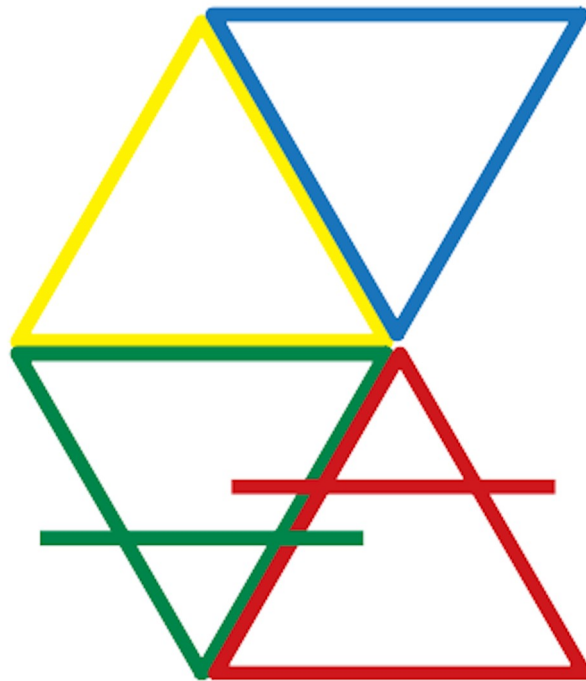


WOCST

World Online Conference on Sustainable Technologies

Book of Abstracts



Edited by

Andrea Baccioli - Angelo Basile - Aldo Bischi

Stefano Frigo - Fausto Gallucci

Guglielmo Liberati - Giuseppe Spazzafumo

March 17-19, 2021

Organised by



Sponsored by



Under the auspices of



Supported by



Media & publishing partners



energies

an Open Access Journal by MDPI

H₂international
E-JOURNAL ON HYDROGEN AND FUEL CELLS



Message from the Chair

On behalf of the Organising Committee of the World Online Conference on Sustainable Technologies, I would like to welcome all delegates.

Some of you hoped to meet in February in Muscat (Oman) for HYPOTHESIS, but we are still fighting against pandemic and HYPOTHESIS has been rescheduled to November. When it happened I decided to give anyway an opportunity to share soon your works. So I discussed with the chairmen of another conference, the World Online Conference on Membrane Processes, and we decided to join our efforts and create WOCST inviting also other colleagues involved in other aspects of sustainability. Unfortunately, the dissemination of invitations to participate has not been effective enough in some sectors and the conference is definitely biased towards the topics of the two originary conferences. With the help of the members of the Organising and Scientific Committees, I will have to make a big effort to involve a greater number of colleagues involved in the sectors of renewable sources and multi-energy systems.

I believe that an online conference was last year a completely new experience for many. And for me even doubly, as I had to organize one in just two months. Later, in the space of a year we have been inundated with a huge amount of online events, more or less useful. Although a live conference is unsurpassed and we all hope to be able to meet again in person soon, we have discovered the advantages of an online conference: a very low registration fee, no travel and accommodation expenses, no waste of time for travelling, possibility to review presentations in the days following the conference.

I hope that we will soon be back to meet live, starting with HYPOTHESIS in November, but I also believe that in the future we will continue to have online conferences because they allow greater flexibility and allow us to discuss with many colleagues whom we would not have met.

I remind you to read the posters on the site before going to the poster sessions and to take advantage of the networking opportunities offered by the platform.

