

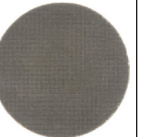


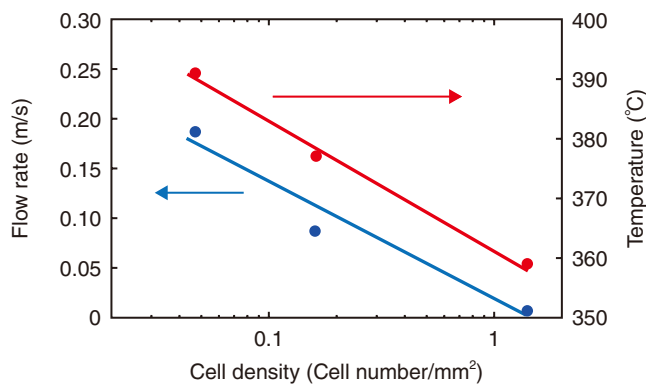
1-6 Determination of the Optimum Shape of Hydrogen Recombination Catalysts

— Hydrogen Elimination Effect Experimentally Verified for Full-Size Equipment —

Table 1-1 Catalyst specifications

Several catalysts were prepared to identify the effect of cell density on the catalytic reaction.

Appearance			
Cell density (Cell number/mm ²)	0.047	0.16	1.4
Cell pitch (mm)	4.6	2.5	0.85
Wall thickness (mm)	0.66	0.43	0.064
Cell length (mm)	3.9	2.1	0.79

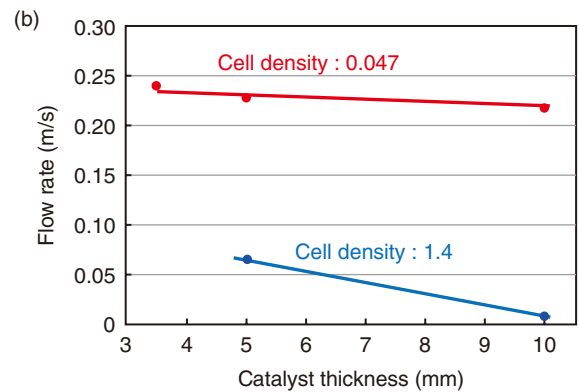
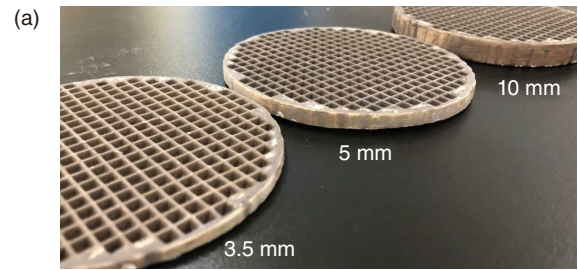

Fig.1-14 Effect of cell density on the catalytic reaction

The flow rate and gas temperature were observed when using several catalysts. The flow rate increased as the cell density decreased.

Nuclear fuel waste storage containers generate hydrogen gases due to the radiolysis of water molecules. Hydrogen elimination systems using hydrogen recombination catalysts, which do not rely upon an external electric power, have attracted much attention. The catalysts make a non-explosive reaction between atmospheric oxygen and the generated hydrogen, thus reducing the hydrogen concentration without the use of external electric power.

In this work, hydrogen recombination catalysts were developed based on an automotive catalyst and evaluated for their hydrogen elimination capabilities using full-scale equipment. The equipment used for performing the hydrogen recombination experiments was located at the Forschungszentrum Jülich in Germany and has a sealed cylindrical shape with an inner diameter of 1400 mm and a height of 3700 mm. After the catalyst was loaded, hydrogen was injected, and the variation in gas temperature, flow rate and hydrogen concentration were observed at several points in the inner space to analyze the hydrogen elimination effect of the catalysts used.

Specifications of the hydrogen recombination catalysts used are detailed in Table 1-1. Precious metal nanoparticles were sprayed on the wall of a monolithic ceramic substrate having many cells. To optimize the catalyst's shape, several catalysts with different cell densities were prepared. The catalysts were placed in a chimney-shaped tube and installed in the center of the test


Fig.1-15 Effect of catalyst thickness

(a) Flow rate was observed for the several catalysts. (b) The flow rate did not decrease even when using the thicker catalyst on a sample with the cell density of 0.047.

equipment. The reaction began after hydrogen injection. Because the reaction between hydrogen and oxygen is exothermic, gas convection proceeds upward through the chimney-shaped tube, reducing the hydrogen concentration in the entire space. The catalytic performance was determined by examining the flow rate, as illustrated in Fig.1-14. As the cell density decreased, the flow rate increased, i.e., the catalytic performance improved as the cell density of the catalysts decreased. Several samples with varying catalyst thickness were prepared (Fig.1-15(a)); their resulting catalytic performance is shown in Fig.1-15(b). The flow rate did not significantly decrease when the catalyst had a cell density of 0.047, even when the catalyst thickness was increased. Because the reaction itself increased as the thickness increased, these results indicate that a catalyst with a cell density of 0.047 can be effective for large amounts of hydrogen.

In collaborations with synchrotron radiation experiments and numerical simulations, studies aimed at developing more effective hydrogen recombination catalysts and at ensuring safety in waste storage have been promoted.

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Reference

Ono, H., Matsumura, D. et al., Research on Hydrogen Safety Technology Utilizing the Automotive Catalyst, E-Journal of Advanced Maintenance, vol.11, no.1, 2019, p.40-45.