Review Report on PhD Thesis

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

Academic year: **2024/2025**

Student: **Sanam Garehbaghi**

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

Supervisor: **doc. RNDr. Lukáš Richtera, Ph.D.**

Reviewer: **doc. RNDr. Lucie Korecká, Ph.D.**

PhD thesis title: Novel approaches in catalytic biosensors

Topicality of doctoral thesis:

Presented thesis addresses relevant challenges in the field of biosensors by introduction of two innovative strategies aimed at improving the stability, cost-efficiency, and applicability of catalytic biosensors. The first part focuses on the detection of lactose in dairy products as an indicator of mastitis infection, which is a problem in the dairy industry. The second part introduces a nanozyme–cDNA conjugate platform for rapid, one-step detection of the cancer biomarker miRNA-21, demonstrating potential for early-stage cancer diagnostics.

Meeting the goals set:

Thesis meets all goals and objectives, which is proven by the successful publication of the results

Problem solving and dissertation results:

All the achieved results are described in detail and very well, confirming the author's good orientation in the given issue. The data are adequately discussed and supplemented with a final summary.

Importance for practice or development of the discipline:

The research focus and gained results confirm the timeliness and importance to both industrial and clinical applications.

Formal adjustment of the thesis and language level:

The submitted thesis takes the form of a detailed description of methodology and results of research in area of catalytic biosensors in connection to functional nanomaterials exploited for biosensors construction, which were included in the author's articles. The applicant is the first author of two papers (one research article and one review), which were already published, and one article in submission process. Both articles were published in peer-reviewed journals with impact factors (Q1), which attests to the high quality of the research presented.

The dissertation thesis comprises 106 pages of original text, divided into a total of 5 chapters, including a theoretical introduction to the topic (Chapter 1, 10 pages), followed by detailed description of attached articles (Chapters 2-4, 82 pages). This dissertation advances the field of catalytic biosensors based on developing innovative systems of natural enzymes and nanozymes (NZs), with a particular focus on improving stability, cost-effectiveness, and practical applicability. It presents an enzyme cascade biosensor for electrochemical lactose detection in dairy products, aimed at food quality control and mastitis diagnosis. The thesis further explores the design and surface modification of gold nanozymes to enhance catalytic selectivity and functionality for broader biosensing applications. A novel biosensor based on Pt-Tyr NZ conjugated with cDNA is introduced for the label-free, one-step detection of the cancer biomarker miRNA-21. Overall, the work contributes to the development of robust, low-cost, and portable biosensors for use in clinical diagnostics and industrial settings.

The text is written clearly and readably, with a balanced presentation of information necessary for understanding the topic. The thesis is written in English, which, in my view, is of high quality, although I am not qualified to assess possible grammatical or formal inaccuracies.

Questions and comments:

From a professional perspective, I would like to present a few points (or questions) for discussion:
1. Chapter 2: An enzyme cascade biosensor based on multiwalled carbon nanotube-RuO2 nanocomposite for selective amperometric determination of lactose in milk samples.

Could you please explain in more detail the physico-chemical principle of the the enzyme (β-Gal and Gox) immobilization process used in your biosensor fabrication? Specifically, how do the enzymes interact with the MWCNT-RuO_2-modified GCE surface? Is it based on adsorption, electrostatic or covalent binding, or encapsulation to chitosan?

2. Question for the same chapter: Is this sensor reusable or disposable for analyzing a single sample? If it is reusable, what is the stability of such a sensor?

3. Chapter 4: A Novel One-Step Approach for miRNA-21 Biomarker Detection Using Tyrosine-Capped Pt Nanozyme Conjugated with cDNA.

The size distribution (mean particle size) and mono/polydispersity was evaluated only from SEM analysis? Or you used any other technique for post-synthetic characterization of prepared PtNz, e.g. Dynamic light scattering? Would this technique be applicable? Or are there properties of the given material that do not allow this method to be used? These methods (DLS, NTA..) are more common for nanomaterial size characterization.

Conclusion:

In conclusion, I would like to state that the submitted dissertation is of high quality and the author has clearly demonstrated the ability to conduct scientific work. In my opinion, the reviewed thesis fulfill all requirements posed on theses aimed for obtaining PhD degree. This thesis is ready to be defended orally, in front of respective committee.

In Pardubice, date July 14th, 2025

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Doc. RNDr. Lucie Korecká, Ph.D.

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