Институт по ФИЗИКОХИМИЯ при БАН
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REVIEW

For the competition for academic position "Assosiete Profesor" in the profetional field 4.2 Chemical Sciences for the scientific specialty "Physical Chemistry" for the needs of the "Phase Formation, Crystalline and Amorphous Materials" by the Institute of Physical Chemistry, Bulgarian Academy of Sciences (IPC-BAS), announced in the State Gazette 63/10.07.2026.

Reviwer: Prof. Dr. Lyubomir Aleksandrov, Institute of General and Inorganic Chemistry, Bulgarian Academy of Sciences

1. Applicant's personal and professional information

In the competition announced by the Institute of Physical Chemistry – Bulgarian Academy of Sciences (IPC-BAS) for the academic position of "Associate Professor" in Professional Field 4.2. Chemical Sciences, scientific specialty "Physical Chemistry", for the needs of the "Phase Formation, Crystalline and Amorphous Materials" section, one candidate has been admitted: Chief Assistant Professor Nikolay Bozhidarov Yordanov, PhD.

Dr. Yordanov completed his higher education in 2000 at the University of Chemical Technology and Metallurgy (UCTM) – Sofia, master degree at "Technology of Organic Synthesis" with the qualification of "Chemical Engineer".

Following his graduation, from 2000 to 2001, he worked as a "Research Fellow" at the Institute for Spectrochemistry and Applied Spectroscopy in Dortmund, Germany. From 2001 to 2004, he held the position of Assistant Lecturer at the Institute of Physical and Theoretical Chemistry at the University of Duisburg-Essen, Germany. In 2009, he was appointed as an Assistant at IPC-BAS until 2022. Concurrently, in 2012, he was enrolled as a PhD student on independent preparation at IPC-BAS, where he obtained the educational and scientific degree of "Doctor" (PhD) in 2017. Currently, Dr. Yordanov holds the position of "Chief Assistant Professor" at IPC-BAS, which he has occupied since 2022.

During the 2007–2008 period, Dr. Yordanov specialized at the University of Rostock, Germany, focusing on Differential Scanning Calorimetry (DSC), and in 2023, he completed a research stay at the University of Padua, Italy, with the topic of "Innovative Materials Science".

2. General description of the materials presented for the competition

Chief Assistant Professor Dr. Yordanov has submitted a List of Publications Equivalent to a Habilitation Thesis (5 items), a List of Publications Excluded from the PhD Thesis and Habilitation Thesis (11 journal publications and 3 book chapters), a List of Publications Excluded from the PhD Thesis (24 items), a List of Publications Included in his PhD Dissertation (2 items), as well as a List of Citations in Scientific Publications Included in Group "D" (83 items).

In the current competition, Chief Assistant Professor Dr. Yordanov participates with 5 publications in journals that are peer-reviewed and indexed in global databases of scientific information, which correspond to the requirements for a Habilitation Thesis. The scientific works are published in journals ranked in quartiles as follows: Q1 – 2 items, Q2 – 2 items, and one publication in a journal with SJR without an impact factor (IF). The works outside the Habilitation Thesis (Indicator G) comprise 10 journal publications and 3 book chapters.

The materials submitted by Chief Assistant Professor Dr. Yordanov correspond to the thematic scope of the announced competition. The comparisons made with the minimum national requirements established by the Act on Development of the Academic Staff in the Republic of Bulgaria and the Regulations for its implementation for occupying the academic position of "Associate Professor" in Scientific Area 4. Natural Sciences, Mathematics and

Informatics, Professional Field 4.2. Chemical Sciences, as well as the Regulations on the terms and procedures for acquiring scientific degrees and occupying academic positions at IPC-BAS, demonstrate that the indicators of Chief Assistant Professor Dr. Yordanov meet, and in some cases exceed, the minimum requirements as follows: Indicator A – 50 points (50 required); Indicator B – 100 points (100 required); Indicator G – 242 points (200 required); Indicator D – 166 points (50 required).

3. General characteristics of the research activity

The research activity of Chief Assistant Professor Dr. Yordanov is directed toward the synthesis of novel foam materials from industrial waste raw materials, the investigation of the physicochemical parameters of the materials, and the accompanying processes occurring during thermal treatment. Metallurgical slag, supplemented with various glass-forming raw materials, was used as the primary precursor.

