2023 Master internship at University of Gdansk

TITLE : MOF-MOF heterostructures for efficient and selective CO_2 photoconversion into valuable chemicals

LAB & PEOPLE

- Name of the hosting lab: Photocatalysis Group (Department of Environmental Technology, Faculty of Chemistry, University of Gdańsk
- General activities of the lab: nanomaterials synthesis, photocatalysis, materials characterization
- Website: https://envir-tech.ug.edu.pl
- Number of staff / PhD: 10 staff members, 9 PhD students
- Supervisor name and contact: Paweł Mazierski (PhD), pawel.mazierski@ug.edu.pl

TOPIC OF THE INTERNSHIP

- Scientific context of the internship (max 20 lines)

One of the significant consequences of excessive fossil fuel consumption is the release of anthropogenic carbon dioxide (CO_2) emissions into the atmosphere, contributing to global environmental changes, including the phenomenon of global warming. To address this issue, scientists have been exploring methods to convert CO_2 into useful hydrocarbons through various processes, including photocatalysis [1][2]. Metal-organic frameworks (MOFs) have emerged as a promising class of hybrid crystalline materials for CO_2 conversion through chemical fixation and photocatalytic transformation [3]. These materials possess several advantageous properties, such as high specific surface area and controllable pore sizes, which make them attractive for efficient CO_2 conversion [4]. However, despite the use of different MOFs in CO_2 photoconversion, several limitations persist. These limitations include the low efficiency of separating photogenerated charge carriers and the mismatch between the abilities to effectively absorb light and adsorb CO_2, preventing the practical application of this technology [5][6].

The proposed research project aims to address these limitations by developing novel MOF-MOF heterostructure materials with strictly defined morphologies, including core-shell, yolk-shell, core-satellite, and asymmetric structures. These heterostructures offer the potential to enhance the overall performance of CO_2 photoconversion. The obtained heterostructures will be extensively characterized using various analytical techniques, including scanning electron microscopy (SEM), photoluminescence spectroscopy (PL), diffuse reflectance spectroscopy UV-Vis (DRS UV-Vis), Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, and X-

ray diffraction (XRD). Finally, the synthesized materials will be subjected to testing in the CO_2 photoconversion reaction under the influence of both UV-Vis and visible (Vis) irradiation.

Keywords : Photocatalysis, metal-organic frameworks, CO_2 photoconversion, heterostructures

Bibliography :

[1] Yang, Y., Ajmal, S., Zheng, X. & Zhang, L. Efficient nanomaterials for harvesting clean fuels from electrochemical and photoelectrochemical CO_2 reduction. Sustain. Energy Fuels 2, 510–537 (2018).

[2] Li, X., Yu, J., Jaroniec, M. & Chen, X. Cocatalysts for Selective Photoreduction of CO_2 into Solar Fuels. *Chem. Rev.* **119**, 3962–4179 (2019).

[3] Zhang, T. & Lin, W. Metal-organic frameworks for artificial photosynthesis and photocatalysis. Chem. Soc. Rev. 43, 5982–5993 (2014).

[4] Wang, J. L., Wang, C. & Lin, W. Metal-organic frameworks for light harvesting and photocatalysis. ACS Catal. 2, 2630–2640 (2012).

[5] Chang, X., Wang, T. & Gong, J. CO2 photo-reduction: Insights into CO_2 activation and reaction on surfaces of photocatalysts. Energy Environ. Sci. 9, 2177–2196 (2016).

[6] Li, K., An, X., Park, K. H., Khraisheh, M. & Tang, J. A critical review of CO_2 photoconversion: Catalysts and reactors. Catal. Today 224, 3–12 (2014).

Tasks and duties entrusted to the student:

As an intern in our research project, you will be responsible for the following tasks:

1. Synthesis of MOF-MOF heterostructures. You will be tasked with synthesizing selected MOF-MOF heterostructures using two-step process or one-pot process.
2. Characterization of obtained materials. After synthesizing the MOF-MOF heterostructures, you will perform comprehensive characterization using various techniques (SEM, PL, DRS UV-Vis, FTIR, Raman, XRD, specific surface and porosity analyzer).
3. CO_2 photoreduction experiments and product analysis. In this task, you will perform CO_2 photoreduction experiments using the synthesized MOF-MOF heterostructures. The goal is to investigate the effectiveness of the heterostructures in converting CO_2 into useful hydrocarbons under the influence of UV-Vis and visible (Vis) irradiation. After the CO_2 photoconversion reaction, you will analyze and identify the products using GC-MS and GC-FID. This analysis will enable you to determine the efficiency and selectivity of the CO_2 photoconversion process and identify the specific hydrocarbon products generated.

Skills to be acquired or developed:

The student will strengthen his skills in photochemistry, materials synthesis and laboratory practice, as well as the techniques for materials characterization. A report with the obtained results will be written at the end of the internship.

PROFILE OF THE DESIRED STUDENT

- Minimum level of study required: **End of Bachelor**

- Field(s) of study: **Chemistry, Environmental Technology, Materials engineering and related fields**

- Scientific skills: **basics of inorganic, organic and analytical chemistry**

- Language skills required: **English (spoken, written)**

THE INTERNSHIP ASSIGNMENT:

Desired duration of the internship (in months): **from 3 to 6 months**

Desired Starting date of the mission: **November 2023 – June 2024**

Indicative weekly schedule: *35h / week*

Remuneration:

Erasmus grant: could be asked to your own university

Internship agreement: *an internship agreement will be signed.*

To SEA-EU students:

If you're interested please send your CV and letter of motivation to the scientist in charge, email : pawel.mazierski@ug.edu.pl before the date 01/11/ 2023.