

R E V I E W

by Prof. Elena Zdravkova Ivanova – IGIC-BAS, member of the Scientific Jury

in a competition for the academic position “Professor”

in professional field 4.2. Chemical Sciences (Solid State Chemistry)

for the needs of the Laboratory “Design and Characterization of Catalytic Materials” at IC-BAS,

announced in the State Gazette, issue 82/07.10.2025.

Candidate: Assoc. Prof. Dr. Hristo Gospodinov Kolev

I. Overview of the submitted materials

The sole candidate, Assoc. Prof. Dr. Hristo Gospodinov Kolev, has submitted an application to participate in the competition for the academic position “Professor” (thematic area “Surface analysis”) and has provided a complete set of documents in accordance with the requirements of the Institute of Catalysis.

The submitted materials include: curriculum vitae (CV), a copy of the diploma for the educational and scientific degree “Doctor (PhD)”, a certificate of professional experience in the specialty, lists of publications (including those submitted for the competition), a statement on fulfillment of the minimum requirements and a reasoned statement of scientific contributions with supporting evidence, as well as full texts/reprints of the works included in the competition.

A certificate from IC-BAS confirms that as of 01.10.2025 the candidate has 23 years, 1 month and 14 days of professional experience in the specialty. The documents have been submitted in one hard-copy set and seven sets on electronic media.

The candidate is an employee of IC-BAS; therefore, a medical certificate and a certificate of criminal record are not required. The file also contains additional supporting materials documenting scientific-organizational, training and expert activity, as well as documents for received awards.

II. Brief biographical information about the candidate

Assoc. Prof. Dr. Hristo Gospodinov Kolev graduated from Sofia University “St. Kliment Ohridski” with a master’s degree in Engineering Physics in 1998. In 01.2009 he obtained the educational and scientific degree “Doctor (PhD)” in Physics (scientific specialty “Electrical, magnetic and optical properties of condensed matter”) at the University of Münster (Germany).

His professional development is closely linked to the Institute of Catalysis – BAS, where since 03.02.2014 he has held the academic position of Associate Professor (professional field 4.2. Chemical

Sciences – “Solid State Chemistry”). His scientific interests and practical expertise are in the area of surface analysis and X-ray photoelectron spectroscopy (XPS), including maintenance and operation of XPS instrumentation and interpretation of spectral data.

The candidate has also completed international specializations/trainings related to the application of XPS and synchrotron methods, including within the Slovak National Scholarship Programme (SAIA) in Košice, as well as specializations at the Abdus Salam International Centre for Theoretical Physics (ICTP) and at Elettra – Sincrotrone Trieste (Trieste, Italy).

III. Overview of the candidate’s scientific and applied scientific activity

The candidate has a total of 139 publications, 113 of which were published after habilitation (2014). For the purposes of the competition, 77 publications are submitted, distributed across quartile categories as follows: Q1 – 32 (including 4 publications in top-ranked journals); Q2 – 21; Q3 – 17; and Q4 – 7.

Table 1. Assessment of the candidate by indicator groups (for “Professor”) – BAS/IC

Indicator group	Content	Minimum points for “Professor”	Points of Assoc. Prof. Dr. Hristo Kolev	Excess
A	Indicator 1	50	50	
B	Indicator 2	–	–	
B	Indicators 3 or 4	100	250	+150
Г	Sum of indicators 5 to 10	200	1359	+1159
Д	Sum of points in indicator 11	100	2080	+1980
E	Sum of indicators 12 to the end	150	487	+337
Total points		600	4226	+3626

Based on the data in Table 1, it is evident that the candidate significantly exceeds the minimum requirements for appointment to the academic position of “Professor,” with a total of 4,226 points compared to the required 600 points. Following the applied correction, the distribution of points remains fully consistent with the current criteria and does not affect the candidate’s overall evaluation. The main contributions to this result come from the indicators for citation impact (Group D – 2,080 points) and scientific output outside the habilitation cycle (Group G – 1,359 points).

