. Hill, High accuracy ion mobility spectrometry for instrument calibration, Anal. Chem. 90 (7) (2018) 4578–4584.
[709] C. Kune, J. Haler, J. Far, E. Pauw, Effectiveness and limitations of computational chemistry and mass spectrometry in the rational design of target-specific shift reagents for ion mobility spectrometry, ChemPhysChem 19 (21) (2018) 2921–2930.
[710] Y. Kuzishchin, G. Kotkovskii, I. Martynov, D. Dovzhenko, A. Chistyakov, A new approach for detection of explosives based on ion mobility spectrometry and laser desorption/ionization on porous silicon, in: Proceedings of the International Society for Optics and Photonics 9824, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII. Baltimore, Maryland, 2016, p. 98241A.
[711] A. Lawrence, L. Elias, New applications for ion mobility spectrometry detection techniques, in: R. Clement, K. Siu, H. Hill (Eds.), Instrumentation For Trace Organic Monitoring, second ed., CRC Press, Boca Raton, FL, 2018, pp. 1–12.
[712] W. Pawłowski, A. Zalewska, L. Matyjasek, M. Karpińska, The air humidity effect on the detection of TNT, PETN and NG by the FAIMS technique, Sensor. Actuator. B Chem. 247 (2017) 343–348.
[713] T. Reinecke, A. Kirk, A. Heptner, D. Niebuhr, S. Böttger, S. Zimmermann, A compact high-resolution X-ray ion mobility spectrometer, Rev. Sci. Instrum. 87 (5) (2016), 053120.
[714] V. Sedwick, M. Massey, T. Codio, K.A. Bakarr, Method validation parameters for drugs and explosives in ambient pressure ion mobility spectrometry, Int. J. Ion Mobil. Spectrom 20 (3/4) (2017) 75–86.
[715] H. Shahraki, M. Tabrizchi, H. Farrokhpor, Detection of explosives using negative ion mobility spectrometry in air based on dopant-assisted thermal ionization, J. Hazard Mater. 357 (2018) 1–9.
[716] A. Sorribes-Soriano, M. de la Guardia, F.A. Esteve-Turrillas, S. Armenta, Review: trace analysis by ion mobility spectrometry: from conventional to smart sample preconcentration methods. A review, Anal. Chim. Acta 1026 (2018) 37–50.

Novel Detection

[717] M. Adib, M. Sommer, UV excited SnO2 nanowire based printed e-nose: potential application as burning smell detector and explosive detector, IEEE Sens (2016) 1–3.
[718] A. Adlin, K. Kumar, Explosive detection approach by printed antennas, Int. J. Adv. Netw. Appl. 9 (6) (2018) 3616–3622.
[719] K. Ahmad, A. Mohammad, P. Mathur, S. Mobin, Preparation of SrTiO3 perovskite decorated rGO and electrochemical detection of nitroaromatics, Electrochim. Acta 215 (2016) 435–446.
[720] M. Ali, S. Shoaee, S. Fan, P. Burn, I. Gentle, P. Meredith, P. Shaw, Detection of explosive vapors: the roles of exciton and molecular diffusion in real-time sensing, ChemPhysChem 17 (21) (2016) 3350–3353.
[721] E. Almenar, A. Costero, P. Gaviña, S. Gil, M. Parra, Towards the fluorogenic detection of peroxide explosives through host–guest chemistry, Roy. Soc. Open. Sci. 5 (4) (2018) 171787.
[722] A. Arshad, H. Wang, X. Bai, R. Jiang, S. Xu, L. Wang, Colorimetric paper sensor for sensitive detection of explosive nitroaromatics based on Au@Ag nanoparticles, Spectrochim. Acta Mol. Biomol. Spectrosc. 206 (2019) 16–22.
[723] N. Bagheri, A. Khataee, J. Hassanzadeh, B. Habibi, Visual detection of

peroxide-based explosives using novel mimetic Ag nanoparticle/ZnMOF nanocomposite, J. Hazard Mater. 360 (2018) 233–242.
[724] A. Baranova, K. Khokhlov, R. Chuvashov, E. Verbitskiy, E. Cheprakova, G. Rusinov, V. Charushin, The portable detector of nitro-explosives in vapor phase with new sensing elements on a base of pyrimidine scaffold, J. Phys. Conf. 830 (2017), 012159.
[725] B. Brockner, C. Veal, J. Dowdy, D.T. Anderson, K. Williams, R. Luke, et al., Convolutional neural network based side attack explosive hazard detection in three dimensional voxel radar, in: Proceedings of the International Society for Optics and Photonics 10628, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XXIII. Orlando, Florida, 2018, p. 106281H.
[726] T. Brulé, G. Granger, N. Bukar, C. Deschênes-Rancourt, T. Havard, A. Schmitzer, R. Martel, J. Masson, A field-deployed surface plasmon resonance (SPR) sensor for RDX quantification in environmental waters, Analyst 142 (12) (2017) 2161–2168.
[727] P. Calvo-Gredilla, J. García-Calvo, J. Cuevas, T. Torroba, J. Pablos, F. García, J. García, N. Zink-Lorre, E. Font-Sanchis, Á. Sastre-Santos, F. Fernández-Lázaro, Solvent-free off-on detection of the improvised explosive triacetone triperoxide TATP with fluorogenic materials, Chem. Eur J. 23 (56) (2017) 13973–13979.
[728] M. Chahal, M. Sankar, β-dicyanovinyl substituted porphyrinogen: synthesis, reversible sensor for picric acid among explosives and unique sensor for cyanide and fluoride ions by switching between various porphyrinoid states, Dalton Trans. 46 (35) (2017) 11669–11678.
[729] S. Chaudhary, P. Sonkusre, K. Bhasin, P. Sabherwal, C. Suri, Trace detection of some nitro-explosives using thermal mediated immunochemical defragmented method, Biosens. Bioelectron. 126 (2018) 590–595.
[730] J. Chen, B. Li, Y. Xiong, J. Sun, A novel turn-off fluorescent probe based on TICT for the detection of NO 2 and nitramines with high sensitivity and selectivity, Sensor. Actuator. B Chem. 255 (2018) 275–282.
[731] Y. Cui, Y. Jin, X. Chen, J. Wu, 2-Dimensional electrochemiluminescence on porous silicon platform for explosives detection and discrimination, ACS Sens. 3 (8) (2018) 1439–1444.
[732] Y. Deng, N. Chen, Q. Li, X. Wu, X. Huang, Z. Lin, Y. Zhao, Highly fluorescent metal-organic frameworks based on benzene-cored tetraphenylethene derivative with the ability to detection of 2, 4, 6-trinitrophenol in water, Cryst. Growth Des. 17 (6) (2017) 3170–3177.
[733] A. Dhilon, D. Mittal, R. Bargota, Triple band ultrathin polarization insensitive metamaterial absorber for defense, explosive detection and airborne radar applications, Microw. Opt. Technol. 61 (1) (2018) 89–95.
[734] Y. El-Sharkawy, S. Elbasuney, Novel laser induced photoacoustic spectroscopy for instantaneous trace detection of explosive materials, Forensic Sci. Int. 277 (2017) 215–222.
[735] J. Erickson, l. Shriver-Lake, D. Zabetakis, D. Stenger, S. Trammell, A simple and inexpensive electrochemical assay for the identification of nitrogen containing explosives in the field, Sensors 17 (8) (2017) 1769.
[736] J.E. Friedel, Development of Unintended Radiated Emissions (URE) Threat Identification System, Doctoral Dissertation, The George Washington University, 2018.
[737] H. Fu, L. Yan, N. Wu, L. Ma, S. Zhang, Dual-emission MOF⊃dye sensor for ratiometric fluorescence recognition of RDX and detection of a broad class of nitro-compounds, J. Mater. Chem. 6 (19) (2018) 9183–9191.
[738] P. Ghosh, P. Roy, A. Ghosh, S. Jana, N. Murmu, S. Mukhopadhyay, P. Banerjee, Explosive and pollutant TNP detection by structurally flexible SOFs: DFT-D3, TD-DFT study and in vitro recognition, J. Lumin. 185 (2017) 272–278.
[739] R. Gillanders, I. Samuel, G. Turnbull, A low-cost, portable optical explosive-vapour sensor, Sensor. Actuator. B Chem. 245 (2017) 334–340.
[740] D. Giri, N. Islam, S. Pantra, Synthesis and characterization of 1,2,3-triazole appended polythiophene based reusable fluorescent probe for the efficient detection of trace nitroaromatics, Polymer 134 (2018) 242–253.
