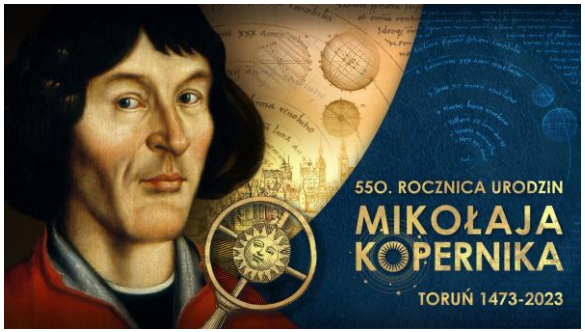
Nicolaus Copernicus University for Green Hydrogen



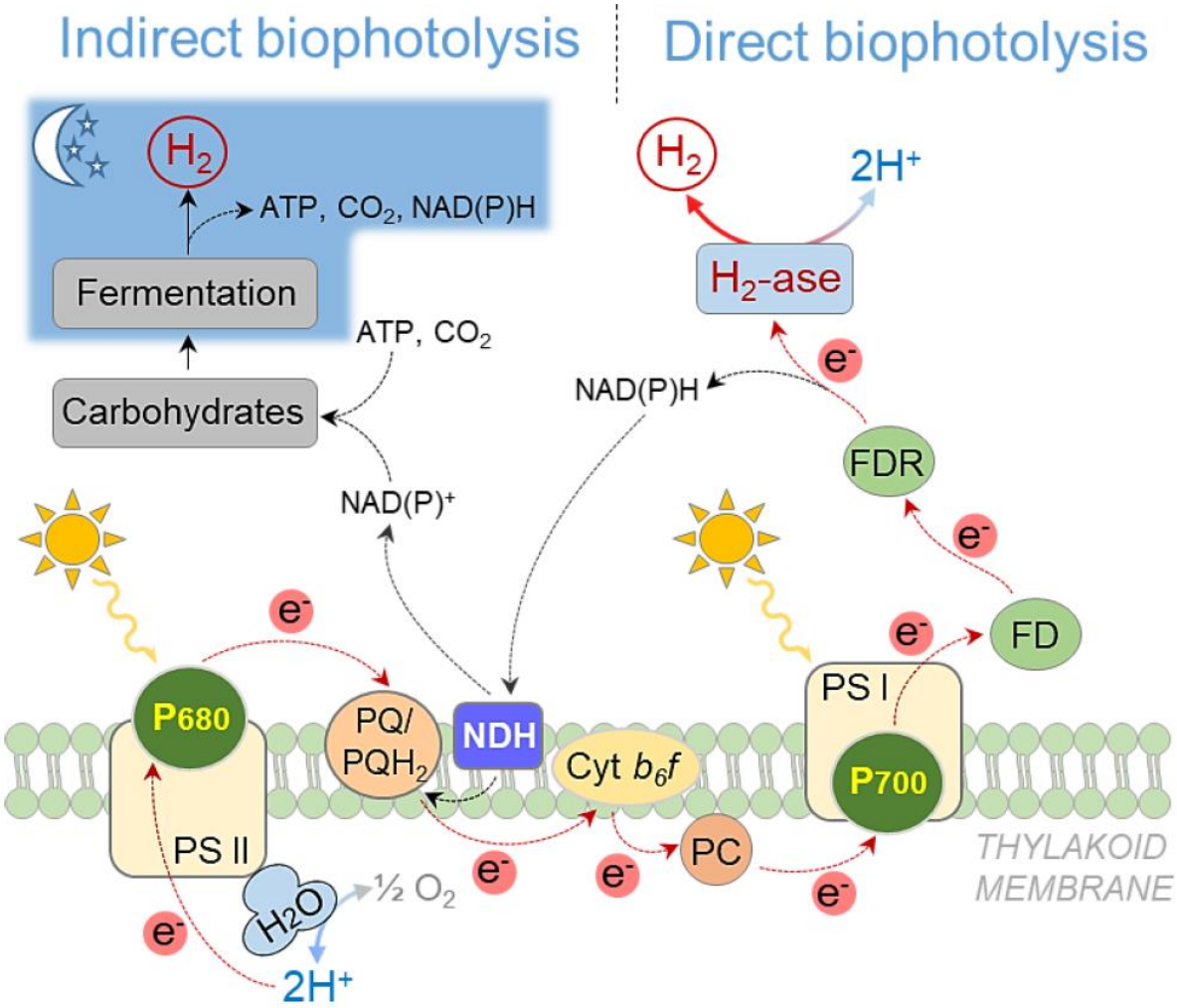
NICOLAUS COPERNICUS
UNIVERSITY
IN TORUŃ

Centre for Modern
Interdisciplinary Technologies

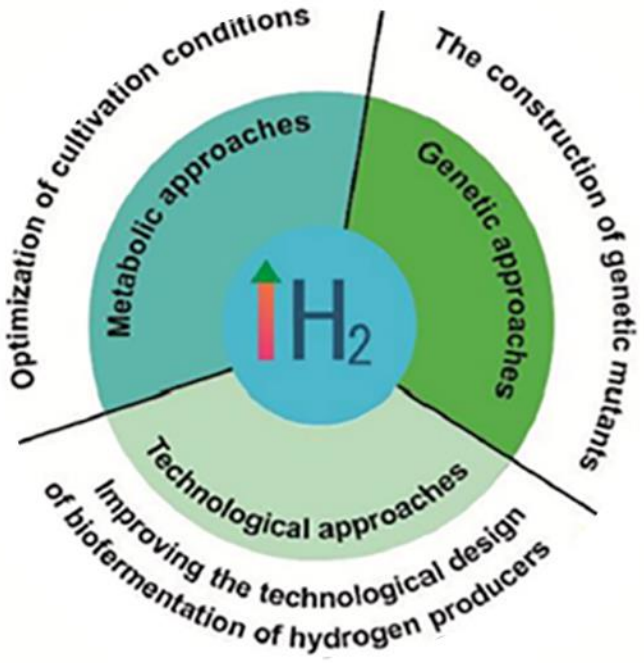
Microalgae-derived bio-hydrogen

Leaders: prof. Agnieszka Zienkiewicz, and prof. Krzysztof Zienkiewicz

Under certain conditions microalgae are natural hydrogen factories



Major strategies of boosting bio-hydrogen production from microalgae?



95% - O_2

5% - H_2

GOAL

50% - H_2

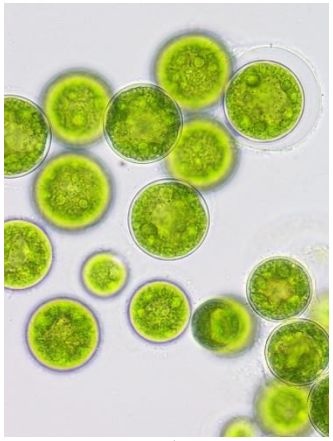
2.80 $/kg

Our goals?

- Addressing the effect of selected environmental factors on the expression of hydrogen-synthesis machinery and H_2 yields in microalga *Nannochloropsis oceanica*
- Boosting the H_2 synthesis in this microalga by using genetic engineering
- Deciphering the molecular crosstalk between photosynthesis and H_2 evolution in *N. oceanica*
- Quantitative analysis of H_2 evolved by selected and genetically modified *N. oceanica* cultures
- Development of efficient carbon-derived matrixes for immobilization of this microalga in stable cultures

