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Investigation of Ammonia Carrier Materials for Next Generation Ammonia Dosing System (Abstract)

CRADA #334 (PNNL #61653)

April 2024

Abhi J. Karkamkar

USCAR

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Abstract

Lean-burn gasoline and diesel engines can offer substantially higher fuel efficiency, good driving performance, and reduced carbon dioxide emission compared to stoichiometric gasoline engines. Various catalyst technologies have been developed to remove the pollutants from these engines. For example, a three-way catalyst (TWC) is used to remove hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx) from gasoline engines during the stoichiometric conditions. During the lean-burn conditions, a TWC or a diesel oxidation catalyst (DOC) is used to control HC and CO emissions. NOx is removed by either lean NOx trap catalyst (LNT) that can store NOx under lean conditions and reduce NOx under rich conditions, or selective catalytic reduction catalyst (SCR) that can selectively remove NOx with a reducing agent.

Among the NOx reduction catalyst technologies, SCR offers a number of advantages, including excellent NOx reduction efficiency over a wide range of temperatures and overall lower system cost. In fact, the SCR technology using ammonia (NH3) as reductant has been proven effective and used commercially for the removal of NOx emissions from stationary sources since the 1970s. Currently, SCR is being used to meet the NOx emission standards for diesel engines in Europe and North America, and also being considered for meeting the future NOx emission standards for lean-burn gasoline engines.

Because of the challenges associated with storage, handling and transportation of ammonia on a vehicle, aqueous urea solution (e.g., Diesel Exhaust Fluid, AdBlue) has been developed as ammonia storage compound for mobile applications. When the aqueous urea solution is sprayed into exhaust gas stream, urea is decomposed to release ammonia, which then reduces NOx over the downstream SCR catalyst. Although aqueous urea solution technology has enabled automakers and engine manufacturers to meet the current NOx emission standards, this process of releasing ammonia requires a hot exhaust gas and sufficient mixing, creating challenges for low temperature NOx emission control and aftertreatment system packaging. For these reasons, alternative technologies have been developed as ammonia sources (e.g., solid urea, ammonium carbamate, metal ammine chloride) during the past few years. These technologies promise more convenient handling and distribution of ammonia sources, and help maximize the low-temperature performance of SCR catalysts and reduce the overall system volume and weight.

However, none of these alternative technologies can be successfully implemented without the industry consensus. Therefore, the USCAR SCR work group, which is comprised of representatives from GM, Ford, and Chrysler, has decided to investigate the potential alternative ammonia carriers, define common standard vehicle interfaces, and address personal and environmental safety concerns with part suppliers and chemical companies.

Under this CRADA Project, USCAR and Battelle will investigate alternative ammonia carrier materials that are currently under development. Based on the data and information derived under the CRADA project, the USCAR SCR work group plans to build the consensus and make recommendations for the industry.

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