

3–5. November 2025.
Hotel Radisson Blu
Split, Croatia

SPS ARW SPLIT2025

*International Workshop on Advanced Technologies and
Mobile Laboratories for Countering Chemical Threats*

https://www.fkit.unizg.hr/CroCerS/SPS_ARW_Workshop_Split2025

Chemical
Threats

T O P I C S

Advanced Detection &
Identification

Mobile Laboratories &
Benefits

Panel & Round Table
& ESR researchers



SPS ARW Split 2025

International Workshop on Advanced
Technologies and Mobile Laboratories
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IMPRESSUM

International Workshop on Advanced Technologies and Mobile Laboratories for Countering Chemical Threats: **SPS ARW 2025 Split**

Web: https://www.fkit.unizg.hr/CroCerS/SPS_ARW_Workshop_Split2025

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Published by

University of Zagreb Faculty of Chemical Engineering and Technology
Trg Marka Marulića 19, HR-10 000 Zagreb

and

Croatian ceramic society
Trg Marka Marulića 20, HR-10 000 Zagreb

ISBN

XXXX-XXXX (Online)

Venue

Split, Croatia 3–5 November 2025., Radisson Blu, Put Trstenika 19, HR-21000, Split, Croatia

pages: 1 – 56, Zagreb, Croatia, 1st November 2025



*This workshop
is supported by:*

The NATO Science for Peace
and Security Programme



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FOREWORD

Countering the disruptive impact of CBRN threats result in profound adverse consequences that asks for not only advanced technologies but also rapidly deployable DIM lab, adhering to the NATO keys priorities. The aim of this International Workshop on Advanced Technologies and Mobile Laboratories for Countering Chemical Threats is to bring together Academia, Industry, Governmental and Policy-making institutions, other Stakeholders, which will lead to enhanced, and synergistic scientific and professional networking, bringing conclusions and recommendations to the field

Therefore, the submissions are welcomed in following topics:

- (i) **CHEMICAL THREATS...**
- (ii) **ADVANCED DETECTION & IDENTIFICATION ...**
- (iii) **MOBILE LABORATORIES & BENEFITS ...**
- (iv) **ESR INVESTIGATORS**

On behalf of the Scientific-Organizing Committee of **International Workshop on Advanced Technologies and Mobile Laboratories for Countering Chemical Threats**, I am honoured and pleased to invite you to support the Workshop with your esteemed presence from **3rd November to 5th November 2025** in Radisson Blu Hotel, Split, Croatia.

Looking forward to welcoming you at the **SPS ARW 2025** in **Split**!

Chair of the SPS ARW 2025 Split

assoc. prof. dr. Vilko Mandić



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#SCHEDULE

Monday, November 3 rd 2025	Tuesday, November 4 th 2025	Wednesday, November 5 th 2025
08:30 Registration (30 min)	08:30 Registration (30 min)	08:30 Registration (30 min)
09:00 WELCOME CEREMONY BALLROOM (30 min) Chair: V. Mandić Opening info (10 min) V. Mandić, D. Jozić Chairmen + Dean – Workshop opening Welcome lecture (20 min) Eyüp Turmus Welcome lecture	09:00 Session PLENARY 2 OLEANDER (60 min) Chair: A. Abdelghani PL2 (25+5 min) Eduard Illobet Unattended wireless sensing networks for warfare agent detection	09:00 Session ADV. DETECTION & IDENTIFICATION 3 BALLROOM (52 min) Chair: L. Panžić 09:00 IL18 (15+3min) Jeremy Van Auker Benchtop-grade science in a field-deployable solution: Portable mass spectrometry, FTIR, and Raman technologies for mobile lab applications
09:30 Session PLENARY 1 (30 min) Chair: N. Lightfoot PL1 (25+5 min) Mark Morgan The Role of the Mobile Forensics Laboratory in Chemical Attack Site Forensic Operations	09:30 PL3 (25+5min) Fabiana Arduini Paper-based electrochemical (bio)sensors as smart, sustainable, and robust advanced detection and identification systems	09:18 IL19 (15+3min) Anders Östlin Experiences of Swedish chemical deployable laboratory
10:00 Coffee break 1 (30min) in front of BALLROOM	10:00 Coffee break 3 (30min) in front of OLEANDER	09:36 IL20 (15+3min) Jean-Charles Quevillon The French mobile laboratory experience
10:30 Session CHEMICAL THREATS 1 Room BALLROOM (133 min) Chair: P. Hotchkiss KL1 (20+5 min) Nigel Lightfoot The importance of networking for mobile chemical laboratories	10:30 Session ADV. DETECTION & IDENTIFICATION Room OLEANDER (133 min) Chair: E. Illobet KL3 (20+5 min) Janez Zavašnik Plasma-engineered lightweight composite materials for broadband electromagnetic wave absorption	09:52 Coffee break 5 (38min) in front of BALLROOM
10:55 IL1 (15+3min) Benjamin Trump Overcoming Friction in Biotechnology Deployment: Pathways to Interoperability for Advanced CBRN Countermeasures	10:55 IL8 (15+3min) Ines Primožič Harnessing Heterocyclic Compounds to Target Cholinesterase Activity	10:55 IL21 (15+3min) Vasile Panainte Strengthening national resilience by using a chemical mobile laboratory in the response to chemical threats
11:13 IL2 (15+3min) Said Galai Biofriendly decontamination of chemical warfare agent simulant using ionic liquid and enzyme	11:13 IL3 (15+3min) Michael Gallagher Raman and FTIR Spectroscopy for military personnel and first responders countering chemical threats	11:13 IL22 (15+3min) Sarah Brewer The 80% solution: balancing integrity and decision making in mobile labs in field-based chemical, biological, radiological and nuclear (CBRN) response
11:31 IL9 (15+3min) Ivana Panžić Nitride Quantum Dots for Rapid and Sensitive Explosive Detection	11:31 IL10 (15+3min) Kwang-Un Jeong Anisotropic liquid crystal networks from programmed reactive mesogens for optical applications	11:31 IL23 (15+3min) Edoardo Cavalieri d Oro Integration of mobile laboratories within a detection sampling and monitoring capacity: the case of the new European capacity designed by Italy called resCEU CBRN-DSIM-IT
11:49 IL4 (15+3min) Laura Marshall Sampling strategies and challenges after a chemical event	11:49 IL11 (15+3min) Behi Syrine Graphene-based gas sensors for real time detection of chemical threats	11:49 IL24 (15+3min) Taoufik Bouayoun Contribution of Forensic Institute of Gendarmerie Royale (ICGR) to chemical counterproliferation
12:07 IL5 (15+3min) Mirna Maravić Implementation of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons by the Ministry of Economy in Croatia	12:07 IL12 (15+3min) Francesca Petronella Plasmonic nanoplateforms as novel optical diagnostic tools in a one-health perspective	12:07 IL25 (15+3min) Beatriz Ambrosio Development and commissioning of mobile laboratories
12:25 IL6 (15+3min) Zrinka Kovarik An overview on recent advancement in biomedical countermeasures on organophosphorus nerve agents	12:25 IL13 (15+3min) Thomas Elßner Detection of current CWA threats by mobile sensors in the field	12:25 IL26 (15+3min) Matteo Guidotti Bridging the gap between labs and incident sites: pros and cons of advanced mobile CBRN laboratories
12:43 Lunch 1 (77 min) Restaurant FIG LEAF	12:43 Lunch 2 (77 min) Restaurant FIG LEAF	12:43 Lunch 3 (77 min) in front of BALLROOM
14:00 Session PANEL BALLROOM (90 min) Chair: L. De Sio Moderated (U-shape): presenting their concerns or challenges. Topic 1: Systems to be addressed, concerning the priorities? Topic 2: The role of the mobile labs in addressing priorities? Topic 3: Challenges to increasing viability of the mobile labs? Topic 4: The role of networking events, such as this one? Topic 5: Bottlenecks?	14:00 Session ADV. DETECTION & IDENTIFICATION OLEANDER (115 min) Chair: L. Marshall KL4 (20+5min) Adnane Abdelghani Nanotechnology for advanced detection and identification of chemical threats	14:00 Session ROUND TABLE BALLROOM (60 min) Chair: N. Lightfoot Moderated (U-shape): underline talks; conclude: T1: Mobile chem. labs play an important role for increasing security. T2: Mobile chem. labs need internal national governmental support. T3: Workshops, are essential for strengthening networking. T4: The high level of communication proves Workshop a success. T5: This workshop should be extrapolated into an annual event.
15:30 Session CHEMICAL THREATS 2 BALLROOM (43 min) Chair: M. Morgan KL2 (20+5 min) Peter Hotchkiss Advances in science and technology: opportunities for and risks to the implementation of the Chemical Weapons Convention	14:30 IL14 (15+3min) Anton Köck Advanced gas sensing detection based on simultaneous thermal and optical activation of nanomaterials 14:48 IL15 (15+3min) Vilko Mandić Nanostructured gas sensors for detection of chemical threats 15:06 IL16 (15+3min) Maria P. P. Iritia Nanostructured Materials for SERS based Gas Sensing of CWAs 15:24 IL17 (15+3min) Zvonko Orehovec Comprehensive Crisis Management and Safety Innovations in CBRN	15:00 Technical break (60 min)
15:55 IL7 (15+3min) Alyssa Walsh Management of Chemical threats	15:42 Technical break (18 min)	
16:13 free time (47 min)	16:00 Session POSTERS – Working Coffee break 4 in front of OLEANDER (30 min) J. Hyeon: Natural Rubber-Based Stretchable Heat Transfer Materials D. Yu: Triphenylamine-based electrochromic films for smart information encryption system J. Jang: Nanostructured Fluorescent Films via Self-Assembly for Acid Vapour Monitoring M. Rim: Interfacial Phonon Engineering in Polymer Composites Using Reactive Mesogens M. Oh: Light-Responsive Ionic Skins for Conductivity Switching and Shape Actuation via Azobenzene Mesogens Y. Wi: Zwitterionic Interlocking Enables Polarization-Dependent Photochromism and Ionic Switching in Diarylethene-Based Smart Films D. Gašparić: Development of next-generation solar cells for environmentally sustainable energy production G. Mihalinec: Enabling Reversible Chemistry in Calcium Batteries through SEI Design I. Curčić: Removal of chemical warfare agent simulant using reverse osmosis membranes: Investigation of efficiency and separation mechanisms F. Zaccagnini: Development of next-generation solar cells for environmentally sustainable energy production A. Avitabile: Selective detection of SARS-CoV-2 spike protein via biofunctionalized gold nanorods	16:00 Session WALKING CITY TOUR (120 min) Working Coffee break 6 Vans from Radisson at 15:40 & 15:50 start from Prokurative at 16:00
17:00 Session VISITS – Working Coffee break 2 (30+30 min) Laboratory tour to KTF chem laboratories starting in front of the KTF (link): Vans from Radisson at 16:50 17:00 Group 1 (30 min) Dražan Jozić Vans from Radisson at 17:20 17:30 Group 2 (30 min) Dražan Jozić (dean – Visit to laboratories opening)	16:30 free time (180 min)	
18:00 free time (90 min)	19:30 Dinner (90 min) Dinner at Restaurant FIG LEAF	18:00 free time (90 min)
19:30 WELCOME RECEPTION addressing of the Distinguished Guests (5 min) (150 min) Dinner at Restaurant FIG LEAF		19:30 CLOSING REMARKS (5 min) WORKSHOP GALA DINNER (150 min) Dinner at Restaurant TRITON

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ABSTRACTS:

PLENARY



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Section: (iii) Mobile Laboratories

The Role of the Mobile Forensics Laboratory in Chemical Attack Site Forensic OperationsMs. Alyssa Walsh¹, **Mark Morgan, PhD²**alyssa.g.walsh2.civ@mail.milmark.j.morgan10.ctr@mail.mil¹ Defense Threat Reduction Agency, Global Threat Reduction Directorate (DTRA GT), 8725 John J Kingman Road MSC 6201, Fort Belvoir, Virginia 22060-6201, USA² A&AS Contractor, Defense Threat Reduction Agency, Global Threat Reduction Directorate (DTRA GT), 8725 John J Kingman Road MSC 6201, Fort Belvoir, Virginia 22060-6201, USA**Abstract**

A credible threat of attribution is key to preventing the use of Chemical Weapons. Accordingly, attribution of the use of chemical warfare agents (CWAs) and other chemicals of security concern (CoSC), supported by chemical forensics, is increasingly of interest to the international community. Mobile laboratories, as national assets, play a key role in supporting the chemical attack site operational component of the chemical forensics and attribution international process. After the introduction of a brief, scene-setting chemical attack scenario, this oral presentation provides a synopsis of the realistic role of mobile laboratories related to forensic operations, investigations, and evidence collection at a chemical attack site while maintaining unassailable standards. The discussion recommends operational activities or components that support the three operational phases of site operations – preparedness, on-site activities, and post-operational activities.

Preparedness examines certifications and training records (e.g., HAZMAT and forensic evidentiary standards); standard operating procedure components (e.g., sampling protocols and analytical equipment calibration); equipment socks and supplies (e.g., sealable and impermeable sample containers); and the importance of joint training, exercises, and prior coordination with the first responder community (especially law enforcement, emergency medical services, and hazmat).

On-site activities addresses interfacing with first responders (e.g., coordination requirements and incident management [command] structure, operational priorities, and site access); site forensics operations plan documentation requirements (e.g., health and safety plan; sampling or collection plan; chain of custody; and photographic evidence log); the types of samples and their use (e.g., public health and safety, consequence management and restoration, and evidentiary); and personnel and sample packaging decontamination protocols.

Post-operational activities explore the laboratory's role related to post operational documentation review, debriefings, remediation/restoration efforts, and evidence transfers/chain of custody, including interfacing with OPCW designated and other "fixed" laboratories.

The presentation concludes with a discussion of operational lessons learned, best practices, and recommendations related to the essential role of mobile chemical laboratories related to chemical forensic operations at chemical attack site as part of an attribution-enabling or prosecution supporting evidentiary package and the ultimate remediation of that site.

Keywords

forensics, attribution-enabling, evidence, preparedness, operations, chain-of-custody



Section: (ii) Advanced Detection and Identification

Unattended wireless sensing networks for warfare agent detection

Eduard Llobet^{1,2,3}eduard.llobet@urv.cat¹ Universitat Rovira i Virgili, MINOS, School of Engineering, Avda. Països Catalans 26, 43007 Tarragona, Spain² TecnATox - Centre for Environmental, Food and Toxicological Technology, Universitat Rovira i Virgili, Avda. Països Catalans 26, 43007 Tarragona, Spain³ IU-RESCAT, Research Institute in Sustainability, Climatic Change and Energy Transition, Universitat Rovira i Virgili, Joanot Martorell 15, 43480 Vila-seca, Spain**Abstract**

The development of unattended wireless sensing networks for detecting warfare agents is an attractive approach, as it would enable monitoring large areas with high granularity. This would help not only protecting both key infrastructures and soft targets against terrorist attacks, but also would provide a fast warning to deploy early responders in a more effective way. To deploy such a network with high granularity implies developing power-lean, highly selective sensors. In this talk I will critically review the efforts made in the last years for developing nanomaterials and solid-state gas sensors for the detection of warfare agents, identifying currently experienced shortcomings and indicating possible research directions to try overcome these. Figure 1 illustrates the general architecture of such a sensing network and shows a typical case-use scenario for the protection of a soft target.