[741] A. González-Calabuig, X. Cetó, M. del Valle, Electronic tongue for nitro and peroxide explosive sensing, Talanta 153 (2016) 340–346.
[742] M. Guillen, F. Gamez, J. Roales, T. Lopes-Costa, S. Pinto, M. Calvete, M. Pereira, J. Pedrosa, Molecular-based selection of porphyrins towards the sensing of explosives in the gas phase, Sensor. Actuator. B Chem. 260 (2018) 116–124.
[743] O. Gungor, M. Kose, Selective detections of nitroaromatic explosives by monomeric and polymeric Bi(III) complexes, Sensor. Actuator. B Chem. 264 (2018) 363–371.
[744] L. Guo, D. Cao, J. Yun, X. Zeng, Highly selective detection of picric acid from multicomponent mixtures of nitro explosives by using COP luminescent probe, Sensor. Actuator. B Chem. 243 (2017) 753–760.
[745] L. Guo, Z. Yang, Y. Li, B. Zu, X. Dou, Sensitive, real-time and anti-interfering detection of nitro-explosive vapors realized by ZnO/rGO core/shell micro-Schottky junction, Sensor. Actuator. B Chem. 239 (2017) 286–294.
[746] S. Gürkan, M. Karapinar, S. Doğan, Classification of explosives materials detected by magnetic anomaly method, in: 4th International Conference on Electrical and Electronic Engineering. Ankara, Turkey, 2017, pp. 347–350.
[747] S. Gürkan, M. Karapinar, S. Doğan, Design of a data acquisition system for passive detection of buried explosives, in: 4th International Conference on Electrical and Electronic Engineering. Ankara, Turkey, 2017, pp. 338–341.
[748] S. Gutierrez, T. Just, J. Sachs, C. Baer, F. Vega, Field-deployable system for the measurement of complex permittivity of improvised explosives and lossy dielectric materials, IEEE Sensor. J. 18 (16) (2018) 6707–6714.
[749] S. Halder, P. Ghosh, Banerjee Rizzoli, P. Roy, Nitroaromatic explosives detection by a luminescent Cd(II) based metal organic framework, Polyhedron 123 (2017) 217–225.
[750] M. Han, G. Wen, W. Dong, Z. Zhou, Y. Wu, J. Zhao, X. Bu, A heterometallic sodium–europium-cluster-based metal–organic framework as a versatile and water-stable chemosensor for antibiotics and explosives, J. Mater. Chem. C 5 (33) (2017) 8469–8474.
[751] T. Han, Y. Zhang, B. He, J. Lam, B. Tang, Functional poly(dihalopentadiene)s: stereoselective synthesis, aggregation-enhanced emission and sensitive detection of explosives, Polymers 10 (8) (2018) 821.
[752] K. Hanabusa, S. Takata, M. Fujisaki, Y. Nomura, M. Suzuki, Fluorescent gelators for detection of explosives, Bull. Chem. Soc. Jpn. 89 (11) (2016) 1391–1401.
[753] L. Hu, X. Hong, X. Lin, J. Lin, Q. Cheng, B. Lokesh, Y. Cai, A versatile anionic Cd(II)-based metal–organic framework for CO2 capture and nitroaromatic explosives detection, Cryst. Growth Des. 18 (11) (2018) 7088–7093.
[754] M. Hurlock, Y. Kan, T. Lecrivain, J. Lapka, K. Nash, Q. Zhang, Molecular association-induced emission shifts for E/Z isomers and selective sensing of nitroaromatic explosives, Cryst. Growth Des. 18 (10) (2018) 6197–6203.
[755] T. Huynh, A. Wojnarowicz, A. Kelm, P. Woznicki, P. Borowicz, A. Majka, W. Kutner, et al., Chemosensor for selective determination of 2, 4, 6-trinitrophenol using a custom designed imprinted polymer recognition unit cross-linked to a fluorophore transducer, ACS Sens. 1 (6) (2016) 636–639.
[756] A. Jaini, L. Hughes, M. Kitimet, K. Ulep, M. Leopold, C. Parish, Halogen bonding interactions for aromatic and nonaromatic explosive detection, ACS Sens. 4 (2) (2019) 389–397.
[757] M. Jurcic, Metal-organic Frameworks for the Trace Detection of Explosive Substances and Related Compounds, Doctoral Dissertation, University College London, 2018.
[758] A. Kalita, S. Hussain, A. Malik, U. Barman, N. Goswami, P. Iyer, Anion-exchange induced strong π–π interactions in single crystalline naphthalene diimide for nitroexplosive sensing: an electronic prototype for visual on-site detection, ACS Appl. Mater. Interfaces 8 (38) (2016) 25326–25336.
[759] L. Kan, J. Li, X. Luo, G. Li, Y. Liu, Three novel bismuth-based coordination polymers: synthesis, structure and luminescent properties, Inorg. Chem. Commun. 85 (2017) 70–73.
[760] A. Kaur, J. Kaur, R. Singh, Graphene aerogel based room temperature chemiresistive detection of hydrogen peroxide: a key explosive ingredient, Sensor Actuator Phys. 282 (2018) 97–113.
[761] M. Kielmann, C. Prior, M.O. Senge, Porphyrins in troubled times: a spotlight on porphyrins and their metal complexes for explosives testing and CBRN defense, New J. Chem. 42 (10) (2018) 7529–7550.
[762] H.Q. Li, Z. Ding, Y. Pan, C. Liu, Y. Zhu, Fluorescence tuning of Zn (II)-based metallo-supramolecular coordination polymers and their application for picric acid detection, Inorg. Chem. Front 3 (11) (2016) 1363–1375.
[763] Q. Li, Z. Yang, Z. Ren, S. Yan, Polysiloxane-modified tetraphenylethene: synthesis, AIE properties, and sensor for detecting explosives, Macromol. Rapid Commun. 37 (21) (2016) 1772–1779.
[764] S. Li, D. Zhang, J. Liu, C. Cheng, L. Zhu, C. Li, Y. Lu, S. Low, B. Su, Q. Liu, Electrochemiluminescence on smartphone with silica nanopores membrane modified electrodes for nitroaromatic explosives detection, Biosens. Bioelectron. 129 (2018) 284–291.
[765] F. Liu, M. Cui, J. Ma, G. Zou, Q. Zhang, An optical fiber taper fluorescent probe for detection of nitro-explosives based on tetraphenylethylene with aggregation-induced emission, Opt. Fiber Technol. 36 (2017) 98–104.
[766] A. Lslan, M. Sasmal, D. Maiti, A. Dutta, B. Show, M. Ali, Design of a pyrene scaffold multifunctional material: real-time turn-on chemosensor for nitric oxide, AIEE behavior, and detection of TNP explosive, ACS Omega 3 (8) (2018) 10306–10316.
[767] M. Lu, P. Zhou, Z. Li, J. Liu, Y. Yang, K. Han, New insights into the sensing mechanism of a phosphonate pyrene chemosensor for TNT, Phys. Chem. Chem. Phys. 20 (29) (2018) 19539–19545.
[768] R. Lv, J. Wang, Y. Zhang, H. Li, L. Yang, S. Liao, X. Liu, An amino-decorated dual-functional metal–organic framework for highly selective sensing of Cr (III) and Cr (VI) ions and detection of nitroaromatic explosives, J. Mater. Chem. 4 (40) (2016) 15494–15500.
[769] P. Majee, D.K. Singha, S.K. Mondal, P. Mahata, Solvent dependent luminescence sensing of nitro-explosives by a terbium-based metal-organic complex, Chemistry 3 (2) (2018) 683–689.
[770] S. Masoumi, H. Hajghassem, A. Erfanian, A.M. Rad, Design and manufacture of TNT explosives detector sensors based on GFET, Sens. Rev. 38 (2) (2018) 181–193.
[771] H.D. Osthoff, Indirect Detection of Explosive Vapours by Thermal Dissociation Cavity Ring-Down Spectroscopy, Doctoral Dissertation, University of Calgary, 2018.
[772] Z. Pan, Z. Shi, X. Gao, H. Zheng, Two luminescent Zn(II) metal–organic frameworks for exceptionally selective detection of picric acid, Inorg. Chem. Commun. 86 (2017) 290–294.
[773] Z. Qin, W. Dong, J. Zhao, Y. Wu, Z. Tian, Q. Zhang, D. Li, Metathesis in metal–organic gels (MOGs): a facile strategy to construct robust fluorescent Ln-MOG sensors for antibiotics and explosives, Eur. J. Inorg. Chem. 2018 (2) (2018) 186–193.
