

Visitor Research Report

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Area of Research: Multifunctional Aerospace Materials

Period of Visit: May 18, 2009 – August 14, 2009

Goal:

Materials formed by self-propagating high-temperature synthesis (SHS) have gained popularity in the past 20 years, but many of their properties still remain a mystery. It is assumed that these reactions emit large amounts of heat due to the excessive temperature rise, but current data is inconclusive. Calorimetry is the science of measuring heat of chemical reactions, and calorimetry is accomplished by using a device called a calorimeter. Modifications were made on a standard bomb calorimeter in order to collect data from two cermet SHS reactions. The results from the calorimetry tests were within an acceptable range of the theoretical values of reaction enthalpies. Many factors for error still exist in these experiments, but the results of the research provide a good starting point for future research.

Strategy:

Modifications were made to the jacket of the calorimeter and a variable transformer was connected to the calorimeter as the ignition unit. It was assumed that variable voltages would be needed to run tests inside the bomb calorimeter. Preliminary tests needed to be performed before tests could be run inside the bomb calorimeter. The reactions needed to be scaled down to the acceptable bomb calorimeter range (0.9-1.25g), and other adjustments needed to be made. The following results show 25 preliminary tests leading up to tests in the bomb calorimeter.

Accomplishments:

A standard bomb calorimeter test consisted of 2000g of deionized water, 0.5g sample for Mg SHS, 1.25g sample for Al SHS, 10 cm of 18 gauge wire for Al SHS reaction, 10 cm of 34 gauge wire for Mg SHS reaction, and a steel Parr crucible. The samples were ignited 5 minutes into the recorded time interval and the temperature was recorded for 30 minutes from start to finish. Five tests were run for the Al SHS reactions and 3 tests were run for the Mg SHS reaction. Graphs of the data collected from the Al SHS and Mg SHS bomb tests were recorded. The results fit the profile for a standard bomb calorimeter run. The average temperature rise of the Al reactions was 0.63°C with a standard deviation of $\pm 0.03^{\circ}\text{C}$. The average temperature rise of the Mg SHS reactions was 0.26°C with a standard deviation of $\pm 0.04^{\circ}\text{C}$. The temperatures for these tests rose over the entire interval, so energy was being added to the system from outside sources. Taking into effect the correction factors for energy being added to the system, the corrected average

temperature rise for the Al SHS reactions was 0.54°C, and the corrected average temperature rise for the Mg SHS reactions was 0.23°C. Logan's theoretical value for the heat of combustion of an Al SHS reaction is 450cal/g which is about half of the test value. The test value for an Mg SHS reaction was determined, but the theoretical value is still to be determined. Test results are still inconclusive.

Future Work:

The heat capacity (C) of the system could not be determined, because oxygen use was not permitted in the lab. Figuring out the heat capacity of the system requires the bomb to be purged with oxygen under high pressure. Future research will involve determining the heat capacity of the system and perfecting current techniques for a higher level of accuracy. Hopefully I will come back over the winter or next summer and do some more research on this project.

Pending Publications: N/A

Seminar Presented: N/A