National Aeronautics and Space Administration

Hydrothermal chemistry test facility for astrobiology experiments

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Objectives: The objectives of this work were: 1) to set up a hydrothermal reactor facility for high-pressure / high-temperature chimney simulation experiments. 2) to successfully incorporate a chimney growth apparatus and "vent fluid" flow capability inside of the pressure vessel.

Background: Hydrothermal vents are seafloor sites on Earth which support life, are natural laboratories to study extreme metabolisms, and are theorized to have driven the origin of life. Various worlds in our solar system may have or once had hydrothermal systems. However, these environments even on Earth are notoriously difficult to study because they are located at the bottom of the ocean and difficult to access except with expensive oceanographic cruises and deep-sea submersibles and/or robotics. It is therefore valuable to study hydrothermal processes is therefore in the laboratory, utilizing flow-through pressure systems that mimic the high temperatures / pressures as well as gradients in terrestrial (or planetary) vents.

Significance/Benefits to JPL and NASA: This new hydrothermal chemistry test facility can now enable various high-impact astrobiology experiments, as the composition of the ocean & vent fluid, flow rate of vent fluid, temperature gradient between vent and ocean, and atmospheric composition under which the ocean is pressurized can all be varied. For example: we can pursue the first demonstration of high-pressure organic production in an early Earth hydrothermal chimney, which would test origin of life theories that could apply to the ocean worlds. Or, we can test whether microbes could live in a hydrothermal chimney grown under the seafloor conditions of Enceladus; potentially using a 3D printed mineral scaffold (using JPL developed technology via a previous ISC award) to culture terrestrial vent microbes. Understanding the probability of life's emergence in hydrothermal systems can help us assess the likelihood that life could exist in ice-covered moons such as Europa or Enceladus; and testing habitability of vents under ocean world chemistries can help in future biosignature investigations relevant to future ocean world missions.