To characterize the materials, a wide spectrum of appropriately selected, comprehensive methodologies was employed, including Hot-Stage Microscopy (HSM), Scanning Electron Microscopy (SEM), Energy-Dispersive Spectroscopy (EDS), Three-Dimensional Computed Tomography (CT), X-ray Diffraction (XRD) analysis, and Infrared (IR) Spectroscopy.

As previously mentioned, the candidate has presented 5 publications that substitute the habilitation thesis. These publications pertain to the synthesis and characterization of a novel type of glass-ceramic foam materials derived from waste raw materials (metallurgical slags) with additions of quartz sand, CaF_2, combinations of both additives, and model borosilicate glasses. The effects of the additives on the melting, crystallization, sintering, and foaming processes were investigated in detail. The studies addressed cases of pre-fritting at high cooling rates of the utilized batches, subsequent milling to approximately 75 microns, and pressing at high temperatures (1400 °C). This approach enabled the researchers to obtain materials with varying properties, namely dense glass-ceramics, self-glazing glass-ceramics, and foam materials. Attention was paid to the possibilities of synthesizing the materials in different gas atmospheres, specifically air and argon. Alterations in the densification (sintering) temperatures, foaming tendency, and crystallization behavior were established. The authors determined that this discrepancy in the thermal behavior of the two samples is primarily due to differences in the viscosity values of the respective materials, which are entirely governed by the equilibrium state of the Fe(II) $\leftrightarrow$ Fe(III) redox pair. Specifically, an inert atmosphere (argon) maintains the equilibrium shifted maximally to the left (inhibiting oxidation), whereas an air atmosphere maintains the Fe(II)/Fe(III) ratio at a minimum value, shifting the equilibrium to the right. The possibilities for pre-pressing a model borosilicate glass were also explored. A critical volume fraction of the crystalline phase was identified, which directly influences the structural densification of the vitreous material. The materials obtained via this route are characterized by a specific porosity, termed by the authors as CIP (Crystallization-Induced Porosity).

Although it is difficult to distinguish, or rather there is a lack of an explicit "Author's Contribution Statement" within the provided materials, the remaining papers outside the habilitation thesis are dedicated to several distinct research directions, as follows: continuation of the topic regarding the synthesis of novel foam materials from various waste slags and waste powders from cement production, proposing interesting options for waste recycling, prevention of landfilling, and reduction of the natural resources utilized for the synthesis of glasses and glass-ceramic materials with specific properties; investigation of thermodynamic characteristics and development of kinetic models for nucleation and crystal

growth of crystalline phases from amorphous specimens; experimental studies related to the thermal and corrosion properties of amorphous and glass-crystalline layers electrochemically deposited onto substrates.

4. Main scientific contributions

4.1 Scientific contributions in the publications substituting for the habilitation thesis

The main publications corresponding to the habilitation thesis can be summarized as follows. The feasibility of conducting successful synthesis of well-sintered glass-ceramics and/or glass-ceramic foams depending on the temperature and the applied atmosphere was evaluated. It was established that synthesis in an inert atmosphere leads to materials with a higher degree of sintering, exceeding 85 vol.%. The subsequent foams are also characterized by fire resistance up to temperatures of 1100 °C.

By applying a two-stage thermal treatment—the first stage being low-temperature sintering at 950 °C and the second stage being foaming at 1100 °C—foam materials with enhanced properties and structural variations were successfully obtained. A well-sintered material with a total porosity below 10–15 vol.% was produced. These materials, obtained via thermal foaming, can be utilized as cost-effective, advanced construction materials and insulation products in various fields.

Technological flexibility was demonstrated as a function of thermal treatment rates and holding temperatures due to variations in crystallinity and apparent viscosity, as well as the bloating tendency resulting from the thermal reduction of iron and manganese oxides contained in the utilized slag. At a heating rate of 10 °C min^{-1} and thermal treatment at 950 °C, a well-sintered glass-ceramic with a bulk porosity of approximately 10% and a moderate degree of crystallization (around 35%) was obtained. Upon applying higher heating rates (20 °C min^{-1}) and a short holding time at 1020 °C, a product with a slightly deformed surface characterized by self-glazing was obtained. Applying even higher heating rates of the order of 30 °C min^{-1} combined with holding at temperatures of 1100 °C enables the fabrication of novel refractory sintered glass-ceramic foams with a cellular structure and a closed porosity of approximately 85–95 vol.%.

