AN INVESTIGATION OF SODIUM IODIDE SOLUBILITY IN SODIUM - STAINLESS STEEL SYSTEMS*

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Abstract

Sodium iodide and major constituents of stainless steel in sodium are determined by using the steel capsules to obtain a better understanding on contribution of the constituents to the apparent iodide solubility in sodium. The capsule loaded with 20 g sodium and 0.1 - 0.3 g powder of sodium iodide is heated at its upper part in a furnace and cooled at its bottom on brass plates to establish a large temperature gradient along the capsule tube. After a given period of equilibration, the iodide and constituents are fixed in solidified sodium by quick quenching of the capsules. Sodium samples are taken from the sectioned capsule tube and submitted to sodium dissolution by vaporized water for determination of the iodine and to vacuum distillation for determination of the metal elements. Iron and nickel concentrations are observed to be lower in the samples at higher iodine concentrations. Chromium and manganese concentrations are seen to be insensitive to the iodine concentrations. The observations can be interpreted by a model that sodium oxide combines with metal iodide in sodium to form a complex compound and with consideration that the compound will fall and deposit onto the bottom of the capsule by thermal diffusion.

1. INTRODUCTION

In a postulated fuel pin failure of a fast reactor, fission products released from the fuel pin will be retained mostly in the sodium coolant, and a little percent of them will be transported further to the environment in some cases. Among various radiological consequences of the fission products, those of iodine isotopes are highly important for the safety assessment due to their higher volatility and lower permissible dose to human thyroid. Therefore, experimental and theoretical efforts have been made for obtaining a better understanding of the iodine behavior in the sodium system[1-8]. Any iodide or free iodine in the sodium is known to be converted to sodium iodide, and volatility of the iodide is essentially controlled by the iodide solubility in sodium.

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The solubility was measured by Bredig[9,10] at temperatures between 550 ~900℃ and by Allan[11] between 250~400℃, and recently supplemented by Miyahara[12] over a temperature range between 350~800℃. Reported solubility data are shown in Fig. 1. The solubility expressions given by Miyahara agree well with the measured data by Bredig in the temperature region higher than 600℃, whereas the expressions yield values about 10 times as large as the data by Allan and Sagawa[13] in the lower temperature region.

Sodium iodide gathering at the free surface of liquid sodium and solid particle formation in the sodium were examined to discuss the discrepancy between Allan's expression and Miyahara's one. Neither the local gathering nor particle formation of the iodide was observed in the experiment[14]. On the other hand, solubility data leaving Allan's expression and approaching Miyahara's expression are obtained in the capsule measurement[14], as seen in Fig. 2.

The aims of this paper are to determine the major elements leached from stainless steel into the sodium as well as the solubility of sodium iodide in sodium and to discuss effect of the leached elements on the apparent solubility transferring from Allan's expression to Miyahara's one.

2. EXPERIMENTAL

2.1. Experimental Device

The solubility of sodium iodide is measured by using stainless steel capsules and major elements of the steel in sodium are determined together with the measurement. The experimental device and method are described in detail elsewhere[13]. Figure 3 illustrates the experimental device. The capsule consists of a stainless steel tube, 10 mm in inner diameter, 1 mm in thickness and 180 mm in effective length, and a small vessel with two nozzles. The capsule is loaded with about 20 g sodium of reactor grade through one nozzle and 0.1~0.3 g powder of sodium iodide through the other nozzle. The capsule is installed vertically with the vessel inserted into an electric resistance furnace and with the tube end standing on brass plates on a brick.

Surface cleaning and iodide dissolving were adopted to stabilize the iodide deposition in the capsule prior to the long duration of heating for the solubility measurement. The surface cleaning was made to remove the oxide layer on stainless steel by the loaded sodium. The iodide dissolving was done to coat sites of adsorption with the dissolved iodide in the sodium. The heating was continued for the duration of 1300 h to let the iodide have settled on the bottom of the capsule by sedimentation and diffusion through the column of sodium. The capsule was then quickly cooled in quenching oil to fix the iodide and the other elements in solidified sodium.