Harmful gases Reduction Characteristics according the support Al_2O_3 and TiO_2 of H_2-SCR

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수소-선택적인환원촉매의 지지체 알루미나와 티타니아에 따른 유해 가스 저감 특성

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Abstract

Hydrogen is an energy source with good low-temperature activity and can be used in various fields. Recently, H_2-engines have been developed, and the gases that can be emitted are NOx and H_2O. In addition, it has a wide range of use in various industrial fields, such as home boilers with low exhaust gas temperature of about 100℃. Research on the reduction of harmful gases according to the type of support (Al_2O_3,TiO_2,) in pure H_2-SCR catalyst is still insufficient, and research on this is meaningful. This study aims to determine the harmful gas reduction characteristics according to support Al_2O_3 and TiO_2 of H_2-SCR. 2Ag/Al_2O_3 H_2-SCR improved the low-temperature activity of the catalyst due to its large specific surface area and the loading amount of active catalyst Ag. 0.5Ag/TiO_2 H_2-SCR showed the highest NOx reduction ability with a NOx conversion rate of about 18% at catalyst temperature 200°C, and the window width was also wide. 2Ag/Al_2O_3 H_2-SCR improved the low-temperature activity of the catalyst due to its large specific surface area and the loading amount of active catalyst Ag. Although the harmful gas reduction performance has decreased significantly compared to the active material Pt used in the H_2-SCR, research on active materials considering performance improvement and economic feasibility must continue.

1. Introduction

Recently, abnormal climates such as abnormally high temperatures, tropical nights, cold waves, heavy rain, heavy snow, and droughts have occurred frequently, and these abnormal climates can be said to be caused by global warming, El Niño, and La Niña. Because the proportion of fossil energy sources used is high, the gases emitted are causing harm to the human body and worsening air quality. Carbon neutral policy is rapidly emerging as a global issue and as part of the measure, the conversion of eco-friendly energy powertrains to electric vehicles (EV) and fuel cell electric vehicles (FCEV) is underway. Recently, the penetration rate of electric vehicles has been slowing down, due to the high price of electric vehicles, lack of infrastructure, and increasing sales of hybrid electric vehicles. The proportion of domestic combustion engine vehicles accounts for more than 90%, and exhaust gas regulations for construction machinery, ships, agricultural machinery, and boilers are becoming more stringent. Hydrogen is an energy source with good low-temperature activity and can be used in various fields. Recently, H_2-engines have been developed, and the gases that can be emitted are NOx and H_2O. In addition, it has a wide range of use in various industrial fields, such as home boilers with low exhaust gas temperatures of about 100°C. The SCR catalyst that reduces harmful gases using a hydrogen reducing agent is called H_2-SCR. The research trend so far has been to improve NOx reduction performance using the reducing agent H_2. To improve the performance of H_2-SCR catalysts, prior research has been conducted on the active catalyst, promoter, support, and reaction mechanism. Among various studies using noble metal-based catalysts, platinum has been demonstrated as a suitably active metal showing superior activity for H_2-SCR at low temperatures [1]. However, research on the reduction of harmful gases according to the amount of Ag supported and the type of support (TiO_2, Al_2O_3) in pure H_2-SCR catalyst is still insufficient, and research on this is meaningful. This study aims to determine the harmful gas reduction characteristics according to the type of support.

2. Experimental Method

The prepared H_2-SCR catalyst was prepared using the impregnation method. The catalyst carrier core is cylindrical, with an inner diameter and length of 18*17mm and a volume of 4.3cc, 400CPSI. The coating amount of the manufactured SCR catalyst was about 198 g/L, and the predetermined catalyst and cocatalyst were supported on a substrate (400 CPSI: Cell Per Square Inch), and calcined in air at 500°C for 3h. Reduction treatment was performed for 1 hour at 400°C using 5% H_2. The gas components and concentrations of the model gas reaction device for evaluating the performance of the H_2-SCR catalyst are shown in Table 1. The model gas reaction device consists of a gas supply section, a catalytic reaction section, a control device, and an analysis device. The gas discharged after the catalytic reaction was quantitatively analyzed using a gas analyzer (VarioPlus Industrial, MRU Instruments, Inc.).

