

Hydrogen Purification and Recycling for an Integrated Oxygen Recovery System Architecture

The United States Atmosphere Revitalization life support system on the International Space Station (ISS) performs several services for the crew including oxygen generation, trace contaminant control, carbon dioxide (CO₂) removal, and oxygen recovery. Oxygen recovery is performed using a Sabatier reactor developed by Hamilton Sundstrand, wherein CO₂ is reduced with hydrogen in a catalytic reactor to produce methane and water. The water product is purified in the Water Purification Assembly and recycled to the Oxygen Generation Assembly (OGA) to provide O₂ to the crew. This architecture results in a theoretical maximum oxygen recovery from CO₂ of ~54% due to the loss of reactant hydrogen in Sabatier-produced methane that is currently vented outside of ISS. Plasma Methane Pyrolysis technology (PPA), developed by Umpqua Research Company, provides the capability to further close the Atmosphere Revitalization oxygen loop by recovering hydrogen from Sabatier-produced methane. A key aspect of this technology approach is to purify the hydrogen from the PPA product stream which includes acetylene, unreacted methane and byproduct water and carbon monoxide. In 2015, four sub-scale hydrogen separation systems were delivered to NASA for evaluation. These included two electrolysis single-cell hydrogen purification cell stacks developed by Sustainable Innovations, LLC, a sorbent-based hydrogen purification unit using microwave power for sorbent regeneration developed by Umpqua Research Company, and a LaNi_{4.6}Sn_{0.4} metal hydride produced by Hydrogen Consultants, Inc. Here we report the results of these evaluations, discuss potential architecture options, and propose future work.