Zachodniopomorski
Uniwersytet
Technologiczny
w Szczecinie

Polish Norwegian Projects in CCS/CCU at West Pomeranian University of Technology in Szczecin

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GLOBAL WARMING

Climate changes

CO_2 emissions – one of causes

Challenge – how to decrease and prevent?

Remedies:

- **Energy saving**
- **Renewable energy**
- **CCS (carbon capture and storage**
- **CCU (carbon capture and utilisation) – the BEST !!!**

CO_2 capture from gases

Technologies in use – based on absorption in liquids

- Amines
- K_2CO_3
- Methanol

Weaknesses:

- -High energy demand
- -Corrosion issues
- -Solvent evaporation
- -Environmental issues

Solid sorbents – one of alternatives

SolSorb POL-NOR project

2014-2017 (prof. U.Narkiewicz)

„Post-Combustion CO_2 Capture on New Solid Sorbents and Application in a Moving Bed Reactor „

Value: 7 972 105 PLN

Consortium Partners:

- **West Pomeranian University of Technology in Szczecin**
- **University of South-Eastern Norway**
- **SINTEF Industry**
- **SINTEF Ocean**

Results of the SolSorb project

- New solid sorbents were produced, characterised and tested
  - **Cheap** and environmentally friendly
  - Based on modified microporous **carbons, zeolites** and **titania**
  - **High mechanical resistivity**
- The sorbents were carefully characterised, mainly their carbon dioxide adsorption
- The most efficient sorbents were based on **zeolites** and on **carbonaceous** materials, they reached a capture capacity above **6 mmol CO_2/g_**sorbent under ambient conditions
- **Deactivation level** of produced sorbents was below 5% after **200 adsorption/desorption cycles.**
- A new efficient laboratory **prototype moving bed reactor**, designed to increase the solid sorbent CO_2 absorption capacity, was developed.
- The environmental effect of the produced sorbents was assessed. A ranking system for environmental impact was established on the basis of an **aquatic fate** and **ecotoxicity** assessment of selected nanomaterials.
- The social awareness of post-combustion carbon capture (PCCC) as a technology aiming to reduce global CO_2 emission was raised within the project.

number of publications: **22**
number of applications/patents: **17**
number of conferences: - **47**
number of students/doctoral students: **7 PhD students, 10 students**
numer of researchers : **16**

SolSorb

Journal of Porous Materials
https://doi.org/10.1007/s10934-018-0601-8

Preparation and characterisation of carbon spheres for carbon dioxide capture

D. Sibera[1] · U. Narkiewicz[1] · J. Kapica[1] · J. Serafin[1] · B. Michalkiewicz[1] · R. J. Wróbel[1] · A. W. Morawski[1]

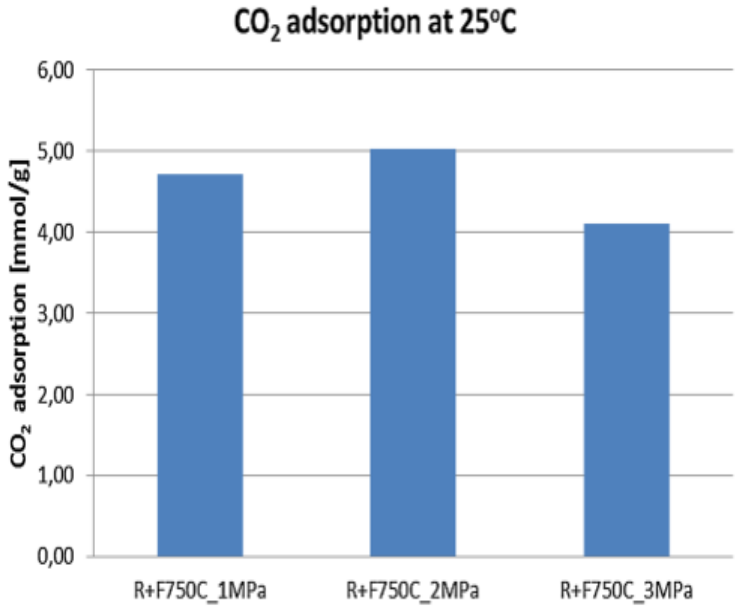


Fig. 5 CO_2 adsorption on the samples obtained in microwave solvothermal reactor under the pressure of 1, 2 and 3 MPa, and next carbonised at 750 °C

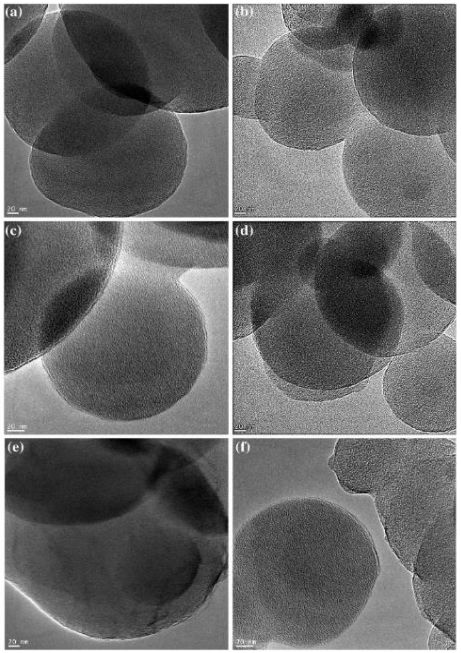
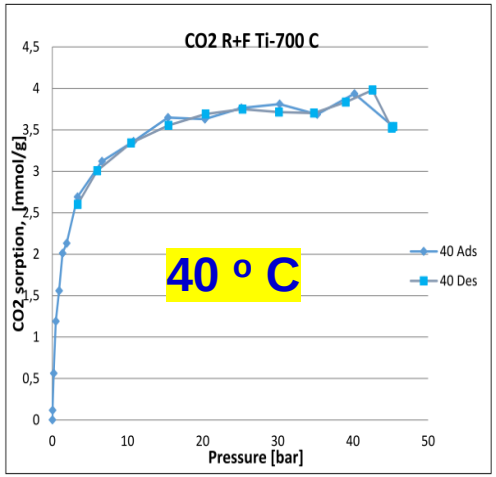


