

REPORT

on the defense of the dissertation work of

STEFAN MARTINOV STEFANOV

on the topic:

"FUEL CELLS WITH ECOLOGICAL ORIENTATION"

for the acquisition of the educational and scientific degree "doctor" in the specialty:

"Processes and devices in chemical and biochemical technology"

in the professional field 4.2. Chemical Sciences

**by Assoc. Prof. Dr. Elitsa Yordanova Chorbadzhiyska,
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I. Biographical data of the candidate

Stefan Martinov Stefanov was born in 1989. He graduated from the University of Chemical Technology and Metallurgy, majoring in Natural and Synthetic Fuels, in 2015. He was enrolled as a doctoral student at the Institute of Chemical Engineering (ICE) in July 2023, and since November of the same year he has been appointed as a chemist in the laboratory of Biochemical Engineering of the Institute of Chemical Engineering - BAS. The submitted documents show that the candidate has passed the necessary exams with distinction, as well as that he has covered all the requirements of the regulations of the BAS. The candidate has research experience in the following areas: electrochemistry and fuel cells; ecology; fundamental and applied research in the fields of electrochemistry; extraction (classical and with compressed fluids).

II. Relevance of the problem

The presented dissertation work is dedicated to a current and significant scientific issue related to the development and improvement of fuel cells as a promising environmentally friendly technology for the production of electricity, combining energy recovery with simultaneous purification of water contaminated with sulfur compounds and nitrate ions. The topic is in full accordance with modern trends in the decarbonization of the energy sector, aimed at increasing energy efficiency, implementing sustainable technologies and

simultaneously solving environmental problems. The scientific work has both fundamental and applied significance, since the results obtained can be used in the development and optimization of modern electrochemical energy systems. In this context, fuel cells represent a promising technology that has the potential to contribute to limiting carbon emissions, protecting the environment and achieving the goals of sustainable development and carbon neutrality.

III. Dissertation Overview

The dissertation is structured in a logical sequence, contains: introduction, literature review, aim and objectives, materials and methods, results and discussion, conclusions and contributions. Future work on the topic is also described. Lists of scientific publications, reports and poster presentations on the dissertation, as well as noted citations are presented. The list of cited literature includes 225 sources published in the period from 1971 to 2026. The volume of the dissertation is 126 pages, including 36 figures and 10 tables.

The literature review is structured in accordance with the thematic focus of the dissertation and covers basic aspects related to the characteristics and ecological significance of hydrogen sulfide, sulfites and nitrates, the main sources and existing approaches for their capture, purification and disposal. The main characteristics, the principle of operation and the types of fuel cells are also considered, which creates the necessary theoretical basis for conducting experimental research. In general, the literature review presents the state of scientific research in the area under consideration and justifies the need to conduct experimental research aimed at developing and optimizing fuel cells with an ecological focus. Based on the analyzed literature data, generalized conclusions are formulated that logically justify the set goals and objectives of the dissertation work. The purpose of the dissertation work is the experimental study and evaluation of the influence of various parameters on the operation of a fuel cell for purifying water contaminated with sulfur compounds.

The Materials and Methods section describes the object of study (the influence of various parameters - concentration of the studied pollutants and background electrolyte, the electrodes and ion exchange membrane used, operating temperature and pH on the performance of a fuel cell for the oxidation of sulfur compounds and reduction of nitrate ions), the reagents and equipment used, as well as the applied electrochemical and analytical methods.

The chapter "Results and Discussion" is logically structured and presents the experimental studies conducted sequentially. The influence of the main factors - concentration of the fuel and oxidant, electrodes, membrane, temperature and background electrolyte - on the efficiency of the fuel cells is monitored. The approach of using sulfite ions as substrates, which combines the production of electrical energy with the neutralization of potential pollutants, is particularly significant. The results obtained are well related to the set goals and objectives and have both scientific and applied value. Overall, the chapter contains a significant amount of experimental data and shows a systematic approach to optimizing the operating conditions of the studied fuel cells. The results are clearly presented, well systematized and analyzed, described in detail and in an understandable way. Extremely informative with high scientific value, illustrating the scientific and applied contribution of the study.

