REVIEW

by Dr. Georgi Ivanov Patronov

Associate Professor in the Department of Chemical Technology

at Plovdiv University "Paisii Hilendarski"

on dissertation for the award of the educational and scientific degree "Doctor"
in field of higher education 4. Natural Sciences, Mathematics and Informatics,
professional field 4.2. Chemical Sciences,
doctoral program *Technology of Inorganic Substances*

Author: Katya Petrova Hristova

Topic: *"Synthesis and investigation of yttrium, lanthanum, and aluminum borates doped with rare earth compounds"*

Scientific supervisor: Associate Professor Dancho Tonchev, PhD, University of Plovdiv "Paisii Hilendarski"

1. General description of the submitted materials

By Order No. PD-22-909 / 22.04.2025 of the Rector of Plovdiv University "Paisii Hilendarski" (PU), I have been appointed as a member of the scientific jury (SJ) for the procedure for the defense of the dissertation thesis entitled "Synthesis and investigation of yttrium, lanthanum, and aluminum borates doped with rare earth compounds" for the acquisition of the educational and scientific degree "Doctor" in the field of higher education 4. Natural sciences, mathematics and informatics, professional field 4.2. Chemical sciences, doctoral program *Technology of inorganic substances*. The author of the dissertation is Katya Petrova Hristova - PhD student (in part-time form of study) at the Department of Chemical Technology with scientific supervisor Assoc. Prof. Dr. Dancho Tonchev Tonchev from the University of Plovdiv "Paisii Hilendarski", currently retired.

The set of materials submitted by the doctoral student on paper is in accordance with Art. 36 (1) of the Regulations for the Development of the Academic Staff of the University of Plovdiv and includes the following documents:

– Application to the Rector of the University of Plovdiv for the disclosure of the procedure for dissertation defense;

– CV in European format;

– Protocol No. 18 of the extended departmental council, related to reporting the readiness to open the procedure and preliminary discussion of the dissertation;

– Dissertation;

– Abstract (in Bulgarian and English);

– List of scientific publications on the topic of the dissertation;

– Copies of the scientific publications;

– List of noted citations (included in the abstract and the dissertation);

– Declaration of originality and authenticity of the attached documents;

– Certificate of fulfillment of the minimum national requirements for acquiring the educational and scientific degree "doctor";

– Opinion of Assoc. Prof. Dancho Tonchev Tonchev, PhD – supervisor of the doctoral student regarding the integrity of the dissertation work and readiness for defense.

The doctoral student has attached 5 publications. Lists of participation in scientific forums and noted citations are presented as appendices in the dissertation and the abstract.

The attached documents are duly formatted and contain the necessary information. The opinion of the scientific supervisor regarding the integrity of the dissertation work, the fulfillment of the minimum requirements and the readiness for defense is positive. The members of the extended department council voted unanimously for the admission of doctoral student Katya Hristova to the defense of her dissertation work before the Scientific Jury, as well as the interdisciplinary nature of the dissertation.

2. Brief biographical data of the PhD student

Katya Petrova Hristova was born in 1997. In 2015 she graduated from the Technical University "Knyaz Simeon Tarnovski" - Stara Zagora, majoring in "Office Manager". In 2019 she graduated from the specialty "Medical Chemistry", bachelor's degree, as well as postgraduate qualification "Chemistry Teacher". She obtained a master's degree "Chemist - Food Chemistry" in 2020. During her studies, she had an internship at the United Dairy Company, Plovdiv, Biovet OOD, Peshtera, clinical laboratory at the "St. Caridat" Hospital, Plovdiv. From October 1, 2020 to the present, she has been working as a chemist at the "Selena" Agricultural University, Plovdiv. She was enrolled as a full-time doctoral student at Plovdiv University "Paisii Hilendarski", Department of Chemical Technology after successfully passing exams in the specialty and a foreign language on March 1, 2021. She transferred to a part-time form of study in 2024.