The habilitation thesis comprises 10 scientific articles published in Q1 journals, evaluated under Group B with a total of 250 points. The candidate’s scientific visibility is confirmed by 1,040 citations in Web of Science/Scopus and an H-index of 19.

Following habilitation, the candidate has participated in 35 research projects (4 as principal investigator), has been granted 2 national patents, and has demonstrated high scientific activity through 140 presentations at 77 scientific forums (32 oral presentations and 107 posters).

IV. Other activities

The candidate participates actively in the scientific-organizational and expert life of the Institute of Catalysis – BAS and BAS. The submitted materials document:

- participation in governance bodies and scientific councils (including member of the Scientific Council of IC-BAS since 2014 and Deputy Chair for the term 2023–2027; Head of the IC-BAS colloquium/scientific seminar for the period 2016–2027);
- organization of scientific forums as a member of organizing committees of international and national conferences/symposia;
- received awards (First Prize, 2011, and Second Prize, 2013 – competition of BAS–IMSTCHA “Acad. A. Balevski” for best theoretical and applied scientific work in honour of 24 May);
- training and mentoring activity – supervision of a trainee/specialization and methodological support in XPS during training visits of PhD students and young researchers; participation as a mentor in organized student internships (project “Student Internships – Phase 2”);
- science popularization activities – participation in media/programmes for the popularization of science.

V. Analysis of the scientific and applied scientific contributions

In the submitted statements, the candidate’s scientific contributions are argued as a consistent development of expertise based on X-ray photoelectron spectroscopy (XPS). The method provides information on the chemical state of the upper few nanometres of the surface, including elemental composition, oxidation states, chemical environment, surface chemical groups and (surface) stoichiometry. This expertise has been purposefully used to elucidate the “composition–structure–functionality” relationships of the investigated materials.

An important feature is the declared methodological standard: minimal intervention in sample preparation, a preliminary plan for measurement and data processing (selection of analytical lines, backgrounds and energy calibration), and correct consideration of method limitations related to surface “screening”, contamination and charging effects.

In all cases, XPS is combined with a wide range of modern experimental methods – XRPD, SEM/TEM, EDX, AFM/STM, IR, Raman, EPR, SQUID, ICP-AES, TG/DSC, N₂ physisorption, temperature-programmed methods (TPR/TPO), electrochemical impedance spectroscopy, cyclic and pulse voltammetry – as well as theoretical interpretations of redox processes, oxygen defect chemistry and surface energy levels. This integrated approach provides a comprehensive understanding of the structure and functionality of the materials and outlines mechanistic dependencies that determine their applications in catalysis, energy technologies, nanomedicine and optoelectronics.

V.1. Habilitation work

The main scientific contributions in the habilitation work (publications B1–B10) can be summarized by grouping them according to the type of catalytic process/reaction for which the corresponding materials have been developed and optimized.

(i) Catalytic combustion of methane and volatile organic compounds (VOCs)

The contributions in this group are directed toward environmentally important reactions of catalytic combustion of methane (CH_4) and n-hexane (as a VOC model compound), through the development and optimization of Pd–Co/ Al_2O_3 systems [B2] and Co/Mn oxide catalysts supported on natural clinoptilolite as a low-cost carrier [B5, B7].

Using XPS it is shown that CoO_x modification increases the activity and stability of the Pd/ Al_2O_3 catalyst in complete methane oxidation. The active centres are interpreted as PdO clusters, while the surface Co-oxide phase acts as an “oxygen reservoir” and stabilizes Pd in an oxidized form. XPS follows the evolution of Pd species, showing an increase of Pd^{2+} (PdO) at the expense of Pd^{4+} (disappearing) and Pd^0 after a catalytic cycle. The unchanged binding energy of Pd^{2+} after thermal ageing indicates an unchanged PdO - support interaction and hence system stability. The comparable $\text{Pd}^{2+}/\text{Pd}^0$ ratios after ageing in Co-modified samples prepared by different approaches are consistent with their similar catalytic activity after ageing.