IV. Main scientific and applied scientific contributions

The main scientific contributions in the dissertation are as follows:

Scientific contributions:

1. The possibility of using fuel cell technology for the treatment of flows contaminated with sulfur compounds has been proven, while simultaneously neutralizing the environmental risk and producing carbon-neutral electricity.
2. The main factors limiting the efficiency of the process have been identified and analyzed, and approaches have been proposed to limit their adverse impact on the operation of the fuel cell.
3. It has been experimentally proven that the studied fuel cell can effectively treat simultaneously two types of contaminated flows - containing sulfide and nitrate ions, and their combination leads to a significant improvement in the operational characteristics of the system.

Scientific and applied contributions:

1. A modified anode material has been studied, which shows a significant improvement in the operating characteristics of the fuel cell compared to standard graphite electrodes.
2. The applicability of CelGard®, Fumapem® and Nafion® membranes in the operation of a fuel cell using sulfur compounds as anolyte has been proven, and their operational capabilities have been evaluated.
3. The possibility of using a fuel cell for neutralizing sulfite ions from model absorption solutions simulating different stages of flue gas cleaning has been studied and evaluated. Optimal operating conditions for achieving maximum energy yield, as well as the degree of pollutant removal under these conditions, have been determined.

V. Evaluation of the submitted published materials on the topic of the dissertation

The candidate has submitted three scientific publications, of which one was published in a journal outside the quartile categories, one – in a journal from the first quartile (Q1), and one – in a journal from the third quartile (Q3). According to the current minimum national requirements, the submitted publications provide and exceed the required minimum of 30 points for acquiring the educational and scientific degree "doctor". All publications, as well as the presented reports and scientific communications, are directly related to the topic of the dissertation work and reflect the main scientific results achieved in the course of the research.

VI. Reflection of the scientific publications on the dissertation in the scientific literature

Twenty-six citations are presented. The presence of independent citations of the publications related to the dissertation work is an indicator of their visibility and recognition in the scientific literature. This can be accepted as evidence of the scientific significance and good perception of the obtained results by the specialized scientific community.

VII. Evaluation of the dissertation abstract

The abstract correctly reflects the content of the dissertation work. The relevance of the topic, the purpose and objectives of the research, the methodology used, the scientific results obtained, the contributions of the author and the publications on the topic are presented in a synthesized form. I believe that the abstract gives a complete and reliable idea of the scientific research carried out and corresponds to the content and conclusions presented in the dissertation work.

VIII. Personal impressions of the reviewer about the candidate

In the process of preparing this review, I became familiar with the scientific work and results presented in the dissertation. The presented materials testify to a doctoral student with good theoretical preparation, in-depth knowledge in the field of electrochemical technologies and skills for independent conduct and analysis of scientific research. The doctoral student demonstrates the ability to formulate and solve scientific problems, correctly apply experimental methods and critically analyze the results obtained. The presented scientific publications and participation in scientific forums show activity, consistency and commitment to the developed scientific topic.

Undoubtedly, the doctoral student possesses the necessary scientific and professional qualities for independent research.

IX. Conclusion

The presented dissertation on the topic "Fuel cells with an ecological focus" is an independent scientific study dedicated to a current and significant scientific problem. Significant scientific and scientific-applied results and contributions have been achieved. The presented scientific publications and citations confirm the significance and recognition of the obtained results in the scientific community. The dissertation meets the requirements for the acquisition of the educational and scientific degree "Doctor" in the professional field 4.2. Chemical Sciences.

After reviewing the submitted dissertation and the materials to it, I confidently propose to the esteemed Scientific Jury to award the educational and scientific degree "Doctor" in the specialty "Processes and Apparatus in Chemical and Biochemical Technology" in the professional field 4.2. Chemical Sciences to Stefan Martinov Stefanov.

Date: 21.08.2026

Prepared by:



/Assoc. Prof. Dr. Elitsa Chorbadzhiyska/