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CHARACTERIZATION OF THE SOLID PRODUCT(S)
FORMED WHEN UF_6 IS RELEASED INTO AMBIENT AIR
IN A CONTAINED VOLUME (U)

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INTRODUCTION

Preliminary characterization of the plume or cloud produced by the release of UF_6 into humid air and the particulates comprising this cloud has been accomplished. The explosive release was conducted in a vessel in which the air at atmospheric pressure was static and the particulate material was collected on microscope grids by gravitational settling. Transmission and Scanning Electron Microscopy (TEM and SEM) have been used to determine the size or range of sizes of the particles produced by the release and the nature of the agglomerates produced from these particles. The particulate material was also analyzed by x-ray diffraction.

SUMMARY

The plume produced dispersed rapidly, completely filling the $\sim 30,000 \text{ cm}^3$ release vessel in less than 10 sec. Settling of the particulate material required several hours for completion. Particles produced by the release were generally $> 1000\text{\AA}$ spheroids but some as small as $100\text{\AA}$ were collected. The agglomerates were like those seen in typical smokes, i.e. catenulate or chain-like in nature and several microns in length, although some were less than 1μ in dimension. X-ray diffraction analysis indicated the material to be $\text{UO}_2\text{F}_2 \cdot 2\text{H}_2\text{O}$ while infrared absorption spectrometry indicated the presence of UO_2^{+2} and H_2O in the material. These results were, of course, not for ephemeral species but stable, long-term products.

EXPERIMENTAL

Since most UF_6 releases which would produce plumes would require the UF_6 to be at elevated temperature (vapor pressure greater than atmospheric), the UF_6 was released by the explosion of the UF_6 container. This was accomplished by liquefaction of the UF_6 in a container which would not accommodate the volume change experienced in liquefaction. The container was a quartz glass tube 0.5 mm in diameter which contained 0.0454 g UF_6 . This container was heated by a helical nichrome element 2 1/2 in. above the floor of a glass release chamber whose volume was 29.767 l and which contained ambient air whose relative humidity was 47%. Two percent of the moisture in the chamber would be required to hydrolyze 0.0454 g of UF_6 if the hydrolysis path were:

Hydration to $\text{UO}_2\text{F}_2 \cdot 2\text{H}_2\text{O}$ would require another 2% of the moisture. Figure 1 is a photograph of the release chamber before the release.

RESULTS AND DISCUSSION

Heating of the helix surrounding the sealed quartz tube containing the UF_6 caused the tube to explode when the UF_6 liquefied. Figure 2 is a photograph of the release ~ 1 sec after the explosion. As can be seen the plume was rising and within 10 sec had dispersed throughout the chamber as Figure 3, a photograph of the chamber 10 sec after the release, shows. Photographs taken 3 min, 10 min, and 20 min after the release showed no change in the cloudiness of the chamber while a photograph taken 6 hr after the release showed most of the cloud had settled. Total settling occurred between 6 hr and 89 hr after release. These photographs are shown in Figures 4, 5, 6, 7, and 8. Figure 9 is a photograph of the floor of the chamber showing the shards of the UF_6 container dispersed by the explosion. Microscope grids were used to collect samples 16 in., 12 in., and 9.5 in. above the floor of the release chamber. Also, samples were collected on the floor of the chamber and $3/8$ in. above the floor. Figures 10, 11, 12, 13, and 14 are transmission electron micrographs of these samples at 6000X. All of the samples except the one obtained at $3/8$ in. were composed of particles very similar in size while the $3/8$ in. sample particles were larger. This probably reflects the fact that the $3/8$ in. sample was much nearer "ground zero", i.e., directly under the explosion. The material on the three highest samples was sparse enough to allow measurement of gasborne agglomerate sizes which were predominantly multimicron with a few submicron agglomerates present. Samples from $3/8$ in. and 0 in. could not be used to estimate agglomerate size ranges because of the obscuring effect of "pile-up" of agglomerates. Figures 15 through 26 are higher magnification transmission electron micrographs showing more clearly the particle sizes present and the nature of the agglomerates. As can be seen, the shapes of the agglomerates were so irregular that precise prediction of their behavior in air by Stoke's Law would be difficult. If the sphere sizes these agglomerates would mimic could be calculated, then predictions about their behavior in air could be made with greater certainty. No obvious trend in particle or agglomerate sizes could be seen on the three samples obtained at 16, 12, and 9.5 in., which is felt to reflect the apparent equilibration resulting from the lengthy collection time. X-ray diffraction analysis of material scraped from the glass slide holding the grids at the $3/8$ in. "ground zero" position showed the deposit to be $\text{UO}_2\text{F}_2 \cdot 2\text{H}_2\text{O}$ while UO_2^{+2} and H_2O were detected in this material by infrared absorption spectrometry.