[774] F. Qu, P. Chen, S. Zhu, J. You, High selectivity of colorimetric detection of p-nitrophenol based on Ag nanoclusters, Spectrochim. Acta Mol. Biomol. Spectrosc. 171 (2017) 449–453.
[775] D. Ramdasi, R. Mudhalwadkar, Thin film sensor materials for detection of

nitro-aromatic explosives, Mater. Sci. Eng. 323 (2018) 1–6.
[776] K. Reddy, A. Kumar, A. Dhir, V. Krishnan, New Ni-Anthracene complex for selective and sensitive detection of 2,4,6-Trinitrophenol, Int. J. Spectrosc. (2018).
[777] M. Ruggeri, J. Luo, I. Nova, E. Tronconi, K. Kamasamudram, A. Yezerets, Novel method of ammonium nitrate quantification in SCR catalysts, Catal. Today 307 (2018) 48–54.
[778] F. Samaeifar, A. Afifi, H. Abdollahi, Trace 2,4-dinitrotoluene detection using suspended membrane micro-hotplate based on heat absorption monitoring, Sensor Actuator Phys. 270 (2018) 25–33.
[779] R. Sarika, D. Shankaran, Colorimetric detection of picric acid using rhodamine dye loaded nanofiber membrane, Sens. Lett. 14 (8) (2016) 813–816.
[780] S. Sheykhi, L. Mosca, P. Anzenbacher, Toward wearable sensors: optical sensor for detection of ammonium nitrate-based explosives, ANFO and ANNM, Chem. Commun. 53 (37) (2017) 5196–5199.
[781] A. Srivastav, B. Agrawal, B. Swami, Y. Agrawal, P. Maity, Ligand exchange synthesis of organometallic Rh nanoparticles and application in explosive sensing, J. Nanoparticle Res. 19 (6) (2017) 216.
[782] D. Strle, B. Stefane, M. Trifkovic, M. Van Miden, I. Kvasic, E. Zupanic, et al., Chemical selectivity and sensitivity of a 16-channel electronic nose for trace vapour detection, Sensors 17 (12) (2017) 2845.
[783] M. Sun, D. Chen, H. Zhang, A two-fold interpenetrated metal-organic framework for the highly selective detection of explosive picric acid, Inorg. Chem. Commun. 73 (2016) 103–106.
[784] Y. Taha, M. Saowapon, H. Osthoff, Detection of triacetone triperoxide by thermal decomposition peroxy radical chemical amplification coupled to cavity ring-down spectroscopy, Anal. Bioanal. Chem. 410 (17) (2018) 4203–4212.
[785] C. Tan, M. Nasir, A. Ambrosi, M. Pumera, 3D printed electrodes for detection of nitroaromatic explosives and nerve agents, Anal. Chem. 89 (17) (2017) 8995–9001.
[786] Y. Tang, H. Huang, Y. Peng, Q. Ruan, K. Wang, P. Yi, D. Liu, C. Zhong, A fluorescent zirconium-based metal-organic framework for selective detection of nitro explosives and metal ions, Chin. J. Chem. 35 (7) (2017) 1091–1097.
[787] C. Tao, J. Li, T. Zhu, Grapefruit photonic crystal fiber long period gratings sensor for DNT sensing application, in: International Symposium on Optoelectronic Technology and Application. Optical Communication, Optical Fiber Sensors, and Optical Memories for Big Data Storage, 2016, p. 101580D.
[788] T. Tao, Y. Gan, J. Yu, W. Huang, Tuning aggregation-induced emission properties with the number of cyano and ester groups in the same dibenzo [b,d]thiophene skeleton for effective detection of explosives, Sensor. Actuator. B Chem. 257 (2018) 303–311.
[789] C. Tian, J. Yin, Z. Zhao, Y. Zhang, Y. Duan, Rapid identification and desorption mechanisms of nitrogen-based explosives by ambient micro-fabricated glow discharge plasma desorption/ionization (MFGDP) mass spectrometry, Talanta 167 (2017) 75–85.
[790] D. Tomecek, P. Fitl, J. Vlcekj, E. Maresova, M. Vrnata, Detection of taggants in explosives on nanostructured metal/silver phthalocyanine chemiresistors: influence of analyte photoactivation, Sensor. Actuator. B Chem. 239 (2017) 147–156.
[791] A. Üzer, U. Yalçın, Z. Can, E. Erçağ, R. Apak, Indirect determination of pentaerythritol tetranitrate (PETN) with a gold nanoparticles– based colorimetric sensor, Talanta 175 (2017) 243–249.
[792] D. Vandenbos, H. Msimanga, C. Dockery, Fast Identification of Components Commonly Used in Homemade Explosives by Spectroscopic and Chemometric Methods, Master's Thesis, Kennesaw State University, 2018.
[793] C. Veal, J. Dowdy, B. Brockner, D. Anderson, J. Ball, G. Scott, Generative adversarial networks for ground penetrating radar in hand held explosive hazard detection, in: Proceedings of the International Society for Optics and Photonics Proceedings from SPIE Defense & Security: Detection and Sensing of Mines, Explosive Objects and Obscured Targets, XXIII, 2018, p. 10628.
[794] H. Wang, S. Chen, A. Gao, Y. Wang, T. Li, Detection of TNT in sulfuric acid solution by SiNWs-FET based sensor, in: Symposium on Design, Test, Integration & Packaging of MEMS and MOEMS (DTIP), IEEE, 2018.
[795] J. Wang, M. Muto, R. Yatabe, Y. Tahara, T. Onodera, M. Tanaka, M. Okochi, K. Toko, Highly selective rational design of peptide-based surface plasmon resonance sensor for direct determination of 2,4,6-trinitrotoluene (TNT) explosive, Sensor. Actuator. B Chem. 264 (2018) 279–284.
[796] J. Wang, F. Yuan, H. Hu, C. Bai, G. Xue, Nitro explosive and cation sensing by a luminescent 2D Cu(I) coordination polymer with multiple Lewis basic sites, Inorg. Chem. Commun. 73 (2016) 37–40.
[797] S. Wang, Q. Wang, X. Feng, B. Wang, L. Yang, Explosives in the cage: metal–organic frameworks for high-energy materials sensing and desensitization, Adv. Mater. 29 (36) (2017) 1701898.
[798] X. Wang, L. Li, D. Yuan, Y. Huang, R. Cao, Fast, highly selective and sensitive anionic metal-organic framework with nitrogen-rich sites fluorescent chemosensor for nitro explosives detection, J. Hazard Mater. 344 (2018) 283–290.
[799] Y. Wang, K. Gao, J. Li, L. Wang, J. Wu, Synthesis and characterization of a Cd compound for selectively sensing of nitro-explosives, Inorg. Chem. Commun. 96 (2018) 189–193.
[800] D. Wild, L. Pschyklenk, C. Theiß, G. Holl, Remote laser drilling and sampling system for the detection of concealed explosives, in: Proceedings of the International Society for Optics and Photonics 10192, Laser Technology for Defense and Security XII, Anaheim, California, 2017, 101920J-101920J.
[801] Y. Wu, B. He, C. Quan, C. Zheng, H. Deng, R. Hu, Z. Zhao, F. Huang, A. Qin, B. Tang, Metal-free poly-cycloaddition of activated azide and alkynes toward multifunctional polytriazoles: aggregation-induced emission, explosive detection, fluorescent patterning, and light refraction, Macromol. Rapid Commun. 38 (18) (2017) 1700070.
[802] J. Xi, B. Zhang, A non-reductive electrochemical sensor for ultrasensitive detection of pM-level TNT, Anal. Methods 10 (38) (2018).
[803] Z. Xie, H. Ge, J. Du, T. Duan, G. Yang, Y. He, Compartmentalizing incompatible tandem reactions in pickering emulsions to enable visual colorimetric detection of nitramine explosives using a smartphone, Anal. Chem. 90 (19) (2018) 11665–11670.
[804] Y. Yang, F. Qiu, C. Xu, Y. Feng, G. Zhang, W. Liu, A multifunctional Eu-CP as a recyclable luminescent probe for the highly sensitive detection of Fe3+/Fe2+, Cr2O72−, and nitroaromatic explosives, Dalton Trans 47 (22) (2018) 7480–7486.
[805] R. Yao, X. Cui, X. Jia, F. Zhang, X. Zhang, A Luminescent zinc (II) Metal–Organic Framework (MOF) with conjugated π-electron ligand for high iodine capture and nitro-explosive detection, Inorg. Chem. 55 (18) (2016) 9270–9275.
[806] Y. Yew, A. Ambrosi, M. Pumera, Nitroaromatic explosives detection using electrochemically exfoliated graphene, Sci. Rep. 6 (2016) 33276.
