Solar sulphur – chemical commodity and carbon-free fuel for baseload power generation

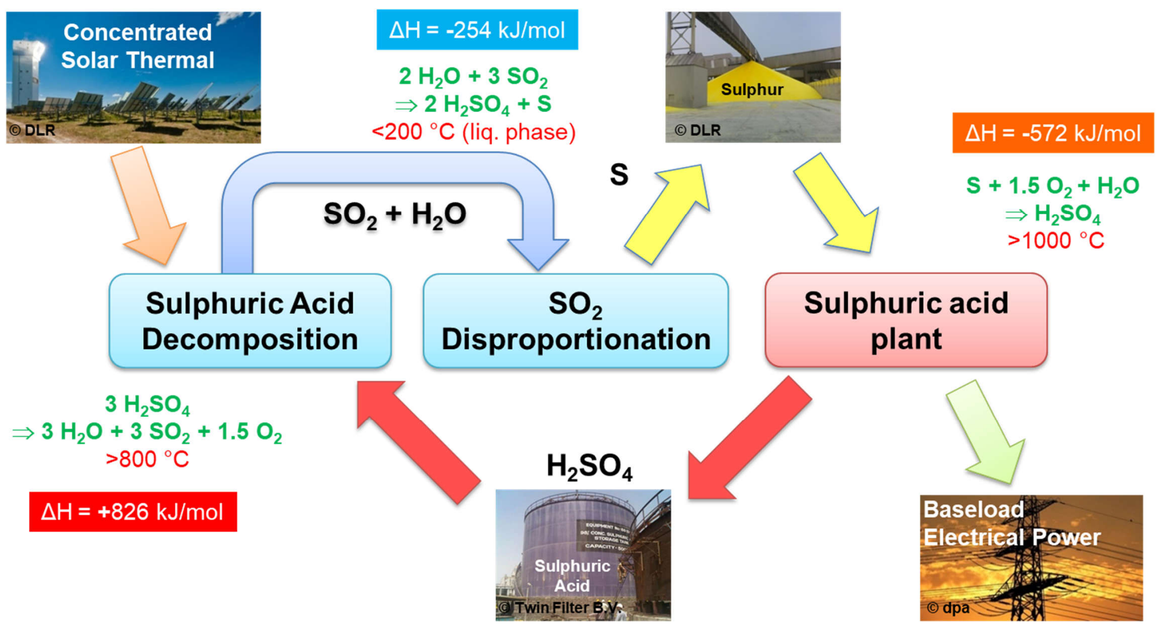
Dennis Thomey*, Krishna Thanda, Andreas Rosenstiel, Christos Agrafiotis, Martin Roeb, Christian Sattler

DLR German Aerospace Center, Institute of Solar Research, Linder Höhe, 51147 Köln, Germany
*dennis.thomey@dlr.de

Introduction

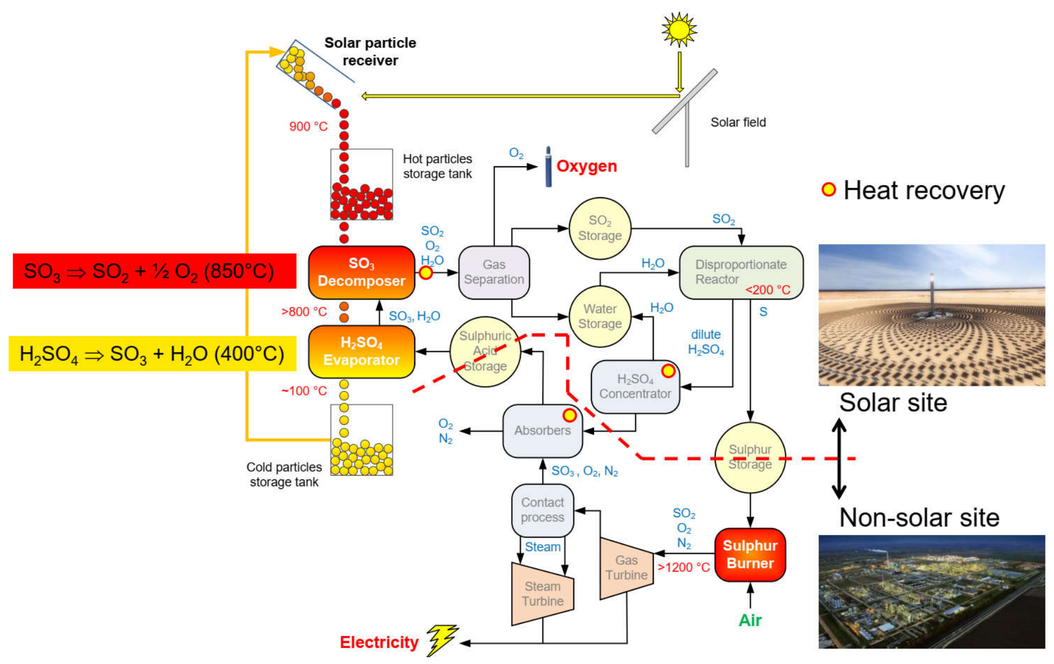
- **Concentrated solar power (CSP) plants** with molten salt storage system are state-of-the-art and commercially established; they can be operated nearly continuously producing on-demand electricity at suitable solar sites
- **Thermochemical energy storage** allows for complete **independency of diurnal and seasonal fluctuation of solar radiation**
- Elemental **sulphur** is promising energy storage medium with **specific energy density >12 MW/kg which is 30-times higher** than molten salt (1)
- This high energy storage density allows for **long-term storage of solar energy** in the desert and transportation to less sunny regions
- Simple and efficient storage and transportation of sulphur as solid (ambient conditions) in open containers or liquid (140 °C) in tanks/pipelines
- **Combustion of sulphur** in commercial sulphuric acid plants at **temperature >1200 °C suitable also for gas turbines** (2) producing sulphuric acid (global output >200 Mio. tons/year) and **baseload electrical power**