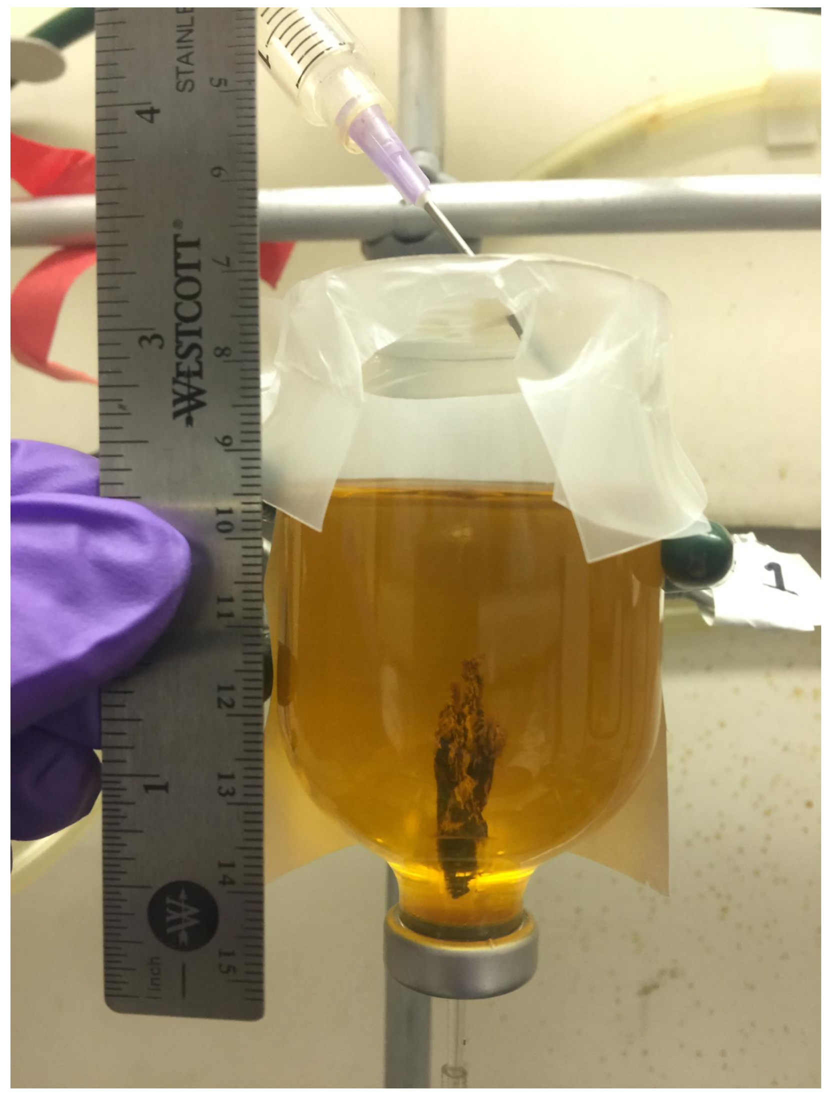

Figure 1. A simulated hydrothermal chimney growth experiment at room temperature / pressure. This is what we will attempt to replicate inside the reactor. (Barge et al. 2020, ACS Earth Space Chem. 4, 1663-1669)

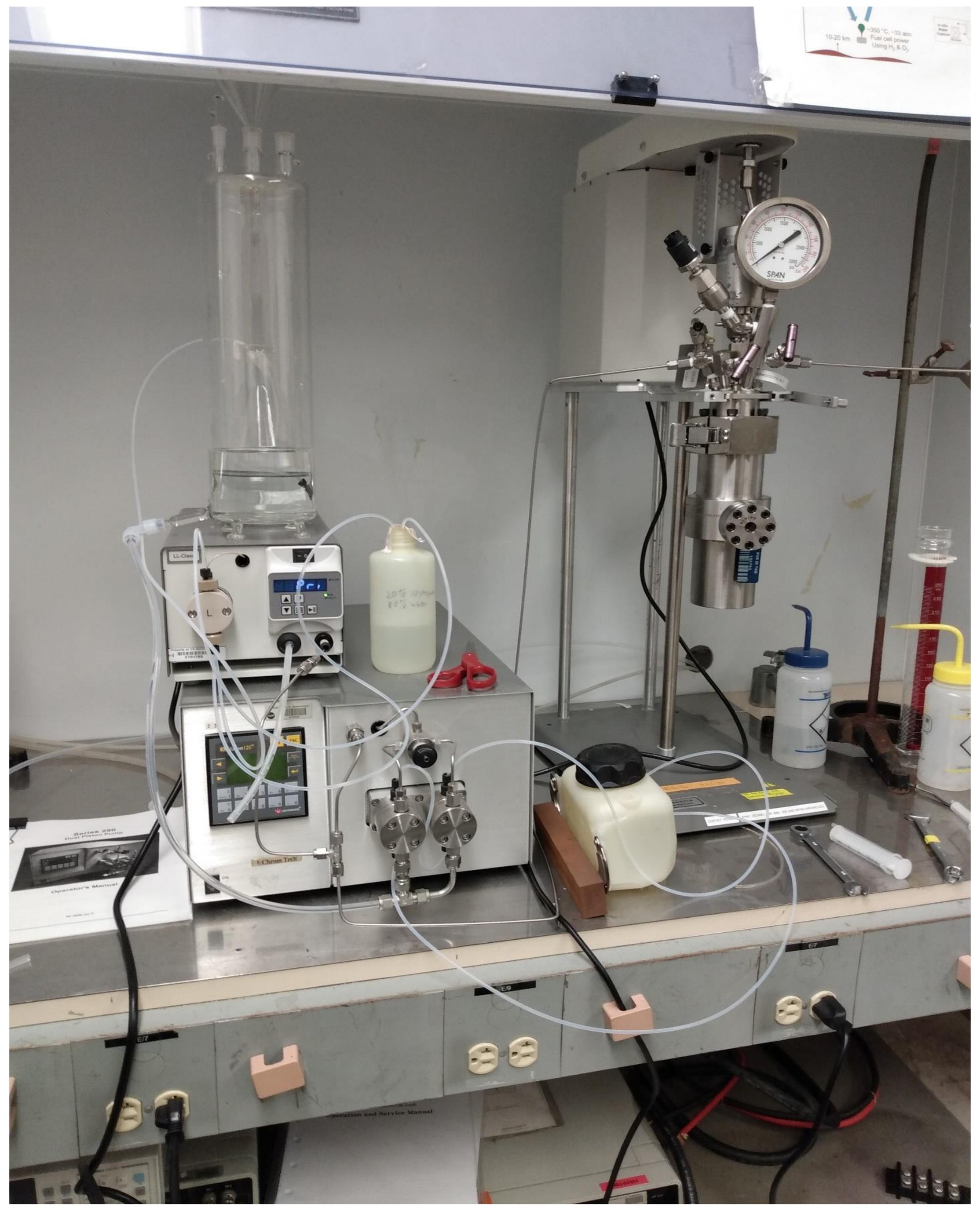

Figure 2. Photograph of reactor with windows for hydrothermal chimney growth at up to 2,650 psi and two pumps in parallel (left side of image) provide precise flow control from 0.01 to 10 mL/min.