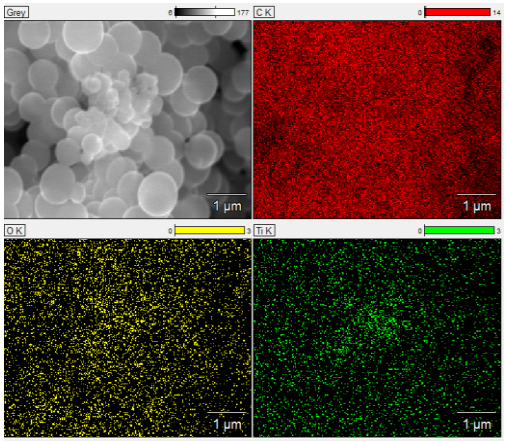
Fig. 9 TEM images of the carbon spheres: a R+F700C, b R+F750C, c R+F800C, d R+F750C_1 MPa, e R+F750C_2 MPa, f R+F750C_3 MPa

SolSorb



Adsorption-desorption isotherms of CO_2 at 40°C on TiO_2-graphitic carbon spheres

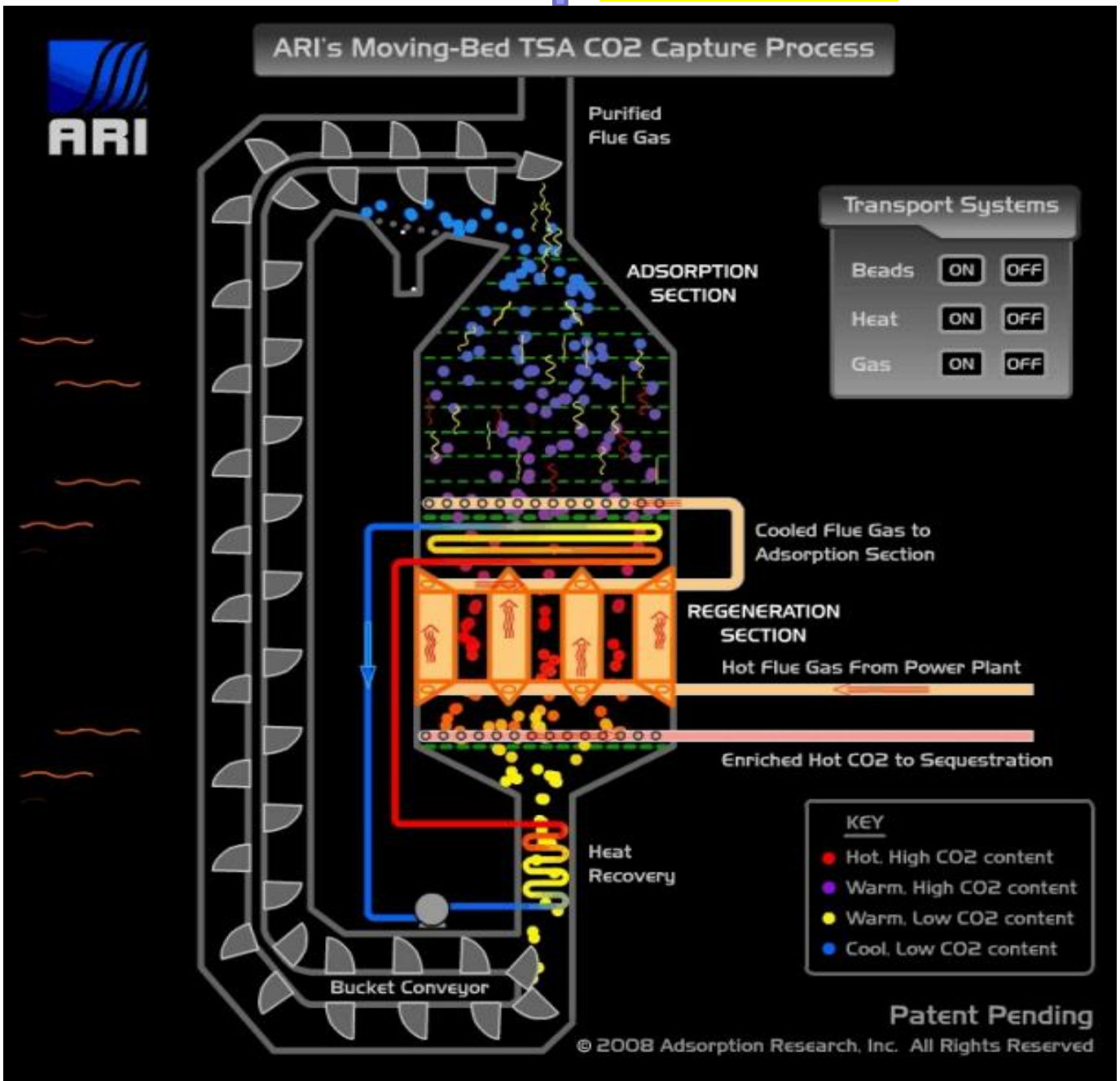
TiO_2-CS



EDX mapping of Ti, O and C from TiO_2-carbon spheres

A.W.Morawski, P.Staciwa, D.Sibera, D.Moszyński, M.Zgrzebnicki, U.Narkiewicz, *Nanocomposite Titania-Carbon Spheres as CO_2 and CH_4 Sorbents,* **ASC Omega**, 5 (2020) 1966-1973; https://dx.doi.org/10.1021/acsomega.9b03806

Purified gases



hot exhaust gases

CO_2

PhotoRed POL-NOR project 2020-2024 (prof. U. Narkiewicz)