CONCLUSIONS

A small quantity of UF_6 rapidly released into ambient air contained in a static release chamber produced a white plume which within 10 sec was dispersed throughout the volume of the chamber. Settling of the particles comprising this aerosol was not quantitatively measured but qualitative observation of the scattering of a beam of light indicated almost all of the airborne particulate material had settled in 6 hr. Transmission electron microscopy of samples collected at these distances above the level of the release showed the airborne entities to be micron-sized, tenuous agglomerates of spheroidized particles 100 to $> 1000\text{\AA}$ in diameter.

Figure 1
RELEASE CHAMBER BEFORE EXPLOSION

Figure 2
RELEASE CHAMBER 1 SEC AFTER EXPLOSION

Figure 3
RELEASE CHAMBER 10 SEC AFTER EXPLOSION

Figure 4
RELEASE CHAMBER 3 MIN AFTER EXPLOSION

Figure 5

RELEASE CHAMBER 10 MIN AFTER EXPLOSION

Figure 6

RELEASE CHAMBER 20 MIN AFTER EXPLOSION

Figure 7
RELEASE CHAMBER 6 HR AFTER EXPLOSION

Figure 8
RELEASE CHAMBER 89 HR AFTER EXPLOSION

Figure 9
FLOOR OF RELEASE CHAMBER AFTER EXPLOSION
SHOWING SHARDS OF UF_6 CONTAINER

JX-1281

Figure 10

6000 X

MATERIAL COLLECTED 16 IN. ABOVE CHAMBER FLOOR
Transmission Electron Micrograph

JX-1285

Figure 11

6000 X

MATERIAL COLLECTED 12 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1301

Figure 12

6000 X

MATERIAL COLLECTED 9.5 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1308

Figure 13

6000 X

MATERIAL COLLECTED 3/8 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1302

Figure 14

6000 X

MATERIAL COLLECTED ON CHAMBER FLOOR

Transmission Electron Micrograph

JX-1276

Figure 15

30,000 X

MATERIAL COLLECTED 16 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1278

Figure 16

30,000 X

MATERIAL COLLECTED 16 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1279

Figure 17

30,000 X

MATERIAL COLLECTED 16 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1280

Figure 18

30,000 X

MATERIAL COLLECTED 16 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1287

Figure 19

30,000 X

MATERIAL COLLECTED 12 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1289

Figure 20

30,000 X

MATERIAL COLLECTED 12 IN. ABOVE CHAMBER FLOOR
Transmission Electron Micrograph

JX-1293

Figure 21

30,000 X

MATERIAL COLLECTED 12 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1295

Figure 22

30,000 X

MATERIAL COLLECTED 9.5 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1298

Figure 23

30,000 X

MATERIAL COLLECTED 9.5 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1313

Figure 24

30,000 X

MATERIAL COLLECTED 3/8 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1314

Figure 25

30,000 X

MATERIAL COLLECTED 3/8 IN. ABOVE CHAMBER FLOOR

Transmission Electron Micrograph

JX-1305

Figure 26

30,000 X

MATERIAL COLLECTED ON CHAMBER FLOOR

Transmission Electron Micrograph

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