

EVALUATION REPORT

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Regarding the competition procedure for the academic position "Associate Professor" in professional field 5. "Technical Sciences", scientific field 5.11. Biotechnologies (scientific specialty: Biotechnology) for the needs of Laboratory "Bioremediation and Biofuels", Department "Biotechnology" at the Stephan Angeloff Institute of Microbiology – BAS (IMicB-BAS), announced in the State Gazette No. 21 of 14.03.2025.

Candidate for participation in the competition: Senior Assistant Professor Elena Yordanova Chorukova, Ph.D (sole candidate).

Grounds for the review: Order No. I-66/29.04.2025 of the Director of The Stephan Angeloff Institute of Microbiology - BAS, Prof. Penka Petrova, DSc., and decision of the first meeting of the Scientific Jury, held on 15.05.2025.

1. Received materials for review

The candidate, Senior Assistant Professor Dr. Elena Yordanova Chorukova, has been admitted to participate in the competition by the Commission appointed by order I-66/29.04.2025 of the Director of IMicB-BAS. The submitted set of materials for participation in the competition fully complies with the requirements of the Academic Staff Development Act of Republic of Bulgaria, the Regulations for its implementation and the Regulations for its implementation at The Stephan Angeloff Institute of Microbiology-BAS. From the presented set of documents, it is evident that the professional qualification of Senior Assistant Professor Elena Yordanova Chorukova, Ph.D is in accordance with the indicated habilitation in the specialty.

2. Scientific and carrier growth of the candidate

The candidate has acquired a Master's degree at the Technical University - Sofia with the qualification "Biotechnical Engineer". The candidate's professional path at IMicB-BAS began as an engineer in 1994, and in the period from 2005 to 2009 she acquired the educational and scientific degree "PhD" after defending a dissertation on topic "Neural and Hybrid Modeling and Optimization of Biotechnological Processes" in professional field "Technical Sciences", specialty "Bioautomation". In the period from 2000 to 2011, she rose to the academic position of "senior assistant professor" at IMicB-BAS, and is still part of the staff of the Laboratory "Bioremediation and Biofuels", Department of Biotechnology at the same Institute. During her dissertation work, Dr. Chorukova also completed some targeted specializations to upgrade her qualifications at the Department of Bioprocess Engineering, University of Karlsruhe, Germany in 2008 for 1 month and at the Laboratory of Signals and Systems in Paris, France in 2006 for 3 months. She won an award for the best presented report at the international conference "Automation and Informatics'05", as well as the Third Prize for the best presented report by a young scientist at the third international symposium "BioInfo'07" within the framework of the international conference "Automation and Informatics'07". She is a member of several scientific organizations: John Atanasoff Union of Automation and Informatics, Society for Environmental Engineering and Environmental Protection, and Union of Mathematicians in Bulgaria.

3. Evaluation of scientific and research activities

The research work of Dr. Elena Chorukova is in the field of biotechnological processes with a focus on the anaerobic degradation of various types of organic waste. Her scientific interests are mainly focused on mathematical modeling, control and optimization of various biotechnological processes. The main emphasis is on the application of various deterministic and artificial

intelligence methods for the mathematical modeling, control and optimization of biotechnological processes.

Dr. Chorukova is a participant in a total of **14 projects**, of which 11 are national and 3 are funded by the European Union, and she also has personal participation in 3 projects external to IMicB-BAS. She is a co-author of **41 scientific papers** with a total impact factor (IF) of **30.82** and is a co-author of one patent: "Biofilm reactor with submerged fixed filling for biogas production", No. 66587, 5.07.2010 and one utility model: "Composition for biogas production", No. 1814, 22.01.2014.

