NOVEL HIGH-PERFORMANCE BATCH MINI REACTOR FOR HYDROGEN PRODUCTION FROM CATALYTIC HYDROLYSIS OF SODIUM BOROHYDRIDE FOR PORTABLE APPLICATIONS.

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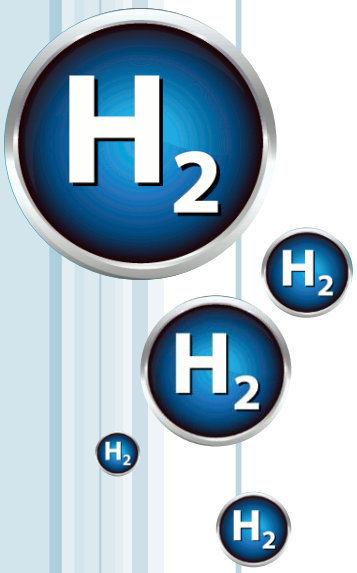

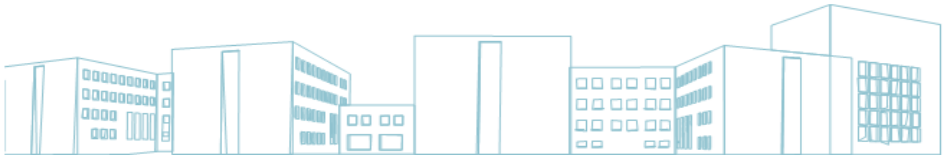

HydrogenDays 2015

March 19th

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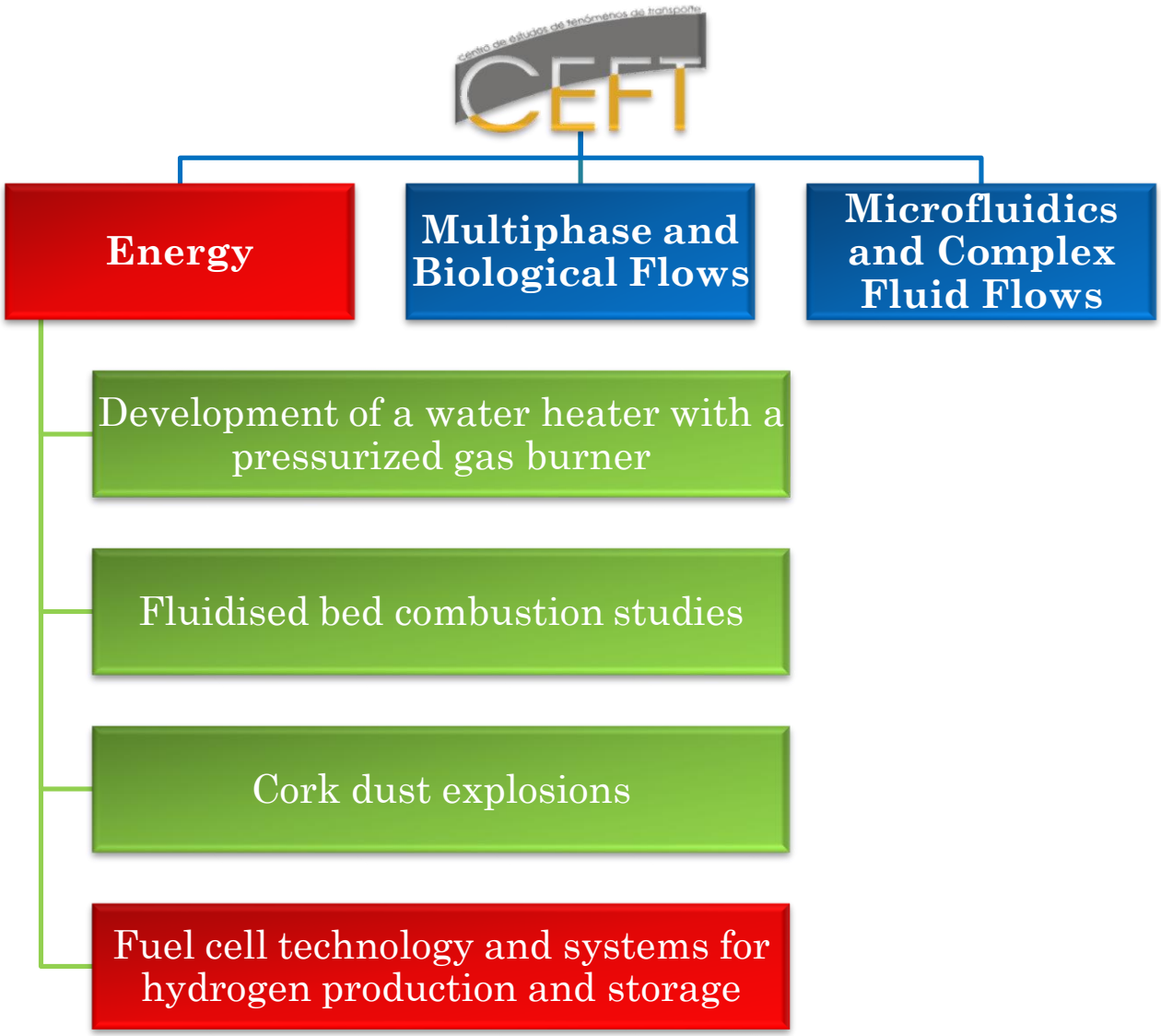
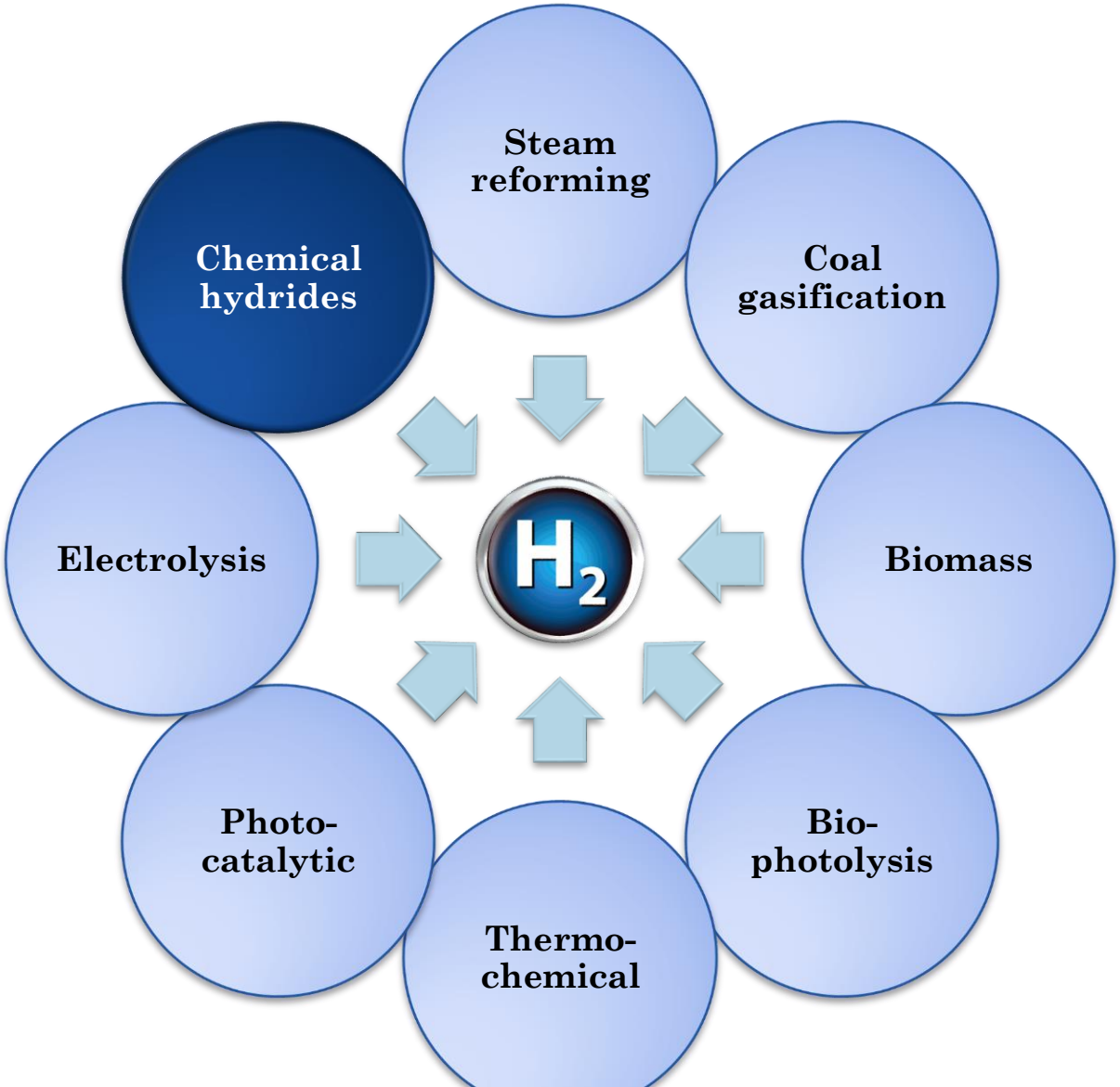
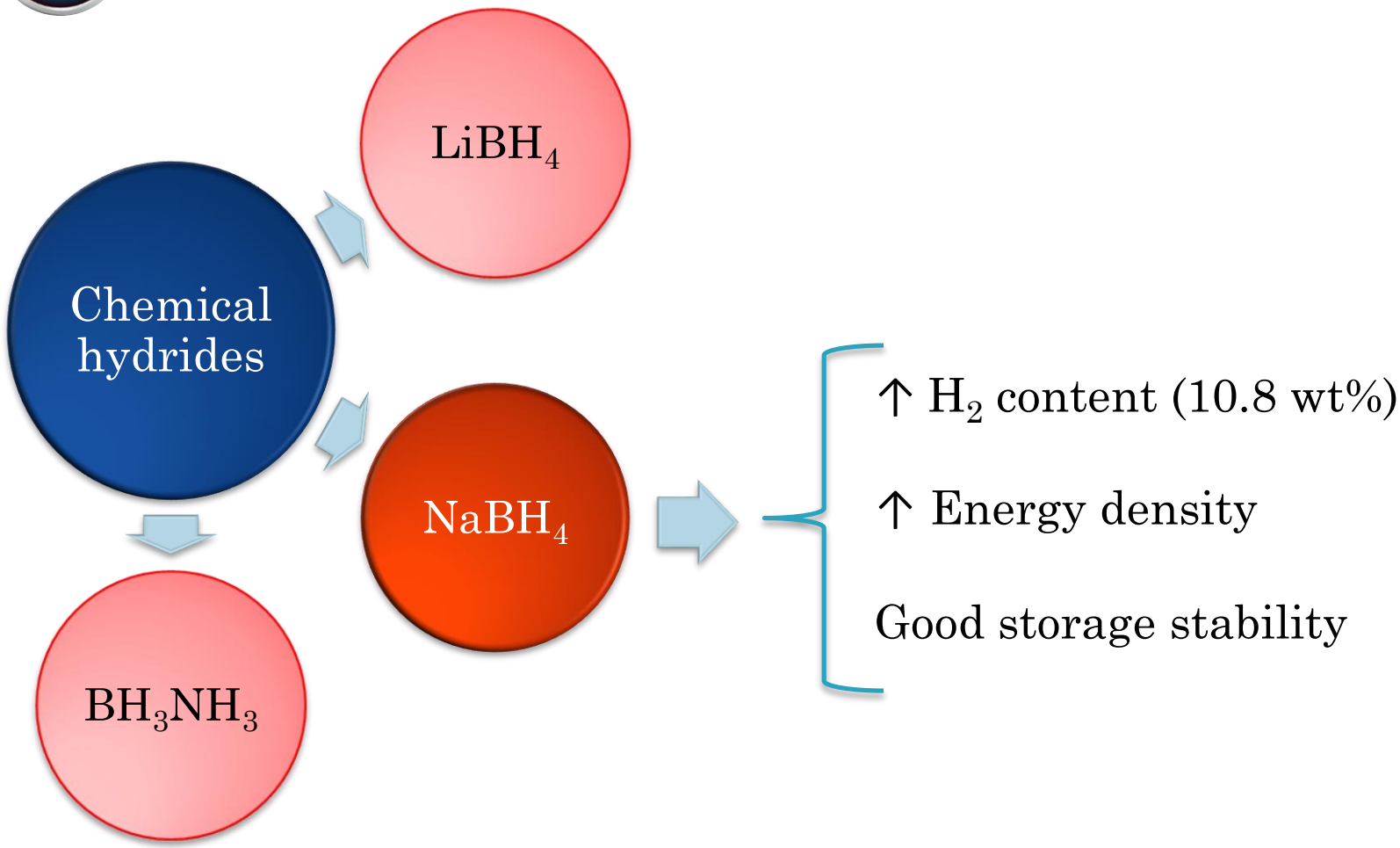
About CEFT


