

REVIEW

by **prof. Dr. Daniela Karashanova,**

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on the materials submitted for participation in the competition for the academic position of “Professor”, announced by the Institute of Physical Chemistry “Acad. Rostislaw Kaischew” at the Bulgarian Academy of Sciences (BAS) for the needs of the Department of “Electrochemistry and Corrosion”, in Professional Field 4.2 Chemical Sciences, scientific specialty “Electrochemistry”.

1. General presentation and brief biographical information about the candidate

By Order No. 75-RD-09 of 18 June 2026 of the Director of the Institute of Physical Chemistry at BAS, I was appointed a member of the Scientific Jury for the competition for the academic position of “Professor” in Professional Field 4.2 Chemical Sciences (Electrochemistry). In the competition announced in State Gazette, issue 44 of 14 May 2026, for the needs of the Department of “Electrochemistry and Corrosion”, the sole applicant is **Assoc. Prof. Dr. Jenia Stefanova Georgieva** from the same institute.

Assoc. Prof. Dr. Georgieva graduated from the Higher Institute of Chemical Technology – Sofia (now the University of Chemical Technology and Metallurgy – Sofia), receiving a Master’s degree in “Electrochemistry and Corrosion” in 1993. In 1999, she was appointed Assistant at the Institute of Physical Chemistry at BAS, where she defended her doctoral dissertation entitled “Electroless deposition of Ni-Cu-P and Ni-Sn-P coatings” in 2008, and since 2011 she has held the academic position of Associate Professor.

Over the years, Assoc. Prof. Georgieva has established collaborations and undertaken research visits at internationally recognized institutions such as Aristotle University of Thessaloniki, Greece; the Free University of Brussels, Belgium; the CEST Kompetenzzentrum für elektrochemische Oberflächentechnologie GmbH, Austria; and the Institute Charles Gerhardt in Montpellier, France.

The main research interests of Assoc. Prof. Georgieva are in the fields of electrocatalysis and photoelectrocatalysis, nanostructured materials, and electroless deposition of metals and alloys.

2. General presentation of the research and applied research activities

The overall research activity of Assoc. Prof. Jenia Georgieva comprises co-authorship of 55 publications, 51 of which are indexed in the Scopus and Web of Science databases. Of these, 36 (65%) were published in Q1 journals, 4 in Q2, 5 in Q3, 1 in Q4, 4 in journals with an SJR, and 1 is a book chapter. These publications have received 1,607 independent citations and yield an h-index of 25. Assoc. Prof. Georgieva has participated in 38 international and 13 national scientific forums. She has participated in 16 internationally funded and 8 nationally funded research projects, serving as project leader in 4 of them.

The research results with which the candidate participates in the announced competition for the position of “Professor” were obtained within 9 of the research projects and are presented in 20 scientific publications in international journals referenced and indexed in internationally

recognized databases. Among them are journals renowned in the fields of catalysis and electrochemistry: *Applied Catalysis B: Environmental* (IF2013=6.007), *Catalysts* (IF2021=4.146), *Journal of Applied Electrochemistry* (IF2014=2.409), and *Journal of Electroanalytical Chemistry* (IF2021=4.598).

Eight of the publications constitute the habilitation work. Six of them are in Q1 journals and two in Q2 journals. In addition to the habilitation work, another 12 publications are presented, distributed as follows: 7 in Q1, 1 in Q2, 2 in Q3, and 2 with an SJR. The results have been presented at 25 national and international scientific forums. The scientometric indicators also include 546 independent citations (excluding self-citations by all co-authors): 210 citations of the publications submitted as the habilitation work and 336 citations of publications outside the habilitation work.

