Carbon Capture and Use: Potential for Climate Change Mitigation and Challenge for Catalysis Chemistry

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Mitigation of the greenhouse effect requires a transition from the current fossil energy system to a system in which solar energy as primary energy source is used as direct electricity and likewise for indirect electrification via chemical energy conversion of water[1] into hydrogen and derivatives. This approach allows utilization the high efficiency of local solar energy harvesting combined with compensation for volatility and insufficient supply via a global market for energy carriers with a low carbon footprint.

Estimates predict a use of hydrogen on the order of 1 Gt/a globally, of which the vast majority needs to be shipped and a smaller contingent can be transmitted by pipeline transport. Derivatives can either be used after reconversion as hydrogen (ammonia cracking) or may serve as solar fuels. Besides ammonia, carbon-based fuels will play a substantial role in such an energy system. They can be considered as chemical batteries[2] in analogy to electrochemical batteries. Sustainability can only be achieved if the finally emitted CO_2 will be collected by biological or physical methods and re-circulated for the production of solar fuels or dumped as solid carbon.

The presentation reveals challenges in such a concept associated with CO_2 capture for catalytic conversion, with the synthesis of methanol from CO_2 via several methods and critical research questions that need answers for such systemic designs. The pertinent question of efficiency arguments will be discussed in terms of system efficiency vs process efficiency.

1. Nong, H.N., et al., *Key role of chemistry versus bias in electrocatalytic oxygen evolution.* Nature, 2020. **587**(7834): p. 408+.
2. Schlögl, R., *Chemische Batterien mit CO_2.* Angew. Chem. Int. Ed., 2021. **60**: p. 2-25.