Methanol synthesis

Student

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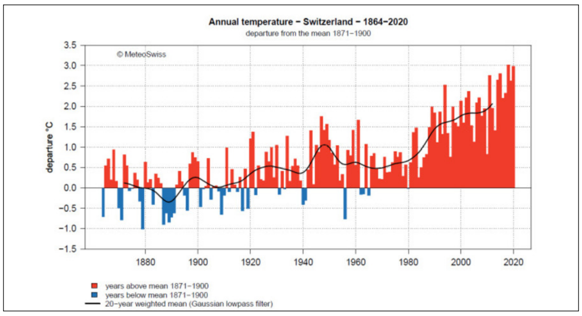
Introduction: The most prevalent topic today in the field of energy and environment is global warming caused by anthropogenic emissions, mainly carbon dioxide. In order to limit the global warming to 2°C or even 1.5°C many countries have agreed to implement necessary actions in the Paris Agreement to reach this goal. It also includes, that global emissions of CO2 must be reduced to net zero by the middle of this century at the latest.

Hence, a new way of energy production without fossil fuels is needed more than ever. In recent years a lot of studies have been conducted, for example the production of electric energy via fuel cells from hydrogen. It is a promising attempt, however, as it is with each technology, it comes with some disadvantages. One problem would be the electric energy needed to produce and store the gaseous hydrogen. Most of the hydrogen is produced using fossil fuels like natural gas, making the overall process an even less effective measure against global warming.

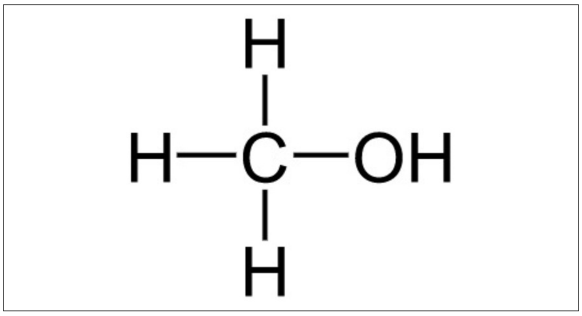
Initial Situation: A new type of fuel, methanol, has been proposed in more recent studies. Compared to hydrogen methanol is liquid under standard conditions. It also has a higher energy density than hydrogen. This results in less storage energy for the same quantity of energy with methanol compared to hydrogen, which either needs to be stored cryogenically or under high pressures of about 350 to 700 bar. However, other kind of problems arise in the production of methanol. State of the art production requires high pressure (min. 50 to 100 bar) and elevated temperatures, as well as steam reforming and CO hydogenation, making it even more energy-intensive.

Approach / Technology: This new approach works with just atmospheric pressure and lower temperatures. Another advantage is that this process can be applied to biogas, which is a mixture of methane and carbon dioxide, and is simpler compared to the conventional direct conversion of methane to methanol which requires the use of molecular oxygen. Additionally, any CO2 formed in the process can be upcycled, making this process carbon neutral (CO2 emitted by providing the necessary heat is neglected here). Zeolite materials containing copper cations have been shown in the literature as being active for the direct conversion of methane to methanol and they were synthesized in this work through an aqueous cation-exchange. The synthesized materials were then screened for methanol production at atmospheric pressure and isothermally with temperatures ranging from 200-350°C. The results indicated that the materials were active for methanol production with the temperature playing a key role in the yield. The highest methanol yield (61 micromols/gram) was obtained at the higher temperature (350°C). CO2 and CO were also identified as reaction products, indicating that methane overoxidation reaction is occurring. This newly stablished approach shows to be promising since no temperature or pressure swing are required being energetically and economically advantageous. In addition, there is no need of molecular oxygen in this process which allows a potential continuous methanol production, a novelty in the field.

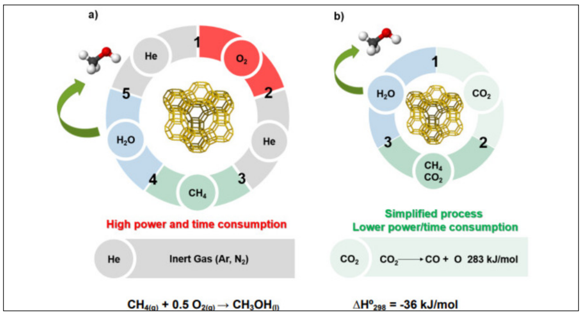
This chart displays the mean temperature of each year in Switzerland since 1864.
Switzerland's Long-Term Climate Strategy, Federal Council



Chemical structure formula for methanol.
https://en.wikipedia.org/wiki/File:Methanol_Lewis.svg



a) The conventional methane-to-methanol catalysis. b) New proposed approach of methane-to-methanol catalysis.
Direct biogas upgrade to methanol, St. Mizuno and A. Heel



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Subject Area
Energy and Environment