A total of **33 scientific publications** were submitted in this competition (22 in publications that are referenced and indexed in world-renowned databases of scientific information and 11 in non-refereed journals with scientific review or in edited collective volumes), and respectively 8 were submitted outside this competition for the acquisition of the "PhD". Articles in refereed and indexed journals are distributed as follows: **2 in Q1** (with the International Journal of Hydrogen Energy topping the rankings); **6 in Q2**; **6 in Q3** and **6 in Q4** with a total IF **30.82**. In 12 of the articles included in the competition, Dr. Chorukova is the first author, and the H-factor and citations for the entire scientific career are 5 and 122, respectively. For her entire scientific career, Dr. Chorukova has 48 presentations (22 papers and 26 posters) at 33 scientific forums, 28 of which with international participation.

The presented scientific papers and participation in conferences are evidence of the candidate's high scientific competence and a wide range of scientific interests in the field of biotechnology.

3. Fulfillment of indicator requirements

The total number of publications included by Senior Assistant Professor Dr. Chorukova in the competition for associate professor is 33, of which 10 under indicator B and 23 under indicator D. The total number of points obtained under the indicator groups is **1,444.43** with minimum national requirements of **400** points.

Under indicator 1 (group A), Dr. Chorukova has **50** points out of **50** required for a dissertation to acquire "PhD".

According to indicators 3 and 4 of group B, the candidate has **142.57** points out of **100** required, which are formed from 10 publications related to the habilitation work and published in publications that are referenced and indexed in world-renowned databases of scientific information.

For indicators 5 to 11 of group D, the points are **250.86** with a minimum required score of **200**. These points are formed by 12 publications (total 193.31 points), which are referenced and indexed in world-renowned databases of scientific information and 11 publications (total 57.55 points) in non-refereed journals with scientific review or in edited collective volumes.

According to indicators from group D, citations or reviews in scientific publications, referenced and indexed in world-renowned databases with scientific information or in monographs and collective volumes, the candidate has **1,001** points (92 citations x 10 points; 21 citations x 3 points and 9 citations x 2 points) with a required **50** points.

Dr. Chorukova's research assets significantly exceed the additional criteria for the development of the academic staff at IMicB-BAS. The number of publications with which she participated in the competition is **33** (with a required **20**). In **12** of the submitted scientific papers (with a required minimum of **5** publications), Senior Asst. Prof. Dr. Chorukova is the first author.

The total IF of the articles in the competition is **30.82** with a required minimum of **20**. The total number of citations is **122** (with a required **100**) and H-factor **5** (with a required **5**). With a required minimum of participation in **3** projects, Dr. Chorukova has participated in **14**.

4. Main scientific directions and contributions

Dr. Chorukova's scientific work can be systematized in the following main areas:

1. Application of deterministic methods for the mathematical modeling, control and optimization of biotechnological processes carried out in one or in a cascade of two bioreactors.

The main contributions here are:

- 1.1. Mathematical models of an aerobic process for the production of the intracellular enzyme superoxide dismutase (SOD) using strain *Humicola lutea* 103 and glucose as the limiting substrate have been developed, with the aim of developing a strategy for optimal process control. Using a deterministic model, the optimal dissolved oxygen profiles in a batch cultivation process were determined, and using neural and hybrid models, the optimal profiles for glucose feeding in a semi-batch process for the production of SOD enzyme were determined.
- 1.2. A deterministic mathematical model of the anaerobic digestion of waste fruits and vegetables for methane production, including a gas phase, has been developed and verified experimentally and through computer simulations.
- 1.3. Deterministic models of a continuous anaerobic digestion process with hydrogen and methane production in a cascade of two bioreactors of the following substrates: beef manure, lignocellulosic waste, corn waste product, as well as mixtures of different wastes have been developed. Based on the models, the optimal ratio of the working volumes of the bioreactors

was determined, with a view to maximizing energy production. Schemes were developed to estimate the specific growth rates of the participating bacteria for some of the models.

- 1.4. Based on the differential-algebraic approach, new observers of the main unmeasurable variables (specific growth rates and biomass concentrations) in a three-stage model of anaerobic decomposition of organic waste have been developed.
- 1.5. Static characteristics of mathematical models of a two-stage anaerobic digestion process for sequential production of hydrogen and methane have been derived. The influence of substrate inhibition in the first and second bioreactors has been considered. The obtained input-output static characteristics for the energy carriers can be used for control and optimization of the processes under consideration.

