CHAMBER FOR SIMULATING PLUTO AND OTHER KBO'S

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Introduction: Pluto is the second most massive dwarf planet in the solar system and is part of the Kuiper Belt. It was discovered in February 18 1930 by Clyde Tombaugh, an astronomer who worked at the Lowell Observatory in Arizona. [1]

The structure of Pluto is not very well understood at present. Nevertheless, spectroscopic observation with the Hubble Telescope from Earth in the 1970s has revealed that the planet surface is covered with methane ice. Because of this solid ice methane, the surface temperature of Pluto never reaches above 70K. It is 50-70% rock and the rest composed of ice. [2] Below the methane ice there is a mantle of water ice. The interior of the surface of Pluto is composed of an iron-nickel alloy and rock.

The surface of Pluto is composed of 98% N_2, 0.5% CO, and 1.5% CH_4. [1] Pluto's orbit is highly eccentric, which makes its distance from the sun vary greatly. When Pluto is closer to the sun the temperatures are warm enough to make the ices sublimate into a gas and temporarily forms a thin atmosphere mostly of nitrogen with a little of methane. As Pluto moves away from the sun, it cools down and the ices re-freeze on the surface of Pluto. [3]

The purpose of the project for this summer is to build a Pluto/Triton chamber. This chamber will simulate the planetary surfaces and atmospheres of both Pluto and Triton because they are very similar with low temperatures and pressures. We will run sublimation experiments of volatile gases like CH_4, CO, N_2 and then use FTIR to measure the sublimation rates of the volatiles. After the above is completed, we will run experiments to try to create tholins.

Technical Approach: The main thing we focused on was to get pressure system set up to reach 3μbar-6μbar. The first step in the construction of the chamber was to unscrew and remove all the flange plates from the already built outer chamber. To create the vacuum, we sealed the flange plates with new copper flange gaskets, so they will resist the vacuum system. The next step was to search for a diffusion pump and a roughing pump. The diffusion pump used is an Edwards Diffstak 160/700M (Fig. 2a) that was already in the lab. Since it had been used already, we fixed and changed all the cables in the electricity connection because the original cables were old, rusty and burned up. We attached a plug so that we could connect the heater. Next we focused on the mechanic part of the diffusion pump, where we first had to run an experiment with the air solenoids to know there mechanism and if they were working. After we defined their function, we installed two air solenoids (Fig. 2b) and created a control box to switch the electricity on/off in the solenoid. We also connected the solenoids to the nitrogen tank, with two pressure gauges and connected it to the diffusion pump. This air solenoids control the opening and closing of the top lid of the diffusion pump, which controls the flow from the diffusion pump to the chamber. Next we focused on obtaining 500ml of Santovac 5 fluid which is needed to run the heater in the diffusion pump. The problem we run into was that this amount of fluid costs $1152, which is out of the budget. As a team we decided to take the oil from other diffusion pumps we had at the lab and collected the 500 ml. Subsequently we focused on connecting the diffusion pump to the water source and to the drain to get extra water out. The roughing pump was filled with oil and connected to an air vent that goes out the window of the lab. We also connected it through a hard tube to the diffusion pump. The final step was to connect the Pressure Mechanism on an outlet on the diffusion pump to be able to measure the pressure inside the chamber.

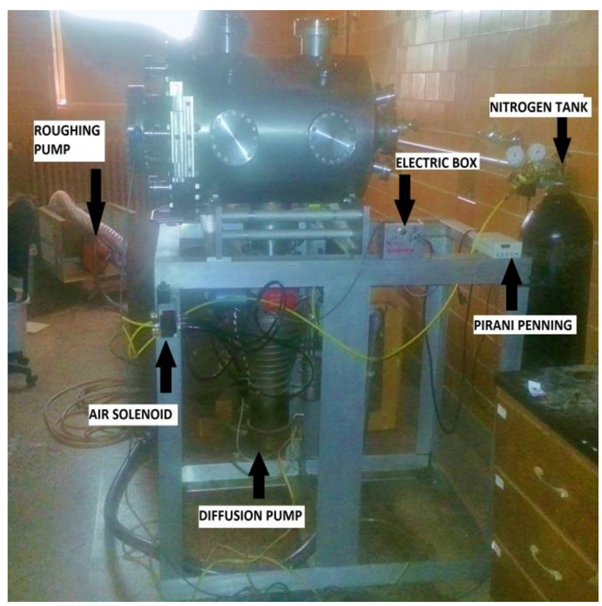
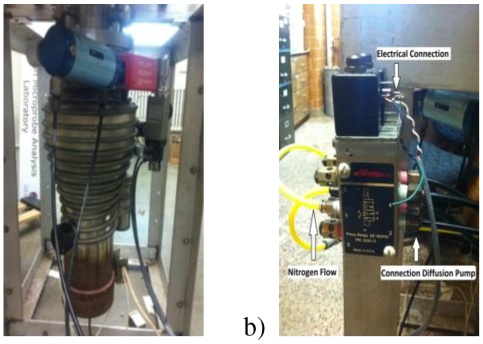


