THE VAPOR PRESSURE OF PALLADIUM AT TEMPERATURES UP TO 1973K. K. G. Gardner,[1] F. T. Ferguson[2,3] and J. A. Nuth[3], [1]University of Oklahoma (NASA Academy Research Associate), [2]Chemistry Department, Catholic University of America (Washington, D.C. 20064), [3]NASA-Goddard Space Flight Center (Code 691, Greenbelt, MD 20770).

Introduction: Understanding high-temperature processes is imperative for modeling the formation of the solar system. It is unfortunate that since the 1950's little has been done in the area of thermodynamics to continue gaining information on metals such as iron (Fe), nickel (Ni), cobalt (Co), palladium (Pd) and many others. Although the vapor pressures of these metals can be extrapolated to higher temperatures, the data is often limited to temperature ranges too low to be applicable to processes that occur during the formation of the solar system (T ~2000K). Experimental techniques inhibited the data in the past by restricting the testing of metals to temperatures below their melting point. Today, higher temperature testing is possible by using a Thermo-Cahn Thermogravimetric system that is able to reach temperatures up to 1973K in vacuo and measure a 10 gram change in a sample with mass of up to 100 grams [1], [2].

This experiment was done in order to test the Thermo-Cahn system for accuracy up to 2000K. The problem that needs to be addressed concerns correction factors for the effusion cell. Standard physical equations for mass loss do not take into account the geometric shape of the cell. Two correction factors must be used in order to obtain measured values for the vapor pressure. The first correction is the pipe correction factor, which takes into account the thickness of the wall of the cell through which the vapor must flow. The second is a disequilibrium correction factor that takes into account the fact that, as vapor leaves the top of the cell, a gradient in vapor pressure is created between the top of the cell and the metallic surface [3].

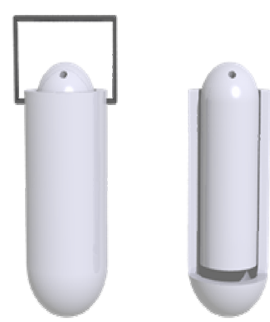
Palladium is used in our experiment because of its physical and chemical properties. It is a noble metal with monomeric mass loss that will not readily react with any material in the Thermo-Cahn system. Its vapor pressure is also reasonably well determined up to its melting point and somewhat beyond, and this property can aide in the evaluation of our data. Using Pd as a standard will help to ensure the accuracy of high-temperature data for Ni, Fe, and Co.

Experimental Procedure: To construct a Knudsen effusion cell, we obtained 2 closed-end alumina tubes—one 6 mm and one 10 mm in diameter (Fig. 1). The tubes are cut so that the smaller tube can fit inside of the larger tube with only a few millimeters overlap. A small effusion hole is drilled into the closed end of the smaller tube and measured with graduated drill bits. After a sample of high-purity Pd is placed inside the tube, the smaller tube with the effusion hole is inserted, open end first, into the larger tube. A zirconia adhesive is used to seal the small space between the two tubes [1].

We made two Knusden effusion cells for our experimentation. One cell had an effusion hole diameter of 1.3 mm and the other had an effusion hole diameter of 2.1mm. Each cell was approximately 4 cm tall.

To measure the vapor pressure of our sample of Pd, the effusion cell was inserted into the Thermo-Cahn system (Fig. 2). A control program is set with a series of temperatures and time intervals for the measurements. The system is first heated to 473K for 1 hour and then to 973K for several hours to remove volatiles before the actual run up to 1973K is started. During each run, cell mass and temperature are recorded at the rate of one measurement per second. Data is easily obtained from the Thermo-Cahn program.

Figure 1: Knudsen Effusion Cell



We ran the experiment 6 times: 3 runs with the 1.3 mm diameter effusion hole and 3 runs with the 2.1 mm diameter effusion hole.

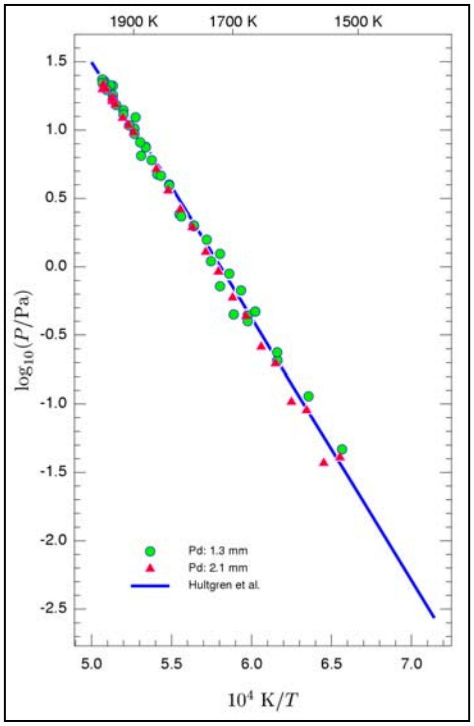
Results and Conclusions: The new data for Pd up to 1973K is shown in Figure 3. The green circles represent data using the 1.3 mm hole size, and the pink triangles represent data using the 2.1 mm hole size. The blue line represents previously determined vapor pressures of Pd by Hultgren et al., extrapolated to 2000K [4].

These measurements are in accord with Hultgren's data and show that the Thermo-Cahn system can be used to provide accurate vapor pressure measurements up to 1973K. From this, more metals can be measured with confidence in the temperature range of protostellar nebulae.

Figure 2: Thermo-Cahn System

Future Work: Now that it has been proven that the Thermo-Cahn system can be used with confidence, the vapor pressures of various silicates can be measured up to 1973K. All of this new information can then be applied to the condensation of newly-forming protostellar systems, including our own early solar system.

Figure 3: Pd Data to 1973K



References: [1] Nuth J. A., Ferguson F. T. and Johnson N. M. (2004) LPSC XXXV #1671. [2] Nuth J. A., Ferguson F. T. and Johnson N. M. (2004) 67th Ann. Mtg. Meteoritical Soc., abstract. [3] Nuth J. A., Ferguson F. T., Johnson N. M. and Martinez, D. (2003) LPSC XXXIV #1598. [4] Hultgren et al (1973) *Selected Values for the Vapor Pressures of the Elements*, ASM, Metals Park, OH.