



Academic research related to hydrogen in Wallonia

Status February 2024





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Introduction

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The objective of the present document is to present an inventory of all academic and research groups based in Wallonia and Brussels working on hydrogen topics. This inventory exercise has been already achieved by WaterstofNet for the Flemish level. Both documents will be compiled in order to provide a complete overview of the Belgian strength in terms of hydrogen research activities. This will help gaining in visibility for the research, both in a national and an international perspective, as well as facilitate new initiatives in the field.

Content



Materia Nova

Functional Materials,
Engineering of advanced
production processes and
integration into energy systems

Clean Energies production (H₂
and H₂ vectors) –
Storage/Transport – Uses (e-
fuels/e-molecules) – Smart REC

General expertise of the research group

Materia Nova, a technology accelerator established in 1996 in Wallonia, which actively support the transition to future sustainable energy systems. Materia Nova is actively working on 'Advanced Materials' products and on innovative and cost-effective processes to produce clean hydrogen, going beyond conventional processes and feedstocks. We are convinced by the importance of developing cost-effective alternative technologies to valorise clean hydrogen and by-products by starting also from others local feedstocks. We are leading research and innovation for Clean and Secure systems integrating H₂ and other vectors production/conversion, their storage, transport and uses. We are committed to our industrial partners on their preparation for the massive integration of sustainable processes and strategic choices in the decarbonization process in future energy systems.

Materia Nova has strongly supported UMONS for obtaining the granted proposal called "TRL7 Plug&Tests" that targets a unique interconnection of decarbonization technologies on an industrial site to demonstrate the effective operation of various modular energy communities at a pre-industrial scale. Materia Nova has also decided a robust intellectual property protection, filing pivotal patents annually and managing freedom-to-operate aspects.

Specific hydrogen- related expertise & research topics

Materia Nova's Sustainable Energy Sector is founded on four key technological pillars:

1. **Clean Energy Production:** Our focus lies in the advancement of materials and processes essential for generating decarbonated useful forms of energy (e.g. bio-CH₄, H₂, NH₃), as well as heat and electricity production technologies.
2. **Innovative Functional Materials for Storage & Transport:** We specialize in the creation of innovative materials such as coatings and nanocomposite polymers designed for efficient transportation and storage of energy. This encompasses both electricity and H₂, featuring special carbon-based electrodes, H₂ barriers, and more.
3. **Energy Management:** Leveraging our rich history, we bring unparalleled expertise in developing surface treatments (both dry and wet) for the preparation of functional materials crucial for converting energy from one form to another. This includes PV technologies, optothermal coatings, polar plates for elevated temperatures, and active materials for sensors.

4. **Physical Integration in Energy Communities:** Our commitment extends beyond technological innovation to the seamless integration of processes within future energy communities. Through initiatives like ILES and TRL7 Plug&Test, we ensure the practical, real-world application of sustainable energy solutions.

"The name Materia Nova means 'New Materials', reflecting our significant expertise in materials science and engineering. We actively support academic research by funding several doctoral theses with our partners, furthering our commitment to advancing sustainable energy solutions."



Available equipment/tools:

Plasma tools for surface treatment:

- Atmospheric plasma torches for surface cleaning, functionalization, deposition
- Vacuum plasma deposition system (PVD and PECVD) from lab scale (8 units) to pilot scale (4 units) and industrial scale (1 unit) for development of coating
- Ion implantation system (lab scale and pilot scale) for treatment of powder, 2D and 3D objects
- Powder engineering by plasma technology : 3 PVD and PECVD coater for powder coating (core-shell structure and decoration), 1 Plasma spheroidization system
- Vacuum plasma system (PVD and PECVD) for deposition inside tube and cavity

Plasma tools for gas treatment (reforming, abatement, conversion)

- Low pressure microwave plasma system (2.45 and 0.915 GHz) and for gas reforming and hydrogen production



- Atmospheric plasma torch (RF and microwave) for gas reforming and hydrogen production
- 3D and 2D gliding arc system for gas reforming and hydrogen production

Electrochemical tools :