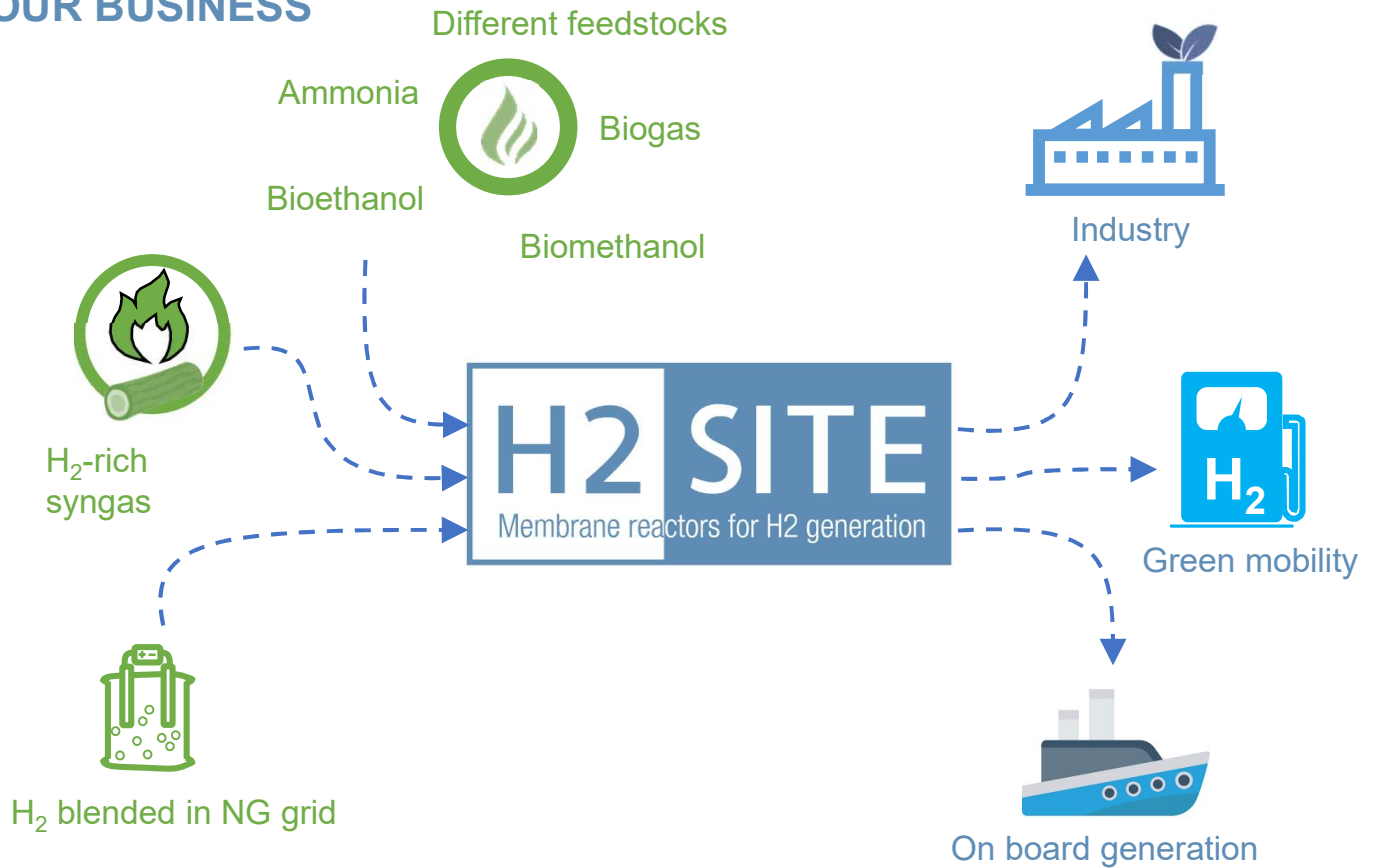
I would like to thank to our sponsor H2Site, the members of Organizing and Scientific Committees, all the authors and all of you who attend the conference. I wish you three days of interesting and fruitful discussions.

