How Urea Dosing in SCR Systems Drives Secondary Particle Formation

Georgi Trendafilov, M. Sc. | Dr.-Ing. Stefan Sterlepper | Univ.-Prof. Stefan Pischinger

Urea injection in selective catalytic reduction (SCR) systems increases particle number (PN) emissions and may become a dominant particle source in low-soot applications, such as hydrogen combustion engines.

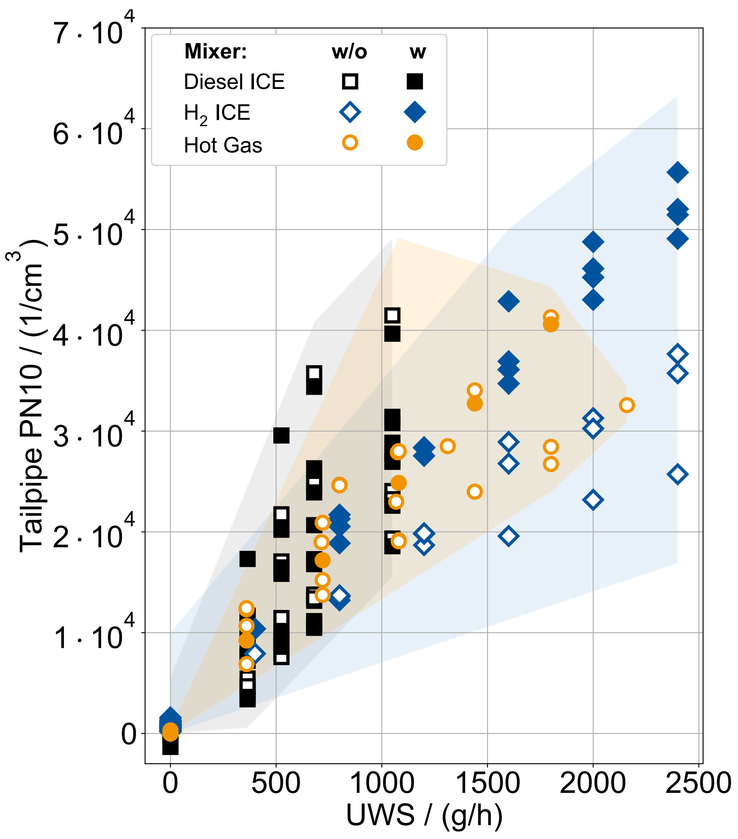
Introduction

- Urea is widely used as a reducing agent in nitrogen oxides (NO_x) aftertreatment
- Urea injection significantly increases tailpipe particle emissions
- Particles generated downstream of the particulate filter are directly emitted into the atmosphere

Motivation

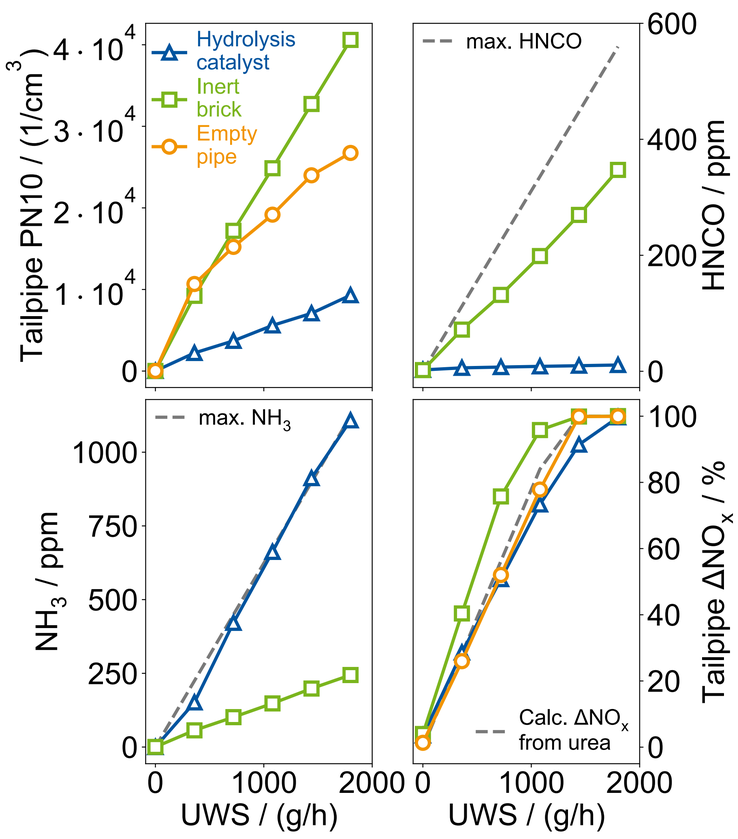
- Investigation of secondary particle formation in the SCR system
- Identification of key factors and particle characterization
- Understanding of the dominant particle formation mechanisms