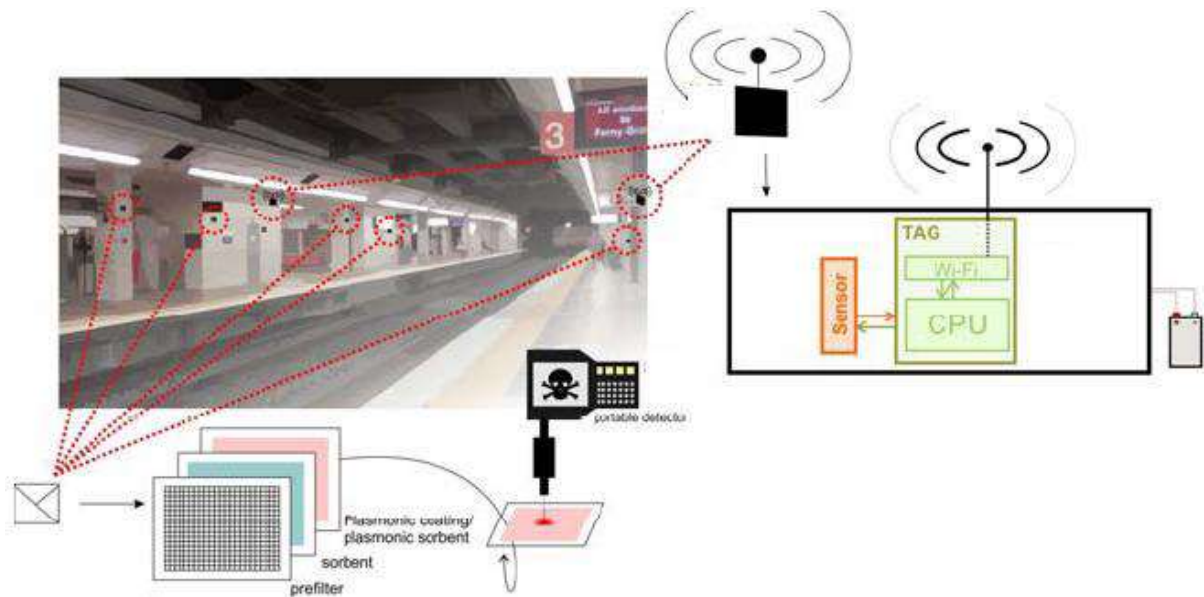


Figure 1. Example of an unattended wireless sensing network deployed to protect transport

Keywords

solid state gas sensor; warfare agent; wireless sensing network; gas sensitive

Acknowledgement

This work was financially supported by the European Commission, Innovation Staff Exchange (RISE) under Grant H2020-MSCA-RISE-2018-823895 "SENSOFT", and by the Agencia Estatal de Investigación (AEI) and FEDER under grant no. PID2022-142451OB-C21.



Section: (ii) Advanced Detection and Identification

**Paper-based electrochemical (bio)sensors as smart, sustainable, and robust
advanced detection and identification systems*****Fabiana Arduini*¹**fabiana.arduini@uniroma2.it¹ University of Rome Tor Vergata, via della ricerca scientifica, 00133, Rome, Italy**Abstract**

As reported in my review entitled "Electrochemical paper-based devices: When the simple replacement of the support to print ecodesigned electrodes radically improves the features of the electrochemical devices" published in Current Opinion in Electrochemistry SI: Emerging Opinions (2022) [Arduini, F. Curr. Opin. Electrochem. 2022, 101090] "*Paper-based electrochemical (bio)sensors have emerged as highly attractive analytical devices for their superior sustainable features, such as avoiding the use of polyester as support and the reduction of waste, being incinerated after use. However, paper-based electrochemical (bio)sensors have recently demonstrated further advantages, including the simple combination with vertical microfluidics and their use as a reservoir to deliver smart electrochemical (bio)sensors able to i) contain the reagents, ii) preconcentrate the target analyte, and iii) synthesize the nanomaterials inside the paper network. Furthermore, these devices have demonstrated their ability to overcome the limitations of the other printed electrochemical sensors in the measurement of entirely liquid samples by detecting the target analyte in the aerosol phase or solid sample, without the additional sampling system. These achievements highlight their valuable and varied advantages in the sensing sector*". In this presentation, I will report on the paper-based electrochemical (bio)sensors applied in the defence field developed in the last 10 years in my group, including the recently developed origami paper-based biosensors for SARS-CoV-2 on the surface and the electrochemical paper-based sensor for the essential oil detection to evaluate the efficacy of antimicrobial functionalized materials.

Keywords

Chemical warfare agents; biological warfare agents; viruses; essential oils.

Acknowledgement

This work was financially supported by the Horizon Europe Reliance Project grant agreement N. 101058570.



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ABSTRACTS:

KEYNOTE



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Section: (iii) Mobile Laboratories

The importance of networking for mobile chemical laboratories**Dr. Nigel Lightfoot CBE¹**nigel@nlassociates.co.uk¹ NATO, Boulevard Leopold III, Brussels, Belgium**Abstract**

The threat exists; malicious release of dangerous chemicals could happen at any time. Countries are at war and desperate measures could be contemplated. Some countries having assessed the risks plan to transport samples to a central testing laboratory, but deployable mobile chemical laboratories provide a unique solution to identification and containment of a malicious chemical threat.

They can be deployed rapidly to the scene of a suspected incident and provide near site testing in a secure and safe environment for the laboratory operatives. Being at the scene of an incident allows repeated testing on a timeline leading to a better assessment of changing risks. Remember that the continued sampling of an affected area will often be required

However mobile chemical laboratories come with their challenges. First of which is the design and build, these laboratories are by their very nature and purpose very complicated pieces of equipment. Containing advanced chemical analytical equipment, sophisticated safety and atmosphere control systems. Expert commissioning is required, maintenance contracts for the laboratory and its equipment will need to be in place. Training of the operational crews is necessary with repeated training and exercises on a regular basis in order to ensure 24/7 operational readiness. Finally, quality control and a quality assurance programme will be essential. It is a big challenge and should not be taken lightly when making the decisions to go down this route.

Sustaining the capability and capacity becomes vital after the heavy investment that has been made. Creating a network of mobile chemical laboratory users will provide the opportunity for those users to share their experiences and problems, take part in joint exercises and create synergies in a very niche field. I will describe the networks that I have managed and their achievements.

Keywords

mobile chemical laboratories; chemical threat response; operational readiness; quality assurance

Acknowledgement

This work was financially supported by the NATO SPS ARW grant G7975.



Section: (i) Chemical Threats

**Advances in science and technology: opportunities for and risks to the
implementation of the Chemical Weapons Convention****Peter Hotchkiss¹**peter.hotchkiss@opcw.org¹ Organisation for the Prohibition of Chemical Weapons, Johan de Wittlaan 32, 2517 JR, The Hague, The Netherlands**Abstract**

Ongoing advances and innovation in science and technology necessitate continuous monitoring by the Organisation for the Prohibition of Chemical Weapons (OPCW) to understand any impacts on the operation and implementation of the Chemical Weapons Convention (the Convention). The OPCW Scientific Advisory Board (SAB), a scientific advisory mechanism whose establishment is mandated by the Convention, is the cornerstone of this process. The Board, comprising 25 esteemed experts from OPCW Member States, reviews developments of science and technology and provides advice and recommendations to the OPCW Director-General, who can then appropriately advise OPCW Member States.

The SAB has recently noted some general trends regarding current advances in science and technology. There is an unprecedented pace of development, and increasingly blurred boundaries between the physical, biological and digital realms, leading to expedited technology convergence and/or transfer between sectors. All of this is benefitting, and benefiting from, increasingly affordable and performant equipment, with flexibility of application. Developments in science and technology present an ever-changing set of both challenges and opportunities regarding the Convention.

For example, there is much discussion these days of the risks of AI. Its ability to predict data could be misused to quickly and easily design new toxic chemicals or to identify novel pathways to known chemical warfare agents, including biotoxins, possibly circumventing the schedules. Automated synthesis by using laboratory robots could reduce some of the handling issues associated with the production of toxic chemicals, allowing less skilled operators to produce them. And AI could also be used to rapidly and indiscriminately spread misinformation and disinformation, undermining the Convention and the work of the OPCW.

AI may also present many opportunities. It is a powerful tool for data prediction and perhaps it could be leveraged to design new ways to destroy or neutralise chemical warfare agents. Automated laboratories can increase safety by removing the operator from the hazard, facilitating research efforts. There are also many exciting possibilities to leverage AI in developing medical countermeasures.

This talk will outline the OPCW and its work, as well as the importance of the SAB in its monitoring of science and technology of relevance to the Convention. An overview will be given on the technologies that the SAB is monitoring, noting both the opportunities and risks they may present.

Keywords

OPCW; Chemical Weapons; Science; Technology



Section: (ii) Advanced Detection and Identification

Plasma-engineered lightweight composite materials for broadband electromagnetic wave absorption

Janez Zavašnik¹, Neelakandan Marath Santhosh¹, Uroš Cvelbar¹

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Abstract

The demand for lightweight and highly efficient materials for terahertz (THz) technologies in security, non-destructive sensing, and next-generation communications is driving innovation in the synthesis of advanced nanocomposites. A plasma-enabled approach enables the one-step formation of ternary structures comprising nitrogen- or boron-doped graphene nanosheets, magnetic nanoparticles (e.g. Fe, Ni), and extends on applications of plasma-modified nanocellulose [DOI: 10.1016/j.apsusc.2024.161698]. With the plasma-assisted synthesis and modification, we ensure controlled surface functionalisation and carbonisation, precise control of metallic nanoparticle anchoring, dopant distribution, and/or surface morphology, without use of hazardous chemicals or multi-step chemical reduction procedures [10.1016/j.cej.2023.143213].

The targeted electromagnetic performance focuses on absorption-dominant shielding behaviour over a broad frequency range across 2–28 GHz and 91–96 GHz bands, which are relevant to both civil wireless technologies and defence radar systems. Theoretical and spectroscopic studies support optimised impedance matching through synergistic dielectric and magnetic loss channels. In particular, our recent experimental work demonstrated plasma-driven tuning of dielectric permittivity in graphene, achieving subunitary and even negative permittivity values across the microwave frequency range, which is attributed to nitrogen doping and surface plasmon resonance effects [DOI: 10.1002/sml.202470209]. Up to now, our preliminary results point toward a robust strategy for realising stealth-enhanced, frequency-tuneable EM absorbers for both civilian electronics and defence platforms.

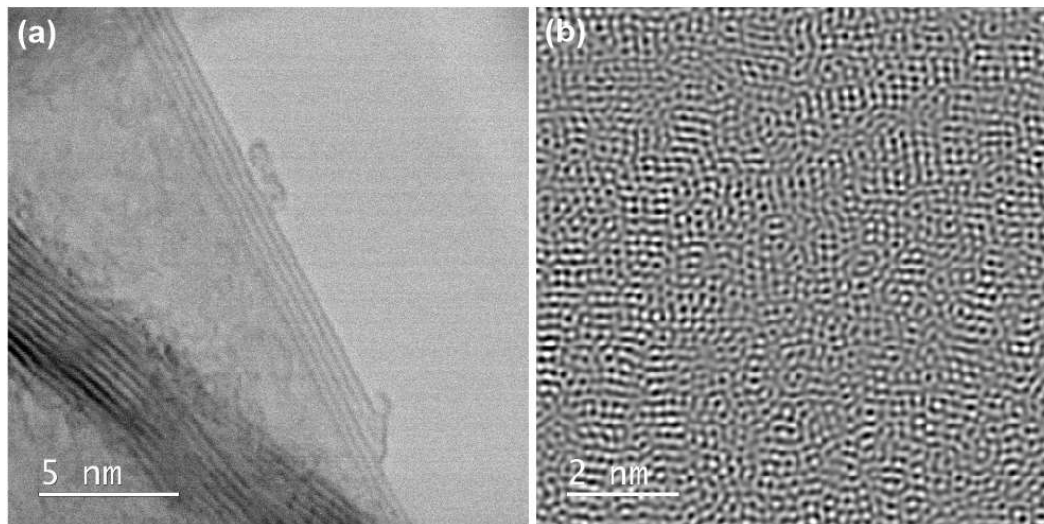


Figure 1. BF-STEM micrographs of carboniferous plasma-synthesized nanostructures. (a) fine edge structures developed in few-layer-nanocomposite; (b) structural modifications of few-layer-composite; IFFT BF-STEM.

Keywords

Graphene composites; Electromagnetic shielding; Plasma synthesis; Radar absorption

Acknowledgement

This work is financially supported by the NATO SPS project #G7918 – Advanced Electromagnetic Graphene-based Shields via Plasma Induced Synthesis (AEGIS).

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Section: (ii) Advanced Detection and Identification

Nanotechnology for advanced detection and identification of chemical threats***Abdelghani Adnane¹, Behi Syrine¹***adnane.abdelghani@insat.rnu.tn¹ University of Carthage, National Institute of Applied Science and Technology, Bp676, Centre Urbain Nord, 1080 Charga Cedex, Tunisia.**Abstract**

The demand for highly functional chemical gas sensors has surged due to the increasing awareness of human health to monitor metabolic disorders or non communicable diseases, safety measures against harmful greenhouse, gas leakage, chemical threats, and determination of food freshness. The most analytical instrument for chemical threats detection and identification are based on handle Fourier Transform Infra-red spectroscopy, Raman Spectroscopy, Ion Mass Spectrometer (IMS) and Gas Chromatography coupled Mass spectrometer (GC-MS) techniques. These techniques are time consuming, expensive and unsuitable for real time remote sensing. Nanotechnology has potential applications across many defensive and offensive weapons areas. It is not a discrete technology; rather, in dealing with matter at the molecular scale, it spans the fields of physics, biology, and chemistry. Nanotechnology offer alternative solution for the development of Quantum dots (QDs) for detecting chemical threats due to their enhanced fluorescence and sensitivity. They can be used in various sensor applications, including detecting pesticides in food, environmental pollutants, and even biological threats. In recent years, considerable efforts have been devoted to developing strategies for the development of low cost IoT (Internet of Thing) solution based on communicated multiplexing chemical sensors embedded on microcontroller with artificial intelligence algorithm on the Edge enabling discrimination and identification of gas. The back end sensor fabrication approach based on CMOS technology can offers rapid, sensitive, simple and low-cost on-site detection capability that would meet the requirements. The use of new technology devices for the detection and identification of chemical threats has become a matter of interest for the international community.

