

CO₂ Hydrogenation

CO₂ capturing and utilization technologies have the potential of decreasing the CO₂ emissions that cause climate change. Utilization of CO₂ also allows to directly recycle the CO₂ produced in the industry to make the process carbon neutral and to produce value-added products (fuels and chemicals). Methanol is an excellent product for CO₂ utilization, since it is already produced world-wide in large scales to be used as a fuel and a solvent.

CO₂ hydrogenation is an excellent candidate technology to convert captured, or recycled CO₂ into methanol. This technology is currently used in the industry to convert a CO rich mixture of CO₂/CO/H₂ into methanol. The most important component of this technology is the catalyst, which has already been optimized for the specific CO rich CO₂/CO/H₂ mixtures available in industrial processes. For captured or recycled CO₂ utilization, more CO₂ is expected in the feedstock mixture and a new catalyst optimization needs to be carried out.

Challenges

One of the main challenges in catalyst research is catalyst deactivation, which is more prominent when more CO₂ is present in the feedstock mixture. CO₂ catalysts for CO₂ hydrogenation are complex nanostructures with at least 2 elements mixed in the nanoscale. In order to study and optimize catalysts for CO₂ utilization, catalytic properties of complex alloyed catalysts need to be screened efficiently.

Solution

The nanoparticle generator (VSP-G1) of VSPARTICLE can produce a nanoscale mixture of transition metals and alloys of virtually any composition. This opens up the possibility to optimize the screening for composition-dependent catalytic properties. The operation of the G1 is at ambient temperature and pressures, which allows a quick exchange of target materials. Some of the complex catalytically active sites that can be engineered with VSPARTICLE tools are illustrated below.

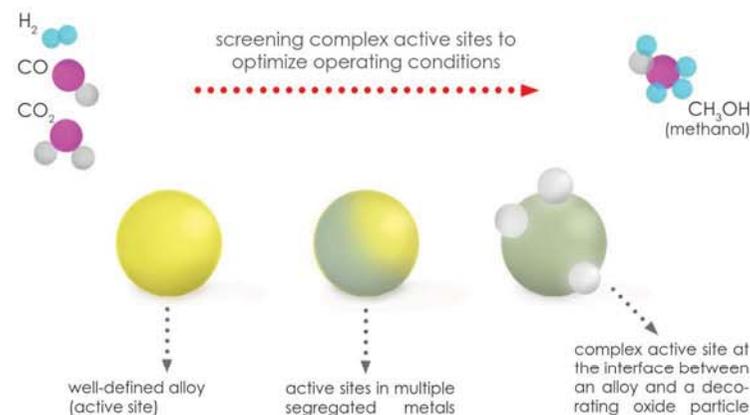
Example experiment setup

Set-up for alloy nanoparticles decorated with single size oxide particles.



In this example set-up, alloyed nanoparticles are produced by the VSP-G1, while single size oxide particles (e.g., In₂O₃) are produced in the VSP-S1. The alloyed and the single size oxide particles are then mixed directly in the gas phase and deposited by diffusion. With this set-up any of the complex active sites illustrated below can be obtained and optimized by tuning the size and composition of each nanoscale component.

Engineering complex active sites with VSPARTICLE tools



TECHNICAL INPUT

Particle Source	VSP-G1 & VSP-S1
Deposition Method	Diffusion
Deposition System	S1
Deposition Parameters	N/A
Sample	SiO ₂ support for fix bed reactors
Material	Transition metals
Application	CO ₂ Hydrogenation
Analysis technique	TEM