Development and Enhancement of Iron-Based Catalysts to Boost the Conversion of CO_2 to Liquid Hydrocarbons

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Abstract

Background and motivation.
A significant challenge in mitigating climate change is the sustainable production of liquid fuels from renewable resources. Conventional power-to-liquid (PTL) plants utilize a two-stage process: initially, CO_2 (separated from flue gases and potentially from air) and renewable H_2 are converted into CO via the reverse-water-gas-shift reaction (RWGS), followed by Fischer-Tropsch synthesis (FTS) to produce hydrocarbons. This research aims to develop iron-sintered catalysts that can perform both reactions in a single step and reactor, respectively, thereby enhancing the efficiency of the overall process. The study examines the effects of Cu, Zn, and K promoters on Fe-based catalysts, evaluating their activity, selectivity, and stability under various $H_2/CO_2/CO$ feed ratios, temperatures (210-300°C), and CO_2 conversion levels.

Results and discussion.
The properties of different promoters (Cu, Zn and K) were studied by varying the temperature (210-300°C), the CO_2/CO reactant ratio and the CO_2 conversion. All studies have identified that the FeCuZnK catalyst exhibits lowest methane selectivity and the highest selectivities to the desired long chain hydrocarbons (C_{5+}) and olefins. By varying the CO_2/CO feed concentration, FeCuZnK was shown to be the only catalyst that is able to convert CO_2 in the presence of CO (up to 30 mol-%). Furthermore, FeCuZnK has been shown to suppress the direct methanation of CO_2. The CO_2 conversion profile as a function of temperature also indicates that potassium presumably inhibits the oxidation of iron carbides to iron oxides, thereby enabling higher CO_2 conversions which can be seen in Figure 1.

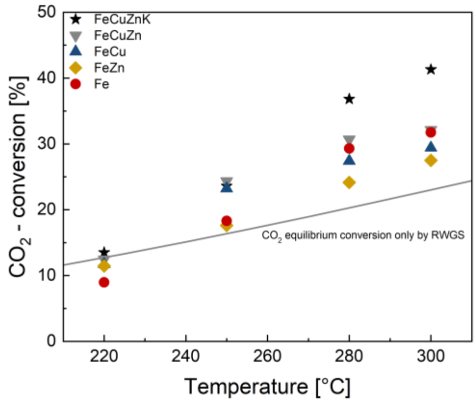

Figure 1: Achieved CO_2 conversion of each catalyst at different temperatures.