

REVIEW

by Assoc. Prof. PhD. Aleksandar Tsanev,
Institute of General and Inorganic Chemistry – BAS,
Member of the Scientific Jury
regarding a competition for filling the academic position of **Professor**
in Professional Field 4.2 **Chemical Sciences**,
Scientific Speciality **Solid State Chemistry**,
announced in the State Gazette, issue No. 82 of 07 October 2025

regarding a competition for filling the academic position of **Professor** in Professional Field 4.2 **Chemical Sciences (Solid State Chemistry)** for the needs of the Laboratory “Design and Characterization of Catalytic Materials” at the Institute of Catalysis – BAS, announced in the State Gazette, issue No. 82 of 07 October 2025, with candidate Assoc. Prof. Dr. Hristo Gospodinov Kolev

Reviewer: Assoc. Prof. Dr. Alexander Svetoslavov Tsanev, Institute of General and Inorganic Chemistry – BAS, Member of the Scientific Jury

This review has been prepared on the basis of Order No. RD-09-91 of 09 December 2025 issued by the Director of the Institute of Catalysis – BAS, adopted pursuant to a decision of the Scientific Council of the Institute of Catalysis – BAS, Protokol No. 11 of 19 November 2025, in connection with the election of a professor under the competition announced in the State Gazette, issue No. 82 of 07 October 2025. The sole candidate in the competition for the academic position of Professor is Assoc. Prof. Dr. Hristo Gospodinov Kolev from the Laboratory “Design and Characterization of Catalytic Materials” at the Institute of Catalysis – BAS.

1. Opinion on the submitted materials

The set of materials submitted to me in electronic form contains all required documents described in the Regulations for the conditions and procedure for awarding scientific degrees and occupying academic positions at the Institute of Catalysis – BAS. Assoc. Prof. Dr. Hristo Kolev meets the requirements specified in the Regulations. A list of a total of 139 scientific publications has been submitted, of which 78 scientific papers participate in the competition and do not duplicate the publications submitted for the acquisition of the PhD degree and the academic position of Associate Professor. Ten publications are designated as equivalent to a habilitation thesis, all of which are in Q1 journals. Another 68 original scientific papers fully meet the requirements of the current procedure.

From the submitted report on compliance with the criteria under Art. 55 of the Regulations for the conditions and procedure for awarding scientific degrees and occupying academic positions at IC – BAS, it is evident that for each indicator the candidate significantly exceeds the minimum

requirements: B – 2.5 times, C – 6.8 times, D – 20.8 times, E – 3.2 times. The candidate participates in the competition with a total of 4,226 points, with the required minimum being 600 points, i.e. more than seven times the required minimum.

2. Biographical data and professional development

Assoc. Prof. Dr. Hristo Gospodinov Kolev graduated in Engineering Physics from the Faculty of Physics at Sofia University “St. Kliment Ohridski” in 1998. In 2004, he obtained the educational and scientific degree **PhD** at the Westfälische Wilhelms-Universität Münster, Münster, Germany, in scientific specialty 01.03.26 – Electrical, Magnetic and Optical Properties of Condensed Matter, with a dissertation entitled “*Electronic Structure and Magnetic Properties of Multicomponent Ferromagnetic Systems*”, Certificate No. 1279-BAK/07.12.2009.

The candidate for Professor has acquired numerous qualifications and trainings in Bulgaria and abroad, including:

- May 2006 – qualification in Synchrotron Radiation and Applications at the Abdus Salam International Centre for Theoretical Physics and the ELETTRA Synchrotron Light Laboratory, Trieste, Italy;

- January–February 2012 – Business start-up course (50 hours) at the Cisco Entrepreneur Institute, Sofia;

- 18.09.2017 – 18.03.2018 – Senior Researcher at the Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Košice, within the research programme “Application of X-ray Photoelectron Spectroscopy (XPS) for better understanding of surface properties”, SAIA National Scholarship Programme of the Slovak Republic, Ministry of Education, Science, Research and Sport of the Slovak Republic.

He worked as a systems engineer from October 1998 to May 1999 at Makronet AD, Sofia, Bulgaria, engaged in the production and implementation of electronic electricity meters. From June 1999 to April 2002 and from May 2004 to April 2006 he worked as a physicist at IGIC – BAS, with main responsibilities including surface analysis of various types of samples and maintenance of X-ray photoelectron spectroscopy (XPS) equipment.

