

Validating a new system that analyses the Selective Catalytic Reduction (SCR) of NOx (Nitrogen Oxides) by propene or decane

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Introduction

Diesel engines emit toxic exhaust gas such as NOx (NO and NO₂). These gases are not only dangerous to the environment, but also to our health. This is the reason why European standards impose a reduction of their emissions by 2014. In order to follow these norms, some research has to be done on the different ways to reduce NOx.

Previous studies have been realised on an analysis system that could follow the SCR of NOx by propene (C₃H₆). For the purpose of getting closer to reality, this system has been modified to be able to analyse the SCR of NOx by propene or decane, both with and without water. New components were added such as the water saturator to add steam water in the reagents (so as to simulate water damage on catalysts in a Diesel engine) and a Peltier to condense steam water when the reaction is done, so that the analyser does not get damaged.

In order to validate this new analysis system, the new components needed to be tested and calibrated.

Experimental methods

For the purpose of testing the water saturator, the amount of water contained in the mixture was analysed by mass spectrometry (MS), when using or not the saturator. During that test, the saturator bath was heated up to 25°C (2-3% of water) and the Peltier was turned off.

The Peltier was tested by analysing the amount of water reaching a MS when the reagents first passed through the saturator (25°C), then into the Peltier (cooled to 0°C) and finally to the MS detector.

The flow meter was calibrated by matching the percentage displayed with the actual flow rate.

The IR/UV (Infrared Spectroscopy/ Ultra Violet Spectrometry), the GC-FID (Gas Chromatography-Flame Ionization Detector) and the μ GC-TCD (Microfabricated GC-Thermal Conductivity Detector) added to the system had to be optimised and calibrated with standard gas.

To be able to quantify 0-500ppm of nitrogen, it was extremely important to run some leak tests to make sure there was not any air entering into the system.

Finally, a catalytic test was carried out with a standard catalyst in order to check if the results for the SCR of NOx by propene were the same with the new analysis system than those with the previous analysis system. This test was realized from 500°C to 25°C on the analysis of a mixture of gas that went through a 1%Pt/SiO₂ catalyst. The mixture was composed of 1000ppm of NO 1000ppm of C₃H₆, 9% of O₂ and the rest of He to reach a total flow rate of 120mL/min. Every 3 minute the quantity of NO, N₂, NO₂, N₂O, C₃H₆, CO₂ and CO was recorded.

Results and discussion

The experiment demonstrated that the water saturator and the Peltier worked well.

The flow meter, the IR/UV, the GC-FID and the μ GC-TCD were calibrated without any problems.

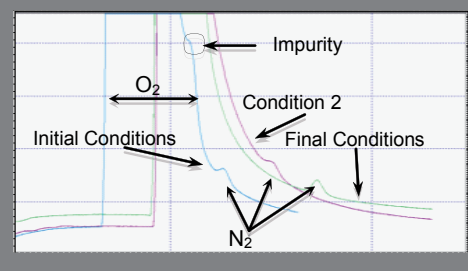
Figure 1 shows μ GC-TCD optimization where 9% of O₂ and 25ppm of N₂ were separated. The different parameters like the column temperature or the duration of the injection influenced the signal resolution.

Figure 1 : Optimization of the separation of 25ppm of N₂ and 9% of O₂ using μ GC-TCD analyser.

Initial conditions: The N₂ peak is at the bottom of the O₂ peak. Only 11ppm of N₂ was integrated instead of 25ppm.

Intermediary conditions : The impurity on the O₂ peak disappeared but the nitrogen integration was not good.

Final conditions: The impurity on the O₂ peak disappeared and the N₂ was integrated better (N₂ = 21ppm).



Concerning the FID, the experiment proved that this detector worked for the analysis of propene but was not adapted for decane analysis. Finally, the catalytic test for the SCR of NOx by propene showed similar results with the new analysis system to those with the previous one.

Conclusion

This new analysis system is by far faster and closer to reality than the previous one but it still needs some improvement. Indeed, the analysis system is validated for the SCR of NOx by propene with or without water.

