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# Enhanced catalytic activity of the Rh/ $\gamma$ -Al<sub>2</sub>O<sub>3</sub> pellet catalyst for N<sub>2</sub>O decomposition using high Rh dispersion induced by citric acid

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## ABSTRACT

Two types of egg-shell-type Rh-based spherical  $\gamma$ -alumina pellets were prepared by simple impregnation and incipient wetness methods with citric acid as an additive. In the case of the simple impregnation method, most of the Rh precursor molecules were selectively located in the outermost region of the spherical  $\gamma$ -alumina pellet because of strong interactions between the Rh precursor and alumina. Thus, it formed a very thin Rh shell (Rh/Al<sub>2</sub>O<sub>3</sub>-Thin) around the pellet. On the other hand, the Rh precursor molecules were widely dispersed in the outer part of the spherical  $\gamma$ -alumina pellet when citric acid was used as an additive. This method led to the formation of a thick Rh shell (Rh/Al<sub>2</sub>O<sub>3</sub>-Thick). The two samples were characterized via N<sub>2</sub> adsorption isotherms and CO chemisorption, and used as catalysts for the decomposition of N<sub>2</sub>O under different reaction conditions and at varying gas hourly space velocities. The N<sub>2</sub>O conversion achieved using the Rh/Al<sub>2</sub>O<sub>3</sub>-Thick catalyst was higher than that attained with the Rh/Al<sub>2</sub>O<sub>3</sub>-Thin catalyst. This implied that Rh dispersion is an important factor governing the performance of Rh-based spherical  $\gamma$ -alumina pellet catalysts in N<sub>2</sub>O decomposition.

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## 1. Introduction

It is very important to reduce the amount of nitrous oxide (N<sub>2</sub>O) present in the atmosphere because it contributes to the destruction of stratospheric ozone and the greenhouse effect (Kapteijn et al., 1996; Konsolakis, 2015). Several researchers have investigated methods for controlling N<sub>2</sub>O emissions including thermal decomposition, selective catalytic reduction (SCR), and catalytic decomposition of N<sub>2</sub>O (Centi et al., 2000; Kapteijn et al., 1996; Shimizu et al., 2000). Among these methods, catalytic decomposition of N<sub>2</sub>O (2N<sub>2</sub>O → 2N<sub>2</sub> + O<sub>2</sub>) has received significant attention from both an academic and industrial point of view (Kapteijn et al., 1996; Konsolakis, 2015). This is because

catalytic decomposition of N<sub>2</sub>O offers a simple and efficient way of removing N<sub>2</sub>O without using any reductant such as ammonia, hydrocarbon, and carbon monoxide (Centi et al., 2000; Kapteijn et al., 1996; Konsolakis, 2015; Shimizu et al., 2000). However, none of the catalysts proposed in literature exhibit a good performance and stability under space velocity and feed composition conditions which are realistic for industrial applications. Therefore, several different types of catalysts such as noble metals (Bueno-López et al., 2006; Centi et al., 2000; Yuzaki et al., 1997), ion-exchanged zeolites (Li and Armor, 1992; Melián-Cabrera et al., 2005), and metal oxides (Abu-Zied and Soliman, 2009; Karásková et al., 2010; Pasha et al., 2008) have been investigated for efficient N<sub>2</sub>O decomposition. Among these various types, rhodium

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