Spatio-temporal Features of NOx reduction on LNT+SCR System:

Effect of Hydrocarbon Reductant and Space Velocity

Mengmeng Li, Vencon G. Easterling, Michael P.Harold

Previous studies have shown, in order of effectiveness, that H_2, CO, and hydrocarbons (HCs) are capable of reducing NOx present in diesel exhaust across a lean NOx trap (LNT) catalyst. Additionally, HCs and NH_3 have been utilized to reduce NOx to N_2 using selective catalytic reduction (SCR) catalysts. Recently, the synergy of combining LNT with SCR has attained NOx reduction levels that equal to or greater than stand-alone LNT or SCR while avoiding the need for the urea feed and reducing the loading of the expensive precious metal over LNT catalyst. Although simpler reductants such as H_2 and CO are capable of attaining higher NOx reduction levels, the study of more complex reductants in a combined LNT+SCR system is warranted for real world application on a vehicle.

In this study, NOx reduction using hydrocarbons (HCs) during the rich was investigated over a lab made LNT-SCR dual brick catalyst system. The effects of three reductants were studied in separate and blended combinations of CO, C_3H_6, C_3H_8, and CO+C_3H_6+C_3H_8. Figure 1 shows the overall performance of using the belended gas as reductant. At temperatures below 300˚C, NO_2 was found re-reduce back to NO during the rich phase across the SCR catalyst. NOx reduction with HCs becomes active above 300˚C, especially for C_3H_6, which could achieve 90% NOx conversion across the dual brick catalyst system. While C_3H_8 is not as active as C_3H_6 when fed in a mixture with C_3H_6 it starts to react at lower temperature than when C_3H_8 is the sole reductant. Figure 2 shows the comparison of three different reductants. The yield of NH_3 was ~40% greater when a C_3H_6 was used as compared to CO at higher temperature.

The gas hourly space velocity (GHSV) effect on NOx reduction was also investigated in this study. Figure 3 shows the GHSV was increased in order to achieve a lower NOx conversion to N_2 over

the LNT which could provide a more desirable NH_3 to NOx ratio (ANR) across the SCR. It was found out at high temperature, GHSV in the range of 105,000 h^{-1} to 120,000 h^{-1} could achieve nearly 50% NOx conversion and an ANR of 1.0 from LNT catalyst which is the ideal gas mixture to the downstream SCR catalyst. The recent research shows that the LNT-SCR dual brick catalyst system could also benefit from the HC-SCR mechanism which not only reduced the HC slip from the system but also improved NOx reduction over the combined catalysts. The HC steam reforming and partial oxidation were carried out by spatially resolved mass spectrometry (SpaciMS), which was utilized to decouple the regeneration reaction from NOx reduction. This method enabled a detailed study of NH_3 formation over LNT catalyst and utilization over SCR catalyst while using a reductant feed that approach real world conditions.