Our exeprimental approach

- Optimization of cultivation conditions
- Construction of transgenic lines



N. oceanica cultures

Nannochloropsis oceanica

WP1

Diverse light and nutrient conditions

WP2

Genetic engineering of H_2-synthesizing machinery

CRISPR/Cas9

Gene over-expression

Selection of positive transformants

WP3

Impairment of photosynthetic systems

CRISPR/Cas9

Disruption of electron transport

Selection of positive transformants

WP4

Solid medium

H_2-sensing overlay assay

Isolation and identification of H_2-positive colonies

Liquid medium

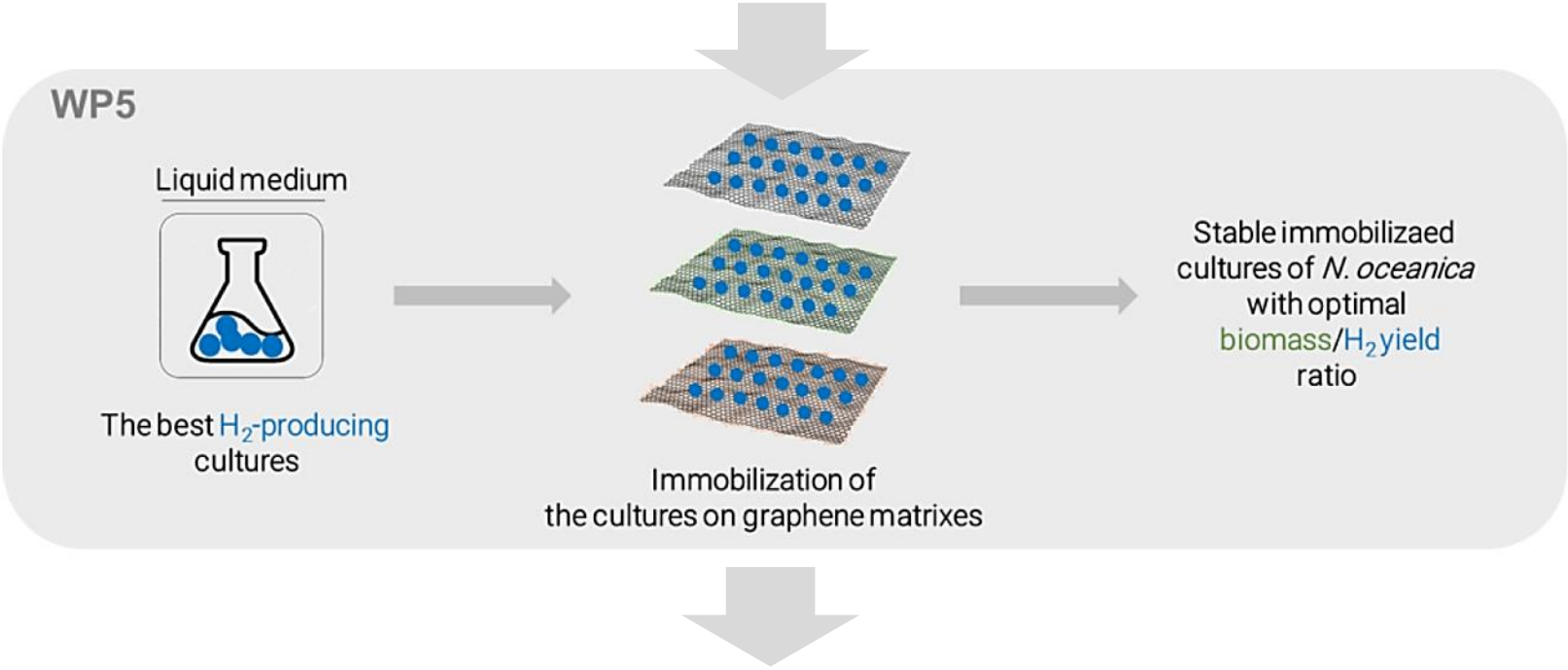
H_2 quantification by GC

Quantitative estimaiton of H_2 yields

Selection of the best *N. oceanica* lines with respect to H_2 production

Our exeprimental approach

Improving the technological design of biohydrogen producers



Long-term goal: a prototype of graphene-based bio-hydrogen fuel cell

Norway grants

