The Development of Models for Carbon Dioxide Reduction Technologies for Spacecraft Air Revitalization

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Through the respiration process, humans consume oxygen (O_2) while producing carbon dioxide (CO_2) and water (H_2O) as byproducts. For long term space exploration, CO_2 concentration in the atmosphere must be managed to prevent hypercapnia. Moreover, CO_2 can be used as a source of oxygen through chemical reduction serving to minimize the amount of oxygen required at launch. Reduction can be achieved through a number of techniques. The National Aeronautics and Space Administration (NASA) is currently exploring the Sabatier reaction, the Bosch reaction, and co-electrolysis of CO_2 and H_2O for this process. Proof-of-concept experiments and prototype units for all three processes have proven capable of returning useful commodities for space exploration.

While all three techniques have demonstrated the capacity to reduce CO_2 in the laboratory, there is interest in understanding how all three techniques would perform at a system-level within a spacecraft. Consequently, there is an impetus to develop predictive models for these processes that can be readily re-scaled and integrated into larger system models. Such analysis tools provide the ability to evaluate each technique on a comparable basis with respect to processing rates. This manuscript describes the current models for the carbon dioxide reduction processes under parallel developmental efforts. Comparison to experimental data is provided were available for verification purposes.

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