COST
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Report on the outcomes of a Short-Term Scientific Mission[1]

Action number:

Grantee name:

Details of the STSM

Title: **Investigation of Porous Ni:FeOOH and MoS2 Co-catalysts for Enhanced Photoelectrochemical Water Splitting**

Start and end date: 19/06/2023 to 13/07/2023

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

The proposed plan focused on combining the strength of both groups together. Kafizas group (host) has expertise in the fabrication of metal-oxide films for photochemistry, and Borenstein (guest) specializes in optically active carbon nanomaterials. The idea was to use advanced methods to composite porous metal oxides with carbon and investigate the effect of the carbon on the optical properties of the metal oxides.

As I come to the host PI and group, I found a very collaborative approach. In a couple of days, I received access to the lab and other research facilities and safety training. I started actual work in lab the second week of my stay in ICL. Unfortunately, the combinatorial CND system was down and its main operator, Yunkai Li (PhD student) spent most of his time fixing it.

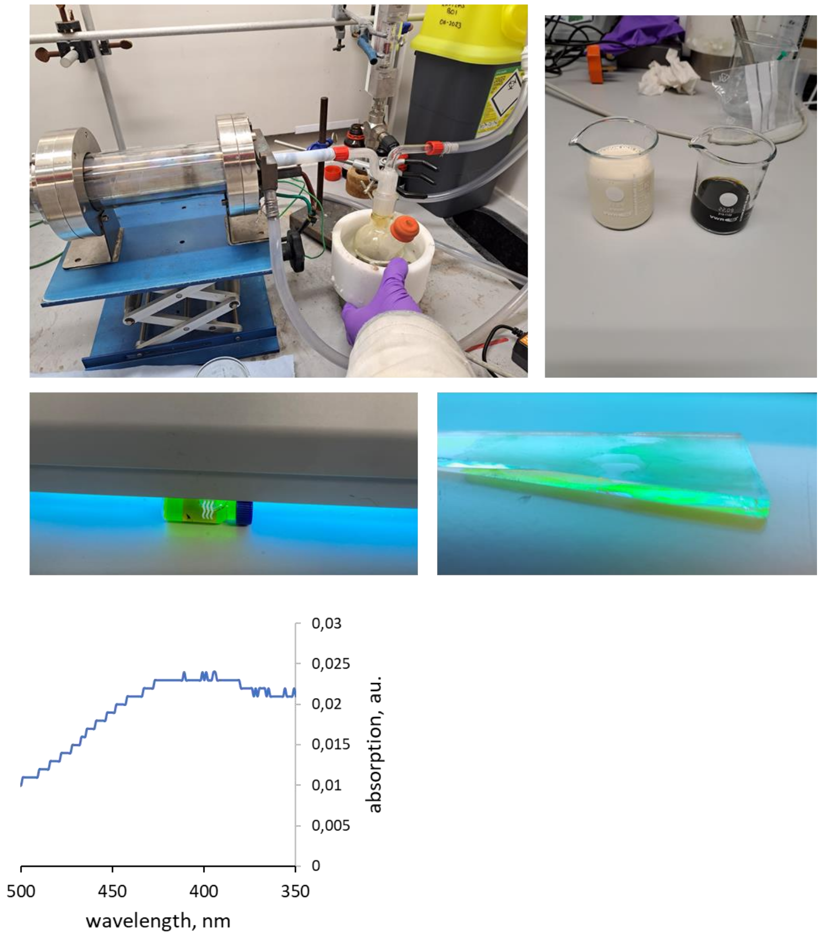
Nevertheless, I overcame this obstacle by finding an opportunity to implement the concept of compositing optically active metal-oxides with carbon materials.

1. Aerosol CVD of bilayer Ni:FeOOH and carbon nanodots

The first project I carried out was applying carbon nanodots (CND) layer on porous films of Ni:FeOOH films using aerosol CVD (A-CVD) instead of the C-CVD that went down. In this method, the carbon nanodots were prepared separately (in a microwave system, another new approach learned by the hosts) and, after dispersion, were applied onto a glass substrate. A picture of the A-CVD system is presented in Figure 1a. The dispersion is filled in the round-bottom flask, with is placed in an ultra-sonic machine to form the aerosol. The CNDs are small and light enough (2 nm in diameter and approximately 10,000 dalton for each

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

nanodot) to be carried away in the stream of the aerosol. The evaporation then enters the CVD chamber and coat the glass substrate, heated to 250 ºC. The successful experiment was easily proved since CND are fluorescent (see Figure 1c). Moreover, the glass was measured in UV-vis spectrometer and the spectra approved the presence of CND (see Figure 1d). Finally, the optical absorption of the coated film was measured. The spectra reveal a maximum at 420 nm that matches the absorption of CND. The actual water splitting test for this bi-layered film was not measured yet. But is one of the experiments palled in future.



