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Report

A Note on the Reaction of Hydrogen and Plutonium

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Plutonium hydride has many practical and experimental purposes. The reaction of plutonium and hydrogen has interesting characteristics, which will be explored in the following analysis.

Plutonium is a radioactive actinide metal that emits alpha particles. When plutonium metal is exposed to air, the plutonium oxides and hydrides, and the volume increases. PuH_2 and Pu_2O_3 are the products. Hydrogen is a catalyst for plutonium's corrosion in air. The reaction can take place at room temperature because it is fairly insensitive to temperature. Plutonium hydride, or PuH_2, is black and metallic. After PuH_2 is formed, it quickly flakes off and burns. The reaction of hydrogen and plutonium is described as pyrophoric because the product will spontaneously ignite when oxygen is present. This tendency must be considered in the storage of metal plutonium. The reaction is characterized as reversible and nonstoichiometric. The reaction goes as such: $Pu + H_2 \rightarrow PuH_2$.

When PuH_2 is formed, the hydrogen/plutonium ratio is between 2 and 2.75 (approximately). As more hydrogen is added to the system, the ratio increases. When the ratio exceeds 2.75, PuH_3 begins to form along with PuH_2. Once the ratio surpasses 2.9, only PuH_3 remains. The volume of the plutonium sample increases because of the added hydrogen and the change in crystal structure which the sample undergoes.

As more hydrogen is added to a system of metal plutonium, the crystal structure evolves. Plutonium has a crystal structure classified as monoclinic. A monoclinic crystal structure appears to be a rectangular prism. When plutonium reacts with hydrogen, the product PuH_2, becomes a fluorite structure. It can also be described as a face centered cubic structure. PuH_3 forms a hexagonal crystal structure. As plutonium evolves from metal plutonium to plutonium hydride to plutonium trihydride, the crystal structure evolves from monoclinic to fluorite to hexagonal. This change in crystal structure as a result of adding hydrogen is a shared characteristic with other actinide elements. Americium is isostructural with plutonium because they both form cubic dihyrides and hexagonal trihydrides.

Reacting hydrogen with plutonium has the practical application of separating plutonium from other materials that don't react as well with hydrogen. When plutonium is placed in a

chamber where there is very little oxygen, it can react with hydrogen without igniting. The hydrogen plutonium reaction can then be reversed, thus regaining the separated plutonium. Another application of this reaction is that it can be used to predict how plutonium reacts with other substances. Deuterium and tritium are two isotopes of hydrogen that are of interest. They are known to react likewise to hydrogen because they have similar properties. The reaction of plutonium and isotopes of hydrogen can prove to be very informative.

References

http://www.sciencedirect.com/science/article/pii/S092583880100932X

http://pubs.rsc.org/en/content/articlepdf/1955/jr/jr9550003932

http://www.google.com/patents?hl=en&lr=&vid=USPAT2915362&id=w-hIAAAAEBAJ&oi=fnd&dq=plutonium+hydride&printsec=abstract#v=onepage&q=plutonium%20hydride&f=false

http://www.osti.gov/bridge/servlets/purl/780923-oYY8uU/webviewable/780923.pdf

Metal Hydrides by Mueller, Blackledge, and Libowitz (text)