Development of Methods for Durability Evaluation and Performance Recovery of After Treatment Devices for Diesel Vehicle Exhaust Gas

Principal Investigator: Junko UCHISAWA
Institution: Engine Combustion and Emission Control group, Research Institute for Energy Conservation, National Institute of Advanced Industrial Science and Technology (AIST), 1-2-1 Namiki, Tsukuba 305-8564, Ibaraki, JAPAN
Tel: +81-29-861-8716 / Fax:+81-29-861-7089, E-mail: junko-uchisawa@aist.go.jp

[Abstract]

Key Words: After treatment devices, Diesel vehicle exhaust gas, Selective catalytic reduction catalyst, Accelerated deterioration, Durability evaluation, Reactivation

Methods of the activity evaluation, accelerated deterioration and reactivation of exhaust gas purification catalysts used in heavy-duty diesel vehicles compliant with the 2016 regulations were studied. For the activity evaluation method, simulated exhaust gas conditions were established for each single-stage catalyst (DOC, SCR catalyst, ASC) and combined multi-stage systems (DOC + SCR catalyst, DOC + SCR catalyst + ASC). The reaction conditions were designed to be as simple as possible, while capturing the intrinsically important performances. The catalyst performances were evaluated based on relative values between new and used catalysts (or between commercial and developed catalysts). In other words, this method is not intended to strictly predict the performance of exhaust gas purification systems in actual conditions, but rather to be a specific method for understanding the degree of change in catalyst performance (deterioration due to long-term use or improvement due to development).

For the accelerated deterioration methods, hydrothermal deterioration of SCR catalysts was systematically studied. It was found that the treatment time required to determine the durability can be significantly shortened by applying hydrothermal conditions at much higher concentrations than those of normal automotive exhaust gas. The deterioration mechanism was clarified to result from the change of redox performance of Cu and the decrease in the amount of acid sites that serves as the NH3 adsorption site.

For the reactivation methods, it was found that the performance of hydrothermally deteriorated SCR catalysts can be reactivated to some extent by treatment in a high concentration of water vapor (>50%) at a relatively low temperature (200-300°C). A small amount of H_2, NH_3, and NH_3+NO addition to water vapor were further effective at certain temperatures.

A series of methods for catalyst activity evaluation and accelerated deterioration established in this study were documented as "Evaluation Method for Durability Performance of Diesel Automotive Emission Gas Purification Catalysts under Small-Scale and Simulated Exhaust Gas Conditions." This is the first evaluation method developed for public use in Japan. This method is expected to enable early diagnosis of catalyst deterioration, as it enables a simplified understanding of catalyst performance. In addition, by disclosing this evaluation method to many industrial sectors related to automotive catalysts, it is expected that the development and improvement of catalysts will be greatly accelerated.

[References]

1) J. Uchisawa, A. Obuchi, A. Yamamoto, S. Suzuki, N. Mizushima: Ind. Eng. Chem. Res. 59、19185 (2020).（IF=3.720）," Total Performance Evaluation of Diesel SCR Catalyst System by Lab-scale

Experiments”

2) J. Uchisawa, A. Obuchi, A. Yamamoto, S. Suzuki, N. Mizushima, N. Hayashi: Ind. Eng. Chem. Res. 59, 19185 (2021).(IF=3.720), ” Effect of Water Vapor on the Accelerated Deterioration Treatment of Cu-SSZ-13 as Catalysts for Selective Catalytic Reduction”