

REVIEW

of dissertation for the acquisition of:

educational and scientific degree " doctor "	X
scientific degree " Doctor of Science "	
	the true is indicated by the sign "X"

Author of the dissertation:

		Christofor	Ivanov	Skandaliev	
academic position	scientific degree	name	middle name	last name	workplace

Topic of the dissertation:

Preparation and Characterization of Environmentally Benign and Low-Toxicity Solid Rocket Propellants
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Scientific area:

5	Technical Sciences
code	name

Professional area:

5.10	Chemical Technologies
code	name

Scientific specialty:

Technology of Natural and Synthetic Fuels

The review was written by:

Assoc. Prof.	PhD	Milko	Komstantinov	Berner	University of Mining and Geology "St. Ivan Rilski" – Sofia
academic position	scientific degree	name	middle name	last name	workplace

1. Completion of the provided documents:

A) The dissertation and the competition documents are in full compliance with the Regulations.	4 points	X
B) The documents are complete but do not fully comply with the requirements of the Regulations.	2 points	
C) The documents are not completed in accordance with the requirements of the Regulations.	0 points	

		one of the answers given is marked with the sign "X"
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Missing documents and violated standards must be described if response C is marked.

2. Meeting the minimum requirements under the Regulations:

A) The candidate meets the minimum requirements	20 points	X
B) The candidate doesn't meet the minimum requirements	0 points	
		one of the answers given is marked with the sign "X"

It must be filled in if answer B is marked. The publication activity of the candidate is analyzed. The response of the results achieved (quoted) is analyzed.

3. The relevance of the topic of the dissertation:

A) The topic is relevant and new (there are no known results on the topic by other authors)	8 points	
B) The topic is relevant and results from other authors are known	6 points	X
C) The topic is not relevant, but results from other authors are known	2 points	
D) The topic is not relevant and no results from other authors are known	1 point	
E) The topic does not correspond to the level of dissertation	0 points	
		one of the answers given is marked with the sign "X"

The evaluation of the relevance of the dissertation must be substantiated

The topic is of contemporary relevance due to the growing interest in environmentally benign and low-toxicity energetic materials. The development of efficient, eco-friendly alternative solid rocket propellants is associated with overcoming significant technological challenges and achieving a judicious balance between an appropriately selected component composition and the desired energetic performance.

A number of studies on various "green rocket propellants" have already been published in the international literature; therefore, the scientific novelty should be considered primarily in the context of specific experimental implementations and applied solutions.

It should be noted that, within the Bulgarian scientific community, the present dissertation constitutes the first research work dedicated to the problem of reducing the environmental impact of combustion products.

4. Knowledge of the problems, subject of research in the dissertation:

A) The doctoral student knows in detail the achievements of other authors on the topic of the dissertation	8 points	X
B) The doctoral student is partially familiar with the achieved results on the topic of the dissertation	4 points	
C) The doctoral student has no prior knowledge of the status of the problems in the dissertation	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.

The candidate demonstrates solid theoretical grounding and a thorough understanding of the main directions in the development of solid rocket propellants. The literature review presented is distinguished by its breadth and systematic organization. In certain sections, however, there is a noticeable predominance of historical and general theoretical information at the expense of a more in-depth critical analysis of contemporary publications in the field of low-toxicity rocket propellants.

5. Type of research:

A) Theoretical	4 points	
B) Applied	4 points	
C) Theoretical with application elements	4 points	X
D) It does not correspond to the level of dissertation	0 points	
		one of the answers given is marked with the sign "X"

The level of research must be substantiated if answer D is marked.

The dissertation integrates theoretical formulations, experimental investigations, and applied engineering solutions. Both laboratory and practical tests of the developed propellant formulations and rocket motors have been conducted, which imparts a distinctly applied orientation to the research.

6. Objectives of the research:

A) Realistic and of scientific and / or applied interest	8 points	X
B) Realistic, but not of scientific and / or applied interest	3 points	
C) Unattainable (unrealistic)	0 points	
		one of the answers given is marked with the sign "X"

Objectives must be specified. The type of the set objectives must be justified.

The objectives set out in the dissertation are clearly formulated and exhibit a pronounced applied research character, consistent with the specific nature of developments in the field of energetic materials and solid rocket propellants. They are defined in alignment with current scientific and technological challenges and are aimed at integrating experimental investigation with the engineering and technological implementation of new heterogeneous propellant systems.

The objective related to the development and characterization of safe solid rocket propellants with reduced environmental impact defines the research character of the work and entails the conduct of

systematic experimental studies and analysis of the results obtained. At the same time, the requirements concerning the use of readily available raw materials, technological feasibility, and practical applicability underscore its engineering-oriented and applied focus. The formulated tasks further specify the overall objective and encompass the main stages of the research process: selection of component systems and formulation development; technologies for the production of propellant grains and experimental investigation of their characteristics; comparative analysis and evaluation of the results obtained. In this way, a coherent link is established between the scientific research and the applied engineering components of the dissertation.

