POTENTIAL USES OF DEPLETED URANIUM

Robert R. Price

U.S. Department of Energy
Germantown, Maryland 20874

M. Jonathan Haire and Allen G. Croff

Chemical Technology Division
Oak Ridge National Laboratory*
Oak Ridge, Tennessee 37831-6180

June 2000

For
American Nuclear Society
2000 International Winter and Embedded Topical Meetings
Washington, D.C.
November 12–16, 2000

---

*Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725.

POTENTIAL USES OF DEPLETED URANIUM

Robert R. Price

U.S. Department of Energy
Germantown, Maryland 20874

M. Jonathan Haire and Allen G. Croff

Chemical Technology Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6180

SUMMARY

The U.S. government has -500,000 metric tons of surplus depleted uranium (DU) stored at U.S. Department of Energy (DOE) sites across the country. This material, mostly depleted uranium hexafluoride (DUF_6) resulting from enrichment operations, is the largest mass of material in the Department's inventory. On August 2, 1999, DOE issued a *Record of Decision (ROD) for Long-Term Management and Use of Depleted Uranium Hexafluoride*. This ROD indicated that DOE has decided to promptly convert the DUF_6 inventory to a more chemically stable form. In addition, DOE has initiated the DU Uses Research and Development Program to explore potential beneficial uses of various forms of converted DU, the fluorine associated with the DUF_6, and emptied carbon-steel DUF_6 storage cylinders to achieve cost savings to the government. The government will also carry out research activities necessary to ensure the direct disposal of these materials to the extent that cost-effective and realistic beneficial uses are not found.

DU uses can be sorted into several broad categories:

1. In **nuclear fuel cycle applications**, the DU can be used as:

   - feed for further enrichment,
   - a fertile material to create plutonium for nuclear fuel in fast breeder reactors,
   - a diluent to down-blend highly enriched uranium to make commercial reactor fuel, or
   - potentially as a component of a waste repository.

2. Because of its high density, a potential market for DU exists in **radiation shielding** from x-rays or gamma rays. One shielding concept involves making a "heavy" concrete using a DU compound as one of the aggregate components of the concrete. If a DU compound is used to make concrete, the same shielding performance could be achieved with up to half the thickness required of normal concrete, depending on the form of the DU.

3. DU metal has been used in conventional **military applications** such as tank armor and armor piercing projectiles.

4. There are a number of possible **commercial applications** for DU. Traditionally, DU has been used commercially as counterweights in a variety of application, most notably in the aerospace industry. But other innovative uses have been and continue to be discovered (e.g., DU catalysts and semiconductors).

While some of the foregoing uses of DU are established practice (e.g., military applications), others have yet to be proven feasible or practicable. Establishing the feasibility or practicality of potential DU uses is one of the goals of the Department's DU Uses Research and Development program.

From the preceding categories, two novel potential uses of DU are highlighted—uranium oxide-based catalysts and semiconductors. The Department has initiated an activity to investigate the basic chemistry of DU with a view to determining its potential usefulness in a variety of catalysis applications. The overall goal of the catalysts research is to investigate a new class of mesoporous sol-gel catalysts containing DU oxides as the active component. The initial goal is to understand how well such catalysts decompose a range of volatile organic compounds (VOCs), including alkanes, aromatics, and chlorinated organic compounds, which would be of interest in environmental restoration. This investigation is motivated by the demonstrated high efficiency and long-term stability of uranium-oxide-based catalysts, as compared to some commercial catalysts using precious metals[1,2], (e.g., TiO_2 and Co_3O_4). Preliminary experiments have demonstrated that mesoporous uranium oxide (U_3O_8) with a surface area as high as 65.1 m^2/g can be synthesized[3]. This surface area is at least 650 times larger than that of commercial U_3O_8 (<0.1 m^2/g). It is well known that heterogeneous catalytic efficiencies are proportional to catalyst surface areas. Accordingly, much higher catalytic efficiencies are expected for the mesoporous uranium oxides. Subsequent investigations will analyze the uses of catalysts in a variety of other applications.

The electrical and semiconductive properties of uranium could potentially lead to a new generation of electronic devices. There has never been an electronic device made using uranium oxide as a semiconductor. Yet, uranium oxides have electrical and electronic properties equivalent to or much better than the properties of conventional Si, Ge, and GaAs semiconductor materials. The 1.3-eV energy band gap[4] for uranium dioxide (UO_2) lies between Si and GaAs at the optimum of the band gap vs efficiency curve, indicating that one should be able to use uranium oxides to make very efficient solar cells, semiconductors, or other electronic devices. The intrinsic electrical conductivity of UO_2 is approximately the same as GaAs. The dielectric constant[4] of UO_2 (-22) is nearly double that for Si (11.2) and GaAs (14.1), perhaps making UO_2 better suited for higher density integrated circuits than are silicon electronics, without suffering CMOS tunneling breakdown due to the smaller nanometer size features. The ceramic oxides of uranium, e.g. UO_2, can withstand much higher operating temperatures (-2600EK) than can Si or GaAs (<473EK). Thus, it appears that a new higher-performance class of semiconductors is possible: DU-based semiconductors. It is envisioned that these new semiconductors may be suitable for use in harsh environments wherein traditional semiconductors are inappropriate, such as in space applications.

It is recognized that major issues exist that must be resolved before commercial uses can be implemented, including addressing a number of technical aspects and obtaining regulatory and user acceptance of any future uses.

The inventory of DU in the United States is seen as an asset—with the realistic potential for beneficial uses. Through the DU Uses Research and Development Program, DOE is working to realize the potential of this DU inventory.

REFERENCES

1. Hutchings, G. J., et. al., “Uranium-Oxide-Based Catalysts for the Destruction of Volatile Chloro-Organic compounds,” *Nature*, **384**, pp. 341–343, 1996.

2. Pollington, S.D., et. al., “Novel Supported Uranium Oxide Catalysts for NO_x Abatement,” *Chem. Comm*., pp. 725–726, 1999.

3. Dai, Sheng, Oak Ridge National Laboratory, Oak Ridge, Tennessee, (Personal communication to M. J. Haire) January 1999.

4. G. V. Samsonov, *The Oxide Handbook*, 2nd Edition, 1982.