2. BiOBr/TiO2/carbon nanodots for NO photo-oxidation

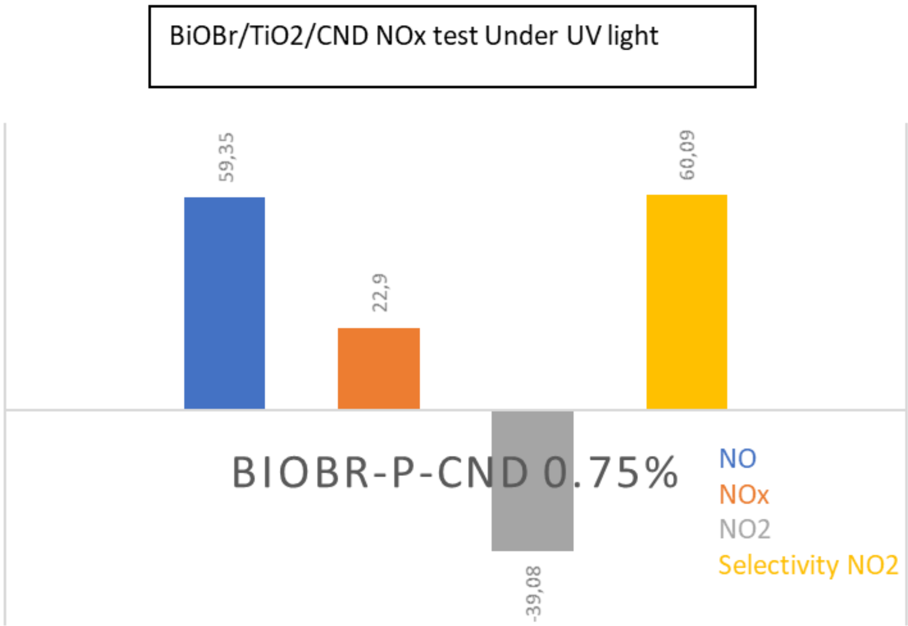
A second project I carried out in the lab was the incorporation of photo-active carbon nanodots in BiOBr for photo-oxidation of NO. Dr. Paransa Alimar was working on porous Bismuth-oxides thin films for photo-derived NOx oxidation. She was just starting a new stage in the project combining graphene in her material and my arrival was just in time. We spent a lot of time together. Since I have more experience in carbon nanomaterials and graphene, I helped her a lot in aspects of fabrication (such as Hammer method from graphite), dispersion, and microscopy and spectroscopy characterization. There was a significant progress in this study.

The findings from this study are presented in Figure 2. In this experiments, the composite exhibited a remarkable 59.35% NO removal efficiency, accompanied by a high conversion rate to NO2 at 60.09%. The NOx test was conducted under UV irradiation at a wavelength of 352nm, with a humidity level of 50%. The initial NO concentration was set at 1 ppm, and the flow rate was maintained at 3 sccm (standard cubic centimeters per minute).

Comparing the NOx test results of the BiOBr/TiO2 composite with and without the addition of CND, we observed that the presence of CND did not significantly alter the NO removal percentage capacity of BiOBr/TiO2. However, it resulted in a slightly lower production of NO2 during the oxidation process of NO, reducing it by approximately 4%.

Here are the NOx test results of BiOBr/TiO2 using the same experimental conditions:

	P25-BiOBr	P25-BiOBr-CND
NO reduction%	59.297	59.35
NOx reduction%	28.513	22.9
NO2 generation%	-32.265	-39.08
NO2 selectivity%	64.421	60.09



Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

The STSM exceeded its intended objectives, yielding remarkable results. Through active participation, I acquired valuable knowledge in aerosol CVD synthesis methods and successfully prepared functional porous composites that demonstrated substantial advancements in photo-catalysis experiments. Furthermore, I explored a novel application involving the photo-oxidation of NO, which was not initially planned but perfectly aligns with my ongoing research in my lab in Israel. This aspect of the STSM significantly contributed to the overarching goals of the NET-PORE action, as we established a groundbreaking synthesis route for porous semiconductors.

The core essence of the STSM, which revolves around knowledge and experience exchange, was thoroughly fulfilled. Apart from enhancing my expertise in new methods and applications, I had the opportunity to share my own insights into nanocarbon with others. This collaborative environment led to a decision to continue and deepen our joint projects, with students from both groups participating actively.

In addition to the substantial work accomplished, the STSM provided an excellent networking platform. I had the privilege of meeting distinguished researchers, such as Prof. Geoffrey Ozin, a prominent figure in nanoscience, and Dr. Eslava Salvador from ICL Chemical Engineering, with whom I engaged in insightful discussions and received an invitation to visit his lab. Moreover, I had a fruitful scientific exchange with Prof. Daren Caruana of UCL, focusing on gas electrochemistry. Despite the scarcity of ionic gas research, Caruana's group employs a fascinating approach using plasma. Our meeting was mutually inspiring, leading us to decide to continue our collaboration in the future.

Overall, the STSM not only achieved its planned goals but surpassed expectations, fostering significant advancements in both my research and the objectives of the NET-PORE action. The valuable connections made during the STSM are set to create further opportunities for productive collaborations in the field of nanoscience.