Keywords

nanotechnology, multiplexing gas sensors, detection and identification, chemical threats

Acknowledgement

This work was financially supported by the Science for Peace and Security Program of the North Atlantic Treaty Organization under grants no.SFP983115, SFP984511 and SFP G5571.

*This workshop
is supported by:***The NATO Science for Peace
and Security Programme**



Section: (ii) Advanced Detection and Identification

Next-generation colorimetric biosensors for real-time detection of harmful pathogens in drinking water

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Abstract

Monitoring the quality of drinking water is essential to protect consumers and minimize potential risks to human health. Biosensors are analytical tools that can track biological entities using physical mechanisms. Recently, nanotechnology-inspired biosensors have garnered significant attention due to their versatility and adaptability in detecting biological and chemical substances. In this context, international collaboration between Sapienza University of Rome (Italy) and Jeonbuk National University (Republic of Korea)—supported by the Air Force Research Laboratory (USA) as an end-user and enhanced by the NATO-SPS Programme—has led to the development of innovative real-time biosensors useful to be utilized as early-warning systems. These biosensors can be used as early warning systems to detect the presence of bacteria or viruses in drinking water within a short timeframe, often just a matter of minutes. These advancements have been made possible by integrating advanced materials, including immobilized and bioactivated gold nanoparticles, as well as smart, responsive materials such as liquid crystals. This presentation explores these remarkable achievements, highlighting a new approach to monitoring water quality through the creation of a new class of real-time biosensors.

Keywords

Biosensors; pathogens; potable water; early warning systems.

Acknowledgement

This work was financially supported by the "NATO - Science For Peace and Security Programme (SPS-G7425, CLC-BIODETECT).



3-5. November 2025. Hotel Radisson Blu Split, Croatia

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International Workshop on Advanced
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ABSTRACTS:

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Section: (i) Chemical Threats

Overcoming Friction in Biotechnology Deployment: Pathways to Interoperability for Advanced CBRN Countermeasures***Benjamin Trump***Benjamin.D.Trump@usace.army.mil¹ University of Michigan School of Public Health, Ann Arbor, USA**Abstract**

Countering the disruptive impact of CBRN threats demands not only advanced technologies but also the ability to rapidly deploy them into complex, often international, operational environments. While the development of mobile laboratories and field-deployable diagnostics represents a significant technological leap, their effective use is often hindered by systemic friction in biotechnology interoperability. This friction—arising from misaligned national regulatory frameworks, divergent risk cultures, and a lack of harmonized technical standards—creates significant barriers to the seamless forward deployment of critical CBRN countermeasures. This presentation will synthesize findings from previous NATO Advanced Research Workshops in Malta (on biomanufacturing and trade standards) and Qatar (on biosurveillance and regional cooperation) to analyze these interoperability challenges.

Drawing on a systems-based approach, this analysis will identify the key sources of friction that impede the agile deployment of biotechnologies. These include inconsistencies in product validation and safety protocols, a lack of common data standards for sharing analytical results from mobile labs, and differing national priorities that complicate international logistics and technology transfer. The presentation will then explore potential pathways to enhance interoperability, moving beyond purely technical solutions to address the underlying governance and policy gaps. Key recommendations will include the adoption of internationally recognized frameworks like Biomanufacturing Readiness Levels (BRLs) to create a common language for technological maturity, the development of principles-based governance for dual-use technologies to foster regulatory trust, and the creation of regional partnerships to pre-position capabilities and streamline deployment protocols. By understanding and addressing these sources of friction, the Alliance and its partners can create a more agile and resilient ecosystem for deploying advanced biotechnologies, ensuring that mobile laboratories and other critical assets can be brought to bear against CBRN threats with the speed and efficiency required.

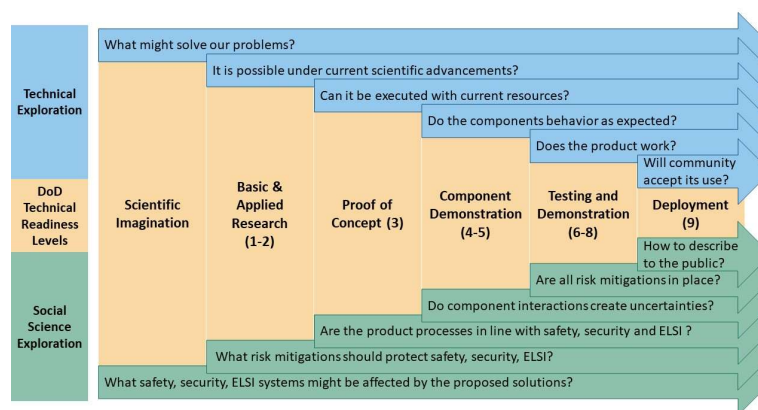


Figure 1. (a) Fusing TRLs with bilateral/multilateral policy requirements for forward deployment of biotechnology.

Keywords

Biosurveillance, Interoperability, Risk Governance

Acknowledgement

Support is acknowledged from USACE ERDC and OUSD(R&E) Office of Biotechnology.



Section: (ii) Advanced Detection and Identification

**Biofriendly decontamination of chemical warfare agent simulant using
ionic liquid and enzyme*****Said Galai^{1,2}, Sihem Haj Kacem¹, Rafaela Silva³, Andreia Rosatella³, Carlos Afonso⁴, Ines Cruz⁵, Pedro Neto⁵, Souheil Omar¹, Karim Ben Ali^{6,7}***said.galai@fmt.utm.tn¹ National Institute of Neurology Mongi Ben Hmida, Laboratory of Clinical Biology, (LR18SP04), Rue Jebbari La Rabta, 1007, Tunis, Tunisia² University Tunis El Manar, Faculty of Sciences of Tunis, Department of Biology, Campus Universitaire Farhat Hached, El Manar I, 2092 Tunis, Tunisia³ University of Lusófona, CBIOS- Research Center for Biosciences and Health Technologies, 1749-024 Lisbon, Portugal⁴ University of Lisbon, Research Institute for Medicines (iMed.Ulisboa), Faculty of Pharmacy, 1649-003, Lisbon, Portugal.⁵ UMLDBQ - Unidade Militar Laboratorial de Defesa Biológica e Química, Exército Português, Av. Dr. Alfredo Bensaúde 8A, 10 piso, 1849-012 Lisboa, Portugal⁶ CBRNe Research Team of ballistics and countering, Science and Technology for Defense Lab (STD), Tunisian Military Research Center (CRM), Military base Aouina, 2045 Tunis, Tunisia⁷ Tunisian Air force, School of Aeronautical Specialties, Sfax Air Force Base, Route Soukra Thyna, 3083, Sfax, Tunisia**Abstract**

In order to develop an efficient multipurpose catalytic system, Laccase, a versatile oxidoreductase with wide substrate range spectrum, has been selected to be the center of this system. In the first stage, it was needed to enhance the laccase activity, hence some ionic liquids (IL) have been screened in the reaction media to increase the catalytic ability and the stability of the enzyme [DOI.org/10.26434/chemrxiv-2024-g5595]. Choline based ILs have shown great interest for these tasks: [Chol][Ac] and [Chol][H₂PO₄]. Among them, [Chol][H₂PO₄] have shown an impressive empowering effect of the laccase activity respectively 20-fold at 30°C and pH 7.0. This ionic liquid was used in combination with [Chol][Ac] to improve the stability of the enzyme during long term application at room temperature in aqueous medium and to resist to pH fluctuation which means to play a “buffer-empowering” role without need to adding supplementary salts. The focus on the two ionic liquids [Chol][Ac]/[Chol][H₂PO₄] have led to implement a new reactional medium composed by 50%-50% (v/v) of each ILs and with buffer-like characteristics and the ability to improve the laccase catalysis. Which was proven by direct reaction using specific substrates (ABTS) but it was also applied in indirect reaction using no-specific substrates (Glyphosate) and redox mediator. The redox mediator acetosyringone (ASGN) has been screened according to its electrochemical proprieties in accordance with laccase activity. The application of the catalytic system composed by new reactional medium (50%[Chol][Ac]/50%[Chol][H₂PO₄]), the laccase and ASGN on different no-specific substrates such Glyphosate (Gly), Hydroquinone (HQ) and dyes (Reactive Black 5 (RB5); Remazol Brilliant Blue R (RBBR)) has shown the efficiency of the system and its versatility. Subsequently it was dedicated to use special substrate the Bis-2-Ethyl-hexyl-Phosphite (BEHP), simulant of VX-Chemical Warfare Agent (CWA), which was demonstrated by spectrophotometric and electrochemical assays that it is possible to oxidase using the new versatile catalytic reactional medium.

Keywords

Catalysis; Laccase; Ionic Liquid; Chemical Warfare Agent

Acknowledgement

This work was financially supported by the projects SPS-NATO-G5713: “Biofriendly decontamination of Chemical Warfare Agents” (EnzIL) - <https://sites.google.com/view/enzil-sps-natoprogram/home>.



Section: (i) Chemical Threats

Raman and FTIR Spectroscopy for military personnel and first responders countering chemical threats

Michael Gallagher, Matko Jakobovic, Roel Crama

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Abstract

Military and civilian first responders confront evolving chemical and explosive threats that demand swift, accurate identification in the field. This presentation shows how handheld FTIR and Raman spectroscopy instruments capture unique molecular fingerprints and match them against reference libraries to deliver rapid, non-destructive analysis. Attendees will gain an overview of core FTIR and Raman principles, a comparison of their complementary strengths and limitations, and insights into frontline devices like the Gemini, TruDefender FTX, FirstDefender RMX, and Omega Defender. Real-world scenarios will illustrate dual-tech workflows that accelerate decision-making and bolster both responder and community safety.



Keywords

1st-Raman; 2nd-FTIR; 3rd- Frontline; 4th-Chemical Threats



Section: (ii) Advanced Detection and Identification

Sampling strategies and challenges after a chemical incident

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Abstract

The strategic response to a CBRN attack within the UK or towards UK assets overseas prioritises: 1) preserving life, 2) mitigating the hazard, 3) preventing further events, 4) return to normal, and 5) promotion of the UK and its interests. The ability to detect, identify, confirm and attribute a chemical following an incident is central to all of these activities. Dstl's CB analysis and attribution capability (CBAAC) provides the analytical response to support cross-government agencies following a chemical or biological incident. Sampling protocols have been established recognising that this represents a key step in the analytical process that ultimately enables the provision of robust evidence for decision makers at all stages following an incident. Any sampling of either physical evidence and/or contaminated environments must take into account the specific requirements of investigative leads, the context of the incident, sampling and analysis efficiencies and the degree of certainty required by the decision makers. Expert scientists at Dstl provide advice throughout the response, investigation and remediation of a chemical incident, to ensure all sampling strategies are constructed to enable useful and informative analysis and reporting. Research along with method development and validation activities conducted within the CBAAC includes a focus on sampling efficiency, matrix effects and limits of detection of tests, to ensure analytical techniques are applied appropriate for the types of tactical or strategic level questions being asked in this talk, case studies will be used to demonstrate effective sampling strategies following a chemical incident.

Keywords

Sampling strategy; detect; confirmation; analysis; attribution

Acknowledgement

This work was financially supported by the UK Ministry of Defence, Home Office and Defra.

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Section: (i) Chemical Threats

Implementation of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons by the Ministry of Economy in Croatia

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Abstract

The Ministry of Economy is the competent authority at the national level for the implementation of the Act on the Management of Chemicals Contained in the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (Official Gazette, No. 127/2013) and the Ordinance on the Management of Chemicals Contained in the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (Official Gazette, No. 34/2014).

The Ministry of Economy for the implementation of the international Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction is obliged, with the obligation to protect the confidentiality of the data obtained, to register each annual change in the situation for individual companies, in the production, processing, use, trade (import/export, transfer, purchase/sale and storage) of toxic chemicals and their precursors listed in Lists 1, 2 and 3, as well as in the production by synthesis of DOC/PSF chemicals and to report the same to the international Organization for the Prohibition of Chemical Weapons.

The Ministry of Economy maintains a Register of Users and End-Users of Toxic Chemicals and Their Precursors. The Register is a record containing data on all users and end-users of toxic chemicals and their precursors. Methods for forwarding the data obtained to the OPCW.

Collaboration is key. Collaboration between government bodies, the scientific community and the industry sector is paramount, and they can raise awareness and have a range of good methods and can work to maintain safety.

Keywords

Chemical Weapons Convention; Toxic chemicals and precursors; Ministry of Economy; Collaboration



Section: (i) Chemical Threats

An overview on recent advancement in biomedical countermeasures on organophosphorus nerve agents**Zrinka Kovarik**^{1,2}zkovarik@imi.hr¹ Institute for Medical Research and Occupational Health, Division of Toxicology, Ksaverska cesta 2, 10000 Zagreb, Croatia² University of Zagreb, Faculty of Science, Horvaticav 102, 10000 Zagreb, Croatia**Abstract**

Organophosphorus compounds (OPs), including pesticides and nerve agents, exert their toxicity by inhibiting acetylcholinesterase (AChE), the key enzyme responsible for terminating cholinergic transmission in the peripheral and central nervous systems through rapid hydrolysis of acetylcholine (ACh). AChE inhibition causes accumulation of ACh at synapses and neuromuscular junctions, leading to paralysis, seizures, respiratory failure, and death. Survivors of OP poisoning may also suffer long-term neurological impairments—such as cognitive and behavioral deficits—due to neurotoxic mechanisms that damage specific brain regions.

Current emergency treatment relies on a combination of an antimuscarinic agent (e.g., atropine), a pyridinium oxime reactivator of AChE (such as HI-6, 2-PAM, or obidoxime), and an anticonvulsant (e.g., diazepam). Many mono- and bispseudopyridinium oximes with quaternary nitrogen atoms have been developed and tested, yet they face significant limitations. Because of their permanent positive charge, they cross the blood–brain barrier (BBB) poorly and thus fail to effectively reactivate AChE in the brain. Moreover, no single oxime demonstrates broad efficacy against different OPs.

These challenges have motivated the development of next-generation AChE reactivators, including uncharged, protonable molecules capable of penetrating the BBB. In parallel, pseudo-catalytic scavenging strategies—where OPs are degraded by efficient reactivators in concert with plasma components—are being investigated as alternative treatments.

The recent use of A-series nerve agents (e.g., in the Skripal and Navalny poisonings) has underscored the urgent need for improved countermeasures, as conventional oximes are largely ineffective against these compounds. In this talk, I will highlight recent advances in antidote design and therapy, with emphasis on novel oximes that can cross the BBB and reactivate OP-inhibited AChE within the central nervous system. Such agents may achieve therapeutically relevant concentrations at both neuromuscular junctions and in the brain, offering the potential for significantly improved outcomes after OP poisoning.

