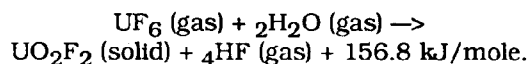


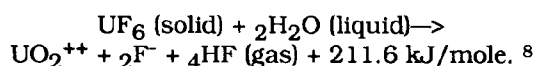
Chemical Reactions And Quick Dispersion

From the perspective of danger to human health, the most important difference between UF₆ and other radioactive materials is that solid, liquid, or gaseous UF₆ will quickly form a highly toxic cloud on contact with air or water. This is the main reason UF₆ is kept in special steel containers. When UF₆ comes into contact with moisture in the air, a gaseous cloud is rapidly formed of highly corrosive, non-radioactive hydrofluoric acid (HF)⁷ and fine particles of radioactive uranyl fluoride (UO₂F₂). The reactions can be written as follows:

a) when UF₆ is in the gaseous phase:



b) when UF₆ is in the solid phase:



A concise description by an NRC scientist of the reaction between UF₆ and air is,

"The reaction occurs very rapidly, generally taking no more than a few seconds with a maximum of about 10 seconds if several tons of uranium hexafluoride are released as a gas or liquid into relatively dry air. The chemical reaction also releases heat, making the plume buoyant and causing it to rise.

"One kg of UF₆ contains 0.68 kg of uranium ions and 0.32 kg of fluorine ions. The reaction with water in the air produces 0.23 kg of HF."⁹

The rate of reaction between UF₆ and water vapor in the air is slower when UF₆ is in the solid phase, as is normally the case during transport. British nuclear scientists writing about safety at the Capenhurst enrichment plant in the U.K. point out that even when UF₆ is in the solid phase,

"One kg of water will react with approximately 10 kg of UF₆ to form approximately two kg of HF and a release of this size would present a serious hazard to site personnel in the vicinity. Hence it was concluded that, with sufficient moisture present a handling accident leading to a spill of UF₆ could produce a serious local hazard..."¹⁰

When a type 48Y cylinder is heated to 121°C and in a horizontal position with its valve open and at the lowest point, it takes only four minutes for 80% of the contents to leak out. At a temperature of 121°C it is estimated that 2.7 kg of UF₆ will vaporize every second.¹¹ How far the vaporized UF₆ travels depends on the temperature of the UF₆, as well as on wind conditions.

When describing the chemical properties of UF₆, E.J. Barber wrote,

"UF₆ tends to be strongly chemisorbed¹² on most materials, giving a high surface coverage and consequently good molecular contact and greatly increasing the opportunity for reactions."¹³

UF₆ does not react with oxygen, nitrogen, or dry air, and will not excessively corrode dry aluminium, copper, monel, nickel, and aluminum bronze. Hydrocarbon oils are a special case. The IAEA has written,

"Due to the oxidizing properties of UF₆, the reaction of liquid UF₆ with some organic materials is unpredictable and may be explosive. Small quantities of hydrocarbon oil may react vigorously resulting in a serious explosion. As a result extreme caution should be used to ensure cylinders are clean and free of organics."¹⁴

⁷ Hydrofluoric acid and hydrogen fluoride are the same substance.

⁸ IAEA, November 1990, p. 31. The "kJ/mole" is a measure of the heat released in the reaction per quantity of UF₆. A "mole" is a number of elementary units (atom, molecule, ion, electron, etc.) equal to the number of atoms in 0.012 kg of carbon-12.

⁹ McGuire, April 1990, p. 2.

¹⁰ Norsworthy and Howarth, 1978, p. 204; in: OECD, 1978.

¹¹ Bouzigues, et. al., 1978, p. 347; in: OECD, 1978.

¹² "Strongly chemisorbed" means that UF₆ spreads out and "sticks" to most materials.

¹³ Barber, 1988, p. 4; in: Strunk and Thornton (eds), undated.

¹⁴ IAEA, November 1990, p. 31. See also Barber, 1988, p. 4; and Williams, 1988, p. 18; both in: Strunk and Thornton (eds), undated.