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SUPERCRITICAL WATER (SCW) INVESTIGATIONS IN THE DECLIC AND DECLIC-EVO: PAST, PRESENT AND FUTURE

Abstract

A series of microgravity investigations have been formulated to be performed in the DECLIC and DECLIC-Evo on board the International Space Station, to provide a better understanding of fundamental processes that take place in water at near-critical conditions. These investigations rely on the design heritage of an earlier fundamental physics study that explored the nearcritical behavior of pure water and for which the High Temperature Insert (HTI) was originally designed and built. They also have the overarching goal of providing some of the scientific underpinnings for future advances in supercritical water oxidation (SCWO) technologies. SCWO technology is one of NASA's candidate technologies for waste management and resource reclamation for extraterrestrial missions. However, during typical SCWO reactions, inorganic salts present in the reactant stream will precipitate and coat reactor surfaces and control mechanisms, often severely impacting the system's performance.

The first of the considered experiments, the Supercritical Water Mixture (SCWM) experiment, is a phenomenological study to provide observations of the phase separation and transport mechanisms of salt precipitate of a dilute solution of Na_2SO_4 0.5%-w (aq) at 0-g. In the absence of gravity a unique window for observation of a variety of near-critical physical phenomena is made possible. Observations of this dilute solution have shown striking differences from pure water in its incipient boiling processes, trans-critical phase partitioning, and density stratification as influenced by an overlay of concentration and temperature gradients. A subsequent experiment, SCWM-2, is planned that will expand on the science obtained in SCWM, using the same High Temperature Insert (HTI), which is to be refurbished and filled with a different test solution. A third microgravity experiment, SCWO-D, will then allow for observations of autoignition and stabilization of hydrothermal flames in supercritical water. This final experiment will require a significant insert redesign to accommodate a flow system and a properly designed test cell for observations of small hydrothermal flames without quenching.

Additionally, significant ground development work is underway in support of the science associated with the generation and stabilization of hydrothermal flames. The science team at the University of Bordeaux is developing the micro-fluidic devices to support the miniaturized infrastructure for the flow system. The science team at NASA Glenn Research Center is currently developing the science behind the autoignition and stabilization of hydrothermal flames. Preliminary findings of the SCWM experiment and progress in the development of the SCWM-2 and SCWO-D experiments will be discussed in this work.