Catalytic Activity of Oxidized Alloy for Methane Steam Reforming.

Hiroshi Yamada[1]*, Yuki Shigematsu[1], Tomohiko Tagawa[2]

1 Chemical SystemsEngineering, Nagoya University, Furo-cho, Chikusa-ku,Nagoya-shi, Aichi-ken, 464-8603 Japan

2 National Institute of Technology, Toyota College, Eisai-cho 2-1, Toyota-shi, Aichi-ken, 471-8525, Japan

**Corresponding author: yamada.hiroshi@material.nagoya-u.ac.jp*

Highlights

- Oxidized Hastelloy shows the methane steam reforming activity.
- Ni is primary catalyst and Co and Mo are co-catalyst.
- Carbon did not deposit on the catalyst surface.

1. Introduction

To produce hydrogen, steam reforming is operated in the industries. Nickel and nickel oxide are widely employed in industrial scale. Moreover nickel base catalysts have been to incorporate with several promoters (e.g. Cr, Fe, Zn and Cu), resulting in the catalytic performance improvement. Nickel also exists in commercial alloys. Oxidized Nickel alloys showed optimally dispersing the catalytically active Nickel component on the mixed metal oxide matrix. The high temperature oxidation pretreatment is an alternative way to make a metal oxide matrix.

With increasing of hydrogen demand, onsite hydrogen production becomes more important. The hydrogen supplying station for vehicles is one of the onsite hydrogen production plants. Workers in these kinds of plant are not technicians of catalyst. Easy handling catalyst is required for these plants. High temperature oxidized alloys are stable in the normal environments. There handling are easy for everyone.

In this presentation screening test of oxidized alloys for methane steam reforming was performed.

2. Methods

The alloy tube (outer diameter 6 mm, 50 cm length) was inserted into the quartz tube reactor (inner diameter 9 mm) and placed in the center of the electrically heated furnace. The upper part of the quartz tube was attached to the vaporizer while its lower part was connected to the condenser and gas sampling valve.

Alloy tubes were oxidized with oxygen flow at the temperature of 1273 K for 2 or 5 hours. Some catalyst was reduced with hydrogen at the temperature of 923 K for 1 hour after oxidation. Steam reforming reaction was carried at the temperature of 1123 K. Methane flow rate was 50.4 μmol/s and water flow rate was 77.2 μmol/s. The effluent gas was quantitatively analyzed with TCD-GC and flow rate was determined with soap film meter.

$CH_4 + H_2O \rightarrow CO + 3H_2$ (1) $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ (2)

Three alloys were used for the reaction. The alloy components are shown in Table 1.

Table 1 Alloy compornent

	C	Co	Si	Mn	Ni	Cr	Mo	V	Fe
SUS 304	<0.08		<1.00	<2.00	10-14.	18-20			Bal
Inconel-600	<0.15		<0.05	<1.00	>72.0	14-17			6.-10
Hastelloy-C-276	<0.01	<2.5	<0.08	<1.00	Bal.	14.5-16.5	15.-17	<0.35	4-7

3. Results and discussion

Oxidized stainless steel did not have catalytic activity for methane steam reforming. The amount of Nickel in the stainless steel is too small to express the catalytic activity.

Hydrogen and carbon dioxide and carbon monoxide were produced with 5 hour oxidized Inconel (Fig. 1). 2 hour oxidized Inconel did not show catalytic activities.

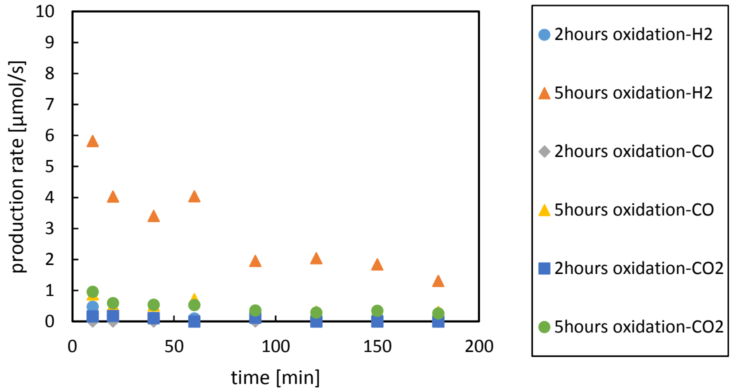

Fig.1 Inconel

Oxidized Hastelloy was used as catalyst (Fig. 2). 5 hour oxidized catalyst showed the larger hydrogen production rate than Inconel. Both Hastelloy and Inconel have large amount of Nickel. Cobalt and Molybdenum in the Hastelloy worked as co-catalyst to improve the hydrogen production rate. Initial hydrogen production rate with 2 hour oxidized catalyst was same as that of 5 hour oxidized catalyst, but slightly decreased with time. Carbon monoxide and carbon dioxide showed the same tendency. 2 hour oxidized catalyst was deactivated with time. 2 hour oxidation was not enough to make the metal oxide matrix. Carbon deposition on the catalyst surface was not observed after the reaction.

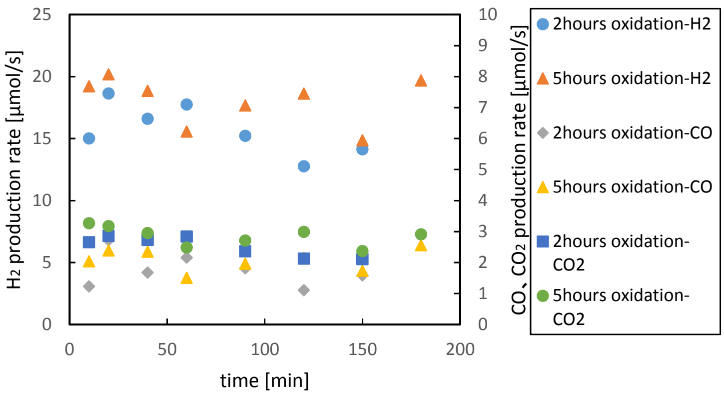

Fig. 2 Hastelloy

Generally, catalyst pre-reduction was carried out before reaction to increase the catalyst activity. 5 hour oxidized Hastelloy was reduced after oxidation. Figure 3 shows the experimental results. Initially, products production rates were same as no reduction catalyst. But catalyst deactivation was occurred.

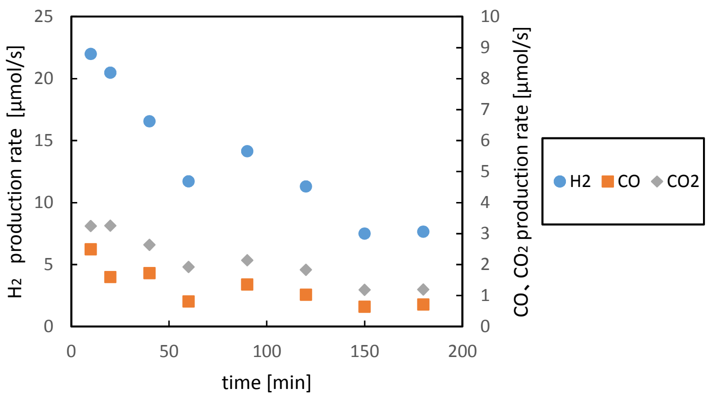

Fig.3 Reduced Hastelloy

4. Conclusions

5 hour oxidized Hastelloy showed the stable and highest activity for methane steam reforming reaction. Cobalt and Molybdenum promoted the high catalyst activity.

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Keywords

Methane steam reforming, Nickel containing alloy, Hastelloy, Onsite hydrogen production.