Since April 2006 he has been working as Research Associate II (PhD) at the Institute of Catalysis – BAS. From 02 May 2011 to 03 February 2014 he was appointed Chief Assistant (PhD), and since 03 February 2014 he has been working as Associate Professor at the Institute of Catalysis – BAS. Consequently, Assoc. Prof. Dr. Hristo Gospodinov Kolev possesses professional experience in the specialty that significantly exceeds the requirements set out in the regulatory documents for the competition for the academic position of Professor at IC – BAS.

Recognition of his scientific achievements includes the following prestigious awards:

- First Prize in the competition for best theoretical and applied scientific development in honour of 24 May 2011, BAS, Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Centre "Acad. Angel Balevski";

– Second Prize in the competition for best theoretical and applied scientific development in honour of 24 May 2013, BAS, Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Centre "Acad. Angel Balevski".

3. Analysis of the scientific and applied scientific activity of the candidate

a) Scientific publications

The total list of publications of Assoc. Prof. Dr. Hristo Kolev included in the competition comprises 139 items, including 78 scientific articles, most of which are published in journals indexed in Scopus/Web of Science. No evidence of plagiarism has been identified for any of the submitted publications. The publications submitted for participation in the competition do not duplicate those used for obtaining the PhD degree and the academic position of Associate Professor. In a considerable number of the publications, Dr. Hristo Kolev is first, second, or third author, demonstrating his leading contribution to the development of the presented scientific works and their associated contributions. The results of the candidate's research activity have been published in authoritative international journals, including 32 publications in Q1 journals (WoS or Scopus), four of which are in leading journals in the field, such as *Applied Surface Science* (IF 6.182), *Applied Catalysis B: Environmental* (IF 22.1), *Electrochimica Acta* (IF 4.578), *Royal Society of Chemistry journals* (IF 5.287), *Catalysis Today* (IF 5.825), *Carbon* (IF 9.594), *Nanomaterials* (IF 5.719), etc. Publications in Q2 journals number 21, while those in Q3 and Q4 journals are totally 24, indicating that the majority of publications involving Assoc. Prof. Dr. Hristo Kolev are in Q1 and Q2 journals (71.6% of all articles).

According to the Regulations, the publications participating in the competition are divided into two groups covering indicators B and C. Under indicator B – “Habilitation thesis – scientific publications in journals indexed in internationally recognized scientific databases (WoS or Scopus)” – 10 publications are presented, all in Q1 journals, yielding 250 points out of the required 100 points, i.e. exceeding the minimum requirement by 2.5 times.

Under **indicator G-7**, a total of 68 publications are presented: 22 in Q1 journals, 21 in Q2, 17 in Q3, 7 in Q4, and one in a journal without a quartile. Publications in Q1 and Q2 journals thus account for over 63% of all publications. Under **indicator G-9** – Invention, patent, or utility model with issued protection documents – the candidate has two granted Bulgarian patents: – “Device for protection of a seismic sensor from near-zone interference” and “Passive infrared motion sensor with a single-focus Fresnel lens and multiple zones”, bringing the total points in group G to 1,359. The minimum required points for the academic position of Professor in this group are 200, i.e. the candidate exceeds them by approximately 6.8 times.

Impact of scientific publications

Indicative of the scientific value of the works of Assoc. Prof. Dr. Hristo Gospodinov Kolev is the significant impact of his publications in the scientific literature. The publications in which he has participated have been cited 1,040 times (Group D – Citations in scientific journals, monographs, collective volumes, and patents indexed in Web of Science and Scopus). With a minimum requirement of 100 points for the position of Professor, this result exceeds the requirement by more than ten times, demonstrating the high scientific value of his work.

Participation in scientific forums and scientific projects

Assoc. Prof. Dr. Hristo Kolev has participated in 77 national and international scientific forums with a total of 140 presentations, including 32 oral presentations and 107 posters. His scientific achievements have been presented in Bulgaria and in numerous countries worldwide, including Romania, Serbia, Slovenia, Slovakia, Greece, Turkey, the Czech Republic, Poland, Belgium, Hungary, Italy, France, Portugal, Montenegro, the United Kingdom, China, India, Israel, and others, further demonstrating the wide international visibility of his work.

Under indicators **E-14–17 – Participation/leadership in national or international scientific or educational projects** – Assoc. Prof. Dr. Hristo Kolev has participated in 33 projects, including 24 national and 9 international projects. He has served as project leader in two national projects and as leader of the Bulgarian team in one international scientific or educational project. Importantly, the funds attracted for Bulgarian science and economy through projects led by the candidate exceed BGN 85.000 (EUR 43.459).