„Photocatalytic and photoelectrochemical carbon dioxide reduction”

- One step further – not only **CCS** but **CCU**
- The same Pol-Nor consortium
- Value: 8 596 500 PLN

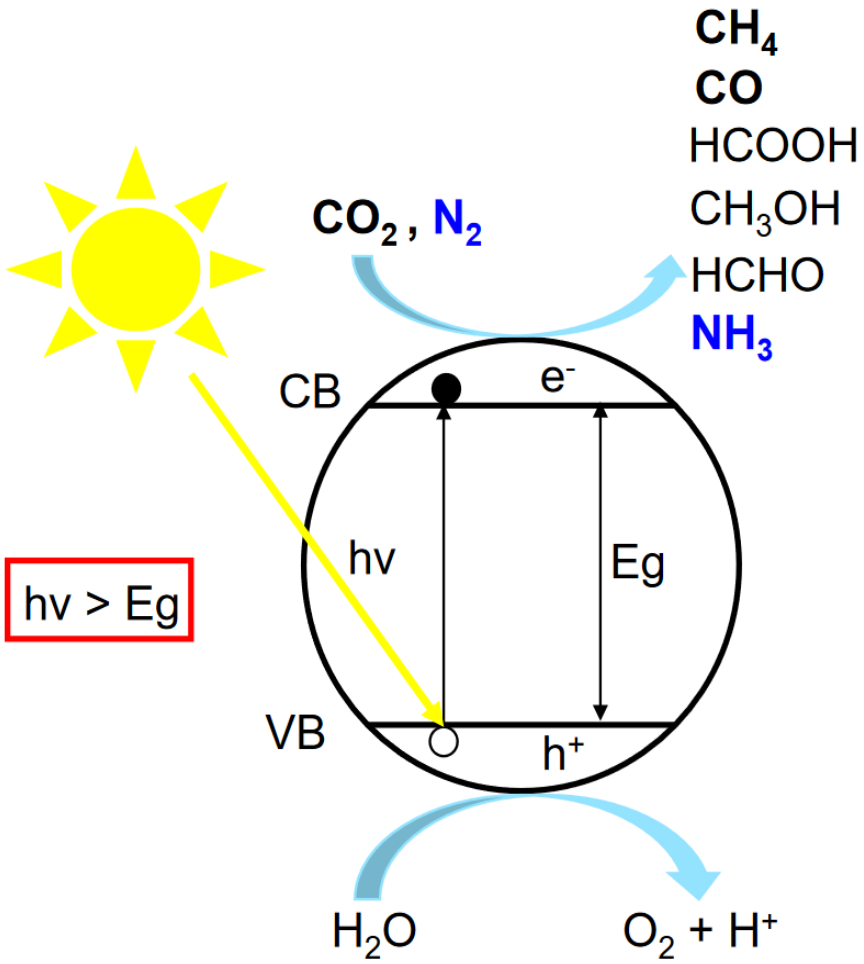
number of publications: **17**
number of applications/patents: **5**
number of conferences: **30**
number of students/doctoral students:
3 doctoral students, 12 students
number researchers: **12**

