Could microbes solve Russia's chemical weapons conundrum?

March 8 2005

One of nature's most versatile microorganisms – a bacterium called Pseudomonas putida – could help mop up the toxic by-products caused by the destruction of the chemical weapon mustard, write Russian researchers in Journal of Chemical Technology and Biotechnology this month.
At 40,000 tonnes, Russia houses the world's largest stockpile of chemical warfare agents (CWAs). The country faces a race against time to dispose of the stockpile by 2007, in accordance with the Chemical Weapons Convention (CWC). This disposal must be achieved in an ecologically-sound manner.

Dr. Inna Ermakova and colleagues from the GK Skryabin Institute of Biochemistry and Physiology of Microorganisms at the Russian Academy of Sciences in Puschino examined the possibility of using P putida to transform the toxic by-products contained in reaction masses (RMs) that arise when mustard is destroyed by chemical detoxification (a procedure developed in response to the CWC).

Currently, incineration or a process called bitumenisation are employed to deal with RMs, how-ever both methods are highly expensive and pose environmental risks.

Mustard is a blistering agent that was first used in World War I. Found in both liquid and aerosol form (mustard gas), it can cause severe burns to the skin, and severe damage to the respiratory system and internal organs if ingested or inhaled. It accounts for around 2 percent of Russia's

CWA stockpile.

Around 60 percent of the mustard RM consists of derivatives of a toxic compound called 1,4-perhydrothiazine (PHT).

Ermakova's research team grew P putida in cultures containing mustard RM. They then moni-tored the levels of PHT derivatives in the cultures until the bacteria stopped growing, using monoethanolamine (MEA) and ethylene glycol (EG) – both residual components of the initial de-toxification process that are present in the RM – for growth.

The results showed that the concentrations of each PHT derivative decreased significantly when P putida was grown in the presence of these carbon sources.

By the time the bacteria had stopped growing, the concentration of the PHT derivatives had de-creased by 50-55 percent. When further MEA and EG were added, the overall PHT decrease was 83 percent.

In the absence of a carbon source other than PHT, the PHT levels remained constant. When no bacteria were present, the PHT concentrations also remained constant.

The authors conclude that the 1,4-perhydrothiazines undergo transformation by the microbial cells when a growth substrate (MEA/EG) is present. However as the cells did not grow in the presence of PHT alone, the authors conclude that the bacteria cannot use them for growth.

The group hopes that the bacterial strain can be used in the context of plant-microbial associa-tions to create a new generation of biotechnologies for remediation of soils contaminated by CWAs or products of their detoxification.

"Bioutilization of organic compounds of reaction masses is a biotechnological method that pro-vides maximum environmental safety, since the pollutants are naturally degraded to innocuous products such as carbon dioxide and water, as well as microbial biomass," said Dr. Ermakova.

Article: "Microbial degradation of the detoxification products of mustard from the Russian chemical weapons stockpile," Inna T Ermakova, Natalya S Safrina, Ivan I Starovoitov, Yelena V Lyubun, Alexander A Shcherbakov, Oleg E Makarov, Paul V Kosterin, and Alexander M Boronin, Journal of Chemical Technology and Biotechnology; Published Online: March 2, 2005.

Source: John Wiley & Sons, Inc.