Sincerely yours,

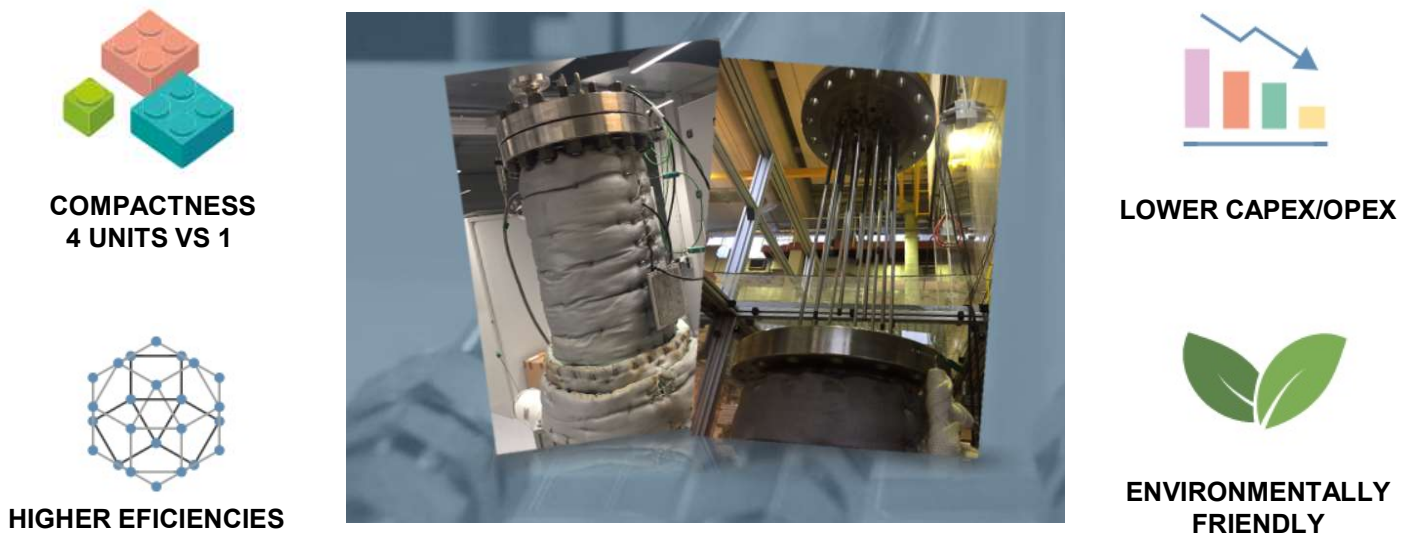
Giuseppe Spazzafumo



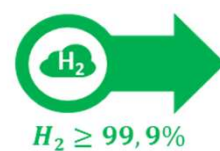
OUR BUSINESS



MAIN BENEFITS



PRODUCT FEATURES



Conference chair

Giuseppe Spazzafumo (University of Cassino and Southern Lazio)

Organising committee

Andrea Baccioli (University of Pisa)
Angelo Basile (retired from CNR)
Aldo Bisch (Skoltech, Moscow)
Stefano Frigo (University of Pisa)
Fausto Gallucci (Technological University of Eindhoven)
Guglielmo Liberati (Italian Hydrogen Forum)

