Conventional decontamination of chemical warfare agents is based on:

- **Dissolution** organic solvents, petrol, paraffin, etc.
- **Removal** bentonite, magnesia, absorbing powders
- ** Destruction** basic solutions, detergents, chlorinated lime
- **Combustion** high temperatures or plasma

All these methods need huge amounts of reagents and/or energy and this poses several problems in terms of safety, environmental and economical sustainability, costs and disposal of the detoxified by-products.

**Saponite Clays Materials**

Among saponites, saponite shows promising features for catalytic applications:
- high specific surface area
- good thermal stability

**Characterization of Nb-SAP**

**Layered morphology even more evident on nano-scale level**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Nb (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb-SAP</td>
<td>1.32</td>
</tr>
<tr>
<td>Na/Nb-SAP</td>
<td>1.35</td>
</tr>
</tbody>
</table>

**Catalytic evaluation**

Sulfur mustard (mustard), among other CW, is not easy degradable.

**Nb Saponite** prepared from Nb(OEt)$_3$, precursor is able to transform $>98\%$ of CEES in less than 8 h, under very mild conditions, using $\text{aq. H}_2\text{O}_2$ and all-clear after 8 h at room T

- active at room T too
- no external heating
- presence of Nb(V) is essential

**Toxicological Evaluation: biotests**

Biotoxins based on different living organisms:

- **Daphnia magna** (Cladocera)
- **Photobacterium letharigene** Vibrio fischeri Sh1 isolated from Black Sea and Sea of Azov in Ukraine.

Development of novel and rapid approaches in biotoxicity testing based on luminescent bacteria:

They emit visible (blue-green, sometimes yellow) light as a result of cell metabolism.

**Principles of bioluminescent testing**

**Biological effect of Nb-saponites on P. leiognathi Sh1**

Saponite-based materials do not show inhibition of luminescence.

**Removal AND Destruction on Heterogeneous Catalysts**

Inorganic oxides are efficient in removal as they have a porous and robust structure.

If we add catalytically active sites on the porous support we get an active protection and a tool for the decontamination.

Not only adsorbent, but also active.

**Towards Niobium**

The robustness of Nb-SiO$_2$ to metal leaching is an advantage for use with aqueous H$_2$O$_2$.

**Insertion of Nb(V) species**

The introduction of Nb ions into the synthesis gel did not alter the structure of saponite clays.

Hami isolated NbO$_2$ centres with tetrahedral and pentahexacoordinated geometry.

**no formation of detectable segregated NbO$_2$-like phases**

**Oxidative degradation of CEES**

Oxidative degradation of CEES at $25\%$ in $\text{aq. H}_2\text{O}_2$.

**Concentration profiles** of CEES (14 Mm), $\text{aq. H}_2\text{O}_2$ (70 mM), 20 ml. n-heptane, 20 mg catalyst, 258 K.

**Destruction**

- CEES over Nb-SAP (I)
- Nb-SAP (II)
- H$_2$O$_2$ (V)
- Nb/SAP (III)

**Gaseous products**

- CEESO
- CEESO$_2$

**Degradation**

- CEES, H$_2$O$_2$ ($78\%$)
- CeSSOl ($10\%$)
- CeSS ($2\%$)
- CeSSO$_2$ ($78\%$)
- CeSSO$_3$ ($10\%$)
- CeSSO$_4$ ($2\%$)

**Catalytic performance**

- Nb-SAP (I)
- Nb-SAP (II)
- Nb-SAP (III)
- H$_2$O$_2$ (IV)

**Comparative reactivity**

Compared to catalysts (I) and (II) as well as to the control, the use of Nb-SAP (III) and Nb/SAP (III) in the presence of H$_2$O$_2$ provides a complete suppression of the gaseous products.

**Turnaround activity by controlling the reaction time**

**Science for Peace and Security Programme**

**Multiple Projects**

**“NanoContraChem” project no. 984481**

Nanostructured Materials for the Catalytic Decontamination of Chemical Warfare Agents

www.nancontrachem.org