The National Centre for Research and Development

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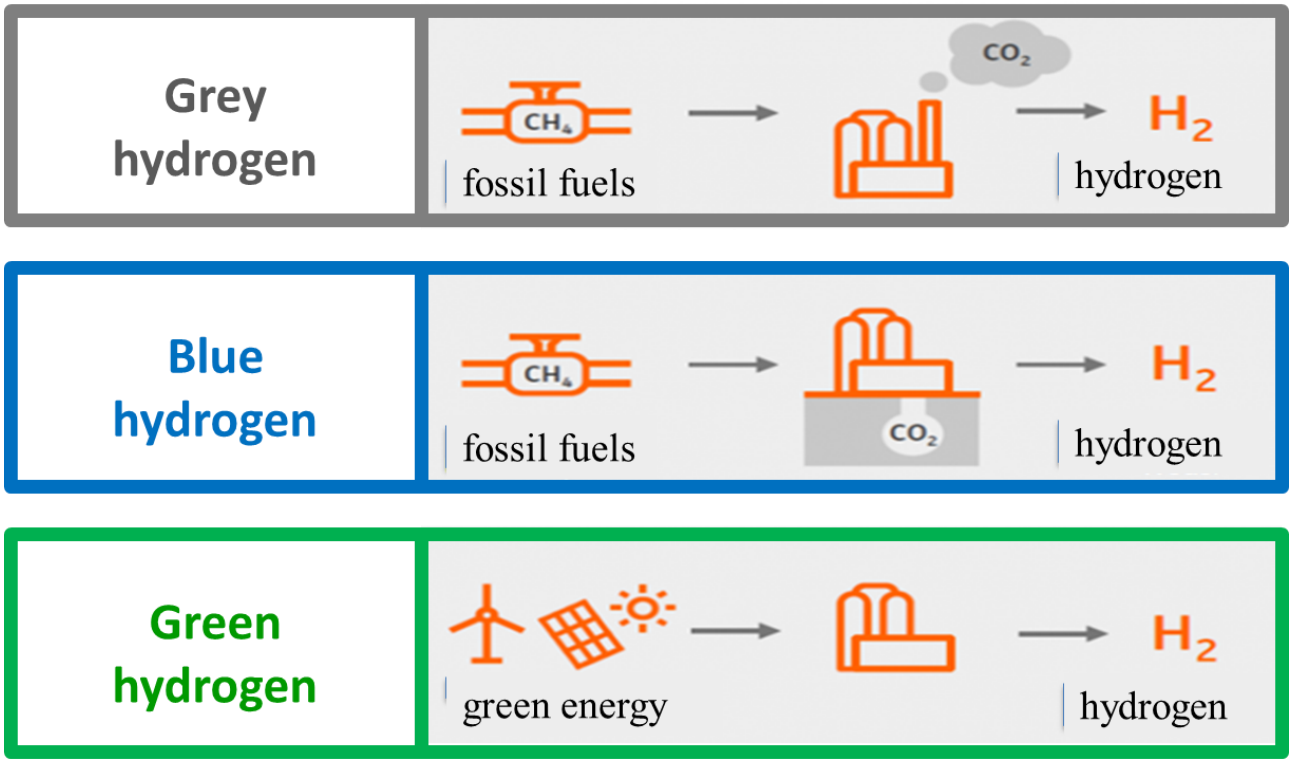
Pt-free graphene-based catalysts for water splitting technology as green method for hydrogen production

Leader: dr hab. Anna Ilnicka, prof. UMK



F. Dawood, M. Anda, G.M. Shafiullah, Hydrogen production for energy: An overview, International Journal of Hydrogen Energy, 45 (2020)

Negative influence for environment

Resourceses are limited

H_2 is an ideal alternative

- ✓ **TARGET:** Green hydrogen produced by electrolysis of water, powered by elecricity generated from renewable energy sources

Stage 1

1-12 month of the project.

Synthesis and characterisation of graphene and its hybrids with heteroatom dopants and metal oxides

Stage 2

5-20 month of the project.

Research of graphene materials in the oxygen evolution reaction (OER) and hydrogen evolution reaction (HER)

Stage 3

21-24 month of the project.