CEFT
Energy
Multiphase and Biological Flows
Microfluidics and Complex Fluid Flows
Development of a water heater with a pressurized gas burner
Fluidised bed combustion studies
Cork dust explosions
Fuel cell technology and systems for hydrogen production and storage

HYDROGEN PRODUCTION



Hydrogen production



Hydrogen production

$NaBH_4$ hydrolysis reaction:

$$NaBH_4 + (2+x)H_2O \xrightarrow{\text{catalyst}} 4H_2 + NaBO_2 \cdot xH_2O + \text{heat}$$

- Hydration factor
- Ideal hydrolysis ($x = 0$)

- Exothermic reaction
- -210 kJ mol^{-1}

- Suitable catalyst
- Induces rapid H_2 production

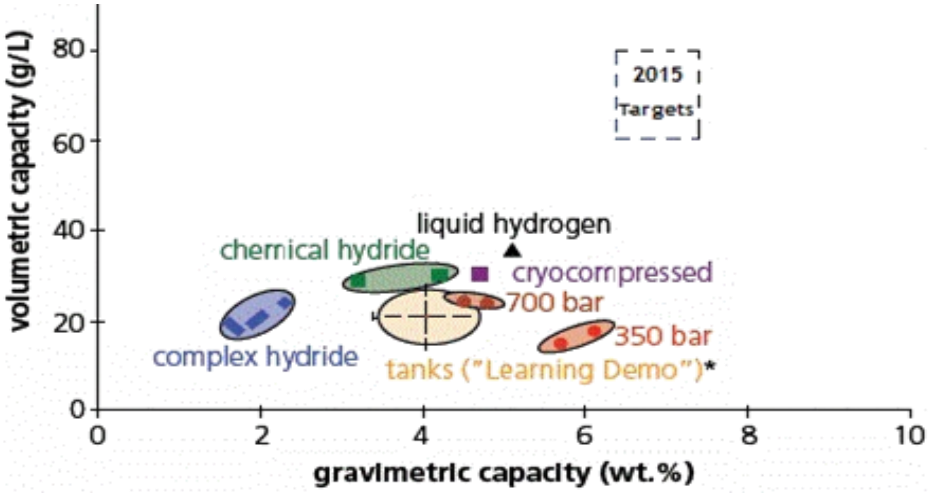
- Sodium borate
- Can be recycled to $NaBH_4$

1940 - 1970	1970 - 2000	2000 - now
Discovery and first interest as H_2 generation and storage material	**No interest as H_2 generation and storage material anymore**	**New interest**

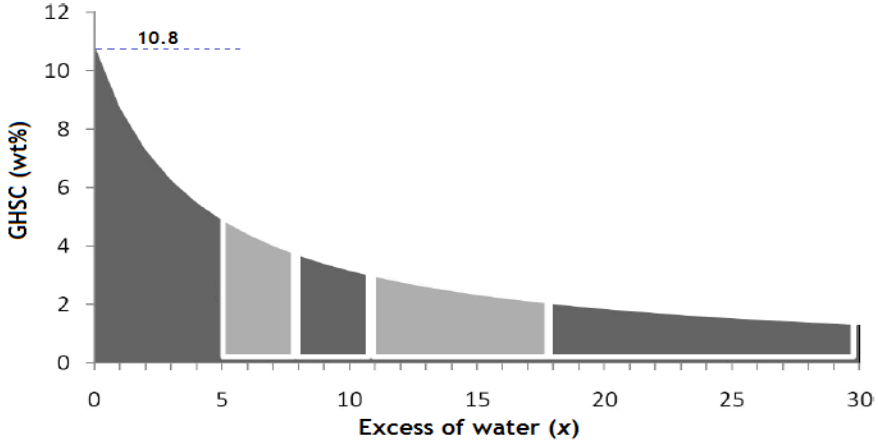
* Schlesinger *et al.* (1953)

