**REVIEW**

**by Prof. Doriana Ivanova Malinovska, Ph.D.,**

**retired, associate member at CL SENES-BAS..**

of the materials submitted for participation in the competition
to occupy the academic position of "**associate professor"**
**at Plovdiv University "Paisiy Hilendarski"**

in: field of Higher Education 4. Natural sciences, Mathematics and Computing
Professional Field: 4.2 Chemical Sciences
(name of the scientific specialty) Inorganic Chemical Technology

In the competition for "associate professor", announced in the State Gazette, issues. 98 of 19.11.2024 and on the Internet page of Plovdiv University "Paisiy Hilendarski" for the needs of the Department of Chemical Technology at the Faculty of Chemistry, as a candidate participates ch. assistant professor Dr. Irena Petrova Kostova from Plovdiv University "Paisiy Hi-lendarski".

**1. General presentation of the received materials**

By order No. PD-22-79/17.01.2025. of the Rector of the Plovdiv University (PU) "Paisiy Hilendarski" I have been appointed as a member of the scientific jury of a competition for the academic position of "associate professor" at the PU "Paisiy Hilendarski" in the field of higher education 4. "Natural Sciences, mathematics and information technology, professional direction 4.2. Chemical Sciences (Inorganic Chemical Technology), announced for the needs of the Department of Chemical Technology at the Faculty of Chemistry.

Only one candidate submitted documents for participation in the announced competition:
**Ch. Assistant Professor Dr. Irena Petrova Kostova** from Plovdiv University "Paisiy Hilendarski".

A set of materials presented by ch. assistant professor Dr. Irena Petrova Kostova, is in accordance with the Regulations for the Development of the Academic Staff of the PU "Paisii Hilendarski" and includes the following documents: a reques to the rector, a CV in European format, diplomas for higher education - for a master's degree and for a doctoral degree, a certificate of compliance with with the minimum national and additional faculty requirements, list of scientific works, copies of publications and list of citations, an annotation of materials under Art. 65 of the PRASPU in Bulgarian and English with an extended habilitation reference, self-assessment of contributions, a certificate of work experience, documents for educational activities, documents for scientific research work, a declaration of originality of the attached documents.

The candidate ch. assistant professor Irena Petrova Kostova has submitted a total of 25 scientific works that are outside her dissertation work. 25 scientific works are accepted for review, which are taken into account in the final evaluation. There are no scientific papers outside the topic of the announced concourse. Scientific works are distributed according to the following indicators:

**According to indicator** B: 5 scientific publications with a total of 102 points (4. Habilitation work - scientific publications referenced and indexed in world-famous databases with scientific information (Web of Science and Scopus);

**According to indicator Г:** 1 published book based on a dissertation work for awarding the educational and scientific degree "doctor", 18 scientific publications and 1 useful model with protected document by the Patent Office of the Republic of Bulgaria, - with a total 304 points.
**According to indicator D**: 11 publications were cited 27 times with a total of 54 points

## 2. Brief biographical data (of the applicant)

The candidate - **Chief Assistant Professor Dr. Irena Petrova Kostova**, has studied as a student at the PU “Paisiy Hilendarski” and in 2010 acquired the qualification "chemist" - bachelor, as well as the professional qualification "chemistry teacher", and in 2011 - "chemist-ecologist" with the qualification "master". In the period 2012-2016 she has been a doctoral student at the PU “Paisiy Hilendarski” and in 2016 and has been awarded the educational and scientific degree "PhD”. In 2013 and 2014 she specialized in the University of Saskatchewan, Saskatoon, Canada and in 2019 - specialized for 3 months at the University of Quebec and Outaouais, Canada. In 2015 is appointed as “assistant”, and since 2017- as a Chief. Assistant Professor in the "Chemical Technology" department at the Faculty of Chemistry of the PU "Paisiy Hilendarski". From 2022 she is the Head of the "Research and Development Activity in the Chemical Industry" Department at the PU “Paisiy Hilendarski”. The scientific research, teaching and the administrative activity of the candidate are in the arrea of the chemical technologies - Materials Science, Applied Inorganic Chemistry; Materials for the medicine, Ecology and environmental protection, which shows the candidate's pedagogical, scientific and professional experience in the field of the subject of the announced competition.

## 3. General characteristics of the applicant's activity

### Assessment of educational and pedagogical activity and preparation of the candidate (study materials, lecture courses, work with students, graduates and doctoral students)

The candidate **Ch. Assistant Professor Dr. Irena Petrova Kostova** had participated in the educational and pedagogical activity in the Department of Chemical Technology (NHT section) at the PU "Paisiy Hilendarski", and the activity covers teaching and ongoing activities related to the training of students from various specialties in regular and part-time form of study in the following mandatory disciplines, which are represented in the curriculum of the department: Inorganic Chemical technology, Environmental chemistry, Materials for medicine, Applied inorganic chemistry, Production practice; as well as the optional ones: Ecology and environmental protection, Chemical and pharmaceutical industry of R. Bulgaria. Part of the scientific-pedagogical activity of the candidate had been also aimed at advising students on course and diploma projects. A reference is presented for the implementation of fulfillment of the additional faculty requirements - participation in teaching and learning activities, in which it is shown that in the period 2015-2024 the candidate had teaching and teaching employment with 3,508 study hours (which also included 20 hours of supervision of a graduate), which exceeded the requirements - 3,240 hours.