[807] R. Yu, K. Li, Y. Cui, F. Tao, B. Zheng, X. Ma, et al., Amino-Functional electrospun nanofibrous membrane for detecting nitroaromatic compounds, J. Appl. Polym. Sci. 135 (40) (2018) 46708.
[808] A. Zhang, D. Fu, Y. Xuan, H. Ma, A multi-channel system for qualitative explosive and drug detection, Sens. Imag. 19 (1) (2018).
[809] S. Zhang, W. Chen, G. Dai, F. Yang, L. Chen, Fused carbazole-based dyads: synthesis, Solvatochromism and sensing properties, Asian J. Organ. Chem 7 (11) (2018) 2223–2227.
[810] Q. Zhu, W. Xiong, Y. Gong, Y. Zheng, Y. Che, J. Zhao, Discrimination of five classes of explosives by a fluorescence array sensor composed of two Tricarbazole-Nanostructures, Anal. Chem. 89 (22) (2017) 11908–11912.

Stand Off

[811] A.E. Akmalov, A.A. Chistyakov, O.I. Dubkova, G.E. Kotkovskii, E.M. Spitsyn, N.M. Buzinov, Laser desorption of explosives traces at ambient conditions, in: Proceedings of the International Society for Optics and Photonics 9995, Optics and Photonics for Counterterrorism, Crim Fighting, and Defence XII. Edinburgh, United Kingdom, 2016, p. 99950G.
[812] V. Ayrapetyan, Laser-based remote sensing of explosives by a differential absorption and scattering method, J. Appl. Spectrosc. 84 (6) (2018) 1061–1065.
[813] V. Ayrapetyan, P. Fomin, Laser detection of explosives based on differential absorption and scattering 106, Optics & Laster Technology, 2018, pp. 202–208.
[814] J. Barber, J. Greca, k. Yam, J. Weatherall, P. Smith, B. Smith, Developing an ANSI standard for image quality tools for the testing of active millimeter wave imaging systems, in: Proceedings of the International Society for Optics and Photonics 10189, Passive and Active Millimeter-Wave Imaging XX, Anaheim, California, 2017, p. 1018905.
[815] S. Belkin, S. Yagur-Kroll, C. Zohar, Z. Rabinovitz, A. Nussinovitch, Y. Kabessa, et al., Remote detection of buried explosives by fluorescent and bioluminescent microbial sensors (Conference Presentation), in: Proceedings of the International Society for Optics and Photonics 10231, Optical Sensors 2017. Prague, Czech Republic, 2017, p. 1023110.
[816] S. Bobrovnikov, E. Gorlov, V. Zharkov, Y. Panchenko, Stand-off detection of explosives vapors and explosives traces using lasers, in: 2018 International Conference Laser Optics, IEEE, 2018, p. 273.
[817] C. Breshike, C. Kendziora, R. Furstenberg, V. Nguyen, R. McGill, Methodology for using active infrared spectroscopy in standoff detection of trace explosives, in: Proceedings of the International Society for Optics and Photonics 10183, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVIII, Anaheim, California, 2017, p. 1018302.
[818] C. Breshike, C. Kendziora, R. Furstenberg, V. Nguyen, A. Kusterbeck, R. McGill, Using infrared backscatter imaging spectroscopy to detect trace explosives at standoff distances, in: Proceedings of the International Society for Optics and Photonics 10629 Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVIII. Orlando, Florida, 2018, p. 10629ON.
[819] C. Carson, J. Macarthur, M. Warden, D. Stothard, L. Butschek, S. Hugger, et al., Towards a compact, portable, handheld device for contactless real-time standoff detection of hazardous substances, in: Proceedings of the International Society for Optics and Photonics Proceedings from 10624, Infrared Technology and Applications XLIV. Orlando, Florido, 2018, p. 10624OF.
[820] J. Castro-Suarez, L. Pacheco-Londoño, J. Aparicio-Bolaño, S. Hernández-Rivera, Active mode remote infrared spectroscopy detection of TNT and PETN on aluminum substrates, J. Spectroscopy (2017) 1–11, 2017.
[821] N. Chantasen, A. Boonpoonga, S. Burintramart, K. Athikulwongse, P. Akkaraekthalin, Automatic detection and classification of buried objects using ground-penetrating radar for counter-improvised explosive devices, Radio Sci.: AGU J 53 (2) (2018) 210–217.
[822] K. Chidella, A. Asaduzzaman, F. Mashhadi, Prior detection of explosives to defeat tragic attacks using knowledge based sensor networks, in: Green

Technologies Conference (GreenTech), IEEE, Denver, 2017, pp. 283–289.
[823] B. Cole, L. Goldberg, C. McIntosh, V. King, A. Hays, Narrow linewidth UV sources at 257nm, in: Proceedings of the International Society for Optics and Photonics Solid State Lasers XXVI: Technology and Devices, San Fransisco, California, 2017, p. 100821O.
[824] P. Cole, C.J. Cal, D.R. Jean, N.F. Fell, *Detection Of Explosives on Surfaces Using UV Ramen Spectroscopy: Effect of Substrate Color* (Research Report ARL-TR-8181), United States Army Research Laboratory, 2017.
[825] Y. Demirağ, B. Bütün, E. Özbay, Plasmonic enhanced terahertz time-domain spectroscopy system for identification of common explosives, in: Proceedings of the International Society for Optics and Photonics 10210, Next-Generations Spectroscopic Technologies X, Anaheim, California, 2017, p. 1021012.
[826] J. Dupuis, J. Hensley, B. Cosofret, D. Konno, P. Mulhall, T. Schmit, W. Marinelli, et al., May). QCL-based standoff and proximal chemical detectors, in: Proceedings of the International Society for Optics and Photonics9836, Micro- and Nanotechnology Sensors, Systems, and Applications VIII. Baltimore, Maryland, 2016, p. 98362F.
[827] S. Elbasuney, Y. El-Sharkawy, Instant identification of explosive material: laser induced photoacoustic spectroscopy versus fourier transform infrared, Trac. Trends Anal. Chem. 108 (2018) 269–277.
[828] S. Elbasuney, A. El-Sherif, May) Complete spectroscopic picture of concealed explosives: laser induced Raman versus infrared, Trac. Trends Anal. Chem. 85 (B) (2016) 31–41.
[829] Y. El-Sharkawy, S. Elbasuney, Hyperspectral imaging: anew prospective for remote recognition of explosive materials, Remote Sens. Appli: Soc. Environ 13 (2018) 31–38.
[830] Y. El-Sharkawy, S. Elbasuney, A. El-sherif, M. Eltahlawy, H. Ayoub, Instantaneous identification of hazardous explosive-related materials using laser induced photoacoustic spectroscopy, Trac. Trends Anal. Chem. 106 (2018) 151–158.
[831] C. Ferrari, A. Ulrici, F. Romolo, Expert system for bomb factory detection by networks of advance sensors, Challeng. New Technol. Sec 8 (1) (2017) 1–18.
[832] T. Forbes, M. Staymates, Enhanced aerodynamic reach of vapor and aerosol sampling for real-time mass spectrometric detection using Venturi-assisted entrainment and ionization, Anal. Chim. Acta 957 (2017) 20–28.
[833] Y. Fu, H. Liu, J. Xie, 100-m standoff detection of a QCL-induced photo-vibrational signal on explosives using a laser vibrometer, Optic Laser. Eng. 107 (2018) 241–246.
[834] Y. Fu, H. Liu, Q. Hu, J. Xie, Photo-vibrational sensing of trace chemicals and explosives by long-distance differential laser Doppler vibrometer, in: Proceedings of the International Society for Optics and Photonics 10183, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVIII., Anaheim, California, 2017, p. 101830B.
[835] F. Fuchs, S. Hugger, J. Jarvis, Q. Yang, R. Ostendorf, C. Schilling, J. Wagner, et al., May). Imaging standoff trace detection of explosives using IR-laser based backscattering, in: Proceedings of the International Society for Optics and Photonics 9836, Micro- and Nanotechnology Sensors, Systems, and Applications VIII. Baltimore, Maryland, 2016, p. 98362I.
[836] M. Glimtoft, M. Svanqvist, M. Ågren, M. Nordberg, H. Östmark, May). Digital micromirror devices in Raman trace detection of explosives, in: Proceedings of the International Society for Optics and Photonics 9823, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XXI. Balrimore, Maryland, 2016, p. 982312.
[837] N. Gomer, S. Tazik, J. Beckstead, C. Gardner, M. Nelson, Standoff, wide-area explosive and narcotic detection using shortwave infared hyperspectral imaging, Spectroscopy 33 (8) (2018) 20–28.
[838] N. Gomer, S. Tazik, C. Gardner, M. Nelson, Real-time, wide-area hyperspectral imaging sensors for standoff detection of explosives and chemical warfare agents, in: Proceedings of the International Society for Optics and Photonics 10183, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVIII, Anaheim, California, 2017, p. 1018303.
[839] B. Gorbunov, Counting individual ions in the air by tagging them with particles, Chem. Phys. 492 (2017) 1–4.
[840] K. Gulati, S. Gulia, N. Kumar, A. Kumar, S. Kumari, V. Gambhir, M. Reddy, Real-time stand-off detection of improvised explosive materials using time-gated UV–Raman spectroscopy, Pramana 92 (2) (2019).
[841] M. Gundawar, J. Rajendhar, M. Gundawar, Standoff detection of explosives at 1 m using laser induced breakdown spectroscopy, Defence Sci. J. 67 (6) (2017) 623–630.
[842] S. Gupta, A. Kumar, V. Gambhir, M.N. Reddy, Pre-resonance Raman spectroscopy-based explosives detector, J. Appl. Spectrosc. 83 (6) (2017) 1096–1101.
[843] S. Harilal, B. Brumfield, M. Phillips, Standoff analysis of laser-produced plasmas using laser-induced fluorescence, Optic Lett. 43 (5) (2018) 1055–1058.
[844] S. Harilal, B. Brumfield, M. Phillips, Standoff detection of bulk and trace elements using laser-induced fluorescence of laser ablation plumes, in: Conference on Lasers and Electro-Optics, IEEE, San Jose, California, 2018.
[845] E. Holthoff, L. Marcus, P. Pellegrino, May). Photoacoustic spectroscopy for trace vapor detection and standoff detection of explosives, in: Proceedings of the International Society for Optics and Photonics 9824, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII. Baltimore, Maryland, 2016, p. 98240R.
[846] Q. Hu, J. Lim, H. Liu, Y. Fu, Photo-vibrational spectroscopy of solid and liquid chemicals using laser Doppler vibrometer, Optic Express 24 (17) (2016) 19148–19156.
[847] K. Hufziger, S. Bykov, S. Asher, Ultraviolet Raman wide-field hyperspectral imaging spectrometer for standoff trace explosive detection, Appl. Spectrosc. 71 (2) (2017) 173–185.
[848] W. Hug, R. Bhartia, K. Sijapati, Q. Nguyen, P. Oswal, R. Reid, Rapid optical detection and classification of microbes in suspicious powders, in: Proceedings of the International Society for Optics and Photonics Proceedings from 10629, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX. Orlando, Florida, 2018, p. 106290J.
[849] I. Israelashvili, A. Coimbra, D. Vartsky, L. Arazi, S. Shchemelinin, E. Caspi, A. Breskin, Fast-neutron and gamma-ray imaging with a capillary liquid xenon converter coupled to a gaseous photomultiplier, J. Instrum. 12 (9) (2017) P09029.
[850] C. Kendziora, R. Furstenberg, M. Papantonakis, V. Nguyen, R. McGill, May). Broadband infrared imaging spectroscopy for standoff detection of trace explosives, in: Proceedings of the International Society for Optics and Photonics 9836, Micro- and Nanotechnology Sensors, Systems, and Applications VIII. Baltimore, Maryland, 2016, p. 98362G.
[851] Y. Kostyukevich, D. Efremov, V. Ionov, E. Kukaev, E. Nikolaev, Remote detection of explosives using field asymmetric ion mobility spectrometer installed on multicopter, J. Mass Spectrom. 52 (11) (2017) 777–782.
[852] L. Kuzovnikova, E. Maksimenko, A. Vorozhtsov, A. Pavlenko, A. Didenko, S. Titov, Detection and identification of the traces of explosives with using of active spectral imaging, Propellants, Explos. Pyrotech. 44 (2) (2018) 181–187.
[853] K. Major, K. Ewing, J. Sanghera, T. Hutchens, M. Poutous, M. Potter, C. Wilson, I. Aggarwai, M. Farrell, E. Holthoff, P. Pellegrino, High-confidence discrimination of explosive materials on surfaces using a non-spectroscopic optical biomimetic sensing method, in: Proceedings of the International Society for Optics and Photonics 10629, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX, 2018, p. 10629.
[854] L. Marcus, E. Holthoff, P. Pellegrino, Standoff photoacoustic spectroscopy of explosives, Appl. Spectrosc. 71 (5) (2017) 833–838.
[855] C. Murzyn, A. Sims, H. Krier, N. Glumac, High speed temperature, pressure, and water vapor concentration measurement in explosive fireballs using tunable diode laser absorption spectroscopy, Optic Laser. Eng. 110 (2018) 186–192.
[856] R. Ostendorf, L. Butschek, S. Hugger, F. Fuchs, Q. Yang, J. Jarvis, D. Boskovic, et al., May) Recent advances and applications of external cavity-QCLs towards hyperspectral imaging for standoff detection and real-time spectroscopic sensing of chemicals, Photonics 3 (2) (2016) 28.
[857] G. Rasskazov, A. Ryabtsev, M. Danuts, Eye-safe near-infrared trace explosives detection and imaging, Optic Express 25 (6) (2017) 5832–5840.
[858] S. Ruan, Y. Chen, P. Zhang, X. Pan, C. Fang, A. Qin, et al., Online remote monitoring of explosives by optical fibres, RSC Adv. 6 (105) (2016) 103324–103327.
[859] F. Schnurer, C. Ulrich, S. Muller, W. Schweikert, Printed explosives standards for the evaluation of stand-off optical systems, in: Proceedings Volume 10802. Counterterrorism, Crime Fighting, Forensics and Surveillance Technologies II. in: Proceedings of the International Society for Optics and Photonics 10802, Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies II. Berlin, Germany, 2019, p. 108020V.
[860] A.K. Shaik, V.R. Soma, Standoff Detection of RDX, TNT, and HMX Using Femtosecond Filament Induced Breakdown Spectroscopy. Light, Energy and the Environment, OSA technical Digest (Optical Society of America, 2018, 2018), paper JW4A.1.
[861] Sharma, R., Kumar, S., Gupta, S., and Suarabh, H. Ultrasonic standoff photoacoustic sensor for the detection of explosive and hazardous molecules. Defence Sci. J., 68(4), pp. 401-405.
[862] R. Waterbury, R. Babnick, T. Conghuyentonnu, H. Hardy, T. Molner, D. Vunck, Recent developments of UV Raman standoff explosive detection systems for near trace detection, in: Proceedings of the International Society for Optics and Photonics 10629, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XIX. Orlando, Florida, 2018, p. 10290K.
[863] J. Weatherall, J. Barber, K. Yam, P. Smith, J. Greca, B. Smith, The identification of explosives in millimeter-wave imaging systems, in: Proceedings of the International Society for Optics and Photonics 10634, Passive and Active Millimeter-Wave Imagine XXI. Orlando, Florida, 2018, p. 106340C.
[864] J. Weatherall, K. Yam, J. Barber, B. Smith, P. Smith, J. Greca, Identifying explosives using broadband millimeter-wave imaging, in: Proceedings of the International Society for Optics and Photonics Proceedings 10189, Passive and Active Millimeter-Wave Imaging XX, Anaheim, California, 2017, p. 1018906.
[865] P. Wen, M. Amin, W. Herzog, R. Kunz, Key challenges and prospects for optical standoff trace detection of explosives, Trac. Trends Anal. Chem. 100 (2018) 136–144.
[866] C. Wynn, R. Haupt, J. Doherty, R. Kunz, W. Bai, G. Diebold, Use of photoacoustic excitation and laser vibrometry to remotely detect trace explosives, Appl. Optic. 55 (32) (2016) 9054–9059.
[867] J. Xia, Q. Yao, L. Zhu, M. Dong, X. Lou, Performance analysis and small signal identification of time-resolved stand-off Raman spectroscopy system, Vib. Spectrosc. 102 (2019) 16–23.
[868] B. Yellampalle, R. Martin, K. Witt, W. McCormick, H. Wu, M. Sluch, B. Lemoff, Performance comparison of single and dual-excitation-wavelength

resonance-Raman explosives detectors, in: Proceedings of the International Society for Optics and Photonics 10183, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVIII, Anaheim, California, 2017, p. 101830E.
[869] A. Zrimsek, S. Bykov, S. Asher, A.B. Zrimsek, S.V. Bykov, S.A. Asher, Deep ultraviolet standoff photoacoustic spectroscopy of trace explosives, Appl. Spectrosc. 73 (6) (2018) 601–609, 2018.