Motivation for this research

$CO_2 + 2H^+ + 2e^- \rightarrow CO + H_2O$

$CO_2 + 8H^+ + 8e^- \rightarrow CH_4 + 2\,H_2O$

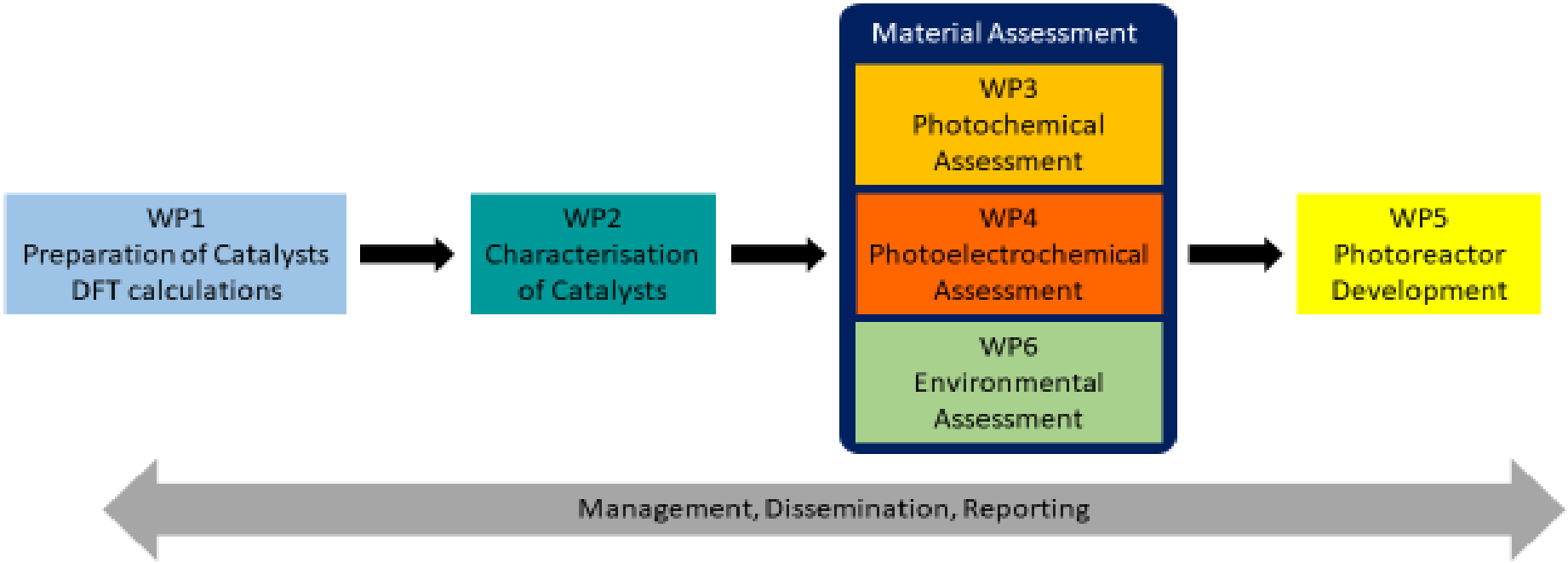
$2N_2 + 6H_2O \rightarrow 4NH_3 + 3O_2$



$H_2O + 2h^+ \rightarrow ½\,O_2 + 2H^+$

$2H^+ + 2e^- \rightarrow H_2$

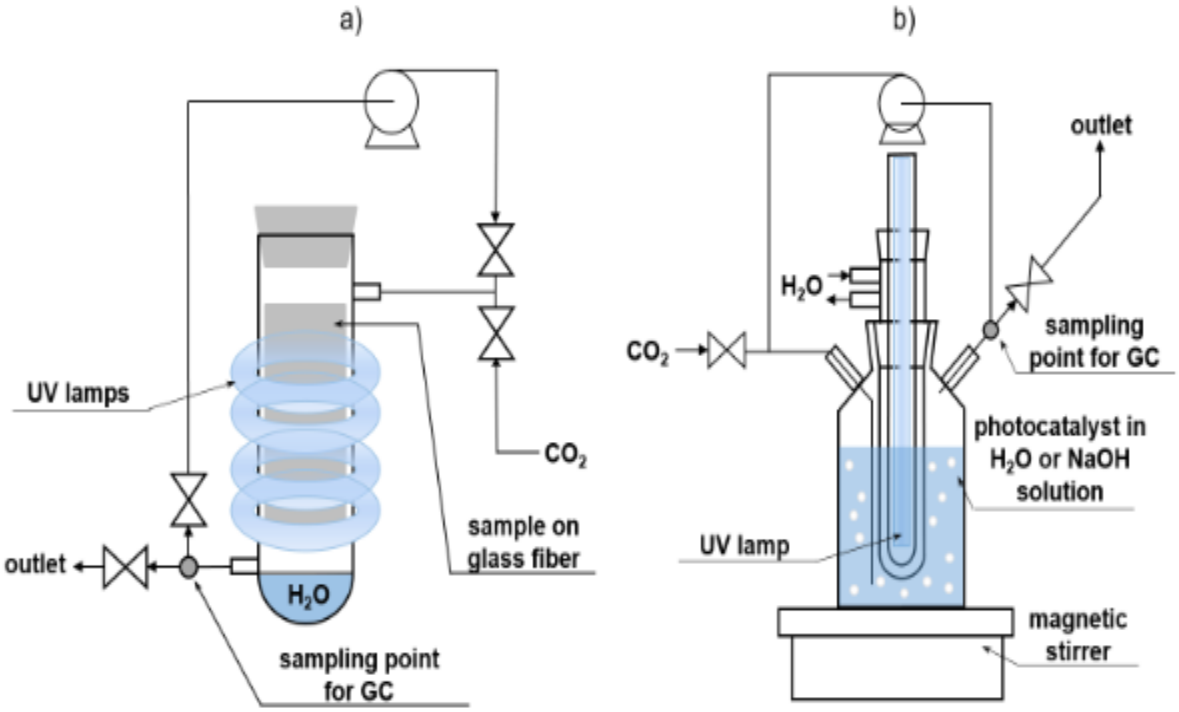
PhotoRed


WP1
Preparation of Catalysts
DFT calculations
WP2
Characterisation of Catalysts
Material Assessment
WP3
Photochemical Assessment
WP4
Photoelectrochemical Assessment
WP6
Environmental Assessment
WP5
Photoreactor Development
Management, Dissemination, Reporting

PhotoRed - objectives

- PhotoRed – continuation of the previous project, aiming to transform captured **CO_2 into useful chemical products** using photocatalysis
- Modification of **carbon sorbents** aiming to produce new photocatalysts (addition of **TiO_2** and **ZnO**)
- Aim – to transform at least **10 micromoles CO2/g/h** under UV radiation at ambient conditions. Stable actibity during at least 200 h
- Desing and construction of **quartz glass reactors** at the laboratory scale. Base to increase to scale and fabricate glass-eteel reactors.
- **Environmental** assessment of the produced photocatalysts
- **Promotion** of social awareness about **CCS** and **CCU** technologies