The publications, citations, conference participation and projects selected for the competition by Assoc. Prof. Dr. Jenia Georgieva provide the required points corresponding to the minimum national requirements stipulated in the Regulations for the Implementation of the Act on the Development of the Academic Staff in the Republic of Bulgaria, as well as in the Regulations of BAS and the Institute of Physical Chemistry, and exceed them for most indicators. For Indicator 11, Group D, the requirement is exceeded more than ninefold: 1,092 points are presented against a minimum of 120; for Indicators 3–4, Group C: 190 points against a minimum of 100; for Indicators 5–10, Group D: 245 points against a minimum of 220; and for Indicators 13–18, Group E: 317 points against the required 150.

3. Main scientific and applied scientific contributions

Thematically, the scientific publications submitted for the competition are divided into the following three areas, within which the candidate's respective contributions can be identified, as she herself presents them in the statement of author contributions:

(1) Electrocatalytic oxidation of methanol (MOR)

This area comprises extensive studies on the synthesis and electrocatalytic and photoelectrocatalytic performance in the methanol oxidation reaction of catalytic systems based on various combinations of metals and non-metals with Pt: Pt(Cu), Pt(Cu)/C, Pt(Ni)/C, Pt(Ni)/TiO₂, Pt(Ni)/TiO₂-C, Pt-WO₃, and Pt-TiO₂/WO₃. The numerous structural, spectroscopic and electrochemical methods applied—scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), transmission electron microscopy (TEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), cyclic voltammetry (CV), linear sweep voltammetry (LSV), chronoamperometry (CA), and electrochemical impedance spectroscopy (EIS)—have enabled important relationships to be established between composition, structure, morphology, and electrocatalytic activity of Pt-based catalytic systems.

For the Pt(Cu)/C systems, TEM studies reveal partial alloying of Pt and Cu, accompanied by the formation of nanostructured particles with a core-shell architecture characterized by a Cu-containing core and a Pt-enriched outer shell. This structure is formed as a result of partial galvanic replacement with Pt of Cu previously deposited chemically on the carbon support. It has been shown that the course of the replacement process and the formation of the final structure of the catalytic material depend on the composition and state of the copper phase, including the presence of Cu₂O and CuO components.

The relationship between the structure of the Pt(Cu) nanoparticles and their catalytic behavior was also analyzed. A protective Pt-enriched shell around the Cu-containing core was established, which is associated with high intrinsic catalytic activity in CO and methanol oxidation. At the same time, nanoparticle agglomeration and the limited electrochemically active surface area were found to decrease the mass activity. These results indicate the need for further optimization of the synthetic approach in order to improve dispersion and increase the accessible active surface area.

For Pt(Ni)/C catalysts synthesized by sequential electroless deposition of Ni followed by galvanic replacement with Pt, the formation of a more complex hierarchical nanostructure was established. It is characterized by a Pt-enriched outer shell, whereas the inner part of the particles contains a Pt–Ni alloy and small Ni-rich regions.

The contributory nature of the studies in this area can be formulated as follows:

- Bimetallic Pt(Cu) and Pt(Ni) nanostructured electrocatalysts on carbon, oxide, and composite supports were developed by combining electroless deposition, photochemical reduction, and galvanic replacement, achieving efficient utilization of the noble metal.
- The key role of metal–support interactions in Pt/TiO₂, Pt/WO₃, and composite systems in controlling electronic properties, CO tolerance, and electrocatalytic stability was demonstrated.
- The mechanisms of synergistic action between metal nanoparticles and semiconductor oxide components were elucidated, including the participation of photogenerated charge carriers in photoelectrocatalytic processes.
- Approaches were proposed for obtaining highly efficient electrocatalysts with reduced noble-metal content through controlled formation of nanostructured metal and metal–oxide systems.

(2) Electrocatalytic reactions involving oxygen (ORR and OER)

This research area explores the development of nanostructured electrocatalytic systems with reduced noble-metal content and clarifies the relationships among the preparation method, structure of the active phase, metal–support interaction, and catalytic efficiency in oxygen-involving reactions.

