1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: Emerging Carbon Materials for Solar Harvesting

1.1. Project goals

The main objective of the project is the design of highly effective, novel materials for thermal energy storage. The main question to answer is whether or not carbon-based nanocomposites can work as active and stable adsorbents/desorbbents for water and/or other vapors in solar evaporators. We would also like to explore the role of nitrogen heteroatoms incorporated into the carbon matrix and the role of porosity on storage efficiency.

The particular goals:

- Designing the adsorbents - synthesis and full physicochemical characterization of C-based composites using adsorptive and spectroscopic techniques
- Surface properties optimization
- Recovery of drinking water from brine

1.2. Outline

The water scarcity crisis has become a serious global challenge. Freshwater production from seawater or wastewater by utilizing solar energy provides a promising approach to alleviate water scarcity in an eco-friendly and cost-effective way. Interfacial solar vapor generation (ISVG) has attracted increasing attention by using solar heating to evaporate water in a high-efficiency strategy. ISVG offers a sustainable method for access to clean freshwater resources, power generation, sterilization, and catalysis. In an ISVG system, rational design on evaporate structure to enhance light absorption and heat utilization is essential for improving solar vapor conversion efficiency. Recent advances in photothermal materials have identified several promising candidates

for solar absorbers. For example, precious metallic materials have an extremely high carrier concentration of free electrons in light−matter interactions, semiconductor solar absorbers possess a highly tunable energy bandgap, and carbon materials have a high density of 2D free electrons and a semiconductor-like band structure.

In the project Herein, we proposed a high-efficiency Janus structured interfacial solar vapor generation (J-ISVG) by a solar photothermal conversion and heat confinement integrating strategy.

1.3. Work plan

1. **Carbon-matrices synthesis. (i) amorphous carbons (based on biocarbons), (ii) Graphene oxide, (iii) reduced graphene oxide,**
2. **Nitrogen-doping.** Various amount of doped nitrogen will be introduced to carbon materials to investigate its effects on the catalytic efficiency.
3. **Nanocomposites synthesis.** The hybrids of the C-matrix and single- bi-, and tri-catalytic systems deposited on carbons will be synthesized.
4. **Porosity measurements.** The low-temperature nitrogen adsorption measurements: surface area and volume; H_2O, NH_3, CO_2 will also be used as adsorbate to characterize the material.
5. **Full phys-chem characterization;** all available techniques will be used:
   - SEM/EDS: the size, shape, surface texture and morphology of the crystals, and chemical composition;
   - HRTEM/EDX: the pore size, internal structure and morphology of crystals, helps to analyze the chemical composition of materials;
   - TG: thermal stability of prepared nanomaterials; this technique is a good method to check whether the MOF has been sufficiently activated (no residual solvent molecules);
   - PXRD: the crystal structure, phase composition;
   - Sorption of NH_3, CO_2 and H_2O combined with spectral studies - determination of chemical properties and mechanism of splitting; for the in situ IR study the pelletized samples will be exposed to particular gas.
   - Additionally, the obtained materials will be fully characterized spectroscopically: XPS, IR, RS.
6. **Finally, the evaporation process of H_2O** (distilled, tap or brine) will be evaluated.

7. The results are expected to be published in high-impact-factor scientific journal.

The results obtained during the project realization
- Activity and selectivity of newly synthesized composites
- Description the process mechanism

will be published in high-impact-factor scientific journal

1.4. **Literature** *(max. 7 listed, as a suggestion for a PhD candidate preliminary study)*

1. Wiśniewski, et al, Synthesis of High Surface Area, Carbyne-Derived, Acidic Nanocarbons Obtained from Municipal Wastes for Daily Sorption Thermal Battery Cycle
DOI: ***10.1002/smll.202412754***

2. *Hou, et. al, J., High-Performance Janus Solar Evaporator for Water Purification with Broad Spectrum Absorption and Ultralow Heat Loss, DOI:* ***10.1021/acsenergylett.2c02567***

1.5. Required initial knowledge and skills of the PhD candidate

- knowledge on chemistry
- basic understanding of catalysis
- understanding of chemical and material's characterization techniques
- analytical thinking and skills
- open to challenging tasks and creative
- hard-working person, eager to learn

1.6. Expected development of the PhD candidate's knowledge and skills

- ability to plan and organize laboratory work
- skilled in novel scientific techniques
- ability to solve research problems
- innovative thinking
- ready to work in an international research group