§18. Study of Solid H_2 Redistribution in the Cryogenic Target for the FIREX Project

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i) Introduction

Preliminary cool-down tests of a dummy foam shell target have been conducted with a surrogate fuel of normal-H_2.[1] Liquefaction and solidification in the foam shell succeeded through a narrow capillary. The liquid and the solid quantity were roughly adjustable. However, some defects were observed in the solid normal-H_2 (SH_2), and then, they disappeared when the cooling temperature was being lowered to ~12 K in a few ten minutes. Therefore, the solid condition might depend on temperature and cooling duration.

Heat loads such as thermal radiation and self–heating from the ortho-para conversion of normal-H_2 might redistribute SH_2 in the shell, like the beta-layering phenomenon for DT fuel.[2] These heat loads would be related to the cooling duration dependence of fuel layering. To show whether SH_2 formed in the shell can be affected by the heat loads, redistribution in a polystyrene (PS) shell target was observed during 40 hours.

ii) Experimental details

A PS shell with 2 mm in diameter was used for a dummy target. Figure 1 shows the photograph of the target with dimensions. A cone guide was attached to the target upward. The target was assembled using epoxy resin, which is the same way as a typical FIREX-I target.

The target was set in the target can of the apparatus which was already reported in reference [3]. Heat exchange gaseous helium (GHe) cooled the target with free convection. Its temperature was controlled by a thermal shield and heat exchanger which was put inside the target can. SH_2 redistribution was observed by a CCD camera with 200 mm macro-lens through viewing windows coated with infrared cut-off filter.

Liquid H_2 (LH_2) was supplied in the shell after temperature was controlled at 12.5 K. Then, the temperature was lowered to 12.4 K and solidification was observed. The redistribution test was conducted at 12.0 K corresponding to the temperature of the previous cool-down test. As the temperature was kept constant, a photograph of SH_2 in the shell was taken every 30 minutes during 40 hours.

iv) Results

Figures 2(a)-(d) show redistribution of SH_2 in the PS shell with cooling duration. Coarse-grained crystalline state was observed at first, and then SH_2 was accumulated to the bottom as time elapsed. This result shows that redistribution was occurred even if normal-H_2 was used as surrogate fuel. Estimated thermal radiation to the shell is negligible small compared with the orthe-para conversion heat. The conversion heat, therefore, can be one of the possible layering phenomenon of HD fuel.

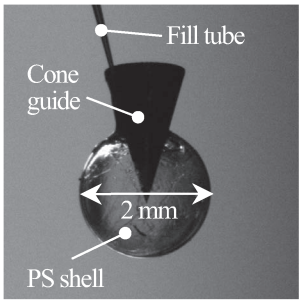
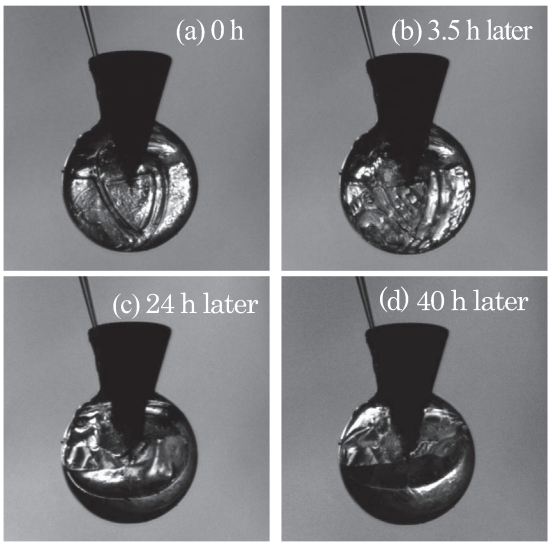


Figure 1. PS shell target with 2 mm in diameter.



Figures 2(a) - (d). Redistribution of SH_2 in the PS shell target.

[1] Iwamoto, A., Nagai, K., Nakai, M., Ito, F., Fujimura, T., Maekawa, R., Mito, T., Norimatsu, T., Motojima, O., Azechi, H. and Mima, K., 2007, Development of the Foam Cryogenic Target for the FIREX Project, *Proc. of the 21st IAEA Fusion Energy Conference*, IF/P-1.

[2] Hoffer, J. K. and Foreman, L. R. 1988 *Phys. Rev. Lett.* **60**, 1310-13.

[3] Iwamoto, A., Maekawa, R., Mito, T., Okamoto, M., Motojima O., Sugito, S., Okada, K., Nakai, M., Norimatsu, T., and Nagai, K., 2006, *Fusion Eng. Des.* **81**, 1647-52.