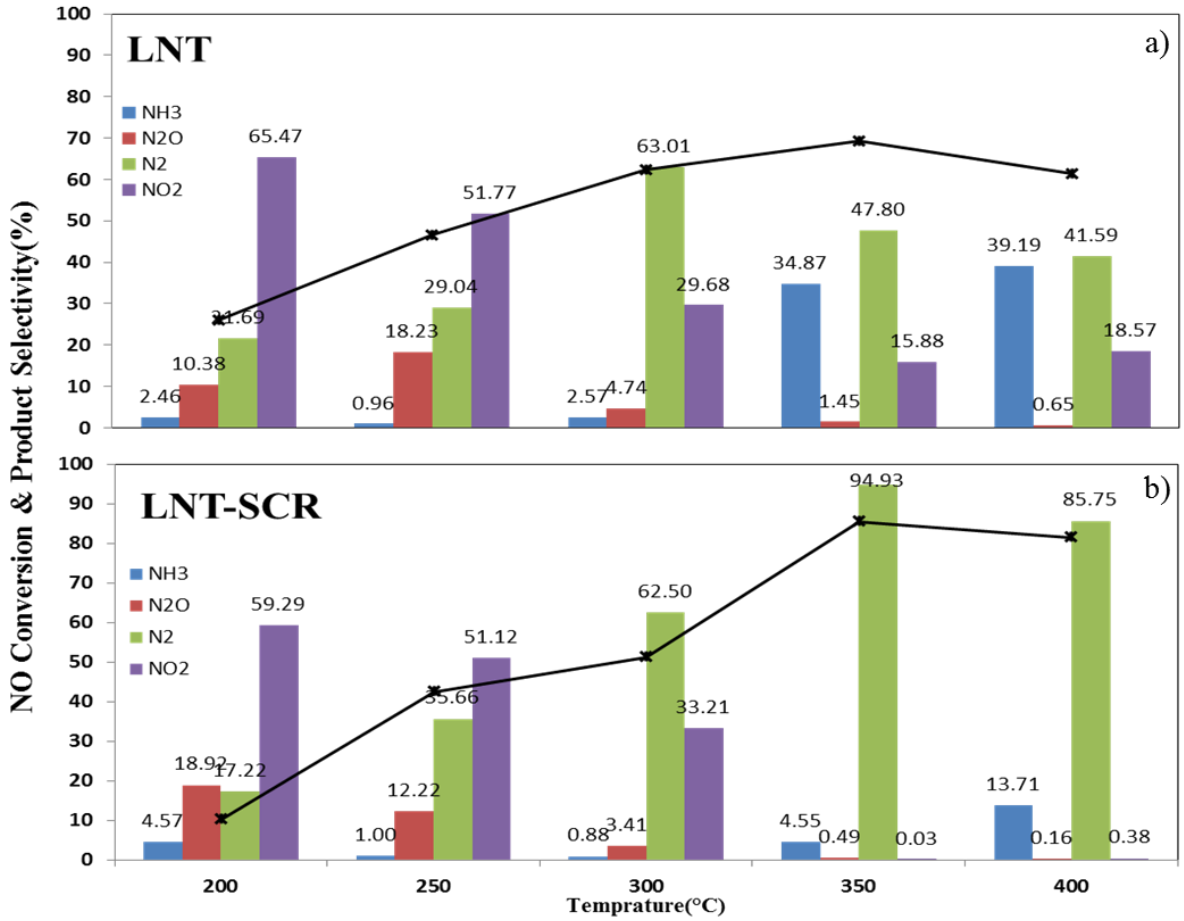


Figure 1. NO conversion and product selectivity using 1.5% CO, 500ppm C_3H_6, 3500ppm C_3H_8 and 1% O_2 as reductant over a) LNT A and b) LNT A-SCR A catalyst (NO conversion in black line).