PhotoRed

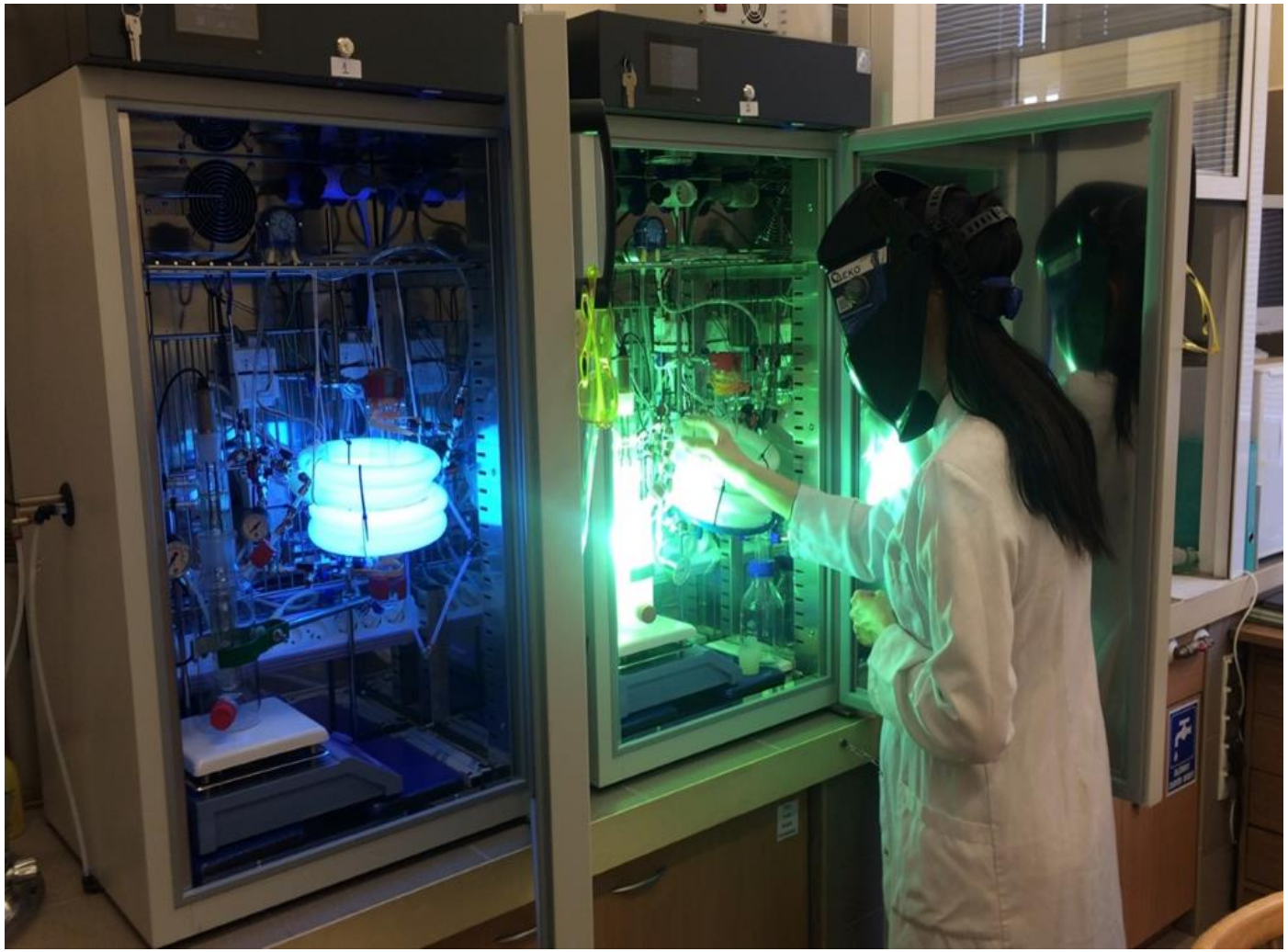


a) The scheme of the gas phase reactor

b) The scheme of the liquid phase reactor (*slurry*)

PhotoRed

Photoreactors in thermostatic chambers

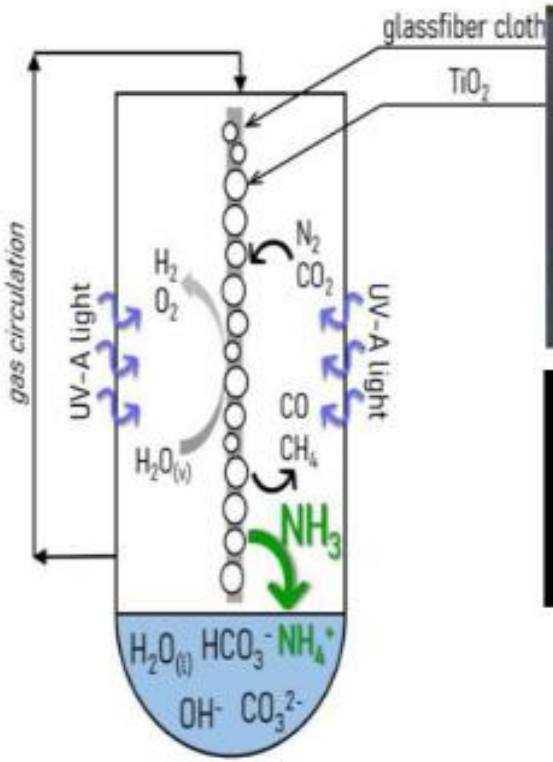


PhotoRed

Green ammonia

A.W. Morawski, U.Narkiewicz, K.Ćmielewska, E.Kusiak-Nejman, I.Pełech, P.Staciwa, E.Ekiert, D.Sibera, A.Wanag, M.Gano, *Sposób wytwarzania amoniaku i reaktor do wytwarzania amoniaku*, **P.439745** (06.12.2021).

P25



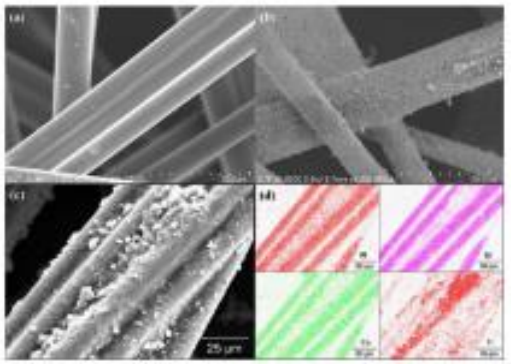
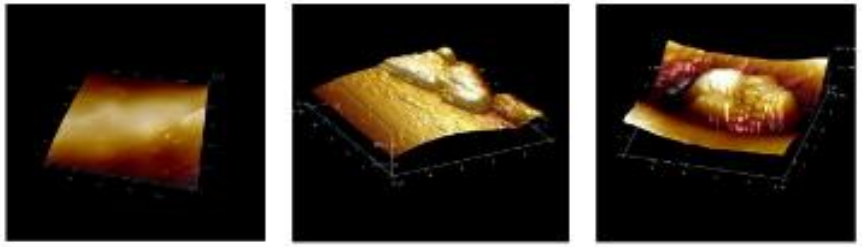


Figure 3. SEM images of pure glass fibres (a) and P25 coated glass fibres (b, c) and EDX chemical elements mapping (d) of area shown in (c)



a) b) c)

