New concept CeO_2-ZrO_2 solid solution for automotive exhaust catalysts

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Introduction

The three-way catalysts for gasoline automobiles can remove three components of CO, HC(hydrocarbons), and NOx most efficiently at the theoretical air/fuel (A/F) ratio at around 14.6, however, CeO_2-ZrO_2 solid solution is indispensable material to maintain A/F precisely at a catalyst surface by a function of oxygen storage capacity (OSC) which originates in valence change of $Ce^{4+} \Leftrightarrow Ce^{3+}$. Emission regulations (EURO5, LEVII, J-SULEV etc) scheduled for introduction in the world will be severer than the former, catalysts should keep their initial performance during life of the car. The improvement of durability of OSC material is one of the most vital factor in a catalyst. The purpose of this research is to improve durability of the CeO_2-ZrO_2 solid solution as an OSC material by a new concept described below.

New concept for improvement of OSC material's durability

Generally, CeO_2-ZrO_2 solid solution particle growth in CZ composed of only CeO_2 and ZrO_2 is caused by contacting of the primary particles. We suggested a new concept that growth of primary particles could be inhibited by restricted contact of mutual primary particles by introducing Al_2O_3 particles in nano-scale. The new concept was named as "Al_2O_3 Diffusion Barrier Concept " and the new OSC material which was composed of CeO_2-ZrO_2 solid solution and Al_2O_3 was called " ACZ " (Fig.1). The ACZ [1] was prepared by co-precipitation method and was used after Pt loaded on.

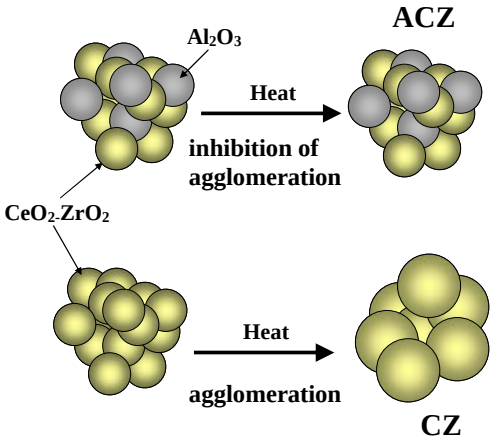

Fig. 1 New concept image

[1] R&D Review of Toyota CRDL,Vol.3, No.4,P28

Results and Discussion

The BET specific surface area (SSA) of ACZ after durability test in air at 1000 degree C was 20 m^2/g and lager than that of the conventional CZ not introduced Al_2O_3 ($2m^2/g$). The

particles size of the CZ in ACZ after durability test was about 10 nm and which was one-half of CZ only.

The OSC was roughly distinguished the total capacity (OSC-c) with the oxygen release velocity (OSC-v). In fresh condition, ACZ and CZ had almost same OSC-c, however, OSC-v of ACZ was twice faster than CZ. After durability test, both OSC-v of ACZ and CZ were reduced remarkably, but OSC-v of ACZ was about 5 times faster than that of CZ.

As described above, it may be shown that the improvement of OSC-v in a fresh catalyst and the inhibition of fall of OSC-v after durability test were achieved as a result of inhibition of particles growth of CZ in ACZ by introducing Al_2O_3 into CZ in nano-scale to improve the durability of an OSC material.

Biographical Sketch

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Akira Morikawa received his Master degree in 1994 in inorganic chemistry at Nagoya University. He had studied inorganic complexes which had central metal of Ni, Rh, Pd, Pt and chelate ligands holding donor atoms of N and P in Nagoya University. Since 1995, he belonged to Toyota Central R&D Labs., Inc., which is one of TOYOTA group's companies, and has been researching the three-way catalysts for automotive exhaust, particularly developing the oxygen storage-release materials (OSC materials). Since this year, he has become a group leader and aims to develop the catalysts that can be activated at lower temperature than the conventional ones. Recently, he pays attention to controlling the primary nano-particles' shape of OSC materials and agglomeration of secondary particles.