Experimental results under steady-state conditions at $\dot{m}_{exh}$ = 500 kg/h and T_{exh} = 400 °C



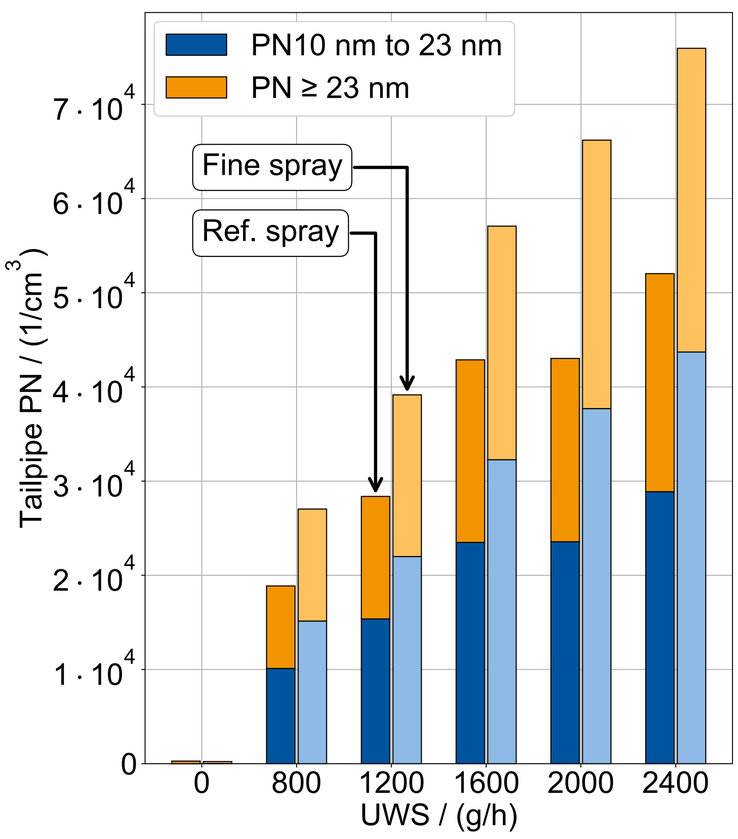
Impact of hardware and gas matrix

- Linear correlation between urea dosing rate and increase in particle number emissions
- Increased particle formation due to enhanced secondary spray atomization by a static mixer



