Solar Steam Reforming with indirect molten salts technology

*International Workshop on Solar Thermochemistry*

14th September 2017, Jülich (Germany)

Alberto Giaconia, PhD
ENEA, Casaccia Research Center, Rome (Italy)
Two different approaches to Solar Reforming:

1) Use an advanced direct «high-temperature solar reformer» to operate under ordinary reaction conditions (> 850°C)

2) Use a modified reforming process at lower temperatures (< 550°C) to operate with ordinary CSP technology (molten salts up to 565°C)

Thermochemical processes can be indirectly powered using «solar salts» (NaNO₃/KNO₃ mixture, 60/40 w/w) as in commercial CSP plants as HTF and storage medium.
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This Solar Steam Reforming process has been first proposed and developed in EU project CoMETHy (2011-2015, FCH JU Grant Agreement No: 279075)

Results have been made available & assessed in the EU project STAGE-STE (FP7 Grant Agreement No: 609837)
Advantages:

- Steady state continuous operation of the chemical plant, 7/24
- Costless materials
- Milder thermal stress (e.g. catalysts, membranes)
- One-step operation (reforming, WGS, purification)
- Lower heat duty to reactor and process integration
- Higher pressures (easier CO$_2$ separation)
- Longer hrs/year operation with solar energy
Challenges

Advanced catalysts for low-temperature steam reforming (NG, biogas, ethanol)

Selective membranes for hydrogen separation

Membrane reformer

Coupling with CSP plants

Reformer design
Catalysts & membranes

- Fuel-flexible catalysts developed for methane (NG or biogas-like mixtures) and bioethanol SR at 400-550°C
- Enhanced heat transfer and low pressure drops
- Developed catalysts proved stable (> 250 hr) with shift activity (outlet CO concentration < 5 %vol.)

- Pd-based composite membranes evaluated and best options identified for the reformer
- Project objectives about permeability (> 10 Nm³/m²/h/bar⁰.⁵) and durability (< 20% selectivity loss over 1,000 hr) met
- Nevertheless, further optimization and qualification required
Bench and pilot scale prototypes

- Integrated membrane reactor prototypes successfully tested and modelled
- The multi-fuel approach successfully proved (feed flexibility for CH\(_4\) and bioethanol)
- Reactors’ stability proved for hundreds operation hours
- Pilot plant successfully tested for CH\(_4\) SR over several hours and conditions
- >60% conversion obtained driving the membrane reformer with molten salts at ca. 550\(^\circ\) C
- up to 3.5 Nm\(^3\)/h H\(_2\) permeate obtained (project target: 2 Nm\(^3\)/h)
- produced H\(_2\) relatively pure (> 99.8 %vol.) with < 100 ppm CO
Thank you for your kind attention!

Alberto Giaconia, PhD
ENEA
Thermal and Thermodynamic Solar Division (DTE-STT)

alberto.giaconia@enea.it