Directly Coupled Production of Methanol and Formaldehyde Based on CO_2

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Abstract

In order to enable the implementation of a circular economy, the use of CO_2 as chemical feedstock is inevitable. Key element of this endeavor is H_2, which is needed for a number of CO_2-based processes. Since the utilized H_2 should preferably be generated sustainably, e.g. via electrolysis, the correlated production costs of CO_2-based products are estimated to be much higher than those of their fossil equivalents. Hence, it is essential to optimize not only H_2-production technologies but also the subsequent process chains to maximize overall H_2-efficiency. This goal then leads to the necessity to modify established industrial processes so that any arising H_2-rich waste gas streams that are currently only thermally exploited may be used for chemical syntheses instead.

One example of an industrial process, which releases a H_2-rich flue gas, is the silver catalyzed oxidative dehydrogenation of methanol (CH_3OH) for the production of formaldehyde (CH_2O). Considering that the manufacture of CH_3OH itself requires a large amount of H_2, especially when CO_2 is deployed as carbon source, it is reasonable to recycle H_2 that is released during CH_2O production to the preceding CH_3OH synthesis.

This study therefore focuses on the concept of the directly coupled production of CH_3OH and CH_2O based on CO_2. The direct connection of the two processes is realized by returning the waste gas of CH_2O production to the feed stream of CH_3OH manufacture. For that purpose, the silver catalyst process has to be modified, so that the N_2 introduced to the system along with atmospheric O_2 is eliminated and cannot accumulate. Thus, it is suggested to substitute N_2 with CO_2, which can easily be fed to the input stream of CH_3OH production together with H_2. This is of particular interest when considering the CO_2-based synthesis route. The schematic flow diagram of the directly coupled processes is shown in Fig.1.

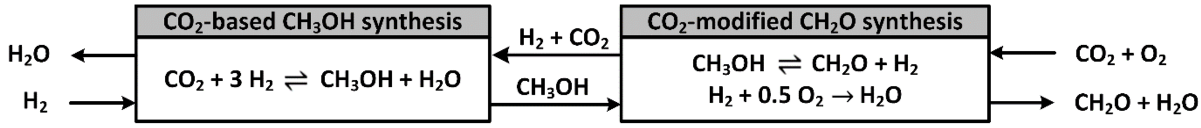

Fig.1: Schematic flow diagram of the directly coupled production of CH_3OH and CH_2O.

In a detailed evaluation of the concept it is shown that directly coupling the manufacture of CH_3OH and CH_2O does not only lead to an increase in overall H_2-efficiency and CO_2 conversion but also results in a reduction of the related CO_2 abatement costs of the process chain. In addition, experimental investigations of the modified silver catalyst process will be discussed.