Keywords

Acetylcholinesterase; OPCW; Antidotes; Nerve agents; Reactivation

Acknowledgement

This work was supported by projects BioMolTox and ReCIMI.



Section: (i) Chemical Threats

**Comprehensive Crisis Management and Safety Innovations in CBRNe -
Innovative Decontamination Strategies and Technologies for CBRNe Response****Zvonko Orehovec¹**zvonko.orehovec@gmail.com¹ DOK-ING, Slavonska avenija 22, HR-10000 Zagreb**Abstract**

Threats involving NBC weapons, selection of industries, warehouses and transport systems as military and terrorist targets, as well as natural and technological disasters and the consequences of their impact, are a source of potential modern CBRNE threats and extreme environmental conditions in which the action of the first response with human teams and crews is limited regarding time and space, and even impossible. This has changed the paradigm of the now traditional definition of the CBRN threat of NBC weapons, and thus the strategy of responding to these threats. Moreover, by expanding CBRN threats, in a narrower sense with CBRN weapons, to threats in a broader sense with CBRN weapons but also with CBRN technologies, the threat zone is expanded mainly to civilians, and thus the number of subjects of the civil defense system's first response is expanded. Case studies from the last 30 years undoubtedly point to the negative aspects of the changed paradigm, which are reflected in the impossibility of intervention or delayed interventions of the first response teams and units, which is why accidents are remedied with delay, they develop uncontrollably and are the cause of enormous human and material losses and damages, as well as catastrophic environmental impacts, and have an enormous political-economic-security impact on the further positive trend of globalization and the development of a secure society.

The only possible answer has proven to be the development of a multifunctional system that is, with the combination of remote control and autonomous functions, capable of the following in extreme environmental conditions: removing obstacles and dangerous objects in the direction of intervention, performing operational and medical survey task, CBRNE reconnaissance and monitoring, taking samples and other forensic evidence, performing CBR decontamination, demolition and neutralization of toxic industrial chemicals, performing firefighting operations, as well as self-decontamination. All the above actions, independently or networked with other air and ground platforms, are monitored, collected and recorded by an extended selection of detectors, sensors, cameras and devices linked by functional and analytical software. The data are delivered in real time to the CCE (C2) where they are processed, analyzed and converted into information and spatial awareness for the needs of first responders, the command and headquarters. The result is a timely and complete response to the threat, which incomparably more effectively protects human lives, tangible assets and the environment.

Keywords

UGV CBRN, Innovations, Crisis Management and Safety in CBRNe, Decontamination, CBRNe Response



Section: (i) Chemical Threats

Harnessing Heterocyclic Compounds to Target Cholinesterase Activity

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Abstract

Organophosphorus (OP) compounds, utilized as pesticides and developed as nerve agents, pose a significant global health threat, causing over 3 million poisoning cases annually. These compounds inhibit cholinesterases (ChEs) – acetylcholinesterase (AChE, EC 3.1.1.7) and butyrylcholinesterase (BChE, EC 3.1.1.8) – critical enzymes in the nervous system. Current antidotes rely on oximes, which reactivate phosphorylated ChEs, and carbamates, which protect against phosphorylation. However, a single, universally effective antidote remains elusive, driving the need for compounds with improved chemical, physical, and biochemical properties, and a deeper understanding of their enzyme interactions. This work details the design and synthesis of a series of novel imidazole, quinuclidine, cinchona-based oximes, *O*-alkyl oximes and carbamates representing a structural shift from existing clinical treatments. Structural diversity was introduced, to clarify differences in the inhibition and oxime reactivation potency. Comprehensive analyses, including molecular docking quantum chemical calculations, and quantitative structure-activity relationship (QSAR) modelling using extensive machine learning protocols, were performed to characterize their joint inhibitory and reactivatory potency against AChE and BChE. Computational studies within the QM/QM framework revealed key interactions between the compounds and the enzyme active site residues. Finally, the best possible regression models, validated by machine learning, were developed to facilitate the smart rational design of more potent compounds.

Keywords

Heterocyclic compounds; cholinesterase inhibition; oxime reactivation; prediction models



Section: (ii) Advanced Detection and Identification

Nitride Quantum Dots for Rapid and Sensitive Explosive Detection

Ivana Panžić¹, Floren Radovanović-Perić¹, Arijeta Baftić¹, Luka Pavić², Vilko Mandić¹ipanzic@fkit.unizg.hr¹ University of Zagreb Faculty of Chemical Engineering and Technology, Trg Marka Marulića 19, 10000 Zagreb, Croatia² Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia

Abstract

The ability to rapidly and accurately detect explosive compounds is essential for improving public safety, environmental protection, and security monitoring. Nitride quantum dots (NQDs) represent a new class of nanomaterials with remarkable stability, tuneable optical and electrical properties, and versatile surface chemistry. These features make them highly suitable for developing next-generation sensing technologies. This contribution presents recent advances in the use of NQDs for explosive detection, focusing on their performance in photoluminescence, electrochemical, and chemoresistive sensing modes. We discuss how their unique material characteristics enable faster response times, higher sensitivity, and improved selectivity compared to traditional materials. Finally, perspectives on future developments and potential real-world applications of NQD-based sensors are outlined, emphasizing their promise for safer and smarter detection technologies.

Keywords

chemoresistive sensors; quantum dots; nanomaterials

Acknowledgement

The authors acknowledge the financial support of MZO under the grant NPOO.C3.2.R3.-1.05.0091.



Section: (ii) Advanced Detection and Identification

Anisotropic liquid crystal networks from programmed reactive mesogens for optical applications

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¹ Jeonbuk National University, Department of Polymer Nano Science and Technology, Department of Nano Convergence Engineering, Jeonju 54896, Republic of Korea,

Abstract

Anisotropic liquid crystal (LC) networks prepared from reactive mesogens (RM) have numerous advantages in optoelectronic devices especially because of the excellent processability. To fabricate the robust LC thin films with excellent thermal, chemical and mechanical stabilities, the photo-polymerization of anisotropically pre-oriented RMs should be conducted on the optimized conditions. Since the final physical properties of anisotropic LC networks depend on chemical functions and physical intermolecular interactions, the hierarchical superstructures of the programmed RMs with specific chemical functions should be controlled on the different length and time scales before polymerization. The presentation describes the fundamental characteristics and recent research interests of anisotropic LC networks, elastomers and gels fabricated using various programmed RMs

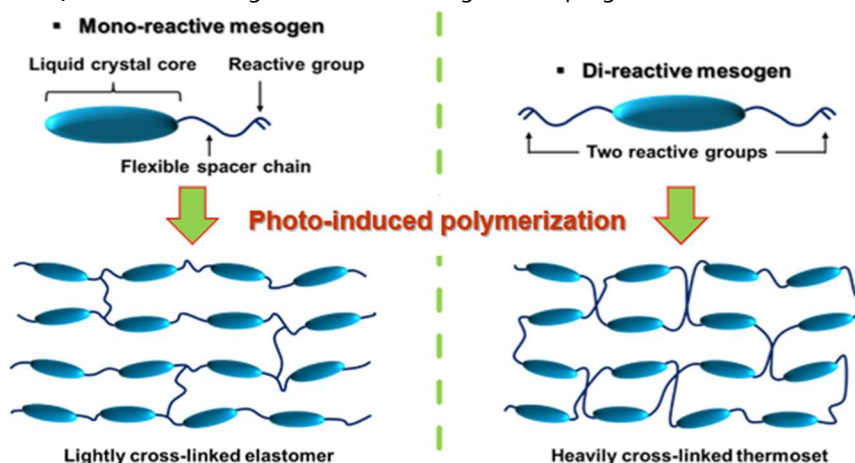


Figure 1. Anisotropic liquid crystal networks from coating, self-assembling and photopolymerization.

Keywords

1st-Liquid crystal; 2nd-Self-assembly; 3rd-Polymerization; 4th-Optical application

Acknowledgement

This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Graphene-based gas sensors for real time detection of chemical threatsSyrine BEHI¹, Adnane Abdelghani²syrine.bahi11@gmail.com¹ University of Carthage, National Institute of Applied Science and Technology, Bp676, Centre Urbain Nord, 1080, Charguia Cedex, Tunisia**Abstract**

The urgent need to detect toxic and hazardous gases such as ammonia (NH₃), carbon dioxide (CO₂), nitrogen dioxide (NO₂), as well as chemical vapours like benzene, toluene, and xylene, has sparked significant interest in the development of advanced chemical gas sensors. These gases pose serious risks to both human health and the environment, underscoring the need for real-time, sensitive, and portable detection systems. While traditional analytical techniques such as FTIR, Raman spectroscopy, IMS, and GC-MS offer high accuracy, they are often costly, time-consuming, and unsuitable for remote or on-site applications.

In response to these limitations, nanotechnology provides promising pathways for the design of smart chemical sensors with improved performance. Graphene, owing to its outstanding electronic, physicochemical, and mechanical properties, has emerged as a highly attractive material. To further enhance its gas detection performance, we have functionalised graphene with metal oxide nanoparticles, specifically tin dioxide (SnO₂) and tungsten trioxide (WO₃). Resistive measurements under various gas exposures demonstrate that these nanocomposites exhibit significantly improved sensitivity, faster response and recovery times, and better selectivity compared to pristine graphene.

Furthermore, we focus on the development of nano-enabled chemical sensors integrated into Internet of Things (IoT) systems. These sensors, based on advanced nanomaterials, are embedded in microcontrollers such as ESP32 and STM32. This integration supports rapid, low-cost detection of gaseous pollutants with real-time monitoring and wireless data transmission.

This nanomaterial-based sensing platform offers a robust, portable and scalable solution that meets the needs of deployable mobile laboratories. These systems are particularly relevant for improving rapid response performances to chemical threats. By combining nanotechnology, embedded systems, and artificial intelligence, our work contributes to the development of innovative platforms for efficient, on-site chemical detection in dynamic and high-risk environments.

Finally, we introduce the roadmap of MIGSens (Multiplexing Intelligent Gas Sensors), a pioneering start-up initiative in Tunisia dedicated to delivering intelligent, IoT-based gas sensing solutions for both strategic and civilian applications.

Keywords

Smart Gas Sensors; Graphene; Metal Oxide; Real-Time Chemical Detection; Embedded Systems

Acknowledgement

This work was financially supported by the Science for Peace and Security Program of the North Atlantic Treaty Organization under grants no. SPS G5571.



Section: (ii) Advanced Detection and Identification

Plasmonic nanoplatforms as novel optical diagnostic tools in a one-health perspective

***Francesca Petronella¹, Annalisa Masi¹, Maria Laura Sforza², Arianna Avitabile², Flaminia Pompeo¹,
Federica Zaccagnini², Luciano De Sio²***

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Abstract

The spread of infectious diseases is driven by current lifestyle paradigms and overpopulation, along with climate change and environmental issues that engender an ineluctable network involving human, environmental, and animal health.

To support both diagnostics and surveillance, fast, reliable and intuitive diagnostic tools are highly desired. In this framework, nanomaterials-based optical biosensors can offer an attractive perspective, particularly for biosensors based on metallic nanoparticles (M-NPs).

M-NPs exhibit the localised surface plasmon resonance phenomenon that makes their optical response dependent not only on their size and shape but also on the surrounding medium where M-NPs are dispersed. Remarkably, the chemical-physical properties of M-NPs enable a precise optical response in the visible and near-infrared spectrum of the electromagnetic radiation. For this reason, M-NPs are recognised as a promising building block for the realisation of optical transducers.

This contribution presents our recent results on the realisation of plasmonic nanostructures with excellent optical and morphological properties, suitable for fabricating optical biosensors, with a focus on gold nanorods. We discuss a deposition protocol purposely developed to immobilise M-NPs on rigid substrates, resulting in an M-NP array that can be activated with a biorecognition molecule, providing specificity toward the desired biological target. The shift of the longitudinal plasmon band, being more sensitive to refractive index variation, is selected as an optimal sensing parameter.

The proposed devices can also be beneficial for multiplexing pathogen detection and give rise to versatile optical devices for gene-sensing applications.

Keywords

Biosensing; plasmonics; optical transducers; one-health

Acknowledgement

This work was financially supported by EU funding within the NextGenerationEU-MUR PNRR Extended Partnership initiative on Emerging Infectious Diseases (Project no. PE00000007, CUP B53C20040570005 INF-ACT)



Section: (ii) Advanced Detection and Identification

Detection of current CWA threats by mobile sensors in the field

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Abstract

Bruker Detection offers a fully comprehensive range of state-of-the-art CBRN detection solutions that have been designed for use in a military context. All our users benefit from our provision of highly reliable and highly sensitive measurement technologies, each designed to support specific mission types, and to meet user's need for simplicity of deployment. The equipment is designed, built and tested to robust Military Standards (MIL-STD) as appropriate. The requirements for consumables and for general maintenance have been reduced to a minimum. Most consumables can be changed at operator level.

Our detection solutions include sensors based on mass spectrometry, ion mobility spectrometry as well as infrared (IR) spectroscopy. All devices have been designed to meet various mission requirements under harsh environmental conditions.

In addition to alarming on detection, all our chemical sensors are able to identify the threat and quantify the detected substances. By employing advanced and permanently improved compound libraries, our mobile detection systems reliably identify even new threats such as novel agents of the fourth generation. Bruker equipment is therefore the number one choice to be prepared for the future.

Bruker offers a wide range of equipment that can be integrated into various vehicle platforms and ships. Bruker is experienced as a prime contractor and can supply, support and deliver complete mobile platform solutions that meet user's requirements precisely.



Figure 1. Overview of Bruker Detection products, including RAPIDPlus, MM2, RAID-S2, RAID-M, RAID-XP.

Keywords

1st-CWA detection and identification; 2nd-Mobile sensors; 3rd-Vehicle platforms; 4th-Standoff detection



Section: (ii) Advanced Detection and Identification

Advanced gas sensing detection based on simultaneous thermal and optical activation of nanomaterials

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Abstract

We present an advanced gas sensing principle, which is based on simultaneous thermal and optical activation of nanomaterials. This is achieved by modularly combining LEDs and micro-hotplate-based gas sensor devices (Fig.1). We have investigated the sensing performance of different materials - bare CuO and SnO₂ ultrathin film sensors, and SnO₂ thin film sensors functionalized with Ag and Cu nanoparticles - towards different target gases - acetone, specific hydrocarbon mixture HC_{mix}, ammonia and carbon dioxide. LEDs with emission wavelengths of 415 nm, 395 nm, 365 nm, and 270 nm were employed for optical activation, which has a big impact on the sensor performance: For the CuO-based sensor, the response can be significantly increased through excitation by the 270 nm LED – up to 30 times for acetone - the higher the LED intensity, the higher the response. In contrast, for the SnO₂-based sensors the response is strongly decreased by light excitation – down to zero for the HC_{mix} - the higher the intensity, the lower the response. These results clearly demonstrate the potential of the dual thermal-optical excitation process as advanced gas sensing principle: Switching the sensor response “on” or “off” by light provides the possibility to achieve a high degree of selectivity. By specifically adjusting the optical activation conditions for the different sensor materials, we have achieved a high degree of selectivity for all four target gases. We are convinced that the combined thermal-optical excitation approach will boost the sensing performance of chemo resistive gas sensor devices for applications ranging from air quality monitoring and breath analysis to the detection of chemical threats.