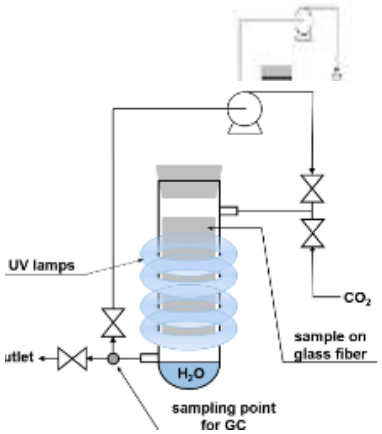
AFM scan images of

(a) pure fiber glass fabric

(b) fiber glass fabiric with TiO_2 P25 on surface of fiber

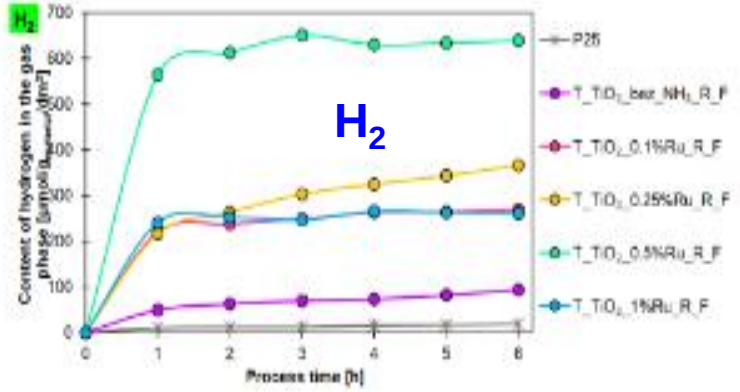
(c) fiber glass fabrics with TiO_2 P25 between two fibers

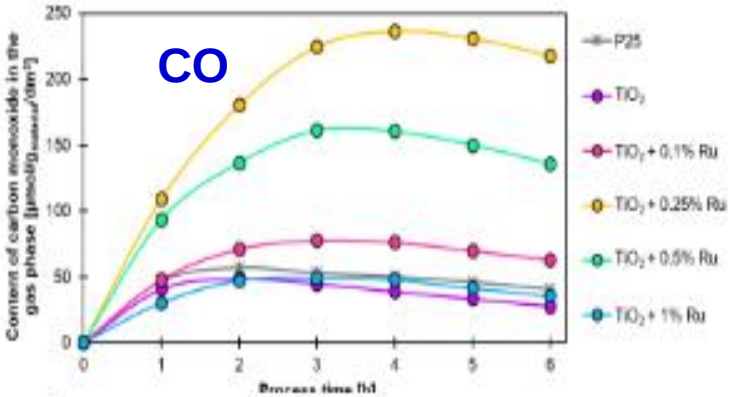
PhotoRed

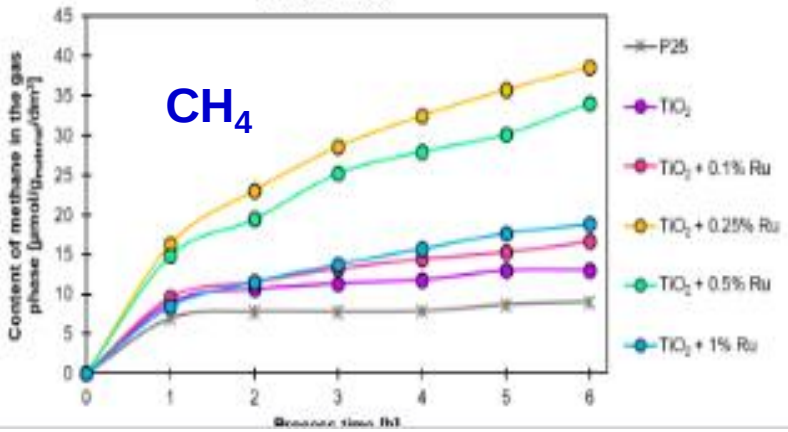


Ru/TiO_2

Gas phase







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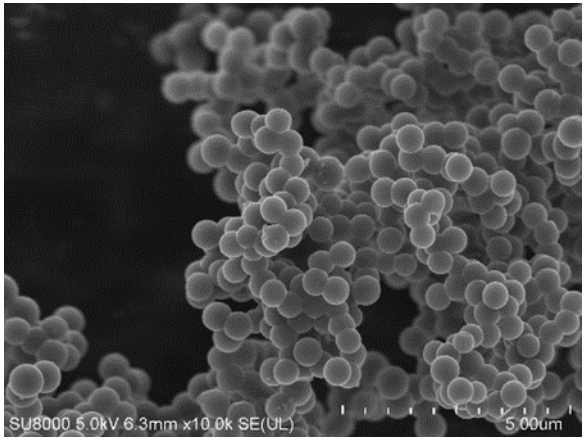
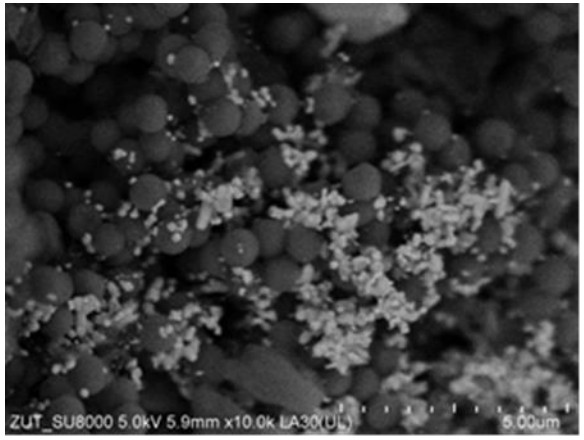
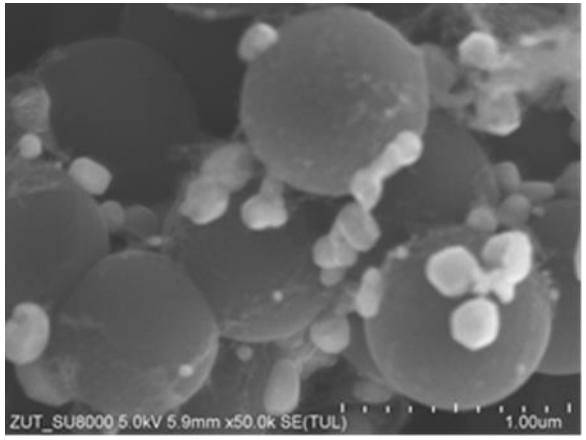
Example of a photocatalyst – carbon spheres

