SHERLOHCK

Sustainable and cost-efficient catalyst for hydrogen and energy storage application based on liquid organic hydrogen carriers

European Hydrogen Week

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Clean Hydrogen Partnership

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Project Overview

- Call year: 2020
- Call topic: H 2020-JTI-FCH-2020-1
- Project dates: 01/01/2021-31/12/2023
- % stage of implementation 28/10/2022: 61 %
- Total project budget: 2,5 M€
- Clean Hydrogen Partnership max. contribution: 2,5 M€
- Other financial contribution: 0
- Partners: CEA, France; FAU, Germany, UPV/EHU, Spain, HYDRO LOHC, Germany; Evonik, Germany; KPRT, Netherlands, NWU, South Africa

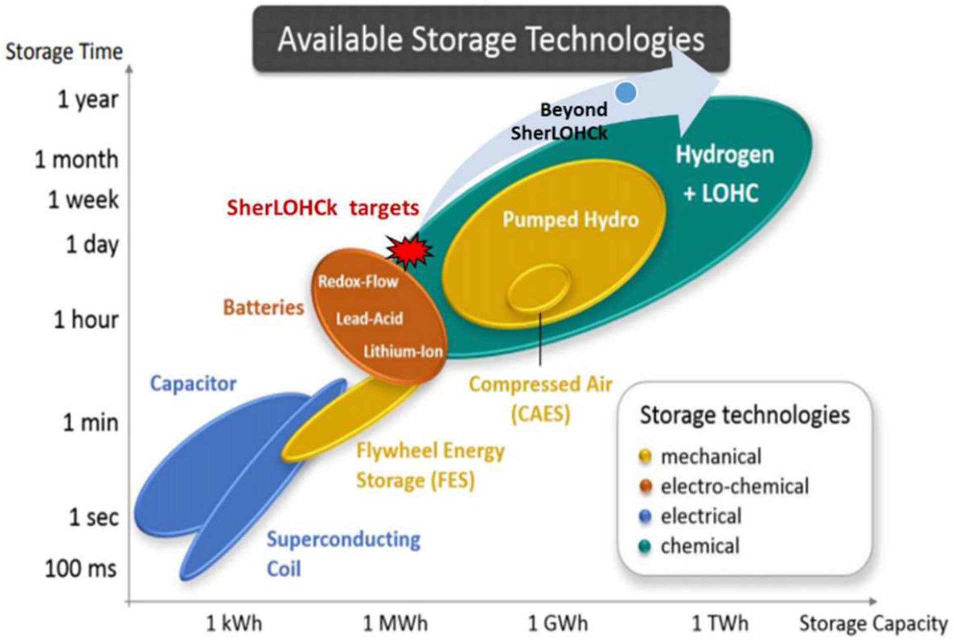
Project Summary

LOHC - liquid organic hydrogen carrier as a solution for storage and transportation

