Novel technologies for chemical hydrogen storage with carbon dioxide

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Highlights

- Methane and methanol are potential products to make use of CO_2 for hydrogen storage
- MgO-supported Ni catalysts exhibit outstanding bifunctional properties for methane formation
- Chemisorption of CO_2 on MgO is an obstacle for methanol synthesis with Cu/MgO catalysts

1. Introduction

The reduction of global CO_2 emissions and the production of renewable energy sources are among the greatest (process engineering) challenges of our time. With a capacity of about two billion metric tons of iron per year and specific CO_2 emissions of two metric tons of CO_2 per metric to of pig iron the iron and steel industry is a major contributor to global CO_2 emissions. Based on siderite ore direct reduction of $FeCO_3$ to elemental iron with hydrogen, releasing highly concentrated CO_2 off-gas has proven applicable. To get CO_2 emissions by CCU under control conversion to marketable products is necessary when intending to make use of CO_2 for hydrogen storage. Two substances play a key role in this context: Methane and methanol. The catalytic hydrogenation of CO_2 to both methane and methanol combines these two still challenging tasks and offers a solution.

2. Methods

In the literature numerous catalysts are described and used for CO_2 methanation. Our investigations have confirmed that MgO-supported Ni catalysts exhibit outstanding bifunctional properties. The basic support material MgO acts as an excellent CO_2 adsorbent and Ni provides the catalytic sites for hydrogen activation. With this robust catalyst, conversions close to equilibrium conversion at methane selectivities $\geq$ 99 % are achieved.

3. Results and discussion

While carbonate intermediates based on the chemisorption of CO_2 on MgO are extremely effective for methane formation, this represents an obstacle to methanol formation with MgO-supported Cu catalysts, with the result of limited CO_2 conversion and low methanol selectivities. Thermal pretreatment of MgO controls the CO_2 adsorption properties. Our group has compared the methanol yield and the methane yield for MgO pretreated at T = 500 °C (highly caustic MgO) with MgO pretreated at 1000 °C and 1300 °C (nearly dead burnt).

4. Conclusions

As mentioned CO_2 conversion to methane is high for the backbone “caustic MgO” and low for nearly dead burnt MgO, while CO_2 conversion to methanol with a bifunctional Cu/MgO catalyst shows a reverse trend

Keywords

Hydrogen storage, CO_2 hydrogenation, methane, methanol, bifunctional catalysts