- Electrochemical workstation : a large variety of potentiostats/galvanostats for the testing of new energy materials :
 - Linear Sweep Voltammetry, Cyclic Voltammetry, Chrono method, Electrochemical Impedance Spectroscopy, etc
 - Catalyst electrochemical characterisations : overpotential (HER, OER, etc), peak power density , faraday efficiency.
- Few sizes of electrochemical cells to evaluate coatings surface from 1 to 25 cm²
- Alkaline Pilot Electrolyser 6 KW (in acquisition)

Surface analysis tools :

- Analysis of the physicochemical properties of coatings, identification of corrosion or failure using XPS or TOF-SIMS with FIB or gas cluster profiling facilities, Scanning Electron Microscope (SEM-EDX), FTIR and Raman spectroscopy, XRD, AFM and C-AFM.
- Accelerated annealing of coating or materials using salt spray test, QUV, Xenon, Climatic conditioning or corrosive gas chamber, mechanical fatigue tests (tension, compression, bending, ...)
- Electrical characterization: 4 probe, hall effect and C-AFM
- Tribological test (hardness, friction coefficient, scratch, ...)
- Chemical analysis: gas chromatography, ICP

Engineering facilities :

- 3D Design software use for draft, final construction drawing or modelling for physical phenomenon simulation.
- Multiphysics simulation software: Flow, Thermodynamics, Structural analysis.
- Process diagram and analytical or numerical resolution (PFD, P&ID)
- Experimental data analysing tools

Participating in RW/B/EU funded projects with H2 related research:

Selection of our key projects :

- PIT Poles Greenwin – **GAZTON** (2011) : Green electricity storage through conversion of CO₂ and LHV gases into storable chemical fuels (ex: CO, methanol) for delayed combustion in industrial environments.
- ENERGINSERE **HYLIFE** (2014) : Development of low-cost fuel cells using coated steel bipolar plates.
- PIT Poles Greenwin – **REFORGAS** (2015) : Plasma reforming of biomethane & CO₂ (biogas) for the synthesis of acrylate molecules and other C1-C2 molecules with green electricity.
- Private project - **H2S2H2** (2015) : Production of hydrogen and solid sulphur from industrial H₂S with plasmalysis.

- Win2Wall - **PYROCARB** (2021) : Correlation Diagnostic Pyrolysis Plasma of hydrocarbons and scientific studies of valuable solid carbon forms production.
- PNRR **HECO2-electrolyzer** (2022): Assessment of environmental sustainability
- PWR/PNRR **HECO2 Hybrid Plasmalysis** (2023) : Hydrogen by Hybrid Plasmalysis of local feedstocks of methane & structured carbons without CO₂ emission' (2 patents)
- Clean Hydrogen for Clean Industry **H2PY** (2023) : Feasibility study aimed at decarbonizing the Seraing gas power plant using plasma pyrolysis hydrogen.
- Feder Portfolio **DECARBOWAL** (2023) coordination and active member of :
 - **Axis/Projects SynFoNH_y** : Virtuous cycle N₂/H₂ to NH₃ to N₂/H₂ by plasmacatalysis
 - **Axis/Projects WALBIOPOWER** : Improvement of biogas production and production of green hydrogen from nitrogen-containing waste waters with advance catalytic materials (1 patent)
- RFCS – **HYDROMINE** (2023) : Hydrogen-oriented municipal waste refinery based on a novel borehole gasification process combined with advanced gas separation and treatments techniques (including plasmacatalysis).
- FTJ – **ILES MANO 1** (2024) : Solutions for GEN. 4 H₂ tanks combining functional nanocomposite polymers and plasma barrier layers.
- FTJ – **ILES MANO 2** (2024) : Scale-up of electrocatalytic process and modelling of agricultural Renewable Energy Communities.
- FTJ – **TRL7 Plug&Tests** (2024) : Materia Nova is a key partner of UMONS for the implementation of smart energy communities (EC) on an industrial site, including conventional production of heat and electricity, renewable energies and decarbonization technologies (H₂, CO₂).
- WIN4EXCELLENCE – **TinTHyN (2024)** : We are actively supporting four thesis (SO(E)C, H₂ tanks, NH₃/H₂ production/reforming and carbon-based materials for PEMFC)b.
- WIN4EXCELLENCE – **EFES (2024)** : We are actively supporting three thesis (elevated temperature heat storage, two on CO₂ valorisation for e-fuels & e-molecules).