2. Application of artificial intelligence methods for the mathematical modeling, control and optimization of biotechnological processes, including the application of artificial neural networks, metaheuristic algorithms, intercriteria analysis and generalized networks.

The main contributions here are:

- 2.1. Neural models of anaerobic digestion processes of organic waste have been developed, which can be used to predict biogas yield at different dilution rates.
- 2.2. A mathematical model of a thermophilic process for anaerobic digestion of wheat straw, carried out in a bioreactor for methane production, has been developed. The identification of the values of the model parameters is performed using two different techniques, one of which is a deterministic algorithm for sequential quadratic programming, and the other is a metaheuristic genetic algorithm.
3. A model of a continuous process of two-stage utilization of corn waste for sequential production of hydrogen and methane is identified based on metaheuristic algorithms. Five different

metaheuristic algorithms are adapted and implemented for the first time to identify model parameters.

4. Conducting and investigating biotechnological processes carried out in bioreactors with various substrates.

Main contributions here are:

- 4.1. A biofilm reactor with a submerged fixed filling has been created for biogas production, in which suitable conditions have been created for the fixation of microorganisms on solid support. It is applicable for continuous operation in batch, semi-batch and continuous modes, avoiding blocking of the activity of the submerged filling zone through spontaneous separation of the biofilm from the carrier without having to interrupt the biogas production process.

5. Systems for automatic control of biotechnological processes.

Main contributions here are:

- 5.1. A pilot biogas installation with a monitoring and control system has been developed at IMicB-BAS with possible industrial application of various anaerobic digestion technologies based on different types of raw materials.
- 5.2. A system for controlling a cascade of bioreactors for the production of hydrogen and methane from organic waste has been developed. The system has been implemented with the aim of verification and scaling up of various technologies for two-phase anaerobic biodegradation of various organic wastes.
- 5.3. Experimental studies have been conducted and the computer system for monitoring and controlling two-phase anaerobic digestion of corn waste in automatic and semi-automatic operating modes of a cascade of two anaerobic bioreactors has been presented. With the help

of the developed computer system for monitoring and controlling pilot bioreactors, an automatic operating mode in a continuous process with simultaneous production of hydrogen and methane has been implemented.

6. Candidate's vision for future research work

Waste disposal is a current topic related to environmental protection. In turn, biotechnological processes are constantly expanding thanks to the properties of biological systems to synthesize and transform practically all natural raw materials. In this regard, however, modern methods are needed to optimize the process to increase its productivity, and one of the main goals that can be achieved is to overcome the existing discrepancies between the mathematical process models used to design control systems and the real processes themselves. For this reason, the candidate intends to focus on modeling, optimization and management of various biotechnological processes, using both classical and new artificial intelligence methods.

7. Conclusion

The volume, quality and content of the presented scientific production, the active research activity, professional and scientific experience of Senior Assistant Professor Elena Chorukova, PhD, including all her scientific indicators, not only meet, but also exceed the minimum national and additional requirements of Academic Staff Development Act of Republic of Bulgaria, and the Regulations of IMicB-BAS for holding the academic position of "Associate Professor" in professional field 5. "Technical Sciences", scientific field 5.11. Biotechnologies (specialty: Biotechnology). The research and its results are original and up-to-date with fundamental and applied significance, fully consistent with the scientific field and scientific direction of this competition. Dr. Chorukova is an established scientist and intends to improve her skills in the field

of biotechnological processes and mathematical modeling, their management and optimization through various deterministic and artificial intelligence methods.

The analysis of the candidate's scientific production gives me reason to express my support and to confidently recommend to the esteemed members of the Scientific Jury that they propose to the Scientific Council of IMicB-BAS to award Senior Assistant Professor Elena Yordanova Chorukova, PhD the academic title of "Associate Professor".

Sofia, 13 June, 2025

Reviewer:.....

/Assoc. Prof. Andrey Marchev, PhD/