Simultaneous detection and decontamination of organophosphorus compounds using a triggered enzyme release system

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The degradation of organophosphorus compounds is an important chemical and biochem research focus, because many of these compounds are neurotoxins that have been used as insecticides and stockpiled as chemical warfare agents. Ideal systems for this purpose would be triggered by the presence of the organophosphorus compound, decontaminate it, and give a visual response of this process. Organophosphorus hydrolase (OPH) is an enzyme capable of degrading a wide range of neurotoxic organophosphorus compounds. Mesoporous silica nanoparticles have several advantages as an immobilization support. They have a large range of pore diameters (20-500 Å), large surface areas (300-1500 m^2g^{-1}), are chemically inert, stable at elevated temperatures, and have surfaces that can be easily functionalized. Immobilization of OPH using porous silica prevents enzyme denaturation and increases enzymatic activity by as much as two orders of magnitude. In the system described here the interior pore volume of the porous silica nanoparticles was loaded with a dye, and the exterior of particle was capped with an OPH inhibitor that was released in the presence of a target organophosphorus compound. Specifically, the exterior of mesoporous silica nanoparticles was functionalized with diethyl 4-aminobenzyl phosphonate (DEABP). DEABP is an inhibitor of OPH and competitive with paraoxon, an organophosphonate that is structurally similar to nerve agents. The competitive inhibition of OPH, both free in solution and immobilized DEABP, was confirmed through enzyme kinetics testing using ^{31}P NMR. Current research is directed towards finding a proper indicator to be loaded into APMS that will give a fast visual response.