Public Abstract
First Name:Michael
Middle Name:Steven
Last Name:Peck
Adviser's First Name:Mark
Adviser's Last Name:Prelas
Co-Adviser's First Name:
Co-Adviser's Last Name:
Graduation Term:FS 2007
Department:Nuclear Engineering
Degree:PhD
Title:Materials Study Supporting Thermochemical Hydrogen Cycle Sulfuric Acid Decomposer Design

Increasing global climate change has been driven by greenhouse gases emissions originating from the combustion of fossil fuels. Clean burning hydrogen has the potential to replace much of the fossil fuels used today reducing the amount of greenhouse gases released into the atmosphere. The sulfur iodine and hybrid sulfur thermochemical cycles coupled with high temperature heat from advanced nuclear reactors have shown promise for economical large-scale hydrogen fuel stock production. Both of these cycles employ a step to decompose sulfuric acid to sulfur dioxide. This decomposition step occurs at high temperatures, in the range of 825Â°C to 926Â°C dependant on the catalysis used. Successful commercial implementation of these technologies is dependent upon the development of suitable materials for use in the highly corrosive environments created by the decomposition products. Boron treated diamond film was a potential candidate for use in decomposer process equipment based on earlier studies concluding good oxidation resistance at elevated temperatures. However, little information was available relating the interactions of diamond and diamond films with sulfuric acid at temperatures greater than 350Â°C.

A laboratory scale sulfuric acid decomposer simulator was constructed at the Nuclear Science and Engineering Institute at the University of Missouri- Columbia. The simulator was capable of producing the temperatures and corrosive environments that process equipment would be exposed to for industrialization of the sulfur iodide or hybrid sulfur thermochemical cycles. A series of boron treated synthetic diamonds were tested in the simulator to determine corrosion resistances and suitability for use in thermochemical process equipment. These studies were performed at twenty four hour durations at temperatures between 600Â°C to 926Â°C. Other materials, including natural diamond, synthetic diamond treated with titanium, silicon carbide, quartz, aluminum nitride, and Inconel were also tested in the simulator to determine corrosion resistances.

The study concluded that boron treated diamonds were not suitable for use in decomposer process equipment. Unacceptable corrosion rates were observed at 600Â°C and increased linearly with temperature up to 700Â°C. The boron treated diamonds completely disassociated at temperatures above 700Â°C. The researcher postulated that the high corrosion rates resulted from diamond carbon having a higher preference for oxygen free radicals formed during the decomposition process. Oxygen free radical concentration also increased as a function of increasing temperature.

Natural diamond and synthetic titanium treated diamond were also unsuitable for use in decomposer process equipment. The corrosion results were similar to that of the boron treated diamonds. Silicon carbide may have potential for used in decomposer process equipment. No appreciable silicon carbide corrosion was observed and more study is warranted. Minor quartz and aluminum nitride corrosion was observed (approximately 0.2% - 0.4%). Inconel corrosion rates were very high at all temperatures tested.