Furthermore, it was established that the atmosphere directly influences the synthesis of sintered and foamed glass-ceramic materials containing high amounts of iron. It was demonstrated that in an argon atmosphere, the activation energies of sintering and the densification temperatures are lower. The crystallization process is favored in argon, whereas the foaming process is enhanced in air. In both the sintered and foamed materials, the precipitated crystalline phases consist of pyroxene crystals in varying amounts. It was determined that to obtain correct results for the activation energies of sintering, it is necessary to perform a preliminary oxidation stage, which ensures the complete oxidation of the samples. This oxidation process occurs near the glass transition region, whereas a thermal reduction process initiates with a further increase in temperature. The argon atmosphere completely inhibits foaming and improves the degree of sintering. Following the introduction of an additional oxidation stage, foaming occurs in both air and argon. It was highlighted that an earlier foaming process takes place in an inert atmosphere. In fact, higher values of the Fe^{3+}/Fe^{2+} ratio in an inert atmosphere favor the early onset of the foaming process. The kinetic effect is more pronounced in an inert atmosphere. Additionally, it was demonstrated that foam materials with different structures can be obtained by applying a pre-oxidation stage, followed by conducting the synthesis in an argon atmosphere.

It was found that the moderate crystallinity and high porosity of 85–95 vol.% of the synthesized glass-ceramic foams determine the final properties of the recycled materials used.

To reduce production costs, the effect of adding CaF_2 to the batch (2.5, 5, and 7.5 wt.%) on the melting, densification, crystallization, and bloating of the glass was also established. Increasing the amount of CaF_2 leads to a significant decrease in both the melting and sintering temperatures. Furthermore, it was proven that variations in the percentage content of CaF_2, fraction size, heating rate, and holding temperatures alter the sintering tendency, phase formation, and foaming capacity.

4.2 Scientific contributions in the materials presented as non-habilitation publications

As mentioned above, the works presented outside the habilitation thesis are dedicated to the following scientific areas: synthesis of novel foam materials from various waste slags, waste powders from cement production, etc., proposing interesting options for waste recycling, prevention of landfilling, and reduction of the natural resources utilized for the synthesis of glasses and glass-ceramic materials with specific properties; investigation of thermodynamic characteristics and development of kinetic models for nucleation and crystal growth of crystalline phases from amorphous specimens; experimental studies related to the thermal and corrosion properties of amorphous and glass-crystalline layers electrochemically deposited onto substrates.

An important scientific contribution is represented by the papers dedicated to the recycling of waste products from metallurgical production and cements. The possibility of obtaining clinker-free, alkali-activated binders and concrete entirely from waste products, such as metallurgical slag, coal fly ash, and cement production dust, was investigated. The developed mortars and concretes are characterized by a compressive strength at 28 days that corresponds to concrete class C20/25.

A geopolymer foam derived from fayalite flotation waste from the copper smelting industry was developed. The resulting materials are characterized by low thermal conductivity and high thermal stability. The possibility of recycling glass slags through a beneficiation process to obtain a new vitreous mass was examined. It was established that the presence of iron oxides contained in the slags creates the prerequisite for an autocatalytic thermal foaming process to occur. The process was optimized by introducing an isothermal oxidation stage to achieve the maximum amount of iron in a higher oxidation state, namely Fe_2O_3. Subsequent reduction at higher temperatures initiates better foaming of the material. It was concluded that the foaming process depends on oxidation or decomposition reactions involving modifying compounds that induce swelling of the glass-ceramic or ceramic materials. In cases where the initial batch contains intermediate oxides (of iron or manganese) that transition from a higher to a lower oxidation state as a result of reduction, the addition of an extra foaming agent is unnecessary.

Fly ash from thermal power plants, waste glass (cullet), and limestone sediment waste from sugar beet processing were utilized to produce a novel vitreous material. Through subsequent thermal treatment and crystallization of the glass, dense glass-ceramics with a porosity below 1% were obtained.

An analysis of the main physical properties of the crystalline and amorphous modifications of silicon dioxide was conducted, with a primary focus placed on their thermodynamic characteristics. An approximate method was developed, allowing the evaluation of the standard entropy and enthalpy of all silicon dioxide modifications based solely on their density data. In this manner, the thermodynamic properties can be calculated with sufficient accuracy even for those modifications for which corresponding measurements are currently lacking or available data are contradictory.

