Catalyst Testing for Methanol Production using Alternative Synthesis Gases generated from Steel-Mill-Gases

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Introduction

A complete decarbonization of the economy appears theoretically possible in the energy sector, but is nearly impossible in the raw materials sector, because essential classes of substances, indispensable for existing technologies and nutrition, are based on carbon. The aim here is to avoid CO_2 emissions by collecting CO_X at the end of process chains and reusing it as carbon source. Ideally, carbon is circulated and there are no additional CO_2 emissions. The generation and catalytic conversion of synthesis gases to valuable chemical products such as methanol are of particular importance in this context because synthesis gases cannot only be converted to basic chemicals, but also energy carriers and fuels are accessible from synthesis gas. The synthesis gas streams generated from alternative sources such as steel-mill-gases can have differing properties from conventional synthesis gases. These differences relate to several aspects, such as deviating CO/CO_2 ratios, high CO_2 amounts, unfavorable or insufficient H_2 concentrations, as well as inert synthesis gas components and/or specific trace substances. Important prerequisite for the utilization of alternative synthesis gas sources is the development of new catalytic processes and the availability of suitable catalytic systems. These catalytic systems can be based on existing catalysts, which are adapted or can be based on new catalyst developments. In both cases, practical catalyst testing is one crucial step in the development of new processes for the utilization of alternative synthesis gases.

Methods and Results

In fundamental heterogeneous catalyst development, testing is usually performed with rather small amounts of catalyst. Transferring the results in terms of performance and catalyst lifetime to industrial relevant pilot-scale is challenging. Thus, a test system in large miniplant-scale for methanol synthesis has been developed, which is especially adapted to the requirements of alternative synthesis gases. Additional lab-scale investigations contribute to a wide range of catalyst testing scale. Industrial synthesis gas processes are characterized by a recycle of unconverted make-up gas compounds influencing the gas composition at the reactor inlet. In order to obtain realistic gas-compositions at the reactor inlet of one-pass test reactor set-ups, the close-to-practice catalyst testing approach is supported by process simulation. The test systems have also been used for higher alcohol synthesis and one-step dimethyl ether synthesis. The utilization of steel mill gases for an industrial methanol synthesis process was investigated in detail. A long-term test series with synthetic steel mill gases proved the stability of the catalyst. The influence of trace compounds is currently investigated in an on-site laboratory with direct access to cleaned and conditioned steel-mill gases at thyssenkrupp-Steel site in Duisburg.