A GREEN AND VERY EFFICIENT SYSTEM FOR DECONTAMINATION AND DETOXIFICATION OF SENSITIVE DEVICES AND EQUIPMENTS

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Abstract*: This paper presents a very efficient decontamination technology far less polluting compared to existing technologies, which is able to rapidly and efficiently decompose the highly toxic organophosphorus compounds and their degradation products. This technology uses a suspension of catalysts and photocatalysts in organic solution and will address the sensitive equipment inside buildings, weapons, aircrafts, ships, vehicles, protective clothing, etc. The decontaminants should be non-corrosive, so that surfaces are not damaged during/following decontamination, they should have an easy usage process, should be easily produced at competitive costs in high amounts and their complete lifecycle should be environmentally favorable.*

Keywords*: life cycle, green decontamination, toxic organophosphorus compounds, CWA, sensitive surfaces.*

1. Introduction

Based on the Chemical Weapons Convention (CWC), which entered into force in 1997 and required all State Parties to destroy all stockpiles of chemical weapons (CW) in 10 years [1], the CWC is now extended to 2017, when it is expected that 99% of the original stockpiles will be destroyed. These stockpiles included significant quantities of the most toxic and lethal compounds ever invented, including nerve gases such as VX and sarin.

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NATO includes the CW threat in its rationale for installing Patriot anti-missile defences in Turkey and starts the construction of an anti-missile shield in Romania at Deveselu.

During our studies, we tried to develop new, very active catalytic and photocatalytic systems, able to carry out the decontamination and detoxification of contaminated equipment and facilities, both military and civilian.

2. Experimental

The major challenge of our researches was to develop a catalytic system to work in good cooperation with a photocatalytic system, but to be able to initiate the decontamination/detoxification reactions of organophosphorus compounds independently of the nature or the presence of a source of radiation, the source of light being necessary for initiating the photocatalytic reaction.

For this purpose we used metal (La, Zn, and Cu) complexes methanolysis system coupled with gold doped TiO_2 photocatalysts (0.5, 1 and 1.5 wt.% Au/TiO_2 samples), under daylight irradiation.

We studied the decontamination process of some simulants of CWAs, like Dimethyl methyl phosphonate (DMMP) and organophosphorus pesticides (Paraoxone, Methyl Paraoxone, Parathion, Methyl Parathion, Malaoxone, Malathion).

The toxic organic compounds are attended to their methanolysis/photocatalytic degradation by using suspensions containing freshly prepared metal (La, Cu, or Zn) complex catalyst. The evolution of the reaction was followed after 1,5, 20 and 30 minutes of daylight exposure, and analyzed by GC-MS.

3. Results and discussions

The metal-ion catalyzed methanolysis of organophosphorous materials proves that lanthanum, zinc and copper appear to be the best choices for this type of application.

As expected, the degradation of all the organophosphonate compounds, which contain P=O bonds, due to the methanolysis process, lead to spectacular results. Still, this was not the case of the organophosphonothioate compounds, which contain P=S bonds; for these compounds, the total degradation processes have not been performed through methanolysis [2,3].

In order to perform this cleavage, but also to accelerate the decomposition rate of all chosen organophosphorus compounds from this study, heterogeneous photocatalysis was taken as a proper alternative since this method could be easily applied under benign reaction conditions.

Taking into account both the advantages of methanolysis and heterogeneous photocatalysis, the combination of these methods could be the "golden key" for the development of an efficient and environmental benign system for the decomposition of chemical warfare agents.

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References

[1] www.opcw.org (accessed on 23 March 2015)

[2] R.E. LEWIS, A.A. NEVEROV, R.S. BROWN – *Mechanistic studies of La^{3+} and Zn^{2+}- catalyzed methanolysis of O-ethyl O-aryl methylphosphonate esters. An effective solvolytic method for the catalytic destruction of phosphonate CW simulants*, Org. Biomol. Chem., Vol. 3, pp. 4082-4088, 2005

[3] S.A. MELNYCHUK, A.A. NEVEROV, R.S. BROWN – *Catalytic decomposition of simulants for Chemical Warfare V agents: Highly efficient catalysis of the methanolysis of Phosphonothioate esters*, Angew. Chem., Vol. 118, pp. 1-5, 2006