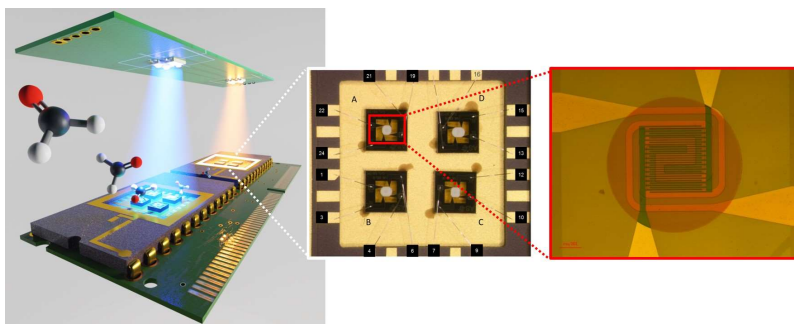


Figure 1. Advanced gas sensor system integrating LEDs and micro-hotplate-based sensor devices for simultaneous thermal and optical activation.

Keywords

Chemical Sensors; Nanomaterials; LEDs; Micro-hotplate devices

Acknowledgement

This work was financially supported under the scope of the project “Nano4E - Integrated thermo-optically activated Nanosensors for environmental monitoring”, which receives funding from the Austrian Funding Agency FFG (project No: FO999899024).



Section: (ii) Advanced Detection and Identification

Nanostructured gas sensors for detection of chemical threats

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Abstract

Downsizings and customisation of gas sensors drives towards various multi-scale systems. An example is merging gas sensing and energy conversion system, each reposing on separate components. Namely, multi-use systems are scarce. Here, we fabricated a composite where the photovoltaic consists of CdSe quantum dots embedded into cellulose microfibrils. The composite comprises sensing embedded into photovoltaic devices and presents a novel concept of a two-in-one sensor in a solar cell.

An aqueous CdSe-based synthetic pathway was tailored to better understand the interaction and functionality of the constituents. Electron microscopy provided initial morphologic and configurational hint. Moreover, EDS mapping pointed to a shift from fibrous to grainy appearance. Atomic force microscopy supported the FESEM results. Spectroscopy and diffraction analyses enabled clear understanding that constituents uniformly organise and homogenously distribute (size distribution below 10 nm), also enabling qualitative discrimination between samples. Several mechanisms govern charge transfer in the composite films, as suggested by the impedance spectroscopy. Significant temperature dependant conductivity behaviour related to the presence of hydroxyl groups and with mobility within cellulose polymer chains. Quantum dots positively facilitates transport properties, with conductivity in the air was higher by more than five orders of magnitude compared to conductivity in an inert atmosphere and instantaneous relaxation process.

Therefore, by implementing the quantum confinement phenomena in aforementioned cellulosic composites it is possible to tailor the sensing and photovoltaic performance of semiconducting materials.

Keywords

Gas sensors; Cellulose; Dual-use

Acknowledgement

This work was financially supported by the project C3.2.R3-1.05.0091.



Section: (ii) Advanced Detection and Identification

Nanostructured Materials for SERS based Gas Sensing of CWAs

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Abstract

In the 21st century, the key “4S” sensor performance parameters — sensitivity (limit of detection, LOD), stability (drift, reversibility), speed (response/recovery time), and selectivity (absence of cross-interference in target response) — have undergone remarkable improvements. Nevertheless, the reliable detection of specific components within complex environments, where multiple species may interfere, remains a major challenge for state-of-the-art chemical microsensors. According to the International Forum to Advance First Responder Innovation (IFAFRI), first responders (FRs) still need technologically advanced tools and equipment that are affordable, lightweight, easy to use and innovative to rapidly detect, identify and monitor (DIM) hazardous agents and contaminants on the scene in real time to facilitate timely and appropriate actions in the event of a chemical incident. As an analytical technique based on Raman scattering, Surface-Enhanced Raman Spectroscopy (SERS) allows for the identification of target molecules in complex mixtures, exploiting their unique molecular vibrational fingerprints in a nondestructive and multiplexed manner. Meeting specifications of end users whose capability gaps can be addressed by SERS is a way to move the field significantly forward.

However, the detection, identification, and monitoring of toxic and harmful gases at concentrations ranging from ppb to a few ppm, though essential to address major environmental challenges, remains technically demanding. The low gas density and the intrinsic surface selectivity of SERS substrates mean that only a few molecules per unit volume are available for detection. Another major limitation arises from the small Raman cross-section (RCS) of nerve agents — up to seven orders of magnitude lower than that of standard SERS probes — which severely limits scattering efficiency.

Therefore, while rational design of metallic nanostructures remains a fundamental aspect of SERS performance, in the case of gas-phase SERS sensing, the development of strategies to confine gas molecules near the plasmonic surface becomes crucial. To date, there are few reported examples of label-free SERS gas detection, even at ppb levels, based on direct interaction with the bare metallic surface. Micro and mesoporous materials present a great potential to develop efficient SERS platforms for gas sensing because of its huge and highly ordered porosity available for selective adsorption and preconcentration. Our strategy is based on the synergistic integration of gold nanostructures (0D or 1D) with nanoporous materials such as metal–organic frameworks (MOFs) and mesoporous silica. Methodologically, it involves the use of rigid or flexible SERS substrates based on these hybrid nanostructures, where gas sampling is performed directly from the ambient atmosphere. The limit of detection and response time are primarily determined by the adsorption probability of the analyte on the SERS-active surface, underscoring the importance of optimized surface functionalization and precise control of fluid dynamics to enhance SERS activity. Within this framework, our main advances will be briefly reviewed.

Keywords

Surface Enhanced Raman Spectroscopy; plasmonic nanostructures, nerve agents, gas phase, trace level, Lab on a chip SERS

Acknowledgement

This work was financially supported by the European Union’s Horizon 2020 research and innovation program under grant agreements No. 883390 (H2020-SU-SECU-2019 SERSing Project), No. 823895 (H2020-MSCA-RISE-2018 SENSOFT), AEI Spain (PID2019-108660RB-I00; PID2022-142451OB-C22).



3–5. November 2025. Hotel Radisson Blu Split, Croatia

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Section: (ii) Advanced Detection and Identification

Benchtop-grade science in a field-deployable solution: Portable mass spectrometry, FTIR, and Raman technologies for mobile lab applications

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Abstract

As mobile laboratory missions evolve to meet the demands of modern CBRNE response, the need for compact, high-performance analytical tools has never been greater. This presentation explores how recent advances in portable mass spectrometry, FTIR, and Raman spectroscopy are bringing benchtop-grade science to the field. These miniaturized technologies offer rapid identification of solids, liquids, and gases—even complex mixtures—directly at the point of need, with minimal training and no sample prep. With built-in libraries, automated analysis, and connectivity for remote support, these tools enhance mobile lab capabilities and enable faster, more informed decisions in dynamic environments. Attendees will gain insight into how these technologies fit into a toolbox approach for mobile operations, supporting missions such as hazard assessment, site remediation, and tactical response.

Keywords

CBRNE response; Field-deployable technology; On-site chemical identification; Portable spectroscopy



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Section: (iii) Mobile Laboratories

Experiences of Swedish chemical deployable laboratory***Anders Östin, Roger Magnusson and Kristina Arnoldsson***anders.ostin@foi.se¹ FOI-Swedish Defence Research Agency, CBRN Defence and Security, Cementvägen 20 901 82 Umeå, Sweden**Abstract**

This presentation will focus on experiences from deployable C-laboratory in military and civilian duty.

The Swedish Armed Forces deployable CBRN-laboratory concept were developed according to NATO deployable lab and NATO-SIBCRA documents. The system consists of C, B and RN-laboratory in 22 foot containers, respectively. These may operate together as a complete CBRN-unit or as individual laboratory resource depending on the given task. This system was finalized around year 2010 when the armed forces focus was support to international peacekeeping missions. Thus it could be expected a broad variety of samples with suspect toxic content. Therefore, the method development for chemical analysis was focused on an all hazard approach with the ability to identify a broad range of threat agents with chemical warfare agents as the most toxic substances.

In parallel to this the Swedish Civilian Contingencies Agency established Hazmat team. These team is in principle a civil version of the armed forces SIBCRA team that are responsible for collecting the samples to the deployable lab. But the requirement on the civilian Hazmat team is to perform field-analysis and provide the responsible commander on-site identification as fast as possible. This demand on rapid identification has enforced analytical method development on the ruggedized in field instruments forming to provide a provisional in field laboratory.

Keywords

Deployable laboratory; field analysis; SIBCRA

Acknowledgement

This work was financially supported by the Swedish Ministry of Defence.

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Section: (iii) Mobile Laboratories

French mobile laboratory

Jean-Charles Quevillon¹jeancharles.quevillon@sdis59.fr¹ SDIS59 (Sapeurs-Pompiers du Nord), 18 Rue De Pas, Lille, Hauts-de-France, 59800, France**Abstract**

CBRN threat:

Several levels of response:

- Chemical units and radiologic units
- Mobile laboratory
- Biotox, piratox, piratom laboratory

Mobile Laboratory Presentation:

Location:

Metz, Lyon, Marseille, Lille, UIISC 1 et 7 + LCPP

⇒ 1 per defence zone vectored by truck or helicopter

Personal :

2 operators and 1 mobile laboratory manager

Civilian or military firefighter personnel CBRN specialists.

The means :

- Sampling methods to be used as early as possible
- Detection means (PID, electrochemical cell, flame spectrometer, etc.)
- Means of identifying liquid, solid and gaseous matrices for biological, chemical and radiological risks.
- Means of protection: hoods
- Work under PPE

Operating methods:

- Relies on operating methods to implement the means to deal with multiple situations
- Relies on a network of experts in several fields.

Objective:

- ⇒ carry out rapid identification to confirm or deny the NRBC threat. First means of analysis to disabuse and advise the authorities. The samples can then be entrusted to specialized approved laboratories.

Keywords

CBRN threat; Mobile laboratory; Rapid identification; Detection and sampling methods



Section: (iii) Mobile Laboratories

Strengthening national resilience by using a chemical mobile laboratory in the response to chemical threats***Vasile Panainte¹, Turcanu Gheorghe¹, Rața Vadim¹, Corețchi Roman¹***gheorghe.turcanu@ansp.gov.md¹ National Agency for Public Health, Gheorghe Asachi 67a street, MD-2028, Chisinau, Republic of Moldova**Abstract**

The Mobile Chemical Detection Laboratory (MCDL) of the National Agency for Public Health is crucial for the national response to chemical incidents, with a role in the detection, identification of chemical risks in real time. The need to strengthen the national chemical incident response capacities arose because of the Ukraine military conflict and the Joint external evaluation of International Health Regulations core capacities of the Republic of Moldova recommendations from 2018. The MCDL consists of: (i) a crew cabin (2+1 seats), (ii) a laboratory compartment, (iii) a multifunctional, modular equipment compartment (iv) an attached trailer.

The technological equipment includes a portable gas chromatograph–mass spectrometer (GC-MS), Griffin™ G510, equipped with a non-radioactive ionisation source, quadrupole analyser, electron multiplier detector, and integrated helium carrier system, capable of identifying chemical warfare agents (CWA) and toxic industrial chemicals (TIC) in liquid, solid, or gaseous samples under field conditions, at concentrations down to parts per trillion, with a reference library of over 270,000 compounds, including Novichok agents. However, its maintenance is very costly, which implies much rarer use. The laboratory is equipped with two spectrometers, RAID S2plus and RAID-M 100plus, based on ion mobility spectrometry (IMS) using a ⁶³Ni radioactive ion source (<100 MBq), used for the detection, monitoring, and rapid real-time identification of CWA and TIC at parts per billion levels, with a complete extended library. RAID S2plus is mounted inside the vehicle with the sampling inlet placed outside, enabling 24/7 monitoring of external hazardous substances, thus protecting the personnel and laboratory. Both RAID S2 Plus and RAID M 100 Plus are equipped with a data logging system with automatic storage of results. The MCDL also includes the Thermo Scientific™ Gemini™ handheld analyzer, which operates using Fourier Transform Infrared Spectroscopy (FTIR) and Raman spectroscopy. The instrument performs real-time measurements, has all spectral libraries preloaded in memory, can identify at least four substances from a mixture, and is ready for a new measurement within seconds. Also included is the FirstDefender™ RMX spectrometer, based on Raman spectroscopy, equipped with the complete required library, which can be used as a handheld instrument or integrated offering greater flexibility. The MCDL is equipped with ChemProX and ChemPro100i, high-performance devices based on open-loop IMS technology, capable of rapidly identifying up to 25 chemical compounds (CWA, TIC, and precursors) without consumables and with minimal maintenance costs. ChemProX has WiFi connectivity with the possibility of simultaneous operation in the field and at the command point, and includes a radiation detection module, integrated training module (with simulated chemical and radiation sources via Bluetooth). All operate within a temperature range of –20 to +52 °C, 10–95% humidity, and have optical and acoustic alarms.

For contamination management, the MCDL is equipped with an autonomous decontamination system and an autonomous heating unit operating at a flow rate of 80 L/min and output temperature of 60 °C. Power supply is provided by two 3.5 kVA generators. Also available are individual protective equipment sets corresponding to protection levels A, B, and C, all stored in the trailer. The integrated IT system includes a laptop and printer.

The laboratory has been operationally tested in multiple national field exercises and regional simulations, including in cooperation with international institutions, demonstrating effectiveness in sample triage, risk area delineation, rapid chemical exposure assessment, and generation of data to support strategic and tactical decision-making. It has been officially included in the National Laboratory Observation and Control Network of the Republic of Moldova. Through its mobility, interoperability, and advanced technology, the MCDL is a key element in strengthening national resilience to chemical threats, in line with international public health obligations.

Keywords1st- mobile chemical laboratory; 2nd- field detection; 3rd- spectrometry; 4th- National Agency for Public Health**Acknowledgement**

The laboratory was donated in 2024 by the World Health Organization, with financial support from the Royal Norwegian Embassy in the Republic of Moldova.