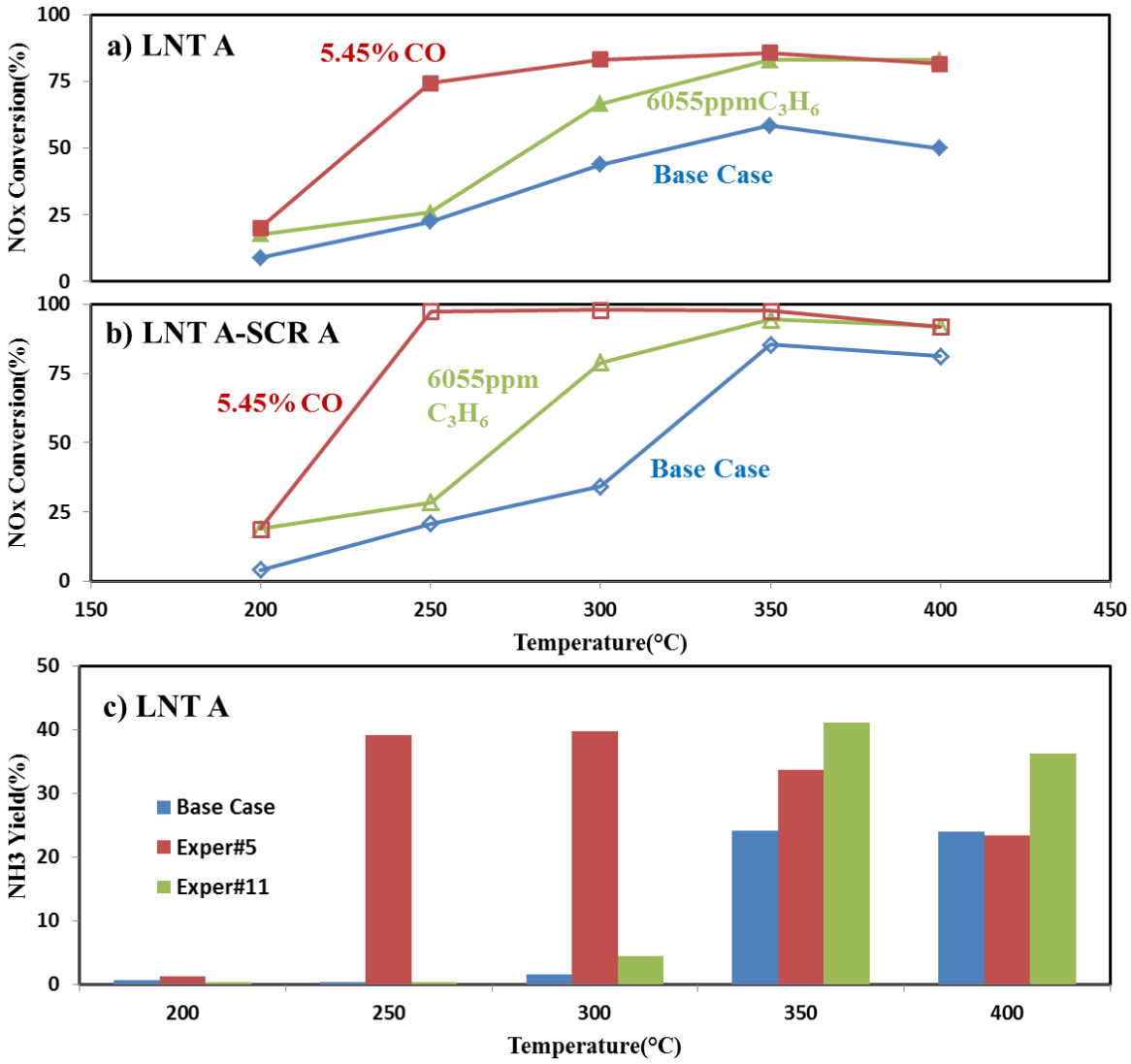


Figure 2: Cycle averaged NOx conversion and NH_3 Yield for Base case (500ppm NO, 1.5% CO, 500ppm C_3H_6, 3500ppm C_3H_8 and 1% O_2), Exper #5 (500ppm NO, 5.45%CO and 1% O_2), and Exper #11 (500ppm NO, 6055ppm C_3H_6 and 1% O_2). a) NOx conversion for LNT A b) NOx conversion for LNT A-SCR A c) NH_3 Yield for LNT A. GHSV=90,000 h^{-1}.

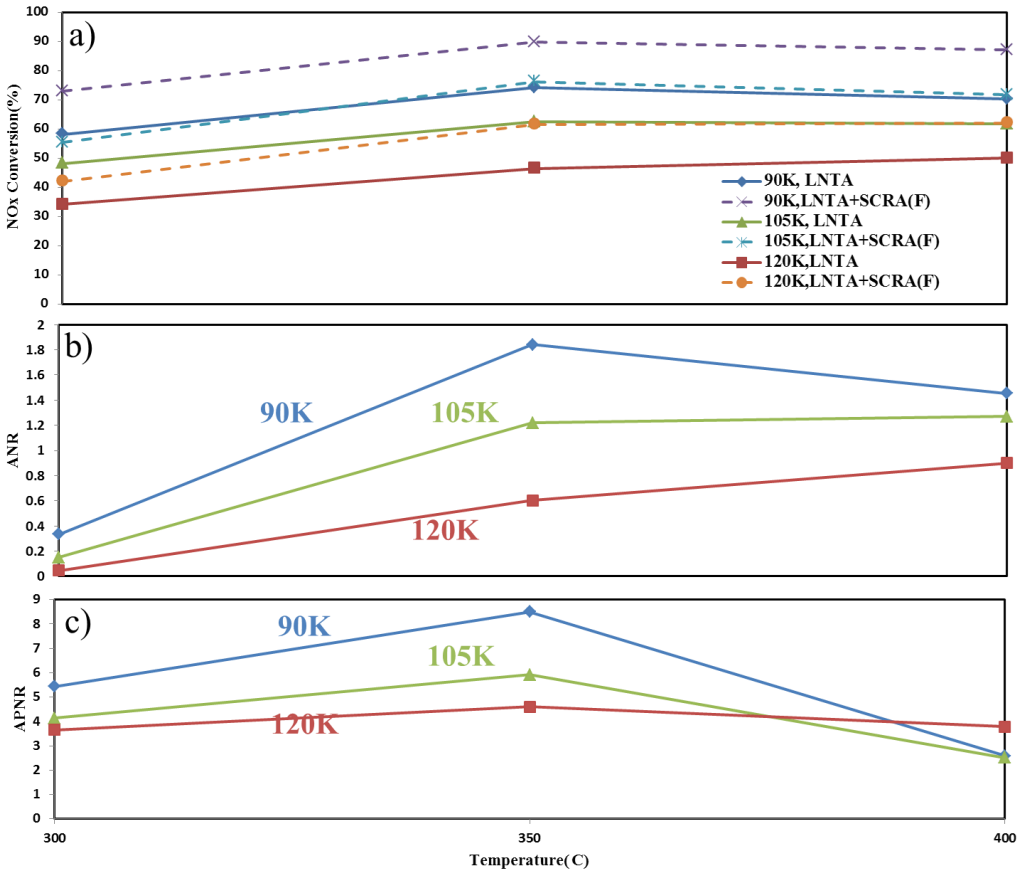


Figure 3: Cycle-averaged a) NO conversion and b) ANR c) APNR using 9300ppm C_3H_6 and 1% O_2 as reductant over LNT A by varying different GHSV (90,000 - 120,000 h^{-1}).