A profound analysis was carried out, and a new approach was developed to describe the kinetics of chemical reactions, phase transitions, structural relaxation, and glass transition within non-isothermal kinetics using classical kinetic models designed for isothermal conditions. An investigated issue was the extent to which it is possible, based on a single experiment (cooling or heating), to determine both the relevant kinetic models and the activation energies that govern and limit the process under consideration. Existing isoconversional methods for non-isothermal analysis based on cooling experiments were examined as a potential alternative. It was established that this approach is necessary and can yield excellent results in analyzing processes such as crystallization from melt or the kinetics of topochemical reactions (e.g., in evaluating the relative activity of nucleating agents). However, within the framework of the proposed method, it is impossible to determine the absolute values of the activation energies or to unambiguously establish the reaction mechanisms.

A study related to the experimental investigation of the thermal and corrosion properties of amorphous nickel-phosphorus alloy layers obtained via electrodeposition was presented. Specimens of hypoeutectic and hypereutectic compositions were synthesized on copper substrates using modified classical and specially developed electrolytic solutions. Thermal treatment of the specimens was carried out to induce crystallization of the amorphous structure and to compare the thermal and corrosion properties of the materials in both of their structural states.

The electrochemical growth of copper crystals on glassy carbon and tungsten substrates was investigated by measuring the time dependence of the crystal radius, R(t), under potentiostatic conditions. The obtained results are interpreted within a theory that accounts for both pure charge transfer and combined limitations arising from charge transfer and diffusion. The values of three vital growth parameters were experimentally determined: the diffusion coefficient, exchange current density, and charge transfer coefficient. Information regarding the steady-state nucleation rate of copper clusters on a tungsten substrate was obtained. Parallel studies on the growth kinetics of copper on a tungsten working electrode demonstrated that copper crystals lose their morphological stability on this substrate at sizes as small as approximately 5 μm.

5. Impact of the publications in the literature

To date, Dr. Yordanov has accumulated 166 citations, 162 of which are visible in Web of Science and Scopus, excluding direct and indirect self-citations. The most cited paper is "Investigations of the hygroscopic properties of ammonium sulfate and mixed ammonium sulfate and glutaric acid micro droplets by means of optical levitation and Raman spectroscopy" with 48 citations, where Dr. Yordanov is the first author. Another heavily cited paper with the participation of Dr. Yordanov is "Sintered glass-ceramics and foams by metallurgical slag with addition of CaF_2" with 39 citations. All papers involving Dr. Yordanov are cited, which indicates the relevance and currency of his research.

6. Critical notes and recommendations regarding the applicant's research activity

I have no critical remarks regarding the scientific work of Dr. Yordanov. I would only venture a slight comment regarding the arrangement of the materials submitted for the competition. From the provided documentation, it is not clear which scientific achievements belong to the habilitation report and which belong to the author's summary of contributions, the latter of which, in my view, are not described. It would be beneficial if the publications relating to the habilitation thesis were separated into a dedicated folder, which would facilitate the evaluation process for the jury.

7. Evaluation of applicant's personal contribution and fulfillment of the requirements for the occupation of the academic position of "Associate Professor"

The works submitted for the competition are the result of teamwork among researchers with diverse expertise. In a large portion of the publications, Dr. Yordanov is the leading author, and in one of them, he is the sole author, which demonstrates that his personal contribution to the scientific papers is substantial and indisputable.

8. Personal impressions from the applicant

Observations regarding the scientific growth of Dr. Yordanov have been shaped within the context of numerous joint forums and workshops. Over this period, he has established himself as a researcher with well-reasoned and strictly professional stances. His scientific activity is characterized by high methodological precision, and his endeavor toward detailed discussion of empirical data contributes significantly to the objective interpretation and validation of the established results.

Conclusion

Chief Assistant Professor Dr. Yordanov has submitted scientific materials that comply with the requirements of the competition and even exceed the established minimum indicators required for occupying the academic position of "Associate Professor" in Professional Field 4.2. Chemical Sciences. Based on the above, and taking into account the scientific indicators as well as the excellent impressions of the candidate, I confidently recommend that Chief Assistant Professor Dr. Nikolay Yordanov be appointed to the academic position of "Associate Professor" in Professional Field 4.2. Chemical Sciences, scientific specialty "Physical Chemistry", for the needs of the "Phase Formation, Crystalline and Amorphous Materials" section at the Institute of Physical Chemistry, Bulgarian Academy of Sciences.

Reviewer:

30.10.2026 /Prof. Dr. Lyubomir Aleksandrov/