Development of the concept of green hydrogen production with an assessment of implementation potential

Stage 2

Electrocatalytic hydrogen generation from water

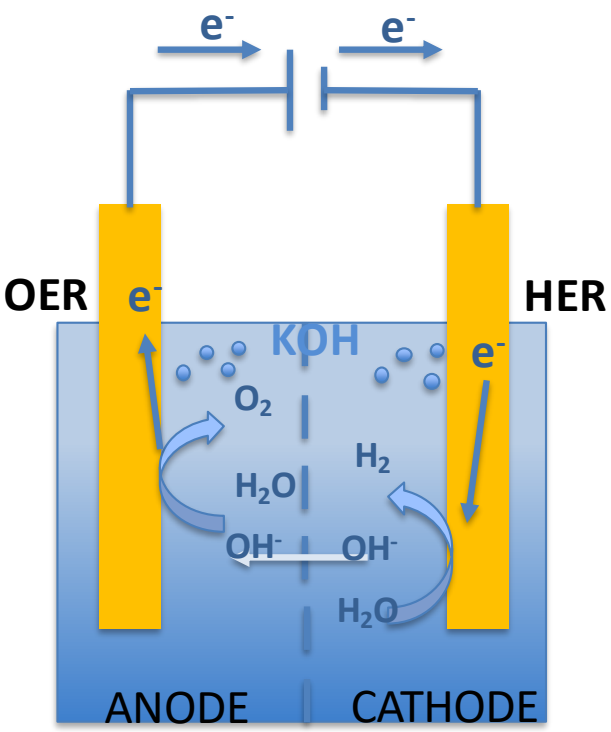
At the anode is the oxidation of water to gaseous oxygen (OER)

<u>in acidic medium</u>

$2H_2O \leftrightarrow O_2\uparrow + 4H^+ + 4e^-$

<u>in alkaline medium</u>

$2OH^- \leftrightarrow O_2\uparrow + 2H^+ + 4e^-$



At the cathode is the reduction of water to hydrogen gas (HER)

<u>in acidic medium</u>

$2H^+ + 2e^- \leftrightarrow H_2\uparrow$

<u>in alkaline medium</u>

$2H_2O + 2e^- \leftrightarrow H_2\uparrow + 2OH^-$

Electrochemical measurements

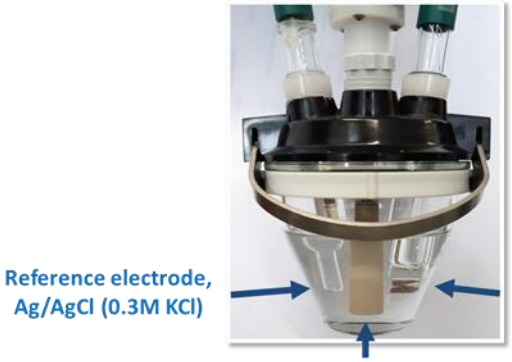


Figure: A three-electrode setup used for electrochemical measurements

Stage 1: Examples of catalysts

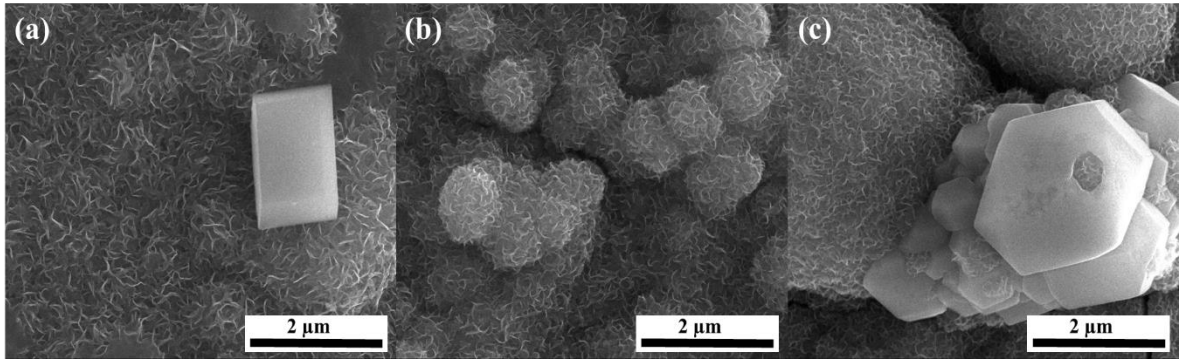


Figure: SEM images of samples: (a) $TiO_2/SrMoO_4$, (b) $TiO_2/CoMoO_4$, (c) $TiO_2/SrMoO_4/CoMoO_4$