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Section: (iii) Mobile Laboratories

The 80% solution: balancing integrity and decision making in mobile labs in field-based chemical, biological, radiological and nuclear (CBRN) response**Sarah A. Brewer**

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¹ 84th Civil Support Team, Wyoming National Guard, 4600 Powderhouse Road, Cheyenne, WY 82009, United States**Abstract**

In hazardous environments, mobile labs must deliver fast, high-confidence answers, even when conditions do not allow for perfect certainty. While fixed laboratories are designed for confirmatory analysis, offering definitive results through extensive time, resources, and controlled conditions, mobile labs operate under significant constraints to provide the best possible assessment in real time. Their role is to bridge the gap between incident onset and final confirmation, enabling informed action when lives, property, and the environment are at risk. This often means delivering a scientifically sound “most likely result” or “80% solution”, based on the totality of the situation. This “80% solution” is a time-sensitive assessment that enables action while acknowledging uncertainty. This discussion highlights three critical elements that most dramatically impact confidence in mobile lab results and their field value: partnerships, training, and operational confidence.

First, partnerships are essential to consequence management, especially during large-scale CBRN events where multiple agencies collaborate and contribute to public messaging and decision support. These relationships span first responders, fixed labs, and trusted technical organizations, and often extend beyond international borders. Establishing rapport before a crisis enhances communication, builds shared understanding, and reduces confusion during operations. Strong partnerships streamline coordination and reinforce a shared commitment to preventing the use of chemical weapons and promoting global security.

Next, training builds the foundation for confident, high-stakes performance. Repetitive, standards-based instruction prepares operators to act quickly and effectively under pressure, allowing them to analyse samples and report findings with consistency. When aligned with clear, mutually agreed-upon standards, training fosters reliable procedures within a team. This standardization strengthens internal confidence in the “80% solution” and enhances external credibility, ensuring that findings are clearly communicated and trusted.

Lastly, operational confidence in reporting does not imply certainty; it means clearly communicating the basis for an educated decision to be made in the moment. A confident field assessment draws on multiple sources including background intelligence, scene conditions, signs and symptoms, and lab data, in order to support a “most likely” identification. This enables timely recommendations and key decision points, while leaving room for future refinement. Recognizing that field conditions rarely allow for conclusive results is essential. Confidence in the process, not just the outcome, supports effective decision-making.

Effective field decision-making in CBRN response requires more than technology or doctrine, it requires well-trained, informed personnel who understand the evidence, the risk, and the weight of their recommendations. When we train to think critically, communicate clearly, and act decisively under uncertainty, we strengthen both our scientific credibility and our response. Our goal is not perfection, it is timely, credible action that protects lives, property, and peace.

Keywords

CBRN response; risk communication; field analysis; mobile laboratories

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Section: (iii) Mobile Laboratories

Integration of mobile laboratories within a detection sampling and monitoring capacity: the case of the new European capacity designed by Italy called rescEU CBRN-DSIM-IT

Edoardo Cavalieri d'Oro¹, Claudio De Maio¹, Matteo Guidotti², Luigi De Dominicis³

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² National Research Council. Milano IT

³ Partners of the rescEU CBRN project coming from various Italian Entities (ENEA, Nucleco, ARPA Veneto, Gemelli Hospital, Sacco Hospital, ISS)

Abstract

This work presents the design and construction of a high-impact fleet of mobile laboratories for CBRN emergency management, developed for the European Civil Protection Mechanism under the Italian rescEU CBRN-DSIM-IT program. Starting from operational functions required for CBRN emergencies, clear design metrics were applied to define vehicle architecture, capabilities, and integration within CBRN operations.

The design of the laboratories is detailed according to European Commission requirements, addressing CBRN agents, reference scenarios, data exchange systems, and telecommunications for effective field deployment.

The fleet, expected to be completed and showcased during the Milano-Cortina 2026 Olympic Games, is the result of a design synthesis developed through a partnership of institutions and private companies with high expertise across CBRN domains.

A dedicated training program has been developed to ensure personnel readiness for managing these advanced mobile laboratories and fleet assets.

Sanitary and decontamination Detection Sampling and Monitoring + Advanced Command Unit

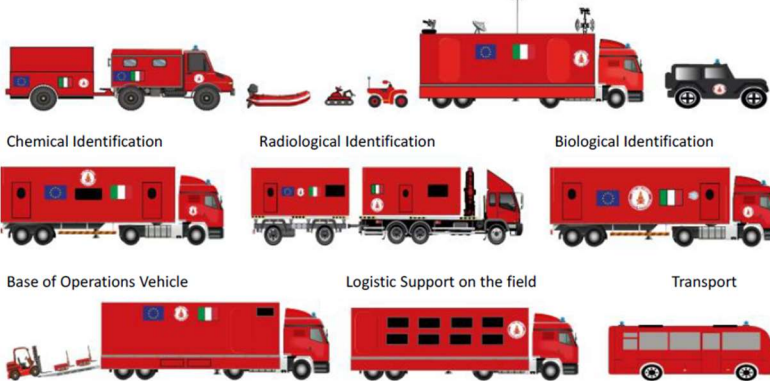


Figure 1. (a) The new CBRN fleet currently designed by Italian Fire and rescue service (b) An illustrative figure reporting M-labs during operations

Keywords

Emergency management design, mobile laboratories, CBRN response, CBRN scenarios

Acknowledgement

This work refers to the rescEU CBRN-DSIM-IT project that is being financially supported by European Commission with the financial instrument NextGeneration EU.



Section:(iii) Mobile Laboratories

**CONTRIBUTION OF FORENSIC INSTITUTE OF GENDARMERIE ROYALE TO
CHEMICAL COUNTERPROLIFERATION*****T. Bouayoun¹, A. Stambouli², A. Elbouri²***Bouayoun.taoufik@gmail.com¹ IT ICGR - FORENSIC INSTITUTE OF GENDARMERIE ROYALE - Souissi, Rabat. MOROCCO CP: 10170**Abstract**

This presentation examines the practical approach to chemical proliferation control incidents at both the operational and forensic levels. It begins by describing the process of managing chemical incidents in the field: Once the approval is obtained from the command post, the decontamination team inspects the area surrounding the incident site and draws the red line separating the cold zone from the hot zone using a Dräger X-AM 8000. It then sets up the decontamination station in the warm zone to accommodate teams arriving from the hot zone. Next, the investigation team moves to the risk area to first search for the potential source of danger, photograph and number the evidence, draw a sketch of the premises, and report back to the command post. Next, the sampling team moves to the crime scene, following security and traceability protocols. Two samples are collected: one for field analysis and the other for laboratory confirmation analysis. The analysis team arrives immediately after the sampling team to set up their station, await sample reception, and analyse them. Analysis is performed using field equipment such as Red Wave ThreatID, RAMAN, and GCMS Griffin. The decontamination team performs decontamination operations according to standard protocols. Reusable tools and equipment will undergo appropriate decontamination, allowing their recovery for subsequent missions. Once the second sample is received at the ICGR laboratory, it will be processed according to the OPCW extraction protocol and then analysed using various GC/MS-MS and LC/MS-MS techniques to identify hazardous chemicals. Unfortunately, some of these chemicals are present in household products: shampoos, disinfectants, pesticides, detergents, and fertilizers, and are therefore available in pharmacies or supermarkets.

To this end, our ICGR institute has developed a Chemical Product Guide for Field Investigators. This non-exhaustive booklet provides Royal Gendarmerie personnel with a tool for detecting chemical threats and assisting in the identification and visual recognition of dangerous solid and liquid precursors, to which particular attention must be paid, particularly by field investigators. The session concludes with a series of practical challenges encountered at chemically contaminated crime scenes, presented as reflection questions, encouraging participants to consider how best to balance the safety of those involved with the integrity of the evidence. Questions:

- 1- This guide remains non-exhaustive and must be updated regularly by adding new precursors used in the manufacture of chemicals weapons and explosives. Is it possible to share information between experts to reinforce our cooperation?
- 2- What efforts are being made by the security services to reinforce surveillance of these commercial chemicals precursors of chemicals weapons and explosives?
- 3- As you know, the CBRNE crime scene has different aspects than traditional crime scene, and not every forensic scientist specialized on 1/fingerprint, 2/documents, 3/GSR, 4/glasses, 5/fibres, 6/autopsy etc... has competency in CBRNE areas.

What is your assessment of mobile and stationary equipment's needed to avoid contamination of laboratory facilities?

4-In CBRN-explosives terrorism attack, the quantity of charge should be evaluated the use of the equivalent TNT formula gives results by excess.

What correction can be made to it to improve the results of evaluation of the quantity of the charge?

Are there any other calculation models?

Keywords

Forensic chemical response; Field sampling; Decontamination; Chemical precursor surveillance



Section: (iii) Mobile Laboratories

Development and commissioning of mobile laboratories

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¹ ADELFA, Association for Development, Education, Law, Training, Art and Security

Abstract

The current geopolitical situation can be complex and quite confusing. This complexity makes it challenging to understand the full picture and anticipate future events. On the other hand, in 2019-2020, the COVID-19 pandemic taught us many important lessons, one of them was the importance of getting rapid and effective communication, being essential the preparedness and flexibility in responding to health emergencies.

At this point, mobile laboratories are essential because they bring testing and analysis capabilities directly to onsite incidents or emergencies situations, especially in remote or underserved areas. They help improve access to important diagnostic services, enable quick responses during emergencies or outbreaks, and support field research in various environments. Overall, mobile labs play a crucial role in making healthcare, environmental monitoring, and scientific research more accessible and efficient.

Projects related to developing mobile laboratories face several challenges, from the first step in designing till logistical issues like transportation and setup. Additionally, they need to be adaptable to various environments and provide reliable power and connectivity. Each project is different from the previous one because each client has different necessities and requests different capabilities. Therefore, each project should be faced as unique.

Keywords

1st-Mobile; 2nd-Laboratories; 3rd-DIM technologies; 4th-CBRN



Section: (iii) Mobile Laboratories

Bridging the gap between labs and incident sites: pros and cons of advanced mobile CBRN laboratories***Matteo Guidotti^{1,2}, Stefano Econdi¹, Massimo C. Ranghieri², Stefano Marchesi³, Chiara Bisio³***matteo.guidotti@scitec.cnr.it¹ CNR – SCITEC Institute of Chemical Sciences and Technologies, via Golgi 19, 20133, Milan, Italy² CBRN Section, Military Corps of the Order of Malta Italy, Milan, Italy³ DISIT, University of Eastern Piedmont "A. Avogadro", viale T. Michel 11, 15121, Alessandria, Italy**Abstract**

Mobile laboratories have emerged as critical assets for early detection, identification and management of CBRN threats [DOI: 10.1007/978-94-024-2041-8_20]. These laboratories are designed to be quickly deployed to the site of an incident, allowing for immediate, on-site analysis and contributing significantly to effective crisis response.

Here we present a brief overview of the advantages and disadvantages associated with the deployment and use of mobile laboratories in CBRN scenarios. It considers operational, logistical, technical and strategic aspects to help guide scientists, first responders, emergency response planners and decision-makers in evaluating the role of these assets in national preparedness and emergency response frameworks.

One of the main advantages of mobile laboratories is their ability to be deployed directly to suspected or confirmed CBRN incident sites, significantly reducing delays in sample collection and analysis. They offer the capability to conduct complex and advanced analyses directly at the location of a CBRN event. By processing samples locally, mobile laboratories minimize the risks linked to the transport of highly hazardous materials, improving both responder safety and environmental protection. Along with flexible and tailored analytical apparatuses, mobile labs are often equipped with communication systems that allow them to relay findings to command centres, enabling rapid coordination of containment, decontamination, and public communication efforts. Furthermore, when configured to handle multiple classes of hazardous agents, mobile laboratories become highly valuable assets in hybrid or uncertain threat environments, especially in scenarios where permanent laboratory infrastructure is unavailable or unreachable, such as in rural or conflict-affected regions.

On the other hand, the initial investment for their acquisition is substantial, often involving specialized vehicles, containment zones, analytical equipment, and integrated IT systems. Maintenance and calibration costs are also considerable, especially to keep equipment ready for rapid deployment. Deploying a mobile lab involves more than moving a vehicle. It requires securing power supplies, ensuring fuel availability, establishing communication networks and mobilizing trained personnel. Training and retaining such personnel is an ongoing challenge, particularly in the case of operators with a non-scientific/technical background. Additionally, weather conditions and terrain (extreme temperatures, flooding or poor road conditions) can significantly affect the functionality of mobile labs. In terms of security, mobile labs, especially in conflict zones or politically unstable areas, may become high-value targets for sabotage or theft due to the sensitive equipment and substances they contain. At a longer time scale, these assets may become obsolete if not regularly updated with the integration of new analytical techniques or replacement of outdated components, although this can be both costly and time-consuming. During operation, the confined working space increases the risk of cross-contamination if proper biosafety and decontamination protocols are not strictly enforced. This could compromise sample integrity and result in false readings.

In conclusion, when employed effectively alongside fixed laboratories and coordinated response teams, mobile laboratories can significantly improve a nation's ability to detect, assess and respond to CBRN threats in a timely and effective manner.

Keywords

Mobile CBRN laboratories; advantages and disadvantages; strategic assessment.

Acknowledgement

This work was financially supported by the projects.



3-5. November 2025. Hotel Radisson Blu Split, Croatia

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Section: (ii) Advanced Detection and Identification

Natural Rubber-Based Stretchable Heat Transfer Materials

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Abstract

To develop stretchable heat transfer materials, thermally conductive natural rubber (TCNR) was newly designed and synthesized by utilizing inherent elastic properties of natural rubber (NR) and introducing thermally conductive monomer (TCM) to NR. Owing to phonon transfer assistance of TCM, TCNR film exhibited around 120% higher thermal conductivity (0.38 W/m·K) compared to the NR film (0.17 W/m·K). When the same hexagonal boron nitride (h-BN) content was incorporated, TCNR composites showed higher enhancement in thermal conductivity, and the TCNR composite film fabricated with h-BN of 15 wt% showed the thermal conductivity of 0.87 W/m·K. Due to the inherent elastic properties of NR, the TCNR composite film fabricated with h-BN of 15 wt% exhibited 140% stretchability. It was demonstrated that the TCNR composites can be utilized as a thermal management material for wearable devices.