7. Methods of research:

A) Adequate to research and set objectives	8 points	X
B) Partially appropriate, enabling part of the scientific objectives and / or applications to be achieved	4 points	
C) Inappropriate methods	0 points	
		one of the answers given is marked with the sign "X"

Methods must be specified. The type of methods used is justified.

The methods employed in the dissertation are of a complex nature and are consistent with established approaches in the field of energetic materials and solid rocket propellants. The methodological framework is based on a combination of experimental investigations, physicochemical analysis, and engineering-analytical methods, in accordance with good practices applied in the study of high-energy materials both domestically and internationally.

The main emphasis is placed on the experimental approach, implemented through laboratory investigations and practical testing of the developed propellant formulations and rocket motors. This approach is appropriate for the problem under consideration, insofar as the properties of solid rocket propellants are to a significant extent determined empirically and require experimental validation.

It should be noted that, although the methodological framework is properly structured, quantitative modelling of the relationship between composition and energetic/ballistic characteristics is presented to a more limited extent, which could further enhance the analytical depth of the study. Additionally, the range of applied physicochemical methods could be expanded to include more detailed structural, thermal, and spectroscopic analyses, which would allow for a more comprehensive characterization of the investigated systems.

Complementary importance is attributed to the comparative method used to juxtapose the obtained results with literature data on analogous heterogeneous propellant systems. This enables an assessment of the positioning of the developed compositions within the current state of research.

In summary, the methodology can be considered adequate, coherent, and aligned with the objectives of the dissertation, providing sufficient reliability of the obtained results, although a certain expansion of the modelling component and enrichment of the physicochemical instrumentation could further strengthen the overall completeness of the research.

8. Contributions of the dissertation:

A) With lasting scientific and / or applied response, they form the basis for new research and applications	20 points	
B) They are of significant scientific and / or applied interest, complete and / or summarize previous research	16 points	
C) They are of scientific and / or applied interest	12 points	X
D) Lack of significant contributions	8 points	
E) Lack of contributions	0 points	

		one of the answers given is marked with the sign "X"
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<p>Contributions must be specified. The type of results achieved must be justified.</p> <p>As a result of the conducted analysis of the dissertation, which is thematically focused on the preparation and characterization of environmentally friendly and low-toxicity solid rocket propellants, it is established that the obtained results are of a complex nature with a clearly defined scientific and applied orientation. The contributions can be systematized as follows:</p> <ol style="list-style-type: none"> 1. Scientific contributions <ul style="list-style-type: none"> - New experimental data have been obtained regarding the behaviour of solid rocket propellants based on alternative oxidizers and organic reductants under various combustion conditions and thermal loading. - Regularities in the thermokinetic and internal ballistic behaviour of the investigated propellant systems have been identified. - The experimental database for systems of the type "alkali metal nitrate/organic reductant" and "alkali metal periodate/organic reductant" has been expanded. 2. Scientific and applied contributions <ul style="list-style-type: none"> - New propellant formulations have been developed and experimentally validated, with potential for application as alternatives to conventional composite solid rocket propellants, aiming at reduced environmental impact. - A combined approach of thermochemical modelling and experimental investigations has been implemented for the assessment of the energetic and ballistic characteristics of the developed compositions, enabling a more reliable interpretation of the obtained results. - Relationships between composition, structure, and functional characteristics of the propellant systems have been derived, which are relevant for future engineering design and optimization of solid propellant grains. 3. Applied contributions <ul style="list-style-type: none"> - A technological approach has been developed for the preparation of laboratory-scale solid rocket propellant samples using readily available and relatively safe components, suitable for experimental and research purposes. - Static and field rocket tests have been conducted, demonstrating the performance of part of the investigated compositions and their suitability for real technical applications on a limited scale. - The results have potential for application in the development of environmentally benign heterogeneous energetic systems, including gas-generating pyrotechnic compositions, educational and experimental rocket motors, and specialized rocket systems intended for atmospheric research applications. <p>The dissertation contains results of a scientific and applied nature, consistent with current trends in the development of safer and environmentally compatible energetic materials. The achieved contributions are relevant, logically substantiated, and supported by experimental data, which determines their applied value.</p>
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9. Evaluation of the compliance of the dissertation summary with the dissertation:

A) Full compliance	4 points	X
B) Compliance of the main parts	2 points	
C) Lack of compliance of the main parts	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.

10. Participation of the doctoral student in the achievement of the results of the dissertation:

A) The doctoral student has at least an equal participation	8 points	X
B) The doctoral student has secondary participation	5 points	
C) The participation of the doctoral student is unnoticeable	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the items B or C is marked.

Based on the presented materials and the nature of the research work, it can be stated with confidence that the doctoral candidate has been actively involved in the experimental work, the analysis of the results, and the development of the investigated rocket propellants.