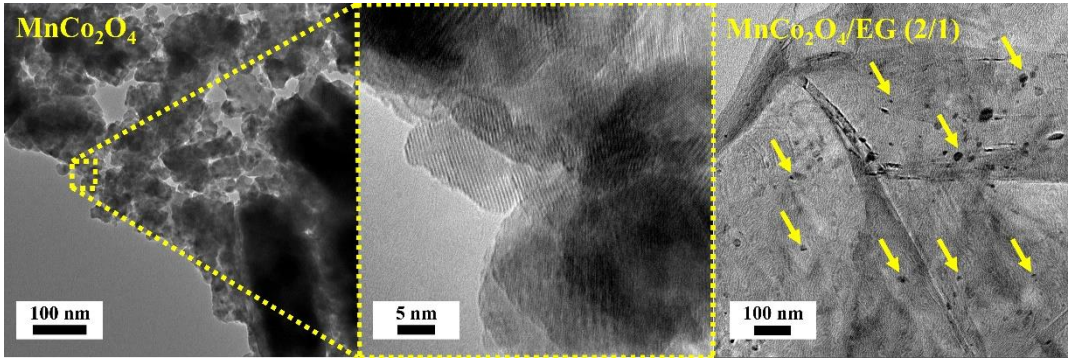
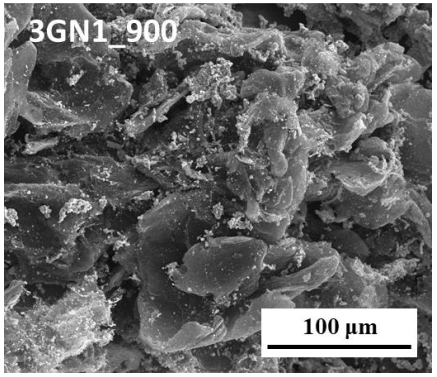


Figure: HRTEM images of $MnCo_2O_4$ and $MnCo_2O_4$/EG (2/1)



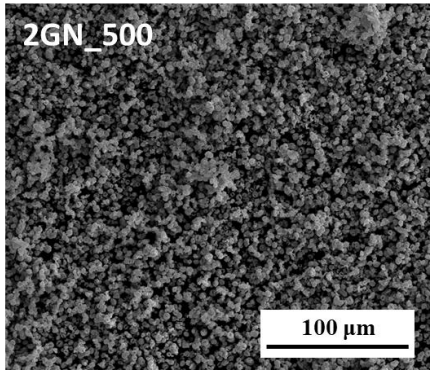


Figure: SEM images of graphene-based catalyst with Mn and Co atoms.

RESEARCH FACILITIES

- ✓ **Laboratory space;**
- ✓ **SEM** (LEO Electron 1430 VP) - the morphology and chemical composition;
- ✓ **HRTEM** (Tecnai F20) - nanostructure;
- ✓ **Low Temperature Adsorption of Gases** (ASAP 2020 PLUS) - surface area, pore volume/size;
- ✓ **XRD** (X'Pert Pro) - crystalline structure;
- ✓ **XPS** - chemical structure/composition;
- ✓ **Elemental Combustion Analysis** (VarioMACRO) – elemental composition;
- ✓ **Potentiostat/galvanostat** (Autolab 302) - electrochemi features;
- ✓ **Raman Spectroscopy** – chemical/structural features.

Hydrogen Technology and Energy Storage Group

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