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High Temperature Workflows in High Throughput Experimentation: From NH_3 Cracking and CO_2 -to-CO to Methane Pyrolysis

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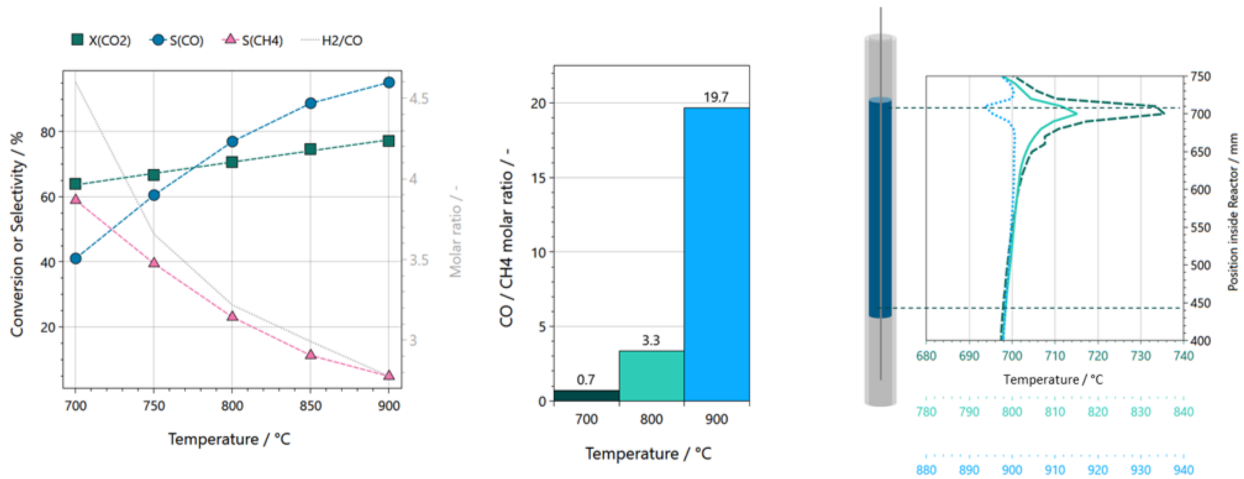
Efficient hydrogen release from ammonia and selective CO production from CO_2 are key enabling steps for resilient supply chains of hydrogen, syngas, fuels, and chemicals. This study presents complementary hte workflows for ammonia cracking and high-temperature CO_2-to-CO conversion using advanced parallel reactor testing units operated under industrially relevant conditions.

For ammonia cracking, a 16-fold parallel fixed-bed reactor system upgraded for NH_3 reactions was used to evaluate an in-house Fe-based catalyst at temperatures of up to 750 °C, pressures of up to 50 bar, and gas hourly space velocities of up to 200 000 h^{-1}. Within only two weeks of testing, the workflow delivered catalyst ranking, kinetic data sets, and stability information, enabling rapid identification of performance windows and scale-relevant limitations under pressurized conditions [1].



rWGS results and T-profiles at 700-940°C using a state-of-the-art commercial catalyst [2].

For CO_2-to-CO conversion, hte's 4-fold high-temperature bench scale unit enables testing of commercial catalyst shapes at up to 940 °C and 30 bar with minimal blank activity, made possible by a sophisticated reactor concept. In addition, axial temperature measurements along the catalyst bed allow intrinsic catalyst performance to be isolated in the kinetically controlled regime and provide detailed insight into thermal behavior under strongly endothermic conditions. In rWGS, a distinct transition from methanation-dominated behavior to selective CO formation was observed between 800 and 900 °C. CH_4 formation was suppressed below thermodynamic equilibrium and reached 0.18 mol% at 940 °C, 10 bar, H_2/CO_2 = 2, and 5% steam [2].

By combining high throughput experimentation with industrially relevant bench scale validation, this work bridges the gap between rapid catalyst screening and process-relevant performance assessment. The resulting thermal, kinetic, and stability data provide a strong basis for derisking scale-up of ammonia crackers, methane pyrolysis reactors, and CO_2 valorization routes for future fuels and chemicals.

[1] B. Mutz, R. Baumgarten, Decarbonisation Technology **2024**, Q1 (Feb), 79-83.
[2] B. Mutz, R. Baumgarten, C. Hauber, Hydrocarbon Engineering **2025**, Q4 (Nov), 24-30.