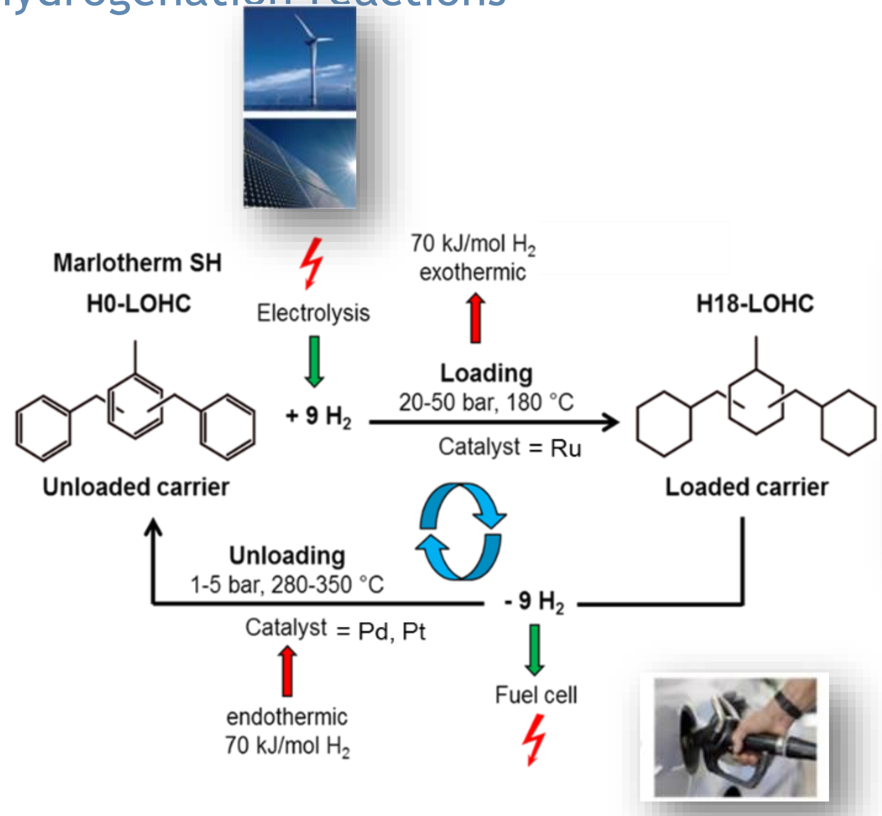
A pair of liquid organic molecules (a H_2-lean and a H_2-rich one) that can be reversibly transformed into each other by catalytic hydrogenation/dehydrogenation reactions

CHIYODA CORPORATION

hydrogenious TECHNOLOGIES



available storage technologies



storage

transport

Project Summary

LOHC – technology

Advantages

-Compatibility with existing liquid fuel infrastructures
-Safety: endothermal dehydrogenation
-Able to store and release H_2 (< 7wt%) (5wt% for GH_2 700 bar)
-Long term energy storage capability
-Proof of concept demonstrated

Drawbacks

- Energy cost in hydrogenation/dehydrogenation
- Need to use PGM for catalyst preparation
- Low thermal exchange in reactor system (hot-spots leading to molecule degradation)

Main Objectives

1. To develop new catalysts with low/no PGM (Platinum Group Metal) content which are active in hydrogenation and dehydrogenation (>3g H2/g cat./min) with a high degree of conversion (>90%) and selectivity (>99.8%).
2. To develop a catalytic system architecture with improved thermal-conductivity properties in order to reduce energy intensity during loading/unloading processes.
3. To evaluate the scale-up and the environmental and economic viability of LOHC technology

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Performances of low PGM catalysts for hydrogenation

Achievement to-date

Conversion > 99.7%
Selectivity > 98.1%

25% 50% 75%

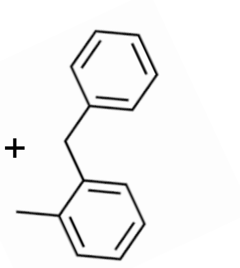
Conversion > 90%
Selectivity > 99.8%

Status at month 20 of a 36 months project at date 28/10/2022

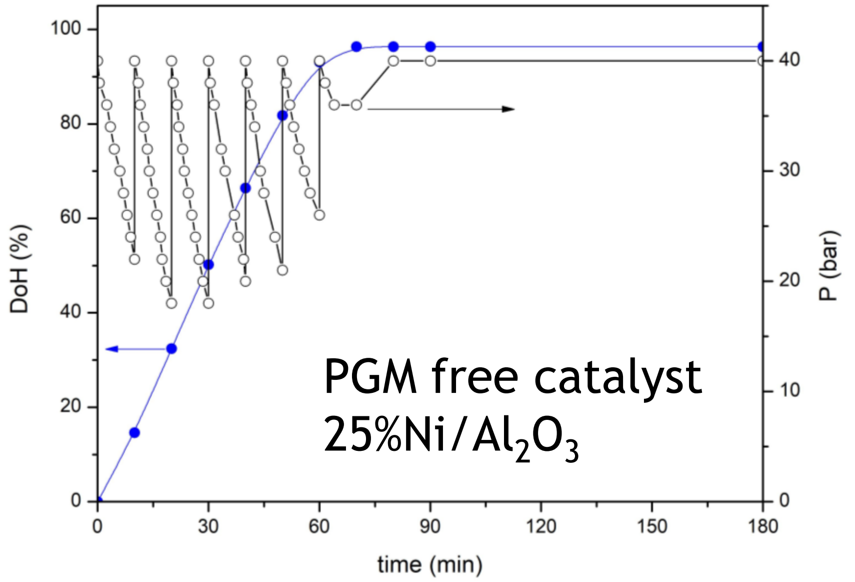
- performed activities :
- developpement of a low and free PGM catalysts for hydrogenation of benzyl-toluene H_0-BT→H_{12}-BT