The presented reference demonstrates the candidate's high activity in educational and pedagogical activity in the Department of Chemical Technology (NHT section) at the TU "Paisiy Hilendarski".

### Evaluation of the candidate's scientific and scientific-applied activity

The candidate's research activity is in the field of materials science and is related to the synthesis and study of the physical, chemical and physicochemical properties of glass and/or glass-crystalline materials, silver nanoparticles, luminescent inorganic materials, polymer-inorganic composite materials.

The presented publications, included in the "Habilitation thesis" **(indicators B and Г),** are dedicated to research results related to the synthesis and investigation of properties of yttrium,

aluminum and lanthanum borates, doped with rare earth elements, as potential fluorescent and phosphorescent markers. Appropriate methods such as X-ray structural analysis, Fourier transformation, Infrared spectroscopy, Raman spectroscopy and Photoluminescence analysis have been applied to perform the research. The characteristics of doped with rear earth elements aluminum and lanthanum borates as potential fluorescent markers have been analyzed. The phosphorescent materials- strontium aluminates doped with rare earth elements, were synthesized and investigated, and their potential for an optical temperature sensor application for fire detection in hazardous environments was evaluated. A method based on differential phosphorescence increasing and decay time has been developed which can serve to effectively monitor temperature changes in real time.

It was found that $H_3BO_3$ helps stabilization the crystalline phase of $SrAl_2O_4$ and prevents the formation of defective oxide structures and a hypothesis is proposed to explain the observed effects. The potential of these materials for an application in optical non-contact sensing applications is demonstrated using interrogation from mobile devices - smartphones. A comparison is made between the time responses of a spectrometer and smartphone, finding that the faster shooting speed of smartphones allows for better examination of weaker phosphorescent signals and better tracking of phosphor responses. Experiments conducted with phosphorescent strontium aluminates show that smartphones are significantly more affordable than spectrometers and offer faster response, which enables faster recording of time responses compared to spectrometers.

As a result of the performed research, reflected in the candidate's publications, important results were obtained, which have a scientific, scientific-applied and applied nature:

i) A temperature sensor based on strontium aluminate has been developed;

ii) The properties of rare earth borates for fluorescent markers have been synthesized and investigated;

iii) Rare earth aluminum and lanthanum borates have been synthesized and used as fluorescent markers active in ultraviolet light;

iv) The possibility of using smartphones for spectral and temporal responses of phosphorescence has been demonstrated for the first time;

v) Rare earth doped glasses and samarium doped glass ceramics have been synthesized for applications in X-ray amplifiers, lasers and as phosphors. The possibility of industrial application in dosimeters, solar cells and for the protection of valuable documents have been also shown;

vi) A new method has been developed for the synthesis of silver nanowires and their application in conductive thin films for touch displays, electronic devices and solar photovoltaic cells;

vii) Sensors based on Sm-doped oxyfluoride glasses with time-multiplexing scintillation and fluorescence responses have been developed. For the first time, a spectrally dependent radiation-induced decay that follows a power law has been observed;

viii) Crystals with photoluminescent properties of strontium/barium aluminates doped with rare earth elements that exhibit strong green phosphorescence have been synthesized. Phosphorescent powders have been successfully integrated into polymer composites and thin films for document protection applications;

ix) The intense luminescence in the visible region of $ZnO-B_2O_3-P_2O_5$ (ZBP) glasses doped with samarium ions has been observed, indicating potential for the use of the material to protect valuable documents, in optical devices and in infrared solid-state lasers;

x) The feasibility of integrating a developed quasi-distributed sensor with phosphorescent optical fibers to integrate a C-LPG array for temperature-sensitive measurements with UV LED excitation has been demonstrated;

xi) A modular atmospheric air monitoring station is proposed, allowing automated collection and sending of data for analysis and visualization. It is adaptable to open atmospheric conditions and requires minimal maintenance.

Innovative sensors and materials based on rare earth elements and nanotechnology have been developed that exhibit high efficiency and sensitivity for applications such as thermal sensing, fluorescence assays, and radiation protection. New methods for the synthesis of materials (microwave-assisted synthesis, green synthesis) have been proposed, which significantly improve the properties of the investigated substances. The unique properties of the synthesized rare earth alloyed glasses and glass-ceramics determine the high potential for applications in dosimetry, optical devices and document protection. The developed materials have a wide range of applications: Document protection through phosphorescent composites; Antimicrobial additives in papers and polymers; Laser technologies and sensors for infrared applications. The new time-multiplexed sensors offer accurate and reliable measurements of radiation and temperature. The automated air monitoring station shows innovation in the environmental sector.

Synthesized materials with controlled properties show potential for creating optical devices with applications in medicine, electronics, industry and security.

