MDF-200 – An Enhanced Formulation for Decontamination and Mitigation of CBW Agents and Biological Pathogens

Sandia National Laboratories has developed and commercialized an aqueous-based decontamination technology that can rapidly neutralize chemical and biological warfare (CBW) agents. The formulation:

- is effective for neutralizing **both** chemical and biological agents which has been demonstrated in live agent testing at approved military facilities such as the Edgewood Chemical and Biological Center and the Dugway Proving Ground;
- is environmentally benign (i.e., non-toxic and non-corrosive);
- works on a number of anticipated material surfaces;
- can be incorporated into a wide variety of carriers (**foams, liquid sprays, fogs**) that satisfy a wide variety of operational objectives.

DF-100 was developed through funding provided by the U.S. Department of Energy's and National Nuclear Security Administration's Chemical and Biological National Security Program (CBNP). One objective of the Decontamination and Restoration Initiative of the CBNP program is to develop rapid, effective, and safe (non-toxic and non-corrosive) decontamination technologies for the restoration of civilian facilities in the event of a **domestic terrorist attack** in the urban environment. Technology development is focused on the decontamination of open, semi-enclosed, and enclosed facilities as well as sensitive equipment. Examples of these types of facilities include a stadium (open), an underground subway station (semi-enclosed), and an airport terminal or office building (enclosed). Decontamination technologies for domestic applications has been focused on two general needs:

- to provide the first responder to the scene of a chemical or biological attack with the capability to rapidly respond to the event and to deal with potential casualties (i.e., **first response**);
- to restore a facility to usefulness after an attack (i.e., facility restoration or facility remediation).

Development of the original formulation occurred during the period of January 1997 to July 1999. The initial development process focused strictly on the facility restoration scenario. In July 1999, field testing of DF-100 began and in October 1999, the process to commercialize the decon formulation by licensing the product to private companies was initiated. During the field testing and commercialization process, it became apparent that the primary interest for the use of the decon formulation was from the **civilian first responder** (e.g., fire departments, police departments, and HazMat units who would be the first to arrive at the scene of an attack utilizing CBW agents) and from the military (for both battlefield and fixed site decontamination) followed by a secondary interest in use of the foam for facility restoration. It also became apparent that two properties of the original formulation (DF-100) makes use of this formulation by the civilian first responder and the military less than optimal. These properties include:

1. *Formulation Adjustment for Decon of Each CBW Agent.* The pH of the DF-100 has to be adjusted for optimal decontamination of specific chemical and biological agents;
2. *Relatively Slow Reaction Rate for Mustard.* The reaction rate for one chemical agent, Mustard, was slower than the reaction rates for the other chemical agents.

In July 2000, Sandia issued a non-exclusive, all field-of-use license to Modec, Inc. of Denver, CO for manufacture and sales of the decontamination technology. In October 2000, Sandia received funding from the DOE CBNP program to develop an enhanced version of the DF-100 product specifically to address the issues described above and to optimize performance for the military and the civilian first responder. The result of this work is DF-200, an enhanced version of the Sandia decon formulation.

The following tables show the improved performance of DF-200. The table below summarizes test results from IITRI on live chemical agents.

Chemical Agent	% Destruction of Chemical Agent		
	1 minute	15 minutes	60 minutes
GD	99.98 ± 0.01	99.97 ± 0.01	99.98 ± 0.01
VX	91.20 ± 8.56	99.80 ± 0.08	99.88 ± 0.04
HD	78.13 ± 10.53	98.46 ± 1.43	99.84 ± 0.32

Figure 1: Reaction rates in kinetic testing for DF-200HF against chemical agents.

Detection of very low levels of GD in the 15 and 60-minute samples was determined to be from carryover in the gas chromatography columns and not from unreacted agent.

Methylphosphonic acid (MPA) and pinacolyl methylphosphonic acid (PMPA) were identified as byproducts in the decon/GD mixtures. Ethyl methylphosphonic acid (EMPA) and MPA were identified as byproducts in the decon/VX mixtures. This indicated that the destruction of the VX followed the more desirable path to the phosphonic acids rather than to EA2192 (a toxic byproduct which can also be produced during VX degradation). The initial degradation products for HD are a mixture of the sulfoxide and sulfone byproducts followed by nearly complete disappearance of each of these byproducts after 60 minutes.

Results of tests utilizing DF-200 against anthrax spores is shown in Figures 6 and 7 and against *Yersinia pestis* (i.e., the plague bacterium) are shown in Figure 8 (NG refers to 'no growth'). The detection limit for these tests were 10 CFU/ml. Note that the 'error bars' in the '% Reduction' column takes into account this detection limit.

B. anthracis **AMES-RIID**	**Average CFU/ml**	**Log Reduction**	**% Reduction**
Control	1.21E+07		
15 min contact	NG	7	100±.00004
30 min contact	NG	7	100±.00004
60 min contact	NG	7	100±.00004

Figure 2: Kill rates for *B. anthracis* AMES-RIID spores in a solution of DF-200HF.

B. anthracis **ANR-1**	**Average CFU/ml**	**Log Reduction**	**% Reduction**
Control	6.42E+07		
15 min contact	NG	7	100±.00004
30 min contact	NG	7	100±.00004
60 min contact	NG	7	100±.00004

Figure 3: Kill rates for *B. anthracis* ANR-1 spores in a solution of DF-200HF.

Y. pestis (ATCC 11953)	Average CFU/ml	Log Reduction	% Reduction
Control	1.33E+07		
15 min contact	NG	7	100±.00004
30 min contact	NG	7	100±.00004
60 min contact	NG	7	100±.00004

Figure 4: Kill rates for *Y. pestis* cells in a solution of DF-200HF.

Bacillus Subtillus (ATCC 19659)	Average CFU/ml	Log Reduction	% Reduction
Control	6.7E+05		
1 hr contact	NG	7	100±.00004
3 hr contact	NG	7	100±.00004

Figure 5: Kill rates for *Bacillus Subtillus* cells in a solution of DF-200HF in AOAC tests.

Aflatoxin Mycotoxin	Toxin Amount	Log Reduction	% Reduction
Control	15 ng		
15 min contact	NG	7	100%
30 min contact	NG	7	100%

Figure 6: Kill rates for *Y. pestis* cells in a solution of DF-200HF.

The petri dishes used for cell growth on each of these tests were saved for 21 days following the tests to verify that DF-200 actually killed the spores rather than just inhibited their growth. No growth on any of the petri dishes was observed after the 21-day period.

Modec's Decontamination Formulation MDF200 was independently confirmed by Sandia National Laboratories in 2002 as effective on G, VX, Mustard and anthrax simulants (Diphenyl chlorophosphate, O-Ethyl S-ethyl Phenylphosphonothioate, 2-Chloroethyl phenyl sulfide and *Bacillus globigii* spores, respectively) by achieving 100% neutralization of all agents. In addition, independent lab tests have shown 100% neutralization of *bacillus subtillus* spores in a solution of MDF200.

Note: The above referenced information represents testing performed by Sandia National Laboratories and others. Modec, Inc. makes no label claims, either direct or implied, that its products are antimicrobial as defined by the USEPA and FIFRA regulations.