- problems encountered :
- shaping of catalysts (powder vs. pellets)
- up-scaling of catalyst synthesis

$6H_2$ +



185 °C, p = 40 bar



Performances of low PGM catalysts for dehydrogenation

Achievement to-date

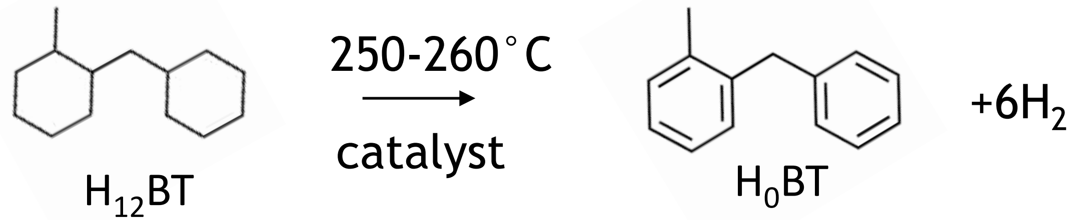
2-5 g H2/g Pt/min
Conversion > 45-77%
Selectivity 90-98%

25% 50% 75%

3-6 g H2/g Pt/min
Conversion > 90%
Selectivity > 99.8%

Status at month 20 of a 36 months project by date 28/10/2022

- performed activities :
  - Catalyst design through DFT (MCH/Toluene)
  - developement of a low PGM catalyst for de hydrogenation of benzyl-toluene H_{12}-BT→ H_0-BT
- problems encountered :
  - DFT design targeted for 'small molecules', not for BT
  - Difficulty in realisation of catalyst compositions predicted by DFT (real alloys vs bimetallic)
  - Shaping of catalysts (powder vs. pellets)



Catalyst	initial productivity g_{H2}/g_{Pt}/min	Conversion % (after 2h)
Commercial (0.3%Pt/Al_2O_3)	*1.9*	*73*
0.3%Pt0.1%Fe0.1%S/Al_2O_3	4.7	45
0.5%Pt0.5%Co/Al_2O_3	2.5	77

Risks, Challenges and Lessons Learned

Description	Strategy
Managerial risks such as problems in coordination, leave of personnel leading to delays, difficulties to achieve project objectives	Continuous monitoring of effort by the Steering Committee (SC) and comparison between achieved and set goals during the whole project.
Problematic application of powder catalysts in lab / demo scale	impregnation of commercial pellet carriers

Exploitation Plan/Expected Impact

Exploitation

- An exploitation roadmap is being drafted to identify, evaluate and assess the positioning of SherLOHCK solution in addressing specific industrial needs in comparison to alternative emerging technological solutions.

1) a SWOT analysis of the SherLOHCk technology considering internal and external factors (eg. performance, scalability, integrability potential, cost for production, time to market assessment);

2) a portfolio analysis of alternative emerging solutions in terms of technology readiness and market attractiveness ;

3) a road-mapping considering key targets and related KPIs, readiness level, barriers and challenges and time related aspects (eg. window of opportunity, hierarchy of actions to be executed).

Impact

Contributing to

- Green transition, by introduction of H_2 technology
- Climate change, by promoting green H_2 uptake
- Energy storage by improving LOHC technology and logistics

Increasing

- Technological competiveness by developing novel processes/materials/concepts
- Dehydrogenation kinetics and maintain high conversion and selectivity
- Energy density higher than 1.6 MWh/m^3

Improving

- Catalyst comprehension for application beyond LOHC (FC, electrolyzers)
- Catalyst compatibility with H_2 from mixed gas streams
- Catalyst stability in dehydrogenation

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