*S.C. Amendola *et al.* (2000)

U.S. DOE TARGETS



Source: http://www1.eere.energy.gov/hydrogenandfuelcells/storage/tech_status.html

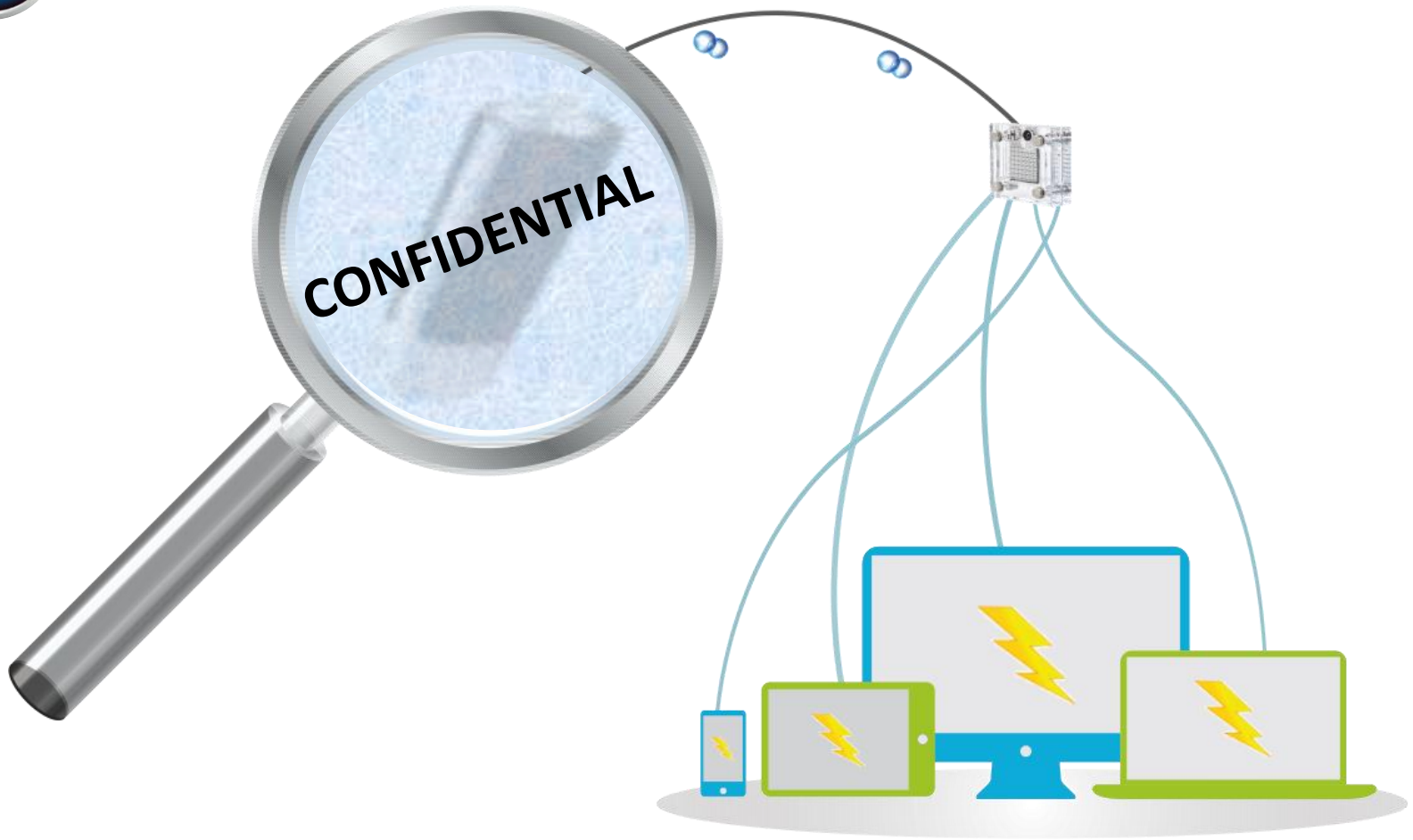


Source: U. B. Demirci *et al.*, "Sodium Borohydride Hydrolysis as Hydrogen Generator: Issues, State of the Art and Applicability Upstream from a Fuel Cell," *Fuel Cells, vol. 10, no. 3, pp. 335–350, Jun. 2010.*

Hydrogen: chicken and egg problem

?