11. Critical notes:

A) Lack of critical notes	8 points	
B) Critical notes of a technical nature	7 points	
C) Critical notes that would partially improve the results achieved	4 points	X
D) Significant critical notes	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the answers C or D is marked.

The following recommendations and critical remarks are offered regarding the dissertation:

1. Regarding the literature review

The literature review is detailed and demonstrates a good theoretical grounding of the doctoral candidate. At the same time, in certain parts disproportionate attention is given to historical information and general theoretical considerations of a predominantly review-oriented and didactic nature. In the context of the stated objectives, a more in-depth presentation and critical analysis of a broader range of publications related to contemporary trends in low-environmental-impact solid rocket propellants would be beneficial.

2. Regarding the experimental methodology and presentation of results

The experimental work is substantial in scope and covers the development, characterization, and testing of various propellant formulations. The presented results demonstrate a systematic approach and good practical skills on the part of the doctoral candidate.

The description of certain experimental procedures however, remains relatively general and does not provide sufficient detail regarding test conditions, the number of repetitions, and the evaluation of experimental uncertainty. In studies of solid rocket propellants, factors such as mixture homogeneity, sample preparation conditions, grain geometry, and test parameters may have a significant influence on the obtained results.

Therefore, a more detailed presentation of these conditions, as well as information on experimental repeatability and statistical data processing, would enhance the robustness of the conclusions. In particular, for internal ballistics tests and comparisons between different propellant formulations, the inclusion of data on repeated measurements and result dispersion would allow for a more objective assessment of the observed differences.

The conducted experimental investigations are sufficient to achieve the set objectives. Nevertheless, the range of applied physicochemical methods could be expanded. The inclusion of additional techniques such as SEM/EDS, FTIR, or Raman spectroscopy would provide more in-depth

information on microstructure, chemical interactions, and structural changes in the developed propellant compositions, thereby enriching the interpretation of the results.

3. Regarding the nature of the analysis

In certain sections, the analysis is primarily focused on design solutions, technological aspects, and experimental confirmation of the operability of the developed systems.

From the perspective of the requirements for a doctoral dissertation, a more in-depth discussion of the physicochemical processes governing the behaviour of the propellant formulations would be beneficial. A more detailed analysis of thermal decomposition mechanisms, component interactions, combustion kinetics, and the influence of composition on the observed characteristics would contribute to a more complete elucidation of cause-and-effect relationships and would strengthen the scientific value of the conclusions.

4. Regarding the style of presentation

In stylistic terms, the text of the dissertation is generally clear, logically structured, and comprehensible. However, certain passages exhibit some inconsistency in terminology and style. There are instances of descriptive and partially popular-scientific formulations that do not fully correspond to the requirements of strict scientific writing.

In addition, the presentation is at times overly detailed at the expense of analytical clarity, which to some extent makes it more difficult to highlight the essential scientific results and contributions of the author. It is recommended that, for potential publication, the work be revised towards greater terminological precision and internal coherence, while avoiding non-scientific, stylistically literary elements.

In conclusion, it should be explicitly emphasized that the above remarks do not significantly diminish the overall positive evaluation of the work but should be regarded as recommendations for its further development and improvement.

12. Conclusion

A) The evaluation of the dissertation is POSITIVE	This evaluation is assigned to a total number of at least 65 points	X
B) The evaluation of the dissertation is NEGATIVE	This evaluation is assigned to a total number below 65 points	
		one of the answers given is marked with the sign "X"

To be filled in at the request of the reviewer

It is a pleasure for me to review the present dissertation, as it falls within a field to which I have had a long-standing scientific interest related to composite rocket propellants. The doctoral candidate has conducted a substantial amount of experimental work, achieved significant scientific and applied results, and demonstrated the ability to conduct independent scientific research in the field of solid rocket propellant technology.

It should be noted that the research topic belongs to a scientific area in which Bulgaria lacks established scientific traditions and a well-developed research infrastructure. In this sense, the choice of topic and the implementation of the research tasks require considerable independence, initiative, and scientific courage. This provides an additional basis for a positive assessment of the achieved results and the efforts invested.

I would like to encourage the doctoral candidate to continue working in the chosen research field, despite the objective challenges related both to the experimental infrastructure and to the specific nature of investigations in this area. The accumulated experience and obtained results provide a solid foundation for further development and deeper investigation.

I consider that the dissertation meets the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria and the Regulations for its implementation, as well as the internal requirements of the University of Chemical Technology and Metallurgy – Sofia for the acquisition of the educational and scientific degree "Doctor".

I propose to the esteemed scientific jury that Eng. Christofo Ivanov Skandaliev be awarded the educational and scientific degree "Doctor" in the professional field 5.10 Chemical Technologies, scientific specialty "Technology of Natural and Synthetic Fuels".

29.05.2026	The review was written by: Assoc. Prof. Eng. Milko Konstantinov Berner, PhD	
date		signature