For single-component CoO_x and MnO_x supported on clinoptilolite [B7], it is shown that the lower loading (10 wt.% vs 20 wt.%) leads to better dispersion/smaller particles and higher reducibility, and therefore to higher activity in complete oxidation of n-hexane. For mixed Co–Mn oxides on clinoptilolite [B5], the optimum ratio between the components is decisive; XPS provides information on the actual surface distribution (for the most active catalyst Co/Mn ≈ 1). XPS also demonstrates the presence of mixed $\text{Co}^{2+}/\text{Co}^{3+}$ and $\text{Mn}^{3+}/\text{Mn}^{4+}$ valence states related to oxygen mobility and redox behaviour of the catalysts. The observed changes in Co and Mn valence after reaction and their recovery after oxidative treatment are compatible with redox cycling of the active phase and support a Mars–van Krevelen type interpretation, as well as good structural stability under redox cycling.

(ii) Catalytic processes for hydrogen production

The contributions here are related to the development of nanoscale catalytic systems for hydrogen production via two complementary approaches: (a) thermocatalytic processes – gas-phase methanol decomposition and aqueous-phase reforming of ethylene glycol; and (b) electrochemical processes – alkaline water electrolysis, where the key stage is the anodic oxygen evolution reaction (OER).

In [B3], activated carbons (from waste biomass and low-grade coals) with different porosity and surface chemistry are synthesized and used as supports for Co-containing catalysts for methanol decomposition. XPS clarifies that activity and selectivity depend strongly on the distribution and accessibility of cobalt oxides in the porous structure (via determination of the surface Co concentration and the $\text{Co}^{2+}/\text{Co}^{3+}$ ratio).

In [B1] it is established that Ni–Sn intermetallic phases supported on $\text{Ce}(\text{Zr})\text{O}_2$, under alkaline conditions (pH ≈ 14), provide the best compromise between conversion and hydrogen yield in aqueous-phase reforming of ethylene glycol. This is explained by an XPS-observed change in surface composition and regulation of exposed Ni^0 sites upon changing the Sn content in Ni–Sn particles, which suppresses methanation and increases selectivity toward hydrogen.

An important and original focus in [B4] and [B8] is the demonstration of a concept for valorizing catalysts spent in methanol decomposition (deactivated due to carbon deposition) as promising anodic electrocatalysts for OER. In [B4], Ce–Fe–Ni oxide composites after H₂ reduction and methanol decomposition undergo transformation of the active phase (reduction/alloying and carburization) followed by carbon coating/encapsulation in carbon nanofibres, leading to a significant increase in OER activity. In [B8], waste activated carbon pre-treated with hydrazine and modified with Ni_xFe_{3-x}O₄ spinels forms a carbon coating after methanol decomposition; it is shown that the material after low-temperature hydrazine treatment achieves improved OER electrocatalytic performance, associated with a larger electrochemically active surface area and lower charge-transfer resistance. In both cases, XPS is a key method for tracking surface phase and redox evolution (Ce⁴⁺/Ce³⁺, Ni²⁺/Ni⁰, Fe³⁺/Fe²⁺), for quantitative description of N/O functionalization of the carbon, and for proving the formation of a carbon coating (screening of metallic signals), supporting the interpretation of differences in electrocatalytic activity.

(iii) Catalytic processes for water purification

The contributions in this group focus on the degradation of pharmaceutical contaminants in water (antibiotics and analgesics) via advanced oxidation processes (AOP) and tribocatalysis over oxide/composite catalysts.

In [B9], SmFeO₃/CuO composites with different ratios are synthesized and shown to exhibit synergy and higher activity than the individual oxides in the degradation of an antibiotic (sulfathiazole) in water under photo-assisted activation of peroxymonosulfate (PMS), with the 2:1 composition being most effective. XPS shows enhanced surface redox activity of the composite through the presence of Fe³⁺/Fe²⁺ and Cu²⁺/Cu⁺ couples (with increased shares of Fe²⁺ and Cu⁺), as well as an increased contribution of non-lattice (defective) oxygen, which supports PMS activation and the generation of reactive oxygen species for antibiotic degradation.