Energy vector for portable applications



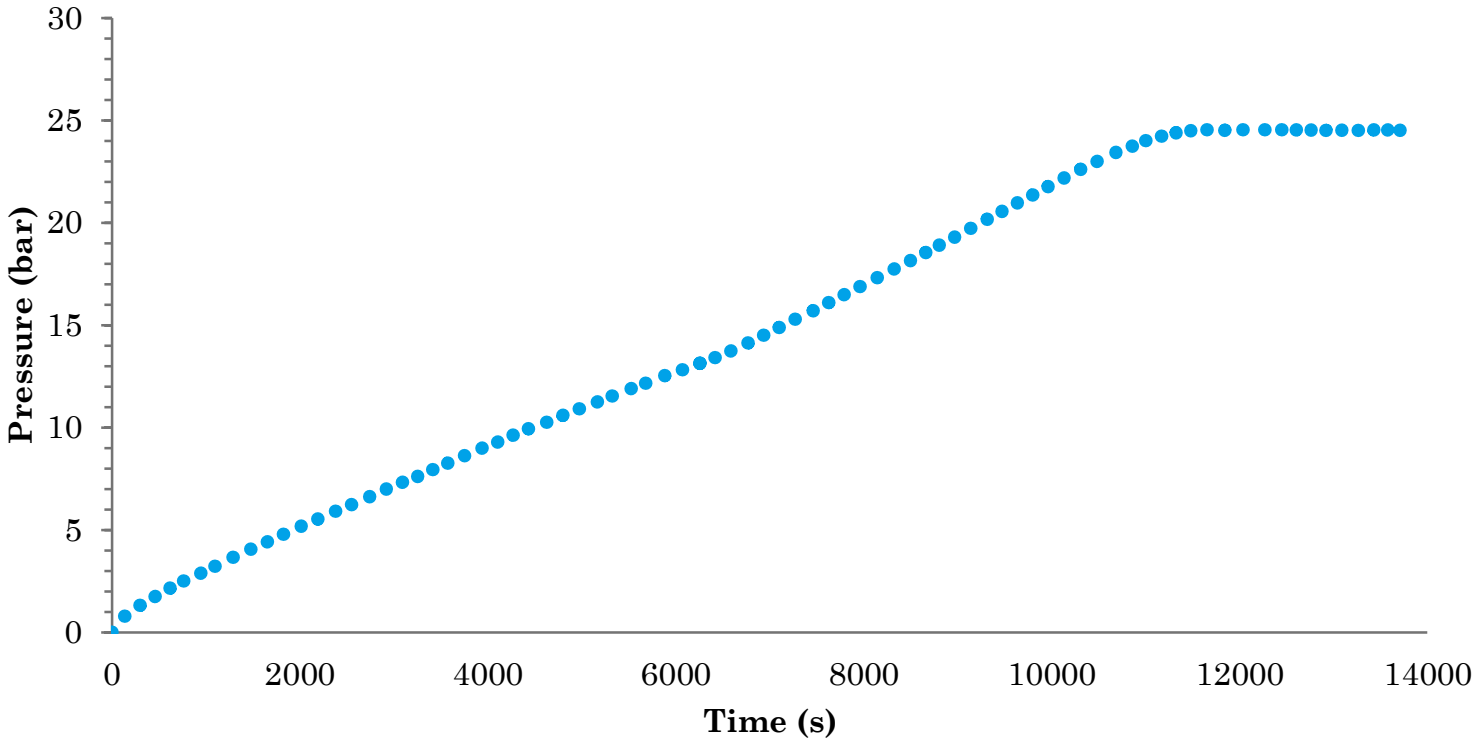
- Volume ≈ 9 cm^3
- Material: AISI 316L stainless steel
- Thickness: 5 mm
- Central ring thickness: 12 mm

Energy vector for portable applications

MOVIE:
"Hydrogen generation by catalytic hydrolysis of $NaBH_4$ for portable H_2-PEMFC application on a mini reactor with an optimized geometry – How it works"