3. Relevance of the topic and appropriateness of the set goals and tasks

The scientific field "Synthesis, characterization and application of optical materials (synthesis and characterization of new, RE-doped (rare earth metals) inorganic materials (glasses, glass ce-

ramics and ceramics) with potential for application as active carriers for optical equipment and materials)", which also includes the present dissertation work, was introduced by Assoc. Prof. Tonchev upon his joining the department in 2010. Soon after, it became the main field of Inorganic Chemical Technology. The field is definitely relevant - optical materials are increasingly widely used as LEDs, sensors and chips in the rapidly developing high-tech fields of optics, optoelectronics, electronics, and energy. The goal set in the dissertation - synthesis and study of borates doped with rare-earth compounds to obtain materials with luminescent and sensor properties and establish their potential applications - definitely fits into the modern trends of the direction. Naturally, the formulated tasks for achieving this goal follow, namely:

1. Establishment of a procedure for the synthesis of powdered yttrium borates by solid-phase and microwave-assisted methods, investigation of their structural and optical properties, with a view to potential applications in various fields of practice.

2. Study of the influence of the synthesis method on the characteristics of the resulting materials.

3. Investigate the influence of H3BO3 added in excess on the structure and properties of yttrium borates.

4. Synthesis of lanthanum and aluminum borates doped and co-doped with rare earth elements. Study of their structure, optical and chemical properties.

5. Comparison of the characteristics of the synthesized materials in terms of luminescent properties.

6. Investigating the possibilities of the obtained luminescent samples as smartphone-readable materials.

The obtained results can contribute to the development of a new generation of materials with potential for application in a number of modern and current high-tech areas.

4. Knowledge of the problem

As set out, the research is interdisciplinary, requiring knowledge of chemistry, physics, materials science, technology. This requires a review of a significant volume of literature. The doctoral student has made significant efforts to successfully complete the tasks set and finalize the present study. It is no coincidence that the dissertation includes 273 literary sources, most of them from the last decade. The literary study consistently and clearly presents the necessary information and outlines the conclusions leading to the formulated goal and tasks. The doctoral student has entered the

essence of the problem, creatively applies the acquired knowledge and can independently plan scientific research.

5. Research methodology

The set goal and formulated tasks imply the use of a number of methods for determining the structure and properties of the synthesized materials. The selected methods are respectively:

– for determining the structure – X-ray structural analysis, Fourier transform infrared spectroscopy, Raman spectroscopy;

– for determining the optical properties – fluorescence analysis, including with a smartphone.

The two synthesis methods used – solid-phase and microwave-assisted, as well as the trivial method for determining chemical stability should also be added.

Thus selected, these methods are sufficient to achieve the set goal and obtain an adequate answer to the tasks solved in the dissertation work.

6. Characteristics and evaluation of the dissertation work

The dissertation is 181 pages long, including 9 pages of appendices. It includes 273 references, 107 figures, 17 tables, 5 schemes and 5 photos. The main chapters are: introduction, literature review, aim and objectives, materials and methods, results and discussion, conclusion. The chapter “Results and discussion” sequentially presents:

– synthesis and characterization of doped yttrium borates – YBO_3:Eu, YBO_3:Eu:Ce, including microwave-assisted synthesis of YBO_3:Eu;

– solid-phase synthesis and characterization of lanthanum borates, doped and co-doped with rare-earth compounds;

– solid-phase synthesis and characterization of aluminum borates, doped and co-doped with rare-earth compounds;

In a separate subchapter, the fluorescence analysis of lanthanum and aluminum borates and, of course, fluorescence analysis using a smartphone is presented.

The dissertation has been tested through the "Strike Plagiarism" plagiarism system. The obtained coefficients are respectively: K1 – 5.98%, K2 – 2.72% and KC – 1.35%. The matching phrases, words, symbols are mainly related to the inevitable citation and should not be paraphrased. The dissertation is original, well-formed and represents a completed study with the relevant conclusions and contributions.

7. Contributions and significance for science and practice

The two scientific and three scientific and applied contributions formulated by the doctoral student are objective and clearly formulated, in accordance with the conducted research.

The scientific contributions are:

- A detailed study of the influence of boric acid in a large excess (from 5 to 60%) on the structural and optical characteristics of yttrium borate doped with europium. The dependencies have been established, the structure has been identified and the main composition-property functions in the studied materials have been derived; the optimal excess of boric acid has been established to achieve maximum fluorescence efficiency.

