Review Report on PhD Thesis

Faculty: **Central European Institute of Technology**
Brno University of Technology in Brno

Academic year: **2023/2024**

Student: **Akshay Kumar Kandambath Padinjareveetil**

Doctoral study program: **Advanced Materials and Nanosciences**

Field of study: **Advanced nanotechnolgies and microtechnologies**

Supervisor: **Prof. RNDr. Martin Pumera, Ph.D.**

Reviewer**:** **Prof. Salvador Pané Vidal**

PhD thesis title: Designing novel catalyst loaded electrode materials towards electrochemical sensing to energy applications

Topicality of doctoral thesis: The dissertation presents several strategies for the manufacturing of electrocatalysts optimized to produce hydrogen and ammonia. The investigation is focused specially in 2D materials such as graphene, MXenes, transition metal dichalcogenides, but also in MOFs and tricalcogenphosphides. The work done in this thesis also capitalizes on 3D printing as a manufacturing approach to process electrocatalysts. This manufacturing strategy is further investigated for healthcare applications such as electrochemical sensors and emergency applications (e.g. COVID 19).

Meeting the goals set: While the goals of the thesis were ambitious, they have been accomplished successfully. The PhD applicant has published 9 papers in peer-reviewed prestigious journals including Advanced Materials Interfaces, Electrochemistry Communications, ACS Applied Electronic Materials, ACS Applied Materials and Interfaces, among others.

Problem solving and dissertation results:

The study addresses critical challenges in electrocatalyst synthesis and performance evaluation, particularly in the context of the hydrogen evolution reaction (HER). Through systematic experimentation and comparison of various synthesis strategies, the research aims to identify optimal methods for fabricating electrocatalysts with superior activity and stability. By investigating both covalent and non-covalent synthesis routes and assessing their efficacy in anchoring palladium nanoparticles, the study endeavors to elucidate the underlying mechanisms influencing catalytic performance.

The dissertation presents compelling findings regarding the synthesis and performance evaluation of electrocatalysts for HER. Notably, covalently bonded electrocatalysts display enhanced performance compared to their non-covalent counterparts, attributed to their ability to anchor a higher density of Pd

nanoparticulates. Furthermore, among the examined MAX phase electrocatalysts, Mo_2TiAlC_2 emerges as a promising candidate with superior HER activity. The integration of 3D printing technology for electrode fabrication demonstrates significant potential for cost-effective production and customization, offering promising avenues for energy conversion and electrochemical sensing applications.

Importance for practice or development of the discipline:

The findings in this dissertation carry substantial significance for the advancement of electrochemical science and technology. By elucidating key factors influencing electrocatalyst performance (specifically in addressing parameters such as physicochemical properties of the surface) and presenting effective synthesis strategies, the research contributes to the development of tailored catalysts for specific applications. Moreover, the identification of promising electrocatalyst candidates and the utilization of innovative fabrication techniques such as 3D printing hold promise for addressing pressing challenges in energy and sensors. The dissertation's insights offer valuable guidance for researchers, engineers or end-users seeking to enhance the performance and applicability of electrochemical systems.

Formal adjustment of the thesis and language level:

The language level is excellent. No formal adjustments are required.

(4) The study is duly completed by a state doctoral examination and the defense of a dissertation, which proves the ability and readiness for independent activity in research or development or for independent theoretical and creative artistic activity. The dissertation must include original and published results or results accepted for publication.)

Conclusion:

In my opinion, the reviewed thesis fulfills all requirements posed on theses aimed for obtaining PhD degree. This is ready to be defended orally, in front of respective committee.

In Zürich, 06/02/2024

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Prof. Salvador Pané Vidal