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Author: Mr. Michael Hicks
NASA Glenn Research Center, United States

Dr. Uday Hegde
NCSER, United States
Eng. Carole Lecoutre
CNRS, France
Dr. Yves Garrabos
CNRS, France
Mr. Gabriel Pont
Centre National d'Etudes Spatiales (CNES), France
Mr. Bernard Zappoli
Centre National d'Etudes Spatiales (CNES), France

SALT PRECIPITATION AND TRANSPORT IN SUPERCRITICAL WATER

Abstract

Supercritical water oxidation (SCWO) technology is a leading candidate for waste management and resource reclamation for long duration space and extraterrestrial missions. However, during typical SCWO reactions, inorganic salts present in the reactant stream will precipitate and coat reactor surfaces and control mechanisms (e.g., valves), often severely impacting the system's performance. The Supercritical Water Mixture (SCWM) experiment, described in this paper, is performed on board the International Space Station (ISS) and serves as a precursor experiment for anticipated SCWO research designed to develop a better understanding of inorganic salt precipitation and transport during supercritical water oxidation (SCWO) processes.

The SCWM experiment employs a small test cell filled with an aqueous solution of sodium sulfate (0.5%-w) at the critical density and is installed in the refurbished High Temperature Insert (HTI-r), which is deployed in the DECLIC (Device for the Study of Critical Liquids and Crystallization) Facility. Objectives of the study include measurement of the shift in critical temperature due to the presence of the inorganic salt, assessment of the predominant mode of precipitation (i.e., heterogeneously on the test cell surfaces or homogeneously in the bulk fluid), determination of the salt morphology including size and shapes of particulate clusters, and the determination of the dominant mode of transport of salt particles in the presence of an imposed temperature gradient.

Observations have shown precipitate forming along channels of small vapor bubbles generated by localized nucleate boiling along the walls of the test cell containing the salt solution. As precipitation progresses, the channels darken forming thread like structures, bridging the sub-critical liquid region between the cell wall and the vapor bubble in the central part of the cell. Interestingly, the subsequent behavior of visible precipitate is dependent upon the heating rate (i.e., temperature ramp rate) of the test cell. The precipitate appears to re-dissolve when the approach to the critical temperature is very slow, however, when the approach to the critical temperature is relatively fast the precipitate appears to persist and then suddenly disappears when the solution becomes supercritical. This behavior has implications to the understanding of the liquid–vapor interface acting as a barrier for salt transport and the diffusion rates of the salt in the sub-critical and supercritical regimes. The critical temperature of the mixture has also been measured and will be reported in the paper.