22th ETH-Conference on Combustion Generated Nanoparticles

Particle emissions from gas engine utilizing natural gas and propane as fuel

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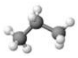
INTRODUCTION

- Natural gas (mainly methane) is an important fuel in energy production and its utilization is increasing.
- The use of new gases like ethane, propane and biogases is expected to increase.


CH_4


C_3H_8

- Emissions from natural gas engine: methane (strong greenhouse gas), formaldehyde (toxic), CO (toxic, indirect greenhouse gas), NO_x (health and environmental effects) and particles (health and environmental effects) (Alanen et al., 2015; Lehtoranta et al., 2017).
- Changing the gas composition is likely to alter the emissions and also its environmental and health impacts.

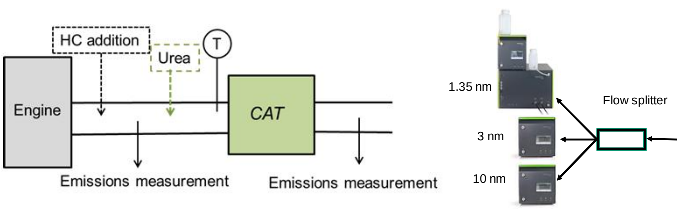


Figure 1. The test set-up and CPC set-up.

EXPERIMENTAL

Experiments were conducted utilizing a recently developed gas engine facility (Murtonen et al., 2016). The catalyst setup consisted of a combination of a SCR and an oxidation catalyst. Exhaust gas temperature was varied from 350 to 500 °C while the effect of catalyst space velocity was studied with exhaust gas flows of 80 kg/h and 40 kg/h. Particle mass (PM) emissions were studied with standard methods. Particle number (PN) concentration was measured using three condensation particle counters with different cut-points and a particle size magnifier (Airmodus Ltd.). A Nano-SMPS (TSI Inc.) was used to determine particle size distribution. The chemical composition of exhaust particles was investigated by using a Soot Particle Aerosol Mass Spectrometer (SP-AMS).

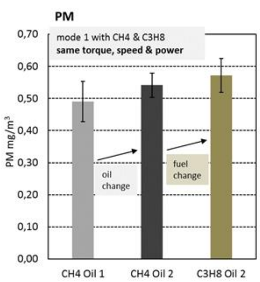


Figure 2. PM measured in different situations.

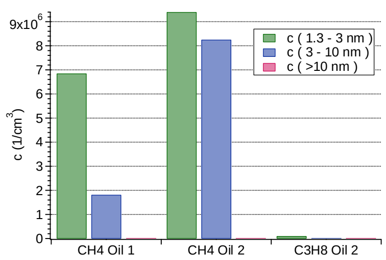


Figure 3. PN concentrations in different measurement situations measured using CPCs with different cut-points and a PSM.

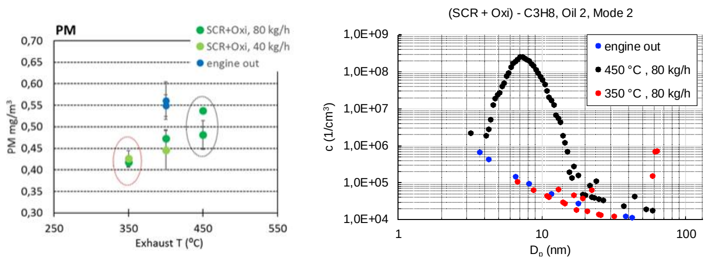


Figure 4. Catalyst effects on particle mass and size distribution.

RESULTS

The particle mass emissions were found to be small in all cases studied. The sizes of observed particles were very small. Most of the particles were below 10 nm in size and significant amount of the particles were even below 3 nm in size. Changing the lubricating oil from higher sulphur content (oil 2) to lower sulphur content (oil 1) had a small decreasing effect on the PM while it caused significant reduction in total PN concentration and the mean size of observed particles was also found to decrease. The particle composition was found to be dominated by organic matter (mostly hydrocarbon compounds). With propane fuel using the catalysts increased particle number concentrations in the size range under 20 nm when the exhaust gas temperature was 450 °C. With the lower exhaust gas temperature (350 °C) that kind of effect was not seen.

CONCLUSIONS

- The particles smaller than 10 nm are in a major role in gas engine emissions.
- Lubricating oil has a role in particle formation.
- Fuel has a role in particle formation.
- Catalysts can have effects on particle emission also.

Acknowledgements

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References

Alanen, J.; Saukko, E.; Lehtoranta, K.; Murtonen, T.; Timonen, H.; Hillamo, R.; Karjalainen, P.; Kuuluvainen, H.; Harra, J.; Keskinen, J.; Rönkkö, T. The formation and physical properties of the particle emissions from a natural gas engine. Fuel 2015, 162, 155-161.

Lehtoranta, K.; Murtonen, T.; Vesala, H.; Alanen, J.; Simonen, P.; Rönkkö, T.; Timonen, H.; Saarikoski, S.; Maunula, T.; Kallinen, K.; Korhonen, S. Natural gas engine emission reduction by catalysts. *submitted to Emission Control Science & Technology 2016*

Murtonen, T.; Lehtoranta, K.; Korhonen, S.; Vesala, H. Imitating emission matrix of a large natural gas engine opens new possibilities for catalyst studies in engine laboratory. In: CIMAC congress, June 6-10, 2016.

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