Technology Offer

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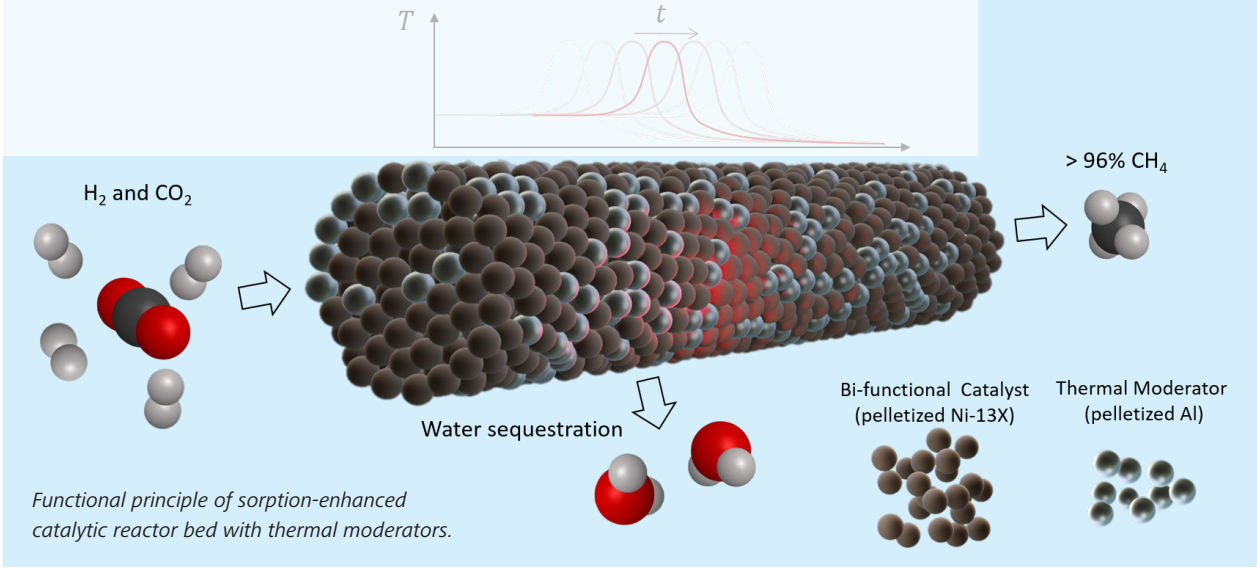
Empa
Materials Science and Technology

Efficient methanation process



Functional principle of sorption-enhanced catalytic reactor bed with thermal moderators.

Highlights

- **Synthesis of natural gas grade methane (> 96% purity)**
- **High CO_2 conversion (> 99.97% in single pass)**
- **Load-flexible reactors and processes (load capability below 10% of design load and fluctuating feed supply)**
- **Heat from catalytic reaction stored in moderator for water desorption step**
- **Applications in sustainable fuels, long distance hydrogen transport and storage, CO_2 capturing**

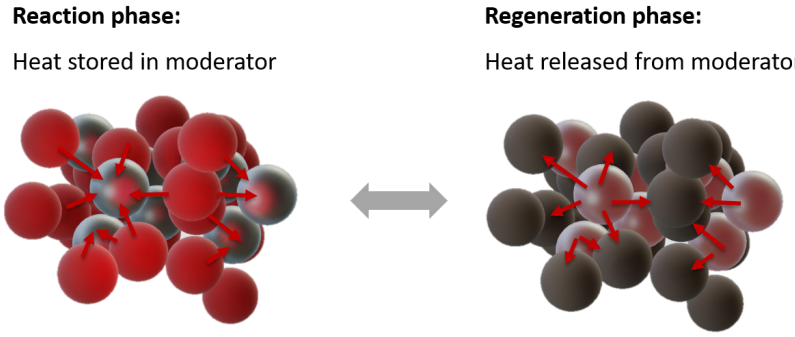
Background

Synthetic energy carriers are expected to be one major vehicle for seasonal energy storage and transport of energy from sunbelt regions to Europe. Methane synthesized from CO_2 and hydrogen plays a key role due to existing infrastructure and drop-in capability for substitution of fossil natural gas.

Catalytic reactors for CO_2 methanation are challenged by the exothermic nature of the reaction and limited conversion. Storage and transport of synthetic methane, especially in existing infrastructure, requires relatively high gas purity. This is generally achieved via several reactor stages and downstream processing. The catalytic reactors themselves show a limited load flexibility due to unstable operation, especially for load-intensified systems. This challenges small and medium-scale setups coupled to renewable energies and fluctuating resource supply.

Advantages

With our invention, scalable reactors for sorption-enhanced catalysis, especially for CO_2 methanation, can be realized. The catalyst and reactor concept allows for high load- and part-load-flexibility and is therefore predestined in application with fluctuating renewable energy especially in small and medium-sized plants. With the sorption-enhancement, realized by the catalyst substructure, extremely high reactant conversion is achieved, which directly converts into high energy efficiency of the overall process. The thermal moderator, integrated in the catalyst bed, lowers the maximal temperature, supports the process and protects the catalyst from degradation.



Heat management during reaction and catalyst regeneration.

Heat released during the reaction phase is stored in the thermal moderator and released during the regeneration phase. This way, excellent gas phase heat transfer is achieved in the catalyst bed and heat is stored directly where required for the desorption. The amount of moderator used can be adjusted to the local requirements in the catalyst bed to maximize the reactor capacity and to limit its local temperature increase.

Applications

The combined catalyst, reactor, and process concept opens new perspectives in reactor and process design for synthesis of renewable energy carriers. High reactand conversion eliminates the need for downstream processing and leads to high overall process efficiency. Through excellent start-up behavior and very low part-load capability, the concept excels in production of renewable energy carriers. This can be in combination with PEM electrolysis for H_2 production relying on minimized hydrogen storage, CO_2 from different sources or direct air capture as well as for direct biogas upgrade.

Ownership

Patent application filed, Owner: Empa, Swiss Federal Laboratories for Materials Science and Technology, Überlandstrasse 129, CH-8600 Dübendorf

References

Florian Kiefer, Marin Nikolic, Andreas Borgschulte, Panayotis Dimopoulos Eggenschwiler, 2022.
Sorption-enhanced methane synthesis in fixed-bed reactors. Chemical Engineering Journal 449, 137872.
https://doi.org/10.1016/j.cej.2022.137872

Keywords

Sorption-enhanced catalysis, CO_2 hydrogenation,
load-flexible process, renewable energy integration

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