Renewable Energy Storage in Hydrides and Hydrocarbons

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The first publication of the global warming due to the increase of the CO_2 concentration in the atmosphere by Svante Arrhenius in 1896 in the Philosophical Magazine was doubted and ignored for almost 100 years. Only at the end of the last century the global consequences of the anthropic CO_2 emission became a major concern and science and technology focused on the conversion of renewable energy (solar, wind, hydro) in order to reduce the dependency on fossil fuels and reduce the emission of CO_2. However, the recent development in installed peak power of wind generators and photovoltaics clearly indicates that storage of energy from renewable sources is the greatest challenge of the coming 10 years. Thereby the production of fuels for mobility and the long term (seasonal storage) of renewable energy are the key technologies, because mobility requires a high gravimetric and volumetric energy density (10 $kWh \cdot kg^{-1}$, 10 $MWh \cdot m^{-3}$) and the storage of large amounts of energy requires an economic energy carrier like fossil oil (few cents per kWh).
The technical solution is to produce hydrogen from renewable electricity. Hydrogen production by electrolysis is an established technology also currently we are facing a lack of large scale electrolysers available. The storage of hydrogen under high pressure, in liquid form or in hydrides is a material challenge and limited to 50% of the energy density of liquid hydrocarbons. The hydrogen can be used to reduce CO_2 from the atmosphere in order to synthesize liquid hydrocarbons. This requires large scale electrolyzers, hydrogen storage, adsorption of CO_2 and finally a well controlled reaction of H_2 and CO_2 to a specific product, e.g. octane. The storage of liquid hydrocarbons is an established technology.

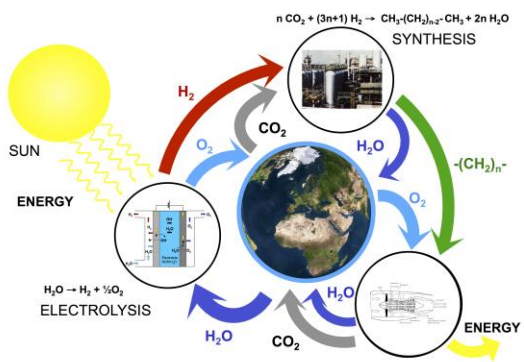

Fig. Schematic representation of the closed materials cycle, where hydrogen is produced from renewable energy and used together with CO_2 from the atmosphere to synthesize hydrocarbons as CO_2 neutral energy carriers.

Hugh progress was made in the development of new hydrogen storage systems in the last 20 years and the gravimetric hydrogen density was increased by an order of magnitude in hydrides. However, based on todays physical and chemical knowledge we will not be able to double the hydrogen density in materials anymore. The only solution in order to provide the energy density comparable to fossil fuels at a low cost is to close the carbon cycle and to develop chemical and electrochemical processes in order to synthesis liquid hydrocarbons from renewable electricity, hydrogen and CO_2 from the atmosphere.

Biography

Born 22. 8. **1963** in Bern, Switzerland. **1985** Engineering Degree in Chemistry, Burgdorf, Switzerland. **1990** Diploma in Physics from the Unversity of Fribourg (UniFR), Switzerland. **1993** Dr. rer. nat. from the science faculty UniFR. **1994** Post Doc with AT&T Bell Labs in Murray Hill, New Jersey, USA. **1997** Lecturer at the Physics Department UniFR. **2003** External professor at the Vrije Universiteit Amsterdam, Netherlands. **2004** Habilitation in experimental physics at the science faculty UniFR. President of the Swiss Hydrogen Association „HYDROPOLE". **2006** Head of the section "Hydrogen & Energy" at EMPA and Prof. tit. in the Physics department UniFR. **2009** Guest Professor at IMR, Tohoku University in Sendai, Japan. **2012** Visiting Professor at Delft Technical University, The Netherlands, **2014** Full Professor for Physical Chemsitry, Institut des Sciences et Ingénierie Chimiques, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland