Abstract

Inorganic nanostructured materials provide a versatile toolbox for CBRN risk mitigation, combining adsorption, catalytic degradation and radionuclide sequestration in deployable solid platforms. The joint activity at CNR-SCITEC and the University of Eastern Piedmont, in Milan and Alessandria, develops tailored clays, mesoporous/nanostructured oxides and nanosized chelating particles for safe, selective decontamination under mild conditions. Natural and synthetic layered silicates are exploited as tunable intercalation matrices: Fe-exchanged or acid-activated bentonites act as “active sponges”, coupling uptake of hazardous molecules with Fenton-like oxidation, while Nb(V)- and Eu(III)-containing saponites integrate Brønsted/redox catalysis with optical detection of sulfur-mustard simulants. These materials address chemical agents through hydrolysis or controlled oxidation, avoiding the use of chlorinated reagents and minimizing toxic by-products. In parallel, mesoporous and nanostructured oxides, including Nb_2O_5, WO_3, TiO_2 and ZrO_2–SiO_2 systems, are optimized to feature acid/base and redox sites for the oxidative abatement of blister-agent simulants and hydrolytic degradation of organophosphorus compounds. Their composition, texture and site proximity are tuned to improve activity, selectivity and compatibility with realistic surfaces and formulations. Radiological contamination is tackled using nanosized Prussian blue, whose high density of ferrocyanide binding sites accelerates Cs^+ uptake in simulated enteric media, enabling internal decorporation of ^{137}Cs with rapid kinetics and high removal efficiency. Particular attention is devoted to regeneration, toxicological compatibility and scalable processing for transition from laboratory powders to prototypes. The research activity bridges fundamental surface chemistry, advanced characterization and prototype-oriented testing, delivering low-cost inorganic nanomaterials for detection, protection and decontamination across chemical, biological and radiological scenarios.