Results and discussion

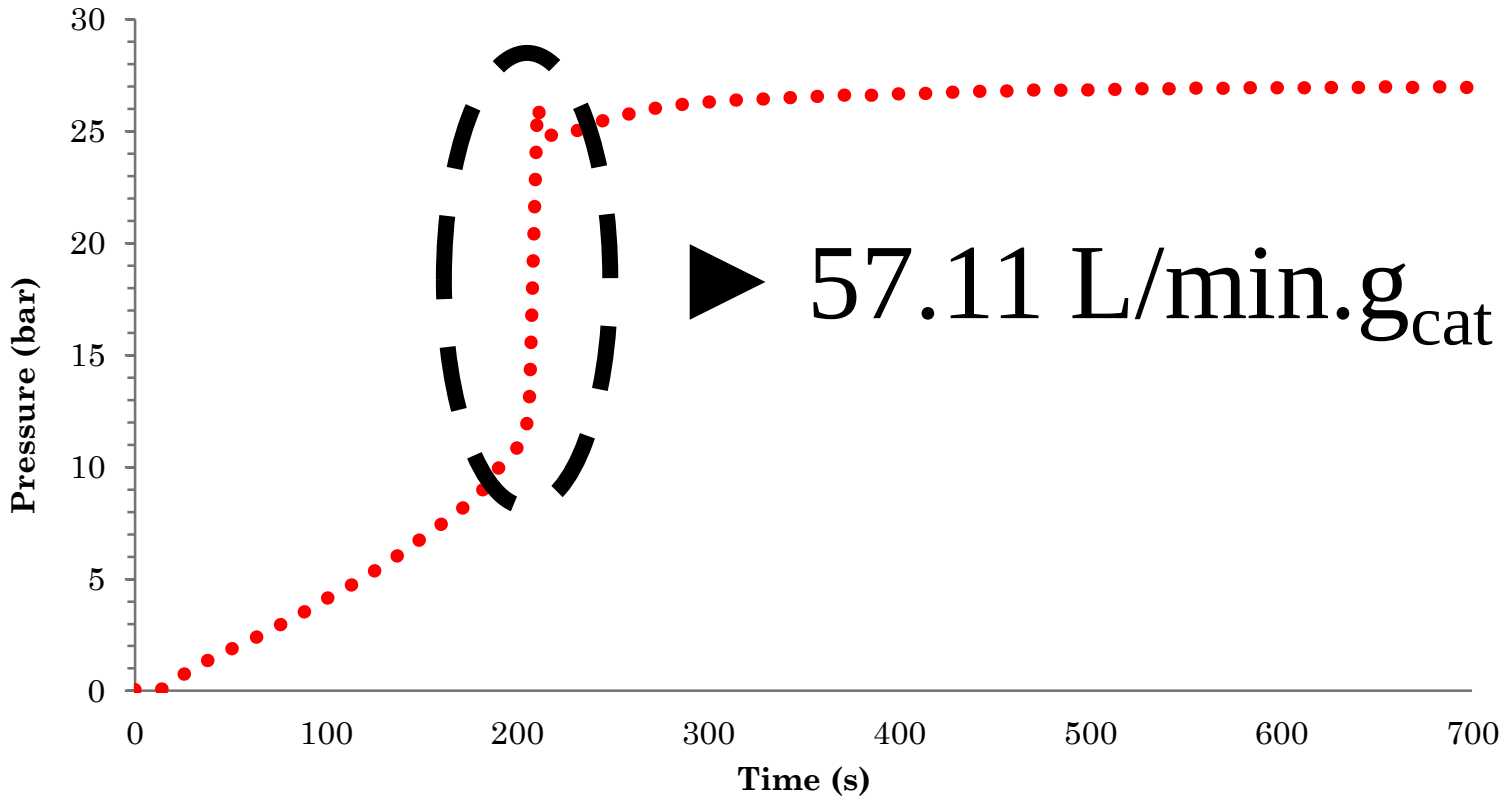
- Single use – Solid state



• • • x=2 | 0.056 L/min.gcat | 92.13% - Uncontrolled room temperature

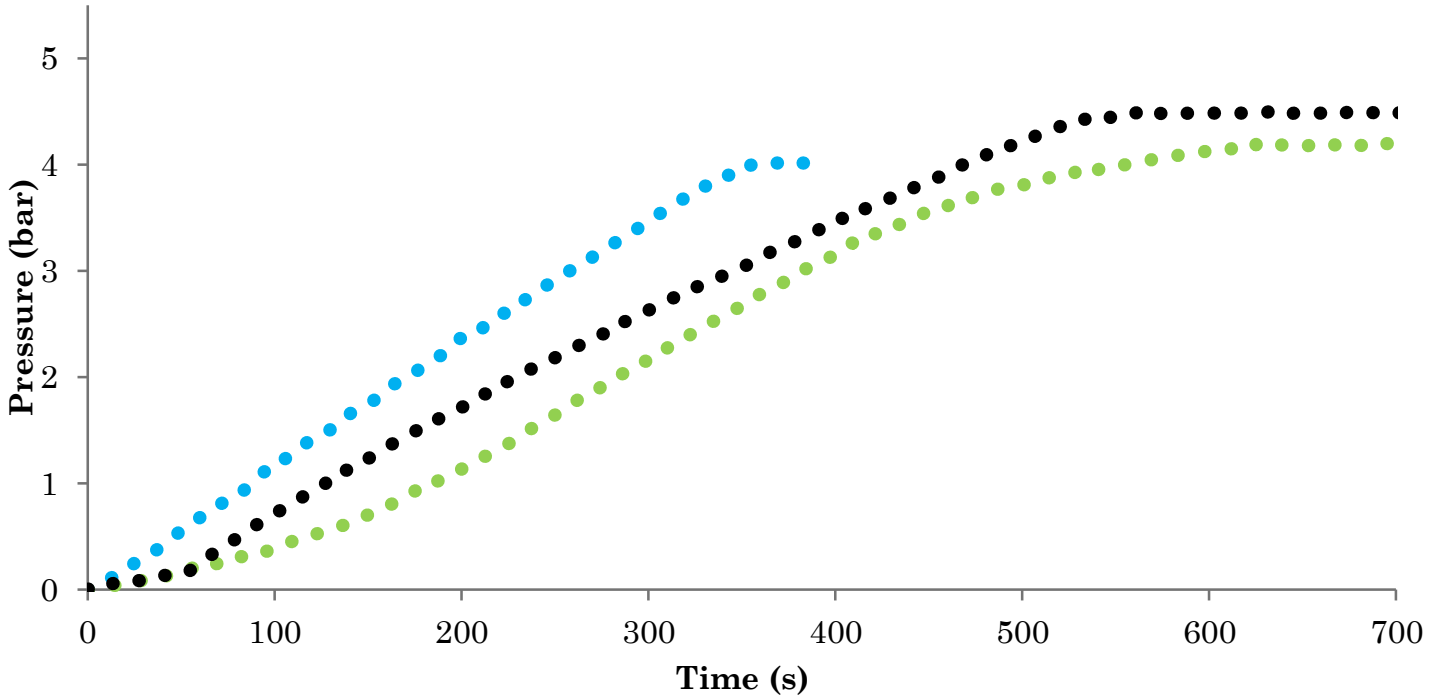
Results and discussion

- Single use – Solid state



Results and discussion

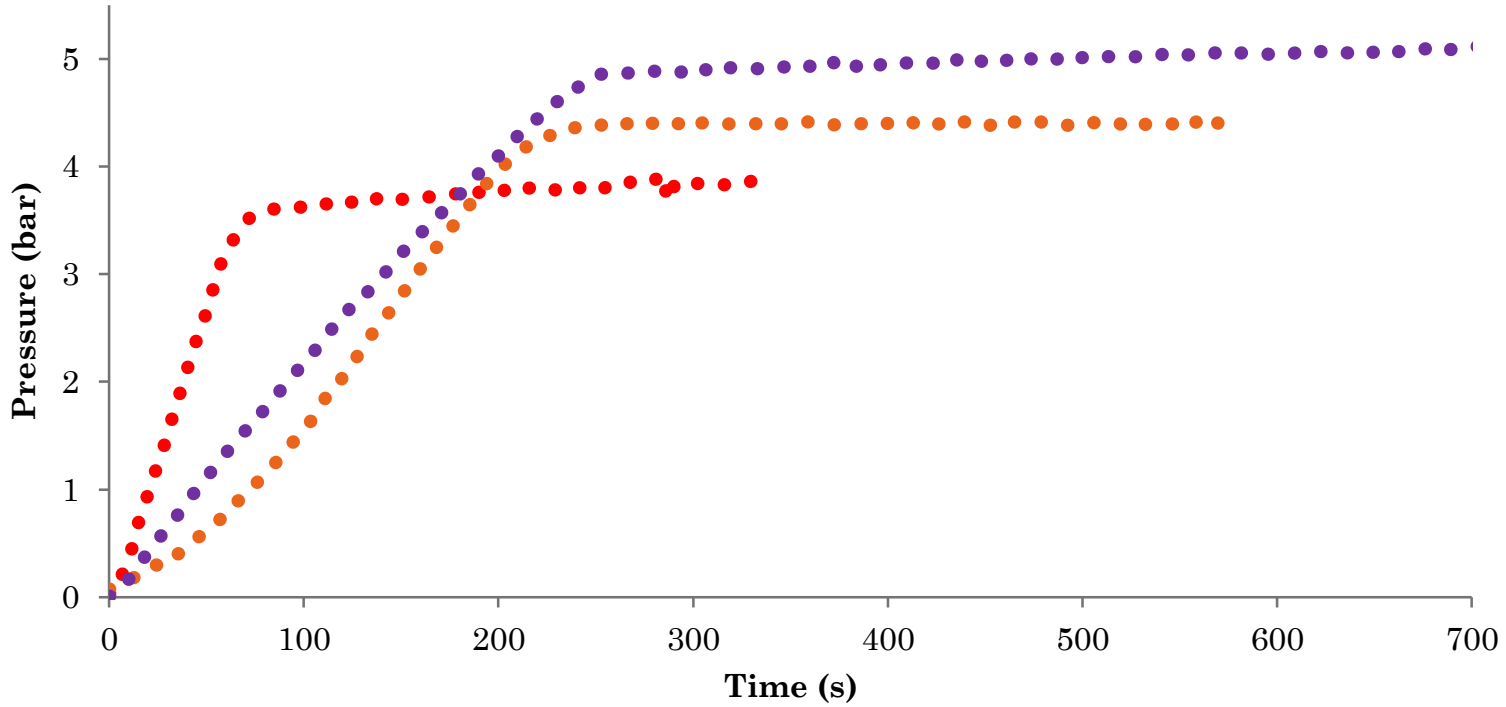
- Successive feeds – 7% NaOH