Pt–Cu/C and Pt–Co/C systems with reduced noble-metal content and improved electrocatalytic characteristics were obtained by electroless deposition of Cu or Co on a carbon support followed by partial galvanic replacement with Pt.

For Pt–Cu/C electrocatalysts, it was shown that modification of Pt by introducing Cu changes the electronic structure of the active phase, improves ORR kinetics, and results in up to 56% higher specific activity than a commercial Pt/C catalyst at a potential of 0.85 V vs. RHE, owing to interactions between Cu and surface Pt atoms.

The developed Pt–Co/C electrocatalysts have a low Co content (≈ 0.7 wt.%) and form a Co–Pt core–shell structure. Despite their lower electrochemically active surface area, the systems exhibit approximately 2.6 times higher mass activity and 4 times higher intrinsic catalytic activity than a commercial Pt/C catalyst at 0.85 V vs. RHE. These results demonstrate the possibility of effectively reducing the amount of noble metal while simultaneously improving catalytic efficiency.

For the oxygen evolution reaction (OER), IrO₂/TiO₂ catalytic systems with high dispersion of the active phase and reduced Ir content were also developed. An original low-temperature photochemical method enabled direct formation of 1–2 nm IrO₂ nanoparticles with 25 wt.% Ir, uniformly dispersed on a TiO₂ support. The resulting systems show intrinsic catalytic activity comparable to that of a commercial IrO₂ catalyst at a significantly lower noble-metal content. The enhanced OER activity of IrO₂/TiO₂ is determined not solely by the electrochemically active surface area but by the increased intrinsic catalytic activity of IrO₂, arising from IrO₂–TiO₂ interactions and the high dispersion of the active phase. UV irradiation was also found to improve the stability of IrO₂/TiO₂ during the oxygen evolution reaction.

The main contributions of the studies in this area concern:

- Development of a consistent strategy for preparing nanostructured electrocatalysts with reduced noble-metal content, based on controlled formation of the active phase, use of bimetallic interactions, and optimization of metal–support interactions.
- Extension of synthesis methods for Pt-based catalytic systems through the use of oxide supports and photochemical approaches, enabling highly dispersed nanostructures with improved electrocatalytic efficiency.
- Establishment of the functional role of the oxide supports TiO₂ and WO₃ in controlling dispersion, electronic properties, stability, and catalytic activity of the active phase.
- Development of Pt–Cu/C, Pt–Co/C, and IrO₂/TiO₂ electrocatalytic systems for ORR and OER in which the noble-metal content is reduced while catalytic performance is maintained or improved.
- Generation of results outlining an independent research line related to the development of efficient electrocatalysts through control of the structural and electronic factors determining catalytic activity and stability.

(3) Electro- and photoelectrocatalytic processes on oxide supports and composite materials

This research area focuses on the development of catalytic systems for photoelectrocatalytic oxidation of methanol, constructed from photosensitive oxide supports such as TiO₂ (anatase or rutile) and WO₃, onto which minimal amounts of the noble metal Pt are deposited. The studies reveal the electrocatalytic and photoelectrocatalytic activity of the resulting systems and its relationship both to the type of support selected and to the interaction between the deposited metal and the oxide substrate. The influence of UV irradiation on photoinduced processes in these systems and on methanol electrooxidation was investigated.

A 25% increase in catalytic activity under UV irradiation was established for Pt–TiO₂–C systems, as a result of photoactivation of titanium dioxide and reduced blocking of active sites by intermediate products. In the Pt/WO₃ system, a photoinduced “self-cleaning” effect under visible-light irradiation was observed, resulting from removal of CO adsorbates from the Pt surface with the assistance of photogenerated holes and oxygen-containing reactive species.

Modified TiO₂ nanostructures (nanotubes) co-doped with boron and nitrogen were also developed with the aim of improving photoelectrochemical activity and extending spectral sensitivity into the visible-light region. This is attributed both to the creation of additional

energy levels in the band gap and to more efficient separation of photogenerated electrons and holes upon simultaneous doping with the two elements.