Environmental

[870] P. Charles, V. Wadhwa, A. Kouyate, K. Mesa-Donado, A. Adams, J. Deschamps, et al., A high aspect ratio bifurcated 128-microchannel microfluidic device for environmental monitoring of explosives, Sensors 18 (5) (2018) 1568, article.
[871] S. Chatterjee, U. Deb, S. Datta, C. Walther, D. Gupta, Review: common explosives (TNT, RDX, HMX) and their fate in the environment: emphasizing bioremediation, Chemosphere 184 (2017) 438–451.
[872] S. Chatterjee, U. Deb, S. Datta, C. Walther, D. Gupta, Common explosives (TNT, RDX, HMX) and their fate in the environment: emphasizing bioremediation, Chemosphere 184 (2017) 438–451.
[873] A. Das, S. Jana, A. Ghosh, Modulation of nuclearity by Zn(II) and Cd(II) in their complexes with a polytopic mannich base ligand: a turn-on luminescence sensor for Zn(II) and detection of nitroaromatic explosives by Zn(II) complexes, Cryst. Growth Des. 18 (4) (2018) 2335–2348.
[874] S. Dasary, A. Singh, K. Lee, H. Yu, P. Ray, A miniaturized fiber-optic fluorescence analyzer for detection of Picric acid explosive from commercial and environmental samples, Sensor. Actuator. B Chem. 255 (2) (2018) 1646–1654.
[875] P. Ghosh, J. Das, A. Basak, S. Mukhopadhyay, P. Banerjee, Nanomolar level detection of explosive and pollutant TNP by fluorescent aryl naphthalene sulfones: DFT study, in vitro detection and portable prototype fabrication, Sensor. Actuator. B Chem. 251 (2017) 985–992.
[876] Y. Ha, N.N. Daeid, L.A. Dawson, D. DeTate, S.W. Lewis, Explosive detonation causes an increase in soil porosity leading to increased TNT transformation, PloS One 12 (12) (2017) 1–18.
[877] A. Horestani, M. Jafari, E. Jazan, M. Mossaddegh, Effect of halide ions on secondary electrospray ionization-ion mobility spectrometry for the determination of TNT extracted by dispersive liquid-liquid microextraction, Int. J. Mass Spectrom. 433 (2018) 19–24.
[878] P. Kumar, P. Chandra Joshi, R. Kumar, S. Biswas, Catalytic effects of Cu-Co* on the thermal decomposition of AN and AN/KDN based green oxidizer and propellant samples, Defence Technol 14 (3) (2018) 250–260.
[879] K. McNesby, B. Gullett, Development of Methodologies for Evaluating Emissions from Metal-Containing Explosives and Propellants. SERDP Project WP2611. Aberdeen Proving Ground, US Army Research Laboratory, M.D., 2018.
[880] V. Medina, S. Waisner, C. Coyle, C. Griggs, M. Maxwell, Laboratory-Scale Demonstration Using Dilute Ammonia Gas-Induced Alkaline Hydrolysis of Soil Contaminants (Chlorinated Propanes and Explosives). *No.* ERDC/EL-TR-16-10. Vicksburg: United States, 2016.
[881] H.W. Schroer, Biotransformation and Photolysis of 2,4-dinitroanisole, 3-Nitro-1,2,4-Triazol-5-One, and Nitroguanidine, Doctoral dissertation, University of Iowa, 2018.
[882] Shemer, B., Koshet, O, Yagur-Kroll, S., and Belkin, S. Microbial bioreporters of trace explosives. Curr. Opin. Biotechnol., 45, pp. 113-119.
[883] B. Shemer, S. Yagur-Kroll, C. Hazan, S. Belkin, Aerobic transformation of 2,4-Dinitrotoluene by escherichia coli and its implications for the detection of trace explosives, Appl. Environ. Microbiol. 84 (4) (2018).
[884] S. Sriyab, K. Jorn-lat, P. Prompinit, P. Wolschann, S. Hannongbua, S. Suramitr, Photophysical properties of 1-pyrene-based derivatives for nitroaromatic explosives detection: experimental and theoretical studies, J. Lumin. 203 (2018) 492–499.
[885] T. Temple, M. Landyman, N. Mai, E. Galante, M. Ricamora, R. Shirazi, F. Coulon, Investigation into the environmental fate of the combined Insensitive High Explosive constituents 2,4-dinitroanisole (DNAN), 1-nitroguanidine (NQ) and nitrotriazolone (NTO) in soil, Sci. Total Environ. 625 (2018) 1264–1271.
[886] M. Walsh, M. Bigel, M. Walsh, E. Wrobel, S. Beal, T. Temple, Physical simulation of live-fire detonations using command-detonation fuzing, Propellants, Explos. Pyrotech. 43 (6) (2018) 602–608.
[887] J. Wu, Y. Lu, Z. Wu, S. Li, Q. Zheng, Z. Chen, et al., Two-dimensional molybdenum disulfide (MoS2) with gold nanoparticles for biosensing of explosives by optical spectroscopy, Sensor. Actuator. B Chem. 261 (2018) 279–287.
[888] H. Yu, D. DeTata, S. Lewis, N. Daeid, The stability of TNT, RDX and PETN in simulated post-explosion soils: implications of sample preparation for analysis, Talanta 164 (2017) 716–726.
[889] A. Zarei, M. Nedaei, S. Ghorbanian, Ferrofluid of magnetic clay and menthol based deep eutectic solvent: application in directly suspended droplet microextraction for enrichment of some emerging contaminant explosives in water and soil samples, J. Chromatogr. A 1553 (2018) 32–42.

Other (Safety, Definitions, etc)

[890] I. Astika, I. Putra, I. Yogi, O. Suharyo, Study of concrete destruction techniques using TNT and C4 to optimize the power of explosives, Int. J. Appl. Eng. Res. 13 (2) (2018) 1101–1108.
[891] R. Bateman, A. Harris, L. Lee, C. Howle, S. Ackermann, May). Application of the modified transient plane source technique for early detection of liquid explosives, in: Proceedings of the International Society for Optics and Photonics 9824, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XVII. Baltimore, Maryland, 2016, p. 98240J.
[892] V. Bellitto, M. Melnik, M. Sherlock, J. Chang, J. O'Connor, J. Mackey, Microstructure effects on the detonation velocity of a heterogeneous high-explosive, J. Energetic Mater. 36 (4) (2018) 485–492.
[893] J. Bernstein, Ab initio study of energy transfer rates and impact sensitivities of crystalline explosives, J. Chem. Phys. 148 (8) (2018), 084502.
[894] K. Bezemer, R. Woortmeijer, M. Koeberg, P. Schoenmakers, A. van Asten, Multicomponent characterization and differentiation of flash bangers — Part I: sample collection and visual examination, Forensic Sci. Int. 290 (2018) 327–335.
[895] S. Bondarchuk, N. Yefimenk, An algorithm for evaluation of potential hazards in research and development of new energetic materials in terms of their detonation and ballistic profiles, Propellants, Explos. Pyrotech. 43 (8) (2018) 818–824.
[896] D. Bonifacio, E. Galante, A. Haddad, Safety assessment of ammonium nitrate fuel oil (ANFO) manufactory, in: P. Arezes, J. Baptista, M. Barroso, P. Carneiro, N. Coasta, R. Melo, G. Perestreio, et al. (Eds.), *Occupational Safety And Hygiene VI: Proceedings Of the 6th International Symposium On Occupation Safety And Hygiene (SHO 2018), March 26-27, 2018, Guimaraes, Portugal*, CRC Press, London, 2018.
[897] P. Brousseau, S. Thiboutot, E. Diaz, Explosives ordnance disposal (EOD) of insensitive munitions: challenges and solutions. Quebec, Canada: Quebec, Defence R&D Canada – Valcartier Research Center, 2018.
[898] G. Butler, S. Pemberton, Checkerboard multi-component explosive simulation, AIP Con. Proc 1979 (1) (2018).
[899] Chao, X., Park, J., Yoo, C., Chen, J. and Lu, T. Identification of premixed flam propagation modes using chemical explosive mode analysis. Proc. Combust. Inst., 17(2), pp. 2407-2415.
[900] P. Choudha, A. Kumaraswamy, K. Dhote, Parametric study of single confined fragment launch explosive device, Defence Technol 15 (2) (2019) 179–185.
[901] S. Courtiaud, N. Lecysyn, G. Damamme, T. Poinsot, L. Selle, Analysis of mixing in high-explosive fireballs using small-scale pressurised spheres, Shock Waves (2018) 1–15.