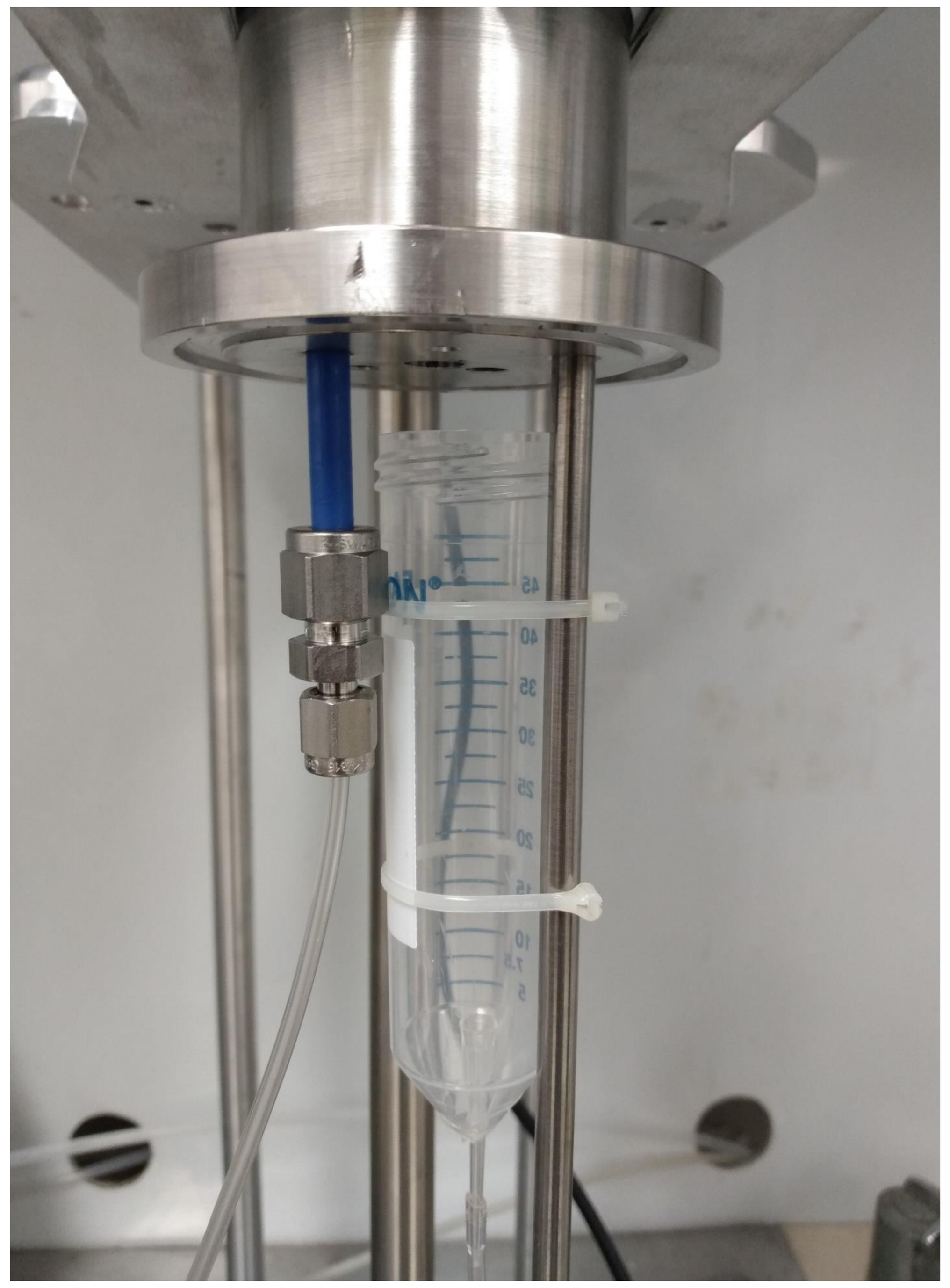

Figure 3. Image of inside of chimney growth scaffold

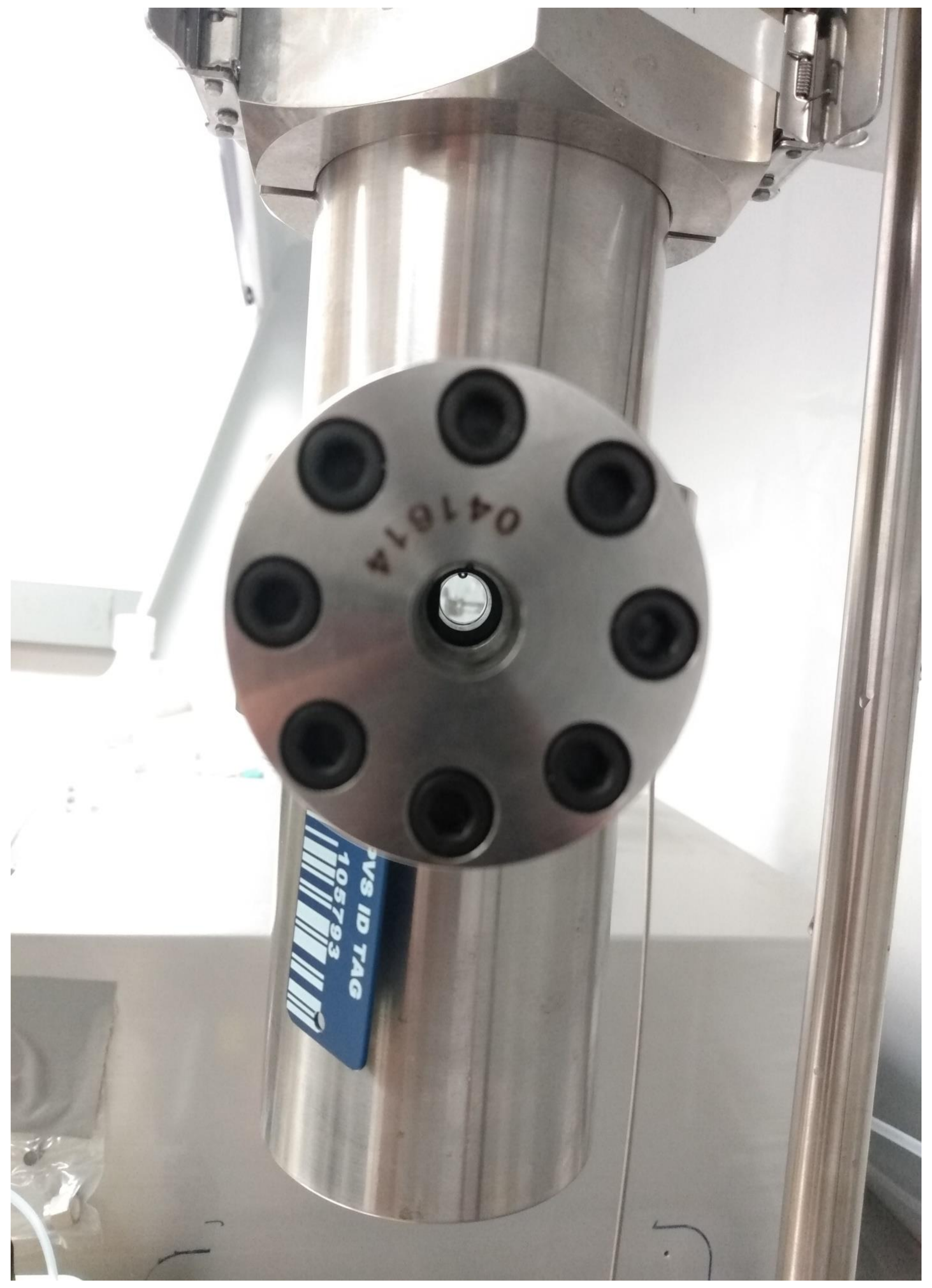

Figure 4. Photograph of pressurized reactor filled with water during pressure test at 2,650 psi.

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