

Report Doctoral thesis:

Preparation and characterization of nanocomposite thin films for electronic and catalytic applications.

Author: **Hassan Ali, M.Sc.**

The thesis addresses a topic of great interest such as the study and the development of novel photocatalytic materials for environmental applications, especially water pollutant remediation. To get this purpose the research conducted by the PhD candidate Ali Hassan was focused on the design and preparation of highly efficient photocatalytic material mostly by band engineering. For that reason, his first approach was to prepare pristine photocatalysts and their combination to form heterostructures in the form of Z-scheme, tuning the band for the selected application. Although the idea of band engineering is not relatively new, the approach of the doctoral student and his supervisors opens the option of the further advance on the understanding of the photocatalytic processes and the development of those materials for highly efficient in the elimination of persistent environmental pollutants and hormones and at the same time, to use them for antibacterial activity. The selected materials were characterized to get the basic characteristics from a structural and optical point of view. Moreover, the use of these photocatalytic materials in the form of thin film layers, as a strategy for the recyclability and stability of the photocatalytic effect of the materials bring them the possibility of pilot-scale implementation and further develop of the functionalization of those materials. Finally, the use of modification strategies such as NPs decoration or surface plasmon technique implies a novel approach that increases the ability of these materials for the suggested applications.

The goals of the thesis are well and clearly defined and the methodology used for the development of the thesis has been adequate, beginning with the study of the state of the art by the doctoral student, finding those aspects that required the appropriate modification. In summary, the thesis developed by the doctoral student Ali Hassan is well structured from the conception of the problem to be solved to the necessary modifications of the synthesis of the materials through the characterization and subsequent application of the studied materials in lab-scale conditions.

It should be mentioned that the PhD student Ali Hassan has an interesting record of publications, with 6 manuscripts published in Q1-Q2 journals, all of them closely related with the topic of the thesis, together with his participation in 5 international conferences, indicative of the high research level conducted during his thesis.

Also, I highly appreciated that the PhD students not only showed the successful results of his thesis but also the weakness of that research. In this sense, the conducted research not only solves the proposed goals but also opens the way to continue the research in the field of efficient photocatalytic materials and water pollutant remediation.

In this sense, some questions should be done to clarify part of the results:

1. During the analysis of the Nanocrystals size obtained with the different structural characterization the PhD student claims that the average domain area size of WO₃ NCs is around 10-50 nm for. However, in SEM and TEM figures no images of the individual NCs

are observed even at higher magnification. As you correlated with XRD, can you explain why even at TEM magnification of 20 nm scale is not possible observed individual NCs of WO₃?

2. At the same time, by Raman spectroscopy you declare that the peaks of WO₃ became weaker due to possibly strong charge interaction, increase of disorder, or exciting laser absorption at 532 nm. Can you explain more precisely these three aspects? Also, which other technique can avoid the 532 nm adsorption that reduces the intensity of the signal in Raman?
3. In Pore size distribution analysis, Do you have some explanation about the reason why the two peaks merged in one in case of the sample with 10 wt% of Cu₂O?
4. In the FTIR analysis, in figure 7.3, is the peak at 812 cm⁻¹ overlapping the peak at 802 cm⁻¹ that is mentioned in the text? Because you claim that the peak at 812 cm⁻¹ is associated with Si-O symmetric bond vibration, however no clear peak associated to the stretching of W-O-W bonds is observed at 802 cm⁻¹ and is the only one that is referring to the presence of WO₃ in the nanocomposite.
5. Tipo in pag. 69, could fig. 7b and 7c be Fig7.8b and 7.8c?
6. Regarding water pollutant remediation, your studies were focused on the degradation of two hormones estrone (E1) and estriol (E3)? What about E2 hormone? Why is the reason or key factor for what you choose these hormones? Can the photocatalyst also be effective against other hormones? If yes, which ones do you suggest and in which way?
7. Are you expecting to continue with antibacterial tests of your systems? Which other techniques can be used to determine the antibacterial activity of your catalysts?

As a conclusion, The PhD thesis of MSc. Ali Hassan entitled: **Preparation and characterization of nanocomposite thin films for electronic and catalytic applications**, fulfils the criteria/requirements for the PhD thesis. I recommend accepting the submitted PhD thesis for its defense at the Univerzita Tomáše Bati ve Zlíně and after its successful defense to award MSc. Ali Hassan the academic title “philosophiae doctor” (PhD.) at Univerzita Tomáše Bati ve Zlíně.

In Trenčín, on 6th September 2023

Ass. Prof. José Joaquín Velázquez García, PhD

Head of Department of Functional Materials

FunGlass – Centre for Functional and Surface Functionalized Glass

Alexander Dubček University of Trenčín

Študentská 2

911 50 Trenčín, Slovakia

Tel: +421 32 7400 518

jose.velazquez@tnuni.sk

www.funglass.eu.