before



after ZnO addition





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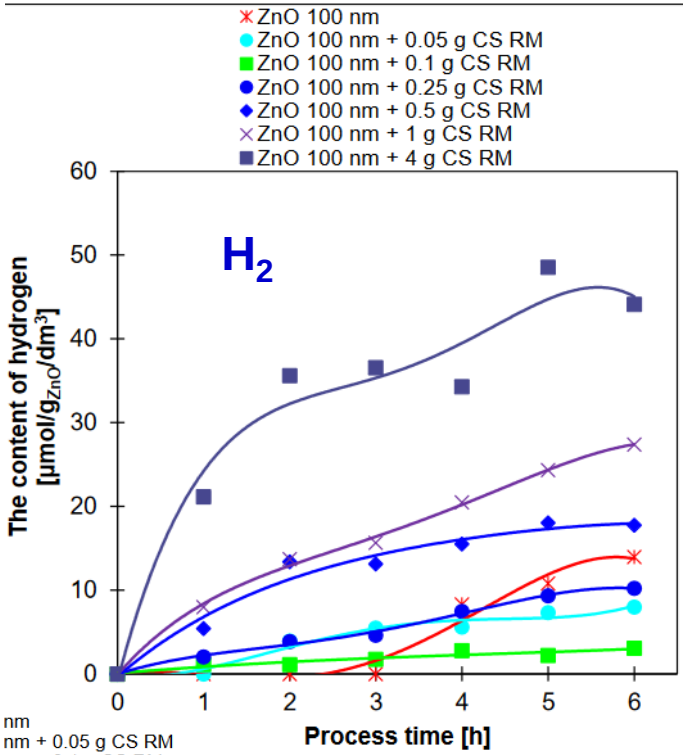
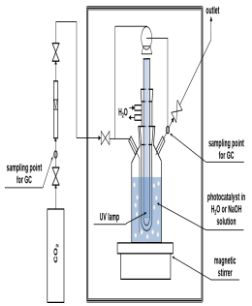
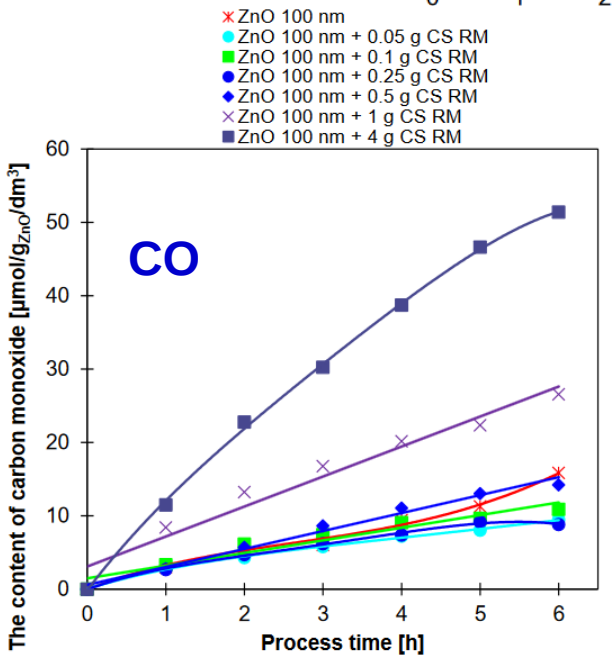
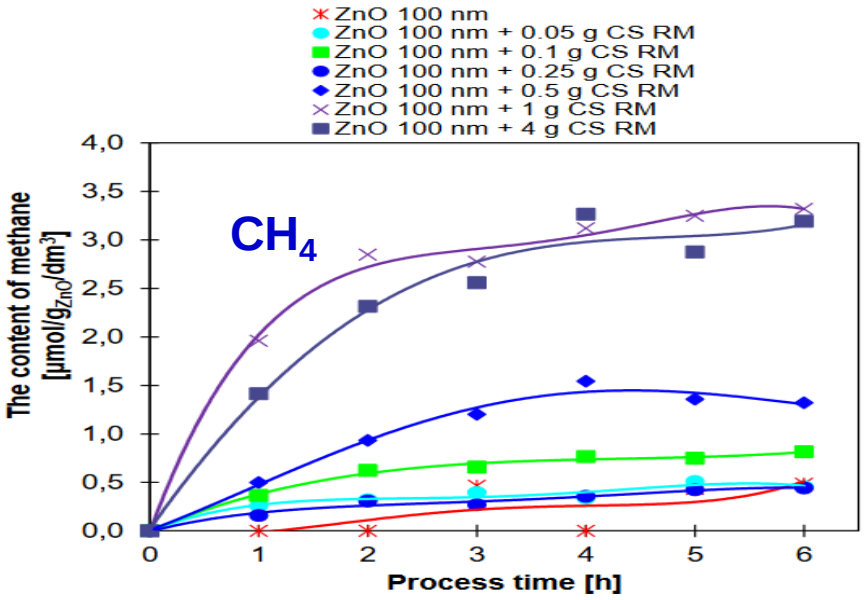




ZnO/CS slurry





FWD-Green-3 POL-NOR project 2023-2024 (prof. I. Pełech)

„Synergistic doping of titanium dioxide with metals and non-metals to produce hydrogen under UV and Vis light „

Value: **1 147 500,00 PLN**.