[902] K. Daudin, F. Beauchamp, C. Proust, Phenomenological study of the premixing step of sodium-water explosive interaction, Exp. Therm. Fluid Sci. 91 (2018) 1–8.
[903] L. DeGreeff, C. Katilie, M. Malito, B. Gioradano, Mixed vapor generation device for delivery of homemade explosives vapor plumes, Anal. Chimcia Acta 1040 (2018) 41–48.
[904] F. DelRio, R. Cook, Quantitative scanning probe microscopy for nanomechanical forensics, Exp. Mech. 57 (7) (2017) 1045–1055.
[905] J.K. Dhall, A.K. Kapoor, Development of latent prints exposed to destructive crime scene conditions using wet powder suspensions, Egypt. J. Food Sci. 6 (4) (2016) 396–404.
[906] V. Dolgachev, A. Khaneft, A. Mitrofanoc, Ignition of organic explosive materials by a copper oxide film absorbing a laser pulse, Propellants, Explos. Pyrotech. 43 (10) (2018) 992–998.
[907] E. DuBois, K. Bowers, C. Rando, An examination of the spatial distribution of the tissue fragments created during a single explosive attack, Forensic Sci. Int. 279 (2017) 122–129.
[908] E. Dzhongova, D. Anderson, J. Ruiter, V. Novakovic, M. Ruiz Oses, False alarm rates of liquid explosives detection systems, J. Transport. Secur. 10 (3–4) (2017) 145–169.
[909] D. Frem, The specific impulse as an important parameter for predicting chemical high explosives performance, Z. Anorg. Allg. Chem. 644 (4) (2018) 235–240.
[910] M. Grant, M. Stewart, Modelling Improvised Explosive Device Attacks in the West – Assessing the Hazard, 165, Reliability Engineering & System Safety, 2017, pp. 345–354.
[911] A.V. Guaman, P. Lopez, J. Torres-Tello, Multivariate discrimination model for TNT and gunpowder using an electronic nose prototype: a proof of concept, in: A. Rocha, C. Ferras, M. Paredes (Eds.), Information Technology and Systems: Proceedings of ICTS 2019, 2019, pp. 284–293.
[912] J. Guo, Q. Zeng, G. Qin, M. Li, Initiation and overdriven detonation of high explosives using multipoint initiation, Propellants, Explos. Pyrotech. 44 (4) (2019) 423–428.
[913] A. Hammouda, Explosives' detection and remote detonation drone, Am. Sci. Res. J. Eng. Technol. Sci 25 (1) (2016) 72–88.
[914] D. Han, H. Sung, B. Ryu, Numerical simulation for the combustion of a Zirconium/Potassium Perchlorate explosive inside a closed vessel, Propellants, Explos. Pyrotech. 42 (10) (2017) 1168–1178.
[915] C. Handley, B. Lambourn, N. Whitworth, H. James, W. Belfield, Understanding the shock and detonation response of high explosives at the continuum and meso scales, Appl. Phys. Rev. 5 (1) (2018).
[916] N. Hattenschwiler, Y. Sterchi, M. Mendes, A. Schwaninger, Automation in

airport security X-ray screening of cabin baggage: examining benefits and possible implementations of automated explosives detection, Appl. Ergon. 72 (2018) 58–68.
[917] M. Hobb, M. Naeshige, Small-scale cook-off experiments and models of ammonium nitrate, J. Energetic Mater. 37 (1) (2018) 29–43.
[918] P. Hsu, S. Strout, G. Klunder, E. Kahl, N. Muetterties, J. Reynolds, et al., Recent advances on thermal safety characterization of energetic materials, in: AIP Conference Proceedings, 1979, 2018, p. 160010.
[919] Q. Jiao, H. Song, J. Nie, R. Liu, X. Xu, Y. Wen, Diameter effect on the propagation of curved detonation waves in micro-channel charges within a strong confinement, Propellants, Explos. Pyrotech. 43 (8) (2018) 771–778.
[920] A. Kalenskii, A. Zvekov, E. Galkina, D. Nurmuhametov, Critical parameters of a micro-hotspot model of the laser-pulse initiation of the explosive decomposition of energetic materials, Russ. J. Phys. Chem. B 11 (5) (2017) 820–827.
[921] A. Kashkarov, E. Pruuel, K. Ten, I. Rubtsov, E. Gerasimov, P. Zubkov, Transmission electron microscopy and x-ray diffraction studies of the detonation soot of high explosives, J. Phys. Conf. 774 (2016), 012072.
[922] M. Keshavarz, J. Azarniamehraban, H. Atabak, M. Ferdowsi, Recent developments for prediction of power of aromatic and non-aromatic energetic materials along with a novel computer code for prediction of their power, Propellants, Explos. Pyrotech. 41 (5) (2016) 942–948.
[923] M. Keshavarz, Z. Hadi, K. Esmaeilpour, S. Damiri, A. Afzali, Modelling of the effect of concentrated nitration conditions on the efficiency of the production of 3,7-Dinitro-1,3,5,7-tetraazabicyclo[3,3,1]nonane (DPT), Cent. Eur. J. Energy. Mater 15 (1) (2017) 72–84.
[924] K. Konstantynovski, G. Nijio, G. Holl, Detection of explosives – studies on thermal decomposition patterns of energetic materials by means of chemical and physical sensors, Sensor. Actuator. B Chem. 246 (2017) 278–285.
[925] H. Kwon, K. Tak, S. Maken, H. Kim, J. Park, I. Moon, Analysis of air blast effect for explosives in a large scale detonation, Kor. J. Chem. Eng. 34 (12) (2017) 3048–3053.
[926] W. Lee Perry, B. Clements, X. Ma, J. Mang, Relating microstructure, temperature, and chemistry to explosive ignition and shock sensitivity, Combust. Flame 190 (2018) 171–176.
[927] J. Li, C. Lin, C. Hwang, K. Lu, T. Yeh, Investigation of the burning properties of low-toxicity B/CuO delay compositions, Combust. Sci. Technol. (2018).
[928] K. Li, X. Li, H. Yan, X. Wang, Y. Miao, New approaches for evaluating detonation properties of commercial explosives using a novel continuous velocity probe, Meas. Sci. Technol. 29 (11) (2018).
[929] K. Li, X. Li, H. Yan, X. Wang, Y. Wang, Study of continuous velocity probe method for the determination of the detonation pressure of commercial explosives, J. Energetic Mater. 36 (2018) 377–385.
[930] X. Li, F. Zhao, J. Qin, A new method for predicting the detonation velocity of explosives with micrometer aluminum powders, Propellants, Explos. Pyrotech. 43 (4) (2018) 333–341.
[931] S. Lichorobiec, V. Kavicky, L. Figuli, Comprehensive assessment of potential threats to all kinds of events arising from the explosion of pipe bomb, Key Eng. Mater. 755 (2017) 219–228.
[932] Y. Liu, Y. Ma, T. Yu, W. Lai, W. Guo, W. Ge, Z. Ma, Structural rearrangement of energetic materials under an external electric field: a case study of nitromethane, J. Phys. Chem. 122 (8) (2018) 2129–2134.
[933] V. Manner, D. Podlesak, R. Huber, R. Amato, A. Giambra, P. Bowden, E. Hartline, C. Sorensen, D. Dattelbaum, Isotope-labeled composition B-3 for tracing detonation signatures, in: Shock Compression of Condensed Matter, AIP, 2019, 1979.
[934] N. McHeese, N. Cooke, R. Branaghan, A. Knobloch, A. Taylor, Identification of the emplacement of improvised explosive devices by experienced mission payload operators, Appl. Ergon. 60 (2017) 43–51.
[935] P. Mertuszka, B. Kramarcyzk, The impact of time on the detonation capacity of bulk emulsion explosives based on Emulinit 8L, Propellants, Explos. Pyrotech. 43 (9) (2018) 799–804.
[936] J. Moore, M. McClelland, P. Hsu, G. Ellsworth, E. Kahl, H. Springer, Thermal safety modeling of TATB-based explosive, in: International Detonation Symposium, Lawrence Livermore National Lab, Livermore, CA (United States), 2019.
[937] A. Nassr, A. Razaqpur, M. Campidelli, Effect of initial blast response on RC beams failure modes, Nucl. Eng. Des. 320 (2017) 437–451.
[938] J. Oxley, J. Smith, E. Bernier, F. Sandstrom, G. Weiss, G. Recht, et al., Characterizing the performance of pipe bombs, J. Forensic Sci. 63 (1) (2018) 86–101.