Figure 1: Final outcome of the Pluto/Triton chamber



a) b)

Figure 2: a) Edwards Diffstak 160/700M Diffusion Pump. b) Air Solenoids

Results: Fig. 3 and Fig. 4 show the relationship between pressure and time in the third attempt to run the pressure system. The pressure goal is 0.0006667 bar and we only got down to 0.11066 bar in the third attempt (Fig. 4), which is higher than what we got in the second attempt. We are speculating that for our third attempt we didn't get as low because we perceived a problem with the solenoids. Both weren't working as well so the valve at the top of the diffusion pump was opened only halfway, which blocked the connection of air between the diffusion pump and the chamber.

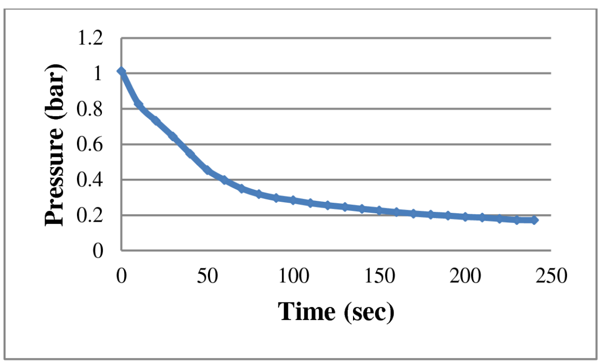


Figure 3: Pressure vs. Time for first 4 min recorded every 10 seconds

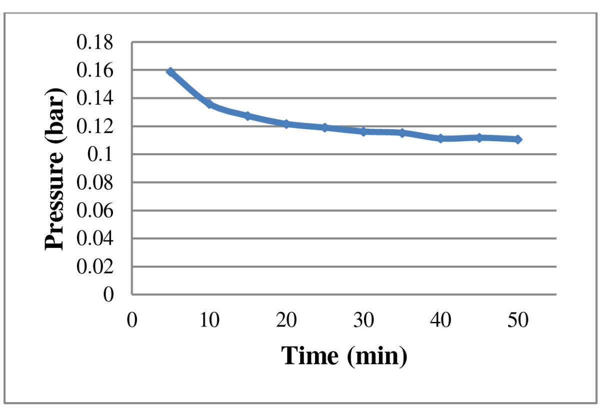


Figure 4: Pressure vs. Time for next 46 min data recorded every 5 min

Conclusion: On our first attempt to create a vacuum inside the chamber we started with ambient pressure. We only got down to 0.9866 bar in 5 minutes. We noticed there were many air leaks around the flanges and the windows, so we repositioned the flanges and tighten them down.

On our second attempt on creating a vacuum the pressure was 0.03533 bar in 5 minutes and then we left the roughing pump on for 25 minutes to see if there was any change in the pressure. In the next 25 minutes the pressure only changed slightly in the tenths place and ended at 0.03493 bar. We further tightened the screws on the flanges and searched for more air leaks.

On the third attempt the pressure was 0.171985 bar in 4 minutes (Fig. 3) and then 0.11066 bar in the next 46 minutes (Fig. 4).

Future Work: Now that the pressure system is working we have to look into more air leaks and ways to bring the pressure to ~0.0006667 bar. After this pressure is accomplished, we can connect the heater and water source in the diffusion pump to get a pressure of 3μbar-6μbar.

The next step in this project is to work on the temperature system. The temperature that has to be accomplished inside the chamber is from 46K to 64K. First a nitrogen system has to be installed to bring down the temperature to about 77K. Then with a Helium refrigerator system that is going to be connected by a He-transfer rod bring the temperature further down to 46-64K. Once all of the above is accomplished, we will start running experiments with the volatile gases of CH_4, CO, N_2. Then use FTIR to analyze the data.

In January 2006 NASA launched the New Horizons mission which will be the first probe to study Pluto and its moons. It will have its closest approach to Pluto on July 2015 and will map Pluto and Charon. The data we obtain from the Pluto/Triton chamber can be compared to the actual data that was collected by New Horizons and this way we can test our results.

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References:

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