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Issues With the Use of DMSO for Warhead Dismantlement Via Dissolution

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Issues with the Use of DMSO for Warhead Dismantlement via Dissolution†

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Abstract

The solvent dimethyl sulfoxide (DMSO) will be used in two warhead dismantlement programs at Pantex to remove plastic bonded HMX explosives from bonded nuclear assemblies. This paper addresses the chemical compatibility of various warhead and workstation materials with DMSO solutions of HMX. The effects of possible exposure of HMX/DMSO solutions to plutonium are addressed in another paper in this conference. Although not reported herein, a number of other issues involved with the DMSO dissolution process may be discussed during the presentation, including: the peculiar behavior sometimes exhibited by DMSO swollen Halthane 73-18 adhesive, and several results from hazards assessments of electrical energy hazards, residues, and detonators.

Introduction

In the HE Dissolution Workstation, dimethyl sulfoxide solvent is used to remove PBX-9404 and LX-10 high explosives from W48 and W79 nuclear assemblies. The primary ingredient in both HE formulations is HMX (Figure 1, Table I). HMX is highly soluble in DMSO – about 460 grams per liter at 23°C.

Figure 1. Chemical structures and some properties of DMSO and HMX

Inside the Dissolution Workstation, a fixed volume of DMSO is continuously recirculated through spray nozzles directed at the high explosive. All materials in the high explosive assemblies and the Workstation are continuously exposed to HMX/DMSO solution during the dissolution process.

Experimental

All materials introduced into and used to construct the HE Dissolution Workstation were evaluated for compatibility with pure DMSO and its solutions with HMX, PBX-9404, and LX-10. Exposures included both long-term immersion tests at ambient temperature and accelerated "Chemical Reactivity Tests" (CRTs) at elevated temperature. Figures 2 and 3 show some of the materials evaluated. Immersion tests were conducted at room temperature for times exceeding 1000 hours with the specimens periodically

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Table I. High explosive formulations

Constituent	PBX-9404	LX-10
HMX, $C_4H_8N_8O_8$	94 wt%	95 wt%
Nitrocellulose, $[C_6H_7N_3O_{11}]_n$	3 wt%	—
CEF, $O=P-(O-CH_2-CH_2Cl)_3$	3 wt%	—
DPA, Diphenylamine	0.5 wt%	—
Viton A, $[-(CH_2CF_2)_{3.5}-(CF(CF_3)CF_2)_1-]_n$	—	5 wt%

removed for inspection and weighing. Elevated temperature exposures were conducted using the CRT test, which yields the volume and type of gases evolved when a material is aged in direct contact with a high explosive over a given period of time-at-temperature (typically 22 hours at 120°C). The CRT exposure is carried out in a confined volume under an inert atmosphere. Incompatibility is indicated when the mixture (usually 0.25 g of sample with 0.25 g HE) yields a greater total volume of gas than either material does alone.

It was anticipated that DMSO might be made acidic by the addition of HMX. For aqueous media, acidity is readily characterized by measuring the pH, or hydronium ion concentration $[H_3O^+]$; however, the pH concept does not apply to aprotic, nonaqueous solvents like DMSO. To get around this problem we used a test method provided by Gaylord Chemical Company, the supplier of our DMSO, which calls for diluting DMSO solutions 1:5 with neutral water for pH determination. Once water is added to HMX/DMSO solutions, the HMX precipitates forming an aqueous/DMSO suspension.

Results and Conclusions

Nearly identical immersion behavior was exhibited by most of the materials in pure DMSO and its solutions with HMX, even though DMSO solutions of HMX were found to be slightly acidic. Exceptions were brass (not used - once considered a candidate workstation material), copper (as conductors in the detonator cables in both the W48 and W79), and magnesium (part of the W48 assembly), all of which exhibited visible signs of corrosion after long immersions. These were also the only materials to also test positive in the accelerated CRT tests (see Figures 2 and 3).

The total gas volumes in Figures 2 and 3 represent the average of two CRT test runs. The values are normalized to a 0.25 gram specimen to account for the differences in the specimen weights used. PBX-9404 appears to be somewhat more reactive than LX-10, which is not unexpected due to its slightly higher acidity. Additionally, the nitrocellulose binder in PBX-9404 might be reactive, as might be the CEF plasticizer (see Table I), which is a potential source of chlorine if degraded.

The apparent "incompatibilities" of copper and magnesium are *not* considered significant because of the relatively brief times that these weapon materials will be exposed to HMX/DMSO solutions inside the Dissolution Workstation. Good selections were made for all the materials used to construct the HE Dissolution Workstation.

Figure 2. Chemical reactivity test (CRT) results for materials in contact with DMSO/PBX-9404/H₂O (100:41:2). 22 hours at 120°C. Sample weights: (a) 0.0325 g, (b) 0.065 g, (c) 0.125 g, (d), 0.250 g

Figure 3. Chemical reactivity test (CRT) results for materials in contact with DMSOLX-10/H₂O (100:41:2). 22 hours at 120°C. Sample weights: (a) 0.0325 g, (b) 0.065 g, (c) 0.125 g, (d), 0.250 g

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