Main relevant publications

- *Feasibility study of a small-scale fertilizer production facility based on plasma nitrogen fixation*, Manaigo F., Rouwenhorst K., Bogaerts A., Snyders R. in *Energy Conversion and Management*, 302, 2024, 118124
- *Magnetic field topology for altering ion density in bipolar sputtering*, Michiels M., Leonova K., Godfroid T., Snyders R., Britun N. in *Applied Physics Letters*, 2022, 121(5), 051603
- *Effect of N₂ on CO₂-CH₄ conversion in a gliding arc plasmatron: Can this major component in industrial emissions improve the energy efficiency ?* Van Alphen S., Slaets J., Ceulemans S., Aghaei M., Snyders R., Bogaerts A. in *Journal of CO₂ utilization* 2021, 54, 101767
- *Techniques de l'ingénieur – L'ACTU DE L'INNOVATION 'Une nouvelle technologie de pyrolyse plasma du méthane pour produire de l'hydrogène' – Juin 2021*
- *Laser powder bed fusion (L-PBF) of Cu and CuCrZr parts: Influence of an absorptive physical vapor deposition (PVD) coating on the printing process*, Lassègue P., Salvan C.,



De Vito Soulas R., Herbin M., Hemberg A., Godfroid T., E, Baffie T., Roux G. in *Additive Manufacturing*, 2021, 39, 101888

- Insights into CO₂ conversion in pulsed microwave plasma using optical spectroscopy, Britun, N., Godfroid, T., Snyders, R. in *Journal of CO₂ Utilization*, 2020, 41, 101239
- Molecularly imprinted electropolymerization on a metal-coated optical fiber for gas sensing applications, Gonzalez-Vila A., Debliquy M., Laheim D., Zang C., Mégret P., Caucheteur C. in *Sensors and Actuators B: Chemical* Volume 244, June 2017, 1145-1151
- Simultaneous dissociation of CO₂ and H₂O to syngas in a surface-wave microwave discharge, Chen G., Silva T., Georgieva V., Godfroid Th., Britun N., Snyders R., Delplancke-Ogletree M.-P. in *International Journal of Hydrogen Energy* Volume 40, Issue 9, 9 March 2015, Pages 3789-3796
- Influence of the stress generated during an ageing cycle on the barrier properties of cathaphoretic coatings, Olivier M.-G., Romano A.-P., Vandermies C., Mathieu X., Poelman M. in *Progress in Organic Coatings*, 2008, Volume 63, 323-329

Contact persons

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- Dr Fabrizio Maseri – Sustainable Energy Sector Manager and Materia Nova's core member of IIS eWallonHy and IIS CETWA – **Core contact** : (fabrizio.maseri@materianova.be).
- Dr Thomas Godfroid – Scientific Leader of CHIPS Unit (functional materials and electrical chemical engineering e.g. plasma)
- Dr Olivier Talon – Scientific Leader of YLCA Unit (LCA, LCC and s-LCA)
- Dr Sylvain Desprez – UAC coordinator (Unit of Analysis & Characterisations)

Some key researchers involved in our Sustainable Energy Programme :

- Dr Adriano Panepinto – Project Leader (e.g. HECO₂ Plasmalysis) and research (functional materials and chemical engineering, H₂)
- Dr Ahmadou Ly – Expert Researcher (Active materials for active devices, SOFC ...)
- Dr, Eng. Arnaud Krumpmann – Expert Researcher (functional materials and chemical engineering, H₂)
- Grégory Guilbert – Research Engineer (Electrocatalytic reactors, H₂)
- Dr Driss Laheim – Senior Expert Researcher (Active materials for Sensors, photocatalytic processes)
- Loan Terrien – Expert researcher (LCA, LCC and s-LCA)
- Eng. Philippe Ramirez Hernan – Senior Engineer Expert (lab. and industrial chemical engineering systems, H₂)