Chemical Energy Storage

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Mankind has underestimated the lever it has in changing the biogeochemical state of the planet earth by emitting greenhouse gasses. We are in a position where the state of the planet is about to change into a condition that may be detrimental for mankind. It is thus extremely urgent to minimize the emission of greenhouse gasses in a global dimension. This can be achieved if the existing world market of fossil energy is replaced by a world market of renewable energies. Even so it is a challenging task and requires rebuilding the largest industry on earth within one generation.

The primary source of renewable energy is electricity that can locally be used with better efficiency than fossil energy carriers. But it cannot be stored and transported (traded) in grid dimensions. Future energy systems need a dual approach using green electrons and green molecules as energy carriers. Hydrogen is the primary molecular source. It needs transformation into transportable derivatives that may also be used as fuels. The central challenge of renewable primary electricity -its intermittency- can thus be overcome by using electrical or chemical batteries[1] allowing short-term and long-term storage respectively.

Catalysis as electrocatalysis and as interfaces for gas phase transformations are consequently the enabling processes operated at the scale of the global energy system. Although all essential process for chemical energy conversion (CEC) do exist as mature technologies they still show substantial deficiencies. One is the sector-coupled systemic interconnection (dynamical operation, feed gas purification), others are production processes for the infrastructure (electrolysers) and it is unclear what the fundamental limitations are driving the processes at thermodynamic limits under optimized conditions. Catalyst design educated by functional understanding and modernized digital tools based upon clean experimental data is a critical scientific contribution to energy science. Likewise, cutting-edge chemical engineering bridged to catalyst material science through computational catalysis science is another critical element.

The presentation links a systemic view[2] on the dimension of energy transformation to examples of where we stand in the functional understanding of important catalytic systems namely MeOH synthesis and ammonia synthesis/ reforming. Research should clearly discriminate between novel approaches that are needed for future generations of CEC processes and contributions to establish the first generation of CEC that is highly time-critical and thus needs focussed efforts translating verified fundamental knowledge into technology relevant transfers.

1. Schlogl, R., *Chemical Batteries with CO2.* Angewandte Chemie-International Edition, 2022. **61**(7).
2. Schlögl, R., *Put the Sun in the Tank: Future Developments in Sustainable Energy Systems.* Angew. Chem. Int. Ed., 2019. **58**(1): p. 343-348.