Publications [B6] and [B10] develop an approach for “dark” tribocatalysis, in which mechanical energy (friction during stirring) is converted into oxidative activity of ZnO-based materials. In [B6] it is shown that modification of ZnO with La₂O₃ or Eu₂O₃ increases the efficiency of tribodegradation of doxycycline; the stronger effect of La₂O₃ is associated with higher specific surface area and better surface exposure of the La-containing phase (supported by XPS). In [B10], a series of ZnO/ Eu₂O₃ (1–3 mol% Eu) obtained by a sol–gel method is developed for tribocatalytic degradation of paracetamol. XPS establishes a correlation between surface europium and the fraction of non-lattice oxygen after the test; on this basis, the participation of surface defect centres (non-lattice oxygen species/low-coordinated sites) in the tribocatalytic process is proposed.

V.2. Author’s report

The publications included in the author’s report (G1–G10) considerably broaden the thematic scope of the candidate’s research and demonstrate diversity of functional materials and applications. The common “core” of these works is again the systematic use of XPS as a key tool for reliable identification of valence states, surface stoichiometry and defectiveness, as well as for tracing the influence of synthesis and treatment on surface chemistry. This directly supports interpretation of

functional properties (conductivity, electrochemistry, emission, (nano)biomedical efficiency). Below, the main contributions are highlighted through one representative example for each area.

(i) Energy conversion/storage

In G6, solid solutions $\text{Ce}_{1-x}\text{Gd}_x\text{O}_{2-x/2}$ ($0 \leq x \leq 1$) obtained by ion gelation are studied by comparing powders after low-temperature treatment and sintered ceramics after high-temperature treatment. XPS confirms incorporation of Gd^{3+} into the CeO_2 lattice and shows that a higher fraction of Ce^{3+} is observed for samples with higher Gd content as well as for the sintered ceramics. The oxygen non-stoichiometry generated upon $\text{Gd}^{3+} \rightarrow \text{Ce}^{4+}$ substitution and the accompanying increased Ce^{3+} content contribute to higher oxygen-ion conductivity and lower operating temperature of solid oxide fuel cells, highlighting the potential of Gd-doped CeO_2 ceramics for this application.

(ii) Luminescence

In G2, thin films of GdNbO_4 and GdTaO_4 are investigated. Comparison of the XPS-determined surface composition ($\text{Gd}/\text{Nb}/\text{O}$ and $\text{Gd}/\text{Ta}/\text{O}$) with optical spectra clarifies the role of charge transfer $\text{O}^{2-} \rightarrow \text{Nb}^{5+}/\text{Ta}^{5+}$ and the f-f transitions of Gd^{3+} for UV emission and the potential for sensing/display applications.

(iii) Nanomedicine

In G10, multinuclear maghemite “nanoflowers” ($\gamma\text{-Fe}_2\text{O}_3$) with ultra-low Gd^{3+} doping are studied as a platform for cancer diagnosis and therapy via magnetic resonance imaging (MRI) and magnetic hyperthermia (MHT). XPS shows that doping induces surface defects – an increase in Fe^{2+} and non-lattice oxygen, interpreted as redox imbalance and oxygen vacancies – which are linked to changes in magnetic anisotropy/spin disorder and to functional performance indicators.

VI. Summary and conclusion

The submitted materials outline a candidate with a stable and recognizable scientific profile in surface analysis and in the application of X-ray photoelectron spectroscopy (XPS) to catalysis and functional materials. The scientometric indicators, publication activity, citation impact, project and applied-science activity, as well as the scientific-organizational and training activity, convincingly support the candidacy.

On this basis, I give a positive evaluation and propose that the esteemed Scientific Jury support the election of Assoc. Prof. Dr. Hristo Gospodinov Kolev to the academic position “Professor” in professional field 4.2. Chemical Sciences (Solid State Chemistry) for the needs of the Laboratory “Design and Characterization of Catalytic Materials” at IC-BAS.

06.01.2026 г.

Sofia

Member of the Scientific Jury:

/Prof. Dr. Elena Ivanova/