The contributions resulting from the conducted research presented in the candidate's publications are related to new discoveries in the field of optics, nanotechnology and materials science. Research has been focused on creating real-world applications in industry, healthcare and ecology, instrument development for automation, miniaturization and environmental friendliness. These contributions provide a perspective for future research and implementation in production, supporting technological progress in important sectors for the stable development of industry and society.

The published book **(indicator Г1)** presents the method of synthesis and the results of the analysis of structural and functional studies of zinc phosphates and strontium (barium) borophosphates doped with samarium, as well as glasses and glass ceramics. The research results of these new optically active materials show their potential for application in dosimeters, solar photovoltaic cells, additives for protecting valuable documents.

The candidate has determined his personal contribution to the research of aluminum and rare earth borates, which includes the development of synthesis procedures, their optimization to achieve maximum fluorescence efficiency, the study of the crystal structure, the performance of optical measurements and the processing of the obtained data, which are essential for conducting the research and obtaining the results published in her articles.

11 of the presented scientific publications are published in journals with an impact factor (total impact factor 28.8).

The publications presented by the candidate **Chief Assistant Professor Dr. Irena Kostova** have found a response among the international scientific community. 27 citations of 11 of the publications presented in the documents have been noted: 1- cited 6 times, 1 - 5 times, 3 - 3 times, 1 - 2 times and 7 - 1 time **[Indicator D].** The authors in many of the citing articles confirm by their obtained results the published results in the articles of the candidate [numbers from the list of the citing publications: [14] T.G. Mathe et al., Current Applied Physics, 67 (2024) 151-163; [28] M. Zagrai et al., Journal of Non-Crystalline Solids, 576, (2022) 121234; [47]. T. Wibawa et al., Engineering, Technology & Applied Science Research, 14, No. 6, 2024, 18911-18922.]

The candidate **Chief Assistant Professor Dr. Irena Petrova Kostova** is the author of one independent publication, 1 article - with one co-author, 4 articles - with two co-authors, and 17 articles - with three or more co-authors, 1 useful model with three co-authors. She has participated with presentations at 3 international scientific conferences and at 5 international schools funded by NATO under the NATO Science for Peace and Security program.

**Chief Assistant Professor Dr. Irena Petrova Kostova** has been participant in 7 research projects financed by PU "Paisiy Hilendarski" (2013-2022) and 1 project, with financial support by the EU through the National Plan for Recovery and Sustainability of the Republic of Bulgaria 2023-2026, as well as she has been worked with the support by the projects under the National Program "Young scientists and postdoctoral students" (2018/2019 and 2020).

The results of the conducted research, published in the scientific articles, presented in the candidate's documents **Chief Assistant Professor Irena Petrova Kostova** demonstrate that the used technological synthesis methods have contributed to obtaining materials with the potential for sensor applications in optical devices for engineering, electronics and medicine. The obtained results have an important contribution to the improvement of the technological synthesis parameters and improving the characteristics of borate materials, thus providing a scientific basis for future developments. The measurements performed with a smartphone show the possibility of a reliable comparison between fluorescence spectra obtained with professional equipment and affordable mobile devices, demonstrating the potential for alternative methods of spectral analysis. This defines the results as scientific and applied, prospective and a basis for the development of optoelectronics, electronics, medicine.

The applicant's quantitative indicators exceed those of the requirements: Indicator A - 50 (requirement 50), Indicator B - 102 (requirement 100), Indicator D - 304 (requirement 200), Indicator D - 54 (requirement 50).

All quantitative indicators meet and even exceed the national requirements and those of the Faculty of Chemistry of PU "Paisiy Hilendarski" for acquiring the position of "associate professor".

## CONCLUSION

The documents and materials presented by **Chief Assistant Professor Dr. Irena Petrova Kostova** meet all the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB), the Regulations for the Implementation of LDASRB and the relevant Regulations of the PU "Paisiy Hilendarski" and of the Faculty of Chemistry at the university.

The candidate in the competition has submitted a significant number of scientific works - 25, published after the materials used in the defense of the ONS "doctor". The scientific publications of the candidate **Chief Assistant Professor Dr. Irena Petrova Kostova** have original scientific, applied and scientific-applied contributions that have received international recognition, a representative part of which has been published in journals and scientific collections issued by international academic publishing houses and for finding a response among the scientific community. The candidate's scientific and teaching qualifications are undoubted.

The achievements of **Chief Assistant Professor Dr. Irena Todorova Kostova** in the educational activities and research results fully correspond to the minimum national and additional requirements of the Faculty of Chemistry, adopted in connection with the Regulations of the PU for the application of ZRASRB.

After getting acquainted with the materials and scientific works presented in the competition and analyzing their significance and the scientific, applied and scientific-applied contributions contained in them, I find it reasonable to give my positive assessment and **"yes"** and recommend the Scientific Jury to prepare report-proposal to the Faculty Council of the Faculty of Chemistry for the election of **Chief Assistant Professor Dr. Irena Petrova Kostova** at the academic position of **"Associate Professor"** in PU "Paisiy Hilendarski" in the field of higher education: 4. Natural sciences, mathematics and informatics, 4.2 Chemical technologies, professional direction "Inorganic chemical technology".

10.02.2025 Reviewer: ……

Prof. D.Sc. Doriana Malinovska