IChF Institute of Physical Chemistry
Polish Academy of Sciences

Juan Carlos Colmenares Quintero, Ph.D. D.Sc.
Full Professor
Research group leader
"Catalysis for sustainable energy production and environmental protection, CatSEE"

Kasprzaka 44/52, PL-01 224 Warsaw, Poland
Tel.: +48 22 343 3215
Fax: +48 22 343 3448
jcarloscolmenares@ichf.edu.pl
http://photo-catalysis.org/

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Review of the PhD thesis of mgr inż. Jakub Szewczyk
Entitled „Development and Characterization of Polydopamine/Semiconductor Laminar Heterostructures for Efficient Photocatalytic Applications"

In the group of currently researched and developed methods for energy and environmental applications, the search for new materials in heterogeneous photocatalysis occupied one of the highest positions.

The doctoral dissertation submitted for review covers such issues as:

1. Physical and surface chemistry,
2. Nanomaterials, nanotechnology,
3. Heterogeneous photocatalysis: development of large-scale heterogenous photocatalytic systems through the fabrication of tailored high-quality films that could be effectively used to construct new types of organic/inorganic heterostructures on a large scale.
4. Environmental protection (detoxification of water and air).

This doctoral thesis was executed thanks to the research collaboration between two research institutions, NanoBioMedical Center Adam Mickiewicz Univeristy in Poznań (Poland), and European Institute for the Membranes at the University of Montpellier (France) under the direct supervision of Dr hab. inż. Emerson Coy, and Dr Mikhael Bechelany (hDr), respectively from those institutions.
This collaborative thesis contains 34 pages of a general introduction where the author concisely and systematically is presenting the work of his six (6) scientific publications which are the based for this PhD thesis.

The thesis is written in English with summaries in Polish and French. The experimental results of the thesis have been a part of four papers already published in the JCR journals. Thus, all these studies have already been reviewed before, and with the Thesis, I have received all co-author's statements that specifically described the participation of all people involved in the articles based on what this thesis is constructed, and it indicates the substantial involvement of Mr. Szewczyk in making these articles a reality. The doctoral dissertation of mgr inż. Jakub Szewczyk is organized into eight chapters. The Chapter 1 is a general introduction on the principles of heterogeneous photocatalysis, then in the Chapter 2, one can find the main goals and research theses of this PhD dissertation. In the Chapter 3, the author explains the research methodology used, passing to Chapter 4 where the whole spectrum of systematically obtained results are presented following the sequence of six (6) perfectly connected articles (included in the Thesis in their original form as published). This series of articles is related, firstly with two review articles where the author explain exhaustively the different methods of polydopamine (PDA) preparation, and its applications, and subsequently, the author developed the whole research hypotheses (four theses) demonstration and main findings through four logically connected experimental-based articles. Finally the thesis contains the final conclusions (Chapter 5), future perspective (Chapter 6), the scientific achievements of Mr. Szewczyk (Chapter 7), and finalizing with the literature (117 citations, apart from the citations already included in each of the articles supporting this doctoral dissertation, Chapter 8).

The main goal of this PhD thesis was to develop a novel, efficient, large-scale, laminar nanocomposite for photocatalysis based on polydopamine (PDA), and well selected transition metal oxides: TiO_2 and ZnO. What I consider highly innovative and worth highlighting from this dissertation are the following elements:

- The author is proposing a totally new system as photocatalyst rather than improving the currently existing ones in the open literature.
- Well-interconnected four (4) thesis, and four complementary and logically connected work packages.
- In the "Research Methodology" section (pages 28-38), the author did precise and comprehensive work on the scientific and complementary values of all six presented publications, which he later included as annexes in Chapter 4, given the information on the thesis-connected articles and his contribution.
- The selection with wisdom is based on the profound state of the art of such a prominent candidate as biomimetic polymer polydopamine (PDA). There is a lot of room to play with: The structural and mechanical properties of PDA nanostructures vary between synthesis strategies.
- The author formulated four main research theses, which were corroborated in his presented experimental-based articles.
- The precise mechanism was investigated on the photocatalytic photodegradation by using scavengers,
- The discovery of a new technique for doping oxide (TiO_2 and ZnO) layers with nitrogen during the experiment. In this method, nitrogen atoms occupied both substitution and interstitial positions of the TiO_2 lattice.
- The high level of control of synthesizing the a/w-PDA free-standing films within a centimeter scale, utilizing a novel Spectroscopic Reflectometry method. A detailed investigation of the mechanism of the PDA-based layers was conducted by changing synthesis conditions.

Below, I would like to mention some of my minor remarks or questions. They do not in any way detract from my positive assessment of the work of mgr inż. Jakub Szewczyk, and I hope to get the answer of them during the PhD defense.

i The objectives collected close to the hypothesis were missing for me in this thesis.

ii More details on the analytical methods used for the reaction assessments (like, GC, GC-MS).

iii If the potential of PDA for scaling up is remarkable, the author should consider carrying out (even on the lab scale) the Life Cycle Assessment and Techno-economic analysis of the PDA production (selecting a well-defined application, for instance, heterogeneous photocatalysis for water detoxification).

iv At which real level of Technology Readiness Level (TRL) is the synthesis of your material? How can the issue of increasing the TRL will be resolved?

To recapitulate, I state that the dissertation presented for evaluation as written by mgr inż. Jakub Szewczyk meets the standards encompassed in Article 187 of the Act of July 20, 2018 Law on Higher Education and Science (Journal of Laws of 2023, item 742, as amended) in Poland, hence the Council of the Faculty of Chemistry of the Adam Mickiewicz University, is requested for approval of PhD candidate to adhere to the next phase of the doctoral defense. Furthermore, in my judgement the submitted thesis by Mr Szewczyk ought to be considered in distinguished category. The strong reasoning for that is apparent from:

- The six high quality papers which support his thesis and other scientific works published by Mr Szewczyk in excellent journals (total impact factors of all publications: 50.2), and equal number of presentations in international meetings.
- Principal investigator in a research project Preludium 20, and active participation in few other research projects.
- The author has received a few awards, among them: Scholarship for Doctoral Students of the AMU Foundation (2022, for scientific achievements during doctoral studies), and Scholarship of the Minister of Science and Higher Education for Students (2019, For scientific achievements in the academic year 2018/2019).
- mgr inż. Jakub Szewczyk has excellent mobility experience through a few international internships in Europe.

I see all of the above as a sign of arduous work and the ability of the candidate to collaborate with the supervisor and collaborators (listed as co-authors). This is a proxy of the candidate's maturity as a scientist and the potential to become a leading researcher in the future. Besides, ample discussion, rational interpretation of the results, and proposed exploratory future possibilities are commendable efforts. Hence, I invite the Council of the Faculty of Chemistry of the Adam Mickiewicz University in Poznań to deliberate bestowing 'distinguish' stature to this thesis.

Sincerely yours,

Institute of Physical Chemistry PAS
Kasprzaka 44/52
01-224 Warsaw, Poland

Prof. dr hab. inż. Juan Carlos Colmenares Quintero