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## From Ammonia Synthesis to CO<sub>2</sub>-based Alkenes: Repurposing Industrial Iron Catalysts

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The defossilization of the chemical industry requires resilient pathways for the production of basic chemicals such as ethylene. One promising approach is the repurposing of established industrial catalyst systems for carbon capture and utilization (CCU). This work investigates an industrial iron-based ammonia synthesis catalyst for the formation of hydrocarbons and short-chain alkenes from CO<sub>2</sub> and H<sub>2</sub>. Due to structural similarities between ammonia synthesis and Fischer–Tropsch catalysts, hydrocarbon formation under CO<sub>2</sub>/H<sub>2</sub> atmospheres is expected [1].

Initial catalytic investigations already demonstrate pronounced activity under CO<sub>2</sub>-containing feed gas. By varying temperature, H<sub>2</sub>/CO<sub>2</sub> ratio, and gas hourly space velocity, conversions of 70–80% and selectivities toward C<sub>2</sub>–C<sub>6</sub> alkenes of up to 17% were achieved. Besides CO formed via the reverse water–gas shift reaction, methane and higher hydrocarbons are produced. Increasing temperature particularly promotes methane formation, while alkene selectivity decreases (Figure 1).

Catalytic screening is performed in fixed-bed and Berty reactors to investigate reaction kinetics under gradient-free conditions. Particular focus is placed on comparing CO<sub>2</sub> and CO as carbon sources and on evaluating the influence of nitrogen-containing feed gases. Catalyst characterization before and after reaction is carried out using BET, XPS, SEM-EDX, TG-MS, and ICP-OES analysis.

The results demonstrate that established ammonia synthesis catalysts show significant potential for the CO<sub>2</sub>-based production of hydrocarbons and alkenes. The combination of catalytic activity, existing industrial relevance, and compatibility with CO<sub>2</sub>/H<sub>2</sub>-based feedstocks highlights their potential for resilient and defossilised chemical production pathways [2].

### Literature

[1] Dry, M. E. *The Fischer–Tropsch process: 1950–2000*. *Catalysis Today* 2002, 71, 227–241.

[2] Liese, T.; Graef, I.; Heck, F.; Hagen, V.; Müller, T. E. *Produktion von Ethen aus Recycleströmen und erneuerbaren Kohlenstoffquellen als eine nachhaltige und ökonomische Route zu Grundbausteinen der chemischen Industrie*; Technische Informationsbibliothek: Hannover, 2025.

**Figure 1:** Influence of temperature on product distribution (25 barg; 320–400 °C; H<sub>2</sub>/CO<sub>2</sub>/N<sub>2</sub> = 66/24/10).