1st Load | 0.9528 L/min.gcat | 89.46% - Uncontrolled room temperature

Results and discussion

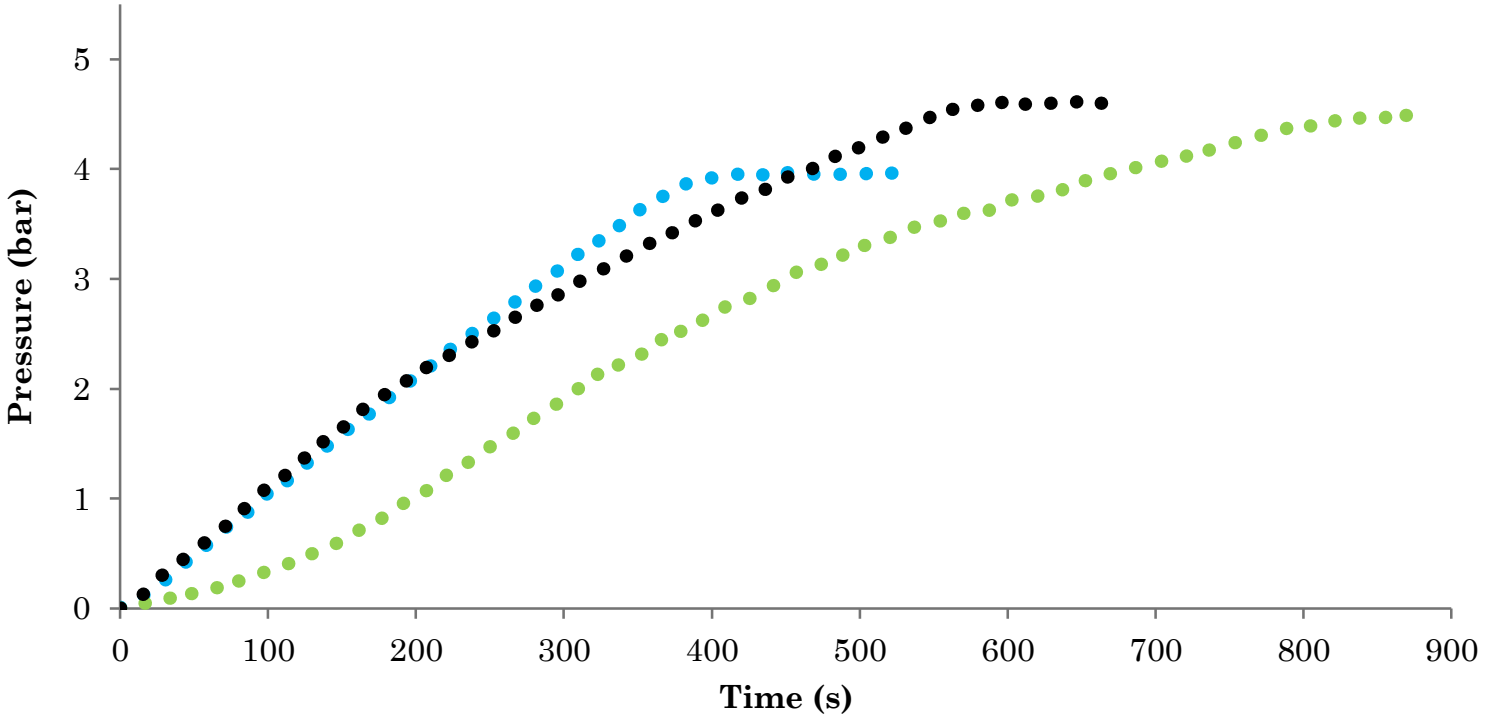
- Successive feeds – 7% NaOH



- 1st Load | 4.3726 L/min.gcat | 81.99% - 50ºC Control temperature
- 7th Load | 1.6668 L/min.gcat | 85.14% - 50ºC Control temperature
- 8th Load | 1.4323 L/min.gcat | 96.68% - 50ºC Control temperaure