Solar sulphur storage cycle



1) Solar sulphuric acid splitting by concentrated solar thermal energy
2) Disproportionation of SO_2 producing elemental sulphur
3) Sulphur combustion in sulphuric acid plant generating baseload power from excess heat

Process diagram



Solar sulphur process applying solar heated particles for sulphuric acid decomposition and sulphuric acid plant with gas turbine in combined cycle for power generation

Solar particle receiver technology

- Supply of high temperature heat at >900 °C by solar heated bauxite particles
- Successful demonstration of centrifugal particle receiver CentRec® (3) at solar tower in Jülich, Germany

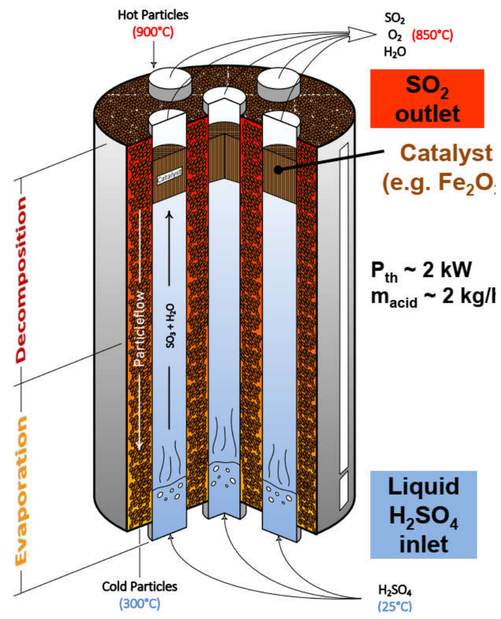
CentRec pilot plant on scaffold infront of solar tower Jülich

CentRec pilot plant during solar operation

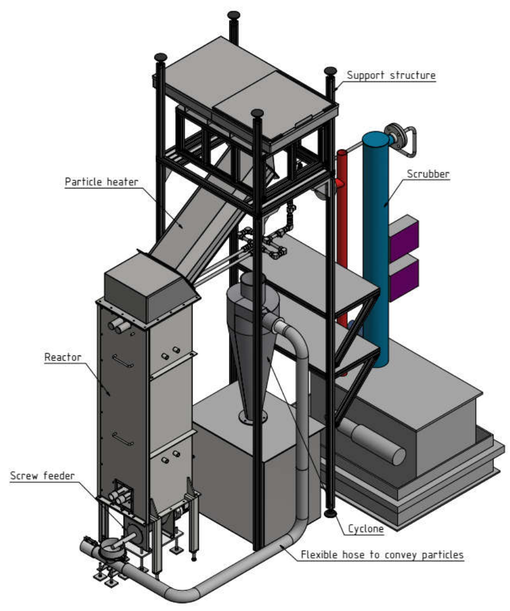
Bauxite particles

Particle reactor for sulphuric acid splitting

- Development of lab scale 2 kW sulphuric acid splitting reactor prototype
- Shell-and-tube design with Fe_2O_3 catalyst on SiC foams inside tubes
- Flow rates: 10 kg/h of bauxite particles (shell side)
  2 kg/h of 75 w% sulphuric acid (inside tubes)
- Electrical particle heater for off-sun operation (4)



Design of particle reactor



CAD model of complete set up

Outlook

- Construction of particle reactor under progress
- Followed by off-sun lab testing
- Subsequent operation in Synlight® solar simulator
- Demo with 300 kW solar particle receiver

synlight

References

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