Scientific committee

David Alique (Spain)
Laura Andaloro (Italy)
Bruno Auvity (France)
Félix Barreras (Spain)
Dmitri Bessarabov (South Africa)
Torsten Berning (Denmark)
Rune Bredesen (Norway)
Adele Brunetti (Italy)
Ulises Cano (Mexico)
Antonio Chica (Spain)
Viviana Cigolotti (Italy)
Antoni Forner Cuenca (The Netherlands)
Giuliana d'Ippolito (Italy)
Roberto C. Dante (Italy)
Dmitry Dunikov (Russia)
Evgueniy Entchev (Canada)
Inci Eroglu (Turkey)
Anna Maria Ferrari (Italy)
Angelo Fontana (Italy)
Raffaella Gerboni (Italy)
Diego Iribarren (Spain)
Adolfo Iulianelli (Italy)
Jens O. Jensen (Denmark)
Jakub Kupecki (Poland)
Dimitrios Kyritsis (UAE)
Marek Łaniecki (Poland)
María Jesús Lazaro (Spain)
Wonyoung Lee (South Korea)
Kang Li (United Kingdom)
Justo Lobato (Spain)
Mykhaylo Lototskyy (South Africa)
Thomas Luschtinetz (Germany)
Camel Makhloufi (France)
Tulio Matencio (Brazil)
Fabio Matera (Italy)
Ian Metcalfe (United Kingdom)
Amelia Montone (Italy)
Rhiyaad Mohamed (South Africa)
Têko Napporn (France)
Alfredo Pacheco (Spain)
Vincenzo Palma (Italy)
Emma Palo (Italy)
Paulo Partidario (Portugal)
Alessandra Perna (Italy)
Roberto Pili (Denmark)
Uwe Reimer (Germany)
Vincenzo Spallina (United Kingdom)
Rodolfo Taccani (Italy)
Edson A. Ticianelli (Brazil)
Ivan Tolj (Croatia)
Silvano Tosti (Italy)
Daniele Trucchi (Italy)
Chung-Jen Tseng (Taiwan)
Panagiotis Tsiakaras (Greece)
Toshinori Tsuru (Japan)
Zhenkai Tu (China)
Viktor N. Verbetsky (Russia)
Antonio Vita (Italy)
José Luis Viviente (Spain)
Hiroshi Yukawa (Japan)
Caizhi Zhang (China)
Xiongwen Zhang (China)
Sabrina Zignani (Italy)

Contents

Invited Lectures	7
High temperature fuel cells	12
Power to fuel	19
Membrane contactors and crystallization	28
Electrolysis	35
Poster session	42
Photocatalysis	67
Hydrogen membranes processes 1	75
Low temperature fuel cells	86
Membrane gas separation	92
Fuel processes	103
Economics / Heat Recovery	114
Metal hydrides	119
Hydrogen membranes processes 2	126



CO₂ methanation of biogas over RhNi/CeO₂ catalyst spin-coated on foam structures

G. Drago Ferrante¹, R. Balzarotti², C. Italiano², M. Laganà¹, A. Vita¹, C. Cristiani², L. Pino¹

¹ CNR-ITAE, Via S. Lucia sopra Contesse 5, 98126 Messina, Italy

² Politecnico di Milano, piazza Leonardo da Vinci 32, 20133, Milan, Italy
 dragoferrante@itae.cnr.it

The increase of energy demand and fossil fuels shortage has led to an increased interest in the use of renewable sources to integrate and progressively replace the conventional fossil fuel-based energy systems with renewable bio-energy units. Nevertheless, the imbalance between production and demand imposes a significant supply challenge. In this regards, the ability to store massive energy for hours, days and months calls for the development of efficient storage technologies, alternative to batteries, to aid further implementation of renewable energy [1]. Among the different options, power to gas technologies, based on the conversion of renewable electricity to hydrogen via electrolysis, can enable the chemical storage of energy into high-value energy carriers [2]. Moreover, in a future energy scenario without fossil fuels, carbon from renewable biomass will be a limited resource. Full carbon utilization through catalytic methanation of CO₂ in biogas appears to be a promising pathway, also considering the potential to replacement of fossil natural gas. In this work, the development of alumina open cell foams based catalysts has been addressed (Figure 1); moreover, the catalytic performances of the prepared structured catalysts have been evaluated towards the biogas methanation process.

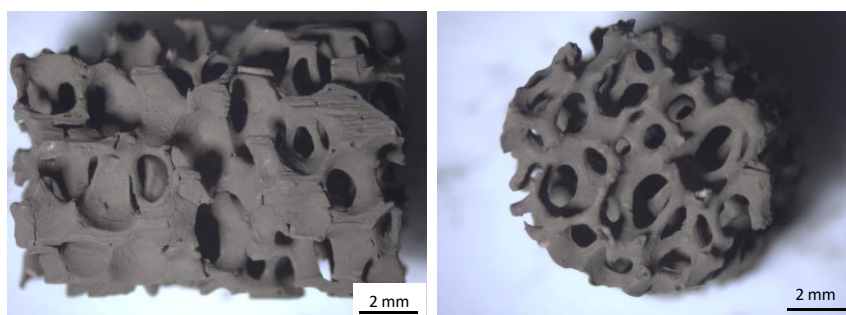


Figure 1: Photographs of 40 PPI alumina foam spin-coated with Rh(0.5wt%)Ni(7.5wt%)/CeO₂ catalyst previously prepared by solution combustion synthesis.

One of the most critical issues for the fabrication of structured catalysts is the deposition of suitable active layers on the geometric support, capable to withstand critical reaction conditions [3]. Washcoats load, thickness and adhesion, depend on several parameters such as the physico-chemical properties of the catalytic material, the morphological properties of the geometric supports and the rheological properties of the catalytic powder slurry. The latter is a key parameter, which calls for a fine tuning in order to precisely govern

the washcoat deposition process. The nature of the solid, particles dimensions of the powder, powder concentration, temperature and liquid medium composition have a significant influence on the final rheological behaviour. In literature, solid particle dispersion via surface charging with acidic solution has been widely reported as a robust methodology to prepare catalytic slurries, especially in case of high surface area catalysts. Unfortunately, this route is not effective in case of non-chargeable low surface area powders or acid-sensitive surfaces.

In this work an acid-free stable catalyst dispersion [4] has been successfully used to investigate the catalytic activation of alumina open cell foams by washcoat deposition of a Rh(0.5wt%)Ni(7.5wt%)/CeO₂ catalyst, prepared by solution combustion synthesis. The dip-spin coating method was used to manage the catalytic layer thickness onto cellular supports of different porosities (namely 20, 30, 40 PPI foams, diameter 1cm, length 1.5cm). Successful results were obtained for all the substrates, with a coating load of about 18% wt. with respect to the bare foam mass. Washcoat layers were found to be homogeneous, well adherent on foams surface, and the high shear spin coating deposition process allowed preventing the occurrence of the highly undesired pore clogging phenomena. The final structured catalysts were characterized by SEM-EDX, TEM and XRD techniques. The catalytic performance of the structured system was evaluated towards the biogas methanation process using the following operating conditions: Feed = biogas (CH₄ =60%, CO₂=40%), H₂/CO₂=4, T=300-600°C, WSV = 60,000 Nm³g_{cat}⁻¹h⁻¹. All the prepared structured catalysts have shown promising performances at 400 and 500°C with a CO₂ conversion ranging between 36.9 and 62.8%. Among the structured catalysts investigated the 20PPI sample has shown, at 400°C, the best catalytic activity (CO₂ Conv.=62.8%, CH₄ yield=65.76%). The results demonstrated that direct biogas upgrading via catalytic route without CO₂ removal could potentially be an efficient and innovative method for biogas utilisation.

References

- [1] C. Dannesboe, J. B. Hansen, and I. Johannsen, Catalytic methanation of CO₂ in biogas: experimental results from a reactor at full scale, *Reaction Chemistry and Engineering*, 5, 2020, 183–189.
- [2] A.Vita, C. Italiano, L. Pino, M. Laganà, M. Ferraro, V. Antonucci, High-temperature CO₂ methanation over structured Ni/GDC catalysts: Performance and scale-up for Power-to-Gas application, *Fuel Processing Technology* 202, 2020, 106365.
- [3] R. Balzarotti, C. Italiano, L. Pino, C. Cristiani, A. Vita, Ni/CeO₂-thin ceramic layer depositions on ceramic monoliths for syngas production by Oxy Steam Reforming of biogas, *Fuel Processing Technology* 149, 2016, 40–48.
- [4] R. Balzarotti, S. Latorrata, C. Cristiani, A. Migliavacca, Washcoating of low surface area cerium oxide on complex geometry substrates, *Particulate Science and Technology*, 34, 2016, 184-193.