HC-SCR for Diesel NOx Reduction on Supported Metal Catalysts

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Introduction

The SCR of NO using hydrocarbons (HC-SCR) has been studied extensively as a potential alternative method for the removal of NO_x under oxygen-rich conditions [e.g., 1, 2]. HC-SCR utilizes the fuel on board the vehicle as the NO_x reductant, and does not require the complex engine control and large amounts of expensive platinum-group metal catalysts employed in NO_x storage catalyst systems. While the conversion efficiencies reported in the literature are commonly > 80% over various temperature ranges, the adaptability of these results to the reduction of NO_x from light-duty diesel exhaust is difficult. A unique catalyst developed using high-throughput discovery techniques in collaboration with BASF Corporation was investigated at General Motors under simulated diesel engine exhaust feed conditions for the selective catalytic reduction of NO_x as part of a Department of Energy (DOE) supported cooperative project (DE-FC26-02NT41218). Consequently the effects of NOx (as NO or NO_2), hydrocarbon concentration level (HC:NOx ratio), oxygen concentration, NO concentration, catalyst space velocity, catalyst temperature, and the co-presence of hydrogen on steady-state NOx reduction activity were measured in a laboratory flow reactor system. NO_x reduction over Ag/Al_2O_3 catalysts in a laboratory flow reactor system using a simulated diesel fuel mixture will be presented at the temperatures, flow rates, and inlet NO_x concentrations likely to be encountered by a HC-SCR catalyst system on a light-duty compression ignition direct injection (diesel) vehicle under the FTP, US06, and HWYFET test schedules [3]. In addition, using a V6 turbo charged diesel engine connected to a dynamometer running light-duty transient test cycles, NOx efficiency was evaluated as a function of catalyst volume, the hydrocarbon to NOx ratio (HC/NOx), and space velocity [4].

Materials and Methods

Experiments were performed in a laboratory fixed-bed flow reactor system. Simulated light-duty diesel exhaust gas was introduced using a series of computer controlled mass flow controllers connected to individual gas cylinders of known composition. A range of reductants were used in this study (figure 1). The engine used for testing was a 4.9L V6 turbo diesel engine essentially the same as the 6.6L V8 Duramax engine with two less cylinders. The test cycles consisted of the highway fuel economy test (HWYFET), the US06 test cycle and cold start federal test procedure 75 (FTP.)

Results and Discussion

Reactor evaluations of this catalyst indicate NOx conversions of sufficient activity to be evaluated for possible automotive applications (figure 1). Key enablers for maintaining high conversion levels include high oxygen concentrations, low inlet NO_x concentration, optimal fuel dosing, and the addition of supplemental hydrogen technologies. The HWYFET with 20L HC-SCR catalyst resulted in 92% NOx efficiency and 76% on the US06 cycle. Using a catalyst heating strategy on the cold start FTP cycle a weighted NOx efficiency of 60% was measured.

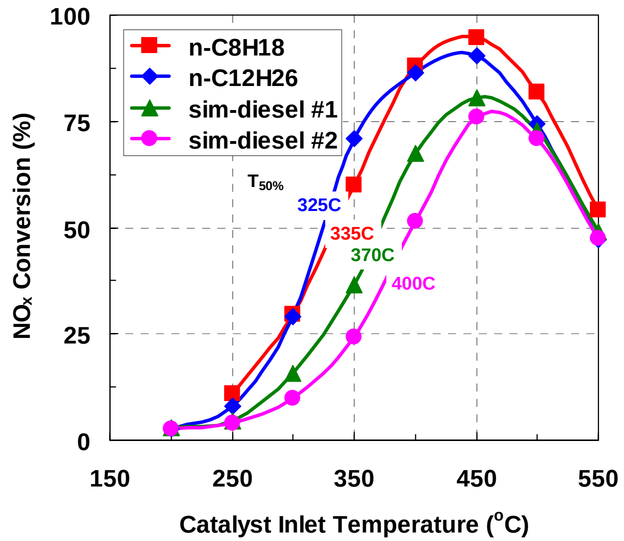

Figure 1. NO_x conversion over 2 wt.% Ag_2O/Al_2O_3 at 50,000 h^{-1} using several different HC reductants (n-octane, n-dodecane, sim-diesel #1, and sim-diesel #2 at $HC_1:NO_x$ ~8). The light-off temperatures ($T_{50\%}$) are indicated on the curves.

Significance

This catalytic material shows promise as a diesel NOx reduction technology.

References

1. M.D. Amiridis, T. Zhang, and R.J. Farrauto, "Selective Catalytic Reduction of Nitric Oxide by Hydrocarbons", Appl. Cat. B: Environ. 10, 203-227 (1996).
2. R. Burch, J.P. Breen, and F.C. Meunier, "A Review of the Selective Reduction of NO_x with Hydrocarbons under Lean-Burn Conditions with Non-Zeolitic Oxide and Platinum Group Metal Catalysts", Appl. Cat. B: Environ. 39, 283-303 (2002).
3. Steven Schmieg, Richard Blint and Leng Deng, "Control Strategy for the Removal of NOx from Diesel Engine Exhaust Using Hydrocarbon Selective Catalytic Reduction", SAE Technical Paper 2008-01-2486, October 2008.
4. Michael Viola, "HC-SCR Catalyst Performance in Reducing NOx Emissions from a Diesel Engine Running Transient Test Cycles", SAETechnical Paper 2008-01-2487, October 2008.