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Spatially and temporally resolved analysis of UWS decomposition inside an SCR catalyst

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The reduction of nitrogen oxide emissions has become increasingly important worldwide over the last decades, particularly for the aftertreatment of lean-burn engine exhaust gases. While urea SCR (selective catalytic reduction) is well established as state-of-the-art technology for NO_x abatement in mobile applications, modern engine developments and ever-stricter regulations (Euro 7, US Tier 3) demand for even higher efficiencies. For safety reasons, the reducing agent NH_3 is supplied in form of urea water solution (UWS) that is decomposed in the exhaust tract. Previous works highlighted the incomplete evaporation and decomposition of UWS upstream the catalyst [1], necessitating comprehensive investigations on the catalytic reactions and interactions of urea decomposition with the SCR inside the monolith channels. To this end, measurements have been carried out in the monolith channels using the invasive capillary sampling techniques SpaciMS and SpaciFTIR. While SpaciMS suffers from pronounced cross-sensitivity between NH_3 and H_2O, SpaciFTIR only provides limited temporal resolution.

To close this gap, an optimized spectroscopic setup was designed that employs tunable diode laser absorption spectroscopy (TDLAS) for quantifying H_2O, CO_2 and NH_3 mole fractions in the sampled gas [2]. By reducing the volume of the instrumentation and performing the measurements at low pressure upstream the vacuum pump, an effective temporal resolution below 1 s is achieved, allowing unprecedented spatiotemporal investigations of the interplay between the UWS spray and the chemical reactions in SCR catalysts.

To acquire the experimental data used to calibrate the models discussed in this work, the newly developed system was combined with a capillary sampling technique on a generic SCR test bench [3]. Operating parameters and sampling positions were varied systematically to generate a comprehensive dataset, which will serve as basis to calibrate a kinetic model of HNCO hydrolysis that can be included in scale-resolving 3D CFD models.

References.

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