In summary, based on the submitted materials, for each scientometric indicator the candidate in the present competition, Assoc. Prof. Dr. Hristo Gospodinov Kolev, significantly exceeds the established requirements for the academic position of Professor in accordance with the Regulations of the Institute of Catalysis – BAS. Out of a minimum required total of 600 points, he has accumulated 4226 points, exceeding the requirement by more than seven times.

4. Evaluation of the scientific and applied scientific contributions of the candidate

The publications included in Group B – *Habilitation thesis – scientific publications in journals indexed in internationally recognized scientific databases (WoS or Scopus)* – number 10, and I would like to emphasize that all of them are published in Q1 journals. The main scientific contributions resulting from the fundamental and applied research of Assoc. Prof. Dr. Hristo Kolev are in the field of catalytic systems based on nanosized metal oxides and are grouped into four thematic areas:

1. **Co-containing oxide catalytic systems**
2. **Fe-containing oxide catalytic systems**
3. **Ni-containing oxide catalytic systems**
4. **Oxide catalytic systems containing rare-earth elements**

The main objective of these studies has been to establish correlations between the surface electronic structure and catalytic activity. For this purpose, X-ray photoelectron spectroscopy (XPS) has been predominantly employed in combination with TPR, EPR, XRD, BET, and TEM techniques.

The XPS results have been used for quantitative determination of the valence states of metal components and the ratio between different oxide forms, enabling clarification of the active sites involved in catalytic processes.

Group 1: Co-containing oxide catalytic systems

Three publications are included in this group. They elucidate the role of cobalt oxide in stabilizing PdO and its involvement in the supply of surface oxygen species in active and thermally stable Pd–Co/ γ -Al₂O₃ catalysts for complete methane oxidation. This has been achieved through control of the Co content and the sequence of metal deposition. The obtained surface information has been crucial for explaining the observed high activity and stability of the Pd–Co catalysts.

The role of the support for the active cobalt phase has also been investigated using activated carbon with different textures. It has been demonstrated that XPS analysis reveals a clear relationship between the porous structure of the carbon supports, the oxidation state of cobalt species, and the catalytic efficiency of the resulting catalysts. Mixed Co²⁺/Co³⁺ phases and their degree of accessibility are key factors determining catalyst activity and selectivity in methanol conversion.

The influence of Co in Co-containing oxide catalytic systems has also been studied in mixed Co–Mn oxide phases deposited on clinoptilolite for the oxidation of volatile organic compounds. The main emphasis here has been placed on the role of cobalt and manganese valence states, oxygen mobility, and the interaction between the active phase and the zeolite support. The objective has been to determine how surface chemistry governs catalytic activity and stability at moderate temperatures. The studies have shown that Co–Mn/clinoptilolite catalysts owe their efficiency to mixed Co²⁺/Co³⁺ and Mn³⁺/Mn⁴⁺ surface states, high oxygen mobility, and structural stability of the active phase. XPS analysis has been crucial in demonstrating the relationship between metal valence states, redox behaviour, and catalytic activity, clearly indicating that the optimal combination of Co³⁺ and Mn⁴⁺ is decisive for efficient oxidation of organic pollutants.

In these studies, the personal contribution of Assoc. Prof. Dr. Hristo Kolev is related to the performance and interpretation of the XPS analyses, which enabled elucidation of the valence states, surface chemistry, and redox behaviour of Co-containing oxide nanophases in various catalytic systems. Through XPS, it was established that in Pd–Co/ γ -Al₂O₃ catalysts cobalt oxide stabilizes palladium in its oxidized form (Pd²⁺), facilitates replenishment of surface oxygen species, and maintains active PdO centres at high temperatures, directly explaining the enhanced catalytic activity in methane oxidation.

In Co/activated carbon systems, XPS analysis revealed different Co²⁺/Co³⁺ ratios depending on the texture of the carbon support, demonstrating that the presence of accessible Co²⁺ species in mesopores correlates with higher activity in methanol conversion, whereas microporous supports limit the accessibility of active centres.

In Co–Mn/clinoptilolite systems, XPS analysis demonstrated a stable presence of mixed Co²⁺/Co³⁺ and Mn³⁺/Mn⁴⁺ valence states, the ratio of which determines oxygen mobility and redox behaviour. Partial reduction of Co³⁺→Co²⁺ and Mn⁴⁺→Mn³⁺ after catalytic reaction, characteristic of a Mars–van Krevelen-type mechanism, as well as complete restoration of the initial oxidation states after oxidative treatment, has been established, confirming the structural stability of the active phase.