Results and discussion

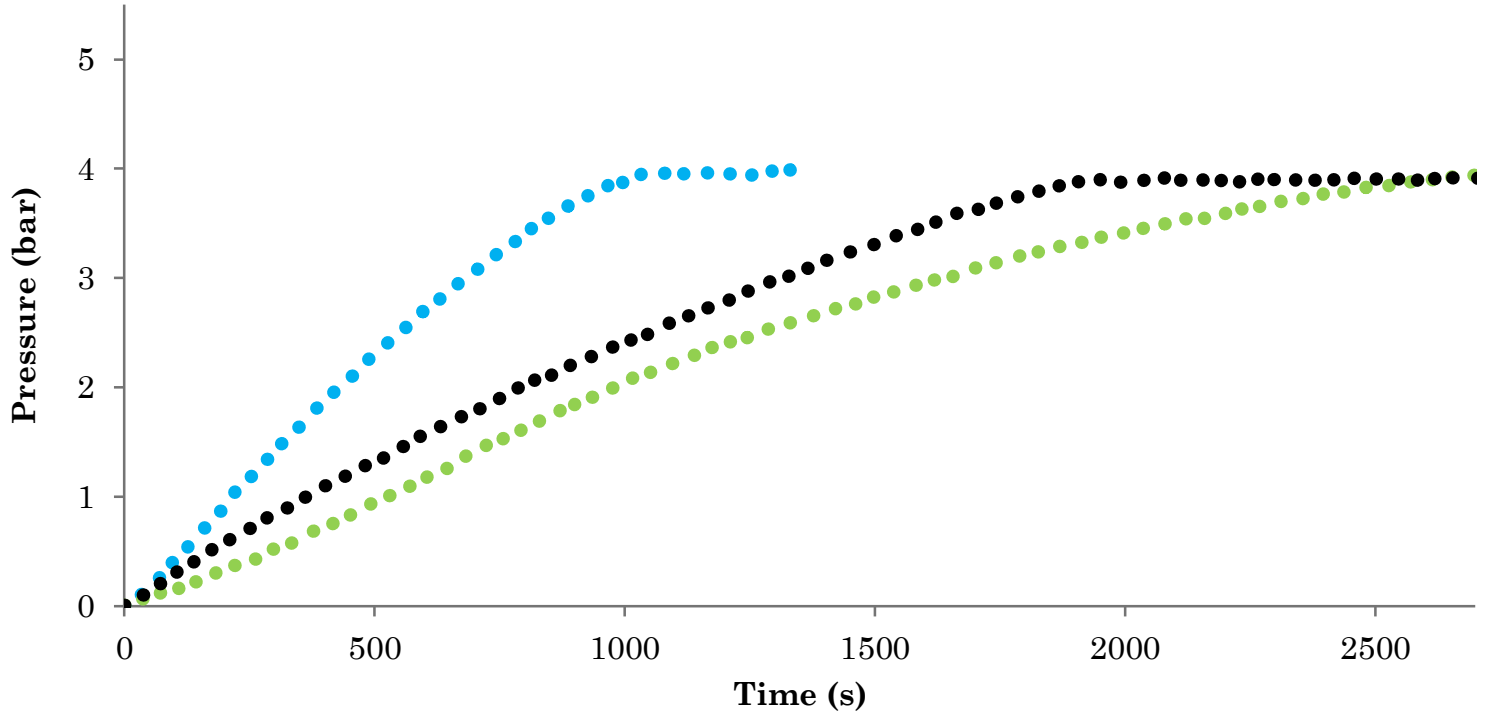
- Successive feeds – 7% NaOH and 0.25% SDS



1st Load | 0.8927 L/min.gcat | 87.87% - Uncontrolled room temperature

Results and discussion

- Successive feeds – 20% NaOH

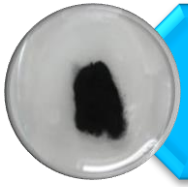


- 1st Load | 0.3633 L/min.gcat | 89.90% - Uncontrolled room temperature
- 7th Load | 0.1633 L/min.gcat | 87.84% - Uncontrolled room temperature
- 8th Load | 0.1679 L/min.gcat | 82.65% - Uncontrolled room temperature

Conclusions

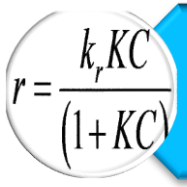
- Single use
  - ✓ Highest HGR reported with a Ru based catalyst ($57.11\ L_{H_2}\ min^{-1}\ g_{Cat}^{-1}$)
  - × Obtained for experiments carried out at 50°C
  - × $GHSC_{Room\ temperature} = 5.8$ wt%
- Successive feeds
  - ✓ Efficient hydrogen generation with successive loadings of fuel
  - × GHSC ≈ 1.7 wt%
  - × Stirring promotes the contact between the reactants → increase of parameters
- Reactor geometry
  - ✓ The optimized geometry exempt the addition of surfactant
  - ✓ Suitable for portable applications

Future works & perspectives



Research/Synthesis of a suitable catalyst for room temperature reaction

New materials that support the construction of a lighter reactor



Development of a kinetic model

Close the reaction loop: recycling $NaBO_2 \bullet xH_2O$

TH$_2$ANK YOU FOR YOUR ATTENTION

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