Consortium:

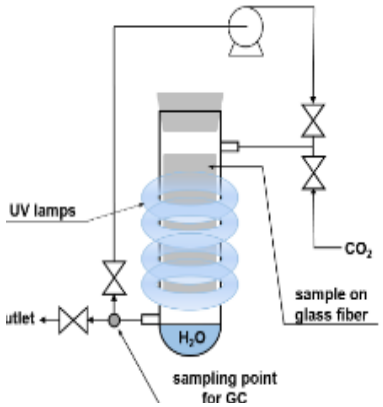
ZUT,

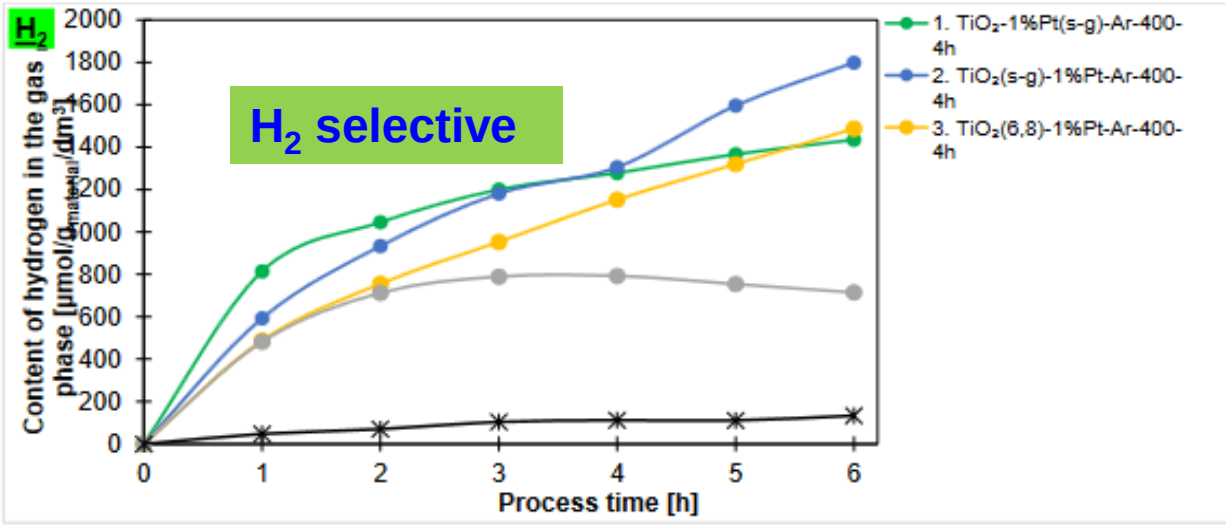
University of South-Eastern Norway,

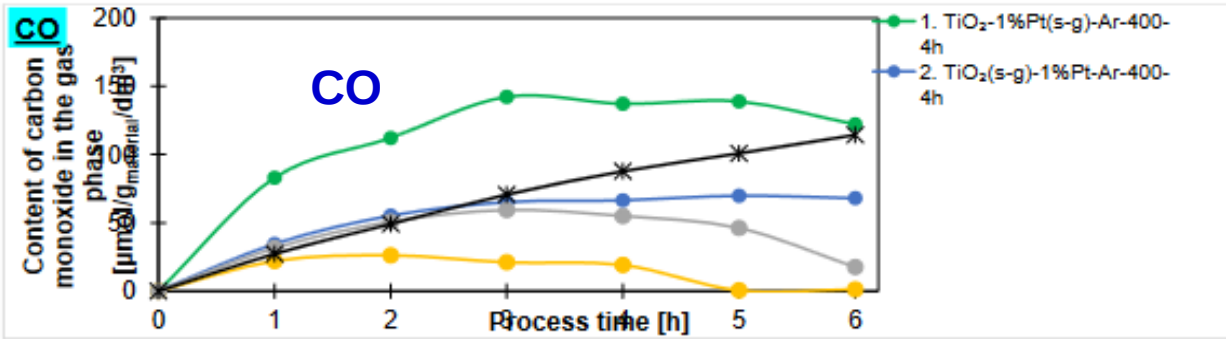
SINTEF Industry,

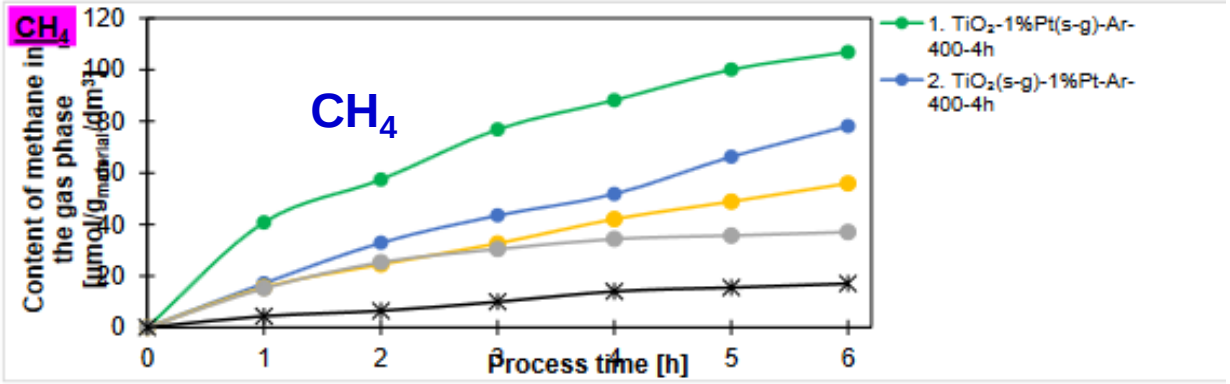
SINTEF Ocean

Pt/ TiO_2 gas phase









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SINTEF

The National Centre for Research and Development

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