- A microwave-assisted method for the synthesis of yttrium borates doped with europium in a series with an increasing excess of boric acid (from 5 to 60%). A detailed comparative analysis of yttrium borate synthesized by solid-phase and microwave-assisted methods was performed, through which fundamental conclusions were drawn about the changes in optical and chemical properties.

The scientific and applied contributions are:

- The chemical stability of yttrium, aluminum and lanthanum borates was evaluated, which provides valuable information for future practical applications.

- The general regularities of luminescence of alloying components in the three types of matrices and the synergistic effect when several components are jointly alloyed in one matrix were derived.

- For the first time, measurement of fluorescent materials using a smartphone camera was presented. The potential for contactless, fast and reliable measurement of luminescent materials was assessed.

Unfortunately, due to confidentiality, specific applications of some of the synthesized new fluorescent materials for obtaining specialized compositions and devices were not presented. The research has a wide potential for development, presented in the directions for continuing the work.

8. Assessment of publications on the thesis

The included publications reflecting the results in the dissertation are five in number. Three of them are in reputable journals with impact factor (IF) and SJR, referenced in Web of Science and Scopus respectively:

- Optics & Laser Technology, $IF_{2023} = 4.6$, Q1

- Photonics, $IF_{2023} = 2.1$, Q2

- Crystals, IF_{2023} = 2.4, Q2

One is in a journal referenced in Scopus:

- Bulgarian Chemical Communications, SJR_{2023} = 0.15, Q4

One is in a book from an international scientific conference:

- Technics. Technologies. Education. Safety Vol. 2, 2021

h-index in Scopus = 2.

The relevance of the study is confirmed by the 5 available citations - 3 for the article in Crystals and 2 for the one in Photonics. One citation is from 2024, and the remaining four - for 2025.

One article has four; two have five, one with six and one with seven authors. In three of the articles, the doctoral student is in first place, in one in third and in one - in fourth.

For the period 2021 - 2024, the results of the research were promoted at five scientific forums in Bulgaria (in them the doctoral student is in first place) and one abroad. There are three reports and three poster presentations.

9. Doctoral student's personal contribution

The active participation and personal contribution of the doctoral student is confirmed by the place among the authors in the presented publications and participation in scientific forums. I would like to remind you again of the interdisciplinary nature of the research.

10. Abstract

The abstract correctly, accurately and completely reflects the essence of the dissertation and the main results achieved in the research. It is prepared in accordance with the requirements of the Academic Regulations of the P. Hilendarski University (Chapter Three, Art. 36, Paragraph 1) for a volume of 32 pages.

11. Critical comments and recommendations

I have no significant remarks and recommendations regarding the conducted research and the presented set of materials. The remarks and recommendations made by me during the reporting to the department councils, including the Extended Department Council, have been taken into account.

I have the following two questions for the doctoral student:

1. What are the main phases that have the described structure, according to the X-ray structural analysis?

2. Are other reagents used to study the chemical resistance of this type of materials and what are they?

12. Personal impression

I have known the doctoral candidate since she was a student. What are not apparent at first glance from the presented set of materials are her diligence, perseverance and consistency in her work. Her growth as a young scientist is obvious.

13. Recommendations for future use of the dissertation contributions and results

I wish Katya Hristova to continue working in this field, according to the guidelines formulated in the dissertation.

CONCLUSION

The dissertation contains ***scientific and applied scientific results, which represent an original contribution to science*** and **meet all the requirements** of the Law for the Development of Academic Staff in the Republic of Bulgaria (LADASB), the Regulations for the Implementation of the LADASB and the relevant Regulations of the University of Plovdiv "Paisii Hilendarski".

The dissertation shows that the doctoral student Katya Petrova Hristova possesses in-depth theoretical knowledge and professional skills in the scientific specialty of technology of inorganic substances, demonstrating qualities and skills for independent conduct of scientific research.

Due to the above, I confidently give my **positive assessment** of the conducted research, presented by the above-reviewed dissertation, abstract, achieved results and contributions, and **I propose the honorable scientific jury to award the degree of Doctor of Education and Science to Katya Petrova Hristova** in the field of higher education 4. Natural Sciences, Mathematics and Informatics, professional field 4.2. Chemical Sciences, PhD program Technology of Inorganic Substances.

10.06.2025 Reviewer: .....

(signature)

Assoc. Prof. Georgi Patronov, PhD