Master thesis: Ru-ZrO_2 aerogels for CO_2 methanation with green H_2

Abstract:

Green energy carriers are pivotal to break our dependence on fossil fuels and enable the energy transition. One potential pathway to boost the success of wind and solar energy is to produce H_2 when energy is abundant and store it for later use. But H_2 is difficult to store and transport due to its low volumetric energy density and the necessity of large, pressurized containers. Carbon capture and utilization may alleviate this problem by utilizing CO_2 from flue gases (e.g. from waste incineration plants) and reducing it with green H_2 to produce methane gas. Methane is a major component of natural gas, and our industries are well adapted to transport, store and use this energy carrier. Highly active heterogenous catalysts are needed to make CO_2 reduction a viable, cost-effective process. To this end we produce transition metal oxide nanoparticles, gel them and supercritically dry them to form ultra-high surface area, open porous catalyst supports. Other catalytically active metals can be co-gelled to achieve the wanted activities and selectivities. These catalysts can then be tested in a custom-built fixed bed reactor that allows for the introduction of light as an additional driving force rather than just heat.

Figure 1 TiO_2-Ni aerogel granules

Aims:

Synthesize crystalline, nanometric ZrO_2 nanoparticles. Refunctionalize them with an adequate ligand to enable good water dispersibility. Introduce Ru and/or Ni as nanoparticles or metal salts and co-gel them to form wet gels. Further process them into aerogels and elucidate methods to remove residual organics. Finally, assess the catalytic performance for CO_2 methanation using our reactor.

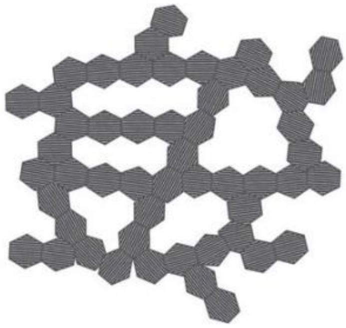

Figure 2 Nanoparticles assembled into a porous gel

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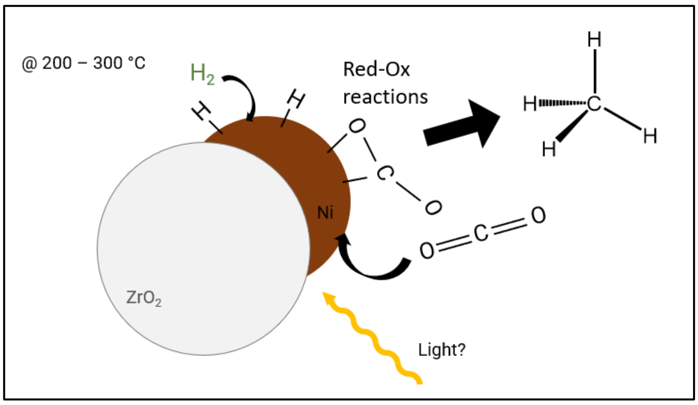

Figure 3 Catalytic mechanism for CO_2 methanation with H_2