Photochemical approaches were also developed for preparing metal–oxide composite materials containing Pt, Cu, and IrO₂ on TiO₂-based supports.

By combining photodeposition and galvanic replacement, Pt(Cu)/TiO₂ catalytic systems with high dispersion and controlled distribution of the active phase were obtained. An original mechanism for formation of the metallic phase was proposed, involving the simultaneous participation of galvanic replacement of Cu by Pt and Ti(III)/Ti(IV) redox transitions in TiO₂. Ti(III) centers were found to participate in the reduction of Pt ions and the formation of the active metallic phase.

In addition, Pt-doped TiO₂/WO₃ bilayer systems with enhanced photoelectrocatalytic activity in methanol oxidation were developed.

The contributions from this group of studies can be summarized as follows:

- Establishment of a synergistic mechanism between photo- and electrocatalytic processes in the oxidation of organic compounds on TiO₂- and WO₃-based systems, clarifying the role of photogenerated charge carriers in enhancing catalytic activity.
- Development of modified TiO₂ nanostructures through co-doping with boron and nitrogen, resulting in altered electronic structure, improved charge-carrier separation, and enhanced photoelectrochemical activity.
- Proposal of a mechanism for preparing Pt(Cu)/TiO₂ composite catalysts in which the role of Ti(III)/Ti(IV) redox transitions in the formation and stabilization of the active metallic phase was demonstrated.
- Establishment of the role of metal–oxide interactions, which determine the electronic and structural characteristics of the composite materials and represent a key factor in achieving high catalytic activity and stability.
- - Development of a concept for controlling electrocatalytic and photoelectrocatalytic properties by combining metal nanoparticles, semiconductor oxides, and controlled photochemical synthesis processes.
- Overall, the candidate's contributions lie in establishing a methodological basis for the synthesis of Pt-based electrocatalytic systems by combining electroless deposition, photochemical reduction, and galvanic replacement. Reduced noble-metal content is achieved through controlled formation of core–shell structures and optimization of interactions between the active phase and the support, while maintaining or enhancing catalytic activity.

The three thematic areas considered are closely related to addressing serious environmental problems and are undoubtedly topical from both scientific and applied perspectives. The established relationships among structural, morphological, and catalytic properties provide a basis for developing highly efficient modern electrocatalytic materials with potential applications in fuel cells, electrolyzers, and photoelectrochemical systems.

4. Teaching and expert activities

Assoc. Prof. Georgieva has supervised one doctoral student who successfully defended her dissertation.

No information is provided on specialized courses taught for doctoral students at the BAS Training Centre, nor on expert activities such as preparing anonymous peer reviews, participation in editorial boards and organizing committees, etc.

5. Questions and comments

I have no critical remarks regarding the candidate. I do, however, have a small comment concerning the structuring of the habilitation work and the grouping of the submitted publications. It appears that, in selecting the publications to be included in the habilitation work, the journal quartile rather than the type of synthesized catalyst or the reaction in which it was applied was the leading criterion. Thus, the three thematic areas simultaneously include publications both from the habilitation work and from outside it.

CONCLUSION

The documents and materials submitted by the candidate in the competition, Assoc. Prof. Dr. Jenia Stefanova Georgieva, demonstrate research of excellent quality and fully comply with the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its Implementation, and the relevant Regulations of BAS and the Institute of Physical Chemistry "Acad. Rostislav Kaischew" at BAS, as well as with the subject of the announced competition for "Professor".

Having highly evaluated the contributions of the works and activities submitted in the competition, I give a fully convinced positive assessment and recommend that the esteemed members of the Scientific Jury prepare a report proposing to the Scientific Council of IPC-BAS that Assoc. Prof. Jenia Stefanova Georgieva be elected to the academic position of "Professor" at IPC-BAS in Professional Field 4.2 Chemical Sciences (Electrochemistry).

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Reviewer:

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