[Table 1] Model gas components for evaluation performance of H_2-SCR

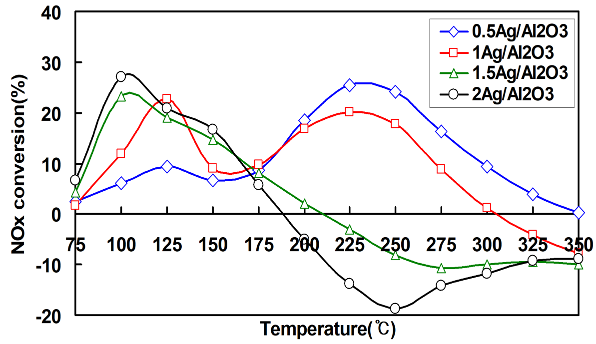
Gas components	Concentration
NO(ppm)	500
CO(ppm)	700
O_2(%)	5
H_2(%)	1
H_2O(%)	1.5
N_2	Balance
SV(h^{-1})	28,000

3. De-NOx Performance according to the support Al_2O_3 and TiO_2 of H_2-SCR

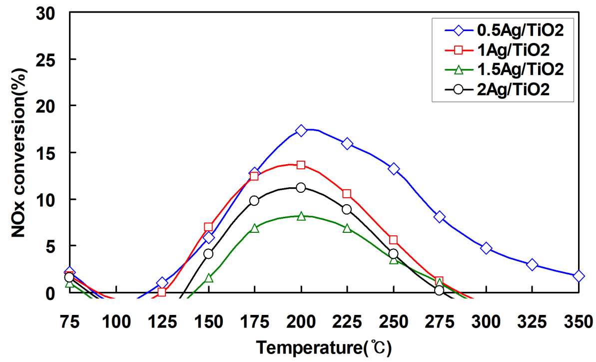
Fig. 1 shows the de-NOx performance according to the types of support H_2-SCR. 0.5Ag/Al_2O_3 H_2-SCR, which has the lowest loading amount of Ag, shows NOx reduction performance of about 8% at 125°C and about 25% at 225°C. 2Ag/Al_2O_3 H_2-SCR, which has the largest loading amount of Ag, shows a NOx reduction ability of about 28% at a catalyst temperature of 100°C. However, at temperatures above 100°C, the NOx reduction ability decreases. At catalyst temperatures above 200°C, 1.5Ag/Al_2O_3 and 2Ag/Al_2O_3 H_2-SCR have negative NOx conversion rates, because the reducing agent H_2 is oxidized and NO and NO_2 increase rather than decrease.

Fig. 1(b) shows the de-NOx/CO performance according to the support TiO_2. 0.5Ag/TiO_2 H_2-SCR shows the highest NOx reduction ability with a NOx conversion rate of about 18% at 200°C, and the window width is also wide. 2Ag/$TiO_2$$H_2$-SCR,which has the largest loading amount of Ag, actually shows a NOx reduction ability of about 11% at 200°C.

Fig. 2 shows the H_2-temperature programed reduction (TPR) behavior of the type Al_2O_3 of H_2-SCR. Depending on the Ag loading amount, the height of the reduction peak of the main peak increases, and the peak band tends to broaden slightly. Since Ag clusters ($Ag_n^{\delta+}$) are more unstable than AgO oxide, they can promote the chemical reaction of Ag catalysts.

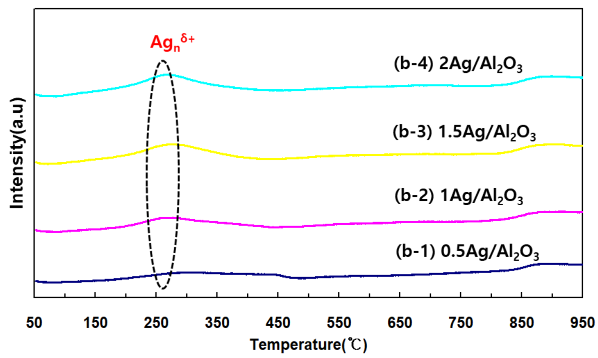


(a) Al_2O_3



(b) TiO_2

[Fig. 1] De-NOx performance according to the types of support of H_2-SCR



[Fig. 2] H_2-TRP according to the types Al_2O_3 of H_2-SCR

References

[1] Y. Guan, "Review on the Selective Catalytic Reduction NOx with H_2 by using Novel Catalysts", Journal of Environmental Chemical Engineering, pp. 106770.