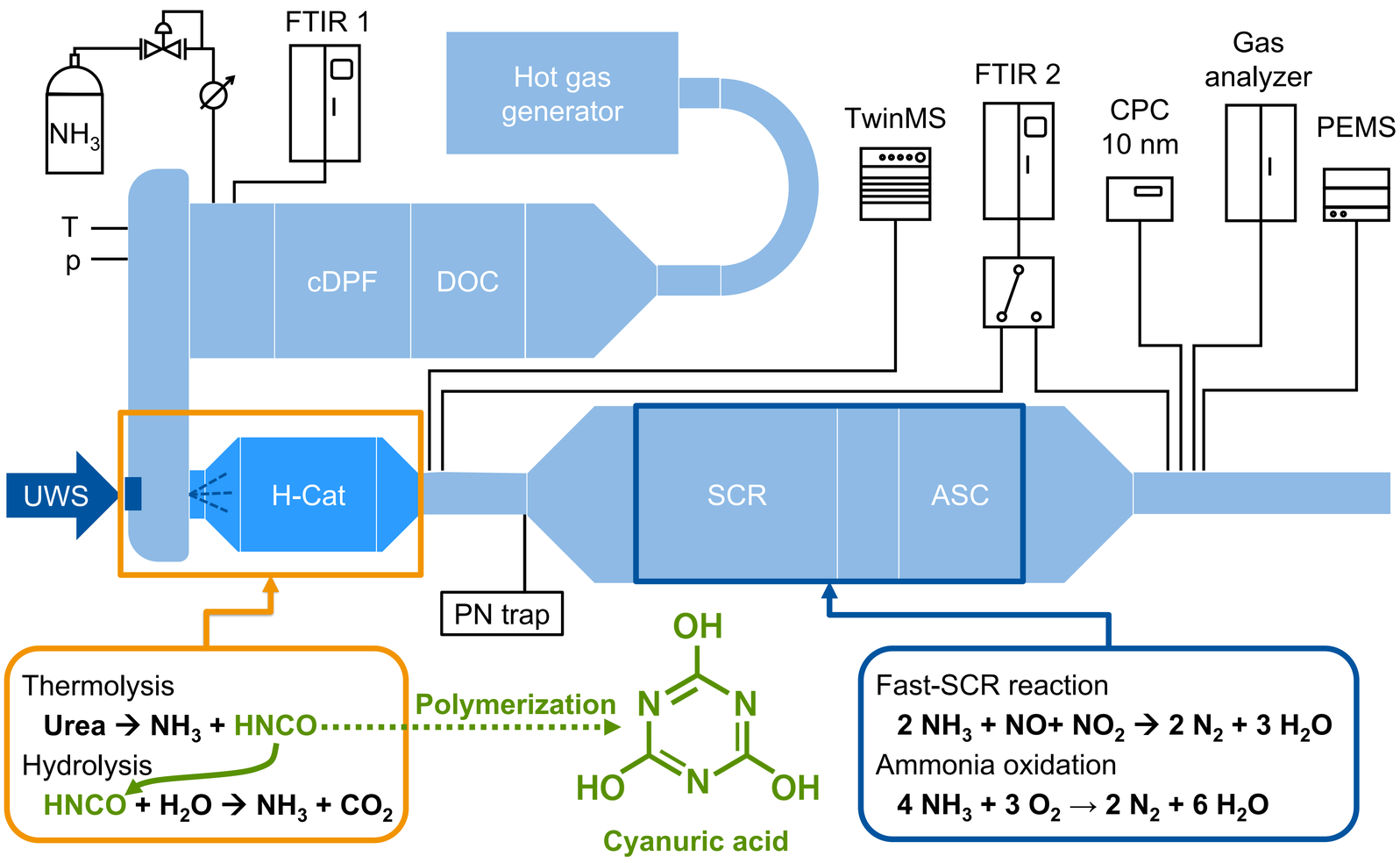
Catalytic urea decomposition

- Enhanced HNCO hydrolysis reduces particle formation and increased NH_3 upstream SCR
- High HNCO concentration in the mixing tube before SCR corresponds to high PN10 results



Particle size distribution from H_2 ICE

- Fine atomization increases particle number
- Mean size of urea-induced particles is < 23 nm
- Rapid gas-phase polymerization dominates urea-induced particle formation



Experimental setup

- State-of-the-art modular exhaust aftertreatment system
- Particulate filter upstream SCR system
- Two UWS dosing systems
- Urea decomposition tubes with and without mixer
- TiO_2 hydrolysis catalyst (H-Cat) for enhanced urea decomposition

Measurement equipment

- Laboratory gas analyzer as reference for:
  - CO, CO_2, HC, NO_x, O_2
- FTIR with methods calibrated for:
  - NO, NO_2, N_2O, NH_3, HNCO, …
- TwinMS mass-spectrometer:
  - Measurement of m/z = 43 (HNCO)
- AVL APC 489 Advanced particle counter
  - Cut-off size 10 nm
  - PCRF 1:100
  - Primary catalytic stripper (350 °C) dilution

Chair of Thermodynamics of Mobile Energy Conversion Systems &
Center for Mobile Propulsion
RWTH Aachen University
Forckenbeckstraße 4
52074 Aachen
www.tme.rwth-aachen.de
office@tme.rwth-aachen.de

This work is part of the research projects “Formation of Particles with UWS Injection I and II,” funded by FVV e.V. (funding nos. 1464 and 1545). The authors sincerely thank all working group members for their valuable discussions, insights, and support throughout the projects. Furthermore, they gratefully acknowledge the project partners for providing all hardware components used in the modular exhaust aftertreatment system.

Science for a moving society