The surface-chemical characteristics determined by XPS in these publications explain the observed catalytic activity in various oxidation processes, including methane oxidation, methanol decomposition, and oxidation of volatile organic compounds.

Group 2: Fe-containing oxide catalytic systems

Three publications are included in this group. In the work by Rosmini et al., *Carbon* (2022), mesoporous Ce–Fe–Ni mixed oxides with controlled metal content were investigated by XPS, followed by stepwise reduction and methanol-driven carbonization to obtain metal–carbon composites containing Ni–Fe alloys and Fe-carbide nanophases encapsulated in carbon nanotubes.

The main objective was to clarify the evolution of mixed oxides and metallic phases during reduction, alloy formation, and carbonization, as well as the effect of these structural changes on electrochemical activity in the oxygen evolution reaction (OER). XPS analysis revealed a complex redox balance between $\text{Fe}^{3+}/\text{Fe}^{2+}$, $\text{Ni}^{2+}/\text{Ni}^0$, and $\text{Ce}^{4+}/\text{Ce}^{3+}$. In the initial oxide samples, Fe was predominantly present as Fe^{3+} in hematite-like structures, while the $\text{Ce}^{4+}/\text{Ce}^{3+}$ ratio indicated the presence of oxygen vacancies and defective Ce–O–Fe interfaces. After reduction, partial transformation of $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+}$ and formation of Ni–Fe metallic alloys were observed. Subsequent carbonization led to the growth of Fe-carbide nanophases ($\chi\text{-Fe}_2\text{C}_5$) and an increase in graphitic carbon, as reflected in the C1s spectra.

The XPS results demonstrated that dynamic Fe-containing oxide and metallic phases, combined with a high degree of defectiveness and the formation of metal–carbon interfaces, create favourable conditions for electron transfer and reduced charge-transfer resistance, explaining the enhanced electrocatalytic activity in oxygen evolution.

Iron as an active phase was also combined with nickel in $\text{Ni}_x\text{Fe}_{3-x}\text{O}_4$ spinels (40 wt.%), which were subsequently subjected to methanol decomposition to induce coking. The objective was to assess whether carbon accumulation—typically undesirable in thermocatalysis—could be exploited as a mechanism for improving electrochemical properties and enabling reuse of “spent” catalysts. The results showed that coking led to the formation of new electrically conductive carbon structures and additional activation of Fe–Ni spinel species, significantly reducing charge-transfer resistance and lowering oxygen overpotential.

It should be emphasized that electrochemical anodic oxygen evolution is far less studied than cathodic hydrogen evolution due to the non-equilibrium nature of the oxygen electrode and its high positive potential. The contributions of Assoc. Prof. Dr. Hristo Kolev to elucidating the kinetics of this process are indisputable.

Iron has also been employed in $\text{SmFeO}_3/\text{CuO}$ composites with varying phase ratios, designed for peroxydisulfate activation and degradation of the antibiotic sulfathiazole. XPS studies demonstrated that the $\text{SmFeO}_3/\text{CuO}$ heterostructure creates stable surface active sites, while $\text{Fe}^{3+}/\text{Cu}^{2+}$ synergy facilitates the formation of $\bullet\text{OH}$, $\text{SO}_4^{\bullet-}$, and $^1\text{O}_2$, the main reactive oxygen species responsible for antibiotic degradation.

Group 3: Ni-containing oxide catalytic systems

One publication is included in this group. Monometallic Ni/Ce–Zr and bimetallic Ni–Sn/Ce–Zr catalysts with controlled Sn content were developed, reduced, and investigated in the aqueous-phase reforming (APR) of ethylene glycol. The main objective was to clarify the synergistic role of Sn and initial pH on the formation of Ni–Sn intermetallic compounds, the stability of Ni⁰ nanophases, and catalytic pathways for H₂ and organic product formation.

XPS analysis revealed that all reduced bimetallic samples exhibited a dominant Ni⁰ component (6.45–6.54 at.%). Residual Ni²⁺ (<1 at.%) indicated complete reduction of NiO under activation conditions. Lower relative Ni⁰ content in samples with high Sn loading was identified as an indicator of stable Ni–Sn intermetallic phase formation. Sn⁰ in the range of 0.5–1.2 at.% appeared only after reduction, confirming reduction of Sn⁴⁺ to Sn⁰ and its incorporation into Ni–Sn intermetallic structures. Partial reduction of Ce⁴⁺ to Ce³⁺ after reduction treatment correlated well with TPR–TGA data, highlighting the redox-active role of the support in stabilizing intermetallic particles.