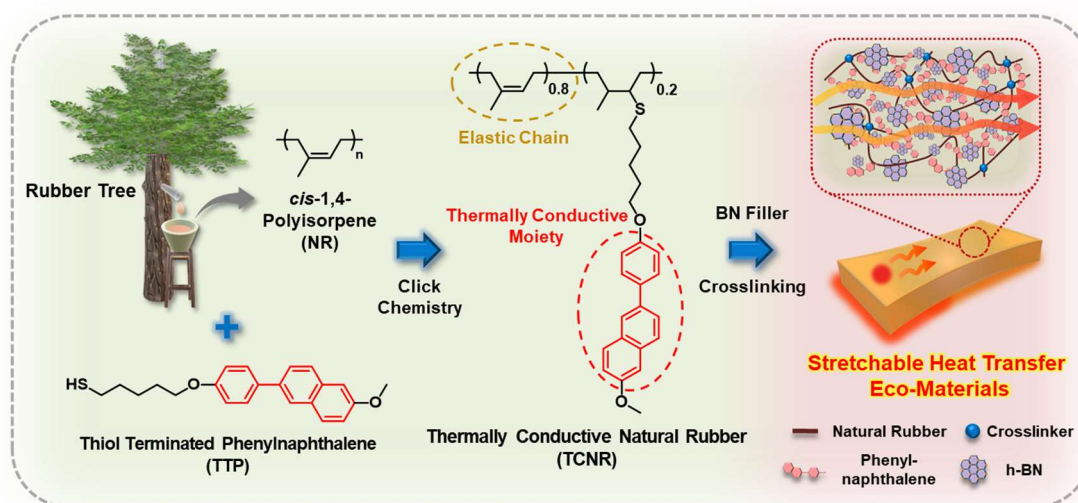


Figure 1. Schematic illustration for newly developed stretchable heat transfer eco-materials.

Keywords

1st-Natural rubber; 2nd-Thermal conductivity; 3rd-Stretchability

Acknowledgement

This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Triphenylamine-based electrochromic films for smart information encryption system

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Abstract

A novel triphenylamine-based asymmetric monomer (TPA-A) is synthesized for use in next-generation information encryption systems. TPA-A is designed with bulky side groups to facilitate self-assembly into a lamello-columnar phase and enable uniaxial alignment through a simple shear-coating process. The resulting thin films exhibit distinct photoluminescence (PL) and reversible electrochromic (EC) responses, enabling dynamic optical modulation. In particular, the films show polarization-dependent electrofluorochromic (EFC) behavior, allowing selective decryption of encrypted patterns only under specific voltage or polarization conditions. Incorporating these properties into an indium tin oxide (ITO)-coated substrate yields a flexible, smart display system capable of dual-mode encryption. This approach demonstrates promising applicability in anti-counterfeiting and wearable optoelectronic devices.

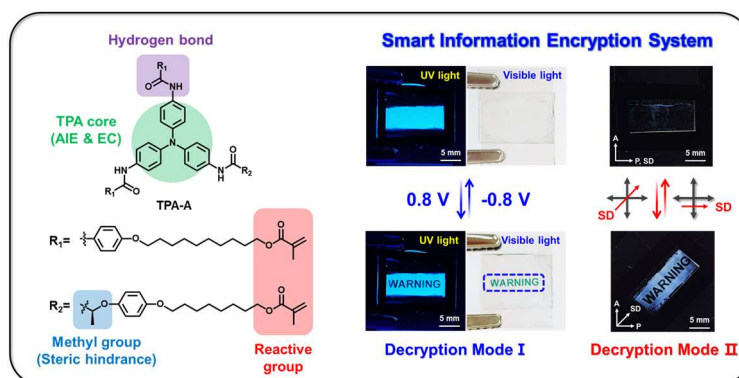


Figure 1. Smart information encryption system based on triphenylamine-based asymmetric monomer

Keywords

1st-Triphenylamine; 2nd-Electrochromism; 3rd-Photopolymerization; 4th-Information encryption

Acknowledgement

This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Nanostructured Fluorescent Films via Self-Assembly for Acid Vapour Monitoring

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Abstract

The prepared PCRM material displays distinct aggregation-induced emission (AIE) behaviour and shows reversible optical changes in response to acidic and basic stimuli. The PCRM-8OBs complexes are capable of forming smectic mesophases due to their structural similarity to rod-like mesogens. Using an optimised formulation, we fabricated two-dimensional (2D) nanostructured sensing films through a combination of molecular self-assembly, photopolymerisation, and selective etching techniques. These 2D nanoporous films demonstrate superior sensitivity to acid vapour compared to nonporous analogues. Additionally, the sensitivity of the films was found to vary with the orientation of the molecular alignment within the 2D structure. We report a novel fluorescence-based sensing platform that can visually communicate varying levels of acid vapour exposure in the surrounding environment.

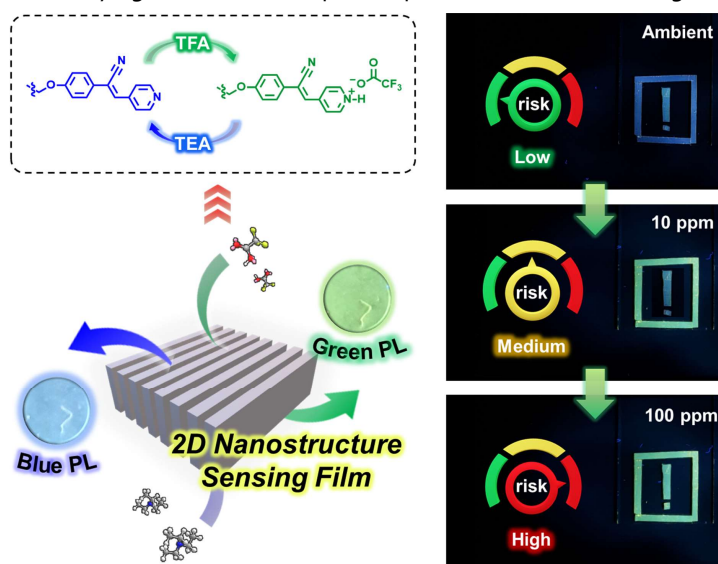


Figure 1. Chemical structure and pH sensing properties of PCRM; schematic illustration and applications of 2D nanoporous sensing films.

Keywords

1st-Reactive Mesogen; 2nd-Self-assembly; 3rd-2D Nanostructure; 4th-Sensing film

Acknowledgement

This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Interfacial Phonon Engineering in Polymer Composites Using Reactive Mesogens

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Abstract

To enhance thermal conductivity in polymer nanocomposites, we developed a tetrathiafulvalene-based reactive mesogen (TRM) designed for strong interfacial interactions with hexagonal boron nitride (BN) and expanded graphite (EG). Unlike typical systems with weak polymer–filler interfaces, TRM offers both high intrinsic thermal conductivity and excellent molecular-level affinity with nanofillers. Comprehensive photophysical, thermodynamic, structural, and computational analyses confirm that TRM significantly improves phonon transfer across interfaces, leading to superior thermal performance. The TRM-based composites also show enhanced structural integration and thermal stability. Depending on the choice of filler, the composites exhibit either electrically insulating (BN) or conductive (EG) behavior, allowing application-specific tunability. Furthermore, TPM–EG composites demonstrate excellent EMI shielding effectiveness, highlighting their potential in power electronics and advanced detection systems. These results demonstrate that effective nano-interface engineering at the molecular level plays a key role in maximizing thermal transport in polymer nanocomposites.

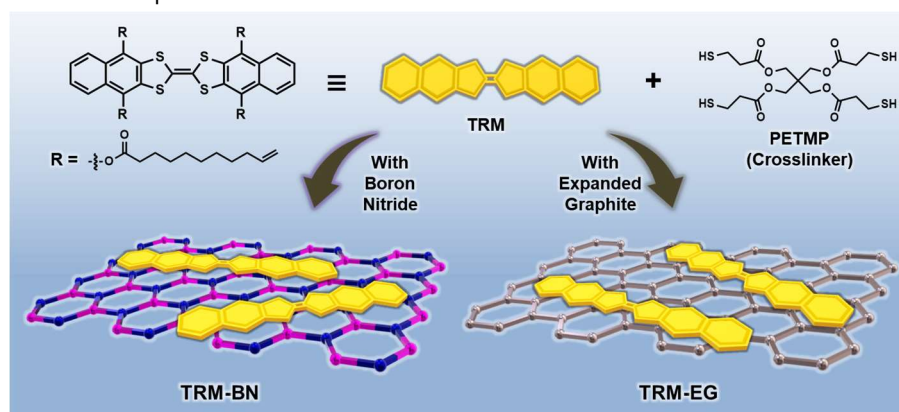


Figure 1. Chemical structure of TRM and thiol crosslinker (PETMP); schematic illustration of interfacial interaction of TRM with BN and EG.

Keywords

1st-Polymer Nanocomposite; 2nd-Reactive Mesogen; 3rd-Thermal conductivity; 4th-Interface Engineering

Acknowledgement

This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Light-Responsive Ionic Skins for Conductivity Switching and Shape Actuation via Azobenzene Mesogens

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Abstract

To realize smart ionic skins with multi-stimuli responsiveness and reversible ionic conductivity, a novel azobenzene-based ionic monomer is synthesized and aligned uniaxially, followed by polymerization into anisotropic liquid crystal elastomers (LCEs). The resulting LCEs containing ionic asymmetric azobenzene monomers (i-AAM) are fabricated through a process involving thermal oligomerization, uniaxial stretching, and photopolymerization. These monodomain i-AAM LCEs undergo thermal contraction above the nematic–isotropic transition temperature (T_{NI}) and UV-induced bending along the alignment direction. In parallel with these shape changes, the ionic conductivity of the LCEs is reversibly modulated by thermal and optical stimuli. Compared to the aligned monodomain LCEs, polydomain i-AAM LCEs prepared without stretching process exhibit enhanced ionic conductivity due to the formation of more stable and continuous ionic pathways. Furthermore, the ionic conductivity can be dynamically switched by external cues, including changes in dipole alignment from photoisomerization, increased ionic mobility from heat, and elastic deformation by mechanical stress. Demonstrating both grasp-and-release actuation and sensitive ionic conductivity switching, these i-AAM LCEs hold strong promise as adaptive smart skin components for advanced soft robotic systems.

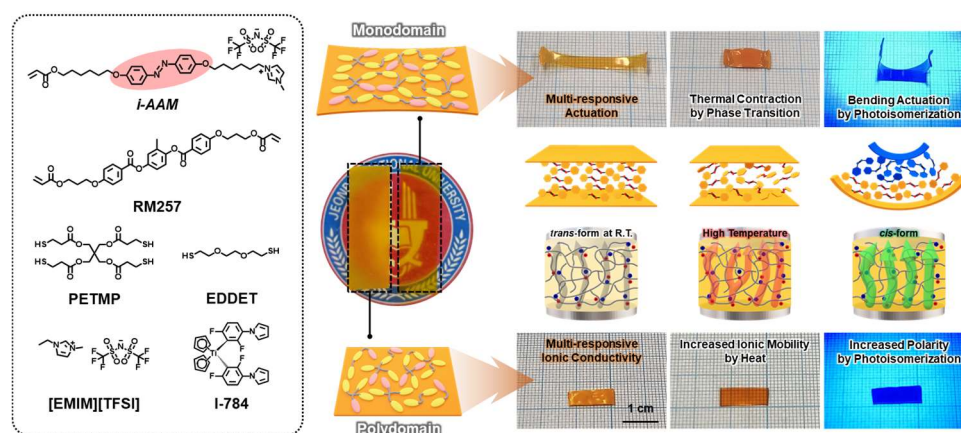


Figure 1. Schematic illustration of mixture composition, monodomain for actuator, polydomain for switchable ionic conductivity.

Keywords

1st-Azobenzene; 2nd-Liquid Crystal Elastomer; 3rd-Switchable Ionic Conductivity; 4th-Actuator; 5th-Sensor

Acknowledgement

This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Twitterionic Interlocking Enables Polarization-Dependent Photochromism and Ionic Switching in Diarylethene-Based Smart Films*Youngjae Wi¹, Kwang-Un Jeong¹*yjwi@jbnu.ac.kr, kujeong@jbnu.ac.kr¹ Jeonbuk National University, Department of Polymer Nano Science and Technology, Department of Nano Convergence Engineering, Jeonju 54896, Republic of Korea**Abstract**

To achieve reversible optical and electrical switching in soft smart films, we developed a zwitterion-interlocked diarylethene-based molecule (DZM) that forms hierarchically ordered nanostructures via self-assembly. Unlike conventional diarylethenes, DZM combines high photoresponsiveness with switchable ionic conductivity through light-triggered electrocyclic isomerization. The zwitterionic interlocking between sulfonate and imidazolium groups, along with dendritic side chains, promotes uniaxial nanocolumn alignment under shear, which is fixed via photopolymerization. Comprehensive photophysical, electrochemical, and structural analyses, including NMR, POM, X-ray scattering, and DFT, reveal that this ordering is key to enabling polarization-dependent photochromism and tunable ionic transport. Without zwitterionic design, the molecular system fails to self-organize, leading to disordered films with diminished function. DZM-based films demonstrate light-dependent conductivity switching and photo-patternability, enabling the fabrication of polarization-encoded, UV-responsive optoelectronic devices. These findings establish molecular-level electrostatic interlocking as a powerful strategy for engineering stimuli-responsive soft materials with optical and electronic dual modulation.

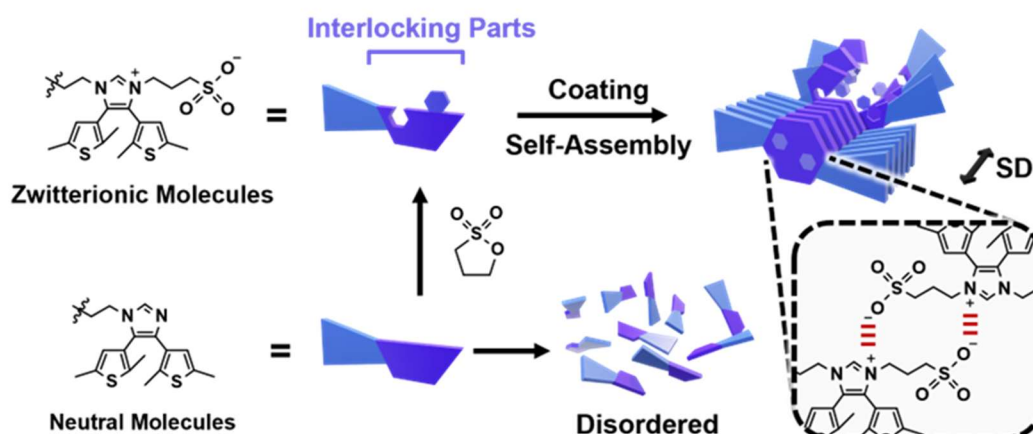


Figure 1. Schematic illustration of zwitterionic interlocking-driven molecular self-assembly.

