

HABILITATION THESIS REVIEWER'S REPORT

Masaryk University

Applicant

Mgr. Markéta Holá, Ph.D.

Habilitation thesis

"Laser-matter interaction as a key process for sampling by laser ablation"

Reviewer

Prof. UW Barbara Wagner, PhD, DSc

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Review:

Dr. Markéta Holá is a researcher at the Laboratory of Atomic Spectrochemistry, Department of Chemistry, Faculty of Science, Masaryk University in Brno (Czech Republic). She holds a PhD in Chemistry, which she received in 2004. From 2014 to 2018, she was a member of the research group for Synthesis and Analysis of Nanostructures at the Central European Technology Institute in Brno, where she gained valuable experience and expanded her knowledge. During her professional career, Dr. Markéta Holá has become an expert in the field of analytical chemistry, with a particular focus on the sophisticated use of a highly specific instrumental technique, Laser Ablation with Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), in a range of research areas, including fundamental studies and applications. A review of her university page shows that she has published a total of 123 papers, with nearly 50 being peer-reviewed scientific papers and 31 conference proceedings. The majority of these papers, apart from other elemental techniques (such as LIBS, SEM-EDS or EPMA), demonstrate the significant role of LA-ICP-MS in all analytical approaches described therein. An evaluation of her scientific record can be conducted using platforms like WoS, Scopus, and ResearchGate. They all assign the same value of 14 (as of August 2024) to her H-index.

Dr. Markéta Holá has presented a habilitation thesis entitled "*Laser-matter interaction as a key process for sampling by laser ablation*". The document is well written, logically structured and demonstrates a high level of knowledge in the field of spectroanalytical chemistry. The habilitation thesis concentrates on the specific use of nanosecond laser ablation for microsampling of solid samples. Her major research is focused on the study of laser-sample interaction processes, the evaluation of laser-generated aerosol, the analysis of trace elements in environmental and geological materials, and elemental imaging using LA-ICP-MS measurements. It is important to recognise the skill and expertise demonstrated by Dr. Markéta Holá in adjusting the various parameters of the LA-ICP-MS system in a manner that resulted in accurate and highly meaningful data, tailored to specific research objectives. The habilitation thesis reflects her interests and demonstrates the range of applications of ns-LA-ICP-MS as well as a detailed discussion of laser ablation parameters, together with a

critical evaluation of their influence on laser-matter interaction and subsequent aerosol formation.

A selection of twelve publications has been provided as a reference, offering the required overview of the achievements across the period from 2006 to 2022. For each of the selected papers, Dr. Markéta Holá provided an overview of her responsibilities, which included experimental work, manuscript preparation, supervision, and direction of research, with varying degrees of contribution across different projects. She was a corresponding author in five publications; while her research has been disseminated in numerous high-impact scientific journals, underscoring her substantial contributions to the advancement of understanding the optimisation of laser ablation techniques, subsequent aerosol formation, and the effects of nanoparticles on laser ablation processes.

The research included an investigation of the impact of diverse laser ablation parameters, including wavelength, pulse duration, and fluence, on the interaction between the laser and the analysed samples, as well as on the formation of the resulting aerosol and distribution of generated particles dimensions. This was followed by a careful evaluation of post-ablation craters. It is clear that shorter laser wavelengths, in particular a transition from 266 nm to 193 nm, have a significant impact on limiting particle sizes during metal sample ablation, thereby enhancing precision. Furthermore, the thesis demonstrates how pulse duration affects thermal dynamics, with femtosecond pulses minimising unwanted thermal effects, thereby enhancing analytical accuracy. Furthermore, the study highlights the importance of considering sample surface properties and modifications, such as roughening/polishing or nanoparticle deposition, to facilitate optimal laser-matter interactions and achieve lower detection limits. Dr. Markéta Holá emphasizes the critical factors in laser-matter interaction and aerosol formation, advocating comprehensive parameter optimization for precise LA-ICP-MS applications. In my opinion, she has made a significant contribution to the field, particularly in the study of laser-sample interaction processes and imaging methods using LA-ICP-MS.

Effective knowledge transfer to students plays an essential role in higher education at the university level. In this regard, Dr. Markéta Holá is a highly experienced academic teacher, responsible for regular courses in Analytical Chemistry for students at the Faculty of Science at Masaryk University and having successfully supervised over 20 bachelor's and master's students. To date, Dr. Holá has served as a consultant for one doctoral dissertation in the field of analytical chemistry. She has also been supervising a second thesis in analytical geochemistry, devoted to the development and optimization of a methodology for determining lead isotope ratios in minerals by LA-ICP-MS.

Dr. Markéta Holá has a substantial track record of project involvement and she was a principal investigator of the postdoctoral project devoted to "*Study of properties of aerosol generated by laser beam interaction with powdered samples for plasma spectrometry techniques*" (GP203/07/P439) funded by Czech Science Foundation. The thematic scope of the project is perfectly aligned with the topic of the habilitation thesis, which evinces a maturation and fulfilment of scientific interest.

Dr. Markéta Holá plays an active role in the organisation of conferences in the fields of analytical chemistry and spectrometry. In 2022, she served as Chair of the Local Organising Committee for the ESAS.2022 (European Symposium on Analytical Spectrometry)

conference. The conference was meticulously organized and proved to be a remarkable success in the society of spectral analysts. As an internationally renowned expert she was invited to present a lecture at the ESAS.2024 conference in Warsaw, where she delivered a talk on the subject of "*Laser Ablation for ICP-MS: Simple Routine or Big Challenge*".

A review of the available information on Dr. Markéta Holá's activities indicates that she is an independent scientist with a strong commitment to developing new experiments in the area of spectro-analytical research. Her organization and teaching experience also demonstrates her high level of competence in these areas. The value of her contributions to the scientific, academic and administrative contexts is substantial and justifies the recommendation of a habilitation.

Reviewer's questions for the habilitation thesis defence (number of questions up to the reviewer)

1. Please provide your opinion as to whether the rapid advances in machine learning, when considered alongside the various factors affecting LA-ICP-MS analysis as outlined in the habilitation thesis, can present an opportunity to revisit and potentially realise the concept of standardless quantification in LA-ICP-MS through the development of specialised algorithms.
2. The combined use of LA-ICP-MS and LIBS has been demonstrated to offer considerable potential for both elemental analysis and imaging. However, the integration of these two techniques in a single instrument presents a number of challenges. How would you evaluate them?
3. I am curious to know whether you have tested other types of nanoparticles besides those described in your paper: '*Feasibility of Nanoparticle-Enhanced Laser Ablation Inductively Coupled Plasma Mass Spectrometry*', in *Analytical Chemistry* in 2018 (90(20), 11820-11826). Could it be a potential approach for isotopic dilution method in LA-ICP-MS measurements.

Conclusion

In my opinion the habilitation thesis entitled "***Laser-matter interaction as a key process for sampling by laser ablation***" by Markéta Holá **fulfils** requirements expected of a habilitation thesis in the field of Analytical Chemistry.

Date: 29/08/2024

Signature: