6–7 Applicability Evaluation of Metallic Materials in Hydrogen Production by the IS Process

— Corrosion Resistance of Nickel-Based Alloy in a Practical Gaseous HI Decomposition Environment —

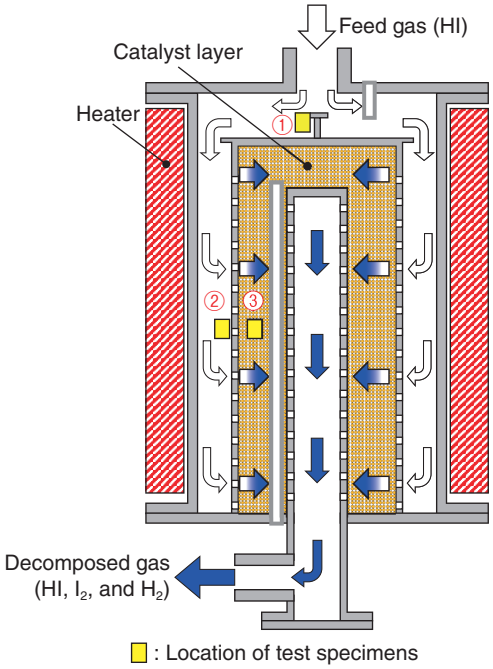

Fig.6-14 Corrosion test for gaseous HI decomposition environment
Gaseous HI fed from the top of the reactor was decomposed into I_2, H_2, and undecomposed HI through the catalyst layer. Test specimens were placed in three regions; ① inlet of the reactor, ② upstream of the catalyst layer, and ③ inside the catalyst layer.

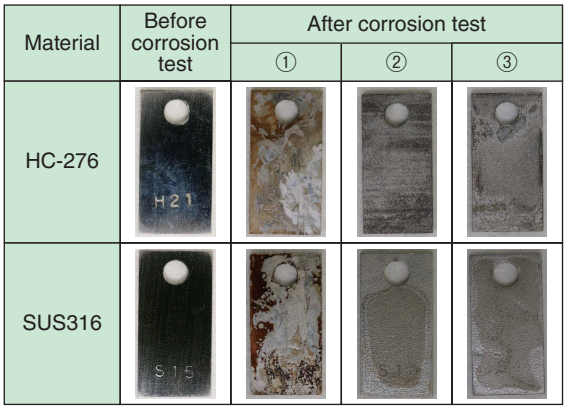

Fig.6-15 External appearance of the test specimens
The specimen placed at ① partially retained its original surface. The surfaces of the specimens placed at ② and ③ were uniformly roughened, confirming overall corrosion. HC-276 shows a smoother surface than SUS316.

Table 6-3 Corrosion rates of test specimens
Corrosion rates were determined by weighing the original and corroded test specimens, and calculating the weight difference. The HC-276 specimen was measurably corrosion- resistant.

Material	Position	Temp. (℃)	Gas composition	Corrosion rate (mm/y)
HC-276	①	110	HI	0.01
	②	500	HI	0.52
	③	500	HI+I_2+H_2	0.75
SUS316	①	110	HI	0.37
	②	500	HI	6.53
	③	500	HI+I_2+H_2	5.76

Structural materials with high corrosion resistance are required in the iodine–sulfur (IS) thermochemical process of water-splitting hydrogen production, which occurs in a corrosive liquid or gaseous environment over a wide temperature range. Although ceramic materials such as SiC and glass are highly resistant to corrosive environments, they are difficult to fabricate for large-scale reactors. Therefore, metallic materials are preferred in commercial large-scale H_2 production.

Previous studies confirmed that nickel-based alloy is corrosion resistant in a gaseous HI environment with water vapor. However, the corrosion resistance of this material in the practical dry gaseous environment of HI decomposition, where dry HI is decomposed into I_2 and H_2 with a catalyst at 500 °C, has not been clarified. Especially, as I_2 can form metal iodides, it might corrode the metallic alloy. To evaluate this possibility, we performed a corrosion test of the nickel-based alloy Hastelloy C-276 (HC-276) in the practical environment.

The test specimens were placed in the HI decomposer (Fig.6-14) and their corrosion rates were determined from their weight changes after the corrosion process. Considering that the corrosion rate obeyed a parabolic rate law in the coexistence of water vapor (as determined in previous studies), the exposure time was conservatively decided as 100 h. For comparison with the candidate material HC-276, we also tested the corrosion resistance of JIS-SUS316. The test specimens were placed in three regions: ① the reactor inlet, ② upstream of catalyst layer, and ③ inside the catalyst layer.

After the test, the specimens showed uniform surface roughening consistent with general corrosion (Fig.6-15). Table 6-3 summarizes the average corrosion rates. Neither specimen was seriously corroded at position ① due to the low temperature in this region. At positions ② and ③, the corrosion rate of JIS-SUS316 was approximately 6 mm/y, meaning that this material cannot withstand the corrosive environment. On the contrary, the HC-276 specimen showed good corrosion resistance (at most 0.75 mm/y), though it is suggested that the specimen was corroded at a rather higher rate in the catalyst by I_2.

In future work, we will clarify the development of the corrosion rate in longer corrosion tests, and will try to improve the corrosion resistance of HC-276 by forming protective oxide layers. This will be attained by pre-oxidizing HC-276 and adding water vapor to the HI decomposition environment.

Reference

Kamiji, Y. et al., Corrosion Resistance of Nickel–Based Alloy to Gaseous Hydrogen Iodide Decomposition Environment in Thermochemical Water–Splitting Iodine-Sulfur Process, Proceedings of 5th International Conference on Chemical and Biological Sciences (ICCBS 2018), Bucharest, Romania, 2018, p.51–54, in USB Flash Drive.