[939] J. Pantoja, F. Vega, F. Roman, N. Pena, F. Rachidi, On the differential input impedance of an electro-explosive device, IEEE Trans. Microw. Theor. Tech. 66 (2) (2018) 858–864.
[940] D. Pappas, I. Paraskakis, HOMER: a semantically enhanced knowledge management approach in the domain of homemade explosives intelligence, Soc. Netw. Anal. Min 7 (1) (2017) 1–20.
[941] V. Petr, E. Lozano, Characterizing the energy output generated by a standard electric detonator using shadowgraph imaging, Shock Waves 27 (5) (2017) 781–793.
[942] T. Piehler, N. Zander, R. Banton, R. Benjamin, R. Sparks, K. Byrnes, B. Bahr, High speed imaging techniques to study effects of pressure waves from detonating explosive charges on biological materials. *Dynamic Behavior of Materials: Proceedings of the 2017 Annual Conference of Experimental and Applied Mechanics* 1, Springer, 2017, pp. 123–126.
[943] S. Rampant, J. Coumbaros, B. Chapman, Post-blast detection of human DNA on improvised explosive device fragments, Aust. J. Forensic Sci. (2019) 1–4.
[944] D. Reid, B. Riches, A. Rowan, M. Logan, Expedient destruction of organic peroxides including triacetone triperoxide (TATP) in emergency situations, J. Chem. Health Saf. 25 (6) (2018) 22–27.
[945] B. Rougier, A. Lefrançois, V. Chuzeville, S. Poeuf, H. Aubert, Static and dynamic permittivity measurement of high explosives in the W band to investigate shock and detonation phenomena, Propellants, Explos. Pyrotech. 44 (2) (2018) 153–159.
[946] U. Roy, S. Kim, C. Miller, Y. Horie, M. Zhou, Computational study of ignition behavior and hotspot dynamics of a potential class of aluminized explosives, Model. Simulat. Mater. Sci. Eng. 26 (8) (2018), 085004.
[947] I. Rubtsov, K. Ten, E. Pruuel, A. Kashkarov, B. Tolochko, V. Zhulanov, L. Shekhtman, P. Piminov, The growth of carbon nanoparticles during the detonation of trinitrotoluene, J. Phys. Conf. 754 (5) (2016), 052004.
[948] E. Salzano, V. Cozzani, The potentiality of improvised explosive devices to trigger domino effects, in: A. Malizia, M. D'Arienzo (Eds.), Enhancing CBRNE Safety & Security: Proceedings of the SICC 2017 Conference, Springer, Cham, 2018, pp. 103–110.
[949] N. Satonkina, Chemical composition of detonation products of condensed explosives and its relationship to electrical conductivity, J. Phys. Conf. 946 (1) (2018), 012059.
[950] H. Schmidt, Explosive precursor safety: an application of the Deming Cycle for continuous improvement, J. Chem. Health Saf. 26 (1) (2019) 31–36.
[951] J. Seman, C. Giraldo, C. Johnson, Reactive not proactive: explosive identification taggant history and introduction of the nuclear barcode taggant model, Propellants, Explos. Pyrotech. 44 (4) (2019) 397–407.
[952] M. Shakhova, N. Muravyey, N. Gritsan, V. Kiselev, Thermochemistry, tautomerism, and thermal decomposition of 1,5-Diaminotetrazole: a high-level ab initio study, J. Phys. Chem. 122 (15) (2018) 3939–3949.
[953] M. Short, J. Quirk, High explosive detonation-confiner interactions, Annu. Rev. Fluid Mech. 50 (2018) 215–242.
[954] M. Short, J. Quirk, The effect of compaction of a porous material confiner on detonation propagation, J. Fluid Mech. 834 (2018) 434–463.
[955] M. Short, C. Chiquete, J. Bdzil, J. Quirk, Detonation diffraction in a circular arc geometry of the insensitive high explosive PBX 9502, Combust. Flame 196 (2018) 129–143.
[956] K. Singer, D. Ray, Army artillery munition warhead explosive fill probabilistic risk analysis, in: 2018 IEEE Symposium on Product Compliance Engineering (ISPCE), IEEE, San Jose, 2018.
[957] E. Sisco, M. Najarro, D. Samarov, J. Lawrence, Quantifying the stability of trace explosives under different environmental conditions using electrospray ionization mass spectrometry, Talanta 165 (2017) 10–17.
[958] J. Sleiman, S. Engelbrecht, L. Merlat, B. Fischer, B. Bousquet, P. Mounaix, Chemometrics applied to terahertz and Raman spectra for explosives analysis, in: 41st International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), IEEE, 2016, pp. 1–2.
[959] V. Sobolev, L. Shyman, M. Nalysko, O. Kyrychenko, Computational Modeling in Research of Ignition Mechanism of Explosives by Laser Radiation, Scientific Bulletin of National Mining University, 2017, pp. 53–60, 2017(6).
[960] J. Talghader, M. Mah, E. Yukihara, A. Coleman, Thermoluminescent Microparticle Thermal History Sensors, 2, Microsystems & Nanoengineering, 2016, p. 16037.
[961] B. Tappan, P. Bowden, V. Manner, J. Leiding, M. Jakulewicz, Evaluation of the deuterium isotope effect in the detonation of aluminum containing explosives, Propellants, Explos. Pyrotech. 43 (1) (2018) 62–68.
[962] E. Tasker, B. LaRue, C. Beherec, D. Gangitano, S. Hughes-Stamm, Research paper: analysis of DNA from post-blast pipe bomb fragments for identification and determination of ancestry, Forensic Sci. Int.: Genetics 28 (2017) 195–202.
[963] M. Tennant, S. Chew, T. Kramer, N. Mai, D. McAteer, J. Pons, Practical colorimetry of 3-nitro-1,2,4-triazol-5-one, Propellants, Explos. Pyrotech. 44 (2) (2018) 198–202.
[964] S. Thandu, P. Bharti, S. Chellappan, Z. Yin, Leveraging multi-modal smartphone sensors for ranging and estimating the intensity of explosion events, Pervasive Mob. Comput. 40 (2017) 185.
[965] D. Trache, A. Tarchoun, Analytical methods for stability assessment of nitrate esters-based propellants, Crit. Rev. Anal. Chem. (2019) 1–24.
[966] E. Verolme, M. Van der Voort, J. Weerhejim, Y. Koh, K. Kang, A method for backward calculation of debris in a post blast scene, J. Loss Prev. Process. Ind. 51 (2018) 54–64.
[967] S. Walley, N. Taylor, D. Williamson, Temperature and strain rate effects on the mechanical properties of a polymer-bonded explosive, Eur. Phys. J. Spec. Top. 227 (1–2) (2018) 127–141.
[968] X. Wang, Y. Wu, F. Huang, T. Jiao, R. Clifton, Mesoscale thermal-mechanical analysis of impacted granular and polymer-bonded explosives, Mech. Mater. 99 (2016) 68–78.
[969] B. Wilks, R. Morgan, N. Rose, An experimental study addressing the use of geoforensic analysis for the exploitation of improvised explosive devices, Forensic Sci. Int. 278 (2017) 52–67.
[970] T.M. Willey, M. Bagge-Hansen, L. Lauderbach, R. Hodgin, D. Hansen, C. May, et al., Measurement of carbon condensates using small-angle x-ray scattering during detonation of high explosives, in: American Institute of Physics Conference Proceedings, 1793, 2017, 030012, 1.
[971] H. Xu, B. Shi, Q. Zhang, A multitarget visual attention based algorithm on

crack detection of industrial explosives, Math. Probl Eng. (2018) 1–11 [online] 2018.
[972] H.A. Yu, T. Becker, N.N. Daeid, S.W. Lewis, Fundamental studies of the adhesion of explosives to textile and non-textile surfaces, Forensic Sci. Int. 273 (2017) 88–95.
[973] O. Zandieh, S. Kim, May). Multi-modal, ultrasensitive detection of trace explosives using MEMS devices with quantum cascade lasers, in: Proceedings of the International Society for Optics and Photonics SPIE Defense+ Security, International Society for Optics and Photonics, 2016, p. 98362H.
[974] F. Zapata, M. de la Ossa, E. Gilchrist, L. Barron, C. García-Ruiz, Progressing the analysis of Improvised Explosive Devices: comparative study for trace detection of explosive residues in handprints by Raman spectroscopy and liquid chromatography, Talanta 161 (2016) 219–227.
[975] J. Zwirner, R. Bayer, A. Japes, F. Eplinius, J. Dessler, B. Ondruschka, Suicide by the intraoral blast of firecrackers- experimental simulation using a skull simulation, Int. J. Leg. Med. 131 (6) (2017) 1581–1587.