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Byproduct formation in lean NO_x traps for diesel exhaust aftertreatment

Overview

Diesel engines are more efficient than their gasoline counterparts. Due to their high fuel efficiency and durability, diesels power nearly all the heavy vehicles that form the backbone of the U.S. commercial ground transportation network. Concerns over CO_2 emissions and their link to global climate change are now driving increased use of diesels in light duty applications as well.

Standard catalytic converters do not work in diesel exhaust. The three way catalyst (TWC) systems used in light duty vehicles have been extremely successful at removing the pollutants found in gasoline engine exhaust. However, a TWC requires stoichiometric operating conditions to achieve efficient removal of all the pollutants in the exhaust. Diesel engines operate with an excess of air, making the exhaust lean. The oxidizing nature of the exhaust makes removal of nitrogen oxides (NO_x) difficult.

Operating conditions in internal combustion engines:

Stoichiometric - air and fuel are injected in quantities such that both are completely consumed in the combustion process

Rich - excess fuel is injected into the combustion chamber

Lean - excess air is injected into the combustion chamber

Lean NO_x traps (LNTs) are a promising technology for removing NO_x from lean engine exhaust. These devices work by chemically trapping NO_x during normal lean operation. The NO_x is released and reduced to nitrogen when the exhaust is periodically switched to rich conditions (see Figure 1).

Research Description

Recent engine testing of LNTs revealed production of several byproducts during regeneration, including ammonia and nitrous oxide. While these compounds are not regulated pollutants, ammonia is toxic and nitrous oxide is a greenhouse gas. Converting NO and NO_2 to these gases amounts to trading one problem for another.

This aim of this research is to identify the regeneration conditions that lead to the formation of these undesirable byproducts. The work will be performed utilizing a bench-scale reactor with synthetic exhaust gas flowing through a temperature controlled catalyst sample. The gases before and after the catalyst will be analyzed using infrared spectroscopy, chemiluminescent detectors, and mass spectrometry (see Figure 2). We also hope to determine the mechanisms of byproduct formation using surface chemistry techniques such as diffuse reflectance infrared spectroscopy.

Figure 1. Schematic of LNT reactions

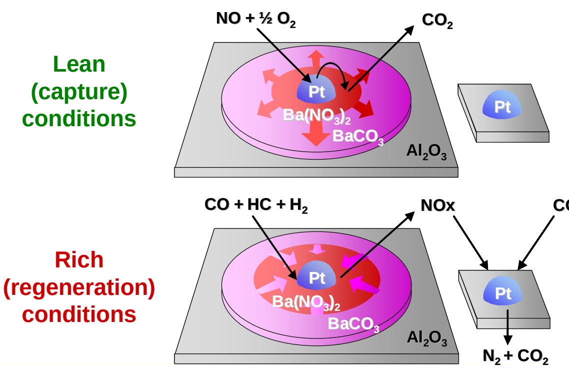
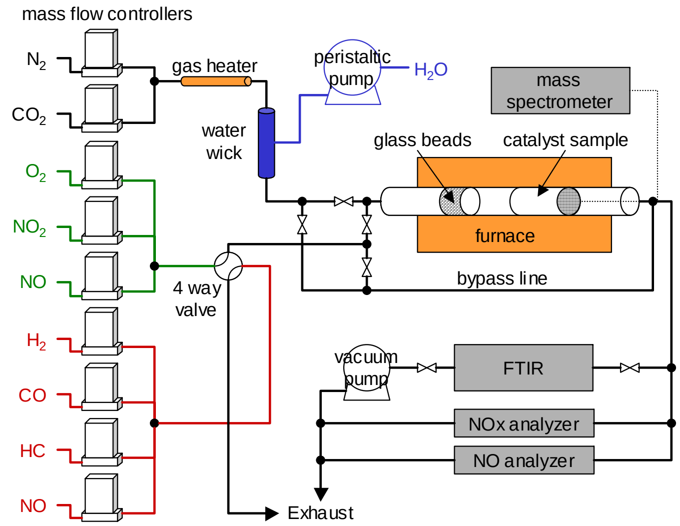


Figure 2. Diagram of flow reactor system



Impacts

Undesirable byproduct formation could be a major stumbling block in the development of commercially viable LNTs. This research will help overcome this hurdle by:

- identifying operating conditions that minimize byproduct formation, and
- providing reaction mechanism information that could aid in design of new materials that avoid byproduct creation.

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