CATALYTIC NANOHYBRIDS APPLIED TO THE NEUTRALIZATION OF CHEMICAL WARFARE AGENT YPERITE

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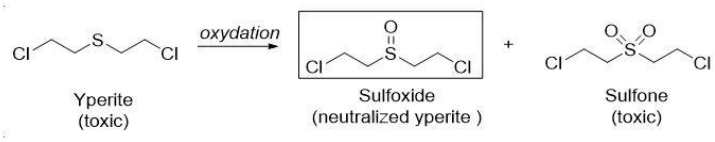
Sulfur mustard (bis(2-chloroethyl) sulfide) is a chemical agent that was first used in combat by Germany during World War I. Classified as a vesicant, sulfur mustard is also known as mustard gas or “yperite”, which refers to the location (i.e., the city of Ypres in Belgium) where it was deployed on the battle field for the first time in 1917.The production, stockpiling, and utilization of yperite and other chemical weapons have been banned by the chemical weapon convention, which came into effect in 1997. To date, most of the stocks have been destroyed but a simple molecule such as sulfur mustard can easily be synthesized by ill-intentioned individuals.Therefore, the development of “green” processes for complete and selective conversion of sulfur mustard to non-toxic derivatives, while generating limited amounts of waste and side-products, is sought. In this context, we have developed a photocatalytic process for the chemical neutralization of sulfur mustard into an inert product (i.e. the corresponding sulfoxide) with no production of the toxic sulfone.



The process was applied to the decontamination of surfaces and the neutralization of the toxic agent both in the liquid and gas phases with full efficiency. It operates selectively under visible light, with low catalytic loading, using oxygen from the air as the sole source of oxidant. Two families other families of catalysts were more recently developed and also favorably evaluated in the photocatalyzed neutralization of yperite simulants:

i) A heterogeneous photocatalyst was assembled through electrostatic immobilization of a cationic porphyrin at the surface of functionalized carbon nanotubes. The supra-molecular nanohybrid catalyst was valorized in the aerobic photo-oxidation of sulfides to the corresponding sulfoxides.

ii) A semi-heterogeneous photocatalytic system was assembled through encapsulation of a lipophilic porphyrin in stabilized polydiacetylene micelles. The colloidal nanohybrid catalyst was valorized in the aerobic photo-oxidation of sulfides to the corresponding sulfoxides. Micelles behaved as nanoreactors by creating a favorable environment for the photo-activation of oxygen nearby thioethers and subsequent sulfoxidation.

These processes allow for the recovery of the catalyst that can be readily recycled and reused.

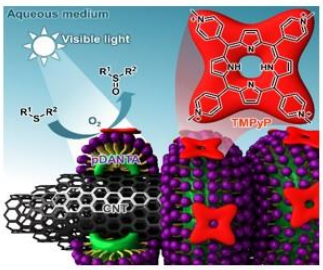


Figure 1 : Heterogeneous photocatalytic system for chemical neutralization of sulfur mustard

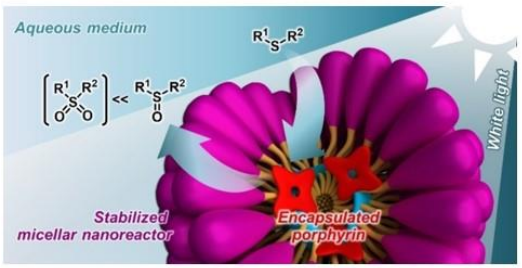


Figure 2 : Semi-heterogeneous photocatalytic system for chemical neutralization of sulfur mustard

References:

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[2] J. A. Tchuiteng Kouatchou, J. Farah, F. Malloggi, E. Gravel, E. Doris, *ChemCatChem* **2024**, 16, e202400685