NATO Science for Peace and Security (SPS) Programme

Workshop on CBRN Defence – 22-24 October 2013 – Brussels

Emerging Security Challenges Division

NATO

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- Warfare Agent (WA) detection techniques are based on semi-analytical methods (time consuming, expensive) such as:

  - Flame photometry,
  - Mass spectrometry
  - Photo-acoustic infrared spectroscopy,

**Gas/Vapour Microsensors** are an emerging technology for detecting WA

- Most popular transduction methods are electrical.
Project Objectives

- Development of an innovative multi-modal sensing approach for warfare agent detection.
- Development of a pre-commercial prototype system and test it in a controlled facility.

What will be achieved:
- Development of new strategies for the functionalization of nanomaterials
- The gas sensors integrating the array will be multi-parameter: D.C. resistance, A.C. impedance, photoluminescence, and response to temperature modulation
- Coupled to a Ion Mobility spectrometer
- A pre-concentrator unit will be also integrated to improve (i.e., lower) the limit of detection of our proposed sensor system.
Novelty in the project

- Development of multisensing platform based on Nanostructered materials (MOX and CNTs) with pre-concentrator for rapid warfare agent detection

Sample conditioning and delivery

Hybrid sensing module: MOX, nanotubes, nanodots, nanoneedles, CNTs and IMS

Pump, micro preconcentrator, mass flow meter and split valves

Sensor data fusion and pattern recognition

DMMP
DMF
Functionalized MWCNTs for vapor detection

CNT Sensor
Functionalized MWCNTs for vapor detection

SEM image of Oxygen plasma treated MWCNTs

TEM image of Oxygen plasma treated MWCNTs

HR-TEM image of a metal decorated MWCNT

$d_{\text{int}} \approx 3.21 \text{ nm}$

$d_{\text{ext}} \approx 14.37 \text{ nm}$

Functionalized MWCNTs for vapor detection

Plasma treatment and metal decoration helps tuning the response of MWCNT sensors

Nanostructured MOXs: Nanowires grown by AA-CVD

Intrinsic (a) and functionalized samples with gold (b), platinum (c), and gold/platinum (d) W(OPh)$_6$ (acetone); HAuCl$_4$·3H$_2$O, H$_2$PtCl$_6$·xH$_2$O, (methanol) At 350-450ºC
Nanostructured MOXs: Nanowires grown by AA-CVD

Metal decoration of MOX nanowires leads to tuning of sensitivity, lowering humidity cross-sensitivity.
Nanostructured MOXs employing smart anodization

Nanotube and nanocolumn sensors employing PAA as template

Algorithm development: Sensor array optimization and pattern recognition

Data-driven computational formalisms


Signal processing

Pre-concentration for improved LOD and ameliorated selectivity
Criteria for Success

- Demonstrator prototype for detecting CWAS is available at the end of the Project

- The detection limits attained by the project are below those offered by conventional IMS Techniques

- At least two different warfare agents can be selectively detected by the systems and methods developed in the project

Strengths:

- Complementarity between different partners.

- Use of MOX and CNTs as recognition element.

- Use of different transduction techniques

- Use of pre-concentrator to enhance sensitivity.
Project outcome

- Technology transfer to Mediterranean countries
- Training of young scientist from Mediterranean countries
- Monitoring air pollution (interesting for ANPE in Tunisia)
- Detection of dangerous gases (e.g., neurotoxic, carcinogenic)
- Prevent public security from terrorist attacks.
What research in CBRN Defense requires urgent and substantial attention?

• Intelligent materials for the detection of CWAs and bio-hazards

What should be the focus of the SPS Programme in CBRN Defense?

• Supporting research on different technologies. Promoting the convergence of technologies for developing rugged systems than could be operated in-field. Benchmarking activities.

Ideas for potential SPS activities in the CBRN field

• NATO could support international conferences to raise awareness among the scientific community and the general public about the importance of CBRN defense.