Combined XPS and EXAFS analyses revealed reduced Ni–Ni coordination numbers (5.0–6.7), characteristic of small nanoparticles and/or intermetallic phases in which part of Ni is substituted by Sn. These data demonstrated that Sn stabilizes Ni⁰, reduces excessive C–C hydrogenolysis, and suppresses methanation, leading to higher hydrogen selectivity.

The surface chemistry determined by XPS explains the observed catalytic performance in APR of ethylene glycol, including enhanced H₂ selectivity and stability of Ni–Sn catalysts in alkaline media.

Group 4: Oxide catalytic systems containing rare-earth elements

Two publications are included in this group, describing the synthesis of ZnO-based catalysts modified with La³⁺ and Eu³⁺. XPS data demonstrated that La³⁺ and Eu³⁺ enhance the generation of superoxide radicals •O₂[−] by facilitating electron transfer to oxygen—a key mechanism for doxycycline degradation. In ZnO/La₂O₃ and ZnO/Eu₂O₃ systems, XPS revealed stable La³⁺ and Eu³⁺ surface states and increased oxygen defect density, correlating with higher tribocatalytic activity.

In sol–gel ZnO/Eu₂O₃ systems, XPS analysis established the coexistence of Eu²⁺/Eu³⁺ prior to catalysis and complete oxidation to Eu³⁺ after reaction, demonstrating the involvement of Eu-induced redox processes in active oxygen species generation. O1s analysis identified the role of oxygen vacancies in the mechanism. In both cases, XPS data enabled establishment of a clear relationship between valence states, defectiveness, and the observed tribocatalytic activity of modified ZnO systems.

Analysis of the submitted habilitation report shows that the candidate for the academic position of Professor has developed a consistent and conceptually grounded research programme in the field of surface chemistry of nanosized metal oxides as active catalytic systems. Through the application of XPS, significant results have been obtained regarding the influence of valence states, oxygen defectiveness, and redox behaviour of the studied oxide materials on catalytic performance, establishing clear correlations between surface electronic structure and catalytic activity. Overall,

the presented studies constitute a substantial contribution to advancing scientific understanding and targeted optimization of nano-oxide catalysts of environmental and technological importance.

5. Reviewer's personal impressions of the candidate

Assoc. Prof. Dr. Hristo Kolev has established himself as a leading researcher with exceptional scientific authority and a clearly defined specialization at the international level. His scientific activity is characterized by impeccable precision, in-depth analysis, and a systematic approach, and his results are original, convincing, and logically derived. The contributions of Assoc. Prof. Dr. Hristo Kolev are of both fundamental and applied significance, substantially enriching the scientific community and stimulating the development of innovative, sustainable, and green technologies that directly contribute to environmental protection and improvement of quality of life. He is an outstanding scientist whose achievements deserve high international recognition.

6. Critical remarks and recommendations

The scientific works of the candidate submitted for participation in the competition fall entirely within the thematic field of "Solid State Chemistry", more specifically "Design and Characterization of Catalytic Materials". The submitted author's report provides an excellent description of the candidate's achievements. The results are significant for both science and the design of new catalytic materials and have potential for direct industrial application. I have no critical remarks or recommendations regarding the candidate's scientific works.

CONCLUSION

The documents and materials submitted by Assoc. Prof. Dr. Hristo Gospodinov Kolev fully comply with the requirements of the Academic Staff Development Act of the Republic of Bulgaria, its Implementing Regulations, and the relevant Regulations for the conditions and procedure for awarding scientific degrees and occupying academic positions at the Institute of Catalysis – BAS. The candidate has presented a sufficient number of scientific publications produced after those used for obtaining the PhD degree and the academic position of Associate Professor. The results of Assoc. Prof. Dr. Kolev's research activity represent original scientific contributions that fully meet and significantly exceed the requirements of IC – BAS for the academic position of Professor within the scope of the competition. **I support the candidacy and firmly recommend that the members of the Scientific Jury and the esteemed Scientific Council of the Institute of Catalysis – BAS award Assoc. Prof. Dr. Hristo Gospodinov Kolev the academic position of Professor in Professional Field 4.2 Chemical Sciences (*Solid State Chemistry*).**

26.01.2026 r.
Sofia

Prepared the review:
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