Keywords

1st-Zwitterionic Self-Assembly; 2nd-Photochromism; 3rd-Switchable Ionic Conductivity; 4th-Polarization-Dependent Optics

Acknowledgement

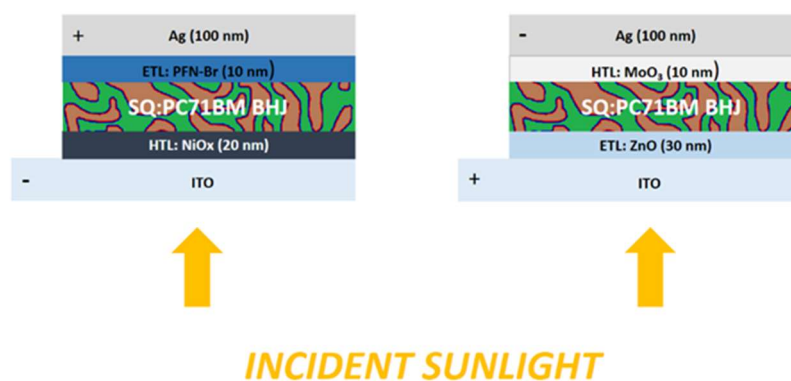
This work was supported by the Basic Research Laboratory Program (RS-2023-00207836), the Mid-Career Researcher Program (RS-2021-NR059321) and Brain Korea 21 Four of Korean Government, and NATO-Science for Peace and Security Program (SPS-G7425, CLC-BIODETECT).



Section: (ii) Advanced Detection and Identification

Development of squaraine-based next-generation solar cells for indoor energy production***Davor Gašparić¹, Floren Radovanović-Perić²***dgasparic@fkit.unizg.hr¹ University of Zagreb Faculty of Chemical Engineering and Technology, Marulićev trg 19, 10 000 Zagreb, Croatia**Abstract**

Squaraine solar cells offer a promising green alternative route to stable and cost efficient solar energy. By fabricating them into photovoltaic devices of the third generation, several things can be studied. It is known that exciton generation and charge carrier recombination in organic photovoltaic devices are influenced by multiple factors such as donor to acceptor ratio, energy offsets in the active layer (HOMO/LUMO) as well as energy alignment at the electron and hole transport layer interface and lastly, active layer morphology. A good bulk heterojunction (active layer) needs to fully utilize excitons generated through the absorption of the acceptor and donor blend by converting the charge carrier flux into a current at quantum yields as high as possible. Important parameters for this process are electron and hole mobilities, which often depend upon the crystallinity of the material inside the active layer as well as the crystal interconnectedness throughout the layer. Here we will present the most important parameters to consider while designing new electron donors for bulk heterojunction organic solar cells based on novel squaraine derivatives. The research encompasses the use of a wide variety of methods to investigate the functioning principle of the solar cells with potential application in self-powering sensor devices.

*Figure 1. Architectures of a bulk heterojunction solar cells used in this work.***Keywords**

Squaraine, bulk-heterojunction, solar cell

Acknowledgement

The authors acknowledge the financial support of the HRZZ under the grant UIP-2019-04-2367 SLIPPERY SLOPE and MZO under the grant NPOO.C3.2.R3.-11.05.0091. ICTM at TU Graz, Austria is gratefully acknowledged for instrumentation access and collaboration. The financial sustenance of University of Zagreb and Ministry of Science and Education of Croatia are acknowledged.



Section: (ii) Advanced Detection and Identification

Enabling Reversible Chemistry in Calcium Batteries through SEI Design

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Abstract

Even though lithium-ion batteries currently dominate portable electronics and electric vehicles, their future is uncertain due to limitations in energy density (240 Wh/kg), safety issues, and lithium scarcity. These limitations drive the search for next-generation chemistries based on multivalent ions. Among various candidates, calcium stands out due to its low reduction potential (-2.89 V vs. SHE), its ionic size is comparable to sodium, its high abundance, and its high volumetric capacity enabled by two electron charge transfers. However, the challenge of practical calcium battery remains, because of sluggish kinetics and the formation of a passivation layer that blocks further reaction. Engineering a solid electrolyte interphase (SEI) provides a foundation for high reversibility and energy density in next-generation calcium batteries, especially when coupled with high-energy cathodes like oxygen and sulphur.

In this work, we developed a novel electrolyte that supports calcium deposition through salt-solvent modification, directly influencing SEI formation. Further optimization of the electrolyte was conducted via concentration adjustment, solvent branching, and the use of additives such as ionic liquids and deep eutectic solvents with the aim of achieving reversible plating/stripping. The performance of the created electrolyte was evaluated using cycling voltammetry, electrochemical impedance spectroscopy, and galvanostatic cycling, while the created interfaces were characterized with FTIR, GIXRD, SEM, and EDX analyses.

Finally, the best-performing electrolyte was implemented into a fully functional Ca-O₂ battery, which has shown significant improvement over existing studies. This study demonstrates a proof of concept and establishes a foundation for next-generation Ca-O₂ energy storage systems.

Keywords

Calcium anode; Oxygen cathode; Multivalent; Calcium-Oxygen; Reversible battery



Section: (i) Chemical Threats

Removal of chemical warfare agent simulant using reverse osmosis membranes: Investigation of efficiency and separation mechanisms

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Abstract

Effective removal of chemical warfare agent (CWA) simulant from water sources is important to ensure environmental safety and public health, especially in the case of an accidental release or deliberate contamination. In this study, the removal of the CWA simulant dimethyl methylphosphonate (DMMP) was investigated using reverse osmosis (RO) membranes. The experiments were conducted using drinking water as the feed solution and the removal process was carried out continuously over a period of three hours.

Three RO membranes (ESPA₄, XLE, and AP) were tested. Both ESPA₄ and XLE achieved complete DMMP removal (>99.9%) throughout the test period. The AP membrane initially showed a slightly lower efficiency, with 93.6% removal after the first hour, which increased to 98.1% after the second hour, and reached complete removal (>99.9%) after the third hour. The primary separation mechanism is attributed to size exclusion, as the molecular weight of DMMP is higher than the molecular weight cut-off (MWCO) of the XLE membrane (100–200 Da). The ESPA₄ and AP membranes are also RO membranes and the exact MWCO values are not given. Nevertheless, the high removal efficiencies suggest that their pore sizes are sufficiently small to retain DMMP molecules (probably because the MWCO values are similar to the XLE membrane), and interactions between the solute and the membrane may contribute.

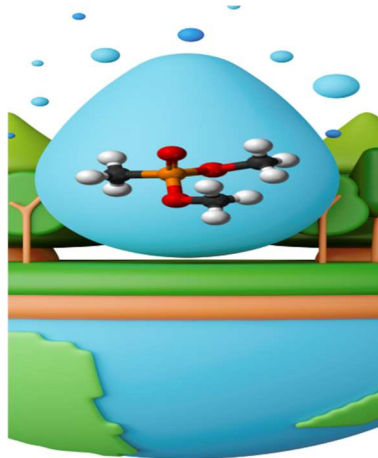


Figure 1. Illustrative representation of DMMP molecule present in drinking water.

Keywords

^{1st}-Dimethyl Methylphosphonate; ^{2nd}-Membrane separation; ^{3rd}-Chemical warfare; ^{4th}-Reverse osmosis

Acknowledgement

This research was funded by the NATO Science for Peace and Security Programme under grant id. G6087 and Croatian Science Foundation project DOK-NPOO-2023-10-8063.

Section: **Advanced Detection and Identification**

Development of next-generation solar cells for environmentally sustainable energy production

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Abstract

A cutting-edge photovoltaic technology is developed by leveraging the broadband optical properties of hybrid plasmonic heterostructures, which act as the sensitizer agent once integrated into the final plasmon-sensitized photovoltaic cells. The hyperbranched nanostructures, composed of silver nanocubes surrounded by gold nanorods, are deposited on the TiO₂-coated Indium Tin Oxide counter electrode, improving the visible and near-infrared light absorption capabilities and, consequently, enhancing their photoelectric efficiency. The realized photoanode is characterized by optical, morphological and spectroscopy analyses. Photothermal and photoelectric responses of the sealed cells are also evaluated under both white light and solar light irradiation. The proposed novel technology boosts long-term stability and efficiency (Figure 1) compared to the performance of easily degradable organic dyes used in conventional dye-sensitized solar cells. As proof of concept, the outstanding photoelectric response under solar light is sufficient to power the liquid crystal display of a timer directly.

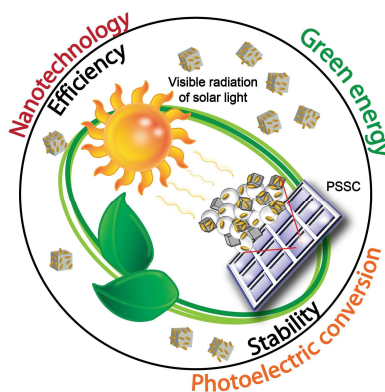


Figure 1. Schematic of sustainable PSSCs activated by the visible spectrum of sunlight.

Keywords

Solar cells; heterostructures; nanomaterials; photovoltaic

Acknowledgement

This work was financially supported by the "Air Force Office of Scientific Research, Air Force Material Command, U.S. Air Force". "Next-Generation Liquid Crystal Devices with Integrated Advanced Plasmonic Solar Cells" FA8655-25-1-7021(P. I. L. De Sio, EOARD 2025-2028); by the "NATO - Science For Peace and Security Programme (SPS-G5759, NANO-LC; SPS-G7425, CLC-BIODETECT).



Section: Advanced Detection and Identification

Selective detection of SARS-CoV-2 spike protein via biofunctionalized gold nanorods

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Abstract

This study presents the development of a plasmonic biosensor based on the bioconjugation of gold nanorods (AuNRs) with specific receptors (antibodies) for the selective detection of the virus responsible for the COVID-19 pandemic. This global event underscored the urgent need for reliable diagnostic systems. The recombinant SARS-CoV-2 spike protein, expressed in HEK293 cells with a C-His tag, was selected as a safe recognition target, paired with a monoclonal antibody of murine origin. This binding pair ensures both high specificity and strong affinity, while avoiding the use of live viruses. Bioconjugation was achieved via an electrostatic functionalisation process: a positively charged polyelectrolyte was first used to reverse the native AuNR surface charge, enabling subsequent antibody adsorption. UV-Vis absorption spectroscopy confirmed successful functionalisation, as evidenced by a red-shift of the longitudinal plasmon peak and an increase in its full-width at half maximum. Stability tests over 14 days revealed no significant spectral variation, demonstrating the excellent storage stability of the bioconjugates. Further characterisation via dynamic light scattering (DLS) and zeta potential analysis confirmed the presence of the antibody layer on the AuNR surface. Recognition experiments were performed by adding increasing amounts of spike protein to the bioconjugate solution. The spectral response was fitted with exponential models, with the best-performing system reaching a detection limit (LOD) of 16 ng/mL. No spectral change was observed in control tests using unfunctionalized AuNRs, confirming the specificity of the antibody–antigen interaction. Additionally, visible aggregation occurred upon antigen binding, suggesting potential for a direct colorimetric readout. These results confirm that antibody-functionalised AuNRs offer a robust and sensitive platform for virus detection using a liquid-form biosensor. Future development is devoted to integrating these bioconjugates into a lateral flow architecture for target recognition, followed by optical signal enhancement through a dedicated visualization module, enabling improved colorimetric readout in point-of-use diagnostics.

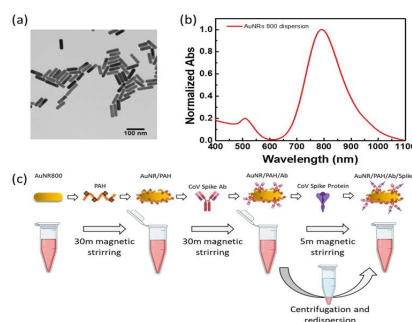


Figure 1. TEM micrographs of AuNRs (a). Representative UV-visible absorption spectrum (b). Schematic illustration procedure used for bioconjugates fabrication and recognition tests (c).

Keywords

1st-Plasmonic biosensor; 2nd-Gold nanorods; 3rd-SARS-CoV-2; 4th Water safety; 5th Optical detection.

Acknowledgement

This work was fully supported by the NATO Science for Peace and Security Programme (Project G7425 – CLC-BIODETEC).

SPS ARW Split 2025

International Workshop on Advanced
Technologies and Mobile Laboratories
for Countering Chemical Threatshttp://bit.unizg.hr/CroCerSPS_ARW_Workshop_Split2025

FINAL REMARKS CONCLUSIONS AND RECOMMENDATIONS

Condensing the content from three intensive days of the **SPS ARW 2025 Split** into just a few lines of conclusions and recommendations requires significant effort.

During the 3 days of the Workshop we had 3 Plenary lectures, 5 Keynote lectures, 25 Invited lectures, 11 Poster presentations within several sessions: (i) chemical threats, (ii) advanced detection & identification, (iii) mobile laboratories & benefits, (iv) ESR investigators.

Recent scientific results were interwoven with practical case studies and real-world challenges. Presentations by early-career investigators were recognized with several awards.

Importantly, the Workshop began with a **PANEL** session that effectively encouraged the exchange of ideas, the expression of concerns, and the initiation of broader discussions.

These discussions continued to evolve during the enjoyable social activities in the comfortable venue, leading up to the final day's **ROUND TABLE** session. This session served as the culmination of the Workshop, where we collectively synthesized the new knowledge gained and distilled the week's reflections into a few viable conclusions and recommendations.

Those efforts are mostly focused on shedding more light on the mobile labs, their roles, positions, and interconnectivity. That being said, organizing events such as this one was recognized as the most important tool for fostering the growth of a strong and cohesive community. Sharing contact information among stakeholders, not only within the mobile lab community but also with governmental policymakers, academia, and industry was identified as another key milestone. This approach is expected to help bridge the gap between these sub-networks. Bridging this gap was recognized as essential, as the sub-networks often operate within somewhat different timeframes and contexts.

Speaking of milestones, this and future meetings can be recognized as important milestones for the mobile laboratories and the broader network. Nevertheless, an annual or biannual meeting means little without meaningful activity and content between these milestones. We need to keep pushing forward on multiple fronts to strengthen and justify the broader vision of mobile labs.

A big thank you goes to all of the participants: speakers, guests, exhibitors (*Thermoscientific, ITR-LAB, go8 Devices, Bruker, Optik Instruments, DOK-ING*), to organizing and supporting institutions (*University of Zagreb Faculty of Chemical Engineering and Technology from Zagreb; Croatian Ceramic Society from Zagreb, Faculty of Chemical Technology from Split, National Institute of Applied Sciences and Technology from Tunis*).

From the specific names, prof CBE Nigel Lightfoot needs to receive big personal thank you.

The biggest acknowledgements goes for the **NATO SPS program (ARW grant G7975)** that enabled this initiative and event.

That being said, looking forward to welcoming you at the next dedicated **WORKSHOP 2027!**

Chair of the SPS ARW 2025 Split

assoc. prof. dr. Vilko Mandić



*This workshop
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SPS ARW Split 2025

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SPS ARW 2025 SPLIT BOOK of ABSTRACTS

Published by:
University of Zagreb Faculty of Chemical Engineering and Technology
Trg Marka Marulića 19, HR-10 000 Zagreb

and

Croatian Ceramic Society
Trg Marka Marulića 20, HR-10 000 Zagreb

ISSN: XXXX-XXXX (Online)

Zagreb, Croatia, November 2025